PAUL SCHERRER INSTITUT

PSI Scientific Report 2008

Cover photo:
Control room of the Low Emittance Gun test stand, where critical components for XFEL's electron source are being tested.

PSI Scientific Report 2008

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Building on our past to prepare our future

The year 2008 marked the 20th anniversary of the Paul Scherrer Institute, PSI, and my colleagues seized the opportunity to organise and run several special events during the year, with the ultimate goal of giving the Institute a higher visibility in the neighbourhood, among critical non-scientific stakeholders and within Switzerland in general. At the same time, important scientific and technological results have been obtained, of which you will learn more in this report. Finally, 2008 was also a special year for me, as I was honoured with the Directorship of the Institute.

20 years Paul Scherrer Institute

In 1988, PSI was founded by the merger of the Swiss Institute for Nuclear Research and the Federal Institute for Reactor Research. The cultures of both institutes were very different at that time, making a new, joint beginning quite difficult. However, from today's point of view, the amalgamation was the right decision: With the focus on the research areas of solid-state research and materials sciences, particle physics, life sciences, energy research and environmental research, a sagacious decision can be judged to have been made.
Nowadays, PSI's concept of focusing on its large-scale facilities – the neutron and muon sources around the proton accelerator and the Swiss Light Source SLS – is considered a success. The Institute focuses, on the one hand, on providing service for external research groups, which receive the support they need as they use the facilities, beamlines and research instruments, whereby it is our strategy to excel in a number of selected disciplines, rather than trying to serve the needs of all users. On the other hand, PSI's own research concentrates on those research topics where an advantage in terms of international competition can be gained by employing our own in-house large-scale and complex research equipments.
In addition, PSI's own research on the complex research equipment itself results in the acquisition of experience that can be used to develop our facilities still further, maintaining the latter's ability to compete internationally.

Three requirements that are essential for success

PSI serves as a successful example of how a research institute can continue to be an internationally acknowledged scientific hub by simply remaining flexible and thus safeguarding its own existence. Three prerequisites are essential for this:
Firstly, a well-defined scientific goal and a clear understanding of the Institute's role in the Swiss research landscape, especially its relationship with the universities; secondly, political decision-makers who understand the importance of basic and applied research for the progress of society, and consequently support us; thirdly, excellent staff. Only with highly qualified, experienced and motivated personnel is success in performing cutting-edge research possible.
Based on these three factors, within the course of the last 20 years PSI has been able on the one hand to generate outstanding fundamental research results and on the other hand to develop key technologies and introduce them successfully to the market. To give you two examples:
Firstly, the development of compact accelerators for the proton therapy of tumours. PSI is a technology leader in this area, and recent developments can be seen on page 56. Several

◀ **"One of the key ingredients in the success story of PSI is the quality of its staff"**

hospitals have already expressed their intention to establish this technology on their own sites.

And secondly, we have developed detectors that are orders of magnitude more sensitive than those existing previously. One such example is the MYTHEN X-ray detector, which is presented on page 26. In combination with recent developments at the SLS, MYTHEN is opening up wholly new perspectives for diffraction experiments.

Both products have already been successfully introduced to the market. It should, however, not go unmentioned that both technologies are the belated offspring of the basic research undertaken in the field of particle physics. As such, they are the results of a development phase of more than 20 years. Where else would such a long-term endeavour be possible, if not at a publicly funded research institute?

Interesting and surprising findings

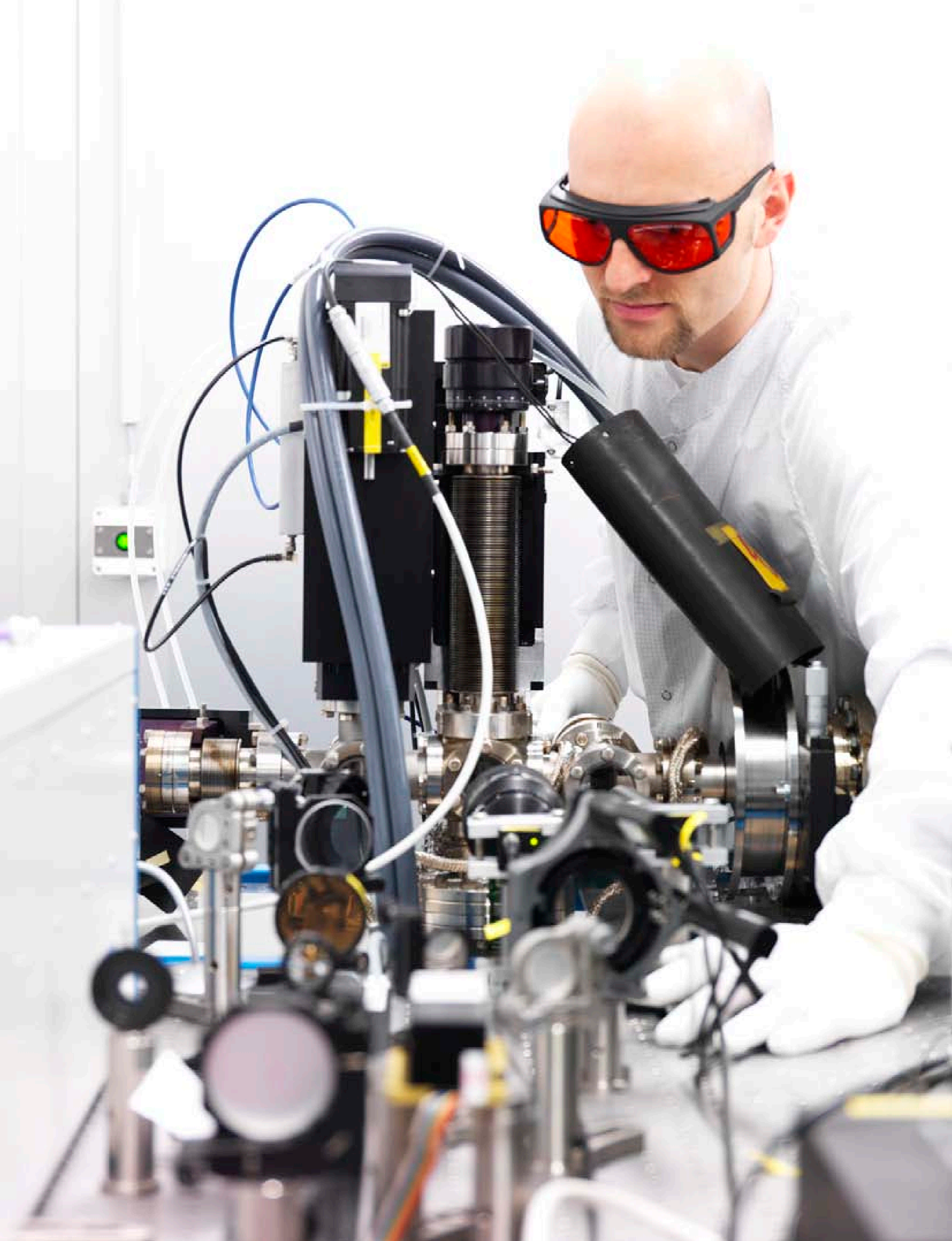
As to our scientific achievements in 2008, let me just highlight a couple, details of which you will find in the individual chapters in this report: Interesting and even surprising findings around superconductivity and magnetism revealed using neutron scattering and muon spin resonance accompanied us throughout the year (p. 28–31); using the high spatial resolution of synchrotron light at the SLS it was possible on the one hand to create new nano-structures (p. 42–45) and on the other hand to reveal microscopic details of the functioning of photo-catalysts (p. 20), fuel cells (p. 68) and bio-molecules (p. 23) with unprecedented accuracy. To complement the work performed at our large-scale facilities, various complementary methods are currently developed in Biology, Energy, or Environmental Sciences. For example, by using selected isotopes it is now possible to date glacier ice with unequalled precision (p. 40), to enhance the NMR sensitivity for potential medical diagnosis (p. 32), to develop efficient SPECT tracers (p. 50), or to assess the long-term safety of radioactive waste repositories (p. 82). On the operational side of the PSI accelerators, two world records were achieved: The proton facility surpassed its own world record, with a new beam power of 1.3 MW, and the SLS operating team announced a significant improvement of beam quality, resulting in a world-record low vertical emittance of 2.5 pm rad.

For the time being, PSI fulfils all the criteria necessary for remaining amongst the world's top research institutes for the next 20 years. For us, one such criterion is the development and construction of a novel and ambitious large-scale research installation for dynamical studies with femtosecond and atomic resolution: the free electron laser PSI-XFEL, whose commissioning is planned for 2016 (p. 7).

As a good and longstanding tradition, I shall end this foreword with my sincere thanks: Thanks to the PSI staff, who have made everything possible on which we proudly report in this volume, and "Thank you" to our research and development partners in academia and industry worldwide, to our home canton of Aargau for its manifold support, and to the Board of the ETH and the Swiss Federal Government for their continued support.

J. Mesot.

Joël Mesot, Director



The PSI-XFEL is planned to be the next large-scale facility at the Paul Scherrer Institute and will contribute to the vitality of the laboratory during the coming decades. The project represents a continuation of PSI's excellence in the field of synchrotron radiation research, established through the outstanding performance of the Swiss Light Source (SLS), which began operation in 2001.

The PSI-XFEL will complement the SLS by being ideally suited for experiments where the combination of atomic spatial resolution and femtosecond temporal resolution is required – detailed images of atoms and molecules in motion will be captured for the first time.

The PSI-XFEL will be one of the first national free-electron laser facilities worldwide that aims to produce coherent light with wavelengths down to 1 Ångström. It will hopefully serve as a model for other national sources, since further projects of this type are a long-term necessity, given the limited number of experiments that can be installed at any one such facility.

With the PSI-XFEL, Swiss and external users will have an excellent scientific instrument with which to perform novel investigations in the fields of chemistry, biochemistry, condensed matter physics and materials science.

New concepts and innovative technical solutions have been incorporated into the facility design to optimize performance and minimize cost. The low-charge concept, combined with an ultra-small electron-beam emittance, is the essence of this design. The higher longitudinal pulse compression required is realized with a newly-developed dual-frequency accelerating cavity. High-gradient and high-voltage acceleration systems are being developed to reduce space charge effects and to guarantee the required electron beam characteristics for the lasing process.

◀ **Romain Ganter, scientist at the PSI-XFEL project, adjusting the intensity of the laser beam which will generate the electron beam in XFEL's electron gun.**

The PSI X-ray Free Electron Laser – XFEL

Hans Braun, Romain Ganter, Marco Pedrozzi, Sven Reiche, Albin F. Wrulich, *Free Electron Laser Project (PSI-XFEL), PSI;* Leonid Rivkin, *Department Large Research Facilities, PSI*

The exciting features of this novel light source will, for example, allow users to unravel the molecular structure of a protein and to effectively take a motion picture of a chemical process on the scale of femtoseconds (fs). X-ray light of unprecedented quality is needed to guarantee the accomplishment of these ambitious goals. This, in turn, requires an electron beam with high performance and sophisticated beam-handling. In the past year, important steps towards the technical realization of the facility were made, and the XFEL concept was further improved.

Project overview

In a Free Electron Laser (FEL), electrons are not bound to an atom, as in a conventional laser, and light is created by transverse acceleration of a relativistic electron beam in an undulator. In a conventional laser, coherence is created by a stimulated transition of the electrons from an excited state of the atom to the ground state, with a corresponding emission of light that forms a narrow bandwidth around a single wavelength (the shortest wavelength possible is in the VUV). In a FEL, coherence arises from the interaction of the emitted electromagnetic wave with the electron beam, and lasing wavelengths can be achieved continuously down to the hard X-ray regime.

The generic elements of a FEL are a linear accelerator, a radiator constructed from several undulators, with beam focusing devices positioned between the undulator sections, and the photon beam distribution lines that house the experiments at their ends.

Acceleration to high energies is necessary for two reasons. Firstly, the resonance wavelength of an undulator for a given (minimum feasible) period length is reduced with the square of the energy, i.e. short wavelengths require higher energies. Secondly, the electrons can only emit in the fundamental radiation mode if the beam size and divergence (expressed by their product, the emittance) are small. Fortunately, the transverse beam size (and emittance) of the electron beam in a linear accelerator decreases with increasing energy (adiabatic damping). However, the latter condition requires high electron energies (and costly, long linear accelerators) for short lasing wavelengths.

In addition to the requirement of a small electron beam cross-section, there is also the pre-condition that many particles are to be involved in the process, i.e. the charge density must be high. This is achieved by compressing the length of the electron bunch in the linear accelerator by a sequence of bunch compressors.

In the PSI-XFEL, the acceleration process starts at the cathode of the electron gun. Two different electron guns are foreseen for the three undulator lines (Figure 1, Athos: 7 nm – 3 nm; Porthos: 3 nm – 0.7 nm; Aramis: 0.7 nm – 0.1 nm). Since the quality requirements are less stringent for the longer wavelengths, a more conventional gun, based on photoemission, can be used here. For the baseline design incorporating the CERN CTF3 gun, an electron pulse (bunch) of 10 ps duration (fwhm) and a peak current of 22 A is extracted from a metallic

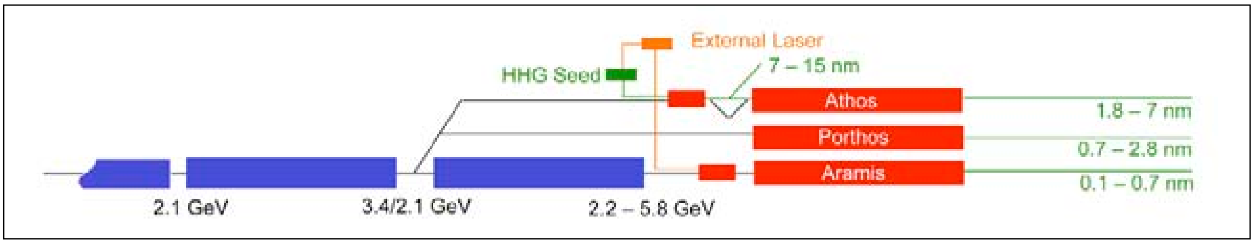


Figure 1: **Conceptual layout of the undulator lines.**

or semiconductor surface by means of a laser beam. The cathode is placed on the axis of a 2½ cell, 3 GHz accelerating cavity, which immediately accelerates the electron bunch after extraction from the cathode. Solenoid and quadrupole magnets in the subsequent structure focus the beam, to minimize the emittance at the exit of the gun complex.

For the second gun, several options are possible. The decision on which will be based on the success of ongoing R&D work. It will either be a newly-developed photo-electron gun or an alternative gun based on field emission arrays, where electrons are extracted from a surface by means of high electric field gradients (~ 5 GV/m). Such high gradients can be easily achieved if the field is applied to micro- or nano-structured surfaces where the field is strongly enhanced around tips with small apex radii. In order to mitigate space charge effects, the energy of the beam is rapidly increased by passing the beam through a high-voltage and high-gradient diode configuration, before entering the first RF accelerating structure. A newly-developed high voltage pulser is currently being tested and further developed. Different surface materials are being explored, to discover those which can sustain high surface gradients without breakdown. Since this concept relies on a longer initial pulse (40 ps fwhm with 5.5 A peak current), a higher compression is required to reach a sufficiently high peak current at the entrance to the undulator. This compression starts in the first accelerating cavity, which is fed by two frequencies (1.5 GHz and 4.5 GHz). In this way, the longitudinal energy distribution in the beam can be suitably shaped to reach a very effective velocity compression. In the low relativistic regime, particles with different energies still have a notable difference in velocities. If they are arranged properly in energy along the bunch, they move towards the bunch centre, and the length is reduced.

After the gun complex, the bunch can be directed into a diagnostic line for complete characterization. A more conventional accelerating structure follows the gun and comprises four S-band structures of 4 m length, surrounded by focusing solenoids. The maximum accelerating gradient is 20 MV/m. In the test setup for this injector presently under construction, a bunch compressor will be placed at the end (250 MeV) for test purposes. In the final layout, an additional accelerating section will be added (Linac 1) in front of the bunch compressor, boosting the energy to 450 MeV. The higher energy will alleviate the risk of emittance dilution due to space charge effects in the bunch compressor. Linac 1 comprises two FODO cells, each of 10 m length, with two accelerating structures of 2 m length between adjacent quadrupoles. One cell will provide an energy increase of 120 MeV on crest, corresponding to an accelerating gradient of 30 MV/m.

During the acceleration process prior to the bunch compressor, an energy chirp will be introduced in the beam. Particles with higher energies will be arranged at the tail of the bunch and particles with lower energies at the head of the bunch. Due to the nonlinearity of the 3 GHz accelerating field, the energy chirp is slightly too large in the head of the bunch and too small in the tail. Therefore an X-band (12 GHz) cavity is introduced before the bunch compressor to compensate for these deviations.

The bunch compressor (BC1) consists of a sequence of four bending magnets, which create an orbit bump around the straight motion path in the linac. Since particles with higher energies are subject to a smaller deflection in the magnets, their orbit lengths are shortened. They are consequently moved from the tail towards the centre of the bunch. Similarly, the lower-energy particles at the head of the bunch experience larger deflections that result in a lengthening of the orbit and a transition towards the bunch centre. The net effect after BC1 is that the length of the bunch is reduced from 10 ps (for the 200 pC mode) to 450 fs.

The subsequent Linac 2 (with the same cell structure as Linac 1) raises the energy to 2.1 GeV. At this point, the second magnetic bunch compressor (BC2) is introduced, which reduces the bunch duration to 30 fs, with a corresponding increase of the peak current to 2.7 kA. For the succeeding Linac 3, the transverse beam dimensions are already considerably smaller, due to the increased beam energy, permitting the distance between the focusing quadrupoles to be increased. One cell here is constructed from four two-metre-long accelerating sections between two adjacent quadrupoles, and has a total length of 19 m.

After Linac 3, the electron beam is extracted for the longer-wavelength FEL lines Athos and Porthos. The nominal energy at this point is 3.4 GeV, but will be reduced to 2.1 GeV for Athos by not powering Linac 3. It remains to be verified by simulations whether the focusing lattice can remain unchanged, since the quadrupole strengths are matched to a higher energy, otherwise a second extraction point after Linac 2 will need to be inserted.

Only for the 1 Ångstrom wavelength of Aramis is an additional boost to 5.8 GeV required, provided by Linac 4, which uses the same cell structure as Linac 3.

The electron beam quality is now sufficient for the lasing process as the beam enters the undulators. The emittance is reduced by adiabatic damping, and the bunch is longitudinally compressed.

In principle, an electron transversally accelerated in a magnetic field emits a broad spectrum of radiation. However, in an undulator the only wavelengths not to be eliminated by interference effects are those for which the electron beam lags behind the photon beam by one wavelength (or an odd integer multiple). Due to the long undulator structure, the intensity of the radiation steadily increases and becomes sufficiently strong to act back on the electron bunch. The transverse electric field of the emitted wave causes acceleration and deceleration of particles within the transversally moving electron bunch in the undulator, which imprints a micro-bunch structure onto the whole. The more this structure is enhanced, the more coherent the radiation becomes. At saturation, the waves emitted from the different micro-bunches are summed up in phase, leading to a tremendous increase in intensity of the transversally, fully coherent light.

At the end of the undulator, a photon beam with 2.9 GW power is extracted from Aramis, with a pulse duration of 40 fs at 1 Ångström wavelength.

The photon beam is then distributed to the various experiments. At the exit of the undulator, no material can withstand the high power density, necessitating long expansion lines before optical elements can be positioned in regions of acceptable heat load. Since X-ray mirrors have useful reflectivity only at very small grazing angles, long optical lines with refocusing are required to guide the photon beam to the experiments.

Project progress

The PSI-XFEL project is being executed in three parallel developments. Major emphasis is given to the realization of a low-emittance gun by exploring the ultimate limits of conventional photo-cathodes and investigating new options based on field-emission from needles and field-emitter arrays (FEA). Simultaneously, the injector of the XFEL facility is being built, which will integrate the major critical R&D elements of the project and allow their verification and optimization at an early stage. Finally, the configuration of the final XFEL facility is being developed and the civil engineering requirements are being specified.

High-brightness electron beams

Operation of the PSI-XFEL will start with a conventional photo-gun for the electron source. Simulations have confirmed satisfactory performance for both the hard and soft X-ray undulator beamlines. Eventually, after successful completion of the R&D, the driver system for the hard X-ray line will be equipped with a cathode based on field-emission from a needle or an FEA, embedded in a diode configuration for high-gradient and high-voltage acceleration.

For the needle cathode, two independent emittance measurement methods have confirmed the target value of 0.2 µm. Further work is needed to reach the required charge and emission current. A major step forward was made for FEAs by controlling the tip apex for homogeneous emission, and a production process for double-gated arrays (Figure 2) has been developed [1]. It could be demonstrated that the focusing gate has little effect on the emitted current, compared to the single-gated array. So far, the current is limited by the available accelerating voltage. A new test setup is being installed to overcome this limitation.

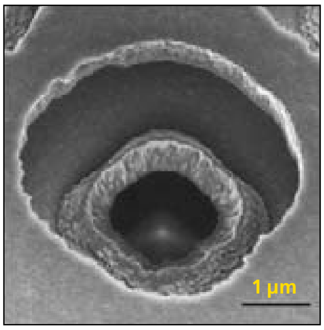


Figure 2: **Double-gate field emitter.**

XFEL injector

Construction of the 250 MeV injector for the FEL facility will allow the testing of critical technical developments, and the verification and optimization of their performance, at an early stage. For optimum performance, two complementary electron guns will feed the linear accelerator. Both gun concepts can be tested in the 250 MeV injector facility. Operation will start with the "CTF" photo gun (Figure 3) [2]. Emission from the cathode is driven by a Ti-Sapphire laser system, which allows longitudinal pulse-shaping and wavelength-tuning for the generation of minimum emittance.

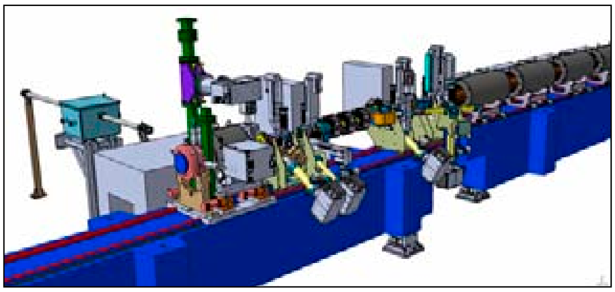


Figure 3: **Injector configuration with the CTF gun.**

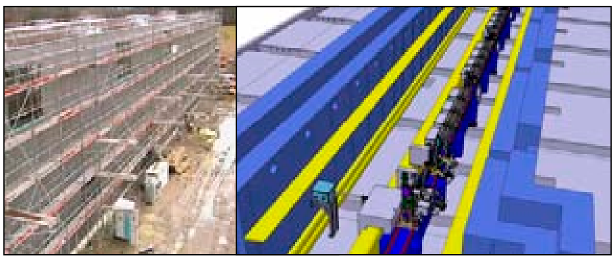


Figure 4: **Injector building.**

Construction of the 250 MeV injector is currently in progress and the procurement of magnets, accelerating structures, klystrons, modulators and laser systems has begun. Building construction is well underway (Figure 4) and will be completed early in 2010.

XFEL facility

Extensive start-to-end simulations have been performed in order to consolidate the basic parameters and the configuration of the XFEL facility. Figure 5 shows the simulation results for Self Amplified Spontaneous Emission (SASE) at 1 Ångström wavelength.

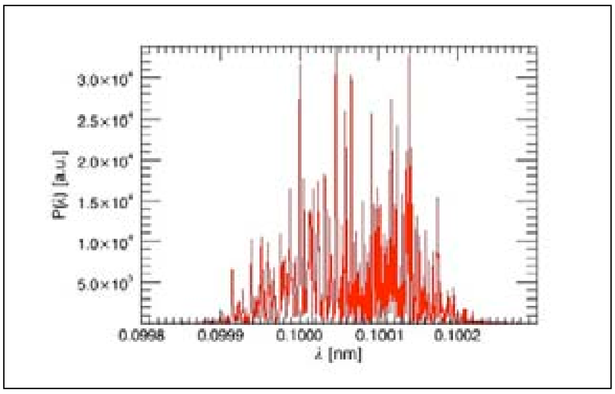


Figure 5: **Spectrum at saturation for SASE operation.**

The three XFEL beamlines have been re-optimized to allow independent operation. For the soft X-ray undulator line, seeded operation is foreseen, possibly based on high-harmonic generation from a Ti-Sapphire laser [3]. This will enhance the longitudinal coherence of the XFEL pulse, even at wavelengths down to 1 nm, and render the XFEL operation more stable in both frequency and time. Provisions for short-pulse operation have been made, based on either laser-slicing or low-charge, "single-spike" operation (Figure 6).

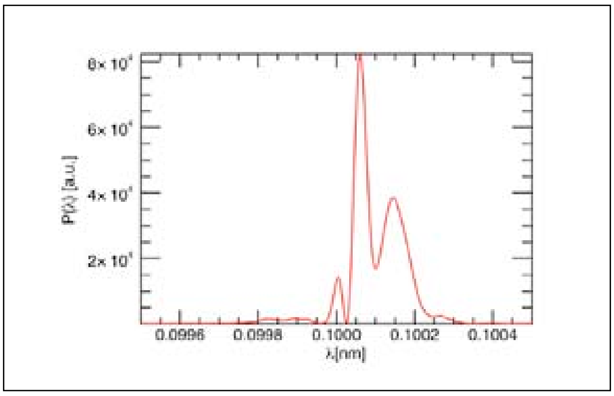


Figure 6: **"Single-spike" spectrum at saturation for 2 pC operation.**

The consolidation of the XFEL configuration has allowed the preparation of a conceptual design of the building with experimental hall and technical infrastructure. The orientation of the building has been slightly modified to increase the available space (Figure 7).
The accelerator and the experimental hall will be completely below ground, with an underground supply area on top of the accelerator tunnel (Figure 8).

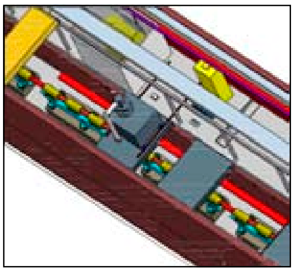


Figure 8: **Design study of the XFEL tunnel, with accelerator and technical gallery.**

For further information see: http://fel.web.psi.ch

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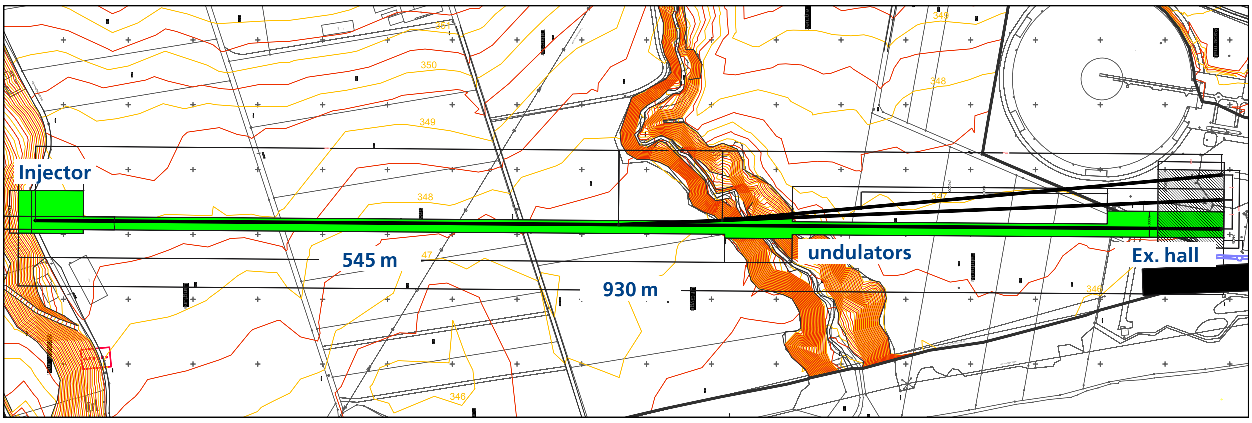

Figure 7: **Layout of the facility adjacent to the PSI site.**

Novel science at the PSI-XFEL

Bruce Patterson, Rafael Abela, *Free Electron Laser Project (PSI-XFEL), PSI*
Kurt Ballmer-Hofer, *Molecular Cell Biology, PSI,* Laura Heyderman, *Laboratory for Micro- and Nanotechnology, PSI;* Chris Milne, *Laboratory for Synchrotron Radiation, PSI and EPFL, Lausanne;* Urs Staub, Pierre Thibault, *Laboratory for Synchrotron Radiation, PSI*

The PSI X-Ray Free Electron Laser (XFEL) facility will offer possibilities for novel science in condensed matter physics, chemistry and biology. The advantage of the XFEL over visible lasers and X-ray synchrotrons is the combination of short wavelength (0.1 – 10 nm), short pulse duration (<20 fs), high peak brightness, and high coherence. These properties will allow observations of time-dependent behaviour at the atomic level.

Scientific strengths of the PSI-XFEL

The photon energies of the PSI X-ray Free Electron Laser (XFEL) [1] will allow a wide range of investigations of matter at the molecular and atomic level (see Figure 1). Furthermore, the extremely short X-ray pulses (<20 fs = 2×10^{-14} s) and high peak flux (10^{11} photons/pulse) will permit the study of ultrafast dynamics, either as equilibrium fluctuations or in "pump-probe" experiments. XFEL-radiation has 100% transverse coherence, allowing "lensless imaging" of nanostructures, down to atomic resolution. Although a focused XFEL pulse will locally destroy the sample, the short pulse duration will ensure that the scattered photons reaching the detector arise from undamaged material. Variable-polarization undulators at the PSI-XFEL will allow observation of magnetization dynamics, using the magnetic contrast of the L absorption features of, for example, Fe, Co and Ni. Interesting magnetic processes may be efficiently initiated at the PSI-XFEL with picosecond, half-cycle pulses of intense terahertz (THz) radiation, produced by a dedicated source, synchronized with the XFEL. The same THz source may also initiate surface catalytic reactions. It is also planned that the PSI-XFEL will deliver highly uniform, "transform-limited" X-ray pulses, suitable for novel "quantum optics" techniques, such as heterodyne spectroscopy. Finally, the maximum photon energy of the PSI-XFEL may be sufficiently high to reach the ultra-narrow (10^{-8} eV) "Mössbauer resonance" of the ^{57}Fe nucleus, yielding the ultimate in high-coherence X-rays. In what follows, we briefly present three proposed XFEL experiments of particular interest to PSI research divisions.

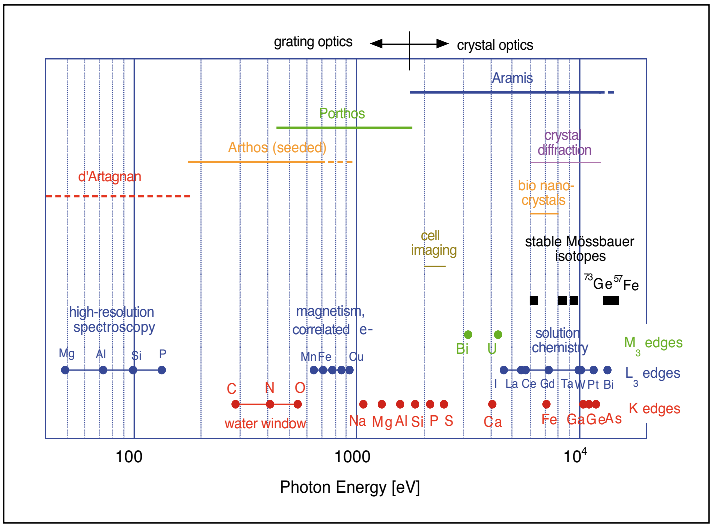

Figure 1: **The range of photon energy spanned by the beamlines of the PSI-XFEL. Also indicated are preferred ranges for studying, for example, organic materials in aqueous solution ("water window"), magnetism and correlated electron materials, and biological material in cellular and crystalline forms. The "M, L and K edges" refer to resonant energies of particular atomic elements.**

Nanoscale magnetic processes

Very stable "magnetic vortices" in planar magnetic nanostructures may in the future be used for high-density information storage. Field-induced switching of the core of such a vortex is predicted to occur on the nm and ps length and time scales [2] (see Figure 2). With the high transverse coherence and the circular polarization of the PSI-XFEL beam, and at photon energies close to the magnetically-sensitive L_2 and L_3 edges of, for example, cobalt (at 793 and 778 eV, respectively), it

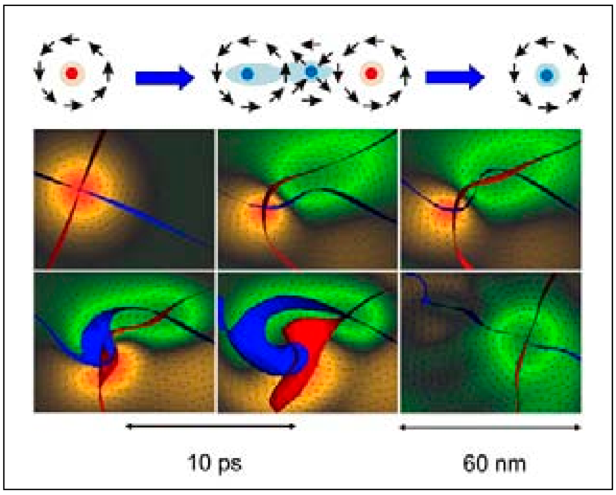

Figure 2: **Predicted magnetic behaviour [2] at the centre of a Co-nanodisk, illustrating how a magnetic field pulse can change the direction of a vortex core from up (red) to down (green).**

will be possible to take "snapshots" of the instantaneous magnetization distribution in thin-film nanostructures, and hence to follow this process in detail.

Unstable intermediates in surface catalysis

Surface catalytic reactions play a central role in many industrial chemical processes, in clean energy production and in eliminating environmental pollutants. A typical reaction is shown schematically in Figure 3. In the presence of a heated substrate, reactant species go through a series of short-lived intermediate states, finally emerging as the desired product. Figure 3 illustrates a possible "THz pump / X-ray absorption spectroscopy probe" XFEL measurement, which will elucidate the chemical nature of intermediate states on a ps-ns timescale [3].

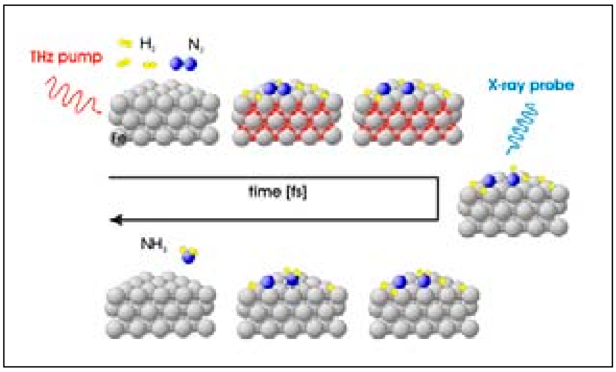

Figure 3: **The "Haber-Bosch" catalytic process for synthesizing ammonia. At the PSI-XFEL, such a reaction may be initiated with a THz pulse and probed at time τ later with soft X-ray spectroscopy [3].**

Protein structure from 2D-crystals

Protein structure determines the function of the building blocks of life, and its knowledge permits the intelligent design of drugs to treat genetic diseases. Many clinically relevant proteins are membrane bound. Their 3D crystallization is difficult and requires tedious optimization to yield well-diffracting crystals. With the PSI-XFEL, it should be possible to extract high-resolution structural data from diffraction experiments on two-dimensional crystals (see Figure 4), complementing the techniques of electron diffraction/microscopy [4]. Although each XFEL shot will locally destroy the sample, with a focus spot size of 100 nm and the 100 Hz repetition rate of the PSI-XFEL, it will be possible to reposition the sample between shots.

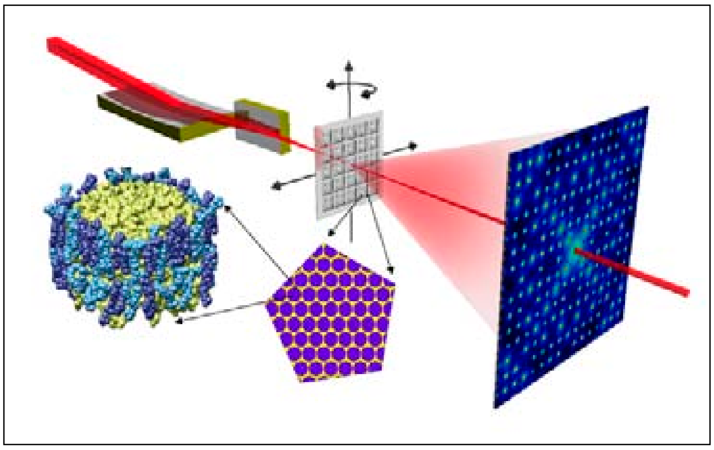

Figure 4: **A high-intensity XFEL pulse scatters on a 2D-membrane protein crystal. Sufficient scattered photons are collected to allow a structural solution before the pulse locally destroys the sample [5].**

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The PSI-LEG test stand

T. Schietinger, B. Beutner, R. Ganter, C. Gough, C. P. Hauri, R. Ischebeck, S. Ivkovic, Y. Kim, F. Le Pimpec, K. B. Li, P. Ming, A. Oppelt, M. Paraliev, M. Pedrozzi, V. Schlott, B. Steffen, A. F. Wrulich, *Free Electron Laser Project (PSI-XFEL), PSI*

The PSI-LEG test stand is PSI's test bed for the development of an ultra-bright electron gun based on a high-voltage pulser configuration. This is one of several promising candidate designs for the electron source to be used at the PSI X-ray Free-Electron Laser. Since the start of operation at the end of 2007, the test stand has provided important information on relevant materials and geometries. The facility was recently upgraded with the addition of a radio-frequency cavity to accelerate electrons up to 4 MeV.

Introduction

Operating an X-ray free electron laser at relatively low electron energy requires an electron beam of unprecedented brightness: the electrons must be as densely packed as possible yet still propagate on highly parallel trajectories. Since any irregularities in the electron beam from the source cannot be corrected further downstream, the quality of the electron source is of paramount importance. To explore and evaluate new concepts for the generation of ultra-bright electron beams, such as field-emitter arrays or needle cathodes, PSI initiated the Low Emittance Gun (LEG) project. (The emittance of a beam is a measure for how well it can be focused – the lower the emittance, the brighter the beam.) The centre-piece of this effort is the PSI-LEG test stand, located in the OBLA building. The installation was implemented in two phases, with electrons reaching energies of 500 keV and 4 MeV, respectively.

Figure 1: **The tungsten mask ("pepper-pot") intercepting the electron beam...**

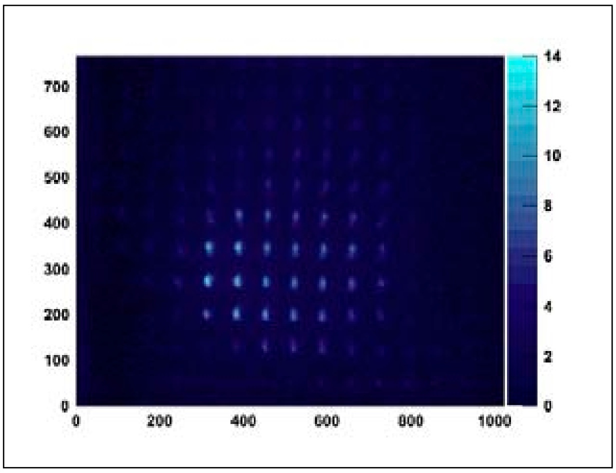

Figure 2: **...and the resulting electron density as imaged by a screen further downstream. The fuzziness of the image is a measure of the beam emittance.**

Phase I: From 0 to 500 keV in 50 ps

In its initial form, the PSI-LEG test stand consisted of a high-voltage pulser followed by a short diagnostic beamline. In this configuration, the test stand was in operation from December 2007 until October 2008.

The pulser generates a "diode" electric field between two metal electrodes (typically copper or stainless steel) separated by a variable gap of several millimetres. The electric field can reach up to 120 MV/m for the duration of about 250 ns. It accelerates electrons emitted at the cathode to a kinetic energy of approximately 500 keV in a few tens of picoseconds. At this energy, the influence of repulsive space-charge forces

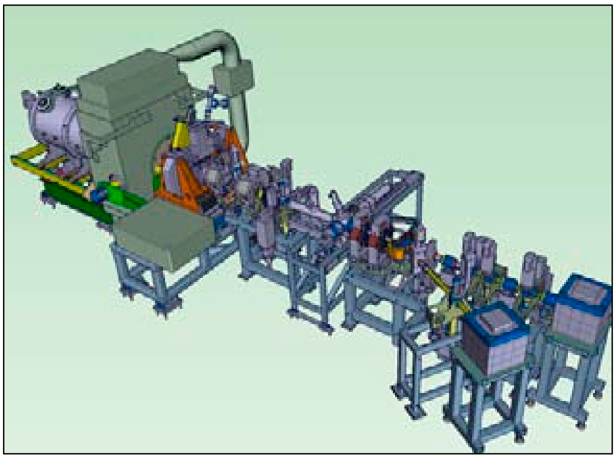

Figure 3: **Schematic layout of the PSI-LEG test stand with the full 4 MeV beamline.**

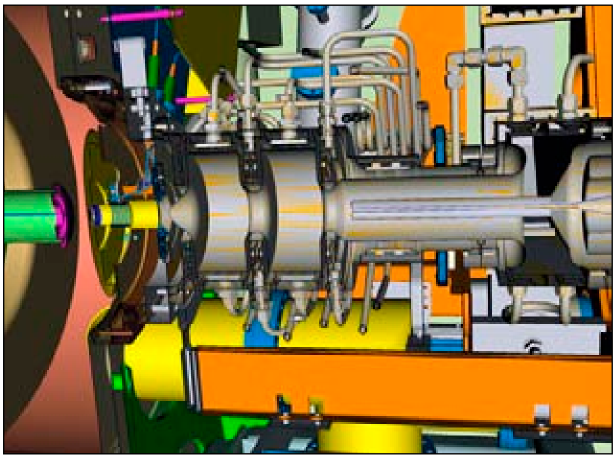

Figure 4: **Close-up of the cathode (magenta), anode (yellow) and two-cell cavity (silver).**

is considerably reduced. The emission of electrons from the metal cathode is either triggered by the electric field itself (field emission), or by a UV laser beam shining onto the cathode for a few picoseconds (photo-emission). The fraction of photons that produce free electrons is called the quantum efficiency, an important characteristic of the cathode material. The laser beam enters the diode through a small hole in the anode (the iris). Through the same iris, the accelerated electrons are allowed to leave the diode gap and enter the diagnostic beamline. A series of solenoid magnets and screens then allows detailed characterization of the electron beam. The emittance of the beam is determined either from the observation of the beam size under progressively stronger solenoid focusing or, more precisely, from the overall beam size and the local uncorrelated divergence. The latter is estimated with the so-called "pepper-pot" method, in which the beam is sent through a tungsten mask pierced with an array of small holes, much like the top of a pepper shaker (Figure1). The broadening of the electron distribution emerging from each hole is a direct measure of the local, uncorrelated divergence of the beam (Figure 2).

Operation of the test stand during Phase I resulted in a wealth of information important to the further development of the programme. In particular, a wide range of cathode materials was investigated with regard to quantum efficiency and highest field gradient achievable with and without laser irradiation. Electrodes made from diamond-like carbon were shown to withstand up to 240 MV/m without, and 100 MV/m with, laser irradiation. The maximum extracted charge was 200 pC, when using a powerful Nd:YAG laser of 262 nm wavelength. The setup also allowed an accurate measurement of the so-called thermal emittance of the electron beam emerging from a metal cathode. This is the residual emittance arising from the thermal motion of the electrons inside the cathode prior to emission.

Phase II: Surfing to 4 MeV

To increase the beam energy into the MeV range, a radiofrequency cavity was added to the test stand during a major upgrade (Figure 4). The beamline now measures some five metres in length and includes a dispersive branch for momentum measurements (Figure 3). Installation was completed in December 2008, and first beam was observed in early January 2009. The new setup will give valuable insights as to how the emittance of the generated electrons can be preserved up to higher energy.

An entirely re-designed laser system will provide laser pulses of tuneable wavelength, thus allowing the study of beam emittance as a function of photon energy. Last but not least, the experience gained by operating the PSI-LEG will be of great value for the commissioning of the much larger future facilities that are planned in the context of the PSI-XFEL project.

Figure 5: **Proud members of the PSI-LEG team posing in front of the beamline shortly before its upgrade to the 4 MeV configuration.**

Research focus and highlights

Examples from PSI's research portfolio in 2008 are presented on the following pages, but this is only a very small sample of the cutting-edge research being performed at the Institute.

A large number of results in various fields of science have been obtained at PSI's large-scale facilities; for example, research at SLS provided insights into the structures of novel nanomaterials, the inner workings of photocatalysts and processes in biomolecules. The fascinating interactions between superconductivity and magnetism were among the topics investigated with muons and neutrons.

The development of a new process for turning wet biomass into methane, and thus making the solar energy stored in these materials available for use in households and vehicles, is but one example of PSI's activities towards a sustainable energy supply. In the field of nuclear energy and safety, current research projects include the investigation of the geological conditions required for the storage of nuclear waste and the development of methods for monitoring material fatigue in nuclear power plants.

In environmental research, information gained from an ice core drilled in the Siberian Altai Mountains showed the influence of solar activity and greenhouse gases on the local climate, and a new method developed by researchers from PSI and ETHZ will allow even more precise dating of ice cores in the future.

Activities in the medical field covered a very broad range, from fundamental research into the origins of various diseases to the treatment of actual patients at the proton therapy facility. The year 2008 was the first year of continuous patient treatment at Gantry 1, as well as a year of considerable progress in the development of future facilities and technologies for proton therapy at PSI.

◀ **Reto Flückiger, PhD student in the Electrochemistry Laboratory, preparing a tomography experiment on gas diffusion layers for fuel cells.**

Structure and trapping properties of corrugated monolayers – new results from across the SLS

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The physical properties of the isoelectronic, two-dimensional structures of graphene and hexagonal boron-nitride are complementary and may also in combination become technologically useful. On solid supports, both deviate from a perfectly flat honeycomb structure and provide the possibility to functionalize them as templates for nanoscaled arrays among other applications. Structural and electronic studies of these systems performed at the Swiss Light Source have provided new insights for their potential use in areas as diverse as molecular recognition, nanoarrays, and novel electronic device fabrication.

Graphene and hexagonal boron-nitride (h-BN) are honeycomb structures that can be grown as single layers, or "sheets", on crystalline substrates. The bonding between these sp^2-hybridised, two-dimensional structures and the substrate varies periodically, due to a moiré-like interference caused by differences in their respective in-plane lattice constants. As a consequence, the atomic sheets become corrugated, resulting in features with periods of a few tens of Ångströms. They are characterised by pronounced and separated triangular elevations on a hexagonal network in the case of graphene, but in h-BN the elevations are more hexagonal with wire-like connected rings, and is thus referred to as a "nanomesh". Their future use as nanotemplates for molecular arrays and in recognition of macromolecules is a tantalizing prospect that can be better assessed only by a deeper understanding of their structures and electronic properties. With this in mind, studies of these systems have been performed at the Surface Diffraction Station and Surface and Interface Spectroscopy Beamline of the Swiss Light Source.

Graphene on Ruthenium

Initial studies of graphene on Ru(0001) (g/Ru) using techniques such as scanning tunneling microscopy and low-energy electron-diffraction produced mutually contradictory results: two different structures were proposed – one in which (12×12) graphene hexagons lie on (11×11) Ru unit cells (denoted henceforth as 12-on-11) [1], and another suggesting an 11-on-10 structure [2]. None of these studies, however, had the necessary spatial sensitivity to unambiguously resolve this inconsistency. Only surface X-ray diffraction (SXRD) has the necessary resolution (approximately two parts in ten-thousand of an in-plane reciprocal lattice unit), and hence SXRD studies were performed on g/Ru at the Materials Science beamline of the SLS.

Surprisingly, in-plane SXRD measurements showed that the moiré structure agrees with neither of those previously proposed, but is in fact unambiguously 25-on-23, having a pe-

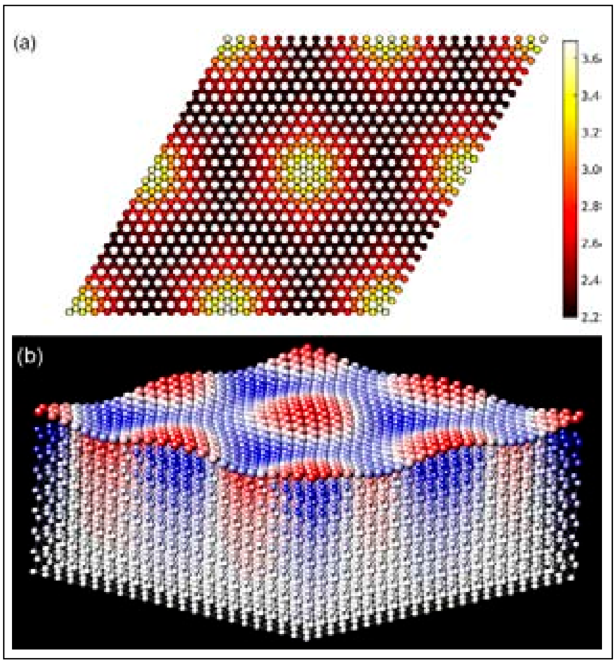

Figure 1: **(a) The vertical displacement field (in Å) of the corrugated supercell of graphene on Ru, which consists of four, not quite identical, subunits; (b) The ruthenium substrate is also slightly corrugated, in antiphase to the graphene.**

riodicity of over 60 Å [3]. This superstructure comprises four translationally inequivalent (but nonetheless nearly identical) subunits [see Figure 1(a)] with chemistries very similar to that of the initially proposed 12-on-11 structure.

Out-of-plane measurements along superstructure rods showed pronounced oscillations and indicated both strong out-of-plane corrugation of the graphene with an amplitude of 1.4Å, and also a weaker corrugation of the Ru. More recent analysis of the data using a parametric approach implemented in GenX, which uses a genetic algorithm [4], shows that the corrugation of the Ru is 180o out of phase with that of the graphene [Figure 1(b) and [5]].

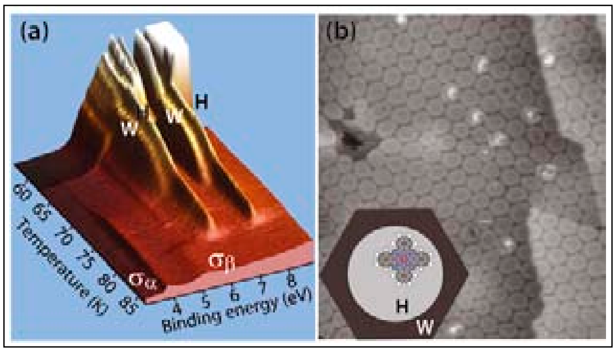

Figure 2: **(a) Three-dimensional rendered photoemission data set of the desorption of Xe from the h-BN nanomesh on Rh(111); (b) STM image of Cu-Pc molecules trapped in the holes of the nanomesh at room temperature.**

Dipole rings in the h-BN nanomesh

h-BN nanomeshes on Rh(111) and on Ru(0001) were also studied using SXRD and showed registries of 13-on-12 [6] and 14-on-13, respectively [7]. Strong modulations of the superstructure rods also indicate significant modulations of the h-BN and substrate. This corresponds well to STM studies of h-BN on Rh, where a clear corrugation of the surface was observed [8].

In contrast to graphene, the h-BN nanomesh is not a metal [9] and a difference in the electronic and electrostatic landscape between the regions close to the substrate (holes) and those further away (wires) is expected. These differences can be measured by angle-resolved photoemission-spectroscopy (ARPES). The difference in electronic structure between the holes and wires is reflected in a splitting of the σ bands [Figure 2(a)], but because of the absence of any states at the Fermi level this has no immediate effect on the lateral electrical resistance. However, this splitting reflects the different electrostatic potentials in the holes and on the wires. This difference in the local work function can also be probed through the adsorption of a closed shell species such as xenon, as is visible from the different core-level lines for adsorbed Xe in the holes and on the wires [H and W in Figure 2(a)].

The difference of 300 meV in electrostatic energy at the Xe atom sites indicates a lateral local electrostatic field on the rims of the holes. This dipole field locally enhances the bonding of atoms or molecules that may be polarized. In order to test this hypothesis, we performed thermal-desorption spectroscopy measurements on adsorbed Xe. Detailed analysis of the respective Xe core-level intensities on the holes and wires as a function of temperature [Figure 2(a)] indicates that the Xe bond energy on the holes and the wires is almost the same, except for the last 12 Xe atoms in every hole. These Xe atoms form a ring at the rim of the holes, where the dipole field is strongest, and are trapped there up to significantly higher temperatures [10].

These results indicate that every hole of the nanomesh has a dipole ring which significantly enhances its trapping potential. This is further illustrated by the ability to trap Cu-phthalocyanine (Cu-Pc) molecules at room temperature, as shown in Figure 2(b). As on most other substrates, the molecules can move within the holes, resulting in the diffuse shapes. However, they cannot cross the dipole ring once they are trapped. Similar trapping mechanisms are expected for all molecules and atoms, where the maximum trapping temperature depends on their size and polarizability.

The h-BN nanomesh is robust in air and even water, thus with the regular spacing of the dipole rings and the relatively easy preparation of large-scale samples the technological relevance of more than 10^{11} molecular traps per square mm is self-evident.

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Exciting heavy metal retrieving structures in photocatalysis

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Photocatalysts play an important role in a broad range of applications, from photochemical conversion of light energy into chemical energy to initiating novel chemical reactions. One family of compounds that has attracted much attention are the dinuclear d^8-d^8 platinum, rhodium and iridium complexes that have a highly reactive electronic excited state. When photo-excited with light, these systems have been shown to abstract H-atoms from a variety of substrates and initiate electron transfer processes. In this work, the structure of the triplet excited state of a diplatinum member of this photocatalyst family is examined.

X-ray absorption spectroscopy (XAS) has long been established as a precise method of measuring local structure in disordered systems such as molecular systems in solution. This technique has recently been introduced into the domain of ultrafast science where the electronic and nuclear dynamics of molecules and crystals are examined on the time scales of atomic motion [1, 2]. In the present investigation, ultrafast XAS has been used to examine the photocatalytic excited state of the $[Pt_2(P_2O_5H_2)_4]^{4-}$ (PtPOP) anion (see Figure 1) dissolved in ethanol.

Time-resolved X-ray absorption spectroscopy

An X-ray absorption spectrum is obtained by measuring either the transmission or total fluorescence of a sample as a function of incident X-ray photon energy. A typical measurement allows the reconstruction of atomic distances on the scale of <0.01 Å. Using this technique, the structure of the ground state of PtPOP was measured for the molecule in solution, indicating a Pt-Pt distance of 2.876(28) Å and a Pt-P bond length of 2.32(4) Å [3]. These values are in agreement with previous spectroscopically derived values as well as DFT calculations [4], and represent a small difference from those measured using crystallographic techniques. In the ground electronic state, this molecule has two electrons in the Pt-Pt $\sigma^*(d_{z^2})$ antibonding molecular orbital. Upon excitation with 350–390 nm ultraviolet light, PtPOP can be excited into the $\sigma(p_z)$ bonding orbital, resulting in the formation of a transient Pt-Pt bond and a predicted decrease in the Pt-Pt distance.

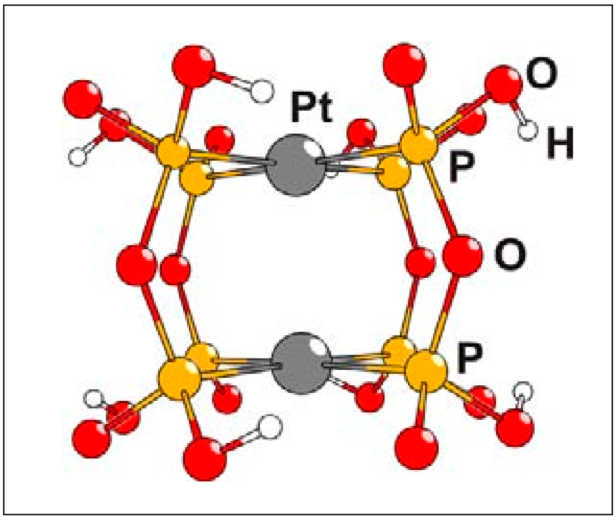

Figure 1: **Structure of the $[Pt_2(P_2O_5H_2)_4]^{4-}$ (PtPOP) anion.**

This excited $^3A_{2u}$ state has a room-temperature lifetime of a few µs in solution and has been thoroughly studied using a range of time-resolved techniques such as X-ray diffraction, optical spectroscopy, X-ray scattering, and EXAFS. The reported estimates on the change of the Pt-Pt distance in the excited state extend from 0.21 Å in crystalline form to 0.52 Å in solution. In addition, many studies were inconclusive about the role of the ligands, which are expected to be affected by the transient bond formation. The structure of this excited state is relevant to its photocatalytic properties and the lack of agreement between previous studies provided the impetus for applying our well-established technique of time-resolved XAS [1] to the PtPOP anion.

Measurements were performed at the MicroXAS beamline at the Swiss Light Source by exciting a 10 mM PtPOP solution in ethanol with 100 fs laser pulses at 390 nm and probing at the Pt L_3 absorption edge (11.56 keV). The transient XAS spectrum (excited minus unexcited), shown in Figure 2a, directly reflects the electronic and structural changes that occur 150 ns after excitation. In this study, the EXAFS region of the XAS spectrum has been exploited to determine the excited-state structure of PtPOP.

Retrieving excited-state structures

The ability to retrieve photoinduced structural changes with high accuracy is based on a rigorous model-based fitting approach. By including prior knowledge in the form of physically reasonable distortion models, the number of free fitting parameters can be reduced considerably, allowing the introduction of additional parameters, such as the photoexcited population and the energy shift between excited and ground-state XAS spectra, which are typical for time-resolved XAS analyses and often difficult to obtain by independent methods. The general procedure followed is to first obtain accurate structural values for the ground state of the system, then to use these values as a starting point for the excited-state structure. By making physically reasonable changes to the ground state structure according to a specific distortion model, then simulating the EXAFS spectrum for the new structures, the resulting transient EXAFS spectra can be calculated by subtracting the ground-state fit. For each excited-state structure, the difference between the experimental and simulated transient spectra can be minimized by introducing fitting parameters such as the energy shift and the photoexcited population. This procedure can then be repeated with various realistic structural distortion models that all involve a contraction along the Pt-Pt axis, allowing the result to converge to the smallest difference between experiment and calculation.

In this way, the best fit was obtained for a Pt-Pt contraction of 0.31(6) Å and a Pt-ligand elongation of 0.013(5) Å (see Figure 2) [5]. The latter is larger than just resulting from the Pt-Pt contraction, which indicates that the coordination bonds are weakened upon the Pt-Pt bond formation in the excited state. This small Pt-P elongation has been predicted by DFT calculations [4], but this represents the first experimental confirmation of such a structural change and illustrates the sensitivity of both time-resolved XAS as a technique to resolve excited-state structures and the analysis procedure used. Remarkably, the bridging P-O-P ligands do not follow the Pt atoms in the contraction movement, which supports the weakening of the Pt-P bonds and the rigidity of these bidentate

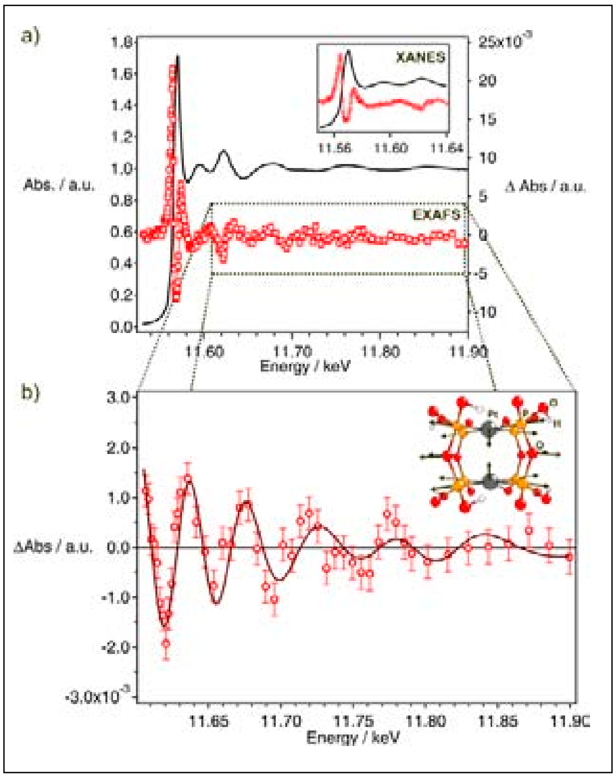

Figure 2: **a) Static Pt L3 XAS spectrum of PtPOP in solution (black line, left axis) and the transient (excited – unexcited) XAS spectrum (red circles, right axis, same units as left) integrated up to 150 ns after excitation; b) Transient EXAFS data (circles) and best fit (solid line, see text). The best-fit structural distortions are indicated in the upper right corner.**

ligands. In addition, the analysis indicates an excitation population of 7% and a zero energy shift. Both of these conclusions seem accurate: optical measurements indicate an excited-state contribution of approximately 8%, and no energy shift of the excited-state X-ray absorption spectrum is expected as the photoexcitation does not affect the charge density on the Pt atoms.

It should be emphasized that the present transient EXAFS analysis goes beyond the simple determination of nearest-neighbour distances. By using a model-based fitting approach, a more global picture of the excited molecule can be obtained. Application of this analysis technique to other photocatalytic systems should provide a wealth of information not directly available through other methods.

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Structural and biochemical basis for novel sulfuryl transfer mechanism

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Together with researchers from ETH Zurich, we have shed light on the protein aryl-sulfate sulfotransferase (ASST), present in pathogenic *E. coli* bacteria, which cause urinary tract infections. In addition to an entirely new structure, we uncovered a transfer mechanism similar to ping-pong, whereby the "ball" is kept in a previously unknown way.

Transfer of information is a basic property of biological systems, with common examples including the transfer of genetic information or nerve impulses. The transmission of signals occurs at an even more fundamental level and is mediated by signaling molecules, which bear a phosphate or a sulfate group. Since these processes are of supreme importance, they have been extensively studied and a number of mechanisms and related protein structures have been revealed. ASST is unusual amongst sulfuryl transfer enzymes in that it exhibits a previously unknown three-dimensional structure. This novel topography was revealed by X-ray crystallography at the SLS [1].

Figure 1: **Ribbon diagram highlighting the β-propeller fold of ASST. The six blades of the propeller are individually coloured while the small N-terminal β-sandwich domain is yellow.**

The crystal structure of ASST, at 2 Ångström resolution, revealed that ASST contains an extremely unusual disulfide bond. In ASST, this bond is characterised by an extremely short distance between the two linked cysteine residues and a high steric strain, which we believe can only be efficiently formed by the action of the disulfide bond formation machinery genetically associated with ASST [2]. This disulfide bridge is a prerequisite for proper folding of this protein and could also play a role in regulating its catalytic activity. More striking than this unusual disulfide bond geometry, however, was the overall structure of ASST. This consisted of two equal propeller-like parts which contain active sites in the central funnel formed by the beta-sheet 'blades' of each of the propellers. Such a fold has never before been observed for a sulfotransferase, leading to fundamental questions regarding the structure-function relationship of ASST.

In order to answer these questions, two complementary approaches were adopted: we replaced individual amino acids and probed the biophysical properties of these mutant forms of ASST, while concomitantly treating the native form of ASST with molecules acting as sulfuryl-donors and solving the crystal structure of these native intermediates. Mutations of ASST showed five nitrogen-containing amino-acids to be essential for function.

These residues build a reaction cage which accommodates both the donor and the acceptor of the sulfuryl group. Furthermore, during sulfotransfer, the sulfuryl group is directly (covalently) bound to a histidine side chain of ASST. Thus, the signal is first transferred from the donor to ASST and subsequently from ASST to the acceptor. Such a ping-pong mechanism is unique in the processes of sulfuryl transfer.

As a number of histidine residues surround the active site of ASST, in order to clarify the catalytic role of each residue,

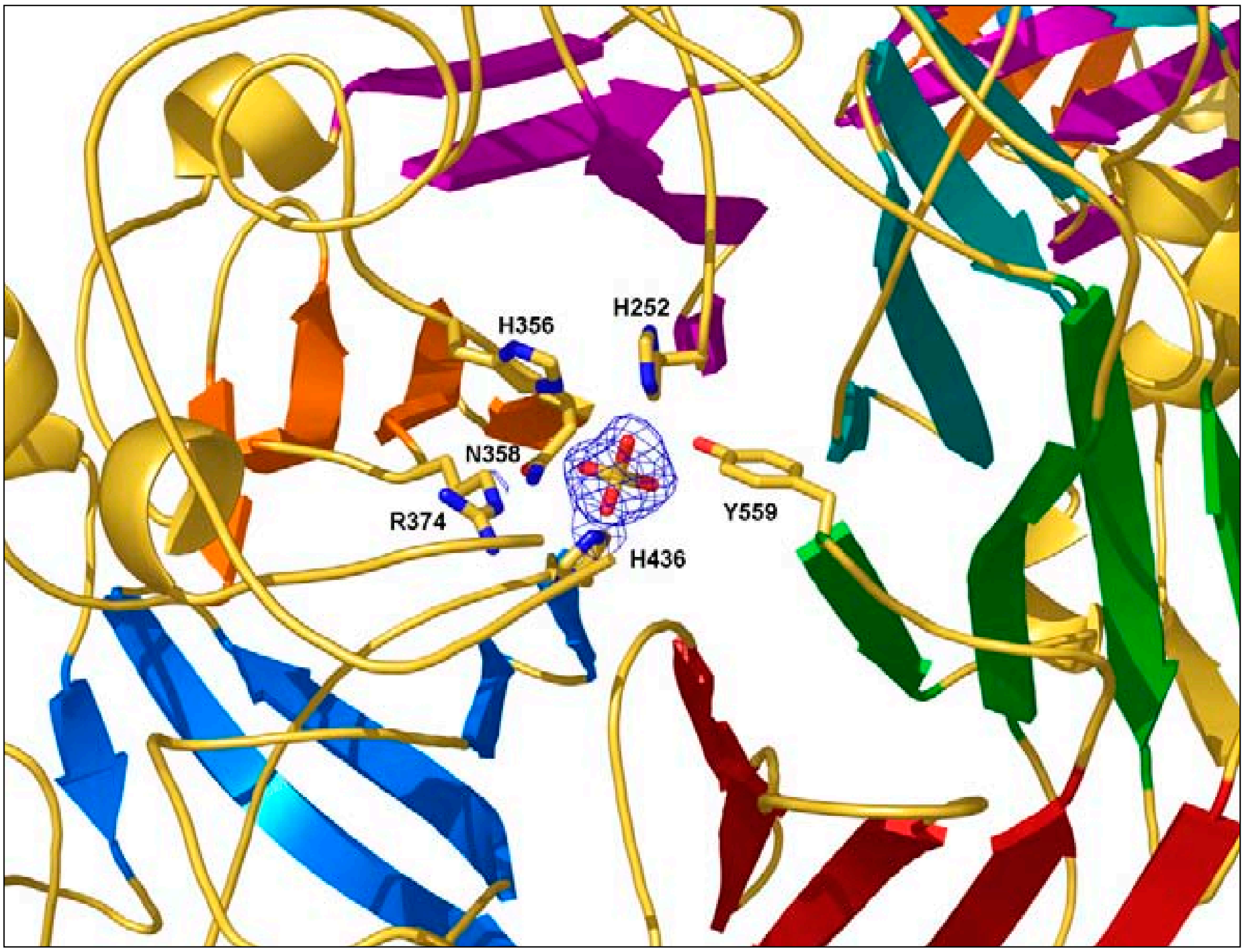

Figure 2: **Close view of the central funnel of native ASST showing a sulfuryl group in the active site. A full understanding of the active site was only possible after combining multiple crystallographic and biochemical experiments.**

electrospray ionization mass spectrometery was performed on both the native and sulfurylated forms of the enzyme. Together with the crystal structure of native ASST, results from these experiments clearly demonstrated that His-436 is the residue that undergoes transient covalent sulfurylation during catalysis. Structural analysis of the two intermediate forms of ASST showed, for the first time, this high-energy sulfuryl-histidine intermediate state, confirming the proposed ping-pong reaction pathway.

The experiments summarised here provide a basis for understanding sulfuryl transfer in a manner independent of the universal sulfuryl donor (adenosine 3'-phosphate-5'-phosphosulfate, PAPS) in mammals, opening up medically interesting perspectives. ASST is a promising target for antibacterial drugs, and together the crystal structures and biochemical data provide a basis for drug design targeting this virulence factor.

It is also interesting to note that these insights were only made possible by combining crystallographic, spectroscopic [3], and other biochemical methods. An advanced form of mass spectrometry, combined with multiple crystallographic models enabled us to understand the architecture of the active site and thus elucidate the catalytic pathway of the enzyme.

The complete account of the work described here can be found in reference [1].

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Unfolding the lung: understanding the alveolarization process

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We have been challenging the historical view of lung development which states that the formation of new alveolar septa from preexisting ones ceases due to the reduction of a double- to a single-layered capillary network inside the alveolar septa. Synchrotron-based tomographic microscopy investigations of developing rat lungs have shown that new alveolar septa are forming until young adulthood – mainly by lifting off from mature septa containing single-layered capillary networks. This newly discovered second phase of lung alveolarization imposes new precautions when using drugs influencing structural lung development.

During lung development, the airways and an extensive gas exchange area have to be formed. The development usually starts with the appearance of two lung buds. At the terminal ends of the buds, a repetitive process starts where elongation of the future airways alternates with branching. After approx. 20 rounds of outgrowth and branching, the ducts and parts of the respiratory airways are formed. During alveolarization, the gas exchange area is further enlarged by a subdivision of the terminal air spaces by the formation of new septa. One leaflet of the double-layered capillary network inside the existing septa folds up and gives rise to a new double-layered capillary network within the newly forming septa (Figure 1, A–C). Later, during microvascular maturation, the double-layered capillary network of the alveolar septa is reduced to a single-layered one (Figure 1D). Currently, it is believed that after this phase the lifting off of new septa from preexisting ones is excluded due to the missing second capillary layer. Consequently, after microvascular maturation is completed, the enlargement of the gas exchange area will be achieved by lung growth and not by addition of new alveolar septa. By the same token, a mature alveolar septum, once lost, will most likely not be reformed. Therefore, a noteworthy amount of lung regeneration is excluded, according to this view. The time when alveolarization in humans stops is not well-defined and has been discussed for decades. Currently, many agree on an age of 2–3 yr [1] whereas older data suggested that the formation of new alveoli ceases at ca. 8 yr or even at 16–18 yr of age [2]. Nevertheless, one question remained open: how may new alveoli be formed at a later time point? It has been proposed that (i) late alveolarization may take place in subpleural areas where a double-layered capillary network is not required or (ii) late alveolarization may follow a different, unknown mechanism. So far, alveolarization after the phase of microvascular maturation is on debate, and the question on how any form of "late" alveolarization may take place remains open.

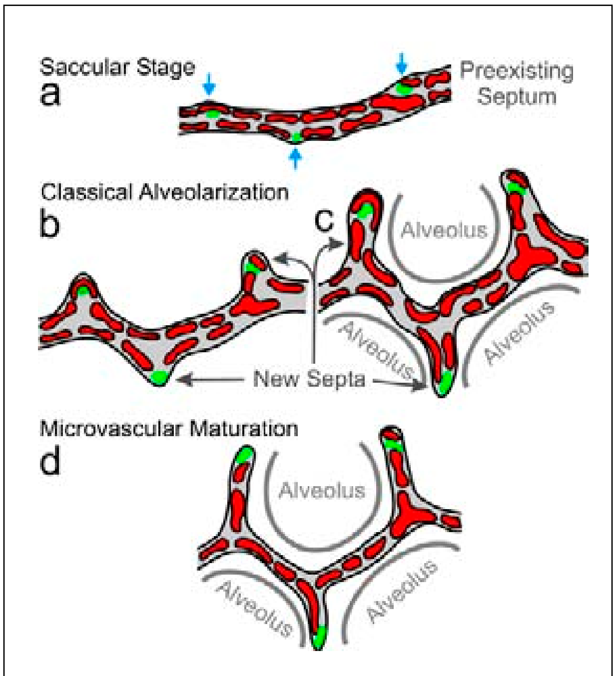

Figure 1: **Formation of new septa during classical alveolarization (A-C) and microvascular maturation (D).**

The large clinical relevance of late alveolarization inspired us to follow two directions. First, we applied a stereological method by estimating the length density of the alveolar entrance rings and developed a novel approach to follow the formation of new alveolar septa throughout lung development and growth. Second, we were wondering how the requirement

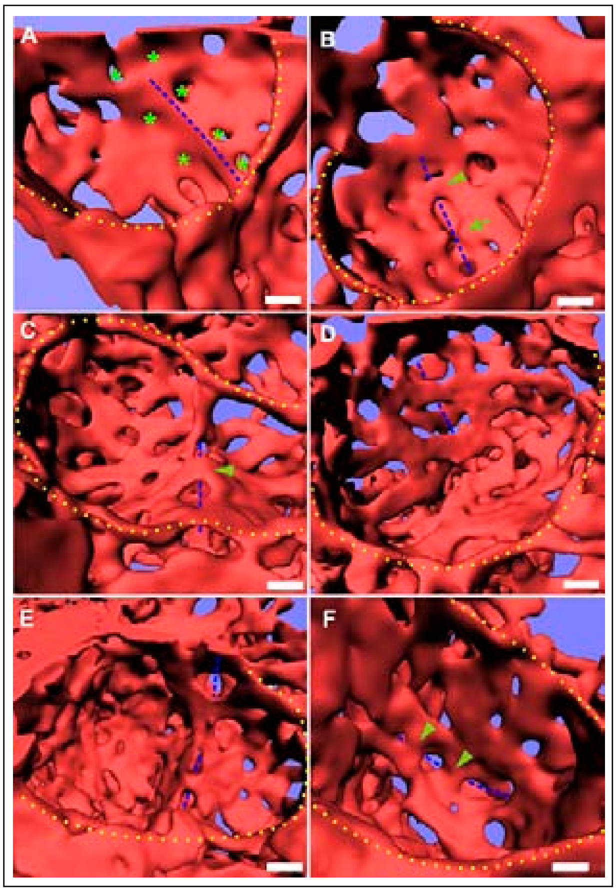

Figure 2: **3D visualizations of the capillary network of single alveoli. The entrances of the alveoli are labeled with a yellow dotted line. Mercox vascular casts of 21-day-old rat lungs were imaged at 12.6 keV with a pixel size of 0.7 microns. Scale bars are 10 microns. See text for details.**

of a double-layered capillary network inside the existing alveolar septa may be overcome. For this purpose, we studied 3D tomographic data sets of vascular casts of rat lungs obtained at the TOMCAT beamline of the SLS.

Figure 2 shows the lumen of the capillaries. Inside the cavity of an alveolus, the up-folding of the single-layered capillary network is observed (blue dashed lines in A, C, and E). The folding is indicative of the formation of a new septum. The 3-D visualization enabled us, for the first time, to look at the reverse side of the same septum (B, D, and F). At the basis of the folding, we detected a local duplication of the existing capillary network (covering of the blue dashed line in B, D, and F). Whereas most duplications are already formed in these examples (arrowhead), one is most likely just forming by sprouting angiogenesis (arrow in B). In addition, (forming) tissue posts inside the capillary network (holes in the vascular cast, green asterisk) are indicative for intussusceptive angiogenesis (the growth of the capillary network to allow the up-folding).

We were able to show that the requirement of a double-layered capillary network at the site of septation is still valid; however, the two layers do not have to be preexisting as currently postulated, but they may be formed rapidly and locally by angiogenesis when needed. Because microvascular maturation takes place during alveolarization, we defined the entire time when new septa/alveoli are formed during lung development and growth as “developmental alveolarization”. This term distinguishes the developmental processes from any kind of lung regeneration, which we called “regenerative alveolarization”.

Synchrotron-radiation tomographic microscopy was essential for the structural understanding on how new alveoli are formed throughout lung development and growth. We could show that new alveoli are formed not only before, but also after, the maturation of the alveolar microvasculature. During the latter, the requirement of a double-layered capillary network at the site where a new septum will be formed is overcome by a local duplication found at the sides of septation. Most likely, many of these duplications were not preexisting. We defined the classically described alveolarization “phase one of developmental alveolarization” and the newly described form “phase two”. Until now, the understanding of phase two is based on structural evidence only. However, due to its clinical significance, we believe that these structural findings will be the starting point for investigations of the molecular mechanisms involved. The description of phase two will most likely force us to rethink our views of (i) lung regeneration and of (ii) side effects on the structure of the lungs during the treatment of children and adolescents with glucocorticoids and retinoids.

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MYTHEN: The fastest high-resolution solid-state X-ray detector for powder diffraction

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MYTHEN is a 1-D detector designed for powder diffraction that is capable of acquiring 120° (in 2θ) diffraction patterns with sub-sec time resolution. It is, therefore, optimal for time-resolved and dose-critical measurements. Thanks to its outstanding performance and the calibration procedure developed at SLS, data quality is now comparable with that of traditional high-resolution detectors, with the further advantage of very fast data acquisition or, equivalently, very high counting statistics, with acquisition times of the order of tens of seconds. MYTHEN is therefore also ideal for the analysis of pair distribution functions (PDFs).

Synchrotron radiation X-Ray powder diffraction (SR-XRPD) experiments require detection systems with low noise, high dynamic range and high angular (FWHM) and *d*-spacing resolution. These requirements can only be fulfilled by single-photon counting systems with high granularity [1]. The MYTHEN detector (Microstrip sYstem for Time rEsolved experimeNts) has been designed to fulfil all these demands and, furthermore, to perform time-resolved measurements. High-resolution powder diffraction patterns acquiring 120° in 2θ can be collected in a fraction of a second.

Detector description

The MYTHEN detector consists of more than 30,000 independent channels (µstrips) working in parallel and positioned at 760 mm from the centre of the diffractometer, with a pitch of 50 µm. This results in an intrinsic detector angular resolution of 0.004° [2].
The detector is based on a silicon micro-strip sensor absorbing the diffracted X-rays and coupled to a custom-made integrated circuit [3].
Thanks to its single-photon counting capability, the detector is virtually noiseless and has a dynamic range of up to 24 bits. The fluctuation in the number of detected photons is purely Poisson-like, and thus the data quality is maximized, with low statistics. The low noise of the front-end electronics allows the detection of photons of energy down to 5 keV, while the short shaping time of the analogue signal permits counting rates of up to 1 MHz/channel. The channels are read out in parallel, with an inter-frame dead time of 0.3 ms. The maximum frame rate of the whole detector is limited by the data transfer rate and is about 10 Hz for the whole detector (increasing to 300 Hz for a 5° partial readout and 16 bits dynamic range). Acquisition times down to 100 ns are possible and can be synchronized to users' experiments using external signals. A small on-board memory can store 4 to 32 frames in real time, depending on the dynamic range. Data acquisition with MYTHEN is possible through a user-friendly graphical interface and is completely integrated in the beamline control system. An upgraded version of MYTHEN was installed at the SLS powder diffraction station in July 2007 and has been available for users since the beginning of 2008, providing excellent data quality.

Applications

Some examples of experiments showing the outstanding performance of the MYTHEN detector are:

1) Bragg crystallography
MYTHEN has worked remarkably well, not only for time-resolved applications but also for structural solution and refinement. Here, time resolution is usually not relevant and, therefore, the intensity of the incoming photon beam is generally sacrificed to achieve an optically aberration-free beam. This results in optimal Gaussian/Voigtian instrumental line-shape functions and, therefore, the diffraction patterns are easily processed by any refining program. Thanks to the exceptional efficiency and fast acquisition of the MYTHEN detector, it is also possible to acquire full diffraction patterns of organic compounds within a few seconds, without any radiation damage, and to solve and refine their crystal structure [5].

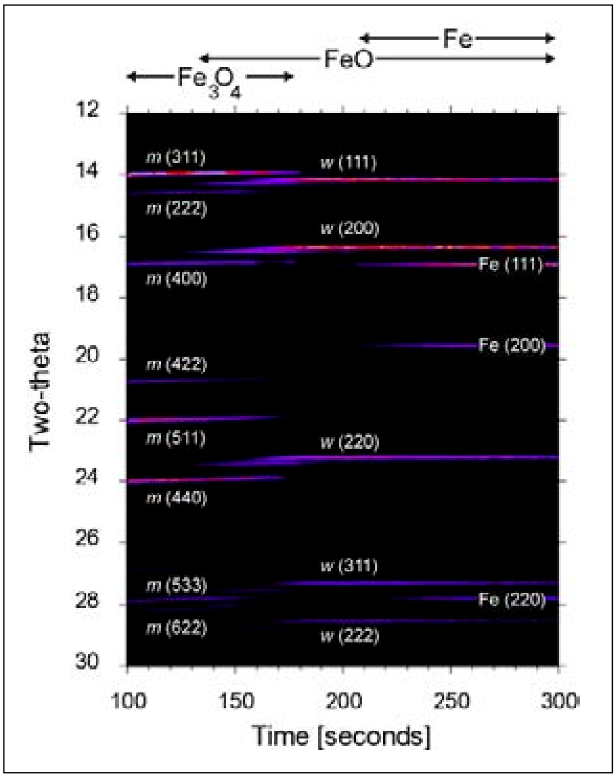

Figure 1: **Two-dimensional map of diffracted intensity during the microwave heating of magnetite /carbon-black mixtures. Legend: m (magnetite), w (wüstite). Courtesy of S. Vaucher et al. [9].**

2) PDF studies

The PDF [6] and Debye [7] methods are total scattering techniques, in which the whole powder pattern is taken into account. This is especially useful when Bragg peaks alone do not contain the desired information, either because samples are disordered or have small particle size, or because the research focuses on disorder of some kind which exists apart from a trivial average crystal order. Of course, all contributions to the total pattern that do not stem from the sample need to be either measured separately or sufficiently well modelled. Multiple exposures and long counting times are normally necessary in order to acquire sufficient statistics at high scattering angles and at relatively high X-ray energies, where the photon flux is small.

The need for comparing and subtracting multiple patterns puts further demands on detector stability and linearity. MYTHEN also stands out in this field, thanks to its large dynamic range, that allows both high-intensity and low-intensity regions to be accessed, and to its high counting efficiency, that allows the acquisition of all relevant data sets within a short time. A PDF experiment can now be performed in times comparable to a classical diffraction experiment using a point detector.

3) Time-resolved experiments

Pioneering in situ microwave heating experiments have been performed by a group from EMPA Thun [9] at the SLS-MS beamline since 2006.

The fast frame rate of the MYTHEN detector enables experiments to be carried out in which the structural and microstructural evolution of solids under microwave application can be accurately followed in near-to-real time, while monitoring the microwave heating processes [8] and eventually fine-tuning the microwave application for processing for a broad variety of materials.

An excellent example of this is the efficient microwave-assisted carbothermal reduction of magnetite Fe_3O_4 to iron, a process of high interest for the steel industry. A transient iron oxide phase was found which intermediates the transition from magnetite, Fe_3O_4, to wüstite, FeO (see Figure 1). The kinetics of this phase transformation provides a deeper understanding of volumetric heating by microwaves [10].

Conclusions

The MYTHEN detector shows outstanding performance, not only for time-resolved experiments but also for structural determination and refinement, and for PDF measurements. The quality of the data acquired with the micro-strip detector is comparable with that obtained by using a crystal analyzer detector, with the further advantage of measurement times that are 5000 – 15000 times faster, depending on the X-ray energy and *d*-spacing resolution required. Time-resolved studies impossible with any other powder diffraction detector can be performed, opening up new perspectives for in situ measurements.

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First results on iron-based superconductors

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In 2008, the Laboratory for Muon-Spin Spectroscopy (LMU) was at the forefront of research on the recently discovered iron-based high-temperature superconductors. In view of the vicinity of the magnetic and superconducting states and of their possible interplay in these compounds, muon spin rotation (μSR) has been widely recognized as one of the key techniques to test for possible microscopic coexistence between different ground states. In addition, μSR has been used to provide fundamental results about the nature of the magnetic and superconducting states.

The observation of high-temperature superconductivity in layered iron pnictides [1] early in 2008 triggered the second gold rush among solid state scientists, after the discovery of high-T_C cuprates. As in the well-studied cuprates, superconductivity in these new compounds takes place mainly in crystal layers (in this case FeAs), with the rest of the structure acting as a charge reservoir. Moreover, a remarkable parallel with the cuprates can be drawn from the observation that superconductivity appears when doping away from an antiferromagnetically ordered mother compound, suggesting the importance of magnetic fluctuations in the mechanism of Cooper pair formation. At the same time, in contrast to the cuprates, the magnetic parent compound is not a Mott-Hubbard insulator but a metal. Therefore, it is believed that, after 20 years of research on high-T_C superconductors, the Fe-pnictides may finally provide insight into the superconducting coupling mechanism. From the beginning, muon-spin spectroscopy (μSR) research at PSI has been playing a key role in the investigation of Fe-pnictides, on the one hand by providing fundamental results about the nature of the magnetic and the superconducting states, and on the other hand by investigating the interplay between these two ground states (see e.g. [2–6]).

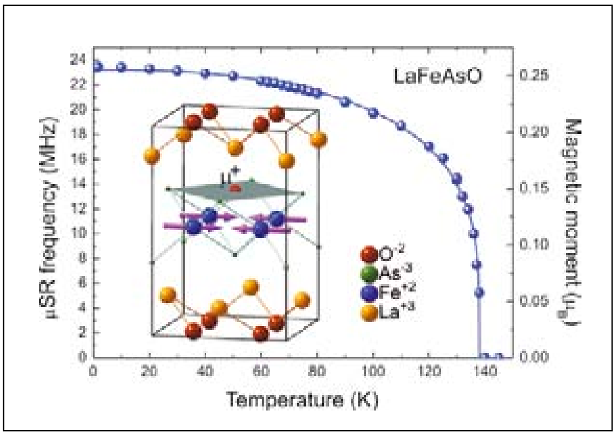

Figure 1: **Iron magnetic moment measured via the μSR precession frequency as a function of temperature [3].**

Diverse studies were conducted on various families of the Fe-pnictides by different research groups at the PSI μSR facilities in 2008. As examples, we present some results on the magnetic and superconducting properties of the first discovered $LaO_{1-x}F_xFeAs$ system.

Magnetic properties

Muon-spin relaxation measurements and ^{57}Fe Mössbauer spectroscopy were used to determine the magnetic properties of LaOFeAs, a mother compound of the newly discovered iron-based superconductors [3].

These studies prove a static magnetic order below T_N = 138 K with a clearly commensurate spin structure and a strongly reduced ordered moment at the Fe site in the ordered phase. The data provide a high-precision measurement of the temperature dependence of the sublattice magnetization. As shown in the inset of Figure 1, the muon thermalizes at an interstitial lattice site in the vicinity of the iron moments, which generate a dipole field at the muon site. Therefore, the μSR technique allows the Fe sublattice magnetization to be determined via the muon spin precession in the local field. In combination with Mössbauer spectroscopy measurement, the absolute value of the Fe moments can also be estimated, even without knowledge of the actual spin structure. In Figure 1, the estimated Fe magnetic moment, as measured via the μSR precession frequency, is shown as a function of temperature.

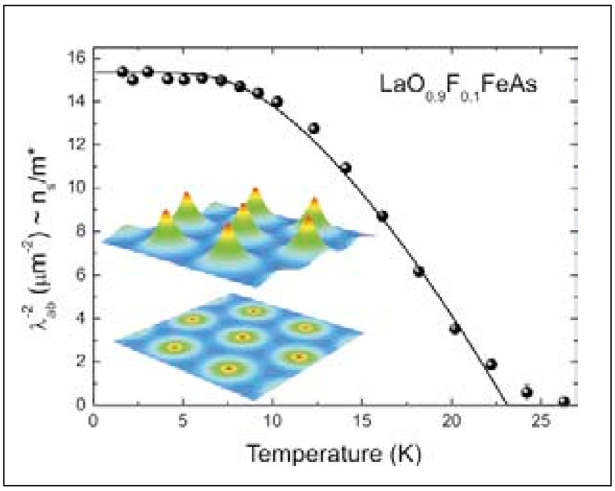

Figure 2: **Temperature dependence of the superfluid density of $LaO_{0.9}F_{0.1}FeAs$ [2].**

The quick saturation below T_N markedly differs from conventional mean field behaviour. Theoretical calculations can reproduce the size of the order parameter as well as its approximate temperature dependence only by invoking a multi-band spin density wave model [3].

Superconducting properties

Muon-spin rotation experiments in applied magnetic fields have been carried out on a series of differently doped $LaO_{1-x}F_xFeAs$ samples. In such experiments on polycrystalline type-II superconductors, bulk superconductivity is revealed by an additional Gaussian relaxation of the muon precession signal below T_C. This additional relaxation arises from the inhomogeneous internal field distribution in the vortex phase of type-II superconductors, see inset of Figure 2. In an anisotropic superconductor, the observed relaxation rate can be converted into λ_{ab}, the in-plane magnetic penetration depth. The expression $1/\lambda_{ab}^2$ is proportional to the superfluid density ns divided by the effective mass m* of the charge carriers. The temperature dependence of $1/\lambda_{ab}^2$ for an $LaO_{0.9}F_{0.1}FeAs$ sample is depicted in Figure 2. A nearly temperature-independent behaviour below $T_C/3$ is found, which is indicative for a low density of states in the superconducting gap and excludes superconducting symmetries with nodes in the gap function.

Phase diagram of $LaO_{1-x}F_xFeAs$

The competition of magnetic order and superconductivity is a key element in the electronic phase diagram of all unconventional superconductors, such as, for example, the high-T_C cuprates, heavy fermions and organic superconductors. In these systems, superconductivity is often found close to a quantum critical point where long-range antiferromagnetic order is gradually suppressed as a function of a control parameter, e.g. charge carrier doping or pressure. It is widely believed that dynamic spin fluctuations associated with this quantum critical behaviour are crucial for the mechanism of superconductivity. In Figure 3, the structural and electronic phase diagram of $LaO_{1-x}F_xFeAs$ that has been determined by μSR, Mössbauer spectroscopy and X-ray diffraction is shown. The μSR experiments yield information on both the doping dependence of the transition temperatures and the respective order parameters. A discontinuous first-order-like change from the spin density wave magnetic state to superconductivity upon doping is found. While these results strongly question the relevance of quantum critical behaviour in iron pnictides, they prove the strong coupling of the structural orthorhombic distortion and the magnetic order with both disappearing exactly at the phase boundary to the superconducting state.

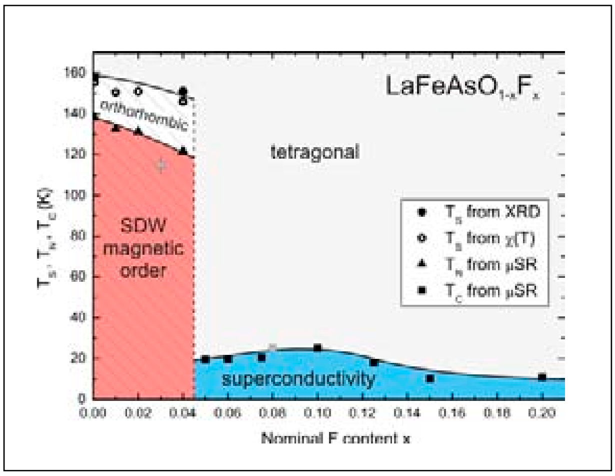

Figure 3: **Structural and electronic phase diagram of the iron-based superconductor $LaO_{1-x}F_xFeAs$ [4].**

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Conspiring magnetic and superconducting order

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Magnetic order and superconductivity have been found to coexist in a number of magnetically mediated superconductors, but these phenomena generally compete. We report that, close to the upper critical field, $CeCoIn_5$ adopts a multicomponent ground state that simultaneously carries cooperating magnetic and superconducting orders. Suppressing superconductivity leads to the simultaneous collapse of the magnetic order, showing that the material needs to be superconducting in order to adopt magnetic order. A symmetry analysis suggests a form of superconductivity that is associated with a non-vanishing momentum.

Superconductors conduct electric current without resistive loss, and thus hold great promise for technological applications. Superconducting materials serve already now in a number of industrial and device applications, but many of them are only marginally understood at best. At the heart of superconductivity are electron pairs, the so-called Cooper pairs, which are quantum-entangled electrons. Electric current in superconductors is transported by Cooper pairs, and not by single electrons as in metallic materials.

Probably the most intriguing question in the field of superconductivity concerns the coupling of electrons into Copper pairs. While this is understood in phonon-mediated superconductors, it is still a mystery in various classes of materials, such as organic, heavy-fermion and doped Mott-insulator superconductors.

The existence of Cooper pairs depends on the preservation of electron entanglement of their wave-functions. External magnetic fields or the ordering of the electrons in charge or spin structures generally perturbs the entanglement. In fact, in order to qualify as a superconductor, a material has to be a perfect diamagnet, which means that all magnetic fields are completely shielded from the inside of the material at sufficiently low field strength.

A similar antagonism also exists between magnetic and superconducting order, which often compete and rarely co-exist. The reason for this is that an ordered spin loses its quantum character and becomes more classical. The loss of the electron's spin quantum nature inhibits superconductivity.

There are a number of examples where magnetic order and superconductivity do co-exist. In these cases, magnetic order and superconductivity arise from different species of electrons, thus preserving the quantum nature of the electrons that contribute to superconductivity. In such materials, magnetic order and superconductivity thus merely tolerate each other.

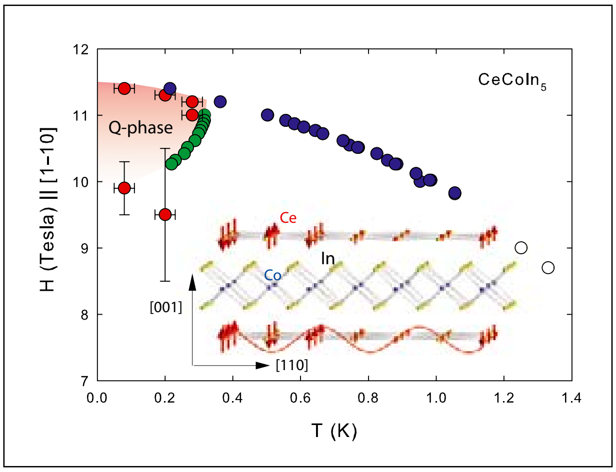

Figure 1: ***H*-*T* phase diagram of $CeCoIn_5$ with the magnetically ordered phase indicated by the red shaded area. The green circles indicate a second-order phase transition inside the superconducting phase, and the red circles indicate the onset of magnetic order, showing that the magnetic order only exists in the Q phase. (Inset) Magnetic structure of $CeCoIn_5$ at $T = 60$ mK and $H = 11$ T. The red arrows indicate the static magnetic Ce^{3+} moments.**

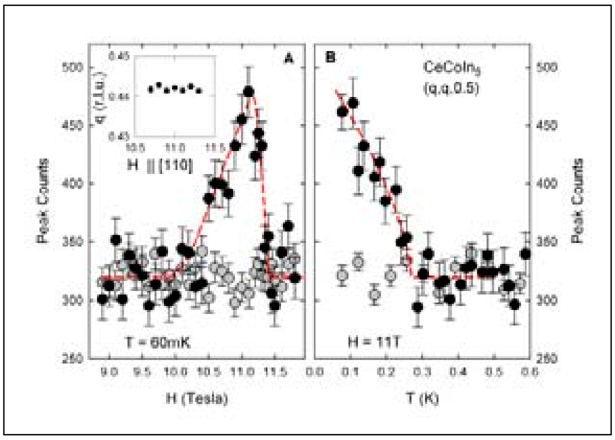

Figure 2: **Peak neutron scattering intensity at the incommensurate reciprocal wave-vector (*q, q,* 0.5), (A) as a function of field at *T* = 60 mK and (B) as a function of temperature at *H* = 11 T. The grey circles represent the background scattering. The dashed red lines indicate the temperature and field dependence of the magnetic intensity. The inset shows that *q* is field-independent.**

Superconductivity-induced magnetic order

We have studied the heavy-fermion superconductor $CeCoIn_5$ using neutron diffraction at very low temperatures and high magnetic fields. $CeCoIn_5$ features d-wave superconductivity which is believed to be magnetically induced [1]. The material features strong electronic hybridization between localized f-electrons and itinerant d-electrons, which leads to charge carriers of composite nature and high mass [2]. $CeCoIn_5$ is believed to be close to a critical point at zero temperature that separates phases of different symmetry. This type of criticality is often also referred to as a quantum critical transition.
The field–temperature (*H-T*) phase diagram of the superconducting phase features two phases that are separated by a second-order phase transition (see Figure 1), indicating they are of different symmetry. It has long been suggested that this additional phase, which we call Q-phase and which can only be reached with high fields, features superconducting order arising from Cooper pairs that carry a finite momentum [3].
The key result of our experiment is that the Q-phase features a long-range ordered spin-density wave which is modulated in an incommensurate manner perpendicular to the magnetic field direction [4]. The magnetic moments point perpendicular to the magnetic field and modulation vector. Most importantly, the spin-density wave is stabilized only in the superconducting phase, and it collapses abruptly when the material becomes metallic above $H \sim 11.4$ T (see Figure 2). This is the first example of superconductivity induced magnetic order that has been observed in nature.

The origin of magnetic order in the Q-phase came as a surprise, and it is currently not understood. Small-angle neutron scattering revealed an anomalous flux line form factor [5], which indicates fluctuating magnetism in the flux line cores. Our results suggest that this fluctuating magnetism becomes static at low temperatures. However, the magnetic fluctuations in the superconducting and metallic phases must be fundamentally different, as no magnetic order is observed in the normal phase.

Cooper pairs carrying momentum

The direct coupling of magnetic and superconducting order in $CeCoIn_5$ allows conclusions to be drawn about the symmetry of the superconducting order. A symmetry analysis shows [4] that possible magneto-superconducting terms include terms where magnetic order couples directly to superconducting order that is associated with momentum. This is indirect evidence that the Cooper pairs could indeed carry a finite momentum, as has been suggested. Our experiment illustrates a novel way of how magnetism and superconductivity can conspire rather than compete, and, as a result, form a novel state of solid matter.

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Dynamic nuclear polarization, from polarized targets to metabolic imaging

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The methods of dynamically polarizing nuclei (DNP) have led to the development of increasingly sophisticated polarized targets used in investigations of the role spin plays in nuclear and particle interactions. Only very recently, DNP has been recognized in the Nuclear Magnetic Resonance (NMR) community as the most promising technique for enhancing the nuclear spin polarization of organic molecules. The tremendous sensitivity enhancement of up to 10,000 potentially obtainable opens a wealth of new applications, with metabolic imaging being a prominent example. The techniques developed in polarized target research need now to be adapted to the new applications.

Dynamic Nuclear Polarization methods were developed during the past decades for applications in nuclear and particle physics research. Continued improvements in DNP, however, are being pursued not only for the development of increasingly sophisticated polarized targets used to investigate the role of spin in nuclear and particle interactions, but also in order to open up new fields in neutron science exploiting the strong spin dependence of neutron scattering [1] or develop transmission polarizers for neutron beams [2].

Recently, a unique enthusiasm for the DNP technique has developed in the magnetic resonance (MR) community, most prominently in the biomedical field. Researchers at Amersham (now part of GE Healthcare) have demonstrated that it is possible to transform a dynamically polarized organic sample from its initial frozen state (such as used in polarized targets) into a liquid solution at room temperature, while retaining a large part of the nuclear polarization by rapidly dissolving it in superheated water [3]. The nuclear relaxation times in such polarized liquid solutions are long enough to open the possibility of injecting them into biological subjects, in order to investigate in vivo metabolic processes in a nearby MR installation (see Figure 1) [4].

Figure 1: **Dissolution DNP machine (left) connected to the 9.4 T rodent scanner (right) installed at the CIBM Lausanne. The sample is polarized in the solid state at around 1 K at 3.35 T and subsequently rapidly dissolved and blown via a thin tube to an injection pump delivering the polarized room temperature solution to the animal in the imager [7].**

A consortium of Swiss researchers, now well-known as the Swiss DNP Initiative (sdnpi.epfl.ch), was formed very soon after this "dissolution DNP" method had become known. It combines the unique know-how of the polarized-target group at PSI with the advanced spectroscopic and imaging methods available at two leading MR institutes sited at EPFL: the Center for Biomedical Imaging (CIBM) and the Laboratory for Biological MR (LRMB) [5].

The DNP techniques developed for building polarized targets had to be adapted to the requirements of magnetic resonance spectroscopy (MRS) and magnetic resonance imaging (MRI). A versatile continuous-flow cryostat system was designed that fits into a standard wide-bore NMR magnet and constitutes the basis of a DNP prepolarizer system which can be coupled to a rodent MRI scanner [6] or an NMR spectrometer.

A main challenge was finding biologically compatible solutions with low concentration of an efficient paramagnetic centre well suited for DNP in which the labelled metabolic precursors could be easily dissolved. The polarization mechanism is based on the transfer of polarization from the electron spins of the paramagnetic centres to the nuclei of the solvent and dissolved molecules, by continuous irradiation with microwaves close to the ESR frequency of the paramagnetic centres. The efficiency of DNP relies on the fact that, at a temperature of about 1 K, the electron spin polarization is close to 100%, even in a moderate magnetic field (3.35 T in a standard polarizer).

Extensive DNP studies have been performed on substances which may well be regarded as model systems for "hyperpolarization" applications [7]. In these studies, compounds of biological interest containing ^{13}C (Na acetate, Na pyruvate, Na bicarbonate, urea, glycine, glucose), ^{15}N (urea, choline chloride) or ^{6}Li (Li chloride) nuclei were dissolved at a typical concentration of a few moles per litre in water-ethanol and water-glycerol doped with TEMPO free radicals. Instead of a proprietary triarylmethyl (TAM) radical, the readily available TEMPO free radical had been chosen as paramagnetic centre, because it has very low toxicity, it dissolves well in water-alcohol mixtures and its DNP characteristics have been studied in various polarized target applications. A ^{13}C polarization of up to 12% was achieved at 1.2 K in a magnetic field of 3.5 T under irradiation with 97 GHz microwaves. This corresponds to an enhancement of 14,000 with respect to the thermal equilibrium polarization in a 9.4 T magnet at room temperature. It is even possible to gain another 50% in polarization by increasing the field from 3.5 T to 5 T [8]. Most importantly, it was found that the DNP properties of the solute compounds are mainly determined by the solvent matrix, which suggests that this approach can generally be used to polarize molecules of metabolic interest.

A hardware characteristic is that the DNP and the MRS and MRI applications are performed in separate magnets, at different fields. The crucial step is an efficient dissolution of the solid-state sample (typically by a factor 10 to 80) to obtain the "hyperpolarized" solution and a rapid transfer from the polarizer to the MR equipment (usually by blowing it through a thin plastic tube), because an intrinsic limitation of the technique is the finite lifetime of the hyperpolarized state. The signal is very intense, but only available for a limited length of time (see Figure 2).

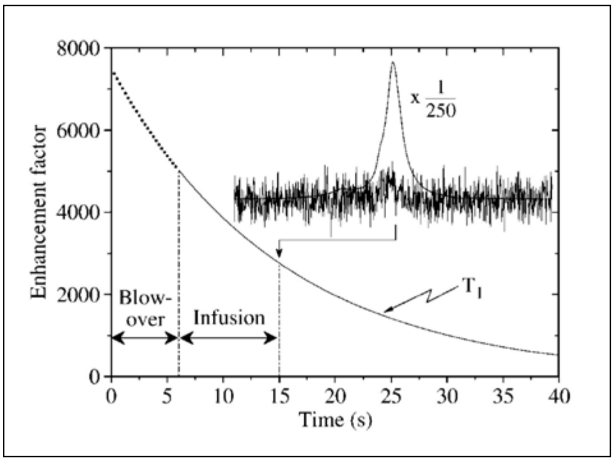

Figure 2: **^{13}C NMR signal enhancement of labelled glycine compared to its thermal equilibrium value in a 9.4 T field. After the dissolution, the polarization starts to decay rapidly. The inset illustrates the tremendous gain in NMR signal obtained [6].**

Fast dissolution experiments have shown that 70% to 80% of the initial solid-state polarization level can be retained for all nuclei studied (^{13}C, ^{6}Li, ^{15}N), while the liquid state NMR amplification factor reached (up to 10,000) mainly depends on the relaxation time T1 of the specific nuclei after dissolution. Optimum samples are now routinely used in metabolic/MRI experiments at CIBM Lausanne employing the developed DNP and dissolution apparatus (see Figure 1).

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Pressure-tuned magnetic frustration

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Multiferroic materials may allow the development of novel electronic devices owing to their ability to couple spontaneous magnetization and ferroelectricity. A detailed microscopic understanding of the underlying coupling mechanism in these materials, however, is currently lacking. Here we report on the multiferroic $Ni_3V_2O_8$ in which ferroelectricity is produced by spin-spiral magnetic order that breaks inversion symmetry. Hydrostatic pressure is found to suppress magnetic frustration, thereby removing the key condition for the occurrence of ferroelectricity. Additionally, small pressure leads to the onset of a step-like change in the spin-spiral magnetic structure. This shows that magnetically-induced ferroelectricity can occur in a first-order-type transition and can thus be switched easily with a small temperature change.

Many of the phenomena in solid-state physics that still lack a profound conceptual understanding comprise mechanisms with a coupling between two order parameters. Unconventional superconductivity as well as spin- and charge-order coupled to conduction electrons in intermetallic materials are some of the most prominent examples.

Another class of materials with similar high technological potential are multiferroics. These exhibit simultaneous magnetic and ferroelectric orders that are directly coupled. Several classes of applications have been suggested, including next-generation electronic devices in which the magnetic properties may be controlled by an electric field, magnetically-controlled ferroelectric memory devices for instant boot-up computers, or magnetically-tuned dielectric capacitor devices [1].

Simultaneous magnetic and ferroelectric order – a rare phenomenon

Until a few years ago, only a small group of materials exhibiting coupled magnetization and electrical polarization had been identified since – quite generally – the ordering of the magnetic moments and cooperative atomic displacements responsible for ferroelectricity occur at distinctly different temperatures. Recently, however, an increasing number of multiferroics have been discovered that are magnetically frustrated magnets, suggesting that competing magnetic interactions play a crucial role in these materials.

It is thought that magnetic frustration naturally leaves the system with some degree of freedom at low temperatures and hence does not allow its entropy to reduce upon cooling. According to the third law of thermodynamics, however, entropy has to be zero at zero temperature, requiring a massive entropy reduction at low temperature. In multiferroics, this is achieved through the coupling to an additional order parameter – ferroelectricity – that, in the process, reduces the magnetic entropy. Ferroelectricity is thus magnetically driven.

Pressure – a powerful stimulus

Experimental studies probing the effects of perturbations on such complex interacting systems have often been proved to be indispensable for validating proposed theoretical models. Application of pressure is particularly powerful since, on the one hand, pressure alters atomic distances and hence directly changes the magnetic interactions between the atoms, making it thus possible to change the degree of magnetic frustration in a material. On the other hand, theory may predict pressure effects relatively simply.

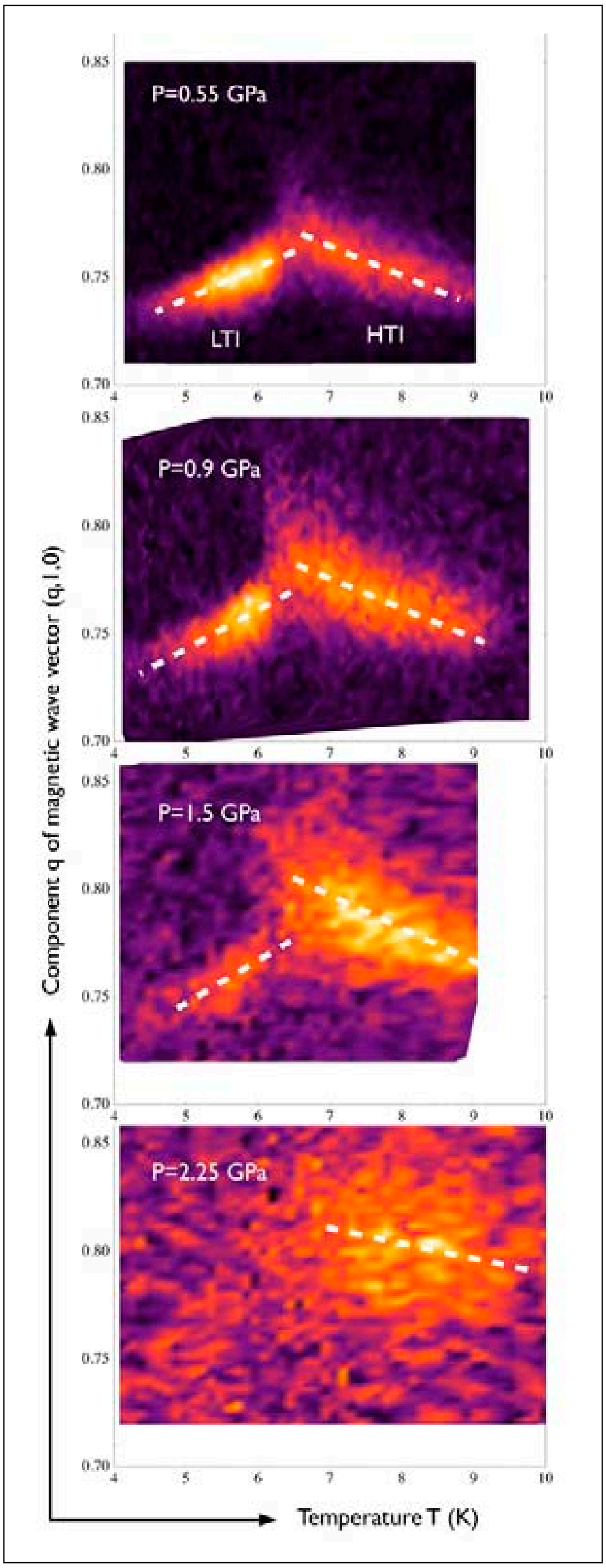

Figure 1: **Density plots of magnetic intensity at (*q*,1,0) as a function of *q* (0.7 < *q* < 0.85) and temperature *T* (4 K < *T* < 10 K). The dashed lines are a guide to the eye. Opposed anvil techniques in a pneumatically driven Paris-Edinburgh press were employed for *in-situ* hydrostatic pressures up to 5 GPa. The single-crystal sample was embedded in a lead matrix that served as a pressure-transmitting medium down to lowest temperatures. The measurement was carried out on the RITA-II triple-axis spectrometer.**

Suppressing frustration with pressure

One of the simplest spin-spiral multiferroic materials, namely $Ni_3V_2O_8$, has been studied, in which magnetic frustration results from the specific geometric arrangement of spins on a so-called Kagome lattice, in which the interactions between neighbouring spins compete with those between next-neighbouring spins. As a result, the compound displays a complex magnetic phase diagram, with at least three different magnetic phases. Ferroelectricity emerges in one of these phases and is magnetically driven [2, 3].

Our neutron diffraction measurements on $Ni_3V_2O_8$ show that pressure removes magnetic frustration and thus suppresses ferroelectricity. The ferroelectric phase (denoted LTI in Figure 1 (top)) gradually becomes suppressed by a phase with a simple commensurate magnetic structure that is typical for unfrustrated magnets and eventually disappears at pressures above 1.5 GPa. At even higher pressures (beyond 3.5 GPa) a remnant incommensurate phase at higher temperature (denoted HTI in Figure 1 (top)) is also fully suppressed, thus removing the last signs of magnetic frustration from our data.

The transition between the two incommensurate magnetic phases (denoted LTI and HTI in Figure 1) changes in nature from being continuous at ambient pressure to being discontinuous at pressures above 0.5 GPa. This feature is evidenced by the discontinuous jump of the magnetic wave-vector shown in the Figure. A small temperature range exhibiting phase-coexistence between the two phases further hints at the first-order (discontinuous) nature of this magnetic phase transition. This clearly shows that magnetically-induced ferroelectricity can occur in a first-order transition, and might thus be switched in principle with relatively small temperature changes.

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Muon lifetime measurement with FAST

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The Fibre Active Scintillator Target (FAST) detector at PSI is designed to measure the lifetime of a positive muon to better than 2 ppm statistical precision. After including theoretical and experimental systematic uncertainties, this will determine the Fermi constant, G_F, to 1 ppm precision. G_F is one of the three free parameters of the Standard Model in the bosonic sector, and the uncertainty in its determination is currently dominated by the muon lifetime [1].

The measurement of the lifetime of a positive muon is a difficult challenge, involving the dual requirements of increasing the event sample by a factor of 100 relative to earlier measurements, while, at the same time, reducing the systematic errors by an order of magnitude. The concept of the FAST experiment is to suppress the systematic effects at the detector level, as far as possible. In this way, only small systematic corrections to the raw measurement are required to reach the final value of the μ^+ lifetime.

Set-up

The FAST detector is an imaging plastic scintillator target comprising 32×48 pixels (Figure 1, [2]). Each pixel corresponds to a plastic scintillator of dimension 4×4×200 mm^3. A π^+ beam from the PSI proton accelerator facility (πM1 beamline) is stopped in the target. A wedge-shaped degrader distributes the stopping positions through the target depth. The system identifies the $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ decay chains and registers the time and space coordinates of each particle. Time-to-Digital converters (TDCs) record a time window from 10 µs preceding the beam particle arrival time to 20 µs afterwards. The wide positive decay region allows the muon decay time to be observed over a period of about 9 muon lifetimes. The negative decay time region is used to calibrate accidental backgrounds. In order to reach the desired precision in the measurement, a data sample of about 5×10^{11} events is required.

This is achieved in FAST by running at an LV2 (i.e. tagged $\pi^+ \rightarrow \mu^+$) trigger rate of about 80 kHz and handling several muon events, with overlapping time windows, in parallel. At this rate, the required statistics can be reached in about 200 days of data taking. Achieving this performance requires a dedicated second-level (LV2) trigger and a highly segmented data acquisition (DAQ) system (Figure 2).

The first part of the DAQ system comprises 8 chains, each consisting of a fast PC attached to a VME crate containing 2 CAEN V767 TDCs and a VME-to-PCI interface. The LV2 trigger

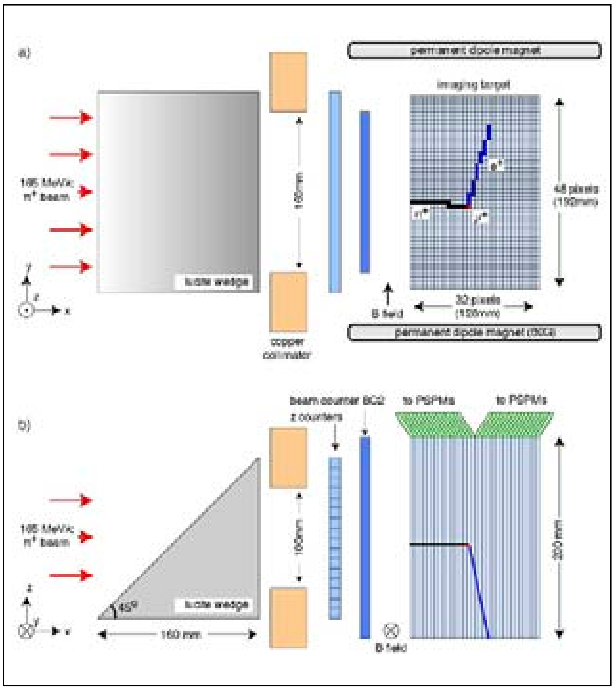

Figure 1: **Schematic drawing of the FAST detector: a) top view, and b) side view. A representative event shows a π^+ beam particle stopping in the target followed by a $\pi^+ \rightarrow \mu^+ \nu$ decay and finally a $\mu^+ \rightarrow e^+ \nu \nu$ decay. This sequence is imaged by the target in the xy projection and the pixel times are recorded.**

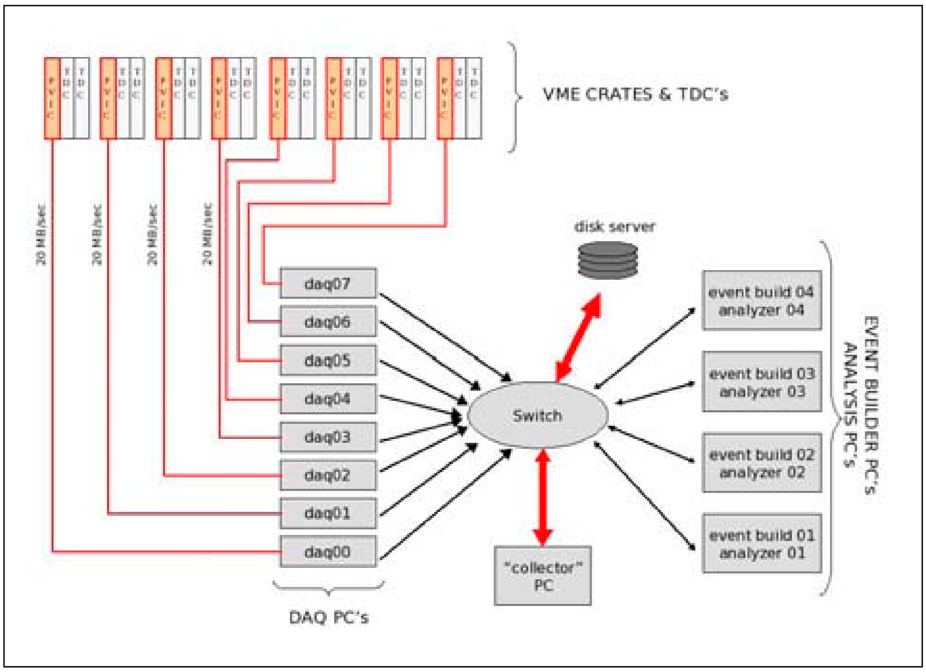

Figure 2: **DAQ architecture design corresponding to a maximum achievable bandwidth of 160 MB/sec. There are 8 readout nodes, 4 analysis PCs, and one collector PC, which stores data on a disk server.**

recognizes a $\pi^+ \rightarrow \mu^+$ decay chain and selectively triggers only those TDCs in the 7×7 pixels surrounding the muon stop pixel. This reduces the data bandwidth by a factor of 2.5. The LV2 trigger also encodes the muon stop pixel and records the information in the TDCs. The huge throughput of data (about 80 MB/s) requires that events are analysed in real time; only lifetime histograms are recorded on disk, together with monitoring information and around 1% of raw events for later analysis of systematic effects. The on-line analysis farm comprises 4 fast PCs, which are supplied with time-slices of data in round-robin fashion. The time-slices are assembed from the 8 DAQ/VME chains with a collector PC, and routed via a Gigabit ethernet switch.

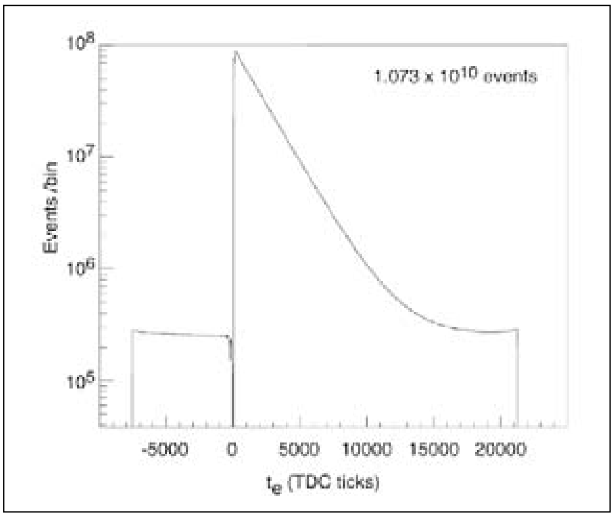

Figure 3: **Muon lifetime distribution for the first measurement of the Fermi constant by FAST (8 ppm precision) [3].**

Operation and results

A pilot physics run of FAST in December 2006 allowed a measurement of G_F with 8 ppm precision (Figure 3, [3]). The average LV2 trigger rate was 30 kHz, and a total of 1.1×10^{10} events were recorded. In spring 2008, the FAST detector was prepared for a long data-taking run at an LV2 trigger rate of about 70kHz. By the end of the 2008 run, FAST had taken data for 140 days and recorded a sample of 3×10^{11} events. During this period, the detector was operated in a fully automated mode. All hardware functions were under the supervision of a slow-control program. The read-out and analysis processes where controlled by watch-dog programs. A web-based online monitoring program controlled the data quality. This allowed remote operation of the experiment by a small experimental group. The overall operation efficiency was of the order of 80%, including unexpected beam down-time and detector stops. For a typical day, without any hardware failure, FAST was active for 96% of beam time. In conclusion, FAST had a very successful data taking period in 2008. The muon lifetime measurement from the 2008 data sample has a statistical precision of about 3 ppm, which allows a determination of G_F to 1.5 ppm. During 2009, FAST will record an additional data sample of about 3×10^{11} events, taken under different conditions, in order to calibrate the systematic errors and accumulate the remaining statistics for a 1 ppm measurement of G_F.

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The electric dipole moment of the neutron

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The rather general CPT theorem of quantum field theory links time reversal (T) to CP violation, i.e. to an asymmetry between matter and antimatter. While a huge matter-antimatter asymmetry exists in our universe, the standard theory fails to explain this observation. Theories beyond the Standard Model (SM) of particle physics, introducing new sources of CP and T violation, often also predict other observable phenomena. In particular, sizeable T-violating permanent electric dipole moments of particles occur which are negligibly small in the SM. In this field, the neutron electric dipole moment (nEDM) is one of the most sensitive probes.

The first experiment to search for the neutron electric dipole moment (nEDM) was performed more than 50 years ago [1]. A non-zero nEDM would violate both parity (P) and time reversal (T) symmetry. Assuming the conservation of CPT, T symmetry is equivalent to CP symmetry. P, T and CP symmetries are violated in weak interactions [2], and all related particle physics observations are so far successfully described within the Standard Model (SM) of particle physics via a phase in the Cabibbo-Kobayashi-Maskawa quark mixing matrix [3]. CP violation is also needed to explain the matter-antimatter asymmetry of the universe [4]. However, the CP violation of the SM is not sufficient. While the electro-weak SM predicts only unobservably small particle EDM values, extensions of the SM often provide extra CP violation and generate sizeable EDM values.

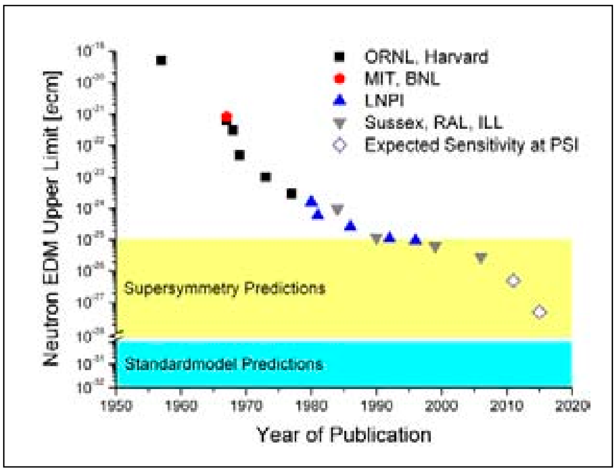

Figure 1: **History of experimental nEDM limits and expectations for this project in Phases II and III.**

Up to now, no permanent particle EDM has been found. Figure 1 displays the history of experimental results setting upper limits on the neutron EDM, presently less than 2.9×10^{-26} *e* cm (90% confidence level) [5]. This constrains many theories beyond the SM, e.g. Supersymmetry [6]. Today, several collaborations around the world are trying to measure the nEDM with 1–2 orders of magnitude improved sensitivity. This might allow CP violation to be discovered beyond the SM.

Experimental approach

This nEDM collaboration (http://nedm.web.psi.ch) follows a three-phase programme: During Phase I, the existing experimental apparatus [5] was operated at the Institute Laue-Langevin in Grenoble. This phase ended with the transfer of the apparatus to PSI in March 2009. Phase II foresees the operation of the upgraded apparatus at the new Ultracold Neutron Facility at PSI. The setup should be ready by the end of 2009 and the collaboration plans on a 2-year operation during 2010 and 2011. The sensitivity of the setup will be about a factor of 5 better than that of [5]. At the same time, a new experiment is being designed and constructed to come online in Phase III, starting in 2012. Its goal is to improve the sensitivity by another order of magnitude, to 5×10^{-28} *e* cm or better.

Phase I – Operation at ILL

Phase I at ILL in 2005–2008 delivered various important results, including the first direct limit on neutron–mirror-neutron oscillations [7], a search for exotic spin-dependent interactions, and systematic studies of the influence of magnetic field gradients on the measurement of the neutron to Hg atom precession frequencies.

The most important experimental issue was a severe deterioration of the transverse polarization decay time T2 of the ultra cold neutrons (UCN) after 2003. Although much work was done to resolve this issue, major progress was achieved only after finding and removing some magnetic components towards the end of 2008. The T2 times came back up to about 400 s and further progress can be expected. Hunting magnetic impurities is a continuing effort and part of the necessary quality control.

The R&D work in Phase I included the adaption and development of highly sensitive laser pumped Cs magnetometers [8], the development of a new insulator ring using DPS (deuterated polystyrene) coated PS [9], the development of high-rate UCN detectors [10], as well as studies on high voltage, leakage current measurements, field mapping, and data acquisition.

Phase II – Running at PSI

Figure 2 shows the experiment [5] located in a thermally stabilized room on the UCN beam in area South of the UCN facility at PSI. The setup will be fully operational and ready for UCN by the end of 2009. The beamline is 3.3 m above the floor, leaving space for the counting house below. A superconducting polarizer magnet is used to polarize the UCN beam upstream of the EDM apparatus. A horizontal beamline will allow test measurements to be made downstream of the EDM 'house'.

A UCN switch below the EDM apparatus will allow the experiment to be filled, monitoring the incoming flux and emptying the UCN into the detection system. Detailed Monte Carlo simulations have confirmed the expectations of an increase in UCN density inside the experiment of 30–50 times that obtained previously at the ILL PF2 beam.

Phase III – A new device

The design of the new experiment started with the evaluation of various conceptual ideas over the past 3 years. It converged on a double UCN chamber inside a 5-layer mu-metal shield using co-magnetometry as well as external ^{3}He and Cs magnetometers. The year 2009 will see more detailed design as well as progress with ordering the magnetic shield. R&D will concentrate on issues with the magnetic shield, such as demagnetization, magnetometry (R&D on ^{129}Xe, ^{199}Hg, readout of ^{3}He via Cs or SQUID magnetometers), the development of non-magnetic equipment, neutron detection, and new neutron-compatible surface coatings.

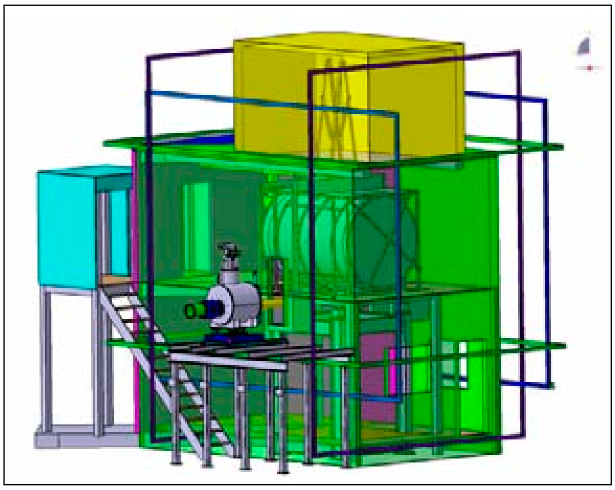

Figure 2: **The setup of the experiment [5] in area South of the new Ultra-Cold Neutron Source (UCN) at PSI. The magnetic shield sits inside a thermal 'house', UCN enter via guide tubes through a 5T polarizer solenoid.**

Acknowledgements

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Radiocarbon dating of glacier ice – an innovative application of micro-sample AMS

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Ice cores from high-alpine glaciers provide regional information about past climatic and environmental conditions. However, a precise chronology is a prime requirement for each natural archive, to allow a precise interpretation of the information recorded. Due to complex ice flow, there is a lack of appropriate dating tools for the deeper ice sections. To overcome this problem, a new dating method has been developed using radiocarbon in carbonaceous aerosol particles included in the ice. This required major technical improvements in AMS technologies allowing samples with sizes in the microgram range to be measured.

The most common method used for ice core dating is annual layer counting, which relies on seasonally varying signals and is supported by the identification of reference horizons such as volcanic layers. For ice cores from high-altitude glaciers, strong ice flow induced layer thinning limits counting of annual layers in the best case to a couple of centuries, and is not suitable for the oldest and deepest part, where individual years can no longer be distinguished. Glacier flow is dominated by the small-scale geometry of bedrock, resulting in a strongly non-linear depth-age relationship over time, which cannot be resolved using physical ice flow models [1].

The lack of an appropriate dating tool for this lowermost section could be overcome in certain cases by wiggle matching of the stable isotope records, using the strong variation during the glacial-interglacial transition (ca. 14,000–9,000 yrs BP) observed in polar ice cores [2]. However, it is evident that a record reaching at least that far back in time is required for this indirect dating method.

For longer timescales, radiocarbon analysis can provide an absolute date. Radiocarbon (^{14}C) dating has been successfully applied to several ice cores, where enough carbon-containing material was incorporated. Suitable material included wood fragments or insects [3], although it is emphasized that macrofossils in ice cores appear rather seldom – a fact limiting the wider application of this technique.

To overcome this problem, we have recently developed a novel radiocarbon method, using carbonaceous aerosols contained in the ice for dating. Carbonaceous particles are a major component of naturally occurring aerosols that are emitted ubiquitously, or formed in the atmosphere, and that reach potential ice core sites [4]. The particles are classified as organic carbon (OC, light polycyclic hydrocarbons) and elemental carbon (EC, highly polymerized hydrocarbons), which have different sources. OC is predominantly emitted from the terrestrial biosphere as primary aerosol, or formed in the atmosphere as secondary aerosol from gaseous precursors, whereas the main source of EC is pyrolysis during combustion. By determining the $^{14}C/^{12}C$ ratios of OC samples from a well-dated ice core from the Swiss Alps (Fiescherhorn, 3,900 m asl), it was shown that the OC incorporated in ice is almost of purely biogenic origin before around 1800 AD [4], making this fraction a valuable target for age determination. However, the very small amounts of OC incorporated in ice core samples (3–30 µg of carbon) make the usual treatment for radiocarbon dating impossible. This would typically require

Figure 1: **Miniaturized gas-handling system for the direct injection of a few micro-liters of CO_2 gas into the MICADAS for radiocarbon dating. The heart of the system is a gas-tight syringe from which the gas is pressed into the ion source via a capillary.**

about 1 mg of material. However, a large step forward has recently been taken to overcome this limitation by exploiting the possibilities of directly analyzing gaseous CO_2 samples using accelerator mass spectrometry (AMS). The novel Mini Carbon Dating System (MICADAS) at PSI/ETH Zurich [5] is equipped with a gas ion source and is able to accept tiny amounts of CO_2 for $^{14}C/^{12}C$ analyses. A dedicated miniaturized

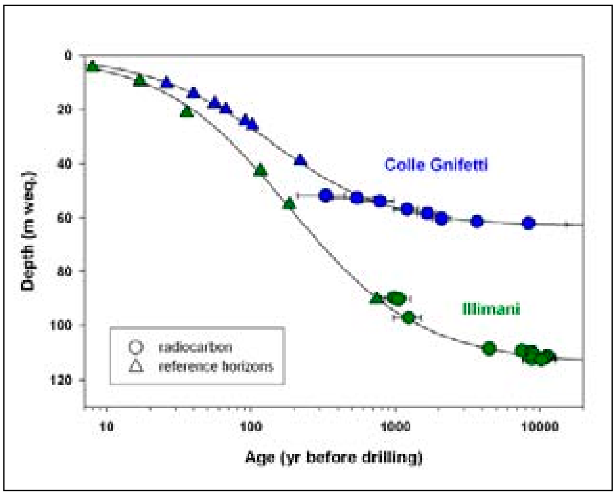

Figure 2: **Age-Depth model for the Colle Gnifetti ice core (Swiss Alps) and the Illimani ice core (Andes), with radiocarbon dating points and independently dated reference horizons.**

gas-handling system (Figure 1) was constructed for continuous sample introduction into the ion source [6]. The system is designed to handle CO_2 amounts of only 6–60 µl (3–30 µg carbon). Particular emphasis has been taken to reduce possible contamination of the sample material with contemporary CO_2 from ambient air by minimizing the volume and thus the internal surface of the equipment. Using CO_2 directly has, in addition, the great advantage that the final reduction step to solid graphite in the sample preparation procedure can be omitted and the related contamination is avoided. Typically, the carbon contamination introduced in this step is of the order of only a few micrograms. This can be neglected for samples in the milligram range, but would influence the analysis of the OC fraction as it can be extracted from the ice cores.

To extract the OC fraction, the aerosols were filtered off the ice and combusted in a two-step heating system. CO_2 from the OC fraction was collected in a first, low-temperature step at 340°C and sealed in a silica glass tube. In a second step, the EC fraction was released at a high temperature of 650°C [7]. The glass tubes containing the CO_2 from the OC fraction were introduced into the ampoule cracker of the gas handling system and the CO_2 gas was released into the syringe and subsequently mixed with He to a ratio 1:20. This gas mixture was directly fed into the ion source at a typical flow rate of 1µl CO_2/min. Inside the ion source, the gas mixture was flashed over a titanium catalyst exposed to a high-intensity caesium beam. Due to interaction with energetic caesium ions, negatively charged carbon ions were formed and extracted as an ion beam from the source, and its isotopic composition measured with the downstream accelerator mass spectrometer. From the resulting $^{14}C/^{12}C$ ratios, radiocarbon ages were calculated and related calendar ages derived from the tree ring calibration record intcal04.

This new ^{14}C dating technique was applied to two ice cores, from Illimani (Andes, 6,300 m asl) and Colle Gnifetti (Alps, 4,450 m asl) (Figure 2). For both ice cores, the ages cover a time span from 1,000 to more than 10,000 years. A strongly non-linear age-depth relationship is prominent in the lowermost part of the cores, in agreement with the expected strong annual layer thinning gradients. Samples close to bedrock are of Late Pleistocene age. Additional, independent dating methods have corroborated these findings and confirmed the accuracy of the method.

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Minimagnets for data storage

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We have fabricated 50 nm-period perpendicular magnetic nanoislands by depositing Co/Pd multilayer films onto arrays of SiO_x pillars created with extreme ultraviolet interference lithography at the XIL beamline, Swiss Light Source. A direct comparison of the island diameters with the magnetic switching fields indicated that island-to-island anisotropy variations are likely to be responsible for the observed switching field distribution (SFD) of 11.5%. Recently we have been able to create magnetic islands with sub-30 nm periods corresponding to data storage densities close to 1 Tbit/in^2.

We are all familiar with the use of computer hard drives for storage of information, from simple text documents and data files through to images and movies. Since the first IBM hard drives in the mid 50s, there has been a phenomenal increase in the data storage density in the magnetic thin-film media, which is now about 10^4 times higher than it was 20 years ago. This tremendous increase has been spurred on by new discoveries, such as the Nobel Prize winning giant magnetoresistive (GMR) effect implemented in the read elements of magnetic recording heads and improvements in the magnetic layers. However, the train of innovation in magnetic data storage faces derailment due to the thermal stability of the written information. This issue is set to change the course of magnetic data storage history.

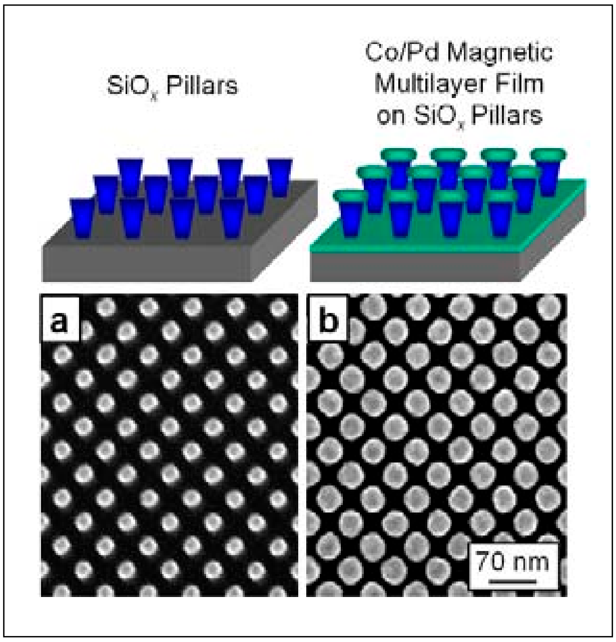

Figure 1: **Schematic diagrams of the fabrication of nanoscale magnetic island arrays with EUV-IL and corresponding SEM images of SiO_x pillars with periods of 50 nm (a) before and (b) after Co/Pd multilayer film deposition [3].**

Current devices record bits of information in continuous magnetic films in the form of magnetised areas which are presently made up of about 100 crystal grains. In order to increase the magnetic storage density, both the magnetic bit size and the grain diameter must be decreased, and at a certain volume limit the grains are no longer stable against thermal fluctuations. Information can therefore no longer be stored below this so-called superparamagnetic limit. One solution to this problem is to replace the continuous grainy magnetic media with a magnetic film patterned into nanoscale magnetic islands, where each island corresponds to a single bit of information [1]. Currently industry is searching for a viable method to fabricate arrays of islands, and extreme ultraviolet interference lithography (EUV-IL), which has been developed at the XIL beamline at the Swiss Light Source since 2003, provides a highly promising fabrication method, with its ability to create high-resolution periodic island structures over large areas and with a high throughput [2].

Towards the beginning of last year we published a method to create 50 nm-period magnetic islands on a square array [3], which are to our knowledge the smallest magnetic islands created by a photolithography rather than an electron-beam lithography method. We succeeded in doing this by first creating an array of SiO_x pillars on a silicon substrate (see Figure 1a) and depositing a Co/Pd multilayer film with perpendicular

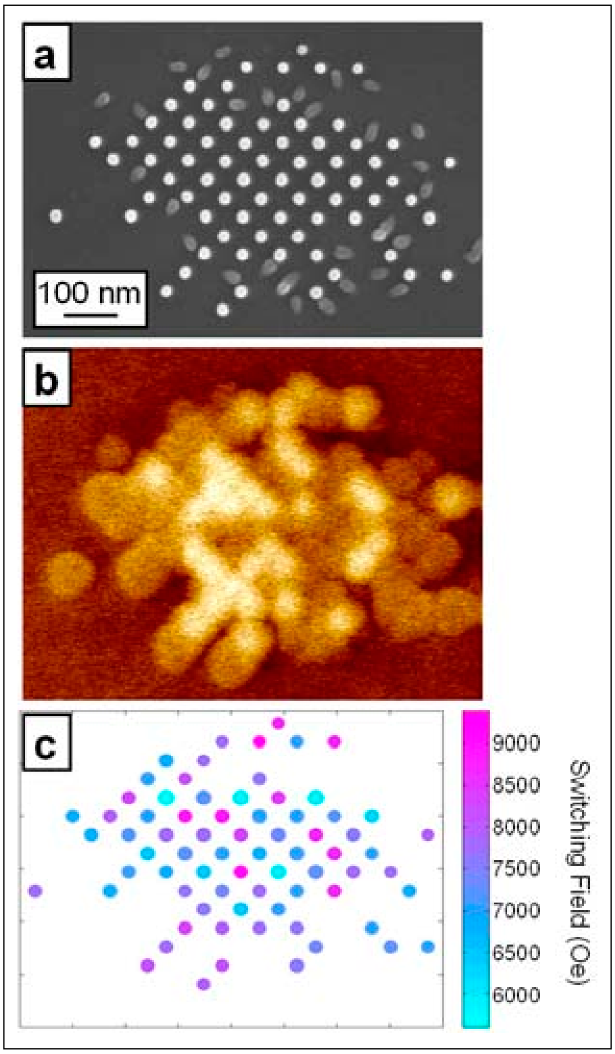

Figure 2: **(a) SEM image of SiO_x pillars with a period of 50 nm and (b) corresponding MFM image of the magnetic island array after coating the pillars with a Co/Pd multilayer film and applying a magnetic field of 7.0 kOe. The darker islands have switched. (c) Map of switching fields for each individual island; the color corresponds to the switching field and the size is proportional to the magnetic island size for the area shown in Figure 2(a).**

anisotropy on top (see Figure 1b). This resulted in single-domain perpendicular magnetic islands on top of the pillars, which were isolated from the material in the valleys due to the serendipitous negative profile of the SiO_x pillars. These 50 nm-period magnetic nanoislands covered an area of 20 by 20 µm^2.

In order to determine whether such islands are suitable for magnetic data storage, it is vital to determine the magnetic switching behaviour [4]. For this we wanted to make a direct correlation between the switching field and dot size, so we chose to look at an inhomogeneous area at the edge of an array (see Figure 2) which allowed us to measure for each and every island both its size with scanning electron microscopy and its switching field with magnetic force microscopy.

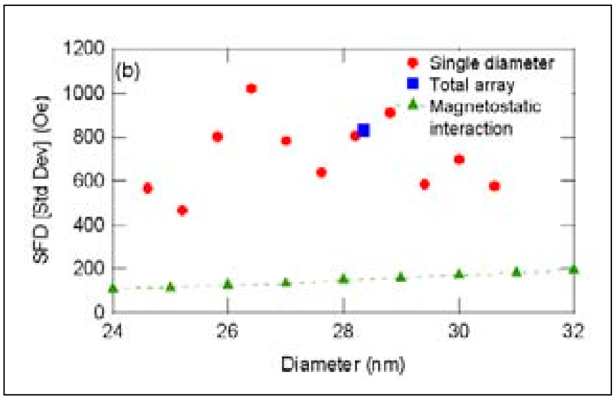

Figure 3: **Comparison of the measured SFD as a function of island diameter (circles) with the simulated SFD (triangles), assuming only magnetostatic interactions from neighbouring islands contributes to the SFD. The single data point (square) is the SFD of the entire island population.**

The mean switching field of the island array was 7200 Oe with a switching field distribution (SFD = σ/mean) of 11.5%, which compares well with values for islands fabricated by electron beam lithography. Looking at the switching field distribution as a function of island size, we were able to deduce that the key cause of the SFD is not a variable island size nor the inter-island magnetic stray field coupling, but rather is linked to a variation in the island-to-island anisotropy. This falls in line with the current thinking in the patterned media community. We are working hard to make the magnetic islands even smaller [5] and have had first success in creating sub-30 nm period arrays. This opens up the possibility of creating patterned media with EUV-IL at densities greater than 1 Tbit/in^2, corresponding to a bit period of less than 25 nm, so answering the call from industry to beat the superparamagnetic limit at higher densities.

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Dots and stripes: Nanofabrication enables new science

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Micro- and nanofabrication technology enables the creation of well-defined structures and patterns in various forms and shapes, down to the size of a few nanometres. Interesting phenomena are expected and observed when small objects, such as colloidal particles and molecules, interact with such structures. In periodic structures it is often easier to observe collective phenomena, since tiny signals originating from well-localized nanoscale objects can sum up to yield a better signal-to-noise ratio.

Pushing the resolution limit of photon-based lithography

The extreme ultraviolet interference lithography (EUV-IL) set-up established a few years ago at the SLS produces periodic structures in the range from micrometers down to a few tens of nanometers [1], a size range not only interesting for future integrated electronic devices, but also for looking at interactions with immobilised biomolecules such as proteins, which are typically a few nanometers in size. Figure 1 shows a recent result with a 22 nm-period structure exposed in hydrogen silesquioxane (HSQ) resist. The lines are only about 11 nm wide, which is the highest resolution achieved with a photo-lithography technique to date. Unique to this technology is the narrow size distribution of the periodic surface features (lines or, for the case of multiple beam interference, dots) which can be of the order of 0.5 nm (1σ), i.e. the size of one resist molecule. Field sizes up to 2×2 mm^2 can be exposed in a few seconds. Controlled nanofabrication on a length scale approaching the size of single molecules allows exciting new science.

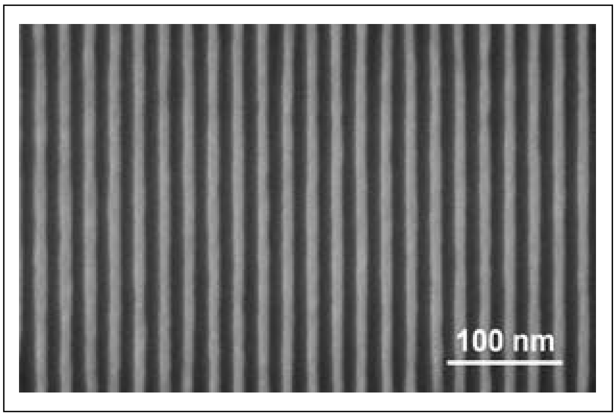

Figure 1: **11 nm-wide lines in HSQ on a silicon surface exposed by EUV-IL. This is the best resolution ever achieved with photon-based lithography.**

Periodic nanostructures at the size of biomolecules.

In addition to being of potential use in bio-analytics, arrays of immobilized single protein molecules are of interest as substrates for cell growth studies, since interactions of single molecules or molecule ensembles with living cells are not

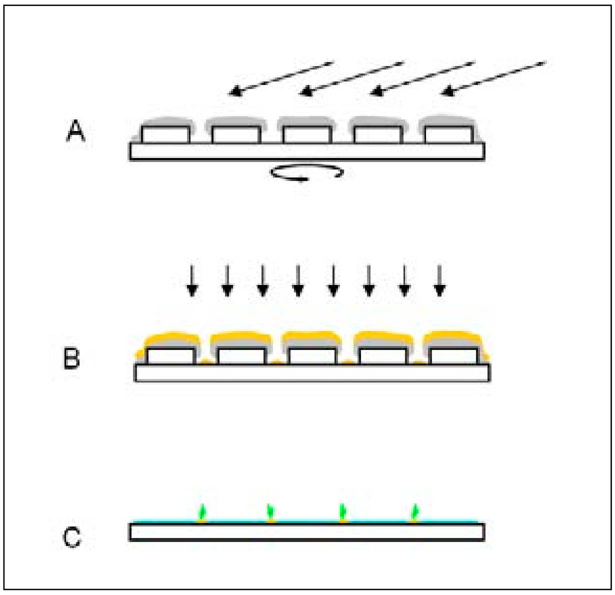

Figure 2: **Process scheme for the fabrication of gold dot arrays (explanations in the main text).**

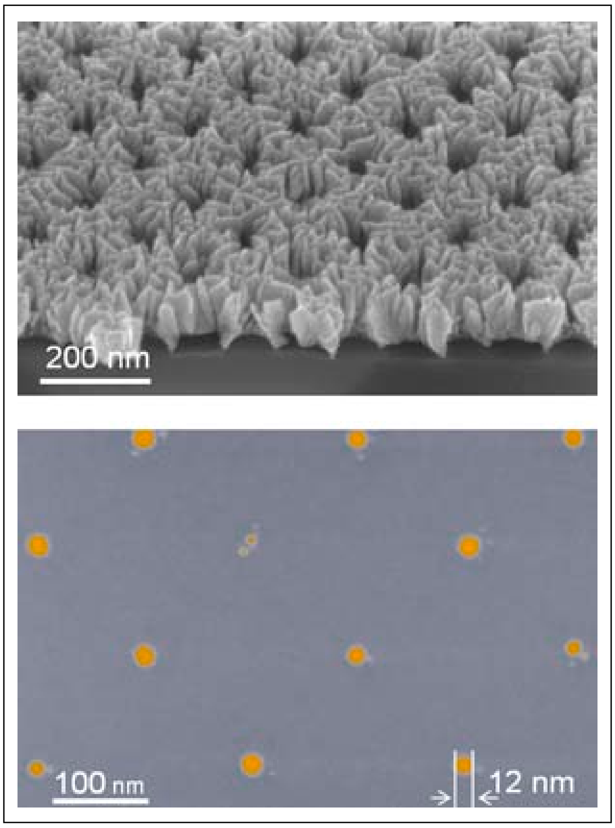

Figure 3: **(Top) chromium layer deposited onto a nanostructured photoresist and (bottom) 15 nm gold islands formed in the process.**

necessarily the same. Here the crucial resolution is reached when the sites for biomolecule immobilization is so small that they can only host single molecules.
The process schematically shown in Figure 2 has been developed to reduce the size of structures produced with EUV-IL towards these dimensions. (A) A layer of chromium is evaporated under a shallow angle and sample rotation onto an array of nanoscale holes produced with EUV-IL in a photoresist leading to minimization of the hole size. (B) A gold layer is evaporated through the holes. (C) Removal of the photoresist and annealing yielded arrays of 12–15 nm gold islands (Figure3). After deposition of a protein-resistant layer, proteins are specifically bound to the gold islands. Such arrangements provide the basis for protein detection at the single-cell level using scanning-force microscopy techniques [2].

Particle ordering in nanochannels

Confinement-induced ordering of particles in nanofluidic devices depends on the ionic charges on the particle and container surfaces as well as in the surrounding solution. However, direct experimental observation is challenging, due to the restrictions imposed on the probe.

A recently developed technique relies on using a nanofabricated array of channels (Figure 4) for confinement, allowing the fluid density profile across the channel to be determined by means of X-ray diffraction [3]. The method was demonstrated on a charge-stabilized colloid, in which the colloidal particles were observed to move from the center of the channel (left panel of Figure 5) to the channel walls (right panel of Figure 5) upon adding a small amount of salt. The observation of the effective channel width depending on the ion concentration should prove useful for future nanofluidic devices.
The present fabrication technique, based on electron-beam lithography, allows structural studies on confined fluids with particle diameters of about 30 nm or larger. However, the application of EUV-IL should make studies on smaller particles, such as macromolecules, feasible.

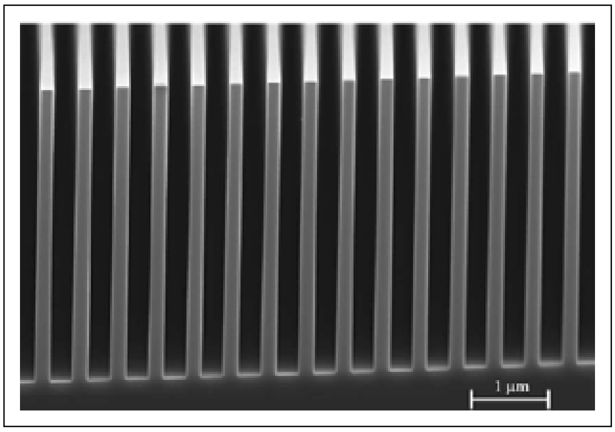

Figure 4: **Nanochannels etched into silicon used for investigation of the ordering of fluids.**

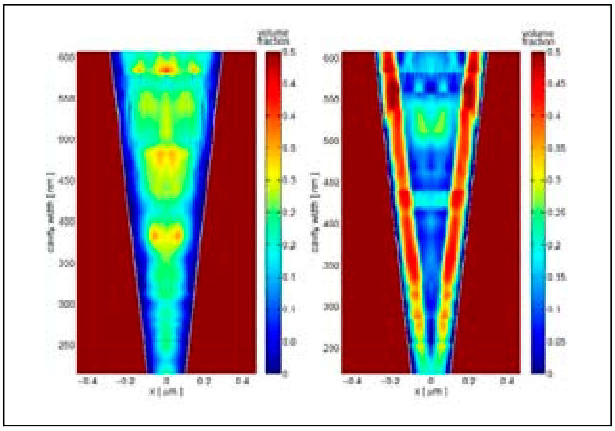

Figure 5: **Colloid density across the confining channel as a function of the channel width: before (left) and after (right) adding 0.2 mM of LiCl.**

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Molecular insight into amyloid fibril formation from a de novo design

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Amyloid fibrils are protein structures that occur in a number of human pathologies, including Alzheimer's and Parkinson's disease. In the present article, methods are presented that allow the study of amyloid fibril formation in the test tube.

Amyloid fibrils are filamentous, insoluble protein aggregates deposited *in vivo* in more than 20 different amyloid diseases or formed *in vitro* from soluble proteins [1]. Although fibril-forming proteins often lack sequence and structural similarity, amyloid fibrils share some common properties which make it feasible to use simple model systems to systematically assess the factors that predispose a native protein to form amyloid fibrils. For this purpose, a 17-residue peptide model system has been generated *de novo,* referred to as ccβ-Met, which can be converted into amyloid fibrils [2, 3]. The simplicity of this peptide system makes it suitable for probing the molecular details of amyloid assembly.

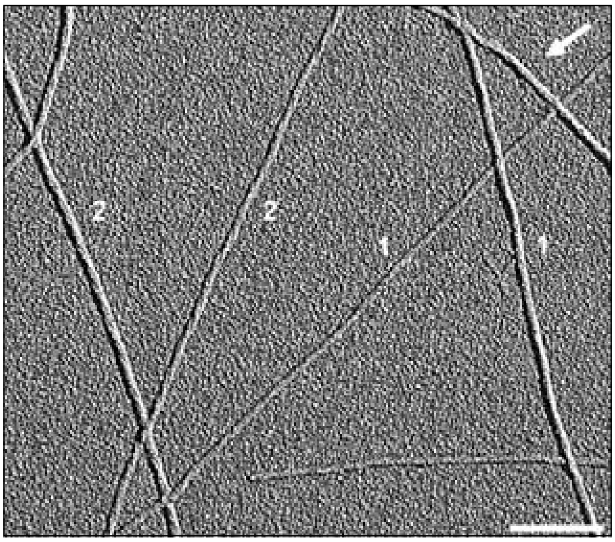

Figure 1: **Electron micrograph of unidirectional metal-shadowed ccβ-Met. The direction of metal shadowing is indicated by the white arrow. Type 1 and Type 2 fibrils are labelled. Scale bar: 70 nm.**

Analysis by electron microscopy

The structure of ccβ-Met fibrils was analyzed by transmission electron microscopy. Electron micrographs of unidirectional metal-shadowed samples revealed single and frequently twisted fibrils, with uniform morphology and with widths ranging from ~5 to 8 nm (Figure 1). Closer inspection of several electron micrographs indicated the presence of at least two polymorphic fibril forms, with a lower (repeat lengths of ~60 nm) and a higher (repeat lengths of ~30 nm) degree of left-handed twist, referred to as Type 1 and Type 2 fibrils, respectively.

Analysis by X-ray fibre diffraction

The packing of the ccβ-Met peptide chains within the fibrils was investigated by fibre diffraction. Diffraction patterns recorded with the X-ray beam perpendicular to the major axis of the fibril revealed signals at 4.7 Å on the meridian and 12.3Å on the equator (Figure 2). This pattern is consistent with a laminated cross-β structure and is characteristic for amyloid structures. In this structure, the polypeptide chains are organized in laminated layers of β-sheets and run perpendicular to the long fibre axis. All the reflection positions were measured and the unit cell was determined to be: a = 9.4 Å, b = 23 Å, c = 58 Å, $\alpha = \beta = \gamma = 90°$, where a is the hydrogen bonding direction along the major fibril axis, b is the inter-sheet direction, and c is the peptide chain direction.

Atomic models and molecular dynamics simulations

To obtain a detailed molecular description of the ccβ-Met amyloid fibril, atomic models were constructed, representing Type 1 and Type 2 fibrils (Figure 3), based on all present experimental restraints (see [4]). To gain insight into the side chain interactions within the ccβ-Met amyloid fibril, molecular dynamics simulations were performed (see [4]). Analysis of structures at the end of the simulation revealed that compatible side chains interdigitate and appear like the teeth of a zipper. Previous experiments showed that chemical oxidation of the sulfur atom of the methionone side chain to a polar sulfoxide (denoted ccβ-MetO) completely abolished amyloid fibril formation of the derivatized ccβ-Met peptide [4]. Calculations indicate that, compared to ccβ-Met, ccβ-MetO strands are more stable in water than in an amyloid fibril. This effect can be explained by the stronger solvation of the methionine sulfoxides compared with methionines and by a perturbation of the packing of the hydrophobic core residues in the fibril.

Conclusions

The simplicity of the ccβ-Met system makes it suitable for probing the molecular origin of amyloid fibril assembly. The detailed structural information presented for the ccβ-Met amyloid fibril provides a basis for understanding the influence of single site-specific hydrophobic interactions on native-state stability, the kinetics as well as the packing and polymorphism of fibril formation and the evaluation of their relative importance.

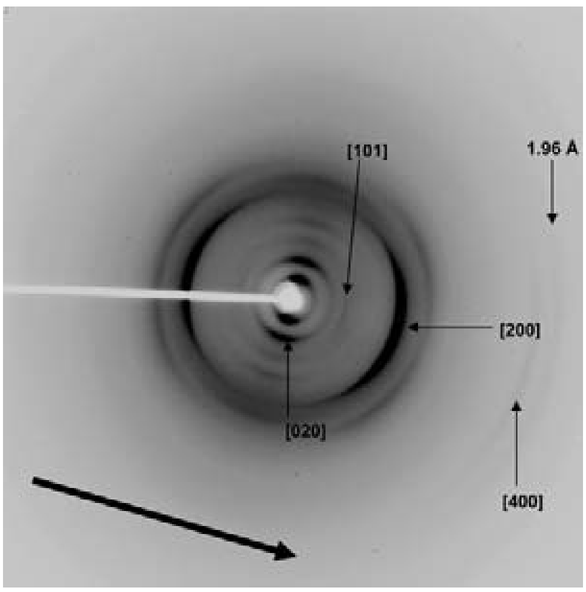

Figure 2: **Fibre diffraction pattern of aligned ccβ-Met fibrils. Miller indices assigned to the reflections are indicated. The diffraction signal labelled [200] corresponds to the 4.7 Å reflection. The signal labelled [101] is the layer line at 9.4 Å. The [020] signal corresponds to 12.3 Å reflection on the equator. Black arrows indicate the direction of the long fibril axis.**

Figure 3: **Side views of idealized atomic models of ccβ-Met fibrils corresponding to Type 1 (left) and Type 2 (right) fibrils observed by electron microscopy (Figure 1): a indicates the direction of the filament long axis; b denotes the intersheet direction; and c is the peptide-chain direction.**

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Monitoring subcellular compartments of mammalian cells with fluorescent proteins

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The analysis of cellular processes is of crucial importance for the understanding of human diseases. The use of genetically engineered fluorescent probes allows the monitoring of biological processes in living cells. A new expression vector system has been developed which makes it possible to modify and study multiple cellular parameters simultaneously.

In contrast to bacteria, mammalian cells contain many different compartments. This allows the assignment of specific cellular functions to defined regions of the cell. Examples of such compartments are the nucleus, mitochondria or endosomes. The nucleus stores genetic information (DNA) and transcribes it to a working copy (mRNA), which is then exported to the cytoplasm. Mitochondria are the major sites of cellular energy production. Endosomes are cytoplasmic transport vesicles, which transfer membrane proteins from the plasma membrane to intracellular sites for sorting, signalling, and degradation. Unfortunately, most of these organelles are too small to be identified by classical light microscopy. In addition, they are intermingled within cells and are highly motile. The identification of interesting cellular structures therefore resembles the search for a "needle in a haystack".

Fluorescence microscopy in cell biology

August Köhler observed at the beginning of the last century that certain structures of plant cells show autofluorescence when they are illuminated with ultraviolet light. In the middle of the century, it became possible to specifically label cellular compartments and to monitor simultaneously several different colours using optical filters. However, the analysis was still limited to fixed material. The analysis of living cells became possible with the introduction of fluorescent proteins. This technology was awarded with the Nobel Prize for Chemistry in 2008. Genetic engineering made it possible for the natural fluorescent proteins from a jelly fish and a coral to be available today in many different colours. Specific targeting signals for subcellular compartments are then added to the genetic information of these fluorescent proteins, and the resulting expression vector is transfected into mammalian cells. The cells translate this information into a new protein, which labels a particular cellular compartment (Figure 1).

The insertion of expression vectors into mammalian cells by transfection is well established, but there are limitations in this approach: (1) Co-transfection with individual vectors leads to cells with different expression ratios, since only small amounts of each plasmid are taken up. This becomes very pronounced when more than two plasmids are transfected simultaneously, or if a cell line is difficult to transfect; (2) The stable integration of expression vectors in a host cell genome works mainly sequentially, meaning that it is a time-consuming process. An expression system has therefore been developed in our Lab that allows the flexible expression of several proteins in a mammalian cell from a single vector.

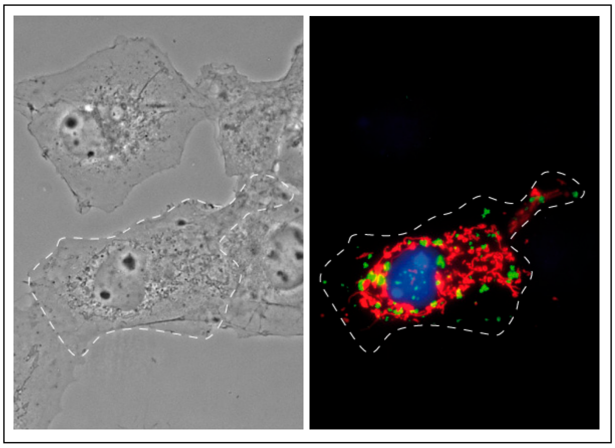

Figure 1: **COS cell transiently transfected with three vectors encoding a blue fluorescent protein with a nuclear localization signal, a green fluorescent protein with endosomal targeting, and a red fluorescent protein with mitochondrial targeting. A phase-contrast picture is shown on the left; the overlay of the three fluorescent pictures is shown on the right. The cell border of the transfected cell is marked with a dashed line.**

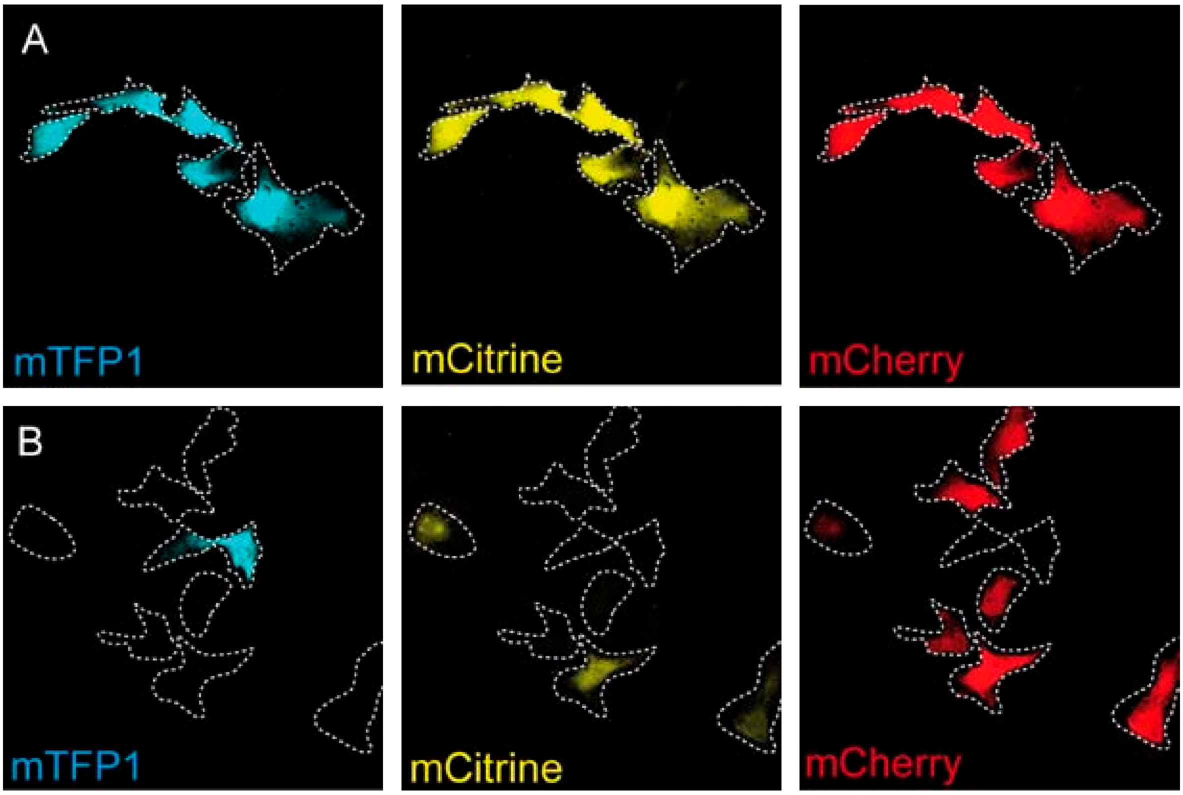

Figure 2: **(A) Expression from a single plasmid leads to the simultaneous expression of several proteins in a cell. The cells were transfected with a plasmid encoding a cyan (mTFP1), a yellow (mCitrine), and a red fluorescent protein (mCherry). (B) The coding sequences for the same fluorescent proteins were located on independent plasmids and cotransfected. Note that not all transfected cells express all fluorescent proteins. The cell borders of the transfected cells are marked with a dashed line.**

Multi-protein expression systems

Our group was previously involved in the development of a recombination-based system (cre/LoxP) for the expression of multi-protein complexes in insect cells and bacteria [1,2]. This system allowed the assembly of up to four plasmids, each containing the genetic information for a particular protein, in a recombination-based reaction followed by selection with appropriate antibiotics. It was used exclusively for the production of protein complexes for structural studies. To develop a similar mammalian expression system, unnecessary elements were removed from these vectors and replaced with regulatory elements for mammalian expression. In addition, the system was kept modular so that it is compatible with our robotics-based high-throughput cloning platform. It is currently possible to integrate the information for five different fluorescent proteins into one expression vector. Figure 2 clearly shows that the system has the expected benefits. Transfected cells express all proteins and it is now possible to efficiently generate stable cell lines with several expression units at once.

Conclusions and outlook

It has been shown in this work that a recombination-based assembly of expression cassettes is a successful strategy for expressing numerous proteins in mammalian cells. So far, work has focused on the expression of fluorescent probes for the analysis of cellular processes. The system also allows the expression of several proteins to reprogram cells, which is extremely important in stem cell research, where pluripotent stem cells are transformed into differentiated cells for clinical applications.

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"Click-to-chelate": functionalization of thymidine with chelating systems for rhenium and technetium

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The site-specific conjugation of metal chelating systems to biologically relevant molecules is an important contemporary topic in bioinorganic and bioorganometallic chemistry. The "click-to-chelate" approach describes the use of the Cu(I) catalyzed cycloaddition of azides and terminal alkynes to synthesize 1,2,3-triazole-containing metal chelating systems, and their simultaneous incorporation into biologically relevant molecules. Using this strategy, a series of thymidine derivatives were prepared, radiolabelled in situ with technetium-99m and evaluated as potential tracers for single photon emission tomography.

Human thymidine kinase type 1 (hTK1) is a cytosolic enzyme which catalyzes the Mg^{2+}-dependent γ-phosphate transfer from ATP to the 5'-hydroxyl group of thymidine (dT). hTK1 is significantly overexpressed in rapidly proliferating and malignant cells and has proven to be a suitable target for non-invasive imaging of cancer cell proliferation using radioactively labeled thymidine and deoxyuridine derivatives. For this reason, there is considerable interest in the development of a thymidine tracer for single photon emission tomography (SPECT) based on the inexpensive radionuclide technetium-99m (^{99m}Tc). ^{99m}Tc is readily available at low cost and possesses excellent decay properties ($T_{1/2}$ = 6h, 140keV γ-radiation) for in vivo diagnosis. However, when we started our studies no such tracer was known, and no technetium-labelled thymidine derivative which retained substrate activity, that is phosphorylation at position C5' by hTK1, had been synthesized. Retaining substrate activity is a prerequisite for in vivo application.

Synthesis and radiolabelling

We identified two potential sites of thymidine (namely C3' and N3) for modification with a bifunctional metal chelating system (Figure 1). It is well known that subtle changes to the lead structure and the metal complex can have a decisive impact on substrate activity. Often such effects can only be identified if larger series of derivatives are synthesized, which in the case of metal complexes is typically associated with multi-step syntheses requiring the use of protecting groups to avoid unwanted side reactions. To speed up this often laborious approach, we employed the "click-to-chelate" strategy, which was recently developed by our group, and which uses the Cu(I) catalyzed cycloaddition of alkynes and azides [1, 2]. This efficient strategy enabled us to assemble and radiolabel thymidine derivatives in a single step using a one-pot procedure, which spares the isolation of the clicked ligands before in vitro screening and assessment.

Commercially available C3' azido-3'-deoxythymidine and an N3 azido-thymidine derivative were reacted with a set of suitable alkynes (Figure 2). The thymidine derivatives were subsequently reacted in situ with the organometallic ^{99m}Tc precursor $[^{99m}Tc(H_2O)_3(CO)_3]^+$ [3]. Using this strategy, ten novel thymidine derivatives with varying structures, hydrophilicity and overall charge were prepared in a matter of a few hours,

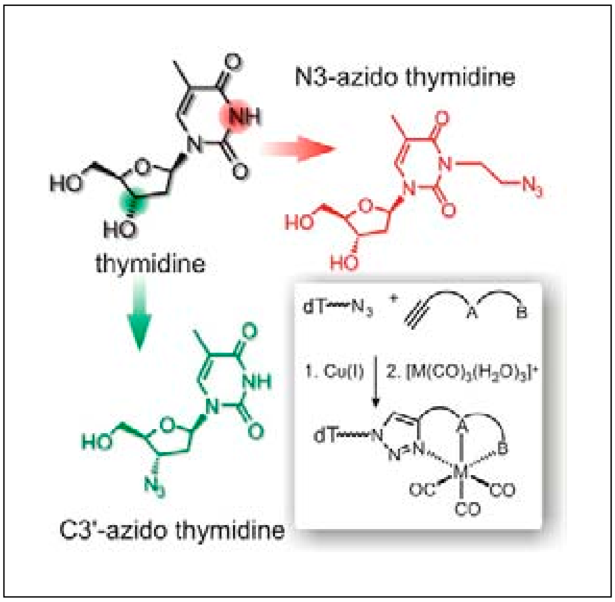

Figure 1: **Chemical structures of thymidine (dT), C3′-azido thymidine and N3-azido thymidine, and general reaction scheme for the "click-to-chelate" approach [2].**

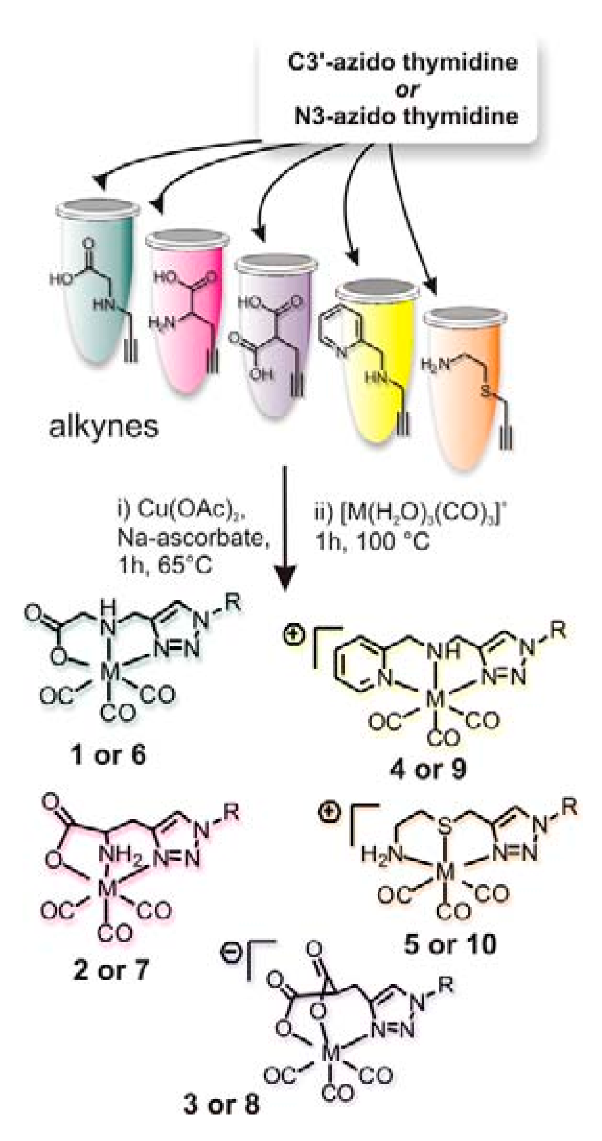

Figure 2: **Parallel, one-pot preparation and radiolabelling of organometallic thymidine derivatives, functionalized at position C3′ (1–5) or N3 (6–10) with various metal chelating systems. Complexes revealed variable substrate activity towards hTK1 depending on their overall charge (M = ^{99m}Tc or Re; R = thymidine).**

which would have taken several weeks using "classical" synthetic procedures [4]. In parallel, the non-radioactive rhenium (Re) complexes were also prepared.

Identification of substrates for hTK1

^{99m}Tc/Re(CO)$_3$ complexes **1–10** were incubated with ATP in the presence of hTK1. The time-dependent formation of the monophosphorylated complexes was monitored by HPLC. We observed that all complexes were substrates for hTK1. This was corroborated by mass spectroscopic analyses. The hTK1 substrate activities of ^{99m}Tc/Re(CO)$_3$ complexes **1–10** were measured quantitatively relative to the natural substrate thymidine using a coupled hTK1-PK-LDH assay.

As the data in Table 1 show, the overall charge of the thymidine complexes had a pronounced influence on the substrate activity. The neutral and anionic C3'-functionalized complexes were similarly good substrates, whereas the cationic complexes were much less readily phosphorylated. On the other hand, for the N3-functionalized derivatives, we observed that anionic complexes were the worst substrates.

Table 1: **Phosphorylation rates of C3′- and N3- functionalized thymidine derivatives.**

C3′ Complex	[%]*	N3 Complex	[%]*
1[a]	20.3 ± 0.8	**6**[a]	17.9 ± 0.1
2[a]	27.6 ± 1.9	**7**[a]	14.1 ± 0.2
3[b]	23.1 ± 1.8	**8**[b]	9.0 ± 0.4
4[c]	14.2 ± 0.2	**9**[c]	16.8 ± 0.2
5[c]	12.5 ± 0.5	**10**[c]	10.9 ± 0.4

* The phosphorylation rate for dT was arbitrarily set to 100%.
[a] neutral [b] anionic [c] cationic

Conclusions

Using the "click-to-chelate" strategy we were able to identify the first metal-containing substrates for hTK1. Furthermore, the approach allowed the fast identification of structure-activity relationships in a matter of a few hours. Thus, we could demonstrate that neither the synthesis or incorporation of different metal chelating systems, nor the subsequent radiolabelling, need to be the rate-determining steps in the development of radiopharmaceuticals. It is important to recognize that the same approach can be used to functionalize any azide-containing biomolecule and in situ (radio)labelling provides rapid access to a set of conjugates for preliminary screening. By making functionalization of targeting molecules fast, efficient and predictable, click chemistry could play a crucial role in expediting the development of potential SPECT tracers.

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Improved imaging of prostate cancer with bombesin analogues functionalized by "click"-chemistry

Elisa Garcia Garayoa, Christian Schweinsberg, Olga Gasser, Alain Blanc, Peter Blaeuenstein, P. August Schubiger, Roger Schibli, *Center for Radiopharmaceutical Science, ETH-PSI-USZ*

"Click"-chemistry offers a powerful tool for the incorporation of chelating systems and other moieties (e.g. glucose) into biomolecules. Using this strategy, new analogues of the tumour-affine peptide bombesin were synthesized which showed higher tumour uptake and lower radioactivity at the abdominal area. This resulted in a better delineation of tumours by Single Photon Emission Computed Tomography / Computed Tomography (SPECT / CT). Moreover, radioactivity wash-out was faster from normal tissues, including receptor-positive organs, than from tumours, which would be advantageous for therapeutic purposes.

A variety of human tumours, including prostate and breast cancers, overexpress bombesin (BBS) receptors on the cell membrane and, thus, BBS analogues are interesting molecules to selectively deliver radionuclides into tumour cells for imaging and therapy [1, 2]. The main drawback of most reported radiolabelled BBS derivatives is their high liver uptake and strong hepatobiliary excretion, which may obscure the detection of tumours or metastases localized at the abdominal cavity. Introduction of carbohydrates in the molecule increases the hydrophilicity and may favour a renal excretion. "Click"-chemistry (the Cu(I)-assisted [2+3] cycloaddition of an alkyne and an azide) offers a convenient way of functionalizing bimolecules [3, 4]. This technique was used to attach glucose to the peptide molecule (BBS-2) as well as a new chelating system (BBS-3). Presented here is the comparison of two glycated BBS analogues as potential radiopharmaceuticals for tumour targeting (Figure 1).

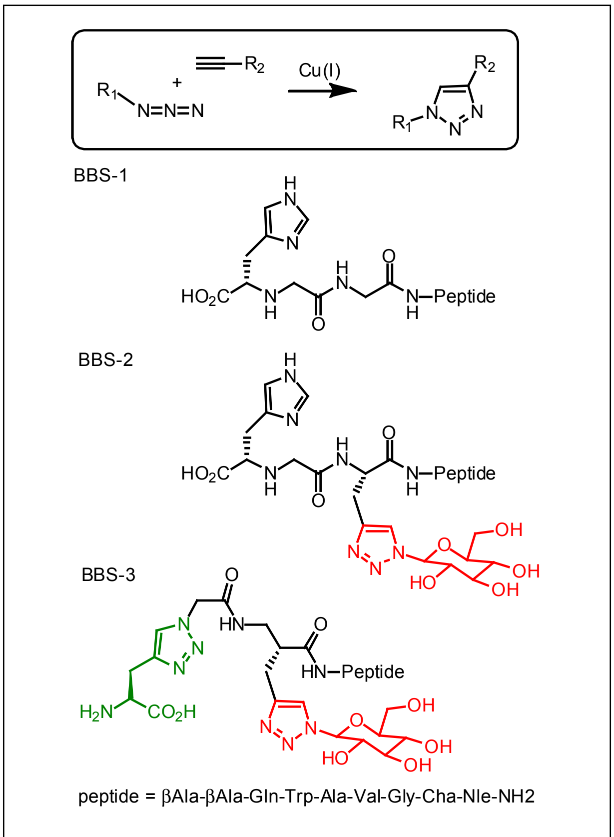

Figure 1: **Schematic presentation of the Cu(I)-assisted [2+3] cycloaddition of an alkyne and an azide, called a "click" reaction. Structure of the analogues BBS-1 ("non-clicked" reference); BBS-2 and BBS-3 ("clicked" carbohydrates in red and "clicked" chelator in green).**

Biodistribution

The presence of glucose neither affected the affinity for the BBS receptors nor the internalization into tumour cells *in vitro* [5]. The biodistribution of the new ^{99m}Tc-labelled BBS analogues was tested in mice with tumour xenografts of PC-3 cells, a human prostate carcinoma cell line that overexpresses BBS receptors. The "click"-glycated analogues BBS-2 and BBS-3 showed significantly higher tumour uptake than the non-glycated analogue BBS-1 (Figure 2).

Uptake in the tumour and in the receptor-positive organs pancreas (data not shown) and colon was very specific, and could be significantly inhibited after co-injection with a high concentration of natural BBS.

The glycated ^{99m}Tc-BBS-2 and ^{99m}Tc-BBS-3 were preferentially excreted through the kidneys and, thus, their liver uptake was substantially reduced compared to the non-glycated

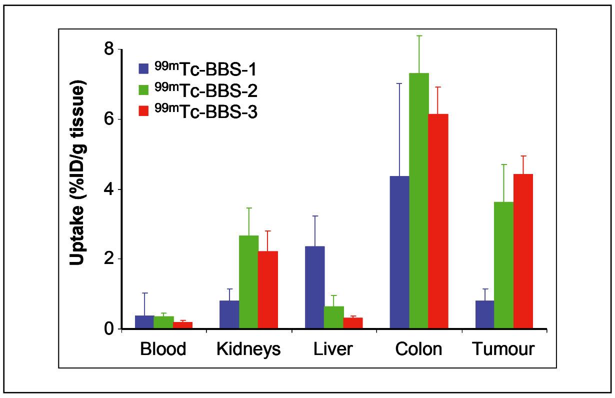

Figure 2: **Biodistribution of ^{99m}Tc-labelled BBS analogues in mice with prostate tumours at 1.5 h p.i. Comparison in selected tissues. High uptake in colon is due to the normal expression of receptors in this tissue in mice.**

^{99m}Tc-BBS-1. In spite of a higher kidney uptake at earlier post-injection times for the "click"-glycated analogues, the activity was rapidly cleared and similar low renal uptake was observed for all the analogues at later times. Moreover, residence times of labelled BBS-2 and BBS-3 in the tumour were longer, whereas activity wash-out was rapid from normal organs, which resulted in much higher tumour-to-tissue ratios.

SPECT/CT imaging

SPECT/CT (Single Photon Emission Computed Tomography / Computed Tomography) is a nuclear medicine imaging technique which combines gamma rays and X-rays. The imaging depicts both the distribution of radioactivity in the body (SPECT) and its anatomic localization (CT). SPECT/CT imaging was performed in mice with PC-3 tumour xenografts 1.5 h after i.v. injection of the radiolabelled BBS analogues. The images corroborated the results obtained in the biodistribution studies. A better delineation of the tumour xenografts was observed with the "click"-glycated analogues, which also showed lower activity at the abdominal area in agreement with their preferential renal excretion (Figure 3).

In conclusion, the insertion of carbohydrates increased the potential of BBS analogues as radiopharmaceuticals for both imaging and therapy of BBS receptor-positive tumours, and "click"-chemistry showed itself to be an elegant method for the glycation of peptides.

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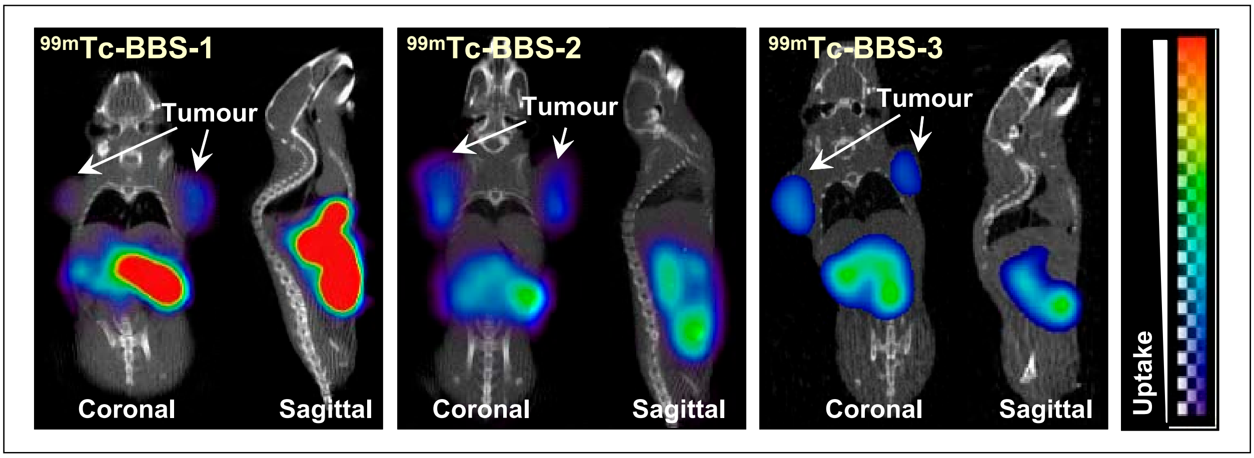

Figure 3: **SPECT/CT images in mice with prostate tumour xenografts (1.5 h p.i.). The glycated analogues BBS-2 and BBS-3 gave better visualisation of the tumours, as well as a much lower accumulation of radioactivity in the abdominal cavity.**

The quest for a perfect optics correction and highest brightness at the Swiss Light Source

Michael Böge, Andreas Lüdeke, Andreas Streun, *Department for Large Research Facilities, PSI*

The storage ring of the Swiss Light Source (SLS) was designed to obtain the highest brightness possible within the constraints of machine size, beam energy and available straight sections for undulators. Imperfections of the tense magnet structure, leading to deterioration of brightness, beam lifetime and injection efficiency, were cured progressively by several beam-based means during the years 2000–2008. These efforts resulted in a world-record low vertical emittance of 2.5 pm rad and excellent agreement of measured beam lifetime with data obtained from simulations, confirming successful beam optics correction.

Brightness, emittance and acceptance

Brightness (photons per time, area at the source and solid angle of the beam) is the key measure of light source performance. High brightness requires small transverse emittances (product of beam size and divergence) of the stored beam.
Horizontal emittance is determined by the layout of the storage ring lattice, i.e. the magnet structure. A small value is obtained by using a large number (SLS: 36) of dipole magnets for the lattice and by providing a horizontal beam focus in all dipole centres by means of strong quadrupole magnets. The quadrupole chromaticity, i.e. the dependency of focusing strength on particle energy, however, is a cause for beam instability and requires compensation by means of sextupole magnets. The non-linear sextupole field, however, leads to a degradation of the lattice acceptance, i.e. its ability to also store particles which deviate from ideal coordinates, due to the onset of chaotic motion beyond some amplitude. In particular, efficient injection into the storage ring requires a large horizontal acceptance, and long beam lifetime requires large energy acceptance, which basically translates to horizontal acceptance for off-energy particles. Thus it became a crucial issue of the SLS design to find an arrangement of sextupoles which minimizes their adverse effects while delivering the indispensable chromaticity compensation [1]. It took several iterations of the lattice layout to simultaneously fulfil the requirements for beam energy (2.4 GeV), number and size of straight sections (6×4 m, 3×7 m, 3×11.5 m), horizontal emittance (5 nm rad) and suitable acceptances (25 mm mrad horizontal, ±3% in energy) within a limited circumference (288 m).
The vertical emittance of an ideal, flat lattice, as given by the quantum emission nature of synchrotron radiation, is very small, ~0.5 pm rad for the SLS, and is usually dominated in a real lattice by two contributions due to imperfections, i.e. magnet misalignments: direct generation of vertical emittance due to spurious vertical dispersion (i.e. vertical orbit excursions due to energy deviations) and transfer of horizontal to vertical emittance due to coupling between the transverse planes.

Acceptance breakdown and recovery

The vertical acceptance in a light source is rather small, due to the narrow gaps of the undulators. In the presence of coupling, particles at large horizontal amplitudes, as they occur in the injection process or due to intrabeam scattering events (Touschek effect), may be deflected vertically and subsequently get lost. Furthermore, any distortion of the sextupole cancellation obtained for the ideal lattice due to asymmetries in the optics will drive additional nonlinear resonances, leading to a direct deterioration of horizontal and energy acceptance.
During the commissioning phase, and later on in parallel with user operation, the lattice imperfections were cured progressively in the following ways:
1. The linear optics is corrected by measurements of the average beta function, i.e. beam size normalized to emittance, in each quadrupole, and subsequent application of individual correction currents to each of the 177 quadrupoles.
2. Transverse displacements between the magnetic centres of the quadrupoles and the centres of the adjacent beam position monitors, i.e. the beam position for zero readings, is measured using the beam itself (beam-based alignment). This allows the beam to be centred in the quadrupoles. Displacements of girders revealed in the process are corrected by careful mechanical realignment utilizing the unique remote girder alignment capability of the SLS [2].

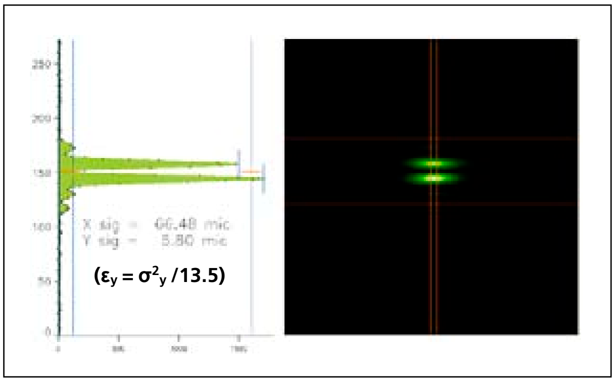

Figure 1: **Vertically polarized synchrotron light image from one of the storage ring dipoles. Beam height σ_y and vertical emittance ε_y are extracted from the "peak to valley" ratio of the image profile [3].**

3. Recent activities employ small skew quadrupole and auxiliary sextupole magnets, installed as additional coils on the main sextupole magnets, to optimize the lattice in the following ways:

Twenty-four skew quadrupoles in dispersion-free regions globally suppress the betatron coupling and are also used to locally compensate coupling introduced by vertical beam excursions in sextupoles, if users require orbit bumps.

Twelve skew quadrupoles in dispersive regions (six installed to date) control the vertical dispersion, and with it the vertical emittance, without introducing coupling.

Twelve auxiliary sextupoles (six installed to date) restore the symmetry of the sextupole patterns, which is not possible with the 120 main sextupoles since they do not have individual power supplies.

The auxiliary sextupole settings are obtained empirically, whereas the skew quadrupoles settings are derived from orbit response measurements with little further empirical adjustment. The ratio of beam lifetime to beam height was chosen as figure of merit for optimization, where lifetime, dominated by the Touschek effect, ideally scales with the beam height and has to be maximized. Beam height, which depends on vertical emittance, has to be minimized for highest brightness. A unique high-resolution monitor developed at the SLS was extensively used to observe the beam size [3]: Figure 1 depicts an image of the vertically polarized light emitted by the storage ring dipole which is used by the monitor.

Performance results

Excellent agreement of measured beam lifetime with data from simulations of the ideal lattice was obtained, as shown in Figure 2, indicating the success of the optics correction.

An injection efficiency of virtually 100% has been achieved, enabling the storage ring to be filled to 400 mA within seven minutes and largely avoiding any radiation background during top-up operation.

An ultralow vertical emittance of 2.5 pm rad has been achieved, just a factor of five away from the ultimate radiation limit set by the quantum nature of the photon emission. The corresponding ratio of vertical to horizontal emittance of 0.05% sets a world record (Figure 1).

In user operation, lifetime may be increased at the expense of vertical emittance or brightness in a controlled way, since the ideal scaling of lifetime with emittance has been largely achieved; for example, 10 hrs of lifetime can be achieved with 7.5 pm rad vertical emittance in 400 mA top-up operation.

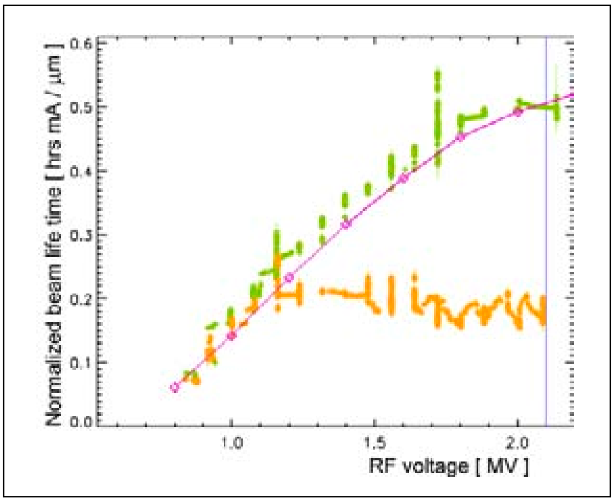

Figure 2: **Measurement of beam lifetime (normalized to beam height and single bunch current) as a function of radio frequency (RF) voltage (which determines the energy acceptance): the green and orange data points were measured with optimum and zero settings of the skew quadrupoles and auxiliary sextupoles, respectively. The purple line is a simulation for the ideal lattice. The blue line marks the RF voltage used in normal operation.**

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Converging missions on cancer treatment at the Center for Proton Therapy (CPT)

Eugen Hug, Beate Timmermann, Eros Pedroni, David Meer, *Center for Proton Therapy, PSI*

2008 marked the first year of continuous patient treatment operation using Gantry 1 at the CPT. The primary mission of providing proton therapy for adults and children with difficult-to-treat tumours is paralleled by a continued commitment to particle research and technical developments, notably Gantry 2 and the next-generation spot-scanning system.

Summary

In 2008, the CPT completed its first full year of continuous patient treatment operation. One hundred and six patients were treated, thereby almost doubling the highest number of patients ever treated per year. Over the entire treatment system, throughout the chain of events from accelerating protons to actual delivery in the patient, availability was exceedingly high, essentially providing patient treatment for more than 97% of the time possible. Sources of patient treatment delay, either scheduled or unscheduled, are depicted in Figure 1. In practice, this meant that there were occasional delays during the day, but very rarely was patient treatment cancelled. This high availability is unprecedented for a prototype and was certainly only achievable due to the remarkable expertise in accelerator physics, beam controls and beam delivery at PSI. The model of integrating technical service, maintenance and system up-grades into the clinical operation without any major shut-downs proved to be manageable by introducing only six long weekends over the course of the year. The reasons for limiting the number of patients treated per day is entirely due to the needs of competing beamtime to complete the OPTIS2 commissioning process and the development and commissioning of Gantry 2. The present clinical programme was continued, with strong emphasis on the treatment of children, while preparing to evaluate new indications, once Gantry 2 becomes operational.

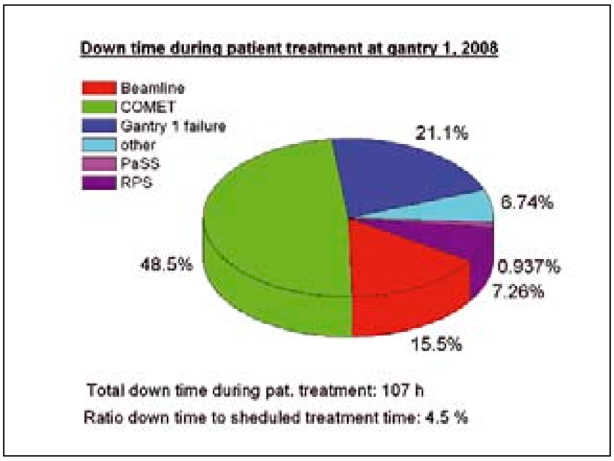

Figure 1: **Downtime during patient treatment at Gantry 1 in 2008.**

Childhood malignancies treated at PSI

After initiating the paediatric project at PSI, over 100 children have so far been treated. Since 2004, the treatment of very young children under deep sedation has also been offered, in cooperation with the children's hospital of the University of Zurich. In addition, the prospective investigation of late effects and quality of life was started in 2004. During 2008, an analysis was performed of all children prospectively investigated at the Institute from 2004 until the end of 2007. Fifty-one children were evaluable for this analysis, with the aim of investigating local tumour control rates and the incidence of acute and late side-effects of treatment. The median age of the children at the time of diagnosis was 2.6 years, ranging from 4 months to 20 years. Twenty-two of these were girls and 29 were boys, sent from 33 hospitals in 8 different countries (Switzerland, Germany, the Netherlands, Denmark, France, the United Kingdom, Spain and Austria). The diagnoses indicated bone or soft-tissue tumours in 24 children, brain tumours in 19 children, chordomas/chondrosarcomas in 5 children, and 3 miscellaneous tumours. The predominant tumour site in 41 children was the head and neck. In 8 children, the tumour was located in the spine, and in 2 in the pelvis. The total median dose of radiation therapy was 54 Gy (range, 45–79.4 Gy). In 46 children, only proton therapy was administered. In 5 children, the radiation therapy was partially given with photon modalities. In 34 children, proton therapy at PSI was administered under deep sedation, reflecting the very young age of the cohort. In 41 children, chemotherapy had been administered before radiotherapy, and in 26 patients chemotherapy was given in parallel to irradiation, in the children's hospital, University of Zurich. In 49 children, only incomplete resection or biopsy was achieved before starting radiotherapy. After median follow-up time of 29.4 months (range, 5–62.3 months), 7 children experienced local recurrence. All local recurrences were found to be located in the high-dose area of the radiotherapy. No systemic dissemination occurred. 44 children (86.3%) are free of disease after proton therapy. Regarding acute side effects, major adverse events (scored according to international standards) were observed only for skin/mucosa (n=5) and bone marrow (n=19) in children having parallel chemotherapy. Regarding late effects, 35 children were evaluable as follow-up time exceeded 6 months. In 5 children, major late effects were observed for skin (n=1), central nervous system (n=1), eye (n=1) or ear (n=2). Quality-of-life analysis data are not yet available. So far, 76 children have entered this study and completed forms on their quality of life status. Early results suggest that, in general, parents consider the status of their child more negative compared with the perception of the child.

Initial commissioning of the Gantry 2 beam line

During the first half of 2008, the beam line on Gantry 2 was completed and the proton beam could be transmitted to the gantry iso-centre. The initial experimental phase was used to demonstrate the new concepts of the system. New and outstanding features are the very fast changes of the beam energy, the parallelism of the 2D scanned beam and the small size of the proton beam, due to a sophisticated nozzle design. The much faster 2D scanning (compared with Gantry 1), with invariant spot shape, is the precondition for delivering the dose with repainting, one of the promising strategies for treating mobile tumours on Gantry 2.

The PROSCAN project – the expansion of the proton therapy facility at PSI – comprises a new treatment station for deep-seated tumours. Gantry 2 is based on long-term experience with a scanned proton beam on Gantry 1. It incorporates many improvements and will be the system for performing further developments of the scanning technique [1]. The mechanical structure of Gantry 2 was finished during 2007 and the beam line was completed during the first half of 2008. First beam at the gantry iso-centre was detected on 9 May. This was the starting point of a new phase of commissioning, to demonstrate the new features of Gantry 2.

Fast energy selection

In contrast to Gantry 1, where the proton beam energy is modulated on the gantry itself, the degrader system in the beam line of PROSCAN is used to set the correct energy for Gantry 2. This has advantages in the design of the nozzle and allows a continuous set of beam energies to be produced. On the other hand, the complete beam line must be set in the shortest time for each new energy. This becomes an even more critical issue in the case of volumetric repainting, where the dose of the complete volume is applied several times. Therefore, beam lines were constructed with laminated magnets, to reduce eddy currents. As shown in Figure 2, typical energy steps corresponding to 5 mm in water can be performed in less than 80 ms.

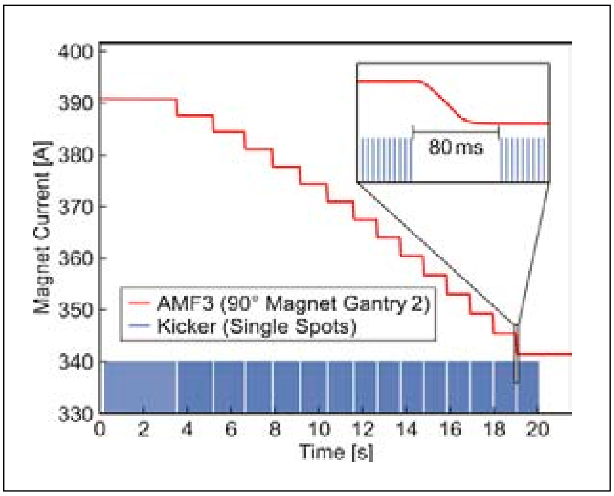

Figure 2: **Sequence of spots with an energy change in between. The currents of the kicker magnet and the 90° bending magnet are shown.**

This time was measured for the 90° bending magnet, which is the slowest, and also the largest, magnet in the beam line. The degrader system has a highly energy-dependent transmission, of the order of two magnitudes, but for precise dose monitoring an energy-independent proton current at the iso-centre is advantageous. The problem cannot be solved with a set of different collimators, since the mechanical switch between different energies would slow down the energy selection. This was solved by introducing additional beam losses for higher energies, which help to equilibrate the proton current. They are controlled by defocusing the beam with quadruple magnets on a fixed collimator. Since these magnets are part of the beam tune, the intensity compensation is solved intrinsically, as shown in Figure 3.
Additionally, an energy parameterization of the beam tunes was found which allows the settings of the complete beam line to be calculated for all possible energies.

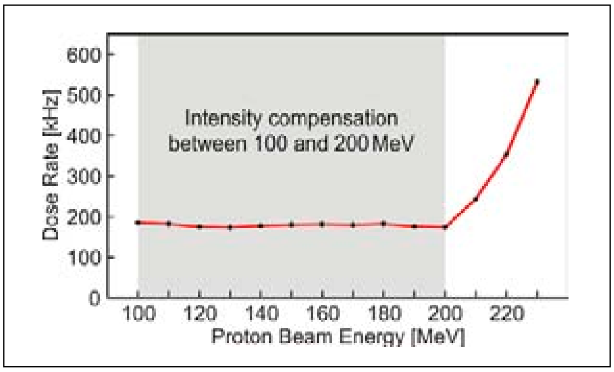

Figure 3: **Energy-independent proton current at iso-centre between 100 MeV and 200 MeV.**

Spot shape and size

An invariant and small proton spot at the iso-centre is of large importance for good quality of treatment planning. Therefore a lot of attention was paid to the design of the beam exit region, the so-called nozzle. Without dose monitors and collision protection, the standard deviation of the Gaussian spot form at iso-centre is about 0.3 cm, as shown in Figure 4.

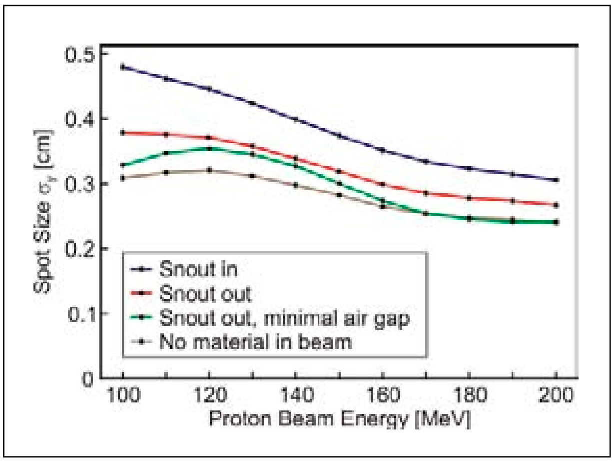

Figure 4: **Influence on the spot size for different nozzle components, measured at the Gantry 2 iso-centre.**

By installing all required material into the nozzle, the beam is broadened due to multiple scattering, especially for low energies. To reduce this effect, the nozzle is designed with a movable snout, containing all affecting material, which can be moved closer to the iso-centre. A further improvement can be achieved if the patient is placed closer to the nozzle. This reduces the air gap, and the spot size approaches the limit of an undisturbed beam.

Gantry 2 is equipped with two sweeper magnets, allowing fast 2D beam scanning. Due to upstream scanning and sophisticated design of the 90° bending magnet, the scanned beam is parallel. It was expected that the spot form would change along the *x* scan axis. To correct for this deformation, a quadruple corrector was installed at the middle of the first doublet on the gantry. With a static corrector value, the spot shape can be optimized for one specific *x* deflection. To achieve the goal of an invariant spot shape in the complete scan region, the quadruple corrector must be changed dynamically with the *x* sweeper magnet. Therefore the corrector magnet was connected in series with the power supply of the *x* sweeper magnet. The resulting spot shapes are shown in Figure 5.

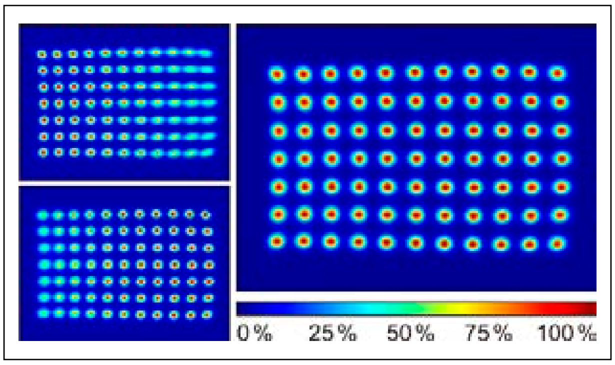

Figure 5: **CCD image of spot arrays (tentative sweeper calibration) with two different static corrections (left) and the action of the dynamic correction (right), for a proton energy of 100 MeV.**

Conclusions

The feasibility of some important concepts of Gantry 2 has been demonstrated and fundamental parameters of the beam delivery system measured. We believe that the new gantry has the necessary potential to become the best performing system in this field. This is a solid basis for further development towards the treatment of moving tumours. The areas which are still awaiting completion are the mechanical system, the finishing of the treatment area, the electronics and the software for patient safety, the steering system for the patient table and the diagnostic equipment for patient positioning. First patient treatment with static tumours is planned for 2010.

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PSI's Annual Press Conference on 6 May 2008. Eros Pedroni, Head of R&D technology at the Center for Proton Radiation Therapy, explains the advantages of Gantry 2, the newest component of PSI's Proton Therapy facility. ▶


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Strategy and highlights of General Energy Research

Alexander Wokaun, *General Energy Research Department, PSI*

The year 2008, the year of PSI's 20th anniversary, was a year of infrastructure and knowledge build-up for future research in General Energy. A process development unit (1 MW) for the production of methane from synthesis gas was completed, so new experience can be gained with this avenue of biomass utilization. Test stands for combustion and hydrothermal gasification have been installed in the new laboratory hall of CCEM. Solar technology and atmospheric research have embarked on several important EU projects, and Electrochemistry laid the groundwork for future avenues in electric mobility, comprising both advanced batteries and fuel cells.

Turmoil in the energy market, concern about a changing global climate, and discussion about the future energy supply for Switzerland have drawn attention to the importance of energy efficiency and renewable energies. The mission of the General Energy Department is responding to these challenges as it targets the generation of low-CO_2 energy carriers from renewables, the efficient provision of energy services, and minimizing material flows from and into the natural environment. Demonstrating their engagement for these issues, researchers from the five Laboratories of the Department have responded to members of the parliament, to interested audiences, and to the general public during the various events of this anniversary year, culminating with the "Open Day" in October 2008.

Energy carriers from renewables

General Energy at PSI is deliberately focusing on the two renewable primary energies of biomass and solar energy, and targeting energy storage in both cases. For solar energy, PSI's specialty is applying concentrated solar irradiation to drive endothermic chemical reactions, thereby producing chemical energy carriers or upgrading low-quality waste streams. For biomass, which represents solar energy stored by photosynthesis, the emphasis is on the production of fuels or electricity, to maximize work rather than heat.

In this context, energy carriers for transportation are of international interest. Which fuels – liquids, gases, or electricity – will be used as oil availability decreases, or as greenhouse gas emission reductions become even more pressing? The project "Transition to hydrogen-based transportation" is taking a comprehensive, unbiased view on the role hydrogen might play in a future transportation system.

Energy and Material Cycles

The project "Methane from Wood" took a big step forward in 2008, with the commissioning and first successful operation of the 1 MW process development unit installed at Güssing, Austria (Figure 1). In the PSI process, raw synthesis gas from the gasifier is converted into methane in a single catalytic step, followed by conditioning to gas grid quality. This development is supported by advanced on-line diagnostic tools for the gasification process.

For waste biomass with high water content, such as agricultural residues or sludges, hydrothermal gasification is being pursued as an alternative route. A Ruthenium catalyst is added to convert organics completely into CH_4 and CO_2, while

Figure 1: **Biomass power plant at Güssing, Austria.**

the nutrients precipitate as the medium is heated above the critical point of water, and can be recycled. For the first time, X-ray absorption spectroscopy at the super-XAS beam-line of the SLS has been successfully applied to look at the catalyst *in situ* under supercritical conditions.

Solar Technology
The solar thermal ZnO/Zn cycle, in which water is split into oxygen and solar hydrogen in two steps, has advanced, and construction and planning are ongoing for a demonstration at the 100 kW scale in 2010. In addition, a variety of novel ideas for high-temperature solar processes is being investigated. In one of these, CO_2 rather than H_2O is reduced by the solar Zn auxiliary medium. Several processes are advancing in which a low-quality feedstock, such as petcoke, is upgraded by solar energy, thereby halving associated CO_2 emissions.

Efficient energy conversion

Efficiency is recognized internationally as one of the most important measures needed to make our energy system more sustainable. The Combustion Research Laboratory devotes itself to efficient, clean combustion of fossil and biogenic fuels. The Electrochemistry Laboratory focuses on advancing efficient electric drive trains in transportation, be they hybrids with internal combustion engines, plug-in hybrids, fuel cell hybrids, or electric vehicles.

New infrastructure created by the CCEM
Several of the projects targeting energy carriers from renewables and their efficient conversion are embedded within the Competence Center Energy and Mobility (CCEM), a joint endeavour of the ETH domain facilitated by PSI. In 2008, important new facilities have been commissioned, in particular a test stand for large (ship) diesel engines (see image on page 71), and a laboratory hall hosting installations for biomass conversion and test stands for combustion research.

Combustion Research
Completion of the CCEM hall enabled the upgrading of two large test rigs for lean premix and catalytic combustion, representing key experimental facilities for research on low-emission gas turbines. This is supported by advanced laser diagnostics and by theoretical modelling, and was presented at the 7th International Workshop on Catalytic Combustion, organized by the Laboratory.
The portfolio further includes important activities in exhaust gas after-treatment, targeting in particular the simultaneous removal of NO_x and particulates from diesel exhausts.

Electrochemistry
The Battery Group is improving high-energy, high-power batteries for electrochemical energy storage by means of novel electrode materials, notably nanoparticulate oxides produced by flame spray pyrolysis.
In fuel cell research, development continues on stable, potentially low-cost polymer electrolyte membranes. Novel simplified stack concepts are being developed in collaboration with an industrial partner, Belenos Clean Power, with the goal of building a fuel cell car operated on hydrogen and oxygen produced by solar energy.
The key for progress in 2008 was the intensive use of *in situ* diagnostic methods, including using the unique analytical capabilities available at PSI's large facilities, such as neutron radiography of operating fuel-cell stacks, microtomography of porous materials, and locally resolved impedance spectroscopy.

Energy, environment and society

The Laboratory of Atmospheric Chemistry has focused on atmospheric particles, their sources, atmospheric transformation, and climatic impact. In particular, the generation of secondary organic aerosol particles from anthropogenic and biogenic precursors is not only of scientific interest, but also of high political relevance for source attribution of particulate air pollution. These activities, including experimentation at the smog chamber, are being pursued within a network of European projects, in several of which PSI is a leading contributor.
Energy system analysis has gained importance in creating scenarios for developing a sustainable energy system, while respecting global climate protection goals. In particular, important contributions have been made to the Energie Trialog Schweiz, in which stakeholders from politics, industry, and academia seek solutions for the Swiss energy system consistent with security of supply, environmental goals, and economic growth.

Outlook for 2009

The activities of the CCEM during the past three years will be evaluated early in 2009, and directions for its future development given. The launching of a major initiative for electromobility is under discussion. In May, PSI will invite major European players to an international conference on 2nd-generation biofuels. The seminal projects of solar fuels, “zero emission” power plants and atmospheric ecosystem quality will be pursued in the context of international consortia.

Hydrothermal gasification of wet biomass – results from SLS

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Laboratory for Energy and Materials Cycles, PSI

Wet biomass (e.g. algae, sewage sludge, manure, food wastes) can contribute significantly to a sustainable energy supply if converted efficiently into synthetic natural gas. PSI is developing a novel process that allows wet biomass to be converted into methane with a net efficiency of 65–70 %. Understanding the key steps of the gasification and methanation is of paramount importance for improving the process. The catalytically active sites involved in the gasification were investigated for the first time by applying in-situ X-ray absorption spectroscopy (XAS) in supercritical water at 25 MPa.

Biomass may be converted into a variety of energy forms, including heat, electricity and mechanical work in the form of traction power. Today, most of the biomass used for energy purposes is combusted to produce electricity and/or heat. Biomass conversion to transportation fuels has been the subject of many studies. Among all options, biogenic synthetic natural gas (Bio-SNG) is particularly attractive because its combustion produces much less atmospheric pollution than fossil fuels. Furthermore, it can be distributed using an existing natural gas grid.

Bio-SNG can be synthesized directly from biomass in water at supercritical conditions (T = 400°C, p = 30 MPa) using a catalyst. This is described in Eqs. 1–3 for the hydrothermal gasification of ethanol, as an example. Ruthenium catalysts have been found to be very active and selective in this process [1,2].

$C_2H_5OH + H_2O \rightarrow CH_4 + CO_2 + 2\ H_2$ (1)

$0.5\ CO_2 + 2\ H_2 \rightarrow 0.5\ CH_4 + H_2O$ (2)

net: $C_2H_5OH \rightarrow 1.5\ CH_4 + 0.5\ CO_2$ (3)

The main advantage of supercritical water gasification over conventional gasification processes is that it allows wet biomass (i.e. manure, crop residues, algae) to be converted efficiently into fuels, since the energy-intensive drying of wet biomass feedstocks is eliminated.

In-situ X-ray absorption spectroscopy

In-situ X-ray absorption spectroscopy (XAS) of a working catalyst was performed, in order to obtain representative information about its active sites responsible for the transformation of organic constituents into the desired product methane [3]. Due to the demanding reaction conditions applied during the supercritical water gasification, a dedicated setup was designed for operation up to 400°C and 25 MPa (Figure 1). The key part of this setup is the sapphire reactor. Sapphire has a high mechanical strength, which is needed to withstand the high pressure, while still showing sufficient transparency for hard X-rays.

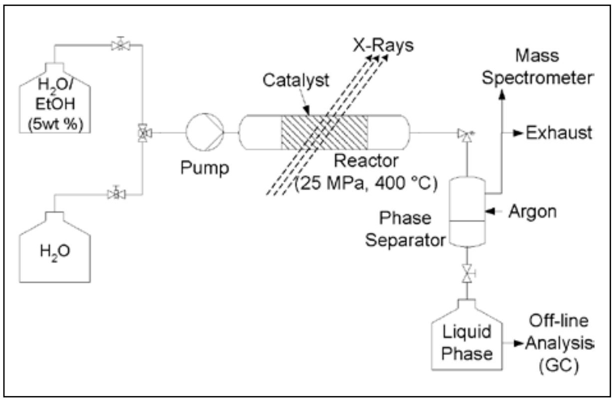

Figure 1: **Schematic of the experimental high-pressure in-situ XAS setup.**

The experiments were conducted with a commercialized ruthenium catalyst (2 wt% Ru on carbon, supplied by Engelhard Corp.). A solution of 5 wt% ethanol in water was used as a simple model feed for wet biomass. Experiments were conducted at the SuperXAS beamline of the Swiss Light Source (SLS), at a total pressure of 25 MPa and temperatures up to 390°C, and spectra were recorded at the Ru K-edge (E_0 = 22118 eV).

Active sites of the ruthenium catalyst

Figure 2 displays ethanol conversion as a function of the reaction temperature. The conversion of ethanol increased sharply above 300°C, and complete conversion was observed at 370°C.

The corresponding in-situ XANES spectra recorded at 25 MPa are shown in Figure 4. For comparison, reference spectra of the fully oxidized and fully reduced catalyst are displayed in Figure 3.

Comparison of the reference spectra (fully oxidized and fully reduced catalyst, Figure 3) with those recorded at different reaction temperatures (Figure 4; 100–250°C and 250–370°C) revealed that a reduction of the catalyst took place between 125°C and 150°C. Metallic ruthenium was formed, as indicated by the appearance of the typical double-peak structure in the XANES spectra. The double-peak structure remained in the spectra at higher temperatures (up to 370°C). The position of the absorption edge did not change. A systematic decrease of the peak intensities with increasing temperature was observed, which was most likely related to surface reactions and/or adsorption of small molecules on the ruthenium surface.

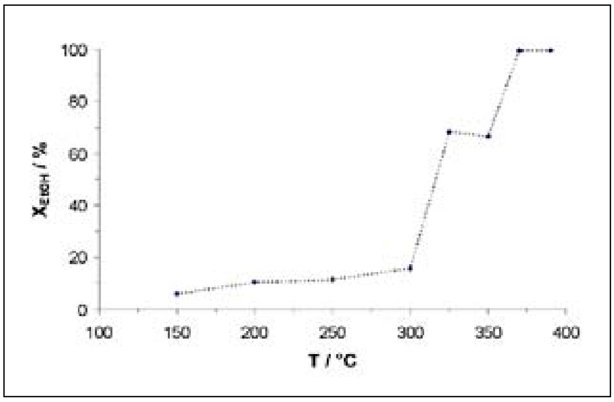

Figure 2: **Ethanol conversion as a function of temperature.**

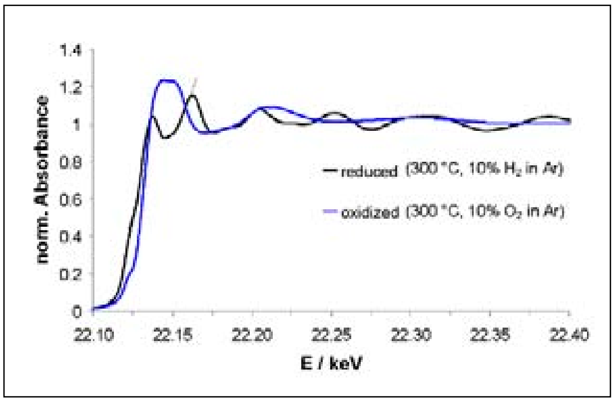

Figure 3: **Reference spectra of the fully reduced and fully oxidized catalyst (2 wt% Ru on carbon).**

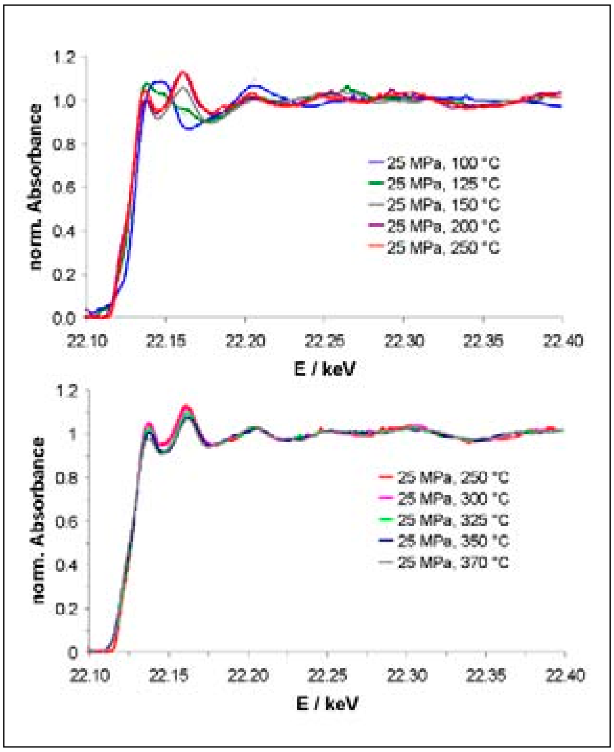

Figure 4: **XANES spectra recorded during the hydrothermal gasification of a 5 wt% ethanol solution at 25 MPa. Top: 100–250°C, bottom: 250–370°C.**

The results obtained clearly indicate that ruthenium metal sites (Ru^0) are catalyzing the hydrothermal gasification of ethanol [3]. These findings do not support the commonly cited reaction mechanism published by Park et al., who proposed a redox-type reaction involving Ru^{II} and Ru^{IV} species [4].

Acknowledgements

We thank E. De Boni and M. Hottiger for their support during the construction of the experimental setup and would also like to thank M. Schubert, T.-B. Truong and J. Müller for their help during the measuring campaign.

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CO_2 splitting via two-step solar thermochemical cycles with redox reactions

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Two-step thermochemical cycles via Zn/ZnO and FeO/Fe_3O_4 redox reactions are being studied to convert CO_2 into renewable fuels using concentrated solar energy. The first, endothermic, solar step is the thermal dissociation of the metal oxide into the metal or a reduced-valence metal oxide and O_2. The second, exothermic, non-solar step is the reaction of the reduced metal/metal oxide with CO_2, yielding CO and/or C, and the initial metal oxide is recycled back to the first step. A Second-Law thermodynamic analysis for the net reaction CO_2 = CO + 0.5 O_2 indicates solar-to-chemical energy conversion efficiencies of up to 39%.

Introduction

Stabilizing atmospheric CO_2 concentration is of major concern today. Considerable effort is currently underway to attain a zero-emission energy production scenario involving the development of more efficient energy systems and renewable energy utilization, as well as CO_2 capture, sequestration and/or utilization. CO_2 capture, either by means of fuel decarbonization prior to combustion, by separation from combustion flue gas, or directly from air, produces a stream of pure CO_2 that is stored long-term or utilized as feedstock for the synthesis of chemical commodities. A promising and sustainable alternative to CO_2 sequestration is the decomposition of CO_2 into C, CO, and O_2. Solid carbon can be safely stored, and both C and CO can be used as combustion fuels or further processed to synthetic liquid fuels for transportation. O_2 is needed for oxy-combustion and gasification technologies. Direct thermal decomposition of CO_2 at atmospheric pressure occurs at ultra-high temperatures, i.e. 30% dissociation is theoretically obtained above 2700 K. Further complication arises from the need to separate the product gases at these high temperatures, in order to avoid recombination.

The operating temperature can be reduced and the separation problem bypassed by making use of thermochemical cycles. Of special interest is the two-step cycle based on metal-oxide redox reactions, shown schematically in Figure 1.

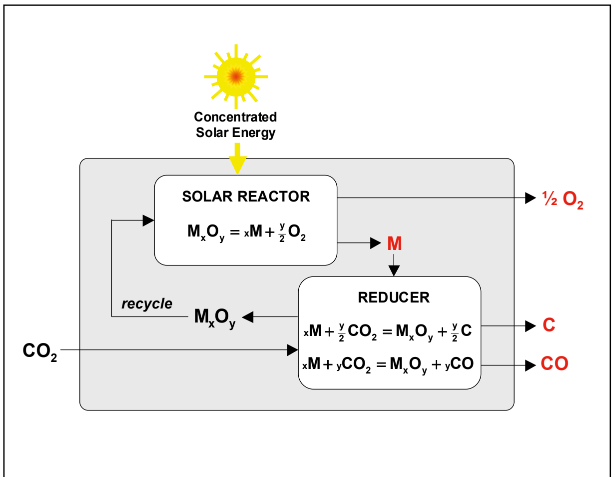

Figure 1: **Scheme of the two-step solar thermochemical cycle for CO_2 reduction via M/M_xO_y redox reactions (M denotes metal).**

Chemical thermodynamic equilibrium

Thermochemical equilibrium calculations for Zn(s) at 1 bar indicate three temperature regimes: below 700 K, C is produced; between 700 and 1000 K, C and CO are produced; and above 1000 K, CO_2 is the only product, which can be reduced to C and CO with Zn(s) at below 1000 and above 700 K, respectively, and with FeO at below 550 K and above 800 K, respectively. In the case of stoichiometric Zn+CO_2 and 3FeO+CO_2 reactions, C(s) formation reaches maxima below 700 K and 300 K, respectively. For all cycles, higher pressures favour the formation of C, according to Le Chatelier's principle. Note that the reduction of CO_2 to C(s) requires double the amount of ZnO or Fe_3O_4 compared with the reduction of CO_2 to CO.

Second-Law analysis

A Second-Law (exergy) analysis has been performed to determine the theoretical maximum energy conversion efficiency of the CO_2-splitting solar thermochemical cycle using the proposed two-step Zn/ZnO and FeO/Fe_3O_4 redox reactions.
A flow diagram for a general CO_2-splitting cycle is shown schematically in Figure 2, composed of a solar reactor, a quench unit, and a CO_2 reducer. Readily available CO_2 is assumed, i.e. after capture. The molar flow rate of CO_2 to the CO_2 reducer is set to 1 mol/s, to produce either CO or C, which implies different molar flow rates of the metal oxide to the solar reactor according to the given reactions. The complete process is assumed to be carried out at steady-state and at a constant pressure of 1 bar. In practice, pressure loss will occur throughout the system and pumping work will be required. Heat exchangers for recovering sensible latent heat are not considered. Additional assumptions are that the solar reactor is a blackbody absorber, all products separate naturally without expending energy, kinetic and potential energies are neglected, and all reactions reach completion. The solar-to-chemical energy conversion efficiency is defined as the portion of solar energy that is converted into chemical energy, given by the Gibbs free energy of the products, i.e. the maximum possible amount of work that can be extracted from the products when transformed back to the reactants at 298 K in a reversible, ideal fuel cell:

$$\eta_{\text{solar-to-chemical}} = \frac{-\dot{n}\Delta G_{products}\big|_{298\,K}}{Q_{solar}} = \frac{W_{FC,ideal}}{Q_{solar}}$$

The baseline parameters are: molar flow rate of CO_2 = 1 mol/s, normal beam solar isolation = 1 kW/m^2, solar flux concentration ratio = 5000 suns, nominal reactor temperature = 2000 K, and ambient temperature = 298 K. For Zn/ZnO cycles, $\eta_{\text{solar-to-chemical}}$ reaches 30% and 39% for C and CO production, respectively. For FeO/Fe_3O_4 cycles, $\eta_{\text{solar-to-chemical}}$ reaches 22% and 29% for C and CO production, respectively. Higher efficiencies for Zn/ZnO than for FeO/Fe_3O_4 are attributed to two factors: 1) the lower enthalpy change of ZnO-dissociation, resulting in 25% lower solar input, and 2) the lower heat capacities (on a molar basis) for Zn and ZnO compared to FeO and Fe_3O_4, resulting in a reduction of heat lost from quenching by a factor of more than 2. Major sources of irreversibility are associated with the re-radiation losses of a solar reactor operating at 2000 K and the quenching of products exiting the solar reactor.
In general, the Second-Law analysis indicates that a favourable aspect of using solar energy at high temperatures is the potential of achieving high solar-to-chemical conversion efficiencies. High efficiencies directly translate to lower solar collection area and associated costs of the heliostat field, which amount to 40–50% of the capital cost for the entire solar CO_2-splitting plant.

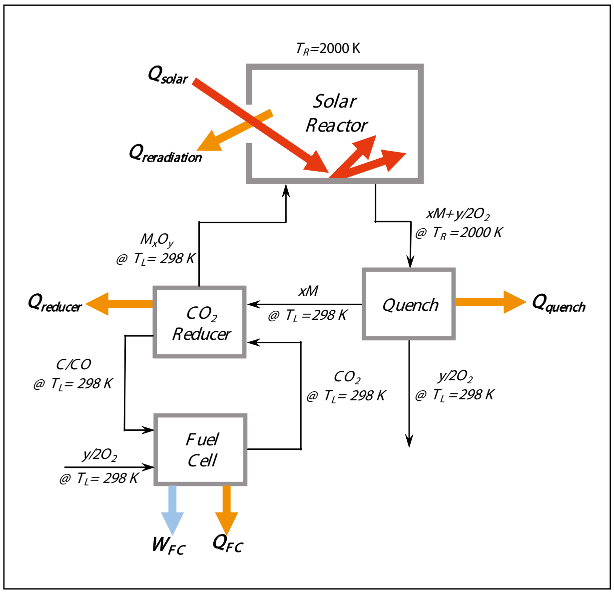

Figure 2: **Model flow diagram of the two-step solar thermochemical cycle for CO_2 reduction applied for the Second-Law analysis.**

Conclusions

Two-step thermochemical cycles for CO_2 splitting via Zn/ZnO and FeO/Fe_3O_4 redox reactions have been thermodynamically examined. The results provide a foundation for pursuing an experimental study for reducing CO_2 with Zn and FeO. Additional measures could be applied in a real system to increase the overall efficiencies that were not considered in these analyses. For example, waste heat may be recovered from the quenching process and from the exothermic $xM+CO_2$ reaction. An in-depth description of the thermodynamics analysis is described in Ref. [1], the reaction kinetics is described in Ref. [2], and the solar reactor technology for thermally reducing ZnO to Zn is described in Ref. [3].

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Combustion reaction dynamics at very different scales

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Combustion processes such as those present in furnaces, heaters, car engines and gas turbines may show certain undesired dynamics: the flame may extinguish or ignite prematurely, or show instationary characteristics which could cause the unnecessarily high emission of pollutants. In order to predict and control these kinetic effects, a detailed understanding of the chemical reactions, the time-dependent flow field and the fuel/air mixing conditions is needed. Projects of the Combustion Research Laboratory address such issues at very different scales, as shown in four examples in this article.

Molecular dynamics of combustion species

Molecular states and energy barrier levels have to be known exactly when assessing reaction processes. Knowing the energy and configuration maps of a single molecule alone is an invaluable contribution to combustion modelling, as dynamical models primarily depend on energy levels and the number of possible states. As the overall progress of a chemical reaction is determined by single discrete rearrangements and the exchange of atoms between two colliding molecules, the kind and state of the resulting species, and the speed at which they form, are strongly dependent on such mechanisms.

Using formaldehyde as an example, the dissociation of molecules along two channels into two possible products was investigated: H + HCO and H_2 + CO. For both channels to proceed, formaldehyde has to be activated to relatively high, and only slightly different, energies (Figure 1). The goal was to understand the underlying mechanisms leading to either molecular or radical products. Currently, an approach to the even more complicated multi-channel dissociation of alkyl peroxy radicals is being made. Better knowledge of the peroxy chemistry in a flame will allow the ignition processes of a flame to be described more accurately than is possible today.

With femtosecond spectroscopy, the intra-molecular energy transfer in formaldehyde was monitored [1], beginning with measurements on the dissociation of di-tert-butylperoxide. Using the experimental facilities at the SLS/VUV beamline, urgently needed data will be added to the peroxy spectroscopy in the domain below 200 nm, in order to obtain highly resolved multi-photon [2] spectroscopic measurements in the laser lab.

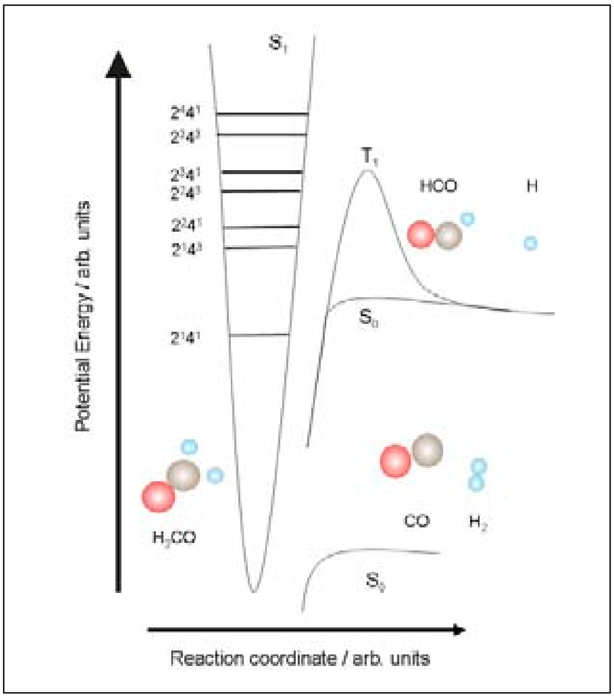

Figure 1: **Energy levels and potential of states of H_2CO relevant for the description of the dissociation reaction channels to H + HCO and H_2 + CO.**

Chemical reactions in micro-scale devices

Flows in complex geometries and with flow regimes of Kn > 0.1 (ratio of mean free path to characteristic geometric dimension), e.g. porous media in catalytic modules and fuel cells, are being investigated by the Lattice Boltzmann (LB) method. A model consistent with kinetic theory that accounts for multi-component, surface-reacting and complex-geometry flows has been established for the first time [3]. This model is able to capture non-trivial microscopic effects, such as velocity slip on rigid boundaries, which depends on the channel dimensions as well as the mixture composition. The model is being applied to transient reacting flow through catalytic pellets (Figure 2). An extension of the current formulation is underway, that will account for flows with temperature and density gradients, e.g. in (partial) oxidation catalysts. The thermal Lattice Boltzmann model [4] will be used as a platform for deriving a new thermal, multicomponent and reacting Lattice Boltzmann model.

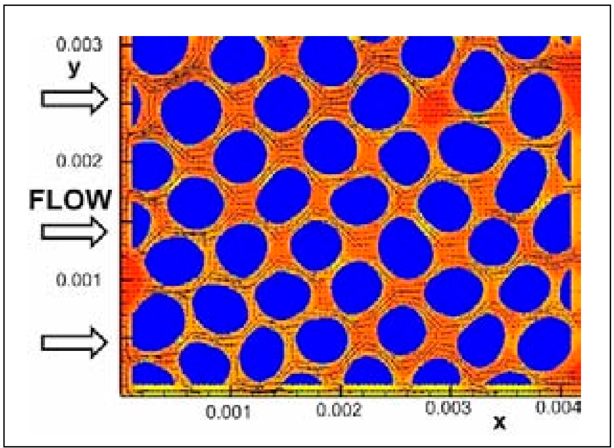

Figure 2: **Catalytic pellet bed reactor (pellets shown in blue). 2D distribution of methane mole fraction (dark red = max. conc.) and flow streamlines.**

Dynamics of flames in meso-scale channel flows

Direct numerical simulation with detailed chemistry and transport is being used to map the dynamics of lean, premixed hydrogen/air flames in planar mesoscale (mm-sized) channels. Different burning modes have been observed, depending on inlet velocity, such as steady and oscillating flames, as well as the chaotic behaviour of cellular flame structures.
Stability maps delineating the regions of different flame types have been constructed showing their dependence on channel

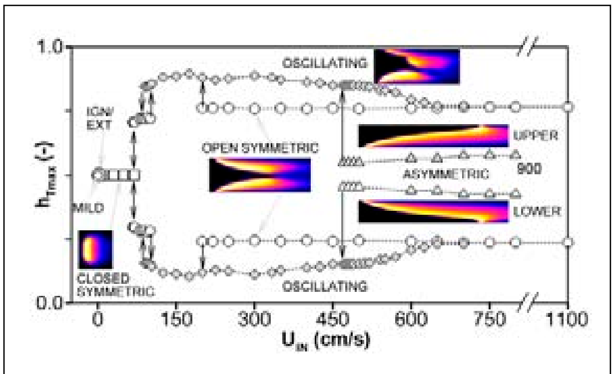

Figure 3: **Flame stability diagram as a function of the inlet velocity (channel height: *h* = 4 mm).**

geometry and inflow conditions [5]. It has also been shown that all intrinsic flame dynamics (Figure 3) can be suppressed by an appropriate catalytic reactivity of the channel walls. Thus, it is possible to eliminate undesirable unsteady combustion modes in practical small-scale combustors by applying a predetermined catalyst loading to the channel walls.

Flame dynamics near the lean extinction limit

Homogeneously mixed, ultra-lean flames are favoured for their low-emission performance in stationary gas turbines. Exploiting this combustion technique to its limit (lean extinction) leads to dynamic extinction/re-ignition behaviour. OH chemiluminescence spectra are indicative of the resulting heat release fluctuations. Power spectra derived from OH-CL data (Figure 4) highlight the dynamic behaviour of lean premixed flames when approaching the lean blow-out limit. While system-specific resonance frequencies (see peaks at around 200 Hz) are observed for "stable" operating conditions, low-frequency pulsations (<10 Hz) dominate at lean blow-out [6].

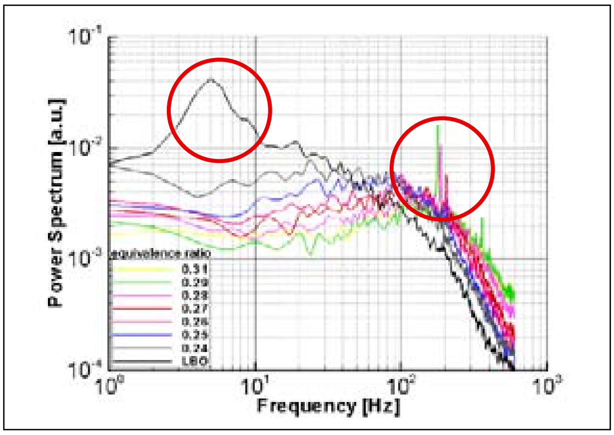

Figure 4: **OH chemiluminescence power spectra for very lean, premixed flames near extinction.**

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Electrochemical research at PSI's large facilities

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PSI's large facilities, the Swiss Synchrotron Light Source (SLS) and the Swiss Neutron Spallation Source (SINQ), offer unique opportunities for the investigation of various questions in the area of electrochemical energy research, ranging from *ex situ* materials characterization to *in situ* monitoring of processes on different length and time scales. In the present article, several examples of research at different beamlines are described. These experiments are aimed at improving energy and power densities of electrochemical devices, such as batteries, supercapacitors, and polymer electrolyte fuel cells.

Examples from the Swiss Light Source

Materials

Fundamental understanding of the interaction of highly porous carbon electrodes with electrolyte ions is of great importance for the optimization of energy storage processes in the electrochemical double layer of supercapacitor electrodes. *In situ* X-ray diffraction (XRD) and small-angle X-ray scattering (SAXS) were performed at the MS and cSAXS beamlines of the SLS, respectively. *In situ* XRD enabled changes in lattice spacing of graphitic materials to be characterized as ions are intercalated. The formation of staged phases was observed for different electrolytes, and the effective size of intercalated ions could be estimated [1]. Experiments with ionic liquids under similar conditions indicate that staging is hindered in these electrolytes, demonstrating that the presence of solvent molecules can have a significant effect on the intercalation mechanism. For the first time, activated carbons for supercapacitors were investigated by *in situ* SAXS during electrochemical charging (see Figure 1). Changes in the scattered intensity were observed, predominantly on the length scale of the microporosity (< 2 nm) of the activated carbon, implying a change in composition of the electrolyte within the pores (double-layer charging) and indicating that dimensional changes on these length scales are likely to occur.

Structural changes accompanied frequently with oxygen evolution are among the major failure mechanisms of positive electrode materials used in lithium-ion batteries [2]. The combined use of *in situ* X-ray synchrotron powder diffraction (Figure 2), *ex situ* X-ray powder diffraction, and *in situ* neutron diffraction is efficient when studying ageing effects of materials in lithium-ion batteries. The goal is understanding the long-term reversibility characteristics of, e.g., $Li_{1.1}(Ni_{1/3}Mn_{1/3}Co_{1/3})_{0.9}O_2$ by investigating the phase transitions the material might undergo when subjected to high potential (> 4.5 V vs. Li^+/Li). The changes in the crystal structure after first cycle charge, extended galvanostatic cycling, and potentiostatic stresses were examined by X-ray powder diffraction. It was found that $Li_{1.1}(Ni_{1/3}Mn_{1/3}Co_{1/3})_{0.9}O_2$ did not undergo any phase transition when deeply delithiated, because of a lithium-nickel exchange degree of about 4% in the present sample.

The latter property is believed to be the reason for improved structural stability as nickel ions present in the interslab space keep the $(MO_6)_n$ slabs in place, thus preventing the O3 phase

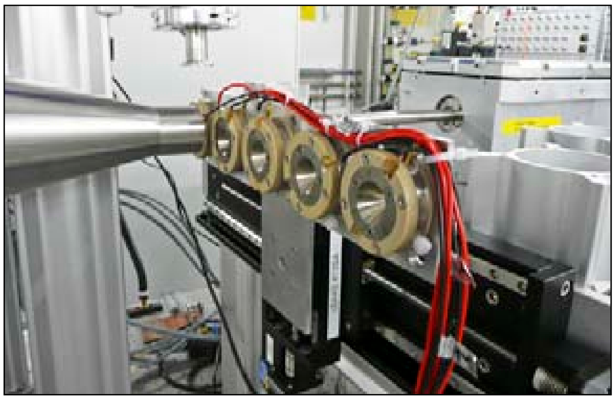

Figure 1: **Cell array for *in situ* small-angle X-ray scattering experiments on carbons during electrochemical experiments.**

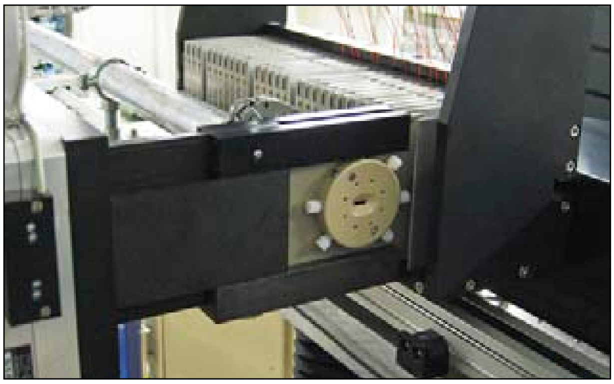

Figure 2: **Sample changer developed at PSI for the MS beamline of the SLS.**

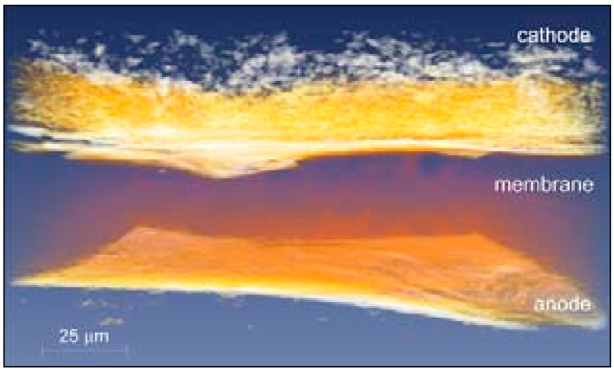

Figure 3: **X-ray micro-tomogram of platinum-polymer membrane interfaces in a polymer electrolyte fuel cell (PEFC). Anode platinum loading 50 µg/cm².**

from converting into the O1 phase. The $Li_{1.1}(Ni_{1/3}Mn_{1/3}Co_{1/3})_{0.9}O_2$ material class is therefore a good candidate as a low cobalt electroactive oxide suitable for high-potential window operation.

Ex situ X-ray micro-tomography at the Tomcat beamline allows the bulk material and interfaces in complex structures to be visualized (Figure 3), e.g. in components of polymer electrolyte fuel cells (PEFCs) [3]. Ultrathin platinum layers serving as electrocatalysts can be displayed down to a typical loading of 25 µg/cm². Hence, this technique offers the chance of visuallizing post-mortem morphological changes occurring in these layers during different operating conditions, e.g. steady-state, potential or relative humidity cycling.

Processes

In the case of PEFCs, a detailed and fundamental understanding of the transport processes – in particular in the microporous gas diffusion layer (GDL) – is important, because these processes contribute to polarization losses and degradation. Research is focused on the role of liquid water in the porous structure. At a given energy (10–40 keV), X-rays are attenuated by both carbon and water. Thus, X-ray micro-tomography allows the micro-porous structure of the carbon-fibre-based GDL materials to be determined simultaneously with the distribution of liquid water contained in parts of the void [4] – with a resolution of 1 µm at the Tomcat beamline. Figure 4 shows a 3-dimensional view of a GDL filled with water from the bottom. “Fingering” of water through the path with largest connecting pores is observed.

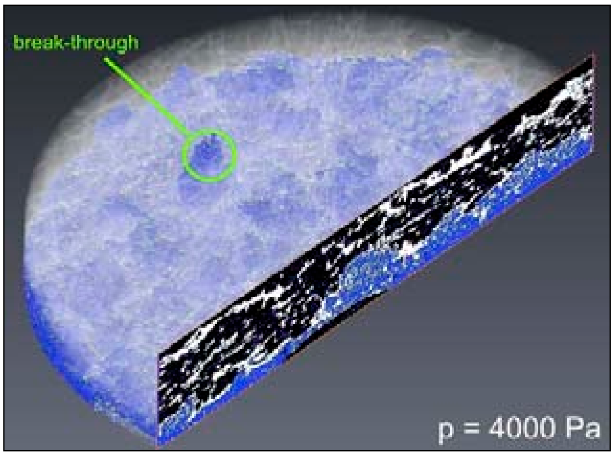

Figure 4: **X-ray micro-tomogram of a gas diffusion layer partially filled with water (blue: water; white: solid phase of GDL; black: void).**

Example from SINQ

Earlier successful work on Neutron Imaging at SINQ was continued and extended to novel aspects of liquid water visualization in PEFCs. Optimizations in the detector system allowed exposure times of less than 10 s to be achieved, while keeping the high spatial resolution required for observing the different layers of a GDL. This opens the way to *in situ* studies of water accumulation and removal dynamics. Additionally, advantage was taken of the isotopic sensitivity of neutrons for *in situ* study of exchange processes at fuel cell electrodes, by labelling either the fuel or external water humidification with heavy hydrogen atoms (^2H) [5].

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Competence Center Energy and Mobility CCEM – infrastructure in place to foster research projects

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In the third year of operation of the Competence Center Energy and Mobility CCEM, several infrastructural investments have been realized, which now offer important opportunities to the research community. In the fields of *Heat and Buildings, Electricity, Mobility,* and *Renewable Fuels,* the networks among the involved groups started to generate fruitful benefits. The first joint Master's programme between ETH Zurich and EPFL, Lausanne has started and is in its initial year. The interdisciplinary approach has clearly increased the exchange and collaboration beyond the borders of the separate institutions.

In 2008, the Competence Center Energy and Mobility CCEM complemented its project portfolio. The scope of this was fully covered by available funds, which in the reporting period of expansion were lower than in years before.
The flexibility of CCEM's structure, which refrained from creating strict boundaries between the research fields as proposed in the business-plan (technologies for mobility, electricity production, and heat and buildings) has proved itself to be very powerful. In the meantime, a cross-cutting field (the generation of fuels based on renewable primary energies) has emerged which is linked to almost all the other fields. Interactions are quite easy to establish and are very effective.
In 2008, several of the infrastructure enhancements were completed, and now offer additional opportunities for interested research groups. Examples include the new experimental hall and the large-engine research facility at PSI, the engine test-bench at ETH Zurich and the test-stand at EMPA, all of which are now in operation.
In 2008, CCEM succeeded in strengthening its relations with the Universities of Applied Sciences (UAS). To date, the Fachhochschule Nordwestschweiz, Fachhochschule Zentralschweiz, Zürcher Hochschule für Angewandte Wissenschaft, and Berner Fachhochschule have signed agreements of common understanding, which secure, at least partially, the funding of participating research groups of the UAS.
From PSI's internal perspective, activities are well connected with the research activities of the departments of General Energy Research and Nuclear Energy and Safety. The new experimental hall has opened new opportunities within CCEM projects, as well as outside the Center.

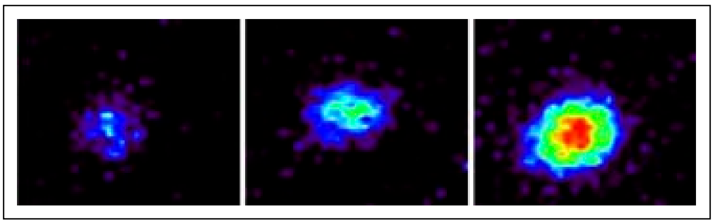

Figure 1: **Scanning transmission X-ray images of a soot particle 200 nm in diameter at 30, 52 and 88% relative humidity, taken in the environmental cell of the POLLUX microscope at the SLS. The pictures were taken at 538 eV, where oxygen absorbs due to a resonant transition. The particle stemmed from a diesel passenger car and was exposed to photo-oxidation for several hours in a smog chamber. The absorption is direct and in situ evidence of the increasing amount of water absorbed by the soot particle with increasing humidity.**

Results of collaborative projects

An educational project, the first joint Master's course between ETH Zurich and EPFL, Lausanne, was started in 2008 with 12 students: Both schools and PSI are collaborating in the 'Master's programme of Nuclear Engineering' supported by CCEM, and large interest has been shown in the second term of this course.

In the field of *electricity,* the platform for high-temperature materials (PHiTEM) has seen the investigation of advanced high-temperature materials with the support of a new nano-indentation device and the FIB multiscale characterization tool. These tests included irradiated, i.e. radioactive, samples. The project is described in more detail in a dedicated article within this scientific report (see page 80).

In the NEADS (Next Generation Exhaust gas After-treatment for Diesel Systems), new SCR catalyst materials are being investigated in order to achieve high reactivity and conversion with low exhaust gas temperature. In addition, a ceramic-foam-based substrate is under development to replace the conventional diesel oxidation catalyst, improving the performance and lifetime of the subsequent after-treatment system (particulate filter and/or SCR system). This project is organised in three sub-projects: Sub-project I develops zeolite-based catalytic materials; Sub-project II concerns the development of the micro reactor; while Sub-project III investigates emission formation and reduction paths from the combustion through the after-treatment systems. The sub-projects in turn make use of tools and knowledge developed and acquired in the three tasks "new instrumentation for particle characterisation", "numerical simulation" and "atmospheric interactions".

One particular tool is the use of X-ray transmission microspectroscopy for imaging phase-separated nanostructured organic material, to obtain a microscopic picture of soot particle properties at the nanoscale. After having designed, constructed and tested a novel environmental cell at the X-ray scanning transmission microscope (POLLUX) at the Swiss Light Source (SLS) at PSI, the tool was used to investigate the morphology, chemical composition and water uptake of diesel soot particles.

Samples were taken from a smog chamber into which diesel soot from a EURO III diesel passenger car had been injected. In a first experiment, particles were studied as they underwent photochemical aging in the smog chamber. The main result was a unique spatially resolved picture of how water interacts with soot particles (see Figure 1). Detailed spectral analysis at the O K-edge allows water strongly bound to hydrophilic functional groups at low humidity to be differentiated from capillary water at high humidity.

The results and activities of other projects, covering the fields of mobility, electricity, heat and buildings, as well as fuels from renewable primary energy sources, can be found in [1] .

New facilities available

A range of new infrastructure became available during 2008. After the indentation devices and focussed ion beam that are already being intensively used this year, the test stand at ETH Zurich was commissioned, with a single-cylinder engine for specific research on combustion and emissions from new fuels and injection strategies.

At EMPA, the construction of a dynamic test bench for large Diesel engines has made good progress and will be inaugurated in 2009.

Figure 2: **Panoramic view of the 1.2 MW 6-cylinder engine at the Large-Engine Test Facility.**

At PSI, two facilities have started operation. In the new multipurpose experimental hall, experiments in the fields of combustion research and the conversion of various types of biomass into gaseous fuels are installed, and the second installation, the Large-Engine Research Facility LERF (Figure 2), was inaugurated in November 2008. Experiments to reduce NO_x, without sacrificing the already good efficiency of large, low-to-medium-speed diesel engines used in ships, will be performed in the years to come.

Interaction with society

In 2008, it was decided by the ETH Board to bring the outreach activities of the Novatlantis project and CCEM together, starting in 2009. In the process of the "Energie Trialog Schweiz", an initiative to explore a road map for the future Swiss energy system, CCEM provided various inputs and studies to back up the formulation of a sound energy strategy. This initiative aims at promoting mutual understanding between society, economy and science.

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The Nuclear Energy and Safety Department and the safe and sustainable use of nuclear energy

Jean-Marc Cavedon, *Nuclear Energy and Safety Department, PSI*

Nuclear energy is an integral part of not only the Swiss but also the global sustainable energy mix, and as such is an important component of PSI's energy research portfolio. The scientific and technical challenges of further enhancing the safety and cost-effectiveness of nuclear electricity production, and at the same time decreasing the associated risks, can be very effectively influenced by the work at PSI. The PSI campus brings together a rare blend of highly qualified physicists, chemists and solid-state scientists, large- and medium-scale experimental facilities of world class, and internationally recognized engineers in all the key disciplines of energy production. Highlights of the scientific and technical contributions made during 2008 in this stimulating environment constitute the sections which follow.

The debate over the benefits and risks of nuclear energy has certainly not ended, but it can be seen in the international press that the tide of opinion is changing. The turbulence in the oil and gas markets, and the now obvious need to restrict the emission of greenhouse gases, compel today's governments to look with new eyes at their nuclear options. A growing number of European governments are starting to invigorate their civilian nuclear programmes, and present them as the most pragmatic option for fighting greenhouse gas emissions. Sweden and Italy are the most spectacular examples as their governments have very recently announced a phase-out of the previous nuclear phase-out policy.

In Switzerland too, nuclear energy is making the headlines. During 2008, three requests for general site permits for nuclear power plants have been submitted: for Beznau, Mühleberg and Niederamt. In addition, the national nuclear waste cooperative, Nagra, has disclosed six potential sites for underground waste repositories.

For us researchers, geared towards the safe and sustainable use of nuclear energy, this confirms our basic conviction: that nuclear electricity generation is an asset to life in Switzerland today, and will remain one tomorrow. Our goal is to integrate nuclear energy in the sustainable energy mix even more comprehensively.

Strategic collaborations and tools

The Nuclear Energy and Safety Department (NES) is an active partner in the overall Swiss energy scene. It is NES's duty on the national level to deliver objective judgments and rational methods to the stakeholders involved in the decision-making processes. The Department is also strongly embedded in the international nuclear energy research community, where it collaborates formally or informally with its contemporaries in other countries. Examples of this engagement are, for example, its active presence in the EU-based Sustainable Nuclear Energy Technology Platform; its formal engagement in support of the VHTR and GFR systems within the Generation IV International Forum; and its membership in the numerous working groups and committees of the IAEA and the OECD Nuclear Energy Agency.

Last but not least, NES is fully integrated in PSI's research portfolio. For example, the use of the large facilities at PSI for addressing basic though far-reaching problems regarding the structure of matter is combined with application to practical, present-day issues, such as the sorption mechanism of radionuclides on specific clays or cements, and the ageing process of the metals used in current reactors. The state-of-the-art analytical, experimental and computer-supported tools available at PSI are an asset to the technologies of today, and will serve future applications in the decades to come.

Fundamental and applied research

In nuclear research, the focus on practical applications can be seen in NES's involvement in the safety and operational issues relevant to present-day operating plants (Generation II), as well as its drive to a deeper understanding of plants offering even higher safety and reliability standards, such as those (Generation III plants) now being constructed worldwide, and also envisaged for Switzerland. The development of the next generation of nuclear plants, for which increased sustainability is a central issue, is NES's contribution to the long-term nuclear perspective. Furthermore, it is participating in the advancement of Generation IV designs, which aim to maintain the advantages of safety and cost-effectiveness of today's plants, while decreasing dramatically the consumption of the planet's fissile resources and recycling a significant share of the radioactive waste.

Six laboratories and a common strategy

NES's portfolio concentrates on selected topics of nuclear science and technology and is organised in six units. The Laboratory of Reactor Systems (LRS) focuses on the high-fidelity numerical simulation of nuclear reactor systems under normal operational conditions, and their transition to abnormal situations. As a counterpoint, an experimental platform on reactor physics is maintained, providing hands-on experience of neutronic behaviour for various reactor concepts. LRS is also involved in developing better understanding of advanced reactor cores operating with fast neutrons.

The Laboratory for Thermal Hydraulics (LTH) addresses the reactor cooling issues. For Generation II reactors, the coolant is water at high pressure and temperature. Both single- and two-phase flows are studied, the latter including mixtures containing water and steam bubbles, and steam with water droplets, and the related heat transfer phenomena. The long-term goal of the research is to link instrumentation of high spatial and time resolution with solutions of the basic equations of fluid motion, not only for water-cooled reactors, but for the variety of coolants which feature in future design concepts, such as gases, liquid-metals and (possibly) molten salt.

Materials, either in the form of oxide or ceramic fuels, or as metallic structural components, determine both the reliability and lifetimes of nuclear reactors, and thereby their overall economic viability. Material behaviour also determines the ultimate operational limits for reactors. The Laboratory for Nuclear Materials (LNM) has a long tradition in the study of nuclear fuels, and in the ageing of structural components under the hostile conditions that exist over decades in a nuclear power plant. With an eye to the future, LNM has recently developed experimental and modelling skills in advanced ceramics and metals for high-temperature environments.

Examination of materials following irradiation is the main focus of the Hot Laboratory at PSI. The Hot Lab (AHL) serves the users of the PSI irradiation facilities, both in regard to their industrial operational needs and in the context of advanced materials research. Dedicated measurement points for the safe handling of radioactive samples are also installed in other large, less-specific facilities at PSI, such as SINQ and SLS.

Nuclear reactions produce fission products as waste, but with an associated risk of radioactive contamination of the biosphere. The Laboratory for Nuclear Waste (LES) investigates the retention capabilities of certain geological layers to isolate the waste from the biosphere over the long time periods commensurate with the longest decay times of the radionuclides present: that is, from tens of thousands to millions of years.

The responsibility of the Laboratory of Energy Systems Analysis (LEA), which is common to both Energy Departments at PSI, is to offer a global perspective over all sustainable energy technologies of interest to Switzerland. The technologies are considered over their entire life-cycles, including their ecological, economic and social implications.

Highlights

The following pages present a selection of highlights of the activities of NES during the past year. The articles aim to give a representative view of the variety of tasks needed to further the understanding of nuclear reactors, both present and future, and of the nuclear fuel cycle.

Coupling classical thermal hydraulics with computational fluid dynamics for nuclear reactor systems

Davide Bertolotto, Annalisa Manera, Rakesh Chawla, *Laboratory for Reactor Physics and Systems Behaviour, PSI*; Simon Frey, Horst-Michael Prasser, *Laboratory for Thermal Hydraulics, PSI*

The use of computational fluid dynamics (CFD) codes to address nuclear safety issues and to improve the accuracy of nuclear system transient analysis has grown significantly in recent years. However, the large computational costs involved in a CFD simulation limit its use to local areas of the nuclear plant system. As a consequence, best-estimate 1-D thermal-hydraulics codes still represent the main workhorse for system analysis. PSI's STARS project is developing a tool capable of performing detailed CFD component analyses, while retaining the full feedback from, and to, the plant 1-D simulation through coupling with a system code.

Introduction

As part of the safety assessment and licensing procedure for nuclear power plants (NPPs), a wide range of analyses are carried out using best-estimate codes. These have been developed and validated to analyze system response during a wide variety of accident scenarios and transients. In these codes, the conservation equations (mass, momentum and energy) that describe the two-phase flow and the heat transfer are usually based on 1-D approximations. The thermal-hydraulics modelling employs an appropriate set of correlations and physical models (closure relationships). The model for a specific nuclear power plant is then built up by connecting 1-D modular components (pipes, tees, pumps, valves, etc.).

There are, however, certain accident scenarios foreseen for NPPs in which strong asymmetries exist in the properties (e.g. boron concentration or temperature) of the coolant entering the reactor pressure vessel (RPV). These asymmetries depend largely on the coolant mixing taking place in the downcomer and in the lower plenum of the RPV. Such mixing phenomena are strongly 3-D and are influenced by turbulence, so that 1-D approximations are unsuitable for this class of problem.

On the other hand, in the context of single-phase mixing applications, CFD codes have reached a satisfactory level of maturity to be able to provide a complementary capability to system codes for accurately dealing with multidimensional flows. The coupling of system codes and CFD is therefore a logical step for nuclear safety applications, especially when applied to the analysis of transients in which 3-D flows play an important role in the evolution of a given accident scenario.

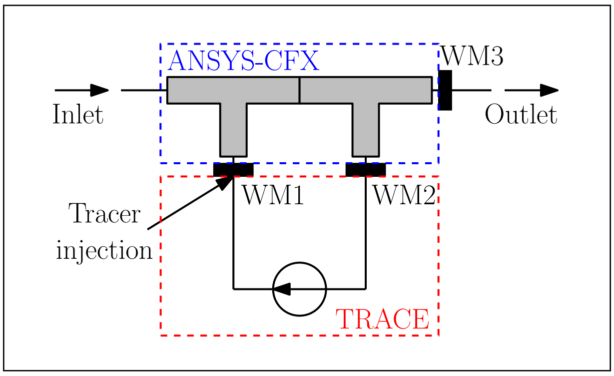

Figure 1: **Simplified scheme of the double T-junction experiment.**

Coupling

A coupling [1] has been developed between the US NRC (Nuclear Regulatory Commission) best-estimate system code TRACE and the commercial CFD code ANSYS-CFX. The PVM (Parallel Virtual Machines) environment has been used to manage the information traffic between the two codes.

Exchange of variables occurs at the boundary elements of each code. The conversion from 1-D to 3-D boundaries is crucial, since additional information on the flow is required (e.g. inlet velocity profile, which is not necessary in 1-D approximations). Another critical point is the numerical stability of the coupling, since it is developed following an explicit or semi-implicit scheme. This limits the choice of the temporal and spatial discretization adopted.

The currently implemented coupling has been verified, firstly against simple numerical tests, and then against an experiment involving 3-D mixing effects.

Double T-junction experiment

The experimental set-up used consisted of two loops connected by means of a double T-junction, with a recirculation loop connecting the two branches (Figure 1). The operating fluid was tap water and the mass flow ratio between inlet and recirculated mass flow rates was 1:1. The loop was instrumented with three wire-mesh sensors [2] to measure the cross-sectional distribution of a tracer, injected at the location WM1 indicated in Figure 1. During the transient, the tracer was partially recirculated (to location WM2) and partially ejected (WM3) from the system at each recirculation, until it was completely expelled from the facility. For the coupling involved in the simulation, the double T-junction was modelled with CFX, while the recirculation loop was modelled with TRACE.

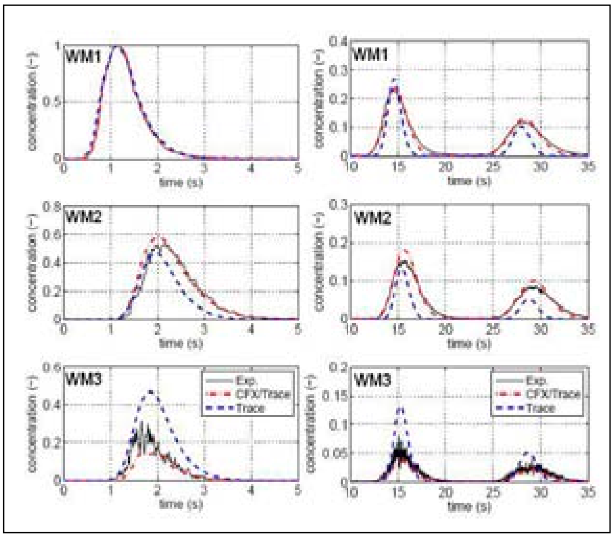

Figure 3: **Comparison of the experimental data with TRACE and coupled TRACE/CFX simulation results at each wire-mesh sensor location; injection and first splitting (left), first and second recirculations (right).**

Results

The velocity field inside the double T-junction is strongly multidimensional (Figure 2), and therefore a TRACE simulation alone cannot capture the correct amount of tracer which is recirculated in the side loop (a 1-D code will partition the tracer according to the mass flow ratio between the junctions themselves). A clear improvement of the computational results was obtained when the coupled tool CFX-TRACE was employed (Figure 3), with some small discrepancies due to the unstable velocity field in the proximity of the outlet boundary WM3. Parametric studies have shown a clear influence of the inlet velocity profile on the simulation results [1]. In the currently presented results, a fully developed turbulent profile has been used, since this is representative of the actual experimental conditions.

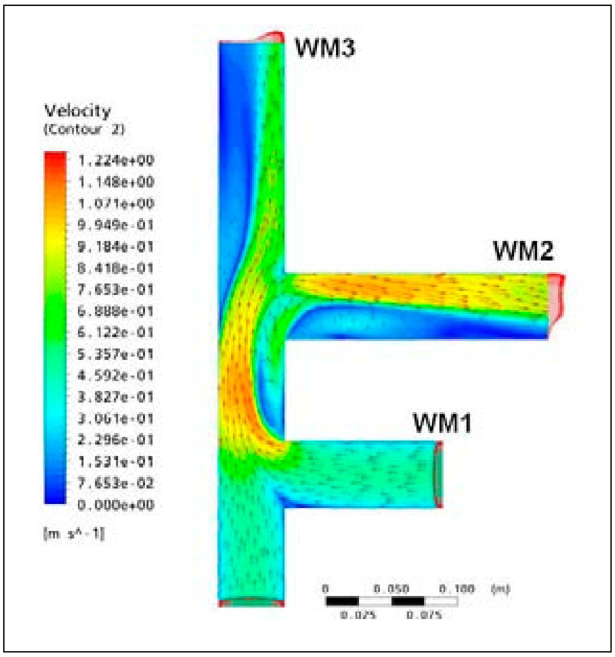

Figure 2: **Velocity field developed in the double T-junction, computed with CFX.**

Conclusions

A coupling between the 1-D system code TRACE and the CFD code ANSYS-CFX has been developed and verified. A first validation experiment, in which 3-D effects in the flow are important, has been carried out and comparison between experimental and simulation results indicate definite advantages of the coupled tool, relative to the use of a stand-alone system code.

References

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Water mixing studies on the way to predict thermal loads relevant for plant lifetime

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As nuclear plants age and as it is generally desirable to extend their life-times, the issue of fatigue associated with cyclic thermal loads becomes increasingly important. Cyclic thermal loads can occur in different parts of a plant and are invariantly associated with mixing of streams at different temperatures occurring at characteristic frequency and over a sufficient number of cycles. A prominent example of such a mixing occurs in T-junctions where hot and cold streams are not yet completely mixed. Here we report on activities within the Laboratory for Thermal Hydraulics aimed at developing methods to measure and predict these phenomena.

In T-junctions, particularly in the regions where hot and cold streams are not completely mixed, significant temperature fluctuations can occur near the walls. Such fluctuations may induce cyclic thermal stresses in the walls and may eventually lead to fatigue cracking. These problems were first considered in the context of Liquid-Metal Fast Breeder Reactors (LMFBRs) in the 1980s. Although the problem is particularly pronounced in a liquid-metal reactor, due to the high thermal conductivity of the liquid-metal coolant, thermal striping is an issue in Light Water Reactors (LWRs) as well. A few instances of high-cycle fatigue have been observed in T-junctions, such as the one at Civaux 1 [1]. Recent research activity in this area includes the experiments and benchmarks undertaken by Vattenfall and the comprehensive, European 5th Framework Program THERFAT. Present research is undertaken as a part of the Plant Life Management (PLiM) project in Switzerland.

Experiments

The high cyclic nature of these phenomena makes them difficult to monitor with conventional thermocouple instrumentation, due to the limited sensor response time. Yet reliable prediction of thermal fatigue loads is an important part of managing the risk. The temperature fluctuations at frequencies up to several Hz caused by the turbulent thermal mixing, present the highest risk of wall thermal fatigue. Significantly higher frequencies than these appear not to pose a risk, as they are strongly attenuated by the thermal inertia of the pipe wall. Using the analogy between turbulent mass and thermal transport and mixing, isothermal experiments have been performed using regular tap water and demineralised water. The setup consists of a horizontal T-junction geometry of Plexiglas pipes of 50 mm inner diameter. Regular tap water flows in the longer pipe (1.5 m) and demineralised water in the shorter, branch pipe (0.5 m).

A photograph of the test section is given in Figure 1. The two streams join and mix at and after the T-junction, and the mixture is drained through a flexible hose shown on the right side (green). Close to the inlets of both pipes, honeycombs are placed to straighten the flow. Both pipes are sufficiently long to ensure a developed flow profile as the fluids arrive at the T-junction, giving well-defined boundary conditions for the CFD simulations. In the arrangement used in this work, the instrumentation consists of two wire-mesh sensors (WMS) placed one behind the other, 51 mm downstream of the junction. The wire-mesh sensors used for this study have 16×16 wires constituting a grid of 236 measurement points (from the 256 combinations, a few points are missing in the corners due to the circular pipe geometry). The pitch of the measurement grid, which also defines the spatial resolution of the measurements, is 3 mm. The time resolution of the measurement is 600 frames per second.

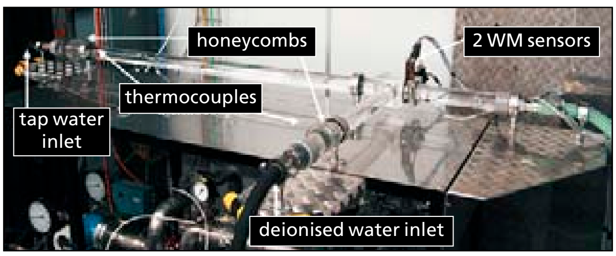

Figure 1: **T-junction test section.**

Calculations

The calculations presented here were based on the Large Eddy Simulation (LES) approach and were carried out using the FLUENT 6.3 commercial CFD package. Previous studies [2,3] on mixing showed the higher suitability of LES with respect to Reynolds-Averaged Navier-Stokes (RANS) and Scale-Adaptive Simulation (SAS) of turbulence. As a drawback, LES is an order of magnitude more expensive than SAS and two orders of magnitude more expensive than RANS [3].

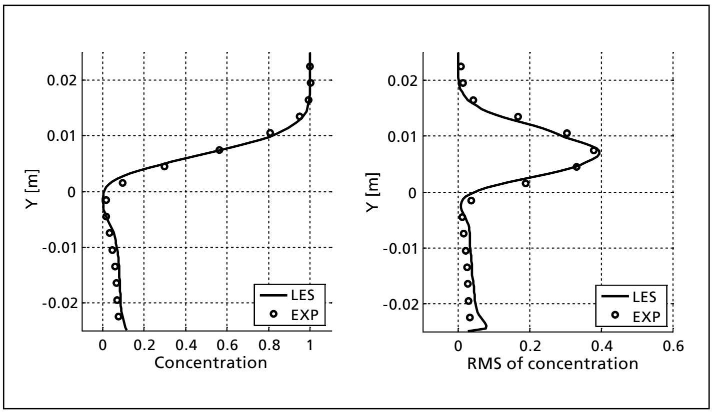

Figure 4: **Conductivity (left) and its RMS (right) in the midline of the measuring planes at *x/D* = 1.0.**

Results

Figure 2 shows a comparison of the conductivity distribution in the pipe cross-section at $x/D = 1$ distance downstream of the T. Apparently, LES is able to qualitatively predict conductivity distribution very well.

At $x/D = 1.0$, the high conductivity region has quite similar half-moon shape for both WMS and LES. The most obvious difference is a slight anti-clockwise tilt visible in the experiments, which is due to the buoyancy of the side flow, but not accounted for by LES. The recirculation region (blue in Figure 2) is also well predicted by LES. Recirculation transports tap water back to the measurement plane, thus leading to a slight increase in conductivity. Distribution of RMS of conductivity at $x/D = 1.0$ is shown in Figure 3. As with conductivity distributions, LES predicts its RMS very accurately.

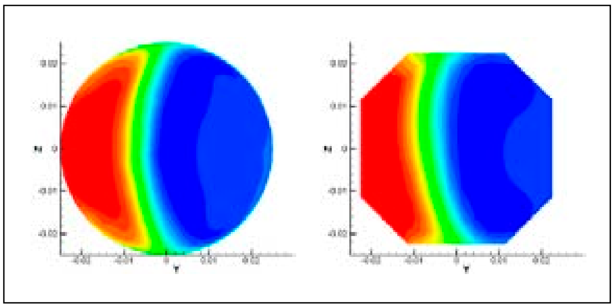

Figure 2: **Computed (left) and measured (right) conductivity in measuring plane at *x/D* = 1.0.**

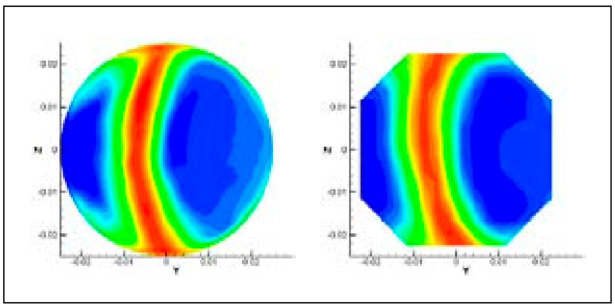

Figure 3: **Computed (left) and measured (right) RMS of conductivity in measuring plane at *x/D* = 1.0.**

The sharp interface region (red) shows high RMS values and results from a strong shear between the two streams. RMS of conductivity reaches a minimum in both high-velocity and recirculation regions, since they are not yet mixed at this position. The interface region (sickle-shaped) is thin for both WMS and LES and has similar thickness. Figure 4 gives comparison of conductivity and its RMS at the midline of the measuring plane. The accuracy of LES is striking for both quantities.

Conclusions

Mixing studies are being performed at PSI's Laboratory for Thermal Hydraulics with the final aim of finding the most suitable experimental technique, as well as to improve modelling aspects to predict these phenomena. WMS is particularly suited for examining such flows, thanks to its spatial resolution and high frequency. From the numerical viewpoint, LES offers the most accurate answer, but as a drawback is very expensive. The striking accuracy of LES in predicting conductivity and its RMS is encouraging but not surprising, since LES is most suitable for predicting phenomena governed by large coherent structures, such as the one featured in the mixing part of the flow in the T-junction. Future experimental and numerical investigations should focus on the near-wall region, which is responsible for generating thermally-induced cyclic stresses, and on prediction of characteristic mixing frequencies.

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The Hot Laboratory – a set of facilities for the study of radioactive samples

Didier Gavillet, Ines Günther-Leopold, Daniel Kuster, Matthias Martin, *Hot Laboratory, PSI*

The Hot Laboratory of the Paul Scherrer Institute (HOTLAB) is the single Swiss infrastructure that allows the manipulation and analysis of large quantities of radioactive materials. In particular, components of nuclear power plants are routinely investigated and analyzed in the laboratory. The facility hosts different PSI as well as guest (EPFL) research groups active in the study and analysis of radioactive materials. The HOTLAB offers a large spectrum of analytical tools for the experimental investigation of highly radioactive materials, together with the basic infrastructure needed for their safe handling, storage and disposal.

The Hot Laboratory (HOTLAB) of the Paul Scherrer Institute started its activity in 1963 (at that time in the Eidgenössiches Institut für Reaktorforschung/EIR). Since then, it has been extended with so-called Pu-Laboratories, which allow the production, study and storage of advanced nonirradiated nuclear fuel for future generations of nuclear reactors. Its infrastructure has been steadily upgraded, to ensure the required safety for such infrastructure and the safe containment of the hazardous materials.

A major effort has been made throughout these years to keep the available analytical infrastructure up to the needs and expectations of the users and also offer new possibilities for detailed analysis of radioactive materials.

Most of the research activities realized in the HOTLAB start with the delivery of heavily radioactive batches of materials to the large concrete hot-cell chain and continue with detailed and often sophisticated analytical analysis.

The concrete hot-cell chain

Heavy transport casks used for the international transport of radioactive goods are unloaded in one of the five large concrete hot cells. Cell number 1 can accept full-length Light Water Reactor (LWR) fuel rods for detailed non-destructive examination. Visual inspection of the rod surface and measurement of the oxide layer thickness and variation of rod diameter and rod length, with regard to their nominal values, allow a detailed analysis of the rod state to be made. This allows the first characterization of flaws resulting from the service life of a rod in a reactor, which is essential for the prediction of the lifetime of new rod design for nuclear power plants.

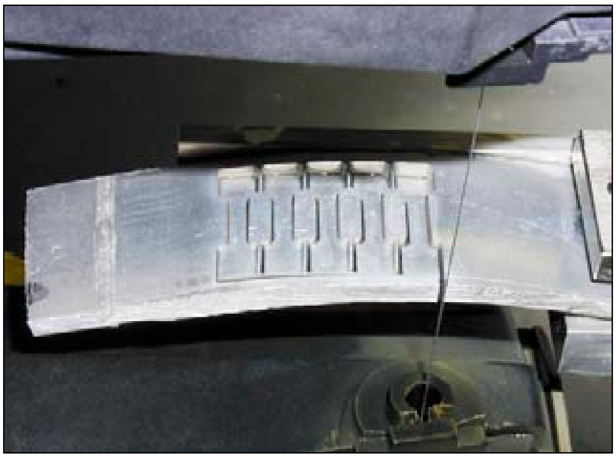

Figure 1: **Sub-specimen production in large cells.**

Smaller batches of material irradiated in accelerator facilities in PSI itself, as well as in research reactors around the world, are unloaded in smaller concrete cells. For example, irradiated test materials for future neutron sources, based on liquid metal technology, are delivered, sorted and cleaned in these cells for the target development group of PSI, as well as irradiated materials developed for future fusion nuclear reactors by the fusion technology group of EPFL. After delivery, subsamples must very often be cut up for further detailed investigation. The HOTLAB had to adapt commercially available equipment, such as the Electrical Discharge Machine (EDM), for their remote handling in the cells. This allows small specimens with complex shape (as seen in Figure 1) to be produced.

After cutting, these samples are dispatched to the many shielded analytical facilities available in the laboratory, where observation of the material structure is often needed.

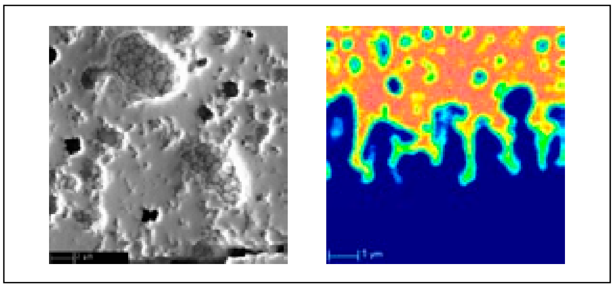

Figure 2: **EPMA observation of fuel restructuring at high burn-up (left – in the pores ,one can see submicron grains and fission products) and U distribution at the fuel-cladding interface (right – blue low / red high concentration).**

Solid-surface analytical tools

Irradiation induces changes in material structures through nuclear reactions, as well as thermal or chemical processes. These modifications can be observed at the micron and submicron length scale on polished specimens with an Optical Microscope (OM), Scanning Electron Microscope (SEM) or Electronic Probe Micro-Analysis (EPMA). The Hot Laboratory has two shielded cells dedicated to the preparation of such specimens, to allow the detection of structural modification in a material, such as in the case of the nuclear fuel restructuration occurring at very high burn-up (Figure 2 – left).
These observations are often the starting point for more sophisticated analysis to understand the degradation processes resulting from the irradiation.

Elemental and isotopic analytical tools

Irradiation also induces modification of element distribution. EPMA allows the distribution of the major elements in a sample to be determined. This helps to understand the thermal and nuclear processes that occurred during reactor operation. For example, observation of the Uranium distribution at the fuel/cladding interface (Figure 2 – right) gives information on the corrosion processes at this critical interface relevant to the integrity of an LWR fuel rod.
Often the elemental information is not sufficient and isotopic details are needed to comprehend properly the irradiation effects. This is often critical for the validation of the very sophisticated modelling software available today. The HOTLAB is a leader in the development of the Secondary Ion Mass Spectrometer (SIMS) as well as in Inductively Coupled Plasma Mass Spectrometry (ICP-MS) techniques for the isotopic analysis of highly radioactive materials. The ICP-MS coupled with High Performance Liquid Chromatography (HPLC) allows, for example, the separation of different neighbouring elements that suffer from isobaric interferences, as shown in Figure 3 for the analysis of fission products in nuclear fuel.

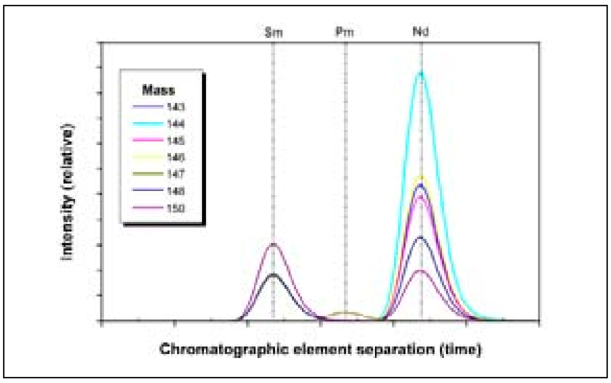

Figure 3: **Elemental separation of Sm, Pm and Nd with an HPLC-ICP-MS.**

Figure 4: **Remotly operated mechanical test machine behind its shielding.**

Mechanical properties

Finally, structural and chemical modification of materials can have a critical effect (often degrading) on the mechanical properties of samples. The HOTLAB offers the basic infrastructure for investigating irradiated specimens in shielded environments, including the transfer, loading and unloading of specimens in dedicated test facilities. Different machines have been developed, and are operated, by PSI and EPFL research groups for the shielded boxes to allow detailed investigation of the mechanical properties of irradiated materials at different temperatures and in different environments (Figure 4).

Summary

The PSI Hot Laboratory offers state-of-the-art infrastructure for experimental studies of radioactive material behaviour and is being successfully used by many PSI and external research groups. Further information on current Hot Laboratory tasks, operators and users can be found on: http://ahl.web.psi.ch.

Mechanical testing of micro- and nano-samples

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Nuclear plants are designed for long-term operation in demanding environments. Limited operational experience with the materials used in such plants necessitates the reliable assessment of damage and residual life of components. Non-destructive condition monitoring of damage is difficult, if not impossible, for many materials. However, periodic investigation of small samples taken from well-defined locations in the plant could provide an attractive method for damage assessment. The possibilities of using very small samples taken from plant locations for condition-based monitoring are being investigated.

Advanced reactors will be exposed to high temperatures, non-aqueous environments and high dose levels. Also, reactor materials are expected to differ considerably from those used in current plants (coarse-grained materials, nickel-based alloys, etc.). These facts suggest a need for non-destructive evaluation (NDE). The major challenge for this is the envisaged plant design lifetime of 60 years, with possible extension. Information about the actual condition of components becomes extremely important, as there is no long-term experience with such plants. Complementary to conventional NDE techniques, the analysis of very small samples taken from significant locations can provide more detailed information concerning damage.

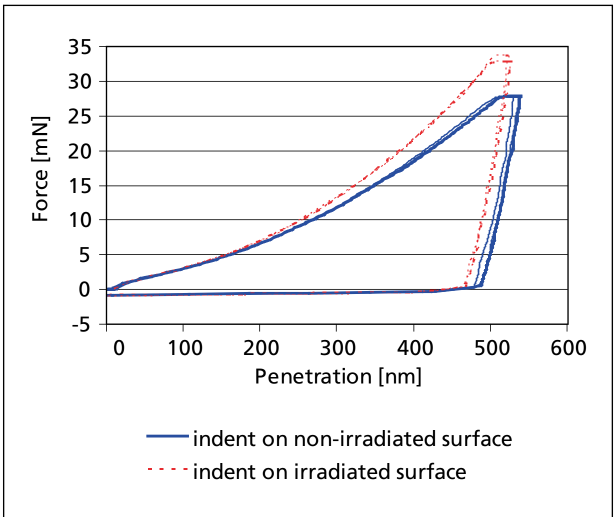

Figure 1: **Nano-indenter signals for the oxide-dispersion strengthened (ODS) material PM 2000 (annealed) in non-irradiated and irradiated conditions. Irradiation hardening is clearly visible.**

Stress-strain information can be obtained from *punch tests*. Discs of 3 mm diameter and about 200 µm thickness are deformed either with a small ball (1 mm diameter) or a cylindrical punch of similar diameter. The resulting load-displacement curves can be converted into stress-strain curves with finite element analysis – a method well established for the determination of irradiation hardening in the laboratory. *Thin strips*, i.e. 100–200 µm-thick dog-bone-shaped samples, can be used for tensile and creep tests. Even less sample material than for thin strips and punch tests is needed for *nano indentation* and *micro/nano-sized samples*, such as *micro bend bars* or *micro pillars*. Nano-indentation and micro-sample testing will be described in the present article. Figure 1 shows the load-displacement response of a ferritic oxide dispersion strengthened (ODS) steel which was tested before and after He-implantation. The implantation creates irradiation damage (point defect clusters), leading to hardening of the material, which can be clearly seen.

Samples of micrometre dimensions can be manufactured with a focused ion beam (FIB) and these samples deformed using the head of the nano-indenter for the application of deformations and loads. Figure 2 shows a small pillar which was tested under compression. The material is again the ferritic ODS steel. This alloy has very large grains and therefore the pillar consists of a single crystal. The shear plane is clearly visible and a correlation with the critical shear stress can be made. Comparison of the shear stress measured with dog-bone samples in tension compare very well with the results obtained from micro-pillar compression. This is not necessarily always the case, and considerable size effects can be found in micro-pillar tests, particularly for single-phase materials [1]. Most important for condition monitoring is the relative change of mechanical properties as a result of damage. Figure 3 shows results from compression tests of the ferritic ODS steel before and after helium implantation. The sample material was the same as that for which the nano-indenter results were shown in Figure 1. Irradiation hardening of about 20% was found for the indenter tests as well as for the micro-pillar tests.

Important additions to the micro-mechanical investigations are micro-characterization with electron microscope and advanced beamline techniques such as extended X-ray absorption fine structure (EXAFS). These techniques allow quantitative assessments of damage to be made, such as the analysis of point defect clusters or coordination analysis.

Another important issue concerns the quantitative understanding of damage with respect to component life. Constitutive equations and other parameterizations of material properties are usually applied with time-independent coefficients and exponents using the properties of virgin material. These can change as microstructure changes. Conversion of these changes into mechanical response could provide a possibility for better assessments of the development of mechanical properties with time. The inclusion of multiscale modelling tools for describing materials through several length (and time) scales, starting at the atomic level up to the level of finite element analysis, is expected to enhance the current modelling schemes used. A detailed discussion of these methods is given in [3].

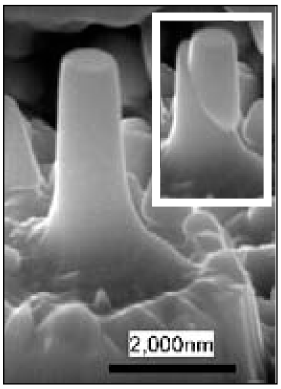

Figure 2: **Micro-pillar of a ferritic ODS steel before and after a compression test. The slip plane is clearly visible [2].**

Mechanical testing of small samples, together with advanced analytical methods and materials modelling, provide a very promising option for the determination of damage in nuclear plants. It is proposed to use these combined tools for the assessment of the residual life of components with an expected lifetime of 60 years or more. Even very small samples (not affecting the integrity of a component) could be investigated. Taking such a "fingerprint" of the condition at scheduled time intervals would provide an improvement in relevant material parameters and design rules. Using these fingerprints in synergy with a multiscale modelling scheme would bring a more fundamental understanding of the mechanisms causing material aging. Information from such methods of condition monitoring goes far beyond the possibilities of current NDE. Micro-sample/micro-scale modelling for condition monitoring should be used complementarily to conventional non-destructive methods, to provide a sound picture of the status of a component, which can be used for safety considerations and reliable risk assessment.

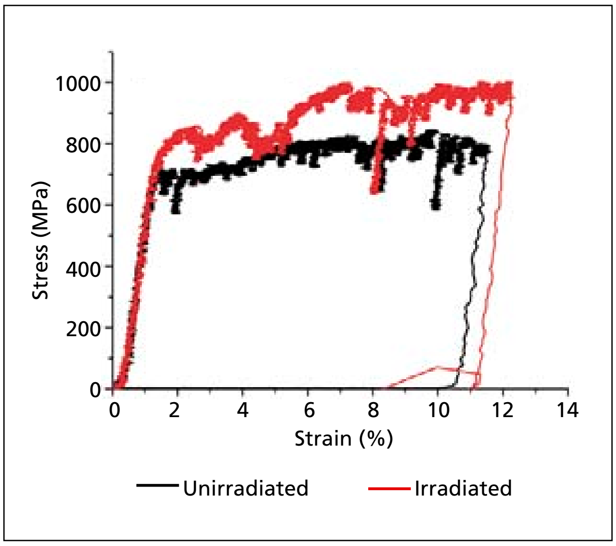

Figure 3: **Stress-strain curve of a ferritic ODS steel before and after helium implantation determined by micro-pillar compression.**

This work was essentially supported by the Swiss Competence Center Energy and Mobility (CCEM).

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Influence of carbonate complexation on the sorption of actinides/lanthanides on clays

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Radioactive wastes have to be isolated from the human environment for the duration of their toxicity. Deep geological disposal ensures protection of man and environment over long time scales. Physical and chemical retention of radionuclides on clay minerals, important constituents in the back-fill material and the host rock, is an important safety barrier to prevent radioactive substances from being dissolved in water and transported to the biosphere. The presence of inorganic carbon in deep groundwaters can have a significant effect on the retention of trivalent actinides/lanthanides because they form strong aqueous complexes. Recent investigations have clearly indicated that ternary actinide/lanthanide-carbonate surface complexes do form on the clay surfaces, and hence contribute in a significant manner to their immobilization.

Assessing the long-term safety of a radioactive waste repository can be greatly assisted by a molecular-level understanding of the behaviour of radionuclides in the geosphere. This knowledge is needed in order to establish reliable thermodynamic data to quantify the retention and transport of radionuclides in deep groundwaters. The fate of released radionuclides in geological environments is primarily controlled by sorption/desorption processes onto mineral surfaces. Clay minerals are major constituents of the potential host rock formations considered in the design of a high-level radioactive waste repository.

The sorption of metal ions is strongly dependent, amongst other things, on ionic strength, pH and the presence of organic or inorganic ligands in solution. A detailed understanding of the sorption mechanisms occurring at the mineral surface over a representative range of relevant conditions is essential for performance assessment.

Carbonate is ubiquitous in deep groundwaters and has a great complexation affinity for actinides. Such complexes in the aqueous phase can potentially lead to a decrease in sorption and thus an increase in the migration rates of actinides.

Thermodynamic and structural data for lanthanide/actinide-carbonate-mineral systems are sparse. However, such data are absolutely essential, since clay rock porewaters often contain quite high carbonate concentrations. For trivalent actinides and U(VI) it has been reported that the formation of ternary (hydroxo)carbonate surface complexes may contribute to surface sorption reactions [1–3] (Figure 1). Taking the latter into account requires unambiguous identification of the mixed surface species. The objectives of the current study are to investigate with a combination of wet chemistry, geochemical modelling and spectroscopic studies whether or not ternary Ln(III)/An(III)-carbonate complexes form at the surface of clay minerals.

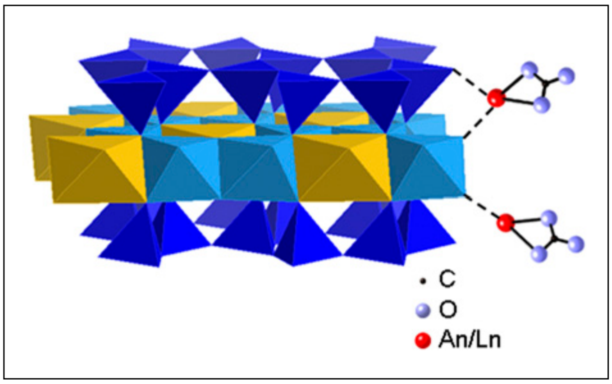

Figure 1: **Schematic representation of the formation of ternary Ln(III)/An(III)-carbonate complexes on clays.**

Macroscopic and microscopic investigations

Macroscopic sorption experiments have been carried out in the absence and presence of carbonate, to quantify the influence of inorganic carbon on the sorption of trivalent actinides/lanthanides on different clay minerals. Sorption measurements were carried out as a function of pH in the presence of various carbonate concentrations. The measurements show that a pronounced decrease of sorption is observed in the presence of carbonate (Figure 2).

Modelling with the 2-*S*ite *P*rotolysis *N*on-*E*lectrostatic *S*urface *C*omplexation and *C*ation *E*xchange (2SPNE SC/CE) sorption model [4], under the assumption that carbonate complexes

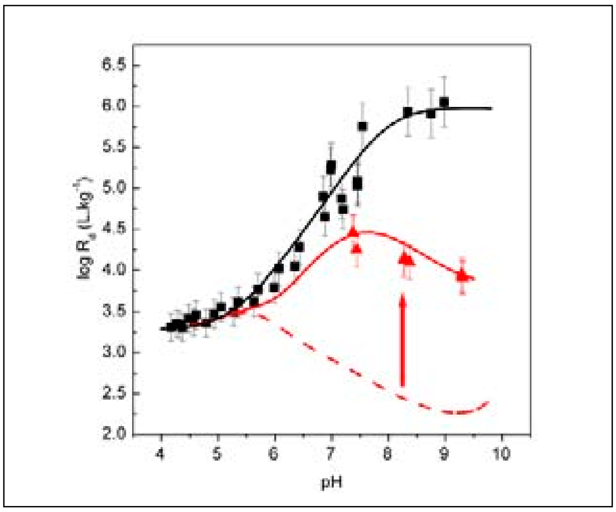

Figure 2: **Sorption of Eu(III) on clay in the absence of carbonate (■) and in 20 mM $NaHCO_3$ (▲). Modelling: (—) in the absence of carbonate and (—) in 20 mM $NaHCO_3$.**

do not sorb, largely under-predicts the experimental data (red dashed line in Figure 2). Consequently, other surface sorption reactions involving carbonate complexes must be considered. The experimental data for Ln(III)/An(III) could only be successfully modelled with the 2SPNE SC/CE sorption model by including two additional surface complexation reactions, forming $\equiv S^SOAnCO_3$ and $\equiv S^SOAnOHCO_3^-$ surface species [3].

*T*ime *R*esolved *L*aser *F*luorescence *S*pectroscopy (TRLFS) has proven to be a versatile tool for Cm(III) speciation studies and for sorption studies on various solids [5, 6]. The TRLFS measurements were carried out on Cm(III)-loaded clay pastes at T < 20 K. In a preliminary step, an iron-poor clay mineral, kaolinite, was chosen in order to avoid any fluorescence quenching by iron. The excitation spectra of the Cm(III) kaolinite samples were measured by scanning the excitation wavelength in the range of the ${}^6D_{7/2} \rightarrow {}^8S_{7/2}$ transition [595–625 nm], recording simultaneously the corresponding Cm(III) emission spectra.

Figure 3a shows the excitation spectra of Cm(III)/kaolinite samples prepared in the absence (black line) and in the presence (red line) of 20 mM $NaHCO_3$. Figure 3b shows the fluorescence emission decay curves of Cm(III) obtained for both systems by exciting at two different wavelength. The fluorescence features (shift to higher wavelength and shape of the excitation spectra, bi-exponential decay and increase of the fluorescence lifetime) of the Cm(III)-carbonate-mineral systems differ strongly from those of the carbonate-free systems, indicating different coordination environments for Cm(III). This is clear evidence that ternary An(III)/(hydroxy)-carbonate surface complexes form on the clay edge surface, as postulated in the macroscopic study.

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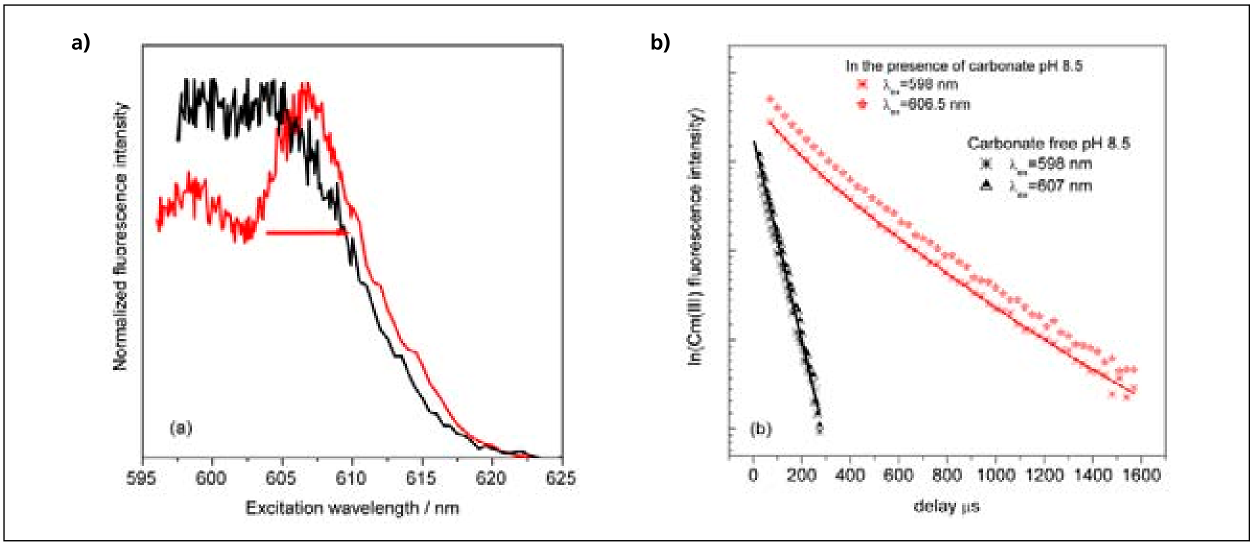

Figure 3: **a) Excitation spectrum of Cm(III)-loaded clay samples prepared in the absence of carbonate (—) and in 20 mM $NaHCO_3$ (—); b) the corresponding fluorescence lifetimes: in the absence of carbonate (black symbols) and in 20 mM $NaHCO_3$ (red symbols).**

Simulating atmospheric aerosol production in the PSI smog chamber

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Secondary organic aerosol formation from biogenic emissions contributes substantially to the total aerosol load both locally and globally. Isoprene is the most abundant biogenic compound; however, its aerosol formation potential in the real world is still poorly quantified. Using carbon-13 labelled isoprene, the formation of secondary organic aerosol was investigated. The labelled isoprene was produced by first feeding plants with $^{13}CO_2$ and then subjected to photo-oxidation together with non-labelled α-pinene in the PSI smog chamber. This approach mimics atmospheric conditions as closely as possible.

Secondary organic aerosol (SOA) is formed by the chemical transformation of gaseous precursors in the atmosphere and comprises a substantial fraction of the organic mass of atmospheric aerosols. At present, the global formation of SOA is poorly constrained, with estimates ranging from 12–70 Tg/year. Such estimates rely critically on laboratory measurements of the amount of SOA produced by individual SOA precursors, typically carried out in large environmental ("smog") chambers. The global emission of isoprene (2-methyl-1,3-butadiene, C_5H_8), estimated at ~500 Tg/year, is far higher than that of biogenic terpenes and anthropogenic hydrocarbons. Thus, even if only a small fraction of the isoprene oxidation products partitions to the atmospheric aerosol, this may result in a very large contribution to the global aerosol. This necessitates careful investigation of the fate of isoprene oxidation products on a global scale, in order to reduce the associated uncertainties. Recent laboratory-chamber studies of isoprene photo-oxidation reported SOA yields that varied by a factor of 5 ([1] and references therein). The determination of the SOA formation potential of low SOA yield precursors is complicated by factors such as losses of particles and semi-volatiles to the chamber wall. The presence of a pre-existing organic aerosol which allows for immediate absorptive partitioning of semi-volatile organic products can reduce this effect. The discrimination between the oxidation products of a specific precursor and the organic matrix of the pre-existing aerosol can be achieved by isotopic labelling.

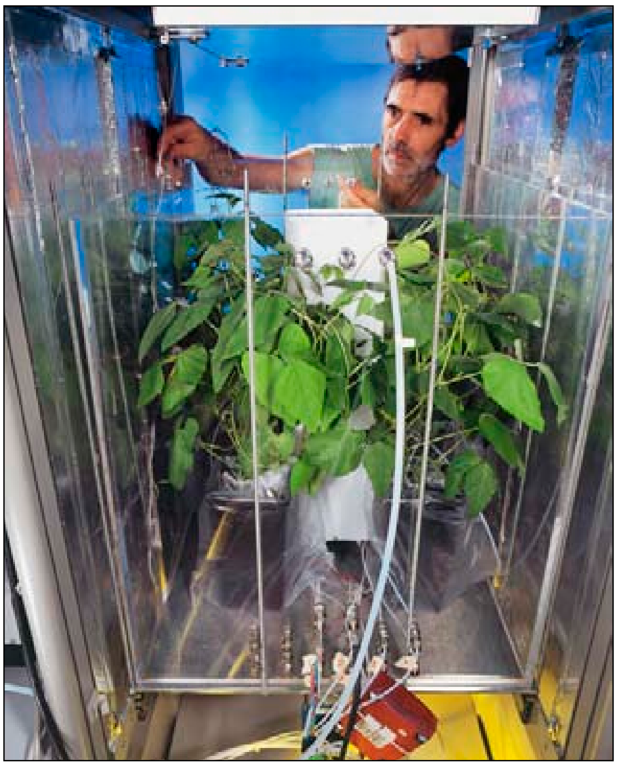

Figure 1: **The plant chamber for the production of carbon-13 labelled isoprene.**

For the production of ^{13}C-labelled isoprene, six potted velvet bean plants (*Mucuna pruriens*) were placed in a 184 L Plexiglas chamber and irradiated with xenon lamps after the addition of 600–700 ppm of $^{13}CO_2$ (Figure 1). The isoprene concentration and its degree of labelling were checked regularly with a proton transfer reaction mass spectrometry (PTR-MS) instrument (Ionicon). Figure 2 shows that 70–80% of carbon was already labelled after one hour, and on average a final labelling of 81±2% was obtained [1].

When the concentration of isoprene in the plant chamber became sufficient (~2200–4100 ppb), the air mixture was

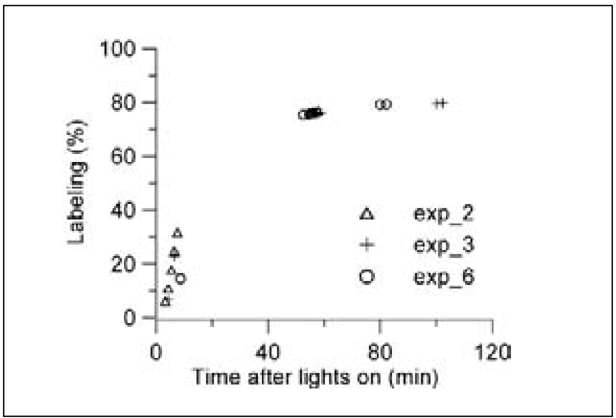

Figure 2: **Development of the ^{13}C labelling in isoprene emitted from plants in different experiments.**

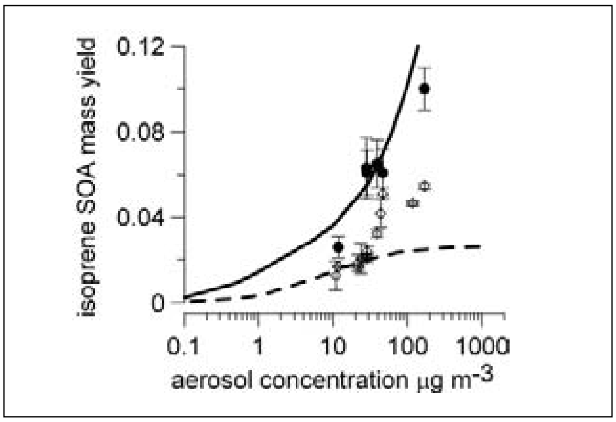

Figure 3: **SOA yield of isoprene as a function of total aerosol mass. Measured yields (◊) at time of measurement and final yields (•) after correction for incomplete reaction. Dashed and solid lines are values from the literature [2, 3].**

transferred to the large smog chamber. Two glass traps cooled to –131 °C were used in the transfer line, resulting in negligible quantities of any impurities also produced by the plants (such as monoterpenes), as shown by PTR-MS. Varying amounts of (non-labelled) α-pinene were added, then nitrous acid (HONO) was continuously injected into the smog chamber as an OH radical source. Thereafter photo-oxidation of the mixture was started by turning on the lamps of the chamber. All experiments were performed at 20 °C and 50 % relative humidity.

Since the photo-oxidation of α-pinene produces SOA much faster than that of isoprene, α-pinene SOA serves as organic seed for the isoprene oxidation products. The amount of organic seed was varied by the addition of different amounts of α-pinene. SOA was then sampled by three different methods for ^{13}C analysis, i.e. an impactor, a filter and electrostatic deposition, with all three sampling techniques providing very similar results. The sampled aerosol was burnt with oxygen in an elemental analyzer coupled to the inlet of the isotope ratio mass spectrometer. From the ^{13}C content, the amount of isoprene SOA as well as the yield (formed isoprene SOA normalized by the amount of reacted isoprene) were determined.

Results

The yield of isoprene as a function of SOA mass is presented in Figure 3. The measured yields are shown, as well as the values after correction for incomplete reaction of the first products of isoprene. The data show a strong increase of the aerosol yield with pre-existing aerosol mass concentration, increasing from 0.02 at 10 µg m^{-3} to 0.1 at 100 µg m^{-3} of SOA. This is explained by the partitioning theory: with a higher aerosol load, more semi-volatile compounds are driven into the aerosol. Figure 3 also depicts isoprene SOA yields used in the literature for modelling studies [2, 3]. Results described here fall somewhere between these two studies. The application of the upper line of Figure 3 in global models could result in an increase of the total SOA burden in the atmosphere by a factor of 2–3, with major increases in the free troposphere [4].

These model results underline the importance of studies of this kind. As the data in Figure 3 show, these studies need to be performed under conditions that are as close to the ambient atmosphere as possible. Here, experiments that take advantage of labelling techniques offer a high potential.

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Temperature response in the Altai lags behind solar forcing

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The influence of changes in solar activity on Earth's climate variability is still discussed controversially. A high-resolution temperature reconstruction using ice-core oxygen isotope data offered the unique possibility to study the relationship between solar activity and temperature in the continental Siberian Altai. A mean lag of 20 years between solar forcing and the Altai's temperature response underlines the importance of indirect sun-climate mechanisms. However, solar forcing is not the dominant cause of warming in the Altai region in the last 150 years.

Direct radiative forcing due to increase in total solar irradiance since 1750 is estimated to be only +0.12 (–0.06, +0.18) W/m^2 [1]. Nevertheless, a number of climate records show a significant response to variations in solar activity [2–4], providing evidence for a solar forcing effect. The underlying physical processes, however, are still not fully understood. Here, we report on a 10–30-year lag between solar forcing and temperature response in the continental Altai, pointing to an indirect sun-climate mechanism in this region.

Figure 1: **Belukha massif in the Siberian Altai and the Ak-kem lake (photo courtesy of Patrick Ginot). The 139 m-long ice core was drilled in 2001 in the saddle between west and east summit (49°48'N, 86°34'E, 4062 m asl).**

Temperature record

The Altai Mountains lie on the border between Russia, Kazakhstan, Mongolia, and China. In 2001, a Swiss-Russian research team drilled an ice core from the Belukha glacier in the Siberian Altai (Figures 1 and 2) that provides information about the climate and atmospheric pollution during the past 750 years in this region with a pronounced continental climate [5]. Temperatures in the Altai were reconstructed using the ice-core oxygen isotope ($\delta^{18}O$) record. It was demonstrated that the $\delta^{18}O$ record followed closely the atmospheric temperatures at a nearby weather station over the past 130 years, and can therefore be used as a temperature proxy [5].

Figure 2: **Location of the drilling site.**

Temperature response lags behind solar forcing

The established temperature record was directly compared with proxy records of solar activity (solar modulation derived

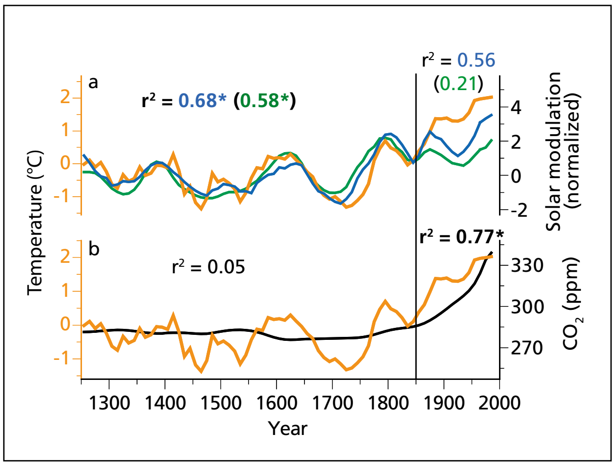

Figure 3: **a) Reconstructed Altai temperature (deviation from mean, orange) and solar activity inferred from ^{10}Be (blue) and ^{14}C (green). The solar modulation curves were shifted by 20 years (average value of the lag between solar forcing and temperature response); b) Reconstructed temperature (orange) and CO_2 concentration (black).**
Given are 10-year means smoothed with a 5-point moving average. The vertical line divides the pre-industrial era (1250–1850) from the last 150 years. Significant r^2 ($p<0.05$) are marked (*, bold).

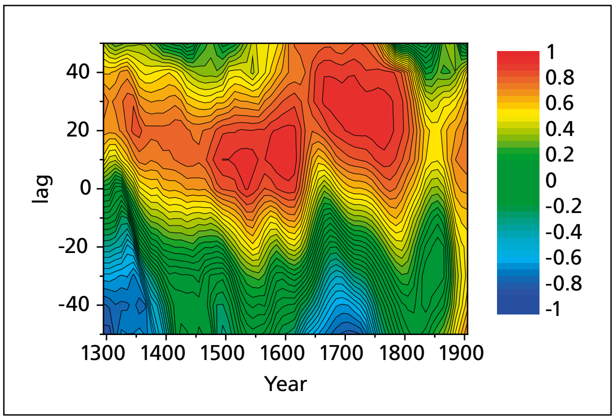

Figure 4: **Cross correlation (r) between Altai temperature reconstruction and ^{10}Be-based solar activity. A window of 200 years was moved through the data in steps of 10 years to obtain the temporal changes of the correlation coefficient.**

from ^{10}Be measurements in polar ice cores and ^{14}C records from tree rings [6]) (Figure 3). The Altai temperature record correlated significantly with the solar activity proxies in the period 1250–1850 (Figure 3), suggesting that the sun was the main driving force for the temperature variation during the preindustrial period. The influence of solar activity on the Altai temperatures is corroborated by a spectral analysis of the temperature record, showing significant periods at 205, 86, and 10.8 years [5], which can be related to the solar Suess, Gleissberg, and Schwabe cycles, respectively.

Interestingly, the regional temperatures followed the solar forcing with a time lag of 10 to 30 years (Figure 4). Since the influence of solar activity on climate has not yet been fully resolved, such observations provide an important contribution to its understanding. One possible mechanism, which might explain this average lag of 20 years, is the indirect effect of the solar activity on temperature changes involving ocean-induced changes in atmospheric circulation [7]. Ocean water warms up more when the solar radiation is most powerful, i.e. in the sub-tropics and the tropics. The heat energy absorbed is carried from lower to higher latitudes by the ocean, then released back into the atmosphere. Because of the high thermal capacity of the oceans and the variable velocities of their currents, these processes are subject to considerable delay. Changes in the North Atlantic atmospheric circulation system, which is responsible for temperature changes in the Altai, may be initiated 20 years earlier by changes of solar radiation in the tropical oceans.

Industrial period 1850–2000

The reconstructed temperatures are significantly correlated with the ^{10}Be-based and ^{14}C-based solar activity reconstructions in the period 1250–1850, but not with the greenhouse gas CO_2 (Figure 3). This indicates that solar activity changes are a main driver for the temperature variation in the Altai region during the pre-industrial period. However, during the industrial period (1850–2000), solar forcing became less important and only the CO_2 concentrations show a significant correlation with the temperature.

Acknowledgements

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Environmental and economic assessment of future fossil technologies

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Power generation based on fossil fuels will substantially contribute to the world's growing electricity demand over the next few decades. However, considering the ambitious goals set for climate change mitigation and the increasing scarcity of resources, fossil technology improvement is essential. Life Cycle Assessment (LCA) shows that it can significantly reduce Greenhouse Gas (GHG) emissions, but only the application of Carbon Capture and Storage (CCS) will allow renewable technology GHG levels to be reached by 2050. However, CCS will at the same time substantially increase costs and consumption of fossil resources.

The recently finalized EU project NEEDS (New Energy Externalities Developments for Sustainability; 2004–2009) included a comprehensive environmental and economic assessment of a wide spectrum of current and future power generation technologies. This evaluation will support the further development of a sound European energy strategy. Among other tasks, PSI was – in collaboration with IER – responsible for the assessment of advanced fossil systems, including CCS technologies [1].

Scope and methods

This analysis covered hard coal, lignite (both as pulverized coal (PC) and IGCC units) and natural gas combined cycle (CC) power plants, with and without CCS, as well as natural-gas-fuelled plants for decentralized combined heat and power generation. Three different scenarios were established for the time frame of the study: the estimation of pessimistic, realistic-optimistic, and very optimistic technology developments, which could reflect the possible spectrum of evolutionary technological progress until 2050. The three most promising options for CO_2 capture – post-, pre-, and oxyfuel-combustion – were considered, along with CO_2 storage in saline aquifers (at a depth of 800 m) or depleted gas fields (2500 m), representing the two types of storage sites most likely to be implemented in Europe on a large scale [2].

The environmental assessment was based on LCA methodology, taking into account complete energy chains, including not only the operation of power plants but all steps in the energy chain, e.g. the extraction and processing of resources, construction of infrastructure, transport and waste disposal. Cumulative environmental burdens (emissions to air, water and soil, land use and consumption of resources) were calculated per kWh electricity at the busbar of a power plant, using

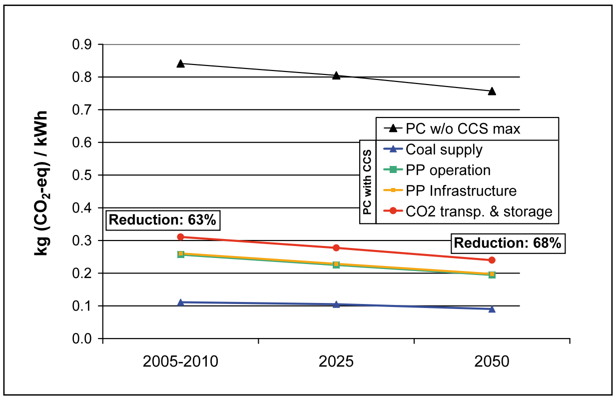

Figure 1: **GHG emissions from hard coal (PC) chains, "worst case" scenario.**

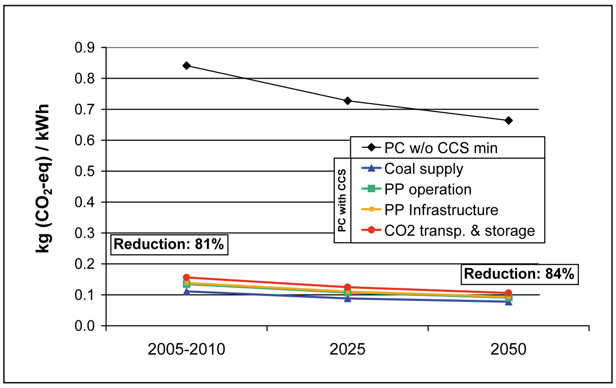

Figure 2: **GHG emissions from hard coal (PC) chains, "best case" scenario.**

'ecoinvent', the world's leading LCA database, as the source of background data [3]. Central elements of these data, such as the European electricity mix (considering various new generation technologies), production processes for metals and building materials, and transport processes, were also modified in order to reflect technological progress throughout the economy [4]. The estimate of future electricity production costs was based on learning curves and literature sources [5, 6].

Selected results and conclusions

The LCA results in Figures 1 and 2 show the "worst case" and "best case" scenarios for hard coal: the former assumes CCS with post-combustion capture and depleted gas field storage of CO_2, while the (very) optimistic scenario considers CCS with oxyfuel-combustion capture and saline aquifer storage. Advanced power plants, with higher efficiencies due to new Ni-based alloys which can withstand combustion temperatures up to 750°C, will allow GHG emissions to be reduced from about 840 g(CO_2-eq.)/kWh today to around 650 g(CO_2-eq.)/kWh in 2050, in the best case, but still exceeding the emission levels of natural gas chains by almost 100%. Application of CCS leads to a more substantial reduction, with about 30–250 g(CO_2-eq.)/kWh of cumulative emissions (red lines in Figures 1 and 2). While hard-coal supply alone is responsible for about 100 g(CO_2-eq.)/kWh, lignite with CCS, due to minor emissions from mining and transport, and natural gas chains with CCS, could reach GHG levels of 30–40 g(CO_2-eq.)/kWh. The rate of CO_2 capture (90% for post- and 100% for oxyfuel-combustion), energy demand for CO_2 injection depending on the depth of the reservoir, and contributions from fuel supply are the factors dominating the GHG performance of fossil energy chains with CCS.

Using Life Cycle Impact Assessment (LCIA) methods and external costs, aggregating a wider spectrum of environmental impacts reduces the advantages of CCS (Figures 3 and 4). Carbon dioxide capture considerably decreases power plant efficiency and, therefore, more fuel is required for the same power generation, which in turn results in higher environmental burdens from the fuel supply. Coal chains with IGCC and PC plants perform similarly in terms of environmental burdens. Due to the high weighting of the scarcer natural gas (compared with hard coal and, especially, lignite), gas chains perform worse using this LCIA method. However, the external costs (not including the monetization of resource consumption) of natural gas chains, emitting less CO_2 and fewer pollutants, are lower.

The economic assessment shows a reduction of capital costs of the order of a few percent for fossil plants, by 2050. However, CCS will increase electricity generation costs significantly: for hard coal and lignite by approximately 35%, resulting in production costs of about 4 €cents/kWh, and for natural gas by almost 50%, resulting in 8.7 €cents/kWh, in 2050.

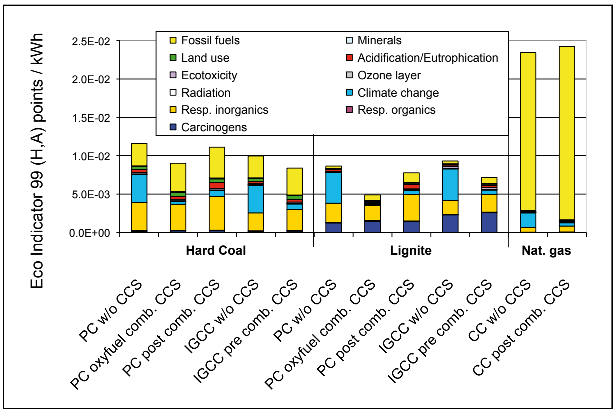

Figure 3: **LCIA results of fossil electricity technologies (year 2050), realistic-optimistic scenario.**

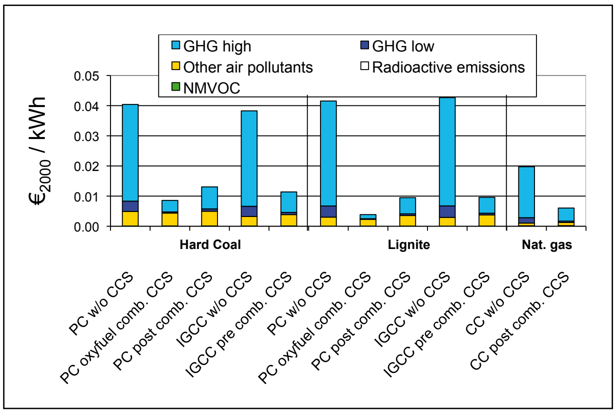

Figure 4: **External costs of fossil electricity technologies (year 2050), realistic-optimistic scenario; "GHG low": 5 €/t(CO_2-eq), "high": 52 €/t(CO_2-eq).**

References

[1] C. Bauer et al., *Final report on technical data, costs, and life cycle inventories of advanced fossil power generation systems,* NEEDS Deliverable 7.2 (2009).

[2] IPCC *Special Report on Carbon Capture & Storage,* Prepared by Working Group III of IPCC (2005).

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User facilities

Operation of the PSI Accelerator Facilities in 2008

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The Department of Large Research Facilities is responsibile for the operation and development of the four accelerator facilities at PSI. Besides a description of operational aspects and statistical figures, this article covers selected performance highlights and new developments. The proton facility reached a new record beam power of 1.3 MW, with very high availability. The cancer treatment facility Proscan is now in its second year of routine operation and showed excellent performance, with only 4% unscheduled downtime. The Swiss Light Source SLS served 16 beamlines and was successfully improved in terms of beam quality. The fourth accelerator, the Injector I Cyclotron, was mainly used for eye cancer treatment in the OPTIS facility.

Operation and development of the high-intensity 590 MeV proton accelerator complex

During the 2008 shutdown, the upgrade programme for the Ring Cyclotron was completed, with the installation of the remaining two copper resonators (Figure 1). Operation with the new resonators has several beneficial effects: Because of better electrical conductivity of the cavity walls, the unwanted conversion of microwave power into heat is reduced and, practice, approximately 600 kW of electrical power is saved under the same operating conditions; the much better properties of the vacuum sealing surfaces lead to a lower leak rate; but the most important benefit is the possibility of generating higher fields in the new resonators. By raising the gap voltage per resonator from 780 kV to 850 kV, the number of turns in the Ring Cyclotron was reduced from 202 to 186. This resulted in a reduction of residual beam losses at extraction by a factor of 2. Consequently, the Ring Cyclotron is now capable of accelerating higher beam currents while keeping losses to acceptable levels.

Figure 1: **One of the four new copper cavities inserted into the Ring Cyclotron.**

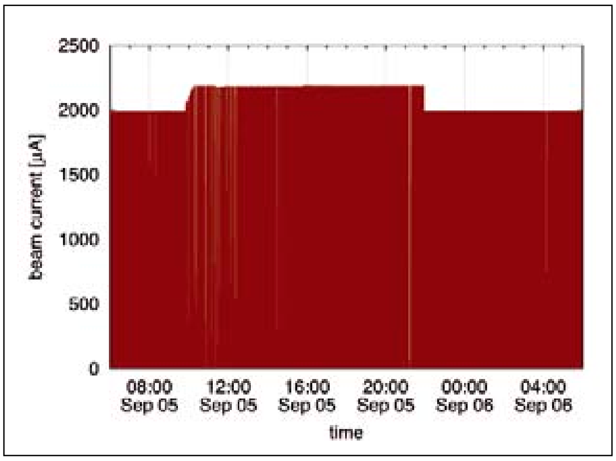


Figure 2: **Example of stable operation at 2.2 mA, which corresponds to 1.3 MW beam power.**

The present licence allows operation at 2.0 mA under standard conditions. In addition, a temporary licence was granted to PSI that foresees operation at 2.2 mA for a maximum time fraction of 10%. In total, 12 runs were performed at this elevated current and it was possible to demonstrate smooth operation without exceeding the loss limits. With the help of the experience gained, a request has been made to the Swiss authorities to raise the licensed current limit to 2.6 mA. It is planned to approach this value in small steps over several years and, as a first goal, standard operation at 2.2 mA is envisaged for 2009.

Accelerator reliability has been improved substantially thanks to the reduced losses in the new setup. During the second half of the year, when the new setup was in operation, availability reached the unprecedented level of 94%, whereas the average over the whole year was 90%. The integrated charge was 9.2 Ah on Target E and 5.5 Ah on the SINQ Target (Table 1).
In preparation for the start-up of the new ultracold neutron source (UCN) in autumn 2009, many short-pulse beam tests were performed on a beam dump in the UCN beamline. These tests represent a first commissioning step for the new mode of operation with UCN.

Beam-time statistics / proton facility	2008
Total beam time	
to meson production targets	5264 h
to SINQ	3700 h
Beam integral	
total on meson production targets	9.2 Ah
total on SINQ	5.5 Ah
Outage	
unscheduled outage longer than 5 min	360 h
total unscheduled outage	428 h
total outage [current below 1mA]	520 h
Availability	**90 %**

Table 1: **Beam-time statistics for the proton facility.**

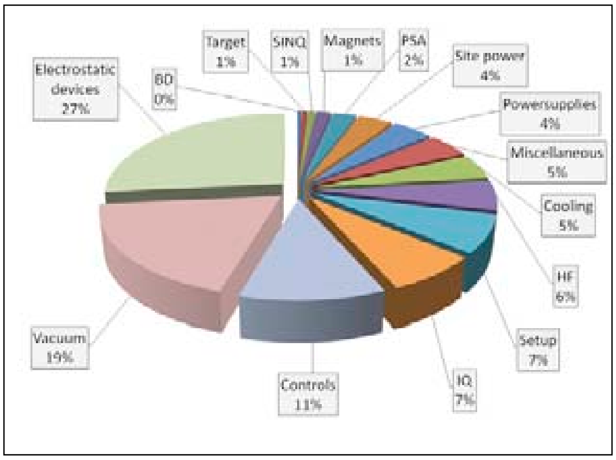


Figure 3: **Breakdown of downtimes for outages longer then 5 minutes (ca. 360 hours).**

In the following, accelerator operation and the most important incidents that occurred during the year are described. After completion of the yearly shutdown in Week 16, some delay was caused by the necessity to re-optimize the Ring Cyclotron settings, since the radial voltage distribution of the new resonators deviated from that of the original cavities. One-and-a-half weeks later, frequent high-voltage trips in both electrostatic elements necessitated their exchange in Weeks 18/19. The extraction element had breakdowns in the oil-insulated, high-voltage feed-through, and the injection element suffered from in-vacuum breakdowns. After these incidents, beam current was continuously increased and the production current of 2000 μA was reached in Week 23. In Week 31, the beam could not be restored for 15h after a regular service. The cause was finally identified as a distortion of the bending field of the Injector II Cyclotron by an inappropriately parked crane hook. In Week 51, a failure of the site power occurred and resulted in a beam interruption of 12 hours followed by 4 hours to reach stable operation. The various relative contributions to the downtimes in 2008 are shown in Figure 3. The longest break was caused by the replacement of the electrostatic devices already mentioned. The other two major contributions were vacuum problems in both cyclotrons and failures of the control system. A prominent control system problem was caused by sporadic failures of the very large CAMAC field-bus system in the experimental hall. Another class of control-system failures is related to start-up problems of new VME hardware that replaces older CAMAC systems. Both problems are expected to vanish when the ongoing CAMAC/VME transition is completed. The above contributions accounted for over 50% of the downtime; the magnitude of other items is similar to past experience. In comparison with recent years, the new category "Setup" was introduced. This accounts for unplanned setup times during scheduled production periods.

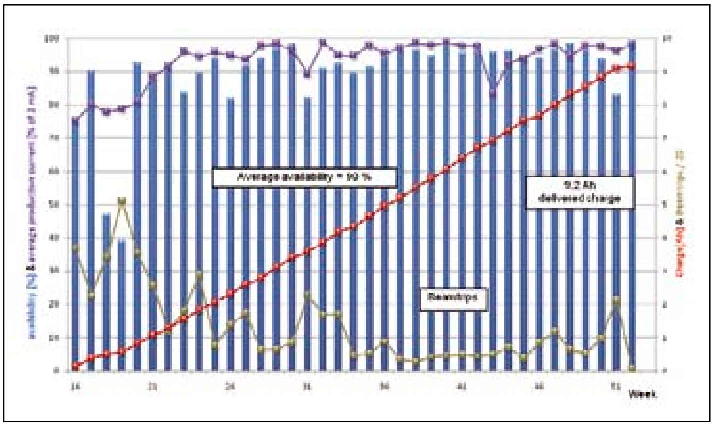


Figure 4: **Operation of the Proton Facility: Availability, average current, delivered charge and beam trip rate.**

Continuous patient treatment with Proscan

Since February 2007, the PSI cancer therapy facility using protons has been operated using a dedicated superconducting cyclotron. This allows, typically, 15 patients to be treated per day on Gantry 1 continuously throughout the year. In the evenings and on weekends, cyclotron and beamlines are used for further development of Gantry 2, the commissioning of the new eye treatment facility OPTIS2, and the proton irradiation facility PIF. Compared with 2007, 2008 showed a doubling of the operational time, to 4690 hours per year, of which 2071 hours were devoted to patient treatment.

Figure 5: **View on the lower pole of the cyclotron before assembly of the Dees on the two new stems.**

The unscheduled downtime of approximately 4% (Figure 7) is defined as the time during which the cyclotron or beam lines were not operational, although scheduled, and it includes unforeseen, but nevertheless "planned", repairs that affected the patient schedule. The inner region of the cyclotron contains a specially shaped copper electrode, called a puller, that extracts protons from the ion source (chimney) and applies the first acceleration to the initial proton beam. Major problems were due to sputtering of the puller by beam particles, and overheating of RF contact springs in the cavity. The latter necessitated the replacement of two stems (Figure 5), and caused a shutdown of five days, including a weekend. The sputtering of the puller is well understood, using tracking simulations (see Figure 6), and developments are in progress

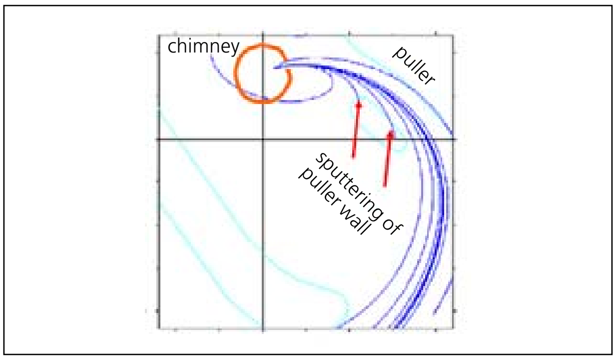


Figure 6: **Tracking calculations at the centre of the cyclotron show that the puller wall is hit by particles that are out of phase (scale: 3×3 cm).**

to increase the puller lifetime. The stability of the beam intensity is now well under control. The relative variation amounts to $(\Delta I/I)_{rms} < 5\%$. The stability of the beam intensity is of major importance for fast three-dimensional scanning of tumours, as it is planned for operation with Gantry 2. The extraction efficiency has been steadily above 80%, giving a typical dose rate of 300–500 µSv/h within the cyclotron and allowing a routine intensity of 800 nA for OPTIS2.

Operation of Injector I

An important part of the Injector I programme consists of the operation of the OPTIS facility for treatment of eye cancer. This facility, which has been in operation since 1983, is used for approximately 250 patients per year, in periods of one week per month. During the first months of 2008, several major repairs were needed to the pressure springs in the RF-vacuum feed-through. Despite these difficult repairs, only one OPTIS-week had to be cancelled. Since June, the Injector I cyclotron has run without major problems. In the present shutdown, a limited refurbishing programme is in progress to ensure smooth OPTIS operation in 2009.

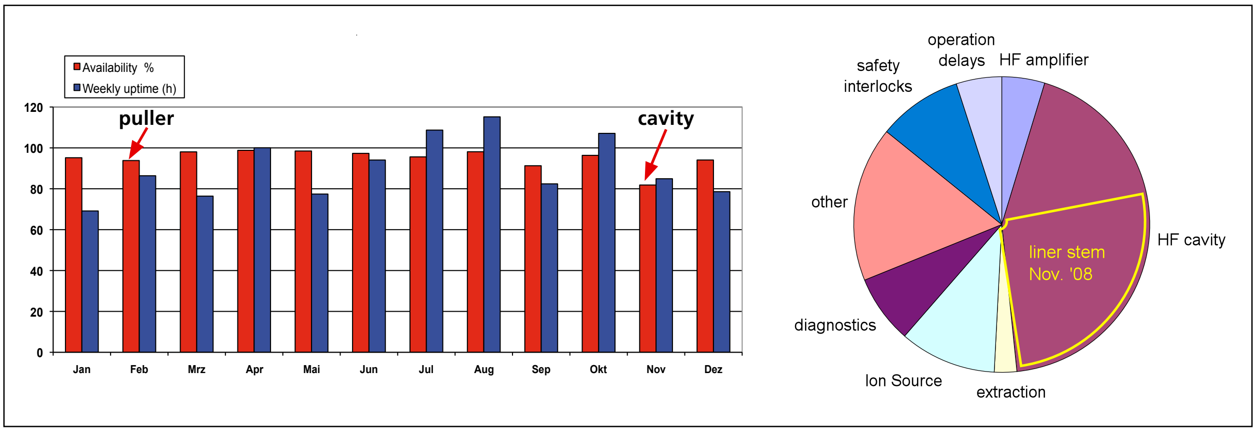


Figure 7: **Average operating hours per week and availability of PROSCAN.**

Operation and development of SLS

A significant improvement of SLS beam quality was achieved in 2008 by better control of local coupling and spurious dispersion, and the design energy acceptance level was finally reached. These improvements are described in a dedicated article within this report [1].

Two beamlines ended their operation this year: LUCIA and SIS/XIL. LUCIA was shipped to the French light source SOLEIL, and its replacement PHOENIX will start operation in March 2009. The two experimental stations SIS and XIL shared one beamline until the end of 2008. The rebuilding of their long, straight section will allow the simultaneous operation of both as two independent beamlines. The new SIS beamline will start operation in March 2009.

Total beam downtime in 2008 was 218 hours. This rather high value, compared with the previous year, was mainly due to a small number of severe incidents. If the downtime is split up into events longer or shorter than 5 hours, as shown in Figure8, it is recognized that the number of shorter outages has remained nearly constant in the past, while the contribution from major incidents has fluctuated strongly from year to year. The longest interruption had a duration of 82 hours and was caused by a water leak in the cooling circuit of the RF coupler of a cavity. As a first measure, the risk of further leakages was decreased by reducing the water flow in those cooling circuits, but the replacement of those couplers by newer types is under investigation. A total interruption of 30 hours was directly and indirectly caused by the scheduled repair of a 50kV mains transformer. A 10-hour scheduled interruption was planned, but afterwards the Helium cryostat system of the 3rd harmonic cavity became unstable and this required a longer beam interruption to restart the system. Figure 9 shows the outage time assignment to individual systems. More than half of the downtime was caused by RF problems. The operational data is summarized in Table 2.

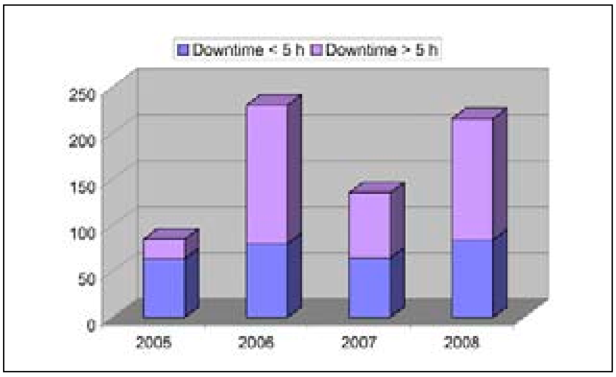


Figure 8: **Downtime during the past 4 years, split into incidents shorter and longer than 5 hours.**

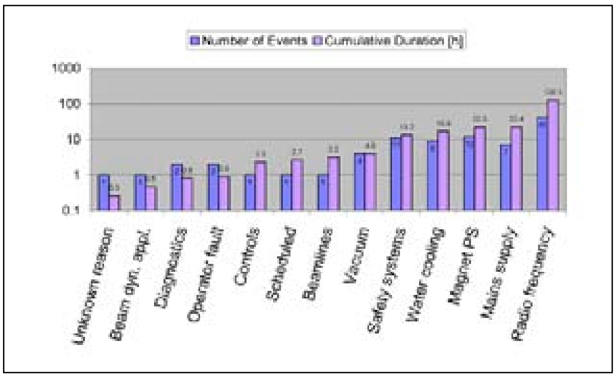


Figure 9: **Downtime events and duration per system.**

Beam-time Statistics	2008		2007	
Total beam time	6824 h	77.7%	6912 h	78.9%
• user operation	5160 h	58.7%	5200 h	59.4%
– incl. compensation time	144 h	1.6%	144 h	1.7%
• beamline commissioning	848 h	9.7%	880 h	10.0%
• setup + beam development	816 h	9.3%	832 h	9.5%
Shutdown	1968 h	22.4%	1856 h	21.2%
User operation downtimes	78		95	
• unscheduled outage duration	218 h	4.2%	138 h	2.6%
• injector outage (non top-up)	23 h	0.5%	28 h	0.5%
Total beam integral	2448 Ah		2345 Ah	
Availability	95.8%		97.4%	
Availability after Compensation	98.5%		100.1%	
MTBF	65.3 h		54.2 h	
MTTR (mean time to recover)	2.8 h		1.4 h	

Table 2: **SLS Operation Statistics.**

In 2009, further steps will be undertaken to optimize the SLS for highest brightness. New correction magnets will be used to further reduce the vertical beam size while maintaining the beam lifetime.

The beamlines PHOENIX, SIS and XIL will start operation in 2009. The latter will be upgraded later to XIL II, with new X-ray optics. Only then will the two beamlines be able to operate independently. The installation of a new type of cryo-cooled permanent magnet undulator (CPMU) is in preparation, as a replacement for the wiggler W61 of the Materials Sciences Beamline. This measure will allow the maximum photon energy of this beamline to be increased to 30 keV. After this, only one new beamline is planned: a dipole beamline to serve the Photo-Emission and Atomic Resolution Laboratory (PEARL), which will start operation in 2010.

References

[1] Michael Böge, Andreas Lüdeke, Andreas Streun, *The quest for a perfect optics correction and highest brightness at the Swiss Light Source* (this report p. 54).

SLS facility in 2008
Great instrumentation for excellent science

Stefan Müller, Rafael Abela, Christoph Quitmann, J. Friso van der Veen, *Swiss Light Source (SLS), PSI*

Over the year, SLS continuously increased the number of beamlines up to 16 at the end of 2008. With this expansion of the facility, the SLS now covers practically the whole spectrum of synchrotron radiation applications. In the reporting year, a broad scientific programme was carried through by a large number of teams – many of them international and multidisciplinary. Public activities at SLS during the reporting period include a number of high-level scientific conferences, seminars and workshops, as well as the two-day public visitor event carried out in the framework of PSI's 20th anniversary.

More than 1000 experiments in 2008

Compared with 2007, the year 2008 showed a significant increase in the number of experiments performed. More than 1600 individual users carried out a total of 1036 experiments, visiting the facility 1.8 times on average. Figure 1 shows the number of proposals submitted per beamline.
While the IR and VUV beamlines operated in the pilot phase, all other beamlines were fully operational. Overbooking was in the range of 1.5 – 3 for the non-PX beamlines and 6.5 for PX I. To cope with this high demand for protein crystallography, the proposals were partly redirected to the new PX III beamline. Figure 2 illustrates the distribution of granted shifts by scientific area and also shows the extent of the programmes in condensed matter research (47%) and in life-science and protein crystallography (24%). However, many attractive new opportunities for environmental and energy-related research activities are arising with the new beamlines VUV, SuperXAS and IR.

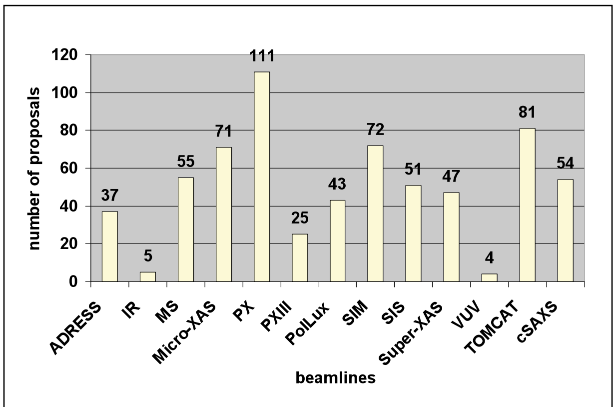


Figure 1: **Number of proposals per beamline.**

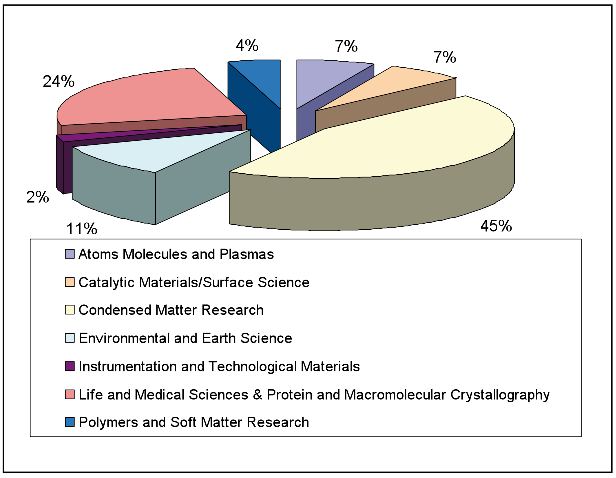


Figure 2: **Breakdown of granted shifts per scientific area.**

Open access and European Support

The geographic distribution of the SLS users remained relatively constant over the last year, showing a 60:40 ratio of international to Swiss users (Figure 3). Within Switzerland, half of the users were hosted by PSI, followed by ETH Zurich (20%), EPFL, Lausanne (10%), the University of Basel (6%) and EMPA (4%). Approximately half of the SLS users came from EU countries, with the largest numbers coming from Germany (36%), France (19%) and the UK (19%); 9% of the beam time was used by groups from outside the EU.
Access to the SLS is supported through the European integrated infrastructure project IA-SFS for users from EU member or associated states. In 2008, 500 projects were supported through IA-SFS. Out of these users, 75% are between 20 and 40 years of age and 30% are women. This shows that SLS has a user base with a high potential for the future. In addition,

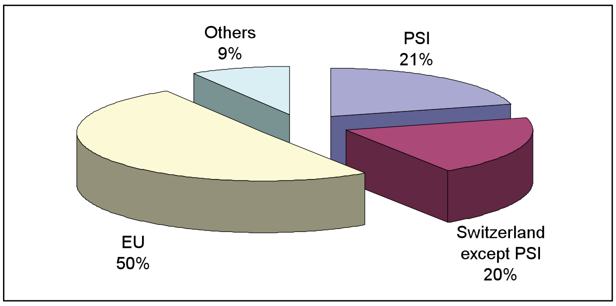


Figure 3: **Geographic SLS user distribution in 2008.**

the IA-SFS project supports joint research activities (JRAs), with the purpose of enhancing the effectiveness of the facilities in serving users.

International conference (XRM2008) and public awareness

In the period 21–25 July 2008, the 9th International Conference on X-Ray Microscopy XRM2008, organized by SLS, brought together almost 300 participants from the international community developing new instrumentation and applications of X-ray microscopy. The Werner Meyer-Ilse Memorial Award went to Pierre Thibault (PSI) and Anne Sakdinawat (Lawrence Berkeley National Lab., USA) for pioneering work in coherent diffraction imaging and for the development of optimized Fresnel zone plates, respectively.
Another highlight was the 20th anniversary of PSI, which was celebrated with many different events. Among the highlights of the celebrations were two days when PSI opened its doors to the public, allowing more than 10,000 visitors to experience the broad range of multidisciplinary research performed at the Institute. The visitors enjoyed the fascinating world of science and took a close look at the neutron, muon and X-ray sources here. At SLS, they were allowed to circumnavigate the whole building on a guided round-trip, with detailed information on the instrumentation and research available at each beamline. In addition, a set of educational movies was shown, presented by scientists.

Committees

As a sign of the maturity achieved at the SLS, which has now been operating for more than 7 years as a user facility, the year 2008 saw the appointment of several new members to the SLS Scientific Advisory Committee (SAC), while the retiring members were thanked for their valuable work. The committee is now chaired by Prof. Dr. Gerhard Materlik from the Diamond Light Source.

The non-PX Proposal Review Committee (PRC) met twice, to elaborate on dedicated proposal evaluations. The four subcommittees (HardXAS, SoftXAS, Photoemission/Infrared and Diffraction/Tomography) evaluated a total of 520 proposals during the year. Since the autumn, this committee is being chaired by Prof. Dr. Philippe Aebi (Univ. Neuchâtel).
The SLS Users Association SUSA has been extended to represent the users of all three PSI User Facilities (SLS, SINQ, SμS). The mission of SUSA is to promote research at the PSI user laboratories, and the SUSA board is newly chaired by Prof. Dr. Bernd Schönfeld, ETH Zurich. The first Joint Users' Meeting (JUM@P 09) will be held in the period 12–13 October 2009, at PSI.

New beamlines

The IR beamline started operation in 2008 and provides a service to an exceptionally wide range of experiments, from bone research to catalysis to the electronic structure of graphene to in-situ gain experiments on quantum cascade lasers. The synchrotron beam exceeds any other source in terms of brightness. The VUV beamline, which is jointly operated by staff from the General Energy and Synchrotron Light departments, produced its first spectra, and interesting programmes in combustion and atmospheric research lie ahead. During its first year of operation, the super-XAS beamline, running in 'quick-EXAFS' mode, demonstrated its capability to monitor oxidation/reduction reactions on catalysts under working conditions in sub-second steps. This beamline also runs in partnership with the General Energy department at PSI, and a further increase in energy-related projects at the SLS are awaited.

Highlights

The SLS highlights presented in this report represent just a few selected out of many. In 2008, a remarkably high number of user publications (41 in total) appeared in the leading journals Science, Nature, Cell and Phys. Rev. Letters. This illustrates the excellence of our user community and our in-house staff. Breakthroughs have been achieved, for example, in high-resolution resonant inelastic X-ray scattering and angle-resolved photoemission studies of correlated electron systems, in ptychographic X-ray imaging and 3D tomography, and in various applications of our PILATUS and MYTHEN detectors in biocrystallography and materials science.

All users are sincerely thanked for the excellent science they have brought to the SLS in 2008.

SINQ User Operation 2008

Stefan Janssen, *User Office;* Werner Wagner, *Spallation Neutron Source Division;* Kurt Clausen, *NUM Department, PSI*

The year 2008 was the 11th year of full user operation of SINQ, and another very successful one, with a record-high number of user visits and experiments demonstrating the strength of the national and international user programmes at Switzerland's unique neutron facility.

Protons and Neutrons

The performance of both the proton accelerator and the SINQ neutron target was outstanding in 2008. The availability of the PSI proton source was 90% and exceeded even slightly the very good values of the year 2007. The new operational schedule, with 3 weeks of proton production interrupted by 3–4 days of maintenance, service or beam development, has now proven to be very successful and well accepted by users, those responsible for the instruments, and facility operation staff. SINQ itself ran very stably and reliably: With an availability between 98% and 99%, SINQ was able to deliver neutrons almost as reliably as Swiss clockwork. Between 12 May and 23 December, the target received a total charge of 5390 mAh (2007: 3885 mAh; 2006: 2796 mAh; 2005: 5822 mAh).

During the winter shutdown of 2008, the SINQ operation staff installed an additional intermediate cooling circuit, to provide an additional barrier between PSI's secondary cooling circuits, operated with normal water, and SINQ's D_2O moderator. This guarantees additional safety and reliability.

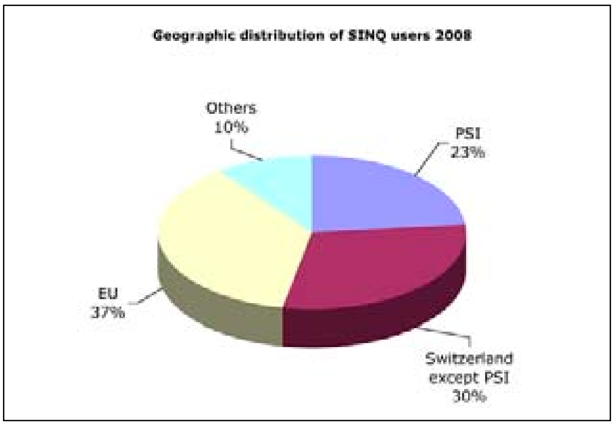


Figure 1: **Approximately 50% of the SINQ beam time in 2008 was used by Swiss groups and almost 40% by user groups from EU countries.**

User Operation statistics

In 2008, 15 instruments for neutron scattering experiments and imaging applications were in operation. Two of them ('MORPHEUS' and 'NARZISS') were mainly used for in-house activities, whereas 13 instruments were fully available to users. On those instruments, almost 450 experiments were performed in 2008, with an average duration of approximately 4 days. As usual, most of the experiments were used for academic research, but on the two imaging instruments 'NEUTRA' and 'ICON' a total of 18 experiments were performed in cooperation with, or even ordered by, industry.

The number of user visits was higher than ever before, and the user office counted a total of 677 visits by 447 different individuals. These numbers clearly exceed those from 2007 and 2006, with their reduced operation times of SINQ, but also those from ordinary fully operational years, such as 2005 and earlier.

As previously, SINQ was strongly used by Swiss user groups and clearly served as home base for the Swiss neutron scattering community, with more than 50% of the beam time being used by Swiss groups. Another 37% was used by foreign groups from EU countries and 10% by groups from countries outside Europe (Figure 1). The largest foreign national communities came from Germany (10%), followed by the United Kingdom (8%), Denmark and France (both 6%).

Looking closer at Swiss use of SINQ (Figure 2), PSI (44%) again provided most of the Swiss groups, followed by ETH Zurich (35%). The remaining share was almost equally distributed between the Universities of Bern, Fribourg and Geneva, EPFL, Lausanne and EMPA in Dübendorf.

The scientific impact of SINQ is documented in more than 120 publications in peer reviewed journals which appeared in 2008, based on data obtained at the SINQ instruments. Thirteen of these articles were in high-impact journals, such as Science, Nature Materials, PRL and JACS.

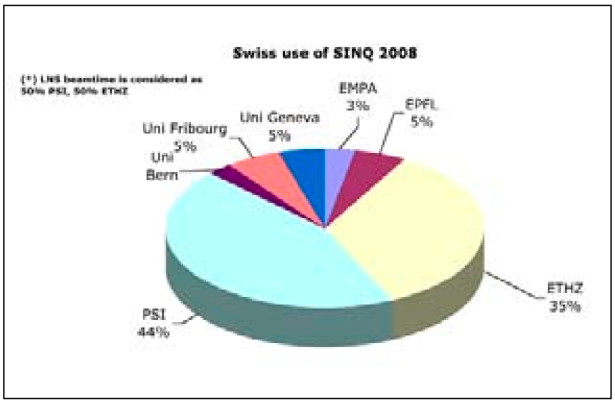


Figure 2: **Within Switzerland the largest user communities came from PSI (44%) and from ETH Zurich (35%).**

The SINQ instruments are also being heavily requested by the user community for the future, as 275 new proposals were submitted during 2008 and the average overbooking factor of the instruments was 2.2.

Complementary use of X-rays and neutrons

PSI can offer three probes for condensed matter research on one site: muons, synchrotron X-rays and neutrons. To enhance the complementary use of these facilities, a new proposal submission channel was opened in 2008. For the first time, users could submit proposals requesting beam time for both synchrotron X-rays and neutrons. This first call was dedicated to experiments in the field of powder diffraction and included the MS-powder beamline 'X04SA' of the SLS and the high-resolution powder diffractometer 'HRPT' at SINQ. The experiments allocated were then performed directly after each other at SINQ and SLS, to reduce travel demands on the users. Because of the positive resonance to this initiative, it will be continued and a second call will be made in 2009.

Twenty years of partnership with ILL

2008 was not only the year of PSI's 20th anniversary. In 1988, the year when PSI was founded, the contract was signed that made Switzerland a full member country of the Institut Laue-Langevin (ILL) in Grenoble. Since then, a very fruitful partnership with manifold collaborations has been established, including the Cryopad/Mupad development, the collaborations on Time-of-Flight spectrometers (IN6/FOCUS), and the PSI development of supermirrors, now also routinely used at ILL. Between 1988 and 2007, 939 Swiss proposals were submitted to ILL, with a success rate of 80%. This is the highest national success rate of all ILL member countries, and the complementary use of SINQ and the ILL neutron source is definitely one of the reasons for this success. A total of 682 publications have appeared from Swiss experiments at ILL, which makes an average of 45 per year (R. Wagner, ILL Grenoble, private communication, 28 November 2008).

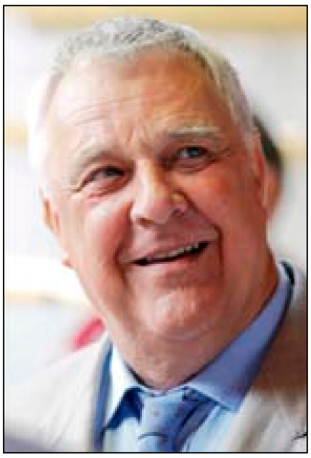
The 20th anniversary of Swiss membership of ILL was celebrated in a dedicated symposium on 28 November 2008 at PSI, jointly sponsored by the Swiss State Secretariate for Education and Research and PSI.

Highlights

In 2008, the impressive number of 125 papers based on experiments performed at SINQ were published in peer reviewed journals – many of them in highly ranked journals such as Science or Physical Review Letters. Results from two of these papers are described in the Highlight section of the present report. In one of them (p. 30) the authors report on a superconductor in which superconductivity and magnetism are intimately connected: the material shows magnetic order only as long as it is superconducting. In the second article (p. 34), new results on multiferroics are presented. These materials exhibit spontaneous coupling between magnetization and ferroelectricity and show great promise as components in new electronic devices.

Goodbye Walter Fischer

For PSI and the Swiss neutron scattering community, 2008 started on a sad note: On 17 March, Walter E. Fischer, one of the pioneers in establishing SINQ, passed away after half a year's battle with cancer. Walter's major contributions to the Swiss spallation neutron source will never be forgotten and his colleagues will greatly miss him.



Walter Fischer, one of the SINQ pioneers, passed away on 17 March 2008 and is sadly missed.

The Swiss Muon Source SμS in 2008

Elvezio Morenzoni, *Laboratory for Muon Spin Spectroscopy (LMU), PSI;*
Stefan Janssen, *PSI User Office, NUM Department, PSI*

PSI offers three major probes for condensed matter research on one campus. Next to SLS and SINQ, the Swiss Muon Source, SμS, provides unique possibilities for muon spin spectroscopy. The facility is highly attractive for the user community, and never before was the number of new proposals as high as in 2008.

User Laboratory SμS

The Swiss Muon Source, SμS, is one of the large PSI user facilities and can look back on 2008 as a very successful year: The six SμS instruments delivered a total of 655 instrument days, and 168 experiments were completed successfully during the operational period between April and December. Two-thirds of the user groups came from abroad, with the largest foreign user community coming from the United Kingdom (19%), followed by Germany and Japan (both 13%). The experiments were carried out by 151 different researchers during 185 visits.

In 2008, SμS for the first time launched two calls for proposals instead of one. In addition to the usual December deadline for all instruments, it was possible to submit proposals for the three instruments 'GPS', 'GPD' and 'LTF' in summer 2008. Having two calls instead of one per year provides higher flexibility and significantly reduces the time between proposal submission and allocation of beam-time. The new scheme was well accepted by the user community and will be continued in the future. A total of 156 proposals were submitted in 2008, which represents a new record for the facility. Several instrumental improvements were realized in 2008. In particular, to cope with the increasing number of proposals, the GPS instrument was provided with a port for an additional cryostat (Figure 1).

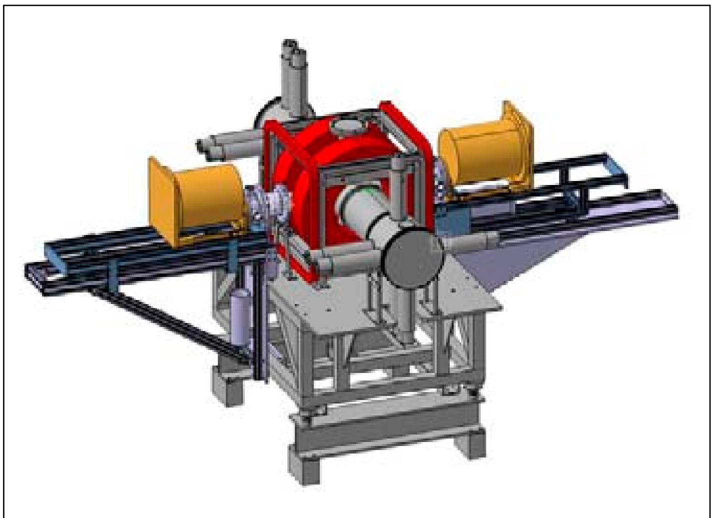


Figure 1: **GPS Instrument, with the two ports reducing the time for cryostat change.**

SμS reveals secrets of the new superconductors

The year 2008 was also outstanding for SμS regarding publications: A total of 54 publications appeared, based on data obtained at the Swiss Muon Source (39 with an LMU author). Even more than the pure number, the impact of the publications is significant: To give an example, μSR at PSI has been at the forefront in rapidly providing essential information about the phase diagram and the superconducting and magnetic properties of the newly discovered iron-based superconductors. Overall, the journal publication record contains one 'Science' and one 'Nature Materials' article, 13 papers appeared in 'Physical Review Letters' and another 24 were published in 'Physical Review B'.

Finally, it should be mentioned that 2008 marked the retirement of Dierk Herlach, Head of Laboratory, and Ueli Zimmermann, GPD instrument scientist. We wish to thank these two esteemed μSR scientists for their long-standing commitment to μSR and to the user programme at PSI, and wish them all the best for the future.

The PSI Ultra-Cold Neutron Source

Bertrand Blau, Manfred Daum, Klaus Kirch, Knud Thomsen, Werner Wagner
for the PSI UCN project team and the PSI UCN collaboration

The construction of the Ultra-Cold Neutron Source (UCN) at PSI is under way. In the beginning, it will be mainly used for extremely precise measurements of the neutron's electric dipole moment. Those are important tests of the Standard Model of particle physics. Source commissioning is planned to start in autumn 2009. A density of 1000 UCN/cm^{-3} is expected in typical experiments – an increase of almost two orders of magnitude over the best source currently available (PF2 at ILL Grenoble). User operation will start in 2010.

Prominent milestone

The most important milestone in 2008 was the delivery of the UCN tank system to PSI. All main components of the UCN source, i.e. the spallation target for neutron production, the 3.5 m^3 heavy water moderator, the solid deuterium cold source and UCN converter at 5 K, and the UCN storage volume (~2 m^3), will be embedded in the 6.5 m-high tank (Figure 1).

Proton beam and spallation target

Tests with kicking the proton beam onto the test beam dump have been successfully performed at full intensity (2 mA, 600 MeV; 10 ms pulse duration). All beam elements worked perfectly well. The spallation target for neutron production, made of 760 lead-filled reactor-grade zircaloy tubes, is also ready for operation.

Figure 1: **UCN tank system in the half-assembled iron radiation shielding.**
1: Vacuum chamber for proton beam and neutron spallation target insert;
2: Heavy water moderator tank;
3, 4, 5: Flanges for UCN guides to area west (3) south (4) and test guide (5);
6: Vacuum tank for UCN storage trap;
7: Vacuum pump port.

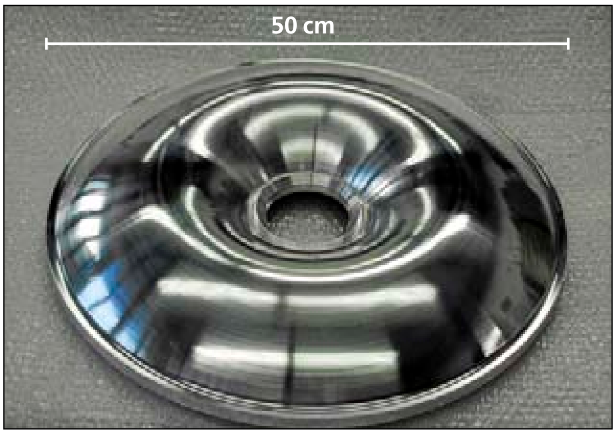


Figure 2: **The cold moderator's top lid is only 0.5 mm thick.**

The heart of the UCN source…

… is the cold moderator: 30 litres of solid deuterium at 5 K will cool neutrons and produce UCN. The moderator vessel must withstand 3 bar overpressure. A peculiarity of this vessel is the top lid (Figure 2), that must be penetrable for UCN and, thus, as thin as possible. Production of the optimal toroidal shape was a formidable challenge.

The UCN flagship

The search for the electric dipole moment of the neutron (nEDM, see page 38 in this report) is the flagship experiment in physics with ultra-cold neutrons. A large international collaboration aims at an improved measurement at PSI. The experiment will be ready for data taking in area south at the end of 2009.
For more information, visit: **http://ucn.web.psi.ch**

The PSI/ETH Laboratory of Ion Beam Physics

Hans-Arno Synal, Vasily Alfimov, George Bonani, Marcus Christl, Max Döbeli, Irka Hajdas, Peter Kubik, Marc Mallepell, Arnold Müller, Matthias Ruff, Tim Schulze-König, Marius Simon, Martin Suter, Christof Vockenhuber, Lukas Wacker, *Research Department Particles and Matter, PSI, and Institute of Particle Physics, ETH Zurich;* Susan Ivy-Ochs, *Institute of Particle Physics, ETH Zurich, and Institute of Geography, University of Zurich*

2008 was a year of change for the PSI/ETH Laboratory of Ion Beam Physics (LIP). After the retirement of Martin Suter and Georges Bonani, a new structure for the laboratory had to be found and the tracks were laid for the integration of the laboratory into the ETH structure from 1 January 2009. A fruitful and successful relationship of more than 24 years has come to an end, but the connection between PSI and the new ETH Laboratory of Ion Beam Physics will not terminate completely, and PSI will continue to support the activities of the Laboratory and benefit from its analytic capabilities.

In April 2008, the analysis of radiocarbon samples was moved from the EN Tandem accelerator to the MICADAS AMS spectrometer. This was a big step forward, because a major fraction of the external financial resources of the laboratory are related to these measurements. From the operational point of view, the new measurement procedure has the great advantage that the efforts of radiocarbon measurements are significantly reduced, and analyses can be performed unattended and fully automated. Moreover, the quality of the analyses has improved. The PSI/ETH MICADAS system is based in its design more on a conventional mass spectrometer than a traditional AMS system. This is a good qualification for achieving more precise $^{14}C/^{12}C$ and $^{13}C/^{12}C$ measurements. During the first year of routine operation, precision limits could be improved and measurements approaching the 1‰ level became possible. The BioMICADAS project has been successfully accomplished. On 25 June, the instrument was shipped to the USA and only 14 days later became operational. Rigid performance tests followed, and final acceptance was achieved on 21 July. Since then, the instrument has been operated at Vitalea Science under commercial conditions, and more than 5000 analyses of biomedical samples were conducted by the end of the year.

EN Tandem Accelerator Operation Hours			
AMS	**2006**	**2007**	**2008**
Be-10	978	617	821
C-14	700	703	215
Al-26	126	56	204
Cl-36	472	287	422
Heavier Elements		126	
MS			
Materials Science	438	447	532
SSIMS	159	94	
Maintenance			
Conditioning/Tests	259	444	333
Total	3116	2774	2527

Table 1: **Beam-time statistics 2006–2008 EN Tandem.**

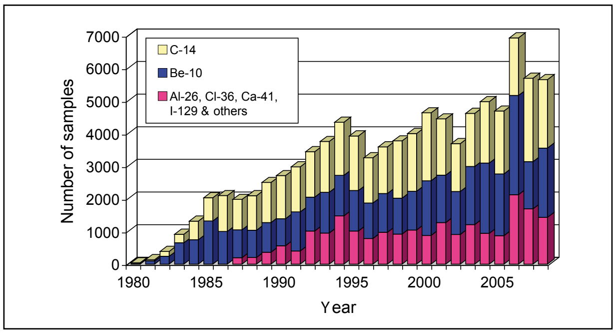
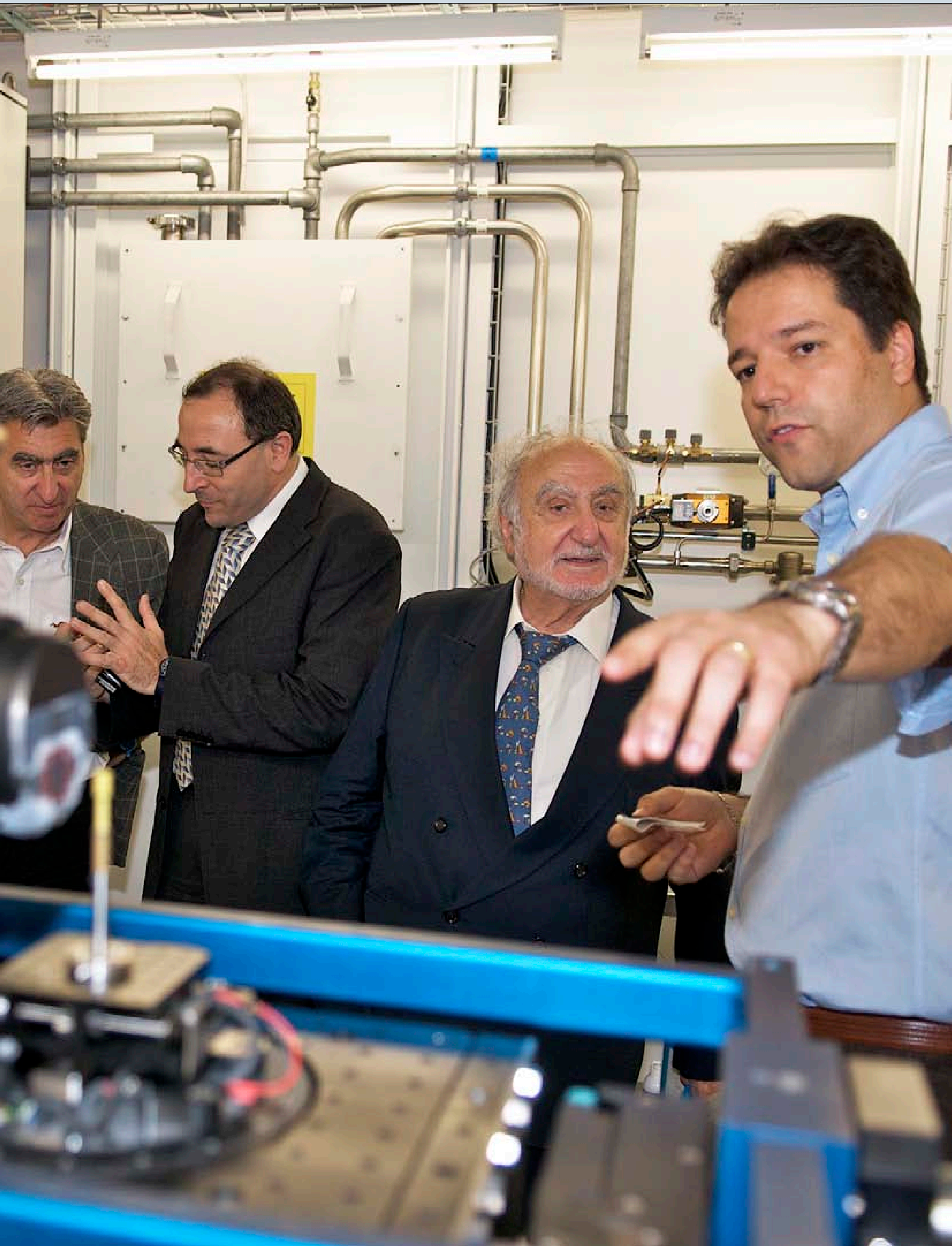


Figure 1: **Statistics of measured samples since 1980.**

At the 6 MV Tandem-based AMS system, a total of 2868 ^{10}Be, ^{26}Al, ^{36}Cl samples were measured. The Tandy AMS system was predominantly used for ^{129}I, Pu and Pa measurements as well as for experimental AMS work. The reduced burden of routine measurements at the EN Tandem left freedom for experiments in material sciences. In a new materials science project, the possibility of using micro-capillaries for the focusing of MeV ion beams is being investigated. The transmission of proton and helium ion beams through capillaries of approximately 1 micron tip size has been observed. The technique has large potential for simplified micro analysis of surfaces and small objects.

Elvezio Morenzoni, head of the Laboratory for Muon Spin Spectroscopy, preparing samples for an experiment. ▶



Technology transfer 105

The design and construction of the large research facilities at the Paul Scherrer Institute require new and innovative solutions at the limit of current technologies. Scientists and engineers are successfully pushing the limits in various technological fields, from power electronics to precision machining to nanotechnology. Combined with achievements in various research fields being investigated at PSI, these accomplishments offer outstanding opportunities for commercialization by industrial partners.

The Technology Transfer Office at PSI is ready to assist partners from industrial companies with their search for sources of innovation at PSI or to prepare the way for solutions to their technological challenges.

The following pages explain the various options for technology transfer models and illustrate a selection of successful commercialization projects, as well as some promising technologies still to be tapped by our industrial partners.

◀ Marco Stampanoni, head of the SLS tomography group, shows the TOMCAT beamline to Nicolas Hayek, president of the Belenos Clean Power Holding AG.
On the left: Philipp Dietrich, Managing Director of Competence Center for Energy and Mobility CCEM, discussing with Georges Hayek.

Technology Transfer: At the gateway between research and industry

Robert Rudolph, *Technology Transfer Office;* Daniel Grolimund, Vinh Dang, *NES Department;*
Alexander Evans, Steven Van Petegem, Helena Van Swygenhoven, *NUM Department;*
Marco Stampanoni, Jörg Raabe, Benjamin Watts, George, Tzvetkov, Christoph Quitmann, *SYN Department;*
Samuel Stucki, Serge Biollaz, Oliver Kröcher, *ENE Department, PSI*

The mission of the Technology Transfer Office is to facilitate the transfer of inventions and technologies generated by PSI's broad research activities from the lab to industrial applications. Such transfer activity aims to increase the competiveness of the industrial partners in their markets by offering innovations for new products and processes, or opportunities for further developments and improvements. If this economic impact subsequently creates new employment and new products that advance everyday lives, the society supporting our Institute benefits from the exploitation of our scientific work.

Technology transfer projects rely on the quality of the relationships between the persons involved in different aspects with both partners. A major factor shaping this relationship is the layout of the contractual framework and collaboration concept, which is adapted to each transfer project. The greatest task within these boundary conditions is the alignment of the needs and expectations of the industrial and scientific partners.

The most effective way to transfer competencies in technologies and know-how is the "transfer" of persons, who take along not only additional intangible knowledge to the company but also the enthusiasm to transform their research into industry-standard applications. PSI has experienced successful "person transfer" of PhD graduates as well as senior scientists.

A very useful way of supporting industrial research and development activities is to make available the instruments and methods used at our large research facilities. As a User Lab, PSI develops and operates instruments and equipment for a wide range of applications, from material and structure analysis to imaging. The following sections showcase a variety of the opportunities present at our particle beam facilities. The services offered by PSI include the evaluation of the appropriate measurement configuration, support with data acquisition and expertise in data analysis.

From the economical point of view, the most significant model for technology transfer is with projects involving intellectual property rights (IPR) generated at PSI. If the right is granted to use PSI-owned IPR, or to transfer patents, industrial partners expect a direct economic advantage from applying such protected IPR in their products and are ready to compensate PSI for this advantage.

Research collaborations enable companies to tap PSI's know-how and technologies early in the innovation process. Depending on the technological situation and requirements, a collaboration framework will be set up that equally suits the interests of the industrial partner and PSI. An agreement which includes the project plan, provisions on intellectual property and confidentiality is the basis for such collaboration. A long-term collaboration project for an energy and mobility concept was launched in 2008 together with Belenos Clean Power Holding (see article on page 111).

If you are interested in one of the technology transfer models described above, or if you are looking for advice or consultation on a specific topic, the Technology Transfer Office is ready to connect you with the matching centre of expertise at PSI.

The following pages give a selection of opportunities and success stories in technology transfer, as motivation to contact PSI concerning a technological solution that is challenging your own R&D department.

X-ray microscopy of active samples: The micro-XAS instrument

The availability of high-performance light sources – such as the Swiss Light Source (SLS) – and remarkable advancements in the field of X-ray optics have enabled the design of efficient hard X-ray microscopes. Recently, such a high-resolution microscope was completed at the SLS: the microXAS beamline.

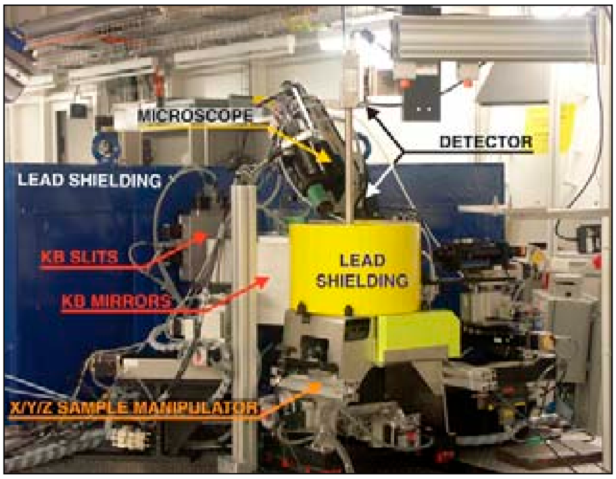


Figure 1: **Experimental setup for the measurement of active samples at the micro-XAS beamline.**

This analytical facility allows materials and matter to be investigated with a high spatial resolution of approximately 1µm² – providing microscopic insights into their structure.
A synchrotron-based X-ray microscope comprises a suite of powerful analytical methods, such as **molecular structure analysis** (X-ray absorption spectroscopy, XAS), **chemical compositional analysis** (X-ray fluorescence, XRF) and **structural analysis** (X-ray diffraction, XRD). These three techniques represent key analytical techniques in many fields of basic and applied science, and now have a major impact on the exploration of chemical reactivity and structural analysis of both engineered and natural systems. Furthermore, micro-XAS is capable of providing chemical information from within single micro-domains and at the same time providing local structural analysis of such domains.
Among other things, one particular unique characteristic of the micro-XAS is that it enables radioactive materials to be investigated. Consequently, after starting user operation, micro-XAS became widely used for investigations in close collaboration with, or relevant to, the nuclear industry. Active samples analyzed so far include solidified radioactive waste, such as glasses or cement materials, irradiated alloys, activated corrosion products (crud), and analogues of next-generation fuel materials.
In most cases, elemental distribution maps (chemical images) were recorded by collecting two-dimensional micro-XRF data, followed by molecular-scale chemical information gained by collecting the micro-XAS spectra at specific locations within the radioactive specimen. Most recently, the capability of collecting structural images was added to the facility through the generation of two-dimensional X-ray micro-diffraction images.

A tool for non-destructive residual stress characterization: POLDI

The time-of-flight (TOF) diffractometer POLDI (Pulse-Overlap Diffractometer) is the dedicated instrument at the SINQ neutron source at PSI for the study of residual stresses and the mechanical behaviour of industrial materials. POLDI uses a beam of thermal neutrons with a range of wavelengths which satisfy the diffraction condition for many crystal lattice spacings. Consequently, the recorded diffraction pattern consists of many crystal reflections (Figure 2), which allow multi-phase and composite materials to be studied, as well as intergranular stresses in single-phase materials.
Residual stresses are of great concern in industry, since they can lead to premature failure of industrial materials and structures if they are not detected. Such stresses can be studied in crystalline materials using neutron diffraction, where the crystal lattice is used as an atomic strain gauge. The penetration of neutrons in many engineering materials allows for the non-destructive determination of residual stresses from the near surface to deep within the bulk. Examples of residual stress experiments that have been conducted include residual stress in pump cases for aerospace, railway wheels, mechanical surface treatments (i.e. laser peening) and welded structures.
Residual stress distribution can be non-destructively mapped in three dimensions by translating the sample through a sampling volume established where the incident beam and diffracted beam intersect.
Concomitantly, the **mechanical deformation** of industrial materials can be studied by in-situ straining, providing phase-specific information during specific loading regimes.
In-situ neutron diffraction during mechanical testing is among the most advanced research methods, providing details of micro-structural evolution under service-like conditions, input that is needed for the development of new predictive engineer-

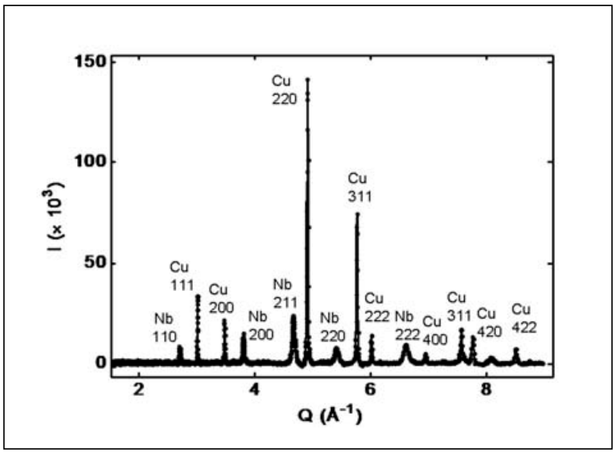


Figure 2: **Diffraction pattern of a CuNb composite.**

ing models. An example of in-situ mechanical deformation studies concerns high-field (>80 T) pulsed magnets, which are subject to large forces during operation. Such loads require conductor materials with a very high elastic limit. In-situ neutron diffraction during tensile deformation of the Cu-Nb-based nanocomposite system is an ideal tool for investigating the evolution of the lattice strain of each component. These observations allow conclusions to be drawn about possible deformation mechanisms in Cu-Nb nanocomposite wires, and reveal the build-up of large internal stresses during deformation.

Pushing the limits in microscopic tomography: TOMCAT

Synchrotron-light-based **Tomographic Microscopy** is a powerful technique for fast, non-destructive, high-resolution quantitative volumetric investigations on samples of diverse nature. At the SLS, a beamline for TOmographic Microscopy and Coherent rAdiology experiments (TOMCAT) has been recently put into operation. TOMCAT covers an X-ray energy range between 8 and 45 keV. The standard TOMCAT detector offers field of views ranging from 0.75×0.75 mm^2 up to 15×15 mm^2, with a theoretical pixel size from 0.37 µm to 7.4 µm, respectively. The beamline design and flexible endstation setup make a large range of investigations possible. In addition to routine measurements which exploit the absorption contrast, the high coherence of the source also enables phase contrast tomography, implemented with two complementary techniques, based on a modification of the 'Transport of Intensity' method and grating interferometry. In-situ experiments are also routinely conducted. Typical acquisition times for a tomogram are of the order of a few minutes, ensuring high throughput and allowing semi-dynamic study. Raw data are automatically post-processed online, and full reconstructed volumes are available shortly after a scan, with minimal user intervention. Quantitative evaluation of the tomographic scans is available on site, see Figure 3.

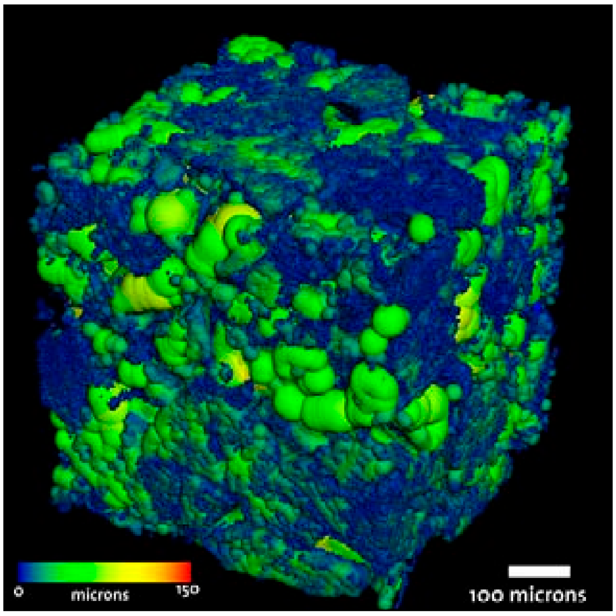


Figure 3: **3D visualization of the pore structure of a sandstone. Data have been obtained at the TOMCAT beamline, with a theoretical voxel size of 740 nm^3.**

TOMCAT is offering its services to applications in the materials and life-sciences area. Examples of these range from the visualization of cellular structures in bone samples to the micro-structure in selected concrete applications. Other applications range from high-resolution, non-destructive investigation of defects in metallic and non-metallic prototype components to the quantitative analysis of pore networks in diverse rock types – for instance, for improving oil recovery, understanding element mobilization by hydrothermal fluids, studying the dynamics of volcanic eruptions, or refining current contaminant diffusion models.

Microspectroscopy of nano-scale materials: PolLux

The PolLux facility at the SLS operates a **scanning transmission X-ray microspectroscope** (STXM). This integration of an advanced STXM with improved sample-handling capabilities and a novel beamline provides unique capabilities. PolLux uses linearly or circularly polarized X-rays from a bending magnet, with a photon energy range between 200 eV and 1400 eV. The present spatial resolution is ~20 nm during routine operation.

Recent advances in nanotechnology have led to the development of new experimental techniques to investigate **nanoscale materials** with unprecedented resolution. The various scanning probe techniques (e.g. scanning tunneling microscopy or atomic force microscopy) have revolutionized modern surface science by allowing resolution at the atomic level. Electron microscopy can compete in terms of spatial resolution with the above-mentioned scanning probe techniques and with transmission electron microscopy (TEM). High-resolution TEM is used to determine atomic positions in materials.

However, obtaining morphological information is often insufficient, and the electronic properties, element composition, chemical state and – in some cases – the magnetic properties of nanoscale materials have to be explored. This requires the combination of high spatial resolution with detailed spectroscopic information. Based on their unique interaction with matter, soft X-rays have developed into a powerful tool to gain insight into the electronic properties and the chemical or

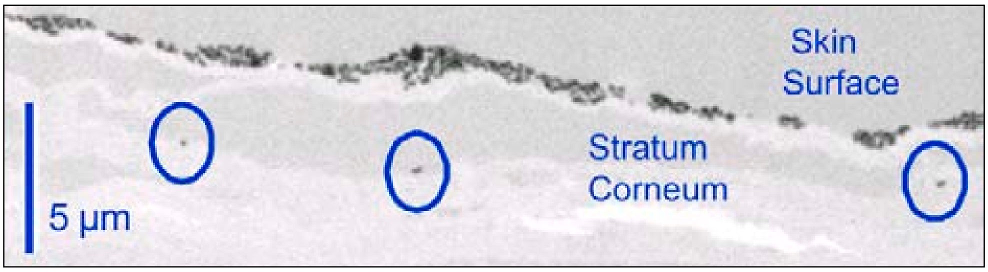


Figure 4: **X-ray microscopy images of ultramicrotome sections of human skin pretreated with nano particles (161 nm diameter) (details in [1]).**

magnetic states. Usually, the characteristic properties vary across the sample, and the spatial distribution of these variations has to be investigated at sufficiently high spatial resolution. Soft X-ray absorption spectroscopy, combined with high spatial resolution, is an ideal tool for such tasks, since it provides the necessary information with high sensitivity and minimum sample preparation. In particular, near-edge X-ray absorption fine structure (NEXAFS) shows superior sensitivity in organic materials.

In order to achieve high spatial resolution in scanning transmission soft X-ray microspectroscopy, Fresnel zone plates are commonly used to focus the X-rays to a point focus. Images are formed from raster-scanning the sample through the focal point while measuring the transmitted intensity using an X-ray detector.

Because of its flexible sample environment, which includes heating, cooling, gas and liquid cells, and electrical connections to the outside, the PolLux-STXM offers a very wide variety of experiments, from hard- and soft-condensed matter as well as in environmental science and biology.

Methane from wood: Pilot Plant is operational

In 2008, the demonstrator plant for the catalytic conversion of wood gas to methane was built and commissioned by our industrial partners in Güssing (Burgenland, Austria). The core component and real innovation of the plant is the **catalytic fluidized bed reactor,** which is responsible for the chemical conversion to methane. This reactor has been developed and built based on experience gained over the past few years with a 10 kW laboratory plant at PSI. In an ambitious scale-up step, the capacity of the reactor was increased by a factor of 100. The team achieved an important milestone in December 2008, when the 1 MW catalytic fluidized bed reactor first started operation, and achieved the expected performance level right from the start.

The project 'Methane from Wood' overcame a crucial technical hurdle on the way to its successful implementation in practice. This achievement was recognised in January 2009 with the "Watt d'Or" prize of the Swiss Federal Office of Energy, for outstanding accomplishments in energy technologies, awarded to the consortia comprising the industrial partners CTU and Repotec, the scientific partners PSI and the TU Vienna, and the biomass power plant in Güssing. For more information on the technology, see http://tpe.web.psi.ch

Improving the design of exhaust-gas after-treatment systems

Commercial vehicles have been increasingly equipped with **urea-SCR systems** for the reduction of NO_x emissions over the past few years. To achieve high NO_x conversions, it is important to mix the reactant urea homogeneously with the exhaust gas before it reaches the catalyst. As the constructed space in vehicles is usually very limited, computational fluid dynamics (CFD), as offered by Swenox, has been used as a design tool to achieve this goal. A specific feature of the Swenox software is its ability to calculate dynamic processes, which is crucial for the realistic modelling of urea-SCR systems in vehicles. Within this collaboration, PSI has contributed significant know-how for the implementation of the SCR chemistry and generated the data used in the models of commercially available vanadium- and zeolite-SCR catalytic converters. In an experimental programme at PSI, samples were cut from such commercial catalytic modules and measured in steady and dynamic states, using laboratory test equipment. The experiments included varying temperature, velocity, concentration and the NO/NO_2 ratio over large ranges. The acquired data were used to successfully parameterise the Swenox model, consequently helping the efficient design of exhaust-gas after-treatment systems. Such improved systems help to further reduce NO_x emissions, for the benefit of human health and nature.

Regulatory support tasks on the human factor

The human factor is an important element of nuclear power plant safety. Methods for treating this element in safety studies, known as Human Reliability Analysis (HRA), are a subject of research within NES. NES's expertise in this area is also used to support the regulatory activities of the Swiss Federal

Nuclear Safety Inspectorate, ENSI. Tasks include reviews of the HRAs within the Probabilistic Safety Assessments (PSAs) of the Swiss nuclear power plants, evaluations of the plants' procedures for emergency operations, and analyses of the implications of new developments in human factors for regulatory activities and guidelines.

The reviews of HRAs address the methods and assumptions used in the analyses, and the failure probabilities obtained for the personnel actions included in the safety studies. These analyses and their results are examined in the light of developments in methods, as well as in safety analysis practice. When a study uses a widely applied method, the implementation is considered in the light of international practice, otherwise comparisons with accepted methods are performed. This review work bases NES's HRA research in actual practices, providing the impulse for research and motivating efforts to enhance current HRA methods.

The personnel actions required in plant emergencies are planned thoroughly and described in formal procedures, e.g. the 'Emergency Operating Procedures', which guide the actions required by, as well as the assessment of, the actual plant situation, and the actions that the operators will need to take in these situations. Tasks in this area evaluate the usability of the procedures, focusing on the most significant accident scenarios postulated in the PSAs. At its most basic level, usability is based on criteria ranging from readability to the technical clarity and specificity of the procedures. A broader assessment of usability is performed by "walking through" the procedures and anticipating the plant indications that will be presented to the operators as they assess the evolving plant situation and perform the actions required by the procedures. The actions are also assessed in terms of the time needed to perform the required assessments of, and actions on, the plant's systems, and of the systems available in the scenario. Such evaluations complement the verification and validation of the procedures by examining the beyond-design-basis scenarios included in PSAs.

Reference

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A new way of cooperation for big challenges

Philipp Dietrich, *Competence Center Energy and Mobility CCEM, PSI*

On the way to a more de-carbonized system for individual mobility, several elements have to be adapted. The whole chain is affected, starting with fuel production, followed by the whole supply logistics of the fuel, including delivery to the customer, and finally its application in transport vehicles. This process creates opportunities as well as threats to several industrial sectors. Even society itself may be influenced by the availability of new mobility concepts. To contribute within this arena, the Belenos Clean Power Holding and PSI are collaborating with a new business model.

The idea behind the concept of Belenos Clean Power (BCP) is to substitute a part of the fossil fuels used in the mobility sector with available renewable energy. Since an alternative fuel will be only used on a large scale if the fuel supply and the fuel converter are already in the vehicle, BCP is involved along the whole energy chain. The concept is visualized in Figure 1.

The business model consists of creating joint venture companies along the complete value chain, from the capture of the primary energy all the way to its use to generate mechanical power to propel passenger cars.

The shareholders in the BCP are, to date, The Swatch Group, Hayek Engineering, Deutsche Bank, group e and the Ammann Group. It is intended that the ETH domain, through PSI, also becomes a shareholder. The share capital is initially CHF 21 million.

The holding company, together with other partners, is interested in creating joint ventures in specific areas of this clean energy chain.

The first joint venture is 'Swiss Hydrogen Power', which is developing the stationary conversion of electricity to hydrogen and oxygen, and the safe decentralized storage of these gases. PSI is mainly involved in the second joint venture, in which the development of a fuel cell system is envisaged, to be used to supply passenger cars with electricity. The integration of the fuel cell system in a car will be carried out in collaboration with a car manufacturer.

A further joint venture is concerned with increasing the efficiency of photo-voltaic cells and systems, mainly through the application of thin-film technologies.

Another joint venture is dedicated to the development of advanced batteries. This technology also strengthens the application of fuel cells, since their combination in a car helps to improve the overall efficiency and use of energy.

The structure of the holding company is designed to be a very flexible way of integrating stakeholders willing to contribute towards the realisation of one form of cleaner mobility, based on lower fossil fuel consumption.

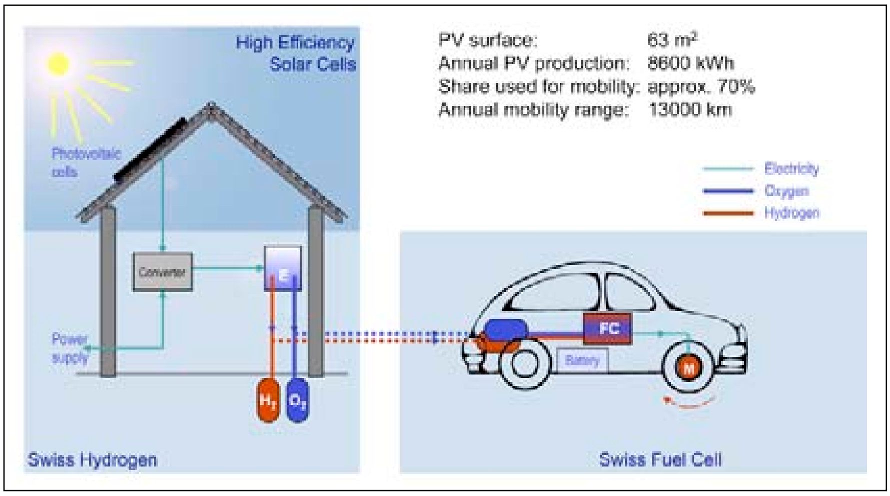


Figure 1: **Clean energy chain, using photo-voltaic panels, local electricity conversion into hydrogen and oxygen and decentralized storage of these gases. The stored H_2 and O_2 gases are used to propel a vehicle with a fuel cell.**

Facts and figures

The essential statistical data for the Paul Scherrer Institute for 2008 is presented on the following pages, giving the most important information about the Institute in a concise form.

The largest proportion of the Institute's budget of CHF 300 million is provided by the Swiss federal government. However, the contribution of third-party revenue is of increasing importance. As a particular example of third-party support for the past year, the sum of 10 million Swiss Francs was donated by the Canton of Aargau as a contribution to the further development of the Proton Therapy facility.

In the field of education, a new figure has emerged to supplement the impressive numbers of PhD students and apprentices shown in previous years, as more than 1600 pupils visited iLab, PSI's newly founded school laboratory, during its first nine months of operation.

The increasing number of external scientists performing experiments at PSI proves the institute's continued attractiveness as a multifarious User Facility. The rapidly growing number of publications in high-profile journals based on research performed at PSI shows that many of the most creative scientists choose the Institute when looking for a place to carry out their experiments.

The large number of users from abroad, and the majority of foreign members on PSI's scientific advisory bodies, are clear signs of the Institute's firm integration in the international scientific community. To illustrate this, complete lists of members of the PSI Research Commission and the Research Committees of the particular departments are included in this chapter.

◀ **Scientists discussing the development of insertion devices for the PSI-XFEL.**

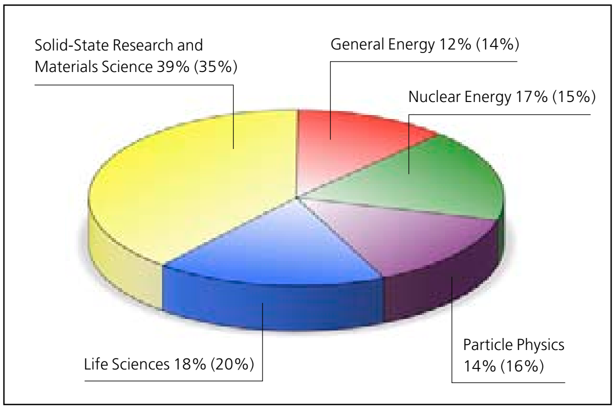
The year 2008 in numbers

Finances

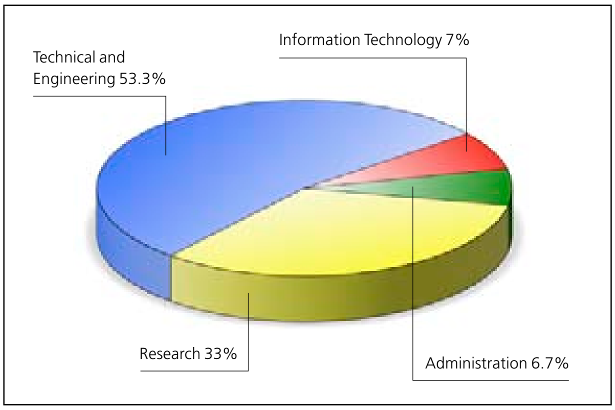
The total expenditure of PSI in 2008 amounted to CHF 300.4 million, with the Swiss government providing 80.4% of this amount, i.e. CHF 241.5 million. Investments totalled CHF 73.2 million (24.35 % of the total expenditure). Third-party funding amounted to CHF 73.1 million, with 38.3% coming from private industry, 14.77% from Swiss federal research programmes and 9.85% from EU programmes. The Canton of Aargau made a once-off supporting contribution of CHF 10 million to the Proton Therapy facility.

PSI Financial Statement (in CHF millions)		
	2008	
Expenditure		
Operations [1]	227.2	75.65 %
Investments [1,2]	73.2	24.35 %
Total	**300.4**	**100 %**
Expenditure according to source of income		
Federal government funding	241.5	80.4 %
Third-party	58.9	19.6 %
Third-party revenue		
Private industry	28.0	38.30 %
Federal research funding	10.8	14.77 %
EU programmes	7.2	9.85 %
Support by the Canton of Aargau for Proton Therapy	10.0	13.68 %
Other	17.1	23.39 %
Total	**73.1**	**100 %**

1 Including personnel costs. Total personnel costs of CHF 181.5 million corresponded to 60.40% of total expenditure
2 Including CHF 18.4 million investment in buildings



Total budget distribution for 2008 across PSI Departments. Research facilities allocated to the various departments. (Values for 2007 in brackets)



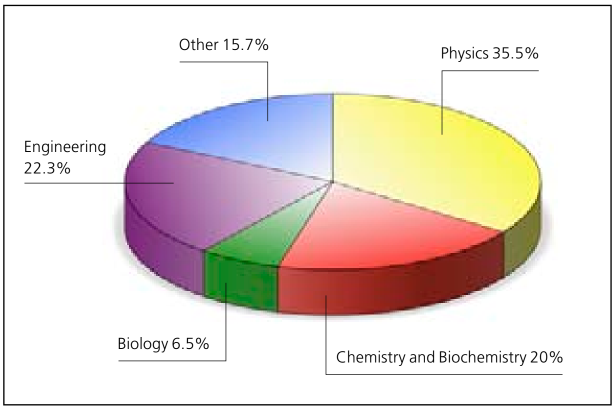
The staffing structure reflects the importance of technical staff for successful research at large-scale facilities.

Employment

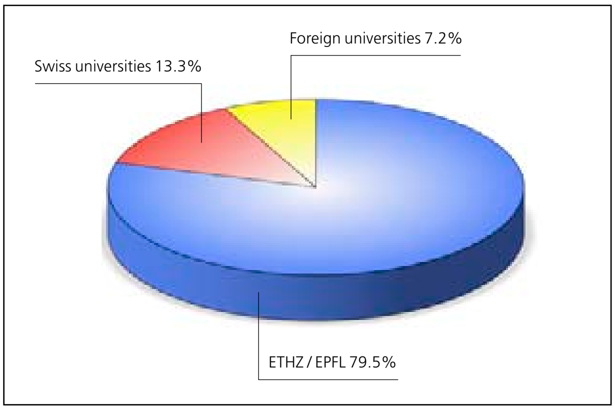
At the end of 2008, employment at PSI corresponded to 1300 full time equivalents; 22.3% of the employees were women and 42% were non-Swiss citizens.

Education

In addition to scientific research, the Paul Scherrer Institute sees education as one of its main tasks. Many PSI scientists give courses at the Swiss Federal Institutes of Technology, the Universities and the Universities of Applied Sciences. About 300 graduate students from the ETH and other universities are working at PSI for their degree. Out of those, 166 PhD students, including 44 women, were employed by PSI. Seventy-seven young people were undergoing vocational training in 13 different professions. In addition, PSI offered courses in radiation protection and reactor technology.
A particularly important event for educational activities was the opening of the iLAB – PSI's school laboratory – on 4 April



PhD students employed by PSI **according to the subjects of their university degrees.**



PhD students employed by PSI **according to the origin of their university degrees.**

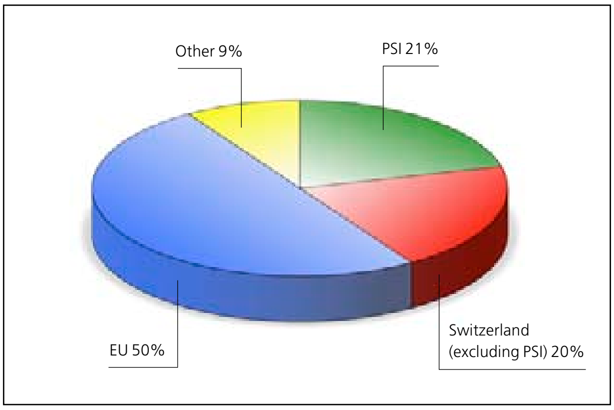
2008. At iLAB, pupils from secondary schools get the opportunity to perform a variety of physics experiments. The idea of the school lab is to spread interest in the natural sciences among the youth. In its first nine months of operation, iLAB hosted 75 classes, with 1600 young people attending from Switzerland and southern Germany.

User Service

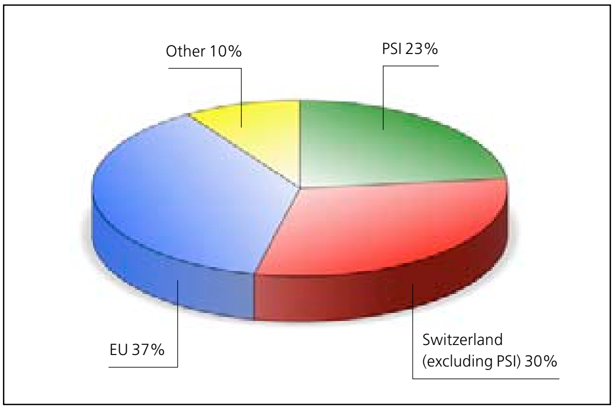
In 2008, PSI kept its position as an attractive User Lab to scientists from all over the world. More than 2300 users visited the Institute and performed more than 1600 experiments at the 40 beamlines available at the large-scale facilities. The high demand is reflected by the overbooking that occurred, that was somewhere between 2 and 3 for most beamlines, and reached a value of 6.5 for the PXI beamline at SLS. The number of publications in high-profile journals, based on research within the departments Synchrotron Radiation and Nanotechnology (SYN) and Condensed Matter Research with Neutrons and Muons (NUM), reached a new high. SYN research produced 41 papers in Nature, Science, PRL or Cell, and research at NUM 33 papers.

User lab 2008

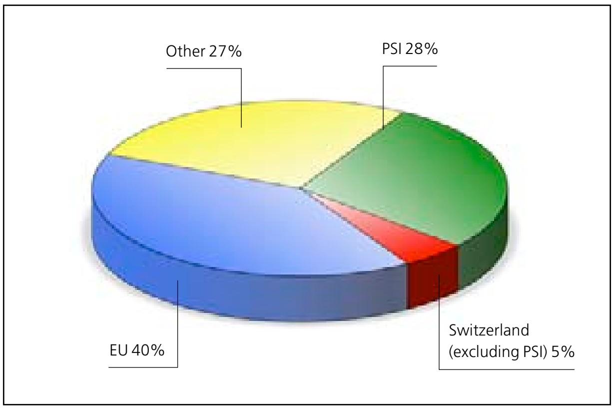
	SLS	SINQ	SμS	Particle physics	PSI total	(2007)
No. of beamlines/ instruments	14	13	6	7	**40**	(40)
No. of experiments	1036	446	168	8	**1658**	(1372)
No. of user visits	2912	677	185	180	**3954**	(3517)
No. of individual users	1616	447	151	120	**2334**	(1887)



Geographic distribution of SLS users 2008, all beamlines.



Geographic distribution of SINQ users 2008.



Geographic distribution of SμS users 2008.

Commission and committees

(status at the end of 2008)

Research Commission

External Members

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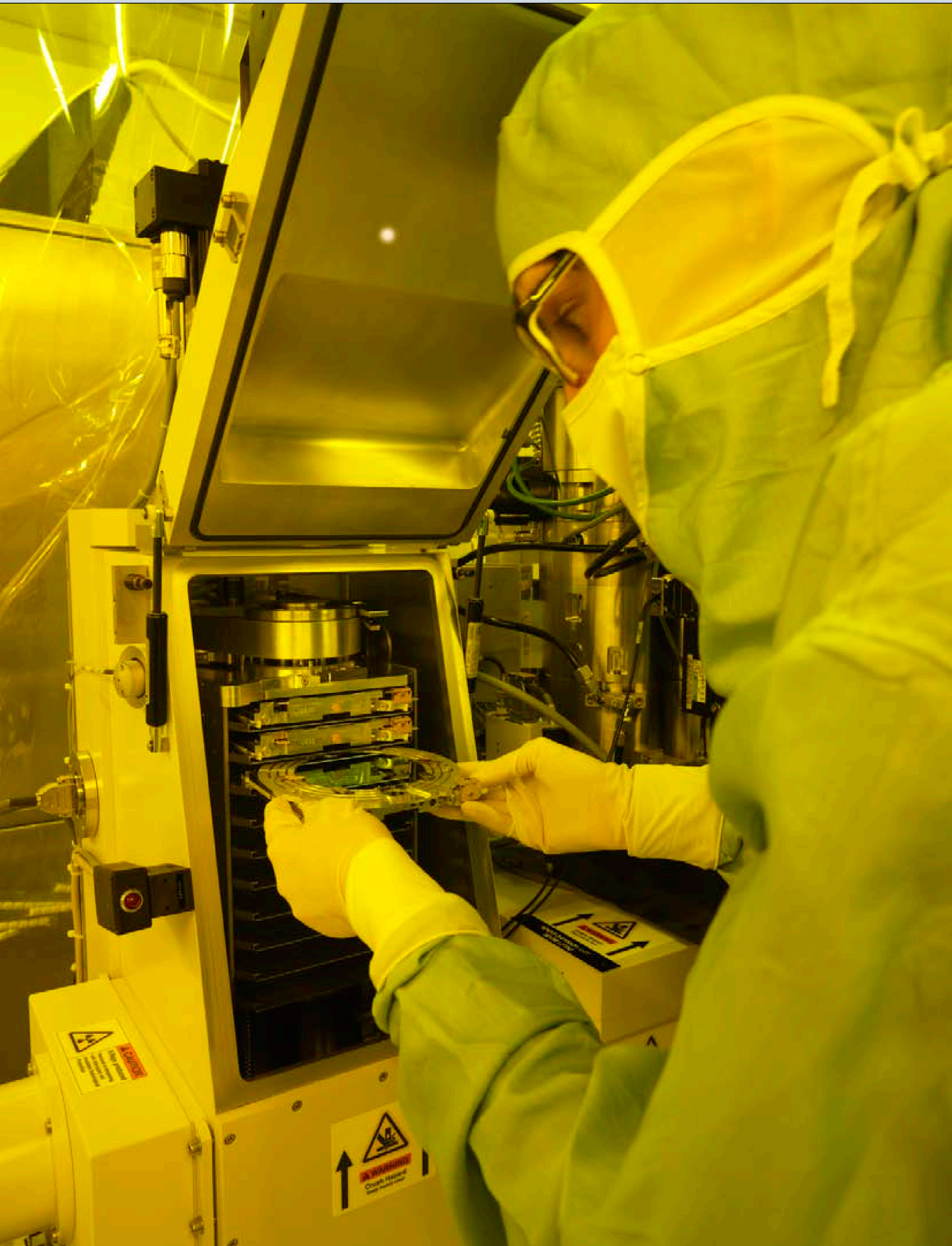
Swiss Federal Office of Energy, Berne, CH



Publications 119

Where to find what

On CD and online

The publication lists for all PSI departments can be found on the CD version of this report, which can be ordered at www.psi.ch (Media/ Info Material) or by phone +41 (0)56 310 21 11.

The lists include the following:

- Peer-reviewed publications
- Invited talks
- Dissertations
- Conference Proceedings
- Lectures

Also included on the CD is the Annual Report (Jahresbericht) in German.

Links to other research not featured here can be found on our website: www.psi.ch (Research at PSI).

◀ **Elena Mengotti, PhD student at the Laboratory for Micro- and Nanotechnology, at the electron writer she uses to prepare nanosamples for her investigations.**

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Lomax, A.J., *Intensity modulated proton therapy and its sensitivity to treatment uncertainties 1: the potential effects of calculational uncertainties.* Phys. Med. Biol. 53 (2008) 1027-1042

Munier FL, Verwey J, Pica A, Balmer A, Zografos L, Abouzeid H, Timmerman B, Goitein G, Moeckli R. *New developments in external beam radiotherapy for retinoblastoma: from lens to normal tissue-sparing techniques.* Clin Experiment Ophthalmol. 2008 Jan-Feb;36(1):78-89.

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CONFERENCE AND WORKSHOP CONTRIBUTIONS

Albertini F, Lomax A. *Intensity Modulated Proton Therapy: influence of starting conditions on the optimized dose distribution.* (SGSMP, Chur 2008)

Ares C, Lomax T, Goitein G, Bolsi A, Timmermann B, Rutz HP, Coray D, Pedroni ES, Hug EB. *First Report on Late toxicity after spot Scanning Proton Radiation therapy for Skull Base Tumors.* 12th Annual Meeting, Scientific Association of Swiss Radiation Oncology, Lausanne, April 2008.

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Bührer S, Frei M, Suetterlin M, Mauch J, Feurer R, Immoos S, Timmermann B, Hug E, Weiss M. *Course of base excess and lactate concentration during repeated prolonged deep propofol sedation in children undergoing proton radiation therapy.* Jahreskongress, Schweizerische Gesellschaft fuer Anaesthesiologie und Reanimation (SGAR), Fribourg, Schweiz, October, 2008

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Schippers M, Duppich J, Goitein G, Hug E, Jermann M, Pedroni E, Heufelder J, van gothem MJ, Verwey J. *The first year of clinical operation of the SC cyclotron and beam lines at PSI's new proton therapy center.* Annual Meeting, Particle Therapy Cooperative Group (PTCOG 47) Jacksonville, Florida, USA, Mai, 2008

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Verwey J, Heufelder J, van Goethem J-M, Zografos L, Jermann M, Goitein G, Hug E. *OPTIS2 – The new ocular proton therapy facility at PSI.* PTCOG 47, May 19-24, 2008, Jacksonville, FL (USA)

Invited Talks:

E. Hug.
Particle Therapy in Europe: Present State and Near Future
21st International Symposium. Foundation for Promotion of Cancer Research. National Cancer Center, Tokyo, Japan, Februar, 2008

E. Hug.
Technische Innovationen in der Strahlentherapie.
Protonen Symposium. Kantonsspital St. Gallen, März, 2008

E. Hug.
Proton Therapy – What could be possible

5th Engadin Prostate Cancer Winter Symposium, März, 2008
E. Hug.
Proton Therapy in Switzerland
Ospedale Regionale Bellinzona e Valli, San Giovanni, April, 2008

E. Hug.
Protonen Therapie für Weichteilsarkome.
14. Jahreskongresss der DEGRO, 25. Jahreskongress, ÖGRO, Wien, May 2008

E. Hug.
Long Term Patient Outcomes Following Proton Beam Therapy for Skull Base Tumors.
5th International Congress of the World Federation of Skull Base Societies. 19th Annual Meeting of the North American Skull Base Society. Vancouver, Canada, September, 2008

E. Hug.
Spot Scanning based proton therapy – the next generation.
Jahreskongress, Children's Oncology Group, Denver, USA, Oktober 2008

E. Hug.
Protontherapy: The Gold Standard for next Generation Clinical Trials?
18. Jahreskongress, AIRO Italienische Gesellschaft für Radioonkologie, Mailand, November 2008

E. Hug.
Technische Innovationen in der Strahlentherapie – Protonen.
Symposium. Kantonsspital St. Gallen, März, 2008

E. Hug.
Proton Therapy – What could be possible.
5th Engadin Prostate Cancer Winter Symposium, März, 2008

E. Hug.
Neurologische Indikationen für die Protonen-Radiotherapie.
KSA, Neurozentrum, März 2008.

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Proton Therapy in Neurooncology: Indications and Results.
USZ, Klinik für Neurochirurgie, Mai 2008.

E. Hug and Manser, P. (2008),
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6. Zuppinger Symposium der Bernischen Radium-Stiftung: Im Technorama der Radioonkologie, Bern, 25.06.08.

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Grundlagen der Protonentherapie und Fragen an den Radiologen.
KSA Klinik für Radiologie, Nov. 2008.

E. Hug.
Protonentherapie von der Forschungsenklave zu akzeptierter Behandlungsmodalität.
USZ, Klinik für Gesichts- und Kieferchirurgie, Nov. 2008.

E. Hug.
Protonentherapie für Patienten mit Sarkomen.
Uniklinik Balgrist, Nov.2008.

A.J. Lomax
Importance of starting conditions for optimising IMPT: Giving power to the planner?
Huangguoshu International workshop on Biomedical Mathematics, Huangguoshu, China, November, 2008

A.J. Lomax.
Clinical proton therapy: Planning, positioning and patients.
Invited seminar, Kantonspital Aarau, October 2008

A.J. Lomax.
Range and robustness: The good and bad of proton therapy
Invited seminar, Varian Ltd, Daetwil, October 2008

A.J. Lomax.
Potential and challenges of Intensity Modulated Proton Therapy.
Invited Seminar, Institute for Bio-medical Technology, ETH, Zurich, October 2008

A.J. Lomax.
Future directions and current challenges of proton therapy.
European Science Foundation workshop, Oxford, UK, September 2008

A.J. Lomax.
Current challenges in hadron therapy.
27th ESTRO congress, Gotheborg, Sweden, September 2008.

A.J. Lomax.
Is there still a role for proton therapy?
BIR/IPEM Spring meeting, London, UK, June 2008

A.J. Lomax
Clinical aspects of proton therapy.
MD Anderson Hospital, Houston, USA, May 2008

A.J. Lomax
Practical aspects of proton therapy with scanned beams.
Invited seminar, MD Anderson Hospital, Houston, USA, May 2008

A.J. Lomax
Treatment planning for scanned proton beams and IMPT
PTCOG teaching course, Jacksonville, USA, May 2008

A.J. Lomax.
State-of-the-art Proton Therapy: The physicist's perspective.
Keynote lecture, PTCOG, Jacksonville, USA, May 2008

A.J. Lomax
Current status of proton therapy at the Paul Scherrer Institute.
Radiation Biology Program Retreat, Stanford University, April 2008

A.J. Lomax
Strahlentherapie mit Protonen: Aktuelle Technik und neue Entwicklungen.
Physikalische Gesellschaft Zurich, Zurich, February 2008.

A.J. Lomax
State-of-the-art in proton therapy: modern delivery techniques and current challenges
MASSTRO, Maastricht, Holland, January 2008.

E. Pedroni
Hadrontherapy facilities worldwide
European Particle Accelertor Conference - EPAC
Genoa 24.06.2008

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Proton Beam Delivery Techniques and Commissioning Issues: Scanning
BeamsEducational Pre-Meeting – 19.05.2008
PTCOG 47 Jacksonville Florida, USA

Timmermann B.
Protonentherapie von Malignomen im Kindesalter am Paul Scherrer Institut: eine prospektive Untersuchung.
Wien, DEGRO 2008, Mai

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Spot-Scanning Proton Therapy for Malignant Brain Tumours in early Childhood: First Experiences at PSI.
SIOP 2008, Oktober, Berlin.

Timmermann B.: Maier S., Stadelmann O., Hug E.
Proton Radiation Therap for Childhood Cancer at PSI.
GPOH 2008, November, Wien.

Timmermann B.
Modern Radiotherapy in Brain Tumours: techniques and Concepts.
SYRAD Workshop, ESFR, Grenoble 6/08

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State of the Art lecture dedicated to Radiotherapy appraoches in CNS tumours.
SIOP 2008, Berlin, 3. Oktober

Timmermann B.
Radiation Therapy for Childhood Malignancies.
Curso de Neuro-Oncologia Pediatrica. Barcelona 10/08

Teaching activities

E. Hug:

Co-Director and lecturer:
ESTRO Teaching Course on Protons and Ions, Heidelberg, 2008

Director and lecturer: PSI Winter School on Proton Therapy, Bad Zurzach, January 2008

T. Lomax:

Lecturer - ESTRO teaching course on Proton and Heavy-Ion Therapy
Co-director and Lecturer – PSI Winter School on Scanned Proton Therapy

Physics Option at ETH – ‘Physics in Medical Research – from Humans to Cells’
Physics Option at ETH – ‘Medical Physics III – New Trends in Radiotherapy’

UNIVERSITY LEVEL AND OTHER TEACHING

B.P. Andreasson
Physik für Informatiker, 402-0038-00 U
Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland 19.02-27.05.2008

B.P. Andreasson
Advanced Solid State Physics, 402-0257-00 U
Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland 02.10-11.12.2008

H. Dil
Electron Spectroscopy
Universität Zürich, Physik 1, FS 2008

J. Gobrecht, H. Schift
Nanotechnologie für Ingenieure
Fachhochschule Nordwestschweiz, Windisch, HS 2008

F. Gozzo
Non-conventional sources: X-ray powder diffraction using Synchrotron Radiation
Structure Determination from Powder Diffraction Data: A Hands-on Workshop on X-Rays, Synchrotron Radiation and Neutron Techniques. Paul Scherrer Institute, Switzerland, 18-22.6.2008

L.J. Heyderman
Magnetic Imaging Techniques
Seminar in Lecture Series 'Magnetism and Spin Dependent Transport' (Prof. Rüdiger), Universität Konstanz, 7.7.2008

L.J. Heyderman
Magnetic Nanostructures and X-rays
Lecture at the Summer School on Condensed Matter Research (Probing the Nanometre Scale with Neutrons, Protons and Muons), Zuoz 16-22.08.2008

L.J. Heyderman
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Lecture at the Summer School NANOMA-II 2008 (Physics and Chemistry of Nano Materials – Preparation, Analytics, Theory and Applications), Cluj-Napoca, Romania 17-30.8.2008

M. Nachtegaal, M. Janousch
Cook and look: Synchrotron techniques
Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland, Kursnr. 701-1336-00L, FS 2008

C. Padeste
Preparation of Bio-Active Model Systems using Micro- and Nanolithographic Tools
Nanobiomat Workshop, Middle East Technical University, Ankara, Turkey 1-2.9.2008

S. A. Pauli
Physik-Kolloquium für Mediziner
University of Zürich, Switzerland, HS 2008

B. Patterson, C. Weyer, H. Sigg,
SLS Student 'Praktikum'
Paul Scherrer Institut, Villigen, Switzerland, 24-27.8.2008

F. Pfeiffer
Coherent Imaging with X-rays and neutrons
PSI Summer School, Zuoz, 08.2008

F. Pfeiffer
Coherent Imaging with X-Rays and Neutrons
HERCULES - European Research School on Soft Matter Imaging & Scattering, ESRF, Grenoble, France, 11.2008

F. Pfeiffer
Coherent X-Ray Imaging for Life Science Applications
Graduate School for Laser Physics, DESY, Hamburg, Germany, 12.2008

F. Pfeiffer
X-Ray Imaging and Tomography
CIBM lecture, EPFL, 12.2008

C. Schulze-Briese
Protein Crystallography
CIMST Summer School on Biomedical Imaging, Zurich, Switzerland, 10.09.2008

H. Schift
LIGA technology
Seminar for Master of Micro- and Nanotechnology (MNT), Dornbirn, Austria 11.01.2008

H. Schift
Nanoreplication technology
Master of Engineering in Packaging Technology, International Packaging Institute (IPI), Neuhausen, Switzerland 13.09.2008

M. Stampanoni
Micro and Nano-Tomography of Biological Tissues
ETHZ-Lecture: 227-0965-00G

M. Stampanoni
Aktuelle Forschung in der biomedizinischen Technik
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M. Stampanoni
X-ray Tomographic imaging: a fascinating trip from macro to nano
CIMST: Interdisciplinary Summer School on Biomedical Imaging, 2-12.9.2008

M. Stampanoni
X-ray Tomographic Microscopy
7th PSI Summer School on Condensed Matter Research, 17-23.8.2008

J.F. van der Veen
Physik
Bachelorstudiengang Informatik, ETH Zürich, FS 2008

J.F. van der Veen
Materials research using synchrotron radiation
Masters course ETH Zürich, HS 2008

P. R. Willmott
Introduction to Synchrotron Radiation and Synchrotron Techniques
University of Zürich, Switzerland,Course No. CHE822, HS 2008

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Surface and Interface Analysis of In-situ Grown Thin Films
7th PSI Summer School on Condensed Matter Research, Zuoz, Switzerland, 16-22.08.2008

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Physik mit Photonen
ETHZ-Studenten Colloquium, PSI, Villigen, Switzerland, 21.05.2008

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– *Entwicklung eines Nanoimprint Prozesses mit breitem Prozessfenster für Nanoporen-Anordnungen*
  C. Spreu, University of Applied Sciences Bremen, 2008

M. Shi, J. Mesot, Master thesis coached

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  E. Razzoli, Politechnico di Milano, Italy, 2008

H. Sigg

- *Characterisierung von Quantenkaskendenstrukturen mittels IR Spektroskopie an der SLS*
  C. Janssen, University of Zurich, 2008

M. Stampanoni, C. Hintermüller

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INVITED TALKS

P. Beaud
Observing Femtosecond Dynamics in Solids with X-ray Diffraction
Seminar, Center for Applied Photonics, Universität Konstanz, Germany, 15.05.2008

R. Bingel-Erlenmeyer
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O. Bunk
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O. Bunk
Scanning SAXS: imaging the nanoscale structure of extended objects
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Recent developments in x-ray phase contrast imaging
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O. Bunk
cSAXS at PSI: The coherent small angle x-ray scattering beamline at the Swiss Light Source
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A. Cervellino
Analysis of partially ordered (nano) materials through the Debye function method
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A. Cervellino
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C. David
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C. David
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C. David
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M. Dierolf
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Workshop on X-Ray Micro Imaging of Materials, Devices, and Organisms, Dresden, Germany, 22-24.10.2008

H. Dil
Influence of the interface on electron confinement in thin metal films
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H. Dil
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A. Fraile-Rodríguez
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NFFA – 2nd Coordination Board Meeting, Diamond Light Source, Didcot, UK, 31.07.2008

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L.J. Heyderman
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T. Huthwelker
Keynote lecture: New experimental approached to the study of ices and aerosols
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G. Ingold
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M. Janousch
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Workshop on X-ray absorption spectroscopy and advanced XAS techniques, Paul Scherrer Institut, Switzerland, 6-10.10.2008

I. Johnson
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Seminar, Photon Factory, Tsukuba, Japan, 01.09.2008

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Nano fracture mechanics for studying adhesion and corrosion on interfaces and grain boundaries
EMPA Seminar talk, Thun, Switzerland, 04.11.200

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2-D Membrane Protein Crystallography at Future XFELs
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F. Luo, L. J. Heyderman, H. H. Solak
Patterned Nanoscale Perpendicular Magnetic Dot Arrays
Seminar at Bochum University, Bochum, Germany, 16.05.2008

F. Marone
Synchrotron-based X-ray Microtomography in the Geosciences
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S. A. McDonald
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Symposium, Physics Institute, University Basel, Switzerland, 10.-11.09.2008

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A close Look at Nanomagnets Using Spectromicroscopy
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V. Olieric
Specific and global radiation damage in nucleic acid crystals at 90K and 5K
Fifth International Workshop on X-ray Damage to Biological Crystalline Samples, Villigen PSI, Switzerland, 03-05.03.2008

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X-Ray Phase Contrast Imaging for Life Science Applications
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Doing Science with Light
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PEEM - Photo Emission Electron Microscopy
Maxlab summer school, Lund, Sweden, 01.06.2008

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Dynamics of mesoscopic magnetic structures
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University of Michigan, Ann Arbor, MI, USA, 07.08.2008

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3rd International Workshop on Approaches to Single-Cell Analysis, Zürich, Switzerland, 11-12.09.2008

WORKSHOPS AND CONFERENCES

A. Fraile Rodríguez
Co-organization of a Special Session on Multiferroics at the Annual meeting of the Swiss Physical Society 2008
Genève, Switzerland, 26-27.03.2008

F. Gozzo
Structure Determination from Powder Diffraction Data: A Hands-on Workshop on X-Rays, Synchrotron Radiation and Neutron Techniques
Paul Scherrer Institute, Switzerland, 18-22.06.2008

F. Gozzo
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C. Quitmann, C. David, F. Nolting, M. Stampanoni, F. Pfeiffer
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C. Schulze-Briese
Workshop on X-ray Damage to Biological Crystalline Samples
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U. Staub
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PUBLIC RELATIONS

R. Abela
- SLS - Ein riesiges Mikroskop: Wie funktioniert die SLS: brilliantes Licht aus beschleunigten Elektronen, Oral Presentation for the 20 years of PSI, Baden, Switzerland, 22.08.2008

A. Fraile Rodríguez
- Presentation at the "Showstation 1 Bühne" during the "Tage der offenen Türe", Paul Scherrer Institut, Villigen, Switzerland, 25.-26.10.2008

J. Gobrecht
- Project reports on applied nanoscience, Industry day 2008, Swiss Nanoscience Institute, Muttenz, Switzerland, 26.02.2008
- Physik zwischen Atomen und Alltagswelt, Forscher im Zelt, Waldshut, Germany, 27–31.08.2008
- Science Fiction wird Realität – dank Nanotechnologie?, TecDay@Kanti Baden, Kantonsschule, Baden, Switzerland, 09.10.2008
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T.A. Jung
- “Stoff für Forscher und Science-Fiction-Autoren”, Beate Peiseler Sutter, Beitrag über das Swiss Nanoscience Institute in der Chemischen Rundschau, Ausgabe Nr. 10, 10.2008

F. Marone
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- Unsichtbares sichtbar machen: brillantes Licht aus beschleunigten Elektronen, Tag der Offene Türen, Paul Scherrer Institut, Villigen, 26.10.2008

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F. Pfeiffer
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C. Quitmann

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H. Schift

- *A precious envelope for budding scientists - an educational film on new fabrication techniques at the nanometric scale,* Animation movie in the framework of the European NaPa project, duration 16 min, director F. Grimal, author C. Cartaillac, production Héladon (Toulouse, France), Multilingual DVD (French, English, German), compiled by H. Schift; available in PSI Forum

M. Stampanoni

- Un viaggio al Paul Scherrer Institut, Live guest at the “Il giardino di Albert”, Televisione della Svizzera Italiana, 07.01.2008

DISSERTATIONS

L.J. Heyderman

- *Spin structure of domain walls and their behaviour in applied fields and currents*
  D. Backes, University of Konstanz, Germany, (2008)

C. Padeste

- *Synchrotron Radiation Grafting: a lithographic method to create polymer micro- and nanostuctures.*
  P. Farquet, ETH Zürich, Switzerland, (2008)

L. Patthey

- *Angle- and spin-resolved photoemission on* $La_{2/3}Sr_{1/3}MnO_3$
  J. Krempasky, Université de Cergy-Pontoise, France, (2008)

AWARDS

M. Dierolf, I. Johnson, O. Bunk, S. Kynde, O. Marti, F. Pfeiffer, *Ptychographic Iterative Diffraction Microscopy with Laser Light,* Best Poster Award, 404. WE-Heraeus-Seminar, “Matter in Coherent Light”, Bad Honnef, Germany, 17-20.03.2008

F. Pfeiffer, *National Latsis Award of Switzerland*, 2008

P. Thibault, *Werner Meyer-Ilse Memorial Award*, X-ray Microscopy Conference, 23.07.2008

MEMBERSHIPS IN EXTERNAL COMMITTEES

R. Abela

- Chairman of the Scientific Advisory Committee, ESRF, France
- Chairman of the Council of the Swiss Norwegian Foundation for Research with X-Rays
- Member of the Scientific Advisory Committee of Diamond, UK

C. David

- Member of the International Program Committee of the Micro- and Nano-Engineering Conference 2007
- Member of the International Consortium for Coherent X-ray Diffractive Imaging (ICCDXI)
- Member of the Scientific Advisory Board of the Courant Research Centre "Nano-Spectroscopy and X-ray Imaging", University of Göttingen, Germany
- Member of the Editorial Board of the Journal of X-ray Optics and Instrumentation
- Member of the International Program Committee of the X-Ray Microscopy Conference Series
- Member of the International Advisory Committee of the Photon Conference Series

J. Gobrecht

- Head of the Institute of Polymer Nanotechnology, University of Applied Sciences Nordwestschweiz, Brugg/Windisch, Switzerland

- Vice Director Technology of the Swiss Nanoscience Institute at the University of Basel
- Member of the board of the Swiss Micro- and Nanotechnology Network
- Member of the nomination committee for the Nano Argovia professorship on quantum optics at the University of Basel
- Member of the management team of the Matlife ERU, CCMX Program of the ETH domain
- Member of the Scientific Advisory Board, HeiQ Materials AG, Bad Zurzach, Switzerland
- External thesis reviewer and member of the board of examiners for the PhD of Dirk Backes, Physics dept., University of Konstanz, 2008
- External thesis reviewer and member of the board of examiners for the PhD of Jean Baptiste Orhan, Microtechnology dept., EPFL Lausanne, 2008
- Member of the advisory board of the Nano-Europe Conference, St. Gallen, Switzerland, Sept. 16-17, 2008
- Member of the board of directors, Eulitha AG, 5232 Villigen PSI
- Member of the jury for the "Nano-Prize 2008" of the "Erwin Schrödinger Gesellschaft für Nanowissenschaften", Vienna, Austria
- Member of the jury for the "Förderpreis für Jungunternehmen" of the "W. A. de Vigier Foundation", Solothurn, Switzerland

F. Gozzo

- Powder Diffraction beamline Expert – Beamlines Coordinator Meeting, SESAME (Synchrotron light for Experimental Sci. & Appl. in the Middle East) Project, c/o UNESCO Amman Office, Amman, Jordan
- Member of the Commission of Instrumentation and Computing, Italian Crystallography Association

L.J. Heyderman

- Intermag 2008 Program Committee
- Member of the Technical Committee of the IEEE Magnetics Society
- MNE2008, International Program Committee

T.A. Jung

- Jung Zukunft Bildung Schweiz Thinktank der Akademien Schweiz, 2008
- Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) European Commission Directorate General Health & Consumer Protection 2005—2008

F. Nolting

Member of the Proposal Review Committee of Soleil, France

Member of DEIMOS beamline review committee, Soleil, France

Scientific Committee of the 5th International school on Synchrotron Radiation and Magnetism 2008, Mittelwihr (France)

Member of the organisation team for the 9th International Conference on X-ray Microscopy, Zürich, 21-25.7.2008

Member of the PhD Thesis committee, Loic Le Guyader, University of Nijmegen, The Netherlands, 2.4.2008

L. Patthey

- Chairman of the Local Organisation Committee, CORPES-09 workshop
- Member of the International Program Committee, CORPES-09 workshop

F. Pfeiffer

- Member of the scientific advisory committee for the first International Workshop on Single Particle Diffractive Imaging at the future EU-XFEL sources, Uppsala, Sweden, November 2008

- Member of the scientific proposal review committee for the European Synchrotron Radiation Facility (Grenoble/ France), the National Synchrotron Light Source in Taiwan, and the Spallation Neutron Source (Oak Ridge/US)

C. Quitmann

- Member of the Diamond Scientific Advisory Committee
- Member of the Editorial Board, Journal of Physics Condensed Matter, Surface and Interface section
- Member Nanoscience Beamline Review Pannel, Diamond

H. Schift

- AVS American Vacuum Society, NSTD Nanometer-scale Science and Technology Division, elected board and executive committee member

C. Schulze-Briese

- APS Renewal Workshop, APS, ANL, USA
- ESRF Upgrade Programme - UPBL brainstorming session, Grenoble, France
- ESRF Beamline Review Committee (ID11), Grenoble, France
- ESRF Methods & Instrumentation Proposal Review Committee, Grenoble, France
- EMBL@PETRA3 Scientific Advisory Board, Hamburg, Germany
- IUCR 2008, Chairman of 'Recent Progress in Data Collection Session, Osaka, Japan

U. Staub

- Member of the Excecutive Committee of the Swiss Physical Society representing condensed Matter

M. Stampanoni

- Member of the steering committee of the Zurich Center for Imaging Science and Technology (CIMST)

J. F. van der Veen

- Science Advisory Committee of Elettra, Trieste
- Scientific Committee for Inorganic and Analytical Chemistry, Science Foundation, Flanders, Belgium
- Chairman of Programme Committee of PSI Summer School on Condensed Matter Research, Zuoz, Switzerland
- Scientific Advisory Committee of HERCULES, Grenoble.
- Chairman of Science Advisory Committee of the Advanced Light Source, Berkeley, USA
- International Advisory Committee of the International Conference Series on Synchrotron Radiation Instrumentation
- Science Advisory Committee of Synchrotron SOLEIL, Gif-sur-Yvette, France
- Advisory Committee of the International Conference Series on Surface X-Ray and Neutron Scattering
- Steering Committee CCMX, Competence Centre for Materials Science and Technology, ETH, Switzerland
- Steering Committee NCCBI, National Competence Center in Biomedical Imagine, ETH, Switzerland
- Science Advisory Committee for the Van der Waals-Zeeman Instituut, University of Amsterdam, The Netherlands
- Advisory Board ‘Structure of Matter’, Forschungszentrum Karlsruhe, Germany
- Member of Committee advising the Bundesministerium für Bildung und Forschung (BMBF) on research with photons in Germany

- Science Advisory Committee of National Synchrotron Radiation Research Center, Hsinchu, Taiwan

P. R. Willmott

- Member of the Committee of the Future of the SNBL Beamline, ESRF

PATENTS

C. David, T. Donath, E. Hempel, M. Hoheisel, F. Pfeiffer, S. Popescu
Röntgen CT-System zur Röntgen Phasenkontrast- und/oder Röntgen-Dunkelfeld-Bildgebeung
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K. Clausen
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Sacchetti A, Weller M, Gavilano JL, Mudliar R, Pedrini B, Magishi K, Ott HR, Monnier R, Delley B, Onuki Y
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Photogeneration of metastable side-on N-2 linkage isomers in [Ru(NH3)(5)N-2]Cl-2, [Ru(NH3)(5)N-2]Br-2 and [Os(NH3)(5)N-2]Cl-2
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Soon A, Wong L, Delley B, Stampfl C
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Tabei SMA, Vernay F, Gingras MJP
Effective spin-1/2 description of transverse-field-induced random fields in dipolar spin glasses with strong single-ion anisotropy
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Todorova T, Delley B
Wetting of paracetamol surfaces studied by DMol3-COSMO calculations
MOLECULAR SIMULATION **34**, 1013 (2008)

Todorova T, Delley B
The Creutz-Taube Complex Revisited: DFT Study of the Infrared Frequencies
INORGANIC CHEMISTRY **47**, 11269 (2008)

Vernay F, Moritz B, Elfimov IS, Geck J, Hawthorn D, Devereaux TP, Sawatzky GA
CuK-edge resonant inelastic x-ray scattering in edge-sharing cuprates
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Zhang H, Soon A, Delley B, Stampfl C
Aluminium adsorption on Ir(111) at a quarter monolayer coverage: A first-principles study
APPLIED SURFACE SCIENCE **254**, 7655 (2008)

Zhang H, Soon A, Delley B, Stampfl C
Stability, structure, and electronic properties of chemisorbed oxygen and thin surface oxides on Ir(111)
PHYSICAL REVIEW B **78**, 045436 (2008)

CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

Chr. Mudry
Delocalization Transitions and Multifractality
A Satellite Meeting at Gregynog Hall, University of Wales, November 2-6, 2008.

Chr. Mudry
Mathematics and Physics of Anderson localization: 50 Years After Delocalization Transitions and Multifractality,
Isaac Newton Institute for Mathematical Sciences, Cambridge University, July 14 - December 19, 2008.

Chr. Mudry
Exact Results in Low-Dimensional Quantum Systems:
2nd INSTANS Summer Conference, Galileo Galilei Institute for Theoretical Physics, University of Florence, September 08 - 12, 2008.

Chr. Mudry
Probing the Nanometer Scale with Neutrons, Photons and Muons
7th PSI Summer School on Condensed Matter Research, 16-22 August 2008, Lyceum Alpinum Zuoz, Switzerland.

Chr. Mudry
WE Heraeus Seminar: *Network Models in Quantum Physics*, at Jacobs University Bremen, July 21 - 25, 2008.

PROCEEDINGS

K. Chuasiripattana, O. Warschkow, B. Delley and C. Stampfl.
The Cu/ZnO(0001) Surface under Oxidative and Reducing Conditions: A First-principles Study
APS March meeting New Orleans Mar 12
BAPS: P21.00007

B. Delley and T.Todorova
Molecular Crystals, a Test System for Weak Bonding
APS March meeting New Orleans Mar 12
BAPS: Q13.00005

INVITED TALKS

Kurt Clausen
Fission, Spallation or Fusion-based neutron sources
International symposium of Neutron scattering, Mumbai, India, 15-18 January 2008

Kurt Clausen
Neutron scattering: properties, status and perspectives
29th Risø International Symposium on materials science: Energy Materials - Advances in Characterization, Modelling and Application, 1-5 September 2008

B. Delley
Quantum mechanics for molecules,surfaces and solids
Feb 5 Chemisches Colloquium Uni. Hamburg

B. Delley
An overview of electronic structure calculations with DMol^3
Apr 3 Colloquium Nanotek Institute, Bangkok

B. Delley
$DMol^3$ applications from molecules to surfaces and solids
Aug 26 FPLO-Workshop Dresden

B. Delley
An overview of electronic structure calculations with $DMol^3$
Mar 30 Thailand Electronic Structure Workshop, at University Ubon Rachathani

B. Delley
An overview of electronic structure calculations with $DMol^3$
Apr 15 ETHZ

Chr. Mudry
Quantum transport of 2D Dirac fermions: The case for a topological metal, Delocalization Transitions and Multifractality
Satellite Meeting at Gregynog Hall, University of Wales, 2008

Chr. Mudry
Electron fractionalization in two-dimensional graphene-like structures
National Seminar Condensed Matter Physics, Dutch Research School of Theoretical Physics, 2008

Chr. Mudry
Electron fractionalization in two-dimensional graphene-like structures
Workshop on Exact Results in Low-Dimensional Quantum Systems: 2nd INSTANS Summer Conference, Galileo Galilei Institute for Theoretical Physics, University of Florence, 2008

Chr. Mudry
Introduction to the physics of grapheme
7th PSI Summer School on Condensed Matter Research, 16-22 August 2008 Lyceum alpinum Zuoz, Switzerland

Chr. Mudry
Quantum transport of 2D Dirac fermions: The case for a topological metal
WE Heraeus Seminar: Network Models in Quantum Physics, at Jacobs University Bremen, 2008

Chr. Mudry
Quantum transport of 2D Dirac fermions: The case for a topological metal
University of Oxford, October 2008.

Chr. Mudry
Electron fractionalization in two-dimensional graphene-like structures
University of Warwick, October 2008.

Chr. Mudry
Freezing transition in a problem of Anderson localization
Cambridge University, October 2008

Chr. Mudry
Electron fractionalization in two-dimensional graphene-like structures
Instituto de Ciencia de Materiales de Madrid (ICMM), March 2008.

LECTURES AND COURSES

Dr. Christopher Mudry
- Visiting Fellowship, Isaac Newton Institute for Mathematical Sciences, University of Cambridge, UK.
- Visiting Research Scholar, Boston University, USA.

MEMBERSHIP IN EXTERNAL COMMITTEES

Dr. K. Clausen
- Member of the ESS-Scandinavia Science Group (since 2004)
- Member of the Board of NMI3 (since 2004)
- Member of the Scientific Selection Panel of the Berlin Neutron Scattering Centre (since 2005)
- Member of the Science Program Advisory Council for Condenced Matter Physics and Nanoelectronics at Research Centre Jülich, Germany (since 2006)
- Chairman of the BENSC Instrument Committee (since 2006)
- International Advisory Committee for The RIKEN-RAL Muon Facility

Dr. B. Delley
- Advisary Board Electronic Structure Theory, EMRS conference series
- Psi-K network local orbital topical group
- PSI-Forschungs Komission

Condensed Matter Research with Neutrons and Muons

Spallation Neutron Source Division (ASQ)

LIST OF PUBLICATIONS (PEER REVIEWED)

Ahrenholz B, Tolke J, Lehmann P, Peters A, Kaestner A, Krafczyk M, Durner W
Prediction of capillary hysteresis in a porous material using lattice-Boltzmann methods and comparison to experimental data and a morphological pore network model
ADVANCES IN WATER RESOURCES **31**, 1151 (2008)

Appleby GA, Vontobel P
Optimisation of lithium borate-barium chloride glass-ceramic thermal neutron imaging plates
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **594**, 253 (2008)

Aswal VK, Van den Brandt B, Hautle P, Kohlbrecher J, Konter JA, Michels A, Piegsa FM, Stahn J, Van Petegem S, Zimmer O
Characterisation of the polarised neutron beam at the small angle scattering instrument SANS-I with a polarised proton target
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Bitzek E, Brandl C, Derlet PM, Van Swygenhoven H
Dislocation cross-slip in nanocrystalline fcc metals
PHYSICAL REVIEW LETTERS **100**, 235501 (2008)

Bitzek E, Derlet PM, Anderson PM, Van Swygenhoven H
The stress-strain response of nanocrystalline metals: A statistical analysis of atomistic simulations
ACTA MATERIALIA **56**, 4846 (2008)

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Boillat P, Kramer D, Seyfang BC, Frei G, Lehmann E, Scherer GG, Wokaun A, Ichikawa Y, Tasaki Y, Shinohara K
In situ observation of the water distribution across a PEFC using high resolution neutron radiography
ELECTROCHEMISTRY COMMUNICATIONS **10**, 546 (2008)

Boillat P, Scherer GG, Wokaun A, Frei G, Lehmann EH
Transient observation of H-2 labeled species in an operating PEFC using neutron radiography
ELECTROCHEMISTRY COMMUNICATIONS **10**, 1311 (2008)

Brandstetter S, Derlet PM, Van Petegem S, Van Swygenhoven H
Williamson-Hall anisotropy in nanocrystalline metals: X-ray diffraction experiments and atomistic simulations
ACTA MATERIALIA **56**, 165 (2008)

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Grain coarsening during compression of bulk nanocrystalline nickel and copper
SCRIPTA MATERIALIA **58**, 61 (2008)

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS **266**, 155 (2008)

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SIMS investigation of the spallation and transmutation products production in lead
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Gilbert MR, Dudarev SL, Derlet PM, Pettifor DG
Structure and metastability of mesoscopic vacancy and interstitial loop defects in iron and tungsten
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Giller L, Filges U, Kuehne G, Wohlmuther M, Zanini L
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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **586**, 59 (2008)

Grosse M, Kuehne G, Steinbrueck M, Lehmann E, Stuckert J, Vontobel P
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JOURNAL OF PHYSICS-CONDENSED MATTER **20**, 104263 (2008)

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Kinetics of hydrogen absorption and release in zirconium alloys during steam oxidation
OXIDATION OF METALS **70**, 149 (2008)

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APPLIED PHYSICS LETTERS **93**, 112504 (2008)

Grunzweig C, Pfeiffer F, Bunk O, Donath T, Kuhne G, Frei G, Dierolf M, David C
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ADVANCES IN WATER RESOURCES **31**, 1174 (2008)

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Assessment of structural evolution of aggregated soil using neutron tomography
WATER RESOURCES RESEARCH **44**, W00C07 (2008)

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Lehmann E

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Lehmann P, Berchtold M, Ahrenholz B, Tolke J, Kaestner A, Krafczyk M, Fluhler H, Kunsch HR
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Maass R, Van Petegem S, Zimmermann J, Borca CN, Van Swygenhoven H
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SUPERCONDUCTOR SCIENCE & TECHNOLOGY **21**, 012001 (2008)

Monni M, Pallecchi I, Ferdeghini C, Ferrando V, Floris A, D'Agliano EG, Lehmann E, Sheikin I, Tarantini C, Xi XX, Massidda S, Putti M
Probing the electron-phonon coupling in MgB2 through magnetoresistance measurements in neutron irradiated thin films
EPL **81**, 67006 (2008)

Moradi AB, Conesa HM, Robinson BH, Lehmann E, Kuehne G, Kaestner A, Schulin R
Neutron radiography as a tool for revealing root development in soil: capabilities and limitations
PLANT AND SOIL **in press**, - (2008)

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Quantitative imaging of infiltration, root growth, and root water uptake via neutron radiography
VADOSE ZONE JOURNAL **7**, 1035 (2008)

Papafotiou A, Helmig R, Schaap J, Lehmann P, Kaestner A, Fluhler H, Neuweiler I, Hassanein R, Ahrenholz B, Toelke J, Peters A, Durner W
From the pore scale to the lab scale: 3-D lab experiment and numerical simulation of drainage in heterogeneous porous media
ADVANCES IN WATER RESOURCES **31**, 1253 (2008)

Peterson AA, Vontobel P, Vogel F, Tester JW
In situ visualization of the performance of a supercritical-water salt separator using neutron radiography
JOURNAL OF SUPERCRITICAL FLUIDS **43**, 490 (2008)

Podofillini L, Dang VN, Thomsen K
Scoping-level Probabilistic Safety Assessment of a complex experimental facility: Challenges and first results from the application to a neutron source facility (MEGAPIE)
NUCLEAR ENGINEERING AND DESIGN **238**, 2726 (2008)

Schaap JD, Lehmann P, Kaestner A, Vontobel P, Hassanein R, Frei G, de Rooij GH, Lehmann E, Fluhler H
Measuring the effect of structural connectivity on the water dynamics in heterogeneous porous media using speedy neutron tomography
ADVANCES IN WATER RESOURCES **31**, 1233 (2008)

Robin Schäublin, Jean Henry, Yong Dai
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In situ Neutron Diffraction Study of Internal Micro-Stresses Developed by Plastic Elongation in < 110 > Textured BCC Wires
ADVANCED ENGINEERING MATERIALS **10**, 951 (2008)

Shokri N, Lehmann P, Vontobel P, Or D
Drying front and water content dynamics during evaporation from sand delineated by neutron radiography
WATER RESOURCES RESEARCH **44**, W06418 (2008)

Tarantini C, Manfrinetti P, Palenzona A, Putti M, Ferdeghini C, Gambardella U, Lehmann E, Cimberle MR
Magnetization decay in neutron irradiated MgB2 bulk samples
JOURNAL OF APPLIED PHYSICS **104**, 013903 (2008)

Thomsen K
Liquid metal leak detection for spallation neutron sources
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **592**, 476 (2008)

Knud Thomsen
Advanced on-target beam monitoring for spallation sources
NIM (2008) in press

Van Swygenhoven H
Footprints of plastic deformation in nanocrystalline metals
MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING **483**, 33 (2008)

Vasin M, Lehmann P, Kaestner A, Hassanein R, Nowak W, Helmig R, Neuweiler I
Drainage in heterogeneous sand columns with different geometric structures
ADVANCES IN WATER RESOURCES **31**, 1205 (2008)

Wagner W, Groschel F, Thomsen K, Heyck H
MEGAPIE at SINQ - The first liquid metal target driven by a megawatt class proton beam
JOURNAL OF NUCLEAR MATERIALS **377**, 12 (2008)

Wagner W, Seidel M, Morenzoni E, Groeschel F, Wohlmuther M, Daum M
PSI status 2008 - Development at the 590 MeV proton accelerator facility
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **11**, 18 (2008)

Yoshizawa K, Ikezoe K, Thsaki Y, Kramer D, Lehmann EH, Scherer GG
Analysis of gas diffusion layer and flow-field design in a PEMFC using neutron radiography
JOURNAL OF THE ELECTROCHEMICAL SOCIETY **155**, B223 (2008)

Zhang H, Long B, Dai Y
Metallography studies and hardness measurements on ferritic/martensitic steels irradiated in STIP
JOURNAL OF NUCLEAR MATERIALS **377**, 122 (2008)

LIST OF PUBLICATIONS

F. Atchison, M. Baumann, B. Blau, K. Bodek, B. van den Brandt, M. Daum, R. Dölling, P.A. Duperrex, A. Fuchs, P. Geltenbort, D. George, W. Gloor, S. Grigoriev, P. Hautle, G. Heidenreich, F. Heinrich, R. Henneck, S. Heule, Th. Hofmann, M. Horvat, F. Jenni, S. Joray, M. Kasprzak, K. Kirch, A. Knecht, J.A. Konter, M. Kuzniak, Ch. Perret, A. Pichlmaier, D. Rebreyend, R. Reiser, U. Rohrer, S. Teichmann, M. Wohlmuther, G. Zsigmond, J. Züllig
The UCN Source at PSI
Proc. of the 18th Meeting of the International collaboration on Advanced Neutron Sources, ICANS-XVIII, April 2007 (printed 2008)

F. Atchison, B. Blau, K. Bodek, B. van den Brandt, T. Brys, M. Daum, P. Fierlinger, A. Frei, P. Geltenbort, P. Hautle, R. Henneck, S. Heule, A. Holley, M. Kasprzak, K. Kirch, A. Knecht, J.A. Konter, M. Kuzniak, C.Y. Liu, C. Morris, A. Pichlmaier, C. Plonka, Yu Pokotilovski, A. Saunders, Y. Shin, D. Tortorella, M. Wohlmuther, A. R. Young, J. Zejma, G. Zsigmond
Measurements of Ultracold Neutron Production and Cold Neutron Transmission for Deuterium, Oxygen and Heavy Methane
Proc. of the 18th Meeting of the International collaboration on Advanced Neutron Sources, ICANS-XVIII, April 2007 (printed 2008)

B. Blau
Cryogenic System of the Swiss Ultra-cold neutron source
Proc. 10th Cryogenics 2008, Praha, Czech Rep., April 21 – 25, 2008, Refrigeration Science and Technology, ISSN 0151-1637, ISBN 978-2-913149-62-5, p. 107 (2008)

K. Thomsen
Experience with VIMOS during the Irradiation Phase of MEGAPIE
Proc. of the 18th Meeting of the International collaboration on Advanced Neutron Sources, ICANS-XVIII, April 2007 (printed 2008)

K. Thomsen
Heat Exchange and Operating Gas Flow Influence on Radiation Resistant Pressure Sensor Properties
Int. Scientific Colloquium, Modelling for Electromagnetic Processing, Hannover, October 27-29, 2008

W. Wagner, G. Kühne, P. Tregenna-Piggott, M. Wohlmuther
Status and Development of the Swiss Spallation Neutron Source SINQ
Proc. of the 18th Meeting of the International collaboration on Advanced Neutron Sources, ICANS-XVIII, April 2007 (printed 2008)

INVITED TALKS

C. Brandl
Dislocation activity within nanocrystalline metals: A molecular dynamics study
4th international conference on multi-scale materials modelling, Tallahassee, Florida, USA, October 27-31 2008

C. Brandl
Atomistic Simulations of Interface Dominated Metals"
Technology Aperitif, CCMX, Competence Centre for Materials Science and Technology, 3rd December, Bern, Switzerland

Y. Dai, F. Gröschel, W. Wagner
Materials research at the Paul Scherrer Institute for developing high-power spallation targets
TMS2008: 137th Annual Meeting & Exhibition, New Orleans, USA, March 9-13, 2008

P. M. Derlet
Atomistic simulations of nanocrystalline metals: dislocation, activity in confined volumes
International Workshop on the Plasticity of Nanocrystalline Metals, Lake Bostal, Germany, September 28-October 1 2008

P. M. Derlet
Plasticity in Nanocrystalline Metals: A Molecular Dynamics Study
8th World Congress on Computational Mechanics, Venice, Italy, 2008

E. H. Lehmann
Neutron Imaging in the conflict between neutron physics, applied research and industrial utilization
Seminar Talk at HMI Berlin, 12 March 2008

E. H. Lehmann
Neutron imaging methods for studies of soil-water-plant interactions
Seminar Talk, Helmholtz Centre Leipzig for Environmental Studies, 14 July 2008

E. H. Lehmann, G. Frei, Neutron Imaging at PSI - Options for improved fuel cell studies, HONDA R&D Centre, Utsunomiya, Sept. 2008

Helena Van Swygenhoven
Nano- and micro-scale materials: mechanical behaviour under extreme conditions
MRS Fall meeting Boston, November 2008

Helena Van Swygenhoven
Small scale plasticity using X-rays and neutrons
Max-Planck Institut für Eisenforschung (MPIE) Duesseldorf, October 2008

Helena Van Swygenhoven
Laboratoire de PHYsique des MATériaux (PHYMAT), Université de Poitiers UMR CNRS 6630, France, June 2008

Helena Van Swygenhoven
Modelling and Simulation (Keynote lecture)
Materials Science and Engineering, symposium, 1 – 4 September 2008, Nürnberg, Germany

Helena Van Swygenhoven
Grenzflächen und Grenzflächendominierte Prozesse
Exzellenzakademie Materialwissenschaft und Werkstofftechnik, computational material science, (" 10. - 14. März 2008. St. Märgen im Schwarzwald, organized by the Deutsche Forschungsgemeinschaft DFG and the Fraunhofer Institut Werkstoffmechanik, 10. - 14. März 2008, St. Märgen im Schwarzwald

Helena Van Swygenhoven
A different view on microcompression
Symposium "Mechanics of nanoscale materials", San Francisco March 24-28, 2008

Helena Van Swygenhoven
Contractors' Meeting of the "Mechanical Behavior and Radiation Effects" Core Research Area (CRA) of the Office of Basic Energy Sciences (DOE), Washington, April 13$^{-16,}$ 2008 (Plenary opening lecture)

Helena Van Swygenhoven
Invited discussion leader in the International Workshop on the Plasticity of Nanocrystalline Metals held at Lake Bostal, Germany, September 28 to October 1, 2008

S. Van Petegem
Mechanical behavior and deformation mechanisms of nanocrystalline f.c.c. metals
2nd Workshop on Nanomaterials: microstructural and mechanical characterizations, simulations (December 11-12, 2008)

S. Van Petegem
Deformation mechanisms in nanocrystalline Ni and NiFe studied by in-situ x-ray diffraction'
Nanoplasticity 2008, Lake Bostal, Germany (September 28 - October 1 2008)

S. Van Petegem
In-situ Laue diffraction and two-dimensional mapping during compression of micron-sized pillars (Keynote lecture)
MSE08, Materials Science and Engineering, Nuernberg, Germany (September 1-4, 2008)

W. Wagner
The PSI large scale accelerator facilities: Techniques and applications in materials science
IAEA Technical Meeting on Applications of accelerators in real time studies of materials, Vienna, A, Sept.15-19, 2008

W. Wagner
PSI Status – Operation and Utilization of the Proton Accelerator Facility
IPS08: International Symposium on Pulsed Neutron and Muon Sciences, Mito, Japan, March 5-8, 2008

W. Wagner
Status and Developments of the Swiss Spallation Neutron Source SINQ
IAEA Consultants Meeting on Applications of accelerators in real time studies of materials Vienna, A, April 28-30, 2008

W. Wagner
Post-MEGAPIE developments at SINQ – PSI's strategy towards an optimized MW(+) spallation source
IWSMT 9th International Workshop on Spallation Materials, Sapporo, Japan, Oct. 19-24, 2008

CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

G. Frei, E. H. Lehmann, P. Boillat
The neutron micro-tomography stup at PSI and its use for research purposes and engineering applications
Int. Topical Meeting on Neutron Radiography, Kobe, Sept. 2008

G. Frei, E. Lehmann, L. Josic, P. Vontobel
Investigations of welding joints by means of energy resolved imaging
NEUWAVE-1 Workshop on energy selective neutron imaging, Munich-Garching, April 2008

G. Frei, E. H. Lehmann
Zerstörungsfreie Materialuntersuchung mittels Neutronen am Paul Scherrer Institut- Lötungen und Schweißungen
Industrie-Workshop Böhler-Welding, Nov. 2008

L. Josic, E. H. Lehmann, G. Frei, M. Tamaki
Cold neutron imaging near Bragg edges as tool for material research
Int. Topical Meeting on Neutron Radiography, Kobe, Sept. 2008

L. Josic, P. Vontobel, E. Lehmann
Nuclear data for neutron interaction with structural materials verification (and improvement) with neutron transmission measurements
NEUWAVE-1 Workshop on energy selective neutron imaging, Munich-Garching, April 2008

E. H. Lehmann
Non-destructive testing with neutrons (and X-rays) for industrial and scientific use at the imaging beam lines at PSI
Consultancy Meeting IAEA, Vienna, 26-28 Nov. 2008

E. H. Lehmann
Recent improvements in the methodology of neutron imaging: higher spatial resolution, energy selective investigations
Int. Conf. on Neutron Scattering, Mumbay, Jan. 2008

E. H. Lehmann, P. Boillat, G. Scherrer, G, Frei
Fuel cell studies with neutrons at the imaging facilities at PSI
Int. Topical Meeting on Neutron Radiography, Kobe, Sept. 2008

E. H. Lehmann, G. Frei, L. Josic, P. Vontobel
The energy selective option in neutron imaging
NEUWAVE-1 Workshop on energy selective neutron imaging, Munich-Garching, April 2008

E. H. Lehmann, D. Mannes, P. Cerubini, P. Niemz
Neutron transmission imaging with imaging plates detectors as competitive method for tree ring determination
EURODENDRO, Hallstadt, May 2008

D. Mannes, M. Grabner, E. H. Lehmann, P. Niemz
Imaging with cold neutrons fort he determination of tree rings in deteriorated wood
EURODENDRO, Hallstadt, May 2008

S. Van Petegem
In-situ x-ray diffraction study of nanocrystalline metals
ICRS-8 - DXC2008, The eight International Conference on Residual Stress - Denver X-ray Conference, Denver, USA (August 4-8, 2008)

S. Van Petegem
From microstructures to mechanical behaviour - neutrons and x-rays
Metallurgy day, Lausanne, Switzerland (September 11, 2008)

S. Van Petegem
In-situ mechanical testing at the time-of-flight neutron diffractometer POLDI
DN2008, Deutsche Neutronentagung, Garching

LECTURES AND COURSES

P. M. Derlet
Defects, dynamics and diffraction patterns: a computational synergy
7th PSI Summer School on Condensed Matter Research, Probing the Nanometer Scale with Neutrons, Photons and Muons, Zuoz, Switzerland, August 16-22 2008

H. Van Swygenoven
Small scale plasticity using in-situ mechanical techniques
7th PSI Summer School on Condensed Matter Research, Probing the Nanometer Scale with Neutrons, Photons and Muons, Zuoz, Switzerland, August 16-22 2008

H. Van Swygenoven
Five research lectures at the International Centre for Mechanical Sciences (CISM) on „*Mechanical Size-Effects of Materials: Processing, Characterizing and Modelling*“,
May 12-16, 2008, Udine, Italy.

H. Van Swygenoven
“Grains and deformation” a research course on "New Materials in New Light" is the 7th course in a series on "New X-Ray Sciences" organized by Prof. Prof. Robert Feidenhans', Niels Bohr Institute, University of Copenhagen at DESY, Hamburg , March 5-7, 2008.

MEMBERSHIP IN EXTERNAL COMMITTEES

Dr. W. Wagner
- Technical Advisory Group, ESS Scandinavia
- International Advisory Committee of ICANS: International Collaboration on Advanced Neutron Sources
- International Technical Committee of the "Fifth edition of the International Workshop on Materials for Heavy Liquid Metal Cooled Reactors and Related Technologies"
- Technical Programme Committee of the “International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators”

Dr. H. Van Swygenhoven
- Member of the reviewing commission of the proposals for beam time at the instruments at FRM II
- Member of the hiring commission for the Professor in Experimental Condensed Matter Physics at ETHZ and Head of Laboratory for Neutron Scattering at PSI (2008)
- Elected by the EC-commission as an expert and member of the External Advisory Group (EAG) of the NMP program (FP7)
- Elected member of the PSI research commission (FOKO).
- Elected member of the International Advisory Committee of the International Risø Symposium on Materials Science
- Vice chair of the International Committee of Strength of Materials (organization of ICSMA conferences).
- Volume editor in the MRS Bulletin 2009, Atomistic simulations of nanomechanics.

Dr. E. Lehmann
- COST-IE0601 "Wood research for cultural heritage", Member of Steering Committees und Deputy Working Group Leader, Swiss Representative of the Action
- ILL: Mitglied des Subcommittes 1 für die Proposal Evaluation (until end of 2008)
- FRM-2: Member of Advisory Committee for Proposal Evaluation (since end of 2008)

Condensed Matter Research with Neutrons and Muons

Laboratory for Neutron Scattering, ETH Zürich & Paul Scherrer Institut (LNS)

LIST OF PUBLICATIONS (PEER REVIEWED)

Agrestini S, Chapon LC, Daoud-aladine A, Schefer J, Gukasov A, Mazzoli C, Lees R, Petrenko OA
Nature of the Magnetic Order in Ca3Co2O6
PHYSICAL REVIEW LETTERS **101**, 097207 (2008)

Altissimo M, Petrillo C, Sacchetti F, Sani L, Stahn J
Neutron diffraction from macroscopic objects and transverse coherence of the wavefunction: The Fresnel zone plates
NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **586**, 68 (2008)

Aswal VK, Chodankar S, Kohlbrecher J, Vavrin R, Wagh AG
Small-angle neutron scattering study of structural evolution of different phases in protein solution
PRAMANA-JOURNAL OF PHYSICS **71**, 877 (2008)

Aswal VK, Chodankar SN, Kohlbrecher J, Vavrin R, Wagh AG
SANS and DLS Studies of Protein Unfolding in Presence of Urea and Surfactant
AIP CONFERENCE PROCEEDINGS **989**, 53 (2008)

Aswal VK, Van den Brandt B, Hautle P, Kohlbrecher J, Konter JA, Michels A, Piegsa FM, Stahn J, Van Petegem S, Zimmer O
Characterisation of the polarised neutron beam at the small angle scattering instrument SANS-I with a polarised proton target
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **586**, 86 (2008)

Aswal VK, Vavrin R, Kohlbrecher J, Wagh AG
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Successive Structural Phase Transitions in Pr0.5 Sr0.5 CoO3 in the Range 10-1120K
JETP LETTERS **88**, 531 (2008)

Balagurov AM, Bobrikov IA, Pomjakushin VY, Sheptyakov DV, Babushkina NA, Gorbenko OY, Kartavtseva MS, Kaul AR
Effect of isotopic composition and microstructure on the crystalline and magnetic phase states in R0.5Sr0.5MnO3
JOURNAL OF EXPERIMENTAL AND THEORETICAL PHYSICS **106**, 528 (2008)

Barilo SN, Shiryaev SV, Bychkov GL, Shestak AS, Flavell WR, Thomas AG, Rafique HM, Chernenkov YP, Plakhty VP, Pomjakushina E, Conder K, Allenspach P
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JOURNAL OF CRYSTAL GROWTH **310**, 1867 (2008)

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NEW JOURNAL OF PHYSICS **10**, 103016 (2008)

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CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

R. Ackermann, U. Filges, M. Schneider, J. P. Embs, R. Hempelmann
A wedge-shaped polarizing analyzer – ray-trace MC simulations and experimental analysis
Deutsche Neutronentagung 2008 TU München, Garching Germany Sep. 14-17, 2008 poster

R. Ackermann, U. Filges, M. Schneider, J. P. Embs, R. Hempelmann
Ray-trace simulations of polarizing components for the cold neutron TOF spectrometer FOCUS
Bunsentagung 2008 Universität des Saarlandes, Saarbrücken Germany Mai 1-3, 2008 poster

A. Cervellino, J. Schefer, L. Keller, A. Schuy, Th. Woike, D. Schaniel
Neutronenpulverdiffraktion an GNNP: Annäherung an die Nanometerskala.
16. Jahrestagung der Deutschen Gesellschaft für Kristallographie (DKG) Erlangen Germany March 3-6, 2008

N. B. Christensen, O. Zaharko
Diffuse scattering in Co_3O_4 *and* $Co(Al_{1.3}Co_{0.7})O_4$ *studied by neutron diffraction and spectroscopy. An indication of a spiral spin liquid phase?*
Materials for Frustrated Magnetism Grenoble France March 3-5, 2008 talk

N. B. Christensen, J. Chang, J. Mesot
Magnetic order and excitations in $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$
29th Risø International Symposium on Materials Science Roskilde Denmark Sept. 1-5, 2008

J.P. Embs, R. Hempelmann
Cation Dynamics in Ionic Liquids be means of QENS
Bunsentagung Universität Saarbrücken Germany May,1-3, 2008 Poster

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Th. Geue, P. Huber, M. Textor, Th. Blaettle
X-ray scattering on ordered colloidal assemblies
SUG Surfaces and Interfaces Fribourg Switzerland January 25, 2008 poster

P. Huber, T. Blättler, M. Textor, W. Leitenberger, U. Pietsch, Th. Geue
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Y. Kawasaki, T. Minami, Y. Kishimoto, T. Ohno, A. Koda, K.H. Satoh, R. Kadono, J.L. Gavilano, H. Luetkens, T. Nakajima and Y. Ueda
Magnetism of A-site ordered perovskite manganites RBaMn_2O_6 (R = La and Y)
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Y. Kawasaki, ,J.L. Gavilano, L. Keller, B. Roessli, N. Christensen, T. Ohno, Z. He, Y Ueda
Neutron Scattering Studies of BaCo2V2O8
7th PSI Summer School on Condensed Matter Research, Laceum Alpinum Zuoz Switzerland August 16-22, 2008

L. Keller
Magnetic Order In $CuCrS_2$ Investigated By Neutron Diffraction
INTAS Workshop, New Layered 3d-Materials for Spintronics Villigen PSI Switzerland March 31 - April 4, 2008

M. Kenzelmann
Magnetically-driven ferroelectric polarization in a molecule-based quantum magnet
Materials for Frustrated Magnetism Grenoble France March 3-5, 2008

M. Kenzelmann
Electric control and switching frequency of magnetism in thin films of Ni3V2O8
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Spin dynamics in SrHo2O4 and SrDy2O4
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M. Kenzelmann
Superconducting Vortices in CeCoIn5: Toward the Pauli-Limiting Field
Fifth Int. Workshop on Sample Environment at Neutron Scattering Facilities Villard de Lans France Mai 25-27, 2008

J. Kohlbrecher
Probing the phase diagram of colloidal suspensions under high pressure by neutron and light scattering Liquid Matter Conference
Lund Sweden August 2008 poster

C. Kraemer, H. Ronnow, K. Kiefer, G. Aeppli, T. F. Rosenbaum, K. Habicht
Quantum Phase transition of a Magnet in a Spinbath
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Quantum Phase transition of a Magnet in a Spinbath
DPG-Conference TU Berlin Germany February 2, 2008

M. Månsson
muSR and Automobiles
Muon Training School ISIS, Oxford, UK France Mai 31 - June 1, 2007 talk

J.C.E. Rasch, D.V. Sheptyakov, M. Boehm, J. Schefer, L. Keller, F. Gozzo, N.V. Volkov
Magnetic and Structural Properties of $Pb_3Mn_7O_{15}$
Annual Meeting of the Swiss Physical Society/MANEP Meeting Geneva Switzerland March 26-27, 2008 poster

J.C.E. Rasch, D.V. Sheptyakov, M. Boehm, J. Schefer, L. Keller, F. Gozzo, N.V. Volkov, K.A. Sablina and G.A. Petrakovskii
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J.C.E. Rasch
Magnetism in $Pb_3Mn_7O_{15}$
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J.C.E. Rasch
Magnetism induced lattice distortion in $CuCrS_2$
16th ICTMC Berlin Germany Sept. 15-19, 2008

B. Thielemann, Ch. Rüegg, H. M. Rønnow, J. Mesot, D. F. McMorrow, K. W. Krämer, D. Biner, H.-U. Güdel, K. Kiefer, J. Stahn, J. Gavilano, S. Gvasaliya, K. Habicht, M. Böhm, B. Grenier
Quantum Statistics of Triplons in One Dimension
Annual Meeting of the Swiss Physical Society/MANEP Meeting Geneva Switzerland March 26-27, 2008 poster

Ph. Tregenna-Piggott
Introducing the new Backscatering spectrometer, MARS at the PSI
Workshop on Backscattering Spectrometers Tokai, Japan Switzerland February 20-21, 2007 poster

N. Tsyrulin
Quantum effects in S=1/2 two-dimensional Heisenberg antiferromagnet
IUCr2008 Osaka Japan August 23-31, 2008 poster

A. Wilk, J. Kohlbrecher, G. Meier, G. Petekidis, J. Roovers, E. Stakiakis, D. Vlassopoulos
Reversible thermal gelation in concentrated star solutions
22nd Conference of the European Colloid and Interface Society Cracow Poland 31.Aug. - 5.Sept. 2008

M.Zayed
Evidence of pressure induced phase transitions in the Shastry-Sutherland compound $SrCu_2(BO_3)_2$.
Materials for Frustrated Magnetism Grenoble France March 3-5, 2008

INVITED TALKS

R. Ackermann
Magnonen und polarisierte Neutronen
Universität des Saarlandes, Saarbrücken Germany June 20,2008

R. Ackermann
Phononen und inelastische Neutronenstreuung
Universität des Saarlandes Saarbrücken Germany June 18,2008

A. Cervellino
Analysis of partially ordered (nano)materials through the Debye function method.
IUCr2008 XXI Congress of the International Union of Crystallography Osaka Japan August 23-31 2008.

A. Cervellino
Debye function: nella cassetta degli attrezzi.
Powder Diffraction Software Workshop „In the Toolchest“ Warsaw Poland September 18, 2008

A. Cervellino
The Debye equation: Powder diffraction patterns directly from atom clusters. What we can really do and when it is convenient.
EPDIC11 – 11th European Powder Diffraction Conference Warsaw Poland September 19-22, 2008

J. Chang
Electronic structure of La-based cuprates near the 1/8-anomaly
UMD CNAM/ICAM Workshop on Cuprate Fermiology University of Maryland USA Nov. 14-15, 2008

J. Chang
Magnetic and Electronic properties of the high-temperature superconductor La2-xSrxCuO4.
Seminar Universite Sherbrooke Canada Mar. 15th, 2008

J.P. Embs
Dynamics of Ionic Liquids (ILs) by menas of QENS
13th International Conference on Neutron Scattering Investigation in Condensed Matter Universität Poznan Poland May 8-10, 2008

J.P. Embs
QENS - a method to probe dynamics in liquids on a molecular scale
Winterschool DFG - SPP 1191 priority program Universität Leipzig Germany Feb., 20-23, 2008

A. Furrer
Admixture of an s-wave component to the d-wave gap symmetry in high temperature superconductors
22nd General Conference of the Condensed Matter Division of the EPS Rome Itay August 25-29, 2008

A. Furrer
Bose-Einstein Condensation in Magnetic Materials
2008 Latsis Symposium Lausanne Switzerland January 28-30, 2008

A. Furrer
Towards establishing a Swiss partnershp with the ILL
Symposium 20 Years Partnership Villigen PSI Switzerland Nov. 28, 2008

C. Garcia
TEM and WAXS complementarity to analyze nanopowder
Laboratory for Neutron Scattering PSI Villigen Switzerland Sept. 22, 2008

U. Gasser
Non-central forces in crystals of charged colloids
GaTech Atlanta USA Sept. 15-25, 2008

S.N.Gvasaliya
Phase Transitions in Relaxors: Neutron Scattering Studies
SNSF Scopes Workshop Tashkent Uzbekistan Sept. 11- Sept 14 2008

S.N.Gvasaliya, G.M. Rotaru, B. Roessli, R.A. Cowley,S. Kojima
Phase Transitions and Lattice Dynamics of Relaxors
Frontiers in Ferroelectricity St. Petersburg Russia June 12 - June 14, 2008

J. Hoppler
Stress induced modulation of the magnetic profile in Y0.6Pr0.4Ba2Cu3O7 / La2/3Ca1/3MnO3 superlattices
Seminar MPI fuer Festkörperfoerschung, Stuttgart Germany March 14, 2008

L. Keller
Upgrade Of The Cold Neutron Powder Diffractometer DMC At SINQ
JCNS Workshop 2008, Modern Trends in Neutron Scattering Instrumentation Bernried Germany October 15 - 17, 2008

M. Kenzelmann
Coupled magnetic and superconducting order in CeCoIn5
Conference on Correlated Electron Systems in High Magnetic Fields Dresden Germany Oct. 13-17, 2008

M. Kenzelmann
Ferroelectricity from magnetic order
International Conference on Highly Frustrated Magnetism Braunschweig Germany Sept. 8-12, 2008

M. Kenzelmann
Ferroelectricity from magnetic order
International Union of Crystallography Osaka Japan Aug. 23-20, 2008

M. Kenzelmann
Magnetically-induced ferroelectricity in frustrated quantum magnets
American Crystallographic Association Oak Ridge USA Mai 31 - June 5, 2008

M. Kenzelmann
Multiferroic Materials
Dept of Materials, ETH Zürich Zürich Switzerland October 1, 2008

M. Kenzelmann
Multiferroic Materials
7th PSI Summer School on Condensed Matter Research Zuoz Switzerland Aug 20-22, 2008

M. Kenzelmann
Nanoscale Magnetization Dynamics
XFEL Bern Switzerland June 5, 2008

M. Kenzelmann
Quantum magnetism, multiferroics and heavy-fermion superconductivity
Dept. of Physics, University of Karlsruhe Karlsruhe Germany April 14, 2008

M. Kenzelmann
Superconducting Vortices in CeCoIn5: Toward the Pauli-Limiting Field
MANEP Review Geneva Switzerland Mai 20, 2008

M. Kenzelmann
Unconventional magnetism in an unconventional superconductor
Stripes 2008 Erice Italy July 27-31, 2008

M. Kenzelmann
Unconventional magnetism in an unconventional superconductor
Annual Meeting of the Swiss Physical Society/MANEP Meeting Geneva Switzerland March 26-27, 2008

J. Kohlbrecher
How scattering techniques can probe the nanometer scale: An introduction to SAS and PCS
PSI
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J. Kohlbrecher
real-time small-angle neutron scattering techniques probing sub-millisecond dynamics in magnetic nanomaterials
NFFA Symposium PSI Villigen Switzerland August 16-22, 2008

J. Kohlbrecher
Small-Angle Scattering (SAS)
ETHZ-LMVT Switzerland 1.5.08

C. Kraemer, H. Ronnow, K. Kiefer, G. Aeppli, T. F.Rosenbaum, K. Habicht, K.Prokes, A. Podlesnyjak, Th. Straessle, O Zaharko, J. Gavilano, A. Schneidewind, P. Link
Quantum Phasetransition of a Magnet in a Spinbath
Departement of Physik, Neutron-Seminar TU München, Garching Germany January 19, 2008

J. Mesot
Doping Dependent Anisotropic Electronic Scattering Rate in La2-xSrxCuO4
American Physical Society (APS) March meeting New Orleans USA March 10-14, 2008

J. Mesot
Electronic and magnetic excitations of high-temperature cuprate superconductors probed by ARPES and neutron scattering
Condensed Matter Colloquium, University Fribourg Fribourg Switzerland April 15, 2008

J. Mesot
Multiple Energy Scales and FS pockets : Neutron and ARPES Studies
CIFAR QM workshop Toronto Canada April 7-11, 2008

J. Mesot
Neutron and ARPES evidences for two energy scales in La(2-x)Sr(x)CuO(4)
The International Conference on Low-Energy Electrodynamics in Solids 2008 Vancouver Canada June 30 - July 4, 2008

J. Mesot
Neutron Scattering Investigation of High-Temperature Superconductors
International Symposium on Neutron Scattering. Mumbai India Jan. 15-18, 2008

M. Shi, J. Mesot
Electronic and Magnetic Excitations of High-Temperature Cuprate Superconductors Probed by ARPES and Neutron Scattering
22nd General Conference of the Condensed Matter Division of the European Physical Society Rome Italy August 25-29, 2008

C. Niedermayer
Tuning competing orders in cuprate superconductors by the application of an external magnetic field
Manep Internal Workshop Neuchâtel Switzerland January 15, 2008

C. Niedermayer
Tuning competing orders in $La_{2-x}Sr_xCuO_4$ cuprate superconductors by the application of an external magnetic field
Stripes 08: Quantum Phenomena in Complex Matter Erice Italy July 26 - August 1, 2008

V.Pomjakushin
Determination of the magnetic structure from powder neutron diffraction
Structure Determination from Powder Diffraction Data Villigen PSI Switzerland June 18-22, 2008

E. Pomjakushina, K. Conder, M. Stingaciu, A. Podlesnyak.
Layered and cubic cobaltites grown by floating zone, structural and magnetic properties study
IUCR2008 Osaka Japan August 23-31, 2008

J.C.E. Rasch
Layered compounds for spintronics
Metal Physics and Technology Winter Colloquium Stoos Switzerland January 15-18, 2008

J.C.E. Rasch
Magnetism induced lattice distortion in $CuCrS_2$
16th SCTE Dresden Germany July 26-31, 2008

J.C.E. Rasch
Neutron and synchrotron X-ray diffraction on $Pb_3Mn_7O_{15}$
INTAS Workshop, New Layered 3d-Materials for Spintronics Villigen PSI Switzerland March 31 to April 1, 2008

J.C.E. Rasch
Neutron scattering on magnetoelastic $CuCrS_2$
ETH Zurich Advanced Materials Science Seminar Zürich Switzerland October 13, 2008

J.C.E. Rasch, D.V. Sheptyakov, M. Boehm, J. Schefer, L. Keller, F. Gozzo, N.V. Volkov, K.A. Sablina, G.A. Petrakovskii
Magnetic and Structural Properties of Pb3Mn7O15
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J.C.E. Rasch, D.V. Sheptyakov, M. Boehm, J. Schefer, L. Keller, N.V. Volkov, K.A. Sablina and G.A. Petraskovskii
Magnetism in $Pb_3Mn_7O_{15}$
Annual Meeting of the Swiss Physical Society/MANEP Meeting Geneva Switzerland March 26-27, 2008

B. Roessli
Neutron Polarimetry in Ferroic NdFe3(11BO3)4
Int. Seminar on Ferroelectricity St-Petersburg Russia June 12 - June 14, 2008

B. Roessli
Neutron Polarimetry in Ferroic NdFe3(11BO3)4
PNCMI2008 Tokai Switzerland Sept. 1-5, 2008

B. Roessli
Thre-dimensional polarimetry: from ILL to PSI Symposium 20 Years Partnership Villigen PSI
Switzerland Nov. 28, 2008

J. Schefer
Neutron Diffraction at the Swiss Neutron Spallation Source SINQ
1st Status Meeting of MaMaSELF Rigi Kulm Switzerland May 6-10, 2008

J. Schefer
Neutron Scattering at the Swiss Neutron Spallation Source SINQ
Department of Materials Engineering and Industrial Technologies University of Trento Italy
May 26, 2008

J. Schefer
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J. Schefer
SINQ and selected Applications: Metastable states, oxygen transport in periovsiktes and other applications using novel materials
Institut für Experimentalphysik Universität Wien Austria Oct. 20, 2008

D. Sheptyakov
Crystal And Magnetic Structures Of The New Mixed Oxides: $Pb_{2-x}Ba_xFe_2O_5$ And $Sr_3Y(Co,Fe)_4O_{10.5+\delta}$
SNSF Scopes Workshop Tashkent Uzbekistan Sept. 11-13, 2008

D. Sheptyakov
Powder Diffraction Using Neutrons And Its Complementarity To The X-Ray Powder Diffraction
Structure Determination from Powder Diffraction Data
Villigen PSI Switzerland June 18-22, 2008

D. Sheptyakov
Tutorial On Powder Diffraction Techniques In Application To The Analysis Of The Particle Sizes And Microstrains In Materials
7th PSI Summer School on Condensed Matter Research Zuoz Switzerland
August 16-22, 2008

V.V.Sikolenko
Phase separation and Co spin state in cobaltites with perovskite-type structure
Hasylab DESY seminar, 23.05.2008 Hamburg Germany Mai 23, 2008

V.V.Sikolenko
Triple-Axis Spectroscopy. Experimental training.
20th Berlin School on Neutron Scattering Berlin Germany Feb. 12-16, 2008

J. Stahn
Elliptic neutron guides from the idea to the implementation
NMI3 annual meeting 2008 Corse France June 25-28, 2008

J. Stahn
Laterally graded and complex multilayers for neutron optical elements
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Th. Strässle
Neutron spectroscopy under high pressure: a vibrational study on the amorphization process of ice
11eme Journee de la Matiere Condensee Strasbourg France August 25-29

Ph. Tregenna-Piggott
Experimental and Theoretical Study of Cyano-bridged Trimers incorporating [Mn(5-Brsalen)]$^+$ Units
Seminar Freiburg Germany December 5, 2008

R. Vavrin
Probing the phase diagram of a colloidal suspension under high pressure by neutron and light scattering
Conference of the European Colloid and Interface Society (ECIS) Cracow Poland Aug. 31 - Sept. 5, 2008

O. Zaharko
Isolated tetrahedra system Cu4OCl6L4:magnetic exchange against cluster plasticity
seminar in Lab. of Crystallography Lausanne Switzerland February 25, 2008

O. Zaharko
Magnetic structure determination combining nonpolarized and polarized neutron diffraction
21st Congress of International Union of Crystallography Osaka Japan August 23-31, 2008

M.Zayed
Pressure induced phase transitions in the Shastry-Sutherland compound $SrCu_2(BO_3)_2$.
Journées de la matière condensée (JMC11) Strasbourg France August 25-29, 2008

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J.C.E. Rasch, D.V. Sheptyakov, M. Boehm, J. Schefer, L. Keller, F. Gozzo, N.V. Volkov, K.A. Sablina, G.A. Petrakovskii
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J. Schefer
Neutron diffraction at the Swiss neutron spallation source SINQ: The central instruments for spintronics
INTAS Workshop: New layerd 3d-Materials for Spintronics, PSI Villigen, Switzerland

LECTURES AND COURSES

M. Kenzelmann
- Introduction to multiferroics + Ferroelectricity from magnetic order, 2nd European School on Multiferroics, Girona, 1.9.2008-5.9.2008, European school
- Magnetic Structures in Crystalline Materials + Symmetry of Multiferroic Structures, ICMR Summer School on Multiferroics, Santa Barbara, 19.7.2008-26.7.2008, International school
- Multiferroic Materials, 7th PSI Summer School on Condensed Matter Research, Zuoz

J. Mesot
- Neutronenstreuung in der Festkörperphysik I, ETH Zürich
- Neutronenstreuung in der Festkörperphysik II, ETH Zürich
- Seminarreihe Neutronenstreuung I, ETH Zürich
- Seminarreihe Neutronenstreuung II, ETH Zürich

J. Schefer
- Magnetic scattering with neutron diffractions, MaMaSELF, Erasmus Mundus Sommer School, University of Rennes, cycle of seminars

V.V. Sikolenko
- Triple-Axis Spectroscopy. Experimental training 20th Berlin School on Neutron Scattering, Hahn Meitner Insitut Berlin, cycle of seminars

T. Strässle
- Neutronenstreuung in der Festkörperphysik I, ETH Zürich
- Neutronenstreuung in der Festkörperphysik II, ETH Zürich

Ph. Tregenna-Piggott
- Magnetism and Transition Metal Compounds, Department of Chemistry, University of Bern, cycle of seminars

MEMBERSHIP IN EXTERNAL COMMITTEES

A. Furrer
- Science Advisory Committee, EU Infrastructure Initiative NMI3 (2002)
- Advisor, 3rd World Academy of Sciences (2003)
- Gutachter-Ausschuss Sonderforschungsbereich 463 DFG (2005)
- Programme Committee, 2008 Latsis Symposium (2007)
- Editorial Advisory Board, The Open Superconductors Journal (2008)

T. Geue
- Scientific Advisory Committee Budapest Neutron Center, BNC, Budapest, Hungary (2008)
- User Selection Panel Budapest Neutron Center, BNC, Budapest, Hungary (2008)

S. Gvasaliya
- Program Committee, RCBJSF-10, TITech, Yokohama, Japan (2008)

M. Kenzelmann

- Executive Committee of the NIST Center for Neutron Research User Group, NCNR, NIST, United States (2008)

J. Kohlbrecher

- Scientific Advisory Committee ILL, ILL Grenoble, France (2008)
- Scientific Advisory Committee NCNR, NIST Center for Neutron Research (2007)

J. Mesot

- Forum of the CH-NCCR/NSF Materials with Novel Electronic Properties (MaNEP), Swiss National Science Foundation (since 2005)
- Member of the organizing committee, Summer School on Condensed Matter Research, Zuoz, Switzerland (2005-2008)
- Member of the International Advisory Committee, Conference on Dynamical Properties of Solids (DYPROSO): International Advisory Committee (since 2002)
- Member of the International Advisory Committee, International Workshop on Polarized Neutrons in Condensed Matter Investigations (PNCMI) (since 2005)
- Member of the International Advisory Board, Workshop on Inelastic Neutron Spectrometers (WINS) International Advisory Board (since 2006)
- Chairman of evaluation committee: Protons Neutrons Ions, Helmholtz Society (2008-2009)
- Member of the Board, European Association of Research Facilities (since 2008)
- Member of the council, European Physical Society (since 2008)

V. Pomjakushin

- Scientific Advisory Committee ILL, Magnetism, ILL Grenoble, France (2009)

B. Roessli

- Scientific Advisory Committee ILL, Dynamics and Magnetism, ILL Grenoble, France (2006)
- Scientific Advisory Committee, International Symposium on the Dynamic Properties of Solids (2008)

J. Schefer

- Scientific Advisory Committee FRM-II, structure, FRM-II, Munich, Germany (since 2008)
- Editor Newsletter of the Swiss Society for Crystallography, SGK/SSCr, Swiss Society for Crystallography (since 2006)
- Member of the Organizing Committee, Summer School on Condensed Matter Research, yearly (since 2008)
- Board Member, Swiss Society for Crystallography (since 2006)

Ph. Tregenna Piggott

- Scientific Advisory Committee for the DNA Backscattering Spectrometer, J-PARC, Japan (2008)

AWARDS

J. Chang

- ETH Medaille for outstanding thesis work Physics Departement ETH Zürich, October 2008

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Barilo SN, Shiryaev SV, Bychkov GL, Shestak AS, Flavell WR, Thomas AG, Rafique HM, Chernenkov YP, Plakhty VP, Pomjakushina E, Conder K, Allenspach P
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PHYSICAL REVIEW B **78**, 014407 (2008)

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JOURNAL OF CHEMICAL PHYSICS **128**, 241102 (2008)

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S. Mayer and U. Filges
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J. P. Urrego-Blanco, C.R. Bingham,B. van den Brandt, A. Galindo-Uribarri, P. Hautle, J. A. Konter, E. Padilla-Rodal, P. Schmelzbach
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SPIN2008, The 18th International Symposium on Spin Physics, Virginia, USA, October 6-11 2008

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Polarized Solid Targets at PSI: Recent Developments and Novel Applications in DNP
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B. van den Brandt, P. Hautle, J.A. Konter, F.M. Piegsa, J.P. Urrego-Blanco
Dilution refrigerators for particle physics experiments: two variants with sample cooling by helium-4
25th International Conference on Low Temperature Physics (LT25), Amsterdam, The Netherlands, August 6-13, 2008

CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

R. Ackermann, U.Filges, J. P. Embs, R. Hempelmann
Ray-trace simulations of polarizing components for the cold neutron TOF spectrometer FOCUS
Bunsentagung, 1-3 May, 2008, Saarbrücken, Germany

K. Conder, M. Stingaciu, E. Pomjakushina, A. Podlesnyak
Layered cobaltites: synthesis, crystal growth, transport and magnetic properties
International Conference on Electronic Materials 2008, Sydney, Australia – 28.07-1.08. 2008. Contributed talk.

K.Conder
Oxygen nonstoichiometry in perovskites:origin, control and determination
Perovskite meeting (ETHZ, EMPA, PSI) 26.05.2008, PSI West

U.Filges
Validation of the RNR11-SINQ beamline and FOCUS instrument with different Monte Carlo packages
MCNSI meeting, 25-28 June, 2008, Ajaccio , France

Th. Gahl, R. Hempelmann, F. Jurányi, J. Mesot, W.-C. Pilgrim, Th. Straessle
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F. Gallmeier, M.Wohlmuther and U.Filges
Implementation of Neutron Mirror Effects into MCNPX and its Validation
11th International Conference on Radiation Shielding, April 13-18. 2008, Pine Mountain, Georgia, USA

Johann Gironnet, Noël Coron, Pierre de Marcillac, Hans Kraus, Vitalii Mikhalik
Scintillation properties of Bi4Ge3O12 (BGO) down to a temperature of 20mK
Cryoscint, IPNL, Lyon, June 6th, 2008

M.Koennecke, M.Zolliker, PSI, N.Hauser, T.Lam, F.Fransecini
Treepath Based Instrument Control
ANSTO NOBUGS 2008, November 3-5, Sydney, Australia

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PSD 4 Circle Data Processing at SINQ
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M. Medarde, M.T. Fernández-Díaz, P. Lacorre, C. Dallera, M. Grioni, J. Mesot, M.J. Martínez-Lope, J.L. Alonso
Combining neutron diffraction and XAS; gap opening through charge disproportionation in RNiO3 perovskites
11th European Powder Diffraction Conference (EPDIC 11), Warsaw, Poland, (19-22)-9-2008. Contributed talk.

M. Medarde, M.T. Fernández-Díaz, P. Lacorre, C. Dallera, M. Grioni, M.J. Martínez-Lope, J.A. Alonso, T. Straessle, V. Pomjakushin and J. Mesot
Gap opening through charge disproportionation in RNiO3 perovskites (R = rare earth): new neutron diffraction and x-ray absorption results
Annual Meeting of the Swiss Physical Society, Genève, Switzerland, (26-27)-3-2008. Poster.

F.M. Piegsa
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J.P. Urrego-Blanco, C.R. Bingham, B. van den Brandt, A. Galindo-Uribarri, P. Hautle, J.A. Konter, E. Padilla-Rodal, P.A. Schmelzbach
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INVITED TALKS 2008

K.Conder
Crystal growth of oxides by Optical Floating Zone technique
MaMaSELF Status Meeting RIGI KULM, SWITZERLAND, 6-9 Mai 2008

M. Medarde
Neutron scattering instrumentation at the SINQ
IV Reunión de la Sociedad Española de Técnicas Neutrónicas, Sant Feliu de Guixols, (Spain), (8-10)-9-2008.

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COMMITTEES

M. Medarde
Member of College 5b (magnetism). Institut Laue-Langevin, France (until April 2008).

LECTURES AND COURSES 2008

K.Conder Keramik II (Semesterprogramm 327-0603-00), Fakultät Werkstoffe ETH Zürich, (together with Prof. L. Gauckler)

Condensed Matter Research with Neutrons and Muons

Laboratory of Muon Spectroscopy (LMU)

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **11**, 18 (2008)

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D.G. Eshchenko, V.G. Storchak and S.P Cottrell
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D.G. Eshchenko, V.G. Storchak, E. Morenzoni, T. Prokscha, A. Suter, X. Liu and J.K. Furdyna
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μSR 2008 - 11th International Conerence on Muon Spin Rotation, Relaxation, Resonance, Tsukuba, Japan, July 21-25, 2008

E. Morenzoni,
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A (closer) look below surfaces and at heterostructures with muons
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T. Prokscha, E. Morenzoni, D.G. Eshchenko, H. Luetkens, G.J. Nieuwenhuys, A. Suter
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T. Prokscha, R. Scheuermann, U. Hartmann, A. Raselli, A. Suter, A. Amato, G.J. Nieuwenhuys, A. Dijksmann, F. Gärtner, U. Greuter, S. Mutter, N. Schlumpf, E. Morenzoni
A novel VME based muSR data acquisition system at PSI
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V.G. Storchak, O.E. Parfenov, J.H. Brewer, R.L. Lichti, P.L. Russo, S.L. Stubbs, D.G. Eshchenko, E. Morenzoni, V.P. Zlomanov, A.A. Vinokurov, V.G. Bamburov
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CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

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T.C. Duan, T. Nakano, J. Matsumoto, I. Watanabe, T. Suzuki, T. Kawamata, A. Amato, F.L. Pratt and Y. Nozue
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P.C.M. Gubbens, S. Sakarya, E. Br□uck, N.H. van Dijk, A. de Visser, Y. Huang, A. Yaouanc, P. Dalmas de R_eotier, A.D. Hillier, D. Andreica, A. Amato, U. Zimmermann
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Y. Ikedo, J. Sugiyama, H. Nozaki, P. L .Russo, D. Andreica, A. Amato, M. Mansson, M. Shizuya, M. Isobe, and E. Takayama-Muromachi
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A novel VME based μSR data acquisition system at PSI
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A. Suter
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H.S. Suzuki, T. Furubayashi, Y. Kawashima, S. Nagata, T. Suzuki, T. Kawamata, I. Watanabe, T. Matsuzaki and A. Amato
μSR study of thiospinel $CuCrZrS_4$
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B.M.Wojek, E. Morenzoni, D.G. Eshchenko, T. Prokscha, A. Suter, E. Koller, E. Treboux, O. Fischer, and H. Keller
Superconductivity and Magnetism in Cuprate Multi-layers (poster)
Annual meeting of the Swiss Physical Society, Genève, March 26-27, 2008

B.M. Wojek, E. Morenzoni, D.G. Eshchenko, T. Prokscha, A. Suter, E. Koller, E. Treboux, O. Fischer, and H. Keller
Magnetism and Superconductivity in Cuprate Heterostructures Studied by Low Energy muSR (poster)
muSR 2008 -- 11th International Conerence on Muon Spin Rotation, Relaxation, & Resonance, Tsukuba, Japan, July 21-25, 2008

B.M. Wojek, E. Morenzoni, D.G. Eshchenko, A. Suter, T. Prokscha, E. Koller, E. Treboux, O. Fischer, and H. Keller
Magnetism and Superconductivity in Cuprate Heterostructures Studied by Low Energy muSR (poster)
7th PSI Summer School on Condensed Matter Research, Zuoz, August 16-22, 2008

INVITED TALKS

A. Amato,
Bulk μSR Facilities at PSI,
μSR User Meeting BVRA 2008, January 2008, Paul Scherrer Institute, Villigen Switzerland

A. Amato
Bulk MuSR: a tool to investigate nanometer scale phenomena - Introduction and selected examples
7th PSI Summer School on Condensed Matter Research, Zuoz, August 16-22, 2008

R. Khasanov
Two energy scales in the superconducting state of high-temperature cuprate superconductors: μSR and ARPES studies
Workshop on Metal Insulator transition in Cuprates (MICuO), 18 March 2008, Parma, Italy

R. Khasanov
Muon spin rotation study of the ternary non-centrosymmetric superconductors $Li_2Pd_xPt_{3-x}B$
Workshop on Non-Centrosymmetric Superconductors, 30-31 May, ETH Zurich

R. Khasanov
Magnetism and Superconductivity in RO1-xFxFeAs and RFeAsO1-x: A Local Probe Study
International Symposium on Fe-oxipnictide Superconductors, 28-29 June, Tokyo, Japan

R. Khasanov
Evidence for complex order parameters in cuprate superconductors
The 22nd General Conference of the Condensed Matter Division of the European Physical Society, 25-29 August, Rome, Italy

R. Khasanov
Partially superconducting "Fermi surface" in Bi2201: evidence for competition between superconductivity and pseudogap from superfluid density studies
Second CoMePhS Workshop in Controlling Phase Separation in Electronic Systems, 30 September - 4 October, Nafplion, Greece

R. Khasanov
μSR study of the superfluid response of Fe-based superconductors
LMU seminar, 11 November, PSI, Villigen

R. Khasanov
μSR study of the superfluid response of Fe-based superconductors
Zurich University seminar, 17 December

H. Luetkens,
Electronic Phase Diagram of $LaO_{1-x}F_xFeAs$:A Muon Spin Rotation Study (invited talk),
LMU Seminar on Fe-based Superconductors, 4.11.2008

E. Morenzoni
Depth dependent μSR on nanometer scale
International Symposium on Pulsed Neutron and Muon Sciences (IPS 08)
March 5-7, 2008, Mito, Japan

E. Morenzoni
A (closer) look below surfaces and at heterostructures with muons (Yamazaki Prize Lecture)
International Conference on Muon Spin Rotation, Relaxation and Resonance, 21-25th July 2008, Tsukuba, Japan.

E. Morenzoni
Superconductivity and Magnetism in Cuprate Heterostructures
6th International Conference on Low Temperature Physics,
6.8-13.8.2008, Amsterdam

E. Morenzoni
Introduction to polarized low energy muons as depth dependent probes of thin films and heterostructures)
7th PSI Summer School on Condensed Matter Research, Zuoz 17.8.2008

A. Maisuradze
Analysis of μSR spectra in the vortex state of type-II superconductor
Paul Scherrer Institut, 28 Feb. 2008

T. Prokscha
PSI Fast and Slow Muons
ISIS Muon Training Course, April 21-25, 2008

T. Prokscha
Thin-film investigations with low-energy muons (Non-locality and spintronics: what can low-energy muons tell us?)
PSI, Oct-24, 2008

A. Suter
Induced Superconductivity in La_2CuO_4/$La_{1.56}Sr_{0.44}CuO_4$ Superlattices
BVRA, Jan. 29, 2008, PSI, Switzerland

A. Suter
Supraleitung und Magnetismus in nominal nicht supraleitenden $La_{2-x}Sr_xCuO_4$ Übergittern
Nov. 10, 2008, Institute for Material Science, Darmstadt University of Technology, Germany

T. Shiroka
Computer Modelling and Simulations of Future Muon Sources
International Workshop on Next Generation Muon Sources, Cockcroft Institute, Daresbury Lab, UK, 8-9 April 2008.

B.M. Wojek
Superconductivity and Magnetism in Cuprate Heterostructures
Studied by Low Energy muSR Seminar in Festkörperphysik, Universität Zürich, May 14, 2008

LECTURES AND COURSES

H. Luetkens
20 Jahre PSI, "Neue Phänomene in mikroskopischen Dimensionen - Bausteine einer Zukunftstechnologie", Baden und Aarau, Germany, August, 2008,

E. Morenzoni
ETH Zürich, FS-2008
Physik mit Myonen: von der Atomphysik zur Festkörperphysik, Vorlesungen und Übungen

E. Morenzoni
ETH Zürich, FS-2008
Praktikum: Myon Spin Rotationsspektroskopie

A. Suter
20 Jahre PSI, "Neue Phänomene in mikroskopischen Dimensionen - Bausteine einer Zukunftstechnologie", Waldshut, Germany, August, 2008,

MEMBERSHIP IN EXTERNAL COMMITTEES

A. Amato
- Swiss Representative COST – Action P16, "Emergent Behaviour in Correlated Matter"
- Facility Subcommittee of the International Society for µSR Spectroscopy (ISMS)
- International Advisory Committee, 11th International Conference on Muon Spin Relaxation, Rotation and Resonance

D. Herlach
- Secretary, PSI µSR International Research Committee
- Swiss Delegate, International Society for µSR Spectroscopy (ISMS) Europe

H. Luetkens
- Executive committee member of the International Society for µSR Spectroscopy (ISMS)

E. Morenzoni
- Program Committee for muSR2008 (Tsukuba, Japan) International Advisory Committee for muSR2008 (Tsukuba, Japan)
- Program Committee for IPS08 (Mito, Japan)
- Program Committee of 7th PSI Summer School on Condensed Matter Research, Zuoz, Switzerland

AWARDS

E. Morenzoni
- Yamazaki Prize awarded by the International Society for µSR spin spectroscopy

LABORATORY FOR PARTICLE PHYSICS AND GROUP UCN PHYSICS

LIST OF PUBLICATIONS IN 2008

J. Becker, K. Bösiger, L. Lindfeld, K. Müller, P. Robmann, S. Schmitt, C. Schmitz, S. Steiner, U. Straumann, K. Szeker, P. Truöl, M. Urban, A. Vollhardt, N. Werner, D. Baumeister, S. Löchner and M. Hildebrandt
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A. Braem, E. Chesi, C. Joram, A. Rudge, J. Séguinot, P. Weilhammer, R. De Leo, E. Nappi, W. Lustermann, D. Schinzel, I. Johnson, D. Renker and S. Albrecht
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P. Lecomte, D. Luckey, F. Nessi-Tedaldi, F. Pauss and D. Renker
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W. Bertl
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Phys. Lett. **B 667**, 584 (2008)

E. Frlež, M. Bychkov, and D. Počanić
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C. Petitjean
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A. Barczyk *et al.* (PSI: K. Deiters, C. Petitjean)
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Phys. Lett. **B 663**, 172 (2008)

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I. Altarev, F. Atchison, M. Daum, A. Frei, E. Gutsmiedl, G. Hampel, F. J. Hartmann, W. Heil, A. Knecht, J. V. Kratz, T. Lauer, M. Meier, S. Paul, Y. Sobolev and N. Wiehl
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CMS Collaboration

Y. Allkofer, C. Amsler, D. Bortoletto, V. Chiochia, L. Cremaldi, S. Cucciarelli, A. Dorokhov, Ch. Hörmann, R. Horisberger, D. Kim, M. Konecki, D. Kotlinski, K. Prokofiev, C. Regenfus, T. Rohe, D. Sanders, S. Son, M. Swartz and T. Speer
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Intercalibration of the barrel electromagnetic calorimeter of the CMS experiment at start-up
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R. Adolphi *et al.* (PSI: W. Bertl, K. Deiters, P. Dick, W. Erdmann, D. Feichtinger, K. Gabathuler, Z. Hochman, R. Horisberger, Q. Ingram, H.C. Kästli, S. König , D. Kotlinski, P. Pörschke, D. Renker, T. Rohe, T. Sakhelashvili, A. Starodumov
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Phys. Lett. **B 659**, 796 (2008)

L3 Collaboration

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Astron. Astrophys. **488**, 1093 (2008)

Theory Group

A. Bredenstein, A. Denner, S. Dittmaier and S. Pozzorini
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S. Brensing, S. Dittmaier, M. Krämer and A. Mück
Radiative corrections to W-boson hadroproduction: Higher-order electroweak and supersymmetric effects
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J. Brod, F. Fugel and B. A. Kniehl
Dominant two-loop electroweak corrections to the hadroproduction of a pseudoscalar Higgs boson and its photonic decay
Phys. Rev. **D 78**, 011303 (2008)

M. Ciccolini, A. Denner and S. Dittmaier
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A. Denner, B. Jantzen and S.Pozzorini
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R. Horsky, M. Krämer, A. Mück and P. Zerwas
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M. Mühlleitner and M. Spira
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PEN collaboration

M. Bychkov
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E. Frlež
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Precise measurement of $\pi^+ \rightarrow e^+ \nu$ branching ratio
Contribution to *New Trends in High Energy Physics: Experiment, phenomenology, theory*,
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A. Palladino
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B. Keil, S. Lehner and S. Ritt
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AIP Conf. Proc.**1037**, 162 (2008)

Muonic Hydrogen

T. Nebel
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UCN Collaboration

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B. Lauss
UCN guides for the ultra-cold neutron source at PSI
Poster at the International Workshop on Particle Physics with Slow Neutrons, Grenoble (France), 29 - 31 May 2008

B. Lauss
Fundamentale Physik mit ultrakalten Neutronen am Paul Scherrer Institut
Poster at the Jahrestagung der \"Osterreichischen Physikalischen Gesellschaft, Leoben (Austria), 22 - 26 September 2008

G. Zsigmond
Monte Carlo optimization of the polarized beamlines of the ultracold neutron source at PSI
Poster at the International Workshop on Particle Physics with Slow Neutrons, Grenoble (France), 29 - 31 May 2008

CMS Collaboration

W. Erdmann
Vertex reconstruction at the CMS experiment
J. Phys. Conf. Ser. **110**, 092009 (2008)

Theory Group

N.E. Adam *et al.* (PSI: M. Ciccolini, A. Denner, M. Spira)
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Z. Bern *et al.* (PSI: A. Denner)
The NLO multileg working group: Summary report
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R. Rosenfelder
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Pionic hydrogen
Proceedings of the International Workshop Physics with Simple Atomic Systems (PSAS 2006), 13 - 17 June 2006, Venice (Italy),
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M. Raidal *et al*. (PSI: K. Kirch)
Flavor physics of leptons and dipole moments
Reports of the CERN Workshop, Flavor in the Era of the LHC, November 2005 - March 2007, eds.
R. Fleischer, T. Hurth and M. L. Mangano
Eur. Phys. J. **C 57**, 13 (2008)

R. Rosenfelder
Perturbative results without diagrams
Proceedings of he 9th International Conference ``Path Integrals - New Trends and Perspectives'',
Dresden, Germany (2007), eds. W. Janke and A. Pelster,
World Scientific, Singapore, 2008

S.Santra *et al.*
Parity-violating gamma asymmetry in $\eta + p \rightarrow d + \gamma$
Proceedings of the DAE Symposium on Nuclear Physics,
Sambalpur, Burla, Orissa (India), 11 -15 December 2007

A. Starodumov
Rare heavy flavor decays at ATLAS and CMS
18th Hadron Collider Physics Symposium 2007 (HCP 2007),
La Biodola, Isola d'Elba (Italy), 20 - 26 May 2007
Nucl. Phys. Proc. Suppl. **177-178**, 92 (2008)

A. Starodumov
Missing particle reconstruction using vertexing
Proceedings of the CERN Workshop on Flavor in the Era of the LHC, October 2006, CERN (Switzerland),
ed. M. Artuso *et al.*
Eur. Phys. J.C **57**, 309 (2008)

INVITED TALKS

M. Hildebrandt
The drift chamber system of the MEG experiment
Seminar f. Teilchen- und Astrophysik,
Universität Zürich, 19 November 2008

F.M. Piegsa,
An accurate measurement of the spin-dependent neutron-deuteron scattering length
International Workshop on Particle Physics with Slow Neutrons,
Grenoble (France), 29 - 31 May 2008

F.M. Piegsa
Neutron spin precession in samples of polarised nuclei and neutron spin phase imaging
Excellence-Cluster Seminar, Garching (Germany), 26 August 2008

F.M. Piegsa
Polarised solid targets at PSI
18th International Spin Physics Symposium, Charlottesville, VA (USA), 6 - 11 October 2008

F.M. Piegsa
Neutron spin precession in samples of polarised nuclei and neutron spin phase imaging
Group Seminar of Prof. G. Gratta, Stanford University, Stanford, CA (USA), 13 October 2008

D. Renker
New developments on photosensors for particle physics instrumentation for colliding beam physics
INSTR08, Novosibirsk (Russia), 28 February - 5 March 2008

D. Renker
Progress in the development of Geiger-mode avalanche photodiodes
IEEE Nuclear Science Symposium, Dresden (Germany), 19 - 25 October 2008

UCN Collaboration

R. Henneck
The new high-intensity ultracold neutron source at PSI
PANIC08, Eilat (Israel), 9 - 14 November 2008

K. Kirch
Towards a new measurement of the neutron electric dipole moment
Int. Workshop on Particle Physics with Slow Neutrons, Grenoble (France), 29 - 31 May 2008

K. Kirch
Betazerfall: R-Parameter
39. Arbeitstreffen Kernphysik Schleching,
Schleching (Austria), 21 - 28 February 2008

K. Kirch
FUN with UCN
Universität Bern, 23 April 2008

K. Kirch
The quest for new physics: Neutrons and muons
ETH Zürich. 3 June 2008

K. Kirch
Neutron EDM experiments
Workshop on *P and T Violation at Low Energies and Related Phenomena*,
Heidelberg (Germany), 9 - 11 June 2008

K. Kirch
Muon electric dipole moment
10th International Workshop on Neutrino Factories, Superbeams and Betabeams (Nufact08),
Valencia (Spain), 30 June - 5 July 2008

K. Kirch
FUN with UCN
Universität Münster, 4 July 2008

K. Kirch
Low energy precision experiments (2 lectures)
Zuoz Summer School on *New Ideas in Particle Physics*,
Zuoz, Engadine (Switzerland), 13 - 19 July 2008

K. Kirch
Ultrakalte Neutronen
Universität Wuppertal, 24 November 2008

K. Kirch
Ultracold neutrons at ILL and PSI
Symposium on the Occasion of 20 Years Partnership between Switzerland and the Institut Laue-Langevin ILL Grenoble, PSI, 28 November 2008

A. Knecht
A direct experimental limit on neutron - mirror neutron oscillations
SPG Jahrestagung, Geneva (switzerland), 26 - 27 March 2008

A. Knecht
A direct experimental limit on neutron - mirror neutron oscillations
Talk and poster at International Workshop on Particle Physics with Slow Neutrons, Grenoble (France),29 - 31 May 2008

M. Kuzniak
An improved electric dipole moment experiment
FCPC08, Taipei (Taiwan), 5 - 9 May 2008.
B. Lauss
Status of the ultra-cold neutron source and the neutron EDM experiment at the Paul Scherrer Institut
4th International Workshop on Nuclear and Particle Physics at J-PARC (NP08), Ibaraki (Japan), 5 - 7 March 2008

B. Lauss
Experiments on muon capture and muon lifetime: Latest results and future goals
Annual Meeting of the Swiss Physical Society, Geneva (Switzerland), 27 - 28 March 2008

B. Lauss
Fundamentale Physik mit ultrakalten Neutronen am Paul Scherrer Institut
Fachausschusstagung Kern- und Teilchenphysik der Österreichischen Physikalischen Gesellschaft, Aflenz (Austria), 21 - 23 September 2008

B. Lauss
Fundamental measurements with muons - View from PSI
International Conference on Particles And Nuclei (PANIC08),
Eilat (Israel), 9 - 14 November 2008

G. Zsigmond
The UCN source at PSI
Workshop on tailored neutron beams & neutron anti-bunching, ATI
Wien (Austria), 6 - 8 March 2008

PEN Collaboration

D. Počanić
Rare pion and muon decays: Summary of results and prospects
``Low Energy Precision Electroweak Physics in the LHC Era,''
Institute for Nuclear Theory, University of Washington,
Seattle, 21 November 2008

D. Počanić
PEN Experiment: A sensitive search for non-(V-A) weak processes
18th International Conference on Particles and Nuclei (PANIC08),
Eilat, Israel, 9--14 November 2008

MEG Collaboration

F. Cei
The MEG experiment
Neutrino Oscillation Workshop (NOE 2008), Conca Specchiulla Otranto,
Lecce (Italy), 6 - 13 September 2008.

L. Galli
An FPGA-based trigger for the search of $\mu \rightarrow e + \gamma$ in the MEG experiment
2008 Nuclear Science Symposium, Dresden (Germany), 19 - 25 October 2008

O. Kiselev
Status of MEG experiment
10th International Workshop on Tau Lepton Physics, Budker Institute of Nuclear Physics,
Novosibirsk, 22 - 25 September 2008

O. Kiselev
Positron spectrometer of MEG experiment at PSI
8th International Conference on Position Sensitive Detectors (PSD8),
Glasgow, Scotland, 1- 5 September 2008

W. Ootani
Status of MEG at PSI & prospects
3rd CHIPP Neutrino Meeting, ETHZ, Zürich, 17 - 18 November 2008

A. Papa
Search for lepton flavour violation with the MEG experiment
New Trends in High Energy Physics (Crimea 2008),
Yalta (Ukraine), 27 September - 4 October 2008

S. Ritt
Tackling the search for Lepton flavour violation with GHz waveform digitizing using the DRS chip
Seminar at Fermilab, Batavia, Illinois (USA), 26 February 2008

G. Signorelli
The MEG experiment at PSI: Status and prospects
PANIC 2008, Eilat (Israel), 11 - 16 November 2008

G. Signorelli
Status of MEG: An experiment to search for the $\mu \rightarrow e\gamma$ *decay*
Symposium on Muon Physics during the Workshop
"Low Energy Precision Electroweak Physics in the LHC Era",
Institute of Nuclear Theory & University of Washington,
Seattle, WA (USA), 27-30 October 2008

Pionic Hydrogen

D. Gotta
X-ray spectroscopy of light hadronic atoms
International Conference on Exotic Atoms (EXA08),
Vienna (Austria), 15 - 19 September 2008

MuLan Collaboration

K. Lynch
The MuLan experiment: Measuring the muon lifetime to 1ppm
10th International Workshop on Tau Lepton Physics (Tau08),
Budker Institute for Nuclear Physics, Novosibirsk (Russia), 22 - 25 September 2008

MuCap Collaboration

C. Petitjean
Muon capture in hydrogen and deuterium
Int. Conference on Exotic Atoms & related topics (EXA08),
Vienna (Austria), 15 - 18 September 2008

I. Alekseev, T.I. Banks, O. Fedorchenko, V. Ganzha, P. Kravtsov, P. Kammel, C. Petitjean, V. Trofimov, A. Vasilyev and M. Vznuzdaev
Deuterium removal unit for the Mucap experiment
NHA Annual Hydrogen Conference 2008, Sacramento, CA (USA), 30 March - 3 April 2008

Muonic Hydrogen

A. Antognini
The thin-disk laser for the muonic hydrogen Lamb shift experiment
International Workshop on Laserspectroscopy,
Ringberg-Tegernsee (Germany), 8 - 12 September 2008

T. Nebel
Lamb shift in muonic hydrogen: Experiment and results from the 2007 campaign
International Workshop on Laserspectroscopy,
Ringberg-Tegernsee (Germany), 8 - 12 September 2008

R. Pohl
2S state and Lamb shift in muonic hydrogen
International Workshop on Laserspectroscopy,
Ringberg-Tegernsee (Germany), 8 - 12 September 2008.

R. Pohl
2S state and Lamb shift in muonic hydrogen
Int. Conf. on Exotic Atoms and Related
Topics (EXA08), Vienna (Austria), 15 - 19 September 2008

CMS Collaboration

L. Caminda and A. Starodumov
Building and commissioning of the CMS pixel barrel detector
Pixel 2008 International Workshop, Fermilab, Batavia (USA), 23 - 26 September 2008.

L. Caminda
Topics in heavy quark physics at CMS
18th International Conference On Particles and Nuclei (PANIC08),
Eilat (Israel), 9 - 14 November 2008

W. Erdmann
Beam spot and primary vertices
CMS b-tagging workshop, CERN, 29 October 2008

W. Erdmann
Tracking in high energy physics
University of Kansas, Kansas (USA), 17 September 2008

R. Horisberger
Conference summary talk of VERTEX 2008
17th International Workshop on Vertex detectors (Vertex2008),
Utö Island (Sweden), 28 July - 1 August 2008

H.-C. Kästli
Integration and installation of the CMS pixel barrel detector
17th International Workshop on Vertex detectors (Vertex2008),
Utö Island (Sweden), 28 July - 1 August 2008

S. König
Building the detector modules for the barrel part of the CMS pixel detector
Vertical Integration Technologies for HEP and Imaging Sensors,
Ringberg Castle, Lake Tegernsee (Germany), 7 April 2008

D. Kotlinski
Status of the CMS pixel detector
Pixel 2008 International Workshop, Fermilab, Batavia (USA), 23 - 26 September 2008

B. Meier
Design studies of a low power serial data link for a possible upgrade of the CMS pixel detector
Topical Workshop on Electronics for Particle Physics Search (TWEPP-08),
Naxos (Greece), 15 - 19 September 2008

T. Rohe
Signal height in silicon pixel detectors irradiated with pions and protons
7th International Conference on Radiation Effects on Semiconductor Materials Detectors and Devices, Florence (Italy), 15 - 17 October 2008
A. Starodumov
Building the CMS pixel barrel detector: Assembling, testing and integration
Pixel 2008 International Workshop, Fermilab, Batavia (USA), 23 - 26 September 2008

A. Starodumov
Flavor physics with CMS at LHC
2nd International Workshop on Theory, Phenomenology and Experiments in Heavy Flavor Physics,
Capri (Italy), 16 - 18 June 2008

Theory Group

A. Denner
Reduction of multiparticle one-loop integrals and amplitudes (5 lectures)
Third Graduate School in Physics at Colliders: from Twistors to Monte Carlos,
Turin (Italy), 7 - 11 January 2008

A. Denner
Electroweak and QCD corrections to Higgs production in vector-boson fusion at the LHC
8th DESY Workshop: Loops and Legs in Quantum Field Theory,
Sondershausen (Germany), 20 - 25 April 2008

A. Denner
Towards reliable predictions for multiparticle processes at the LHC
Seminar Elementarteilchentheorie,
Würzburg (Germany), 5 June 2008

A. Mück
Squark decay chains at NLO SUSY-QCD
Theory Seminar, MPI München (Germany), 28 January 2008

A. Mück
Electroweak precision at the LHC
Frühjahrstagung der Deutschen Physikalischen Gesellschaft,
Freiburg (Germany), 4 March 2008

A. Mück
Electroweak precision for W-boson production at the LHC
Swiss Physical Society Annual Meeting,
Geneva (Switzerland), 26 March 2008

A. Mück
Squark decay chains at NLO SUSY-QCD
CMS SUSY Meeting, CERN, 30 April 2008

A. Mück
Squark decay chains at NLO SUSY-QCD
ATLAS SUSY Meeting, CERN, 21 May 2008

A. Mück
Squark decay chains at NLO SUSY-QCD
Particle Physics Seminar, ETH Zürich, 27 May 2008

A. Mück
Electroweak corrections to W hadroproduction
LHC-D workshop on QCD and EW Physics, Zürich, 3 June 2008

A. Mück
Precise prediction for MSSM Higgs-boson production in bottom quark fusion
MSSM Higgs Physics at the LHC: Theory meets Experiment,
Santander (Spain), 8 October 2008

M. Spira
Associated MSSM Higgs production with heavy quarks: SUSY-QCD corrections
SUSY08 conference, Seoul (Korea), 16 - 21 June 2008

M. Spira
Recent progress in Higgs cross section (and branching ratios) calculations
CMS-Meeting, CERN, 4 July 2008

M. Spira
Associated MSSM Higgs production with heavy quarks: SUSY-QCD corrections
SUSY08 conference, Seoul (Korea), 16 - 21 June 2008

M. Spira
Higgs & ILC: Reality or wishful thinking?
LC08 School, Frascati (Italy), 22 - 25 September 2008

OUTREACH AND OTHER SCIENTIFIC ACTIVITIES

P.-R. Kettle
New COMET brings a promising future to proton therapy
AAPPS (Association of Asia Pacific Physical Societies) Bulletin **18**, 24 (2008)

A. Knecht and M. Kuzniak
Mirror matter - Experimental search for neutron to mirror neutron oscillations
SPG Mitteilungen **22**, 6 2008

A. Knecht and M. Kuzniak
Mirror matter - experimental search for neutron to mirror neutron oscillations
Nucl. Phys. News **18,** No. 1, 2008

R. Rosenfelder and M. Spira (organizers)
New ideas in particle physics
Summer School, Lyceum Alpinum, Zuoz, Engadine (Switzerland), 13 - 19 July 2008

LECTURES AND COURSES

A.Denner
Das Standardmodell der elektroschwachen Wechselwirkung und dessen Erweiterungen
ETH Zürich, HS 08

R. Horisberger
Elektronik für Physiker I, Analog
ETH Zürich, HS 08

R. Rosenfelder
Pfadintegrale in der Quantenphysik
ETH Zürich, HS 08

M. Spira and A. Mück
LTP-Colloquium
PSI, FS 08, HS 08

M. Spira
Einführung in die Quantenchromodynamik
ETH Zürich, FS 08

M. Spira (with F. Moortgat)
Jenseits des Standardmodells
ETH Zürich, HS 08

THESES

S. Heule
Production, characterization and reflectivity measurements of diamond-like carbon and other ultracold neutron guide materials
Doctoral thesis, Universität Zürich, 2008

M. Kasprzak
Ultracold neutron converters
Doctoral thesis, Universität Wien, 2008

M. Kuzniak
The neutron electric dipole moment experiment: Research and development for the new spectrometer
Doctoral thesis, Jagiellonian University, Krakow (Poland), 2008

H. Nishiguchi
An innovative positron spectrometer to search for the lepton flavour violating muon decay with a sensitivity of 10^{-13}
Doctoral Thesis, University of Tokyo, 2008
Advisors: T. Mori (Tokyo), J. Egger (PSI)

D. Noth
Supersymmetric precision calculations of bottom Yukawa couplings
Doctoral thesis, Universität Zürich, December 2008
Advisors: M. Spira (PSI), D. Wyler (U. Zürich)

COMMITTEES

R.Horisberger
- President of the Internal PSI Forschungskommission (FOKO).
- Member of the Photon Science Committee at HASYLAB , DESY Hamburg,
- Member of the Advisory Commitee of VERTEX-Conferences

K. Kirch
- Member of the Committee of the Swiss Physical Society,
- Swiss Correspondent for Nuclear Physics News

S. Ritt
- Elected member of the IEEE Nuclear & Plasma Sciences Society Administrative Committee (AdCom)

R. Rosenfelder
- Member of the Research Committee BVR at PSI

M. Spira
- Convenor of the working group 'Electroweak Gauge Theories and Alternative Theories' of the 'ECFA Study of Physics and Detectors for a Linear Collider'

Radio- and Environmental Chemistry
LIST OF PUBLICATIONS

HEAVY ELEMENTS

R. Eichler, N.V. Aksenov, A.V. Belozerov, G.A. Bozhikov, V.I. Chepigin, R. Dressler, S.N. Dmitriev, H.W. Gäggeler, V.A. Gorshkov, F. Haenssler, M.G. Itkis, V.Y. Lebedev, A. Laube, O.N. Malyshev, Yu.Ts. Oganessian, O.V. Petruschkin, D. Piguet, P. Rasmussen, A. Serov, S.V. Shishkin, A.V. Shutov, A.I. Svirikhin, E.E. Tereshatov, G.K. Vostokin, M. Wegrzecki, A.V. Yeremin
Thermochemical and physical properties of element 112
Angew. Chem. Int. Ed., **47**(17),3262-3266 (2008).

R. Eichler, N.V. Aksenov, A.V. Belozerov, G.A. Bozhikov, V.I. Chepigin, R. Dressler, S.N. Dmitriev, H.W. Gäggeler, V.A. Gorshkov, F. Haenssler, M.G. Itkis, V.Y. Lebedev, A. Laube, O.N. Malyshev, Yu.Ts. Oganessian, O.V. Petruschkin, D. Piguet, P. Rasmussen, A. Serov, S.V. Shishkin, A.V. Shutov, A.I. Svirikhin, E.E. Tereshatov, G.K. Vostokin, M. Wegrzecki, A.V. Yeremin
Thermochemische und physikalische Eigenschaften von Element 112
Angew. Chem. **120**(17), 3306-3310 (2008).

J.M. Gates, M.A. Garcia, K.E. Gregorich, Ch.E. Düllmann, I. Dragojević, J. Dvorak, R. Eichler, C.M. Folden, W. Loveland, S.L. Nelson, G.K. Pang, L. Stavsetra, R. Sudowe, A. Türler, H. Nitsche
Synthesis of rutherfordium isotopes in the $^{238}U(^{26}Mg, xn)^{264-x}Rf$ reaction and study of their decay properties
Phys. Rev. C **77**, 034603 (2008).

S.L. Nelson, C.M. Folden III, K.E. Gregorich, I. Dragojevich, Ch.E. Düllmann, R. Eichler, M.A. Garcia, J.M. Gates, R. Sudowe, H. Nitsche
Comparison of complementary reactions for the production of $^{261,262}Bh$
Phys. Rev. C **78**, 024606 (2008).

SURFACE CHEMISTRY

J. Abbatt, T. Bartels-Rausch, M. Ullerstam, T. Ye
Uptake of acetone, ethanol and benzene to snow and ice: Effects of surface area and temperature
Env. Res. Let. **3**(4), 045008 (2008).

T. Bartels-Rausch, T. Huthwelker, M. Jöri, H.W. Gäggeler, M. Ammann
Interaction of gaseous elemental mercury with snow surfaces: Laboratory investigation
Env. Res. Let. **3**(4), 045009 (2008).

M. Kerbrat, B. Pinzer, T. Huthwelker, H.W. Gäggeler, M. Ammann, M. Schneebeli
Measuring the specific surface area of snow with x-ray tomography and gas adsorption: Comparison and implications for surface smoothness
Atmos. Chem. Phys. **8**(5), 1261-1275 (2008).

M. Ndour, B. D'Anna, C. George, O. Ka, Y. Balkanski, J. Kleffmann, K. Stemmler, M. Ammann
Photoenhanced uptake of NO_2 on mineral dust: Laboratory experiments and model simulations
Geophys. Res. Let. **35**(5), L058/2 (2008).

K. Stemmler, A. Vlasenko, C. Guimbaud, M. Ammann
The effect of fatty acid surfactants on the uptake of nitric acid to deliquesced NaCl aerosol
Atmos. Chem. Phys. **8**(17), 5127-5141 (2008).

O. Vesna, S. Sjogren, E. Weingartner, V. Samburova, M. Kalberer, H.W. Gäggeler, M. Ammann
Changes of fatty acid aerosol hygroscopicity induced by ozonolysis under humid conditions
Atmos. Chem. Phys. **8**(16), 4683-4690 (2008).

ANALYTICAL CHEMISTRY

E. Dietze, A. Kleber, M. Schwikowski
Response of regional climate and glacier ice proxies to El Niño-Southern Oscillation (ENSO) in the subtropical Andes
Clim. Past. Discuss. **4**, 173-211 (2008).

S. Kaspari, R. Hooke, P.A. Mayewski, S. Kang, S. Hou, D. Qin
Snow accumulation rate on Mt. Everest: synchroneity with sites across the Tibetan Plateau on 50-100 year timescales
J. Glaciol., **45**(185), 343-352 (2008).

F. Vimeux, P. Ginot, M. Schwikowski, M. Vuille, G. Hoffmann, L.G. Thompson, U. Schotterer
Some aspects of the climate variability during the last 1,000 years from Andean ice cores: a review of recent results
Palaeogeography, Palaeoclimatology, Palaeoecology, doi:10.1016/j.palaeo.2008.03.054 (2008) in press.

RADWASTE ANALYTICS

S. Chiriki, J. Fachinger, R. Mormann
Decommissioning and safety issues of liquidmercury waste generated from high power spallation sources with particle accelerators
11th International Conference on Radiation Shielding (ICRS-11) of American Nuclear Society, Pine Mountain, Georgia, USA.

J. Neuhausen, S. Horn, B. Eichler, D. Schumann, T. Stora, M. Eller
Mercury purification in the Megawatt Liquid Metal Spallation Target of EURISOL-DS
Proceedings of the Eighth International Topical Meeting on Nuclear Applications and Utilization of Accelerators (AccApp'07), Pocatello, Idaho, July 29- August 2, 2007, American Nuclear Society, LaGrange Park, Illinois, USA.

D. Schumann, J. Neuhausen, S. Horn, P.W. Kubik, I. Günther-Leopold
Radiochemical separation and analytical determination of ^{10}Be from proton-irradiated graphite targets
Radiochim. Acta **96** (31) (2008).

D. Schumann, J. Neuhausen
Accelerator waste as a source for exotic radionuclides
J. Phys. G: Nucl. Part. Phys. **35** 014046 (2008).

E. E. Tereshatov, H. Bruchertseifer, G.A. Bozhikov, N.V. Aksenov, G.Ya. Starodub, G.K. Vostokin, A.G. Belov, S.V. Shishkin, S.N. Dmitriev, H.W. Gäggeler, R. Eichler, D. Schumann
Cation-exchange separation of group V elements: Model experiments on isolation and chemical identification of Db
Radiochemistry **50 (3)**, 290-293 (2008).

PROTON IRRADIATION FACILITY

E. Bellm, M.E. Bandstra, S.E. Boggs, W. Hajdas, K. Hurley, D.M. Smith, C. Wigger
RHESSI Spectral Fits of Swift GRBs
GAMMA-RAY BURSTS 2007: Proceedings of the Santa Fe Conference. AIP Conference Proceedings, Volume 1000, p. 154-157 (2008).

H.D.R. Evans, P. Bühler, W. Hajdas, E.J. Daly, P. Nieminen, A. Mohammadzadeh
Results from the ESA SREM monitors and comparison with existing radiation belt models
Advances in Space Research, **42**, Issue (9), p. 1527-1537 (2008).

U. Grossner, W. Hajdas, K. Egli, R. Brun, R. Harboe-Sorensen
Proton Irradiation Facility at the PROSCAN project of the Paul Scherrer Institute
Proceedings of the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, PD4 (256).

A. Javanainen, M. Sillanp, W.H. Trzaska, A. Virtanen, G. Berger, W. Hajdas, R. Harboe-Sørensen, H. Kettunen, T. Malkiewicz, M. Mutterer, J. Perkowski, A. Pirojenko, I. Riihimaki, T. Sajavaara, G. Tyurin, H.J. Whitlow
Experimental Linear Energy Transfer of Heavy Ions in Silicon for RADEF Cocktail Species
Proceedings of the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, PH3 (470).

P. de Korte, J. Anquita, F. Bakker, X. Barcons, P. Bastia, J. Beyer, D. Boersma, F. Friones, M. Bruijn, J. Bussons, A. Camòn, F. Carrera, M. Ceballos, L. Colasanti, D. Drung, L. Fabrega, L. Ferrari, F. Gatti, R. Gonzalez-Arrabal, L. Gottardi, W. Hajdas, P. Helistö, J.W. den Herder, H. Hoevers, Y. Ishisaki, M. Kiviranta, J. van der Kuur, C. Macculi, A. McHedlishvili, K. Mitsuda, B. Monna, R. Mossel, T. Ohashi, S. Paltani, M. Parra, L. Piro, R. Rohlfs, J. Jésé, Y. Takei, G. Torrioli, H. van Weers, N. Yamasaki
EURECA: European-Japanese Microcalorimeter Array
Journal of Low Temperature Physics, **151**, Issue (3-4), p. 733-739 (2008).

J. Řípa, A. Mészáros, R. Hudec, C. Wigger, W. Hajdas
The RHESSI Satellite and Classes of Gamma-ray Bursts
GAMMA-RAY BURSTS 2007: Proceedings of the Santa Fe Conference. AIP Conference Proceedings, Volume 1000, pp. 56-59 (2008).

J. Řípa, D. Huja, A. Mészáros, R. Hudec, W. Hajdas, C. Wigger
A Search for Gamma-ray Burst Subgroups in the SWIFT and RHESSI Databases
2008 NANJING GAMMA-RAY BURST CONFERENCE. AIP Conference Proceedings, Volume 1065, p. 71-74 (2008).

St. Scherrer, W. Hajdas, U. Grossner, N. Schlumpf
Proton radiation test of DC/DC converter with high voltage output
Proceedings of the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, PA2 (70).

C. Wigger, O. Wigger, E. Bellm, W. Hajdas
Prompt spectrum of GRB 021206 supports the Cannonball Model
GAMMA-RAY BURSTS 2007: Proceedings of the Santa Fe Conference. AIP Conference Proceedings, Volume 1000, p. 170-173 (2008).

C. Wigger, O. Wigger, E. Bellm, W. Hajdas
Observation of an Unexpected Hardening in the Spectrum of GRB 021206
The Astrophysical Journal, **675**, (1), p. 553-565 (2008).

ENVIRONMENTAL RADIONUCLIDES UNIVERSITÄT BERN

T. Barrelet, A. Ulrich, H. Rennenberg, C.N. Zwicky, U. Krähenbühl
Assesing the suitability of Norway Spruce wood as an environmental archive for sulphur
Environmental Pollution **156**, 1007-1014 (2008).

M. Döbeli, M. Ruff, M. Suter, H.-A. Synal, E. von Wartburg, L. Wacker
Detection of trace deuterium in depleted protium by MeV ion beam techniques
Nucl. Instr. Meth. Phys. Res. B **266**, 1820–1823, doi:10.1016/j.nimb.2007.12.007 (2008).

A.A.M. Gaschen, M. Döbeli, A. Markwitz, B. Barry, S. Ulrich-Bochsler, U. Krähenbühl
Restrictions on fluor depthprofiling for exposure age dating in archaeological bones
Journal of Archaeological Science **35**, 535-552 (2008).

N. Homazava, A. Ulrich, U. Krähenbühl
In situ element-specific and time-resolved investigation of micro-corrosion processes
Chimia **62**, 530 (2008).

N. Homazava, A. Ulrich, U. Krähenbühl
Spatially and time-resolved element-specific in situ corrosion investigations with an online hyphenated microcapillary flow injection inductively coupled plasma mass spectrometry set-up
Spectrochimica Acta Part B **63**, 777-783 (2008).

N. Homazava, A. Shkabko, D. Logvinovich, U. Krähenbühl, A. Ulrich
Element-specific in situ corrosion behaviour of Zr-Cu-Ni-Al-Nb bulk metallic glass in acidic media studied using a novel microcapillary flow injection inductively coupled plasma mass spectrometry technique
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  23 December 2008.

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Klimasignale im Gletschereis und in Bäumen
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Proton Irradiation Facility

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Radiation detectors for space weather monitoring
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  June 2008.

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  2 December 2008.

MEMBERS OF SCIENTIFIC COMMITTEES
EXTERNAL ACTIVITIES

Dr. Markus Ammann:
- Air-Ice Chemical Interactions (AICI), Member of Steering Committee
- Atmospheric Chemistry and Physics: member of editorial board
- Member of the IUPAC Subcommittee on gas kinetic data evaluation
- PSI internal research commission (FoKo), member

Dr. Robert Eichler:
- PSI internal research commission (FoKo), member

Prof. Dr. Heinz W. Gäggeler:
- Nuklearforum Schweiz, Member of the Executive Board and Member of the Science Board
- Schweizerische Kommission für die hochalpine Forschungsstation Jungfraujoch der SANW (Mitglied)
- Astronomische Kommission der Stiftung Jungfraujoch und Gornergrat (Member)
- Joint IUPAC/IUPAP Working Party (JWP) on the discovery of new elements (Member)
- International Union of Pure and Applied Chemistry (IUPAC) (Fellow)
- Steering Committee of EURISOL (Member)
- Division of Nuclear and Radiochemistry, European Association for Chemical and Molecular Sciences (EuCheMS) (Chairman)
- Oeschger Centre for Climate Change Research, Member of the Scientific Board

Dr. Wojtek Hajdas:
- Official Reviewer for the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, Jyvaskyla, 10-12 September 2008
- Session Chair for the session "dosimetry and facilities" of the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, Jyvaskyla, 10-12 September 2008
- International Technical Committee of the 8th European Workshop on Radiation Effects on Components and Systems RADECS2008, Jyvaskyla, 10-12 September 2008
- Organizing Committee for 9th ESA Final Presentation Days and RADECS Thematoc Workshop, 27-29 January, PSI Villigen

Dr. Dorothea Schumann:
- Member of the Nuklearforum Schweiz
- Member of the Schweizerische Gesellschaft der Kernfachleute
- Member of the PSI internal Neutron Source Development Group

PD Dr. Margit Schwikowski:
- Expert of the Matura Examination of Kantonsschule Baden
- Member of the Coordinating Committee of the Pages/IGBP initiative LOTRED SA (Long-Term climate Reconstruction and Diagnosis of (southern) South America)
- Schweizerische Gesellschaft für Schnee, Eis und Permafrost (SEP), board member
- Member of the Oeschger Centre for Climate Change Research

Leonhard Tobler:
- Experte Physik, 42. Nationaler Wettbewerb Schweizer Jugend forscht,
  April 25, 2008, Freiburg, Schweiz. Betreuung der Arbeit: „Der Nachweis von gesundheitsschädlichen Stoffen in handelsüblichen Fischen mit Hilfe der Neutronenaktivierungsanalyse"

BACHELOR THESIS

Stephan Keller

Anionenbestimmungen von Aerosolfiltern

Dr. S. Szidat / Uni Bern
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
May 2008

MASTER THESIS

Beat Muther

Chemische Modellstudien für die Elemente 113 und 114

Dr. R. Eichler / PSI
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
January 2008

Stephan Heinitz

Extraction of polonium from lead-bismuth eutectic

Dr. D. Schumann / PSI
Prof. Dr. H. Morgner / University Leipzig
November 2008

Andreas M. Bernhard

Photo-induced reduction of mercury in ice

PD Dr. M. Schwikowski / PSI & Uni Bern
Dr. M. Ammann / PSI, Dr. T. Bartels-Rausch / PSI
December 2008

Stéphane Schmoker

Isolierung einzelner Bodenkomponenten aus Bodenproben für die Radiokohlenstoffdatierung

Dr. S. Szidat / Uni Bern
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
December 2008

David Wittwer

Stopping force measurements of ^{48}Ca induced reaction products in Mylar and argon

Dr. R. Eichler / PSI
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
December 2008

DOCTORAL THESIS

Olga Vesna

Ozonolysis of unsaturated organic acids in aerosol particles:
products, secondary chemistry and hygroscopicity studies

Dr. M. Ammann / PSI
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
February 2008

Kaizhen Li

On the investigation of I-129 in the environment by ICP-MS: possibilities and limitations

Prof. Dr. U. Krähenbühl / Uni Bern
April 2008

Hanna Franberg

Production of exotic, short-lived carbon isotopes at ISOL-type facilities

Dr. M. Ammann / PSI
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
October 2008

Thomas Kellerhals

Holocene climate fluctuations in tropical South America deduced from an Illimani ice core

PD Dr. M. Schwikowski / PSI & Uni Bern
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
December 2008

Matthias Ruff

Radiocarbon measurement of micro-scale samples – a carbon dioxide inlet system for AMS

Dr. S. Szidat / Uni Bern
Prof. Dr. H.W. Gäggeler / PSI & Uni Bern
December 2008

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RF-plasma assisted pulsed laser deposition of nitrogen-doped SrTiO3 thin films
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A.M. Müller, M. Christl, M. Döbeli, P.W. Kubik, M. Suter and H.-A. Synal
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Nuclear Instruments and Methods **B 266,** 2207-2212 (2008).

N. Akçar, S. Ivy-Ochs, C. Schlüchter
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Quaternary Science Journal **57,** 226-238 (2008).

Publikationen 2008
Labor für Ionenstrahlphysik

K.P. Norton, F. von Blanckenburg, F. Schlunegger, M. Schwab and P.W. Kubik
Cosmogenic nuclide-based investigation of spatial erosion and hillslope channel coupling in the transient foreland of the Swiss Alps
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A. Oron, G. Hadas, N. Liphschitz and G. Bonani
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J.M. Schaefer, P. Oberholzer, Z. Zhao, S. Ivy-Ochs, R. Wieler, H. Baur, P.W. Kubik and C. Schlüchter
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Nuclear Instruments and Methods **B 266,** 2246-2250 (2008).

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Labor für Ionenstrahlphysik

R. Zech, J.H. May, C. Kull, J. Ilgner, P.W. Kubik and H. Veit
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Journal of Quaternary Science **23,** 635-647 (2008).

LIST OF PUBLICATIONS 2008

BIOMOLECULAR RESEARCH

UNIVERSITY LEVEL AND OTHER TEACHING

K. Ballmer-Hofer
Celullar signalling
Biozentrum, University of Basel, Switzerland, HS 2008

K. Ballmer-Hofer
Hypoxia signaling in angiogenesis, applications in tumor therapy
Cancer Network, ETH Zurich and University of Zurich, Switzerland, March 2008

R. Jaussi
„Gentechnik" for students in medicine
University of Zurich, FS 2008

R. Jaussi
"Molekulare Zellbiologie" for students in life sciences
University of Zurich, HS 2008

Ch. Kambach
EMBO Practical Course on the Structural Characterization of Macromolecular Complexes
EMBL Grenoble, France, June 2 – 7, 2008

X.-D. Li
Membrane protein purification
7th NCCR Practical Course and EMBN Summer School "Practical Course 2D Membrane Protein Crystallization and Observation", Basel, Switzerland, October 20 – 24, 2008

F.K. Winkler
Grundlagen der Biologie I
ETH Zurich, FS 2008

F.K. Winkler
Molecular Biology and Biophysics III: Proteins: Structure, Function and Engineering
ETH Zurich, HS 2008

PUBLICATIONS

A. Akhmanova, M.O. Steinmetz
Tracking the ends: a dynamic protein network controls the fate of microtubule tips
Nat. Rev. Mol. Cell Biol. 9, 309 – 322 (2008)

O. Azzaroni, M. Mir, L. Tiefenauer, W. Knoll
Electrochemical rectification with redox-labeled supramolecular bioconjugates: Molecular building blocks fort he construction of biodiodes
Langmuir 24, 2878 – 2883 (2008)

S. Cébe-Suarez, F.S. Grunewald, R. Jaussi, X. Li, L. Claesson-Welsh, D. Spillmann,
A.A. Mercer, A.E. Prota, K. Ballmer-Hofer
Orf virus VEGF-E NZ2 promotes paracellular NRP-1/VEGFR-2 coreceptor assembly via the peptide RPPR
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J. Dolenc, R. Baron, J.H. Missimer, M.O. Steinmetz, W.F. van Gunsteren
Exploring the conserved water sites and hydration of a coiled-coil trimerization motif: A MD simulation study
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O. Eidam, F.S. Dworkowski , R. Glockshuber, M.G. Grütter, G. Capitani
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I. Grigoriev, S. Montenegro Gouveia, B. van der Vaart, J. Demmers, J.T. Smyth,
S. Honnappa, D. Splinter, M.O. Steinmetz, J.W. Putney, C.C. Hoogenraad, A. Akhmanova
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J.P. Grimshaw, C.U. Stirnimann, M.S. Brozzo, G. Malojcic, M.G. Grütter, G. Capitani,
R. Glockshuber
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J. Mol. Biol. 380, 667 – 680 (2008)

S. Hartmann, J.H. Missimer, C. Stoeckel, E. Abela, J. Shah, R.J. Seitz, B.J. Weder
Functional connectivity in tactile object discrimination – A principal component analysis of an event related fMRI-study
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S.J. Hwang, S.H. Kim, H.Z. Kim, M.O. Steinmetz, G.Y. Koh, G.M. Lee
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A. Javelle, D. Lupo, P. Ripoche, T. Fulford, M. Merrick, F.K. Winkler
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Proc. Natl. Acad. Sci. USA 105, 5040 – 5045 (2008)

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A. Shimizu, D. Edholm, K. Ballmer-Hofer, L. Kjellen, M. Klagsbrun, L. Claesson-Welsh
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K. Licht, J. Medenbach, R. Lührmann, Ch. Kambach, A. Bindereif
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T. Manna, S. Honnappa, M.O. Steinmetz, L. Wilson
Suppression of microtubule dynamic instability by the +TIP protein EB1 and its modulation by the CAP-Gly domain of $p150^{Glued}$
Biochemistry 47, 779 – 786 (2008)

M. Mir, M. Álvarez, O. Azzaroni, L. Tiefenauer, W. Knoll
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C. Puorger, O. Eidam, G. Capitani, D. Erilov, M.G. Grütter, R. Glockshuber
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E.S. Rennel, M.A. Hamdollah-Zadeh, E.R. Wheatley, A. Magnussen, Y.Schuler, S.P. Kelly, C. Finucane, D. Ellison, S. Cébe-Suarez, K. Ballmer-Hofer, S. Mather, L. Stewart, D.O. Bates, S.J. Harper
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Atomic models of de novo designed ccβ*-Met amyloid-like fibrils*
J. Mol. Biol. 376, 898 – 912 (2008)

M.O. Steinmetz, A. Akhmanova
Capturing protein tails by CAP-Gly domains
Trends Biochem. Sci. 33, 535 – 545 (2008)

L. Tiefenauer, A. Studer
Nano for bio: Nanopore arrays for stable and functional lipid bilayer membranes
Biointerphases 3, FA74-FA79 (2008)

R.A. Vacca, S. Giannattasio, G. Capitani, E. Marra, P. Christen
Molecular evolution of B6 enzymes: binding of pyridoxal-5'-phosphate and Lys41Arg substitution turn ribonuclease A into a model B6 protoenzyme
BMC Biochem. 9, 17 (2008)

R. Verel, I.T. Tomka, C. Bertozzi, R. Cadalbert, R.A. Kammerer, M.O. Steinmetz, B.H. Meier
Polymorphism in an amyloid-like fibril forming model peptide
Angew. Chem. Int. Ed. Engl. 47, 5842 – 5845 (2008)

M. Weichel, R. Jaussi, C. Rhyner, R. Crameri
Display of E. coli alkaline phosphatase pIII or pVIII fusions on phagemid surfaces reveals monovalent decoration with active molecules
Open Biochemistry J. 2, 38 – 43 (2008)

INVITED TALKS

K. Ballmer-Hofer
Structure/function analysis of the activation of VEGF receptor tyrosine kinases and how coreceptors modulate signal output
University of Manchester, Manchester, United Kingdom, March 10, 2008

K. Ballmer-Hofer
Structure/function analysis of the activation of VEGF receptor tyrosine kinases and how coreceptors modulate signal output
University of Bristol, Bristol, United Kingdom, March 11, 2008

K. Ballmer-Hofer
Signaling in angiogenesis; structural and mechanistic insights into activation of VEGF receptor tyrosine kinases
ESH Conference on Angiogenesis, Paris, France, May 9 – 12, 2008

K. Ballmer-Hofer
Signaling in angiogenesis; structural and mechanistic insights into activation of VEGF receptor tyrosine kinases
7th D-BIOL Symposium ETH Zurich, Davos, Switzerland, June 2 – 4, 2008

K. Ballmer-Hofer
Structure/function analysis of the activation of VEGF receptor tyrosine kinases and how coreceptors modulate signal output
Gordon Conference on Growth Factors and Signalling, Oxford, United Kingdom, August 3 – 8, 2008

K. Ballmer-Hofer
Activation of receptor tyrosine kinases: VEGFR-2/Neuropilin-1 co-receptor complex formation by distinct VEGF isoforms
25th Conference of the European Society for Microcirculation, Budapest, Hungary, August 26 – 29, 2008

K. Ballmer-Hofer
Structure/function analysis of the activation of VEGF receptor tyrosine kinases and how coreceptors modulate signal output
Novartis, Basel, Switzerland, November 17, 2008

K. Ballmer-Hofer
Structure/function analysis of the activation of VEGF receptor tyrosine kinases and how coreceptors modulate signal output
Basilea Pharmaceutica, Basel, Switzerland, December 15, 2008

X.-D. Li
Ammonium transported by Amt/Mep/Rh proteins
First Chinese Conference on Life Sciences in Switzerland, ETHZ, Zurich, Switzerland, May 17, 2008

X.-D. Li
AmtB-GlnK complex and nitrogen regulation in bacteria
Symposium “Micromechanics”, Institute of Microbiology, ETH Zurich, July 18, 2008

X.-D. Li
Ammonium transported by Amt/Mep/Rh proteins
First CAS-SSSTC Joint Workshop, ETH, Zurich, Switzerland, November 18, 2008

X.-D. Li
Understanding membrane protein function: present and future
PSI-XFEL Science Workshop on "Coherent Diffraction by Nanostructures”, Swiss National Science Foundation, Bern, Switzerland, November 27, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
EMBL Heidelberg, Cell Biology and Biophysics Unit, Heidelberg, Germany, January 17, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
3D Repertoire Annual Meeting, Milan, Italy, February 14 – 15, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
Canceropôle PACA “Cytosquelette Microtubulaire & Cancer”, Marseille, France, February 26, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
INSERM U836, Institut des Neurosciences, Université Joseph Fourier, Grenoble, France, March 2, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
Microtubule Dynamics Workshop 2008, Trevereux Hill Oxted, Surrey, United Kingdom, May 11 – 12, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
University of Manchester, Wellcome Trust Centre for Cell-Matrix Research, Manchester, United Kingdom, July 2, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
CNRS, Centre de Recherche de Biochimie Macromoléculaire, Montpellier, France, July 10, 2008

M.O. Steinmetz
Key interaction modes of dynamic +TIP networks
FOM Institute for Atomic and Molecular Physics, Cytoskeleton-based Force Generation, Amsterdam, The Netherlands, September 2, 2008

M.O. Steinmetz
Tracking the ends: A dynamic protein network controls the fate of microtubule tips
Institute of Pharmaceutical Sciences, ETH Zurich, Switzerland, October 29, 2008

M.O. Steinmetz
Tracking the ends: A dynamic protein network controls the fate of microtubule tips
Institute of Biochemistry, ETH Zurich, Switzerland, November 13, 2008

M.O. Steinmetz
Tracking the ends: A dynamic protein network controls the fate of microtubule tips
Institute of Structural and Molecular Biology, University of London, United Kingdom, November 17, 2008

M.O. Steinmetz
Molecular mechanism of EB1-dependent microtubule tip tracking
Annual Meeting of The American Society of Cell Biology, San Francisco, USA, December 13 – 17, 2008

A. Studer, M. Di Berardino, L. Tiefenauer
Measuring membrane protein-mediated transport across lipid bilayers
The 10th World Congress on Biosensors, Shanghai, China, May 14 – 16, 2008

L. Tiefenauer
AFM and nanopores in service for biosciences
Indo-US Workshop on Science and Technology at the Nano-Bio Interface, Bhubaneswar, India, February 19 – 22, 2008

BOOK CHAPTERS

B.L. Zaric, Ch. Kambach
Reconstitution of recombinant human LSm complexes for biochemical, biophysical, and cell biological studies
In: L.E. Maquat, M. Kiledjian (eds.), Methods of Enzymology, Vol. 448, RNA Turnover in Eukaryotes: Nucleases, Pathways and Analysis of mRNA Decay, Academic Press, San Diego, London, Chapter 4, p. 57 – 74 (2008)

CENTER FOR RADIOPHARMACEUTICAL SCIENCE

UNIVERSITY LEVEL AND OTHER TEACHING

S.M. Ametamey
Einführung in die pharmazeutischen Wissenschaften I
ETH Zurich, HS08

R. Schibli
Metal Based Drug and Drug Development
ETH Zurich, FS08

R. Schibli
Practicum Medicinal Chemistry
ETH Zurich, HS08

P.A. Schubiger, S.M. Ametamey, R. Schibli
Einführung in die pharmazeutischen Wissenschaften II
ETH Zurich HS08

P.A. Schubiger, S.M. Ametamey, R. Schibli
Radiopharmazeutische Chemie
ETH Zurich HS08

P.A. Schubiger
CIMST Interdisciplinary Summer School
ETH Zurich, 2008

PUBLICATIONS

S.M. Ametamey, M. Honer, P.A. Schubiger
Molecular imaging with PET
Chem Rev. 108, 1501 – 1516 (2008)

W.H. Bisson, G. Westera, P.A. Schubiger, L. Scapozza
Homology modeling and dynamics of the extracellular domain of rat and human neuronal nicotinic acetylcholine receptor subtypes α4β2 and α7
J. Mol. Model. 14, 891 – 899 (2008)

L. Brans, V. Maes, E. Garcia Garayoa, Ch. Schweinsberg, S. Daepp, P. Bläuenstein, P.A. Schubiger, R. Schibli, D.A. Tourwé
Glycation methods for bombesin analogs containing the (N^{α}His) Ac chelator for $^{99m}Tc(CO)_3$ radiolabeling
Chem. Biol. Drug. Des. 72, 496 – 506 (2008)

E. Garcia Garayoa, Ch. Schweinsberg, V. Maes, L. Brans, P. Bläuenstein, D.A. Tourwé, R. Schibli, P.A. Schubiger
Influence of the molecular charge on the biodistribution of bombesin analogues labeled with the [^{99m}Tc(CO)$_3$]-core
Bioconjugate Chem. 19, 2409 – 2416 (2008)

A. Höhne, L. Mu, M. Honer, P. A. Schubiger, S. M. Ametamey, K. Graham, T. Stellfeld, S. Borkowski, D. Berndorff, U. Klar, U. Voigtmann, J. E. Cyr, M. Friebe, L. Dinkelborg, A. Srinivasan
Synthesis, ^{18}F-labelling, and in vitro and in vivo studies of bombesin peptides modified with silicon-based building blocks
Bioconjugate Chem. 19, 1871 – 1879 (2008)

Th.L. Mindt, V. Jungi, S. Wyss, A. Friedli, G. Pla, I. Novak-Hofer, J. Grünberg, R. Schibli
Modification of different IgG1 antibodies via glutamine and lysine using bacterial and human tissue transglutaminase
Bioconjugate Chem. 19, 271 – 278 (2008)

Th.L. Mindt, C.Müller, M. Melis, M. DeJong, R. Schibli
"Click-to-chelate": In vitro and in vivo comparison of a ^{99m}Tc(CO)$_3$-labeled N(τ)-histidine folate derivative with its isostructural, clicked 1,2,3-triazole analogue
Bioconjugate Chem. 19, 1689 – 1695 (2008)

L. Mu, A. Höhne, P. A. Schubiger, S.M. Ametamey, K. Graham, J.E. Cyr, L. Dinkelborg, T. Stellfeld, A. Srinivasan, U. Voigtmann, U. Klar
Siliciumbausteine für die einstufige ^{18}F-Radiomarkierung von Peptiden für die PET-Bildgebung
Angew. Chem. 120, 1 – 5 (2008)

C. Müller, F. Forrer, R. Schibli, E.P. Krenning, M. DeJong
SPECT study of folate receptor-positive malignant and normal tissues in mice using a novel ^{99m}Tc-radiofolate
J. Nucl. Med. 49, 310 – 317 (2008)

C. Müller, R. Schibli, E.P. Krenning, M. DeJong
Pemetrexed improves tumor selectivity of ^{111}In-DTPA-folate in mice with folate receptor–positive ovarian cancer
J. Nucl. Med. 49, 623 – 629 (2008)

I. Novak-Hofer, S. Cohrs, J. Grünberg, A. Friedli, M.C. Schlatter, M. Pfeiffer, P. Altevogt, P.A. Schubiger
Antibodies directed against L1-CAM synergize with genistein in inhibition growth and survival pathways in SKOV3ip human ovarian cancer cells
Cancer Lett. 261, 193 – 204 (2008)

T.L. Ross, M. Honer, Ph. Lam, T.L. Mindt, V. Groehn, R. Schibli, S. M. Ametamey, P.A. Schubiger
Fluorine-18 "click" radiosynthesis and preclinical evaluation of a new ^{18}F-labelled folic acid derivative
Bioconjugate Chem. 19, 2462 – 2470 (2008)

H. Struthers, B. Spingler, Th.L. Mindt, R. Schibli
"Click-to-chelate" : Design and incorporation of triazole-containing metal-chelating systems into biomolecules of diagnostic and therapeutic interest
Chemistry – A European Journal 14, 6173 – 6183 (2008)

Ch. Schweinsberg, V. Maes, L. Brans, P. Bläuenstein, D. A. Tourwé, P.A. Schubiger, R. Schibli, E. Garacia Garayoa
Novel glycated [^{99m}Tc(CO)$_3$]-labeled bombesin analogues for improved targeting of gastrin-releasing peptide receptor-positive tumors
Bioconjugate Chem. 19, 2432 – 2439 (2008)

R. Waibel, H. Treichler, N.G. Schäfer, D.R. van Staveren, S. Mundwiler, S. Kunze, M. Küenzi, R. Alberto, J. Nüesch, A. Knuth, H. Moch, R. Schibli, P.A. Schubiger
New derivatives of vitamin B12, show preferential targeting of tumors
Cancer Res. 68, 2904 – 2911 (2008)

CONFERENCE PROCEEDINGS

J. Grünberg
Radioimmunotherapy of ovarian cancer metastasis with Lu-177-labeled antibody chCE7agl directed against L1-CAM
Annual Congress of the European Association of Nuclear Medicine, Munich, Germany, October 11 – 15, 2008

S. Jeger
Enzymatic functionalization of the tumor targeting antibody chCE7agl produces single species radioimmunoconjugates
Annual Meeting of the Swiss Society of Nuclear Medicine, St. Gallen, Switzerland, May 29 – 31, 2008

Th.L. Mindt
Click-to-chelate: Expedited development of metal-based imaging probes and therapeutic agents by click chemistry
Symposium on Medicinal Organometallic Chemistry, St. Martin, Germany, April 2 – 5, 2008

Th.L. Mindt
Expedited development of imaging probes by click chemistry
Center for Imaging Science and Technology Symposium, Zurich, Switzerland, May 2008

Th.L. Mindt
N*ew strategies for the development of molecular imaging probes*
236th National Meeting of the American Chemical Society, Philadelphia, USA, August 17 – 21, 2008

Th.L. Mindt
Click-to-Image: Application of Click Chemistry to the Design of Novel Imaging Probes and Therapeutic Agents
236th National Meeting of the American Chemical Society, Philadelphia, USA, August 17 – 21, 2008

Th.L. Mindt
Application of click chemistry to the design of novel imaging probes and therapeutic agents
World Molecular Imaging Congress, Nice, France, September 10 – 13, 2008

H.R. Struthers
“Click to chelate”: Functionalization of thymidine with chelating systems for rhenium and technetium and their evaluation as substrates for human thymidine kinase type 1
16. Arbeitstagung der Arbeitsgemeinschaft Radiochemie/Radiopharmazie, Münster, Germany, September 25 – 27, 2008

DISSERTATIONS

D. Eichenberger
Wasserstoffperoxid in Pharma Isolatoren
Eidgenössische Technische Hochschule ETH Zurich, Nr. 17’857, 2008

A. Friedli
Targeting the L1 cell adhesion molecule in cancer: mechanism involved in the anti-proliferative properties of anti-L1 antibodies
Eidgenössische Technische Hochschule ETH Zurich, Nr. 17’859, 2008

K. Hajdin
Phage display selected peptides identify furin as therapeutic target on pediatric rhabdomyosarcoma
Eidgenössische Technische Hochschule ETH Zurich, 2008

A. Höhne
Development of new proprietary F-18 radiolabeling methods
Eidgenössische Technische Hochschule ETH Zurich, Nr. 17’680, 2008

U. Künzle
Verunreinigungsprofil und Stabilität von Aminosäuren diverser Herkunft
Eidgenössische Technische Hochschule ETH Zurich, 2008

M. Martic
Development of new nucloside analogues as PET imaging agents for monitoring gene expression
Eidgenössische Technische Hochschule ETH Zurich, Nr. 17’632, 2008

Ch. Schweinsberg
Novel 99mTc-labeled bombesin analogues with improved pharmacokinetics and targeting of gastrin-releasing-peptide receptor-positive tumors
Eidgenössische Technische Hochschule ETH Zurich, Nr. 17’952, 2008

M. Zimmermann
Cell death in kerationcytes induced by IFN-gamma and ligands of the tumor necrosis factor receptorsuperfamily
Eidgenössische Technische Hochschule ETH Zurich, Nr. 18’006, 2008

INVITED TALKS

S.M. Ametamey
PET radioligand development for the imaging of a CNS target
CIMST Summer School Zurich, Switzerland, June 25 – July 6, 2008

S.M. Ametamey
Functional brain imaging with PET
Swiss Society for Experimental Pharmacology Zurich, Switzerland, August 29, 2008

S.M. Ametamey
Hypoxia tracers
Annual Congress of the European Association of Nuclear Medicine, Munich, Germany, October 11 – 15, 2008

S.M. Ametamey
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E. García Garayoa
Tumour targeting with $^{64/67}$Cu-labelled neurotensin analogues
14th European Symposium on Radiopharmacy and Radiopharmaceuticals, Skopje, Macedonia (former Yugoslav Republic of Macedonia), April 24 – 27, 2008

J. Grünberg
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28th International Symposium Radioactive Isotopes in Clinical Medicine and Research, Bad Hofgastein, Austria, January 9 – 12, 2008

R. Schibli
New strategies for the development of tracer for non-invasive imaging
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R. Schibli
"Click" to image: Chemical strategies for the design of multiple modality imaging probes
Seminar at the University of Oxford, Dept. of Chemistry, Oxford, United Kingdom, February 2008

R. Schibli
Site-specific radiolabelling of recombinant proteins for imaging and quantitative in vivo studies
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P.A. Schubiger
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ASTRA

Projektleiter: R. Gehrig[1], N. Bukowiecki[1], U. Baltensperger, M. Furger
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[1] EMPA Dübendorf

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Projektleiter: S.M.A. Biollaz
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BAFU

Projektleiter: S. Andreani, J. Keller, A.S.H. Prévôt
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Partner: Berner Fachhochschule Technik und Informatik (BFH-TI, Biel BE), CEKA Elektrowerkzeuge AG & Co. KG (Wattwil SG), MES-DEA SA. (Stabio TI)

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Laserdiagnostik in sehr mageren Flammen

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Verbrennung von wasserstoffhaltigen Synthesegasen: Grundlagen und Designregeln für Gasturbinen

Projektleiter: Ch. Ludwig
MOPSID: Monitoring of process gases with a surface ionization detector

Projektleiter: A. Meier
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Solar Production of Zinc and Hydrogen – Reactor Optimization for Scale-up
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Optimierung der Hydrolyse und Salzabtrennung bei der hydrothermalen Vergasung von Biomasse

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Projektleiter: O. Kröcher, Ch. Gerhart[1]
NO_x-Reduzierung im motorischen Abgas mit Guanidinsalzen
Prof. Dr. Th. Sattelmayer, Lehrstuhl für Thermodynamik, TU München, Germany
Prof. Dr. G. Wachtmeister, Lehrstuhl für Verbrennungskraftmaschinen, TU München, Germany
[1] AlzChem Trostberg GmbH, Germany
NIGU Chemie GmbH, Germany

CCEM

Projekt:
Woodgas SOFC (Integrated Biomass - Solid Oxide Fuell Cell Cogeneration):
WP2: Gas Analysis (Projektleiter: J. Wochele)
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Projektleiter: F.N. Büchi
hy.muve: Development of ***hy****drogen powered* ***mu****nicipal* ***ve****hicle*
with EMPA Dübendorf and Industrial Partners

Projektleiter: P. Dimopoulos[1], M. Ammann, U. Baltensperger, K. Boulouchos[2], H. Burtscher[3], N. Heeb[1], O. Kröcher, M. Mohr[1]
NEADS (Next Generation Exhaust Aftertreatment for Diesel Propulsion Systems)
[1] EMPA Dübendorf
[2] ETH Zürich
[3] FHNW Windisch

Projektleiter: P. Jansohn
Clean and Efficient Large Diesel Engines (CELaDE)

Projektleiter: U. Lohmann[1], Th. Peter[1], U. Baltensperger, Th. Heck, Ch. Hüglin[2], H. Burtscher[3], I. Bey[4]
IMBALANCE (IMpact of Biomass burning Aerosol on Air quality aNd ClimatE)
[1] ETH Zürich
[2] EMPA Dübendorf
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[4] EPF Lausanne

Projektleiter: I. Mantzaras
Computational engineering of multiscale transport in small-scale surface based energy conversion

Projektleiter: S. Stucki
Second generation biogas

Projektleiter: S. Ulli-Beer, F. Büchi
Technische und wirtschaftliche Datenanalyse eines wasserstoffbetriebenen Brennstoffzellen-Fahrzeuges im Alltagstest
with Hy-Muve, BFE

Projektleiter: F. Vogel
Hydrogen-enriched fuel on demand for future hybrid powertrains (HEFD-HY)

Projektleiter: A. Wokaun
Transition to Hydrogen Based Transportation
Project Part: Dynamics of transportation technology development and diffusion (Projektleiter: S. Ulli-Beer)
in collaboration with MIT (Alliance for Global Sustainability)

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Transition to Hydrogen Based Transportation – Challenges and Opportunities
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Projektleiter: M. Zimmermann, S. Ulli-Beer
Advanced Energy-Efficient Renovation of Buildings
(Project Part: Diffusion dynamics of energy efficient renovations)
with IEA, SNF, BFE, Stadt Zürich, Novatlantis

CompactGTL

Projektleiter: I. Mantzaras
Gas-to-liquid catalytic technologies

Energie Trialog Schweiz

Projektleiter: A. Wokaun, Ph. Dietrich, S. Hirschberg
Studies on Energy Efficiency, Renewable Electricity, Scenarios, Multi-Criteria Decision Analysis

ETH

Projektleiter: D. Cziczo[1], U. Lohmann[1], E. Weingartner, U. Baltensperger
The relationship between aerosol chemical composition and hygroscopic growth
[1] ETH Zürich

ETH-Rat

Projektleiter: A. Wokaun, S. Ulli-Beer
- Erdgas- / Biogasfahrzeuge
- Wasserstoff-Fahrzeuge
Erlebnisraum Nachhaltige Mobilität Basel
novatlantis – Nachhaltigkeit im ETH Bereich

EU

Projektleiter: U. Baltensperger, J. Dommen
EUROCHAMP (Integration of European Simulation Chambers for Investigating Atmospheric Processes)

Projektleiter: U. Baltensperger, E. Weingartner, M. Gysel
EUSAAR (European Supersites for Atmospheric Aerosol Research)

Projektleiter: U. Baltensperger, J. Dommen
POLYSOA (Polymers in secondary organic aerosols)

Projektleiter: U. Baltensperger, A.S.H. Prévôt, E. Weingartner
EUCAARI (European Integrated project on Aerosol Cloud Climate and Air Quality Interactions)

Projektleiter: U. Baltensperger, E. Weingartner
CLOUD-ITN (Cosmics Leaving OUtdoor Droplets, Initial Training Network)

Projektleiter: U. Baltensperger, A.S.H. Prévôt, E. Weingartner
MEGAPOLI (Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation)

Projektleiter: P. Jansohn
HERCULES (High efficiency engine R&D on combustion with ultra low emissions for ships)

Projektleiter: A. Meier
SOLHYCARB (Hydrogen from Solar Thermal Energy: High Temperature Solar Chemical Reactor for Co-production of Hydrogen and Carbon Black from Natural Gas Cracking)

Projektleiter: A.S.H. Prévôt
CIRCE (Climate change and Impact Research: The Mediterranean Environment)

Projektleiter: M. Saurer
MILLENNIUM, (European climate of the last millennium)

Projektleiter: G.G. Scherer
CARISMA

Projektleiter: I.A. Schneider
Nanoglowa (Diagnostics workpackage)

Projektleiter: E. Weingartner, M. Gysel
QUANTIFY (Hygroscopic properties of ship exhaust particles)

Projektleiter: E. Weingartner, U. Baltensperger
GeoMon (Global Earth Observation and Monitoring of the atmosphere)

EU-PROJECTS (6. FWP)

Projektleiter: S.M.A. Biollaz
BIOCELLUS

Projektleiter: T. Schildhauer
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HSK

Projektleiter: F. Gassmann
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Industry

Projektleiter: P. Boillat, G.G. Scherer
Diagnostics of polymer electrolyte fuel cells
Automotive industry

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Diagnostics of polymer electrolyte fuel cells
Nissan Motor Co. Ltd., Yokohama, Japan

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Diagnostics of polymer electrolyte fuel cells
Automotive Industry

Projektleiter: J.-L. Hersener, S. Biollaz
Verfügbarkeit von Gras für Kombikraftwerke in der Schweiz
Ingenieurbüro Hersener, Ernst Basler und Partner AG

Projektleiter: O. Kröcher, A. Johansson[1]
Development and parameterization of a catalyst model for NO/NO_2 SCR
[1] Swenox AB, Schweden

Projektleiter: O. Kröcher
Development of a TG-FTIR system for exhaust gas aftertreament
Mettler-Toledo AG
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Projektleiter: O. Kröcher, R. Althoff[1]
Development of new metal-exchanged zeolites for NH_3/urea-SCR
[1] Süd-Chemie AG, Germany

Projektleiter: O. Kröcher
Investigation of the decomposition of urea in the SCR process
Anonymous industry partners, France

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Investigation of the influence of ammonia on the soot oxidation in Diesel particulate filters
[1] Emitec GmbH, Germany

Projektleiter: O. Kröcher
Thermoanalytic investigation of the urea decomposition
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Projektleiter: P. Maire
Electrochemical characterization of polymeric organic active materials
Ciba, Basel

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Graphite für Lithiumionen-Batterien
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Confidential
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Projektleiter: F. Vogel
Gasoline reforming kinetics
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Projektleiter: F. Vogel
Kinetik der präferentiellen Oxidation von CO
Umicore AG

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Projektleiter: I. Mantzaras
Sequential combustion technology for gas turbine power generation with CO_2 mitigation

METEO SCHWEIZ

Projektleiter: U. Baltensperger, E. Weingartner, M. Gysel
GAW-CH (Aerosol Monitoring Programm auf dem Jungfraujoch)

Projektleiter: U. Baltensperger, E. Weingartner, M. Gysel
Cloud Condensation Nuclei and Carbonaceous Aerosol Characterisation at the Jungfraujoch Research Station

MIT

Projektleiter: F. Vogel
Ecogas: Nutrient salt recovery during conversion of wet biomass into methane

NATIONALFONDS

Projektleiter: U. Baltensperger
Investigation of Secondary Organic Aerosol Formation in the PSI Smog Chamber

Projektleiter: A. Foelske-Schmitz
Degradation mechanisms of electro-catalysts used in Polymer electrolyte fuel cells
PSI

Projektleiter: M. Geiser Kamber[1], M. Kalberer[2], J. Ricka[1], J. Dommen
From aerosol to health effects: Mobile system for controlled, standardized studies of health-effects by inhaled (nano)particles and gases
[1] University of Bern
[2] University of Cambridge, UK

Projektleiter: Ch. Körner[1], R.T.W. Siegwolf
Swiss Canopy Crane Project: CO_2–enrichment
[1] University of Basel

Projektleiter: P. Novák, R. Kötz, T. Lippert, R. Nesper[1]
Advanced materials for efficient portable energy supplies
PSI und ETHZ
[1] ETH Zürich

Projektleiter: F. Nüesch, M. Nagel[1], T. Lippert, A. Wokaun
Fabrication of patterned organic multilayer devices using dynamic release layer assisted Laser Induced Forward Transfer
[1] EMPA Dübendorf

Projektleiter (CCMX): J. Rupp[1], L. Gauckler[1], T. Lippert, K. Conder, T. Graule[2], S. Pratsinis[1]
NANCER (Nanocrystalline ceramic thin film coating without sintering)
[1] ETH Zürich
[2] EMPA Dübendorf

Projektleiter: M. Saurer, R.T.W. Siegwolf
Climatic changes, tree-ring growth and C- and O-isotope variations along longitudinal transects in Siberia and in the Urals

Projektleiter (MaNEP): L. Schlapbach[1], A. Weidenkaff[1], T. Lippert, A. Wokaun
Plasma enhanced anionic substitution (PEAS) for the generation of perovskite phases with different properties
[1] EMPA Dübendorf

Projektleiter: F. Vogel
Salt particle formation in near- and supercritical water

Projektleiter: A. Wokaun, T. Lippert
Laser ablation of inorganic materials and thin film deposition studied by mass spectrometry and in-situ surface analysis

Projektleiter: A. Wokaun, T. Lippert
Thin Metal Oxide Films by PLD: "Tracing" the oxygen and understanding its role

NATO

Projektleiter: M. Dinescu[1], E. Verona[2], T. Lippert
Polymers based piezoelectric sensor array for chemical warfare agents detection
[1] National Institute for Lasers, Plasma and Radiation Physics, Romania
[2] CNR-IDAC Rome, Italy

NOVATLANTIS

Projektleiter: A. Wokaun, S.F. Lienin, S. Ulli-Beer, C. Bach
Erlebnisraum Mobilität: Aufbau einer sozio-technologischen Feldversuchsumgebung
Nachhaltigkeit im ETH Bereich

Projektleiter: S. Ulli-Beer
Innovative Fahrzeugflotte Basel
Nachhaltigkeit im ETH Bereich

OSTLUFT

Projektleiter: A.S.H. Prévôt
Mobile Aerosolmassenpektrometer-Messungen im Rheintal und in Zürich

SBF

Projektleiter: U. Baltensperger, A.S.H. Prévôt
ACCENT (Atmospheric Composition Change, the European Network of Exellence)

Projektleiter: J. Keller
COST 728: Linking meteorological and photo-chemical dispersion models: development and tests of an interface with improved turbulence schemes

Projektleiter: R.T.W. Siegwolf
COST 639 (Carbon cycling in alpine soils in a warmer world)

SNF

Projektleiter: R. Kaufmann[1], S. Ulli-Beer, S. Bruppacher[1]
Diffusions dynamics of energy efficient buildings
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Projektleiter: I. Mantzaras
Direct Numerical Simulation of Catalytic Combustion

Projektleiter: A. Wokaun, Th. Lippert
Thin oxide films by PLD: "Tracing" the oxygen and understanding its role

Projektleiter: A. Wokaun
NCCR-Climate
Project Task 4.1: Energy Technology Strategies

STIFTUNG AUTO RECYCLING SCHWEIZ SARS

Projektleiter: Ch. Ludwig, S. Stucki
KVA plus

Swisselectric (CCEM)

Projektleiter: I. Mantzaras, P. Jansohn
Technologies for Gas Turbine Power Generation with CO_2 Mitigation

Swisselectric Research

Projektleiter: S.M.A. Biollaz
Methan aus Holz

Projektleiter: J. Wochele, Ch. Ludwig
TREPGAS: Trace Elements in Product Gases

UGZ

Projektleiter: E. Weingartner, J. Brunner[1]
Entwicklung eines SMPS-Systems für den kontinuierlichen Einsatz
[1] Amt für Umwelt- und Gesundheitsschutz, Zürich

Universities

Projektleiter: Ch. Ludwig
Hydrothermal methane from microalgae (the SunChem process)

Projektleiter: P.P. Radi
Detection of Weak Overtone and Combination Bands of Methane
Dr. D. Kozlov, General Physics Institute, Moscow, Russia

Projektleiter: P.P. Radi
DFWM and TC-RFWM Spectroscopy on Transient Molecules and Radicals
Prof. J.P. Maier, Universität Basel

Projektleiter: P.P. Radi
REMPI and Photoelectron-Spectroscopy on Formaldehyde
Prof. F. Merkt, ETH Zürich

Projektleiter: P.P. Radi
Unimolecular Dissociation of Formaldehyde
Prof. R. Marquardt, Laboratoire de Chimie Quantique, Institut de Chimie - Université Louis Pasteur 4, Strasbourg, France

Projektleiter: E. Weingartner, P. Villani[1]
Development of new Differential Mobility Analyzers
VELUX STIFTUNG
[1] Laboratoire de Météorologie Physique, University of Clermont-Ferrand (France)

TEACHING ACTIVITIES (LECTURES)

University Level Teaching

Prof. Dr. U. Baltensperger, Prof. Dr. H. Burtscher, Dr. C. Marcolli
Aerosole II
ETH Zürich, FS 2008.

Prof. Dr. U. Baltensperger, Prof. Dr. H. Burtscher, Dr. C. Marcolli
Aerosole I
ETH Zürich, HS 2008.

Prof. Dr. U. Baltensperger
European Research Courses on Atmospheres
– *Sources, sinks and global distribution of aerosols*
– *Direct and indirect aerosol effect on climate*
– *Smog chamber activities and other new directions of research*
ERCA, Grenoble, France, January 7 – February 8, 2008.

Prof. Dr. K. Boulouchos[1], Dr. O. Kröcher
IC-Engines and Propulsion Systems II
ETH Zürich, FS 2008.
[1] ETH Zürich

Dr. F. Gassmann, Prof. Dr. F. Stähli[1]
Wege zu einer nachhaltigen Energiezukunft
FHA Brugg-Windisch, HS 2008.
[1] FHA, Brugg-Windisch

Dr. P. Jansohn
Verbrennung in Gasturbinen
ETH Zürich, FS 2008.

PD Dr. T. Lippert
Mikro- und Nanostrukturen: Laseranwendungen in Industrie und Forschung
ETH Zürich, HS 2008.

Prof. Dr. Ch. Ludwig
Advanced Solid Waste Treatment
Master 7th and 9th semester
EPF Lausanne, FS 2008.

Prof. Dr. Ch. Ludwig, Dr. Felippe de Alencastro[1]
Analyse des polluants dans l'environnemen
Bachelor 5th semester
EPF Lausanne, FS 2008.
[1] EPFL

PD Dr. I. Mantzaras and Dr. C. Frouzakis
Theoretical and Numerical Combustion
ETH Zürich, HS 2008.

PD Dr. P. Novák, Prof. Dr. A. Wokaun
Technische Elektrochemie
ETH Zürich, HS 2008.

Dr. A.S.H. Prévôt, Prof. J. Staehelin
Tropospheric Chemistry
ETH Zürich, FS 2008.

Dr. R.T.W. Siegwolf, Dr. M. Saurer
Einsatz stabiler Isotope in der Oekologie und Physiologie der Pflanzen I
University of Basel, HS 2008.

Dr. R.T.W. Siegwolf, Dr. M. Saurer
Stabile Isotope in der Oekologie
University of Zürich, WS 2007/2008.

Prof. Dr. A. Steinfeld, Prof. Dr. R. Abhari
Energy Systems and Power Engineering
ETH Zürich, FS 2008.

Prof. Dr. A. Steinfeld, Prof. Dr. R. Abhari
Thermodynamics III
ETH Zürich, HS 2008.

Prof. Dr. A. Steinfeld, Dr. W. Lipinski
Energieübertragung durch Wärmestrahlung
ETH Zürich, HS 2008.

Prof. Dr. A. Steinfeld, Prof. Dr. A. Wokaun
Renewable Energy Technologies I
ETH Zürich, HS 2008.

Dr. F. Vogel (gemeinsam mit Prof. Dr. Ph. Rudolf von Rohr)
Einführung in die Verfahrenstechnik / Vorlesung 5. Semester Maschinenbau und Verfahrenstechnik
ETH Zürich, HS 2008.

Prof. Dr. A. Wokaun, Dr. G.G. Scherer, Prof. Dr. K. Boulouchos
Renewable Energy Technologies II
ETH Zürich, FS 2008.

Contributions to Courses at Universities, FH, and Other Institutes

Dr. S.M.A. Biollaz
Renewable Energy Technologies I (lectures on biomass, biofuels)
ETH Zürich, WS 2007/08.

M. Brandenberger
Biological Gas Treatment
Master in environmental engineering, environmental sciences and engineering, SSIE, EPFL
EPF Lausanne, HS 2008/09.

Dr. P.F. DeCarlo
Online measurement of Organic Aerosols - Summer School on Organic Aerosols
University of Gothenburg, Sweden, June 24, 2008.

Dr. W. Durisch
Photovoltaik - Strom aus Sonnenlicht
ABB University, Lerncenter Business Processes and Power System Management, Baden, November 7, 2008.

Dr. W. Durisch
Photovoltaik - Strom aus Sonnenlicht
Energietechnische Aus- und Weiterbildung für nichttechnische Fach- und Führungskräfte, ABB Technikerschule, Baden, May 19, 2008.

Dr. F. Gassmann
Die Physik des Fliegens für Kinder von 6-12 Jahren
Kinderuniversität Waldshut, Dogern, Germany, November 8, 2008.

Dr. F. Gassmann
Realität des Klimawandels
Veranstaltungsreihe "Dynamik der Energiewirtschaft" der FHNW, Windisch, December 2, 2008.

PD Dr. T. Lippert
Inorganic Thin Films: Processing, Properties and Applications
Contributions (4 lectures on the topic: *Vacuum thin film deposition techniques* and *Thin film industrial applications*) to the lecture: by L. Gauckler, J. Rupp, A. Bieberle.
ETH Zürich, FS 2008.

PD Dr. T. Lippert
Der Laser – vom Kuriosum zum Werkzeug: Anwendungen aus Industrie und Forschung
Senioren Universität Zürich, October 2008.

Prof. Dr. Ch. Ludwig (joint course with Prof. Dr. J.-L. Scartezzini, Dr. D. Robinson, Prof. Dr. A.G. Dumont, Dr. J.-J. Hefti, Prof. Dr. A. Mermoud, Prof. Dr. R. Schlaepfer, Dr. M. Soutter)
Quartiers urbains, infrastructures et aménagements durables
Bachelor 6th semester
EPF Lausanne, HS 2008.

A.S.H. Prévôt, M. Hallquist
Summer school on organic aerosols
University of Gothenburg, June 23-27, 2008.

Dr. S. Ulli-Beer
Systeme, Komplexität – und wie Menschen damit umgehen können
Einführung in Allgemeine Ökologie - Systemansätze, Interfakultäre Koordinationsstelle für Allgemeine Ökologie, Universität Bern, November 26 – December 3, 2008.

Dr. S. Ulli-Beer
Methodological issues on “Diffusion dynamics of energy efficient buildings” (DeeR)
Seminar of the Geographical Department of the University of Zürich, December 12, 2008.

PUBLICATIONS

Books and Reviewed Book Chapters

S. Alkan-Gürsel, L. Gubler, B. Gupta, G.G. Scherer
Radiation grafted membranes
Adv. Polym. Sci. **215**, 157–217 (2008).
In Fuel Cells I
Edited by G.G. Scherer, Springer Verlag Berlin-Heidelberg, Germany, ISBN 978-3-540-69755-8.
doi: 10.1007/12_2008_153

S. Andreani-Aksoyoglu, J. Keller, M.R. Alfarra, A.S.H. Prévôt, J.J. Sloan, Z. He
Contribution of biogenic emissions on carbonaceous aerosols in summer and winter in Switzerland: A modelling study
29th NATO/CCMS International Technical Meeting on Air Pollution Modelling and its Application, Aveiro, Portugal, Edited by C. Borrego and A. I. Miranda, Eds., Springer, 101-108, ISBN 978-1-4020-8452-2 (2008).

U. Baltensperger, M. Furger
Aerosol chemistry in remote locations
I. Colbeck, Environmental Chemistry of Aerosols, Blackwell Publishing, 217-252, ISBN 978-1-4051-3919-9 (2008).

K.A. Friedrich, F.N. Büchi
Fuel cells using hydrogen
Hydrogen as a Future Energy Carrier, **8.1**, 335-363 (2008).
Edited by A. Züttel, A. Borgschulte, L. Schlapbach, Wiley VCH, Weinheim, Germany,
ISBN: 978-3-527-30817-0.

L. Gubler, G.G. Scherer
A proton-conducting polymer membrane as solid electrolyte – Function and required properties
Adv. Polym. Sci. **215,** 1-14 (2008).
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Edited by G.G. Scherer, Springer Verlag Berlin-Heidelberg, Germany, ISBN 978-3-540-69755-8.
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B. Mishra, Ch. Ludwig, S. Das (Eds.)
Proceedings of the global symposium on recycling, waste treatment and clean technology
Publishing house TMS, 2008.

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M. Schwaninger, S. Ulli-Beer, R. Kaufmann-Hayoz
Transdisciplinary Modelling, Policy Analysis and Design: A System Dynamics Approach
Editors: G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, Ch. Pohl, U. Wiesmann and E. Zemp. Handbook for Transdisciplinary Research. Springer, Frankfurt (Main), Germany (2008).

A. Steinfeld
Editor-in-Chief
ASME Journal of Solar Energy Engineering **130**, Issues 1, 2, 3, 4 (2008).

Peer Reviewed Papers

M.H. Aguirre[1], S. Canulescu, R. Robert[1], N. Homazava[1], D. Logvinovich[1], L. Bocher[1], T. Lippert, M. Döbeli[2], A. Weidenkaff[1]
Structure, microstructure and high temperature transport properties of $La_{1-x}Ca_xMnO_{3-\delta}$ thin films and polycrystalline bulk materials
J. Appl. Phys. **103,** 013703-1–013703-6 (2008).
[1] EMPA Dübendorf
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A.C. Aiken, P.F. DeCarlo, J.H. Kroll, D.R. Worsnop, J.A. Huffman, K. Docherty, I.M. Ulbrich, C. Mohr, J.R. Kimmel, D. Sueper, Q. Zhang, Y. Sun, A. Trimborn, M. Northway, P.J. Ziemann, M. Canagaratna, T.B. Onasch, M.R. Alfarra, A.S.H. Prévôt, J. Dommen, J. Duplissy, A. Metzger, U. Baltensperger, J.L. Jimenez
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S. Alkan Gürsel, J. Schneider[1], H. Ben youcef, A. Wokaun, G.G. Scherer
Thermal properties of proton-conducting radiation grafted membranes
Doi: 10.1002/app.27947; J. Appl. Polym. Sci. **108**, 3577-3585 (2008).
[1] ETH Zürich

J.D. Allan, D. Baumgardner, G.B. Raga, O.L. Mayol-Bracero, F. Morales-García, F. García-García, G. Montero-Martínez, S. Borrmann, J. Schneider, S. Mertes, S. Walter, M. Gysel, U. Dusek, G.P. Frank, M. Krämer
Clouds and aerosols in Puerto Rico - a new evaluation
Atmos. Chem. Phys. **8**, 1293–1309 (2008).

I. Alxneit
Assessing the feasiblity of separating a stoichiometric mixture of zinc vapor and oxygen by a fast quench – Model calculations
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S. Andreani-Aksoyoglu, J. Keller, C. Ordonez, M. Tinguely, M. Schultz, A.S.H. Prévôt
Influence of various emission scenarios on ozone in Europe
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S. Andreani-Aksoyoglu, J. Keller, A.S.H. Prévôt, U. Baltensperger, J. Flemming
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S. Arcidiacono, J. Mantzaras, I. Karlin[1]
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Phys. Rev.E **78**, 046711 (2008).
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A.R. Armstrong[1], D.W. Tee[1], F. La Mantia, P. Novák, P.G. Bruce[1]
Synthesis of tetrahedral $LiFeO_2$ and its behavior as cathode in rechargeable lithium batteries
doi: 10.1021/ja077651g; J. Am. Chem. Soc. **130**, 3554-3559 (2008).
[1] University of St. Andrews, UK

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[1] Universität der Bundeswehr München, Germany
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D.P. Banks[1], K. Kaur[1], R. Gazia[1], R. Fardel[2], M. Nagel[3], T. Lippert, R.W. Eason[1]
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P. Boillat, D. Kramer, B.C. Seyfang, G. Frei, E. Lehmann, G.G. Scherer, A. Wokaun, Y. Ichikawa[1], Y. Tasaki[1], K. Shinohara[1]
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E.C. Buruiana[1], L. Hahui[1], T. Buruiana[1], L. Urech, T. Lippert
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Ph.D. Thesis, No. 17979, ETH Zürich, September 17, 2008.

F. Rosciano
In situ synchrotron and neutron diffraction based methods for the characterization of cathodic materials for lithium-ion batteries
Ph.D. Thesis, No. 17847, ETH Zürich, June 4, 2008.

J. Sandradewi
A study of wood burning versus traffic aerosols using a multi-wavelength aethalometer (AEROWOOD)
Ph.D. Thesis, No. 17694, ETH Zürich, March 18, 2008.

L.O. Schunk
Solar thermal dissociation of zinc oxide – reaction kinetics, reactor design, experimentation and modeling
Ph.D. Thesis, No. 18041, ETH Zürich, October 2008.

A.M. Walser
Time resolved four wave mixing spectroscopy of gaseous formaldehyde
Ph.D. Thesis, No. 18044, ETH Zürich, October 15, 2008.

S. Weimer
Particle emission of traffic and wood combustion and its impact on spatial distributions of submicron particulate matter
Ph.D. Thesis, No. 17995, ETH Zürich, September 19, 2008.

DIPLOMA-/MASTER THESES

X. Antoñanzas De Andrés
Design of a passive and active control system for flashback
PSI Villigen and Berner Fachhochschule, March 2008.

N. Badawi
Analysis of pollutants emissions from a landfill in soil and water, Cali, Colombia: Heavy metals
PSI Villigen, EPF Lausanne and Uni Valle, Cali, Colombia, June 2008.

M. Burger
Steady-state fuel processor modeling for the on-board production of hydrogen-enriched fuel blend from gasoline
PSI Villigen and ETH Zürich, 2008.

C. Caprez
Wood burning emission and diesel exhaust experiments at the smog chamber: PTR-MS results
University of Zürich, 2008.

D. Douçot
Municipal waste and recycled material flow analysis of Ho Chi Minh City
PSI Villigen, EPF Lausanne and National University of HCMC, Vietnam, June 2008.

A. Evans
In situ colorimetric analsysis of lithium intercalation into graphite electrodes of lithium-ion batteries
ETH Zürich, February 2008.

A. Fleischer
Experimental study of solar steam gasification of cabonaceous materials
PSI and ETH Zürich, September 2008.

C. Good
Source apportionment of a highly time and spatially resolved organic aerosol dataset from the Rhine valley by the use of positive matrix factorization
ETH Zürich, August 2008.

V. Klass
AMS/MAN copolymerization onto ETFE base film using DIPB as crosslinking agent
ETH Zürich, April 2008.

A. Maric
Identification of As-Cu-FA complexes in Laboratory samples and characterization of association between arsenic and dissolved organic matter in china's groundwater
PSI Villigen and EPF Lausanne and Chinese Academy of Sciences, Beijing, China, 2008.

M. Nso
Assessment of high-temperature electrolysis for solar hydrogen production
PSI and ETH Zürich, October 2008.

D. Rätz
Sub-mm Membranwiderstand in PEFC – Methodenentwicklung und Bestimmung des Einflusses der Gaszusammensetzung an der Kathode
ETH Zürich, February 2008.

J. Regler
Untersuchungen zur kontinuierlichen Salzabtrennung aus wässrigen Lösungen unter Bedingungen der hydrothermalen Vergasung von Biomasse
PSI Villigen and Fachhochschule Weihenstephan, Abteilung Triesdorf, Germany, May 2008.

V. Silberstein
Prédiction des flux des élements traces au cours de la réaction des mâchefers avec les poussières de climent enrichies en chlore
PSI Villigen and EPF Lausanne, January 2008.

M. Steiger
An overview of diesel and wood burning soot smog chamber experiments and a loading effect correction for aethalometer measurements
ETH Zürich, July 2008.

C. Suter
Development and experimental investigation of quench unit for a solar thermal rotary reactor
PSI and ETH Zürich, May 2008.

D. Tehlar
Investigation of the cross-convection in PEFC serpentine flow-fields
ETH Zürich, March 2008.

M. Uldry
Elektrochemische Charakterisierung von gesputterten Pt/C-Katalysatoren
Fachhochschule beider Basel (Nordwestschweiz), July 2008.

T. Ulrich
An in- situ XAFS investigation of a ruthenium on carbon catalyst during the gasification of ethanol in supercritical water
PSI Villigen and ETH Zürich, October 2008.

K. Volkart
Test von Katalysatoren für die Methanisierung, die Umsetzung von Schwefelspezies, die Wassergas-konvertierung und die Ethylenhydrierung in einem Teilstrom eines Holzvergasers
PSI Villigen and ETH Zürich, 2008.

BACHELOR THESES

J. Aubert
Untersuchungen zur kontinuierlichen Salzabtrennung aus wässrigen Lösungen unter Bedingungen der hydrothermalen Vergasung von Biomasse
PSI Villigen and ETH Zürich, June 2008.

S. Möllencamp
CO_2 reduction via a solar thermochemical cycle based on metal oxide redox reactions
PSI and ETH Zürich, October 2008.

T. Müller
Simulation of the hydrolysis and pyrolysis of a wood particle under hydrothermal conditions
PSI Villigen and ETH Zürich, June 2008.

M. Wirz
Solar steam gasification: Characterization and study of thermal behaviour/kinetics of industrial sludges
PSI and ETH Zürich, July 2008.

G. Zanganeh
Solar thermal cracking of methane - experimental campaign at the PSI solar furnace
PSI and ETH Zürich, December 2008.

SEMESTER THESES

L. Besnier
Caracterisation of carbonaceous particles with an ECOC instrument
PSI Villigen, 2008.

J. Gaabab
Characterization of a packed bed of carbonaceous materials during gasification
PSI Villigen and ETH Zürich, September 2008.

A. Kiristopuryan
Fluorite-type solid electrolyte layers by aerosol assisted CVD & PLD
PSI Villigen and ETH Zürich, April 2008.

A. Paillet
Contribution to the production of improved iron-exchanged zeolite SCR catalysts
Université d'Orléans, April 1 – August 31, 2008.

N. Rizwan Farid
Chemical simulation of syngas flames
PSI Villigen and ETH Zürich, March 2008.

H. Wallimann
Experimental investigation of the aerodynamic protection of a solar reactor's window
PSI Villigen and ETH Zürich, June 2008.

TALKS

Invited Talks

U. Baltensperger
Atmospheric aerosols - recent development in elucidating their sources
4th Aarhaus Winter Meeting, Trends in Modern Chemistry, Aarhus, Denmark, February 1, 2008.

U. Baltensperger
Sources of organic aerosols in the atmosphere - recent results from lab and field experiments
University of Copenhagen, Sweden, January 31, 2008.

U. Baltensperger
Feinstaub in der Schweiz - Zusammensetzung, Quellen, Auswirkungen
Forum Medizin und Energie, Aarau, March 6, 2008.

U. Baltensperger
Aerosole - winzige Teilchen beeinflussen globales Klima
Klimasonntag, PSI Villigen, April 13, 2008.

U. Baltensperger
Chemical and physical properties of organic aerosols
EGU, Vienna, Austria, April 13-18, 2008.

U. Baltensperger
Aerosol research at the high-alpine site Jungfraujoch
Grosses Physikalisches Kolloquium an der Universität zu Köln, Germany, May 6, 2008.

U. Baltensperger
Sekundärorganisches Aerosol, HULIS, Polysäuren, hochmolekulare Verbindungen: Eine Wanderung durch den Terminologie-Dschungel und erste Einblicke in Bildungsprozesse und Eigenschaften
Start-Treffen der DFG-Forschergruppe 763, Oberflockenbach, Germany, May 14-15, 2008.

U. Baltensperger
Atmospheric aerosols - sources, transformation, processes and impact
3rd Conference on Atmospheric Science, Gothenborg, Sweden, May 20, 2008.

U. Baltensperger
Das CLOUD-Projekt am CERN
AMI Maschinenbau-Kolloquium, PSI Villigen, May 30, 2008.

U. Baltensperger
Primary and secondary organic aerosol from Diesel engines
12th ETH-Conference on Combustion Generated Nanoparticles, Zürich, June 23-25, 2008.

U. Baltensperger
Formation and transformation of secondary organic aerosols
University of Colorado, Boulder, USA, August 1, 2008.

U. Baltensperger
Nucleation, growth, and aging of secondary organic aerosol
Workshop on Organic Aerosols, Telluride, USA, August 4-8, 2008.

U. Baltensperger
Secondary organic aerosols: formation, transformation, and source apportionment
University of California, Berkeley, CA, USA, August 11, 2008.

U. Baltensperger
Feinstaub: Kleine Teilchen mit grossen Auswirkungen
Forschung im Zelt, PSI, Aarau, August 20, 2008.

U. Baltensperger
New Frontiers on Organic Aerosols
Plenary talk, EAC 2008, Thessaloniki, Greece, August 24-29, 2008.

U. Baltensperger
Der Beitrag der Holzfeuerungen zum Feinstaub-Hintergrund und Forschung am PSI
Medienkonferenz Feinstaub aus Holzheizungen, Balsthal, October 2, 2008.

U. Baltensperger
Aerosole und ihre abkühlende Wirkung auf das Klima
Lokal messen, Global verstehen. Schweizer Klimabeobachtung als globaler Beitrag, Swiss GCOS, Zürich, October 21, 2008.

U. Baltensperger, E. Weingartner
Aerosol measurements in the context of the global atmosphere watch programme and several EC projects
Spawning the Atmosphere Measurements of Jungfraujoch, Bern, November 25-26, 2008.

U. Baltensperger, E. Weingartner
Aerosol Measurements at the High-Alpine Station Jungfraujoch, Switzerland
CANDAC Workshop, Toronto, Canada, November 27-29, 2008.

S.M.A. Biollaz
Vergasung von Biomasse
E-World 2008, Workshop A: Biomasse und biogene Kraftstoffe, Essen, Germany, February 19, 2008.

S.M.A. Biollaz
Biomasse im Erdgasnetz - SNG für die KWK -
OTTI Profiforum, KWK mit Biomasse, Regenstauf bei Regensburg, Germany, April 7-8, 2008.

S.M.A. Biollaz
Erzeugung von Erdgassubstituten (SNG) aus Vergasungsgasen
Berliner Abfallwirtschafts- und Energiekonferenz, Berlin, Germany, September 25-26, 2008.

A. Bodi
Imaging photoelectron photoion coincidence spectroscopy at the Swiss Light Source
Group Seminar (Prof. John P. Meier) University of Basel, October 27, 2008.

M. Brandenberger
BrandenbergerSunCHem: A 3rd generation biofuel technology to produce methane from algae
36th Discussion Forum LCA of Future Biofuels, EMPA Dübendorf, November 17, 2008.

F.N. Büchi
Hydrogen based mobility: Developments in Europe
COME 2008, International Conference on Mobility and Energy, Vienna, Austria, February 28, 2008.

F.N. Büchi
Sizing of fuel cell powertrains for mobile applications
HYCELTEC 2008, International Symposium on Hydrogen and Fuel Cells, Bilbao, Spain, July 3, 2008.

I. Czekaj
How can combination of experimental and theoretical methods contribute to the development of catalysts at macroscopic scale?
Young Chemist’s Workshop “Modeling of complex systems”, CERC3, Perugia, Italy, May, 1-4, 2008.

P.F. DeCarlo
Characterizing Submicron Aerosols with the High Resolution Time-of-Flight Aerosol Mass Spectrometer
Online Aerosol Mass Spectrometry Workshop, Leeds, UK, April 8 -11, 2008.

W. Durisch
Fuel-fired TPV at PSI
7th FULLSPECTRUM Meeting, Freiburg, Germany, May 28, 2008.

W. Durisch
Fuel-fired TPV Activity Report
8th FULLSPECTRUM Plenary Meeting, Madrid, Spain, November 14-15, 2008.

M. Furger
Feinstaub: Kleine Teilchen mit grossen Auswirkungen
Forschung im Zelt, PSI, Waldshut, Germany, August 27, 2008.

F. Gassmann
Erneuerbare Energie – 2000 Watt Gesellschaft
Aargauische Naturforschende Gesellschaft, Naturama Aarau, January 9, 2008.

F. Gassmann
Unser Klima im Wandel
- AEW, Wärmeverbund Bremgarten, January 31, 2008.
- Electra Schneisingen, March 27, 2008.

F. Gassmann
Klimawandel – Ursachen und Auswirkungen auf unser Leben
Forum für Wirtschaft und Umwelt der FDP des Kt. Schwyz, MythenForum Schwyz, September 26, 2008.

F. Gassmann
Der Klimawandel ist voll im Gang
- Tec Day der KME Zürich, November 13, 2008.
- Tec Day der Kantonsschule Baden, November 26, 2008.

F. Gassmann
Treibhauseffekt und Klimawandel
Delegation der Axpo, PSI, November 15, 2008.

F. Gassmann
Wellen als zentrales Thema der Physik – Experimente mit Schallwellen
Volkshochschule der Region Zurzach, PSI, November 20, 27, 2008.

F. Gassmann
Erneuerbare Energie
Thurgauische Naturforschende Gesellschaft, Frauenfeld, December 9, 2008.

F. Gassmann
Klimaveränderungen und Auswirkungen auf den Wasserkreislauf
Axporama, Böttstein, December 12, 2008.

F. Gassmann
Erneuerbare Energie – wie weit reicht sie?
Ringvorlesung "Energie" der Zürcher Hochschule der Künste (ZHDK), Zürich, December 16, 2008.

L. Gubler
Trends for fuel cell membrane development
12th Aachener Membran Kolloquium, Aachen, Germany, October 29, 2008.

M. Gysel
Hygroscopic properties of laboratory generated and atmospheric aerosol particles and their interaction with clouds
Johann Wolfgang Goethe Universität, Frankfurt (Main), Germany, June 26, 2008.

M.P. Hofer, M. Papra, F.N. Buechi, T. Gloor
Freezing of PEFC
IEA HEV Annex XIII Workshop, Cold start behavior of FC vehicles, Geneva, March 12, 2008.

P. Jansohn
Perspektiven in der Energieversorgung
Manfred Eigen Nachwuchswissenschaftler Gespräche, Deutsche Bunsen-Gesellschaft für Physikalische Chemie, Bad Herrenalb, Germany, April 24, 2008.

P. Jansohn
Kraftwerk 2020 – An option for swiss power generation in a carbon constrained world
ABB Corporate Research Lunch Talk, Baden-Dättwil, November 17, 2008.

G. Knopp
Prospective experiments on catalytic surfaces
PSI-XFEL Science Workshop on Sub-ps Solution Chemistry and Surface Catalysis, EPF Lausanne, October 10, 2008.

R. Kötz
SuperCaps basics
International Max Planck Research School (IMPRS) "Energy", Patras, Greece, June 1-8, 2008.

R. Kötz
Applications of SuperCaps
International Max Planck Research School (IMPRS) "Energy", Patras, Greece, June 1-8, 2008.

O. Kröcher
Chemical challenges in the development of urea-SCR systems
Seminar for Caterpillar, USA, January 14, 2008.

O. Kröcher
Ein neues TG-FTIR-System für die Abgasnachbehandlung
Forschungsvereinigung Verbrennungskraftmaschinen (FVV), Frankfurt (Main), Germany, August 19, 2008.

O. Kröcher
Guanidinium formate as new reductant for the low NOx-SCR technique
2. Internationale MinNO$_x$-Konferenz, Berlin, Germany, June 19–20, 2008.

O. Kröcher, M. Casapu
Katalysatormaterialien für die NO$_x$-Reduktion
VDI forum, Nürnberg, Germany, December 11, 2008.

O. Kröcher
New reducing agents for the low-NO$_x$ SCR technology
5th International Exhaust Gas and Particulate Emissions Forum, Ludwigsburg, Germany,
February 19-20, 2008.

O. Kröcher
Zukunft der Mobilität: Das Auto von morgen
Am Puls der Forschung, Waldshut, Germany, August 23, 2008.

T. Lippert
Der Laser – vom Kuriosum zum Werkzeug: Anwendungen aus Industrie und Forschung
Senioren-Kolleg Liechtenstein, Mauren, Liechtenstein, November 2008.

T. Lippert
Excimer laser for the deposition/transfer of thin films and structuring: Applications for fuel cells and OLEDs
Plenary talk at 2nd International Symposium on Laser-Micromachining, Chemnitz, Germany, November 2008.

T. Lippert
Thin films prepared by pulsed laser deposition for renewable energy applications
FZ Karlsruhe, Germany, November 2008.

T. Lippert
Laser-induced forward transfer (LIFT) of polymers using a sacrificial layer
- 28th Physical Chemistry Colloquium – Laser Chemistry and Nanomaterials –, Tohoku University, Sendai, Japan, September 2008.
- University of Southampton, Optoelectronics Research Centre, UK, February 2008.

T. Lippert
Laser interaction with materials: From structuring to thin film deposition
RIKEN, Wako, Japan, August 2008.

T. Lippert
From laser ablation to laser transfer techniques – experiences and current developments
IMM Mainz, Germany, June 2008.

T. Lippert
Materials for laser propulsion
7th International conference on High Power Laser Ablation, Taos, USA, April 2008.

T. Lippert
Thin film deposition by laser based methods
University of Vienna, Physical Chemistry Department, Austria, April 2008.

Ch. Ludwig
RESH Behandlung mit KVA^{plus}
Stiftung Auto Recycling Schweiz, Bern, June 23, 2008.

Ch. Ludwig
Understanding the fate of elements in industrial processes and the environment
IMX seminar series on Advances in Materials, EPF Lausanne, November 10, 2008.

A. Meier
Concentrating solar power – present status and future prospects
High Temperature Solar Processes: Concentrated Solar Power (CSP) – State of the art and projects in Switzerland, Neuchãtel, October 28, 2008.

C. Mohr
Analyse primärer organischer Feinstaub-Emissionen aus Grillaktivitäten
Bundesamt für Umwelt BAFU, Bern, November 4, 2008.

C. Mohr
Partikelzusammensetzung im Rheintal und in der Stadt Zürich
Ostluft-Vollversammlung, Fildern, May 27, 2008.

M. Nachtegaal, M. Harfouche, M. Willimann, R. Abela, T. Waterstradt, C. Venkataraman, M. Schwoerer-Böhning, W. Diete, K. Nurdan, J. A. van Bokhoven, R. Frahm
Commissioning of the QEXAFS monochromator at the Swiss Light Source
5th international conference on Mechanical Engineering Design for Synchrotron radiation Instrumentation in Saskatoon, Canada, June, 2008.

F.P. Nagel
Verstromung von Holz über die Hochtemperaturbrennstoffzelle
SAH Statusseminar, EMPA, Akademie, Zürich, March 19, 2008.

P. Novák
Beyond the conventional approach: An in situ look at battery materials
- Seminar in the Laboratory for Inorganic Chemistry, ETH Zürich, February 19, 2008.
- Seminar at Toyota Central R&D Labs., Inc., Nagoya, Japan, June 20, 2008.
- 49th Battery Symposium in Japan, Sakai, Japan, November 6, 2008.

P. Novák
Oxygen loss from NMC materials
BASF SE, Ludwigshafen, Germany, July 18, 2008.

P. Novák
In situ investigations of battery materials
Seminar at the State Key Laboratory of Physical Chemistry of Solid Surfaces, Xiamen University, Xiamen, China, July 9, 2008.

P. Novák
Materials for lithium-ion batteries
Seminar at the Department of Chemistry, Zhejiang University, Hangzhou, China, July 3, 2008.

P. Novák
In situ characterization methods - the scientific key to battery materials
14th Int. Meeting on Lithium Batteries, Tianjin, China, June 22-28, 2008.

P. Novák
Energy storage in advanced batteries
Seminar “A Physics Perspective on Climate Change and Energy Supply” of the German Physical Society, Bad Honnef, Germany, May 29, 2008.

T.J. Patey
Nanoparticles in lithium-ion batteries – opportunities and challenges
Particle Formation Symposium, Vitznau, July 5, 2008.

A.S.H. Prévôt
Organic carbon source analysis in aerosols
Organics in the Atmosphere, Vienna, Austria, October 6-8, 2008.

A.S.H. Prévôt
Source apportionment of particulate organics in ambient air and secondary organic aerosol formation studies in the smogchamber at the Paul Scherrer Institute in Switzerland
University of Stockholm, Sweden, September 26, 2008.

A.S.H. Prévôt
Fine and ultrafine particle measurements in Central Europe in ambient air
International Workshop on Environmental Nanoparticles, Tsukuba, Japan, January 18, 2008.

A.S.H. Prévôt
Fine and ultrafine particle measurements in Switzerland in ambient air
University of Tokyo, Japan, January 21, 2008.

A.S.H. Prévôt
Aerosolmassenspektrometer
Fachtagung Immissionstechnik, EMPA Dübendorf, January 25, 2008.

M. Saurer
The climatic content of carbon and oxygen isotope ratios in tree-rings from northern Eurasia
Barnaul, Russia, June 1-6, 2008.

M. Saurer
The use of isotopes in ecosystem studies
Pisa, Italy, June 15-19, 2008.

G.G. Scherer
Radiation grafted membranes as solid electrolyte in fuel cell applications
Advances in Polymer Science and Technology, plenary lecture, New Delhi, India, January 28-31, 2008.

G.G. Scherer
Fuel cells for transportation - an overview on European activities
Nissan Motor Company, Research Center, Kanagawa, Japan, February 6, 2008.

G.G. Scherer
The lithium-ion battery - activities at PSI’s Electrochemistry Laboratory
Dainippon Screen, Kyoto, Japan, February 7, 2008.

G.G. Scherer
Fuel Cells I
Fuel Cells II
International Max Planck Research School (IMPRS) “Energy”, Greece, June 2–6, 2008.

G.G. Scherer
Die Funktionsweise der Polymer Elektrolyt Brennstoffzelle
SKZ - ConSem GmbH, „Kunststoffe in der Brennstoffzelle“, Würzburg, Germany, June 11, 2008.

G.G. Scherer
Radiation grafted polymer membranes for fuel cell applications achievements and challenges
IRAP2008, 8th International Symposium on Ionizing Irradiation and Polymers, keynote lecture, Angra Dos Reis, Brasil, October 12-17, 2008.

G.G. Scherer
Radiation grafted fuel cell membranes
IPEN, Centro de Química e Meio Ambiente, Sao Paulo, Brazil, October 23, 2008.

G.G. Scherer
Polymer electrolyte fuel cells: In situ diagnostic methods & materials development
IPEN, Centro de Células a Combustível, Sao Paulo, Brazil, October 24, 2008.

G.G. Scherer
Electrochemical energy conversion and storage - R & D at Paul Scherrer Institut
IPEN, Centro de Química e Meio Ambiente, Sao Paulo, Brazil, October 25, 2008.

T. Schildhauer
Methane from wood: Reducing deactivation by carbon "management" on nickel catalysts
Rideal Conference, Cambridge, UK, March 17-20, 2008.

I.A. Schneider, M.H. Bayer, A. Wokaun, G.G. Scherer
Impedance response of the proton exchange membrane in polymer electrolyte fuel cells
5th Symposium on FC Modelling and Validation, Winterthur, March 12, 2008.

I.A. Schneider, M.H. Bayer, P. Boillat, A. Wokaun, G.G. Scherer
Recent insights obtained from local in situ diagnostics in polymer electrolyte fuel cells
214th Meeting of The Electrochemical Society, Honolulu HI, USA, Oct 16, 2008.

M. Schubert, J.W. Regler, F. Vogel
Effiziente Salzabscheidung als ein wichtiger Schritt bei der katalytischen, hydrothermalen Vergasung nasser Biomasse
10. Tagung Ionenchromatographie, Luzern, May 7, 2008.

L.O. Schunk
Erneuerbare Energien – heute und morgen
- TecDay@KME, Kantonale Maturitätsschule für Erwachsene, Zürich, November 13, 2008.
- TecDay@KantiBaden, Kantonsschule Baden, November 26, 2008.

B.C. Seyfang
Micro polymer electrolyte fuel cells – simple, small, but still sophisticated enough
Catalysis Group Seminar, University of Cape Town, South Africa, February 14, 2008.

A. Steinfeld
High-temperature thermochemical processing of fuels using concentrated solar energy
EUROTHERM 2008 - 5th European Thermal-Sciences Conference, Eindhoven, The Netherlands, May 18, 2008.

A. Steinfeld
Solar Hydrogen – Present and Future
Int. Conf. Renewable Energy and Beyond, Tel Aviv, Israel, May 22, 2008.

A. Steinfeld
In-situ formation and hydrolysis of Zn nanoparticles for H_2 production via a 2-step solar thermochemical cycle
ASME – 3rd Energy Nanotechnology International Conference, Jacksonville, USA, August 12, 2008.

A. Steinfeld
Die Versorgungssicherheit – Potenzial erneuerbarer Energien
Climate Forum, Thun, October 9, 2008.

A. Steinfeld
Concentrated solar power & fuels – early pioneering research, present status, and future prospects
Symposium honoring the 90th birthday of Prof. Dostrovsky "Outward Bound; From Nuclear Chemistry to Solar Neutrinos", Weizmann Institute, Rehovot, Israel, October 26, 2008.

A. Steinfeld
Global potential of renewable energy technologies
Ringvorlesung Energie, University of Zürich, October 30, 2008.

R.P.W.J. Struis
Studying sulfur deactivation of Ni-based methanation catalysts using X-ray absorption spectroscopy
Materials Science and Engineering congress, MSE 2008, Nürnberg, Germany, September 2, 2008.

S. Stucki
Neue Technologien im Bereich Holzenergie
GV Aarg. Waldwirtschaftsverband, Fislisbach, October 23, 2008.

S. Stucki
Biotreibstoffe: Aktuelle Möglichkeiten, künftige Bedürfnisse
AWEL Werkstatt, Zürich, October 21, 2008.

S. Stucki
New pathways to efficient use of biomass for power and transportation
CCEM Project 2nd Generation Biogas, SVGW Arbeitsgruppe „Koordination Biogas", Zürich, June 6, 2008.

S. Ulli-Beer
Wege zu sparsameren Autos: Die Autowahl vor dem Hintergrund sich verändernder Technologie-Landschaften
Mitgliederversammlung der Gruppe Energieperspektiven, Baden, March 27, 2008.

S. Ulli-Beer
Die gelebte Erlebnisraum-Mobilität Strategie. Was macht uns aus, wie können wir uns erhalten und verbessern
Strategie-Workshop Erlebnisraum Mobilität, Basel, September 19, 2008.

S. Ulli-Beer
Nachhaltigkeitsmanagement im Fuhrpark: Energieeffiziente und umweltfreundliche Flotten
Event für Schweizer Fuhrparkmanager, organisiert von aboutFleet, Zürich, November 26, 2008.

F. Vogel
Catalytic Process Engineering at PSI
Process and Energy Department, TU Delft, The Netherlands, February 13, 2008.

F. Vogel
Technologien und Perspektiven der Energiegewinnung aus Biomasse – Hydrothermale Vergasung von nasser Biomasse
ETH Alumni - Process Alumni event, Zürich, April 3, 2008.

F. Vogel, M. Schubert, M. Brandenberger, J.W. Regler
Recent advances in catalytic hydrothermal gasification of biomass to synthetic natural gas
XVII Congresso Nazionale di Chimica Industriale, Società Chimica Italiana, Genova, Italy,
June 30 - July 3, 2008.

F. Vogel
Katalytische Aspekte der hydrothermalen Vergasung nasser Biomasse zu Methan
Kolloquium am Institut für Technische Chemie, Forschungszentrum Karlsruhe, Germany, July 8, 2008.

E. Weingartner
Study of Aerosol from Wood Burning Versus Other Sources (AEROWOOD) Using a Multiwavelength Aethalometer
Aerosol & Atmospheric Optics: Visual Air Quality and Radiation, Moab, USA, April 28 - May 2, 2008.

E. Weingartner
Current Aerosol Mesurement at the Jungfraujoch
Air Pollution and Climate Change at Contrasting Altitude and Latitude, Murten, September 11, 2008.

E. Weingartner
CPC, SMPS, APS im Messbetrieb
Fachtagung Immissionsmesstechnik, EMPA Dübendorf, January 25, 2008.

E. Weingartner
Feinstaub: Kleine Teilchen mit grossen Auswirkungen
Forschung im Zelt, PSI, Baden, August 13, 2008.

A. Wokaun
Erneuerbare Energien in der Schweiz – Stand der Forschung und aktuelle Beispiele
Der 4. Deutsche Wasserstoff Congress, E-world 2008, Essen, Germany, February 20-21, 2008.

A. Wokaun
Energie – Perspektiven und Optionen für die Zukunft
Departement Bau, Verkehr und Umwelt, Aarau "Klimawandel im Aargau: Folgen, Chancen und Risiken", Baden, September 8, 2008.

A. Wokaun
Klimaprognosen versus Energieprognosen
Energie Schweiz, Energie Apéro, Baden and Lenzburg, October 14 and 16, 2008.

A. Wokaun
Alternative Fuels and Propulsion Concepts for a Sustainable Mobility
Berner Chemische Gesellschaft, Bern, November 5, 2008.

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- Light Scattering: Mie and More - Commemorating 100 Years Mie's 1908 Publications, Forschungszentrum Karlsruhe, Germany, July 3-4, 2008.

PATENT APPLICATIONS

O. Kröcher, M. Elsener
A method and a system for a treatment of a NO_x-containing exhaust gas
Patent Application No. EP 2008P07268, 2008.

CONFERENCES, WORKSHOPS & EXHIBITIONS

S. Andreani-Aksoyoglu
International Symposium on Air Quality Management at Urban, Regional and Global Scales
Scientific Advisor

W. Durisch
World Renewable Energy Congress
Steering Committee Member

M. Furger
Jahrestagung der Schweizerischen Gesellschaft für Meteorologie
Swiss Geoscience Meeting 2008, Symposium 04 'Meteorology and Climatology', scnat Annual Meeting, Lugano, November 21-23, 2008.

P. Jansohn
Forschungsprogramm "Kraftwerk 2020" (Jahrestagung)
Bundesamt für Energie (BFE), Bern, Juni 26, 2008.
Organisator/Programmleiter

R. Kötz
59th Annual Meeting of the International Society of Electrochemistry
Seville, Spain, September 7-12, 2008.
Co-Organizer and Chair of Symposium 8b, Electrochemical Energy Conversion and Storage

R. Kötz
ESSCAP 2008, 3rd European Symposium on Supercapacitors and Applications
Roma, Italy, November 6-7, 2008.
Member of Scientific Committee

S. Lienin, S. Perret, S. Ulli-Beer
Strategie-Workshop
Erlebnisraum Mobilität, Basel, September 17, 2008.
Organizers

Ch. Ludwig
REWAS 2008, Global Symposium on Recycling, Waste Treatment and Clean Technology
Cancun, Mexico, 2008.
Co-chair

I. Mantzaras, P. Jansohn, A. Wokaun
IWCC7 – 7th International Workshop on Catalytic Combustion
Seedamm Plaza, Pfäffikon, September 29 – October 1, 2008.
Veranstalter/Gastgeber

J. Mantzaras
Int. Symposium on Combustion
Chairman of committee in heterogeneous combustion and materials synthesis section

A. Meier
European Energy Research Alliance (EERA) Workshop on Concentrated Solar Power (CSP)
PSI Villigen, December 4, 2008.
Organizer

M. Nachtegaal
Workshop on X-ray absorption spectroscopy and advanced techniques
PSI Villigen, October 6-10, 2008.
Organiser

P. Novák
59th Annual Meeting of the International Society of Electrochemistry
Seville, Spain, September 14-19, 2008.
Organizing Committee

P. Novák
IMLB-14, 14th Int. Meeting on Lithium Batteries
Tianjin, China, June 22-28, 2008.
Int. Scientific Committee

A.S.H. Prévôt, J. Staehelin, M. Sosonkin
Summer school on Atmospheric Chemistry
Kiev, Ucraine, September 16-18, 2008.
Organizing Comittee

A.S.H. Prévôt, J. Staehelin, O. Tarasova
Summer school on Atmospheric Chemistry
Borok, Russia, May 19-21, 2008.
Organizing Comittee

A.S.H. Prévôt, H. Gygax, J. Staehelin
Ozon und Sommersmog, Fachtagung zum Stand der Forschung und zur Reduktionsstrategie
Bern, October 30, 2008.
Organizing Comittee

P.P. Radi
European Conference on Nonlinear Optical Spectroscopy
Steering Committee

G.G. Scherer
Advances in Polymer Science and Technology - Asian Polymer Association
New Delhi, India, January 28-31, 2008.
Int. Advisory Board

G.G. Scherer
59th Annual Meeting of the International Society of Electrochemistry
Seville, Spain, September 7–12, 2008.
Co-Organizer and Chair of Symposium 8b, Electrochemical Energy Conversion and Storage

G.G. Scherer, R. Kötz
Electrochemical Materials Processing
24th One-Day-Symposium, PSI Villigen, May 7, 2008.
Organizers

A. Steinfeld
2nd IASTED Africa Conference on Power and Energy Systems, Botswana
Scientific Committee

A. Steinfeld
Smart EnergyStrategies, Zürich
Scientific Committee

S. Ulli-Beer, M. Müller
Projekt-Workshop DeeR - Diffusionsdynamik energieeffizienter Renovationen
Akteursanalyse inkl. Workshop Bericht, Zürich, Juni 20, 2008.
Organizers

S. Ulli-Beer, S. Grösser, S. Bruppacher
Projekt-Workshop DeeB – Diffusionsdynamik energieeffizienter Bauten. Entwicklung Effizienzsteigerung im Neubau
Inkl. Workshop Bericht, Langenthal, February 15, 2008.
Organizers

A. Wokaun
iamf EET-2008, Forum focused on the mobility of the future, Geneva, March 11-13, 2008
Member of Scientific Committee

A. Wokaun
Energy Com: Conference Moderation
Swiss Re Centre for Global Dialogue, Rüschlikon, December 5, 2008.

MEMBERSHIPS IN EXTERNAL COMMITTEES

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Umweltforschung der Forschungszentrum Jülich GmbH
Wissenschaftlicher Beirat, Vorsitzender
Wissenschaftlich-Technisches Ausschuss Mitglied

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sc nat Commission, Atmospheric Chemistry and Physics
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COST 728-European Cooperation in the field of Scientific and Technical Research
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Prüfungsexperte

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International Energy Foundation, IEF
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Schweizerische Gesellschaft für Meteorologie
President

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SNC-IUGG - Swiss National Committee of the International Union of Geodesy and Geophysics
National Correspondent of the International Association of Meteorology and Atmospheric Sciences (IAMAS), 2008.
Member

F. Gassmann
Naturama, Aarau
Vice President of Geschäftsleitung

F. Gassmann
Naturforschende Gesellschaft in Zürich
Member of editing committee of Vierteljahrsschrift, Neujahrsblatt and treasurer of the Society

F. Gassmann
Maturakommission für die Kantonsschulen Baden und Wohlen
Experte für Mathematik und Physik

L. Gubler
Prüfungskommission Physiklaboranten, Kanton Zürich
Experte

P. Jansohn
European Turbine Network (ETN); Conference Advisory Committee
Member

P. Jansohn
International Energy Agency (IEA), Implementing Agreement on Energy Conservation and Emission Reduction in Combustion
Collaborative Task Leader "Gas Turbine Combustion"

P. Jansohn
ProcessNet Fachgemeinschaft „Sustainable Production, Energy and Resources", Fachausschuss „Hochtemperaturtechnik"
berufenes Mitglied

P. Jansohn
European Technology Platform – Zero Emission Fossil Fuel Power Plants (ETP-ZEP), Taskforce Technology and Government Group
Member

R. Kötz
Electrochimica Acta
Advisory Board

R. Kötz
International Society of Electrochemistry
Publications Committee

T. Lippert
E-MRS
Board of Delegates

T. Lippert
E-MRS
Member of the Executive Committee

T. Lippert
Journal of Laser Micro/Nanoengineering (JLMN)
Co-Editor

T. Lippert
Laser Chemistry
Associate Editor

T. Lippert
Materials
Editorial Board

Ch. Ludwig
BFE-Projekt: Bewertungsmethode für Technologien zur Nutzung von biogenen Abfällen
Experte und Mitglied der Begleitgruppe

A. Meier
International Energy Agency SolarPACES
Operating Agent

A. Meier
SOLLAB – Alliance of European Laboratories on Solar Thermal Concentrating Systems
Steering Committee

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International Society of Electrochemistry
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The Electrochemical Society, Inc.
Member of the Technology Award Committee of the Battery Division

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sc nat Commission, Atmospheric Chemistry and Physics
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German Association for Stable Isotope Research (GASIR)
Stellvertretender Vorsitzender der Arbeitsgemeinschaft

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Director of Research and PhD Studies
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Steering Committee

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IMDEA-Energía, *Spain*
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TMS (Minerals, Metals & Materials Society)
Member – Energy Committee

A. Steinfeld
SANDIA Laboratories "Sunshine to Petrol" program
Member Advisory Board

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DGM Fachausschuss Strahllinien
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BMBF Programm BioEnergie 2020
Gutachter

S. Stucki
EU Technology Platform Biofuels, WG4, Sustainability
Member

S. Ulli-Beer
System Dynamics Review
Associated editor

E. Weingartner
Fachgruppe zum Thema: Partikelzählung / Partikelgrössenanalyse
Ziel: Erarbeiten von Empfehlung zum Einsatz von Partikelzählern und Partikelgrössenanalysatoren bei Aerosolen
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Hydropole-Swiss Hydrogen Association
Board Member

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Schweiz. Akademie der Technischen Wissenschaften (SATW)
Einzelmitglied

A. Wokaun
Helmholtz-Gemeinschaft deutscher Forschungszentren
Mitglied der Senatskommission

A. Wokaun
European Climate Forum
Member of Council

A. Wokaun
novatlantis – Nachhaltigkeit im ETH-Bereich
Mitglied des Leitungsausschusses

A. Wokaun
Studiengruppe Energieperspektiven
Präsident

A. Wokaun
CORE
Mitglied

A. Wokaun
Advisory Group on Energy (AGE), European Union
Mitglied

A. Wokaun
Competence Center Energy and Mobility (CCEM)
Chairman of Steering Committee

AWARDS

D. Cericola
Master Thesis
Materiali carboniosi e liquidi ionici per supercapacitori a doppio strato
Premio di Laurea "PhotoAnalytical srl " of the Divisione di Elettrochimica della Societa' Chimica Italiana

I. Czekaj, F. Loviat, J. Wambach, A. Wokaun
Nickel deposition on γ-Al_2O_3: modelling of metal particles behaviour at the support
SCS Swiss Chemical Society Fall Meeting, University of Zürich, September 11, 2008.
Best Poster Award

P. Jansohn
Member of the Year
European Turbine Network (ETN), Brussels, Belgium, September 2008

M. Kalberer
Marian Smoluchowski Award 2008

H. Kuhn
PhD-Thesis
In situ Charakterisierung von Polymer-Elektrolyt Brennstoffzellen mittels elektrochemischer Impedanzspektroskopie
ABB Forschungspreis 2008

P. Ruch
In situ X-ray diffraction of the intercalaction of $(C_2H_5)_4N^+$ and BF_4^- into graphite from acetonitrile and propylene carbonate based supercapacitor electrolytes
Electrochim. Acta **53**, 1074-1082, 2007.
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M. Schubert, J.W. Regler, M. Brandenberger, Ch. Ludwig, F. Vogel
Salt Separation as a crucial step in continuous catalytic hydrothermal gasification of wet biomass to SNG
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B.C. Seyfang, P. Boillat, G.G. Scherer, T. Lippert, A. Wokaun
Micro-structuring of glassy carbon for micro polymer electrolyte fuel cells: Ns-shadowgraphy during laser ablation
E-MRS Spring Meeting 2008, Strasbourg, France, May 26-30, 2008.
Best Poster Award

LIST OF PUBLICATIONS 2008

Large Research Facilities and PSI-XFEL Project

UNIVERSITY LEVEL AND OTHER TEACHING

A. Adelmann
Statistics and Probability theory
University of Technology Economics and Business Administration Zürich, Switzerland
Spring Semester 2008

M. Böge
Closed Orbit Correction
CERN Accelerator School on Beam Diagnostics, Dourdan, France
28 May - 6 June 2008

M. Böge
Closed Orbit Feedback
CERN Accelerator School on Beam Diagnostics, Dourdan, France
28 May - 6 June 2008

D. Kiselev
Aktuelle Experimente am Beschleuniger zur Kern- und Nukleonenstruktur
University of Basel, Switzerland
Spring Semester 2008

D. Kiselev, B. Krusche
Einführung in die Kern- und Teilchenphysik
University of Basel, Switzerland
Autumn Semester 2008

J.A. Patorski
Thermographische Temperaturmessung
Paul Scherrer Institut, PSI Lehrlingsausbildung, Villigen, Switzerland
November 2008

L. Rivkin
Introduction to Particle Accelerators
EPFL Lausanne, Switzerland
Autumn Semester 2008

L. Rivkin
Synchrotron Light, Electron Dynamics with Radiation and Synchrotron Light Sources
CERN Accelerator School, Frascati, Italy
2-14 November 2008

L. Rivkin
Accelerator Physics (emphasis on LHC and ILC/CLIC)
CHIPP PhD Winter School, Näfels, Switzerland
13-20 January 2008

J.M. Schippers
Accelerators for proton therapy
PSI Winterschool on proton therapy, Bad Zurzach, Switzerland
January 2008

J.M. Schippers
The SC-cyclotron at PSI and other accelerators for proton therapy
Joint university Accelerator school (JUAS), PSI, Villigen, Switzerland
6 March 2008

V. Schlott
Femto-Second Diagnostics
CERN Accelerator School on Beam Diagnostics, Dourdan, France
28 May - 6 June 2008

M. Schneider
Grundlagen der Elektronik
Technikerschule HF, Zürich, Switzerland
Autumn Semester 2007/08, Spring Semester 2008

U. D. Straumann, M. Dittmar, U. Langenegger, W. Lustermann, K. Müller, O. Steinkamp, A. Streun
Experimental Methods of Particle Physics
Joint lecture University and ETH Zürich, Switzerland
Autumn Semester 2008/09

PEER REVIEWED PAPERS

Å. Andersson, M. Böge, A. Lüdeke, V. Schlott, A. Streun
Determination of a small vertical electron beam profile and emittance at the Swiss Light Source
Nucl. Instr. and Meth., A **591**, 437 (2008)

M. Calviani, P. Cennini, D. Karadimos, V. Ketlerov, V. Konovalov, W. Furman, A. Goverdowski, V. Vlachoudis, L. Zanini, the n_TOF Collaboration
A fast ionization chamber for fission cross section measurements at n_TOF
Nucl. Instr. and Meth., A **594**, 220 (2008)

J. Chrin, T. Schmidt, A. Streun, D. Zimoch
Local correction schemes to counteract insertion device effects
Nucl. Instr. and Meth., A **592**, 141 (2008)

S. Dementjev, F. Groeschel, N. Jekabsons
Experience of Electromagnetic pumps Operation in Swiss Spallation Neutron Source
Magnetohydrodynamics, **44**, No. 3, 279 (2008)

C. Fazio, F. Groeschel, W. Wagner, K. Thomsen, B.L. Smith, R. Stieglitz, L. Zanini, A. Guertin, A. Cadiou, J. Henry, P. Agostini, Y. Daib, H. Heyck, S. Dementjev, S. Panebianco, A. Almazouzi, J. Eikenberg, A. Letourneau, J.C. Toussaint, A. Janett, Ch. Perret, S. Joray, J.A. Patorski, W. Leung, P. Meloni, P. Turroni, A. Zucchini, G. Benamati, J. Konys, T. Auger, A. Gessi, D. Gorse, I. Serre, A. Terlain, J.-B. Vogt, A. Batta, A. Class, X. Cheng, F. Fellmoser, M. Daubner, S. Gnieser, G. Groetzbach, R. Milenkovic, C. Latge, J.U. Knebel
The MEGAPIE-TEST project: Supporting research and lessons learned in first-of-a-kind spallation target technology
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R. Ganter, R. Bakker, C. Gough, S.C. Leemann, M. Paraliev, M. Pedrozzi, F. Le Pimpec, V. Schlott, L. Rivkin, A. Wrulich
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L. Giller, U. Filges, G. Kuehne, M. Wohlmuther, L. Zanini
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B. Kalantari, T. Korhonen, A. Schiper
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B. Oswald, P. Leidenberger, C. Hafner
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J.A. Patorski, F. Groeschel
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M. Seidel, K. Zapfe
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P. van Luijk, J.M. Schippers
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A. Adelmann, S. Reiche, P. Derlet, H. van Swygenhoven, S. Churakov, G. Kosakowski, W. Pfingsten, M. Samaras, D. Kiselev, V. Markushin, S. Teichmann, M. Wohlmuther, L. Zanini, S. Mayer, U. Grossner, M.A. Zimmermann, M.F. Murphy, E. Kolbe, A. Vasiliev, G. Perret, P. Grimm, M. Krack, M. Iannuzzi
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PSI-Bericht 08-02, ISSN 1019-0643 (2008)

M. Dehler
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M. Dehler
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F. Groeschel, S. Dementjev, H. Heyck, W. Leung, K. Thomsen, W. Wagner, L. Zanini
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M. Humbel, A. Mezger, M. Schneider
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T. Schilcher
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F. Stulle, A. Adelmann, M. Pedrozzi
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L. Zanini, J.C. David, A. Yu. Konobeyev, S. Panebianco, N. Thiolliere
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PSI-Bericht Nr. 08-04, ISSN 1019-0643 (2008)

L. Zanini, Y. Dai
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A. Anghel, B. Blau, M. Daum, K. Kirch, S. Grigoriev
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G. Dutto, R.A. Baartman, P.G. Bricault, I. Bylinskii, A. Hurst, E. Laxdal, Y.N. Rao, L. Root, P. Schmor, G. Stinson, J.M. Schippers
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B. Keil, S. Lehner. S. Ritt
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B. Keil, R. Kramert, G. Marinkovic, P. Pollet, M. Roggli
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C. Kharoua, R. Rocca, O. Alyakriskiy, M. Ashrafi-Nik, M. Barbui, J. Freibergs, F. Groeschel, M. Gross, A. Herrera-Martinez, Y. Kadi, J. Lettry, M. Lindroos, F. Nebel, F. Negoita, Y. Romanets, K. Samec, L. Serbina, L. Tecchio, P. Thirolf, P. Vaz, L. Zanini
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Y. Kim, A. Adelmann, B. Beutner, M. Dehler, R. Ganter, R. Ischebeck, T. Garvey, M. Pedrozzi, J.-Y. Raguin, S. Reiche, L. Rivkin, V. Schlott, A. Streun, A.F. Wrulich
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42nd ICFA Advanced Beam Dynamics Workshop on High-Intensity, High-Brightness Hadron Beams, Nashville, USA (2008)

F. Le Pimpec, R. Ganter, C. Gough, C. Hauri, M. Paraliev
Comparison of high gradient achievement for different metals in dc and pulsed dc mode
Proc. FEL 2008, Gyeongju, Korea (2008)

A. Lüdeke
The Operation Event Logging System of the SLS
Proc. EPAC 2008, Genoa, Italy, 3318 (2008)

M. Paraliev, C. Gough, S. Ivkovic
Status of 500kV Low Emittance Electron Gun Test Facility for a Compact X-ray Free Electron Laser at Paul Scherrer Institute
IEEE Power Modulator Conference, Las Vegas, NV, USA, 532 (2008)

J.A. Patorski
Planning of the COOLWETT Experiment
Proc. Int. Workshop on Thermal-Hydraulics of Innovative Reactor and Transmutation Systems – THIRS, Forschungszentrum Karlsruhe, Germany (2008)

M. Pedrozzi, Å. Andersson, R.J. Bakker, R. Ganter, C. Gough, C.P. Hauri, R. Ischebeck, S. Ivkovic, Y. Kim, F. Le Pimpec, S.C. Leemann, K.B. Li, P. Ming, A. Oppelt, M. Paraliev, T. Schietinger, V. Schlott, B. Steffen, A.F. Wrulich
First measurement results of the PSI 500 kV low emittance electron source
Proc. EPAC 2008, Genoa, Italy, 169 (2008)

T. Schietinger, A. Adelmann, Å. Andersson, R.J. Bakker, M. Dietl, R. Ganter, C. Gough, C.P. Hauri, R. Ischebeck, S. Ivkovic, Y. Kim, S.C. Leemann, F. Le Pimpec, K. Li, P. Ming, A. Oppelt, M. Paraliev, M. Pedrozzi, V. Schlott, B. Steffen, A.F. Wrulich
Measurements and modeling at the PSI-XFEL 500-kV Low Emittance Electron Source
Proc. LINAC 2008, Vancouver, Canada (2008)

J.M. Schippers, J. Duppich, G. Goitein, E. Hug, M. Jermann, A. Mezger, E. Pedroni
First year of operation of PSI's new SC cyclotron and beam lines for proton therapy
Proc. Cyclotrons 2007 Giardini Naxos, Italy, 15 (2008)

J.M. Schippers, D. Anicic, R. Dölling, A. Mezger, E. Pedroni, L. Stamsnijder, A.Geisler, H. Röcken, J. Timmer
Beam intensity stability of a 250 MeV SC cyclotron equipped with an internal cold cathode ion source.
Proc. Cyclotrons 2007 Giardini Naxos, Italy, 300 (2008)

M. Seidel
Operation of the High Intensity Proton Beam Facility at PSI
Proc. 42th ICFA Advanced Beam Dynamics Workshop on High-Intensity, High-Brightness Hadron Beams, Nashville, USA (2008)

K. Thomsen, D. Kiselev, U. Rohrer, M. Wohlmuther, L. Zanini
Influence of beam foot print on neutron production in SINQ
Proc. 3rd High-Power Targetry Workshop, Bad Zurzach, Switzerland (2007), PSI Proceedings 07-01, ISSN 1019-0643, 101 (2008)

T. Wehrli, M. Böge, E. van Garderen, J. Krempaský
Properties of X-ray beam position monitors at the Swiss Light Source
Proc. EPAC 2008, Genoa, Italy, 3312 (2008)

J.J. Yang, A. Adelmann, M. Humbel, M. Seidel, T.J. Zhang
Numerical study of beam dynamics in high intensity cyclotrons including neighboring bunch effects
Proc. 42th ICFA Advanced Beam Dynamics Workshop on High-Intensity, High-Brightness Hadron Beams, Nashville, USA (2008)

L. Zanini, Y. Dai
MCNPX calculations for the STIP-IV irradiation program at PSI
Proc. ANS annual meeting, Nuclear Science and Technology, Anaheim, USA (2008)

L. Zanini
Synthesis, Applications to ADS and Feedback to other Tasks
Proc. MEGAPIE Technical Review Meeting 2008, Aix-en-Provence, France (2008)

L. Zanini
Activation & Radiation Damage Calculations for PIE
Proc. MEGAPIE Technical Review Meeting 2008, Aix-en-Provence, France (2008)

L. Zanini
Neutronics of a tungsten target as a future option for SINQ
Proc. 3rd High-Power Targetry Workshop, Bad Zurzach, Switzerland (2007), PSI Proc. 07-01, ISSN 1019-0643, 33 (2008)

INVITED TALKS

A. Adelmann
State of the art of high intensity simulation codes: new algorithms and methods for rings
Accelerator Modeling and Advanced Simulation (AMAS)
HB2008, Nashville, USA, 24-29 August 2008

A. Adelmann
Accelerator Modeling and Advanced Simulation (AMAS) Mission - Projects and Challenges
University of Strassbourg, France, 18 April 2008

A. Adelmann
The PSI-XFEL Project and related Program Development
ISR-6, Los Alamos National Laboratory, Los Alamos, USA, 6 August 2008

A. Adelmann
Challenges and Achievements in Computational Electromagnetics in the Context of Particle Accelerator Modeling
SIAM PP08 Atlanta, USA, 12 March 2008

M. Dehler
Low energy beam dynamics simulation for the PSI Free Electron Laser
Project ACD seminary, Stanford Linear Accelerator Center, Stanford, USA, 9 May 2008

M. Dehler
Synergies between X-band for Linear Colliders and Light Sources X-Band
RF Structure and Beam Dynamics Workshop - 44th ICFA Advanced Beam Dynamics Workshop, Daresbury, UK, 1-4 December 2008

J. Duppich
Swiss Light Source at PSI – Technical Infrastructure, Interfaces to the Building and Installation of Accelerators
ALBA – Seminar, Barcelona, Spain, 9 April 2008

J. Duppich
The first year of patient treatments at Paul Scherrer Institute using the new superconducting cyclotron Comet
Loma Linda University Medical Center, Loma Linda, Los Angeles, California, USA, 17 July 2008

J. Duppich
The first year of patient treatments at Paul Scherrer Institute using the new superconducting cyclotron Comet and beam lines of the new proton therapy facility PROSCAN
VARIAN Medical Systems, Palo Alto, California, USA, 24 July 2008

J. Duppich
The first 1.5 years of clinical operation of the SC cyclotron and the beam lines at PSI – From a parasitic user to a stand-alone facility
University of Washington, Medical Center, Seattle, Washington, USA, 6 August 2008

J. Duppich
The first 1.5 years of clinical operation of the SC cyclotron and the beam lines at PSI – From a parasitic user to a stand-alone facility
Triumf, Vancouver, B.C., Canada, 8 August 2008

R. Ganter
Quantum effciency from different cathode types
Mini-Workshop on High Brightness Beam Characterisation, Zeuthen, Germany, 26-30 May 2008

R. Ganter
Photo-Field emission source for free electron laser applications
IVESC (International Vacuum Electron Source Conference), London, UK, 3-6 August 2008

M. Gaspar
Solid State RF PA. Practicality, Cost, Potentials, Feasibility, Trend and Outlook
5th CW and High Average Power RF Workshop, CERN, Geneva, Switzerland, March 2008

M. Gaspar
500 MHz Solid state Power Ampliefier Design – Results of the 4 kW Prototype
12 ESLS-RF Meeting, Diamond Light Source, Didcot, UK, October 2008

C. Gough
Low Emittance Electron Source for the PSI-XFEL Project
Institute of High Current Electronics, Tomsk, Russia, 6 May 2008

R. Ischebeck
The PSI-XFEL
ESLS XVI, Cockcroft Institute, Daresbury, UK, 27 November 2008

Y. Kim
Realistic Thermal Emittance measurements at the Low Emittance Gun test facility for the PSI XFEL Project
Mini-Workshop on High Brightness Beam Characterisation, Zeuthen, Germany, 26-30 May 2008

Y. Kim
Simple Solutions against COTR in LCLS and Design Concpets of XFEL Driving Linacs
2nd Microbunching Instability Workshop, LBNL, USA, 6-8 October 2008

Y. Kim
Microbunching Instability Experimental Plans at Coming PSI-XFEL Test Facilities
2nd Microbunching Instability Workshop, LBNL, USA, 6-8 October 2008

Y. Kim
Does Ultra-Bright Beam induce OTR Intensity Change During No Compression Periods in LCLS Injector ?
2nd Microbunching Instability Workshop, LBNL, USA, 6-8 October 2008

D. Kiselev
Activation of Targets and Accelerator Components at PSI - a Comparison of Simulation and Measurement
42nd ICFA Advanced Beam Dynamics Workshop on High-Intensity, High-Brightness Hadron Beams, Nashville, USA, 25-29 August 2008

B. Oswald
Time Domain Eigenmodal Analysis with the Finite Element Method Including a Surface Impedance Boundary Condition
EUROEM 2008, European Electromagnetics. EPF Lausanne, Switzerland, 21-25 July 2008

B. Oswald
Electromagnetic fields scattered by subwavelength-sized tip - Finite element time domain (FETD) model with a dispersive Drude dielectric
4th Workshop on Numerical Methods for Optical Nano Structures, ETH Zürich, Switzerland, 7-8 July 2008

B. Oswald
The portable, open and scalable data storage standard H5Fed - Tranparent finite element data storage for tetrahedral meshes and associated data
37th SPEEDUP Workshop on High-Performance Computing ETH Zürich & EPF Lausanne, Switzerland, 9 September & 12 September 2008

T. Pal
Tasks and Challenges in the TAGS DB Project
CERN, Geneva, Switzerland, 17 July 2008

L. Rivkin
Engines of Discovery: the role of accelerators in scientific exploration
The Zürich Physics Colloquium, Zürich, Switzeralnd, 1 October 2008

L. Rivkin
Evolution of Light Sources
Jagiellonian University, Kraków, Poland, 29 May 2008

L. Rivkin
X-ray Sources
ICFA Seminar, SNAL, USA, 28 October 2008

W. Roser
Reduction of radioactive waste production of a proton therapy facility
Jahrestagung Schweizerische Gesellschaft für Strahlenbiologie und Medizinische Physik, Chur, Switzerland, 6 November 2008

J.M. Schippers
Technical aspects of proton therapy at UMCG
University Medical Center Groningen, Groningen, the Netherlands, 10 June 2008

J.M. Schippers
Developments for proton therapy at PSI
Maastro Clinic, Maastricht, the Netherlands, 19 June 2008

J.M. Schippers
New developments in technologies for particle therapy
ESTRO-Symposium "All you need to know about hadron therapy", ESTRO-27, Göteborg, Sweden, 14-18 September 2008

J.M. Schippers
Radiotherapie met protonen: doel-gerichte High-Tech
Inaugural Lecture at University of Groningen, Groningen, the Netherlands, 16 December 2008

J.M. Schippers
A novel design of a cyclotron based accelerator system for multi-ion-therapy
Particle Therapy Co-operative Group PTCOG-47, Jacksonville (Fl), USA, 22-24 May 2008

J.M. Schippers
A novel design of a cyclotron based accelerator system for multi-ion-therapy
European Cyclotron Progress Meeting, Berlin, Germany, 16-18 October 2008

J.M. Schippers
The first 1.5 year clinical operation of the SC cyclotron and beam lines at PSI's new Center for Proton Radiation therapy
European Cyclotron Progress Meeting, Berlin, Germany, 16-18 October 2008

V. Schlott
PSI Accelerator Activities and Diagnostics Highlights
SLAC Advanced Instrumentation Seminar, Menlo Park, CA, USA, 23 July 2008

M. Schneider
Status of the RF-system for the proton accelerator facility at PSI
CW and High Average Power RF Workshop, CERN, Geneva, Switzerland, 25-28 March 2008

M. Seidel
Operation of the High Intensity Proton Beam Facility at PSI
ICFA Workshop on High Brightness Hadron Beams, Nashville, USA, 24-29 August 2008

M. Seidel
Operational Experience and Recent Achievements with the High Power Proton Accelerator at PSI
European Cyclotron Progress Meeting, Berlin, Germany, 16-18 October 2008

A. Streun
Latest Results from the Swiss Light Source
ESLS XVI, Cockcroft Institute, Daresbury, UK, 27 November 2008

A.F. Wrulich
Challenges of Cost Optimized X-Ray Free Electron Lasers
14^{th} User Meeting and Workshop, NSRRC, Hsinchu, Taiwan, October 2008

A.F. Wrulich
Synchrotron Radiation Light Sources: From the origins to the most advanced sources today
National Cheng Kung University, Tainan, Taiwan, October 2008

L. Zanini
Les Acquis neutroniques de la cible MEGAPIE
Meeting GEDEPEON, Aix-en-Provence, France, 14-15 October 2008

WORKSHOPS

A. Adelmann
Co-Organizer
HPC Workshop
ETH Zürich, Switzerland, 8-9 September 2008
EPFL Lausanne, Switzerland, 1 September 2008

B. Keil, V. Schlott
Organizers
European X-Ray FEL BPM and Beam Stability Workshop
Schloss Böttstein, Böttstein, Switzerland, 18-19 February 2008

M. Pedrozzi
Organizer
Second Solid State Modulator Workshop
Paul Scherrer Institut, Villigen, Switzerland
19-20 November 2008

R. Ganter
Organizer
Mini-Workshop on Girder, Components Supports and Alignment Concept
Paul Scherrer Institut, Villigen, Switzerland
4 December 2008

S. Teichmann, D. Kiselev, M. Wohlmuther, D. Lerch, M. Seidel, J. Züllig
Organizers
First International Workshop on Accelerator Radiation Induced Activation (ARIA'08)
Paul Scherrer Institut, Villigen, Switzerland
13-17 October 2008

BACHELOR-/ DIPLOMA-/ MASTER-THESES

Y. Ineichen
A parallel multigrid solver for beam dynamics
Theses advisors: Prof. Dr. P. Arbenz (ETH Zürich), Dr. A. Adelmann (PSI Villigen), 2008

A. Ichsanov
Modell-Experiment für den zukünftigen X-ray Free Electron Laser mit Anwendung der Photonen Korrelation
Theses advisors: Prof. Dr. B. Patterson (PSI Villigen), 2008

DISSERTATIONS

K. Li
An Ultra-Low Emittance Electron Gun for the PSI-XFEL Design and Construction
Theses No. 18168 / ETH Zürich, Switzerland, 2008
Theses advisors: Prof. Dr. R. Eichler (ETHZ)
Prof. Dr. M. Ferrario (INFN)
Dr. M. Pedrozzi (PSI)

MEMBERSHIPS IN EXTERNAL COMMITTEES

A. Adelmann
- Speedup Society (treasury)
- CSCS "Horizon Project" Steering Committee
- Program Committee ICFA High Brightness Beam Dynamics Workshop
- Program Committee ICAP International Computational Accelerator Physics Conference
- International Super Computing Conference (ISC), Program Committee
- Member of the Project Group "Swiss National Strategic Plan for High Performance Computing and Networking".
- Expert for Mathematics "Maturitaets Exams"

M. Böge
- TPS Machine Advisory Committee, NSRRC, Taiwan

T. Garvey
- International Linear Accelerator Conference Organising Committee
- UK (STFC) Accelerator Science and Technology Advisory Board
- French (CEA/CNRS) Committee of Experts on Accelerators (ComEA)
- CTF/CLIC Collaboration Board

D. Kiselev
- Auswahlkomitee der Deutschen Studienstiftung

L. Rivkin
- CERN Accelerator School, Advisory Committee
- CERN, CLIC CTF3 Collaboration Board
- DESY, Machine Advisory Committee (Chairman)
- European Physical Society Accelerators Group, Prizes Selection Committee Chairman
- Lund University Research Evaluation, RQ08
- Joint Universities Accelerator School, Program Committee
- PAC2009 Program Committee
- Stanford Synchrotron Radiation Laboratory, Scientific Advisory Committee

W. Roser
- Swiss Society for Radiation Biology and Medical Physics, Board Member
- Comité Electrotechnique Suisse (CES), Member of TC 62

T. Schietinger
- European Committee for Future Accelerators (ECFA)

J.M. Schippers
- Board member of the Groningen Particle Therapy Facility, University Medical Center Groningen, Groningen, the Netherlands
- TRIUMF Accelerator Advisory Committee, Vancouver BC, Canada

V. Schlott
- ALBA Spanish Light Source, Machine Advisory Committee, Bellaterra, Spain
- CARE Governing Board
- CERN Accelerator School on Beam Diagnostics, Program Committee
- DIPAC Scientific Program Committee (Chairman)
- In Kind Review Committee for the European XFEL (Chairman)
- Scientific and Technical Issues Working Group for the European XFEL (XFEL-STI)

L. Schulz
- SESAME, Jordan, Technical Advisory Committee

M. Seidel
- Int. Conferences on Cyclotrons and their Applications: Int. Organizing Committee + Program Committee
- Series ICFA Workshops on High Brightness, High Intensity Hadron Beams, Scientific Advisory Committee
- European Cyclotron Progress Meetings, Scientific Advisory Committee
- OECD/NEA Int. Workshop on Technology and Components of Accelerator Driven Systems (TCADS) Int. Scientific Advisor

A. Streun
- The 12th Hiroshima International Symposium on Synchrotron Radiation, Committee Member

A.F. Wrulich
- CNAO, I, Comitato Tecnico
- MAX-lab, S, Scientific Advisory Committee
- NSLS-II, US, Project Advisory Committee
- SESAME, Jordan, Technical Advisory Committee, Chair
- Co-Editor of ‘Journal of Synchrotron Radiation’

AWARDS

J.M. Schippers
Professorship in “physics of particle therapy” at the University of Groningen, Groningen, the Netherland

Logistics

LIST OF PUBLICATIONS

Schober H., Farhi E., Mezei F., Allenspach P., et al (2008)
Tailored instrumentation for long-pulse neutron spallation sources
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTOS AND ASSOCIATED EQUIPMENT, Volume: 589, Issue: 1, Pages: 34-46

Mayer S., Zsigmond G., Allenspach P. (2008)
Monte-Carlo simulation of phase space transformation of ultra-cold neutrons
Conference Information: European Workshop on Neutron Optics (NOP 07)
March 05-07, 2007 Paul Scherrer Inst Villigen, Switzerland
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTOS AND ASSOCIATED EQUIPMENT, Volume: 586, Issue: 1, Pages: 110-115

Schnabel S., Künzi R., Emmenegger M., Jäckle H., Jenni F. (2008)
New Generation of AD-Mesurement Cards for High Accuracy Measurments
EPAC GENOA 2008

Marone F., Hintermüller Ch., Geus R., Stampanoni M. (2008)
Towards Real-Time Tomography: Fast Reconstruction Algorithms and GPU Implementation
ISBN: 978-1-4244-2715-4, IEEE Catalog #: CFP08NSS-CDR

Fabbrizio A., Schmidt M., Guenther D., Eikenberg J. (2008)
Experimental determination of Radium partitioning between Leucite and Phonolite melt and 226Ra-disequilibrium crystallization ages of Leucite
CHEMICAL GEOLOGY, 255, 377 - 387

Kehrwald N., Thompson L., Tandong Y., Mosley-Thompsen E., Schotterer U., Beer J., Eikenberg J., Davis M. (2008)
Mass loss on Himalayan glacier endangers water resources
GEOPHYSICAL RESEARCH LETTERS, 35, No 22

Wersin P., Soler J.M., Van Loon L., Eikenberg J., Baeyens B., Grolimund D., Gimmi T., Dewonck (2008)
Diffusion of HTO, Br-, I-, Cs+, 85Sr2+ and 60Co2+ in a clay formation: results and modeling from an in situ experiment in Opalinus Clay
APPLIED GEOCHEMISTRY, 23, 678-691

Boschung M., Fiechtner A., Mayer S., Wernli C. (2008)
Field calibration and comparison of personal neutron dosemeter designs based on CR-39 for the use around high energy accelerators
RADIATION MEASUREMENTS, Volume 43, pp. 1081-1084

Mayer S., Boschung M., Fiechtner A., Fuerstner M., Wernli C. (2008)
Response study of fission track detectors using two different moderator designs in a high-energy radiation field
RADIATION MEASUREMENTS, Volume 43, pp. 1085-1088

CONFERENCE, WORKSHOP AND SEMINAR CONTRIBUTIONS

Barilo SN, Shiryaev SV, Bychkov GL, Shestak A.S., Flavell W.R., Thomas A.G., Rafique H.M., Chernenkov Y.P. Pakhty V.P., Pomjakushina E., Conder K. and Allenspach P. (2008)
Large single crystals of LnBaCo(2)O(5.5): Initial nucleation, growth and study
Conference Information: 15th International Conference on Crystal Growth, August 12-17, 2007 Salt Lake City UT
JOURNAL OF CRYSTAL GROWTH, Volume: 310, Issue: 7-9, Pages: 1867-1874

Japichino E., Stampanoni M., Pfeiffer F., Frommherz U., Thermer R. (2008)
Verification of input to output ratio of a flexure based nanoconverter
Proceedings of the euspen International Conference - Zurich - May 2008

Rossetti D., Baechli H., Japichino E., Ellenberger U., Schlott V. (2008)
Compact and light-weight design of a Martin Puplett interferometer for synchrotron radiation beam measurements
Proceedings of the MEDSI international Conference - Saskatoon (Can) – June 2008

Rossetti D., Japichino E., Ellenberger U., Pradervand C., Pauluhn A., Ulmer D., Schulze-Briese C.
Novel design and first results for a high precision kappa goniometer to be used with X-ray diffraction analysis
Proceedings of the SRI international Conference - Saskatoon (Can) – June 2008

Eikenberg J. (2008)
Radiochemical procedures for determination of actinides in soil samples
Internat. Conf. on Radionuclide Metrology (ICRM)
PTB Braunschweig, September, 22-26, 2008.

Mayer S., Filges U. (2008)
Problem 4: Uncertainty assessment of a photon irradiation facility
Proc.: Workshop on Uncertainty Assessment in Computational Dosimetry, A comparison of approaches, CONRAD-WP4 Computational Dosimetry, Bologna, Italy, 8-10 October 2007, ISBN:978-3-9805741-9-8.

Beličev P., Milošević M., Ilić R., Mayer S., Spasić-Jokić V., Pešić M. (2008)
Problem P7: Energy response characteristics of a RADFET radiation detector,
Proc.: Workshop on Uncertainty Assessment in Computational Dosimetry, A comparison of approaches, CONRAD-WP4 Computational Dosimetry, Bologna, Italy, 8-10 October 2007, ISBN:978-3-9805741-9-8

◀ **Behind the scenes: the water-cooling facility for some of PSI's large-scale facilities.**

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