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SwissFEL – the new large-scale facility at the Paul Scherrer Institute

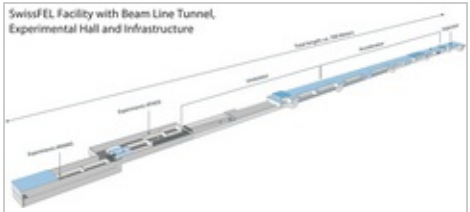
The next large-scale facility at PSI – the X-ray laser SwissFEL – should come on-line in 2016. It will produce very short pulses of X-ray light, with laser-like properties. Researchers will be able to use these pulses to visualize extremely fast processes, such as how new molecules are created in a chemical reaction; to determine the detailed structure of vital proteins; or to determine the relationship between electronic and atomic structure in materials. From such studies, researchers will gain insights which are not possible to obtain with the methods available today. This new knowledge will expand our understanding of nature and lead to many practical applications; for instance, new pharmaceuticals, more efficient processes in the chemical industry, new materials for electronics, or alternative processes in energy production.

View along the tunnel of the 250 MeV injector. Technologies are being tested here for the first part of the SwissFEL accelerator. As soon as the final SwissFEL buildings are ready, the facility will installed in them and will comprise the first section of SwissFEL. (Paul Scherrer Institut/Frank Reiser)

As at PSI's other large scale facilities, SwissFEL will be accessible to external researchers, although the requirements of the Swiss Technical Universities and industry will be given special consideration at the planning stage. Until now, there are only two comparable facilities in operation anywhere in the world, with an additional two under construction.

X-ray laser

The facility will be 700 metres long and composed of four sections: Injector with electron gun, linear accelerator, magnet undulator, and experimental facilities.



Layout of the SwissFEL buildings. Electron pulses will be generated in the injector and then brought to a high energy in the accelerator. The electrons are then forced onto a wavy path by the magnets of the undulators, thereby generating X-rays which will be used for experiments in two experimental halls. The facility will be covered by earth, so that it will not be visible from the footpath running parallel to it.

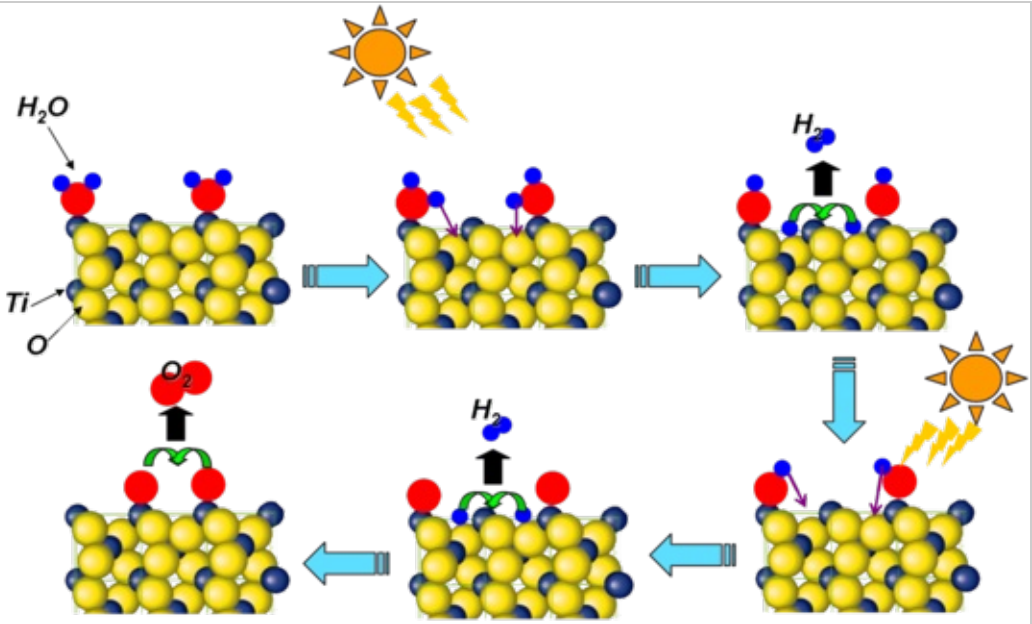
SwissFEL is a free-electron X-ray laser (the "FEL" in its name stands for "Free Electron Laser"), which will deliver extremely short and intense flashes of X-ray radiation of laser quality. The flashes will be only 20 to 60 femtoseconds in duration (1 femtosecond = 0,000 000 000 000 001 second). These properties will enable novel insights to be gained into the structure and dynamics of matter illuminated by the X-ray flashes.

The creation of the X-rays begins at the electron gun: Electrons are initially set free when a burst of light strikes a metal plate. They are then brought to the high velocity required by means of an electric field in a linear accelerator. In this process, the electrons acquire as much energy as if they had crossed a voltage of 6 billion volts. They are then fast enough to be fed into a snake-like path along a magnetic "undulator" – as the long magnet array used is called by specialists. Along their path, the electrons create X-rays, which amplify like an avalanche, producing the uniquely intense X-ray radiation of SwissFEL. The SwissFEL magnetic undulator will be 60 metres long and composed of 26,400 magnets, and it will represent a great engineering accomplishment to achieve the required precision of construction.

The X-ray beam will then be routed to the experimental location, where it will available for researchers' experiments.

New findings for science, technology and medicine

It will be possible at SwissFEL, for example, to follow step-by-step how the smallest components of a substance separate during a chemical reaction and then recombine to create a new substance. These processes are so fast that it has previously never been possible to observe them. For the first time, the extremely short flashes of the SwissFEL will make it possible to take a snapshot of the individual intermediate steps by means of its extremely "short exposure time". A more precise understanding of this sequence of events could help to make processes in the chemical industry more efficient and therefore more efficient in the use of basic resources.



It will be possible in the future, with the help of sunlight and artificial photosynthesis, to create methanol or methane from water and carbon dioxide, and these new products can be used as the basis for chemicals or as fuel for gas-fired power stations. In order to optimize the chemical reactions involved must be precisely understood. For the first time, with the help of SwissFEL, it will be possible to follow these reactions step-by-step.
The diagrams show in detail the first step of artificial photosynthesis. A water molecule (H_2O) attaches itself to the surface of the catalyst and can then, with the help of sunlight, be broken down into its component parts: First, the hydrogen atoms are removed and combine to form molecules (H_2), and then left-over oxygen atoms also form molecules (O_2).

It will also be possible at SwissFEL to determine in detail how vital biological molecules are built up. Such molecules are composed of tens of thousands of atoms, and it is crucial for their functioning that the atoms are correctly arranged. Today, researchers can only determine the structure when many copies of such a molecule are arranged in a regular crystal structure. The intense X-rays of SwissFEL will also make it possible to resolve the structure of molecules which do not form crystals. This knowledge could be the basis for new pharmaceuticals, in that they could show, for example, how important biological processes can be suppressed in pathogenic bacteria.

Workplace for researchers from science and industry

As for the other large-scale facilities at the Paul Scherrer Institute, SwissFEL will also be available for use by scientists from research centres and universities – from Switzerland as well as from other countries. Researchers who publish their scientific results will be able to obtain access free of charge upon approval by the scientific selection committee. Individual arrangements will also be made for the use of the facility by industrial partners.

For industry, SwissFEL already offers opportunities for cooperation during its development phase. SwissFEL is a great technological challenge, which PSI wants to overcome alongside industry. In the process, a transfer of knowhow will take place to industry, making it possible for these companies to develop innovative products.

Ideas and experiments are being developed and tried out at the SLS to see how they should be performed at SwissFEL. A piece of equipment is being developed here with which catalytic reactions can be investigated to find out how they could, for example, be important for new energy technologies. (Scanderbeg Sauer Photography)

Operational at Würenlingen beginning in 2016 – Location, Schedule and Cost

The SwissFEL will be built in the Würenlingen forest, adjoining the existing PSI site in the Swiss Canton of Aargau. After comprehensive analysis, this location proved to be the one most suitable. Here, the temperature variations and ground vibrations are particularly low, which is essential for the successful operation of this high-precision facility. SwissFEL's close proximity to the present PSI site will allow the Institute's existing infrastructure to be used. After completion, most of the buildings will be covered by soil and gravel, creating a natural habitat for threatened plants and animals.

The surroundings of SwissFEL in the Würenlingen forest after completion of the facility. The SwissFEL buildings are hidden under the sloping hillside on the left-hand side and not visible from the footpath. Ecologically valuable rough grassland will be planted on the hillside.

SwissFEL will begin operation in 2016, initially with one measurement station. Construction work on the buildings will be carried out during 2013 and 2014, and the technical facilities will be installed during 2015 and 2016. In August 2010, a test facility was put into operation at the PSI-West zone of the Institute's site – near the existing SLS and SINQ large-scale facilities - in which the first part of SwissFEL accelerator is gradually being assembled. Here, components are being tested and various technical solutions tried out. As soon as the final buildings are completed, this test facility will become a part of SwissFEL itself.

The cost of constructing SwissFEL will be approximately CHF 270 million, the majority of which will be borne by the Swiss federal government. According to plan, the Swiss Federal Parliament will vote on the financing in the autumn session of 2012. The Canton of Aargau is already convinced of the innovative potential of SwissFEL and has approved a contribution of CHF 30 million towards its construction.

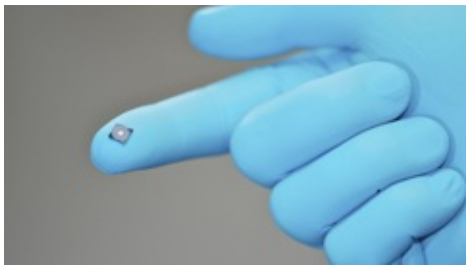
PRESS RELEASES

Schweizer Hochpräzision stabilisiert den SwissFEL[5]

9. December 2011

Das Paul Scherrer Institut PSI und die MDC Max Daetwyler AG (Bleienbach), haben heute einen Vertrag unterzeichnet, nach dem Daetwyler wesentliche Komponenten für den Röntgenlaser SwissFEL, die neue Grossforschungsanlage des PSI, gemeinsam mit dem PSI entwickeln und bauen wird. Die Massnahmen des Bundes zur Abfederung der Frankenstärke erlauben es, den Bau der Komponenten vorzuziehen und so das SwissFEL-Projekt schneller voranzutreiben.

This news release is only available in French and German.



Diamanten sind auch des Forschers bester Freund[6]

7. September 2011

Einem vom PSI geleiteten Forscherteam ist es gelungen, harte Röntgenlaserstrahlung 100'000-fach zu konzentrieren und so an einem Punkt Röntgenstrahlung zu erzeugen, die so intensiv war wie wohl nirgends zuvor. Als Linsen verwendeten die Forscher winzige Ringstrukturen aus Diamant – dem Material, das am besten dem Röntgenlaserlicht standhält. Diese Entwicklung schafft die Voraussetzung für einen Teil der Experimente am SwissFEL, dem geplanten Röntgenlaser des PSI.

This news release is only available in German.

Standort des SwissFEL entschieden[7]

23. August 2011

Das Paul Scherrer Institut hat einen weiteren Meilenstein auf dem Weg zur Realisierung seiner neuen Grossforschungsanlage erreicht.
Heute stimmte der Grosse Rat des Kantons Aargau der Anpassung des Richtplans zum Siedlungsgebiet in Würenlingen sowie der Anpassung des Nutzungsplans für das dortige Grundwasserschutzareal zu. Das Paul Scherrer Institut PSI freut sich über diesen wichtigen Entscheid auf dem Weg zur Realisierung seiner neuen Grossforschungsanlage SwissFEL (Schweizer Freie-Elektronen Röntgenlaser).

This news release is only available in French and German.

URLs:
[1] : http://www.psi.ch#X_ray_laser
[2] : http://www.psi.ch#New_findings_for_science_technol
[3] : http://www.psi.ch#Workplace_for_researchers_from_s
[4] : http://www.psi.ch#Operational_at_W_renlingen_begin
[5] : http://www.psi.ch/media/schweizer-hochpraezision-stabilisiert-den-swissfel-in-german
[6] : http://www.psi.ch/media/diamanten-sind-auch-des-forschers-bester-freund-in-german
[7] : http://www.psi.ch/media/standort-des-swissfel-entschieden-in-german