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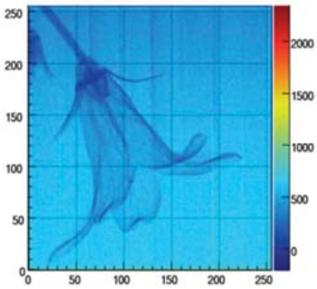


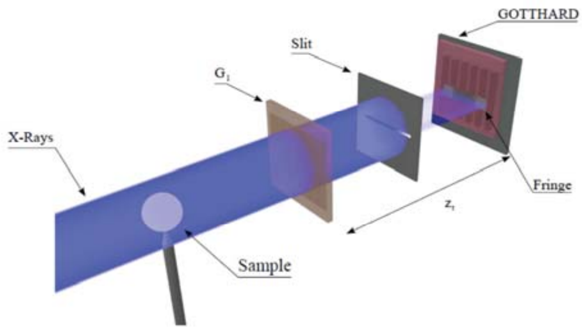


# SLS Symposium on

# Instrumentation

**Tuesday, June 2, 2015**

**10:00 to 12:15, WBGB/019**

**10:00 G2-less X-Ray Phase Contrast Imaging with Single Photon Sensitive Hybrid Detectors**
*Matias Kagias, Sebastian Cartier, Zhentian Wang, Anna Bergamaschi, Roberto Dinapoli, Aldo Mozzanica, Bernd Schmitt and Marco Stampanoni*

**10:30 Ultrafast X-ray diffraction of structural dynamics induced by broadband terahertz pulses**
*S. Grübel, J.A. Johnson, P. Beaud, G. Ingold and S.L. Johnson*

**11:00 Coffee**

**11:15 The JUNGFRAU Pixel Detector for Photon Science**
*J. H. Jungmann-Smith, A. Bergamaschi, M. Brückner, S. Cartier, R. Dinapoli, D. Greiffenberg, D. Maliakal, D. Mezza, A. Mozzanica, M. Ramilli, Ch. Ruder, L. Schaedler, B. Schmitt, X. Shi and G. Tinti*

**11:45 GlobalDiagnostiX – Diagnostic imaging for developing countries**
*David Haberthür, Ivan Kasanzew, Maïka Guillemin, Matthias Huser and Marco Stampanoni¶*

# G2-less X-Ray Phase Contrast Imaging with Single Photon Sensitive Hybrid Detectors

Matias Kagias[a, b,*], Sebastian Cartier[a,b], Zhentian Wang[a,b], Anna Bergamaschi[b], Roberto Dinapoli[b], Aldo Mozzanica[b], Bernd Schmitt[b], and Marco Stampanoni[a, b]

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X-ray phase contrast imaging is capable of measuring the electron density of a sample without the need of photon absorption. This is particularly advantageous for the study of dose-sensitive samples in biological and medical investigations. Recent developments relaxed the requirement for the beam coherence, such that conventional X-ray sources can be used for phase contrast imaging and thus clinical applications are enabled. One of the prominent phase contrast imaging methods, Talbot-Lau grating interferometry, is limited by the manufacturing, alignment and photon absorption of the analyzer grating, which is placed in the beam path in front of the detector. We propose an alternative improved method based on direct conversion charge integrating detectors, which enables a grating interferometer without an analyzer grating. Algorithms are introduced, which resolve interference fringes with a periodicity of 4.7μm recorded with a 25μm pitch Si microstrip detector (GOTTHARD). A robust phase retrieval method based on the Hilbert transform (HT) is introduced to tackle the challenging phase retrieval problem. Experiments conducted at the Swiss Light Source (SLS) supported the validity of the method.

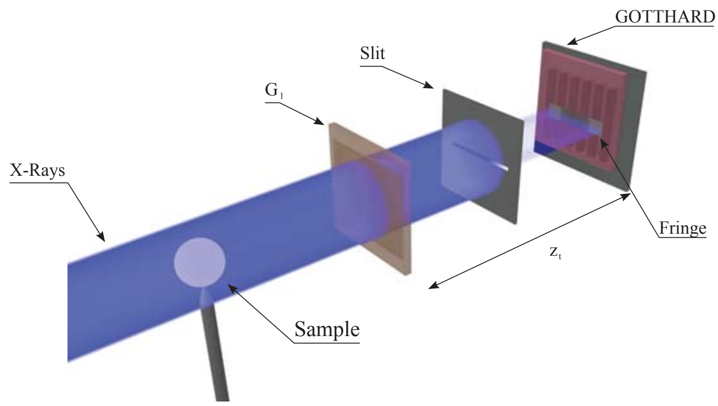


Fig. 1 Setup of the G2-less grating interferometer. The microstrip detector is placed at a distance of zt = 15 cm downstream of the G1. The mircostrips have a length of several mm and therefore the beam is additionally collimated by a 2 μm tungsten slit directly in front of the sensor.

## References

[1] T. Weitkamp et al, *Optics Express*, 13 (2005) p. 6296-6304.
[2] S. Cartier et al , *J. Instrum*. 9, C05027 (2014).
[3] S. Cartier, M. Kagias et al, *Submitted* (2015).

# Ultrafast X-ray diffraction of structural dynamics induced by broadband terahertz pulses

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Recent advances in the generation of short terahertz pulses with high electric fields using ultrafast lasers (1) have made such pulses attractive tools for the selective control and excitation of structural motions. The broad spectrum and high electric field can in particular be used to couple directly to various low-frequency vibrational modes in molecules and crystals with a dipole moment without the danger of creating large populations of electronic excitations leading to sample damage.

We generated broadband terahertz pulses with frequency content in the range of 0 – 2.5 THz and peak field as high as 150kV/cm to excite coherent vibrational modes at frequencies ranging from 0.8 to 1.2 THz in the ferroelectric semiconductor material $Sn_2P_2S_6$. Using femtosecond X-ray diffraction from the Swiss Light Source (SLS) slicing beamline we were able to measure the temporal evolution of the (332) Bragg reflection which is sensitive to the displacement of the Sn atom in the soft phonon mode (2). The experiment was performed for different polarizations of the terahertz pulses and at different sample temperatures. The measurements show distinctive oscillations of the diffraction intensity with a maximum relative diffraction intensity change of 0.05%. We were able to fit the data using a harmonic oscillator model driven by the electric field of the terahertz pulses measured during the experiment and extract the phonon frequencies and the damping ratios. The results of this analysis show a softening of the phonon mode towards the phase transition in agreement with neutron scattering experiments performed on the same compound (2).

These results demonstrate efficient excitation of structural dynamics in $Sn_2P_2S_6$ which are directly linked to the ferroelectric polarization state and the phase transition. Further developments toward higher electric field strength may allow such pulses to drive the vibrational mode much harder, into a regime where reversible domain switching on a picosecond time scale becomes possible.

(1) H. Hirori, A. Doi, F. Blanchard and K. Tanaka, Appl. Phys. Lett. **98**, 091106 (2011)
(2) S. W.H. Eijt, R. Currat, J. E. Lorenzo, P. Saint-Grégoire, B. Hennion and Yu. M. Vysochanskii, Eur. Phys. J. B **5**, 169-178 (1998)

# The JUNGFRAU Pixel Detector for Photon Science

*J. H. Jungmann-Smith, A. Bergamaschi, M. Brückner, S. Cartier, R. Dinapoli, D. Greiffenberg, D. Maliakal, D. Mezza, A. Mozzanica, M. Ramilli, Ch. Ruder, L. Schaedler, B. Schmitt, X. Shi, G. Tinti*

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JUNGFRAU (adJUstiNg Gain detector FoR the Aramis User station) is a dedicated pixel detector development for photon science applications at free electron lasers (FEL), in particular SwissFEL [1], and synchrotron light sources. The readout chip of the JUNGFRAU detector is characterized by single photon sensitivity and a low noise performance over a dynamic range of $10^4$ 12 keV photons. These distinguishing characteristics are achieved by a three-stage, gain-switching preamplifier in each pixel, which dynamically adjusts its gain to the amount of charge deposited on the pixel (similar to AGIPD [2] or GOTTHARD [3]).
Geometrically, a JUNGFRAU chip consists of 256×256 pixels of 75×75 $\mu m^2$ each. The chips are bump bonded to 320 μm silicon sensors. Arrays of 2×4 chips are tiled to form modules of 4×8 $cm^2$. Several multi-module systems with up to 16 Mpixels per system will be delivered to the two end stations at SwissFEL. The anticipated readout rate of >2kHz is independent of the detector size and serves both the readout requirements of SwissFEL and enables high count rate synchrotron experiments with a dead time free, linear count rate capability of 20 MHz/pixel (50MHz/pixel) at 12 keV (at 5 keV).
The JUNGFRAU systems for SwissFEL are presented along with promising characterization results from the full-size JUNGFRAU 1.0 chip. The results include an electronic noise as low as 65 electrons r.m.s., which enables single photon detection down to X-ray energies of < 2 keV. Noise well below the Poisson statistical limit is demonstrated over the entire dynamic range. The linearity of the pixel response is characterized to be below 1%. First successful imaging tests will be shown.
A prototype variation of JUNGFRAU specifically dedicated to low-noise performance (with a noise of 30 $e^-$ r.m.s. ~ 110 eV) will be introduced and the performance for spectroscopic X-ray science will be evaluated.

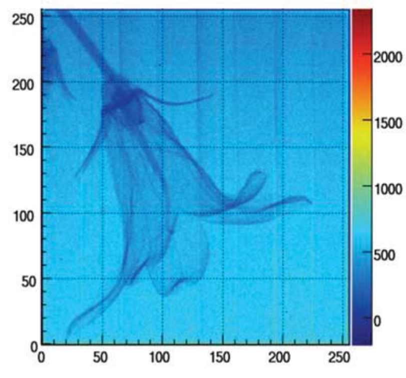


Figure 1: First JUNGFRAU 1.0 prototype module (left), X-ray transmission image of a flower recorded with JUNGFRAU 1.0 (right).

[1] SwissFEL Conceptual Design Report, 2011
[2] AGIPD - The Adaptive Gain Integrating Pixel Detector for the European XFEL. Development and Status, J. Becker et al, IEEE Nucl Sci Conf R, 1-5, 1950, 2011
[3] The GOTTHARD Charge Integrating Readout Detector: Design and Characterization, A. Mozzanica et al, J Instrum, 7, C01019, 2012

# GlobalDiagnostiX – Diagnostic imaging for developing countries

**Version 968dc8e**

David Haberthür* Ivan Kasanzew† Maïka Guillemin‡ Matthias Huser§ Marco Stampanoni¶

First image of a hand phantom acquired with the GlobalDiagnostiX detector prototype.

Approximately 4 billion people—about two-thirds of the world population—do not have access to diagnostic imaging. First world countries try to solve this problem by donating old radiological equipment to hospitals in need. But, according to the WHO, "about 70 % of the more complex devices do not function when they reach their destination" [1]. The GlobalDiagnostiX project aims to solve this problem by developing a robust, high-tech and low-cost digital radiology system to be deployed to district hospitals in developing countries.

As part of the alliance between partners from both North and South, we challenged existing systems for detecting x-rays for the medical domain. In the process we face the challenge of developing a diagnostic system which targets a tenfold reduction in the total cost of ownership as compared to existing solutions, and is adapted to the context of developing countries without compromising on performance and quality.

Bound by very tight budgetary constraints we evaluated components to convert x-rays to visible light and to image a large field of view of $43\,\text{cm} \times 43\,\text{cm}$. We realized a the task with a mosaiced setup of self-contained imager modules and finally built a prototype detector which was integrated into a fully working demonstrator system with all the other submodules of the different GlobalDiagnostiX alliance teams. The demonstrator system was presented to the media on March 9, 2015.

In our talk we present the issues we faced evaluating and testing components for a standard-compliant and cost-effective modular medical x-ray detector and our results which lead to a working detector prototype.

Demonstrator system. Our detector is on the bottom left.

## References

[1] WHO. *First WHO Global Forum on Medical Devices: context, outcomes, and future actions*. Tech. rep. WHO, 2011. URL: `http://is.gd/qDMekI`.

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