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The high speed microstrip detector Gotthard-II: Architecture, features and applications

IFDEPS flash talk, 01.04.2021

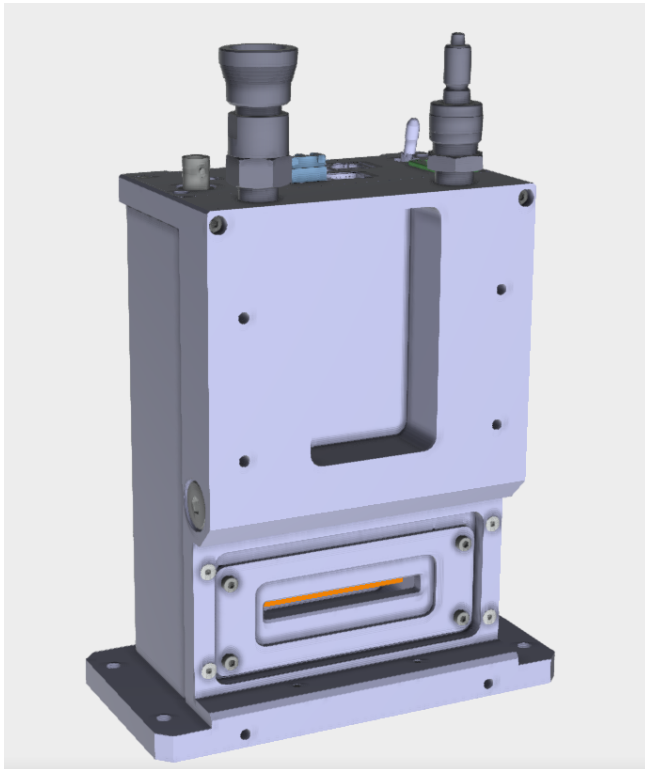
On behalf of Gotthard-II contributors:

PSI: A. Mozzanica, X. Shi, D. Mezza, Ch. Ruder, C. Lopez-Cuenca, S. Vetter, J. Zhang, B. Schmitt

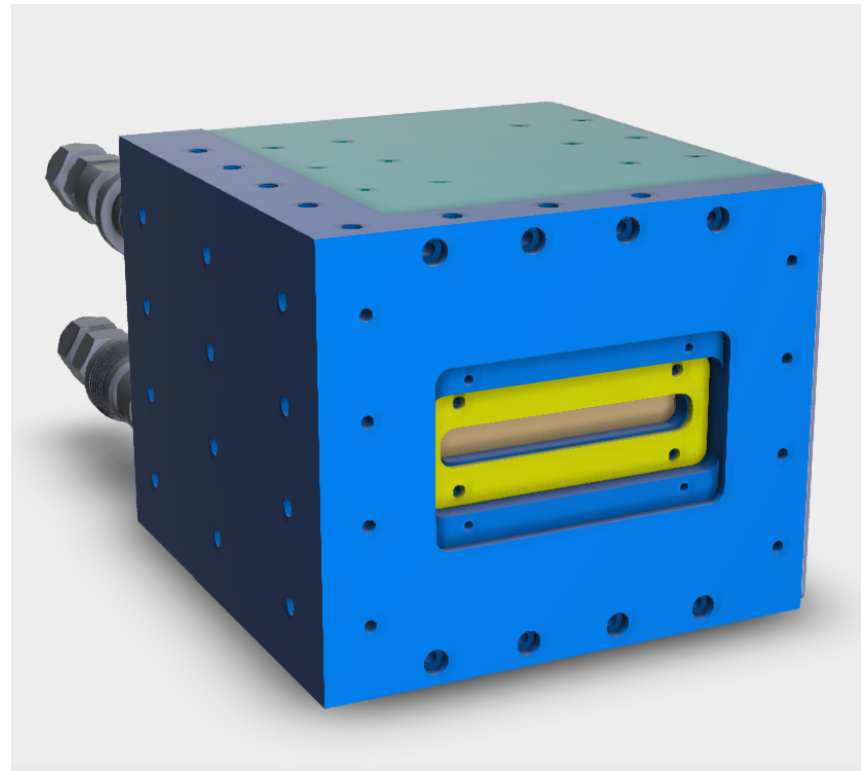
EuXFEL: M. Ramilli, M. Turcato, M. Kuster, P. Gessler, B. Fernandes, A. Parenti

- The Gotthard-II detector:
 - High speed silicon microstrip detector specifically developed for EuXFEL capable of taking images at **4.5 MHz frame rate** for all the **2700 pulses** at the EuXFEL
 - Extended applications and usage at synchrotrons when operating in different modes
 - **50 um / 25 um** pitch strips of **1280 / 2560 channels** on **450 um / 320 um** thick silicon
 - **29** Gotthard-II detectors (46 modules) to be commissioned at the EuXFEL in 2021
→ talk of M. Ramilli in Session 3

50 um pitch Gotthard-II (1280 ch.)

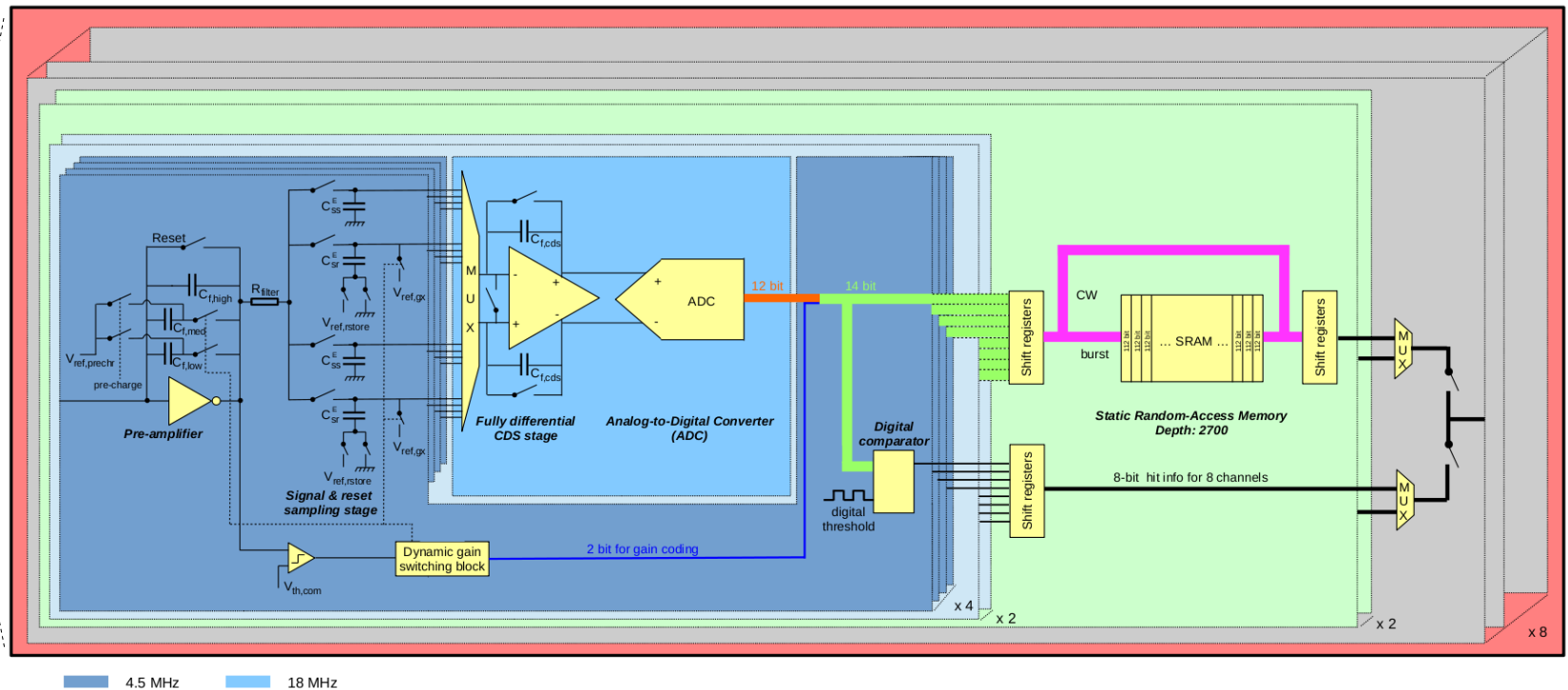
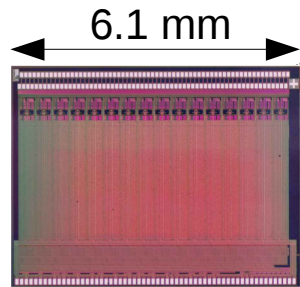


25 um pitch Gotthard-II (2560 ch.)



The architecture and possible operations

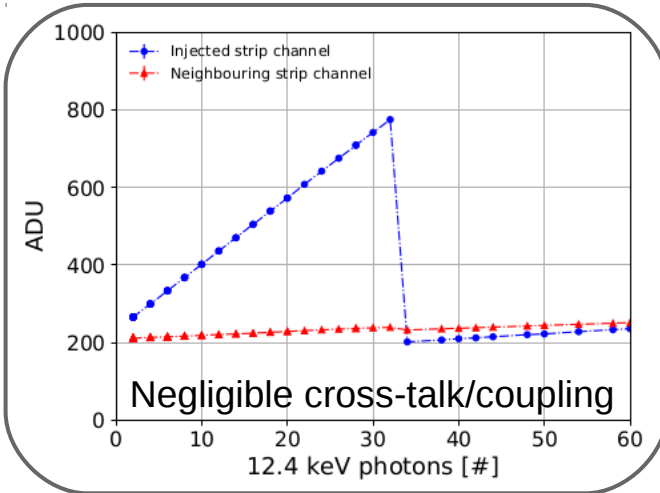
- The Gotthard-II ASIC architecture (128 channels / ASIC): [details → arXiv:2103.15405](https://arxiv.org/abs/2103.15405)
 - 128 dynamic gain switching pre-amplifier (→ G1, AGIPD & Jungrau) with high DC gain
 - 32 fully differential CDS stages (S&H) and “12-bit” on-chip SAR ADCs of > 18 MS/s
 - 16 compact SRAMs with a memory depth for 2720 images
 - 128 digital comparators with 14 bit for each channel



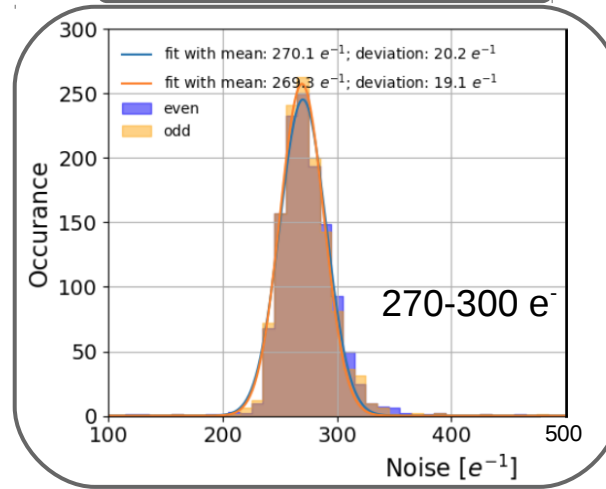
- The 3 operating modes in Gotthard-II:
 - Burst mode @ max. **4.5 MHz for 2720 images** → EuXFEL
 - **Continuous mode @ max. 410 kHz** frame rate → Synchrotrons and CW FELs
 - **Counting mode @ max. 4.5 MHz** (1 bit per channel) → Synchrotrons

The features and characteristics

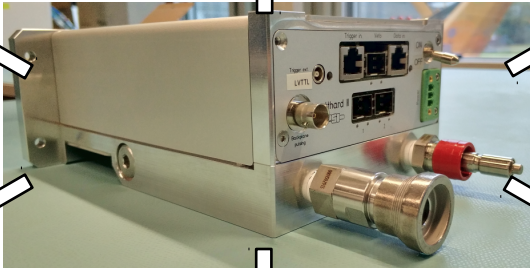
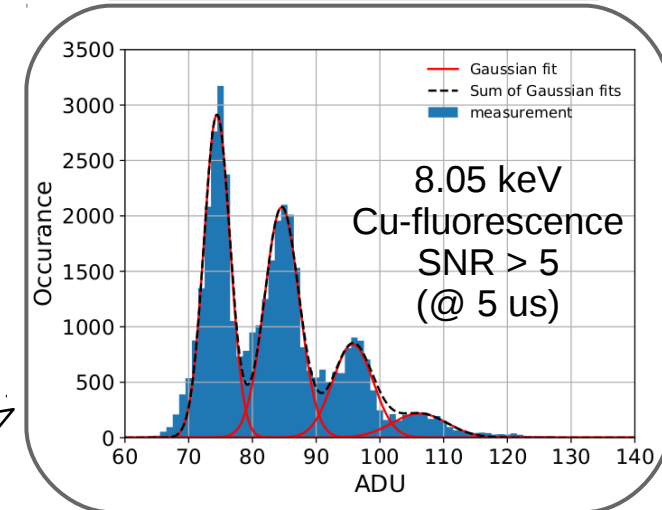
Cross-talk between channels



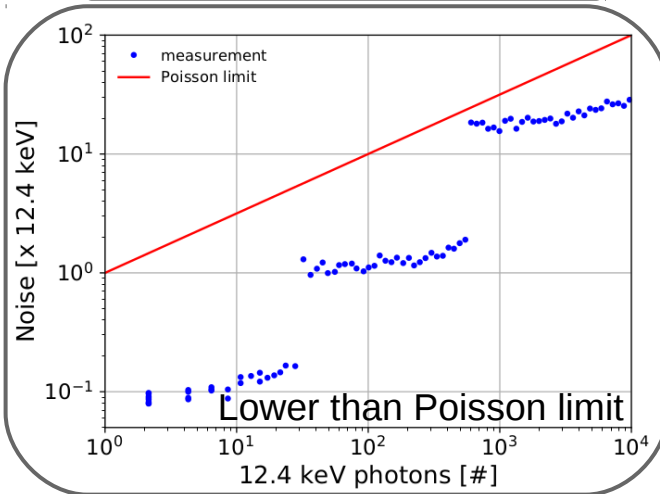
Noise in G0



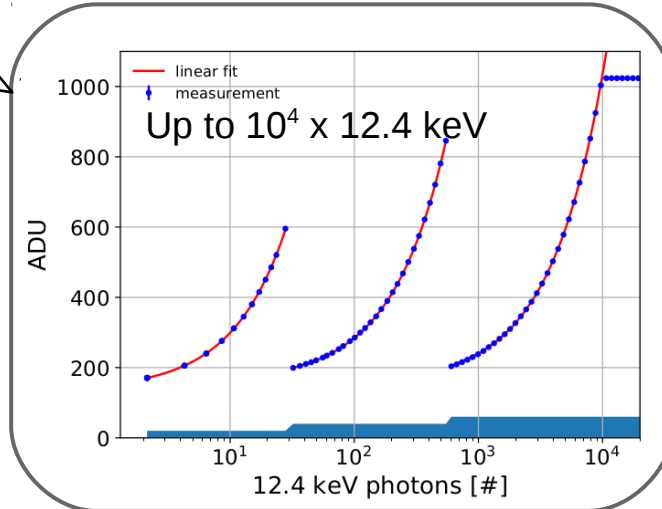
Single photon sensitivity



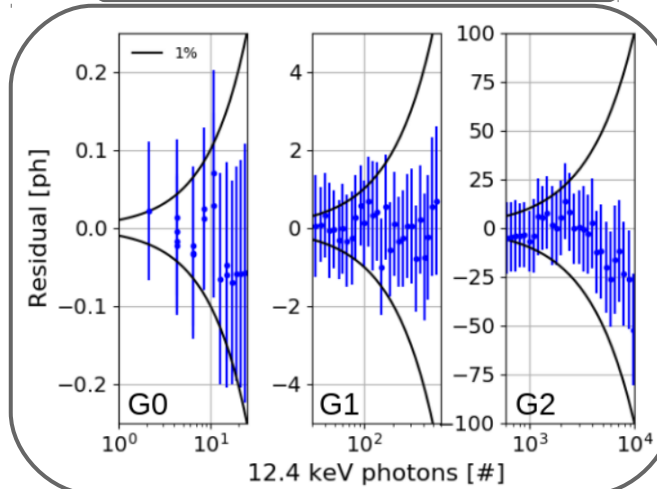
Noise over dynamic range



Dynamic range



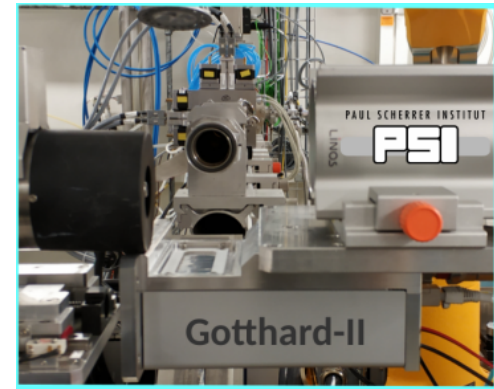
Non-linearity within 1%



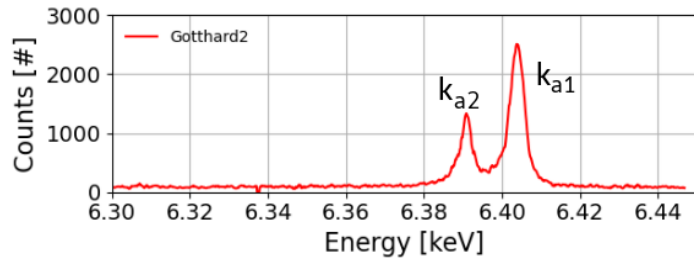
- References: [arXiv:2103.15405 \(2021\)](https://arxiv.org/abs/2103.15405)
[JINST 13 P01025 \(2018\)](https://arxiv.org/abs/1801.01025)
[JINST 12 C12052 \(2017\)](https://arxiv.org/abs/1701.02052)

The Gotthard-II applications

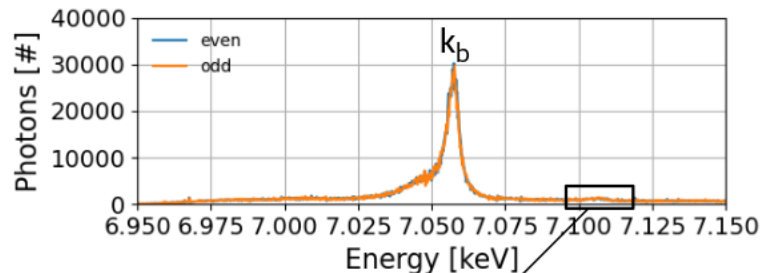
- Applications: Suitable for experiments with 1-D geometry
 - Photon beam shot-to-shot diagnostics using hard X-ray high resolution single shot spectrometer (HiREX)
 - Photon arrival time monitor (PAM) for pump-probe exp.
 - Veto signal generation for pixel detectors
 - X-ray emission, absorption and diffraction spectroscopy
 - Energy dispersive experiments, i.e. EDXAS



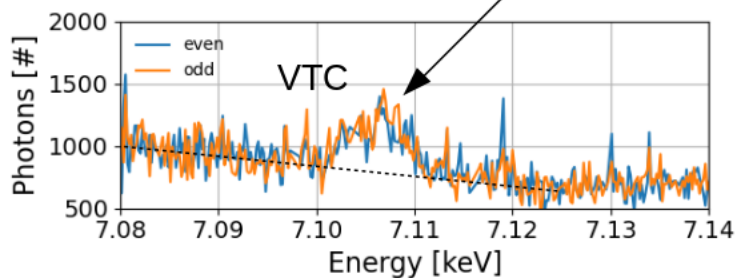
XES of Fe sample for K_{a1} , K_{a2} & VTC



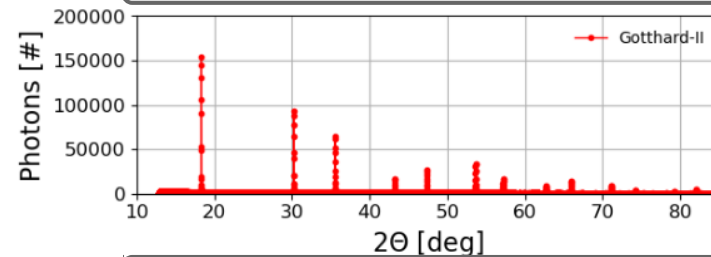
260/350 kHz
Ge<220>
@SuperSAX
(SLS)



260/350 kHz
Si<521>
@SuperSAX
(SLS)

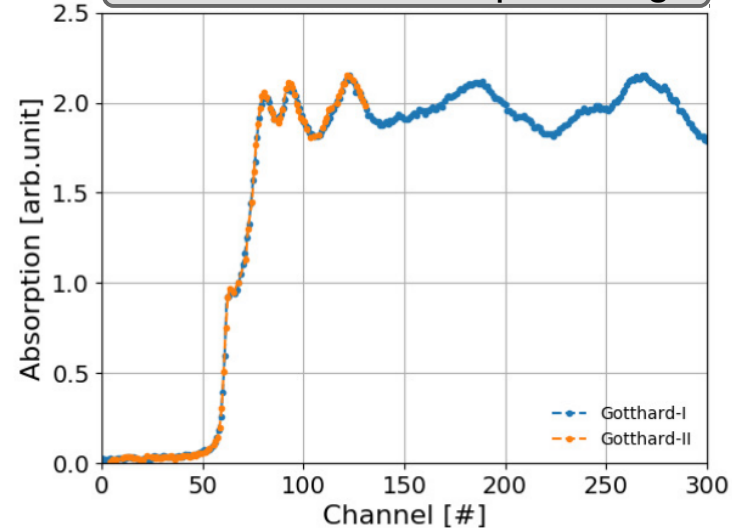


X-ray diffraction on Si sample



Burst mode
@MS beamline
(SLS)

EDXAS at Cu absorption edge



Burst mode
@ODE beamline
(Soleil)



Summary

- The Gotthard-II detector main characteristics:
 - Single photon sensitivity for > 5 keV with $\text{SNR} > 5$
 - Dynamic range up to $10^4 \times 12.4$ keV (34.4 Me^-) with good linearity
 - Three operational modes:
 - 4.5 MHz frame rate for 2720 images in burst mode
 - 410 kHz frame rate in continuous mode
($> \text{MHz}$ possible using on-chip high speed serializer)
 - 4.5 MHz frame rate in counting mode
- Project status:
 - 50 μm pitch detectors produced, now working on their calibration
 - 25 μm pitch detectors to be produced and delivered later this year

Thanks for your attention!