DECTRIS®

detecting the future

Detector Systems for Advanced X-Ray Studies

Stefan Brandstetter

HSC19, Grenoble, May 15th 2017

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Switzerland
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About DECTRIS

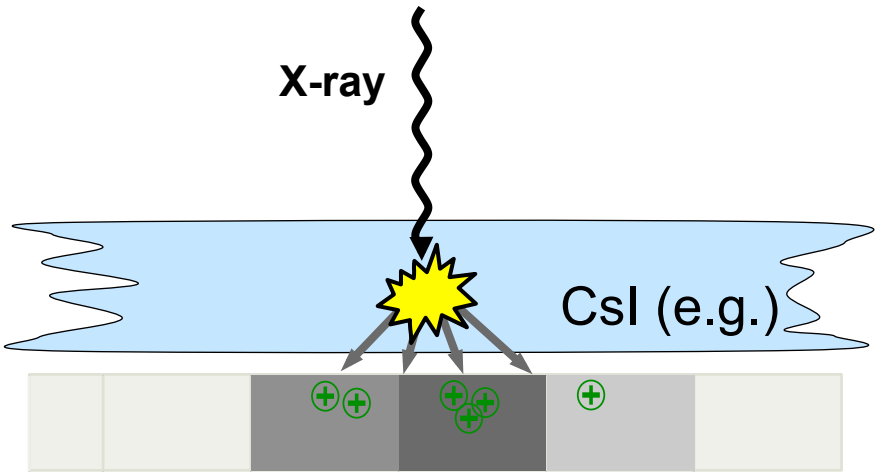
– *Founded in 2006 as a spin off from the Paul Scherrer Institute*

– *90 employees, located in Baden, Switzerland*

HPC - Hybrid Photon Counting Technology

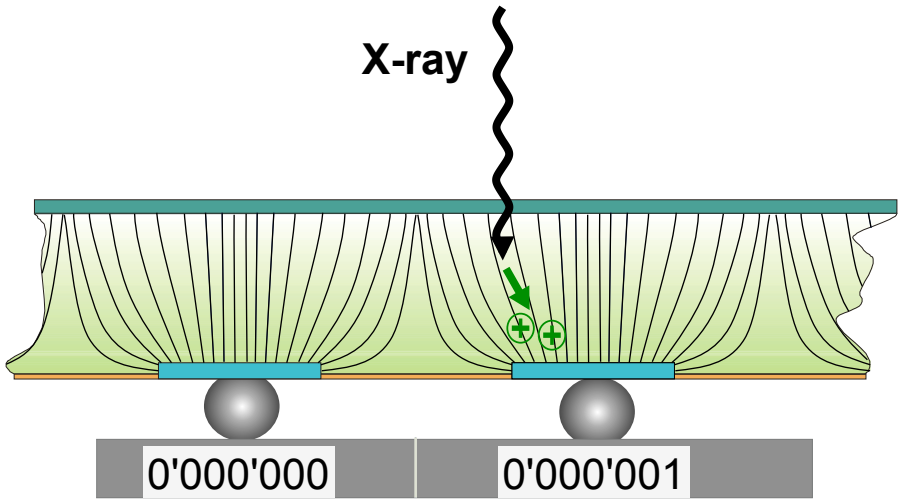
X-ray Detection

Indirect Detection
scintillator + CCD



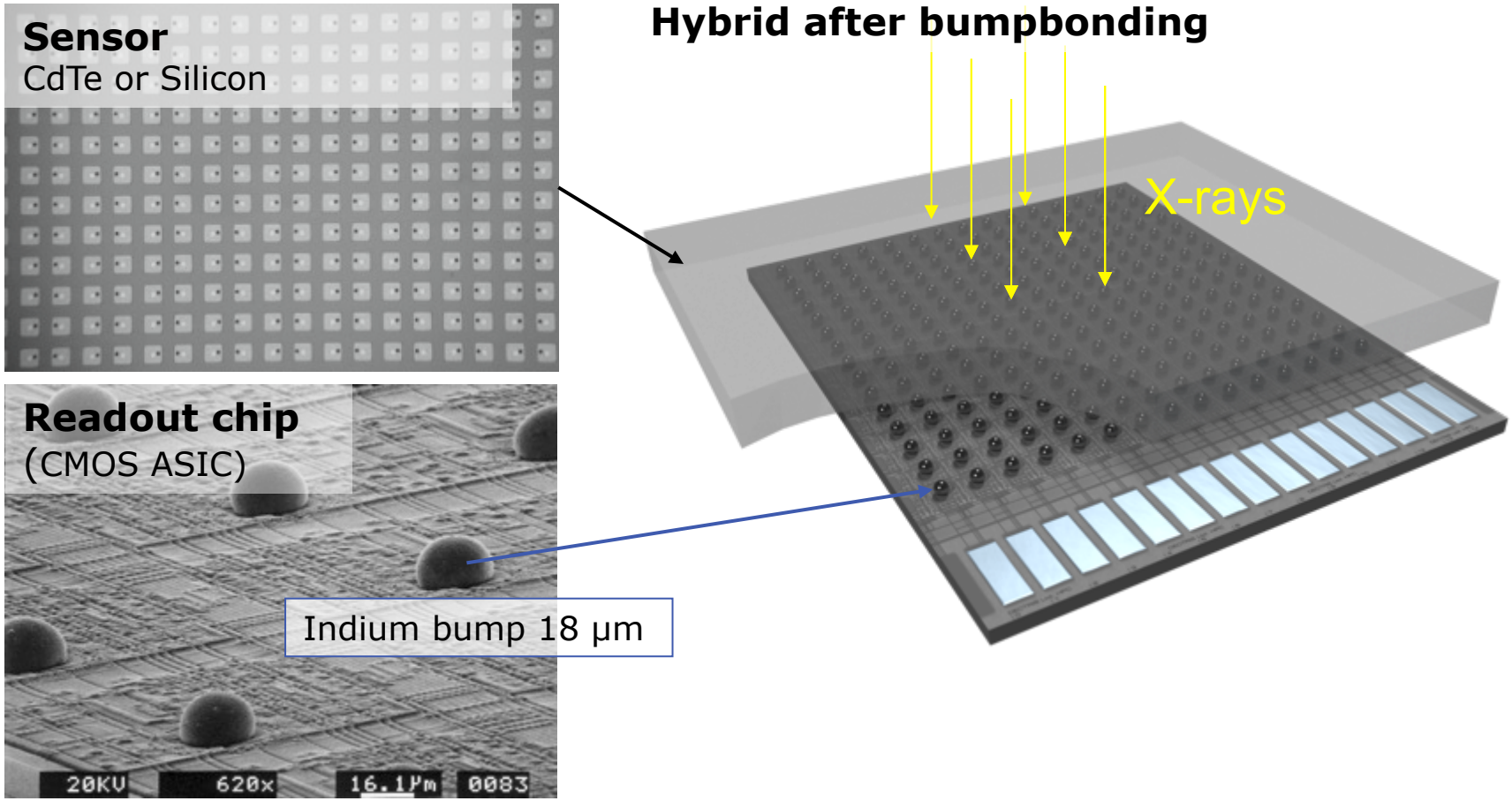
- blur over several pixels
- charge integration

Direct conversion
hybrid photon counting (HPC)



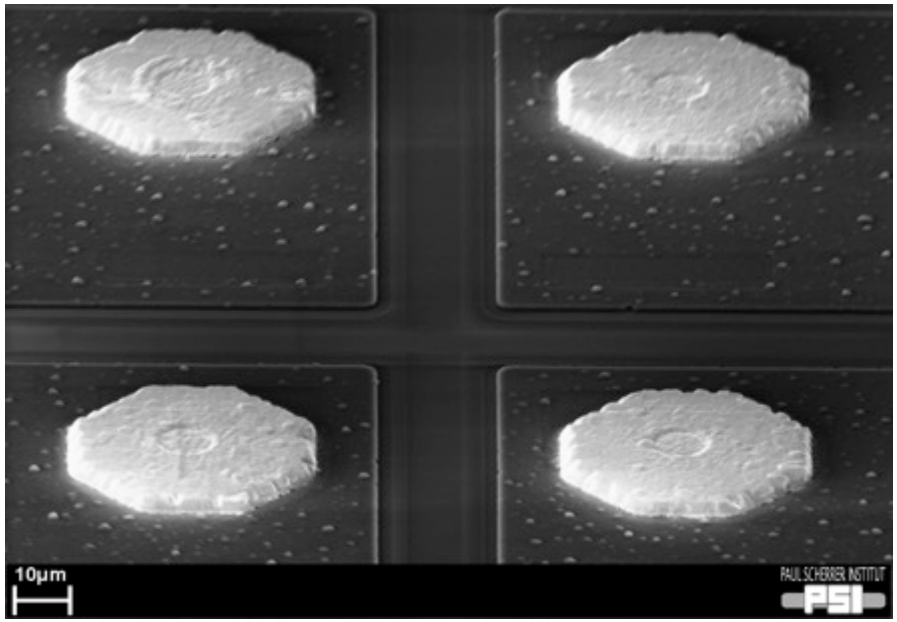
- 1 pixel spread, sharp image
- digital counting

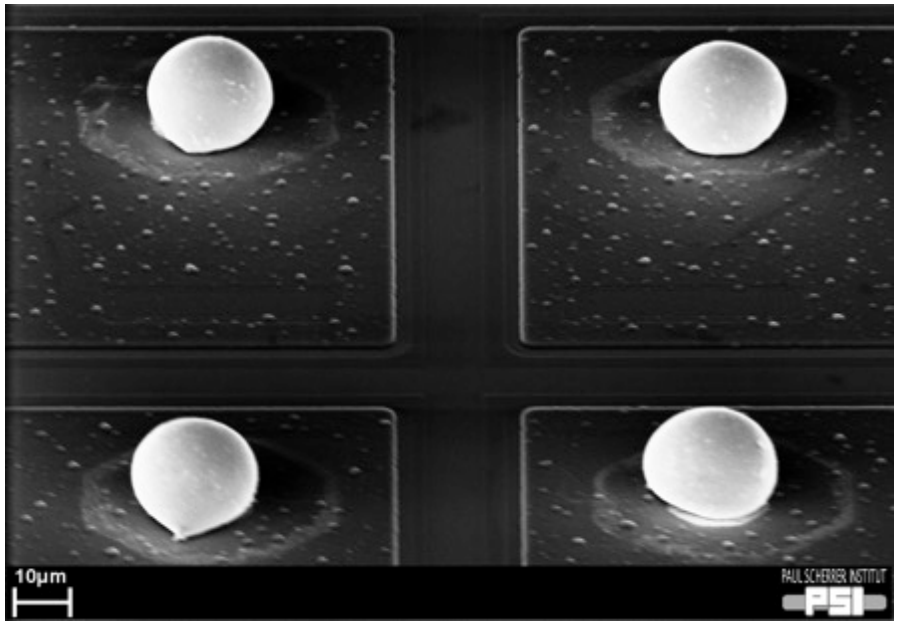
Hybrid Photon Counting (HPC) - Technology



Indium Bump-bonding technology

Indium "Cakes" → Indium Bumps

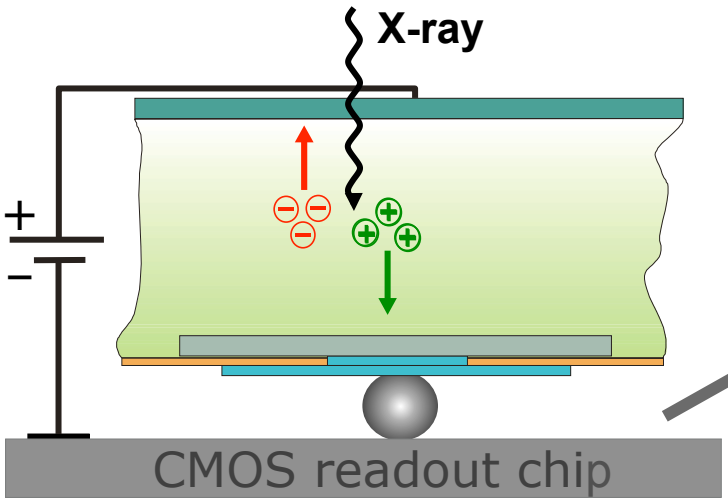




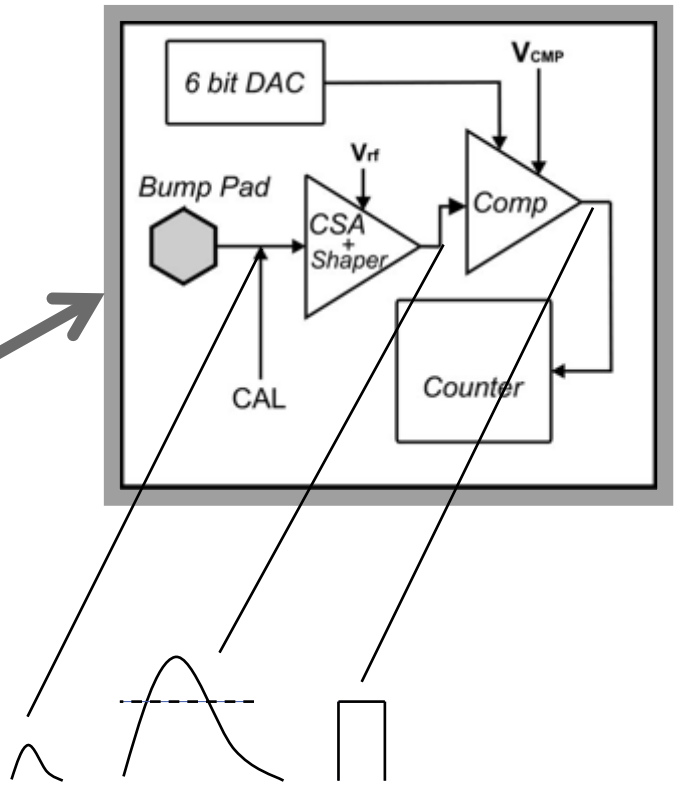
before reflow → after reflow

Hybrid Photon Counting (HPC) – Technology

Sensor pixel



Readout pixel

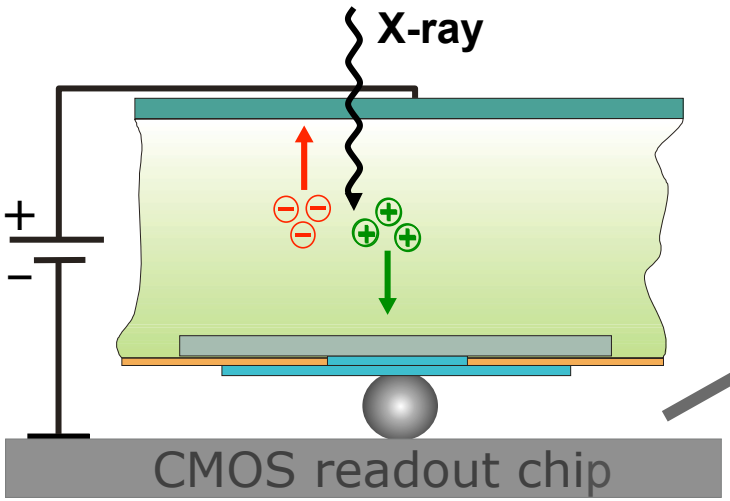


Direct conversion of X-rays in semiconductor sensor

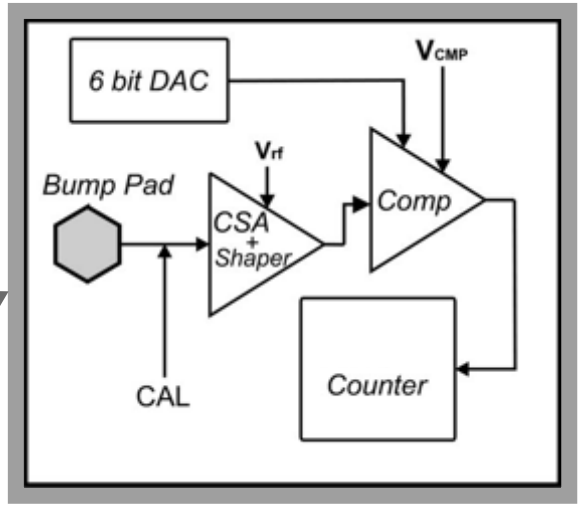
→ Point-spread function: ~1 Pixel

Hybrid Photon Counting (HPC) – Technology

Sensor pixel



Readout pixel



Direct conversion of X-rays in semiconductor sensor

→ Point-spread function: ~1 Pixel

Single-photon counting with adjustable energy threshold

→ Noise free / no dark signal

→ high dynamic range

→ fast readout

PILATUS & EIGER - 2D Detectors

PILATUS3 Series

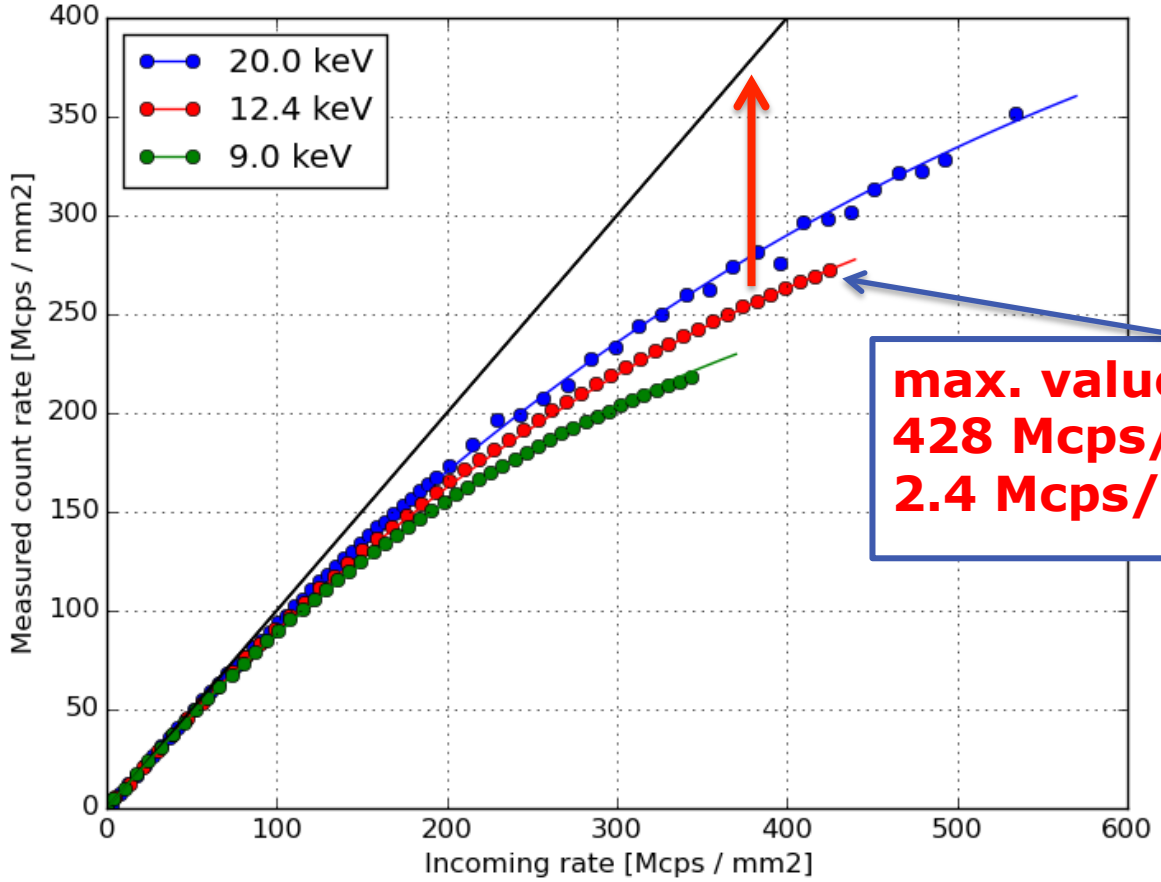
- Pixel size 172 µm
- Sensor Si & CdTe
- Readout time 0.95 ms

EIGER Series

- Pixel size 75 µm
- Sensor Si
- Readout time 3 µs

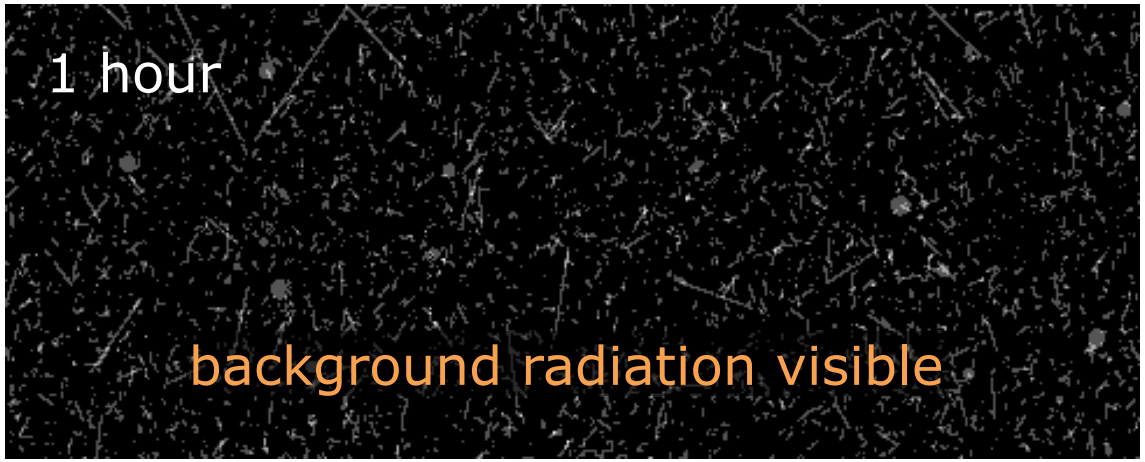
Characterization

Count rate performance



max. value at 12.4 keV
428 Mcps/mm²
2.4 Mcps/pixel

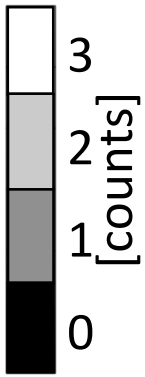
Noise-free detection



Dark images show

- no readout noise

- no dark current

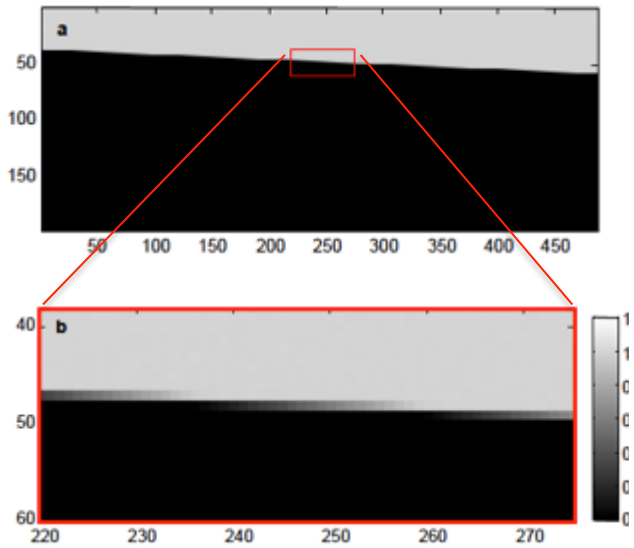


Darkfields from PILATUS 100K detector

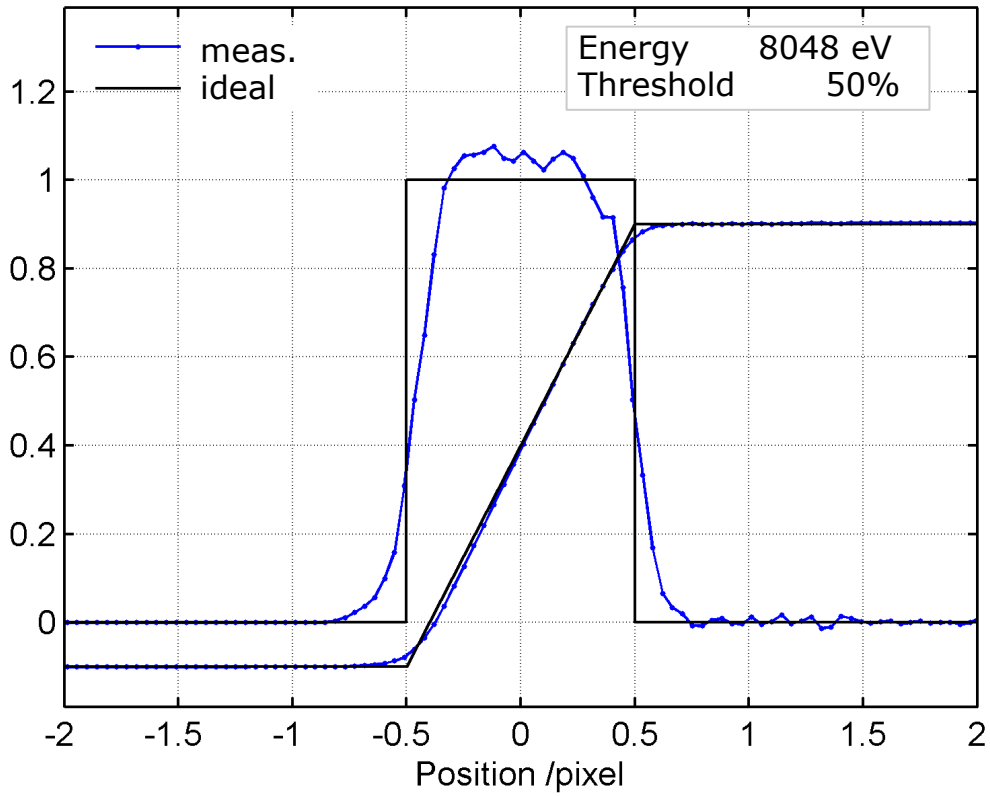
Spatial resolution

Edge Spread Function

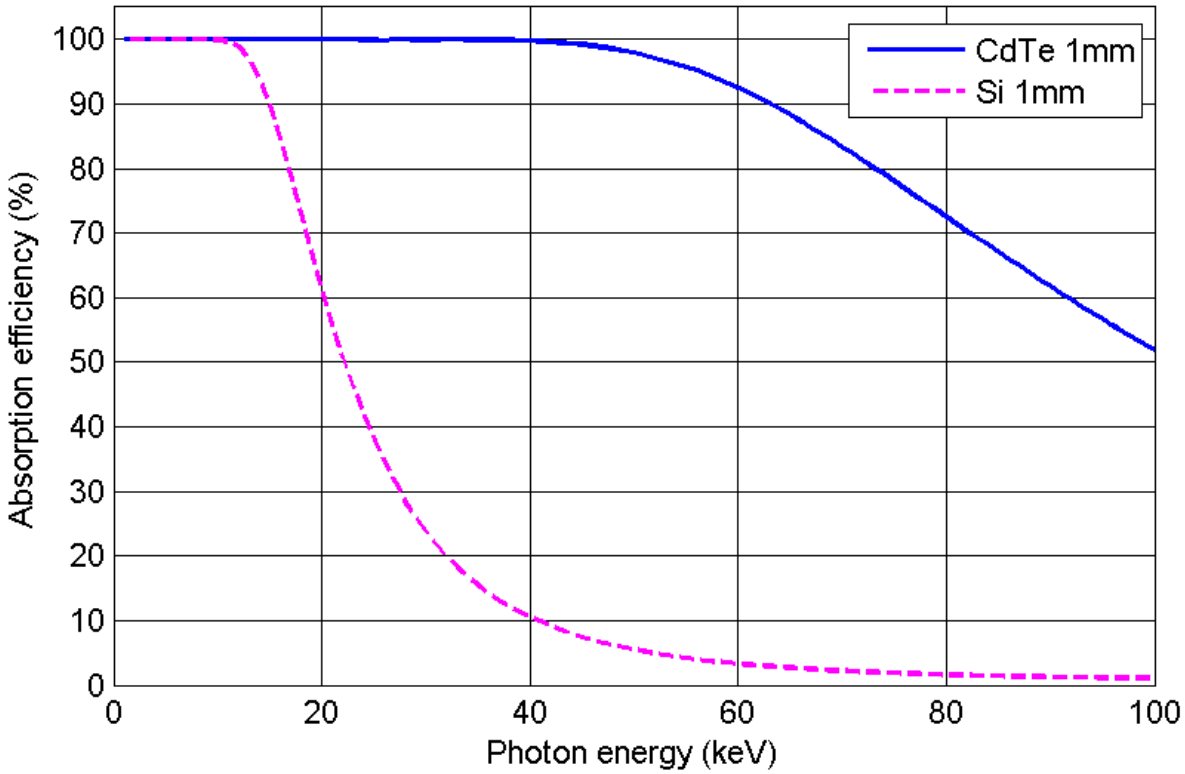
by slanted edge method



Derivative (ESF) => LSF (EIGER)

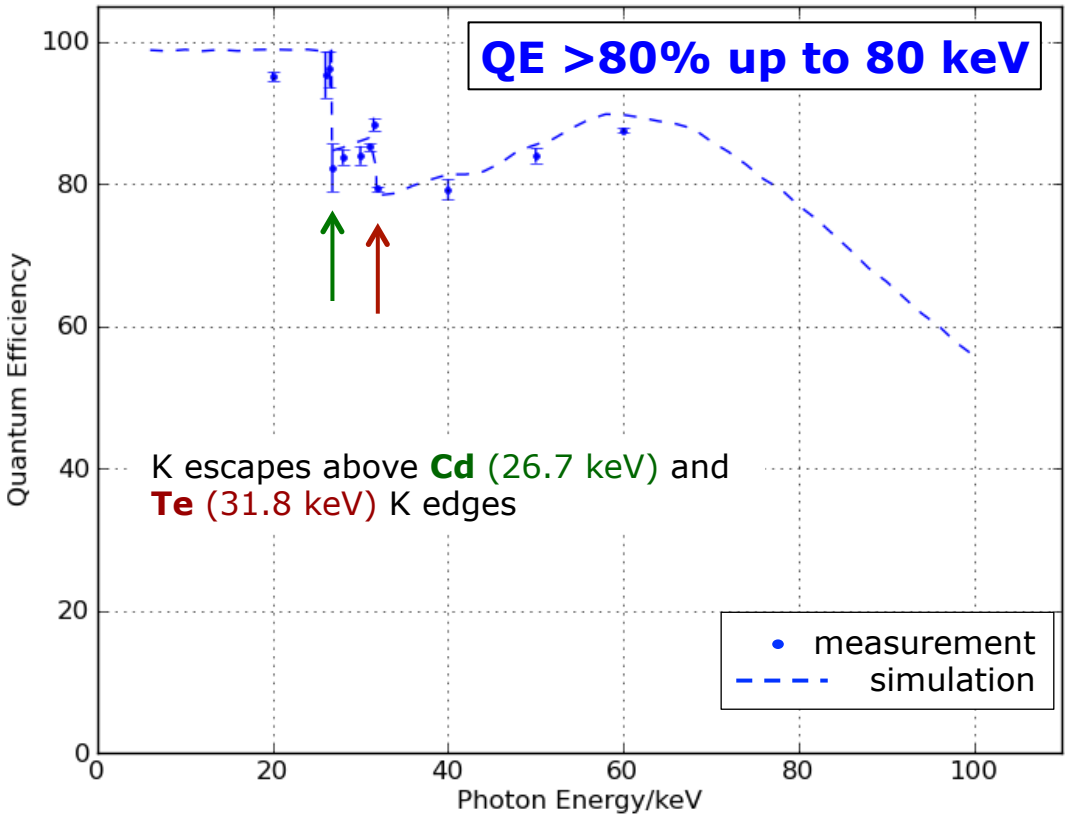


Efficiency of the Sensor Material



calculated using tabulated lin. attenuation coefficients

Efficiency CdTe, measured



QE measured in cooperation with PTB at BAM beamline at BESSY II

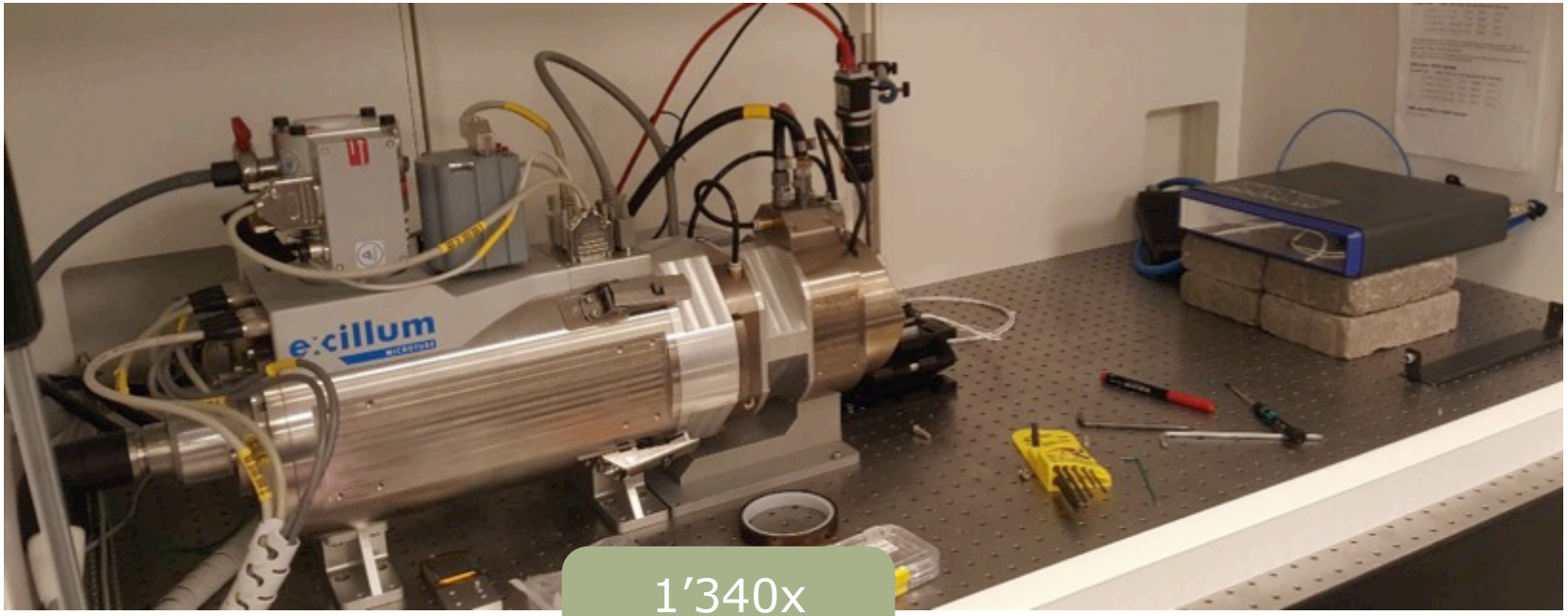
- *photon energy 20 to 60 keV*
- *low flux of max. 50 kcps*
- *E_{th} = 50% photon energy*

Simulation using HORUS

- *D. Pennicard and H. Graafsma, JINST 6, P06007 (2011)*

Applications

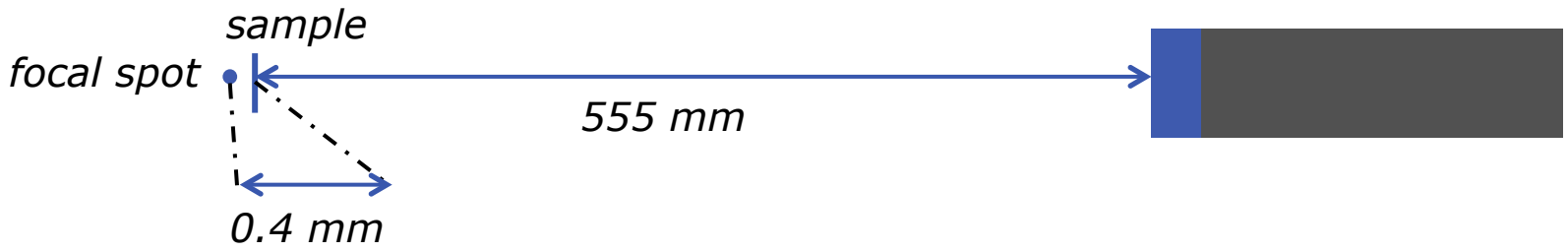
Nano setup with CdTe detector



1’340x Magnification

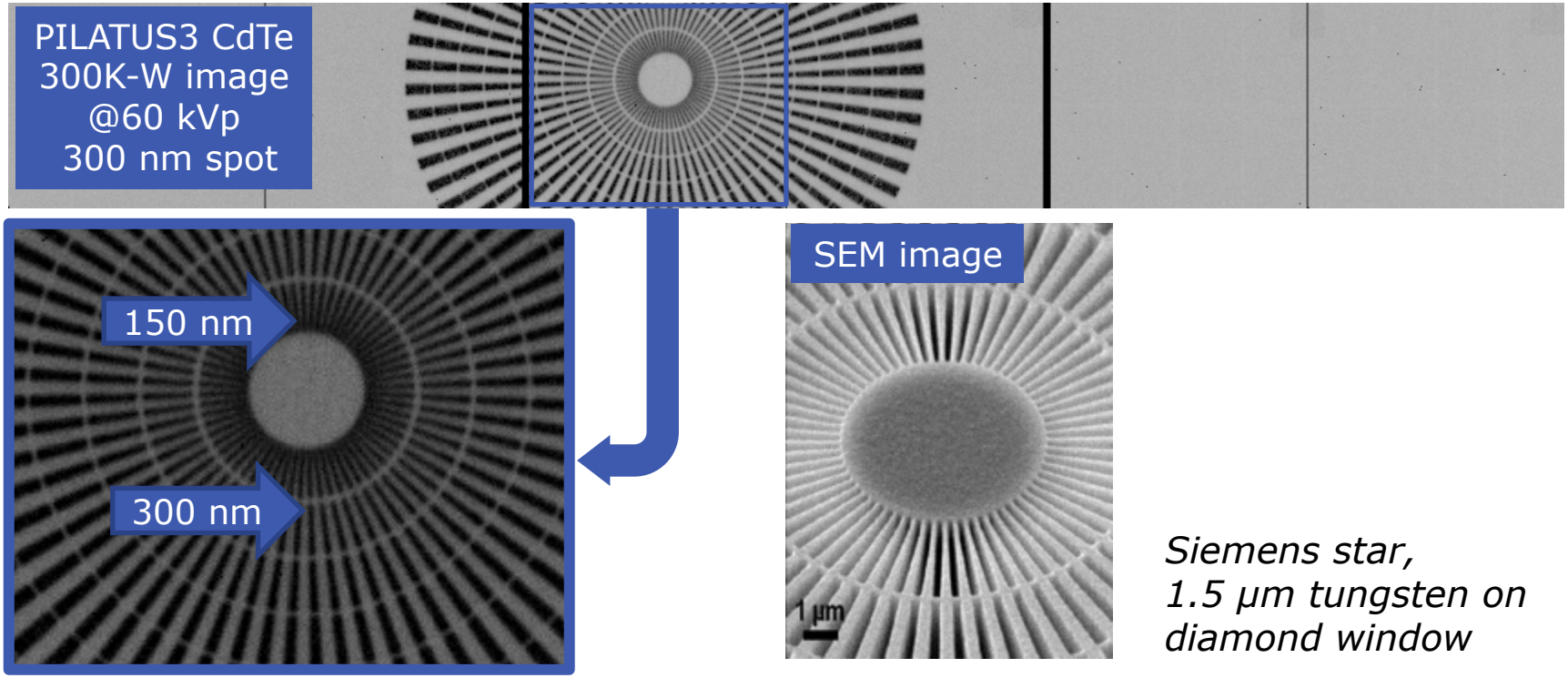
X-ray Nanotube N1

PILATUS3 X CdTe 300K-W



Measurements with Fraunhofer EZRT, Excillum AB

Nano setup with CdTe detector



Siemens star,
1.5 µm tungsten on
diamond window

- *Effective pixel size 128 nm (172 µm @ 1340x magnification)*
- *Structures down to 150 nm resolved*

Projection X-ray Microscope

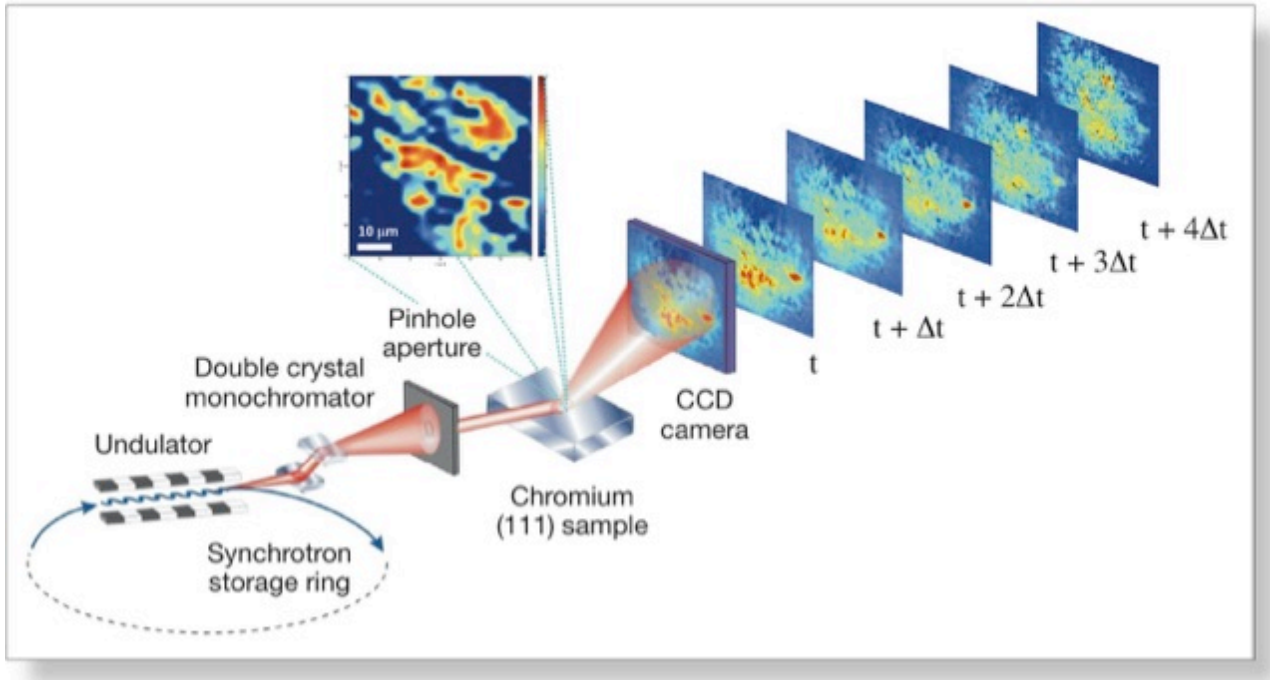
Measurements with Fraunhofer EZRT, Excillum AB

MYTHEN PILATUS EIGER

XPCS

CHX beamline, NSLS-II, BNL

X-ray Photon Correlation Spectroscopy



Requirements

- *Highest frame rates*
- *Small pixel size to resolve speckle patterns*

Results

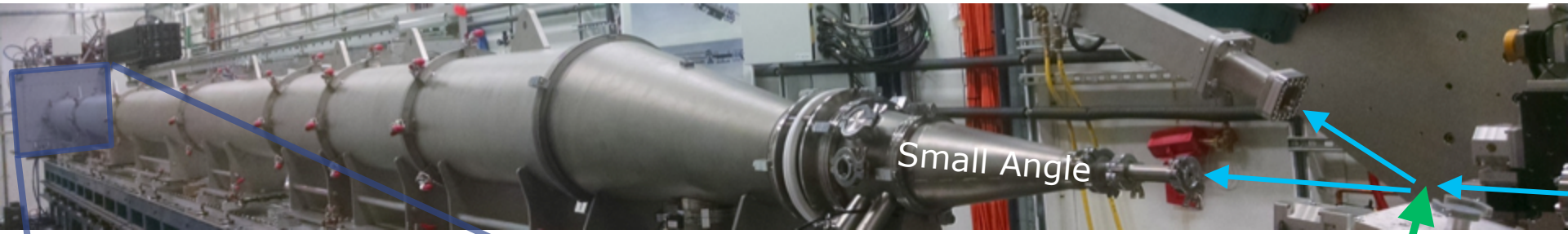
Fluctuations in the

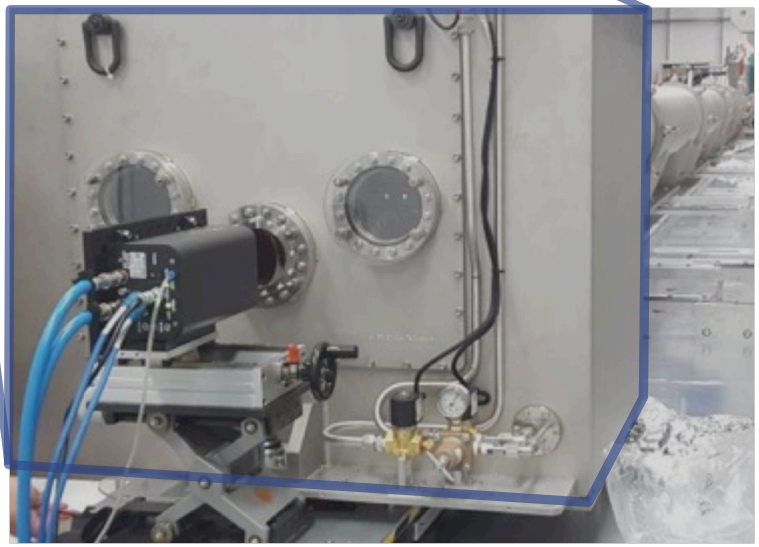
- *structural,*
- *chemical, or*
- *magnetic order in the material*

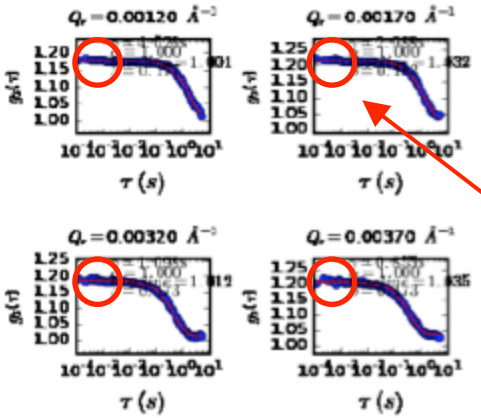
EIGER 500K with 9000 fps

XPCS Measurements at CHX Beamline

Wide Angle







Sample Position

Explore time regions below the ms regime

MYTHEN PILATUS EIGER

Coherent Diffractive Imaging

Coherent Diffractive Imaging

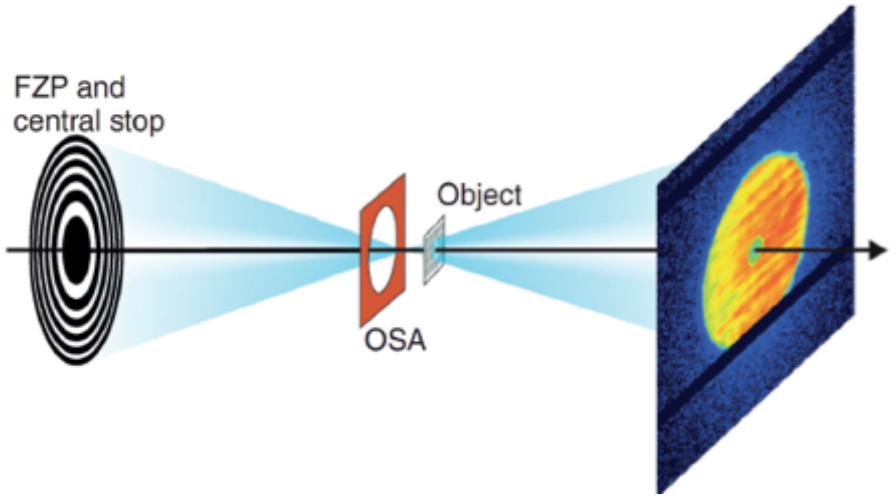
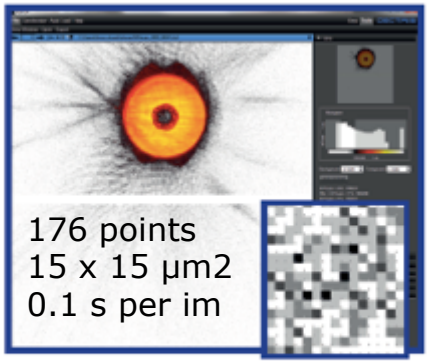


Image adapted from [M. Guizar-Sicairos et al., Phys. Rev. B 86, 100103 (2012)].

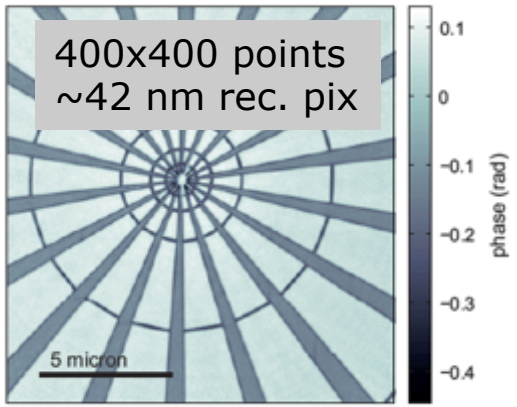
Test ptychography measurements at cSAXS beamline at the Swiss Light Source

Acknowledgment: M. Holler, A. Diaz andM. Guizar-Sicairos

EIGER X 1M detector



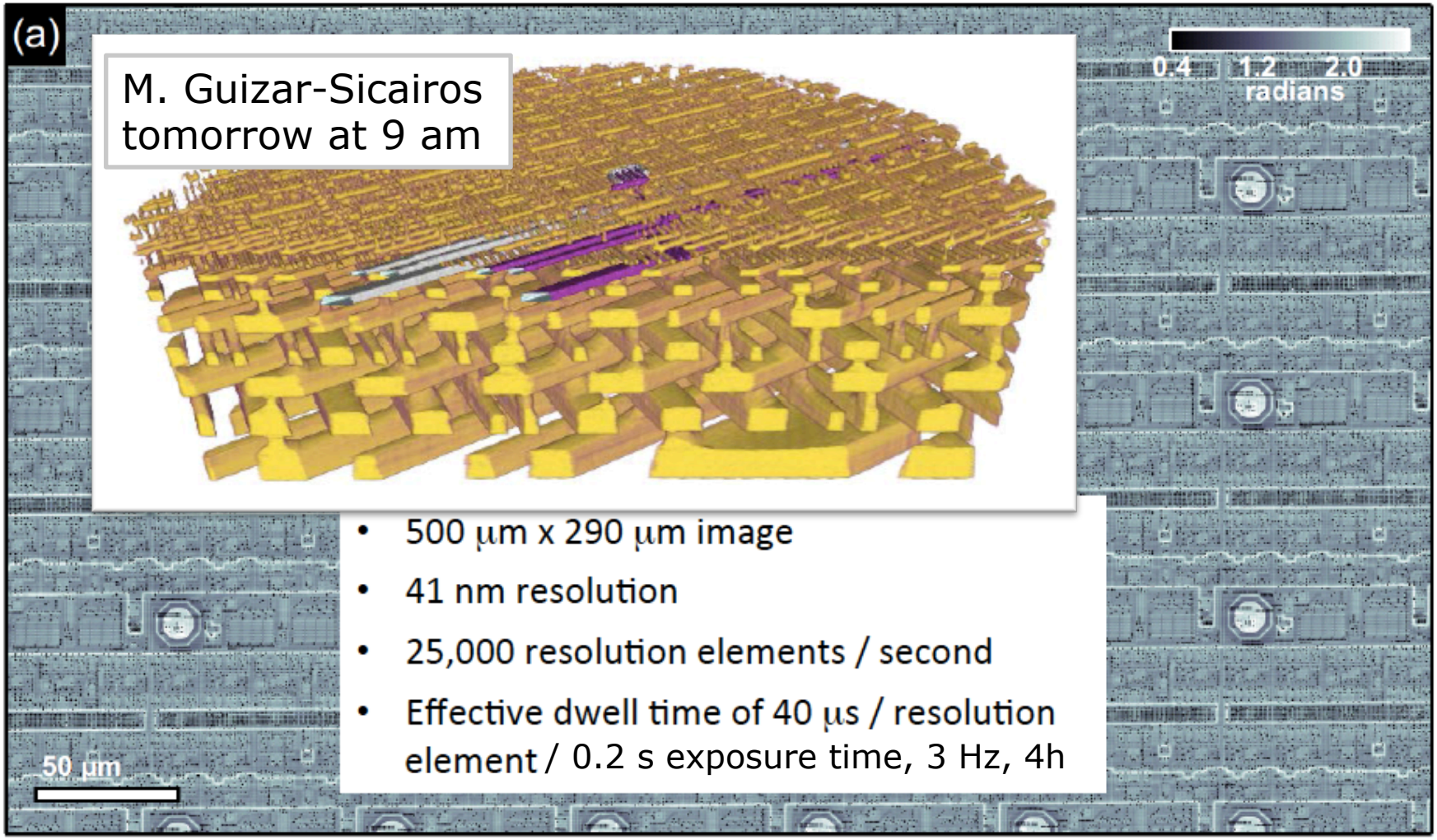
Diffraction pattern on EIGER



Reconstructed phase image

High throughput ptychography

The EIGER "selfie" M. Guizar-Sicairos *et al.*, Opt. Express **22** (2014) 14859

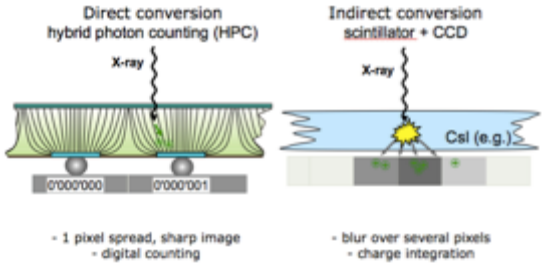


Summary

Summary

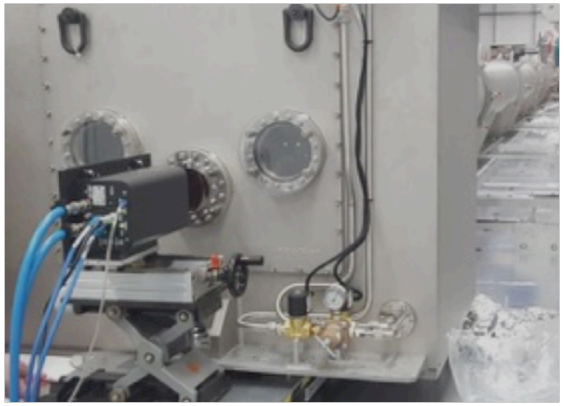
Hybrid Photon Counting (HPC) Technology is superior

- *direct detection of photons*
- *sharp PSF (1 pixel)*
- *no dark current*
- *fast readout*



Extremely High Frame Rate with HPC

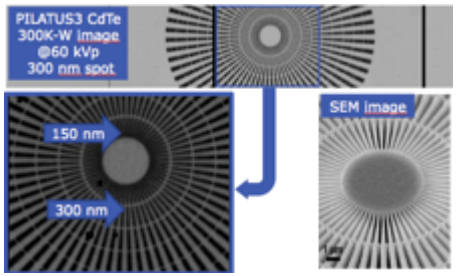
- *Each pixel a detector*
- *Parallel readout*
- *Very high frame rates*
- *Time resolution below ms*



Summary

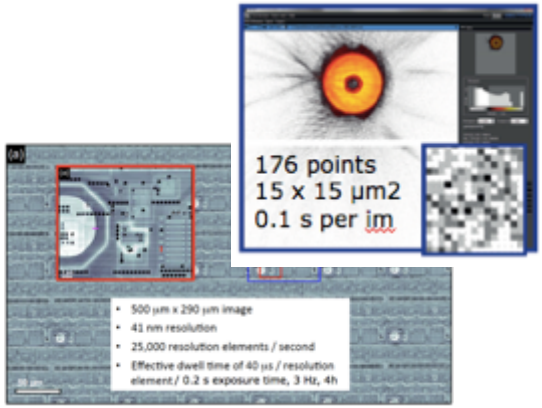
Lab Based NanoCT

- *Noise free and and direct detection*
- *Magnifications up to 2000*
- *with optimized setup*
- *=> 3D resolutions < 200 nm*



Coherent Methods at Synchrotrons

- *Fluorescence suppression*
- *No dead time*
- *Large detection area*
- *Very high frame rates*



Acknowledgment

- J. Herzen, TUM
- cSAXS team at SLS
- CHX team at BNL

DECTRIS team in front of EIGER

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Thank you for your attention!

www.dectris.com

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