

Energy-resolved interferometric X-ray imaging

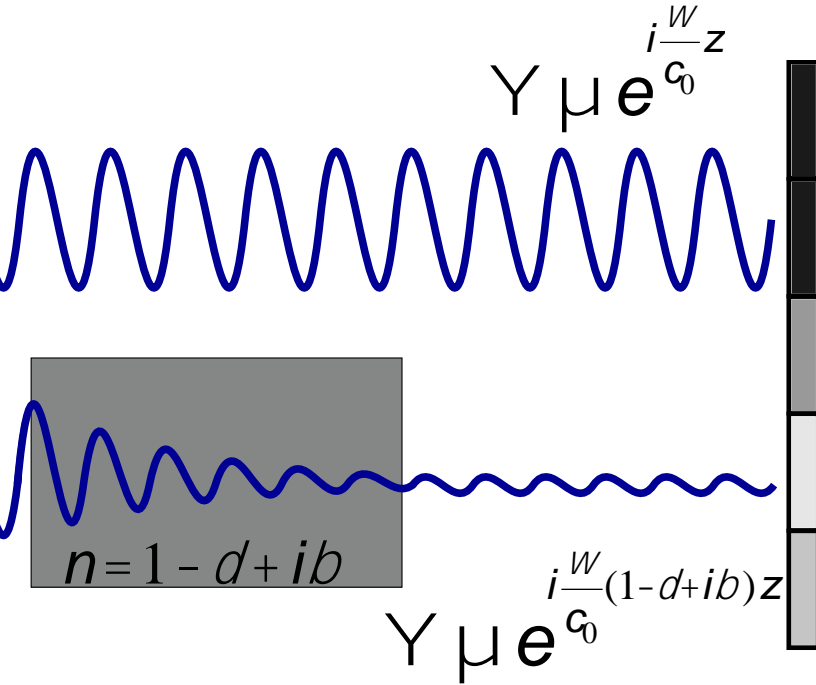
ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

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Outline:

- Interferometric X-ray imaging
- Experimental setup
- Medipix2 detector
- Simulation framework
- Results

X-ray imaging



Intensity:

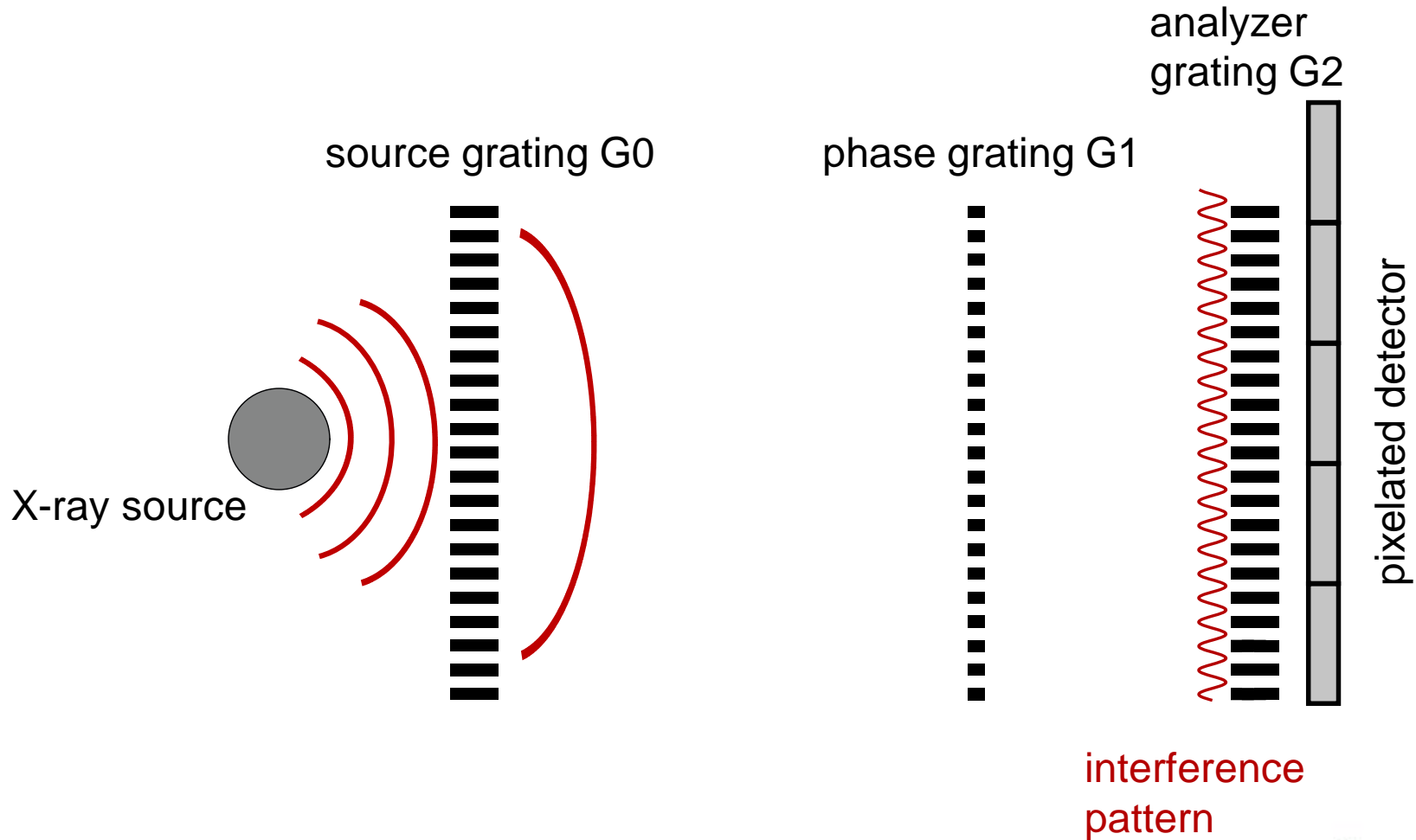
$$I = |Y|^2 = I_0 \times e^{-2bk_0z} = I_0 \times e^{-mz}$$



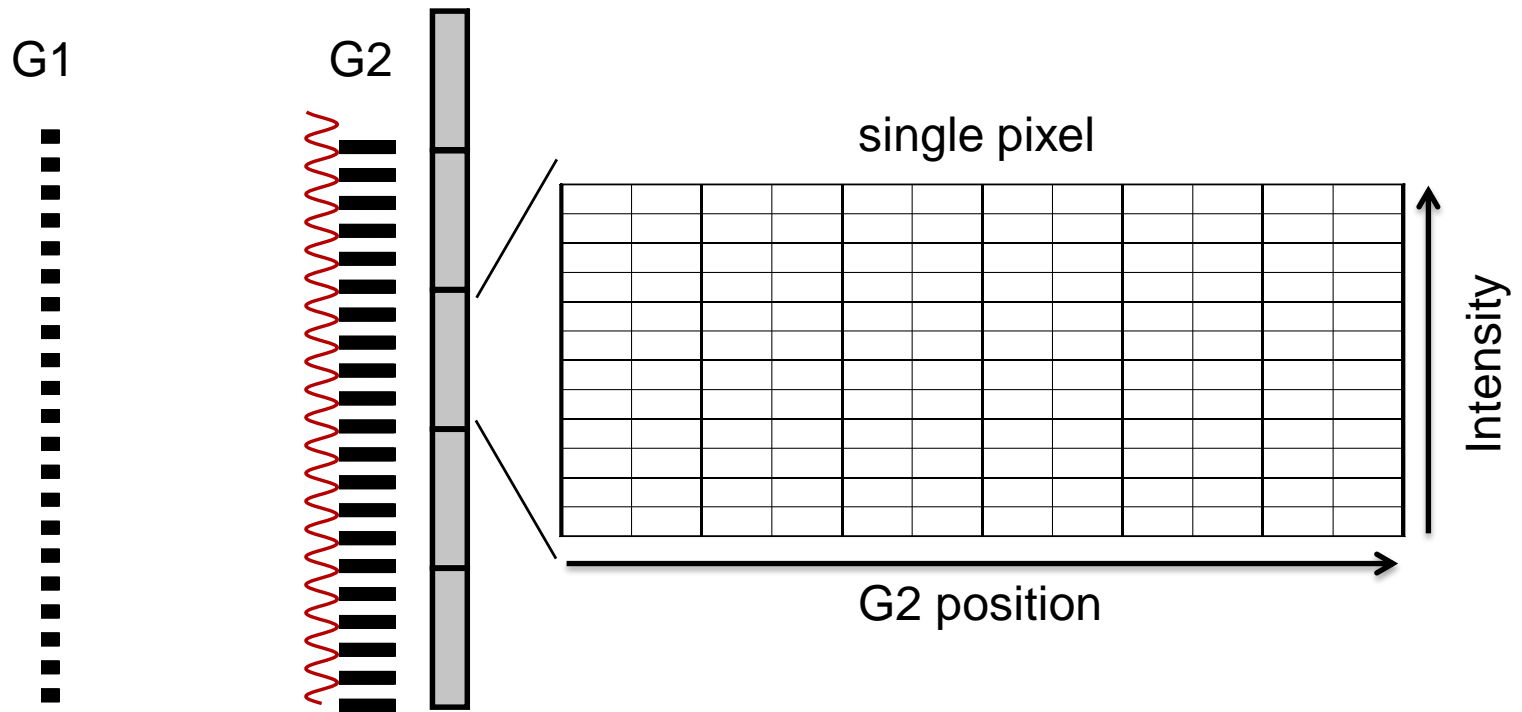
For soft tissue δ promises much higher contrast than β

How to image δ ?

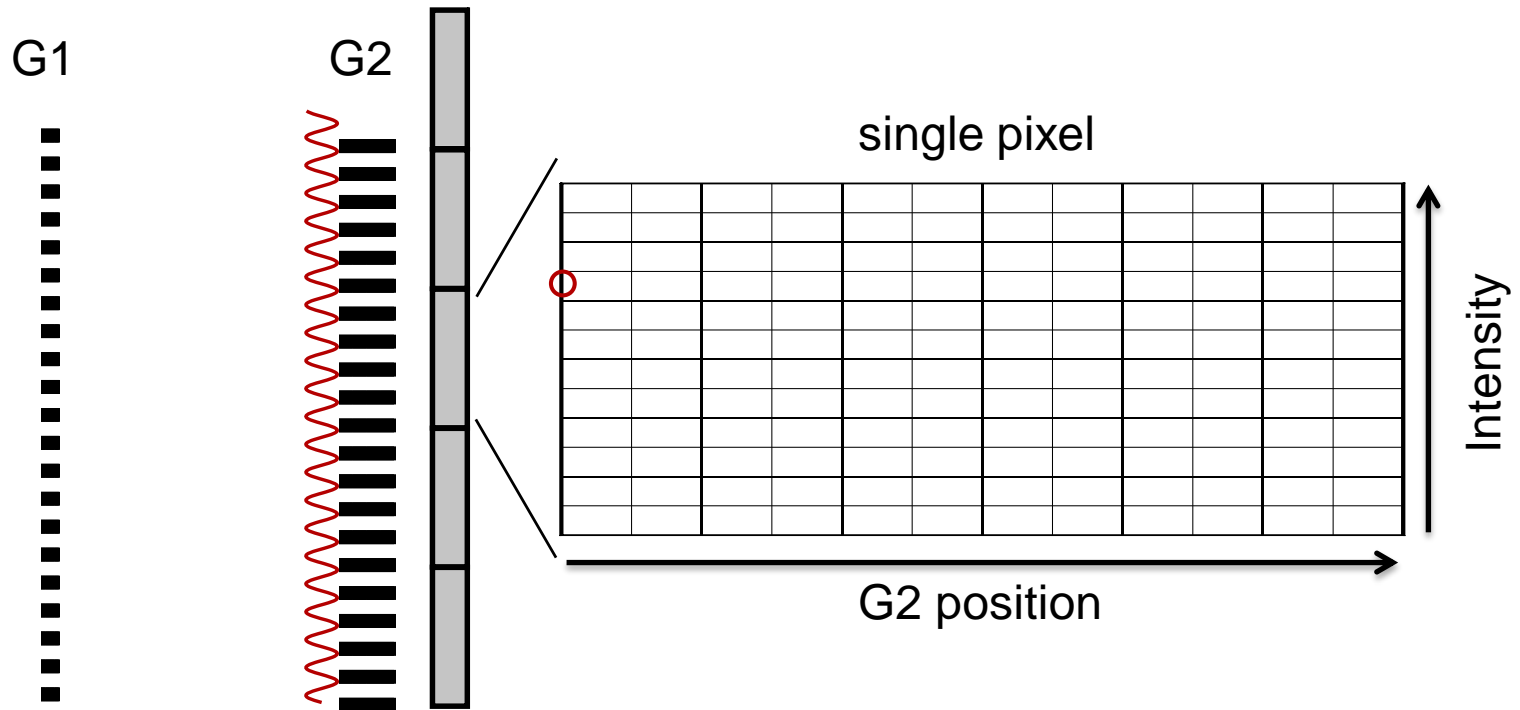
Interferometric X-ray imaging: The Talbot-Lau interferometer



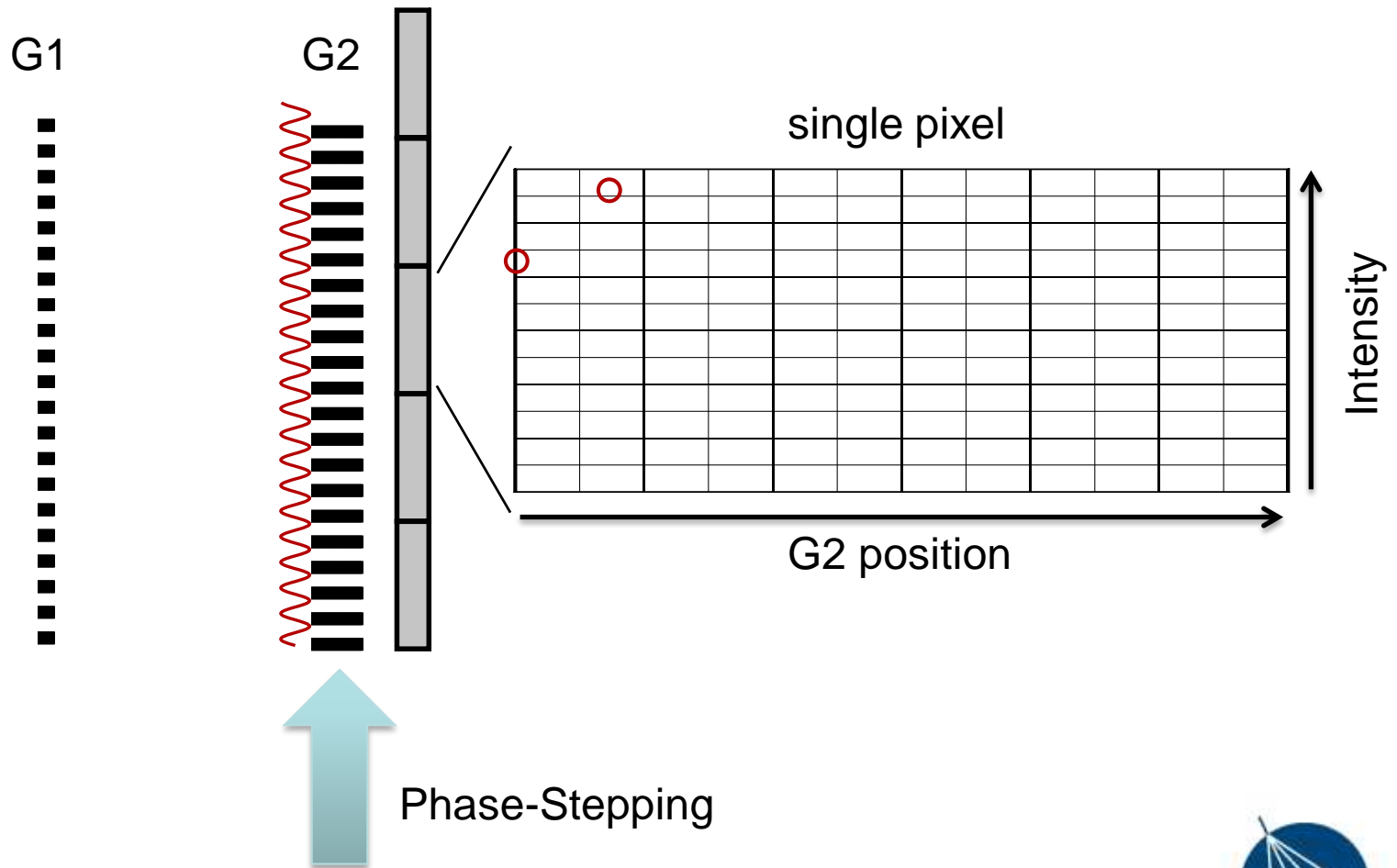
The Talbot-Lau interferometer



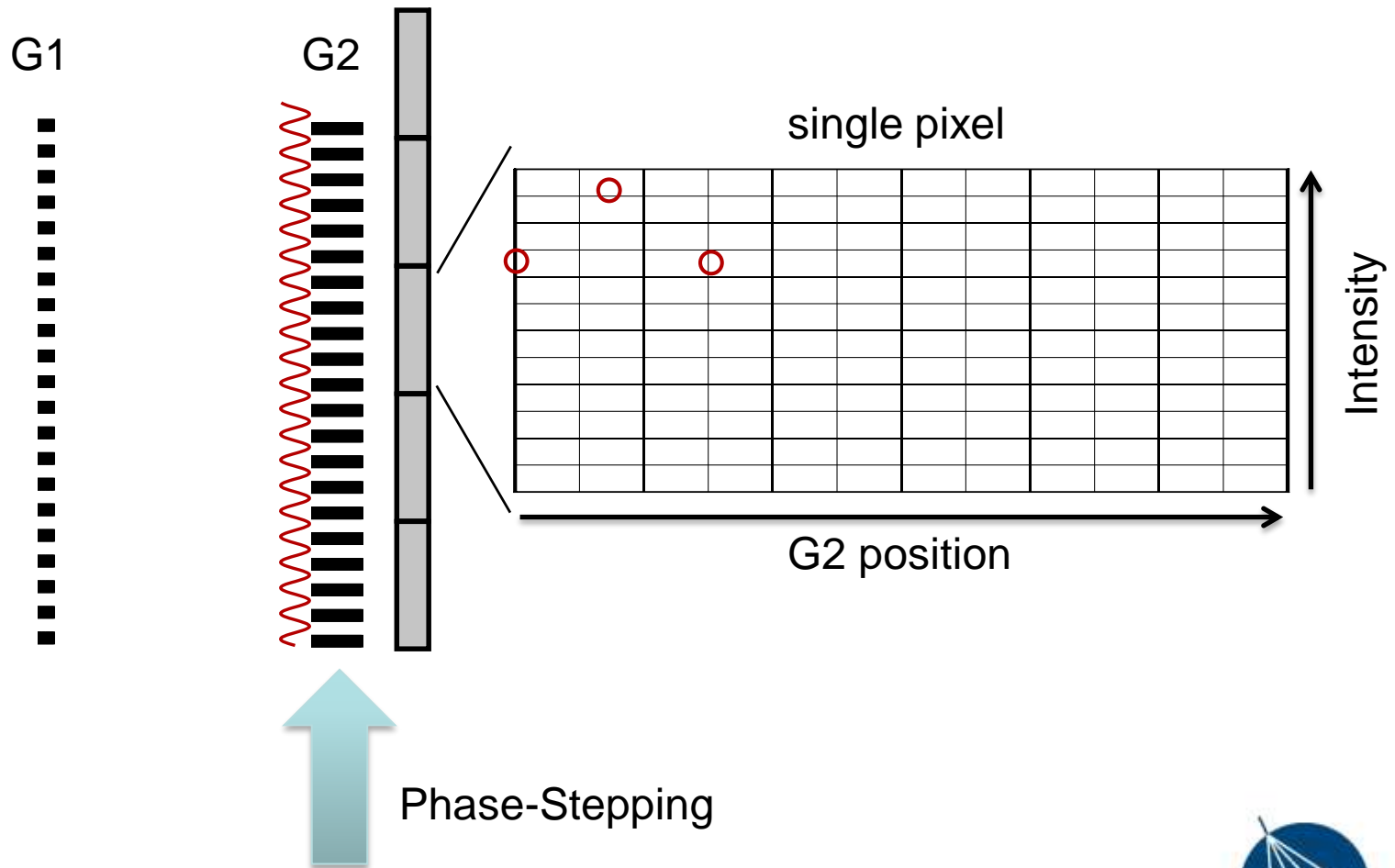
The Talbot-Lau interferometer



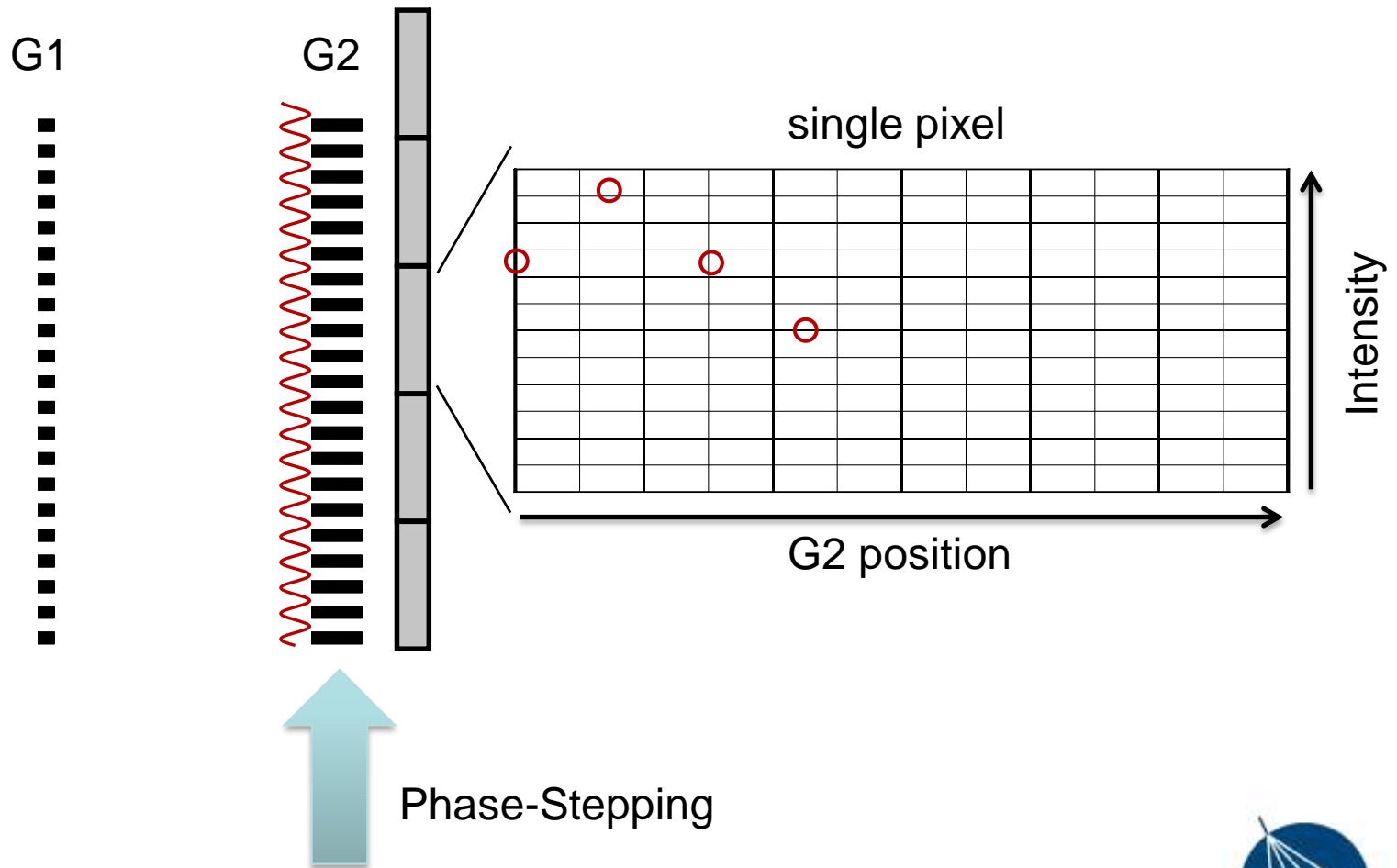
The Talbot-Lau interferometer



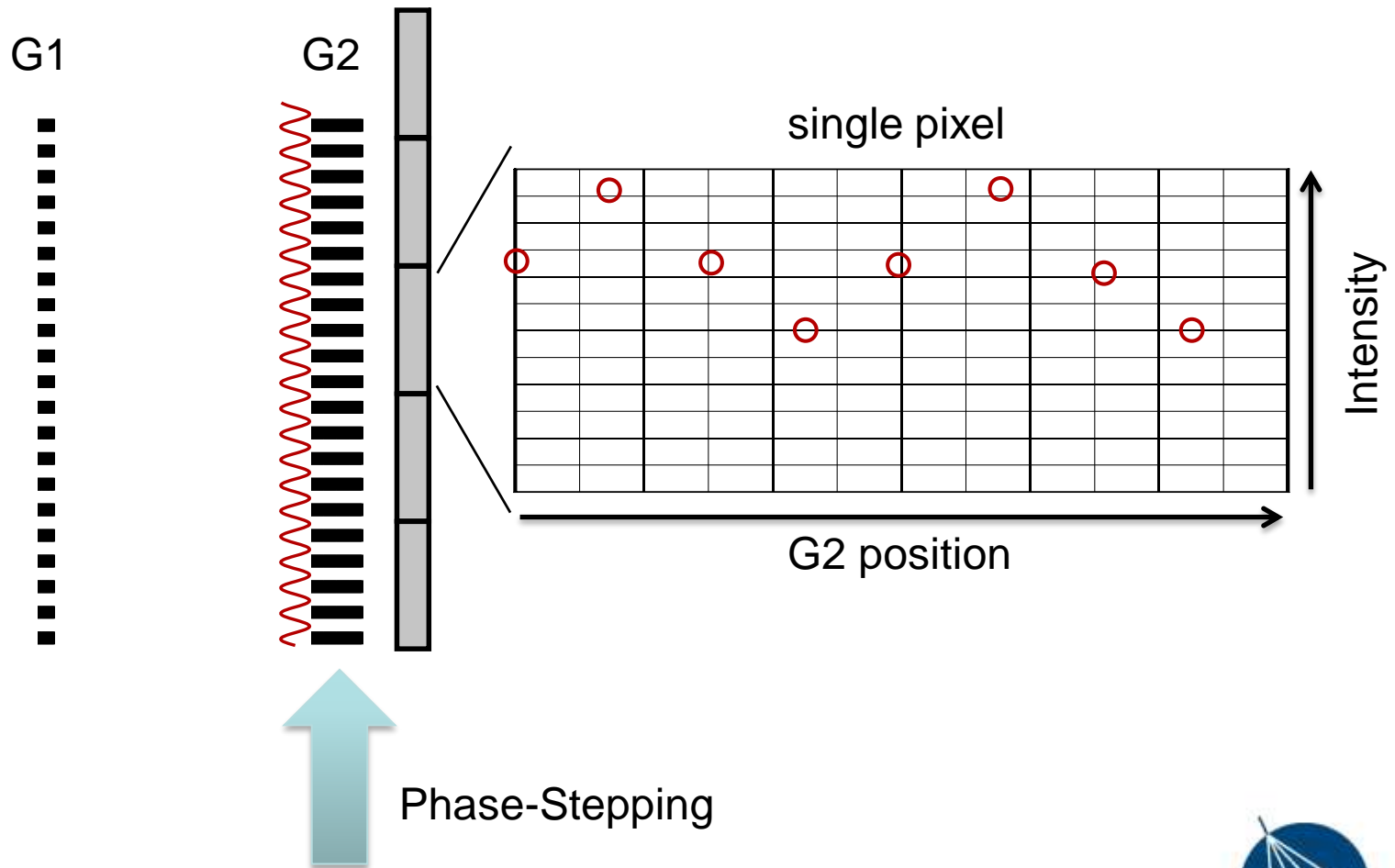
The Talbot-Lau interferometer



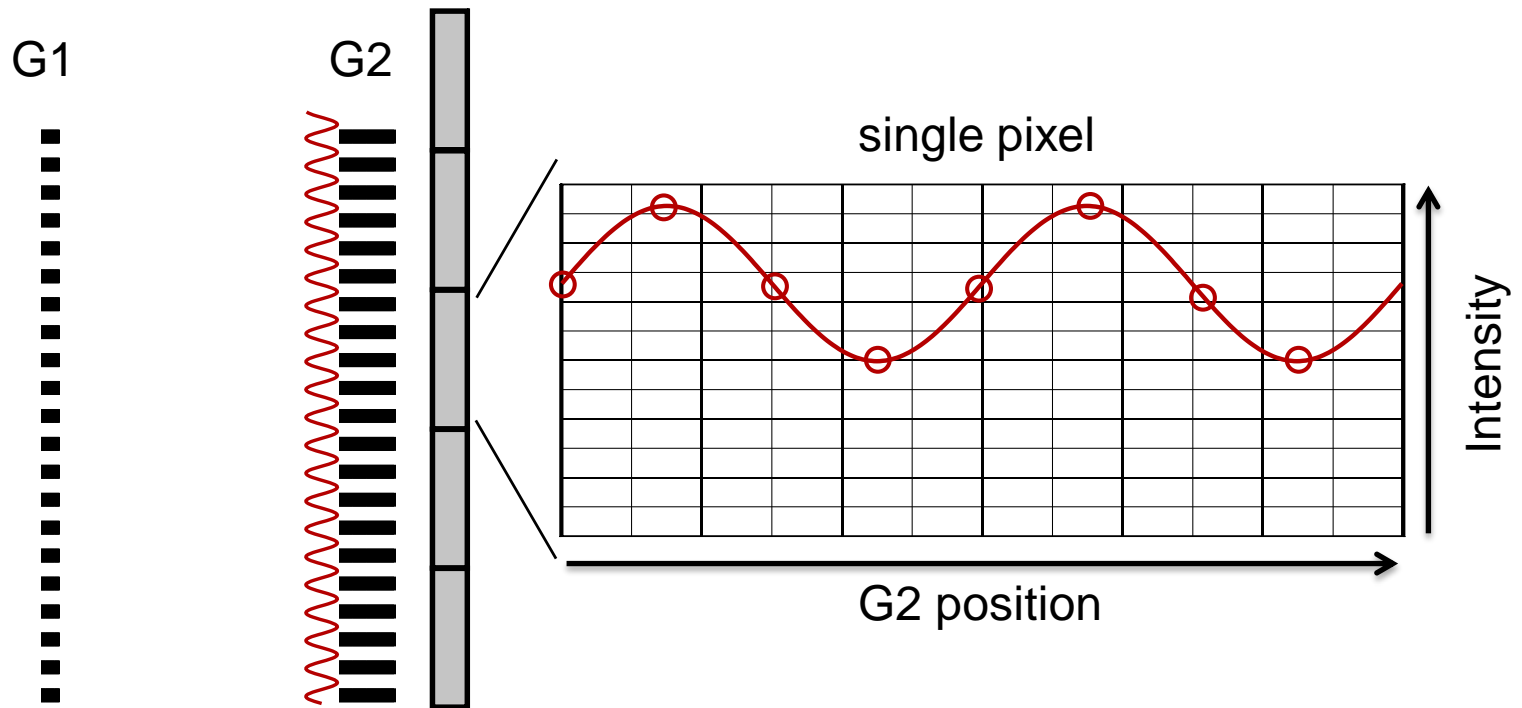
The Talbot-Lau interferometer



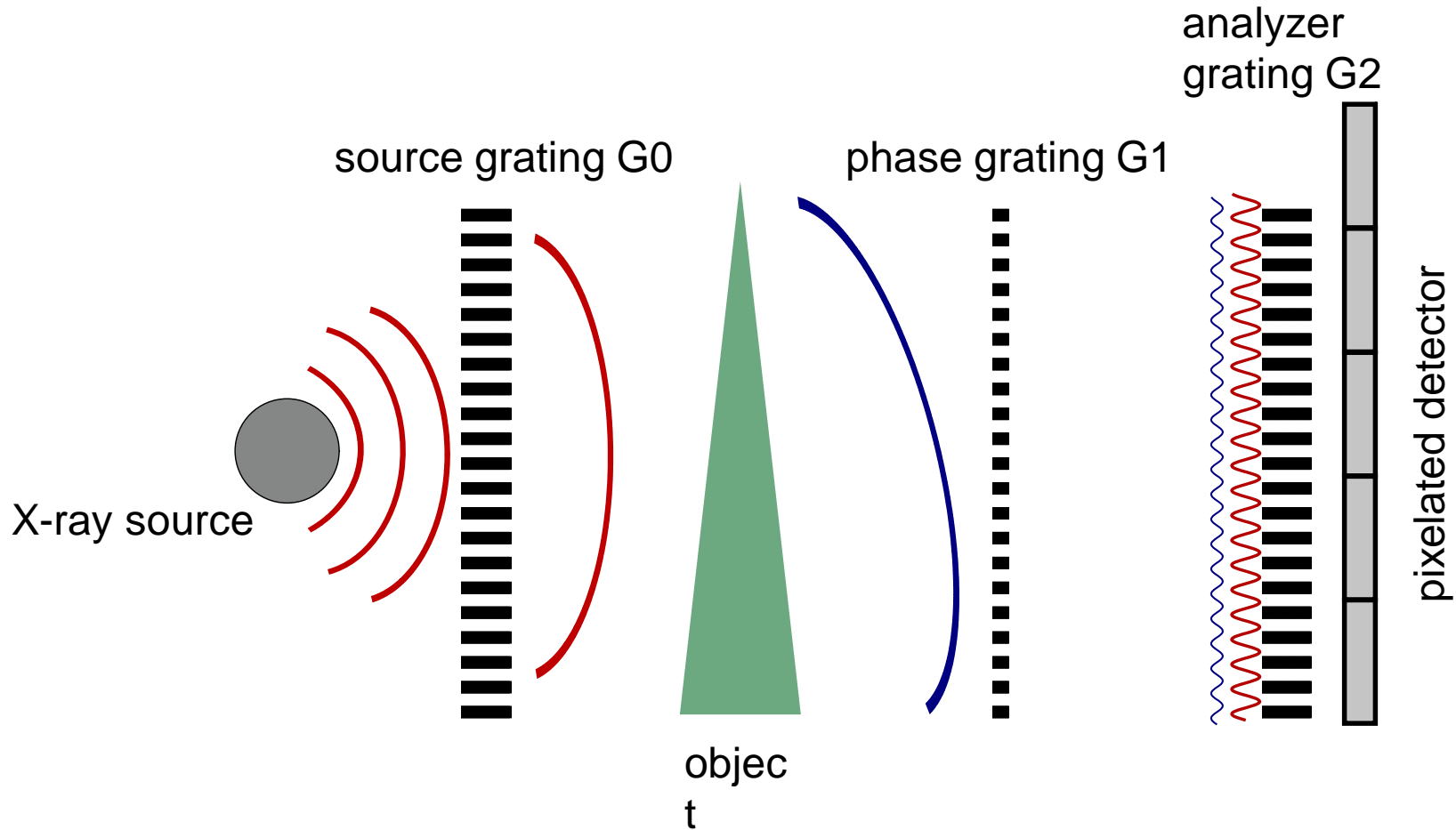
The Talbot-Lau interferometer



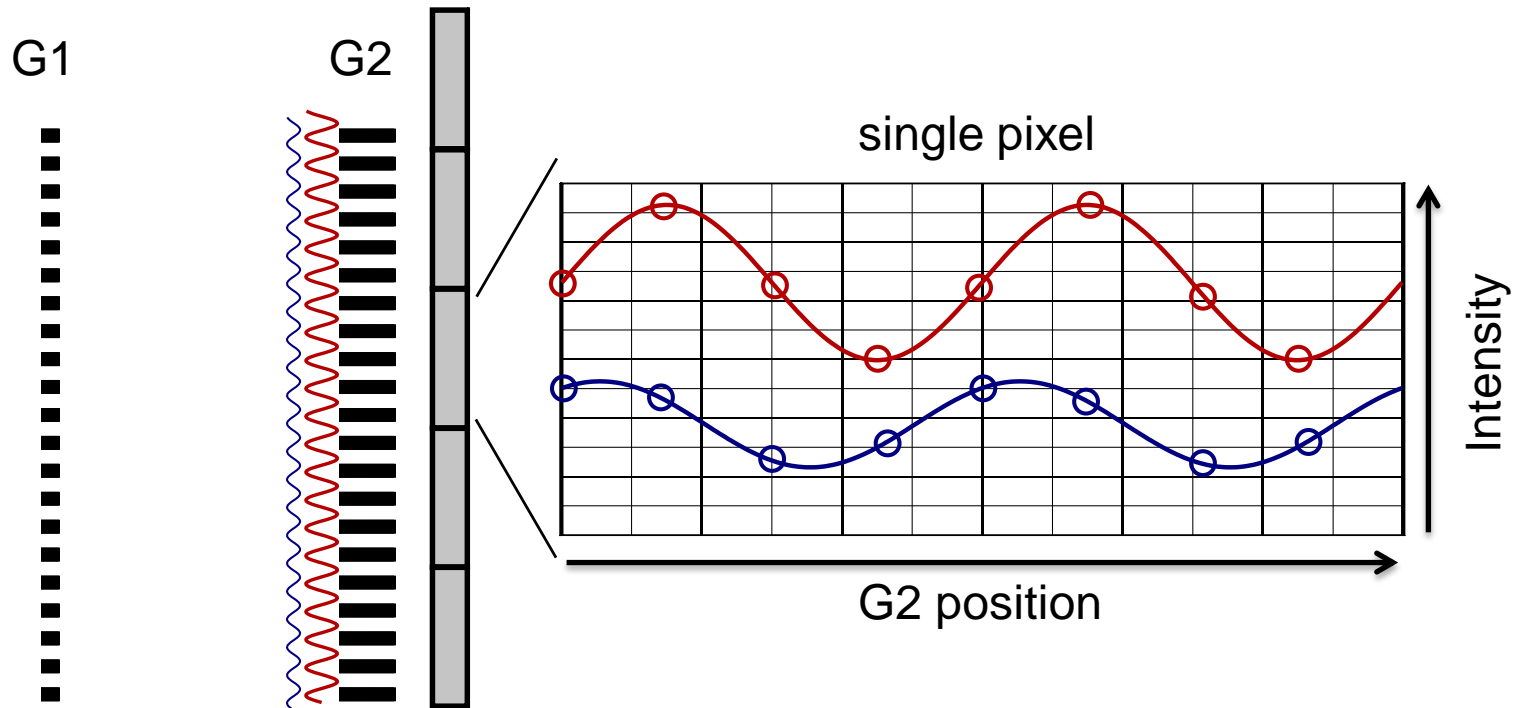
The Talbot-Lau interferometer



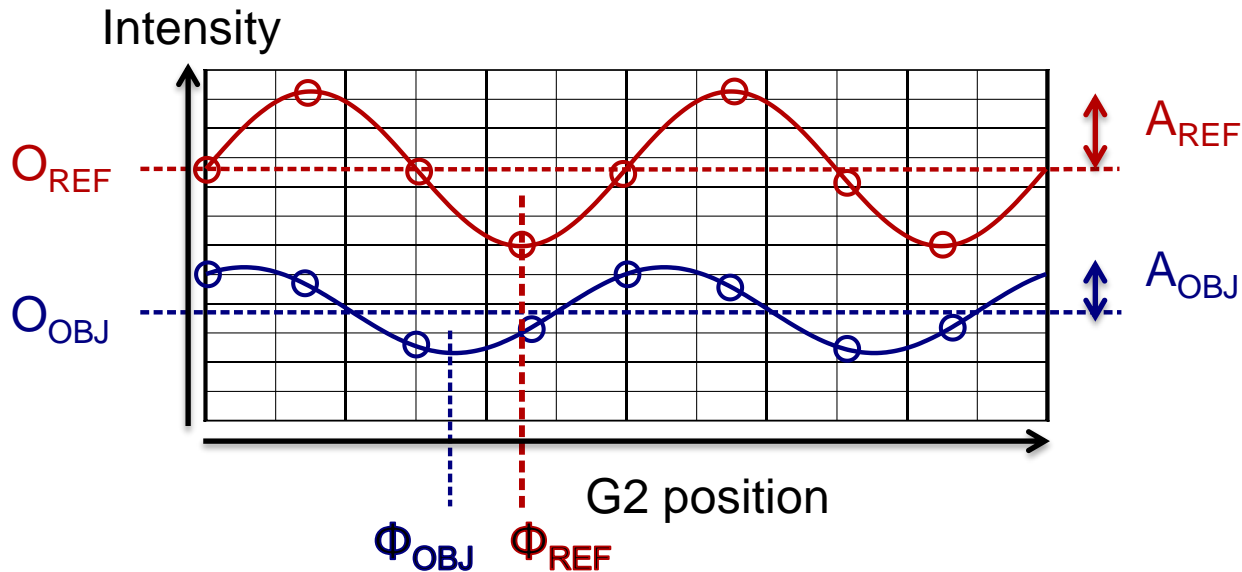
The Talbot-Lau interferometer



The Talbot-Lau interferometer



The Talbot-Lau interferometer



Parameters:

- Offset O
- Amplitude A
- Phase Φ
- Visibility $V = A/O$
for every pixel

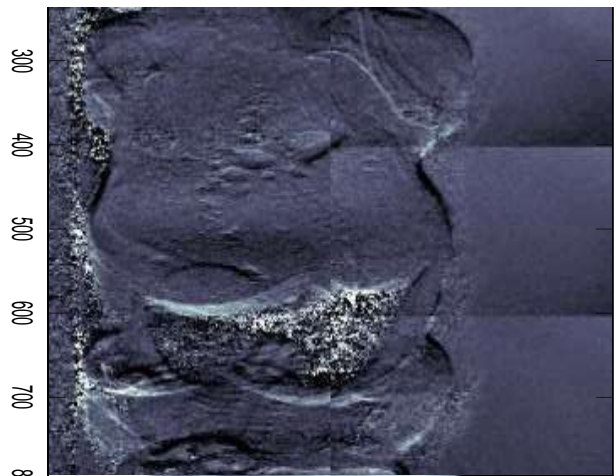
3 different image information:

- Absorption: $-\log(O_{OBJ} / O_{REF})$
- Differential phase: $\Phi_{OBJ} - \Phi_{REF}$
- Darkfield: V_{OBJ} / V_{REF}



AMP

Absorption



NDPC

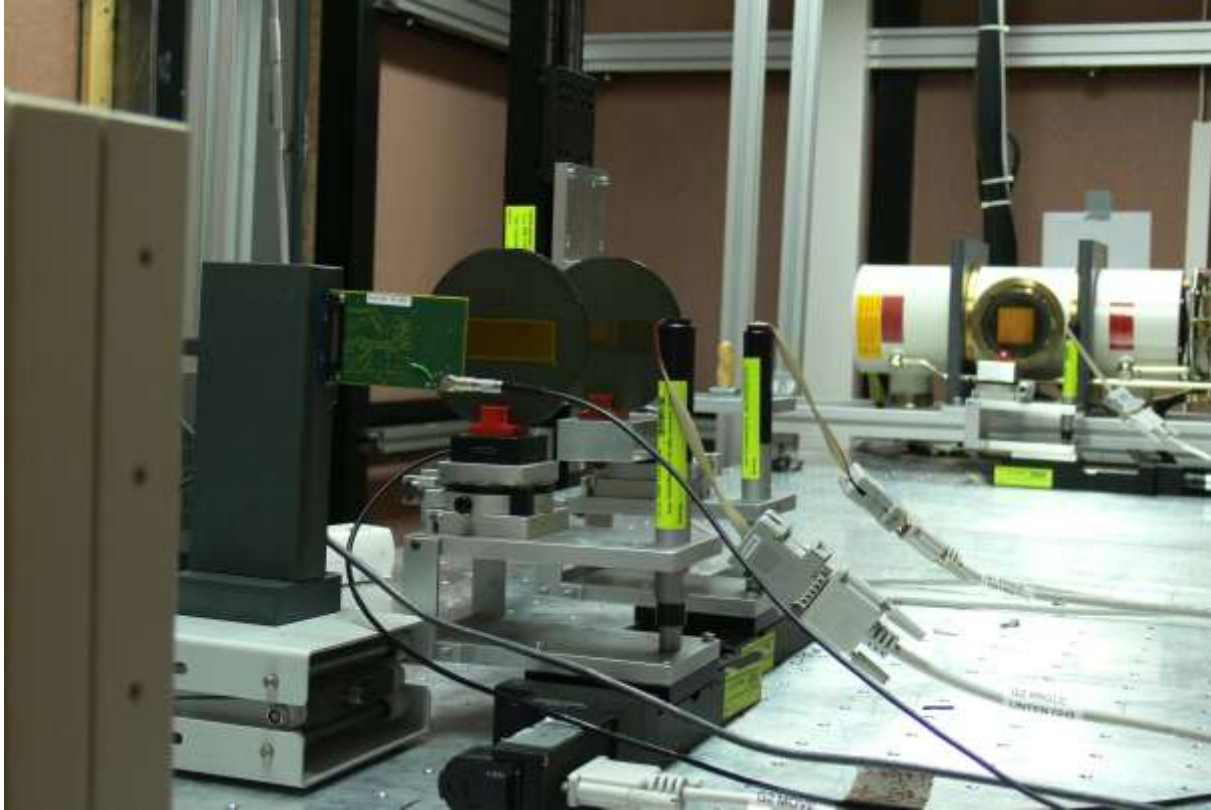
Differential phase



1-DCI

Darkfield

Experimental setup



Source:

- Siemens Megalix Cat Plus

Detectors:

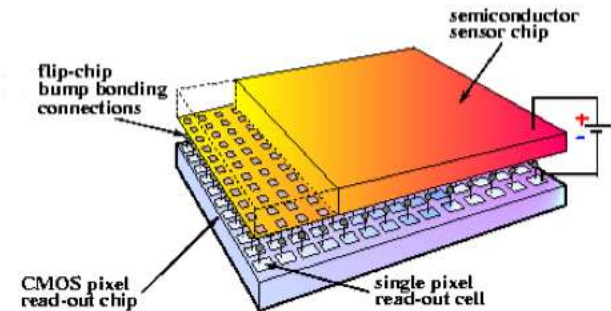
- Medipix family
- Varian PaxScan 2520D

Setup:

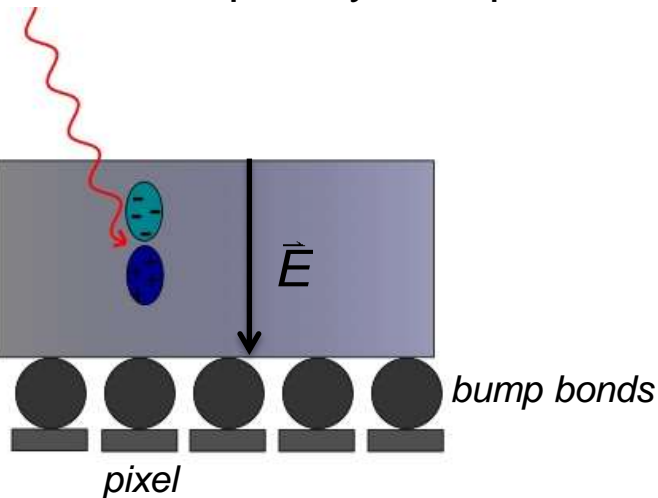
- 3rd Talbot distance
- 25keV design energy

Gratings	Period	Material	Height
G0	24.39 μm	Au	150 μm
G1	4.37 μm	Ni	8.7 μm
G2	2.4 μm	Au	110 μm

Detector: Medipix2 MXR



- Hybrid, photon counting detector
- 256x256 pixel
- 55 μm pixel pitch
- Sensor material: 300 μm Si
- Developed by Medipix-Collaboration @ CERN



1. Photon interacts with sensor layer
2. Charge carriers are released
3. Drifting towards the electrodes
4. Where a voltage pulse is induced
5. If voltage pulse exceeds a threshold level (THL), the pixel counter is incremented

Measured counting rate:
$$C(E_{THL}) = \int_{E_{THL}}^{\infty} D(E) dE$$

Simulation framework: SPHINX

1. Monoenergetic simulation of the wavefront intensity
2. Weighting with X-ray spectrum
3. and detector efficiency (Si)
4. Image reconstruction:
(Absorption, phase and darkfield signal)
 - Monoenergetic with or without efficiency and spectrum
 - For arbitrary energy thresholds (THL-scan)

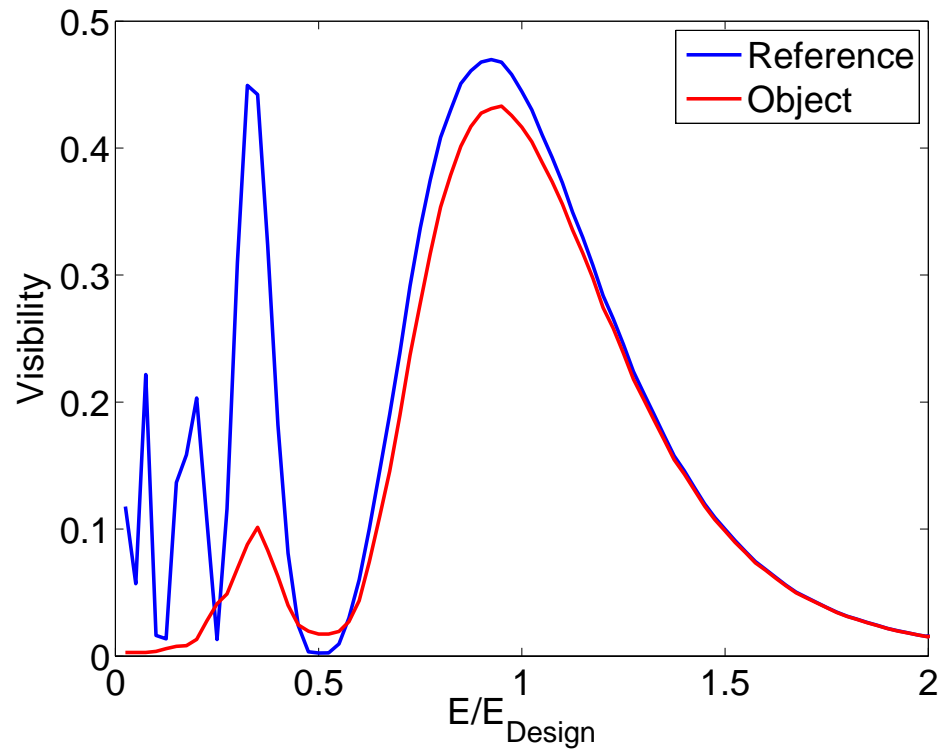
Energy-resolved interferometric X-ray imaging

Object: 1mm of glass spheres ($r \approx 75\mu\text{m}$)

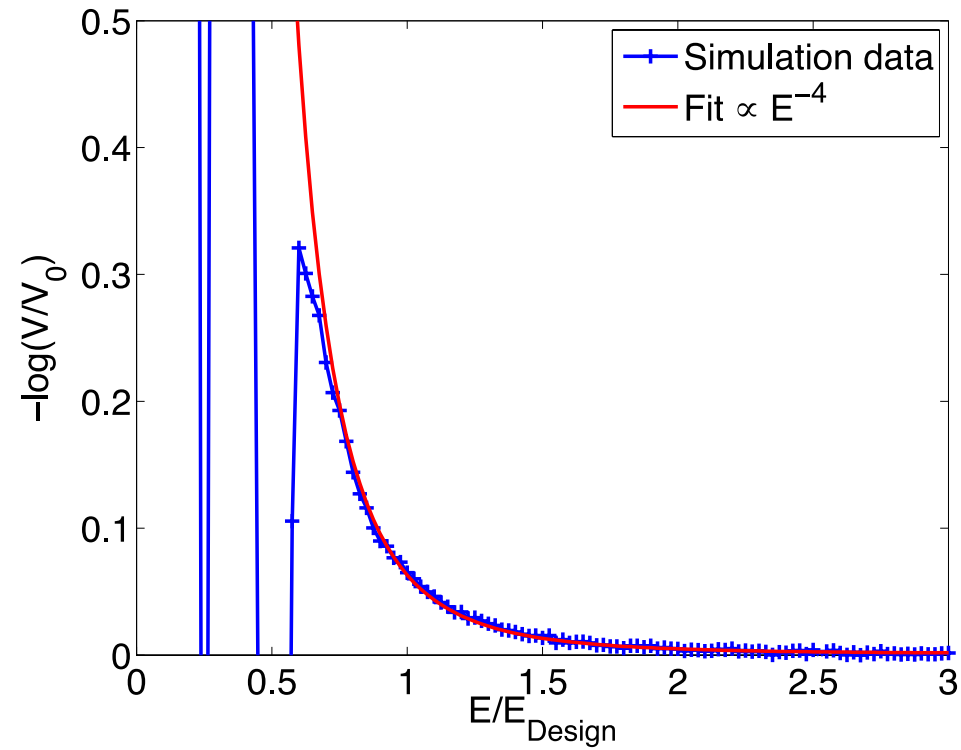
- Simulation of the monoenergetic behavior of darkfield signal
- Measurement of the darkfield signal via THL-scan
- Comparison with simulated THL-scan

Simulation data

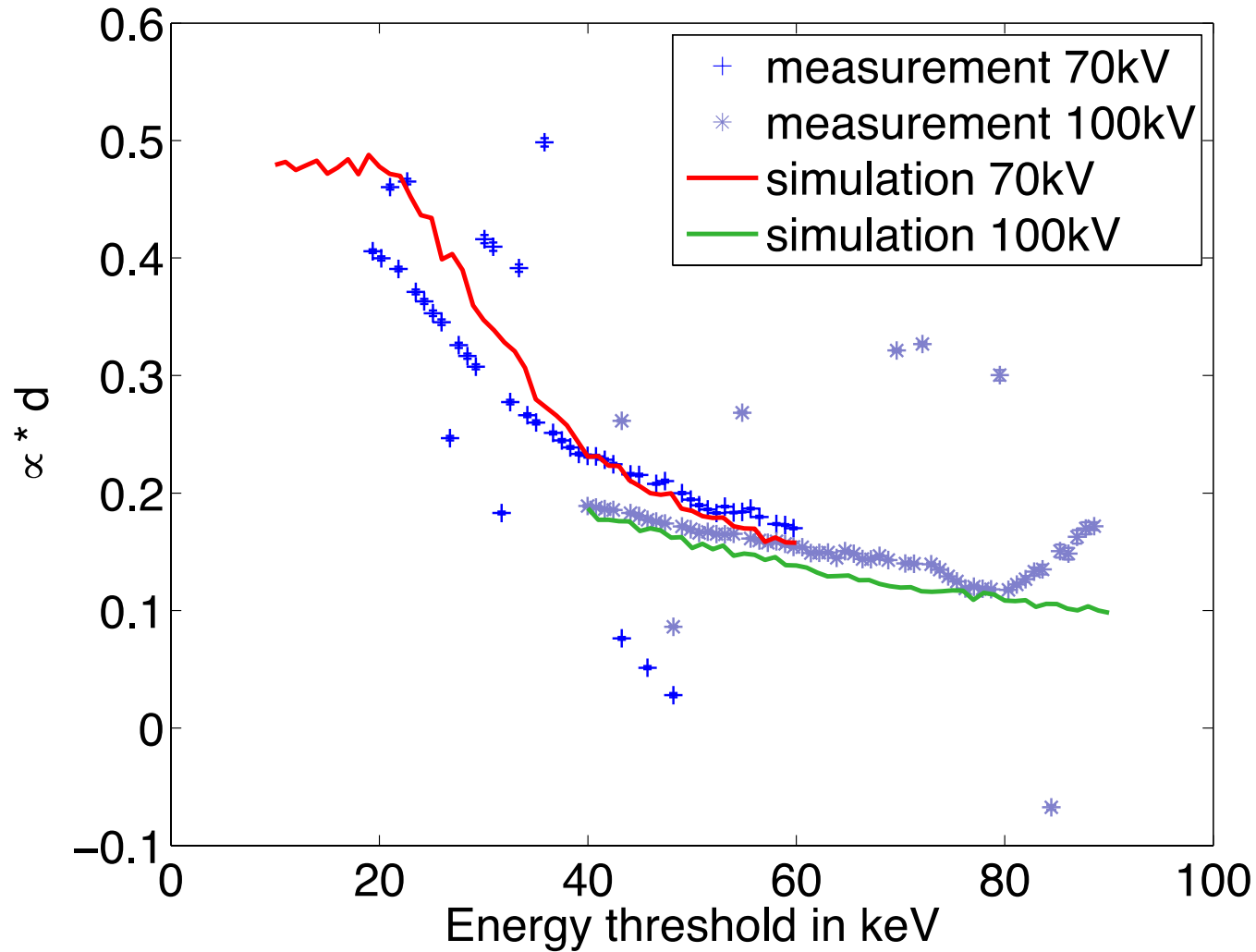
Visibility



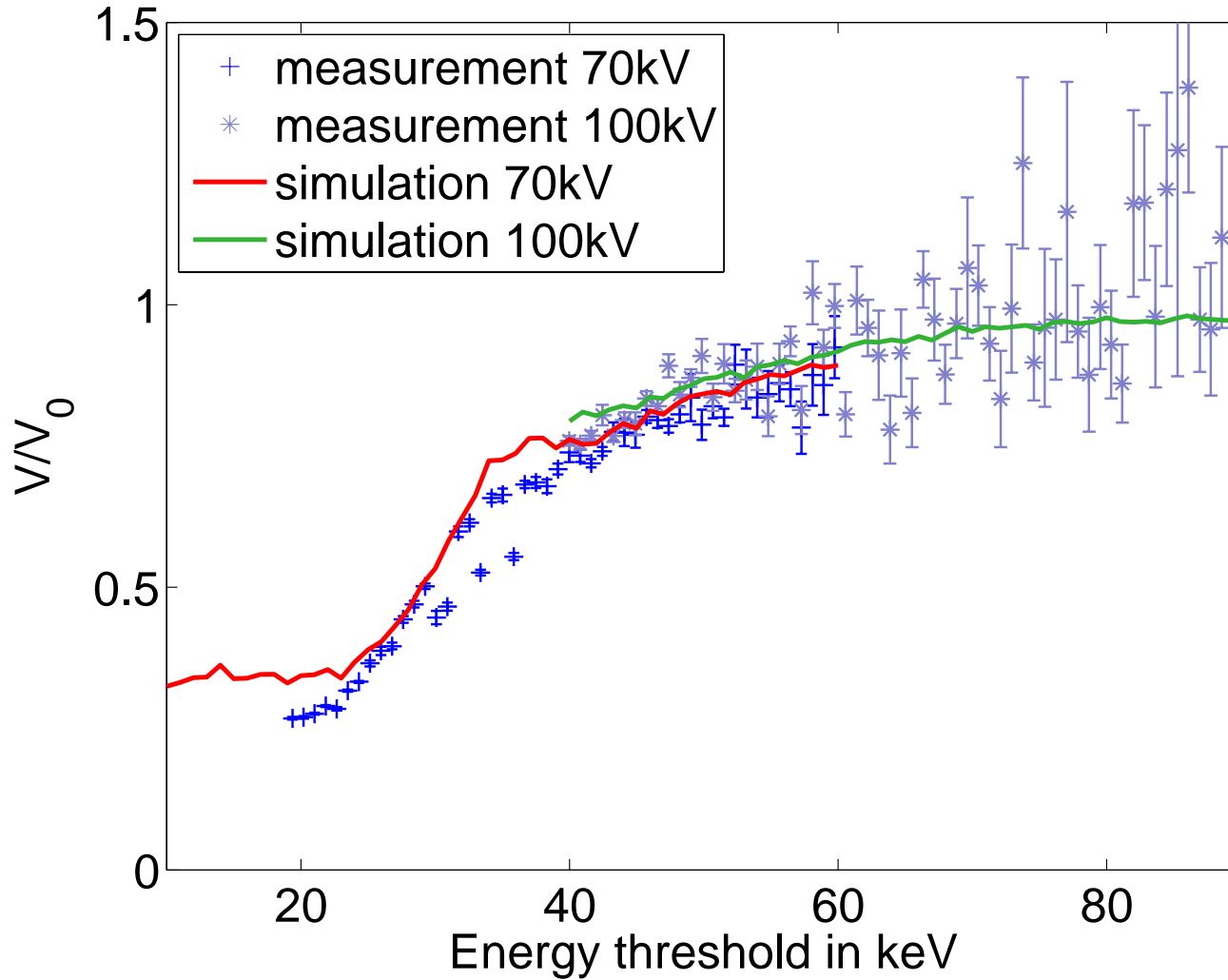
Darkfield signal



Measurements: Absorption



Measurements: Darkfield



Conclusion and outlook

- Simulation and measurement of absorption and darkfield signal of glass spheres
- Good agreement of simulation and measurement
- Energy dependence of darkfield signal in monoenergetic simulation seems reliable

- Measurement of the darkfield in energy bins (Medipix3)
- Examine energy dependence for different setups and objects

Thanks for your attention!