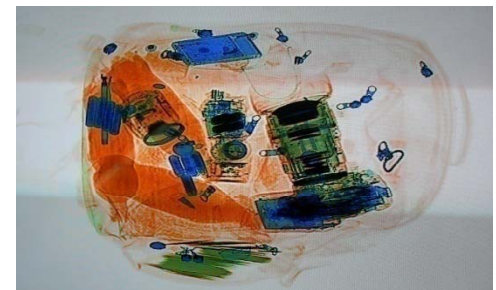
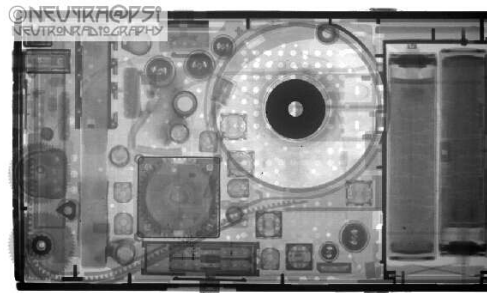
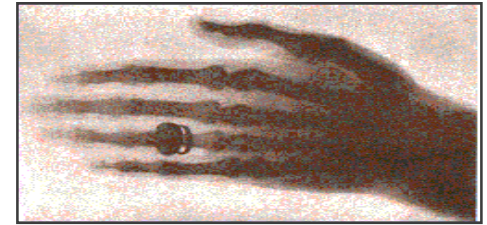

X-ray Phase Contrast Imaging

Vincent Revol

Zürich, 04.06.2009

X-ray Imaging : The story

- Discovered in 1895 by W. Roentgen (Nobel Prize)
- Found widespread applications in imaging and structural analysis
- Phase contrast imaging found interest in the 80's (3rd generation synchrotrons)
- **Project Motivation:** Democratize the method for real applications
Develop the technology toward higher energies



Outline of the talk

- Physical Principle
 - What is phase contrast imaging?
- Operating Principle
 - How can we measure the phase with X-rays?
- Set Up Presentation
 - How is it implemented?
- Results
 - How does it look like?
- Outline
 - What are the challenges?

X-ray Imaging Terminology



X-ray source

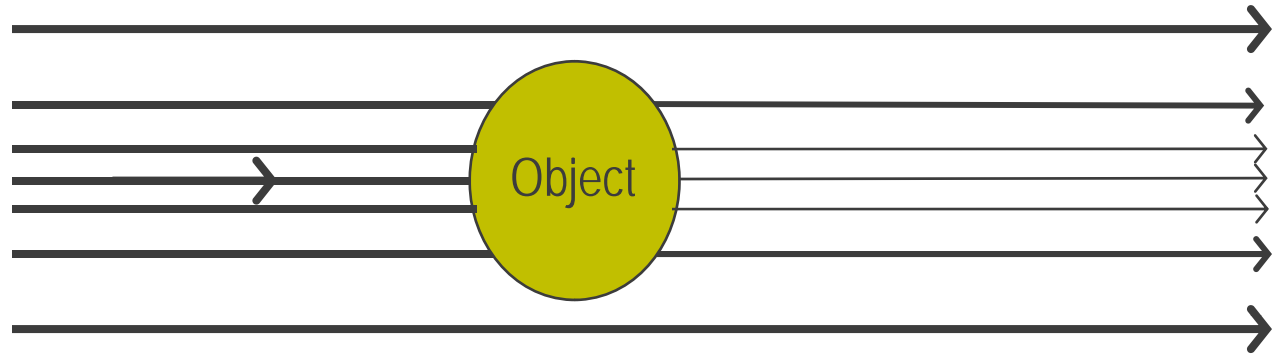
Object

Detector

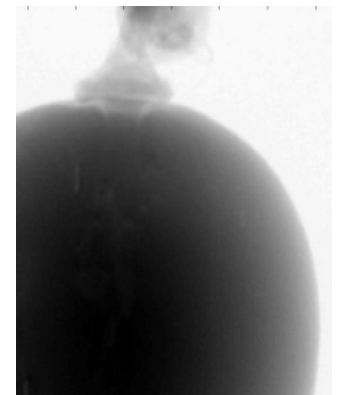
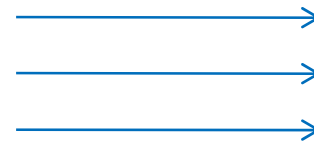
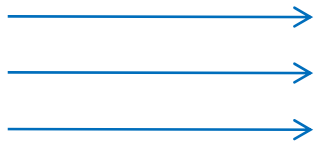
Interaction between object
and x-rays = „contrast“

Conventional Radiography

Photoelectric effect
Compton Scattering



Absorption Image

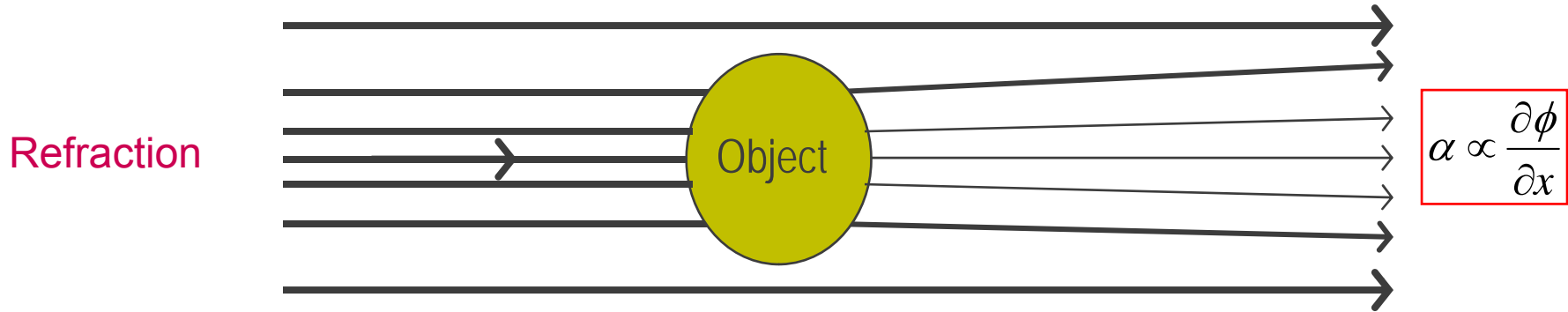


X-ray source

Object

Detector

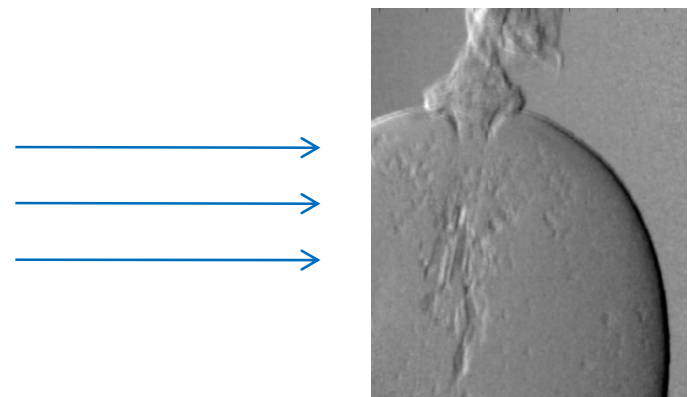
Differential Phase Contrast Image



X-ray source



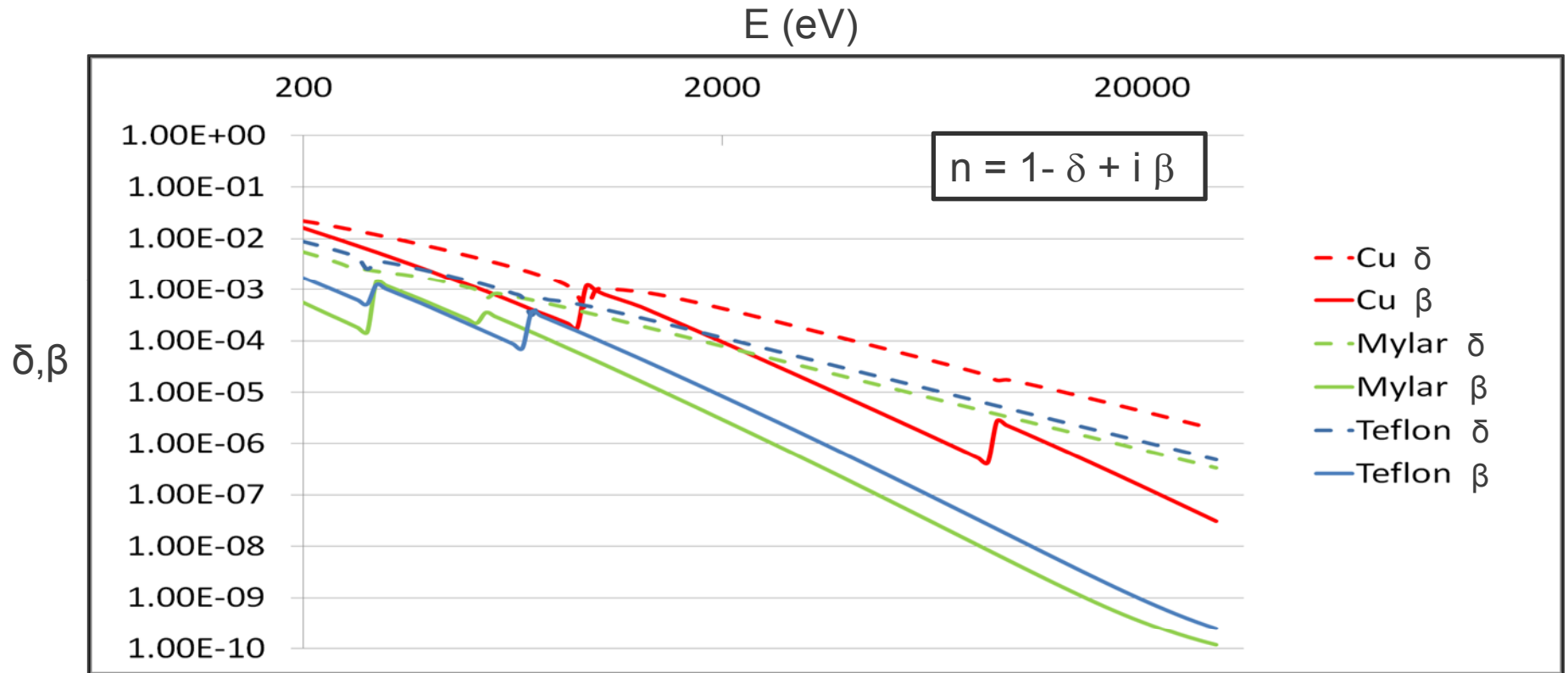
Object



Differential Phase Contrast Image

Detector

Why is Phase Contrast Imaging better?

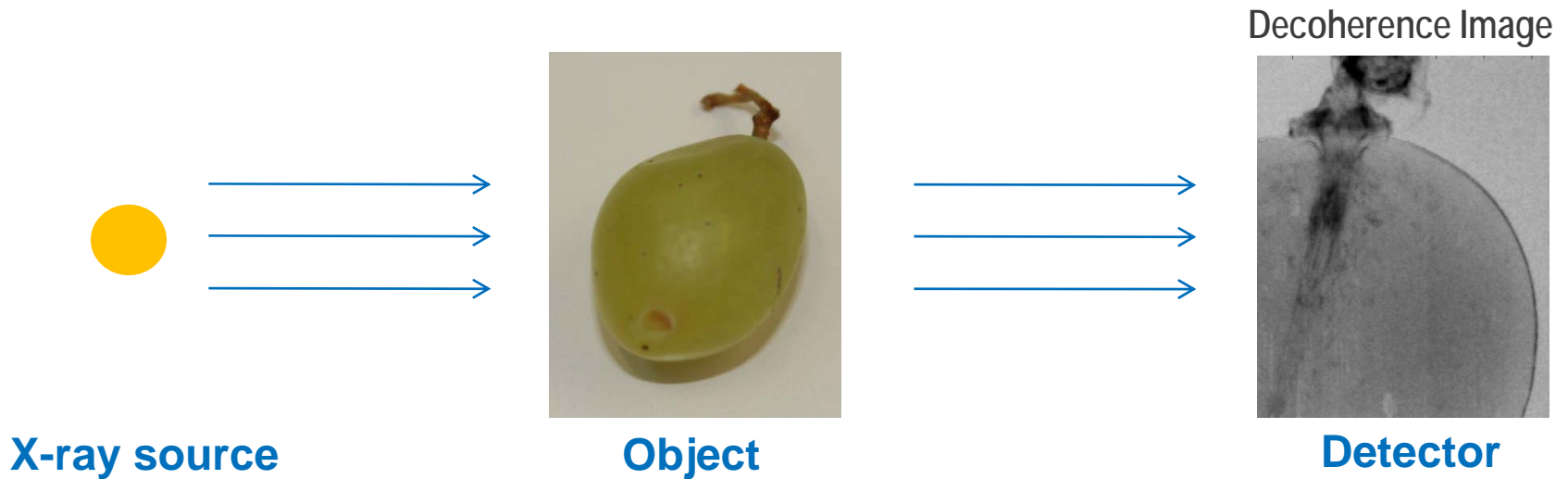
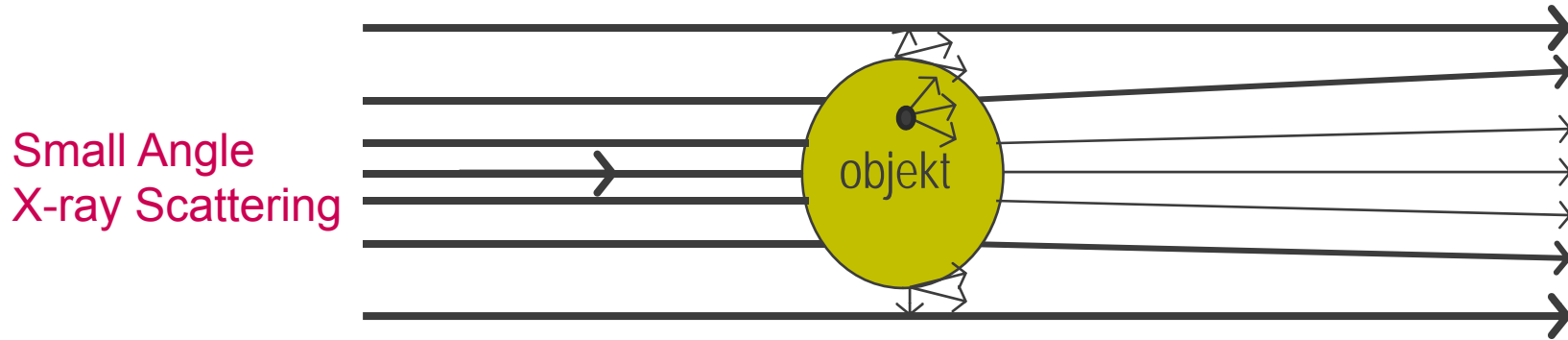


100 μm Mylar behind 100 μm Copper



Absorption Contrast = 0.2%
Phase Contrast = 17.6%

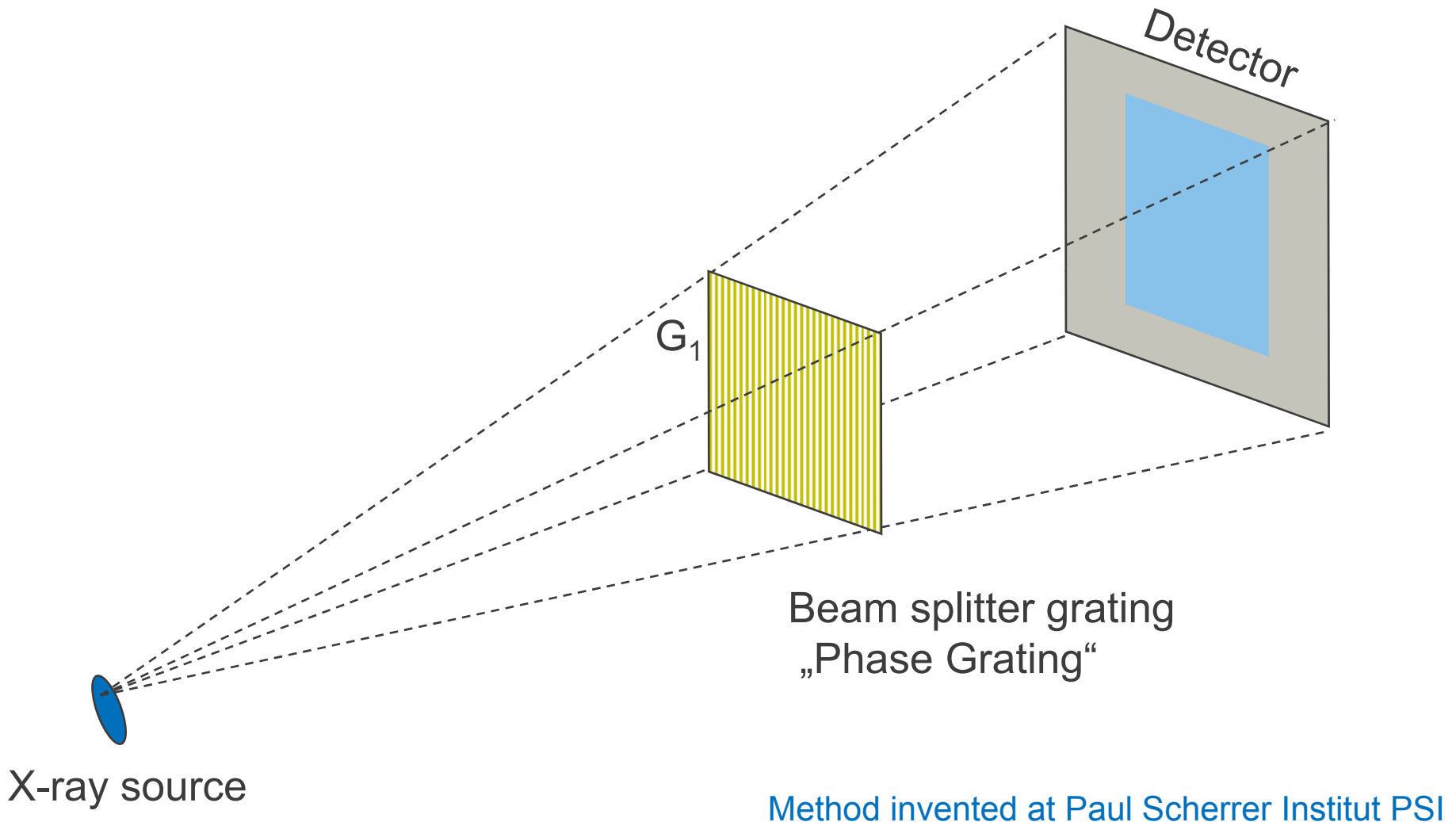
Decoherence Image



Outline of the talk

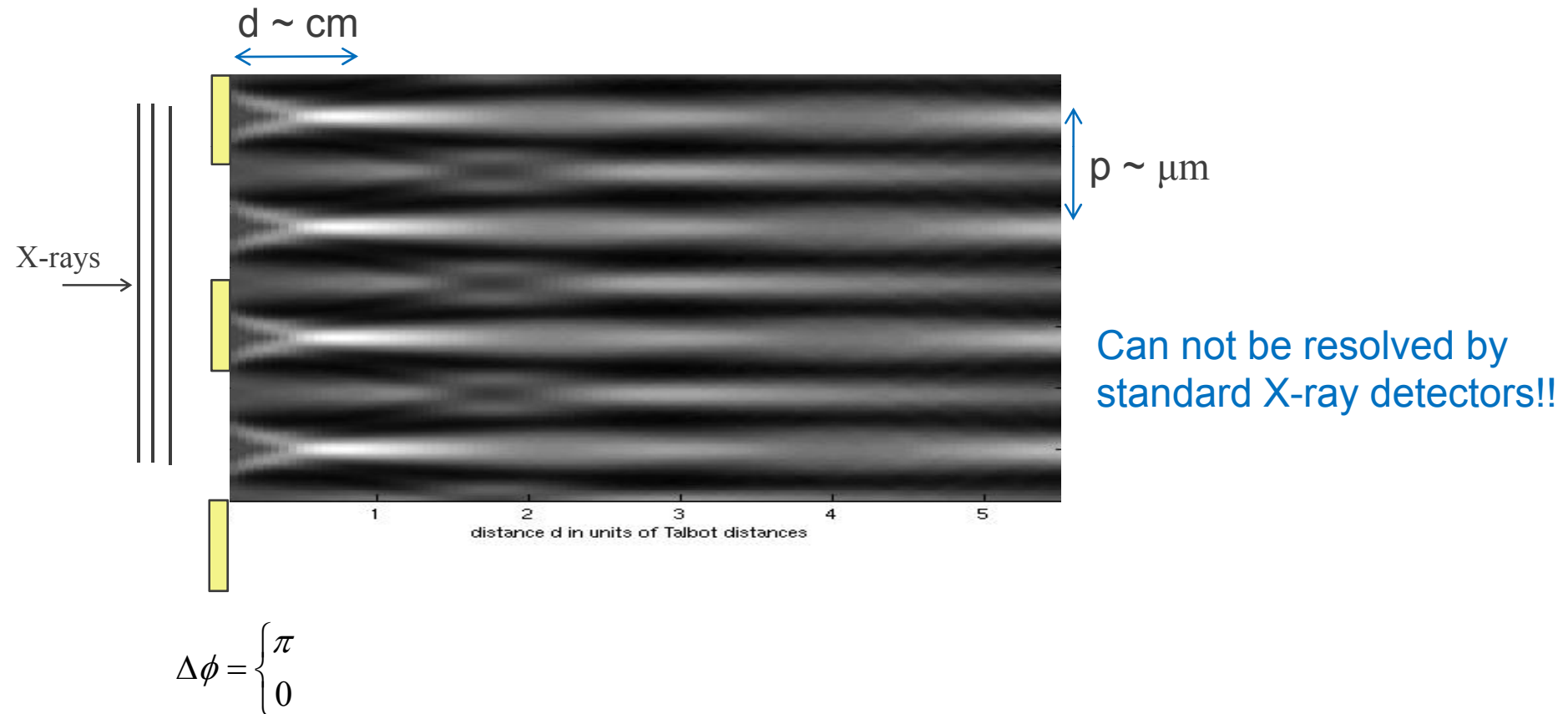
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Talbot-Lau grating interferometer set-up

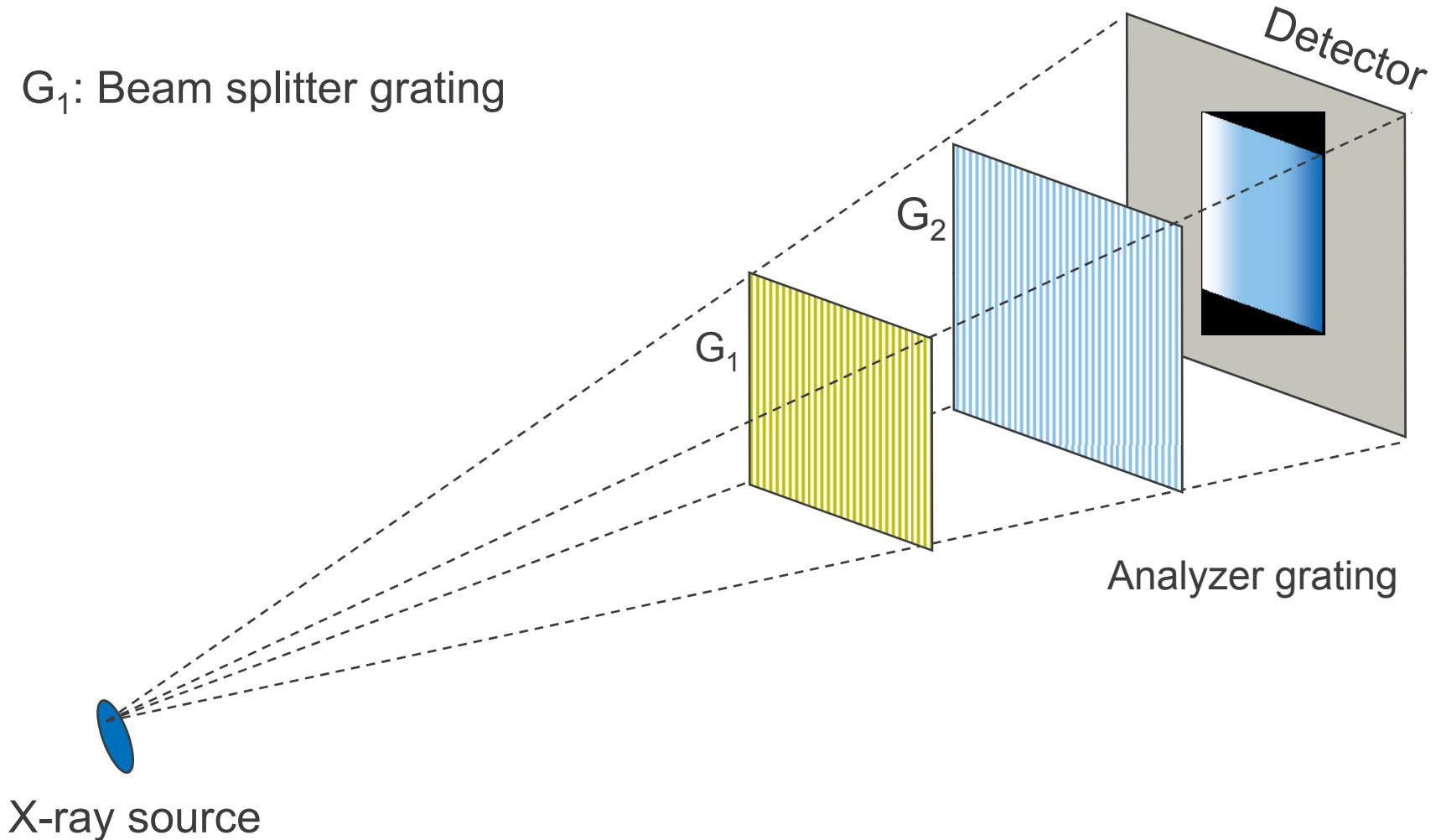


Operating Principle

Beam Splitter Grating: “Talbot Effect”

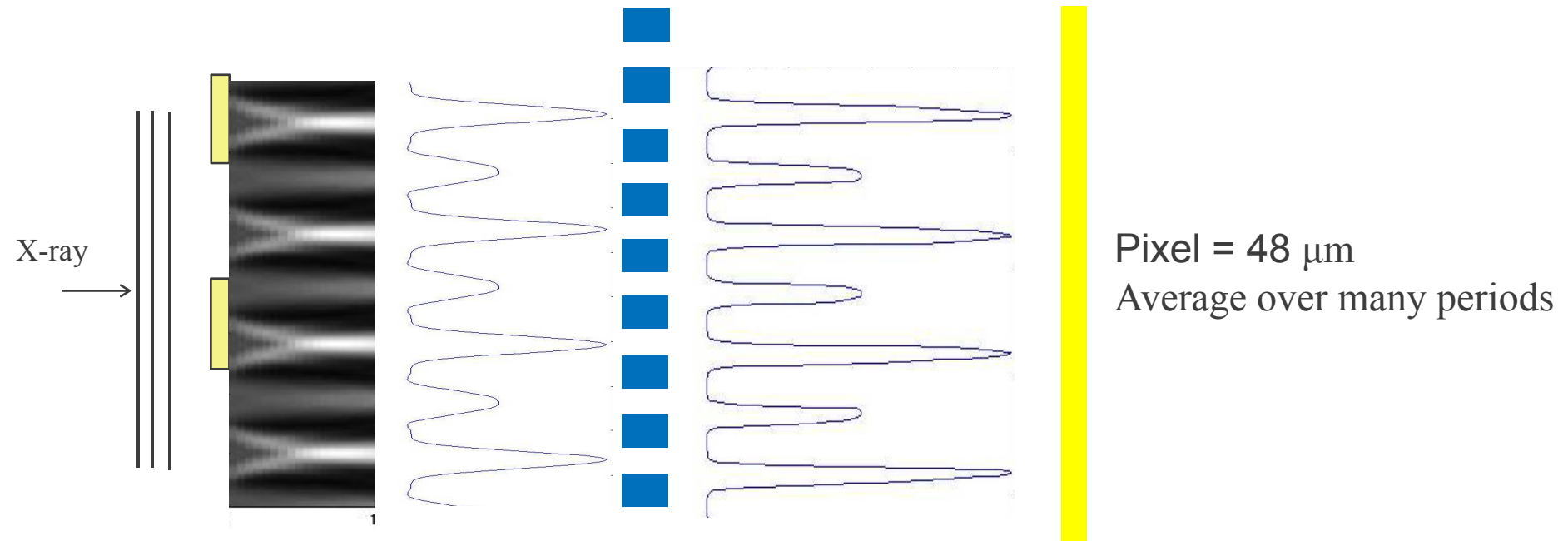


Talbot-Lau grating interferometer set-up



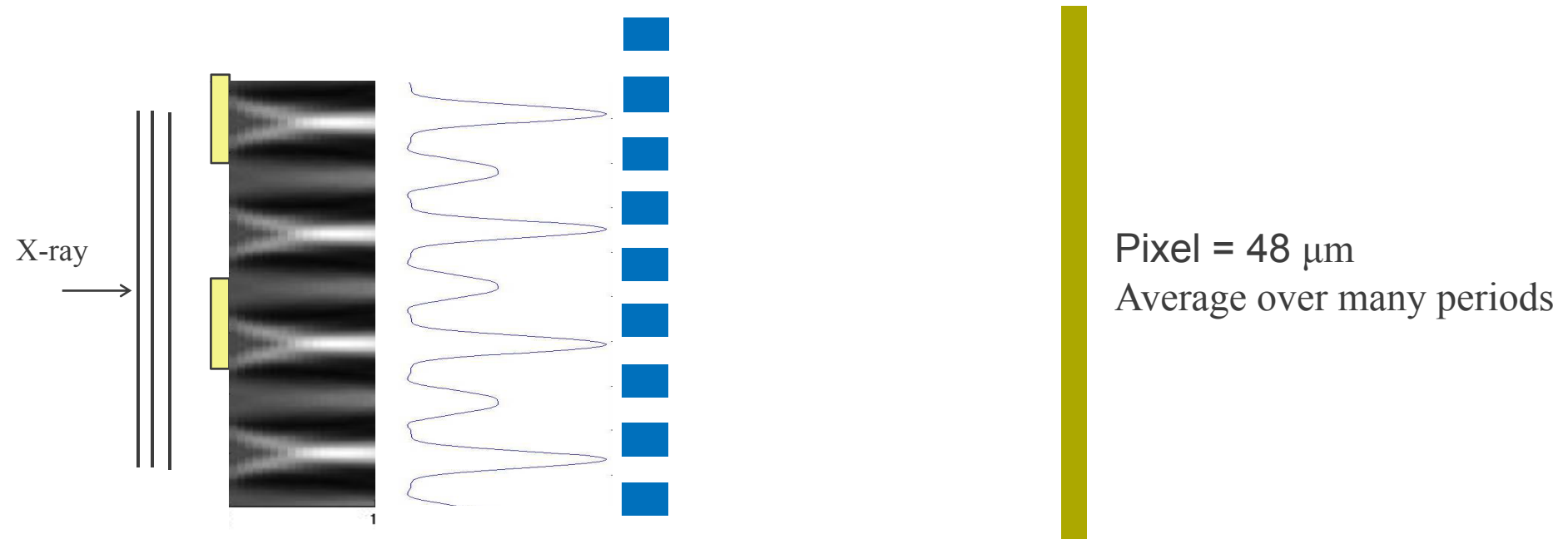
Operating Principle

Phase Stepping:



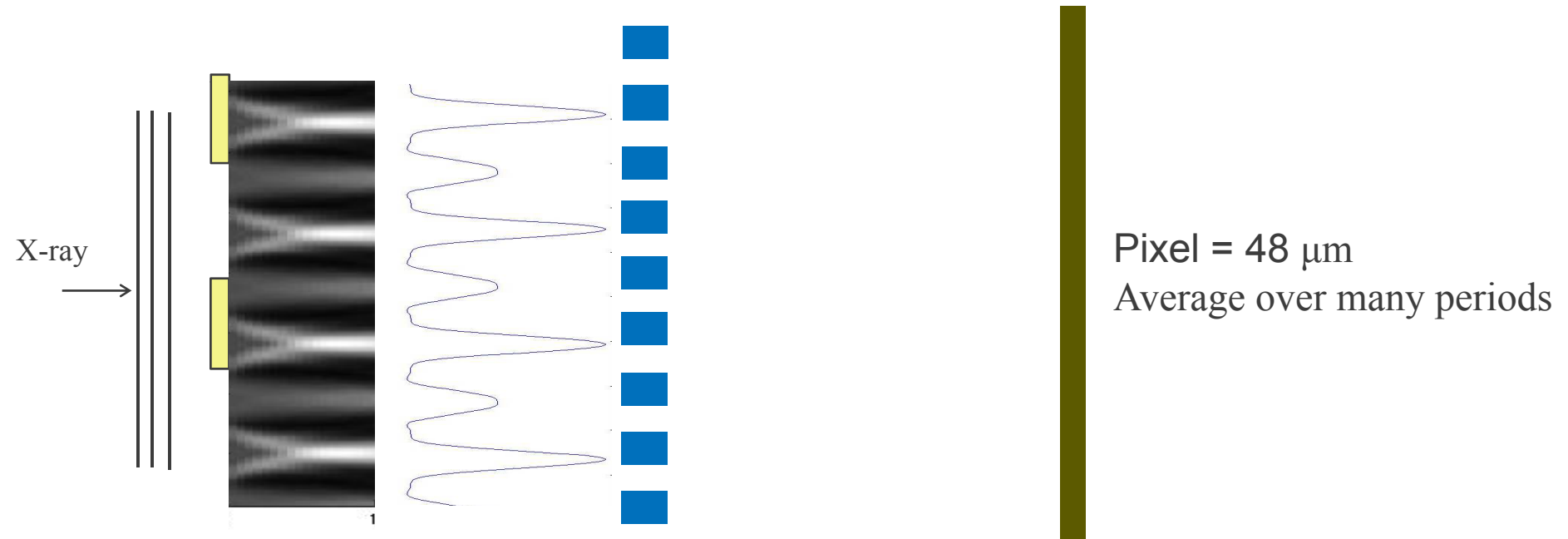
Operating Principle

Phase Stepping:



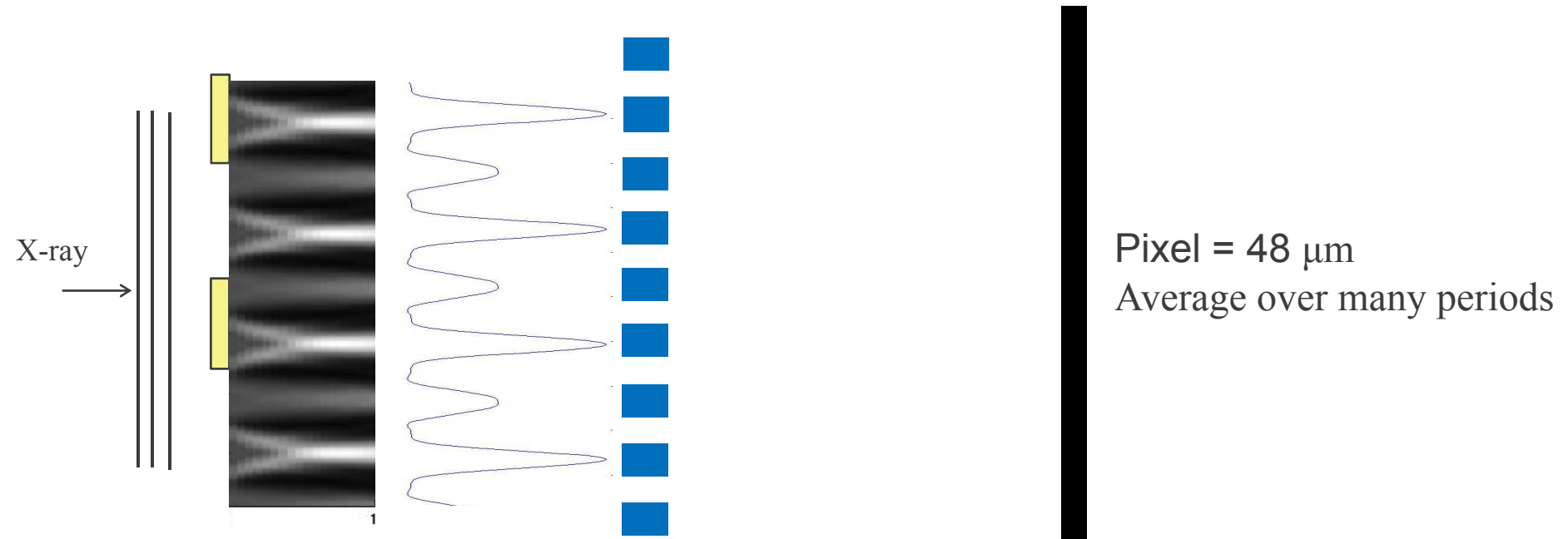
Operating Principle

Phase Stepping:



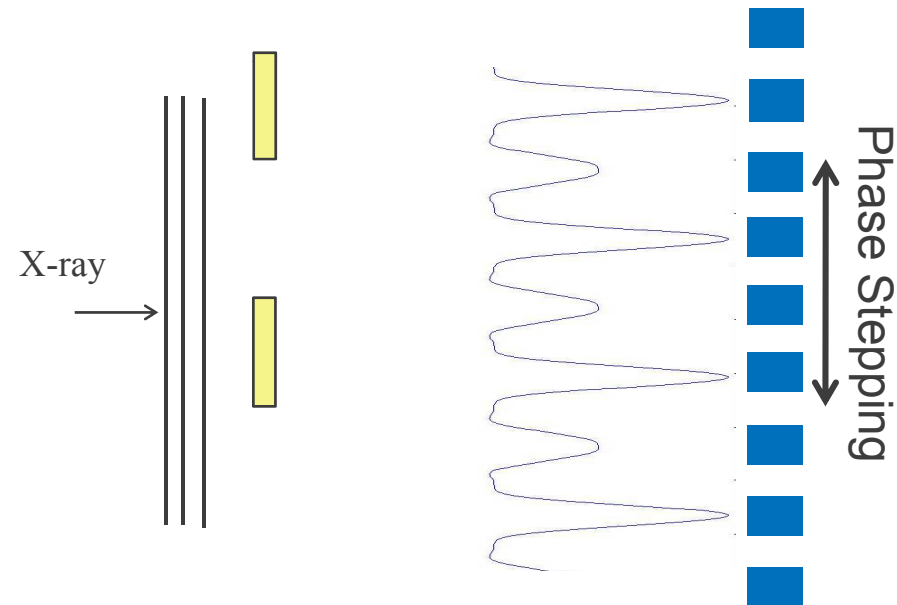
Operating Principle

Phase Stepping:

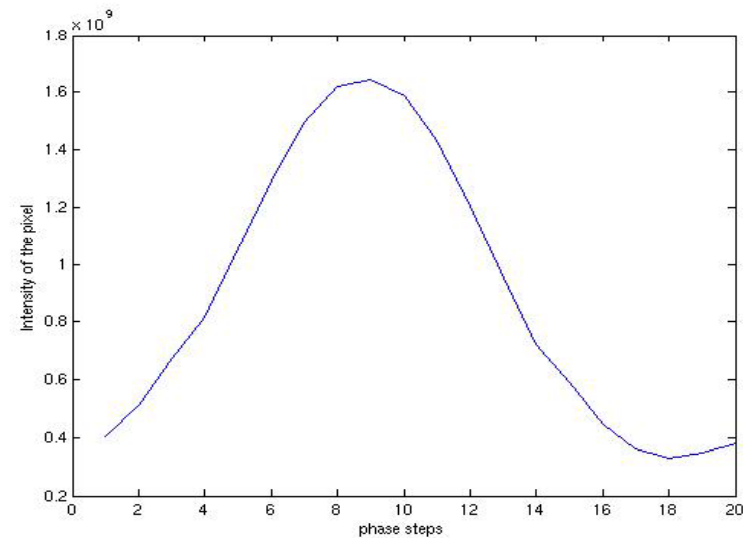


Operating Principle

Phase Stepping:



$$V = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$



Phase Stepping Curve

Talbot-Lau grating interferometer set-up

- G_0 : Source grating
- G_1 : Beam splitter grating
- G_2 : Analyzer grating

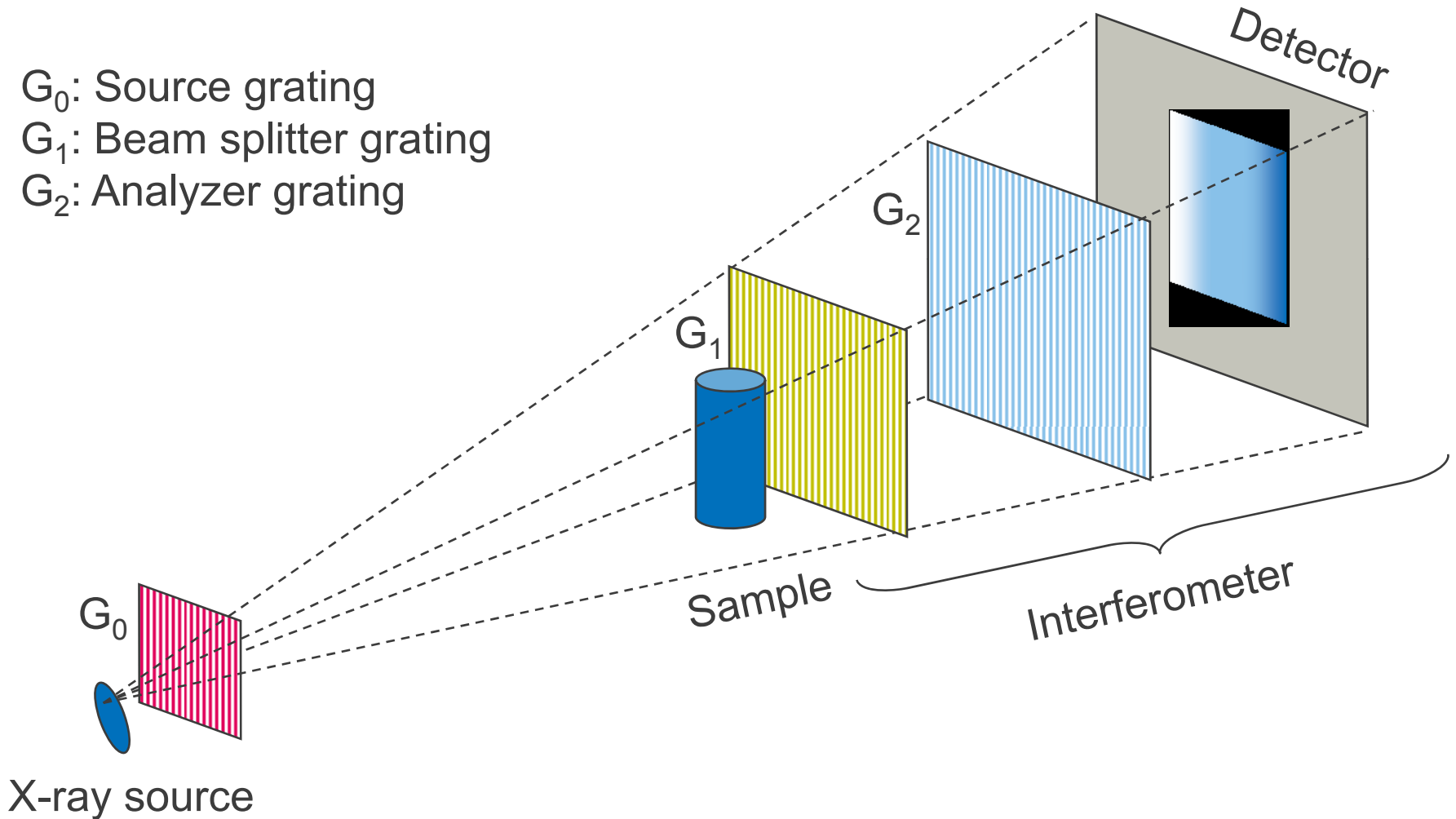


Image Extraction

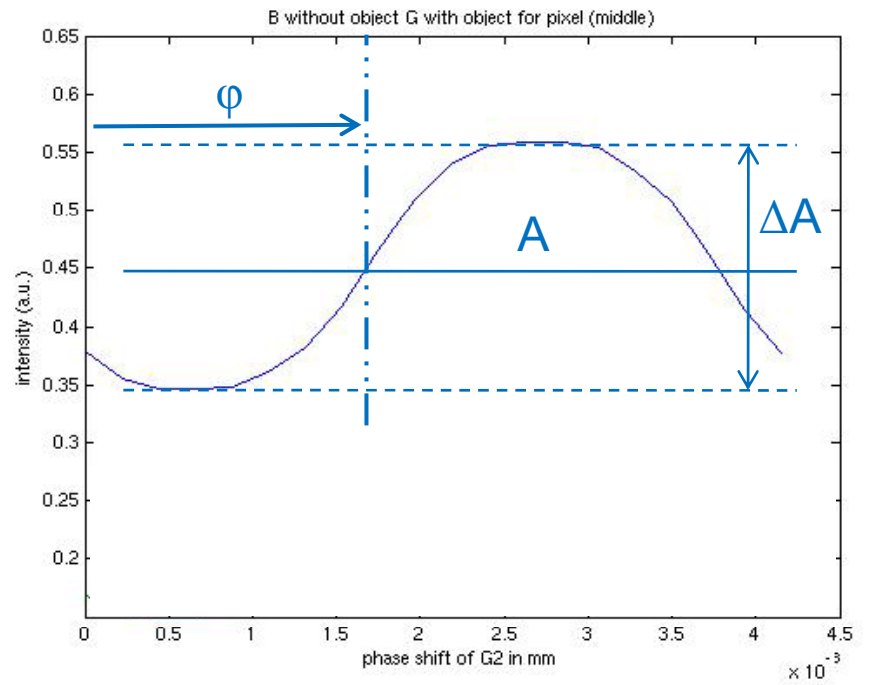
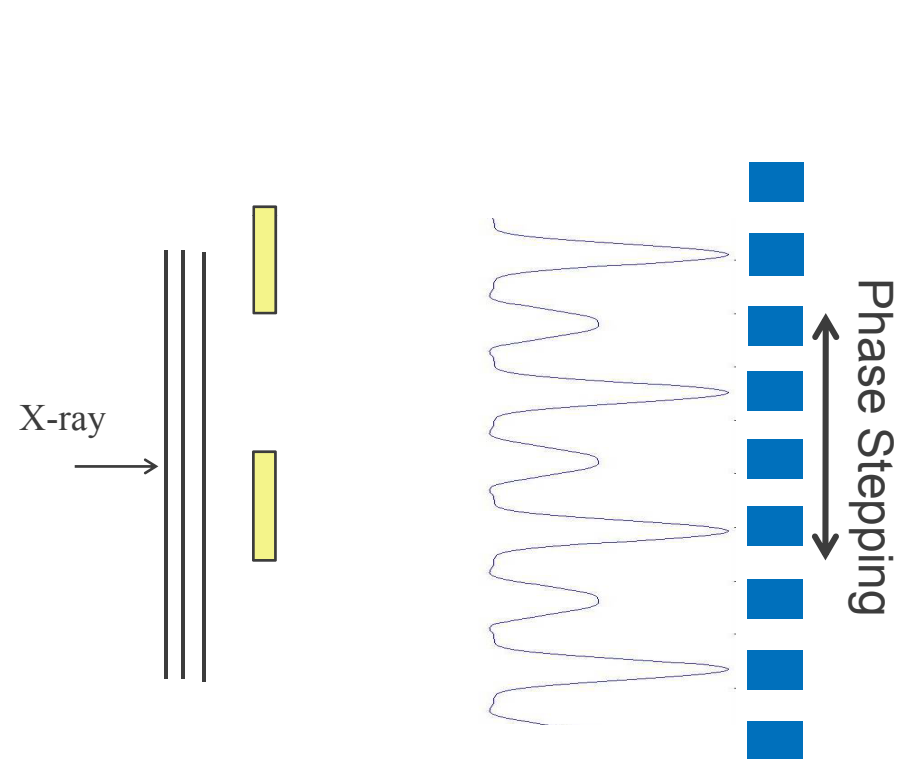
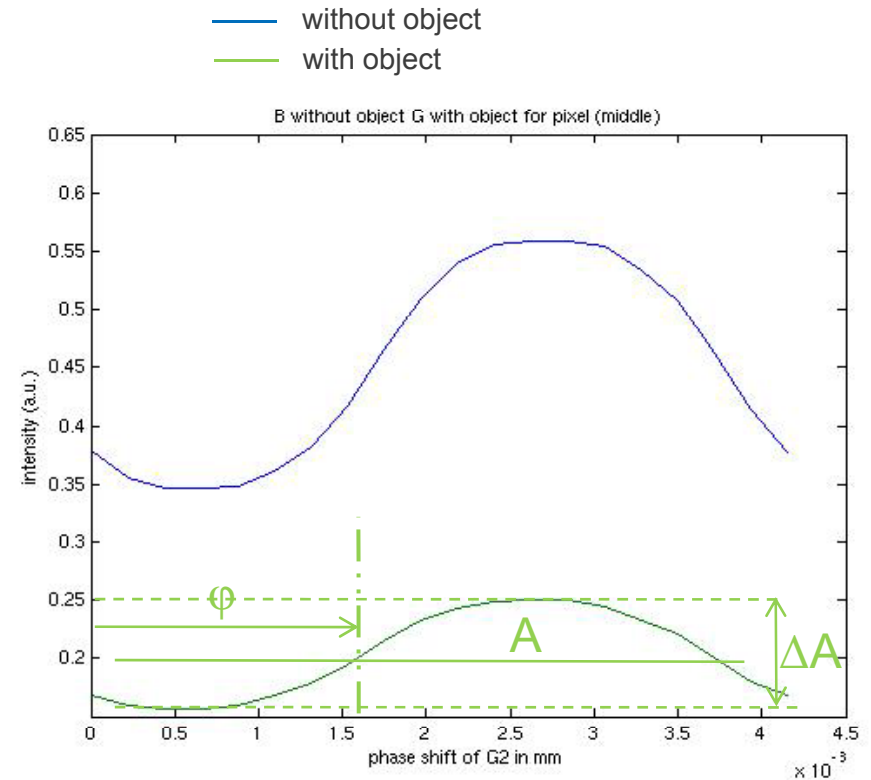
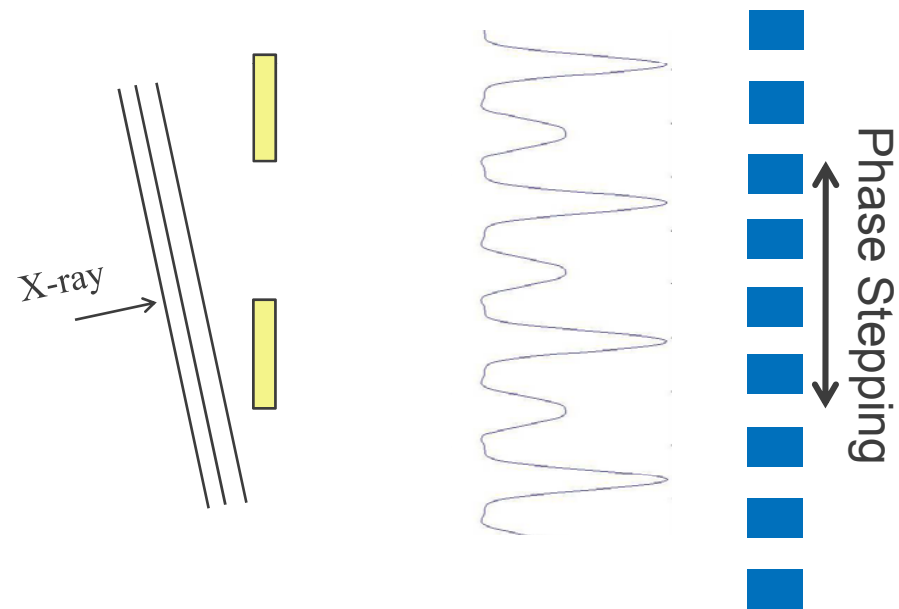


Image Extraction

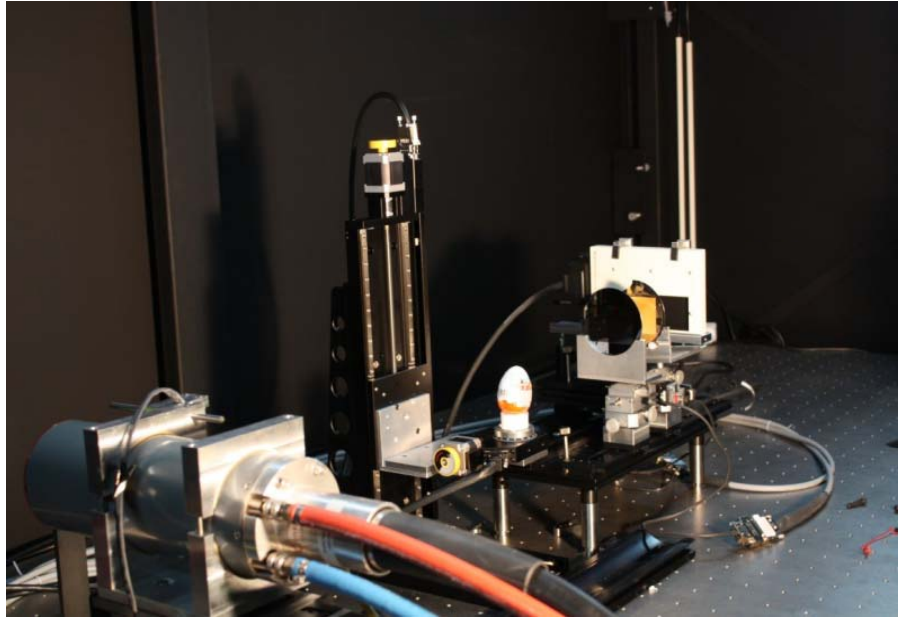


- A Absorption Image
- ϕ Differential Phase Contrast
- $\Delta A / A$ Decoherence Image

Outline of the talk

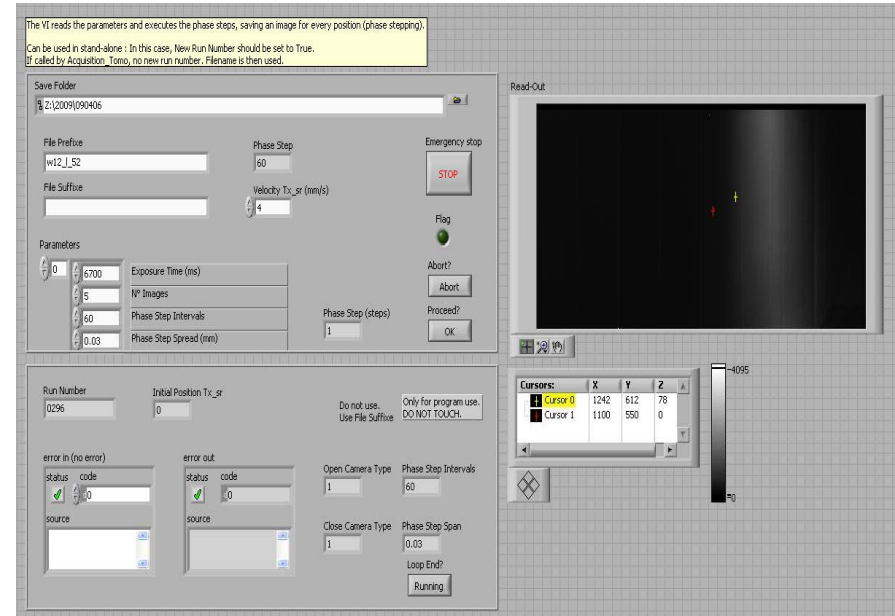
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System Construction



Mechanical Assembly

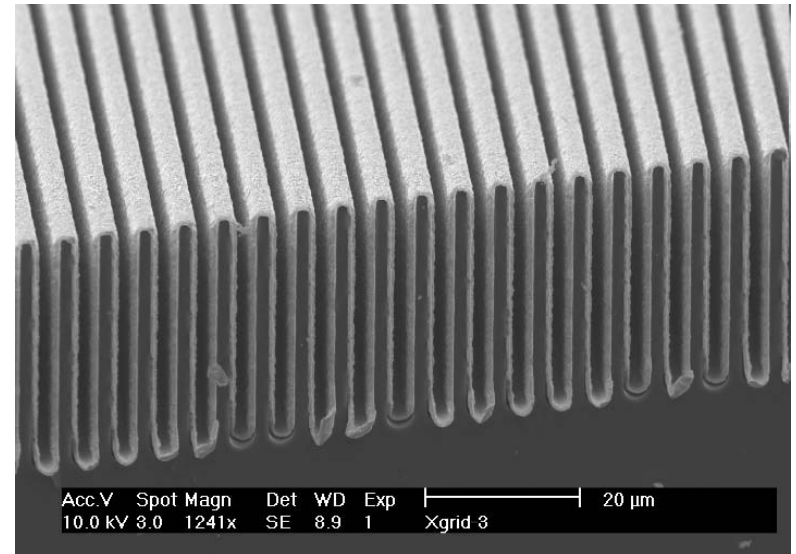
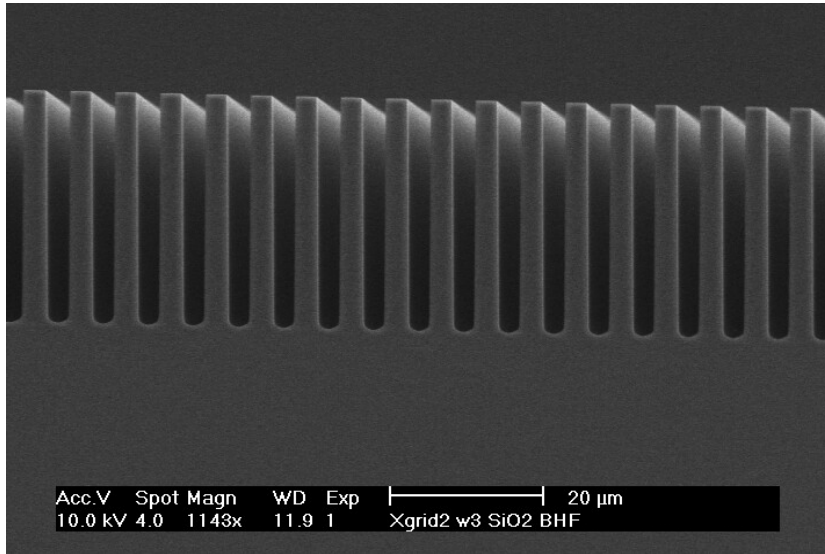
- Design done by CAD (Solidworks)
- Fabrication at the Physics Institute Workshop



Measurement Automation

- Control of the motors, detector...
- Programmed in the Labview environment

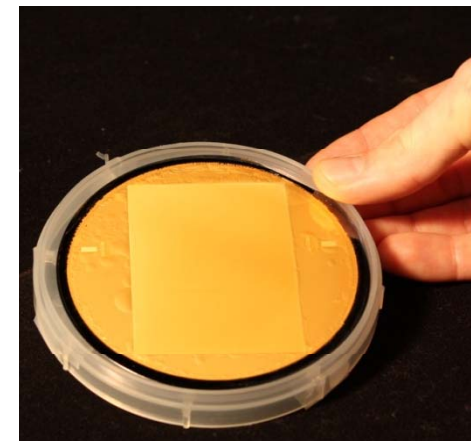
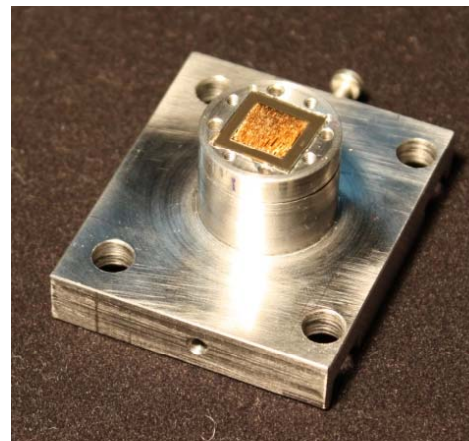
Gratings Fabrication



Fabricated at the CSEM Neuchâtel

Grating set for 25keV

- Fabrication at the CSEM Neuchâtel



Outline of the talk

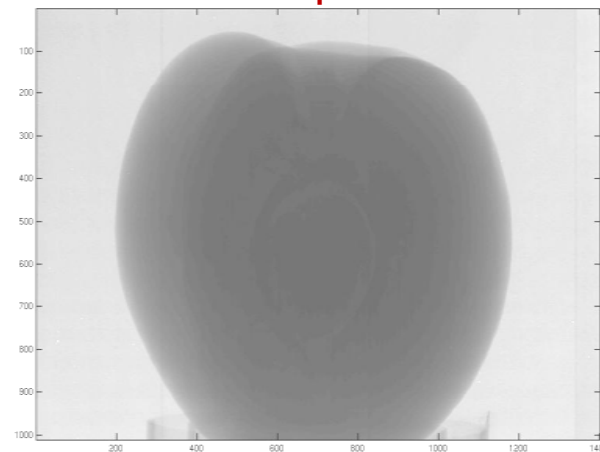
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Results : Single Projection

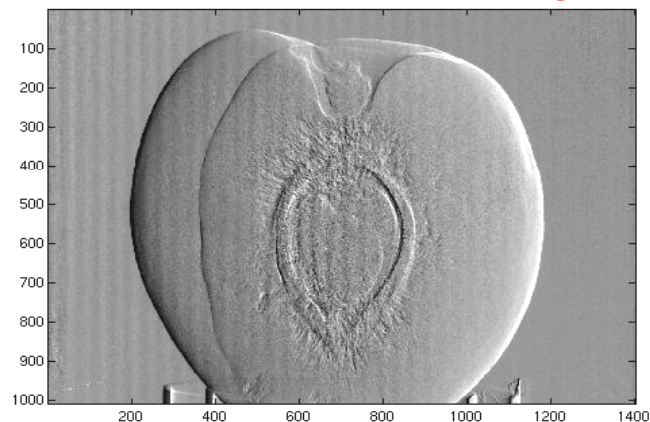


Images of an apricot
 $V_{\text{tube}} = 40\text{kV}$

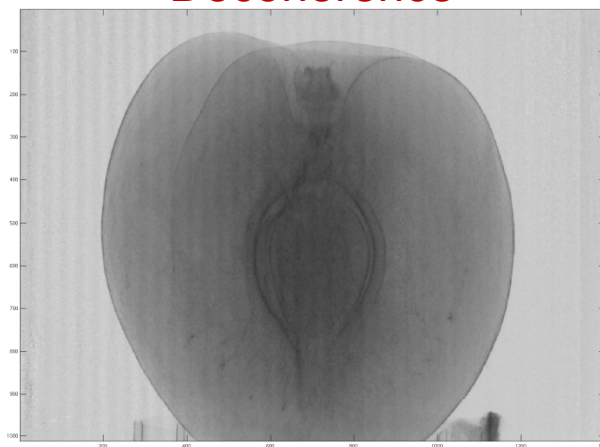
Absorption



Differential Phase Image

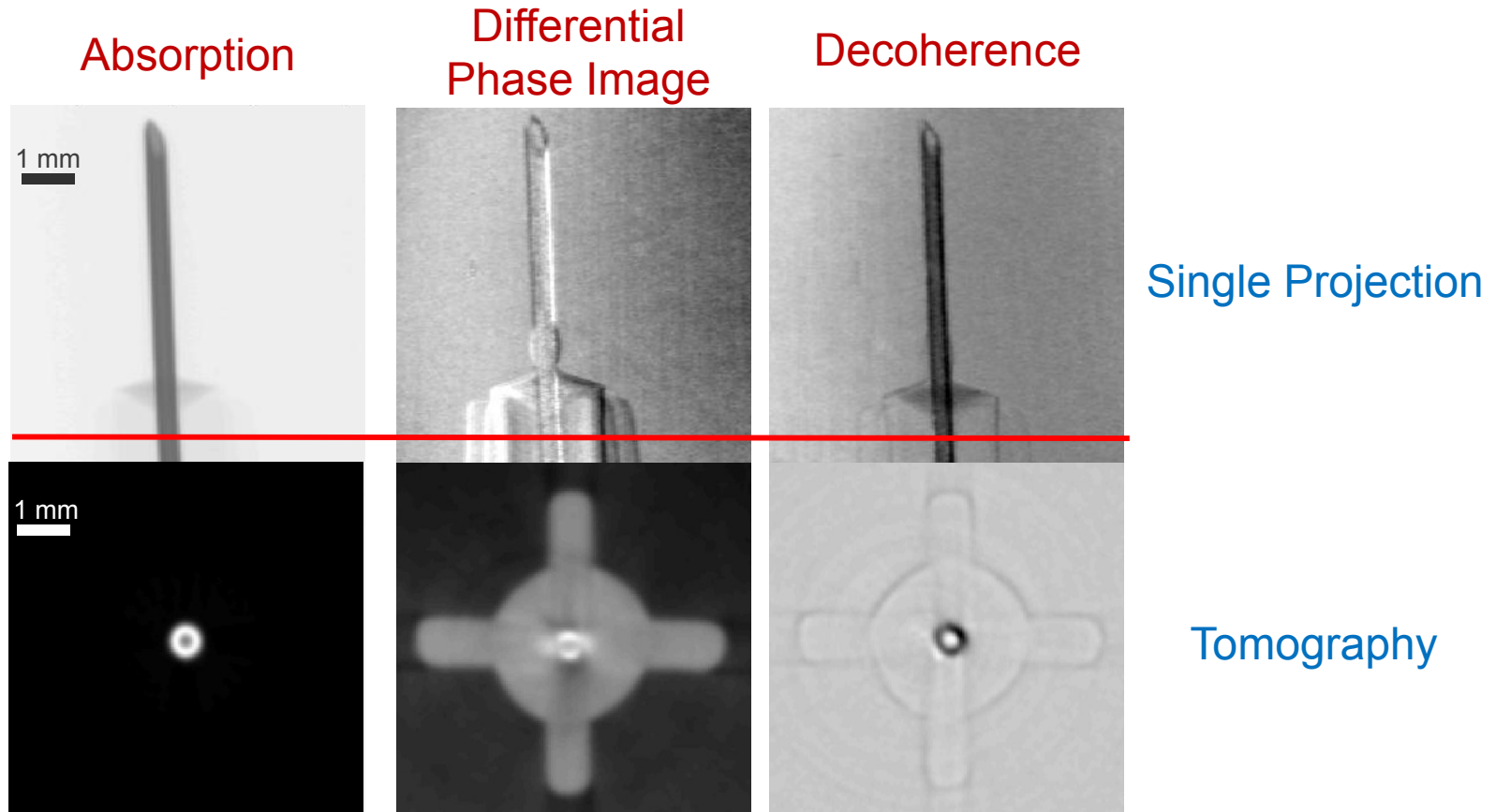


Decoherence



Results : Single Projection and Tomography

Images of a polymer fiber in a syringe
 $V_{\text{tube}} = 40\text{kV}$

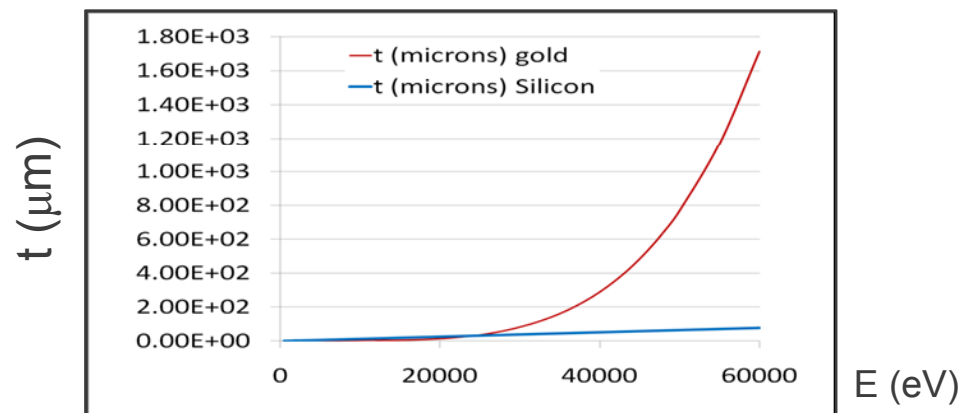
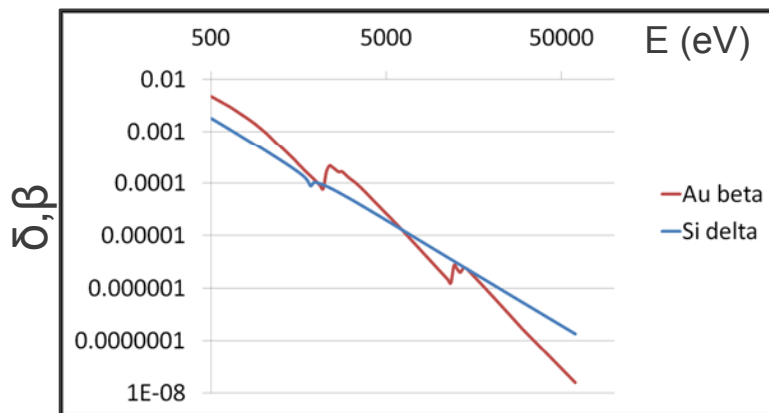


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Objectives

- Achieve Phase Contrast Imaging at 60-80 keV
→ Build gratings with higher aspect ratio
- Increase the field of view
→ Compensate the non-spherical profile of the gratings
- Optimize the set up for real applications
→ Reconstruction, tomography and features extraction algorithms
- Develop some new ideas...



Thank you for your attention!