Preservation of Coherence

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Optics Satellite Workshop
SR Users Meeting
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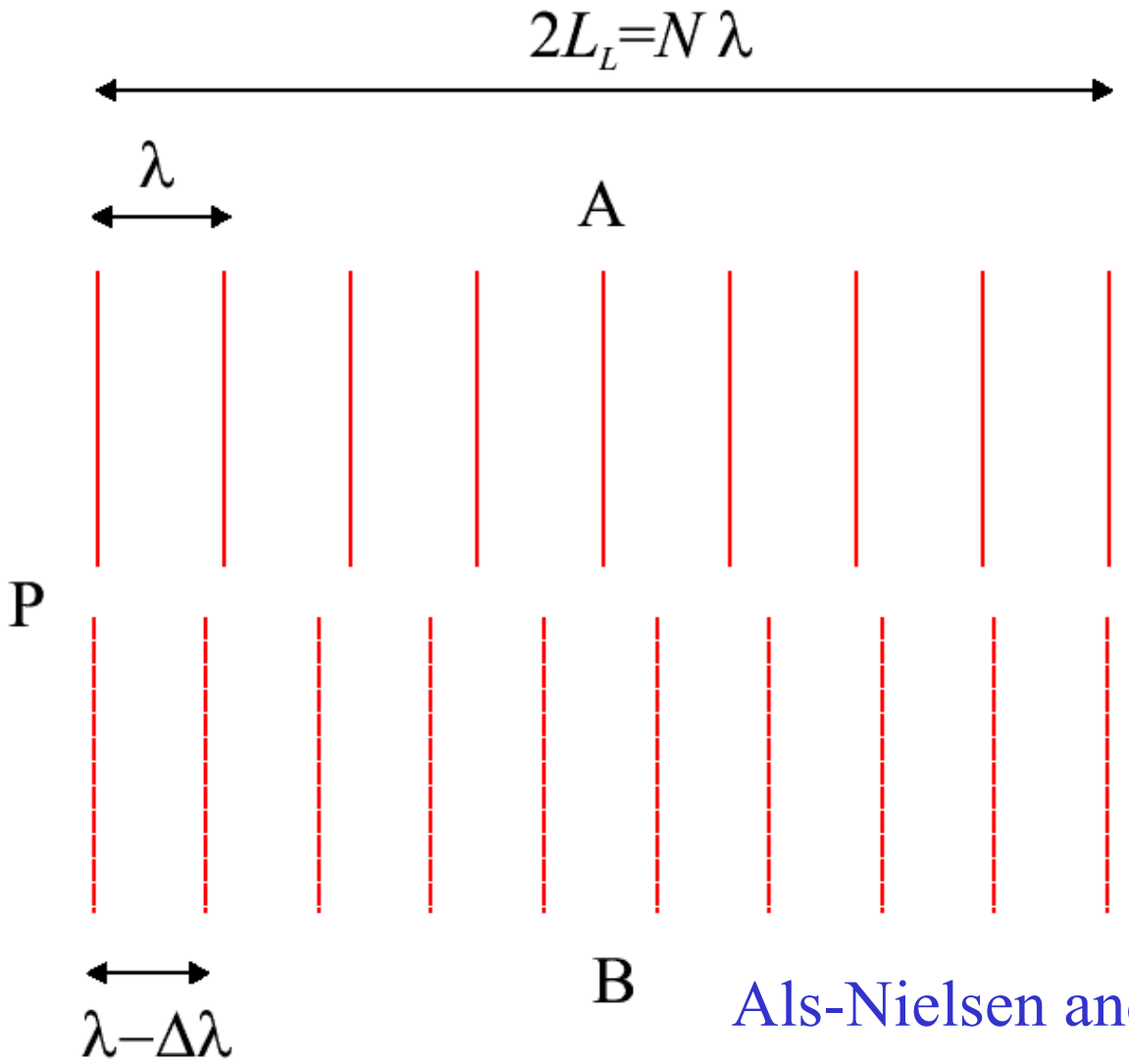
Outline

- Coherent Diffraction Overview
- Coherence in Kirkpatrick-Baez focus
- Effect of windows on coherence
- Geometry and Longitudinal coherence

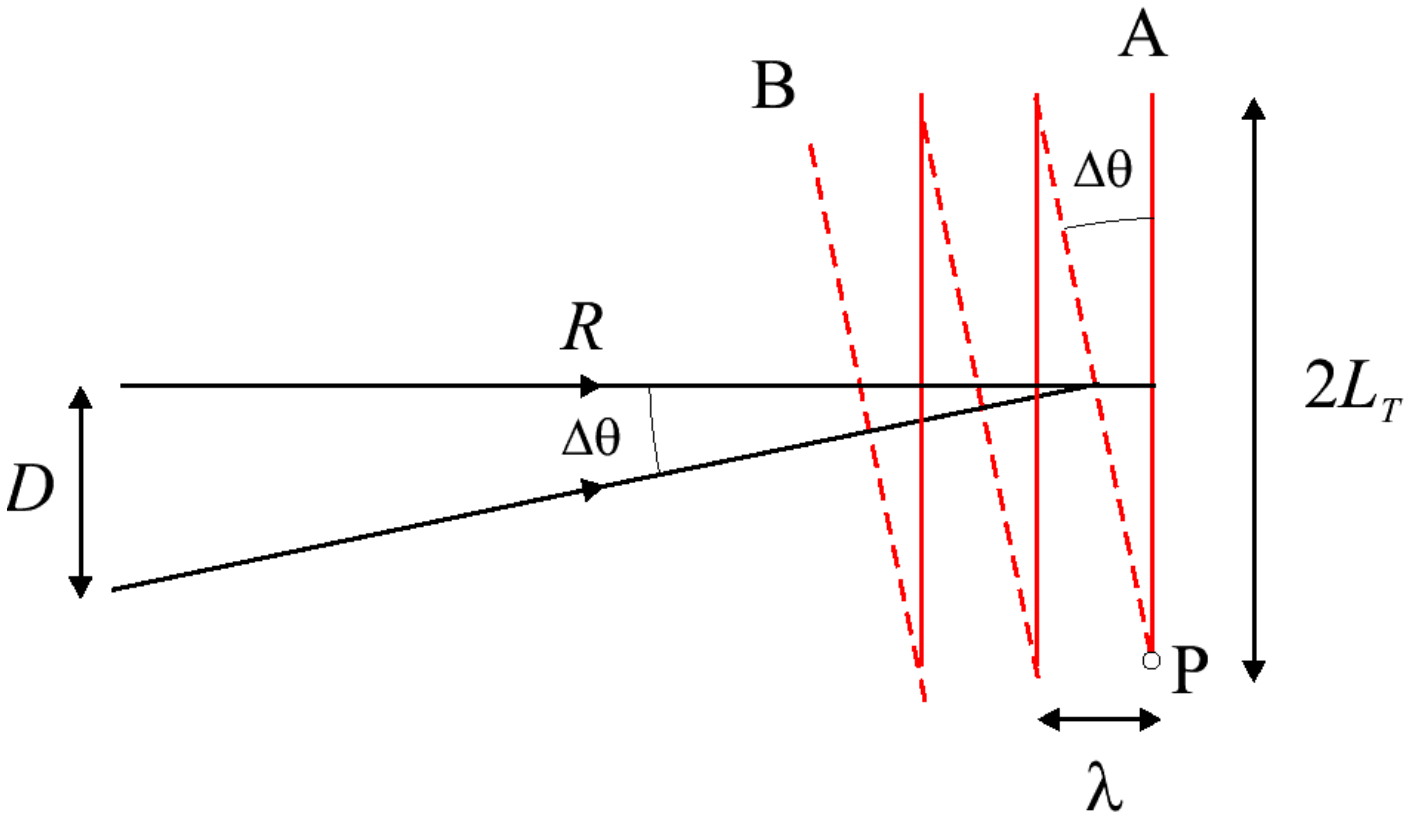
Longitudinal Coherence



$$L_L = \frac{1}{2}\frac{\lambda^2}{\Delta\lambda}$$

Als-Nielsen and McMorrow (2001)

Lateral (Transverse) Coherence



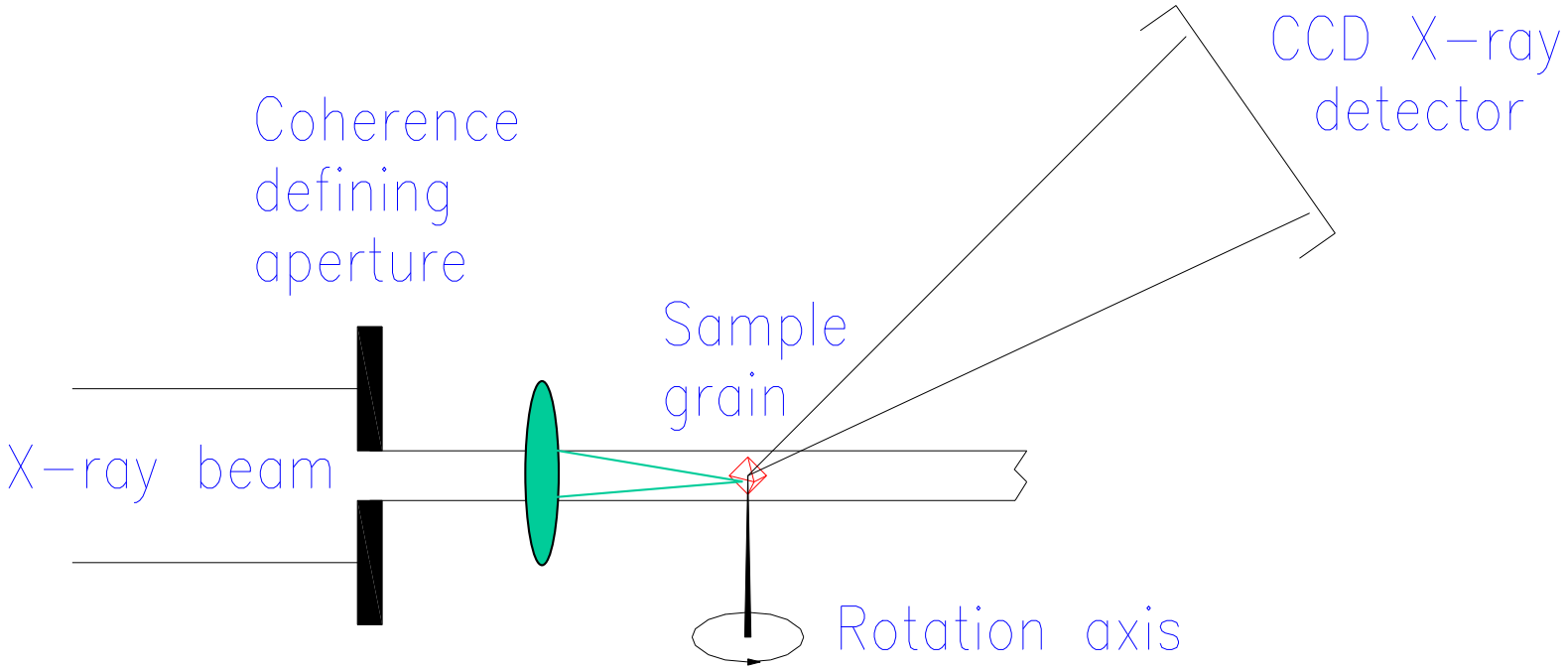
$$L_T = \frac{\lambda}{2}\frac{R}{D}$$

Als-Nielsen and McMorrow (2001)

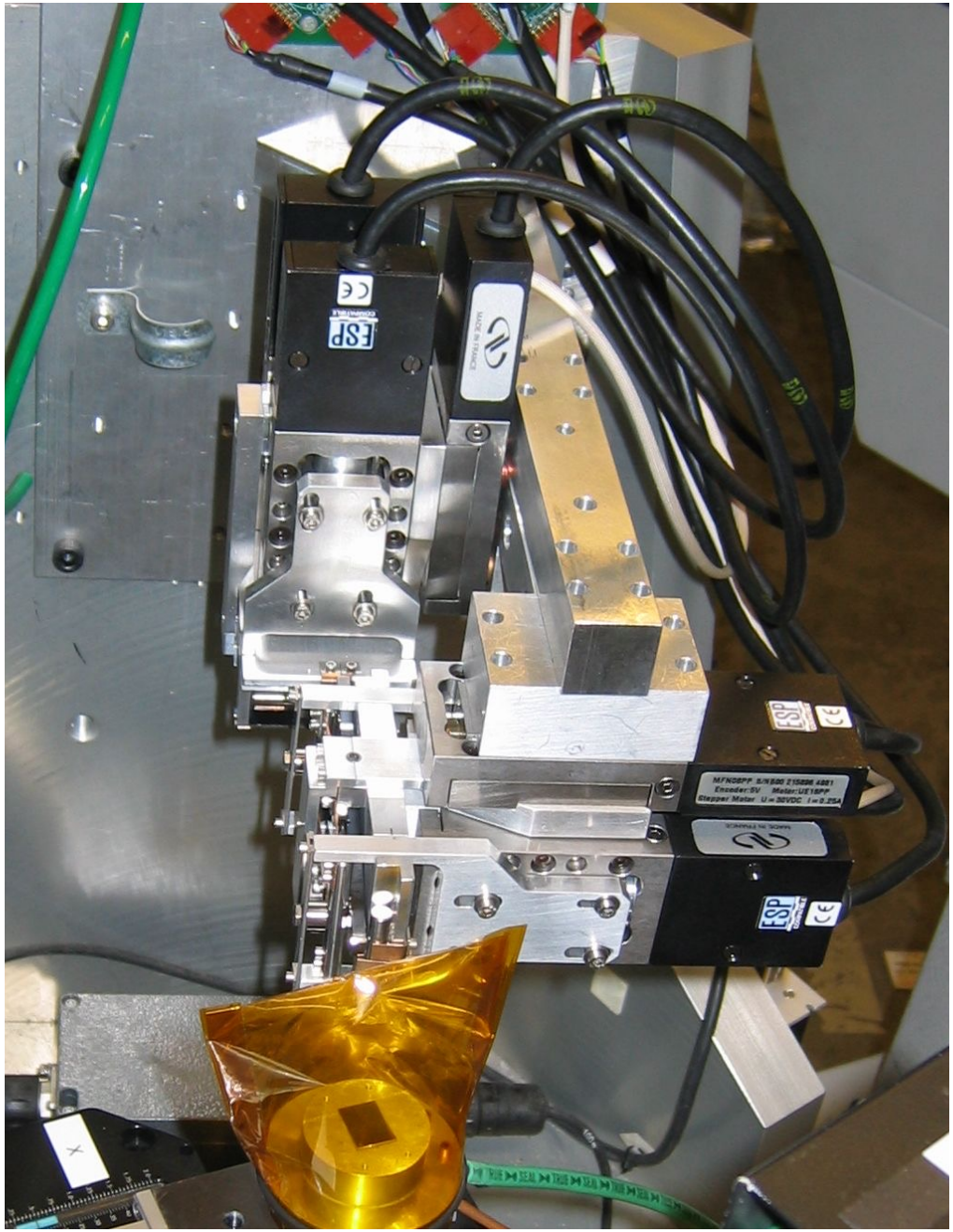
Ideal Focusing Optics

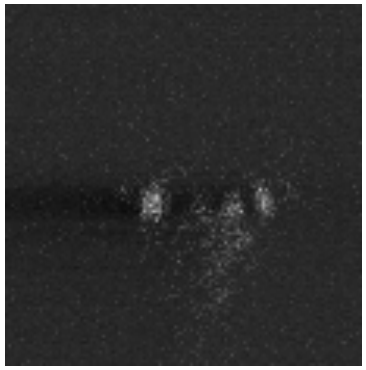
- Smaller beam, more flux on sample
- Increased divergence by Liouville theorem
- Proportionately reduced coherence length
- Coherent: Cylindrical or spherical wave
  - Curved wavefront = phased plane wave
- Incoherent: Smearing of information
  - Loss of resolution
  - Fringe contrast (definition of partial coherence)

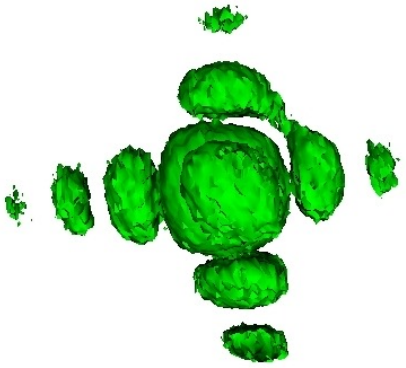
Lensless X-ray Microscope

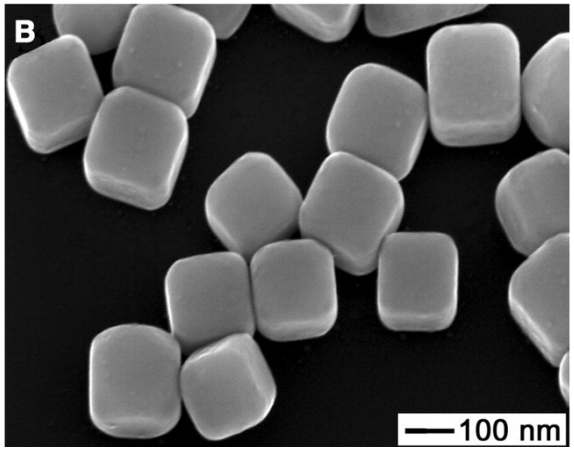


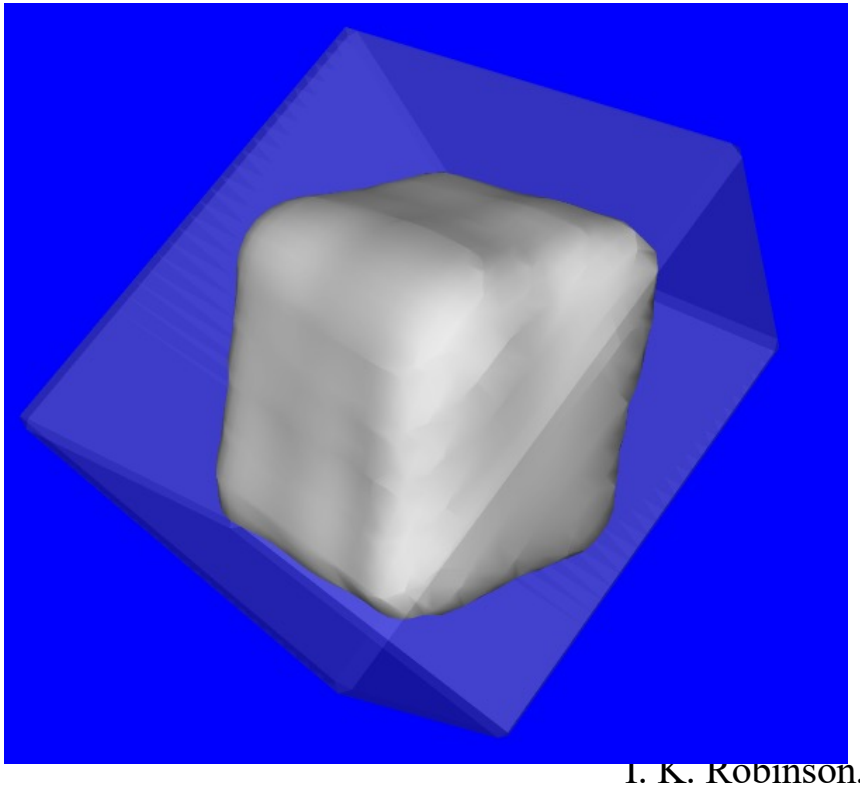
KB mirrors at 34-ID-C

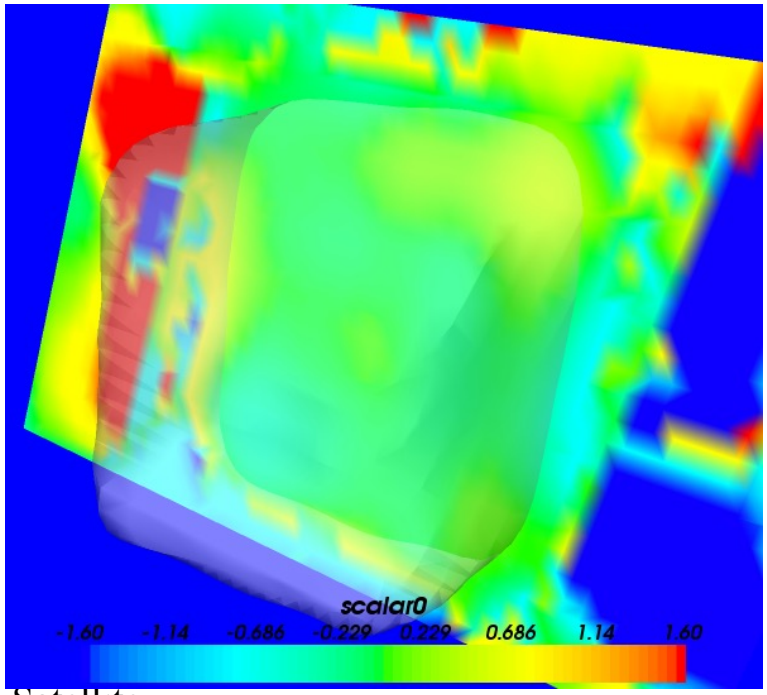




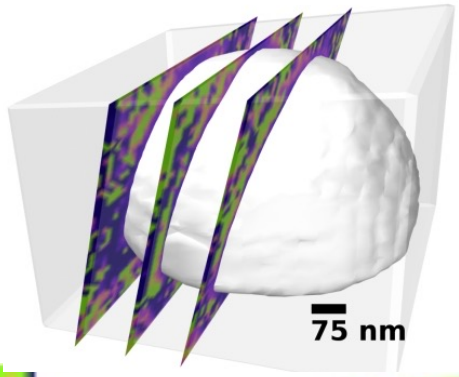


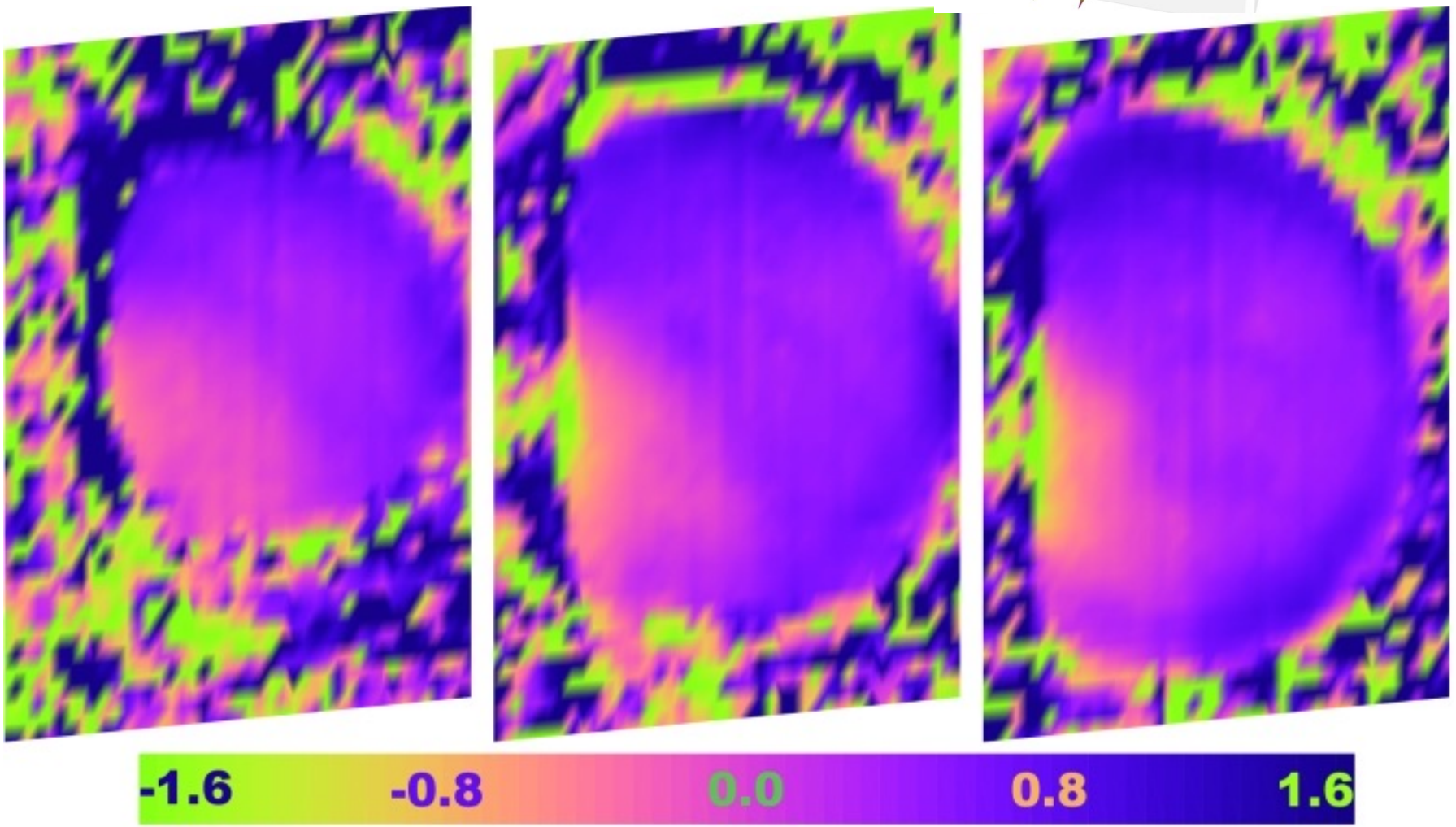

B
100 nm



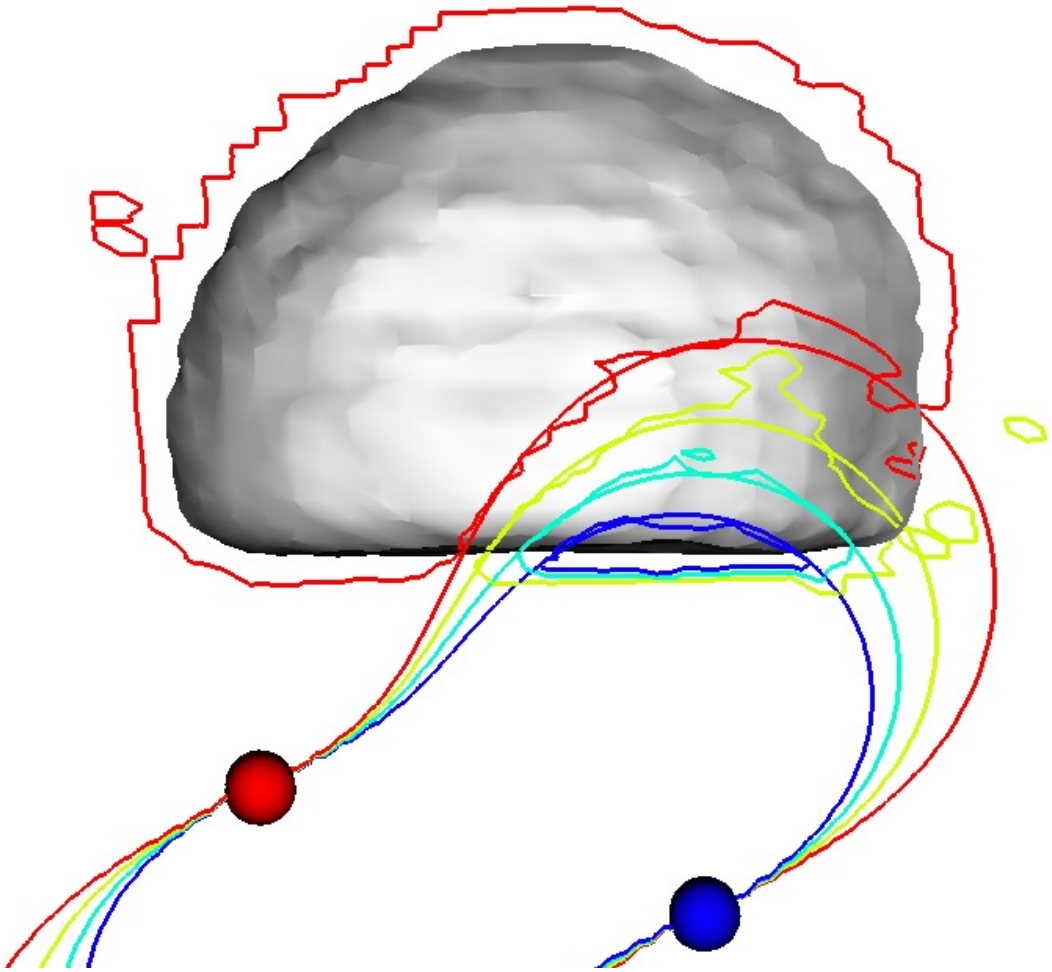

scalar0
-1.60
-1.14
-0.686
-0.229
0.229
0.686
1.14
1.60

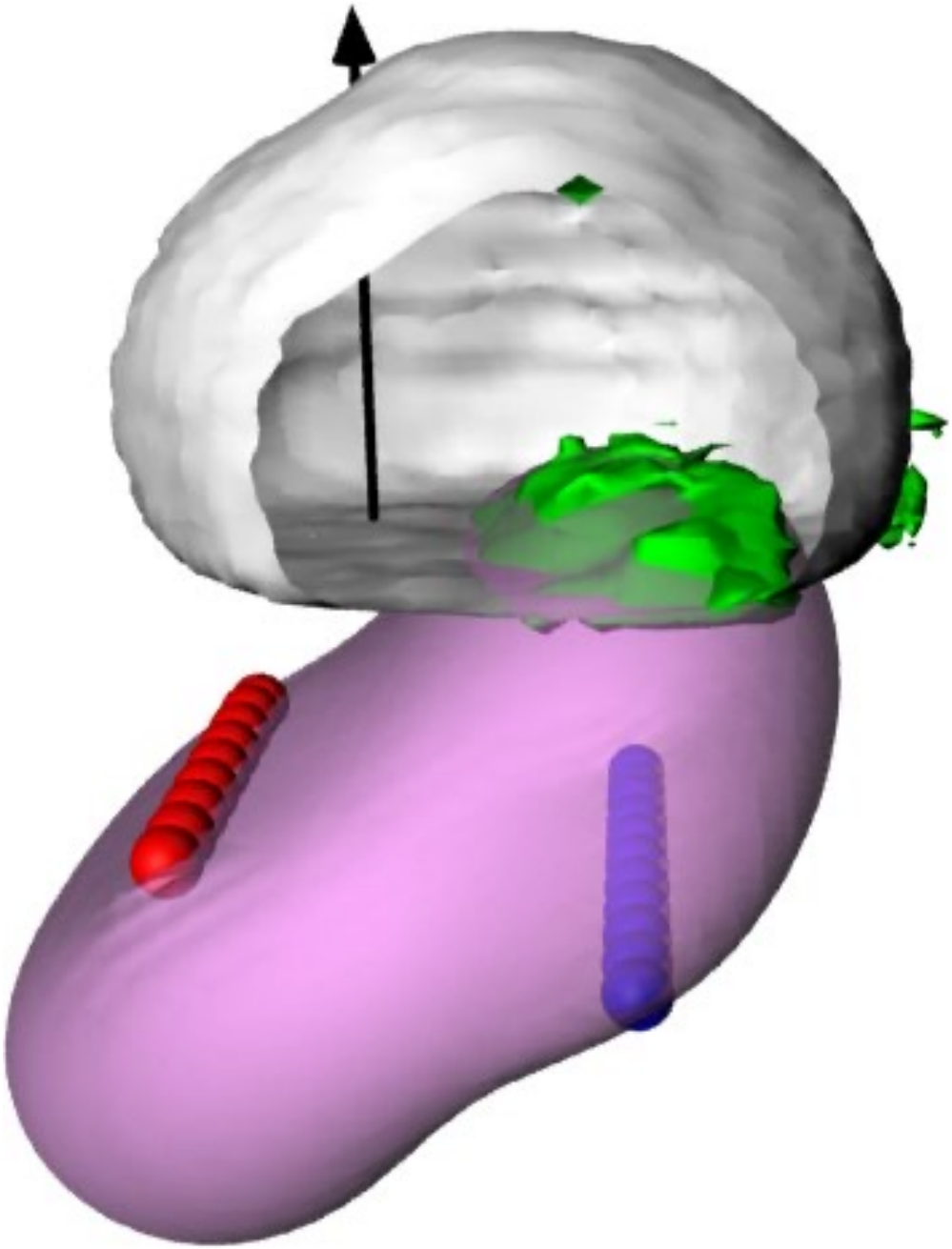
3D phase map sections





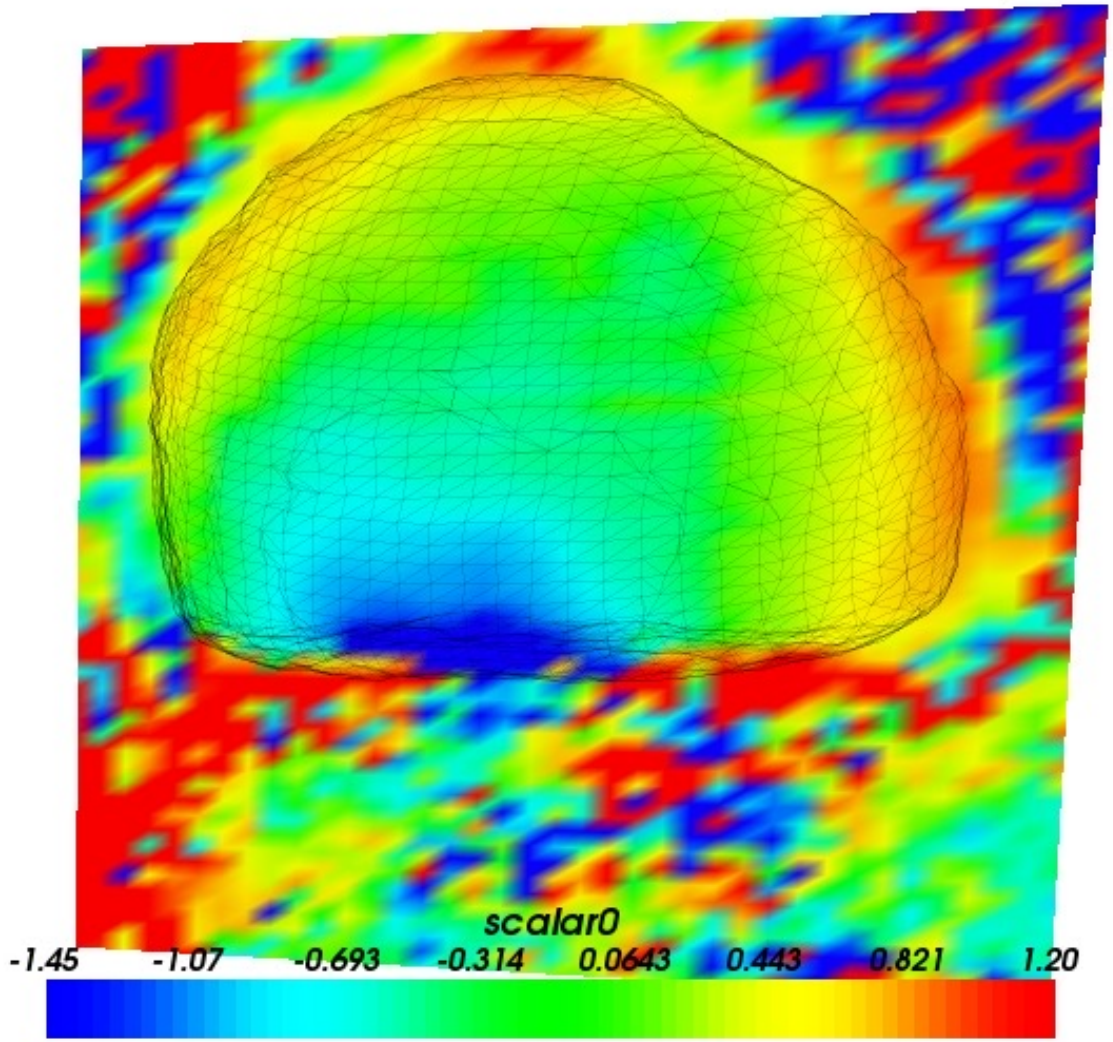
Field lines of Point Charges





3D Strain Map of Pb Nanocrystal

including correction for refraction by crystal



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- Coherence in Kirkpatrick-Baez focus
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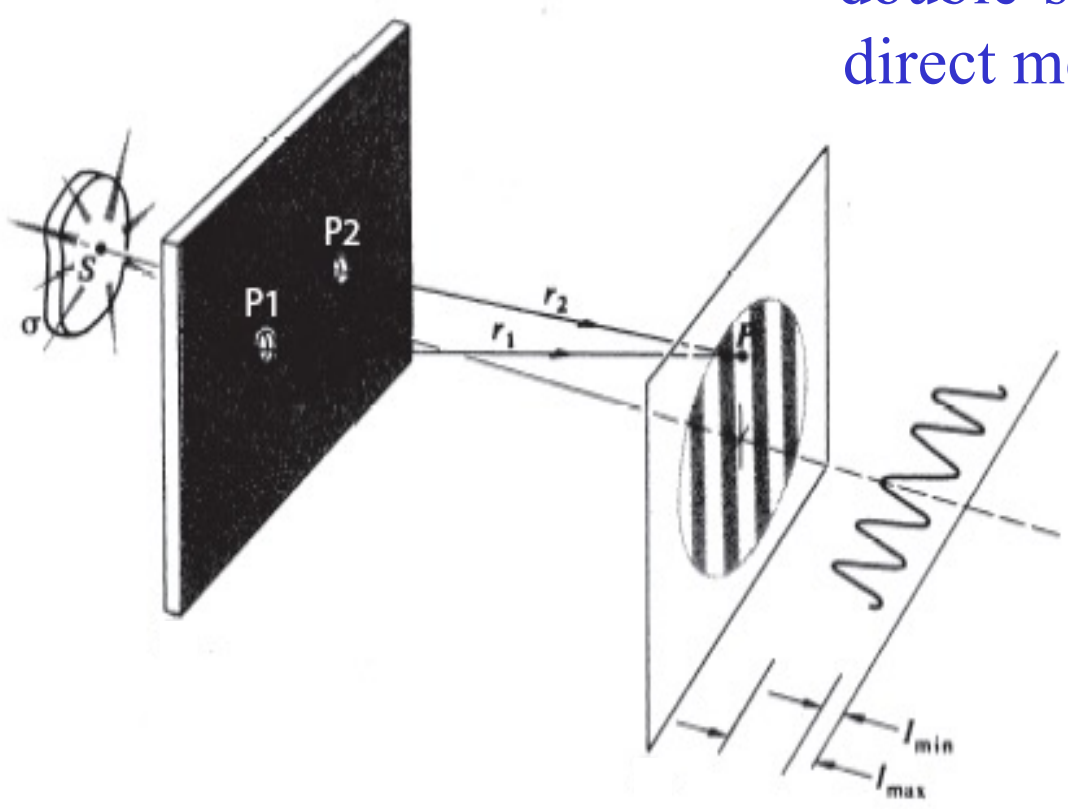
Measurement of coherence

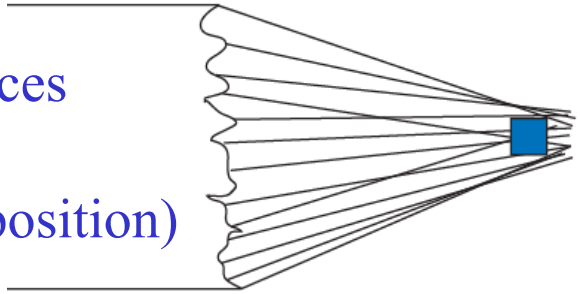
Visibility of Fringes in a double-slit experiment is the direct measure of the degree of partial coherence

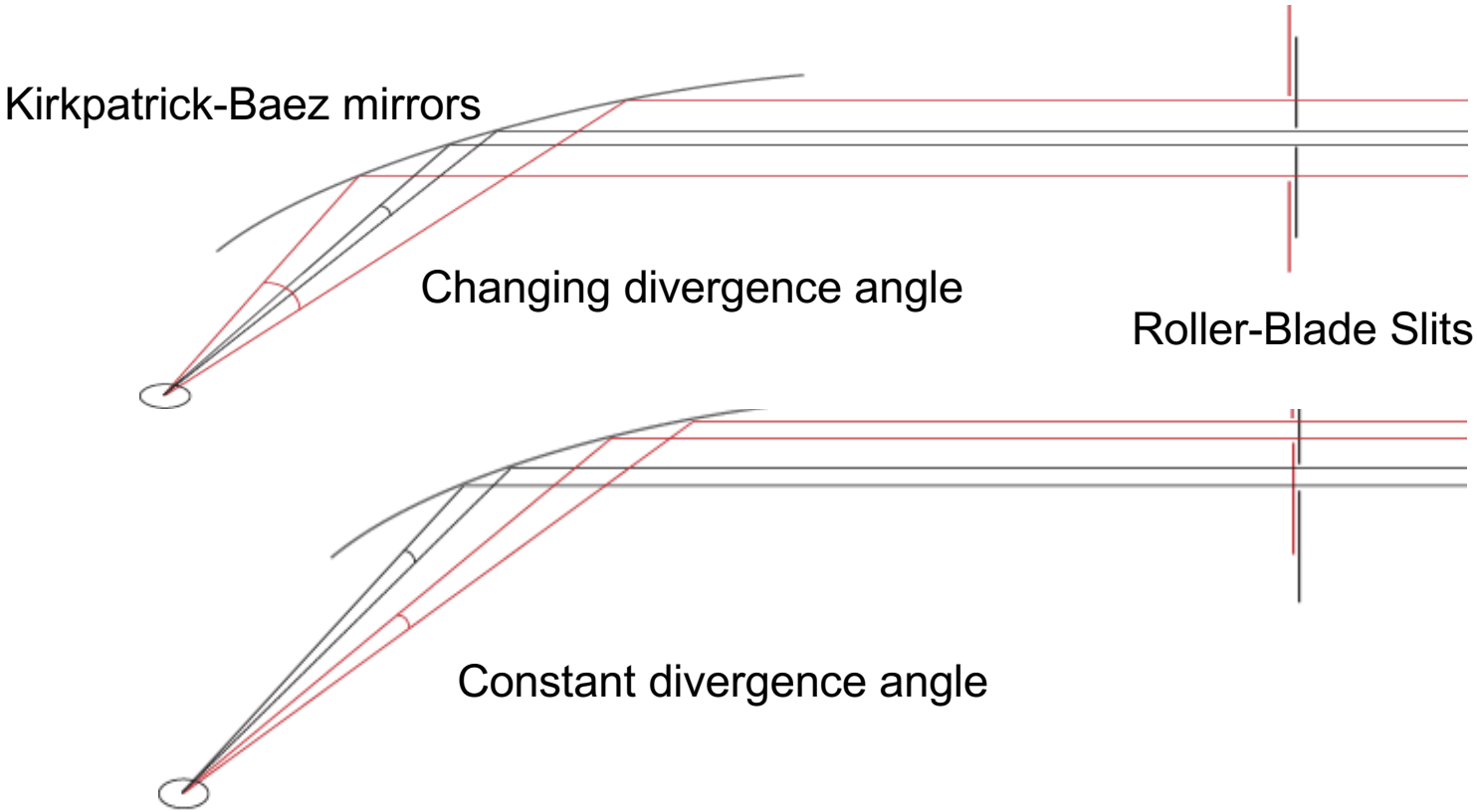


$$V = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

Effects of Focusing on Coherence

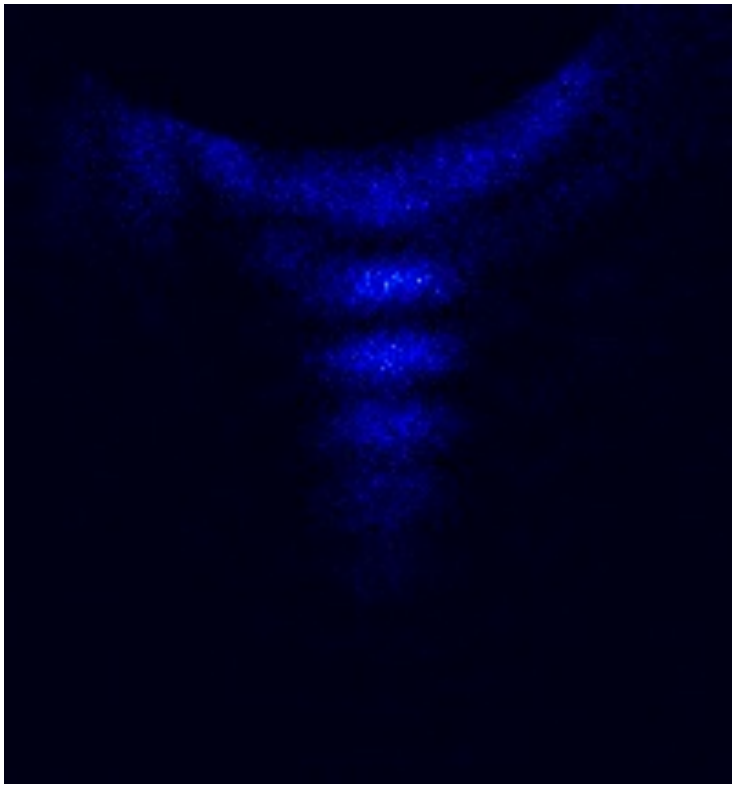
- Imperfect optics just rearranges the coherent pieces
- Small sample probes the local wavefield
- Explore by varying entrance aperture (size and position)



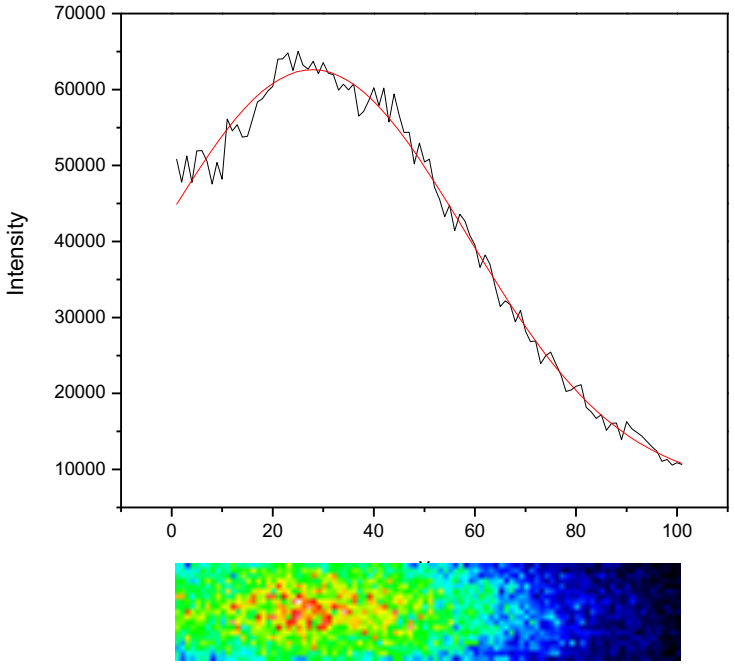


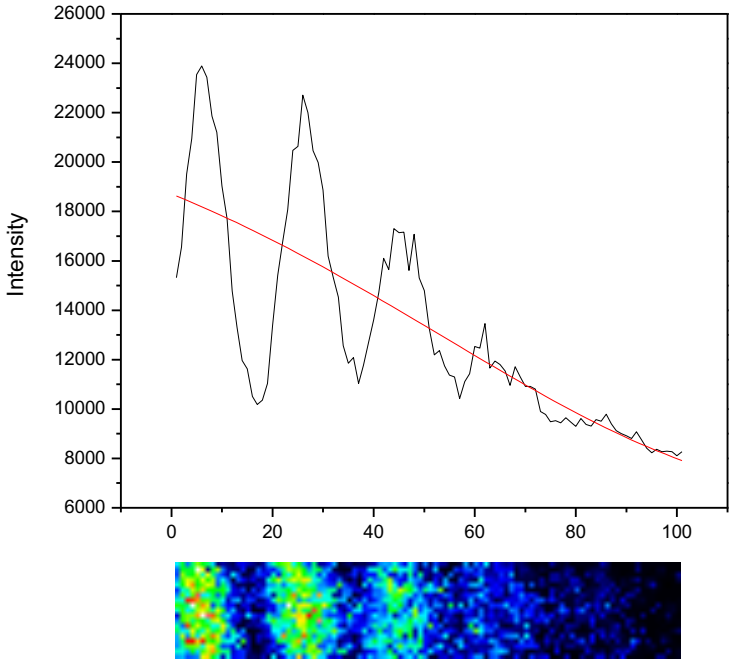
0.5μm gold crystal in 1.5μm KB focus

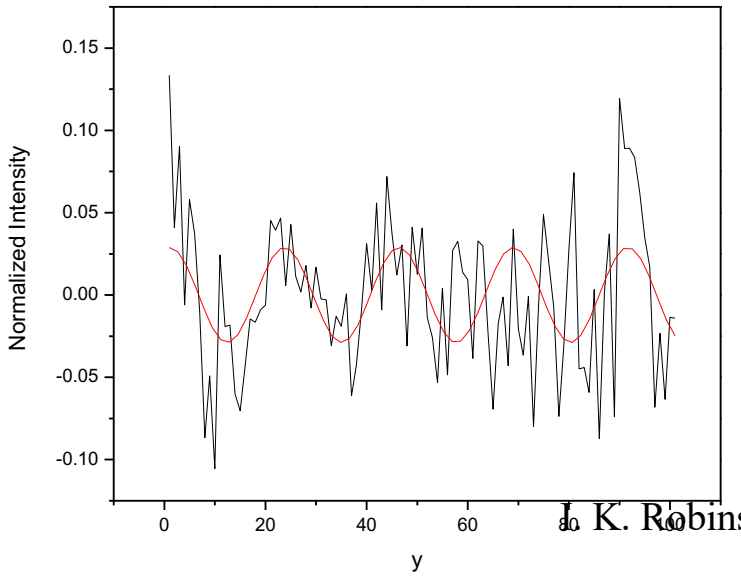
Vertical gap scanned from 5μm to 100μm in 2.25μm steps at the same position

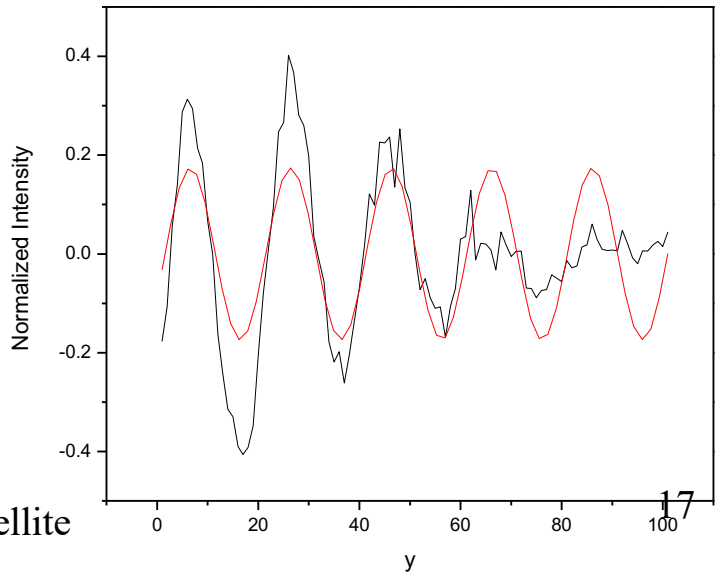


Gaussian-modulated fringe fitting

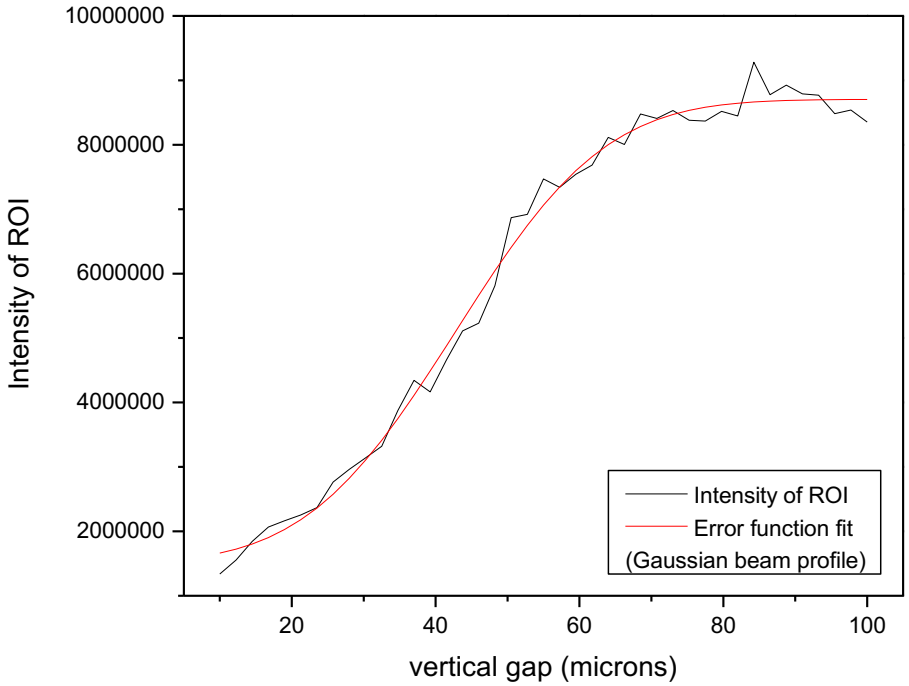


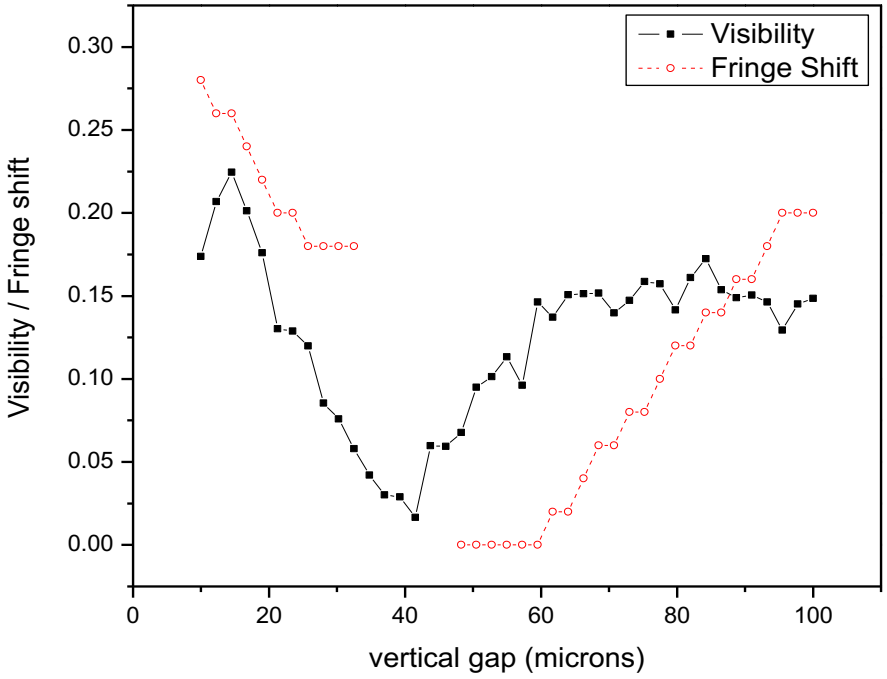


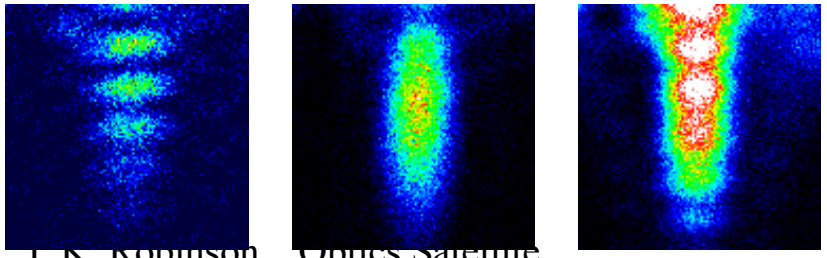




Results for vertical gap scans







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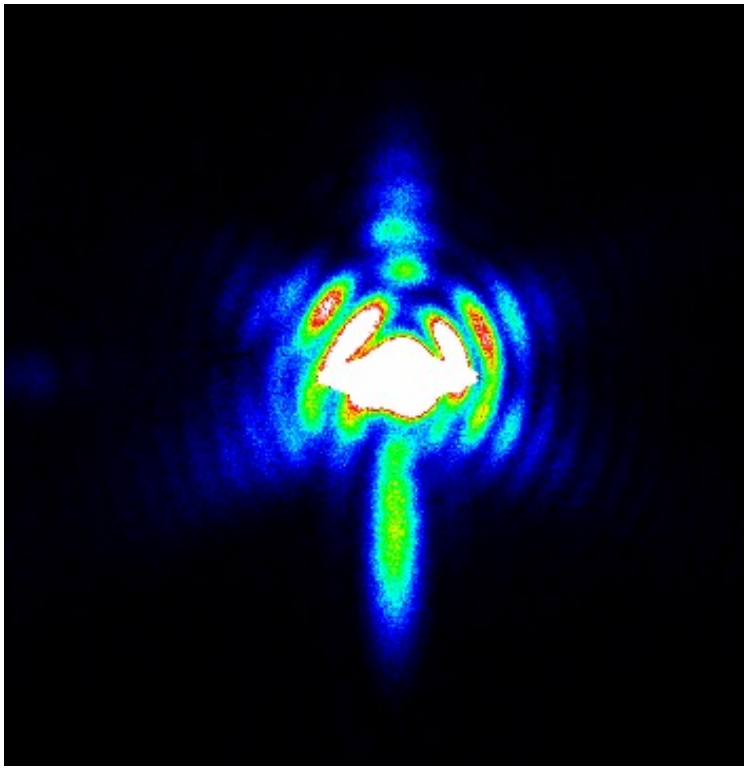
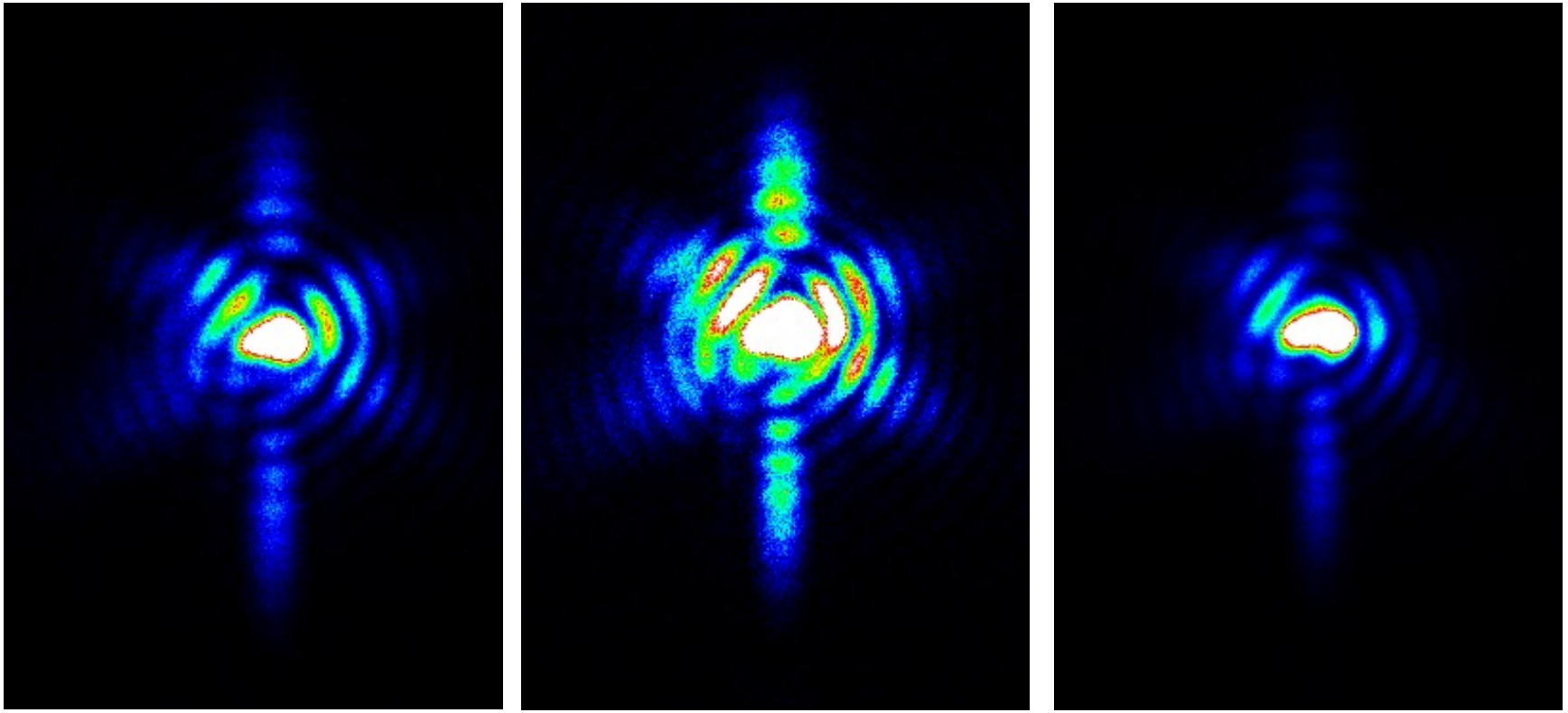
Vary vertical aperture before KB



10 micron steps from 10 to 100 microns

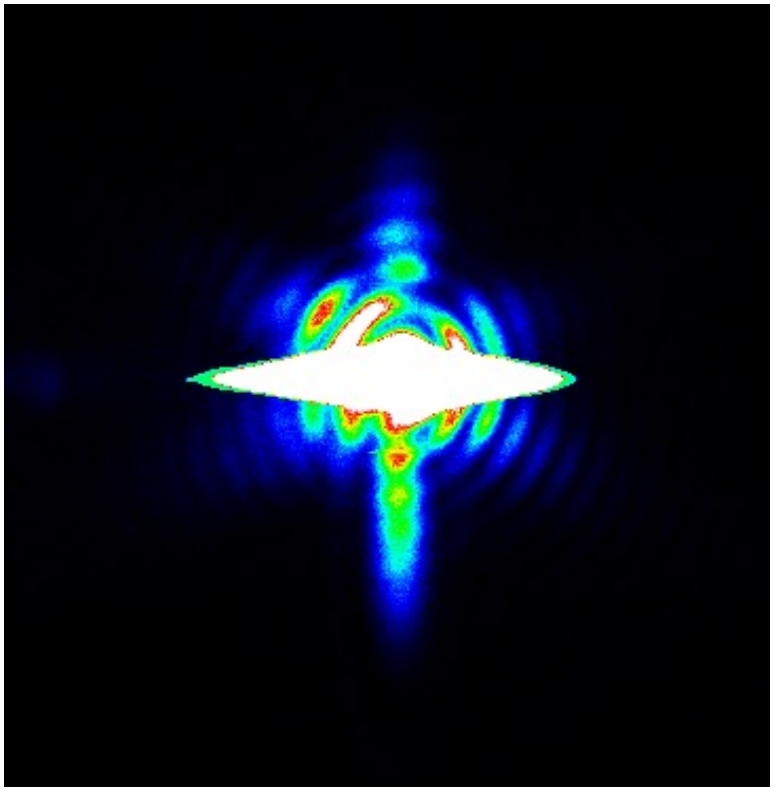
Insert diffuser before sample

all with 50 micron entrance slit



-138, none -140, 50mm -141, 15mm

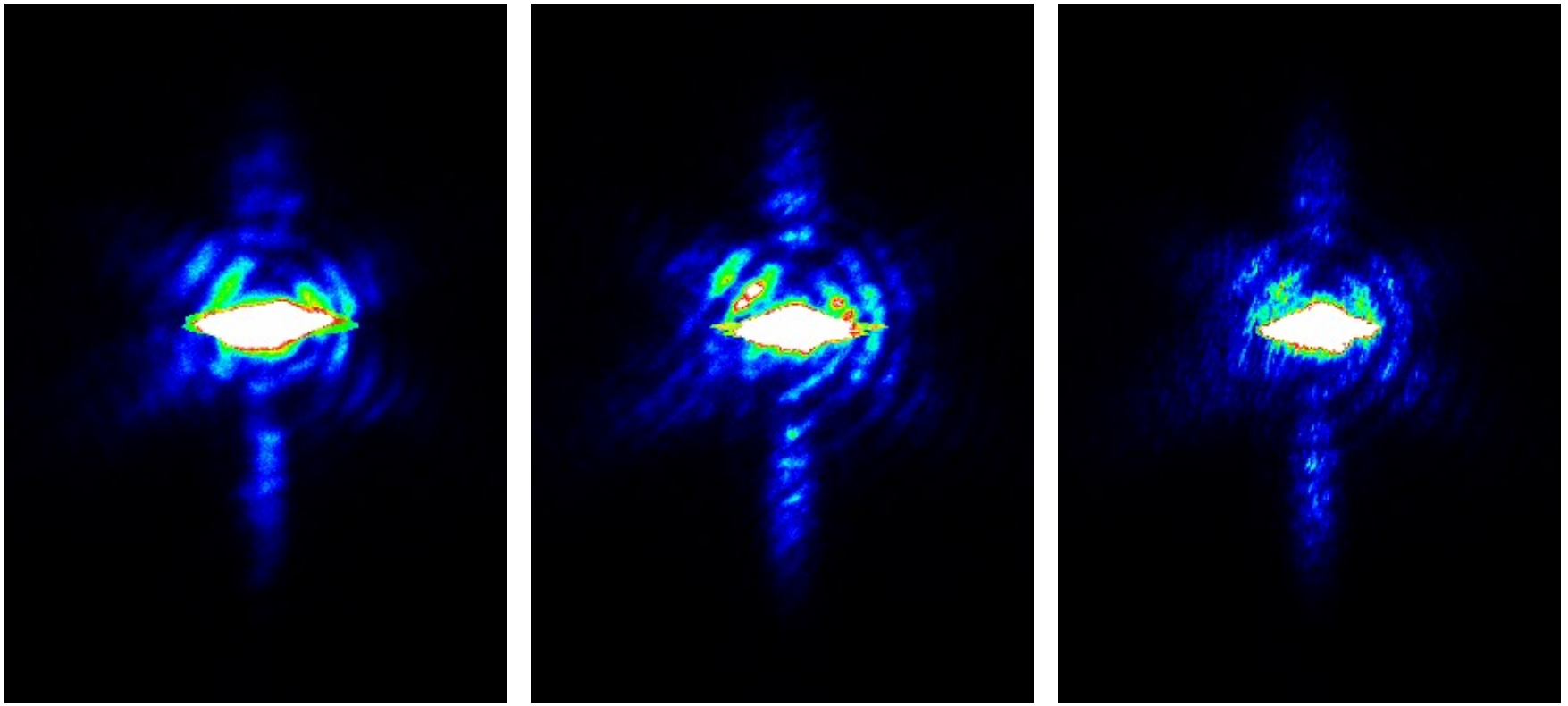
Diffuser added 15mm before sample



10 micron steps from 10 to 100 microns

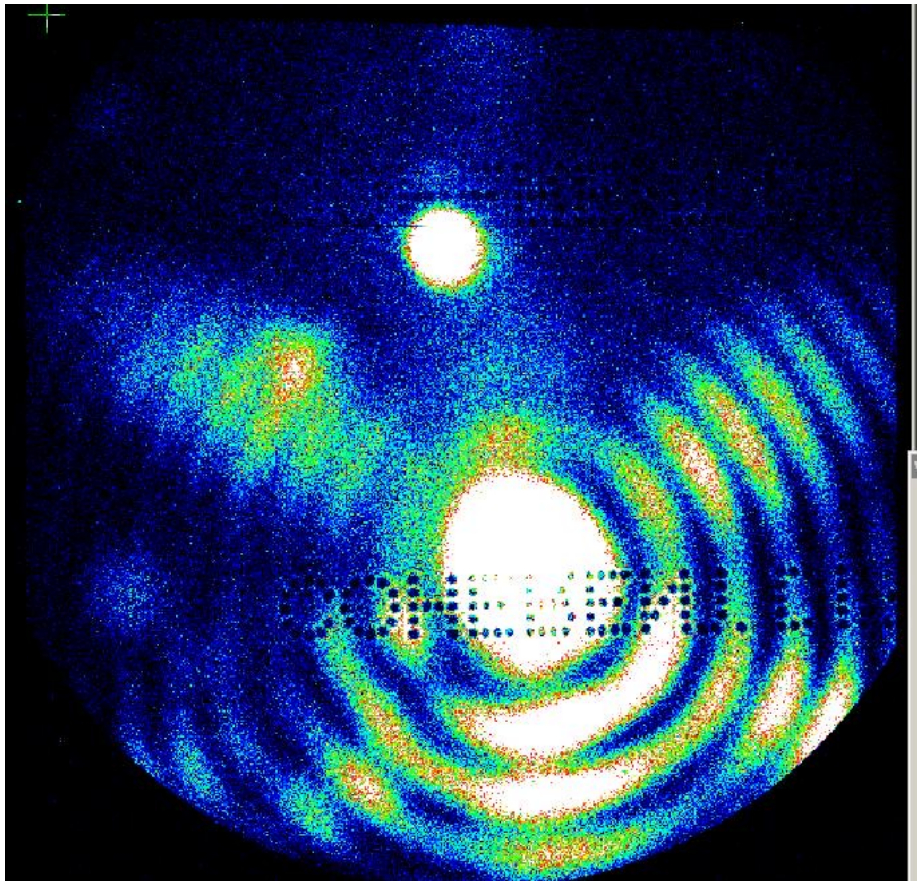
Add diffuser after sample

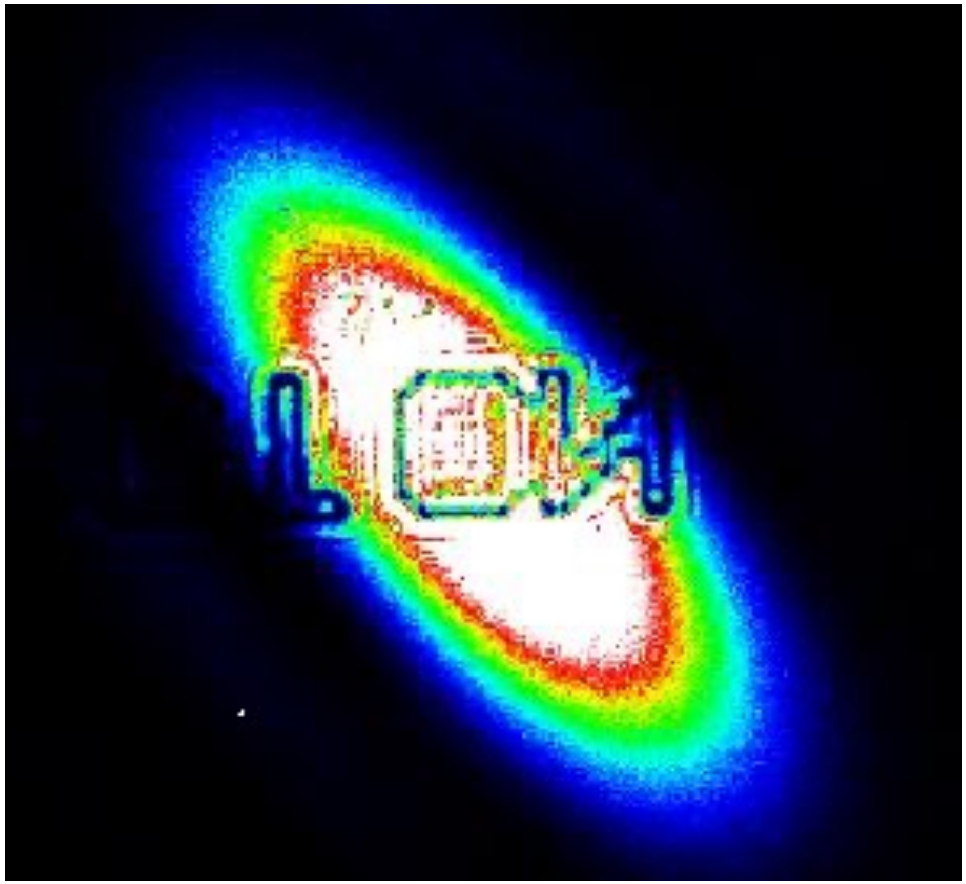
all with 50 micron entrance slit



-142, 10mm -143, 37mm -144, 250mm

Use nanocrystal as spherical source for projection imaging





-37

-19

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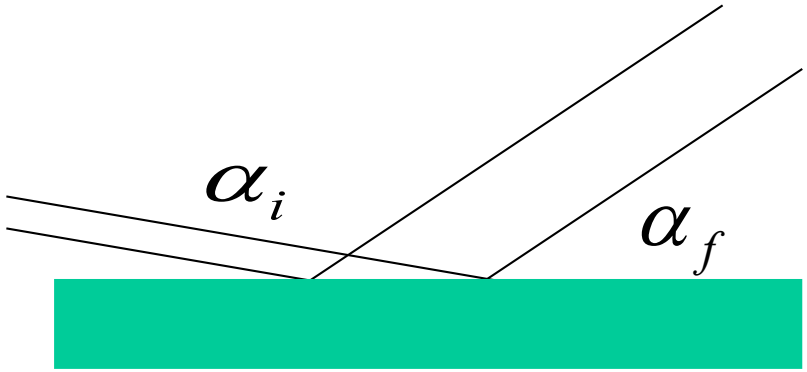
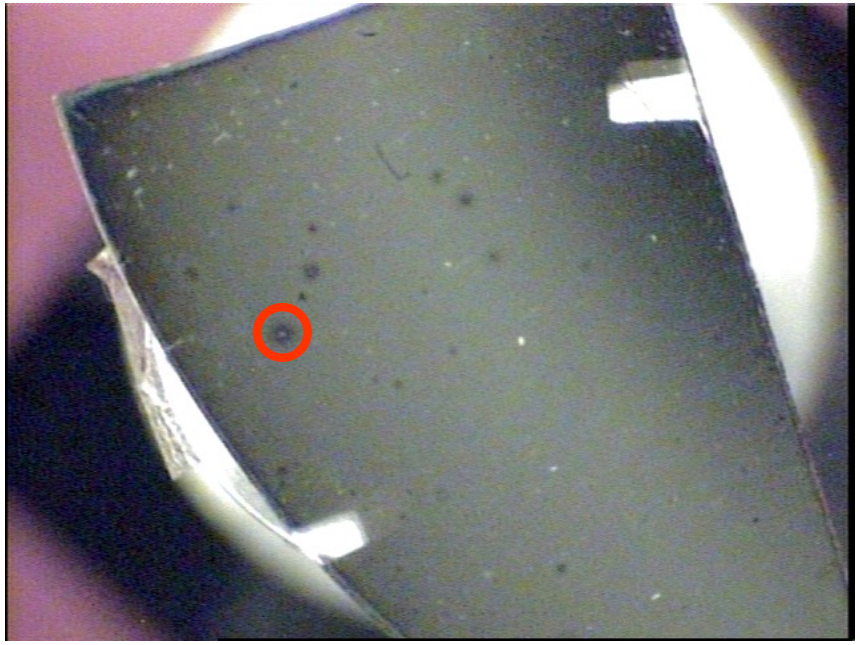
Asymmetric geometry is bad for longitudinal coherence



Path length difference

$$= d\,\frac{(\cos\alpha_i - \cos\alpha_f)}{\sin\alpha_i}$$

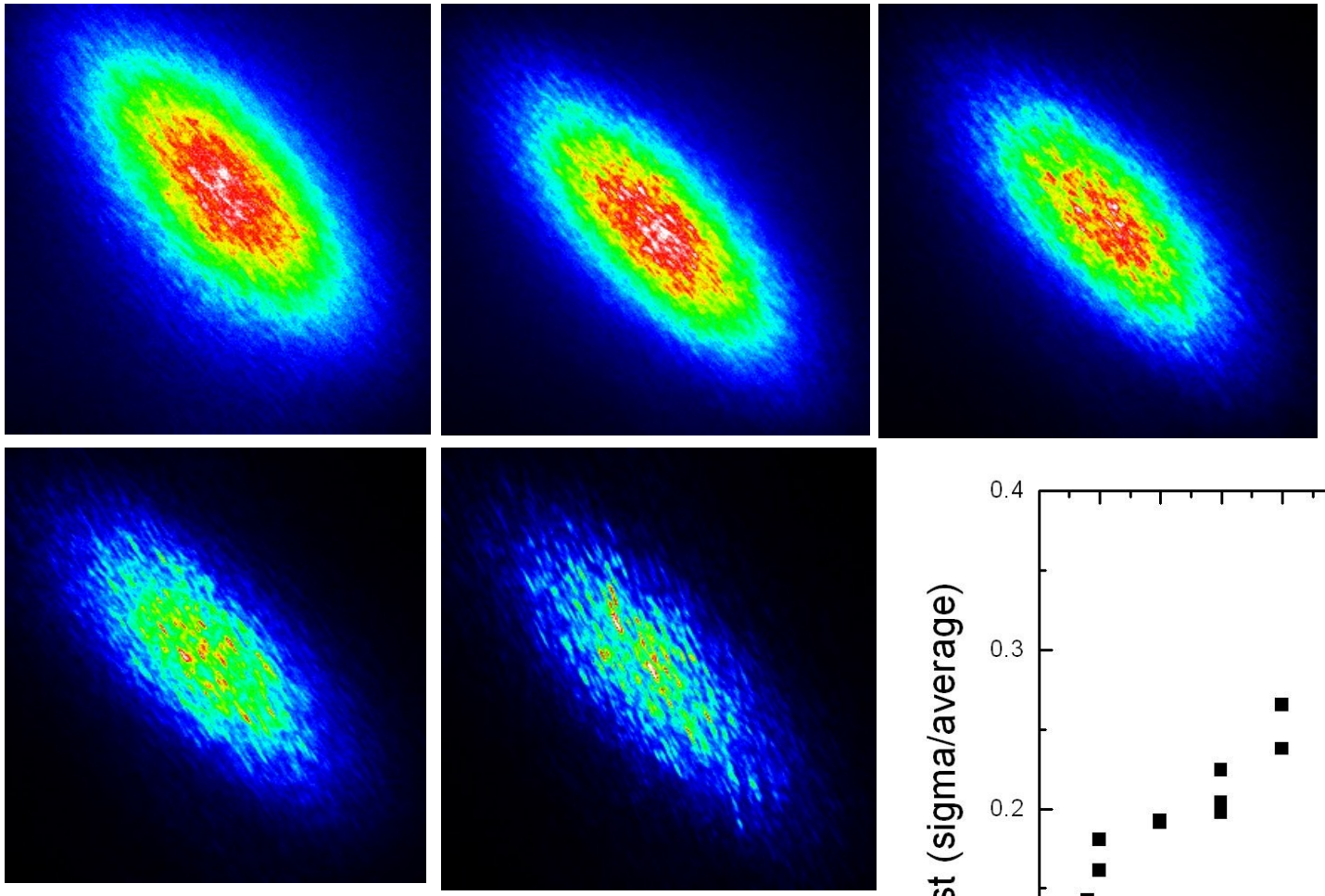


1000Å vanadium thin film

MBE-grown on sapphire

(001) with grain structure

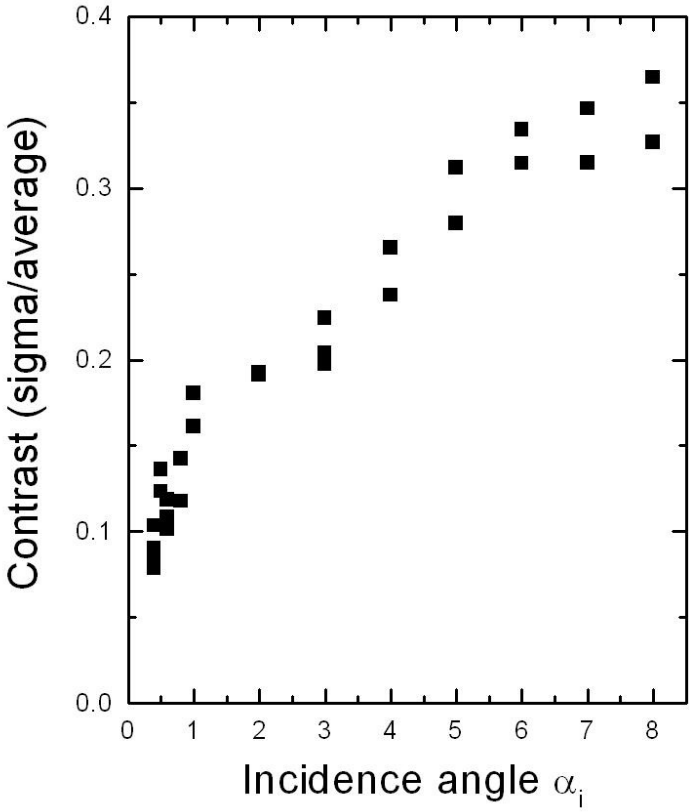
(101) Bragg reflection



-112 -113 -97 0.4º 0.6º 1.0º

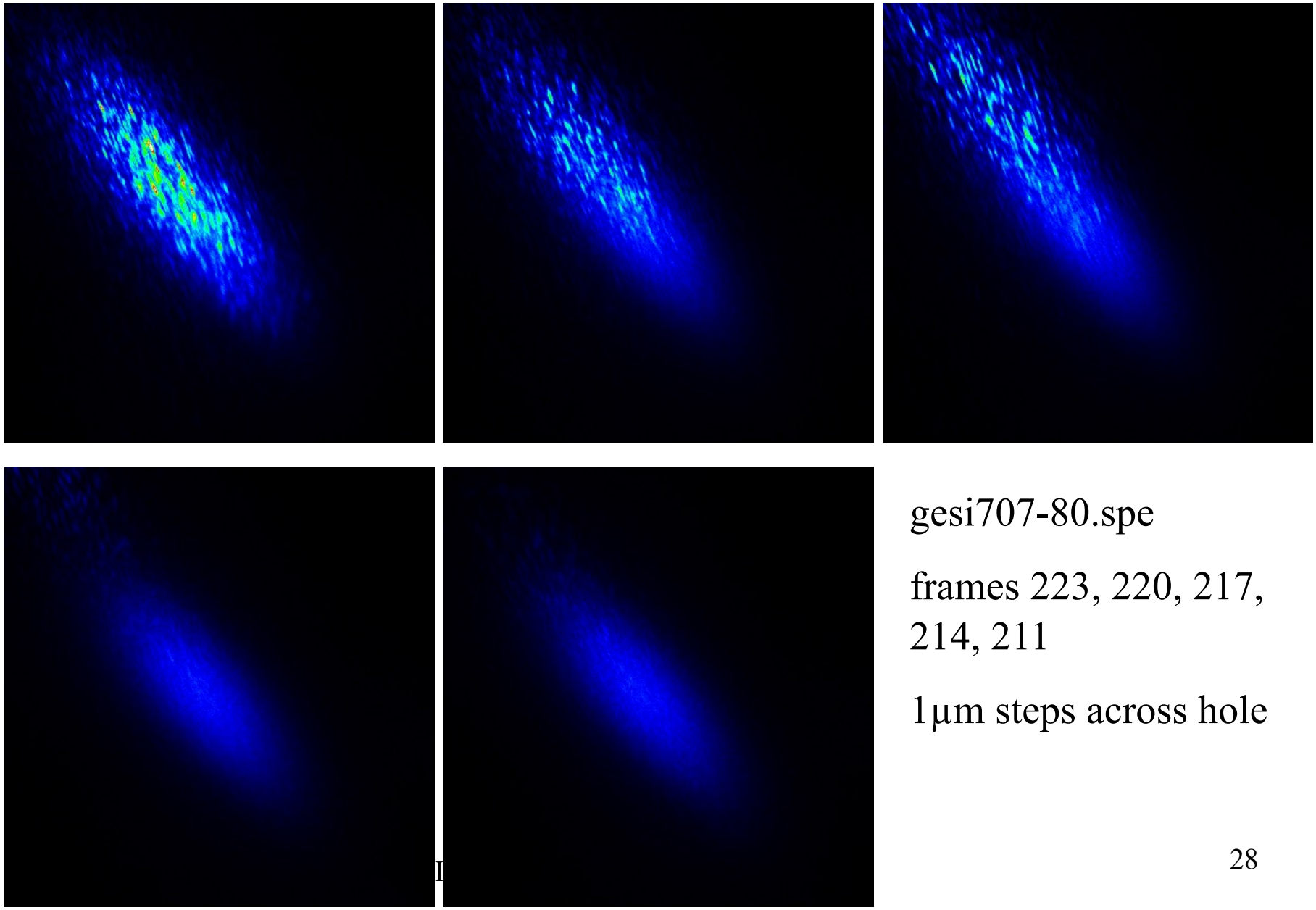
-90 -99 4.0º 8.0º

GeSi707 incidence angle



I. K. Robinson, Optic

Mystery at pinholes of V(001) film



gesi707-80.spe

frames 223, 220, 217, 214, 211

1μm steps across hole

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