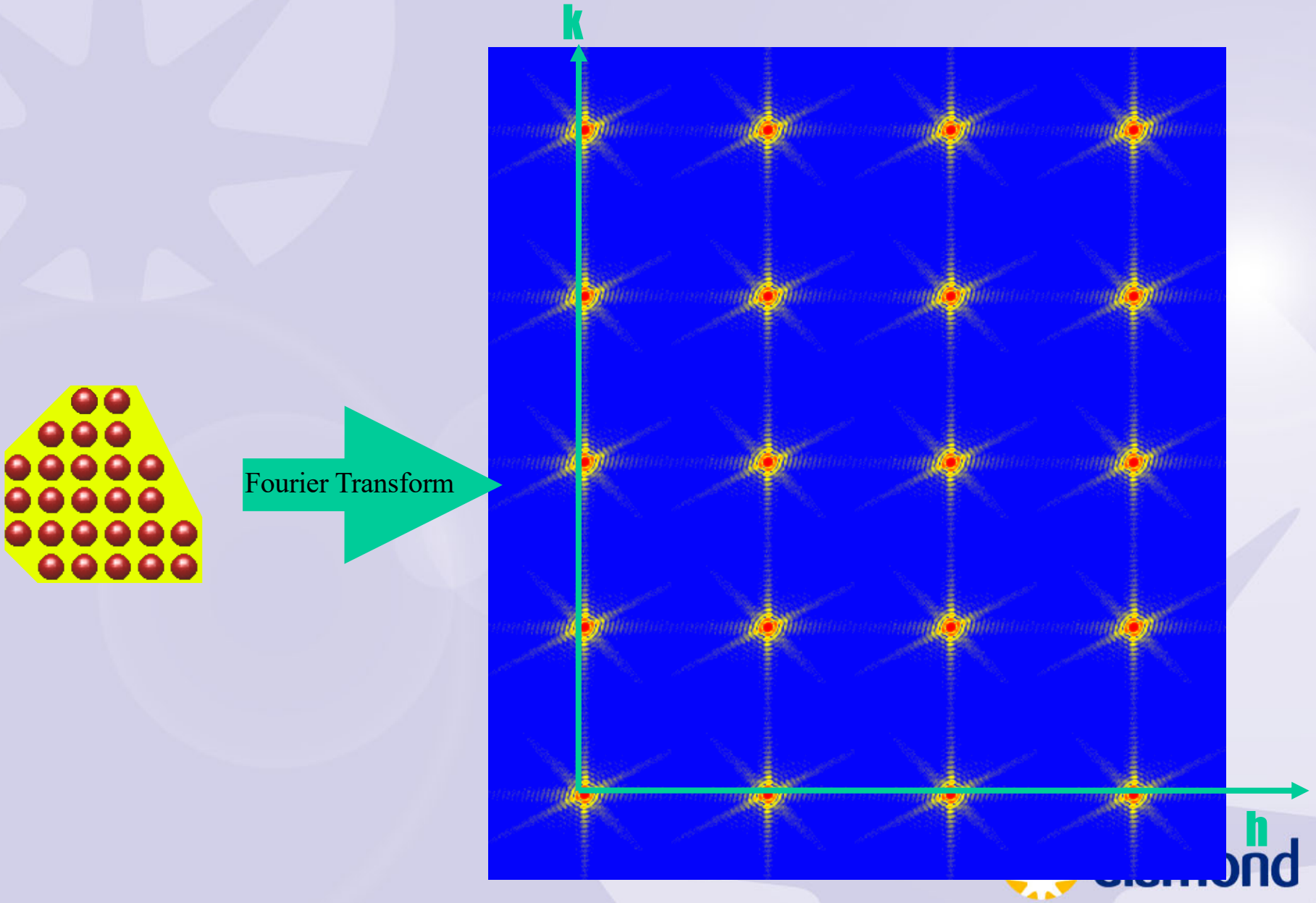
Coherent Diffraction Plans for Diamond

Coherence/Imaging Planning Meeting, July 11, 2006

Ian Robinson
UCL and Diamond Light Source

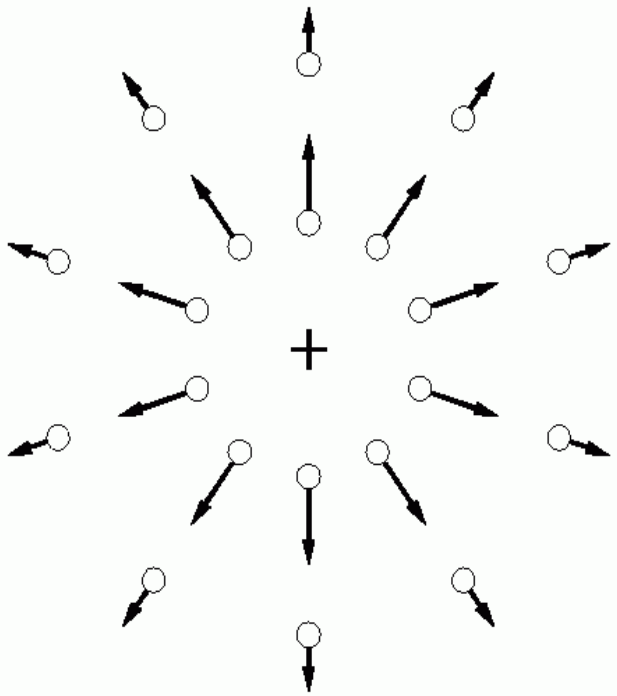
Coherent Diffraction from Crystals

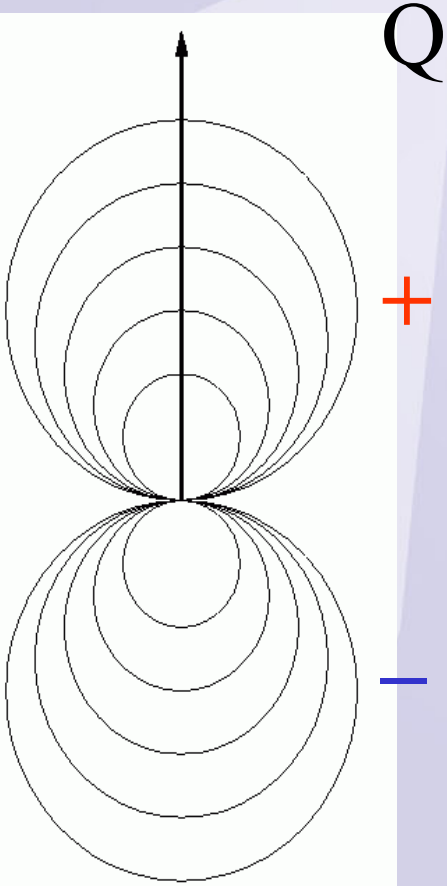


Diffraction by Strain of Point Defect

$$A \sim \sum e^{i\mathbf{Q}\cdot(\mathbf{R}_j+\mathbf{u}_j)}$$
$$\approx \sum e^{i\mathbf{Q}\cdot\mathbf{R}_j}(1+i\mathbf{Q}\cdot\mathbf{u}_j)$$

Imaginary density





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Good statistics, 3D diffraction data

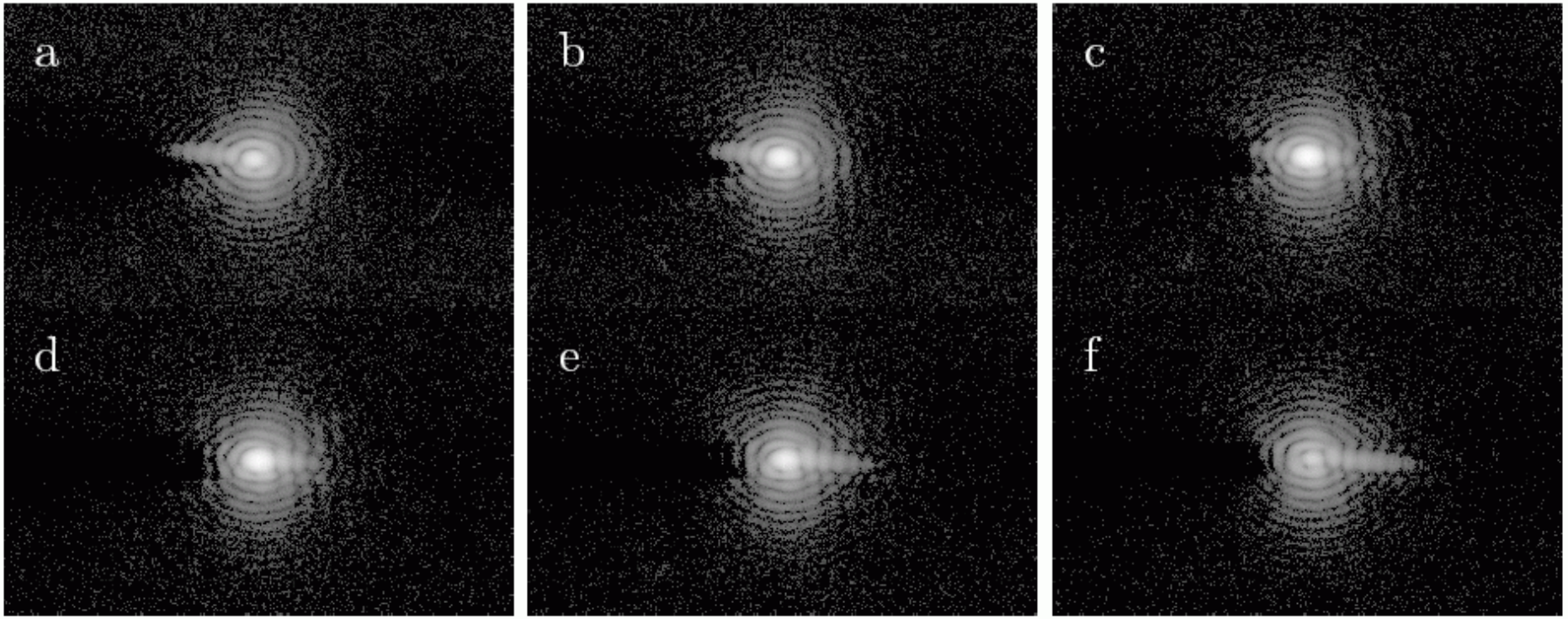
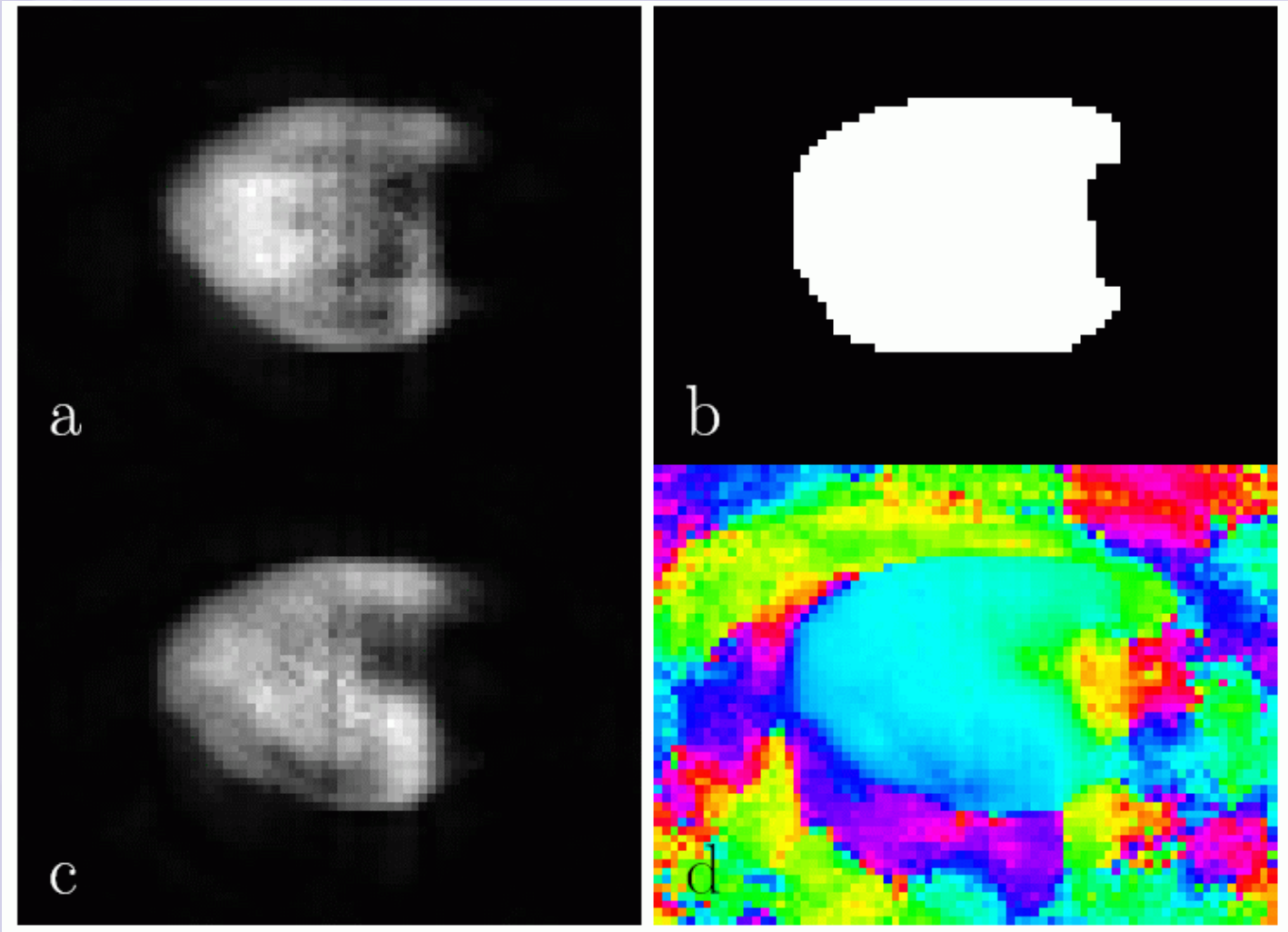
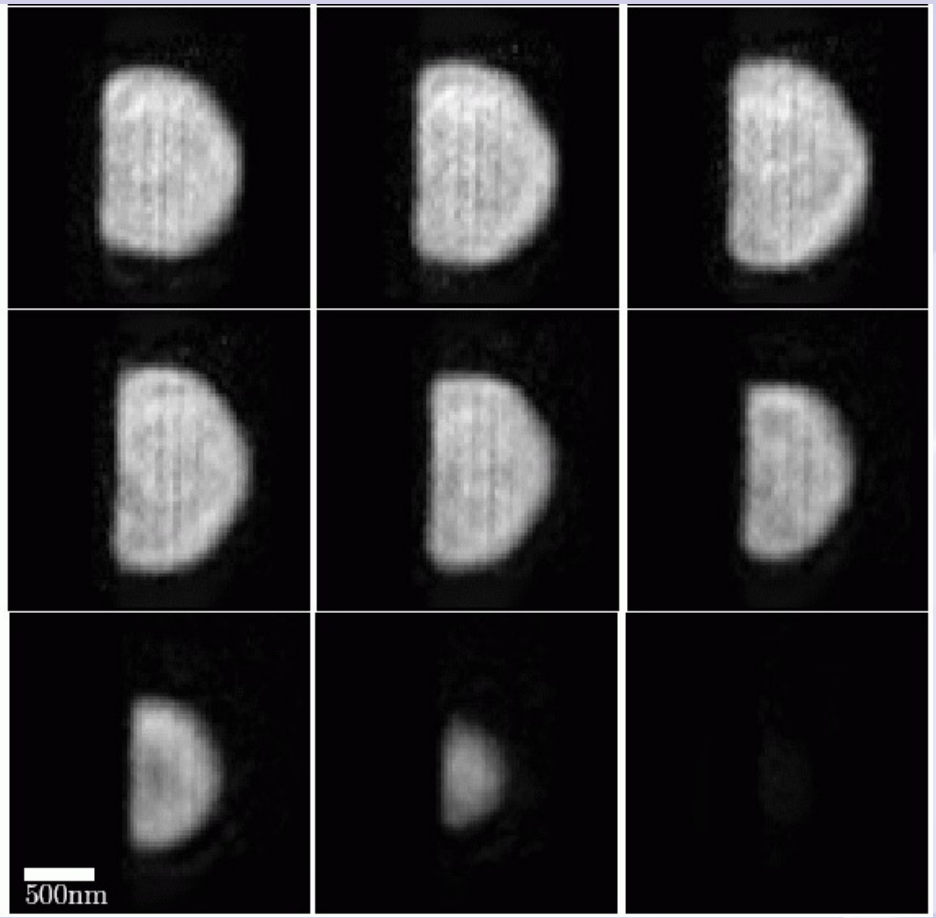


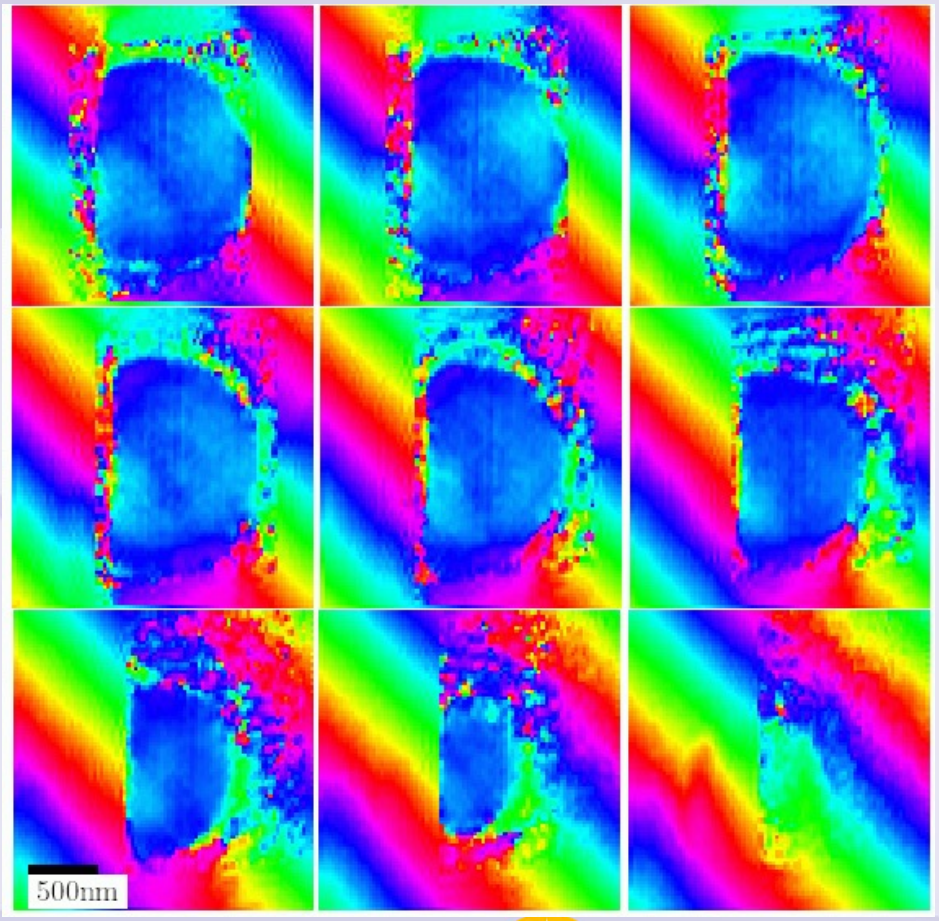
Figure 4.12: Center slices from 3D CXD pattern from Pb sample, on a log scale. Data file 296 from 10/03.

Learn shape of “tight” support



Then refine amplitude *and* phase





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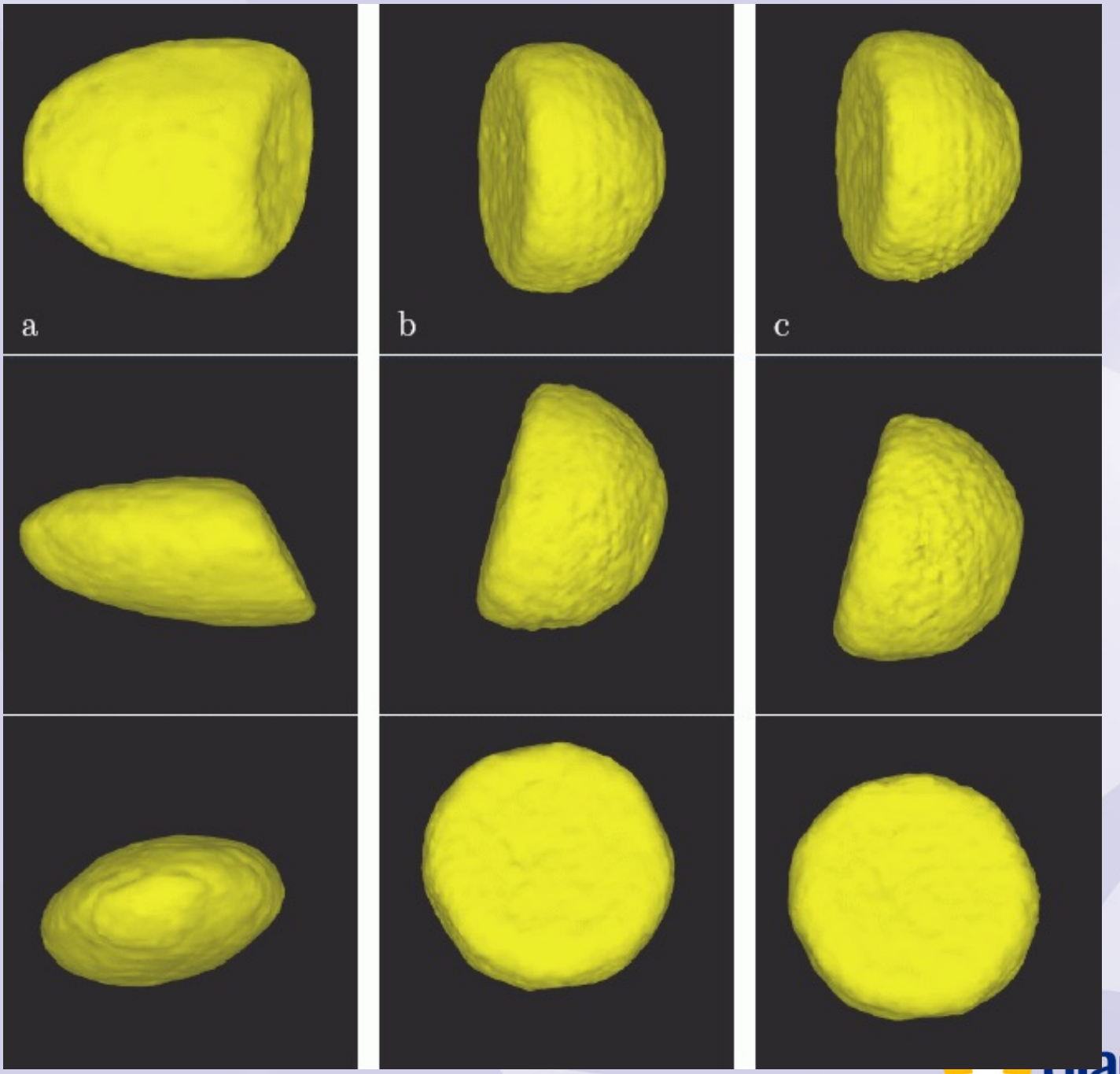
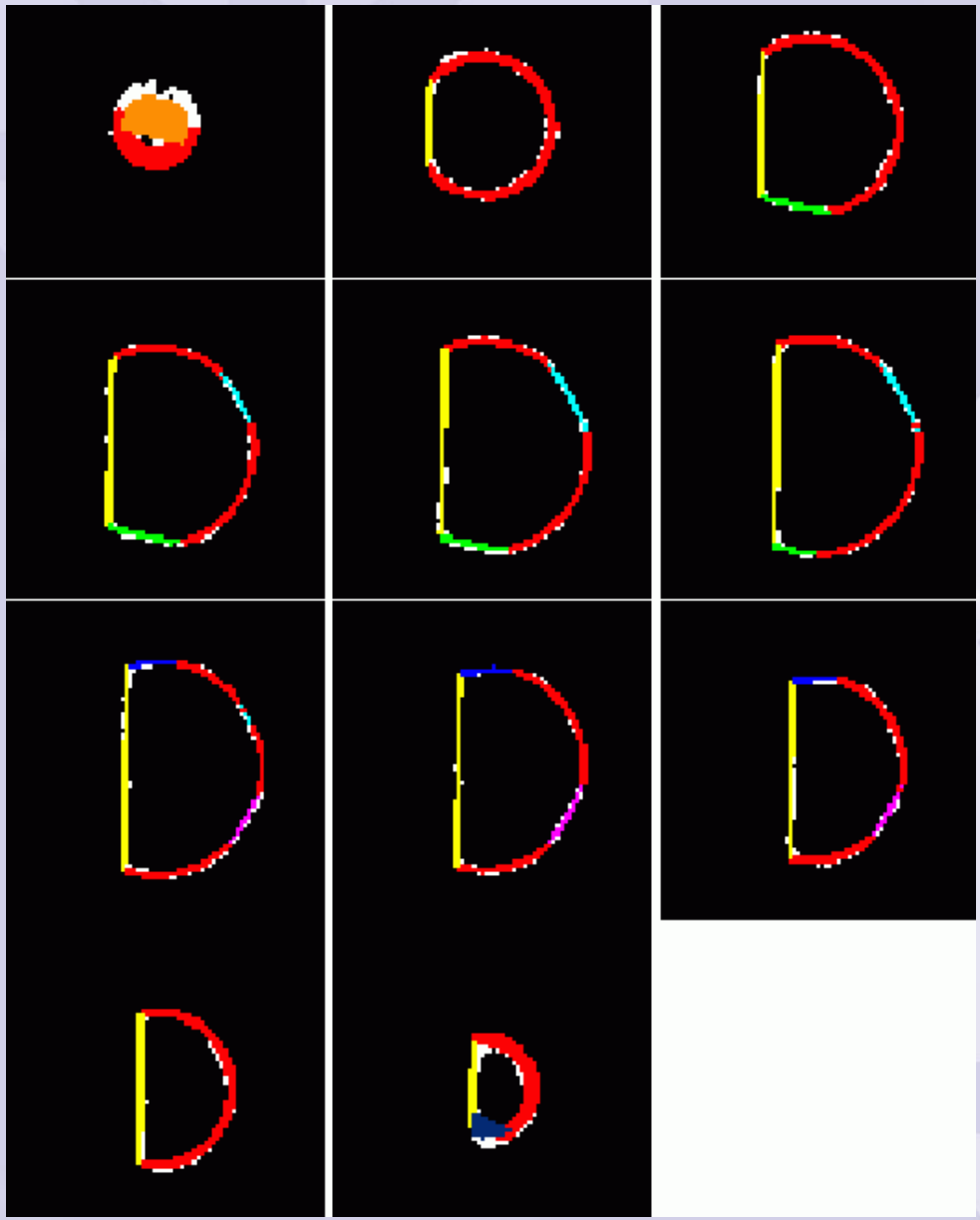
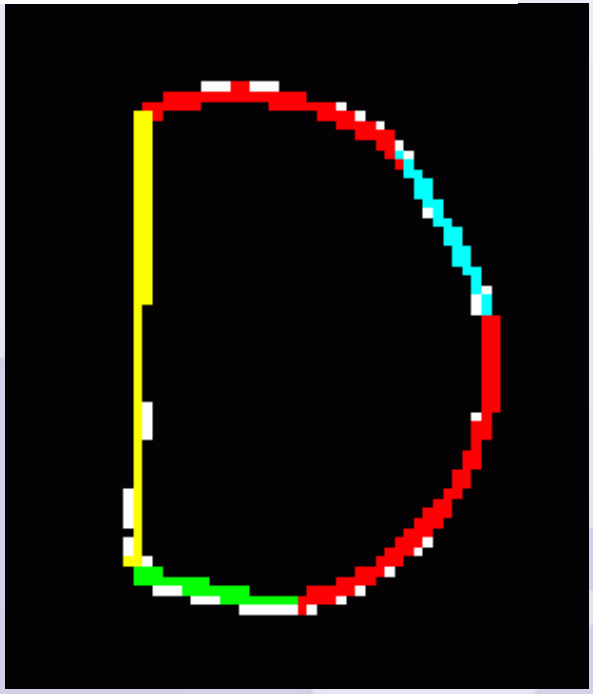

a
b
c

Fitting to facetted shape

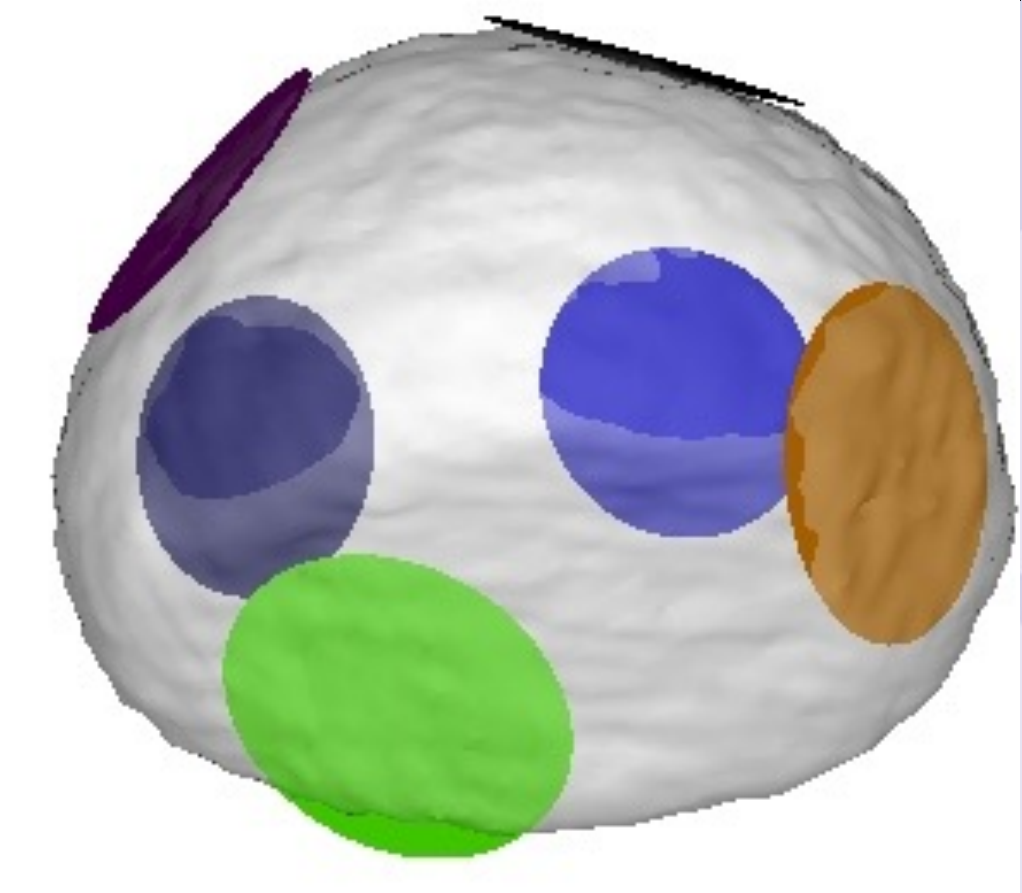


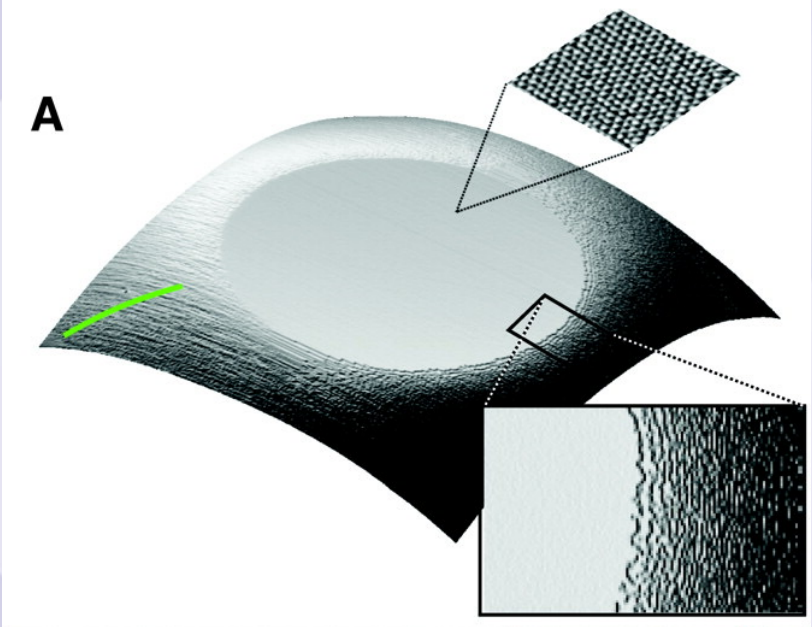
	$\|R\|$		P0	P1	P2	P3	P4	P5	P6
	9.4	P0	0	85	149	79	134	106	71
	25.7	P1		0	123	164	83	76	102
	25.1	P2			0	72	67	74	110
	25.9	P3				0	111	106	76
	25.4	P4					0	113	68
	25.4	P5						0	176
	26.0	P6							0 0

Angles between facets



Facets of Equilibrium Crystal Shape





Thurmer K, Williams E, Reutt-Robey J
Science **297** 2033 (2002)

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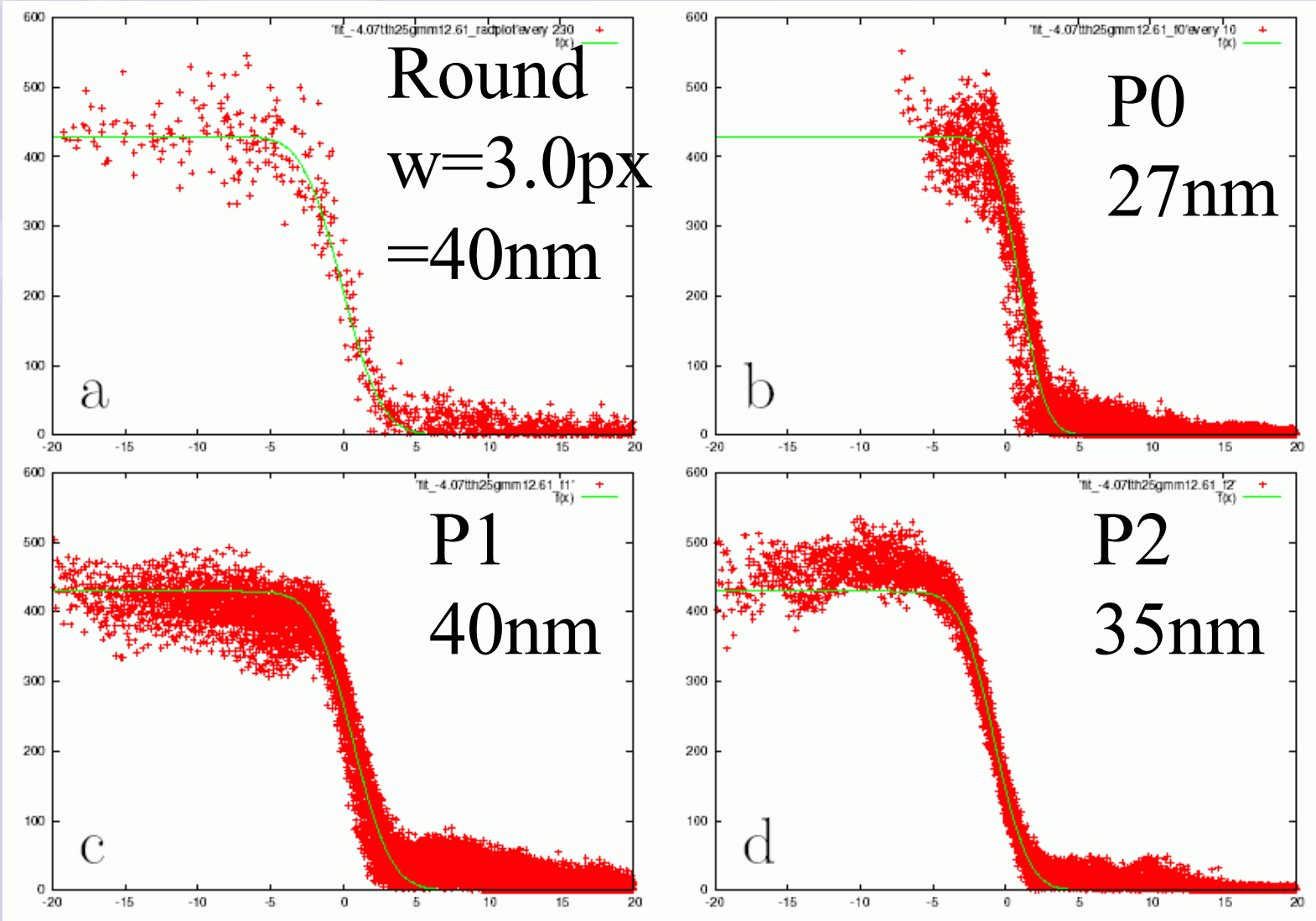
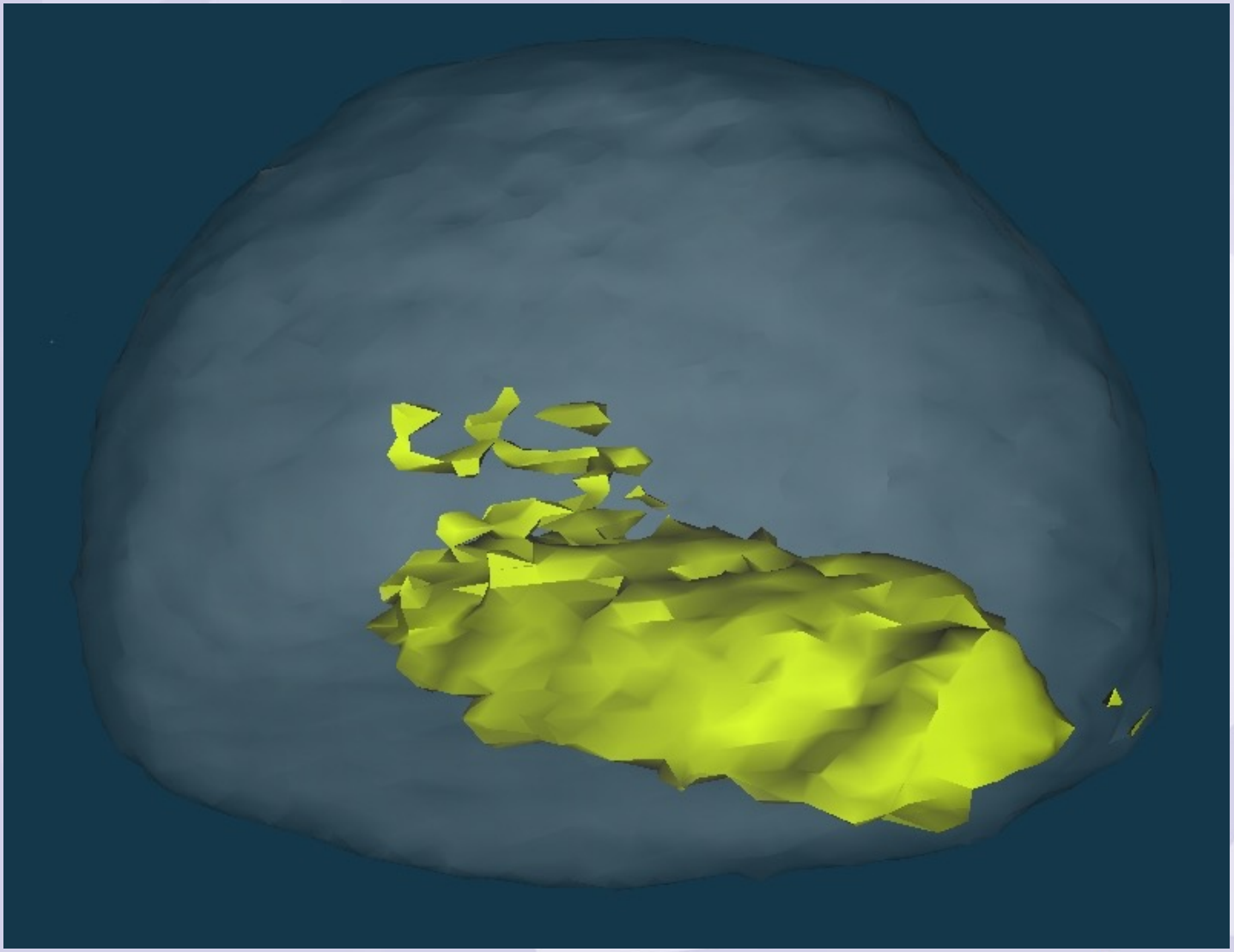
Density distribution across surface



Modeling of 3D Phase Bump



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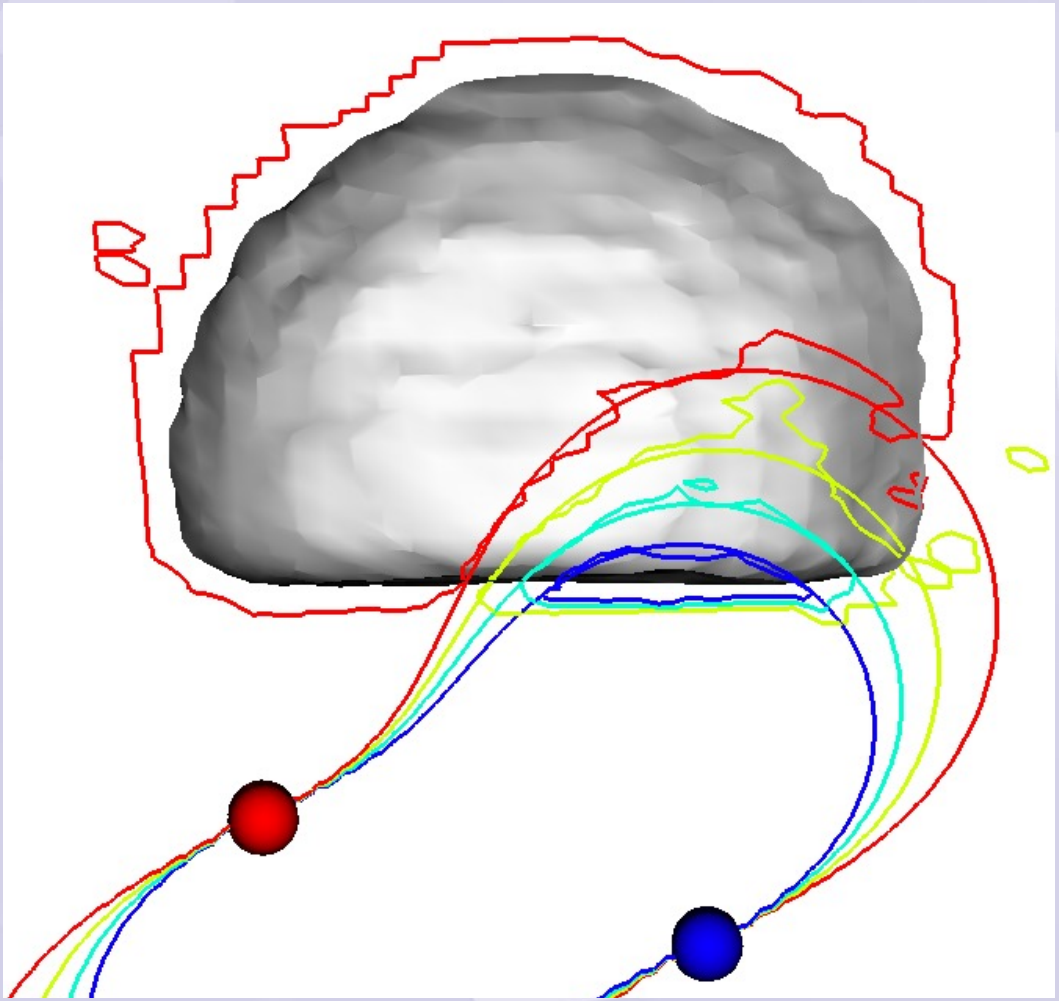
Field lines of Point Charges



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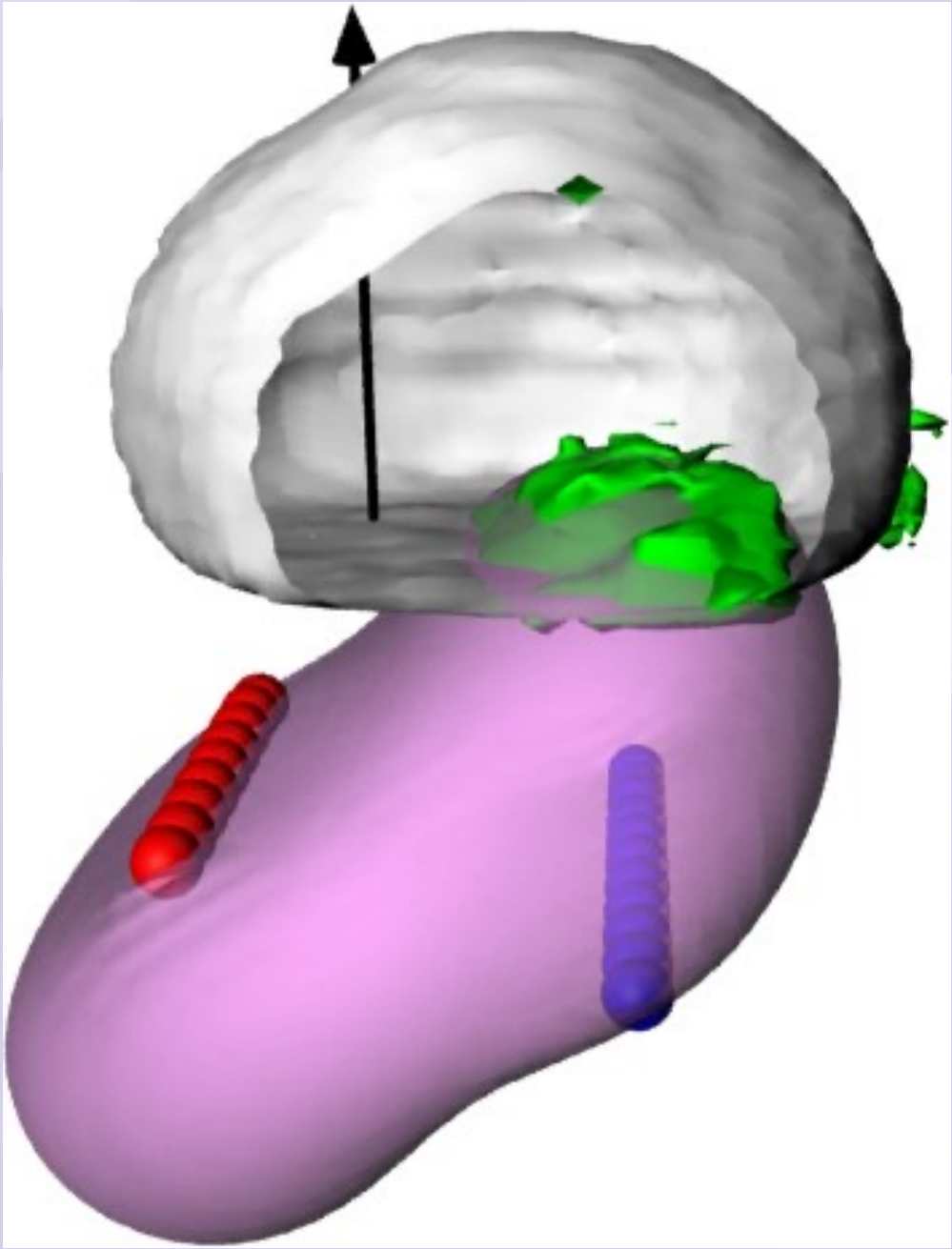

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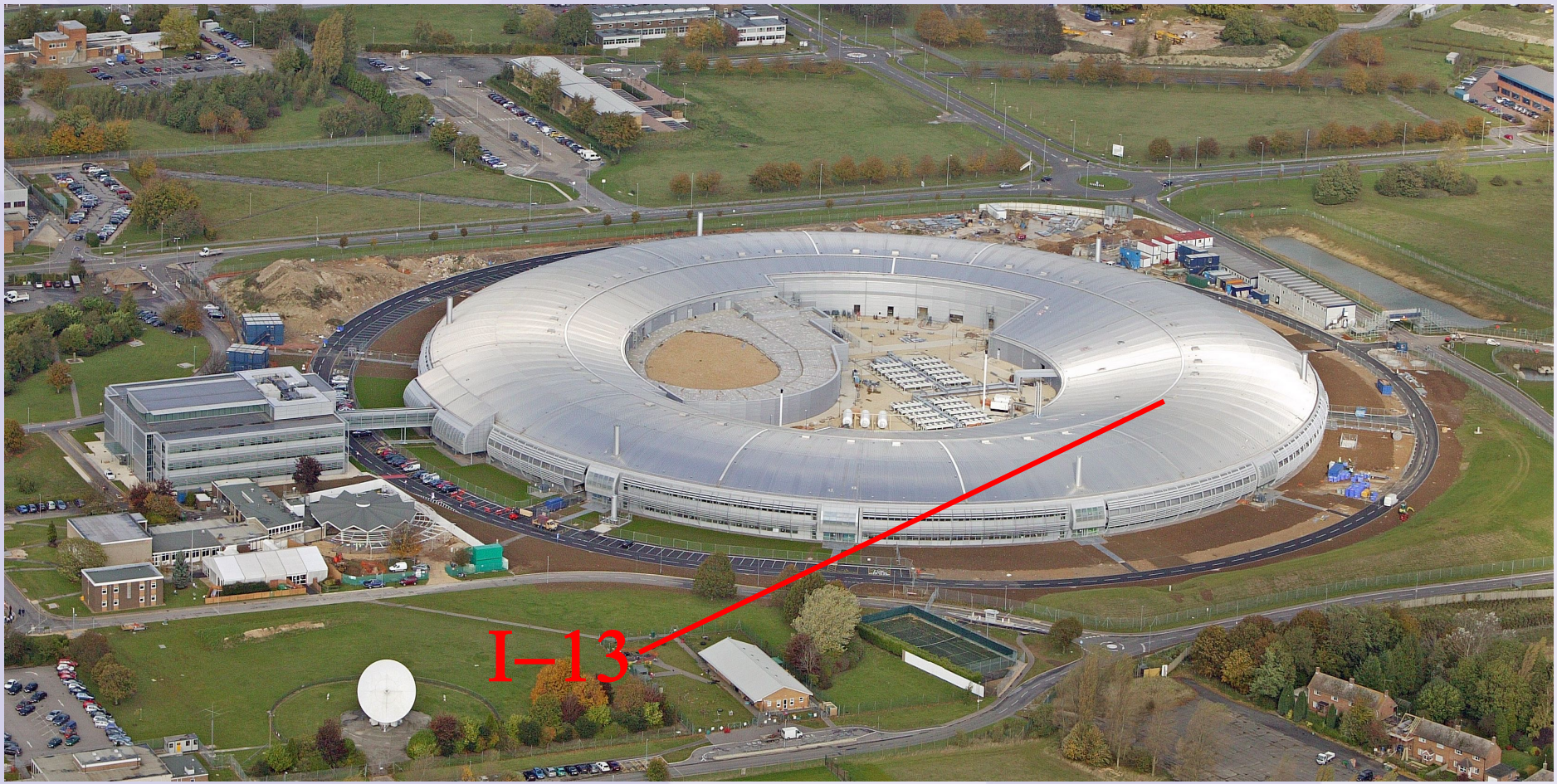
I-13 Beamline History

- I-13 is the last-but-one phase 2 beamline at Diamond
- Combines “Coherence” and “Imaging” proposals with parts of SAXS
- Approved by SAC
- Principal Beamline Scientist search in progress: to start Aug 2006
- First Users in 2010-11

Features of I-13 Port

- 8m straight – space for 2 full length ID's
- Slightly degraded emittance, which might be compensated with magnets
- Space to extend outside building.
- Convenient length of ~200m.

Diamond Light Source in Oct 2005



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Three long branches

- USAXS and XPCS
  - XPCS needs coherence
- Coherent Diffraction, lensless imaging
  - Needs coherence
- Tomography and full-field Imaging
  - Needs coherence for phase constrast

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Coherence

- Source is not fully coherent (hard X-rays)
  - 6x8mm (VxH) field of view at 200m
  - 0.4x0.04mm region is coherent
- Can divide one undulator beam into branches
  - mirrors, crystals, multilayers etc
- Secondary Source improves coherence
  - horizontal slit at shield wall (25m)
  - costs flux, but not coherent flux

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Radiation Damage in XPCS

- Much interest in polymers, biomaterials
  - inherently radiation sensitive
- Dynamics affected even before structure?
- Long exposures needed to get statistics
- Beat by spreading beam over larger area
  - sample far from source (long beamline)
  - increase coherence length (sec. source)

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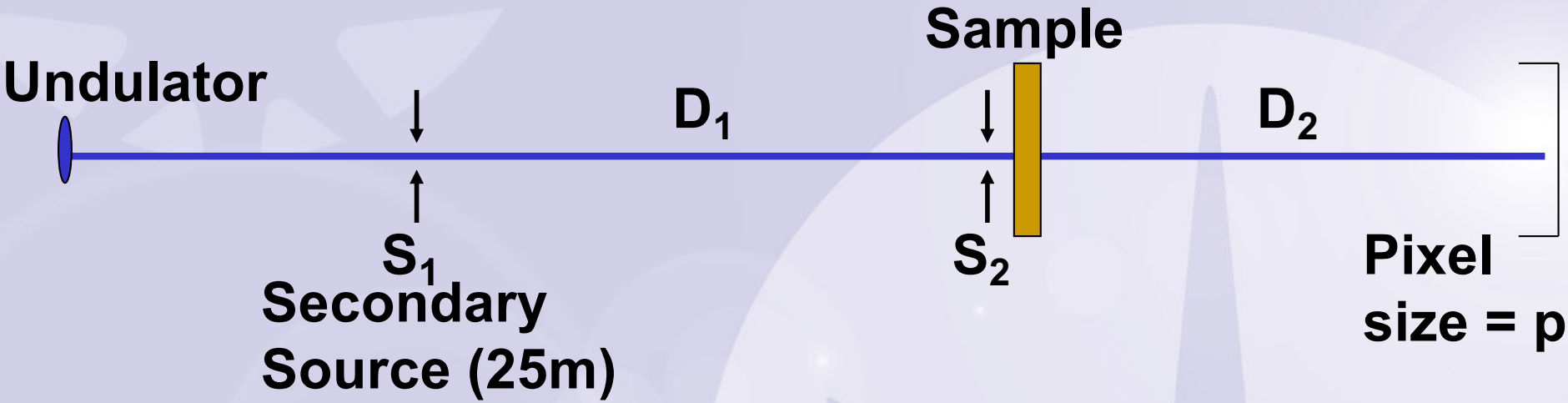
XPCS beamline to beat radiation damage



- Need $2p = \lambda D_2/S_2$ to resolve speckles, but also $p > S_2$ to be in far field
- Need $S_2 = \lambda D_1/S_1$ to have coherent illum.
- Works with D_1=40m, D_2=200m, λ=0.2nm, S_1 = 80μm, S_2 = 100μm, p = 200μm

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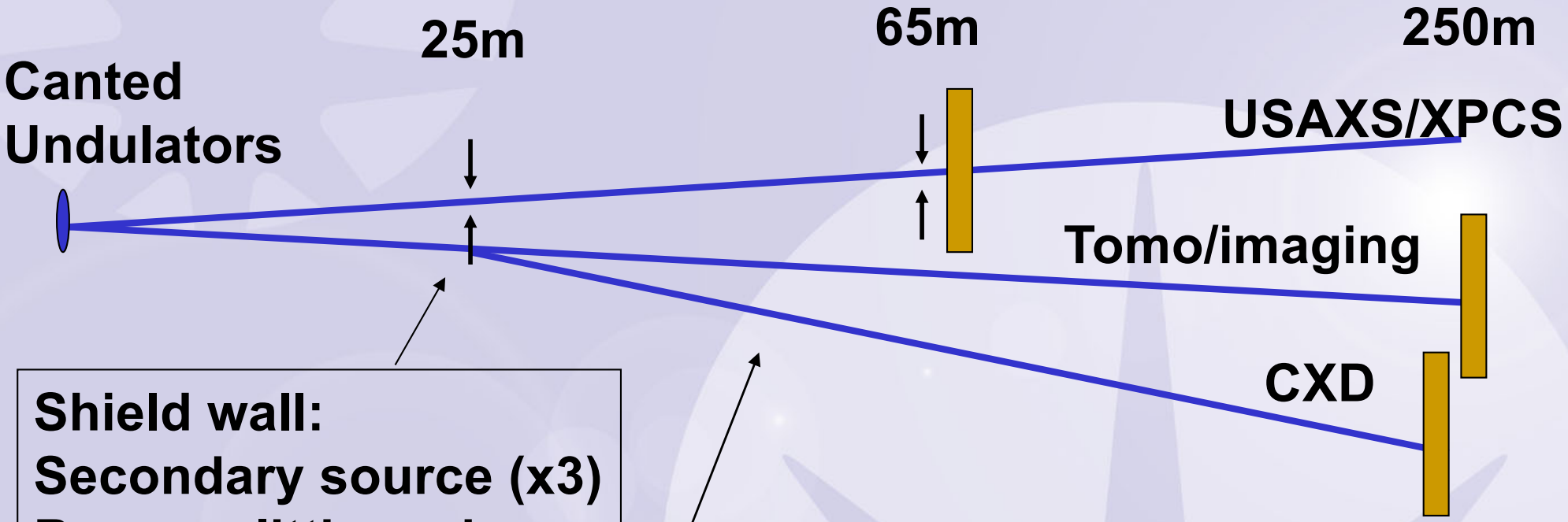
Schematic layout of I-13



Shield wall:
Secondary source (x3)
Beam splitting mirror

Floor:
Control cabins
USAXS samples
Monochromators (x3)

Outhouse:
USAXS/XPCS detector
Endstations (x2)
Control cabins (x2)

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