Sector 4 Beamlines: Avenues for Improvements

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Advanced Photon Source

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Sector 4 Main Features

Beam lines dedicated to:

- spectro-microscopy with polarized radiation
- scattering

Two independently operating branches:

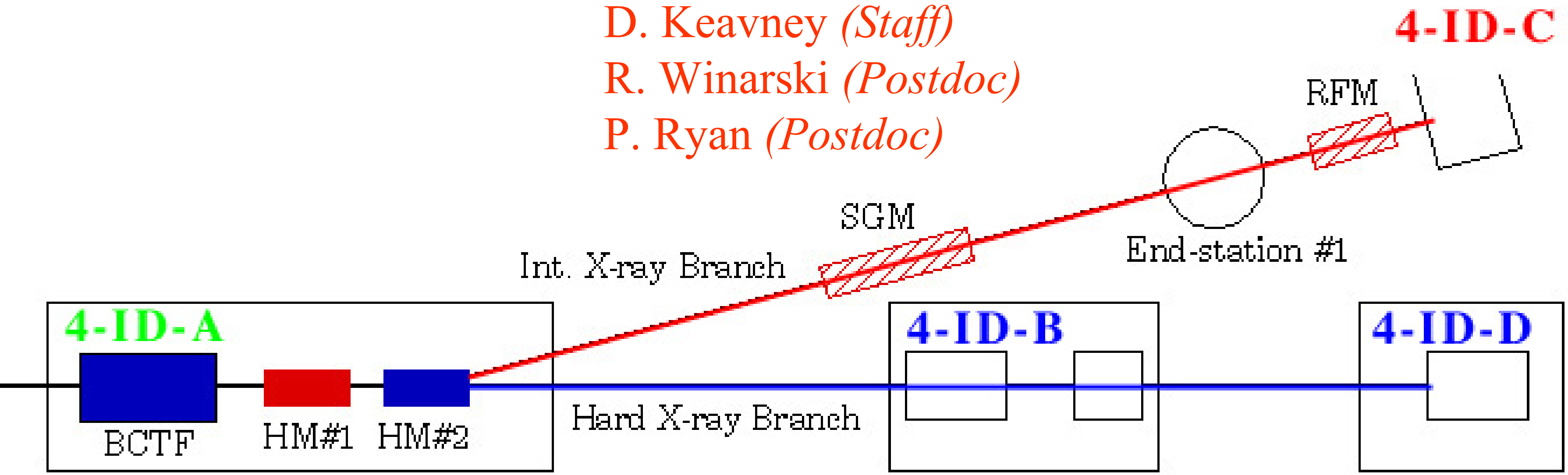
4-ID-C: 0.5 - 3 keV ⇒ circularly polarized undulator

4-ID-D: 3 - 100 keV ⇒ undulator A

Sector 4 Main Layout

G. Srajer - Group Leader

J. Freeland *(Staff)*
D. Keavney *(Staff)*
R. Winarski *(Postdoc)*
P. Ryan *(Postdoc)*



S. Sinha *(UCSD)*
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D. Haskel *(Staff)*
D. Lee *(Postdoc)*
C. Kmety-Stevenson *(Postdoc)*
Y. Choi *(Grad student)*

Sources of Polarized Radiation

4-ID-C: $\Rightarrow$ circularly polarized undulator

- Current operating mode : circular
- Frequency: ~ 10 minutes to switch helicity

Sources of Polarized Radiation, continued

4-ID-D: ⇒ undulator A + phase retarding optics

- Diamond single crystal as a phase retarder

Beam acceptance limited by:

- Size of the crystal (3 mm x 6 mm)
- Diffraction geometry

  45 degrees ⇒ 0.707

  Bragg angle (~ 20 deg) ⇒ 0.364

Types of Experiments

1. Photoemission Electron Microscopy (PEEM)

- spatial resolution affected by photon beam size
- lower beam emittance desirable, however not critical

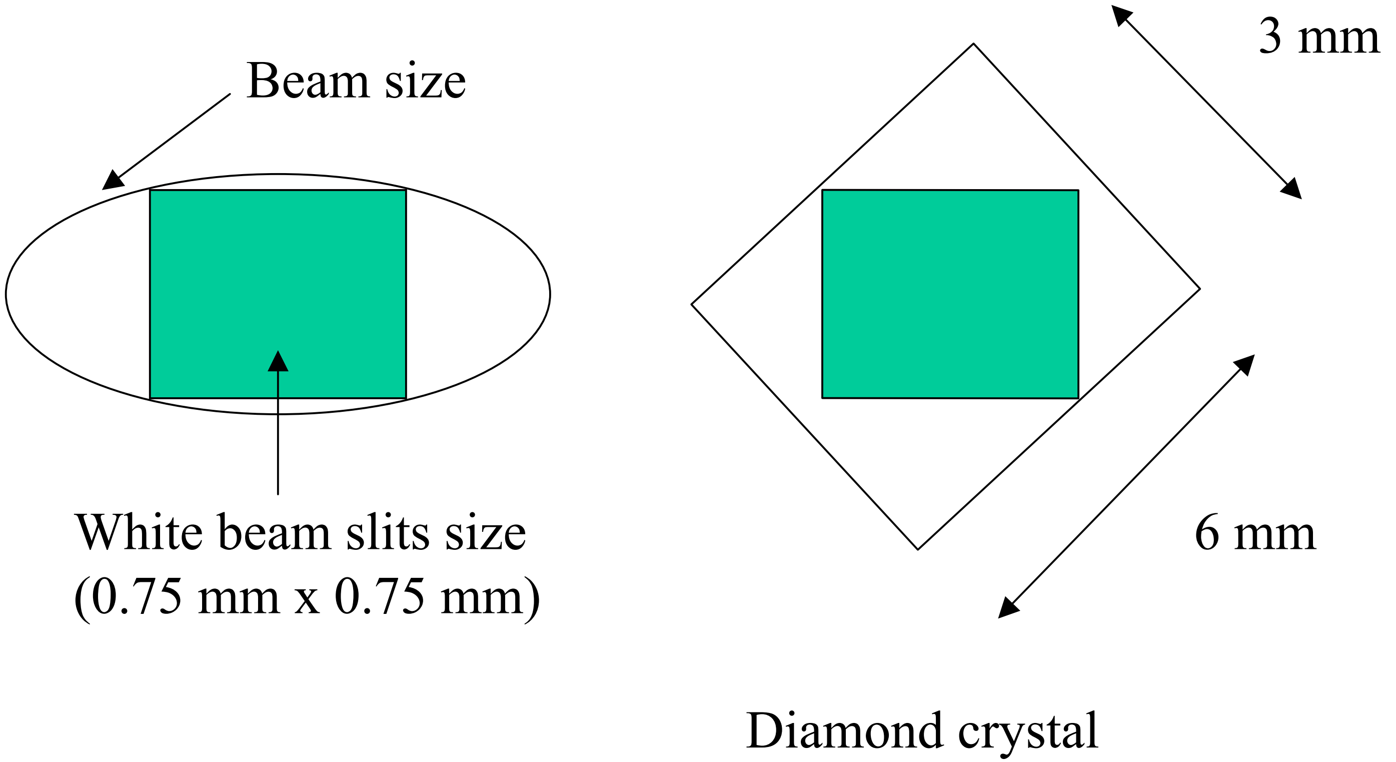
2. Reflectivity

- small samples and thin interfaces
- low beam emittance very important

Types of Experiments, continued

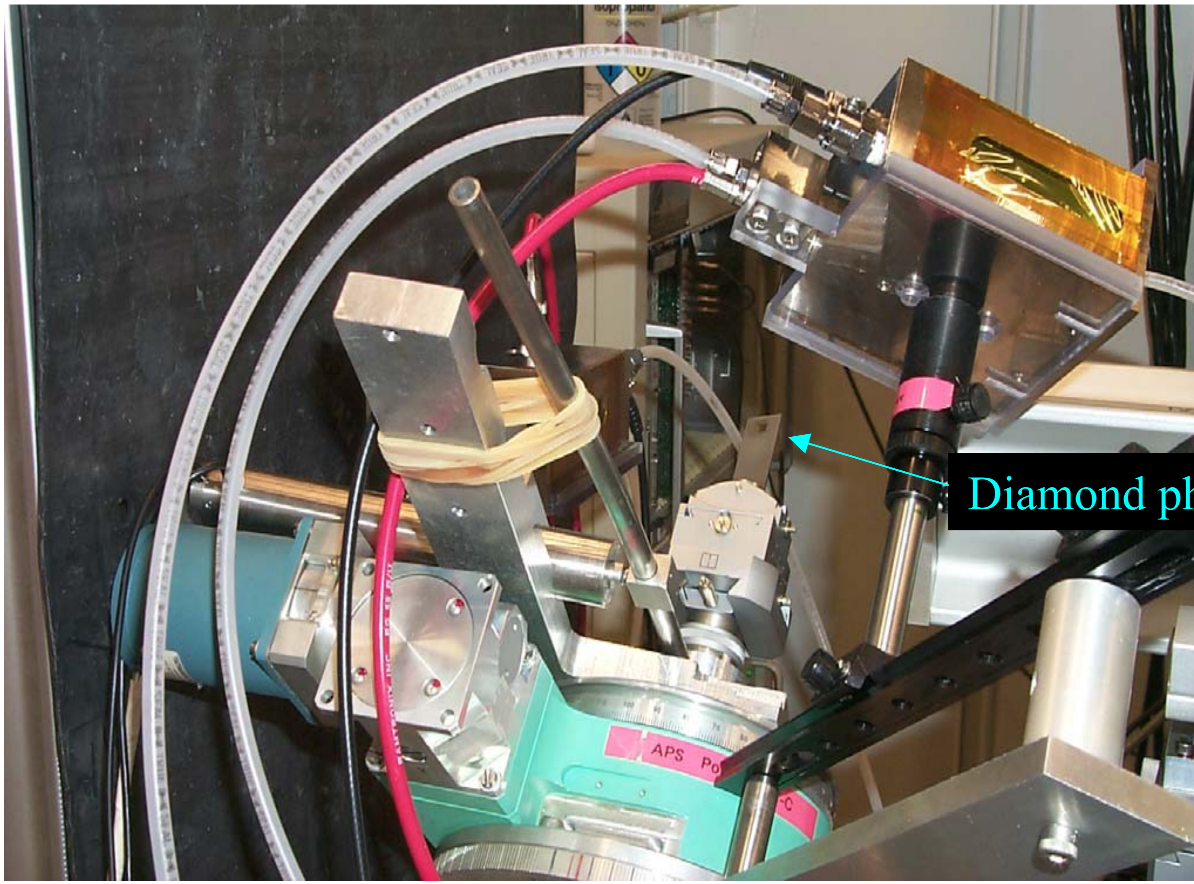
3. Magnetic Imaging

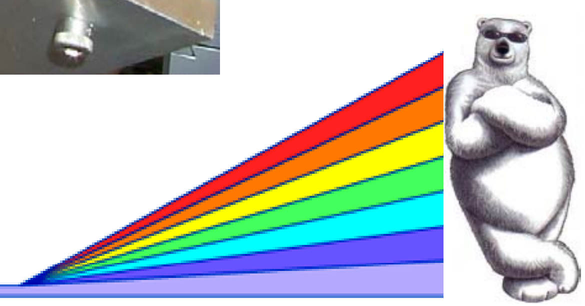
- combining polarized radiation with focusing optics
- assuming ideal optic, spatial resolution limited by source
- low emittance critical



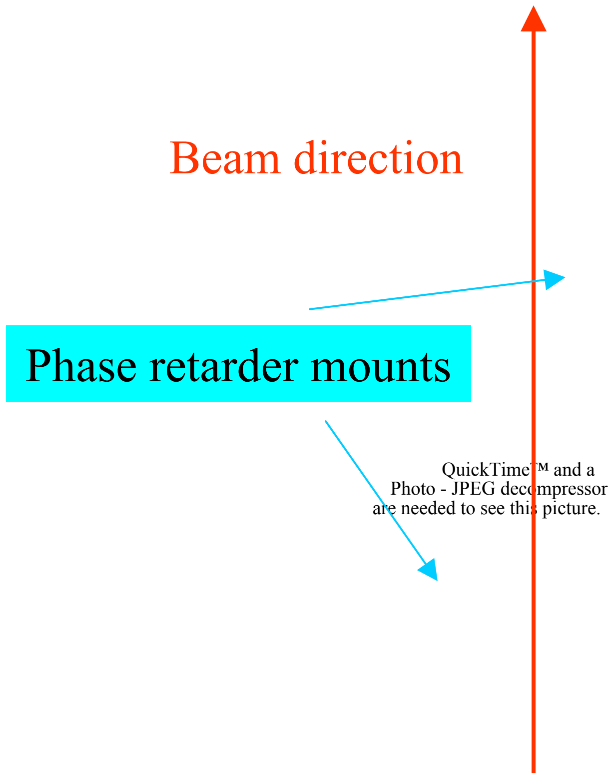
Small crystal size limits horizontal acceptance to 25%

Phase Retarder Assembly (Before)

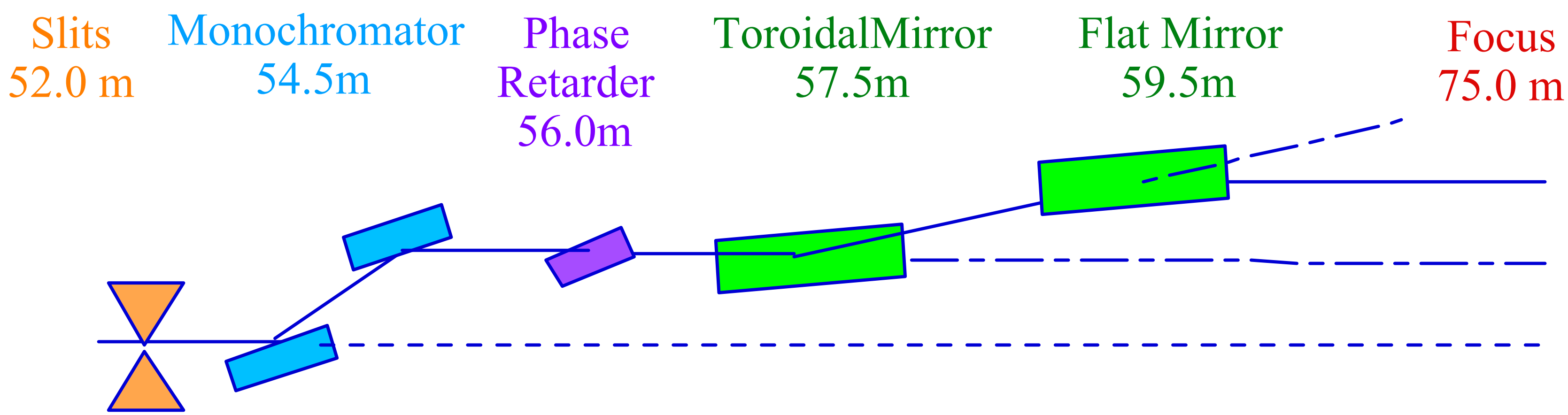




Phase Retarder Assembly (Now)



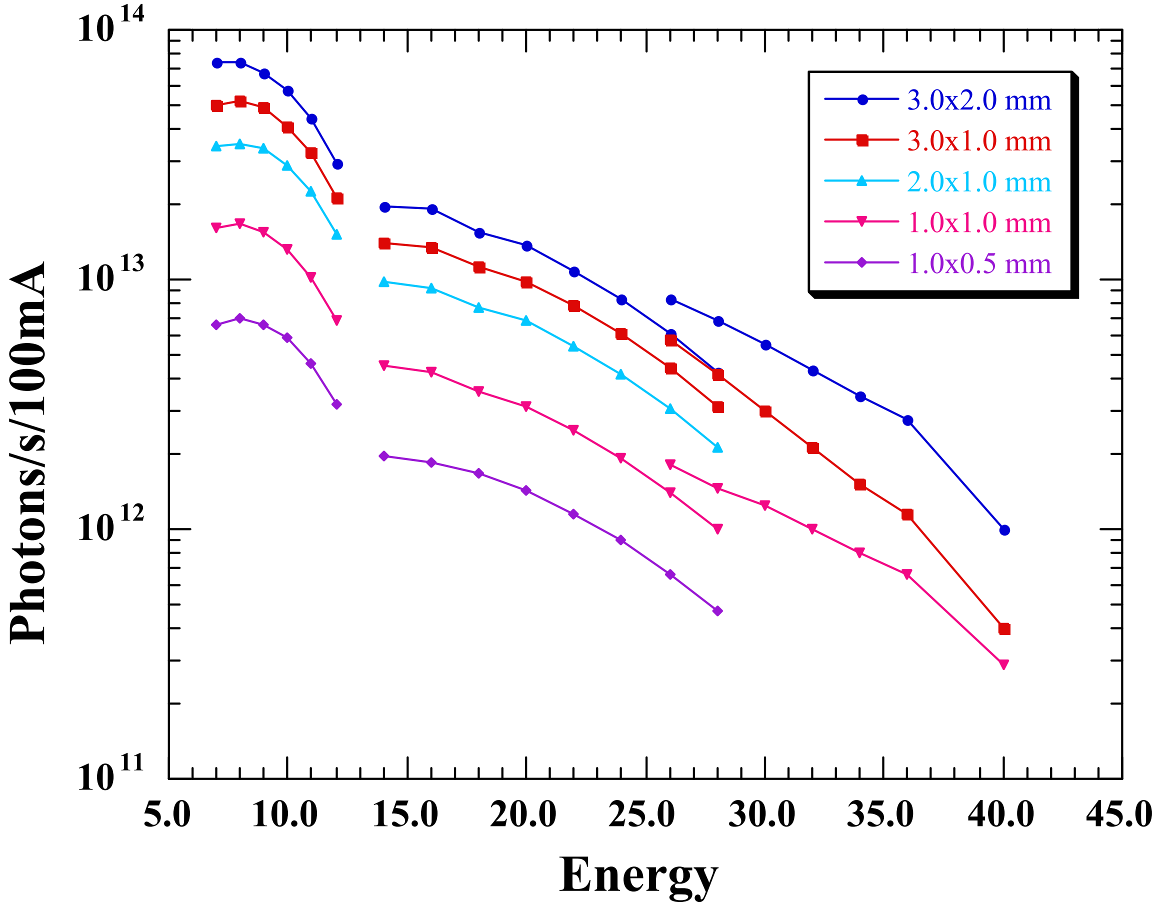
Hard X-ray Optics



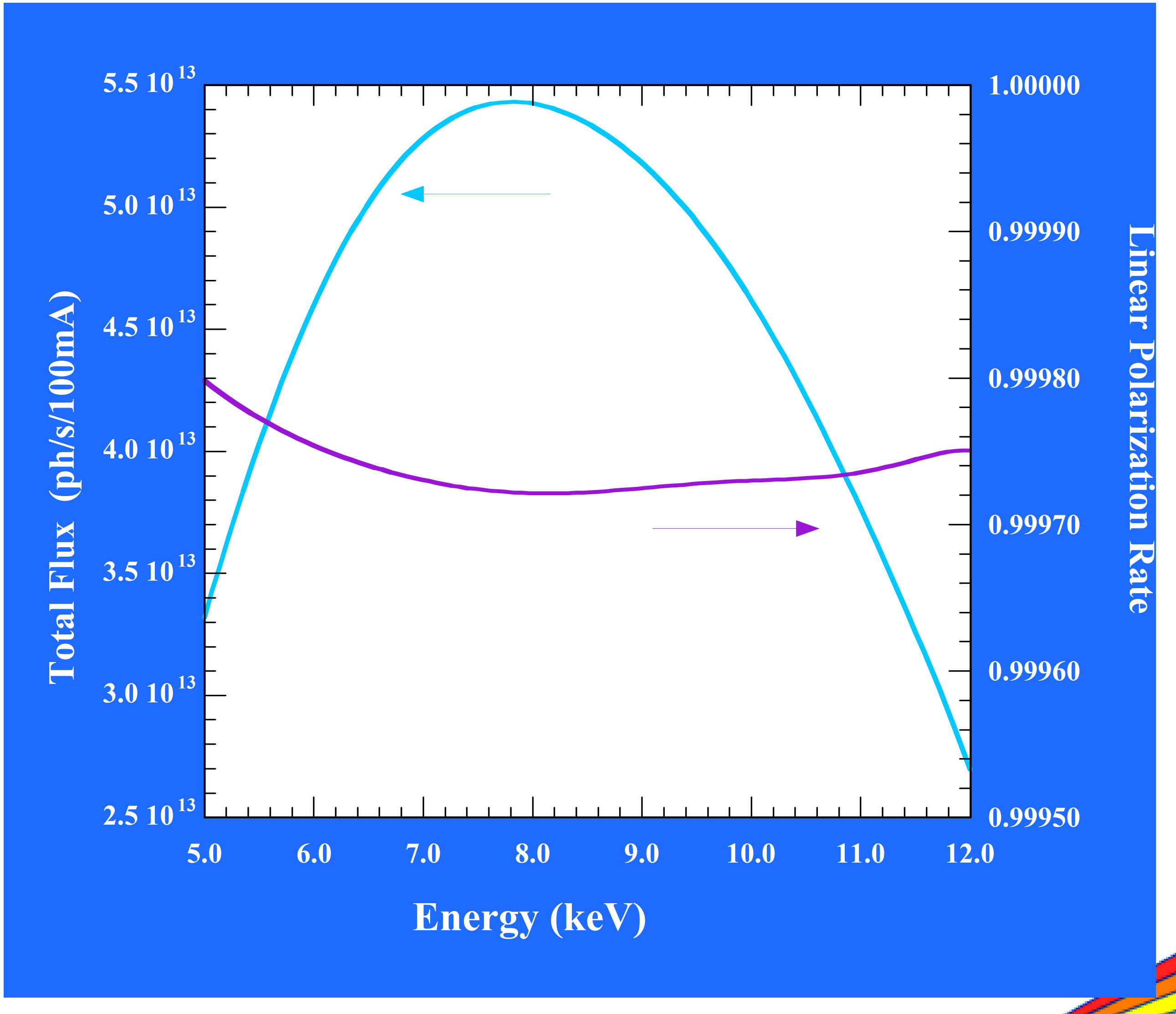
- Cryo Mono; Si (111) 2->45keV
- Phase Retarder; $I/I_o \sim 0.2, P_{lin} \to P_{circ}$
- Toroidal Mirror; Focusing (or Collimating)

  θ = 1.0->3.7 (6.0) mrad
- Flat Mirror
- Focus 250µm x 100µm

Measured Flux

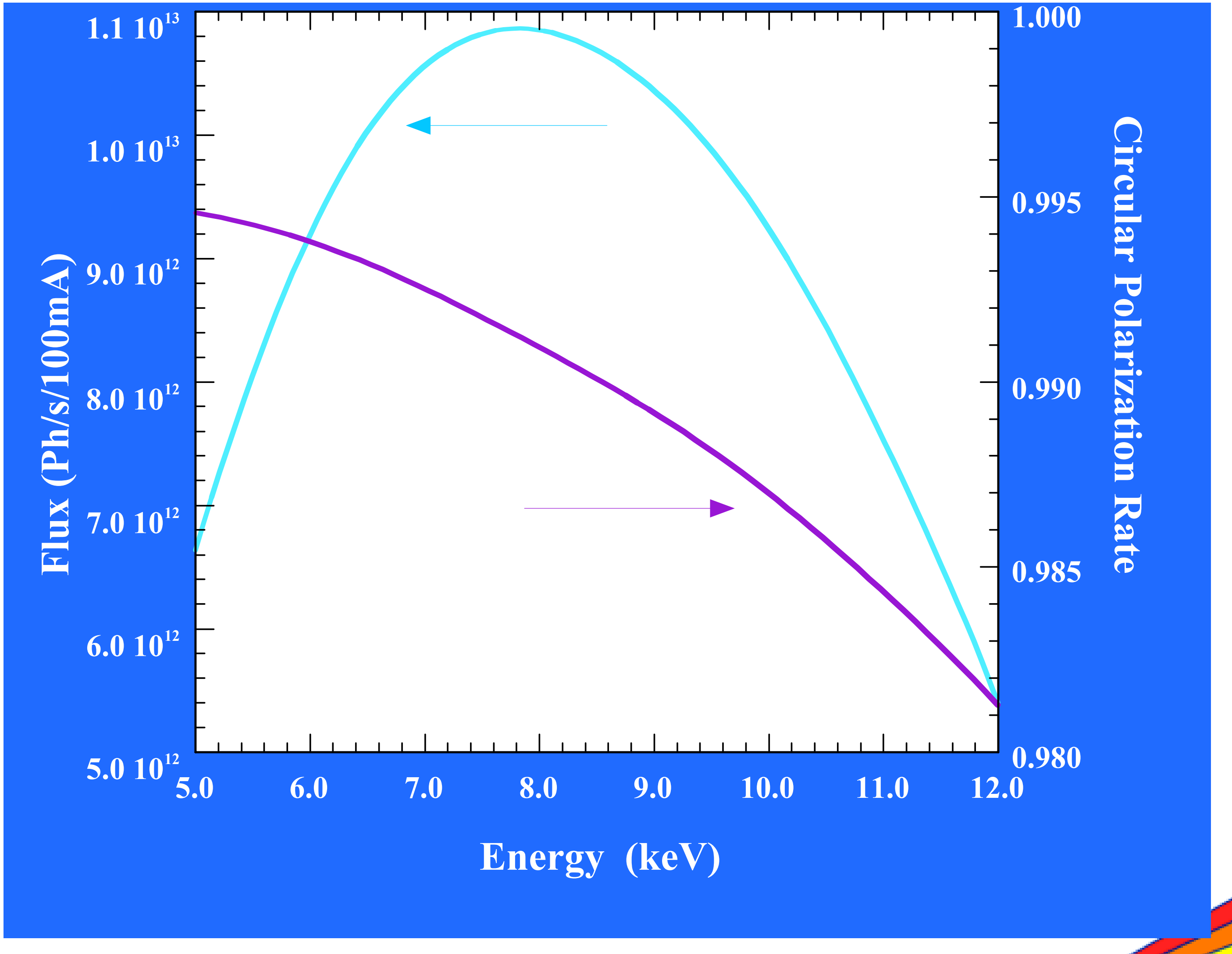


Sector 4 Flux and Linear Polarization

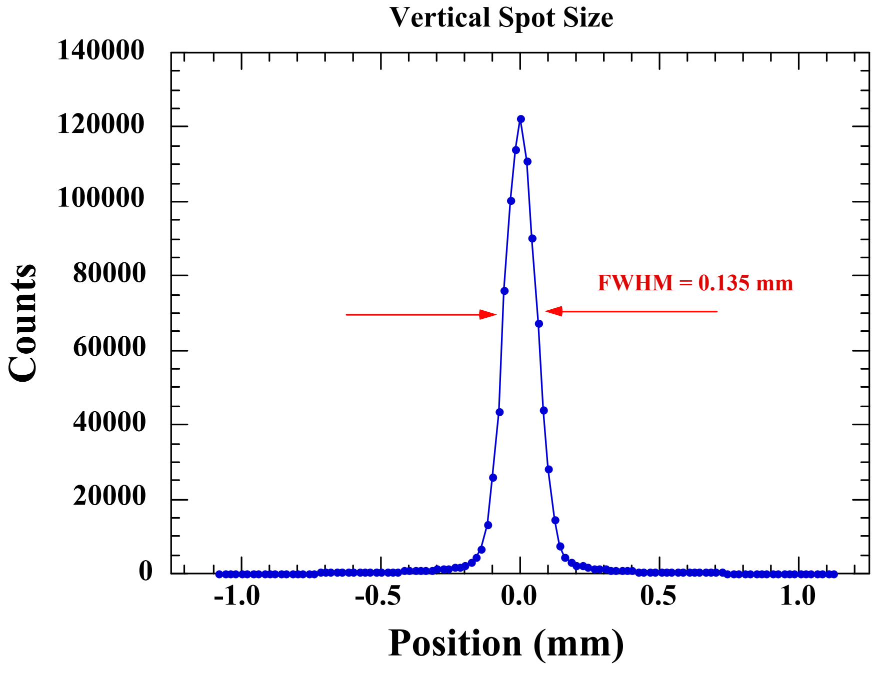


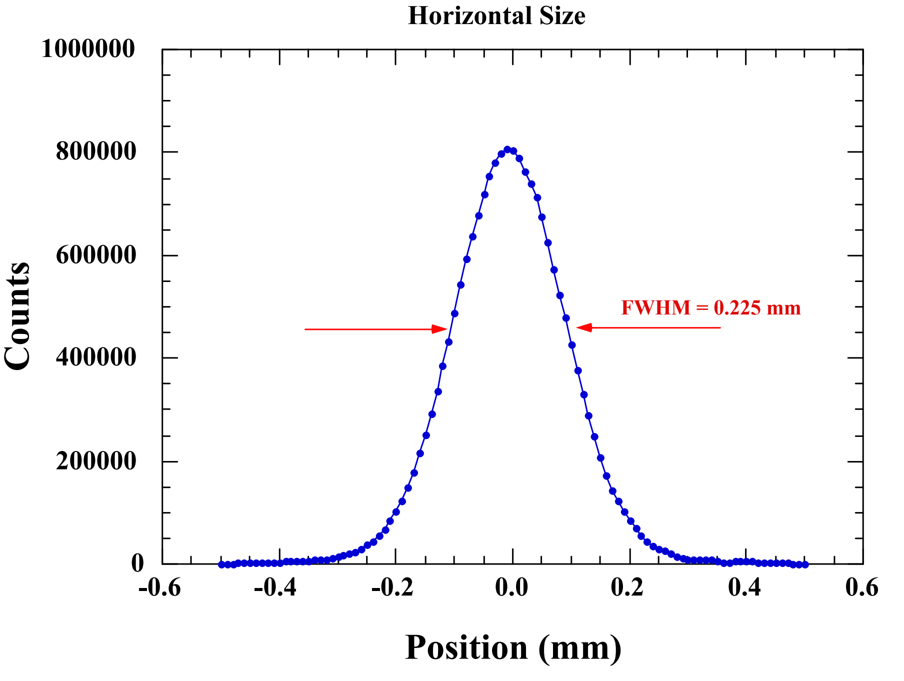
Advanced Photon Source-Polarization Studies

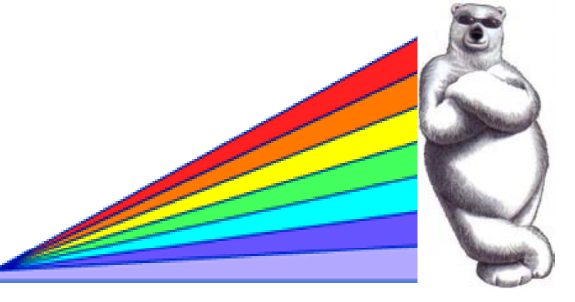
Sector 4 Flux and Circular Polarization Rate



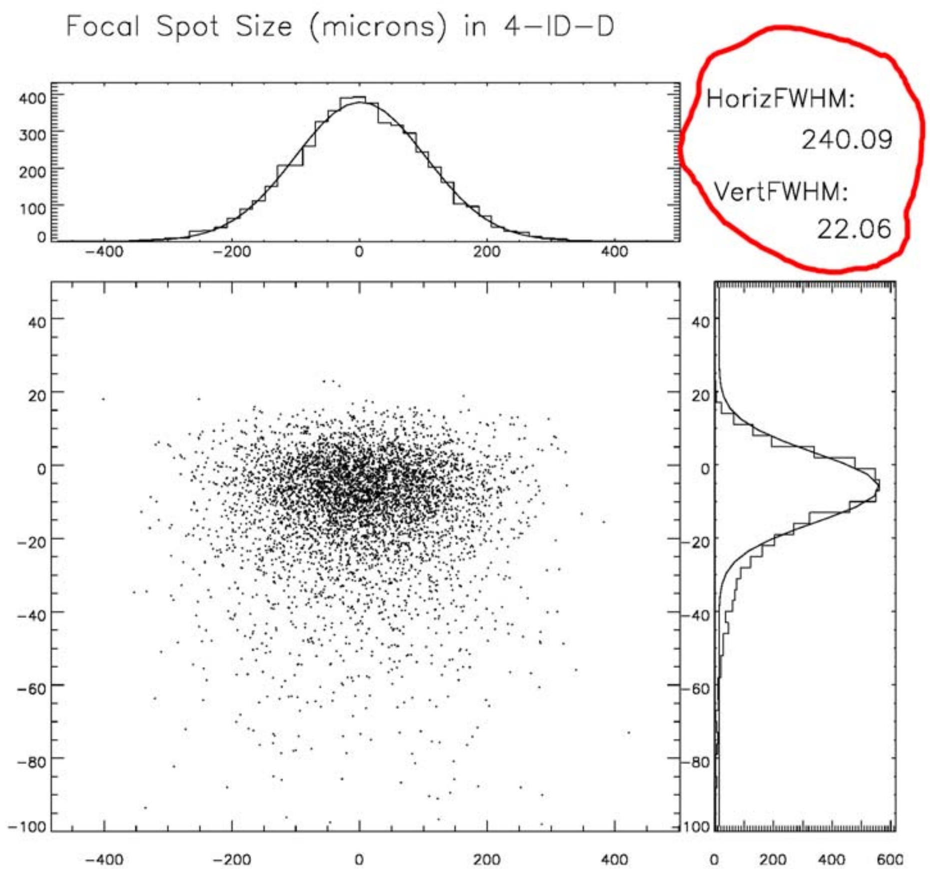
Beam Size in Focal Spot



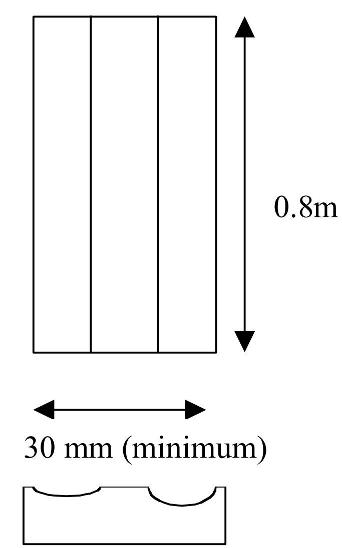




Toroidal Mirror Focus



Pd mirror
V. Focus: Adjustable
H. Focus: 2 Groves + Flat



Imaging of Magnetic Domains in SmCo/Fe

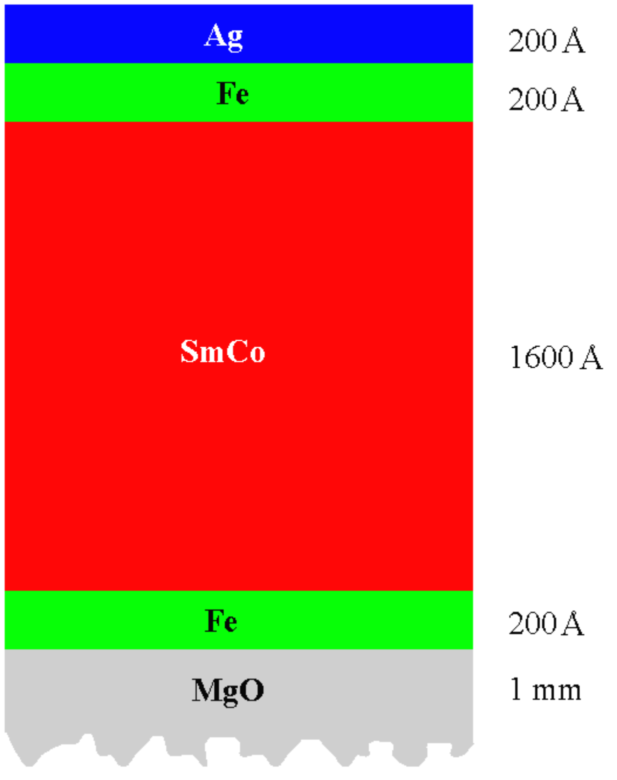
Spring magnets = nanocomposites of soft and hard magnets

Promising applications:

- very strong magnets
- non-volatile memory cells

No tools (up to now) could probe "buried" interfaces!!

SmCo/Fe Spring Magnets



SmCo buried under Fe and Ag capping layer
Other techniques can not image the SmCo magnetic structure

∴ use hard x-ray microprobe

Structure
Size
Orientation

Imaging...

Technique is to combine:

(a) **Helicity-dependent fluorescence**

(b) Microfocusing

Cross section:

$$\sigma \propto \sigma_0 + MP_c \cos\theta$$

Imaging...

Magnetization could be extracted by:

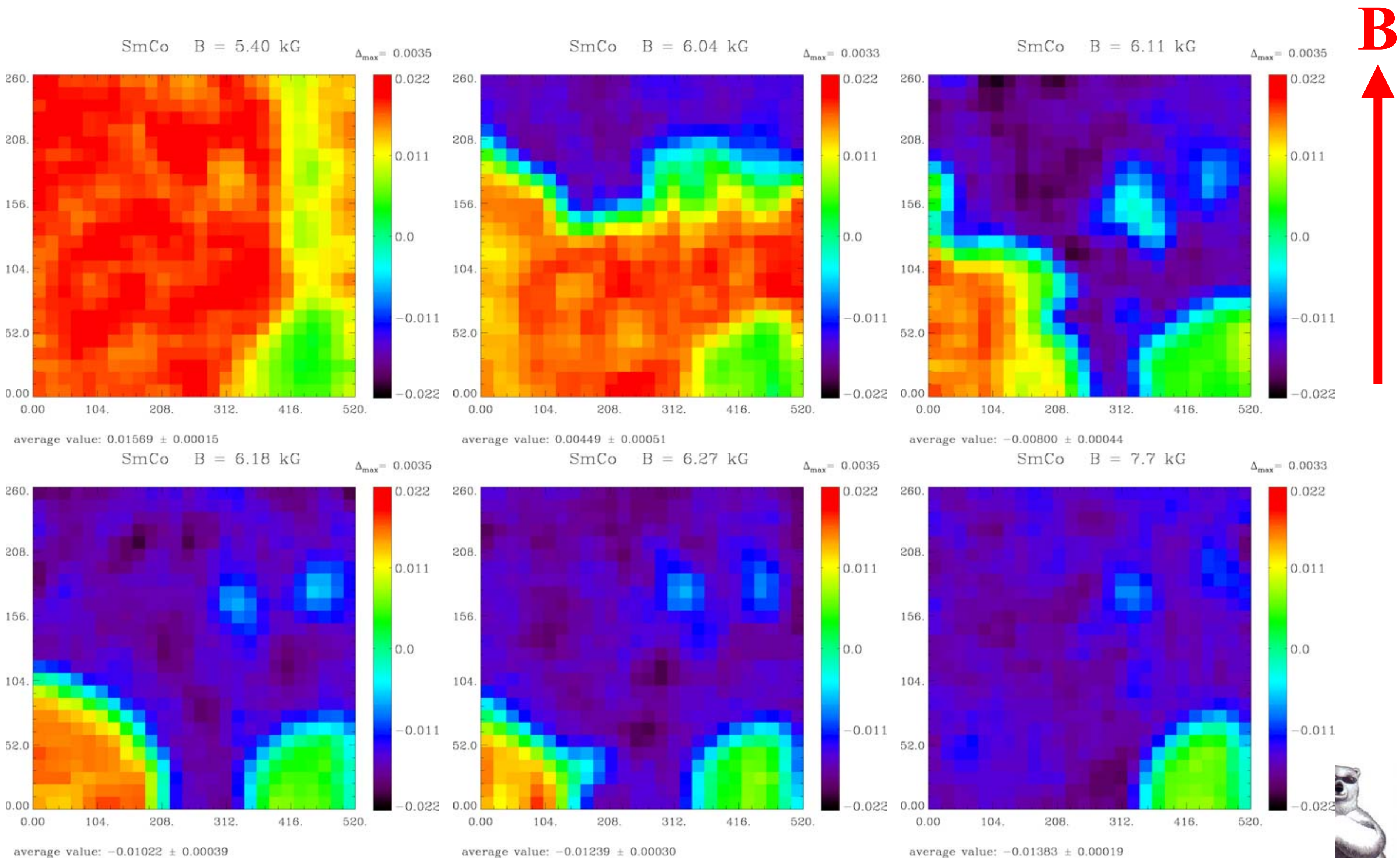
- switching photon helicity and
- subtracting intensities

$$M \propto \frac{I_+ - I_-}{I_+ + I_-}$$

⇒ Flipping ratio

Energy tuned near the Sm L_3 edge: 6.710 keV

Magnetic Domains Images 250x500 μm^2



Advanced Photon Source-Polarization Studies

Priority List for Improved Performance

1. Low beam emittance
   - diffraction limit ($\varepsilon \sim 0.01$ nm rad)
2. Switch CPU with ~ 1 sec transition time
3. Beam position and angle stability for all polarizations
   - $\Delta x < 10\ \mu m$
   - $\Delta\theta < 1\ \mu rad$
4. AC modes of operation up to 10 Hz

5. Extend energy range on the hard x-ray branch to 2.5 keV
    - ID gap 9.5 mm

6. Beam stability
    - OK, hard to judge with so much optics

7. Beam current increase
    - probably a good idea to pursue