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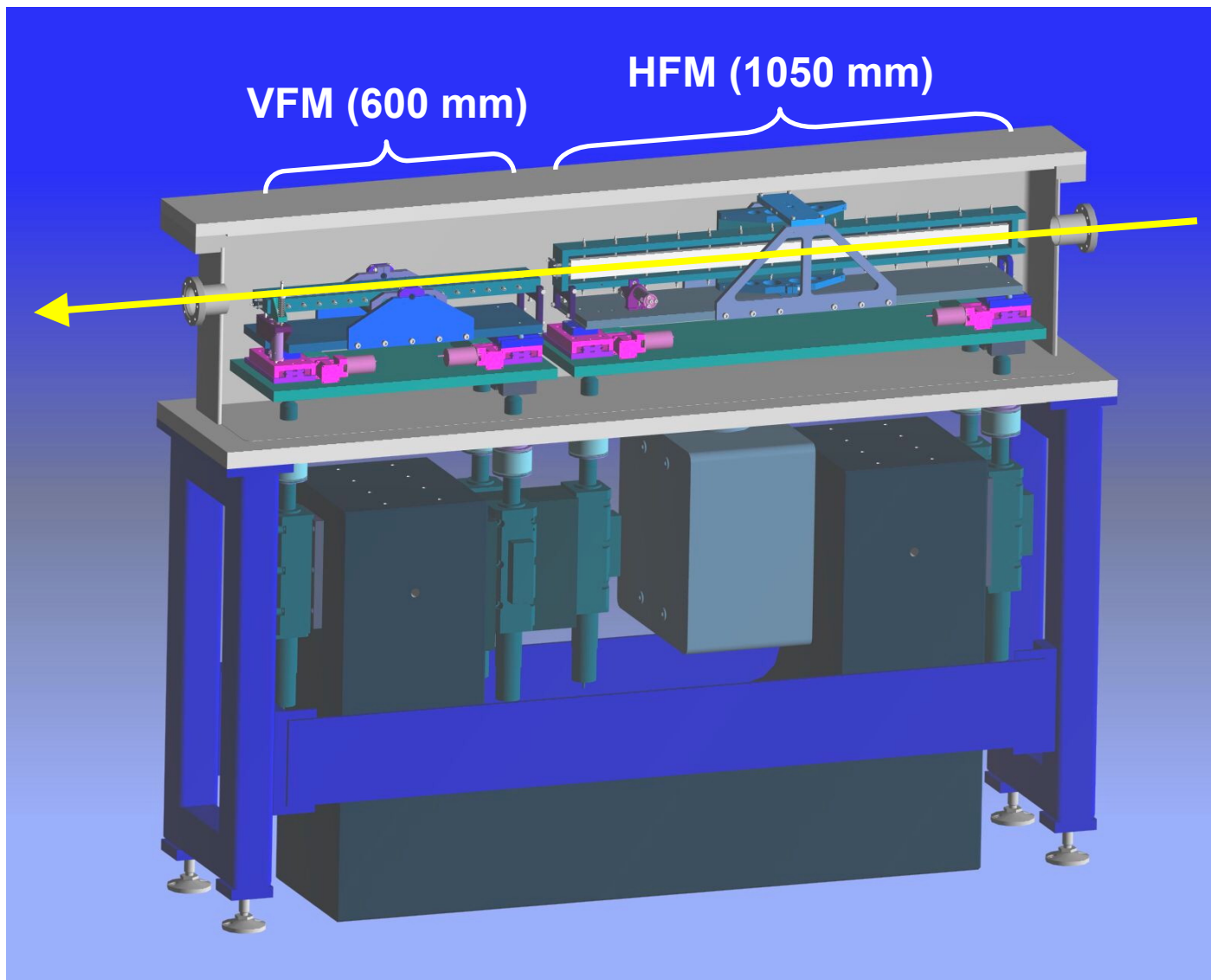
X-ray Focusing with Large Kirkpatrick-Baez Bimorph Mirrors

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GM/CA CAT
Argonne National Laboratory

February 21, 2008

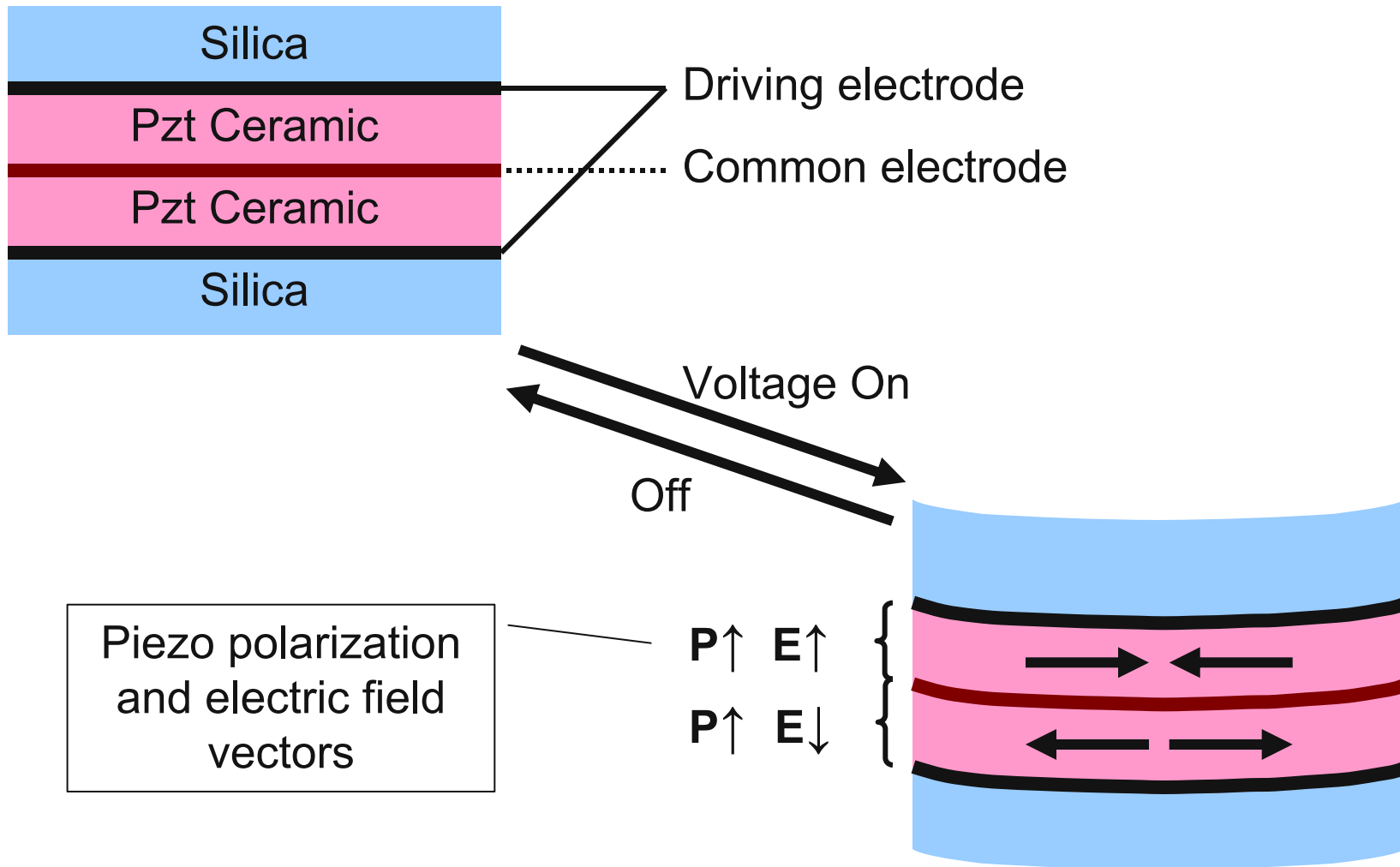
Our Mirrors



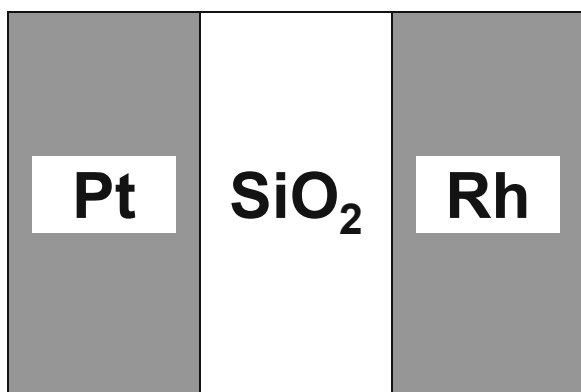
Beamline Positions and Focal Parameters

	ID_{in}	ID_{out}
Source	1.3 m	-1.3 m
HFM	65.8 m	48.0 m
VFM	66.7 m	48.9 m
Focus @ xtal (other possibility)	72.0 m (74.0 m)	(54.2 m) 56.2 m
Horizontal demag	10.4 (7.9) : 1	6.0 (7.9) : 1
Vertical demag	12.5 (9.0) : 1	6.9 (9.6) : 1
Theoretical focal size at current position	62 μm Horz 1.6 μm Vert	108 μm Horz 3.0 μm Vert
Realistic focal size (1 μrad slope error)	69 μm Horz 25 μm Vert	114 μm Horz 34 μm Vert

Bimorph Mirrors – Basic Principle



Our Mirrors - Coatings



Useful energy range (mirrors @ 3 mrad):

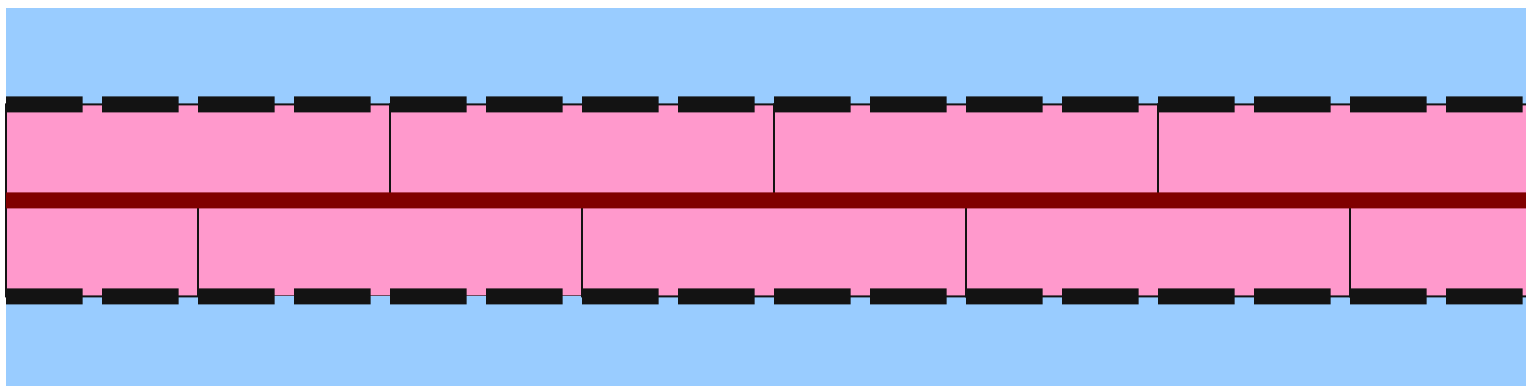
SiO₂ < 10 keV

Rh < 20 keV

Pt < 27 keV

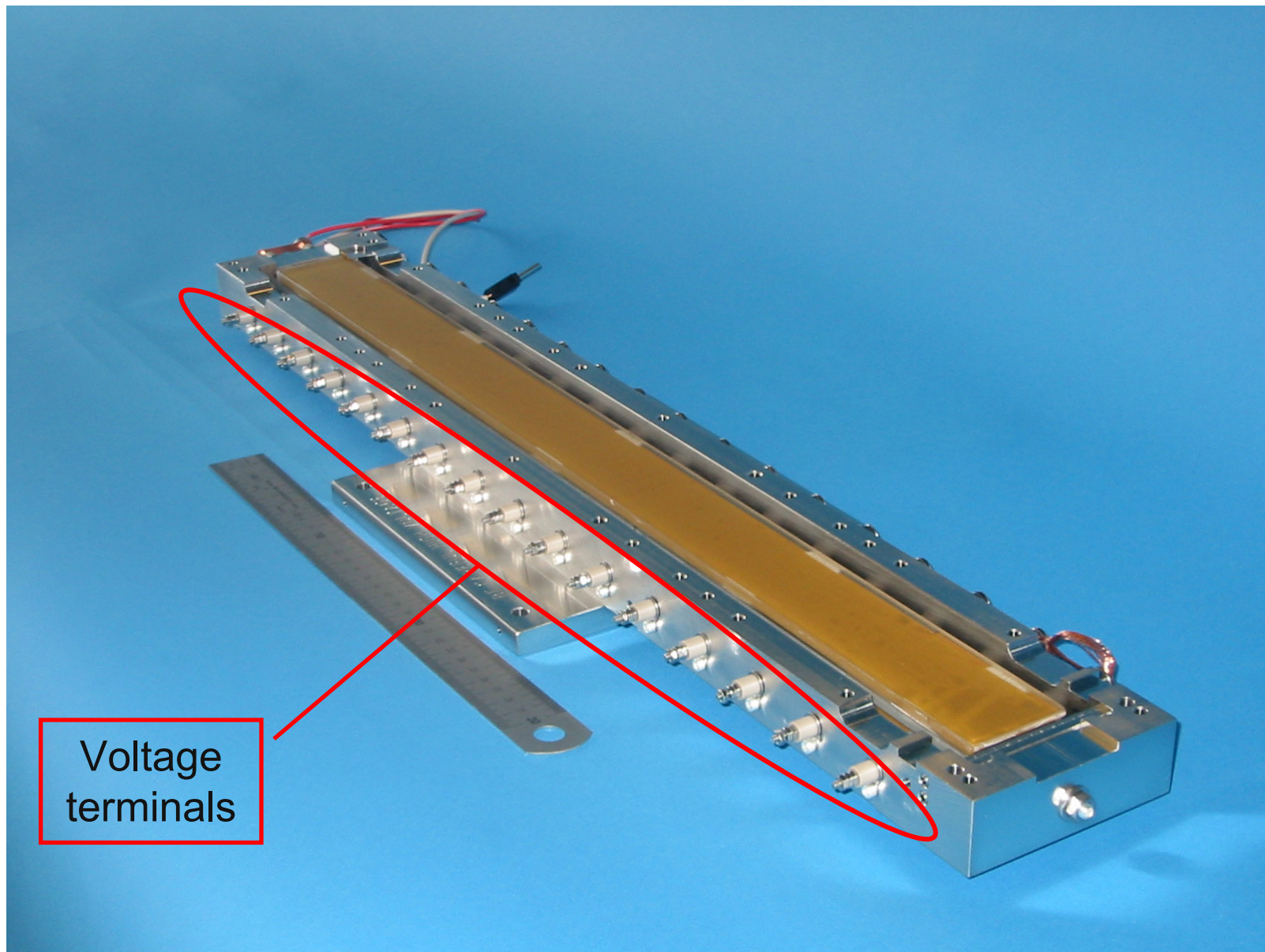


“Large” Mirrors



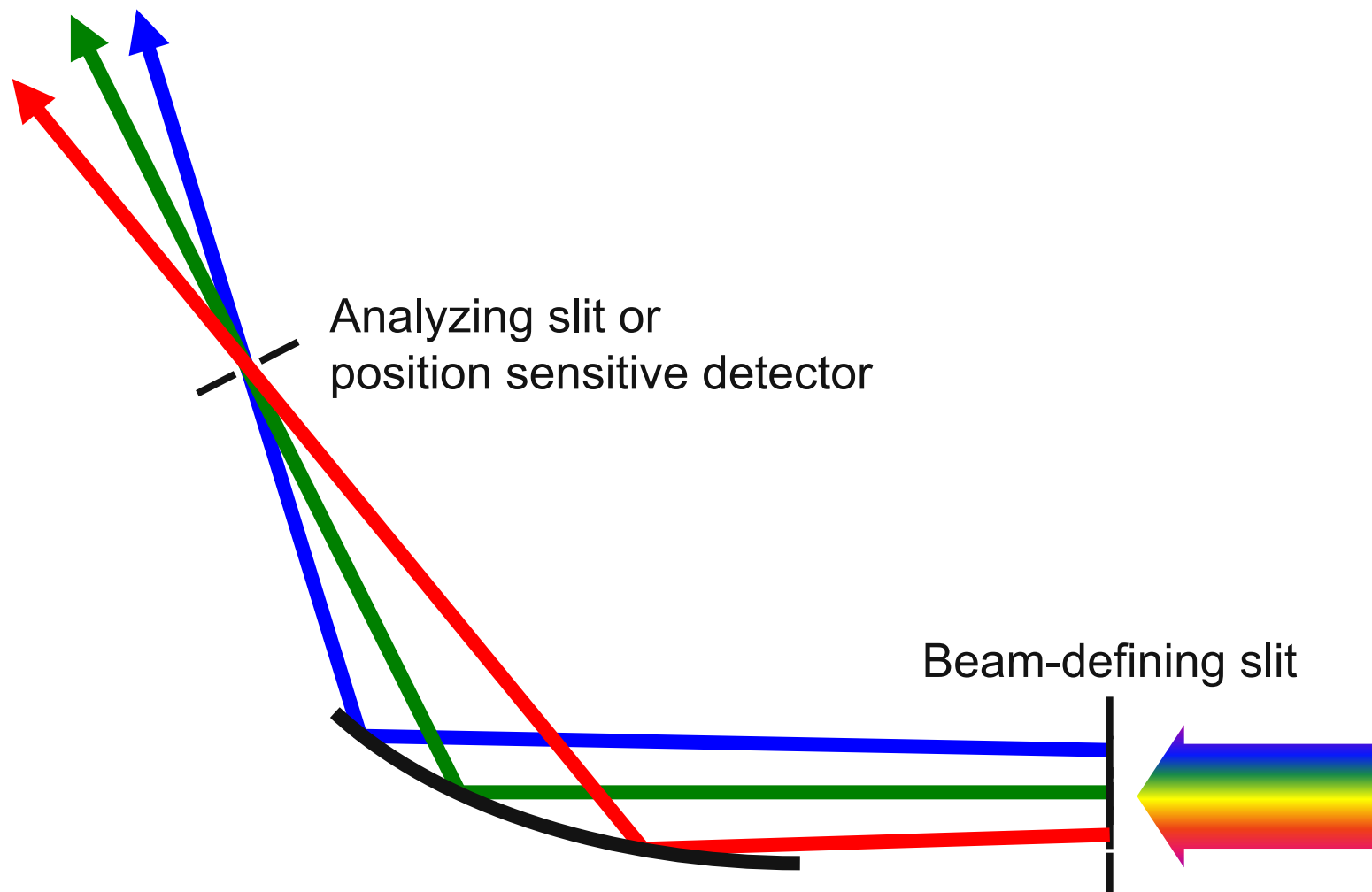
(A schematic of our VFM with 4 segments and 16 electrodes.)

- Our mirrors actually consist of multiple ceramic segments sandwiched between two single layers of silica.
- Multiple electrodes are deposited per segment.
- The exact construction is proprietary. In general terms, SESO may interleave segments (as above) or add additional layers to strengthen the mirror.

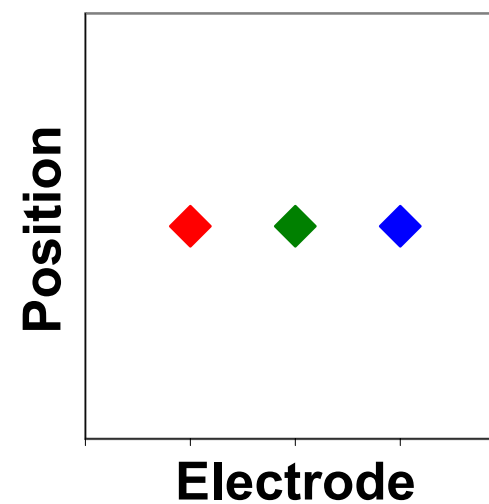
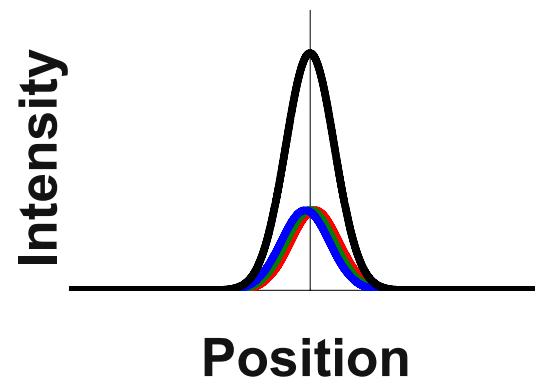
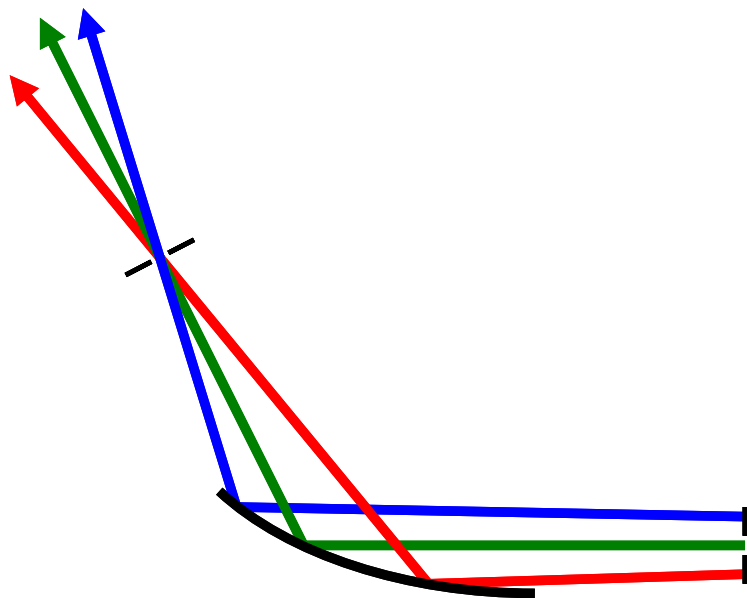


Voltage terminals

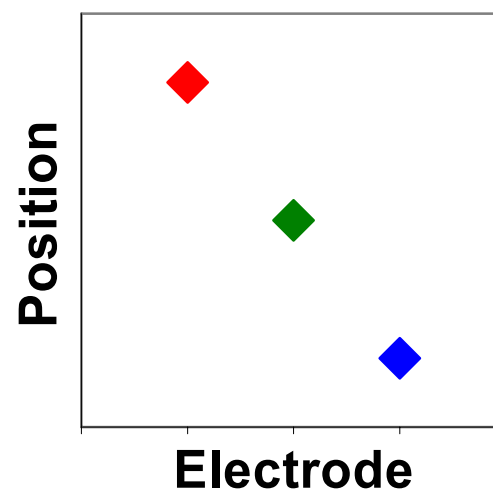
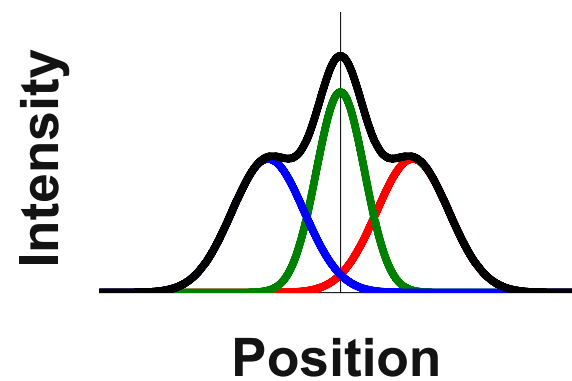
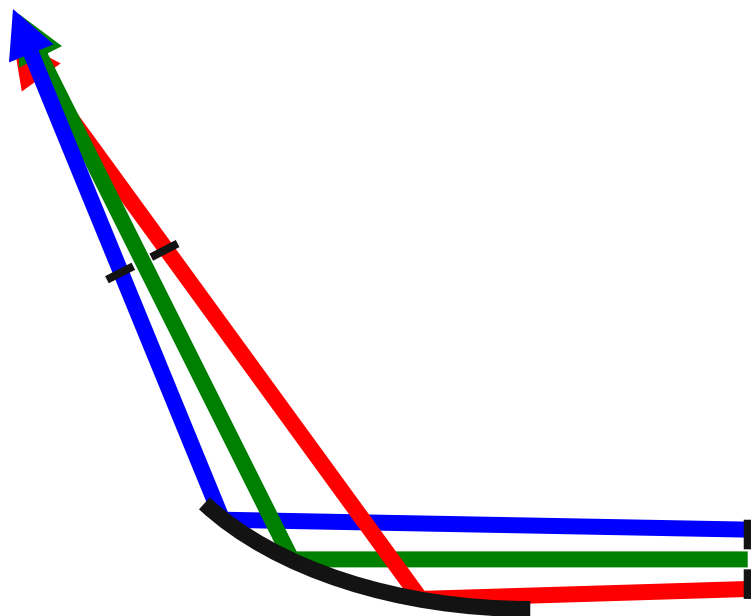
Focal Techniques



Focal Techniques



Focal Techniques



EPICS Mirror Controls



Controls by S. Stepanov
and ACCEL

Focal Techniques – Matrix Inversion

- Measure beamlet centroids at a certain voltage
- Pulse one electrode by a certain amount and re-measure all the centroids
- Continue this process with the remaining electrodes
- From this “interaction matrix”, one can calculate the voltage correction needed to focus the beamlets
- Details available: Signorato, *et al.*, JSR, vol. 5 (1998), 797-800.

Automated Focusing

The screenshot shows a software window titled "Mirror Matrix" with a subtitle "23o Mirror Focusing Matrix". The interface includes several configuration options:

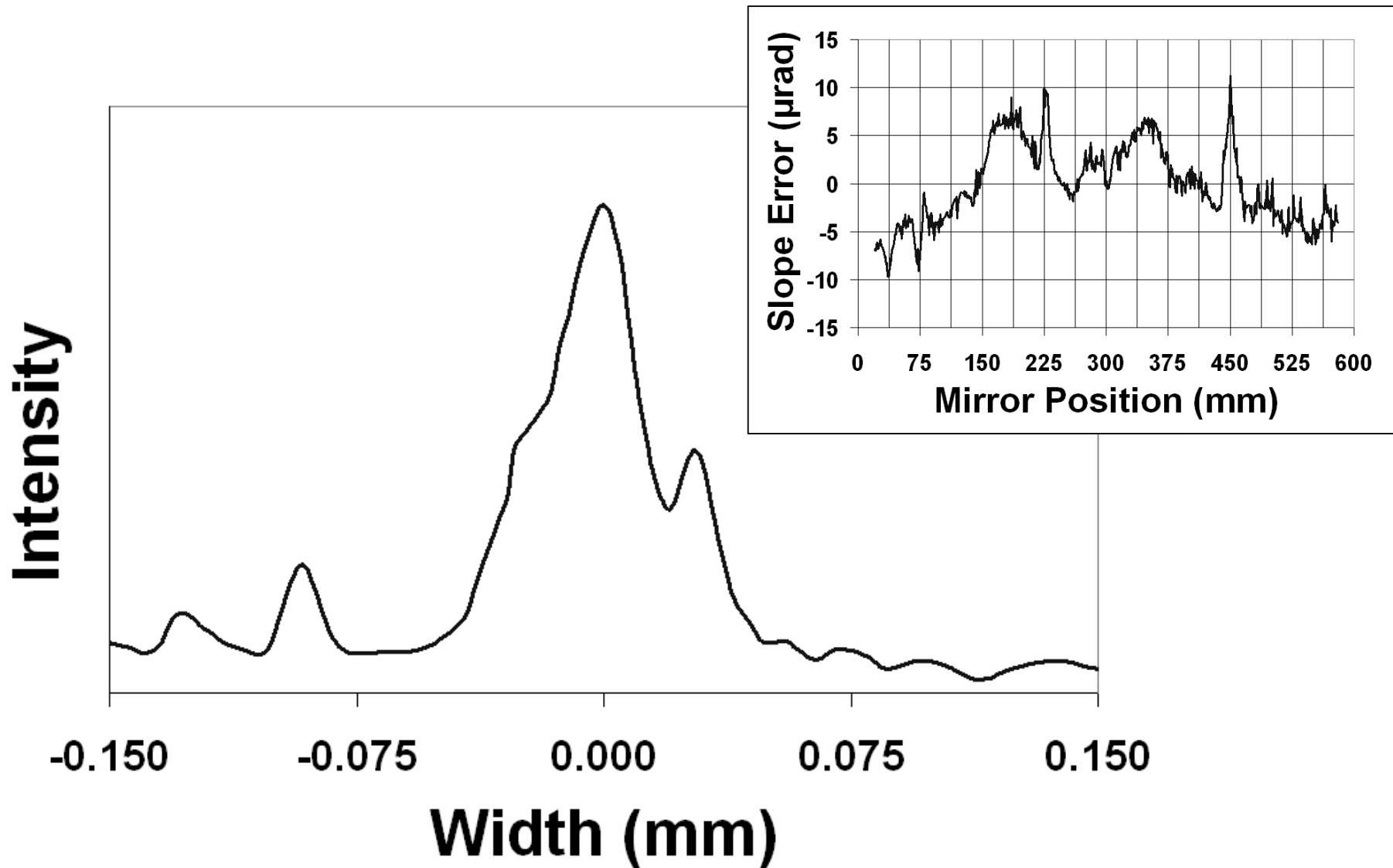
- Focus at:** radio buttons for "sample" (selected), "CCD", and "BPM".
- Mirror:** radio buttons for "VFM" and "HFM" (selected).
- Mirror angle:** a dropdown menu set to "3.0".
- Segment sampling:** a dropdown menu set to "2".
- Ignored edge beamlets:** a dropdown menu set to "4".
- Mirror pulse:** a text input field set to "15." with a unit "V".
- After-pulse delay:** a text input field set to "300" with a unit "s".
- Scan Type:** radio buttons for "ScanRec" and "HardSync" (selected).
- Analyzer time/pt:** a text input field set to "0.02" with a unit "s".
- Analyzer +/- range:** a text input field set to "0.4".
- Analyzer step:** a text input field set to "0.005".
- Struck input for I0:** a dropdown menu set to "18".
- Struck input for I1:** a dropdown menu set to "17".
- Struck input for I2:** a dropdown menu set to "16".
- BPM counting time:** a text input field set to "1" with a unit "s".
- Attenuation Option:** a checked checkbox labeled "Use Attenuation".
- MEDM Option:** a checked checkbox labeled "Show MEDM".
- Output file prefix:** a text input field containing "focus".

At the bottom of the window are three yellow buttons: "GO!", "Simulate", and "Cancel".

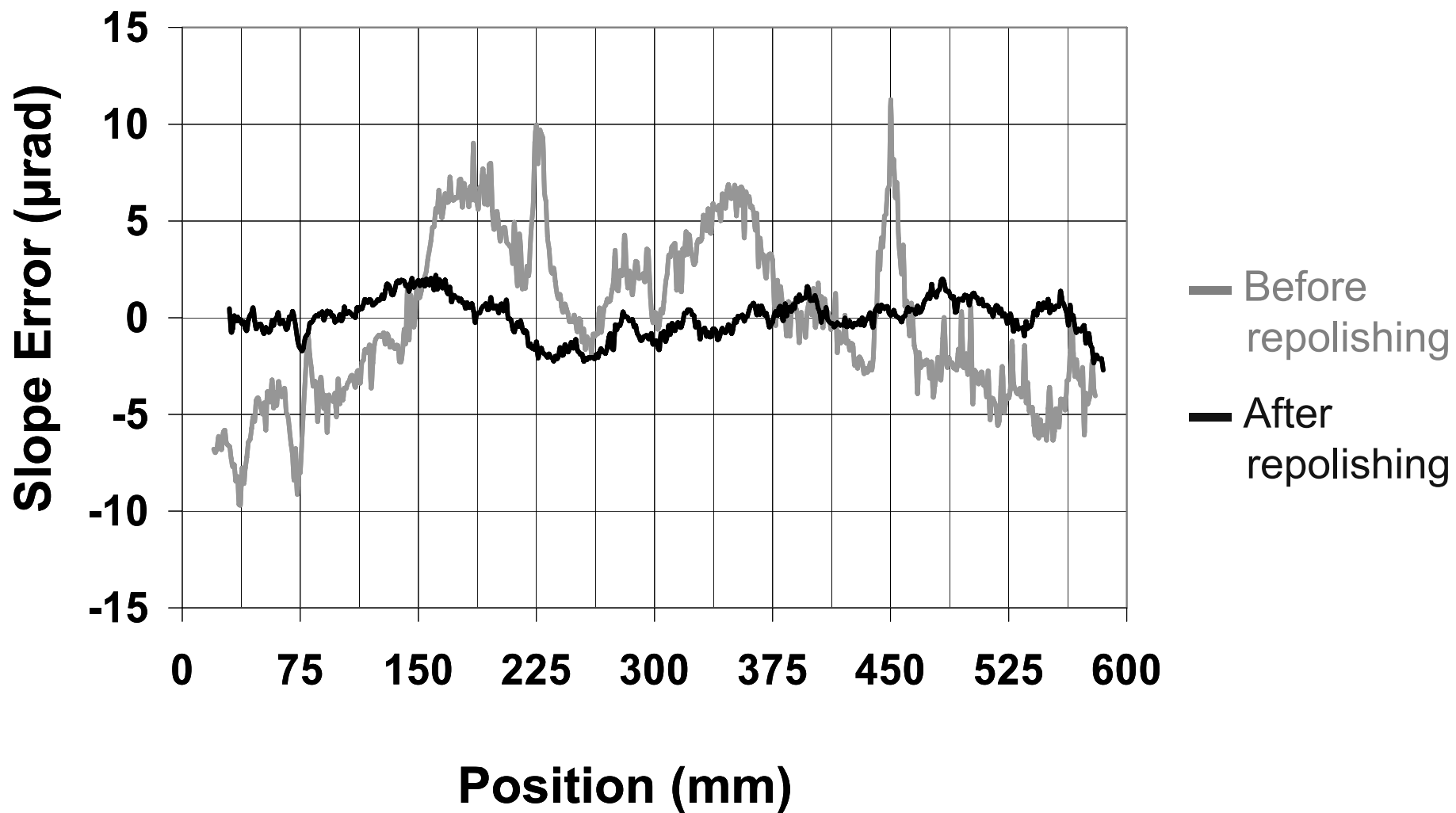
Automated focusing combines beamline scans with mirror controls

Described in detail in S. Stepanov's talk

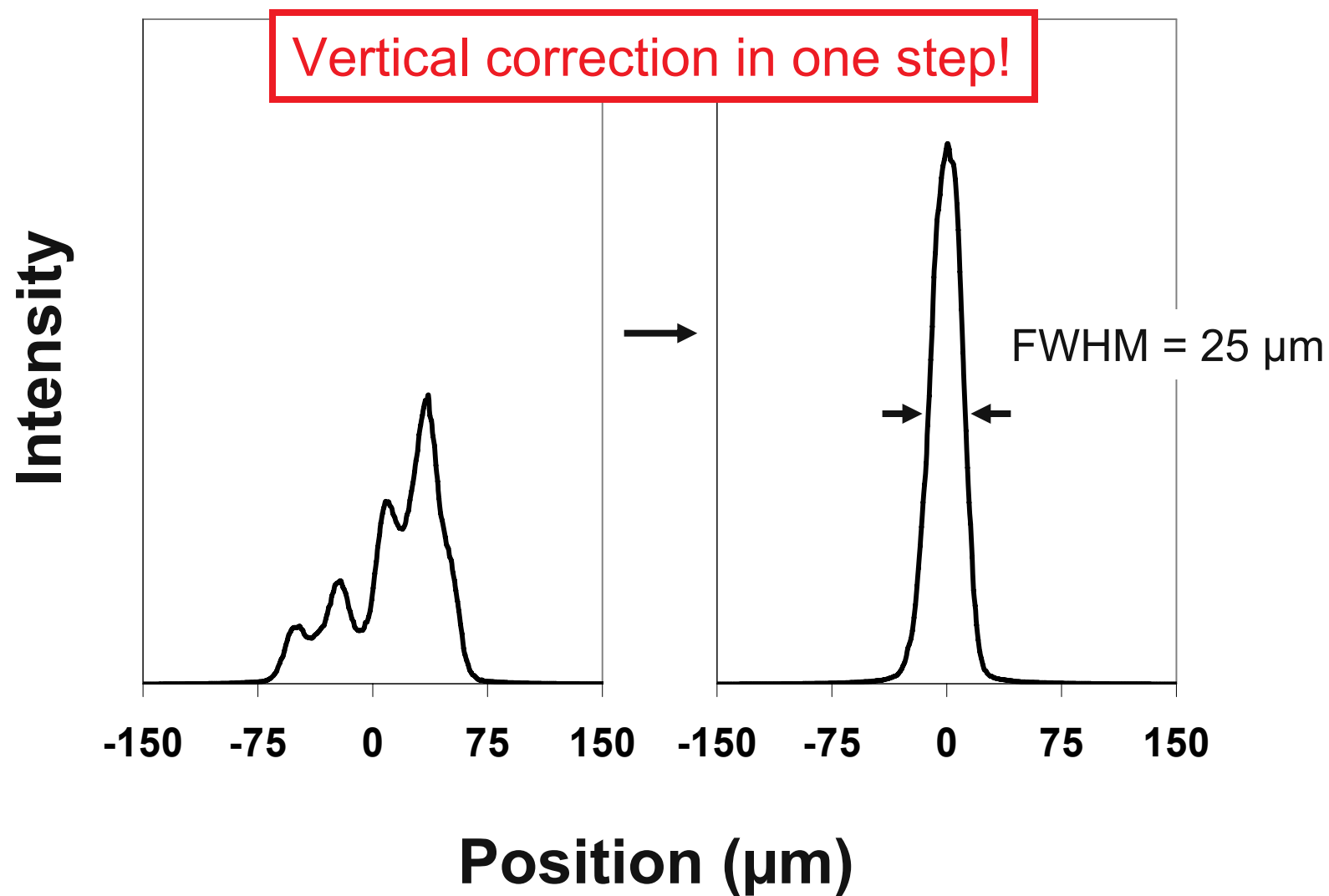
Challenges – “Best” Focus?



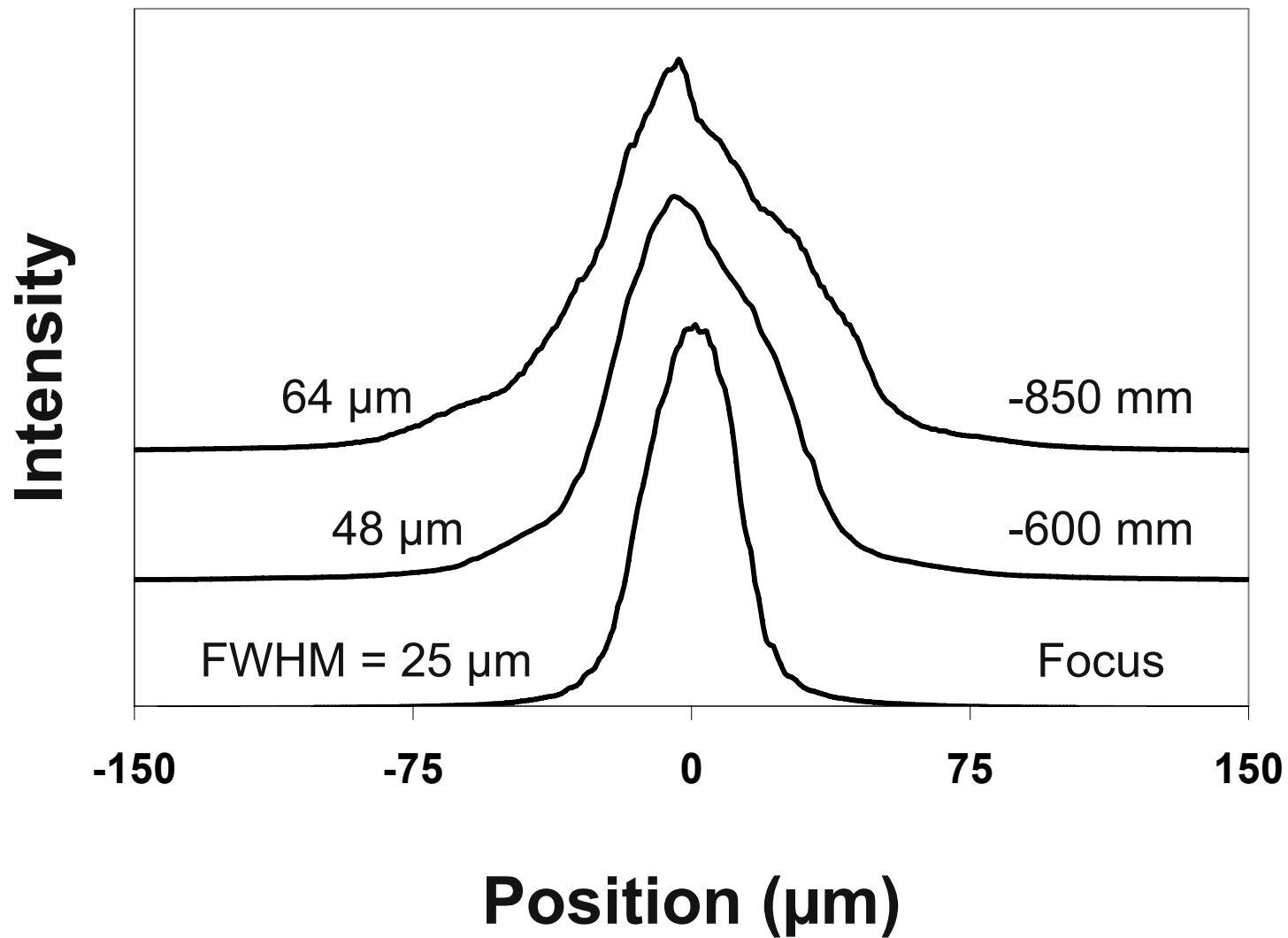
Challenges



Focal Results – VFM (ID_{out})



Focal Results – VFM (ID_{out}), Off Focus



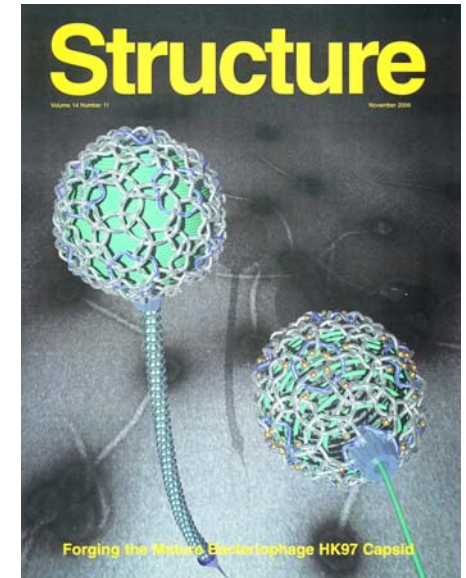
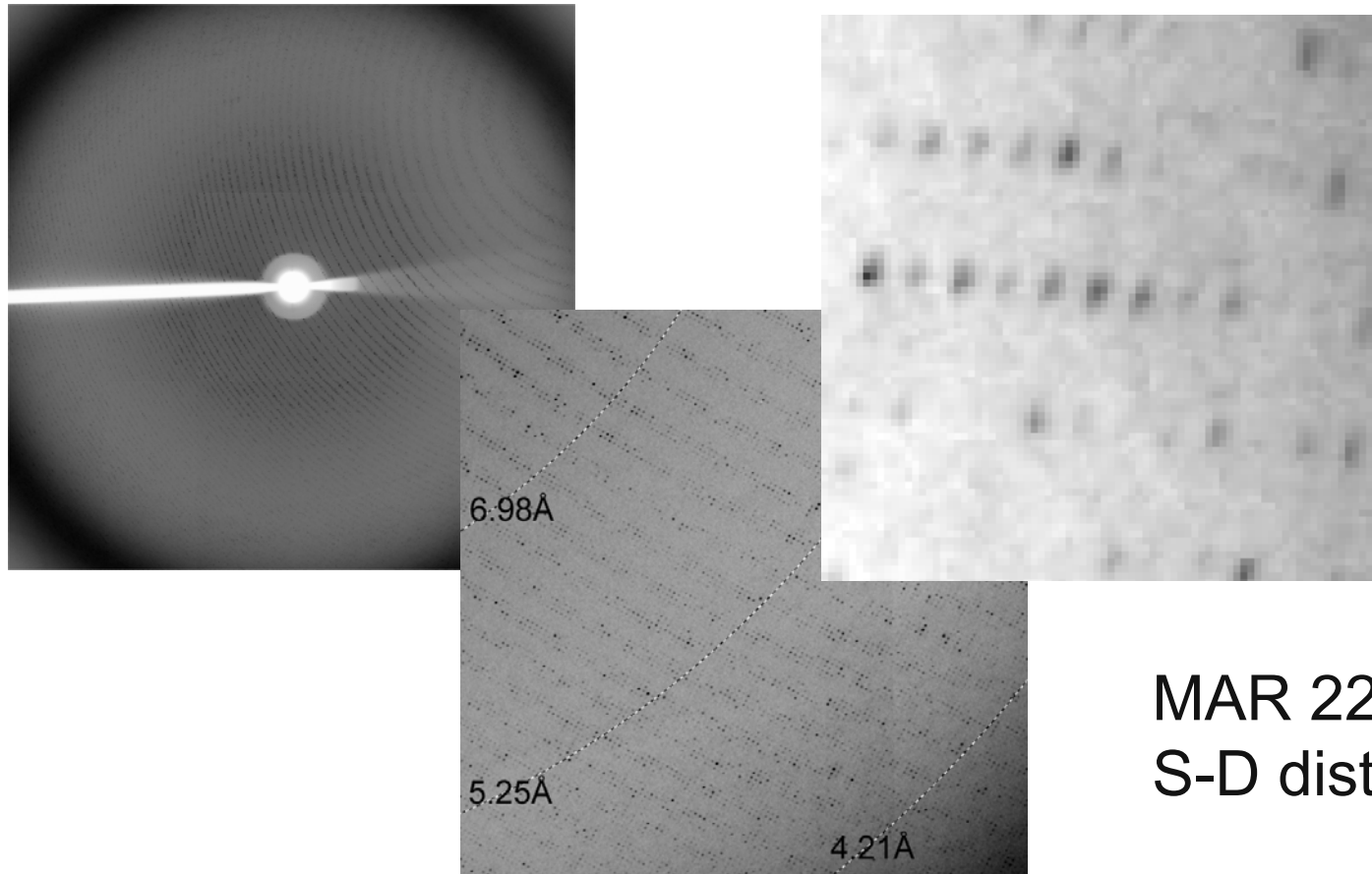
Comparison of Typical and Theoretical Sizes

Typical Values	ID _{in}	ID _{out}
Horizontal	70-75 μm	105-125 μm
Vertical	25-30 μm	25-30 μm

Calculated (1 μrad slope error)	ID _{in}	ID _{out}
Horizontal	69 μm	114 μm
Vertical	25 μm	34 μm

Large Unit Cells

Diffraction pattern from HK97 virus capsid.
Unit cell dimensions: 1010 x 1010 x 732 Å



MAR 225
S-D distance 680 mm

L. Gan, *et al.* & J. E. Johnson *Structure* 14, 1655-65 (2006)