X-ray Focusing with Large Kirkpatrick-Baez Bimorph Mirrors

Derek Yoder

GM/CA CAT
Argonne National Laboratory

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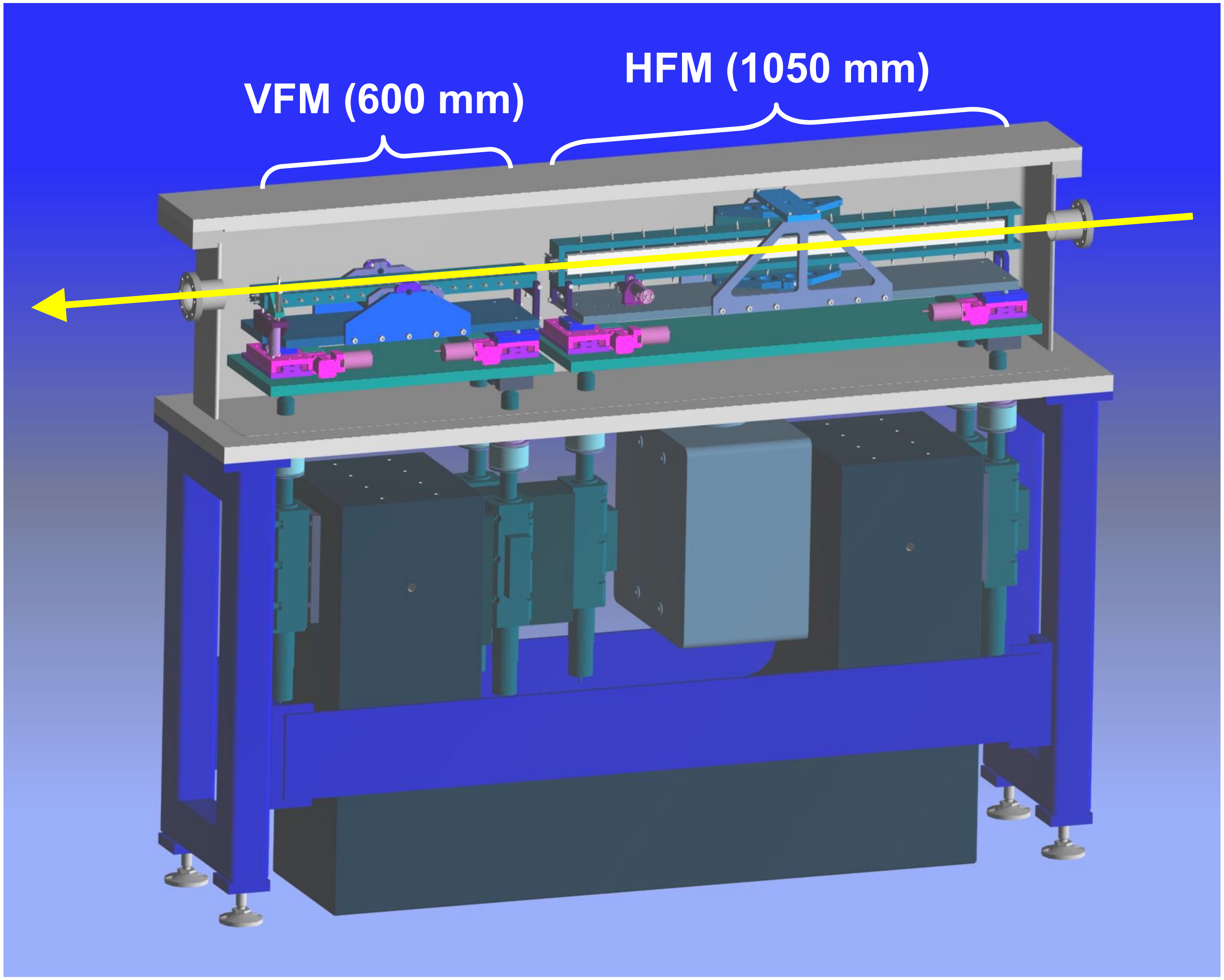
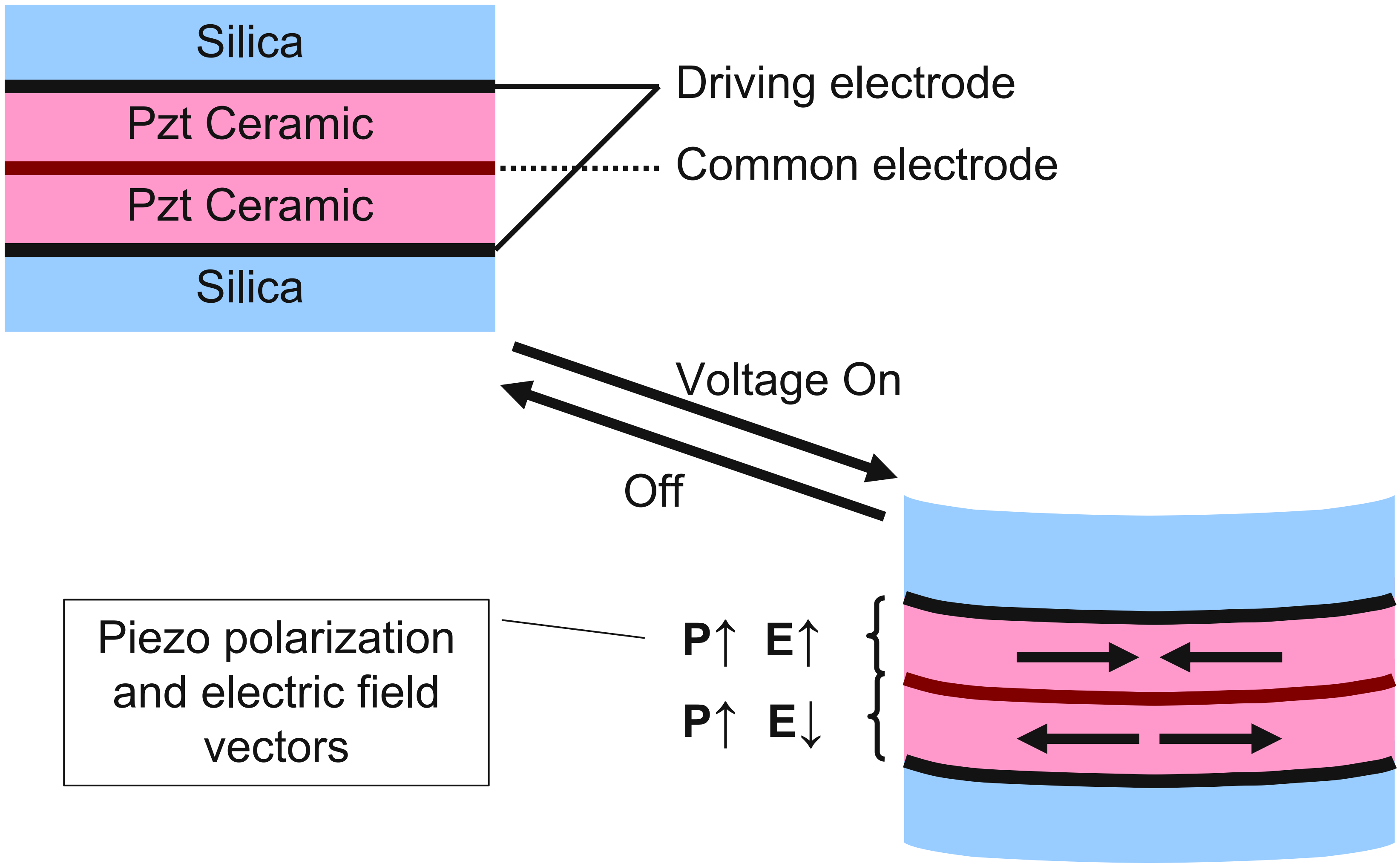
Our Mirrors



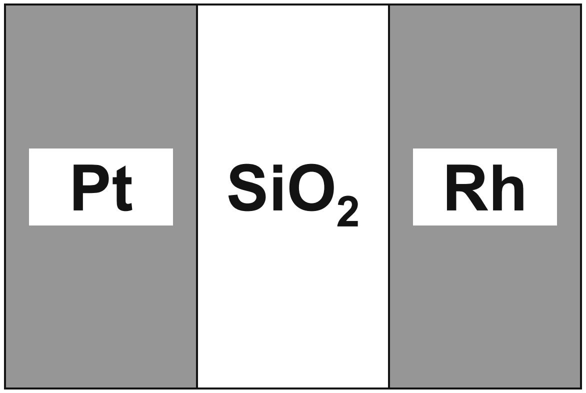
Beamline Positions and Focal Parameters

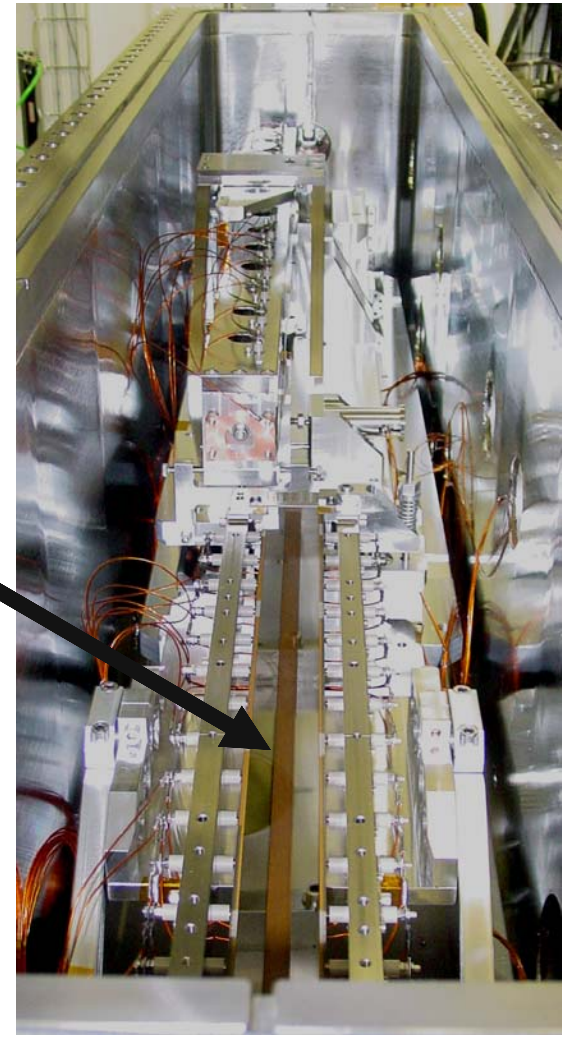
	ID_{in}	ID_{out}
Source	1.3 m	-1.3 m
HFM	65.8 m	48.0 m
VFM	66.7 m	48.9 m
Focus @ xtal **(other possibility)**	72.0 m (74.0 m)	(54.2 m) 56.2 m
Horizontal demag	10.4 (7.9) : 1	6.0 (7.9) : 1
Vertical demag	12.5 (9.0) : 1	6.9 (9.6) : 1
Theoretical focal size at current position	62 μm Horz 1.6 μm Vert	108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

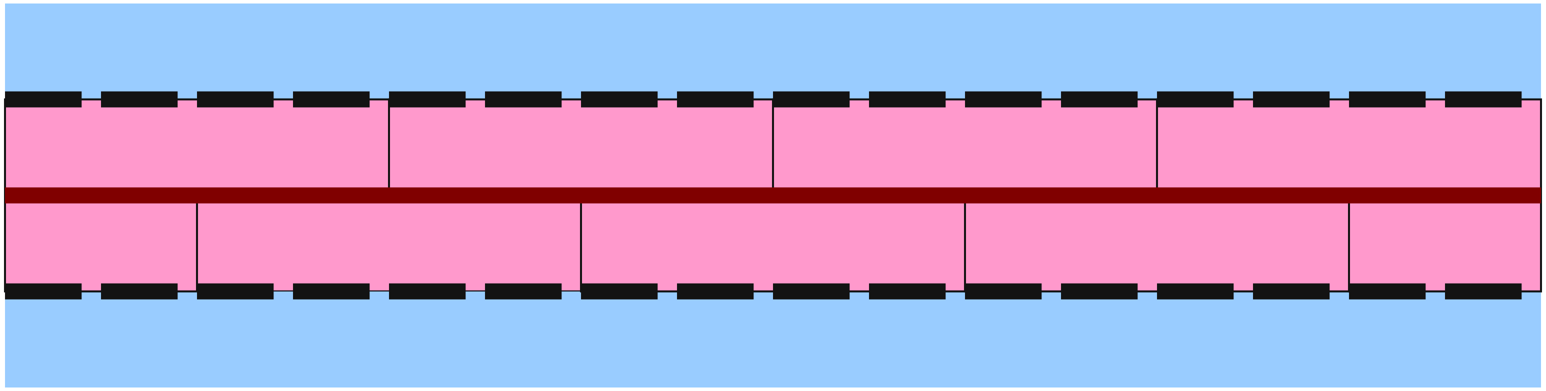




Useful energy range (mirrors @ 3 mrad):

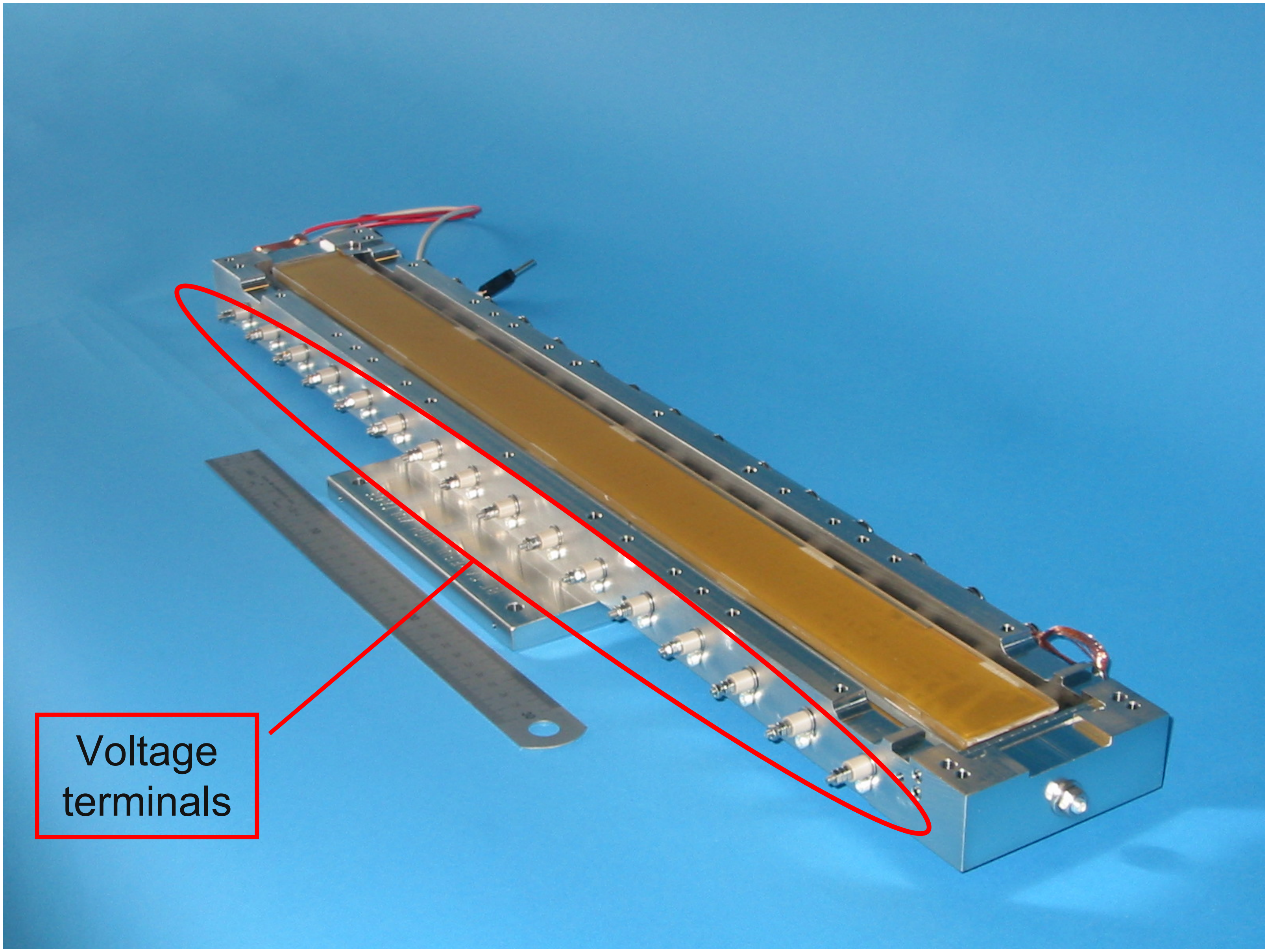
SiO_2	< 10 keV
Rh	< 20 keV
Pt	< 27 keV

“Large” Mirrors

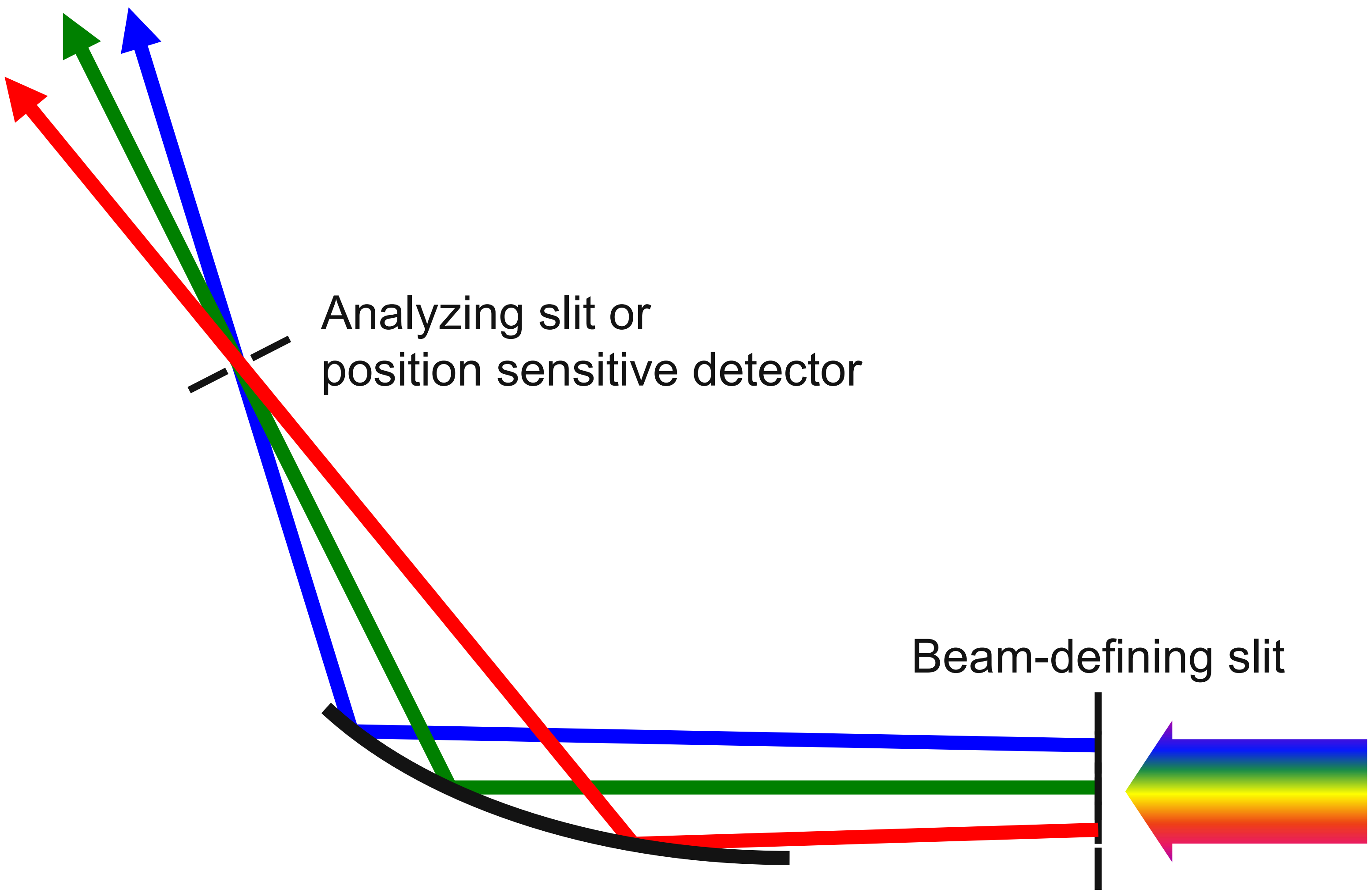


(A schematic of our VFM with 4 segments and 16 electrodes.)

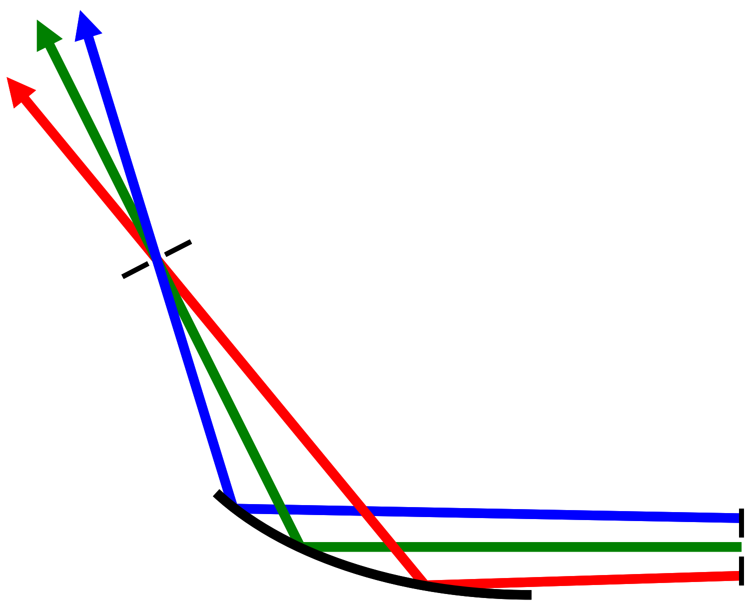
- Our mirrors actually consist of multiple ceramic segments sandwiched between two single layers of silica.
- Multiple electrodes are deposited per segment.
- The exact construction is proprietary. In general terms, SESO may interleave segments (as above) or add additional layers to strengthen the mirror.

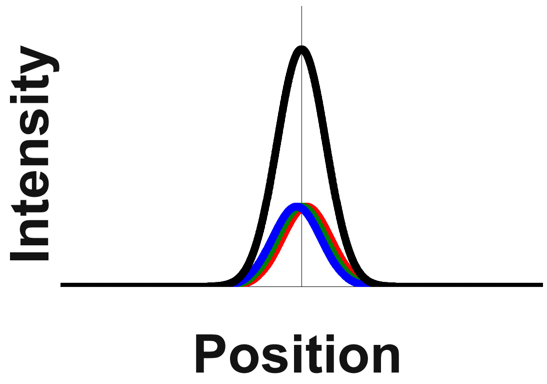

Voltage
terminals

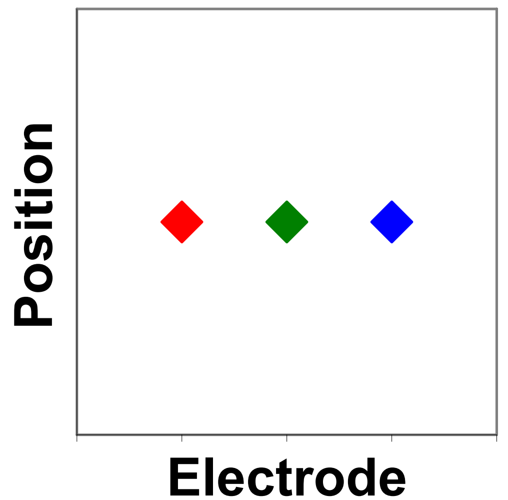
Focal Techniques



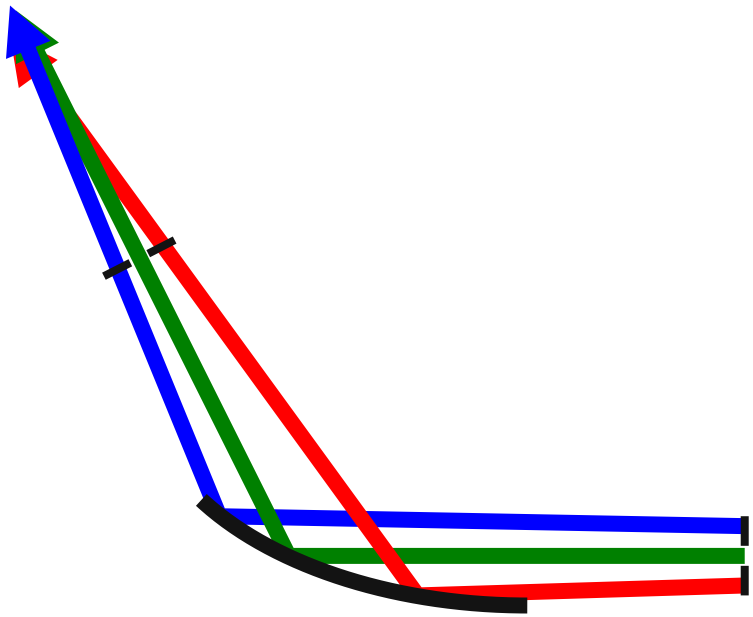
Focal Techniques

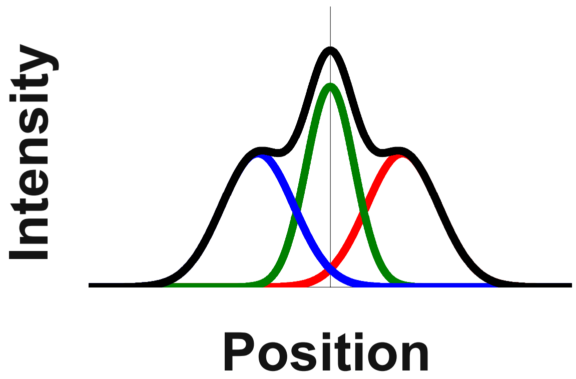


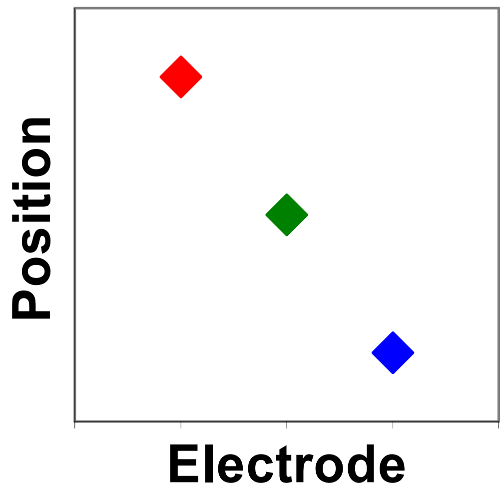




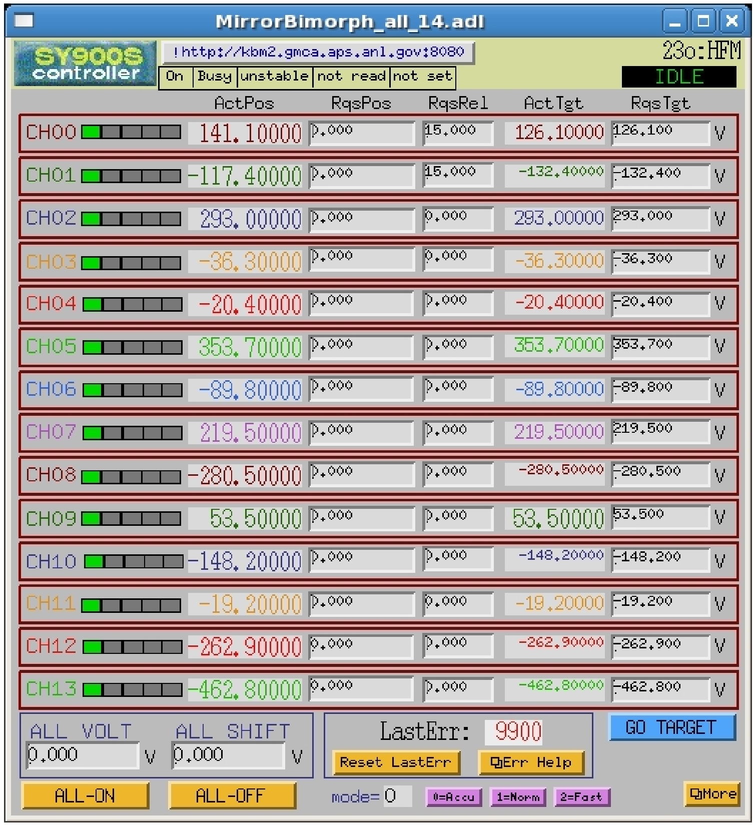
Focal Techniques







EPICS Mirror Controls



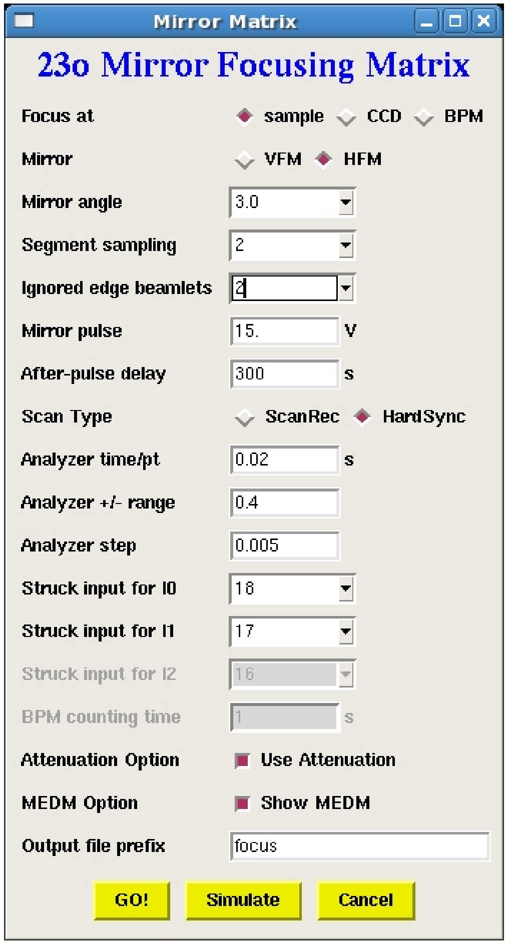
Controls by S. Stepanov
and ACCEL

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.

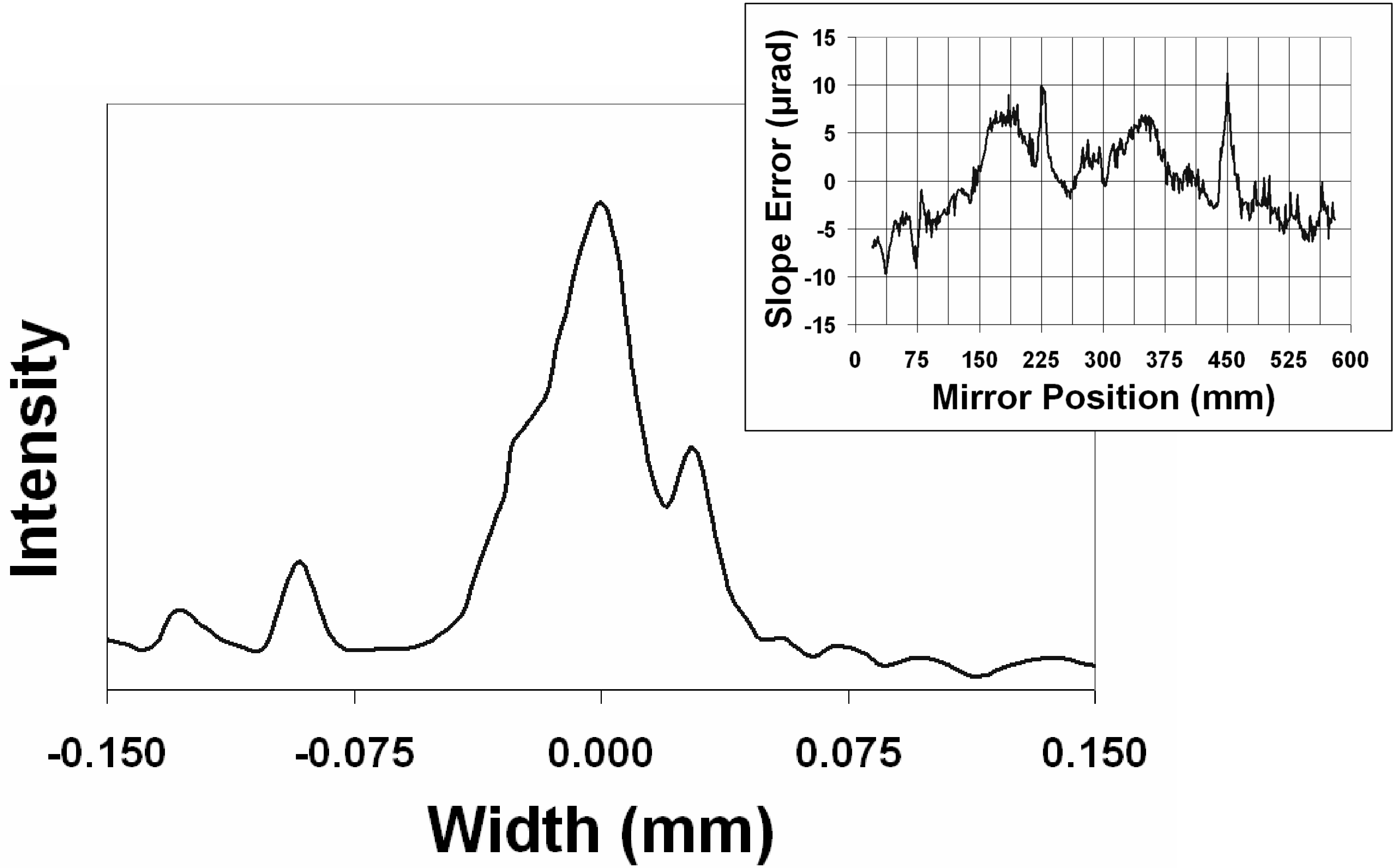
Automated Focusing



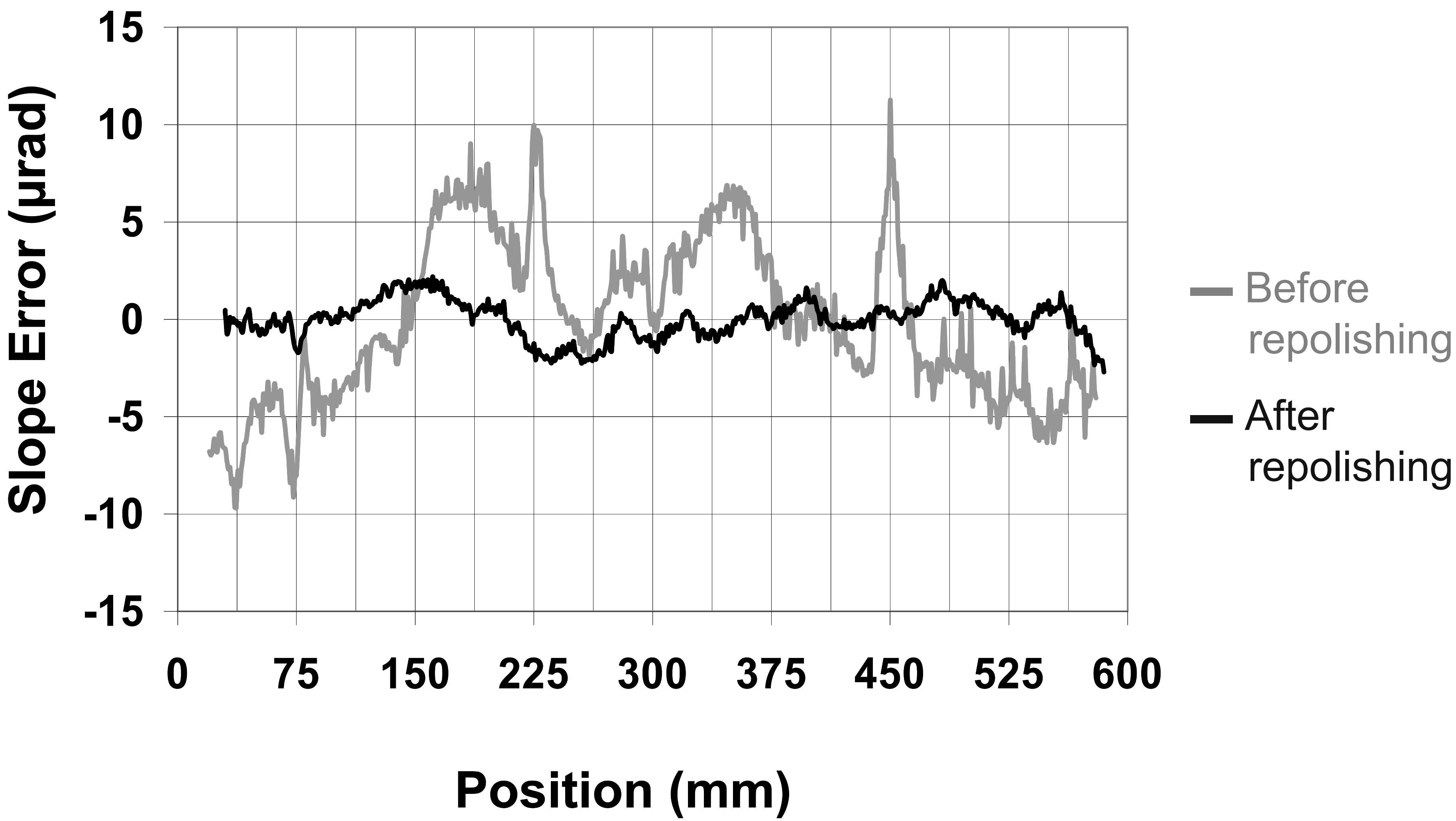
Automated focusing combines beamline scans with mirror controls

Described in detail in S. Stepanov's talk

Challenges – "Best" Focus?

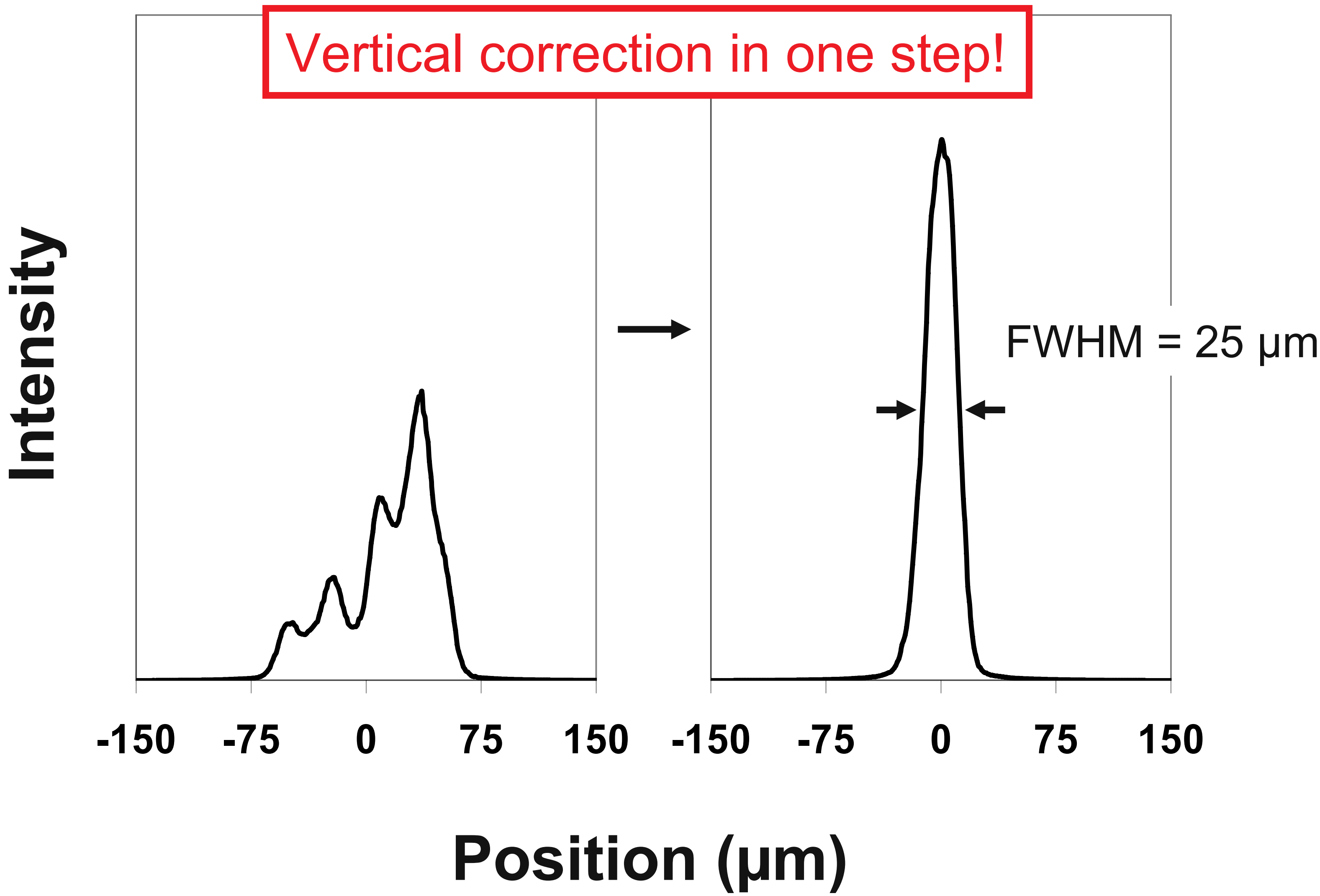


Challenges

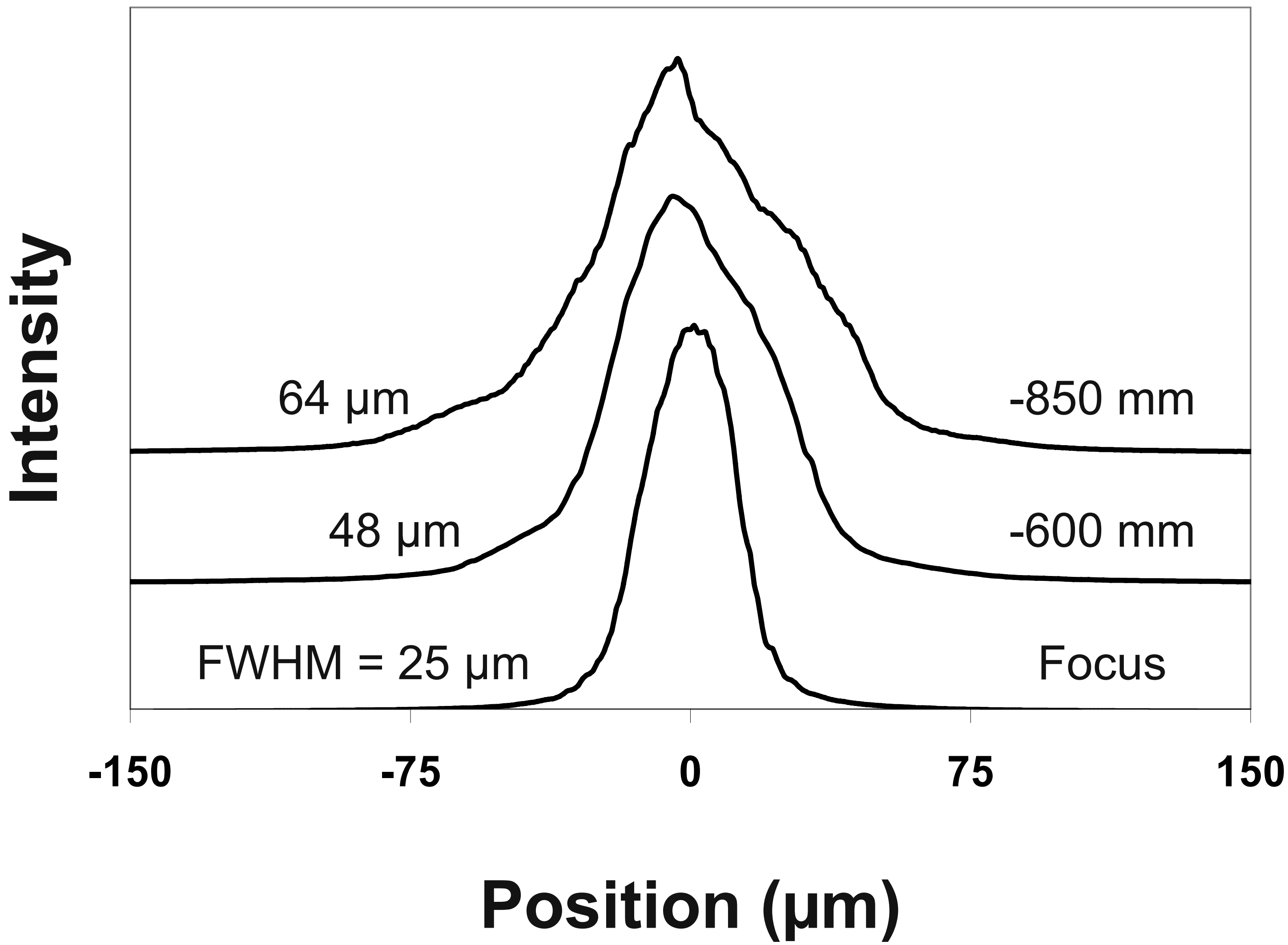


15
10
5
0
-5
-10
-15
Slope Error (µrad)
0
75
150
225
300
375
450
525
600
Position (mm)
Before repolishing
After repolishing

Focal Results – VFM (ID_{out})



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



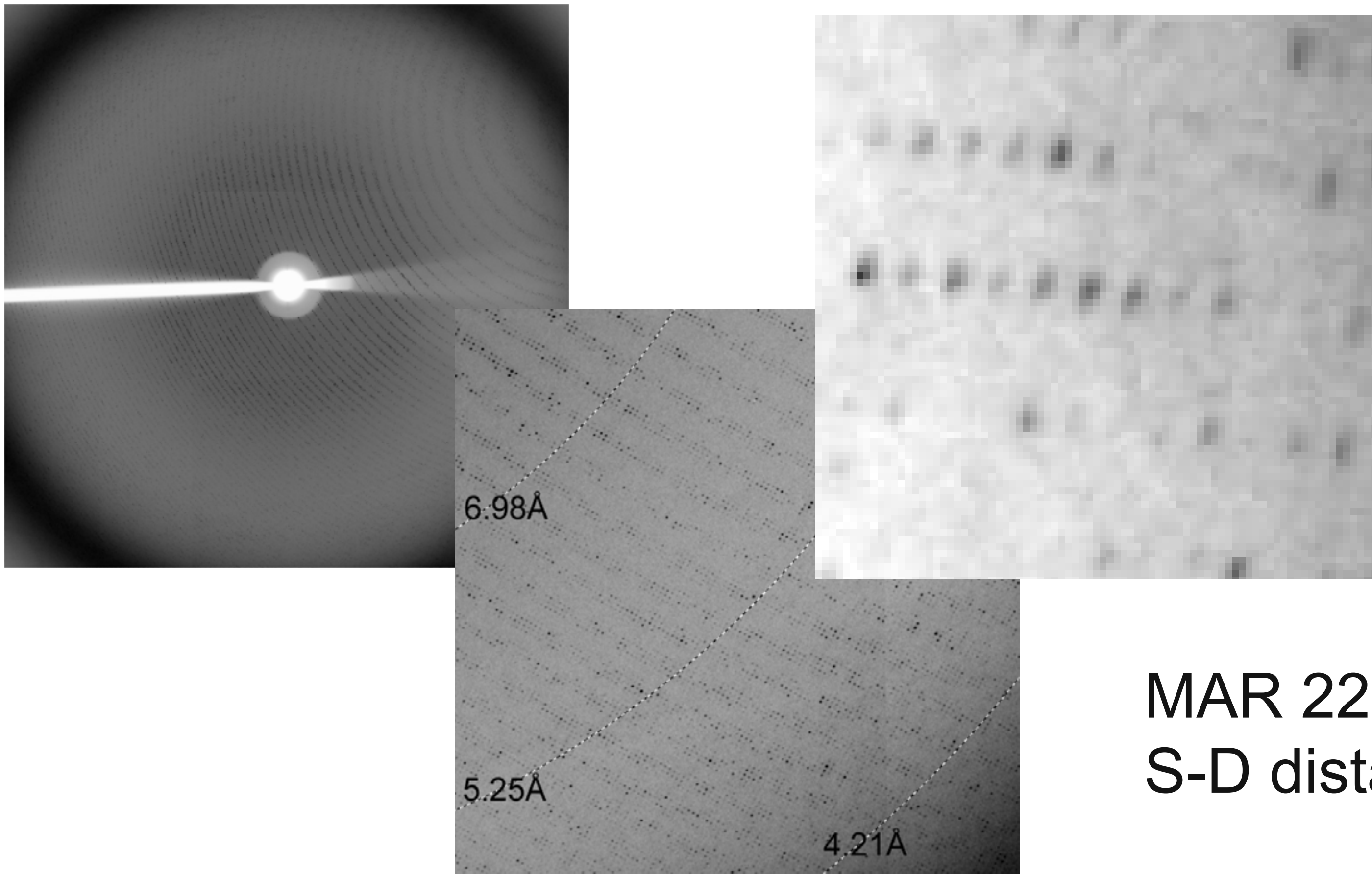
Comparison of Typical and Theoretical Sizes

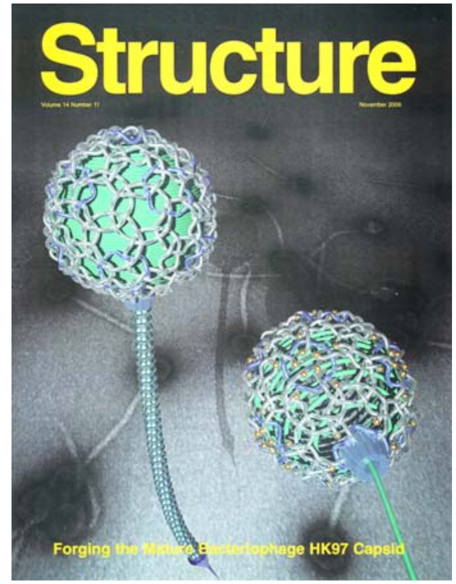
Typical Values	ID_{in}	ID_{out}
Horizontal	70-75 μm	105-125 μm
Vertical	25-30 μm	25-30 μm

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)