X-ray Focusing with Large Kirkpatrick-Baez Bimorph Mirrors

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Our Mirrors

VFM (600 mm)  HFM (1050 mm)
# Beamline Positions and Focal Parameters

<table>
<thead>
<tr>
<th></th>
<th>ID$_{\text{in}}$</th>
<th>ID$_{\text{out}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td>1.3 m</td>
<td>-1.3 m</td>
</tr>
<tr>
<td><strong>HFM</strong></td>
<td>65.8 m</td>
<td>48.0 m</td>
</tr>
<tr>
<td><strong>VFM</strong></td>
<td>66.7 m</td>
<td>48.9 m</td>
</tr>
<tr>
<td><strong>Focus @ xtal</strong></td>
<td>72.0 m (74.0 m)</td>
<td>(54.2 m) 56.2 m</td>
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</tbody>
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<tbody>
<tr>
<td><strong>Horizontal demag</strong></td>
<td>10.4 (7.9) : 1</td>
<td>6.0 (7.9) : 1</td>
</tr>
<tr>
<td><strong>Vertical demag</strong></td>
<td>12.5 (9.0) : 1</td>
<td>6.9 (9.6) : 1</td>
</tr>
<tr>
<td><strong>Theoretical focal size at current position</strong></td>
<td>62 µm Horz 1.6 µm Vert</td>
<td>108 µm Horz 3.0 µm Vert</td>
</tr>
<tr>
<td><strong>Realistic focal size (1 µrad slope error)</strong></td>
<td>69 µm Horz 25 µm Vert</td>
<td>114 µm Horz 34 µm Vert</td>
</tr>
</tbody>
</table>
Bimorph Mirrors – Basic Principle

Silica
Pzt Ceramic
Pzt Ceramic
Silica

Driving electrode
Common electrode

Voltage On
Off

Piezo polarization and electric field vectors

P↑ E↑ P↑ E↓
Our Mirrors - Coatings

Useful energy range (mirrors @ 3 mrad):

- SiO$_2$ < 10 keV
- Rh < 20 keV
- Pt < 27 keV
“Large” Mirrors

- 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.

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

Analyzing slit or position sensitive detector

Beam-defining slit
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

![Graph showing slope error against position before and after repolishing. The graph indicates a significant improvement in slope error after repolishing.]
Focal Results – VFM ($I_{D_{out}}$)

Vertical correction in one step!

FWHM = 25 µm
Focal Results – VFM ($I_{D_{out}}$), Off Focus

![Graph showing intensity vs. position for different focus settings and FWHM values.]

- Intensity on the y-axis.
- Position on the x-axis in micrometers (µm).
- Focus settings at -600 mm and -850 mm.
- FWHM values: 25 µm, 48 µm, and 64 µm.

Focus at 0 µm.
# Comparison of Typical and Theoretical Sizes

<table>
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<tr>
<th>Typical Values</th>
<th>ID$_{in}$</th>
<th>ID$_{out}$</th>
</tr>
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<tbody>
<tr>
<td>Horizontal</td>
<td>70-75 µm</td>
<td>105-125 µm</td>
</tr>
<tr>
<td>Vertical</td>
<td>25-30 µm</td>
<td>25-30 µm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculated (1 µrad slope error)</th>
<th>ID$_{in}$</th>
<th>ID$_{out}$</th>
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<tbody>
<tr>
<td>Horizontal</td>
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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