Design Developments and Innovations for the I08 SXM Beamline

MEDSI 2014
Dr Jon Kelly
Talk Outline

- Introduction to the I08 Beamline
- Bellows Vibration Transmission
- Steel Frame Stability
- Endstation Stability
- Conclusion
I08-SXM: Refocusing scheme

- Source focused on to 10 µm slit
- 10 µm secondary source focused to 20 nm on sample
- Pitch stability of mirrors is critical
- Relative position of slit, zoneplate & sample critical

- 250 – 4200 eV
- Up to $10^{10}$ ph/s in 20nm spot
- Raster-scanned sample

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Bellows Vibration Transmission

Vibration from frames can conduct to sensitive optics
Bellows Vibration Transmission

I23 Optics Hutch: Seismometers on DCM

- Tap DCM Vessel
- Tap GBC3 Vessel
- Tap GBC2 Vessel: Longer bellows

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Steel Frame Stability

How to minimise frame resonance
Steel Frame Stability

An ANSYS modal analysis performed to find expected resonant modes
Steel Frame Stability

- ANSYS predicts fundamental modes at 36.2 Hz & 36.5Hz
- Measured modes at 34 Hz and 36 Hz
- Horizontal motion amplification factor of ~ 1.8
Steel Frame Stability

- Test metric: Time taken for amplitude to drop to ¼ of maximum

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Configuration</th>
<th>¾ Decay Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Original fabricated frame no extra plates</td>
<td>3.5 s</td>
</tr>
<tr>
<td>2</td>
<td>Bolted frame of similar dimensions no side plates</td>
<td>4.0 s</td>
</tr>
<tr>
<td>3</td>
<td>Frame with 2 side plates lightly clamped top &amp; bottom</td>
<td>0.8 s</td>
</tr>
<tr>
<td>4</td>
<td>Frame with 2 side plates firmly clamped top &amp; bottom</td>
<td>0.75 s</td>
</tr>
<tr>
<td>5</td>
<td>Frame with 2 side plates firmly clamped top &amp; lightly clamped bottom</td>
<td>0.45 s</td>
</tr>
<tr>
<td>6</td>
<td>Double sided tape 4 x 25 mm² under bottom tight clamps</td>
<td>0.15 s</td>
</tr>
<tr>
<td>7</td>
<td>2 Layers of double sided tape over 4 x 25 mm² area</td>
<td>0.075 s</td>
</tr>
<tr>
<td>8</td>
<td>Roush® RA954-2mil Damping Adhesive 4 x 50mm x 80mm</td>
<td>0.12 s</td>
</tr>
</tbody>
</table>

- Firmly clamped side plates raise resonant frequency
- Constrained layer damping:
  - reduces decay time by factor of ~50
  - reduces amplification factor to 1.1
Conclusion

• Double sided tape borrowed from the technician’s tool box offers a massive stability improvement for fabricated frames
• Viscoelastic damping fitted to all I08 frames
Granite Endstation Support

Support for
20nm resolution microscope
with 3m translation
I08 End station

End station on moving granite

Cable chain & drive train

Exit slit/Secondary source

Wedges

Airpads

Static, 4.5m base granite

Exit slit granite
Granite Endstation Support

Practice installation & stability check
- Granite blocks surveyed on to 14 wedges
- Surprisingly low vertical resonance at 62Hz & 83Hz

Granite tapped to highlight resonant modes

Sensors located in middle of granite
Granite Endstation Support

ANSYS model suggests 3 point support: 2 under slit & 1 under middle of base slab
- Confirmed by laser tracker data
- Confirmed by feel of wedge screws

Explanation: Displacement of grease over time
Solution: Remove grease from wedges & double check survey after installation
Granite Endstation Support—Fully Installed

Fully Installed Endstation Performance

- Base granite clamped directly to concrete
- Moving granite clamped to base granite
- Microscope stability:
  - 50nm Pk-Pk integrated over 1-500Hz
  - 10nm Pk-Pk integrated over 25-500Hz
  - 6nm Pk-Pk integrated over 40-500Hz
Granite Endstation Support-Fully Installed

Pallet truck effect
• Concreate slab conducts vibration from > 10m away
• Support has a 60Hz resonance due to wedge stiffness
Result: Secondary Source - ZP – Sample miss-aligned rendering microscope unusable

Brown=Granite V, Blue=Granite H, Cyan=floor V, Pink=floor H
Granite Endstation Support

Vibration Isolation Investigation
• Can not isolate whole base granite due to moving mass
• Can only isolate moving granite
• Test various Sorbothane® and Farrat elastomers
• Test microscope while floating on airpads
Result: Isolation not effective
Conclusion: The cables & pipes require an energy chain guide, but this effectively shorts the microscope to ground
Granite Endstation Support

Possible mitigating actions for vibration sensitivity
• Repeat corrupted data sets as required
• Take data over night
• Schedule users around significant construction
• Change technician working practice
• Upgrade granite clamping to raise resonant frequency
• Upgrade support design to include active damping

Ptychographic reconstruction of a mouse fibroblast
Conclusion

- Bellows transmit more vibration than you might think
- Double-sided sticky tape is ideal for improving steel frames
- Wedges are not as stiff as you might think
- Pallet trucks are the enemy