Vibration and Stability at LCLS

Corey Hardin, Lance Lee Lin Zhang, Daniele Cocco

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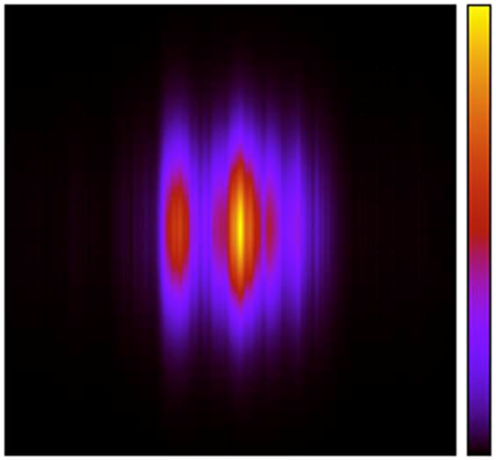
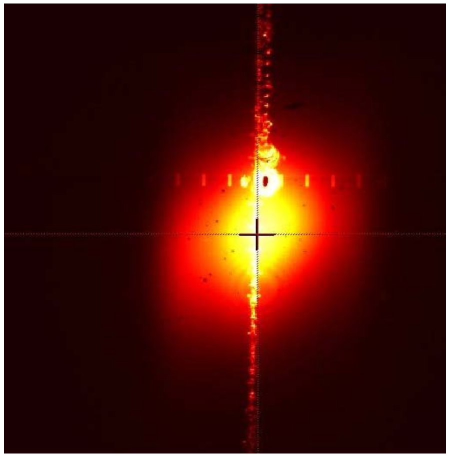
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Mirror upgrade at LCLS

- There are a number of systems being worked on at LCLS with very strict vibration/stability requirements
- In this presentation I will focus on the Hard X-ray Offset Mirror System (HOMS) upgrade that was performed this year, as it is one the first of the LCLS-II ready optical systems, and we have recent data on their performance.

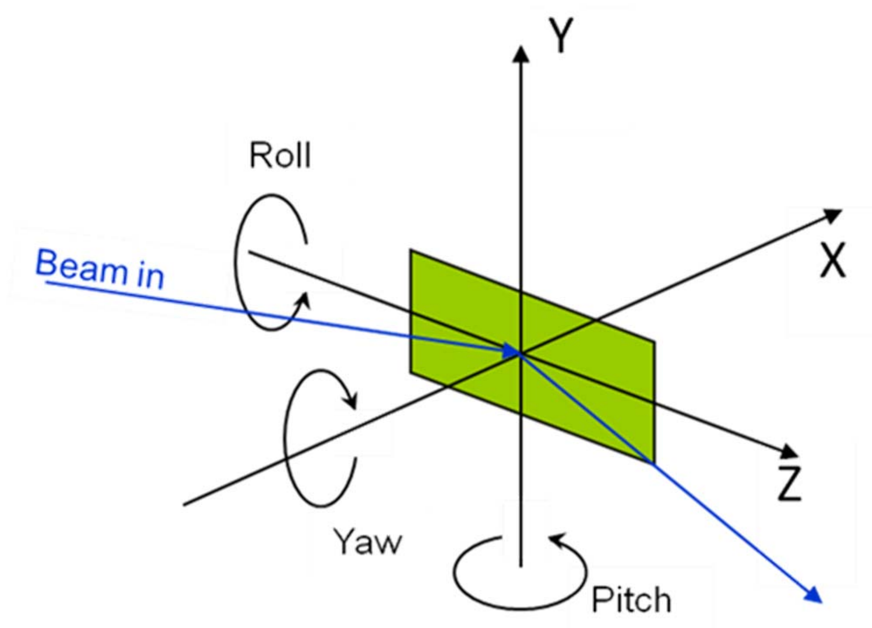




Required motions and precision

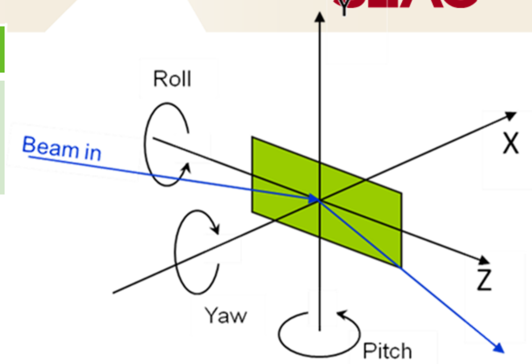
ITEM	Precision	Range	Actuator
Pitch	0.05 μrad	± 0.5 mrad ± 1.25* mrad	Motorized
Roll	10 μrad	± 1 mrad	Manual
Yaw	1000 μrad	design dependent	Manual
Y (Vertical)	100 μm	25 mm	Motorized
X (Horizontal)	10 μm	-1/+5 mm -1/+19* mm	Motorized
Z (beam direction)	1000 μm	10 mm	Manual

* for MEC/MFX only.

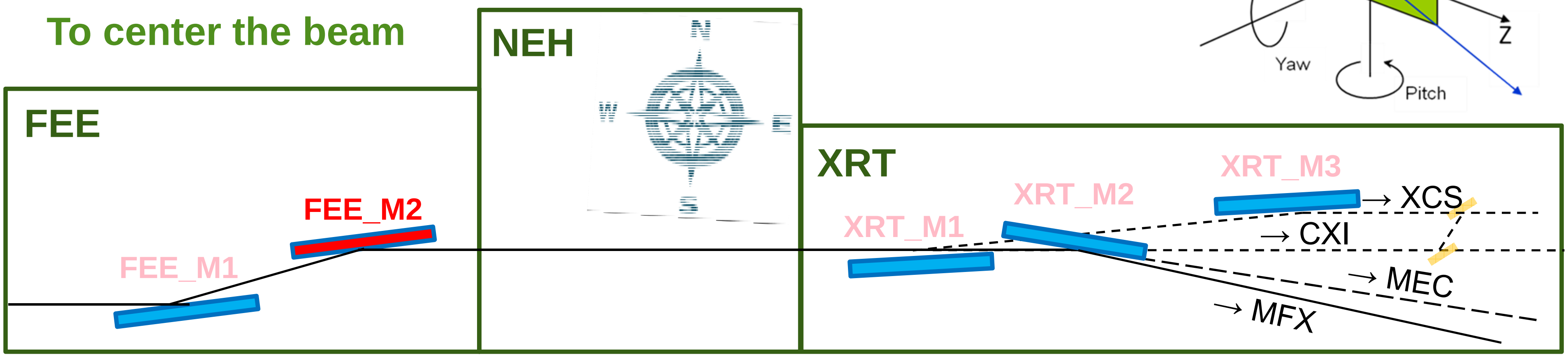


Required motions and precision - PITCH

ITEM	Precision	Range	Actuator
Pitch	0.05 μrad	± 0.5 mrad ± 1.25* mrad	Motorized



To center the beam



To XRT mirrors ← ~75m →

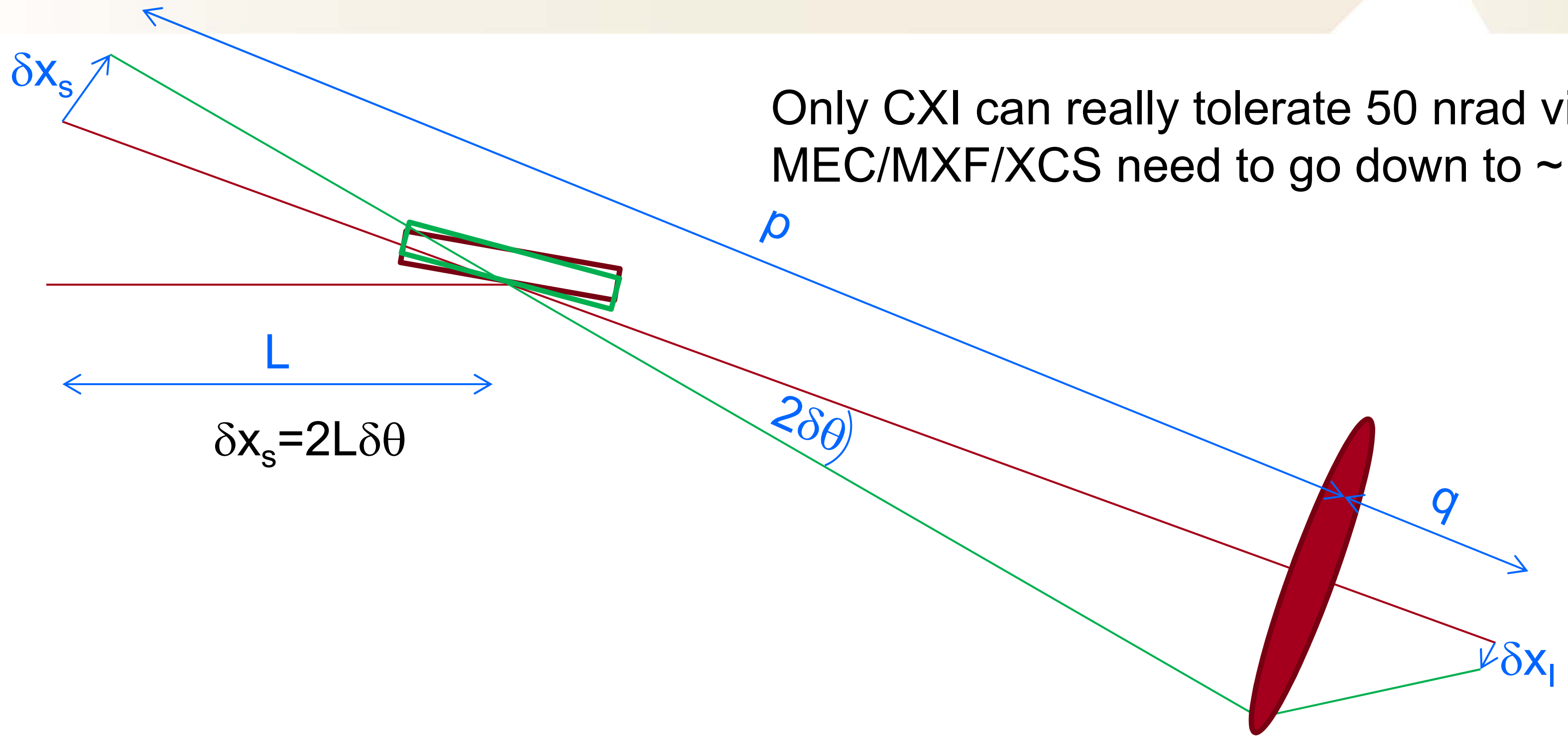
$2 \times 0.05\mu rad \times 75\ m \approx 8\ \mu m$

To CXI KBs mirrors ← ~280m →

$2 \times 0.05\mu rad \times 280\ m \approx 30\ \mu m$

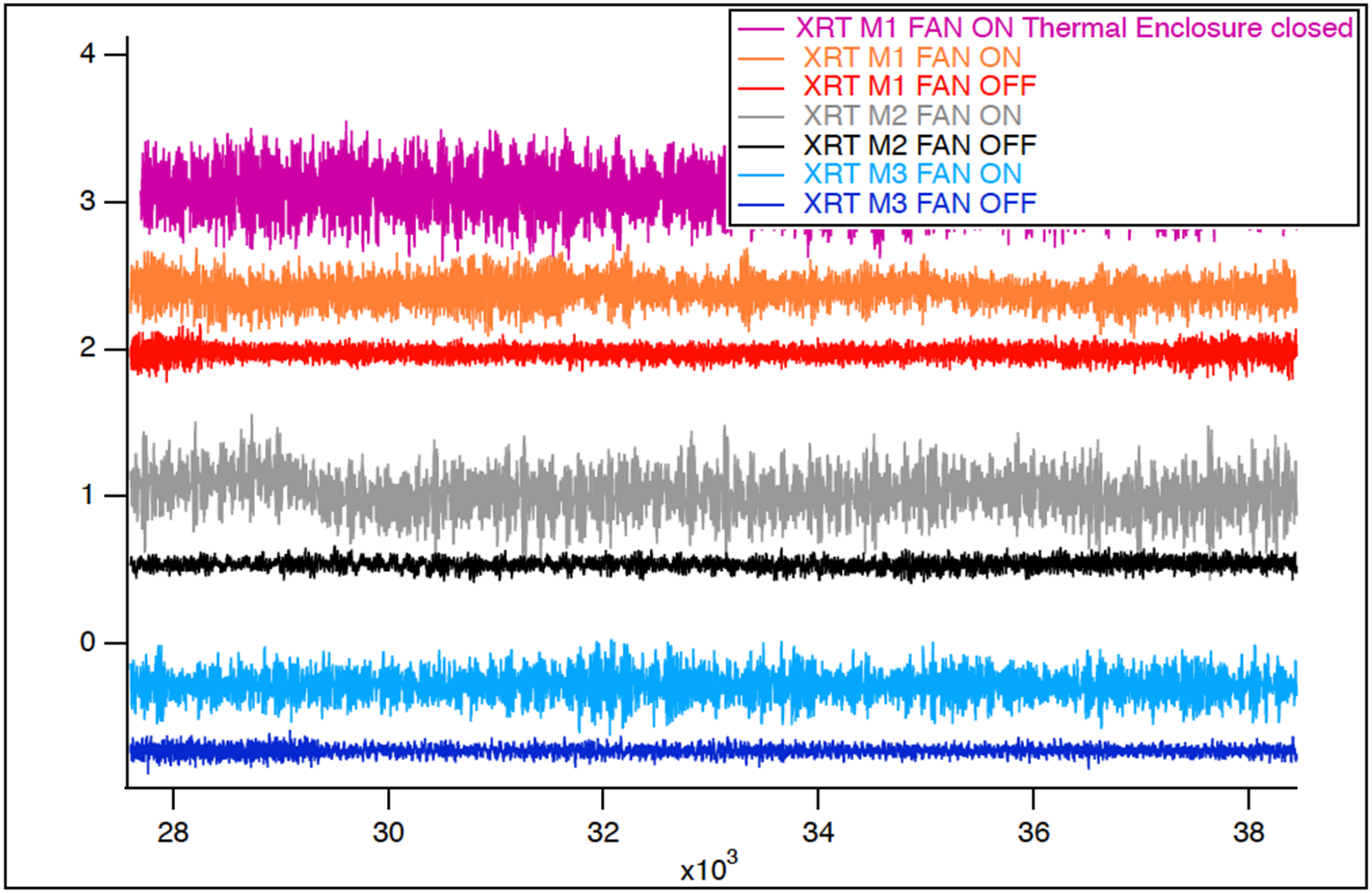
Required motions and stability - PITCH

Only CXI can really tolerate 50 nrad vibrations
MEC/MXF/XCS need to go down to ~ 20 nrad



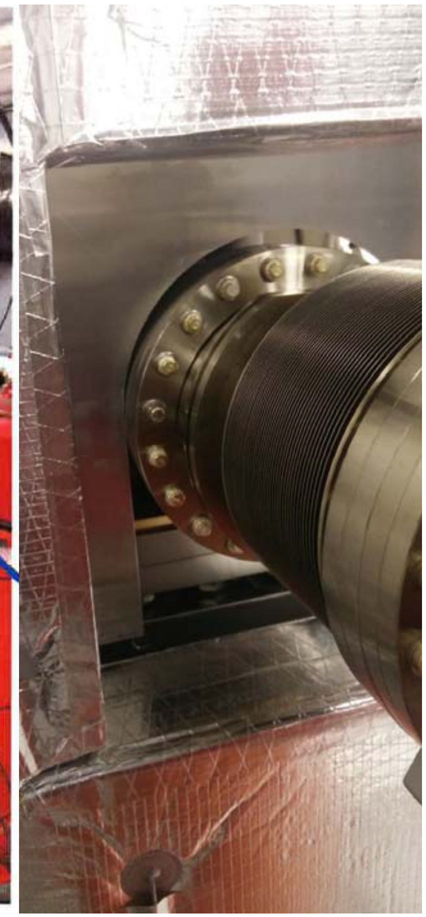
Beamline	Mirror involved	L (m)	Spot movement (mm) with:			
			δθ=50 nrad		δθ=15 nrad	
			For a spot dimension of:			
			1.2 μm	0.15 μm	1.1 μm	0.15 μm
CXI	FEE_M2	83	0.20	0.07	0.06	0.02
MEC/MFX	XRT_M2	148	0.33	0.13	0.11	0.04
XCS	XRT_M3	281	0.67	0.27	0.20	0.08

Minimize Excitation!

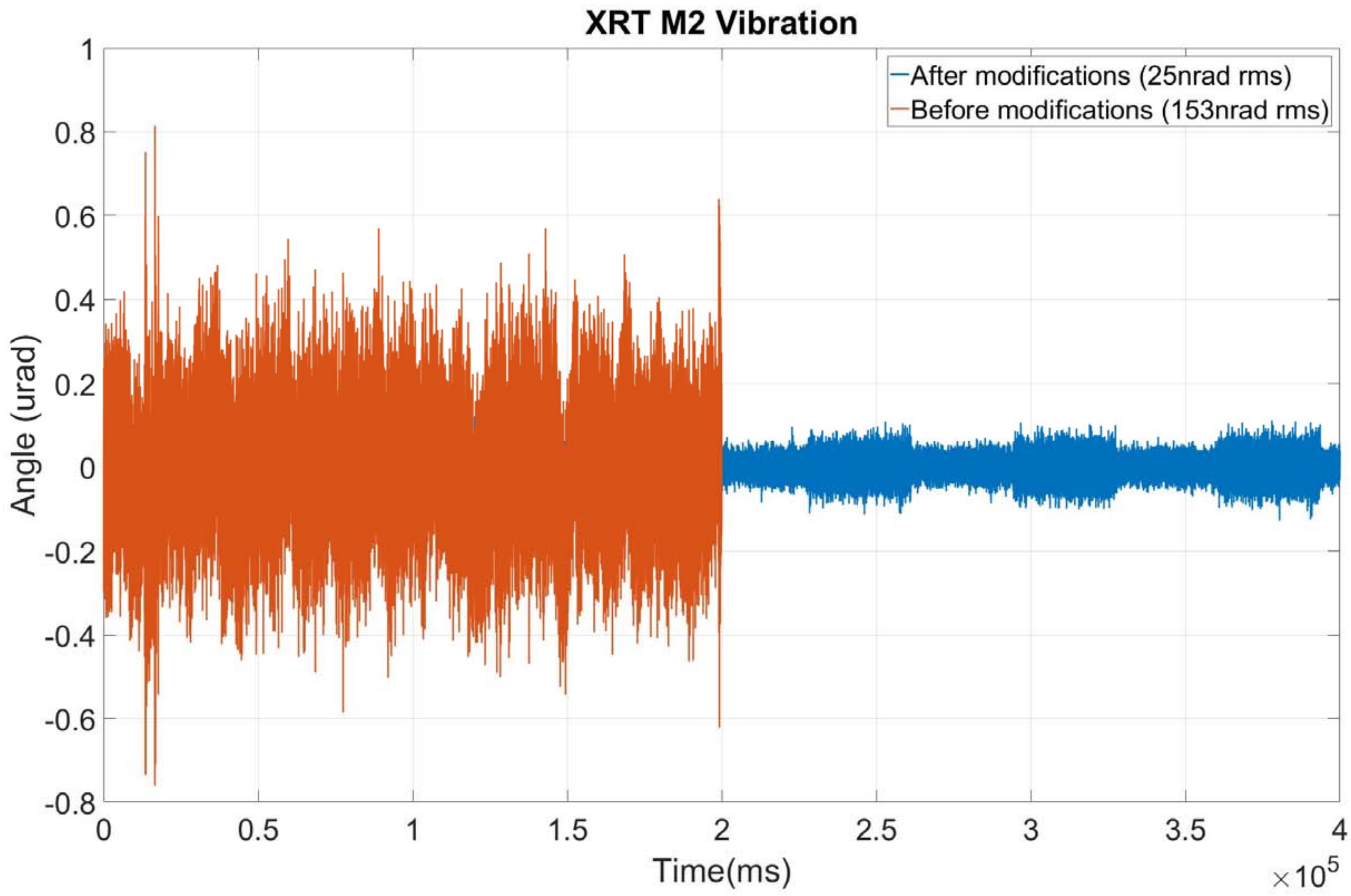


Attention to detail is key

- The largest vibration issue we hit with the new mirrors was caused by contact between the thermal enclosures and the mirrors
- The enclosures have large amplification factors of vibration and transferred that into the chambers. Eliminating this brought vibration levels down to <30nrad rms

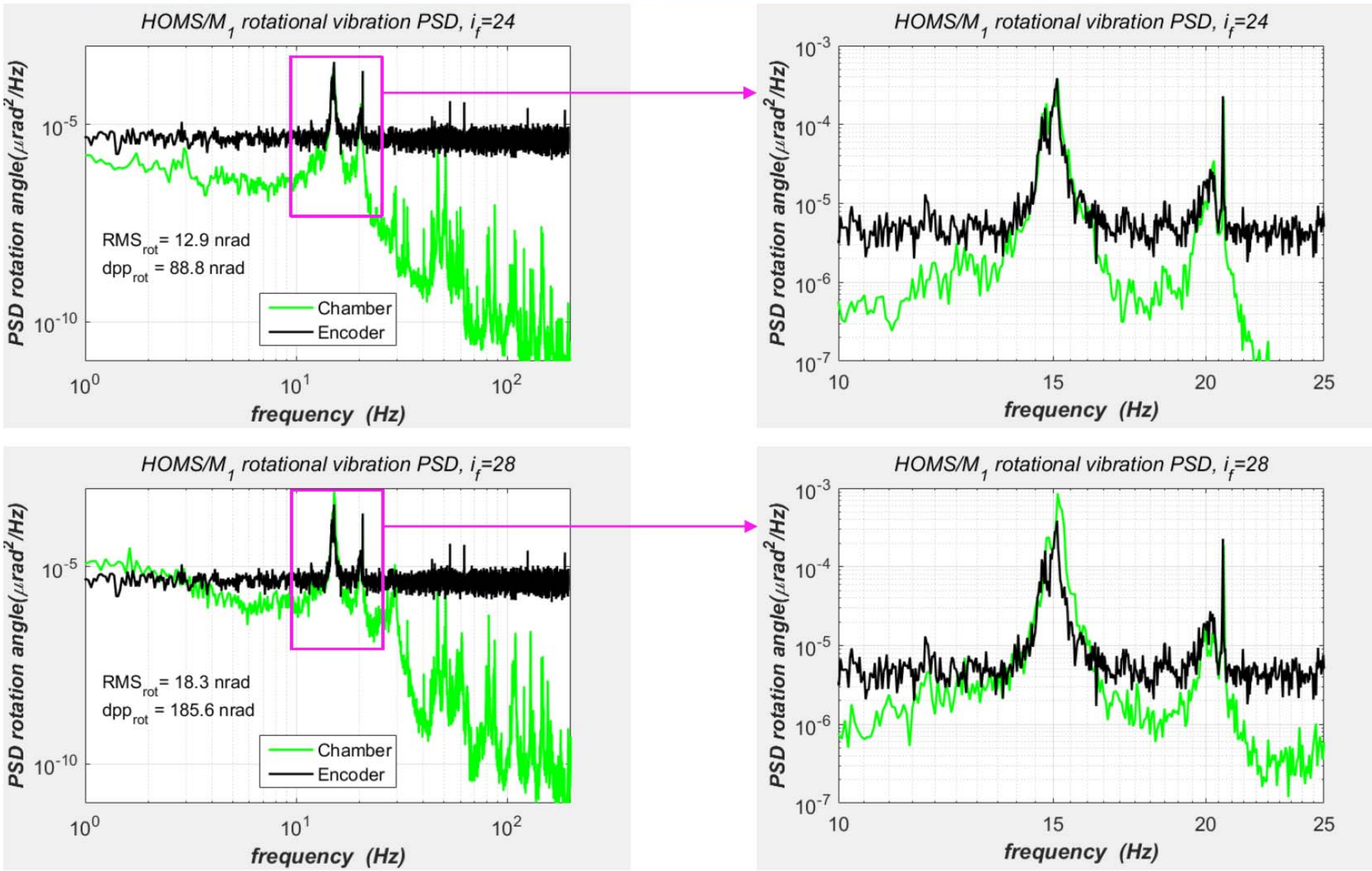


Improvement



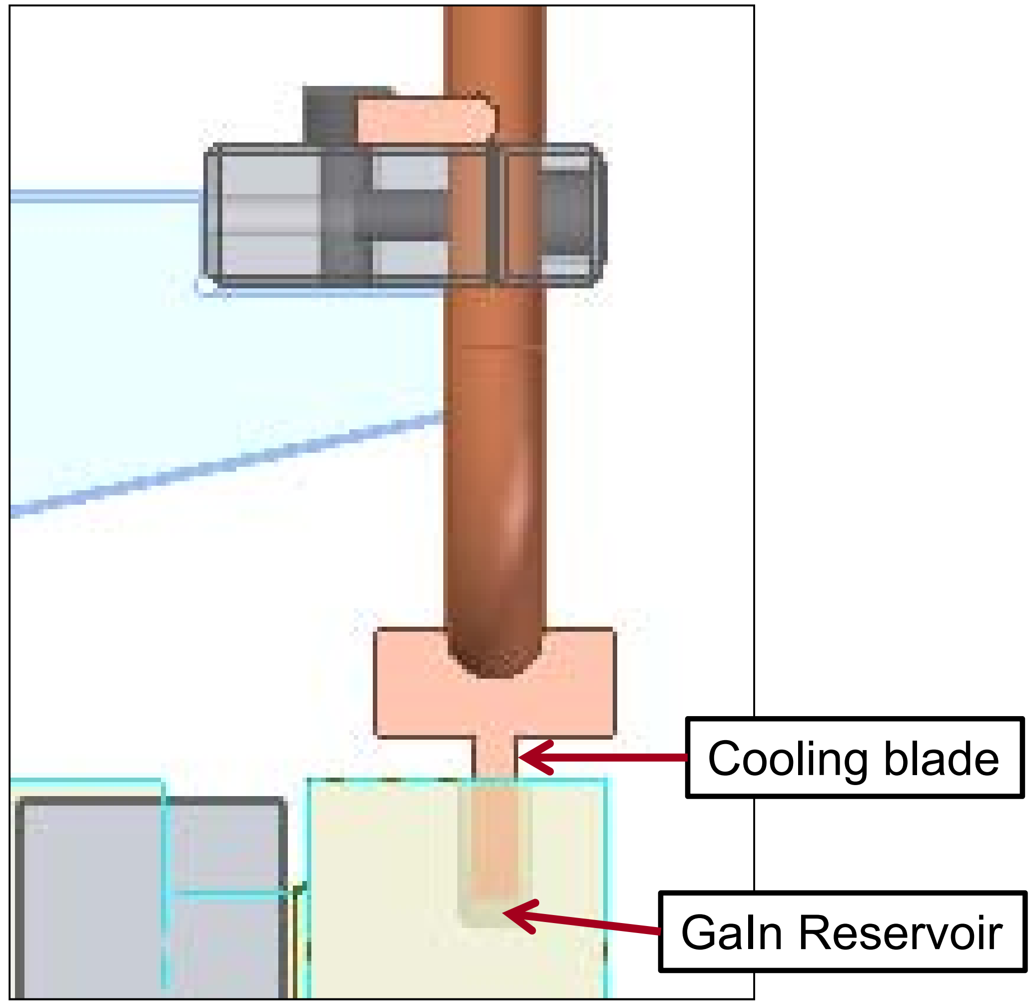
Refined vibration measurements using geophones

Rotational angle of the chamber **zoom**



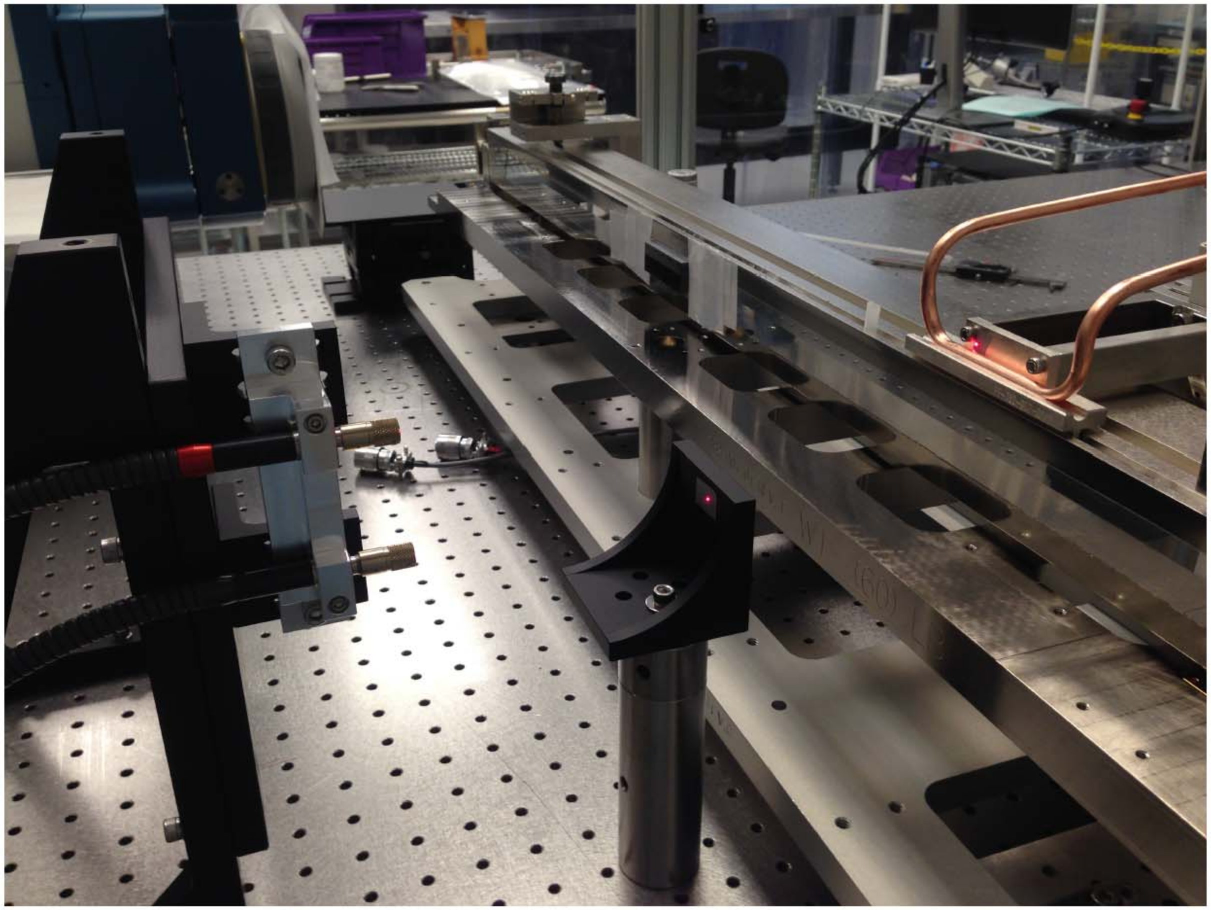
Effect of cooling on mirror vibration

- One concern is whether we can maintain vibration stability with cooling for the LCLS-II upgrade
- We ran some tests on a prototype system to verify the Gallium indium cooling interface eliminates vibration coupling to the mirrors



Effect of cooling on mirror vibration

Example of setup II. The aluminum mirror is in place on the bender. Dual beam configuration shown measuring the displacement movement of the cooling block relative to a reflector mounted on the table.



Effect of cooling on mirror vibration

Figure 10a
Comparison of vibration enhancements between the cooling blade, the mirror surface and the table top.

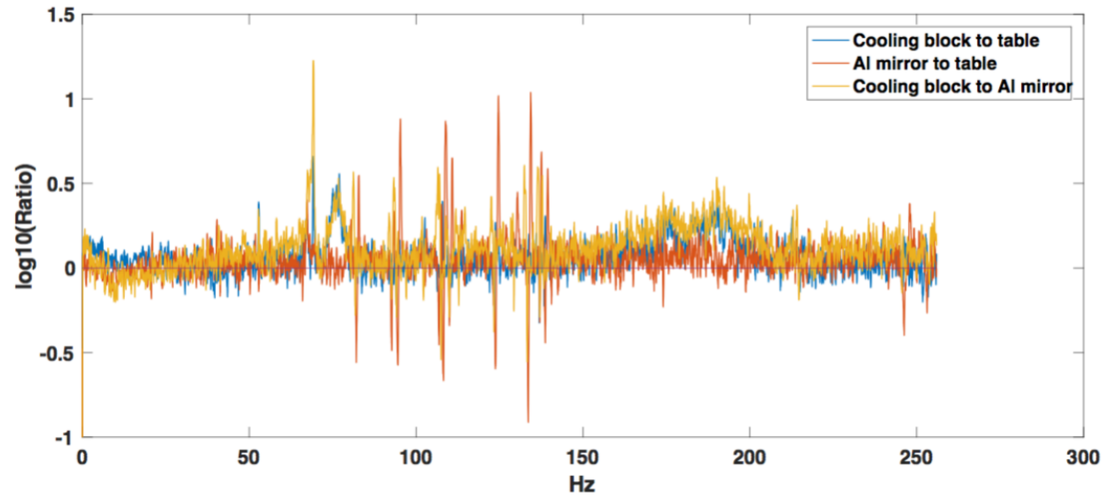
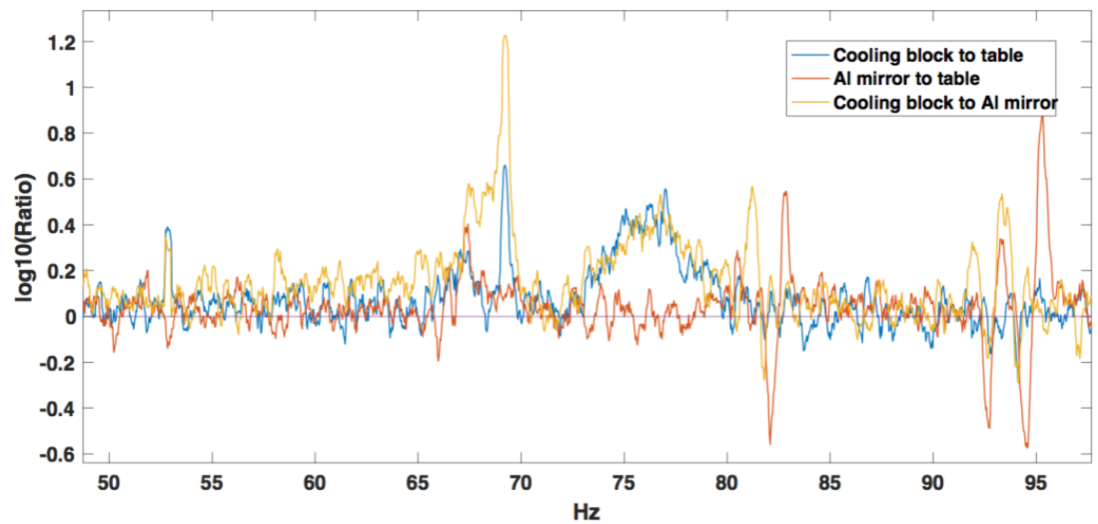
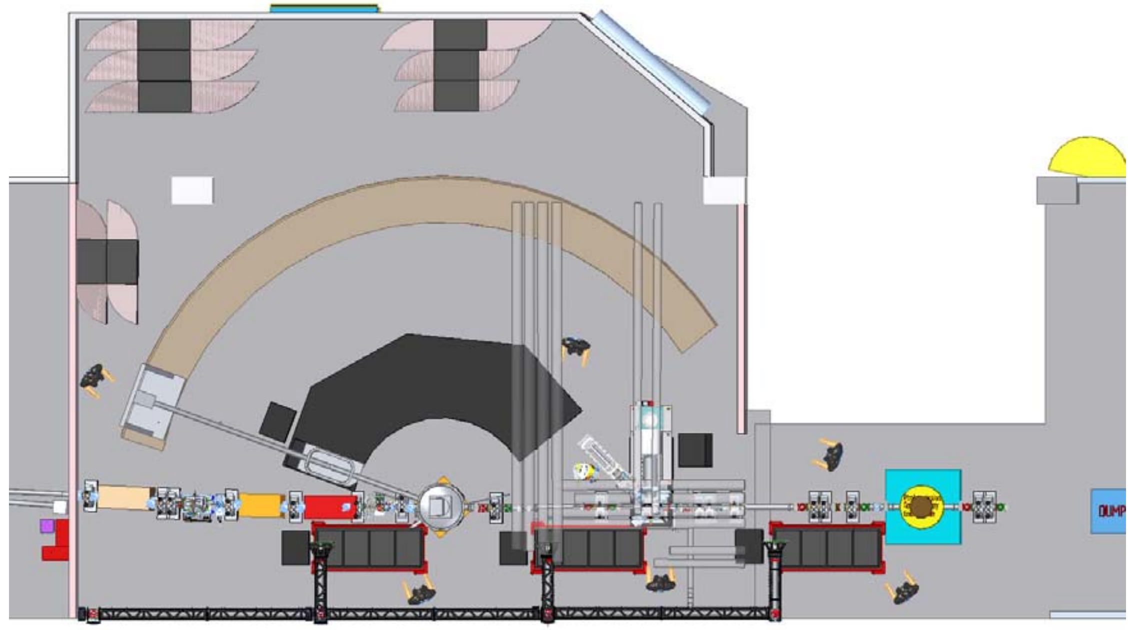


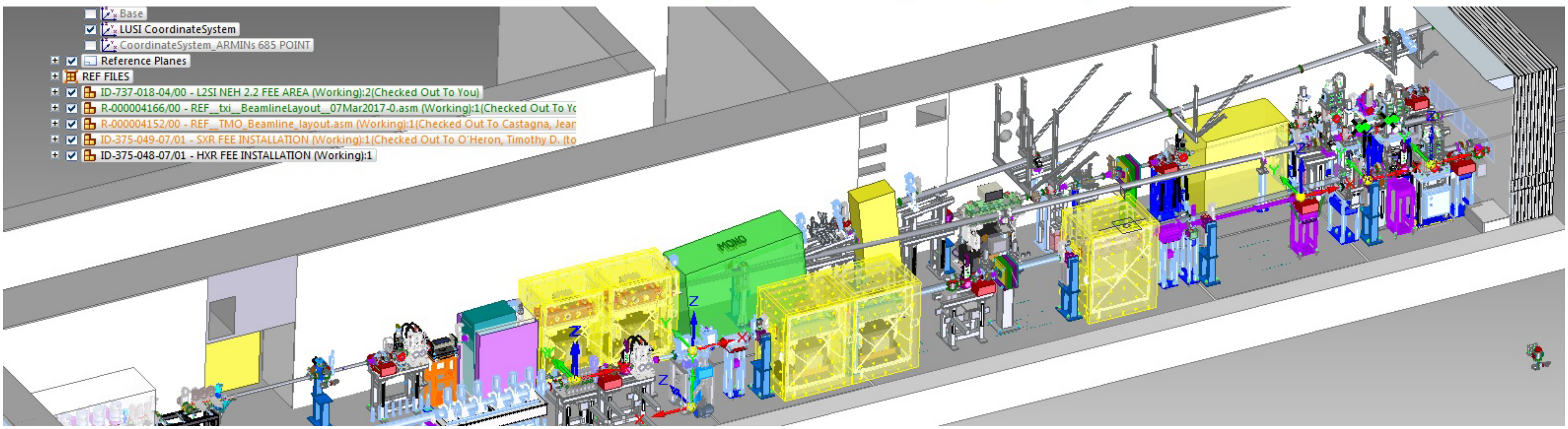
Figure 10b
Zoomed in section of figure 10a



LCLS L2SI 2.X Beamline

- Vertically deflecting monochromator steers mirror from sub basement of LCLS to Basement floor to RIXS Spectrometer





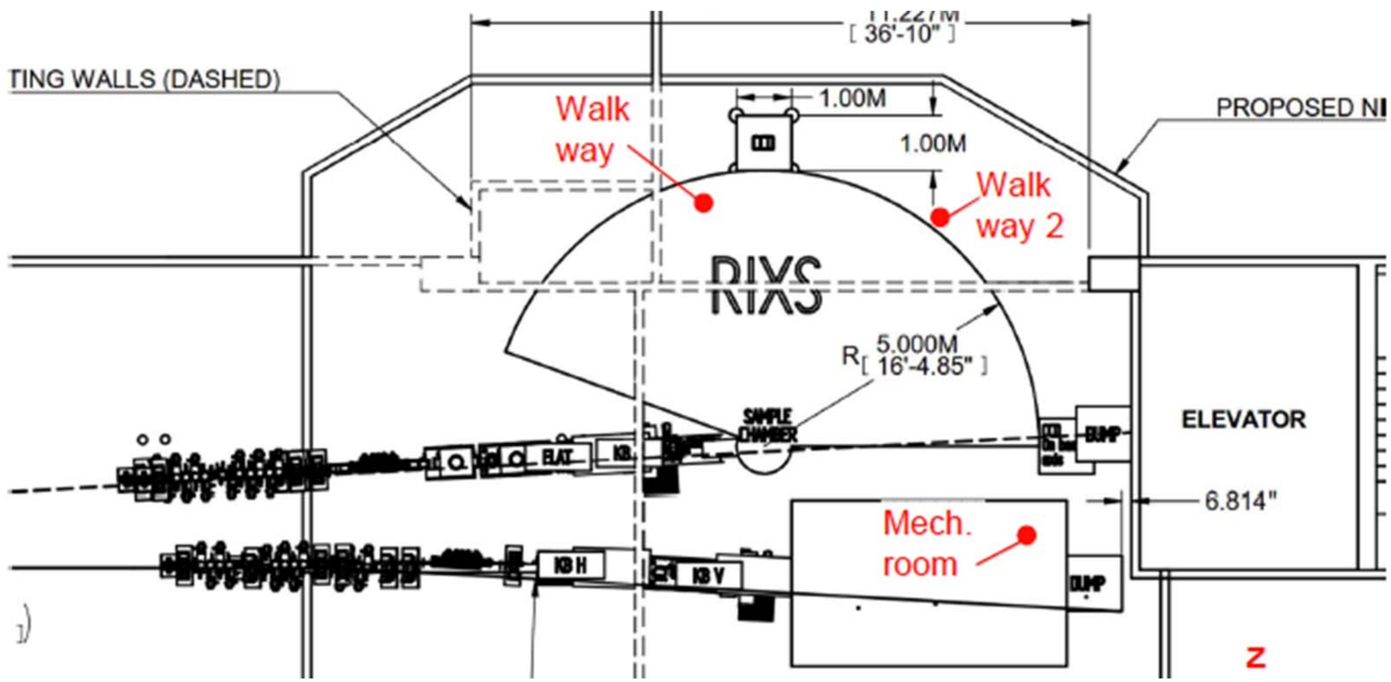
Effect of vibration

0.25 - 200 Hz	Z-walk way	Z-walk way 2	Z-Mech. room
RMS_max	264	291	145
RMS_min	113	123	101

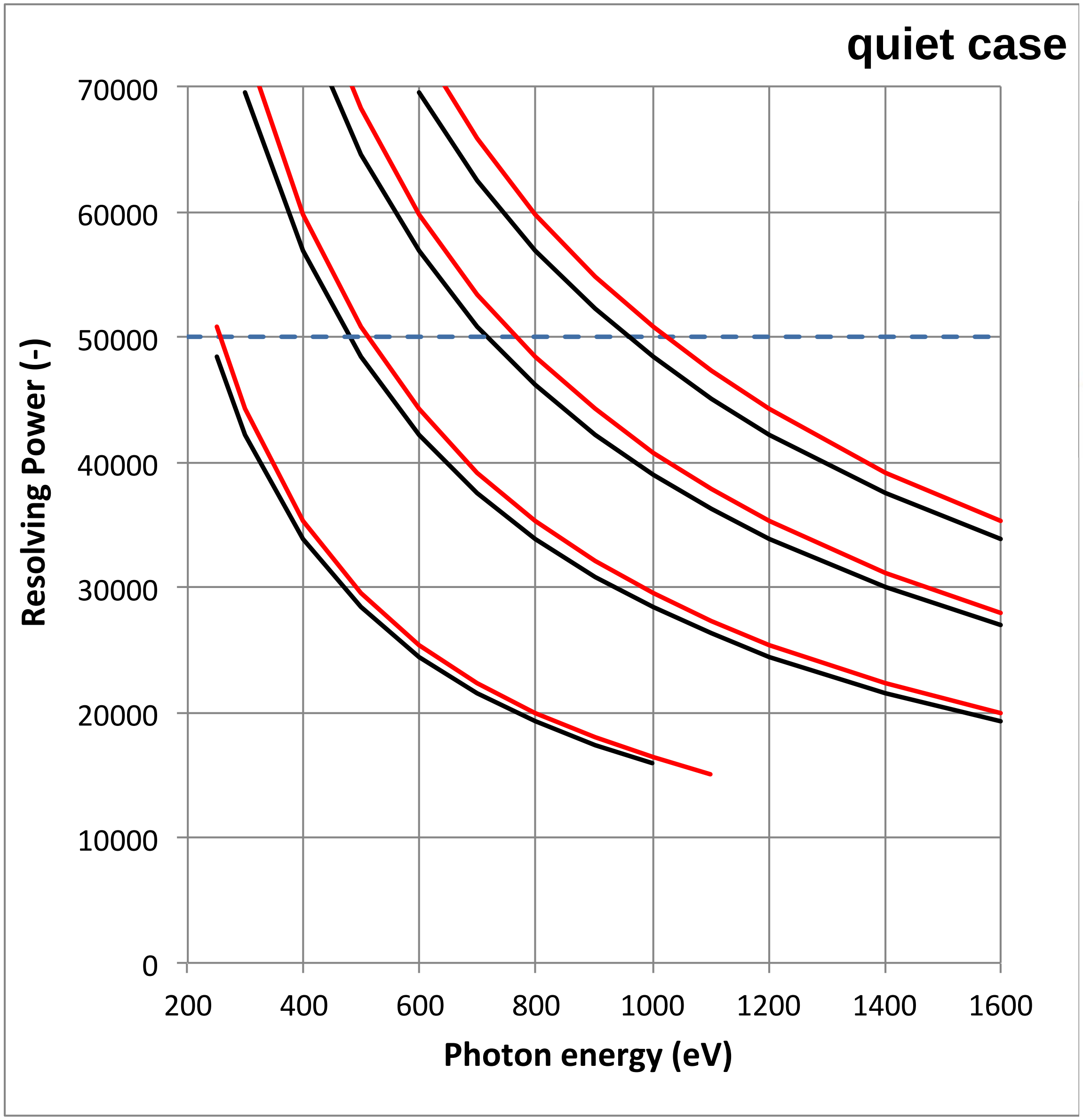
1 - 200 Hz	Z-walk way	Z-walk way 2	Z-Mech. room
RMS_max	195	128	**49**
RMS_min	36	32	**16**

rms (nm) vibration amplitude measured by L. Zhang and L. Lee inside and outside the mechanical room (e.g. RIXS spectrometer location)

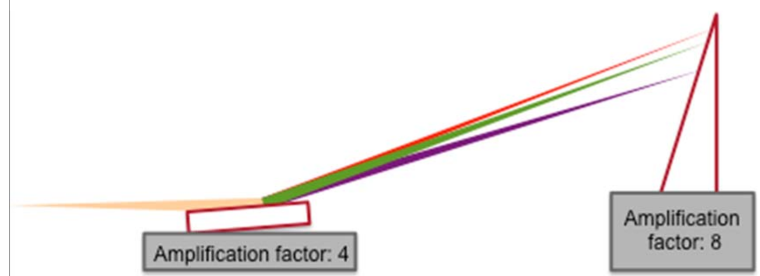
0.25-200 Hz used in the next slides



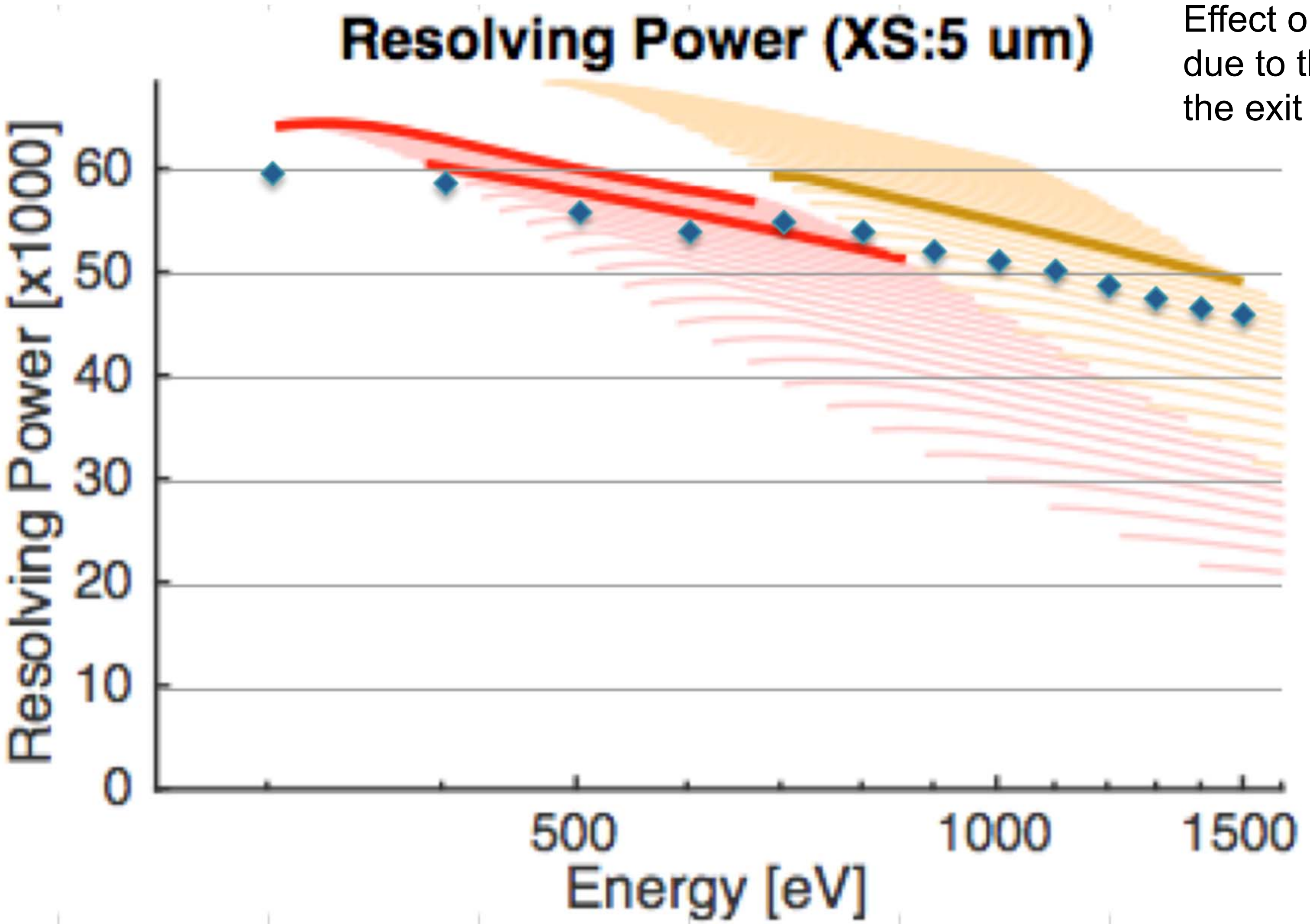
Vibration induced effect on resolution



Red lines: Ideal resolution with
10 μm spatial resolution detector
No vibrations



Effect on the exit slit



Effect on the resolution due to the vibration on the exit slit

Challenges Looking forward

- The L2SI program at LCLS is developing many new optics (~10 KB mirrors, SXR Monochromator, etc.)
- The 2.X beamline for the L2SI program will send beam from the sub-basement of the LCLS Near Experiment Hall up to the basement floor
  - Stability of the two floors relative to each other is a key factor we are investigating
- Monochromator for 2.X beamline requires very high stability of ~15nrad
- There is currently a lack of reliable data on long term drift to a reliable fiducial (too many free variables to correlate user data)
  - The new “Skywalker” auto-alignment system will log the alignment positions of every mirror to a single pixel independently for each mirror
- LCLS-II HE is coming, and may require Cryo-cooled components

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Michael Rowen

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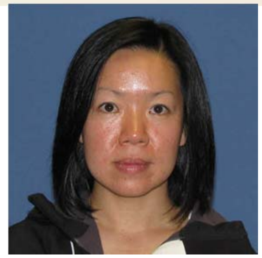






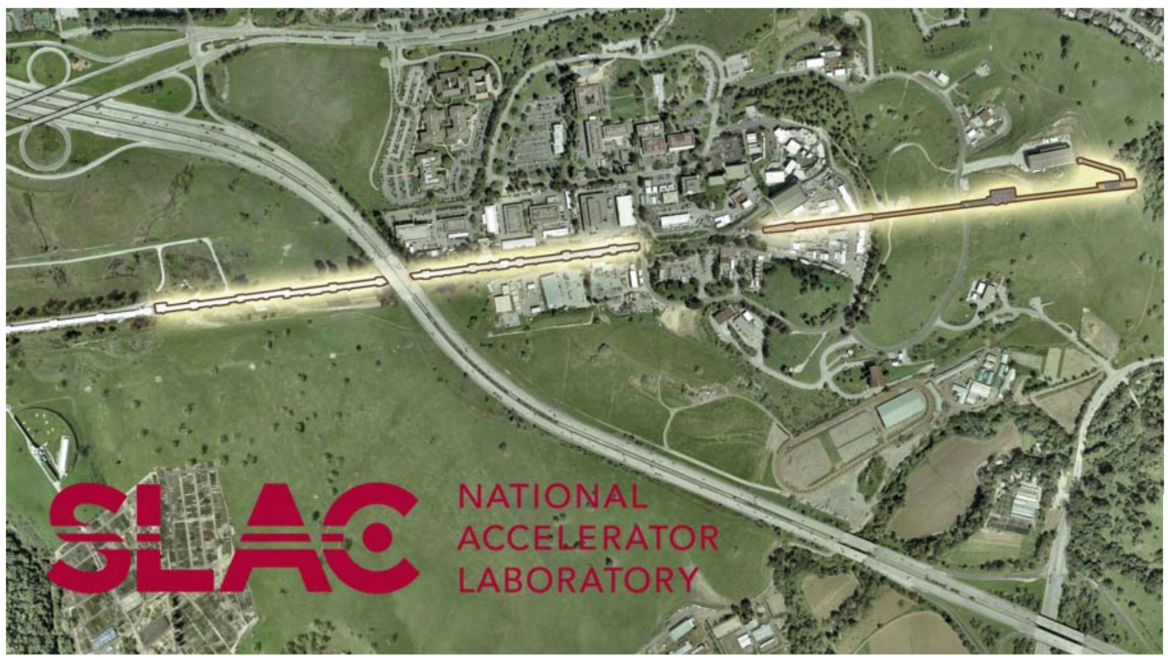

Thanks for your kind attention

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