Alignment activities for the LCLS-II project at SLAC

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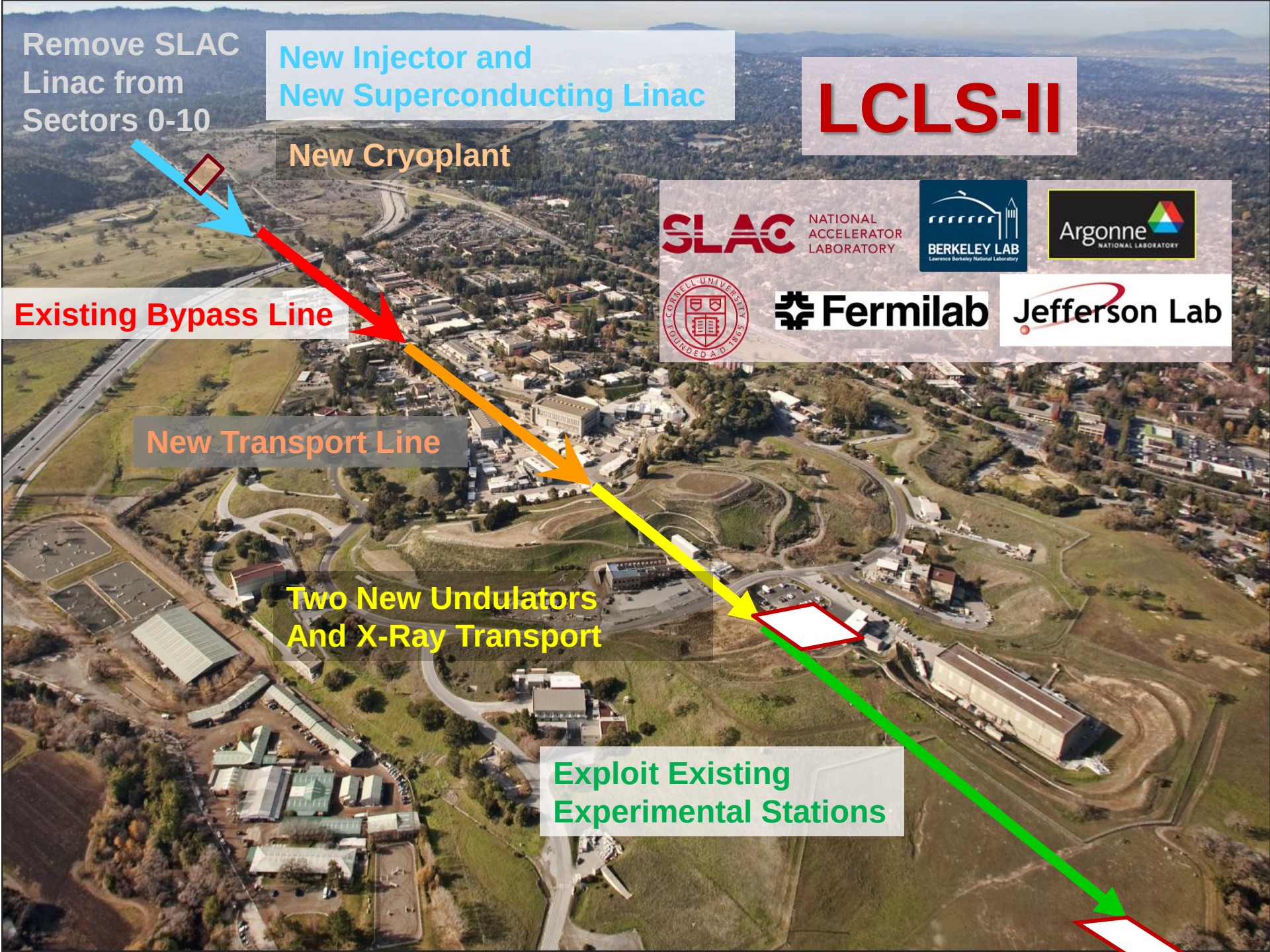
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY


Remove SLAC Linac from Sectors 0-10
New Injector and New Superconducting Linac
LCLS-II
New Cryoplant
SLAC NATIONAL ACCELERATOR LABORATORY
BERKELEY LAB
Argonne NATIONAL LABORATORY
Fermilab
Jefferson Lab
Existing Bypass Line
New Transport Line
Two New Undulators And X-Ray Transport
Exploit Existing Experimental Stations

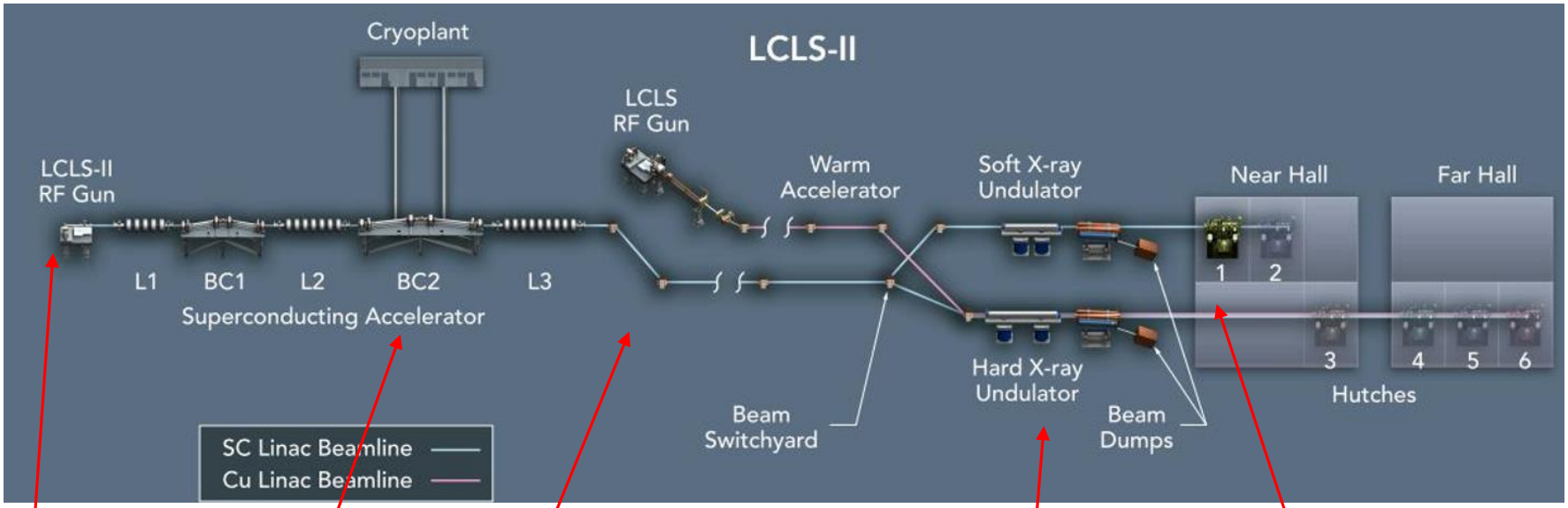
LCLS-II

- LCLS-II adds a 4 GeV SC linac to the first kilometer of the SLAC linac tunnel.
  - The copper linac in that region will be removed
- The new beam will run CW at up to 1 MHz
  - The LCLS-1 linac is not altered, retains performance
- The new beam can be directed at either of two new undulators
  - The LCLS-1 beam can be directed to the new Hard X-ray Undulator

Key Performance Parameters for LCLS-II:

Performance Measure	Threshold	Objective
Variable Gap Undulators	2 (SXR & HXR)	2 (SXR & HXR)
Super Conducting Linac Based FEL System		
Super Conducting Linac Energy	3.5 GeV	≥ 4 GeV
Electron Bunch Repetition Rate	93 kHz	929 kHz
Super Conducting Linac Charge per Bunch	0.02 nC	0.1 nC
Photon Beam Energy Range	250-3,800 eV	200-5,000 eV
High Repetition Rate Capable End Stations	≥ 1	≥ 2
FEL Average Power (10^-3 BW)	$5x10^{8}$ (10x spontaneous @2,500 eV)	$>10^{11}$ @ 3,800 eV
Normal Conducting Linac Based FEL System		
Normal Conducting Linac Electron Beam Energy	13.6 GeV	15 GeV
Electron Bunch Repetition Rate	120 Hz	120 Hz
Normal Conducting Linac Charge per Bunch	0.1 nC	0.25 nC
Photon Beam Energy Range	1,000-15,000 eV	1,000-25,000 eV
Low Repetition Rate Capable End Stations	≥ 2	≥ 3
FEL Photon Energy (10^{-3} BW[a])	10^{10} (lasing @ 15,000 eV)	$> 10^{12}$ @ 15,000 eV

Alignment Activities



Gun Alignment

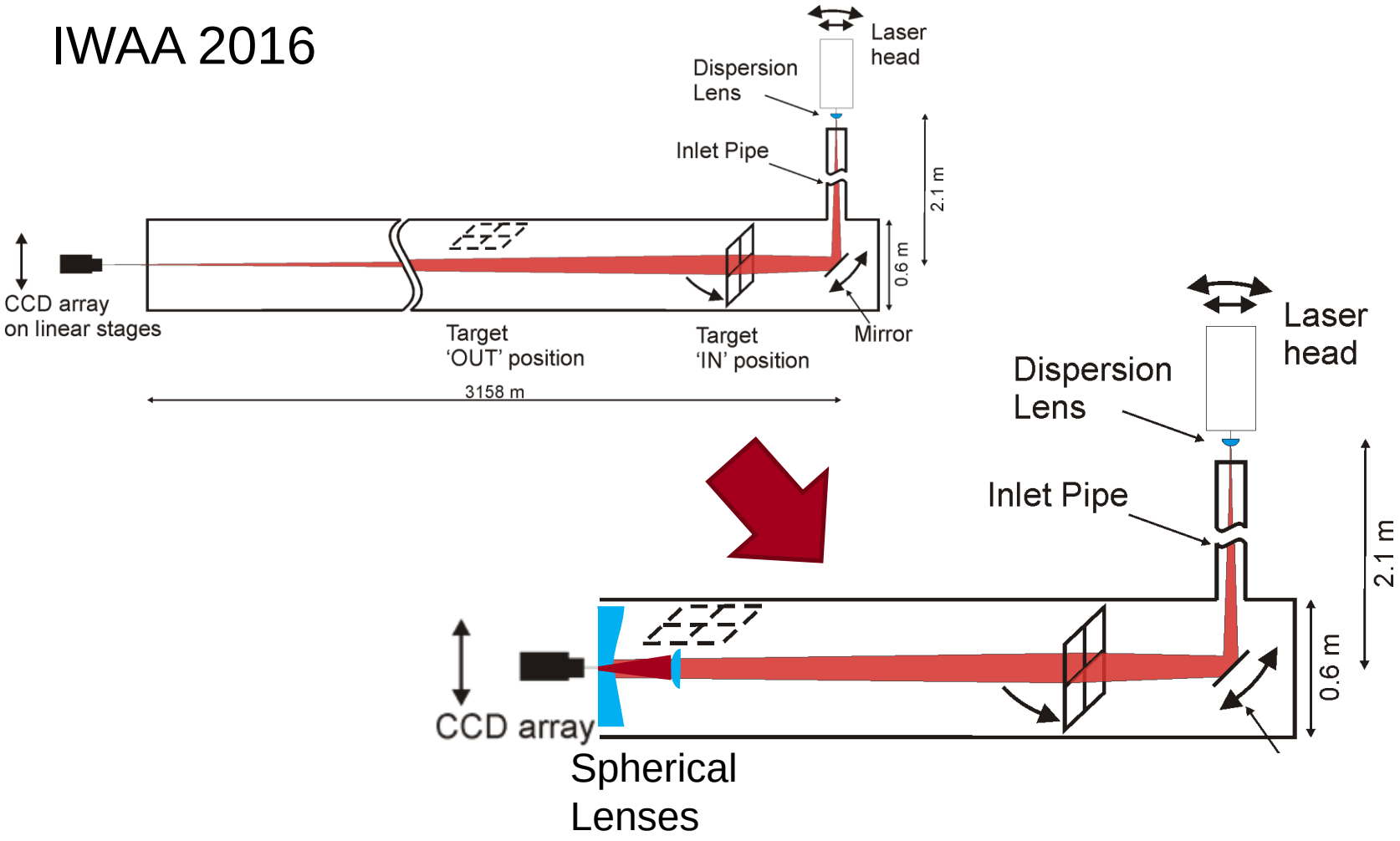
Re-config. of Linac laser alignment system

Monument based network

Design support for undulators

Floor stability measurements

Alignment Network – Reconfigure LLAS

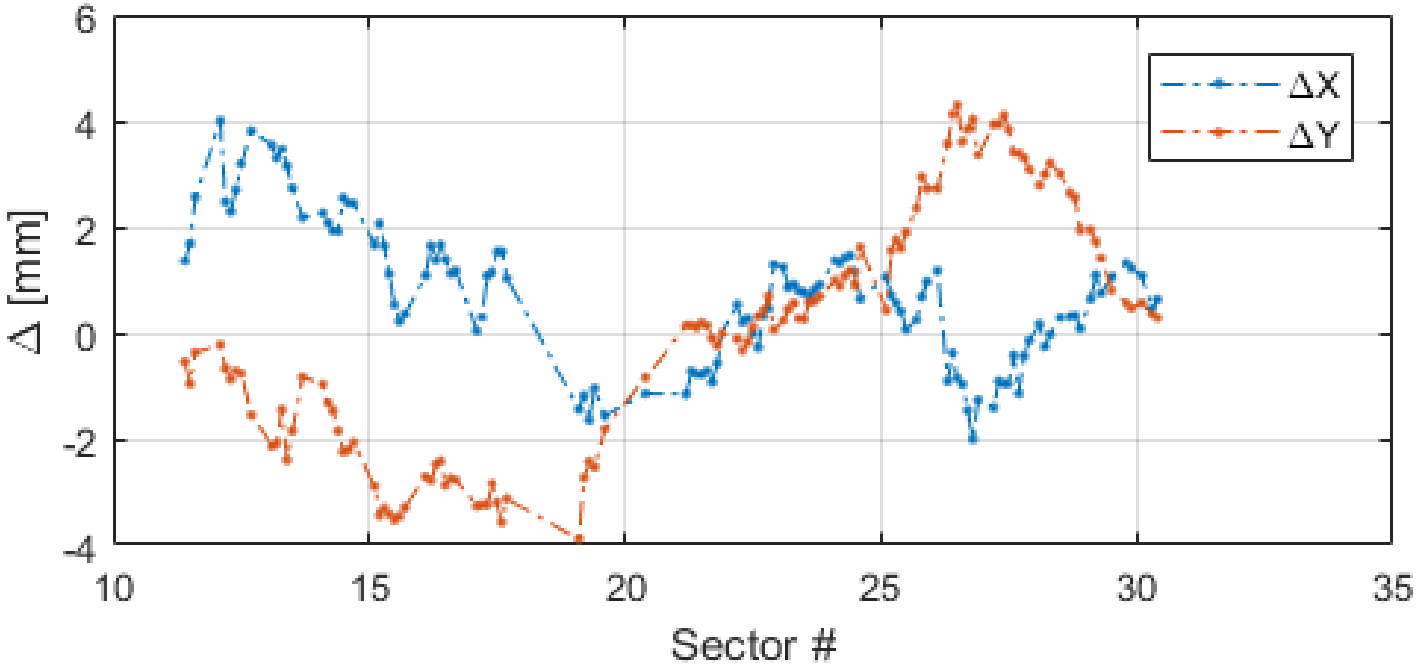


Alignment Network – Reconfigure LLAS - Pictures

Alignment Network – Reconfigure LLAS

Results:

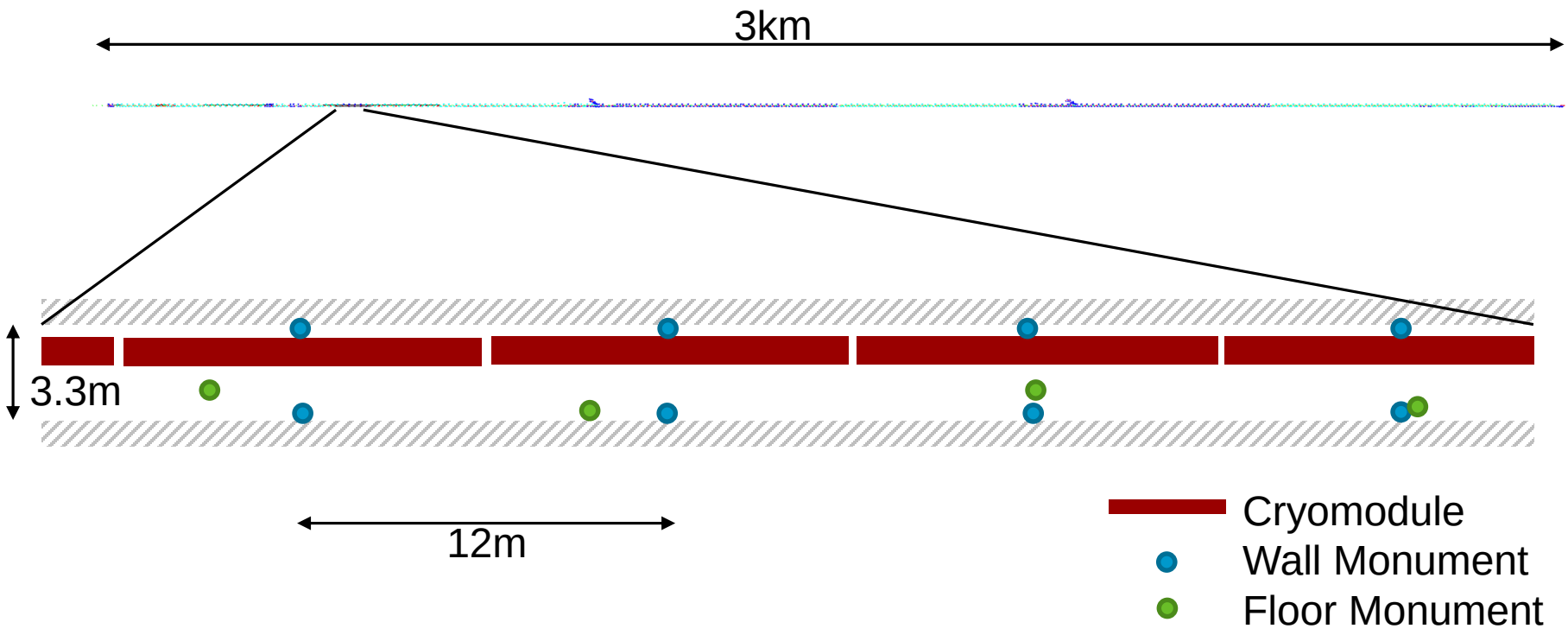
With the larger CCD array the mapping of the 2km accelerator structure only takes 4hours.



Alignment Network S0-S30 – Layout

S0-S10 no longer does have a light pipe and bypass lines are not tied to girders -> Monument based network

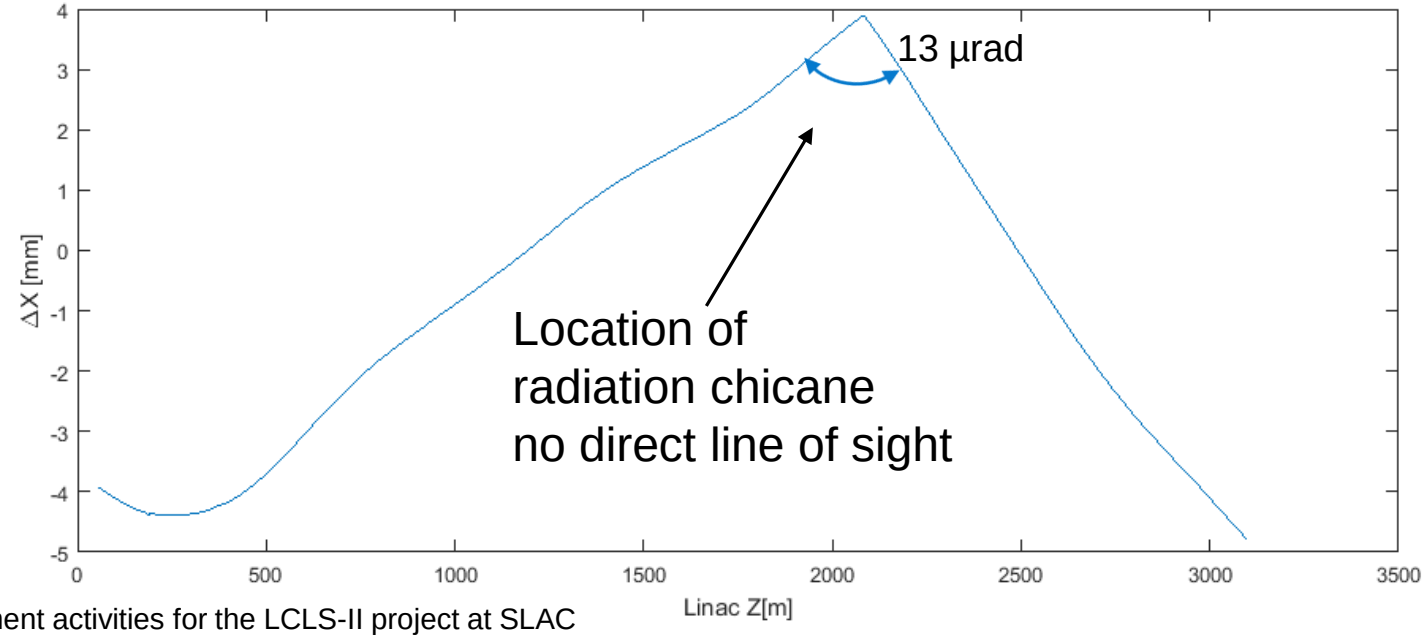
Opposing wall monuments to mitigate effect of refraction



Alignment Network S0-S30 – Results

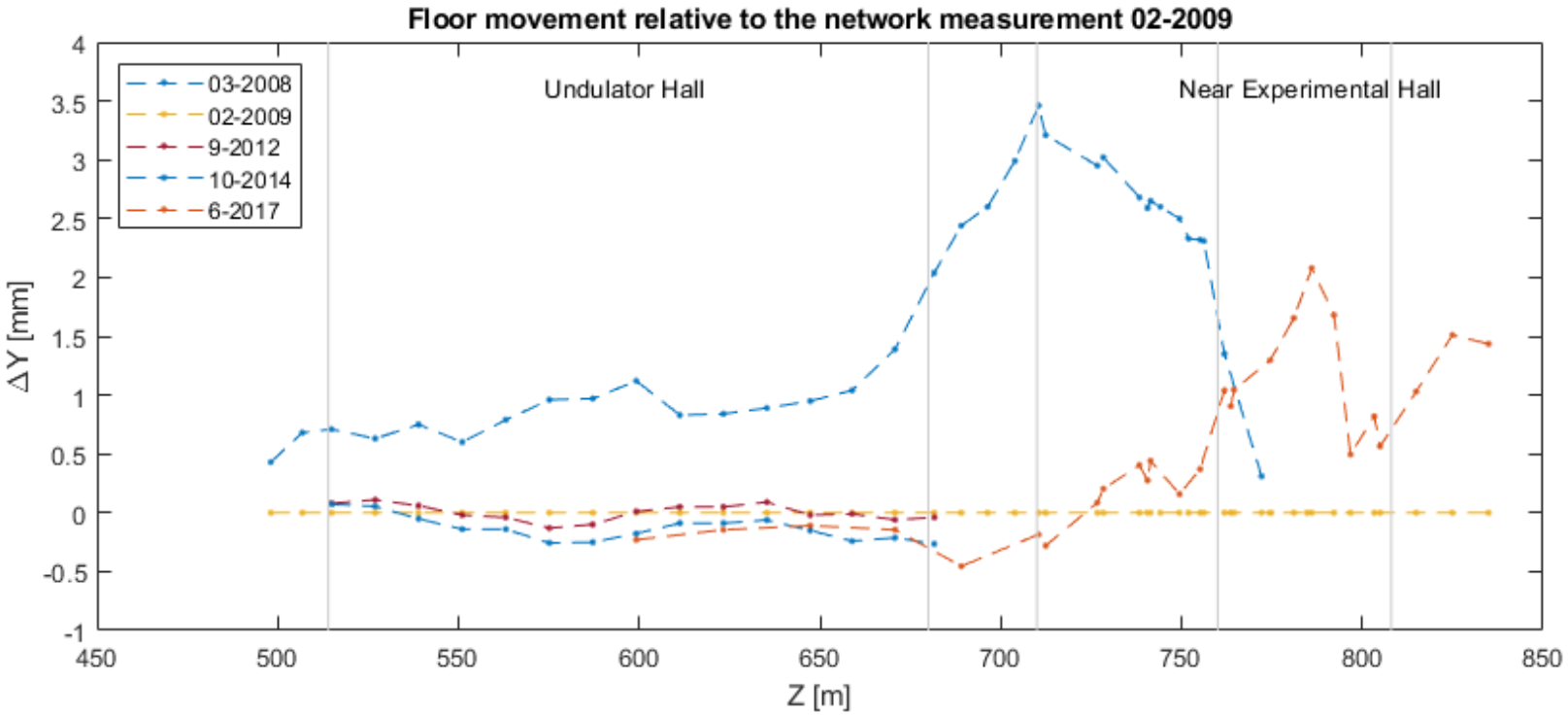
Least Squares Adjustment with GEONET which allows the Linac Light Pipe readings (σ=±0.5mm) to be included as deviations from a straight line

Comparison of coordinate results between adjustment with LLAS and without LLAS.



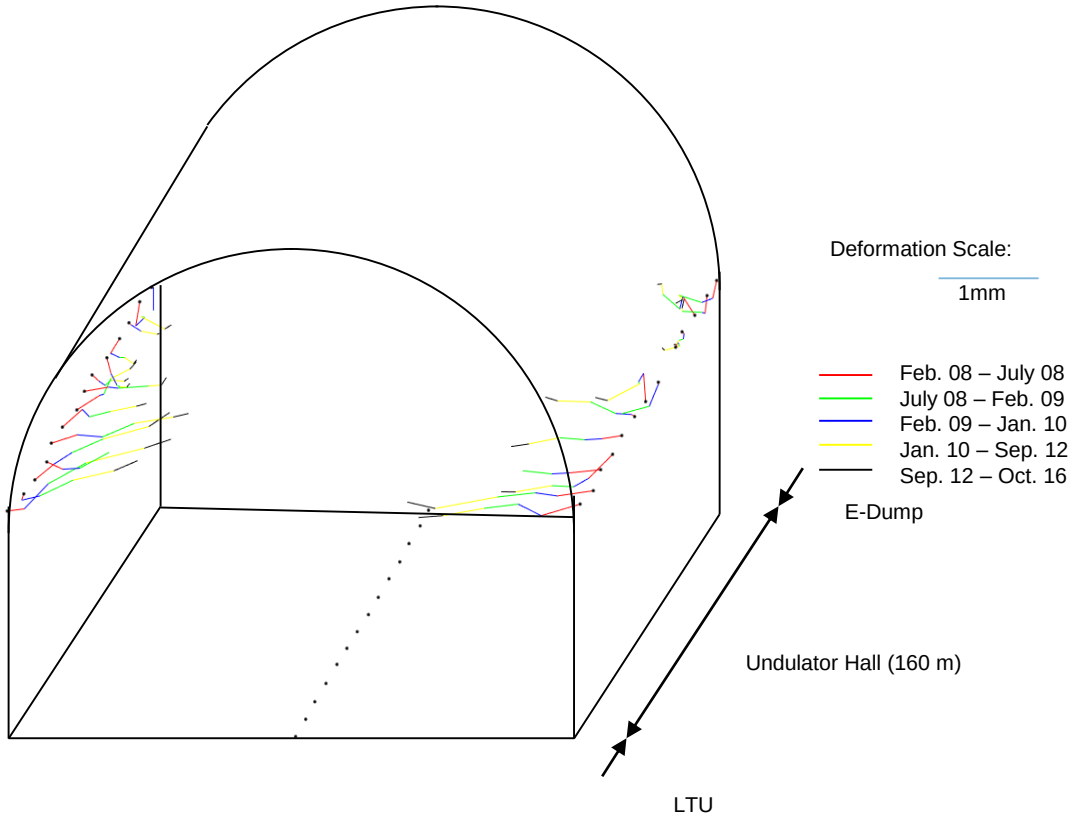
Alignment Network – Building stability

The floor in the undulator hall showed very little movement over the last 10 years, the only significant movement was in the FEE and NEH during construction on top of the building.

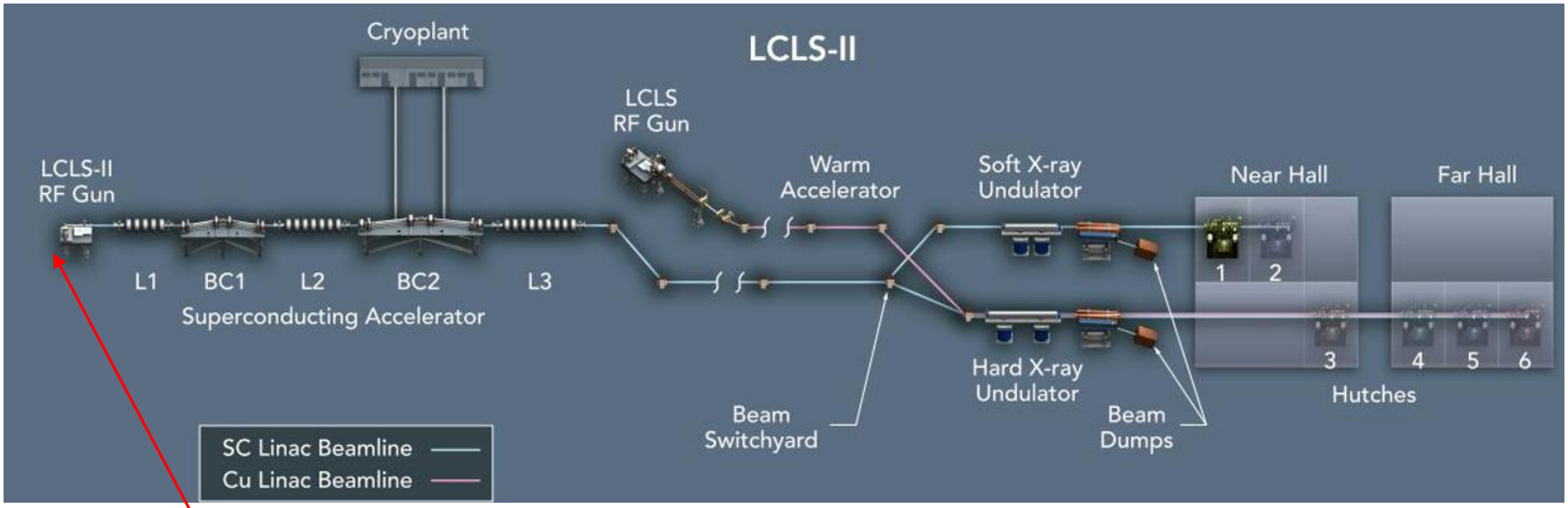


Alignment Network – Building stability

The walls in the undulators are still moving inward, the rate has slowed down.



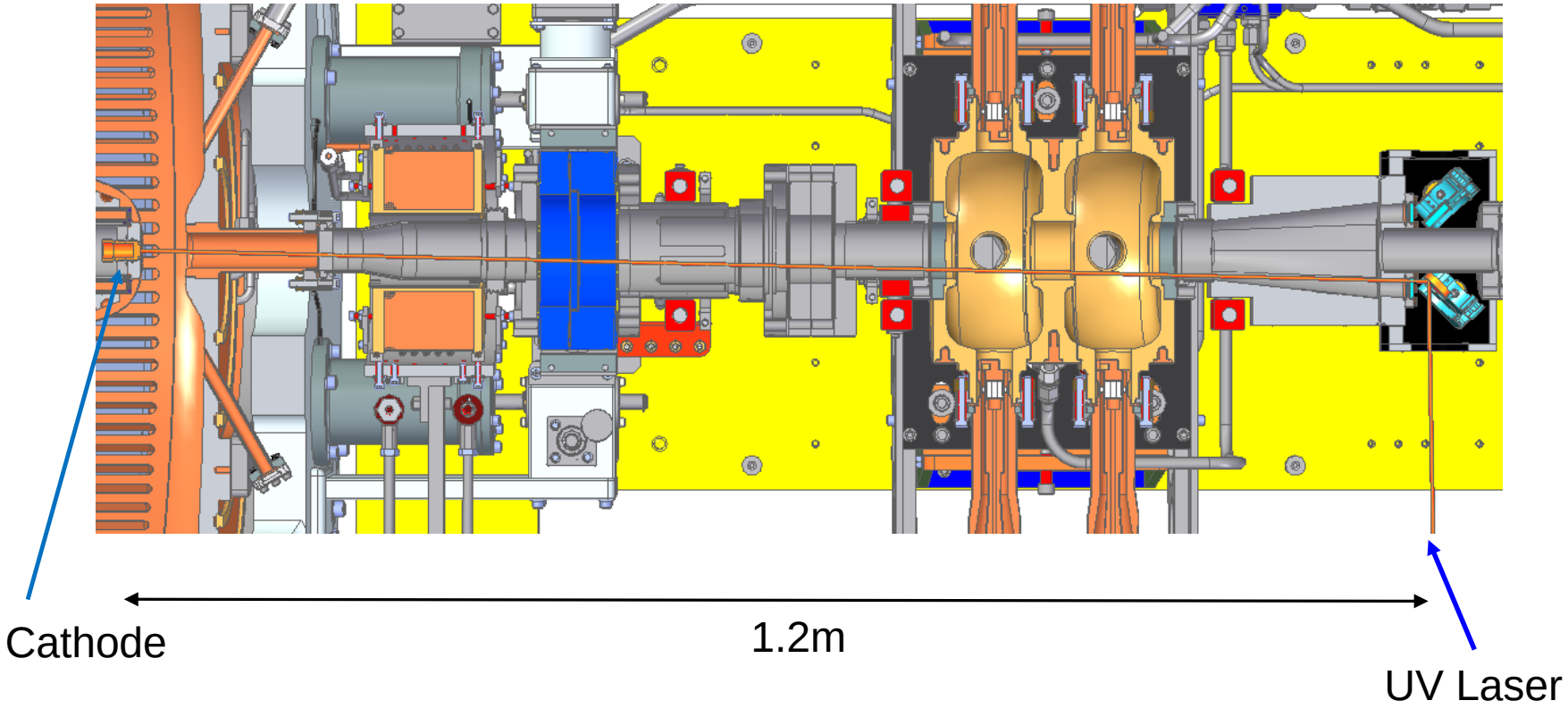
Alignment Activities – Gun Laser Alignment



Gun Alignment

Gun laser alignment

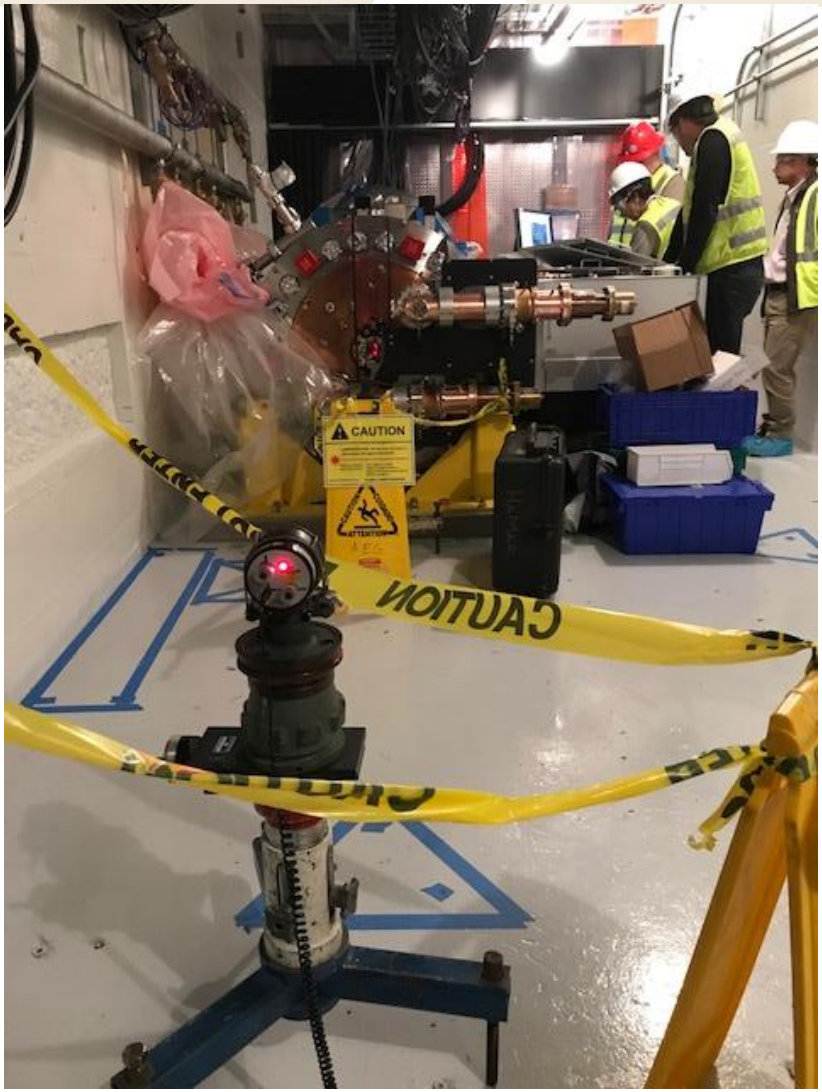
Objective: Align laser beam onto gun cathode without clipping the beam.



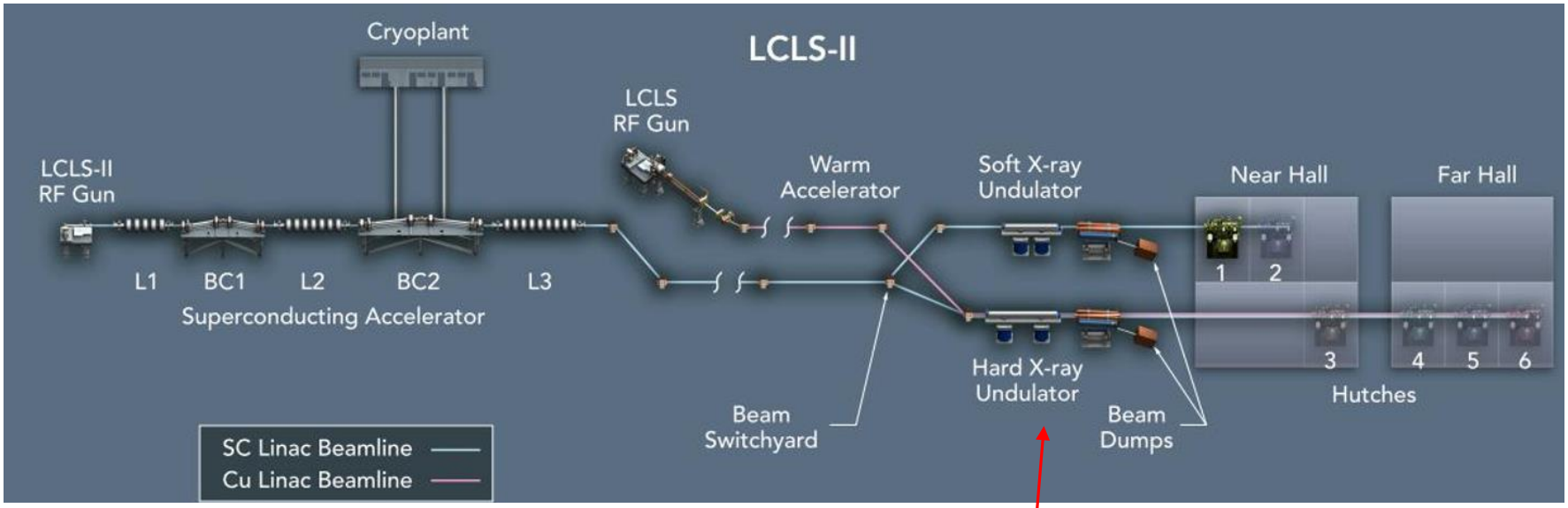
Gun laser alignment

Alignment approach:

- Shine a low power visible laser in reverse direction and align mirror system and irises up beam.
- Align a CCD array behind the Cathode and verify alignment of high power UV laser.

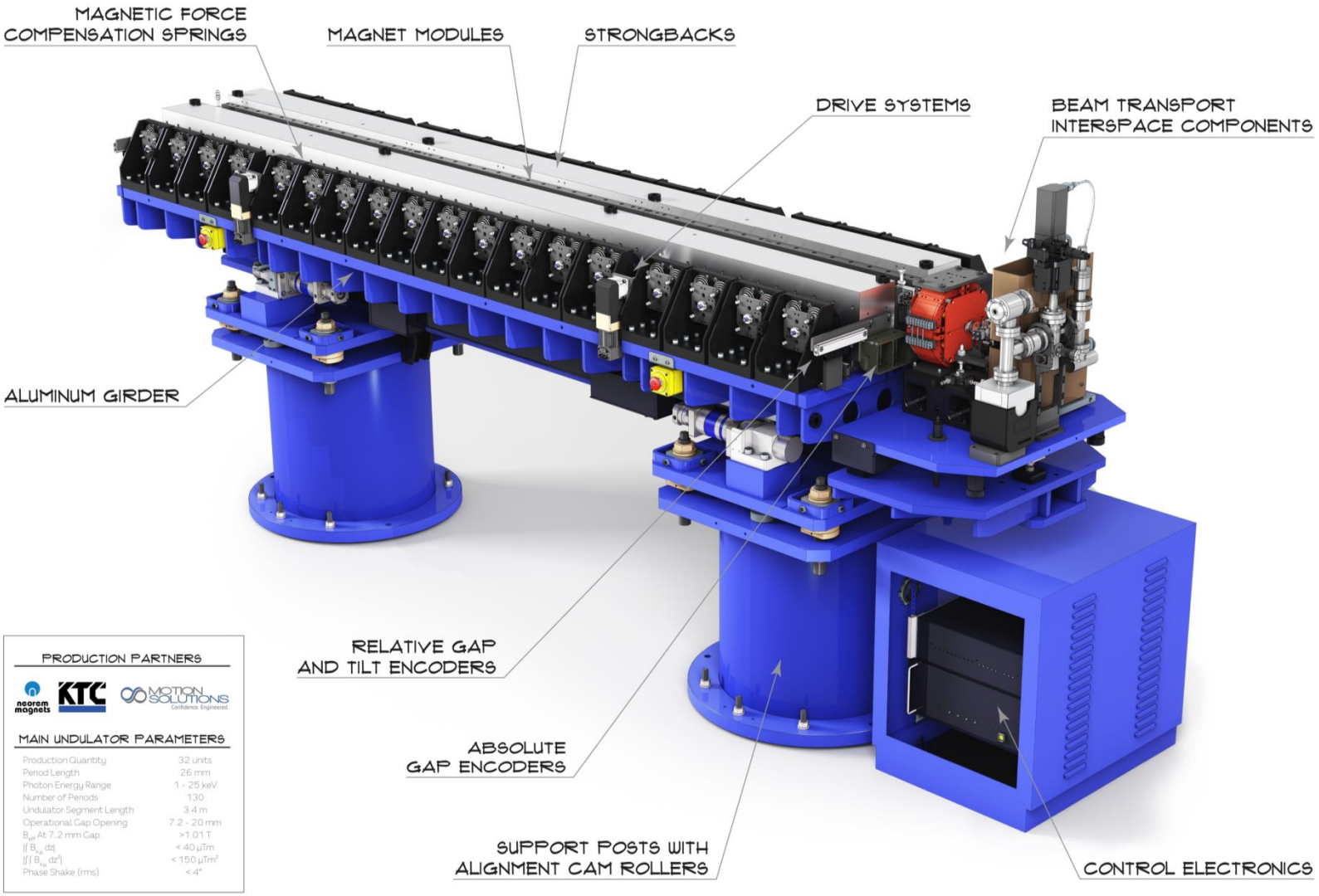


Alignment Activities – Undulator



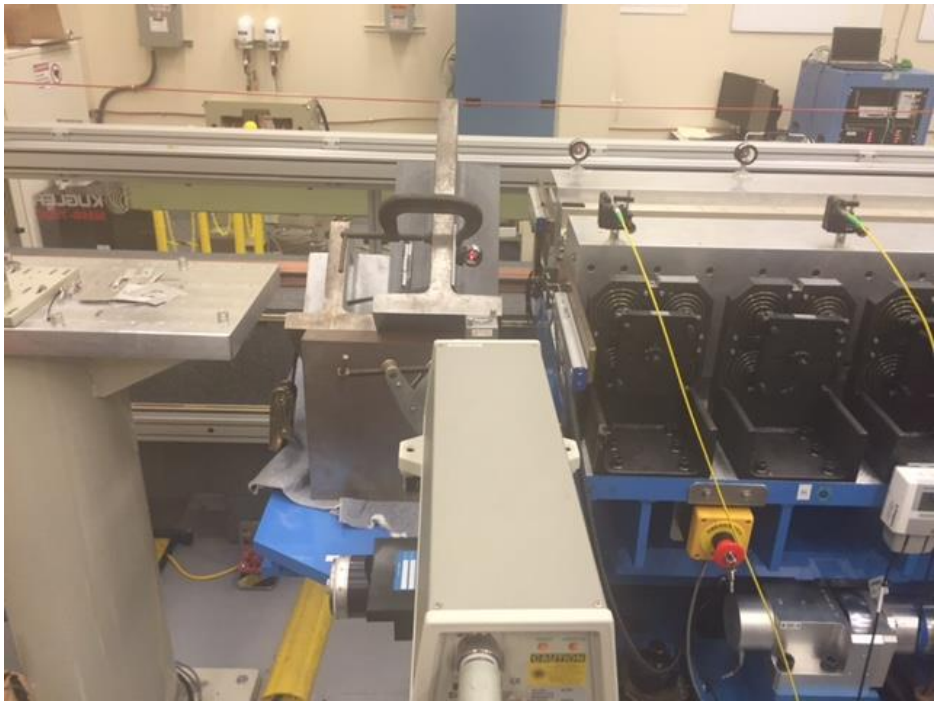
Design support for undulators

HXR Undulator

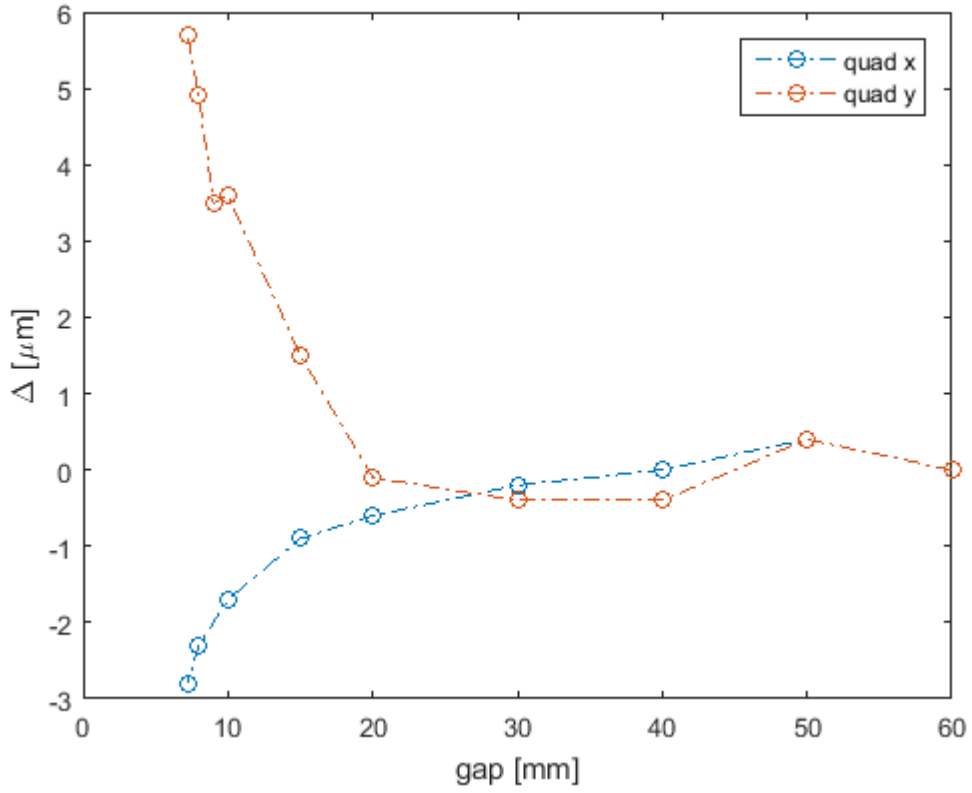


LCLS-II HGVPU Gap change effects

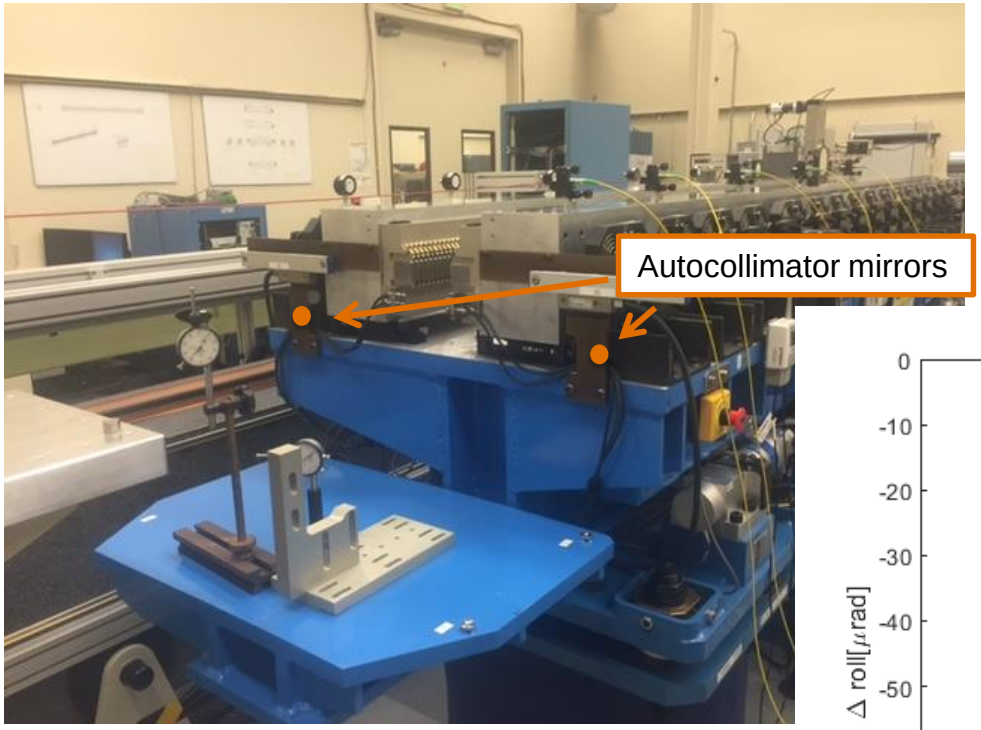
To determine the effect of opening and closing the gap on the geometry of the girder components a series of interferometer and autocollimator measurements were performed.



Undulator Quadrupole position

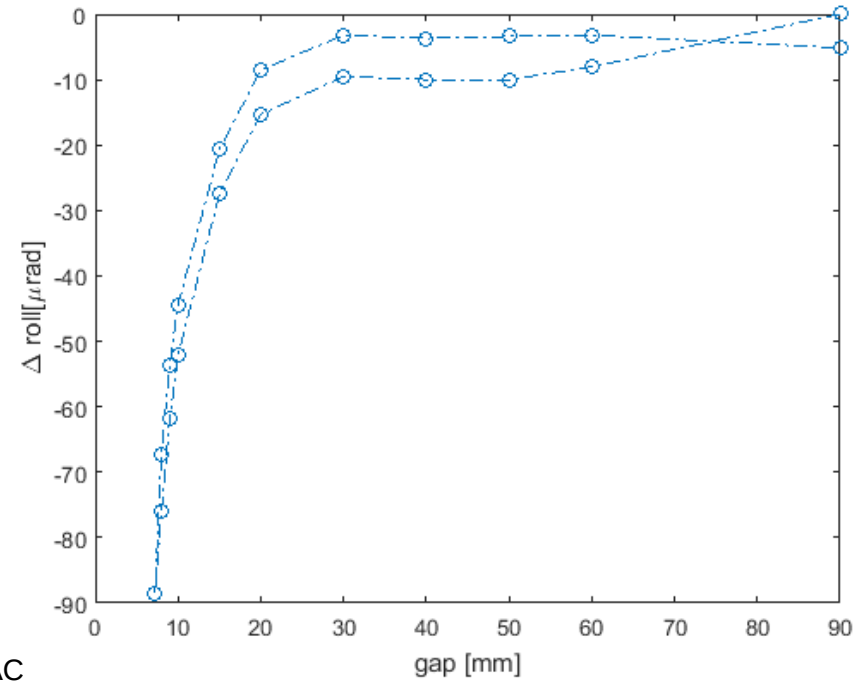


Undulator Girder Bending

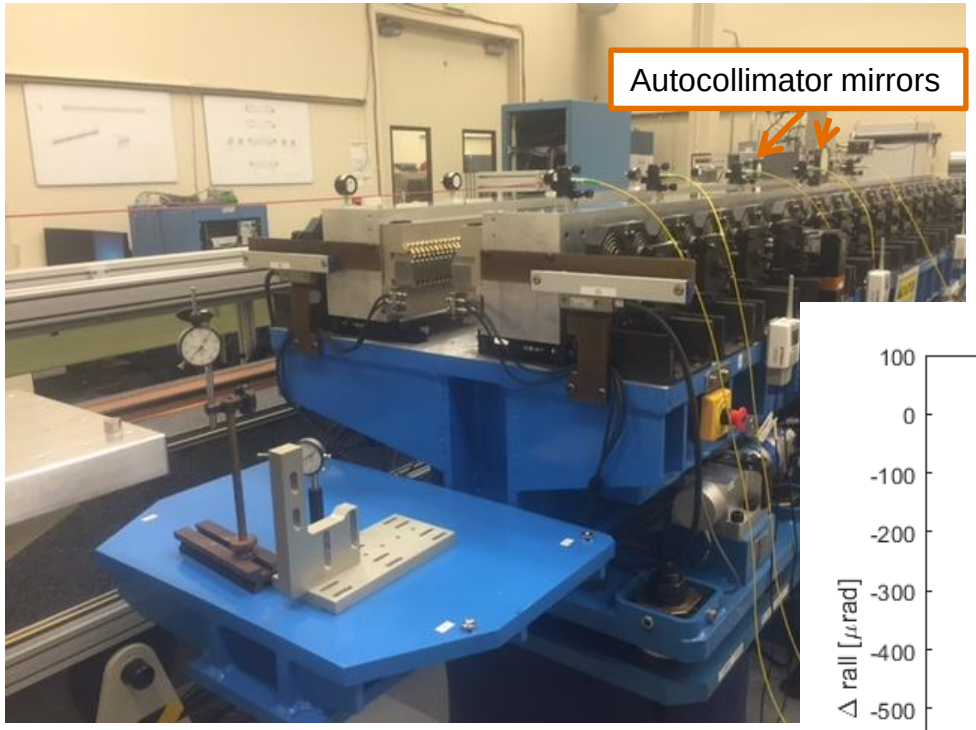


Aisles side: 90µrad

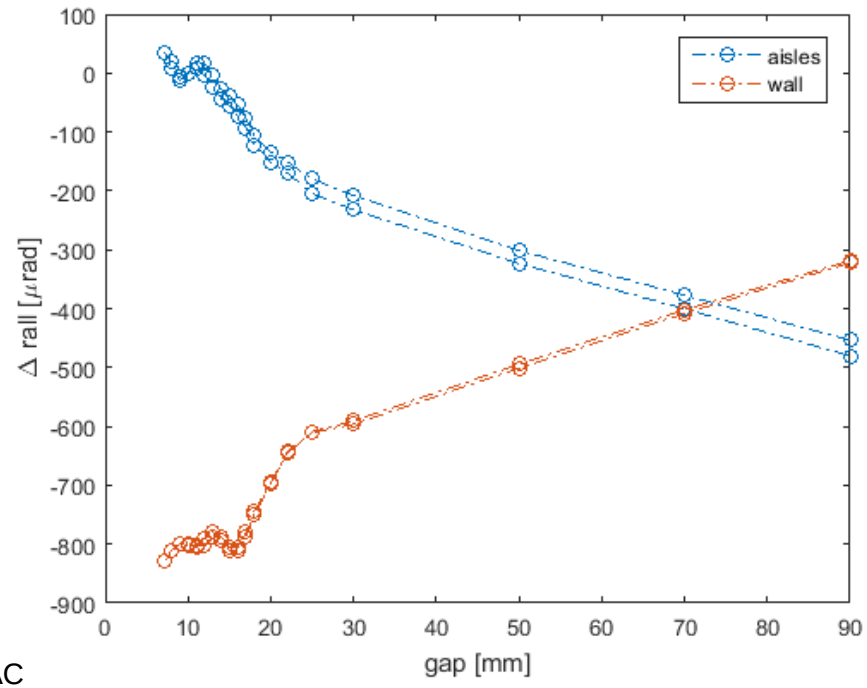
Wall side: 25µrad



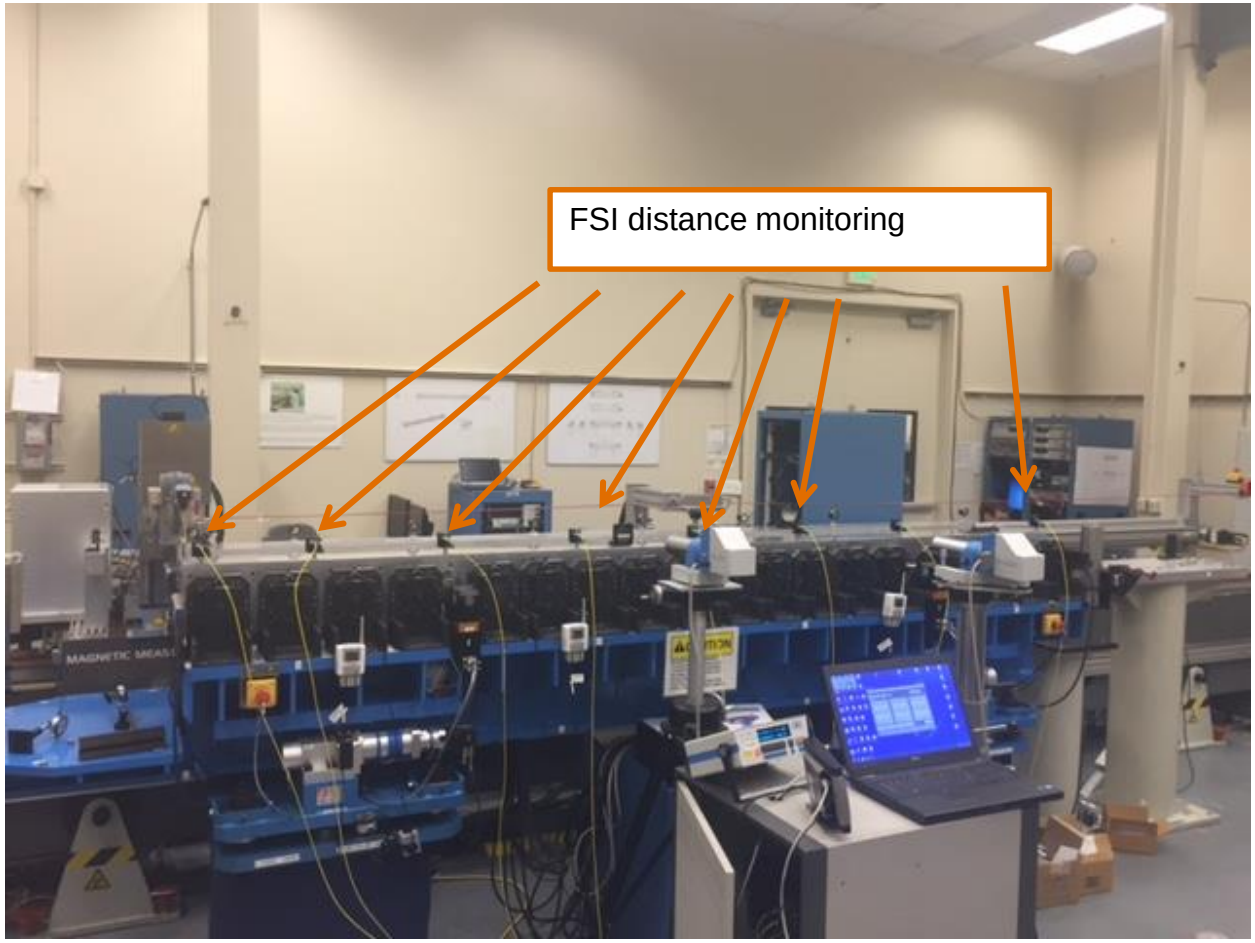
Roll of undulator jaws



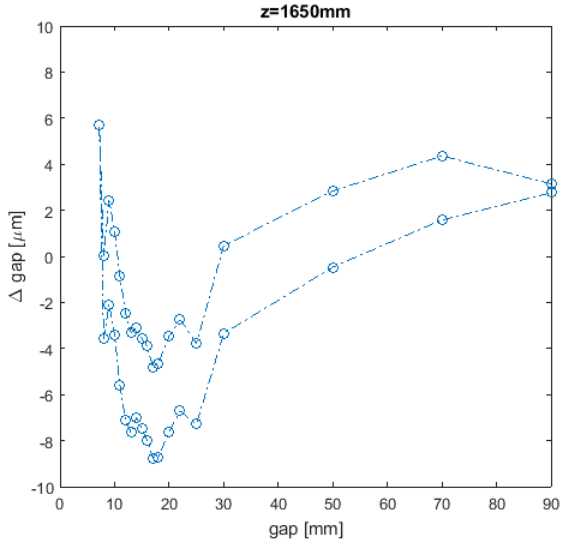
The roll was measured simultaneous with two autocollimators, each

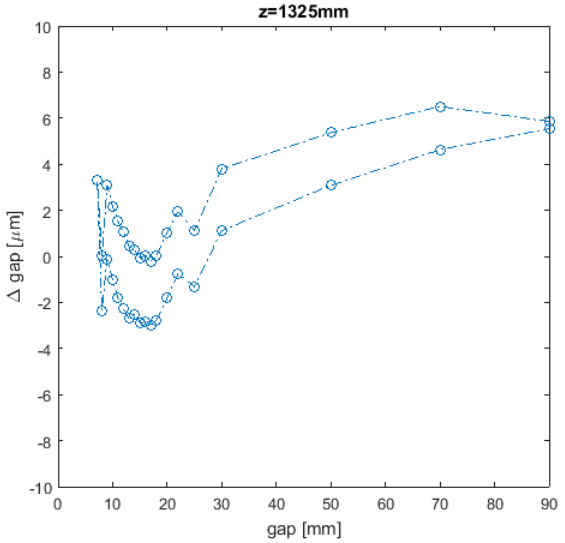


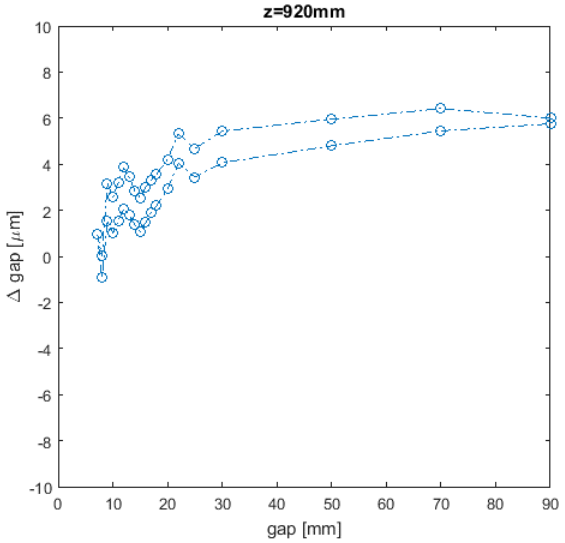
Gap change at different z locations – Setup

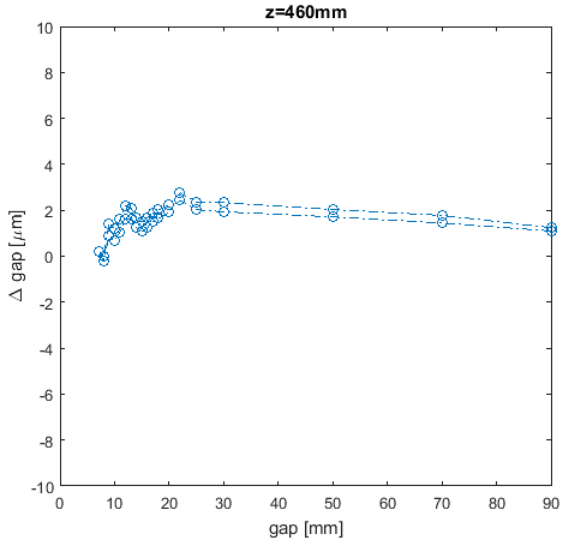


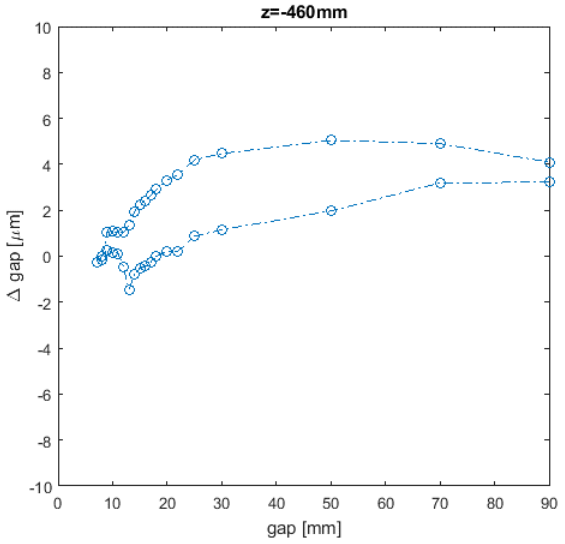
Gap change at different z locations – Results

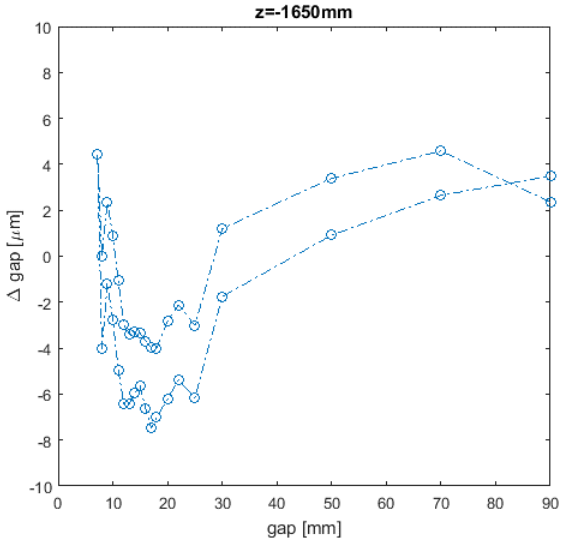




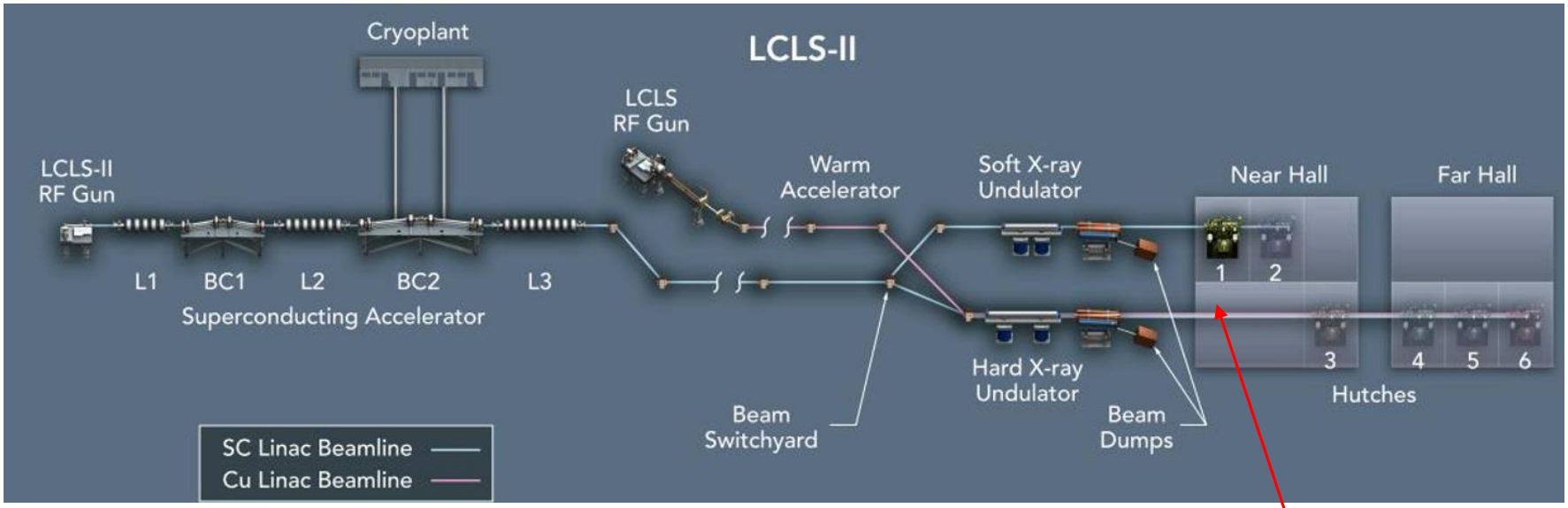








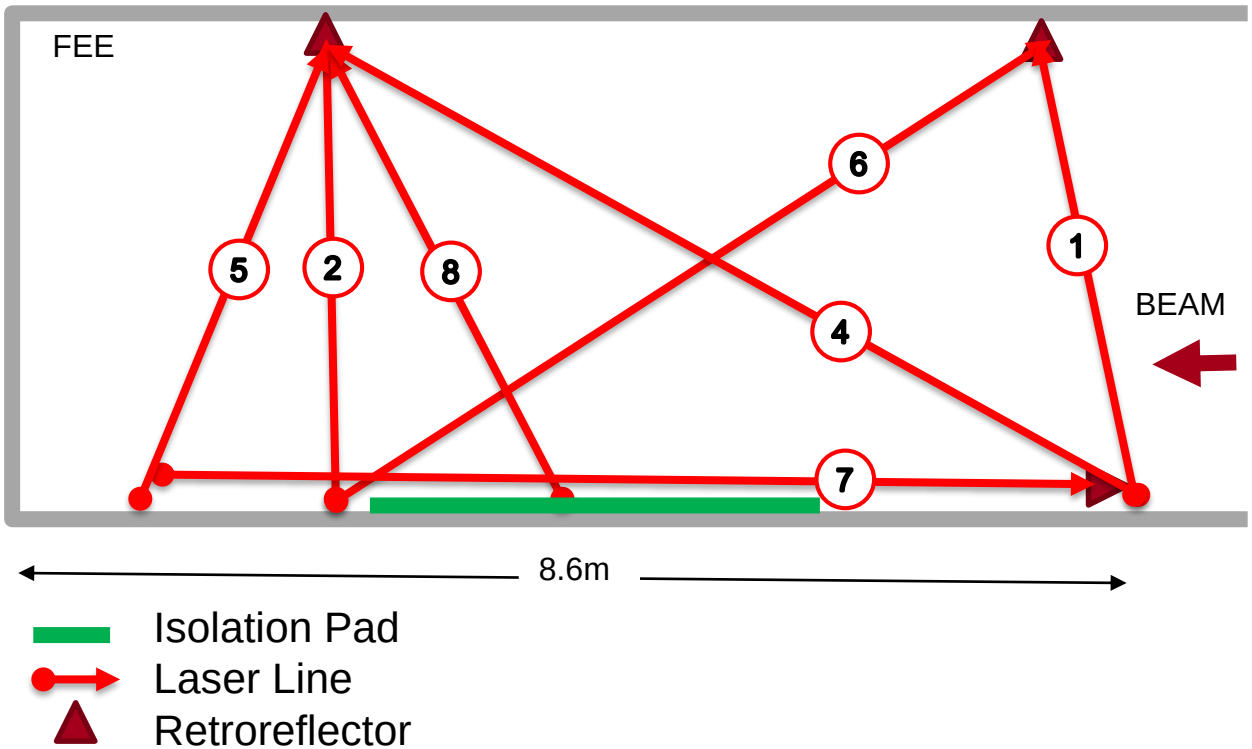
Alignment Activities – Gun Laser Alignment



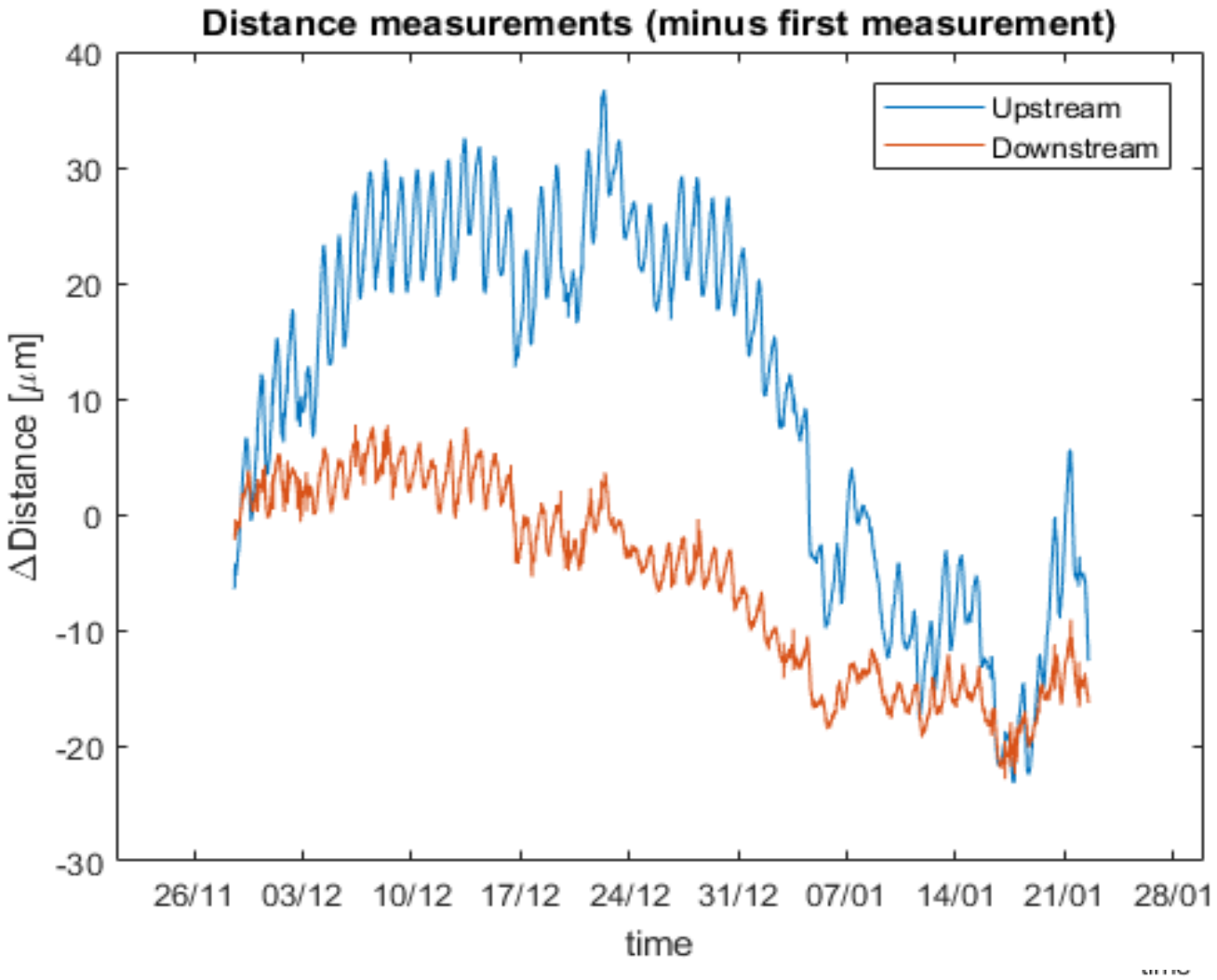
Floor stability measurements

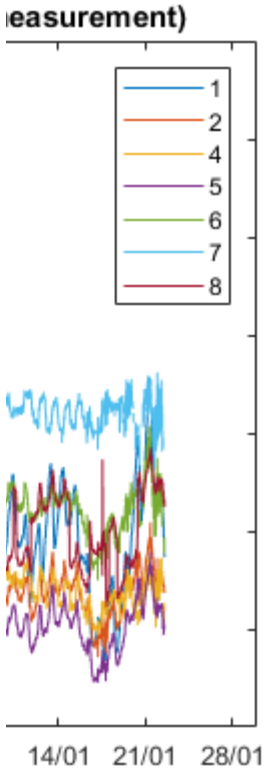
NEH Floor Movements

To get an idea of the expected magnitude of movements for the new L2Si installation we monitored several distances at the last few meters in the FEE with an FSI system (Etalon Multiline)



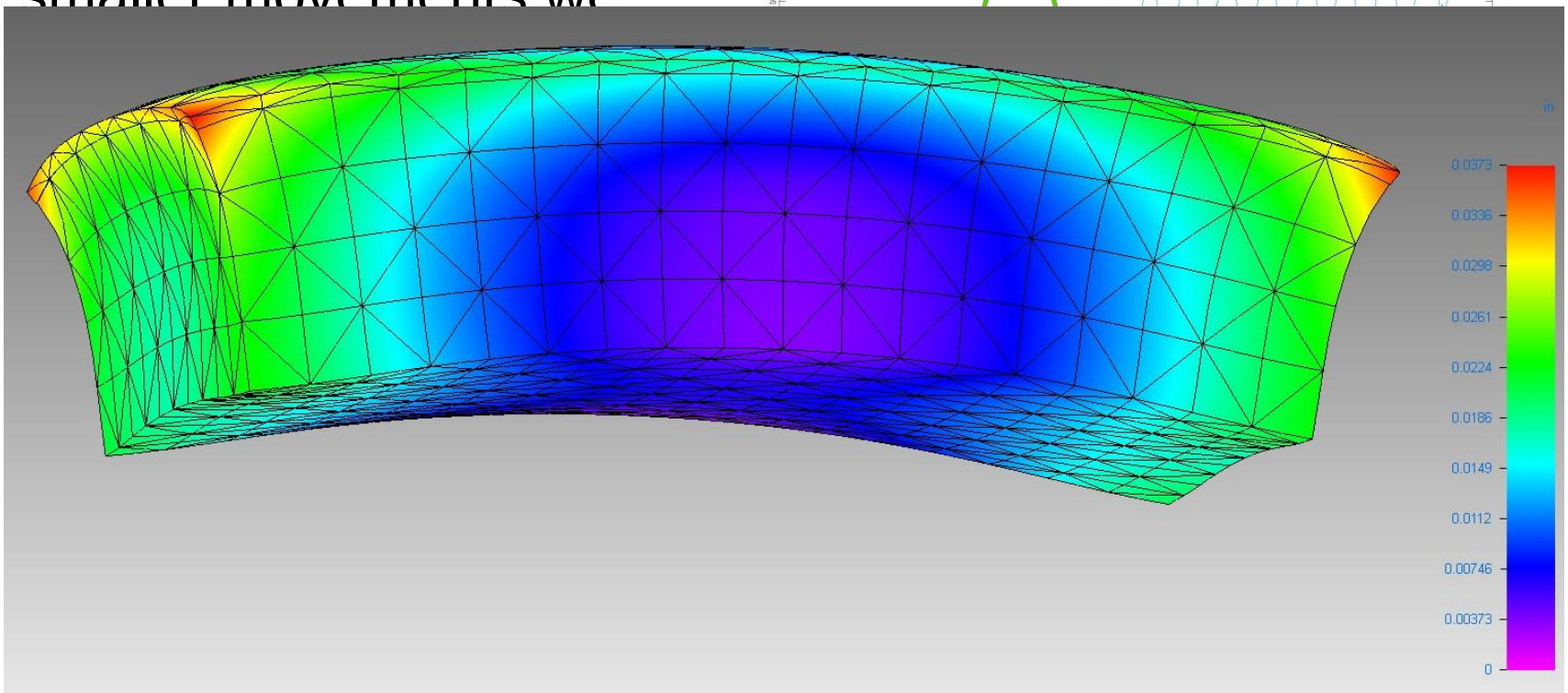
NEH Floor Movements





Movement Correlated to Outside Temperature

Looking at the days with smaller movements we



Michael Holmes

Summary

Preparation work for the LCLS-II project has been completed. We have a reference network and we have started installation.

Ahead of us is a busy year with the installation completed by the end of Q4 2019 for the warm sections and the undulator. Super conducting Linac completed by Q3 2020.

The Cu Linac is scheduled to restart Q1 2020.

First Light for SC Linac is scheduled Q2 2021.