Optics@LCLS

New HOMS *The very big*
NanoX *The very small*

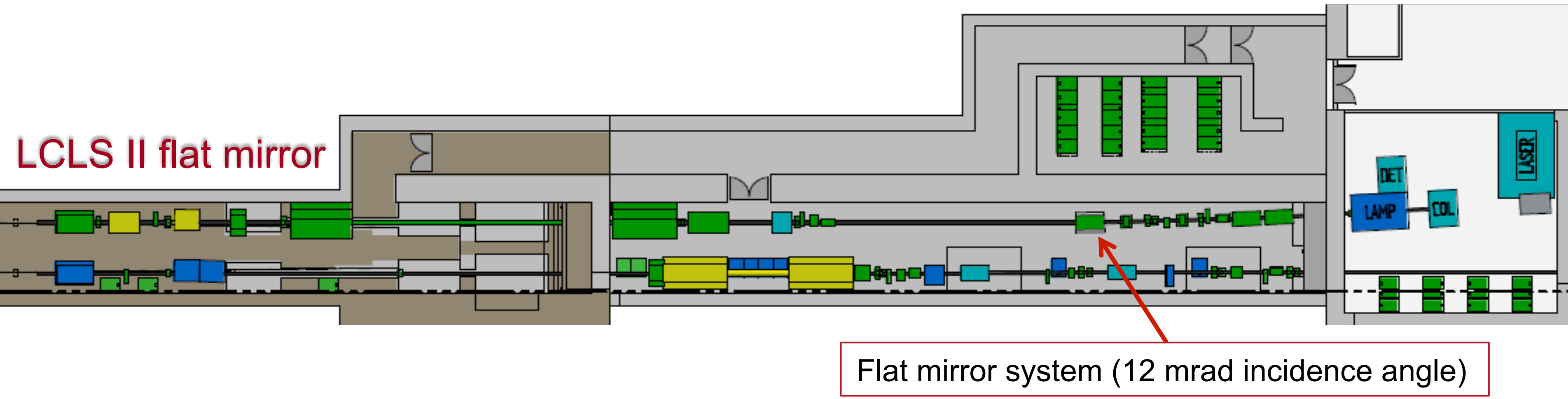
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

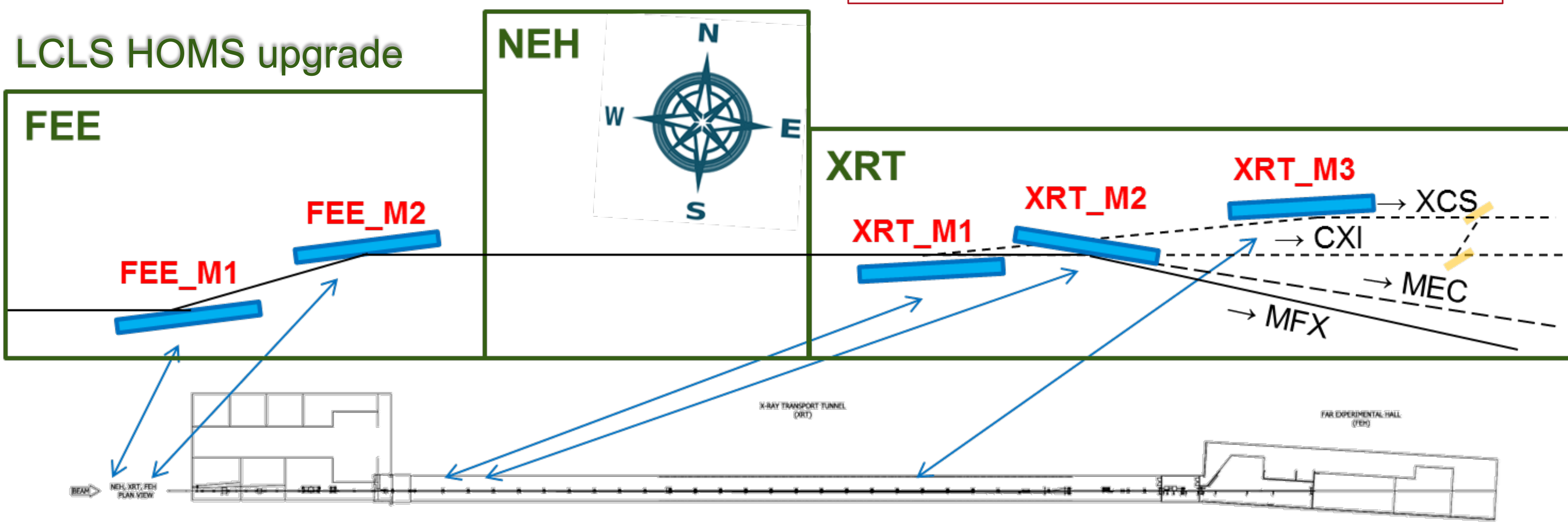
Mirror upgrades for LCLS and LCLS-II

SLAC

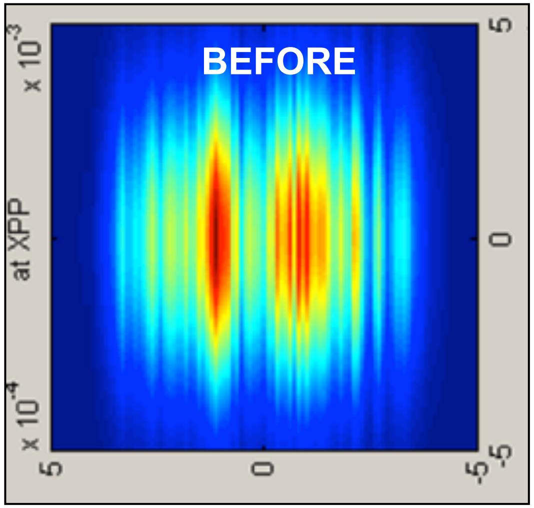
LCLS II flat mirror

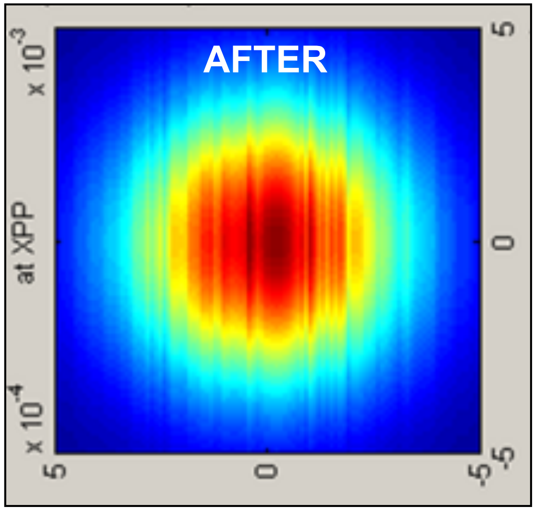


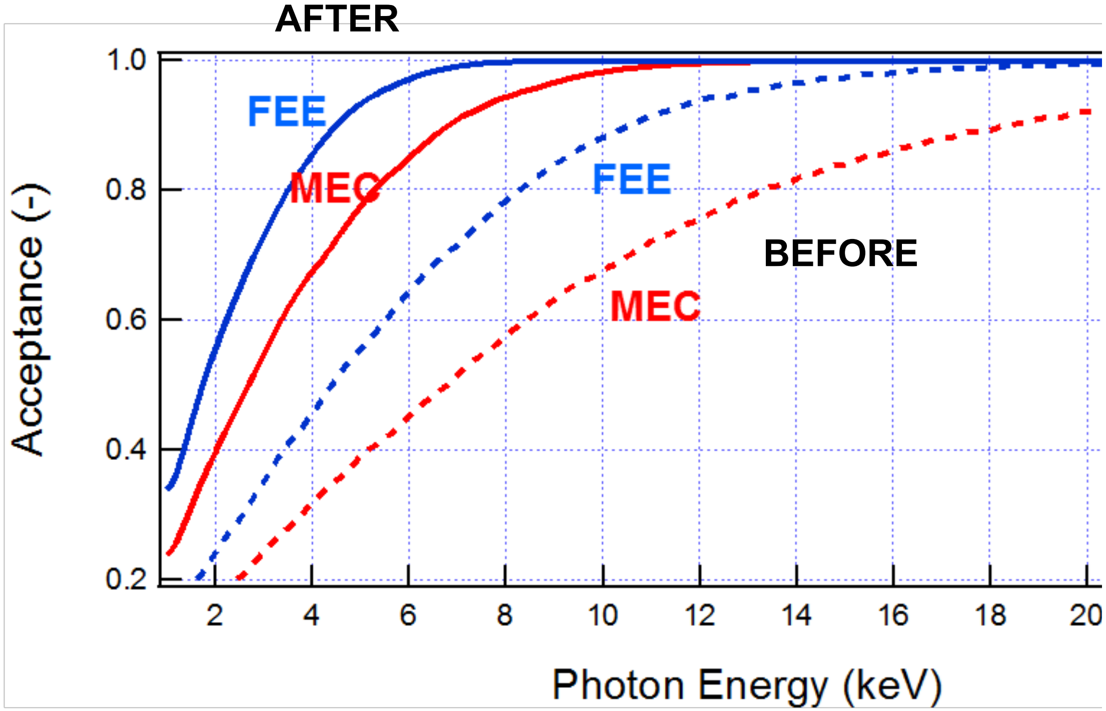
LCLS HOMS upgrade



X-ray mirror upgrade motivation

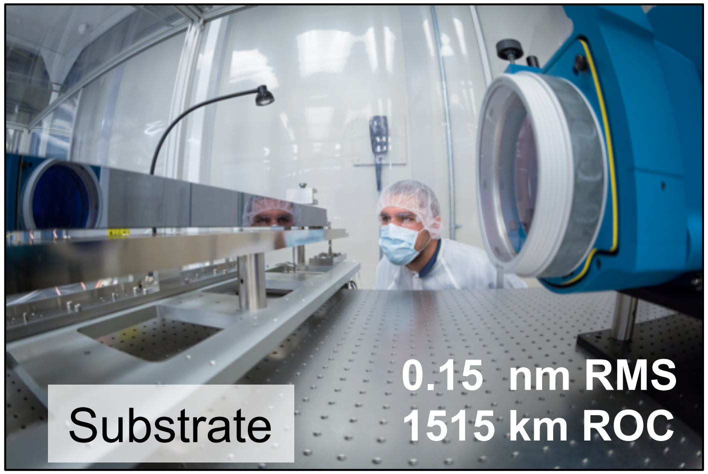


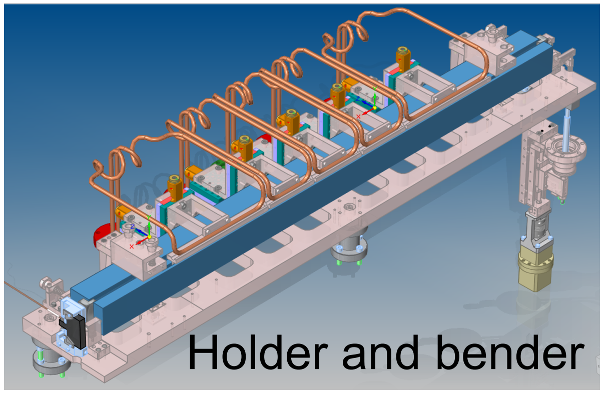




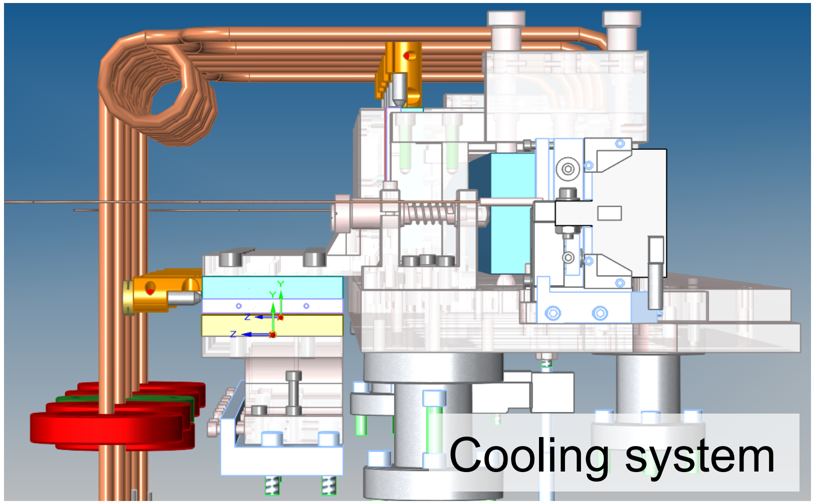
- **Substantial improvement in HXR near-field quality & overall beam transport efficiency**

Mirror system overview

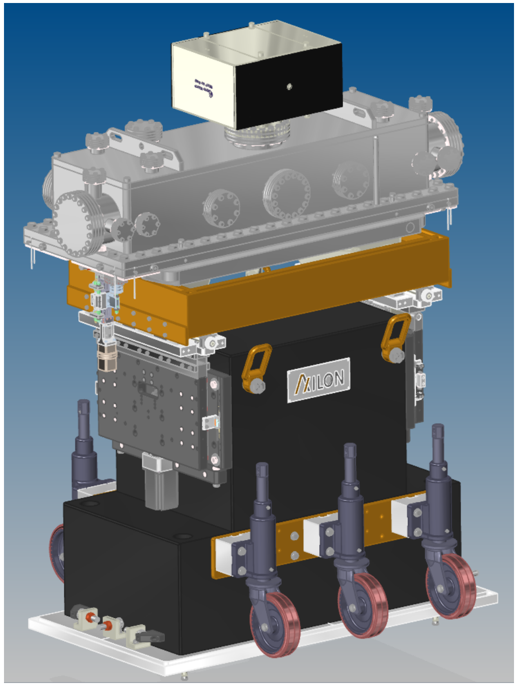




"Distortion Free" substrate mount

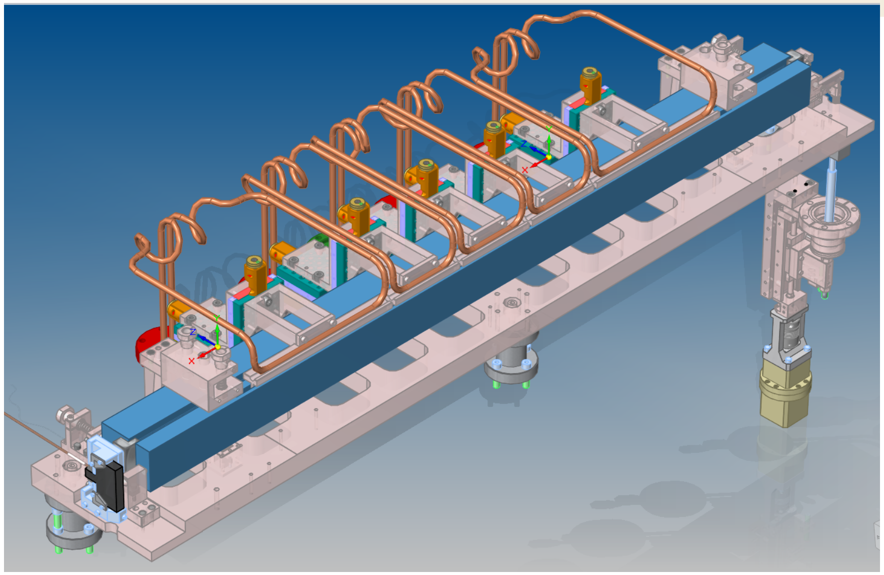


Multi-circuit cooling system - designed, assembled and tested in house

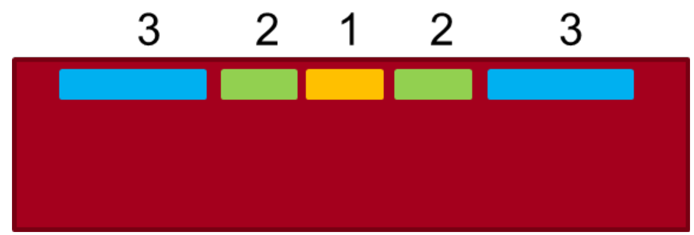


Vacuum and high precision support/motion system built to specification by external vendor

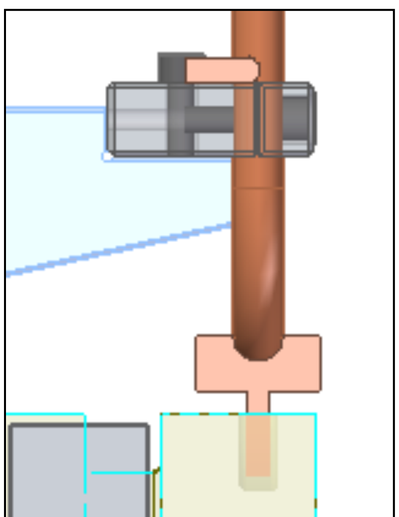
Multi-circuit cooling scheme



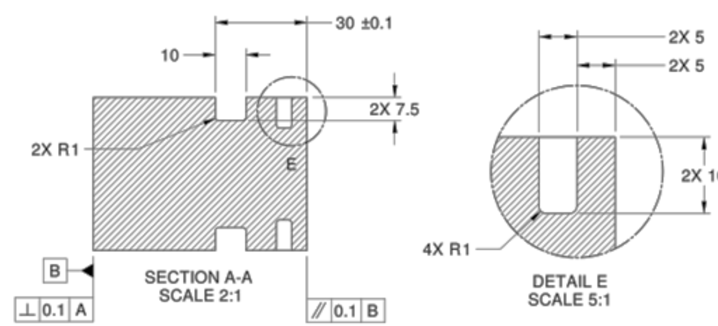
Five cooling circuits (3 lengths) are used to best match the FWHM beam footprint for the full energy range



Energy Range (eV)	Cooling Footprint (mm)
< 400	700
~ 400 – ~ 800	300
> 700	100

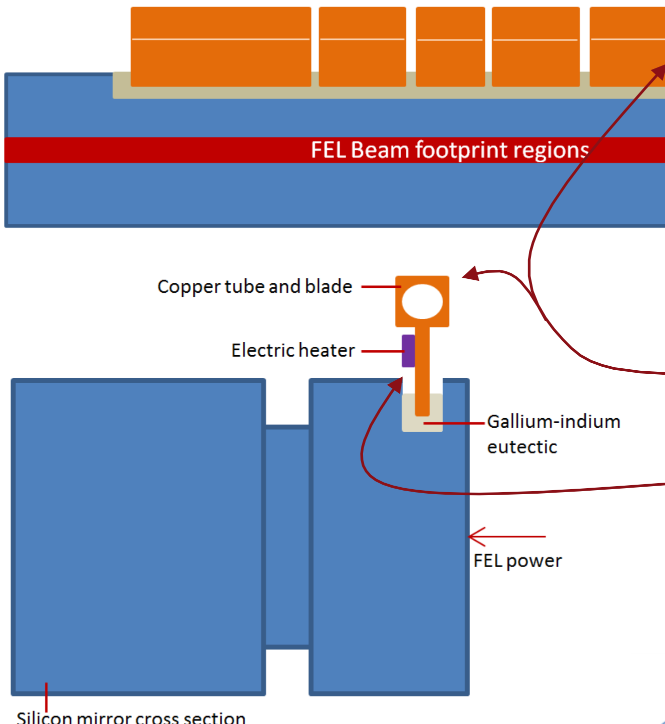


The mirror is cooled from one side through a GaIn eutectic filled trough 5 mm from the optic surface. An additional notch is added 20 mm from the surface to minimize the thermal bump and provide mounting features.

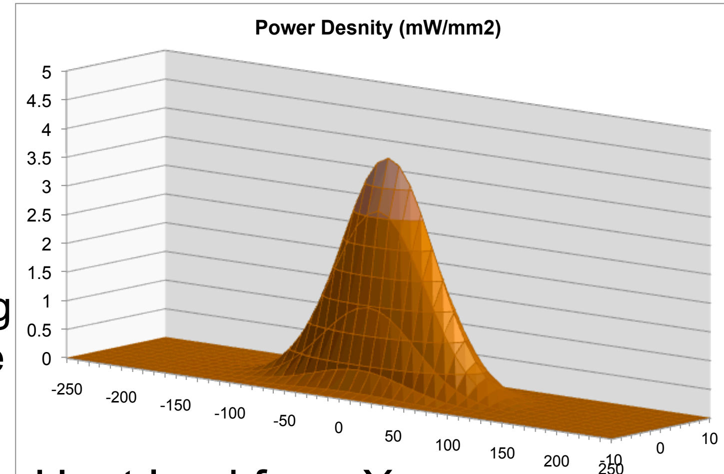


Future development:
REAL (Resistive Element Adjustable Length) Cooled Optics

Project funded by BES over two years

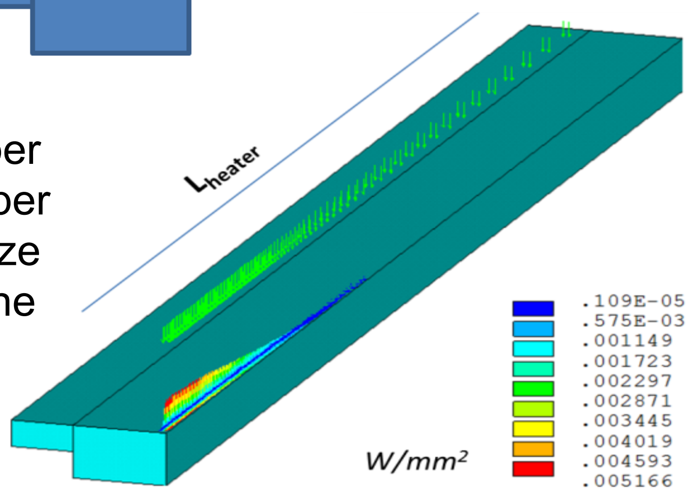


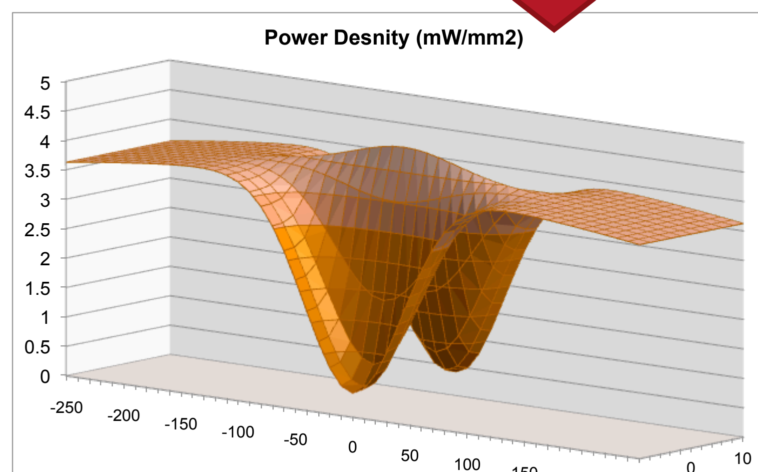
1) Add to the existing fins, used to cool the mirror, some resistive heaters



Heat load from X-ray

2) Apply the proper power to the proper heaters to equalize deformation on the mirror

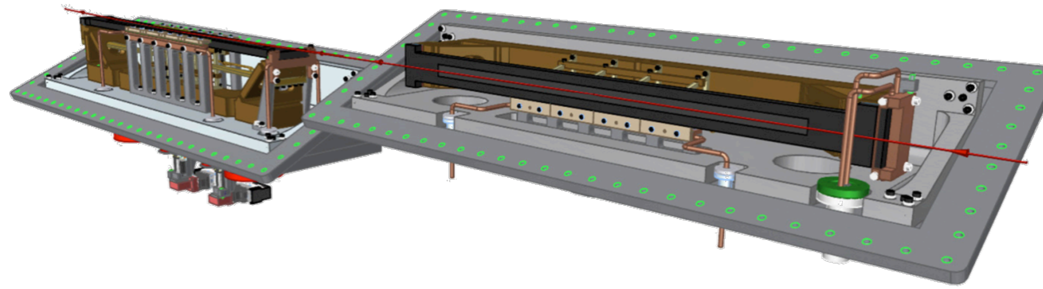


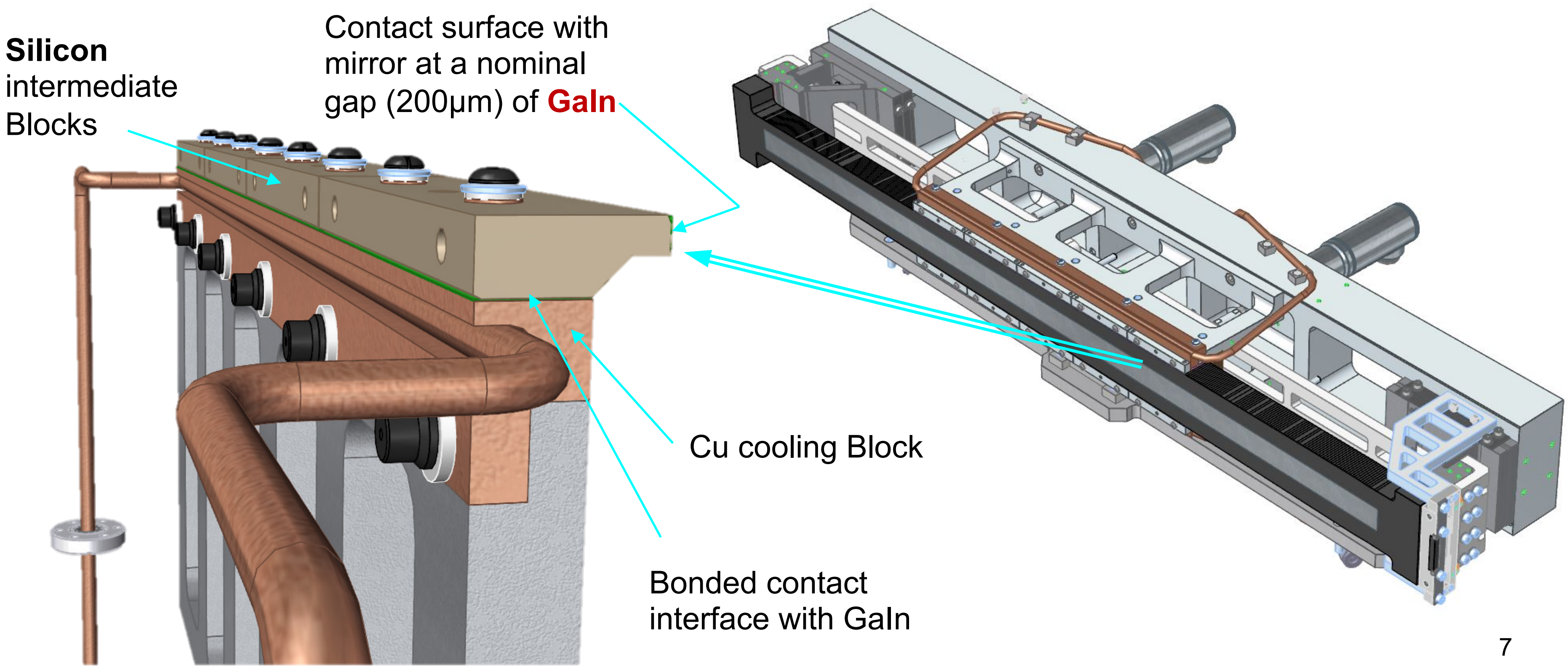


Combined power load

Cooled KB mirrors with dynamic bending

- **Flexure based optic mount applies unequal moments at the mirror ends to go from flat to the required ellipse(s).**
- **Substrate is "side-cooled" through GaIn interface**





Characterizing

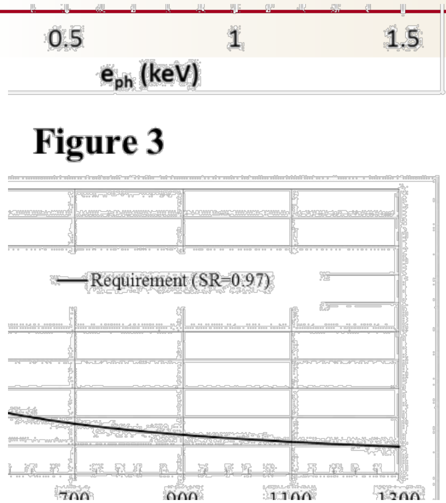
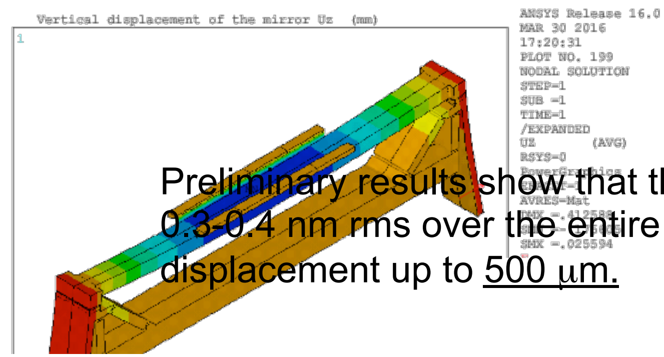
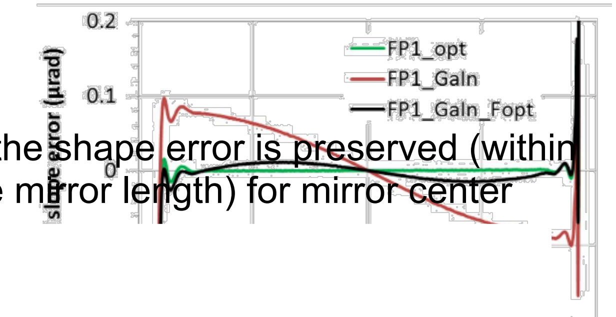


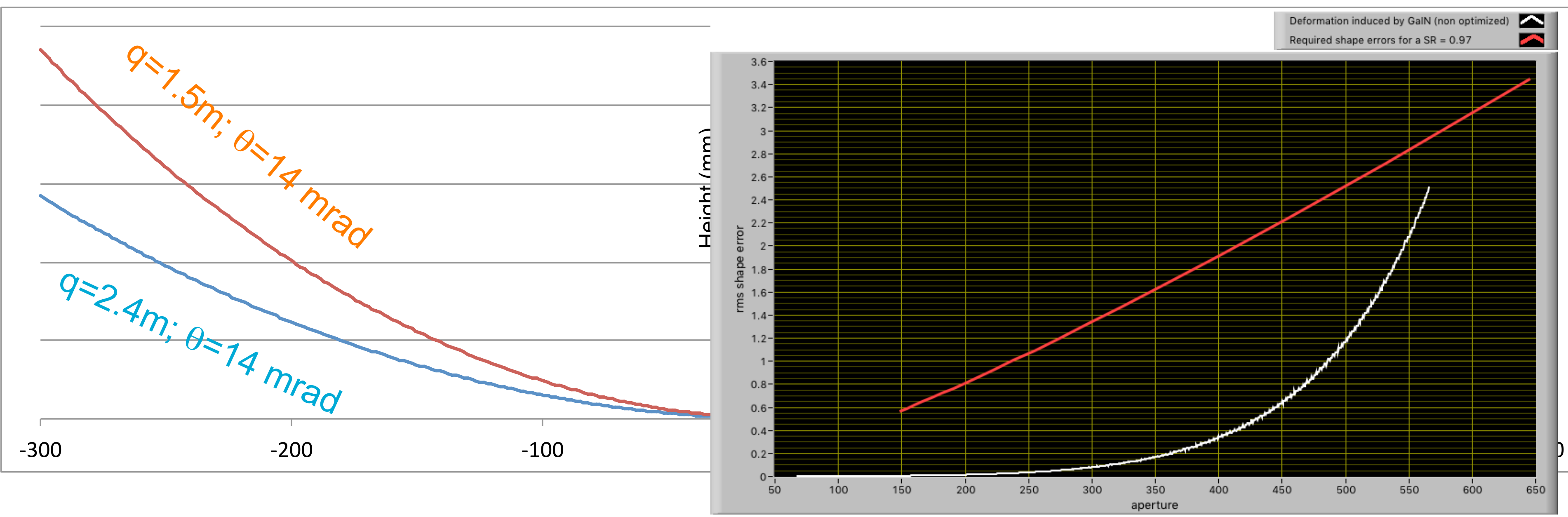
Figure 3



FEA results wit



Preliminary results show that the shape error is preserved (within 0.3-0.4 nm rms over the entire mirror length) for mirror center displacement up to 500 µm.

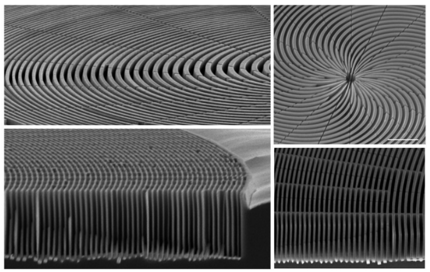


Nano-X for LCLS

Anne Sakdinawat, Georgi Dakovski, Andrew Aquila, Dan DePonte, Yiping Feng, Don Gardner, Hae Ja Lee, Yanwei Liu, Bob Nagler, Bill Schlotter, Fan Zhou, Diling Zhu

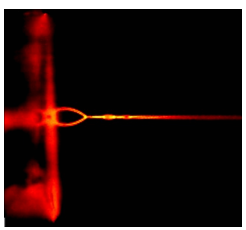
Nano-X interfaces broadly with SLAC's science programs

Nano-X draws providing a flexible environment and precision tools for new nanoscience-based solutions to serve the SLAC community.



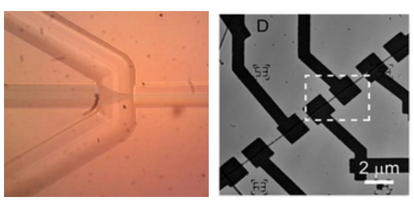
Nano-X for X-rays

Optics for spatial and temporal control of x-rays, injectors, collimators, beam metrology



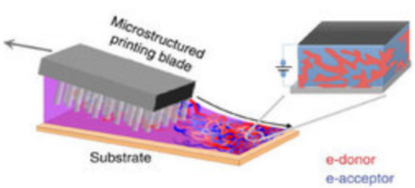
Nano-X for Biology

Injectors for single particle imaging, Optics for coherent diffractive imaging, neuroprobes, advanced optics for multi-scale imaging



Nano-X for Chemistry

On-chip *in-situ* and *in-operando* platforms for interface chemistry, advanced spectroscopy at FELs/synchrotrons



Nano-X for Materials

Theory-guided materials and nanosystems fabrication, devices and materials for energy storage and conversion

Nano-X Toolset:
Fast, Flexible Nano and Micro Fabrication

SLAC

The Nano-X Toolset is aimed towards providing SLAC's scientific community with ***rapid nano-prototyping*** capabilities.

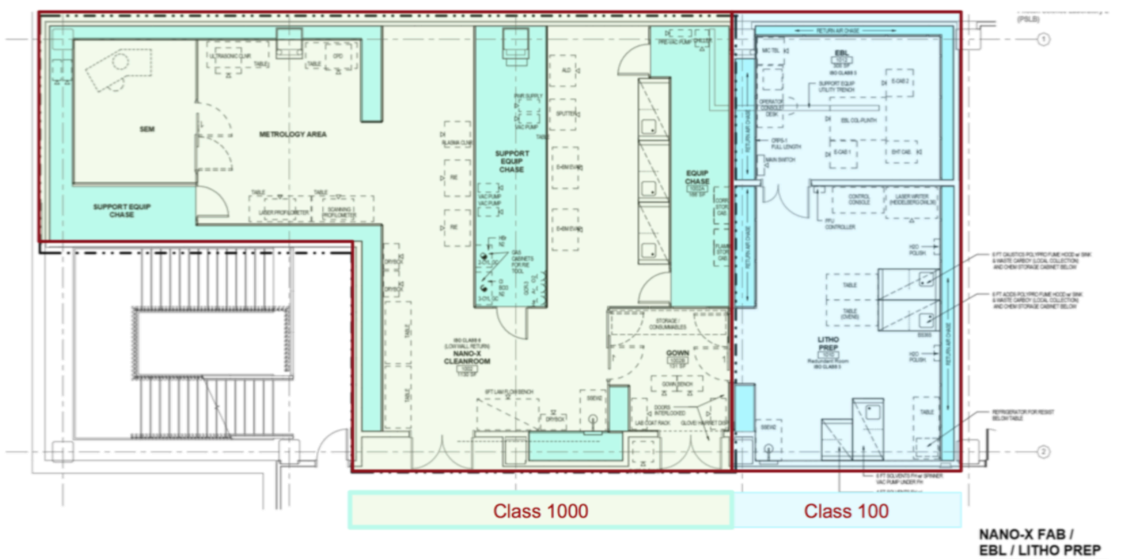
Metallization/Materials deposition: ebeam evaporation, sputtering, atomic layer deposition, electroplating, electroless plating

Lithography: direct write electron, ion and photon beam lithography systems, laser cutter, microfluidics printer

Etching: wet etching, reactive ion etching

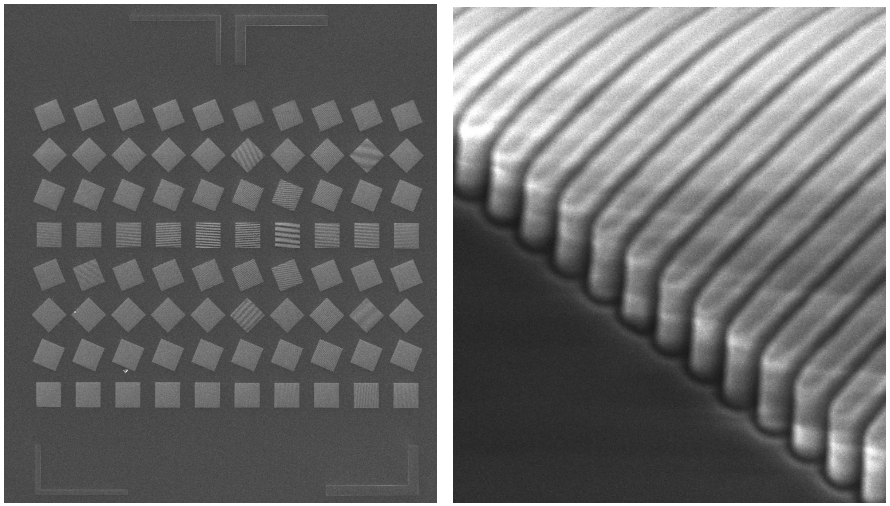
Metrology: FIB/SEM, visible light microscopy, profilometer, interferometric thin film measurement tools, ellipsometer, AFM/MIM

- Nano-X has a 3000 sq. ft. class 100/1000 facility



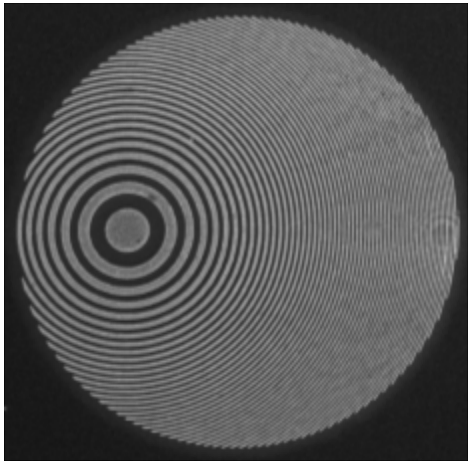
Wavefront Measurement

Ronchi Sensors

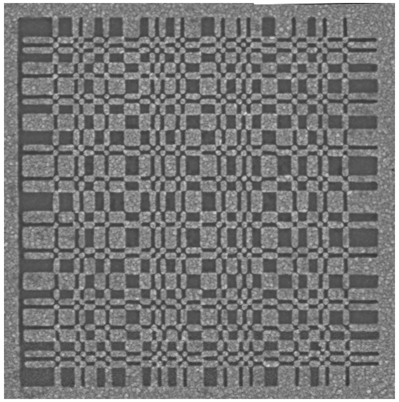


Yanwei Liu, Bob Nagler SLAC

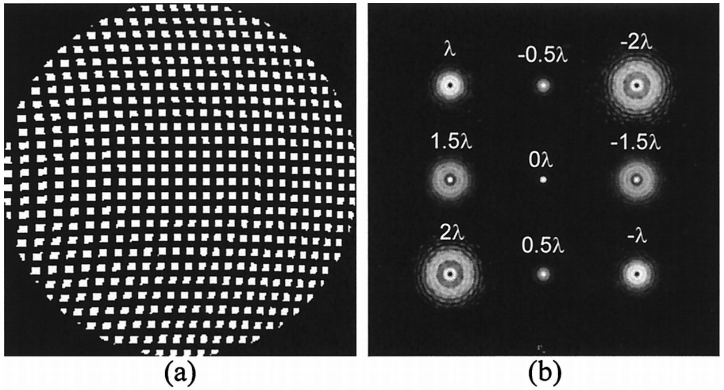
Off-axis zone plate/arrays



Holographic sensors



Multi-plane diffractive sensors

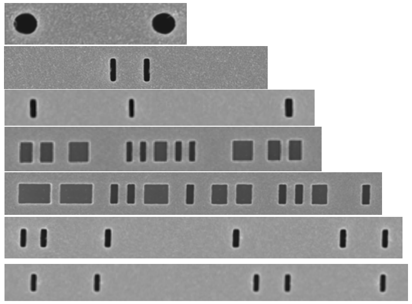


Blanchard and Greenaway, Applied Optics 1999

What optics and nanostructures will be necessary during LCLS-II instrument commissioning?

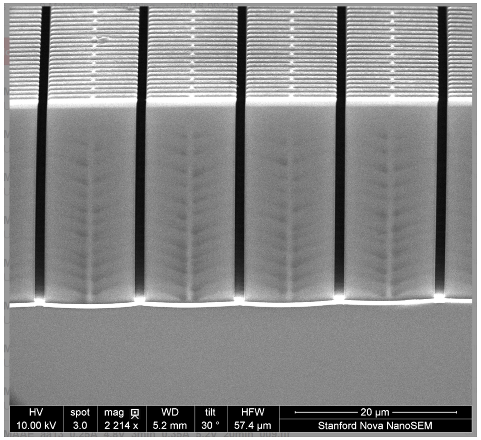
Coherence measurements

- Array of single-shot apertures
  - Pinholes and redundant arrays
- High aspect ratio fabrication methods being explored for high energies as well as reflective



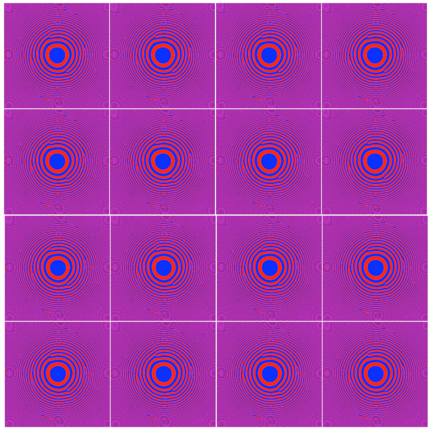
Wavefront measurements

- Toward single-shot wavefront measurement



Hartmann sensors

- High aspect ratio for tender and hard x-ray Hartmann sensors being developed



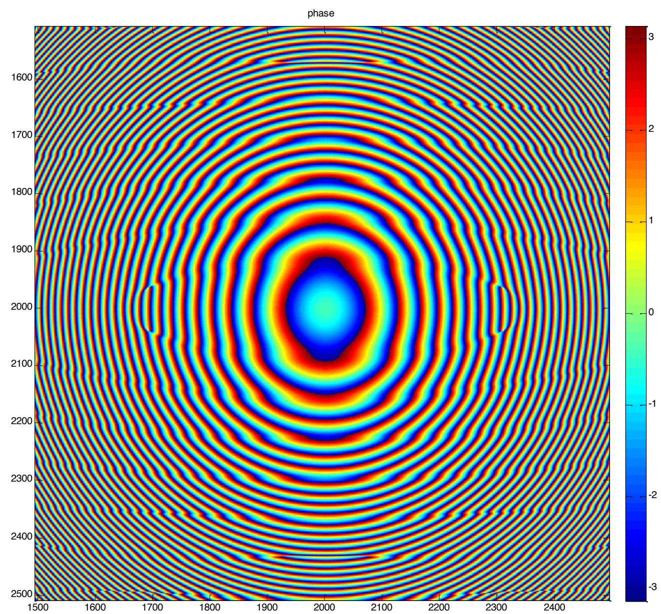
Structured Shack-Hartmann

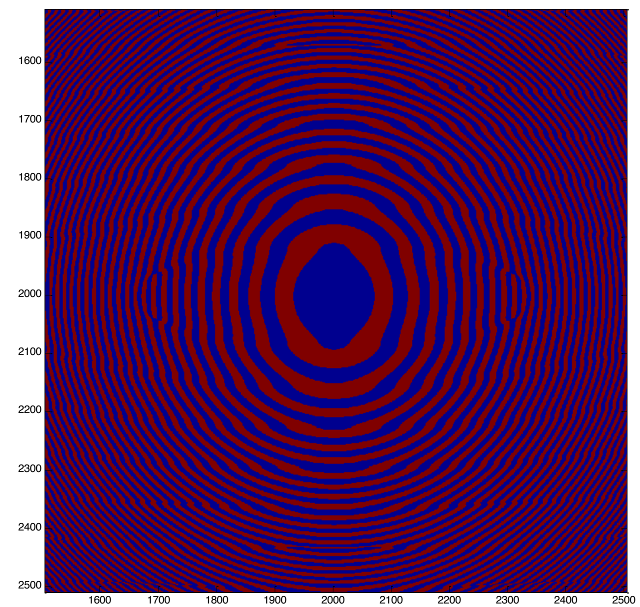
- Improvement of dynamic range, resolution

X-ray Beam Shaping Optics

SLAC

Flat-top Beam Shaper for Isochoric Heating of Samples using X-rays



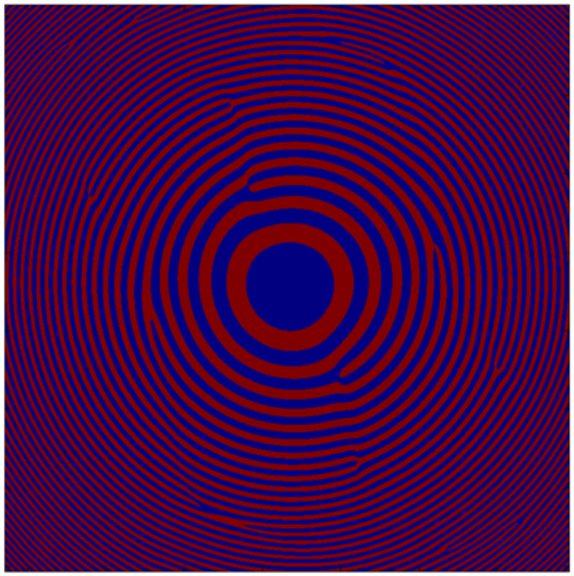


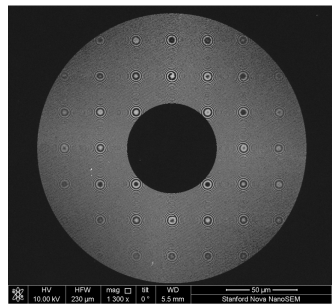
Converts Gaussian beam to Top-Hat beam

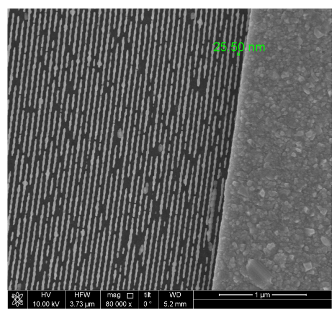
Uniform heating of a sample over its volume allows for comparison with theoretical models that assume a single temperature and density throughout the material.

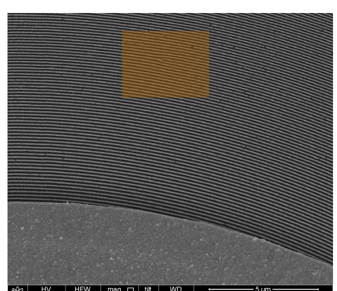
Optics for Imaging and Interferometry

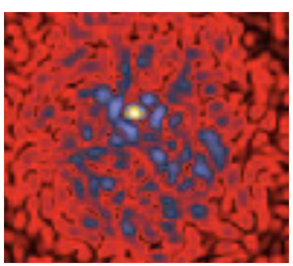
Structured illumination beam shaper for coherent imaging methods





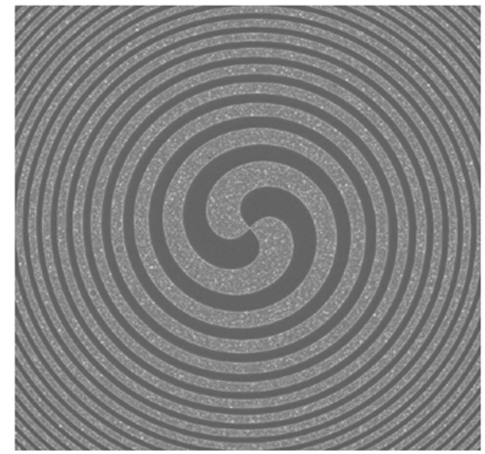


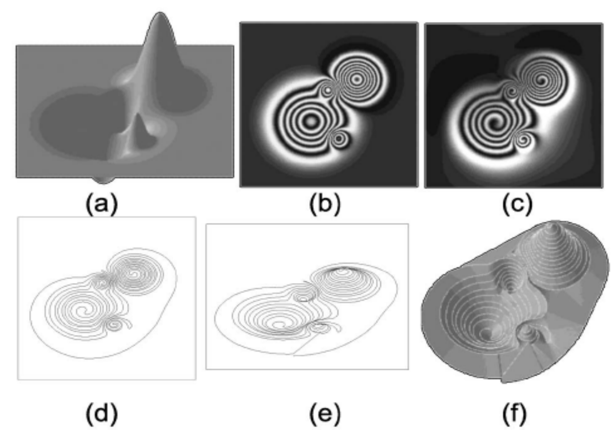




X-ray focal spot @ 800 eV

Spiral Interferometry





Furhapter, et.al. Opt. Lett. 2005

In collaboration with Stefano Marchesini, LBL

Possible Collaboration Topics

SLAC

- Diffractive “concentrators” for arrival time diagnostics and spectrometers
- Soft x-ray XAS with diffractive optics
- Diffractive optical elements to generate orbital polarized beams…..diagnostics???
- Wavefront sensor development…invasive and non-invasive.
- *In situ* cleaning methods for optical surfaces

END