APS-U FORUM MEETING

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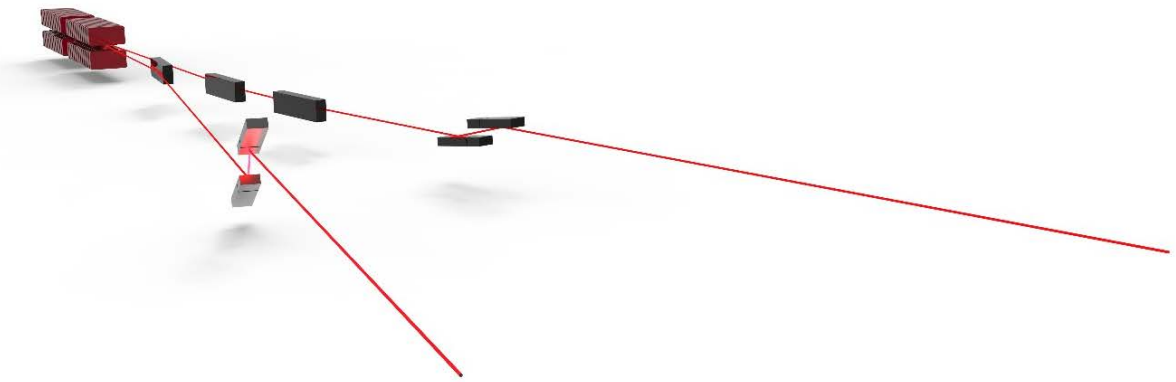
THERMAL ANALYSIS OF HIGH HEAT LOAD MIRRORS FOR ISN BEAMLINE



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APS-U FEATURE BEAMLINES

	Undulator	WB mirror	Monochromator
3Dnano	2.1 m planar 2.7 or 2.8	Yes, H	DCM, H or V
Atomic	2.1 m revolver 2.5/2.1	Yes, H	DCM/DMM, H
CHEX	Cant (1.2 m SCU 1.85, 1.65)	no	Diamond SBM, DCM
CSSI	4.6 m revolver 2.5/2.1, or planar 2.7	Yes, H	DCM&DMM
HEXM	(1.75 m SCU1.65) X2	no	Bent DLM, H
ISN	4.6 m revolver 2.5/2.1	Yes, V, two	DCM/DMM
Polar	(1.8 m SCAPE SCU 3.1) X2	no	DCM, H
Ptycho	4.6 m revolver 2.5/2.1	Yes, H	DCM, H
XPCS	4.6 m revolver 2.5/2.1 or HGVPU 2.7	Yes, H, two	DCM/DMM, H

IN-SITU NANOPROBE

APS-U FEATURE BEAMLINE

- The In-Situ nanoprobe (ISN) beamline delivers highest-resolution imaging, spectroscopy, and tomography of energy materials and energy devices, as well as of other complex, hierarchical systems under in-situ and operando conditions.

- The ISN beamline will provide a spot size as small as 20 nm using reflective optics.

- Approximately 220 m long

- Currently planned to be located at Sector 19.

- 5 – 30 keV

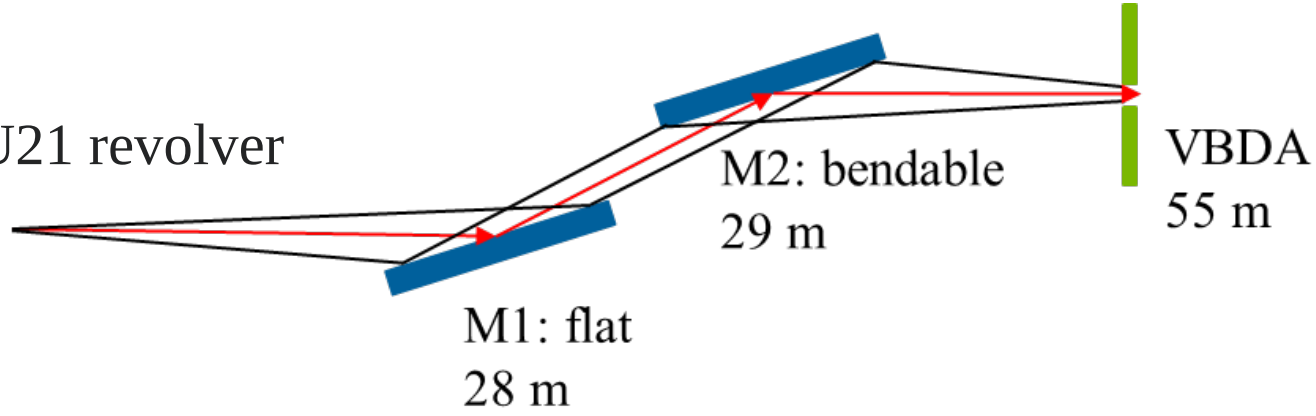
- Two Mirrors as first optics for Harmonic Rejection and bouncing back the beam. Will focus to a BDA.

CORRECTING FOR THERMAL BUMP

- The thermal bump on both M1 and M2 can be corrected by bending M2. Due to the near 1:1 demagnification, bending M2 to a spherical cylinder is sufficient. The angle of M2 will need to be changed by small amounts accordingly to compensate for the vertical displacement.

- The heat load absorbed in M1 and M2 was calculated using SRCalc for Si coated mirrors. The insertion device, 25 mm period and 4.6 m long, was tuned to different energies (5-12 keV).

ISN BEAMLINE

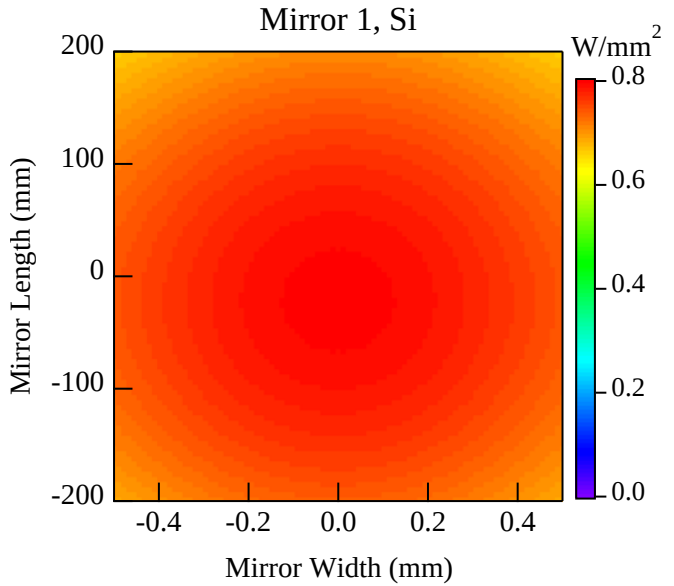


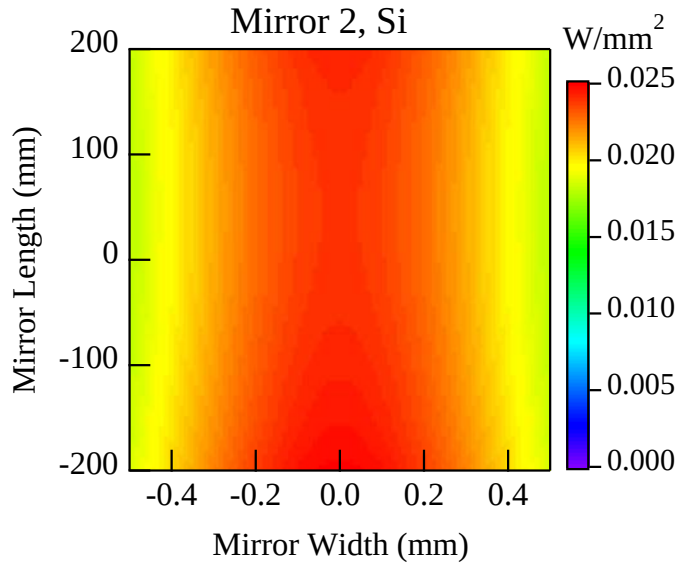
5 keV

M1

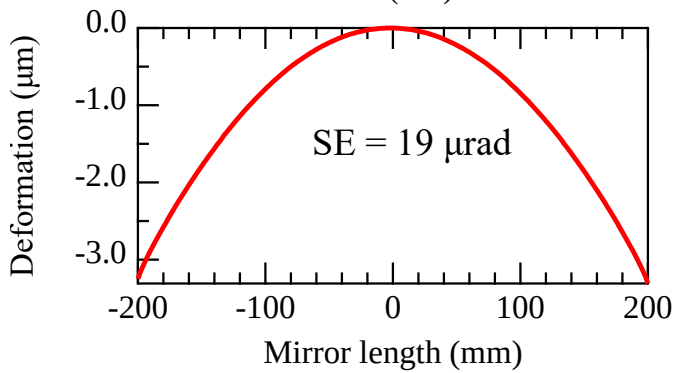
M2

Absorbed power





Deformation



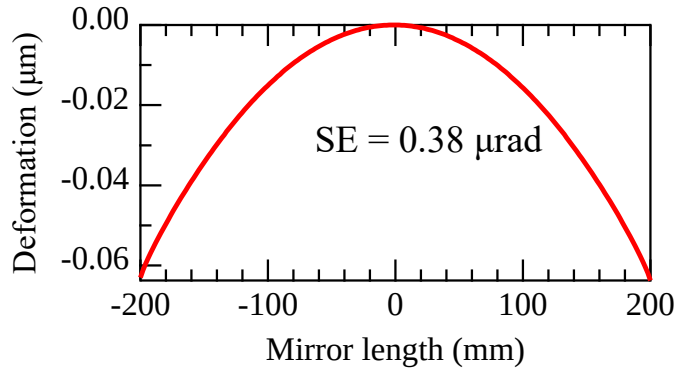


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Table 1. Result summary for fixed energy operation

Photon energy	5 keV	6 keV	7 keV	8 keV	9 keV	10 keV	11 keV	12 keV
K_y for undulator U25	1.862	1.599	1.381	1.191	1.019	0.857	0.697	0.528
Total power absorbed by M1 (W)	429	329	260	190	130	80.9	44.2	20.3
Total power absorbed by M2 (W)	10.6	7.58	9.06	6.96	6.23	5.85	5.73	5.79
Focal size at BDA without deformation (μm), FWHM	16.6	15.4	14.4	13.6	13.0	12.5	12.0	11.6
M2 radius to focus at BDA without deformation (km)				11.0				
Focal size at BDA with deformation[1] (μm), FWHM	1129	809	589	398	257	155	84	47
Virtual source position relative to BDA[2] (m)	-39.9	-47.6	-60.3	-113.9	156.1	32.8	12.1	5.6
Corrected M2 radius (km)	4.38	5.10	5.72	6.57	7.51	8.49	9.4	10.1
M2 angle correction (degree)	-1.4E-05	-1.1E-05	-9.0E-06	-7.0E-06	-5.0E-06	-3.0E-06	-5.0E-07	-1.1E-06
Corrected focal size at BDA (μm), FWHM	16.8	15.4	14.2	13.6	13.0	12.5	12.2	11.6

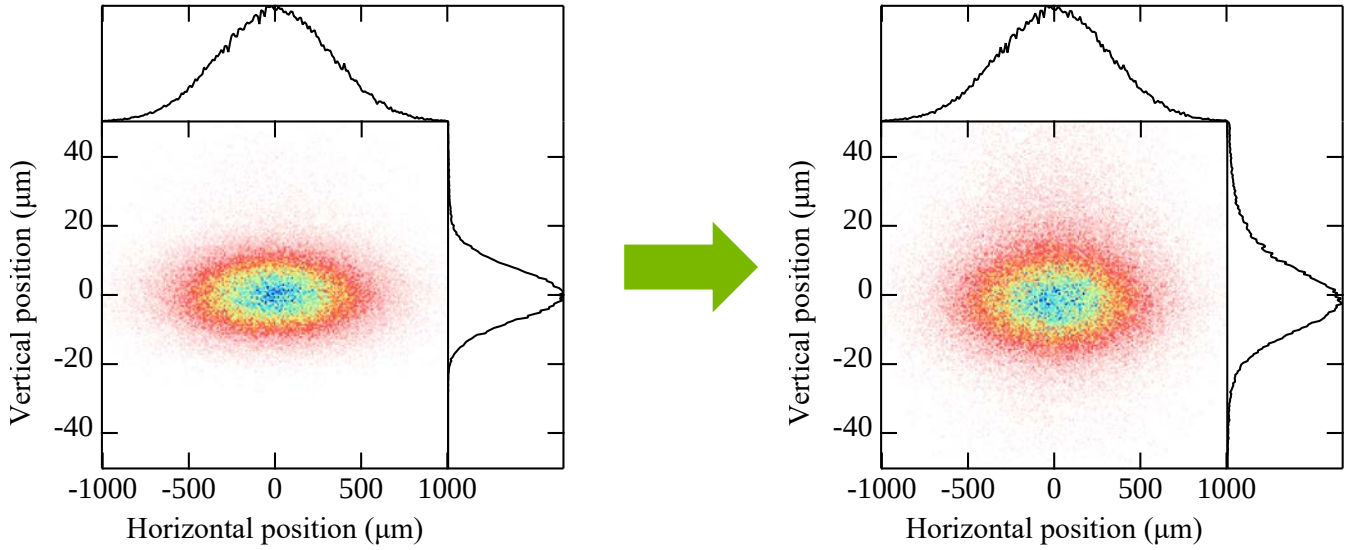
[1]M2 radius fixed at 11.0 km
[2]Positive means downstream

The thermal bump on both M1 and M2 can be corrected by bending M2. Due to the near 1:1 demagnification, bending M2 to a spherical cylinder is sufficient.

Table 2. Result summary for energy scan with undulator at 5 keV

Photon energy	5 keV	5.1 keV (no correction on M2)
K_y for undulator U25	1.862	1.833
Total power absorbed by M1 (W)	429	418
Total power absorbed by M2 (W)	10.6	10.0
Focal size at BDA with R2 = 4.38 km optimized for 5 keV (μm), FWHM	16.8	21.0
Focal position relative to BDA (m)	0	-1.7

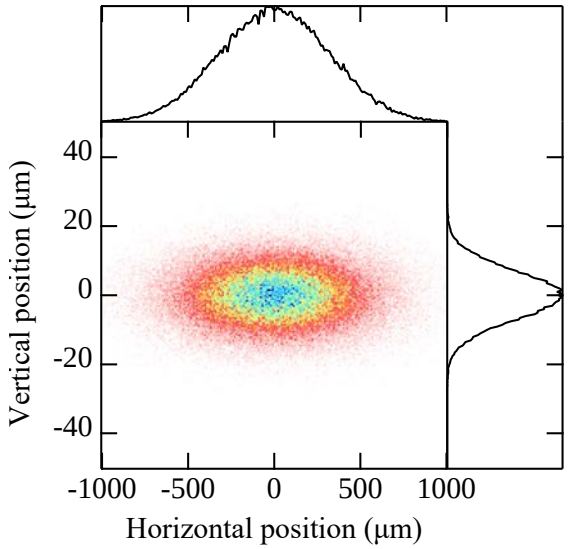
- Scan energy by 100 eV at 5 keV will result in a focal size change from 17 μm to 21 μm at the BDA position. This will lead to some flux variation at the sample, but depends on the BDA size.



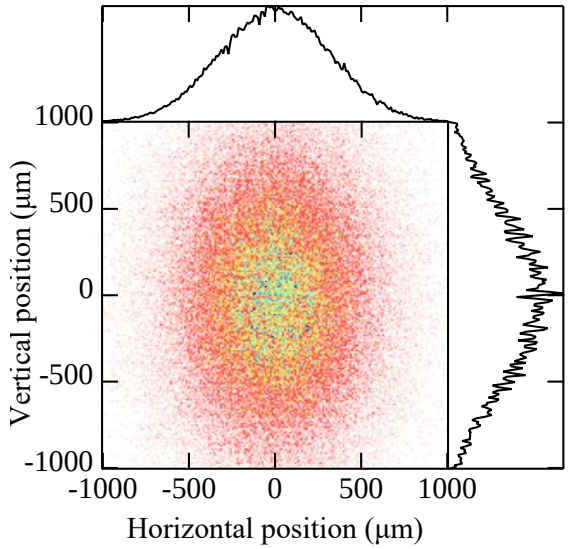
RAY-TRACING STUDY

- The ray tracings below compare the ideal focus (left) with the image obtained when the deformation on M1 and M2 are included (middle).
- The figure on the right shows the focus when the radius of M2 as been decreased from the original value (11.0 km) to the value calculated (4.38 km) from the virtual image created by the heat bumps.
- Note that the angle of M2 will need to be change by 0.24 µrad to compensate for the vertical displacement

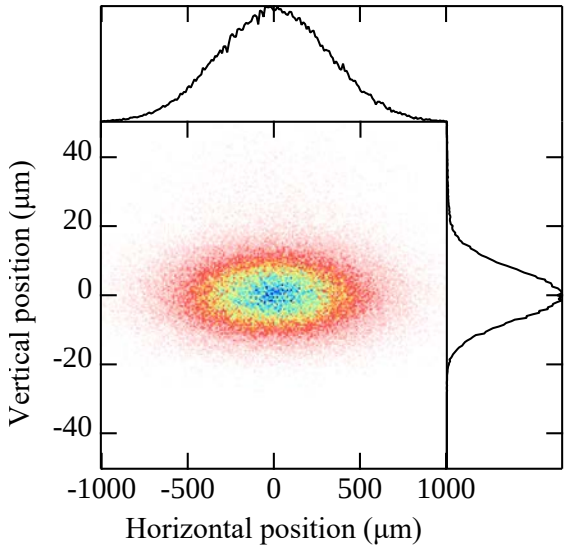
Plane M1
Cylinder M2 (R_{M2} = 11.0 km)



With thermal bump
on M1, M2



After bending correction
of M2 to R_{M2} = 4.38 km



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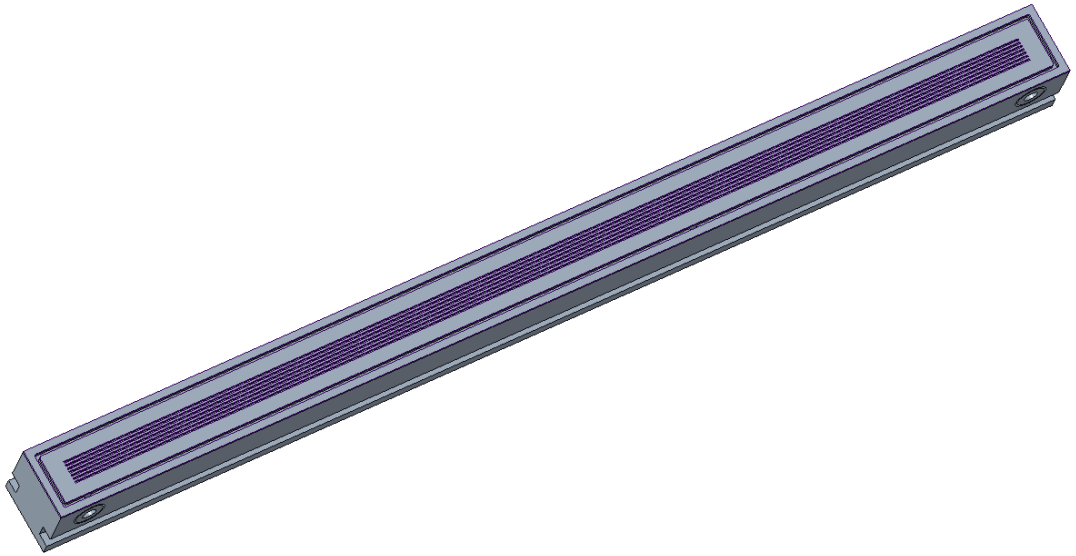
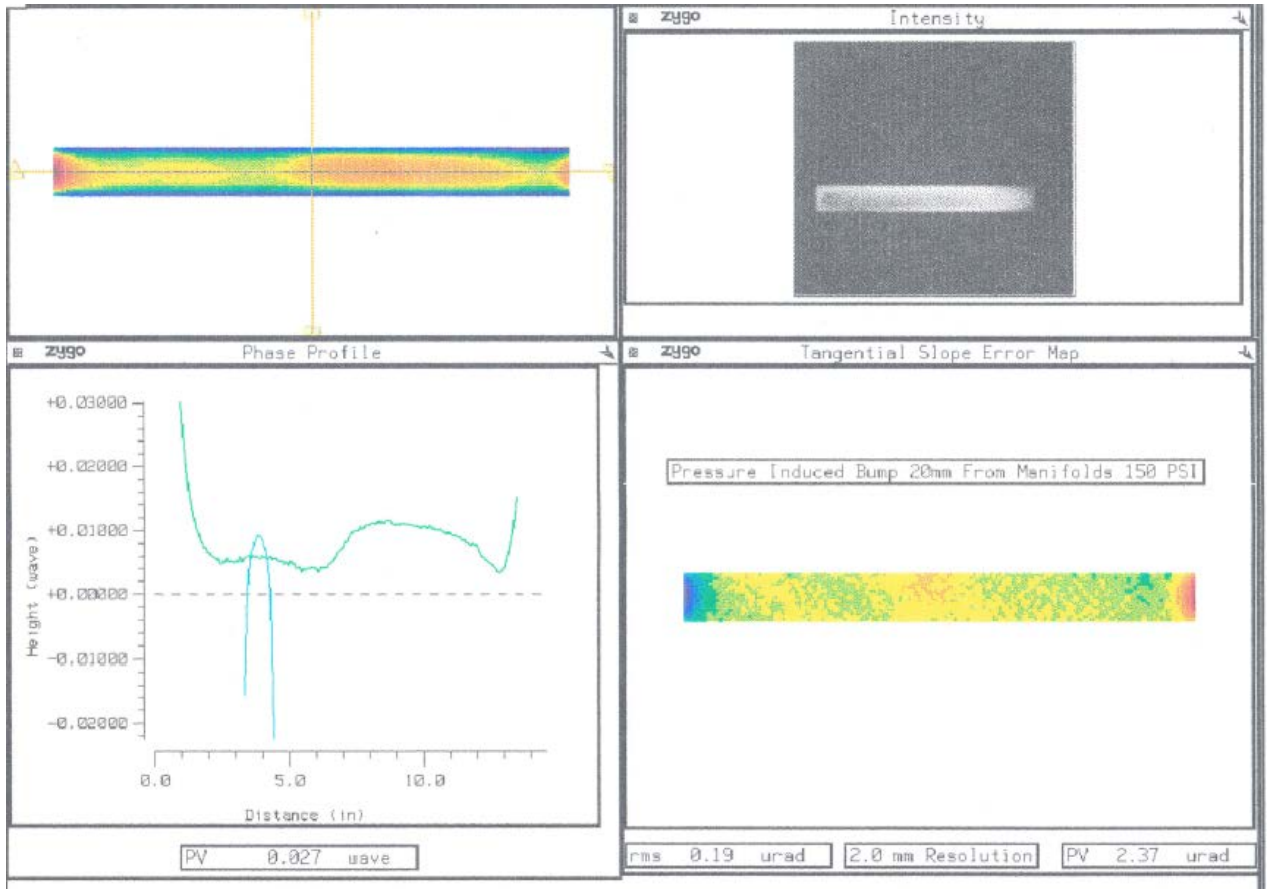
COOLING SCHEME

Internal Cooling

- InSync Internally Cooled Mirrors. No Longer Frit Bonded
- Modeled a mirror based on their drawings
- InSync provided metrology data showing the deformation due to internal pressure





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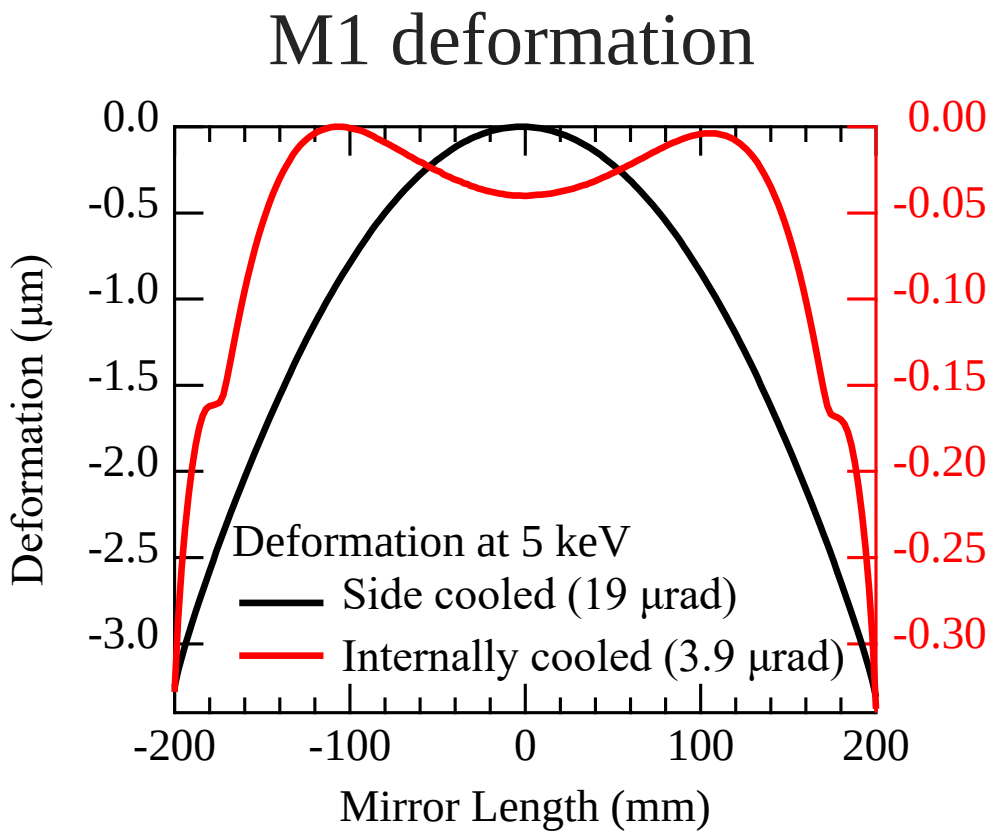
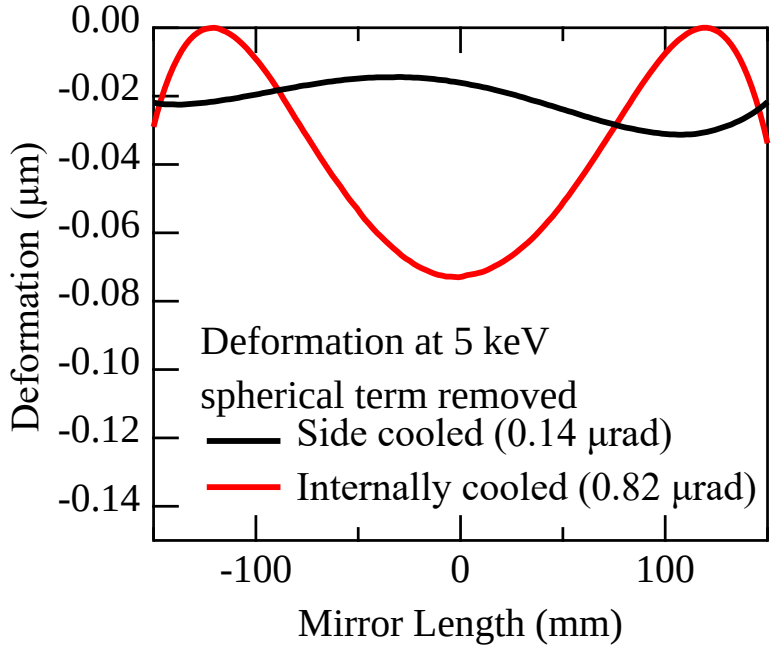
COOLING SCHEME

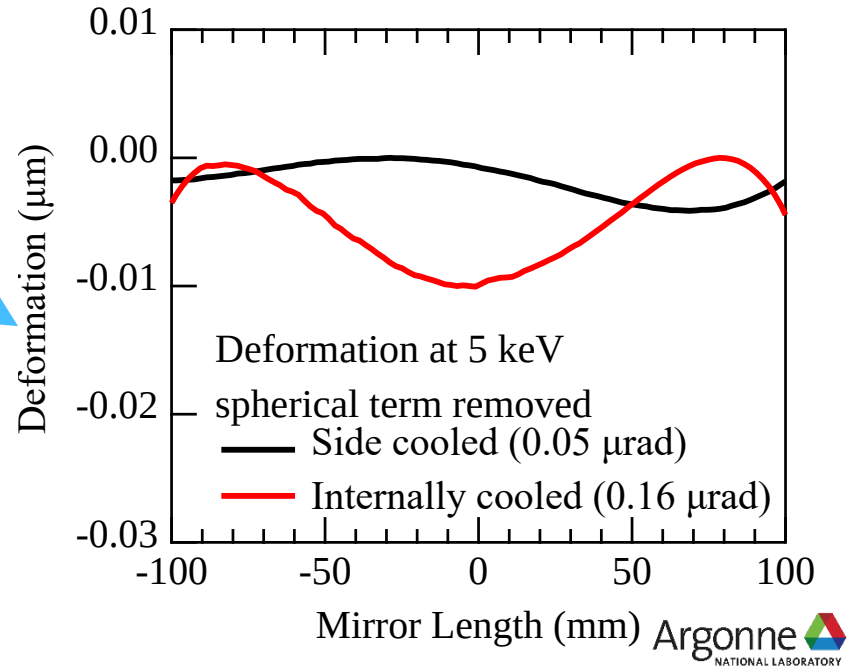
Internal Cooling



Correct 300 mm

Correct 200 mm





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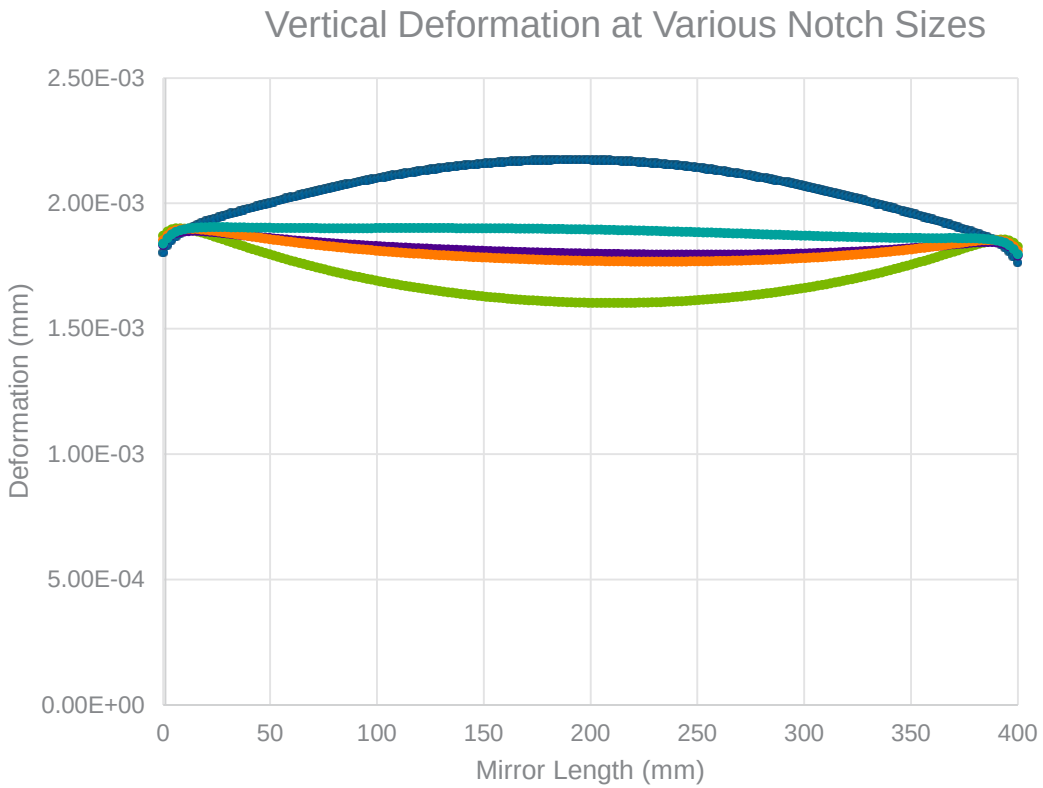
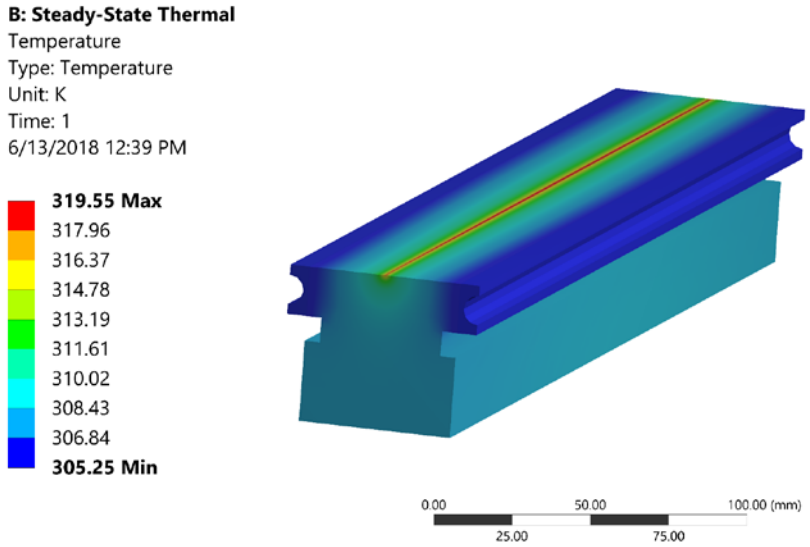
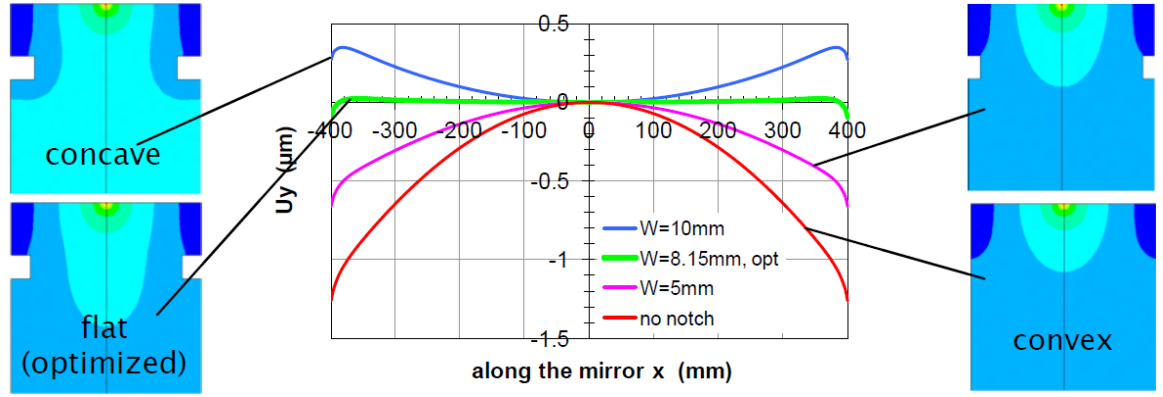
COOLING SCHEME

Side Cooled with Notch







* L. Zhang ESRF

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HIGH HEAT LOAD OPTICS WORKING GROUP

Jonathan Knopp and Xianbo Shi

- Discuss analysis and cooling schemes of Mirrors, Monos, Masks, Beamstops, etc.
- Discuss best practices for cooling and mounting optics
- Peter Eng will present next meeting on thermal considerations at Sector 13
- NEXT MEETING JUNE 20th AT 2:00 P.M.
  - B4100

THANKS! QUESTIONS?