MEDSI PARIS 2018

MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

ENGINEERING DESIGN AND COMMISSIONING PERFORMANCE OF THE ESM AND SIX SOFT X-RAY BEAMLINES AT NSLS-II

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U.S. DEPARTMENT OF ENERGY | Office of Science

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BROOKHAVEN NATIONAL LABORATORY | National Synchrotron Light Source II

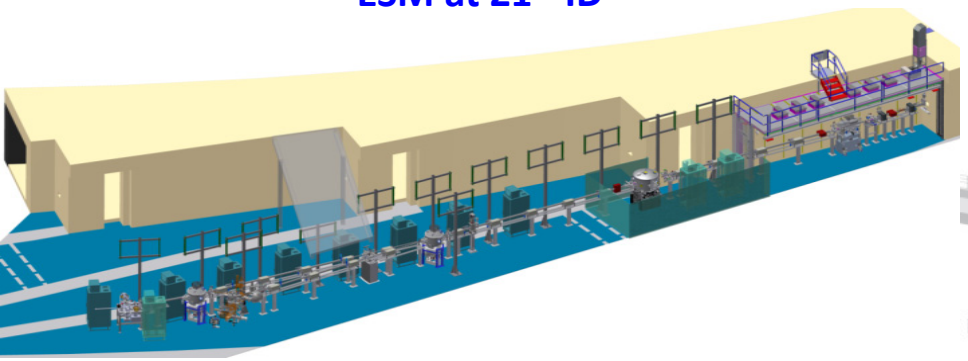
Outline

- **ESM and SIX Overview**
- **ESM and SIX Design and Implementation**
  - *Optics Engineering Design and Metrology*
  - *Thermal Cooling Scheme*
  - *Diagnostics Components Design*
- **Commissioning and Performance**
- **Conclusion**
- **Acknowledgements**

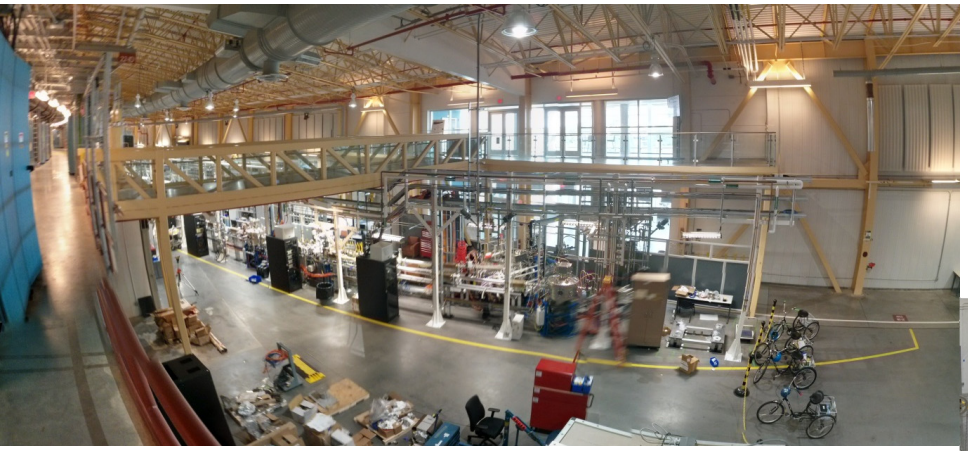
***ESM**: Electron Spectro-Microscopy beamline*
***SIX**: Soft Inelastic X-ray Scattering beamline*

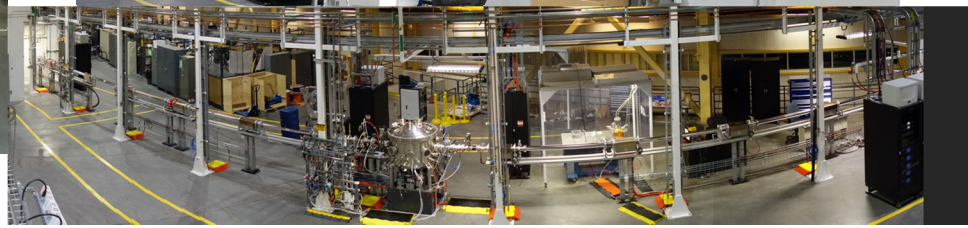
ESM and SIX Overview

ESM at 21 - ID



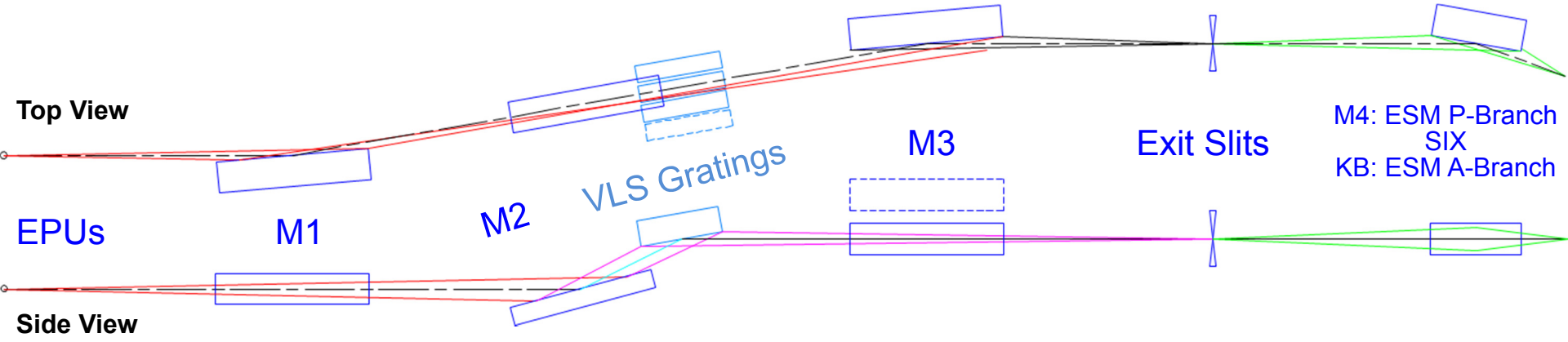
SIX at 2 - ID





ESM and SIX Overview

Optical Scheme of ESM and SIX



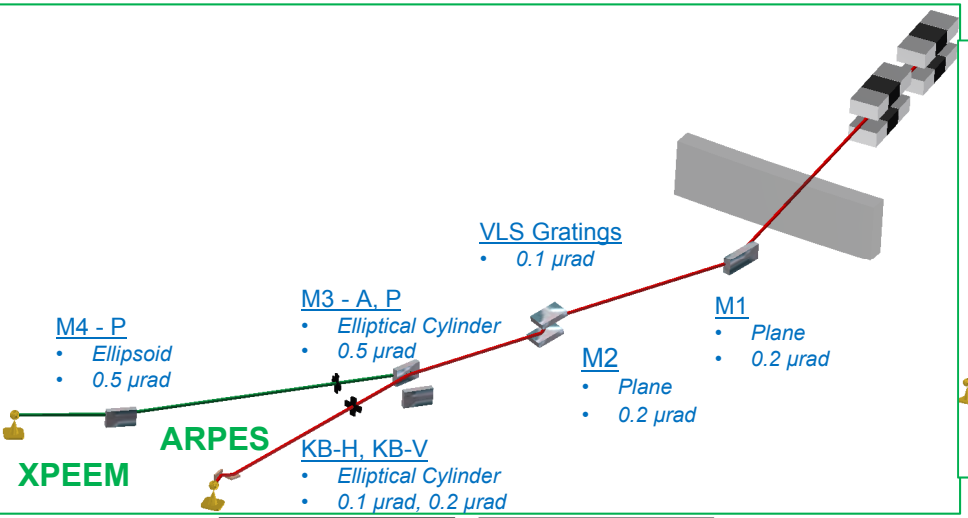
	ESM		SIX
Source	EPU105	EPU57	EPU57
Energy Range	15 - 200 eV	200 - 1500 eV	180 - 2300 eV
Resolution (ΔE)	~1 meV up to 100 eV ~ 100 meV up to 1000 eV		~10 meV at 1,000 eV
Flux	μ-ARPES: 10^{10} - 10^{11} photons/second XPEEM: 10^{11} - 10^{12} photons/second		10^{11} - 10^{12} photons/second
Beam Size at sample (FWHM)	μ-ARPES: ≤ 1 μm, XPEEM: ≤ 40 μm		6 μm (horizontal) × 0.6 μm (vertical)

Optics Engineering Design and Metrology

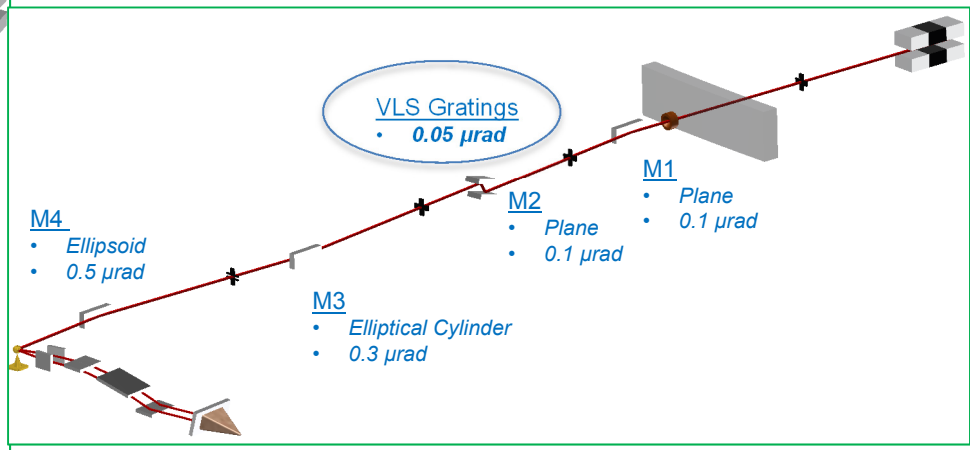
Total: 11 mirrors and 7 gratings

+ 12 multilayer mirror for NSLS-II DiagOn

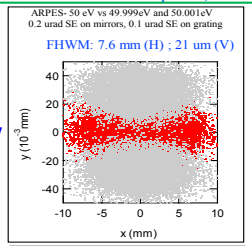
ESM Optics

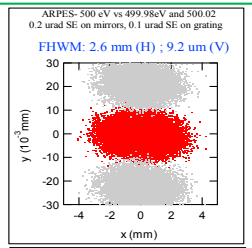


SIX Optics



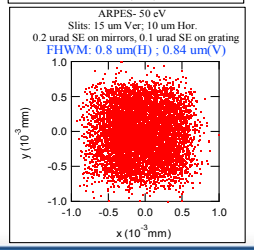
50 eV, ΔE=1 meV

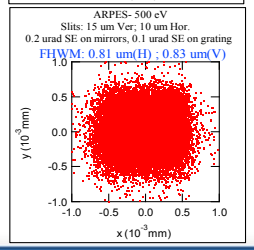




500 eV, ΔE=20 meV

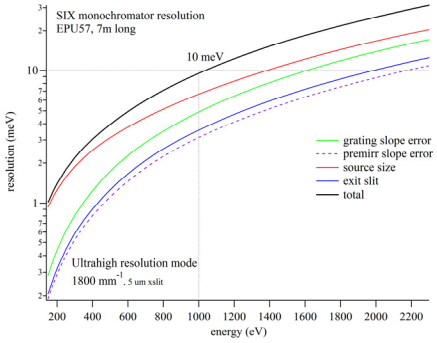
50 eV, < 1μm



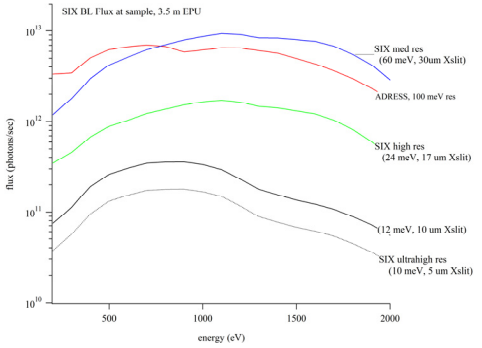


500 eV, < 1μm

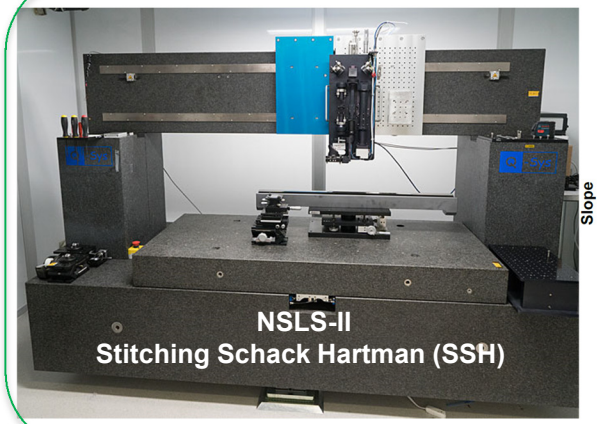
SIX resolution

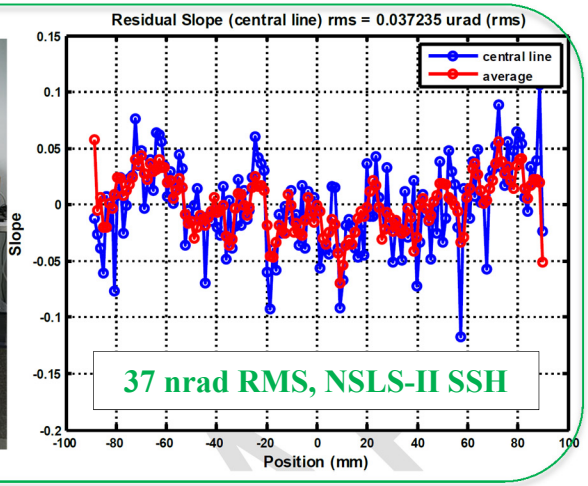


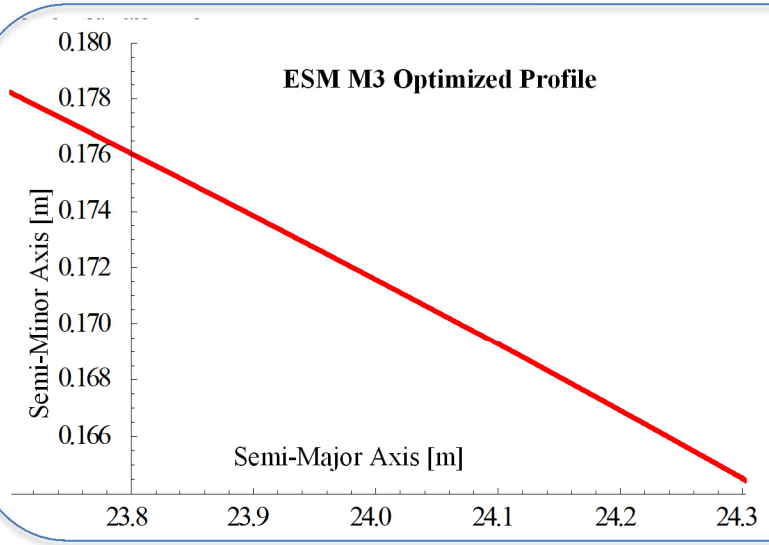
SIX flux at sample

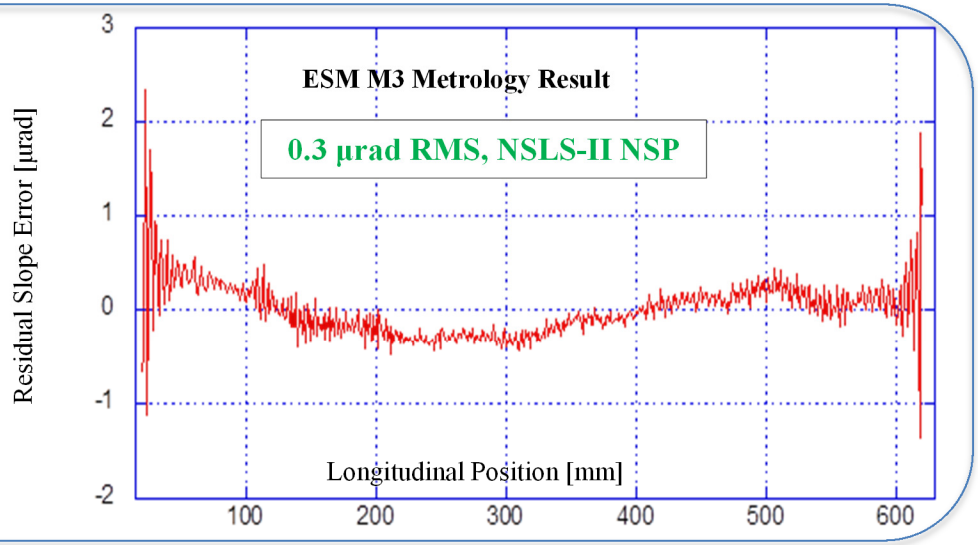


Optics Engineering Design and Metrology

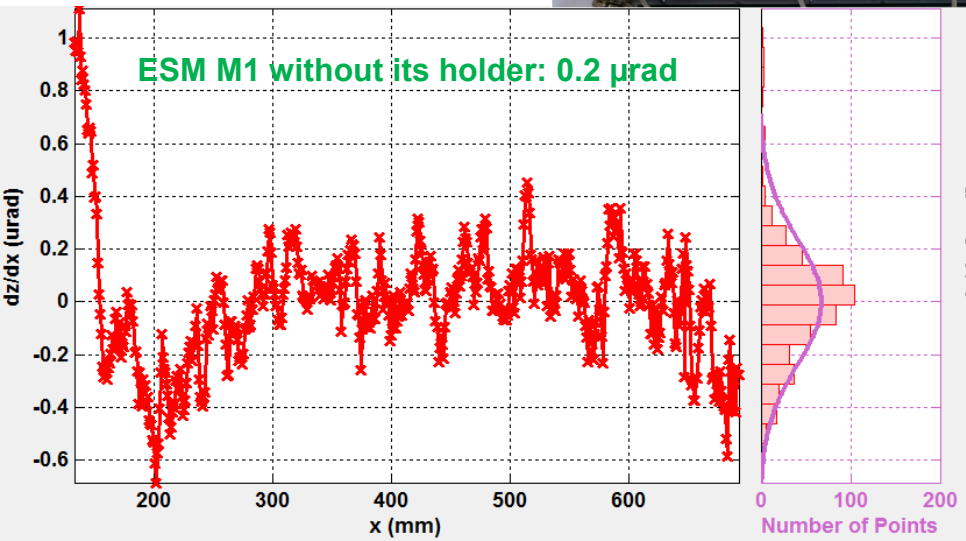


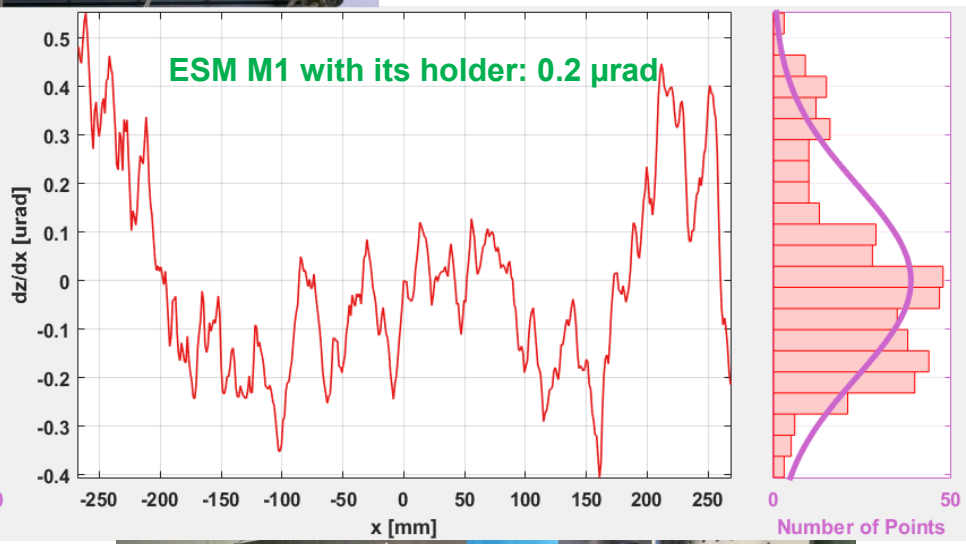


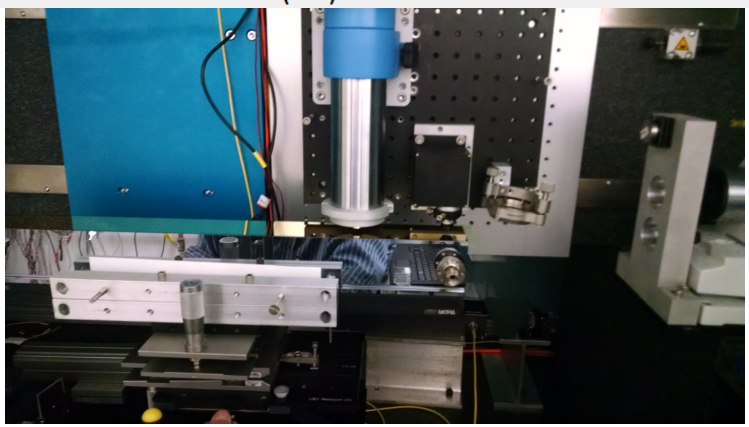


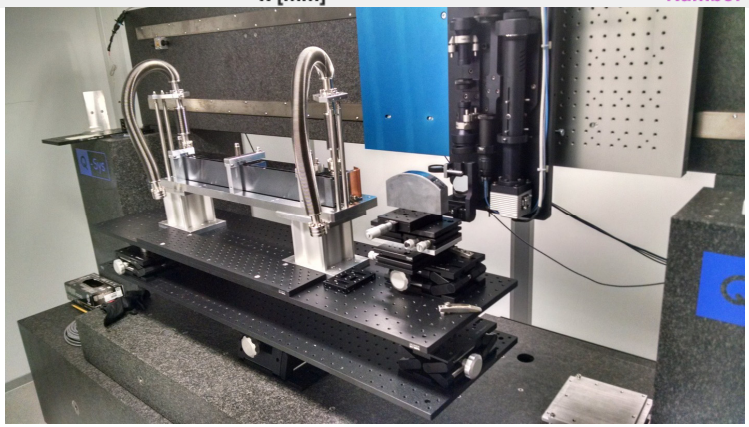


Optics Engineering Design and Metrology



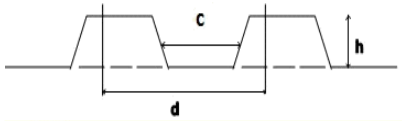






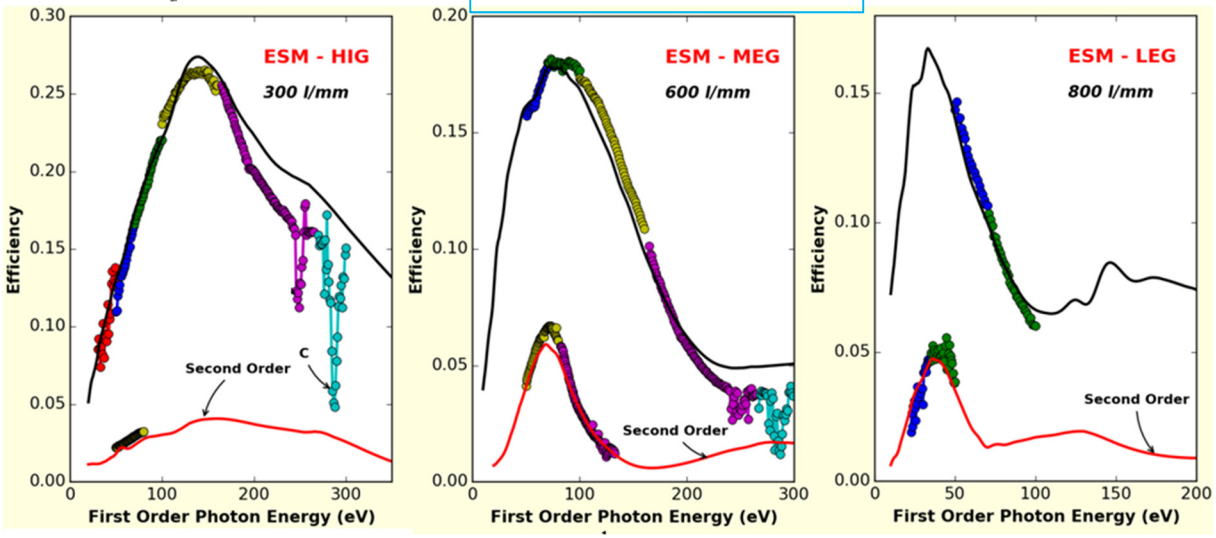
Optics Engineering Design and Metrology

	LEG	MEG	HIG	HEG
Energy Range (eV)	15 - 100	50 - 200	50 - 350	200 - 1500
Line Density, a_0(l/mm)	800	600	300	1200
Meridional RMS slope error (µrad)	< 0.1			
Groove Depth (nm)	48.5	36	30	6 - 12
Duty Cycle	0.7			0.65



Duty Cycle $= \frac{c}{d}$; (h: groove depth; c: width of groove; d: period length)

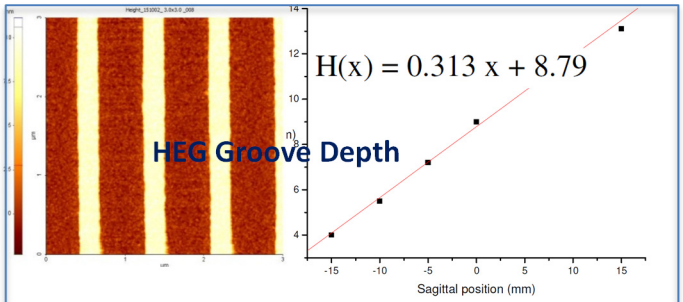
Measured at SOLEIL



(Unit: nrad)

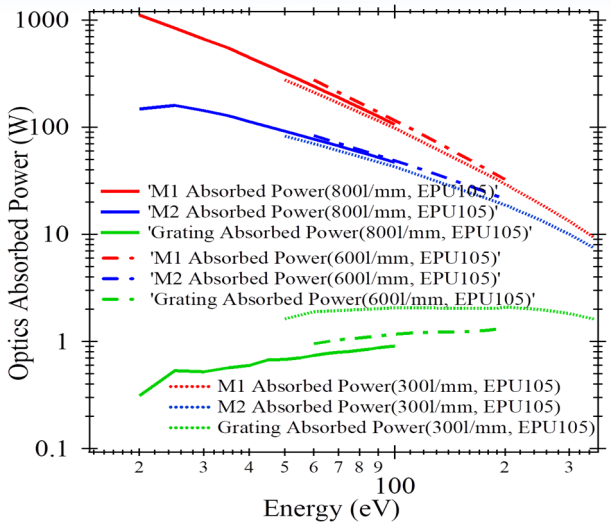
		MED	HIG	LEG	HEG
SOLEIL (LTP)	Clamped	259	195	180	150
NSLS-II (SSH)	Clamped	182.3	144	-	-
	Adjusted	106.2	85.4	106.4	101

Measured at SOLEIL



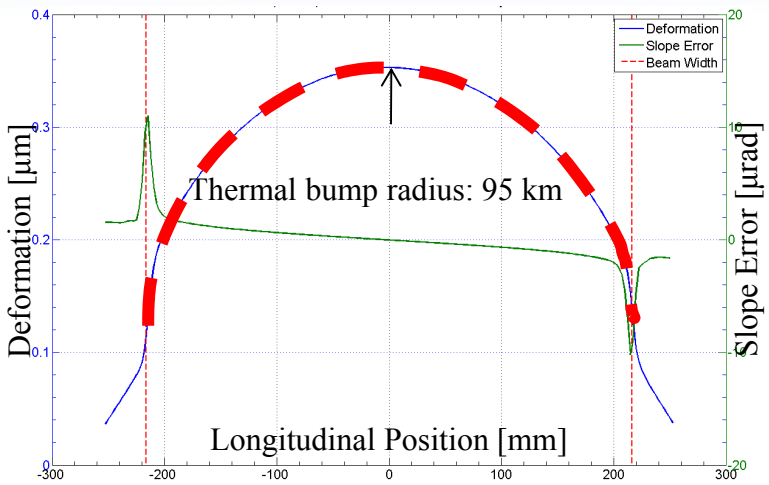
	a_1	a_2	a_3
Specified	0.232	2.06×10^{-5}	1.9×10^{-9}
0 mm	0.230	1.87×10^{-5}	3.1×10^{-9}
+10 mm	0.230	2.00×10^{-5}	2.5×10^{-9}
-10 mm	0.230	2.00×10^{-5}	2.7×10^{-9}

Thermal Cooling Solution

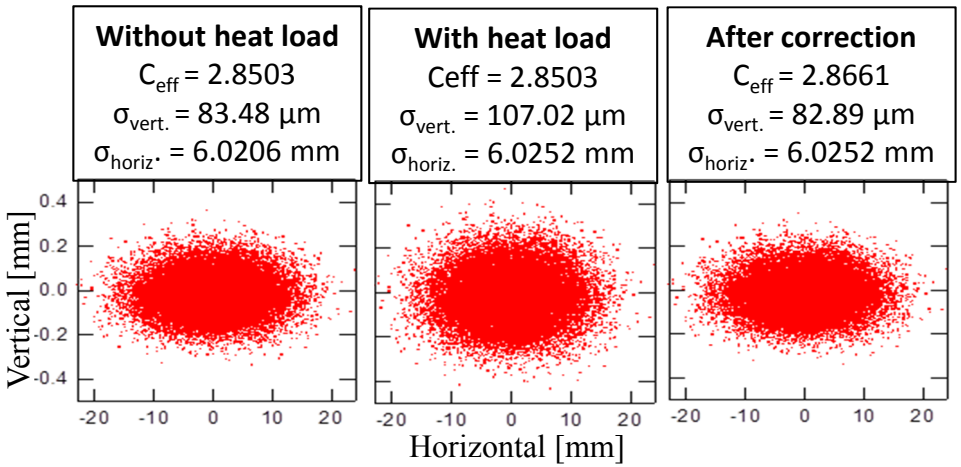


M1, M2:
Internal water cooling

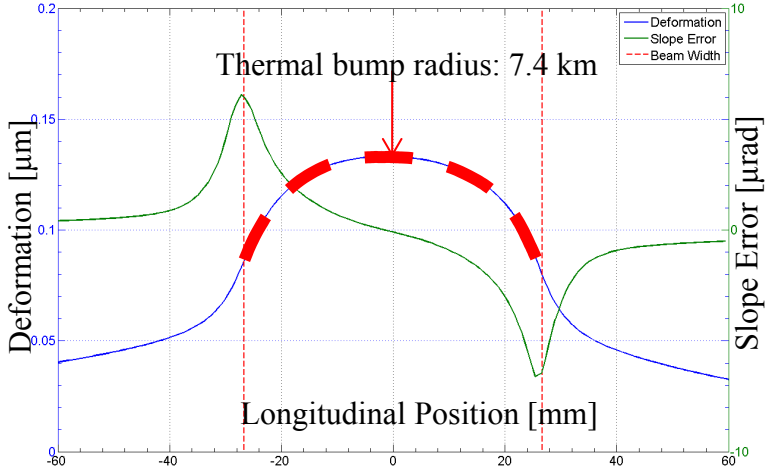
VLS gratings:
Indirect water cooling



ESM M1, Longitudinal Direction Distortion, 15eV

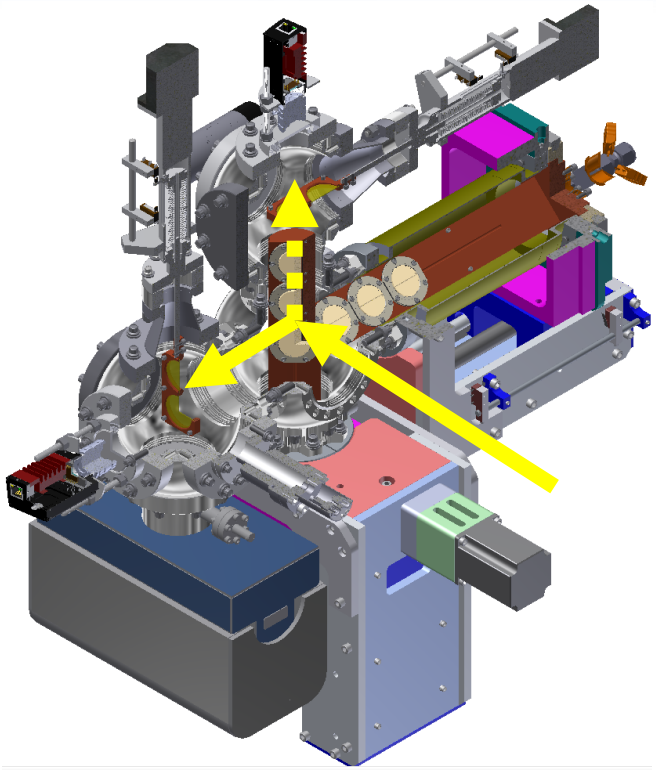


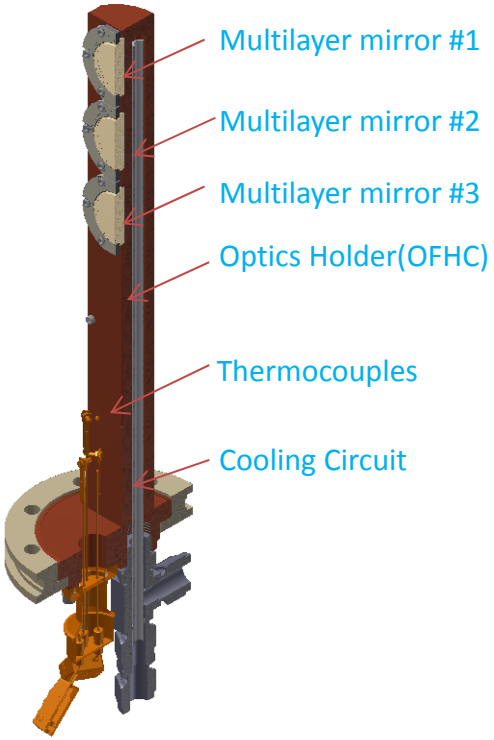
ESM M2, themal bump correction at 15eV

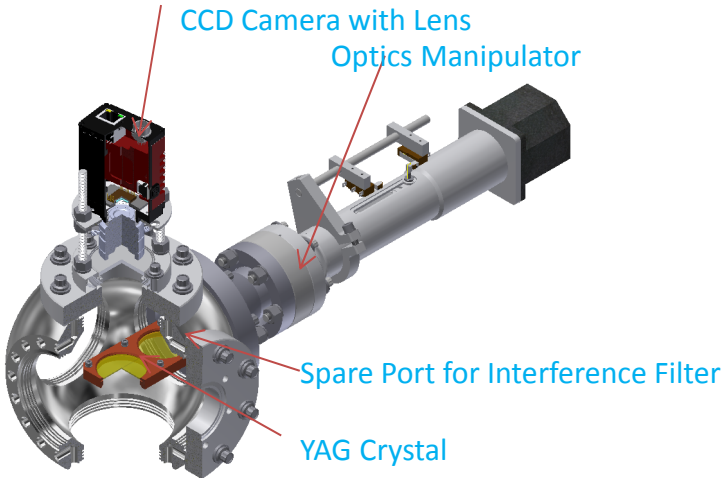


ESM M2, Longitudinal Direction Distortion, 15eV

Diagnostics Components Design



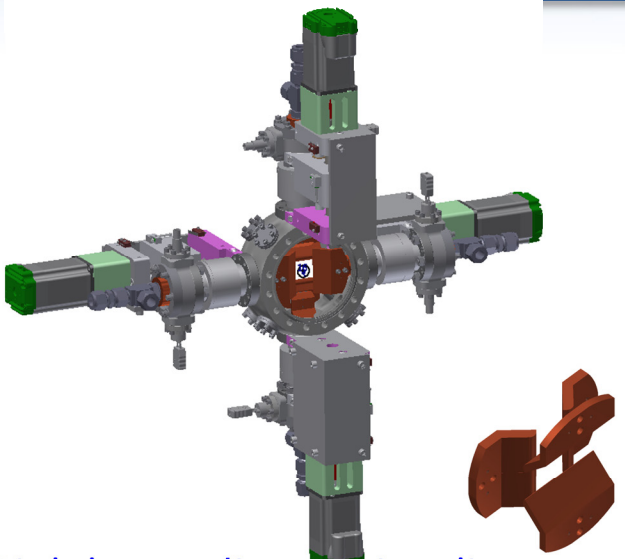




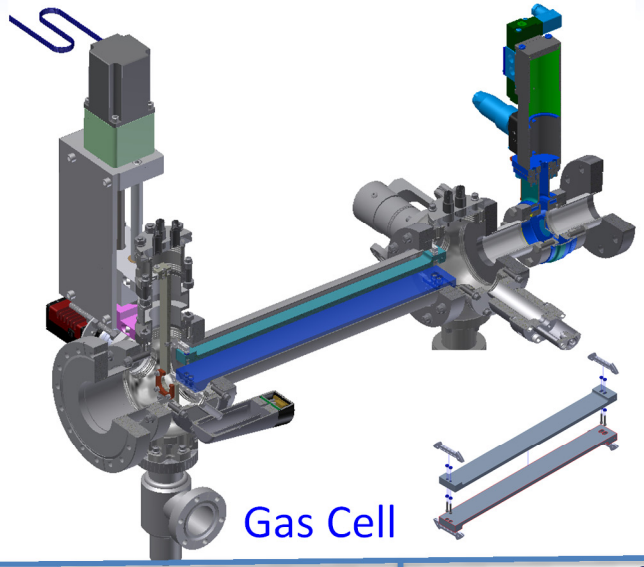
NSLS-II DiagOn has extended its function to provide source and beamline alignment during operation

K. Desjardins et al., "The DiagOn: an undulator diagnostic for SOLEIL low energy beamlines", IEEE Nuclear Science Symposium Conference Record, Dresden, Oct. 2008, pp. 2571-2574, doi: 10.1109/NSSMIC.2008.4774883

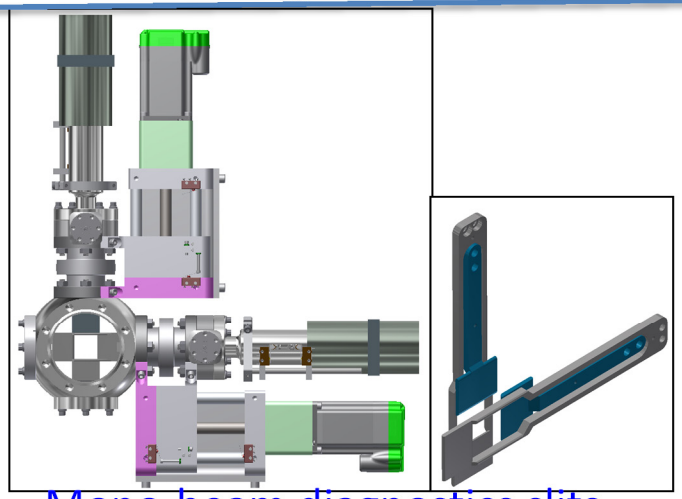
Diagnostics Components Design



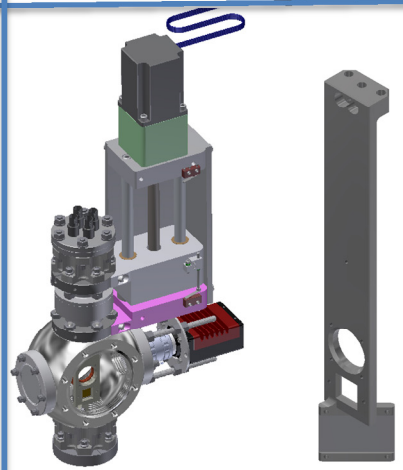
Pink-beam diagnostics slits



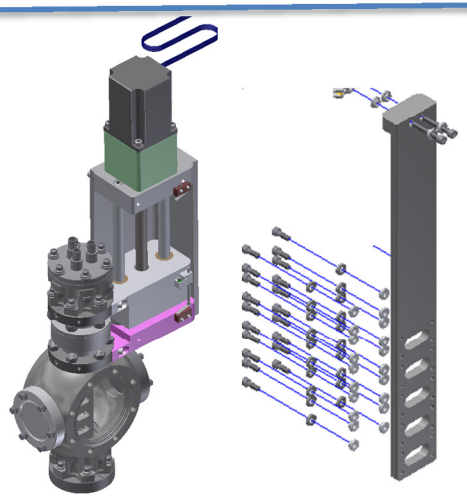
Gas Cell



Mono-beam diagnostics slits



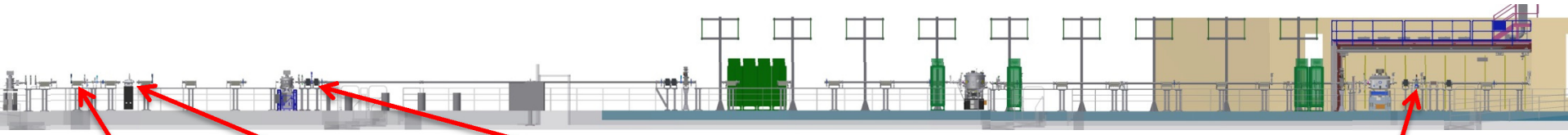
Diagnostics unit #1

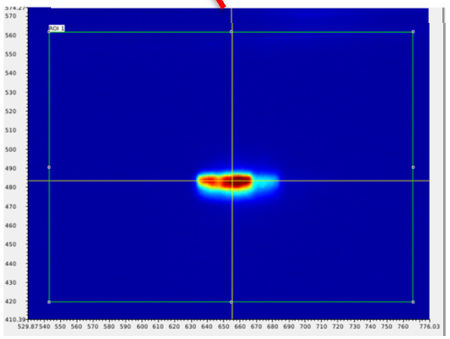


Diagnostics unit #2

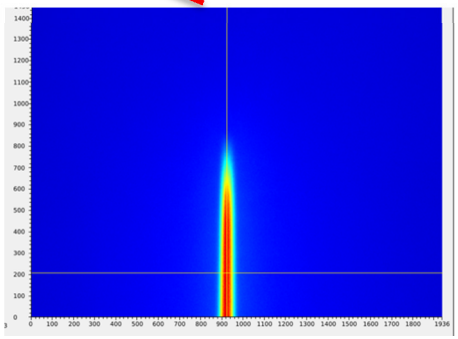
Commissioning and Performance

First Light of SIX on Feb. 21, 2017

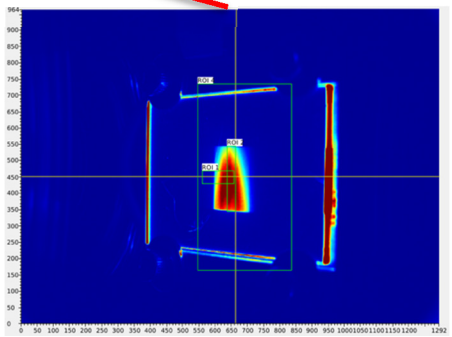




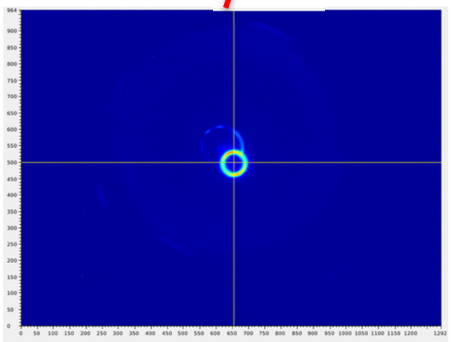
Upstream of M4



Exit slit

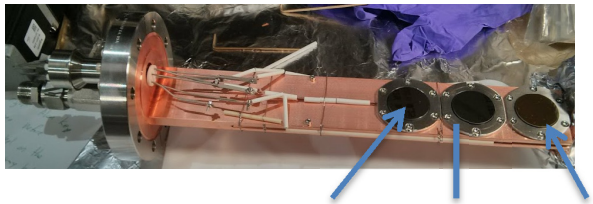


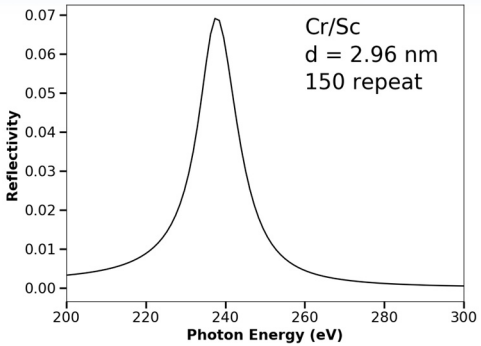
Upstream of M3



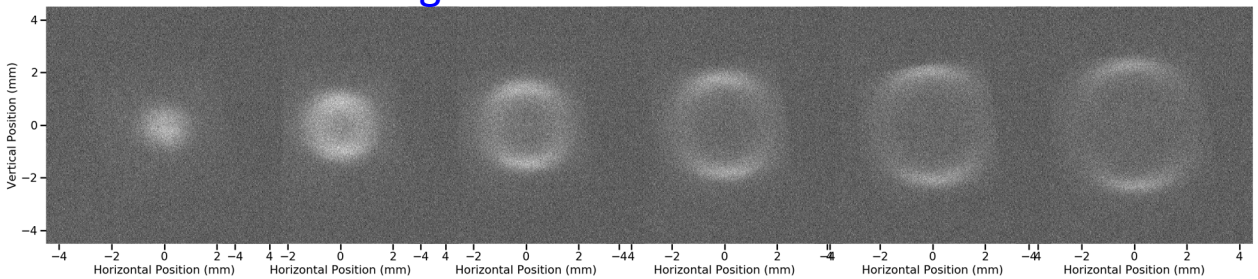
Upstream of M1

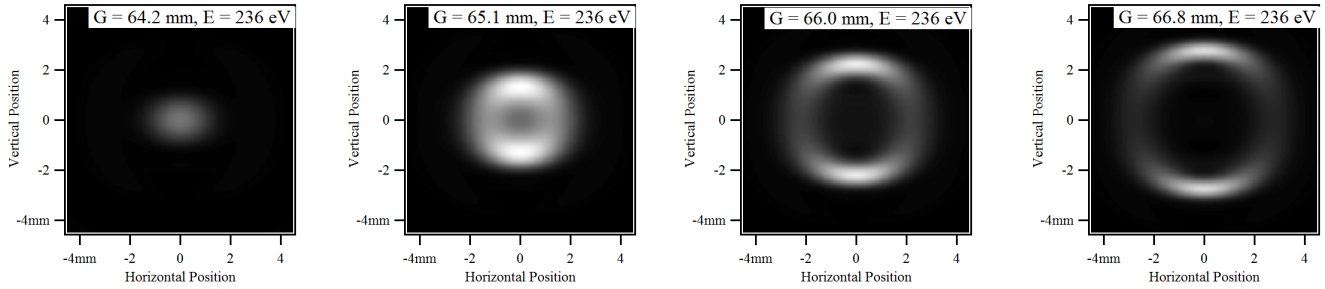
Commissioning and Performance



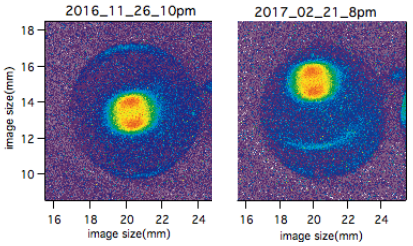


EPU105– 2 mA ring current



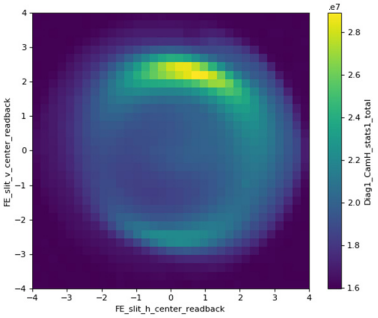


Beam Position with Time



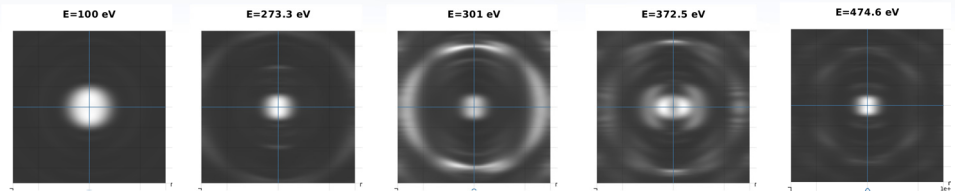
DiagOn in operation

EPU105 – gap 64 mm



Scanning FE (320mA)

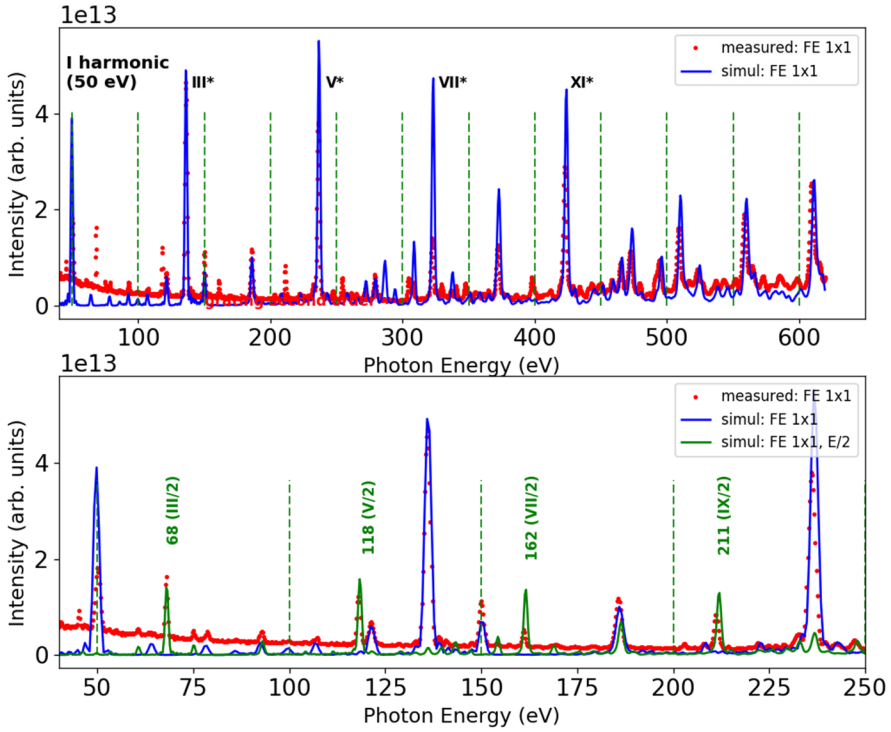
Commissioning and Performance



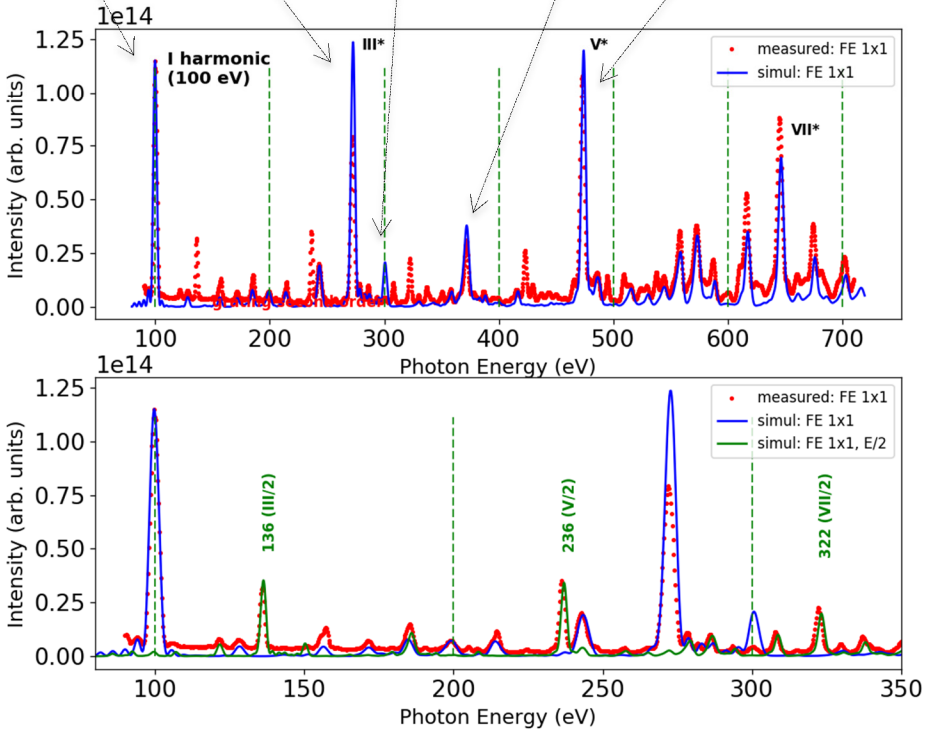
High ring current – FE small

I III* III IV* V*

QP-EPU105 *** I_ring = 320 mA *** gap = 36.4 mm

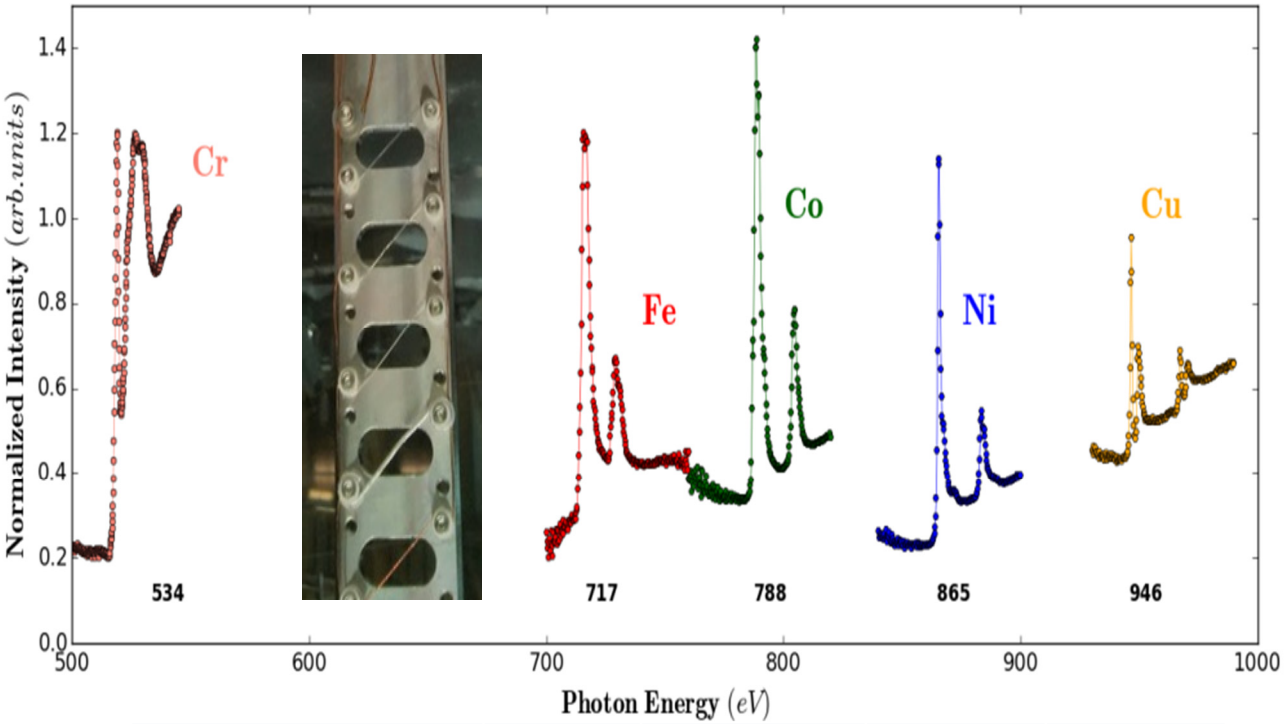


QP-EPU105 *** I_ring = 320 mA *** gap = 48.2 mm



Commissioning and Performance

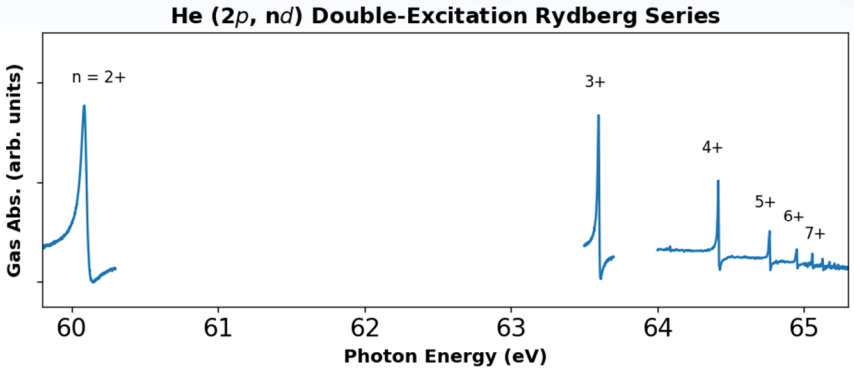
Energy Calibration: Setting M2 and grating offsets

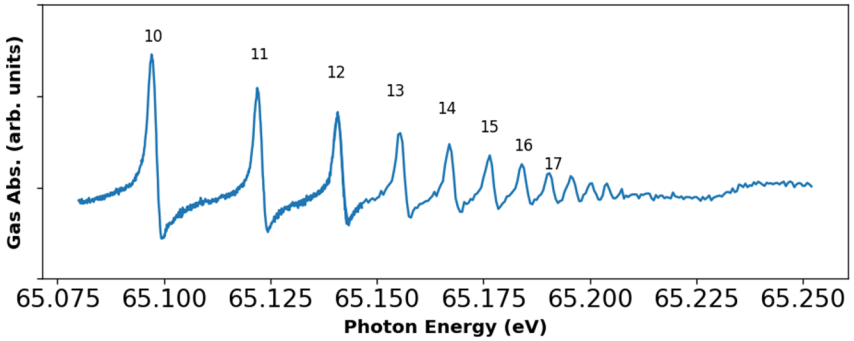


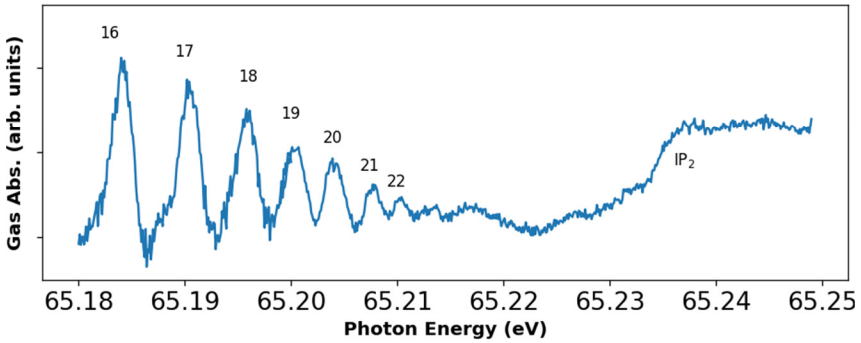
EPU57
1200 l/mm

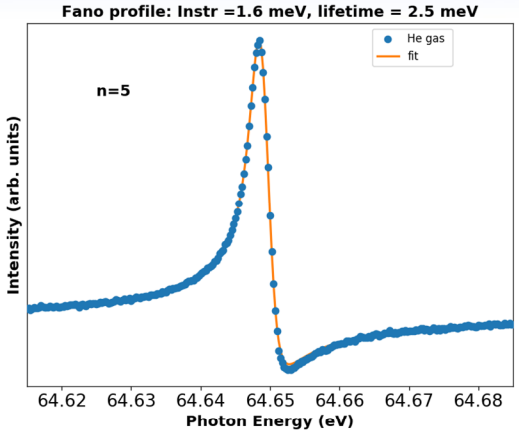
XAS	Fe	Co	Ni	Cu
Energy Expected	710	780	853	932
Energy Measured	707.7	778.6	853.7	932.9
Offset (eV)	**-2.3**	**-1.4**	**0.7**	**0.9**

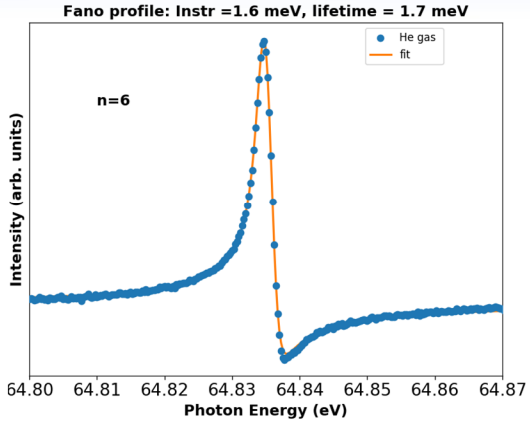
Commissioning and Performance

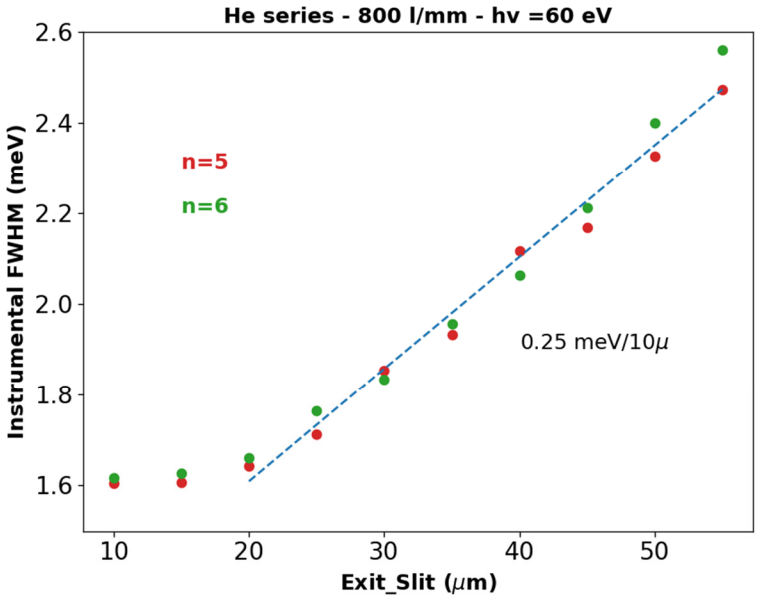




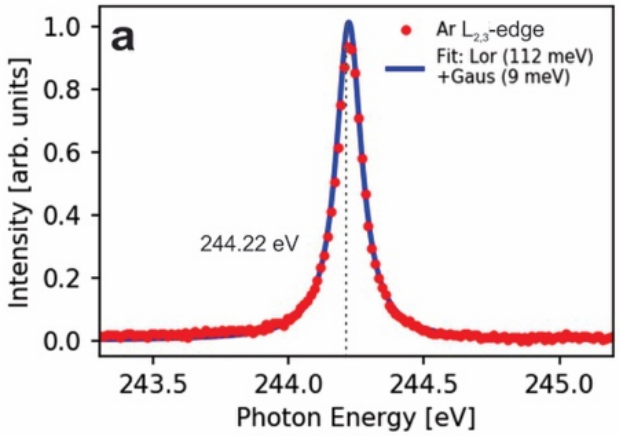


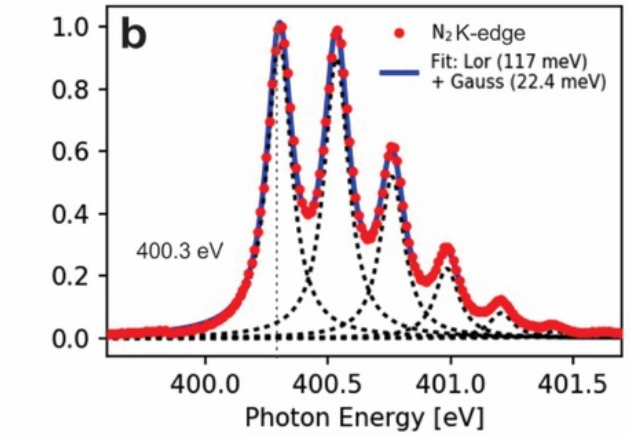


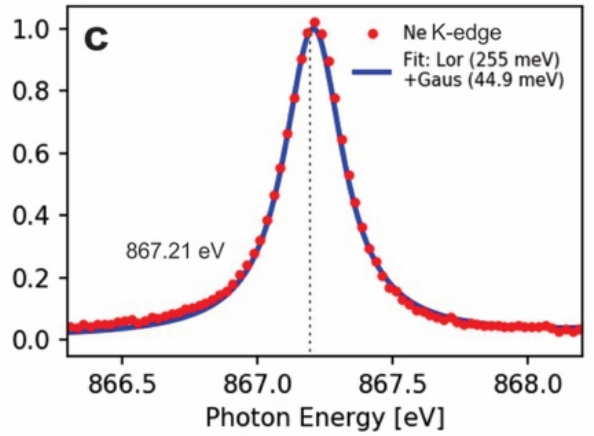


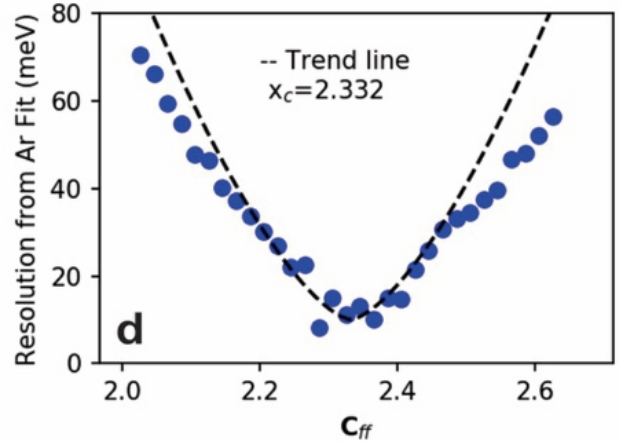


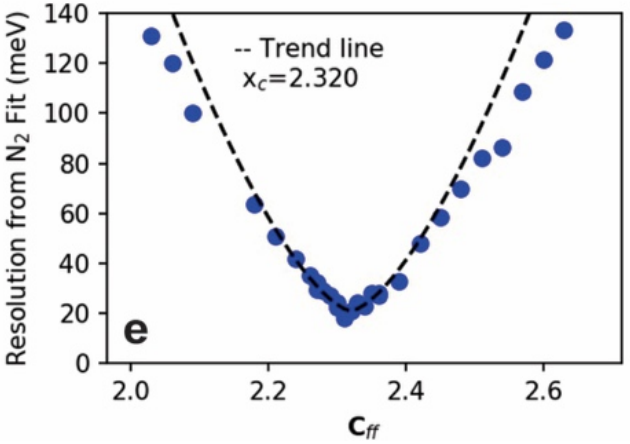
Commissioning and Performance

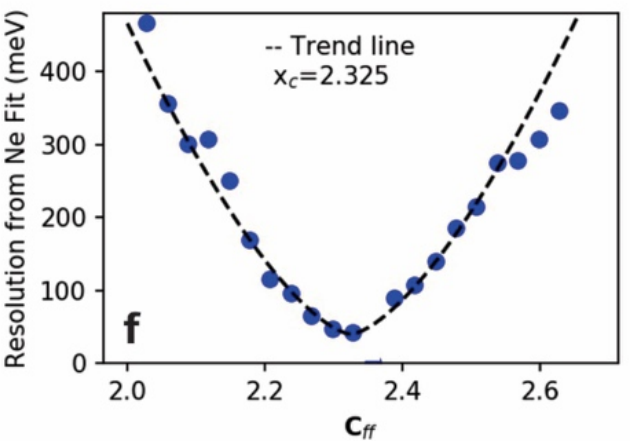








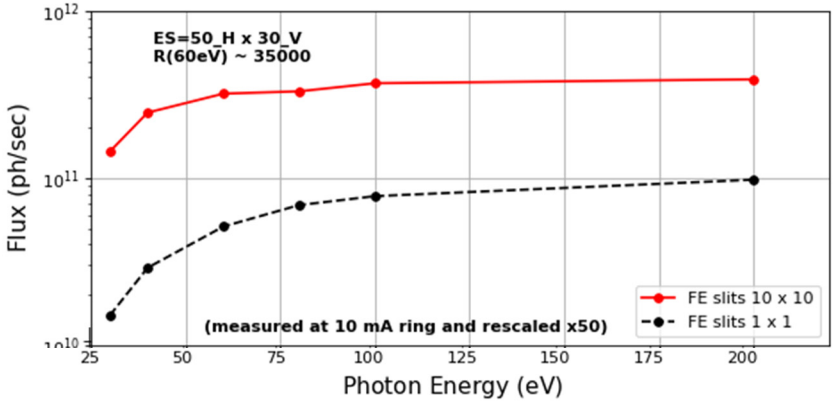




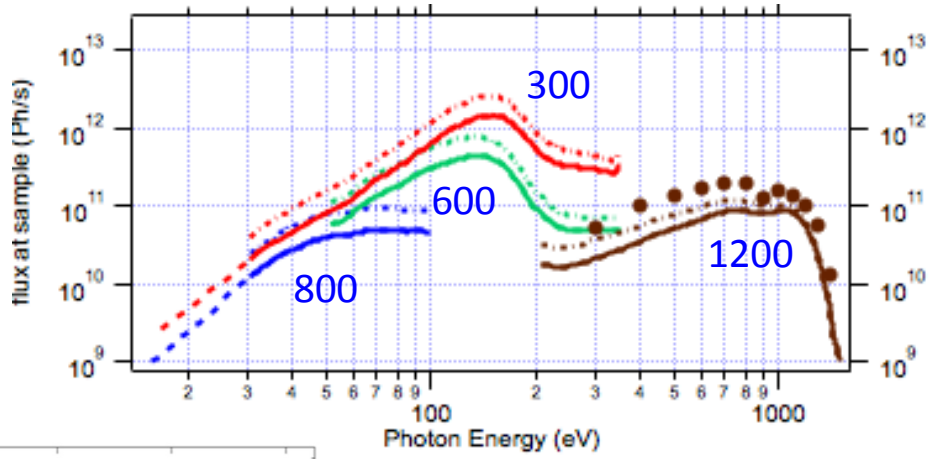
Energy:	244 eV	400 eV	867 eV
Measured res:	9 meV	22.4 meV	44.9 meV
Simulated res:	7.2 meV	13.9 meV	42.4 meV

Commissioning and Performance

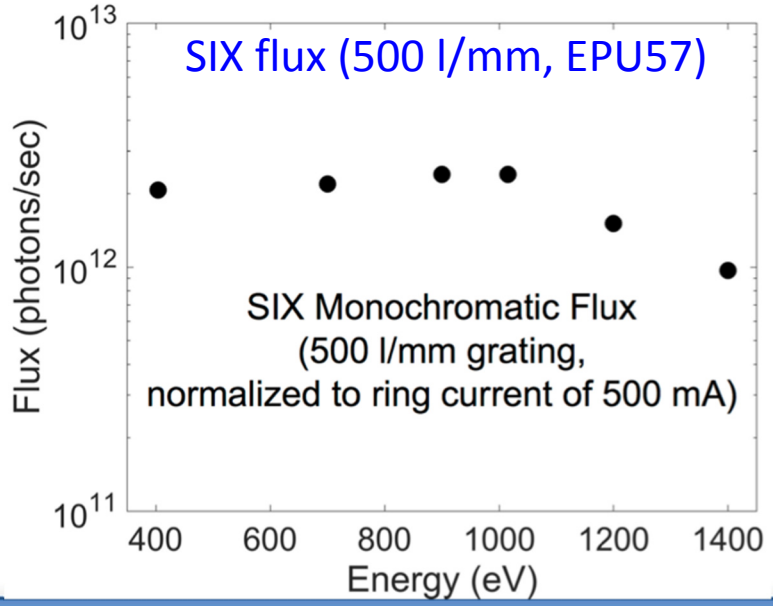
ESM flux (800 l/mm, EPU105)



ESM flux (1200 l/mm, EPU 57)

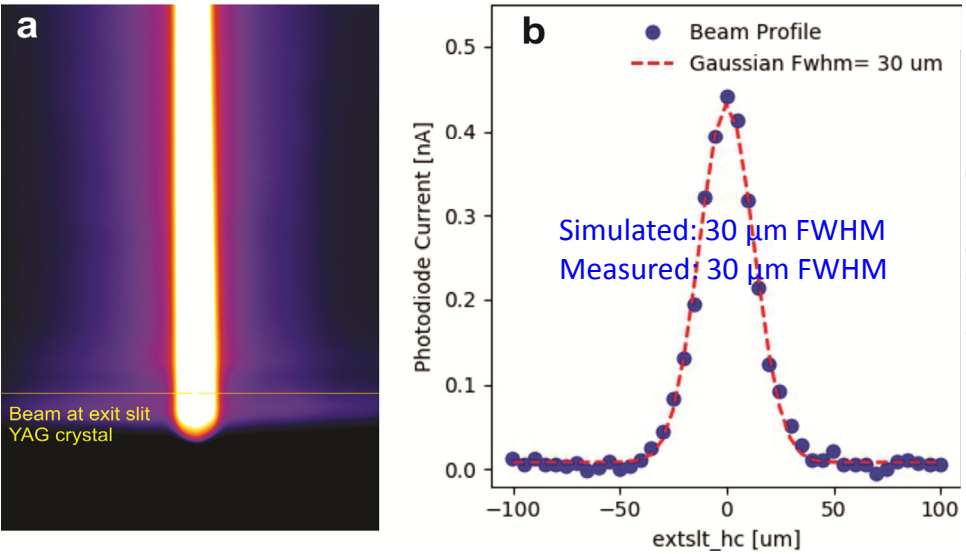


SIX flux (500 l/mm, EPU57)



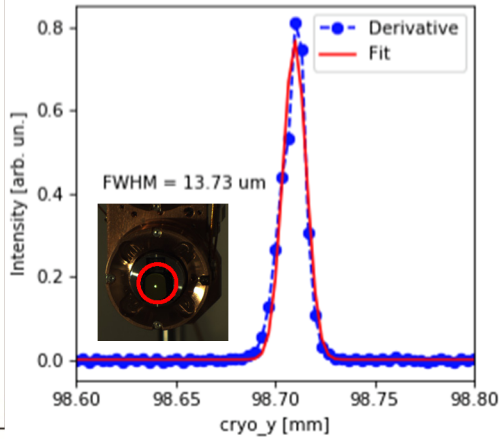
Commissioning and Performance

Beam spot after SIX M3

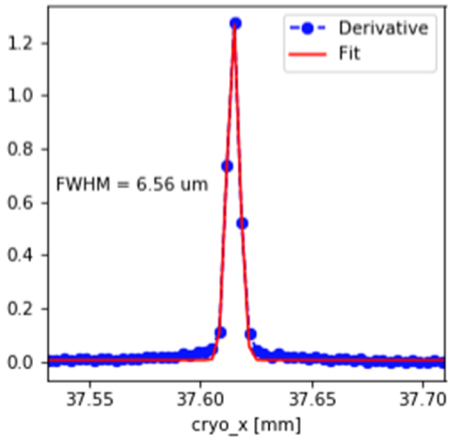


Beam spot after SIX M4

Vertical

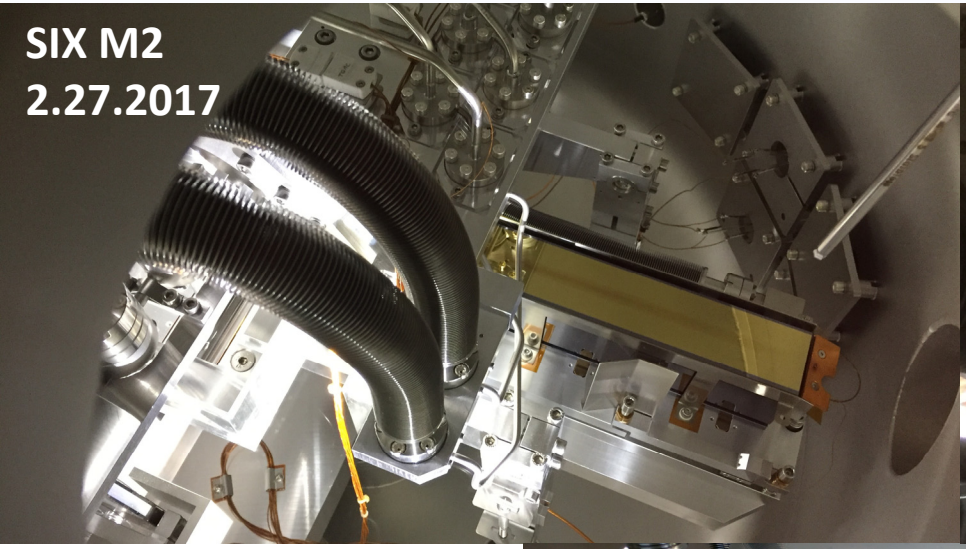


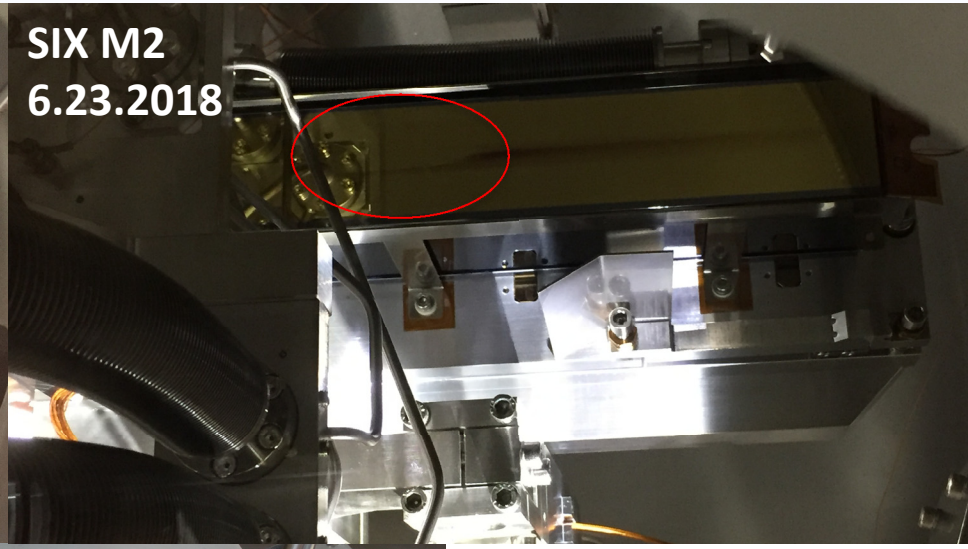
Horizontal



Improvements in progress…

Optics Contamination and Cleaning





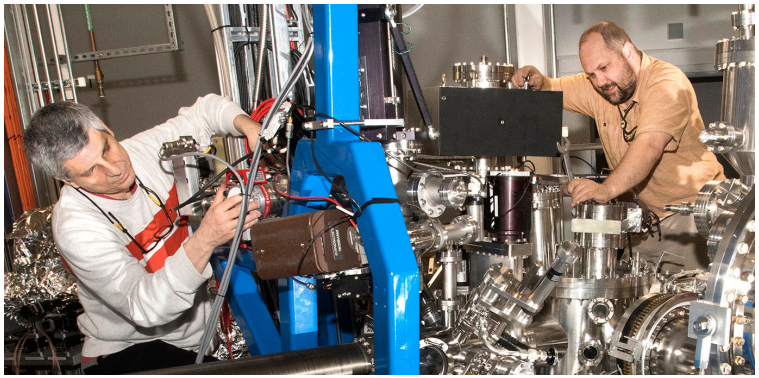
C. Chauvet et al., "Handling the carbon contamination issue at SOLEIL", Proc. SPIE 8077, Damage to VUV, EUV, and X-ray Optics III, 807712 (18 May 2011), doi: 10.1117/12.886970

Conclusion

In conclusion, ESM and SIX have successfully accomplished commissioning, and the preliminary test results have closely achieved the calculated values.

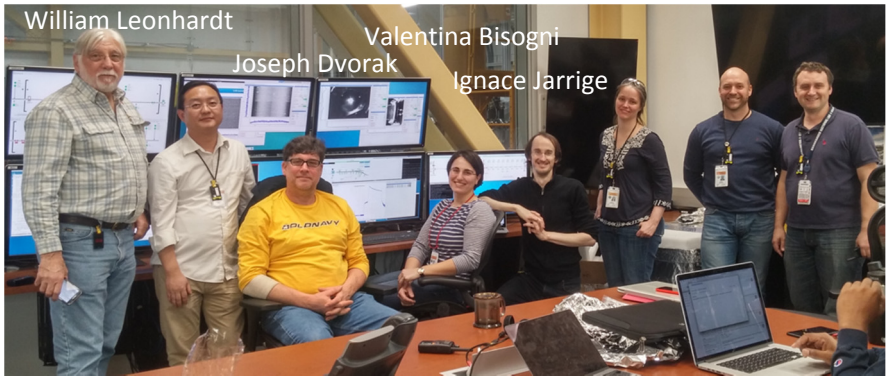
Acknowledgements

ESM team



Elio Vescovo Andrew Walter

SIX team



Metrology

NSLS-II Optical Metrology Lab

SOLEIL Optical Metrology Lab

Optics

InSync, Inc.

JTEC CORPORATION

zygo

HORIBA

SHIMADZU
Excellence in Science

Optics mechanical system

BESTEC