Resonant Inelastic X-ray Scattering at SIX of NSLS II:
An update on the beamline status and its performances

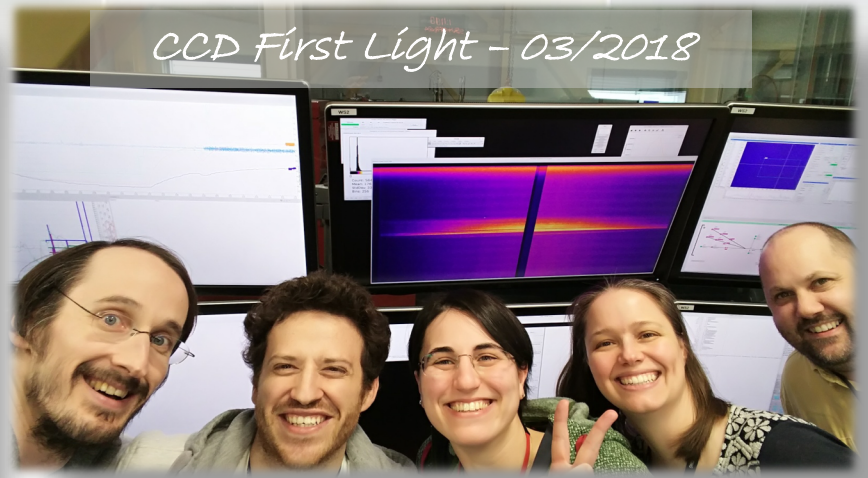
Valentina Bisogni

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY | Office of Science

BROOKHAVEN NATIONAL LABORATORY

Acknowledgements:



SIX Beamline Team

2-ID
SIX

Andi Barbour
Ignace Jarrige
Jonathan Pelliciari

Optics Scientist
Joe Dvorak

Soft X-ray Scattering & Spectroscopy Group

Claudio Mazzoli
Daniel Mazzone
Andrew Walter
Stuart Wilkins
….

Mechanical Engineers
Stephen Antonelli
Daniel Bacescu
Lukas Lienhard
Bill Leonhardt
Yi Zhu

Control Engineers
John Sinsheimer
Jun Ma
Wayne Lewis

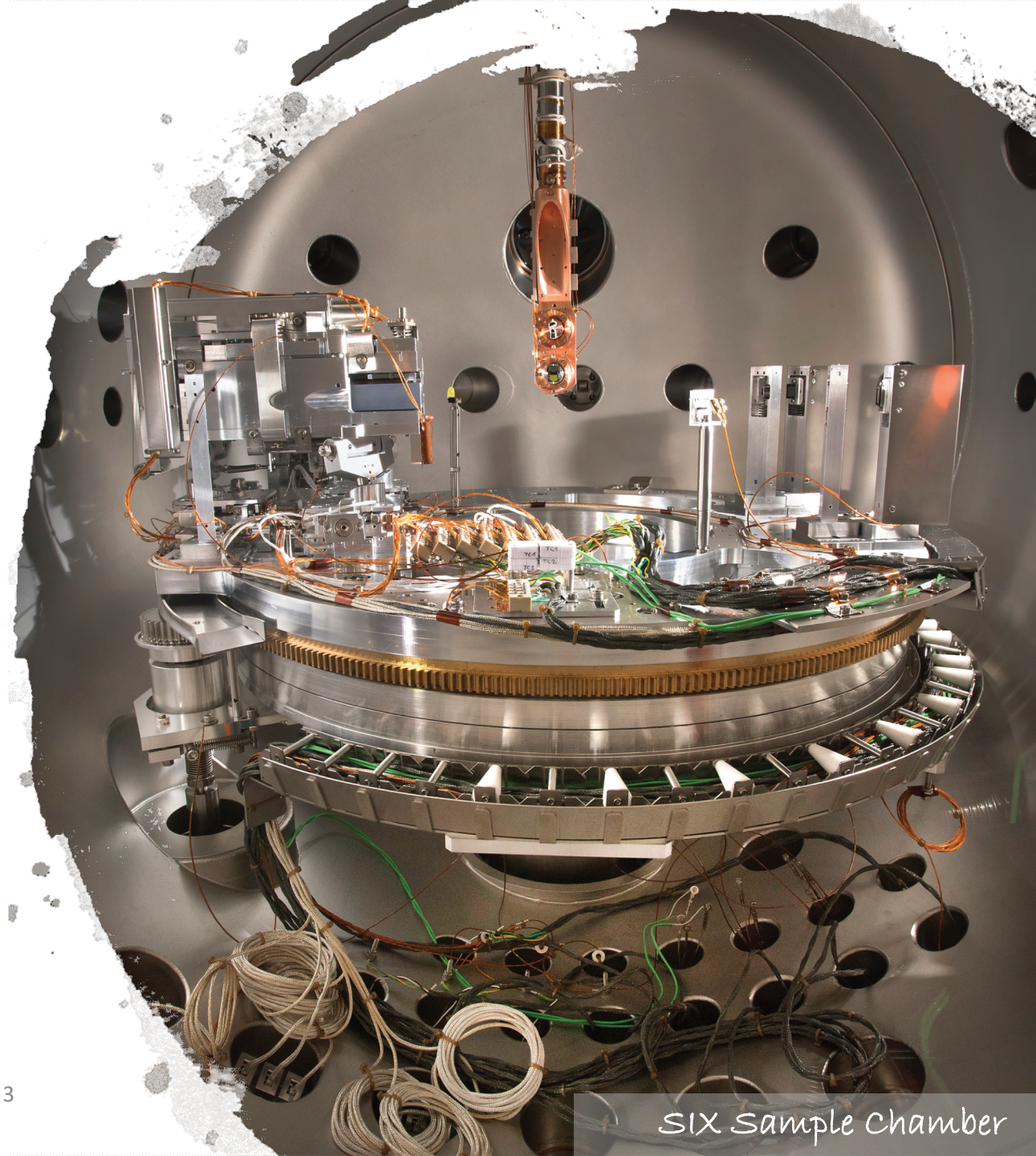
Technicians
Larry Fareira
Andy Mingino
Joe Sullivan

And many more ….

Outline:

A. **Soft Inelastic X-ray Scattering Beamline SIX at NSLS -II**
   - Beamline overview
   - Status update: flux, BL energy resolution, beam size at the sample, spectrometer resolution

B. **Collective excitations in model devices**
   - Scope of the research project
   - First data measured at SIX



SIX Sample Chamber

2-ID

SIX

Design Parameters for Resonant Inelastic X-ray Scattering at SIX

Energy: soft x-rays, 200 – 2000 eV

Polarization of incoming light:
LV, LH, Circular

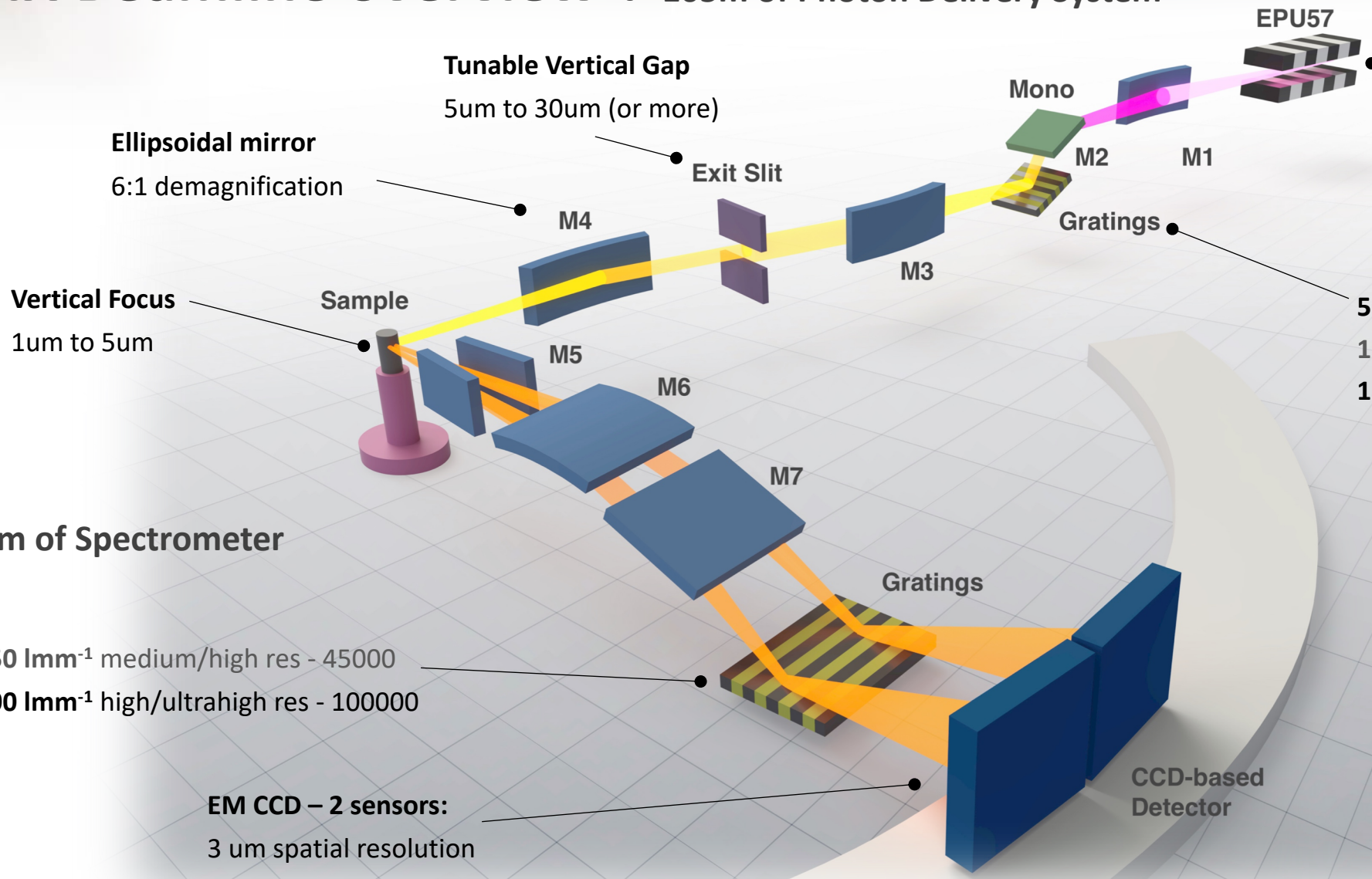
Operation modes:
Medium Resolution (R~ 15000)
High Resolution (R~ 35000)
Ultra High Resolution (R~ 70000)

Scattering angle:
Continuous in vacuum rotation from 38 deg to 150 deg

Beamline open to user proposals:
Next Call: September 30th

https://www.bnl.gov/ps/beamlines/

SIX Beamline overview*: 105m of Photon Delivery System



Tunable Vertical Gap
5um to 30um (or more)

Ellipsoidal mirror
6:1 demagnification

Vertical Focus
1um to 5um

3.5 m long EPU 57mm
Polarization: LH, LV, Circular
Energy range: ~200 – 2300 eV

500 lmm^{-1} medium res - 20000
1200 lmm^{-1} high res - 45000
1800 lmm^{-1} ultrahigh res - 100000

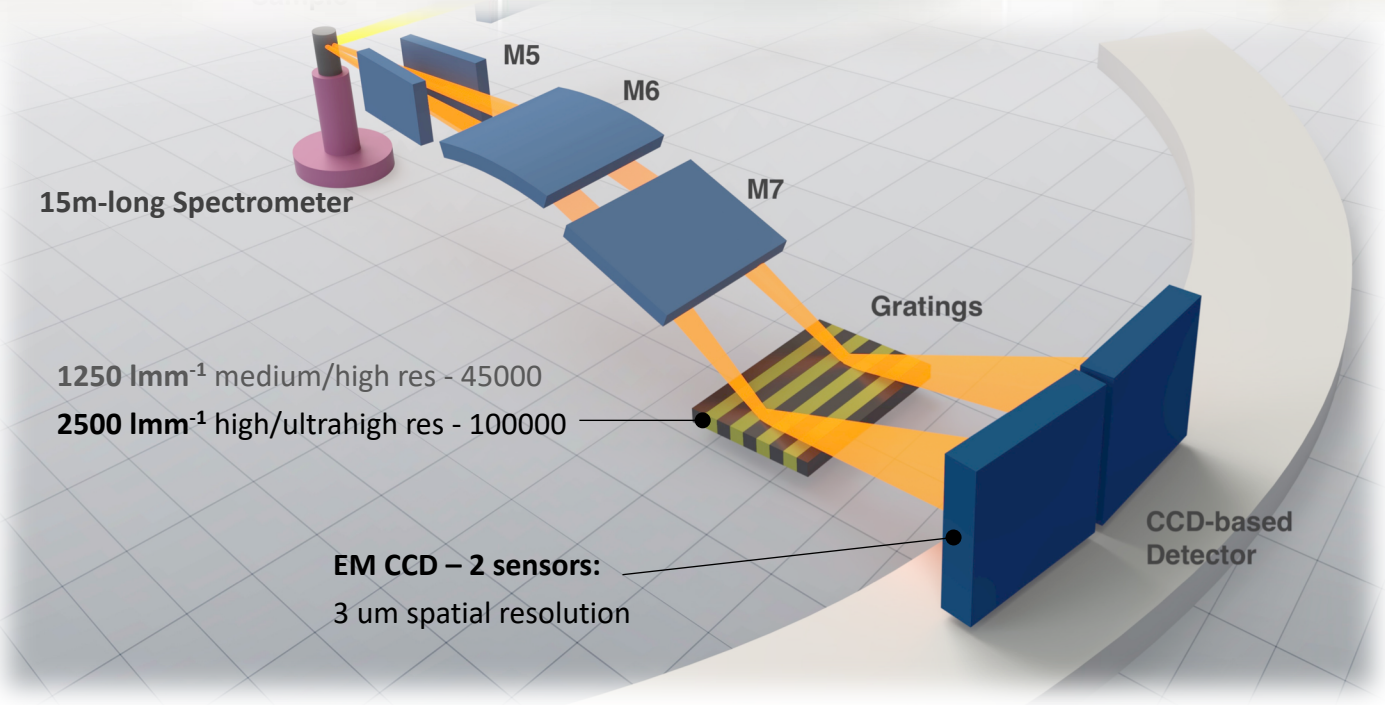
15m of Spectrometer

1250 lmm^{-1} medium/high res - 45000
2500 lmm^{-1} high/ultrahigh res - 100000

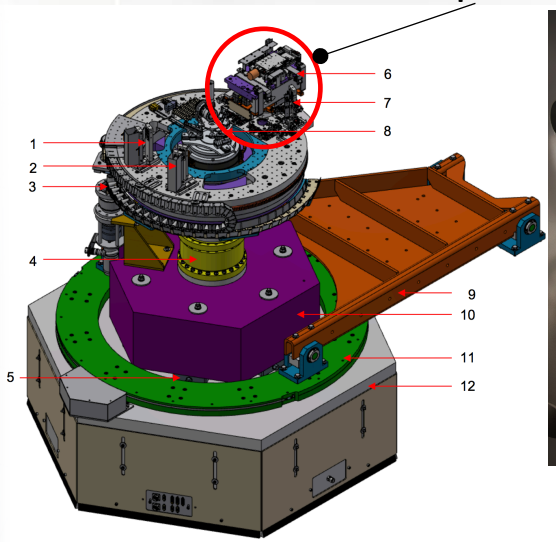
EM CCD – 2 sensors:
3 um spatial resolution

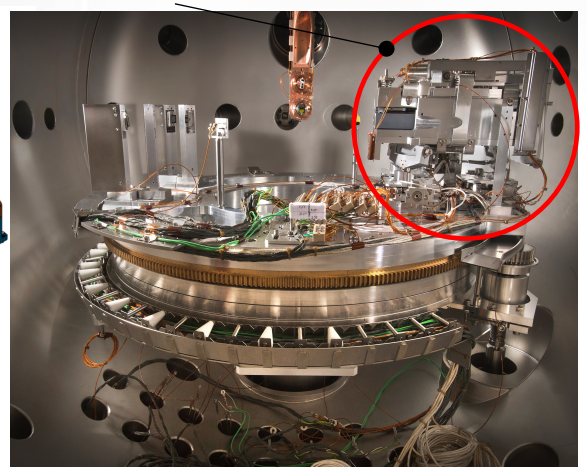
*Not in scale

Centurion Spectrometer: M5 collecting mirrors

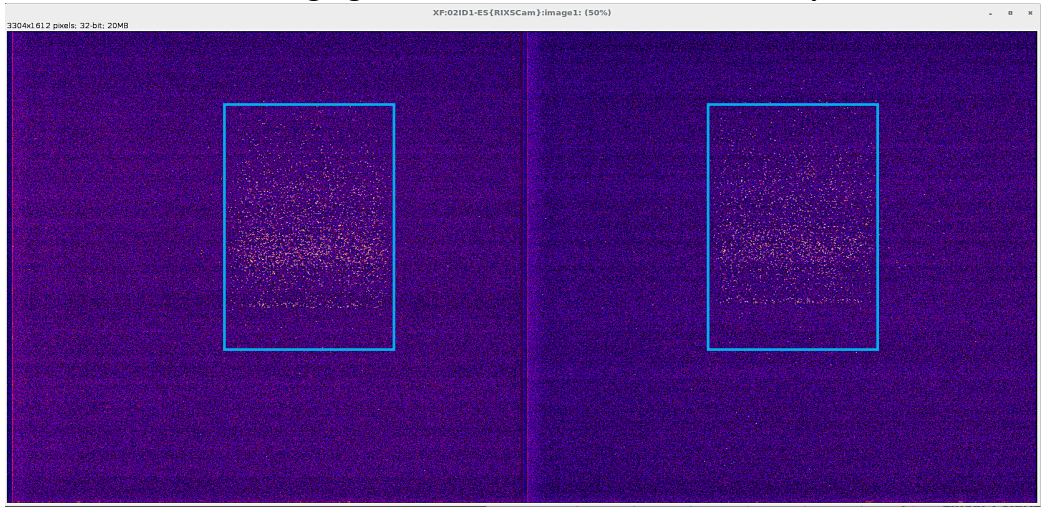


M5 dual parabolic mirror unit on 2θ wheel





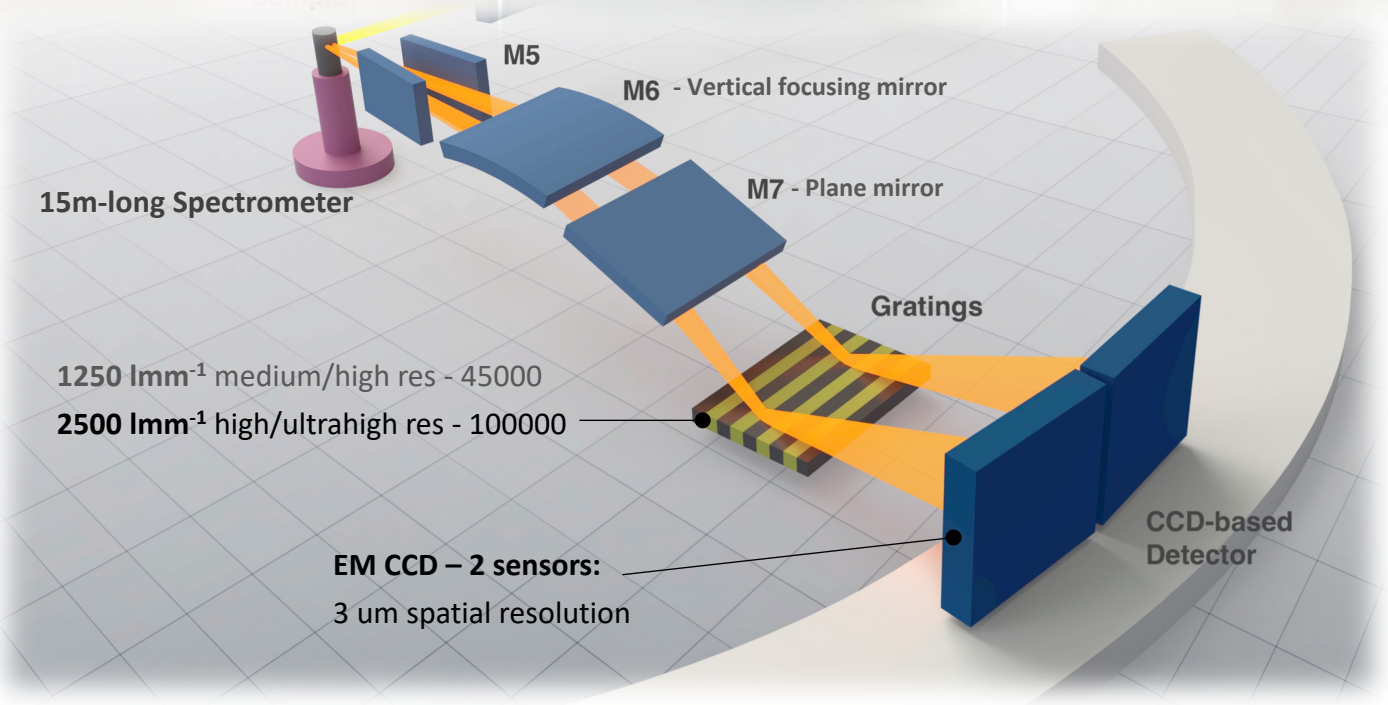
Two CCD sensors imaging each one of two beams from the parabolic mirror



- M5 alignment requires a µm-sensitive alignment procedure
- It is fundamental to have the M5 focal point, the center of rotation of the 2θ optics wheel and the M4 focal spot all at the same point!

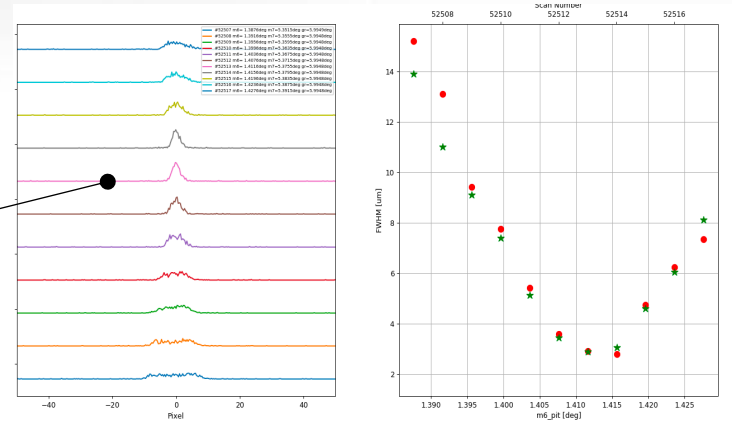
Review of Scientific Instruments **87**, 115109 (2016)

Centurion Spectrometer: M6/M7/GR focalize and analyze energy



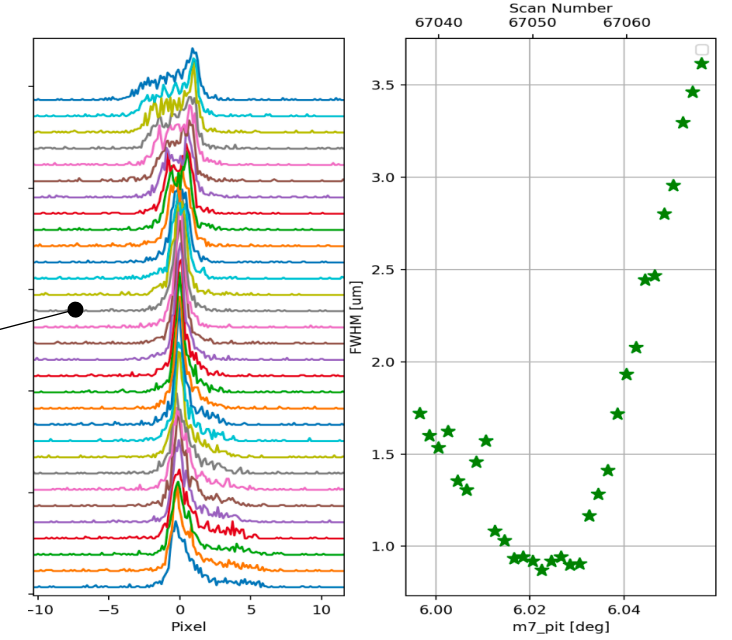
M6(M7) pitch scan at fixed GR pitch

Pick the narrowest line!



GR(M7) pitch scan at fixed M6 pitch

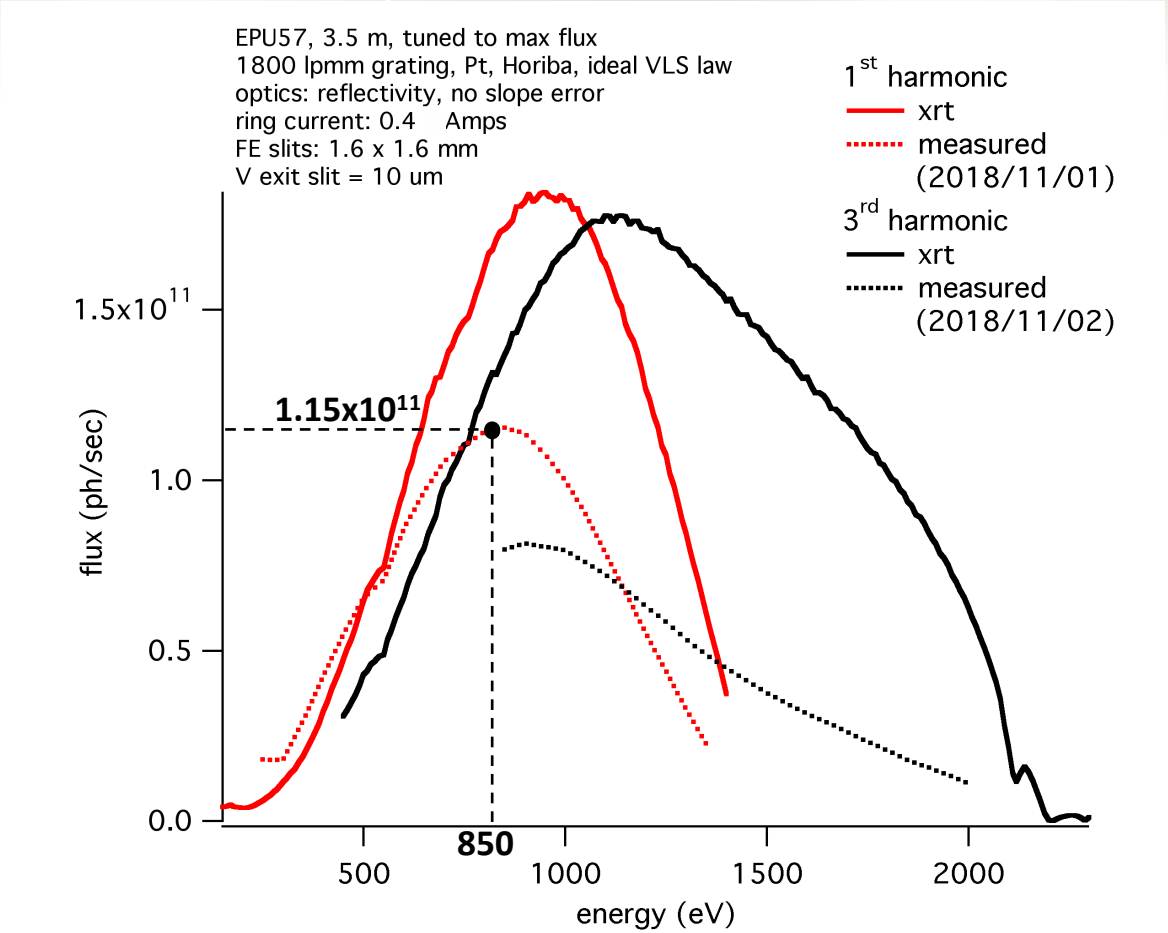
Pick the line without tail!

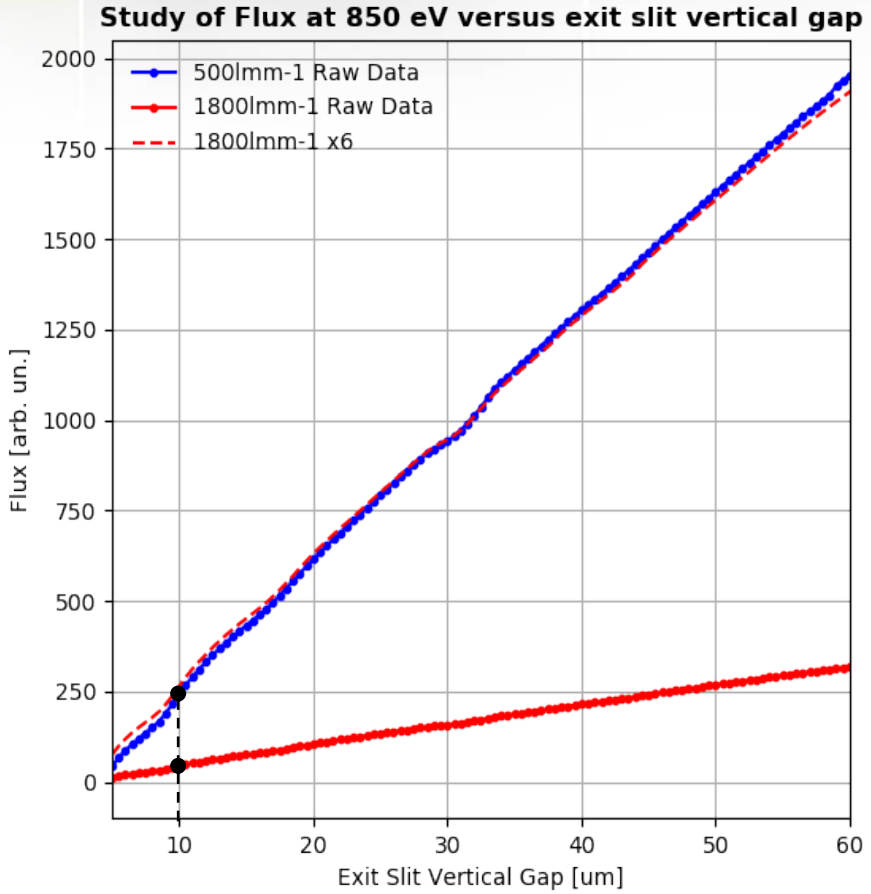


- Hettrick-Underwood scheme + Dvorak's mirror (M7) keep outgoing beam angle fixed at -1° at all energies
- CCD height is fixed

Review of Scientific Instruments **87**, 115109 (2016)

SIX Beamline: Flux



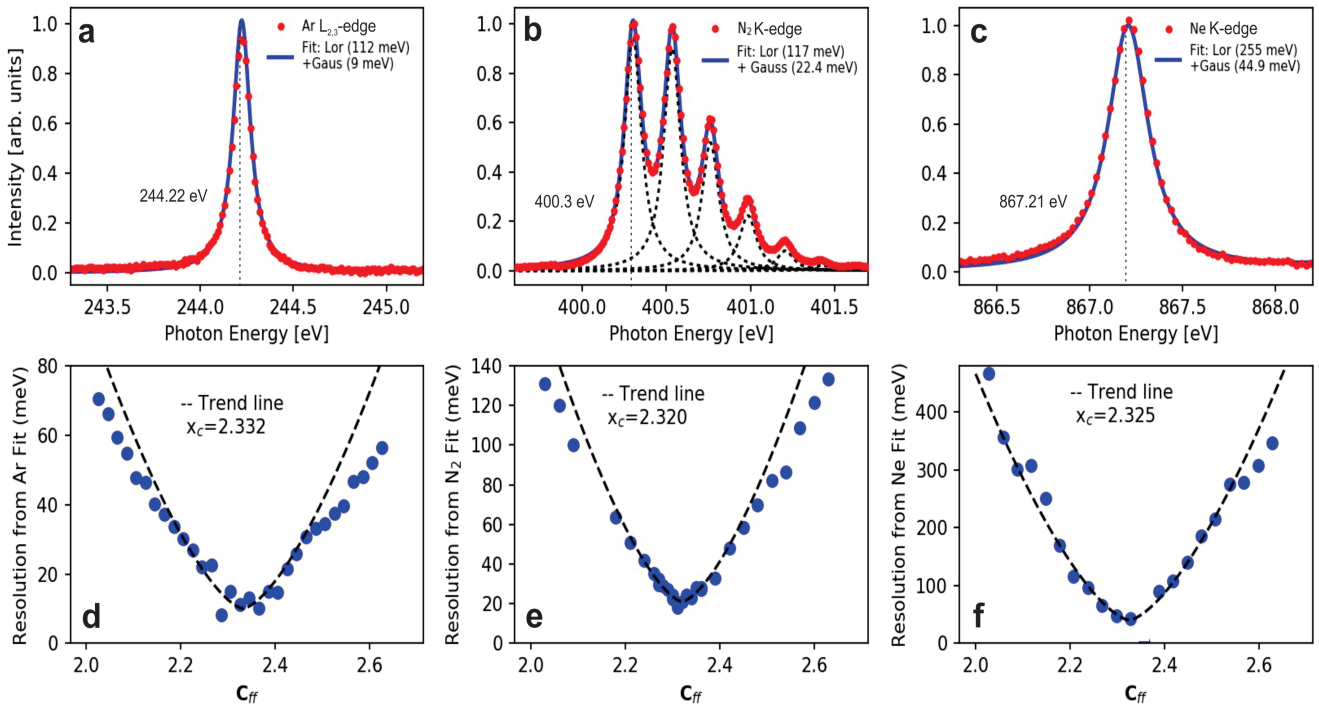


- GR 500 lmm^{-1} provides 6 x more flux then GR 1800 lmm^{-1}
- Flux linear with exit slit vertical gap: **medium res mode** (GR 500lmm^{-1}, 30um es vg) **~40x** more flux then **ultra high res mode** (GR 1800lmm^{-1}, 5um es vg)

SIX Beamline: Energy Resolution for GR 500 lmm^{-1}

- XAS transmission measurement of reference gases

GR 500 lmm^{-1} – Resolving Power ~ 20000



BL 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

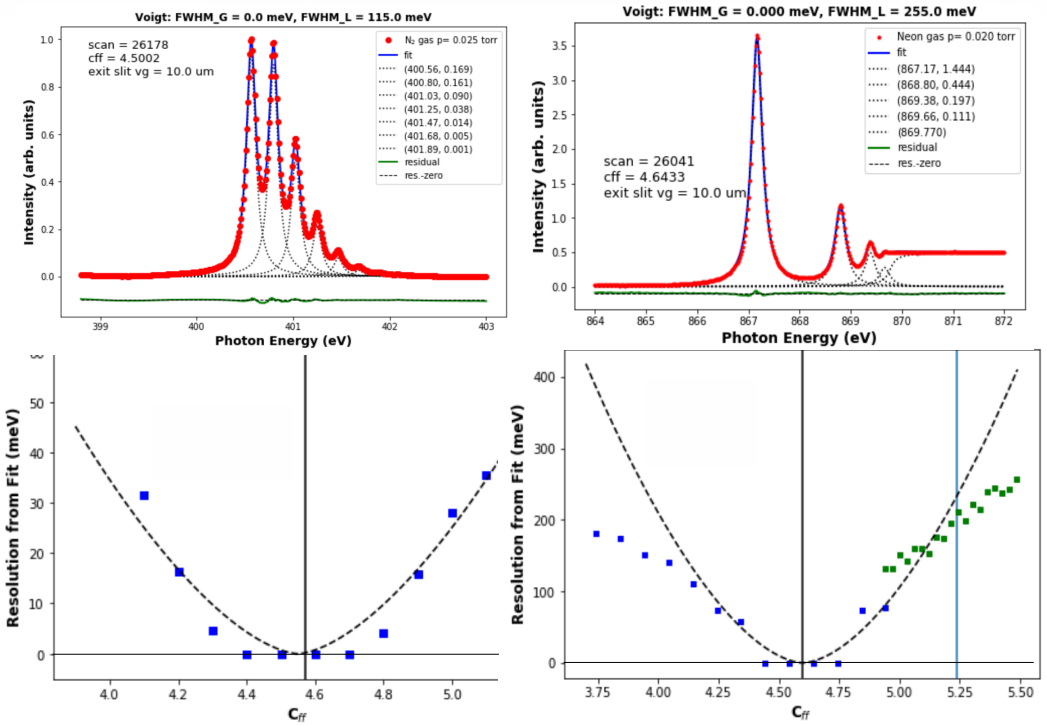
=> R ~ 19000 – 27000

- ✓ Calibrate the PGM energy
- ✓ Estimate the energy resolution
- ✓ Identify the optimum C_{ff} value

SIX Beamline: Energy Resolution for GR 1800lmm^{-1}

- XAS transmission measurement of reference gases

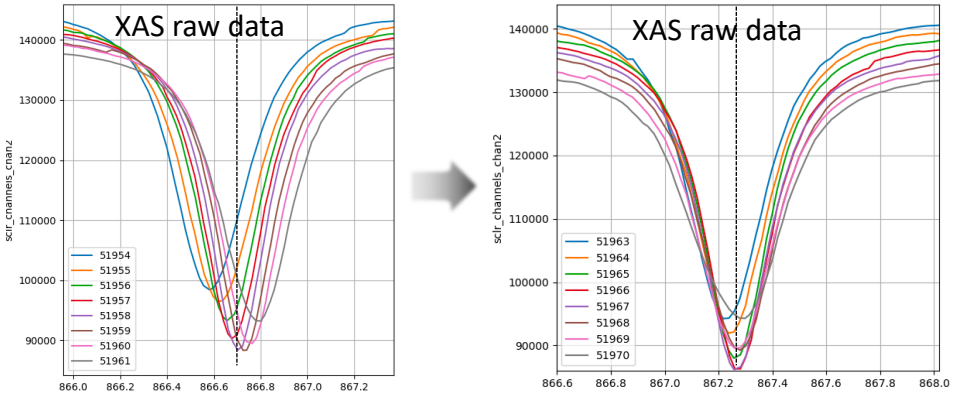
GR 1800 lmm^{-1} – Resolving Power ~ 100000



BL Energy:	**400 eV**	**867 eV**
Measured Res:	0 meV	0 meV
Simulated Res	4 meV	8.7 meV

- ✓ Calibrate the PGM energy
- X Estimate the energy resolution
- X Identify the optimum C_{ff} value

- PGM is calibrated when the same energy goes through the exit slit during a C_{ff} scan

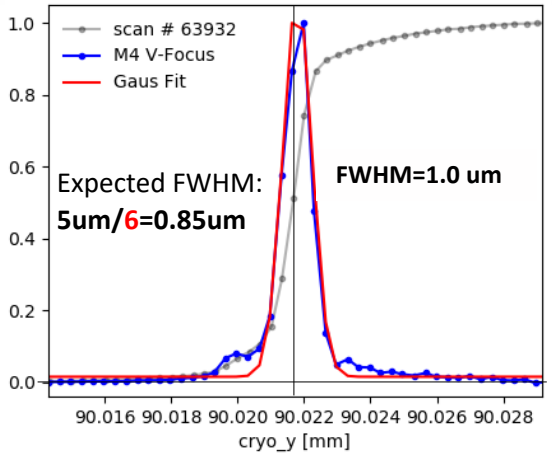


- Fine tuning of C_{ff} optimal value is done using the spectrometer

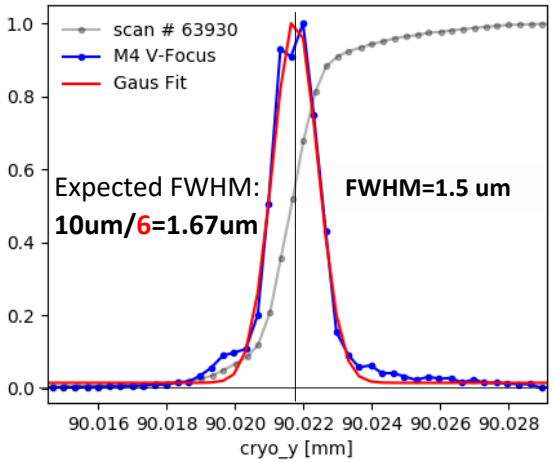
SIX Beamline: Beam Size at the Sample

- New M4 refocusing mirror from JTEC installed in April 2019

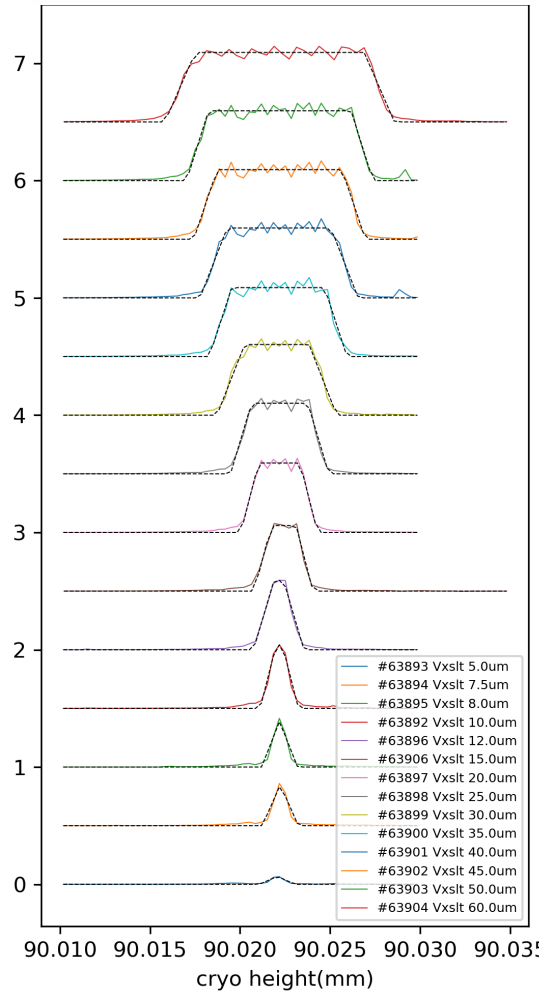
EXIT SLIT VG 5 um



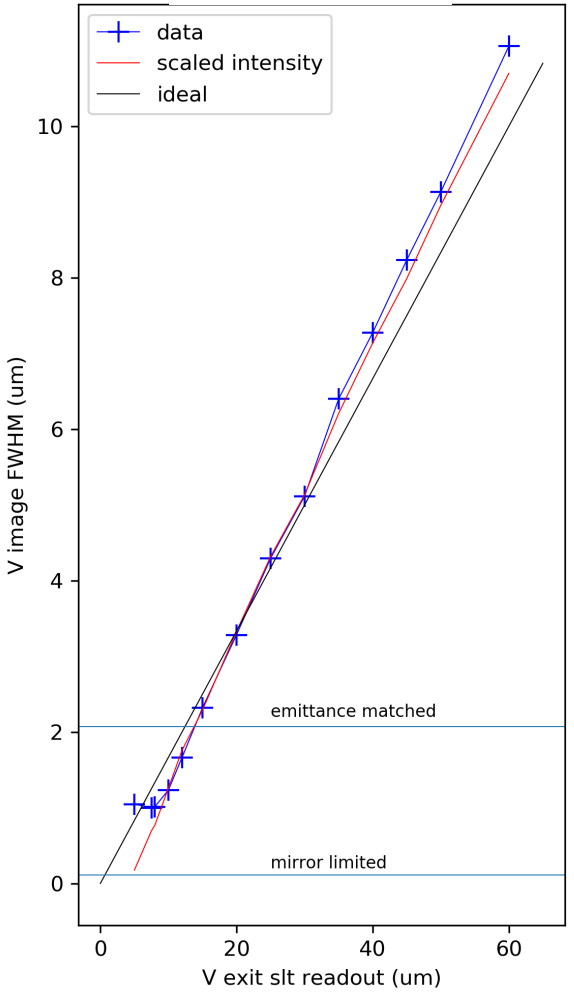
EXIT SLIT VG 10 um



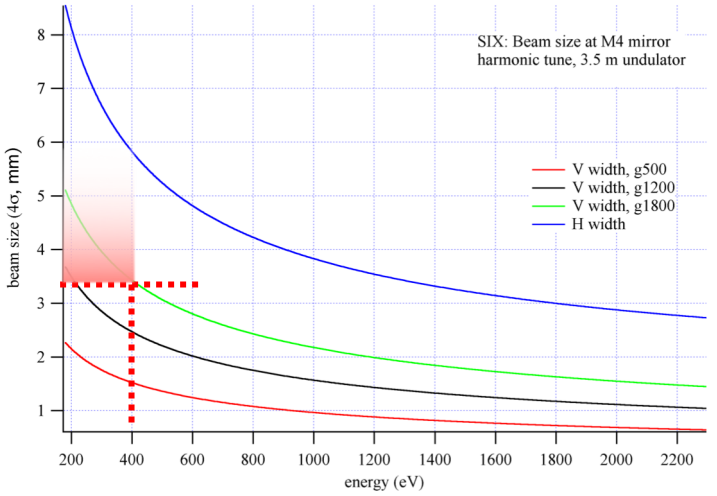
Vertical Beam Profile vs Exit Slit VG



Vertical Focus Size



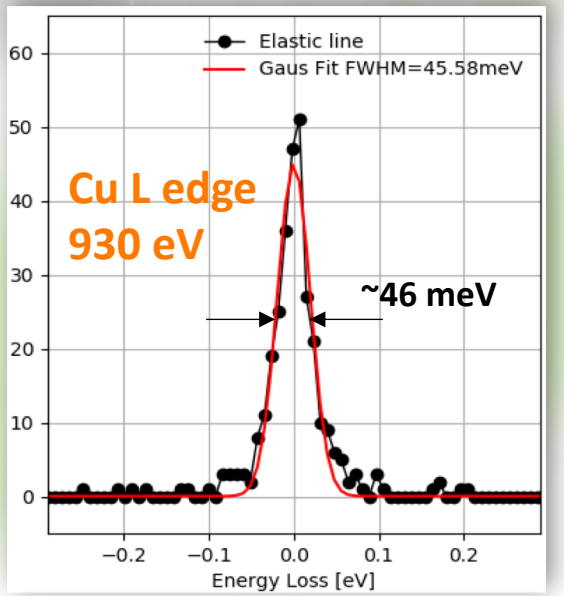
Performance close to ideal while using a 2 mm vertical gap on the baffle slits prior to the mirror

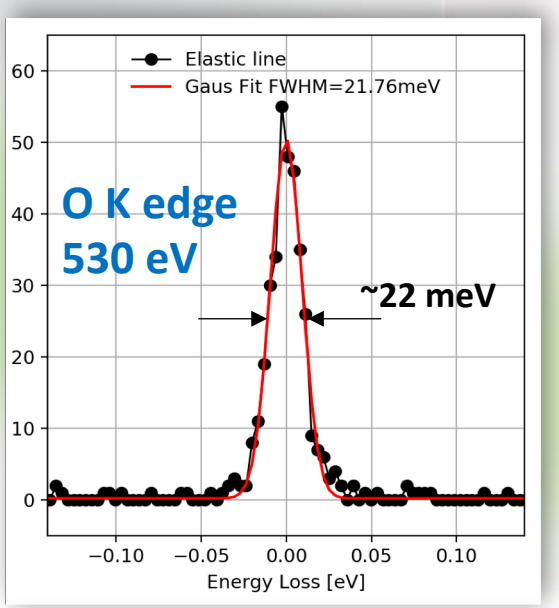


Centurion Spectrometer: Current Performances

BL GR 500 lmm^{-1} / SP GR 2500 lmm^{-1}

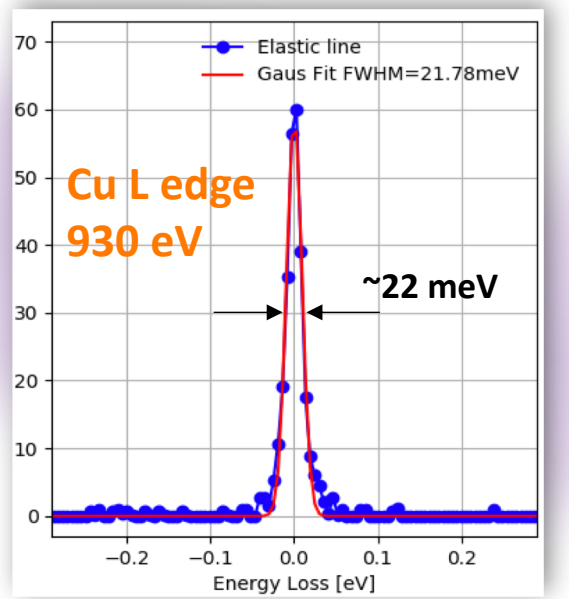
Resolving Power ~ 21000

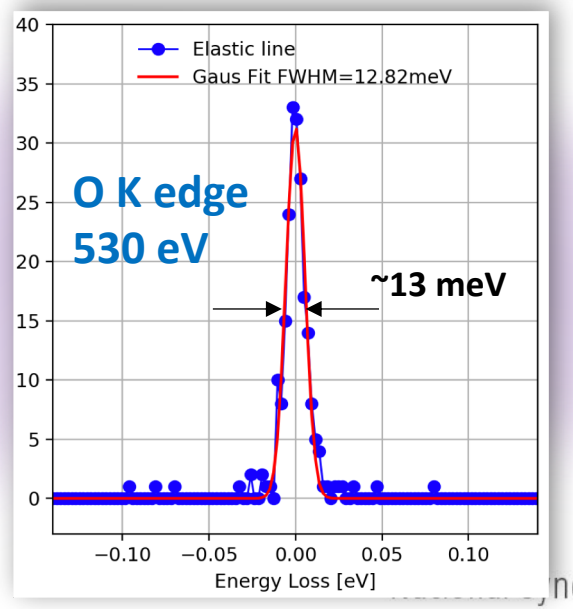




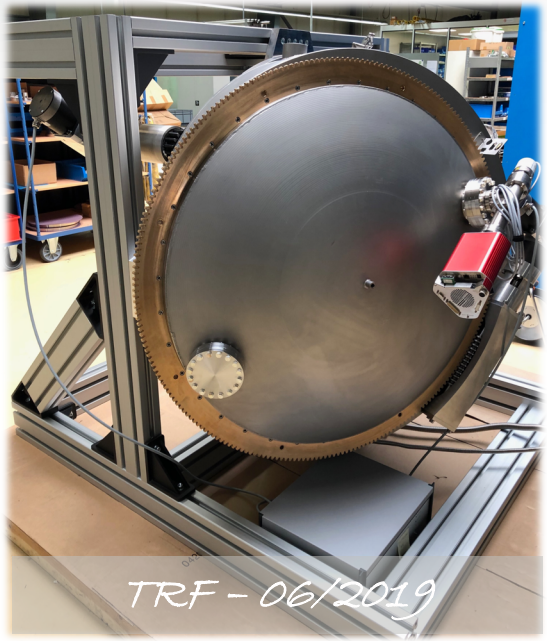
BL GR 1800 lmm^{-1} / SP GR 2500 lmm^{-1}

Resolving Power ~ 42000

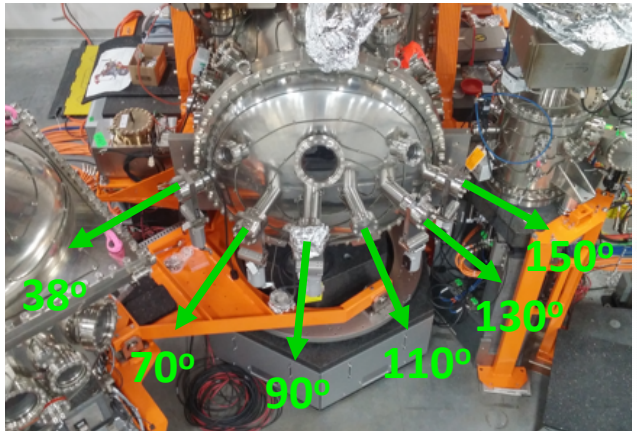




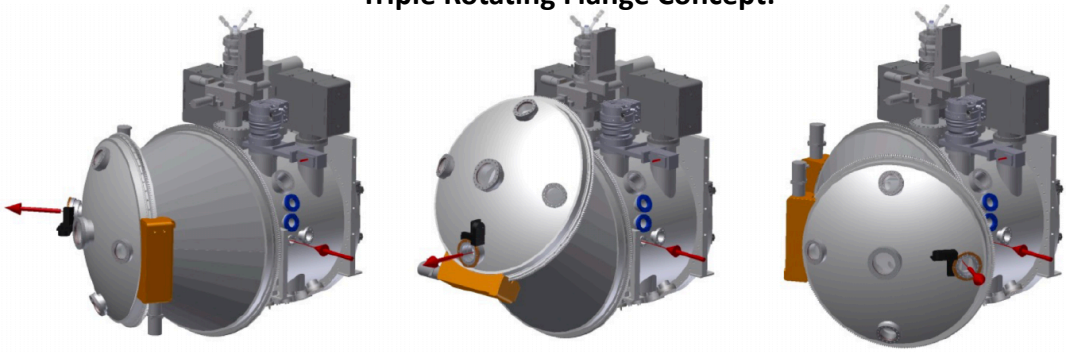
Centurion Spectrometer: Scattering Arm Rotation



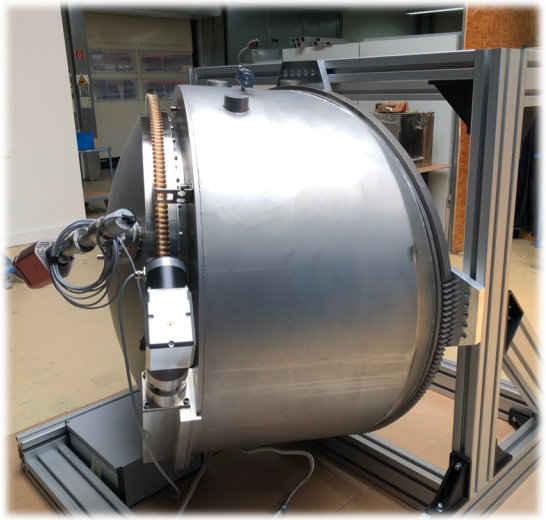
- Spectrometer arm motion system fully implemented and commissioned.
- Sample chamber is equipped with a discrete number of fixed exit ports.
- Long term solution: fully in vacuum rotation with Triple Rotating Flange



Triple Rotating Flange Concept:



2θ = 38° 2θ = 94° 2θ = 150°



Thanks for your attention!