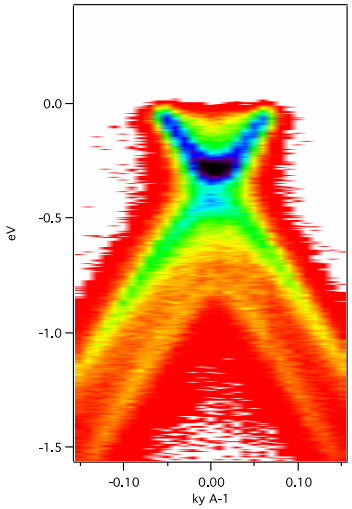
Argonne NATIONAL LABORATORY

Exploring Emergent Electronic Behavior with Intermediate Energy X-Rays at the New Sector 29

Jessica McChesney

U.S. DEPARTMENT OF ENERGY

IEX Beamline: Scientific Case



Interacting electrons in the valance band lead to novel physics

- Spinon excitation
- Charge ordering (stripes)
- Deconfined magnetic monopoles

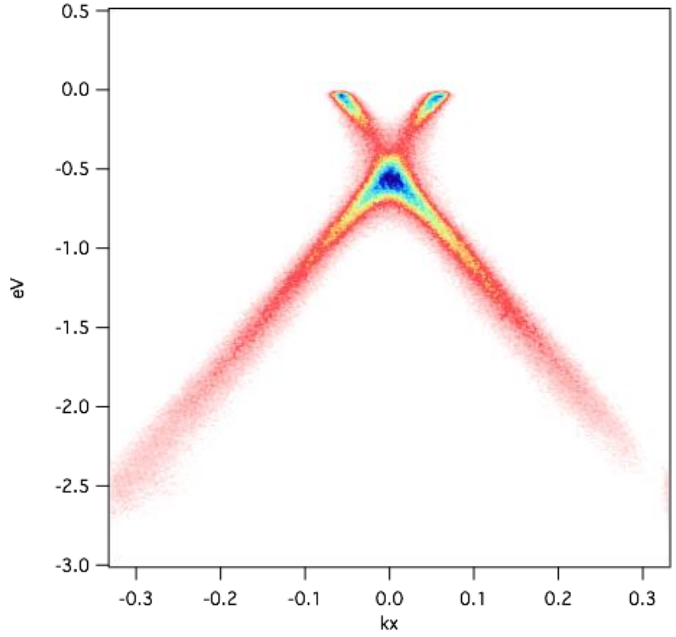
This emergent behavior arises when several energy scales are of the same size:

- Coulomb repulsion
- Valance bonding
- Kinetic energy of the mobile electrons
- Magnetic interaction energy

Probe the electronic structure via

Resonant Elastic Scattering

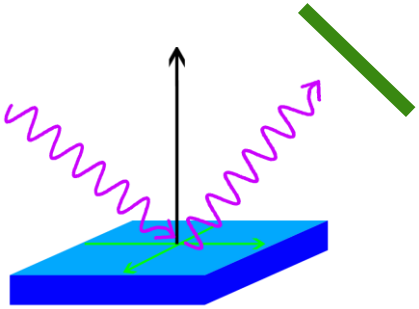
Angle-Resolved Photoemission Spectroscopy

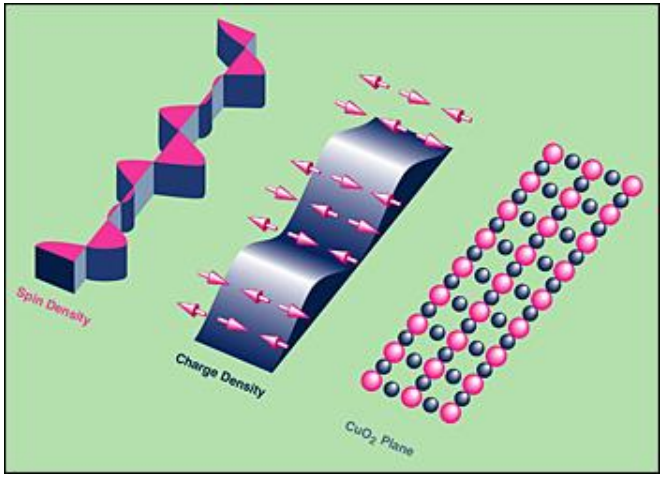


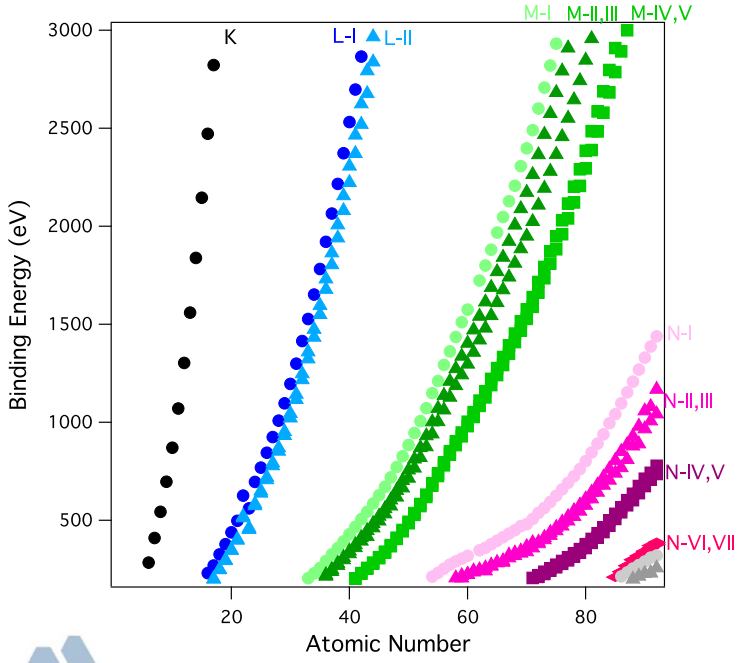
Resonant Elastic Soft X-Ray Scattering (RSXS)

RSXS spatial correlations/ordering

Photon in – photon out
Measures Q = k_{in} - k_{out}







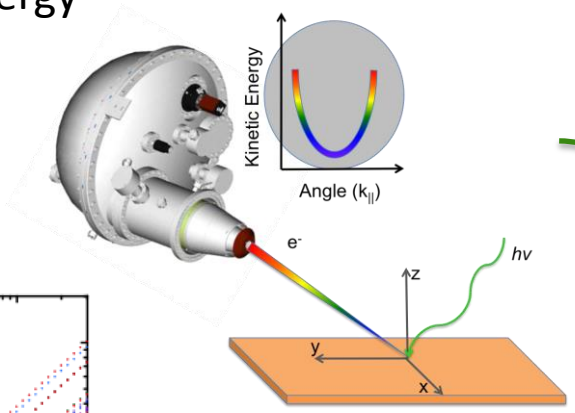
- L-edge of transition metal (d electrons)
- M-edge of rare-earths (f electrons)
- K-edge (N to S)

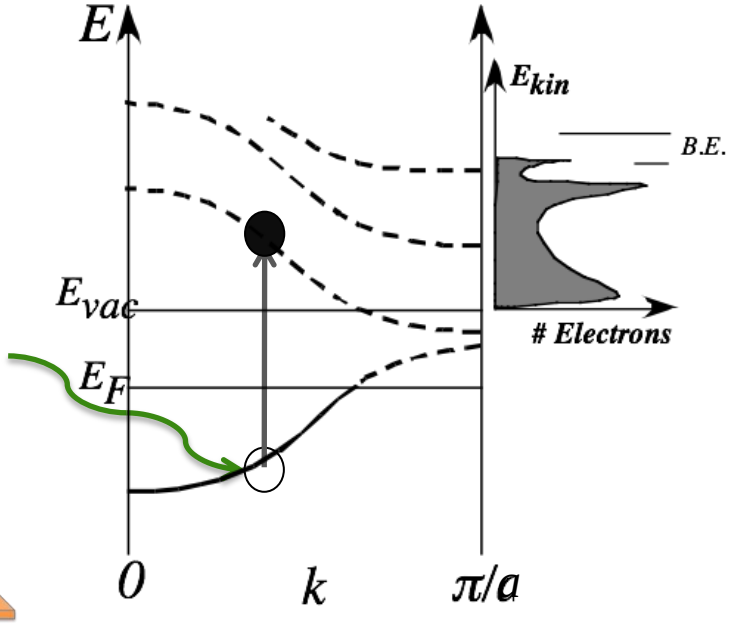
Wave length well matched
- λ ~ 0.5 to 5 nm

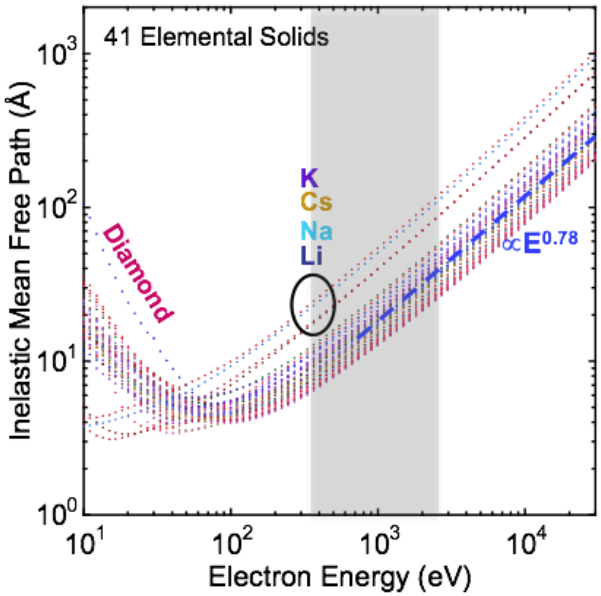
Angle-Resolved Photoemission Spectroscopy (ARPES)

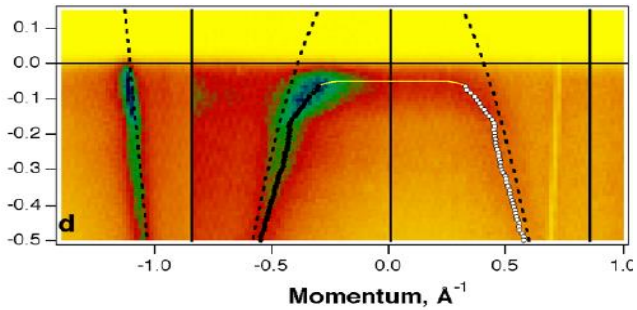
ARPES maps excitation in energy-momentum space

Photon in – electron out
Measures E(k)



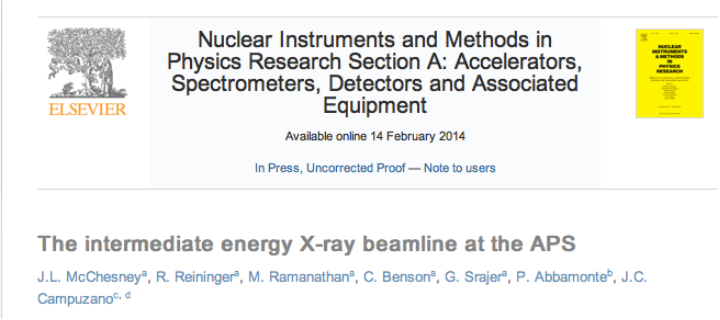


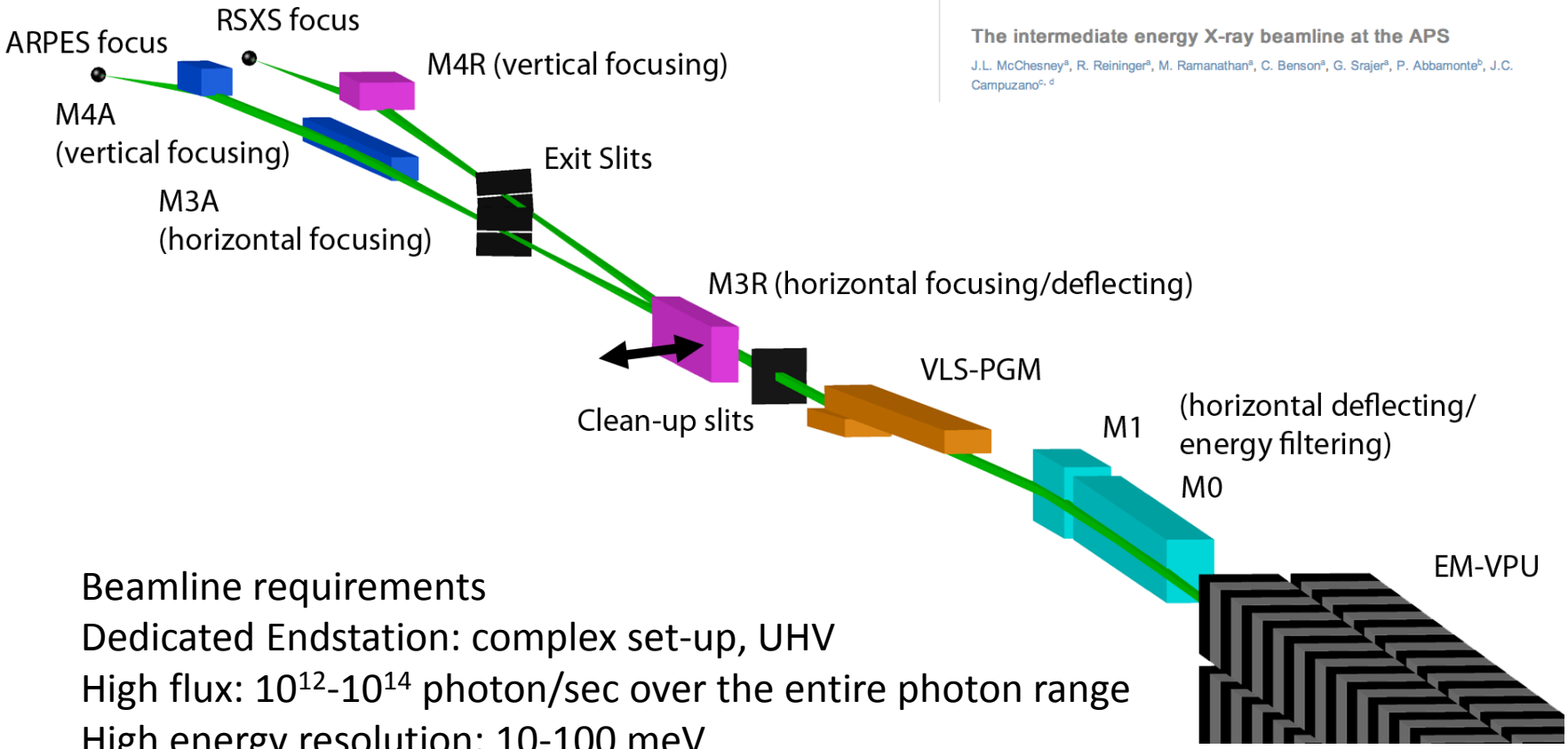




Increased Bulk Sensitivity - longer e^- escape depth

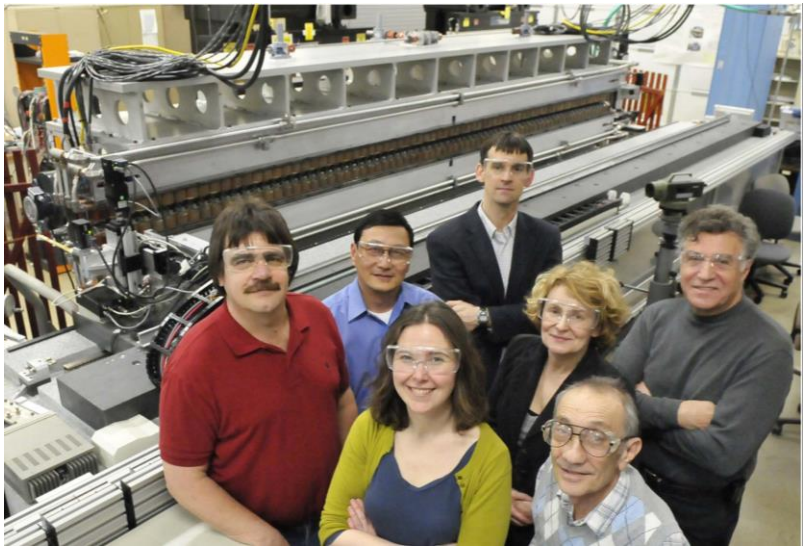
IEX Beamline: 29ID overview



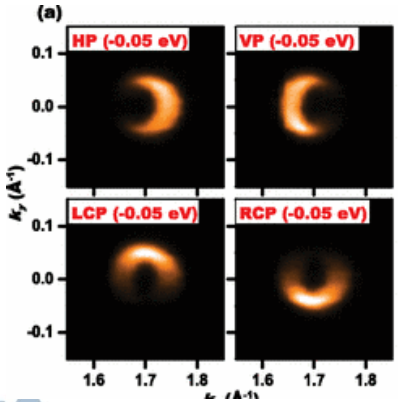


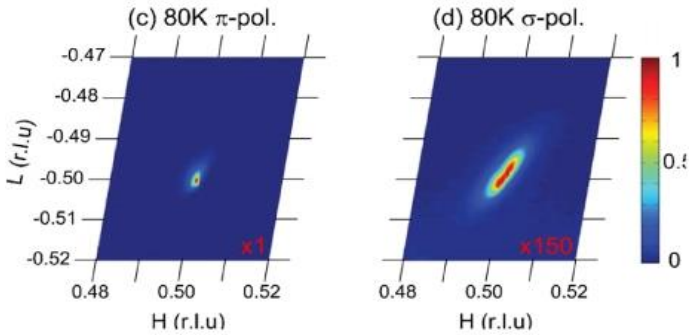
Beamline requirements
Dedicated Endstation: complex set-up, UHV
High flux: 10^{12}-10^{14} photon/sec over the entire photon range
High energy resolution: 10-100 meV
Small spot size: 5-50 µm

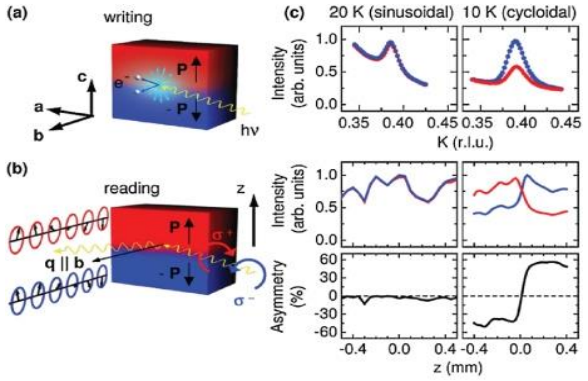
Electromagnetic Variable Polarizing Undulator (EM-VPU)



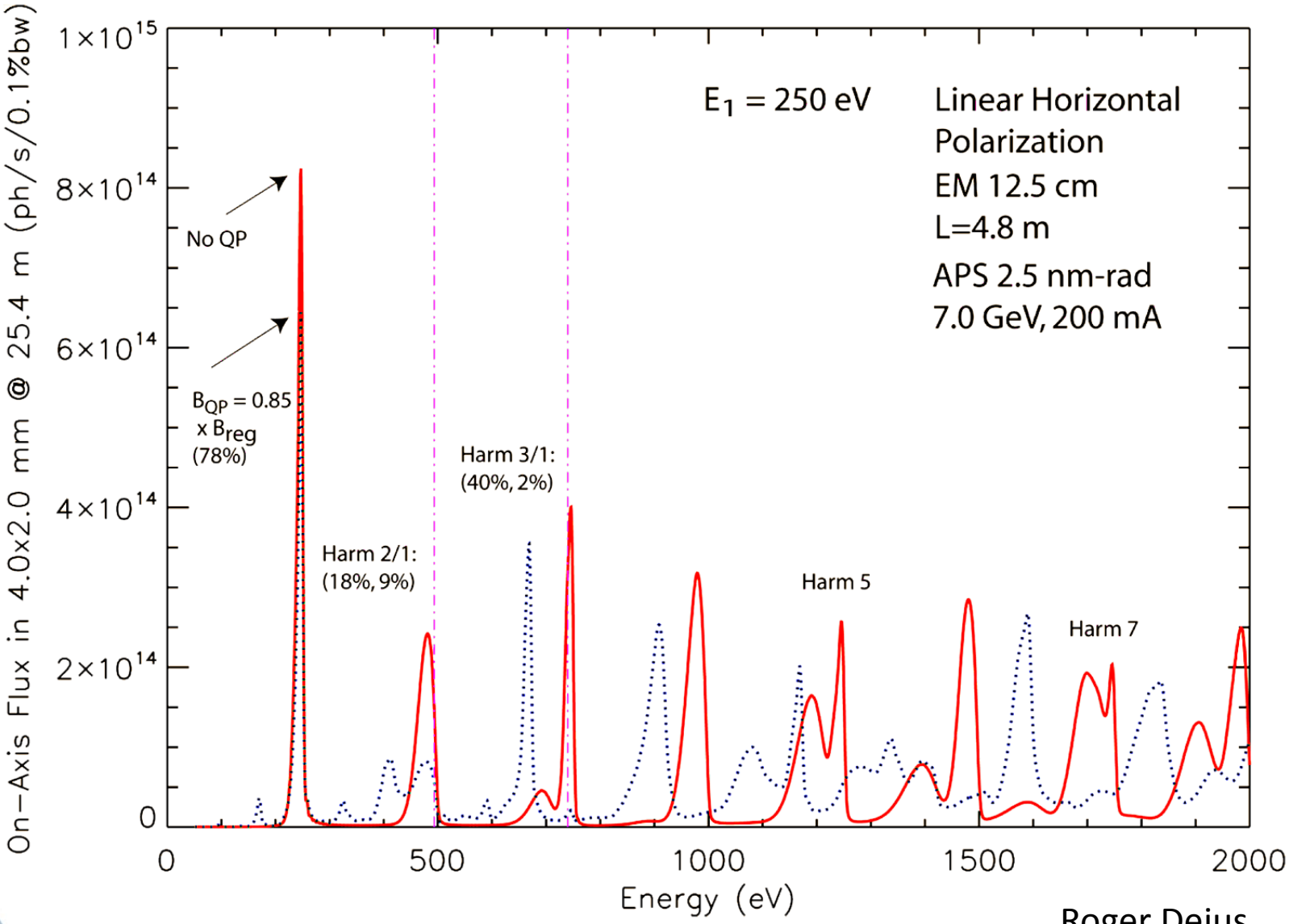
- 12.5 cm period; 38 periods
- 10.5 mm fixed gap
- Quasiperiodic – Reduction in higher order light
- $LP_{Horizontal}$: 250 eV – 2500 eV
- $LP_{Vertical}$ and CP: 440 eV – 2500 eV





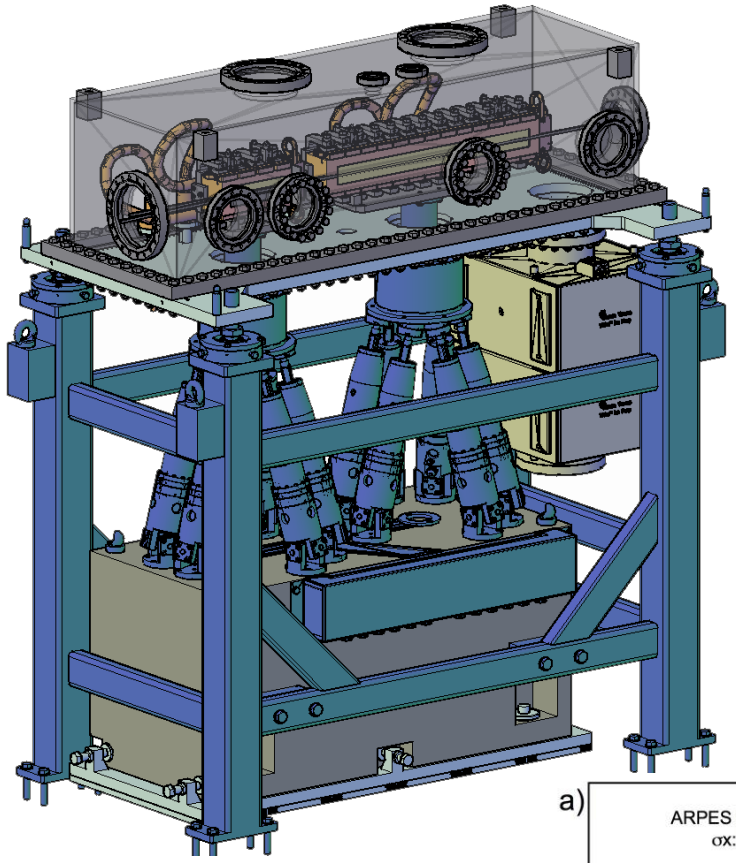


Quasiperiodicity



Roger Dejus

Optics:



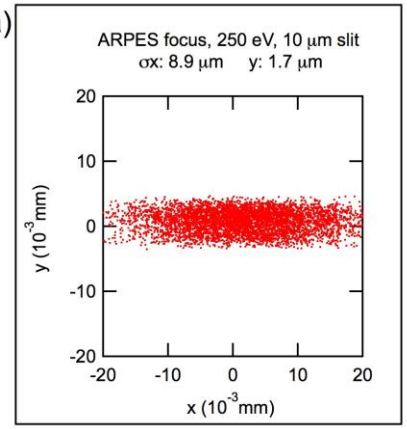
Energy Filtering:
M0: planar (0.8° outboard)
M1: planar (3.8° outboard)

Monochromator (VLS-PGM):
M2: internally cooled planar, (downward)
Gratings: VLS (0.8° upward)

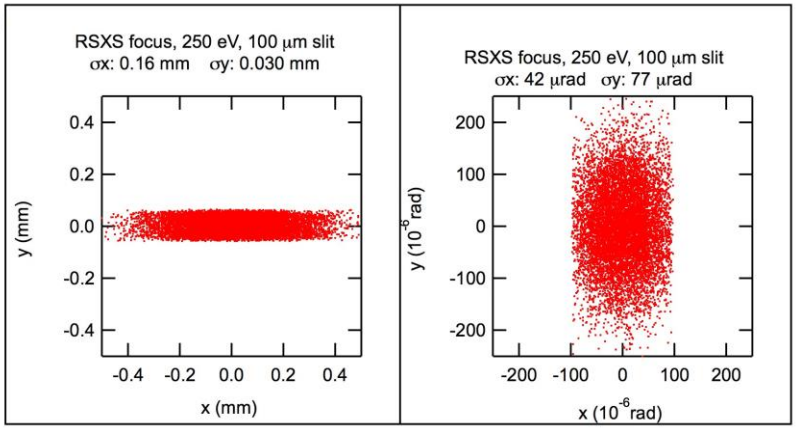
C-branch (ARPES focus: 21 µm x 4 µm)
M3A: elliptical (6.8° outboard)
M4A: elliptical (2.2° downward)

D-branch (RSXS foucs: 160 µm x 30 µm)
M3R: spherical (1.3° outboard)
M4R: spherical (1.7° downward)

a)

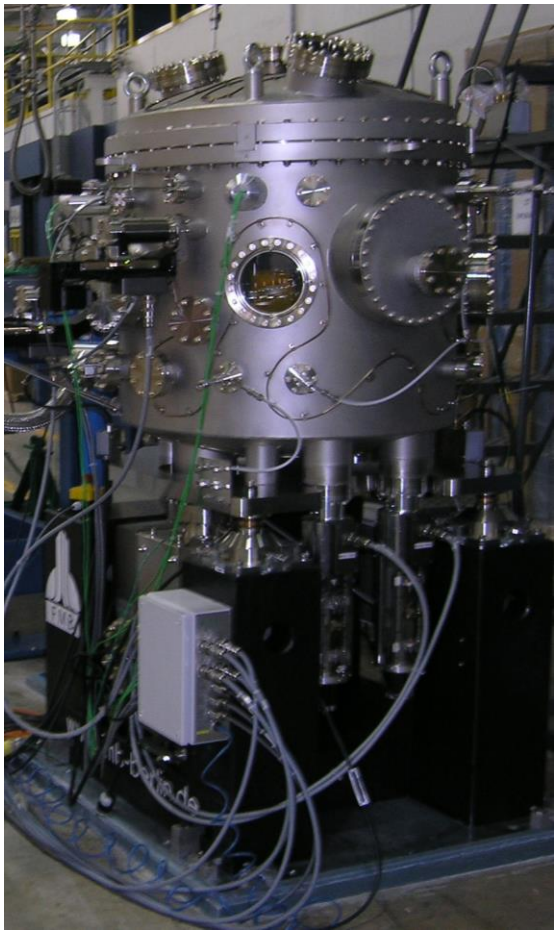


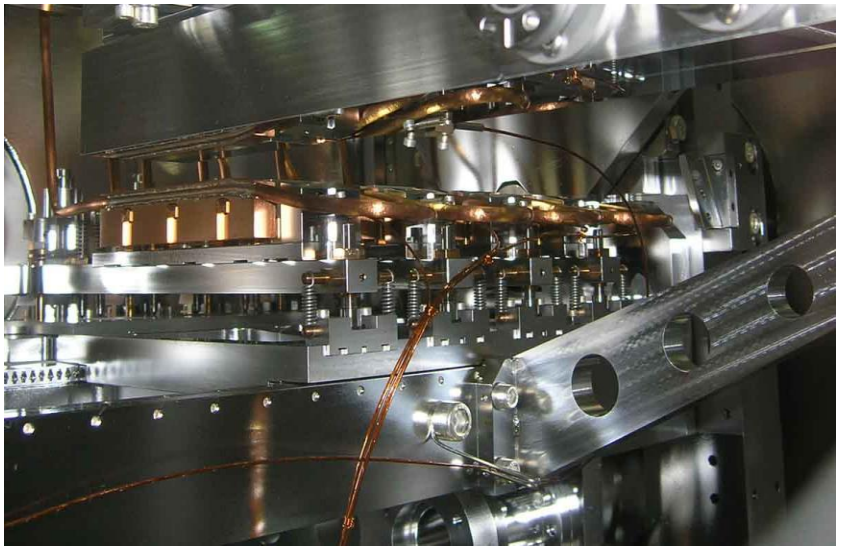
b)



Variable Line Space Plane Grating Monochromator (VLS-PGM)

Grating	k_0 (line/mm)	*Resolving Power (E/ΔE)*	*Flux (photon/sec)*	Energy range
HEG	2400	50,000	2×10^{10}	250 – 2,000 eV
MEG	1200	10,000 2,500	2×10^{11} 2×10^{9}	250 – 2,000 eV 2,000 – 3,000 eV
LEG	400	2,500	4×10^{12}	250 – 2,000 eV

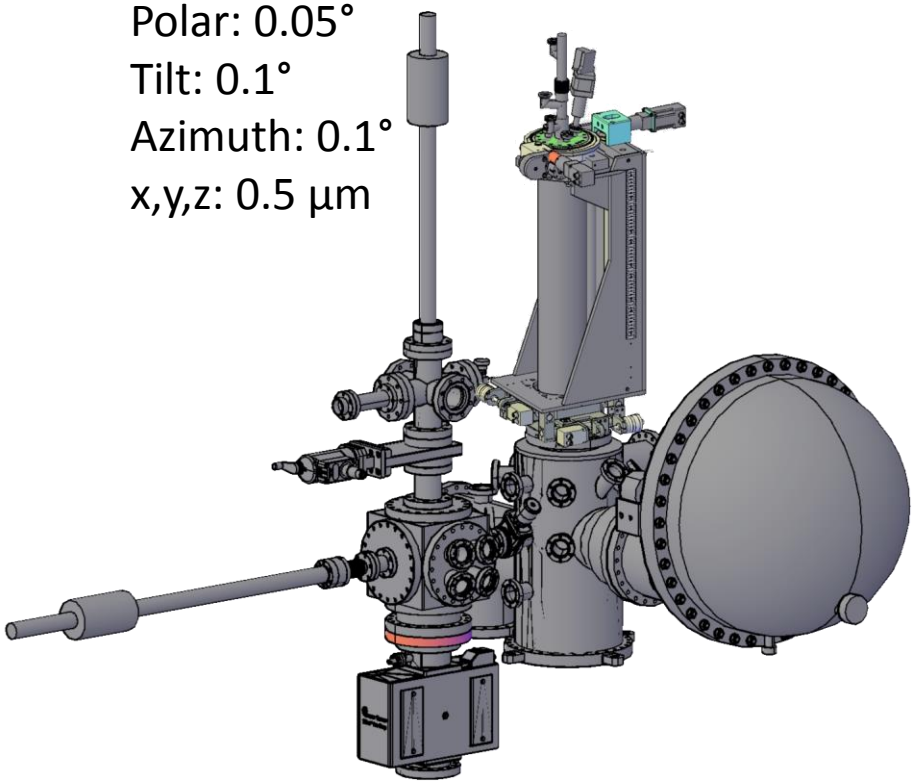




Endstations

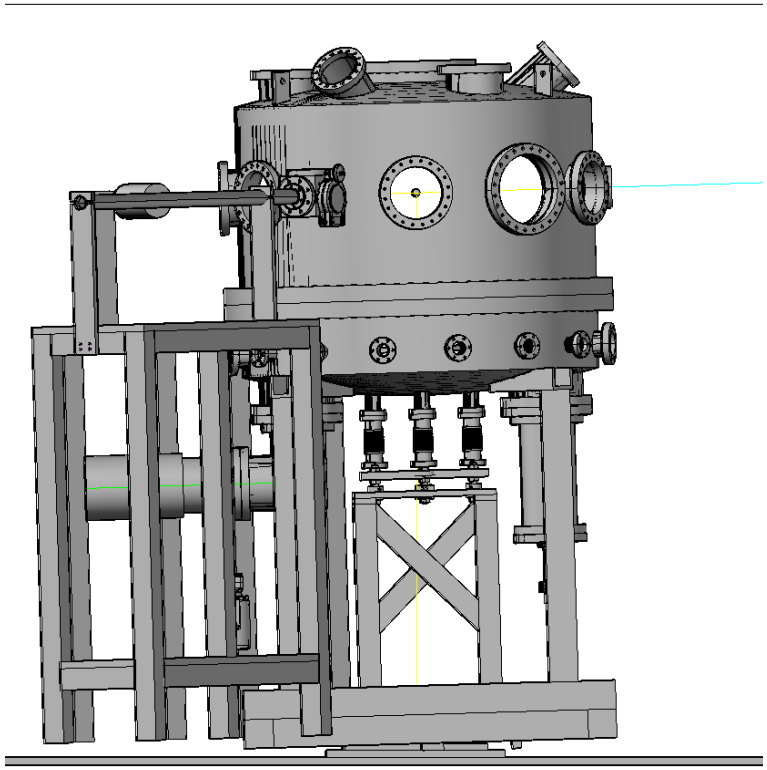
Angle-resolved photoemission spectroscopy (ARPES)

- Scienta R4000 electron analyzer
  energy: 1.8 meV, angle: 0.01°
- Low temperature 6-axis goniometer (T<7K)
  Polar: 0.05°
  Tilt: 0.1°
  Azimuth: 0.1°
  x,y,z: 0.5 µm

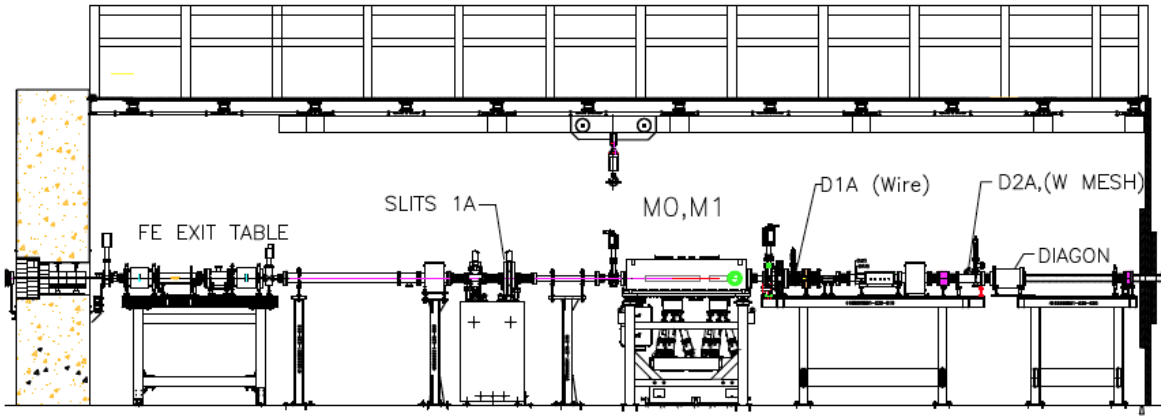


Resonant elastic scattering

- Kappa diffractometer with delay line area detector
- Closed cycle cryostat T<20K
- TES detector



First commissioning results February 2013



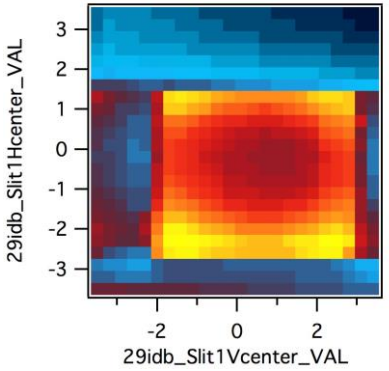
Diagnostic tools:

Slit 1A: is a movable aperture and electrically isolated

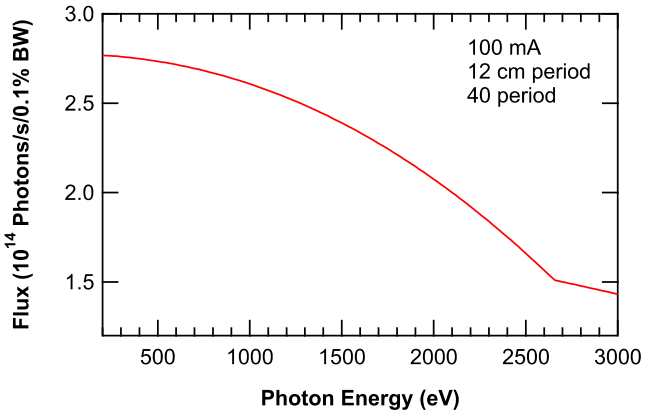
Wire monitor: both horizontal and vertical

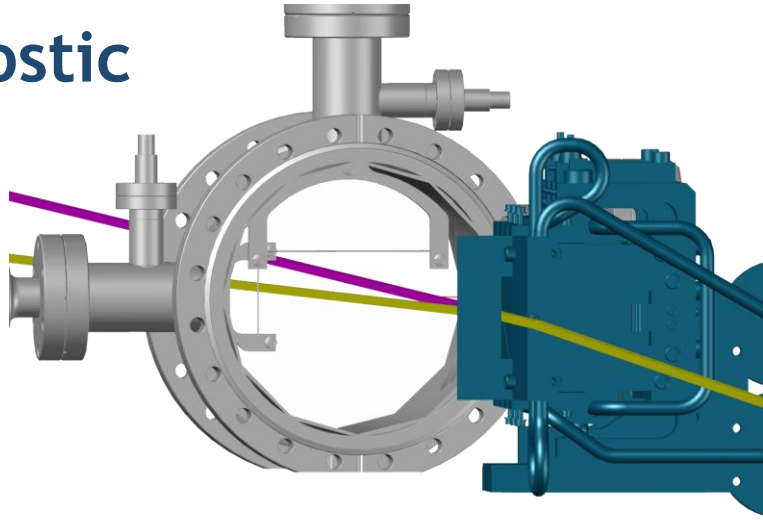
Tungsten Mesh:

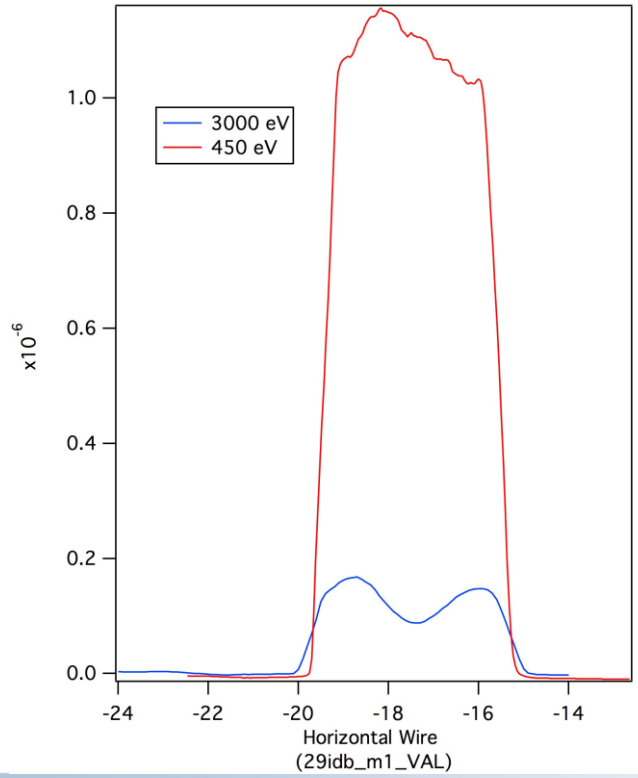
DiaGon: undulator diagnostic, image pink beam

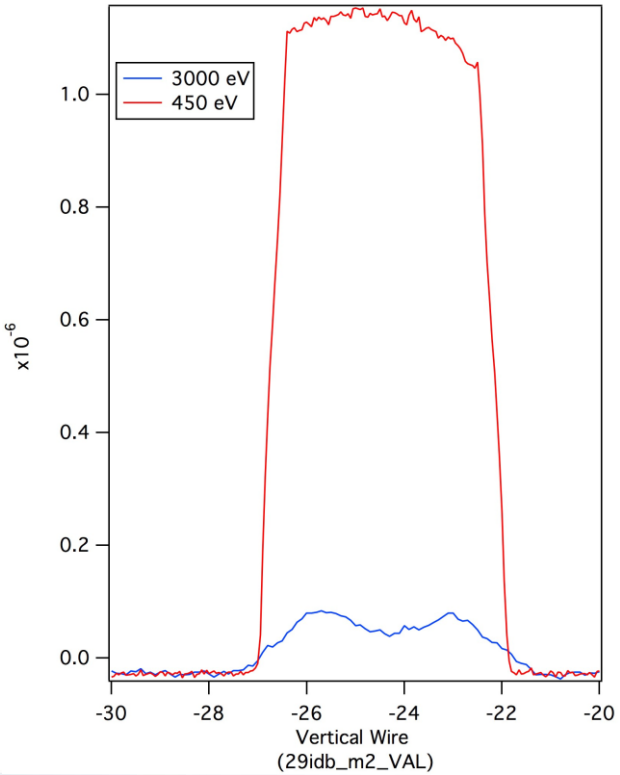


Beam profile via the wire diagnostic

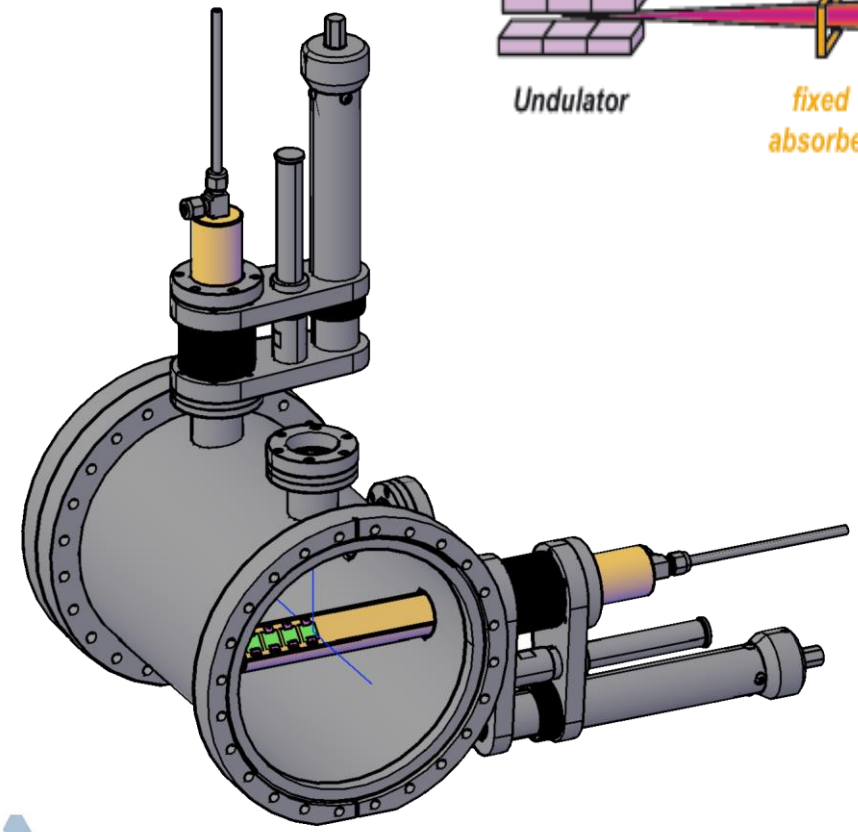


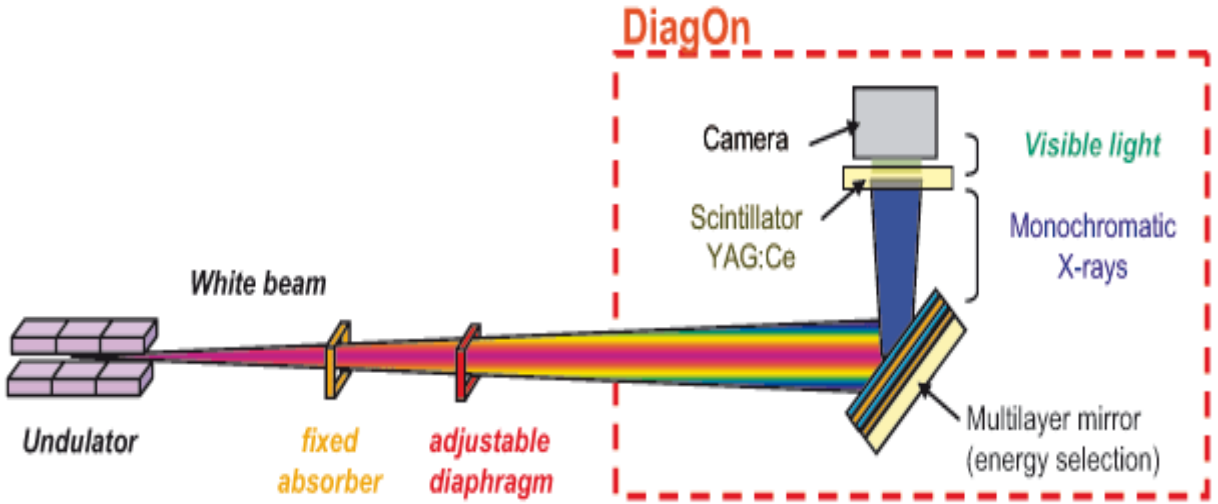




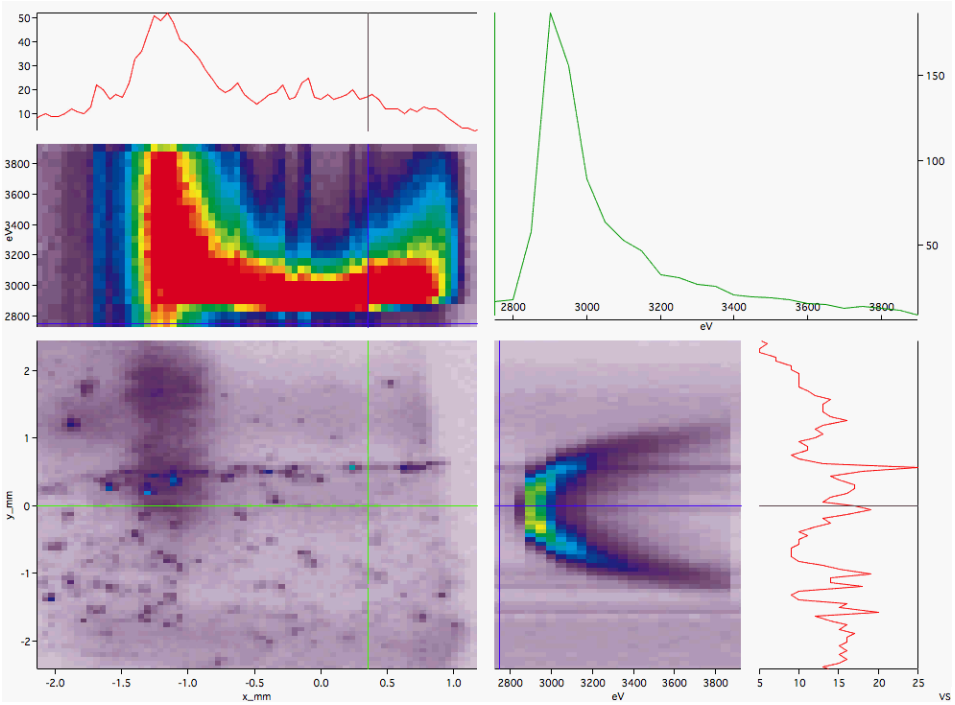


DiaGon: Imaging Pink Beam

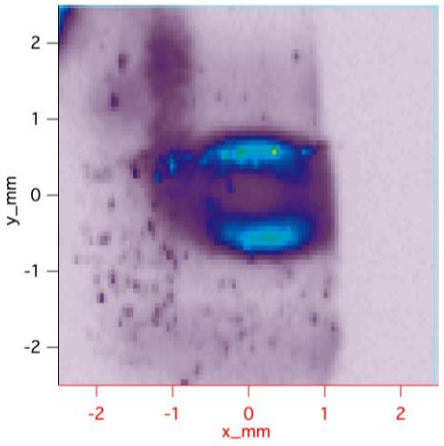




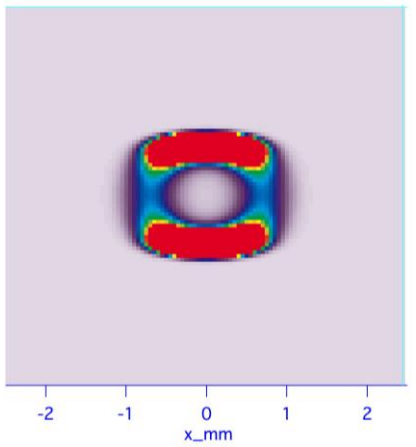
Si(111): 2800eV



3000 eV



Calculation



Timeline:

2014-1 cycle: finish installation, put beam on mono, test gas cell

2014-2 cycle: characterize beamline optics and insertion device

Complete endstations and begin commissioning

2014-3 cycle: Preliminary experiments

2015-1 cycle: Begin GU program (50%)

Acknowledgements

Beamline Design and Development

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Isaac Vasserman
Aimin Xiao
Boris Deriy
Joe Xu
Marty Smith

Beamline Installation and Implementation
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AES-MOM mechanical group

BCDA: Dohn Arms and Tom Walsh

Survey and Alignment