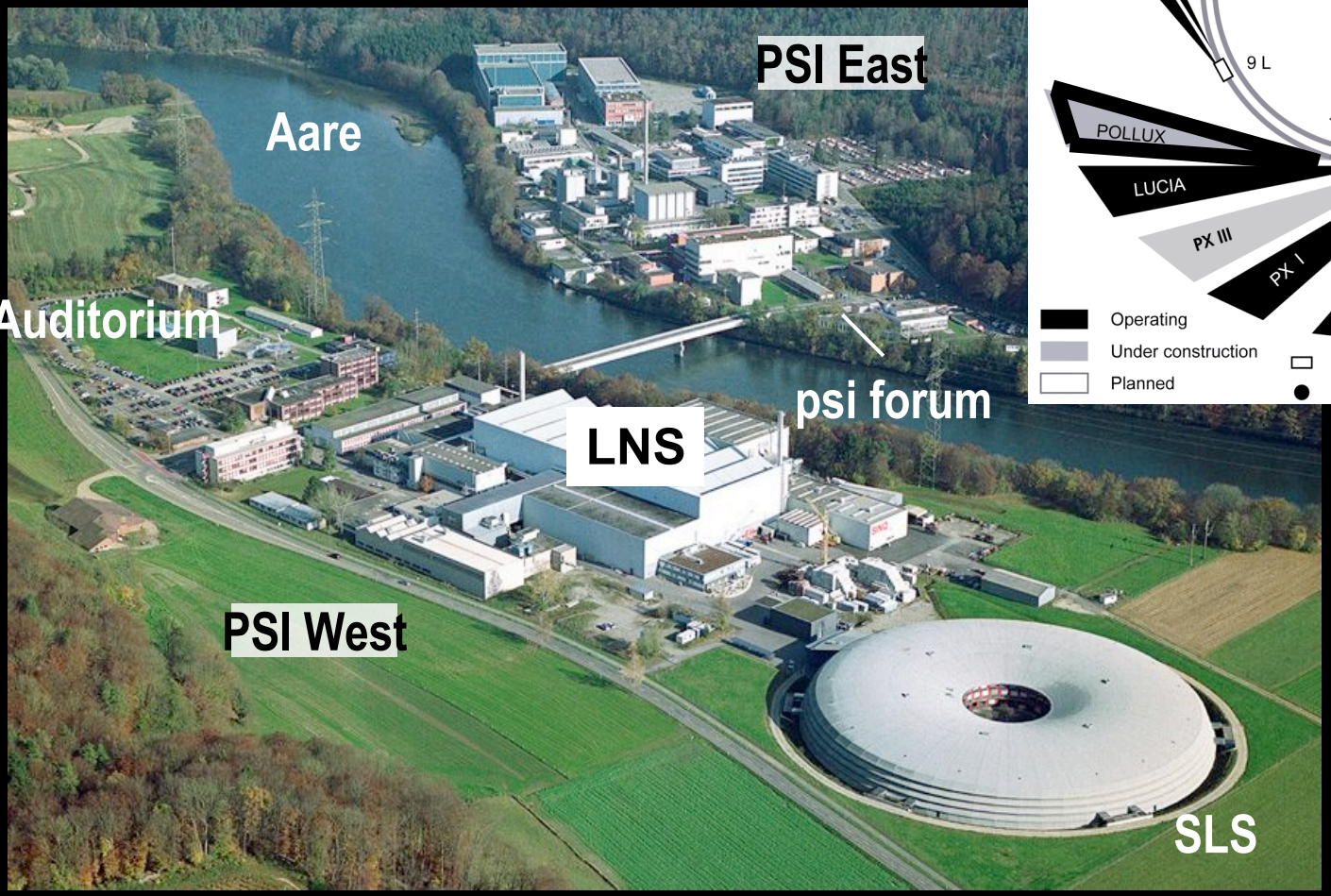
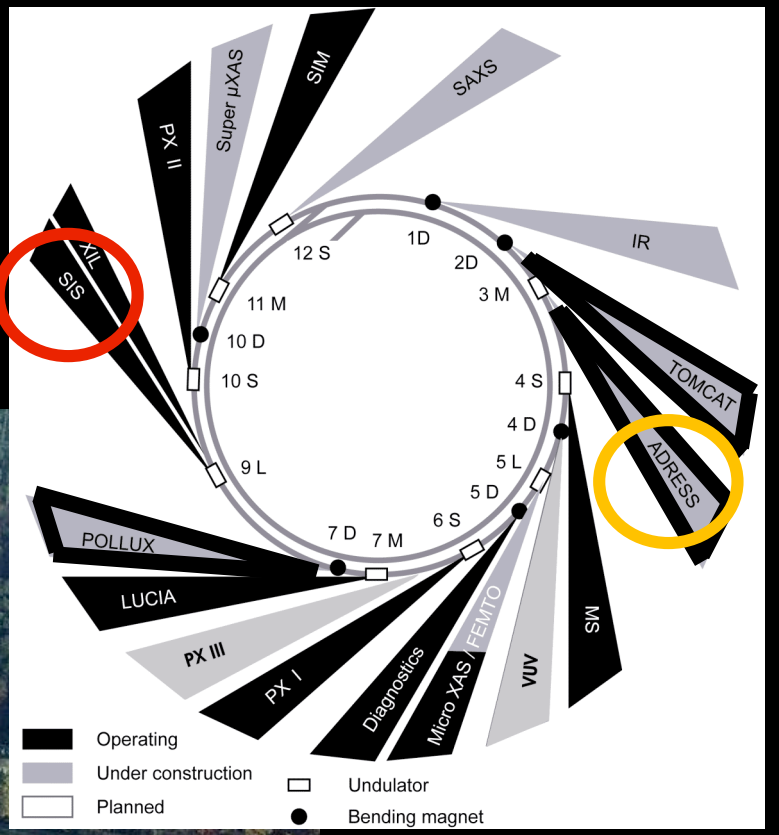
Soft X-ray ARPES: Getting around the surface and final state effect

L. Patthey

Swiss Light Source (SLS) @ Paul Scherrer Institut (PSI) in Villigen



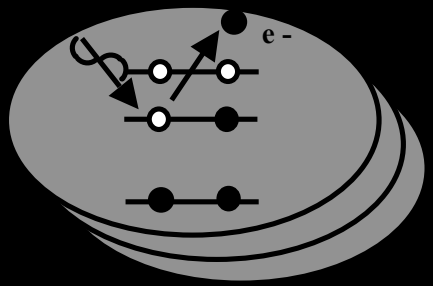


12 BLs operat.
5 BLs constr.

SIS versus ADRESS beamlines

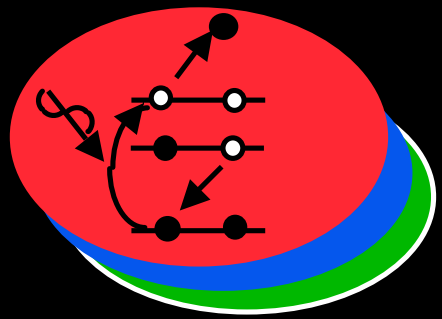
Low energy (10 - 800 eV) versus High energy 400 - 1800 eV

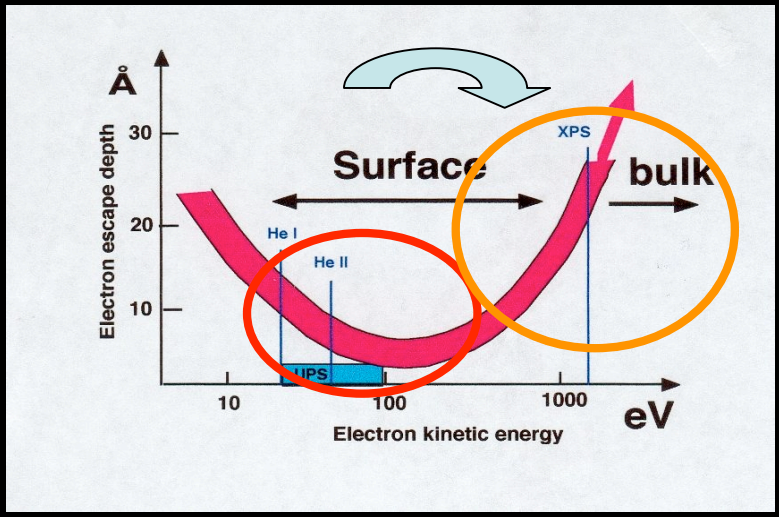
ARPES/SR-ARPES (UniZH)

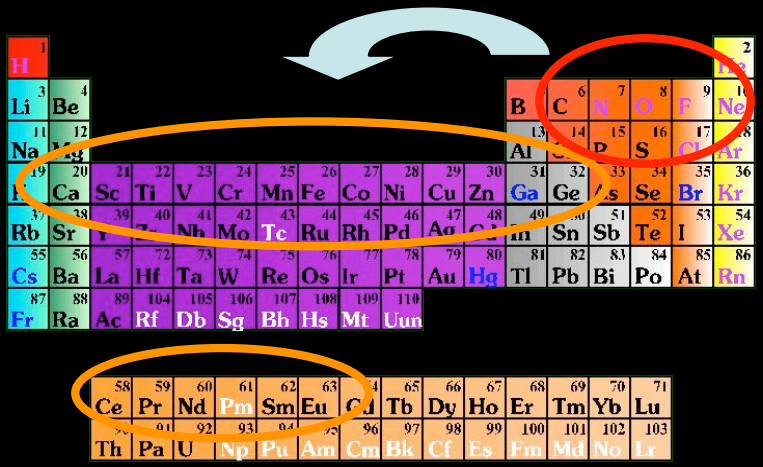


High photon flux
High resolution
Full polarization control
Low Temperature

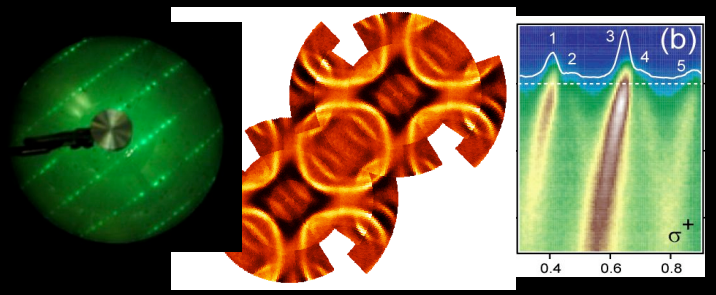
RIXS/RPES



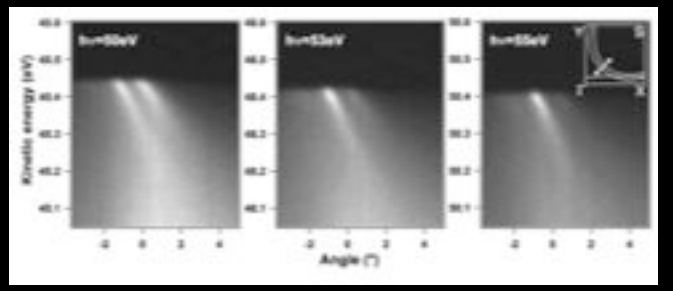




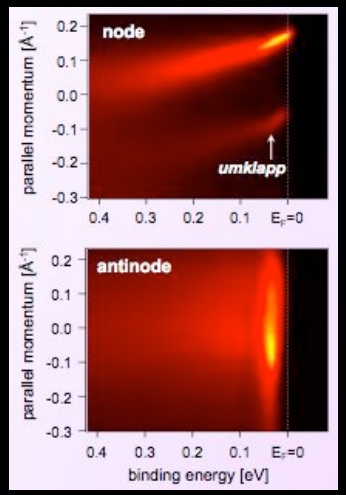
Some highlights



Shooting light into the Shadow Fermi surface
A. Mans et al. PRL (06)

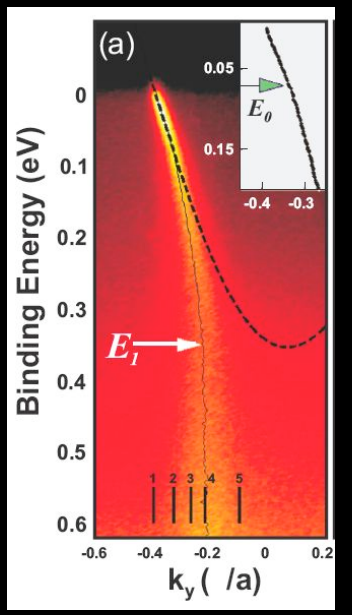


Kinks, Nodal Bilayer Splitting, and Interband Scattering in YBa2 Cu3 O6
V. Borisenko et al. PRL (06)

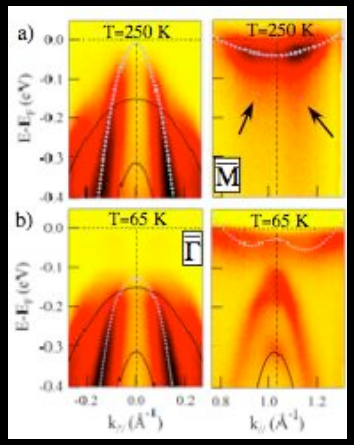


Photoemission investigation on triple layered BISCCO superconductor A. *Bendounan et al.*

Study of low- and high-energy electronic responses in hightemperature superconductors
J. Chang et al. PRB (07)
Presentation by J. Chang on Friday, April 27

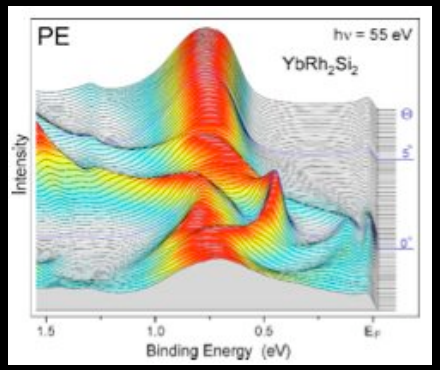


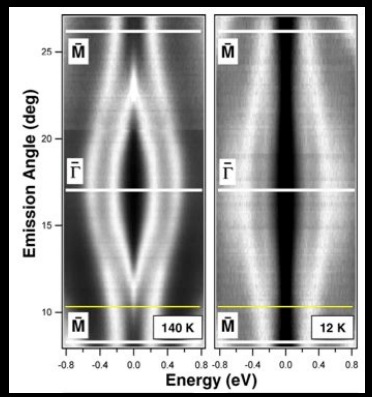
Some highlights



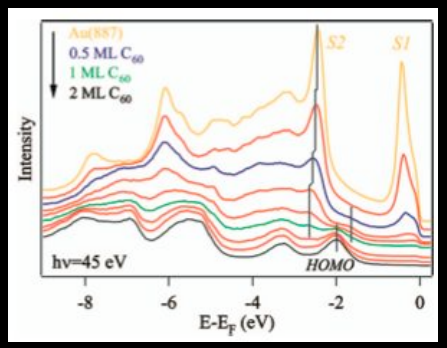
Evidence for an excitonic insulator phase in 1T -TiSe2
H. *Cercellier et al.*

Momentum dependence of 4f hybridization in heavy-fermion compounds
S. Danzenbächer et al. PRB (07)



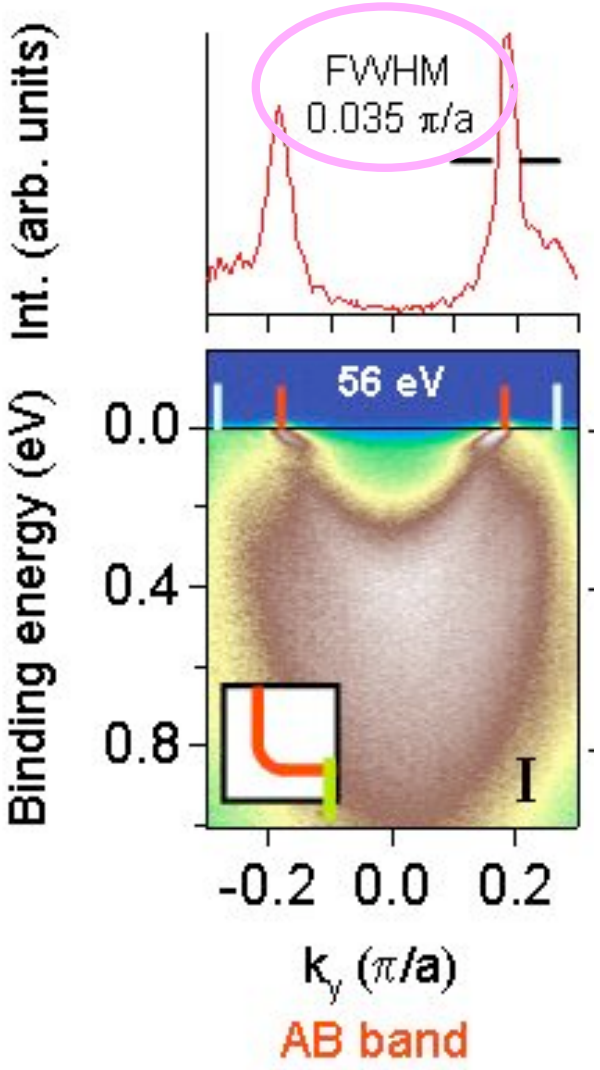


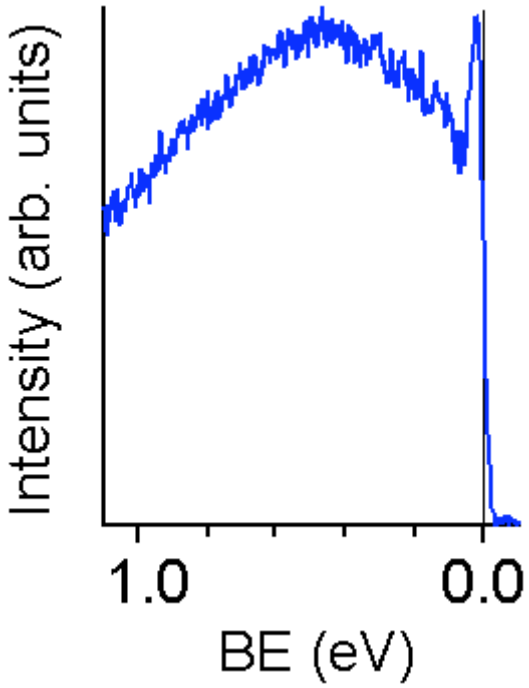
Observation of a Mott Insulating Ground State for Sn/Ge(111) at Low Temperature
R. Cortés et al. PRL (06)



Electronic structure of C60 on Au(887)
F. Schiller et al. JCP (06)

μ - ARPES: AB band (at the SLS)





hν=56eV

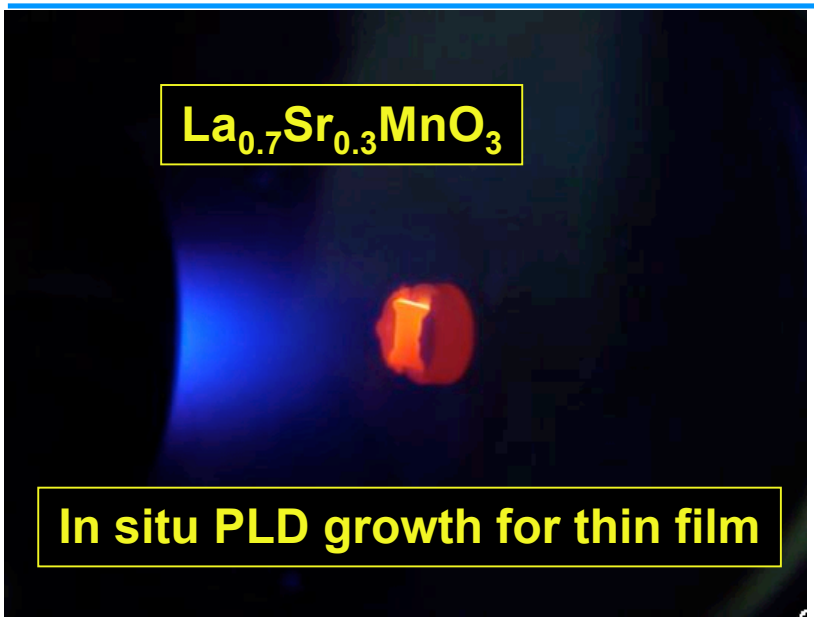
at (π/a,0)

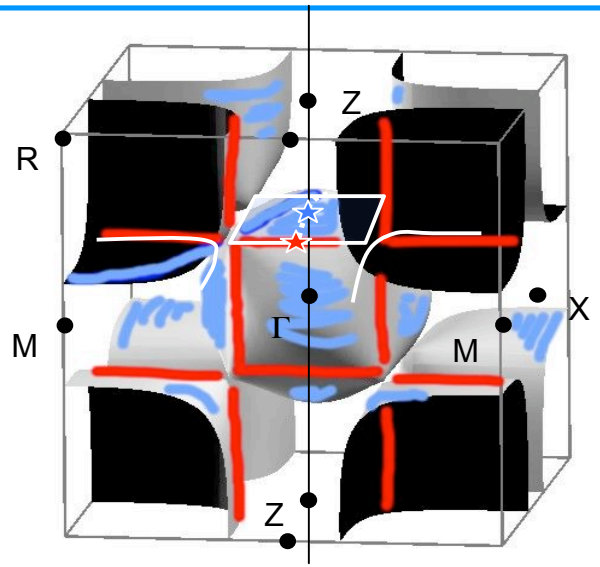
- antibonding band:
  sharp QP, resolution limited width

S. de Jong *et al.* 2006

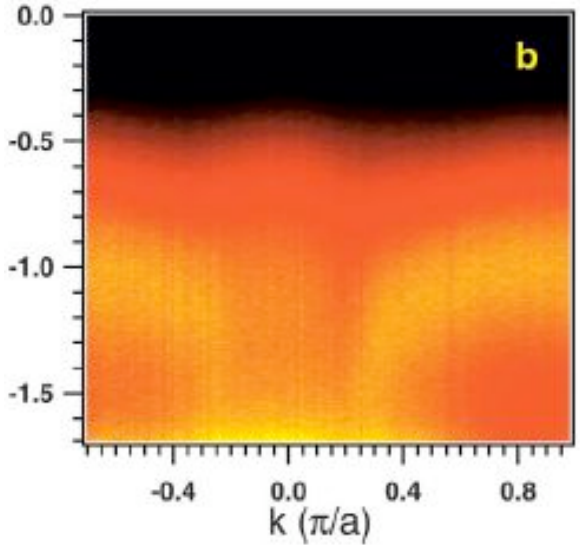
PAUL SCHERRER INSTITUT

Electronique structure of 3D complex material

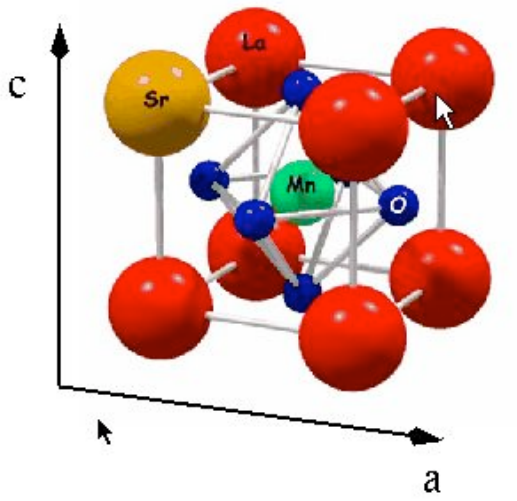




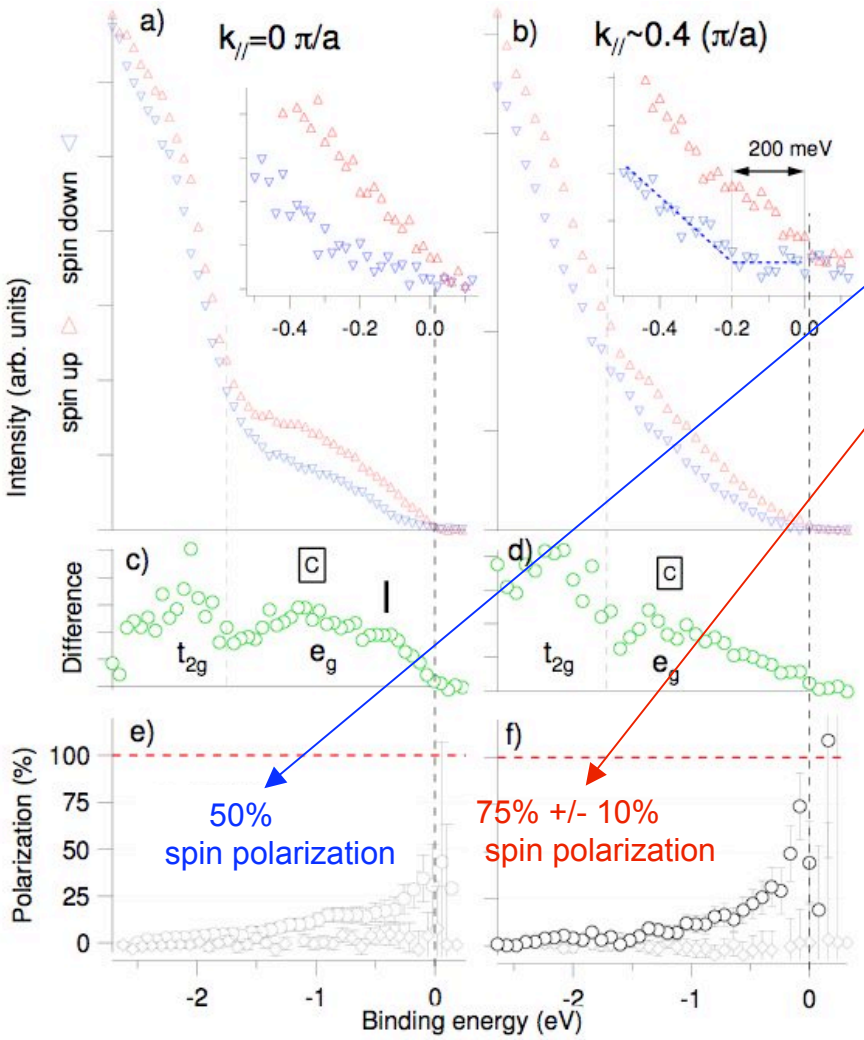
Cal.: P. Blaha, GGA LDA+U



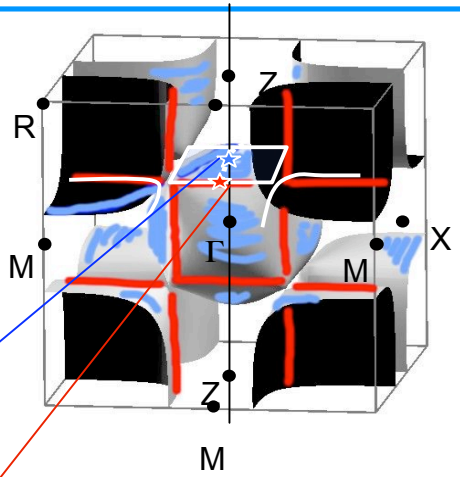
M. C. Falub et al.
PRB 72 054444, 05



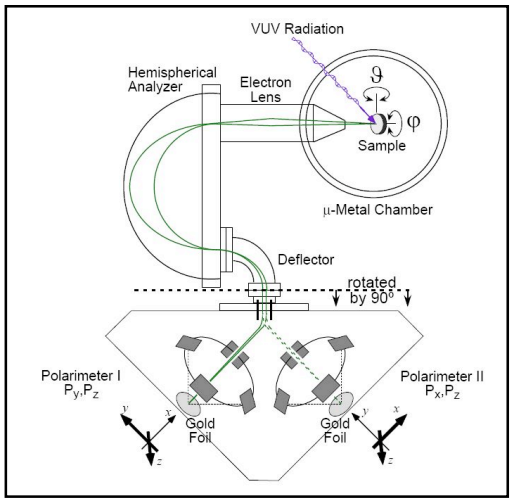
SRARPES on LSMO



J. Krempasky et al.



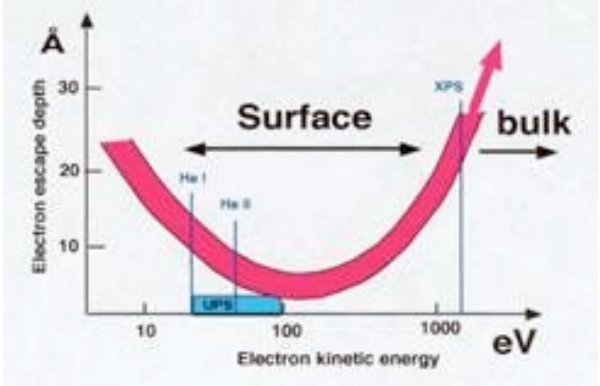
COPHEE: J. Osterwalder, UniZh

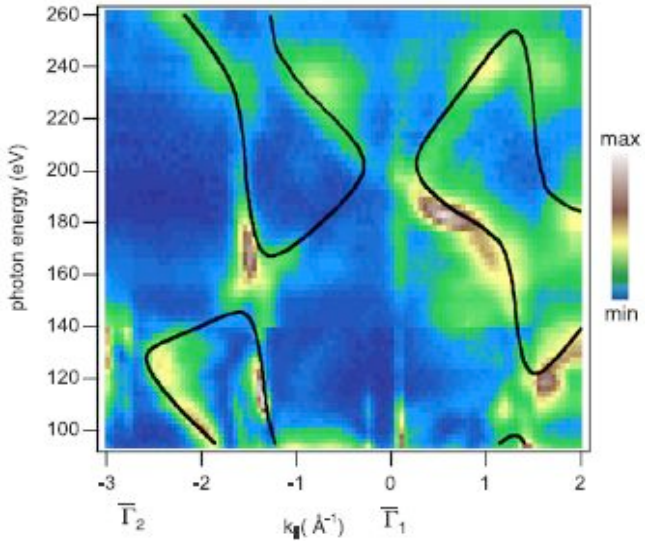


M. Hoesch et al., JESRP (02)

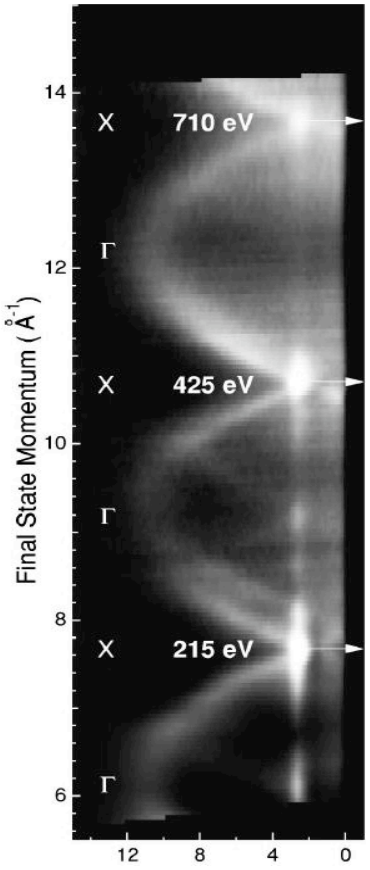
Why ARPES in the soft x-ray range ?

- **enhanced probing depth ~2 nm**
- **k⊥ broadening**
- **free-electron final states**
- **reduced matrix element effects**

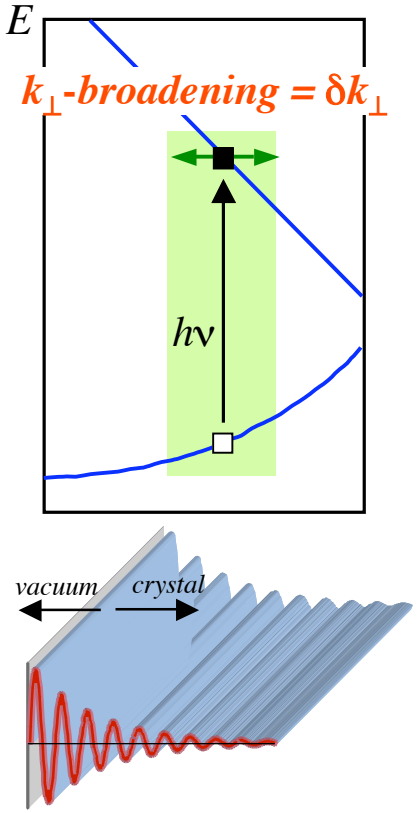




3-dimensional FS mapping for Cu
*(Nielsen et al JPCM **15**, 6919, 03)*



Hofmann et al
PRB 66, 245422, 02



PAUL SCHERRER INSTITUT

High energies: Soft-X-ray ARPES @ SLS

ADvanced RESonant Spectroscopies (ADRESS) Beamline

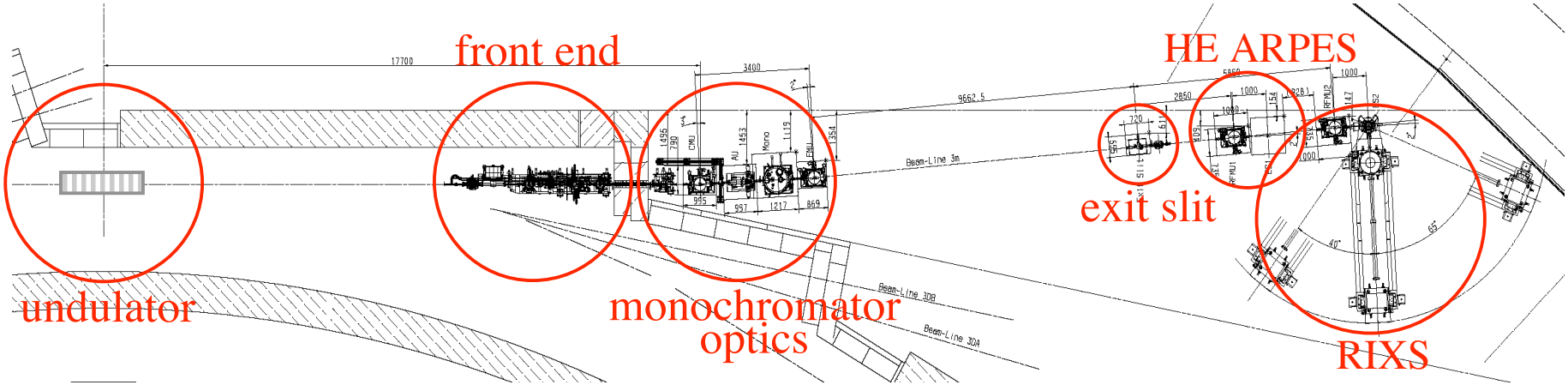
V. Strocov and T. Schmitt

- energy range 400-1800 eV
- soft-X-ray radiation with variable polarization
- resolution 35 meV @ 1 keV
- $3x10^{11}$ to $1x10^{13}$ photons/s/0.01%BW
- RIXS endstation:

- spectrometer (70 meV @ 1 keV)
Coll. Politechnico di Milano, EPFL and PSI
- rotating platform to study **q**-dependences

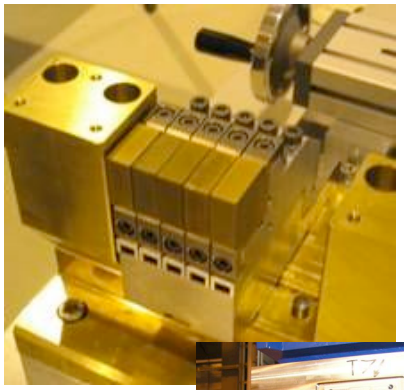
- ARPES endstation

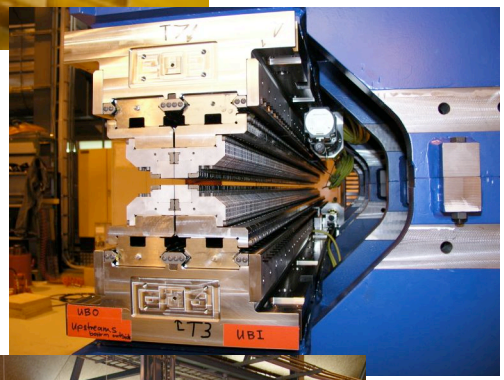
- operation in spring 2008

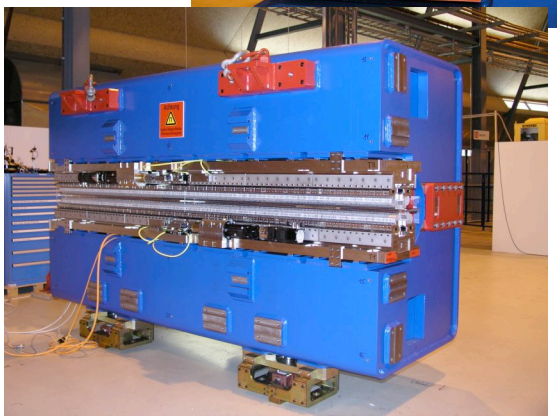


PAUL SCHERRER INSTITUT

Undulator

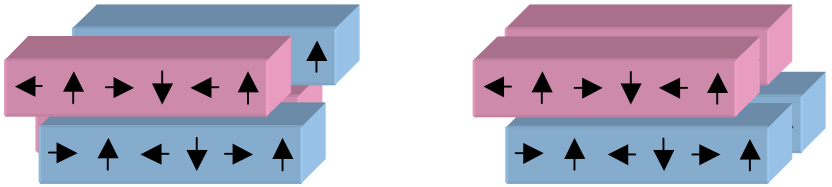






Apple II-type undulator with fixed gap

***P*-shift** **E-shift**



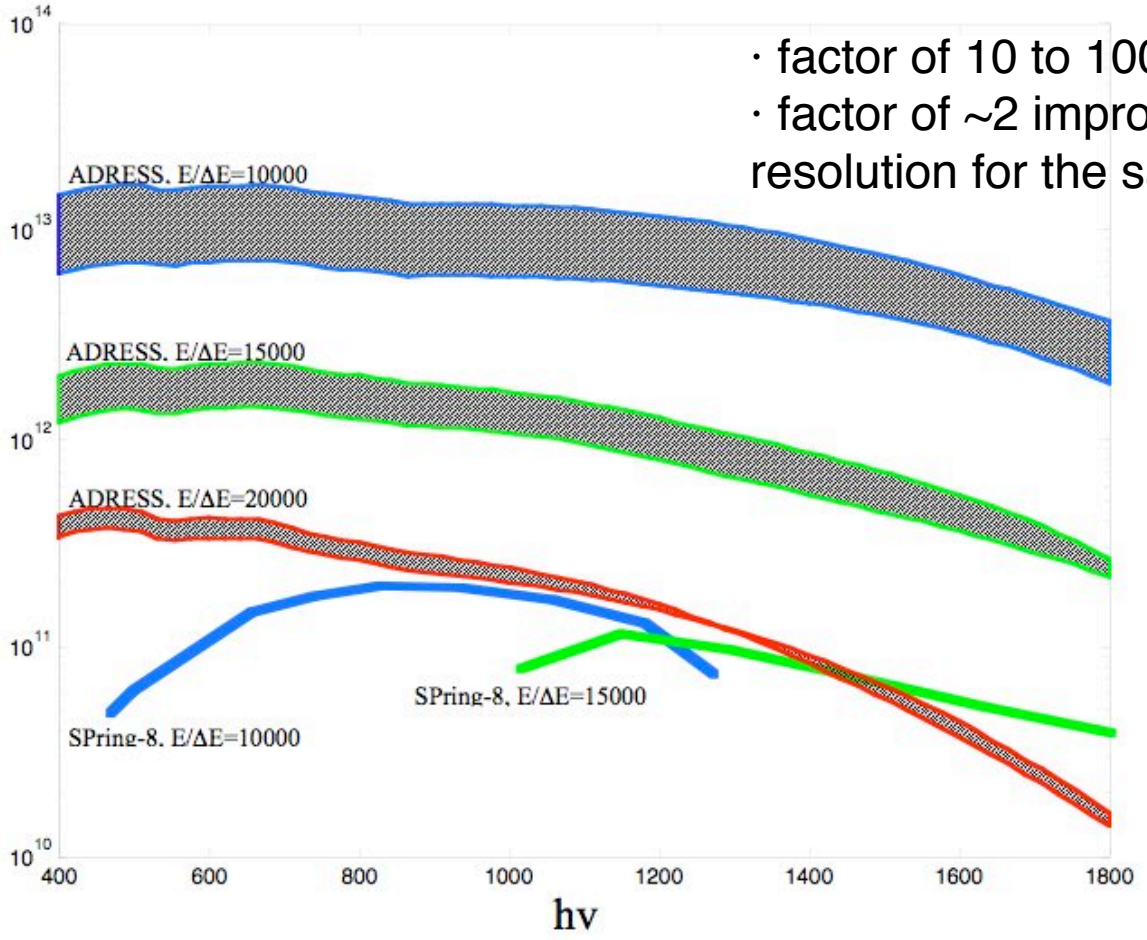
- variable polarization
- fixed gap = 11.6 mm
- period length = 44 mm

optimized for *hv* = 400-1800 eV

- number of magnet pairs: N = 75
- length of undulator: L = 3.5 m

Flux

comparison with BL25SU @ SPring-8

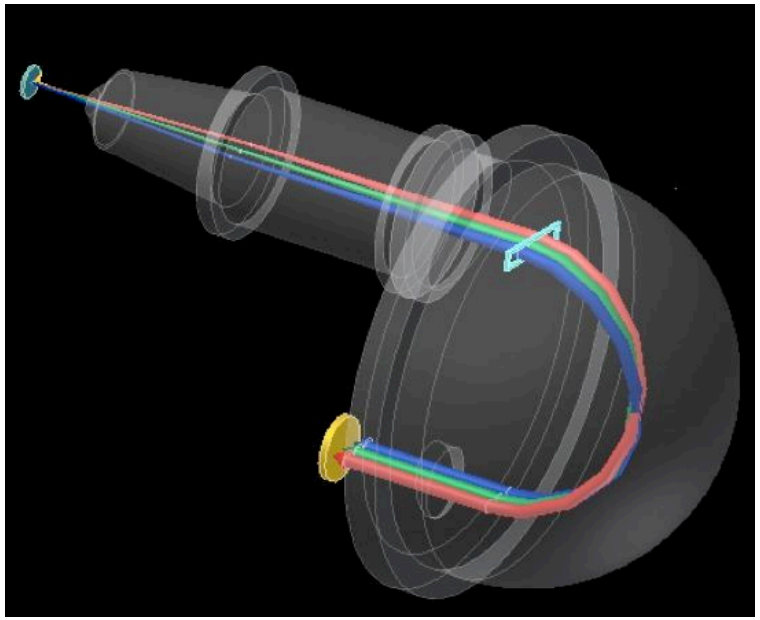


· factor of 10 to 100 flux increase
· factor of ~2 improvement in resolution for the same flux

superior resolution and flux parameters of ADRESS do allow for soft-X-ray ARPES

SX-ARPES end station

-Spectrometer
(commercial version)
Requirements:
- $\Delta E < 20meV$ @ Ek=1keV
- $\Delta K// \sim 0.05Å^{-1}$ @ Ek=1keV
- angular res < 0.1deg
+ 2D detection, all BZ in one shot



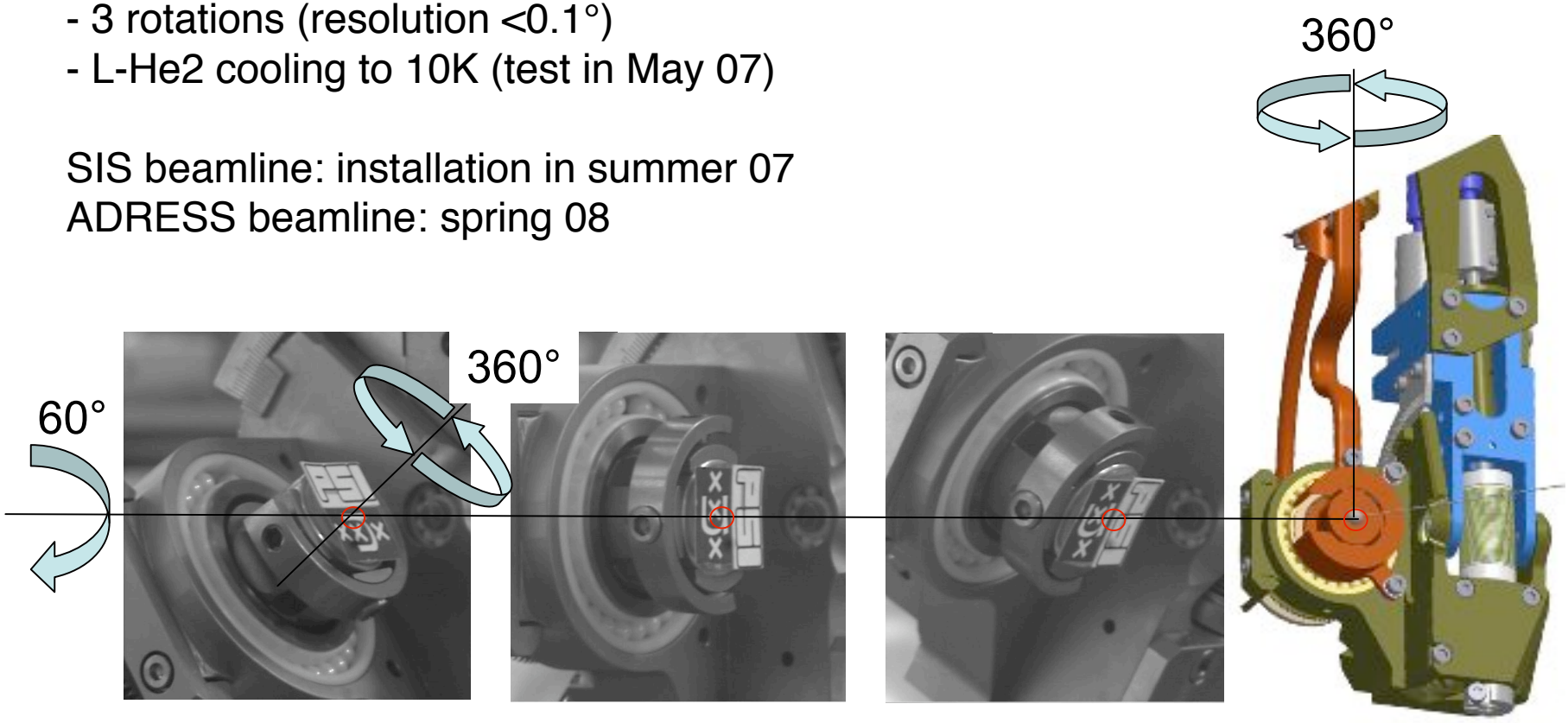
-New Manipulator CARVING™
6DoFs, 10K
-**spot size** 15-100 μm x 100 μm
-Sample quality
-SIS and PLD compatible
-Grazing incidence to match photon penetration deth and electron escaping deth
-**Design phase**, your input is welcome
-**CFT** in July 07
-**Operation** spring 08

New Manipulator CARVING™ with 6 DOFs

Complete Angle Resolved Variation for electron spectroscopy IN VilliGen

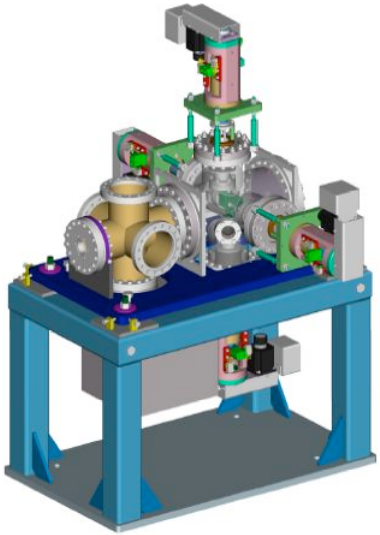
Proprietary design of
PSI-Uni Amsterdam (M.Golden)
- 3 translations (resolution 5μm)
- 3 rotations (resolution <0.1°)
- L-He2 cooling to 10K (test in May 07)

SIS beamline: installation in summer 07
ADRESS beamline: spring 08

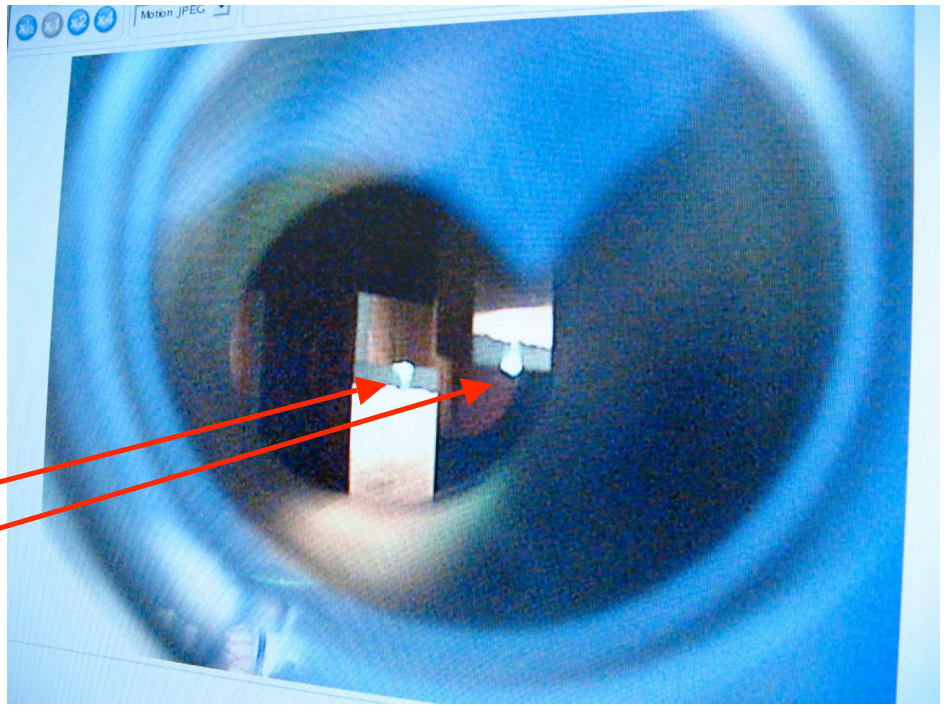


PAUL SCHERRER INSTITUT

1st undulator light at ADRESS beamline: December 21, 2007

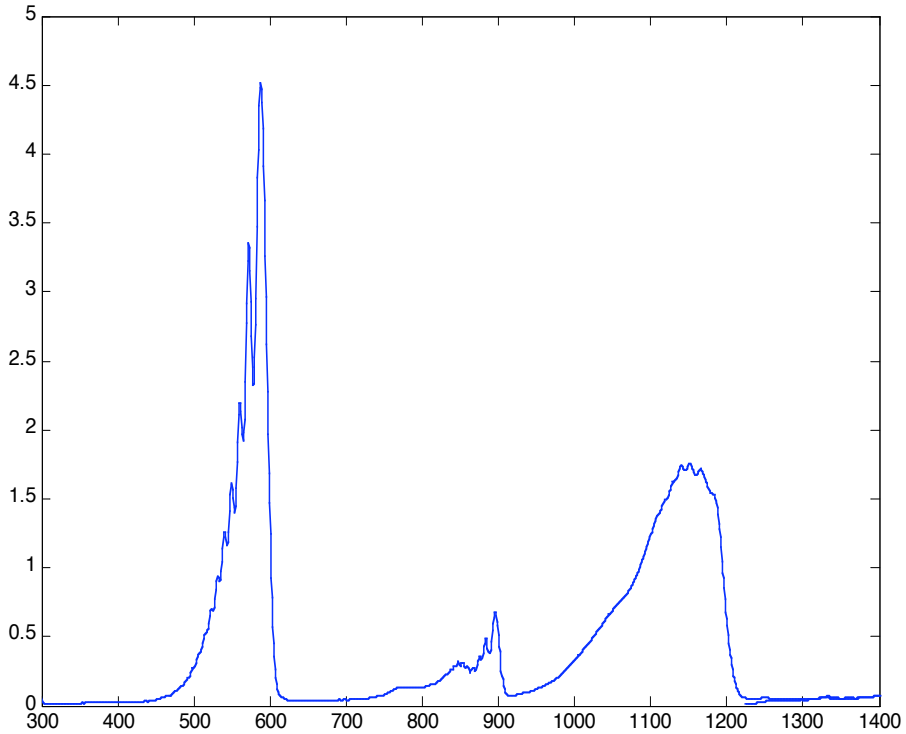


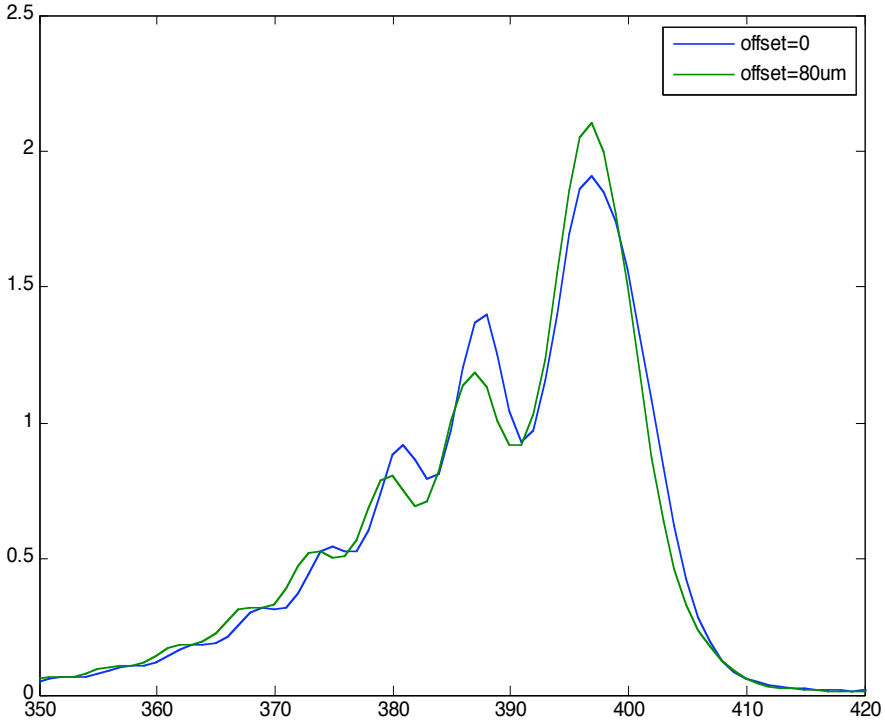
Light at baffles in aperture unit



First Undulator Spectra @ ADRESS

April 2007



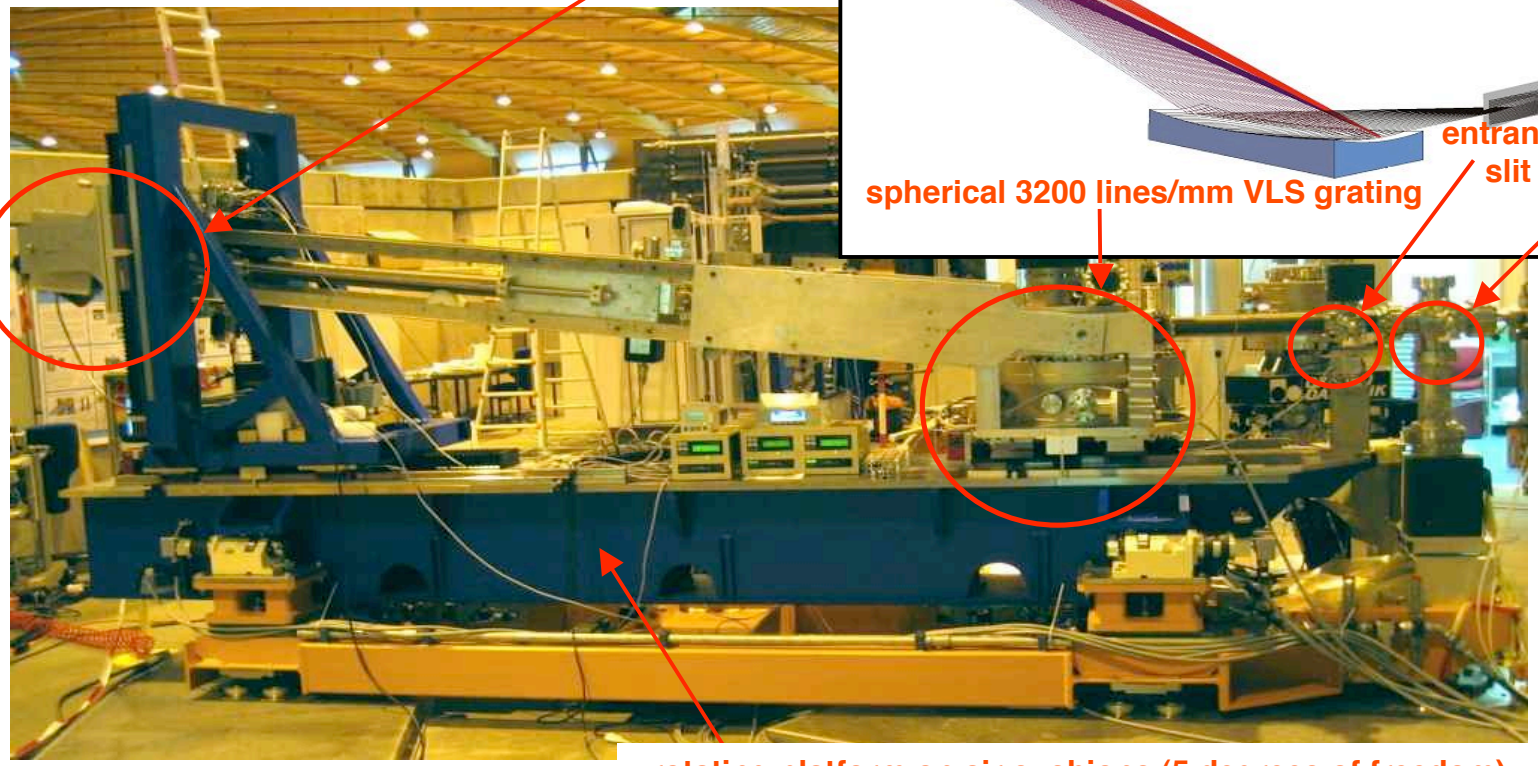


First expert users for RIXS experiment planned for June / July 2007

RIXS end station

Super Advanced X-ray Emission Spectrometer (SAXES) on rotating platform, collaboration with *Politecnico di Milano* (L. Braicovich et al.) and EPFL Lausanne (M. Grioni et al.)

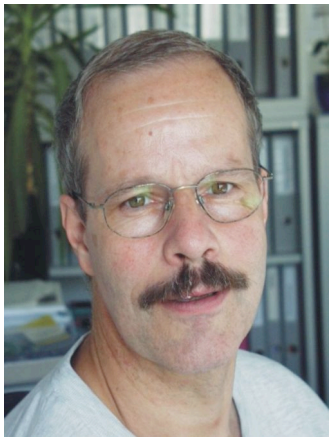
Resolving Power:
8'000 @ 1400 eV
10'000 @ 1200 eV



PAUL SCHERRER INSTITUT

Spectroscopy of Novel Materials @ SLS

Hugo Dil
Postdoc



Fritz Dubi
Technician

Christoph Hess
Technician

Markus Kropf
Technician

Luc Patthey
Group leader

Justine Schlappa
Postdoc

Thorsten Schmitt
Beamline scientist

Ming Shi
Beamline scientist

Vladimir Strocov
Beamline scientist

PAUL SCHERRER INSTITUT

Thank to

PSI
J. Raabe
T. Schmidt
U. Flechsig
A. Imhof
B. Jakob
C. Vollenweider
V. Schönherr
Q. Chen
N. Riccardi
R. Betemps
J. Krempaski
J. Mesot
A. Bendounan
Y. Sassa
P. Willmott

Politechnico di Milano
C. Dallera
G. Ghiringhelli
A. Piazzalunga
L. Braicovich
A. Piazzalonga

EPFL
M. Grioni
X. Wang

Université Pierre et Marie Curie
S. G. Chiuzbaian

Alba
V. Perez-Dieste

Neuchâtel University
P. Aebi

Amsterdam University
M. Golden
Hans Ellermeijer

Zürich Unversity
J. Osterwalder

ESRF
M. Hoesch

Basel University
J. Lobo-Checa

Welcome to SLS for an experiment -User lab (techniques available: ARPES, Spin resolved ARPES, Soft X-Ray ARPES, PEEM, RIXS, microXAS,…..)

sls.web.psi.ch or luc.patthey@psi.ch

We are supporting CORPES07+X!….