Scientific Case

for the

VUV-Soft X-ray Free Electron Laser
On the Elettra LINAC at 500 MeV

Fulvio Parmigiani

INFM-Elettra and Catholic University

Scientific Case

Brief outline of the scientific case for the VXFEL

Main parameters to be considered:

- Time structure of the pulses
- Photon flux
- Polarization

Examples of the actual state of the art physics that can be overtaken by the VXFEL source :

time resolved experiments,

nano-microscopy spectroscopy,

static and dynamic scattering,

momentum space microscopy.

Scientific Case

Time structure of the VXFEL pulses allows time resolved studies:

Optical
Electron Spectroscopy
Time resolved magnetic studies
Scattering

The photon flux, 3 to 4 order of magnitude higher than the actual will give access to the following experiments:

Momentum space microscopy by ARUPS
Tunable nano-spectroscopy by ZP of the valence band

Variable polarization

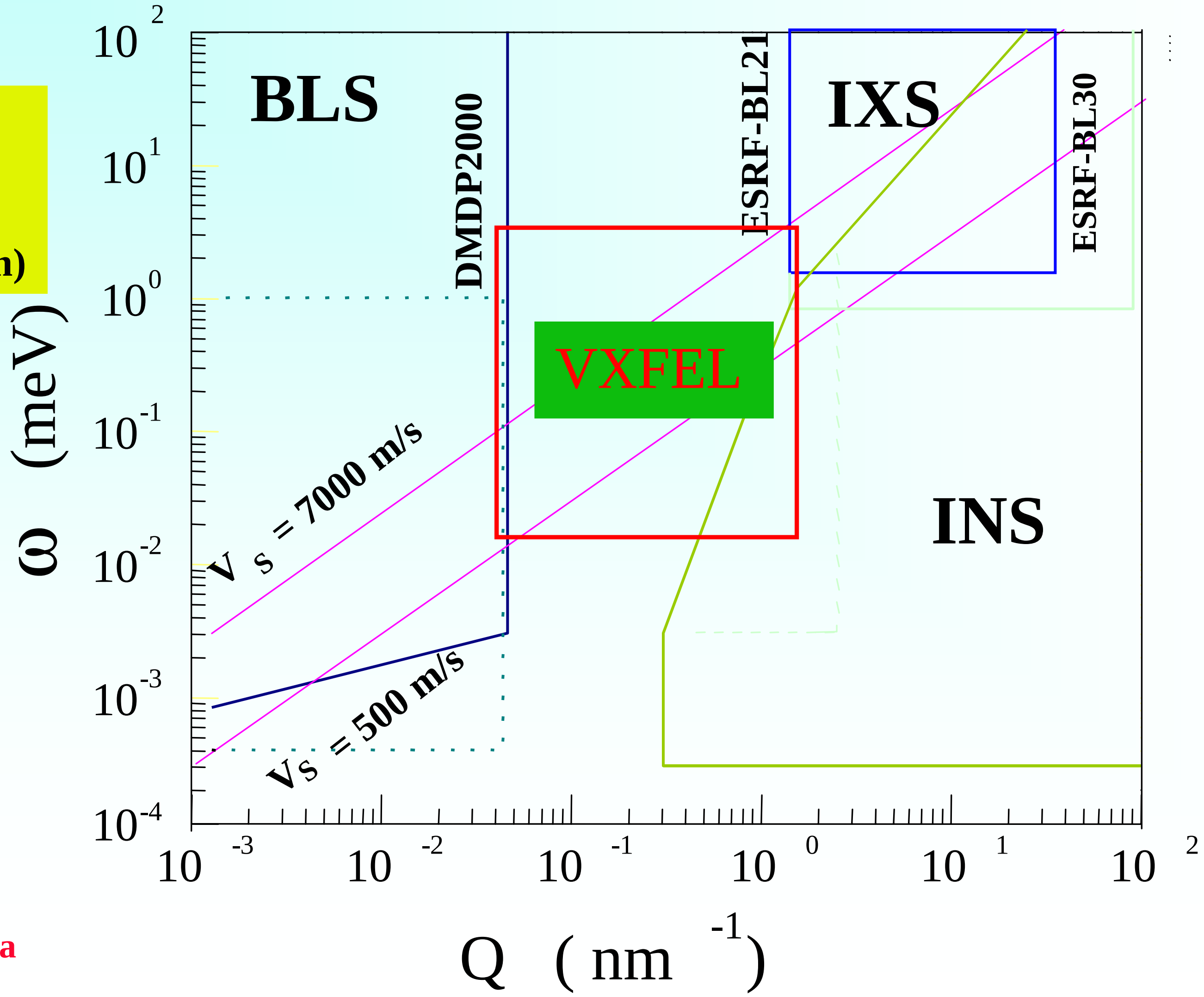
Study of dichroic systems also in time resolved and nano-scale configuration.

Available probes to investigate collective excitations in the 4-120 eV photon energy region

BLS (Brillouin)

IXS (Inelastic X)

INS (Inelastic Neutron)



Masciovecchio, Elettra

From the Hydrodynamc to the Single Particle

Noble Gases as simple liquids

	E_1	λ (*nm*)
Helium	19.8	62
Neon	16.1	77
Argon	11.8	105
Krypton	9.9	125
Xenon	8.7	143

Gaussian-like

High Q (Low Density)

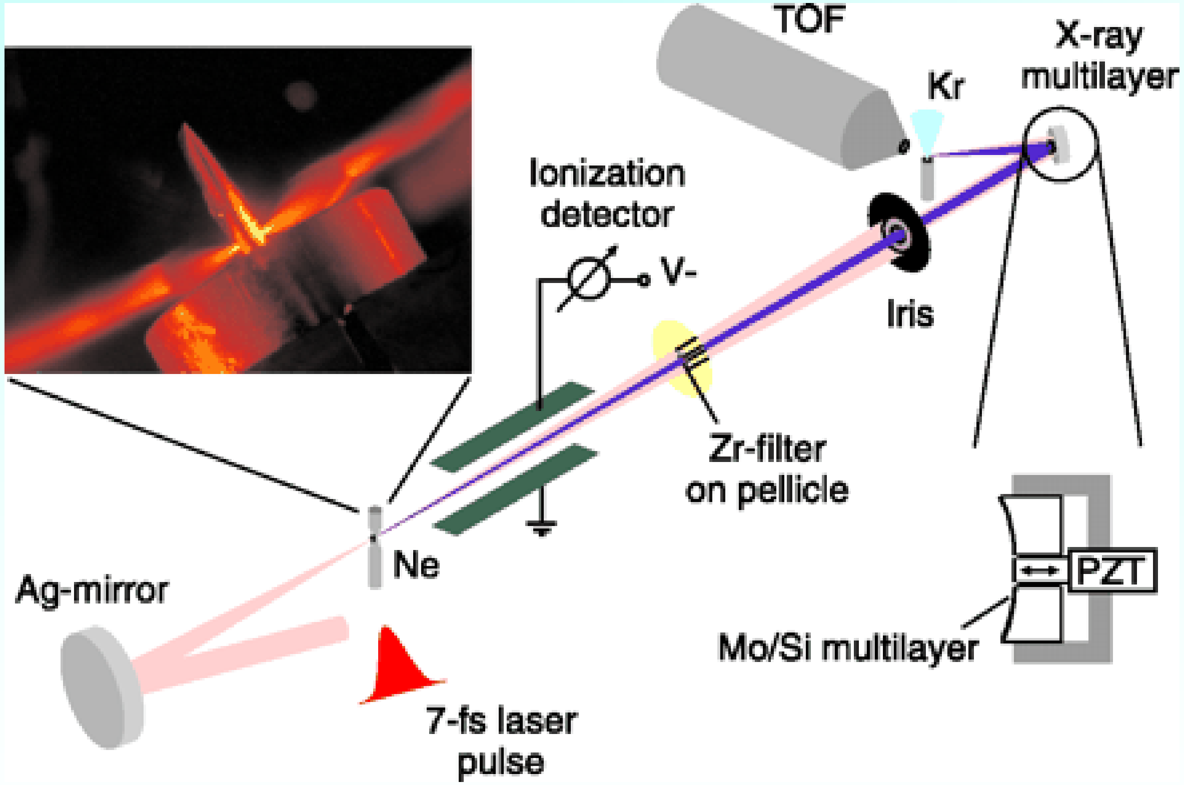
Rayleigh-Brillouin triplet

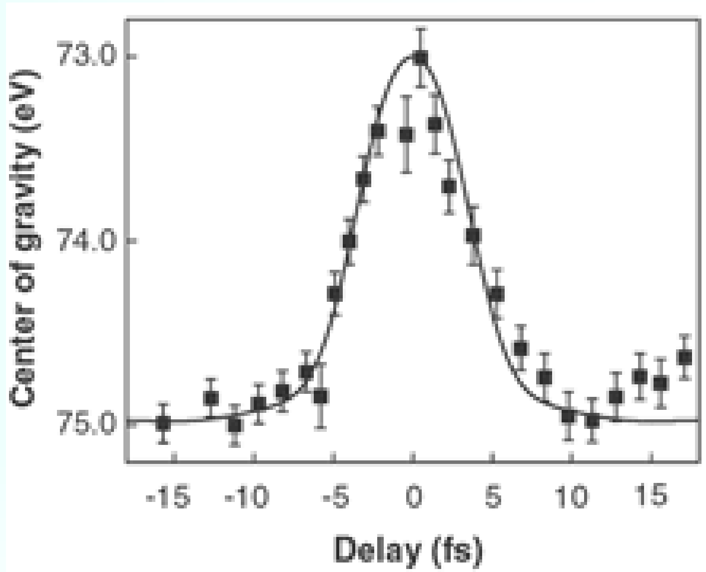
Low Q (High Density)

Essential features of the Intermolecular Potential

Behaviour in the Condensed Phase

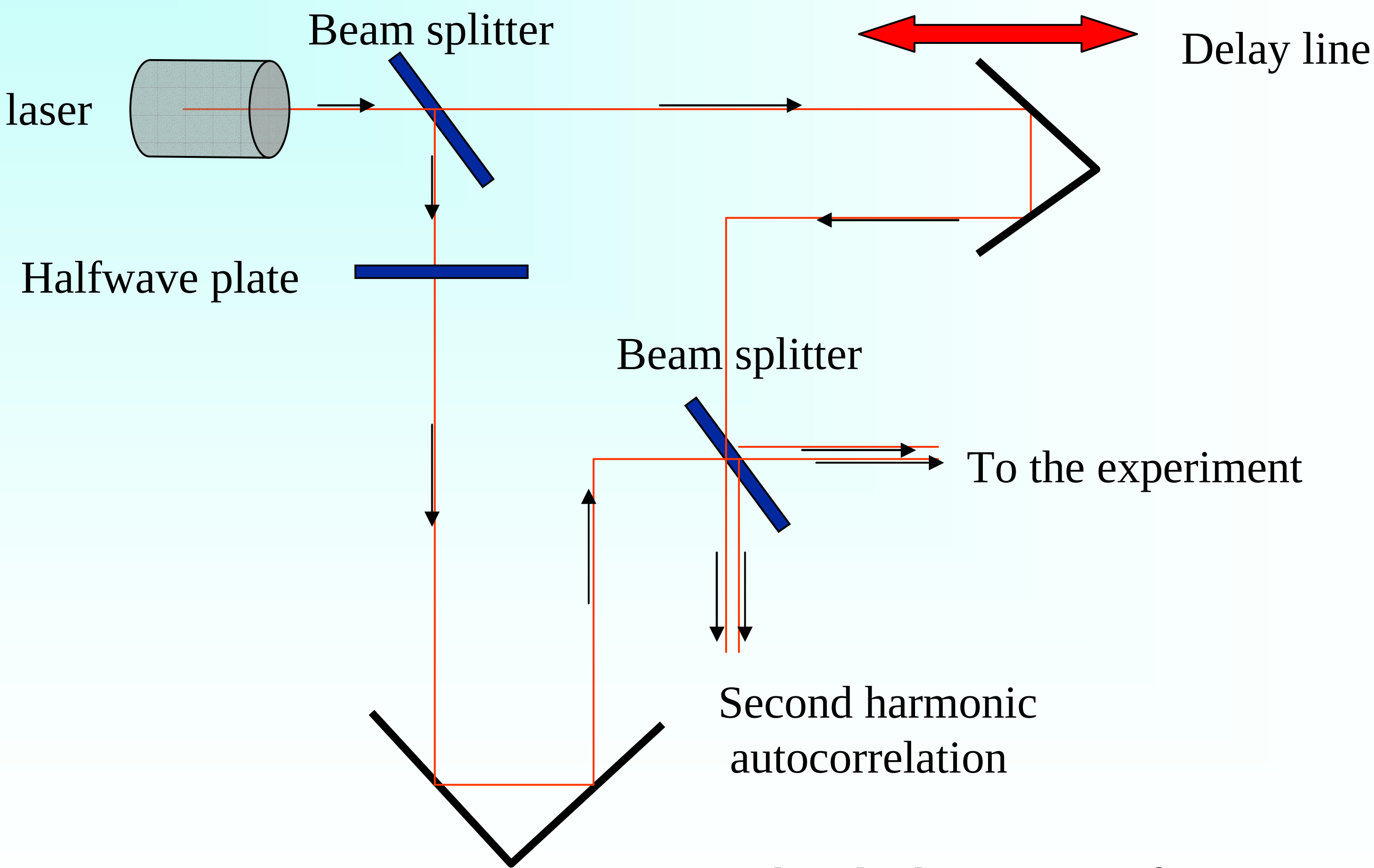
Temporal Characterization of VUV and X -ray fs pulses





M.Drescher et al., Science 291, 192 (2001)

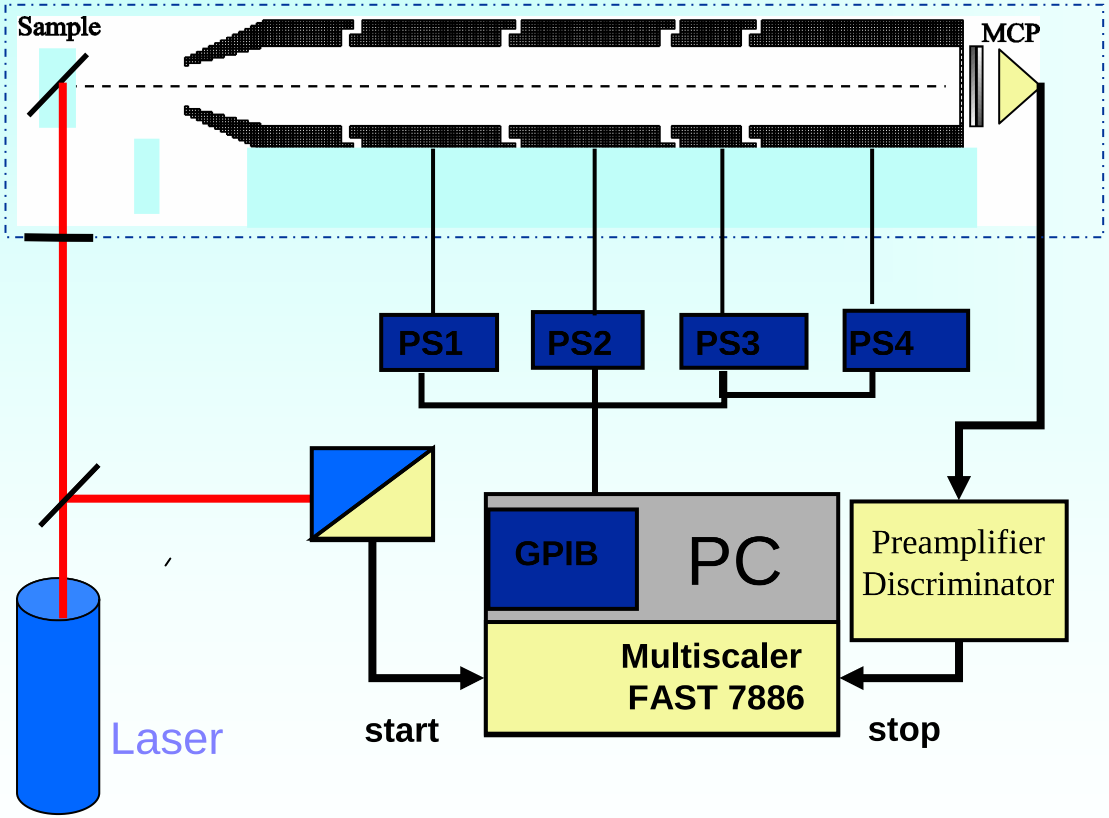
Pump & Probe setup for photon energy up to 12 eV

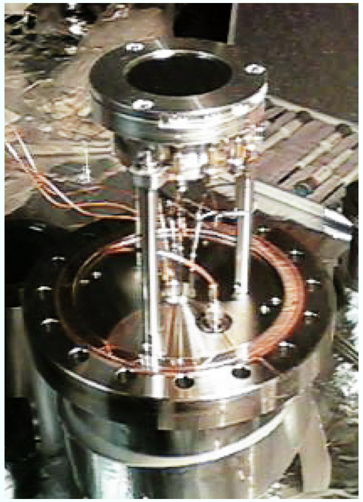


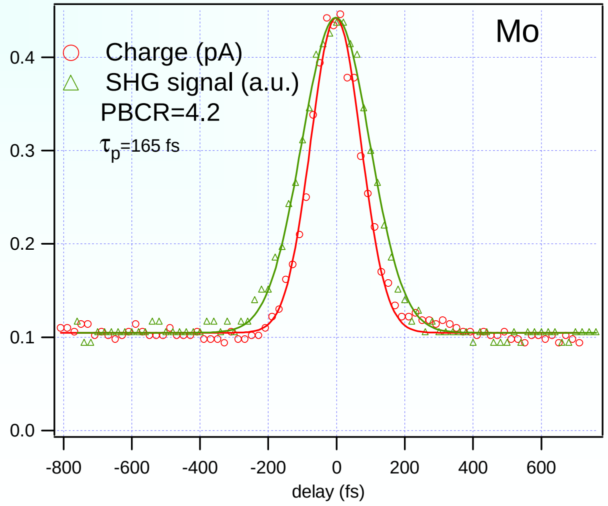
Mach Zehnder type interferometer

F.Parmigiani et al.

150 fs Laser Pulse Measured by an Electron Time of Flight Spectrometer







F.Parmigiani et al.

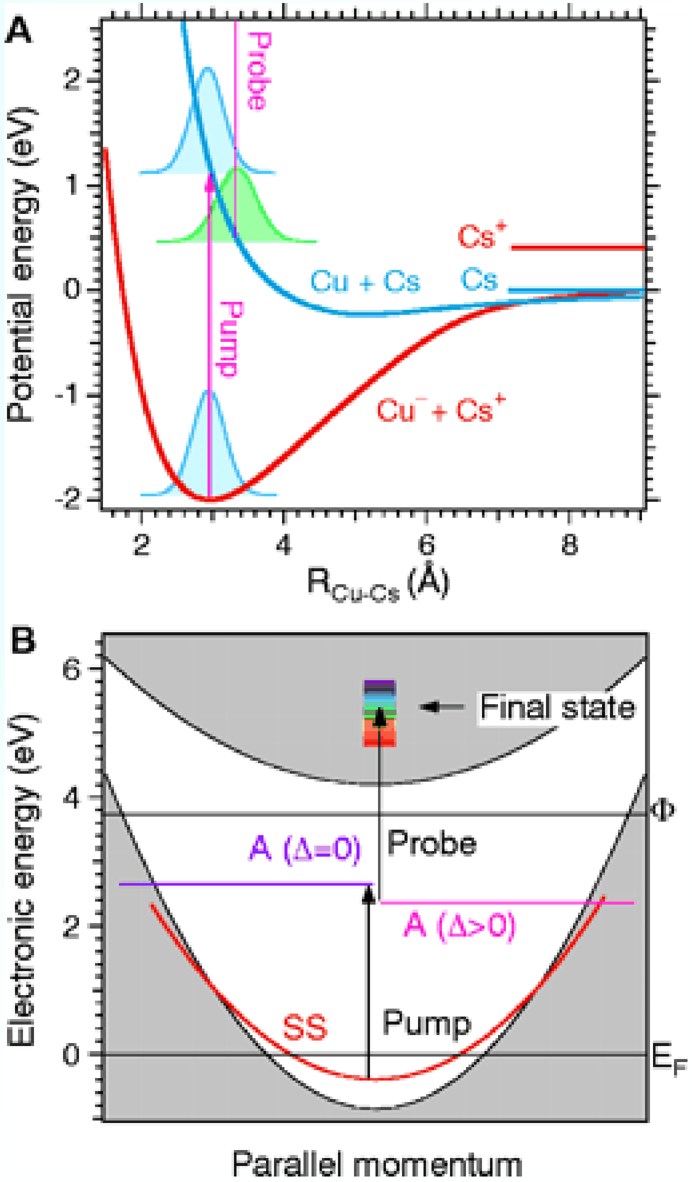
Scientific Case

Time resolved

Real-Time Observation of Adsorbate Atom Motion Above a Metal Surface

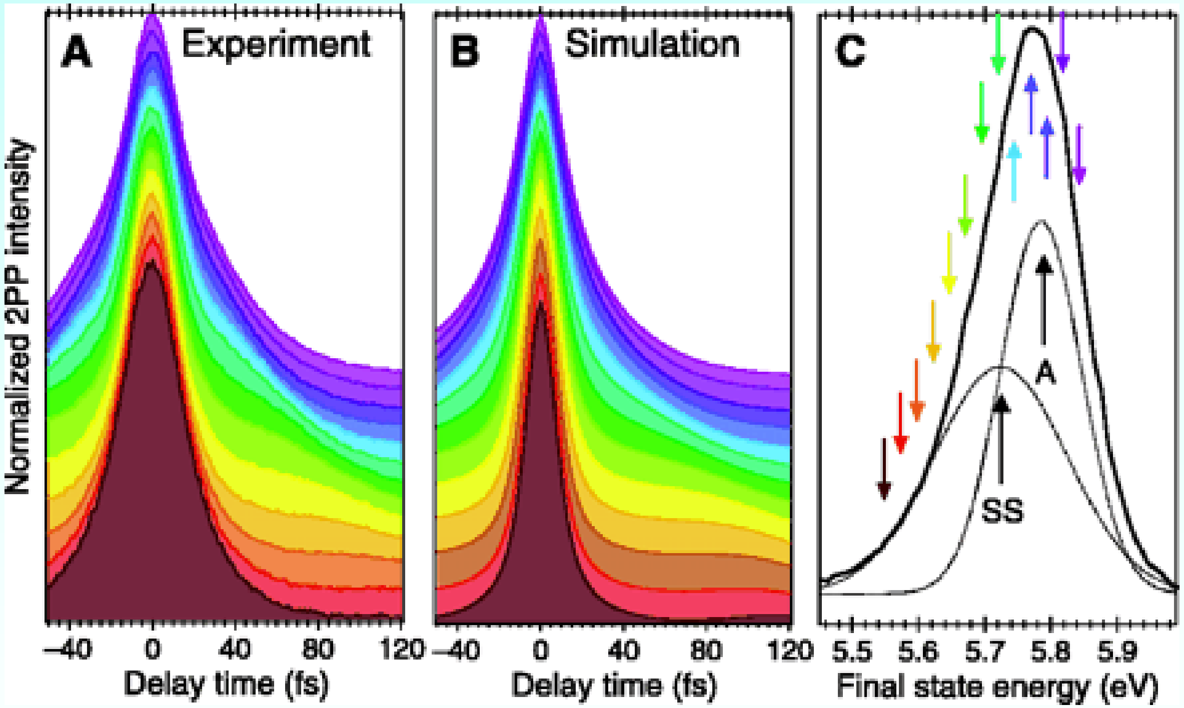
Observation of atomic and dynamics on surface is possible by time-resolved two photon photoelectron spectroscopy. The unusual changes in the surface electronic structure within 160 fs after excitation are attributed to atomic motion in a Cu-Cs bond-breaking process.

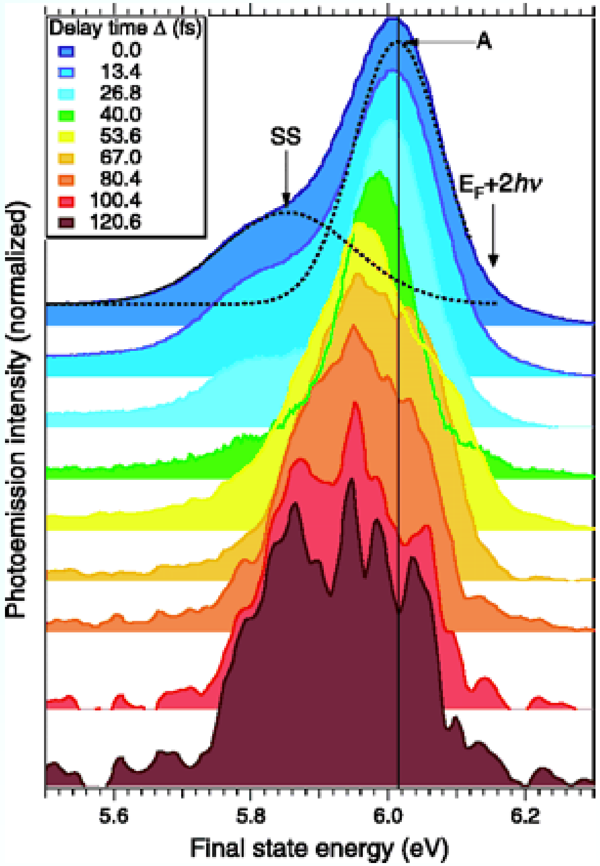
The availability of sub ps coherent VUV and soft X-ray pulses with variable polarization will extend this technique to e very large set of systems where also the momentum and the structural parameters depending on the polarization can be explored.



H. Petek et al., Science 288 1402 (2000)

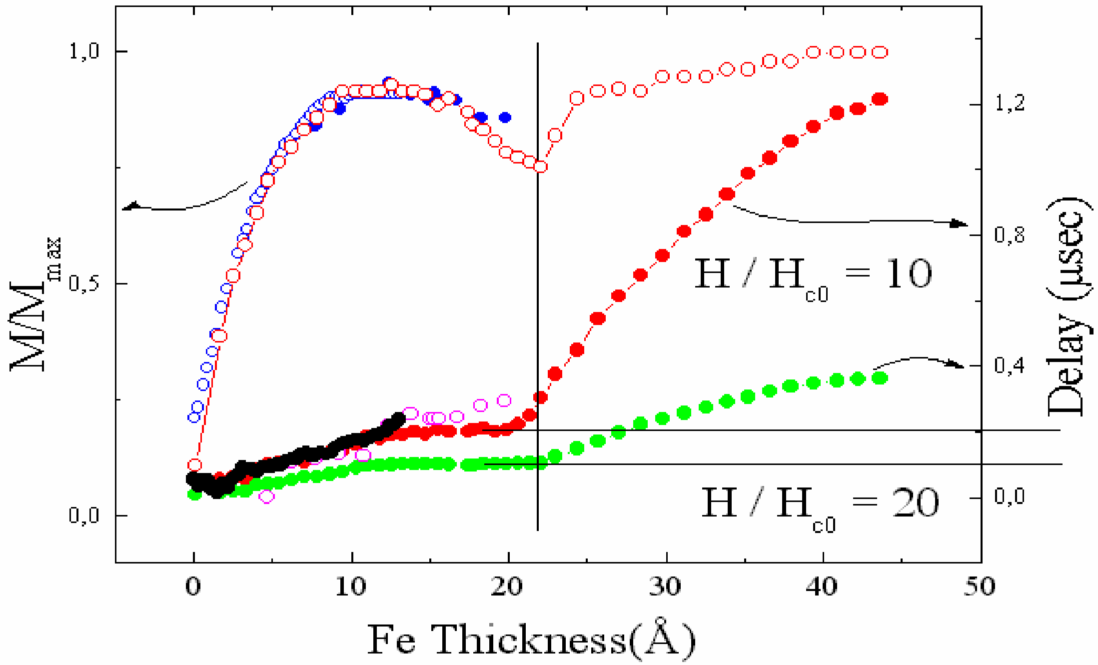
Real-Time Observation of Adsorbate Atom Motion Above a Metal Surface





H. Petek et al., Science 288 1402 (2000)

On-line growth of a Fe ultrathin film onto $Fe_{40}Ni_{40}B_{20}$: two regimes of magnetisation reversal



LURE - SU7 F. Sirotti et al

Time-resolved Magnetization Dynamics

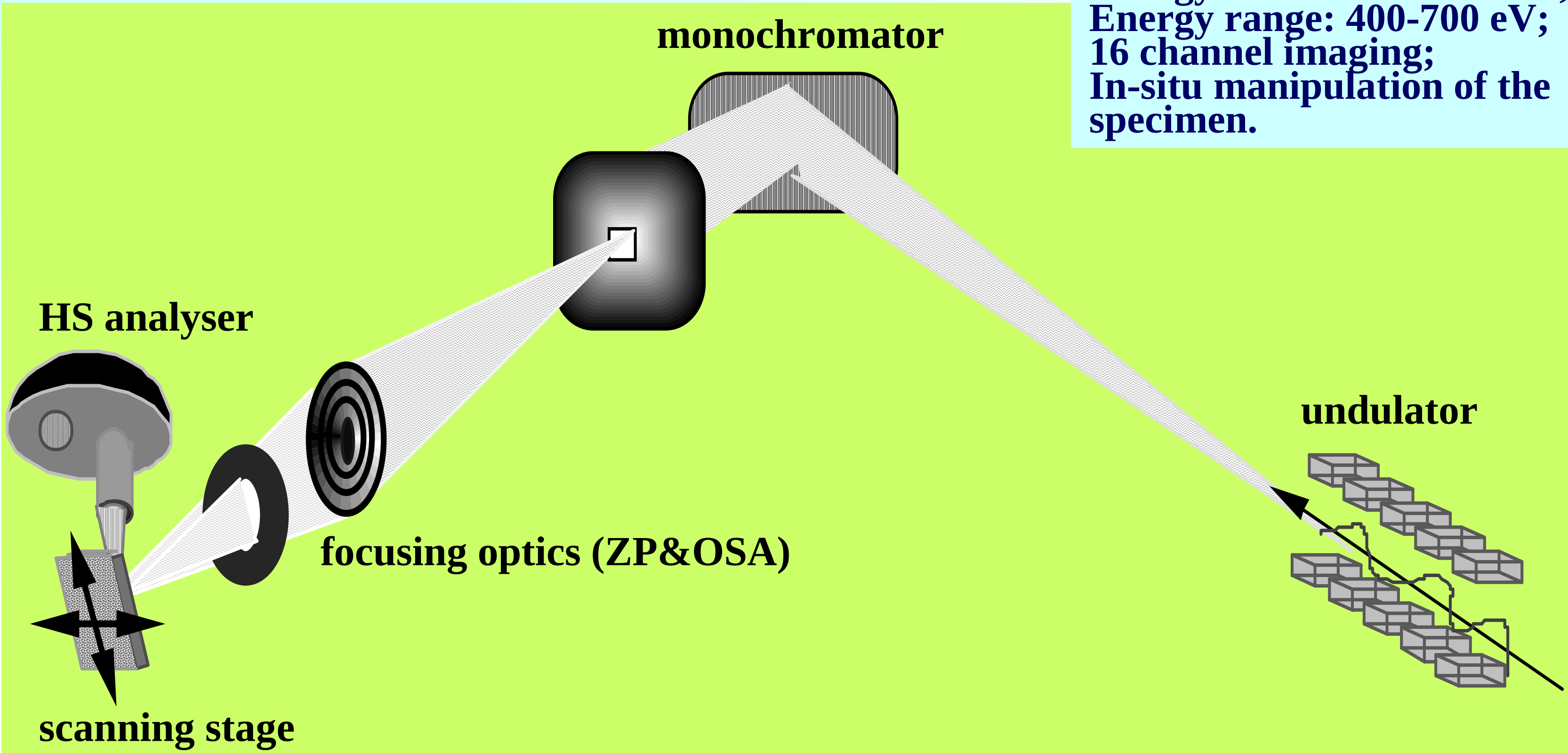
SR-based time resolved magnetometry of surfaces is a able to directly address the dynamical magnetisation of surfaces and ultrathin films

The limits of data rate in storage/retrieval of magnetic devices can be studied

On-line processing can be followed in real time

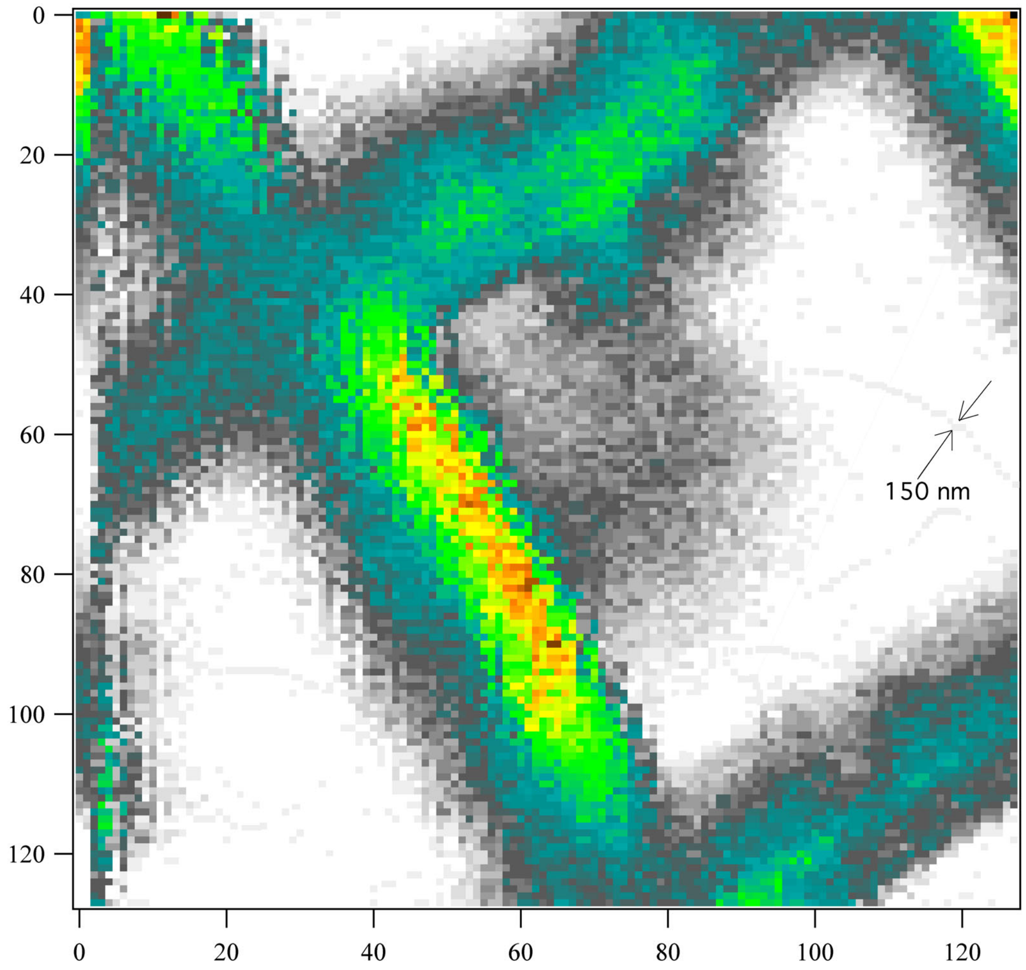
Beamline and scanning microscope layout

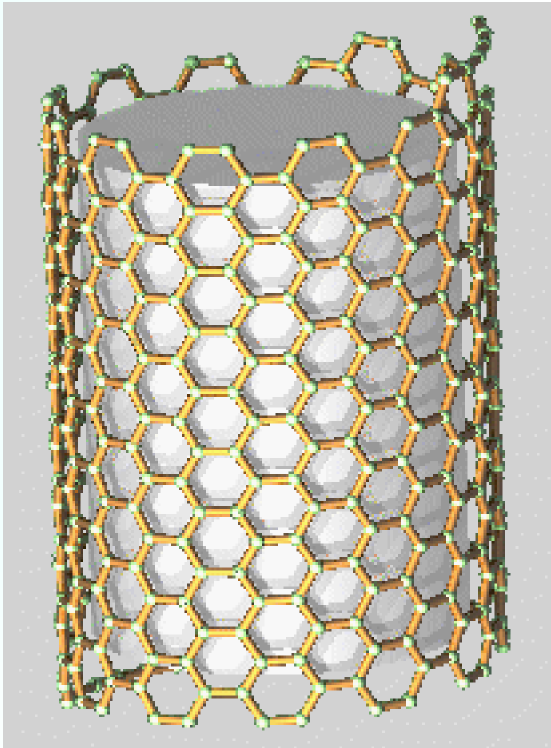
Lateral resolution: 90-120 nm;
Energy Resolution: 0.35 eV;
Energy range: 400-700 eV;
16 channel imaging;
In-situ manipulation of the specimen.



M. Koskinova, Elettra

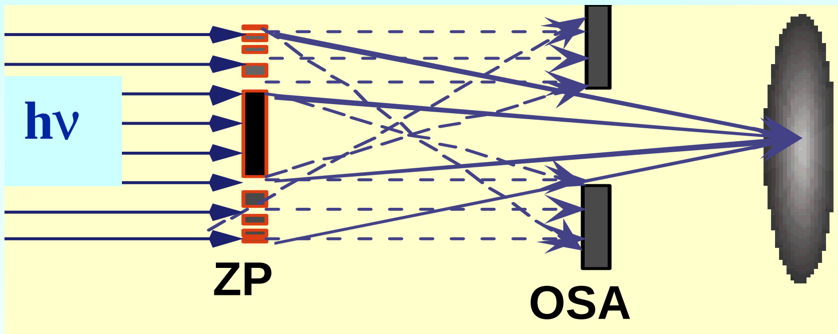
C1s nanomicroscopy of a single C-nanotube





F.Parmigiani et al.

Diffractive photon optics: Fresnel zone plates
For valence band photoemission

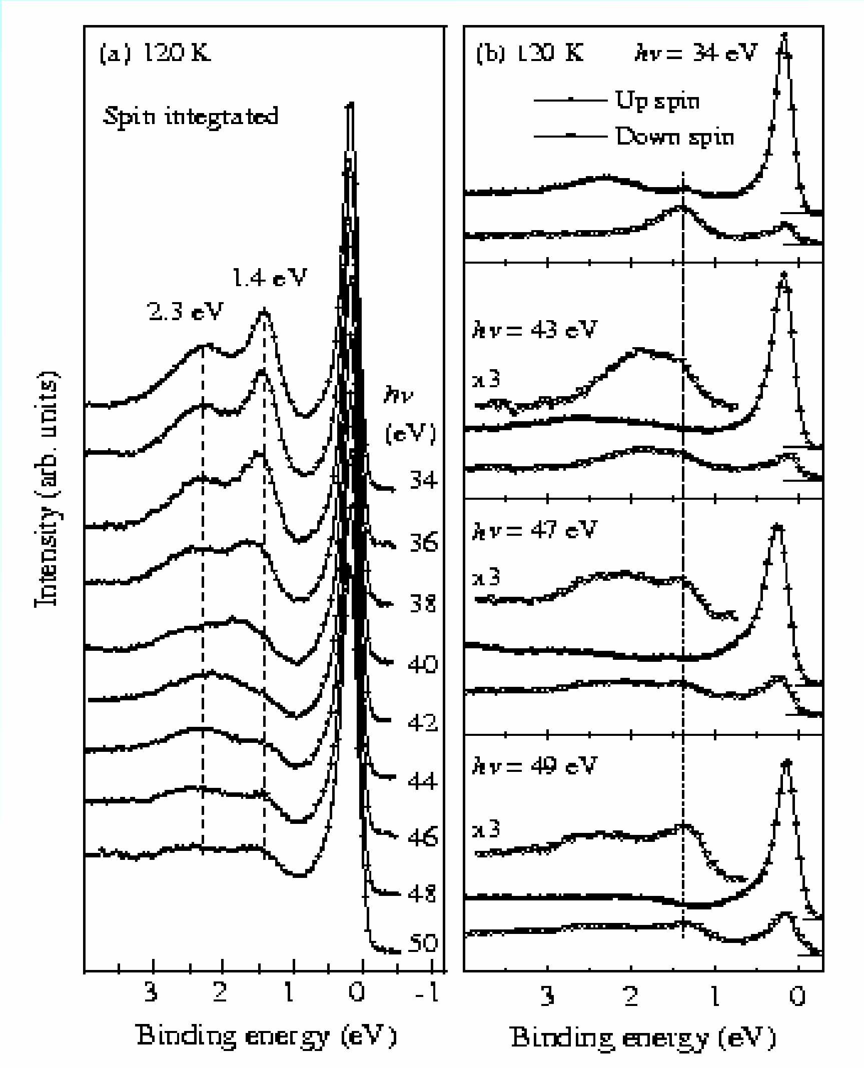


Photon energy : 80 eV
ZP size: 500 μm
Focal distance : 3.2 mm
Beam size on the sample : 50 nm
Efficiency: 10%

Important parameters:
Width of the finest zone: $R = 1.22 * \Delta r$
Diameter: $f = D * \Delta r * / l$
Efficiency % of diffracted x-rays: ***10-40% (4-25%)***
Monochromaticity: $l / \Delta l \geq N$

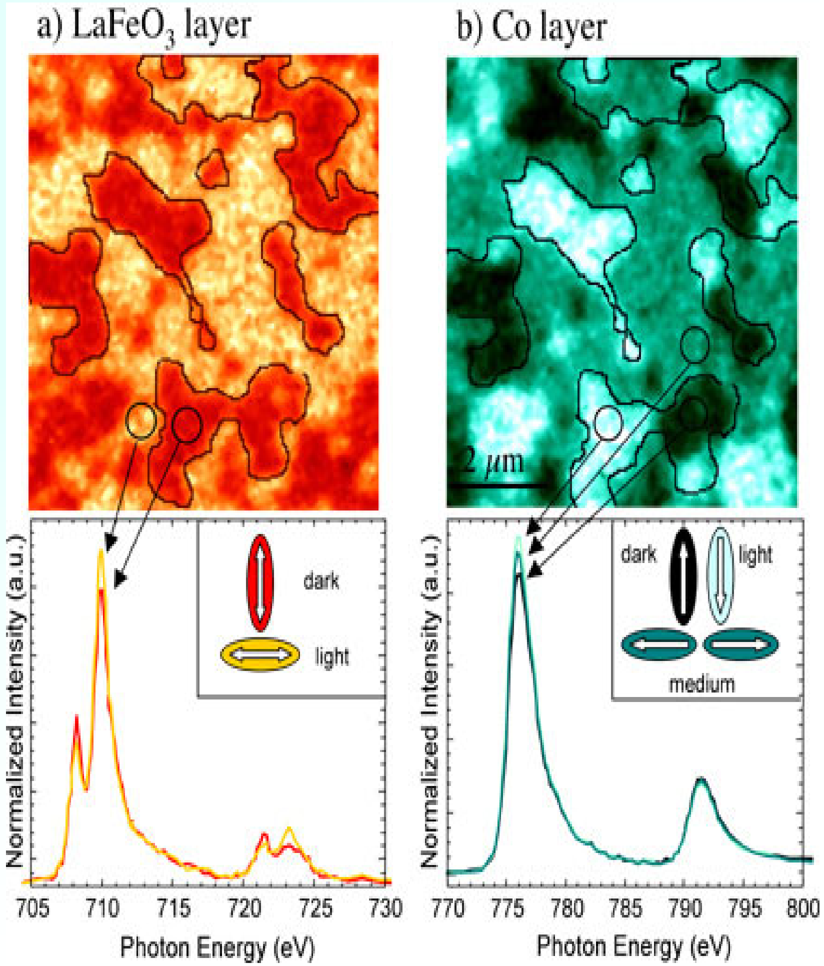
High photon flux and Polarization

Gd (5d6s) valence states: band dispersion



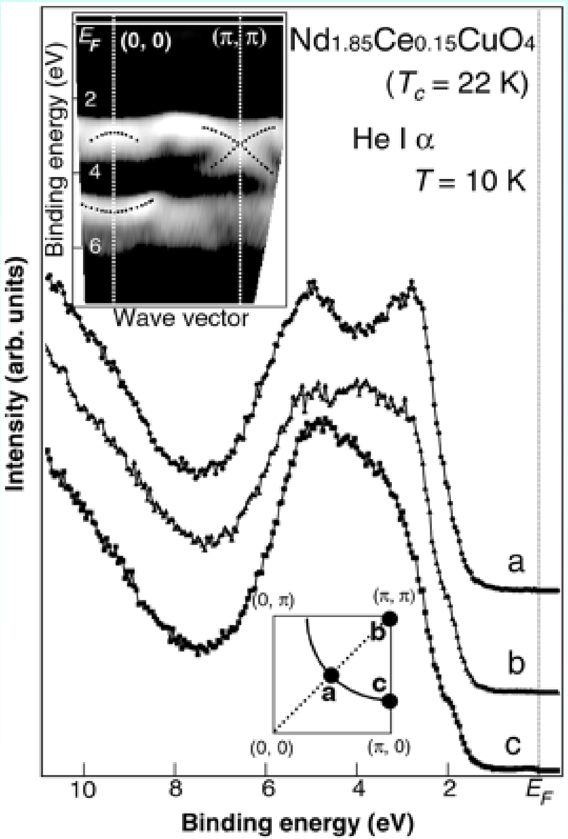
Maiti et al. PRL 86,2846 (2001)

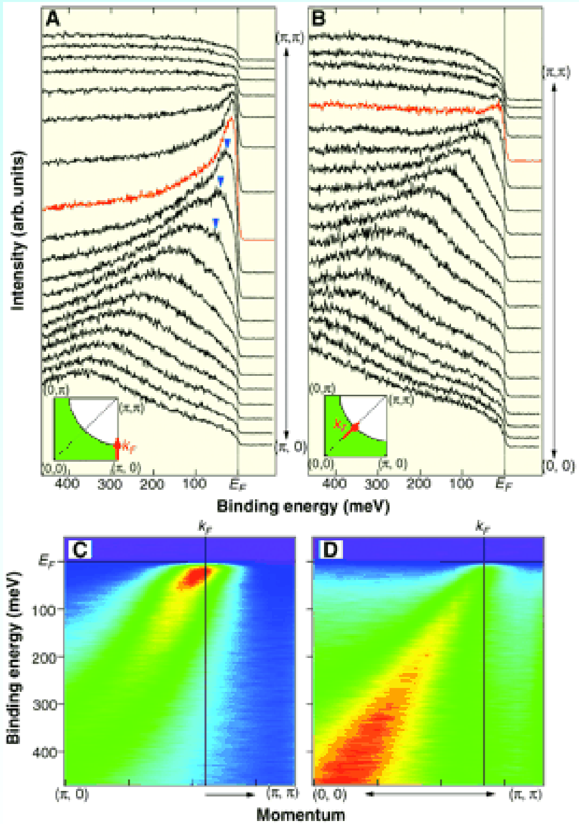
Microscopy by MXLD - MXCD: AF-FM interface coupling

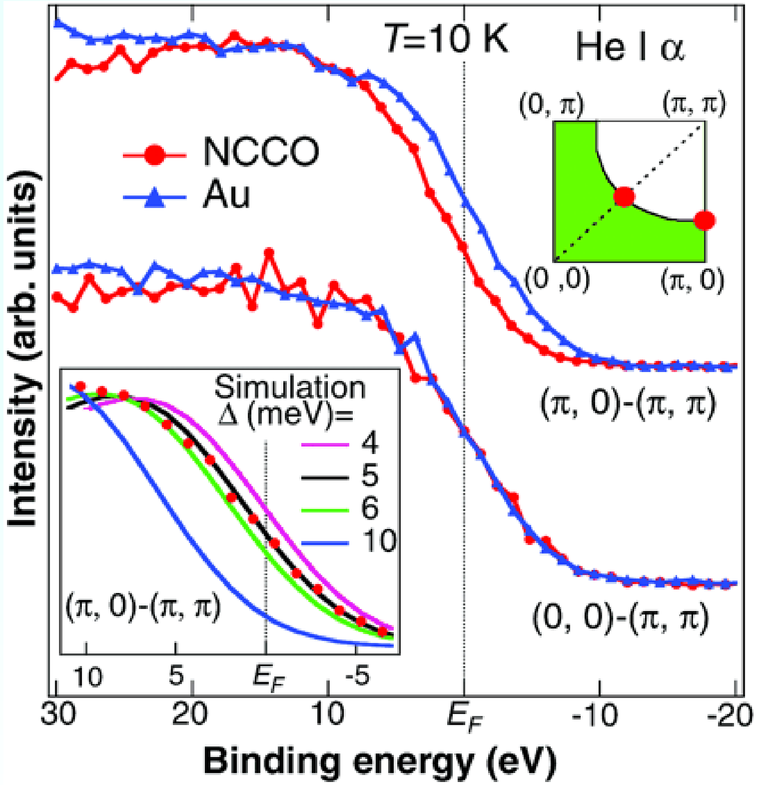


F. Nolting et al., Nature 405, 767 (2000)

Gap in an Electron-Doped High-Temperature Superconductor





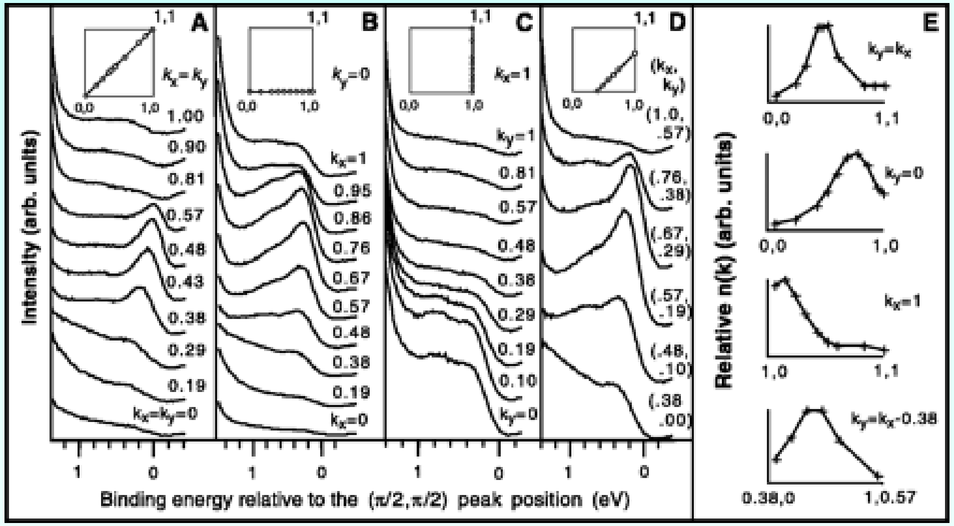


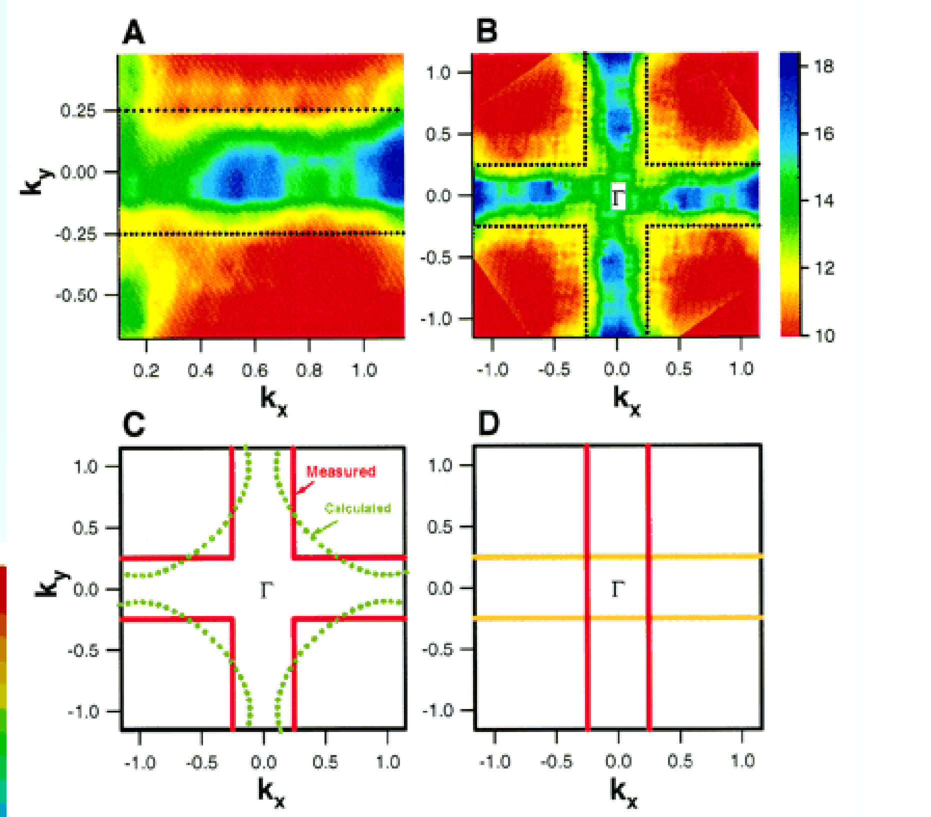
T.Sato et al., Science 291, 151 (2001)

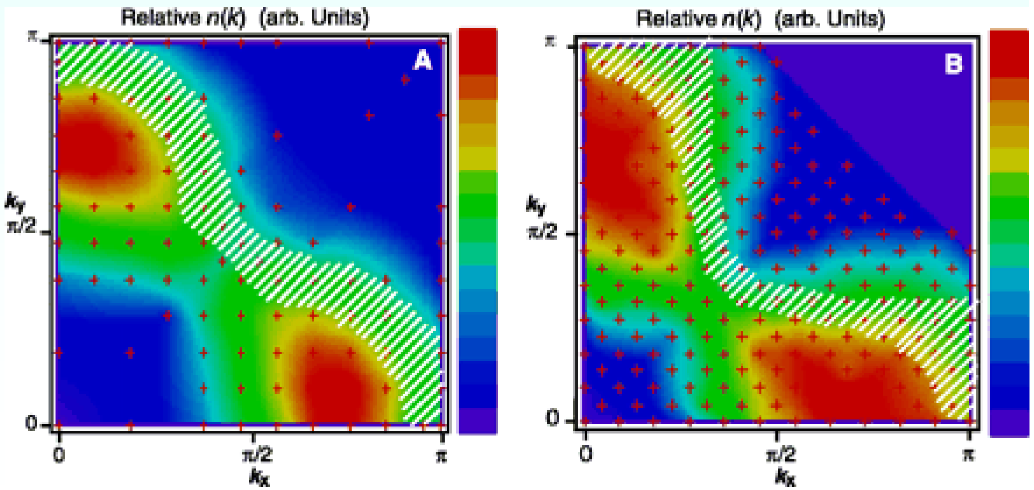
Scientific Case

High photon flux and momentum microscopy

D-wave-like Dispersion in Insulating $Ca_2CuO_2Cl_2$







F.Ronning et al., Science, 282, 206 (1998)