Elettra, FERMI@Elettra e IOM-TASC nel 2010

Istituto Officina dei Materiali

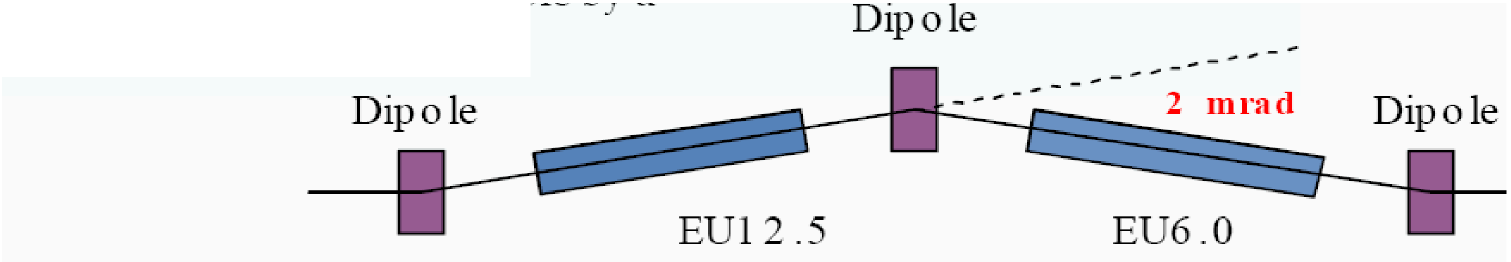
Advanced Photoelectric effect Experiment (APE) @ ELETTRA: Zig-zag undulators

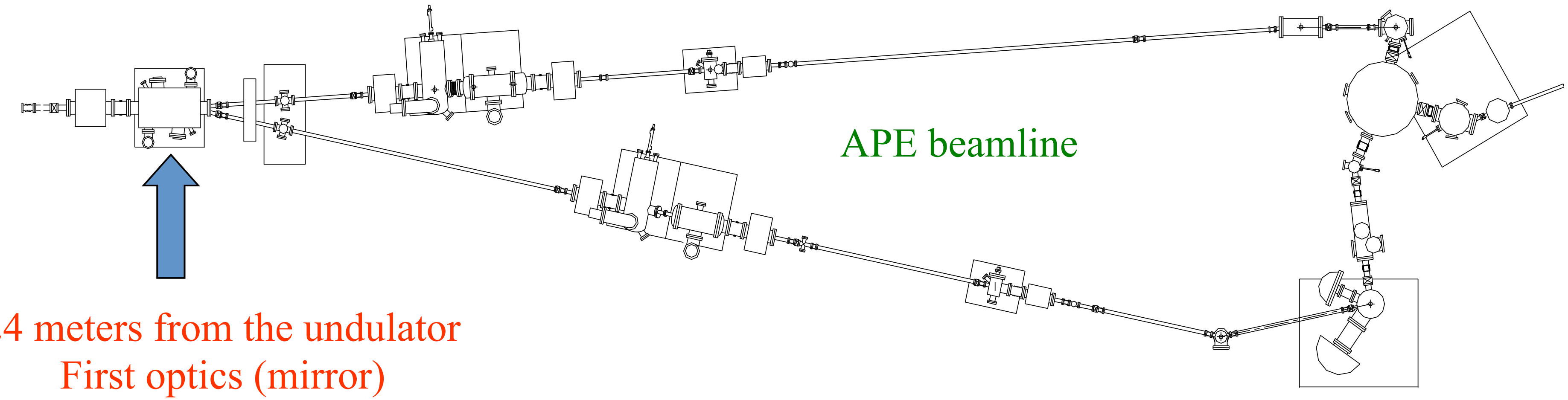
Two undulators are placed in the same straight section

2 mrad zig-zag angle.

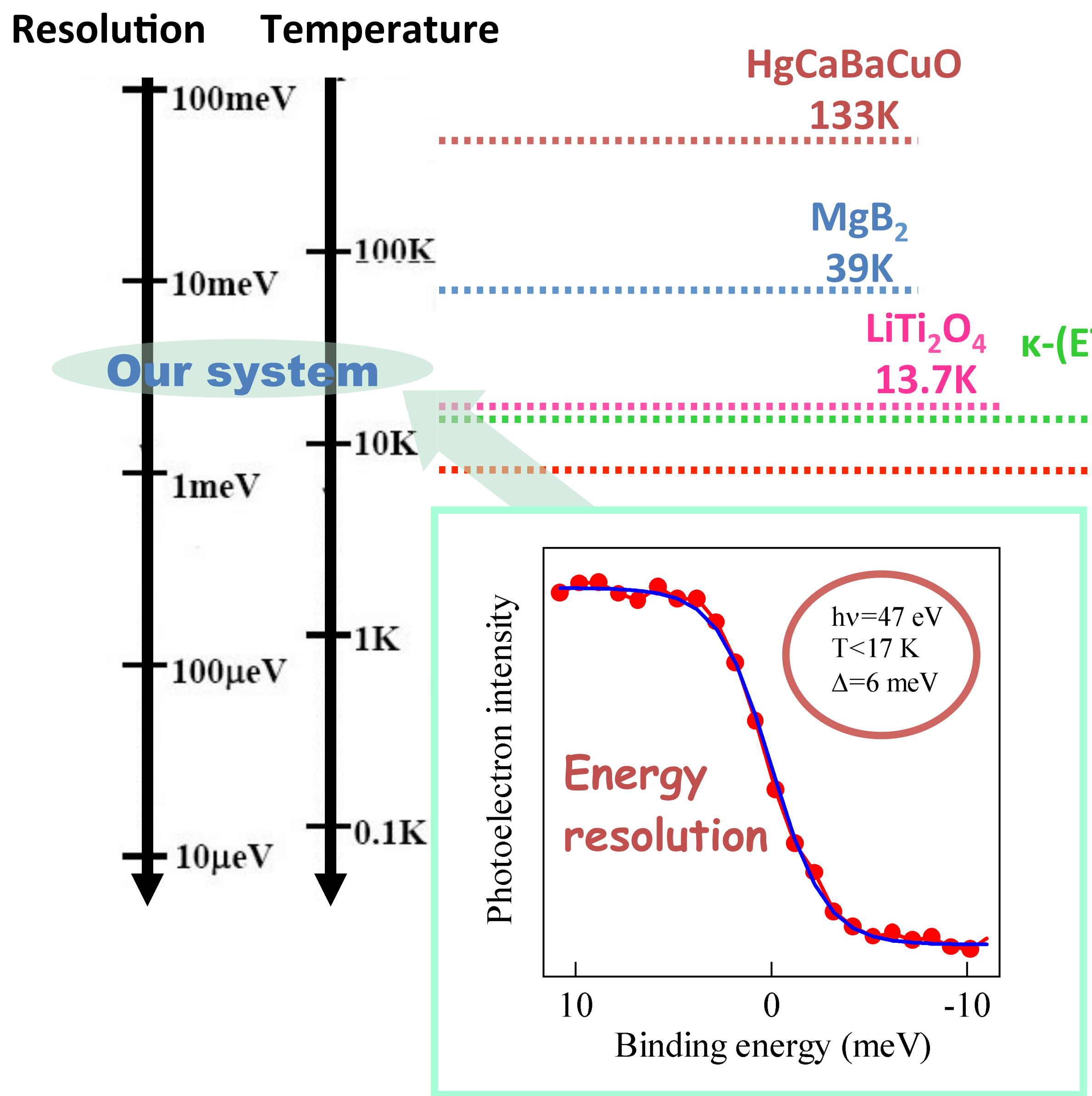
No pinholes, high thermal load

Two independent (almost)) beamline with dedicated end station(s)



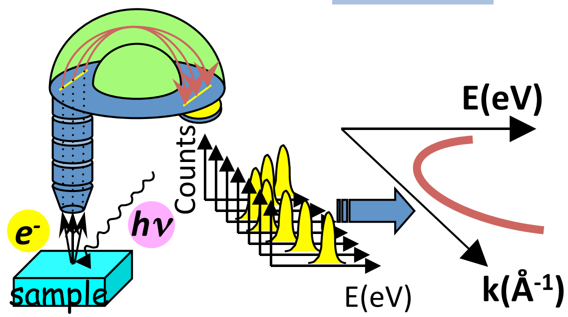


Photoemission spectroscopy:
the ‘right’ energy scale for electronic and magnetic properties

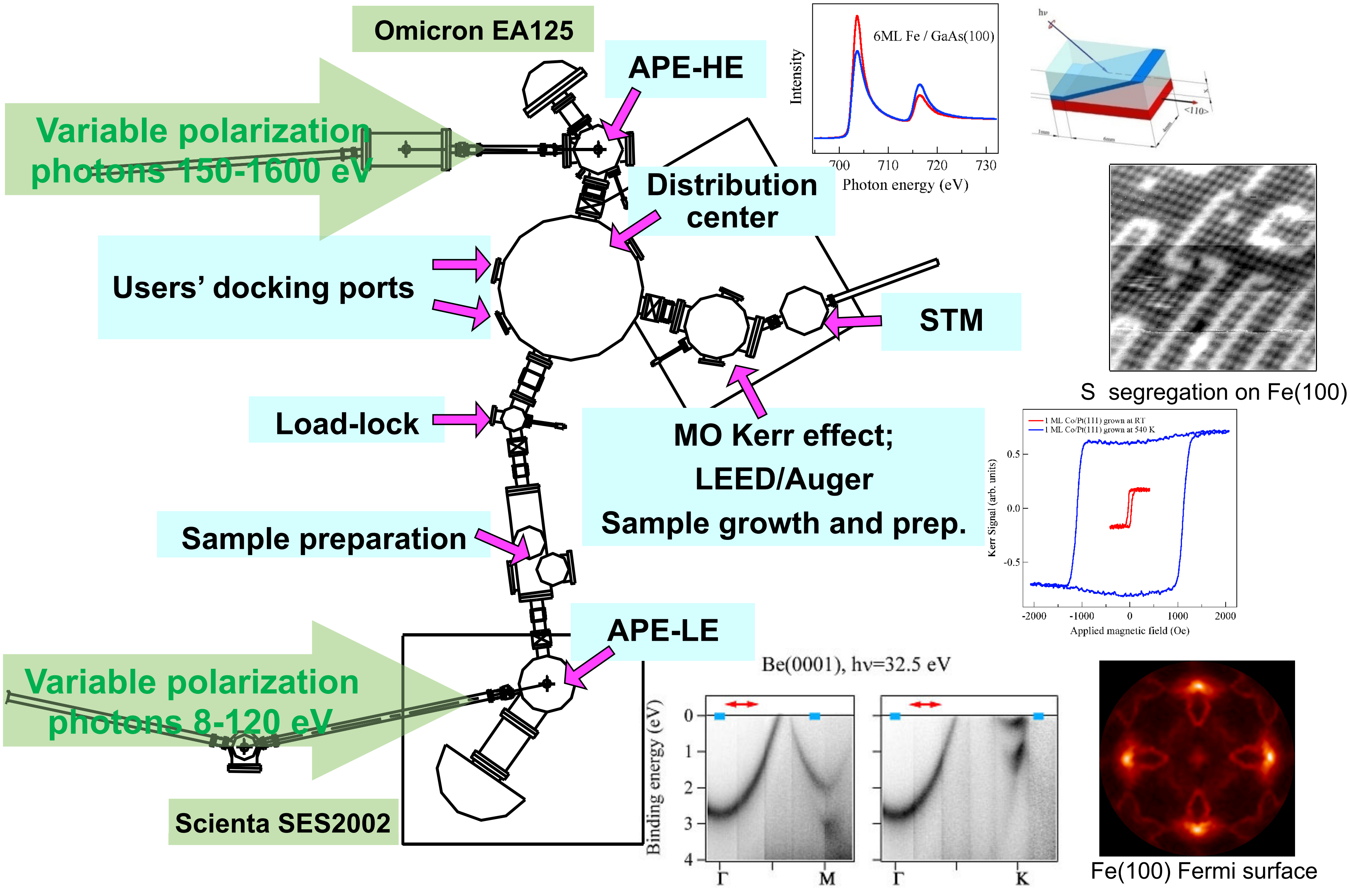


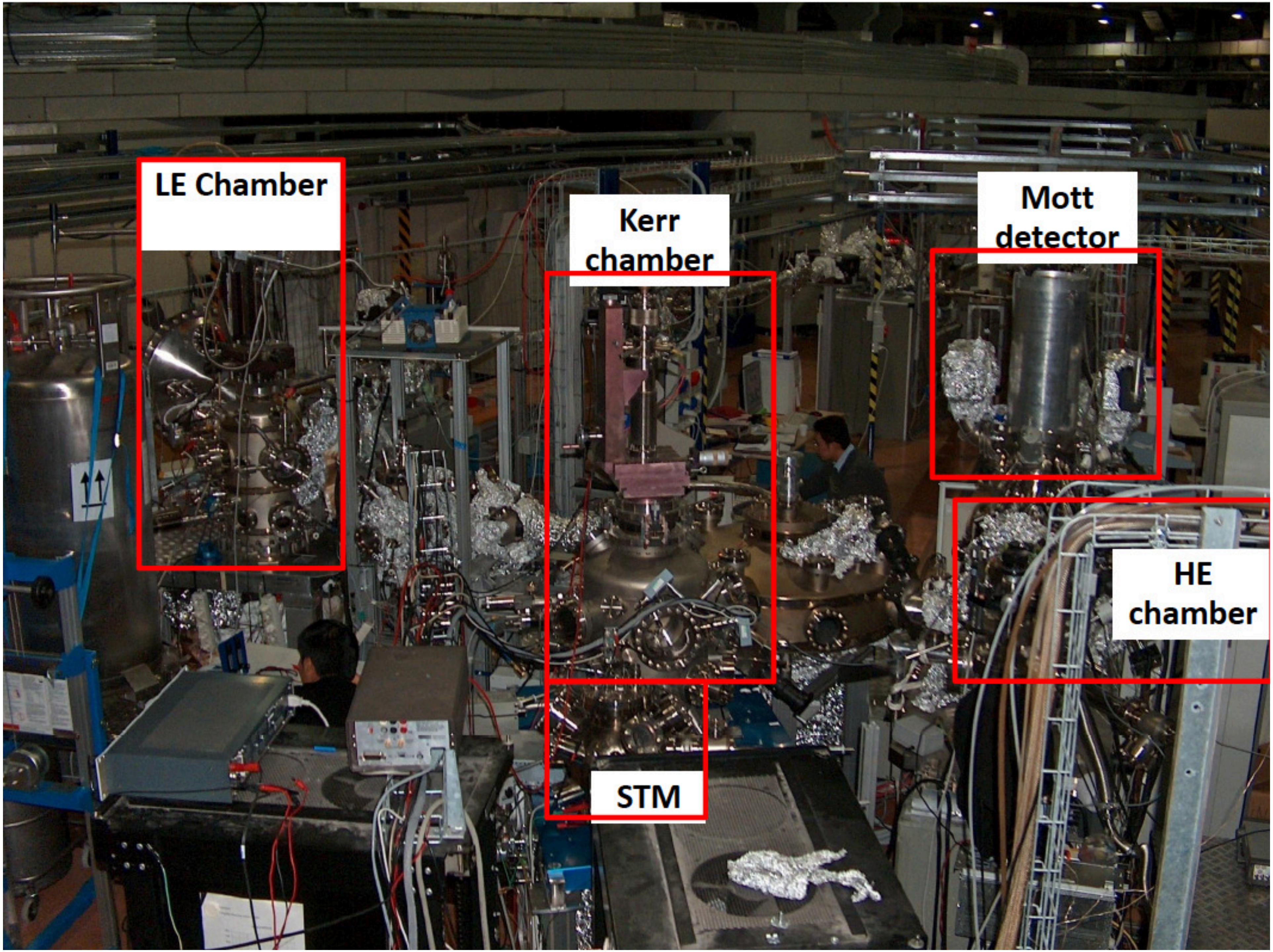
Angular resolution

- Achieved electronically
- In one shot – dispersion within ~14° in <0.2° step



APE Laboratory




LE Chamber
Kerr chamber
Mott detector
HE chamber
STM

Fermi surface ‘tomography’ with synchrotron radiation &

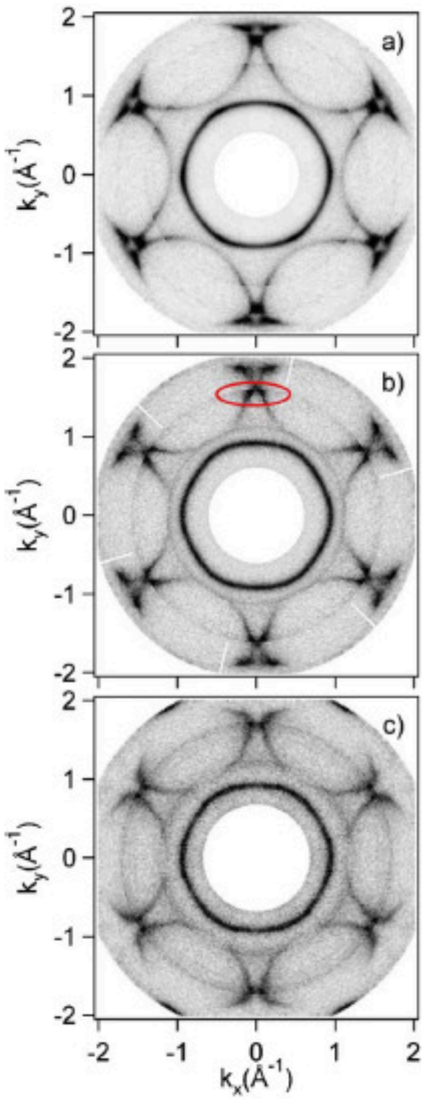


FIG. 1 (color online). The stereographic in-plane projection of the FS cuts measured with $h\nu = 31$ (a), $h\nu = 38$ (b), $h\nu = 42.5$ eV (c); the oval emphasizes the "discontinuity" (see text) ascribed to the coronet.

PRL **99**, 166403 (2007) PHYSICAL REVIEW LETTERS week ending 19 OCTOBER 2007

Three-Dimensional Tomography of the Beryllium Fermi Surface: Surface Charge Redistribution

I. Vobornik,[1] J. Fujii,[1] M. Hochstrasser,[1,2] D. Krizmancic,[1] C. E. Viol,[1] G. Panaccione,[1] S. Fabris,[3] S. Baroni,[3] and G. Rossi[1,4]

[1]*TASC National Laboratory, INFM-CNR, SS 14, km 163.5, I-34012 Trieste, Italy*
[2]*Laboratorium für Festkörperphysik, ETH Hönggerberg, CH-8093 Zürich, Switzerland*
[3]*SISSA and INFM-CNR DEMOCRITOS Theory@Elettra group, Via Beirut 2-4, I-34014 Trieste, Italy*
[4]*Dipartimento di Fisica, Università di Modena e Reggio Emilia, via Campi 213/A, I-41100 Modena, Italy*

(Received 20 April 2007; published 19 October 2007)

Be(0001) – large surface relaxation
Direct measure of surface induced charge redistribution from bulk to 2D surface state

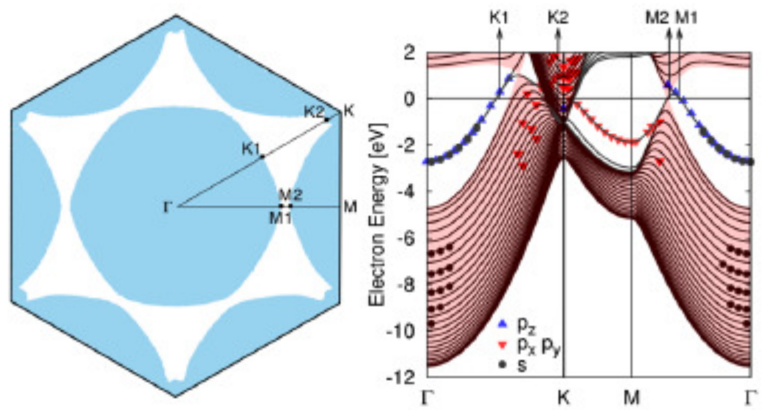
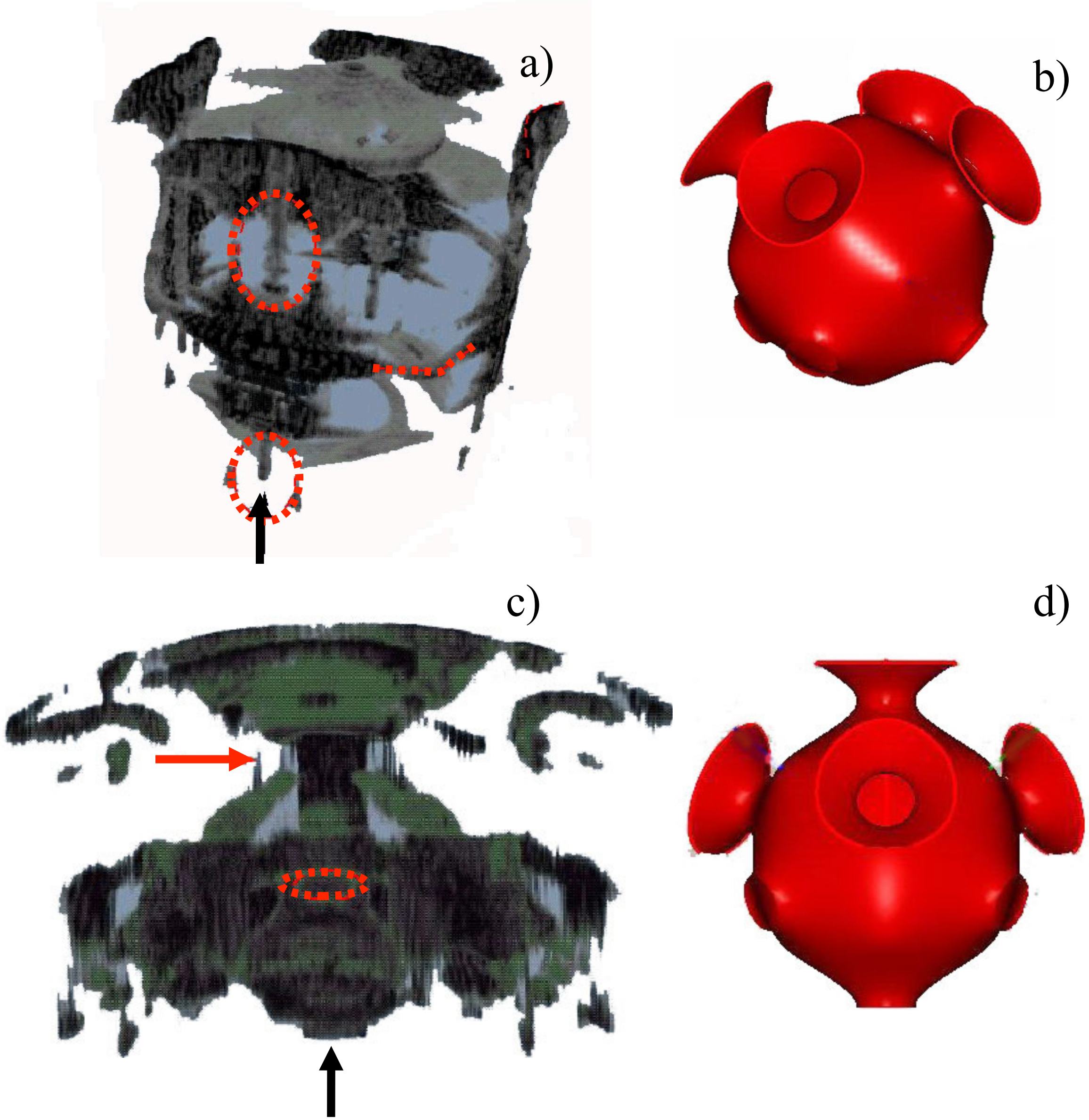


FIG. 4 (color online). Calculated FCs for the surface states (left) and band structure of Be(0001) (black lines) and of Be bulk (shaded red area; right); the symbols mark the electron states whose contribution from the outermost atomic layer is larger than 10%; the total area enclosed by the FCs of the surface states is ~34% (for the $\bar{\Gamma}$ surface state) and ~43% (for the $\bar{M}$ surface state) of the 2D Brillouin zone.

M@N6O4P$E?Q(R?;J-(E&;S$T?(LFJF";$KUV(WMN6



Measured on Cu(100) face

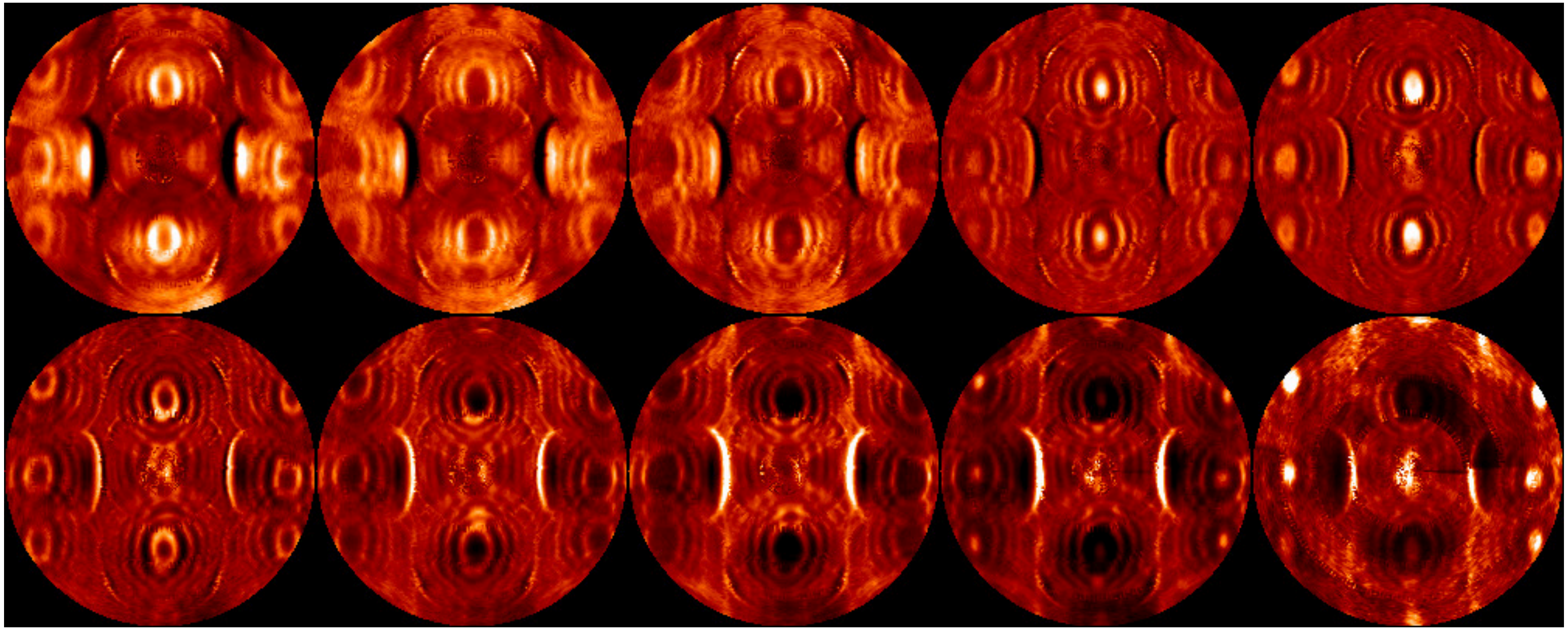
Direction	ARPES	dHvA [10,11]
ΓKX (1)	1.30±0.04	1.292
ΓΔX (2)	1.39±0.04	1.439
L-K (3)	0.21±0.05	0.256
L-U (4)	0.25±0.05	0.256
ΓΔX (5)	1.5±0.2	1.439

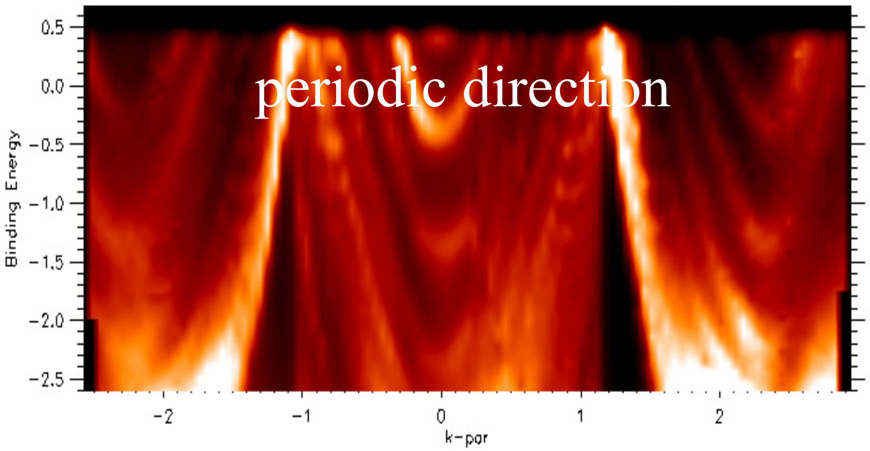
Measured on Cu(111) face

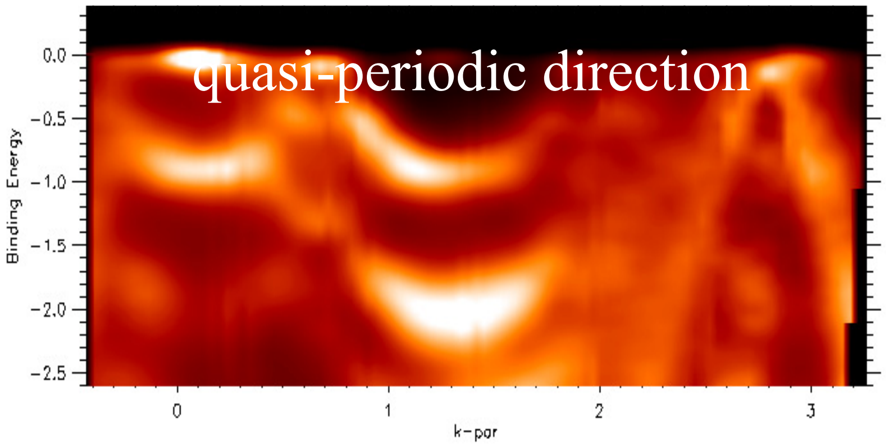
Direction	ARPES	dHvA [10, 11]
ΓM (1)	1.38±0.07	1.361
ΓM' (2)	1.37±0.05	1.361
ΓK (3)	1.32±0.03	1.292

I. Vobornik et al.&

Ag on GaAs(110): bandmaps of a 1-D quasi-crystal



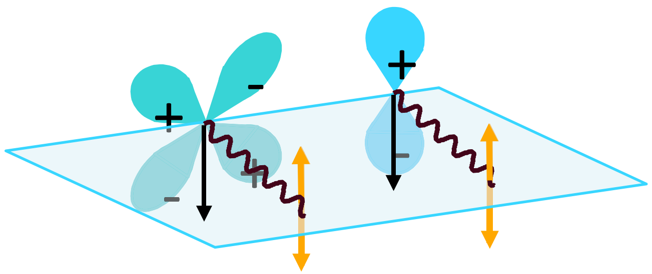




APE beamline, 2004

P. Moras et al. PRL 96, 156401 (2006)

Polarization control and ARPES: matrix elements



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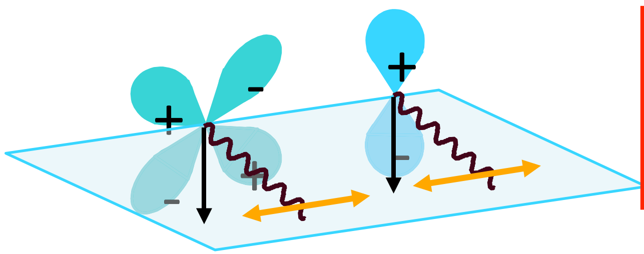
Vertical Polarization
odd simmetry states

Allowed emission



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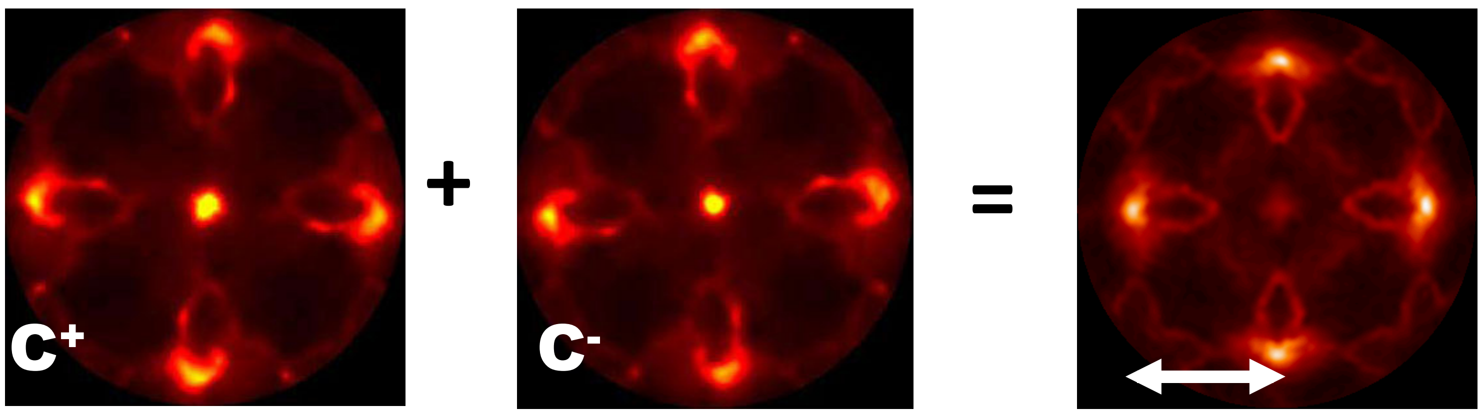
Linear Polarization
even simmetry states

Forbidden emission

Synchrotron Radiation: Linear and Circular polarization available

hn = 50 eV
Fe(001)
Fermi Surf.

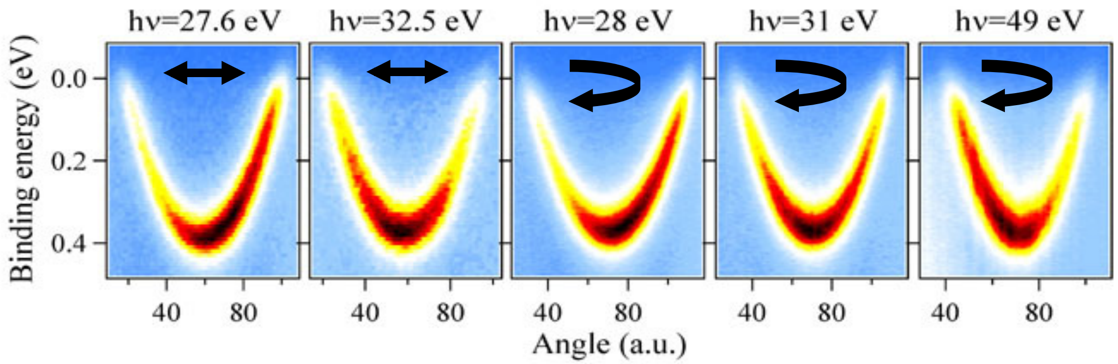


Istituto Officina dei Materiali

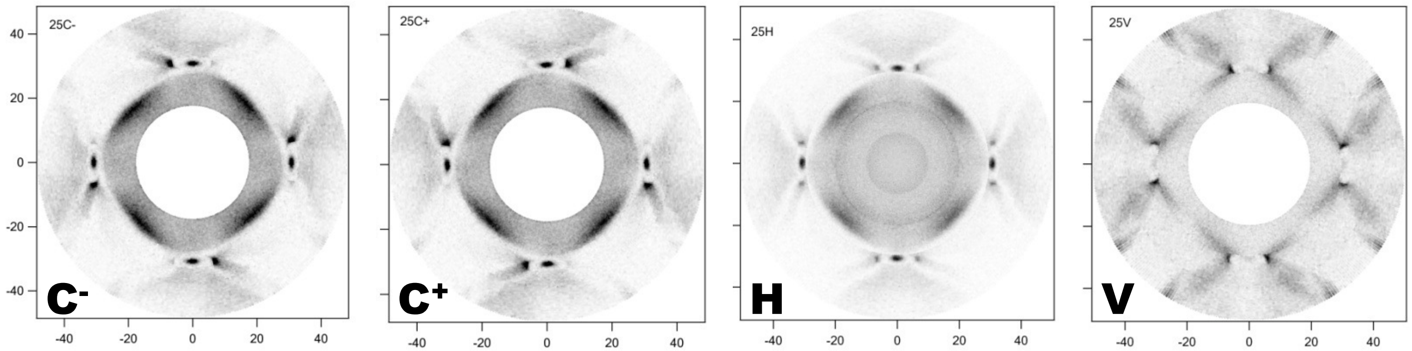
ARPES with tunable polarization

- Understanding photoemission matrix element $I(\vec{k},\omega) \propto \left|\langle f|\vec{A}\cdot\vec{p}|i\rangle\right|^2 A(\vec{k},\omega) f(\omega)$

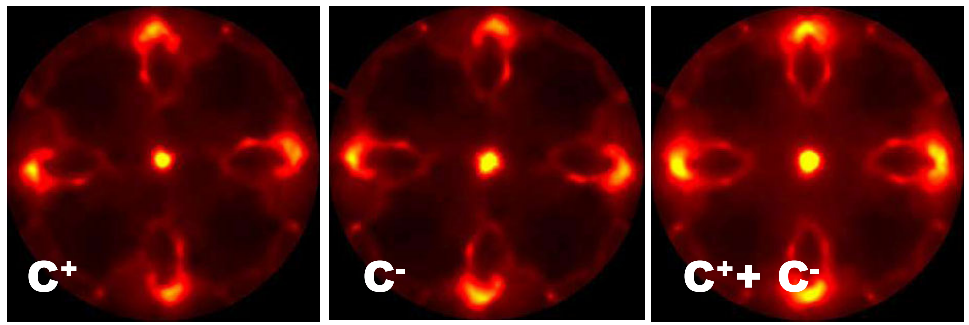
Cu(111) – surface state



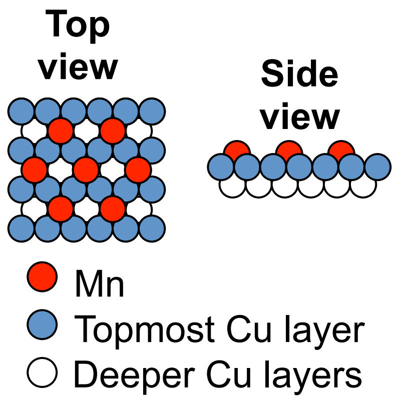
Cu(100)
Fermi surface

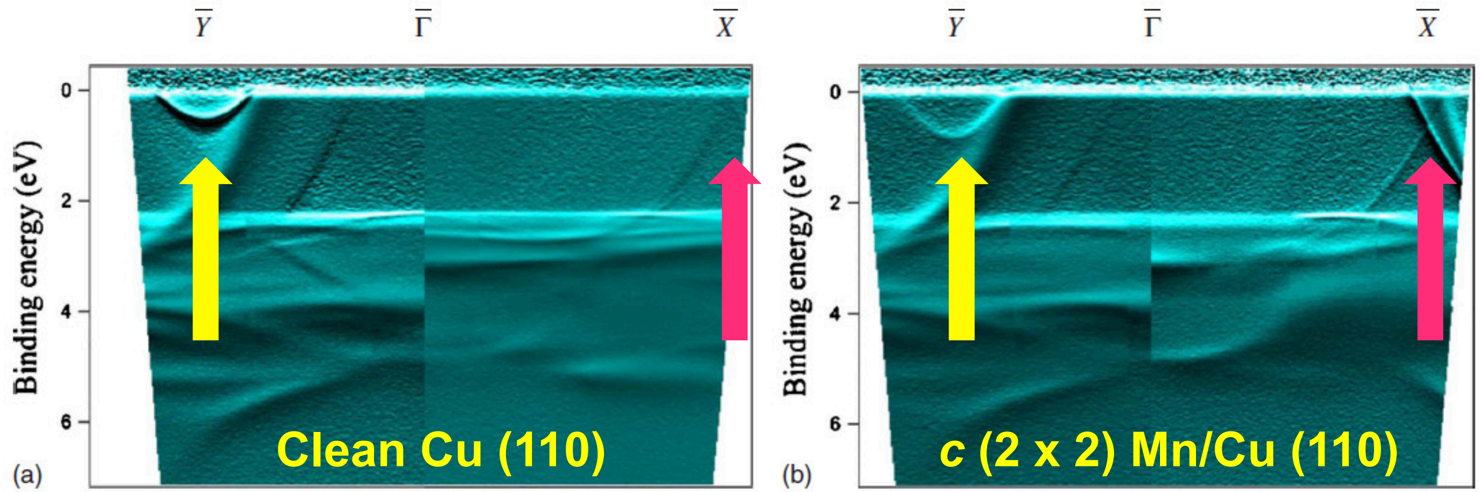


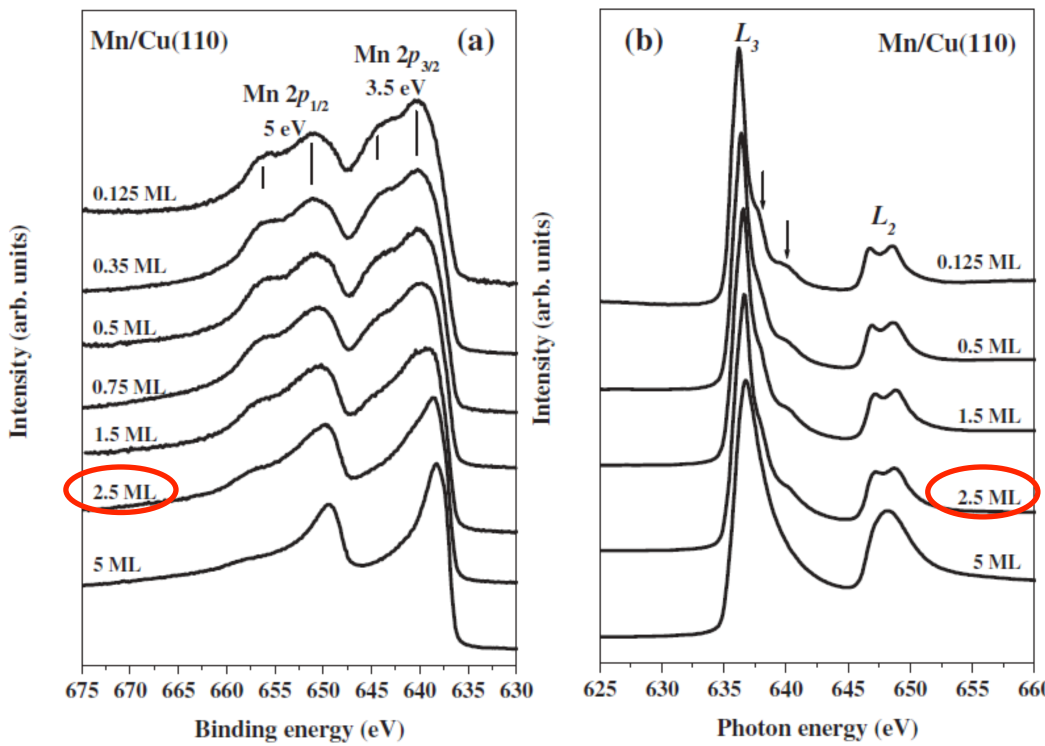
Fe(001) Fermi surface



Electronic properties of *c(2X2)* Mn/Cu(110)







Evolution of the electronic structure and the correlation effects:

- **Alloy related bands** with ~100 meV gap in the occupied states; **increased occupancy** of the Cu(110) surface state
- **Persistence of the correlation satellites** over large range of Mn concentrations
- **Calculations** by N. Binggeli et al., ICTP

U. Manju et al., Phys. Rev. B **82**, 035442 (2010)&

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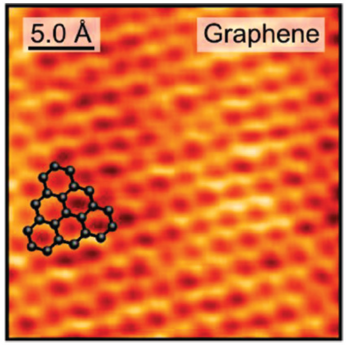
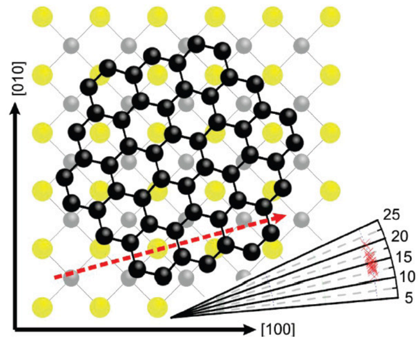
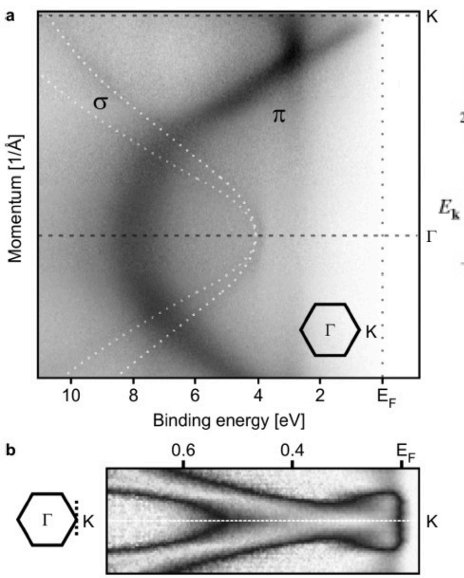
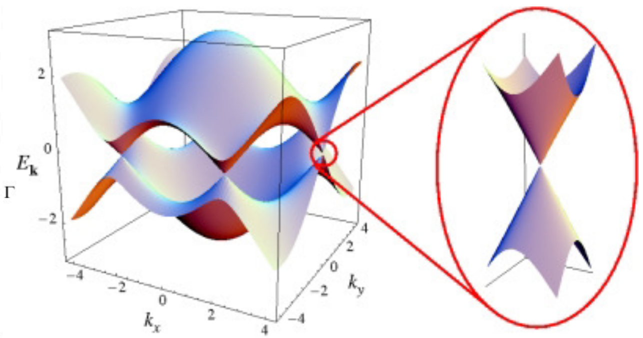
- **PROBLEM:** a number of production methods result in **small** graphene flakes **interacting with the substrate – altered electronic properties**
- **AIM:** mass production of graphene with **preserved properties**





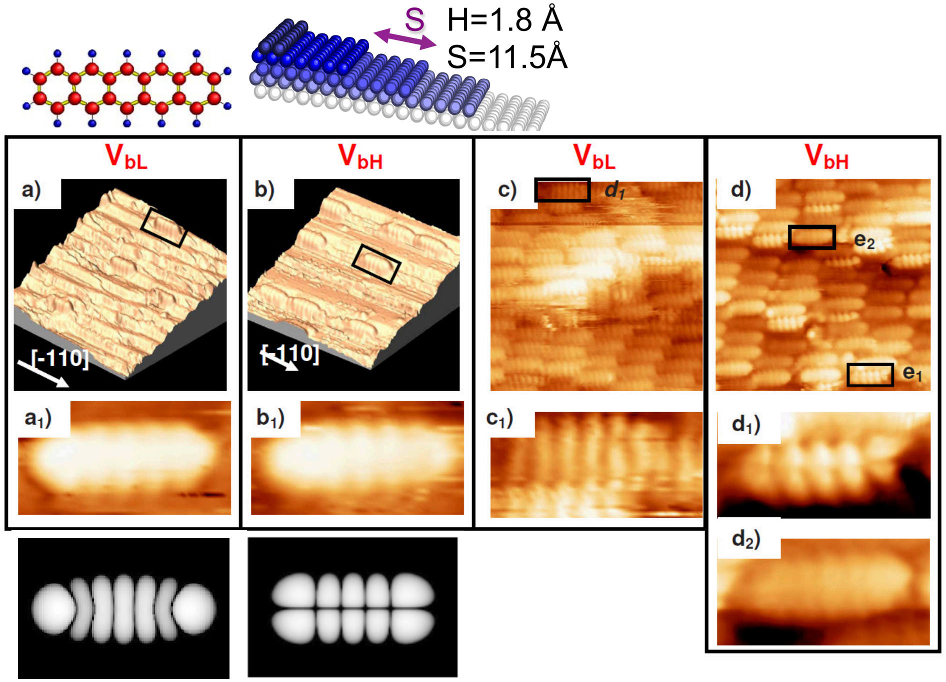




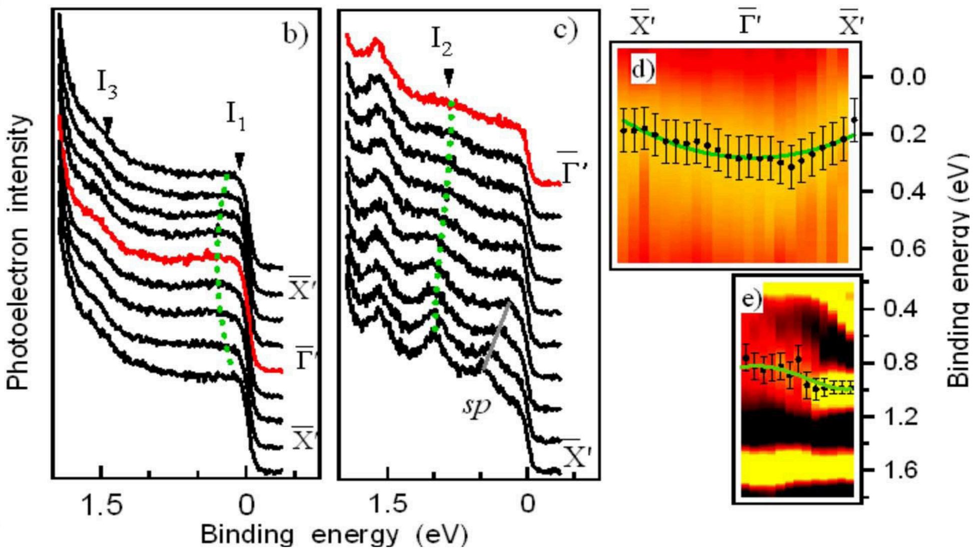
- Despite apparent lattice mismatch, graphene can be grown on β-SiC/Si cheap and commercially available wafers
- Very weak interaction with the substrate – likely because of the lattice mismatch

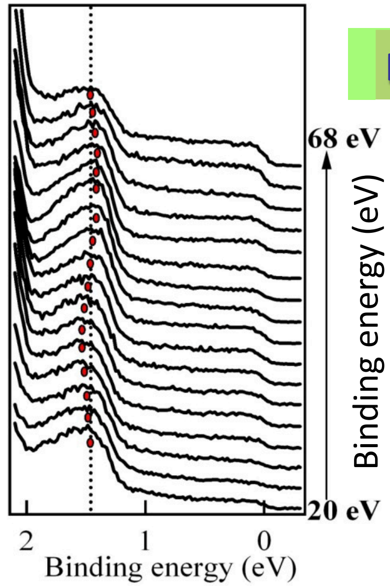
V. Aristov et al. Nano Letters 2010, **10**, 992–995
Among top-20 most downloaded Nano Letters in 2010 2nd

Pentacene/Cu(119) - HOMO/LUMO states

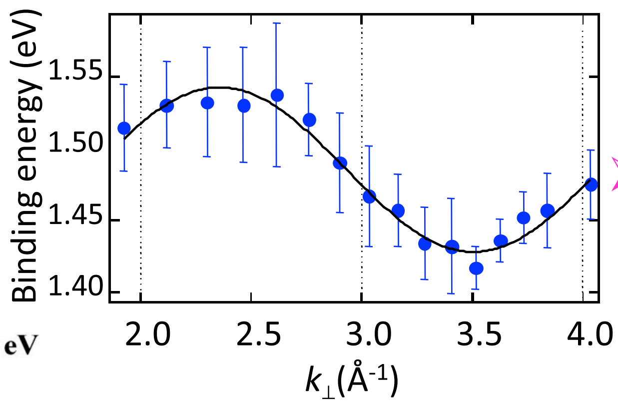


LUMO dispersion, 1ML film





HOMO dispersion, multilayer



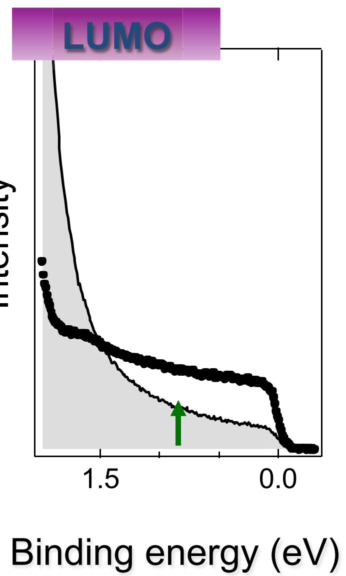
- A **peculiar charge density distribution** on the molecules involved in the interface electronic structure with partially populated **dispersive LUMO**

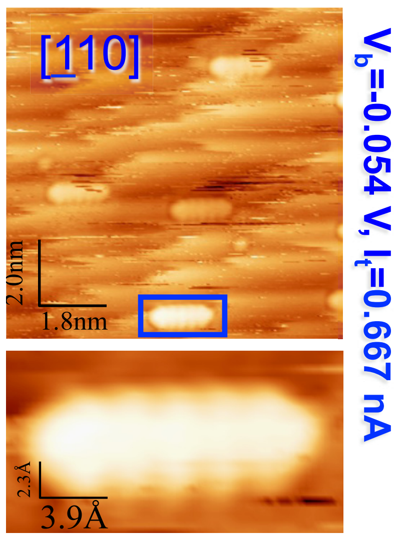
- Further pentacene overgrowth is compatible with weak intermolecular cohesion; **HOMO** interaction plays a crucial role

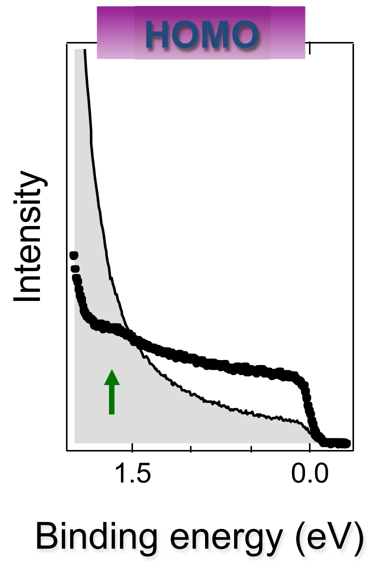
E Annese et al., Phys. Rev. B **77**, 205417 (2008), Langmuir 2010 - accepted

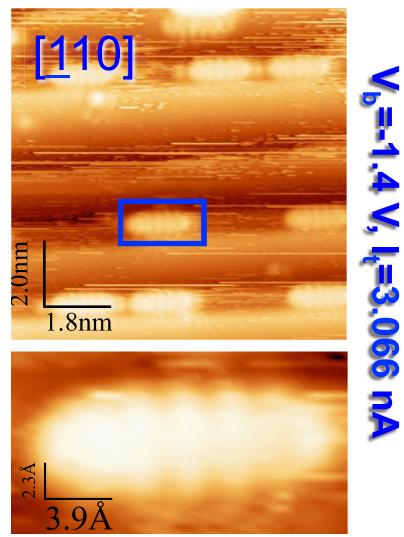
Molecular charge distribution of pentacene on Cu(119) in the contact layer

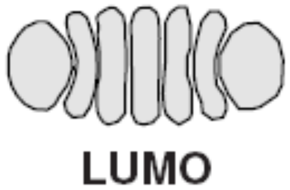
Pentacene
Sub-ML

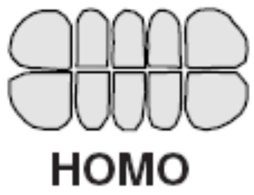




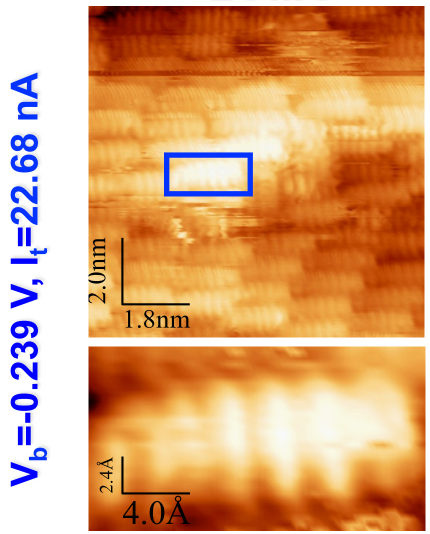




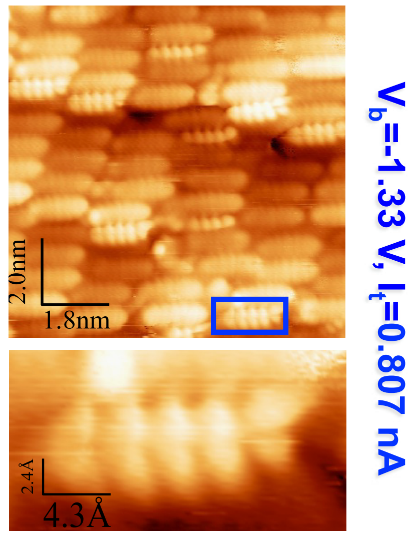




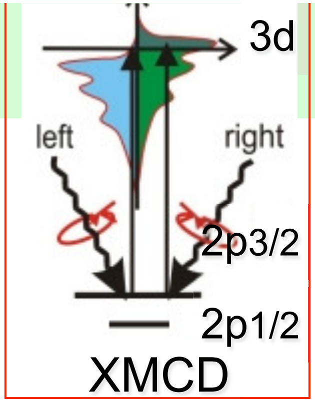
Pentacene
Overlayer(>1.5 ML)



A peculiar charge density distribution of the molecules at the interface

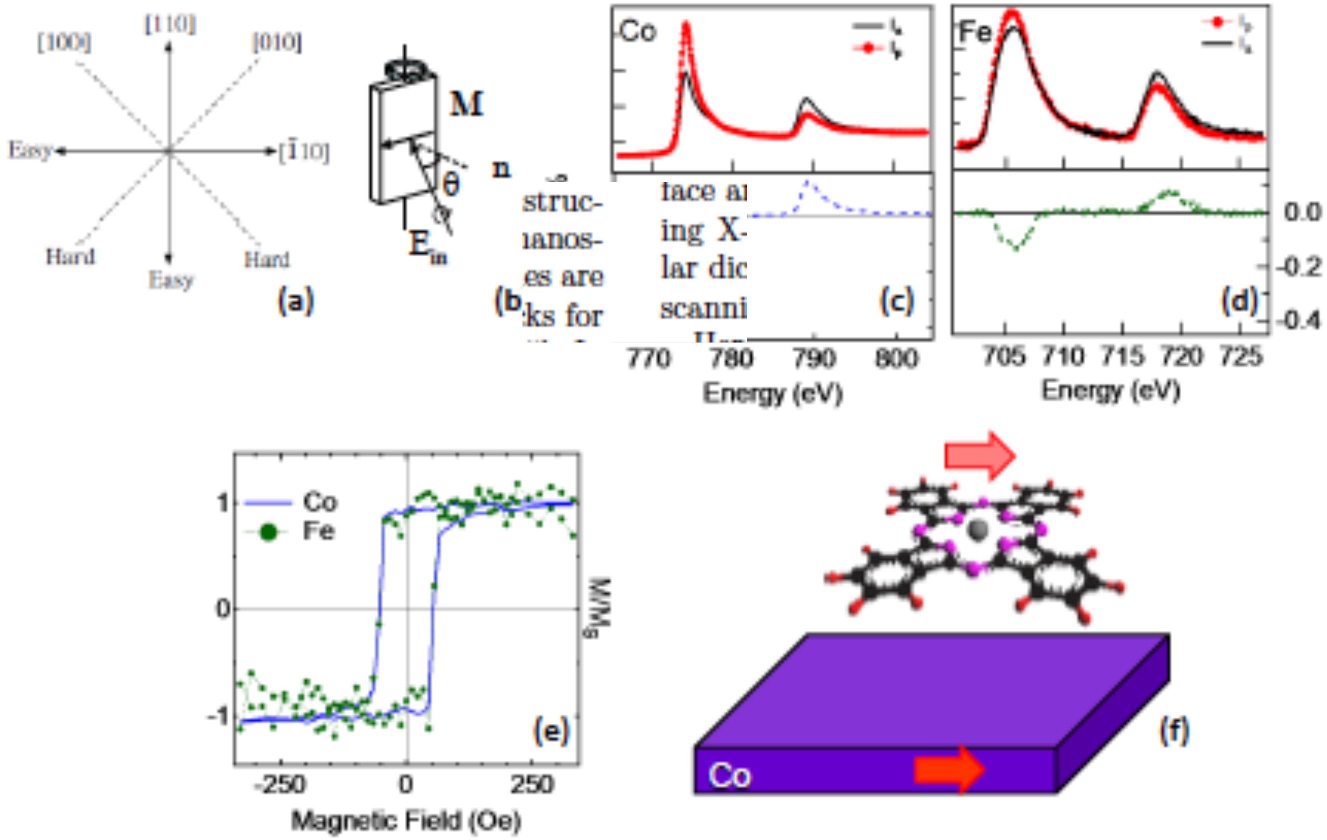


E Annese et al., Phys. Rev. B 77, 205417 (2008)



E. Annese,[1,2,3] F. Casolari,[1,2] J. Fujii,[2] and G. Rossi[4,2]
[1]Dipartimento di Fisica, Università di Modena e Reggio Emilia, via Campi 213/A, I-41100 Modena, Italy
[2]TASC Laboratory, IOM-CNR, SS 14, km 163.5, I-34149 Trieste, Italy
[3]Elettra Synchrotron S.C.p.A Trieste, SS 14, km 163.5, I-34149 Trieste, Italy
[4]Dipartimento di Fisica, Università statale di Milano, Via Celoria 16, 20133 Milano, Italy
(Dated: January 31, 2013)

Co magnetic anisotropy



E. Annese *et al*, PRB (2011); PRB (2013)
F. Casolari, Thesis 2012

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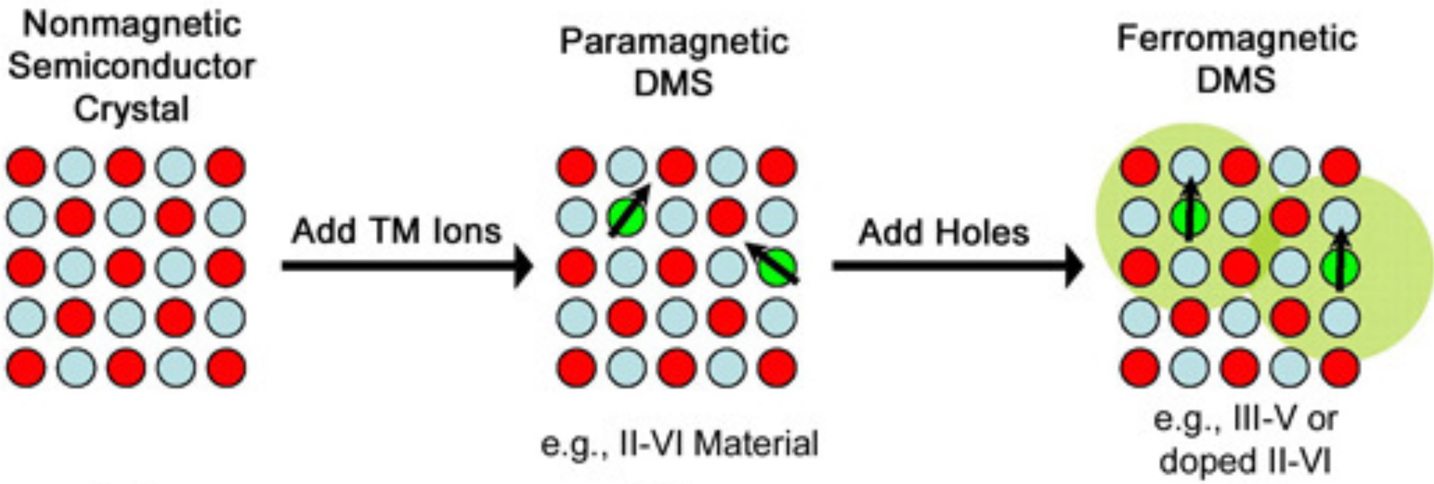

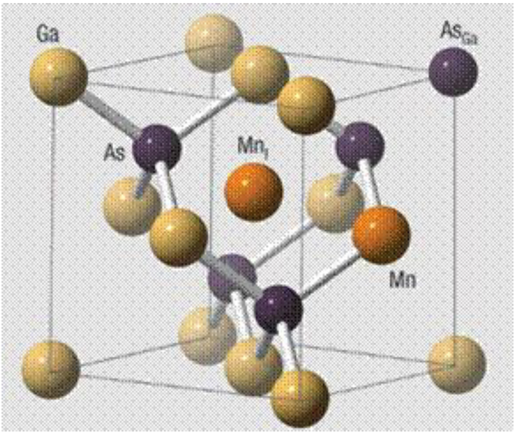

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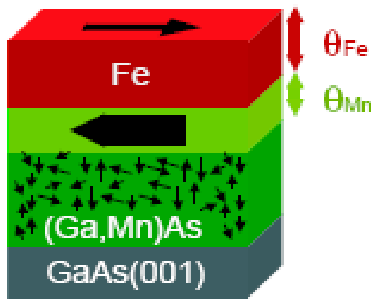


Highest Curie temperature ≈ 170K

Spintronics applications ???

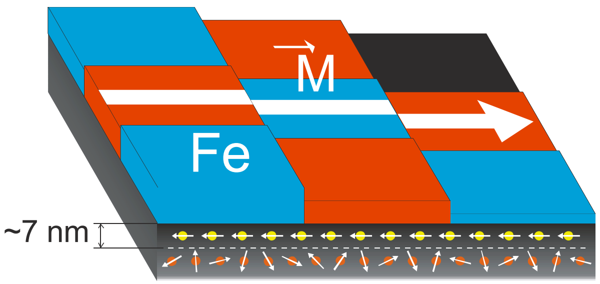
SFTF&O,42#0,72&/1&,7F)&U,16$/&O,1F&;)&8VG&@<==GB&

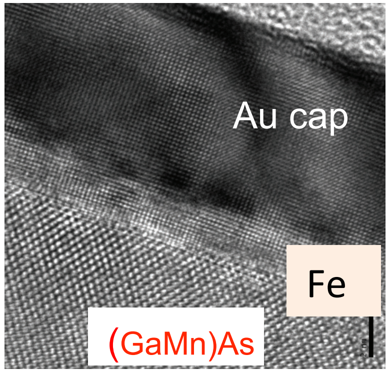
Selected for **Viewpoint, Physics** 1, 43 (2008)

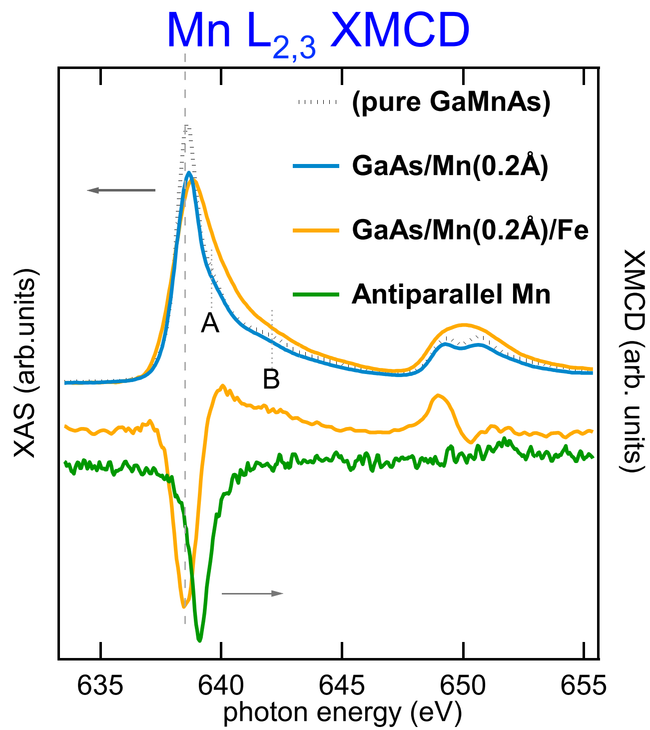
F. Maccherozzi *et al.* Phys. Rev. Lett. **101**, 267201 (2008)

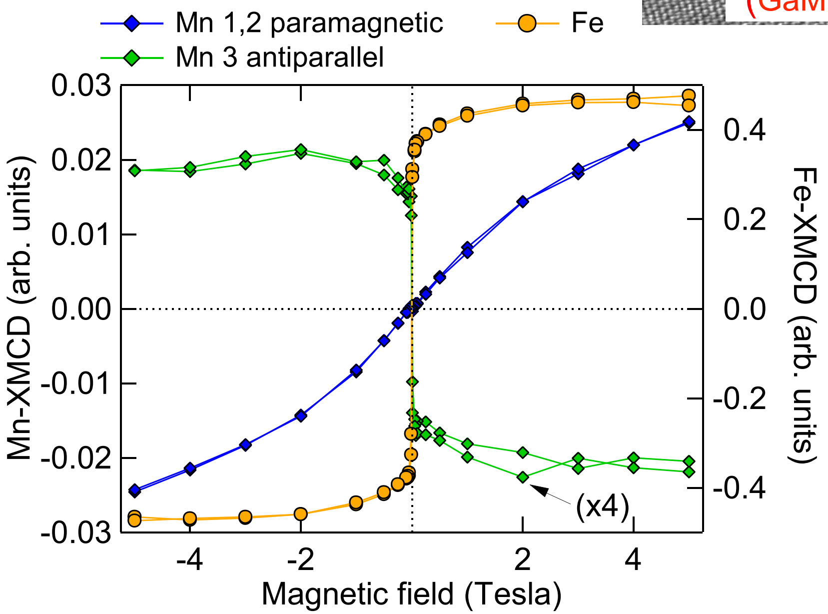
Tecnologie Avanzate e nano SCienza
Convincing a Magnetic semiconductor to work at room temperature
advanced Technology And nano SCience

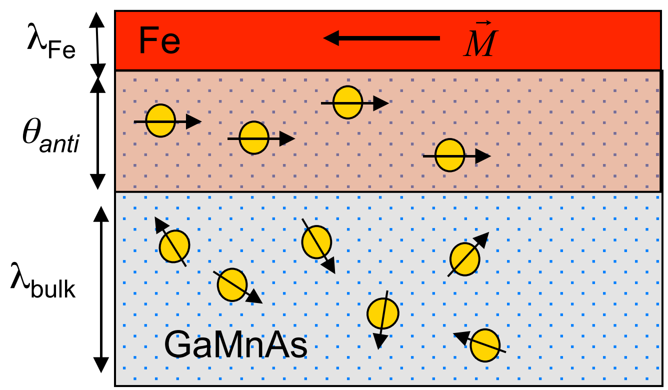
F. Maccherozzi *et al.* *APE beamline and ID08*
Phys. Rev. Lett. 101, 267201 (2008).











US Pat. 61/133,344, filed in Aug 2008 (CNR 40%)
Selected in Viewpoint, Physics 1, 43 (2008)

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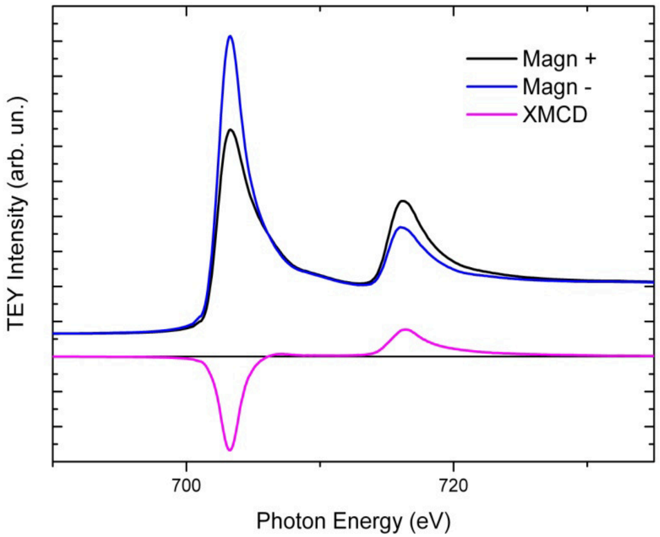

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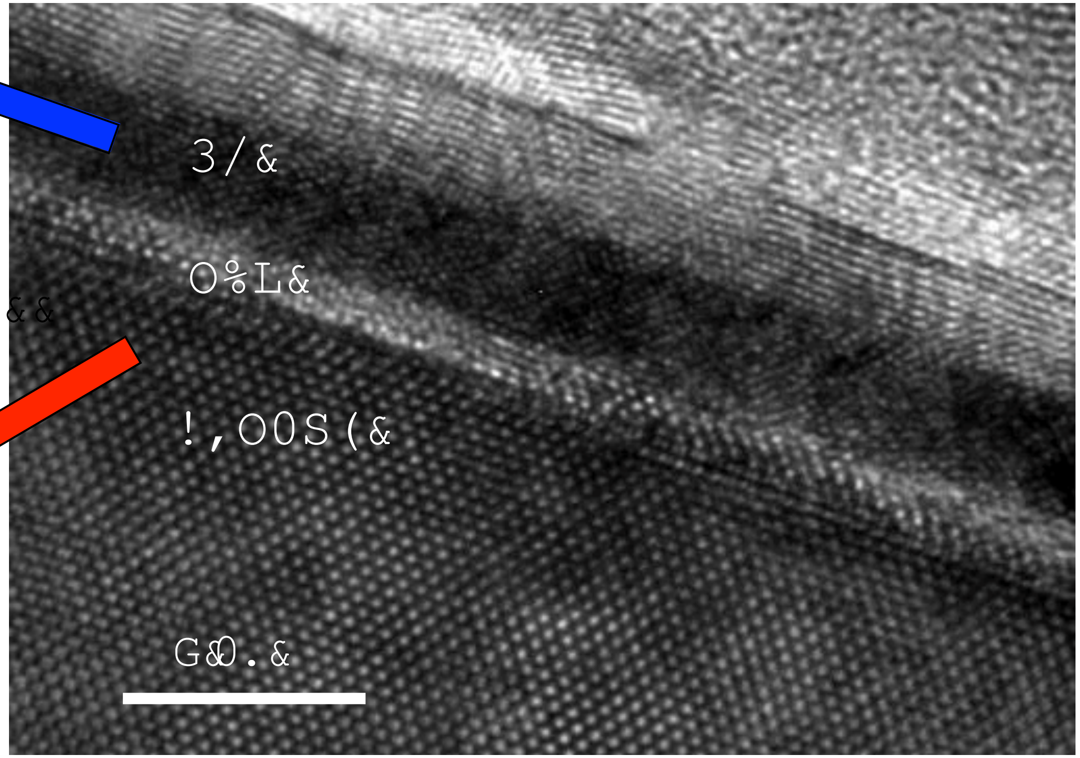

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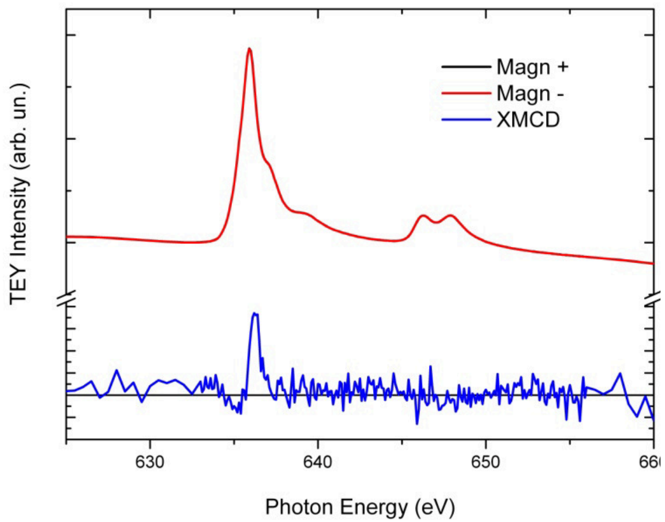

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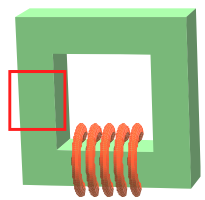
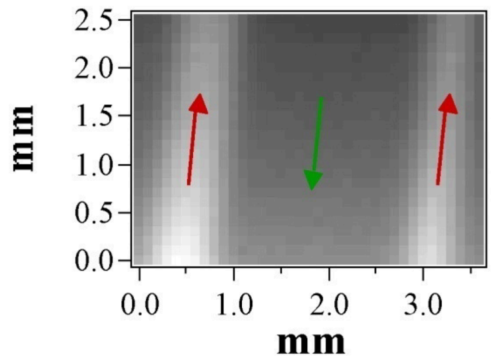
Vectorial twin-mott detectors @ APE beamline

J. Fujii et al., Phys. Rev. B **73**, 214444 (2006), M. Medici et al. (2011)

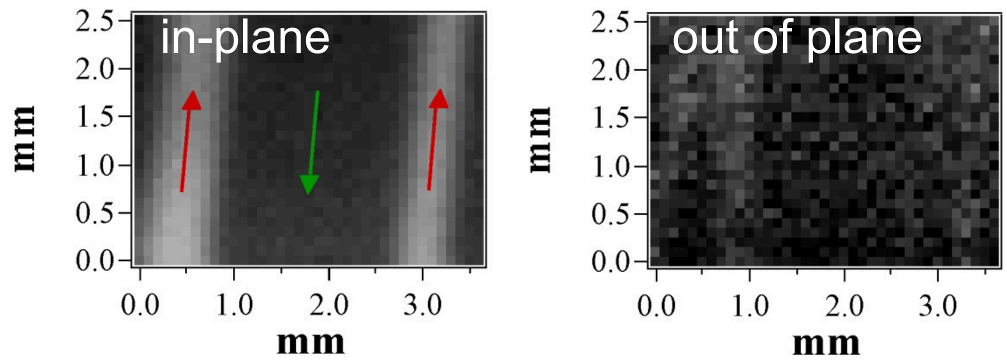
a) Fe(001) substrate

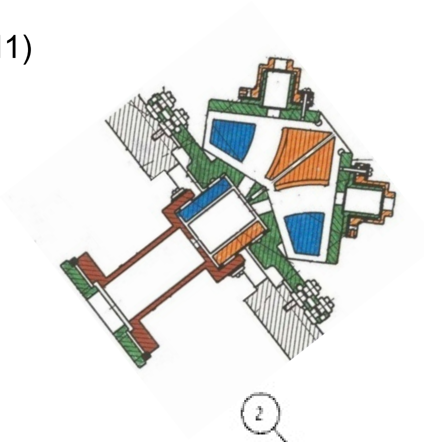


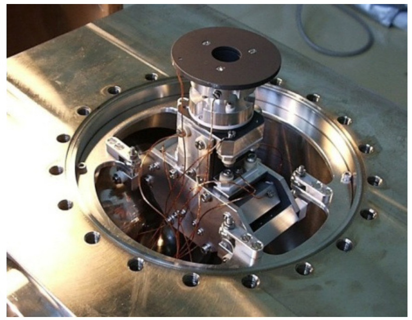
b) XMCD Fe L_3 edge

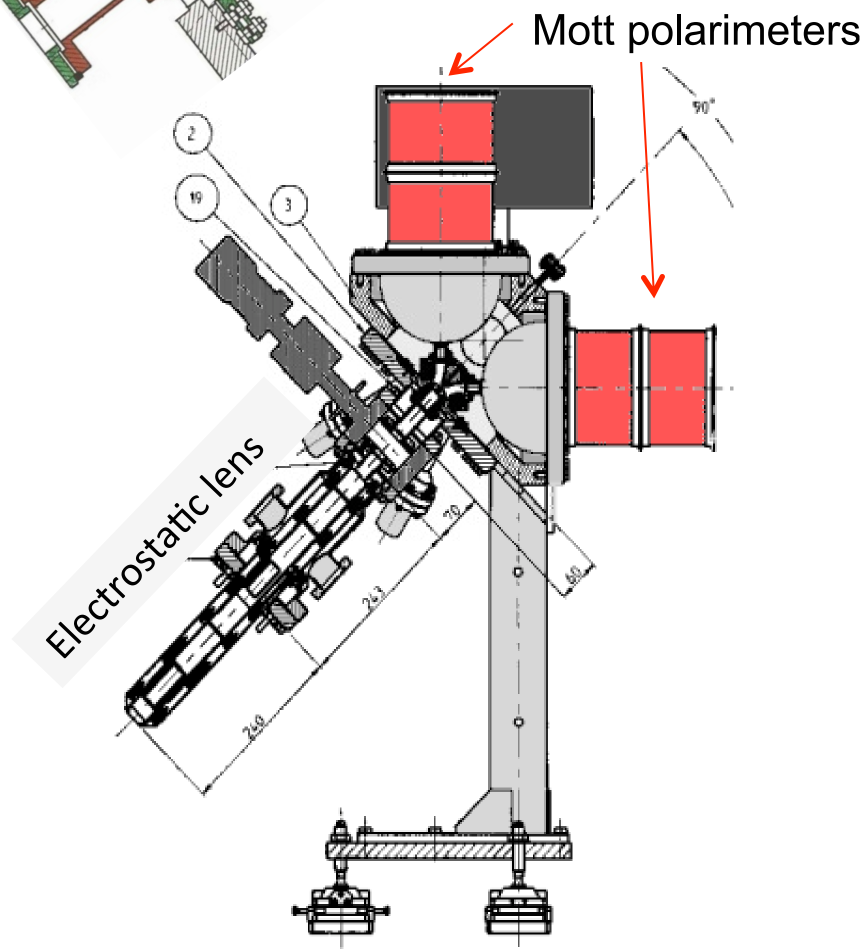


c) Spin resolved secondary electron yield





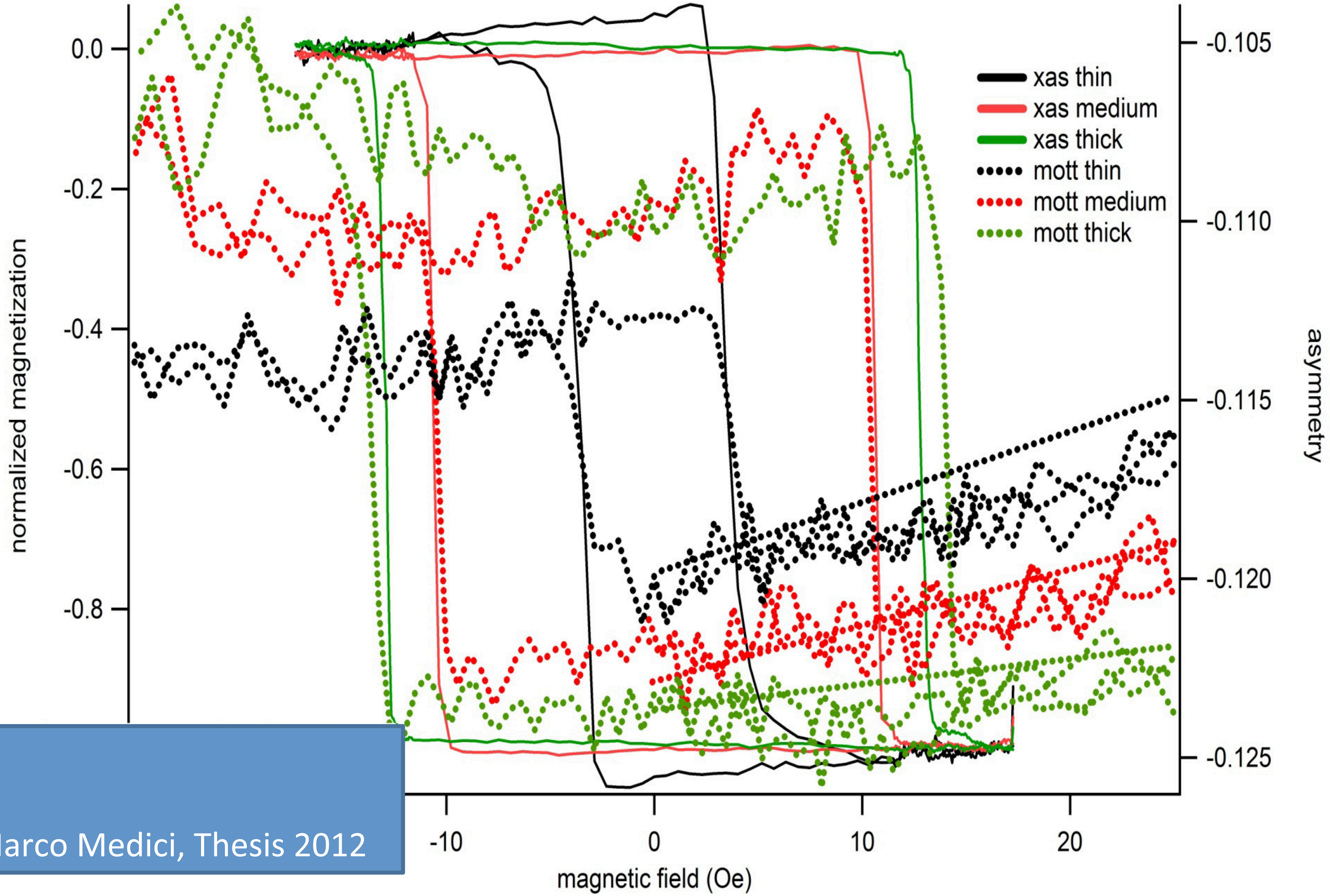




Spin resolved secondary electron yield
Measurement of both in-plane and out of plane spin polarization

V.N. Petrov et al. Rev. Sci. Instruments 72, 3728 (2001)

Magnetometry of ultrathin Fe films on GaAs



Marco Medici, Thesis 2012