Threshold time resolved surface magnetometry of low dimensional systems

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EUFELE: HPRI-CT-2001-50025

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Collaboration for Time resolved magnetometry

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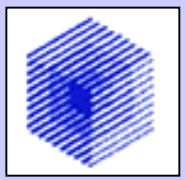

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Technological importance

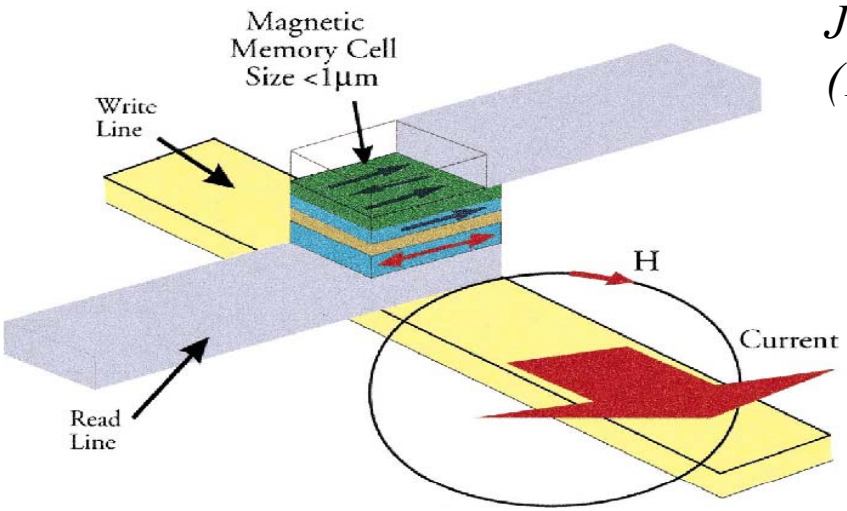
* Magnetic Hard drive :

2002: 130 Gbit/in2

Domain size: ~ 0.1 μm

Writing speed: 100 ps

* Magnetic memory cell:



J.B. Kortright et al.
Journal of Magnetism and Magnetic Materials 207 (1999) 7-44

Size: ~1 μm

Reversal time ~ few ps

* Spin Electronics:

Spin polarized Current-induced switching in the orientation of magnetic moments

Physics of magnetization reversal:

* Landau-Lifshitz equation

$$\frac{d\vec{M}}{dt} = \underbrace{-|\gamma|(\vec{M} \times \vec{H}tot)}_{\text{Precession}} + \underbrace{\frac{\alpha}{M}(\vec{M} \times \frac{d\vec{M}}{dt})}_{\text{Rotation}}$$

γ : Gyromagnetic ratio

α : Damping constant

$$\vec{H}_{tot} = \vec{H}_{ex} + \vec{H}_{D} + \vec{H}_{A}$$

* Important role of electronic states for magnetic properties: (oscillatory magnetic coupling, giant magneto resistance, and interface doping)

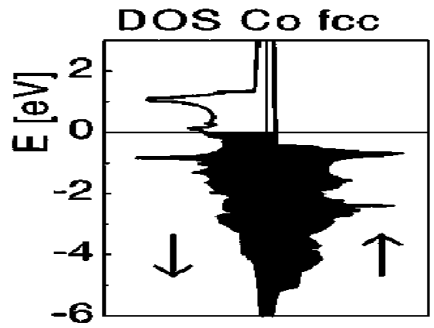
Description of the existing experiment @Saco_LURE

Measure of the spin polarization

Secondary electrons photoemission:

Spin polarization

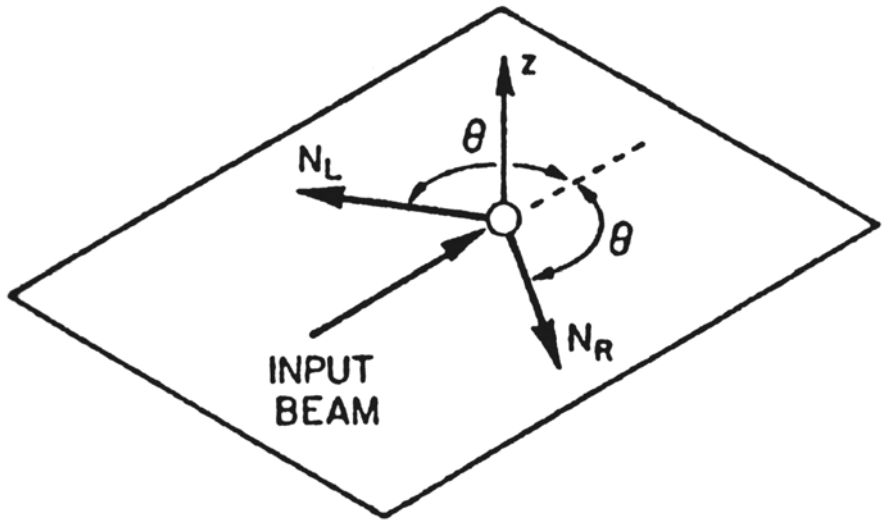
High surface sensibility



Mott Analyzer

$$A(\vartheta) = \frac{N_L - N_R}{N_L + N_R}$$

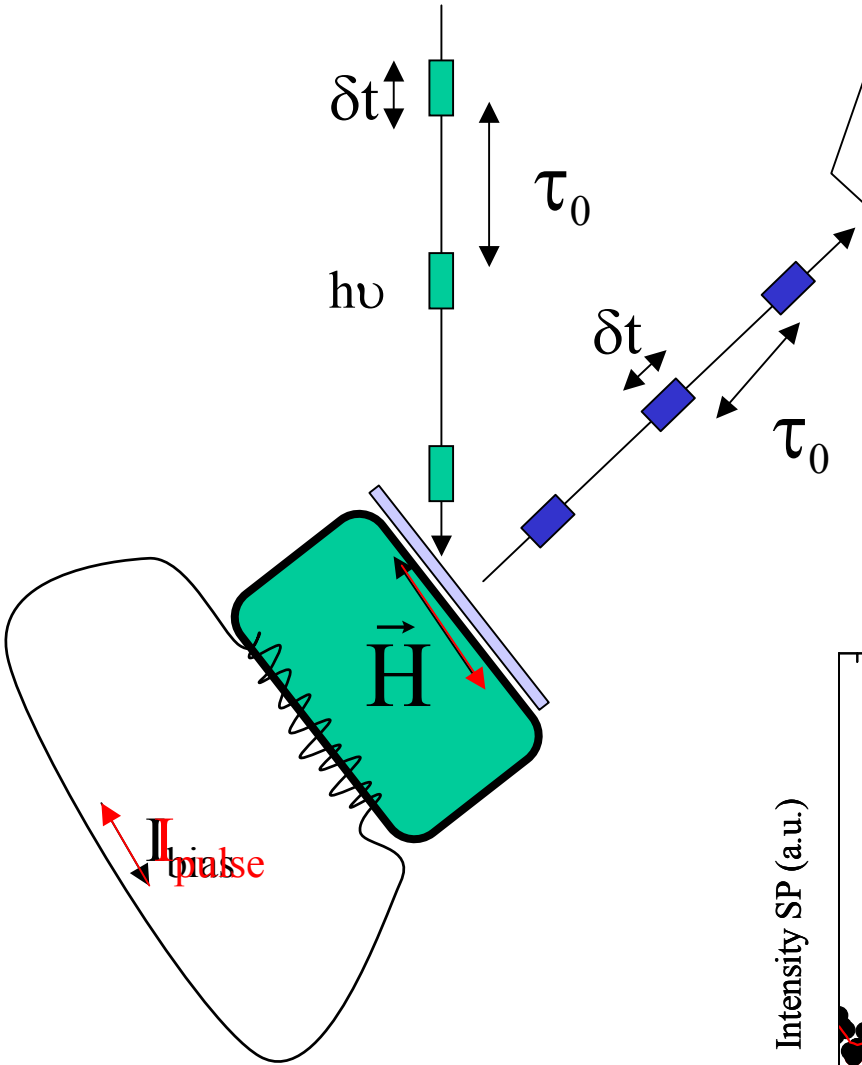
$$A(\vartheta) = PS(\vartheta)$$



N_L and N_R are the scattering intensities of electrons of opposite spin polarization.

The connection between the measure asymmetry and the spin polarization is given by the Sherman function.

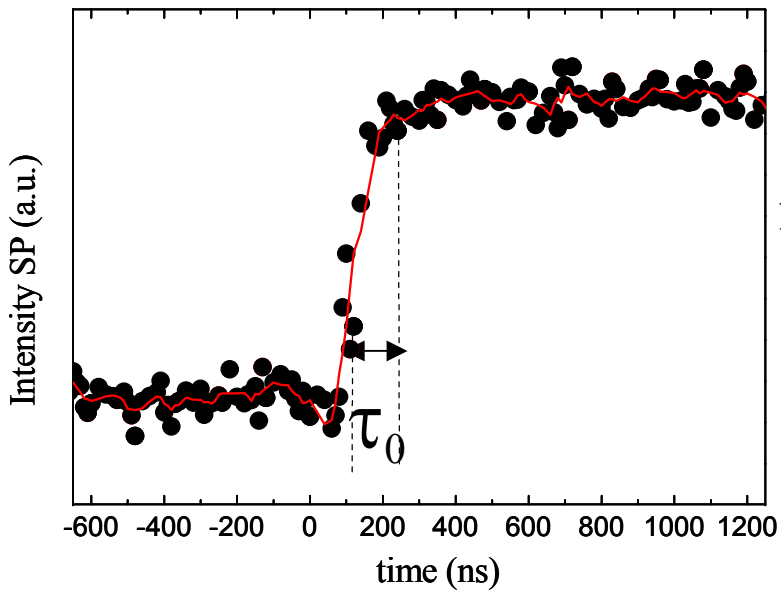
Time Resolved Surface Magnetometry



Mott detector

10^5 e- in the counters of the detector.

F.Sirotti,
***PRB61**,R9221(2000)*



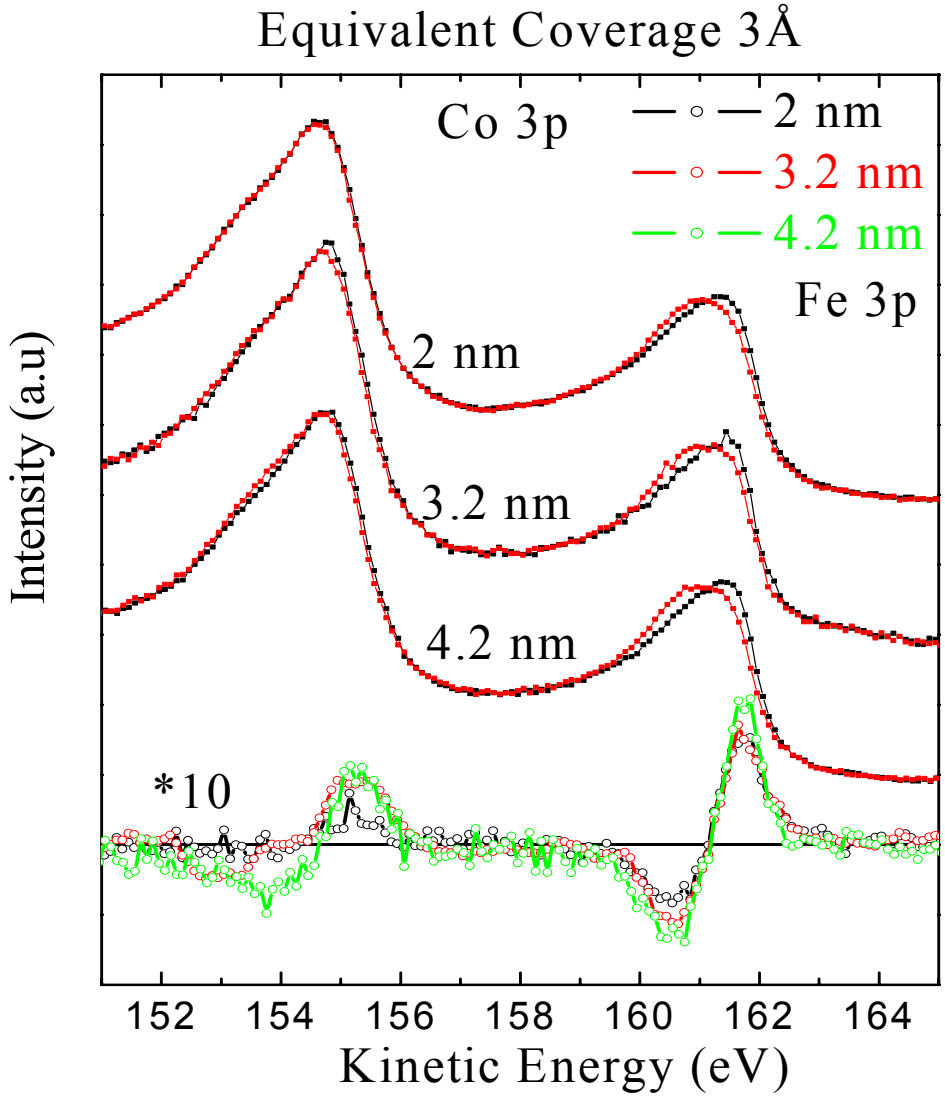
Time resolution

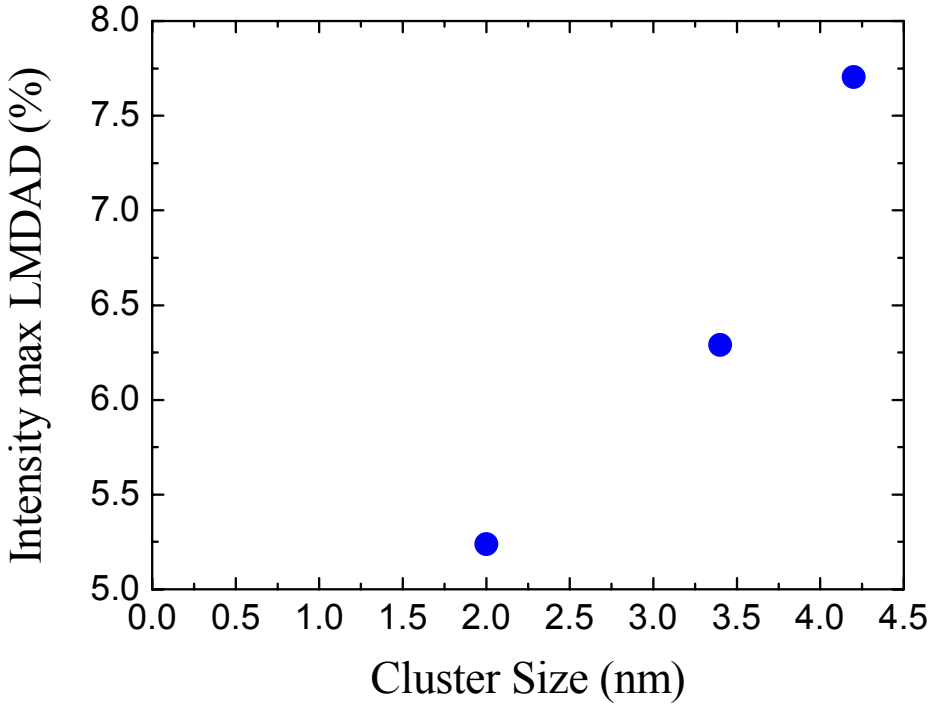
1 ns=δt

@ T=0 Apply magnetic pulse

Magnetic property of Iron Isolated nano-cluster by LMDAD

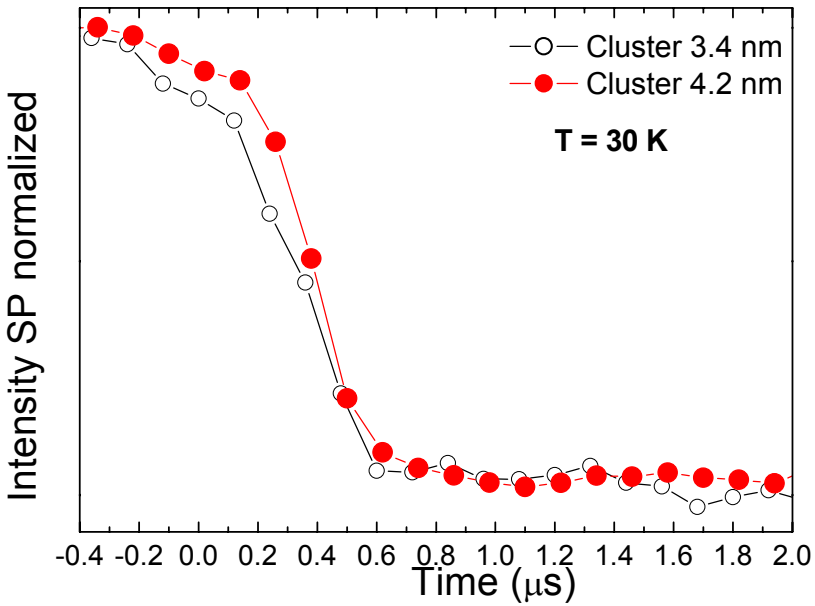
(H. Cruguel, C. Binns, S.H. Baker, F. Sirotti, P. Prieto)



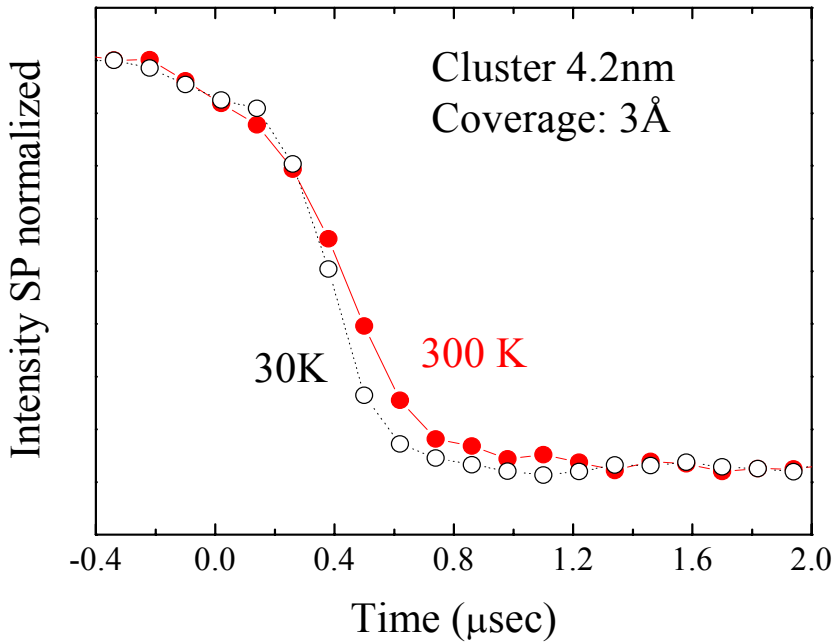


Magnetic moment increase with the cluster size

Dynamic behavior of magnetization of Iron nano-cluster



- Magnetization reversal is faster for smaller cluster at low temperature



-Magnetization reversal of mass selected clusters is faster at low temperature

-For the highest available applied field the different cluster size present the same reversal time of 20ns

T. J. Jackson, J. Phys. **12** 2000: *on Fe/Ag*

Relaxation time: 12±4 ns

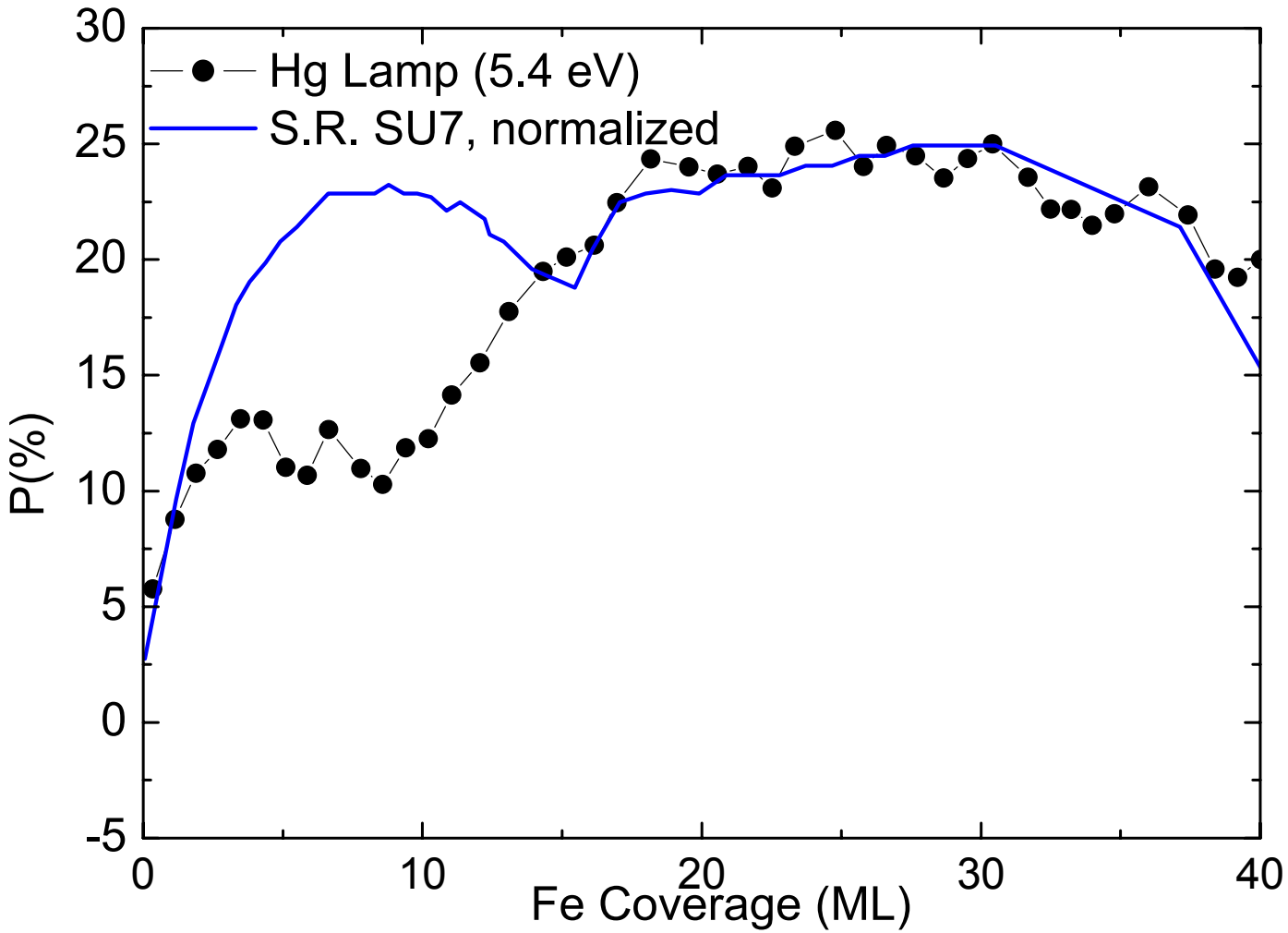
Limitations of the existing experiment

* Time resolution ~ 1ns

* Beam size ~mm

* Wavelength: Integrating the all Density Of State

* Magnetic pulse ~ 50 ns



P in lure for the all DOS: 25%

P @threshold: 40%

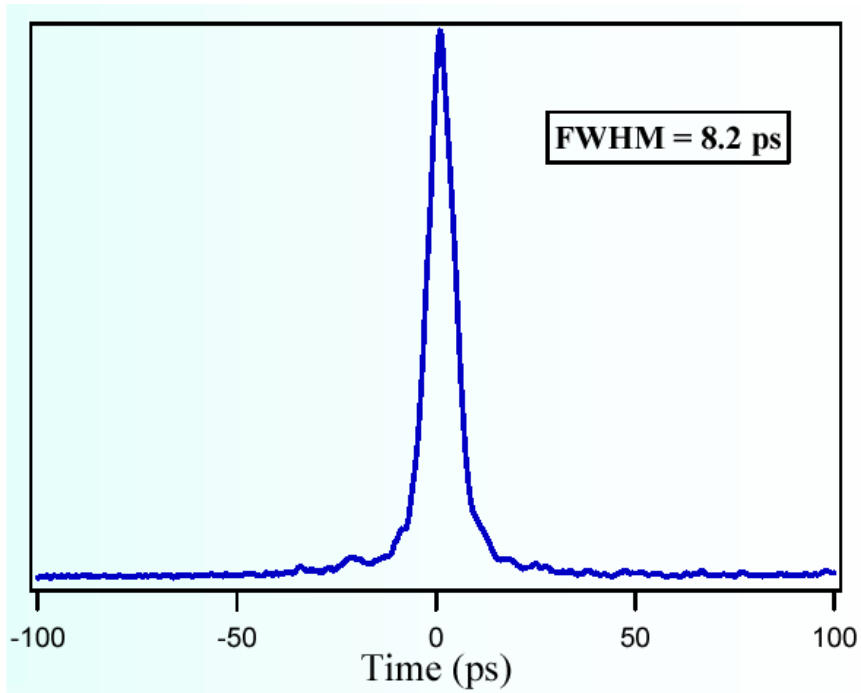
EUFELE project: HPRI-CT-2001-50025

FEL characteristics in Elettra:

High Photon flux with tunability in the range of [3.5,…, 8 eV]
(350,..,160 nm)

Time resolution : 10 picoseconds

Wavelength (nm)	$\Delta\lambda/\lambda$	t (ps)
355	$4.2\ 10^{-4}$	8.9
224	$2.2\ 10^{-4}$	8.2
208	$2.7\ 10^{-4}$	8.2
190	$2.\ 8\ 10^{-4}$	7.7



Beam Size : $< \mu m^2$

Small beam size: Study of sample smaller than 1μm (1 magnetic domain)

Time resolution: Study of faster dynamic behavior

Fast dynamic on small sample : Precession of magnetic moment
(Y. Acremann, science 290 (2000), 492)

Use of 4 detector : precession measurement in plane

New pulse generator: ~ 20 ps

Energy Range: - possibility to work at photoemission threshold

- Study of the spin population of the DOS

{ Narrowing of the d Band, increase of DOS at Ef when decreasing cluster size

Change in DOS by injection of spin polarized current

Status of the experiment

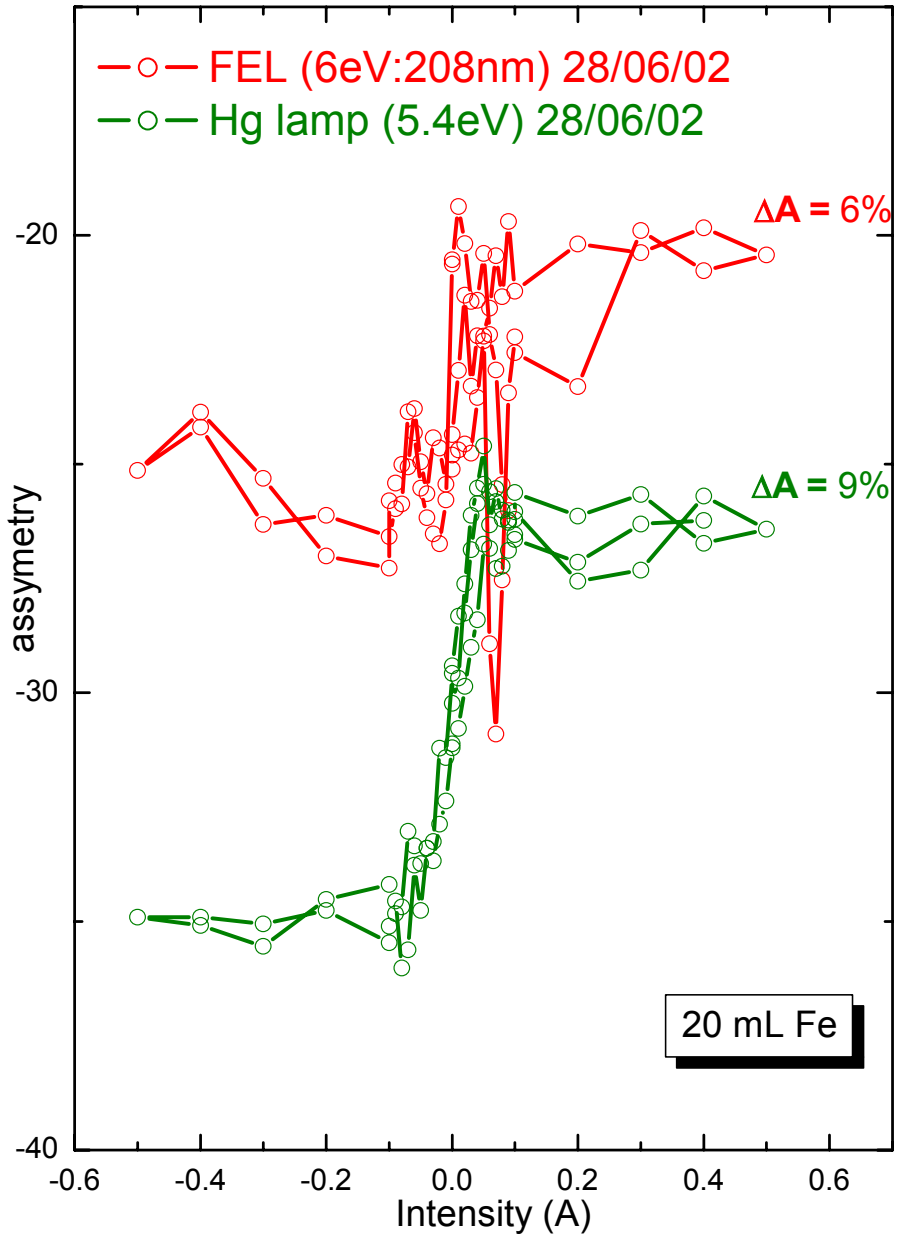
* Experimental system has been moved to ELETTRA

(June 2002)

* first test in static mode performed (End of June)

* time resolved test before the end of the year

* // development of new electronic system and new sample holder



Total polarization:

ΔA/S S: Sherman function

P=41 % @ 5.4 eV

P=27% @ 6eV with FEL

P in lure for the all DOS: 25%

Conclusion:

First ELETTRA FEL user experiment in the VUV

FEL performances will allow to study:

- Low dimensional system (~ μm)
- Fast dynamic behavior (10 ps resolution)
- Density of State (Range 3.5,…, 8 eV)