BACH – Beamline for Advanced diCHroism

Performances and first experimental results of BACH, the beamline for dichroism and scattering experiments at ELETTRA

Marco Zangrando

EIGHTH INTERNATIONAL CONFERENCE
ON SYNCHROTRON RADIATION INSTRUMENTATION
August 25-29, 2003 • Yerba Buena Arts Center, San Francisco

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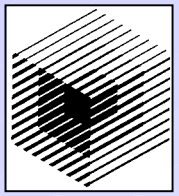

Staff:

F. Parmigiani *(INFM-Univ. Brescia)*
F. Bondino *(INFM-TASC)*
R. Rochow-Carbone *(Sincrotrone TS)*
M. Zacchigna *(INFM-TASC)*
M. Zangrando *(INFM-TASC)*

X-ray spectrometer

D. Cocco *(Sincrotrone TS)*
K.C. Prince *(Sincrotrone TS)*
M. Matteucci *(Sincrotrone TS)*

Insertion Devices:

B. Diviacco *(Sincrotrone TS)*
D. Zangrando *(Sincrotrone TS)*

Collaborators:

J.P. Kappler *(IPCM-LURE)*
Ph. Sainctavit *(LMC-LURE)*
Ch. Cartier dit Moulin *(LCIMM-LURE)*
G. Krill *(U. Paris Sud-LURE)*
M. Kiskinova *(Sincrotrone TS)*
B. Kaulich *(Sincrotrone TS)*
M. Platè *(Univ. Pavia)*
T. Pardini *(Stanford Univ.)*
K.M. Shen *(Stanford Univ.)*
Y. Chen *(Stanford Univ.)*
Z. Hussain *(ALS)*
D. van der Marel *(Groningen)*
A. Damascelli *(U. British Columbia)*
M. Finazzi *(Politecnico Milano)*

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Scientific case:

•Complex materials physics

(fullerenes, manganites, HTSC, silicides, dilute magnetic semiconductors, etc.)

•Physical processes in the meV-energy scale (magnetic, e-phonon and many-particle interactions) studied for critical phenomena like phase transitions and/or low dimensionality systems

⇓

high brilliance, circular polarization, broad energy range, high spatial and energy resolution

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BACH @ ELETTRA

- *Energy range: 25 - 1600 eV*
- *Polarization control: linear H or V, circular R or L*
- *High flux: ≥ 10^{11} photons/s*
- *High resolution: $\mathcal{R}_{min}$ = 5000 @ 1500 eV; $\mathcal{R}_{max}$ = 30000 @ 160 eV*
- *Small spots: ~ 200×12 μm^2 (branch A → Spectrometer);*

  ~ 350×40 μm^2 (branch B);

  ~ 50×50 nm^2 (microscope)
- *"Easy" optical design (alignment, reproducibility…)*
- *3 separate endstations can be set up*

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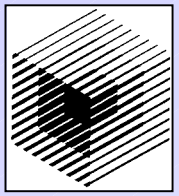

Beamline layout

Top View

Technical specifications

- *2 APPLE II taperable undulators optimized in the LE (35 – 200 eV) and HE (150 – 1600 eV) ranges*
- *Kirkpatrick-Baez pre-focusing and post-focusing mirror systems*
- *Padmore monochromator (variable included angle)*
- *4 spherical gratings: 3 → high resolution (35 – 1600 eV)*
  1 → high flux (300 – 1600 eV)
- *Critical parameters of all the optics (pitch, roll and Z) → motorized*
- *Beamline control software developed in LabVIEW → fully customizable*

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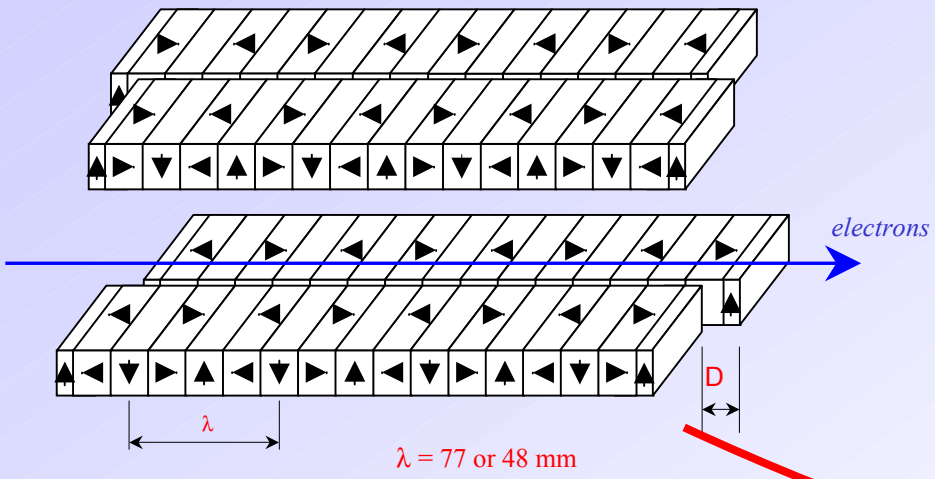
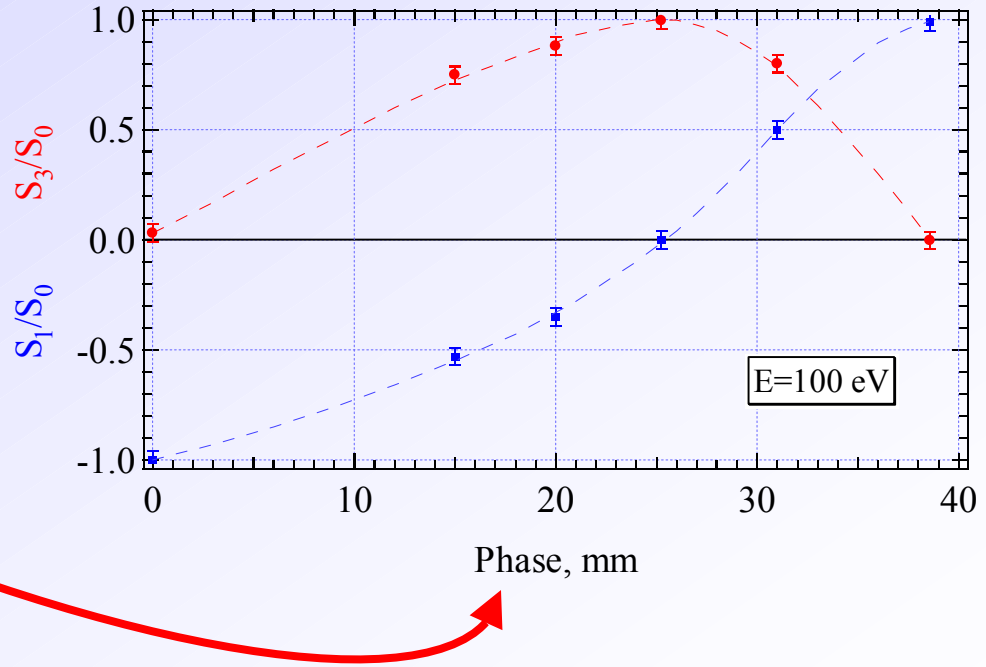
BACH undulators

APPLE II elliptical undulator
(Sasaki-type undulator)

Photon source size:
250 × 50 μ m²



Twin 8-axis multilayer polarimeter (F. Schafers et al., Appl. Opt. 38, 4074 (1999))
Courtesy of Evgueni Meltchakov - Marseille



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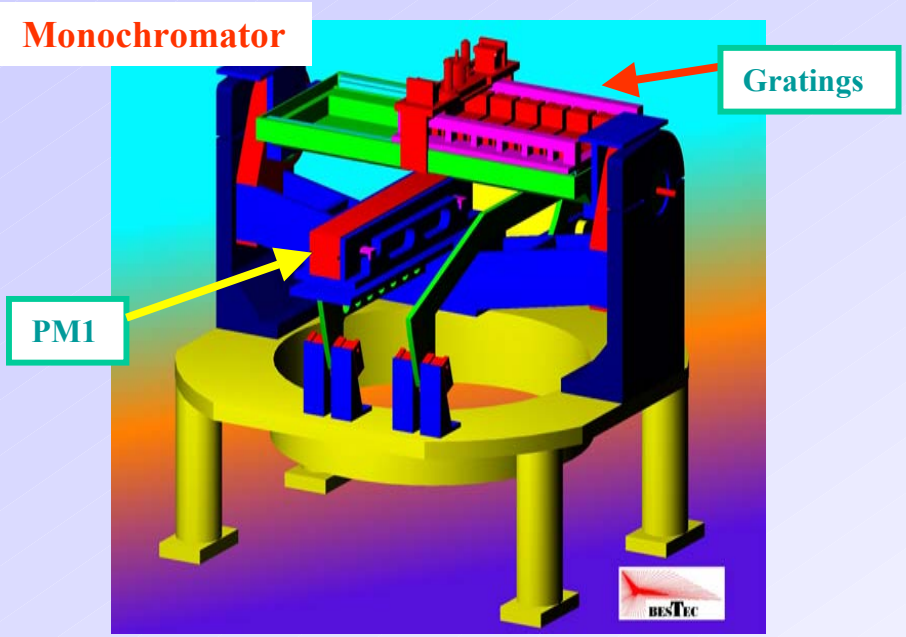
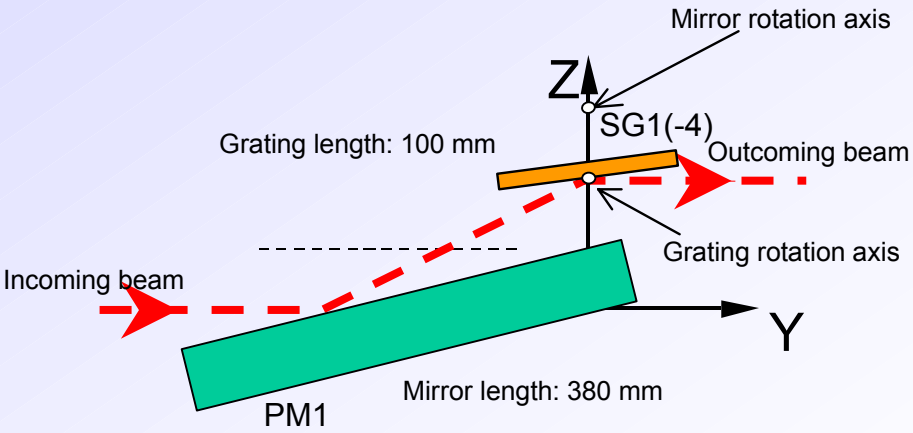
Variable included angle Monochromator (Padmore)





Technical specifications

Combined movement of mirror and grating(s)

Remotely controlled grating change

0.21 μrad-resolution angular movements

Maximum scanning speed = 1°/s

Future developments

New software for the control of the energy scans:

•Better precision and reproducibility

•Turboscan

In collaboration with “Sincrotrone Trieste” electronics and software group (R. Tommasini)

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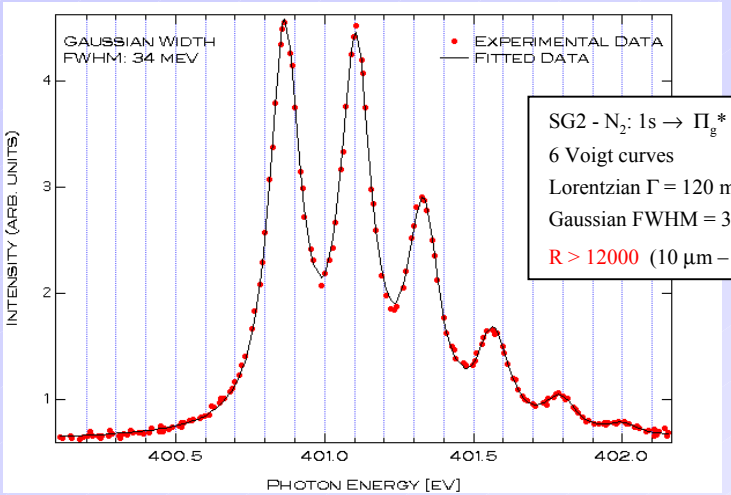
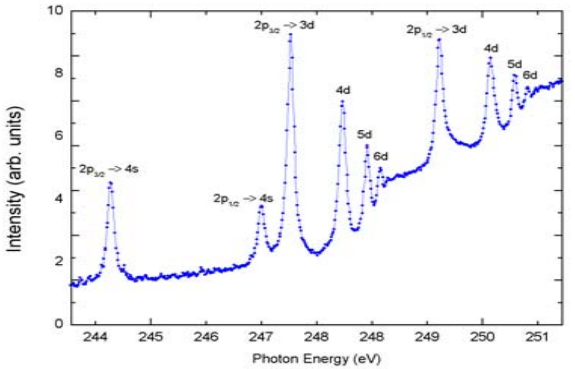
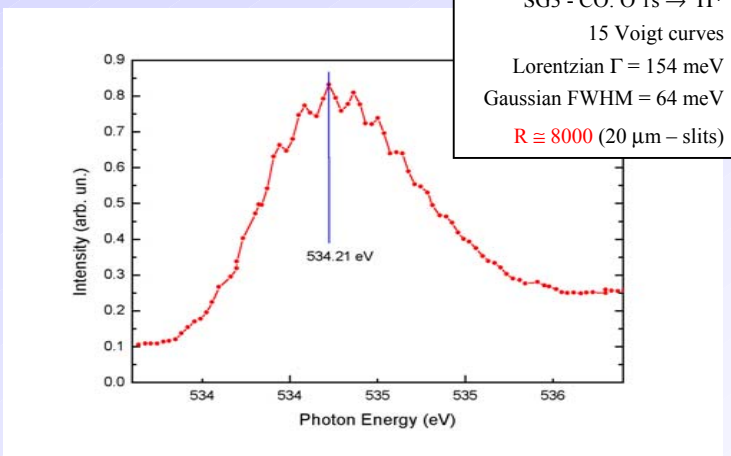
BACH resolving powers



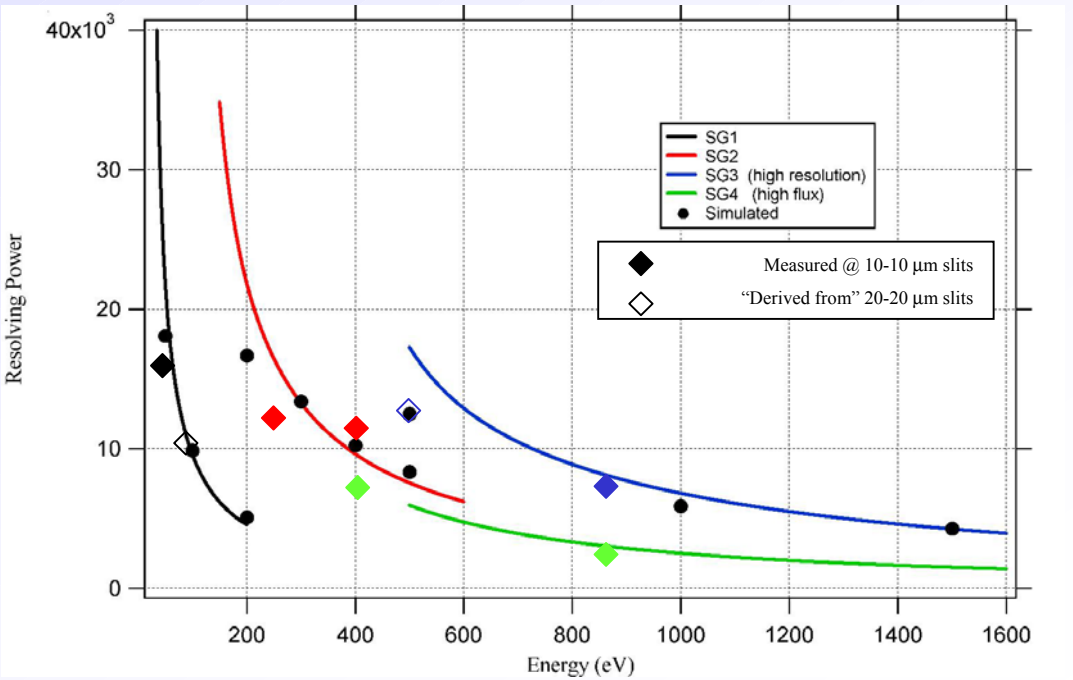
SG2 - N_2: $1s \rightarrow \Pi_g^*$
6 Voigt curves
Lorentzian Γ = 120 meV
Gaussian FWHM = 33 meV
R > 12000 (10 µm – slits)

SG2 - Ar: $2p_{3/2} \rightarrow 4s$
1 Voigt curve
$\Gamma = 116 \pm 2$ meV
FWHM = 20 ± 3 meV
R > 12000 (10 µm – slits)

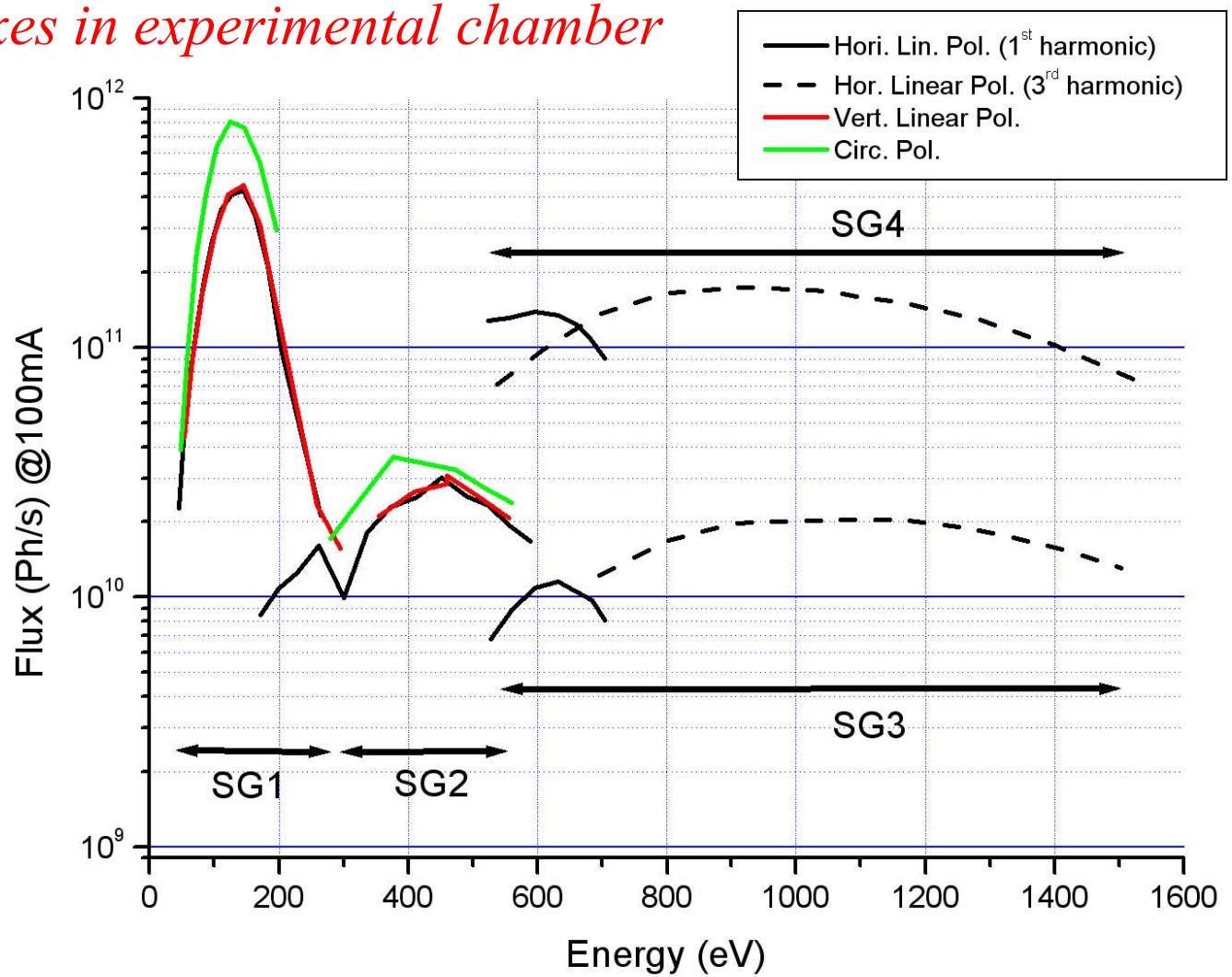




SG3 - CO: O $1s \rightarrow \Pi^*$
15 Voigt curves
Lorentzian Γ = 154 meV
Gaussian FWHM = 64 meV
R ≅ 8000 (20 µm – slits)



Fluxes in experimental chamber



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BACH experimental capabilities

Techniques	*Instrumentation*
XAS – XMCD	*LHe cryostat with SC coil: T_{min} = 2K (soon upgraded to 300mK), H = ± 7 T*
XES – RIXS	*ComIXS spectrometer @ BACH experimental chamber (T_{min} = 10K)*
Spin Resolved ARPES	*Scienta 200 (ΔE = 5 meV, $\Delta\theta$ = 0.3°) + Spin detector ($\rightarrow$, $\otimes$, $\uparrow$) + Cryostat (10K)*
SPEM – STXM	*Zone Plates microscope: 50×50 nm^2 spot; T_{min} = 50K*
XAS – PES	*BACH experimental chamber: T_{min} = 10K, VSW CLASS 150 (ΔE = 40 meV), surface preparation*

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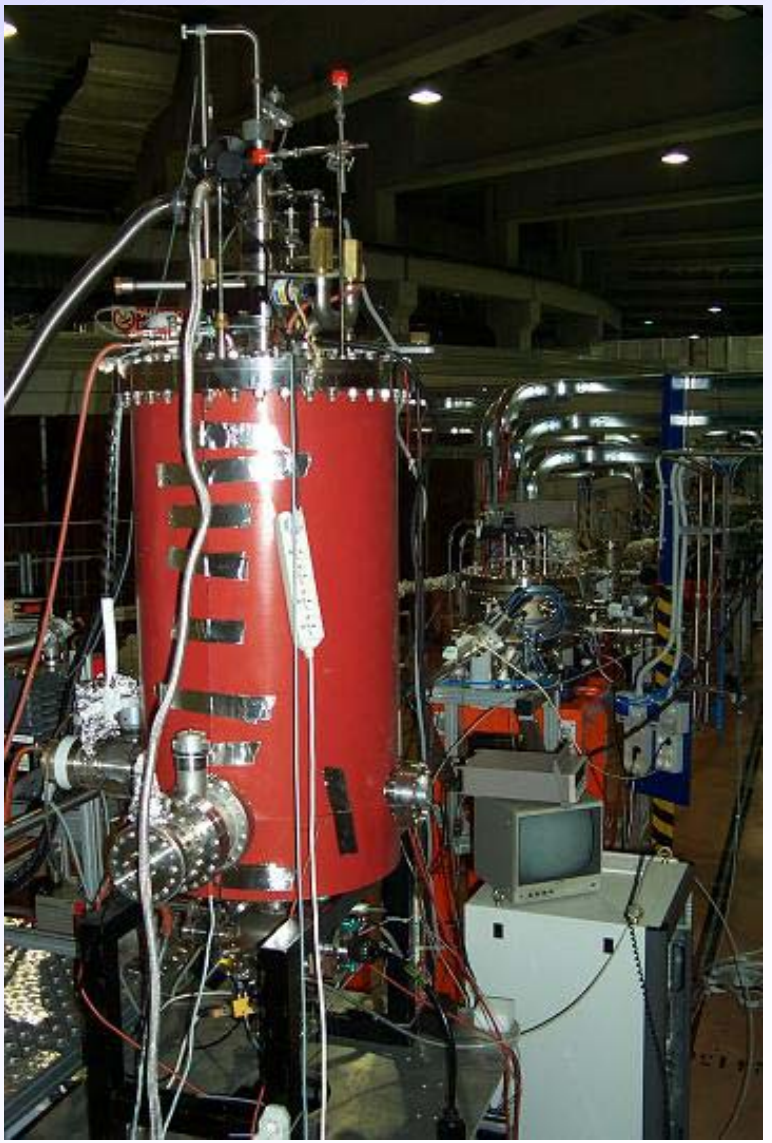
XAS – XMCD: Cryostat

- Temperature range: from 300 to 0.3 K
- Magnetic field range: from -7 to +7 T
- Absorption measurements
- Photodiode for transmission measurements
- Photodiode array for fluorescence
- Sample preparation chamber



J.P. Kappler (Univ. Strasbourg),

G. Krill (Univ. Paris Sud, LURE),

Ph. Sainctavit (IPCMS Strasbourg)

and INFM (BACH) collaboration

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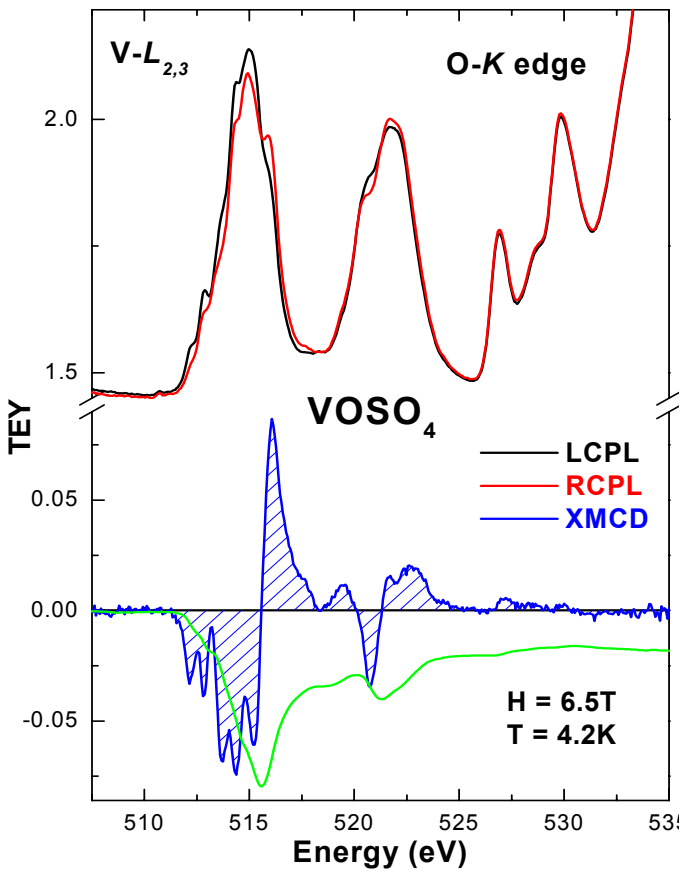
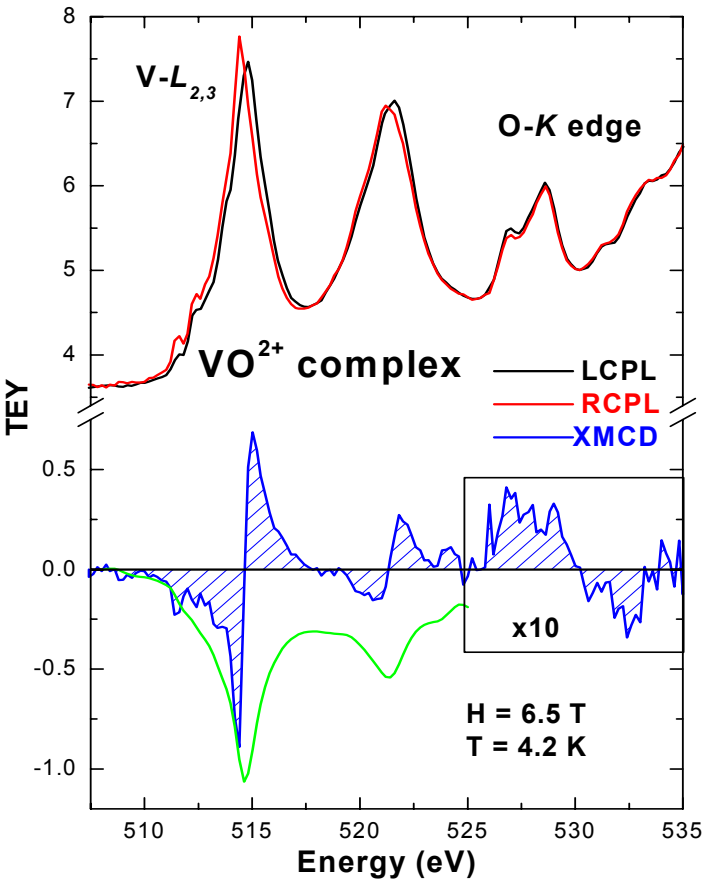
LURE

XAS – XMCD: performances (vanadium complexes)

ESRF: (ID08 beamline)



ELETTRA: (BACH beamline)



Courtesy of Jean Louis Gallani - ICPMS-GMO Strasbourg

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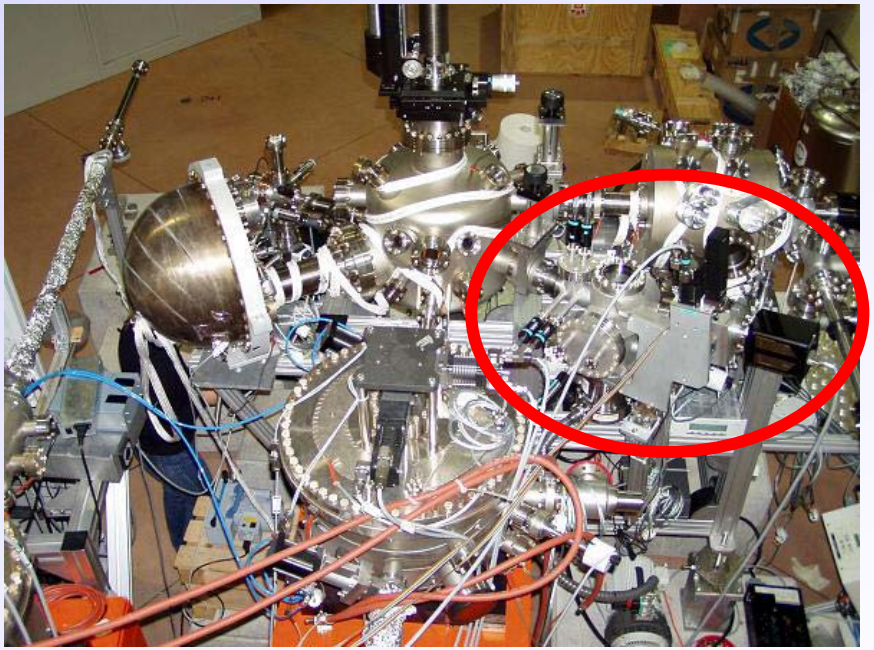
XES – RIXS: ComiX S *on BACH*



- **Energy range: 20 - 1200 eV**
- **Polarization control**
- **Low temperature measurements (10 K)**
- **High efficiency:** **≥ 8 - 80 counts/pixel/s (800 eV)**
  ≥ 1 - 10 counts/pixel/s (100 eV)
- **High resolutions: $\mathcal{R}$ > 1000 on the entire energy range**
- **Compactness: < 1 meter**

Topics:

TM silicides (FeSi, MnSi, CoSi) – collaboration with D. van der Marel (Groningen)

Manganites (Na-doped) – collaboration with University of Pavia (Italy)

Iron oxides and sulphides – collaboration with D. Cocco, K.C. Prince, M. Matteucci (Elettra)

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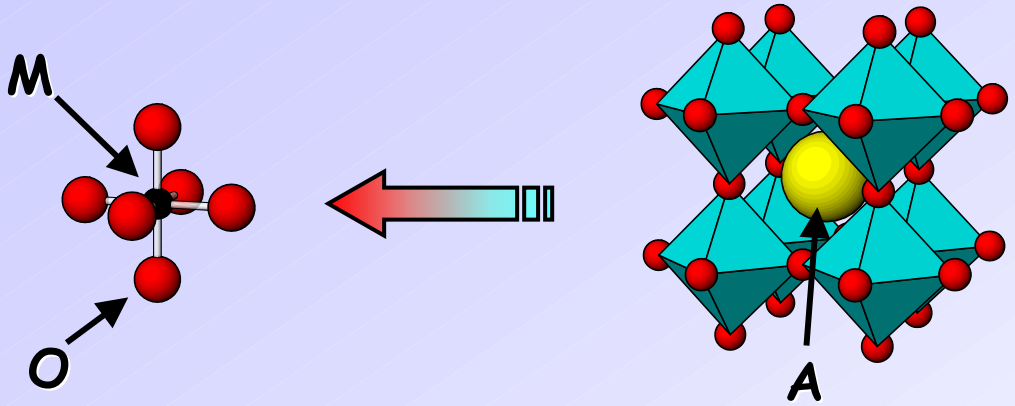
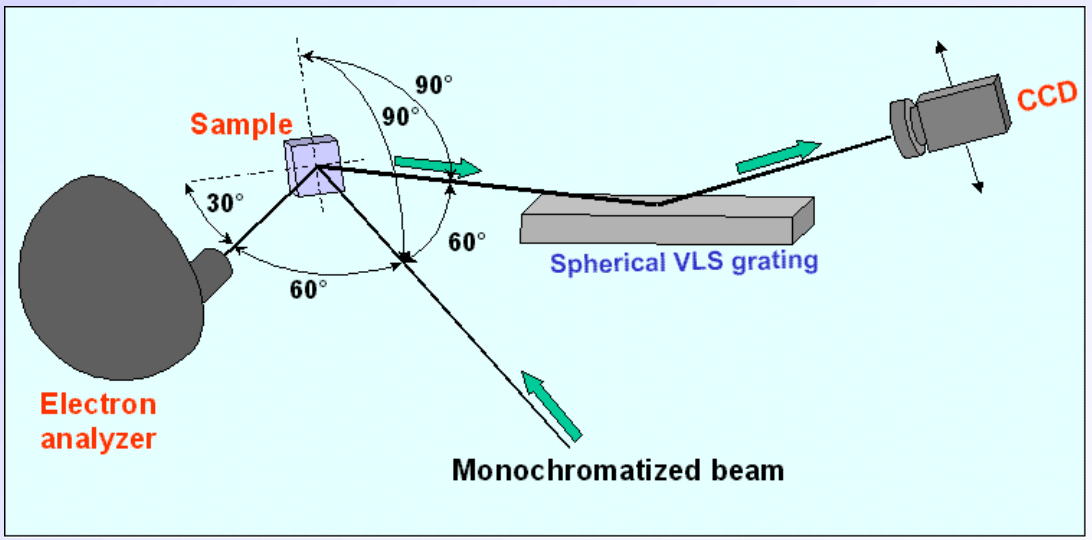
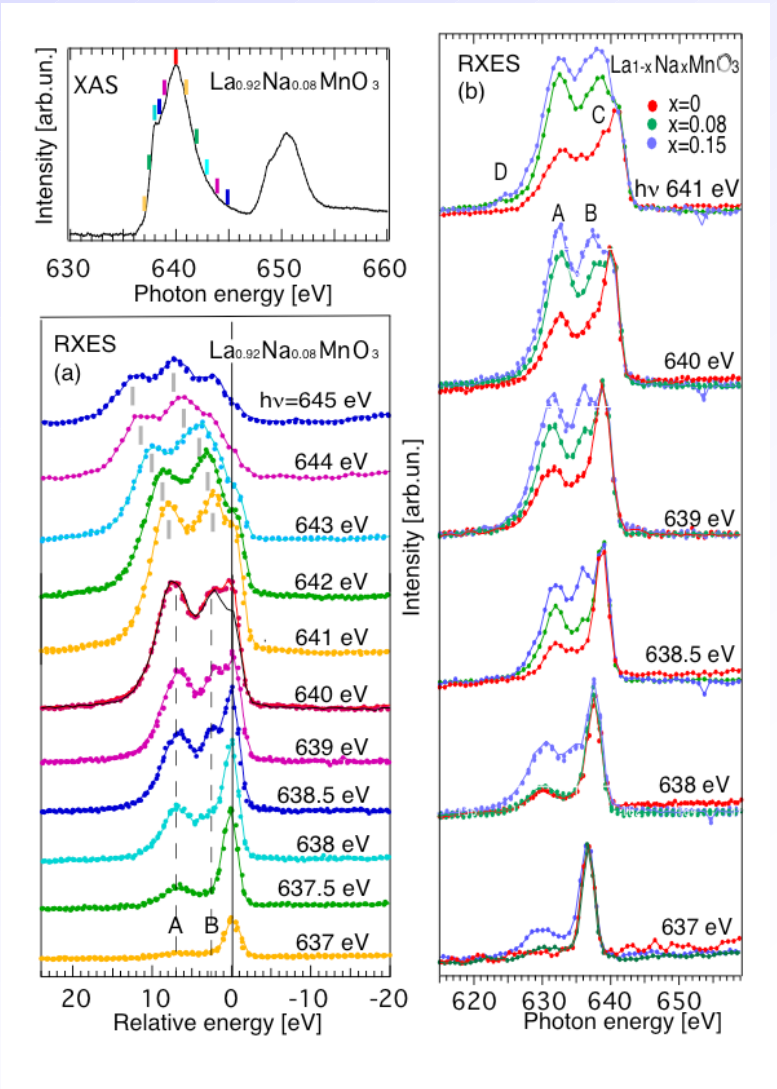
XES – RIXS: manganites





$La_{1-x}Na_xMnO_3$ Mn $L_{3,2}$ edges (300K)



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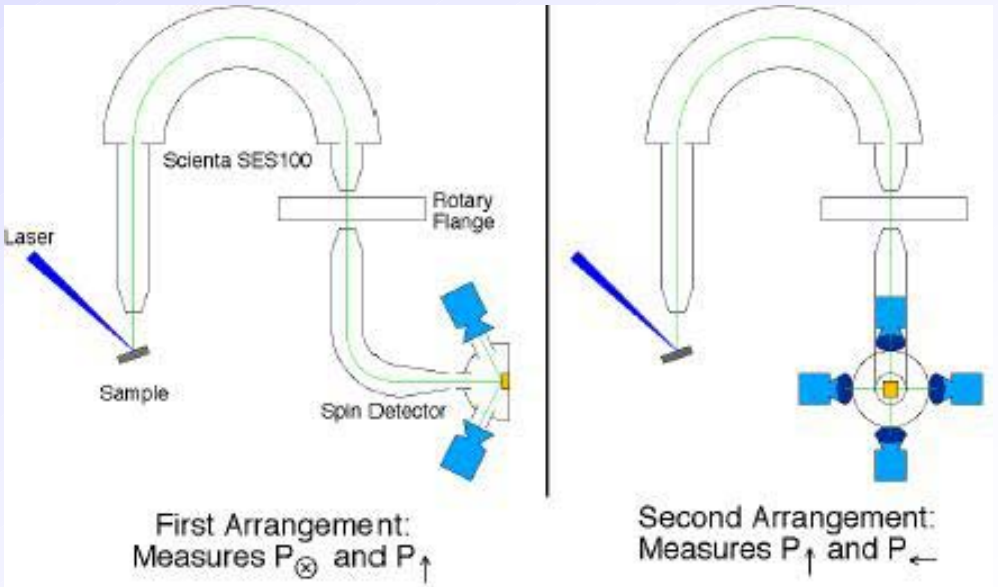
Spin Resolved ARPES: main features

- **Low energies (30 – 70 eV) and medium energies (1000 – 1600 eV) accessible**
- **Polarization control (circular right and left)**
- **Low temperature (10K), high energy and angular ($\Delta E = 5$ meV, $\Delta\theta = 0.3°$) resolution**
- **Spin resolution (3 components)**



Instrumentation:

Scienta 200

3-components ($\rightarrow$, $\otimes$, $\uparrow$) spin detector

LHe cryostat (10 K)

Topics:

- Fermi surfaces (spin resolved) of strongly correlated and molecular materials
- e-phonon interactions
- Time reversal symmetry

Stanford University (Z.X. Shen), ALS (Z. Hussain) and INFM (BACH) collaboration

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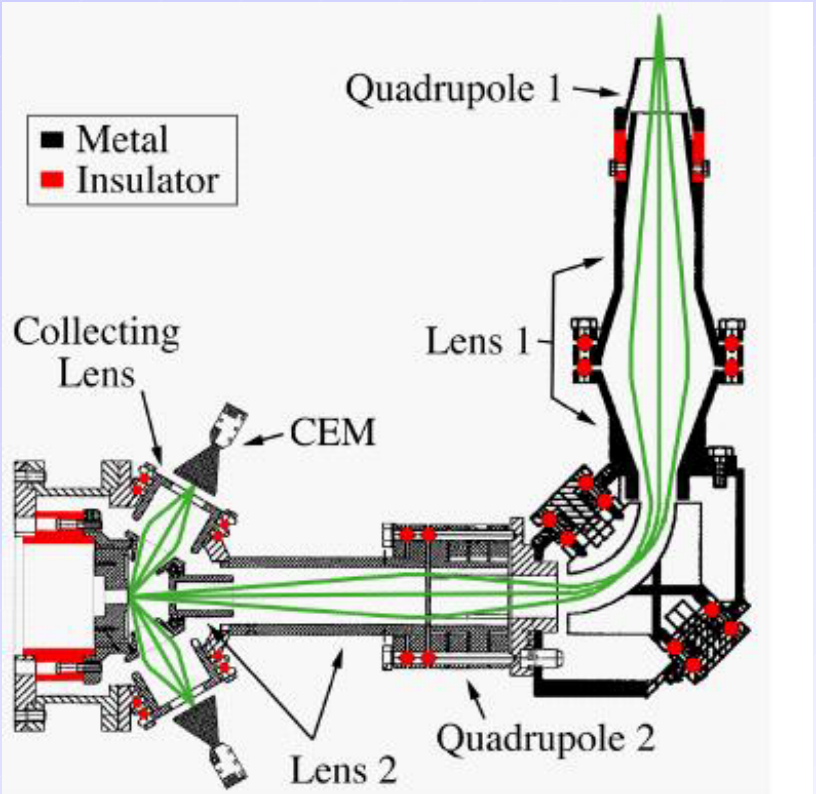
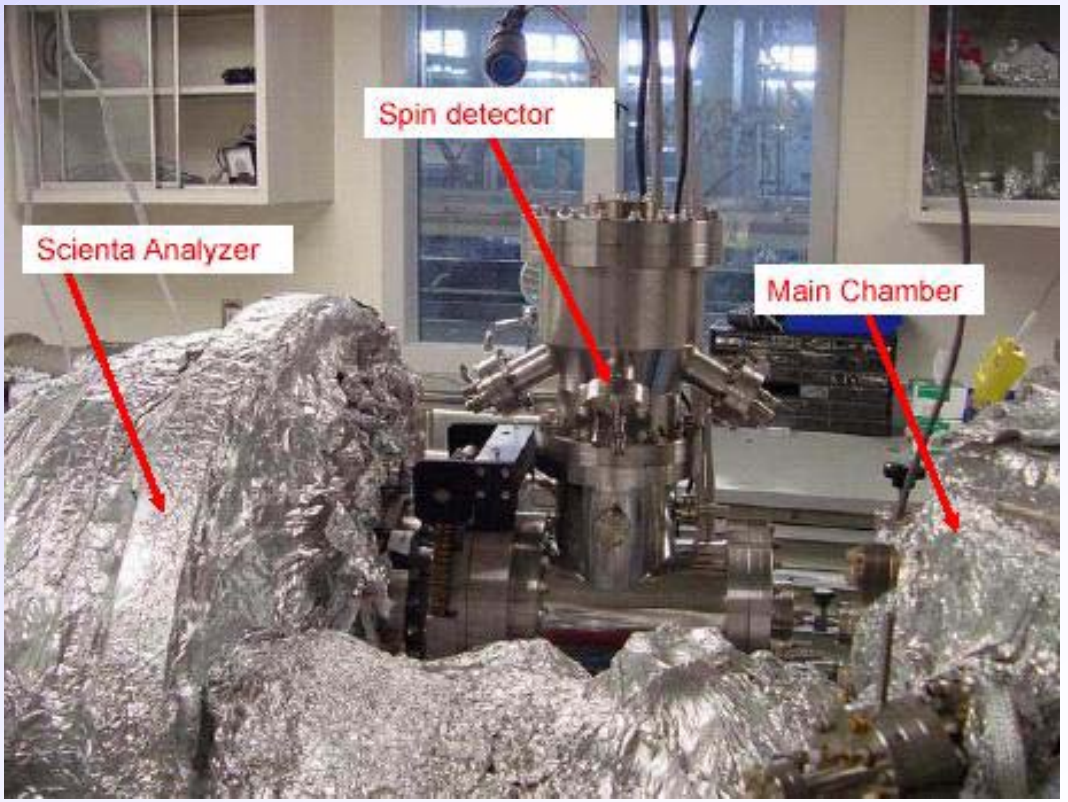
Spin Resolved ARPES: experimental station





See also the Poster Session 3 on Wednesday 27 – Poster 10.28 by Y.Chen et al.

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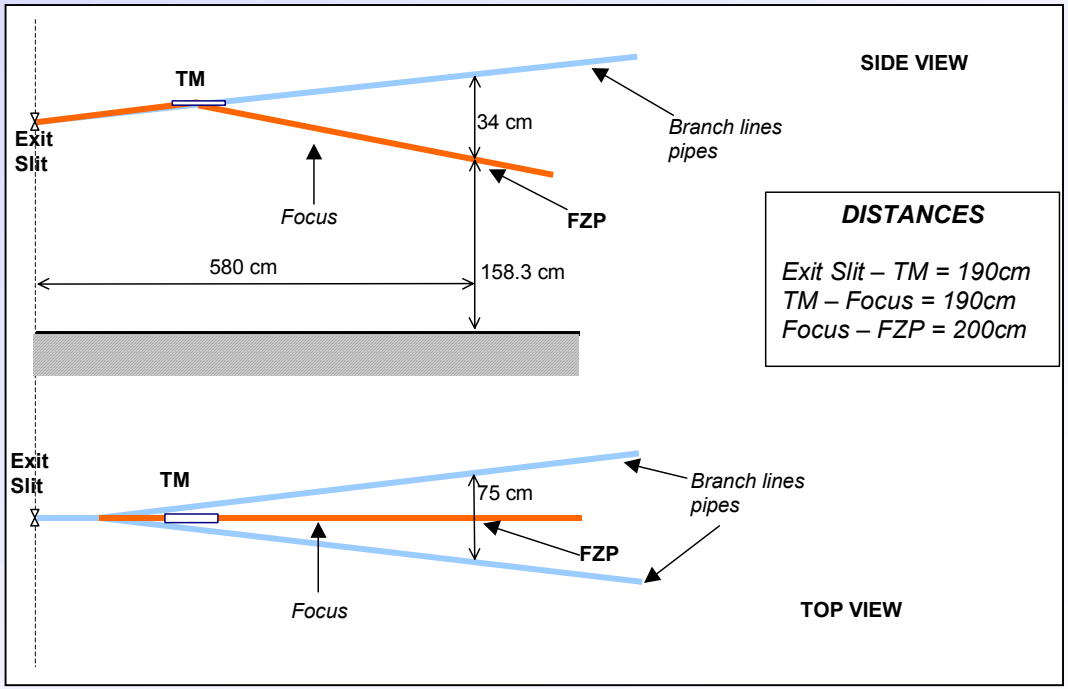
SPEM – STXM: BACH microscope (MICROBACH)

- Nanometric spatial resolution: 50×50 nm^2
- Low temperature experiments: 50 K
- Polarization selectivity
- Fluxes ≥ 10^8 photons/s on the sample



Topics:

Manganites in-homogeneities (phase separation)

…

Mirror	*Figure* – Focalisation	Source arm (cm)	Image arm (cm)	Angle of incidence (°)	Radius of curvature (cm)	Useful area (cm×cm)
TM	***Toroidal*** **Horizontal** **Vertical**	**940** **190**	**190** **190**	**2.5**	**4355.9** **13.8**	**3×1.5**

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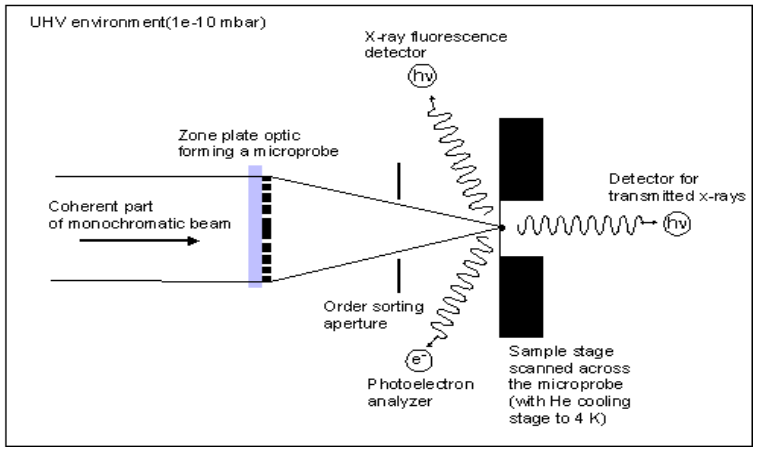
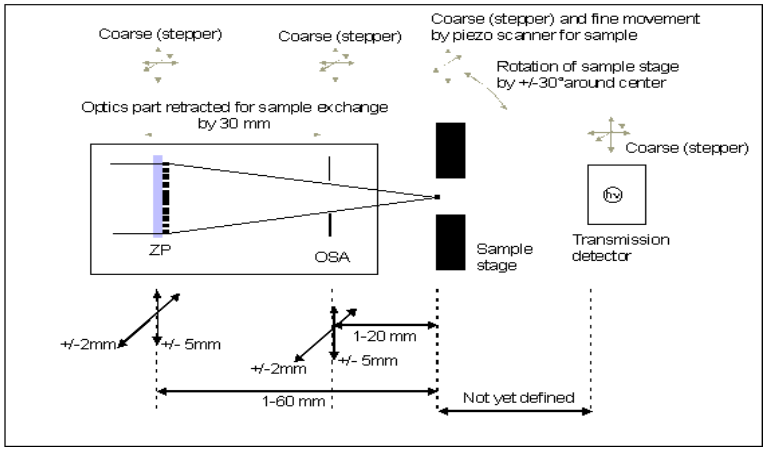
SPEM – STXM: layout

Optical scheme of the BACH x-ray microscope end-station for scanning transmission, photo-emission and x-ray fluorescence microscopy



Stage characteristics



Before the final realization and installation of MicroBACH, another microscope (TwinMIC by B.Kaulich, M.Kiskinova et al.) will be installed on the microscopy branchline tentatively at the beginning of 2004.

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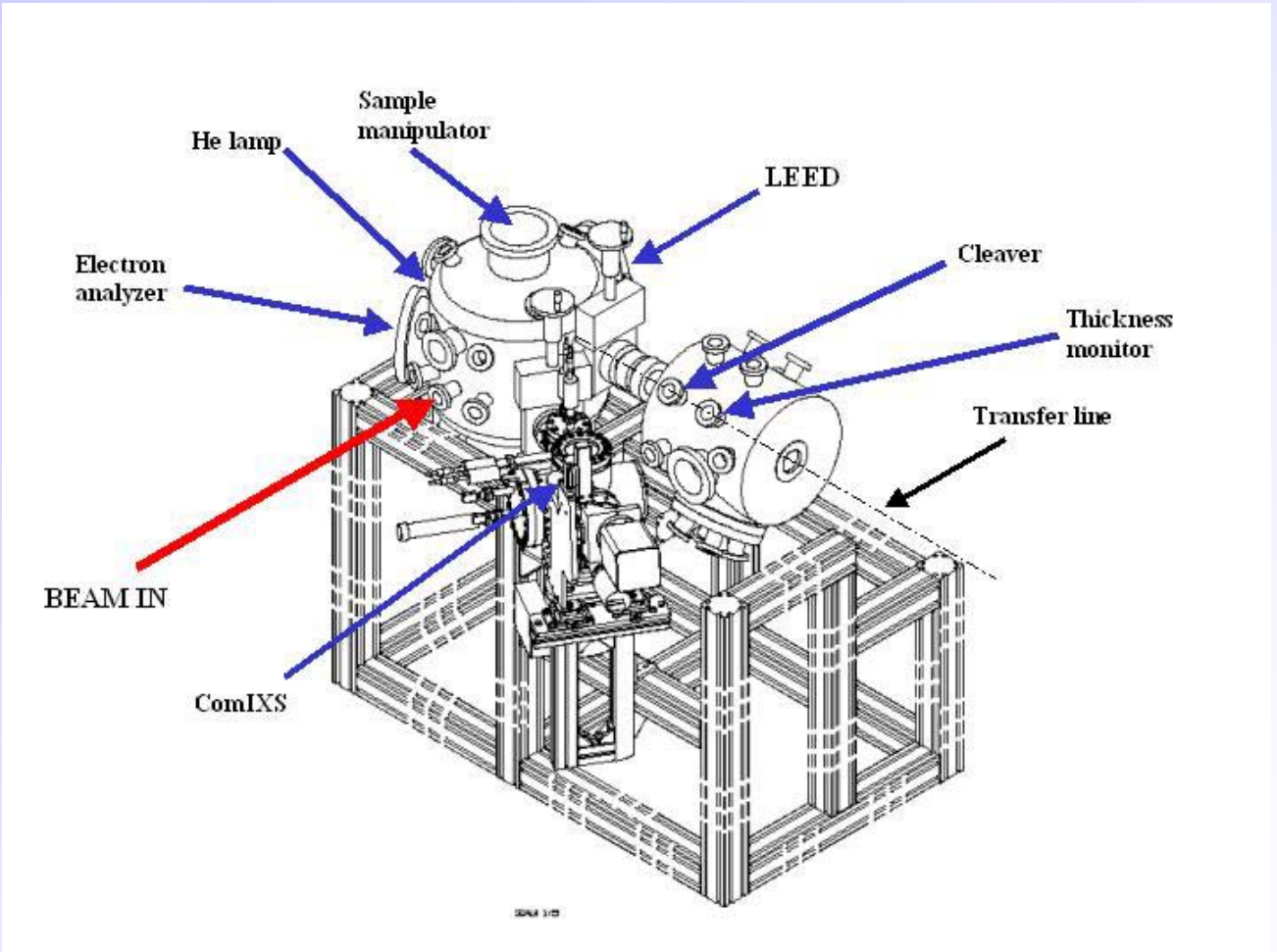
XAS – PES chamber: layout



Technical specifications

T_{min} *= 10K*

VSW CLASS 150 (ΔE = 40 meV)

Surface preparation

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People involved in BACH project – collaborations

CRYOSTAT	**J.P. Kappler, Ph. Sainctavit** – Univ. and IPCMS Strasbourg (France) **G. Krill** – Univ. Paris Sud (France)
SPECTROMETER	**D. Cocco, K.C. Prince, M. Matteucci** – Sincrotrone Trieste (Italy)
ARPES	**Z.X. Shen, K.M. Shen, Y. Chen, T. Pardini** – Stanford University (USA) **Z. Hussain** – ALS (USA)
MICROSCOPE	**M. Kiskinova, B. Kaulich** – Sincrotrone Trieste (Italy) **E. Di Fabrizio** – TASC-INFM (Italy)
SILICIDES	**D. Van der Marel, F. Carbone** – RUG, Groningen (The Netherlands)
MANGANITES	**M. Platè, L. Malavasi, G. Flor** – University of Pavia (Italy)
FULLERENES	**A. Goldoni** – Sincrotrone Trieste (Italy)
BEAMLINE DEVELOPMENT	**M. Finazzi** – Politecnico di Milano (Italy)

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Status of the BACH project

BEAMLINE	→	**officially open to external users since January 2003**
XAS-XMCD Cryostat	→	**operative in February 2004**
ComIXS Spectrometer	→	**operative and available**
Spin-Res. ARPES	→	**operative at the end of 2003**
MicroBACH	→	**designing and (a part of it) under realization**
XAS-PES Chamber	→	**operative and available**

Deadline for submitting proposal for the first semester of 2004: August 31st