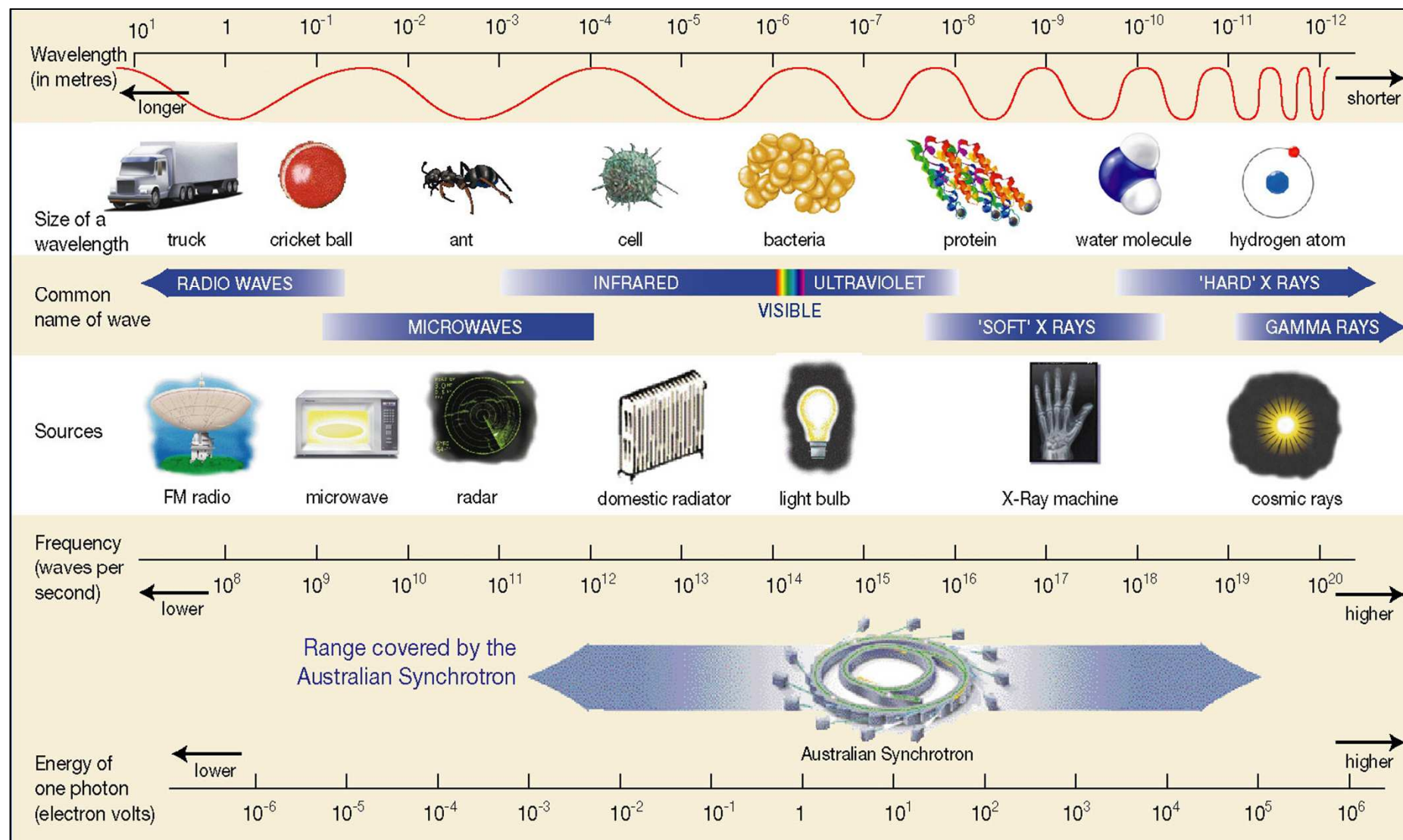


Overview on Synchrotron Techniques at CELLS-ALBA

Eric Pellegrin

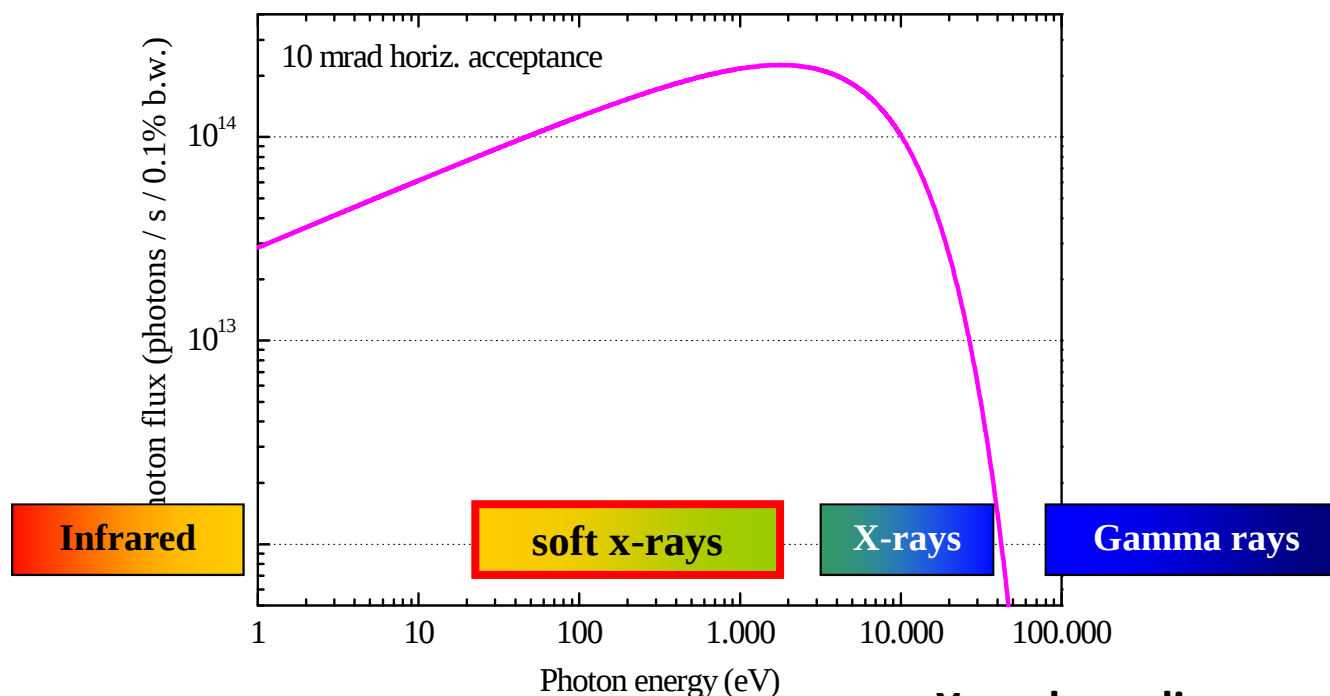
***on behalf of the
CELLS-ALBA Experiments Division***

The Electromagnetic Spectrum



Splitting up the Spectrum – Choosing the Beamline

Photon spectrum from a bending magnet source



Infrared beamlines:

Molecular vibrations,
low-energy excitations

- IR microscopy
- IR spectroscopy

Soft x-ray beamlines:

Electronic excitations

- microscopy
- spectroscopy
- lithography

X-ray beamlines:

Electronic excitations,
scattering (electronic, nuclear)

- structural analytics
- spectroscopy
- imaging techniques



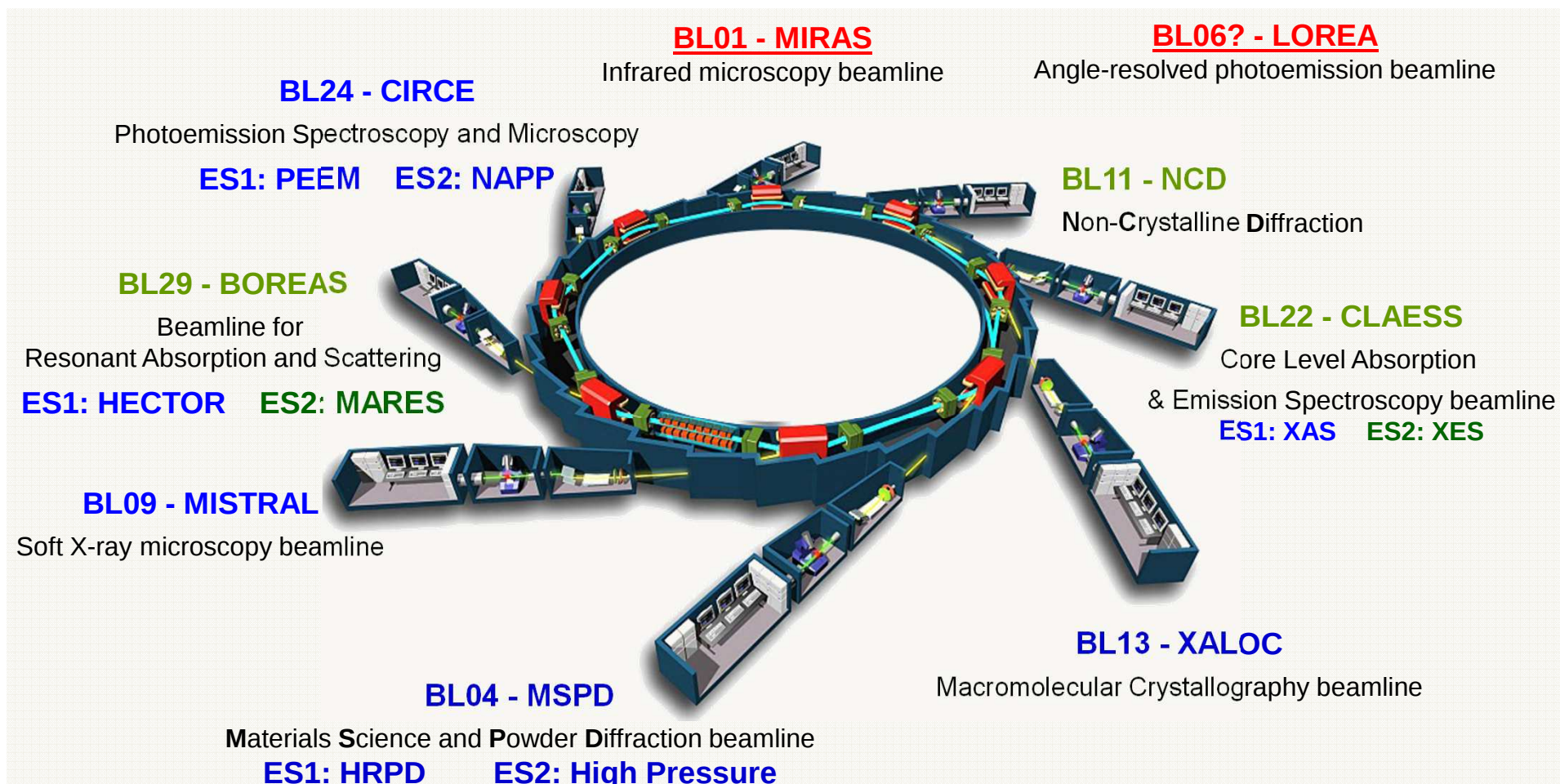
Textbook definition:

“Synchrotron light is the electromagnetic radiation emitted when charged particles travel in curved paths”

Synchrotron light has the following salient features:

- **High intensity**
- **Broad spectral range (tunability)**
- **Highly collimated**
- **Tunable polarization (linear, elliptical, circular)**
- **Pulsed time structure**
- **(Partial) Coherence**

⇒ **A powerful tool for basic and applied studies in biology, chemistry, medicine, physics, human heritage and their many subfields.**





BL04 MSPD

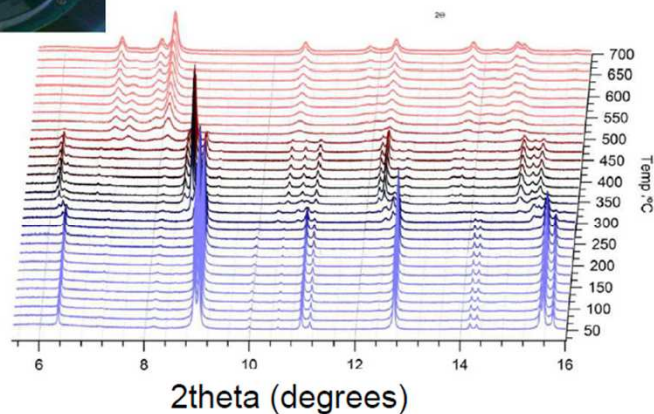
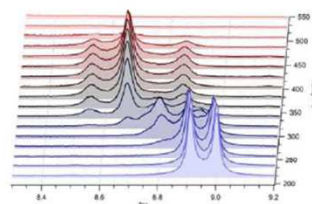
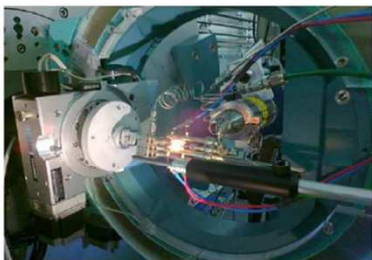
Materials Science & Powder Diffraction

- *Two state-of-the-art end stations:*
 - *High resolution powder diffraction.*
 - *High pressure powder diffraction using diamond anvil cells.*
- *Photon energy range: 8 - 50 keV.*

Staff:

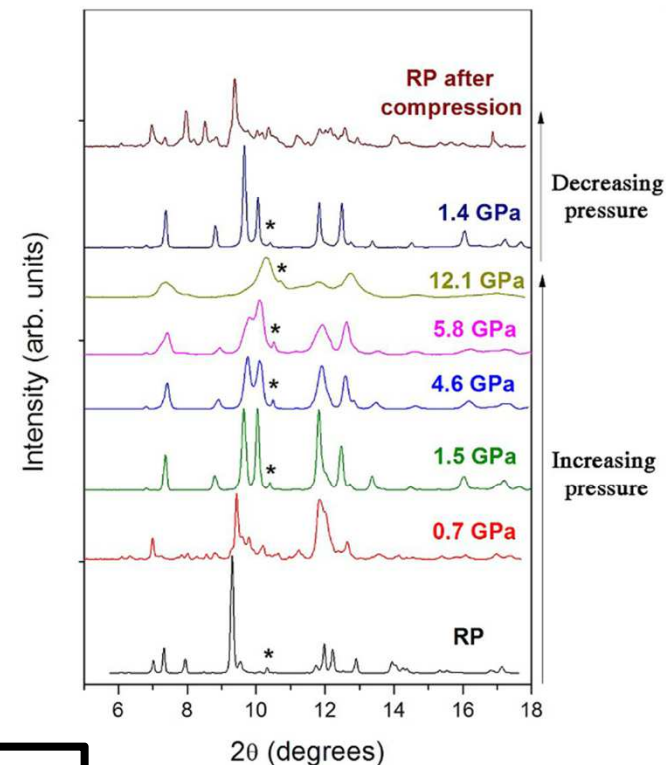
Francois Fauth (Swiss)
Inma Peral (Spanish)
Catalin Popescu (Romanian)
Oriol Vallcorva (Spanish)

Reduction of LaCO_3 to $\text{La}_2\text{O}_3 + \text{Co}$ under 5% H/He gas flow.
Capillary reactor flow with temperature



Each temperature scan
was collected in 8 minutes

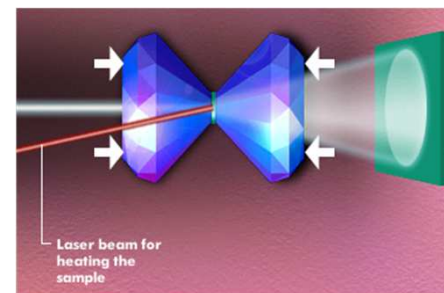
High pressure end station:



Powder diffraction end station:

MAD26 detector (10–50 keV) => **High angular resolution**

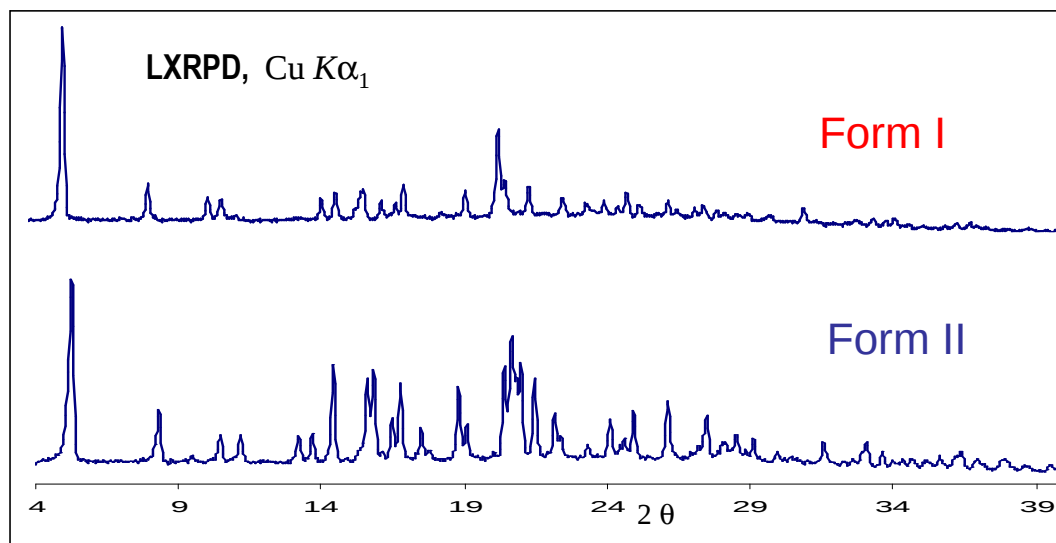
Mythen II detector (8–30 keV) => **Time-resolved data with ms resolution.**



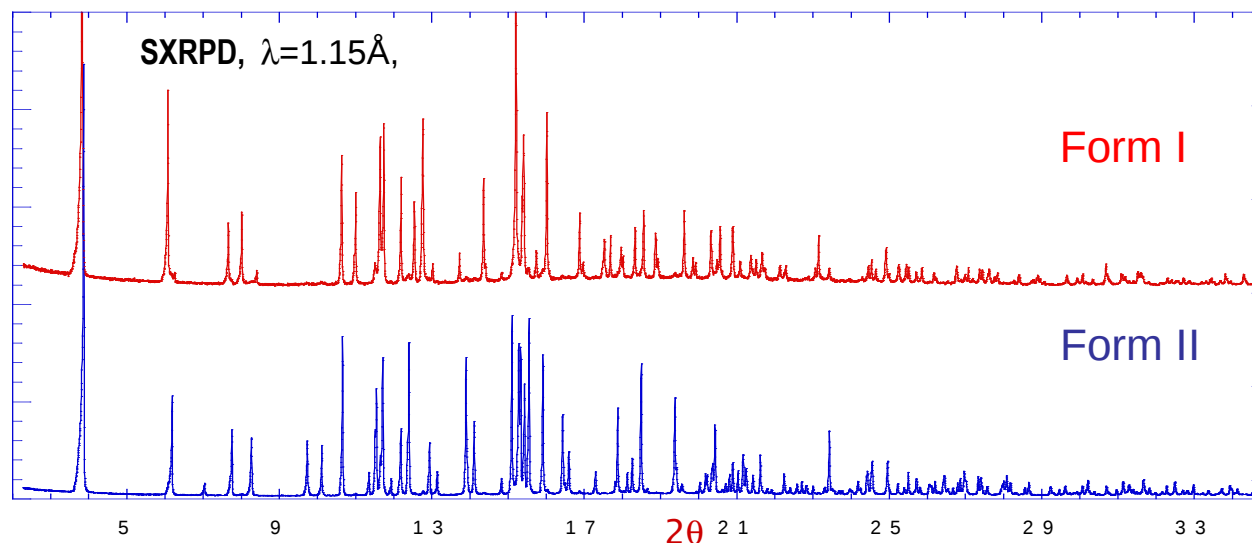
Powder Diffraction Patterns of Enalapril Maleate



Cu $K\alpha_1$ lab
source.



Synchrotron
light source.



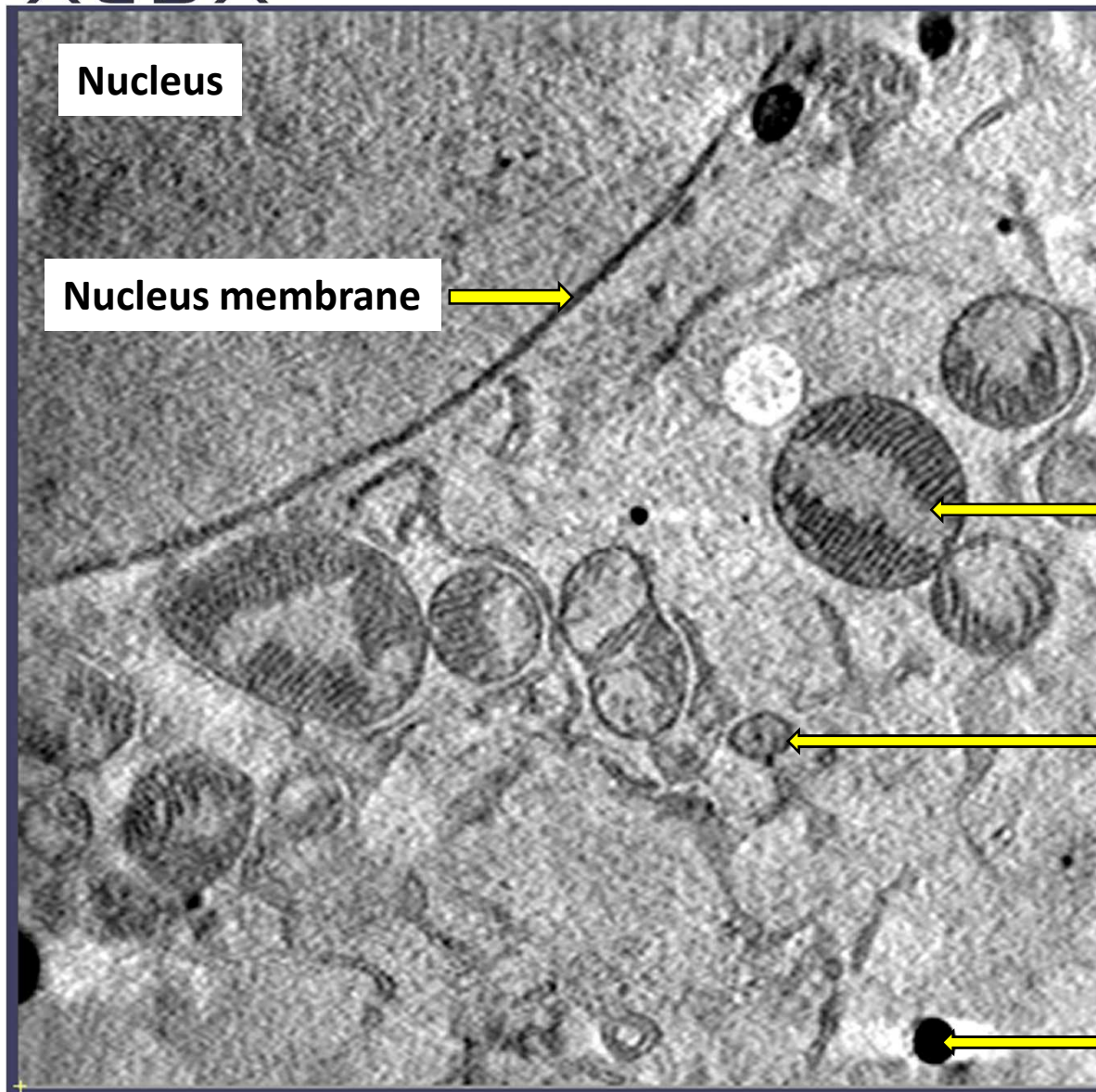


BL09 Mistral Transmission Soft X-Ray Microscopy

- Cryo nano-tomography in water window for biological applications.
- Spectroscopic imaging of thin films.
- Photon energy range: 0.27 - 1.2 keV.

Staff:

Eva Pereiro (Spanish)
Tanja Ducic (Serbian)
Ana Perez (Spanish)
Andrea Sorrentino (Italian)



Subcellular structure
of a single intact cell
after reconstruction
of one tomography.
(10 μm x 10 μm size
25 nm resolution
12 nm/pixel)

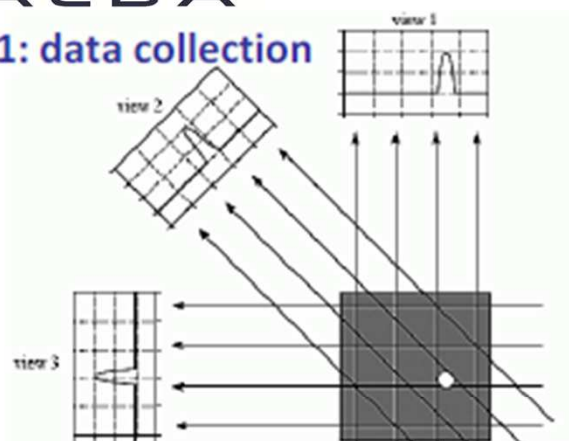
Mitochondria

Endoplasmatic reticulum

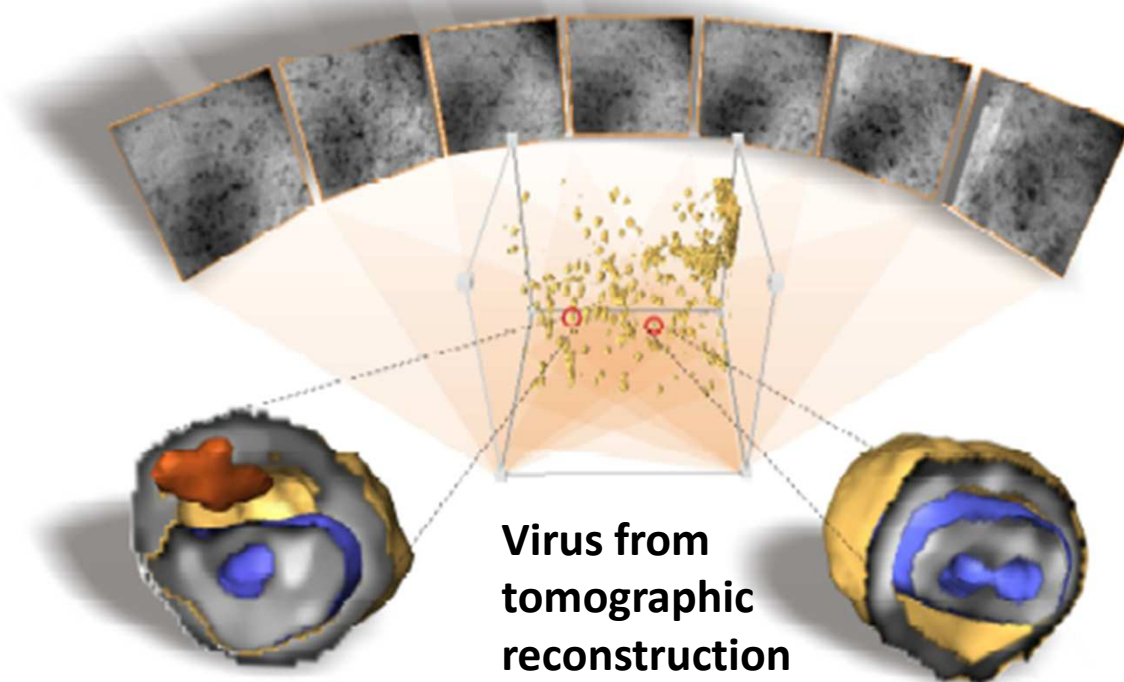
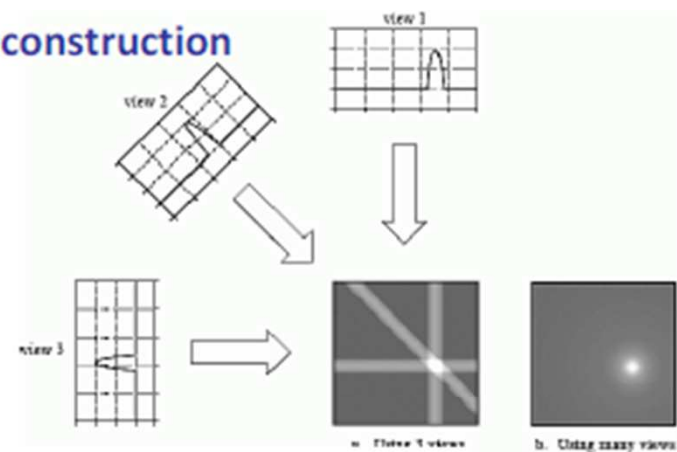
Lipid droplet

Beamline 09 – MISTRAL: Tomography

1: data collection



2: reconstruction



3: real data*

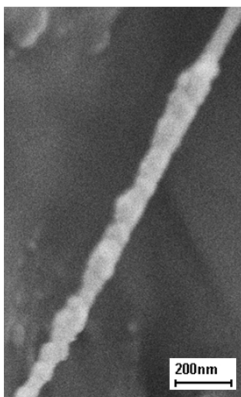
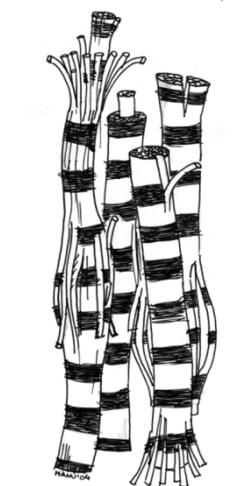


BL11 NCD Non-Crystalline Diffraction

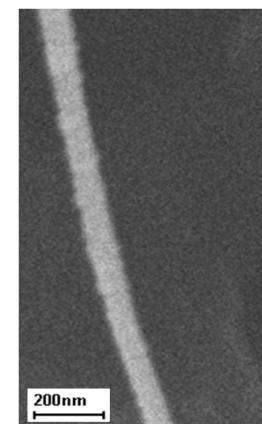
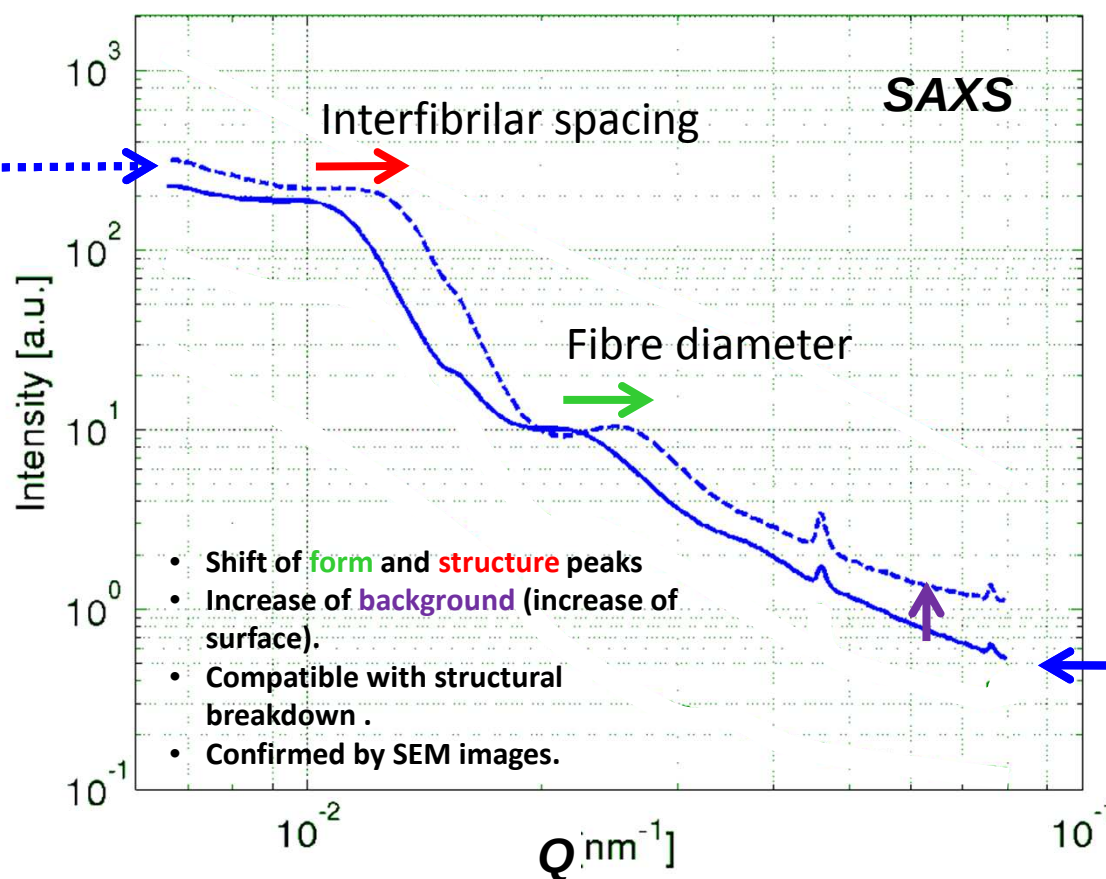
- *Simultaneous recordings of SAXS and WAXS for structural and functional insight at the molecular level.*
- *Study of long- and short-range structures in soft condensed matter.*
- *Time resolution of milliseconds.*
- *Photon energy range: 6.5 - 13 keV.*

Staff: Marc Malfois (French)
Christina Kama-Longer (Greek)
Juan Carlos Martínez (Spanish)
Eva Crosas (Spanish)

Structural Studies of Collagen: SAXS versus SEM



Damaged collagen



Healthy collagen



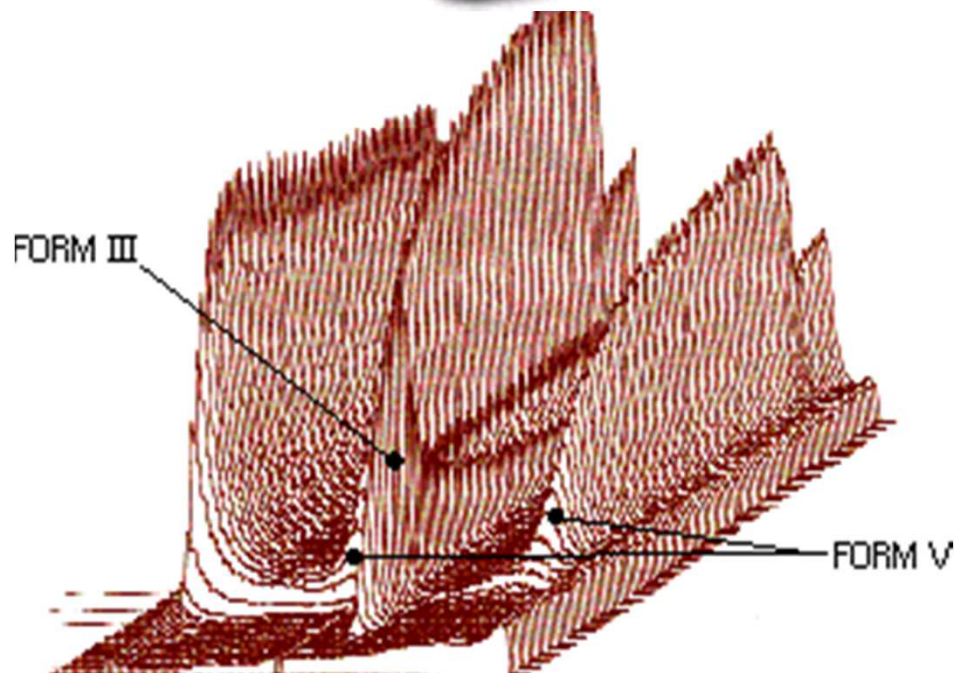
Very fast measurements
(under very different conditions)

For instance the solidification
of chocolate for a 'good taste'

(One of the first very important
industrial applications in 1990s
@ SRS-Daresbury with Cadburys)

Form V good taste and texture.

Form III poor taste.





BL13 XALOC Macromolecular Crystallography

- Flexible and reliable for solving structures of macromolecules and complexes.
- Copes with a broad variety of crystal sizes and unit cell parameters.
- Allows both wavelength dependent and independent experiments.
- Photon energy range: 5 - 22 keV.

Staff: Jordi Juanhuix (Spanish)
Roeland Boer (Dutch)
Daniel Fulla (Spanish)
Fernando Gil (Spanish)

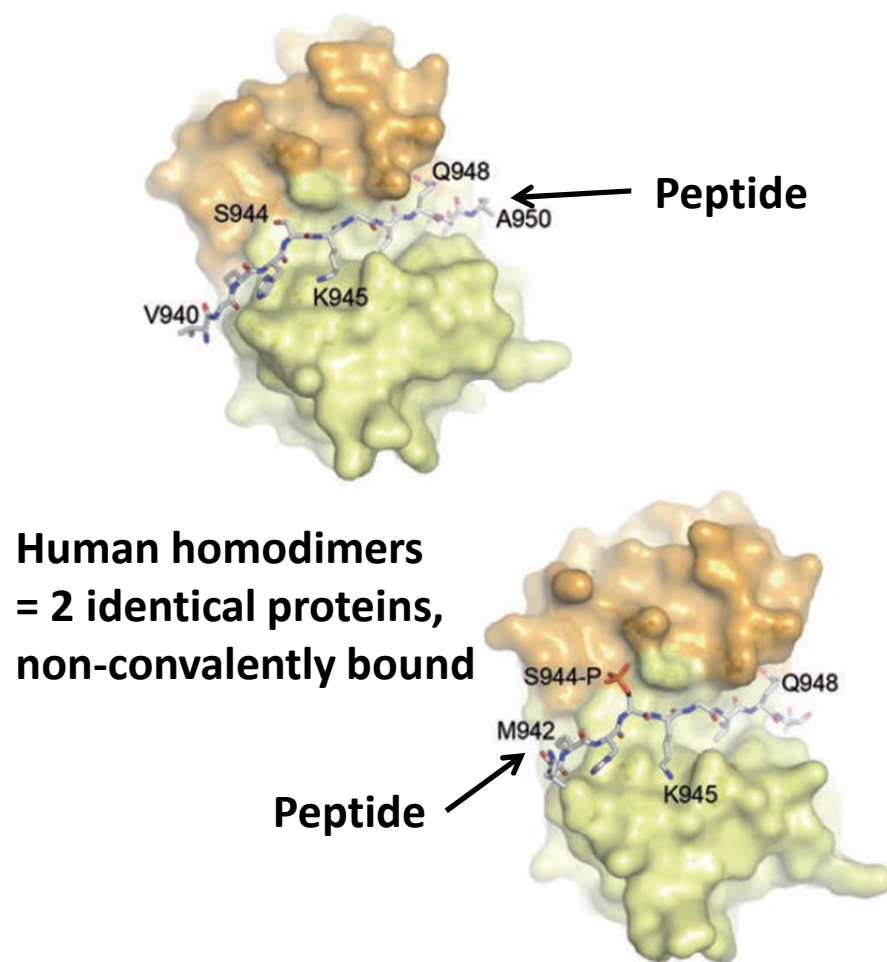


Figure 1. Complexes of human LC8 homodimers (yellow and orange) with the phosphorylated (lower right, PDB ID 3ZKF) and non-phosphorylated (upper left, PDB ID 3ZKE) versions of a Nek9 peptide.

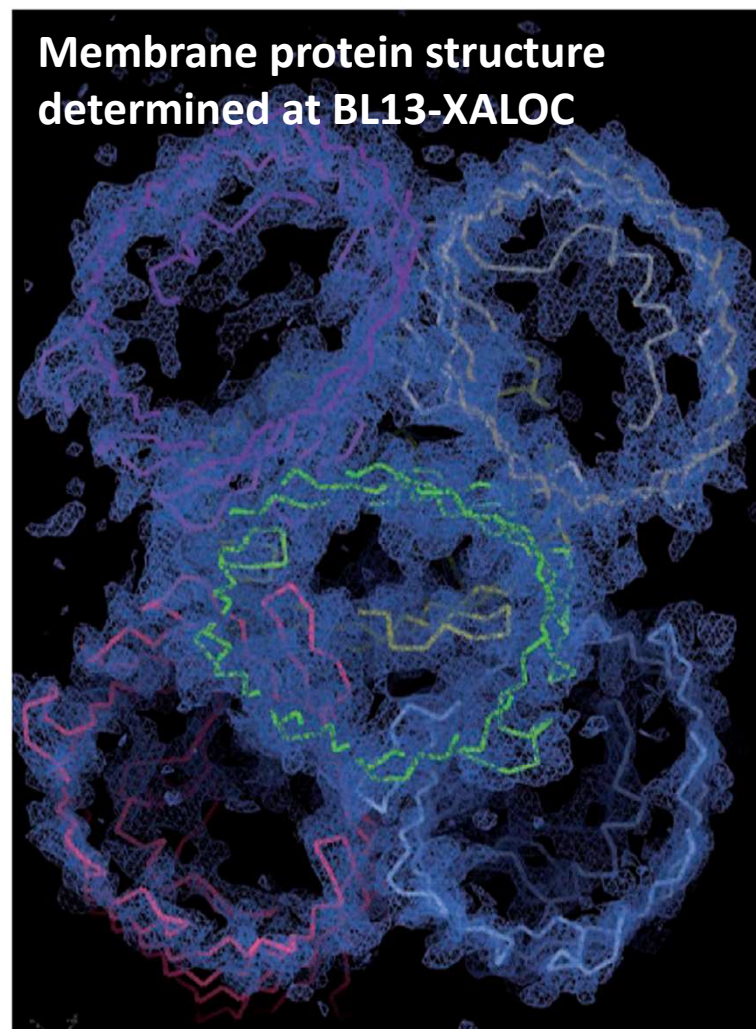
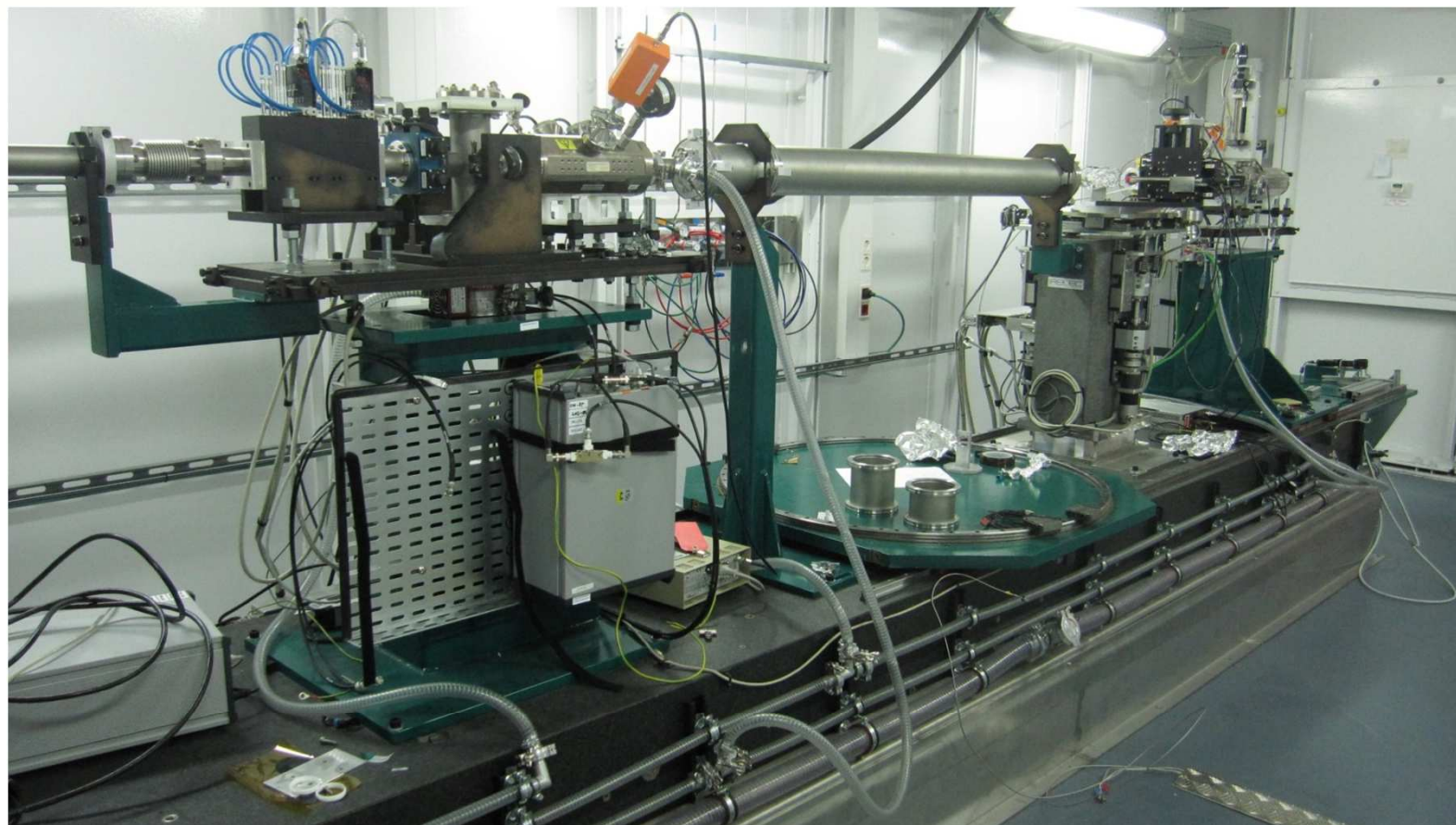


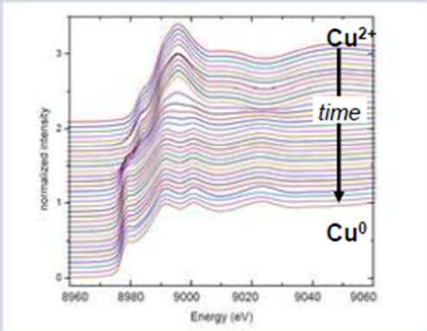
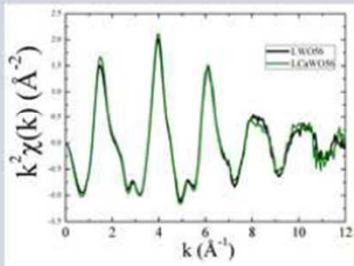
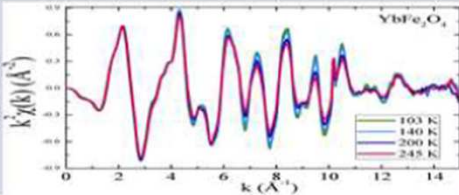
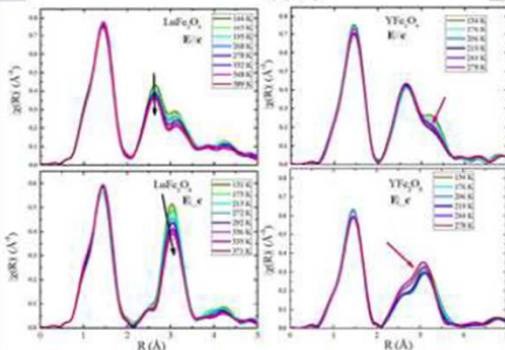
Figure 2. $2F_o - F_c$ map at 3.2 Å resolution of the first integral membrane protein solved at BL13-XALOC.

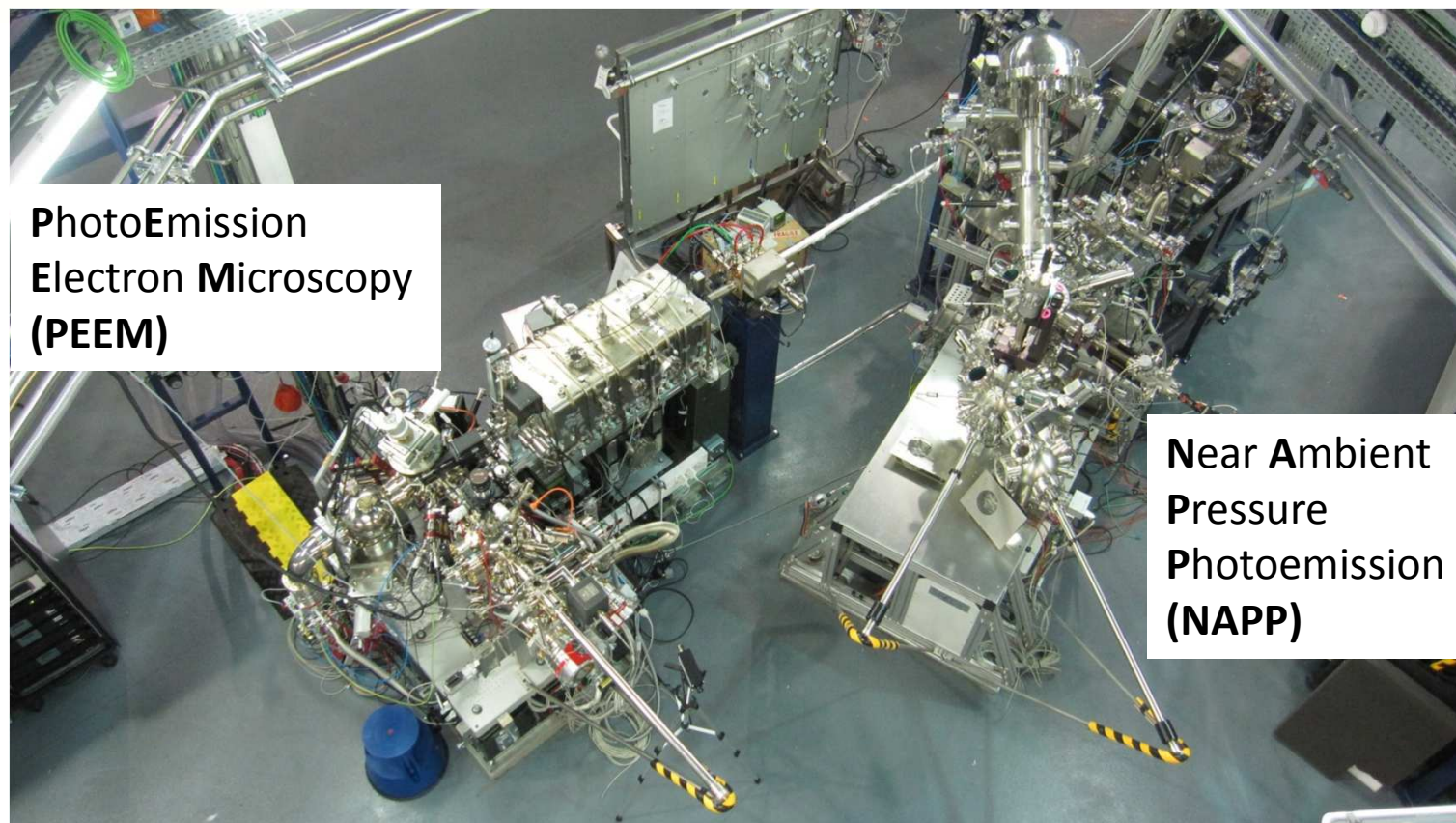


BL22 CLAESS Absorption & Emission Spectroscopies

- *Simultaneous & unified access to complementary techniques: Absorption and emission spectroscopies.*
- *Quick EXAFS.*
- *Photon energy range 2.4 – 65 keV.*

Staff: Laura Simonelli (Italian)
Carlo Marini (Italian)
Wojciech Olszewski (Polish)
Marta Avila (Spanish)

	ICIQ (CSIC-Tarragona)	ICMAB (CSIC-Barcelona)	ICMA (CSIC-Zaragoza)
Experiment	Investigation of CO ₂ and NO _x catalytic reduction by in situ XAS	Tungsten environment study in La ₆ WO ₂₄ proton conductor	XAS study of the charge ordering phase transitions in hexagonal RFe ₂ O ₄ (R=Y,Lu)
Experimental Conditions	High pressure reactor system 	Room Temperature	Low (LN₂) and High Temperatures 
Results			 



**PhotoEmission
Electron Microscopy
(PEEM)**

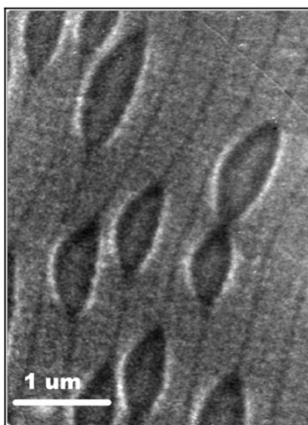
**Near Ambient
Pressure
Photoemission
(NAPP)**

BL24 CIRCE Photoemission Microscopy & Spectroscopy

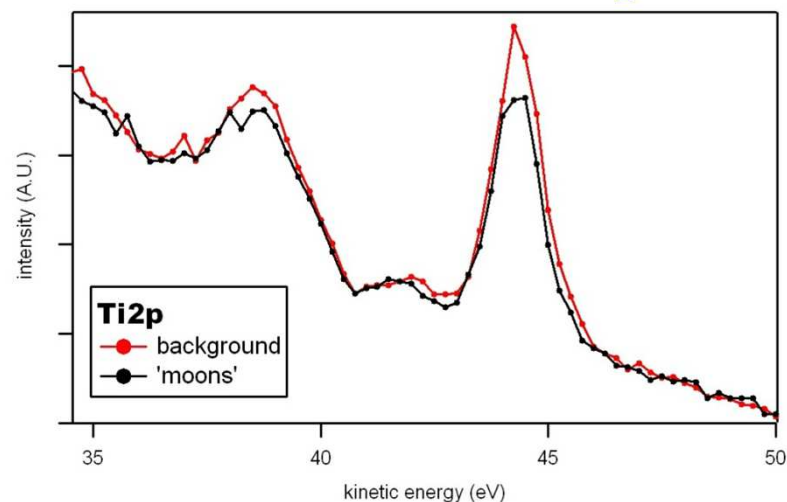
- *Variable polarization BL dedicated to advanced photoemission microscopy and spectroscopy.*
- *Two state-of-the-art end stations:*
 - *PEEM (photoemission electron microscopy).*
 - *NAPP (near ambient pressure photoemission).*
- *Photon energy range: 0.1 - 2.0 keV.*

Staff: Lucia Aballe (Spanish)
Virginia Perez (Spanish)
Michael Foerster (German)
Carlos Escudero (Spanish)

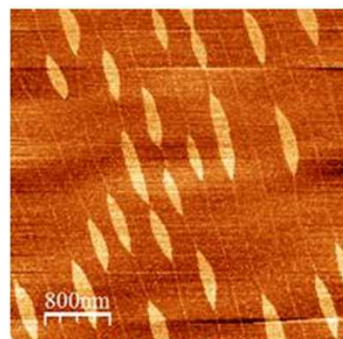
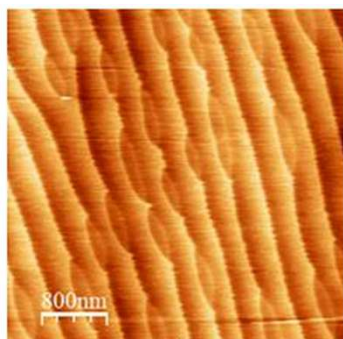
Self assembled distinct termination areas on $\text{SrTiO}_3(100)$



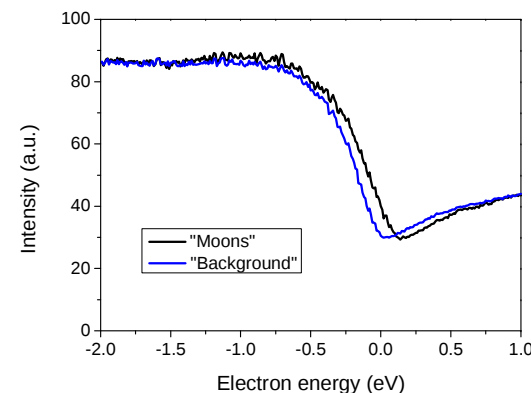
MEM image:
- SrO/TiO_2 areas
- steps



XPEEM spectromicroscopy at minimum electron escape depth confirms surface SrO vs TiO_2



AFM: topography (left) & lateral force (right)

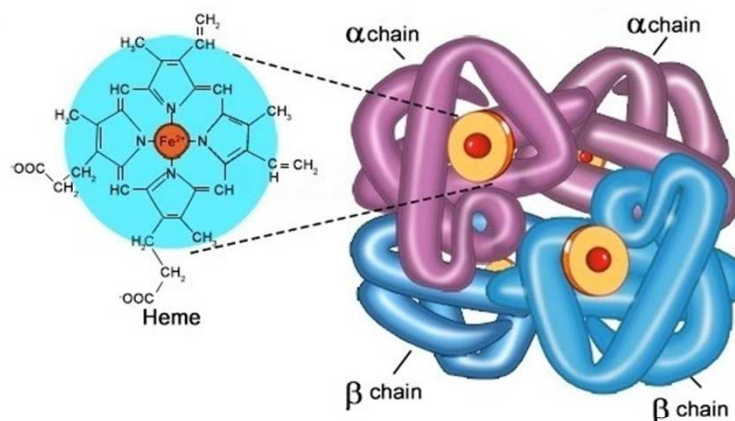


Work function difference from MEM-LEEM transition shift < 70 meV

C. Ocal, E. Barrena, S. Matencio, J. Fontcuberta (ICMAB-CSIC)

NAPP: Breathing chemistry

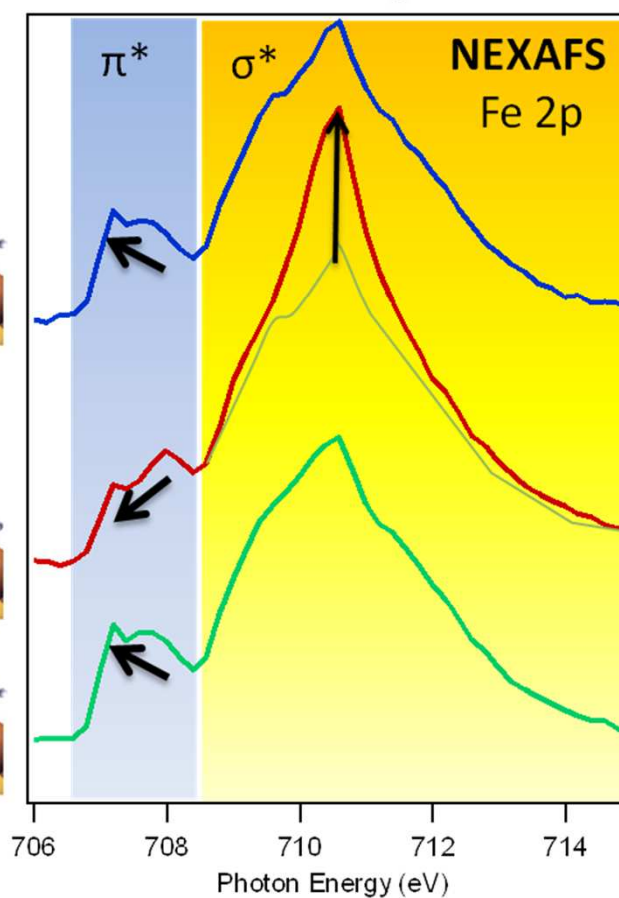
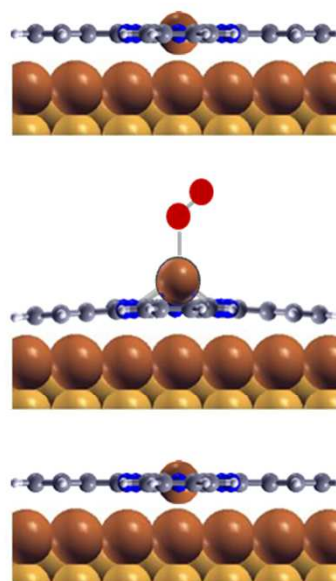
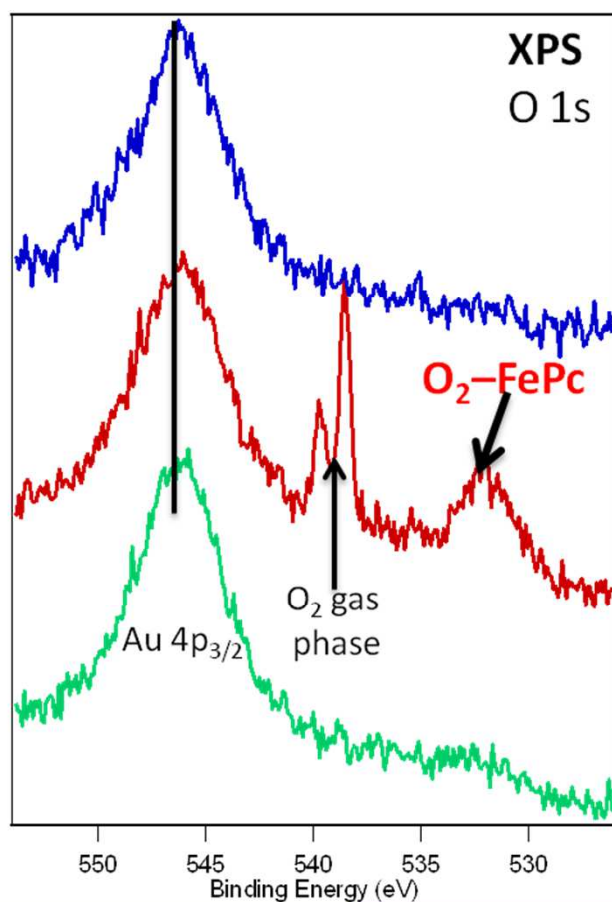
By courtesy of Dr. Celia Rogero (CSIC-UPV/EHU)

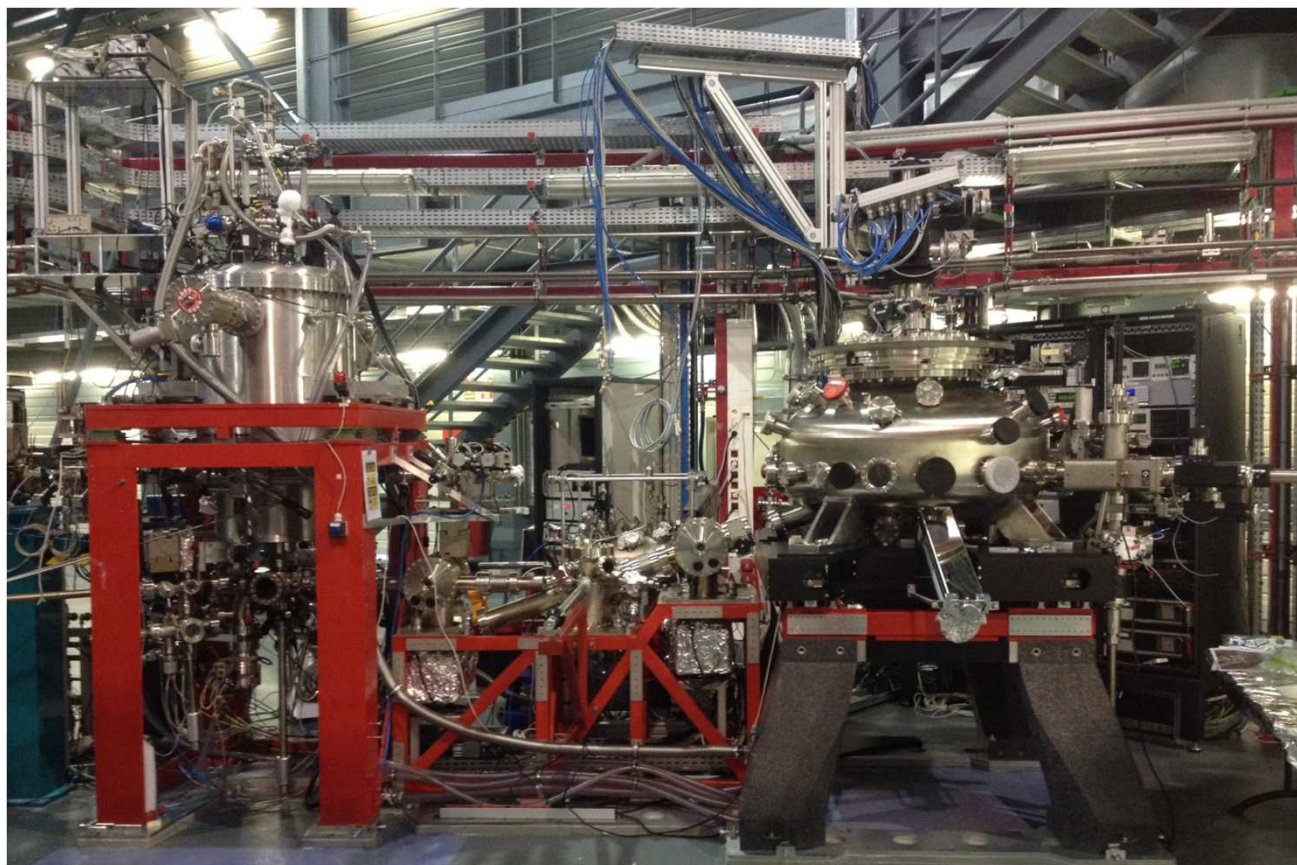


UHV

0.01 mbar
O₂

UHV



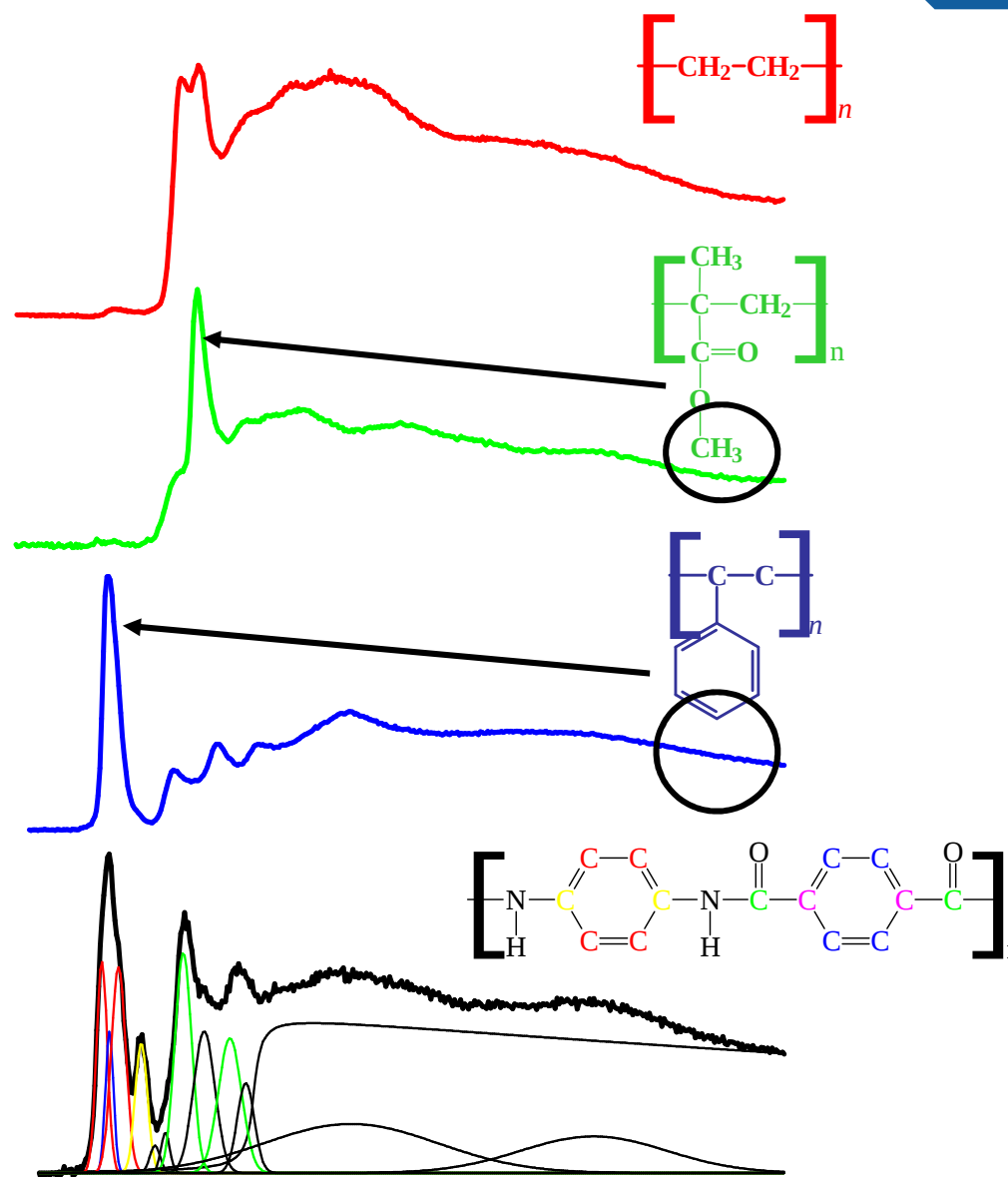
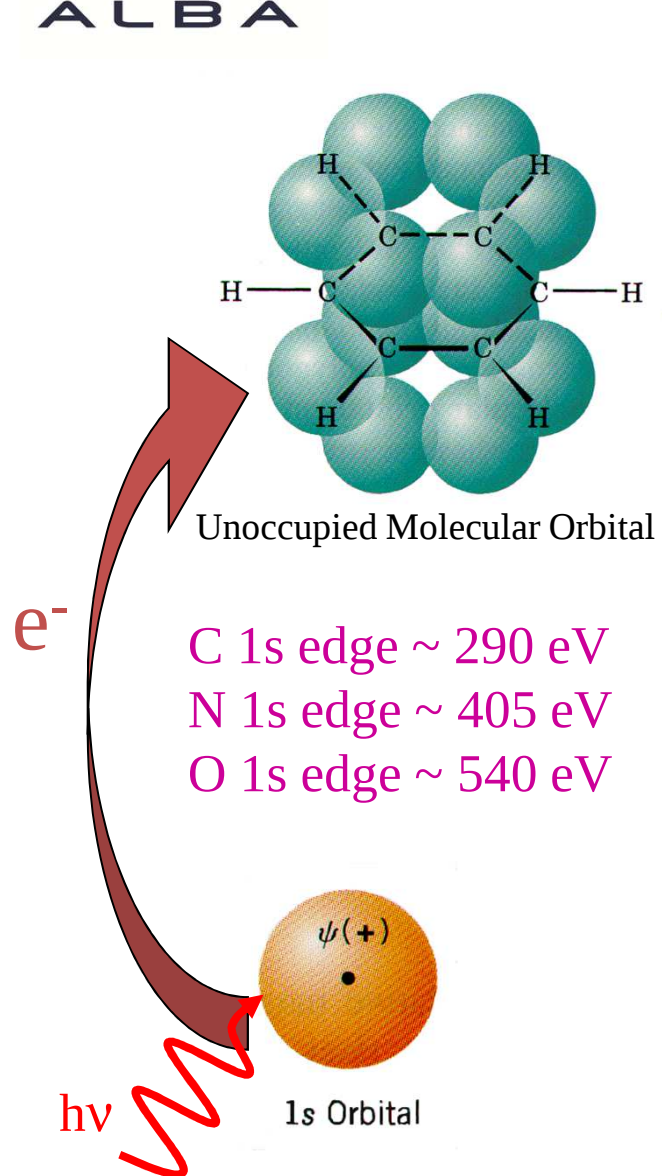


BL29 BOREAS Resonant Absorption & Scattering

- Dedicated to polarization-dependent spectroscopies of advanced materials.
- Two cutting-edge end stations:
 - HECTOR vector magnet (up to 2 / 6 Tesla) for absorption methods.
 - MARES UHV reflectometer for scattering and reflection measurements.
- Photon energy range: 0.08 - 4.0 keV.

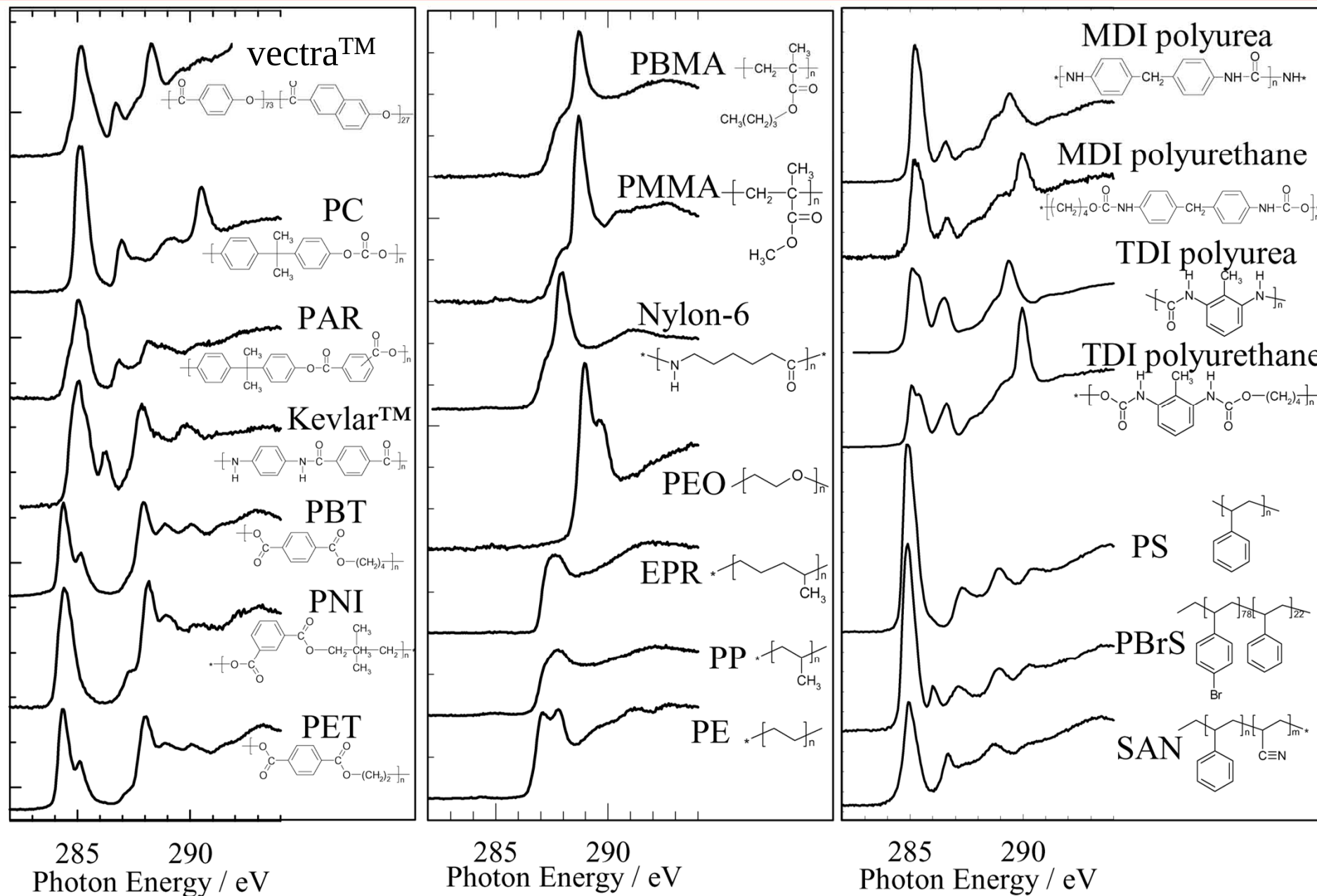
Staff: Manuel Valvidares (Spanish)
Javier Herrero (Spanish)
Pierluigi Gargiani (Italian)
Hari Babu Vasili (Indian)

NEXAFS/XANES on C1s edges

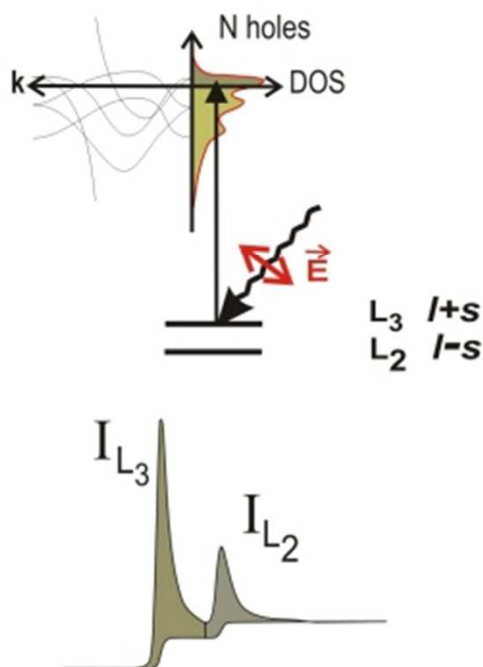


Some Polymer NEXAFS Spectra

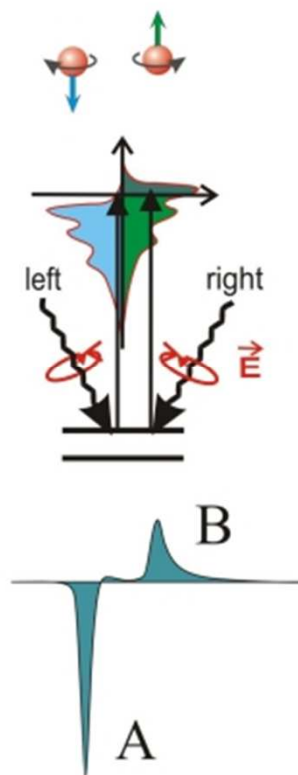
Dhez, Ade, and Urquhart
J. Electron Spectrosc. 128, 85 (2003)



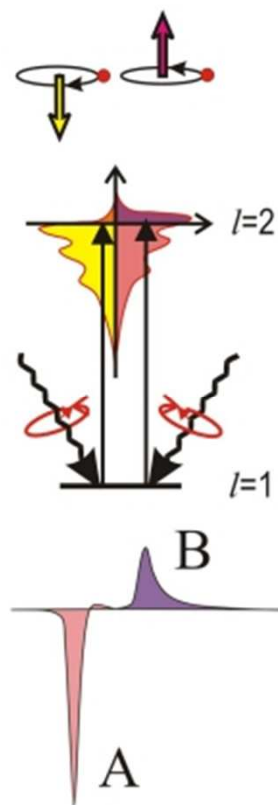
(a) d-Orbital Occupation



(b) Spin Moment



(c) Orbital Moment



NEXAFS:

- Unoccupied local electronic density of states
- Atom-specific
- Mapping out unoc. states with TM 3d character

XMCD:

$$m_{spin} \sim \frac{A - 2 B}{I_{ISO}}$$

$$m_{orbital} \sim \frac{A + B}{I_{ISO}}$$

