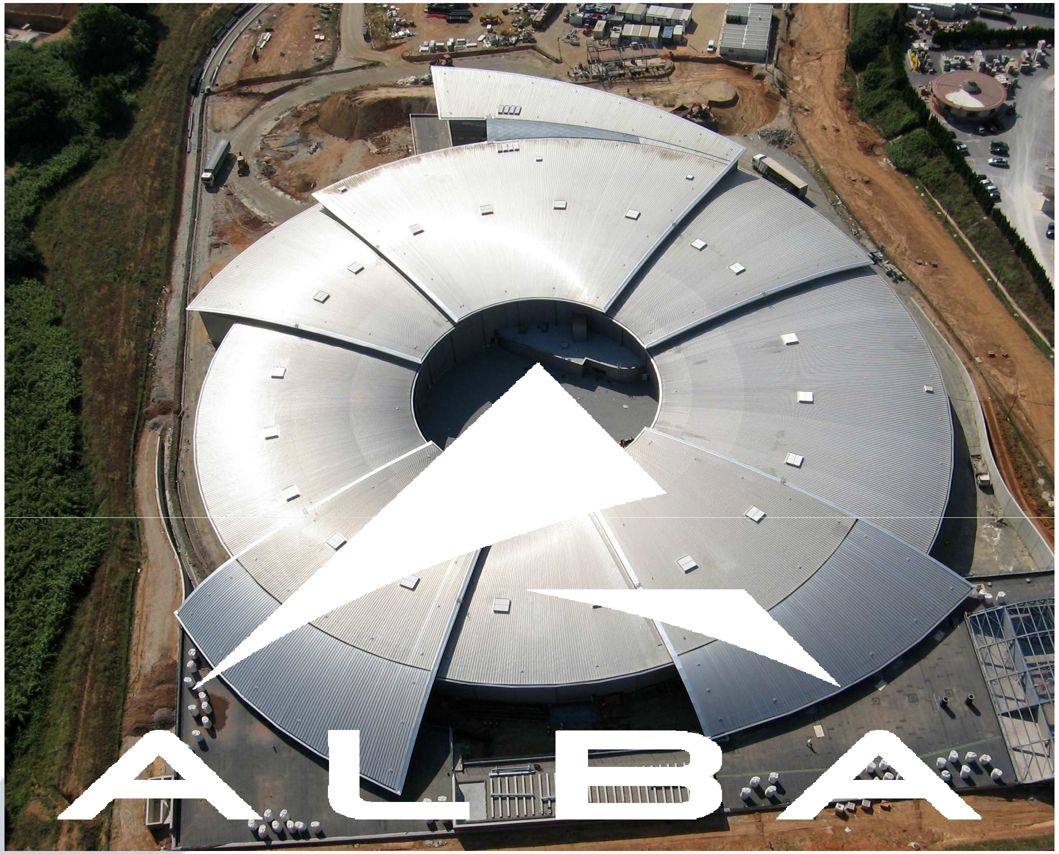


LA FUENTE DE LUZ SINCROTRÓN ALBA. ESTADO DE LA FUENTE Y LÍNEAS EN CONSTRUCCIÓN

Igors Šics

OUTLINE

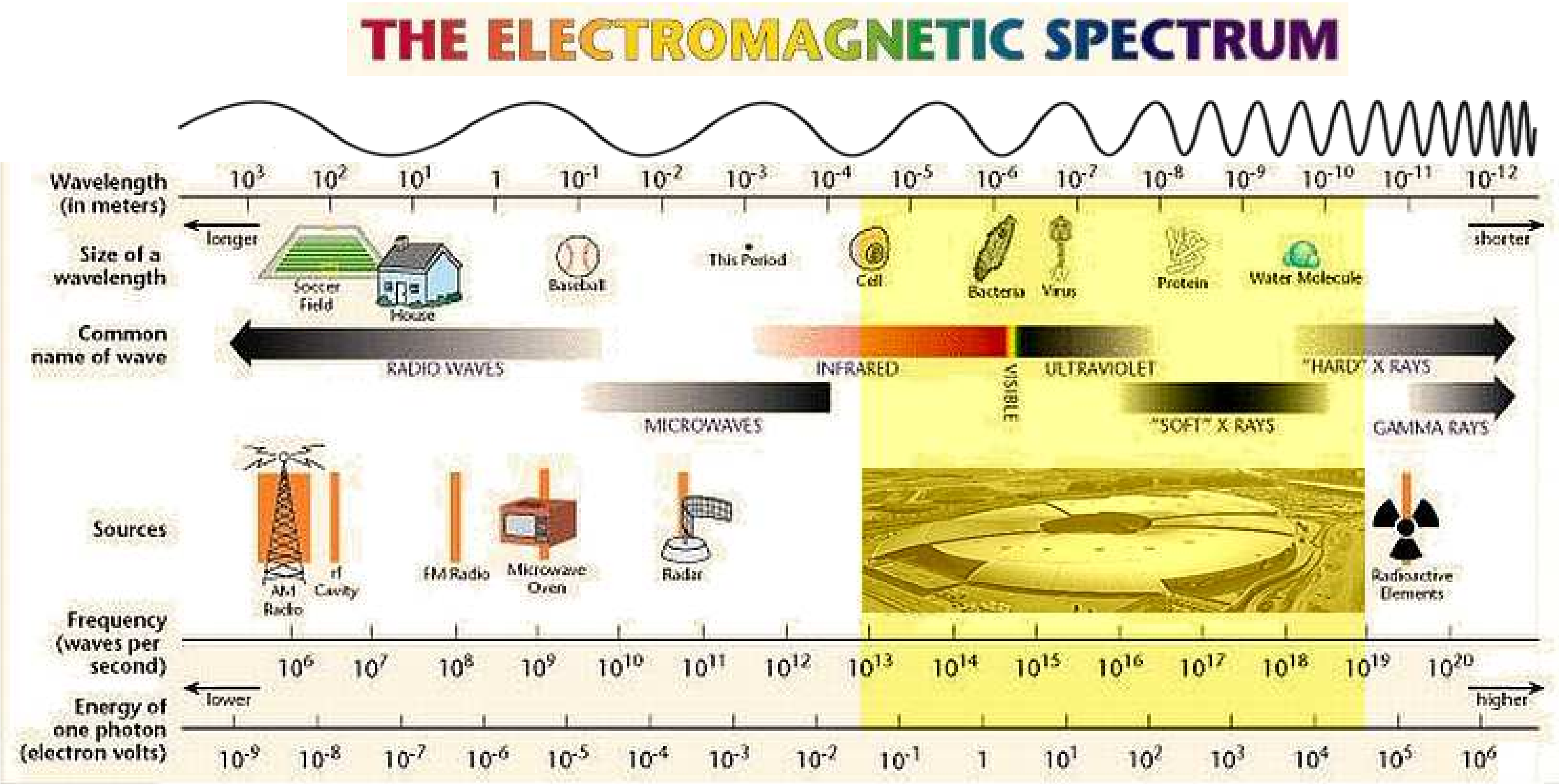
-INTRODUCTION TO SYNCHROTRON LIGHT

-ALBA PROJECT GENERAL OVERVIEW

- ACCELERATOR STATUS

- ALBA BEAMLINES

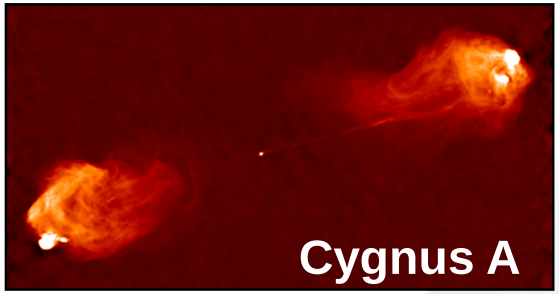
Electromagnetic spectrum



X-ray sources

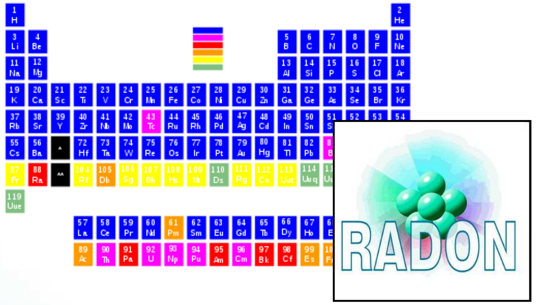
NATURAL SOURCES

Astronomical objects



Cygnus A

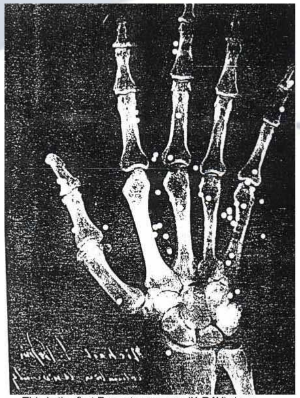
Radioactive elements



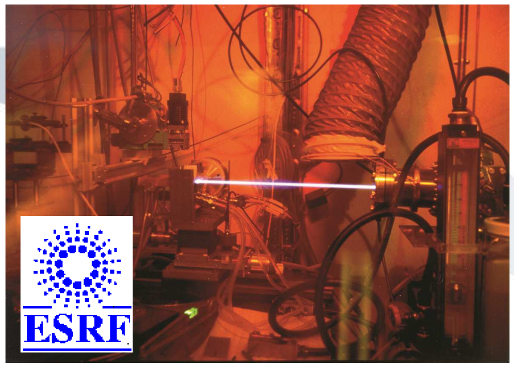
MAN-MADE SOURCES

Cathode-ray tube

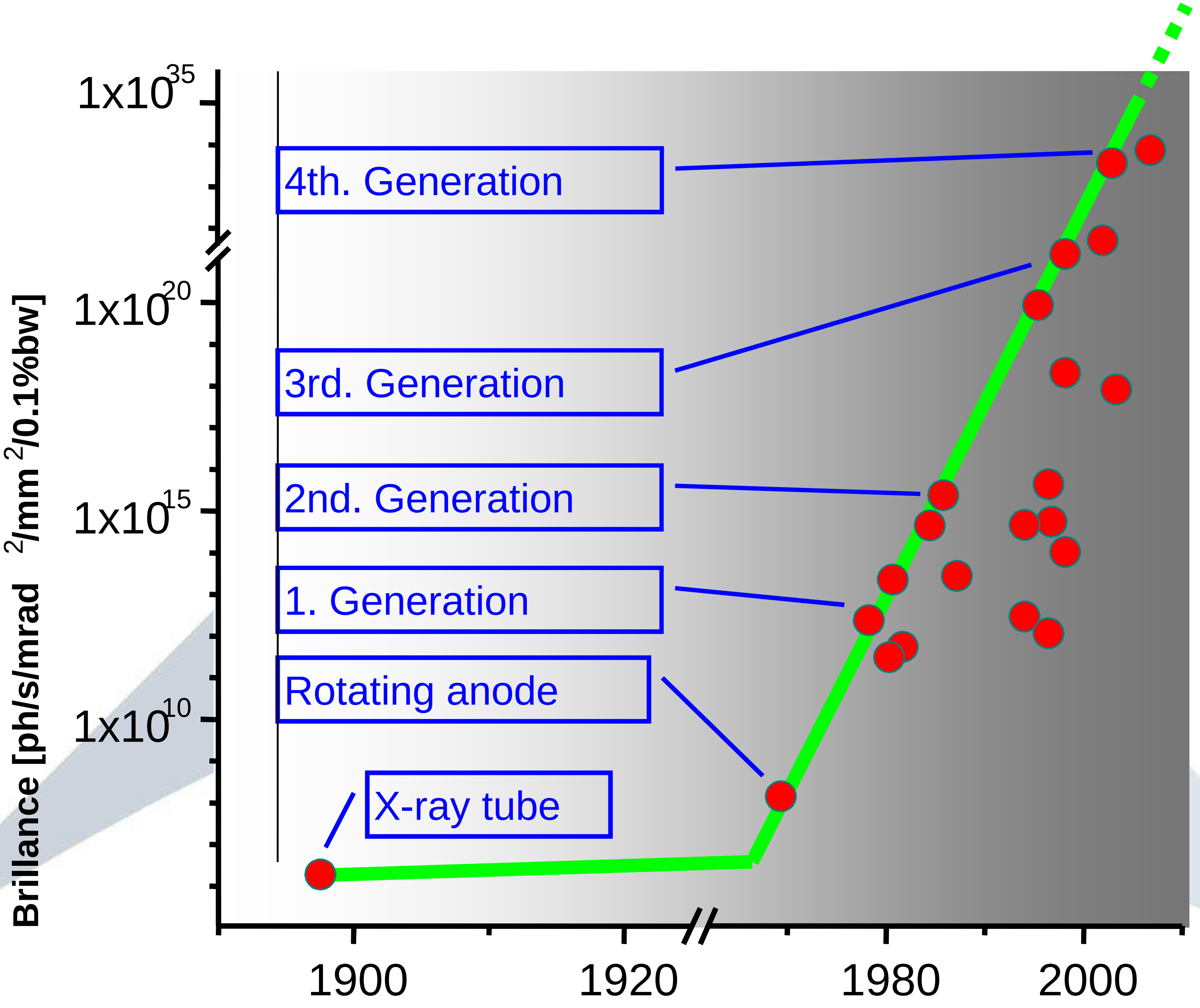
First x-ray pictures
February 1896



Accelerators



Timeline of artificial x-ray sources

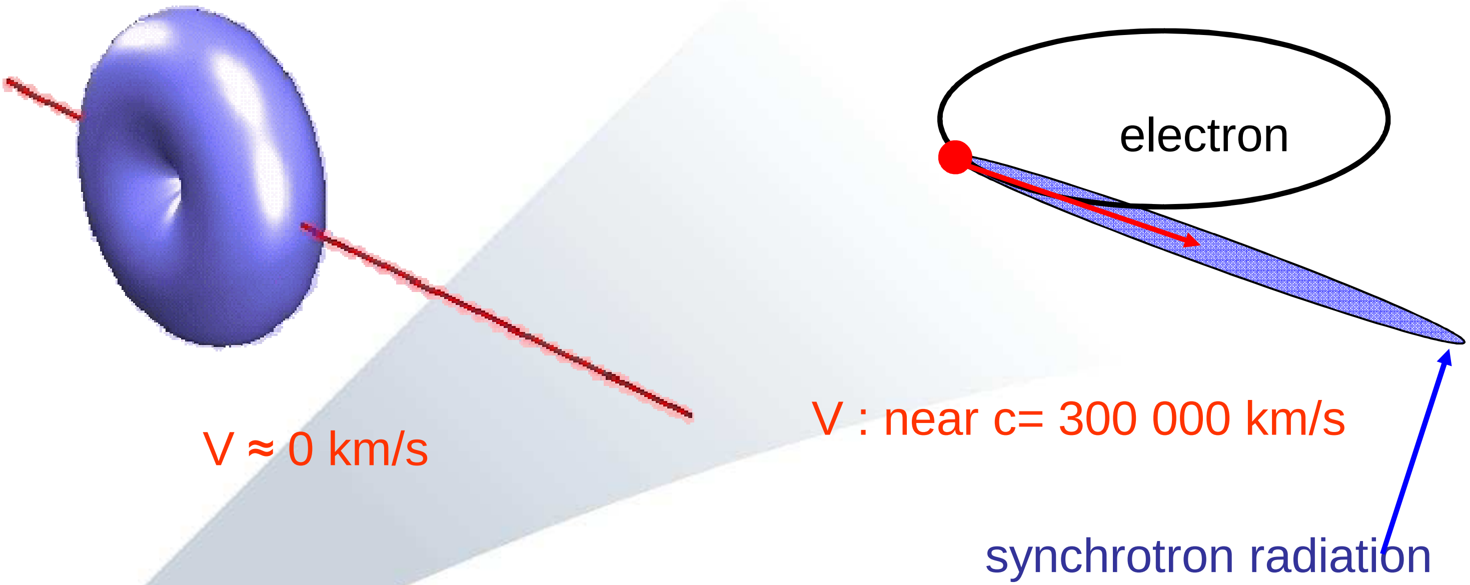


Why synchrotron radiation?

- High flux (photons/s ·0.1%BW)
- High brilliance (ph/s·mm^2·mrad^2·0.1% BW)
- Wavelength tunability
- Variable polarization
- Temporal structure

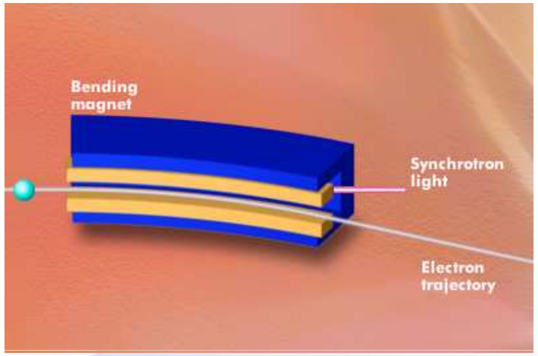
Synchrotron radiation

Synchrotron radiation are the electromagnetic waves emitted by a charged particle that moves in a curved trajectory at a speed close to the speed of light.



Synchrotron Radiation

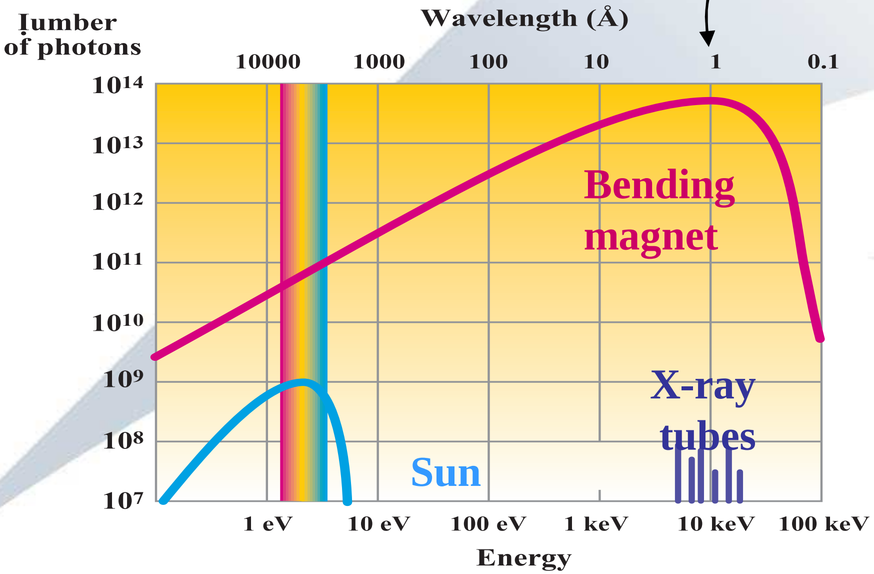
Synchrotron radiation can be generated by an application of a magnetic field forcing relativistic electrons to change their trajectory.



The angle of aperture of the radiation is very small : $1/\gamma$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

Emission spectrum



Characteristic energy ½ total power:

$$E_c(\text{keV}) = 0.66\, B(\text{T})\, E^{2}(\text{GeV})$$

B=1, E=3 , Ec = 5.94 keV

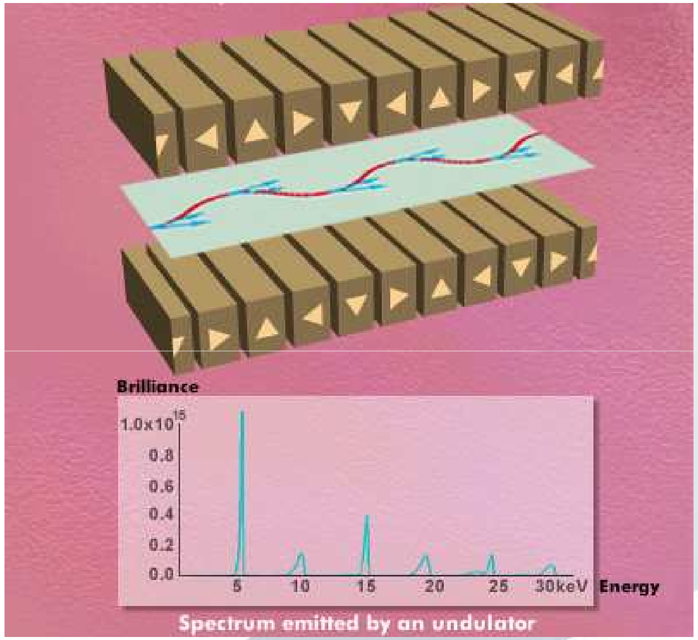
λc= 2.0 Å

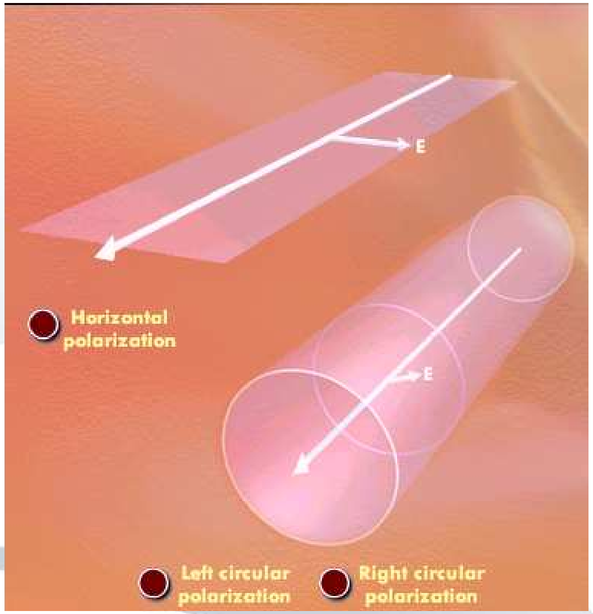
B=1 , E= 6 , Ec = 23.8 keV

λc= 0.52 Å

Synchrotron Radiation

Third generation SR sources are characterized by sources of radiation more brilliant and intense than bending magnet sources. Wiglers and undulators allow to tune the photon energy and provide high flux and brilliance

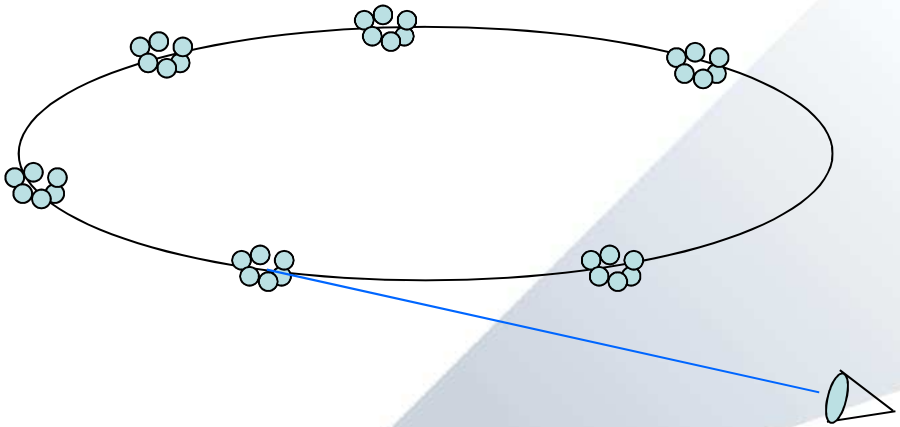




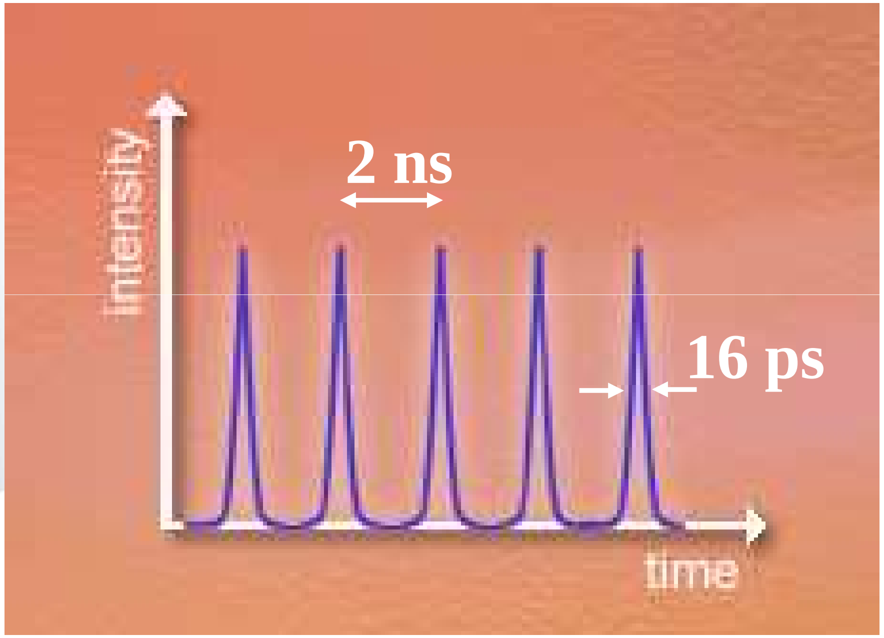
Natural synchrotron radiation is plane polarized since the e^- orbit is horizontal but the polarization may be manipulated with suitable insertion devices achieving variable polarization.

Synchrotron radiation

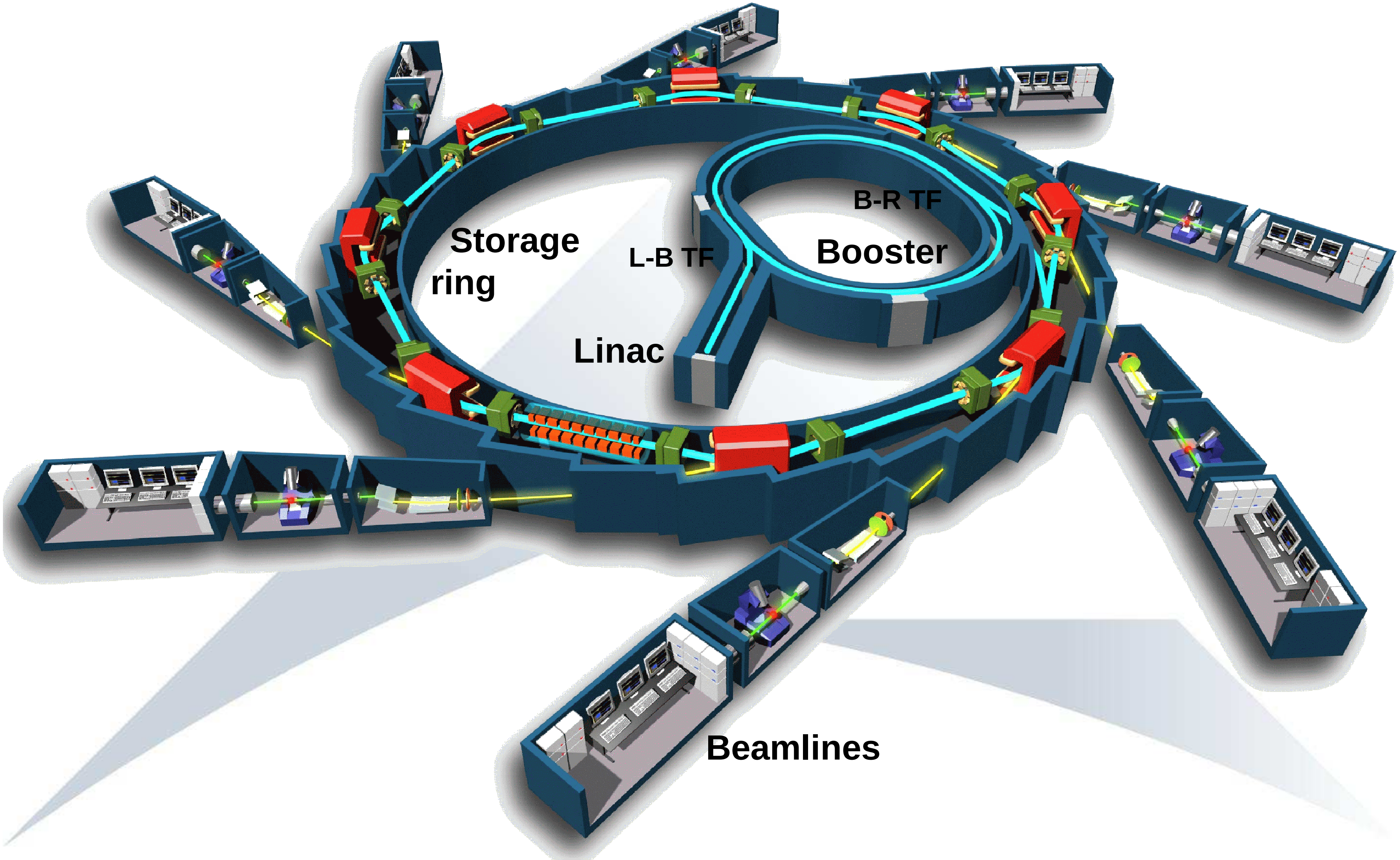
The electrons are grouped in packets and generate pulsed SR radiation with a temporal structure:



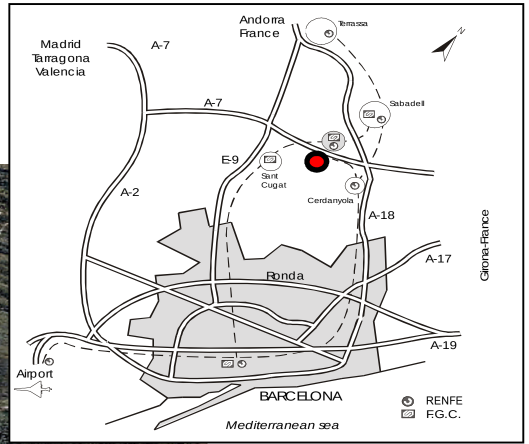
A flash of radiation each time that the e- packet is seen by the observer



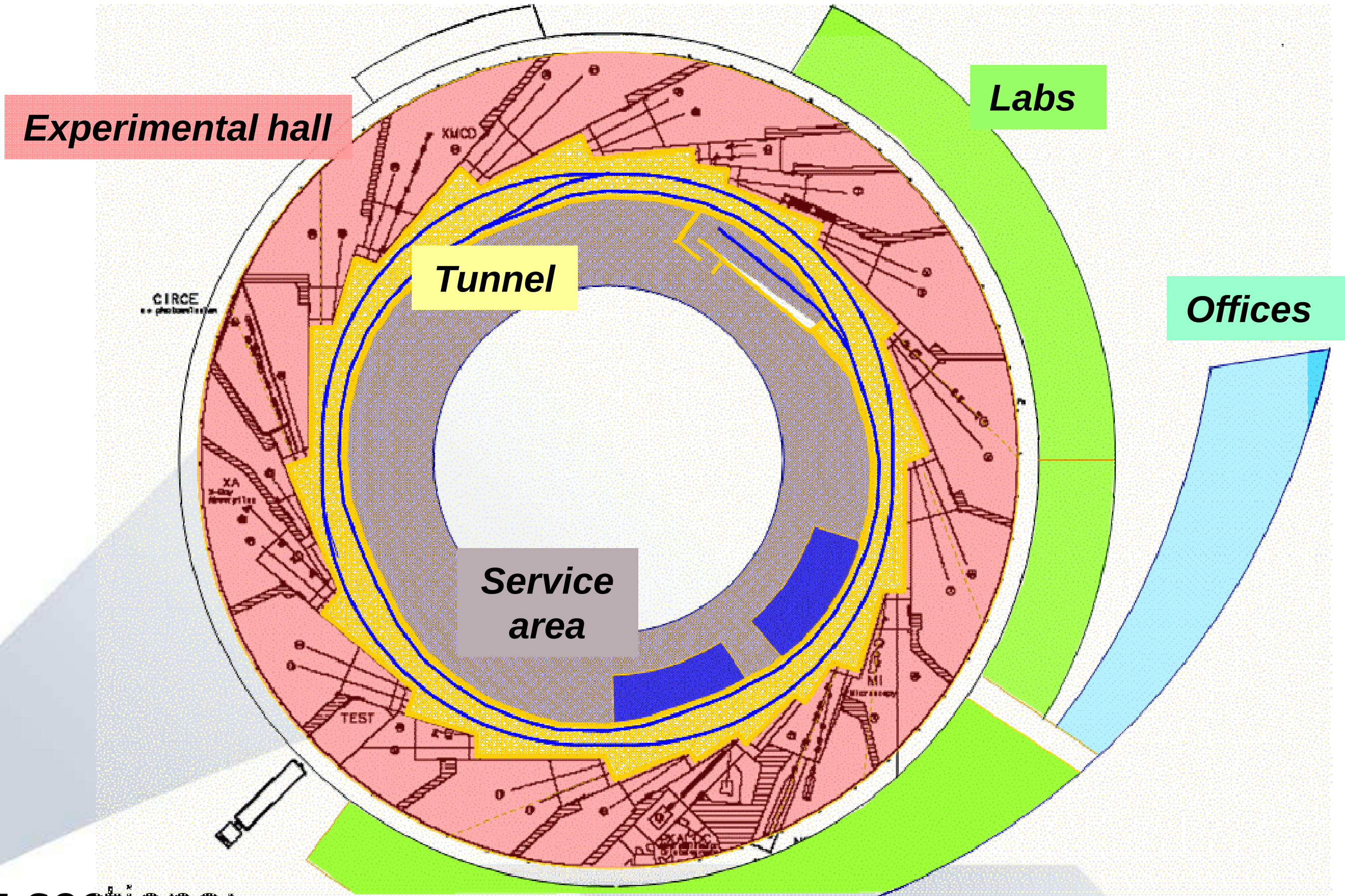
Generic synchrotron scheme



ALBA - location



ALBA parameters

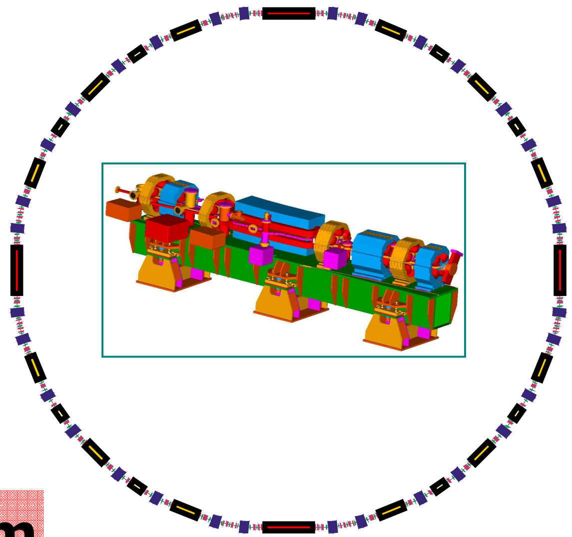


E = 3.0 GeV
C = 268.8 m
4 fold lattice
ε = 4.3 nm.rad
I=400 mA

3 different straight sections:

- 4x 8 m: 3 useful for Beam-lines
- 12x 4.3 m: 12 useful for Beam-lines
- 8x 2.6 m: 2 useful for Beam-lines

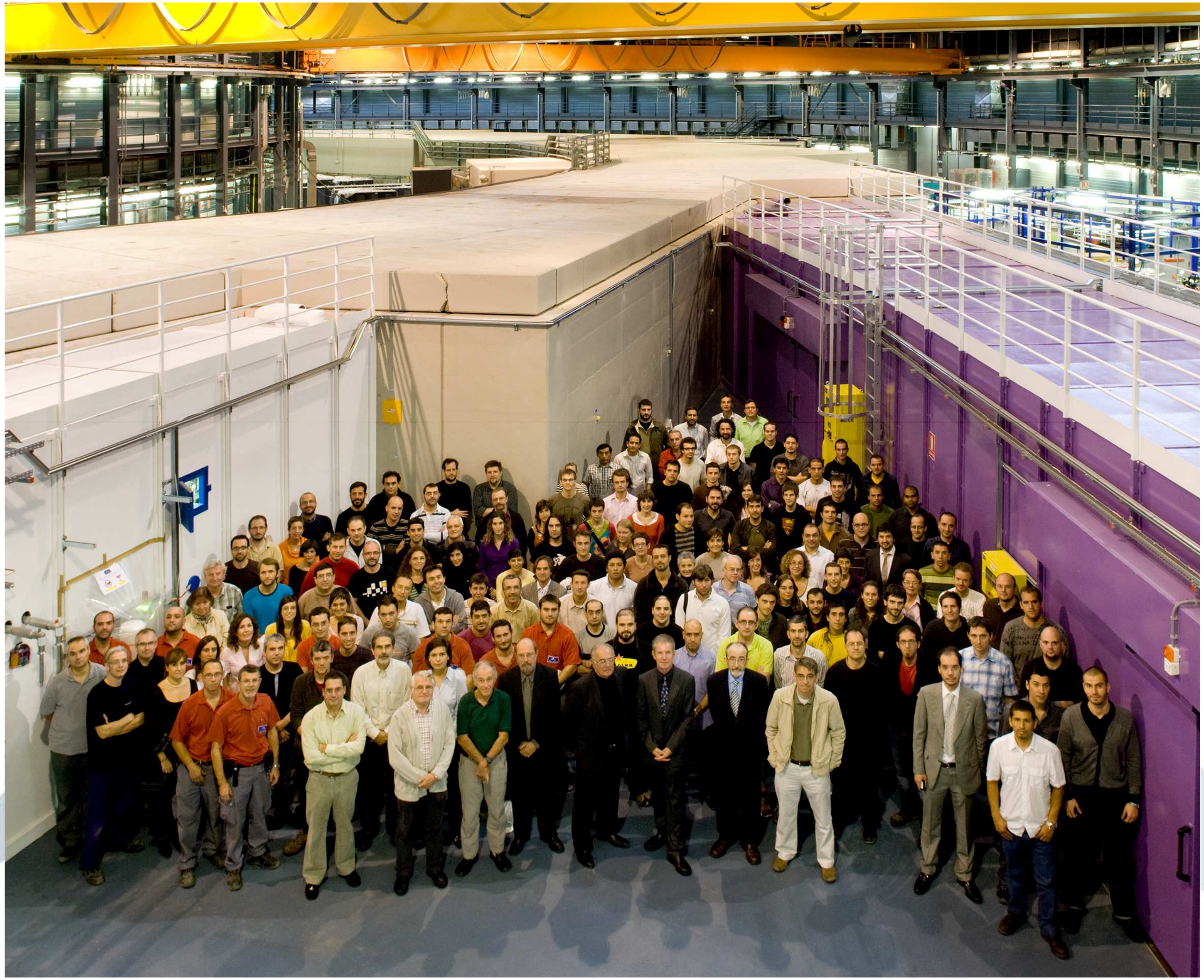
ALBA parameters



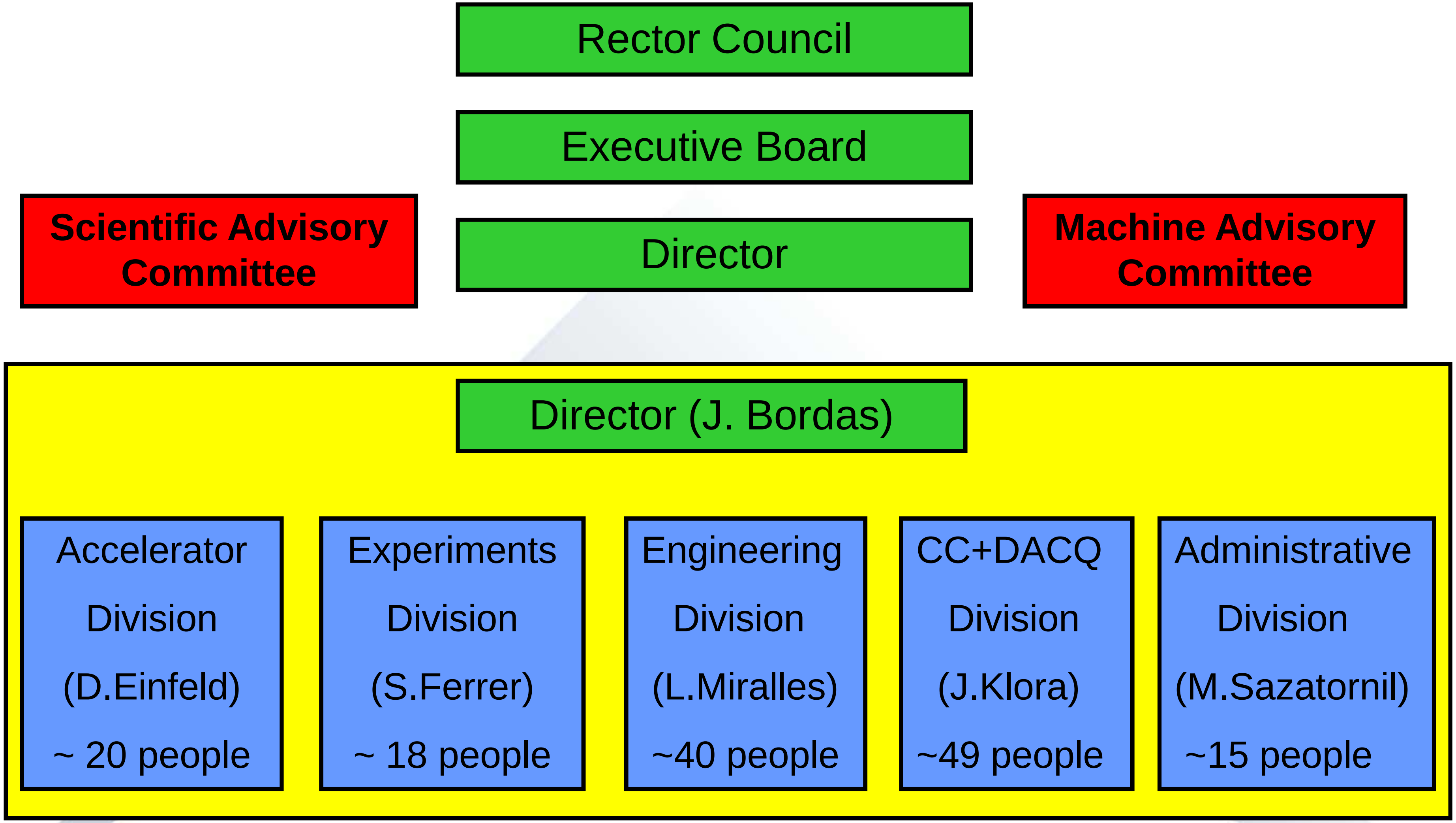
ELECTRON BEAM SIZE AND DIVERGENCE

Straight lengths	8 m	4.3 m	2.6 m
σ_x (μm)	225.0	151.0	276.0
σ'_x (μrad)	20.6	40.0	18.8
σ_y (μm)	14.4	6.0	15.7
σ'_y (μrad)	2.5	5.9	2.3

People of ALBA



ALBA – organizational scheme



ALBA – project timeline

History:

1990: 1st attempts (bottom up) to get an accelerator and SL source in Spain

1994: Generalitat (Commissió Promotora in 1992) appoints staff for the preparation of a conceptual design report for a SL source

1996: LLS (as an IFAE subgroup and funded by Generalitat and OCYT) started to detail the Conceptual Design Report and Scientific Case.

1998: Conceptual design report handed to relevant authorities

2000: Creation of the LLS Consortium between DURSI and UAB to promote SR Lab.

2002: Approval of the project by the Spanish and the Catalan Government.

2003: Creation of a Consortium for the Construction, Equipping and Exploitation of the SL Laboratory as well as the governing Commissions: "Rectora" and" Ejecutiva".

2003: Appointment of the Chairman of the Executive Commission and the Director

2003: Announcement of the positions for the Heads of the 5 Divisions

2003 October : Meeting in Mahon to present the project

2004 February : Meeting in Malaga to start defining scientific cases for future beamlines

2005: Ground breaking. Presentation of the Phase I Beamline projects to SAC

2006: Cornerstone of ALBA building laid.

Milestones – Construction

Milestones – Construction

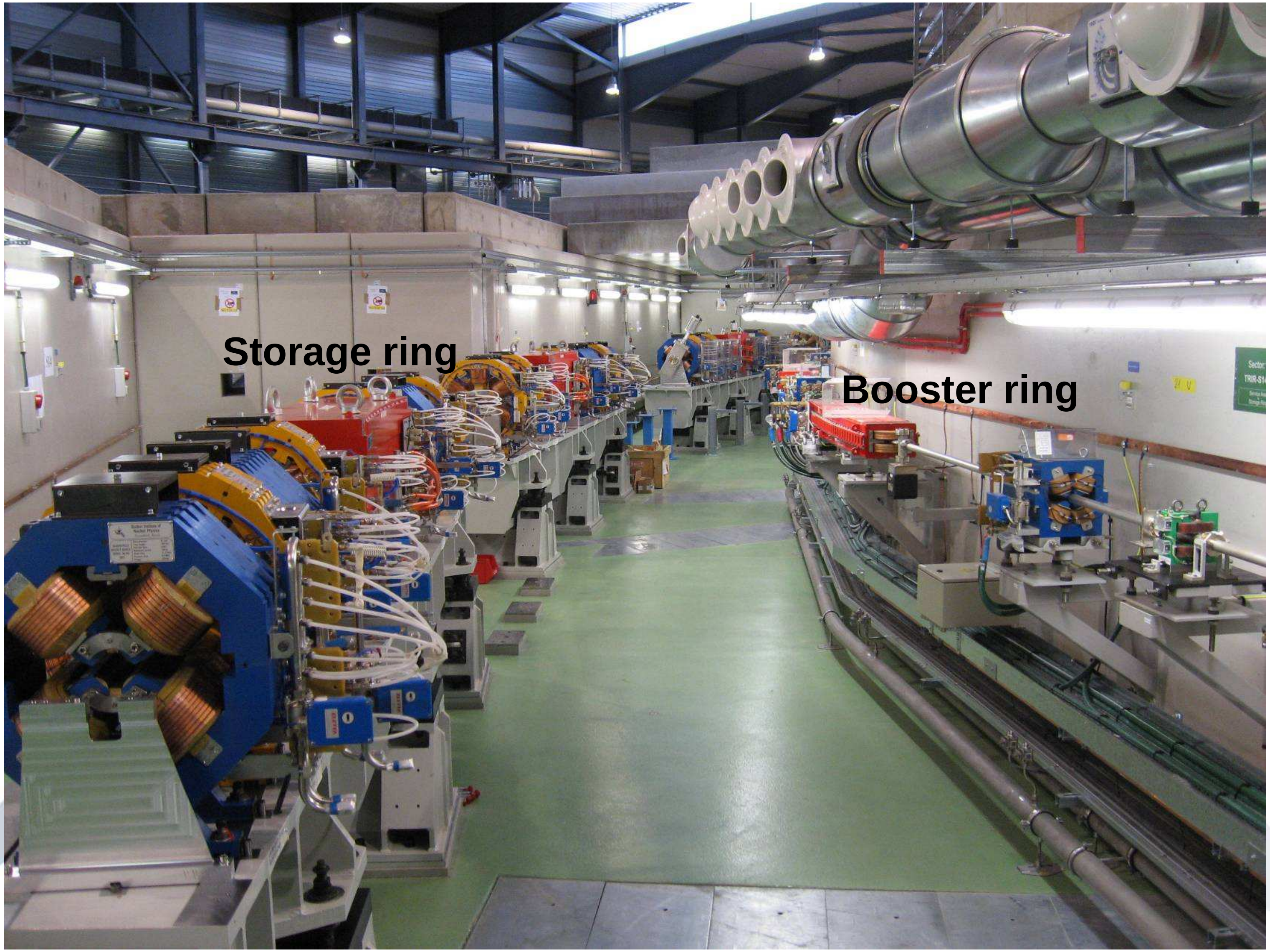
Milestones – Construction

Milestones – Construction

ALBA Experimental hall

ALBA Tunnel

ALBA Tunnel



ALBA's LINAC (May 2008)

Milestones – Linac operational

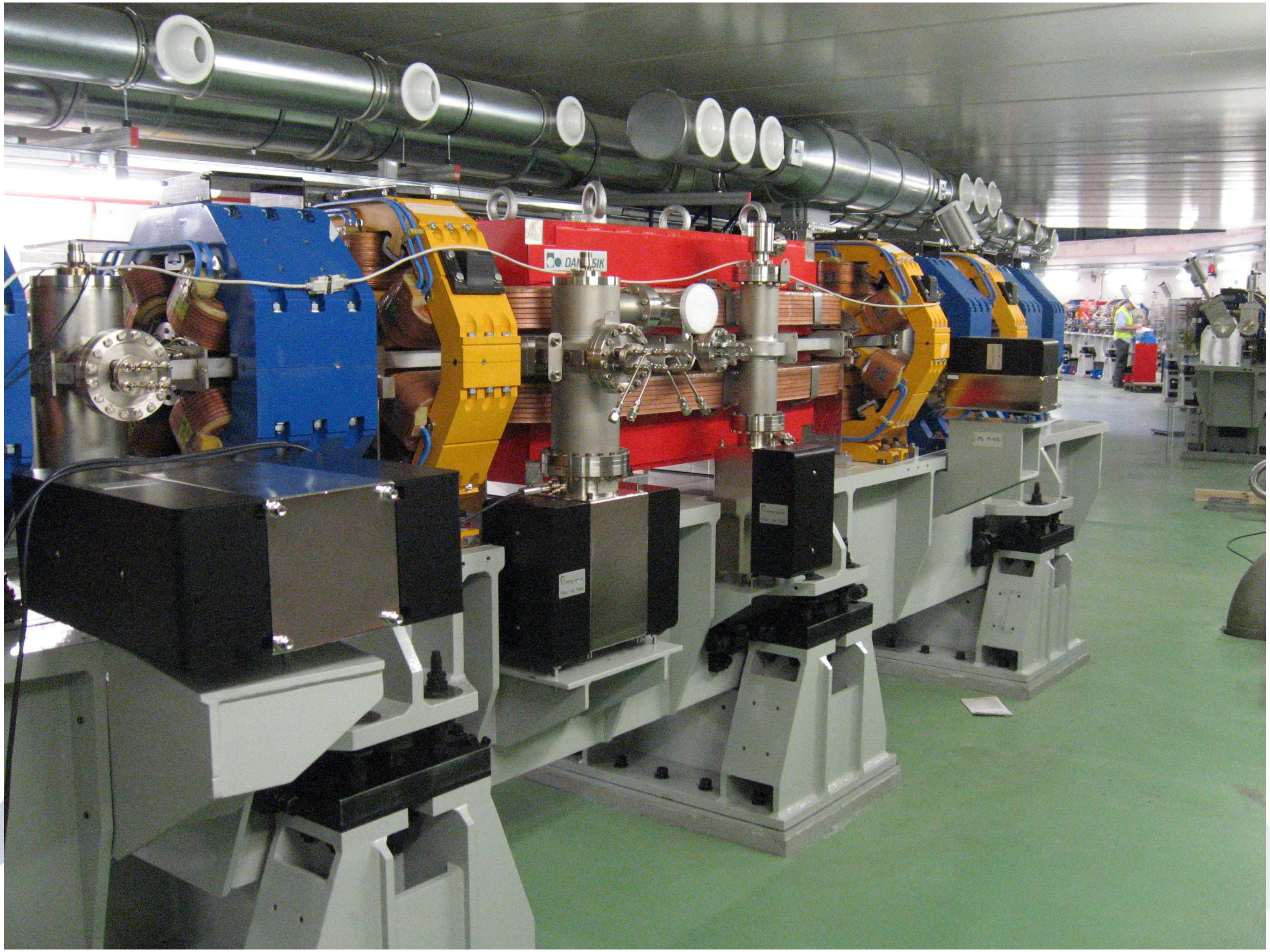
July 2, 2008 , 22 h

Status of the Machine: Linac

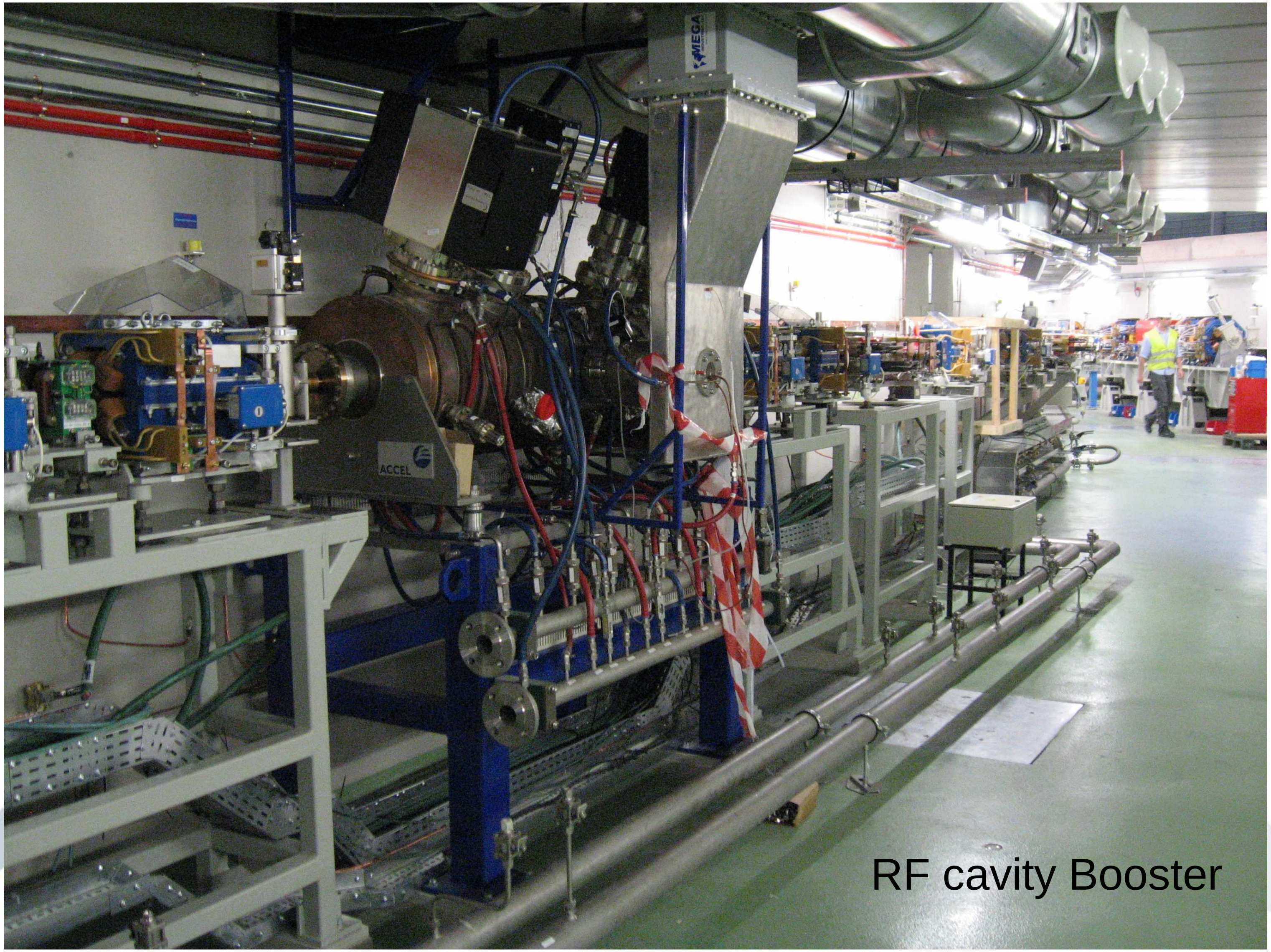
Figure 6: Beam image at SM3 (Linac Exit)

Celebration of first beam from Linac with a glass of Fanta (orange)

ALBA's Booster (2010)



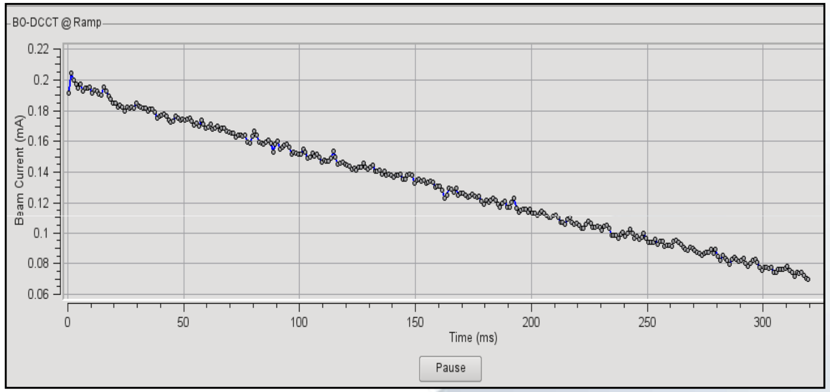
ALBA's Booster (2010)

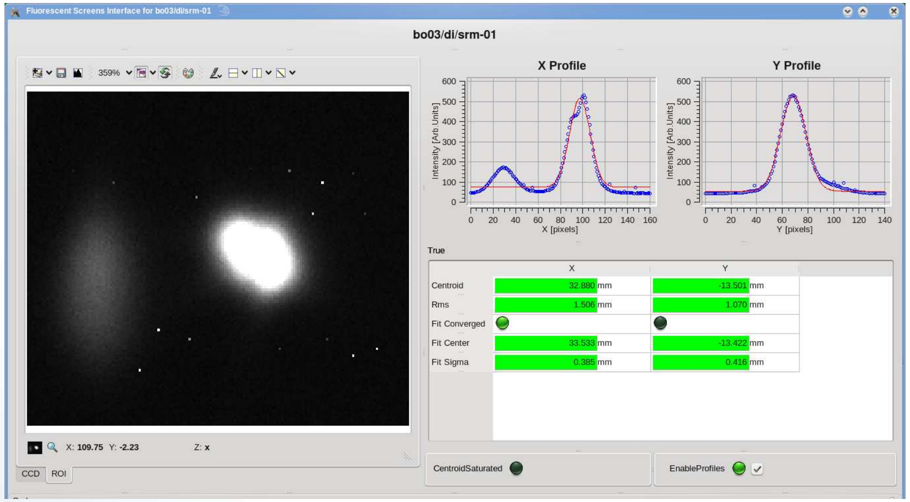


RF cavity Booster

Milestones–Booster commissioning(2010)

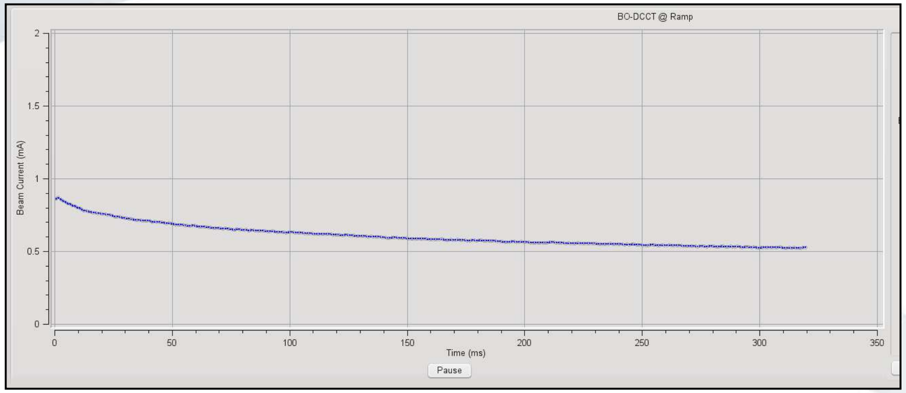
Beam in the BO at 100 MeV, w/o RF





Synchrotron light in booster, 01/2010

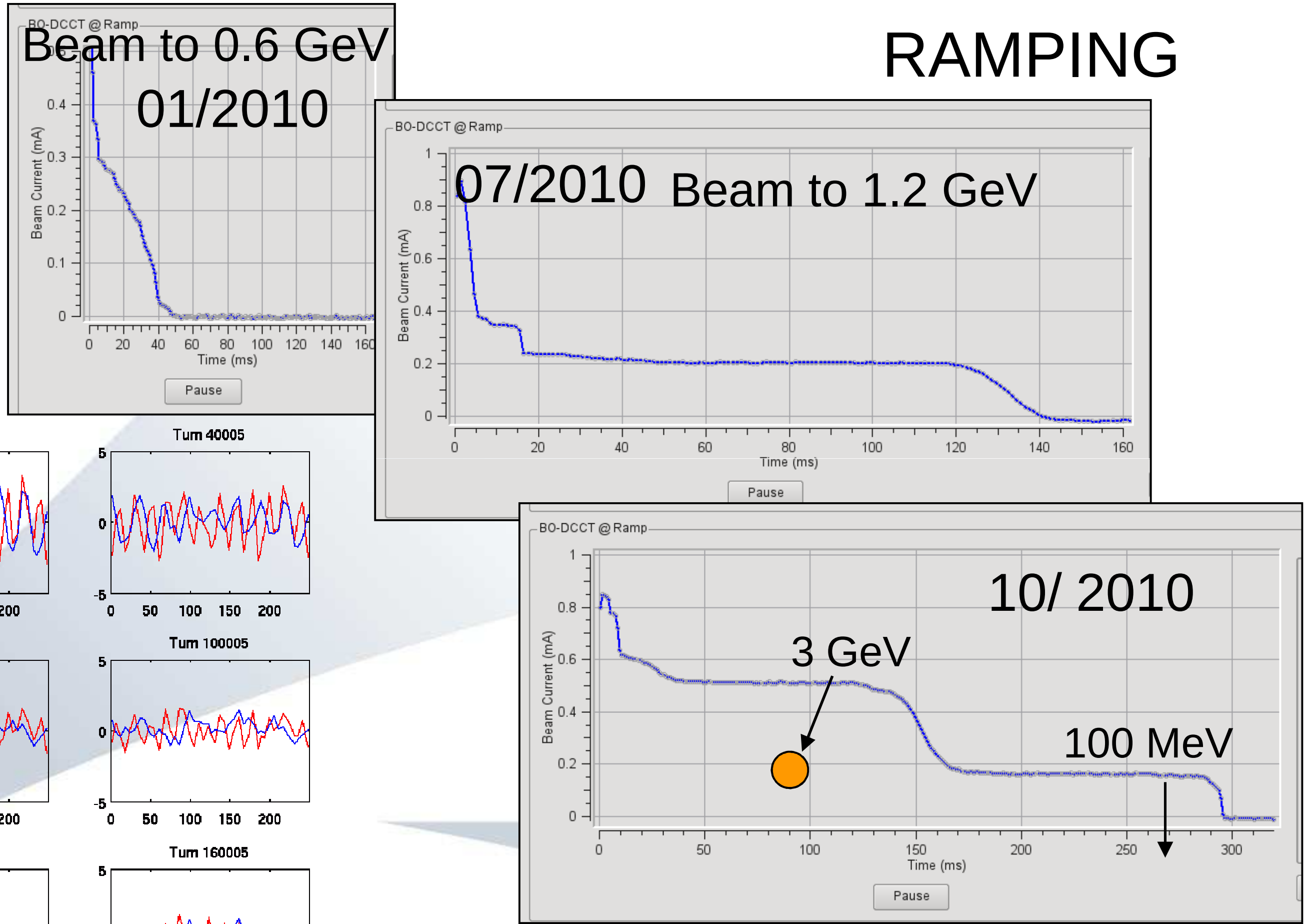
Beam in the BO (1 mA) at 100 MeV, with RF, after injection optimisation and orbit correction



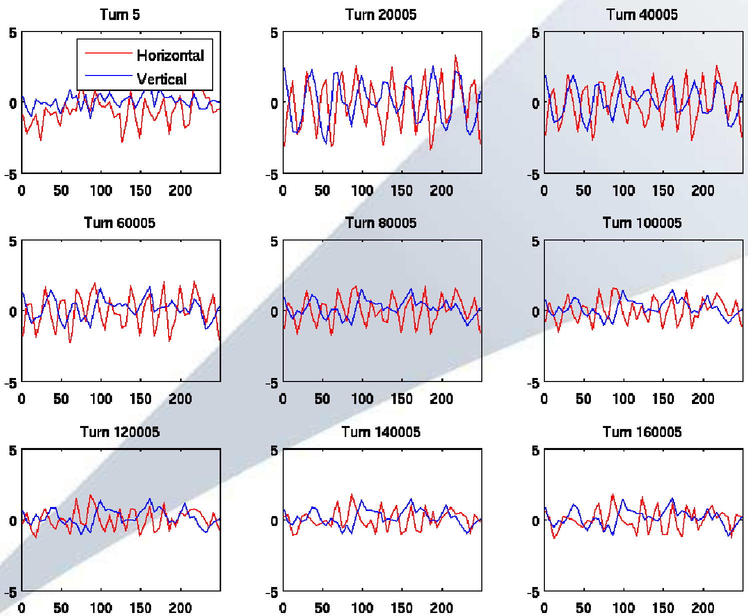
Milestones–Booster commissioning(2010)

During 2010 - 3 commissioning turns: January(1), July(2), October(3)

RAMPING



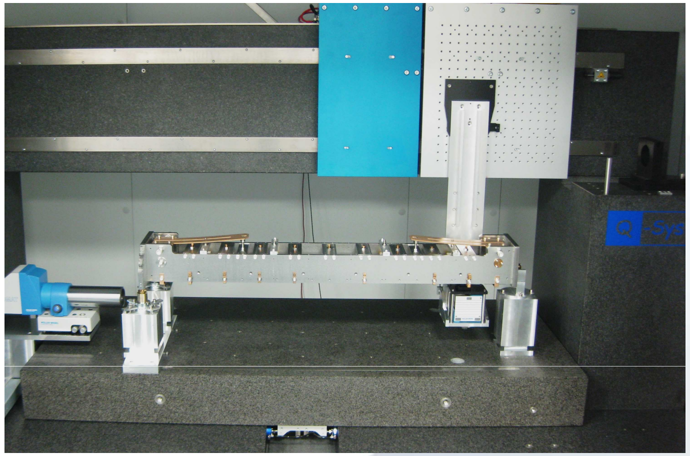
Beam to 3 GeV and back to 0.1 MeV



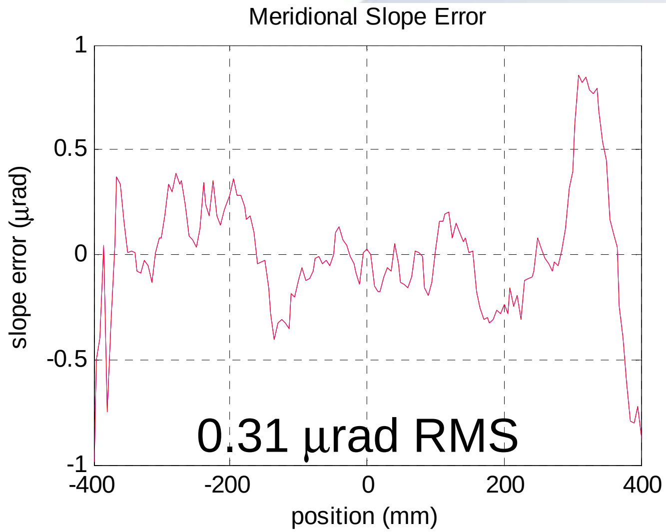
Close orbit during ramping:
± 2mm in both planes

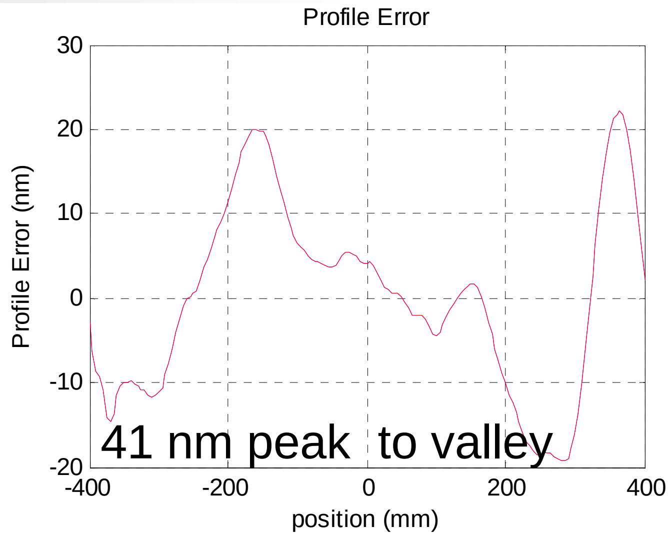
ALBA – Optics Lab

State of the art Long Trace Profiler.   Resolution in slope error: 40 nrad

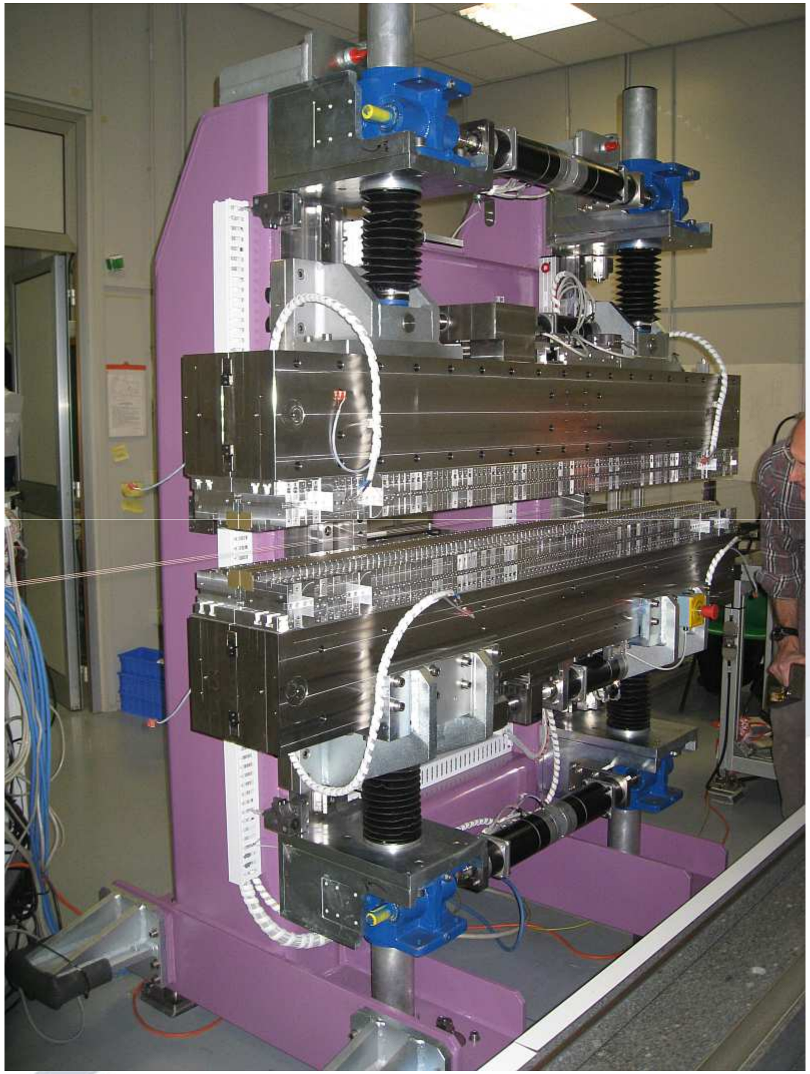


Mistral 800 m mirror
Ellipse corrected with gravitational sag
p = 2311 mm   q= 3316 mm





ALBA Insertion devices



Apple-II devices for CIRCE BL, BOREAS BL:

- Delivered.

-Factory Acceptance Tests and Site Acceptance Tests successfully passed. They are provisionally installed in the tunnel, waiting for final vacuum chamber installation.

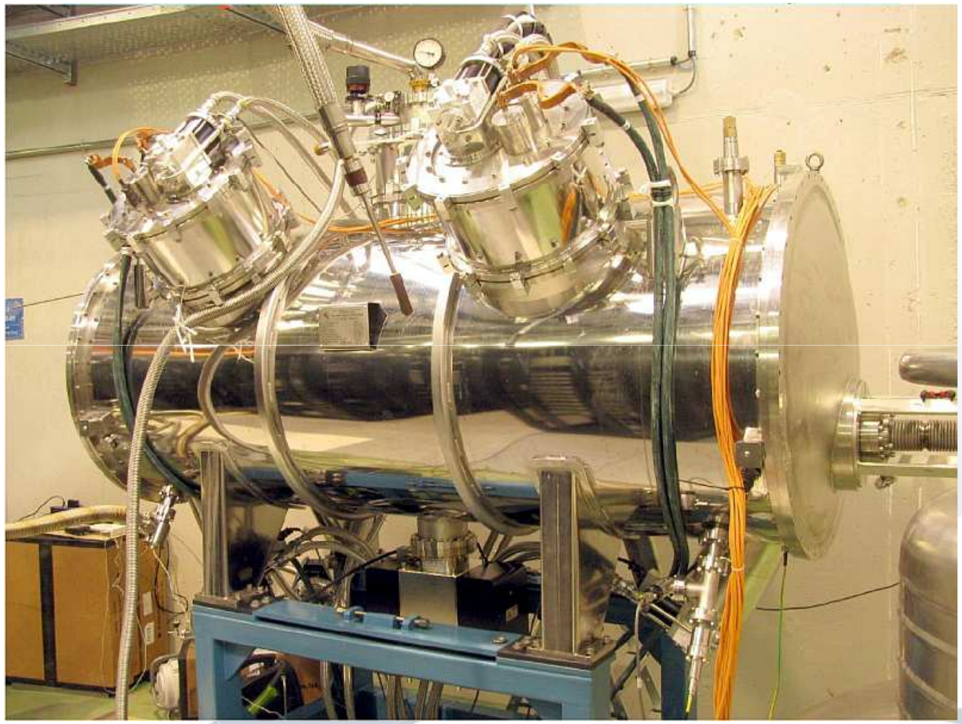
This is scheduled for February - March 2011.

ALBA Insertion devices

Multipole wiggler MPW80 for CLAESS BL:

- Delivered.
-Factory Acceptance Tests and Site Acceptance Tests successfully passed. It is stored in the magnetic measurement laboratory waiting for the final vacuum chamber installation.
This is scheduled for March 2011.

ALBA Insertion devices



Superconducting wiggler SCW 30 for MSPD BL :

- Delivered.
- Factory Acceptance Tests and Site Acceptance Tests successfully passed. It is stored (at room temperature) in the Service Area of ALBA. Installation scheduled for May 2011

ALBA Insertion devices

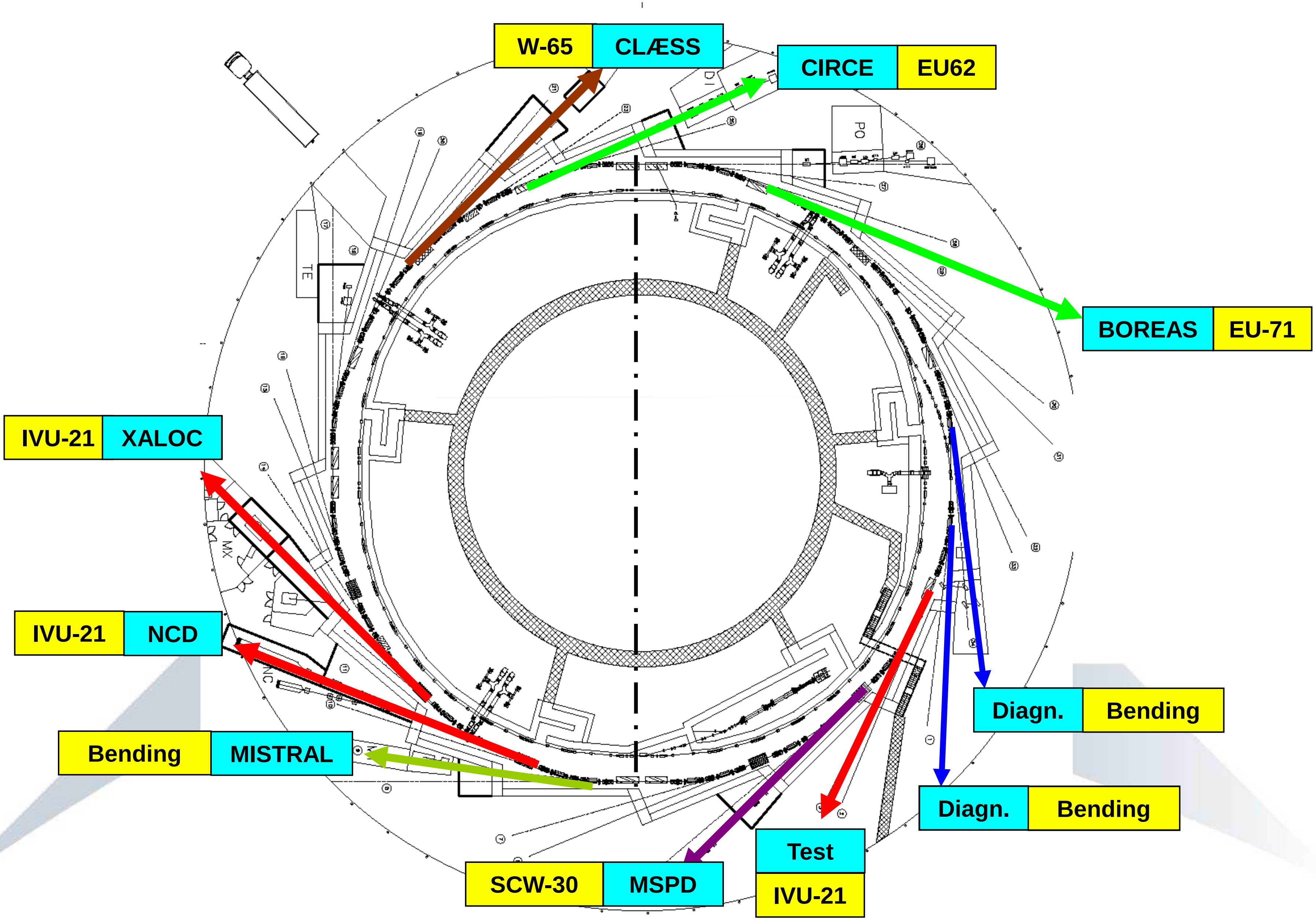
In-vacuum undulators IVU-21 for NCD BL and XALOC BL:

-**Delivery pending.**
- Factory Acceptance Tests successfully passed. They are still being finished at Bruker-ASC (bake out, final wiring, etc). First one is expected to be received in December 2010, and second one in February 2011.
Installation in the storage ring is scheduled for June 2011.

ALBA – Phase I beamlines

- XALOC: Macromolecular crystallography
- NCD: Non-Crystal Diffraction
- MSPD: Material Science and Powder Diffraction
- CLÆSS: Core Level Absorption and Emission SpectroscopieS
- MISTRAL: X-ray microscopy
- BOREAS: X-ray circular magnetic dicroism and resonant scattering
- CIRCE: Photoemission microscopy and ambient pressure photoemission

ALBA – Phase I beamlines



ALBA – Phase II beamlines

9 Proposals

SAC recommendation:

MIRAS2 : An infrared microspectroscopy beamline for ALBA

LOREA : A beamline for Low-Energy Ultra-High-Resolution Angular Photoemission for Complex Materials at ALBA

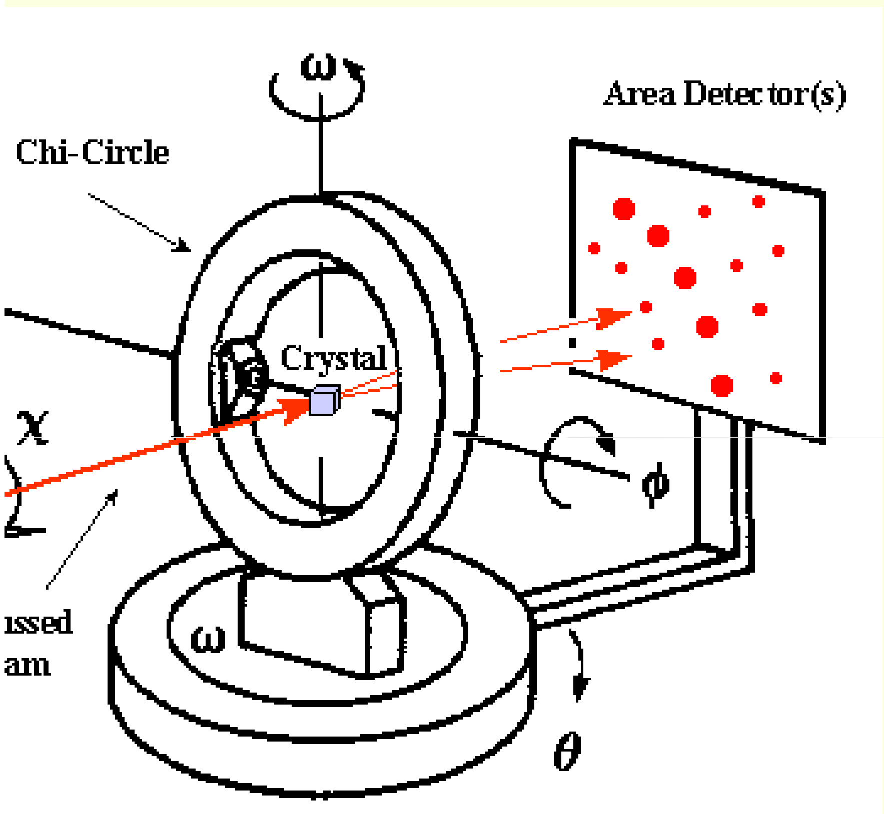
Consejo Rector (21/12/09):

Aprobar la construcción de las líneas experimentales de "micro espectroscopía de infrarrojo" y de "foto emisión con resolución angular", a partir del año 2011, de acuerdo con la memoria adjunta al presente acuerdo, sujeto al esquema de financiación que acuerden las administraciones consorciadas y su formalización.

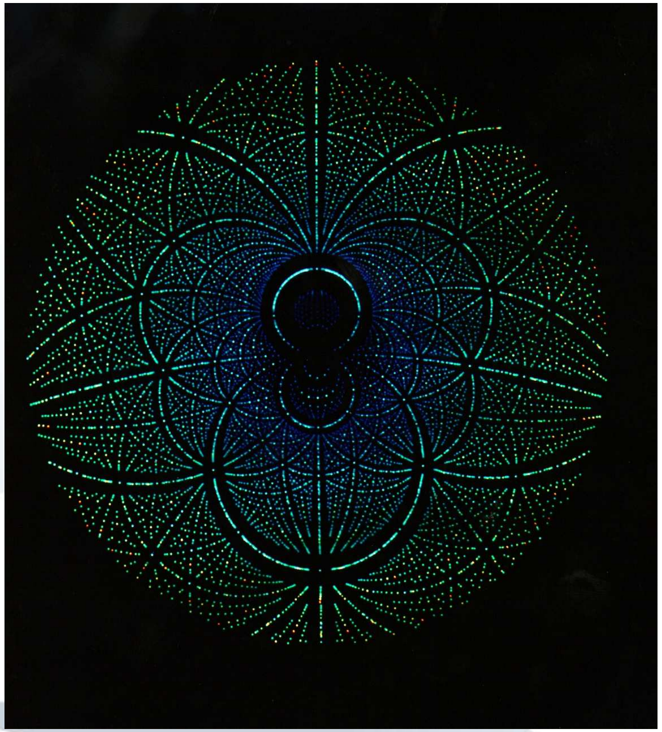
Microfocus Beamline for Macromolecular Crystallography at ALBA

" Evaluar, en el año 2012, la demanda de la comunidad científica en relación a la línea experimental de "micro difracción" . Si dicha evaluación resultara positiva, en el año 2013 podrá iniciarse la construcción de la mencionada línea experimental, de acuerdo con la memoria adjunta al presente acuerdo y sujeta a la existencia de las disponibilidades presupuestarias pertinentes.

XALOC: macromolecular crystallography



Difractometer



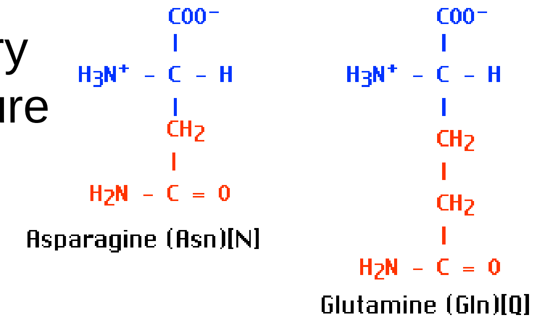
Diffraction pattern

XALOC: macromolecular crystallography

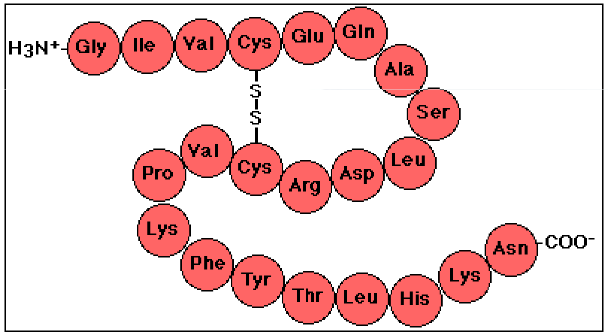
Protein structure

Solved in a synchrotron

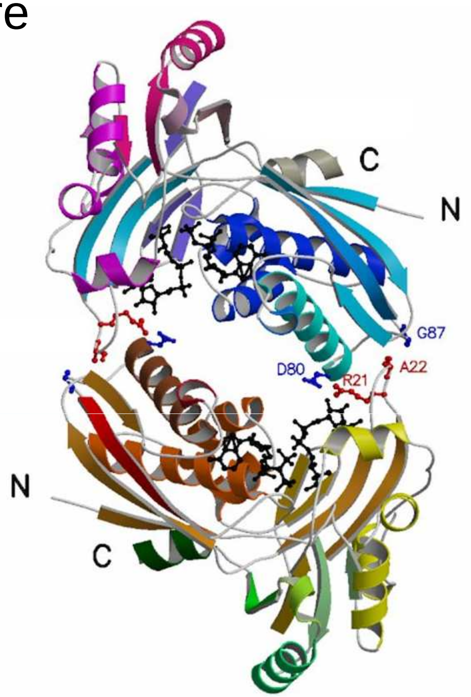
Primary structure



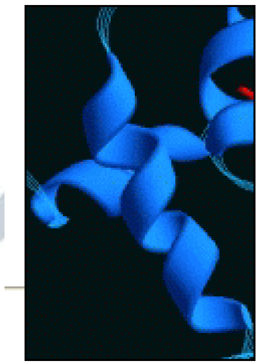
Secondary structure



Quaternary structure

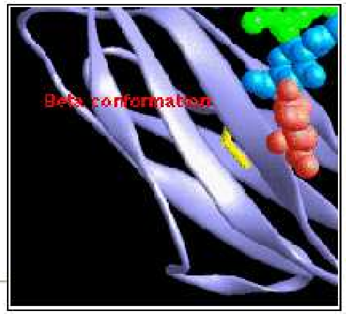


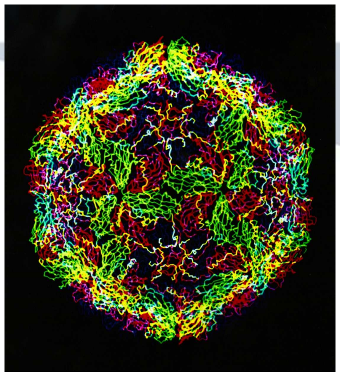
Tertiary structure



α helix

β sheets





- Virus capsids can be solved
- **Function and form are often related**

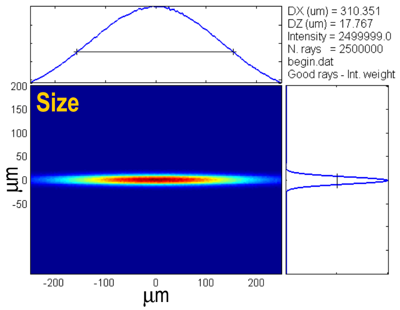
XALOC: macromolecular crystallography

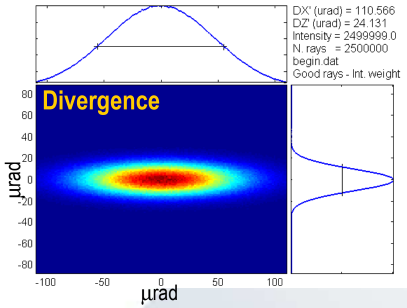
Source: In-vacuum undulator

Photon source size (H×V, FWHM):	309 × 18	μm^2
Photon source divergence (H×V,FWHM):	0.11 × 0.03–0.02	μrad^2

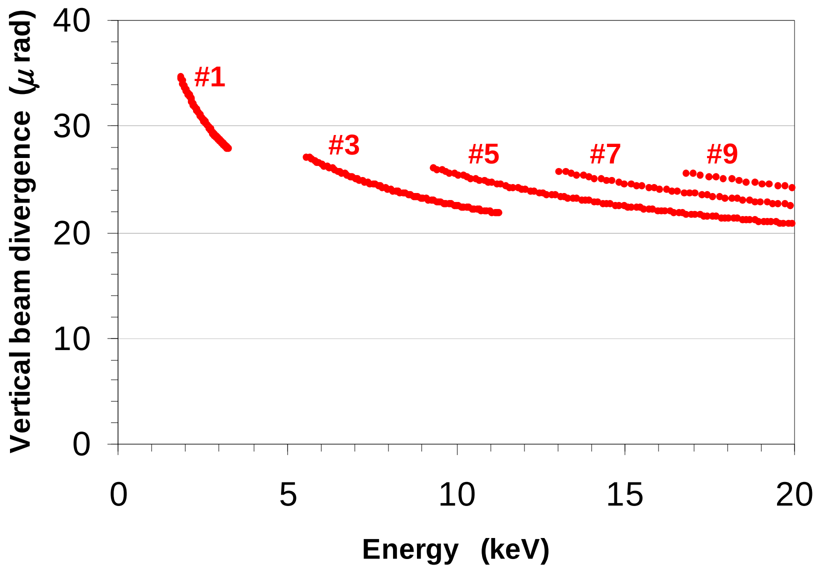
Source dimensions are basically constant in 5-15 keV range.

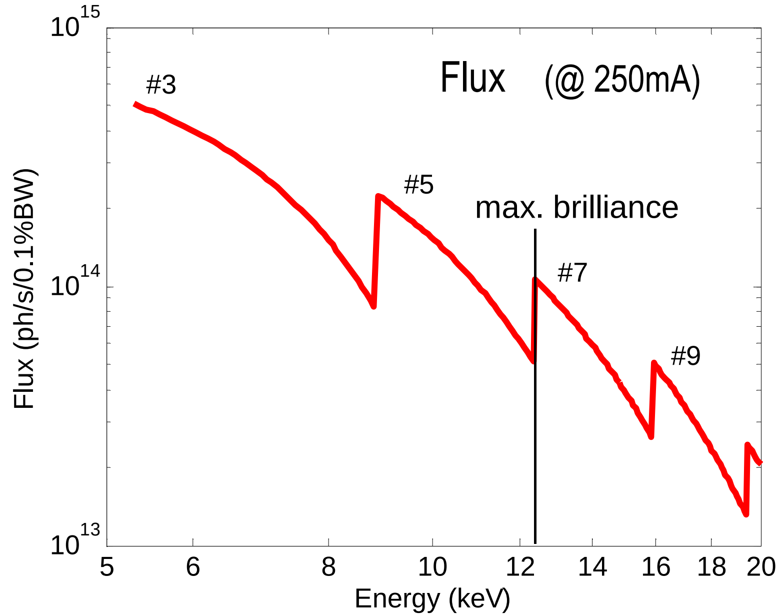
Only the vertical divergence changes due to the electron energy spread





Flux > 10^{12} ph/s in 100 x 100 μm^2 for all hv range



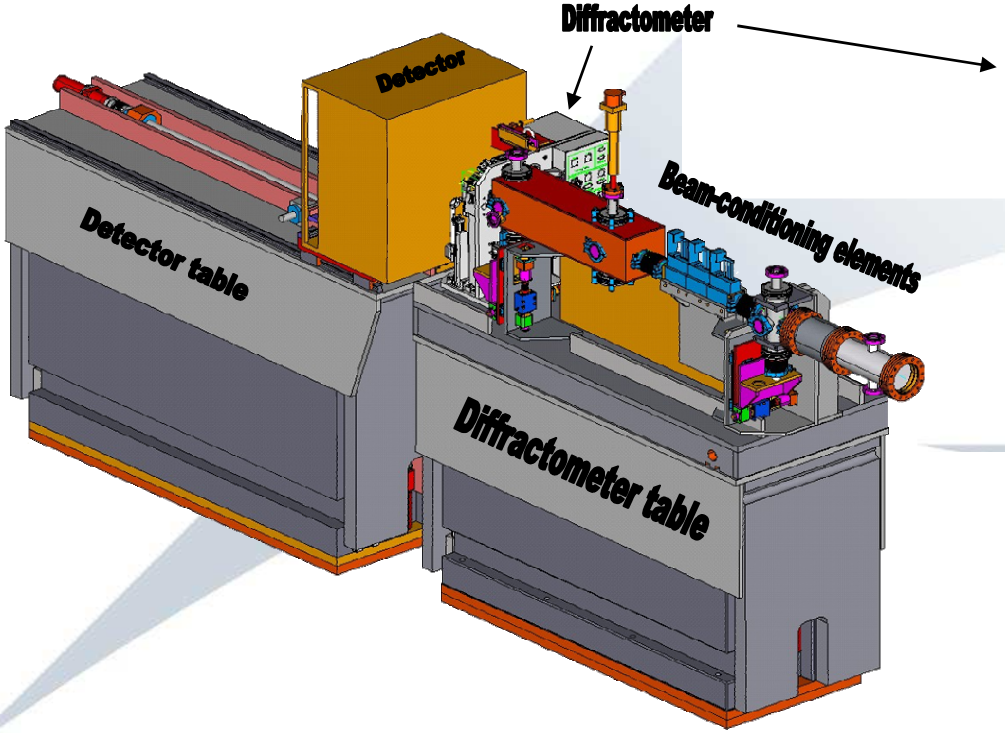


XALOC: macromolecular crystallography

The in-house translation rotation tables that support the diffractometer and the detector can be adjusted in XYZ with 1μm resolution

An automatic sample changer will sit in an adjacent table

End Station

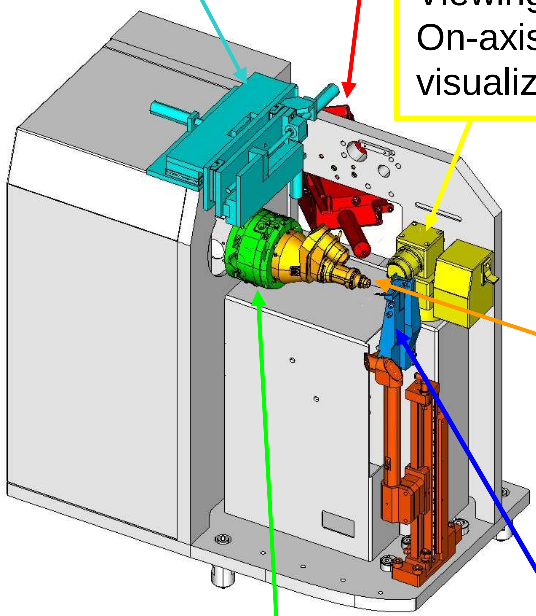


Diffractometer

XYZ movable beamstop (in house project)

Fluorescence detector (for MAD SAD)

Viewing system On-axis clear sample visualization

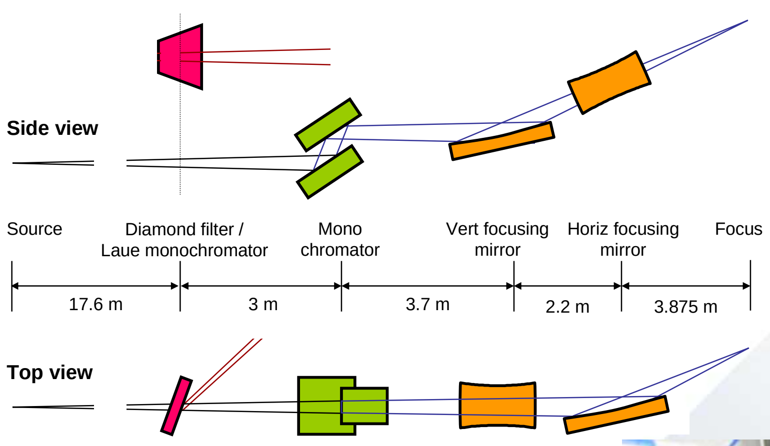


Removable mini-kappa

Collimator and beam size defining aperture (to remove scattering)

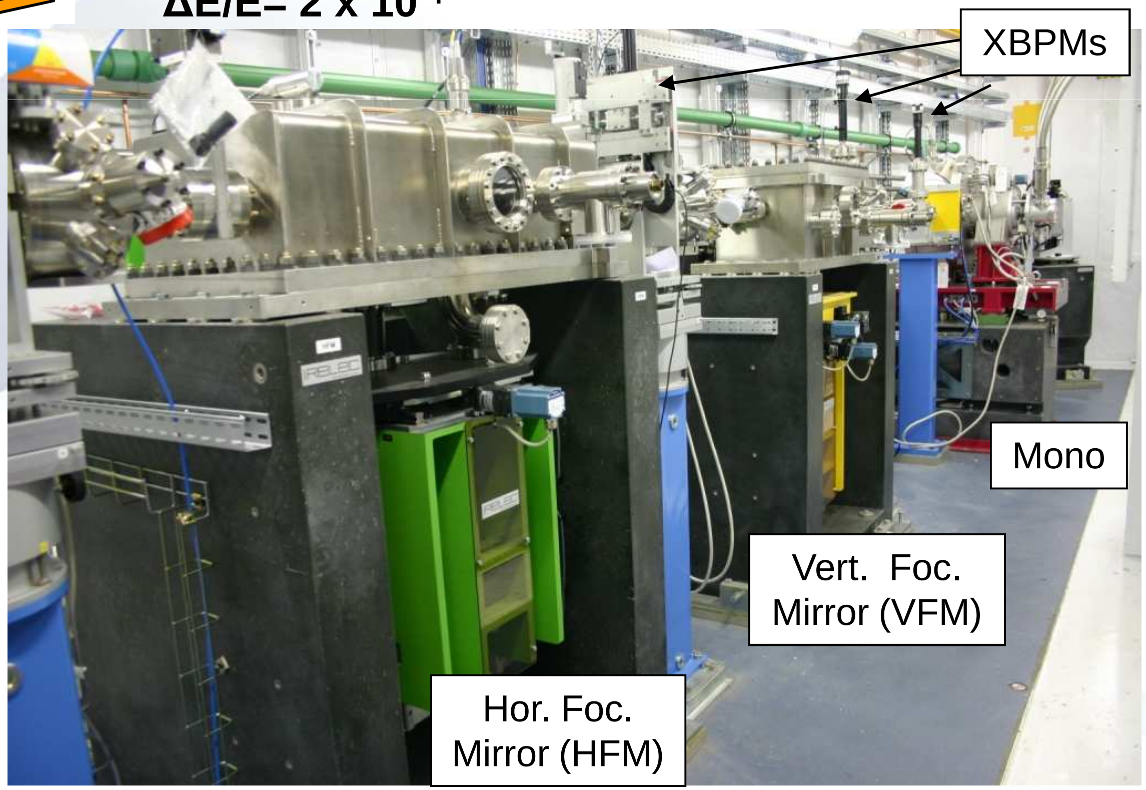
ω axis. Accuracy ±0.7 mdeg

XALOC: macromolecular crystallography



Optics: Layout

- **A diamond vacuum window will remove most of the power, and separate FE and BL vacuum sectors.**
- **The diamond filter can be used to extract a diffracted beam.**
- **The beam size can be varied between 50x10 μm^2 and 500x500 μm^2 to adapt to crystal size.**
- **Full wavelength tunability and high resolution: $\Delta E/E = 2 \times 10^{-4}$**



Status of XALOC on September 2010

- Optics almost all completed
- End-station under installation
- Commissioning with beam just after installing undulator

Status of XALOC on September 2010

Procurement

in-house

commercial

mixed

Diffractometer
Status: **To be integrated**

Beam condit. el’s
Status: **Designing**

Diffractometer table
Status: **Motor tests**

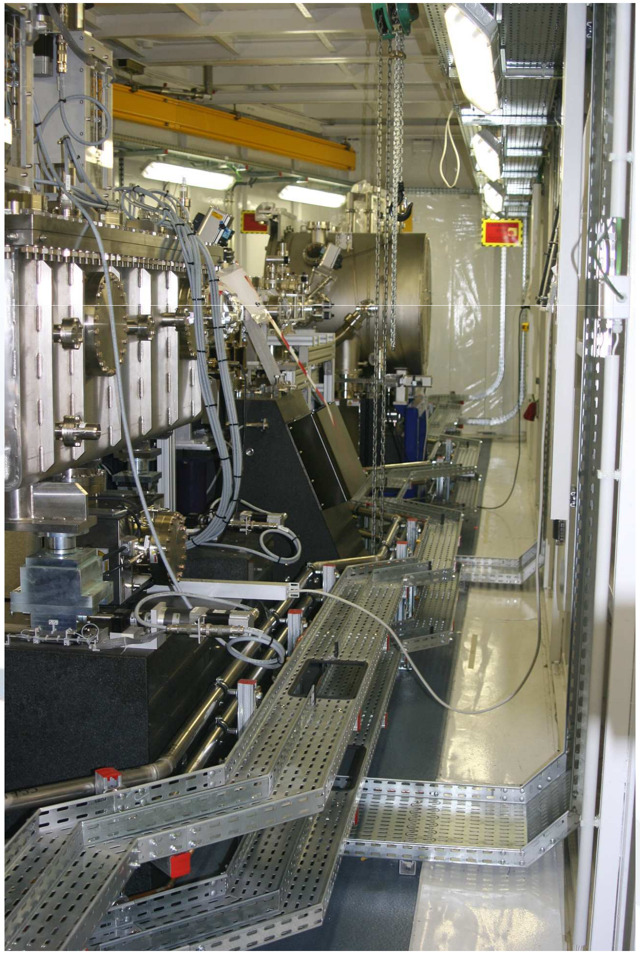
Detector table
Status: **Design finished**

Detector
Status: **Awarded**

Sample changer
Status: **To be commiss.**

NCD: non-crystalline diffraction

Optical hutch



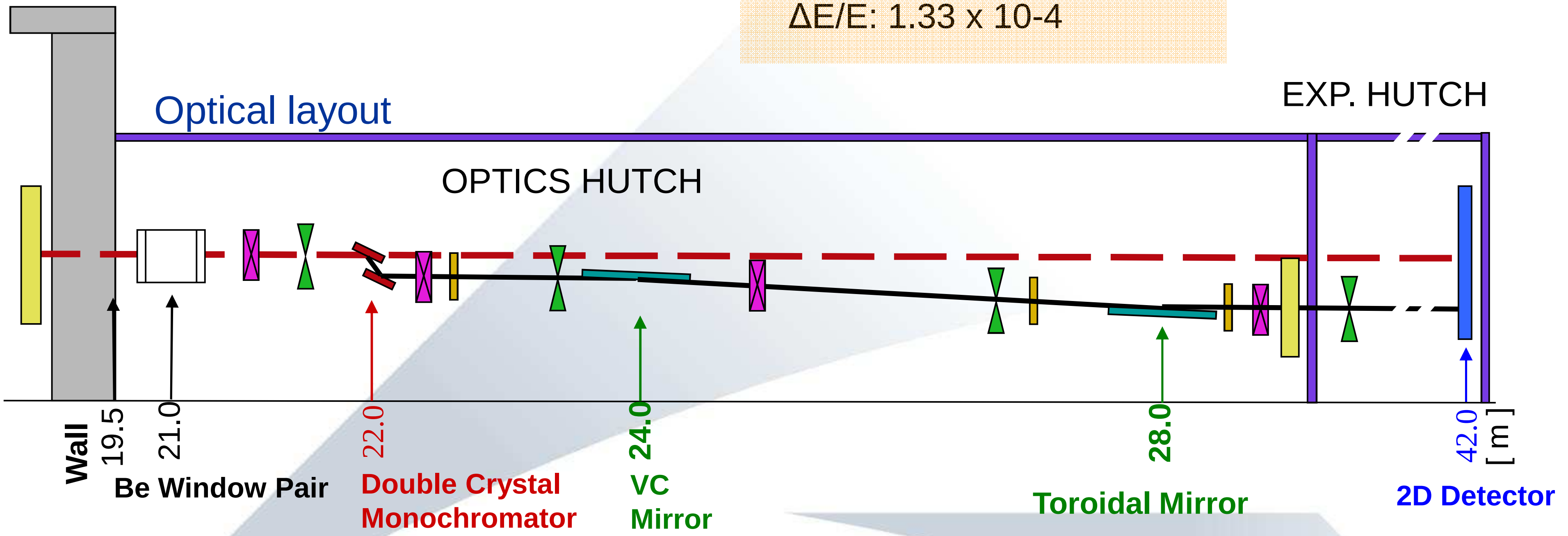
NCD: non-crystalline diffraction

Time Resolved Small Angle X-ray Scattering

For solutions, polymers and biological polymers or fibers (d spacing ~ 1000 nm)

Source: In-Vacuum Undulator

Flux ~ 5 x 1011 ph /s
Energy Range: 6 - 13 keV
ΔE/E: 1.33 x 10-4



Photon Shutter
Horizontal/Vertical Slits
2D Position Sensitive X-ray Detector
Vacuum Valve
Beam Diagnostics

Beam Height:
Nominal height: 1400 mm
Beam Vertical Offset ca. 50 mm

NCD: non-crystalline diffraction

COMBINATION OF SMALL ANGLE SCATTERING AND WIDE ANGLE SCATTERING

Polymers: Natural: proteins, nucleic acids, polysaccharides …

Synthetic: nylon, polystyrene, polyethylene

polyethylene → (Poly)crystalline parts: unit cell ~ a few Ǻ

↓

polyethylene → Ordered lamellae: Lamellae thickness ~ 250 Ǻ

For a typical hard X-ray BL photon energy, for example: hv=8.5 keV, i.e., λ=1.5Ǻ

(Poly)crystalline parts: d~1Ǻ → θ~48º

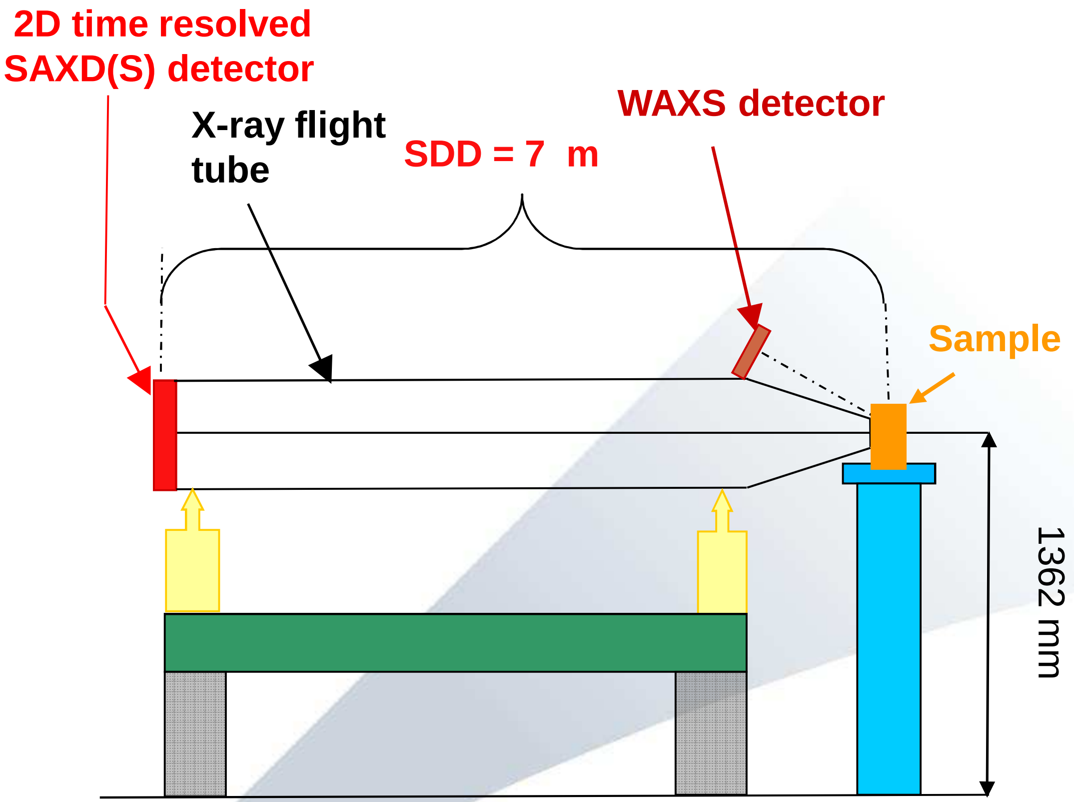
$n\lambda=2d\sin(\theta)$

Semi-ordered lamellae: d ~ 250 Ǻ → θ~0.17º

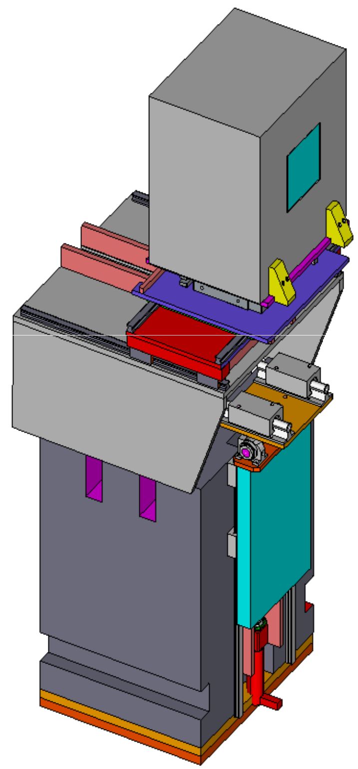
In NCD smaller possible diffraction angle= 5.7 mdeg

NCD: non-crystalline diffraction

EXPERIMENTAL STATION



In house 2D detector mount



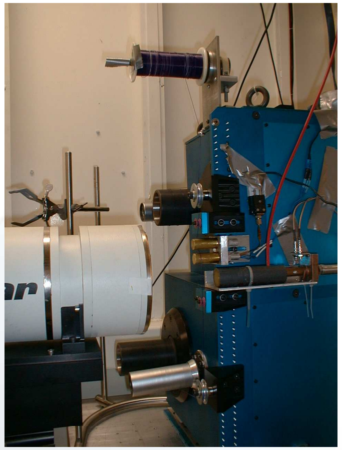
~ 4 orders of magnitude in q=(4π/λ) sinθ are accessible

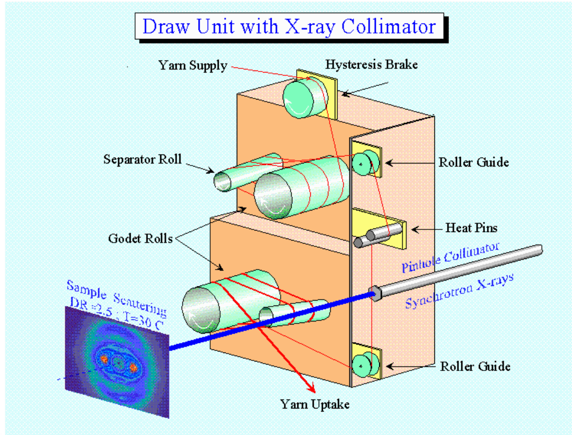
- Variable sample to SAXD distance 0.5-7 m
- Detector frame rate < 1 ms
- Maximum beam size at sample position: 1.8 (H) x 0.36 (V) mm^2

NCD: Polymer research

Synthetic fiber structure

Draw Unit





Spinning Unit

Plunger

Heating barrel

Spinneret

Helium pass

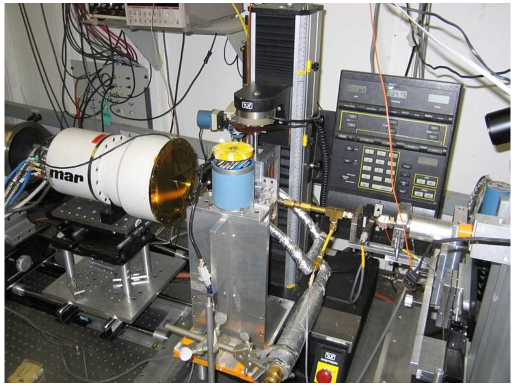
Water bath

Take-up wheel

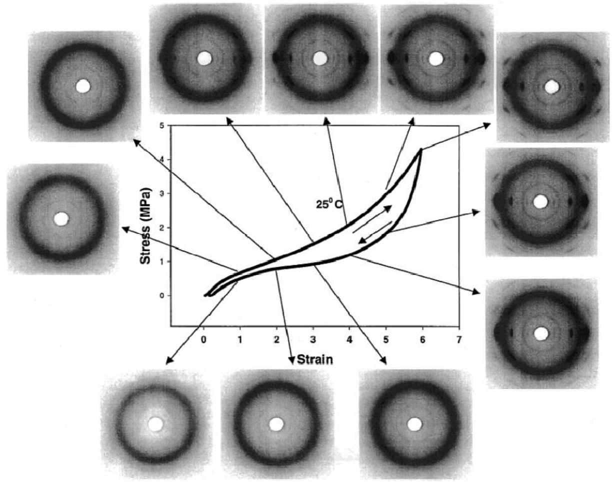
Mar CCD

NCD: Polymer research

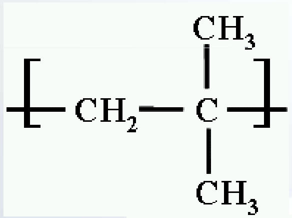
In-situ Tensile testing



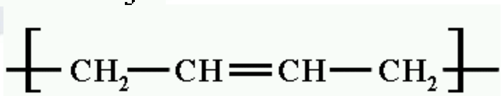
Stress-strain relationshipand in-situ WAXD in case of Natural rubber



Butyl rubber (IIR) poly-isobutylene
1 usually contains up to 3% isoprene

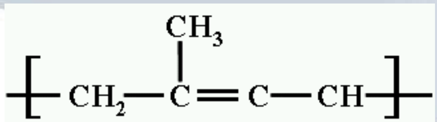


Butadiene rubber (BR) poly-cis-1,4-butadiene



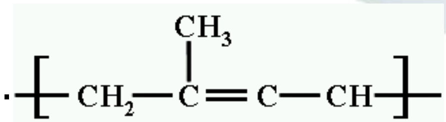
Natural rubber (NR)

poly-cis-1,4-isoprene: 1contains 6% impurities; 2 branched molecules; 3 stereoregular;



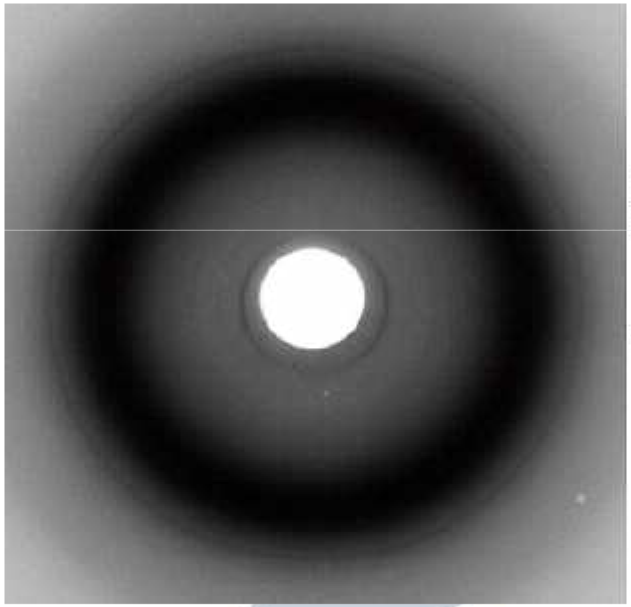
Isoprene rubber (IR)

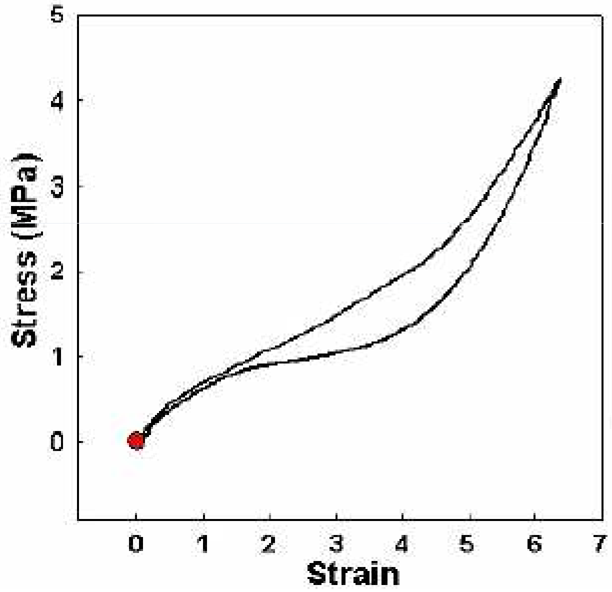
poly-1,4-isoprene: 1mixture of –cis and –trans approx. 98/2; 2. linear molecules

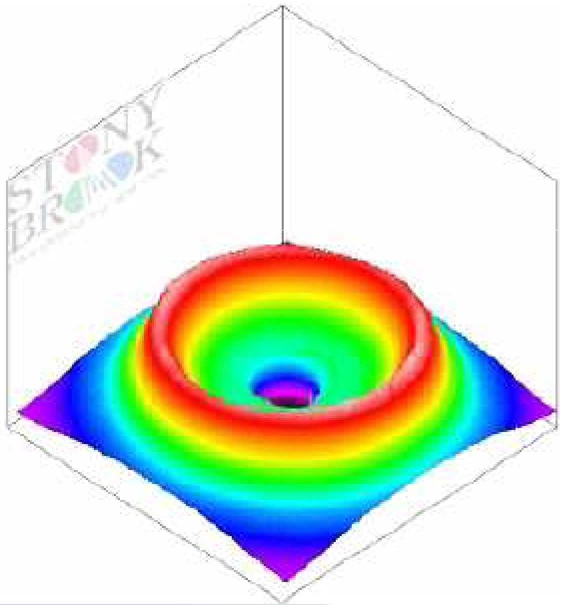


NCD: Polymer research

Stress-strain and in-situ WAXD in Natural Rubber at 25ºC







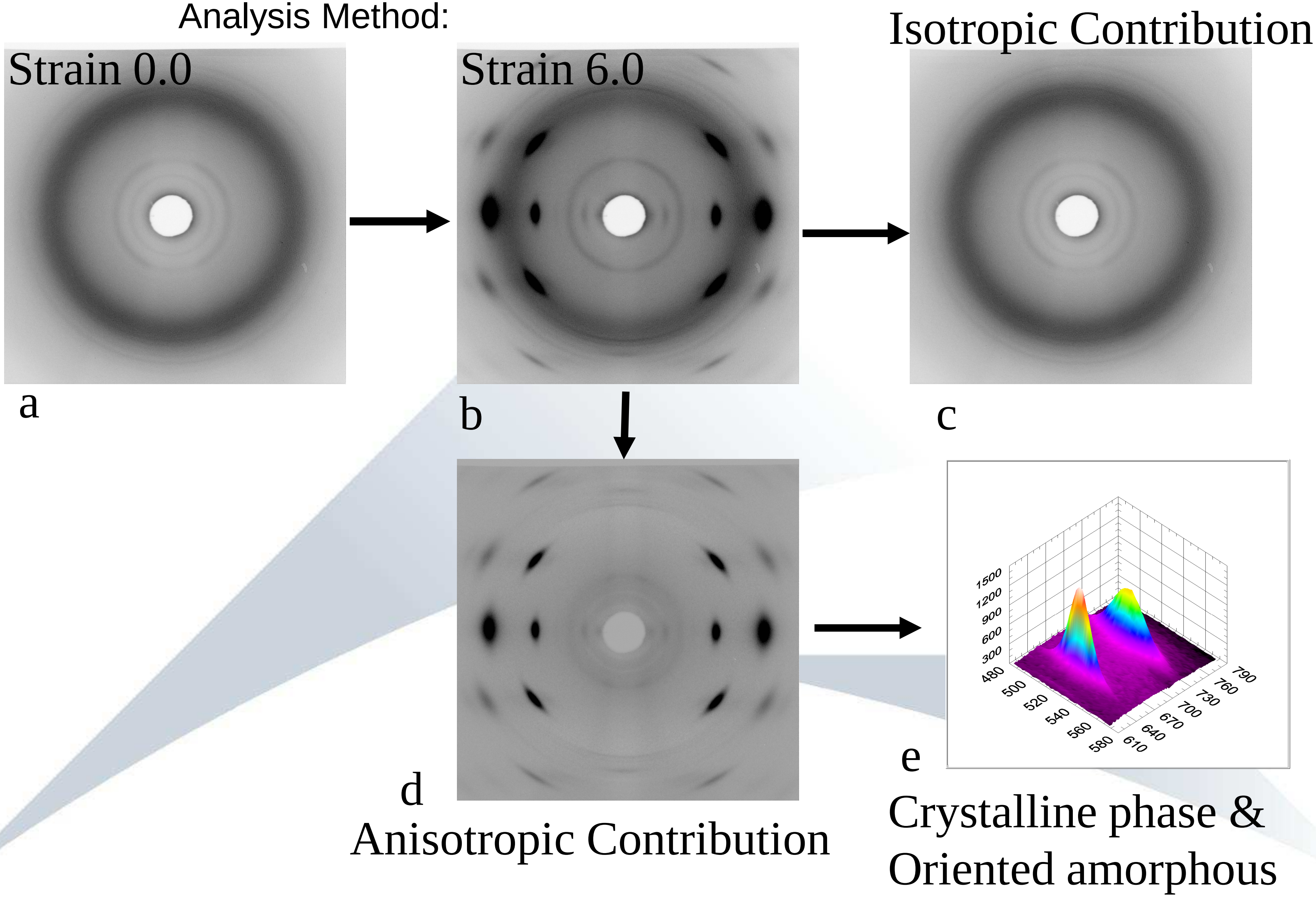
DR

Drawing direction -DR

DR

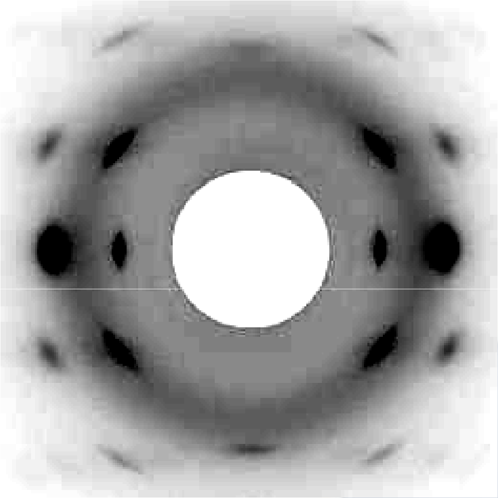
NCD: Polymer research

Analysis Method:

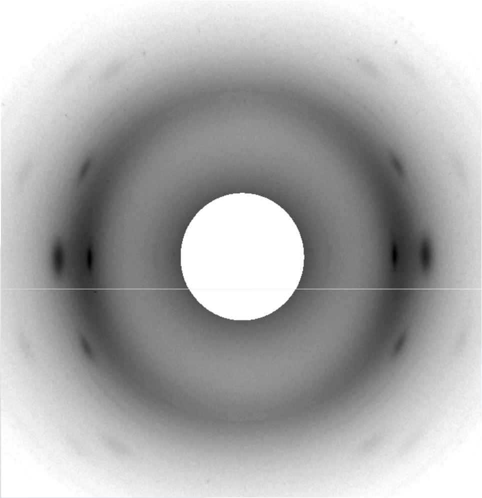


NCD: Polymer research

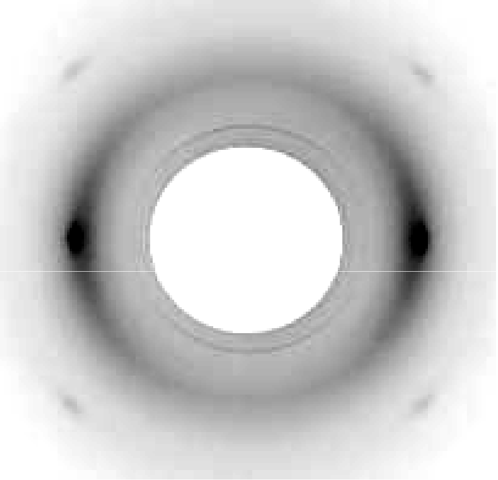
WAXD patterns of different rubbers at
same strain (0ºC)



IR Strain 5.0



BR Strain 5.0



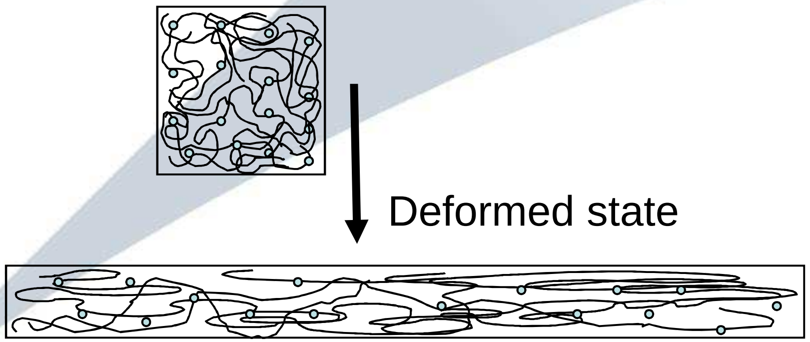
IIR Strain 5.0

NCD: Polymer research

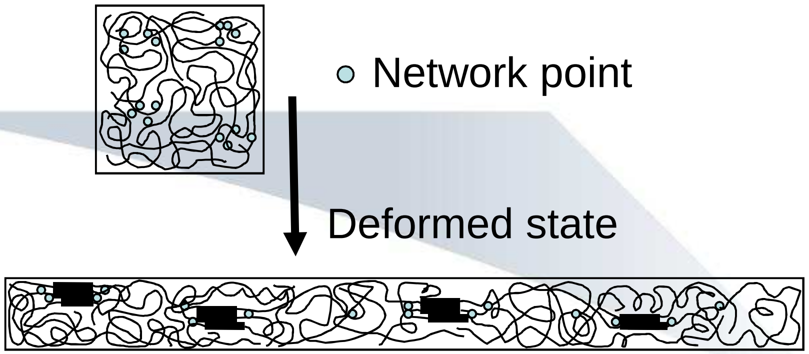
Conclusions

- Majority of rubber molecules at max strain: **un-oriented amorphous state;**
- Oriented amorphous phase is a precursor of strain-induced crystallites;
- Molecular orientation and induced crystallization: polymer crystallizability and network topology: **In-homogeneity of network structure;**
- Oriented amorphous dominates: **IIR**
- Induced crystallization governs: **IR, NR**
- Orientation and crystallization balances: **BR**

Ideal Homogeneous Network

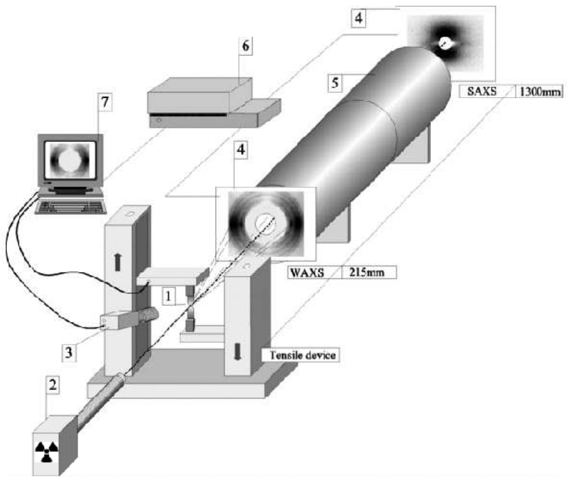


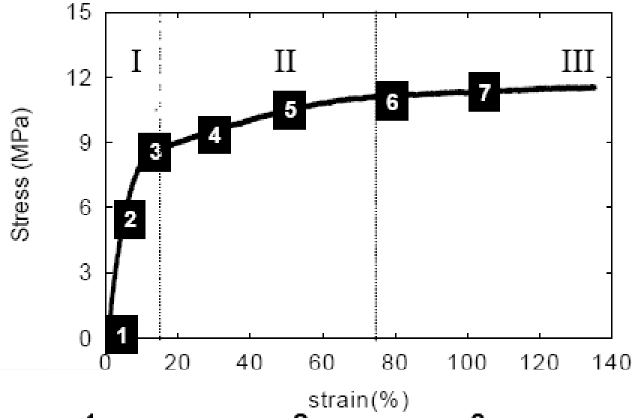
Real Inhomogeneous Network

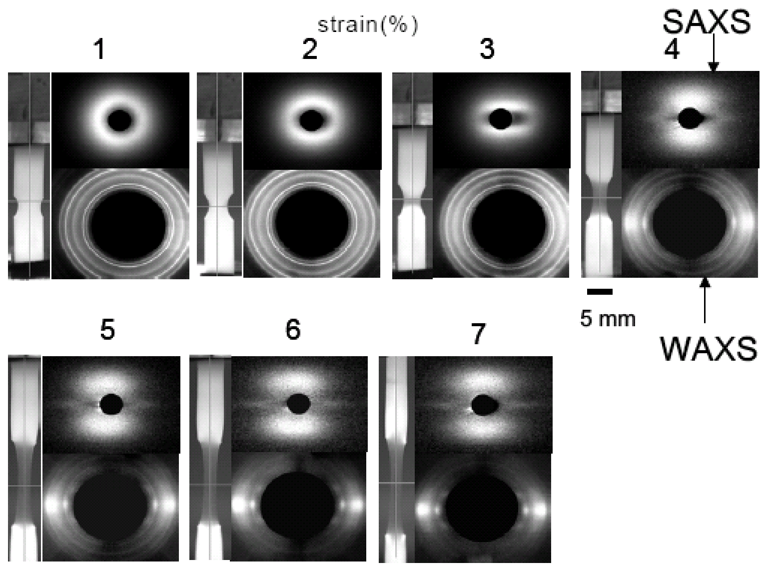


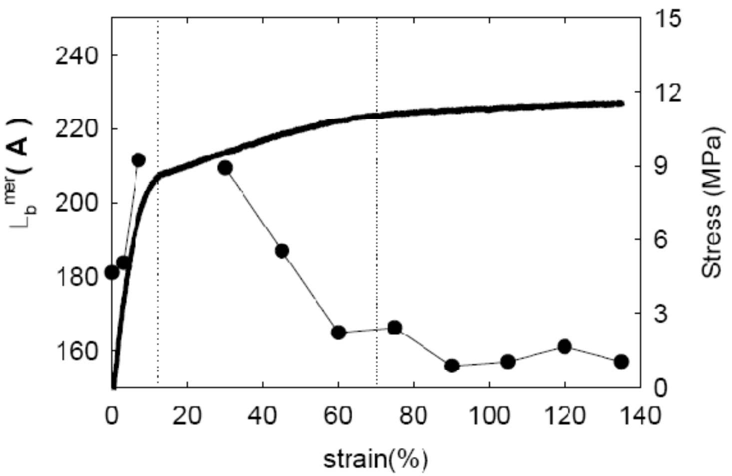
NCD: Polymer research

In-Situ Simultaneous Small- and Wide Angle X-ray Scattering Study of Poly(ether ester) during Cold Drawing





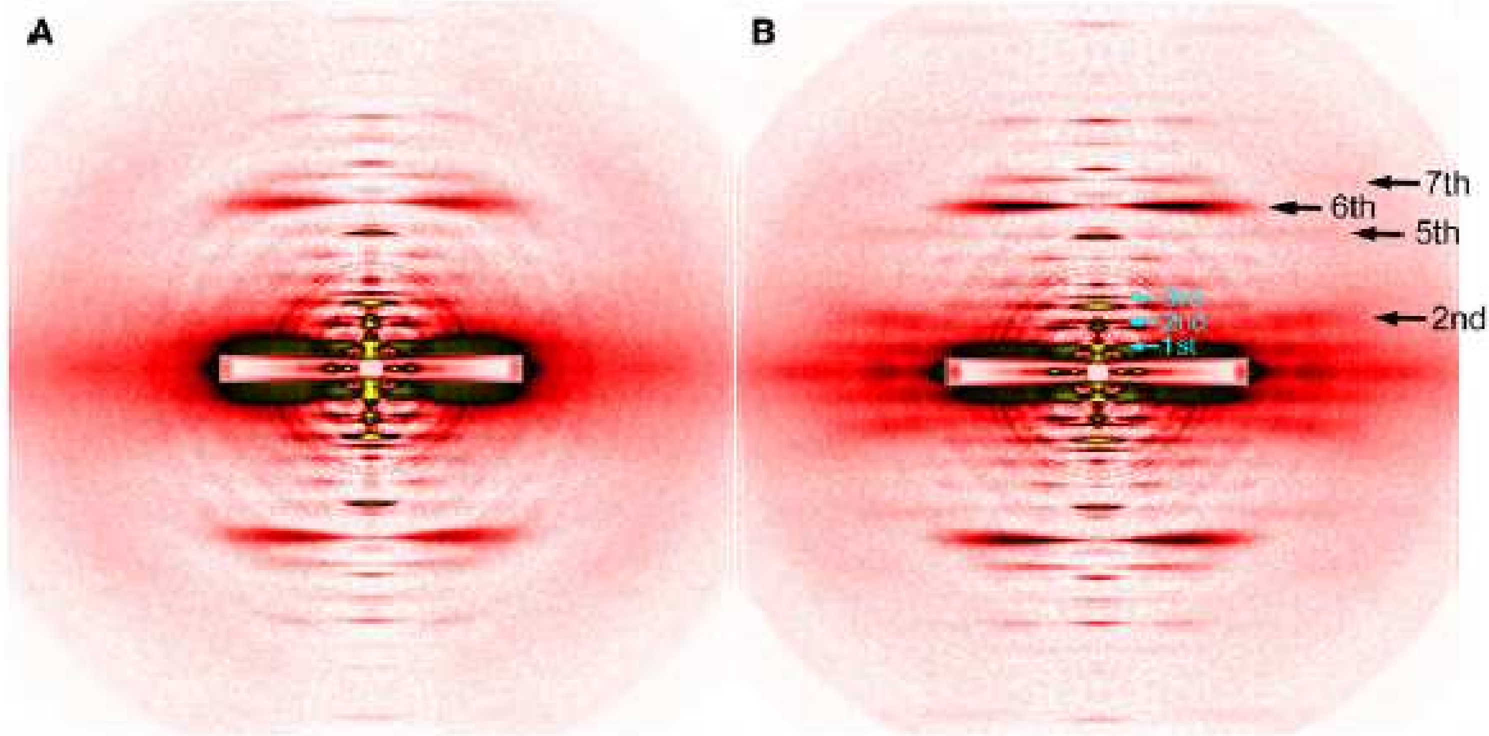




NCD: Bio-related research

DIFFRACTION PATTERN OF RABIT MUSCLE FIBERS

Tamura et al., Biophysical Journal 2009

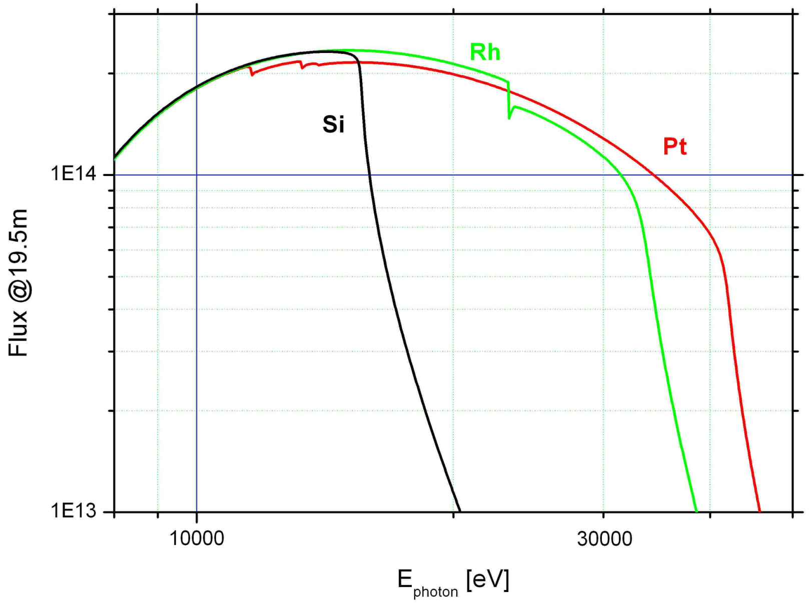


Diffaction patterns from skinned-rabbit psoas fibers. Static diffraction patterns recorded at BL45XU beamline of Spring-8. (A) Pattern in relaxing solution (B) Pattern during isometric contraction recorded from the same fibers as in (A). Black arrows indicate actin layers lines that are enhanced during contraction. Cyan arrows indicate meridional reflection from troponin. Total exposure time 120 s.

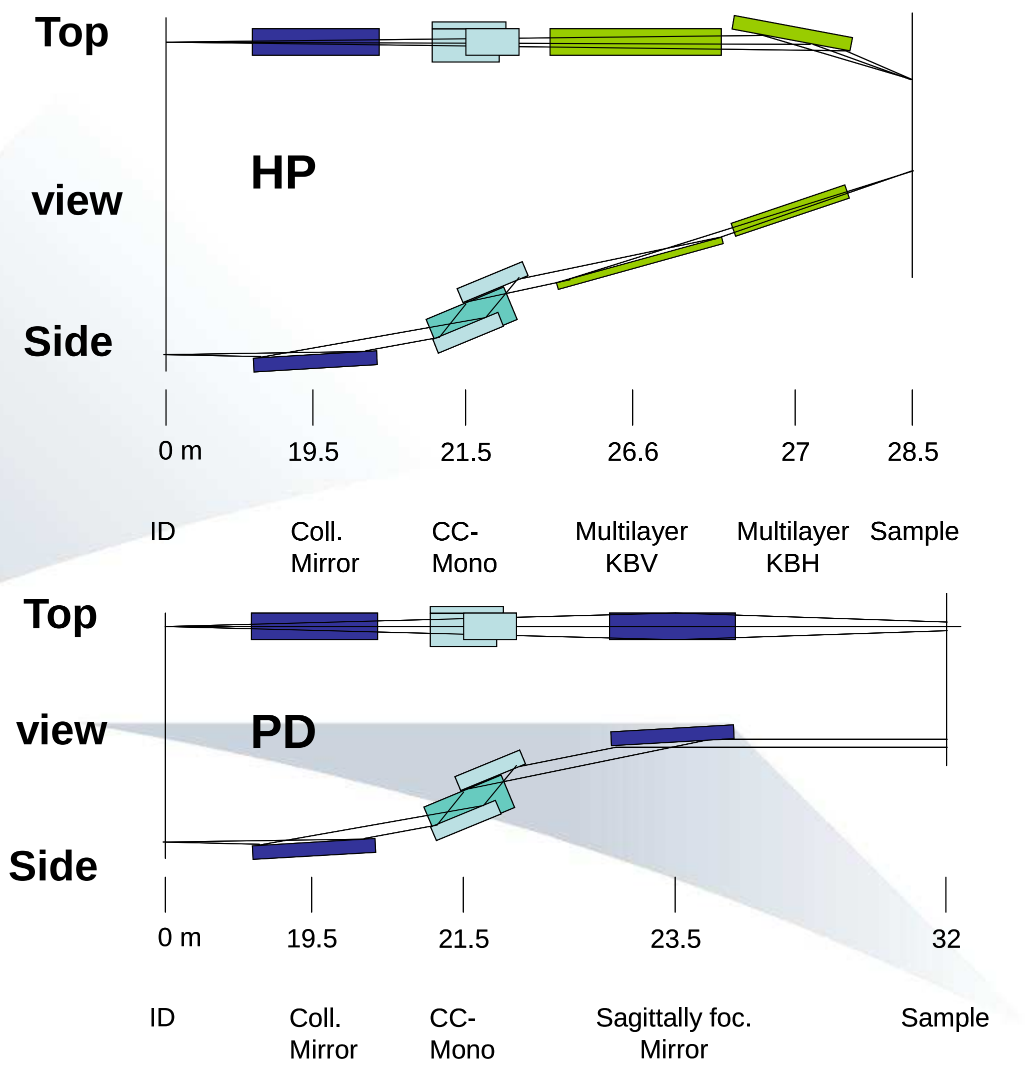
MSPD: high resolution powder diffraction

SOURCE: superconducting Wiggler SCW 30 (Budker Institute of Nuclear Physics)

P_{tot}=19kW   hν=8-50 keV



Optical layout



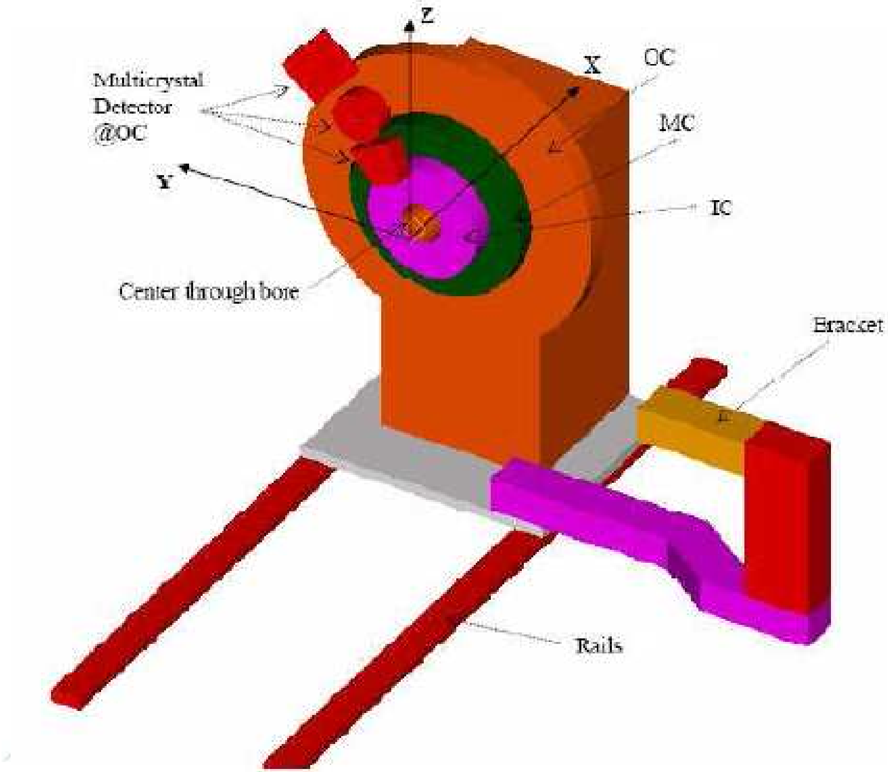
Flux @ 19.5 m, opening 5.85x2.4 mm
Transmitted by collimating mirror
Si, Rh, Pt coating
@ 2mrad glancing angle

HP: KB mirror up to 50keV (optional)
PD: sag. 1:1 focusing mir. (optional)

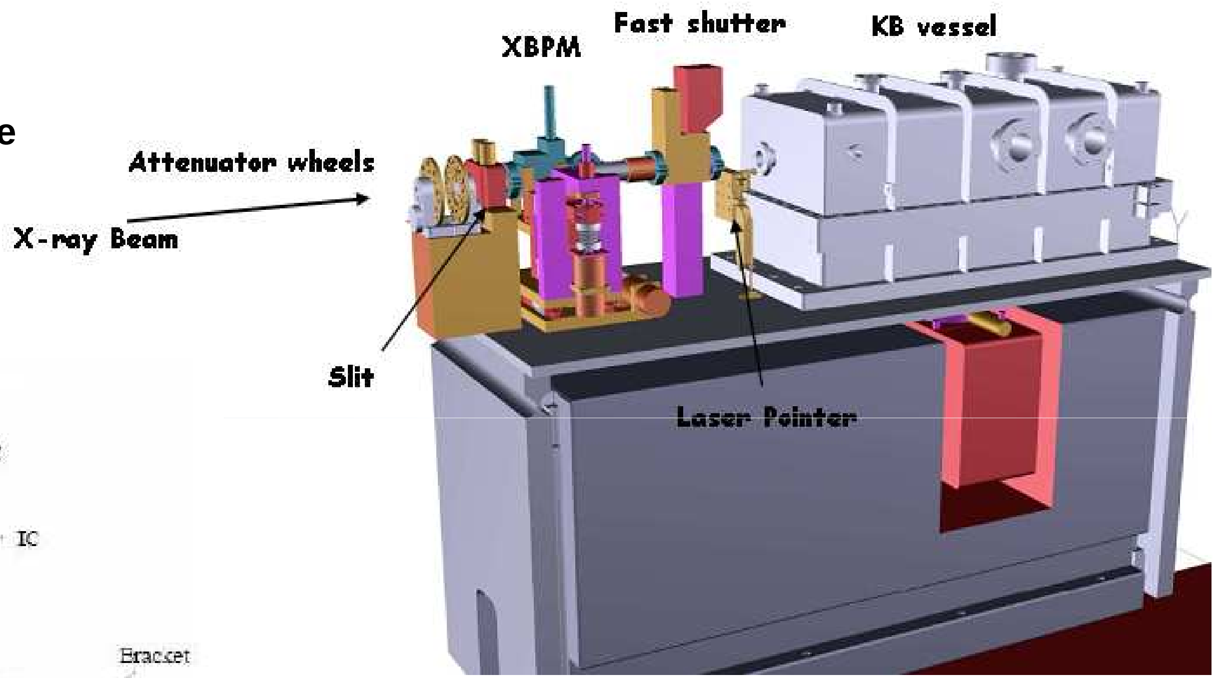
MSPD: high resolution powder diffraction

Powder diffraction endstation

3-circle Diffractometer (Huber)
Angular resolution: 0.0002°
Fast PSD with limited angular range
Eulerian Cradle optional
2nd table for sample environments



High pressure endstation

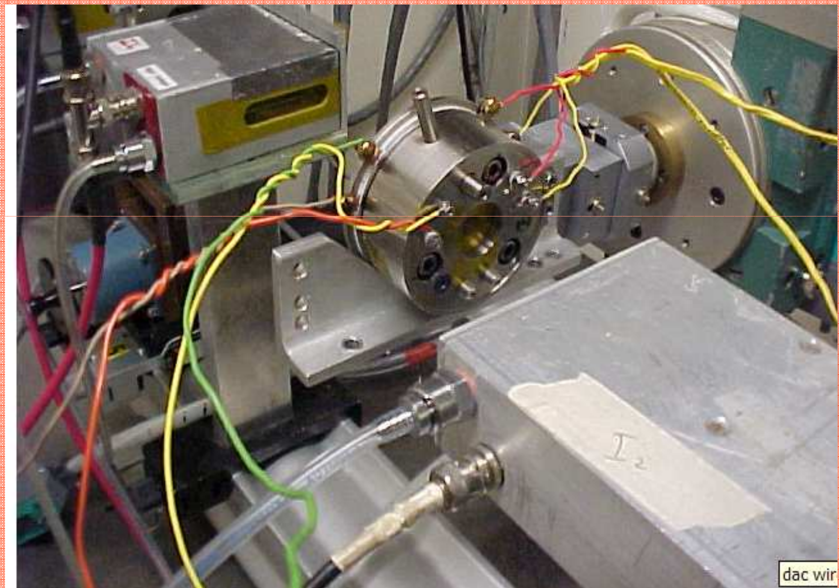


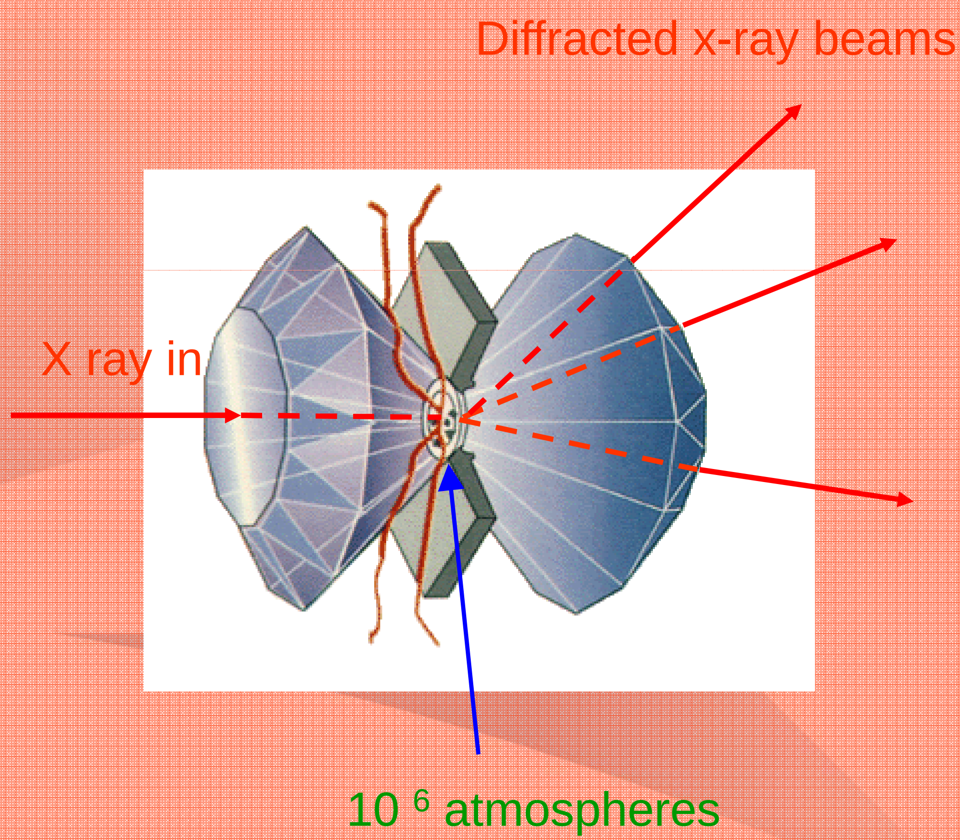
HP Endstation components
Beam conditioning table:
KB-mirror (Irelec), minimum spot size HxV: 15 x 5 µm
Slits, attenuator wheel, XBPM
- **Granite table for sample and detector:**

Positioning stage for Diamond Anvil Cell DAC
Positioning stage for CCD detector

MSPD: high resolution powder diffraction

Diamond Anvil Cells to investigate the structure of crystals at elevated pressures:





MSPD: high resolution powder diffraction

MSPD DETECTORS

Si-strip detector (SLS-Mythen)

I. Peral, J. McKinlay, J. Lidon

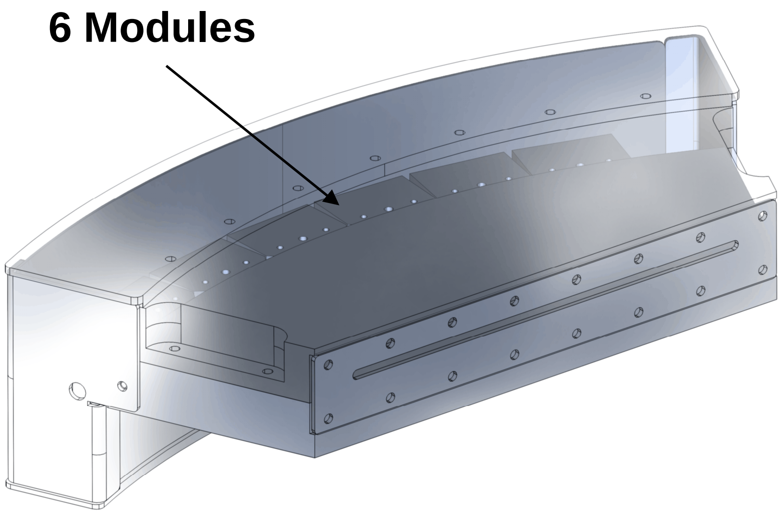
6 Modules

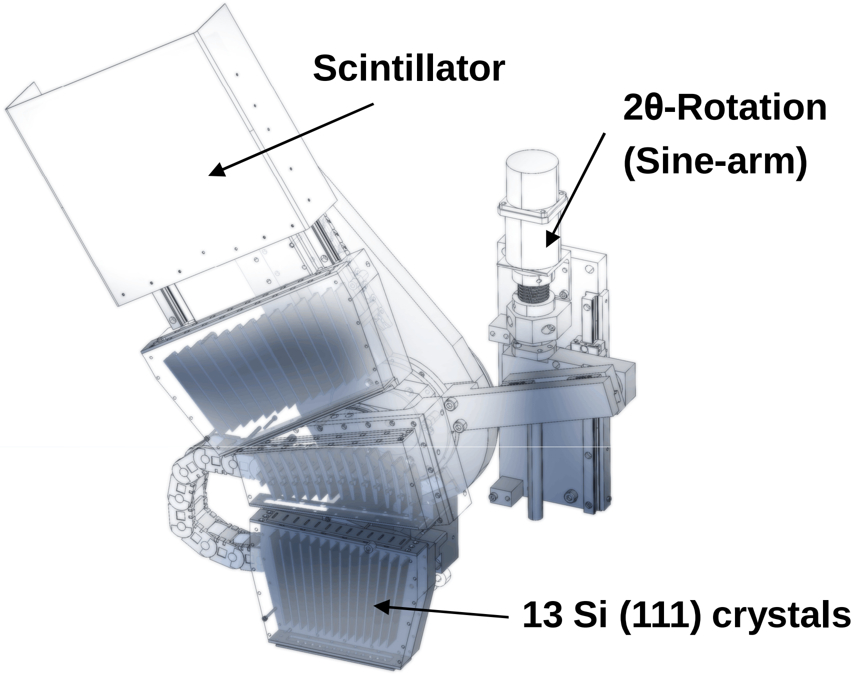
Strip-pitch 50µm

Radius 550mm

Covered Angular Range 40˚

Energy Range 8 - 30keV





Multicrystal detector MAD13. Installed in one of the circles of the diffractometer

In-house development by:

I. Peral, L. Ribo, C. Ruget

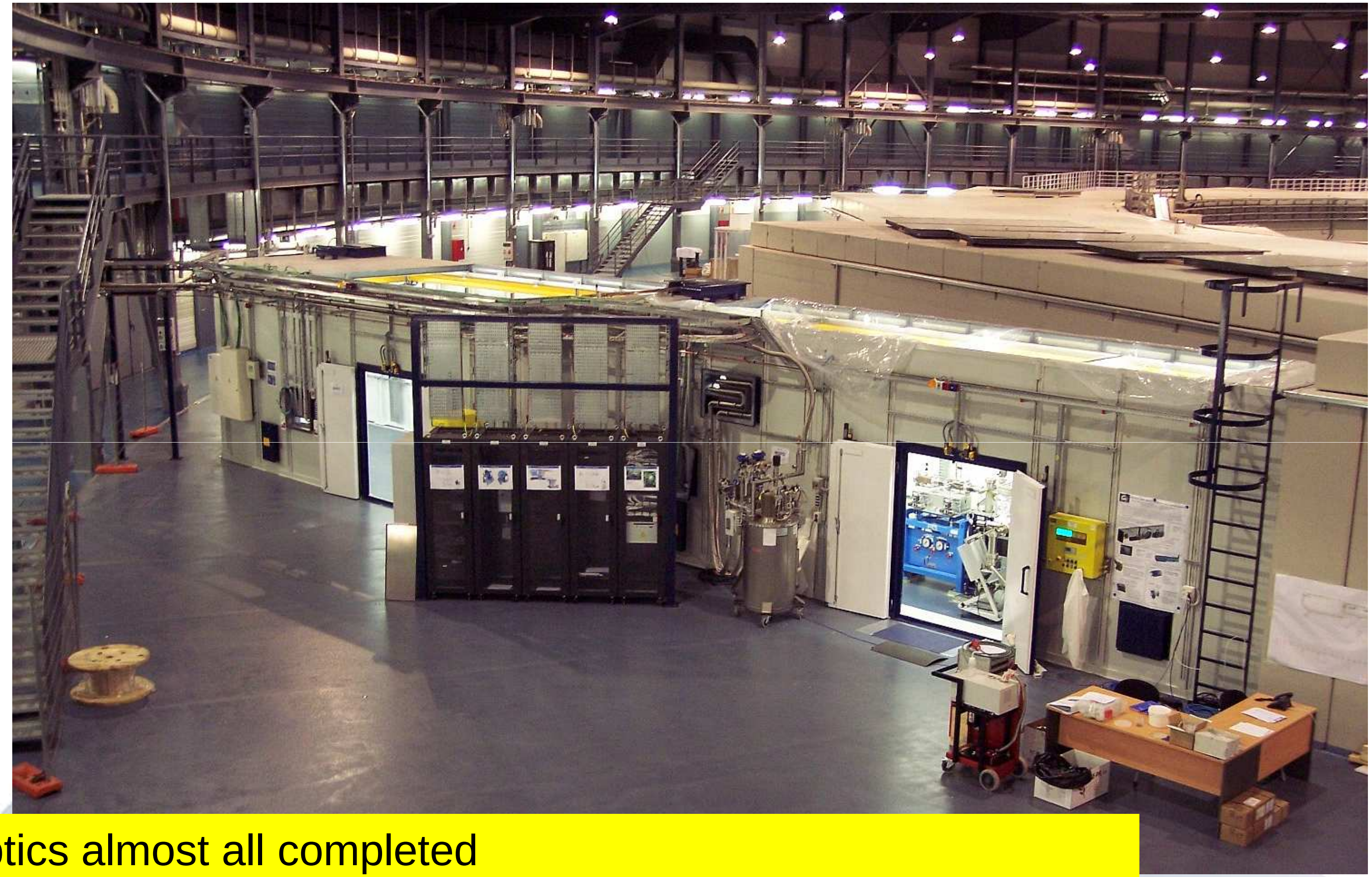
13 Channels

Channel separation 1.5˚

Energy range 8-50keV

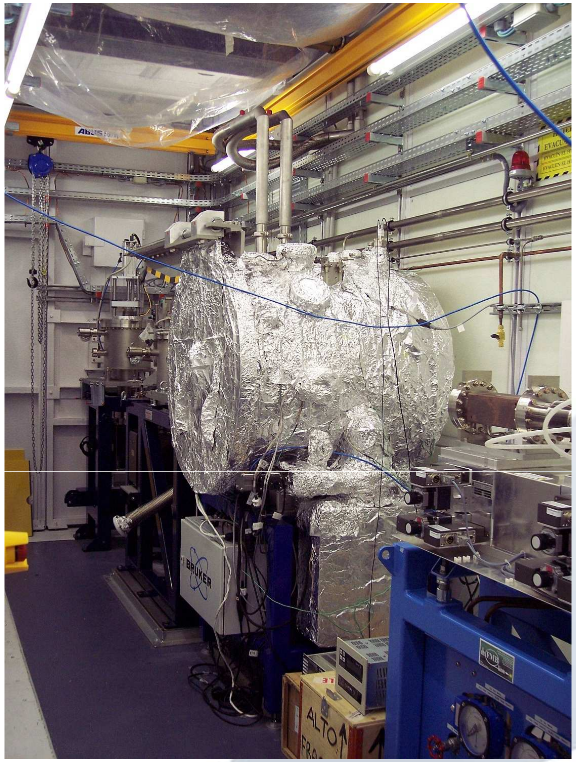
Exchangeable slits

Status of MSPD on September 2010



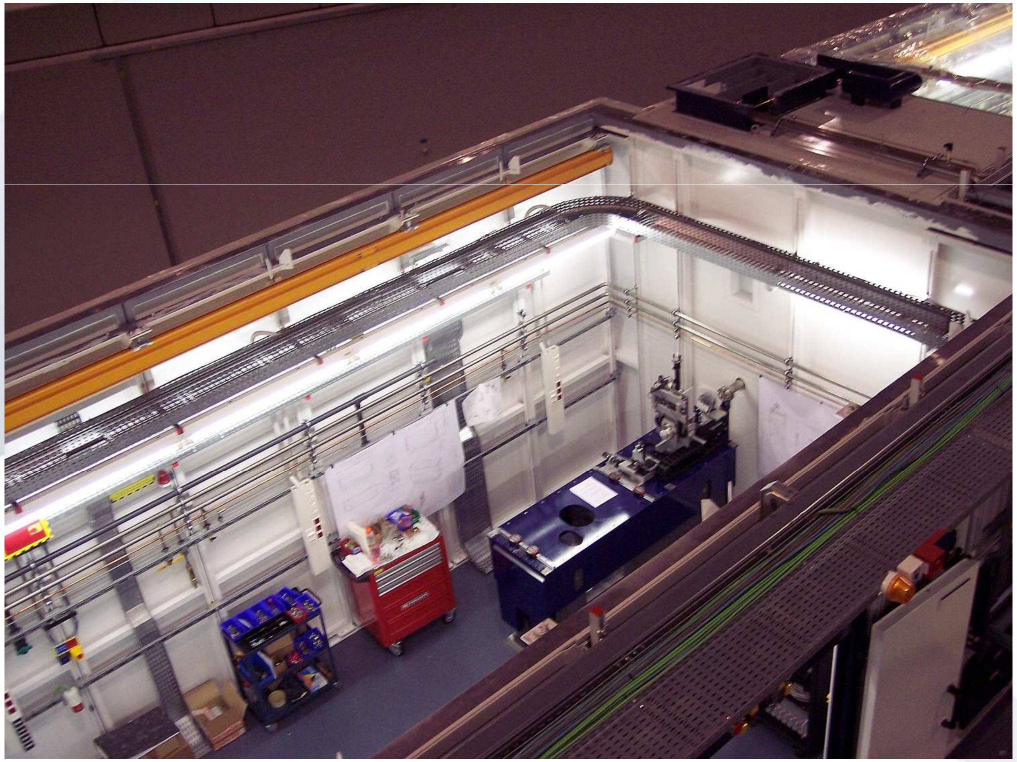
- Optics almost all completed
- End-station under installation
- Commissioning with beam just after installing wigler

Status of MSPD on September 2010

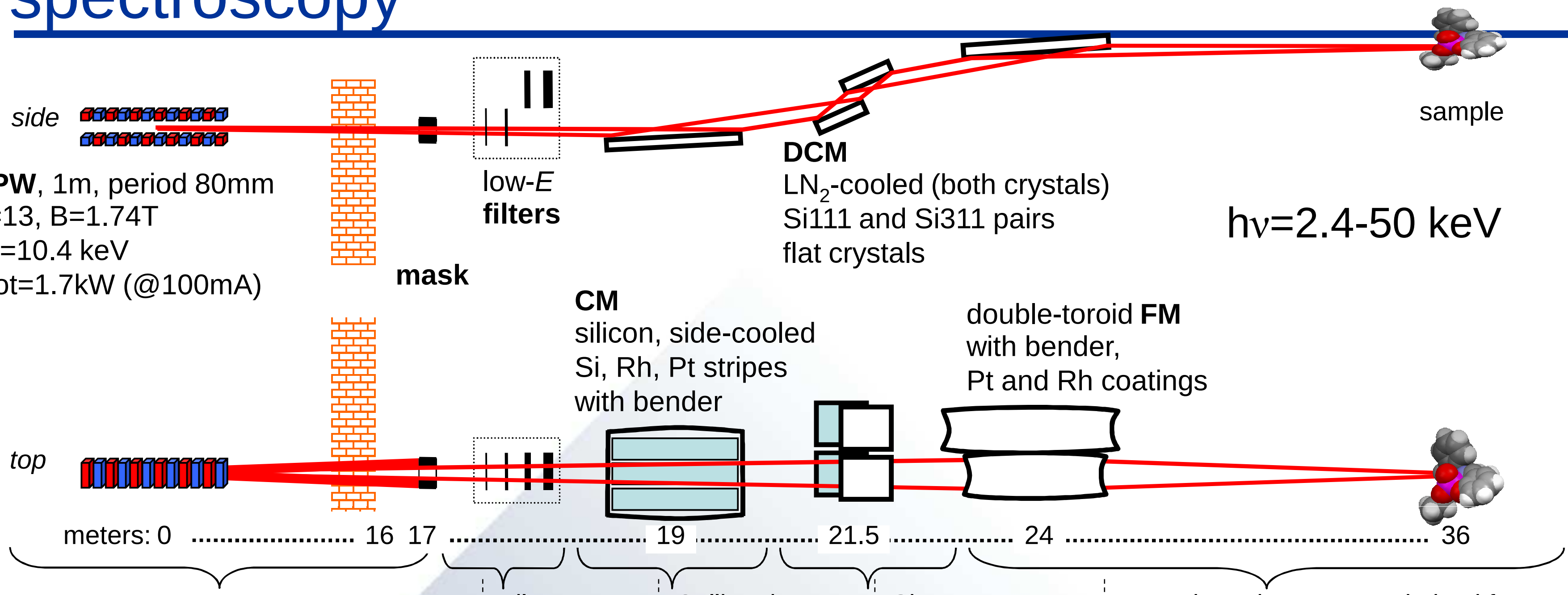


Optical hutch

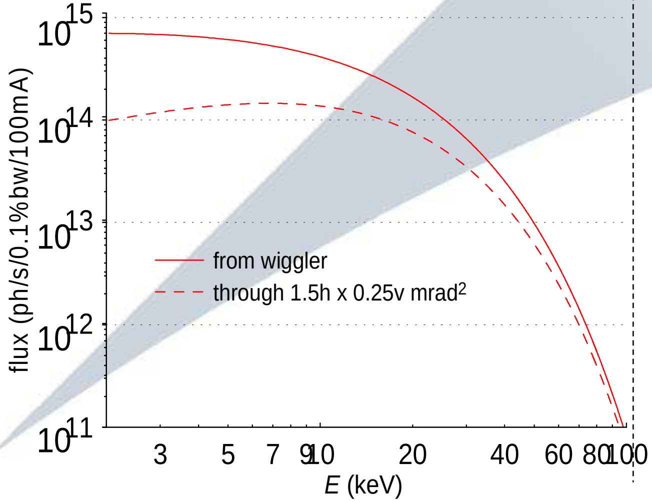
End-station



CLÆSS: X-ray absorption and emission spectroscopy



PHOTON FLUX



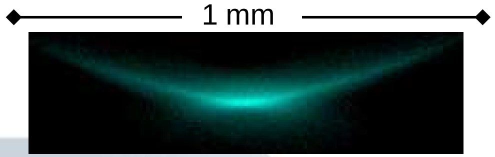
Filters remove low-energy photons: four CVD – diamond plates 70 μm – 3 mm

Collimating mirror removes high-energy photons and makes the beam parallel vertically for best possible energy resolution

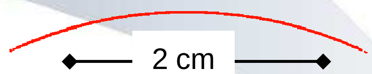
Si111:
2.4 – 15 keV with >$2 \cdot 10^{12}$ ph/s at the sample; $1.3 \cdot 10^{13}$ ph/s @ 9 keV

Si311:
up to 30 keV with $5 \cdot 10^{11}$ ph/s and **up to 50 keV** with $5 \cdot 10^{10}$ ph/s at the sample

Focusing mirrors are optimized for 2.4 – 35 keV: excellent focusing (**200×40 μm² FWHM**)



30 – 50 keV: poor focusing

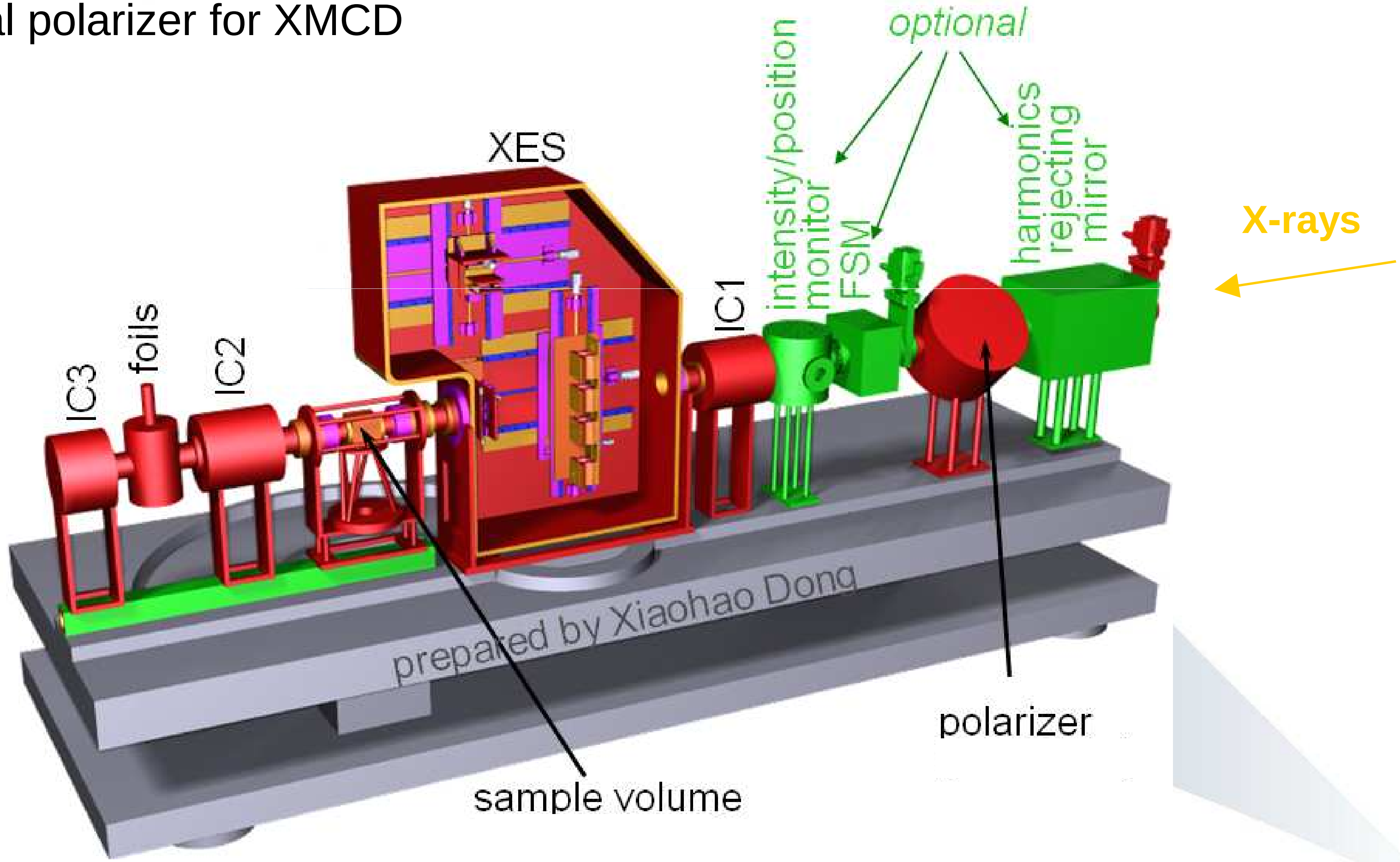


but still a good flux at 50 keV: in the central part (0.8×0.4 mm²) flux~ $2 \cdot 10^{10}$ ph/s at the sample

CLÆSS: X-ray absorption and emission spectroscopy

EXPERIMENTAL STATION

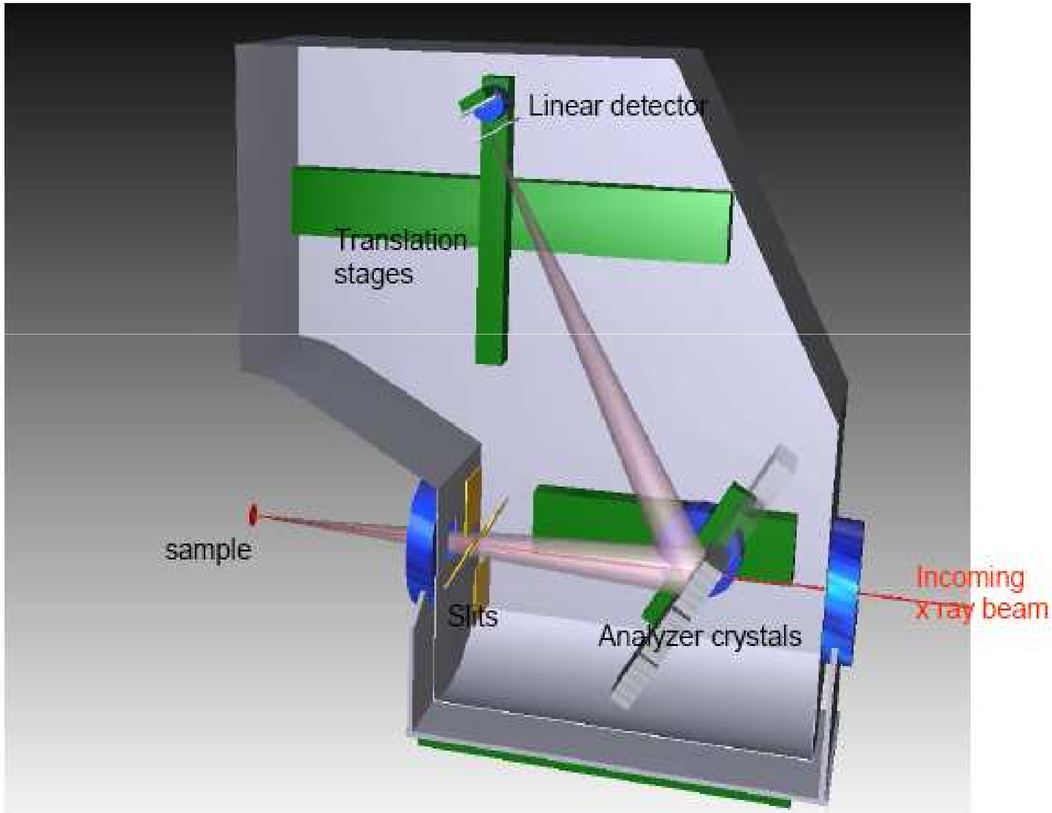
- High pressure cell
- Optional polarizer for XMCD



CLÆSS: X-ray absorption and emission spectroscopy

CORE LEVEL EMISSION ANALYZER AND REFLECTOMETER (CLEAR)

- Compatible with common in-situ cells, cryostats and a magnet, with no side window required
- Static acquisition, no θ-2θ scans
- 3 Johansson-like diced Si crystals with in-situ exchange
- Sagittal crystal bending 1D detector
- For RIXS, reflXAS and polarimetry



The analyzer crystal bending radius and the diffraction geometry define the wavelength impinging to the detector.

CLÆSS: X-ray absorption and emission spectroscopy

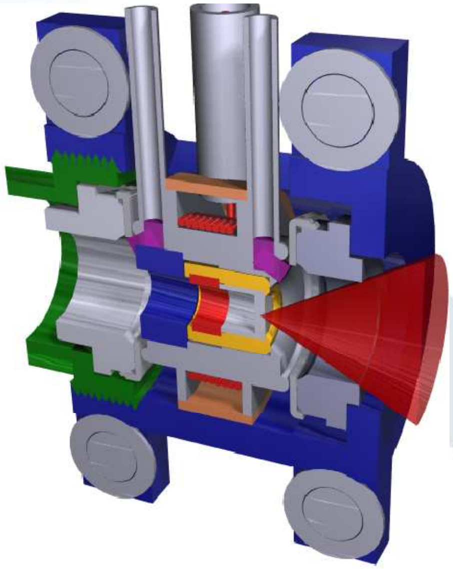
One of the main applications at the beamline will be **in-situ and in-operando studies of catalytic reactions**.

Collaboration with Instituto de Tecnología Química de Valencia (ITQ-CSIC), partially financed by the Spanish “Ministerio de Ciencia e Innovación”.

Scope: chemical reactors, gas handling system, controls and software. This complete set-up will be fully integrated into the beamline control system and **will be available to all beamline users**.

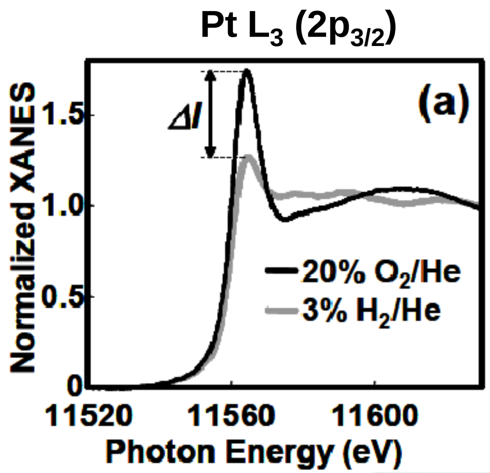
Size ~10 cm. For transmission and fluorescence, also for classical detection at 90º with a common fluorescence detector. High P (only at high E), high T.

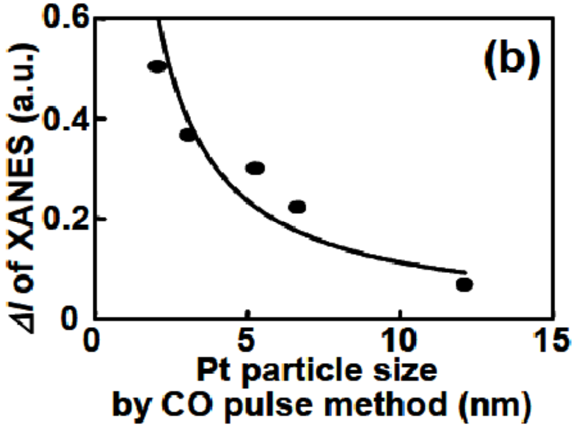
Size ~3 cm. For transmission and fluorescence with CLEAR, at high P, LNT and high T, also at low x-ray energies.

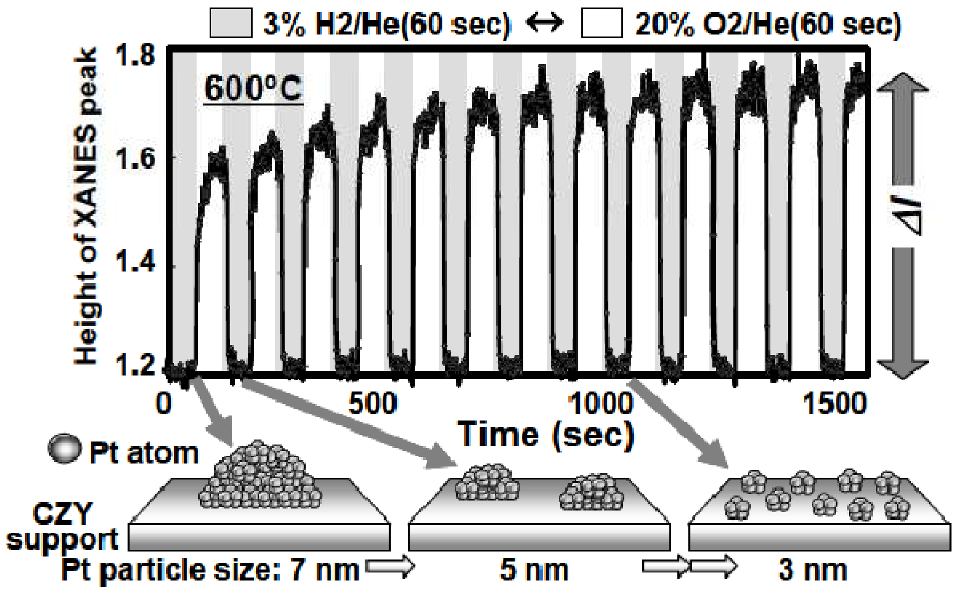


CLÆSS: X-ray absorption and emission spectroscopy

Real-time observation of Pt redispersion on Ce based oxide





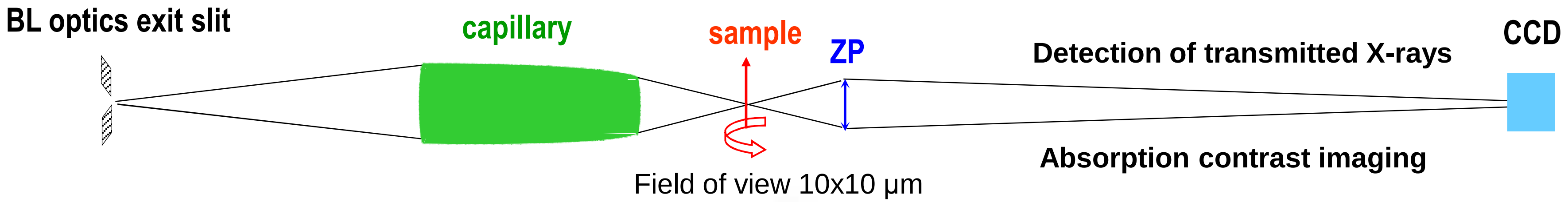


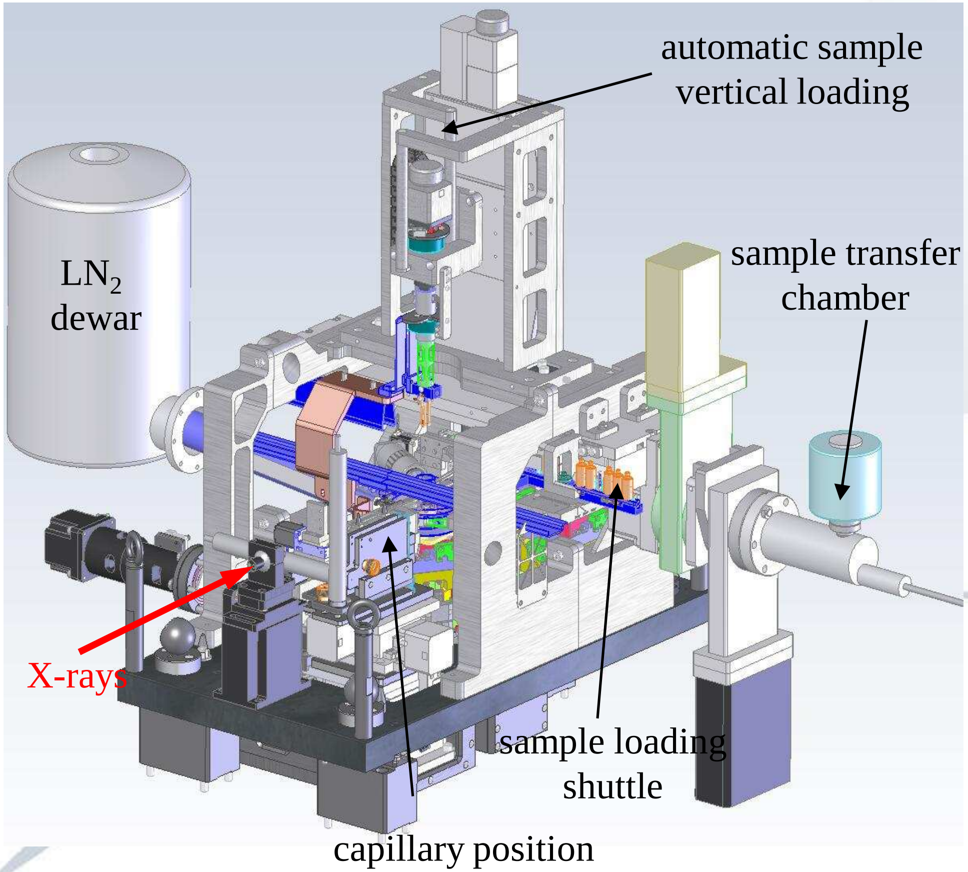
Nagai,.., Guilera et al.
20th NAM

Data from ID24 ESRF

MISTRAL: X-ray microscopy

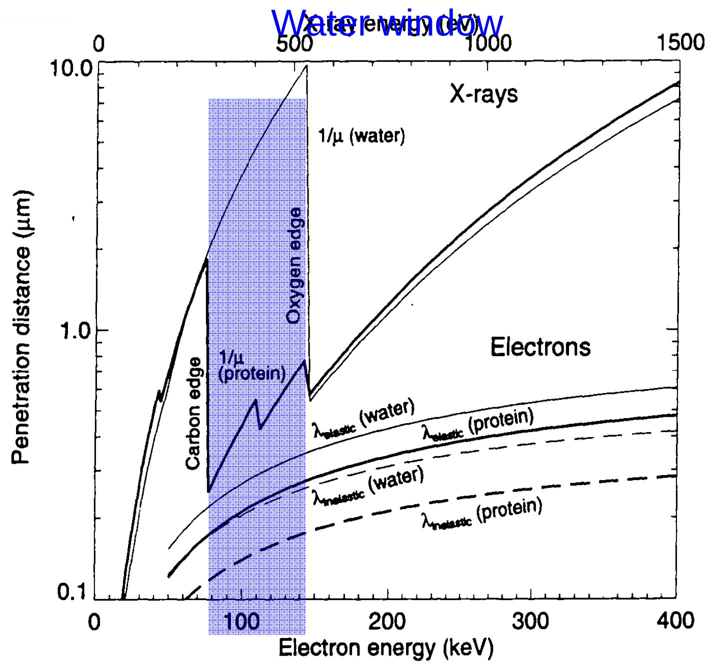
Transmission X-ray microscope





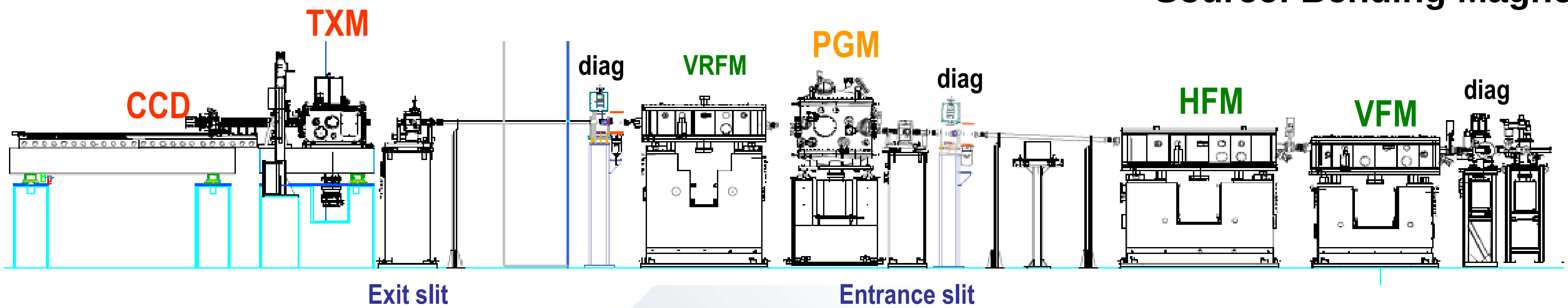
Tomography: 3D imaging, 50 nm resolution

Spectroscopic 2D imaging at X-ray absorption edges, 30 nm resolution

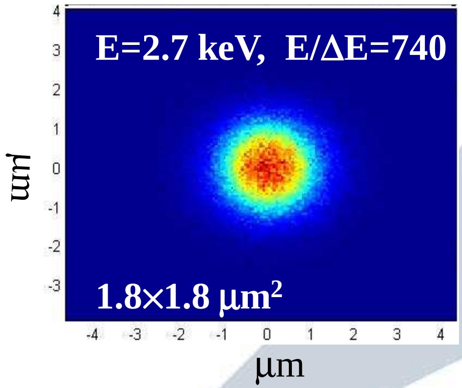


MISTRAL: X-ray microscopy

Source: Bending Magnet



Spot at sample position

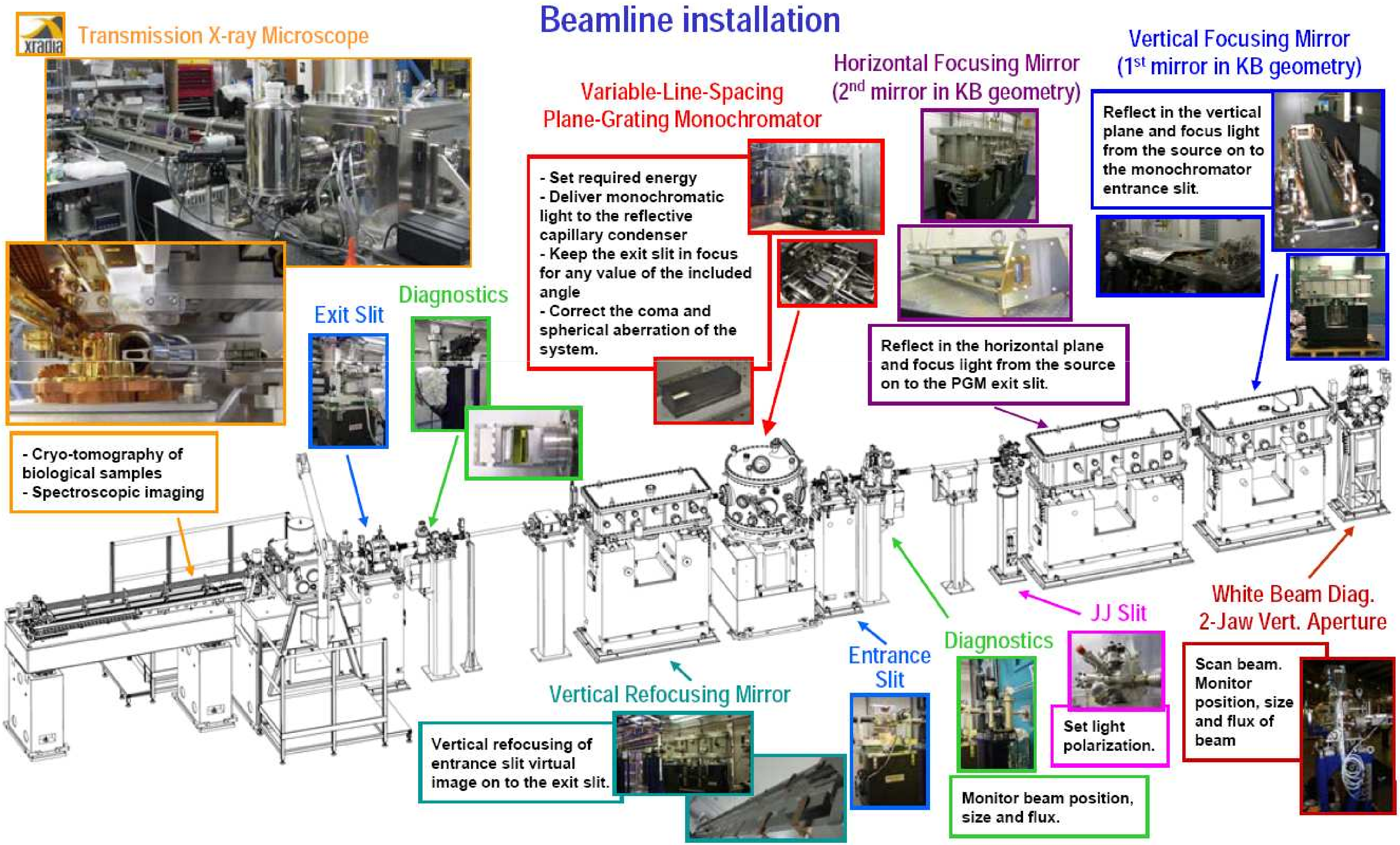


flux ~ 2.5×10^9 ph/s/μm^2/actualBW

Biological samples→ low radiation dose required

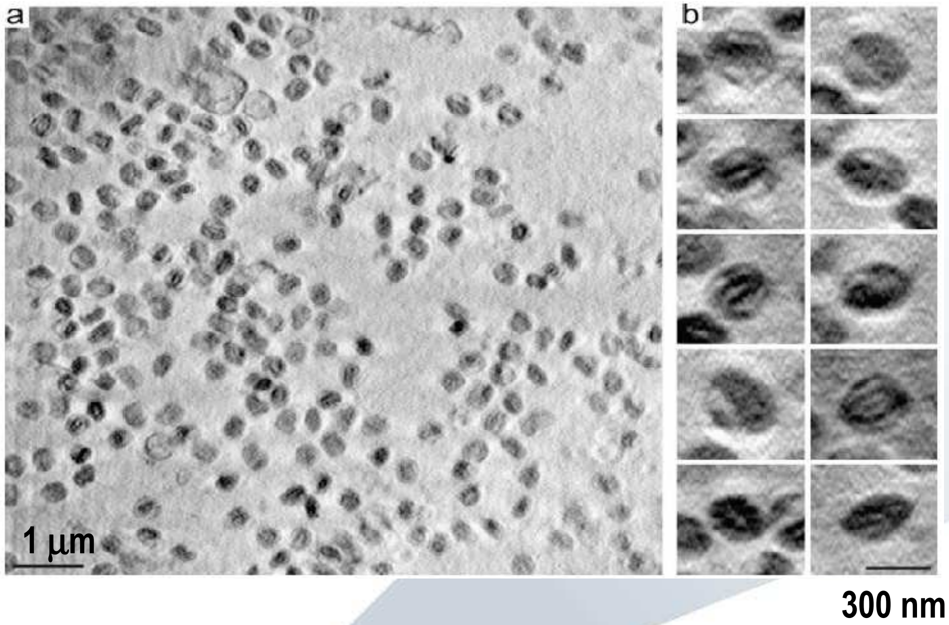
Beamline photon energy: 270- 2600 eV

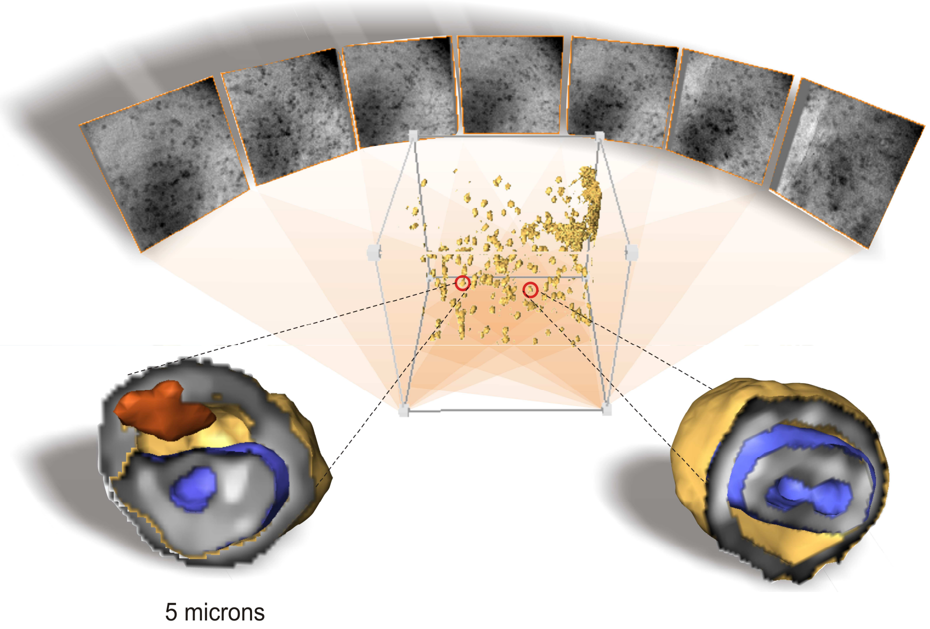
MISTRAL: X-ray microscopy



MISTRAL: X-ray microscopy

Cryo-X-ray tomography of vaccinia virus membranes and inner compartments





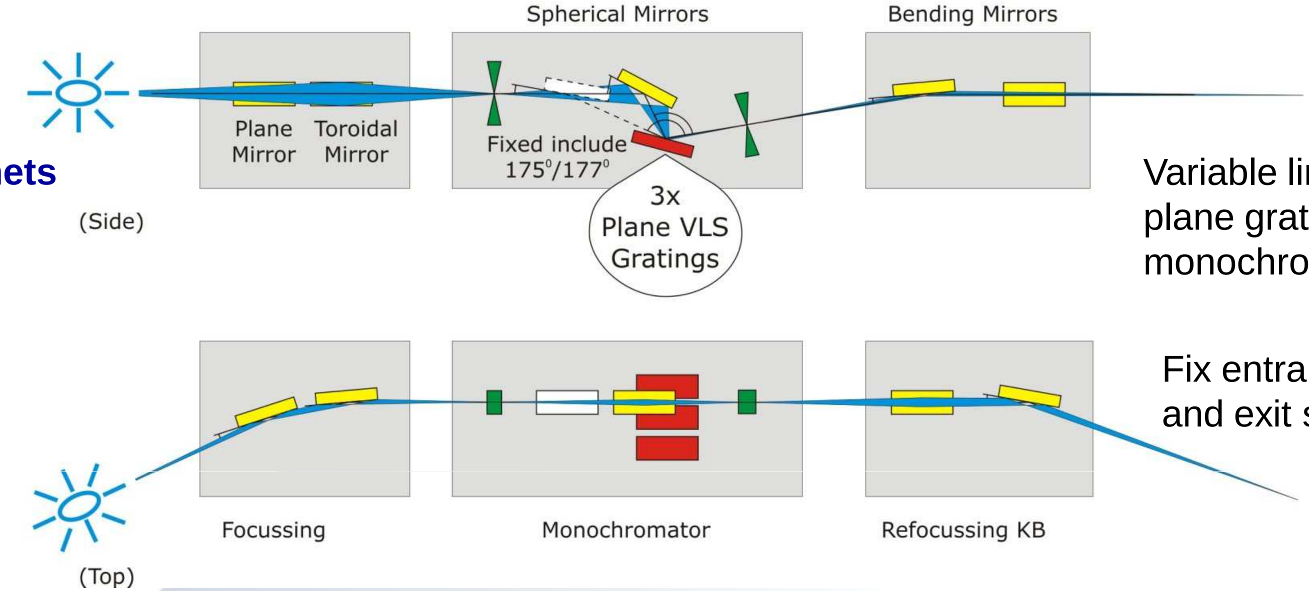
X-ray tomographic reconstruction with a 25 nm OZP. a) Oblique slice extracted from a tomogram b) Central slices of subtomograms containing different viral particles.

3D rendering from the X-ray tomographic reconstructed volume using a ZP of 40 nm.

J.L. Carrascosa et al. J. Struct. Biol. (2009)

BOREAS: XMCD and RSXS

Source: APPLE II Undulator, pp magnets with variable polarization



Variable line spacing plane grating monochromator

Monchromator:
"Monk-Gillieson"
80 – 4000 eV
E/ΔE ≥ 8000

Fix entrance and exit slits

Photon flux

KB mirrors allow to focus the beam in either of the 2 endstations

BL optimized for fast and stable hv scanning

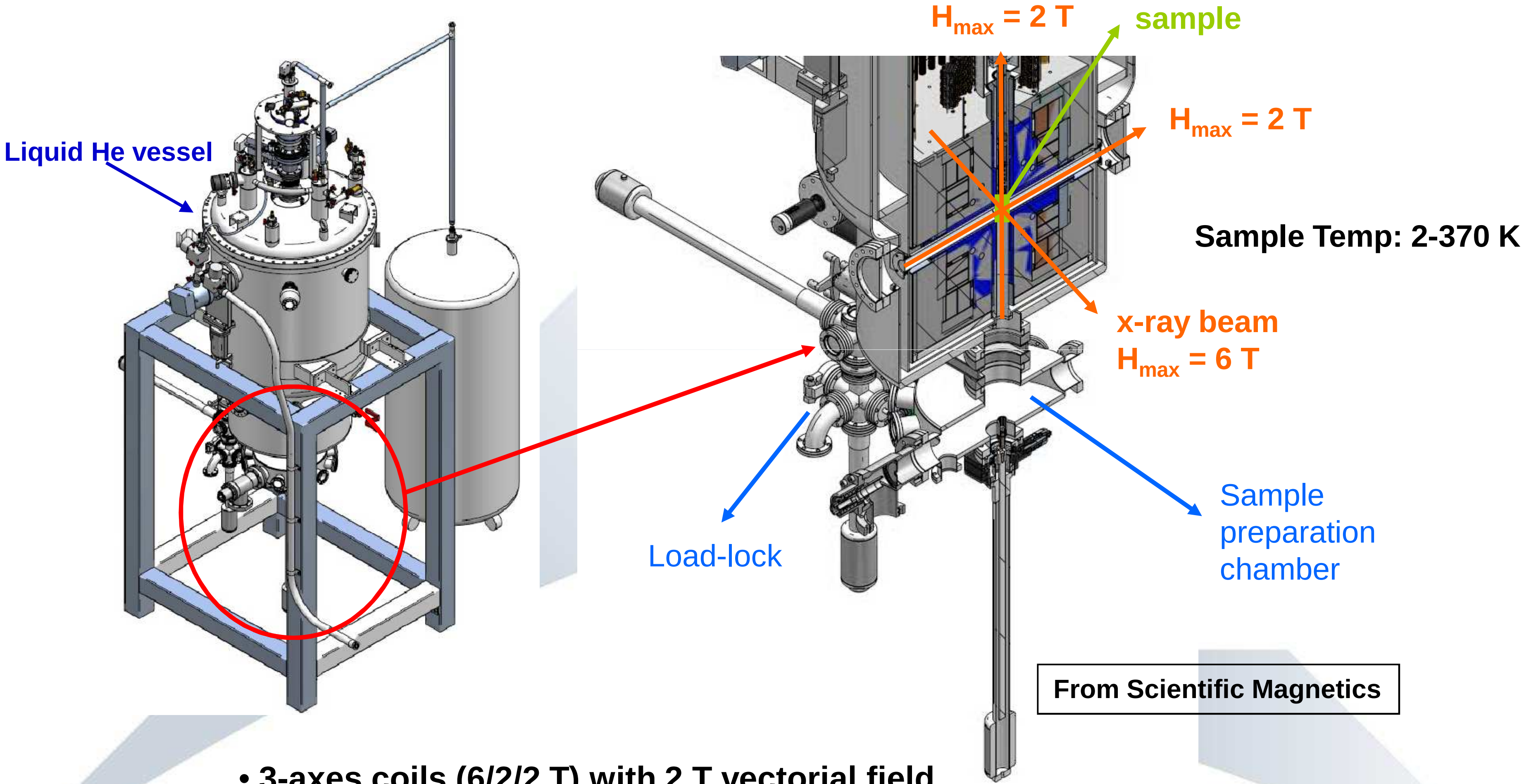
"On-the-fly" scans

Zero order diffraction for coherent scattering

Choice between focused (100 x 20 µm) and collimated (1x1 mm) sample illumination

BOREAS: XMCD and RSXS

XMCD end-station with superconducting cryomagnet



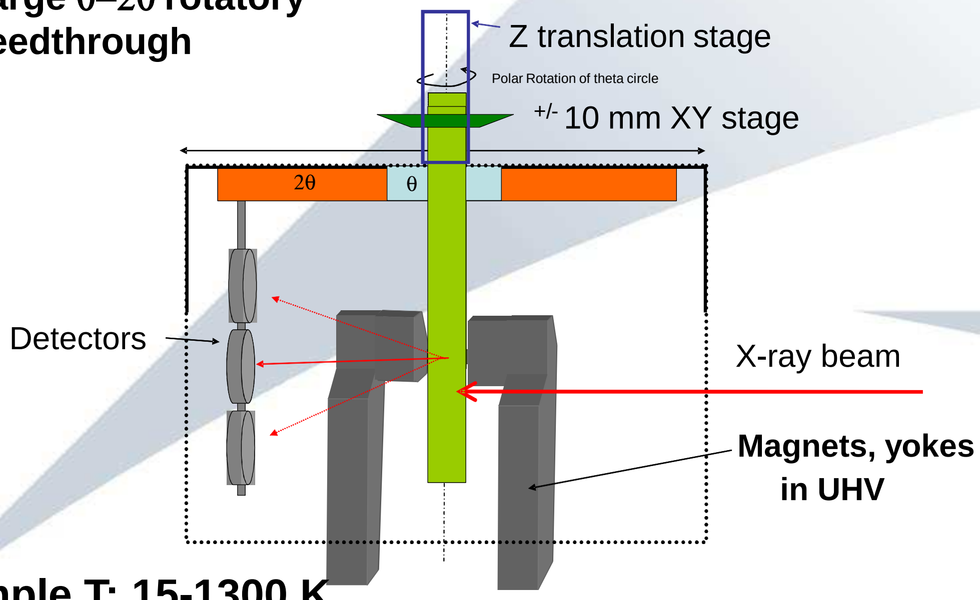
- 3-axes coils (6/2/2 T) with 2 T vectorial field
- Maximum field sweep rate of 2 T/minute
- Detection: total electron yield and fluorescence yield
- Possibility of UHV-connected STM (through collaboration with ICN)

BOREAS: XMCD and RSXS

RSXS endstation (in design stage)

- **UHV reflectometer for in-situ surface science studies using soft x-rays: In-plane and out-of-plane scattering, reflection & transmission geometries**
- **Magnetic field ~ 0.4 T ; flanges to host user UHV equipment (ion gun, evaporators,…etc)**
- **Variable temperature manipulator with electrical isolation (TEY, bias, electric field…)**
- **Upgradeable system: Polarimeter, LEED, RIXS….**

Large θ–2θ rotatory feedthrough

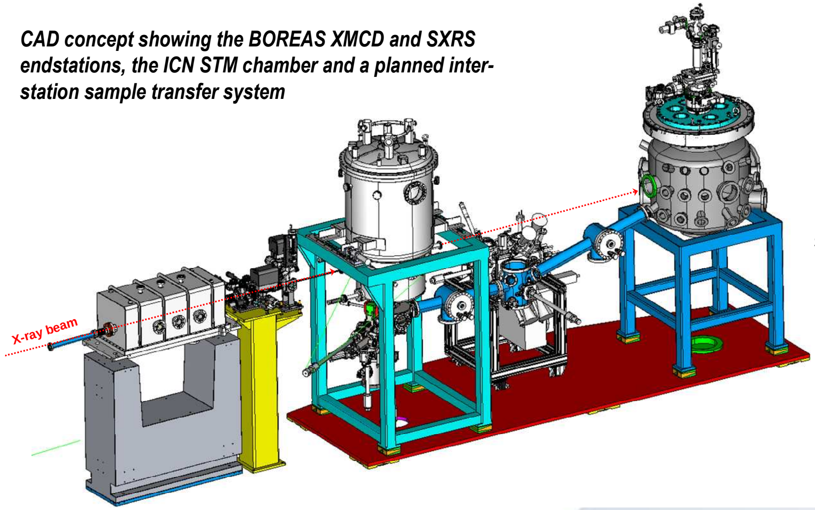


Sample T: 15-1300 K

•Techniques:
•In-situ growth, surface science studies of thin films, multilayers and nanostructured materials by
•- NEXAFS spectroscopy
•- linear magnetic dichroism
•- circular magnetic dichroism
•- natural linear magnetic dichroism
•- natural circular magnetic dichroism
•- natural linear magnetic dicroism
•- resonant magnetic reflectivity
•- magnetic Gisaxs and scattering from nanostructured samples such as nanomagnets, polymer nanotemplates

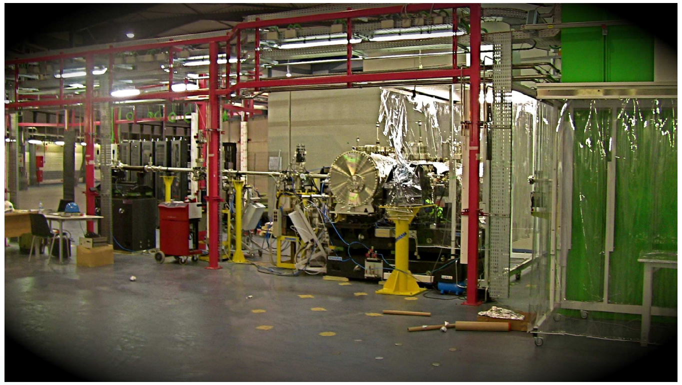
BOREAS: XMCD and RSXS

CAD concept showing the BOREAS XMCD and SXRS endstations, the ICN STM chamber and a planned inter-station sample transfer system

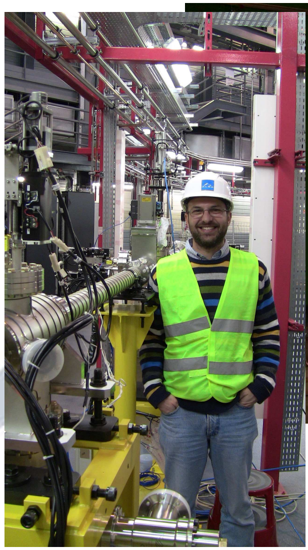


Overview

The beamline is designed for polarization-dependent soft x-ray absorption and scattering spectroscopy. It has two end-stations: one for x-ray magnetic circular and linear dichroism (XMCD/XMLD) experiments, and one for soft x-ray resonant scattering (SXRS).

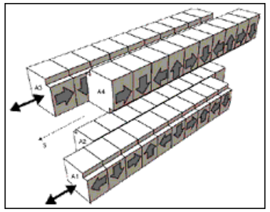


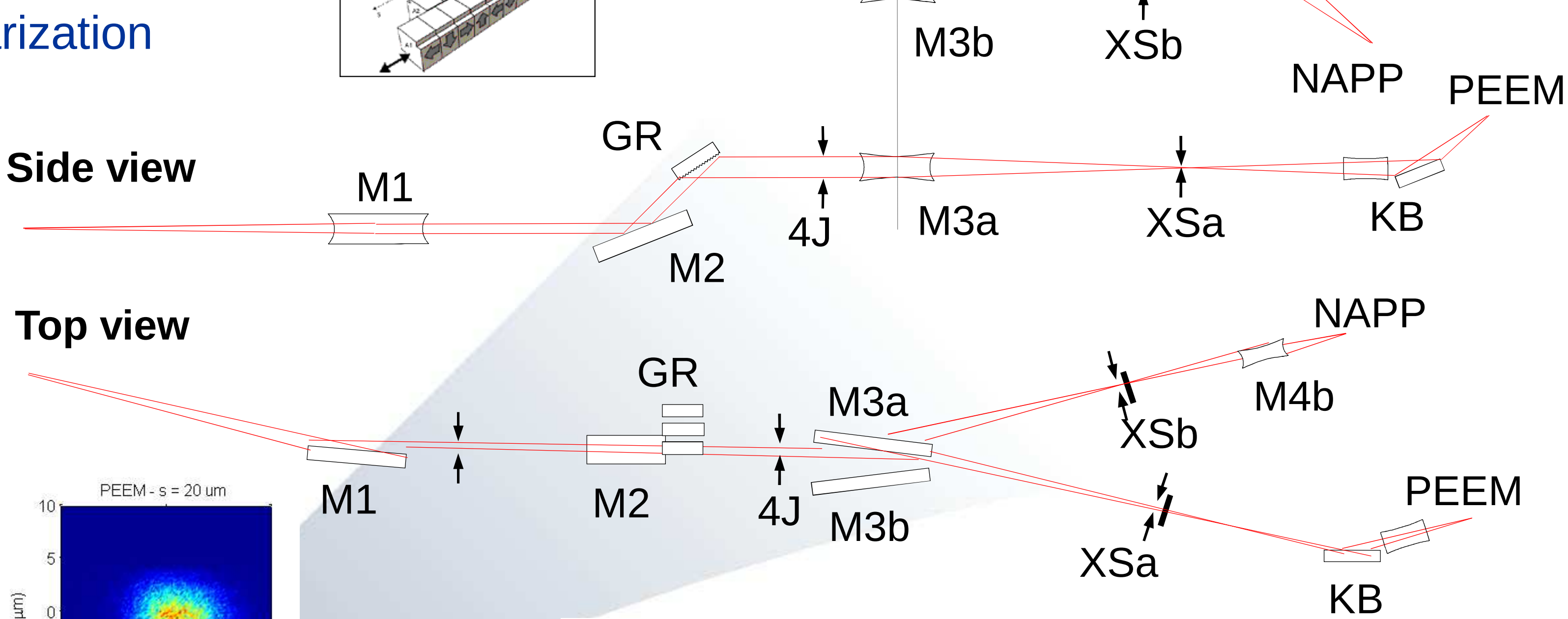
ALBA-BL29 panoramic view during the beamline optics installation campaign, on March 2010



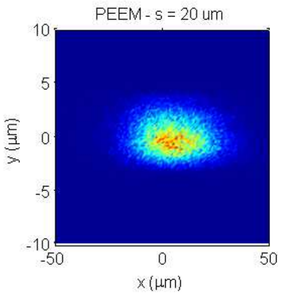
CIRCE: PEEM and in-situ XPS (NAPP)

Source: APPLE II undulator variable polarization

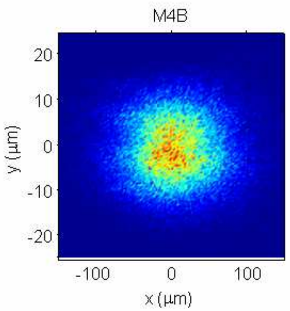




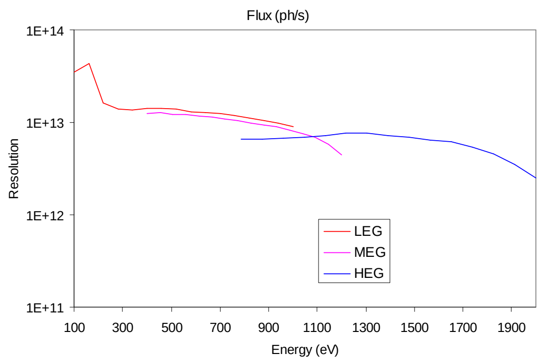
PEEM



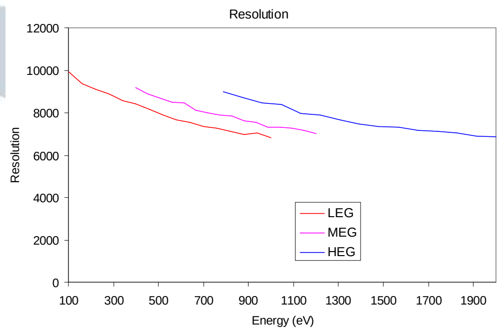
NAPP



flux (ph/s)



resolution

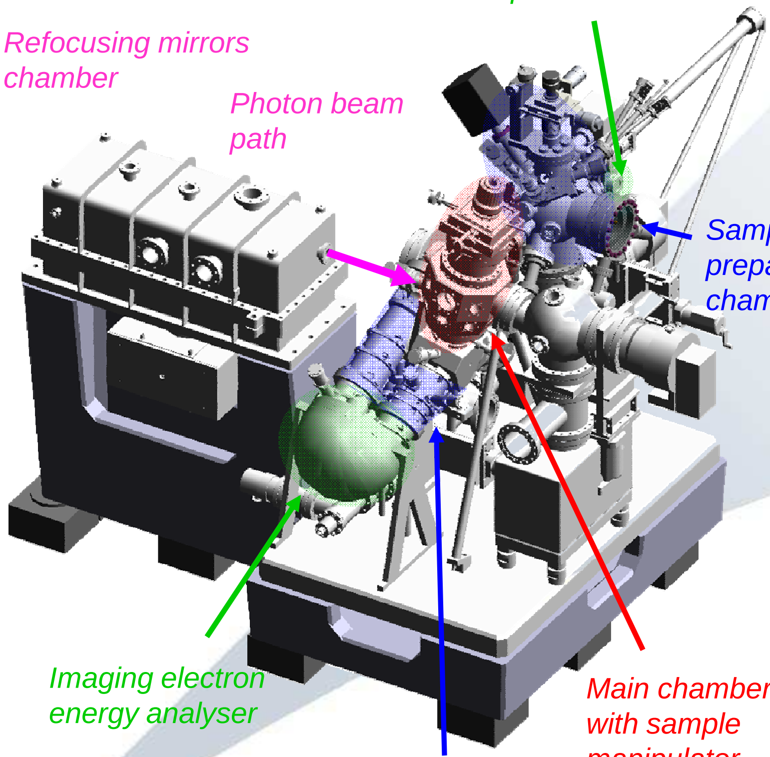


CIRCE: PEEM and in-situ XPS (NAPP)

PEEM EXPERIMENTAL STATION

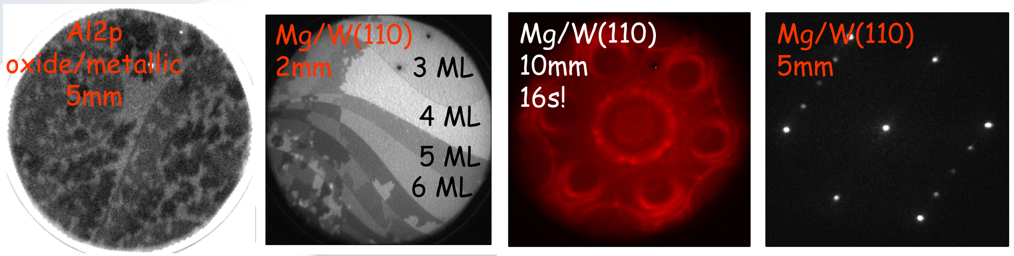
PhotoEmission Electron Microscope with electron gun for Low Energy Electron Microscopy and Diffraction, and electron energy analyzer for spectro-microscopy.

State of the art multi-technique spectro-microscope for surfaces, nanostructures, thin films,…



- Analyzer resolution 0.2 eV
- Lateral resolution LEEM ~ 10 nm, PEEM ~ 15 nm
- Sample temperature ~ 2000K - 150K
- Horizontal near grazing incidence
- Sample rotation around normal:
  any relative orientation to linear polarization

Many complementary experimental techniques:



Spectro-PEEM | LEEM | Microspot phD and spectroscpy | Microspot LEED

Detector=phosphor screen and in-air CCD camera

Contrast mechanisms: chemical, structural, magnetization, polarization.

CIRCE: PEEM and in-situ XPS (NAPP)

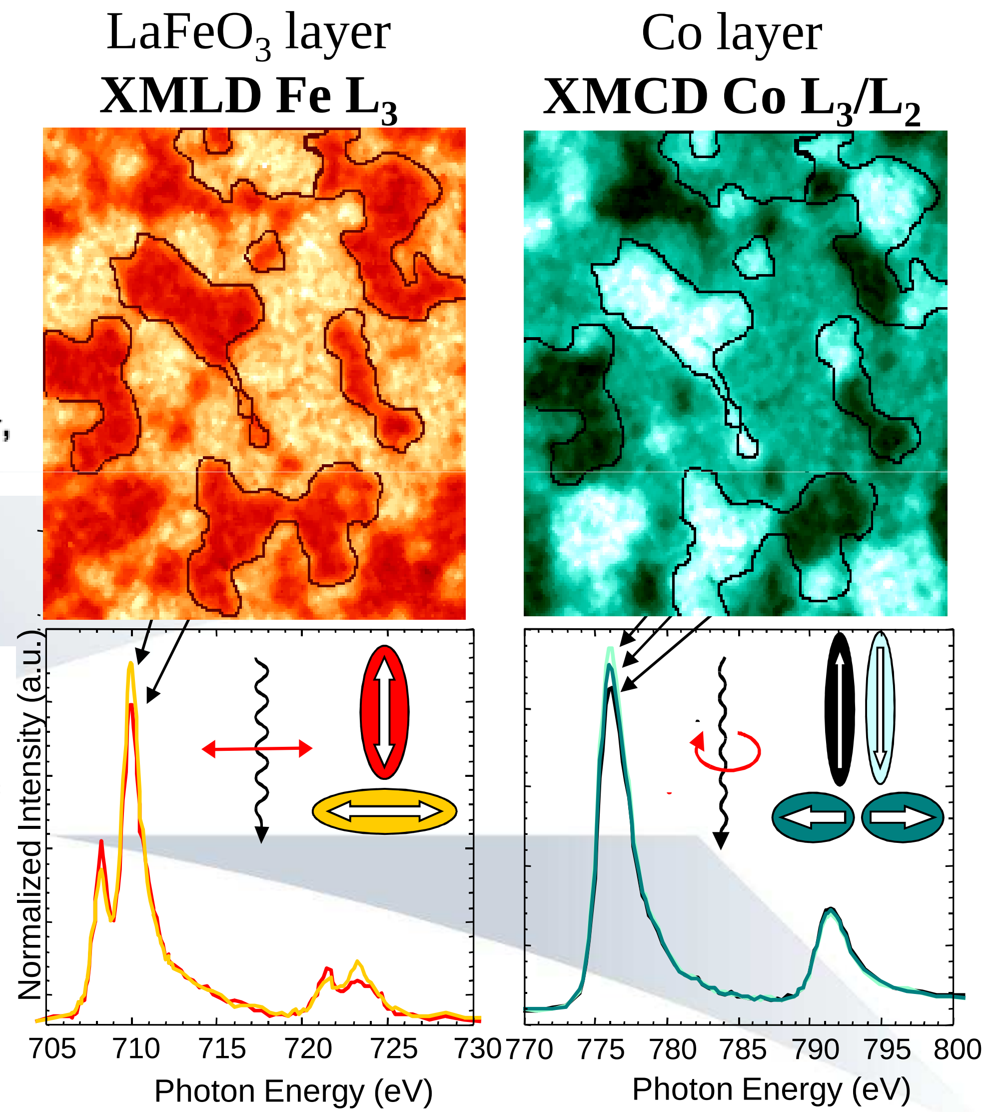
magnetic & elemental sensitivity

Direct observation of the alignment of ferromagnetic spins by antiferromagnetic spins

F. Nolting*, A. Scholl*, J. Stöhr†, J. W. Seo‡§, J. Fompeyrine§, H. Siegwart§, J.-P. Locquet§, S. Anders*, J. Lüning†, E. E. Fullerton†, M. F. Toney†, M. R. Scheinfein|| & H. A. Padmore*

Nature, 405 (2000), 767

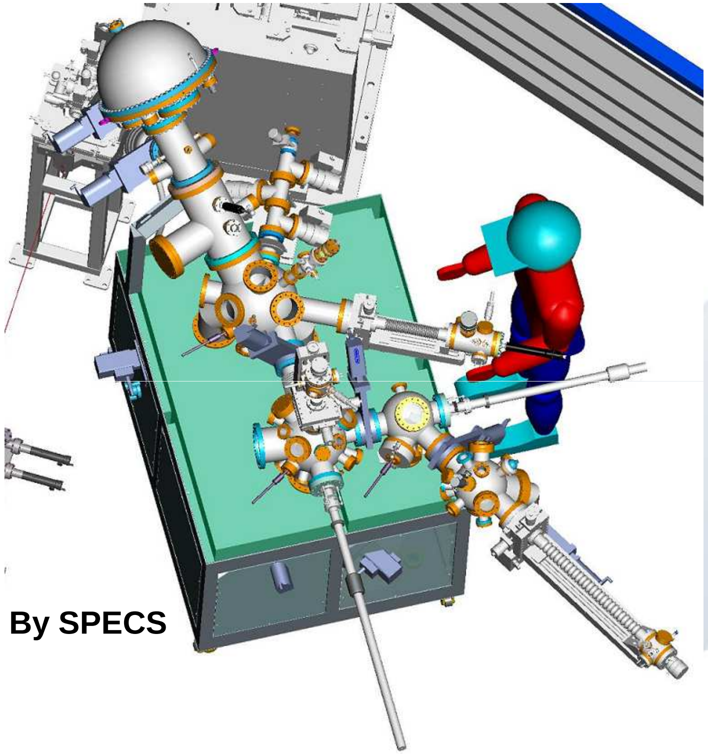
Figure 1 Images and local spectra from the antiferromagnetic and ferromagnetic layers for 1.2-nm Co on $LaFeO_3/SrTiO_3(001)$. **a**, Fe L-edge XMLD image; **b**, Co L-edge XMCD image. The contrast in the images arises from antiferromagnetic domains in $LaFeO_3$ (**a**) and ferromagnetic domains in Co (**b**) with in-plane orientations of the antiferromagnetic axis and ferromagnetic spins as indicated below the images. The spectra shown underneath were recorded in the indicated areas and illustrate the origin of the intensity contrast in the PEEM images.



CIRCE: PEEM and in-situ XPS (NAPP)

NAPP EXPERIMENTAL STATION

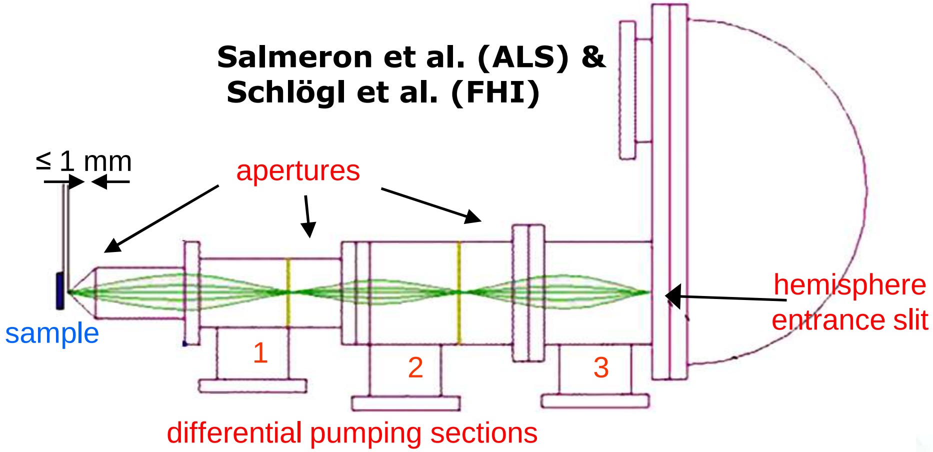
Near Ambient Pressure Photoemission: differentially pumped photoelectron energy analyzer with lens system to maximize transmission



By SPECS

- Pressure ratio sample/detector ~ 10^9
- Maximum pressure at the sample ~ 20 mbar
- Analyzer energy resolution ~ 5/10 meV (UPS/XPS)
- Sample in horizontal position
- Variable beam incidence & detection angle
- Residual gas analyzer to monitor reaction products
- Infrared laser heating & Peltier cooling:
  sample temperature ~ 1300K - 240K
- Differentially pumped photon beam entrance
- Gas inlet manifold

Salmeron et al. (ALS) &
Schlögl et al. (FHI)



For the study of surface reactions, heterogeneous catalysis, gas-liquid and gas-solid interfaces,…

Future upgrades: catalysts preparation chamber for up to atmospheric pressure reactions.

CIRCE: PEEM and in-situ XPS (NAPP)

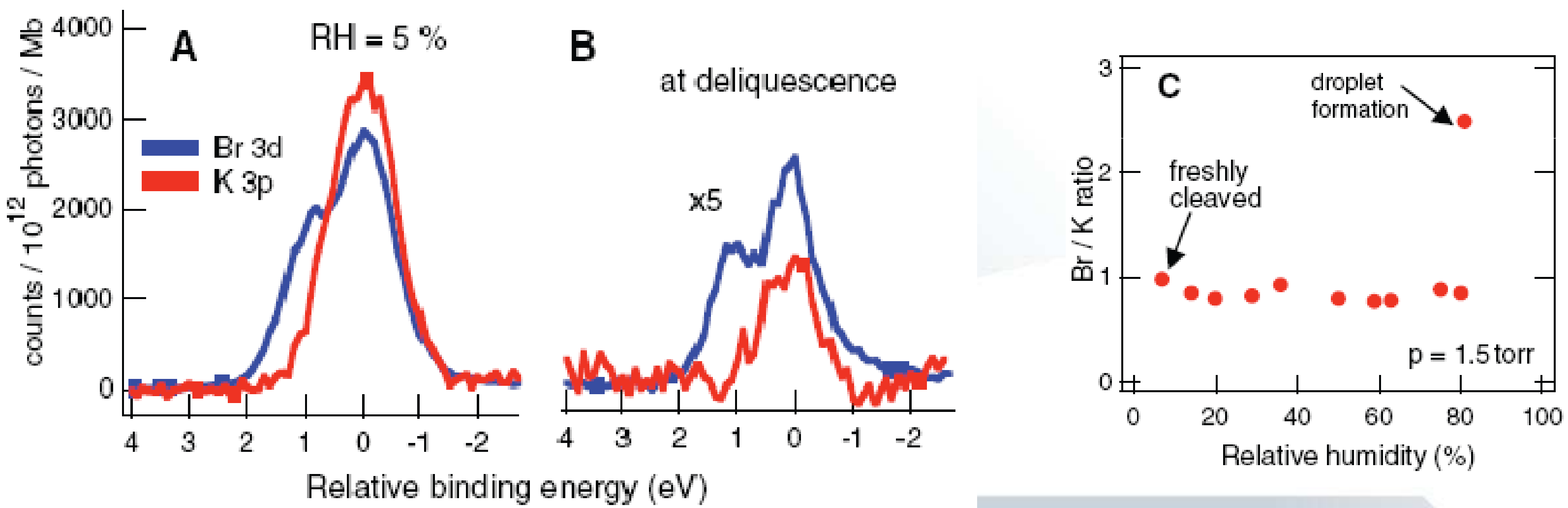
NEAR AMBIENT PRESSURE PHOTOEMISSON

EXAMPLE:

Dissolution of KBr salts

Ghosal *et al.* Science (2005)

ALS, BL 9.3.2



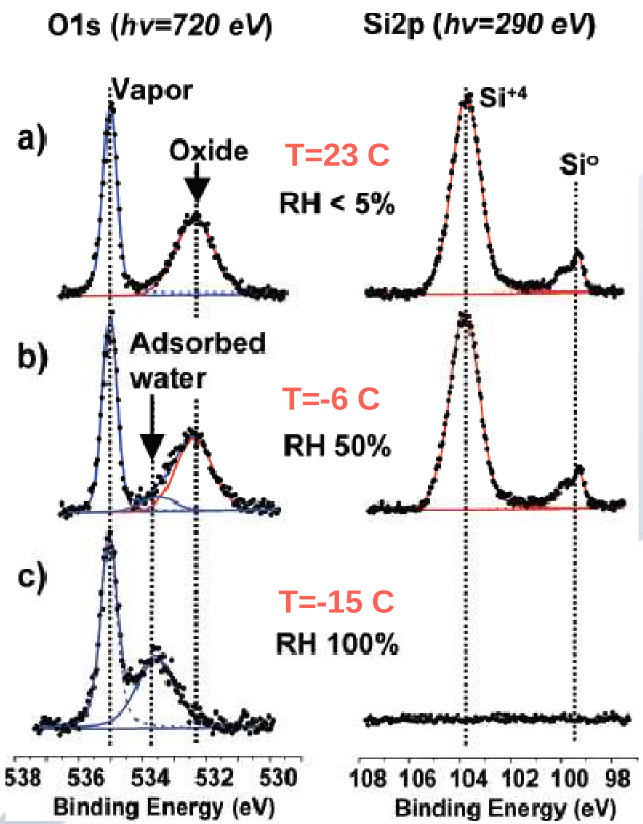
- The relative humidity (RH) was increased from 5% to the deliquescence point.
- For that value, an abrupt raise of the Br/K XPS peaks areas takes place

CIRCE: PEEM and in-situ XPS (NAPP)

GROWTH AND STRUCTURE OF WATER ON SiO_2

P_{H_2O}=1.5 Torr

A. Verdaguer et al, Langmuir, 2007, ALS BL 11.0.2



Surface-induced modifications?
How many water layers are needed to reach the water bulk structure?

•Water film thickness as a function of RH was determined by XPS:

O1s region: water gas phase+ adsorbed water+ Oxygen in SiO_2

•Changes in Surface potential during water Growth were measured by AFM

•Structure of the film investigated by NEXAFS

Thank You