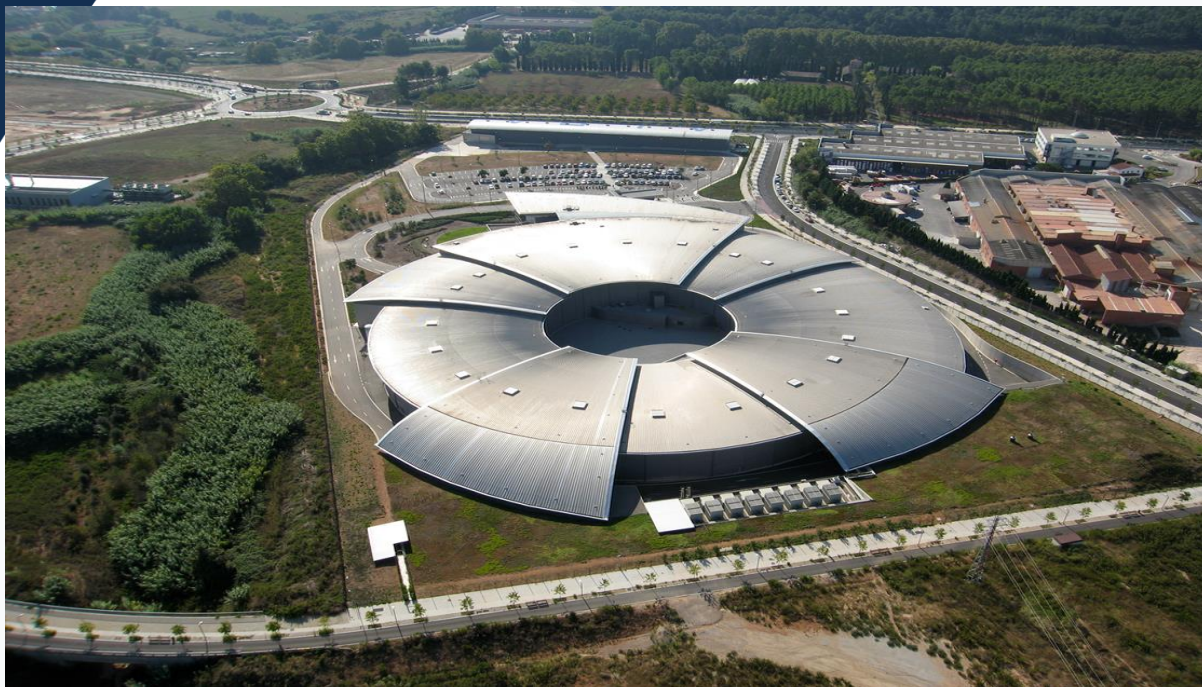




ALBA Synchrotron: what is it and what is it used for?

Alejandro Sánchez
Industry Liaison Office Director

ALBA Synchrotron in short



1st SCIENCE FACILITY
IN SOUTH-WEST EUROPE

300 M€ PUBLIC INVESTMENT (2022)

250 STAFF (28% INTERNATIONAL)

2500 RESEARCHERS PER YEAR
(35% INTERNATIONAL)

300 EXPERIMENTS PER YEAR +
60 INDUSTRIAL EXPERIMENTS PER YEAR

4500 HOURS PER LAB PER YEAR

A large facility to study the structure at atomic scale of materials in:



CHEMISTRY



PHARMACEUTICAL



ADVANCED
MATERIALS



ENERGY



HEALTH



NANOTECHNOLOGY



AUTOMOTIVE AND
AEROSPATIAL



FOOD AND PACKAGING



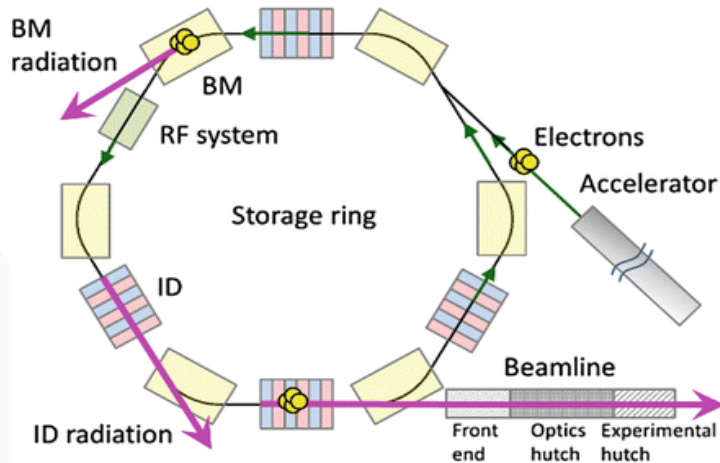
ENVIRONMENT



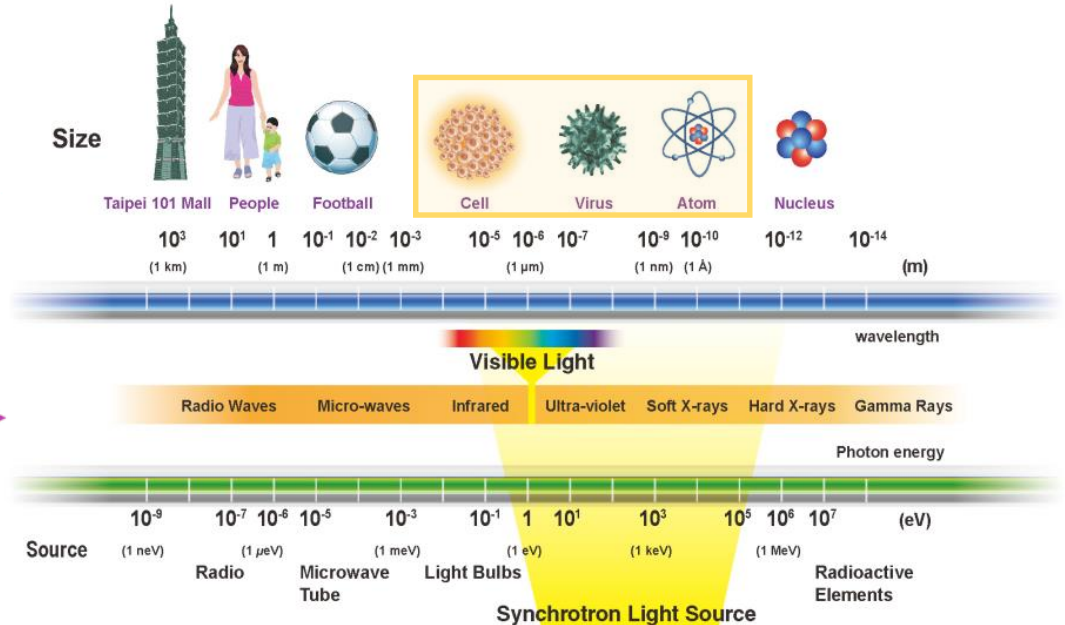
CULTURAL HERITAGE
& FORENSIC SCIENCES

What is a synchrotron?

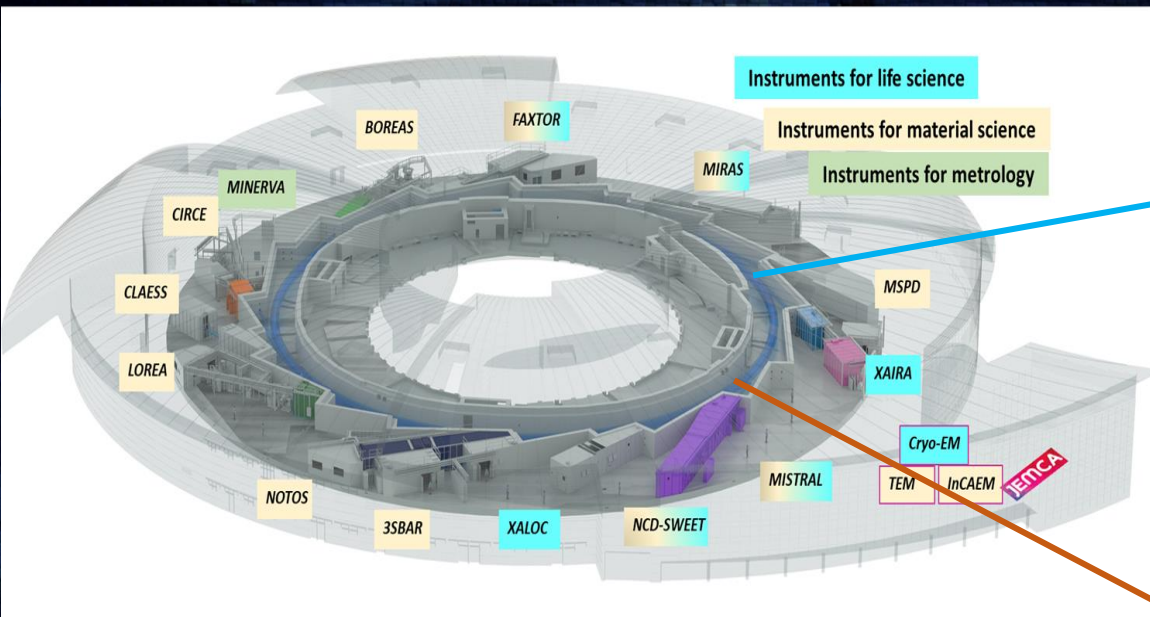
- ❑ A synchrotron is a particle (electron) accelerator
- ❑ Electrons in a synchrotron travel to nearly the speed of light and generate synchrotron light (IR, UV, soft and hard X-rays)
- ❑ Synchrotron light can be used to study materials up to atomic scale like cells, viruses, proteins, drugs...



Schematic representation of a synchrotron



Synchrotron light range in the electromagnetic spectrum

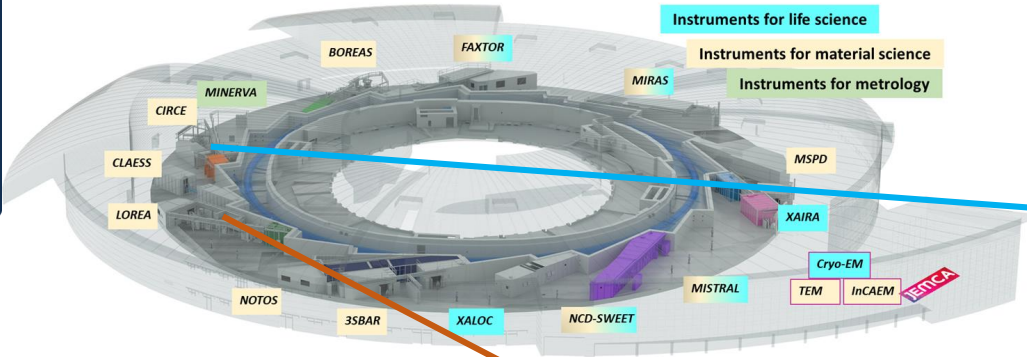


3 GeV e- synchrotron
270 m circumference
250 mA operating current
> 98% availability

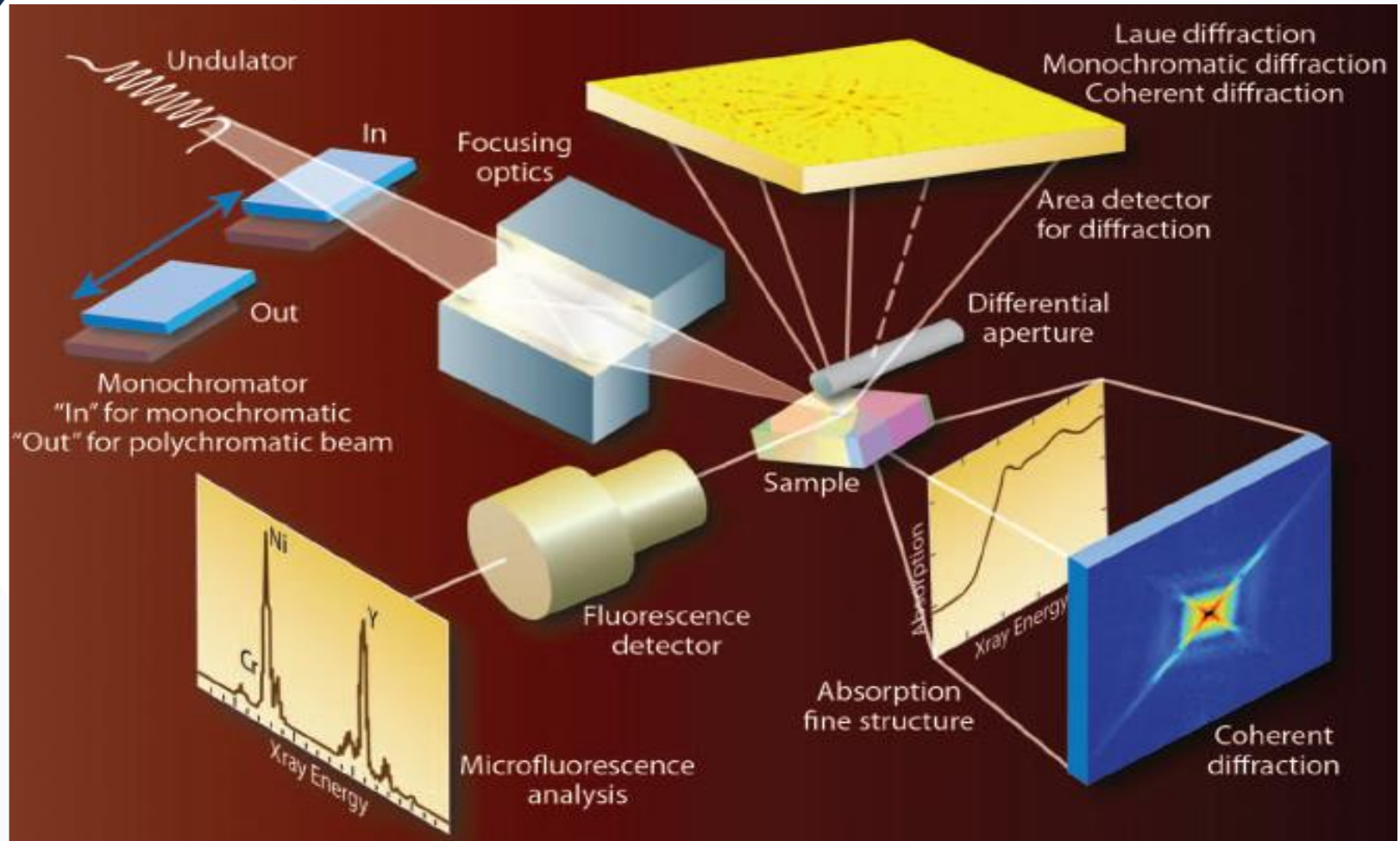
11 operating beamlines
+ 3 beamlines in construction
+ Joint Electron Microscope Center
(JEMCA)

Typical Beamline structure

16



Using the synchrotron light

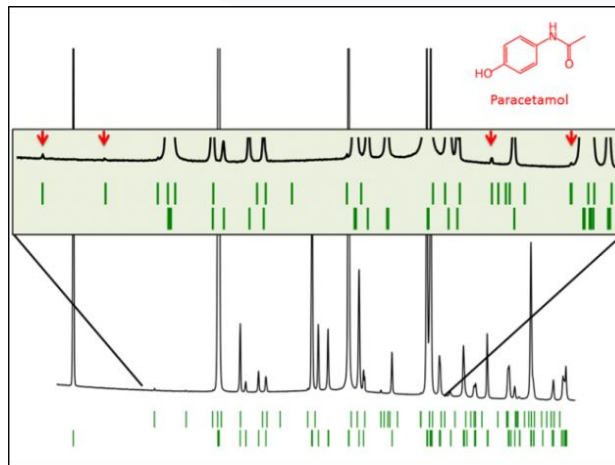


What is a synchrotron used for?



DRUGS

Polymorphism studies and detection of impurities in drugs



ALBA researches, MSPD beamline



- ❑ *High resolution synchrotron X-ray powder diffraction helps determining the presence of polymorphs in drugs.*
- ❑ *It is the “gold standard” technique for identifying and distinguishing polymorphic forms and avoid patent infringement.*



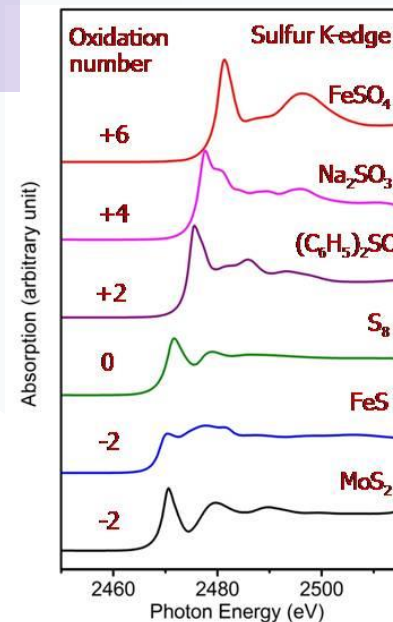
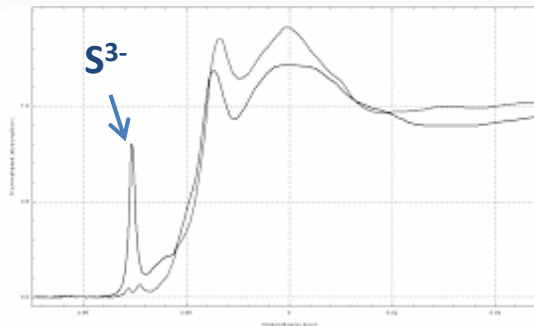
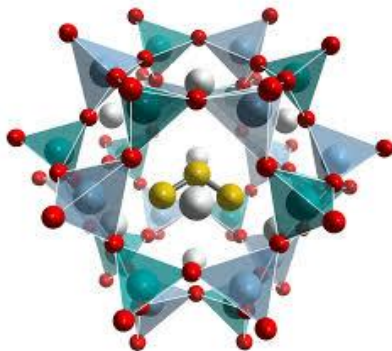
CHEMISTRY

Improvement of the color properties of pigments

FERRO company



Ultramarine blue



- ❑ Sulfur species into aluminosilicate cage can be S_3^{2-} , S_2^{2-} , S_4 , S , SO_4^{2-} ...
- ❑ But the higher the amount of S^{3-} specie the better the color parameters.
- ❑ That helps to improve the production process.

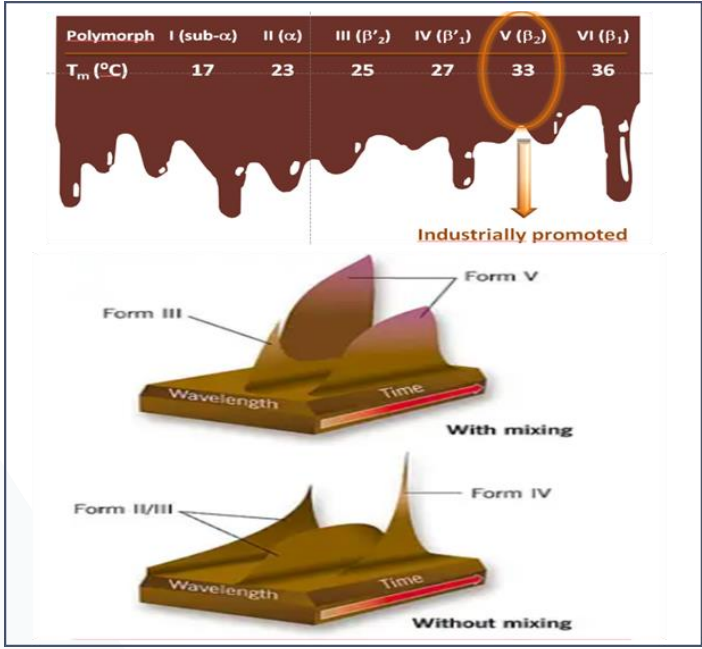


Project supported by CDTI



FOOD

Making better chocolate for Cadbury



- ❑ Cadbury made one of the first important industrial experiments at synchrotron (1998, UK)
- ❑ At that moment, there were several polymorphs on the chocolate composition.
- ❑ Only polymorph V produces good taste and smooth texture.

The data obtained at the synchrotron helped Cadbury to determine the optimum conditions for good tasting chocolate manufacturing.

Source: www.newscientist.com/article/mg15821331-100-cool-chocolate/

INDUSTRIAL APPLICATIONS



FOOD AND PACKAGING



WHAT INFORMATION CAN BE OBTAINED?

- Dynamics and stability of food emulsions.
- Phase transitions in fat and rheological act carbohydrate food.
- Determination of toxic chemicals including fish, legumes and vegetables.
- Identification of chemical elements and spec food for designation of origin purposes.
- Study of structural changes in plastics used storage of products.
- Determination of copper and other metals at their different oxidations steps.
- Chemical imaging of plants, seeds, grains,

WHAT ALBA DOES



HELPING TO DESIGN F
The ingestion of selenium to prevent cardiovascular metabolism of selenium by following the different determine the best method.



HAM CURING PROCESS
Cured hams from different were characterised in order traceability. The evolution at different times during results enabled Spanish



HOW TO OBTAIN THE V
The crystallisation of van ALBA using chocolate as The results demonstrate 16 C, a velvety texture and this texture improve



WHAT CAN BE STUDIED?

- ♥ PRODUCTS FOR PERSONAL CARE AND HYGIENE
- ♥ COSMETICS
- ♥ DENTAL MATERIALS
- ♥ EMULSIONS, FOAMS AND GELS
- ♥ BIOLOGICAL TISSUES
- ♥ CELLS AND BIOLOGICAL PROCESSES
- ♥ BIOMATERIALS FOR BIOCOMPATIBLE IMPLANTS
- ♥ BIODEGRADABLES FOR DRUG ADMINISTRATION

WHAT ALBA DOES



ANALYZING ALZHEIMER'S MECHA
Aggregates of different proteins are suffering Alzheimer. Location and neuronal cells have been studied at the Alzheimer's mechanisms, to be disease and eventually to prevent it



ESSENTIAL OILS
Essential oils are widely used as na preparations. Different vesicles use in the ALBA synchrotron. Results st in the vesicles without altering the of the vesicles to release essential



SKIN CARE COSMETICS
X-ray synchrotron diffraction makes structure of collagen present in the that infrared rays produce disorgan effect can be prevented by using bil to address new formulations to prote

12

HEALTH

WHAT INFORMATION CAN BE OBTAINED?

- Study of the struc environments suc
- Characterisation chemical product times after applic
- Structural inform and adhesives for
- Determination an tissue (muscles, ,
- 3D reconstruction of cellular mecha
- Structural studies

TECHNICAL LABORATORIES

In addition to synchrotron light laboratories, ALBA has a set of **highly specialised technical laboratories** supporting synchrotron techniques and particle accelerator developments also able to offer their expertise in these fields.



Magnetic measurements laboratory

SERVICES

- Accurate magnetic measurements (100 ppm) of high magnetic fields of big structures (up to 2 m long).
- Measurement of coils for motors or other applications.
- Measurement of field maps of any type of magnetic structure.
- Measurement of multipole magnets (quadrupoles, sextupoles, etc).
- Measurement of pure permanent magnetic blocks, isolated or assembled in holders, and sorting and shimming for constructing insertion devices.
- Modelling and optimisation of magnetic designs using 3D simulation tools.
- Calculation of the main features of measured magnetic fields (integrals, high order harmonics and fiducialisation of magnetic fields with respect to mechanical references).



https://www.cells.es/en/industry/industrial_applications_baja.pdf



WHAT CAN BE STUDIED?

- △ CATALYSTS
- △ PLASTICS, ELASTOMERS AND POLYMERS
- △ PAINTS AND PIGMENTS
- △ FIBRES
- △ PULP AND PAPER
- △ ENCAPSULATION OF ORGANIC COMPOUNDS
- △ HOME CARE PRODUCTS
- △ CHEMICAL REACTIONS

CHEMISTRY

WHAT INFORMATION CAN BE OBTAINED?

- Structural characterisation of solid samples at the atomic level.
- Determination of the oxidation states and species in a wide variety of samples.
- Nanoscale characterisation of the shape, size and density of molecular aggregates.
- Characterisation of depositions, contamination and photochemical processes on surfaces.
- Microstructural characterisation of dispersions, emulsions and materials partially ordered.
- Chemical identification and characterisation of contaminants.
- Study of chemical reactions and processes in both a dynamic and steady state at the atomic level.

WHAT ALBA DOES



CUSTOM-MADE AND MORE EFFICIENT CATALYSTS

Rhodium and Palladium nanoparticles deposited on a ceria substrate are used as catalysts for the production of hydrogen. The analysis of their surfaces under working conditions conducted at ALBA showed that the oxide substrate induced a rearrangement of the nanoparticles that increased the reaction yield. This result helps to design catalysts with improved performance.



IMPROVING THE PROPERTIES OF PIGMENTS AND THEIR MANUFACTURING

The low detection limits and the possibility to determine oxidation states provided by ALBA permitted the colour properties of a commercial pigment, produced by different synthetic routes, to be correlated with its crystal and atomic structure. This information is very valuable for developing more efficient methods for pigment manufacturing.



GIVING SHAPE TO POLYMERS

Different degrees of crystallisation provide plastic materials with properties that are halfway between hard/solid and soft/flexible. ALBA characterised the degree of crystallisation of different polymers cooled down at different cooling rates, similar to those used under industrial conditions, to determine the most suitable process for tuning the rigidity or plasticity of the polymers for particular applications.



ADVANCED MATERIALS

WHAT INFORMATION CAN BE OBTAINED?

- In situ study of materials under similar conditions to the production process.
- Atomic structure, electronic and magnetic characterisation of materials.
- Oxidation state and chemical species determination.
- Structure of ceramics and its evolution during synthesis and manufacturing processes.
- Phase determination of materials such as cements and concretes.
- Surface corrosion characterisation with different agents and working conditions.
- Characterisation under high pressure and temperature.

WHAT ALBA DOES



TAILOR-MADE CEMENTS

The evolution of the crystalline phase of concrete, clinker and cement were determined during an in situ hydration process using the ALBA's powerful X-rays. The results permitted the kinetics and mechanisms for early stage hydration of eco-cements to be established and this will help improve their performance.



ADDITIVE MANUFACTURING/3D PRINTING

3D printed extruded filaments of poly-ε-caprolactone (PCL) were analyzed at ALBA under different manufacturing conditions. Results showed that polymer composition and extruder jet temperature are the main factors determining the internal structure and the mechanical properties of the manufactured object. With such findings, the process can be tuned to obtain objects with the desired properties.



MATERIALS UNDER EXTREME CONDITIONS

A new crystalline phase of CdAl₂Si₄ at very high pressure (250,000 atmospheres) has been identified at ALBA, which remains unaltered after pressure removal, at 1 atmosphere. This new phase could enhance the performance of photovoltaic cells and could have industrial applications in optoelectronics and nonlinear optics.



WHY

DO COMPANIES USE ALBA SYNCHROTRON?



ALBA Synchrotron techniques provide **outstanding results** that cannot be achieved with other equipment and techniques and which are very valuable in boosting a company's competitiveness.



LOWER DETECTION LEVELS



CHEMICAL MAPPING



OXIDATION STATE DETERMINATION



HIGHER RESOLUTION



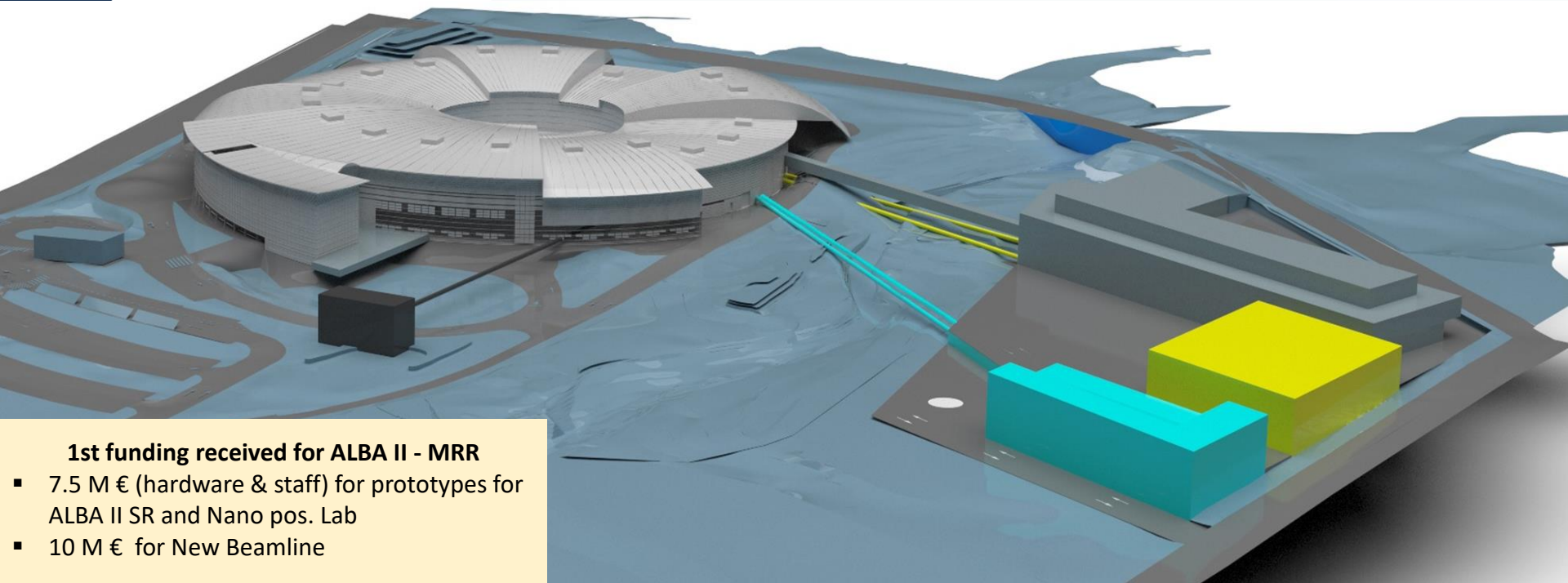
FASTER EXPERIMENTS



WIDE VARIETY OF SAMPLE
ENVIRONMENTS



INDUSTRY program from ALBA to **ALBA II**: Possible evolution of Parc de l'ALBA



1st funding received for ALBA II - MRR

- 7.5 M € (hardware & staff) for prototypes for ALBA II SR and Nano pos. Lab
- 10 M € for New Beamline

InnoFab

Generalitat de Catalunya

ICN2

ALBA

ENM

ICFO

INBRAIN

UAB

Barcelona & Partners

2.000 m2 clean room infrastructure for semiconductor technologies

One Health (R²OH)

UAB

ALBA

CRISA

CNB

Impact of climate change, zoonotic and neurodegenerative diseases on public health



HOW TO CONTACT ALBA



FAST



CONFIDENTIAL



FULL SERVICE

One-stop shop service which provides guidance and coordinates everything

industrialoffice@cells.es

Some ALBA Industry clients

Long term contract between HENKEL and ALBA



BASF, UPC and ALBA propose a methodology for producing better additives for concrete technology



- ✓ 75 different clients using ALBA beamlines
- ✓ More than 530 industry measurements

SAMTACK benefits from synchrotron light for improving food packaging

The company is analysing nanoparticles contained in a new food packaging system that will prevent food oxidation and extend its lifetime.



ENANTIA uses ALBA's X-rays to detect crystalline impurities in drug products



TOYOTA and CSIC proved viability of calcium-based batteries



The Spanish Research Council (CSIC) in collaboration with TOYOTA Motor Europe (TME) demonstrates the viability of Calcium rechargeable batteries using ALBA techniques.

ESTEVE, UAB and ALBA Synchrotron join efforts to investigate the mechanism of action of new inhibitors against pain



industrialoffice@cells.es

THANK YOU!

