SCTB Section Review

Status and Vision of Existing Tools

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MIRAS BL: Status and Current User Program

8th – 9th November 2021

MIRAS BL01 Staff

Scientific staff

Ibraheem Yousef (Group leader)
since 2015
Biomedicine, material science, instrumentation

Tanja Ducic (BL scientist)
since 2016
Neurodegenerative, biomedicine

Martin Kreuzer (BL scientist)
since 2016
Polymers and thin films

Yesid Hernandez (Post-doc)
since June 2021
Catalysis and energy related materials

Matrix staff

Three engineers shared with other beamlines and general services

Llibert Ribó
Mechanical

Domingo Alloza
Electrical

Carlos Falcon
Control

Alejandro Enrique
Beamline technician shared with other beamlines

Role of MIRAS within the life science section

ALBA

Life Science section mission:

- Make **accessible effective, state-of-the-art scientific services and instruments** dedicated to solving societal challenges related to life sciences such as health and environment.

- Act as a **catalyst** for regional and national collaborations addressing societal challenges for which life sciences may provide solutions.

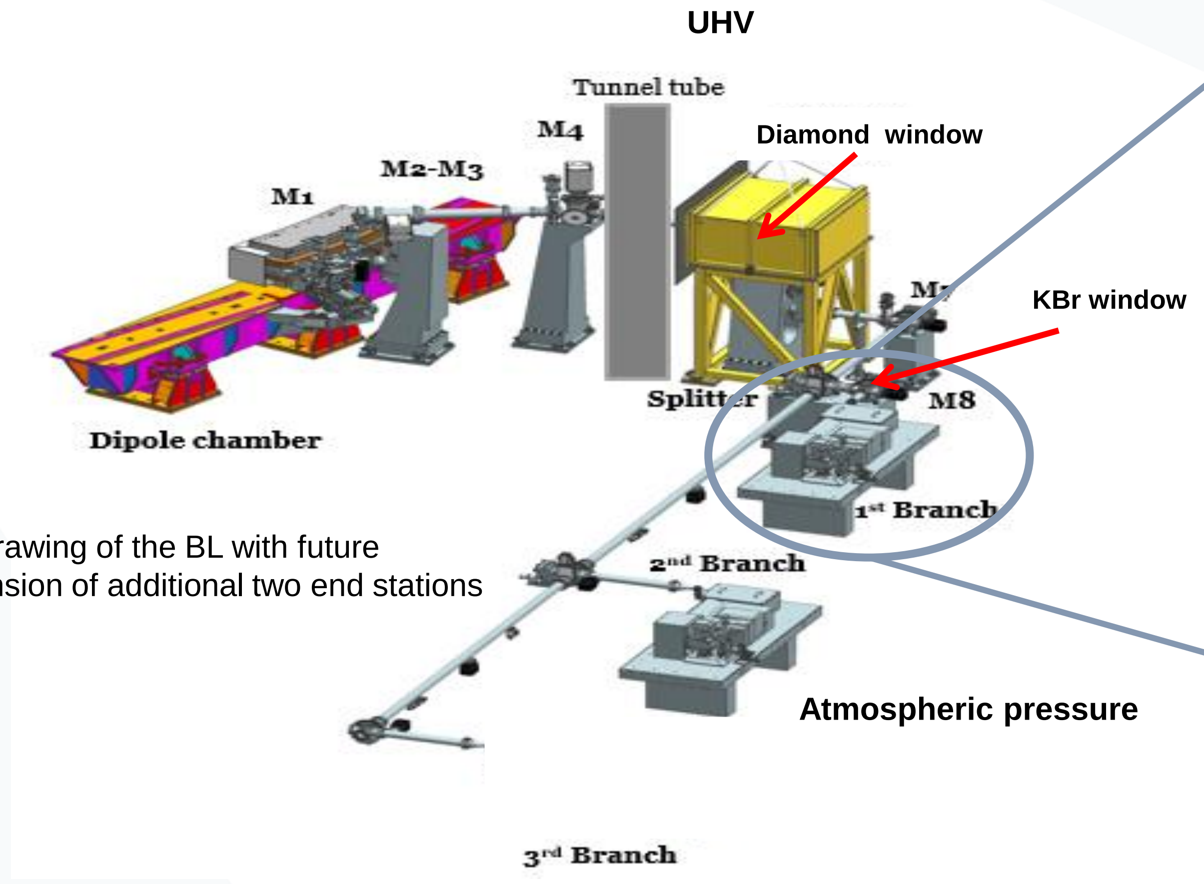
MIRAS Role:

- Non-destructively map the state of the **bio macro molecules** in their natural environment.
- Develop new methods adapted to IR-based **biological and biomedical applications for:**

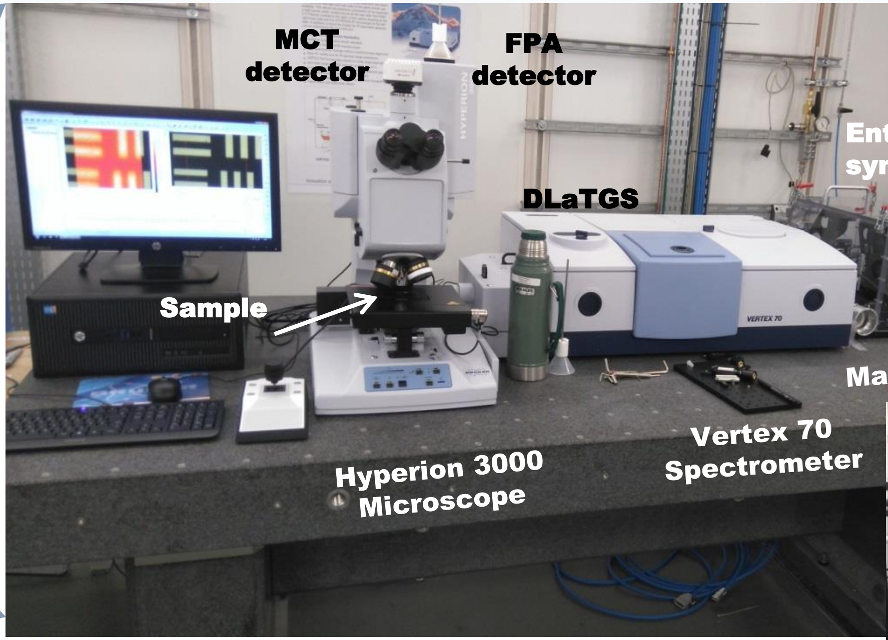
  - **Bio-multidisciplinary research** projects**: connecting** groups with diverse expertise to solve a specific biological problem.
  - Multimodal approach: Use FTIR as a **complementary tool** to other techniques.

Overview of Current instrumentation - Experimental Hutch

Microscopy Beamline (imaging & spectroscopy).
Fields: material science, bioscience, cultural heritage, food science, environmental science.



3D drawing of the BL with future extension of additional two end stations



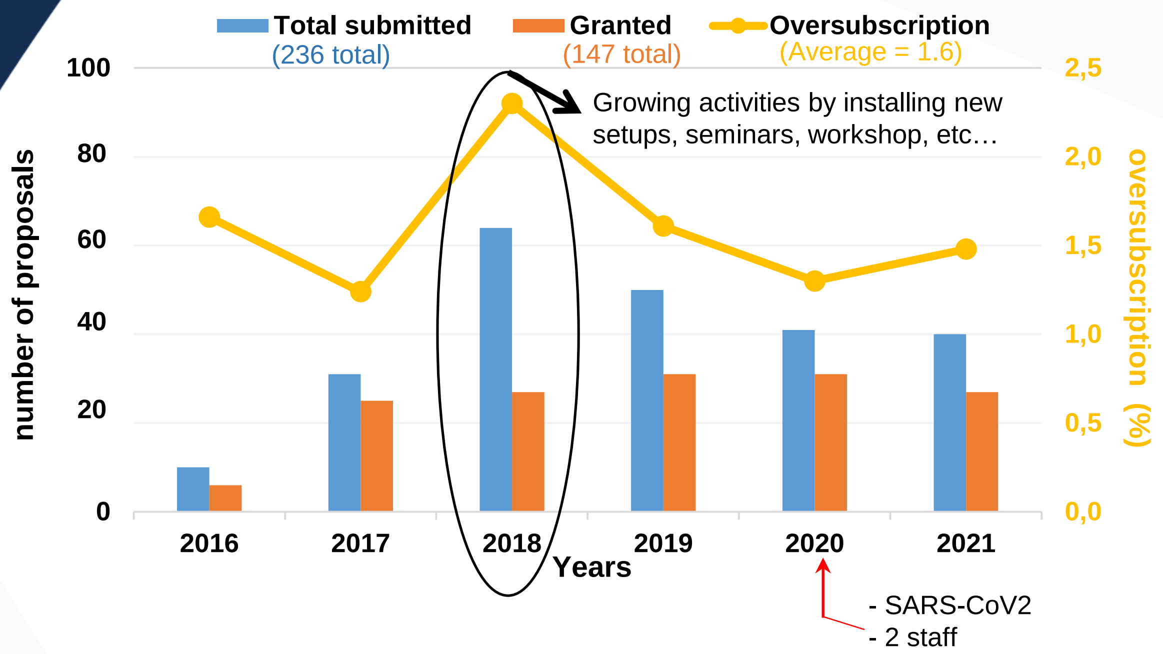
- Chemical and biochemical composition.
- Resolution up to 3x3 µm².
- Photon energy range : ~ 1.2 µm to 100 µm.

Detectors

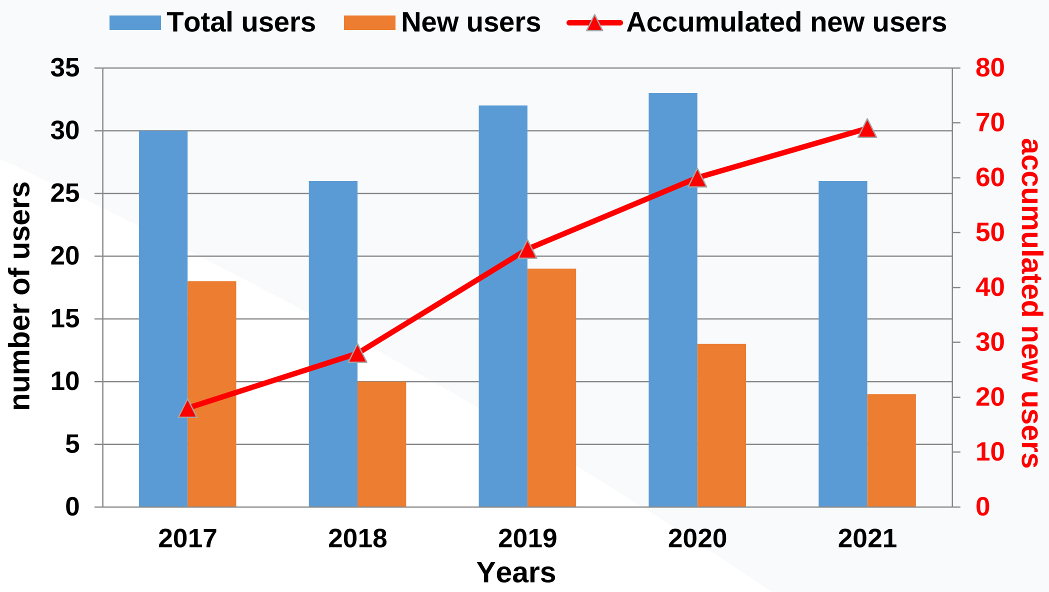
- 50 µm HgCdTe (MCT) detector (10000-600 cm^{-1})
- 250 µm HgCdTe (MCT) detector (12000-550 cm^{-1})
- 64x64 Focal Plane Array (FPA) detector (4000 – 900 cm^{-1})
- TE Cooled DLaTGS detector (12000-350 cm^{-1})
- 4.2 K Bolometer detector for Far-Infrared (10 – 660 cm-1)

Proposals and users

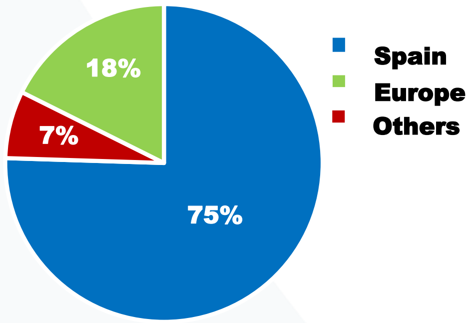
Total number of Submitted proposals



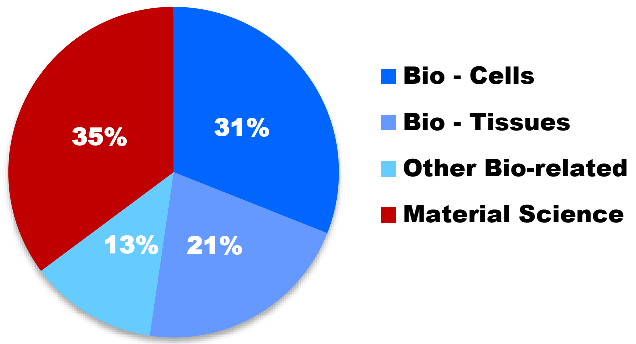
New users



Nationalities of researchers institution



Research Area

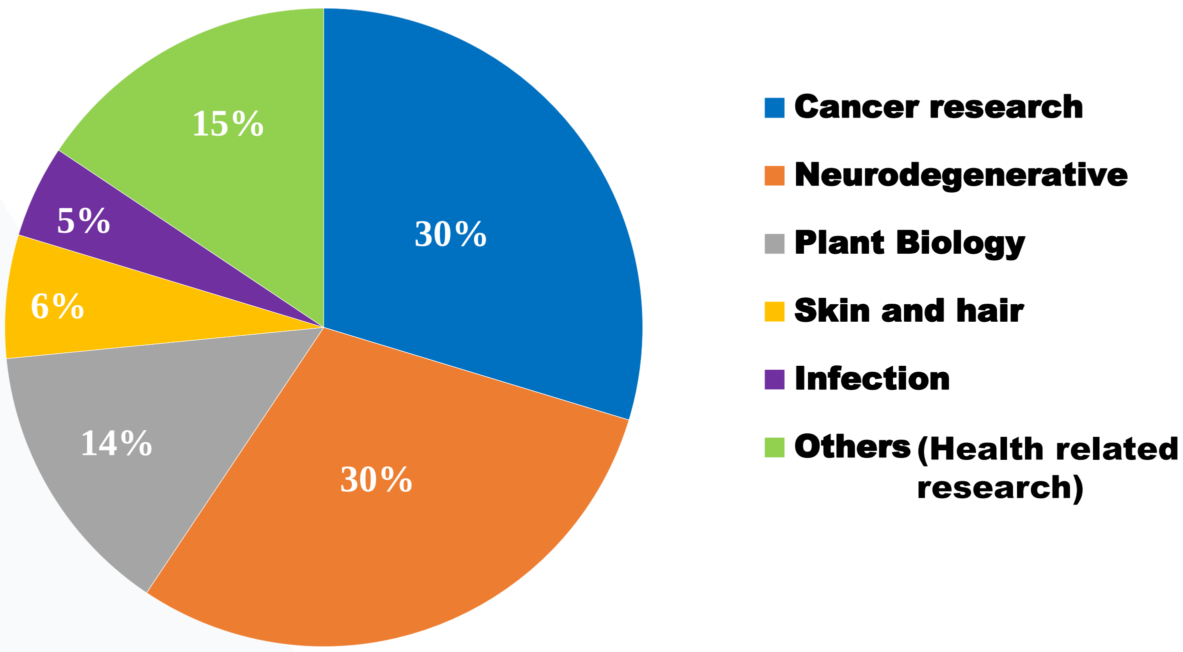


- **Proposals submission is stable since 2019.**
- **Average oversubscription rate of 1,6**
- **65% total of beamtime related to bio-science.**
- **Majority of users are from Spanish community.**
- **Growing number of new users.**

Accepted proposals from Oct 2016 until Sept 2021

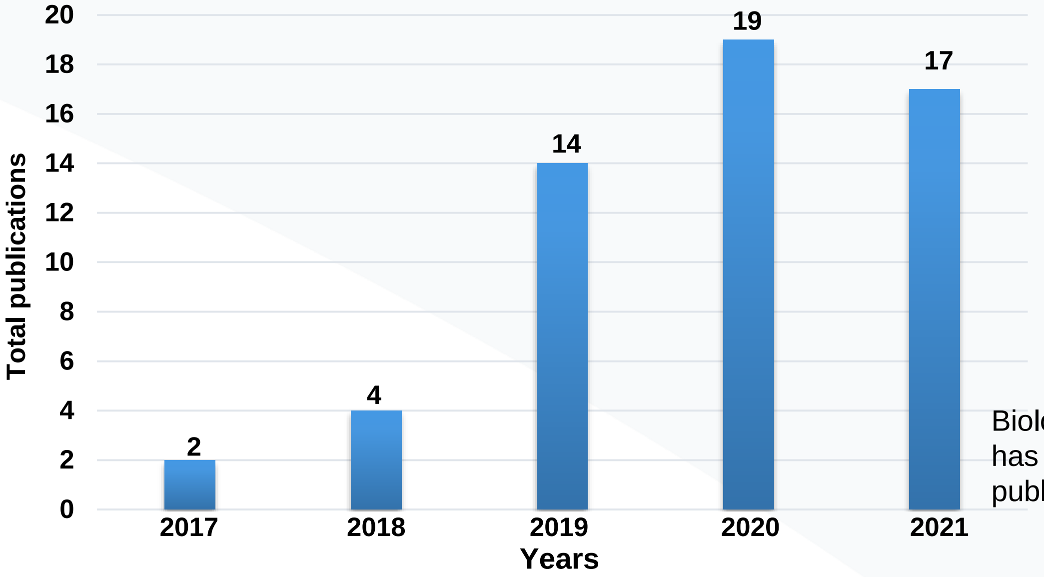
Current User Program in biology
Proposals and publications

Scientific fields in Biology and Biomedicine



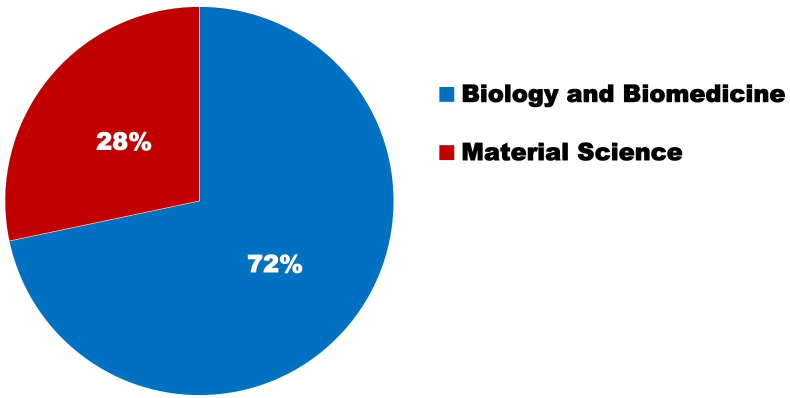
Growing number of Publications

(56 total)
Average IF = 5,5



Biological research has a long publication cycle.

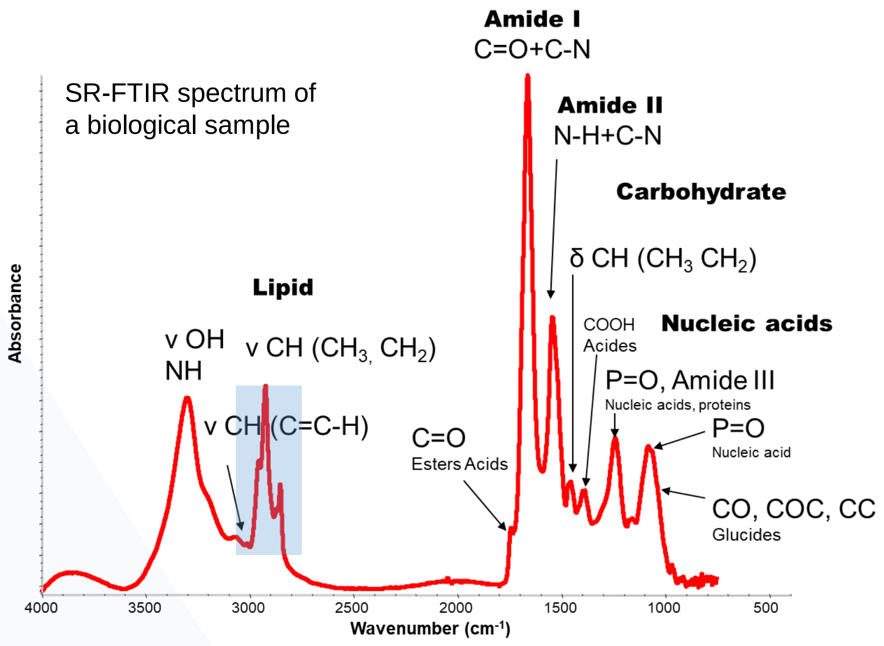
Majority of publications are emerging from biological applications



Through ALBA beamtime from 2016 until Oct 2021

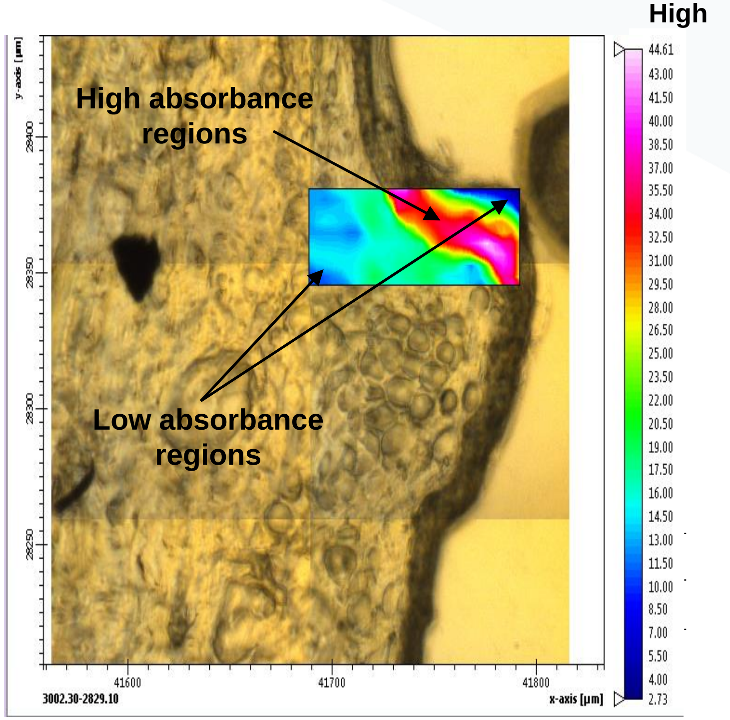
Overview of Current instrumentation – Data output

IR Spectra



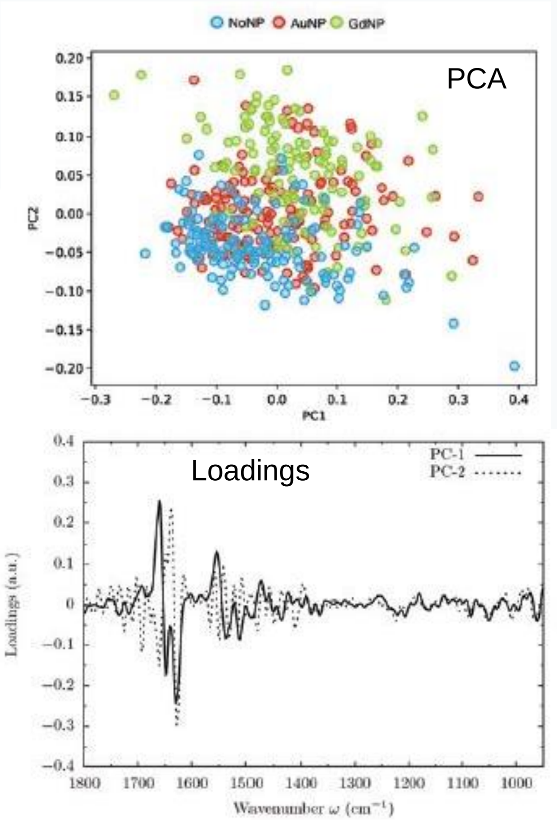
I. Yousef et al, SRN, 2017

IR Chemical imaging



V. Moner et al, AUSE, 2017

Statistical analysis PCA, HCA, etc..

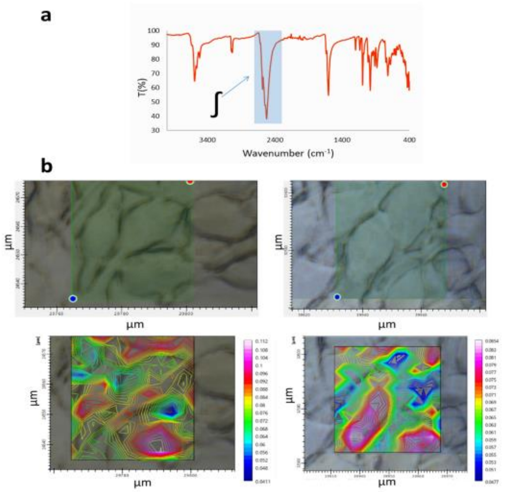


I. Martinez-Rovira et al, Analyst, 2020

- User friendly control system
- Remote Access of users to data analysis software

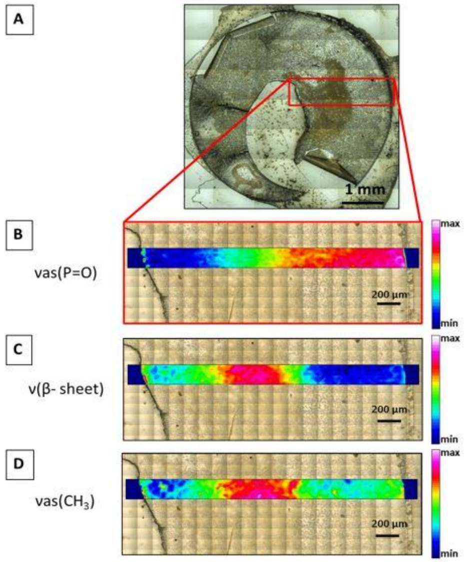
Techniques and science

A. Single cell analysis



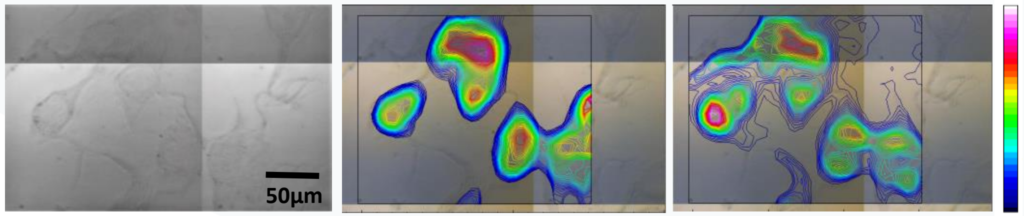
Int. J. Mol. Sci. 2021 doi.org/10.3390/ijms22189937

B. Tissue Analysis



Int. J. Mol. Sci. 2021 doi: 10.3390/ijms22105249

C. Live cells chamber (T. Ducic talk)

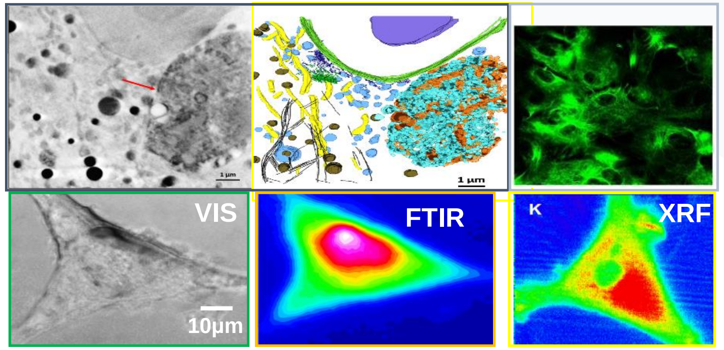


Ducic et al, 2021 (submitted)

D. Multimodal approach

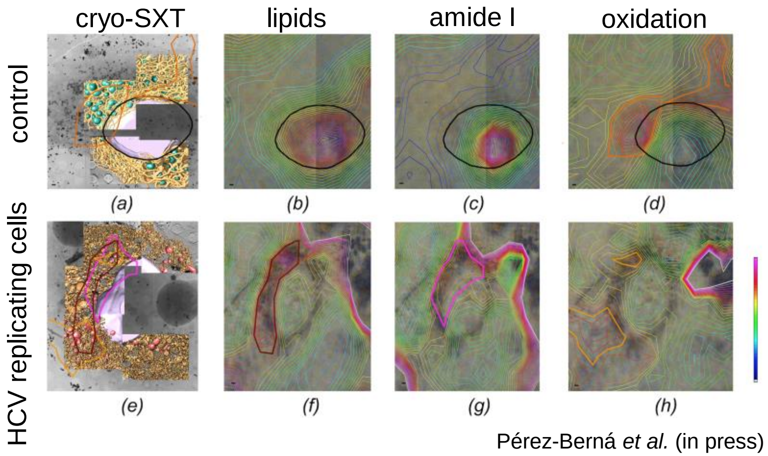
The X-ray full field microscopy

Confocal VIS microscopy



Ducic et al, Analytical Chemistry 2019

Examples of FTIR correlated to cryo-SXT



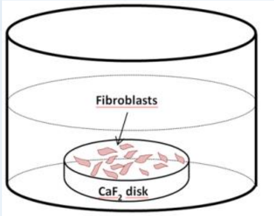
Pérez-Berná *et al.* (in press)

Overview of Current instrumentation - Sample environment

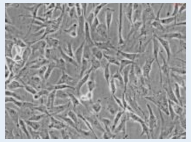
Available tools at ALBA biology lab

✓ **Cell Culture**

Cells culture medium

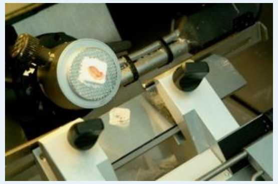


Microscopic view of the fibroblasts

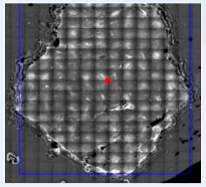


✓ **Cryosectioning**

Embedding material (paraffin)



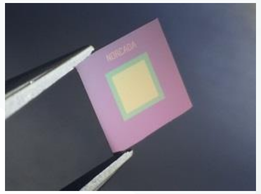
Microscopic view of the liver Cut-cross section



SR-FTIR
MIRAS BL

Soft X-ray cryotomography
MISTRAL BL

Si3N4



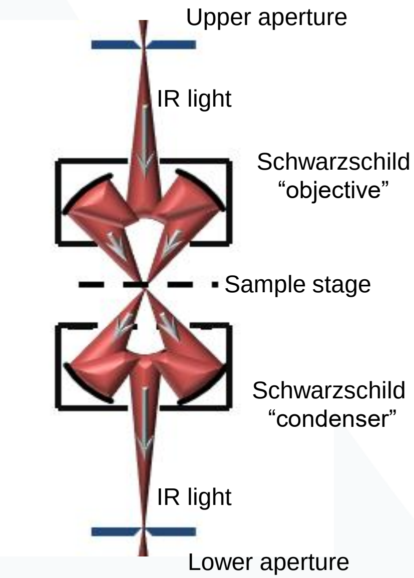
Gold grids

IR Transmission mode

95% of BT

FTIR transparent windows

CaF2, BaF2, ZnSe, ZnS, Si



2cm thick sample

~10µm thick sample (2D imaging)

X-ray Micro-tomography
FAXTOR BL

Cryo plunging
Vitrification

Soft X-ray cryotomography

Fixing or freeze drying

Live cells (under evaluation/development)

Cryo plunging
Vitrification

Reflection
Attenuated total reflection (ATR)

Limitation of Existing Instruments

(follow up is provided in the vision talk)

- **Spatial resolution** is limited by diffraction limit.
- Energy range in the **low frequency range** is limited (in air spectrometer) **60cm-1**.
- **Rapid scan** is not implemented (currently 1s/scan).
- **Working distance** under the microscope limiting the sample environment with external setups.
- **Extracting IR from 4th Generation** source is not clear.

Infrared beamline in the 4^{th} generation Machine

Challenge

- Extracting a large solid angle from the 4^{th} generation machine.
- The compactness of the proposed **lattice** and the significant reduction in the vacuum chamber diameter

Objective

Develop a new design which will allow the extraction of at least the same photon flux as the present sources.

Possible scenarios of extraction:

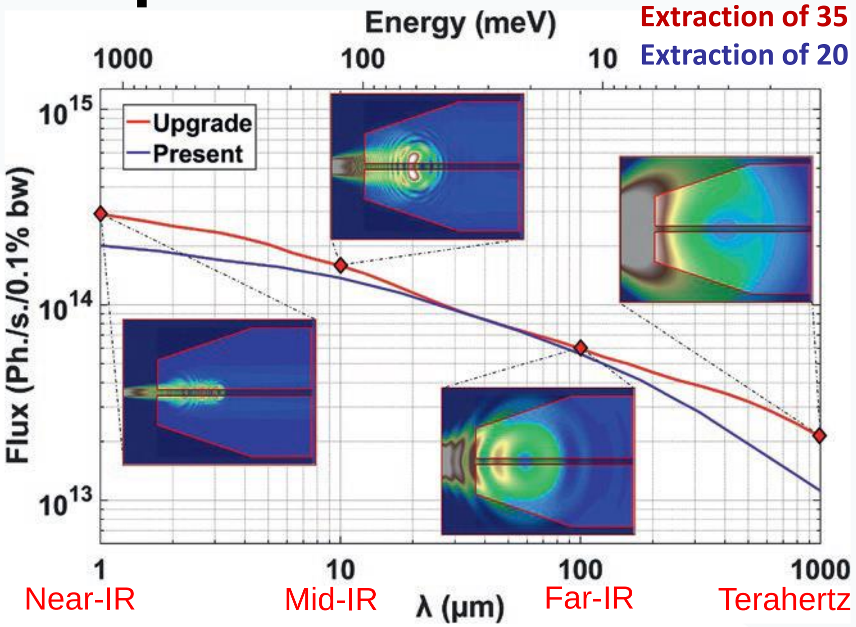
1. The extraction mirror to be placed inside the magnetic gap of the dipole magnet:
   a. The distance from the electron beam: impact the impedance and e beam dynamics
   b. The dimension of the mirror : dictate the geometry of the dipole vacuum chamber and bending magnet.

2. The extraction mirror to be placed between the dipole and the sextupole magnets

Proposed Solution at ALBA

- Machine group at ALBA are looking for different solutions for the extraction angle.
- Extraction from an ID is under evaluation/discussion.
- SRW simulations and expected performances will be carried out after defining the extraction angle.

Example: IR at SOLEIL2



A. Equal or higher extracted flux in the range 10 to 10000 cm-1.

B. The lowest energy should be extended toward the THz range.

C. The brilliance of the source is expected to be significantly higher.

D. High stability of the synchrotron source will allow performances for both FTIR spectroscopy and spectromicroscopy including Scanning Near Field Optical Spectroscopy (SNOM).

Conceptual design report SOLEIL2, 2021
https://www.synchrotron-soleil.fr/en/news/conceptual-design-report-soleil-upgrade

SWOT

Strengths

- Multidisciplinary scientific applications.
- Diversity of sample types and measurements modes
- Spectroscopic and microscopic analysis in the (Far/Mid-IR) ranges
- Collaborations and Synergies with other beamlines/techniques and resources available in ALBA

Weaknesses

- Dependency on basic instruments limits throughput and growth of the program
- Unstable users demand and long publication cycle
- Lack of complementary vibrational analysis
- Kinetics experiments not optimum
- Sophisticated sample preparation

Threats

- Extraction of IR light from 4th generation machine is not clear yet and can be under risk
- Rapid and significant development of conventional IR sources that compete with the IR synchrotron source.
- Competitive European environment.

Opportunities

- Growth of the local community of users with expertise in FTIR
- Growth of the demand from upgrades and new instruments. (Nano-FTIR, Raman,….)
- ALBA –II upgrade: enhanced brilliance of the source and performances in the Far-IR frequency
- New instruments will attract industrial projects

Thanks!