DAΦNE-Light INFN-LNF synchrotron radiation facility

Antonella Balerna

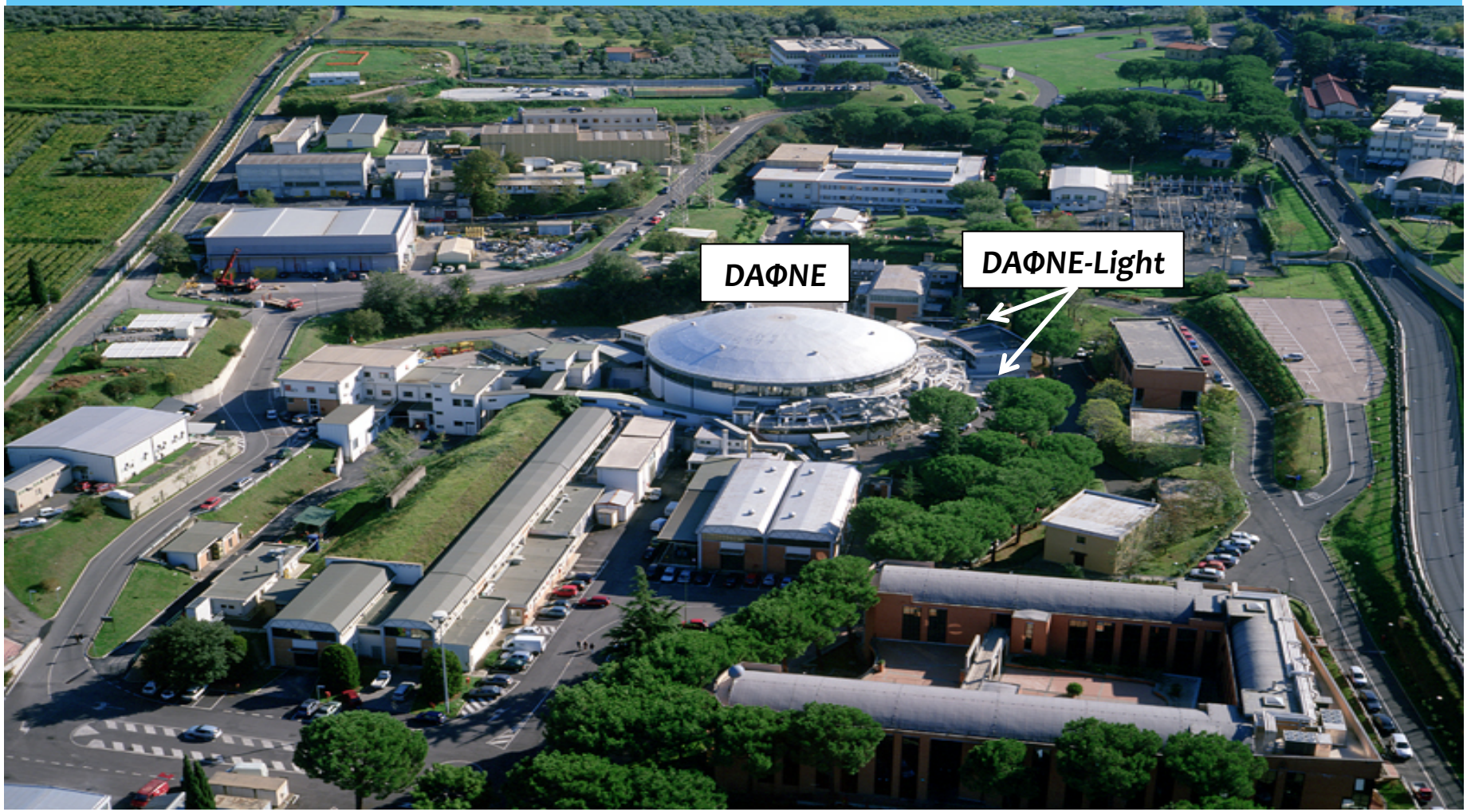
DAΦNE-Light Synchrotron Radiation Facility

INFN – Frascati National Laboratory

LNF – October 14th, 2016

DAΦNE-Light

INFN-LNF synchrotron radiation facility



Beamlines @ DAΦNE

Building 12

1) SINBAD - IR beamline (1.24 meV - 1.24 eV)

2) DXR1- Soft x-ray beamline (900-3000 eV)

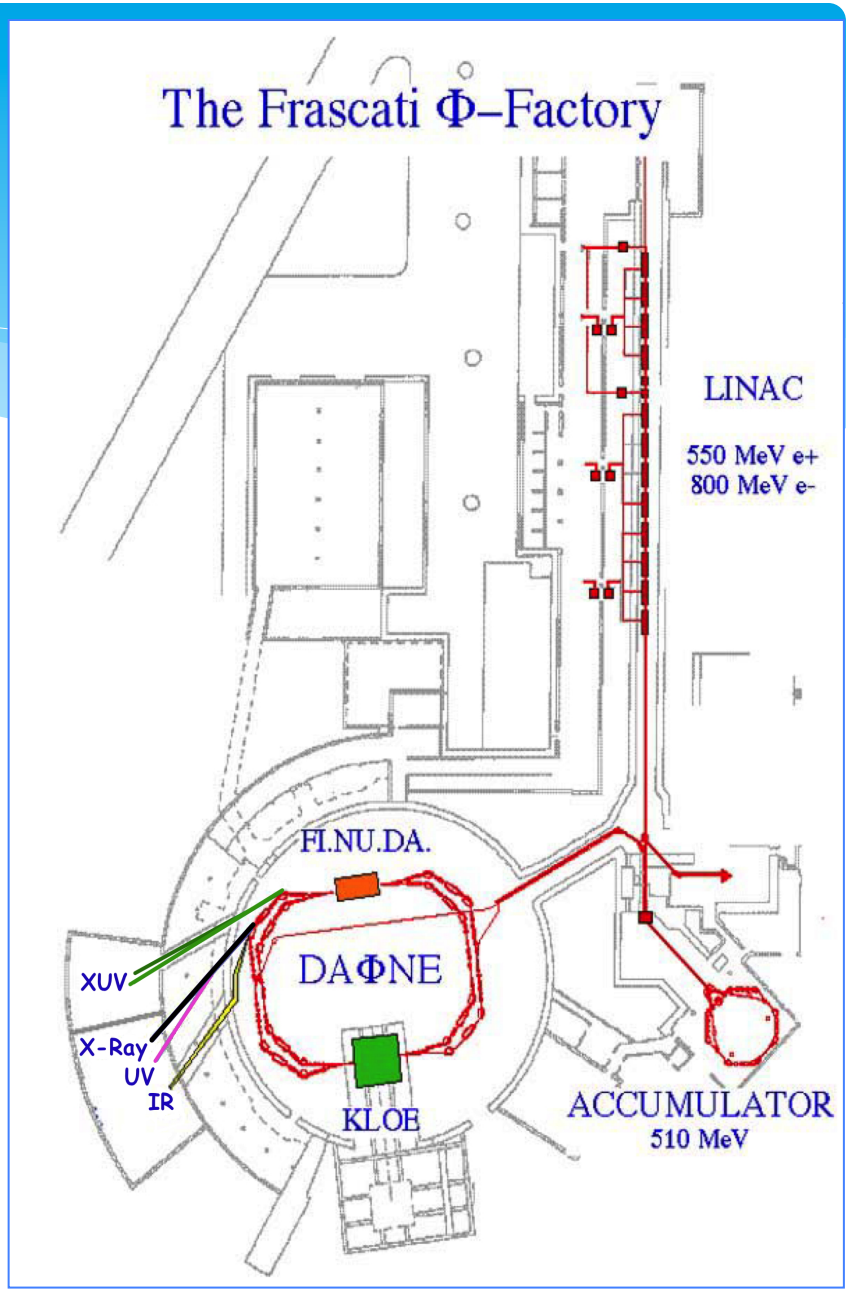
3) DXR2 – UV-VIS beamline (2-10 eV)

Building 13

XUV beamlines ongoing commissioning

4) LEB - Low Energy Beamline (35-200 eV)

5) HEB - High Energy Beamline (60-1000 eV)

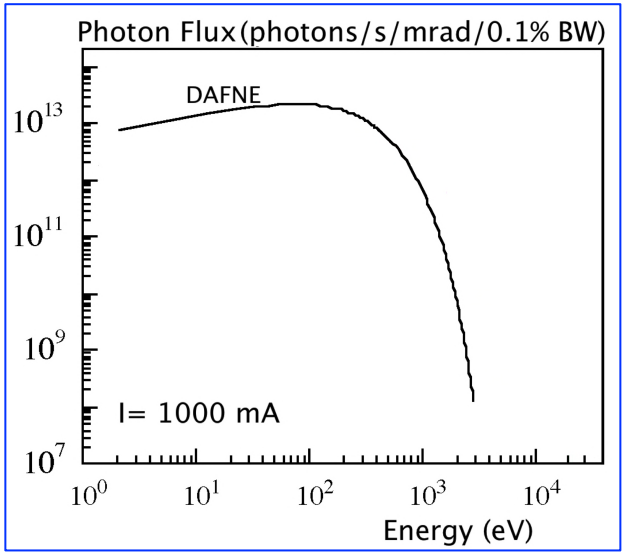


DAΦNE-Light
INFN-LNF synchrotron radiation facility

The DAΦNE accelerator complex is the largest scientific asset of the Frascati National Laboratory. ***DAΦNE-Light is a Synchrotron Light facility where material science studies can be performed but also a laboratory where new detectors and optics in a wide energy range moving from IR to soft X-rays can be tested using synchrotron radiation but also conventional sources.***

Available techniques

- ***FTIR spectroscopy, IR microscopy and IR imaging***
- ***UV-Vis absorption spectroscopy***
- ***Photochemistry: UV irradiation and FTIR micro-spectroscopy and imaging.***
- ***Soft x-ray spectroscopy: XANES (X-ray Absorption Near Edge Structure) light elements from Na to Cl***
- ***SEY (secondary electron yield) and XPS (X-ray photoelectron spectroscopy) – by electron and photon bombardment***



In **2015** more than ***50 experimental teams*** got access to the **DAFNE-Light Laboratory** coming from **Italian Universities and Research Institutions, and also from EU Countries.**

DAΦNE-Light
People involved

Scientists

SINBAD - Infrared beamline – Mariangela Cestelli-Guidi

DXR2 - UV beamline - Emanuele Pace (INFN - Univ. Fi)

DXR1 - Soft X-ray beamline - Antonella Balerna

DXUV- XUV beamlines - Roberto Cimino, Eliana La Francesca (PHD)
External collaborator: Rosanna Larciprete (CNR-ISC)

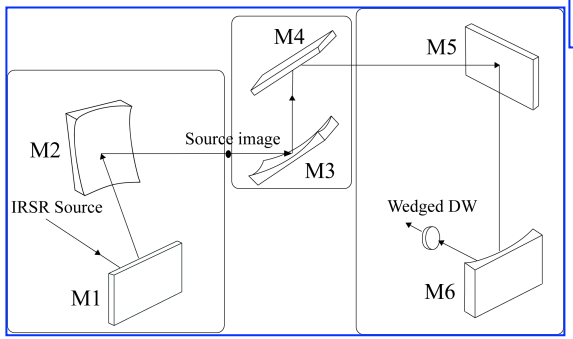
Technical staff

Antonio Grilli, Agostino Raco, Marco Pietropaoli, Vittorio Sciarra, Vinicio Tullio and *Giacomo Viviani*

SINBAD IR Beamline

SINBAD IR Beamline

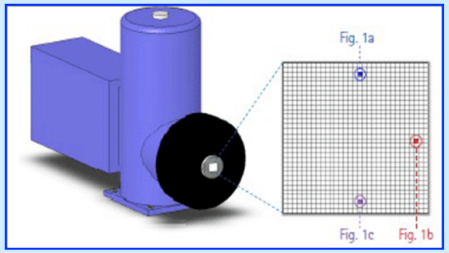
Resp. Mariangela Cestelli Guidi



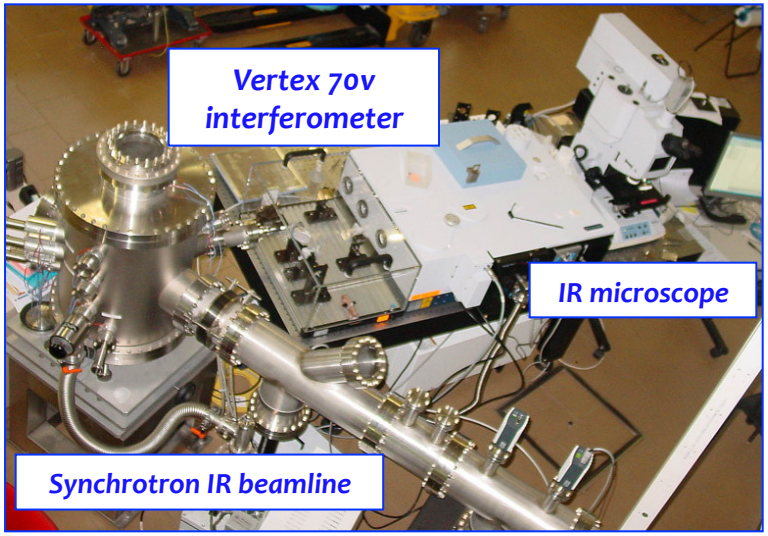
Infrared range from 10 to 10000 cm^{-1} (1.24 meV to 1.24 eV)

Some Applications

Material Science
Biology
Cultural heritage
Geophysics



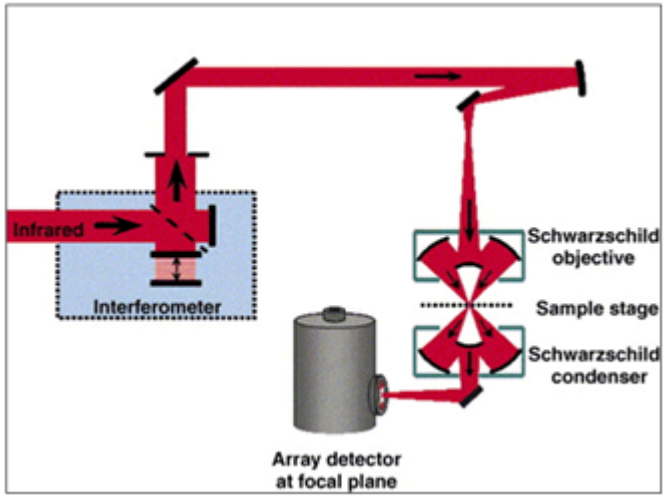
FPA- Imaging array detector 64x64 pixel

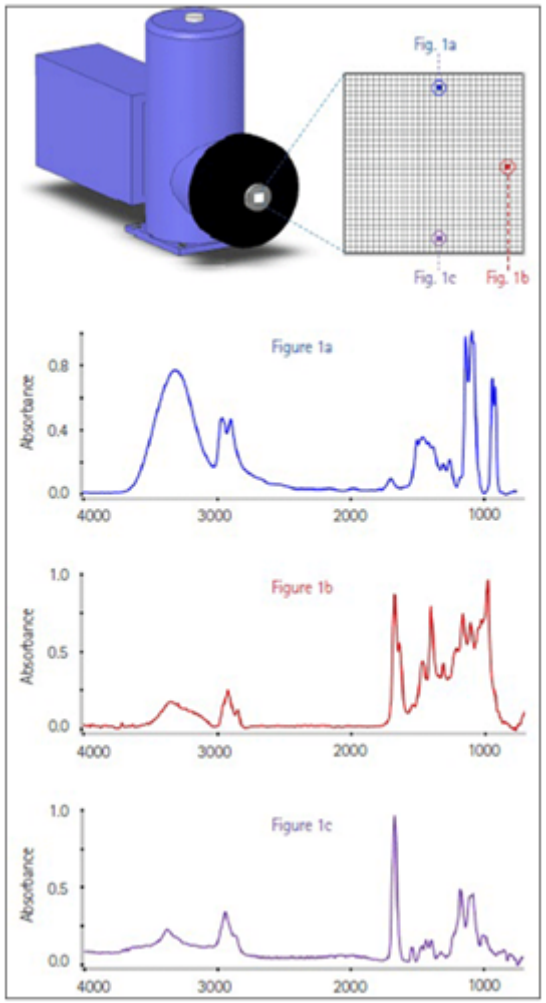


Clean-room laboratory to support sample preparation and conservation

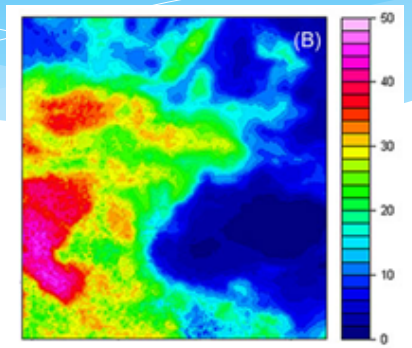
Two experimental end-stations: Equinox 55 and Vertex 70v interferometers

IR radiation and applications

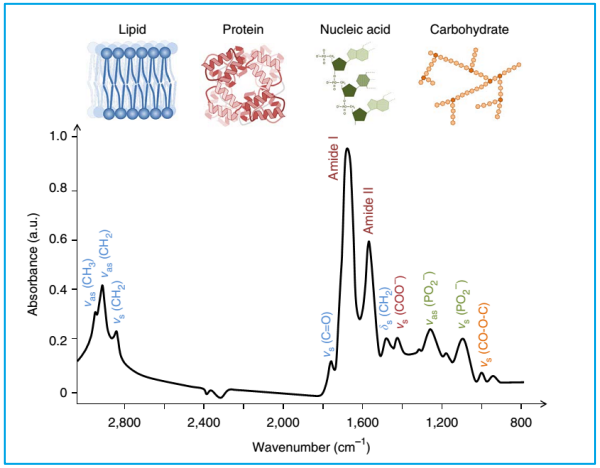




170x170 μm detector area



Chemical imaging



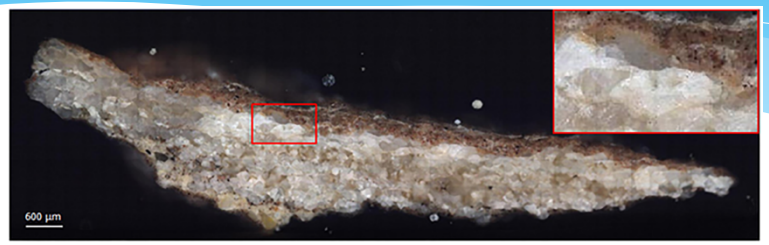
FTIR microspectroscopy

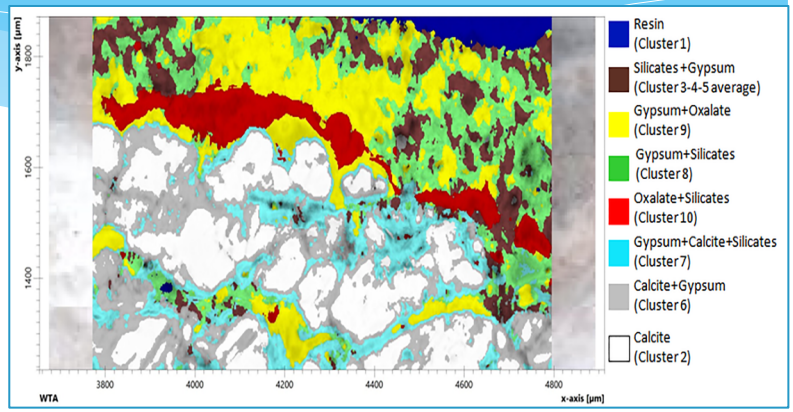
FTIR microspectroscopy applications

Cultural heritage	**Among the different analytical techniques, FTIR imaging provides information on the molecular composition of the material on a micrometric-scale in a NON DESTRUCTIVE way. Establishing the distribution of materials and that of their degradation products in historical monuments/paintings is fundamental to understand their Conservation Status and give information for Art Restoration.**
Biology	**FTIR microspectroscopy of biological CELLS and TISSUES is a rapidly growing area of biomedical research, especially, in Cancer Research. The technique sheds the brightest light on the dynamics of the molecular contents, and their changes over time. Those signs, of crucial importance for Diagnostic and/or Therapeutic studies.**
Material Science Geophysics Space related applications	**FTIR is a commonly used method for identifying either organic or inorganic materials providing specific information on molecular structure, chemical bonding and molecular environment. It can be applied to study Solids, Liquids or Gaseous samples being a powerful tool for Qualitative and Quantitative studies.**

FTIR microspectroscopy applications

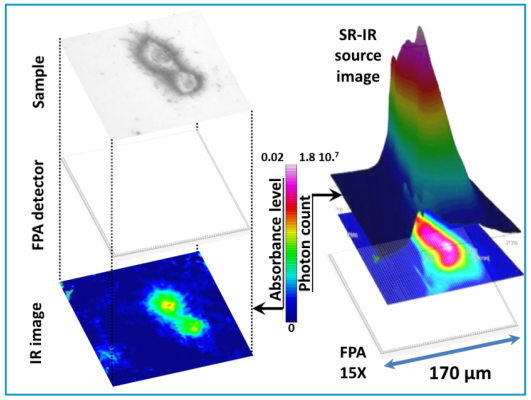
Cultural heritage

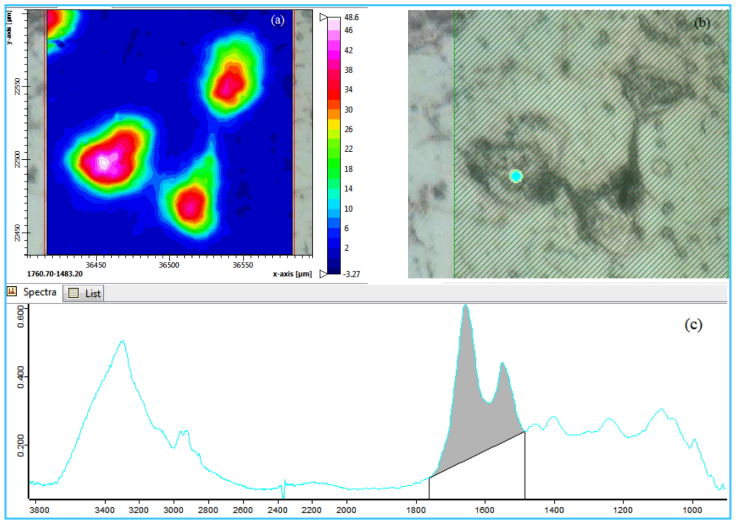




Small* fragment of Septimius Severus's Arch - *Foro Romano (III AD)* new perspectives for FTIR imaging in art conservation for the study of the distribution of different components – *M.P. Bracciale et al.

Biology and medical applications



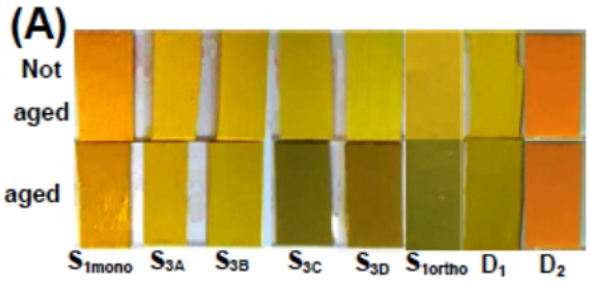


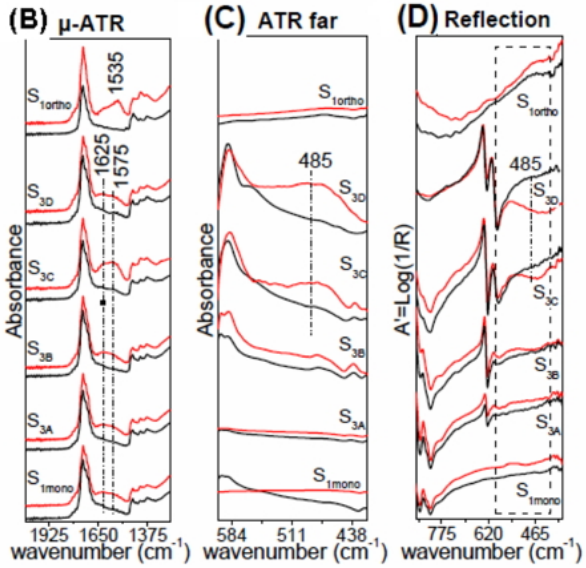
FTIR spectroscopy helps discriminating cancer cells – FTIR chemical image of a *lung cell*, representing the *spatial distribution of the protein content of the cells.* *C. Petibois – Univ. Bordeaux*

The Degradation Process of Lead Chromate in paintings by Vincent van Gogh studied by means of spectromicroscopy methods

Previous investigations about the darkening of chrome yellow pigments in Vincent van Gogh paintings revealed that their alteration is attributable to a reduction of the original Cr(VI) to Cr(III) and that the presence of sulfur-containing compounds plays a key role during this process.

In the present work it is shown how ***both the chemical composition and the crystalline structure of lead chromate-based pigments influence their stability***. For this purpose, artificially aged oil model samples made with in-house synthesized powders of $PbCrO_4$ and $PbCr_{1-x}S_xO_4$ were artificially aged and characterized. Analyses employing UV-visible diffuse reflectance and ***Fourier Transform infrared (FTIR) spectroscopy*** were performed ***on (un) aged model samples in order to obtain additional information on the physicochemical changes induced by the aging treatment***.





These results are a part of a very extended study on the darkening of yellow pigments in paintings of Van Gogh.
L. Monico et. al

DXR2 UV-VIS beamline

DXR2 beamline and applications

Resp. Emanuele Pace (Uni. Firenze)

Wiggler UV branch line-deflection by a *grazing incidence gold coated mirror* (about 2°)

UV-VIS beamline new setup *2 -10 eV* (650nm - 120nm). *Branch line in a 1000-class cleanroom*

-Space applications
-Astrobiology and photo-biology
-Optical technology
-Detector technology (Diamond detectors)
-Instrumentation testing and calibration
-Optical properties of materials

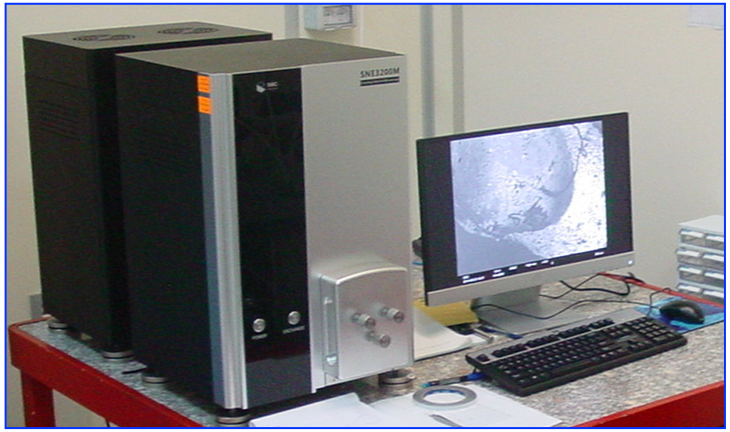
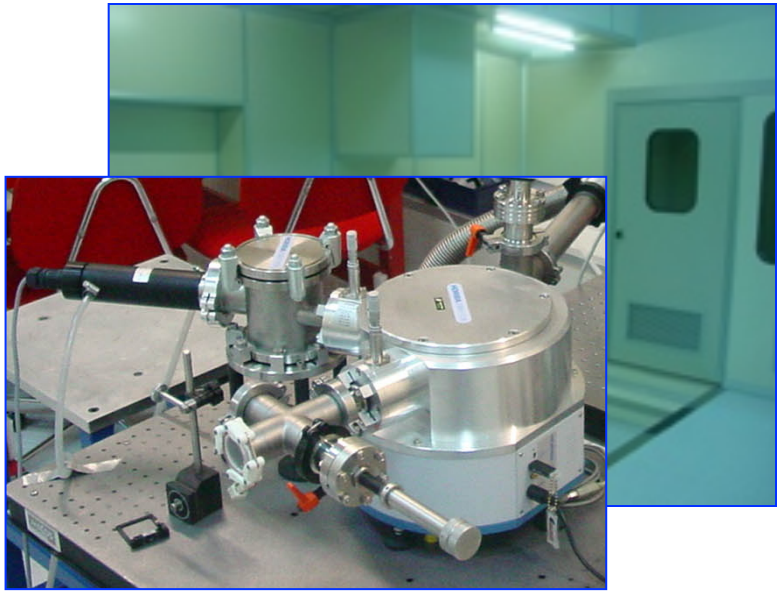
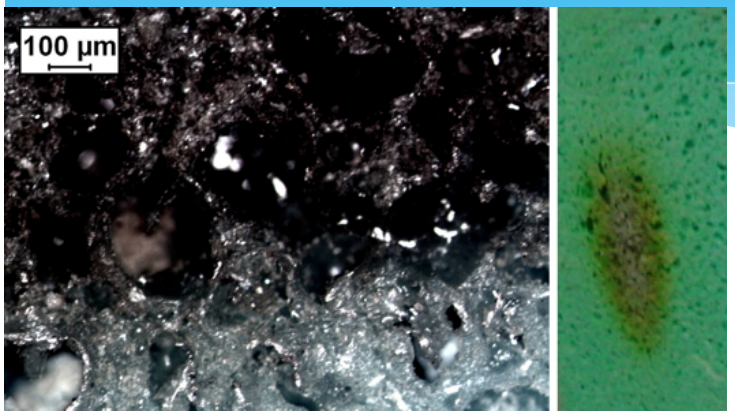


Table-top Scanning Electron Microscope (mini-SEM) with EDS to discriminate atomic elements.



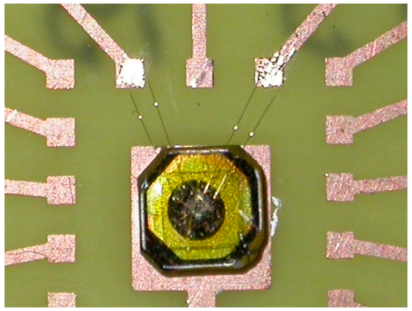
Instrumentation has been upgraded with a ***VUV monochromator*** (UVXL200 by Jobin Yvon) operating in the 120-250 nm spectral range. The other monochromator operates in the range 200-650 nm.

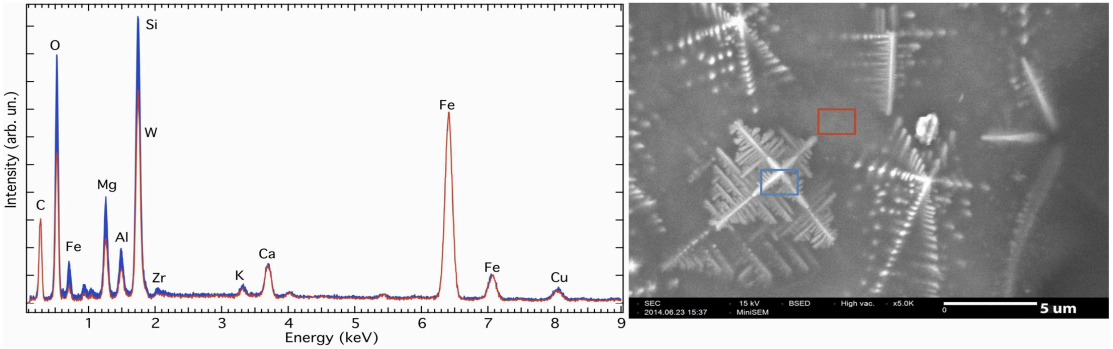
Some applications



FOAM is a new material developed for space application. Memory FOAM materials can be modified, stretched, pressed and turned, for specific applications and recover the original configuration under specific condition, generally being warmed up to 100 C. The study of this material, using UV radiation, is important to understand its behavior under solar-UV radiation in space.

DIAMONDS have high carrier mobility, wide band gap, high thermal conductivity and an extremely high radiation hardness and these properties suggest that this material is an excellent candidate for a new generation of UV detectors. This kind of detector has very low noise, due to the 5.5 eV band gap. Different diamond-based Deep UV (120-240 nm) and soft x-ray detectors have been testes in the last few years.





METEORITES studied using SEM and EDS: the blue and red squares reported in SEM microscope image correspond to the blue and red spectra recorded in the EDS analysis. The different concentrations of Fe, Al, Mg, O and C atoms in different areas of the sample confirm the formation of spinels and their iron-based structure.

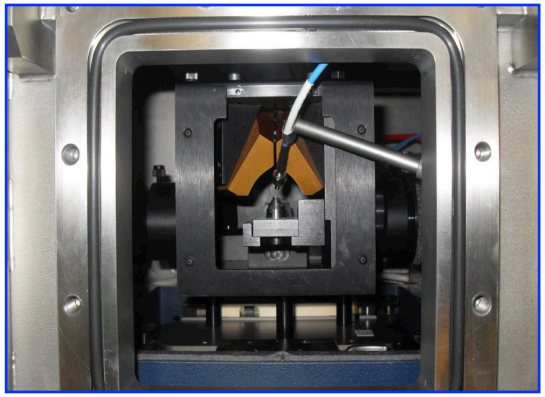
Photochemical facility

Resp. Mariangela Cestelli Guidi and Emanuele Pace

- *UV synchrotron source*
- *UV monochromator*

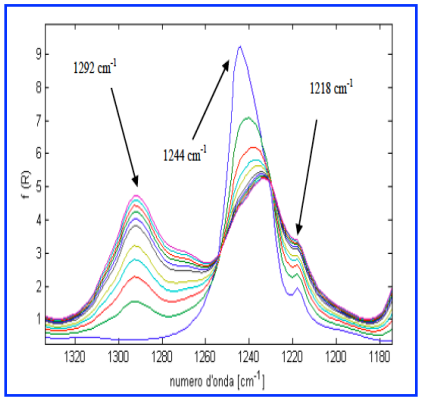
+

- *IR synchrotron beamline*
- *IR imaging detector and IR microscope*
- *Clean room to support users for biology experiment*



UV radiation transferred through solarized optic fiber.

Simultaneous study of the effect of UV damage on DNA, cells, tissues and materials



FTIR spectrum of the as-prepared (blue) and irradiated Uracil sample.

To study:

1) ***Photochemistry experiments like studies on exo-planet gasses***
2) ***Radiobiology on biological tissues***
3) ***UV aging*** of organic materials useful for ***space missions***

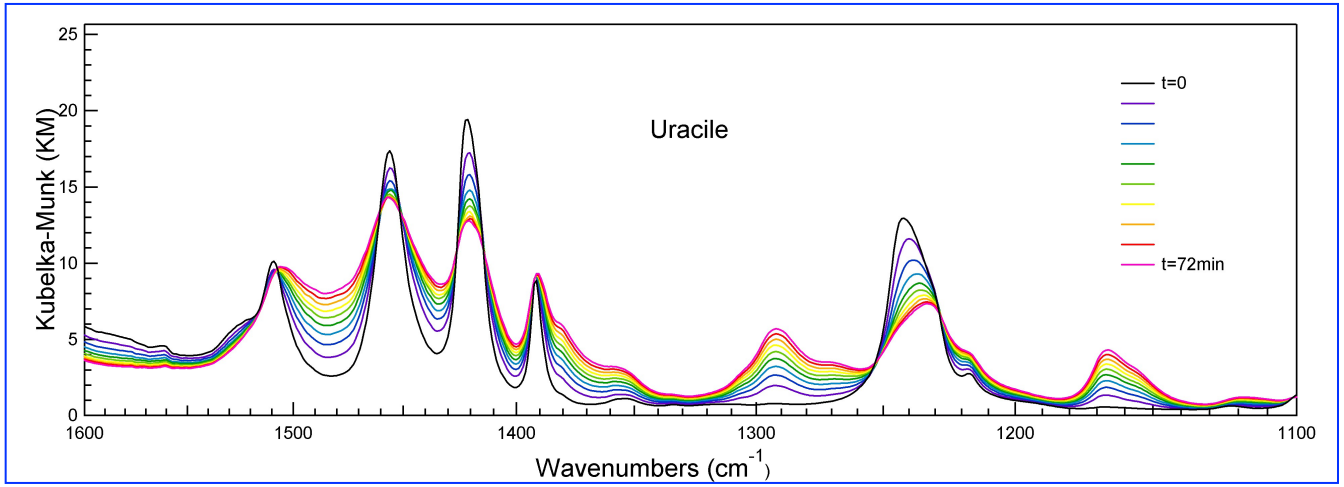
Photochemical facility

Resp. Mariangela Cestelli Guidi and Emanuele Pace

INFRARED SPECTROSCOPICAL INVESTIGATIONS ON THE EFFECTS OF UV IRRADIATION ON NUCLEOBASES ADSORBED ONTO MINERAL SURFACES: MAGNESIUM OXIDE AND FORSTERITE

Photo-chemical reactions can be analyzed in real time, letting unveil inter-phases not normally observable by analyzing the reagents and products of the reaction itself. Complex unstable systems can be irradiated and analyzed without changing the sample condition (morphology, humidity, irradiation etc.).

Nucleobases are relevant bio-molecules to investigate both in the prebiotic context, because they are ***coding components of nucleic acids***, and from the standpoint of ***the Survival of Biological Systems in Space Conditions.***

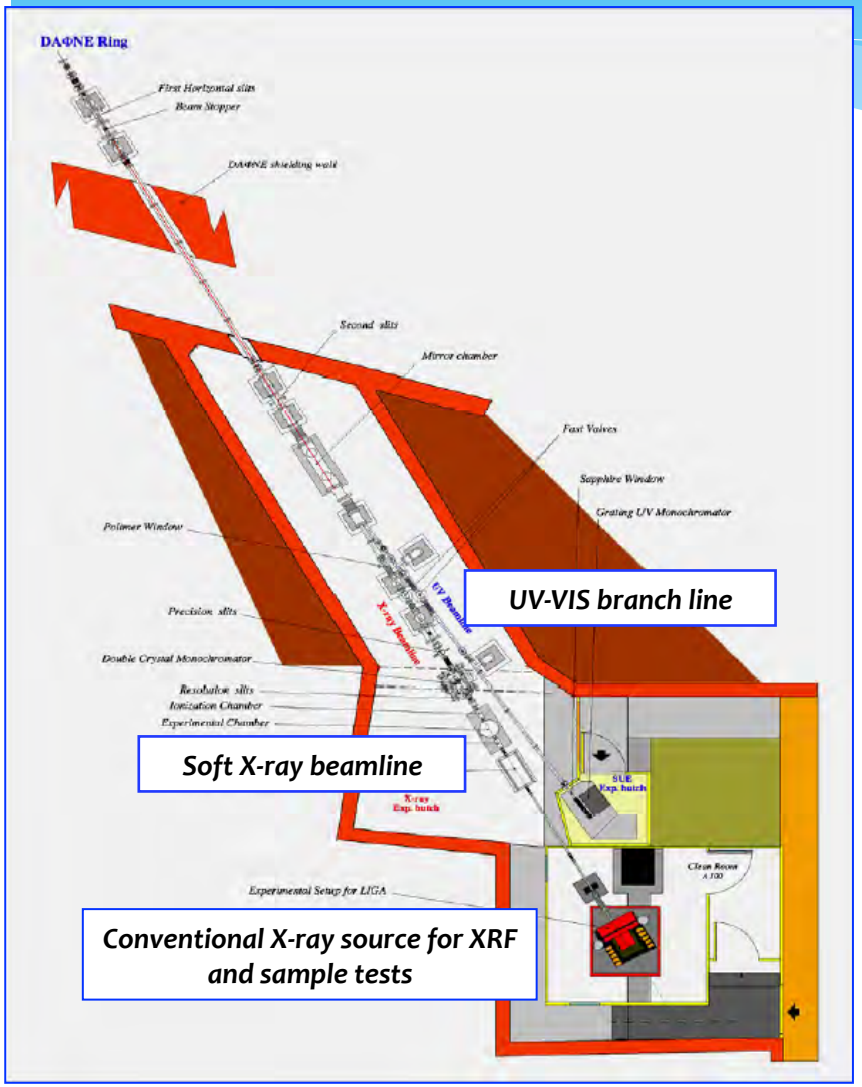


***J. of Physics* 425,** *072024 (2013),* ***Icarus* 226,** *1068 (2013)*

DXR1 soft X-ray beamline

DXR1 soft X-ray Beamline

Resp. Antonella Balerna



- *DXR1 is a wiggler soft x-ray beam line*

- Energy range *0.9 - 3.0 keV*

- **TOYAMA double crystal monochromator with KTP (011), Ge (111), Si (111), InSb (111) and Beryl (10-10) crystals**

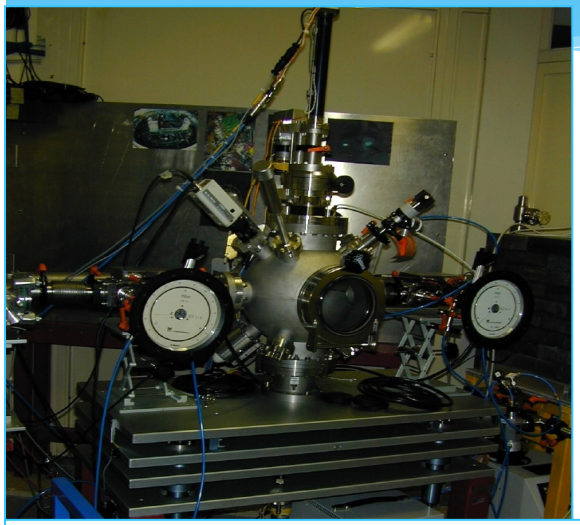
- **From 2016 working in top-up mode**

- ***Some applications: Soft X-ray absorption spectroscopy and tests of soft x-ray optics and detectors.***

The ***monochromatic photon flux*** available as a function of photon energy, crystals used and DAFNE current is between 10^7 and 10^9 ***ph/s***

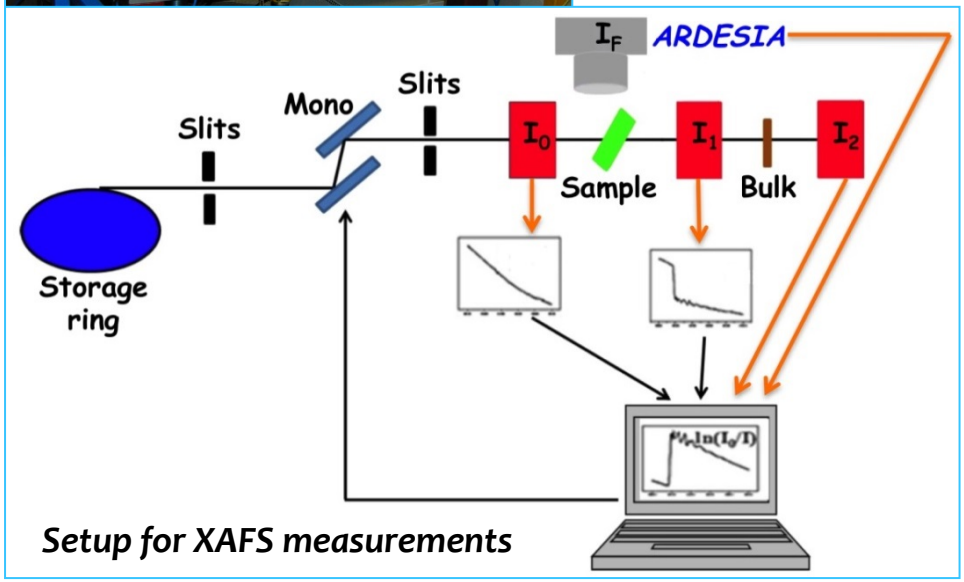
White beam for optics tests is also available.

Soft X-ray applications

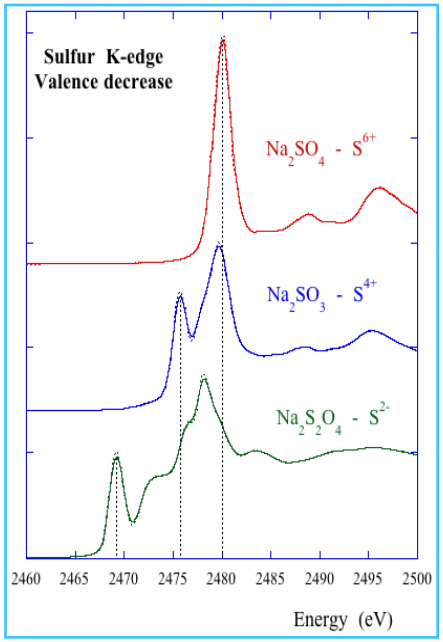


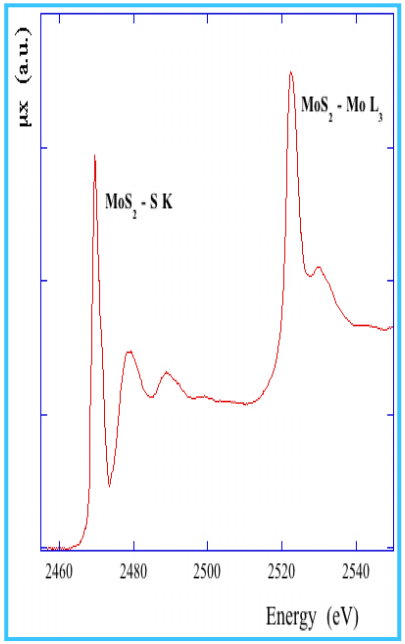
X ray Absorption Fine Structure or XAFS spectroscopy is particularly useful for investigating the electronic structure and local environment of atoms in quite different samples (solids, liquids and gasses).

At the DXR1 beamline the K absorption edges of all light elements from Na to Cl can be studied.

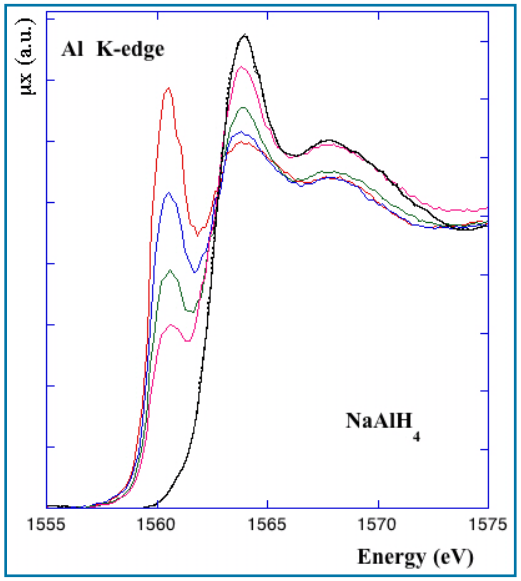


Setup for XAFS measurements

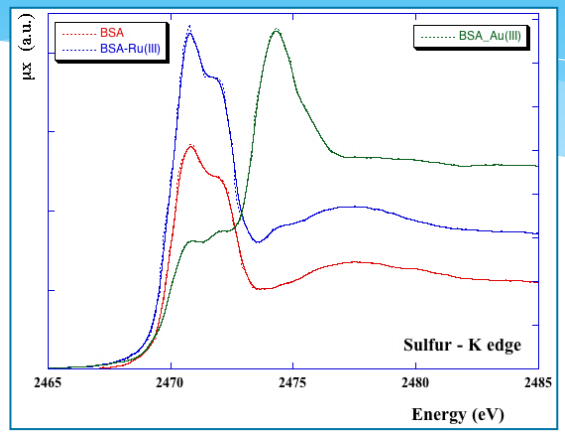




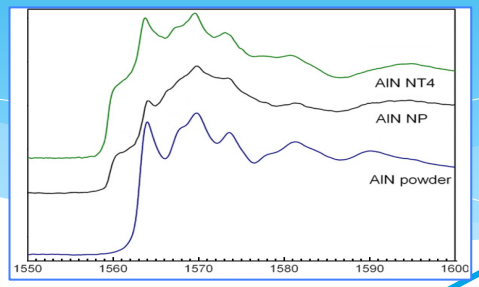
Soft X-ray applications and developments



Development of higher-efficiency hydrogen storage materials
A. Leon et al. - KIT

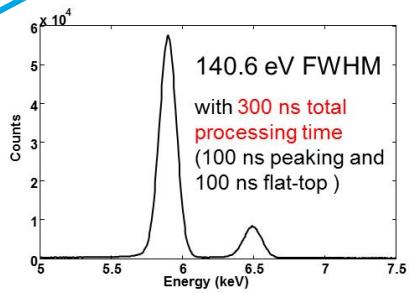


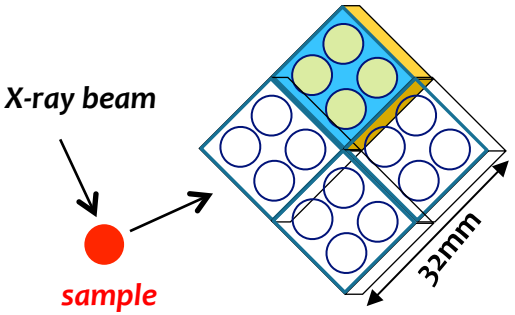
Interactions of metal-based drugs with serum proteins having biological and pharmacological implications
I. Ascone et al.



Catalysis and nanomaterial
C. Balasubramanian et al.

XAFS in fluorescence mode for studies on dilute samples and thin films on thick supports.





ARDESIA
ARRAY of DETECTORS for SYNCHROTRON RADIATION APPLICATIONS

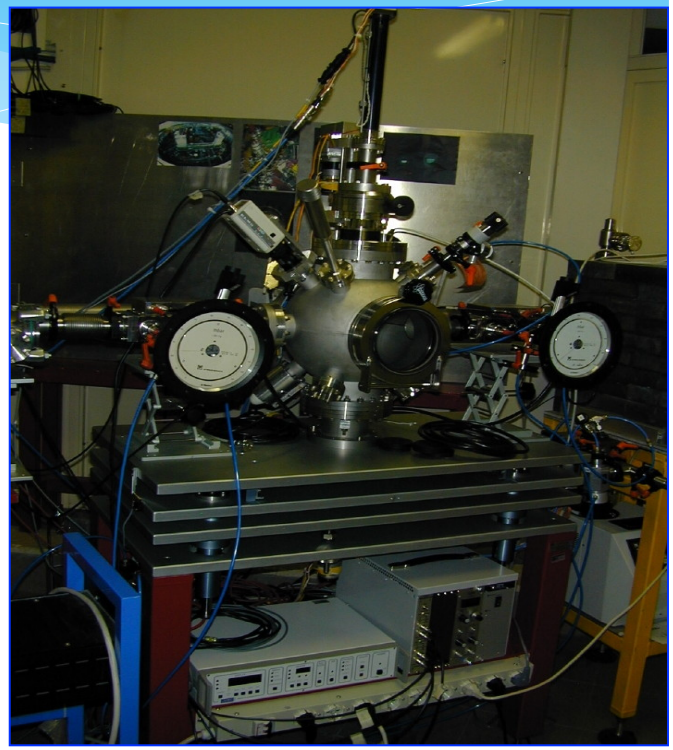
Development of a multi-element SDD detector high resolution and high count rate (INFN-CSN5).

Potentialities of using the DXR1 beamline within this collaboration

At the moment, the space to host any experimental station to use monochromatic light is strongly limited to about a 1 m^3, so at present it would be impossible to host any beam pipe or sample longer than 50 cm.

The beamline as it is designed, has no focusing mirrors, so that the photon fan diverges and looses density along its path.

This beamline, at the present stage, can only host a setup allowing the future collaboration to measure with monochromatic light from 900eV to 3000 eV or with white beam of moderate intensity.

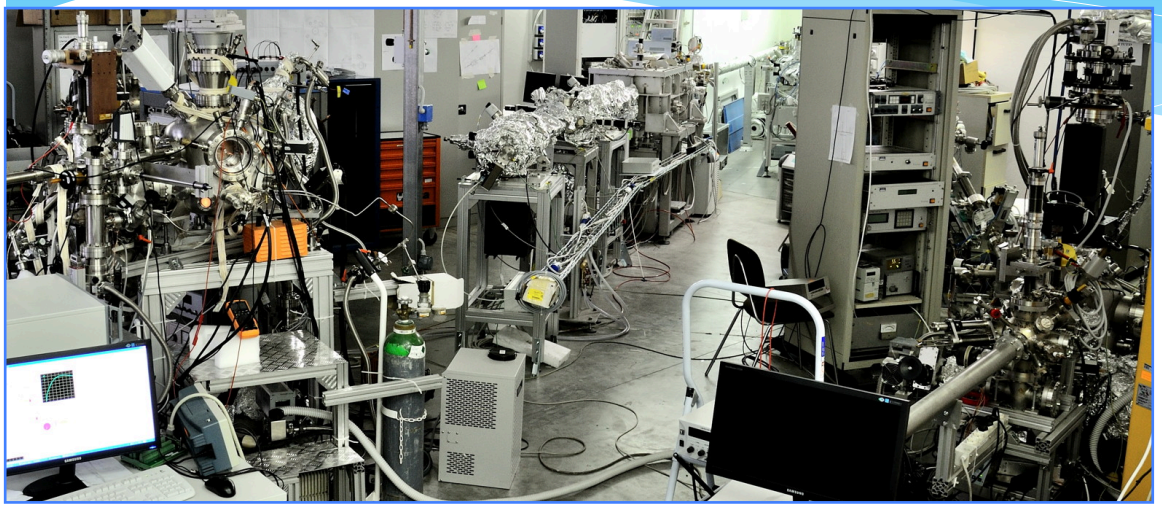


To access to the full wiggler spectrum containing all energy photons one should remove the Be window and upgrade all the beamline to UHV condition.
Anyway, if needed, a dedicated set up not UHV, could be designed and constructed to measure Reflectivity and Photo Yield in the available photon energy range, eventually on cold samples of reduced size.

XUV beamlines

XUV beamlines

Resp. Roberto Cimino



LEB (35-200 eV)
under commissioning

HEB (60-1000 eV)
under commissioning

Fields of interest:

Material Science

R&D studies of INFN interest

More details in the talks of Rosanna Larciprete and Roberto Cimino

In the same laboratory also a **micro-Raman** XPLORA instrument is installed.

DAFNE-Light and EU Projects

In 2016 we participated to the **submission of 2 EU projects:**

- CALIPSOplus (**Transnational Access of EU Users**) 

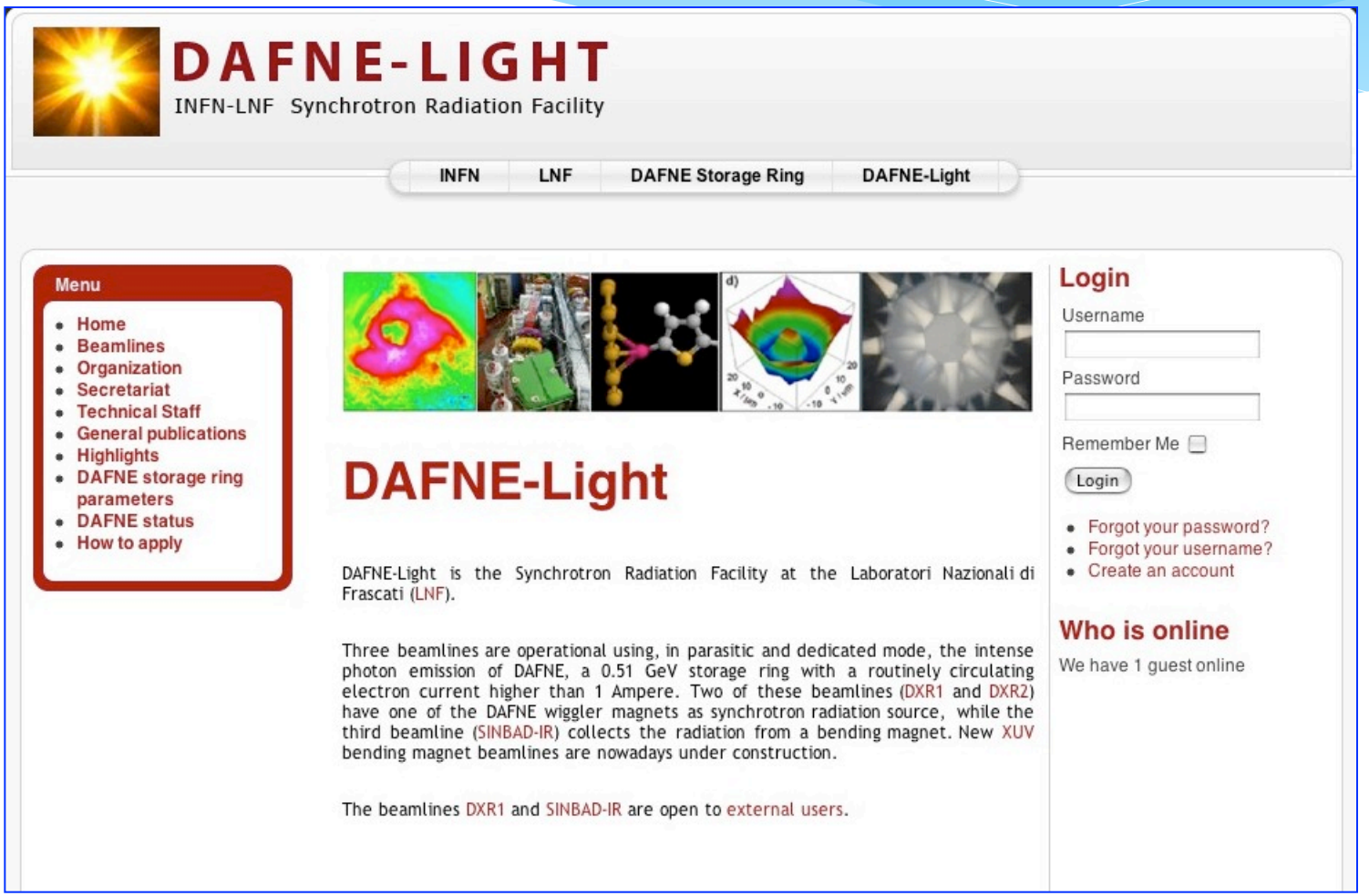
- OPEN SESAME (**training** of people involved in the **SESAME light source in Jordan** and **organization of a IR school** for Middle East users)

both EU projects will be financed between the end of 2016 and 2017 (info received in September 2016).

From ***June 2015*** the ***Synchrotron Radiation Service*** has been involved in the ***WP 4 of the EU project EuroCirCol*** (**R. Cimino**) focused on **issues related to cryogenic vacuum systems and their stability upon photon, electron and/or ion irradiation.**

More information on the DAΦNE- Light facility

http://web.infn.it/DAFNE_Light



Thank you for your attention