

DAΦNE-Light

INFN-LNF Synchrotron Radiation Facility



Antonella Balerna



48th LNF Scientific Committee - November 13th, 2014

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- New XUV beamlines - Roberto Cimino - External collaborator: Rosanna Larciprete (CNR-ISC)

Technical staff - Servizio LDS

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

Beamlines @ DAΦNE

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

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

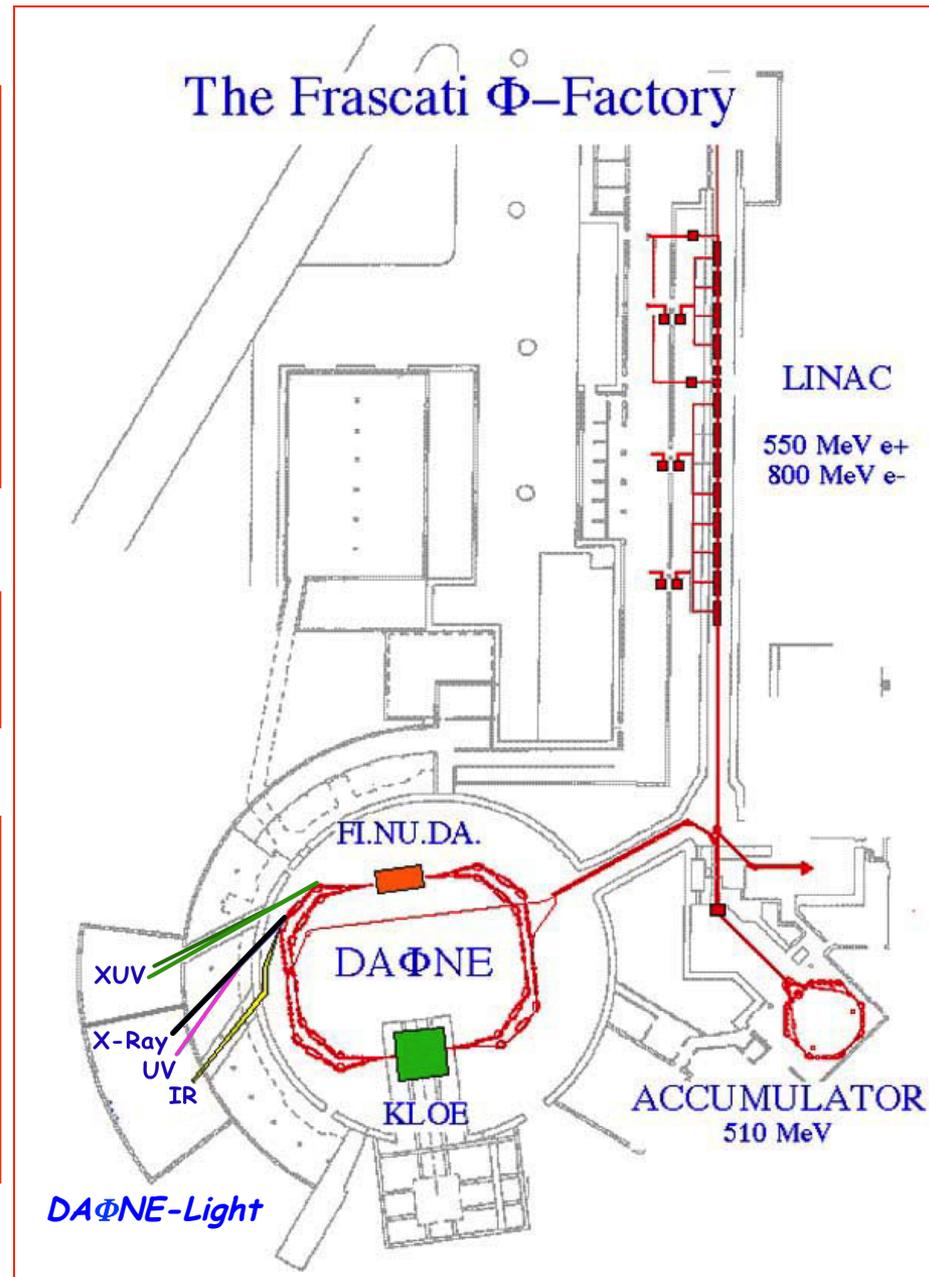
Open to Italian and EU users

3) **DXR2 - UV-VIS beamline** (2-10eV)
new setup.

2 new XUV beamlines

4) **Low Energy Beamline** (35-200 eV)
ready for commissioning;

5) **High Energy Beamline** (60-1000eV)
ready for commissioning.



Available techniques

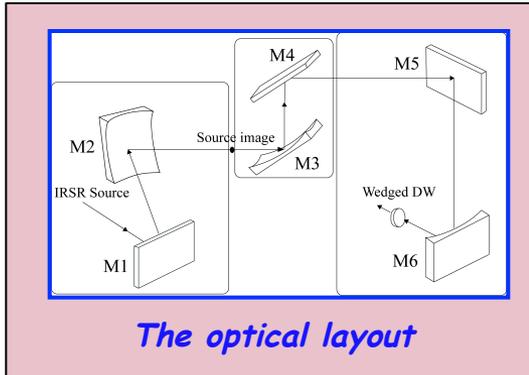
- *FTIR spectroscopy, IR microscopy and IR imaging*
- *UV-Vis absorption spectroscopy*
- *Photochemistry: UV irradiation and FTIR micro-spectroscopy and imaging.*
- *Soft x-ray spectroscopy: XANES (X-ray Absorption Near Edge Structure) light elements from Na to S*
- *SEY (secondary electron yield) and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

SINBAD -IR beamline

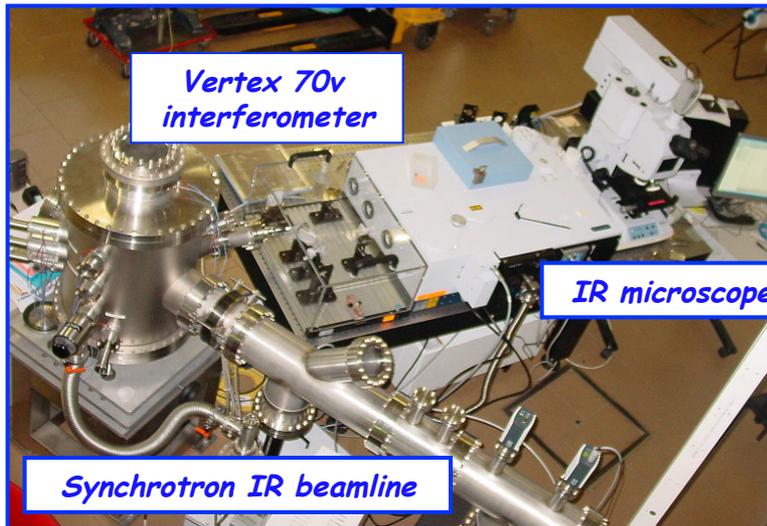
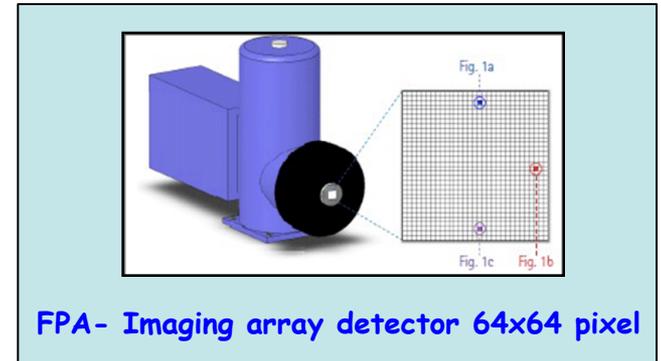
SINBAD IR beamline

Resp. Mariangela Cestelli-Guidi - Gihan Mohamed (CALIPSO 1 year)

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



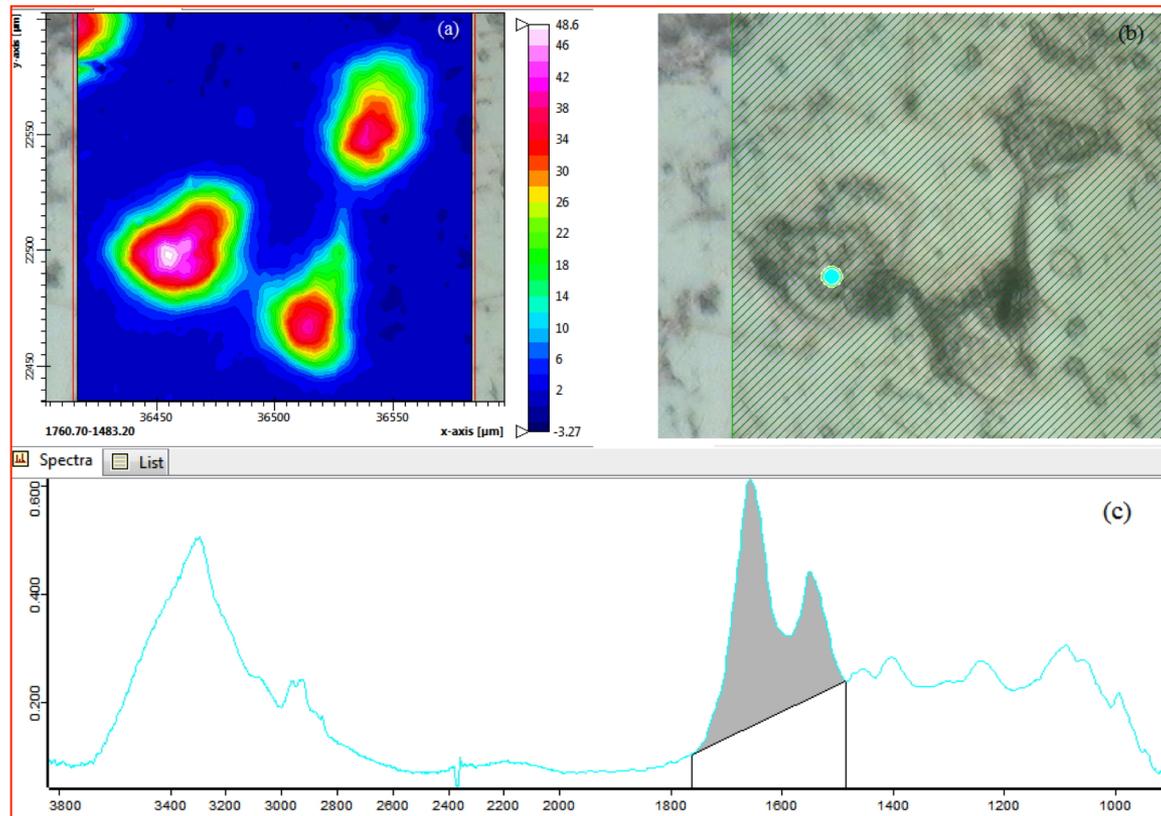
Some Applications
Material Science
Biology
Cultural heritage
Geophysics



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

SR-FTIR imaging of single cell/fiber interaction for recognition of amphibole-related lung pathogenesis

Synchrotron radiation-FTIR used for the acquisition of high-quality spectral images from cells with the aim to analyze specifically *the extracellular matrix (ECM)* of lung cells facing the presence and toxicity of long fibers in their environment, which represents a *major biochemical aspect of fibrosis development in asbestosis*. ECM is difficult to analyze using conventional cell biology due to its molecular composition. *The use of SR-FTIR allows to describe the molecular composition of ECM and its changes over time when the cell produces specific ECM for trapping toxic fibers.*

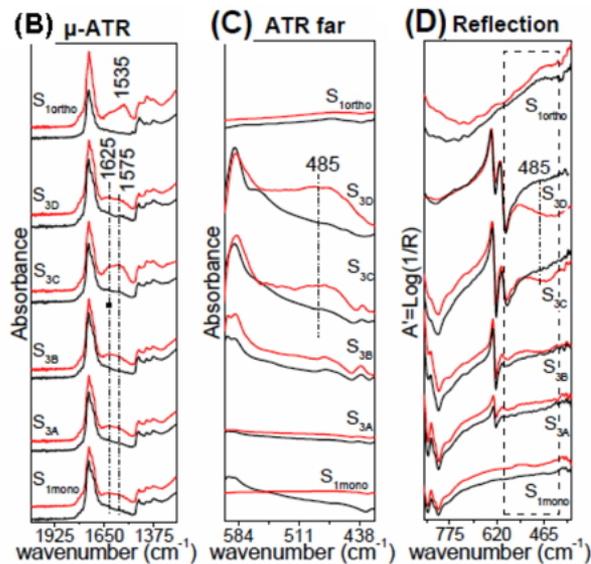
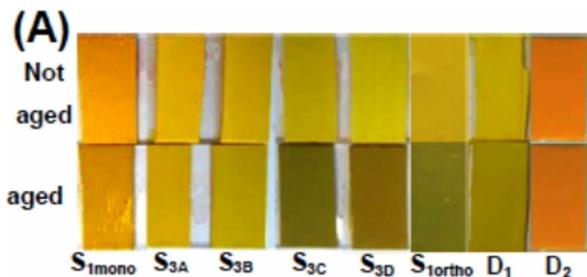
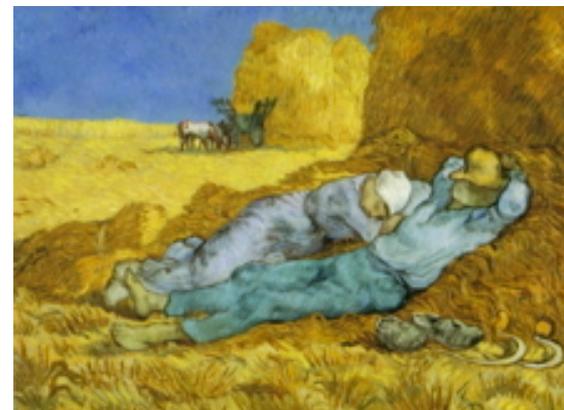


FTIR chemical image of a *lung cell*, representing the *spatial distribution of the protein content of the cells*.
C. Petibois - Univ. Bordeaux - CALIPSO 2014

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 $\text{PbCr}_{1-x}\text{S}_x\text{O}_4$ 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 yellow paintings of Van Gogh: *Anal. Chem.* **85**, 860 (2013)

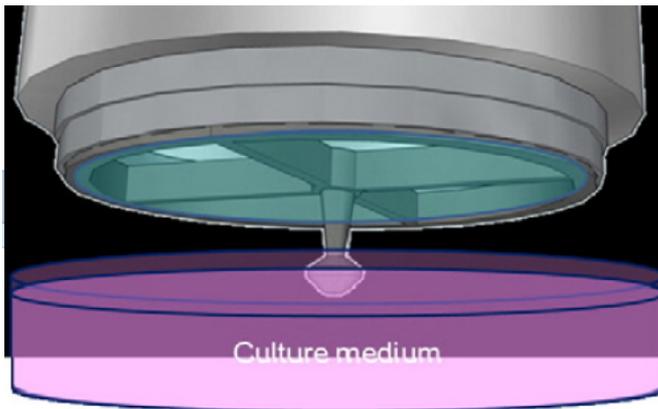
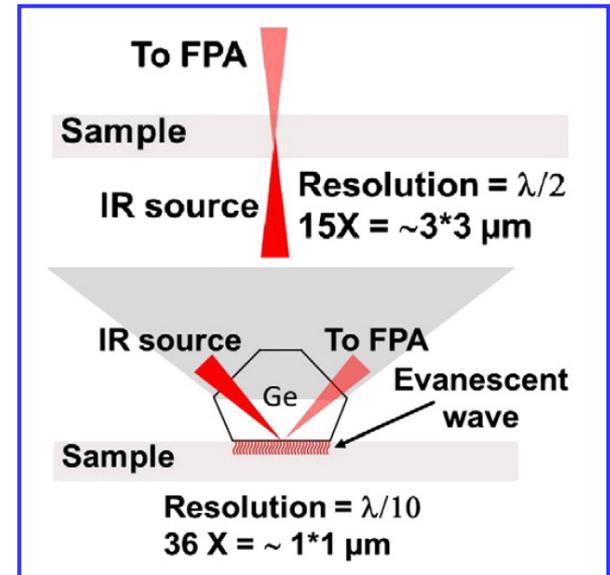
Experimental ATR device for real-time FTIR imaging of living cells using brilliant synchrotron radiation sources

An original *Attenuated Total Reflection (ATR)-based device designed for an IR microscope coupled to a FPA detector and optimized for in-vivo cell imaging has been designed and tested.*

The device includes a manually removable Ge-crystal that guarantees an *ease manipulation during the cell culture and a large flat surface to support the cell growth and the required change of the culture wells.*

This layout will allow performing sequential ATR IR imaging with the crystal immersed in the culture wells, minimizing contributions due to water vapors in the optical system and protecting the the ATR objective with hydrophobic membrane.

Using existing brilliant synchrotron radiation sources this ATR device may collect images at the surface of the Ge crystal at a sub-cellular spatial resolution with a penetration depth of the evanescent wave inside the sample of ~500 nm within few seconds.



UV-VIS beamline

DAΦNE UV branch line

Resp. Emanuele Pace (Univ. Fi.) - Marco Angelucci (Postdoc. 1 year)

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
- Instrumentation testing and calibration
- Optical properties of materials



Table-top Scanning Electron Microscope (mini-SEM)



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

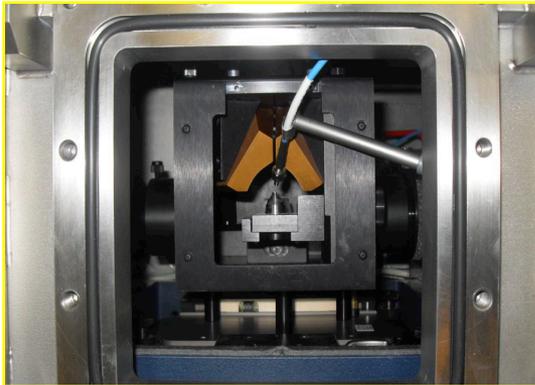
UV and Infrared (IR) radiobiology synchrotron radiation facility

Resp. Mariangela Cestelli-Guidi and Emanuele Pace

- UV synchrotron source
- UV monochromator

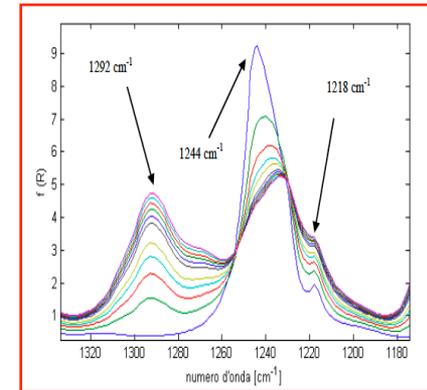


- IR synchrotron beamline
- IR imaging detector and IR microscope
- Clean room to support users biology experiment



UV radiation transferred through solarized fiber optics

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:

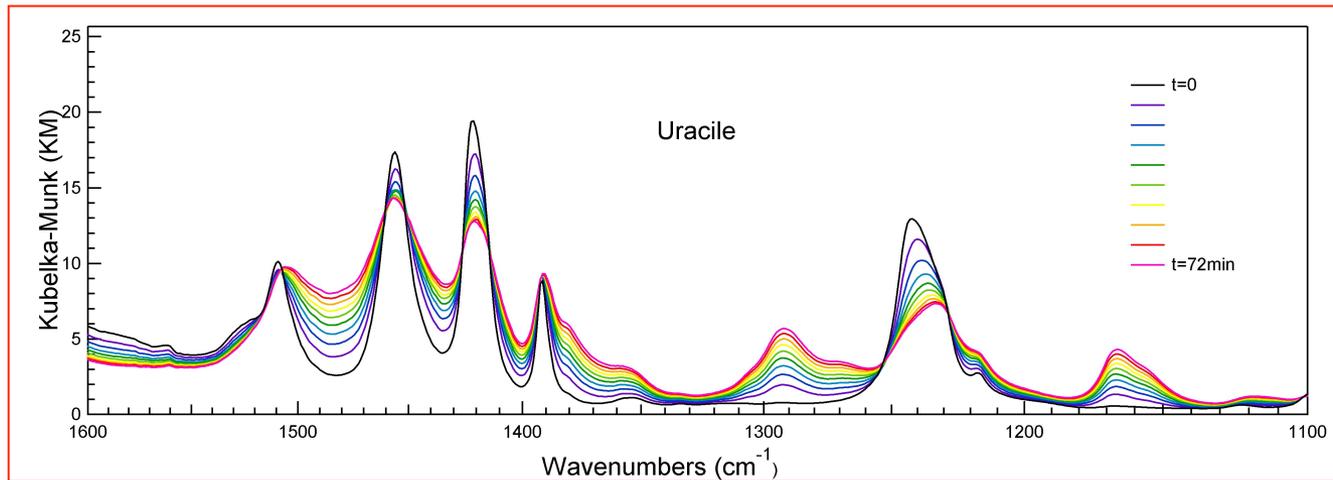
- 1) Photochemistry experiments like studies on exo-planet gasses
- 2) Radiobiology on biological tissues
- 3) UV aging of organic materials useful for space missions

Photochemical facility

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.



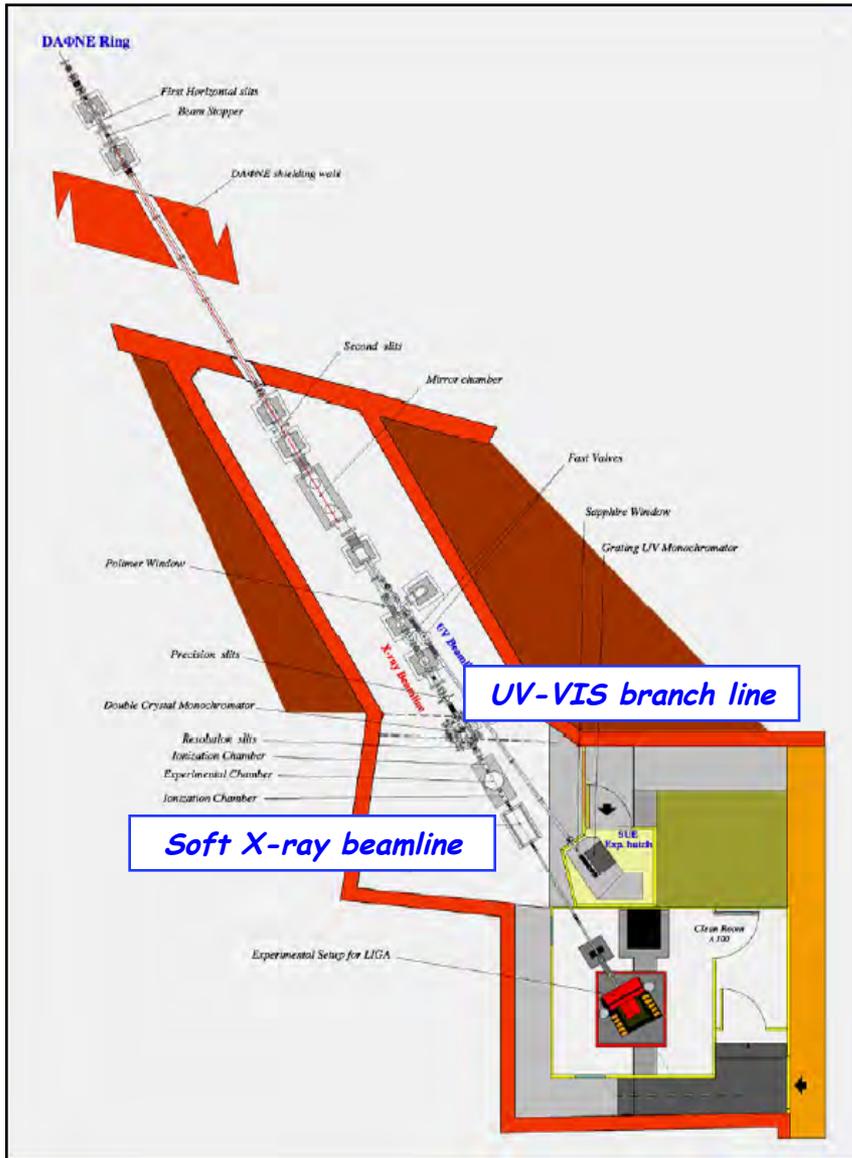
J. of Physics 425, 072024 (2013), Icarus 226, 1068 (2013)

Exo-Biosphere's Evolution and Biosignature Characterization with FT-IR Spectroscopy - Thesis: Debora Schierano - Univ. Firenze, in collaboration with: Dip. Biologia-Univ. Tor Vergata and INAF IAPS

Soft X-ray beamline

DXR1 Soft X-ray Beamline

Resp. Antonella Balerna



- Wiggler soft x-ray beam line

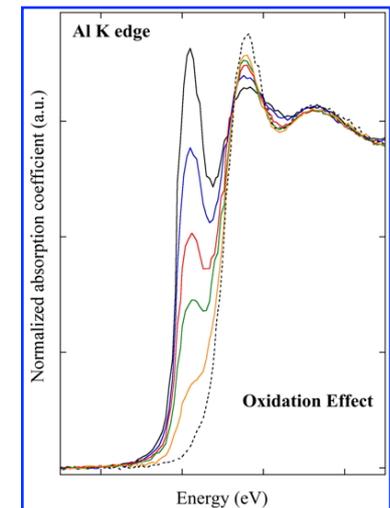
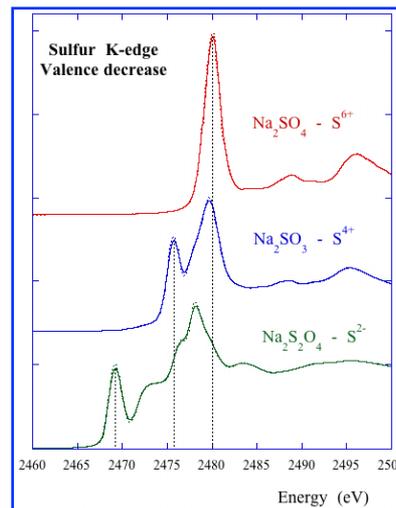
- Working range 0.9 - 3.0 keV

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

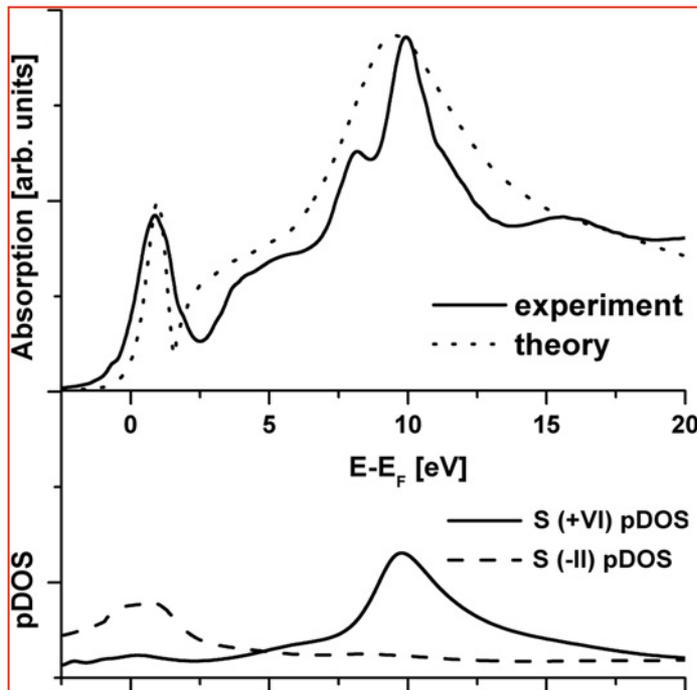
- Some applications: Soft X-ray absorption spectroscopy and tests of soft x-ray optics and detectors.

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

White beam for optics tests is also available.



First approach to studies of sulphur electron DOS in prostate cancer cell lines and tissues studied by XANES



Urological cancers comprise approximately one-third of all cancers diagnosed in men worldwide and out of these, prostate cancer is the most common one (WHO World Cancer Report, 2008).

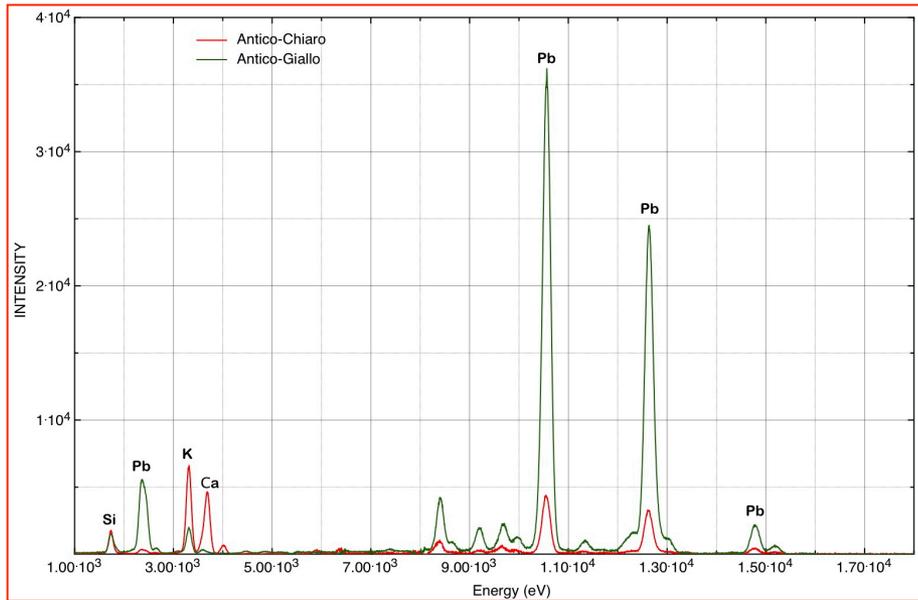
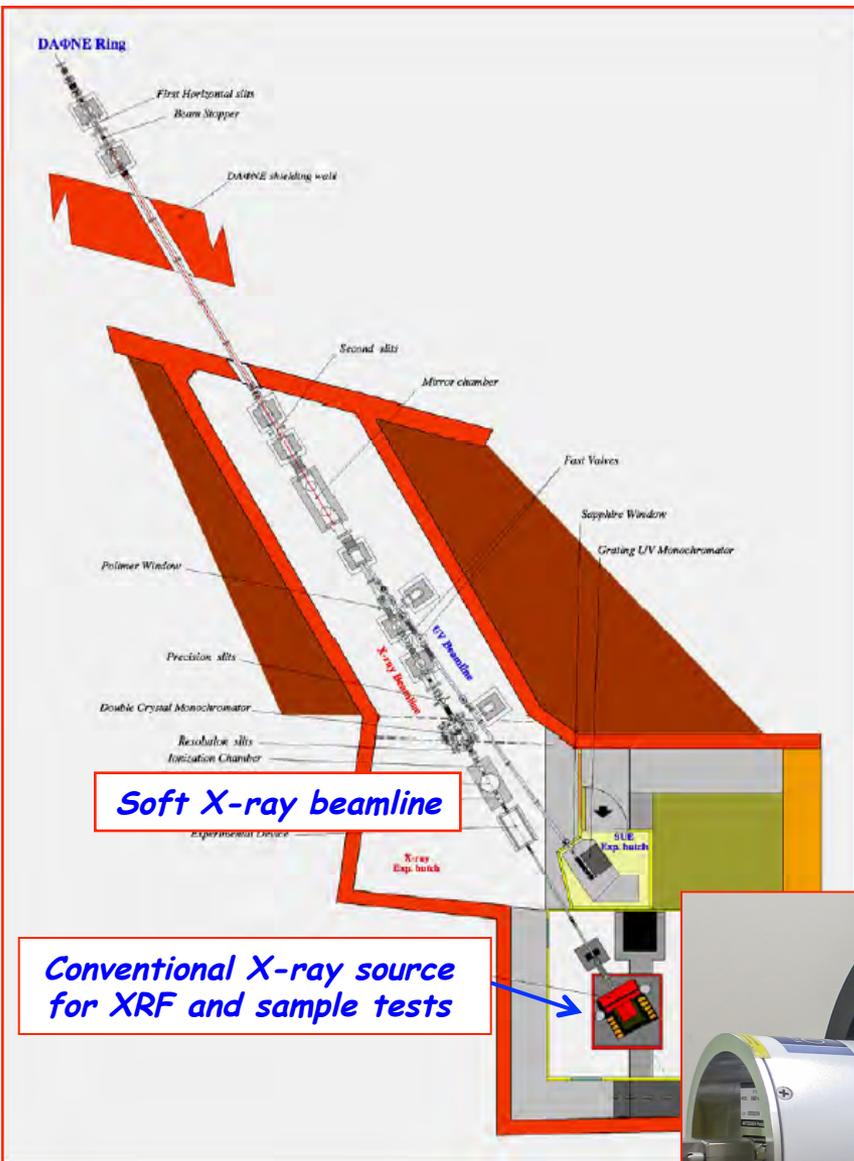
Several risk factors such as age, hormone levels, environmental conditions and family history are suspected to play a role in the onset of this disease of otherwise obscure aetiology.

It is therefore the medical need that drives multidisciplinary research in this field, carried out by means of various experimental and theoretical techniques.

Out of many relevant factors, it is believed that *sulfur can take an important part in cancer transformations.*

Radiation Chemistry and Physics (2012).

Studies of Valence of Selected Rare Earth Silicides determined using Si K and Pd/Rh L2,3 XANES - Submitted in 2014



XRF feasibility tests on prisms of very old telescopes to control differences in the atomic composition

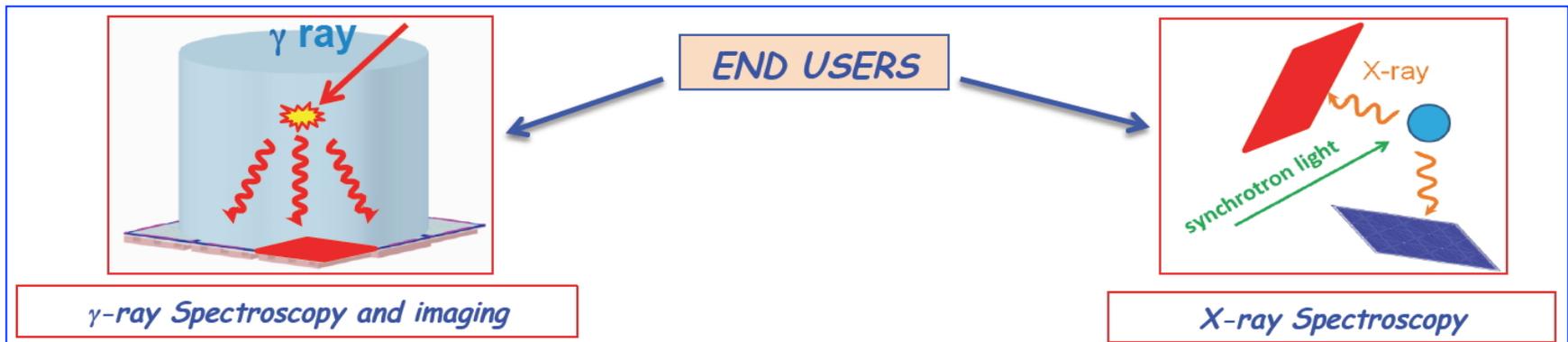
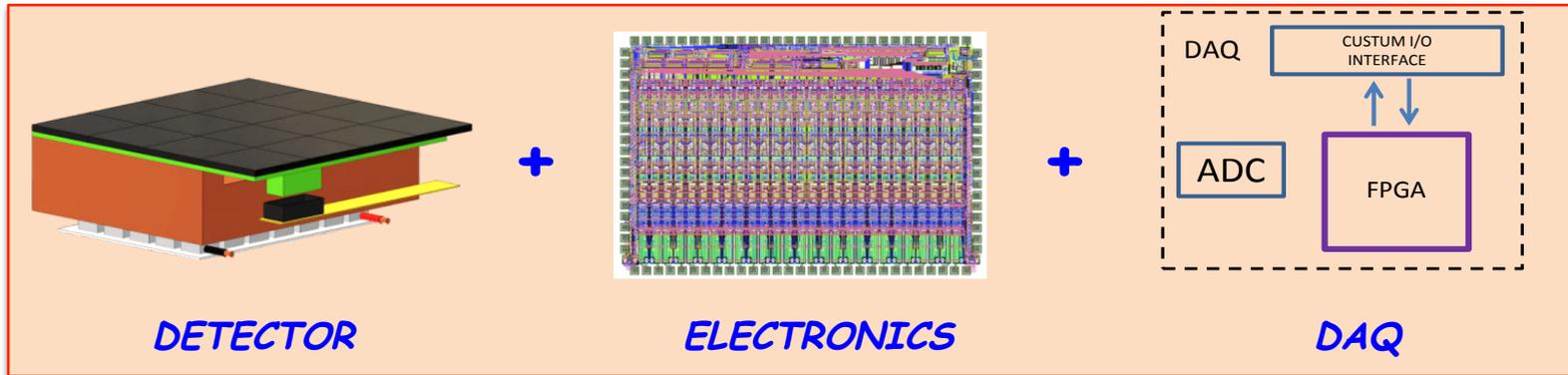


ARDESIA

ARray of DEtectors for Spectroscopy and Imaging Applications

Resp. Naz. C. Fiorini (Politecnico Mi) - Resp. Loc. Antonella Balerna (LNF)

INFN CSN5 experiment - *Development of a new detector based on an array of Silicon Drift Detectors (SDD) with low noise, high energy resolution and high counting rates for synchrotron radiation X-ray spectroscopy and γ imaging*



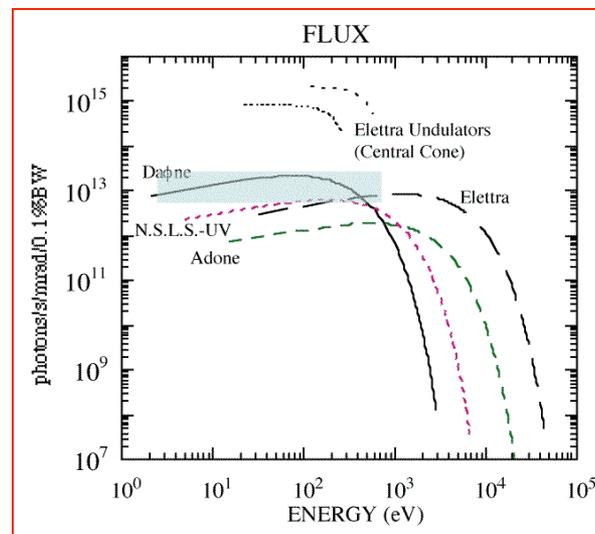
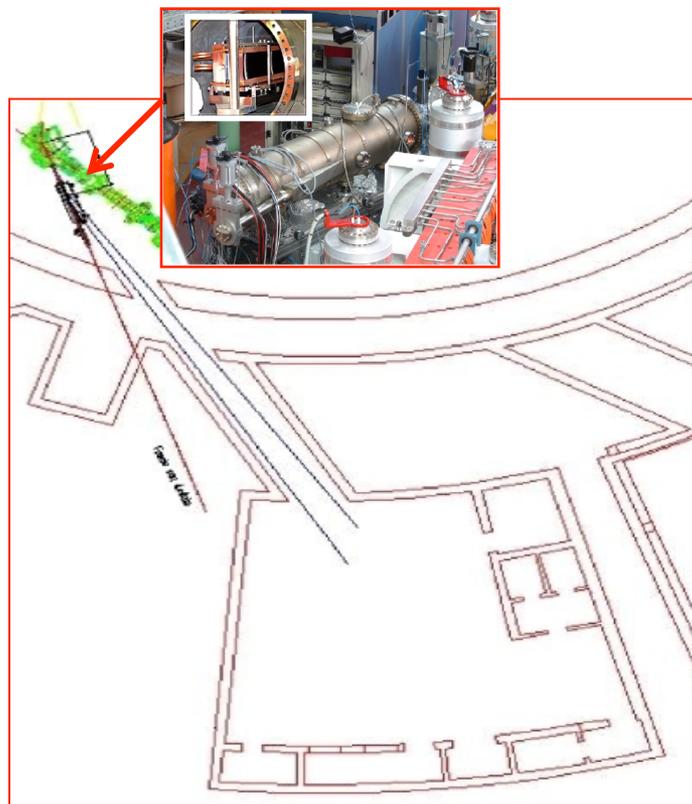
Will start in 2015 together with Politecnico di Milano and SIDDHARTA LNF Group

New XUV beamlines

New XUV beamlines

Resp. Roberto Cimino - Collab. Rosanna Larciprete (CNR)

LEB (35-200 eV) ready for commissioning
HEB (60-1000 eV) ready for commissioning



Fields of interest:

Biology

Surface Science

Material Science

R&D studies of INFN interest

New XUV beamlines



*Micro-Raman instrument XPLORA
from Horiba Jobin-Yvon (LNF-CSN5)*



*Scanning tunneling microscope
(STM) from RHK (LNF-CSN5)*

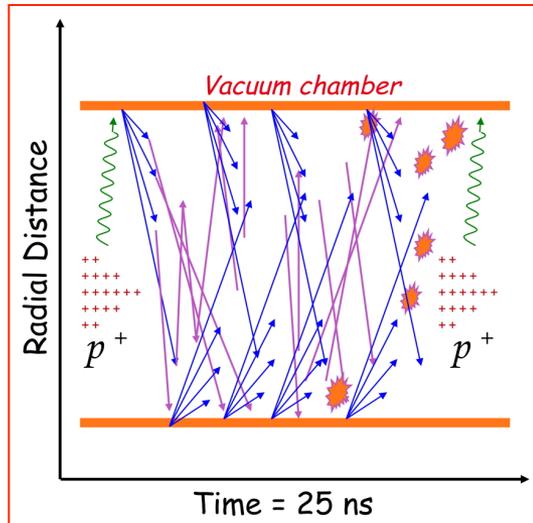


INFN CSN5 experiments **IMCA** and **GARFIELD** hosted in this laboratory.

IMCA

Innovative **M**aterials and **C**oatings for **A**ccelerators

Resp. Naz. Roberto Cimino (LNF) - Resp. Loc. Rosanna Larciprete (CNR)



The "e-cloud" phenomenon

The accelerated particle beam produces SR and/or e^- that, by hitting the accelerator's walls generate photo- e^- or secondary- e^- .

Such e^- can interact with the beam (most efficiently for positively charged beams) and multiply, inducing additional heat load on the walls, gas desorption and may cause severe detrimental effects on machine performance.

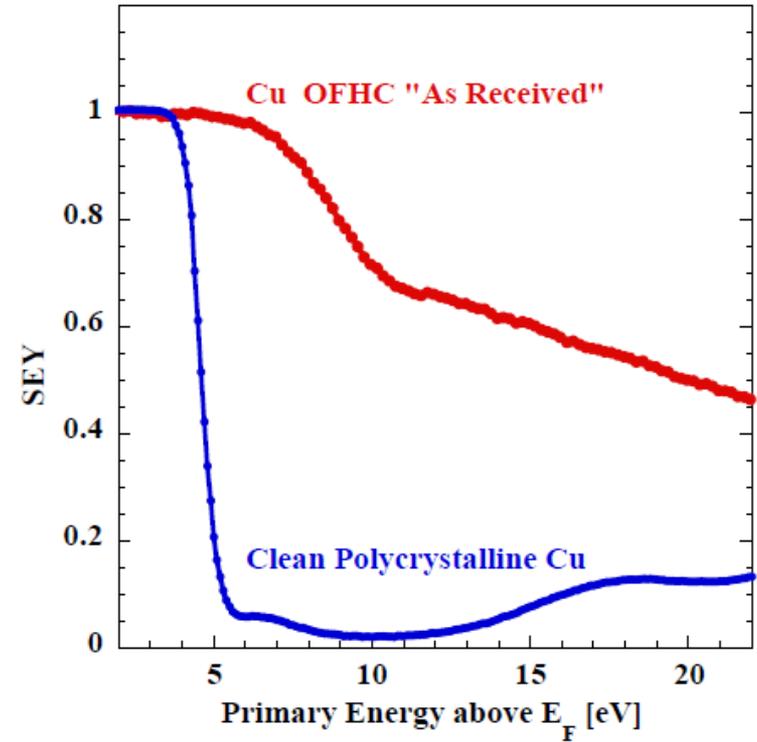
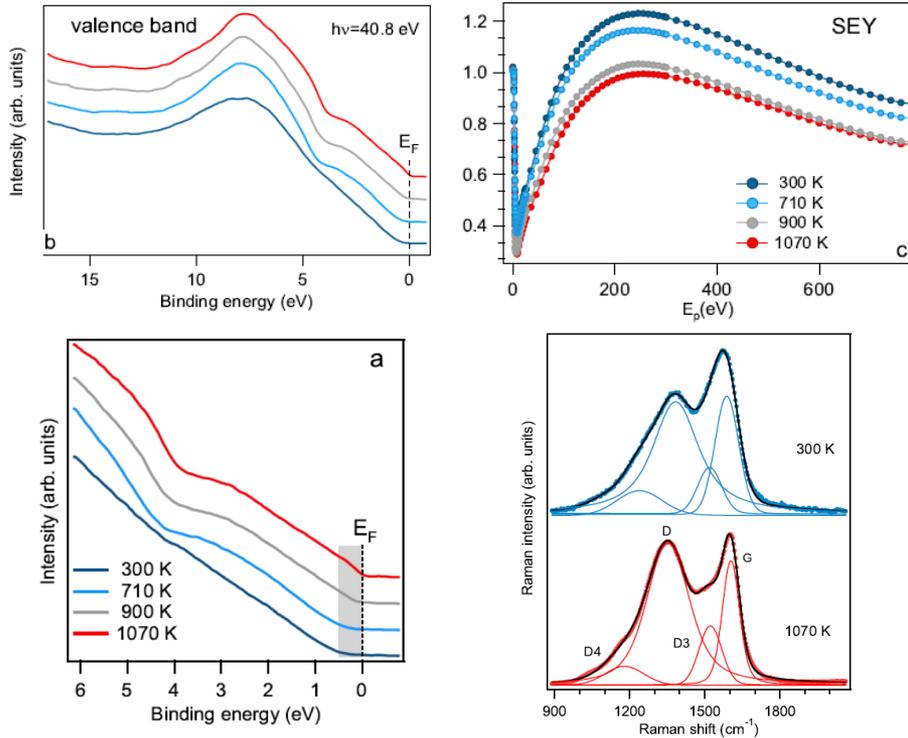
International collaborations: CERN, SLAC, ANKA, DESY, Cornell, RICH, BESSY 2

Electron cloud in accelerators, R. Cimino, T. Demma,, *Int. J. Mod. Phys. A* 29, 1430023 (2014)

Secondary electron yield of Cu technical surfaces: Dependence on electron irradiation, R. Larciprete, D. R. Grosso, M. Commisso, R. Flammini, and R. Cimino, *Phys. Rev. ST* 16, 011002 (2013)

Nature of the Decrease of the Secondary-Electron Yield by Electron Bombardment and its Energy Dependence. R. Cimino, M. Commisso, D.R. Grosso, T. Demma, V. Baglin, R. Flammini and R. Larciprete, *Phys. Rev. Lett.* 109, 064801 (2012)

Some IMCA highlights 2014



Evolution of the secondary electron emission during the graphitization of thin C films.

A few nm film of amorphous C is sufficient to lower the SEY of a clean copper surface. With increasing graphitization the sp^3 bonds convert into sp^2 domains and the electronic structure in the Fermi level region determines the SEY decrease. The comparison between the Raman spectra and the SEY curves shows that small aromatic clusters (~ 4 nm) behave as bulk graphite.

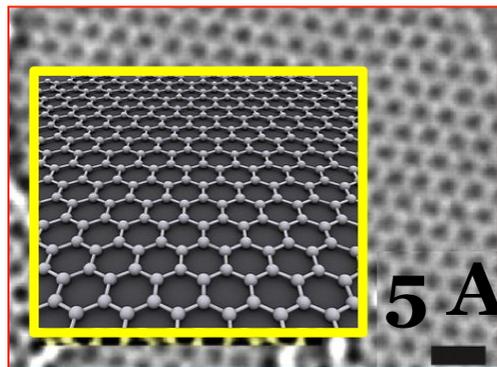
Study of the low energy SEY of metal surfaces

This study has demonstrated that for clean metal surfaces SEY tends to vanish at primary electron energies approaching the metal work function. On the contrary "technical" metal surfaces exhibit SEY values between 0.5 and 0.7 even at low energy and electron reflectivity of the order of 1.

Graphene Active Films for Electronic Devices and Radiation Detection

Coordinated by Alessandra Di Gaspare

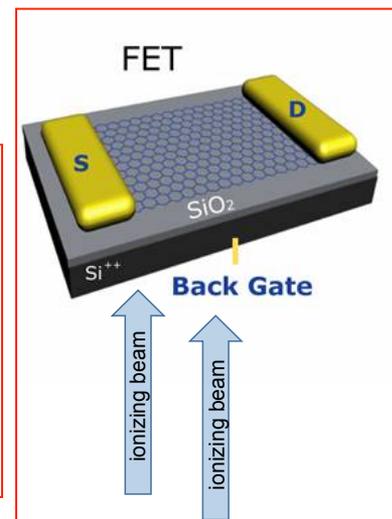
One of the three grants for young researchers funded by the INFN-CSN5 in the 2014/15



2D honeycomb array of C atoms

Graphene: Gapless material (Dirac System) - High stability and mobility $\mu \sim 2 \cdot 10^5 \text{ cm}^2/\text{Vs}$: wide range of applications!

GARFIELD Key concept: *Graphene based devices for novel schemes of radiation detection* - Graphene used as active layer in a Field Effect Transistor detecting the transient change in the electrostatic potential driven by incoming radiation!



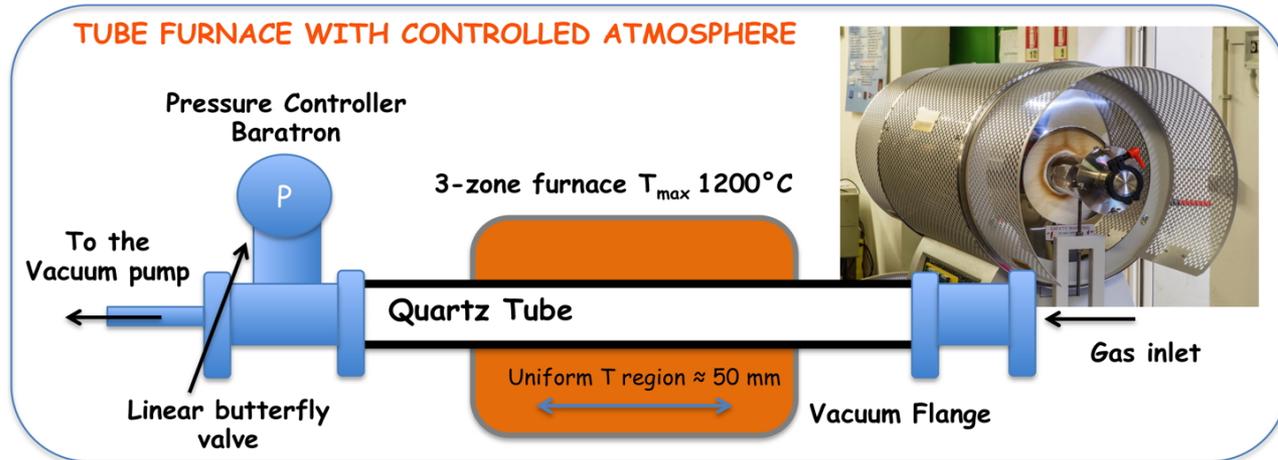
Research Objectives :

- Implementation of a full-capability graphene-platform within the LNF-INFN
- Development of graphene-based detectors for application of recognized interest to the INFN

GARFIELD Milestones

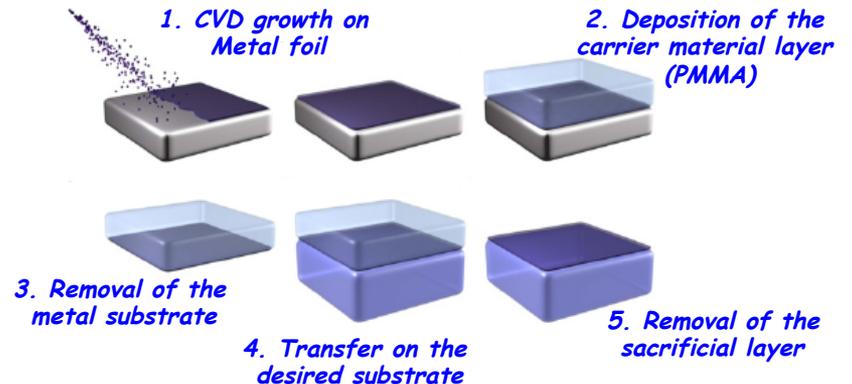
1) Graphene Synthesis of monolayer graphene via CVD on Cu films (year 1)

Design and Installation of the CVD System enabling growth process in a controlled atmosphere at $T \approx 1000^\circ\text{C}$ (Furnace and Gas distribution OK!)



2) Development of graphene-based detectors (prototypes/proof-of-concepts devices) (year 2)

- Study of the CVD synthesis of monolayer graphene on Cu-foil, optimization of the film properties;
- Test of manipulation of the graphene film, for the transfer of the graphene from the Cu-foil to the desired substrate (semiconducting or insulating, as required by most of applications)



Activities and DAΦNE-Light

Activities at the DAΦNE-Light Beamlines

The **IR** and the **Soft X-ray** beamlines are **open to users**. Beamtime given to **Italian** and **EU users**, in the framework of the **INFN-Group V experiments**, of collaborations with **Italian Universities and Institutions** and of the **EU Transnational Access to Research Infrastructures FP7 program C.A.Li.P.S.O.**

The previous **Transnational Access to Research Infrastructures FP7 program E.Li.S.A.** (**European Light Sources Activities**) successfully ended in **August 2011**.

10 EU proposals achieved - 8 accepted - 588 hours beamtime given / 380 promised hours

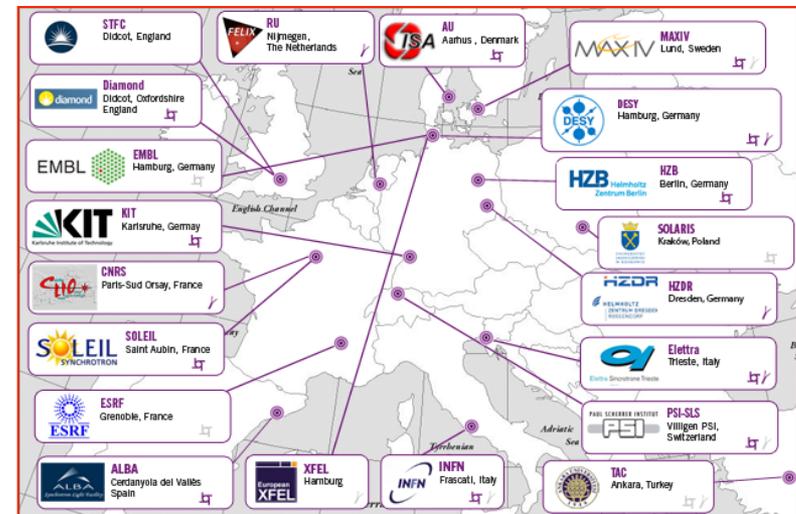
2010 -2011 186 days - 24 DAΦNE dedicated beamtime days

20 different research Italian and EU teams

First beamtime related to the **EU project C.A.Li.P.S.O.** (**Coordinated Access to Lightsources to Promote Standards and Optimization**) for **transnational access** given in **2014**. **C.A.Li.P.S.O.** will end in **May 2015**



Last CALIPSO call for proposals 22 November 2014-13 January 2015





the european lightsources single entry point

wayforlight

synchrotrons the European Synchrotrons | **fels** the European Free Electron Lasers | **stories** experiences with light

umbrella login

DAFNE

Results: 5 beamlines

TECHNIQUES

- ▶ Photoelectron emission
- ▶ Imaging
- ▶ Scattering
- ▶ Emission or Reflection
- ▶ Absorption
- ▶ Diffraction
- ▶ Lithography
- ▶ Ion Spectroscopy

TYPE OF FACILITY

- Synchrotron 289
- XRay - FEL 9
- IR - FEL 10

DAΦNE-Light Frascati (RM) Italy

- **DXR1**
The DAFNE soft x-ray beamline, DXR-1, is mainly dedicated x-ray absorption
- **HEB**
HEB or High Energy Beamline is a DAFNE bending magnet beamline that will cover
- **SINBAD IR**
The beamline operates in dedicated and parasitic regime of the Dafne storage ring with
- **DXR2**
The synchrotron radiation photon beam from a wiggler installed on the DAFNE storage ring is
- **LEB**
LEB or Low Energy Beamline is a DAFNE bending magnet beamline that will cover

Video tutorial

8 FELs

13 synchrotrons

300+ beamlines

1 website

the European lightsources single entry point

www.wayforlight.eu

wayforlight is an initiative of the European I3 project CALIPSO

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an integrating initiative supported under the European Commission Framework Programme

DAΦNE-Light other activities

School for PhD students - Laser, Synchrotron Radiation and Particle Beam Test Facilities at LNF- 16/19 June 2014 one day fully dedicated to Synchrotron Radiation including experimental applications.



SPRINGLETS

Solar system **P**ayloads of laser **R**etroreflectors of **I**NFN for **G**eneral re**L**ativity, **E**xploration and plane **T**ary **S**cience

On September 15th, 2014 NASA Signed Agreement for Italian Research Partnership with INFN to become an Affiliate Member of the NASA - Solar System Exploration Research Virtual Institute (SSERVI).

DAΦNE-Light one of the **Internal Special Facility of INFN-LNF** included in the **FURTHER AREAS FOR LONGER-TERM CULTIVATION OF COLLABORATIONS**

1. *The identification of cystic fibrosis (CF) cells and their pharmacological correction by mid-infrared microspectroscopy and unsupervised data analysis methods.* G. Bellisola, S. Caldrer, G. Cinque, M. Cestelli Guidi, B. M. Assael, P. Melotti, C. Sorio, *Science Jet*, 3:51 (2014)
2. *Zinc Oxide Microrods and Nanorods: Differential Antibacterial Activity and their Mode of Action against Gram-positive Bacteria,* Ilaria Rago, Chandrakanth Reddy Chandraiahgari, Maria Paola Bracciale, Giovanni De Bellis, Elena Zanni, Mariangela Cestelli Guidi, Diego Sali, Alessandra Broggi, Claudio Palleschi, Maria Sabrina Sarto and Daniela Uccelletti, *Royal Soc.Chem. Adv.* (2014) - DOI: 10.1039/C4RA08462D - Published online 23 Oct 2014
3. *DAΦNE-Light Facility Update,* Antonella Balerna, *Synchrotron Radiation News*, 27:1 (2014), DOI: 10.1080/08940886.2014.869159
4. *North-American microtektites are more oxidized than tektites,* G. Giuli, M. R. Cicconi, S. G. Eeckhout, C. Koeberl B. P. Glass, G. Pratesi, M. Cestelli-Guidi and E. Paris *American Mineralogist*, **98**, 1930 (2013)
5. *Infrared spectral investigations of UV irradiated nucleobases adsorbed on mineral surfaces,* T. Fornaro, J. R. Brucato, E. Pace, M. Cestelli Guidi, S. Branciamore, A. Pucci;, *Icarus*, **226**, 1068 (2013)
6. *An innovative photochemical facility at DAΦNE-Light,* E. Pace, M. Cestelli Guidi, A. De Sio, L. Gambicorti, A. Grilli, M. Pietropaoli, A. Raco, G. Viviani, *J. of Phys: Conf. Series*, 425 ,072024 (2013)
7. *Experimental ATR device for real-time FTIR imaging of living cells using brilliant synchrotron radiation sources.* M. Cestelli-Guidi, S. Yao, D. Sali, C. Sabine, A. Marcelli and C. Petibois, *Biotechnol. Adv.* **31**, 402 (2013)
8. *The Degradation Process of Lead Chromate in paintings by Vincent van Gogh studied by means of spectromicroscopic methods,* L. Monico, K. H. Janssens, C. Miliani, G. Van der Snickt, B. G. Brunetti, M. Cestelli Guidi, M. Radepont, and M. Cotte, *Anal. Chem.* **85**, 860 (2013)
9. *In vivo skin leptin modulation after 14 MeV neutron irradiation: a molecular and FT-IR spectroscopic study.* M. Cestelli Guidi, C. Mirri, E. Fratini, V. Licursi, R. Negri, A. Marcelli & R. Amendola. *Anal. Bioanal. Chem.* **404**, 1317 (2012)
10. *Vibrational properties of LaPO₄ nanoparticles in mid- and far-infrared domain.* P. Savchyn, I. Karbovnyk, V. Vistovskyy, A. Voloshinovskii, V. Pankratov, M. Cestelli-Guidi, C. Mirri, O. Myahkota, A. Riabtseva, N. Mitina, A. Zaichenko, and A. I. Popov, *J. Appl. Phys.* **112** , 124309 (2012)

More information on the DAFNE- Light facility

http://web.infn.it/DAFNE_Light



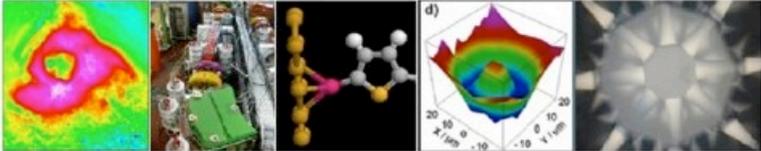
DAFNE-LIGHT

INFN-LNF Synchrotron Radiation Facility

INFN LNF DAFNE Storage Ring DAFNE-Light

Menu

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- DAFNE status
- How to apply



DAFNE-Light

DAFNE-Light is the Synchrotron Radiation Facility at the Laboratori Nazionali di Frascati (LNF).

Three beamlines are operational using, in parasitic and dedicated mode, the intense photon emission of DAFNE, a 0.51 GeV storage ring with a routinely circulating electron current higher than 1 Ampere. Two of these beamlines (DXR1 and DXR2) have one of the DAFNE wiggler magnets as synchrotron radiation source, while the third beamline (SINBAD-IR) collects the radiation from a bending magnet. New XUV bending magnet beamlines are nowadays under construction.

The beamlines DXR1 and SINBAD-IR are open to external users.

Login

Username

Password

Remember Me

Login

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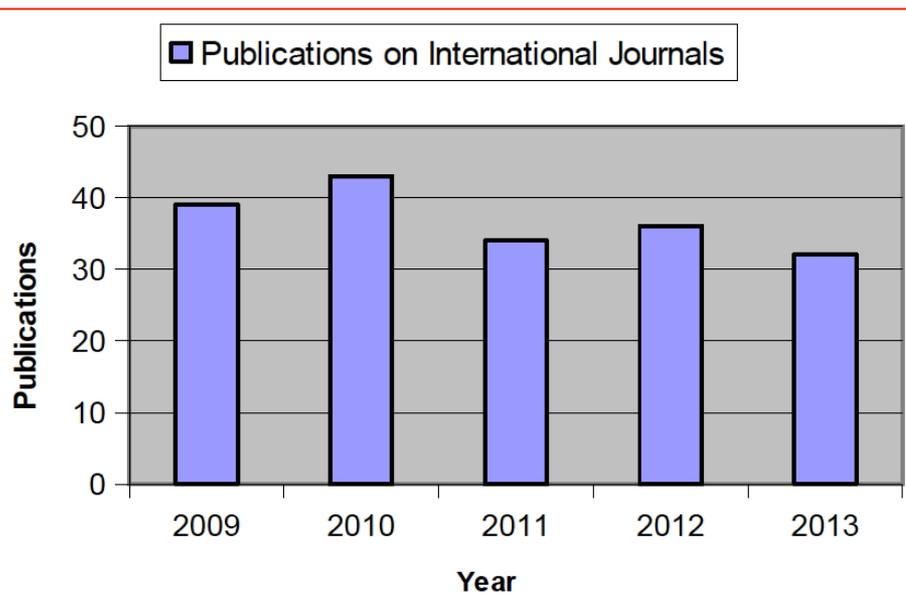
GILDA beamline at ESRF

Beamline Review Panel BM08

The panel would like to congratulate the GILDA staff for the remarkable quality and quantity of science that the beamline has delivered over the reviewed period of operations despite the challenging landscape for funding and staffing encountered during this period. The recommendations given by the previous panel review was partially fulfilled. The lack of funding did not permit the implementation of the recommended refurbishment of the optics. An improvement of fluorescence detection was found by the staff through taking equipment from Hasylab. It was regrettable that lack of resources resulted in the suspension of the diffraction capabilities of the beamline in 2012 together with the suspension of the operation of the beamline for Italian users through the CRG route for one year. Despite this “black” period, the scientific efficiency (ratio of publications to scheduled experiments) significantly increased compared to the previous review period and new scientific communities (cultural heritage and environment) have been attracted giving new opportunities for the renewal of the future science programme at GILDA.

The panel was very pleased to see the incorporation of GILDA into the CNR-IOM Italian research centre which provides a stable environment for operation, support and development. This involvement has also consolidated support from the Italian Research Ministry and resulted in a guaranteed investment of at least 1 M€ in the next two years and potentially a further 0.5 M€ in 2016.

May 2014



The *upgrade of the ESRF machine*, requires a massive intervention on the GILDA Beamline and *CNR* was asked to define a *long term strategy* for the activity of *GILDA* including *necessary financial and human resources* for its effective operation.

The *contract between INFN and CNR* for the maintenance of GILDA will *expire at the end of December 2014*.

Thank you for your attention

