DAΦNE-Light Laboratory and Activity

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1 Summary

The scientific activity at the DAΦNE-Light laboratory, in 2016, was performed using conventional sources and the DAΦNE synchrotron radiation beam. About 30 experimental teams got access to the DAΦNE-Light laboratory coming from Italian Universities and Research Institutions.
From September 2016 the commissioning of the two XUV beamlines started and, also if this activity will go on also in the first months of 2017, a beam was already observed at both beamlines. The experimental activities, performed in 2016, included also some upgrades of the other beamlines, and the installation of new instrumentation.

2 Activity

2.1 SINBAD IR beamline - *Resp. Mariangela Cestelli Guidi*

The SINBAD IR beamline is dedicated to FTIR (Fourier Transform InfraRed) micro imaging and spectroscopy in different research fields, including material science, biologyradiobiology, live cell imaging, cultural heritage and geophysics. All these studies are possible owing to the imaging capabilities of the IR microscope coupled to the synchrotron source. The beamline is open to all users involved in the experiments mainly coming from institutions involving Italian and International teams.
During 2016 a new spectrometer, Tensor II, was installed to perform high throughput analysis of biological samples. The instrument has been commissioned and is now fully operational. It will be dedicated to the analysis of biofluids for Italian and International research projects.
Some of the scientific studies performed at the SINBAD-IR beamline are here summarized:

1) *Methodology for FTIR Imaging of Individual Cells. - S. Yao, Centre for NanoHealth, Swansea University, Swansea, UK*

   FTIR imaging is a novel spectroscopic technique able to provide cell imaging, in vivo and in real-time. However, one key issue is developing methodologies for cell culture on IR-transparent substrates fitting cell biology requirements.
   In this work different IR-transparent substrates in terms of biotoxicity, surface properties, and spectral image acquisition qualities were tested. Only a few substrates, namely Si_3N_4, Ge, GLS, LaF_3, Si, SrF_2, ZnSC, ZnSF, were found to provide cell culture conditions comparable to those observed on usual polycarbonate Petri dishes, the main limiting parameter being the toxicity of the material (ZnS, GLS, PbF_2, $PbCl_2$) or a poor adhesiveness (notably diamond, AgCl, CaF_2, ZnS).
   From substrates eligible for a good-quality cell culture, the spectral acquisition quality is mainly affected by the refractive index value. Finally, the best compromise between cell culture quality and image spectral quality could be obtained using Si and Ge substrates. This rationalization of the available IR-transparent substrates for bio-imaging is particularly relevant for live cell analyses, where cell culture conditions must remain unaffected by substrate properties.

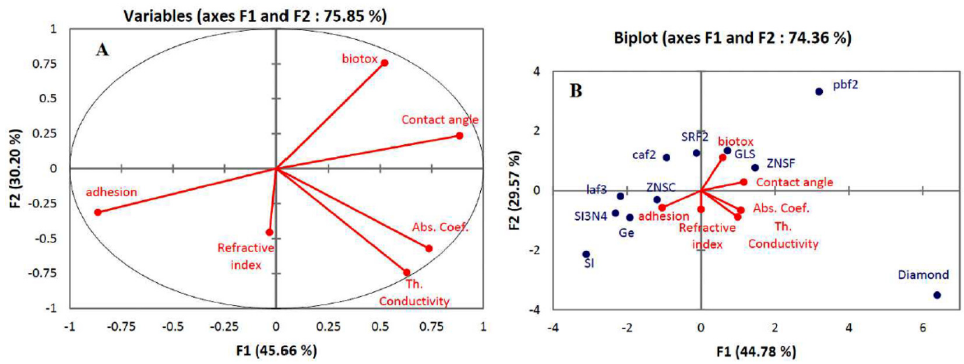

Figure 1: Principal component regression. A) The ellipse shows the correlation between different parameters and the factors F1, F2. B) Biplot of parameters and substrates positions vs. the factor F1 and F2.

2) *Chemometrics approach to FT-IR hyperspectral imaging analysis of degradation products in artwork cross-sections. - G. Capobianco et al., DICMA and CISTeC, Sapienza University of Rome, Rome, IT*

Ascertain the distribution of materials and that of their degradation products in historical artifacts is crucial to understand their conservation status. Among the different analytical techniques that can be used, FT-IR imaging supplies information on the molecular composition of the material on a micro metric-scale in a nondestructive way.
When thin sections of the material are not exploitable for transmission, and when ATR imaging mode is not suitable due to possible damages on the sample surface, FT-IR imaging is performed in reflection mode on thick polished, matrix embedded samples.
Even if many efforts have been done in the optimization of the sample preparation, the material's surface quality is a critical issue that can hinder the achievement of good infrared images. Moreover, spectral artifacts due to volume and surface interactions can yield uncertain results in standard data treatment. In this paper we address a multivariate statistical analysis as an alternative and complementary approach to obtain high contrast FT-IR large images from hyper spectral data obtained by reflection μ-FTIR analysis.
While applications of Principal Component Analysis (PCA) for chemical mapping is well established, no clustering unsupervised method applied to μ- FTIR data have been reported so far in the field of analytical chemistry for cultural heritage.
In order to obtain certain chemical distribution of the stratigraphy materials, in this work the use of Hierarchical Cluster Analysis (HCA), validated with a supervised Principal Component based k-Nearest Neighbor (PCA-kNN) Analysis, has been successfully used for the re-construction of the μ-FTIR image, extracting useful information from the complex data set (Fig. 2).
A case study (a patina from the Arch of Septimius Severus in the Roman Forum) is presented to validate the model and to show new perspectives for FT-IR imaging in art conservation (Fig. 3).

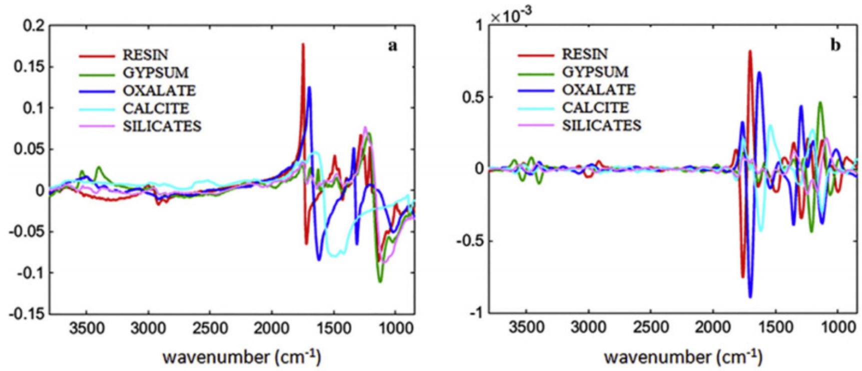

Figure 2: a) Average spectra of the selected ROI; b) average preprocessed spectra, 2^{nd} derivative and mean centering of the data.

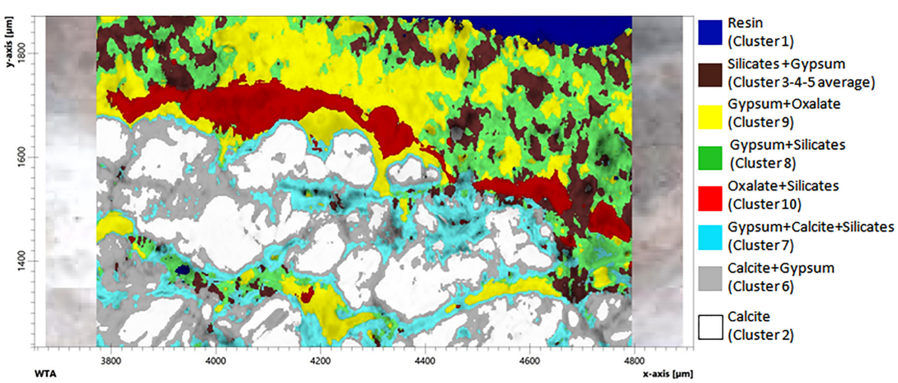

Figure 3: Chemical image of the cross section of a small fragment of the Septimius Severus' Arch, where each single component is assigned to a different color.

3) *Hydrogen diffusion in nominally anhydrous minerals: implications for mass and charge transport. - B. Poe et al. University of Chieti, Italy*

In the last decades, knowledge about hydrogen incorporation in nominally anhydrous minerals has become essential to understand the dynamic behavior of the Earths mantle, because it plays a key role in several processes and has a large effect on the physical and chemical properties of minerals. Using HP and HT devices, we synthesized polycrystalline samples of hydrous forsterite and olivine (Fig. 4) , reaching pressure and temperature values of 15 kbars and 1100 °C, respectively. FTIR spectra were acquired at LNF, using the SINBAD (Synchrotron Infrared Beam At DAΦNE) beamline. FTIR spectroscopy represents the primary method to analyze the presence of hydrogen in nominally anhydrous minerals, because OH bonds are very sensitive to interaction with IR source, leading to stretching vibrational modes in a frequency range between (3200 3700) cm^{-1}. FTIR spectra (Fig. 4) were acquired by smoothed and polished sections with thickness between (300 - 700) micron: for every sample we acquired images using Hyperion 300 microscope (15x objective), and we obtained a series of data point spectra to analyze the presence of H_2O and the homogeneous distribution of hydroxyl groups in all sample area. Using Paterson calibration we obtain total OH concentrations of our samples (wt ppm H_2O), while using the Peakfit 4.2 software we identified each peak with a Lorentzian equation characterized by three parameters such as frequency (wavenumber) absorbance and FWHM. These parameters allow us to study the mechanisms by which hydroxyl groups are incorporated in the olivine and forsterite crystal lattices.

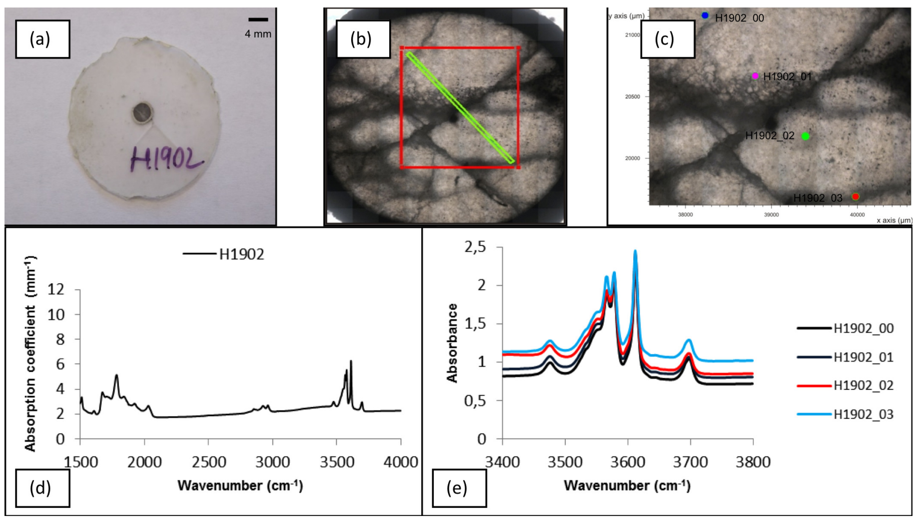

Figure 4: a) Olivine sample (H1902) embedded in epoxy resin, prepared for transmission measurements. (b) Measurements for the determination of the position related to OH concentration, (c) measurements positions. (d) IR spectrum of water in olivine and (e) OH stretching modes at different positions across the sample

During 2016 the SINBAD beamlines has been involved in two different projects:

1. **INFN-ASRT**
   The title of this project, that is a collaborations between INFN and the Egyptian Academy of Science and technology (ARST), is: *Leptin and related lipid metabolism after Radiation Exposure: Combined Heavy Charged Particles Irradiation, Infrared FTIR Imaging, and Biological Approaches.*

2. **ETHICS**
   This project funded by the INFN National Scientific Committee 5 (CSN5) is related to: *Preclinical experimental and theoretical studies to improve treatment and protection by charged particles.*

Both projects were also submitted and obtained beamtime at the INFN-LNS Proton Facility in 2016. Between the different activities performed at the SINBAD beamline, also the training and the Master Thesis (2016-2017) of Elena Missale from the University of Tor Vergata (Rome) must be included.

2.2 DXR1 Soft X-ray Beamline - *Resp. Antonella Balerna*

The DAΦNE soft X-ray beamline, DXR-1, is mainly dedicated to soft X-ray absorption spectroscopy. The X-ray source of this beamline is one of the 6-poles equivalent planar wiggler devices installed on the DAΦNE electron ring (0.51 GeV) for the vertical beam compaction. The 6 wiggler poles and the high storage ring current (higher then 1 Ampere) give a useful X-ray flux for measurements well beyond ten times the critical energy. The useful soft X-ray energy range is 900 eV - 3000eV where the lower limit is given by the Beryl crystals used in the double-crystal monochromator and the higher limit is given by the wiggler working conditions.
In 2016, operation in top up mode was tested on many different samples. Using these new working conditions good measurements were performed in the presence of good and stable DAFNE beam conditions. Tests were perfomed on bulk and thin samples.
The soft X-ray beamline is equipped also with a microfocus, W, x-ray source to test samples and to perform X-ray fluorescence (XRF) measurements using an available SDD (Silicon Drift Detector) detector and a vacuum compatible experimental chamber for samples containing low Z materials. Using this experimental setup, preliminary tests of the first 2x2 SDDs chip of the ARDESIA project (ARray of DEtectors for Synchrotron radIation Applications) were performed in July (Fig. 5) with the digital data acquisition system. The goal of the ARDESIA project is the development of a new detection system for XAFS measurements in fluorescence mode, based on arrays of SDDs with high energy resolution and able to handle high count rates.

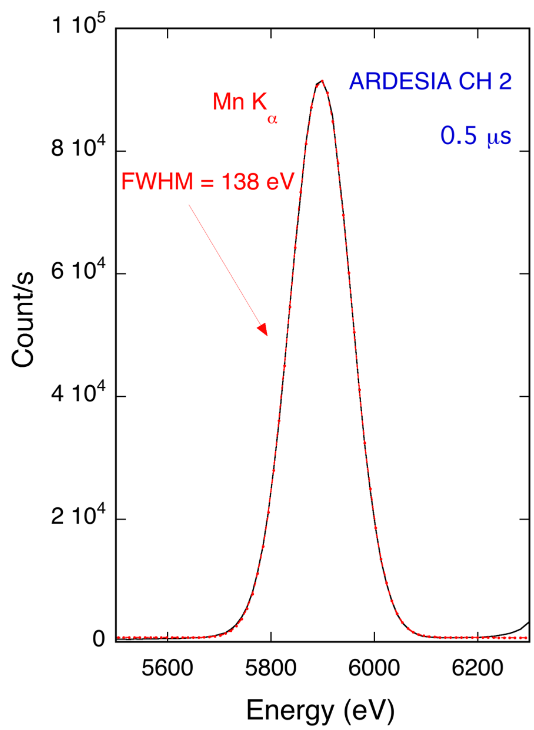

Figure 5: Mn K_α peak measured using one of the ARDESIA 4 channels showing a FWHM= 138 eV with a peaking time of 0.5 μs.

Starting from the end of 2016, tests related to an experimental proposal on *Al K-edge XANES study* *of alkali aluminum hydrides*, submitted by researchers of the Karlsruhe Institute of Technology (DE), started with measurements on reference compounds having a tetrahedral structure.

2.3 DXR2 UV branch Line - *Resp. Emanuele Pace*

The DXR2 beamline at DAΦNE- Light operates with UV radiation on an extended spectral range from 120 nm to 650 nm. The UV radiation can be used in a wide range of experiments such as reflectance/transmittance, ageing and response of optical systems and detectors. The UV light has been used at the DXR2 branch-line in many and different research fields from biological to high energy physics experiments, to study solar-blind UV diamond-based detectors or FOAM for space missions. Furthermore, coupling the UV radiation and IR spectroscopy it is possible to study the evolution of analyzed samples in real time, measuring the variation of IR spectra during UV exposure. The facility operates with UV radiation obtained as synchrotron radiation (SR) or standard sources (HgXe lamp in the 200-650 nm range and Deuterium lamp for the Deep UV 120-250 nm). During 2016, the activity of the DXR2 Synchrotron Radiation Beamline was characterized by improvements of the instrumentation and experiments by users and by the DXR-2 team as core research. Concerning the improvements, the DXR-2 facility setup is almost completed. Improvements have concerned small instrumentation that will be used for ultrafast time-resolved experiments exploiting the characteristics of the pulsed synchrotron radiation as well as to characterize the optical performances of the beamline, in particular the radiation losses along the beamline due to optical elements and possible misalignments. A transimpedance preamplifier from ELETTRA S.p.A. has been acquired in order to get a readout electronics for ultrafast signals (of the order of 1 ns). It has a very wide bandpass (4 GHz) and high gain (40 dB) that is perfectly suitable for coupling to detectors such as SiPMT or solid state detectors as MCT (Mercury-Cadmium-Telluride) for the VIS-IR spectral range. A UV-enhanced CCD camera has been purchased to have an imaging camera providing information on the UV spot size and distribution, to evaluate the presence and distribution of spurious signals, straylight and the amount of unfocused or uncollimated light (depending on the position along the optical path). UV light requires specific detectors as it is not visible with other standard methods, such as visual inspection or photodiodes. In addition a pixelated array allows spatial resolution that is crucial for the required testing and measurements. Concerning the the activity at the DXR2 beamline it opened to users in 2015. After some experiments exploiting the unique performances of a high intensity UV beamline with an extension to the visible region, it was realized that a better characterization of the optical path and components was required in order to improve the light transfer function of the whole beamline. Therefore, during the last part of the year, an optical characterization program started, willing to check efficiency losses in light transmission along the beam line. The team has defined the intervention areas and techniques, the program has started and the measurements will be completed before the end of March 2017 in order to open the beamline to the users. The facility has also developed an experimental setup to combine UV and IR radiation. Some tests have also been performed to check the availability of the IR radiation at the output of the DXR2 beamline. Some scientific results and tests performed at the DXR2 -UV beamline are here summarized:

1) *Characterisation of new photocathodes and silicon PMT - University of Napoli 'Federico II' and INFN- Sec. of Napoli*

   This activity started in late 2015 and was completed in 2016. A team from the INFN-Sezione Napoli leaded by F. Di Capua has developed an innovative detector for ultra-low, UV light, levels for high energy applications and they were willing to characterize the spectral and time response of both the photocathode and the SiPM. The DXR2 beamline offers the possibility to make measurements both in continuous and in pulsed mode. A deuterium lamp provides for continuous emission in the (120-400) nm spectral range, while the latter exploits the intense photon emission from DAΦNE, the 0.51 GeV storage ring with a circulating current of electrons higher than 1 A. At the beamline there are three channels dedicated to the VUV, visible and white beams. The tests started with the deuterium lamp and were used as reference for the following measurements with the synchrotron light. To test the feasibility of a 1-inch VSiPMT (Vacuum Silicon PhotoMultiplier Tube), a pre-prototype has been designed and realized. The idea was to have a structure where the single parts of the VSiPMT can be positioned and modified. With this aim, a special flange has been designed, where the MPPC (Multi-Pixel Photon Counter) is positioned on the movable support while the photocathode under test can be positioned in front of the MPPC at different distances (Fig. 6).

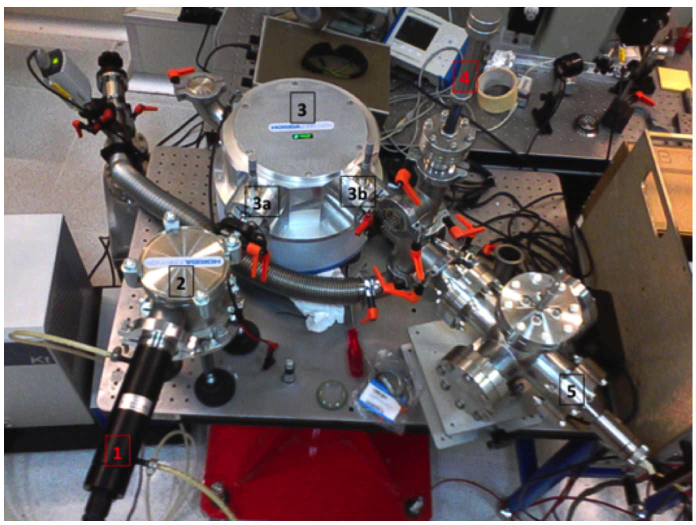

Figure 6: The final assembly of the VSiPMT system tested at the DXR2 beamline.

Since the MPPC under test is a custom device, it has an unexplored behavior in the spectral region of interest. Since a transmission mode VSiPMT exploits a semitransparent photocathode, photons not absorbed by the photocathode can hit the SiPM causing a pre-pulse, due to photons faster than electrons. However, the measurements show that the response of the MPPC approaches zero for λ <180nm in the VUV region (120-400) nm. The photocathode response was measured twice: as deposited on a MgF_2 window and two days after. A degradation likely due to humidity and exposition to air (Fig. 7) was clearly visible.

2) *Characterization of pre-amplifiers and IR emission from the DXR-2 beamline.*

An experimental setup was arranged on the white beam channel in order to test two different high-gain ultra-fast preamplifiers: the ZFL-1000LN MiniCircuit (20dB gain) and the ELETTRA amplifier mod. PIT-RFLN-XLS (40dB gain) by using an IR solid-state detector operating at room temperature. The advantage of this experiment was also to verify the presence of a IR radiation component in the white beam. UV signals of approximately 1 mV were detected with MiniCircuit amplifier while, with the ELETTRA amplifier, it was about 2.5 mV. The signals of the individual bunches were not observed but the 13-bunches

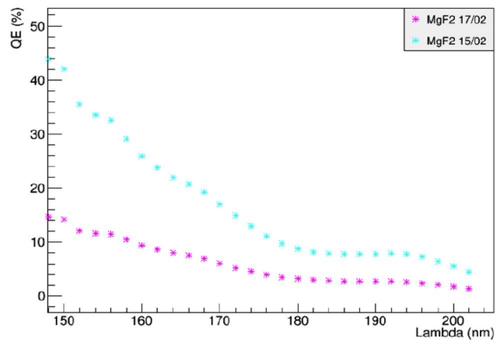

Figure 7: Spectral response of the photocathode: measurements were performed when deposited on the MgF_2 window and after 2 days to check the stability.

gap was well distinguishable, so the rise time was slower than 2.7 ns. This limit was due to the detector and not to the oscilloscope used for the measurement. The Vigo (PC-10.6) IR detector has an adequate rise time, but unfortunately the light signal was too weak. Filters along the light path, at the entrance, were used to test if the acquired signal was due to the wavelength band of the detector or to the response of photons in the IR or in the visible regions. By inserting IR filters, the signal was lowered but still present, proving that the detector acquires photons also at shorter wavelengths. By inserting IR + VIS and UV filters signals were no more detected, showing that the detector is not UV sensitive, while VIS + IR photons are present in the beam.

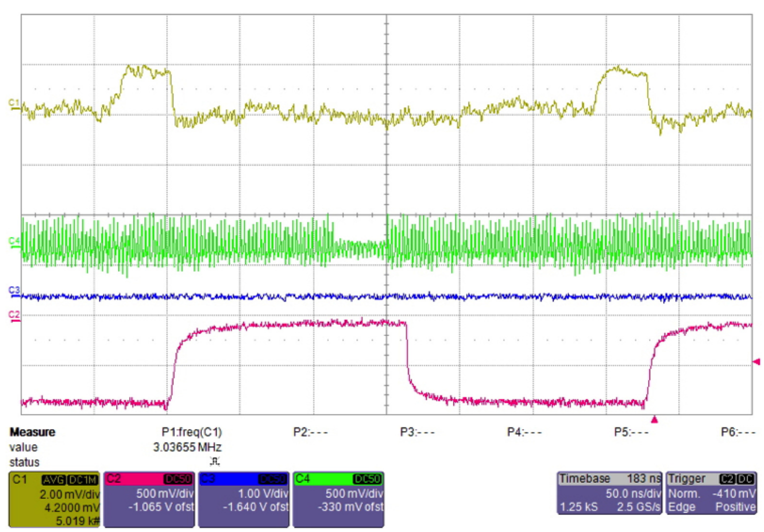

Figure 8: Print screen of the oscilloscope. The upper trace is the signal from the detector coupled to the PIT-RFLN-XLS pre-amplifier. The green trace represents the bunches as detected at DAΦNE. The bottom red trace is the trigger.

2.4 XUV beamlines and laboratory - *Resp. Roberto Cimino*

Aim of this laboratory is to host two bending magnet beamlines covering the photon energy range from 30 eV to 1000 eV. One beam line will cover the low energy part of this interval (30-200 eV) and is called LEB (Low Energy Beam line), the other will cover the range from 60 eV to 1000 eV and is called HEB (High Energy Beam line). Both beam lines are in UHV and directly connected to the vacuum of the main DAΦNE ring. All the safety protocols and control systems are ready and tested. Since the beginning of last year, the two beam lines are ready to start commissioning with light. Since September 2016, the two beam lines are under commissioning with light. After careful alignment, the white light (WL) emitted from DAΦNE has been reflected/collimated by the *ad hoc* optics inside accelerator building to be transported into the 20 meters far Laboratory. One example of the nowadays available WL in the laboratory is shown in Fig. 9. In this figure, we show the visible part of the WL as seen on a screen at 22 m from the DAΦNE BM source, after being collimated by the first optic of the high Energy beamline. On the side and at the bottom of Fig. 9, the vertical and horizontal X-ray beam profile is shown. This profile is measured by moving across the photon beam a 100 μm thick W wire (BPM), reading the current at each spatial position. The data show that the photo-current that a W target would measure when fully intercepting the WL beam would be as high as 0.1 mA, confirming the high photon flux available in the laboratory.

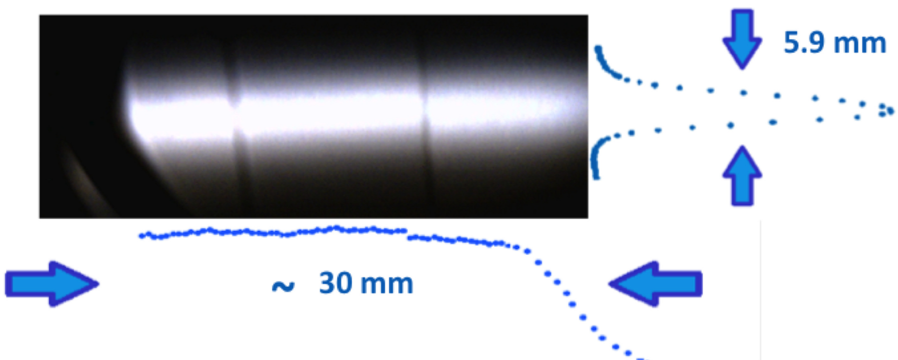

Figure 9: Picture of the visible part of the WL as seen on a screen at 22 m from the DAΦNE BM source. On the side and at the bottom the X-ray beam profile as measured by a moveable BPM.

The beamlines are ready to be aligned and commissioned bringing the light (WL and monochromatic) into the UHV systems to enable spectroscopic studies of interest of INFN and Italian as well as International users. We are presently considering to partially utilize the laboratory, to exploit SR at DAΦNE to study in detail reflectivity, photo-yield and photo induced desorption for studying and optimizing existing and planned accelerators like the Large Hadron Collider (LHC) and its High Luminosity planned upgrade (HL-LHC) and for planning and designing future circular colliders (FCC) of various types. A Memorandum of Understanding (MoU) with CERN is getting finalized to define the scientific aims of the collaboration, together with its technical and economic requirements. In this context, it is conceivable to deviate the WL shown in Fig. 9 to have the possibility to irradiate long (up to 2-3 meters) samples, to obtain complementary data to the ones obtainable on small surface samples from the other two beamlines. This would allow to extract quantitative information on surface reflectivity, photo and photo-induced desorption yield, secondary electron emission, chemical modifications etc., both on small samples and on real beam

pipes, rendering the laboratory a powerful tool to study and qualify materials in accelerators.
In 2016, the XUV laboratory has hosted the experimental activities of the Work Package 4.4 of the European Project EuroCirCol, focused on issues related to cryogenic vacuum and its stability upon photon, electron and/or ion irradiation. In order to perform the required study we need to measure all surface properties at very low operating temperatures. For this purpose, we fully refurbished the cryogenic manipulator, so that we are now able to routinely measure, at low temperatures, Secondary Electron Yield (SEY) on various cold surfaces in the presence of various adsorbates. We are also able to follow the desorption process from such surfaces as thermally induced or as induced by various irradiation processes (like electron or photon irradiation). In Fig. 10 we show, as an example of this activity, the SEY curve of a clean polycrystalline Cu sample during the exposure to controlled doses of Ar at cryogenic temperature. This system was studied for calibration reasons as well as to deeply understand the physical origin of SEY and results will be presented at International Conferences in 2017.

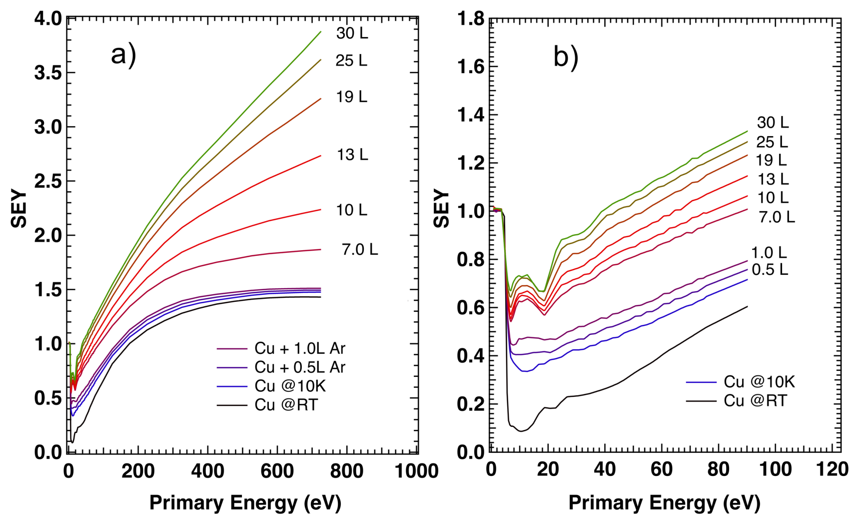

Figure 10: SEY curves versus primary electrons energy as a function of Ar doses. In the left panel (a) the behavior in the complete region between 0 and 720 eV is shown. In the right panel (b) an enlargement of the region between 0 and 90 eV is presented.

We also contributed to Task 4.6 of the EuroCircol Project *Measurements on Cryogenic Beam Vacuum System Prototype*. The goal of the task is to study synchrotron radiation induced photo-desorption, heat loads and photo-electrons generation inside the FCC-hh beam-screen prototype. The designed test bench will be installed at the ANKA synchrotron facility. The experiment will consist on the exposure of the beam-screen prototype to significant levels of synchrotron radiation. Photons with similar energy spectrum and power as those expected to impinge on the FCC-hh arc vacuum chamber will be extracted by one of the ANKA bending magnets using a fixed aperture crotch absorber. In order to collimate the photons impinging on the beam screen a slit system provided by ANKA will be implemented after the gate valve. The test bench will be installed within the walls of the ANKA ring, so that, during operation, all equipment must be controlled remotely.
The laboratory has been also active in continuing studying SEY and Low energy SEY of graphite and metals. The results were relevant in the framework of material study relevant to for both

Particle accelerators and RF satellite devices coatings. Part of this work will be presented in Mulcopim ′17 Noordwijk (The Netherlands).
A time-consuming experiment studying the conditioning of stainless steel and eventual differences with the already measured effect as observed on Cu, has been performed and will probably have an impact addressing the compatibility of SPS to run with the higher currents expected during the injection chain upgrade foreseen for High Lumi LHC.
The laboratory, in the spirit of opening resources to external users, has performed different further works:

1) In collaboration with ELETTRA (Trieste) (SuperESCA beamline) and the Dep. of Physics of the University of Trieste, we have investigated the growth and the characterization of MoS_2 ultra thin layers on Si(100) and SiO_2(300 nm)/Si(100) substrates. The aim of this research was to identify the experimental parameters which allow to obtain in a controlled way mono-, few- or multi-layers of MoS_2, in order to exploit the thickness dependent properties of this 2D material. The growth was performed in a tube furnace by heating sulphur and MoO_3 powders in the presence of an Ar flux. By properly positioning S and MoO_3 crucibles in the quartz tube which was heated to 760 C, we could set different temperatures for the two solid state precursors. The layer thickness was determined by varying the total quantity of reactants in the range 100-200 mg, with the S/MoO_3 ratio changing between 5 and 9. Samples were characterized by XPS and Raman spectroscopy. The former provided the chemical analysis of the grown layers whereas the latter was used to determine the MoS_2 thickness. Fig. 11 shows the Raman spectra excited at 532 nm taken from MoS_2 samples grown on SiO_2 by using different quantities of reactants. The main spectral features in the MoS_2 Raman spectrum excited by visible radiation are the $E^1{}_{2g}$ and A_{1g} lines occurring around 400 cm^{-1}. It is well assessed in the literature that the distance between the two lines changes with the number of layers being $\sim$ 20 cm^{-1} for the monolayer and increasing up to 25-26 cm^{-1} for a thick multilayer. The curves shown in Fig. 11 illustrates this behavior for three samples. The red curves show a $E^1{}_{2g}$ -A_{1g} separation of 20.1 cm^{-1} indicating the formation of a single monolayer. The larger separation measured for the black and light blue curves stem for the formation of a few (3-4)-layer and a thick($\sim$ 10)-layer MoS_2 film, respectively, in agreement with the decreasing intensity of the line at 520 cm^{-1} due to the substrate.

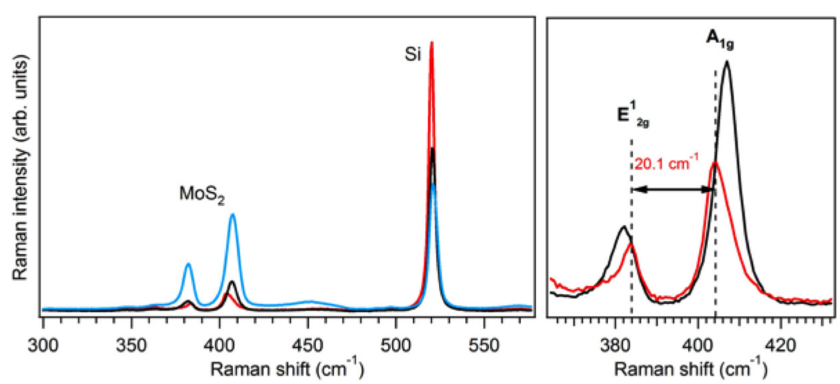

Figure 11: Raman spectra excited at 532 nm on three MoS_2 layers grown on SiO_2(300 nm)/Si(001) substrates by using different amounts of S and MoO_3 precursor powders. A magnification of the spectra taken on the monolayer and few-layer samples in the region around 400 cm^{-1} is shown in the left panel.

2) XPS and Raman spectroscopies were also used also to investigate the reduction of graphene oxide (GO) induced by pulsed laser processing in collaboration with the laboratory of Photonics and Non-Linear Photonics of the University Sapienza (Rome). The final aim of this study is to create a biocompatible scaffold to enhance the stem cell growth based on surface rough graphene stripes embedded in a GO matrix, and possibly written with sufficient lateral resolution by using a laser beam to reduce graphene oxide into graphene. Thin GO layers were drop casted on Si substrates and exposed to the focused beam of a Nd:Yag laser (532 nm, 4 ns, energy density at the sample surface 2x10^9 W/cm^2) that was scanned to write the reduced stripes. The XPS spectra acquired in pristine and laser treated samples are shown in Fig. 12a, as normalized to the height of the C1s peak. The C1s and O1s peaks arising in the pristine sample from the C and O atoms forming the GO layer, appear as well after laser irradiation, however with a different intensity ratio corresponding to the decrease of the oxygen concentration from 35% to 18%. The C1s shapes measured before and after laser irradiation are compared in Fig. 12b and analyzed in Fig. 12c and Fig. 12e. For the pristine

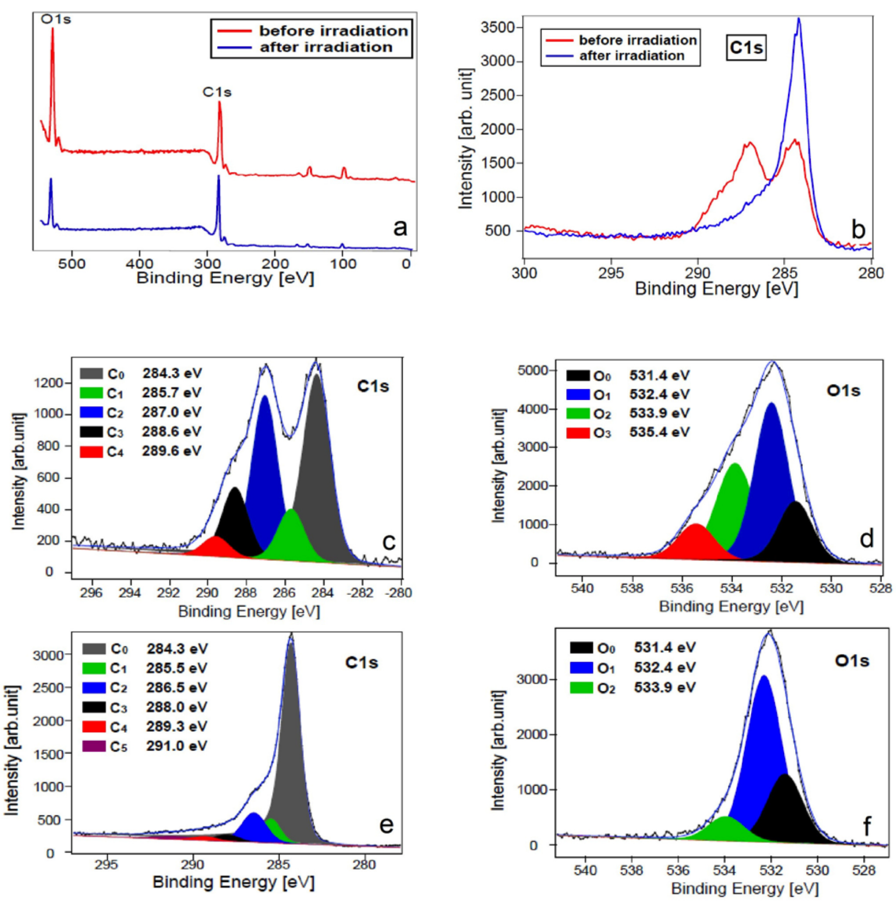

Figure 12: XPS analysis of the pristine and laser irradiated GO films. a) Survey and b) high resolution C1s XPS spectra taken before and after laser irradiation; c-f) decomposition of the C1s and O1s core level spectra measured on the pristine GO films (c, d) and on the laser reduced samples (e, f). See text for the component assignment.

sample (Fig. 12c), spectral decomposition shows the presence of sp^2 hybridized C atoms in aromatic rings (C0), C atoms bonded to hydroxyl groups (C1) or part of C-O-C bonds in epoxy and ether groups (C2), C=O bonds in carbonyls or quinones (C3), and O-C=O bonds in lactones or carboxylic groups (C4). Analogous assignments are derived for the O1s components (Fig. 12d). After laser irradiation, the loss of oxygen corresponds to the almost complete removal of the oxidized components in the C1s spectrum (Fig. 12e). In general GO reductions proceed through photochemical and photo-thermal processes, or through a combination of both. In this case, the low photon energy ($\sim$ 2.3 eV) in comparison with the binding energy of the oxygen-containing functional groups (3.0-3.4 eV) and the high laser energy density gives a strong indication for a purely thermal process. Moreover, the presence of morphological modification observed in the GO layer demonstrated the occurrence of laser ablation. The GO layers containing laser-reduced patterns were used as substrates for human mesenchymal stem cells growth at Institute of Physics of Universit Cattolica del Sacro Cuore. Preliminary results showed that cell reproductions were significantly enhanced in the photo-reduced stripes with respect to the surrounding area, indicating that the combination between GO reduction and morphological modification induced by laser processing can produce a unique platform for biocompatible tissue engineering.

3) Within a collaboration with the Institute of Complex Systems of CNR, Raman spectroscopy has been employed to study the layered growth of MoS_2 and the possible presence of secondary oxide phases in transition metal doped ZnO thin films. In the first case, samples of MoS_2 have been grown by pulsed laser deposition on c-plane sapphire substrates and Si(100). Raman analysis revealed that few monolayers and multi-layers may be grown by mainly varying the number of laser pulses. In the case of Co-doped ZnO thin films also grown by pulsed laser deposition, Raman spectroscopy allowed to investigate the occurrence of Co oxides. Since the technique is sensitive down to the nanoscale, it has been possible to rule out sizable concentrations of Co oxides which could affect the electric transport and the magnetic properties, thus hampering the understanding of the mechanism responsible for the observed ferromagnetism.

3 List of Conference Talks

1. M. Cestelli Guidi, ″Interaction of Radiations with Matter: Applications to Life Sciences on the Earth and in the Space″, Advanced Accelerator & Radiation Physics (AARP) Workshop, Dept. of Condensed Matter Physics of the National Research Nuclear University - MEPhI (Moscow Engineering Physics Institute), Moscow, Russian Federation, 6 -10 Jun 2016.

2. R. Cimino, M. Angelucci, Eliana La Francesca, L. A. Gonzalez, A. Di Trolio, and Rosanna Larciprete, ″Vacuum and Material Science Challenges for Future Circular Colliders ″, IVC 2016, European Vacuum Conference Portorož, 6^{th} - 10^{th} June, 2016.

4 Lectures

1. M. Cestelli Guidi, ″Diagnostic techniques for cultural heritage: applications of Synchrotron FourierTransform Infrared (FT-IR) spectroscopy″, INternational School on modern PhYsics and REsearch (INSPYRE 2016), LNF, 15-19 February 2016.

2. M. Cestelli-Guidi, ″La spettroscopia IR e i Beni Culturali: gli spettri ed i materiali″, Scuola di Spettroscopia IR Applicata alla Diagnostica dei Beni Culturali: V edizione - Venaria Reale (TO), 7-11 November 2016.

5 Publications

1. F. Radica, G. Della Ventura, F. Bellatreccia, M. Cestelli Guidi, ″ HT-FTIR micro-spectroscopy of cordierite: the CO_2 absorbance from in situ and quench experiments″, Phys. Chem. Minerals **43**, 69-81 (2016)

2. F. Radica, G. Della Ventura, F. Bellatreccia, G. Cinque, A. Marcelli, M. Cestelli Guidi, ″ The Diffusion Kinetics Of CO_2 In Cordierite: An HT-Ftir Microspectroscopy Study ″, Contrib. to Mineralogy and Petrology (2016) DOI: 10.1007/s00410-016-1228-x

3. A. De Sio, L. Tozzetti, Ziyu Wu, A. Marcelli, M. Cestelli Guidi, G. Della Ventura, H. Zhao, Z. Pan, W. Li, Y. Guan and E. Pace, ″Physical vapor deposition synthesis of amorphous silicate layers and nanostructures as cosmic dust analogs″, A & A **589**, A4 (2016) - DOI: http://dx.doi.org/10.1051/0004-6361/201527222

4. S. Yao, M. Cestelli Guidi, M. Delugin, G. Della Ventura,A. Marcelli and C. Petibois, ″Methodology for FTIR Imaging of Individual Cells″, Acta Phys. Polonica A **129**, 250-254 (2016)

5. H. Klym, I. Karbovnyk, M. Cestelli Guidi, O. Hotra and A. I. Popov, ″Optical and Vibrational Spectra of CsCl-Enriched GeS_2-Ga_2S_2 Glasses″, Nanoscale Res. Lett. **11**, 132 (2016) - DOI: 10.1186/s11671-016-1350-8

6. A. Balerna, C. Evangelisti, R. Psaro, G. Fusini, A. Carpita ″Structural characterization of bimetallic Pd-Cu vapor derived catalysts″, J. of Physics: Conf. Series **712**, 012057 (2016)

7. A. Di Gaspare, A. Valletta, G. Fortunato, R. Larciprete, L. Mariucci, A. Notargiacomo and R. Cimino, ″Graphene-based field effect transistors for radiation-induced field sensing″, NIM A **824**, 392-393 (2016).

8. L.A. Gonzalez, R. Larciprete and R. Cimino, ″The effect of structural disorder on the secondary electron emission of graphite″, AIP Advances **6**, 095117 (2016).

9. A. Di Trolio, P. Alippi, E.M. Bauer, G. Ciatto, M.H. Chu, G. Varvaro, A. Polimeni, M. Capizzi, M. Valentini, F. Bobba, C. Di Giorgio, A. Amore Bonapasta, ″Ferromagnetism and Conductivity in Hydrogen Irradiated Co-Doped ZnO Thin Films″, ACS Appl. Mater. Interfaces **8**, 12925-12931 (2016).

10. M. Commodo, G. De Falco, R. Larciprete, A. D′Anna, P. Minutolo, ″ On the hydrophilic/hydrophobic character of carbonaceous nanoparticles formed in laminar premixed flames″, Experimental Thermal and Fluid Science **73**, 56-63 (2016)