INFN-LNF POSITIONS FOR "SUMMER STUDENT" GRANTS (2020)

Name of the project/experiment/group: TIDE /ARYA/GroupV-LdS

Research Field: R&D in Vacuum Science and Technologies

Title: TIDE: photon and electron sTImulated DEsorption: Its study and its impact to accelerator vacuum behaviour

Description of the activity: Electron and photon stimulated desorption from technical materials are essential input parameters to properly simulate vacuum behavior of new accelerators. Those parameters are even more important when analyzing accelerators that routinely use cryogenic components. Such cold surfaces will not be able to thermally desorb contaminant gasses. Only non-thermal processes (like electron and photon irradiation) may be inducing desorption and need full characterization. During this fellowship, the successful candidate will study electron desorption by using Secondary Electron Spectroscopy as recently proposed by the host laboratory, with the aim to help characterizing and calibrating the photon desorption station on small and cold surfaces which will be operating in the Frascati laboratory using synchrotron radiation produced by the DAFNE storage ring or by external sources.

Period: June – July 2020

Tutor: Roberto Cimino) (roberto.cimino@lnf.infn.it)

Name of the project/experiment/group: DesorptionAnalysis/ARYA/GroupV-LdS

Research Field: R&D in Vacuum Science and Technologies

Title: Desorption processes: analysis through SEY measurements

Description of the activity: Particular attention is recalled by the evolution of the dense molecular clouds, in which the low temperatures (10-20 k) allow the formation of elementary molecules ices on the dust grains in the innermost areas of the proto-planetary disks. The origin of the presence of more complex species, is thought to arise from a combination of surface chemistry and the evaporation of these molecular ices. The reasons of these desorption processes are found in thermal and radiative photo/electro desorption phenomena. In this work we want to study above all the second phenomenon, which is predominant in these environments, analyzing how the ice of simple molecules changes as a result of the thermal and energetic processes that arise through irradiation with electrons or photons. This survey, based on the measurement of surface parameters such as the secondary electron yield (SEY), can also influence other R&D areas, like the development of material for applications in vacuum chambers and particle accelerators.

Period: June – July 2020

Tutor: Roberto Cimino (roberto.cimino@lnf.infn.it)

Name of the project/experiment/group: SIDDHARTA-2

Title: Kaonic atoms measurements with SIDDHARTA-2 to understand the strong interaction with strangeness at threshold

Description of the activity: The SIDDHARTA-2 experiment aims to perform the first measurement in the world of the X-ray transitions in the kaonic deuterium exotic atom, which will help to understand the strong interaction described by the Quantum ChromoDynamics (QCD) theory in the non-perturbative regime in systems with "strangeness" (i.e. with strange quarks). The SIDDHARTA-2 experiment will measure the X rays produced in the de-excitations of kaonic deuterium by using new Silicon Drift Detectors developed to perform precision X-ray spectroscopy and which can have applications going from physics and astrophysics to industry and medicine. SIDDHARTA-2 is in data taking at DAFNE, an electron-positron collider delivering kaons and 2020 is a very exciting period for the exp[eriment! The kaonic deuterium measurement plays a fundamental role in understanding how QCD works, with implications going from particle and nuclear physics to astrophysics (equation of state of neutron stars).

The student will be involved in all the exciting phases of the experiment, from the data taking and optimization of the setup on the DAFNE collider, one of the very few working colliders in the world, to data analyses and advanced Monte Carlo simulations, and will have the opportunity, unique in a lifetime, to see the first signal of kaonic deuterium ever!

Period: June – July or September – October

Tutor: Dr. Catalina Curceanu (catalina.curceanu@lnf.infn.it)

Name of the project/experiment/group: CYGNO

Title: Convolutional neural network approach to particles identification in CYGNO experiment

Description of the activity: The CYGNO experiment (https://web.infn.it/cygnus/) aims to demonstrate the feasibility and capability of large gasses TPC for the identification of light dark mater candidates and very low energy solar neutrinos. The Particles are detected by means of high granularity and sensitivity sCMOS cameras. Inside the detected pictures, software algorithms have to identify signal candidates against natural radioactivity background, determinating the efficiency and energy threshold of the experiment. In this framework, the convolutional neuronal network could play a role in improving the today detector capability. The work will consist of studying and modeling a CNN approach to the analysis of the available data.

Period: June – July

Tutor: Giovanni Mazzitelli (giovanni.mazzitelli@lnf.infn.it) & Emanuele Di Marco (Roma1)

Name of the project/experiment/group: PADME

Title: Search for dark matter signals at LNF with PADME

Description of the activity: There are models attempting to solve the dark matter problem, as well as the muon (g-2) anomaly, postulating the existence of a low-mass spin-1 particle (A') that would possess a gauge coupling of electroweak strength to dark matter, and a much

smaller coupling to the Standard Model (SM) hypercharge. The PADME experiment, by using the positrons of the Frascati National Laboratory (LNF) LINAC, is searching for invisible decays of the dark photon by measuring the missing mass of the process e^+e^- -> gamma A', with the A' undetected. The measurement requires the determination of the 4-momentum of the recoil gamma and the rejection of all possible source of background. PADME is an international collaboration that comprises Bulgarian, Hungarian, Italian and American researchers. The detector has been installed on the LNF positron beam-line in 2018 and took data from October 2018 to February 2019. Now, an intense activity of data calibration and analysis is ongoing and next data taking will take place from February 2020 till early summer.

Period: 1 June – 14 August

Tutor: Paola Gianotti (gianotti@lnf.infn.it), Fabio Ferrarotto (fabio.ferrarotto@roma1.infn.it)

Name of the project/experiment/group: Nanotechnologies NEXT (1 position)

Title n. 1: Nanosensors for biomedical applications

Description of the activity: Electrochemical DNA – sensors are one of the most promising tools with very diverse areas of application such as medical diagnostics, environmental pollutants monitoring, biological weapons defence etc. In spite of DNA – sensors already widely used in practice, they have a perspective for the improvement of functionality and cost – effectivity. One of the important directions in this matter is the increasing selectivity and sensitivity of sensors in expense of enhancement of electric signal and target – probe hybridization stability. Another important direction is the improvement of the electrode effectivity and manufacturability. From this point of view the best choice is the polymer – CNT enhanced nanocomposites, combining these two important features. At the same time, the better understanding of molecular mechanisms behind the DNA and RNA hybridization on the surface of electric transducer, and polymer – CNT nanocomposites formation is relevant for the improvement of effectivity and manufacturability of DNA – sensors. The Student will carry out all-round activity in nanoscience, with a specific calling for technological applications, stemming from scientific achievements and with the help of a careful theoretical research and modeling activity.

The Student will also participate to the realization of the Nanomaterial (e.g. carbon nanotubes and graphene) that are synthesized in the nanotechnology laboratory, and the corresponding biosensor nano-devices, which he will subsequently characterize and test. The student will engage in the Chemical Vapour Deposition of carbon nanotubes (CNT) and Graphene on catalytic substrates and/or in porous templates, as well as in the arc discharge synthesis of carbon nanotubes, without impurities and with a low density of defects. Purification and functionalization of carbon nanotubes are carried out by LNF team by physical and chemical methods.

Main references:

1. "Biological interactions of carbon-based nanomaterials: From coronation to degradation" Kunal Bhattacharya, Sourav P Mukherjee, Audrey Gallud, Seth C Burkert, Silvia Bistarelli, Stefano Bellucci, Massimo Bottini, Alexander Star, Bengt Fadeel, Nanomedicine: Nanotechnology, Biology and Medicine, Available online 17 December 2015.

2. "Multiwalled carbon nanotube buckypaper induces cell cycle arrest and apoptosis in human leukemia cell lines through modulation of AKT and MAPK signaling pathways", Simona Dinicola, Maria Grazia Masiello, Sara Proietti, Pierpaolo Coluccia, Gianmarco Fabrizi, Alessandro Palombo, Federico Micciulla, Silvia Bistarelli, Giulia Ricci, Angela Catizone, Giorgio De Toma, Mariano Bizzarri, Stefano Bellucci, Alessandra Cucina, Toxicology in Vitro 7 (2015) 1298-1308

3. "Collapse and hybridization of RNA: View from replica technique approach", Y Sh Mamasakhlisov, S Bellucci, Shura Hayryan, H Caturyan, Z Grigoryan, Chin-Kun Hu, The European Physical Journal E 38 (2015) 1-9.

4. "Growth inhibition, cell-cycle alteration and apoptosis in stimulated human peripheral blood lymphocytes by multiwalled carbon nanotube buckypaper", O Zeni, A Sannino, S Romeo, F Micciulla, S Bellucci, MR Scarfi, Nanomedicine 10 (2015), 351-360

5. "Differences in cytotoxic, genotoxic, and inflammatory response of bronchial and alveolar human lung epithelial cells to pristine and COOH-functionalized multiwalled carbon nanotubes", Cinzia Lucia Ursini, Delia Cavallo, Anna Maria Fresegna, Aureliano Ciervo, Raffaele Maiello, Giuliana Buresti, Stefano Casciardi, Stefano Bellucci, Sergio Iavicoli, BioMed Research International,Volume 2014 (2014), Article ID 359506, 14 pages

6. "Targeted Nanodrugs for Cancer Therapy: Prospects and Challenges", Massimo Bottini, Cristiano Sacchetti, Antonio Pietroiusti, Stefano Bellucci, Andrea Magrini, Nicola Rosato, Nunzio Bottini, J. Nanosci. Nanotechnol 14 (2014) 98-114.

Period: June-July 2020.

Tutor: S. Bellucci (bellucci@lnf.infn.it).

Title n. 2: Electron beam acceleration for advanced materials characterization.

Description of the activity: With the advent of the era of graphene, the universally famous two-dimensional allotrope of carbon, with its lightweight, amazing strength and unsurpassed ability to conduct electricity and heat better than any other material, previously unconceivable technological opportunities are opening up in a manifold of various applicative areas, in the true spirit of enabling technologies. The use of graphene can be envisaged in nanoelectronics, as a promising alternative to customary materials such as copper, which show well-known limitations in their utilization at the nanometer scale, owing to the challenges of dealing with higher values of frequencies and smaller sizes in beyond state of the art applications. Features like tunable electronic properties may be exploited to realize, for instance, a microwave electronically tunable microstrip attenuator. Electronic systems intended for Aerospace and Aeronautics applications are requested to exhibit such high performances in terms of operating conditions and reliability, that the used materials must retain outstanding mechanical, thermal and electrical properties. New technological solutions must provide significant reduction of weight of parts and supports (such as electronic cases), realized with optimized shapes. A solution to such problems can be provided by exploiting the recent advances in Nanotechnology in the synthesis of the so-called nanocomposites, a class of composites where one or more separate phases have one dimension in the nanoscale (less than 100nm).

The Student will participate to the Raman and Fourier Transform Infrared spectroscopies, and the Electron microscopy, electrical aand electronic characterizations of the nanomaterials, e.g. graphene, nanotubes, and epoxy nanocomposites. The Student will also engage in the

realization and characterization of epoxy resin nanocomposites based on nanocarbon materials and study their electrical and mechanical properties and the electromagnetic shielding they provide up to the microwave frequency range.

Main references:

1. "What does see the impulse acoustic microscopy inside nanocomposites?" VM Levin, YS Petronyuk, ES Morokov, A Celzard, S Bellucci, PP Kuzhir, Physics Procedia 70 (2015) 703-706
2. "Microstructure, elastic and electromagnetic properties of epoxy-graphite composites", SS Bellucci, F Micciulla, VM Levin, Yu S Petronyuk, LA Chernozatonskii, PP Kuzhir, AG Paddubskaya, J Macutkevic, MA Pletnev, V Fierro, A Celzard, AIP Advances 5 (2015) 067137
3. "Broadband Dielectric Spectroscopy of Composites Filled With Various Carbon Materials", Stefano Bellucci, Silvia Bistarelli, Antonino Cataldo, Federico Micciulla, Ieva Kranauskaite, Jan Macutkevic, Juras Banys, Nadezhda Volynets, Alesya Paddubskaya, Dmitry Bychanok, Polina Kuzhir, Sergey Maksimenko, Vanessa Fierro, Alain Celzard, IEEE Transactions on Microwave Theory and Techniques, 63 (2015) 2024-2031
4. "Nanocomposites of epoxy resin with graphene nanoplates and exfoliated graphite: Synthesis and electrical properties", A Dabrowska, S Bellucci, A Cataldo, F Micciulla, A Huczko, physica status solidi (b) 251 (2014), 2599-2602.
5. "Heat-resistant unfired phosphate ceramics with carbon nanotubes for electromagnetic application", Artyom Plyushch, Dzmitry Bychanok, Polina Kuzhir, Sergey Maksimenko, Konstantin Lapko, Alexey Sokol, Jan Macutkevic, Juras Banys, Federico Micciulla, Antonino Cataldo, Stefano Bellucci, physica status solidi (a) 211 (2014), 2580-2585
6. "Multi-walled carbon nanotubes/unsaturated polyester composites: Mechanical and thermal properties study", MSI Makki, MY Abdelaal, S Bellucci, M Abdel Salam, Fullerenes, Nanotubes and Carbon Nanostructures 22 (2014), 820-833

Period: June-July 2020.

Tutor: Stefano Bellucci (bellucci@lnf.infn.it).

Name of the project/experiment/group: LHCb

Title: Study of b-hadron decays, a tool for New Physics discovery.

Description of the activity: One of the key assumptions of the Standard Model of fundamental particles is that the interactions of the charged leptons differ only because of their different masses. Recent studies of semileptonic decays of B-mesons have resulted in observations that challenge lepton universality (LFU) at the level of about three-four standard deviations. A confirmation of these results would point to the existence of new particles or interactions, and could have profound implications for our understanding of particle physics.

LHCb is one of the main experiments collecting data at the Large Hadron Collider accelerator at CERN. One of its primary goal is to study with high accuracy the properties of b-hadrons that are copiously produced in the proton-proton collisions at LHC. The LFU test results obtained at LHCb concern so far two classes of transitions in b-quark hadron decays. Measurements of highly suppressed flavour-changing neutral-current decays, b → s ℓ^+ ℓ^−, hint at a difference involving muons and electrons, while measurements of the more frequent tree-level charged current processes, b → c ℓ^+ ν_ℓ, hint at a difference between muons and

taus. These two classes of decays present very different challenges, both experimentally and theoretically.

In the LHCb group in Frascati we are deeply involved in several studies concerning b-hadrons, ranging from the study of LFU in semileptonic decays of the B_s mesons and \Lambda_b hadrons, to the study of the rarest B_s → \mu^+ \mu^- or B^0 → \mu^+ \mu^- decays.

Activities:

The student will be involved on key aspects of the data analysis. Depending on the chosen analysis, on his/her interests and when he/she will be with us, the work can focus on:

- the optimisation of signal selection and the study of a suitable sample to control the most dangerous backgrounds;

- the developments of novel algorithms to control efficiency determination;

- the improvements of the resolution of the signal kinematic useful for precise measurements of some observables.

The student will learn how to handle big sample of data with modern tools typically used in High Energy Physics. In particular, in various stages of the work, there

will be a large usage of modern Machine Learning techniques.

Some knowledges in computing (e.g. python, C++, root,...) are desirable but not mandatory.

Additional information:

LHCb collaboration website for useful general information:

http://lhcb.web.cern.ch/lhcb/

News about latest LHCb measurements on LFU (http://lhcb-public.web.cern.ch/lhcb-public/Welcome.html#RDst2 and

http://lhcb-public.web.cern.ch/lhcb-public/Welcome.html#RK2) and on the last update of B_s to \mu\mu

(http://lhcb-public.web.cern.ch/lhcb-public/Welcome.html#BsMuMu2017), all with many interesting links.

About LFU tests with B-decays:

https://cerncourier.com/a/beauty-quarks-test-lepton-universality/

http://inspirehep.net/record/1516196

Period: 3 June - 31 July 2020 or 1 September - 30 October 2020

Tutors: Marcello Rotondo (marcello.rotondo@lnf.infn.it),

Marco Santimaria (marco.santimaria@lnf.infn.it)

Name of the project/experiment/group: KLOE-2

The KLOE-2 experiment completed its data taking campaign at the upgraded e+e- DAPHNE collider of the INFN LaboratoriNazionali di Frascati, at the end of Mach 2018, collecting more than 5 fb-1 at the center of mass energy of the phi-meson. The KLOE-2 collaboration

activities are now focused on data reconstruction and analysis towards Precise Measurements and searches of Physics Beyond the Standard Model. The physics program is mainly focused on KS and eta meson rare decays as well as on kaon interferometry, fundamental symmetry tests and physics beyond the Standard Model, including searches for new exotic particles that could constitute the dark matter.

Title n. 1 : Light dark matter searches with the KLOE-2 detector.

Description of the activity: The possibility to detect light dark matter in the sub-GeV regime through the decay of a light dark sector mediator is a unique opportunity for KLOE-2 which is presently hunting for the B-boson, a possible mediator of Dark Matter and Standard Model (SM) particles interaction. To this extent more than 5 fb-1 of data are available. The B-boson decay mimics the Standard Model known decays, therefore representing a challenge in analysis techniques to achieve a precise measurement of the upper limit on the coupling between dark and SM sectors in the sub-GeV mass range.

The summer student will participate in the ongoing analysis, contributing to the implementation of new approaches in calculating Upper Limits and applying Bayesian methods.

Basic knowledge in C++ and ROOT framework of CERN is welcome.

Period: June-July

Tutor: E. Perez del Rio (Elena.PerezDelRio@lnf.infn.it)

Title n. 2: Towards testing Quantum Mechanics with neutral kaons at KLOE-2

Description of the activity: The entanglement in the neutral kaon pairs produced at the DAPHNE phi- factory is a unique tool to test discrete symmetries and the basic principles of quantum mechanics.

The decay phi $\rightarrow$ KSKL $\rightarrow \pi^+\pi^-\pi^+\pi^-$ will be used among the others, significantly improving present results exploiting the insertion of a dedicated GEM-based tracking detector.

Both neutral kaons will decay within few cm from the interaction point, therefore detector performance in terms of spatial resolution and its stability along data taking are essential to better isolate signal selection and improve signal to background rejection. The student will participate in the development of dedicated algorithms to select 4-track final states and in the measurement of tracking and vertexing performance by studying different event topologies in the KLOE-2 detector and using the stability of Ks lifetime measurement as one of the figures of merit.

Basic programming skills are required.

Period: September-October

Tutor: Erika De Lucia (erika.delucia@lnf.infn.it)

Title n. 3: High precision tests of low-energy QCD with fully neutral final states at KLOE-2

The low-energy regime of the Quantum chromodynamics (QCD), characterizing strong interactions between quarks and gluons, is described by the Chiral Perturbation Theory (ChPT). This effective field theory is built as a series expansion in power of momenta.

KLOE-2 could test with high precision theoretical predictions by measuring the eta -> pi0 gamma gamma decay channel.

In this ChPT "golden mode", the first two terms are suppressed, giving the possibility to test the theory at a very precise level. The student will participate in the analysis of fully neutral final states, focusing on the calorimeter performance by studying photon counting for different multi-photon decay channels.

Basic programming skills are required.

Period: September-October

Tutor: Simona Giovannella (simona.giovannella@lnf.infn.it)

Title n. 4: Data Management & Preservation at KLOE-2

Students with a background in Physics and/or Computer Science are warmly welcome to join the KLOE-2 Offline Group to participate in the development of monitoring tools, code optimization and algorithm design as well as data management, such as data preservation and storage.

Familiarity with programming languages like C++, Python, FORTRAN and Perl, together with different debugging tools and High Energy Physics frameworks, like ROOT from CERN, are desirable.

Particularly, we offer the possibility of joining the Offline Group in designing and implementing new algorithms more adapted to a new target language and newly installed KLOE-2 computing resources.

This gives a unique opportunity to improve/learn new programming skills and experience team work within a collaborative and friendly environment.

Period: June-July or September-October

Tutors: Fabio Fortugno (Giuseppe.Fortugno@lnf.infn.it), Paolo Gauzzi

(paolo.gauzzi@roma1.infn.it)

Name of the project/experiment/group: The RICH of CLAS12/CLAS/JLAB12-LNF

Title: Study of the performance of the CLAS12 RICH

The Jefferson Laboratory in Newport News (USA) is one of the leading facilities in the study of the internal structure of the nucleon. Here, high intensity and high polarization electron beams are scattered by hydrogen or nuclear targets, producing various particles in the final state. The accurate measurement of the rate and angular distributions of these particles allows to extract information on the quark and gluon structure of the nucleon. In the Hall B of the Jefferson Laboratory, the CLAS12 detector is able to perform these measurements over a wide kinematic acceptance.

A Ring Imaging CHerenkov (RICH) detector has been built by INFN to extend the particle identification capabilities of CLAS12 to kaons in the momentum range between 3 and 8

GeV/c. This will allow the CLAS12 to extend the study of the nucleon structure in kinematic regions otherwise not accessible.

The detector uses aerogel tiles as Cherenkov radiator, multi-anode photomultiplier tubes as photon detectors and a mirror system to collect as much as possible of the Cherenkov photons. The kaons are separated from the prevalent background of pions and protons by reconstructing the emission angle of the Cherenkov photons and studying the measured hit pattern. A likelihood approach is used to make the final particle identification.

Description of the activity: The student will analyze the CLAS12 experimental data to study several important parameters that ultimately determine the RICH detector performance, as for example:

- the mapping of the Cherenkov angle reconstruction as a function of the impact point on the aerogel radiator wall.

- the quality of the alignment of the planar and spherical mirrors by looking at photons detected in different topologies

- the optimization of the particle identification algorithm parameters, by looking at particular final states as elastic events or mesonic and baryonic resonances.

The student will develop dedicated algorithm to extract from the data the relevant information and to store them in the CLAS12 database.

Period: June-July 2020

Tutor: Marco Mirazita (Marco.Mirazita@lnf.infn.it)

Name of the project/experiment/group: SPARC_Lab

Title: Low Level RF control and fs laser synchronization

Description of the activity: Measurement and calibration of RF systems for beam control and feedback in high brightness linear electron accelerators. Characterization of opto-electronics devices for laser-electron beam femtosecond synchronization in plasma wakefield acceleration experiments

Period: June 1st - August 14th or October 7th – November 6th 2020

Tutors: Luca Piersanti, Marco Bellaveglia

Secretary: ad.seg@lnf.infn.it

Name of the project/experiment/group: Accelerator Division

Title: Accelerator magnet design

Description of the activity: Design of electromagnets to guide particle motion in accelerators based on the Poisson 2D simulation code

Period: June 1st - August 14th or October 7th – November 6th 2020

Tutors: Lucia Sabbatini, Alessandro Vannozzi

Secretary: ad.seg@lnf.infn.it

INFORMATIONS

- Accommodation: students may be accommodated in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
- Lunches at the LNF canteen (Monday-Friday) are free of charge.
- LNF Summer closing period: 10-21 August 2020

Local Exchange Program Contacts:
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