LNF PROJECTS FOR SUMMER STUDENT GRANTS (2022)

Project: PADME

Title: Commissioning and calibration of the PADME electron tagger detector

Description: In recent times, studying the de-excitation via electron-positron pairs production of some nuclear systems, a research group based at the ATOMKI of Debrecem has observed an anomaly that can be explained postulating the existence of a proto-phobic boson of mass 17 MeV (X17). The Positron Annihilation into Dark Matter Experiment (PADME) was approved to search for invisible decays of a dark photon produced in the process e^+e^- -> gamma A', with the A' undetected. By changing the energy of the incoming beam PADME can try to produce resonantly the X17 boson.
The measurement requires the determination of the 4-momentum of the e^+e^- pairs resulting from the decay of this hypothetical new particle and the rejection of all possible source of background. To perform such a measurement the PADME collaboration is building a new electron tagger that will be placed in front of the e.m. calorimeter. For more information visit: http://padme.lnf.infn.it/

Activities: The candidate will participate in the data taking for the commissioning of the new detector and in the analysis of the data for its calibration.

Tutor: Paola Gianotti (paola.gianotti@lnf.infn.it)

Activity period: September-October 2022

Project: SHERPA (Slow Highefficiency Extraction from Ring Positron Accelerator)

Title: SHERPA bent crystal data analysis

Description: Characterization of bent silicon crystals studied for slow extraction of positrons and electrons from one of the DAFNE rings.

Activities: Data analysis of the measurements performed at the BTF-2 beam line to characterize beam deflection properties of the silicon bent crystals. The data will be acquired by a 2D silicon detector (TimePix3) and the main observables to be extrapolated are deflection angle and efficiency of each bent crystal.

Tutor: Marco Garattini (SHERPA P.I.) (marco.garattini@lnf.infn.it)

Activity period: June-July or September-October 2022

Project: CYGNO

Title: LIME, zero prototype for Dark Matter search and Neutrino astronomy based on Time Projection Chamber optical read out.

Description: LIME is the first prototype of the CYGNO experiment (https://web.infn.it/cygnus/) dedicated to the development of a large gas Time Projection Chamber with optical read-out

dedicated to the search of dark matter and the study of solar neutrinos. LIME has been installed at the LNGS of the INFN and is going to start the collection of the first data.
After a phase dedicated to the commissioning of the detector and auxiliary systems (DAQ, gas system, LV / HV, PMT etc.), a calibration campaign and data collection is started, evaluating resolutions, efficiencies, pileup, etc. and the radioactive background of LNGS in different experimental configurations.

Activities: The candidate will be included in the R&D activity of the LNF group by participating in the laboratory tests and in the implementation of the experimental setup, calibration and data taking from the LNGS.

Tutor: Giovanni Mazzitelli (Giovanni.mazzitelli@lnf.infn.it)

Activity period: June-July or September-October 2022

Project: Exotic atoms measurements with SIDDHARTA-2 at DAFNE

Title: Kaonic atoms measurements at the DAFNE collider with the SIDDHARTA-2 experiment

Description: 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 installed on DAFNE, an electron-positron collider delivering kaons, and will be in data taking through all 2022; a very exciting period for a student! 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).

Activities: The student will be involved in all the exciting phases of the experiment, from the data taking of SIDDHARTA-2 on the DAFNE collider, one of the very few working colliders in the world, to optimizations of various detector sub-systems and of the data taking chain, along the run and data analyses. He/she will be also introduced to data analyses and advanced Monte Carlo simulations.

Reference: The modern era of light kaonic atom experiments, C. Curceanu et al., Rev. Mod. Phys. 91, 025006 (2019)

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

Activity Period: September – October 2022

Project: Quantum Mechanics: tests of the Pauli Exclusion principle and of collapse models

Title: Tests of Quantum Mechanics within the VIP experiment: Pauli Exclusion principle and gravity related collapse models

Description: The VIP experiment, installed at the Gran Sasso underground laboratory, LNGS-INFN, is performing experimental searches of signals coming from possible violations of standard quantum mechanics, such as atomic transitions violating the Pauli Exclusion Principle (PEP) and spontaneous radiation coming from modified Schroedinger equation within the so-called collapse models. The VIP collaboration developed a series of radiation detectors and data analyses methods which allowed to set extremely competitive limits on PEP violation and collapse models. Presently, the experimental apparata are under optimization, in parallel with the data taking and data analyses, to either set even stronger limits or find signals of violations of standard quantum mechanics, which, of course, would be initiating a revolution. The obtained results are also important for quantum technologies.

Activities: The student will be involved in all the exciting phases of the experiment, from the preparation and testing of future detector systems, to data analyses using advances statistical analyses methods. He/she will be also introduced to interpretation of results in the framework of modern theories, including gravity related collapse models.

References: Underground test of gravity-related wave function collapse, A. Donadi et al., Nature Physics volume 17, pages 74–78 (2021) and Test of the Pauli Exclusion Principle in the VIP-2 Underground Experiment, C. Curceanu et al., Entropy 2017, 19(7), 300.

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

Activity Period: September – October 2022

Project: Electrons to Cure Mirror Charging

Title: Determination of Surface Charging/Discharging Conditions by Secondary Electron Yield Investigations

Description: Electrostatic charge forming on the Gravitational Wave (GW) mirrors severely affects detection sensitivity. At LIGO, a charging mitigation method has been successfully applied. This requires long mirror's exposures to a relatively high pressure of N_2 ions flux. It is impossible to apply this method when mirrors are at cryogenic temperatures, since a significantly thick condensed gas layer will develop on the mirror surface severely affecting its performance. An intense effort needs to be devoted to find new charging neutralization methods compliant with the constraints derived by the use of cryogenic optics. A possibility is given by selected energy electrons (between 10 to 100 eV) which, at very low doses, can impinge on the surface mirror. It is known, indeed, that according to their energy, the Secondary Electron Yield (SEY, which is the number of electrons emitted per incident ones) could be ≤ 1 or ≥ 1, i.e. removing or adding electrons at will on the mirror's dielectric surface. Even if conceptually simple, the actual refinement of this method and its implementation are a challenge. A first mandatory step is to know how much electronic charge is delivered (or removed) as a function of dose and energy of the impinging electron flux in realistic small samples, representative of materials composing the mirrors. This project aims to address this issue by using all the surface science spectroscopies available in the laboratory to first determine the SEY of mirrors samples in neutral and unperturbed conditions. After identifying and checking a measurement technique to quantify the surface charge, the goal is to define the electron beam parameters to induce on purpose charging/discharging on surface.

Activities: Laboratory and data analysis activity

Tutors:
Luisa Spallino (luisa.spallino@lnf.infn.it)
Marco Angelucci (marco.angelucci@lnf.infn.it)
Roberto Cimino (roberto.cimino@lnf.infn.it)

Activity period: June-July or-September-October 2022

Project: a-C coatings for Electron Cloud reduction

Title: Investigation of a-C at cryogenic temperature by SEY

Description: Electron cloud is a serious issue for most performing proton beam like the ones at LHC and for the planned Electron-Ion Collider (EIC). Electrons, produced by ionization of the residual gas by the passage of short spaced high-intensity bunches, can be accelerated toward the vacuum chamber walls by the proton beam, thereby releasing more electrons from the walls. This can create an electron avalanche that builds up rapidly in the beam vacuum chamber (that is electron cloud), thus causing detrimental effects (heat load, gas desorption, vacuum degradation, …) that gives rise to beam instabilities.
The key parameter governing the electron cloud formation is the Secondary Electron Yield (SEY, which is the number of electrons emitted per incident one) of the vacuum chamber material. To prevent electron cloud buildup, the choice of the material of the vacuum chamber surfaces is then crucial and a SEY close to (or below) 1 is needed. SEY is an intrinsic material property, highly sensitive to surface modifications. Then, when working at cryogenic temperature, the physisorption of residual gas species in the vacuum system may strongly affect SEY characteristics, especially in the low energy region of the spectrum.
It is known that an amorphous carbon (a-C) layer on Cu substrate can reduce SEY down to a value ~1. It is also known that this reduction may depend on the specific way a-C is grown, eventual presence of contaminants during its growth etc. Therefore, an experimental campaign could be launched to verify the SEY dependance upon growing parameters. This may be a crucial issue to validate an industrial production as the one planned for the Cu plated screen coated with a-C t to be installed in the RICH superconductive magnets. Validation should occur also at the low temperatures in which such materials will operate, since the chemical, structural and morphological characteristics of the a-C coating may be different at Low temperature.
This project aims to investigate the effects induced by the cryogenic conditions on the SEY of a-C coatings grown by various type of deposition of a-C on Cu. By using all the surface science spectroscopies available in the laboratory (SEY, XPS, RGA), electron irradiation will be also performed to investigate the modifications during operation (if any) of the relevant parameters of the different samples.

Activities: Laboratory and data analysis activity

Tutors:
Luisa Spallino (luisa.spallino@lnf.infn.it)
Marco Angelucci (marco.angelucci@lnf.infn.it)
Roberto Cimino (roberto.cimino@lnf.infn.it)

Activity period: June-July or-September-October 2022

Project: LHCb

Title: Semileptonic decays of the B_s meson, a tool for New Physics discovery

Description: LHCb is one of the main experiment collecting data at the Large Hadron Collider accelerator. 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. Measurements performed at B-Factories and LHCb, show an hint of violation of Lepton Flavour Universality (LFU) from the comparison of the B —> D(*) tau nu_tau (semi-tauonic) and B —> D(*) mu nu_mu (semi-muonic) decay widths. If these hints would be confirmed by other measurements, it will clearly be a sign of Physics Beyond the Standard Model. It is of paramount importance to study semi-tauonic decays in other b-hadron species both to check the presence of large LFU violation in alternative environments. The LHCb group in Frascati is deeply involved in the study of semileptonic decays of B_s mesons. The B_s mesons (containing an anti-b quark and a s-quark instead of a u- or d-quark, as in ordinary B meson) are interesting because have various advantages compared with the B mesons. A crucial one is that they allow to overcome some important source of backgrounds that affects the semitauonic decays of the B mesons. Moreover, semileptonic B_s decays offer many interesting kinematic observables that can be exploited to constrain various plausible New Physics scenarios.

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

- the developments of novel algorithms to control the soft photon efficiency, which is required by some of the measurements we are interested in;
- the optimisation based of signal selection and the study of a suitable sample to control the most dangerous backgrounds;
- the improvements of the resolution of the signal kinematic useful for precise measurements of some observables using Machine Learning.

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

Tutors:
Marcello Rotondo (marcello.rotondo@lnf.infn.it)
Barbara Sciascia (barbara.sciascia@lnf.infn.it)

Activity period:
1 June - 5 August, 1 September - 28 October 2022

Project: MITIQO

Title: Innovative ultra-high resolution X-ray spectrometer for liquid sources

Description: Bragg spectrometers are widely used in physics to perform extreme precision measurements of X-rays emitted from various types of sources. Among all their possible applications, measurements of metals in liquids, as well as the identification of their oxidation states, could be extremely useful for food quality checks.
The MITIQO collaboration, at the INFN Laboratories of Frascati, is realizing a Von Hamos spectrometer which, exploiting the high reflectivity and efficiency of mosai crystals based on graphite, aims to measure iron oxidation states in wine as well as the relative concentrations of many other elements.

Activities: Students involved in these activities will have the opportunity to work on the experimental setup, to perform several measurements as well as to learn the basic principles of X-ray spectroscopy and of statistical data analysis.

Tutor: Alessandro Scordo (alessandro.scordo@lnf.infn.it)

Activity period: September – October 2022

Project: **Nanosensors for biomedical applications**

Title: Nanosensors for biomedical applications

Description: 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.

Activities: 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.

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

Activity period: June-July or September-October 2022.

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

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

Activity period: June-July or September-October 2022.

Project: Electron beam acceleration for advanced materials characterization

Title: Electron beam acceleration for advanced materials characterization

Description: 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).

Activities: The Student will also participate to the Fourier Transform Infrared spectroscopy, and the Electron and atomic force microscopy, characterizations of the nanomaterials, e.g. graphene, nanotubes, and epoxy nanocomposites. The Student will become experienced with modelling and simulation of the CNT growth over catalyst patterned substrates and porous templates, along with the conductance properties of CNT/metal junctions, as well as in modelling CNT electron transport properties. The Student will 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 in 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

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

Activity period: June-July or September-October 2022.

Project: NanoElectromagnetics (microwave/RF/photonics)

Title: NanoElectromagnetics (microwave/RF/photonics)

Description: We have experience in the frequency (energy)/time-domain full-wave multiphysics modeling of the combined electromagnetic-coherent transport problem in carbon-based (graphene, CNT) nano-structured materials and devices. The core concept is that while the advancement of research in this area heavily depends on the progress of manufacturing technology, still, the global modeling of multi-physics phenomena at the nanoscale is crucial to its development. Modeling, in turn, provides the appropriate basis for design. The bridge between nanosciences and the realized circuits can be achieved by using the panoply of microwave/RF engineering at our disposal. From the theoretical models and techniques, we produced efficient software for the analysis and design.
In our models, the quantum transport is described by the Schrödinger equation or its Dirac-like counterpart, for small energies. The electromagnetic field provides sources terms for the quantum transport equations that, in turn, provide charges and currents for the electromagnetic field. In the frequency-domain, a rigorous Poisson-coherent transport equation system is provided, including electrostatic sources (bias potentials). Interesting results involve new concept-devices, such as Graphene-Nano-Ribbon (GNR) nano-transistors and multipath/multilayer GNR circuits, where charges are ballistically scattered among different ports under external electrostatic control. Further examples are given by the simulation of cold-cathodes for field emission based on graphene and by the analysis of optical emission/absorption by single or few layers GNR.
Recently, we began to work on the model of the graphene/CNT-metal transition and related equivalent circuits models, ii) the inclusion of thermal effects in graphene/CNT, e.g. as deriving from ballistic path reduction due to phonon scattering and as arising at the contact between graphene and silicon dioxide.

In the time-domain, we now avail a novel Schrödinger/Dirac-based transmission line matrix (TLM) solver for the self-consistent analysis of the electromagnetic-coherent transport dynamics in realistic environments. It is highlighted that the self-generated electromagnetic field may affect the dynamics (group velocity, kinetic energy etc.) of the quantum transport. This is particularly important in the analysis of time transients and in the describing the behavior of high energy carrier bands, as well as the onset of non-linear phenomena due to impinging external electromagnetic fields. We are now capable of modelling THz carbon-based emitters/detectors, CNT-enabled traveling wave (TW-CNT) devices, and the carbon-metal transition; we are exploiting novel properties and devices based on frequency multiplication, graphene gyrotropic effects, photoconductive effects.

Activities: The Student's activity we will be focusing on:
- Multiphysics Schrödinger/Dirac-based modeling of the electromagnetic-coherent transport phenomena of the graphene/CNT devices. Microwave and Terahertz circuit characterization stemming from the above analysis in a form suitable for design.
- Models of the graphene/CNT-metal transition. Their equivalent circuits models.
- Inclusion of thermal effects in graphene/CNT (e.g. the contact between graphene and silicon dioxide). Their circuit models in system characterization.
- Characterization and validation of electromagnetic/quantum-mechanics properties of carbon nanostructures.
- Electromagnetic characterization of carbon-based foams. Shielding EM interference in chaotic environments.

Main references:

1. "Spatial dispersion effects upon local excitation of extrinsic plasmons in a graphene micro-disk" Davide Mencarelli, Stefano Bellucci, Antonello Sindona, Luca Pierantoni, Journal of Physics D: Applied Physics 48 (2015), 465104
2. "Broadband microwave attenuator based on few layer graphene flakes", Luca Pierantoni, Davide Mencarelli, Maurizio Bozzi, Riccardo Moro, Stefano Moscato, Luca Perregrini, Federico Micciulla, Antonino Cataldo, Stefano Bellucci, IEEE Transactions on Microwave Theory and Techniques, 63 (2015) 2491-2497
3. "Applications of Graphene at Microwave Frequencies", Maurizio Bozzi, Luca Pierantoni, Stefano Bellucci, Radioengineering 24 (2015) 661-669.
4. "Sharp variations in the electronic properties of graphene deposited on the h-BN layer", DG Kvashnin, S Bellucci, LA Chernozatonskii, Physical Chemistry Chemical Physics 17 (2015) 4354-4359
5. "Graphene-based electronically tuneable microstrip attenuator", L Pierantoni, D Mencarelli, M Bozzi, R Moro, S Bellucci, Nanomaterials and Nanotechnology 4 (2014), 4-18

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

Activity period: June-July or September-October 2022.

Project available for the LNF Summer Student Program only

Progetto: PEROV Gr5

Titolo: Caratterizzazione di sensori di perovskite

Descrizione delle attività: L'attività si inserisce del progetto PEROV che ha lo scopo di osservare la moltiplicazione a valanga in sensori basati sui semiconduttori di perovskite e di studiare la loro stabilità.
Lo studente dovrà svolgere delle misure su sensori di perovskite, di diversi spessori e aree, prodotti con diverse tecnologie: film policristallini di 300 nm, monocristalli in forma di canali micrometrici e monocristalli di forma cubica spessi qualche centinaio di micron.
Le misure da svolgere sono:

- curve IV in continua, in condizione di buio e di luce
- misure di efficienza quantica
- misure di stabilità della risposta al variare del tempo e della tensione di bias
- acquisizioni di segnali da luce impulsata/sorgente radioattiva e studio delle forme d'onda
- confronto tra campioni

Parte dei setup per le misure sono presenti a LNF, altri a Roma1 e Roma2, che partecipano al progetto PEROV, con cui lo studente collaborerà.

Tutor: Marianna Testa (Marianna.testa@lnf.infn.it)
Periodo: Giugno – Luglio, Settembre – Ottobre, da concordare.

Project: EuPRAXIA

Title: High brightness beam generation, transport, matching in plasma, diagnostics.

Description: In the framework of the EuPRAXIA project, SPARC_LAB is focused in achieving high brightness electron beams accelerated by means of plasma acceleration. Six undulator modules follow the accelerator allowing the generation and amplification of FEL radiation. Detailed studies of beam dynamics, plasma physics, laser physics, FEL radiation process, high brightness beam diagnostics, are foresee in the following months.

Activities: The candidates will participate in the machine shifts, installation and commissioning of different instrumentation, beam properties measurements and cross check with simulations.

Tutor: Vladimir Shpakov (vladimir.shpakov@lnf.infn.it)

Activity Period: September-October.

Project: PMu2E

Title N. 1: Development of DQM and DCS system for the calorimeter of the Mu2e experiment

The Mu2e experiment aims to improve the search for the Standard Model forbidden conversion of a muon into an electron. Discovery of such a signal is a clear indication of new physics. The detector is under construction at Fermi National Laboratory (US). The INFN-LNF group is leading the

construction of the Electromagnetic Calorimeter to provide confirmation of the electron signal registered with a tracker system. The Mu2e calorimeter is a state of the art detector composed by 1350 un-doped CsI crystals, each one readout with two new generation UV-extended large area Silicon Photomultipliers (SiPMs) and two custom Front End Electronics (FEE) boards.
A very sophisticated Trigger DAQ (TDAQ) system is under development. The TDAQ is based on software tools both on the data readout and on the trigger system. The LNF group is working on the definition and writing of the related SW modules needed for the Data Quality Monitor (DQM) and the Detector Control System (DCS ala slow control) for the calorimeter detector. The DQM is based on the construction of a set of histograms (1D, 2D, graphs, profiles) that have to be visualized automatically by the Run Control interface or by a standalone ROOT Application. The DCS is based on EPICS and allows to control the parameters both on TDAQ or on ethernet connected instrumentation. A possibility to develop or improve the firmware exists, as well as to collaborate with the TDAQ experts located at Fermilab by remote. *For a successful student, there will be the possibility to continue this job at Fermilab in the next future, if/when pandemics get reduced.*

Period: July-September 2022

Tutor dates: July-10/Aug-1, Aug-20/Sep 30

Tutor names: S.Giovannella, E. Diociaiuti

Required skills: Good knowledge of C++ and programming languages, ROOT. Preference for students with an informatic profile

Title N. 2: Data analysis of Cosmic Ray data of the Mu2e calorimeter large size prototype (Module-0)

The Mu2e experiment aims to improve the search for the Standard Model forbidden conversion of a muon into an electron. Discovery of such a signal is a clear indication of new physics. The detector is under construction at Fermi National Laboratory (US). The INFN-LNF group is leading the construction of the Electromagnetic Calorimeter to provide confirmation of the electron signal registered with a tracker system. The Mu2e calorimeter is a state of the art detector composed by 1350 un-doped CsI crystals, each one readout with two new generation UV-extended large area Silicon Photomultipliers (SiPMs) and two custom Front End Electronics (FEE) boards.
A large size prototype (dubbed Module-0) has been assembled at LNF with 51 CsI crystals. A good fraction of the detector has been equipped with the final SiPMs and final FEE electronics. A Vertical Slice Test of the system will be carried out by reading out the channels with the final Mezzanine Board, that allows a control of the settings and a continuous logging of the detector parameters (HV, T and I), and the final Digitizer Board (DIRAC), that allows digital recording of the detector signals. We foresee to acquire three sets of data: (i) noise runs with a random trigger, (ii) Cosmic Rays data triggering on a set of external scintillation counters and (iii) laser runs by illuminating with a pulsed-laser each sensor by means of a bundle of optical fibers.
The student will be in charge of reconstruct and analyze the large quantity of data collected to determine: the calibration points for energy and timing, the timing resolution and the stability of detector parameters, detector response and calibration along the running time.

Period: Aug- September 2022

Tutor dates: July-10/Aug-1, Aug-20/Sep 30

Tutor names: S. Giovannella, D. Paesani

Required skills: good knowledge of C++, good knowledge of ROOT

Summer Student Programs Contacts:

Paola Gianotti (coordinator)
E-mail: paola.gianotti@lnf.infn.it

Maria Cristina D'Amato (secretary)
E-mail: maria.cristina.damato@lnf.infn.it
Phone +39-06-94038133

OTHER INFORMATION

- Accommodation: students may be accommodated, free of charge, 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: 8-19 August 2022.
- Local web page: http://user.lnf.infn.it/summer-student-opportunities/