INFN-LNF POSITIONS FOR “SUMMER STUDENT” FELLOWSHIPS (2019)

DOE-INFN Summer Exchange Program

and

LNF Internal Summer Student Program

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

Title: Kaonic atoms measurements by the SIDDHARTA-2 experiment on DAFNE accelerator: strangeness in neutron stars.

Description of the activity: 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 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 will be in installed on DAFNE, an electron-positron collider delivering kaons, starting with Spring 2019; a very exciting period will then follow! 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 installation on the DAFNE collider, one of the very few working colliders in the world, to tests of the detector systems and data acquisition. He/she will be also introduced to data analyses and advanced Monte Carlo simulations.

Period: September-October 2019

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

Name of the project/experiment/group: CYGNO

Title: Advanced detectors for directional Dark Matter search

Description of the activity: At the National Laboratory of Frascati is under design the CYGNO project. CYGNO is a new proposal supported by INFN, the Italian National Institute for Nuclear Physics, within CYGNUs proto-collaboration (CYGNUS-TPC) that aims to realize a distributed observatory in underground laboratories for directional Dark Matter (DM) search and the identification of the coherent neutrino scattering (CNS) from the Sun. CYGNO is one of the first prototypes in the road map to 100-1000 m^3 of CYGNUs and will be located at the National Laboratory of Gran Sasso (LNGS), in Italy, aiming to make significant advances in the technology of single phase gas-only time projection chambers (TPC) for the application to the detection of rare scattering events at keV energy threshold.

During he fellow, the candidate will take part to the design and characterization of the Optical Read Out technique based on Micro Pattern Gas Detector (MPGD) amplification of the ionization and on the visible light collection with a sub-millimeter position resolution sCMOS (scientific COMS) camera. This type of readout - in conjunction with a fast light detection - allow on one hand to reconstruct 3D direction of the tracks, offering accurate sensitivity to the source directionality and, on the other hand, a high particle identification capability very useful to distinguish nuclear recoils.

Period: June-July or September-October 2019

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

Name of the project/experiment/group: LHCb

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

Description of the activity: LHCb is one of the main experiments 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, and to explore different kinematic variables aiming to pin down the kind of New Physics than explains the observed anomalies.

We, in the LHCb group in Frascati, are 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 an 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 one the most important background that affects the semi-tauonic decays of the B mesons. This background, which is associated with the decays of orbitally and radially excited charm-meson states, is in fact much less relevant in B_s decays than in B decays. Moreover, semileptonic B_s decays offer many interesting kinematic observables that can be exploited to constrain various plausible New Physics scenarios.

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 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.

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

LHCb collaboration website for useful general information: http://lhcb.web.cern.ch/lhcb/; Latest LHCb measurements on semi-tauonic B decays with many interesting links: http://lhcb-public.web.cern.ch/lhcb-public/Welcome.html#RDst2 A recent review about LFU:

http://inspirehep.net/record/1516196

Period: 3 June - 2 August, 2 September - 31 October 2019

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

Name of the project/experiment/group: LHCb

Title: A fixed gas target for LHCb

Description of the activity: LHCb is one of the main experiments collecting data at the Large Hadron Collider accelerator. Among the several important features, its geometry and the advanced sub-detectors installed give several unique possibilities in the panorama of the high-energy physics. Indeed, LHCb is going to mount the first fixed gas target device ever installed on a high-energy collider like LHC. A storage cell, the only object present in the primary vacuum of the accelerator, will allow for beam-target collisions in synergy with the normal proton-proton collisions. All this will open to unique physics measurements in unexplored kinematic regions. The LHCb group in Frascati, having the leadership, is deeply involved in all the aspect, both technical and physical, of the project. The physics reach goes from the knowledge of the Parton Distribution Functions to the Quark Gluon Plasma, from the nucleon tomography to the astro-particle and dark matter, just to mention some of the possibilities. The setup will allow to inject several different types of gas from the lightest Hydrogen to the heaviest Xenon.

From one side, more instrumental effects like the embrittlement or the accumulation on the LHC triplets must be carefully studied by molecular flow simulations. From the other side the physics opportunities offered by this setup must be studied according to the running time and the specific gas injected. According to the interest and the skills of the student, as well as the development status of the project, there is the possibility to focus the studies on the first or the second item.

Period: 24 June - 30 August 2019

Tutor: Pasquale di Nezza (pasquale.dinezza@lnf.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 tuber 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 main characteristics of the RICH readout electronics, like the dark rate, the cross talk, the time-walk corrections;
- the study of the time resolution, that will allow to select in-time Cherenkov photons and to distinguish between photons detect directly from those detected after reflections on the mirrors;
- the mapping of the Cherenkov angle reconstruction as a function of the impact point on the aerogel radiator wall.

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 2019

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

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 final state 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.

This is only the first phase of the experiment. There are plans to extend the physics program of the experiment to the search of other type of dark sector mediators such as long lived Axion-Like-Particles, proto-phobic X bosons, Dark Higgs.

Depending on the period of stay, the student will take part to the data taking activity, the calibration of the detector, and to the various analysis activities at the Frascati National Laboratory.

Period: June-July or September-October 2019

Tutors: Paola Gianotti (paola.gianotti@lnf.infn.it), Barbara Sciascia (barbara.sciascia@lnf.infn.it)

Name of the project/experiment/group: CarbonSEY/MICA/GroupV-LdS

Research Field: R&D in Vacuum Science and Technologies

Title: Thickness dependence of SEY in thin film coated surfaces

Description of the activity: The Secondary Electron Yield, i.e. the number of electrons produced per incident electron of a given energy, is an ubiquitous problem in many fields of research, spanning from Accelerator to Spacecraft R&D. It is well known that two materials may have different values of SEY, determining their potentialities to be used in many applications. Moreover, the intrinsic SEY can be strongly modified by different atomic and molecular layers on the surface. What is not yet been studied is the thickness dependence of SEY and which is the minimum coverage of the overlayer that will grant the desired SEY. This project aims to address this issue by using all the surface science spectroscopies available in the laboratory, including Synchrotron Radiation, to study "in situ" thin Carbon films (known to have low SEY) onto different metal substrates (with higher SEY) to identify the thickness at which the SEY is dominated by the overlayer. Thermal, photo - and electron induced desorption will be studied from such surfaces and compared to the ones of other material generally used in accelerator technology.

Period: September-October 2019

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

Name of the project/experiment/group: TIDE /MICA/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 2019

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

Name of the project/experiment/group: NEMESYS

Title: NanoElectromagnetics (microwave/RF/photonics)

Description of the activity: 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.

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.

Period: June-July or September-October 2019.

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

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

Name of the project/experiment/group: NEMESYS

Title: 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 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.

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

Period: June-July or September-October 2019.

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", S 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.

Name of the project/experiment/group: NEMESYS

Title: 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 defense 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 Vapor 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.

Period: June-July or September-October 2019.

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

Period: June-July or September-October 2019.

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.

Name of the project/experiment/group: F2S (Fibers For Space) /StratoFly Accademy

Title: Development of an FBG remote sensing device embedded in a metallic material

Description of the activity: The candidate is expected to join our group to learn how to use / operate FBGs and to propose innovative use of these fibers to be adopted and embedded in metallic materials. This activity is interdisciplinary and related to the StratoFly accademy, an H2020 Italian founded project. The candidate will run ANSYS simulations to estimate and calculate the coatings that the fibers would need to have in order to be protected, such coatings could be 3D printed with polymers. Finally the embedded could be constructed via a metallic 3D printing (inserting the protected fiber in the inside), or via traditional ways.

Period: Flexible from mid-May to mid-August 2019

Tutors: Luigi Benussi (lugi.benussi@lnf.infn.it) Stefano Colafranceschi (Eastern Mennonite University, Harrisonburg VA USA) can work remotely as external student advisor

Name of the project/experiment/group: GGM++/CMS

Title: Upgrade of the DAQ and analysis routing of the CMS GGM subsystem

Description of the activity: The GGM project was developed several years ago at LNF and installed at CMS Experiment in 2009. After almost a decade, the system needs a complete update of hardware and software to ensure its usability and maintenability for the next decade.

The candidate should be familiar with C++ coding and open minded to propose solutions that would fit into the complex CMS/DAQ environment. As the new hardware/electronics will be provided the activity would focus on the software update and efficient exploitation of the new hardware/electronics.

Period: Flexible from mid-May to mid-August 2019

Tutors: Stefano Bianco (stefano.bianco@lnf.infn.it), Stefano Colafranceschi (Eastern Mennonite University, Harrisonburg VA USA) can work remotely as external student advisor)

For more information: http://user.lnf.infn.it/student-opportunities/