Istituto Nazionale di Fisica Nucleare

PROGETTO FORMATIVO
"LA FISICA DELLE PARTICELLE PER ESPLORARE L'UNIVERSO"
Edizione 2023

ELENCO PROGRAMMI DI RICERCA PER BORSE DI STUDIO TRIMESTRALI PER LAUREANDI o NEOLAUREATI MAGISTRALI IN FISICA DELLE PARTICELLE

BEPC-1

Hosting Laboratory	Available period	Contact person(s)
BEPC	**01/06/2023 – 31/12/2023**	**Michela Greco - Ilaria Balossino**

Scientific program	Daily activity, skills required and to be acquired
Hybrid construction of the CGEM-IT Layer 3 for the BESIII experiment The BESIII experiment is located at the electron-positron collider BEPCII at the Institute of High Energy in Beijing, PR China. BESIII plays a leading role in the study of hadron spectroscopy in the energy range of the tau lepton and charm quark. An upgrade program is underway for both the detector and accelerator to compete with and complement studies of new generation B-factories and hadron accelerators. A major upgrade of the detector, scheduled for July 2024, is to replace the current inner drift chamber, which is exhibiting aging effects, with an innovative cylindrical gas electron multiplier (CGEM) with charge and time readout. The CGEM-IT consists of three concentric layers of triple GEM detectors. The first two layers were designed, built and tested in Italy and have been operated remotely since 2020. Construction of the third layer is currently being developed in a hybrid way: The five electrodes will be built in Italy, while the final assembly will take place at IHEP. After the completion of Layer 3, the activity will proceed with a full CGEM-IT cosmic data taking to complete the commissioning before the installation into the BESIII spectrometer.	The activity plan will be adjusted according to the candidate's availability. The candidate will participate in Layer 3 construction and commissioning of CGEM-IT as part of one of the major tasks, under the supervision of the INFN advisor. Knowledge of laboratory instrumentation and particle physics detector operation are required at basic level. Knowledge of the Micro Pattern Gas Detector is a plus. The candidate will be part of an international collaboration and will learn from direct experience advance techniques in the operation of a highly technological detector, providing a boost to his/her studies.

CERN-1

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2023 – 30/11/2023**	**Ernesto Migliore – Stella Orfanelli**

Scientific program	Daily activity, skills required and to be acquired
The upgrade of the CMS Inner Tracker for HL-LHC: Characterization of prototype modules in a test bench and in beam tests. The High Luminosity upgrade of LHC (HL-LHC) will be the main scientific instrument for the investigation of the subatomic world through the 2020s and 2030s. To cope with the unprecedented particle rates and radiation levels expected at HL-LHC, the present Tracker of the CMS experiment will be replaced during the LHC long shutdown in 2026-2028. With the main decisions about the technology for the pixel detector (Inner Tracker) now taken, 2023 will be devoted to the study of the performance of systems of increasing complexity. In this project we propose two complementary activities on the Inner Tracker: - the characterization in the laboratory of multi-chip assemblies and eventually of multi-module arrays performed on the setup for the system test, including active cooling, currently under development at CERN; - the characterization of simpler sensor-chip assemblies exposed to a particle beam at the CERN SPS.	The project consists of laboratory activities (contributing to set up the test bench with prototype modules, running independently systematic tests for optimizing the prototype readout chain, developing a set of ROOT-based scripts for fast feedback on the tests performed), and beam test activities (tuning of the DUTs before the exposure to the beam, subsequent analysis of the data collected). Required skills: - knowledge of basic electronic lab equipment (power supply, digital scope, pulse generator); - good knowledge of C++ programming language and usage of ROOT data analysis framework; - experience in working in a Linux environment; - basic experience in reading and understanding technical documentation.

CERN-2

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 31/09/2023	Biagio Di Micco – Adelina D'Onofrio

Scientific program	Daily activity, skills required and to be acquired
Kinematic constraints for the HH->bbgamma gamma analysis in ATLAS One of the main target of the Run-3 LHC is the search for the HH non-resonant production, one of the most sensitive decay channel is the HH -> bb gamma gamma that profits of the excellent photon resolution of the ATLAS calorimeter to search for di-photon invariant mass peaks on a continuous background. Background can be reduced by performing a selection on the di-jet invariant mass of the bb system, a variable that suffers of poor resolution. A kinematic fit can be used to impose transverse energy momentum conservation resulting in an improvement of the jet energy resolution. The project consists in the implementation and validation of a kinematic fit procedure using ATLAS simulation and validating it with real data in the signal sidebands acquired during the RUn-3 of LHC. The student will work side by side with the contact person to analyse ATLAS data in the format of plain root files. Several fit configurations will be tested by varying the jet energy response functions and testing different methods to implement the constraints. The impact on the di-jet invariant mass distribution will be estimated and the data/MC level of agreement in the signal sidebands will be studied in detail.	The student will work inside the root environment, it is required to have basic c++ knowledge and ability to handle the root analysis software. The student will learn how to implement a kinematic fit in a challenging analysis and how to validate its output. He will learn how to implement algorithms inside the ATLAS analysis software. Software and statistical skills will be acquired in order to implement the procedure and evaluate the kinematic fit performance on simulation and compare them with data in the signal sidebands.

CERN–3

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/07/2023 – 30/09/2023**	**Paola Salvini – Roberto Guida**

Scientific program	Daily activity, skills required and to be acquired
Evaluation of the performance of gaseous detectors operated with eco-friendly gas mixtures. Several gaseous detectors, developed for high-energy physics but also for various applications, use gas mixtures containing components potentially harmful to the environment. A classic case is Resistive Plate Chambers (RPC), which use fluorinated compounds, but the same consideration applies to various MicroPattern Gaseous Detectors (MPGD). The European Union is severely restricting the use of such components, therefore the study of so-called "eco-gas mixtures" will become increasingly important in the future. In this project we propose an R&D study aimed at validating these new eco-gas mixtures through the measurement of the performance of different technologies (RPCs and MPGDs) operated with them. The student will be involved in the preparation of the measurement setup, but will also take care of the analysis of the data collected. In parallel, the impact of possible reuse of the exhausted gas mixtures, through the so-called "Gas recuperation systems", currently under development for the LHC experiments, will also be evaluated. By the end of the project, the student will have gained experience on the characterization of different gas detector technologies, but also on the impact of gas systems on detctor operation and on the most common gas analysis techniques.	The activity will consist in the simulation, preparation and management of small tests in which gaseous detectors are operated with different gas mixtures. The goal is to simulate and measure their performance with different gas mixtures and evaluate possible sources of ageing effects. The competencies required include: basic knowledge of gaseous detectors, especially MPGD and RPC; basic experience with laboratory instrumentation for gaseous detectors characterization. A prior knowledge of programming languages (C++, python), software analysis packages (ROOT) and simulation tools (Geant4) will be appreciated.

CERN–4

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 31/12/2023	Sandra Leone – Henric Wilkens

Scientific program	Daily activity, skills required and to be acquired
Installation and characterization of the new optical line for the ATLAS hadron calorimeter Laser Calibration system. In the ATLAS hadron calorimeter drift of the photomultiplier (PMT) response is a relevant source of systematic uncertainty for the energy scale. To maintain the performance within requirements a calibration of each PMT at percentage level is required. A laser system, used to measure the stability of the PMTs response, will be upgraded for the high luminosity (HL)-LHC period. The current setup provides time-stable light transmission and is performing very well. However, due to ageing, the laser source and the optical components must be replaced. Besides, it was observed that response to laser pulses may vary as a function of the current induced by Minimum Bias events. To handle this, it was decided to add a tool for controlling the PMT response as a function of the anode current. The simplest way to mimic what happens during collisions is to add a continuous light component to laser pulses. The current laser light mixer will be replaced with an integrating sphere which will allow to simultaneously inject pulsed laser light and LED-generated DC light and to uniformly mix them. The DC LED light component will be provided by a power LED array. The new optical line is being installed at CERN.	Month 1: Installation of the optical line, understanding the features of the laser and of the individual elements. Month 2: Characterization of the integrating sphere mixing properties, running the laser in stand- alone mode and using the oscilloscope to study pulse characteristics at the sphere output. Month 3: Integration with the electronics used for the laser data acquisition system. All activities will be conducted with the supervision of experts at CERN. Required skills: basic knowledge of C++ programming language and of the ROOT program. Basic knowledge of Python programming and bash scripting language would be a plus.

CERN–5

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2023 – 01/10/2023**	**Ivano Sarra – Nazar Bartosik**

Scientific program	Daily activity, skills required and to be acquired
Development and test of an innovative semi-homogeneous calorimeter for the future Muon Collider Crilin, a crystal calorimeter with longitudinal segmentation, is a possible solution for calorimetric needs at a future Muon Collider. Crilin tries to combine the advantages in terms of energy and time resolution of a homogeneous crystal calorimeter with longitudinal segmentation. The longitudinal segmentation is crucial to distinguishing signal showers from beam-induced background (BIB) showers. The proposal consists of lead fluoride crystals read out by UV- extended SiPMs. Many studies have been done to support the Crilin proposal: simulated jet reconstruction in a muon collider with BIB, gamma and neutron irradiation of lead fluoride crystals, and time resolution of the front- end electronics including the SiPMs. Present plan is to develop a 2-layer Crilin "Proto-1" detector.	The selected candidate will study an innovative approach to the calorimetry in the Muon Collider simulation framework, and with a real prototype. Goals are: 1) perform a complete simulation of the prototype; 2) obtain data for a complete analysis of digitized signals from the detector for electrons and minimum-ionizing particles; 3) test the cluster reconstruction capability and measure the time resolution; 4) measure longitudinal and transverse shower profile and compare with results obtained in the simulation. The ideal candidate has a reasonable knowledge of programming languages (C, C++) and Root package. Pre-existing "beginner" expertise in data analysis and Geant4.

CERN–6

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 01/10/2023	Lorenzo Sestini – Donatella Lucchesi

Scientific program	Daily activity, skills required and to be acquired
Search for the Higgs boson decay to $c\bar{c}$ jets by using quantum machine learning algorithms at LHCb The LHCb experiment at CERN has the possibility to measure the inclusive Higgs to bb and Higgs to $c\bar{c}$ production in a phase space region complementary to ATLAS and CMS. Thanks to the excellent vertex reconstruction system, the LHCb detector has demonstrated its capabilities in the identification of b- and c-jets. The current performance is obtained with classical machine learning methods. LHCb has already demonstrated the benefit of using Quantum Machine Learning (QML) in the jets classification by studying the bb separation. The QML algorithms and the quantum computers in the latest years advanced very rapidly and now it is possible to exploit intrinsic features of the quantum methods like the study of the entanglement entropy to better distinguish the correlations in jet sub-structure. The proposed activity will consist of learning the use of QML algorithms already developed, the definition of the best method for this project and the optimization for b-to-c quark jets separation. The entanglement entropy will be then evaluated to enhance the b-to-c jet separation. Finally, the algorithm will be used to distinguish $H \to bb$ from the $H \to c\bar{c}$ and determine the $H \to c\bar{c}$ sensitivity.	The activity will be organized as follow: Presentation of the jet's physics including the jets reconstruction and identification algorithms focusing to LHCb Introduction to quantum computing algorithms and to QML with examples/applications developed in LHCb. Optimization of a QML method for b-to-c-jets separation starting from available algorithms. This step includes the algorithm training, the study and application of the entanglement entropy. Algorithm application to simulated samples of $H \to bb$ and the $H \to c\bar{c}$ to determine $H \to c\bar{c}$ sensitivity. Required skills: Basic knowledge of machine learning methods and software like ROOT and python

CERN–7

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 30/11/2023	Paolo Francavilla – Hannah Arnold

Scientific program	Daily activity, skills required and to be acquired
The beauty of Higgs: Higgs to b-quark couplings in ATLAS One of the main physics goals of the current Higgs boson analyses is the precise investigation of the Higgs boson coupling to b-quarks. The project will focus on the study of the Higgs boson events decaying into pairs of b-quarks (H→bb) when the Higgs Boson is produced in association with a leptonically decaying vector boson (pp→ (W/Z)H). Both the ATLAS and the CMS collaboration are working on the completion of the measurements of this channel, based on the dataset collected during the Run2 of LHC. The candidate will take a part on the analysis of the Run2 dataset collected by the ATLAS experiment, profiting from the synergies with the ongoing activities of the ATLAS Hbb group. The timing for the project is coherent with schedule for the next ATLAS publication on this topic. The candidate will have a role in the development of the analysis, giving support to the use of hadronic-τ in the final results, and participating to the needed studies on the statistical treatment of the analysis. The candidate will have the opportunity to get a first glimpse at the ATLAS Run3 dataset.	The candidate under this project will collaborate with the ATLAS Hbb group, acquiring experience on all the needed aspects which brings an analysis to a publication. Month 1. Study of the performances of the H→bb measurement. Study of the modelling of the leading backgrounds. Month 2. Statistical treatment of the analysis. Month 3. Support to all the needed activities for the publication. The following required skills will be sharpened during the project: python and c++ programming, ROOT data analysis framework, statistical frameworks (WSMaker, ROOFIT or ROOSTAT). The candidate will get familiar with advanced MVA techniques, and with the state-of- the-art Monte-Carlo generators.

CERN–8

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 01/10/2023	Nicola De Filippis – Lucia Silvestris

Scientific program	Daily activity, skills required and to be acquired
Machine Learning techniques for track seeding and full reconstruction During the Run3 operations of the CMS experiment, an important issue would be to make some improvements in the CMS track reconstruction algorithm, starting from the seeding. It represents the first step of the CMS tracking iterative process, which provides the initial estimate of the trajectory parameters with the related uncertainties. The Cellular Automaton (CA), the default seeding algorithm for all iterations, starts matching consistent hit-doublets candidates provided by the pixel detector. Then, it generates seeds with three or four hits. The project will consist in optimizing the CA seeds production, extending its usage to the outer tracker by means of GPUs. Hence, Deep Learning (DL) algorithms will be used (e.g. Graph Neural Networks, designed to apply DL to non-tabular data), in order to perform the track building phase, the track fitting, as well as the estimate of the track parameters. A detailed study of the tracking efficiency, the fake rate, the parameter resolutions and the computational performance is planned. The final scope of the previous activity will be also to evaluate the impact of the aforementioned developments on a physics analysis for the study of events producing two Higgs, then decaying into pairs of muons and b-jets respectively.	The goals of the activity will be the acquisition of skills in the implementation of seeding at GPU level and the tracking test with GNNs, studying the fake rate, track parameter resolution and tracking efficiency. The required initial skills are a good knowledge of the most important Machine Learning algorithms, such as Deep Neural Networks (DNN), Graph Neural Networks (GNN), Boosted Decision Trees (BDT), Random Forest (RF), etc. A good familiarity with the CMS analysis software is recommended too, as well as the fundamentals of the CMS tracking system and the Cellular Automaton algorithm.

CERN–9

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 31/12/2023	Francesca Cavallari – Stefano Argirò

Scientific program	Daily activity, skills required and to be acquired
On-beam testing of the new readout electronics of the Electromagnetic Calorimeter of the CMS experiment at the CERN HL-LHC The High Luminosity upgrade of the LHC (HL-LHC) at CERN will provide unprecedented instantaneous and integrated luminosities of around 5 x 10^{34} cm^{-2} s^{-1} and 3000 fb^{-1}, respectively. An average of 140 to 200 collisions per bunch-crossing (pileup) is expected. In the barrel region of the Compact Muon Solenoid (CMS) electromagnetic calorimeter (ECAL), the lead tungstate crystals and avalanche photodiodes (APDs) will continue to perform well, while the entire readout and trigger electronics will be replaced. INFN is taking an important role in the upgrade with the design and production of the LiTE-DTU ASIC, which provides sampling of the calorimeter signal at 160 MHz, data processing, analysis, loss-less compression, synchronization and data transmission. The ASIC is about to be produced in 85000 samples that will equip the entire calorimeter. A prominent role is being undertaken in the integration and test process. The new electronics will be equipping 400 crystals before June. At that time, beam time has been requested at the CERN H4 facilities, where the crystals will be exposed to an electron beam in the range 20-200 GeV. The candidate is expected to take active part in the development and commissioning of the Data Acquisition system for the beam test and analysis of the data.	The candidate will participate in the interface of the new electronics with the existing DAQ system. The new system includes a novel back-end card, powered by large FPGAs. New procedures must be implemented to control and read out the card. In addition, integration with ancillary detectors, scintillators and MCPs, is required. To ensure acquisition of useful data, the real-time Data Quality Monitor system needs to be updated. This consists of a preliminary reconstruction that allows to estimate the time of arrival, energy and position of the incoming electrons, and a visualization system to present the data in an intuitive manner. In the second part of the internship, the candidate is expected to analyse the data acquired during the beam test, to quantify time resolution, energy resolution and linearity. In addition, the stability and reliability of the system will be assessed.

CERN-10

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2023 – 31/12/2023**	**Paolo Giacomelli – Gerardo Ganis**

Scientific program	Daily activity, skills required and to be acquired
Full simulation of the muon detection system of the IDEA detector concept for FCC-ee. The research program will be carried out in the framework of the FCC-ee project of a future very large leptonic collider to be built at CERN. The activity will be the development and implementation of the full simulation, using the GEANT4 and the DD4HEP software packages, of the muon detection system of the IDEA experimental apparatus, that has been proposed for an experiment at FCC-ee. The muon detector is made of a central cylindrical barrel, closed at the extremities by two endcaps. The muon detector is foreseen to be realized with a large mosaic of μRWELL detectors, each with a typical size of 50x50 cm^2. After having introduced the geometrical shape, all the materials and characteristics of the μRWELL detectors will be added. The detailed simulation will comprise both the simulation of the ionizing particle interaction with the detector, as well as the simulation of the digitization of the electronics signals produced.	Full simulation of the muon detector of the IDEA detector concept at the FCC-ee. This will be implemented using the GEANT4 and DD4HEP software packages. The whole simulation will be integrated into FCC-SW which uses the KEY4HEP software framework. Among the computing skills required there are: a good knowledge of C++ and Linux, knowledge of the basics of GEANT4 and DD4HEP, and operational skills with FCC-SW. Other needed skills: knowledge of the interaction of ionizing particles with matter and a knowledge of the behavior of μRWELL detectors.

CERN–11

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 31/08/2023	Antonio Cassese – Stefano Mersi

Scientific program	Daily activity, skills required and to be acquired
DAQ testing activities for the CMS Phase 2 Inner Tracker The High Luminosity upgrade of LHC (HL-LHC) is currently one of the biggest and fascinating challenges in particle physics. The unprecedented particle rate and radiation levels expected at HL-LHC, lead to the need of the replacement of the present Tracker of the CMS. The CMS Tracker for the HL-LHC phase will be a brand-new detector: hardware, firmware, and software completely different from the one currently in use are in development. The first prototype of the CROC has been released about one year ago and the full characterization of the full acquisition chain has immediately started and still ongoing. After a first phase where the candidate will get used to the tracker full readout chain usage, a deeper focus on Inner Tracker DAQ characterization will be carried on. In particular, low-level studies and characterization of the front-end characteristics as well as dedicated calibration and timing studies will be performed.	The project consists in laboratory activities with hardware set-up to be installed, dedicated acquisition software to be developed and analysis of collected data to be performed. The main required skills are: • - Basic knowledge of electronic lab equipment such as power supplies, digital scopes, pulse generator and so on. • - Knowledge of C++ programming language and usage of ROOT data analysis framework. - Experience in Linux environment.

CERN–12

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 01/10/2023	Fabrizio Palla – Giacomo Fedi

Scientific program	Daily activity, skills required and to be acquired
Data acquisition and L1 track trigger for the CMS Tracker Phase II upgrade. The CMS detector will undergo a major upgrade of the experiment for the High- Luminosity Phase of the LHC (Phase II). In particular, the Tracker system will provide relatively high-pT tracks for every bunch crossing, thanks to novel Silicon detector modules (aka "pT-modules") and generic ATCA processing boards hosting FPGA and high-speed (25G) optical links. A group of boards (the "Data acquisition, Trigger and Control" aka DTC) receive and format data from the front-end modules, and distribute them to another board (the "Track Finder" aka TF) that reconstructs the tracks in real time, using a fully time-multiplexed architecture, The scope of the project is to work on the commissioning of the firmware of the system, in particular the latency introduced in the readout chain and the formatting of the data. In fact, the track reconstruction must guarantee a maximal efficiency for the reconstruction of all interesting tracks in a maximum latency of 5 µs. The tradeoff between the latency of the algorithm and the efficiency of track reconstruction is the key element of the game. A telescope composed by several "pT-modules" will provide a test bench for learning detector configuration and operation. It will provide real data to measure the latency in all steps of the data acquisition and formatting using one DTC board. The data will be sent to TF board that will re-format and use to find tracks.	The student will be introduced to the detector operation using the software and firmware already developed. The latency of the system will be measured through different stages: signal travel time from the pT-module output to the input of the DTC board, formatting of the data and implementation of the time multiplexing architecture, If possible, the TF algorithm will be run. The student needs to have a good knowledge of the C++ language, and some firmware programming. At the end of the stage the student will learn the operation of Silicon detectors, data acquisition skills and trigger latency.

CERN-13

Hosting Laboratory	Available period	Contact person(s)
CERN	01/07/2023 – 01/10/2023	Piet Verwilligen–Antonello Pellecchia

Scientific program	Daily activity, skills required and to be acquired
Performance and Integration of the first ME0 stack prototype The Phase-2 upgrade of the CMS detector will include a new triple-GEM detector station, ME0, for increasing the acceptance of the CMS muon spectrometer. The ME0 system will be made of stacks of six layers for standalone online segment reconstruction. The first ME0 stack is under assembly at CERN in 2023. The student will test a single detector layer at first, then perform the integration of its front-end electronics and add it to the stack. They will optimize the electronics for low-noise performance. They will operate the stack to take cosmic data and do an offline track analysis to measure its efficiency, space and time resolution. The student will learn the principles and operation of a GEM detector from the basics, using at first laboratory electronics and then moving to a high-granularity readout and full modern FPGA-based DAQ system. The student will learn how to analyze the data and how to extract basic measurements such as efficiency and position resolution. The student will be involved in the testing of his/her test setup with beams at the SPS North-Area and be involved in the final measurements. He/She can go to a conference to present the results obtained.	The student will operate Triple-GEM detectors starting from basics up to using a modern DAQ system. The activity will consist of detector and electronics calibration measurements, noise-busting and cosmic-ray data taking. He/She will analyze the data and reconstruct tracks with multiple hits in the muon detectors. **Required skills:** basic programming (C++), basic lab experience (Oscilloscope, NIM electronics, HV) **Acquired skills:** Advanced programming (C++) & Data Analysis (ROOT); Triple-GEM Detectors operation; Calibration and Setup of electronics; Data-taking with FPGA board; hardware problem solving skills; Analysis of Cosmic Ray data to extract detector performance; Work & collaborate in international scientific environment.

CERN–14

Hosting Laboratory	Available period	Contact person(s)
CERN	01/07/2023 – 30/10/2023	Paolo Gandini – Nicola Neri

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the LHCb UT detector The LHCb detector at CERN has undergone a major upgrade for Run3, which will start in 2022. The LHCb Milan group is deeply involved in the Upstream Tracker (UT) detector activities since the beginning of its design. The UT is a 4-plane silicon-strip detector situated before the dipole magnet. It allows the detection of particles originated far from the interaction point and the area serviced by the vertex locator, e.g. Ks and Λ. The Milano group has de designed and built the hybrid circuits that host the readout chips. Furthermore, it has been involved in the design of the cooling and other critical aspects of the detector. The detector is currently being installed underground in the experimental area and close to commissioning. The commissioning is expected to last all 2023, where the Milano group will continue to provide support to this important activity. In particular, the group will be responsible for the data quality and evaluation of the performance of the detector. The Milano PI Nicola Neri is the deputy project leader of the UT and will supervise the candidate in loco. He/She will also be supported by the chief engineer of the project, who is also a member of the INFN group.	The candidate will be involved in the commissioning of the detector and will have the opportunity to look at the very first data collected by the tracker. The student will be responsible for developing the monitoring plots for the control room shifters and for this activity the presence at CERN in person is mandatory. The main required skills are a good knowledge of C++/Python. A basic knowledge of electronics and detector technology would be highly beneficial.

CERN-15

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2023 – 31/08/2023**	**Ilirjan Margjeka – Stefano Mersi**

Scientific program	Daily activity, skills required and to be acquired
Synchronous data acquisition of cosmic rays and stubs formation with the Phase-2 CMS tracker modules The CMS Tracker phase-2 upgrade for high luminosity of the HL-LHC project will require improved radiation hardness, higher detector granularity, increased bandwidth, and an improved trigger capability. The CMS Tracker modules will also provide the Level 1 Trigger track segments. Such conditions are fulfilled by the silicon pixel detectors of the Inner Tracker and silicon pixel-strip (PS) and silicon two-strip (2S) modules of the CMS Outer Tracker. To simulate the HL-LHC L1 trigger track segments and stubs formation, a cross section of the CMS tracker has been built within a burn-in cooling box at CERN, which can hold up to 8 modules (Outer Tracker-2S, Outer Tracker-PS and Inner Tracker). It is currently equipped with x, y modules. This project aims to characterize the trigger capability of the CMS tracker Phase-2 using cosmic rays as a source, specially the study of the Level 1 Trigger track segments (stubs formation). This study allows the student to understand synchronous data acquisition of the silicon modules using cosmic rays. The synchronous data acquisition of cosmic rays and stubs formation with the Phase-2 CMS tracker modules will be performed at the CMS Tracker laboratory at CERN. The student will join an international research group of physicists working on the development of silicon tracking detectors for LHC upgrade.	The student will have to perform data analysis for the synchronous data acquisition of cosmic rays with the layers of the silicon pixel, pixel-strip and two-strip modules and the study of the stubs formation. Basic knowledge of electronics laboratory practice is required. Basic programming skills will be beneficial both for the measurements and data analysis. The student will benefit from new skills on track formation by silicon detectors with cosmic rays, triggering and data analysis with CMS Tracker software.

CERN–16

Hosting Laboratory	Available period	Contact person(s)
CERN	01/07/2023 – 01/10/2023	Federica Simone – Etiennette Auffray

Scientific program	Daily activity, skills required and to be acquired
Nanomaterials for detector development at future colliders The advantages of nanomaterials (NM) over traditional semiconductors are many, some of which are their compact size, the fast operation, the superior transport and optical properties which are determined by their size and shape. In the field of particle physics, a joint effort is growing to apply NM to HEP and beyond. In the context of the ECFA Detector R&D roadmap process, many physics targets have been identified that could benefit from the unprecedented sensitivity and precision of nanomaterials. In particular, materials based on semiconductor nanodots/nanoplatelets such as CdSe, InGaN/GaN or perovskite nanocrystals are being studied as scintillators for calorimetry and fast-timing applications. If combined with high stopping power bulk crystals (e.g. LYSO) into heterostructures, the nanomaterial can meet the future HEP needs for efficient and fast scintillators. This project aims at characterizing perovskite-based heterostructures with different geometries and compositions. The photoluminescence (PL) response of the device in terms of yield and timing will be studied, both in the CERN Crystal Clear laboratories and under beam irradiation at the CERN SPS. The student will join an international research group of physicists working on the development of calorimeter detectors for LHC upgrade and future collider experiments.	The activity will consist of laboratory measurements and the associated data analysis. The student will characterize different materials, measuring the light yield under gamma irradiation and operating a time correlated single-photon counting test bench for time response measurement. Furthermore, the student will join the test beam preparation and operation. Basic knowledge of electronics laboratory practice is required. Basic programming skills will be beneficial both for the measurements and data analysis.

CERN-17

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 01/10/2023	Federica Simone – Rosamaria Venditti

Scientific program	Daily activity, skills required and to be acquired
Development of a MPGD-based HCAL for a future Muon Collider Experiment In the European Strategy for Particle Physics, a multi-TeV Muon Collider machine has been proposed as one of the main tools to investigate the Standard Model with unprecedented precision after the LHC. The design of the experimental apparatus for the Muon Collider is one of the most exciting challenges of the next years. A crucial role is played by the hadron calorimeters (HCAL), as the main detector involved in the jet reconstruction. In this project we will study a particle flow HCAL for a Muon Collider experiment, based on a sampling of absorber and MPGD (micro pattern gas detectors). Ongoing simulation studies showed that the MPGD based HCAL has comparable performance as the solid-state ones. Therefore, micro-rwell and micromegas prototypes have been built and qualified in the lab with the goal to realize a MPGD-based HCAL cell prototype to be tested with beams. The proposed research activity will focus on: • - Simulation studies of the expected performance (occupancy, energy resolution, shower containment ...) of the MPGD-based HCAL with charged pions, using an existing analysis framework • - HCAL cell prototype performance measurement in test beam at the CERN H4 line or participation in the test beam preparation in lab at CERN.	Skills: basic knowledge of radiation-matter interaction and HEP detectors operating principles. Basic knowledge of c++. The student will learn the physics principle of gaseous detectors and calorimeters. She/he will be initiated to the GEANT4 simulation framework to study the energy deposited by hadrons in a sampling calorimeter. She/he will learn how to operate lab equipment for data acquisition, joining the test beam preparation and operation. Skills on basic data monitoring and analysis will also be acquired.

CERN-18

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2023 – 30/09/2023**	**Marco Pizzichemi – Loris Martinazzoli**

Scientific program	Daily activity, skills required and to be acquired
Characterization of SPACAL modules for the LHCb Electromagnetic Calorimeter Upgrade II In view of the High-Luminosity (HL) phase of the LHC, the Electromagnetic Calorimeter (ECAL) of the LHCb experiment will require a considerable redesign, to maintain the current performance in terms of energy resolution, while copying with larger radiation dose and higher detector occupancy, especially at lower angles close to the beam pipe. The baseline solution for the central region of ECAL, under study by the LHCb PicoCal project, is based on spaghetti calorimeter (SPACAL) modules, consisting of dense absorbers and scintillating fibers. This technology is expected to provide the necessary radiation hardness, picosecond timing performance, and better granularity. The student will participate in the characterization and optimization of several SPACAL modules. Different prototypes will be assembled and tested on electrons and pions beams at the CERN-SPS test beam facility. The candidate will participate in the preparation of the experimental setup, in data collection during the test beam campaign, and finally in data analysis. The performance of the modules will be characterized in terms of energy, timing, spatial and angular resolution. The possibility to use the SPACAL modules to perform some level of Particle Identification (PID) will also be evaluated. The results will be compared with detailed Monte Carlo simulations.	The research will involve both experimental and data analysis activities. On one side, the student will acquire knowledge in the field of characterization of particle detectors, familiarize themselves with the most advanced tools used in the field, and acquire great practical experience in the everyday challenges of high-energy physics experiments. On the other hand, they will develop significant experience in data analysis, exploiting the opportunity to work side by side with top-level experts in the field, while interacting with the deeply stimulating international environment of CERN. Basic knowledge of detector principles and the use of ROOT libraries is required.

CERN-19

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 30/09/2023	Francesco Brizioli – Renato Fiorenza

Scientific program	Daily activity, skills required and to be acquired
Identification of charged kaons with the RICH detector of the NA62 experiment at CERN The NA62 experiment at CERN is aimed to study the very rare decay $K^+ \rightarrow \pi^+ \nu\nu$. A BR measurement with 10% precision will allow to probe New Physics at mass scales up to $O(100)$ TeV. A crucial role in the rejection of the background coming from the $K^+ \rightarrow \mu^+ \nu$ decays is played by the RICH detector , that provides a rejection power of a factor greater than 100 in the momentum range of interest. The data collected by NA62 show that tracks of charged kaons scattered from the beam line are clearly visible in the RICH detector . Such tracks can be studied using the information coming from the RICH detector and the magnetic spectrometer, in order to reconstruct the charged kaon mass. Therefore, the study can be used as a tool to provide an independent procedure to calibrate the RICH and/or the momentum scale measured by the magnetic spectrometer. Moreover, it can become the basis of a project to measure the charged kaon mass with the RICH detector. Several experiments already used the RICH detectors to measure the masses of charged hadrons, for example.	The student will take part in the analysis of the collected data sample: with the NA62 framework, he/she will learn how to build an event selection, to produce histograms and to statistically interpret the data and evaluate uncertainties. The student will learn the main methodologies of a physics analysis, increasing the expertise and skills on computing and coding. He/she will experience to work as a part of an international collaboration, with the opportunity to discuss the work progress during the collaboration meetings. The student will have also the possibility of taking part in the operation of the NA62 data taking in 2023, learning the basic functioning of the RICH detector and monitoring its performance. A student with a Physicist profile and a basic knowledge of C++ and ROOT is preferred.

CERN-20

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 31/08/2023	Giacomo Graziani – Saverio Mariani

Scientific program	Daily activity, skills required and to be acquired
Measurement of the luminosity for fixed-target collisions with the new SMOG2 gas target of LHCb Within the major upgrade of the LHCb experiment for the LHC Run3, a new gas target device, SMOG2, has been installed. The new device will boost the unique physics possibilities offered by fixed-target collisions with LHC beams, already pioneered by LHCb during Run 2. First tests of SMOG2 operation were performed during 2022, recording collisions of proton beams on three target species (H, He, Ar) and Pb-Ar collisions. The goal of the project is the estimation of the acquired beam- gas luminosity in some of these test runs from the observed rate of beam-electron elastic scattering events. This can be compared with the independent determination of the luminosity from the measured injected gas flow. The reconstruction of proton- electron scattering events and their discrimination from the abundant hadronic background requires a detailed understanding of the experimental setup and of the performance of the new tracking detectors. It is therefore an important milestone toward the physics exploitation of beam-gas collisions with SMOG2. The student is expected to take part to the data-taking activity of 2023, where possibly new datasets with SMOG2 will be acquired and cross-checks can be performed to assess the systematic limitations of the two proposed methods for luminosity determination.	The project will imply analysis of the 2022 fixed-target data and participation to the commissioning and data-taking activities with SMOG2, which will be ongoing during the period of presence at CERN. The student will work in strict contact with experts from the "Ion Physics and Fixed target" physics working group and with the team operating the SMOG2 device. A basic knowledge of the python and C++ programming languages is required, as well as previous experience with the ROOT analysis framework. Knowledge of machine learning techniques is also appreciated.

CERN-21

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2023 – 30/09/2023	Pietro Govoni – Felice Pantaleo

Scientific program	Daily activity, skills required and to be acquired
Using the time information for improved global event interpretation at the CMS experiment The CMS design for the HL-LHC is required to sustain a high dose rate and pile up (PU). CMS uses the Particle Flow (PF) algorithm as its main tool for pileup mitigation. The PF efficiency is significantly degraded with a vertex overlap along the beam axis higher than 1 vertex/mm. The power of a space-time 4D reconstruction lies in the fact that vertices overlapping in space are not necessarily overlapped in the time domain. The number of effective PU vertices is therefore reduced to only the ones with compatible time measurements. In order to do so, for HL-LHC, CMS will replace the current endcap calorimeters with the novel High Granularity HGCAL and will add an innovative MIP Timing Detector (MTD). HGCAL exhibits an electromagnetic (CE-E) and a hadronic (CE-H) section, both characterized by excellent transverse and longitudinal segmentation, and excellent timing resolution, which are designed for 4D shower topology identification. MTD is dedicated to timing measurements for Minimum Ionizing Particles (MIP). Combining the time information coming from Tracker, MTD and HGCAL is key to achieving an excellent Particle Flow reconstruction and pileup rejection. The student will study the available time information of both the detectors, both from the simulation and reconstruction.	The candidate for the project should have a basic knowledge of the Python programming language. Experience with C/C++ and ROOT will be helpful as well. The project will mainly focus on physics (90%) and computing (10%), providing an excellent opportunity for the student to delve into the world of event simulation and reconstruction techniques while working on extracting and combining timing information from the detectors. Furthermore, the student will have the opportunity to work with cutting-edge timing technology, thus gaining valuable knowledge and experience in this field.

FNAL-1

Hosting Laboratory	Available period	Contact person(s)
FNAL	01/06/2023 – 31/08/2023	Simone Donati – Pavel Murat

Scientific program	Daily activity, skills required and to be acquired
Study of the antiprotons background to the muon-to-electron conversion search at the Fermilab Mu2e experiment The Mu2e experiment will search for the neutrinoless muon-to-electron conversion in the field of an aluminum nucleus. With the expected sensitivity for Run I, Mu2e will improve the previous limit set by the SINDRUM II experiment by three orders of magnitude. To achieve the very ambitious Mu2e sensitivity goals, an adequate level of detector complementarity and redundancy is required to accurately measure the single conversion mono-energetic electron track that constitutes the final state of signal events, and to minimize and/or keep under control the expected sources of background. These include cosmic rays, muon decays in orbit, radiative pion/muon captures, and residual antiprotons in the muon beamline annihilating in the aluminum stopping target and producing electrons which may fake a conversion electron. The antiproton background is affected by the largest relative uncertainty mostly due to the uncertainties on the production cross section and the alignment of the collimators placed along the beamline. Data-driven methods are thus required to improve our knowledge of this background source. The proposed research program is aimed to estimate the beamline misalignments from the ratio between the negative and positive muon stopping rates in the stopping target and the reconstructed asymmetries of the stopped muon decays.	**Required knowledge:** general confidence with particle physics, particle accelerators and detectors, and a reasonable knowledge of computing methods, Unix/Linux environment, programming languages (C, C++) and Root package. Pre-existing “beginner” expertise in statistical data analysis will be beneficial. **Acquired knowledge:** improved usage/learning of C and C++ languages and Root package, Improved capability in statistical data analysis. Learning of the Mu2e reconstruction software, GEANT4, *art* framework and grid and cloud computing usage. Improved oral and written communication skills. **Daily activity:** generation of needed Monte Carlo samples, development of analysis code, attendance / report to weekly meetings (Mu2e- Tracker, Calorimeter, Software, General Groups).

KEK–1

Hosting Laboratory	Available period	Contact person(s)
KEK	01/06/2023 - 15/12/2023	Francesco Forti - Katsuro Nakamura

Scientific program	Daily activity, skills required and to be acquired
Analysis of the cosmic ray data from the commissioning of Belle II Vertex Detector. The silicon Vertex Detector (VXD) is the central part of the tracking system of the Belle II experiment, composed of a pixel detector (PXD) and strip detector (SVD), in operation since 2019. During summer 2023 the PXD will be replaced with a new detector (called PXD2), to obtain full angular coverage. The combined system (VXD) will be commissioned prior to installation in Belle II using cosmic rays. The proposed program is broad, starting from taking data with the dedicated scintillator trigger setup, helping in the development of the reconstruction and data quality monitor software, and performing the data analysis. Depending on the exact dates of permanence at KEK, the candidate will be participating in one or more of these aspects of the program. The final goal is to validate the VXD system, understand the noise and efficiency, and determine the alignment parameters.	The student will work in a team and assisted by a tutor. He/she will participate in the development of the VXD cosmic ray analysis programs and will learn how to extract basic information on noise, time, alignment from the data, comparing with the design parameters of the detector and the calibration data. Basic knowledge of programming and of the principles of particle detectors are required. Some experience with the ROOT analysis software and python are desirable. The activity is well suited for students pursuing a thesis in experimental high energy physics and can be adapted to the actual level of the candidate.

KEK–2

Hosting Laboratory	Available period	Contact person(s)
KEK	01/06/2023 - 30/11/2023	Alessandro Gaz – Uno Kenta

Scientific program	Daily activity, skills required and to be acquired
Study of Particle Identification techniques at Belle II The Belle II experiment, after collecting data for 4 years, is undergoing extensive maintenance and upgrade, with the goal of resuming data taking in January 2024. In order to meet the ambitious physics goals, substantial developments also in the reconstruction and analysis software are foreseen, targeted especially at coping with harsher than expected background conditions. Particle Identification (PID) plays a special role in the Belle II physics program and several projects have been launched, with the goal of improving the PID discrimination capabilities of the experiment and thus of extending its physics reach in key observables. We foresee a more aggressive use of machine learning in our PID strategies and, in parallel, a more thorough characterization of their efficiencies, dependence on background conditions and possible deterioration of detector performance. Assessment and reduction of the systematic uncertainties related to PID will acquire more and more importance as the size of the Belle II data set increases. Adequate data control samples from the Run1 of Belle II are already available, a common software infrastructure for their analysis is in place and cosmics/calibration data with the upgraded detector will be taken in preparation for the start of Run2.	Depending on the interest, the student will be involved either in the development of new PID algorithms or in the data analysis for the measurement of the performance of existing ones. If compatible with the schedule of the experiment, involvement in data taking of cosmics and calibration runs could be possible. Knowledge of particle physics and detectors is highly desired as well as some familiarity with the python and C++ programming languages. If the student is interested in the development of tools based on machine learning, some experience with popular frameworks such as *TensorFlow* or *pytorch*.

KEK–3

Hosting Laboratory	Available period	Contact person(s)
KEK	01/06/2023 - 15/12/2023	Diego Tonelli/Mirco Dorigo – Taichiro Koga

Scientific program	Daily activity, skills required and to be acquired
Improving the photon-energy calibration for the Belle II detector. This is a project at the interface between data analysis and hardware targeted at the improvement of the calibrations of the measurements of photon energies in the electromagnetic calorimeter of the Belle II experiment. Belle II is designed to reconstruct billions of weak-interaction decays of bottom mesons and τ leptons from 10 GeV electron-positron collisions in search for indirect indications of non-Standard- Model physics. It started operations in 2018 and has collected so far about 420 million B meson pairs, which are being used to obtain unique and world-leading measurements. Many key measurements rely on decays into neutral particles, such as π0 and η mesons. These are reconstructed in their decays into photons by using a crystal-technology electromagnetic calorimeter. An accurate calibration of photon-energy measurements is critical for the precision on the final physics observables. Current calibrations are determined as functions of the photon energy using control samples in data. However, calibration performance is suboptimal as shown by residual mismodeling of up to 30%. This project consists in exploring improvements to these calibrations by introducing yet-unaccounted-for corrections to energy dependences, such as those on the photon angle of incidence in the calorimeter.	The student explores the development of a novel approach aimed at accurate and reliable calibrations. This implies understanding of low-level calorimeter cluster reconstruction, classification of calibration samples using statistical-learning methods, studies of sample composition and of the multiple dependences of the raw photon energies on the relevant instrumental variables. We will document these studies into an internal note and include results in the standard correction procedures. Skills include undergraduate-level background on the interaction of particles with matter and electronics, simple programming and data-analysis packages, along with team-work and communication capabilities. The student will be co-supervised by Taichiro Koga (KEK, neutral reconstruction leader).

PSI - 1

Hosting Laboratory	Available period	Contact person(s)
PSI	**01/06/2023 – 31/12/2023**	**Marco Francesconi – Angela Papa**

Scientific program	Daily activity, skills required and to be acquired
Search for the μ→eXγ decay in the MEG II experiment The MEG II experiment is searching for the lepton flavor violating decay μ→eγ with unprecedented sensitivities. The experiment is fully commissioned, and the data collection will continue until 2026. Aside the forementioned channel, the collaboration is evaluating the sensitivity that can be associated to other beyond standard model and exotic muon decays. Among such channels, the decay μ→eXγ, where X is invisible and long-lived, is of particular interest for the exploration of the "Dark Sector". This process is predicted in theories including light Axion-like particles which could introduce couplings across the lepton families. The signal has many similarities to the standard model radiative muon decay μ→eνvγ, in which X takes the role of the neutrino pair, therefore the signal is observable as a bump in the eγ missing mass. To evaluate the sensitivity reach of MEG II, a dedicated simulation needs to address the optimal data taking conditions in terms of trigger logic, thresholds, and beam intensity. The goal of this program is to study the run conditions with MC simulation and analyze the available data from previous years.	The candidate will perform a full MC study of the channel of interest and participate in the discussions on how accommodate a preliminary data collection in the 2023 run or in the short future. He/She will work within the C++-based MEG II framework both for the detector simulation and the event reconstruction. Basic knowledge of the C++ language and ROOT analysis framework is required.

PSI–2

Hosting Laboratory	Available period	Contact person(s)
PSI	**01/06/2023 – 31/12/2023**	**Cecilia Voena – Angela Papa**

Scientific program	Daily activity, skills required and to be acquired
Advanced imaging of the MEG target and improvement of the MEG drift chamber performances. The search for lepton flavour violation is one of the main roads in the quest for New Physics beyond the Standard Model. The MEG experiment, at the Paul Scherrer Institute (PSI) set the most stringent limit on the $\mu \rightarrow e\gamma$ decay: BR($\mu \rightarrow e\gamma$<4.2 x 10^{-13})@90% C.L. Its upgraded version MEG-II will push down the sensitivity to few 10^{-14}, testing largely unexplored scales of New Physics. The 2021-2022 physics runs have been successfully completed and another run is about to start (Jun 2023). A precise and continuous monitoring of the detector and of the muon target is one of the key ingredients to reach the desired sensitivity. The MEG Rome group built two dedicated sub-systems. The first is a gas monitoring chamber, which measures the gas mixture properties (as gain and drift velocity) used to improve the conversion from time to distance of the main drift chamber, with the aim to improve its spatial resolution. The second is a monitor of the muon target position and deformation with a photogrammetric method, based on a camera that continuously acquires pictures of a dot pattern printed on the target, illuminated by a LED. Advanced analysis techniques are required to exploit at best these two systems.	The students will collaborate in the hardware deployment and data analysis related to the two calibration systems. A new photo camera needs to be installed in place of the present one, that suffered significant radiation damage. Advanced image analysis algorithms are needed to extract the information from the target pictures and to integrate it into the global positron reconstruction to search for the µ®eg process. At the same time the gas monitoring chamber data will be analyzed to provide a correction scheme to be applied to positron reconstruction as well. Required knowledge: good knowledge of English, possibly basic knowledge of C++/ROOT.

PSI – 3

Hosting Laboratory	Available period	Contact person(s)
PSI	**01/06/2023 – 31/12/2023**	**Angela Pala – Stefan Ritt**

Scientific program	Daily activity, skills required and to be acquired
A first large calorimeter prototype for future charged Lepton Flavour Violation searches at the intensity frontiers. The challenge for new calorimetry for incoming experiments at intensity frontiers is to provide detectors with ultra-precise time resolution and supreme energy resolution. Two very promising materials on the market are BrilLanCe (Cerium doped Lanthanum Bromide) and LYSO (Lutetium Yttrium OxyorthoSilicate). Based on recent developments and dedicated Monte Carlo simulation studies a LYSO based detector coupled to silicon-photomultipliers could match the requested performances for charged Lepton Flavour Violation (cLFV) searches. The MEG experiment searches fort he $\mu^+ \to e^+ \gamma$ decay and has set the most stringent upper limit on its branching ratio $B(\mu^+ \to e^+ \gamma) < 4.2 10^{-13}$ at 90%C.L.The MEG upgrade (MEGII) has been approved at PSI and by the institutions of the international collaboration aiming at an improving the sensitivity on this channel by one order of magnitude. MEGII has started data taking since fall 2021. In the context of MEGII, for the calibration of the apparatus, a charge exchange reaction of negative pions on proton is performed, for which an auxiliary calorimeter is requested. The assembly, test, commissioning of such a new LYSO detector will be twofold: A candidate for a new auxiliary detector for MEGII and a first large prototype for future calorimeters for cLFV searches.	The program includes both software and hardware activities. The student will collaborate in performing the Monte Carlo simulations based on GEANT4 to optimise the reconstruction algorithms for the gamma kinematical variables. He/she collaborate on the assembly and the commissioning of the detector. He/she will be involved in setting up of the experimental apparatus during the beam time, in studying the trigger strategy and in carrying out the data analysis for the final assessment of the detector performances. Required knowledge: good English, C++. By the end of the program the student will gain good skill in experimental techniques.

PSI-4

Hosting Laboratory	Available period	Contact person(s)
PSI	01/06/2023 – 31/12/2023	Angela Pala – Stefan Ritt

Scientific program	Daily activity, skills required and to be acquired
The muon entrance detector system for the muEDM search at PSI. A new experimental effort is taking shape with the aim at searching for the Electric Dipole Moment (EDM)ofthemuonwithasensitivityof10^{-21} e·cm using, for the first time, thefrozen-spin technique in a compact storage ring. This staged search for a non-zero muon EDM (muEDM) is a unique opportunity to probe previously uncharted territory and to test theories of Beyond Standard Model physics. One key point of the experiment is to accumulate muons on the proper orbit and then measuring the asymmetry of the positrons from the muon decays as a signature of a non-zero muon EDM. In this project the so-called muon entrance detector system will be studied and a first prototype will be built and tested. This detector system will consist of a thin entrance scintillator in anti-coincidence with a set of active apertures, also made of scintillators. It generates an entrance signal for muons within the acceptance phase space to trigger a magnetic pulse in the center of the muEDM solenoid, where the muons will be accumulated, and the whole apparatus installed. The 100 ns magnetic pulse (pulse coil) will turn the remaining longitudinal momentum, i.e. along the solenoid field, of the incident muon into the transverse direction, and then the muon is stored on a stable orbit.	The program includes both software and hardware activities. The student will collaborate in performing the Monte Carlo simulations based on GEANT4 to optimize the experimental setup of the entrance detector system. He/she will collaborate on the assembly and the commissioning of the detector. He/she will be involved in setting up of the experimental apparatus during the beam time, in studying the trigger strategy and in carrying out the data analysis for the final assessment of the detector performances. Required knowledge: good English, C++. By the end of the program the student will gain good skill in experimental techniques.