Istituto Nazionale di Fisica Nucleare

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

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	01/05/2020 – 31/11/2020	Giulio Mezzadri - Ilaria Balossino

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the CGEM-IT for the BESIII Experiment The BESIII experiment is hosted at the electron-positron collider BEPCII, at the Institute of High Energy, Beijing, PRC. Its physics program is focused on hadron spectroscopy at charmonium energies. An upgrade program is on-going on both the detector and the accelerator. A major upgrade of the detector consists of the replacement of the present inner drift chamber, which is showing aging effect, with innovative Cylindrical Gas Electron Multipliers (CGEM) with charge and time readout. Thanks to the microTPC reconstruction algorithm, this detector can achieve excellent tracking performances in a magnetic field for a wide range of angles. The detector is now in IHEP cleanroom taking cosmic data for the validation and commissioning of both the hardware and electronics. External tracking with planar GEMs provides the telescope to assess the performances. Optimization of the setup is on-going to prove the full potential of the CGEM-IT. This involves studies on grounding, electronics preparation, and data analysis. The CGEM-IT will enter the BESIII experimental area ready for the final insertion inside the BESIII spectrometer in Summer 2020. After the installation, the commissioning will proceed with a full spectrometer cosmic data taking to complete the final alignment.	With all the layers ready for the installation, the student will be inserted into one of the core activities, supervised by the INFN advisor. The student will work in the IHEP clean room in the commissioning of the final layers or in the installation in the experimental area. By means of the collaboration with experts in IHEP, the students will learn how to use all the techniques studied and apply them to a real running experiment. Knowledge of laboratory instrumentations and detectors, ROOT/C++ programming are required at basic level. Prior experience with Micro Pattern Gas Detector is considered a plus.

CERN-1

Hosting Laboratory	Available period	Contact person(s)
CERN	01/02/2020 – 30/06/2020	Davide Boscherini - Marco Schioppa

Scientific program	Daily activity, skills required and to be acquired
Construction and test of triplets of small size gas gap RPC for the ATLAS muon barrel spectrometer upgrade for the LHC Run-3 The Resistive Plate Chambers provide in the ATLAS experiment the muon trigger and two coordinate measurements in the pseudo-rapidity region letal<1.05 (barrel). In preparation for the LHC high luminosity run, a triple small size gas gap RPC, named BIS78, is being developed aiming at the installation during the LHC Long Shutdown 2 (2019-2020). The scope of the BIS78 camber is to reinforce the selectivity of the muon trigger in the transition region 1.3>letal>1.05 by adding 32 RPC triplets along z on the edges of the inner barrel even sectors. Due to the narrow available space, it is necessary to replace the existing MDTs in this area with chambers made of small diameter tubes MDT coupled with these new RPC chambers, capable of withstanding the higher rates and provide a robust standalone muon confirmation. These new RPCs are based on novel design of the gas volume with thinner gas gap (1mm), thinner resistive electrodes, lower operating voltage and new high gain front-end electronics. These new RPC chambers also represent a pilot test in view of the LHC High Luminosity upgrade when an additional full layer of RPC triplets is expected to complement the full barrel $_{region}$ in the innermost plane.	The assembly of the triplets will take place in building 885 at CERN. We propose the following activities: • participation on the assembly of the triplets; • triplets High Voltage ramp-up and test; • test of the chambers at Gamma Facility Infrastructure; • cosmic ray data taking and data analysis. It is required knowledge of basic functioning of gas detectors, capability to use software instruments and basis of C++ programming.

CERN-2

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2020 – 30/05/2020	Piet Verwilligen - Marcello Maggi

Scientific program	Daily activity, skills required and to be acquired
Development and test of MPGDs based on Diamond-Like Carbon The present generation of Micro-Pattern Gaseous Detectors (MPGDs) are radiation hard, rate capable of several MHz/cm^2, while exhibiting good spatial resolution (≤ 50μm). They have a time resolution of 5–10 ns, which satisfies the current generation of experiments (HL-LHC upgrades CMS & ATLAS) but is not sufficient for bunch crossing identification of fast timing systems at FCC-hh or for vertex identification in order to reduce the effective pile-up from O(1000) to manageable levels O(25). New developments for MPGDs point at (1) the use of resistive materials naturally spark protected devices (crucial for high backgrounds) and (2) improved time resolution to for triggering & vertex identification. Diamond Like Carbon (DLC) has recently been introduced in MPGD prototypes and is a very promising material of which the resistivity can be produced at will, opening the roads to spark-protected single amplification stage detectors on the one hand and stacks of such devices to improve time resolution on the other hand. Current R&D is ongoing in (1) producing DLC thin films on kapton foils and their etching properties; (2) investigating thicker	The student will be involved in the GEM R&D activity at CERN. She/He will assist the construction of new MPGD prototypes, test characterize new prototypes with the X-ray setup, and adapt the prototypes to the experimental needs. She/He will measure gain and detection efficiency and confront the prototype performance w.r.t. state of the art MPGDs. **Required skills:** • basic programming skills (C++) • basic lab experience (Oscilloscope, NIM electronics) **Acquired skills:** • Advanced programming (C++) & Data Analysis (ROOT) • MPGD Detector assembly in Clean Room • MPGD Detector test with X-rays • Detector Hardware Problem solving skills • Work & collaborate in international scientific

kapton foils (125um) to increase the gain of a single gain layer (3) investigating the electrical transparency of a several layer stack.	environment

CERN-3

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2020 – 30/10/2020	Mauro Iodice - Paolo Iengo

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the New Small Wheel Micromegas for the ATLAS upgrade The ATLAS collaboration is presently involved in the detector upgrade for next LHC phase. Part of the Italian ATLAS-muon community (Cosenza, Lecce, Napoli, LNF, Pavia, Roma1, Roma3) is taking care of building one (SM1) of the four types (SM1, SM2, LM1, LM2) of Micromegas modules needed for the New Small Wheels of the muon spectrometer. Other ATLAS institutions (CERN, Dubna, Thessaloniki, Germany, Saclay) are taking care of the remaining three module types. Most part of the modules have been built and sent to CERN where they undergo again (after having been transported from the construction sites to CERN) gas tightness and HV stability tests. Further, most of the modules are also brought to the Gamma Irradiation Facility (GIF++, CERN) in order to check rate performance and ageing. Modules are then assembled in pairs (SM1+SM2 and LM1+LM2), integrating them inside the main structures, the wedges, that would then be mounted on the wheel. Detectors in each wedge are then aligned, equipped with front-end electronics and tested again using a cosmic rays test stand. These activities are carried out at CERN by a team of researchers, technicians and PHD students, inside which also undergraduate students can find many opportunities to contribute.	She/he would be involved in one (or two) of the foreseen activities (modules HV stability and GIF++ tests, wedge cosmic tests) participating to the setting up of the needed instrumentation, to the data taking and to the data analysis. Knowledge of C++ and Root would be an advantage but not mandatory. The student will have the opportunity to acquire hands-on experience on: • Micromegas detectors • HV and gas systems • readout electronics and acquisition packages • particle physics data analysis tools

CERN-4

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2020 – 30/09/2020	Ernesto Migliore - Stefano Mersi

Scientific program	Daily activity, skills required and to be acquired
Development of a test system for the upgrade of the CMS tracker for HL-LHC The High Luminosity upgrade of LHC (HL-LHC) will be the main scientific instrument for the investigation of the subatomic world in the 2020s. To cope with the unprecedented particle rate and radiation levels expected at HL-LHC, the present Tracker of the CMS experiment will be replaced during the LHC long shutdown in 2024-2025. The new Tracker will be a brand new detector with hardware, firmware, and software different from the one currently in use. Developing a working test bench with these new components, from the hardware to the DAQ, is an essential step in the construction of the upgraded detector. In the first part of the project, the candidate will become familiar with the hardware, firmware and software components used in the pilot test bench currently under development at CERN. In the second part of the project, the candidate will focus on the Inner Tracker subsystem, contributing to setting up a chain of prototype detectors based on the RD53A read-out chip, with active cooling, and study the interaction of the	The project consists in laboratory activities (contribute to set up a test bench with prototype modules, run independently systematic tests for the optimization of the grounding scheme of the prototype readout chain), software developments (implement simple changes in the code used for the system test) and in the analysis of the collected data (develop a set of ROOT-based scripts for a fast feedback on the tests performed). 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.

chip activity with the cooling performance. Other possible studies to be carried in parallel or alternative to this are the study of the influence of calibration procedures on expected detector performance and the optimization of the existing calibration procedure to minimize delays during production. Part of the proposed activities is in common between the Inner and Outer Tracker detectors.	

CERN-5

Hosting Laboratory	Available period	Contact person(s)
CERN	20/02/2020 – 1/7/2020	Giovanni Punzi - Riccardo Fantechi

Scientific program	Daily activity, skills required and to be acquired
Real-Time tracking at LHC crossing rate with FPGAs LHCb has now removed the Level-0 trigger that was previously used to reduce the DAQ rate to 1 MHz, and is preparing for the 2021 run, when complete event reconstruction will need to be performed at the full LHC average crossing rate of 30 MHz. An FPGA-based system is under development for performing parts of the reconstruction of the new VELO-pixel detector in real-time during detector readout. During 2020, prototypes of this system will be tested in the Vertical Slice setup of the new LHCb DAQ, to evaluate performance and viability of this innovative system, which is based on the "retina architecture" concept developed by INFN. The selected candidate will join a diverse team of experts during a period of intense activity of assembling, commissioning and testing of this new system, in the environment of a state-of-the-art DAQ system being prepared for actual physics data taking.	The student will have opportunities to participate in a variety of activities under the guidance of an expert team, including: mechanically assembling fast optical link networks and testing their reliability; setting up and testing integrity of fast data transfers between FPGA cards; preparation and validation of test vectors for fast FPGA data processing firmware; writing or adaptation of simple pieces of FPGA firmware; testing and evaluation of performance of reconstruction algorithm on simulated FPGA data. The candidate will need some knowledge of programming and the ROOT framework, basic familiarity with electronics, and interest in learning about data acquisition in HEP.

CERN-6

Hosting Laboratory	Available period	Contact person(s)
CERN	1/03/2020 – 30/09/2020	Riccardo Paramatti - Francesca Maria Addesa

Scientific program	Daily activity, skills required and to be acquired
Characterisation of preproduction LYSO arrays for the CMS Barrel Mip Timing Detector The CMS detector at the CERN Large Hadron Collider is undergoing an extensive Phase II upgrade program to prepare for the challenging conditions of the High-Luminosity LHC starting in 2026. In particular, a new timing detector, the MTD, will measure minimum ionizing particles with a time resolution of 30-50 ps. The technology selected for the central part of the detector, the Barrel Timing Layer, consists of scintillating crystals of Lutetium Yttrium Orthosilicate doped with Cerium (LYSO:Ce) read out with Silicon PhotoMultipliers. This project is aiming at characterize LYSO:Ce scintillating crystals by measuring geometrical and optical properties of crystal array samples. In 2020 in fact a pre- production of O(100) arrays from two or three selected LYSO vendors will be tested to investigate more deeply the homogeneity in the properties of the crystals and the reliability of the final producer. Finally this project will be crucial in the identification of the vendor for the full detector production and the tuning of the procedure for the Quality Control of the crystals during the final production.	The selected candidate will perform laboratory measurements on dedicated crystal benches, will analyze the data and produce reports. Knowledge of an analysis framework (ROOT or python) is required. The candidate will acquire a detailed knowledge of the scintillating crystal properties, including radiation resistance, and a good mastery of laboratory setup to perform crystal light yield and time resolution measurements.

CERN-7

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2020 – 30/05/2020	Piet Verwilligen - Jeremie Merlin

Scientific program	Daily activity, skills required and to be acquired
Quality Control of Triple-GEM detectors for CMS with Cosmic Rays In 2018 CMS has established the coupling of the Higgs boson to the fermions of the third generation. For multi- purpose experiments at the LHC to observe the first hints of the Higgs boson coupling to the second generation an additional ~150 fb^{-1} of data is needed (Run-3). The doubling of the dataset in only three years will come with increased background rates. To maintain low muon pt trigger thresholds to efficiently select Higgs boson events, CMS will install triple-GEM detectors in the first muon station during Long Shutdown 2 (2019-2020). These detectors have been built and tested successfully in site at INFN Bari and INFN LNF. A first endcap has been installed in October 2019 and the 2nd endcap will be installed in Spring 2020. The quality control procedure foresees to perform an ultimate test --using the final readout electronics-- at the Cosmic Stand in the GEM Laboratory at CERN. With this test efficiency and time resolution of the triple-GEM detectors will be measured before being installed in CMS. This is of utmost importance to prepare the GEM detectors for data-taking right from the beginning of Run-3 in 2021 in optimal conditions.	The student will be involved in the GEM Production & QC Lab at CERN. She/he will equip the GEM detectors with the final electronics and will install them at the Cosmic Test Stand. She/he will operate the detectors and analyze the collected data to extract detector efficiency and determine the optimal working point through HV scan. **Required skills:** • basic programming (C++) • basic lab experience (Oscilloscope, NIM electronics) **Acquired skills:** • Advanced programming (C++) & Data Analysis (ROOT) • Triple-GEM Detectors operation • Detector Hardware Problem solving skills • Analysis of Cosmic Ray data to extract detector performance • Work & collaborate in international scientific environment

CERN-8

Hosting Laboratory	Available period	Contact person(s)
CERN	01/09/2020 – 01/12/2020	Alberto Messineo - Duccio Abbaneo

Scientific program	Daily activity, skills required and to be acquired
System test of the High-Luminosity upgrade of the CMS Inner Tracker At the High-Luminosity LHC, the CMS Inner Tracker will be exposed to unprecedented radiation levels and hit rates. The CMS collaboration is developing a high granularity pixel detector that will be able to cope with such challenging conditions. The electronics system will feature a readout chip developed in the 65 nm CMOS technology, connected through lightweight electrical links to data transceivers and optical converters. In order to limit the mass of the detector, the power is distributed to the readout chip with a novel architecture, where the current flows through several modules connected in series. Dedicated on-chip regulator circuitry generates the required voltages from the current supply. Prototype chips will be assembled with silicon sensors, readout through different prototype variants of electrical links and powered through custom-design aluminum flex circuits or copper-cladding aluminum wires. The test of the whole electronics chain in different configurations will enable the optimization and validation of the system, as well as the qualification of its individual components while developing procedures and routines that will form the basis for the final detector calibration.	The student will join a team at CERN working on the test and optimization of the Inner Tracker electronics system, participate in experimental measurements in the lab and on test beams, and contribute to the development of data acquisition, calibration, and analysis software.

CERN-9

Hosting Laboratory	Available period	Contact person(s)
CERN	01/04/2020 - 30/06/2020	Alessandro Di Mattia - Stefano Mersi

Scientific program	Daily activity, skills required and to be acquired
Signal calibration and noise characterization of the prototype modules for the phase-2 CMS tracker As time of the phase-2 construction is approaching detector modules prototypes are now ready for being tested. At this stage it is necessary to verify the homogeneity of the characteristics of the various prototypes so as to set up the calibration procedures in situ of the operating parameters. Among these, the study of the noise is of particular importance because it is connected to the radiation damage suffered and to the depletion voltage of the sensor: these are two parameters that must be constantly monitored during the detector operations at HL-LHC. The proposed project sees a student working to calibrate the modules available at CERN exploiting the signal induced by a photon source. With such technique the absolute calibration (in terms of electrons) of the comparator thresholds can be obtained thus allows for verifying the homogeneity of the comparator thresholds and the degree of reproducibility of the calibration pulse inside the read-out chips. Subsequently it will be possible to carry out a systematic study of the noise and attempt to measure the sensor depletion voltage from it. Other methods for estimating the depletion voltage will also be tried and then being compared with the technique of estimation from the noise.	The program is aimed at students who have good skills in C ++ and are versed in ROOT. The student will have to familiarize with the phase-2 data acquisition software (Ph2_ACF) and operate the module test stand which consists of a PC for the acquisition and an FC7 board that implements the DAQ backend of the modules. Simple calibration procedures will have to be developed and then integrated into the Ph2_ACF for being run and produce results in an output root file. The student will have to write the scripts to do the data analysis required by the research program.

CERN-10

Hosting Laboratory	Available period	Contact person(s)
CERN	01/02/2020 – 30/11/2020	SGUAZZONI Giacomo - Stefano Mersi

Scientific program	Daily activity, skills required and to be acquired
Testing of prototype Front-End chips for the HL-LHC CMS Tracker The CMS Tracker for HL-LHC will be a pixel and strip silicon detector read out by innovative chips, and powered through a serial powering scheme or via local DC-DC converters. The various Front-End chips, connected to the silicon detectors, must be readout in a consistent and dependable way under the different powering and grounding solutions envisaged. Hence a suitable suite of software packages must be provided to the community, that are versatile and universal enough to be used both in laboratory setups and in test beams. A non-trivial amount of development will focus on FPGA firmware, needed to drive the Front-End chips and provide fast and reliable data formatting and forwarding to the Back-End systems. The characterization of the Front Ends will require the low-level study of the circuit behavior in terms of noise and signal performance, and, given the high granularity of the detectors involved, will require the acquisition of large quantities of data in controlled and stable conditions. The user-defined parameters that specify the working points of the Front-End Chips will have to be stored and cross-linked to the data obtained so as to facilitate the comprehension of the behavior of the system.	The student will contribute to the testing of Tracker prototype chips, by collaborating to the development of testing procedures in C++/python and the optimization of these procedures for execution time and resolution. The activity will take place both in laboratory and in test beams. The student will also calibrate the devices, and then analyze the resulting data to measure all relevant parameters. The required skills are: basic laboratory experience to operate electronic equipment and instruments; advanced computing skills to program a DAQ system running on a PC, digital circuit design capabilities, and most importantly, experience in FPGA design and programming.

CERN-11

Hosting Laboratory	Available period	Contact person(s)
CERN	01/02/2020 – 30/06/2020	Alessia Bruni - Davide Boscherini

Scientific program	Daily activity, skills required and to be acquired
Construction and commissioning of a new generation of RPC detector for the ATLAS upgrade The student will join the team of the project BIS78 at CERN, for the construction and commissioning of RPC chambers, their FE electronics and DAQ. This new type of RPC has a gas gap reduced to 1 mm and an improved time resolution. BIS78 is a small project for the ATLAS Phase I upgrades, with the goal to have the system installed for ATLAS data taking starting in 2021. Using new generation of RPC, it is a pilot project for the major Phase II upgrade of the barrel muon trigger	The daily activity will mainly consist of laboratory measurements, also with a cosmic and the associated data analysis, participation and report to the daily meetings of the international group Programming skills will be beneficial both for the measurements and data analysis. The student will learn about: experience with team work; construction and test of a detector; how to write software in an online environment for DAQ.

CERN-12

Hosting Laboratory	Available period	Contact person(s)
CERN	02/03/2020 – 20/12/2020	Mariagrazia Alviggi - Paolo Iengo

Scientific program	Daily activity, skills required and to be acquired
Performance of the Small Pads resistive Micromegas prototypes for operation at very high rates Resistive strips Micromegas detectors have already proved to be suitable for precision tracking in dense particle rate environment up to few kHz/cm^2. In order to achieve higher rate capability with low occupancy (at future colliders or LHC upgrades) fine-segmented strips have been replaced by few mm^2 pads. To protect the pads from sparks, a resistive structure has been implemented using two different techniques to realize the charge evacuation route to ground: 1) embedded resistors are produced (using a resistive paste) between each readout pad and the superimposed resistive pad (placed towards the gas gap); 2) two uniformly resistive DLC (Diamond Like Carbon) coated layers are used: the first one faces the gas gap, the second one connects the first layer with the readout pads, through silver vias every few mm. Within the R&D51 project, four prototypes have been constructed at CERN and tested using ^{55}Fe, high	She/he would be involved in one (or two) of the foreseen activities, 'tests in lab with ^{55}Fe and Xrays', 'test beam' or 'GIF++', participating to the setting up of the needed instrumentation, to the data taking and to the data analysis. Knowledge of C++ and Root would be an advantage but not mandatory. The student will have the opportunity to acquire hands-on experience on: • Micromegas detectors • Small readout electronics chain and acquisition packages • particle physics data analysis tools • 'handling' of a small scale experiment

rate X-rays generator and charged particles beams. Very good results have been already achieved and comparison among the various prototypes suggested to implement some modification in new prototypes, already in production. Further, we plan to bring our prototypes to the Gamma Irradiation Facility (GIF++, CERN) in order to study its tracking capability in a high rate environment and the detector ageing.	

CERN-13

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2020 – 31/08/2020	Donatella Lucchesi - Paola Sala

Scientific program	Daily activity, skills required and to be acquired
Study of multi-TeV muon collider beam-induced background Muon accelerators offer unique potential for particle physics at the frontier energy. Muon beams can be accelerated to TeV-scale energies before suffering of synchrotron radiation. Nevertheless, muons decay producing electrons and neutrinos, that in turn, generate a stream of secondary and tertiary particles that arrive to the interaction region posing a serious issue to physics measurements. The exact rate and composition of the beam-induced background depends on the beam energy, the layout of the accelerator around the interaction point, and the detector itself. The study of this background needs to be done for each center of mass energy to find the proper way to mitigate it. The proposed activity consists in the simulation of the beam-induced background at 3 or 6 TeV center of mass energy, never explored up to now, by using the FLUKA package. The simulated data will be analyzed by using root package with a set of macros already available and new ones that will be developed by the student. An important part of the activity will be to understand if the results are correct. The student will be asked to present and discuss and them with FLUKA experts and accelerator expert at CERN.	The activity will start with the study of the characteristics of a muon collider and in particular the beam-induced background. It will proceed by understanding FLUKA simulator and practicing on its usage. Then the work will develop through: • - generation of the beam-induced background using the FLUKA code for one of the two proposed center of mass energies; • - characterization of the background; • - presentation and discussion with FLUKA and accelerator experts. The student is required to have a minimum expertise of Linux OS and data analysis and knowledge of elementary particle physics in particular the particle interaction with matter.

CERN-14

Hosting Laboratory	Available period	Contact person(s)
CERN	30/03/2020 – 30/06/2020	Giancarlo Panizzo - Arturo Sanchez Pineda

Scientific program	Daily activity, skills required and to be acquired
Exploring High Energy Physics data analysis pipelines using a multi-platform design approach The deployment of analysis pipelines has been tightly related and conditioned to the computer infrastructure of the scientific facility or academic institution where it is carried on. Nowadays, Software as a Service (SaaS) and Infrastructure as a Service (IaaS) have reshaped the industry of data handling, analysis, storage, and sharing. The science sector does not escape those changes. Indeed, in multinational collaborations, distributed resources allow researchers to deploy data analysis in diverse computational ecosystems. This project explores how the current multi-cloud (e.g., SaaS + IaaS) approach can be adapted to modest scenarios where analysis pipelines can be deployed with the use of Virtual Machines and Containers containing analysis tools and protocols. This has the aim to replicate sophisticated computer facilities in places with fewer resources like small universities, start-ups, and even individuals that want to learn and contribute to this and other sciences and its replicability. The candidate will eventually improve a previous work about the study of Triple Gauge Couplings at future colliders with ATLAS experimental and simulated data, by exploring the development of multi-cloud-compatible tools to be used in physics analysis and operations monitoring, adding the Big	During the program the candidate will acquire confidence with the existing multi- cloud infrastructure at CERN, will learn about experience with team work, how to write software in an online environment, as well as to handle large-scale databases. Experience in data analysis of high energy physics processes is welcome. Programming skills will be beneficial both for the daily activity and the final analysis.

Data component that the High Energy Physics field has by nature.	

CERN-15

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2020 – 01/09/2020	Marco Paganoni - Etiennette Auffray Hillemanns

Scientific program	Daily activity, skills required and to be acquired
Test of PbWO4 crystals to assemble a calorimeter for a pilot run of MUonE, to measure the elastic scattering μe →μe In the framework of new physics ideas, presented at the Physics Beyond Collider workshop at CERN, we presented a proposal (MUonE) to measure, with very high precision, the running of α(t) as a function of the momentum transfer t, in the space- like region by means of the differential cross section of the elastic μ − e scattering in order to extract the hadronic corrections to α_{em} (Eur.Phys.J.C(2017)77:139) An important step towards the approval of the experiment has been the submission of a Letter of Intent in June 2019. To prove that an experimental measurement of the hadronic corrections to the running of α is possible through the elastic process μ+e → μ+e, the MuonE has requested 3 weeks of pilot run in 2021, on the M2 beam line. The main purpose will be to validate the basic design of the detector and its operation, and the importance of using of a calorimeter. One possibility under study is the re-use of PbWO4 crystals that the CMS collaboration could lend us. These crystals have the right properties for the application in MUonE, and	The work will consist in a hardware part, and a software part. The latter will consist in optimizing the geometry of the crystals matrix, its implementation in the MUonE simulation, to study the potential performance in separating muons and electrons when they are very close in angle, and the use of the calorimeter to construct the correlation between angle and energy of the electrons emitted in the elastic interaction. The aim will be to determine to what extent a cut in angle determines a cut in energy in the region of E ~ few GeV The candidate will help to study the light readout options, and of the corresponding readout electronics. The candidate will work in contact with the CMS experts of the calorimeter project. She/He should have knowledge of particle physics, ROOT and C++.

work is necessary in order to assemble the crystals in the way the MUonE pilot run requires, and start testing the changes in the electronics which will be necessary.	

CERN-16

Hosting Laboratory	Available period	Contact person(s)
CERN	01/04/2020 – 30/06/2020	Pasquale Di Nezza - Massimiliano Ferro Luzzi

Scientific program	Daily activity, skills required and to be acquired
LHCb as fixed target experiment The LHCb experiment pioneered fixed-target physics, thanks to the idea to have an internal gas target. Collisions of proton and heavy-ion beams on different targets can be recorded at a centre-of-mass energy of 115 GeV. Due to the unique kinematical coverage in the unexplored region of high x and the potentialities of the upgraded LHCb detector, this physics program is very wide, going from HEP to BSM, from Dark Matter to Cosmic Ray physics. Just as an example, using different targets it is possible to constrain (n)PDF, access Heavy Flavor physics creating a big lever arm to constrain models over 2 order of magnitude (sqrt(s) 115 GeV and 13 TeV), search for the QGP transition region, as well as Drell-Yan measurements and excusive physics through Ultra Peripheral Collision. Undoubtfully, this project can give very unique contributions achievable in the worldwide context. The SMOG2 storage cell is the only object present in the primary vacuum of LHC, so the gas types, their flow and a clear figure of merit to be used for the LHC RUN3 data taking must be define. In particular this must happen in order to be able run in parallel with the pp collider mode at sqrt(s) = 13 TeV.	Due to the presence, in the regions near the target cell, of NEG surfaces, LHC cold triplets and pumps in different locations, the type and amount of injectable gas must be quantify. All this can be studied using proper simulations and programs (i.e. Molflow) under the supervision of LHCb and LHC vacuum experts. The values will be encoded in the LHCb simulation and the reachable luminosity will be calculated. The activity will be devoted to the definition of these limits according to the physics program. The data taking scenarios will be identified and presented to the collaboration in dedicated WGs.

FNAL-1

Hosting Laboratory	Available period	Contact person(s)
FNAL	01/04/2020 – 01/07/2020	Franco Spinella - Ryan Rivera

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the Mu2e calorimeter data acquisition system The student will join the team responsible of building and commissioning the Mu2e calorimeter and associated DAQ system. The detector is composed of two identical matrices of 670 Cesium Iodide (CsI) crystals readout with silicon photomultipliers (SiPM). The calorimeter has three main tasks: defining an acceptance time-window for straw-tracker hits to improve track reconstruction, aiding the cosmic-ray veto detector in rejecting cosmic muons, and providing a tracker-independent electron trigger. Monte Carlo simulation has shown the calorimeter contribution is crucial if it measures the electron time of impact with a resolution better than 500 ps @100 MeV and energy with a resolution of 5%. This implies performing SiPM signals digitization with a minimum sampling frequency of 200 MHz and 12-bit resolution. The Digitizer ReAdout Controller (DIRAC) performs digitization and transfers zero-suppressed data to the Mu2e global DAQ. Electronic design has been challenging due to the high radiation level, 1 tesla magnetic field and 10^{-4} Torr vacuum expected inside the cryostat where the calorimeter and the 136 DIRAC boards are installed. The calorimeter construction and commissioning will reach its apex in the year 2020. Participating in this endeavor will be an excellent training for a student	**Required knowledge:** to have a reasonable experience in C and C++ software development and basic knowledge of digital electronics and firmware. Programming skills will be beneficial also for cosmic data analysis. **Acquired knowledge:** improved usage/learning of C and C++ languages, software and firmware debugging and development for online systems; improved understanding of complex DAQ systems for particle physics experiments. **Daily activity:** software development for the DIRAC board online control, firmware debugging, integration testing of the DIRAC in the DAQ, followed by analysis of the results; participation and report to weekly meetings (Calorimeter, DAQ, Mu2e-general).

interested in particle detectors and associated electronics. He/She will be involved in the operation of the electronic cards, development of control and monitoring software, and firmware debugging. He/She will study the calorimeter performance on cosmic data and compare it to simulation.	

FNAL-2

Hosting Laboratory	Available period	Contact person(s)
FNAL	01/03/2020 - 30/10/2020	Marco Incagli - Brendan Casey

Scientific program	Daily activity, skills required and to be acquired
Measurement of the muon anomalous magnetic moment in the Muon g-2 experiment The subject of this research program is the analysis of the g-2 oscillation frequency within the E989 (*Muon g-2*) experiment at Fermilab. The *Muon g-2* experiment aims to measure the anomalous magnetic moment of the muon to an unprecedented accuracy to verify the current discrepancy of 3.7σ observed between the theoretical prediction and the value measured by the previous experiment (E821 at Brookhaven National Laboratory), discrepancy which leaves room for new physics beyond the Standard Model. The final result of the experiment will be the ratio of two frequencies measured independently, and with very different techniques: the muon precession frequency ω_a and the free proton precession frequency . Both quantities have to be measured with an accuracy of 0.07 ppm. One of the ω_a analyses will be performed by the ω_a - europa group, in which INFN has a leading role. The Muon g-2 experiment collected a first set of data in the period March-July 2018 and a second one in March-July 2019, reaching a statistics which is two times the one collected by E821. A third set of data (Run3) just started in November 2019, with the aim of collecting 10 times the statistics of E821.	The successful candidate will be involved in data analysis and will contribute to this first, very important, result which will confirm, or disproof, the current difference between theory and experiment. General confidence with particle detectors and skills towards software activities are prerequisites for this research program. At the end of the program the student will gain the experience of participating in the realization and commissioning of a modern elementary particles experiment and of contributing to a research of possible physics beyond the Standard Model.

KEK-1

Hosting Laboratory	Available period	Contact person(s)
KEK	01/03/2020 - 30/11/2020	Stefano Lacaprara - Kodai Matsuoka

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the monitoring tool for the TOP detector calibration system at Belle II The Time Of Propagation (TOP) counter is a novel particle identification detector (PID) that provides efficient pion/kaon separation in the barrel region of the Belle II detector using the Cherenkov light produced by particles inside quartz bars. The TOP detector makes use of micro-channel plate photomultipliers (MCP-PMT's) for the measurement of the arrival time and position of the photons. The construction of the Belle II detector is complete, and since Spring 2018 is taking data at the SuperKEKB accelerator. As the scientific program of the experiment will span over several years it is important to assess the stability of the detector performances. A calibration system that uses a laser with very short pulses (less than 20 ps) was installed to measure the time response of the MCP- PMT's with a resolution better than 100 ps. In order to have a reliable calibration over the time of the experiment it is important to monitor the behavior of the laser system itself, for this reason a high precision monitoring system for the laser is under development. The laser stability monitor system must be installed in the next year and integrated with the slow control system of the detector.	The student will join the TOP operations team at KEK and will learn how to setup and operate the the laser monitoring system. He will integrate the system with the Slow Control system based on the CSS platform. The student will be assisted by the members of the TOP group located at KEK and in other countries, we will work together to validate and optimize monitoring procedures. The required skills are basic experience with C++ and the ROOT toolkit. Some familiarity with programming Arduino boards is desirable. A program of study in experimental high energy physics is preferred.

KEK-2

Hosting Laboratory	Available period	Contact person(s)
KEK	01/04/2020 - 30/06/2020	Diego Tonelli - Hiroyuki Nakayama

Scientific program	Daily activity, skills required and to be acquired
Performance optimization of the Belle II diamond detector The project focuses on the optimization of the diamond detector for radiation monitoring and beam abort of the Belle II experiment at the SuperKEKB collider. SuperKEKB aims at luminosities 50x higher than its predecessors, positioning Belle II at the forefront of searches for non-standard-model physics in the next decade. High collision intensity implies high beam-induced radiation, which can damage essential Belle II subdetectors and SuperKEKB components. Diamond sensors read-out by purpose-built electronics are installed on the beam-pipe to measure radiation and prevent damage. They operate as solid-state ionization chambers, providing measurements of pA to mA currents proportional to the radiation-dose rates to monitor instantaneous radiation, record integrated radiation, and trigger beam aborts. Intensive physics data taking is expected in 2020, due to steep luminosity ramping. In-situ monitoring of diamond parameters will be essential to operate the system optimally under challenging and rapidly changing data-taking conditions. The candidate will contribute to daily operations and diamond-data analysis data, supervised by local experts. Goals include achieving optimal (safe and smooth) operations and devising the system specifics for upcoming	Required skills include basic undergraduate-level background on the interaction of particles with matter and electronics, familiarity with standard lab equipment and with simple programming and data-analysis packages, along with strong team-work, communication, and self-motivation capabilities. Interest or a perspective thesis in experimental particle physics is preferred. The student will develop and refine these skills in a real research environment during one of the most intense and exciting phases of a HEP experiment.

upgrades. The fluid conditions associated with luminosity ramping and the need for daily close collaboration with detector and SuperKEKB experts require continuous presence on site.	

KEK-3

Hosting Laboratory	Available period	Contact person(s)
KEK	01/04/2020 - 01/07/2020	Francesco Forti - Katsuro Nakamura

Scientific program	Daily activity, skills required and to be acquired
Data Quality Monitoring of the Belle-II Silicon Vertex Detector at the SuperKEKB accelerator The Silicon Vertex Detector (SVD) is the central part of the tracking system of the Belle II experiment, crucial to perform a precise measurement of the position of the decay vertices, with the capability of reconstruction of low momentum tracks. The SVD is composed of four layers of 300 μm-thick double- sided silicon strip detectors, covering the polar angle from 17 to 150 degrees and radius from 39 to 135 mm. The SVD has been successfully operated during the first months of data taking, started in spring 2019, and has shown excellent performance in terms of efficiency, fraction of defective strips and operation stability. This project is focused on monitoring the detector performance during data taking, including calibration parameters, like strip noise, gain and timing, reconstructed quantities like cluster charge and signal-to-noise ratio, and overall efficiency. The stability and dependence of these quantities on machine background will also be investigated.	The student will work, inside a team of experts and assisted by a tutor, participating to the data taking operation of the SVD. He/she will learn how to acquire the calibration constants of the SVD (noise and gain), using the DAQ system of the experiment. He/she will collaborate in the improvement of the existing tools used for the online monitoring of the detector performances, like addition of new histograms for quantities related to clusters used in tracking. He/she will also be involved in the setup of a new web-based tool needed for the assessment of time evolution of the quality of the SVD data. The required skills are basic knowledge of the most popular operating systems. Some experience with the ROOT analysis software as well a basic understanding of silicon radiation detectors is desirable. The setup of the web-based tool will require to slightly modify existing javascript and PHP files, but experience

	with those languages is not mandatory. Program of study or thesis in experimental high energy physics is preferred.

PSI-1

Hosting Laboratory	Available period	Contact person(s)
PSI	01/03/2020 – 01/07/2020	Alberto Messineo - Wolfram Erdmann

Scientific program	Daily activity, skills required and to be acquired
Test of the pixel detector prototypes for the endcap disks of the CMS Inner Tracker upgrade At the High-Luminosity LHC, the CMS Inner Tracker will be exposed to unprecedented radiation levels and hit rates. The CMS collaboration is developing a high granularity pixel detector that will be able to cope with such challenging conditions. The endcap disks of the CMS pixel detector for the high luminosity LHC house a large number of detector modules. A low mass electrical system for reliable operation in the boundary conditions given by the detector geometry is challenging. Prototype circuit boards have been manufactured that integrate the distribution of power and control signals, as well as high-speed readout. Electrical tests must establish the viability of this approach under as realistic conditions as possible. The integrity of high-speed readout shall be tested in different scenarios of crosstalk, external interference, grounding and powering.	The work includes the operation of a CMS inner tracker readout system with prototype and dummy modules, as well as FPGA based systems for bit error rate tests. Basic familiarity with electronics (analog/digital) concepts is required; Basic knowledge of Semiconductor physics principles and of silicon segmented detector.

PSI-2

Hosting Laboratory	Available period	Contact person(s)
PSI	01/05/2020 – 31/10/2020	Luca Galli - Malte Hildebrandt

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the MEG II experiment drift chamber The MEG II experiment is searching for the lepton flavor violating decay $\mu \rightarrow e\gamma$ with unprecedented sensitivities. The cylindrical drift chamber plays a crucial role in the background suppression by performing an unprecedented precise positron tracking in an ultralow mass drift chamber. The detector is being commissioned in fall 2018 and 2019 and is supposed to be ready to look at the first positron tracks in 2020. The contract holder will be involved in the final steps of drift chamber HW commissioning and, in parallel, in the development and optimization of signal processing codes and detector calibration techniques. She/he will benefit of deep interactions with local experts and other collaboration members in the development of software programs for data acquisition, detector calibration and monitoring and will be an active member of analysis groups for data collected during the beam tests envisaged for summer/fall 2020. At first cosmic rays will be used to calibrate the chamber. The calibration will consist in time and gain factors assessment and the obtained results will be compared with the performance measured by means of muon and positron beam induced events. The beam will be available since July the 1st 2020.	At the beginning of the activity the contract holder must have a good knowledge of particle detectors and especially of drift chambers and a good autonomy in the use of analysis software. Experience in C++ programming is also required. During the contract period she/he will acquire skills and experience about the setting up and starting up procedures of a new experiment and on the signal handling, for real and calibration events too. She/he will also acquire a deep knowledge of the structure of data acquisition and trigger systems and of on-line software.

PSI-3

Hosting Laboratory	Available period	Contact person(s)
PSI	01/06/2020 – 31/12/2020	Luca Galli - Stefan RItt

Scientific program	Daily activity, skills required and to be acquired
Commissioning of the MEG II TDAQ system The MEG II experiment is searching for the lepton flavor violating decay $\mu \rightarrow e\gamma$ with unprecedented sensitivities. An upgraded detector is accompanied by and completely revised and full custom TDAQ system which will efficiently select signal candidate events with a background suppression of 7 order of magnitudes. During 2020 the complete MEG II detector and read out TDAQ electronics will be commissioned, the collaboration expects to register the first data to be used for the final detector set up in the engineering run. The trigger for the physics run is based on the selection of a high energy gamma in the LXe detector which is in time with a positron in the Timing Counter. The particles hit positions are also reconstructed in the trigger and used to select back-to-back events. Preliminary trigger algorithms and the read out routines were developed	The candidate will collaborate with the TDAQ responsible in the system calibration and commissioning. She/he will develop the FPGA Firmware in terms of new event reconstruction algorithms and/or methods for data read out and compression and system monitoring. The FPGAs present in the system are programmed both in Verilog and VHDL, so the candidate must be familiar at least with one of the two languages, the DAQ read out is written in C++, which is then also mandatory. The candidate will also participate in the trigger calibration, a basic knowledge of ROOT would also help for this task.

for single detectors runs but this is the first attempt to optimize the spatial and time coincidence between gamma- rays and positrons emerging from the target to be used as principal selection algorithm in the physics runs. The TDAQ read out scheme will also be revised and improved. The candidate will also critically analyze the data and propose improvements.	