BEPC-1-

Hosting Laboratory	Available period	Contact person(s)
IHEP(Beijing, PRC)	01/01/2025 – 30/11/2025	GIANLUIGI CIBINETTO (INFN-FE) GIULIO MEZZADRI (IHEP)

BESIII/CGEM	Daily activity, skills required and to be acquired
The BESIII experiment is carried out at the BEPCII electron-positron collider at the Institute of High Energy Physics in Beijing, PR China. BESIII plays a leading role in the investigation of hadron spectroscopy in the energy range of the tau lepton and the charm quark. An upgrade program is underway for both the detector and the accelerator to compete with and complement the studies of the new generation of B-factories and hadron accelerators. A major upgrade of the detector is to replace the current inner drift chamber, which shows aging effects, with an innovative cylindrical gas electron multiplier (CGEM) with charge and time readout. The CGEM Inner Tracker consists of three concentric layers of triple GEM detectors. Installation is planned for summer 2024. CGEM has been successfully installed in October 2024. From January 2025, BESIII operation will resume and CGEM commissioning under beam will start.	The candidate will participate in the commissioning under beam of the CGEM Inner Tracker under the supervision of his advisors as part of one of the main tasks. Basic knowledge of laboratory instrumentation is required. Knowledge of operation of particle physics detectors is an advantage. The candidate will be part of an international collaboration and will learn from direct experience advanced techniques in the operation of an innovative detector, which will give a boost to his/her studies.

CERN- 1 -

Hosting Laboratory	Available period	Contact person(s)
CERN	**1/5/2025 – 31/10/2025**	**Francesco Terranova, Henrique Souza – Filippo Resnati**

Detecting the argon scintillation light in ProtoDUNE-VD	**Daily activity, skills required and to be acquired**
DUNE is the largest neutrino oscillation experiment currently under construction in the USA, utilizing an innovative liquid argon Time Projection Chamber (LArTPC) technology. Two 400-ton demonstrators, ProtoDUNE-HD and ProtoDUNE-VD, have been built at CERN and are being operated in 2024-2025. ProtoDUNE-VD is designed to detect cosmic rays and beam-produced charged particles from the CERN North Experimental Area, which interact with liquid argon, generating both ionization and scintillation light. For the first time, scintillation light will be detected using sensors located on the cathode of the TPC, operating within a -300 kV plane. To prevent electrical discharges, these detectors are powered by a laser, and their signals are transmitted using optocouplers and optical fibers, rather than traditional copper wires. The optocoupler system was developed by INFN Milano Bicocca in collaboration with APC, Paris. The ProtoDUNE-VD run will validate this novel readout method. The specific goal of this project is to demonstrate that the ProtoDUNE-VD optocoupler system ("Signal-over-Fiber") can achieve single-photon sensitivity with a signal-to-noise ratio greater than 4, which is required for the full-scale experiment in South Dakota, USA.	The student will join the ProtoDUNE-VD onsite team at CERN during a cosmic ray or beam particle run. They will become familiar with the ProtoDUNE-VD data quality monitoring and acquisition systems and contribute to data analysis. This analysis involves interpreting waveforms triggered by light bursts, identifying single photon signals, and evaluating the signal-to-noise ratio. The analysis software is based on ROOT or Python, and students can select the framework that best suits their background. While basic knowledge of ROOT or Python is beneficial, it is not mandatory, as it will be developed throughout the project. Additionally, the student will gain expertise in data acquisition and cryogenics for particle detectors as part of the skill set acquired during the project.

CERN- 2 -

Hosting Laboratory	Available period	Contact person(s)
CERN	1/5/2025 – 31/10/2025	Francesco Terranova – Manuel Arroyave, Filippo Resnati

Light-charge association and time-tagging in liquid argon	Daily activity, skills required and to be acquired
Liquid argon detectors are a key technology for the next generation of neutrino physics experiments and pose significant challenges. CERN is validating a novel approach in this field that will change the way liquid argon detectors are built. For the first time in 2024, we replaced the conventional copper wires in liquid argon Time Projection Chambers (LArTPCs) with metal strips, achieving excellent track reconstruction capabilities. In 2025, we will validate this method on a larger scale using ProtoDUNE-VD, a large-size LArTPC where charged particles generate both ionization electrons, which are recorded by the strips, and scintillation light. The goal of this project is to uniquely associate the tracks reconstructed by the strips with their corresponding scintillation light flashes. This analysis will focus on cosmic ray muon tracks collected at ProtoDUNE-VD during the 2025 run. The association will be accomplished by merging and time-tagging the ionization charge data from the LArTPC with the information from a set of scintillation photon detectors, which are positioned along the lateral walls of the ProtoDUNE-VD cryostat.	The student will work with the CERN ProtoDUNE-VD analysis team and actively participate in a series of dedicated cosmic ray runs focused on studying time resolution. They will use a custom Python-based analysis tool designed to collect photon detector data with absolute time tagging. Throughout the project, the student will gain an understanding of the physics principles underlying LArTPCs, the operation of large-scale experiments, and the techniques for analyzing detector performance. Basic programming skills, preferably in Python, are preferred.

CERN– 3 –

Hosting Laboratory	Available period	Contact person(s)
CERN	01/03/2025 – 30/11/2025	Filippo Errico – Caterina Aruta

Beam spot constraint in muon reconstruction for Run 3	Daily activity, skills required and to be acquired
Muons play a central role in the CMS experiment being the most natural and powerful tool to detect interesting events over the background. They are less affected than electrons by radiative losses in the tracker material, stand out after the high magnetic field and stand out from the large hadronic background typical of hadron colliders. CMS has a dedicated system to detect muons (the so called muon system) composed of different detectors which allows it to measure muon momentum with good precision till the order of TeV. In order to improve muon reconstruction, the inclusion of beam spot information has been exploited, bringing an improvement in muon resolution at most of 10% in Run 2, strongly depending on data taking conditions. The student will study muon momentum scale and resolution when beam spot information is included in the object reconstruction, looking at Run 3 data. Few key channels (as H—> μμ or H —> 4μ) will be instigated as benchmarks.	The student will learn how a muon is reconstructed in a complex detector as CMS, focusing on how the different sub-detectors (tracker and muon system) play a role according to the value of the muon momentum. The candidate will then study the muon momentum scale and resolution of the algorithm with and without the inclusion of beam spot information, looking at Run 3 data, using few key channels. The student will experience the real world of an international laboratory, having the opportunity to discuss the work progress during the collaboration meetings. The student is supposed to have some basic knowledge of Linux shell scripting and ROOT analysis framework, as well as a basic knowledge of C++ and/or python languages. A good knowledge of English is considered a plus.

CERN – 4 –

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/04/2025 – 30/10/2025**	**Andrea Massironi – Simone Gennai**

New and challenging Higgs boson decay searches	**Daily activity, skills required and to be acquired**
As of today, the ATLAS and CMS collaborations have studied the Higgs boson production at the LHC for several years, giving a lot of attention to its most probable production and decay mechanisms. To complete the overall picture about the Higgs boson decay searches, few additional and more challenging decay channels are missing from the current landscape, which are becoming accessible thanks to the increased statistics delivered by the LHC. A systematic test and optimization of new analyses targeting the Higgs boson decaying into gluons will be developed with the data from CMS, based on run 2 and run 3 data. A parton level analysis will be followed by a detector level analysis with real CMS data.	Required skills: basic coding, c++, python Skills acquired: coding, working in a big collaboration, learn how to present results Daily activity: development of the CMS software code to perform new analyses, develop machine learning based approaches, and finalize new searches. The results will be then presented in working meeting and general CMS meetings

CERN - 5 -

Hosting Laboratory	Available period	Contact person(s)
CERN	01/05/2025 – 30/10/2025	Giorgio Baldinelli

CO_2 cooling deep analysis for the CMS Phase-2	**Daily activity, skills required and to be acquired**
The cooling of the Phase-2 upgrade of the CMS detector foresees a new and improved cooling system, using the two-phase CO_2 as refrigerant, flowing inside small diameter pipes. The operating temperatures of CO_2 are well below -30°C, a field that is not covered by literature-available correlations for the definition of the fluid pressure drop and the heat transfer coefficient between the pipe and the CO_2. The objective of the project consists of conducting a measurement campaign of pipes with different flavors in terms of material, mass flow rate, heat load and CO_2 saturation temperature. A suitable setup is already available at CERN, fed by a refrigerating machine (TRACI) that works with CO_2 down to -40°C. Once the tests will be executed, new theoretical correlations for the CO_2 behavior within this frame of boundary conditions should be produced, along with their uncertainty and range of application.	The selected candidate, with the help and supervision of the contact persons and other members of the team, will work on the facility that will host the CO_2 pipes to be investigated. He will verify that the system is operational, calibrate the probes used in the test and check for possible problems that could arise during the experiments. Furthermore, he should analyse the existing correlations for the boiling CO_2 properties and propose the updated ones after the gathering of the tests data. Required skills: basic knowledge of applied physics, rudiments of acquisition data systems, Excel-like tools. Skills to be acquired: the candidate will take advantage of the opportunity of understanding the way of managing the evaporators working with an environmental-friendly fluid like CO_2. Besides, the candidate will take home hands-on experience on pressure drop and heat transfer coefficient measurements, sensors calibration and data management.

CERN - 6 -

Hosting Laboratory	Available period	Contact person(s)
CERN	01/05/2025 – 31/10/2025	M. Pizzichemi – L. Martinazzoli

Study of scintillation-based electromagnetic calorimeter prototypes for LHCb PicoCal	Daily activity, skills required and to be acquired
The upcoming High-Luminosity (HL) phase of the LHC will pose new technological challenges to the detectors. The LHCb Electromagnetic Calorimeter (PicoCal) will have to keep its energy resolution while dealing with increased radiation exposure and higher detector occupancy. Timing resolution in the order of O(10ps) and radiation-hard materials will be necessary, requiring novel solutions to be studied and implemented. Similar considerations will also drive the design of experiments at future colliders, such as the FCC. The LHCb Picocal baseline option foresees the development of new SpaCal and Shashlik modules featuring innovative scintillating materials and dense absorber technologies. The student will participate in the characterization of the final design of the modules produced for the Long Shutdown 3 Enhancement, via laboratory and test beam measurements or Geant4-based Monte Carlo simulations.	The research will involve both experimental and data analysis activities. On one hand, the student will acquire knowledge in the field of characterization of scintillating materials and particle detectors, familiarise 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 world-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– 7 –

Hosting Laboratory	Available period	Contact person(s)
CERN	01/04/2025 – 30/11/2025	Valentina Mariani – Matteo Presilla

Jet reconstruction in VBS searches	Daily activity, skills required and to be acquired
Vector Boson Scattering (VBS) is one of the most promising processes we can investigate to indirectly search for physics beyond the standard model. Although many measurements have been already performed, a deep characterization especially in terms of polarization components is still missing. In association with the two vector bosons, W or Z, two highly separated jets are also produced. Thus, depending on the final state of the vector bosons, there will be from 2 to 6 jets as signal signatures. The jet reconstruction in a hadronic environment as LHC represents a challenge. The application of innovative machine learning techniques is pivotal to reach a good signal identification over background. We propose to exploit different available algorithms, performing optimization for the specific physics case of the VBS process, to maximize the sensitivity to access the polarization components of the interacting vector bosons.	**Daily activity:** The activity of this project consists in learning the main features of the LHC and of CMS, reviewing the recent CMS tools for jet reconstruction, compare them and optimizing the algorithms for the VBS process. **Required skills:** knowledge of fundaments of collider physics, detectors, and c++/python. **Skills to be acquired:** At the end of the project, he/she will gain knowledge about how reconstruct jet in physics analysis. He/she will gain a good knowledge on machine learning techniques and how to apply them to HEP. He/she will be able to critically understand the details of a data analysis in HEP and how to present physics results to the scientific community and interact with colleagues in an international and diverse environment.

CERN - 8 -

Hosting Laboratory	Available period	Contact person(s)
CERN	**20/07/2025 – 20/08/2025**	**Enrico Robutti – Diego Figueiredo**

Operation and monitoring of performance of the silicon pixel tracker of the CMS Precision Proton Spectrometer	Daily activity, skills required and to be acquired
The CMS Precision Proton Spectrometer (PPS) reconstructs protons escaping intact from proton-proton interactions in the Large Hadron Collider (LHC) at CERN. It is located in the LHC tunnel about 200 m from the interaction point of the CMS experiment, on both sides. It has been collecting data since 2016, and its data used for several published searches for rare Standard Model processes or signatures of New Physics. For the LHC Run3 (2022-2025), PPS detectors have been upgraded. The new setup has collected data in 2022, 2023 and 2024 and will continue in 2025. This project consists in contributing to the regular operations of the silicon pixel tracker of PPS and to the monitoring of its performance, so as to assure the most continuous and effective working conditions during data taking.	The students will learn the basics of the physics investigated at the LHC and of the CMS experiment, with particular focus on the processes studied by PPS and the operating principles of its tracking detectors. The task will involve participating to data taking shifts, monitoring the detector performance through the standard tools available, and discussing possible concerns and maintenance operations with the PPS crew working on the project. Some familiarity with the Linux operating system environment is required. Basic programming skills in C++ and/or phyton may be occasionally useful.

CERN– 9 –

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2025 – 01/11/2025**	**Stefano Argirò (TO) Riccardo Salvatico (CERN)**

Upgraded Electronics for the readout of the Electromagnetic Calorimeter of CMS	**Daily activity, skills required and to be acquired**
Starting from 2030 LHC will enter the High-Luminosity phase, in which the detectors will be challenged by the increased interaction rate. The CMS Electromagnetic Calorimeter (ECAL) will be equipped with a completely revised electronic readout to cope with the new running environment. INFN designed and produced an ASIC chip to sample the signal at high frequency and manage its transmission, which will equip the Very Front End boards. The production of the Very Front End cards is expected to start in Spring 2025 and their qualification is the subject of this proposal.	The successful candidate will take part in the testing and integration of the upgraded electronics. This will extend to laboratory setup for test and qualification of the electronics boards, storage and analysis of the test data, assembly of a test module of the calorimeter and participation in test-beam data taking. The candidate will familiarize with lab instrumentation, data acquisition and analysis. Some knowledge of python will be an advantage.

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Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 01/09/2025	Antonello Pellecchia (INFN Bari) – Camilla Galloni (Wisconsin/CERN)

Automated performance monitoring of GEM detectors at CMS using machine learning tools	**Daily activity, skills required and to be acquired**
The GE1/1 system is part of the CMS muon detector upgrade. It consists of 144 triple-GEM (Gas Electron Multiplier) chambers, each readout by 24 frontend ASIC, installed in the forward region. The GE1/1 station is fully integrated in CMS and it is successfully taking data during the Run 3. Moreover, some GE2/1 detectors are also installed and fully working. Communication instabilities and malfunctioning of the readout electronics can cause transient issues, which translate into low occupancy regions. During the LHC runs, events are promptly analyzed, allowing for an online monitoring of the GEM system. Nevertheless, given the complexity of the system and the variability of the data taking conditions, it is desirable to automate the inspection of the monitoring plots. This project aims at using machine learning tools for anomaly detection to automatically inspect the occupancy and efficiency maps of all GE1/1 and GE2/1 detectors, to help experts in promptly identifying problematic regions. The candidate will start from some existing tools based on CNN and autoencoders. She/he will train the algorithm on good data and then implement an anomaly map for the automated inspection of new runs during the 2025 data taking.	The student will work with the GEM Run Coordination Team in the CMS Control Room, joining the CMS operations during LHC runs. She/he will work on the training of machine learning tools while learning about typical issues occurring in the detector. This will allow her/him to deploy the algorithm output for identifying sensitive anomalies, thus helping the GEM experts. Skills required: - python coding skills are desirable Skills to be acquired: - principles of detector physics and data acquisition - basics of machine learning (data preparation, training, inference) - data analysis and plotting tools to interface the machine learning output with the detector geometry

CERN – 11 -

Hosting Laboratory	Available period	Contact person(s)
CERN	01/05/2025 – 15/12/2025	Piet Verwilligen (INFN Bari) – Pieter Everaerts (Wisconsin/CERN)

Characterization of the new ME0 detectors for the CMS Muon Upgrade	**Daily activity, skills required and to be acquired**
Ahead of the High-Luminosity LHC, the CMS muon system will undergo a major upgrade featuring Gas Electron Multiplier (GEM) detectors in the very forward region. The new ME0 station will be made of 6 layers of triple-GEM detectors (so called ME0 modules), thus requiring several phases of production, testing and quality control, from the individual detector element to the integrated 6-layers stack together with its final readout electronics. The production of ME0 modules is a global effort, with 216 modules manufactured at CERN and partner facilities worldwide, among others INFN Bari and INFN Frascati. After production, all modules are sent to CERN for the final tests before being assembled into stacks. In this context, one of the sensitive aspects is the performance of the final readout electronics and its integration with the detector, which will determine the detector performance in the CMS experiment. In this project, the student will be involved in the ongoing detector production and characterization at the CMS-GEM lab at CERN. In particular, she/he will instrument the modules and test the frontend electronics and their integration in terms of calibration and noise levels. The student will thus contribute to the successful production of ME0 detectors for the CMS experiment.	The student will work in the GEM laboratory at CERN, equipped with several test benches and advanced instrumentation for the detector production and testing. In the lab, she/he will work with GEM experts and with the large team devoted to the ME0 project. The candidate will operate the detectors in the lab to study their stability under high voltage. She/he will also install the readout electronics on the detectors, calibrate the system and produce some benchmark noise measurements as part of the detector characterization. Skills required: - python coding skills desirable Skills to be acquired: - principles of detector physics and readout electronics - how to operate lab equipment - how to read and interpret ASICS calibration data

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Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 01/08/2025	Federica Simone (INFN Bari) – Georgios Karathanasis (CERN)

Measurement of B meson decays with Run-3 data	**Daily activity, skills required and to be acquired**
Decays of B^0_s mesons are crucial for both testing the Standard Model (SM) and searching for physics beyond the SM, as they can be used for CP violation studies and to test the theoretical predictions of their branching fraction and angular distributions. The excellent tracking and muon identification of the CMS experiment make it well-suited to study B^0_s decays such as the B^0_s->J/Psi phi decays with high precision, both in its most probable final state in 2 muons and 2 kaons, and in the 4 muons final state despite the much lower branching fraction. This is allowed in Run 3 by new muon triggers with loose requirements on the dimuon momenta and mass. In this project, the student will measure the yield of B^0_s->J/Psi phi decays in the newly collected data in 2025 in both final states, with a twofold objective: comparing the yields with the theoretical predictions and monitor the data taking performance with respect to previous years. This measurement will benchmark the quality of the new datasets for new flavor physics analyses at CMS.	The student will work in close contact with the CMS B-Physics group at CERN, attending working meetings for data analysis while gaining some theoretical background. The student will develop the B^0_s->J/Psi phi analysis and fit on 2025 data, using existing results from previous runs as a reference. She/he will learn the basics of CMS trigger, data acquisition and analysis. Skills required: - python coding skills desirable Skills to be acquired: - elements of particle physics and standard model - typical HEP analysis workflow, from trigger to final data - data analysis using ROOT

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Hosting Laboratory	Available period	Contact person(s)
CERN (Ginevra, CH)	**01/06/2025 – 30/09/2025**	**Marcello Rotondo (LNF)** **Abhijit Mathad (CERN)**

Studies of low energy hadrons identified as muons at LHCb	**Daily activity, skills required and to be acquired**
LHCb is a forward-spectrometer located at LHC and specialised in the study of hadrons containing charm and beauty quarks. For the study of many decays of heavy hadrons, it is crucial a good identification of the muons (Muon ID). The Muon ID is affected by the pollution of charged particles, like pions and kaons, that traverse the full detector and mimic a muon (muon MisID). At low momentum, the primary cause of muon MisID is the decay in flight of pions and kaons that occurs before reaching the muon detector. The goal of the project is to define a consistent approach for the determination of the muon MisID probability that can be useful to any analysis using muons. At present, the muon MisID is evaluated using D meson decay into a kaon and a pion using an approach called tag-and-probe. While these decays are reconstructed with very large rates in LHCb, they cover mainly the region useful for high momentum muons. To improve coverage in the low-momentum region, it is essential to study additional control samples, particularly the three-body decays of D mesons, as well as soft $\Phi \to KK$ and $K_s \to \pi\pi$ decays, in order to accumulate large statistics.	The selected student will analyze various control samples using the tag-and-probe approach to determine the probability of muon MisID. In addition to the standard decay of D —> K pi, the control samples will include various three-body decays such as D —> K pi pi, as well as clean samples of kaons from Phi —> KK and pions from K_s —> pi pi. This analysis will be performed using data collected in 2024 and 2025, with support from experts at CERN. Skill acquired: - learn how to analyze large data samples, in particular in designing the offline signal selection, and the fitting of parameters of interest; - advanced coding in Python/C++ and learning the ROOT/RooFit analysis framework Skill required: some knowledge of the Linux operating system is required. Basic programming skills in Python and C++ may be useful.

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Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 31/10/2025	Martino Borsato (INFN-MiB) Renato Quagliani (CERN)

Testing the new LHCb photon conversion trigger	Daily activity, skills required and to be acquired
The LHCb experiment at the Large Hadron Collider is designed to precisely study flavour-changing quark transitions and probe the intricate flavour structure of the Standard Model at unprecedented energy scales. Following a recent upgrade, LHCb can now analyse 30 million proton collisions per second in real time, leveraging a cutting-edge software trigger powered by GPUs. An exciting aspect of LHCb's extensive physics program involves the study of decays that emit high-energy photons. At LHCb, photon reconstruction is most precise when photons convert into electron-positron pairs within the detector material. To capitalise on this, a dedicated real-time selection for such photons is being developed which relies on partially reconstructed electron tracks and a machine-learning based classifier. This novel photon selection is set to be deployed for the first time during the 2025 data-taking run. The project will involve analysing the initial data collected in 2025, focusing on a decay channel involving photons selected by the new algorithm that will be used to demonstrate the effectiveness of this real-time photon selection process.	The selected candidate will gain an introduction to the LHCb experiment and foundational concepts in high-energy physics data analysis. They will work with the fresh data collected at the start of the 2025 run, using a control decay channel involving photon emission to validate the newly implemented trigger line. The results will be compared against detailed Monte Carlo simulations. A basic knowledge of Python (or C++) is required to analyse the data. The candidate will also be trained in advanced tools used for LHC data analysis and guided through the identification of the specific decay channel of interest. Additionally, they will gain insights into the operation of detectors at the LHC by huge collaborations of physicists from all over the world and they will participate first-hand in the exciting process of analysing newly collected data for the first time.

CERN - 15 -

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 30/09/2025	Viacheslav Duk – Lisa Fantini

Study of heavy neutral lepton in the decay $B_c^{\pm} \rightarrow \mu N$, $N \rightarrow \pi e$ with the data collected by the LHCb experiment	**Daily activity, skills required and to be acquired**
The search for processes with Lepton Flavor/Number violation (LFV/LNV) is important to understand phenomena that cannot be explained by the Standard Model and to constrain parameters of various New Physics models. One of the best tests for LFV/LNV are decays of B mesons with leptons in the final state, e.g. decays B->l N where N could be a heavy neutral lepton (HNL) and l is a lepton. The LHCb experiment collected a huge amount of data in 2016-2018 (Run 2) corresponding to 9 fb^{-1} that allows for a wide physics program including LFV/LNV searches. The Perugia group is currently doing the search for HNL in the $B_u^{\pm} \rightarrow \mu$ N, N$\rightarrow \pi$ e decay using Run 2 data. Similar analysis can be done for the decay channel $B_c^{\pm} \rightarrow \mu$ N, N$\rightarrow \pi$ e which extends the range of masses accessible for the search of N. Montecarlo and filtered data samples have been already produced for this process. The analysis is supposed to start in early 2025. The student will take part in the data analysis for the HNL search in B_c decays and will profit from the working environment already developed by the Perugia group.	The student will learn how to analyze data and Monte Carlo samples working daily in close contact with the main analysts. From the analysis of the data the student will learn the main methodologies of a physics analysis, increasing the expertise and skills in computing and python/C++ coding. He/she will learn how to estimate the values of relevant physics variables, and evaluate their statistical and systematic uncertainties. He/she will experience to work as a part of an international collaboration, with the opportunity to discuss the analysis progress at meetings of dedicated working groups. The student will also have the possibility to contribute to the ongoing data taking of the LHCb experiment, learning the basic functioning of the detector. A student with a physicist profile and a basic knowledge of C++ and ROOT is preferred.

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Hosting Laboratory	Available period	Contact person(s)
CERN	01/07/2025 – 30/09/2025	Giovanni De Lellis – Richard Jacobsson

Development of a tool to identify electromagnetic showers in the SND@LHC experiment	**Daily activity, skills required and to be acquired**
The project is part of the SND@LHC experiment at CERN which has observed neutrino interactions at a collider for the first time. The project focuses on developing a software tool for detecting electromagnetic showers produced by electron neutrino interactions in the emulsion films, which are the tracking layers instrumenting the neutrino target region of the apparatus. Using the computational resources and data infrastructure of the experiment available at CERN, the candidate will process a dataset of emulsion images to identify basic electromagnetic shower patterns. The work involves implementing image preprocessing routines, applying simple clustering algorithms, and evaluating the results against reference data.	The candidate will develop and test a prototype software tool for detecting electron neutrino-induced showers in emulsion films. Daily tasks include preprocessing image data, applying clustering algorithms to identify particle tracks, validating results with simulated datasets, and documenting the workflow. Basic programming (Python or C++), image processing knowledge, and familiarity with particle physics concepts are required

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Hosting Laboratory	Available period	Contact person(s)
CERN	**15/08/2025 – 15/09/2025**	**Leonardo Carminati – Lorenzo Pezzotti**

Study of the performance of a Dual Readout calorimeter on electrons and pions beams	**Daily activity, skills required and to be acquired**
The project aims to study the performance of a prototype of dual readout calorimeter to a beam of high energy electrons and pions at the SPS-H8 line. The dual-readout method is based on the use of two different types of signals, which provide complementary information about the showers developing in the calorimeter. The technique makes it possible to avoid/eliminate many of the problems that have traditionally strongly limited the performance of hadron calorimeters. In addition, the possibility to sample the showers with high granularity will provide additional capabilities such as the possibility to exploit particle flow algorithms in general purpose colliders detectors. A module of high-granularity, dual-readout calorimeter is being assembled within the HiDRa project using steel capillary tubes as absorber and scintillating/cherenkov fibers as active material. The transverse size of the HiDRa prototype is optimized to guarantee a full containment of the showers produced by high energy pions. The module performance will be measured on SPS pions and electrons beams in summer 2025. For the first time it will be possible to fully characterize the response to hadrons setting a fundamental milestone in the development of the dual readout calorimetry. This project is incardinated in the CERN future accelerator strategy as a dual readout calorimeter is foreseen in one of the detector concepts being developed for FCC-ee.	The first part of the project will consist in preparing the setup for the testbeam: calorimeter module cabling and positioning, readout setting, ancillary equipments preparation. In this phase we foresees a team work with duties decided day by day.The second part of the project will consist in directly partecipating to the data collection by taking shifts during the period when the beam will be availble. For this project, we expect students with a strong interest in experimental particle physics and hardware setups development. Through this project, the student will have the unique opportunity to work with a fully functional, cutting-edge real detector prototype, contributing to the development of the FCC-ee project. The exact time period will be determined once the SPS-H8 line schedule will be available.

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Hosting Laboratory	Available period	Contact person(s)
CERN	**One month in the period** **01/07/2025 – 31/10/2025**	**Pierluigi Paolucci – Brieuc Francois**

Study and simulation of dual-readout crystals for applications at FCC	Daily activity, skills required and to be acquired
The technology of dual readout calorimeters, able to simultaneously detect scintillation S) and Chernekov (C) light, represents a promising research avenue for potential deployment at future colliders after the LHC era. The community performing R&D for the IDEA experiment at the Future Circular Collider, FCC-ee, is currently studying a concrete working hypothesis for a homogenous S/C detection in crystals. Several crystal options are being considered and tested via experimental setups at different sites and at CERN, including test-beams foreseen in the upcoming year. The proposed project will consist of studying the features of a crystal in DD4HEP, the software tool for the IDEA detector simulation, learning how to implement simulate a system that could be used within the context of the IDEA electromagnetic calorimeter.	Study of the DD4HEP toolkit, A basic knowledge of python and particle-matter interaction is recommended. A daily interaction with the experts at CERN will allow to learn the mechanics of the DD4HEP simulation, and to apply it to the required use-case.

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Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 30/09/2025	Maurizio Martinelli (INFN-MiB) Nathan Jurik (CERN)

Study of $D^0 \longrightarrow K^0 \pi^+ \pi^-$ decays in Run3 of LHCb	**Daily activity, skills required and to be acquired**
The LHCb experiment at the Large Hadron Collider is designed to precisely study flavour-changing quark transitions and probe the intricate flavour structure of the Standard Model at unprecedented energy scales. Following a recent upgrade, LHCb can now analyse 30 million proton collisions per second in real time, leveraging a cutting-edge software trigger powered by GPUs. The student will contribute to the analysis of LHCb's large 2024 data set of $D^0 \longrightarrow K^0 \square \pi^+ \pi^-$ charm meson decays. This sample accounts for more than 30M signal decays. With the increased statistics relative to the Run 2 data set, and the brand new detector, special care will need to be taken to ensure that systematic effects and potential biases remain under control and are handled properly. The student will work on optimising the suppression and estimation of residual effects, improving the techniques used in previous analyses in order to meet the demands of improved statistical precision. In particular, they will study the contamination and bias introduced by the reconstruction of secondary $B \rightarrow D^0(\longrightarrow K^0 \square \pi^+ \pi^-)\mu X$ decays in the signal sample.	The selected candidate will gain an introduction to the LHCb experiment and foundational concepts in high-energy physics data analysis. They will work with data collected during the 2024 run and will develop a technique to limit the systematic uncertainties of one of the golden charm decay channels of LHCb A basic knowledge of Python (or C++) is required to analyse the data. The candidate will also be trained in advanced tools used for LHC data analysis and guided through the identification of the specific decay channel of interest. Additionally, they will gain insights into the operation of detectors at the LHC by huge collaborations of physicists from all over the world and they will participate first-hand in the exciting process of analysing newly collected data for the first time.

CERN –20–

Hosting Laboratory	Available period	Contact person(s)
CERN	01/06/2025 – 31/07/2025	Biagio Di Micco – Michela Biglietti

Analysis optimisation for the search for HH production in the yybb final state	**Daily activity, skills required and to be acquired**
LHC is the most energetic particle collider ever built. It collects proton-proton interactions at the center of mass energy of 13.6 TeV. ATLAS is one of the experiments working at the LHC and it has been optimised for the search of the Higgs boson and heavy mass particles. One of the main targets of ATLAS is to look for the pair production of Higgs boson. This process is affected by the energy potential of the Higgs boson, and it could be visible with the present collected integrated luminosity if the Higgs boson self-interaction is enhanced by Beyond Standard Model physics. One of the most sensitive channels is the gamma gamma b anti-b channel, where one Higgs boson decays in a pair of photons and the other Higgs boson in a b-anti-b quark pair. In this project the student will analyse the data collected by the ATLAS experiment in order to optimise the sensitivity of the analysis search. Particular effort will be dedicated to the optimisation of a variable, known as single-topness, that is used to reject background from the top anti-top H process. In this process the Higgs boson, H, decays to a photon pair while the top and anti-top quarks decay to two W bosons and two b-quarks. It can be distinguished from the HH production by pairing the b and light jets to the W boson and to the top and anti-top quarks. The student will run on the Monte Carlo simulation and will perform a cut and count sensitivity study using several definitions of such variable. In particular he/she will study different pairing criteria of the jets to the intermediate W and top particles.	In the first week of the project the student will become familiar with the root analysis framework and will perform first studies of the kinematic variables for samples of signal and background. During the second week of the project, he/she will produce distributions of the single-topness variable using different criteria for the pairing of jets to the W and top particles. For each configuration he/she will find the optimum cut optimising the signal sensitivity expressed as S/sqrt(B), where S and B are the signal and the background, respectively, and he/she will compare the several configurations in order to find the most performing ones. It is preferred a basic knowledge of c++. The student will acquire skills in c++ programming using the root analysis framework library and he/she will have the opportunity to acquire hands-on experience on particle physics and data analysis tools.

CERN –21–

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/06/2024 – 30/09/2024**	**Mauro Iodice – Michela Biglietti**

Large size resistive Micromegas for future detectors	Daily activity, skills required and to be acquired
Micromegas are a relatively modern concept for micropattern gaseous detectors, designed to handle high particle flux while providing high gain, high spatial resolution, fast response times and flexibility for different radiation detection applications. Following the design and construction phase of the resistive micromegas for the upgrade of the ATLAS muon spectrometer, we initiated an R&D project aimed at pushing this technology to operate at high gains, superior stability, and with the capability to handle high particle fluxes. The project, known as Resistive High-Granularity Micromegas (RHUM), has successfully completed its initial phase, achieving excellent performance on small-size prototypes configured with double Diamond-Like Carbon (DLC) resistive layers. The focus of the R&D has now shifted towards demonstrating the scalability of this technology for large-size detectors, which will be compatible with the next generation of detectors at future research facilities. At present, we are in the process of constructing two large-size modules (50x50 cm2) of high-granularity resistive Micromegas. These modules differ in terms of their resistive layout. We intend to conduct a comprehensive characterisation of these new detectors using radioactive sources (such as 55Fe) and an X-ray gun available at the GDD Lab at CERN. Additionally, depending on the availability of beam time at the SPS test-beam facility, we may further evaluate their performance.	The student will be involved in one of the foreseen activities: tests and characterization of the detectors in the Lab with 55Fe and X-rays, or test-beam. He/she will participate and learn the steps of setting up the experiment, the data taking and 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 - 22 -

Hosting Laboratory	Available period	Contact person(s)
CERN	**01/07/2025 – 30/09/2025**	**Pierluigi Bortignon – Mia Tosi**

Title: Search for Higgs decay to a pair of muons with the Run 3 dataset collected by the CMS experiment	**Daily activity, skills required and to be acquired**
The Higgs boson decay to muon pairs (H→μμ) provides a unique opportunity to probe the Higgs boson's couplings to second-generation fermions, offering critical insights into the Standard Model and potential new physics. This is a rare process, with only about one in five thousand Higgs bosons predicted to decay to muons. The CMS experiment found the first evidence (3 standard deviations) of this process with the Run 2 dataset (138 fb-1) collected at 13 TeV centre-of-mass pp-collisions. Using the full Run2+Run 3 dataset (~350 fb-1), a luminosity based scaling projection predicts a ~4.7 sigma excess above the null hypothesis for this process. Analysis efforts on a partial Run 3 dataset are now underway in CMS, and provides exciting new opportunities to improve upon the Run 2 result.	The candidate will be introduced to experimental analysis techniques used by the CMS experiment. The candidate will familiriaze themselves with event reconstruction and object selection at hadron collliders, using C++ and python based coding software. The candidate will then proceed to deploying an analysis workflow that studies the Vector Boson Fusion production of the Higgs boson. The candidate will develop a machine-learning based classifier to distinguish signal event from the background process (such as Z →μμ), and perform a preliminary sensitivity estimate for the signal strength in this channel. The candidate should have a basic knowledge of coding in C++/python.

KEK- 1 -

Hosting Laboratory	Available period	Contact person(s)
KEK	May-October 2025	Laura Zani – Kodai Matsuoka

Study on online trigger selection for precision measurements at Belle II	Daily activity, skills required and to be acquired
Leptons are powerful tools for searching for new physics beyond the Standard Model. Particularly, tau leptons offer an ideal testbed since they are the only lepton heavy enough to decay into hadrons, allowing for precision tests of the Standard Model, through the measurement of several fundamental parameters. Belle II experiment at the electron-positron asymmetric energy collider SuperKEKB will collect the largest data set of more than ten billion tau pairs at the end of its data taking. However, tau event selection and reconstruction is challenging. Tau leptons decay before being detected into final states including neutrinos, and they need to be reconstructed from the stable particles produced in their decays. Dedicated trigger lines for online selection of tau pairs events have been developed at Belle II experiment. Testing the performance of the triggers and the agreement in the selected samples between data and simulation is crucial to achieve measurement at a precision below fraction of percent. With the new data sets acquired in 2024 new online selections have to be tested and characterized, in order to control with high precision systematic effects in physics measurements.	A basic knowledge of python, root and C++ is very useful, but can also be acquired during the project. Principles of interaction of particles with matters must be already known and mastered. Reference groups are available to train the interested student, before going to KEK, to the basic usage of Belle II software. Work at KEK will consist mainly in software activity: running the scripts on reconstructed data to measure the efficiency of trigger selection on simulation and actual data. Analysis work to optimize the trigger performance is also possible. Everything will be supervised not only by the reference contacts, but also by Dr. Marcela Garcia, a post-doc at KEK, who is a tau physics expert. Dr. Garcia will be in touch daily with the student.

PSI - 1 -

Hosting Laboratory	Available period	Contact person(s)
Paul Scherrer Institute	01/05/2025 – 30/11/2025	Giovanni Gallucci (INFN - Pisa) Angela Papa (PSI)

Commissioning of the MEG II detectors for run 2025	Daily activity, skills required and to be acquired
The MEGII experiment is searching for the lepton flavor violating decay $\mu \rightarrow e\gamma$ with unprecedented sensitivity. Several detector and calibration procedures will be commissioned for the run 2025. The candidate will be involved in Pisa group activities related to detector commissioning, trigger and data acquisition electronics configuration and simple data analysis.	The candidate will have the opportunity to participate in the various phases of commissioning under the supervision of experts responsible for calibrations and detectors. A basic experience in C++ programming language could be useful.

PSI - 2 -

Hosting Laboratory	Available period	Contact person(s)
Paul Scherrer Institute	**01/05/2025 – 30/11/2025**	**Giovanni Gallucci (INFN - Pisa)** **Angela Papa (PSI)**

MuEDM positron tracker detector development	**Daily activity, skills required and to be acquired**
The Electrical Dipole Momentum (EDM) of fundamental particles are intimately connected to the violation of time invariance T and the combined symmetry of charge and parity CP. The MuEDM experiment, using for the first time worldwide the innovative frozen spin technique, aims to measure the muon EDM with heightened sensitivity studying the asymmetry up/down of the positron from the muon decay. The muon beam of Paul Scherrer Institute (PSI) will enter in a uniform magnetic field region and the muons will be trapped inside the region. The positron from decay will be measured by a dedicated scintillating fibers detector coupled with silicon photomultipliers (SiPMs) and read by CAEN FERS electronics. The candidate will be involved in Pisa group activities related to test of fibers, SiPMs and readout electronics, construction, assembly and integration of positron tracker, simple analysis.	The candidate will have the opportunity to participate in testing, construction and assembling of a new detector under the supervision of experts. A basic experience in C++ programming language could be useful.