Istituto Nazionale di Fisica Nucleare

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

CERN-1

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 January 2018 - 15 March 2018**	Roberto Tenchini (INFN Pisa) Piergiorgio Verdini (INFN Pisa) Clara Matteuzzi (INFN Milano Bicocca)

Scientific program	Daily activity, skills required and to be acquired
"Muon-Electron Elastic Scattering for the muon (g-2) anomaly" The program we are proposing is related to the studies we are performing in order to assess the feasibility of a very-high precision measurements of the muon-electron elastic cross section, aiming to measure the running of $\alpha(t)$, for space-like transferred four-momenta ($t = q2 < 0$). It has been recently realized that the precise measurement of the running of $\alpha(t)$ in the space-like four-momentum region can be used in turn to measure the leading order hadronic contribution to muon (g-2) anomaly.	The project activity consists of two different activities: data analysis of multiple scattering data. Data will be collected in a preliminary dedicated test beam at CERN (planned by the first week of October 2017) using high-energy electron and muons beams. We aim to test the accuracy/precision of the GEANT4 multiple scattering models comparing the predictions to scattering data, which are not available in the literature. The second activities concern the assembling of a strip silicon tracker based telescope (prototype of detector module), to then detect elastic scattering events $\mu + e(\text{rest}) \rightarrow \mu + e$ in a dedicated run on a high-energy CERN's muon beam for a measurement feasibility study. Required skills: Computer programming: basic knowledge of the CERN's ROOT package and C++ language; basic knowledge of the Linux OS commands environment.

CERN-2

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**1 February 2018 – 1 April 2018**	Oscar Francisco (UFRJ Rio de Janeiro) Lorenzo Sestini (Univ. Padova)

Scientific program	Daily activity, skills required and to be acquired
"b-jets and c-jets identification in the forward region at LHCb by exploiting jets sub-structure with deep-learning techniques" The LHCb experiment at CERN has already demonstrated its capability of performing measurements with b-jets by determining the Z->bb-bar production cross section. With the upgraded detector, the experiment will have the possibility to collect a huge sample of jets important for the Higgs and new b-bbar resonances searches and measurements involving c-jets. One of the main challenge is the identification of b-jets against light quarks jets and in particular versus c-jets. The wanted separation can be obtained with new computing algorithms based on deep learning techniques. The proposed project sees a student involved in the full understanding of the internal structure of the jets originated by b-, c- and light quarks. Thereafter, the student will be involved in the training and optimization of a deep neural network using simulated data. Then, the algorithm will be applied to data collected during the current data taking to measure the performance. With this project, the student will have the possibility to experience the everyday life in a LHC experiment and to understand one of the most difficult object of particle physics, jets. In addition, he/she will learn and use the deep neural network, one of the most up-to-date computing algorithm to manipulate data.	In order to participate to this project no particular skills are required. It may be useful if the student is familiar with *root* and Linux-based operation systems. The project is structured in different phases in which the student will: - learn the concept of jet objects, how they are produced in pp collisions and simulated by monte carlo programs; - learn the deep neural network algorithm and its implementation in LHCb software; - train the algorithm using simulated data to distinguish b-jets from c-jets and light quark jets - apply the algorithm to collider data to identify the Z->bb-bar resonance.

CERN-3

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 –1 January 2018**	Paolo Iengo (CERN)

Scientific program	Daily activity, skills required and to be acquired
"Test of the performance of the Micromegas chambers for the upgrade of the ATLAS Muon Spectrometer " Large area Resistive Micromegas chambers (MM) are being built for the upgrade of the forward stations of the ATLAS Muon Spectrometer within the New Small Wheel project (NSW). This upgrade has been designed to significantly extend the research program of the ATLAS experiment. In particular the MM chambers will allow to maintain an excellent efficiency and space resolution over large areas in the high rate environment of the upgraded LHC. For this purpose, the mechanical and electrical properties of the detectors will be taken accurately under control. The main components of the Micromegas detectors are the Read-Out boards including the read- out strips. All these boards are tested in a very detailed way at CERN before the detector assembly. Then, once validated, are shipped to the external laboratories in different countries where the detectors are assembled. The assembled detectors are then sent to CERN where their performance are measured using a cosmic rays facility and beams with and without irradiation (GIF++ facility). In the next months the ATLAS NSW CERN group will be in charge for assessing the quality of all the Read-Out boards, and to test in a complete way the built chambers.	The student will join the ATLAS NSW CERN group under the supervision of Dott. Paolo Iengo. He/she will spend part of the time in the study and validation of the Read-Out boards, and part of the time in the study of the chambers performance. A good attitude in performing precision measurements of mechanical and electrical properties using different kinds of instruments is required. Some previous experience in taking data with set-ups of different detectors and the capability in analyzing them is also appreciated.

CERN-4

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 June 2018**	Vincenzo Vagnoni (INFN Bologna) Angelo Di Canto (CERN)

Scientific program	Daily activity, skills required and to be acquired
"Search for CP violation in D->K_s K and D_s->K_s pi at the LHCb experiment" The LHCb experiment, owing to the large cc cross section in proton-proton collisions at LHC, has been collecting the world's largest sample of charmed hadrons, which is now being increased during the RUN-2. Charm physics offers the unique opportunity to search for physics beyond the Standard Model in the up-quark sector, by looking at indirect effects of unknown particles in loop processes. In particular, CP violation in charm decays is still unobserved, and this remains as an important aspect of the Standard Model seeking experimental clarification. The forthcoming LHCb measurement of the difference in CP asymmetries between $D' \to K^*K+$ and $D' \to \pi^*\pi+$ decays will reach an unprecedented precision close to theoretical expectations. Further investigations in other charm decay modes will be therefore extremely important to provide a complete picture of CP violation in the charm sector. The quasi-two-body singly Cabibbo-suppressed decays of the D^* and D^* mesons into a K' and a charged hadron are good channels for this purpose. The selected student during his/her period of stay at CERN will work on an analysis searching for CP violation with the $D\pm \to K'K\pm$ and $D\pm \to K'\pi\pm$ decays, using the LHCb RUN-2 data. For conducting the analysis efficiently, it will be of primary importance to spend a period at CERN, in order to participate actively to the charm working group activities and to be in strict contact with the LHCb charm physics experts there.	The candidate will work at CERN in strict contact with the members of the Charm working group of the LHCb Collaboration, under the supervision of the contact persons (Vincenzo Vagnoni, INFN and Angelo Di Canto, CERN). In particular, he/she will work to the optimization of the algorithms aimed at selecting the decays of interest, using a multivariate analysis technique. He/she will also attend weekly working group meetings, reporting progresses of his/her work. The candidate needs basic knowledge of the UNIX/LINUX environment, of the C/C++ programming language and the ROOT/ROOFIT package. After his/her period at CERN he/she will improve his/her knowledge in advanced analysis techniques employed in high energy physics, as well as his/her skills of working in a team.

CERN-5

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 January 2018**	Luca Fiorini (Univ. Valencia, CERN) Antonio De Maria (Univ. Gottingen, CERN)

Scientific program	Daily activity, skills required and to be acquired
"Study of the hadronic tau decays in the Higgs to tau tau channel" LHC data collected in run 2 ,about 50 fb-1, allows a detailed study of the Higgs properties. In particular the analysis of Higgs decays into tau-lepton pairs provides a unique opportunity to precisely measure the Higgs coupling to fermions which is a crucial test to confirm or disprove the Higgs of standard model, in the latter case opening a window to new physics. Especially in the hadronic tau decay channels analysis a very significant improvement was done in the tau identification efficiency and background rejection making the leptonic-hadronic tau pair final states the most promising channel for a precise Higgs to tau-pairs branching fraction measurement. New approaches are at work to disentangle the different particle contents in the hadronic tau jet decay. A better measurement of the hadronic tau kinematics (4-momentum) will largely improve the Higgs mass measurement with a consequence of a more effective rejection of the most important background in this channel: the Z-boson decays to tau pairs. The identification of single components contributing in the tau-hadronic jet, such as the pion and the rho particles, will allow the study of variables sensitive to the CP structure of the Higgs boson Yukawa couplings, to be compared with what already done in boson pair decays.	Month 1: learning data format and content of rootples to be used for the analysis, reproduce simple results to understand the context of the problem. Month 2: Studies of tau-jets from Higgs and Z decays at truth level (no detector effects) for signal and background processes Month 3: Include detector effects. Participation to the test beam activities of the ATLAS hadronic calorimeter, important for the hadronic tau measurement, is also foreseen. All activities will be conducted with the supervision of experts at CERN. The required skills are: basic knowledge of C++ programming language, use of a linux system and knowledge of the ROOT program. Basics of python programming language and bash scripting language would be a plus.

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Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 December 2017**	Riccardo Manzoni (Univ. Milano Bicocca) Sara Fiorendi (Univ. Milano Bicocca)

Scientific program	Daily activity, skills required and to be acquired
"Search for τ−>3μ decays from W-> τν events in CMS Run2 data " The Physics case: Lepton Flavor Violation in τ decays is a unique probe of new physics. The BR(τ−>3μ), vanishingly small in the Standard Model (SM), is predicted 10−10−10−8 , i.e. within the experimental sensitivity, in various SM extensions. The world limit, from Belle, is BR(τ−>3μ) <2.1 x10 -8@90%. The LHCb limit is BR(τ−>3μ) < 4.6 x 10-8. @90% CL, based on τ leptons from Heavy Flavor decays. τ's from W and Z decays, although less copious, can be more conveniently triggered by ATLAS and CMS. This project is a search for τ→ 3μ from W→τν decays in CMS Run2 data. A preliminary analysis of the CMS 2016 data has provided a promising limit motivating further studies in view of 2017-2018 higher statistics. The three-muon event selection and a dedicated trigger are crucial to evaluate the CMS competitiveness. This study is also relevant to reliably extrapolate the CMS sensitivity for HL-LHC. Selection optimization - Yield estimates: assuming the world limit, 16 W−> τ (3μ)ν events are expected in 40 fb-1 @ 13 TeV: the CMS acceptance is ~30% for three-muon events in the relevant η−pT region. - Dedicated trigger: a new optimized HLT trigger has been online in CMS since August 2017 -Offline analysis: a further optimization is based on : 1. muon identification and fake muon rejection through a through a BDT-based muon ID 2. W signature through missing ET 3. Global BDT optimization	The planned tasks are: 1. Adapt the muon-ID BDT optimized for Bd,s-> 2 μ to τ-> 3μ 2. Exploit the MVA MET resolution and its discriminating power 3. Select variables for global BDT and train it 4. Measure the trigger efficiency of 2017 data Daily interactions with muon and trigger experts at CERN to - check the certified collected data - address issues related to the muon topology of τ-> 3μ− (i.e three collimated muons, one soft muon) - address trigger issues (also at L1) The project requires knowledge of - python and C++ language . - MET algorithms - Machine Learning tools (BDT) At the end of the stage period, the candidate will: - strengthen his/her programming expertise - become familiar with muon reconstruction algorithms - learn how to perform an analysis optimization - understand the basis of the trigger implementation in a high-rate experiment

CERN-7

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017**	Marcello Maggi (INFN Bari)

Scientific program	Daily activity, skills required and to be acquired
"Constraints on the Higgs self-coupling at the LHC" The standard model (SM) of particle physics successfully describes the structure of matter in terms of elementary fermions and their interactions through gauge bosons. An important test of the SM will be a determination of the Higgs potential and in particular of the Higgs self-coupling. The trilinear self-coupling can be extracted from the measurement of a nonresonant Higgs-boson pair (HH) production. A direct measurement of the self-coupling will not be feasible and only the Higgs decay channels with the highest branching ratios were used to set upper limits on the HH cross section until now. In this project we intend to study the double Higgs production in the final states bbZZ*, profiting from the expertise at CERN on the ZZ* and the HH analyses; the interaction with the theorists from the LHC Higgs Cross section group at CERN, experts of the calculation of the double Higgs production cross section, will be also fundamental. Resonant states decaying into two Higgs bosons give identical signatures. Such heavy resonant states are predicted in beyond the SM (BSM) theories, like radions or excitations of the graviton in the Randall-Sundrum model. The analysis will be then extended to search for such BSM heavy states.	**Daily activity:** The activity would consists of a feasibility study of the HH bbZZ* channel reconstruction in the final with four leptons in the final state and two b-jets. The student would develop a cut-based analysis involving the most relevant physics observables. Monte Carlo simulation of the events would be needed, together with a deep study of the double Higgs production cross section. The analysis would require the study of the reconstruction of leptons and b-jets and the evaluation of their performance by using real data collected by CMS in 2017. Required skills: basic programming skills (C++), basic experience with ROOT and CMS software, good background in particle physics and statistics. Acquired skills: ability to develop a full physics analysis exercise, ability to evaluate the sensitivity of a search and perform a statistical analysis, interaction with theorists from the LHC Higgs XS WG.

CERN-8

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 - 15 December 2017**	Gianluca Lamanna (INFN Pisa), Riccardo Fantechi (INFN Pisa)

Scientific program	Daily activity, skills required and to be acquired
"Photon identification at NA62" The scientific activity will be performed within NA62, a ultra-high-intensity kaon-beam experiment operating at the CERN SPS. It will focus on the photon rejection in the analysis of K->pi nu nu decay. In particular, advanced methods for efficiency assessment will be developed, we plan to develop alternative methods to identify photon clusters in the electromagnetic calorimeter to crosscheck the veto performances of the detector. As a byproduct, the program will allow on the other side to optimize the selection of photon candidates for the study of other kaon decays with photons in the final state. We propose a search for axion like particles produced in special beam-dump runs and decaying in two photons which can reach new sensitivity and be a study in preparation for the NA62 activity after LS2.	The candidate is expected to be familiar with basic concepts of kinematics of particle decays and the working principle of high-energy-physics detectors: magnetic spectrometer, the energy deposit, electromagnetic and hadronic calorimeters, ring-imaging and differential Cherenkov counters. Basic knowledge of C++ is welcome. Under the day-by-day guidance of the reference researchers, he/she will develop and follow a programme to: i) precisely assess the performance of the calorimeter as a photon detector, comparing data and Montecarlo to study peculiar cases of photon configurations; ii) evaluate the efficiency of a simple algorithm for selection of ALPs decays with two photons in the final state; iii) evaluate the expected background from data side-bands and Monte Carlo. After a three- month experience, he/she will have gained familiarity with modern methods for efficiency evaluation, systematic error assessment and background evaluation.

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Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 30 March 2018**	Giacomo Fedi (INFN Pisa) Alessio Boletti (Univ. Padova)

Scientific program	Daily activity, skills required and to be acquired
"Search for New Physics in B meson decays with the CMS experiment at the LHC" As most of the phase space for direct searches for New Physics has been explored, it is becoming evident that one the best opportunity to look for it relies on precise measurement of sensitive observables in the physics of Bs mesons. In particular, the CP violating weak phase ϕs originates from the interference between direct Bs meson decays into a CP eigenstate and decays through Bs- Bs/bar mixing to the same final state. Its value being precisely predicted within the SM can be compared with the measured value: any deviation from the SM prediction might indicate a possible contribution of new particles to the loops describing the Bs mixing. The measurement is performed by fitting decay rates of $Bs \rightarrow J/\psi \phi$ decays as a function of proper decay time and angular variables, including the possible knowledge of the initial flavor (Bs or Bs/bar) of the meson, typically determined with either leptons from the 'other B' decay.	The proposed research will support the analysis in the following areas: development of an improved tagger using the jet charge; adapting the current fit model to the new data taking. In particular, the description of the proper time resolution with the new CMS pixel detector Required skills: experience of data analysis; experience with Monte Carlo and advanced statistical analysis techniques; good knowledge and experience of programming in C++; experience with Root and RooFit; ability to communicate complex information clearly; ability to work as part of a team.

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Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 - 15 December 2017**	Francesco Lo Sterzo (Academia Sinica Taiwan, CERN)

Scientific program	Daily activity, skills required and to be acquired
"Beauty from Higgs" Foreseen and discovered within High Energy Physics, the Higgs mechanism has not a clear role yet in our picture of the history of the Universe. For instance, the connection between the strength of the electroweak phase transition and the properties of the Higgs boson is still under study, mostly for regions of parameter space that can realize electroweak baryogenesis. Measuring and understanding Higgs couplings to Standard Model fermions is one of the most important activities in this respect and direct evidence for the coupling of the Higgs boson to τ-leptons and bottom quarks was properly celebrated as a major achievement by the ATLAS and CMS collaborations. Searches for Higgs decays into a bottom pair deal with large QCD backgrounds, usually suppressed by considering associated productions. Quite differently, the initial state radiation (ISR) may be exploited to select H(bbar) events already at trigger level, strongly reducing QCD contaminations. Further background reduction is achieved considering an high-pt recoiling H(bbar) reconstructed using dedicated techniques aimed at identifying hadronically-decaying heavy objects. The activity proposed here is to inclusively search for H(bbar) decays in association with ISR, learning from expert ATLAS scientists how to characterize the signal, model the background and compare findings with expectations.	C++ and python programming skills are required. Knowledge of basics of collider physics (Standard model processes, Higgs physics, kinematics) is required too. The student is expected to take part in the work in the hosting group, produce plots of the relevant kinematic distributions and report to the wider ATLAS analysis group.

CERN-11

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 December 2017**	Henry Bachacou (DAPNIA Saclay) Nello Bruscino (Univ. Bonn)

Scientific program	Daily activity, skills required and to be acquired
"Study of Yukava coupling of the Higgs boson with the top quark through the associated production of the Higgs boson with a pair of a top quark and anti-top(ttH) in final state with two same sign light leptons and a hadronic tau" Several aspects of the Higgs boson properties are still largely unexplored, most notably the coupling of the Higgs boson to quarks. The research project is focused on the study of Yukawa coupling of the Higgs boson with the top quark through the associated production of the Higgs boson with a pair of a top quark and anti-top, ttH in the the final state with two same sign light leptons and one tau decaying hadronically in the final state, which increases the channel sensitivity. After the pioneer work based on Run1 data based on cut flow analysis, the ATLAS experiment is analyzing the data collected in LHC Run2, expecting improved results. Few factors will contribute. The ttH process is the one that benefits the most from the increase of energy in the centre of mass energy, with a factor four versus a factor two for the other production modes. The higher statistics collected, together with improvements to the analysis strategy and the better understanding of the backgrounds will be another important element. The exploitation of multi-variate techniques, as Boosted Decision Trees, is a powerful tool to disentangle the signal from background, exploiting the information derived from the distributions of many variables, at same time. Its optimization relies on the identification the most discriminant variables to disentangle signal from the main backgrounds.	The thesis work will be focused on a new analysis method, the multivariate analysis, in particularly exploiting new kinematical and geometrical variables to separate efficiently signal from backgrounds. After to have established the best set of variables and settled the procedure, using MonteCarlo events, a comparison with data will be performed in control regions, poorer of signal. The following step will be use data driven method to evaluate fakes and some backgrounds. For the student will surely an enormous benefit from his/her permanence at CERN, allowing to contribute in more efficient way to data analysis, if the application will be accepted.

CERN-12

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**1 March 2018**	Michele Bianco (CERN) Marcello Maggi (INFN Bari)

Scientific program	Daily activity, skills required and to be acquired
"Fast Timing MPGD for Future Accelerators " Future Hadron Accelerators (e.g. FCC-hh) will operate at instantaneous luminosities of about one magnitude higher than the current LHC. The bunch crossing frequency of 40MHz is resulting in on average 1000 Pile-Up (PU) events or 200MHz, resulting in on average 200 PU events, comparable to the level of HL-LHC. To assign correctly the event to the right bunch crossing (BX) requires detectors to have a time resolution of the order of 1– 2 ns (40MHz) or <1ns (200MHz). The present Micro-Pattern Gaseous Detectors (MPGDs) are radiation hard detectors, capable of dealing with rates of several MHz/cm^2 , while exhibiting good spa al resolution (≤ 50 μm) and can be constructed with flexible geometries and the use of resistive materials can make them naturally spark protected. The current genera on of MPGDs has a good time resolution of 5–10 ns, which satisfies the current generation of experiments (HL-LHC upgrades of CMS and ATLAS) but is not sufficient for bunch crossing identification of fast timing systems at FCC-hh. The Fast Timing MPGD (FTM) project seeks to improve the time resolution with one or two orders of magnitude with respect to conventional MPGD detectors, aiming at a resolution of the order of 500 ps and reach ultimately 100 ps, maintaining all advantages such as high rate capability, high spatial resolution and radiation hardness.	Daily activity: The student will be involved in the GEM R&D activity at CERN. She/He will assist the construction of new MPGD prototypes in the CERN MPGD Lab and will test and characterize these prototypes with the X-ray setup at CERN, will adapt the prototypes to the experimental needs and will prepare the prototypes to be tested in test beam at CERN (SPS, H4) in May 2018. With the X-ray setup the induced signal will be studied along with the rate capability, while in test beam the efficiency and time and spatial resolution of the detector will be assessed. She/He will subsequently be involved in the analysis of the test beam data. 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 in lab; detector hardware problem solving skills; design and implementation of beam test setup (detectors and electronics); analysis of test beam data; work and collaborate in international scientific environment.

CERN-13

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 January 2018 – 15 March 2018**	Roberta Arcidiacono (Univ. Torino) Valentina Avati (AGH Univ.) Jonathan Hollar (LIP Lisbona)

Scientific program	Daily activity, skills required and to be acquired
"Commissioning and performance studies of the CT-PPS pixel tracker " The CMS-TOTEM Precision Proton Spectrometer (CT-PPS) aims at studying central exclusive production (CEP) at LHC, pp --> pXp, a process in which the protons lose a small fraction of their momentum and are measured in Roman Pot stations along the LHC beam-line. These reactions give access eg to the so-called anomalous quartic gauge couplings, to the proton structure and to QCD in conditions so far unexplored. Since the process is exclusive, the mass of the centrally produced system X can be determined with excellent precision from the momenta of the scattered protons, independently of the decay mode. CT-PPS consists of tracking and timing detectors. Two tracking stations of silicon 3D pixel planes have been installed in March 2017 and are successfully taking data. Because of the very high non-uniform irradiation, the detector packages will need to be replaced during the next winter technical stop and new modules are being prepared. The fellowship recipient will take part in the installation and commissioning of the new detector packages and in the data taking of CT-PPS. He/she will participate to the performance studies of the tracking detector, and, if he/she so desires, will join a physics analysis that uses the CT-PPS data.	The main activities will be: participation to the re-commissioning and operation of the CT-PPS pixel tracker after the LHC 2017-2018 winter technical stop; data analysis to understand the performance of the detector (eg tracking efficiency, backgrounds, correlations between tracking and timing detectors); participation to an analysis based on the data collected with CT-PPS. Requirements: knowledge of C++; basic knowledge of silicon tracking detectors; knowledge of the CMS software environment welcome. Acquired competences: experience with near-beam detectors; in-deep knowledge of pixel tracking detectors and their performance; fluency in the ROOT analysis package; familiarity with the physics of CEP and accelerator physics.

CERN-14

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 January 2018**	Henric Wilkens (CERN)

Scientific program	Daily activity, skills required and to be acquired
"Implementation of a new laser calibration method for the ATLAS Tile Calorimeter" The goal of this program is to update of the official laser calibration procedures of the ATLAS Tile hadron calorimeter by exploiting a new method. A down-drift with time of the response of PMTs reading the hadron calorimeter cells was observed in Tile calibrations and an accurate measurement of the laser calibration constants, corrected for the response drift, is essential for assuring the needed precision in measuring the calorimeter energy. The present laser calibration procedure assumes that systematic effects on the global PMT response can be controlled by normalization to non-drifting cells. The new method is based on the measurement of the PMT absolute gain using a statistical approach that correlates the responses of PMTs fed with laser pulses with the same optical path. The only and less stringent assumption of the new procedure, based on the producer experience, is that the PMT gain evolution of the less exposed cells entirely represents the PMT response variation with time. All corrections due to systematic effects are measured by comparing the evolutions of PMT gain with the global response in less exposed cells, and then applied to all cells. Aim of the project is to extensively test and deploy the new procedure. For each module, looking at the difference between the individual PMT signal and gain of less exposed cells, it is possible to extract the drift caused only by the optics and correct each PMT response for this drift.	Month 1: understanding of the calorimeter calibration procedures and absolute gain calculation with the statistical method Month 2: implementation of the new laser calibration procedure in the official ATLAS calibration repository Month 3: reprocessing of the laser calibration data and test of the new method. All activities will be conducted with the supervision of experts at CERN. The required skills are: basic knowledge of C++ programming language, use of a linux system and knowledge of the ROOT program. Basic knowledge of Python programming language and bash scripting language would be a plus.

CERN-15

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 15 January 2018**	Aberto Orso Maria Iorio (INFN Napoli) Jeremy Andrea (IPHC Strasbourg)

Scientific program	Daily activity, skills required and to be acquired
"Measurement of the CKM matrix elements in t single top events in CMS experiment at LHC" The program consists in an analysis of proton-proton collision data collected by the CMS experiment at the LHC during Run-II at the centre-of-mass energy of 13 TeV in order to measure the Cabibbo Kobayashi Maskawa matrix elements from the single-top quark production in the t-channel. The single-top quark t-channel process is the main electroweak mechanism for top quark production at the LHC, and is sensitive to new physics manifesting in the production vertex where a top quark and either a b,s, or d quark are coupled via electroweak flavor changing charged current. The candidate will take advantage of an already-existing data analysis and selection software developed with the top-quark analysis group, and will study event samples requiring one lepton, two or three jets, one or two of which being recognized as stemming from a b-quark hadronisation. The small contributions of single-top quarks coupling to d or s quarks manifest only in the channels with 1 b-jet. By measuring simultaneously the cross sections in channels with different multiplicity of b-jets it will be possible to add an interpretation of the measured cross section in terms of the different CKM matrix elements involved in the process.	The main activity will consist in exploiting the existing CMS analysis framework for single-top quark processes, in expanding the event selection to improve the coverage for the small signals sought for, and in adapting the fitting procedure to be sensitive to the signatures of different processes. An intense exchange with the CMS top quark community is foreseen, which will involve participating in person to discussions and working meetings. An expertise in the main programming languages used in the CMS software, i.e. C++ and python, is required, as well as proficiency with the ROOT package and the unix-linux working environment.

CERN-16

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 1 January 2018**	Maurizio Pierini (CERN)

Scientific program	Daily activity, skills required and to be acquired
"Study of jet substructure techniques with CMS data scouting and search for trijet resonances " LHC searches for hadronic resonances with sub-TeV masses are hindered by the high jet thresholds required to limit trigger rates. The novel CMS technique of "data scouting", based on online event reconstruction and small record sizes, is used to lower trigger thresholds and extend searches for new particles into hitherto unexplored regions. As an example, some new physics scenarios - called trijet resonance models - foresee the production of sub-TeV mass resonances (Res1) decaying to a quark/gluon and a second resonance (Res2) which, in turn, decays into two quarks/gluons. If Res2 is significantly lighter than Res1, Res2 is produced with large momentum, it's decays products are collimated and can be reconstructed in a single massive jet. Jet substructure techniques can be used to distinguish between the massive jet coming from Res2 decay (signal) and jets in QCD events originating from hadronization of single quarks/gluons (background). This research project aims at performing the first detailed study in CMS of jet substructure observables with data in "scouting" event format using the trijet resonances as a benchmark signal model. The goal is to measure the jet mass resolution/scale and the efficiency to identify massive jets in the online reconstruction, and compare with the offline reconstruction. These measurements will not only extend the discovery potential for new physics searches using scouting data, but could also be employed to improve the calibration of jet substructure observables at trigger level with positive impact on a wider set of analyses in CMS.	The selected candidate will analyze proton-proton collision data collected by CMS detector in 2016 and 2017. A good knowledge of the ROOT analysis framework and C++ programming language is required, together with a basic knowledge of jet clustering and jet grooming algorithms used at hadron colliders. Previous research experience in the CMS experiment is recommended. The candidate will acquire knowledge in advanced analysis methods, in jet substructure techniques, and in alternative procedures for the online selection of events (trigger) at hadron colliders, facing both instrumental and theoretical problems.

CERN-17

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**1 November 2017 – 30 April 2018**	Davide Boscherini (INFN Bologna) Alessandro Polini (INFN Bologna)

Scientific program	Daily activity, skills required and to be acquired
"Monitoring of the ATLAS RPC system" The ATLAS RPC system is finely monitored and controlled via its Detector Control System, which stores into the online database a large amount of data. The analysis of these data would allow to carry out very detailed detector studies. These data have a large potential to understand the detector status and study important aspects of RPC detector physics (working point, environmental conditions, ageing,...). This project aims at the analysis of a subset of relevant information extracted from the online archive. The analysis of the current time dependence of all the RPC gas volumes during the Argon-CO2-Argon gas transitions, will allow to check the gas flow over the entire RPC system and to spot the problematic regions which should be investigated and fixed to ensure their proper operation. Further studies of the gas volume currents (also across the years) during the luminosity runs will be possible.	RPC DCS information will be extracted from the online archive and analyzed using the ROOT package and shell scripting. The activity will consist in reading data from files, parsing text, producing distributions/correlations of the relevant variables. Familiarity with the Linux operating system and ROOT are required.

CERN-18

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 1 January 2018**	Valerio Dao (CERN) Carlo Pandini (Univ. Geneva)

Scientific program	Daily activity, skills required and to be acquired
"Physics modeling of pp→VH,H→b\bar{b}" Five years after the Higgs boson discovery, ATLAS and CMS reported this summer the first evidence at the LHC for the the Higgs boson decay in b-quarks. The coming years will be very important to exploit at best all the potentiality of this decay channel. Measurements of H→b\bar{b} produced in association with a vector boson V(W or Z) are already limited in precision by systematic uncertainties (~30%), especially the one due to the acceptance and modelling of the Standard Model pp→VH process (~17% in the ATLAS analysis). In this project we want to study in detail the modelling of the pp→VH process to reduce the impact of its uncertainties on future measurements. These studies will cover the needs for the future analysis of the pp→VH,H→b\bar{b}, with special attention to the needs for the measurement of the so called simplified template cross sections, which recently became one of the standard strategies in measuring the Higgs boson cross sections at the LHC. These studies will be done coherently with the plans and recommendations of the LHC Higgs Cross Section WG.	Month1: learning the existing tools/data format (i.e. Rivet, truth-DxAOD); getting familiar with the existing calculations/generators/tunes reproducing of one of the existing uncertainties for pp→VH,H→b\bar{b}. Month2: comparison of the variations to the signal prediction induced by PDF, by the electro-weak corrections, and by the neglected higher orders in αs and potential differences between NLO, MINLO and NNLOPS (if released by the authors). Month3: Detailed study to understand of the origin of the differences induced by the choice of parton shower - hadronization - underlying event algorithms and tunes in Pythia8 and Herwig7 by carefully inspecting the distribution of kinematic variables.

CERN-19

Hosting Laboratory	Available starting date	Contact person(s)
CERN	**15 November 2017 – 30 September 2018**	Andrea Triossi (CIEMAT)

Scientific program	Daily activity, skills required and to be acquired
"Trigger-less readout and data processing from a CMS Drift Tube chamber" Availability of low cost, high throughput optical links and the evolution of FPGA I/O capabilities and processing power brought a dramatic change in the data acquisition architectures and triggering models. On detector electronics can be reduced to the minimum required for digitization and time-stamping, data being then streamed in parallel to centralized units, with an asynchronous merging and processing. Such a solution relaxes triggering constraints, opening up to an unbiased continuous, realtime monitoring and reconstruction of physics quantities even before the event data are stored. Aiming to explore solutions for the LHC Phase 2 upgrade, a CMS Drift Tube spare chamber has been equipped with a prototypal readout chain, and is being operated at SX5 to demonstrate the effectiveness of the upgraded architecture, on a first instance by direct comparison with the legacy system by mimicking the original behavior. A further ongoing step foresees the integration with a CMS DAQ2 node prototype, which carries appropriate hardware interfaces to feed incoming streamed data to high level C++ processing code.	Having to deal with a working detector, most of the activity will focus on exercising the data taking (e.g. latencies measurements), defining performance indicators and evaluating different algorithms efficiencies through cosmic muons runs. Existing detector performance monitoring tools will have to be adapted or evolved accordingly, also through excerpts from the fast reconstruction software (e.g. the present CMS HLT). Hence knowledge of the CMSSW framework is recommended, as well as a general knowledge of the CMS data taking workflow and an awareness of the data acquisition system components.

FERMILAB–1

Hosting Laboratory	Available starting date	Contact person(s)
FERMILAB	**1 February 2018 - 31 March 2018**	Brendan Casey (Fermilab) Marco Incagli (INFN Pisa)

Scientific program	Daily activity, skills required and to be acquired
"The laser calibration system of the Muon g-2 experiment at Fermilab" The subject of this research program is the commissioning, operation and data analysis of the high-precision calibration system of the 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. Central to this is the laser calibration system, which will monitor the gain fluctuations of the calorimeter silicon photomultipliers (SiPM) at sub-permille accuracy. It consists of six lasers operated in pulsed mode (405 nm, 1000pJ / pulse, 10 kHz rate), whose pulse energy stability is measured with 6 "source monitors" that rely on 241Am source for absolute energy reference. The system includes also 24 "local monitors", where the stability of the laser light distribution is measured by comparing the laser light intensity delivered to the 24 calorimeter modules along the ring with the laser light intensity at the origin. The distribution system will be placed in a Laser Hut, close to the g-2 ring. The Muon g-2 experiment will start collecting data in mid-November 2017. The first 2 months will be spent to commission the detector, while in the 5 months January-May 2018 the experiment will collect a statistics which, assuming designed luminosity, will be equivalent to the one collected by the previous BNL experiment. The successful candidate will contribute to the commissioning and the operation of the laser calibration system and to the data analysis of the whole experiment, in particular the "wiggle plot" fit, which measures the precession frequency of the muon spin vector with respect to its momentum, and which requires a precise calibration of the calorimeter.	The program is a three-month stay at Fermilab, to be agreed in the time window from 1/2/18 to 30/6/18, during which the candidate will contribute to the commissioning of the laser calibration system, its data analysis and its operation. General confidence with particle detectors and skills towards hardware activities are prerequisites of this research program. At the end of the program the student will have the experience of participating in the realization and commissioning of a modern elementary particles experiment.

FERMILAB-2

Hosting Laboratory	Available starting date	Contact person(s)
FERMILAB	**1 January 2018 – 30 March 2018**	Pavel Murat (Fermilab)

Scientific program	Daily activity, skills required and to be acquired
"Study of radiative-pion-capture spectrum for the Mu2e experiment at Fermilab " The Mu2e experiment at Fermilab aims to discover the CLFV neutrino less muon conversion into an electron in the field of an Al nucleus, by improving of four orders of magnitude (6.7 ×10-17) the previous limit. The conversion's signature is a mono-energetic electron with an energy close to the muon rest mass. Momentum and energy of the conversion electrons are measured respectively by a straw-tube tracker and a pure CsI crystal calorimeter. The low-energy muon has a significant pion contamination. Pions can produce a high energy photon through radiative pion capture (RPC): $\pi^- + N \rightarrow \gamma + N^*$, with a kinematic endpoint near to the pion rest mass energy. If the photon then converts in the stopping material, an electron-positron pair is produced and, in case of an asymmetric conversion, the outgoing electron can be near the conversion energy, thus faking a conversion electron. The RPC energy spectrum in Aluminum has not been measured yet. We propose to study an algorithm to trigger and identify the RPC events when these photons do not convert in order to evaluate the calorimeter capability in determining the RPC energy spectrum. Simulation studies with the official Mu2e offline software will be performed to develop the algorithm and measure the spectrum.	Required knowledge: to have a reasonable knowledge of programming languages (C, C++) and Root package. Pre-existing "beginner" expertise in data analysis. Acquired knowledge: improved usage/learning of C++ language and Root package. Improved capability in data analysis. Learning of the Mu2e software, art framework and grid usage. Improved communication skills. Daily activity: creation of needed simulated samples, development of analysis code, attendance / report to weekly meetings (Calorimeter, Software, Mu2e- general).

KEK–1

Hosting Laboratory	Available starting date	Contact person(s)
KEK	**1 January 2018 – 30 April 2018**	Hiroyuki Nakayama (KEK) Katsuro Nakamura (KEK)

Scientific program	Daily activity, skills required and to be acquired
"Radiation monitoring and SuperKEKB interlock with Belle II diamonds " The program centers on the commissioning, initial operation, and data analysis of the Belle II diamond detectors. Conceptually, diamond sensors mirror solid-state ionization chambers, providing measurements of pA-nA currents proportional to the radiation dose rates. In Belle II, eight diamond sensors read out by purpose-built electronics are installed on the SuperKEKB beam-pipe to monitor the radiation field. The SuperKEKB electron- positron collider at KEK aims at an increase in luminosity that will provide the upgraded Belle II detector with 50 times more data than previous B-factory experiments. This positions Belle II at the intensity frontier in indirect searches for new laws of physics in the next decade. The "phase 2" (Feb to Jul 2018) commissioning of accelerator and detector is a crucial step towards this goal. A key task will be the characterization of the unprecedentedly harsh radiation environment in the vertex-detector volume. This will be achieved by the diamond detectors, which are essential in protecting Belle II by monitoring continuously instantaneous radiation dose-rates, collecting information on the integrated radiation doses close to the interaction region, and ultimately triggering SuperKEKB beam-abort in case of excessive losses.	Diamonds require calibrations with radioactive sources and in-situ monitoring of noise and pedestals during operations. The student will analyze the diamond data, correlate it with other detectors' and accelerator's data, and use them to track the sources of beam losses. The fluid experimental conditions associated with the commissioning and the need for close communication with other experts require presence on site. Required skills include basic knowledge of interactions of particles with matter; familiarity with standard lab equipment and with simple programming and data-analysis packages. The student applies these skills in a real research environment and gains insight in experimental HEP.

KEK-2

Hosting Laboratory	Available starting date	Contact person(s)
KEK	**1 November 2017 – 15 January 2018**	Alessandro Gaz (Nagoya Uni.) Koda Matsuoka (Nagoya Univ.)

Scientific program	Daily activity, skills required and to be acquired
"Commissioning of the TOP detector at Belle II with cosmic ray data " The Time Of Propagation (TOP) counter is a novel particle identification detector (PID) that will be devoted to efficient pion/kaon separation in the barrel region of the Belle II detector. The construction of the Belle II detector is almost complete, and since Summer 2017 the Global Cosmic Run has already started involving the Central Drift Chamber, the TOP counter, the Electromagnetic Calorimeter and the KLM (K0L and Muon) detector. For the TOP detector, this is the first opportunity to assess its performance, as precise tracking information is needed in order to compute a meaningful PID likelihood. While the basic functionality of the TOP counter has been established, most of the calibration work is yet to be done, particularly for what concerns the geometrical alignment and the channel-by-channel time calibration. For the latter, the laser calibration system developed by the INFN collaborators will be used and the results of the procedure will be validated using cosmic ray data. This activity will have a crucial importance, since in Spring 2018 the first e+e- collisions will be delivered by the SuperKEKB accelerator and the physics capabilities of the detector in realistic data taking conditions will have to be verified.	The student will join the TOP operations team at KEK and will learn how to setup and operate the system for the local calibration runs. He will then participate in the analysis of the data collected with the local calibration and global cosmic runs. The student will be assisted by the other members of the TOP group located at KEK and in other countries, we will work together to validate and optimize the calibration procedures. The required skills are basic knowledge of the UNIX operating system and some familiarity with NIM hardware. Some experience with the ROOT analysis software is desirable. A program of study in experimental high energy physics is preferred.

BEPC-1

Hosting Laboratory	Available starting date	Contact person(s)
BEPC	**1 March 2018 – 15 September 2018**	Rinaldo Baldini (INFN Frascati) Lia Lavezzi (Univ. Torino)

Scientific program	Daily activity, skills required and to be acquired
"CGEM-IT assembly, quality control, installation and commissioning" The CGEM-IT is the new tracker that will replace the inner drift chamber of the BESIII experiment, carried out at BEPCII in Beijing. The system is composed of three cylindrical GEM (Gas Electron Multiplier) detectors with analog readout. The detector is expected to be installed during the 2018 upgrade and is currently under production at INFN. For mechanical safety, each detector layer, the supporting structure, the electronics and the cables will be shipped independently, and the final assembly and tests will be performed on site at IHEP. Once arrived, each part must be individually tested and mechanically assembled. The CGEM-IT will be equipped with the frontend electronics, the heat exchangers, signal and high-voltage cables. Then, each layer will be tested with a radioactive source in order to assure the quality of the assembled detector. Once the full CGEM-IT is assembled, cosmics data will be taken to test the full readout chain. Once the detector is installed into BESIII, the commissioning stage will bring the CGEM-IT to be fully operational and integrated with the experiment. Cosmic data will be taken, with the entire spectrometer, in order to start the detector alignment and calibration, and to evaluate its performance.	Depending on the period of availability of the candidate the tasks may include: setup of the lab, assembly of the detector, quality control test and data analysis, installation and commissioning of the CGEM-IT. Required Skills (at basic level) Knowledge of: Laboratory Instrumentation, Measurement Techniques, Remote Control, Applied Physics, Particle detector operation. Knowledge of Labview, analysis software (ROOT) and/or MPGD is a plus. Training Value: The student will work in an international collaboration, gaining experience in particle detector readout systems, from the physics to the data acquisition systems. He/she will have access to high- end instrumentation to perform his/her studies.

PSI–1

Hosting Laboratory	Available starting date	Contact person(s)
PSI	**15 November 2017**	Stefan Ritt (PSI)

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 μ→eγ 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 backgournd suppression of 7 order of magnitudes. In this fall MEG II will run a combined data acquisition with the LXe calorimeter to measure the γ 4-momenta and a highly segmented scintillation device for the positron time of flight (Timing Counter). The trigger for the physics run is based on the selection of a high energy gamma in the calorimeter which is in time with a positron in the Timing Counter (TC). 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 for single detectors runs but this is the first attempt to use complex LXe-TC correlation triggers. This is an unique opportunity to put hands on the TDAQ system of the experiment and and contribute to the development of the methods that will e adapted in the MEG II physics run. In January the candidate will also critically analyze the and propose improvements.	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 on 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.