ISTITUTO NAZIONALE DI FISICA NUCLEARE

Announcement n. 26407

DOE-INFN Summer Students Exchange Program 2024 Edition

The US Department of Energy (DOE) and the Istituto Nazionale di Fisica Nucleare of Italy (INFN) announce the 2024 edition of the Summer Exchange Program dedicated to promote the exchange of students in science between the two countries.

INFN (http://www.infn.it) is one of the leading organization worldwide promoting basic scientific research and has tight connections with DOE activities in many areas of interest: Particle Physics, Astroparticle Physics, Nuclear Physics, Theoretical Physics and Detector Physics.

We call for applications of US students willing to join a INFN research team in Italy for a two-month period between June 1st and October 31st, 2024.

There are 11 positions available. Applicants can choose among 15 different INFN sites and 49 research projects.

Grants amount to €6.000,00 to cover travel and living expenses.

To qualify for the fellowship, it is mandatory, that each university student to undertake an insurance policy, at their own expense, covering medical, assistance, accident and illness expenses for the duration of the fellowship.

Eligible candidates must be enrolled as students at a US university and they must have begun, at the time of application, at least the third year of a US University curriculum in physics, engineering or computing science, or planning to start the third year in 2024.

Applications, in electronic form, must be sent to INFN not later than March 3rd,, 2024 (11.59 pm CET) through the website: https://reclutamento.dsi.infn.it/.

The application should include:

- a short CV following the template provided in the recruitment site, describing the applicant's academic and research experience. Only PDF files will be accepted.
- a list of the University courses and scores. Only PDF files will be accepted.
- the three preferred INFN sites and the research projects chosen among those listed in the Annex I.
- the motivation for applying to this program and a statement on research interests, specifying and justifying the selected projects.

Candidates will be excluded from participation in this call if they submit their application later than the indicated deadline.

Incomplete applications (lack of information or missing files) will not be considered.

Direzione Risorse Umane

Selection of participants will be carried out by the Selection Committee which will establish the evaluation criteria before having seen the applicant's documentation.

The selection of the candidates will be based on:
- the statement on research interests;
- the curriculum vitae and studiorum.

At the end of the selection process, the results of the selection will be published on the INFN website (Job Opportunities – Details of the announcement). Successful candidates will then receive an official communication from the INFN administration Offices.

Selected students are also requested to send their official University transcript by e-mail (digital scanned copy) before accepting the appointment with INFN.

Since September 2010, citizens of countries like US may enter Italy for a period of up to 90 days without a visa, to take part in the exchange program (please check here http://vistoperitalia.esteri.it/home/en).

Rome, 12th February 2024

ISTITUTO NAZIONALE DI FISICA NUCLEARE
Il PRESIDENTE
(Prof. Antonio Zoccoli)[1]

RC/ADV

[1] Documento informatico firmato digitalmente ai sensi della legge 241/90 art. 15 c 2, del testo unico D.P.R. 28 dicembre 2000, n. 445, del D.Lgs. 7 marzo 2005, n. 82, e norme collegate, il quale sostituisce il testo cartaceo e la firma autografa

ANNEX 1

INFN Sections and Laboratories	Research Projects
1.Bari	1. Fermi-LAT - Gamma-ray analysis of transient sources at high energies
1.Bari	2. R&D activities for gamma-ray instruments - Characterization of a prototype detector for MeV gamma-rays
1.Bari	3. R&D activities for very high energy gamma-ray astronomy - calibration studies for the frontend electronics of the prototype Schwarzschild Couder Telescope for CTA
1.Bari	4. LHCb - Search for the flavour partners of the X(3872) meson
2. Bologna	5. DUNE - Construction and tests of a prototype for the tracking system at the DUNE Near Detector Complex
2. Bologna	6. ATLAS - Building the next generation tracker for the ATLAS experiment upgrade at LHC
2. Bologna	7. EIC - Development of modern and fast analysis tools to reconstruct the dRICH beam test data
3. Cagliari	8. CMS - Higgs searches with the CMS experiment at CERN
3. Cagliari	9. LHCbHeavyIon - Studies of Heavy Nuclei collisions at LHCb
4. Ferrara	10. LHCb 1 - A hunt for exotic multiquarks with LHCb data
4. Ferrara	11. LHCb 2 - Parallel simulation of the propagation of optical photons with the NVIDIA ray-tracing software OptiX on GPU
4. Ferrara	12. LHCb 3 - The Ring Imaging Cherenkov (RICH) detector upgrade project of the LHCb experiment for the High-Luminosity LHC: R&D activities and characterization of fast-timing and radiation-hard single-photon detectors and electronics
4. Ferrara	13. Medipix/Timepix - Characterization of state-of-the-art hybrid pixel detectors for applications in fundamental physics, life sciences and outreach
4. Ferrara	14. DUNE - Cryogenic characterization of the Silicon Photomultipliers (SiPMs) sensors for the DUNE Far Detector experiment
4. Ferrara	15. BESIII - Precise charmonium measurement at BESIII
4. Ferrara	16. RD_FCC - uRWELL for muon detector development for muon detector of the IDEA spectrometer
5. Firenze	17. SQMS / SFT - Quantum algorithms and simulation methods for noisy intermediate-scale quantum processors
6. Genova	18. JLAB12-BDX - JLAB12-BDX detector prototype test
6. Genova	19. Phenomenology and ATLAS - Theoretical and Experimental Studies of Heavy Flavours at the LHC
6. Genova	20. ATLAS - Pixel Detector for the ATLAS Upgrade at HL-LHC
7. Lecce	21. DUNE - Test on prototypes of elements of the DUNE Near Detector
8. LNF	22. MU2E - Calibration of the Mu2e calorimeter
8. LNF	23. ALICE - Tuning of NΩ meson-exchange model potential with femtoscopy data from LHC by ALICE.
8. LNF	24. Belle II - Optimization of *KL* reconstruction and identification in Belle2 with Machine Learning techniques.
8. LNF	25. LHCb - Search for New Physics in semileptonic decays of the B_s meson
8. LNF	26. EXOTIC ATOMS MEASUREMENTS AT THE DAFNE COLLIDER - Kaonic atoms measurements with SIDDHARTA-2 experiment at the DAFNE collider: a strangeness adventure!
8. LNF	27. QUANTUM FOUNDATIONS: experimental tests of Quantum Gravity (via the Pauli Exclusion principle) and of quantum collapse models - The Schrödinger cat is meowing: testing Quantum Foundations within the VIP experiment. Search for violation of the Pauli Exclusion principle and gravity related collapse models
8. LNF	28. a-C COATINGS FOR EIC - SEY investigation of a-C coatings
8. LNF	29. ELECTRONS TO CURE MIRROR CHARGING - Determination of Surface Charging/Discharging Conditions by Secondary Electron Yield Investigations
8. LNF	30. PADME - Search of dark matter signals in positron-electron annihilations
8. LNF	31. ANALYSIS IN THE H-> ZZ*-> 4l DECAY CHANNEL - Study of the Higgs Boson properties in the H->ZZ*->4l decay channel using early Run 3 data collected by the ATLAS detector at LHC
8. LNF	32. CYGNO - CYGNO Dark Matter and Solar neutrino research

9. LNGS	33. LUNA 2 - Commissioning and characterization of the setup for the study of the 12C+12C process inside the LNGS underground laboratory.
9. LNGS	34. LUNA 1 - Test beam for the study of the 12C+12C process inside the LNGS underground laboratory.
10. Napoli	35. DarkSide - Characterization of SiPM based Photon Detection Modules for the DarkSide Prototype
10. Napoli	36. DUNE - Test of DUNE Vertical Drift Optical Module in Liquid Argon
11. Padova	37. SWGO - Deep learning optimization of SWGO Gamma Ray Observatory
11. Padova	38. QUAX - Dark Matter Search: Axion Haloscope
11. Padova	39. LUNA - Experimental design for Nuclear Astrophysics at LUNA
11. Padova	40. RD_Mucol - Jet reconstruction and identification at Muon Collider
11. Padova	41. LHCb 1 - Study of single photon timing resolution of photodetectors for LHCb RICH upgrade
11. Padova	42. LHCb 2 - Optimization of the measurement of the branching fraction for$\Lambda\Lambda BB \rightarrow \Lambda\Lambda c^{*}\ DDs^{(*)}$
11. Padova	43. MuOne - Analysis of the data collected with a MuOnE prototype
12. Perugia	44. FERMI-LAT - Application of machine learning methods on Fermi-LAT images.
13. Pisa	45. GW VIRGO-ET - Development of seismic attenuation systems for current and next-generation gravitational wave detectors
13. Pisa	46. Mu2e - Commissioning and Data Analisys of the Mu2e Calorimeter
14. Torino	47. PROGETTO - Silicon-tracker at the Muon collider experiment – Development and testing of LGAD silicon sensors
15. Trieste	48. BELLE II - Improving the photon-energy calibration for the Belle II detector
15. Trieste	49. ITS3 - 65 nm CMOS process MAPS detector characterization

1. BARI

1. Fermi-LAT

Title: Gamma-ray analysis of transient sources at high energies

Description: Gamma-ray emissions in our Universe are clear signatures of non-thermal and/or catastrophic events happening in or outside our Galaxy. The gamma-ray sky is in constant evolution, being characterized by a number of variable or transient sources, such as flaring Active Galactic Nuclei (AGN) or Gamma-ray Bursts (GRBs). In its almost 15 years of operation, the Large Area Telescope (LAT) onboard the Fermi satellite proved to be an ideal instrument to monitor the gamma-ray sky thanks to its high sensitivity and wide field of view. In this project, a selection of variable sources will be analyzed with Fermi-LAT data, in order to detect its gamma-ray emission and study the mechanisms originating this emission.

Activities: The student will learn how to analyze Fermi-LAT data using the tools *fermitools* and *fermipy*. The most important data products, such as light curves and spectra, will be obtained. A detailed study of the emission mechanisms will be conducted, in order to derive an interpretation model to study the origin of the gamma-ray emission.

Tutor: E. Bissaldi (elisabetta.bissaldi@ba.infn.it)

Activity period: June-July 2024

Local Secretariat: Sig. Antonio Silvestri - 0805442332 - (tonio.silvestri@ba.infn.it)

Other information:

1. BARI

2. R&D activities for gamma-ray instruments

Title: Characterization of a prototype detector for MeV gamma-rays

Description: The MeV sky is poorly explored and at present there are no scientific missions dedicated to the study of the Universe in this energy band. Hence the necessity of a new satellite instrument optimized for the MeV energy range. In this project, a prototype of an active converter module for the detection of MeV gamma-rays will be characterized. The prototype is made of thin scintillator crystals coupled to WLS fibers readout by Silicon Photomultipliers. The design allows the photon conversion through Compton scattering and the measurement of position and energy of the recoil electron.

Activities: The student will study the prototype detector, focusing on the characterization of the photosensors (SiPMs) and of the readout electronics. The student will learn the basics of data acquisition systems, using different programming languages, such as *python* and *LabVIEW*. The student will characterize the detectors with a particular focus to the readout electronics.

Tutor (s):
M. N. Mazziotta (marionicola.mazziotta@ba.infn.it),
L. Di Venere (leonardo.divenere@ba.infn.it)

Activity period: June-July 2024 or September-October 2024

Local Secretariat: Sig. Antonio Silvestri - 0805442332 - (tonio.silvestri@ba.infn.it)

Other information:

1. BARI

3. R&D activities for very high energy gamma-ray astronomy

Title: calibration studies for the frontend electronics of the prototype Schwarzschild Couder Telescope for CTA

Description: The Schwarzschild-Couder Telescope (SCT) is a dual mirror telescope proposed for the Cherenkov Telescope Array (CTA) Observatory to detect very high energy astrophysical gamma rays. The design of the telescope is based on a dual mirror optics and a high resolution SiPM focal plane, which allow an increased sensitivity and angular resolution compared to similar single-mirror telescopes. A prototype (pSCT) is installed and being commissioned at the Fred Lawrence Whipple Observatory (FLWO) in Arizona, USA. An upgrade of the current camera is ongoing.

Activities: The student will learn the main functionalities of the frontend electronics (FEE) modules developed for the pSCT upgraded camera, based on the SMART ASIC, used for the SiPM signals preamplification, and the CTC and CT5TEA ASICs, for the signal digitization amd trigger generation respectively. The will learn the basic concepts of data acquisition systems, using different programming languages, such as *python* and *LabVIEW*. The student will perform the basic measurements for the FEE module calibration procedure, studying the FEE performance as a function of the operating temperature.

Tutor (s):
L. Di Venere (leonardo.divenere@ba.infn.it)
S. Loporchio (serena.loporchio@ba.infn.it)

Activity period: June-July 2024 or September-October 2024

Local Secretariat: Sig. Antonio Silvestri - 0805442332 - (tonio.silvestri@ba.infn.it)

Other information:

1. BARI

4. LHCb

Title: Search for the flavour partners of the X(3872) meson

Description:
After 20 years the nature of the X(3872) is still unclear. Its properties challenge the potential models of the charmonium states and many authors have suggested that the X(3872) might be a 4 quark state. A neat prediction of such scenario is the existence of flavour partners as for the conventional hadrons. The student will look for charged and strange partners of the X(3872) by analysing data collected by the LHCb experiment.
The project demands good analytical and programming (C++, root, Python, or similar) skills.

Further readings:
https://cerncourier.com/a/tetraquarks-back-in-the-spotlight/
https://lhcb-outreach.web.cern.ch/2020/05/28/more-on-χc13872-puzzle/

Tutor: Marco Pappagallo

Activity period:
June-July (recommended)
September-October

Local Secretariat: Sig. Antonio Silvestri - +39 805442332 - (tonio.silvestri@ba.infn.it)

Other information:

https://www.ba.infn.it/eng/

https://www.viaggiareinpuglia.it/en/homepage

2. BOLOGNA

5. DUNE

Title: Construction and tests of a prototype for the tracking system at the DUNE Near Detector Complex

Description: The student will participate in the integration and tests of a drift detector prototype being developed for the tracking system of the SAND detector at the DUNE Near detector complex.

Tutor: Sergio Bertolucci, Michele Pozzato, Gabriele Sirri

Activity period: June-July 2024

Local Secretariat: Elena Amadei (elena.amadei@bo.infn.it)

Other information: The activity will be carried out at INFN-Bologna and at INFN-LNF (in case of a test beam at the Frascati Beam Test Facility)

2. BOLOGNA

6. ATLAS

Title: Building the next generation tracker for the ATLAS experiment upgrade at LHC

Description:
The primary goal of this summer internship program is to engage a student in hands-on research related to the testing and characterization of pixel modules for the ATLAS Inner Tracker (ITk) project. The ATLAS ITk is a crucial component of the ATLAS detector at CERN, designed to improve the precision of tracking and vertexing, enabling the exploration of new physics at the High-Luminosity Large Hadron Collider (HL-LHC).
The Italian community is responsible for the construction of one of the two End Caps, composed of thousands of silicon pixel modules. In close collaboration with the other Italian and international groups involved in the project, the Bologna group is responsible for testing the pixel modules and readout software development.

This internship program provides a unique opportunity for the student to gain practical experience in cutting-edge research within the field of particle physics while contributing to the advancement of the ATLAS ITk project

Requirements:

- Interest in experimental high-energy physics and detector technologies.
- Basic knowledge of particle physics and semiconductor detectors.
- Proficiency in programming languages (e.g., Python, C++) is advantageous.
- Strong communication and interpersonal skills.

Activities:

- Summarize the current state-of-the-art in ITk pixel module testing
- Gain hands-on experience with the tools and instrumentation used for pixel module testing in the Bologna laboratory at the ATLAS experiment.
- Collaborate with local researchers and technicians to understand the testing and readout setup.
- Participate in the collection of data from pixel modules using the established testing procedures.
- Develop skills in data analysis using software tools
- Contribute to readout development
- Evaluate the performance of pixel modules by analyzing data on parameters such as noise, efficiency, and response uniformity.
- Contribute to the development of metrics for assessing the quality of pixel modules.
- Work closely with the team to identify and troubleshoot issues that may arise during testing.
- Propose and implement optimization strategies to enhance the efficiency and reliability of the testing process.
- Maintain detailed records of experimental procedures, observations, and results.
- Prepare regular progress reports and a final research summary highlighting key findings, challenges encountered, and recommendations for future work.
- Actively participate in group meetings, presenting findings and seeking feedback.

- Collaborate with team members and contribute to a positive and inclusive research environment.

Tutor: Antonio Sidoti (antonio.sidoti@bo.infn.it) Giuseppe Carratta (giuseppe.carratta@bo.infn.it)

Activity period: 2 months September-October 2024

Local Secretariat: Elena Amadei (elena.amadei@bo.infn.it) Barbara Simoni (barbara.simoni@bo.infn.it)

Other information: The activity will be carried out in the INFN-Bologna laboratories (including clean room, silicon labs) after the Summer closure period
Local web page: https://www.bo.infn.it/

2. BOLOGNA

7. EIC

Title: Development of modern and fast analysis tools to reconstruct the dRICH beam test data

Description: During the year 2023 a large-area SiPM-based photodetector readout plane for the EIC ePIC-dRICH detector prototype has been developed and constructed. The prototype readout photodetector surface was equipped with a complete readout chain of electronics and successfully collected data in October 2023 with particle beams at the CERN-PS T10 test beam facility.
A large set of data from the October 2023 beam test is already available for analysis of the various aspects of the performance of the detector prototype and more data will be collected in two new beam tests expected in the Spring and Fall of 2024, respectively.
Current efforts in the analysis of the beam test data foresee to include both the use of classical pattern recognition and reconstruction algorithms (ie. Hough transformation for ring detection) and the use of more modern strategies exploiting artificial intelligence with the application of deep machine learning approaches.
The person joining this project will actively take part in the development of software algorithms for the analysis of the already existing beam test data. The focus will be on the development of modern algorithms that can provide a fast reconstruction of the data of the detector and that can be utilized in the future beam test to provide online feedback on the data taking. The person joining the project will explore the use of machine learning algorithms for RICH data reconstruction as well as making use of modern computing strategies based on parallelisation paradigms to exploit GPU acceleration.
Moreover, the person joining this project will participate in the hardware activities for the preparation of the SiPM readout and electronics for the dRICH prototype beam test expected to happen in Fall 2023. The hardware preparation activities and the understanding of the various aspects and components of the SiPM readout prototype will be important for the development of the reconstruction tools, for the global involvement of the person joining the project in the activities of the EIC group in Bologna and for the overall success of the dRICH beam test.
Depending on the actual dates, the person joining this project might also have the possibility to directly participate in the data-taking operations of the dRICH detector at CERN-PS.

Activities: Data analysis of the EIC ePIC-dRICH SiPM prototype. Development of machine learning algorithms for RICH data reconstruction, parallelisation and exploitation of GPU acceleration. Preparation of the hardware of the SiPM readout electronics for the dRICH beam test.

Tutor: Roberto Preghenella

Activity period: June-July or September-October

Local Secretariat: Elena Amadei (elena.amadei@bo.infn.infn.it)

Other information: The activity will be carried out in the INFN-Bologna laboratories either before or after the Summer closure period.

3. CAGLIARI

8. CMS

Title: Higgs searches with the CMS experiment at CERN

Description: -CMS is a multipurpose particle detector installed along the Large Hadron Collider at the CERN laboratories in Geneva. Since 2016 it recorded data from proton proton collisions at center of mass energy of 13 TeV. Analysing this data will provide a better understanding of the Higgs boson, a particle discovered in 2012 [1]. Data observations deviating from theoretical predictions would lead to insights of new physics. An important part of the study of the Higgs boson is to determine whether it decays into quarks of the second generation, question still unanswered [2]. These decays are predicted to happen very rarely. The most promising channel to study them is the Higgs decay into charm quarks. CMS has already analysed the data collected during Run2 [3]. The candidate will analyse the large dataset of 137 fb-1 collected by CMS during Run2 and beginning of Run 3 (2016, 2017, 2018, 2023). In this context they will collaborate with international experts from institutes of the CMS collaboration. The candidate will focus their research on the Higgs decay into charm quarks using VBF production mode. They will analyse CMS data learning how to use and optimise the most recent data analysis techniques and the latest machine learning and computing tools.
References:
[1] CMS Collaboration. "Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC." PLB 716 (2012) 30. CDS record: http://cds.cern.ch/record/1471016
[2] CMS Collaboration. "Combined measurements of Higgs boson couplings in proton-proton collisions at sqrt(s) = 13 TeV. EPJC 79 (2019) 421. CDS record: https://cds.cern.ch/record/2640611
[3] CMS Collaboration. “Search for Higgs boson decay to a charm quark-antiquark pair in proton-proton collisions at sqrt(s)=13 TeV”. Accepted for publicatino by PRL. CMS-HIG-21-008, CERN-EP-2022-0811. arXiv:2205.05550. CDS record: https://cds.cern.ch/record/2809290

Tutor: Pierluigi Bortignon

Activity period: 5th September – 31th October

Local Secretariat:
Maria Grazia Dessi (Administration Office)
Maria Assunta Lecca (Personnel Office)
Phone +39-06-675 4985, 4901

Other information:
The INFN CA site will be closed around August 5th-25th 2024.
More information on accomodation can be found on the website dedicated to the project at www.ca.infn.it .

3. CAGLIARI

9. LHCbHeavyIon

Title: Studies of Heavy Nuclei collisions at LHCb

Description: LHCb is one of the four LHC experiments which started operations in 2010 and it has collected more than 10 fb-1 of pp collision data at several centre of mass energies. In addition to the pp run, LHCb has also operated during the LHC Heavy Ion run and has collected data both in pPb and PbPb collisions, the latter since 2015. It does as well run an innovative fixed target program recording collisions of proton and lead with noble gases like Argon, Neon, Helium. With its forward geometry optimised for the study of heavy-flavor production and decay, LHCb is an ideal position to complement the Quark Gluon Plasma studies performed in ALICE, ATLAS and CMS in this area. The candidate will be involved in the activities of the group with a truly international composition. She/he will prevalently study the production of quarkonia and open charm in the PbPb,pPb and p-GAS samples collected between 2016 and 2023, and could be involved in collectivity studies in these samples. The candidate will optimise the extraction of the signal yields and will correct it for the efficiencies she/he measured in the dedicated Monte Carlo samples. The ratio of different states could also be measured, which would gives crucial indications on the formation of Quark Gluon Plasma.

Tutor: Giulia Manca (giulia.manca@cern.ch)

Activity period: *June 1st - August 4th or September 5th - October 31st 2024.*

Local Secretariat:
Maria Grazia Dessi (Administration Office)
Maria Assunta Lecca (Personnel Office)
Phone +39-06-675 4985, 4901

Other information:
The INFN CA site will be closed around August 5th-25th 2024.
More information on accomodation can be found on the website dedicated to the project at www.ca.infn.it .

4. FERRARA

10. LHCb 1

Title: A hunt for exotic multiquarks with LHCb data

Description: Since the first observation of the X(3872) state in 2003, physicists have started studying a new class of particles called "exotic", due to the fact that they do not fit within the expected pattern and present unusual properties. It is believed now that exotic particles are composed by four (tetraquarks) or five (pentaquarks) valence quarks/antiquarks. Many experiments have reported the observation of dozens of new exotic hadrons in the past 20 years, and many more are expected to exist. The LHCb experiment at CERN has observed 21 new such states and it is today one of the major players in the field of exotic spectroscopy. The Ferrara group is involved in a search for exotic particles contributing to the process $pp \rightarrow J/\psi\ \pi\ \pi\ \gamma$. To improve the mass resolution and remove combinatorial background, the photon is selected through its conversion to an electron-positron pair after having interacted with the detector materials.

Activities: The candidate will learn the statistical and computational tools used in High Energy Physics data analysis. They work with experts in the field of exotic spectroscopy to train and test multivariate machine learning algorithms and develop part of the analysis code to search for new exotic particles in the process $pp \rightarrow J/\psi\ \pi\ \pi\ \gamma$.

Tutor: Lorenzo Capriotti (lorenzo.capriotti@fe.infn.it)
Giovanni Cavallero (giovanni.cavallero@cern.ch)

Activity period: Both periods (June-July or September-October) are available.

Local Secretariat: Paola Fabbri, phone +39-0532-974280, email: paola@fe.infn.it

Other information: The department is closed in August, usually in the week of August 15th. Cheap accommodation available in town or in the University guest house.
Local web-page: http://www.fe.infn.it/doe

4. FERRARA

11. LHCb 2

Title: Parallel simulation of the propagation of optical photons with the NVIDIA ray-tracing software OptiX on GPU

Description: The analysis of optical photons is crucial in the technological development of various particle detectors in many different contexts such as high energy physics, neutrino physics or medical imaging. The simulation of those processes is today one of the most critical steps in terms of time and resources necessary. In the LHCb Ring-Imaging Cherenkov (RICH) detector, a single charged particle can generate up to O(1000) Cherenkov photons, which must be transported individually within the material volume before they reach the PMTs and are converted into a signal. A possible solution to this problem lies in a massive parallelisation of the photon transportation. The library Opticks allows to interface the Geant4 simulation software, widely used in high energy physics, with the NVIDIA ray-tracing software OptiX running on GPUs with RTX platform.

Activities: The canjdidate will learn the basics of CUDA programming and study the performances of simulations generated with Geant4 and OptiX.

Tutor: Lorenzo Capriotti (lorenzo.capriotti@fe.infn.it)

Activity period: Both periods (June-July or September-October) are available.

Local Secretariat: Paola Fabbri, phone +39-0532-974280, email: paola@fe.infn.it

Other information: The department is closed in August, usually in the week of August 15th. Cheap accommodation available in town or in the University guest house.
Local web-page: http://www.fe.infn.it/doe

4. FERRARA

12. LHCb 3

Title: The Ring Imaging Cherenkov (RICH) detector upgrade project of the LHCb experiment for the High-Luminosity LHC: R&D activities and characterization of fast-timing and radiation-hard single-photon detectors and electronics

Description*:* LHCb is one of the main experiments at the Large Hadron Collider (LHC) accelerator at CERN. Its primary goal is to study with high accuracy b and c quark decays to improve the knowledge of the Standard Model or to reveal the contributions of New Physics to the decay processes. One of the main features of the LHCb experiment is the capability to identify the particles produced in the final state. Several detectors are dedicated to this purpose. In particular the separation between pions, kaons and protons is provided by two Cherenkov imaging detectors (RICH-1 and RICH-2). The identification of muon particles is performed using a dedicated (Muon) detector. LHCb has upgraded many of its sub-detectors and the entire read-out and data acquisition chain during the Long Shutdown 2 (2019-2022), to cope with a five-fold increase in the instantaneous luminosity. LHCb is also proposing a new upgrade to take full advantage of the flavour physics opportunities at the High-Luminosity LHC, operating (a decade from now) with a ten-fold increase in instantaneous luminosity compared to the current one ($1\text{-}2\times10^{34}$ $cm^{-2}s^{-1}$). The design of a very challenging RICH detector is being evaluated by the Collaboration and dedicated R&Ds have started, focused on high granularity single-photon detectors with excellent timing resolution (few tens of ps) and fast read-out electronics with time-stamping capabilities. This effort is also promoted in the recommendations 1 and 3 of the 2023 Particle Physics Project Prioritization Panel (P5). P5 recommend the investment and the support of the DOE at the ongoing experiments at High-Luminosity LHC such as LHCb.

Activities: The student, joining the Ferrara group in Summer 2024, will have the opportunity to participate to the different R&D activities: test and characterization of novel fast-timing single-photon detectors; test and characterization of front-end electronics; detector simulations.

Tutor: Massimiliano Fiorini (fiorini@fe.infn.it), Marco Guarise (guarise@fe.infn.it)

Activity period: June-July 2024

Local Secretariat: Paola Fabbri, phone +39-0532-974280, email: paola@fe.infn.it

Other information*:* Cheap accommodation available in town or in the University guest house. Local web-page: http://www.fe.infn.it/doe

4. FERRARA

13. Medipix/Timepix

Title: Characterization of state-of-the-art hybrid pixel detectors for applications in fundamental physics, life sciences and outreach

Description: The Medipix Collaboration at CERN designed and produced the first Medipix chip in 1998. This Application Specific Integrated Circuit (ASIC) was aimed at providing noise-free particle imaging by incorporating a counter on each pixel and combining the sensitive pixel matrix with a shutter-based camera-type of read-out. Since then, the Medipix family of pixel detector readout chips has grown in size and complexity, reaching the fourth generation with the Medipix4 Collaboration. The aim of the Medipix4 Collaboration, launched in 2016, is the design of two ASICs: Timepix4, which provides particle detection with excellent spatial and timing precision at high rates, and Medipix4, that targets spectroscopic X-ray imaging at rates compatible with medical CT scans. These ASICs are designed to be fully prepared for Through-Silicon Via (TSV) processing and may be tiled on all four sides, enabling large area detectors.
The Ferrara group is developing a new kind of hybrid photodetector based on a vacuum tube encompassing a photocatode, a microchannel plate and the Timepix4 ASIC. This detector will be used both in particle physics and in life science applications. Within this project, funded by the European Research Council, the group is carrying out activities related to the Timepix4 characterization. Among those: detector performance tests; measurement of time, position and energy resolutions; pixel calibration as a function of the energy; characterization of the Timepix4 analog front-end and digital signal processing electronics chain.
Moreover, the Ferrara group is also developing a custom data acquisition system, including an FPGA-based board and a software framework for the Timepix4 configuration and data acquisition.

Activities: The student, joining the Ferrara group in Summer 2024, will have the opportunity to participate to the different R&D activities: test and characterization of novel pixel detectors based on the Timepix4 ASIC bump-bonded to Silicon sensors; test and characterization of front-end electronics and data acquisition system; imaging for medical physics applications and outreach activities

Tutors: Massimiliano Fiorini (fiorini@fe.infn.it), Paolo Cardarelli (cardarelli@fe.infn.it), Nicolò Biesuz (biesuz@fe.infn.it), Riccardo Bolzonella (rbolzonella@fe.infn.it)

Activity period: June-July 2024

Local Secretariat: Paola Fabbri, phone +39-0532-974280, email: paola@fe.infn.it

Other information: Cheap accommodation available in town or in the University guest house.
Local web-page: http://www.fe.infn.it/doe

4. FERRARA

14. DUNE

Title: Cryogenic characterization of the Silicon Photomultipliers (SiPMs) sensors for the DUNE Far Detector experiment

Description: The Deep Underground Neutrino Experiment (DUNE) is an international experiment for neutrino science that will use different neutrino detectors placed in the world's most intense neutrino beam. DUNE first phase program and R&D for upgrades represent one of the major suggestions of the 2023 Particle Physics Project Prioritization Panel (P5) about the recommendations at the DOE for the future program of particle physics. A complex of detectors (SAND, ND-LAr, ND-GAr) will measure the neutrino parameters in the proximity of the source of the neutrino beam, at the Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois. A second, much larger, detector will be installed more than a kilometer underground at the Sanford Underground Research (SURF) Laboratory in Lead, South Dakota, at a distance of about 800 miles from the source. The main goal of DUNE is the investigation of neutrino oscillations to test Charge-Parity (CP) violation in the lepton sector, which is a key factor in the comprehension of why the Universe is made of matter. The DUNE Far Detector (FD) modules will be a liquid Argon Time Projection Chamber (LArTPC) with a total volume of 70-kilotons of liquid Argon located about 1 mile under the surface. This detector will take advantage of both charge and light signals coming from neutrino interaction in Argon. In particular, the light will be collected in opportune sub-modules called X-Arapuca and will be read by Silicon Photomultiplier detectors. The Ferrara University and INFN group is involved in the photodetection consortium of the FD and in particular we coordinate the quality assurance (QA) of the SiPM sensors that will be installed in the detector. We developed an ancillary system which is capable to test and characterize more that 100 sensors in a single measure. Furthermore our group is involved in the simulation and reconstruction working group of the SAND detector.

Activities: The student, joining the Ferrara group in Summer 2024, will have the opportunity to collaborate with the group and participate to the laboratory activities and to detector simulations and data analysis.

Tutor: Luca Tomassetti (tomassetti@fe.infn.it), Marco Guarise (marco.guarise@fe.infn.it)

***Activity period*:** June-July 2023

Local Secretariat: Paola Fabbri, phone +39-0532-974280, email: paola@fe.infn.it

Other information: Cheap accommodations are available in town. A Canteen and a lunch room are available in the University.

4. FERRARA

15. BESIII

Title: Precise charmonium measurement at BESIII

Description: The discovery of the charmonium spectrum, a system that resembled the hydrogen atom, but composed of quark-antiquark pairs, opened a new era in the study of hadron spectroscopy. In the past 40 years, many results have been achieved with incredible precision. Nevertheless, information for some states, like the singlet states eta_c and h_c, is sparse. BESIII has recently measured with high precision the radiative decay of h_c to eta_c, opening the opportunity to search for the EM Dalitz decay h_c → e+e- eta_c. These results, combined with the similar transition psi(2S)→ e+e- eta_c, can provide crucial information to our understanding of charmonium singlet states and to their transition form factor. The candidate will work with BESIII experts on the analysis code, studying the major source of background to finally observe the h_c → e+e- eta_c transition thanks to the recently collected 3B psi(2S) dataset.

Activities: The activities will be focus on the development of the analysis code, the study of the selection efficiencies and the background rejection. Study of the resolution will be performed, as well as check on the inclusive MC. Given the remaining time, possibility to look at few percent of data will be investigated. All the work will be performed inside the BESIII official software releases.

Tutor: Gianluigi Cibinetto, Marco Scodeggio, Isabella Garzia, Giulio Mezzadri

Activity period: June-July.

Local Secretariat: paola@fe.infn.it;

Other information: The department is closed in August, usually in the week of August 15. Ferrara has a large tradition of touristic city, so plenty of apartments are available, as well as some rooms from university dorm shall be available.

4. FERRARA

16. RD_FCC

Title: uRWELL for muon detector development for muon detector of the IDEA spectrometer

Description: *The IDEA detector is one of the proposed spectrometers for the Future Circular Collider, the CERN-based proposal for the future Higgs factory. Muons come from both the Higgs decay and from the Z boson in ZH production, so their reconstruction is crucial for the success of the FCC physics program. Moreover, the muon detector can play a crucial role in searching for Long-Lived Particles (LLP), a family of Beyond Standard Model particles that decays away from the interaction point. In IDEA, muon detectors are constituted by microRWELL detector, an innovative resistive Micro Pattern Gas Detector that provides high efficiency and resolution for the reconstruction of these particles. In Ferrara, the candidate will work on the uRWELL with experts both in hardware and software developments, to further increase the readiness of this technology for the FCC challenges.*

Activities: The activities will be discussed with the candidate based on the time of their arrival. Some hardware (test with planar uRWELL prototypes) and software (data analysis of test beam or cosmic data) are available. The candidate will work in C++, with ROOT software and/or with GEANT4.

Tutor: Gianluigi Cibinetto, Riccardo Farinelli, Isabella Garzia

Activity period: Both periods (June-July or September-October) are available.

Local Secretariat: paola@fe.infn.it;

Other information: The department is closed in August, usually in the week of August 15. Ferrara has a large tradition of touristic city, so plenty of apartments are available, as well as some rooms from university dorm shall be available.

5. FIRENZE

17. SQMS / SFT

Title: Quantum algorithms and simulation methods for noisy intermediate-scale quantum processors

Description: This activity sets in the framework of the DOE project "Superconducting Quantum Materials and Systems", to which INFN takes part as the only European partner. SQMS has two main goals: develop quantum devices based on a combination of superconducting RF cavities and trasmons, and develop detection technologies for quantum states of very-low energy for applications in experimental fundamental physics. The INFN – Sezione di Firenze takes part to the project contributing to the theoretical work of the "Algorithms and Simulation" thrust. In particular, the research group involved will study new quantum algorithms and quantum simulation methods, specifically designed for current noisy intermediate scale quantum processors. Researchers of the group have theoretical expertise on benchmarking and programming such processors, possibly with hybrid quantum-classical procedures. They have studied how to map relevant problems of practical interest, such as combinatorial optimization problems or problems arising in material science or chemistry, into operations that can be performed in superconducting gate-based quantum computers or (Gaussian) boson sampling devices. The student who will possibly join the group will study how to tackle the unavoidable noise of these devices and help improving the available algorithms using feedback from probabilistic quantum-measurement outcomes. She/He might also take part to the design of new simulation methods to study non-equilibrium quantum effects with transmon devices, directly using the hardware to estimate low-energy excited states of quantum many-body systems.
Finally, the student is welcome to participate in activities related to the SQMS project, or anyway of interest, that will possibly take place at the INFN Galileo Galilei Institute for Theoretical Physics during her/his time in Firenze.

Further references:
https://sqms.fnal.gov/
https://home.infn.it/newsletter-eu/pdf/NEWSL_INFN_75_ing_2.pdf
https://www.ggi.infn.it

Tutors:
Leonardo Banchi leonardo.banchi@unifi.it
Alessandro Cuccoli cuccoli@fi.infn.it
Jason Pereira pereira@fi.infn.it
Paola Verrucchi verrucchi@fi.infn.it

Activity period: June-July or September-October (one of the Tutors will always be available)

Local Secretariat: Antonella Pagliai antonella.pagliai@fi.infn.it

6. GENOVA

18. JLAB12-BDX

Title: JLAB12-BDX detector prototype test

Description: Test and assess the Beam Dump eXperiment detector prototype performance.
BDX is a beam-dump, Light Dark Matter search experiment scheduled to run at Jefferson Lab (VA) in the next few years. The detector, made from a CsI(Tl) electromagnetic calorimeter surrounded by two plastic scintillator veto layers, will be tested using cosmic muons to measure veto layer inefficiency as a function of the energy deposited in the calorimeter crystals.

Activities:
Commission the detector (test and equalize 46ch sipm channels), use the EEE cosmic muon test facility to measure veto and ECal absolute efficiency, run a cosmic test with the full prototype assembled to determine the veto inefficiency as a function of the energy deposited in the ECal crystals, data analysis and comparison to simulations.

Tutor: Marco Battaglieri e Andrea Celentano

Activity period: June-July 2024

Local Secretariat: Agnese Cresta

Other information:

6. GENOVA

19. Phenomenology and ATLAS

Title: Theoretical and Experimental Studies of Heavy Flavours at the LHC

Description:
Flavour physics studies the relations between different species of particles in the Standard Model. For instance, it aims to find a mechanism that can explain the strong hierarchy between the particles' masses. It also allows for stringent tests of the theory and, indeed, some of the most intriguing discrepancies between theory and experiment are the so-called flavour anomalies. This project pursues a novel approach for the interrogation of the LHC high-energy collision data that are sensitive to quark flavour differences. We aim to study new algorithms that exploit both theory-inspired observables and novel machine-learning techniques and test them on realistic simulation of the data collected with the ATLAS detector.

Activities: Attività (optional)

Tutors: Francesco Di Bello (francescoarmando.dibello@unige.it) and Simone Marzani (simone.marzani@ge.infn.it)

Activity period: 1st June – 31st July 2024

Local Secretariat: Agnese Cresta (agnese.cresta@ge.infn.it)

Other information: Altre informazioni (es. periodo di chiusura estivo, sistemazioni economiche o convenzionate, sito web locale, ecc..) (optional)

6. GENOVA

20-ATLAS

Title: Pixel Detector for the ATLAS Upgrade at HL-LHC

Description: : The program for LHC foresees an upgrade of the accelerator complex in the next long shutdown in 2026 that will allow to increase the integrated luminosity by a factor of 10 (High Luminosity LHC – HL-LHC). The present detectors of ATLAS have been designed according to the rates and radiation dose expected at the nominal LHC luminosity and the Inner Tracker system will be completely replaced for the HL-LHC by a fully Silicon tracker, with a Pixel detector in the innermost part and Strip detector in the outermost part. After several years of R&D's to develop a detector able to fit the even more demanding conditions than the actual ones, the Pixel detector collaboration is now stepping into the preproduction: the first parts produced need to be validated with several tests, to be sure that everything is ready before launching the massive production of the 13 mq large detector.
The Genova group has been involved since 20 years in the ATLAS pixel detector, and is now playing a key role in the construction of the new one for the high luminosity program. In particular, the Genova team is responsible for the high precision and large scale loading task of quad-modules (hybrid modules made of ~ 4x4 cm^2 planar sensors equipped with 4 2x2 cm^2 FE chips of new generation: the ATLAS flavor ITkPixV1 of the RD53b development project) on the composite C-fibre/C-foam, half-ring-shaped supports of the Outer EndCap Section of the ITk Pixel detector, and for the Quality Control of the module loaded Half Ring structures (including large temperature range thermal cycling of the loaded structures). All these activities are performed on a highly internationalized context, with many commonalities with analogous activities performed in US laboratories and universities. The Genova group, in collaboration with US laboratories and universities, is also responsible for the 3D modules, the technology chosen for the innermost layer thanks to its intrinsic higher radiation tolerance.

Activities: The student will have multiple opportunities of participating to key activities in the construction and test of the ITk Pixel detector: from contributing to the quality assessment of the high-precision and large-scale module loading task, which has to match very stringent and challenging goals of high reproducibility and robustness, to being involved in the system test for the qualification of multiple-modules-loaded Outer Endcap support structures, both in standard and in extreme ambient conditions, to participating to the assembly and test of 3D modules for the Inner System section of the detector.

Tutor: Stefano Passaggio (stefano.passaggio@ge.infn.it)

Activity period: June-July or September-October

Local Secretariat: Agnese Cresta (agnese.cresta@ge.infn.it)

Other information: cheap accommodation is available in town – see local web site: www.ge.infn.it

7. LECCE

21. DUNE

Title: Test on prototypes of elements of the DUNE Near Detector

Description: DUNE (Deep Underground Neutrino Experiment) is an international project with the strong support by the USA Department of Energy. DUNE is devoted to the measurement of mass hierarchy and CP violation in the neutrino sector. To this aim, a wide-band neutrino beam will be generated at Fermilab and monitored by a Near Detector (ND). Then the neutrino flux will be studied 1300-km far away by a Far Detector. SAND (System for on-Axis Neutrino Detection) is an element of the ND. It includes a liquid argon (LAr) target to be exploited by acquiring the scintillation light signal from neutrino events. This goal is a strong challenge, and an experimental activity is going on to verify the feasibility of the light readout in LAr. A student can be involved in these challenging hardware activities or contribute to the definition of reconstruction algorithms to be tested on simulated events. The choice between hardware or software jobs will depend on the student tendency**.**

Activities: Hardware activity on the LAr target prototype
Software activity for event reconstruction and background removal

Tutor: A. Surdo

Activity period: June-July 2024

Local Secretariat: **Carla Gentile** carla.gentile@le.infn.it

Other information: Salento University is closed in August. More information:
https://web.le.infn.it/ about INFN in Lecce
https://www.italia.it/en/puglia/lecce about Lecce city

8. LNF – FRASCATI NATIONAL LABORATORY

22. MU2E

Title: Calibration of the Mu2e calorimeter

Description: The calorimeter of the Mu2e experiment is composed by two disks of pure CsI crystals, readout by two custom array of large area UV-extended Silicon Photo-Multipliers (SiPMs). The experiment is currently in the construction phase, with the calorimeter assembly expected to be completed by Spring 2024. The calorimeter will then start the commissioning and calibration phase, where its performance will be assessed. This will be obtained by acquiring half calorimeter disk at a time, corresponding to about 350×2 channels, on a Vertical Slice Test with final detector components and electronics. Laser runs will be used to monitor and calibrate the gain of the SiPMs, and to measure the time resolution of the readout channels. Validation and calibration of the calorimeter response will be carried out with Cosmic Ray data using 3D-traced minimum ionizing particles selected by two segmented scintillator counters to be installed above and below the calorimeter disk under test. Selected events will provide calibration of the energy response (<1%), time offset alignment (< 50 ps), and measurement of the crystals Longitudinal Response Uniformity. A dedicated data-MC comparison of energy and time resolution will also be carried out before and after calibration.

Activities: The activity will be focused on the development and tuning of the reconstruction and calibration algorithms based on cosmic ray and laser events. The candidate will acquire technical competence on electromagnetic calorimetry and its calibration techniques, and expertise in professional software coding in C++, Python and ROOT.

Tutor: Simona Giovannella (simona.giovannella@lnf.infn.it)

Activity period: September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

23. ALICE

Title: Tuning of NΩ meson-exchange model potential with femtoscopy data from LHC by ALICE.

Description: The ALICE Collaboration has released unique data on baryon-baryon interactions in the strangeness S=-3 sector. Notably, the p-Ω correlation function, measured in proton-proton collisions at the LHC, stands out as the most accurate dataset on hadron interactions at low relative momentum in this sector.

Meson-exchange models, rigorously tested and constrained by data in the |S|<2 sectors, predict an attractive strong interaction at all distances for the NΩ interaction. Such an interaction potential implies the potential existence of a di-baryon bound state. The identification of such a state would constitute the first observation of a di-baryon (six quark state) with strangeness content.

The NΩ potential consists of several components: the long-range part is constructed through meson-exchange mechanisms and is well-constrained by existing data. However, the short-range part requires specific input from the NΩ system, for which Lattice QCD calculations were employed in the absence of experimental data.

With the availability of ALICE data, there is now an opportunity to, for the first time, fine-tune the potential and extract relevant parameters by fitting the correlation function data. This approach sheds light on the question of the existence of an NΩ quasi-bound state.

[1] ALICE Coll., *Nature 588 (2020) 232-238*, arXiv: 2005.11495 [nucl-ex]
[2] T. Sekihara, Y. Kamiya, and T. Hyodo, *Phys. Rev. C 98, 015205 (2018)*, arXiv: 1805.04024 [hep-ph].

Activities: Tune of theoretical models. Use of LHC ALICE data. Determination of bound state characteristics.

Tutor: Oton Vazquez Doce (Oton.VazquezDoce@lnf.infn.it)

Activity period: September-October 2024.

Local Secretariat: Maria Cristina D'Amato (maria.cristina.damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
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8. LNF – FRASCATI NATIONAL LABORATORY

24. Belle II

Title: Optimization ofK_L reconstruction and identification in Belle2 with Machine Learning techniques.

Description: The Belle II experiment runs at thee^+e^- SuperKEKB collider in Japan. SuperKEKB currently holds the world record of instantaneous luminosity and aims to reach by early 2025 the unprecedented luminosity $10^{35}cm^{-2}s^{-1}$, which will allow Belle II to collect a huge-statistics dataset of$B$,Dandτdecays (among others).
The reconstruction and particle identification ofK_L mesons is key in Belle II for time-dependent charmonium or charmless decays such as$B^0 \to J/\Box K_L$ and$B^0 \to \Box K_L$. The optimization of detector and analysis performance ofK_L mesons is also crucial to control systematic uncertainties in analyses such as dark matter searches or decays with neutrinos in the final state, which are sensitive probes of New Physics and are unique to Belle II.

Activities: The student will perform the analysis of data collected by the Belle II detector to measure and optimize theK_L reconstruction and particle identification. This will involve a deep understanding of the electromagnetic and hadronic calorimetry used to the detect theK_L mesons, as well as the use and development of sophisticated machine-learning techniques to improve the identification efficiency and reduce contamination from unwanted sources.
Knowledge of the Python and C++ programming languages is required.

Tutor: Giuseppe Finocchiaro (Giuseppe.finocchiaro@lnf.infn.it)

Activity period: June-July or September-October

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

25 LHCb

Title: Search for New Physics in semileptonic decays of the B_s meson

Description: LHCb is one of the main experiment collecting data at the Large Hadron Collider accelerator. One of its primary goal is to study with high accuracy the properties of b-hadrons that are copiously produced in the proton-proton collisions at LHC. The semileptonic decays of the B mesons have been studied with great precision at B-Factories. These decays are processes like B-> D mu nu_mu, where the b-quark inside the B meson transforms in a c-quark (giving the D meson in the final state) with the emission of a virtual W-boson, which subsequently couples to the muon and the anti-neutrino in the final state. At present there are various puzzles and anomalies observed studying semileptonic decays of these mesons. Some of these anomalies could be hints of Physics Beyond the Standard Model. It is paramount to study semileptonic decays in other b-hadron species to check these anomalies in alternative environments, and to access other observables very sensitive to new physics contributions. The LHCb group in Frascati is deeply involved in the study of semileptonic decays of B_s mesons. The B_s mesons (contain an anti-b quark and a s-quark instead of a u- or d-quark, as in ordinary B meson) are interesting because they offer various advantages compared with the B mesons on both the experimental and theoretical side.

Activities: The student will be deeply involved on key aspects of the data analysis using both data collected in Run II and the data that will be collected till this summer. Depending on her/his interests and when she/he will be with us, the work can focus on:

- The development of novel algorithms to control the soft photon efficiency, which is required by some of the measurements we are interested in;
- The optimization of signal selection to reduce the most dangerous backgrounds using Neural Networks or other Machine Learning approaches;
- The final multi-dimensional fit to extract the parameters of interest.

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

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

Activity period: 1 June - 31 July, 1 September - 31 October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

26. EXOTIC ATOMS MEASUREMENTS AT THE DAFNE COLLIDER

Title: Kaonic atoms measurements with SIDDHARTA-2 experiment at the DAFNE collider: a strangeness adventure!

Description: The SIDDHARTA-2 experiment is performing unique measurements of kaonic atoms X-ray transitions using the kaons beam delivered by the DAFNE collider. These measurements will contribute to a better understanding of the strong interaction in systems with "strangeness" (i.e. with strange quarks). The experiment is measuring for the first time the X rays produced in the de-excitations of kaonic deuterium by using new Silicon Drift Detectors, developed to perform precision X-ray spectroscopy. Other detectors (CdZnTe and HPGe) are used to measure intermediate and heavy mass kaonic atoms, such as kaonic carbon or kaonic lead. SIDDHARTA-2 is installed on DAFNE, an electron-positron collider unique in the world, delivering kaons, and will be in data taking and data analyses, also using Machine Learning techniques, in 2024, a very exciting period for a student! The kaonic atoms measurements play a fundamental role in understanding how strong interaction works in the strangeness sector, with implications going from particle and nuclear physics to astrophysics (equation of state of neutron stars).

Activities: The student will be involved in all the exciting phases of the experiment, from the data taking of SIDDHARTA-2 on the DAFNE collider, one of the very few working colliders in the world, to the optimizations of various detector sub-systems and of the data taking chain, along the run. He/she will be also introduced to data analyses, also by using Machine Learning techniques, and advanced Monte Carlo simulations. A real strangeness adventure!
Reference: The modern era of light kaonic atom experiments, C. Curceanu et al., Rev. Mod. Phys. 91, 025006 (2019); Kaonic atoms at the DAϕϕNE collider: a strangeness adventure, C. Curceanu et al., Front.in Phys. 11 (2023) 1240250

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

Activity period: June - July or September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

27. QUANTUM FOUNDATIONS: experimental tests of Quantum Gravity (via the Pauli Exclusionprinciple) and of quantum collapse models

Title: The Schrödinger cat is meowing: testing Quantum Foundations within the VIP experiment. Search for violation of the Pauli Exclusion principle and gravity related collapse models

Description: The VIP experiment, installed at the Gran Sasso underground laboratory, LNGS-INFN, is performing experimental searches of signals coming from possible violations of standard quantum mechanics, such as atomic transitions violating the Pauli Exclusion Principle (PEP) and spontaneous radiation coming from modified Schrödinger equation within the so-called collapse models, proposed to solve the measurement problem (connected also to the Schrödinger cat paradox).. The VIP collaboration developed a series of radiation detectors and data analyses methods, based on Machine Learning protocols, which allowed to set extremely competitive limits on PEP violation probability and collapse models. Presently, the experimental apparatuses are under optimization, in parallel with the data taking at Gran Sasso and data analyses, to either set even stronger limits or find signals of violations of standard quantum mechanics, which, of course, would represent a revolution in whole science. The obtained results are also relevant for upcoming quantum technologies.

Activity: The student will be involved in all the exciting phases of the experiment, from the preparation and testing of the detector systems to data analyses, using advances statistical methods and machine learning. He/she will be also introduced to interpretation of results in the framework of modern theories, including gravity related collapse models and quantum gravity models.
References: Underground test of gravity-related wave function collapse, A. Donadi et al., Nature Physics volume 17, pages 74–78 (2021) and Experimental test of noncommutative quantum gravity by VIP-2 Lead, K. Piscicchia et al., Phys. Rev. D 107, 026002 – Published 4 January 2023

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

Activity period: June - July or September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

28. a-C COATINGS FOR EIC

Title: SEY investigation of a-C coatings

Description: Electron cloud is a serious issue for EIC proton beam. Electrons, produced by ionization of the residual gas by the passage of short spaced high-intensity bunches, can be accelerated toward the vacuum chamber walls by the proton beam, thereby releasing more electrons from the walls. This can create an electron avalanche that builds up rapidly in the beam vacuum chamber (that is electron cloud). This can cause detrimental effects (as heat load, gas desorption, vacuum degradation, …) giving rise to beam instabilities.
The key parameter governing the electron cloud formation is the Secondary Electron Yield (SEY, which is the number of electrons emitted per incident one). To prevent electron cloud buildup, the choice of the vacuum chamber' surface material is crucial and a SEY close to (or below) 1 is needed. SEY, indeed, is an intrinsic material property, highly sensitive to surface modifications. Then, when working at cryogenic temperature, the physisorption of residual gas species in the vacuum system may strongly affect SEY characteristics, especially in the low energy region of the spectrum.
It is known that an amorphous carbon (a-C) layer on Cu substrate can reduce SEY down to a value ~1. In the beampipe of the RHIC superconducting magnets, a Cu plated screen coated with a-C is planned to be installed. Chemical, structural, and morphological characteristics of the a-C coating may affect the SEY and low temperature behavior.

In close collaboration with Brookhaven National Laboratory (BNL), this project aims to test and validate various material surfaces proposed to be used in the EIC hadron ring vacuum chamber using all the surface science spectroscopies available in the laboratory (SEY, XPS, RGA). SEY investigations will be made at room and cryogenic temperatures, with physisorbed gas monolayers and as a function of electron irradiation at various electron impacting energies to investigate any induced modification. Moreover, the project will also include activities in the design, realization and commissioning of an ultra-high vacuum system dedicated to SEY measurements and electron irradiations.

Activities: Experimental activities

Tutors:
Marco Angelucci (Marco.Angelucci@lnf.infn.it)
Roberto Cimino (Roberto.Cimino@lnf.infn.it)
Luisa Spallino (Luisa.Spallino@lnf.infn.it)

Activity period: June - July or September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

29. ELECTRONS TO CURE MIRROR CHARGING

Title: Determination of Surface Charging/Discharging Conditions by Secondary Electron Yield Investigations

Description: Electrostatic charge forming on the Gravitational Wave (GW) mirrors severely affects detection sensitivity. At LIGO, a charging mitigation method has been successfully applied. This requires long mirror's exposures to a relatively high pressure of N_2 ions flux. It is impossible to apply this method when mirrors are at cryogenic temperatures, since a significantly thick condensed gas layer will develop on the mirror surface severely affecting its performance. An intense effort needs to be devoted to find new charging neutralization methods compliant with the constraints derived by the use of cryogenic optics. A possibility is given by selected energy electrons (between 10 to 100 eV) which, at very low doses, can impinge on the surface mirror. It is known, indeed, that according to their energy, the Secondary Electron Yield (SEY, which is the number of electrons emitted per incident ones) could be ≤ 1 or ≥ 1, i.e. removing or adding electrons at will on the mirror's dielectric surface. Even if conceptually simple, the actual refinement of this method and its implementation are a challenge. A first mandatory step is to know how much electronic charge is delivered (or removed) as a function of dose and energy of the impinging electron flux in realistic small samples, representative of materials composing the mirrors. This project aims to address this issue by using all the surface science spectroscopies available in the laboratory to first determine the SEY of mirrors samples in neutral and unperturbed conditions. After identifying and checking a measurement technique to quantify the surface charge, the goal is to define the electron beam parameters to induce on purpose charging/discharging on surface.

Activities: Laboratory and data analysis activity

Tutor:
Luisa Spallino (Luisa.Spallino@lnf.infn.it)
Roberto Cimino (Roberto.Cimino@lnf.infn.it)
Marco Angelucci (Marco.Angelucci@lnf.infn.it)

Activity period: June - July or September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
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Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

30. PADME

Title: Search of dark matter signals in positron-electron annihilations

Description: PADME - Positron Annihilation into Dark Matter Experiment - is devoted to the search of light dark matter signals produced in positron-electron annihilations. The experiment consists of an active diamond target, where annihilations occur, a charged particle magnetic spectrometer and a system of calorimeters for photon detections. The main goal of the experiment has been the search for a dark photon produced in association to an ordinary one.
The PADME collaboration is international and consists of Italian, Bulgarian and American researchers. After the commissioning in 2018, the experiment had three data acquisition periods in 2019 (Run I) 2020 (Run II) and 2022 (Run III). The analysis of the collected data is ongoing while the preparation of Run IV, foreseen for the second half of 2024, will start next spring.
More information on the PADME experiment is available at the experiment web site: https://padme.lnf.infn.it/.

Activities: The student will be inserted in the analysis group that at present is mainly involved in the search for a signal of a hypothetical new particle of mass ~ 17 MeV (X17) that has been proposed to explain the anomalies observed by some recent nuclear physics experiments studying de-excitation of light nuclei via e^+e^- emission. PADME has tried to produce resonantly this particle during Run III with a reverse process: $e^+e^- \rightarrow X17$.

Tutor: Tommaso Spadaro (tommaso.spadaro@lnf.infn.it)

Activity period: June - July 2024.

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

31. ANALYSIS IN THE H-> ZZ*-> 4l DECAY CHANNEL

Title: Study of the Higgs Boson properties in the H->ZZ*->4l decay channel using early Run 3 data collected by the ATLAS detector at LHC

Description: The Higgs boson is a fundamental particle in the Standard Model and precision measurements are of outmost importance in High Energy Physics. Within the project, the candidate will work together with the H-> ZZ*-> 4l analysis team, learning how to study the Higgs boson properties using the most recent analysis techniques and produce results on their own.

Activities: Analysis coding, machine learning, team building, presenting at ATLAS CERN internal meetings.

Tutor:
Chiara Arcangeletti (chiara.arcangeletti@lnf.infn.it)
Giada Mancini (giada.mancini@lnf.infn.it)
Mario Antonelli (mario.antonelli@lnf.infn.it)

Activity period: Candidate can choose between 2 periods: 9 weeks across June-July OR 9 weeks across September-October

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

8. LNF – FRASCATI NATIONAL LABORATORY

32. CYGNO

Title: CYGNO Dark Matter and Solar neutrino research

Description: The CYGNO experiment is harnessing advancements in commercial scientific Active Pixel Sensors (APS) based on CMOS technology to develop a large gaseous Time Projection Chamber (TPC) for Dark Matter and Solar neutrino research. The project is currently collecting data at LNGS using a prototype named LIME, which is being studied to compare its performance against Monte Carlo expectations. Additionally, tests on new hardware are ongoing at the LNF laboratory to finalize the selection of the full-scale demonstrator intended for installation in the underground lab by the beginning of 2015. This process involves a continuous integration of experimental tests and data analysis. The candidate will be involved in this work within the CYGNO international collaboration, focusing on conducting tests at the LNF and LNGS labs and interpreting the results. This will include utilizing cutting-edge analysis tools such as machine learning methods.

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

Activity period: September - October 2024

Local Secretariat: Maria Cristina D'Amato (damato@lnf.infn.it)

Other information:
Accommodation: students may be accommodated, free of charge, in the LNF guesthouse (for information: http://www.lnf.infn.it/funz/concorsi/foresterie.html).
Lunches at the LNF canteen (Monday-Friday) are free of charge.
LNF Summer closing period: one week in mid-August.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNGS – GRAN SASSO NATIONAL LABORATORY

33. LUNA 2

Title: Commissioning and characterization of the setup for the study of the $^{12}C+^{12}C$ process inside the LNGS underground laboratory.

Description: The LUNA (Laboratory for Underground Nuclear Astrophysics) collaboration aims to study the $^{12}C+^{12}C$ reaction via photon detection at the new "Bellotti" Ion Beam Facility, located inside the LNGS (Laboratori Nazionali del Gran Sasso) underground laboratory in Italy. A key component of this experiment is a high-purity germanium (HPGe) detector, enclosed in a 25 cm thick lead shielding to suppress the low-energy background gamma radiation in the experimental site and improve the sensitivity.

Activities: The goal of this internship is to actively participate in the commissioning and the characterization of the setup that will be used for the study of the $^{12}C+^{12}C$ process, including the development of online monitoring tools, the study of environmental backgrounds, calibrations and first tests with proton and carbon beams.

Tutor: Federico Ferraro (federico.ferraro@lngs.infn.it)

Activity period: June-July 2023

LNGS UserOffice: Vincenzo Fantozzi and Serena Cavalcante (useroffice@lngs.infn.it)
Local LNGS site https://www.lngs.infn.it/en
LNGS Summer Students Program site https://www.lngs.infn.it/it/summer-student-lngs

Other information: open positions: 1, further information on LUNA: https://luna.lngs.infn.it/

9. LNGS – GRAN SASSO NATIONAL LABORATORY

34. LUNA 1

Title: Test beam for the study of the $^{12}C+^{12}C$ process inside the LNGS underground laboratory.

Description: The LUNA (Laboratory for Underground Nuclear Astrophysics) collaboration aims to study the $^{12}C+^{12}C$ reaction via photon detection at the new "Bellotti" Ion Beam Facility, located inside the LNGS (Laboratori Nazionali del Gran Sasso) underground laboratory in Italy. A key component of this experiment a high-purity germanium (HPGe) detector, enclosed in a 25 cm thick lead shielding to suppress the low-energy background gamma radiation in the experimental site and improve the sensitivity.

Activities: The goal of this internship are the study of beam-induced backgrounds and the analysis of preliminary high-energy data during the test beams that will follow the commissioning of the setup, including the implementation of advanced techniques for offline analysis and the accurate determination of the cross section.

Tutor: Federico Ferraro (federico.ferraro@lngs.infn.it)

Activity period: September-October 2023

LNGS UserOffice: Vincenzo Fantozzi and Serena Cavalcante (useroffice@lngs.infn.it)
Local LNGS site https://www.lngs.infn.it/en
LNGS Summer Students Program site https://www.lngs.infn.it/it/summer-student-lngs

Other information: open positions: 1, further information on LUNA: https://luna.lngs.infn.it/

10. NAPOLI

35. DarkSide

Title: Characterization of SiPM based Photon Detection Modules for the DarkSide Prototype

Description: The search for Dark Matter represents one of the most intriguing open frontiers in modern cosmology and astroparticle physics. The science case is extremely strong: observations of the cosmic microwave background fluctuations, large-scale galaxy surveys, studies of large scale structure formation and of the dynamics of galaxy clusters, all point to the existence of cold dark matter. Weakly Interacting Massive Particles (WIMP) are an excellent candidate for cold dark matter. These particles, predicted in many new theories extending beyond the standard model, may collide with ordinary nuclei via ultra-weak interactions, and could be detected by means of special, lowbackground detectors, capable of selectively identifying nuclear recoils - the likely signature of WIMP interactions.

The DarkSide Project for direct dark matter detection makes use of underground argon as a target in a two-phase time projection chamber, capable of achieving background-free conditions. The next step of the project carried out by the Global Argon Dark Matter Collaboration, counting over 350 members from 70 international Institutions, is a 20 ton detector equipped with new SiPM-based cryogenic photodetectors.
Napoli CRYOLAB hosts the largest photodetector testing facility of the DarkSide Collaboration, where all the Photon Detection Units built for the experiment will be characterized at cryogenic temperature.

Activities: The selected student will participate in laboratory activities for the test and characterization of the photon detectors for the DarkSide detector, acquiring experience with noble liquid techniques, cryogenic systems, photosensors, data read-out and acquisition, data analysis.

Tutor: Giuliana Fiorillo

Activity period:
June 1 – July 31, 2023
September 1 – October 30, 2023

Local Secretariat: Adelaide Aversano

10. NAPOLI

36. DUNE

Title: Test of DUNE Vertical Drift Optical Module in Liquid Argon

Description: Deep Underground Neutrino Experiment (DUNE) is one of most relevant next generation experiments investigating new physics beyond the Standard Model, addressing the measurement of the CP violating phase in the leptonic sector. DUNE Far Detector is based on the liquid argon TPC technology and will implement the novel X-ARAPUCA photodetector to collect scintillation light from neutrino interactions. X-ARAPUCA is a light trap, capturing wavelength-shifted photons inside a box with high-reflective internal surfaces. The entrance window of the box is made of a short-pass dichroic filter which has the properties of being highly transparent to photons with wavelength below a given cut-off (400 nm), while being highly reflective to photons with wavelength above the same cut-off. The dichroic filter is coated on the external side of the entrance window with para-Terphenyl (pTP), a wavelength shifter downshifting photon from 128 nm to 350 nm. An X-ARAPUCA module has a light collecting area of 600x600 mm^2; light is read-out by 160 SiPMs distributed around the perimeter of the photodetection module.

Activities: A whole X-ARAPUCA module will be tested at Napoli in a big cryostat filled with liquid argon. The photon detection efficiency of the device will be measured by means of an alpha source producing scintillation light in the liquid argon. The selected student will participate in laboratory activities, acquiring experience with cryogenic systems, signals in liquid argon, silicon photomultipliers and data-analysis.

Tutor: Francesco Di Capua

Activity period:
June 1 – July 31, 2023
September 1 – October 30, 2023

Local Secretariat: Adelaide Aversano

11. PADOVA

37. SWGO

Title: Deep learning optimization of SWGO Gamma Ray Observatory

Description: In this project, the student will participate in the optimization of the layout of 6000 Cherenkov detectors to be constructed in South America to detect ultra-high-energy gamma rays by the SWGO Collaboration. The end-to-end optimization is performed by a fully differentiable model of the reconstruction and classification of cosmic ray showers and the extraction of a utility function that is maximized by gradient descent. The student will contribute by working at the improvement of parts of the model of the reconstruction of showers. The work is performed with software written in C++ and/or Python.

Activities: There is the possibility to participate to a workshop of the MODE Collaboration in Valencia (September 24-26) with a poster describing the work.

Tutor: Tommaso Dorigo

Activity period: September- October 2024

Local Secretariat: salente@pd.infn.it

11. PADOVA

38. QUAX

Title: Dark Matter Search: Axion Haloscope

Description: The QUaerere AXions (QUAX) experiment is a direct search for galactic dark matter in the form of axion or axion like particles.
The detector is being built at Legnaro National Laboratories of INFN, and the collaboration includes members from the INFN sections of Padova, Salerno and Trento.
Hybrid and dielectric microwave cavities operated in multi-Tesla magnetic fields, coupled to quantum-limited receivers will allow for probing axions with (35-45) microeV mass.
Research activity is also focused on operation of a ferrimagnetic haloscope, based on the axion-electron interaction.
These experiments might in the near future help to put new insights in the understanding of our still very unknown Universe.
Activities: Mostly hardware devoted: Dilution refrigerator, microwave cavity , strong magnetic field, quantum limited microwave electronics, DAQ system
Quax webpage: https://www.pd.infn.it/eng/quax/

Tutor: Giovanni Carugno (carugno@pd.infn.it) , C.Braggio (braggio@pd.infn.it)

Activity period: June - July

Local Secretariat: salente@pd.infn.it

11. PADOVA

39. LUNA

Title: Experimental design for Nuclear Astrophysics at LUNA

Description: LUNA (Laboratory for Underground Nuclear Astrophysics) is an experiment devoted to study nuclear reactions of astrophysical interest. LUNA deep underground location at the Gran Sasso National Laboratories (LNGS) guarantees an environmental background level orders of magnitude lower than above ground empowering reaction measurements to be performed down to astrophysical energies. Recently a new accelerator has been installed at the LNGS with outstanding beam (H+, He+ and 12C+,++) stability and intensity features. Most of the targets are produced in the National Laboratories of Legnaro (10 km from Padua city center).

The candidate will focus on the experimental design, working on the characterisation of the setup and on the outline of the experimental campaign. Moreover, the candidate will participate to the target preparation and characterization at the LNL and at LNGS. This candidate will definitely participate to all phases of the experimental activities having the opportunity to work in two Italian national laboratories. In addition to this the candidate could work on the new program if machine learning implementation in the analysis algorithms we are developing in the Padua group.

Activities: Setup construction and characterization with hands on activities. Data analysis with C++ and python codes and machine learning tools for reaction signal recognition

Tutor: Prof. Antonio Caciolli (antonio.caciolli@unipd.it)

Activity period: or June-July or September-October

Local Secretariat: Marina Andreazzo, marina.andreazzo@pd.infn.it

11. PADOVA

40. RD_Mucol

Title: Jet reconstruction and identification at Muon Collider

Description:

The Muon Collider is one of the most promising machines for the future of particle physics with accelerators. Muon collisions at multi-TeV center of mass energies are the ideal place to perform precison physics measurements like the study of the Higgs boson properties, and to search for new high mass particles. Jets play a crucial role in both researches and dedicated algorithms for their recosntruction and identification need to be developed and optimized.
The main challenge is the treatment of the contribution of the beam-induced background, that is produced by the decay in flight of muons of the beams and subsequent interactions with the environment. This background poses potential limitations on the jets and tracks reconstruction. Beam-induced background hits in the tracker system create spurious hits that contribute to fake tracks while photons arriving to the electromagnetic calorimeter generate a continuous background difficult to subtract.
In this internship, the trainee will be introduced to the muon collider simulation. He/she will be involved in the development of the algorithms for the particles reconstruction in the tracker and in the calorimeter depending on the interests. After the definition of the algorithms, he/she will study the jet properties by using simulation samples of interesting physics processes, such as Higgs and/or Z' decay channels.
During this period, the trainee will gain the basic knowledge for working in an High Energy Physics experiment, and he/she will develop the computing skills that are necessary to analyse data, mainly using the software ROOT and/or Python. He/she will also learn how modern machine learning techniques work and how to apply them to High Energy Physics problems.

Activities: Development and application of calorimeter and tracks reconstruction algorithms. Analysis of simulated and reconstructed data by using machine learning algorithms.

Tutor: Donatella Lucchesi, Lorenzo Sestini and Davide Zuliani

Activity period: June-July or September-October

Local Secretariat: segreteria-gruppo1@pd.infn.it

11.PADOVA
41. LHCb 1

Title: Study of single photon timing resolution of photodetectors for LHCb RICH upgrade

Description: During the LS4 shutdown of LHC the LHCb detector will be upgraded to cope with the increased event rate expected during the HL-Luminosity running of the LHC. The LHCb RICH detector will be modified in order to perform particle identificatoin in this harsh environment. In particular the photon detectors will need to have a factor 10 smaller granularity and time stamping at the order of ~100ps. For this reason in this project we propose to study the important item of the single photon time resolution of the photon detectors for the next LHCb RICH upgrade.

Activities: The student will measure the time resolution of SiPM samples from FBK and other vendors and compare the performance of different designs.

Tutor: Gabriele Simi, Anna Lupato

Activity period: settembre-ottobre

Local Secretariat: segreteria-gruppo1@pd.infn.it

11.PADOVA

42. LHCb 2

Title: Optimization of the measurement of the branching fraction for $\Lambda_b \to \Lambda_c^* D_s^{(*)}$

Description: *The decay of the* $\Lambda_b \to \Lambda_c^* D_s^{(*)}$ *represents an important source of irreducible background in the test of Lepton Flaour Universality (LFU) using the decay* $\Lambda_b \to \Lambda_c^* \tau \nu_\tau$ *. In order to reduce the systematic error on this semitauonic LFU it is necessary to know the branching fraction of* $\Lambda_b \to \Lambda_c^* D_s^{(*)}$*. This project aims at optimize the measurement of this branching fraction with the LHCb detector at the LHC collider using the LHCb data from run 1 and run 2.*

Activities: The student will contribute to the optimization of the measurement of the branching fraciton using also multivariate techniques and neural networks. The will also study some of the systematic uncertainties involved in this measurement.

Tutor: Gabriele Simi, Anna Lupato

Activity period: settembre-ottobre

Local Secretariat: segreteria-gruppo1@pd.infn.it

11. PADOVA

43. MuOne

Title: Analysis of the data collected with a MuOnE prototype

Description: We propose the analysis of the data collected during Fall 2022 and Fall 2023 with a prototype module of the MuOnE experiment. The aim of this study is a proof of concept of the experiment, which, albeit far from the target goal, should allow a measurement of the differential cross section of the elastic scattering mu e -> me e with percent precision, large enough to observe for the first time the running of the fine structure constant \alpha in the space-like "t" channel.

Activities: Data analysis, use of c++ or python and of the ROOT CERN analysis package.

Tutor: Prof Franco Simonetto

Activity period: Both the terms (June-July) or (Sept.-Oct.) fit with my agenda

Local Secretariat: segreteria-gruppo1@pd.infn.it

12. PERUGIA

44. FERMI-LAT

Title: Application of machine learning methods on Fermi-LAT images.

Description: Gamma-ray radiation within our cosmos is an indicator of non-thermal emission or catastrophic events, within or beyond our galaxy. The gamma-ray sky is in continuous evolution and observing it for several years we could detect many types of sources such Active Galactic Nuclei, Pulsars and transient events. Over its nearly 15-year operational span, the Large Area Telescope (LAT) onboard the Fermi satellite had detected more then 7000 gamma-ray sources unveiling the nature of emission mechanisms responsible for such high energy photons.
Activity: The student will work on the Fermi-LAT counts maps images to develop new methods of detection of gamma-ray sources using Machine Learning methods directly on images (e.g. YOLO or fully convolutional neural network) in order to optimize detection and the de-blending of gamma-ray sources.

Tutor: Sara Cutini (sara.cutini@pg.infn.it) and Stefano Germani (stefano.germani@pg.infn.it)

Activity period: June-July

Local Secretariat: Ilaria Binaglia, email: ilaria.binaglia@pg.infn.it

Other information:
Website of Department: http://www.fisica.unipg.it/fisgejo/index.php/it/
Students useful information: https://www.adisu.umbria.it/
Leisure: https://www.umbriajazz.it/, https://www.itinerarinellarte.it/it/mostre/umbria, https://www.quintana.it/

13. PISA

45. GW VIRGO-ET

Title: Development of seismic attenuation systems for current and next-generation gravitational wave detectors

Description:

The search for gravitational waves is being pursued at present with large interferometers in Europe, US and Japan. Furthermore, there is an increasing activity toward the development of third-generation detectors, such as the Einstein Telescope in Europe and Cosmic Explorer in the US. Advanced Virgo is the interferometric gravitational wave detector, located at the European Gravitational Observatory near Pisa, Italy.
One of the key aspects of experimental development of new detectors is the attenuation of seismic noise, in order to improve the sensitivity at low frequencies. The Virgo-ET research group in Pisa has a longstanding tradition in this field, thanks to its key role in the construction of the Virgo Superattenuator and is now active in the development of next-generation super attenuators. During the stay we will offer to the student the possibility to participate actively in the experimental work related to the development of super attenuators, with particular attention to the simulations, electronics and control systems.

Activities: Attività (optional)

Tutor:
Massimiliano Razzano (massimiliano.razzano@pi.infn.it)
Francesco Fidecaro (francesco.fidecaro@pi.infn.it)

Activity period: June-July or September-October

Local Secretariat: Giacomo Betti giacomo.betti@pi.infn.it

Other information: The INFN will be closed from 10th to 18th August 2024

13. PISA

46. Mu2e

Title: Commissioning and Data Analisys of the Mu2e Calorimeter

Description: *The Mu2e experiment, currently under construction at the Fermi National Accelerator Laboratory (FNAL) in Chicago, will search for neutrinoless mu-→e- conversion in the field of an aluminum atom. A clear signature of this charged lepton flavor violating two-body process is given by the monoenergetic conversion electron of 104.97 MeV produced in the final state. An 8 GeV/c pulsed proton beam interacting on a tungsten target will produce the pions decaying in muons; a set of superconducting magnets will drive the negative muon beam to a segmented aluminum target where the stopped muons will eventually convert to electrons; a set of detectors will be used to both identify conversion electrons and reject beam and cosmic backgrounds. The experiment will need 3-5 years of data-taking to achieve a factor of 10^4 improvement on the current best limit on the conversion rate. An eventual discovery would a clear sign of physics beyond the Standard Model of particle phyiscs. The INFN group is responsible for the contruction and the commissioning of the Mu2e electromagnetic calorimeter (ECAL) made of CsI crystals read by silicon photon multipliers. This detector is currently being assembled and will be installed in the Mu2e experimental hall at FNAL in late 2024. The Mu2e Pisa group is focusing on the ECAL digital readout that will be crucial for the acquisition and the analysis of the first data. The group has also a key role in the simulation of ECAL detector and of the complete Mu2e apparatus that is fundamental to understand and optimize the physics potential of the experiment.*

Activities: Readout of Mu2e electromagnetic calorimeter element. Analysis of collected data (using root). Creation of a simple event display. Monte Carlo simulation (Geant4).

Tutor: Luca Morescalchi <luca.morescalchi@pi.infn.it>

Activity period: June-July or September-October 2024

Local Secretariat: Giacomo Betti <giacomo.betti@pi.infn.it>

Other information: Please contact the tutor to have more information about accomodation opportunities

14. TORINO

47. PROGETTO

Title: Silicon-tracker at the Muon collider experiment – Development and testing of LGAD silicon sensors

Description: The project focuses on planar silicon sensors based on Low-Gain Avalanche Diode (LGAD) technology that is of interest for the instrumentation of silicon tracker detector at the Muon Collider experiment.

The project involves characterizing the performances of LGAD sensors and their read-out electronics in terms of:

- spatial and temporal tracking of charged particles with precisions of the order of tens micro-meters and pico-seconds (4D-tracking),
- radiation resistance at extreme irradiation fluences ($> 10^{15}$ particles/cm^2).

The activity will be carried out at the Laboratory of Innovative Silicon Sensors at the INFN and Physic Department of the University of Turin.
The laboratory is equipped with state-of-the-art instrumentation for the development and characterization of LGAD silicon sensors and their read-out electronics.

Activities:
The laboratory activities involve i) DC electrical tests on probe station setups, and ii) characterization in the transient mode, using the Transient Current Technique (TCT) and β/α radioactive sources, in order to stimulate the generation of signal in the device.

The candidate will acquire skills in the most advanced techniques (TCT and DC electrical tests) and setups (probe station and read-out electronics) of characterization of silicon sensors.

Tutor:
Marco Ferrero, marco.ferrero@to.infn.it

Activity period:
1 June 2024 – 31 July 2024 or 1 September 2024 – 31 October 2024

Local Secretariat:
Valentina Lissia, valentina.lissia@to.infn.it

Other information:
https://www.to.infn.it/

15. TRIESTE

48. BELLE II

Title: Improving the photon-energy calibration for the Belle II detector

Description:
This is a data analysis project aiming at the improvement of the current calibration of the photon energies measured in the electromagnetic calorimeter of the Belle II experiment. Belle II is a detector designed to reconstruct billions of decays of heavy *B* mesons and τ leptons from 10 GeV electron-positron collisions in search for indirect indications of non-Standard-Model physics. It started operations in 2018 and has collected so far about 420 million *B* meson pairs, which are being used to obtain unique and world-leading measurements of primary relevance. Many use decay channels with neutral particles, such as π^0 and η mesons. For these the calibration of the photon energy measurement is critical. Such calibrations are currently obtained as functions of the γ energy using known control samples in data. However, their performance is suboptimal as physics analyses show residual 30% mismodeling. This project consists in trying to suppress these mismodeling by introducing corrections to energy dependences that are not yet accounted for, such as those on the photon angle of incidence in the detector. The student will explore the development and implementation of a novel, and more sophisticated photon-energy calibration approach that is likely to lead to more accurate and reliable results. We expect to document these into an internal note and include them in the standard Belle II correction procedures after internal review. She/he will gain experience in data analysis in a modern collider-physics experiment (statistical analysis of multidimensional distributions, fitting, hypothesis testing), will become acquainted with the details of reconstruction of neutral particles in crystal-based electromagnetic calorimeters, and she/he will generally experience a taste of real-life research work in a dynamic and stimulating environment. The Trieste group is a strong and international group involved in both analysis and hardware, playing a key role in many aspects of the experiment. A major area of interest is the reconstruction of neutral particles for enhancing physics reach. She/he will be supervised on a daily basis by a junior postdoc under the intellectual guidance of a senior tutor.

Activities:
- Data analysis
- Programming in Python and ROOT/C++

Tutor: Diego Tonelli (diego.tonelli@ts.infn.it), Mirco Dorigo (mirco.dorigo@ts.infn.it)

Activity period: about 9 weeks between June-October 2024.

Local Secretariat: Alessandra Filippi (alessandra.filippi@ts.infn.it)

Other information:
- Affordable accommodation close to the lab can be arranged with adequate notice.
- Local INFN webpage https://www.ts.infn.it/en/
- Belle II Trieste webpage https://web.infn.it/Belle-II/index.php/our-research
- Practical information about the Trieste Science System: http://www.welcomeoffice.fvg.it/

15. TRIESTE

49. ITS3

Title: 65 nm CMOS process MAPS detector characterization

Description:
A quasi-massless, truly cylindrical silicon detector based on Monolithic Active Pixel Sensors (MAPS) technology is being currently developed. Such a detector, named ITS3, will upgrade the Inner Tracking System for the ALICE detector at LHC in 2026. The same technology has been chosen as the baseline for the Silicon Vertex Tracker (SVT) of the ePIC detector at EIC, and is considered for the future ALICE 3 experiment at LHC.
To achieve the target performance, the design of a new large-area (~25 cm x 10 cm), extremely reduced thickness (30-40 microns) monolithic pixel sensor based on 65 nm CMOS process, is now ongoing, with the goal of building a series of curved silicon layers with minimal infrastructures in the active area. The first large-area chips featuring a stitched design are now under characterization.

Activities:
In Trieste, the ITS3 R&D for 2024 will focus on the characterization in laboratory of the 65 nm CMOS process test structures and stitched chip single units and will extend to sensors in curved geometry. The student will participate in the tests, contribute to the development of test procedures and software, gain experience in the interpretation of the results and learn how the sensor design affects the sensor performance. The work will train the student to conduct independent tests of the CMOS sensors.

Tutors:
Giacomo Contin (giacomo.contin@ts.infn.it)
Paolo Camerini (paolo.camerini@ts.infn.it)

Activity period:
Preferably June-July 2024.
September-October 2024 can also be considered.

Local Secretariat:
Alessandra Filippi (alessandra.filippi@ts.infn.it)

Other information:
- Affordable accommodation can be arranged with adequate notice.
- The local INFN website: https://www.ts.infn.it/en/
- Practical information about the Trieste Science System: http://www.welcomeoffice.fvg.it/