ISTITUTO NAZIONALE DI FISICA NUCLEARE

Announcement n. 25272

DOE-INFN Summer Students Exchange Program 2023 Edition

The US Department of Energy (DOE) and the Istituto Nazionale di Fisica Nucleare of Italy (INFN) announce the 2023 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, 2023.

There are 11 positions available. Applicants can choose among 21 different INFN sites and 77 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 2023.

Applications, in electronic form, must be sent to INFN not later than March 2nd, 2023 by 11:59:59 pm 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, January 31st 2023

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. APT** - Characterization of a prototype detector for MeV gamma-rays.
1. BARI	**2. CTA** - Calibration studies for the frontend electronics of the prototype Schwarzschild Couder Telescope for CTA.
1. BARI	**3. Fermi LAT** - Gamma-ray analysis of transient sources at high energies.
1. BARI	**4. HEPAWtools -**HEP analysis workflow with cutting-edge tools
1. BARI	**5. LHCb -** Study of the performance of new-generation eco-friendly gaseous detectors for the future LHCb Muon System.
2.BOLOGNA	**6. ATLAS** - Quality Certification of the ATLAS ITk pixel modules
2.BOLOGNA	**7. EIC** - Commissioning of the EIC-dRICH SiPM readout prototype
3.CAGLIARI	**8. CMS** - Higgs searches with the CMS experiment at CERN
3.CAGLIARI	**9. LHCB** - Studies of Heavy Nuclei collisions at LHCb
4. CATANIA	**10. FRIDA** - Characterization of novel detectors for dosimetry of Ultra-High Dose-Rate (UHDR) beams for FLASH radiotherapy
5. FERRARA	**11. DUNE** - Cryogenic characterization of the Silicon Photomultipliers (SiPMs) sensors for the DUNE Far Detector experiment
5. FERRARA	**12. BESIII** - Study of benchmark channels of BESIII CGEM-IT
5. FERRARA	**13. BESIII** - Precise charmonium measurement at BESIII
5. FERRARA	**14. LHCb** - The Ring Imaging Cherenkov (RICH) detector upgrade project of the LHCb experiment: R&D activities and characterization of fast-timing and radiation-hard single-photon detectors and electronics
5. FERRARA	**15. Medipix -** Characterization of state-of-the-art hybrid pixel detectors for applications in fundamental physics, life sciences and outreach
5. FERRARA	**16. NA62/HIKE** - Development of the Small Angle Calorimeter for the High Intensity Kaon Experiments (HIKE) at the CERN Super Proton Synchrotron
5. FERRARA	**17. RD_FCC** - uRWELL for muon detector development for muon detector of the IDEA spectrometer
6. FIRENZE	**18. CMS** - Measurement of the Higgs boson production in the WW decay channel with the CMS experiment at LHC using Machine Learning techniques
6. FIRENZE	**19. CMS** - Characterization of Si-pixel based detectors for CMS HL-LHC Upgrade
6. FIRENZE	**20. GAMMA** - Data analysis and detector characterization in the framework of the AGATA project
6. FIRENZE	**21. NUCLEX** - Activity of construction, assembling and testing of scintillating detectors for experiments with heavy-ions.
7. GENOVA	**22. ATLAS** - Pixel Detector for the ATLAS Upgrade at HL-LHC
7. GENOVA	**23. ATLAS** - Theoretical and Experimental Studies of Heavy Flavours at the LHC
7. GENOVA	**24. DUNE** - Tests of detector prototypes for imaging charged particle tracks in liquid Argon
7. GENOVA	**25. EIC NET** - Streaming DAQ for the future Electron-Ion Collider
7. GENOVA	**26. ICARUS** - Neutrino events reconstruction with Time Projection Chamber detector in the ICARUS experiment
7. GENOVA	**27. JLAB 12** - BSM searches at Jefferson Lab
7. GENOVA	**28. JLAB 12** - AI-supported analysis of CLAS and CLAS12 data
8. LECCE	**29. DUNE** - Refurbishing of the KLOE calorimeter as an element of the DUNE near detector
9. LNF	**30. ATLAS** - 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
9. LNF	**31. ATLAS** - Test of the performances of the ATLAS MDT detectors at the Cosmic Ray Stand (CRS)
9. LNF	**32. CLAS12 RICH** - Physics analysis with the CLAS12 RICH

9. LNF	**33. CYGNO/INITIUM** - R&D for CYGNO/INITIUM experiment
9. LNF	**34. EIC** - SEY investigation of a-C coatings
9. LNF	**35. GGM** - Gas Gain Monitor (GGM) for the RPC detector of the CMS experiment at CERN
9. LNF	**36. LHCb** - Analysis of Run 2 and current Run 3 LHCb data
9. LNF	**37. PADME** - Search for the X17 anomaly in positron-electron annihilation events with the PADME experiment
9. LNF	**38. SIDDHARTA-2** - Kaonic atoms measurements at the DAFNE collider with the SIDDHARTA-2 experiment from particles to neutron stars!
9. LNF	**39. SPARC-LAB** - Measurement and tests of electro-optical femtosecond synchronization system for an electron linear accelerator (SPARC_LAB).
9. LNF	**40. VIP** - Tests of Quantum Mechanics within the VIP experiment: violation of the Pauli Exclusion principle and gravity related collapse models
10. LNGS	**41. CUPID** - Development of rare events (Neutrinoless Double Beta Decay) particle detectors at LNGS, in the CUPID experiment
10. LNGS	**42. LUNA** - Measurement of the gamma background of a shielded HPGe detector inside the LNGS underground laboratory
10. LNGS	**43. LUNA** - Measurement of the cross section and branching ratios of the 14N(p,γ)15O reaction at LUNA.
11. LNL	**44. OCRA** - Cosmic rays: what they are, how to observe them, how to measure them at sea level.
12. LNS	**45. CHIRONE** - Tagging System LNS Fragment Separator
12. LNS	**46. CHIRONE** - Experimental Activity in Neutron Detection Simulation
12. LNS	**47. DUNE** - Study of the performance of a Near Detector for the DUNE experiment at FNAL (USA)
12. LNS	**48. KM3NET** - Construction of the km3net high energy neutrino telescope at 3500 m depth offshore CapoPassero
13. MILANO	**49. AUGER** - Limits on the emission of ultra-high energy cosmic rays from known magnetars
14.NAPOLI	**50. DarkSide** - Characterization of SiPM based Photon Detection Modules for the DarkSide Prototype
14.NAPOLI	**51. DUNE** - Test of DUNE Vertical Drift Optical Module in Liquid Argon
15. PADOVA	**52. ENUBET** - Assembly and characterization of a large detector prototype for monitored neutrino beams (ENUBET project)
15. PADOVA	**53. LUNA** - Experimental design for Nuclear Astrophysics at LUNA
15. PADOVA	**54. RD_Mucol** - Study of detector performance at Muon Collider
15. PADOVA	**55. SWGO** - Study of the performance of a proposed high-altitude particle detector for gammaray astroparticle physics
16. PISA	**56. ATLAS** - Machine learning studies for particle trajectories reconstruction in ATLAS
16. PISA	**57. ATLAS** - Double Higgs and trilinear Higgs self coupling at the Large Hadron Colliders
16. PISA	**58. ATLAS** - Test of Photomomultipliers for the ATLAS Calorimeter Upgrade
16. PISA	**59. SWEATERS** - Characterization measurements of a gas detector based on bulk-MicroMegas technology for low energy ionizing particles of SWEATERS Project
16. PISA	**60. VIRGO** - Machine learning techniques for gravitational wave physics
16. PISA	**61. VIRGO** - Multimessenger study of transient sources
16. PISA	**62. VIRGO** - Laboratory measurements campaign by using high precision and low noise sensors for future Gravitational Waves detectors
17. ROMA	**63. AMS02** - Non-Target Effects induced Galactic Cosmic Rays in Exploratory Space Missions: Improvements using the AMS detector data
17. ROMA	**64. CYGNO** - Background studies for the CYGNO experiment with the LIME underground prototype
17. ROMA	**65. FOOT** - The FOOT experiment. Cross-Section measurements for Particle Therapy and Space Radiation Protection applications

17. ROMA	**66. LUNA** - Detector and target characterization measurements in the underground laboratory
18. ROMA TRE	**67. BELLE II** - SIPM studies for the KLM detector upgrade.
18. ROMA TRE	**68. DARKSIDE** - The DARKSIDE program for Dark Matter searching
18. ROMA TRE	**69. LEGEND-200** - Analysis of LEGEND-200 data with an innovative technique
19. TIFPA	**70. NuJET** - Neutrinos as engine for the production of relativistic jets
20. TORINO	**71. FUSION** - Modelling of laser-particle interaction for radioisotope production
20. TORINO	**72. LUNA** - Low energy nuclear astrophysics at LUNA (Laboratory for Underground Nuclear Astrophysics): study of the 21Ne(p,γ)22Na reaction
21. TRIESTE	**73. BELLE II** - Improving the photon-energy calibration for the Belle II detector
21. TRIESTE	**74. BELLE II** - Search for B → KS0 τ+τ- decays at the Belle II experiment
21. TRIESTE	**75. CTA** - Search for transient emission in CTA data
21. TRIESTE	**76. Fermi/LAT** - Search for short duration transient in Fermi/LAT data
21. TRIESTE	**77. SWGO** - Scientific simulation of the upcoming SWGO experiment

1. BARI

1. Fermi-LAT

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.

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

Activity period: June-July 2023 or September-October 2023

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

Other information: Institute will be closed August 7-18/08, 2023.

1. BARI

2. CTA

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 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.

Activity: 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 and trigger generation respectively. The student 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. Loporchio (serena.loporchio@ba.infn.it)

Activity period: June-July 2023 or September-October 2023

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

Other information: Institute will be closed August 7-18/08, 2023.

1. BARI

3. 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 analysed with Fermi-LAT data, in order to detect its gamma-ray emission and study the mechanisms originating this emission.

Activity: The student will learn how to analyse 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 2023

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

Other information: Institute will be closed August 7-18/08, 2023.

1. BARI

4. HEPAWtools

Title: HEP analysis workflow with cutting-edge

Description: In recent years, new technologies and new approaches have been developed in industry and academia to answer the necessity to both handle and visualize easily huge amounts of data, the so-called “big data”. Good examples are the PANDAS framework, which is an open source set of data analysis tools allowing data structures building and fast manipulation, and the Jupyter Notebook, which is a web application that allows users to create and share documents that contain executable live code. The combination of these two technologies may result in a powerful and easy-to-use tool for a data analyst in the context of High Energy Physics.

A student working on this project will join the efforts of the CMS Bari B-Physics group and will help to configure, test and document a complete HEP analysis workflow in a Jupyter environment, leveraging on tools such as uproot and RDataFrames, that easily allow the accessing and manipulating large datasets. These aspects have already been preliminarily studied in 2022 in the context of the DOE-INFN student exchange program and resulted in a contribution to the ACAT22 conference [1][2]. For 2023, we expect the work to be a continuation of last year's program, the results of which will be the starting ground for the new studies.

Thus, working completely within the Jupyter Notebook framework, as a first step, the student will learn how to preprocess, filter and skim, visualize and interpret the data typically produced by an HEP experiment. For this step, machine learning techniques will be explored as data selection tools with the aim of enhancing fake candidates’ rejection and signal extraction efficiency. Specifically, the student will learn how to use python-based libraries such as Keras, to develop, train and evaluate neural networks, and XGBoost that is widely used in the HEP community to design boosted decision trees.

Finally, the student will be introduced to the usage of GooFit, a tool that exploits the computational capabilities of GPU to perform maximum likelihood fits and that will come in aid when dealing with a highly populated dataset. As a physics application to carry out the project, we would like to extract, from the CMS Run-2 dataset, the signal associated with the rare decay such as, for instance, Bc → Psi(2S) Pi where Psi(2S) is reconstructed in its decays to 2 muons and to J/psi Pi Pi. We also expect a joint effort to document every step with the needed recipes that can be used in the future as material for teaching purposes as well.

All the studies described above will be conducted exploiting the resources provided by the ReCas-Bari HPC cluster, which hosts servers equipped with NVIDIA A100 GPUs [3].

The student should have a good background in Python programming. Some experience with C++ will be useful. Background in physics or statistics would also be useful. Our group is also in contact with a student association which arranges accommodation for visiting students and professors. Alternatively, an accommodation in the student dormitory of the University College might be arranged.

References

[1] https://indico.cern.ch/event/1106990/contributions/4998152/
[2] https://parallelhep.github.io/acat-2022-poster/
[3] https://www.recas-bari.it/index.php/en/

Further references:

https://jupyter.org
https://pandas.pydata.org
https://uproot.readthedocs.io/en/latest/
https://zenodo.org/record/260230#.Y86CqC9aZMA
https://github.com/GooFit/GooFit

Tutors:

Adriano Di Florio (adriano.diflorio@ba.infn.it)
Alexis Pompili (alexis.pompili@ba.infn.it)

Activity period: 2 months. June-July (highly preferred) or September-October

Local Secretariat: INFN BARI - Antonio Silvestri tonio.silvestri@ba.infn.it

Other information:

- https://www.ba.infn.it/index.php/it/
- Other information: Institute will be closed August 7-18/08, 2023.
- Price range for a private furnished room/studio: 500€/month in average

1. BARI

5. LHCb

Title: Study of the performance of new-generation eco-friendly gaseous detectors for the future LHCb Muon System.

Description: One of the challenges for future applications of gaseous detectors is the use of ecological gas mixtures with low impact on the environment, preserving their excellent performance in the harsh conditions expected at High Lumi LHC. In the framework of ongoing R&D activities for the Upgrade II LHCb Muon Detector, new detector technologies as well as new generation RPCs are being tested at INFN Bari and at CERN.
The student will work on thin RPCs, analysing data collected during beam tests at CERN. He/she will assess the detector efficiency as a function of the particle rate and characterize the detector performance with different gas mixtures. He/she will take part in the research activity carried on in the INFN Bari RPC Lab, gaining experience in detector operation, data acquisition and electronics. Basic knowledge of C++/Python programming is required.

Tutor:
Marilisa De Serio (marilisa.deserio@ba.infn.it)
Alessandra Pastore (alessandra.pastore@ba.infn.it)

Activity period: June-July 2023 or September-October 2023

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

Other information: Institute will be closed August 7-18/08, 2023.

2. BOLOGNA

6. ATLAS

Title: Quality Certification of the ATLAS ITk pixel modules

Description: ATLAS is one of the main experiments at the Large Hadron Collider at CERN. In 2026, to match/cope with the unprecedented and extremely demanding beam conditions of the High Luminosity LHC (HL-LHC), the ATLAS inner tracker will be completely replaced by an all-silicon detector, ITk, composed by pixel and strip modules. 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 the Quality Certification (QC) of pixel modules assembled by other groups. QC consists in several tests using local infrastructures in Bologna: visual inspection, thermal cycles, electrical and data transmission tests, cold tests, and so on.

Activities: The student will be deeply involved in QC with the infrastructures available in the Bologna laboratory. According to the student's inclinations and interests the work can focus on several activities:

- Pixel module visual inspection;
- Pixel module electrical tests and analysis of results;
- Pixel Module thermal cycles
- Development of the DAQ/DCS system

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

Tutor: Giuseppe Carratta (giuseppe.carratta@bo.infn.it), Carla Sbarra (carla.sbarra@bo.infn.it), Antonio Sidoti (antonio.sidoti@bo.infn.it)

Activity period: September/October 2023

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

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

2. BOLOGNA

7. EIC

Title: Commissioning of the EIC-dRICH SiPM readout prototype

Description: During the year 2023 a large-area SiPM-based photodetector for the EIC-dRICH prototype detector will be developed and constructed to be tested during future beam tests at the CERN-SPS, CERN-PS and other accelerator facilities. The prototype readout photodetector surface will be equipped with a complete readout chain of electronics and will need to be thoroughly tested in the laboratory before being installed on the actual EIC-dRICH detector prototype for beam tests. The commissioning of the SiPM photodetector and its readout will be carried out in the laboratories at INFN-Bologna. The readout prototype will be connected to all services needed to be operated and data will be collected to characterise the detector in a realistic running mode before the actual beam test operations. The person joining this projet will actively take part in the commissioning operations by helping local scientists to complete the final steps of the assembly of the photodetector prototype, to start with the data-acquisisition part of of the commissioning phase and to analyse the output data collected. The project might also include the possibility to participate in the preparations of the beam test itself with the installation and operations of the detector at CERN-PS.

Activities: EIC-dRICH SiPM readout prototipe, commissioning of the readout system in preparation of beam tests at the CERN-PS

Tutor: Roberto Preghenella (roberto.preghenella@bo.infn.it)

Activity period: 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 after the Summer closure period. The project might also include the possibility to participate to the actual beam tests at CERN.

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 (2016, 2017, and 2018). 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: *September 5th - October 31st 2023.*

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 2023.
More information on accomodation can be found on the website dedicated to the project at www.ca.infn.it .

3. CAGLIARI

9. LHCb

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 and pPb samples collected in 2015, 2016 and 2018, 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 2023.*

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 2023.
More information on accomodation can be found on the website dedicated to the project at www.ca.infn.it .

4. CATANIA

10. FRIDA

Title: Characterization of novel detectors for dosimetry of Ultra-High Dose-Rate (UHDR) beams for FLASH radiotherapy

Description: Preclinical studies have shown that the use of ultra-high dose rate (UHDR) beams may substantially improve normal tissue sparing (so-called FLASH effect) while maintaining high tumour control probability (TCP) compared to conventional dose-rate radiotherapy. FLASH radiotherapy is characterized by average dose rates of dozens/hundreds of Gy/s instead of only a few Gy/min of conventional radiotherapy. A great effort is nowadays addressed to understand the physical and biological mechanism behind the observed FLASH effect and to develop new technologies for accurate dosimetry and real-time monitorin of UHDR beams to facilitate the clinical transition of the FLASH radiotherapy. The activity proposed will be performed within the INFN project "FLASH Radiotherapy with hIgh Dose-rate particle beAms" (FRIDA) and will focus on the experimental characterization of novel technologies for dosimetry of UHDR beams. In particular, among the available technologies currently under investigation for this purpose at the INFN Catania Division, newly silicon carbide detectors (SiC) are being developed in collaboration with the ST-Lab start-up as alternative dosimeters and monitoring devices for UHDR beams. Single sensors with different thicknesses (0.1-20 um) and area (1-10 mm^2) have been already realized and proved to be perfectly linear with the dose-rate up to 5 MGy/s. In the perspective of clinical translation, a 2D geometrical configuration with high spatial resolution using multiple SiC detectors, is also currently under development with the specific aim to perform the measurement of the dose transversal profiles in the FLASH regime in a single-shot measurement. A small portable calorimeter is being also developed for absolute and reference dosimetry for UHDR electron and proton beams. The activity proposed will regard the experimental tests of the newly developed devices with both low and high dose-rate electron and proton beams in international facilities to test the response of the devices. Comparisons with standard reference dosimeters are also planned. Monte Carlo simulations through the Geant4 (GEometry ANd Tracking) toolkit will be also performed to model the devices. The student will have the possibility to both perform experimental activities and to learn a wide-spread multi-purpose simulation toolkit, which can be used for several other physical applications, tacking advantages from the presence of official Geant4 Collaboration Members present at the INFN Catania Division.

References

1. Francesco Romano, Claude Bailat et al., *Ultra-high dose rate dosimetry: Challenges and opportunities for FLASH radiation therapy*, *Med Phys.* 2022;1–21.
2. F. Romano, G. Milluzzo* et al., First characterization of novel Silicon Carbide detectors with ultra-high dose rate electron beams for FLASH radiotherapy, submitted to Applied Science *Corresponding author
3. G. Milluzzo, S. Capaccioli et al., "*Characterization of novel ultra-thin Silicon Carbide detectors with ultra-high dose rate electron beams for FLASH radiotherapy*", Flash Radiotherapy and Particle Therapy (FPRT 2022), Barcellona

Activities: Data analysis, Data acquisition, Monte Carlo simulations

Tutor: Francesco Romano (francesco.romano@ct.infn.it)
Giuliana Milluzzo (giuliana.milluzzo@ct.infn.it)

Activity period: June-July 2023

Local Secretariat: Anna Linda Magrì annalinda.magri@ct.infn.it
Other information: FRIDA web page: https://web.infn.it/FRIDA/index.php/en/
Local web page: https://www.ct.infn.it/it/frida
Geant4 web page: https://geant4.org

5. FERRARA

11. 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. One detector 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 module 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 Far Detector 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.

Activities: The student, joining the Ferrara group in Summer 2023, will have the opportunity to collaborate with the group and participate to the laboratory activities aimed to perform the quality assurance tests of SiPMs.

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 accommodation available in town. A Canteen and a lunch room are available in the University.

5. FERRARA

12. BESIII

Title: Study of benchmark channels of BESIII CGEM-IT

Description: The BESIII experiment program has been recently extended up to the 2030s together with an upgrade plan to both the detector and the accelerator. The CGEM-IT (Cylindrical Gas Electron Multiplies Inner Tracker) will replace the innermost part of the present drift chamber to increase radiation tolerance and rate capability, and improve spatial resolution along the beam axis for better vertex reconstruction and background rejection in complex topology decays. The first two layers are in IHEP since 2019 and the data have been used to tune the simulations and test the reconstruction capabilities. The candidate will work with CGEM-IT software experts to finalize the last studies on single particle reconstruction and later will test the capabilities with golden channels for the BESIII future program, to extract the impact of the CGEM-IT on the physics analyses and to provide information on which additional tools may be implemented before the CGEM-IT installation in 2024.

Activities: The activities will be focus on the development of the analysis code, and the comparison with the present drift chamber performance with the official BESIII software release. The candidate will work with C++ and will increase their knowledge on how the detector performance influences the physics analyses.

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. FERRARA

13. 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: 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. FERRARA

14. LHCb

Title: The Ring Imaging Cherenkov (RICH) detector upgrade project of the LHCb experiment: 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. The Ferrara University and INFN group is involved in both the RICH and Muon detectors.
Activities: The student, joining the Ferrara group in Summer 2023, 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 2023

***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

5. FERRARA

15. Medipix

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 2023, 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 2023

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

5. FERRARA

16. NA62/HIKE

Title: Development of the Small Angle Calorimeter for the High Intensity Kaon Experiments (HIKE) at the CERN Super Proton Synchrotron

Description: The Standard Model (SM) of particle physics describes the experimental results obtained so far by experiments with exceptional precision. The culmination of this success was the discovery of the Higgs boson by the ATLAS and CMS collaborations at the LHC in 2012. Thus the SM provides a solid foundation for the present understanding of elementary particles and their interactions. Despite this success, cosmological observations, experimental tensions, and theoretical motivations strongly suggest that the SM is an approximation of a more fundamental theory.
HIKE intends to study New Physics using kaon beams in both high-scale Beyond Standard Model and Feebly Interacting Particles directions. For more details, see *https://arxiv.org/abs/2211.16586*.
For the measurements of rare kaon decays hermetic photon vetoes/small angle calorimeter are required. For photons with energy, $E > 30$ GeV, the inefficiency must be very low ($< 10^{-4}$), while maintaining insensitivity to the nearly 600 MHz of neutral hadrons in the beam. A solution for this is the development of a new type of an ultra-compact electromagnetic calorimeter, made of inorganic scintillator crystals (PWO) with their lattice oriented along the beam direction.

Activities: During the two months of the internship, the student will participate in the design of the calorimeter prototype using the *Geant4*, an *Object Oriented* toolkit for the simulation of the passage of particles through matter (see *https://geant4.web.cern.ch/).* Furthermore, the student will be involved in the assembly of the first prototype made of a matrix of 3x3 PWO crystals and may participate to the foreseen test beam at CERN PS&SPS extracted lines.

Tutor: Dr. Laura Bandiera, bandiera@fe.infn.it – Dr. Gianfranco Paternò, paterno@fe.infn.it

Activity period: June-July or September-October

Local secretariat: Paola Fabbri, paola@fe.infn.it

Additional Information:
Summer break: circa August 7 – 20
Housing: Camplus Darsena city, (400 m from the university campus)
Canteen open at lunch-time in Campus Polo Scientifico e Tecnologico

5. FERRARA

17. 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.

6. FIRENZE

18. CMS

Title: Measurement of the Higgs boson production in the WW decay channel with the CMS experiment at LHC using Machine Learning techniques

Description: The candidate will join one of the leading groups involved in studying the Higgs boson decay to a W boson pair in the CMS collaboration.
After the Higgs boson discovery announced by the CMS and ATLAS collaborations in 2012, the precision measurement of its properties has become one of the main priorities of the two experiments. The proton-proton collisions at a center-of-mass energy of 13 TeV delivered during the Run 2 of the CERN Large Hadron Collider (LHC) allowed the collection of a large data sample, which opened new frontiers to study the details of Higgs boson physics and represented a change of paradigm: from seeking the Higgs boson to performing precision measurements. These are key measurements to expand our knowledge of the Higgs boson sector and to search for new physics that could show up in any deviation with respect to the Standard Model predictions. Among the Higgs boson decay channels, the one to a W boson pair (H→WW) followed by the leptonic W boson decays is characterized by a large branching ratio and a good signal sensitivity, besides the significant contamination of background processes sharing a similar final state. These features make the H→WW channel the perfect candidate both for precision measurements and for searches of new particles.
The Summer Exchange Program project will focus on the development of novel approaches extensively based on the usage of Deep Neural Network techniques, with the goal of improving the H→WW signal identification and reducing the background contamination. Moreover, the recent restart of the LHC at the unprecedented center-of-mass energy of 13.6 TeV marked the beginning of a new data acquisition campaign, and we can profit from the data collected by the CMS experiment at the new frontier energy to further improve these measurements.

Activities: Within the the CMS group of Firenze, the student will learn the basics of the statistical data analysis in the context of the H→WW measurements, as well as the tools to set up and optimize Deep Neural Network based algorithms. The ideal candidate should have a basic knowledge of programming and python scripting.

Tutor: Lorenzo Viliani lorenzo.viliani@fi.infn.it

Activity period: June-July or September-October

Local Secretariat: sig.ra Antonella Pagliai, antonella.pagliai@fi.infn.it, 055.4572074

Other information: INFN Firenze summer closure mid-August, http://www.fi.infn.it

6. FIRENZE

19. CMS

Title: Characterization of Si-pixel based detectors for CMS HL-LHC Upgrade

Description: You will join the development of cutting-edge technologies for upcoming particle physics experiments at HL-LHC.
The LHC machine, by which the Higgs boson has been unveiled, will be enhanced to boost the instantaneous luminosity up to 5-7.5×10^{34} $cm^{-2}s^{-1}$. This High Luminosity LHC program, HL-LHC, due to start in 2027, aims to reach integrated luminosities of 3000-4000 fb^{-1} over about a decade. To cope with this extreme scenario, CMS, one of the LHC experiments, will be substantially upgraded before starting the HL-LHC, a plan known as CMS Phase-2 upgrade. In particular the entire CMS Tracker will be rebuilt. The new apparatus will feature increased radiation hardness, higher granularity and capability to handle higher data rate and longer trigger latency.
The *Summer Exchange Program* project consists of participating to the extensive R&D program put in place to identify the Si-pixel detector suitable for instrumenting the innermost part of the new CMS Tracker. The current stage of the activity features 2- or 4-chips detector modules equipped with planar- and 3D- pixel sensors and prototype ASICs; these modules need to be characterized with respect to radiation hardness, efficiency, charge collection, spatial resolution, etc.

Activities: Within the CMS group in the INFN Firenze lab, you will learn how to use the FPGA-based data acquisition system to measure detector basic parameters and performance, configure testing procedures via python scripting and analyze results.

Tutor: Antonio Cassese, antonio.cassese@fi.infn.it

Activity period: June-July or September-October

Local Secretariat: sig.ra Antonella Pagliai, antonella.pagliai@fi.infn.it, 055.4572074

Other information: INFN Firenze summer closure mid-August, http://www.fi.infn.it

6. FIRENZE

20. GAMMA

Title: Data analysis and detector characterization in the framework of the AGATA project

Description: The INFN division of Florence, Italy, is one of the INFN divisions involved in the AGATA project. AGATA is a state- of- the- art gamma- ray spectrometer built by European institutions and is dedicated to studies in the fields of nuclear structure, reaction mechanisms and nuclear astrophysics. The spectrometer is the twin instrument to GRETA, the US equivalent project, and is presently installed at the INFN Legnaro National Laboratories in Padova, Italy. AGATA and GRETA are the very last generation spectrometers of their kind and are based on the reconstruction of the path of the gamma rays via tracking and pulse shape analysis techniques. The idea of these new methods is to exploit the high segmentation of the high- purity germanium (HPGe) detectors composing the spectrometer to avoid the use of the more commonly employed Compton suppressors, and gain in terms of detection efficiency without decreasing the sensitivity to weak transitions.
In Florence, we develop particle detectors to be used with AGATA and we perform experimental campaigns employing the low- energy Coulomb excitation technique, which is the primary experimental tool to study the shape and collectivity of atomic nuclei. The technique has the unique sensitivity to observables allowing for the extraction of parameters describing the shape of the ground and excited nuclear states, and it is therefore ideally suited to study quantum phenomena in nuclei such as shape coexistence, octupole deformations, and superdeformation.
Within the proposed project, the student will be part of our group and will work on testing and characterizing segmented silicon detectors, and on data analysis. The student will learn about semiconductor devices such as silicon and HPGe detectors, nuclear structure physics, and techniques such as gamma-ray tracking and pulse shape analysis.

Activities: To be chosen by the student (it is also possible to perform both activities):

1) Characterization of the SPIDER heavy-ion detector – The student will test and characterize the segmented silicon detectors composing SPIDER, which is used with AGATA, learning about semiconductor devices, signal treatment, and radioactivity measurements.
2) Data analysis of a low-energy Coulomb excitation experiment performed with AGATA and SPIDER to study quantum phenomena in the ^{96}Zr isotope – The student will contribute to the analysis of a dataset recently collected with AGATA and SPIDER to study some peculiar quantum features of the ^{96}Zr isotope, learning about data analysis techniques with common coding languages and nuclear physics software.

Tutor: Naomi Marchini (naomi.marchini@fi.infn.it), Adriana Nannini (adriana.nannini@fi.infn.it), Marco Rocchini (marco.rocchini@fi.infn.it)

Activity period: June-July or September-October

Local Secretariat: sig.ra Antonella Pagliai (antonella.pagliai@fi.infn.it)

Other information:
INFN Florence summer closure: mid-August
On-site canteen available
AGATA website: https://www.agata.org
INFN Florence website: https://home.infn.it/it/

6. FIRENZE

21. NUCLEX

Title: Activity of construction, assembling and testing of scintillating detectors for experiments with heavy-ions.

Description: The INFN division of Florence, Italy is one of the leader groups within the Indra-Fazia (Fazia since now) collaboration. Since more than one decade, Fazia is an international collaboration performing state-of-the-art experiments with heavy-ions, mainly at cyclotron energies (20-80 MeV/ u) using very performing modular detectors that are continuously upgraded, revised, improved between the data taking campaigns. The arrays under the responsibility of the Fazia collaboration and specifically of the Florence group are meant to measure and characterize (in terms of mass, charge and energy) the many charged reaction products produced during the nuclear collisions. In Florence, the group is responsible of most of the construction of detectors and their assembling, following each phase from the mechanical design and the integration studies to the final construction and testing of the sensors. These latter are both silicon detectors and scintillators. This project deals with the scintillators. The candidate will participate to the activity in the lab after a short initial training period to guarantee the necessary background to be collaborative and to appreciate the various aspects of the work to be done

Activities: The student will take part to the following specific tasks which are related to both ordinary construction and test of detectors of existing devices and activity on new detectors and/or photosensors to pave a possible road for future experiments for the detection on hard gammas together with charged ions as done so far.

- Assembling CsI(Tl) detectors and tests mainly with gamma source in lab
- Assembling some sample of different scintillators useful for photon detection; wrapping with various materials to improve light collection, measurements of E-spectra with photomultipliers and SiPM.
- Test of SiPM with conventional CsI(Tl) for the detection of charged particles
- Similar studies on organic scintillators, in view of fast beam monitors.

Background: The student will be introduced within the context of the team research by means of an initial phase where the local ongoing activity will be explained. According to the requests for the candidates applying to this Call, the student should/could have a minimum knowledge of detector electronics and of the basic principles of operation of detectors. The student's skill in computing and programming is not requested but it will ease the activity. As well, the manual ability in lab is not mandatory but it will be one of the aspects in which this specific fellowship can be quite beneficial for the future scientific activity of the candidate**.**

Tutor: Giovanni Casini

Activity period: September-October

Local Secretariat: Mrs. Antonalla Pagliai, pagliai@fi.infn.it

Other information: A cantine is present also for students in the Campus.

7. GENOVA

22. 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, we are responsible for the 3D modules, the technology chosen for the innermost layer thanks to their intrinsic radiation tolerance, the production of the forward support structures and their electrical services, the loading of the modules on these structures. All these activities are shared with other institutes of the ITk collaboration, in particular from US laboratories and universities.

Activities: The student will have a chance to participate to the assembly and test of the 3D modules, the development of the system test for the electrical qualification of several modules on a support structure; the optimization of the mechanical and thermal qualification of the supporting structures.

Tutor: Claudia Gemme (claudia.gemme@ge.infn.it)

Activity period: June-July or September-October

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

Other information: cheap accommodation is available in town. – sito web locale: www.ge.infn.it

7. GENOVA

23. 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.

Tutors: Simone Marzani (simone.marzani@ge.infn.it) and Federico Sforza (federico.sforza@ge.infn.it)

Activity period: 1st June – 31st July 2023

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

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

7. GENOVA

24. DUNE

Title: Tests of detector prototypes for imaging charged particle tracks in liquid Argon

Description: An innovative device for imaging particle tracks in liquid Argon by means of the scintillating light is currently under design. This device might be used for enhancing the capability of the Near Detector of the DUNE experiment for the neutrino interaction detection. Each camera is made by a lens optical system and a Silicon Photon Multiplier matrix. The first prototypes with different lens optical system have been built and they will be tested in a liquid Argon cryostat already available in the Genova laboratory. Firstly, some tests will be performed by using a point-like artificial vacuum ultraviolet light source for characterizing the sensors, secondly the detection of cosmic muon by means of the scintillation light observed by three cameras will be proved and the track reconstruction performances will be evaluated

Activities: The student will perform tests of the prototypes for characterizing the new devices and for comparing the point spread function of each lens optical system. Then the reconstruction performance for point source and for muon track will be evaluated and compared with respect to the simulations results. During the training period, the student will have the opportunity to work with a cryogenic apparatus and to study all the aspect of the prototypes design and of the readout chain and data acquisition. Finally, he/she will develop software tools for the data analysis.

Tutor: L. Di Noto

Activity period: September - October

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

Other information: https://www.ge.infn.it/wordpress/

7. GENOVA

25. EIC_NET

Title: Streaming DAQ for the future Electron-Ion Collider

Description: Thanks to recent developments in computing and networking, the particle physics experiment trigger scheme based on FPGA is being replaced by streaming readout approaches, in which every detector channel is read out independently and all data above a minimum threshold are transferred to a CPU farm for further processing. This scheme has the advantage of simplifying the trigger implementation, since this can be developed using high-level programming languages (C++, JAVA, Python, ...), and increasing the versatility of the system in adapting to diverse experimental conditions. During this stage, the student will participate in the validation tests of a prototype of a triggerless readout system designed for the readout of an electromagnetic calorimeter for the future Electron-Ion Collider in the US. The experimental activity will include the optimization of the setup consisting of a matrix of scintillating glasses, the streaming readout with commercial and custom digitizers, the data recording and processing with TRIDAS (TRIggerless Data Aquisition System), and the implementation of different trigger conditions.

Tutor: M.Battaglieri

Activities: Attività (optional)

Tutor: Marco Battaglieri (marco.battaglieri@ge.infn.it)

Activity period: June – July or September – October

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

Other information: www.jlab.org/Hall-B/clas12/ and www.ge.infn.it

7. GENOVA

26. ICARUS

Title: Neutrino events reconstruction with Time Projection Chamber detector in the ICARUS experiment

Description: The ICARUS experiment at the Fermi National Accelerator Laboratory, started the data taking on November 2020 and together with the SBND and MicroBooNE experiments will address the possible existence of the 1 eV mass scale sterile neutrinos. The detector is a 600 ton liquid argon Time Projection Chamber (TPC), located on axis along the Booster Neutrino Beam and designed for detecting muon and electron neutrino interactions in the liquid argon volume.
In a Time Projection Chamber the energy deposited by the charged particles is acquired by 3 planes of wires, which will provide two coordinates of the 3D tracks in the detector volume, while the third coordinate, along the drift direction, will be identified by the light signal acquired by photo-multiplier tubes. Thus, the event reconstruction by means of the wires signal is a crucial tool for achieving the final goal of the ICARUS experiment.
This training program is focused on the data analysis and Monte Carlo simulation of the events detected by the ICARUS TPC detector and in particular on the 3D reconstruction of the tracks and showers in neutrino events.

Activities: The student will learn to work with the common physics software package LArSoft, specifically created for the simulation, reconstruction and analysis of events in liquid argon TPCs, and will be involved in the optimization of the algorithm which, starting from the raw signals, leads to the reconstruction of the final 3D track in the liquid argon volume. He/she will work both on the Monte Carlo simulation data for optimizing the algorithm and for understanding the systematic effects and on acquired data. Finally, she/he will contribute to evaluate the overall performance for the selection and reconstruction of the different particles emitted by neutrino events.
During the training period, the student will have the opportunity to spend a big fraction of the time devoted to the comprehension of the detector functionality together with the development of software tools for the analysis.

Tutor: S. Di Domizio

Activity period: June - July

Local Secretariat: Eleonora Ferroni, Eleonora.Ferroni@ge.infn.it

Other information: https://www.ge.infn.it/wordpress/

7. GENOVA

27. JLAB12

Title: BSM searches at Jefferson Lab

Description: The JLAB12 experiment includes all INFN-Italy activity at Jefferson Lab (USA). The Genova Group is deeply involved in the hadron spectroscopy program of the CLAS and CLAS12 experiments and in novel searches for BSM physics.

- Precision data collected with the CLAS and CLAS12 detectors provide new insight into the hadron structure and spectrum. New methodologies are under study to exploit the large statistics of the CLAS/CLAS12 data and extract the information preserving correlations between variables of measured particles. In particular, the use of AI/ML has already been demonstrated to be a powerful tool to learn about subtle features of the data, providing a completely new way to extract the physics information. In collaboration with the JLab Theory Group and ODU Data Science Dept. we developed a new method based on Generative Adversarial Networks (GANs) to reproduce and interpret CLAS and CLAS12 spectroscopy (2pi photoproduction) and SIDIS (single pion semi-inclusive DIS) data. The student will learn the methodology and join the ongoing effort to extend the method to other reaction channels.

Within these frameworks, we can provide two summer-student activities, one related to the Meson-Ex experiment and the other on Light Dark matter search. For further information see:

Activities: Attività (optional)

Tutor: Marco Battaglieri (marco.battaglieri@ge.infn.it), Raffaella De Vita (devita@ge.infn.it)

Activity period: June – July or September – October

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

Other information: www.jlab.org/Hall-B/clas12/ and http://www.ge.infn.it

7. GENOVA

28. JLAB12

Title: AI-supported analysis of CLAS and CLAS12 data

Description: The JLAB12 experiment includes all INFN-Italy activity at Jefferson Lab (USA). The Genova Group is deeply involved in the hadron spectroscopy program of the CLAS and CLAS12 experiments and in novel searches for BSM physics.

- Search for physics beyond the Standard Model can be carried out with high-precision experiments in the GeV energy range. Failure in direct observation of Dark Matter in the 10 GeV – 10 TeV mass range suggests extending the hunting territory at lower masses (1 MeV -1 GeV), opening up new opportunities for accelerator-based experiments. Light dark matter fermions and bosons, carriers of new interaction, are actively searched for in several experiments running at Jefferson Lab (APEX, HPS, BDX, Dark Light ...). The Genova Group is leading the R&D program for the new Beam Dump eXperiment (BDX) which is being proposed at Jefferson Lab as a new facility for light-dark matter search. We are currently studying the experimental sensitivity to a new scalar particle produced by secondary muons in the beam dump. The student will work on simulations and detector tests in the Genova Lab.

Within these frameworks, we can provide two summer-student activities, one related to the Meson-Ex experiment and the other on Light Dark matter search. For further information see:

Activities: Attività (optional)

Tutor: Marco Battaglieri (marco.battaglieri@ge.infn.it), Raffaella De Vita (devita@ge.infn.it)

Activity period: June – July or September – October

Local Secretariat: Eleonora Ferroni (eleonora.ferroni@ge.infn.it)

Other information: www.jlab.org/Hall-B/clas12/ and http://www.ge.infn.it

8. LECCE

29. DUNE

Title: Refurbishing of the KLOE calorimeter as an element 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 detection of neutrinos from SuperNova, the measurement of mass hierarchy and CP violation in the neutrino sector. A wide-band neutrino beam will be generated at Fermilab and monitored by a Near Detector (ND). Then the neutrino flux will be studied by a Far Detector at a distance of 1300 km. At present KLOE superconducting magnet and calorimeter are at the national Frascati laboratories in Italy. The refurbishment of the calorimeter is required to reuse them as ND with the acronym SAND (System for on-Axis Neutrino Detection). The introduction of high resolution TDC and the measurement of the Time-Over-Threshold will allow to avoid the ADC use for measurement of the energy release. Furthermore, the HV system for photomultipliers must be updated and remotely controlled, the calorimeter modules must be tested with cosmic rays before the shipment to USA. 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 in laboratory to test calorimeter performances
Software activity for event reconstruction and background removal

Tutor: Paolo Bernardini

Activity period: September-October 2023

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

9. LNF

30. ATLAS

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: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

31. ATLAS

Title: Test of the performances of the ATLAS MDT detectors at the Cosmic Ray Stand (CRS).

Description: Candidate will have the opportunity to work in a fully working Cosmic Ray Stand to reconstruct muon tracks via highly performing gas detectors such as the ATLAS Monitored Drift Tubes (MDTs). MDTs were produced at LNF and are still working in the ATLAS experiment at CERN. One of the most interesting parts will be to understand how to run a detector, to acquire and analyze data. Such points are of fundamental importance and the candidate will be able to understand and follow the full chain up to the data acquisition and analysis. Concerning the analysis, the final step would be to use the MDT CRS for tomography of a brick. Using gas detector telescopes for tomography is a recent technology developed for archeological and geological purposes. For the broadness of the arguments touched and for its complete view of a detector running, we really encourage students to take part to this activity.

Activities: working in a laboratory, understanding how to run a detector, analysis coding, team building.

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

Activity period: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

32. CLAS12 RICH

Title: Physics analysis with the CLAS12 RICH

Description: The Thomas Jefferson National Accelerator Facility (Jefferson Lab), in Newport News, VA (USA), is one of the leading facilities in the study of the internal structure of the nucleon. High intensity and high polarization electron beams are scattered by hydrogen or nuclear targets, producing various particles in the final state. The accurate measurement of the rate and angular distributions of these particles allows to extract information on the quark and gluon structure of the nucleon. The CLAS12 detector in Hall B at Jefferson Lab is able to perform these measurements over a wide kinematic acceptance. Two Ring Imaging CHerenkov (RICH) detectors have been built by INFN to extend the particle identification capabilities of CLAS12 to kaons in the momentum range between 3 and 8 GeV/*c*. This is allowing CLAS12 to extend to study of the nucleon structure in kinematic regions otherwise not accessible. A wealth amount of data has been collected so far and more measurements are underway.
The student will perform the physics analysis of channels involving charged kaons in the final state in the so-called Deep Inelastic Scattering region. The work will involve the analysis of single hadron (example: $ep \rightarrow eK^{+}X$ and $eK^{-}X$) channels and can be extended to di-hadron channels (example $ep \rightarrow epKX$) channels.

Activities: The student will perform the physics analysis of channels involving charged kaons in the final state using the two RICH detectors for particle identification. Comparison of kaon identification with and without the RICH will provide pion/kaon misidentification ratios for the four out of six CLAS12 sectors not instrumented with RICH. By the end of this internship, benchmark observables (like for example the beam spin asymmetry) will be extracted in a fully multidimensional analysis.

Tutor: Marco Mirazita (marco.mirazita@lnf.infn.it)

Activity period: June-July 2023

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.
LNF Summer closing period: 7-18 August 2023.

Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

33. CYGNO/INITIUM

Title: R&D for CYGNO/INITIUM experiment

Description: LIME, part of the CYGNO/INITIUM roadmap, is the first prototype of the CYGNO experiment (https://web.infn.it/cygnus/) dedicated to the development of a large gas Time Projection Chamber with optical read-out dedicated to the search of dark matter and the study of solar neutrinos. LIME has been installed at the LNGS of the INFN and is collecting data available for analysis to define and optimise preliminary algorithms from DM and Neutrino search.
Moreover, at the LNF, some prototypes are under testing for the final choice of materials and low radioactivity components (GEM, cathode, fried cage, etc) for the final detector CYGNO04 that will be installed at LNGS in 2015.
Activities: The candidate, depending on them skills and interests, will be included in the R&D activity of the LNF group by participating in the laboratory tests and in the implementation of the experimental setup, calibration and data taking and analysis from the LNGS. Keywords: scientific CMOS sensors, Optical Read Out, Gas Electron Multiplier, low radioactivity components, Python, clustering, PID.

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

Activity period: June-July 2023.

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

34. 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.

Activities: Experimental activities

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

Activity period: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.

Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

35. GGM

Title: Gas Gain Monitor (GGM) for the RPC detector of the CMS experiment at CERN

Description: the candidate will collaborate in the upgrade of the GGM both in the hardware and both in the software part of the system.

Activities: programming (C, C++)

Tutor: Luigi Benussi (luigi.benussi@lnf.infn.it)

Activity period: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

36. LHCb

Title: Analysis of Run 2 and current Run 3 LHCb data

Description: The LHCb experiment is one of the four large detectors on the Large Hadron Collider (LHC) accelerator at CERN, and its primary purpose is to search for new physics through studies of CP-violation and rare decays of heavy-flavour hadrons. Although LHCb was designed primarily for precision measurements in heavy-flavour physics, the experiment has demonstrated excellent capabilities in many other domains ranging from electroweak physics to heavy ion and fixed target physics. LHCb has been successfully operated from 2010 to 2018 during the LHC Run 1 (2010–2012) and Run 2 (2015–2018) with excellent performances. Between 2019 and 2022, the LHCb detector has been almost fully renewed to allow running at an instantaneous luminosity five times larger than that of the previous experiment. In addition, an all-software trigger will allow to fully reconstruct the events at the maximum LHC bunch crossing rate of 30 MHz, and to select the physics signals in real time. From Spring 2022, with the start of LHC Run 3, LHCb is commissioning the upgraded detector. A bunch of data has been collected at the end of 2022 and are being analysed while preparing the restart of data taking in Spring 2023.
The large LHCb Frascati group is deeply involved in all the ongoing experimental activities. These range from the operation of the detector to the data analysis for flagship measurements (in particular of semileptonic and rare B-decays which provide sensitive probes to search for new particles beyond the Standard Model), from the commissioning of the upgrade (in particular of the Muon System and the first internal fixed gas target at the LHC, called SMOG2) to the R&D in view of possible future upgrades after LS3 and LS4 of the LHC.

Activities: The student will be deeply involved on key aspects of the data analysis. Depending on his/her interests and when he/she will be with us, the work can focus on:
• ***Semileptonic B-decays***: developments of novel algorithms to control the selection efficiencies; optimisation of control samples to study the most dangerous backgrounds; improvements of the resolution of the signal kinematic using Machine Learning techniques.
• ***Rare B-decays***: studies to reduce the background due to the mis-identification of the charged particles using data control samples and new techniques, including modern machine learning (background reduction is of paramount importance to improve the rare B-decays results that can be achieved with the upcoming Run 3 data).
• ***Software Trigger***: GPU software development for real-time muon identification in the first level of the trigger (HLT1).
• ***Fixed target***: analysis of the first data collected in 2023 will allow to have the first hints of Transverse Momentum Distribution (TMD) measurements by performing some comparison with the future Electron-Ion Collider (EIC) potentialities.
Some knowledges in computing (e.g. python, C++, root) are desirable but not mandatory.

Tutor:
Barbara Sciascia (barbara.sciascia@lnf.infn.it) LHCb group leader; the student will actually work with one or more of the LHCb researchers depending on the specific item.

Activity period: 5 June – 4 August 2023 or 4 September – 3 November 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

37. PADME

Title: Search for the X17 anomaly in positron-electron annihilation events with the PADME experiment

Description: Studying the de-excitation, via electron-positron pairs production, of some light nuclear systems, a research group based at the ATOMKI of Debrecem has recently observed an anomaly that can be explained postulating the existence of a proto-phobic boson of mass 17 MeV/c^2 (X17). If confirmed, this new particle would represent the first evidence of a dark matter signal.
The Positron Annihilation into Dark Matter Experiment (PADME) was conceived to search for invisible decays of a dark photon produced in the process $e^+e^- \rightarrow \gamma$ A', with the A' undetected. By changing the energy of the incoming positron beam, PADME can try to produce resonantly the X17 boson. The data taking devoted to this study took place in the second half of 2022 and now the PADME collaboration is performing the analysis to confirm/disprove the existence of this new state.

Activities: The candidate will participate to the data analysis devoted to the search of the X17 particle.

Tutor: Paola Gianotti (paola.gianotti@lnf.infn.it)

Activity period: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.

Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

38. SIDDHARTA-2

Title: Kaonic atoms measurements at the DAFNE collider with the SIDDHARTA-2 experiment from particles to neutron stars!

Description: SIDDHARTA-2 experiment aims to perform the first measurement in the world of the X-ray transitions in the kaonic deuterium exotic atom, which will help to understand the strong interaction described by the Quantum ChromoDynamics (QCD) theory in the non-perturbative regime in systems with "strangeness" (i.e., with strange quarks). The SIDDHARTA-2 experiment will measure the X rays produced in the de-excitations of kaonic deuterium by using new Silicon Drift Detectors developed to perform precision X-ray spectroscopy and which can have applications going from physics and astrophysics to industry and medicine. SIDDHARTA-2 is installed on DAFNE, an electron-positron collider delivering kaons, and will be in data taking in 2023, a very exciting period for a student! The kaonic deuterium measurement plays a fundamental role in understanding how QCD works, 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 optimizations of various detector sub-systems and of the data taking chain, along the run and data analyses. He/she will be also introduced to data analyses and advanced Monte Carlo simulations
Reference: The modern era of light kaonic atom experiments, C. Curceanu et al., Rev. Mod. Phys. 91, 025006 (2019)

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

Activity Period: June-July or September-October 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

39. SPARC-LAB

Title: Measurement and tests of electro-optical femtosecond synchronization system for an electron linear accelerator (SPARC_LAB).

Description: The student will be involved in the activities of the Radiofrequency group of the Accelerator Division of LNF concerning the synchronization system upgrade. Tests on fast photodetectors, fiber lasers, optical and radiofrequency devices, fast locking electronics (PLLs) will be carried out during the stay.

Tutor: Luca Piersanti (luca.piersanti@lnf.infn.it), Marco Bellaveglia (marco.bellaveglia@lnf.infn.it)

Activity period: September-October 2023

Local Secretariat: Maria Rita Ferrazza, ad.secretariat@lists.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: 7-18 August 2023.

Local web page: http://user.lnf.infn.it/summer-student-opportunities/

9. LNF

40. VIP

Title: Tests of Quantum Mechanics within the VIP experiment: 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 Schroedinger equation within the so-called collapse models. The VIP collaboration developed a series of radiation detectors and data analyses methods which allowed to set extremely competitive limits on PEP violation and collapse models. Presently, the experimental apparata are under optimization, in parallel with the data taking and data analyses, to either set even stronger limits or find signals of violations of standard quantum mechanics, which, of course, would be initiating a revolution. The obtained results are also important for quantum technologies.

Activity: The student will be involved in all the exciting phases of the experiment, from the preparation and testing of detector systems to data analyses using advances statistical analyses 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 2023

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.
LNF Summer closing period: 7-18 August 2023.
Local web page: http://user.lnf.infn.it/summer-student-opportunities/

10. LNGS

41. CUPID

Title: Development of rare events (Neutrinoless Double Beta Decay) particle detectors at LNGS, in the CUPID experiment.

Description:
CUPID (Cuore Upgrade with Particle IDentification) is the successor of the CUORE experiment, searching for neutrinoless double beta ($0\nu\beta\beta$) decay with Li_2MoO_4 scintillating crystals enriched in ^{100}Mo. The crystals are operated simultaneously as bolometric and scintillation detectors. The student will take part in the preparation and running of innovative tests for particle detectors (preparation, installation, data-taking and analysis) and will get familiar with bolometric particle detectors. Basic knowledge of particle physics is preferred.

Tutor: Paolo Gorla (paolo.gorla@lngs.infn.it)

Activity period: June-July 2023 or 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: 2, further information on CUPID: https://www.lngs.infn.it/en/pages/cupid-en

10. LNGS

42. LUNA

Title: Measurement of the gamma background of a shielded HPGe detector inside the LNGS underground laboratory.

Description:
The Laboratory for Underground Nuclear Astrophysics (LUNA) experiment, located at Laboratori Nazionali del Gran Sasso (LNGS) underground laboratory in Italy, aims to study the 12C+12C reaction via photon detection at the new LUNA-MV accelerator. A key component of this experiment is the use of 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. The goal of this internship is to measure the background of this detector and to characterize it accurately in order to optimize its performances and enhance the sensitivity of the LUNA experiment to the 12C+12C reaction cross section. This measurement will be carried out using advanced equipment and data analysis methods, as well as Monte Carlo simulations.

Tutor: Federico Ferraro (federico.ferraro@infn.it), Riccardo Gesuè (gesue.riccardo@gssi.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. LNGS

43. LUNA

Title: Measurement of the cross section and branching ratios of the $^{14}N(p,\gamma)^{15}O$ reaction at LUNA.

Description:
This internship project aims to measure the cross section and branching ratios of the $^{14}N(p,\gamma)^{15}O$ reaction at LUNA (Laboratory for Underground Nuclear Astrophysics). The $^{14}N(p,\gamma)^{15}O$ reaction plays a crucial role in the nucleosynthesis of elements in stars and is particularly important for understanding the production of neutrinos in the CNO cycle. The internship will involve the use of a state-of-the-art accelerator and detector setup to accurately measure the cross section and branching ratios at the energies relevant to stellar conditions. The data obtained will be analyzed using advanced nuclear physics techniques and will be compared to theoretical models. This project will provide students with hands-on experience in experimental nuclear physics and the opportunity to contribute to the study of the fundamental processes that make stars shine.

Tutor: Ferraro Federico (federico.ferraro@infn.it), Alessandro Compagnucci (alessandro.compagnucci@gssi.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/

11. LNL

44. OCRA

Title: Cosmic rays: what they are, how to observe them, how to measure them at sea level.

Description: The standard cosmic ray detection technique based on plastic scintillators will be used. In the National Laboratories of Legnaro (LNL) a muon telescope and two single plastic scintillators with the necessary electronic chains for coincidence mode measurements are available and usable. The data analysis for the verification of the muon flux measurement as a function of the inclination angle of the telescope detectors and as a function of the position of the scintillators with respect to the east-west direction can be performed.

Activities: Data analysis; measurement of the effects of varying environmental conditions (temperature, humidity, atmospheric pressure) on the average values of the muon flux.

Tutor: Stefania Canella, Marco Cinausero

Activity period: About 9 weeks from the beginning of June 2023 to the end of July 2023.

Local Secretariat: Luisa Pegoraro
Servizio di Direzione dei LNL
luisa.pegoraro@lnl.infn.it

Other information: (local web-site www.lnl.infn.it)

Free lunch at LNL Canteen
LNL Free Guesthouse

12. LNS

45. CHIRONE

Title: TAGGING SYSTEM LNS FRAGMENT SEPARATOR

Description: The new LNS fragment separator – FRAISE - is going to be installed. More intense radioactive beams will be available on 2023. To use these beams, we need to develop a tagging system able to event by event identify the beam in charge, mass, energy and impinging angle. This will be done using a new tagging system based on silicon carbide detectors able to sustain a yield of 10^7 particle/sec without large radiation damage. Various tests of the system must be performed to understand the its performances. Fundamental will be the synchronization between the ACQ system of the different tagging detectors that will be operated along the fragment separator and the main ACQ system of the experiment using the tagged beam.

Activities: The student will perform test with sources of the tagging system, test with random pulse generators for the synchronization of different ACQ and data analysis.

Tutor: RIZZO Francesca (rizzo@lns.infn.it), MARTORANA Nunzia Simona martorana@lns.infn.it), CARDELLA Giuseppe (Giuseppe.cardella@ct.infn.it)

Activity period: settembre-ottobre

Local Secretariat: N.Schilirò (schiliro@lns.infn.it)

Other information: web site of the laboratory www.lns.infn.it – availability of ticket lunch.

12. LNS

46. CHIRONE

Title: EXPERIMENTAL ACTIVITY IN NEUTRON DETECTION SIMULATION

Description: the CHIRONE group is involved in the design and construction of the NArCoS (Neutron Array for Correlation Studies) detector array. Its prototype consists of 64 elementary cells of the plastic scintillator EJ-276G read by a SiPM, assembled in a linear cluster configuration containing four elementary cells. In the prototype 16 clusters will be assembled in a cubic geometry.
The study and construction of such proton-recoil neutron detector has been recently financed by the national PRIN2020 funding call, the name of the project being ANCHISE. The neutrons and charged particles detection at the same time is a goal that the community wants to reach in the next years, in particular with the advent of the new facility for Radioactive Ion Beams (RIBs) line FraISe, under construction at LNS.

Activities: During the stay, the student will be engaged principally in simulation activities, using the GEANT4 simulation toolkit to study the detector response with a detailed attention to the cross-talk problematic.

Tutor: RIZZO Francesca (rizzo@lns.infn.it), PAGANO Emanuele Vincenzo epagano@lns.infn.it), RUSSOTTO Paolo (russotto@lns.infn.it)

Activity period: settembre-ottobre

Local Secretariat: N.Schilirò (schiliro@lns.infn.it)

Other information: web site of the laboratory www.lns.infn.it – availability of ticket lunch.

12. LNS

47. DUNE

Title: Study of the performance of a Near Detector for the DUNE experiment at FNAL (USA)

Description: After the Big Bang, matter and antimatter were created equally, but now matter dominates. The study of the properties of neutrino and antineutrino oscillations to determine if charge parity (CP) symmetry is violated in the lepton sector is currently the most promising way for understanding this asymmetry. The main objective of the DUNE experiment is the measurement of the CP violation in the leptonic sector with high sensitivity (> 5 sigma). Neutrino and anti-neutrino oscillations will be measured at 1300 m from the production site in the so-called FAR detector. In order to monitor the beam and control the systematics a Near Detector (ND) close to the beam production site is necessary. Moreover the ND can exploit the unique features of (anti)neutrinos to study fundamental interactions with unprecedented precision.The LNS team is working on several topics including simulations finalized to the optimization of the ND performances. The students will have the opportunity to join the activities of the team with special focus on the development of simulations of the ND detector.

Activities: Attività (optional)

Tutor: DISTEFANO Carla (distefano_c@lns.infn.it)

Activity period: settembre-ottobre

Local Secretariat: N.Schilirò (schiliro@lns.infn.it)

Other information: web site of the laboratory www.lns.infn.it – availability of ticket lunch.

12. LNS

48. KM3NET

Title: Construction of the km3net high energy neutrino telescope at 3500 m depth offshore CapoPassero

Description: High energy cosmic neutrinos were discovered in 2013 by the IceCube collaboration by means of a deep under-ice cubic kilometer telescope. This discovery opened the era of (high energy) neutrino astronomy in the very exciting and expanding field of multimessanger physics for the investigation of the violent Universe. The LNS km3net team is very active in the construction of the underwater cubic kilometer telescope for high energy neutrinos in the Mediterranean sea at 3500 depth 100 km off-shore Capo Passero. The list of activities is very large and includes construction, sea operations and installation, data taking and data analysis. The students will participate to various aspects of the projects contributing to the realization and exploitation of a gigantic, very challenging detector. km3net will be in operation for more then 10 years and it is expected to produced science at the frontier of our knowledge in synergy with photon, Gravitational Waves and cosmic ray observations.

Activities: Attività (optional)

Tutor: SAPIENZA Piera (sapienza@lns.infn.it)

Activity period: settembre-ottobre

Local Secretariat: N.Schilirò (schiliro@lns.infn.it)

Other information: web site of the laboratory www.lns.infn.it – availability of ticket lunch.

13. MILANO

49. AUGER

Title: Limits on the emission of ultra-high energy cosmic rays from known magnetars

Description: Ultra-high energy cosmic rays (UHECR) are the most energetic particles ever measured. Their sources are still unknown, though the most plausible candidates are AGNs and particular types of compact objects such as magnetars. Magnetars are highly magnetized neutron stars and some models predict that under certain conditions they can emit cosmic rays up to the highest energies. Few magnetars are known in our Galaxy, and the results of the measurements made by the Pierre Auger Observatory exclude that the majority of UHECR come from our Galaxy. This, however, does not rule out that magnetars are the sources of UHECR: they might be able to accelerate up to the highest energies only in the very first stages of their life, and the flux we observe now might come from magnetars in nearby galaxies. However, since we can estimate the age of the observed magnetars in our Galaxy and we know their position we can put limits on their emission at birth, thanks to the presence of the Galactic Magnetic Field that deflects and thus delays cosmic rays.

Activities: The activity would be carried out within the Pierre Auger Observatory group at the INFN and university of Milan. The Pierre Auger Observatory, located in Argentina, is the largest UHECR detector in the world and is operative since 2004. The student will be able to use dedicated software to simulate the galactic magnetic field deflection from the different positions of the known magnetars. Different spectra and composition at birth will be simulated and then propagated and compared with the spectrum, composition and arrival directions distributions the Pierre Auger Obsevatory has measured in nearly 20 years of operation to place limits on the accelerating capabilities of magnetars. We will have the opportunity of discussing these results with the compact object experts at the nearby group of the National Institute of Astrophysics (INAF) in Milan.

Tutor: Lorenzo Caccianiga lorenzo.caccianiga@mi.infn.it

Activity period: either june-july or september-october

Local Secretariat: Silvia Rognoni silvia.rognoni@mi.infn.it

Other information: group site https://www0.mi.infn.it/auger/

14. NAPOLI

50. 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, low-background 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

14. NAPOLI

51. 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 photons 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.
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 30, 2023
September 1 – October 30, 2023

Local Secretariat: Adelaide Aversano

Other information: www.na.infn.it

15. PADOVA

52. ENUBET

Title: Assembly and characterization of a large detector prototype for monitored neutrino beams (ENUBET project)

Description: The ENUBET experiment is promoting a new approach to produce neutrino beams with an unprecedented precision. This new approach consists in measuring charged leptons associated with neutrinos at the moment of the decay of the unstable mesons from which they derive, exploiting in particular the semi-leptonic decays of the K mesons. In this way there is no need to rely on complex simulations that come with a large budget of systematic uncertainties. The project led to the development of a large detector prototype to demonstrate the feasibility of this idea. The demonstrator has collected data collected in October 2022 at the PS accelerator of CERN. It is an object of about 3.5 tons that reproduces a 90-degree fraction of an instrumented "decay tunnel". It was exposed to beams of pions, muons and electrons from 1 to 5 GeV/c at the T9 area of CERN-PS. We are studying the uniformity of the channels, the energetic resolution for the electrons and the ability to distinguish electrons and muons from pions that constitute the main background. In parallel the detector, which is currently at the INFN Legnaro laboratories, is being significanlty extended by adding additional readout channels.

Activities: the student could be involved in the construction activities of an extended prototype that will be exposed again at CERN in September 2023 (hardware) and/or eventually in the analysis of the data collected during the test beam (software).

Tutor: Andrea Longhin

Activity period: Periodo di 2 mesi (circa 9 settimane) giugno-luglio

Local Secretariat: Pina Salente pina.salente@pd.infn.it

Other information: http://enubet.pd.infn.it

15. PADOVA

53. 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. The $^{14}N(p,\gamma)^{15}O$ reaction is the first reaction to be investigated within the dense program of the new facility. This is the bottleneck reaction of the CNO cycle and therefore it controls the entire cycle with huge impact on solar neutrinos. The measurements of neutrino flux from the Sun is one of the main tool to understand the metallicity in the Sun interior and therefore a precise knowledge of the $^{14}N(p,\gamma)^{15}O$ reaction is crucial. The study of this reaction will be performed by the LUNA collaboration whose efforts will cover all aspects of the experimental design and the measurement fulfilment: from target preparation, detection installation and characterization to data taking and analysis. The targets will be indeed prepared by the National Laboratories of Legnaro (LNL) which is an important INFN laboratory located at 10 km distance from the Padua city center.
The candidate will focus on the experimental design, working on the characterisation of the setup with the LUNA simulation code 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 campaign having the opportunity to work in two Italian national laboratories.

Tutor: Antonio Caciolli (antonio.caciolli@pd.infn.it)

Activity period: June – July or September – October 2023

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

Other information: https://www.pd.infn.it/eng/luna/

15. PADOVA

54. RD_Mucol

Title: Study of detector performance at Muon Collider

Description:

The Muon Collider is one of the most promising machines for the future of particle physics with accelerators. It puts together the advantages of having relatively clean events as in lepton colliders, and the possibility to reach high collision energy as in hadron colliders, since bremsstrahlung is very limited. Muon collisions at multi-TeV center of mass energies are ideal for studying Higgs boson properties. At these energies the Higgs production rates will allow precise measurements of its couplings to fermions and bosons.

The main challenge is the reconstruction of physics objects in the presence 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 to the experiment performance and it is significantly different from what is experienced in hadron and electron-positron colliders. For this reason all the studies should be performed with a detailed simulation of the detector. 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 or in the calorimeter depending on the interests. After the definition of the algorithms, he/she will study the performance by using the simulation samples of important Physics processes, such as Higgs 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 particle objects 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:

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

15. PADOVA

55. SWGO

Title: Study of the performance of a proposed high-altitude particle detector for gamma-ray astroparticle physics

Description: SWGO (southern wide-field gamma-ray observatory) is an ongoing R&D for the design, installation and control of a particle detector array made primarily of water tanks to detect cosmic gamma-rays in the TeV-PeV range. Primary gamma rays generated particle showers in the atmosphere that are detected via their Cherenkov emission in the water of tanks thanks to fast photosensors. The array is made of thousands of individual tank unit (ITU). The position of the ITUs over an array of more than 2 square km can be optimized with direct Monte Carlo simulations or via regression methods based on Neural Networks. The Padova group is involved in both activities.

Activities: The candidate will contribute in comparing the performance of different SWGO layout (sensitivity, effective area, angular resolution, energy resolution) with either Monte Carlo simulations (Geant4 code) or with NN.

Tutor: prof. Michele Doro

Activity period: September/October

Local Secretariat: direzioneinfn@pd.infn.it

Other information: Support is given to find lodging. Private health insurance required. Padova is a young international town, with moderate cost of living compared to other cities and with optimal weather expected in fall.

16. PISA

56. ATLAS

Title: Machine learning studies for particle trajectories reconstruction in ATLAS

Description: The ATLAS experiment is one of the two general purpose experiments collecting data at the Large Hadron Collider accelerator. Upgrade activities are ongoing to prepare the experiment for the Phase-II data taking where instantaneous luminosity could be as high as $5\text{-}7\times10^{34}$ $cm^{-2}s^{-1}$ with pileup pp interactions reaching 140-200. As part of the broad upgrade program that will enable the experiment to cope with the challenging conditions of Phase-II, ATLAS is developing novel techniques for the reconstruction of particle trajectories. Recent advances in heterogeneous computing systems, and software developments created the opportunities to consider innovative techniques and to exploit machine learning approaches. The general goal is to provide ATLAS the most effective implementation for trajectory reconstruction evaluating the use of CPUs with and without GPU and FPGA accelerators, while achieving high processing rate and keeping trajectories reconstruction quality close to offline quality.

Activities: The student under this project will collaborate with colleagues in Pisa to study machine learning based algorithms for cluster reconstruction in the pixel detector data and for charged particle trajectories reconstruction. Benchmark plots will be produced comparing the performance of algorithms under evaluation. The student will acquire experience in python programming, machine learning applications, and data visualization and analysis.

Tutor: Alberto Annovi – INFN Pisa (alberto.annovi@pi.infn.it)

Activity period: June-July

Local Secretariat: Dr. Giacomo Betti Ph.: +39.050.2214 270 e-mail: giacomo.betti@pi.infn.it

Other information: Basic knowledge of python or C++ programming is required.
https://atlas.cern/

16. PISA

57. ATLAS

Title: Double Higgs and trilinear Higgs self coupling at the Large Hadron Colliders

Description: One of the main physics goals of the future High-Luminosity LHC will be to study the shape of the Higgs field potential through the measurement of the self-coupling of the Higgs boson. This is done by searching for double Higgs production in a variety of final states determined by the Higgs decay modes. The project will focus on the study of double Higgs events decaying into pairs of tau-leptons and pairs of b-quarks. In particular, the study will highlight the key features of the analysis and the required performances of the detectors at the LHC, needed to reach a precise determination of the self-coupling of the Higgs boson.
The study will be carried out on simulated events generated by the ATLAS collaboration. The goal of the study is to define a possible roadmap for the HH measurements at the LHC Run3 and HL-LHC.

Activities: The student under this project will collaborate with colleagues in ATLAS Pisa and in the Higgs groups in ATLAS to study the Higgs boson physics, and in particular the details of the HH measurements. Based on the skills of the student, part of the activities could involve event generation using the state-of-the-art Monte Carlo Generators, and analysis of the real data collected by the ATLAS experiment. The student will acquire experience in python and C++ programming, and in advanced techniques in statistical data analysis for HEP.

Tutor: Paolo Francavilla – University of Pisa and INFN Pisa (paolo.francavilla@pi.infn.it)

Activity period: September-October

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214 270 e-mail: giacomo.betti@pi.infn.it

Other information: Basic knowledge of python or C++ programming is required.
https://atlas.cern/

16. PISA

58. ATLAS

Title: Test of Photomomultipliers for the ATLAS Calorimeter Upgrade

Description: The ATLAS experiment is one of the two experiments at the LHC which observed the Higgs boson and from then on continued to explore the mysteries of the world of particle physics.
The ATLAS Pisa group is involved, among other activities, on the maintenance and upgrade of the hadronic calorimeter for the Phase-II data taking where instantaneous luminosity could be as high as $5\text{-}7\times10^{34}$ $cm^{-2}s^{-1}$
The ATLAS hadronic calorimeter, called TileCal, is a sampling calorimeter using steel as absorber and plastic scintillators as active medium. As particles hit the layers of steel, they generate a shower of new particles.
The plastic scintillators in turn produce photons, which are converted into an electric current whose intensity is proportional to the original particle's energy. The scintillators are read-out by wavelength shifting fibres coupled to photomultiplier tubes (PMTs).
In Summer 2023 we are planning to test in Pisa new PMTs that will be installed in the ATLAS experiment for the high luminosity Phase-2 run.

Activities: For this summer research project in the ATLAS lab located in Pisa, we are looking for a student willing to work hands-on in our lab. The group is composed of senior physicists and students. The new student will have the opportunity to learn how a test bench is organized. He/she will familiarize with the use of
NIM and VME electronics, will learn how PMTs work and will have the opportunity to exercise with the basics of Labview programming. The student will learn also how to organize the results obtained and present them at meetings.

Tutor: Sandra Leone INFN Pisa (sandra.leone@pi.infn.it) and Giorgio Chiarelli - INFN Pisa (giorgio.chiarelli@pi.infn.it)

Activity period: June-July

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214 270 e-mail: giacomo.betti@pi.infn.it

Other information: No previous experience is required.

https://atlas.cern/

16. PISA

59. SWEATERS

Title: Characterization measurements of a gas detector based on bulk-MicroMegas technology for low energy ionizing particles of SWEATERS Project

Description: In the last years Micro-Megas gas detectors have been widely used as tracks reconstruction instrument of ionizing particles, operating at standard temperature and pressure (STP), in high energy physics experiments on the modern colliders.
At the INFN Pisa Laboratory an experimental group involved in the gas detectors research activity, is developing a gas chamber detector, based on the bulk-MacroMegas (MM) technology, to be filled and operated with different gas mixtures at low pressure down to 50 mbar.
Thanks to the encouraging results obtained so far, the working group is conceiving a gas detector with the possibility to reconstruct the incident ionizing particle in 3D, and with a good energy track resolution in the range 1-100 keV. These features will be very innovative for future applications of MM detectors in the Dark Matter (DM) search and Space Weather monitoring.
The proposed task of this stage period, deals with a typical laboratory activity to be carried on with the goal performing a characterization measurement campaign on a (10 x 10) cm2 Micro-Megas detector prototype of the SWEATERS Project.

Tutor: F. Pilo – INFN Pisa; e-mail: Federico.pilo@pi.infn.it
F. Frasconi – INFN Pisa; e-mail: franco.frasconi@pi.infn.it

Activity period: September-October 2023

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214270 e-mail: giacomo.betti@pi.infn.it

Other Information: INFN Laboratory will be closed in the time period: August 5 – August 27, 2023 included.

16. PISA

60. VIRGO

Title: Machine learning techniques for gravitational wave physics

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. The huge amount of data generated by gravitational wave interferometers provides a unique challenge for the development of fast, advanced analysis methods using machine learning. During the stay we will offer to the student the possibility to participate in the development of deep learning algorithms applied to gravitational wave detection, either for the analysis of data from existing detectors or for real time application in the development of future detectors.
Activities: Attività (optional)

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

Activity period: September-October 2023

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214270 e-mail: giacomo.betti@pi.infn.it

Other Information: INFN Laboratory will be closed in the time period: August 5 – August 27, 2023 included.

16. PISA

61. VIRGO

Title: Multimessenger study of transient sources

Description: The detection of the electromagnetic (EM) counterparts of the gravitational wave (GW) transient source GW170817 has clearly demonstrated the huge informative power of multimessenger observations, i.e. coordinated observations involving different "messengers" (photons, GWs, neutrinos). In the near future, many other detections of GWs are expected, mainly associated with Compact Binary Coalescences (CBCs) and multi-messenger observations will be the key to further probe the rich physics of these sources. The project will be focused on the investigation of the prospects for multi-messenger detection of CBCs with a GW detector network composed by LIGO, Virgo and KAGRA, and with different electromagnetic facilities, with particular attention to X-ray and gamma-ray telescopes.

Activities: The student will be engaged principally in simulation activities and interpretation of the results. She/He will become experienced with modeling and simulation of multi-messenger signals from CBCs, and will learn how to use several analysis/simulation tools of the LIGO-Virgo-KAGRA collaboration. The candidate should have a basic knowledge of programming and python scripting.

Tutor: Barbara Patricelli (barbara.patricelli@pi.infn.it)

Activity period: June-July 2023 or September-October 2023

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214270 e-mail: giacomo.betti@pi.infn.it

Other Information: INFN Laboratory will be closed in the time period: August 5 – August 27, 2023 included.

16. PISA

62. VIRGO

Title: Laboratory measurements campaign by using high precision and low noise sensors for future Gravitational Waves detectors

Description: The INFN Pisa Group, deeply involved in the construction and continuous operation of the Advanced VIRGO interferometer for Gravitational Waves direct observation on Earth, is starting a detailed Research and Development (R&D) program to prepare the new anti-seismic suspension for the optical components of the 3rd generation detectors.
To this purpose a detailed comparison of micro-seismic motion measurements carried out with different available sensors, represent a key point for the future developments of high precision and low noise device. The final goal is the development of a new sensor to be integrated within a future suspension system for seismic noise suppression at the level of the optical components. Starting from the characterization measurements for each sensor, the possibility to integrate different components in a single multi-sensors device will be evaluated.
This task is considered very challenging for many aspects: the required sensitivity, the material selection for its construction, the presence of a low noise and high sensitivity front-end electronics on board with the possibility to be included in the feedback control strategy of an inertial platform with six degrees of freedom.

Tutor: F. Frasconi – INFN Pisa; e-mail: franco.frasconi@pi.infn.it
and A. Gennai – INFN Pisa; e-mail: alberto.gennai@pi.infn.it

Activity period: September-October 2023

Local Secretariat: Dr. Giacomo Bett Ph.: +39.050.2214270 e-mail: giacomo.betti@pi.infn.it

Other Information: INFN Laboratory will be closed in the time period: August 5 – August 27, 2023 included.

17. ROMA1

63. AMS02

Title: Non-Target Effects induced Galactic Cosmic Rays in Exploratory Space Missions: Improvements using the AMS detector data

Description: Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The knowledge of the risk assessment of the health hazard related to human space exploration is crucial to reducing damages induced to astronauts from galactic cosmic rays and sun-generated radiation.
Galactic Cosmic Rays (GCRs) have been identified as one of the primary sources of radiation exposure in space. In this context, an accurate characterization of the possible risk of carcinogenesis induced by exposure to GCRs particles is a significant concern for human exploratory space missions.
With unprecedented precision and energy range extension, the AMS detector (WebSite: ams02.space) installed on the International Space Station has produced a dataset of the charged components of the cosmic rays measuring its characteristics and its variation in fluxes in 2011-2022.
AMS data are used to investigate fundamental physics problems and the damage to human health from exposure to space radiation in exploratory space missions.

Activities: Using the tool developed by the AMS Roma group, using the RStudio IDE, and the Cosmic Ray measurements done by the AMS detector over the last 12 years, the student will participate in the development and tuning of a new dose-effect model for the evaluation of the Health Risk induced by the charged particles components (Protons and heavy Ions) of the space radiation. In particular, the analysis of the so-called Non-Target Effect (NTE) will be the main focus of the study, as well as the design of a new technique for the experimental measurements of such NTE.

Tutors:
Alessandro Bartoloni (alessandro.bartoloni@roma1.infn.it)
Aboma Negasa Guracho (aboma.guracho@roma1.infn.it)

Activity period: June-July 2023 or September-October 2023

Local Secretariat: Mauro Mancini (mauro.mancini@roma1.infn.it)

Other information:
https://www.roma1.infn.it/en/la_sezione/opportunit%C3%A0_lavoro/opportunit%C3%A0_lavoro.html

17. ROMA1

64. CYGNO

Title: Background studies for the CYGNO experiment with the LIME underground prototype

Description: The CYGNO collaboration works to the development of a gaseous Time Projection Chamber for the detection of dark-matter-induced nuclear recoils and other rare events, to be installed underground at the INFN Gran Sasso Laboratories. In 2022 a 50-liter prototype called LIME was installed underground and started taking data with different configurations of detector shielding. Tests will continue throughout 2023 with the goal of validating the background simulations in view of the development of a 0.4 m^3 detector. The student will take part to this program, elaborating data taken with LIME, including the tuning and refinement of reconstruction tools based on Machine Learning approaches, comparing them with simulations of the detector and its response and contributing to the interpretation of the results. The project will also encompass the participation to the data taking activities at Gran Sasso Laboratories.

Activities: Data analysis and simulation. Participation to data taking activities.

Tutor: Davide Pinci

Activity period: September-October 2023

Local Secretariat: Mauro Mancini (mauro.mancini@roma1.infn.it)

Other information:
https://www.roma1.infn.it/en/la_sezione/opportunit%C3%A0_lavoro/opportunit%C3%A0_lavoro.html

17. ROMA1

65. FOOT

Title: The FOOT experiment. Cross-Section measurements for Particle Therapy and Space Radiation Protection applications

Description: The main purpose of the FOOT experiment (FragmentatiOn Of Target) is to improve the tumour treatments in particle therapy by studying the behaviour of the particle beams usually employed. These particles (mainly protons and carbon ions) interact with the nuclei constituting the human body, then leading to nuclear fragmentation. The nuclear fragments are an important source of biological damage, both for cancer cells and for nearby healthy tissues, and it is of fundamental importance to have a deep knowledge of this process to make the most effective and safe medical treatment. FOOT will measure with the nuclear fragmentation cross-section of medium-light ions such as those that abound most in our organism (Carbon, Nitrogen, Oxygen), for which experimental measurements are absent in the energy range used in particle therapy (100-300 MeV / nucleon). The accuracy of the theoretical models is not in fact sufficient by itself to guarantee a satisfactory accuracy during the treatment of the patients. These measurements are also interesting for other applications, like radioprotection in space. NASA and other space agencies have started since several years the study of the risk assessment for astronauts in view of long duration space missions, such for instance the travel to Mars. Beyond many important risks of other nature, both galactic cosmic rays and particles from the almost unpredictable Solar Particle Events must be considered. The design and optimization of spacecraft shielding requires a detailed knowledge of fragmentation processes.

Activities: Analysis of the collected data.

Tutor: Marco Toppi (marco.toppi@roma1.infn.it)

Activity period: June-July 2023

Local Secretariat: Mauro Mancini (mauro.mancini@roma1.infn.it) Tel. ++39 0649914318

Other information: FOOT experiment website https://web.infn.it/foot/en/home/
Place of work: Dipartimento SBAI, Via Antonio Scarpa 16, Roma.

17. ROMA 1

66. LUNA

Title: Detector and target characterization measurements in the underground laboratory

Description: In view of the operation of the new accelerator 3.5 MV LNGS facility at Gran Sasso Laboratory, a complete study of the 14N(p,g)16O cross section study at high energy is foreseen. The grant period will be devoted to a detailed characterization measurements of the 14N solid target in terms of stability, purity and reproducibility through gamma detection using a HpGe detector. Basic software analysis will be developed.

Tutor: Alba Formicola

Activity period: September-October 2023

Local Secretariat: Mauro Mancini (mauro.mancini@roma1.infn.it)

Other information:
https://www.roma1.infn.it/en/la_sezione/opportunit%C3%A0_lavoro/opportunit%C3%A0_lavoro.html

18. ROMA 3

67. BELLE II

Title: SIPM studies for the KLM detector upgrade.

Description: Silicon photomultipliers are young devices designed as a matrix of single-photon avalanche detectors, which have become popular for their miniature dimensions and low operating voltage. We are considering these devices for the KLM sub-detector of the BELLEII experiment upgrade, that will occur in 2027-2028. Their superior sensitivity moreover allows detecting low-photon-count with a very good time resolution. This last property is of paramount importance when Klong particle's identification in involved

Activities: In our laboratory experiment we`ll analyze the performance of these devices exploiting our equipment which can allow us very low working temperature thus reducing thermal noise.
Timing resolution will be measured studying the properties of the waveform obtained with the digital scope.

Tutor: Paolo Branchini (paolo.branchini@roma3.infn.it)
Diego Tagnani (Diego.Tagnani@roma3.infn.it)

Activity period: June-July or September-October

Local Secretariat: Cristiano Maria Genolini, cristiano.genolini@roma3.infn.it, +390657337312

Other information:
Roma Tre INFN https://www.roma3.infn.it
Matematics and Physics Department: https://matematicafisica.uniroma3.it/
Roma Tre University: https://www.uniroma3.it
Summer closure: August

18. ROMA 3

68. DARKSIDE

Title: The DARKSIDE program for Dark Matter searching

Description: The research program is based on the collaboration to the DS-20k project within the DARKSIDE program. DS-20k is a detector consisting of a liquid Argon TPC that will be installed at the INFN Gran Sasso National Laboratories in Italy. It consists of about 50 tons of active volume which will ensure a sensitivity to measure the WIMP-nucleon cross section down to 10-48 cm2 for WIMP of mass of about 1 TeV.

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

Tutor: Severino Bussino (sbussino@uniroma3.it)
Stefano M. Mari (smari@uniroma3.it)

Activity period: June-July 2023

Local Secretariat: Cristiano Maria Genolini, cristiano.genolini@roma3.infn.it, +390657337312

Other information:
Roma Tre INFN https://www.roma3.infn.it
Matematics and Physics Department: https://matematicafisica.uniroma3.it/
Roma Tre University: https://www.uniroma3.it
Summer closure: August

18. ROMA 3

69. LEGEND-200

Title: Analysis of LEGEND-200 data with an innovative technique

Description: The project consists in the analysis of recent data from LEGEND-200, an experiment located in the underground Gran Sasso Laboratory of INFN searching for neutrinoless double beta ($0\nu\beta\beta$) decay. The core of the experiment is an array of High Purity Germanium (HPGe) detectors, for a total of 200 kg, deployed directly in liquid argon (LAr) and enriched in the double beta isotope 76Ge up to 98%, working both as detector and source of the $0\nu\beta\beta$ decay. The surrounding LAr is able to shield external particles and veto events that release energy in LAr and in the HPGe detectors, thanks to the detection of the LAr scintillation light with an instrumentation composed of wavelength shifting fibers and Silicon PhotoMultipliers (SiPMs). When energy is released in the HPGe detectors, an electrical signal is produced, this signal is amplified, digitized and stored with a dedicated read-out chain. The signals are then processed offline with a custom Python software currently in development.

Activities:
The project concerns the implementation of an innovative signal processing technique for the energy reconstruction of HPGe detector signals in the LEGEND software. This technique is based on the application of a digital filter that performs the parameter estimation with the best possible signal-to-noise ratio. The filter is created with the Digital Penalized Least Mean Squares (DPLMS) method, consisting on the estimation of the pulse amplitude minimizing the deviations between experimental samples and a reference curve. The correct implementation of this technique will have a strong impact on LEGEND-200 with a more precise energy estimation and an improved energy resolution in the region of interest for the $0\nu\beta\beta$ decay search, thus resulting in an increased experimental sensitivity.

Tutor: Valerio D'Andrea (valerio.dandrea@roma3.infn.it)
Giuseppe Salamanna (giuseppe.salamanna@uniroma3.it)

Activity period: June - July 2023

Local Secretariat: Cristiano Maria Genolini, cristiano.genolini@roma3.infn.it, +390657337312

Other information:
Roma Tre INFN https://www.roma3.infn.it
Matematics and Physics Department: https://matematicafisica.uniroma3.it/
Roma Tre University: https://www.uniroma3.it
Summer closure: August

19. TIFPA

70. NuJET

Title: NuJET – Neutrinos as engine for the production of relativistic jets

Description: The recent detection of gravitational waves (GWs) and electromagnetic radiation from a binary neutron star (BNS) merger has opened the era of multimessenger astrophysics driven by GWs. In particular, the first BNS observed by Ligo and Virgo, GW170817, was followed by a short gamma-ray burst (GRB) and a kilonova. This milestone observation was crucial in many aspects, including the fact that it confirmed the long-standing hypothesis that BNS mergers are progenitors of short GRBs. Despite this smoking gun evidence, the way in which a BNS merger can launch a jet is still very uncertain. While it seems plausible that black hole formation and magnetic field winding play a central role in this process, it is also very plausible that neutrinos can, at least partially, deposite a significant fraction of the energy required by the jet. Indeed, the remnants of BNS mergers are copious sources of neutrinos of of all flavors with energies ranging between a few MeV up to 100 MeV. Neutrino-antineutrino annihilation above the remnant is a very promising mechanism to deposit energy in the region where the jet forms. An accurate calculation of the energy deposition rate, as a function of the BNS properties and based on the most recent BNS merger simulations, is a key ingredient in understanding such an open problem.

Activities: The project is rooted in the analysis of a large set of recent simulations in Numerical Relativity, modeling the BNS merger and its aftermath. They differ because of the masses of the two stars and the still unknown equation of state of nuclear matter. These simulations include neutrinos through different radiative transport schemes (including a new moment transport scheme) representing the state of the art in the field). The student is expected to compute in post-processing the rate of energy deposition due to neutrino-antineutrino annihilation based on electroweak cross-sections and starting from the detailed neutrino information contained in the simulations. The calculation must be performed everywhere inside the computational domain and for each relevant time (several tens of milliseconds, corresponding to several dynamical timescale), corresponding to the jet formation time scale. The outcome of this calculation could be used in future numerical relativity simulations or can guide the construction of an algorithm for self-consistent tetra-momentum deposition rate calculations.

Tutor: Albino Perego (albino.perego@tifpa.infn.it)

Activity period: 2 months: June-July

Local Secretariat: TIFPA-INFN - Giuliana Pellizzari, giuliana.pellizzari@tifpa.infn.it

Other information:

- website: https://www.tifpa.infn.it/
- Summer closure: 14-18 August, and with reduced amount of people also between 21-25 August;
- possibility to stay in a nearby B&B with special prices; large availability of other B&B (also with kitchen) and hotel accomodations

20. TORINO

71. FUSION

Title: Modelling of laser-particle interaction for radioisotope production

Description:
In the last 15 years, $p^{11}B$ fusion has been effectively induced by means of high-power lasers. In this case, an impressive and not yet explained progression in the reaction yield has been observed to the extent that the reaction has become of interest to the energy sector, where it is being considered as an alternative approach to conventional inertial confinement fusion schemes. The chance to optimize the $p^{11}B$ reaction producing intense α-particles streams in a compact, and potentially economic way, could also open the path for the realization of future table-top sources to be used in medical (i.e. radioisotopes production) and multidisciplinary applications. In the framework of the FUSION experiment, an extensive systematic investigation of laser-based $p^{11}B$ fusion, aimed at a better and deeper understanding of the underpinning physics of the nuclear reaction in plasma, is being performed.
This proposal will focus on the development of a simplified analytical model of the entire process, including: (i) laser/target interaction, (ii) the generation of the particles and (iii) their interaction with the selected isotopes to generate the radioisotope [1].
This approximate model will allow a first quantification of the particles (energy) / radioisotopes generated, that needs to be better assessed through more detailed models, in turn requiring validation. Depending on the available time, a suitable modeling strategy will also be investigated. This will involve particle-in-cell (PIC) simulation tools like EPOCH [2].

[1] D. Margarone, et al., "Generation of α-Particle Beams With a Multi-kJ, Peta-Watt Class Laser System," Frontiers in Physics, 2020, Vol. 8, Art. ID 343.
[2] T. D. Arber, et al., "Contemporary particle-in-cell approach to laser-plasma modelling," Plasma Physics and Controlled Fusion, 2015, Vol. 57, Art. ID 113001.

Activities:
1. Literature analysis on laser-particle interaction for radioisotope production.
2. Development of a model to address the problem of laser-particle interaction for radioisotope production.
3. Development of a PIC model of the experiment.

Tutors:

R. Bonifetto (roberto.bonifetto@to.infn.it, roberto.bonifetto@polito.it)
R. Testoni (raffaella.testoni@to.infn.it, raffaella.testoni@polito.it)
A. Froio (antonio.froio@to.infn.it, antonio.froio@polito.it)

Activity period: June-July (highly preferred) or September-October

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

Other information:
The activity will be carried out at Sezione INFN di Torino and Politecnico di Torino (Energy Department).
Experiment web site: http://fusion.lns.infn.it/

20. TORINO

72. LUNA

Title: Low energy nuclear astrophysics at LUNA (Laboratory for Underground Nuclear Astrophysics): study of the $^{21}Ne(p,\gamma)^{22}Na$ reaction

Description: The **L**aboratory for **U**nderground **N**uclear **A**strophysics (LUNA) is an experiment located deep underground at Gran Sasso National Laboratories (LNGS), whose mission is to study charged-particle-induced nuclear reactions of astrophysical interest. The proposed activity focuses on the study of the $^{21}Ne(p,\gamma)^{22}Na$ reaction which plays a key role in hydrogen burning in Asymptotic Giant Branch Stars and Novae. The main goal is the direct measurement of two resonances at low energies (below 400 keV) responsible for the large uncertainty in the $^{21}Ne(p,\gamma)^{22}Na$ reaction rate. The work includes the characterization of the experimental setup presently mounted in Gran Sasso, the data taking and the analysis. The cross sections of these processes are extremely low, in the micro-barn range. Successful modelling of Asymptotic Giant Branch Stars and Novae requires the cross section to be known down to around 100 keV. Due to the extremely low counting rate, direct experiments are challenging already at energies above 400 keV. Measurements will be done with a gas target setup and detecting the γ rays generated by the decay of the ^{22}Na excited states with two High Purity Germanium detectors. Thanks to 1400 meters of rock overlying the experimental halls, LNGS is the ideal location to perform a γ-ray detection experiment.
The candidate will be involved in the measurement of the $^{21}Ne(p,\gamma)^{22}Na$ reaction and perform the data analysis. The work will be done at INFN Torino with several visits to LNGS.

Tutor: Francesca Cavanna (francesca.cavanna@to.infn.it), Paolo Colombetti (paolo.colombetti@to.infn.it)

Activity period: June – July or September – October 2023

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

Other information: https://luna.lngs.infn.it/

21. TRIESTE

73. BELLE II

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

Description: This is a data analysis project targeted at the improvement of the calibrations of the measurements of photon energies in the electromagnetic calorimeter of the Belle II experiment.

Belle II is a detector designed to reconstruct billions of weak-interaction decays of bottom mesons and τ leptons from 10 GeV electron-positron collisions in search for indirect indications of non-Standard-Model physics. It started operations in 2018 and has collected so far about 420 million *B* meson pairs, which are being used to obtain unique and world-leading measurements. Many key measurements rely on decays into neutral particles, such as π^0 and η mesons. These are reconstructed in their decays into photons by using a crystal-technology electromagnetic calorimeter. An accurate calibration of photon-energy measurements is critical for the precision on the final physics observables. Current calibrations are determined as functions of the photon energy using control samples in data. However, calibration performance is suboptimal as shown by residual mismodeling of up to 30%.

This project consists in exploring improvements to these calibrations by introducing yet-unaccounted-for corrections to energy dependences, such as those on the photon angle of incidence in the calorimeter. The student will explore the development and implementation of a novel, and more sophisticated approach that is likely to lead to more accurate and reliable results. This will imply selection and classification of calibration samples using statistical-learning methods, statistical studies of sample compositions, and a careful study of the multiple dependences of the raw photon energies on the relevant instrumental variables. We expect to document these studies into an internal note and include them in the standard Belle II correction procedures after internal review.

The student 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 calorimeters, and she/he will generally experience a full immersion in real-life research work in a dynamic and stimulating environment. The Trieste group is a strong and international group including about ten between students and postdocs. We are mostly involved in analysis and hardware, and play key roles in many aspects of Belle II physics. A major area of interest is the reconstruction of neutral particles for enhancing physics reach. The student will be supervised on a daily basis by a junior postdoc under the intellectual guidance of a seniorer tutor.

Activities:

- Statistical analysis of the data (classification of samples using statistical-learning methods, study of statistical distributions, fits, hypothesis testing)
- Programming in Python and ROOT/C++

Tutor: Diego Tonelli (diego.tonelli@ts.infn.it). Co-tutor Sebastiano Raiz (sebastiano.raiz@ts.infn.it)

Activity period: About 9 weeks, preferably during September-October 2023

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

Other information:

- Affordable accommodation close to the lab can be arranged with adequate notice as well as meals.
- Local INFN website: https://www.ts.infn.it/en/
- Practical information about the Trieste Science System: http://www.welcomeoffice.fvg.it/

21. TRIESTE

74. BELLE II

Title: Search for B → K_S^0 $\tau^+\tau^-$ decays at the Belle II experiment

Description:

This is a data analysis project aiming to search for a rare B-meson decay in Belle II data. 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. One of these is the measurement of the fraction of B mesons decaying into a final state made of a K_S^0 meson and two oppositely-charged τ leptons, that is the branching fraction of B → K_S^0 $\tau^+\tau^-$ decays. This decay is highly suppressed in the SM and a very sensitive probe of new dynamics. The measured branching fraction would indicate towards non-SM physics if any deviation is observed from its predicted value. The student will get familiar with the reconstruction of this decay from different charged and neutral final-state particles detected at Belle II, and then will analyze reconstructed data by inspecting distributions of relevant physics observables. As this decay is highly suppressed, the signal events will be way underneath a lots of background events. Hence, we will devise a strategy to categorize the different backgrounds and develop a background-rejection algorithm, possibly using machine-learning techniques. We will finally estimate the sensitivity to find a signal with the current Belle II dataset. This project would be a great opportunity to learn some flavor physics, gain experience in data analysis in a modern collider-physics experiment, and 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. The student will be supervised on a daily basis by a junior postdoc under the intellectual guidance of a staff tutor.

Activities:

- Statistical analysis of the data (classification of samples using statistical-learning methods, study of statistical distributions, fits, hypothesis testing)
- Programming in Python and ROOT/C++

Tutor: Mirco Dorigo (mirco.dorigo@ts.infn.it) and Niharika Rout (niharika.rout@ts.infn.it)

Activity period: September-October

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

Other information:

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

21. TRIESTE

75. CTA

Title: Search for transient emission in CTA data

Activities: the student will partecipate in the data analysis of simulated CTA data to search and characterize transient events

Period: June – July

Tutor: Francesco Longo (francesco.longo@ts.infn.it)

Possible dates: between June 1st and July31

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

Other information:
- Affordable accommodation can be arranged with adequate notice.

- Local INFN website: https://www.ts.infn.it/en/

- Practical information about the Trieste Science System: http://www.welcomeoffice.fvg.it/

21. TRIESTE

76. Fermi/LAT

Title: Search for short duration transient in Fermi/LAT data

Activities: the student will participate in the data analysis of Fermi/LAT data to search and characterize transient events, possibly associated to GRB, FRB and GW events.

Period: June – July

Tutor: Francesco Longo (francesco.longo@ts.infn.it)

Possible dates (between June 1st and July 31)

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

Other information:

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

21. TRIESTE

77. SWGO

Title: Scientific simulation of the upcoming SWGO experiment

Activities: the student will participate in the first scientific simulation of Very High Energy sources as seen by SWGO

Period: June – July

Tutor: Francesco Longo (francesco.longo@ts.infn.it)

Possible dates: between June 1st and July 31st

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

Other information:
- Affordable accommodation can be arranged with adequate notice.

- Local INFN website: https://www.ts.infn.it/en/

- Practical information about the Trieste Science System: http://www.welcomeoffice.fvg.it/