Università di Genova | DIFI DIPARTIMENTO DI FISICA

PhD in Physics and Nanoscience (XXXV cycle) First Year Report

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Supervisor: Prof. Marco Pallavicini

28 September 2020

Scientific activity

DUNE (Deep Underground Neutrino Experiment) is a long-baseline neutrino oscillation experiment aimed at the precise measurement of the neutrino flavour oscillation parameters, such as the CP-violating phase in the lepton sector. In particular, the INFN Genova research group is mainly involved in the design and simulation of the SAND detector which will be part of the near detector complex at Fermilab (Illinois, USA) and will primarily act as an on-axis beam monitor. SAND will re-use the large superconducting magnet, iron yoke and electromagnetic calorimeter of the KLOE experiment along with a new inner tracker system inside. Different inner tracker technologies have been proposed, but each of them foresees the presence of a liquid Argon (LAr) target (~ 1 ton) in the upstream part of the magnetic volume.

My main activity has been focused on the simulation and development of an optical readout system for the 128 nm scintillation light produced in the LAr target. Since the spectrum is peaked in the VUV region, traditional imaging systems using lenses or mirrors are difficult to implement due to the low transmission efficiency of materials and the constraints of the cryogenic setup. I studied the possibility of solving these issues by applying a technique known as Coded Aperture Imaging (CAI), which works independently from the light wavelength. CAI exploits the use of masks placed in front of pixelated photodetectors: scintillation light coming from the tracks casts a shadow of the mask on the photodetector underneath. Thanks to the mathematical properties of the 2D pattern of the mask, it is then possible to decode uniquely the recorded shadows to get an image of the event. Using coded aperture systems, I performed GEANT4 Monte Carlo simulations of neutrino interaction events in the proposed modular geometry of the LAr target and developed a reconstruction chain to obtain a preliminary 3D reconstruction of the tracks by combining multiple views of the same event. These studies allowed to understand the limitations of the technique for this application and optimize the geometrical parameters of the design. Additional work is also ongoing to explore more traditional imaging systems.

Moreover, in the prospect of future tests with prototypes of the imaging system, I am contributing to the DAQ development and current commissioning activities of ARTIC (ARgon Test InfrastruCture). ARTIC is a large ($\varnothing$ 1.5 m) vacuum-insulated cryostat which has recently been installed at DIFI and will be used for R&Ds in liquid Argon, both for DUNE and the DarkSide experiment.

Among the Italian contributions to the neutrino physics activities at Fermilab, I also took part in the test and assembly shifts of the CRT (Cosmic Ray Tagger) modules at LNF for the

ICARUS-T600 detector of the SBN (Short Baseline Neutrino) experiment, for a total of three weeks. The ICARUS detector is currently undergoing commissioning and I will also be involved with taking remote monitoring shifts in the next months.

Attended courses

- *Applied Cryogenics* (exam passed)
  Dr. Riccardo Musenich (INFN)
- *Design of Superconducting Magnets* (exam passed)
  Dr. Stefania Farinon (INFN)
- *Deep Learning: a hands-on introduction* (exam passed)
  Prof. Nicoletta Noceti (Unige-DIBRIS)
- *Neutrinos and Nuclear Astrophysics* (exam to be given soon)
  Dr. Sandra Zavatarelli (INFN), Dr. Federico Ferraro (Unige-DIFI)

Attended conferences/workshops

- *Dark-matter and Neutrino Computation Explored (DANCE)*
  Machine Learning remote workshop, 3-7 August 2020 (no talk)

Other activities

- Didactic Tutor (General Physics 1, Laboratory 1)
  September 2019 - July 2020 (44 hours)