Università di Genova | DIFI DIPARTIMENTO DI FISICA

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

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1 Research activity

My research activity fits in the context of DUNE (Deep Underground Neutrino Experiment), a long-baseline neutrino experiment, aiming to measure neutrino oscillation parameters, determine the neutrino mass hierarchy, and potentially observe CP violation in the leptonic sector. DUNE includes a new, high-intensity neutrino source generated from a proton accelerator at Fermilab, a massive Far Detector (FD) at 1.5 km underground in South Dakota and a Near Detector complex (ND) installed downstream of the neutrino source.
SAND (System for On-Axis Neutrino Detector) will be one of the three components of the Near Detector; it will be permanently located on the neutrino beam axis and its main purpose will be to monitor the beam flux.
SAND consists of a solenoidal magnet, an electromagnetic calorimeter, an inner Straw Tube Tracker, and finally GRAIN (GRanular Argon for Interaction of Neutrinos), a 1-ton Liquid Argon (LAr) target, placed in the upstream part of the inner magnetized volume.
During my first PhD year, the main goal of my research activity was to develop and test prototypes of the novel lens-based optical detector for the GRAIN detector in SAND. This innovative detector employs a focusing system made by two plano-convex lenses enclosing gas, and a 32×32 matrix of Silicon PhotoMultiplier (SiPM), allowing vacuum ultraviolet Liquid Argon scintillation light (VUV) to be transmitted by the lens material and focused on the SiPM plane. The aim of these tests was to test and calibrate the acquisition board using an artificial light source. The source light system is made up of a Xe pulsed lamp at 5 W made by HAMAMATSU, with a monochromator that gives the possibility to select a specific wavelength connected to it. In particular, it's important to select the same wavelenght of the peak of scintillation light in LAr (i.e. 127 nm) in order to simulate the same conditions of the DUNE experiment. The readout of SiPM matrices requires the use of a multi-channel mixed-signal ASIC, while the back-end electronics is implemented with an FPGA (Field Programmable Gate Arrays).
The tests were performed both at room temperature and in liquid Nitrogen, in order to test the SiPMs matrix at cryogenic temperatures, as will be in LAr. The first tests were carried out in a small dewar while subsequent tests were carried out in the facility ARTIC (ARgon Test InfrastruCture) at the Physics Department in Genoa. ARTIC is a big ($\varnothing$ 1.5 m) vacuum-insulated cryostat used for R&Ds in LAr.
These tests made it possible to verify the correct functioning of the readout and channels. In order to have a correct acquisition, a calibration of the various ASIC parameters (thresholds, gain of the individual channels) was carried out. These results were satisfying and so in the next future we will proceed with the lens tests.
In addition, I was involved in the design of a dedicated ASIC for the 32×32 SiPM matrix readout in GRAIN. In particular, I performed a dedicated analysis on Monte Carlo data for validating the proposed design.
Neutrino interactions in GRAIN were simulated by considering photon scintillation emission events in pure

LAr and in Xenon-doped LAr[1].
The goal of these studies was to validate the baseline design of the ASIC, by evaluating the reconstruction performances on the total number and on the arrival time of photons on each SiPM channel as a function of different ASIC parameter values or different ASIC configurations.
Finally, as I am also a member of the ICARUS collaboration, an experiment that is taking data for the search of the sterile neutrino from the observation of short-distance oscillations, I took part in the detector, beam and data-taking shifts.

2 Attended courses

- Advanced Statistics for Data Analysis (3 CFU) - exam not given yet
- Applied Cryogenics (3 CFU) - exam not given yet
- Electronics & Data Acquisition (3 CFU) - exam not given yet
- Quantum Optics (3 CFU) - exam not given yet

3 Conferences and PhD schools

- DUNE Collaboration Meeting, Lecce (Italy) - 6th November 2023, 7th November 2023
- DUNE Collaboration Meeting, CERN (Geneve, Switzerland) - 22th January 2024, 26th January 2024
- INFN School of Underground Physics (SoUP 2024), Bertinoro (FC, Italy) - 14th October 2024, 18th October 2024 (I will present a poster)

4 Publications

1. B. Bottino, A. Campani, R. Caravita, S. Copello, F. Ferraro, A. Caminata, M. Cariello, S. Di Domizio, L. Di Noto, P. Musico, M. Pallavicini, **S. Repetto**, G. Sobrero, G. Testera, *LArRI - a new setup for Liquid Argon Refractive index measurement*, Submitted to Elsevier for Nuclear Instruments and Methods in Physics Research Section A
2. M. Cariello, B. Bottino, A. Caminata, A. Campani, R. Caravita, S. Copello, S. Di Domizio, L. Di Noto, F. Ferraro, P. Musico, M. Pallavicini, **S. Repetto**, G. Sobrero, G. Testera, *A Wide Dynamics Range Front-End Electronics for SiPMs using High-Speed Operational and Integration Amplifiers*, Submitted to Elsevier for Nuclear Instruments and Methods in Physics Research Section A

5 Other activities

- Tutor for high school students on internship - 29th January 2024, 2nd February 2024

[1] Since SiPMs have a quantum efficiency of 15-20% at the peak of the scintillation light in LAr (126.8 nm), the addition of small amounts of Xe could increase the light yield by converting the 127 nm LAr scintillation light to 174 nm light.