Università di Genova | DIFI DIPARTIMENTO DI FISICA

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

Matteo Vicenzi
Supervisor: Prof. Marco Pallavicini

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Scientific activity

My research activity has been mainly focused on detector simulation and development for DUNE, a long-baseline neutrino oscillation experiment aimed at the precise determination of the mass hierarchy and the CP-violating phase. I am involved in the design and simulation of the SAND detector which will be part of the DUNE Near Detector complex at Fermilab, tasked with monitoring the neutrino beam and constraining systematic uncertainties for the oscillation analysis. In particular, I worked on developing an optical readout system for the scintillation light produced in the ~ 1 ton liquid Argon (LAr) target inside SAND. Since the spectrum is peaked in the VUV region, traditional imaging systems are difficult to implement due to the low transmission efficiency of materials and the constraints of the cryogenic setup.

Having investigated the possibility of exploiting coded masks as an imaging device last year, I moved my focus on the development of an innovative UV lens system. Similarly to the mask concept, lenses would be placed in front of pixelated photodetectors (arrays of SiPMs) in order to get a picture of the charged tracks through the emission of the scintillation light they generate while crossing the liquid Argon. The configuration is made of two plano-convex lenses, with a N_2 gas layer between them. The geometrical parameters are optimized in order to limit the defocusing for the possible range of expected track distances in the LAr module ($\sim 1\,\mathrm{m}$). Xe-doping in liquid Argon (< 10 ppm) shifts scintillation light from 128 nm to 175 nm, mitigating the typically low transmission at VUV wavelengths and allowing to find a suitable material for the lenses.

The lens configuration was optimized using Monte Carlo and ray-tracing simulations. In particular, I co-wrote a `C++` Geant4 application that handles the optical simulation of scintillation light inside the LAr target within the SAND software framework. I also developed preliminary reconstruction techniques to identify and fit tracks based on the Hough transform.

A lens prototype was also commissioned and manufactured by an external company, and is now ready to be tested. The first tests are planned in a warm setup, using optical wavelengths and water as a medium, in order to validate the Monte Carlo simulations.

In addition to my activities for DUNE, I also took part in activities for the ICARUS detector at Fermilab. ICARUS-T600 is a liquid Argon time-projection chamber, the far detector of the SBN (Short Baseline Neutrino) experiment. I have been contributing in the scanning effort to search for neutrino events in the data collected during the first commissioning runs, as well as participating in remote monitoring shifts both as a shifter and shift-helper. Moreover, I will

be traveling to Fermilab in the next months to work on the installation and commissioning of the CRT (Cosmic Ray Taggers) modules that are going to be installed on top of the ICARUS detector.

Attended courses

- *Introduction to the Foundations of Quantum Mechanics and Applications*
  Prof. Pierantonio Zanghì (Unige), Dr. Paolo Solinas (Unige)
  (exam to be given soon)

Attended schools

- *DUNE Neutrino Interaction School 2021*, June 7th - July 9th, 2021 (remote)
  Summer school on neutrino interaction models and cross-sections.

- *ISAPP 2021 Valencia*, July 21-30, 2021 (remote)
  Summer school on "Neutrino Physics, Astrophysics and Cosmology"
  Poster: "*System for on-Axis Neutrino Detection (SAND) at the DUNE Near Detector Complex*"

Attended conferences/workshops

- *107° Congresso Nazionale SIF*, September 13-17, 2021 (remote)
  Comunicazione: "*System for on-Axis Neutrino Detection (SAND) at the DUNE Near Detector Complex*"

- *NuFact 2021*, September 6-11, 2021 (remote)
  Poster: "SAND - System for on-Axis Neutrino Detection - in the DUNE Near Detector Complex"

Publications

- DUNE Collaboration, *Deep Underground Neutrino Experiment (DUNE) Near Detector Conceptual Design Report*, arXiv:2103.13910, accepted for publication.

- M. Andreotti et al., *Coded masks for imaging of neutrino events*, arXiv:2105.10820, under review.

Other activities

- Didactic Tutor (General Physics 1, Laboratory 1)
  September 2020 - July 2021 (40 hours)