

« DUNE's Far Detector Prototype: Calibrating at the MeV-scale »

Neutrinos have been central in the Standard Model since its beginning: the weak theory was built around these nearly massless, poorly interacting particles. Since its first measurements in 1956 by Poltergeist to its latest direct mass measurement in Katrin, neutrinos have been carriers of new physics. They have challenged our detector designs, finally forcing us to build bigger and better detectors to characterise them. The Liquid Argon Time Projection Chamber (LArTPC), based on scintillation photons and ionisation electrons, is one kind of detector design used for neutrino detection. It offers a good background rejection, via centimetre spatial resolution and precise timing.

DUNE, whose primary goal is to measure the mass-ordering and charge-parity violation, via accelerator neutrino oscillation characterisation, is the next generation of LAr-TPC detector. With its large volume and good cosmic rejection, the Far Detector of DUNE could be a perfect detector for MeV-scale neutrinos. Indeed, DUNE should be able to accurately reconstruct the Supernova neutrino burst and extract essential astrophysical or particle physics-related information. This range of energy is not optimal for DUNE, and a lot of radioactive background can be encountered. The main one is Ar39 beta-decays, which offer a uniformly distributed sub-MeV energy deposit. Some dedicated reconstruction tools and calibration methods must be developed to reach the best precision in this MeV physics. Moreover, using these tools on Ar39 can, while probing their working, offer some precious information about the detector itself, like the recombination or the purity.

This thesis happens in this context: using 2024 data from the prototype of the Far Detector, I identify several MeV sources and perform the first MeV calibration within DUNE. This work presents a reconstruction algorithm, SingleHit, that identifies point-like MeV deposits in the detector. This algorithm is thoroughly tested on simulations, showing that MeV and sub-MeV signals can be reconstructed. Then, the reconstructed simulations are used to calibrate the detector with three different sources identified in the detector: Ar39, Bi207 and Th232. From this calibration in the 0 to 5 MeV energy range, I characterise the recombination factor and find a value consistent with other experiments. A part of this thesis was also dedicated to characterising a test bench and building a procedure to validate the cathode suspension system within one of the Far Detector modules.