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ENUBET: a monitored neutrino beam for high precision cross section measurements

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The main source of systematic uncertainty on neutrino cross section measurements at the GeV scale is represented by the poor knowledge of the initial flux. The goal of cutting down this uncertainty to 1% can be achieved through the monitoring of charged leptons produced in association with neutrinos, by properly instrumenting the decay region of a conventional narrow-band neutrino beam. Large angle muons and positrons from kaons are measured by a sampling calorimeter on the decay tunnel walls (tagger), while muon stations after the hadron dump can be used to monitor the neutrino component from pion decays. This instrumentation can provide a full control on both the muon and electron neutrino fluxes at all energies. Furthermore, the narrow momentum width (<10%) of the beam provides a $\mathcal{O}(10\%)$ measurement of the neutrino energy on an event by event basis, thanks to its correlation with the radial position of the interaction at the neutrino detector. The ENUBET project has been funded by the ERC in 2016 to prove the feasibility of such a monitored neutrino beam and is cast in the framework of the CERN neutrino platform (NP06) and the Physics Beyond Colliders initiative.

The ERC project has entered its last year and the efforts are now devoted to the final tuning of the beamline shielding elements. These studies are being pursued exploiting a powerful genetic algorithm that scans automatically the parameter space of the focusing beamline in order to find a configuration minimizing halo particles in the tagger while preserving a large meson yield. Realistic particle identification algorithms have been setup to reconstruct muons and positrons in the decay tunnel with high signal to noise ratio on an event by event basis. A full Geant4 simulation of the facility is employed to assess the final systematics budget on the neutrino fluxes with an extended likelihood fit of a model where the hadro-production, beamline geometry and detector-related uncertainties are parametrized by nuisance parameters. In parallel the collaboration is building a section of the decay tunnel instrumentation (”demonstrator”, 1.65m in length, 7 ton mass) that will be exposed to the T9 particle beam at CERN-PS in autumn 2022, for a final validation of the detector performance and as a proof of the effectiveness of the technique.

In 2019-2022 ENUBET has devised the first end-to-end simulation of the facility and demonstrated that the precision goals can be achieved in about three years of data taking employing neutrino detectors of moderate mass (ICARUS at FNAL, ProtoDUNE at CERN). The technology of a monitored neutrino beam has been proven to be feasible and cost-effective, and the complexity does not exceed significantly the one of a conventional short-baseline beam. The ENUBET results will play an important role in the systematic reduction programme of future long baseline experiments, thus enhancing the physics reach of DUNE and HyperKamiokande. In our contribution, we summarize the ENUBET design, physics performance and opportunities for its implementation in a timescale comparable with next long baseline neutrino experiments.

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