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ENUBET: the first monitored neutrino beam

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The main source of systematic uncertainty on neutrino cross section measurements at the GeV scale originates from 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, since 2019, ENUBET is a CERN neutrino platform experiment (NP06/ENUBET).
ENUBET is going to present the final results of the ERC project in ICHEP, together with the complete assessment of the feasibility of its concept. The breakthrough the project achieved is the design of a horn-less beamline that allows for a 1% measurement of ν_e and ν_μ cross sections in about 3 years of data taking at CERN-SPS using ProtoDUNE as far detector. Thanks to the replacement of the horn with a static focusing system (2 s proton extraction) we reduce the pile up by two orders of magnitude, and we can monitor positrons from kaons plus muons from pion and kaon decays with a signal/background >2.
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.
The ENUBET design is such that the same sensitivity can be achieved using the proton accelerators available at FNAL using ICARUS as neutrino detector. The technology of a monitored neutrino beam has been proven to be feasible and cost-effective (the instrumentation contributes to about 10% of the cost of the conventional neutrino beam), and the complexity does not exceed significantly the one of standard short-baseline beams. ENUBET will thus 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.

In-person participation

Yes

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