Available online at www.sciencedirect.com
ScienceDirect
Nuclear Physics B Proceedings Supplement 00 (2010) 1–1
Nuclear Physics B Proceedings Supplement

The International Design Study for the Neutrino Factory

Marco Apollonio, Alan Bross, Joachim Kopp, Ken Long
(on behalf of the IDS-NF collaboration)

Keywords: Neutrino factory

The International Design Study for the Neutrino Factory (IDS-NF) is an international collaboration of 126 physicists and engineers from 52 institutes in the Americas, Asia, and Europe, with the aim of developing a conceptual design for a future Neutrino Factory facility. Such a facility would provide the best possible sensitivity to most of the neutrino mixing parameters, similar to what B-factories have achieved in the quark sector. The basic idea of a Neutrino Factory is to produce neutrinos in the decay of high energy muons, $\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$ (or the charge conjugate process), and observe oscillations, in particular in the $\nu_e \to \nu_\mu$ channel, over distances of several thousand kilometers. The three working groups of the IDS-NF focus on the evaluation of the physics potential of a Neutrino Factory, on accelerator R&D, and on detector R&D, respectively.

Physics and performance evaluation. The peculiar flavor structure of the Standard Model is still one of the least well understood mysteries of particle physics. Precision measurements of the neutrino masses and mixing parameters have a great potential to distinguish different models of flavor and shed light on the mechanism of neutrino mass generation. In addition, they can answer the question whether lepton mixing violates the CP symmetry by a large amount, which has fundamental importance to our understanding of the matter-antimatter asymmetry in the universe. With respect to these questions, the sensitivity of the Neutrino Factory is superior to that of all other proposed neutrino oscillation experiments if $\sin^2 2\theta_{13}$ is smaller than 10^{-3}, and highly competitive for larger values. The Neutrino Factory is also an excellent tool for probing certain classes of physics beyond the Standard Model that are hard to test otherwise, such as the existence of sterile neutrinos or of new interactions unique to the neutrino sector.

Accelerator Development. The main components of the accelerator complex for a Neutrino Factory are a multi-MW proton driver, the muon production target, the front end that bunches, phase rotates, and cools the muons, the muon accelerator, and the decay rings. Except for the decay rings, these components are very similar to what is required for a muon collider, so there are interesting synergies between the two facilities. The accelerator complex should ultimately deliver 10^{21} muon decays per year at a muon energy of 25 GeV, although a low-energy Neutrino Factory (LENF) with an endpoint energy of 5 GeV is also under consideration. The baseline design for the muon production target, a liquid mercury jet, has been tested successfully in the MERIT experiment, while the components of the front end are being developed by the MICE collaboration.

Detector development. The baseline configuration of the IDS Neutrino Factory is equipped with two detectors at distances around 3 000 km and 7 500 km from the source. The main requirement for the detectors is efficient muon charge identification to distinguish the signal from $\nu_e \to \nu_\mu$ oscillations from the "wrong sign muon" background due to unoscillated muon neutrinos. The most promising concept for such detectors is the magnetized iron calorimeter. The performance of this technology and of the required off-line analysis algorithms is being studied in detailed simulations. The detector at 3 000 km is envisioned to have a fiducial mass of 100 kt, while for the detector at 7 500 km (the "magic baseline"), 50 kt are sufficient. For the detection of neutrinos from a LENF, an externally magnetized liquid argon time projection chamber or totally active liquid scintillator detector are under investigation as well.