Compact Neutrino Sources for π^+ Decay-at-Rest Experiments

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Physics opportunities for Decay-at-Rest (DAR) sources are highlighted in G. Karagiorgi's note in this session. Key is that the DAR spectrum is essentially devoid of $\bar{\nu}_e$, inasmuch as most all pi minus produced are absorbed before decaying. The spectrum is well suited for appearance of $\bar{\nu}_e$ employing inverse beta decay in detectors with free protons (water Cherenkov or liquid scintillator).

This note addresses the accelerator requirements and work to date towards developing the compact, cost-effective accelerator systems needed to address these opportunities, in particular using requirements for the DAEδALUS experiment deploying neutrino sources at 1, 8 and 20 km from the large LBNE detector at the Sanford Underground Research Facility (SURF) in South Dakota.

Proton beams of 800 MeV provide optimal production of π^+, maximizing the π^+ / π^- ratio. Matching the event rate anticipated for LBNE requires average beam powers of 1, 2 and 5 MW. For identification of events only one accelerator can be running at a time, (a 20% duty factor is assumed), ramping the instantaneous power up by a factor of 5.

We are working on a cyclotron concept (L. Calabretta et al, arXiv:1107.0652) accelerating H_2^+ ions which offers excellent prospects for meeting the ambitious requirements given above. Stripping extraction to protons overcomes the difficult turn-separation problem, and so avoids a primary concern for beam loss at high energies. The low charge-to-mass ratio (2 protons for every charge) helps overcome the space-charge problem encountered at low energies. We are working through the long list of questions regarding the concept, and are developing an R&D program to address the most critical. To date no show-stopper problems have emerged.

Ion sources producing protons can be tuned for H_2^+ with excellent intensity and beam quality. We are working with a cyclotron company to mount a test using an existing source to design the central region of the Injector Cyclotron, which will accelerate up to 3 mA of H_2^+ to 50 MeV/amu. Designs for this Cyclotron are well along. The main cyclotron is an 800 MeV/amu Superconducting Ring Cyclotron with 8 sector magnets and a maximum field of 6T. Beam dynamics are being studied at INFN-LNS (Catania) and PSI (Villigen), and engineering studies of the sector magnet will commence shortly. A workshop of cyclotron experts will convene in Erice (Sicily) in December 2011 to further the design efforts.

Our timetable calls for establishment of design and cost baselines within about a year, and we are developing a roadmap for building and testing of prototypes. We will shortly begin planning for construction of the first neutrino source.

In the interim, experiments using these sources should be refined to develop specific flux requirements and configurations.