Searches for CENNS at the Spallation Neutron Source

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The Spallation Neutron Source (SNS) offers unique opportunities for neutrino physics. Properties of this source and a wide variety of opportunities are described in [1, 2, 3, 4].

A very interesting possibility for a stopped-pion neutrino source like the SNS is the detection of nuclear recoils from coherent elastic neutrino-nucleus scattering (CENNS), which is within the reach of the current generation of low-threshold detectors [5, 6, 7]. This reaction is also important for supernova processes and detection. This measurement also has excellent prospects for standard model tests; even a first-generation experiment has sensitivity beyond the current best limits on non-standard interactions of neutrinos and quarks [8]. Sterile oscillation searches are also possible [9]. Eventually, one may be able to measure neutron density distributions [10, 11].

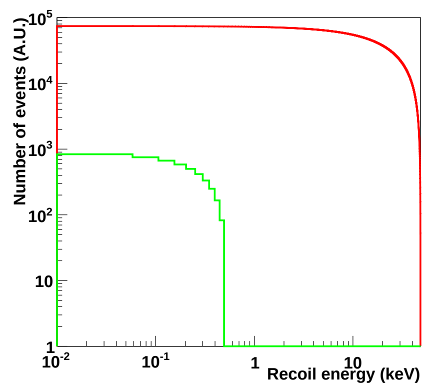

Figure 1: Red line: recoil energy spectrum in argon for monochromatic 30 MeV neutrinos (stopped-pion energy scale). Green line: for the same flux, recoil energy spectrum for monochromatic 3 MeV neutrinos (reactor energy scale).

Although ongoing efforts to observe CENNS at reactors [12, 13, 14, 15] are promising, a stopped-pion beam has several advantages with respect to the reactor experiments. Although reactor fluxes are higher, cross-sections at stopped-pion energies (up to 50 MeV) are about two orders of magnitude higher than at reactor energies (see Fig. 1). Perhaps more importantly, higher recoil energies bring detection within reach of the current generation of low-threshold detectors, which are scalable to relatively large target masses. Furthermore, the pulsed nature of the source allows both background reduction and precise characterization of the remaining background by measurement during the beam-off period. Finally, the different flavor content of the SNS flux (ν_μ, ν_e and $\bar{\nu}_\mu$) means that physics sensitivity is complementary to that for reactors ($\bar{\nu}_e$ only).

One can imagine approximately three experimental phases with different experimental scales that will address different physics:

Phase 1: a few to few tens of kg of target material (depending on distance to the source) could make the first measurement.

Phase 2: a few tens to hundreds of kg of target material could set significant limits on non-standard neutrino interactions, and could also begin to address sterile neutrino oscillations, depending on configuration.

Phase 3: a tonne-scale or more experiment could begin to probe neutron distributions.

Various technologies are suitable at different scales and offer various advantages and disadvantages. Some possibilities are noble liquids such as neon, argon, and xenon [8, 17, 16], existing germanium detector technology [18, 19], *e.g.* point-contact detectors, and bolometers [20]. For the long term, multiple nuclear targets will be valuable.

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