Opportunities for Neutrino Measurements at the Spallation Neutron Source

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The Spallation Neutron Source (SNS) offers unique opportunities for neutrino physics. While designed as a neutron source, neutrinos are produced as a free by-product, and this neutrino source is of exceptional quality. The SNS protons on target produce numerous pions, which stop in the target and decay at rest, yielding monochromatic 30 MeV ν_μ from pion decay at rest, followed on a 2.2-μs timescale by $\bar{\nu}_\mu$ and ν_e with a few tens of MeV from μ decay; there should be very little contamination from decay-in-flight pions, and hence the spectral uncertainties are small. Flavor content uncertainties are also small, as the fraction of neutrinos originating from π^+ is high. The expected ν flux is $\sim 10^7$ cm^{-2}s^{-1} per flavor. The short-pulse time structure is excellent for neutrino experiments, with 60 Hz of sub-μs pulses providing a 10^{-3}-10^{-4} background rejection factor [1]. **The SNS is currently the world's best neutrino source of this nature and will likely remain so for at least a decade.**

A rich program of physics is possible with such a stopped-pion ν source. In addition to sterile oscillation searches and coherent elastic neutrino-nucleus scattering studies (addressed in separate whitepaper contributions [2, 3]), the SNS is ideal for measurements of ν-nucleus cross sections in the few tens-of-MeV range in a variety of targets relevant for supernova neutrino physics [4]. This territory is almost completely unexplored: so far only ^{12}C has been measured at the $\pm$10% level [5, 6]. The ν spectrum matches the expected supernova spectrum reasonably well (see Fig. 1); the slightly harder stopped-pion spectrum makes for higher event rates. Understanding of ν-nucleus interactions in this regime is vital for understanding of supernovae: core-collapse dynamics and supernova nucleosynthesis are highly sensitive to ν processes. Neutrino-nucleus cross section measurements will furthermore enhance our ability to extract information about ν mixing properties (in particular, mass hierarchy) from the observation of a Galactic supernova ν burst, via understanding of both the supernova itself and of the ν detection processes. The highest-priority targets for which to measure cross sections are argon (relevant for current and planned detectors like Icarus, MicroBooNE and LBNE), lead (relevant for the new detector HALO), water (relevant for water Cherenkov detectors) and carbon (relevant for scintillator detectors). Such measurements have previously been proposed for the SNS [7], which offers the excellent duty factor desirable for rejection of backgrounds. More details can be found in [8, 9, 10].

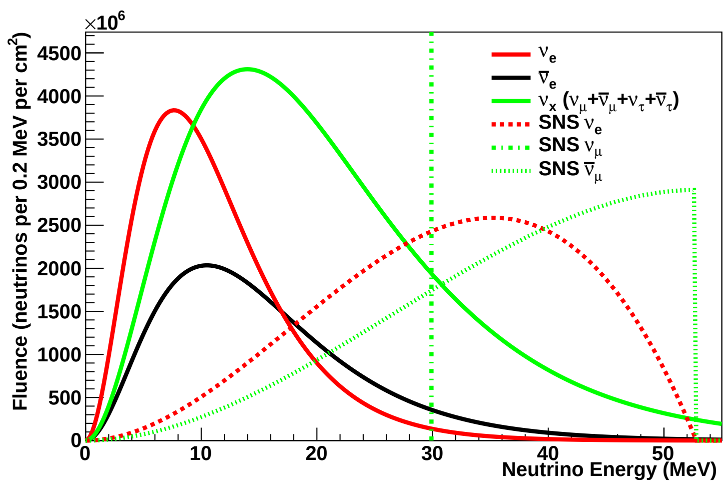

Figure 1: Solid lines: typical expected supernova spectrum for different flavors; fluence integrated over the $\sim$15-second burst. Dashed and dotted lines: SNS spectrum; integrated fluence for one day at 30 m from the SNS target.

References

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