Background Studies for the COHERENT Experiment at the Spallation Neutron Source (P3.002)

COHERENT Collaboration

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Collaborating Institutions

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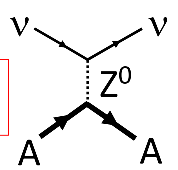
Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) Experiment

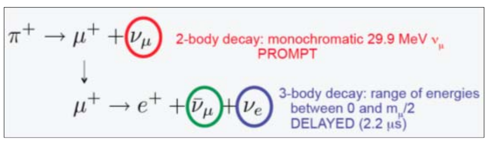
$$\nu + A \rightarrow \nu + A$$

A neutrino 'smacks' a nucleus via exchange of a Z, and the nucleus recoils as a whole; coherent up to E_ν ~ 50 MeV

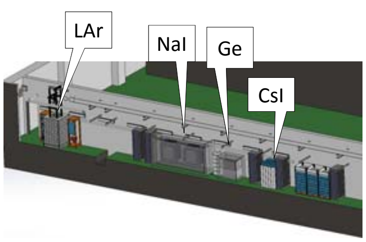


Detection observable – measure low-energy nuclear recoil.

Neutrino source – Oak Ridge National Laboratory, Spallation Neutron Source (SNS)



Multiple Detector Systems – located in SNS basement hallway



CsI[Na] – 14 kg, 19 m

HPGe PPC – 10 kg, 21 m

NaI[Tl] – 185 g (future 2T), 22 m

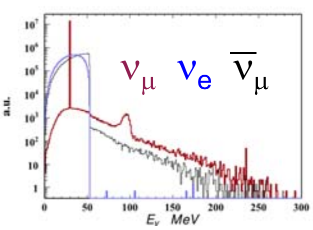
CENNS10 LAr – 35 kg, 28 m

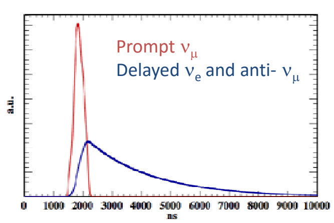
(COHERENT Poster P2.038)

COHERENT Collaboration, arXiv:1509.08702

Backgrounds

Neutrino Beam Flux and Timing - enables background rejection





➢Signal - low-energy recoiling nuclei with no visible incoming or outgoing particles

- Use timing window to reduce steady-state backgrounds by factor of $10^3 – 10^4$
  – radioactivity and cosmogenics (8 mwe overburden)
- Precise characterization of environmental backgrounds unrelated to the beam
  – measure outside prompt and delayed timing window (neutrino emission)
  – simulations
- Neutron Shielding helps and hurts
  - Easily stops low-energy neutrons but creates low-E shower from high-E neutrons
  - Inelastic scattering of neutrinos in lead produces neutrons
  Neutrino-Induced-Neutron production – poster P2.039
- Gamma-ray backgrounds – easily shielded; do not pose a problem
  – Nearby pipe – source of 511 keV γ measured: ~25 γ's/cm²/s
  – wall flux ~0.9 γ's/cm²/s, floor flux ~1 γ's/cm²/s (measured and simulated)

~100 keV – 1 MeV neutrons in the detector can produce similar recoil spectra as our neutrino scattering signal → Neutron backgrounds must be carefully characterized

Neutron Background Studies

Combination of multiple technologies and complementary analysis by multiple groups provides confidence in background results

Systems available for monitoring:

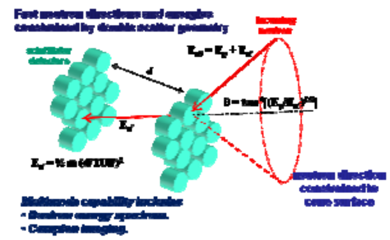
Initial studies with portable LS cells, coded aperture imager (ORNL, U. Tennessee)

Systematic studies with Neutron Scatter Camera (Sandia National Lab)

Single-Plane Single Scatter (SciBath) detector (Indiana U.)

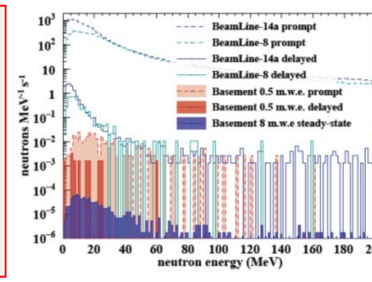
All neutron studies indicate the basement location is "neutron quiet"
In delayed beam window and steady state: fast neutron flux greatly reduced and low-energy neutrons easily shielded

Scatter Camera Measurement



Mascarenhas, *et al.*, *IEEE Trans. Nucl. Sci* **56**, 1269 (2009)

- Fast neutron backgrounds in the basement are clearly associated with 800 ns protons on target
- A 2.2 μs window after the beam would highlight muon decay neutrinos ($\bar{\nu}_\mu$, ν_e)
- Neutron backgrounds reduced by at least an order of magnitude and are lower in energy in the delayed window compared to prompt



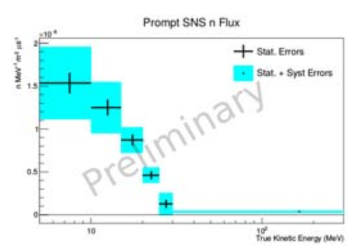
SciBath Detector Measurement

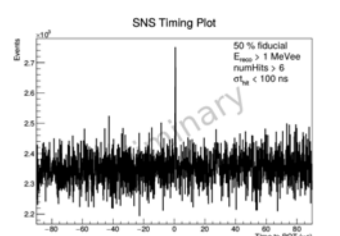
- Liquid scintillator with 3 sets of mutually orthogonal, parallel arrays of wavelength-shifting optical fibers
  3D fiber grid gives fine position resolution and accurate directional spectra
- Timing resolution ~20ns

Tayloe, *et al.*, *Nucl. Instrum. Meth.* **A562**, 198 (2006)

Measurements in LAr Position

Prompt neutron flux (2.1 ± 0.4) × 10^{-5} n/m²/spill
Muon flux ~(60 ± 3) μ's/m²/s
Delayed neutron flux – expected to be low
fast neutron flux consistent with zero
calculated limit in progress





Prompt spectrum propagated to LAr system with shielding – 3.3 events/year

This work is supported in-part by ORNL SEED funds, Sandia National Lab LDRD and NA-22 funds, and Indiana University National Science Foundation grants.
COHERENT Collaborators are supported by the US Department of Energy Office of Science, National Science Foundation, and Sloan Foundation. The collaboration acknowledges the support of ORNL personnel especially at the SNS, Pacific Northwest Laboratories and Triangle Universities Nuclear Laboratory for detector resources, and Fermilab for the loan of the CENNS-10 apparatus.
DMM acknowledges support from NSF Award HRD- 1345219, NASA Award NNX09AV07A