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

COHERENT Collaboration

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 \( E_{\nu} \sim 50 \text{ MeV} \)

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

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Neutrino Beam Flux and Timing - enables background rejection

- Use timing window to reduce steady-state backgrounds by factor of \( 10^8 - 10^9 \)
- Precise characterization of environmental backgrounds unrelated to the beam
- Neutron Shielding helps and hurts
  - Use timing window to reduce steady-state backgrounds by factor of \( 10^8 - 10^9 \)
  - Precise characterization of environmental backgrounds unrelated to the beam
- Neutron-induced neutron production – poster P2.039

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

- Fast neutron backgrounds in the basement are clearly associated with 800 ns protons on target
- A 2.2 \( \mu \text{s} \) window after the beam would highlight muon decay neutrinos \((\nu_{\mu}, \bar{\nu}_{\mu})\)
- 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 \(~20\text{ns}~\)

Measurements in LAr Position

Prompt neutron flux \((2.1 \pm 0.4) \times 10^{-5} \text{n/m}^2/\text{spill}~\)
Msnu flux \((60 \pm 3) \mu\text{s/m}^2/\text{s}~\)

delayed neutron flux – expected to be low

Neutrino-Induced-Neutron production – poster P2.039

- Gamma-ray backgrounds – easily shielded; do not pose a problem
- Nearby pipe – source of 511 keV \( \gamma \) measured: \(-25 \gamma/s/cm^2/s\)
- wall flux \(-0.9 \gamma/s/cm^2/s\), floor flux \(-1 \gamma/s/cm^2/s\) (measured and simulated)

~100 keV – 1 MeV neutrinos in the detector can produce similar recoil spectra as our neutrino scattering signal \( \rightarrow \) Neutron backgrounds must be carefully characterized

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