Toward a CEvNS Measurement with Germanium

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Outline

• The Spallation Neutron Source (SNS) as a neutrino source.
• First measurement of coherent elastic neutrino-nucleus scattering (CEvNS) by COHERENT in 2017.
• Motivation and benefits of a Ge detector at the SNS.
• Background measurements in anticipation of deployment.
The SNS has many favorable features as a neutrino source:

- Decay at rest (DAR) pion spectrum is ideal for CEvNS
- Pulsed beam at 60 Hz with a very small duty factor
- Detector placement available only 20m from the target
- Large flux (>10^7 ν/cm^2/s at 20m)
- > 1 MW Beam Power

- The COHERENT CEvNS measurement was done at the SNS at Oak Ridge National Lab
- This site was chosen because of the optimal features of the neutrinos produced
In September 2017 the COHERENT Collaboration published the world’s first measurement of Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) in Science Magazine.
The Standard Model cross section for CEvNS has an $N^2$ dependence.

We want to measure CEvNS across multiple detector materials.

Provides confirmation of initial result and accounts for systematics.
Germanium offers several advantages:

- Low-backgrounds, low (<1keV) thresholds, and excellent energy resolution
- Well-established technology
- Quenching factor is known
- It is a “medium” $^2\text{N}$ nucleus

The planned location of the COHERENT Ge detector system is next to the existing CsI detector in Neutrino Alley.

The MARS detector is currently taking data in this location to assess neutron backgrounds.
Measuring Backgrounds

- Neutron backgrounds have been measured previously in the basement with the Neutron Scatter Camera and SciBath detectors.
- The dramatic reduction in neutron background w.r.t. the experiment hall makes the basement an excellent location for neutrino experiments.

[Images of experimental equipment and graphs showing neutron energy distribution and time-of-flight spectra.]
MARS (Multiplicity And Recoil Spectrometer)

- MARS has been collecting data in the planned location for Ge since September 2017
- Gadolinium doped plastic scintillator instrumented with 16 PMTs ([https://doi.org/10.1016/j.nima.2016.04.032](https://doi.org/10.1016/j.nima.2016.04.032))
- Neutrons will show up with a “recoil” signal – an initial energy deposition followed by a capture on Gd
- Will be used to measure the neutron spectrum in this location.
Plan for Germanium Deployment

• Location available for Ge detector deployment, but specifics still tentative.

• Nominal plan is to use current on-hand Ge detectors to perform ‘first-light’ measurements in 2018.

• These detectors may be sensitive to CEvNS, but planning is underway to ultimately phase these out with 10 kg of state-of-the-art low threshold detectors (approx. 150 eVee threshold).

• Such detectors will not only allow for extremely sensitive measurement of CEvNS, but could potentially probe neutrino electromagnetic properties as well.
Summary

• The first measurement of CEvNS on CsI proved that it is possible at the SNS
• COHERENT has deployed other detectors (CsI, Ar, NaI) to measure CEvNS and a germanium detector will soon be added.
• Backgrounds are being measured and will inform shielding package
• The physics potential for low-threshold, low background Ge detectors at the SNS is very high!
http://sites.duke.edu/coherent

~80 members, 19 institutions, 4 countries

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