Toward a CEvNS Measurement with Germanium

Jacob Daughhetee & Justin Raybern

For the COHERENT Collaboration

Outline

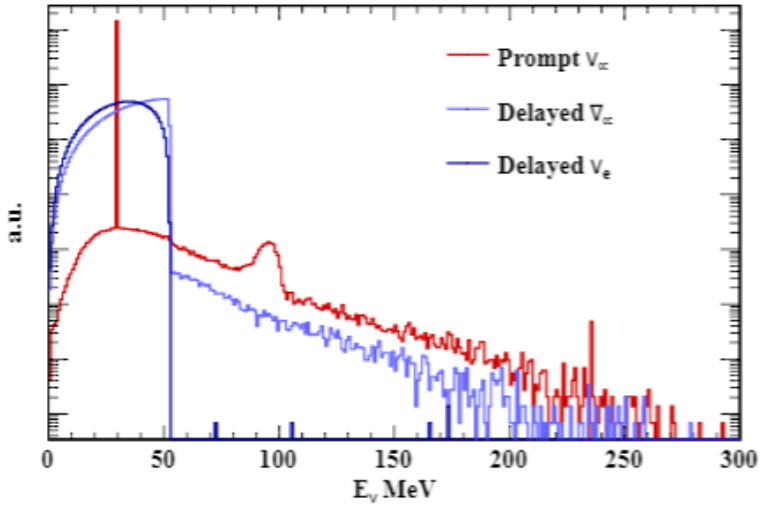
- The Spallation Neutron Source (SNS) as a neutrino source.
- First measurement of coherent elastic neutrino-nucleus scattering (CEvNS) by COHERENT in 2017.
- Motivation and benefits of a Ge detector at the SNS.
- Background measurements in anticipation of deployment.

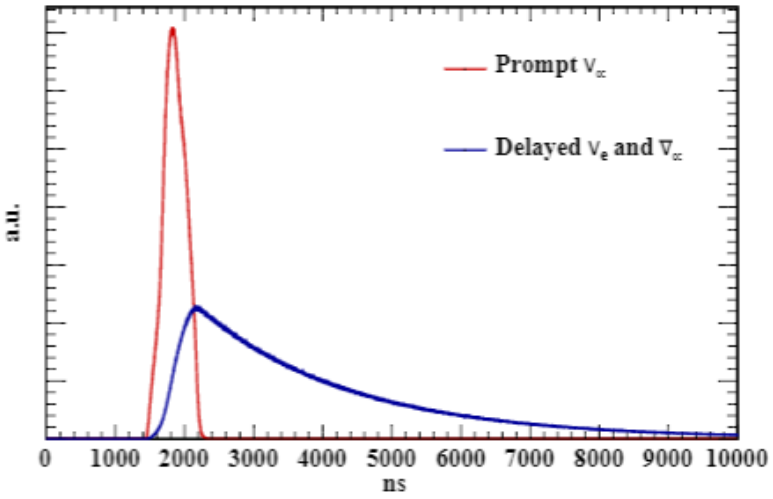
The Spallation Neutron Source (SNS)

The SNS has many favorable features as a neutrino source:

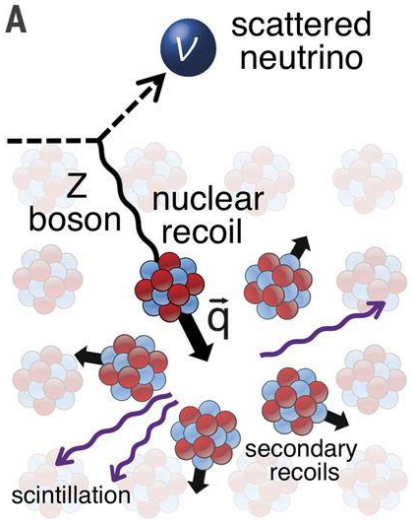
- Decay at rest (DAR) pion spectrum is ideal for CEvNS
- Pulsed beam at 60 Hz with a very small duty factor
- Detector placement available only 20m from the target
- Large flux (>10^7 $\nu/cm^2/s$ at 20m)
- > 1 MW Beam Power

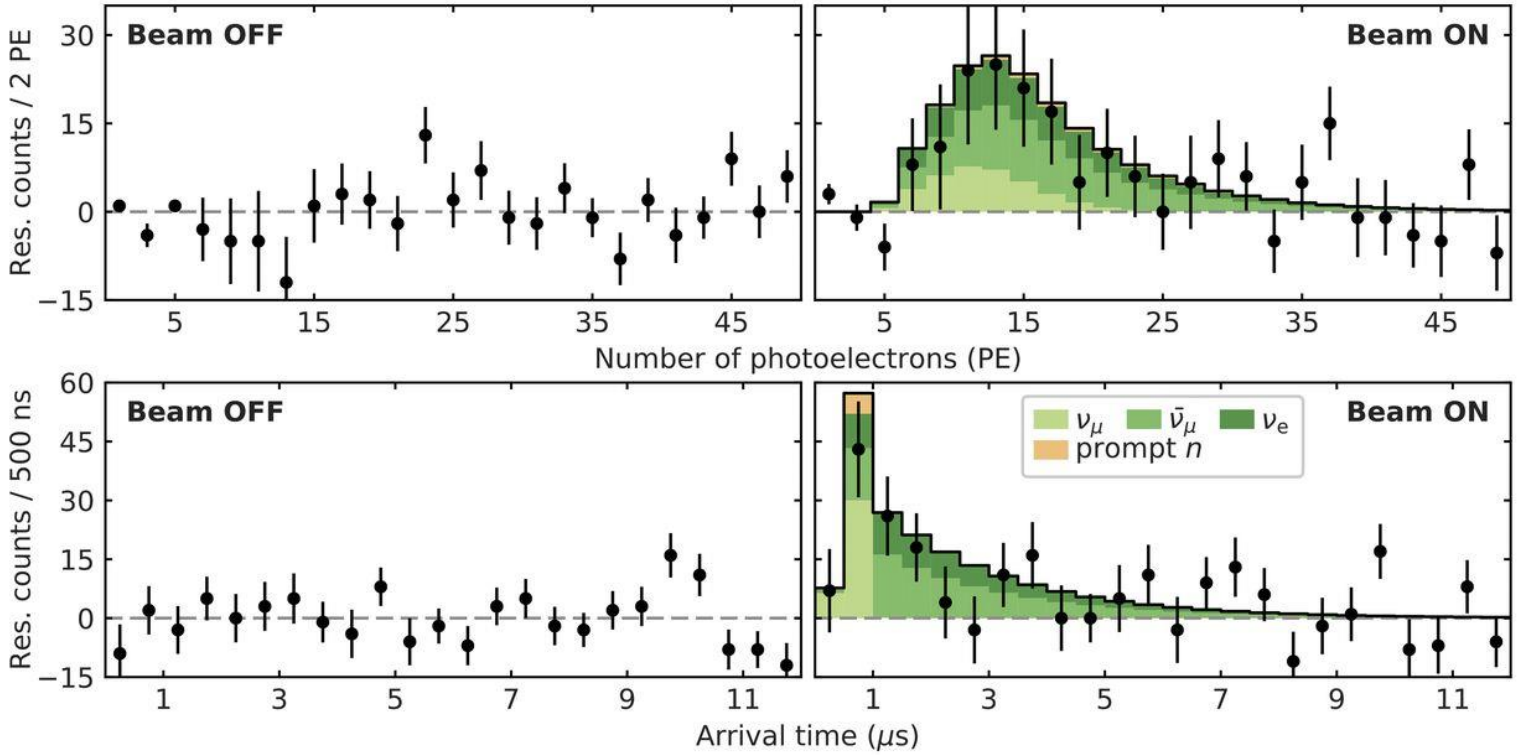
- The COHERENT CEvNS measurement was done at the SNS at Oak Ridge National Lab
- This site was chosen because of the optimal features of the neutrinos produced





A First Measurement of CEvNS

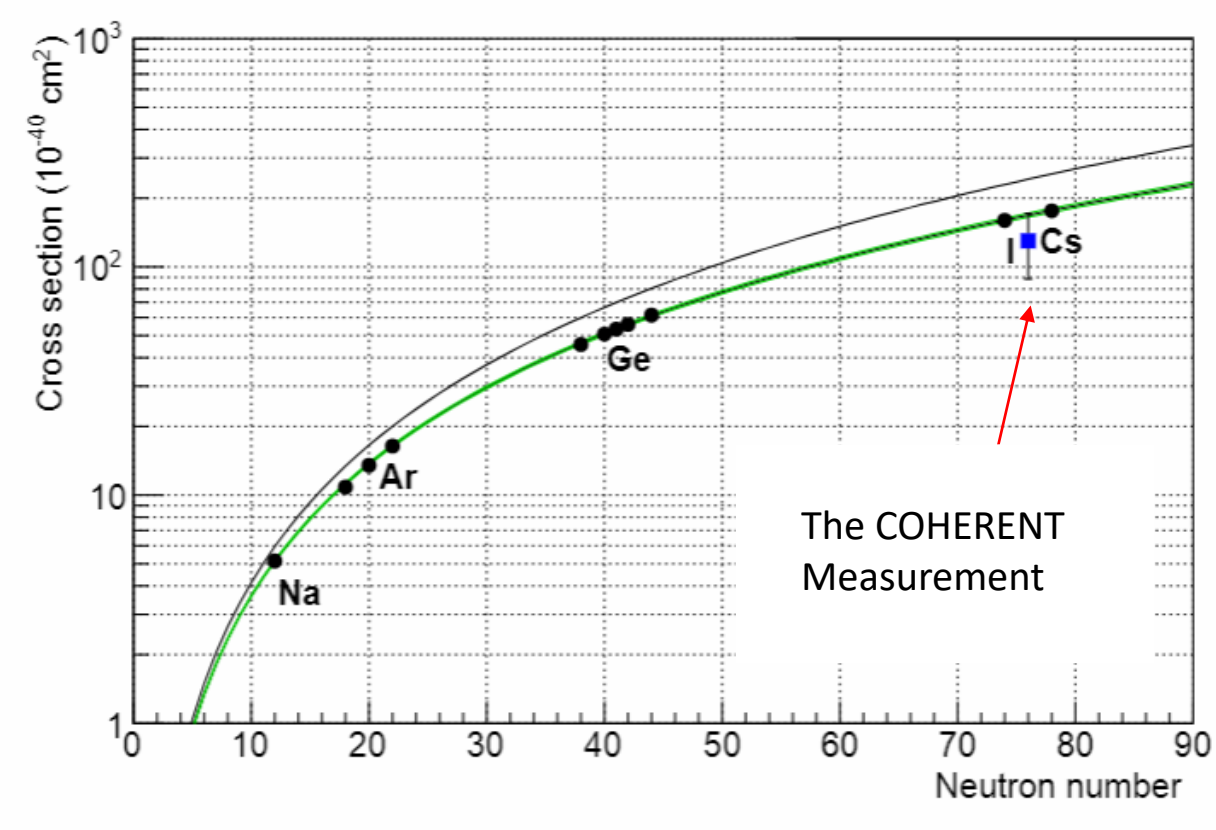




In September 2017 the COHERENT Collaboration published the world's first measurement of Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) in Science Magazine

CEvNS Cross Section

A Sample of COHERENT Proposed CEvNS Isotopes

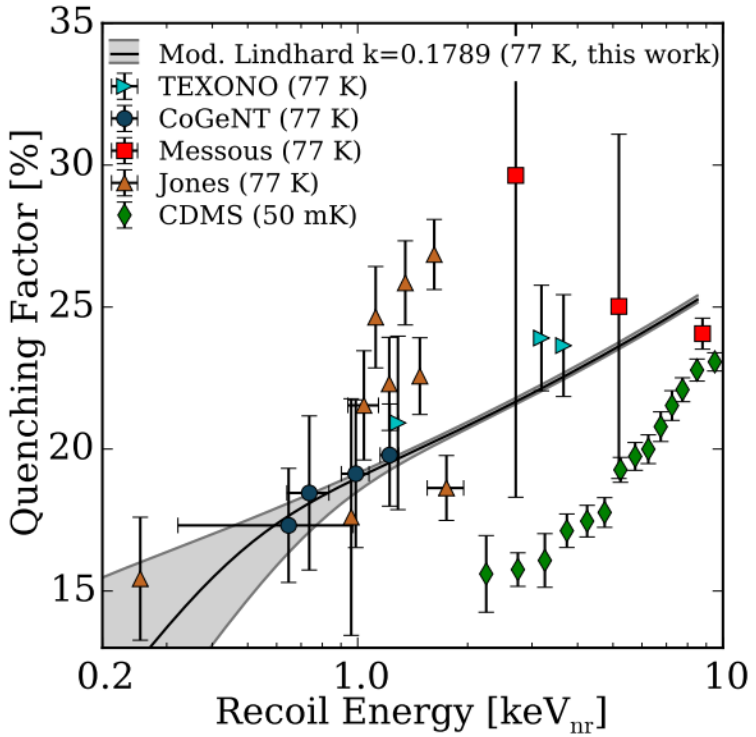


- The Standard Model cross section for CEvNS has an N^2 dependence
- We want to measure CEvNS across multiple detector materials
- Provides confirmation of initial result and accounts for systematics

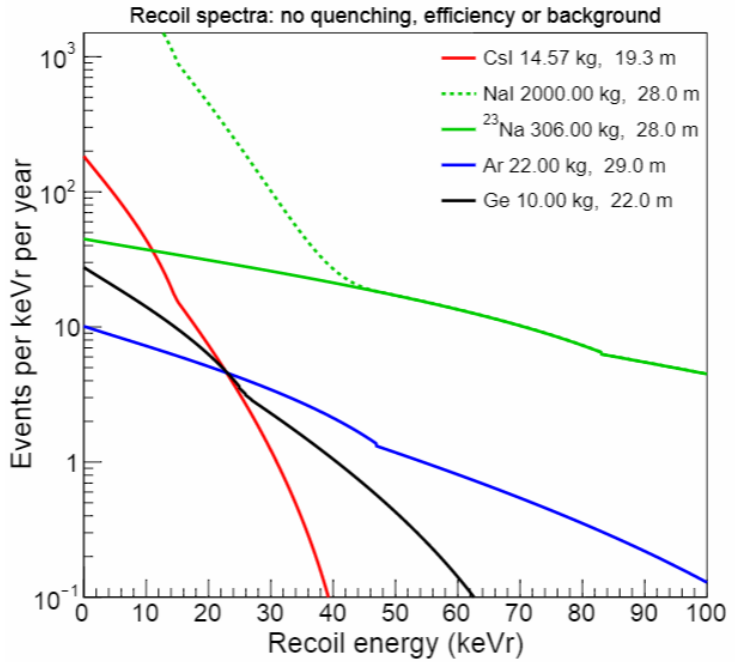
A Measurement With Germanium

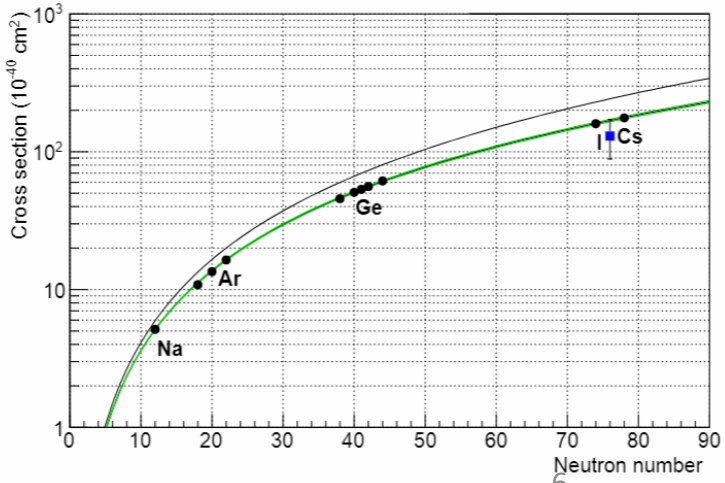
Germanium offers several advantages:

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

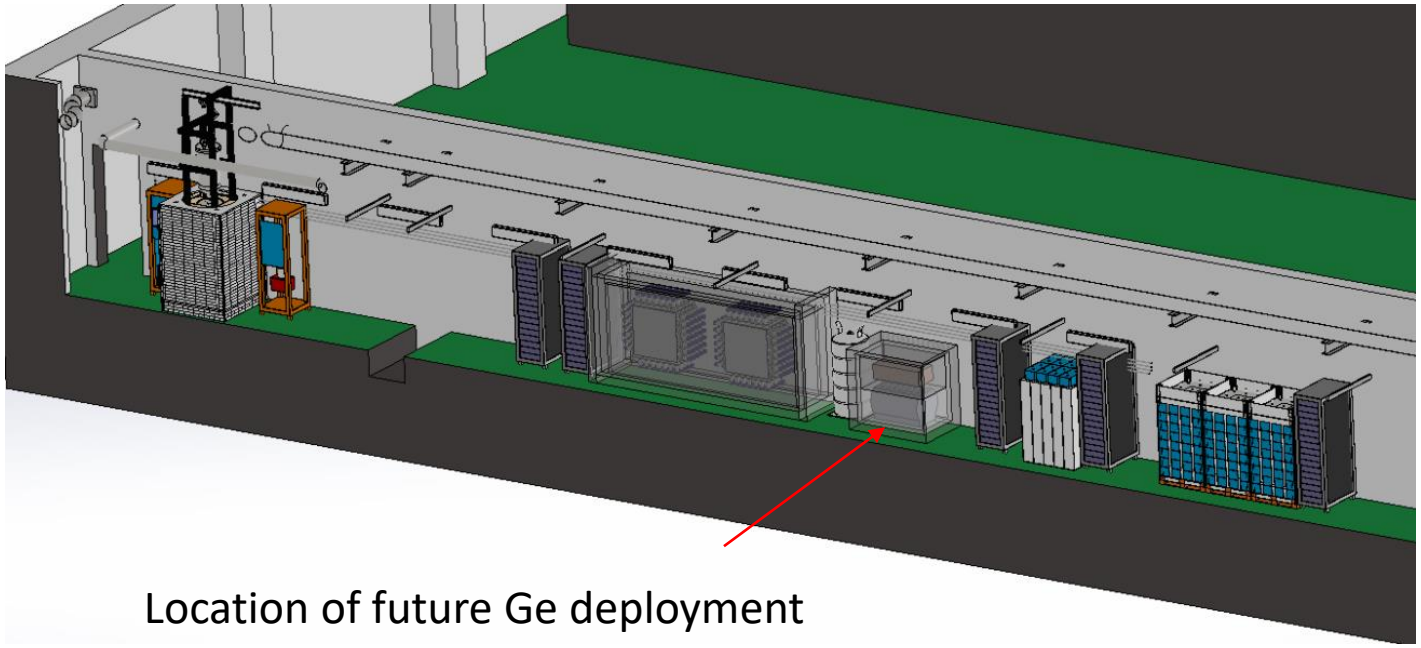


https://arxiv.org/pdf/1608.03588.pdf

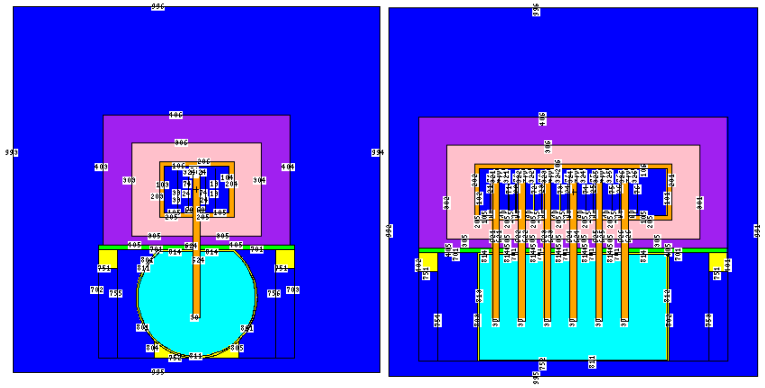




Location in Neutrino Alley



Location of future Ge deployment



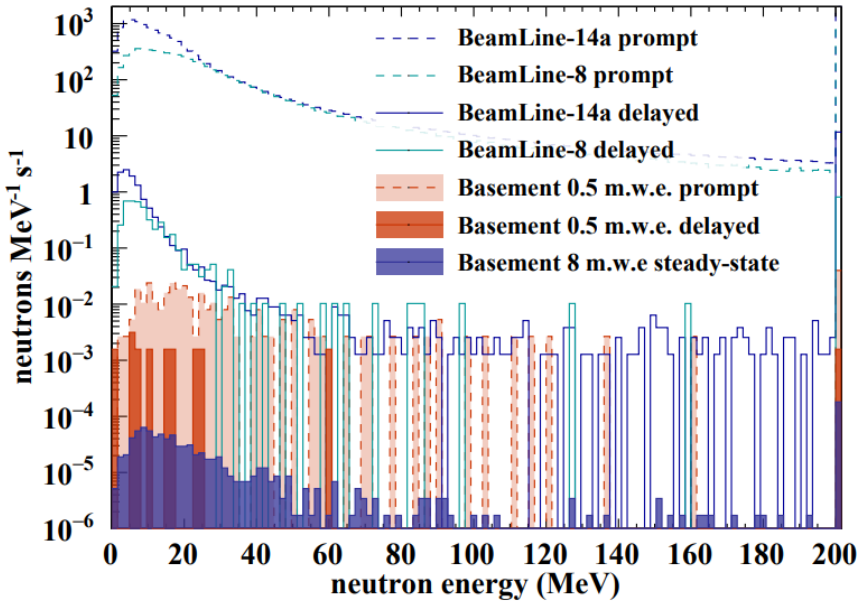
Sketch of Ge system design

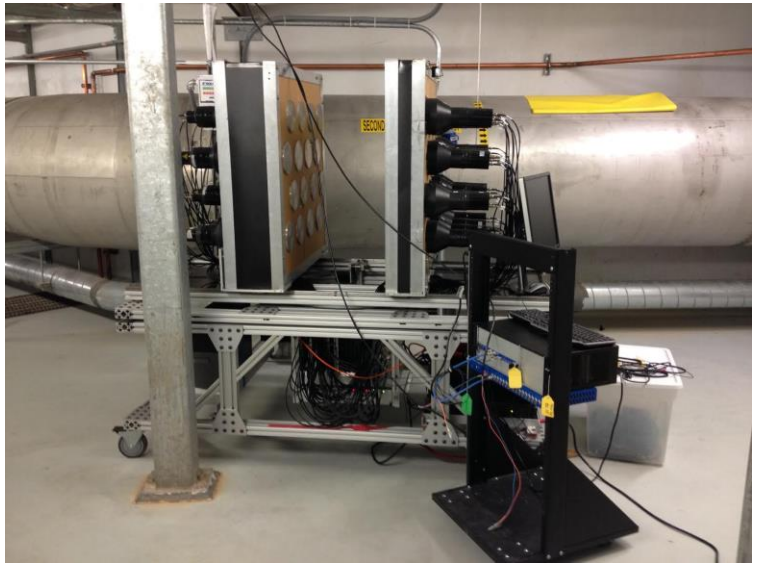
- The planned location of the COHERENT Ge detector system is next to the existing CsI detector in Neutrino Alley.
- The MARS detector is currently taking data in this location to assess neutron backgrounds.

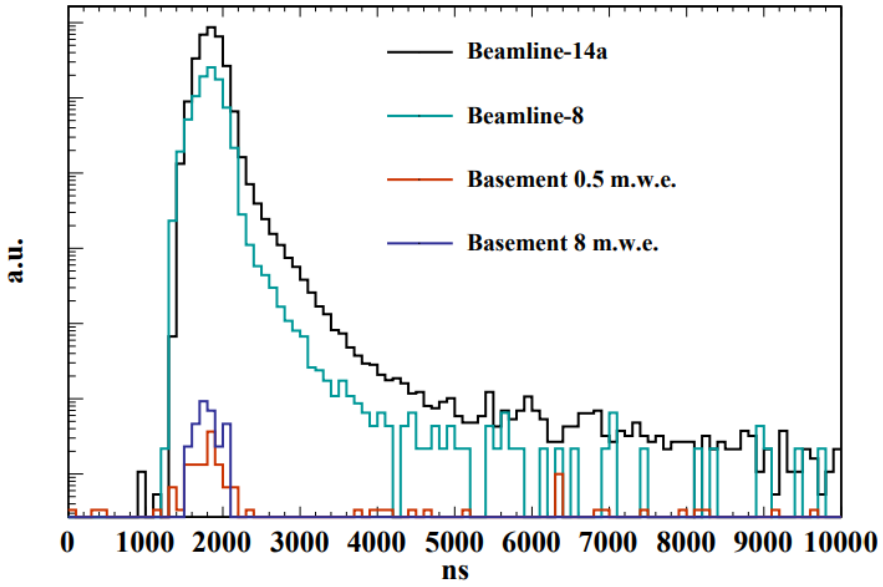
Measuring Backgrounds

- 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.

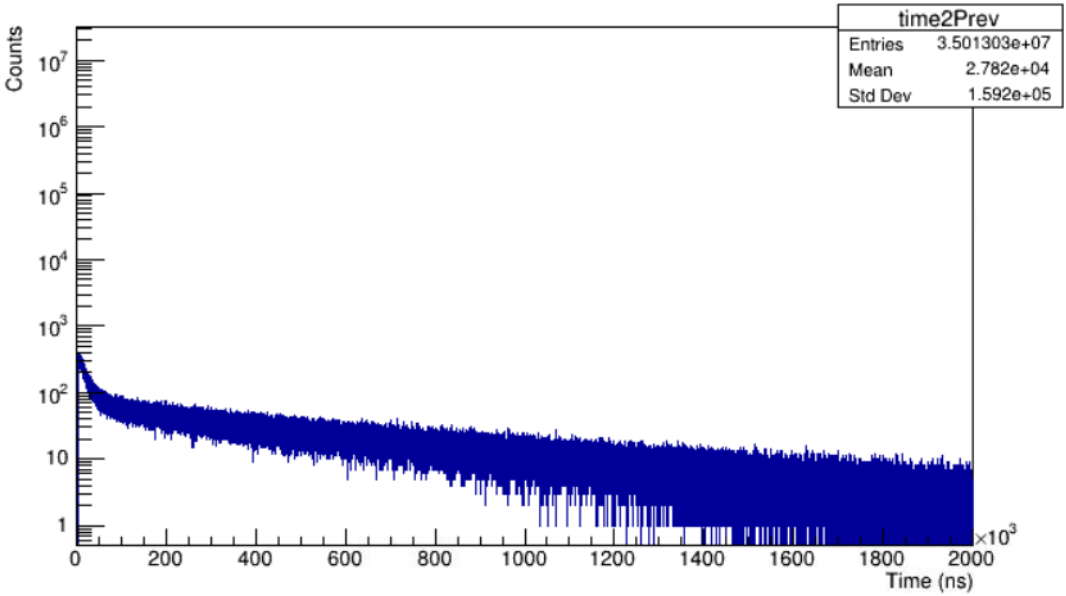






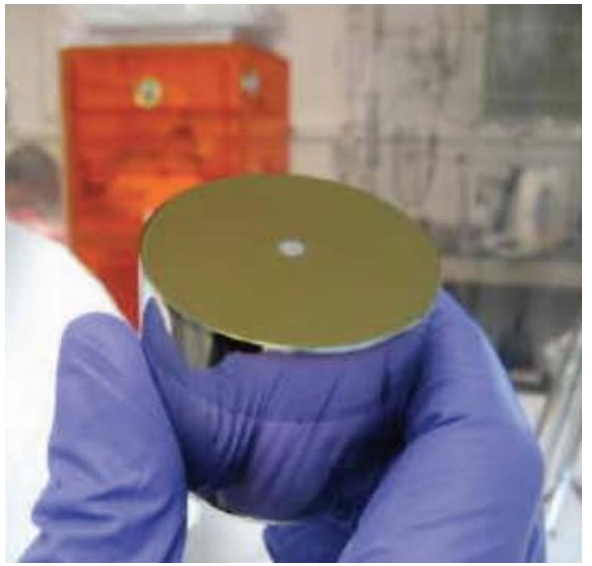
MARS (Multiplicity And Recoil Spectrometer)

- 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)
- 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.



23.9 µs neutron capture time shown

Plan for Germanium Deployment

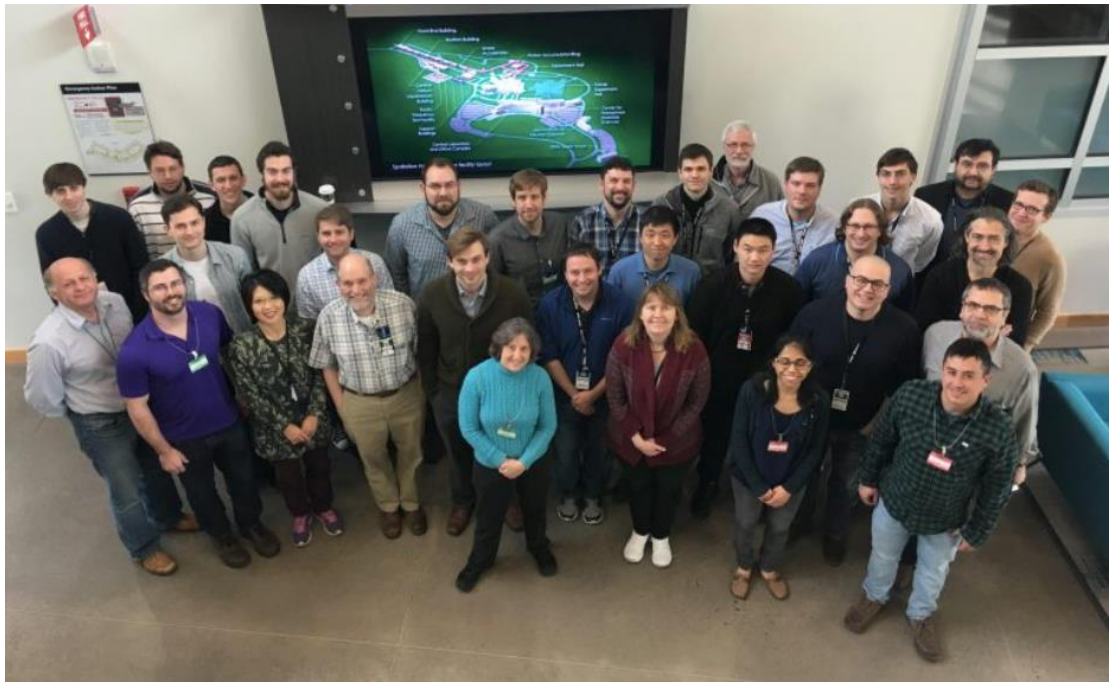


- Location available for Ge detector deployment, but specifics still tentative.
- Nominal plan is to use current on-hand Ge detectors to perform ‘first-light’ measurements in 2018.
- These detectors *may* be sensitive to CEvNS, but planning is underway to ultimately phase these out with 10 kg of state-of-the-art 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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