COHERENT At The Spallation Neutron Source

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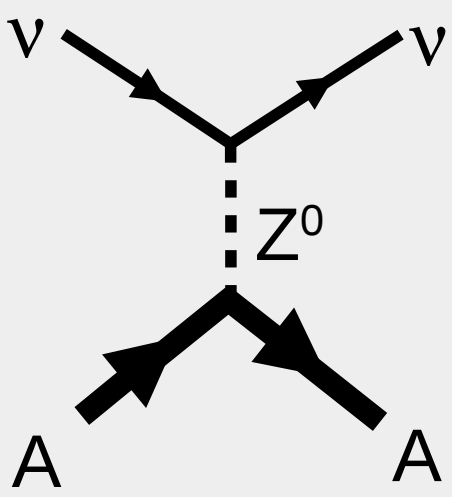
Coherent elastic neutrino-nucleus scattering (CEvNS)



- Nuclear recoil from Z exchange is coherent for all nucleons
- Well accepted but never directly measured
- Flavor blind
- Enhanced cross section
- Important background for future DM experiments
- Proportional to N^2

$$\frac{d\sigma}{d\Omega} = \frac{G^2}{4\pi^2} k^2 (1+cos\theta) \frac{\left(N-\left(1-4\sin^2\theta_\omega\right)Z\right)^2}{4} F^2\left(Q^2\right)$$

A. Drukier & L. Stodolsky, Phys. Rev. D (1984)

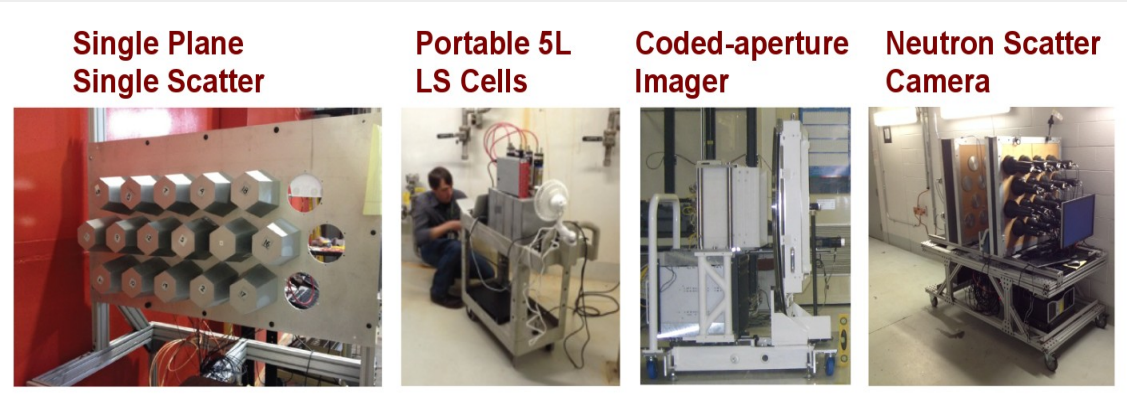
CEvNS by COHERENT

"The COHERENT collaboration aims to measure CEvNS (Coherent Elastic Neutrino-Nucleus Scattering) using the high-quality pion-decay-at-rest neutrino source at the Spallation Neutron Source"

Why look for CEvNS?

- Large σ in supernova processes
- Excellent test of Standard Model calculations
- Possible applications in reactor monitoring

Detectors used by COHERENT for background assessment



COHERENT.phy.duke.edu

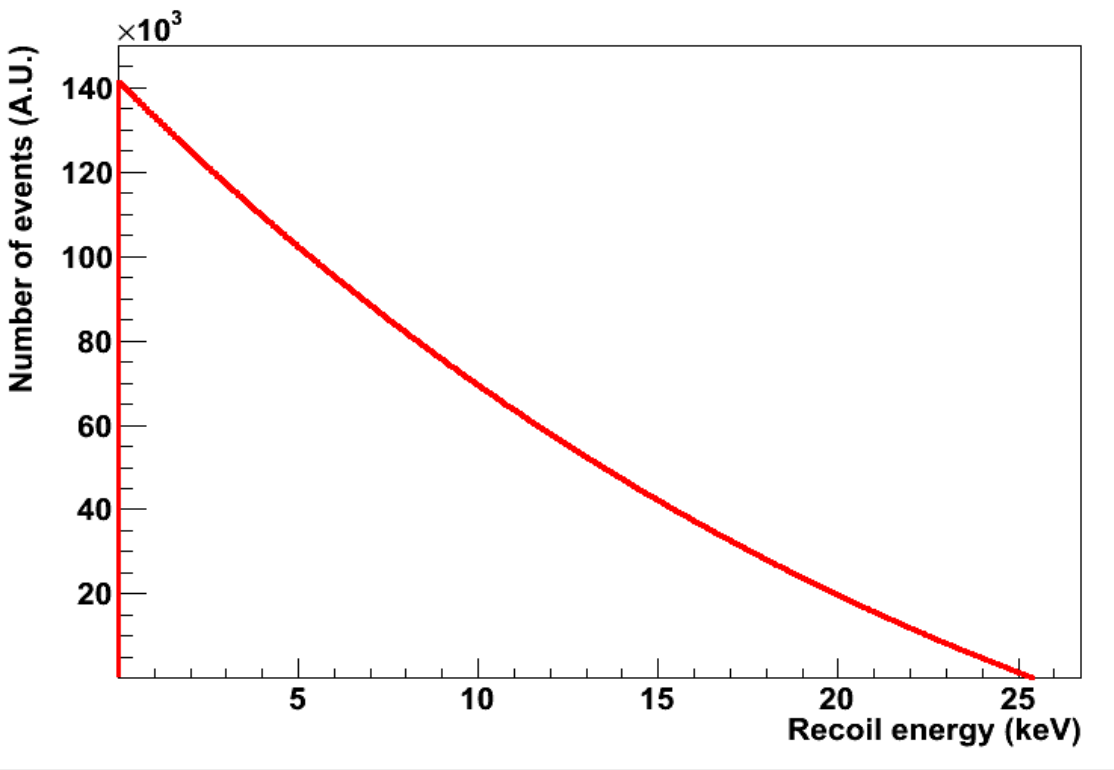
CEvNS detection

It is very difficult to observe....

- Intense neutrino source of appropriate energy needed
- Detection signal of order 10keV nuclear recoil

$$E_{MAX,recoil} = \frac{2E_\nu^2}{M}$$

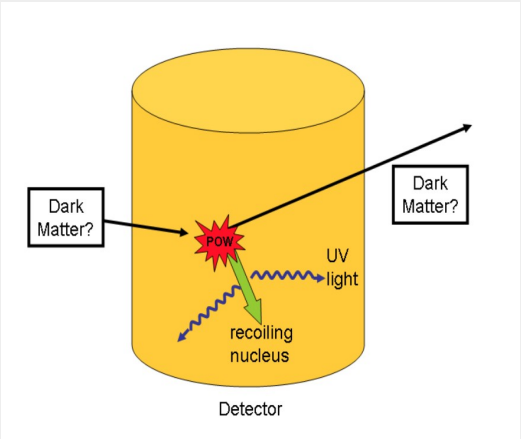
Recoil energy in Ge for a 30 MeV neutrino



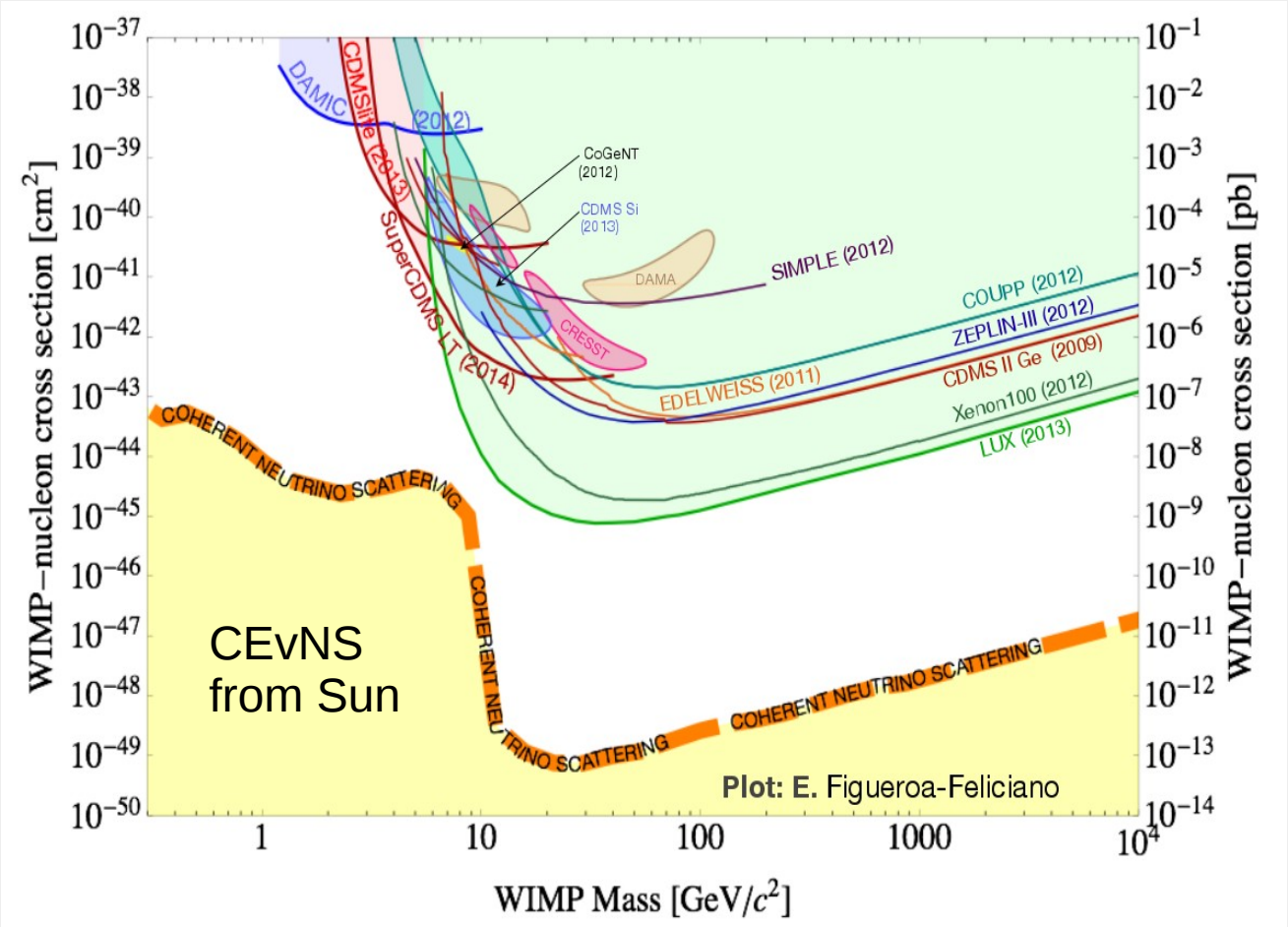
CEvNS as WIMP background

But....

Dark matter detectors have been developed with order 1keV sensitivity!
We can measure CEvNS!

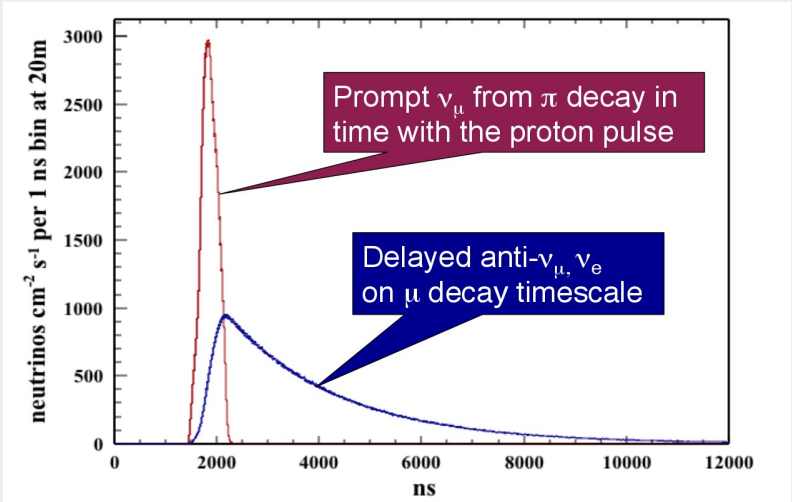


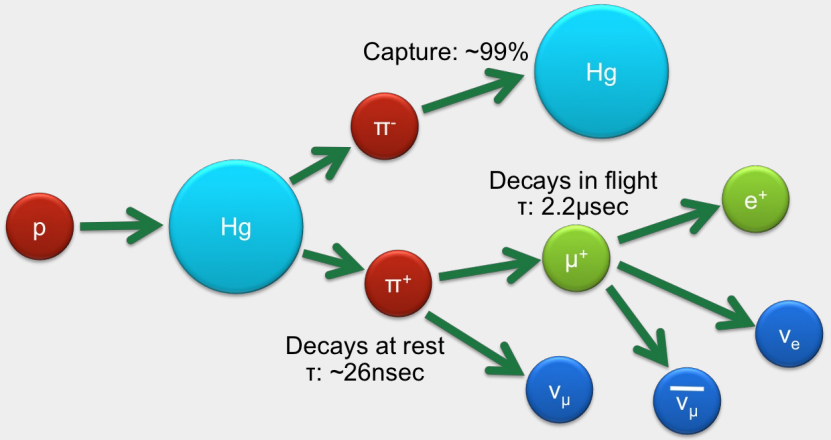
CEvNS background for WIMP dark matter searches



CEvNS at the SNS

"SNS is a one-of-a-kind research facility that provides the most intense pulsed neutron beams in the world"
neutrons.ornl.gov/sns





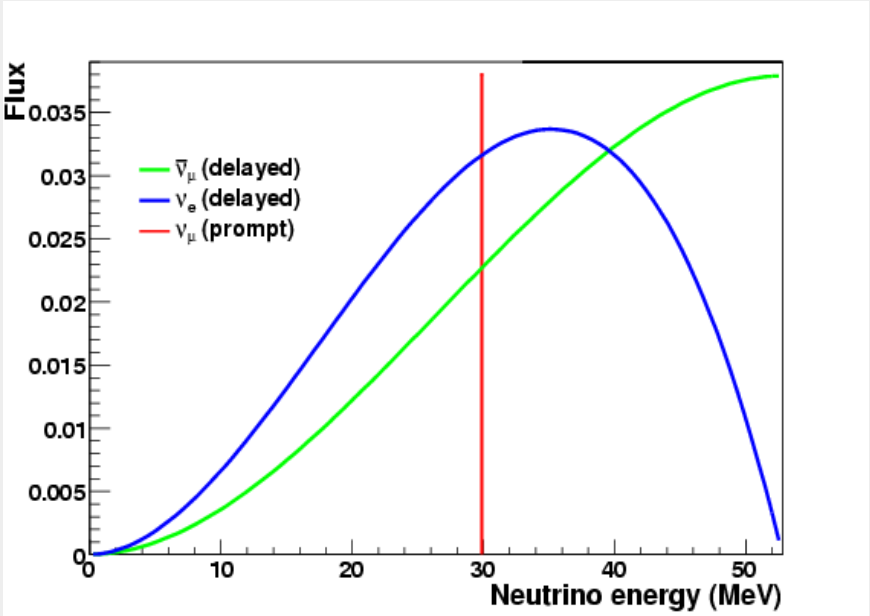
A stopped pion neutrino source

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

$$\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$$

- Lots of FREE neutrinos
- ~1GeV POT pulse at 60 Hz with 380 ns FWHM
- Spectrum comparable to that of SN

CEvNS at the SNS



- Timing structure of the SNS is a huge advantage in background rejection
- Neutrino flavors have prompt/delayed time structure

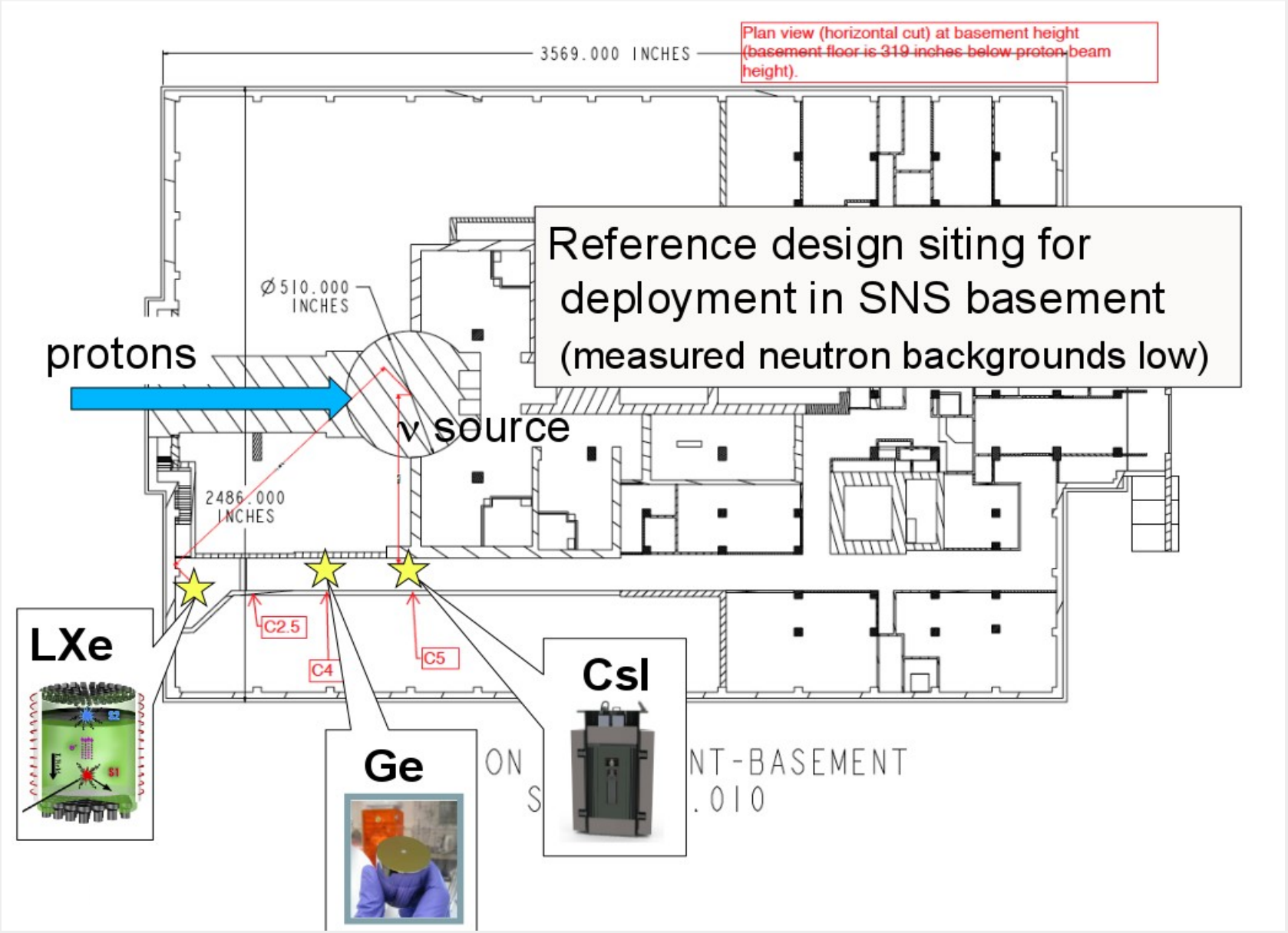
$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

$$\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$$

$$\frac{G^2 N^2}{4\pi} E^2$$

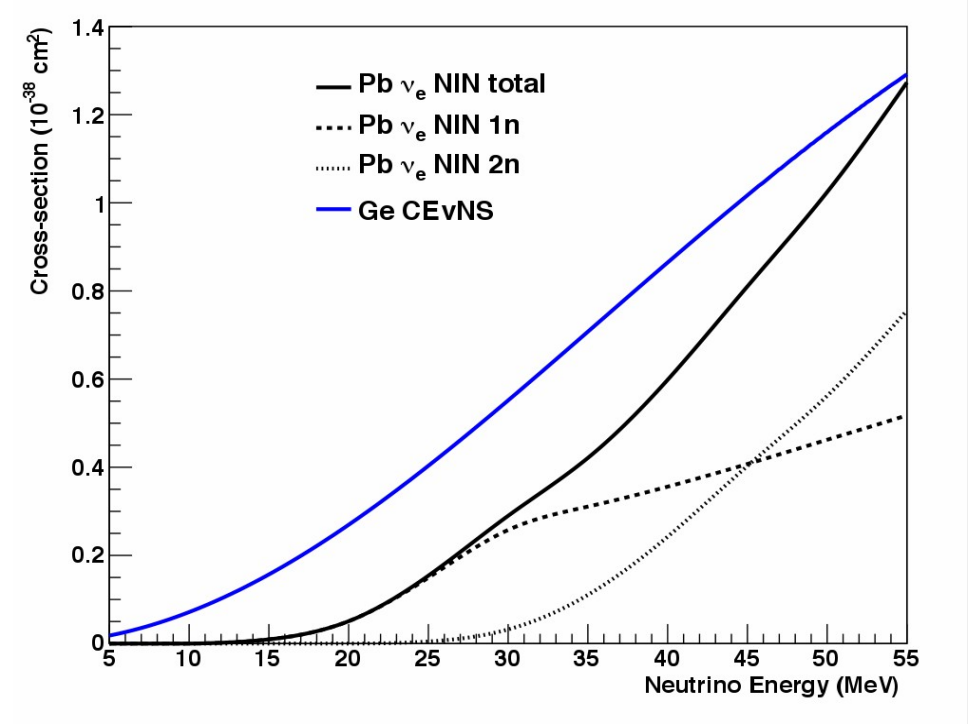
REMEMBER
Cross section and nuclear recoil energy increase with neutrino energy

Detector siting at the SNS

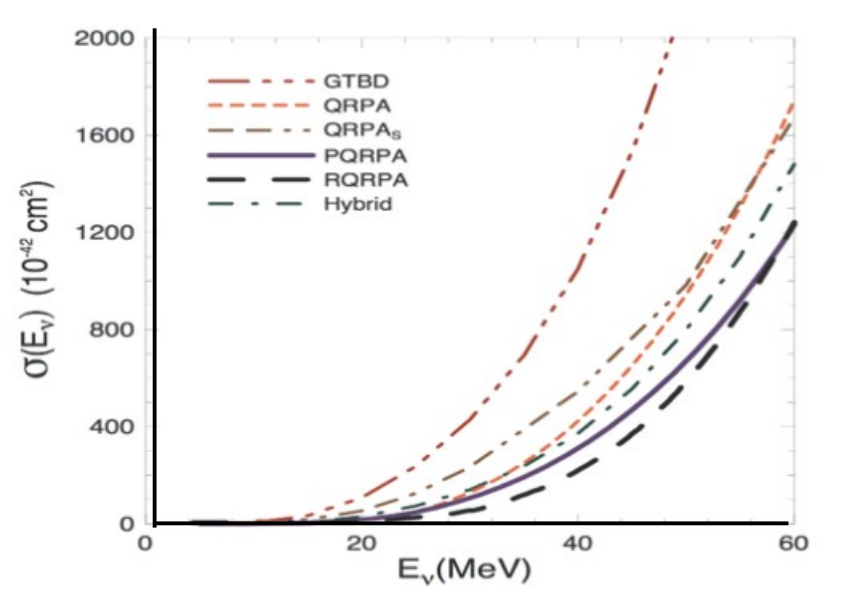


Other Physics – Neutrino Induced Neutrons (NINs)

- Important in R process nucleosynthesis and SN detection
- Pb and Fe are used extensively in shielding
- A substantial flux of NINs can be contamination (or a chance for measurement) in a CEvNS experiment
- Currently ongoing at the SNS



Model dependence on ν-Fe cross-section



A.R. Samana and C.A. Bertulani, Phys. Rev. C (2008)

What is COHERENT doing

CsI and ν cubes deployed at the SNS

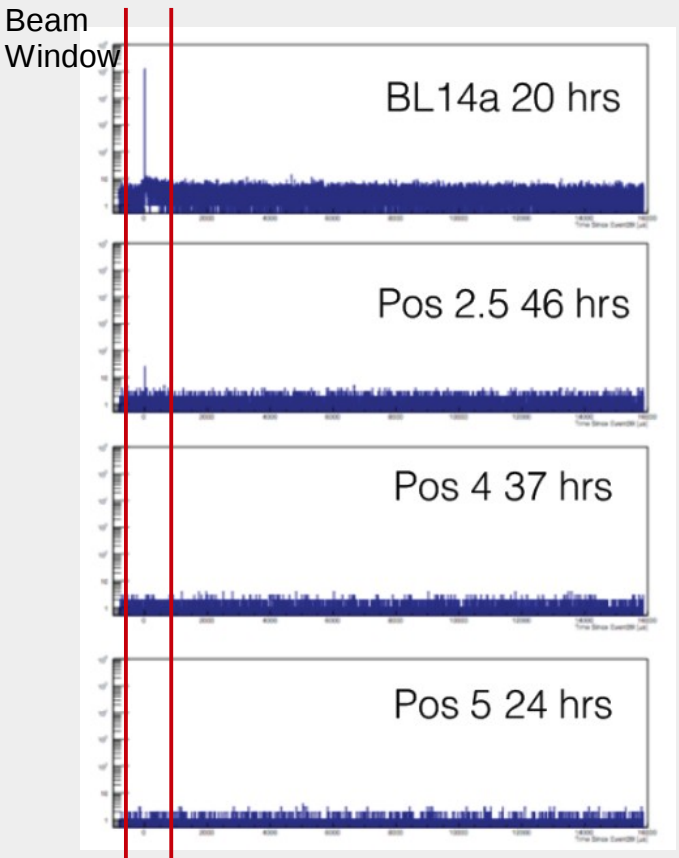
- Search for NINs in CsI and ν cubes
- Up selection of 3 detector technologies (CsI, Ge, Lxe) and continued development
- Continuing background measurement efforts
- Data is coming in

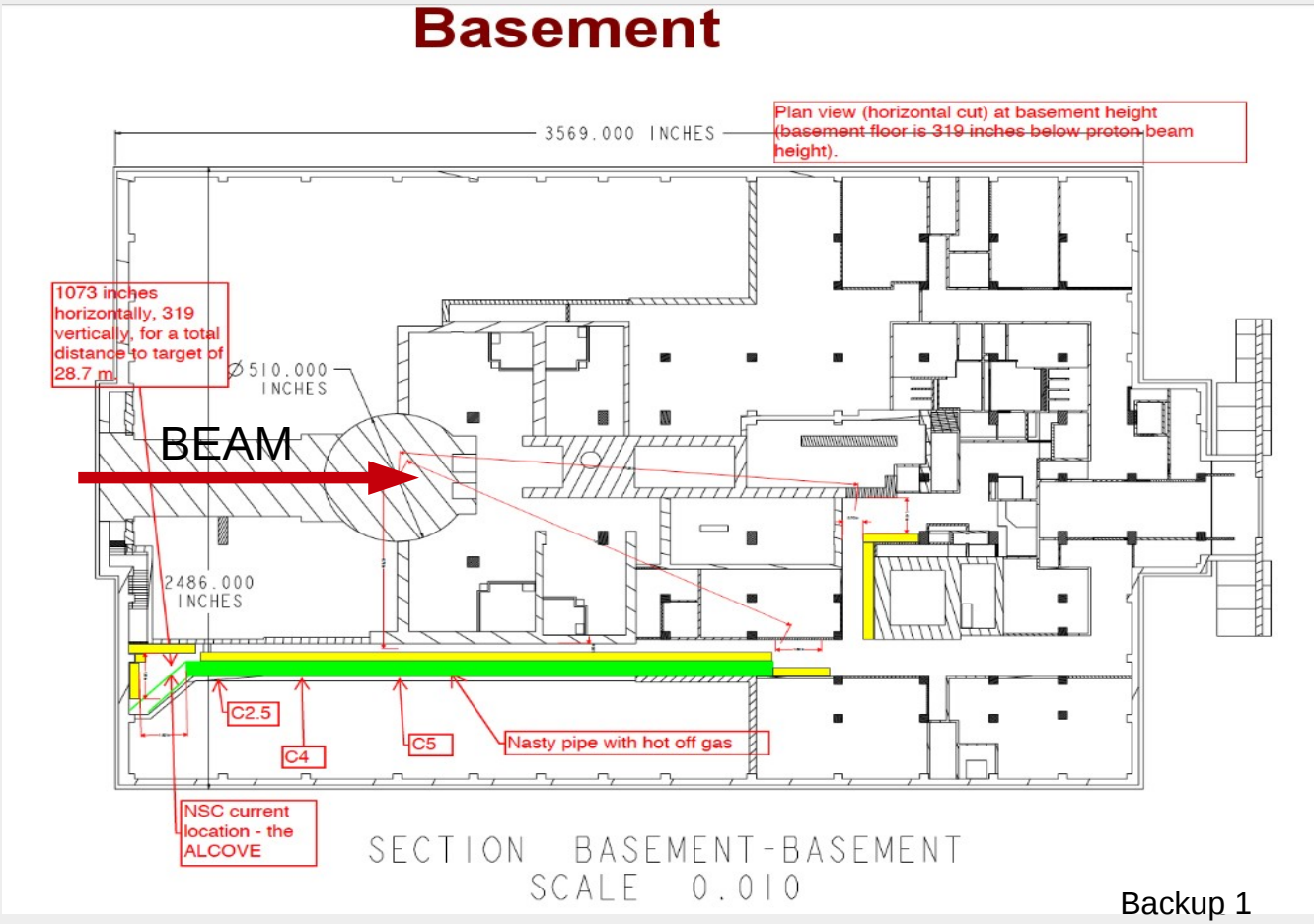
Summary

- CEvNS has never been measured directly.
- Detector technology has improved
  to the point that this measurement is now possible.
- The physics is important for many applications.
- Along the way, other new measurements
  can be made.
- The results will come in on
  short (few year) time scales.

Neutron background measurements

- Have been ongoing at SNS
- Several potential experiment sites have been identified
- SNS basement has substantial reduction in neutron flux





Comparison of stopped pion neutrino sources