SAND2015-2414PE

Background Measurements at the SNS

David Reyna

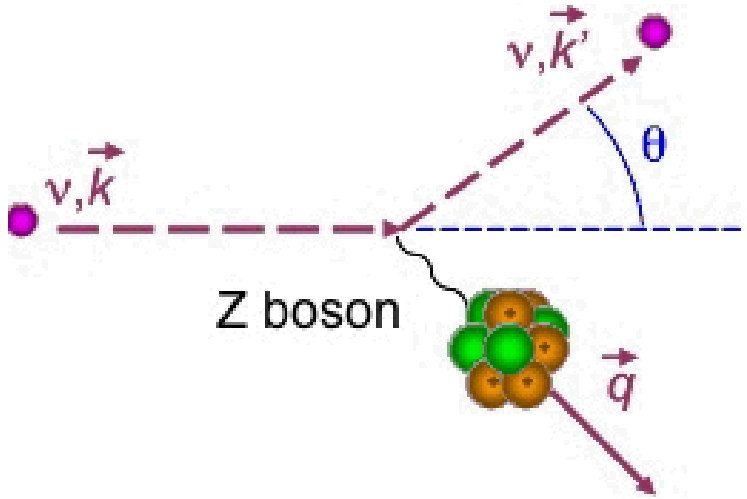
Sandia National Laboratories, CA

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000 SAND:2014-0101P

Sandia National Laboratories

Fast Neutrons Matter

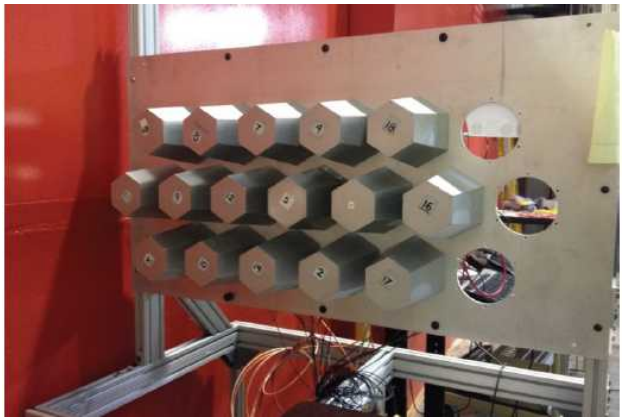
- Our signal is based on recoiling nuclei with no visible incoming or outgoing particles
  - Energy deposition characteristics can exclude other interactions (pulse-shape, timing cuts, etc.)
- Neutrons can create the same nuclear recoil
  - ~100keV-1MeV neutrons in the detector cause similar recoil spectra to our intended neutrino events
- Shielding helps and hurts
  - Easily stops the low-energy neutrons
  - Creates showers of low-energy neutrons from incident high-energy neutrons
  - Can also produce neutrons from inelastic neutrino interactions in Pb
- Simulations suggest that fast neutrons (10-100 MeV) create the largest concern



A Big Effort from ORNL and SNL

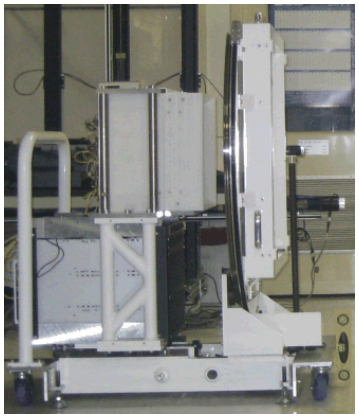
- LDRD investment by both labs to deploy and operate neutron detectors at the SNS
- Leveraged unique skills/capabilities of NNSA supported neutron diagnostics and imaging
  - Combination of multiple technologies and complementary analysis by both groups provides significant confidence in background results

Single Plane Single Scatter



Portable 5L LS Cells

Coded-aperture Imager

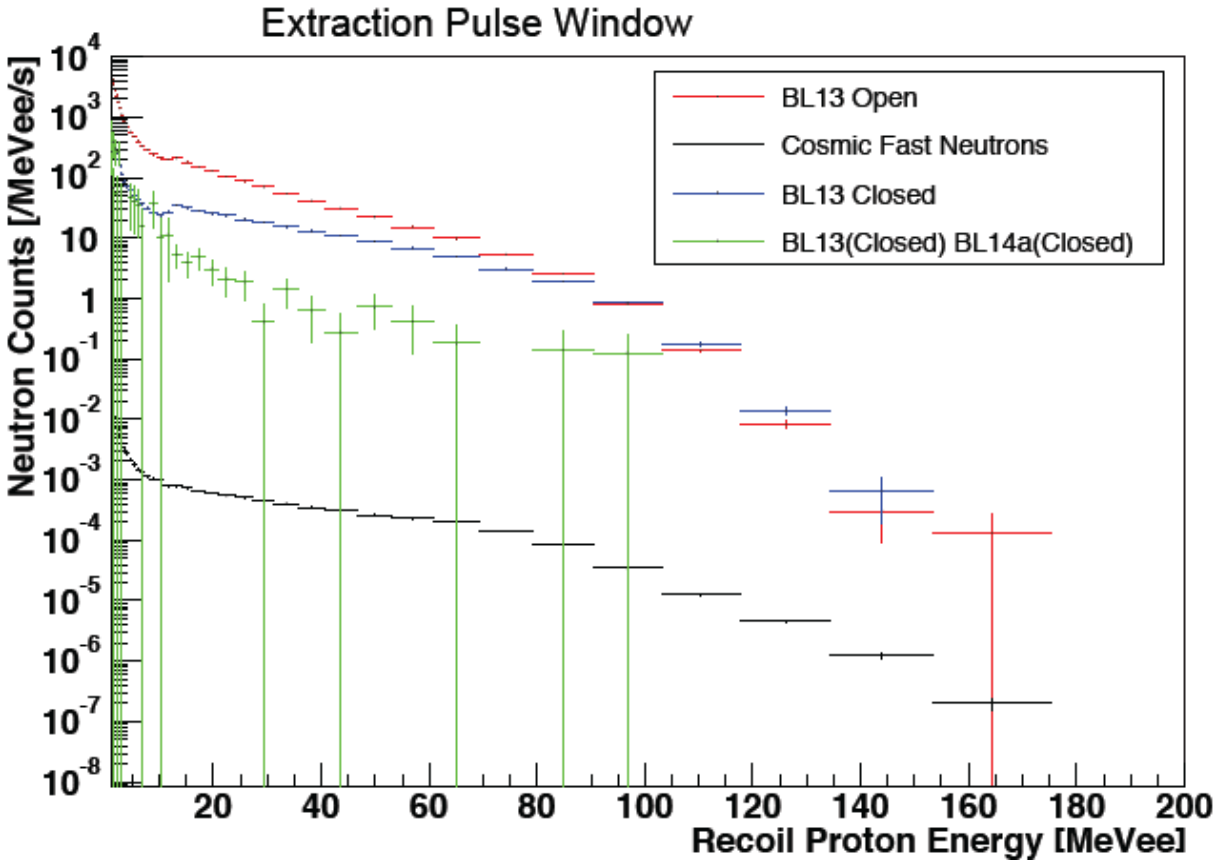


Neutron Scatter Camera

Backgrounds Vary with SNS Operational Conditions

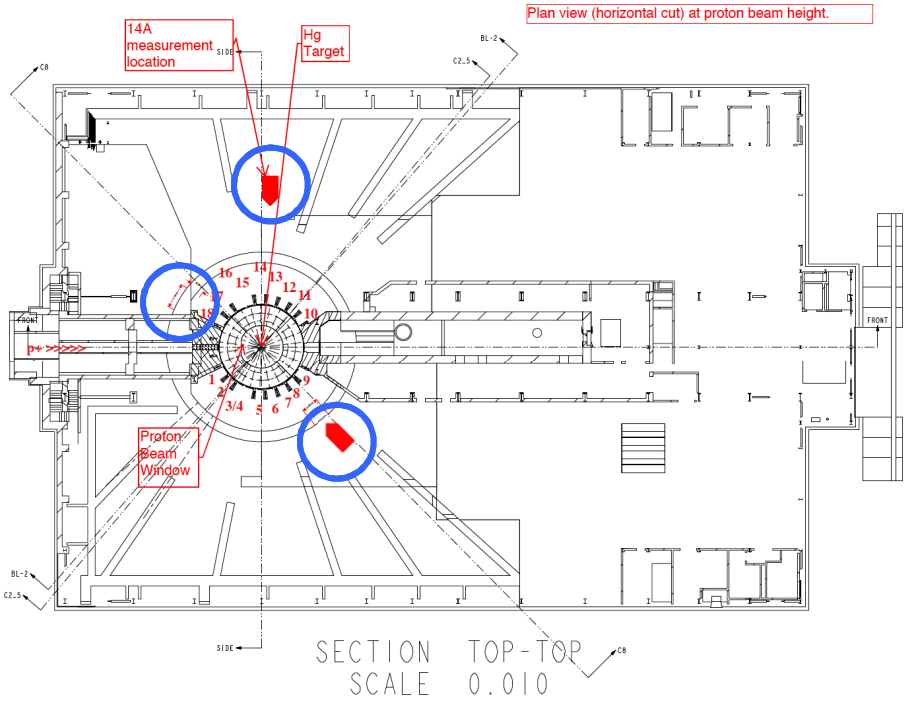
First look on the floor of the experimental hall showed high neutron backgrounds associated with operation of the SNS

1-2 order of magnitude variations can be seen based on which beam lines are operating

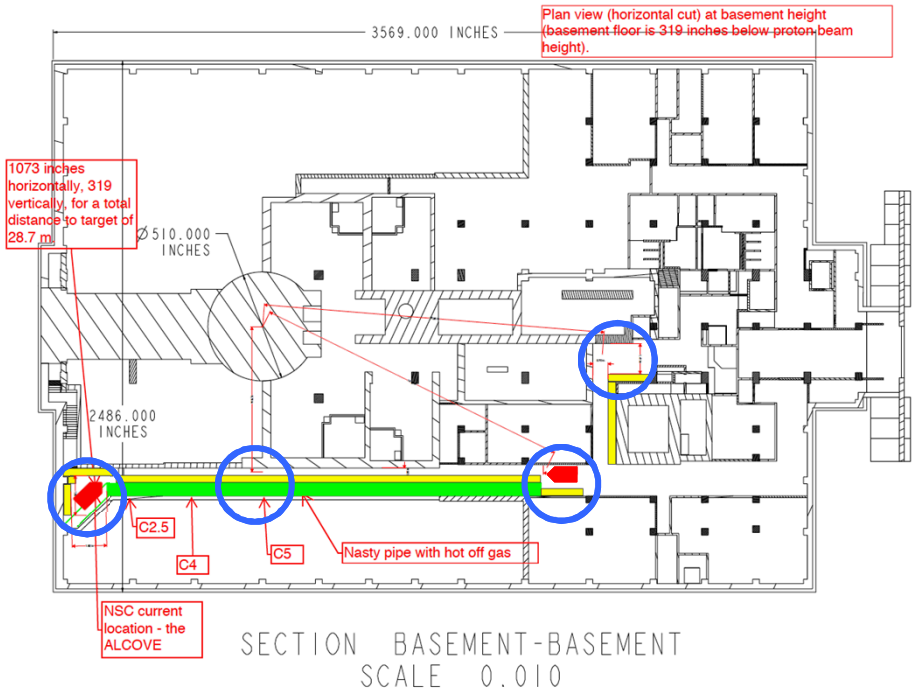


Potential Experimental Locations

Ground Level



Basement

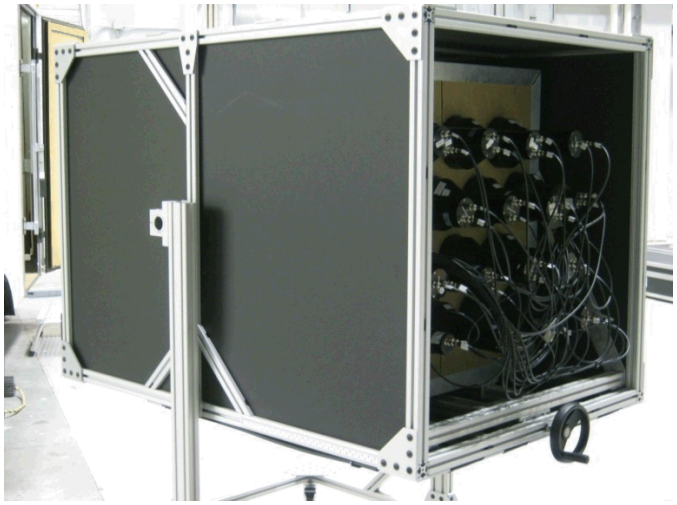


We have worked closely with the SNS to identify possible areas where we could have minimal impact on existing SNS efforts

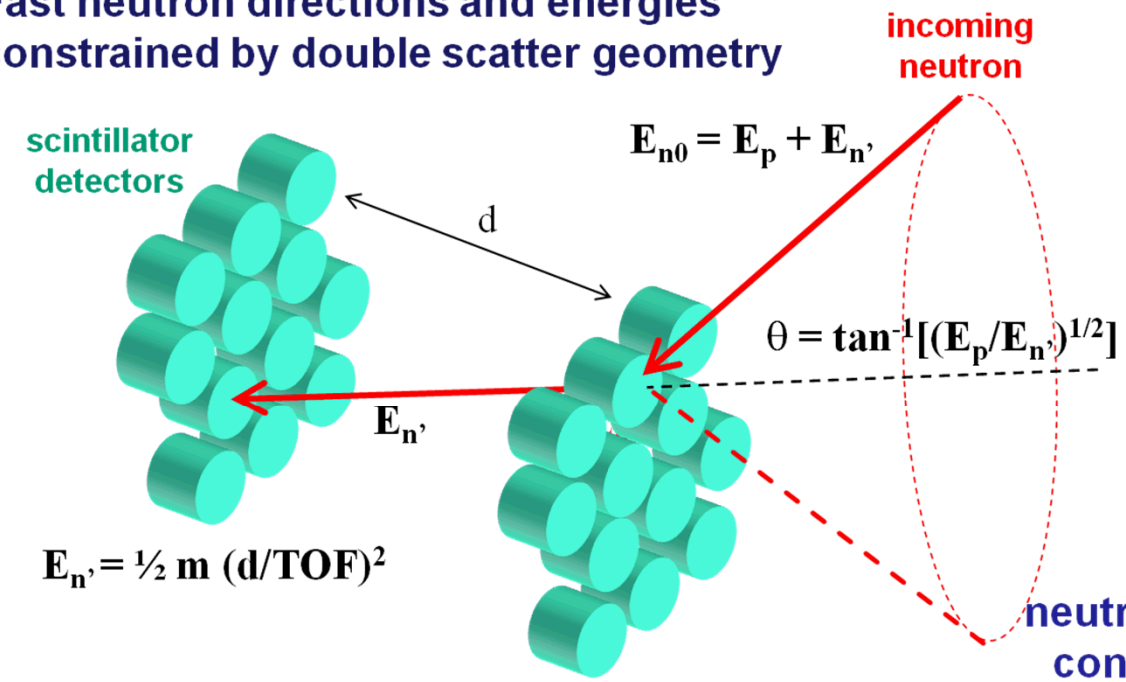
We have attempted to make careful measurements of neutron backgrounds at all these locations. Will focus on Neutron Scatter Camera results, but multiple technologies have been used to give us confidence

Neutron Scatter Camera

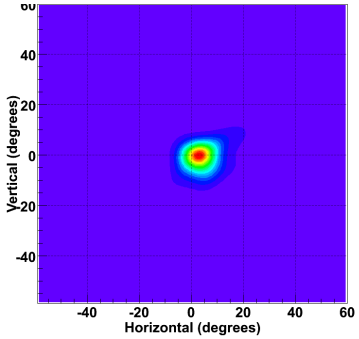
- Fast neutron imaging spectrometer developed under NNSA and DNDO support
- Variable plane separation allows tradeoff of effective area, image resolution



Fast neutron directions and energies constrained by double scatter geometry



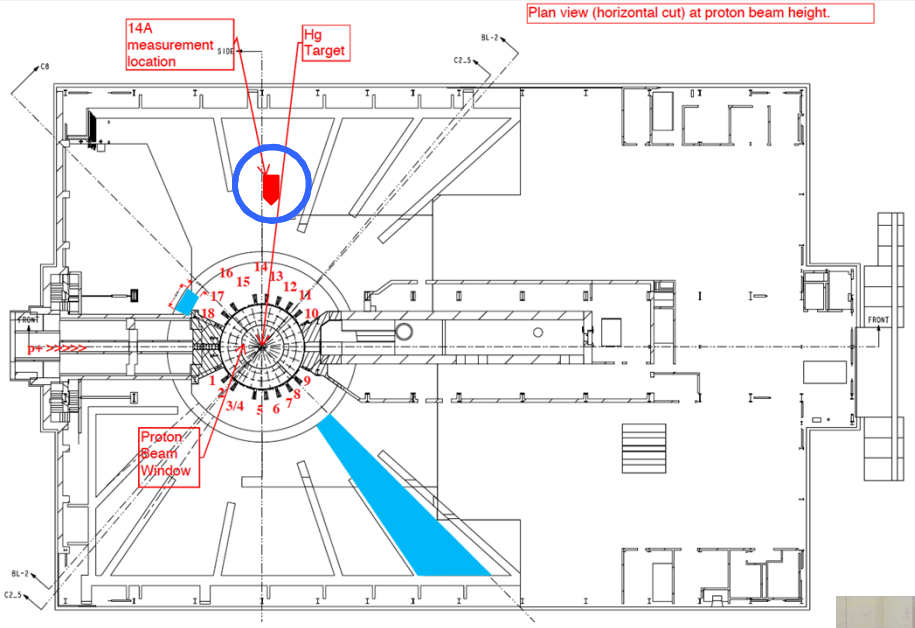
neutron direction constrained to cone surface



An MLEM-reconstructed neutron point source image.

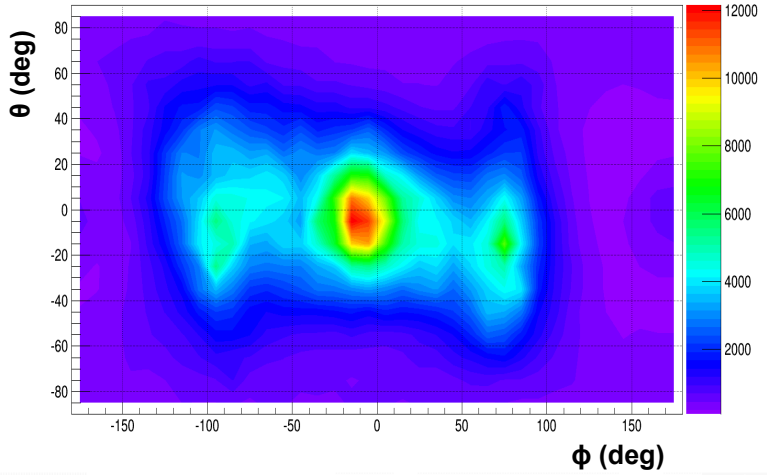
Multimode capability includes
- *Neutron energy spectrum.*
- *Compton imaging.*

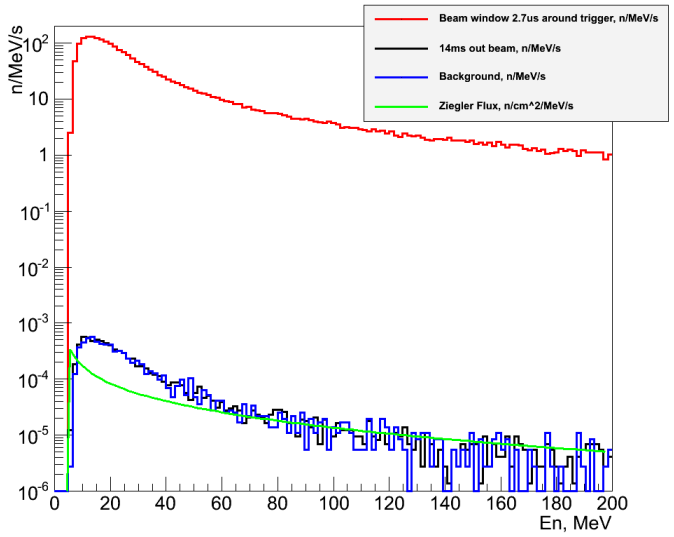
First Beam Line 14a Measurement



Clear 5 order of magnitude background increase inside beam time window

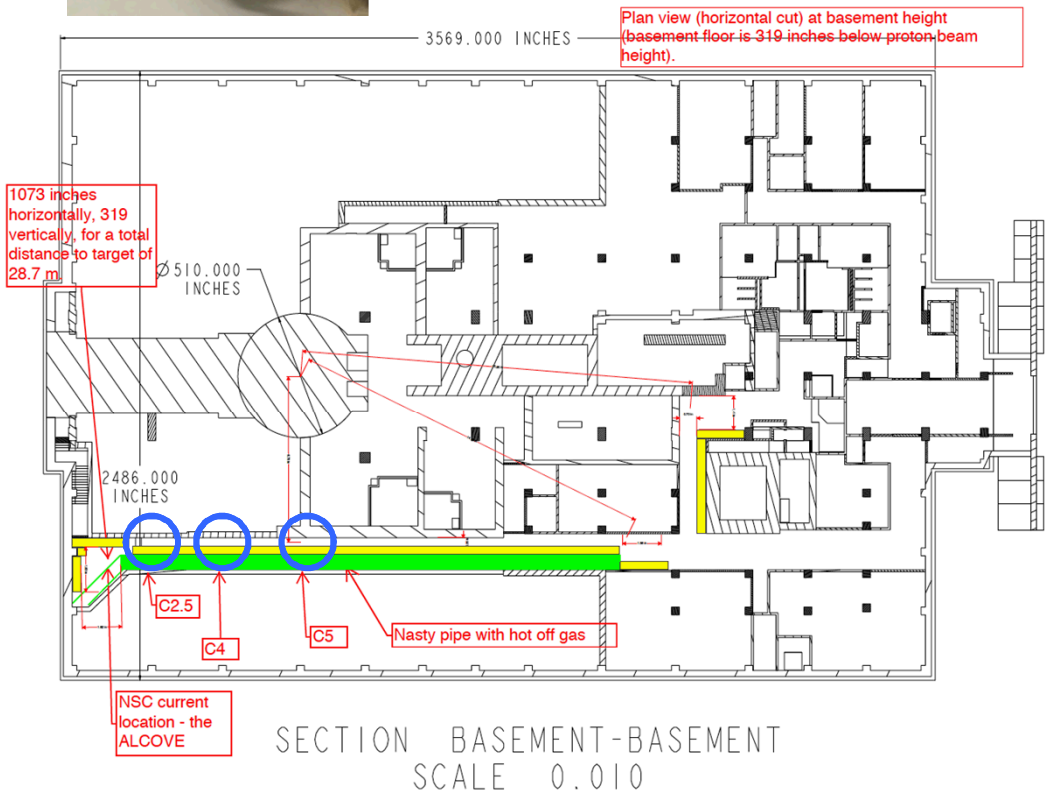
Confirmed "known" shielding leakage from neighboring beam lines

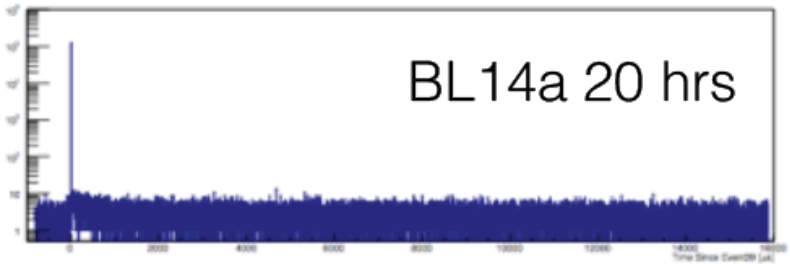


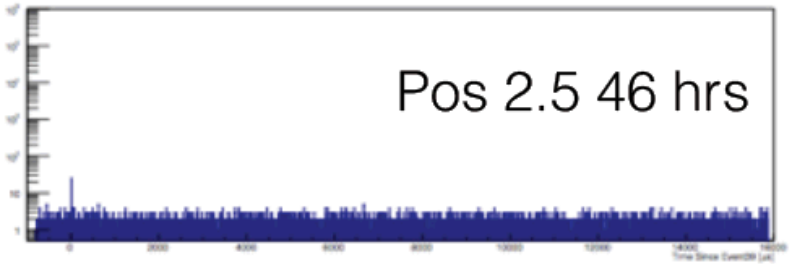


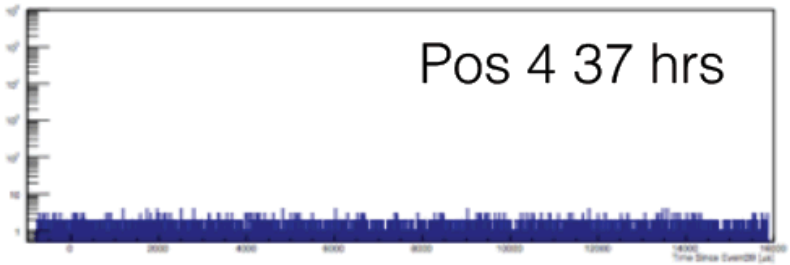
First Basement Look

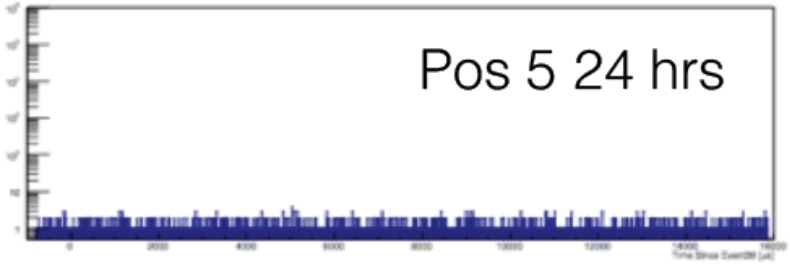
Using Portable 5L LS Cells



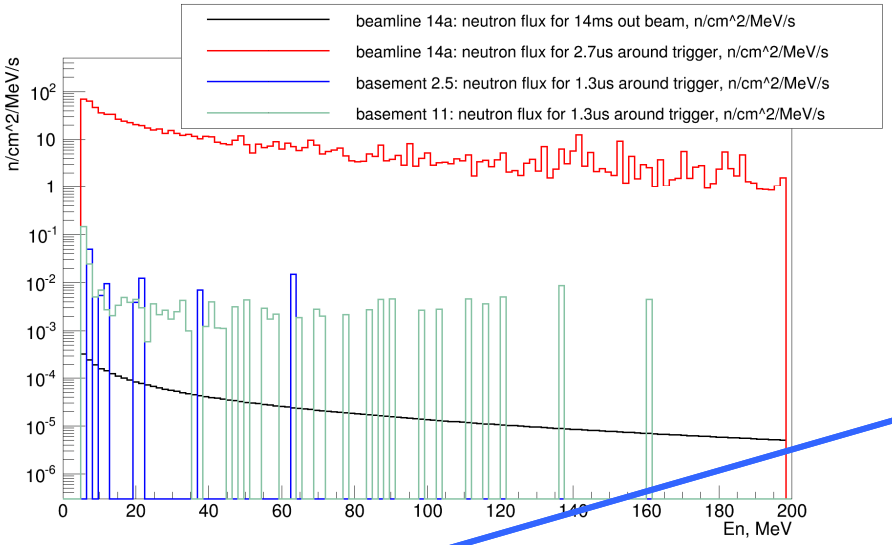


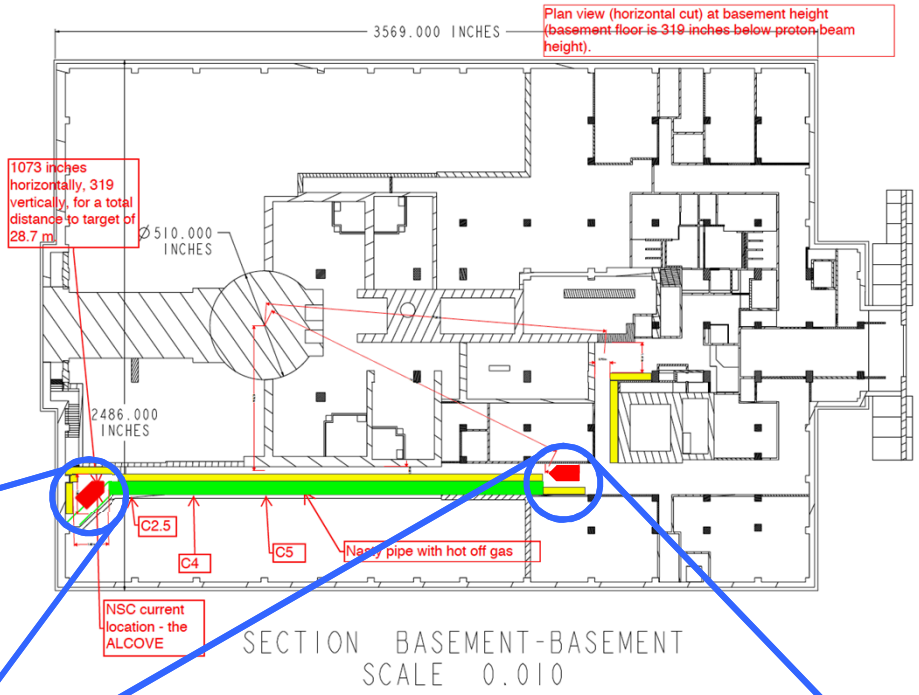


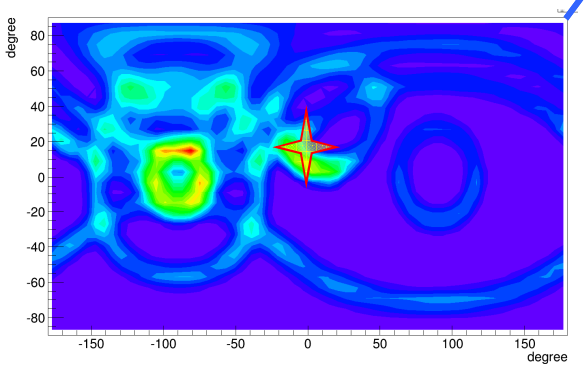


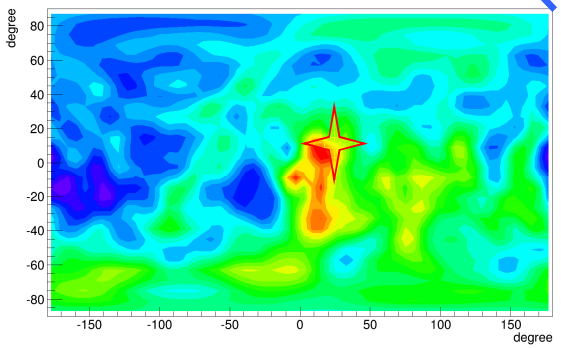


Basement Neutron Measurements









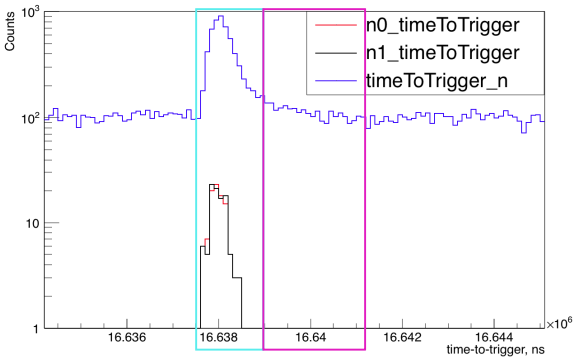
Timing Allows Risk Mitigation

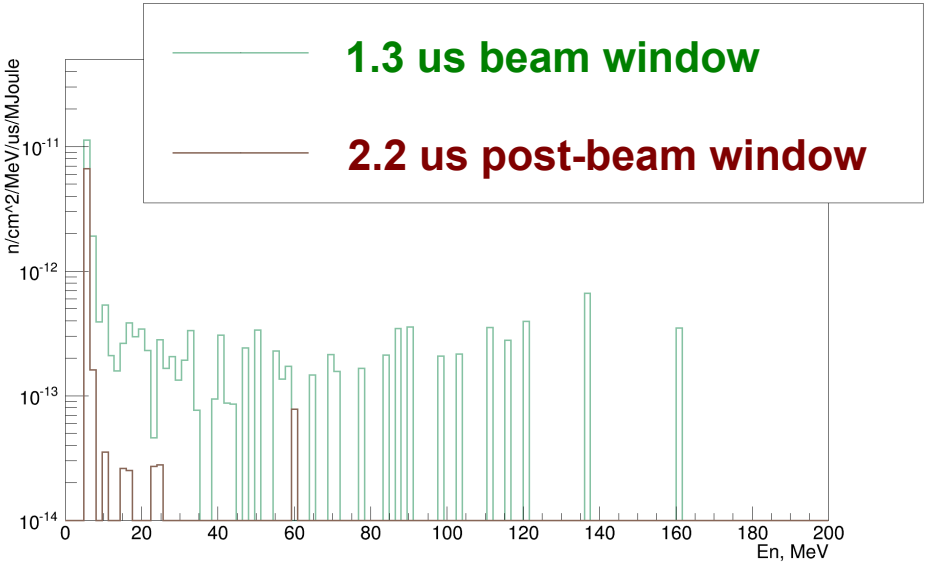
Fast neutron backgrounds in basement are clearly associated with 700ns POT

A 2.2us window after the beam would highlight muon decay neutrinos

Neutron backgrounds reduced by at least an order of magnitude in delayed window

Neutrons in delayed window are significantly lower in energy and therefore relatively easy to shield

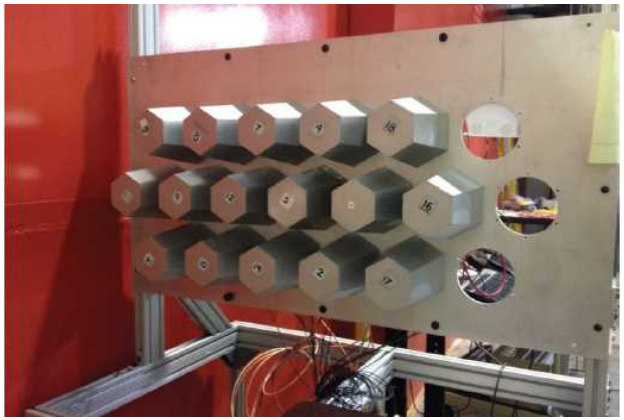




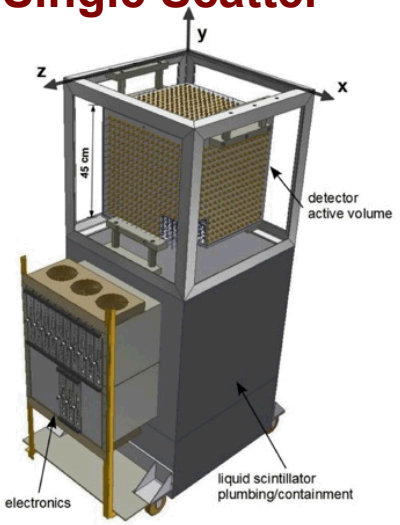
Ongoing Monitoring Needs

- **Still in planning stages**
  - Dependent on final detector shielding designs
- **Existing equipment can be re-purposed**
  - Full double scattering/imaging not needed for long-term monitoring

Single Plane
Single Scatter

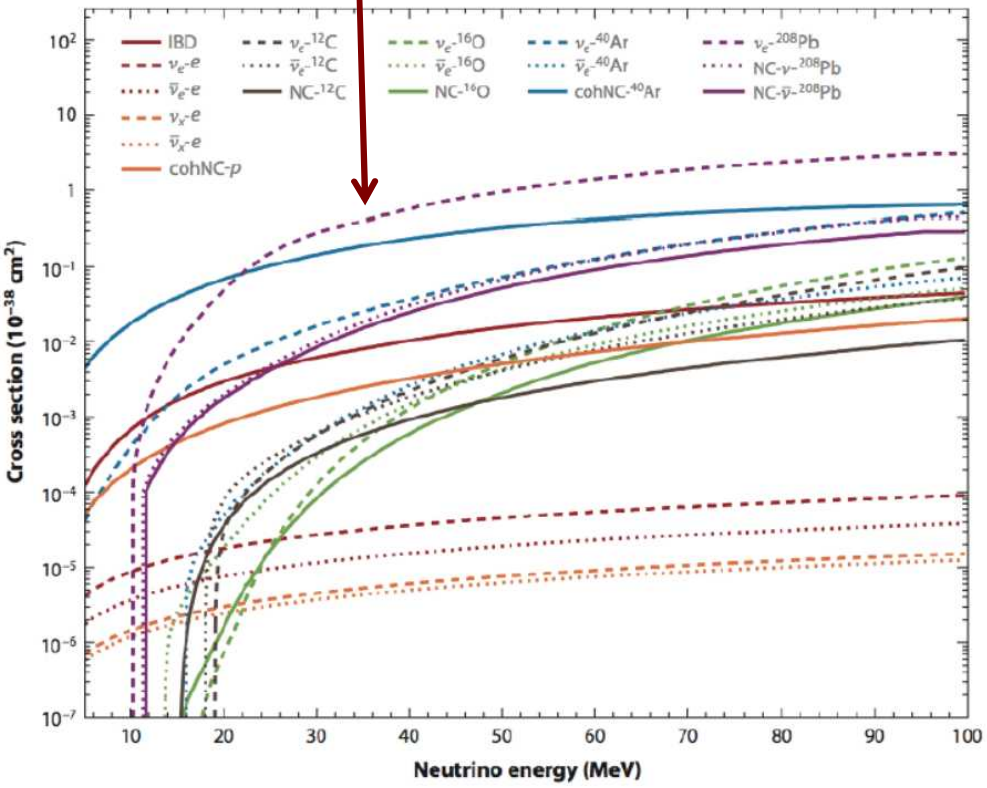


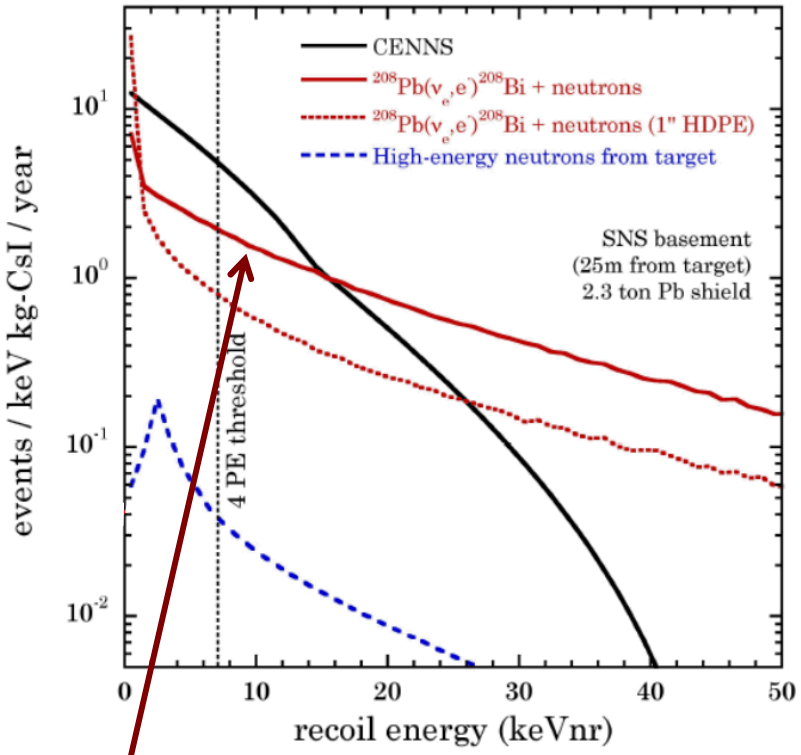
SciBath
Single Scatter



Neutrino Induced Neutrons

Inelastic cross-section on Pb can be larger than coherent cross-sections

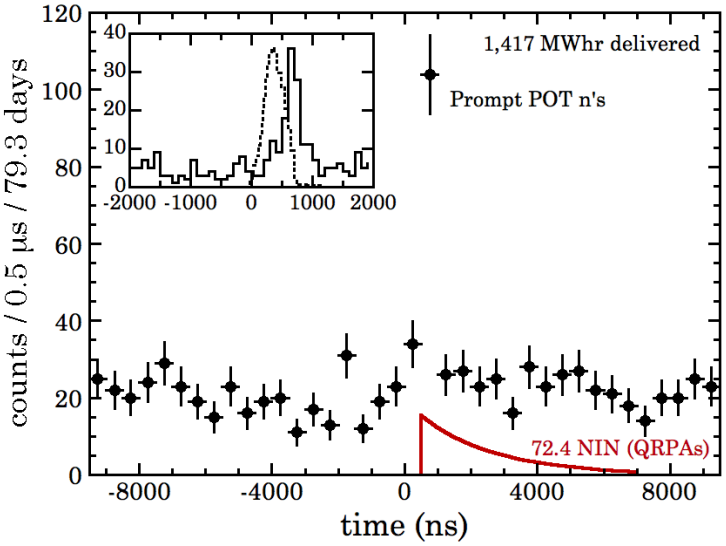




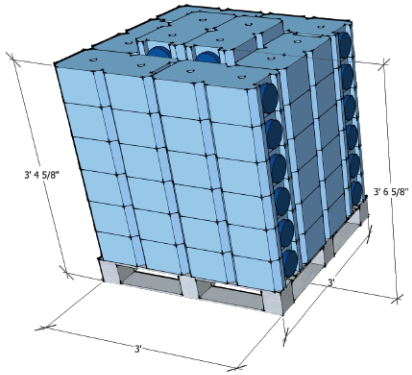
Expectation of signals from neutrons produced off of Pb shielding could be comparable to coherent signature but there are large uncertainties in these cross-sections

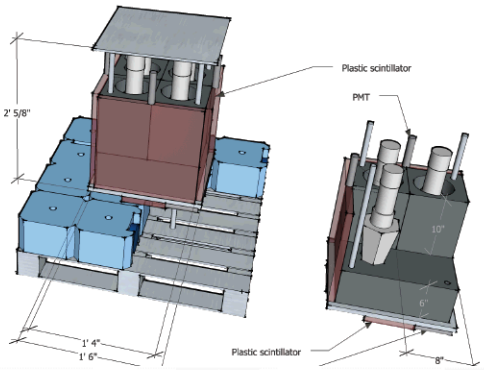
Nothing Beats a Direct Measurement

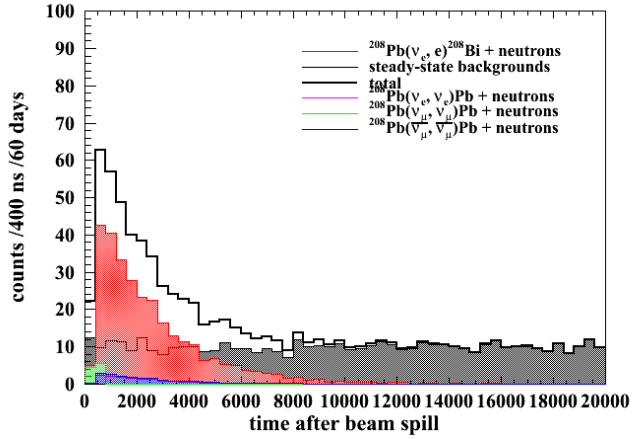
In-situ measurement of NINs inside of CsI sheild



Dedicated Pb and Iron measurement of NINs starting soon







Summary

- We have measured the critical backgrounds in locations of interest
- We believe we have located viable locations for detector deployments that do not impact SNS operations
- Continuous monitoring of environmental backgrounds will be critical for the success of the experiment