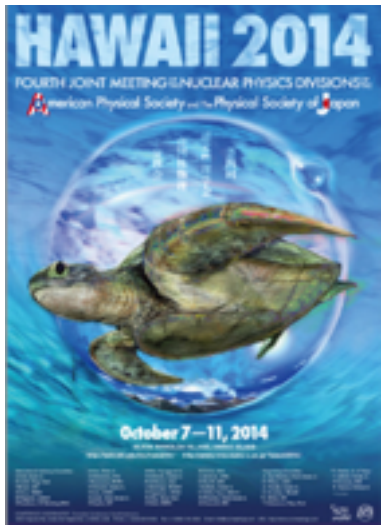
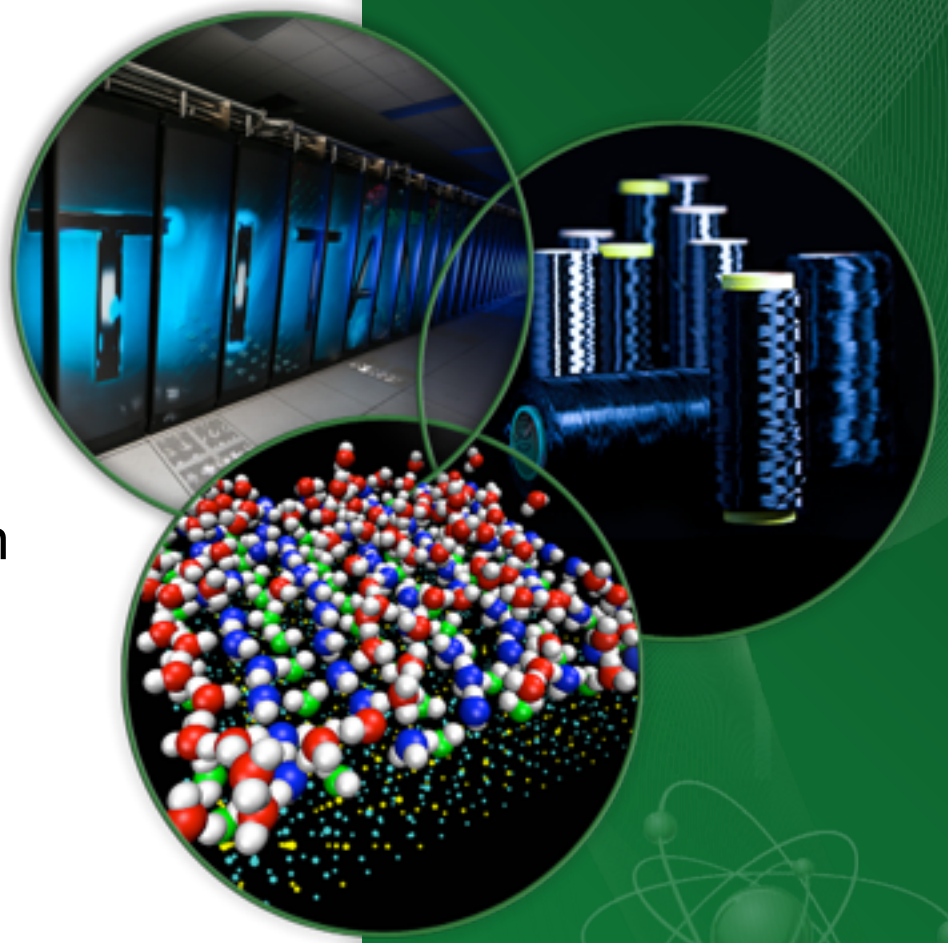
Background Studies for an Experimental Neutrino Program at the Spallation Neutron Source

Jason Newby

for the COHERENT Collaboration

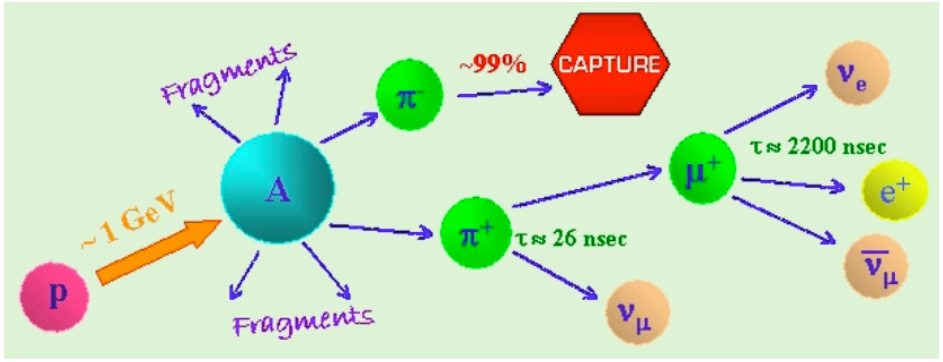


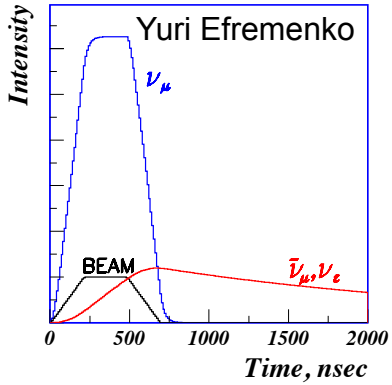


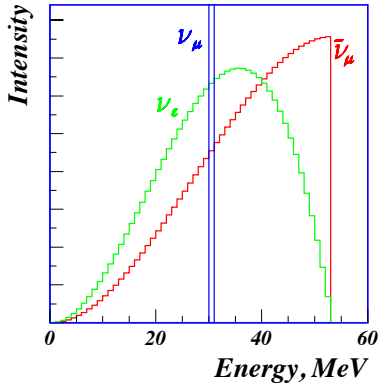
COHERENT SNS

Why SNS? The Neutrinos come for free.

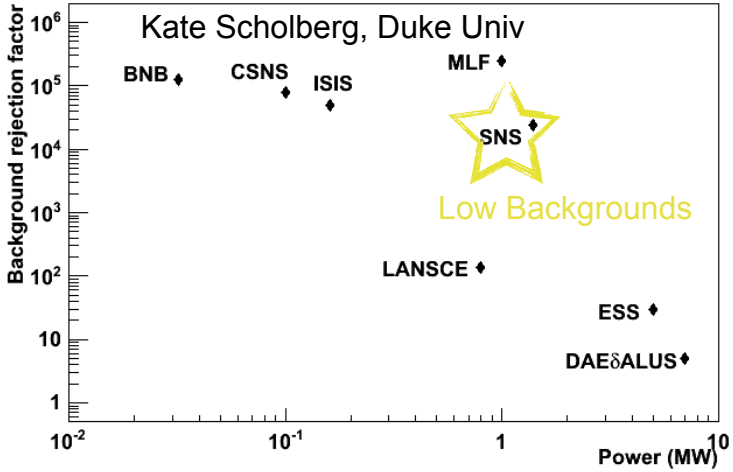
- Spallation Neutron Source is an ideal neutrino source: SνS





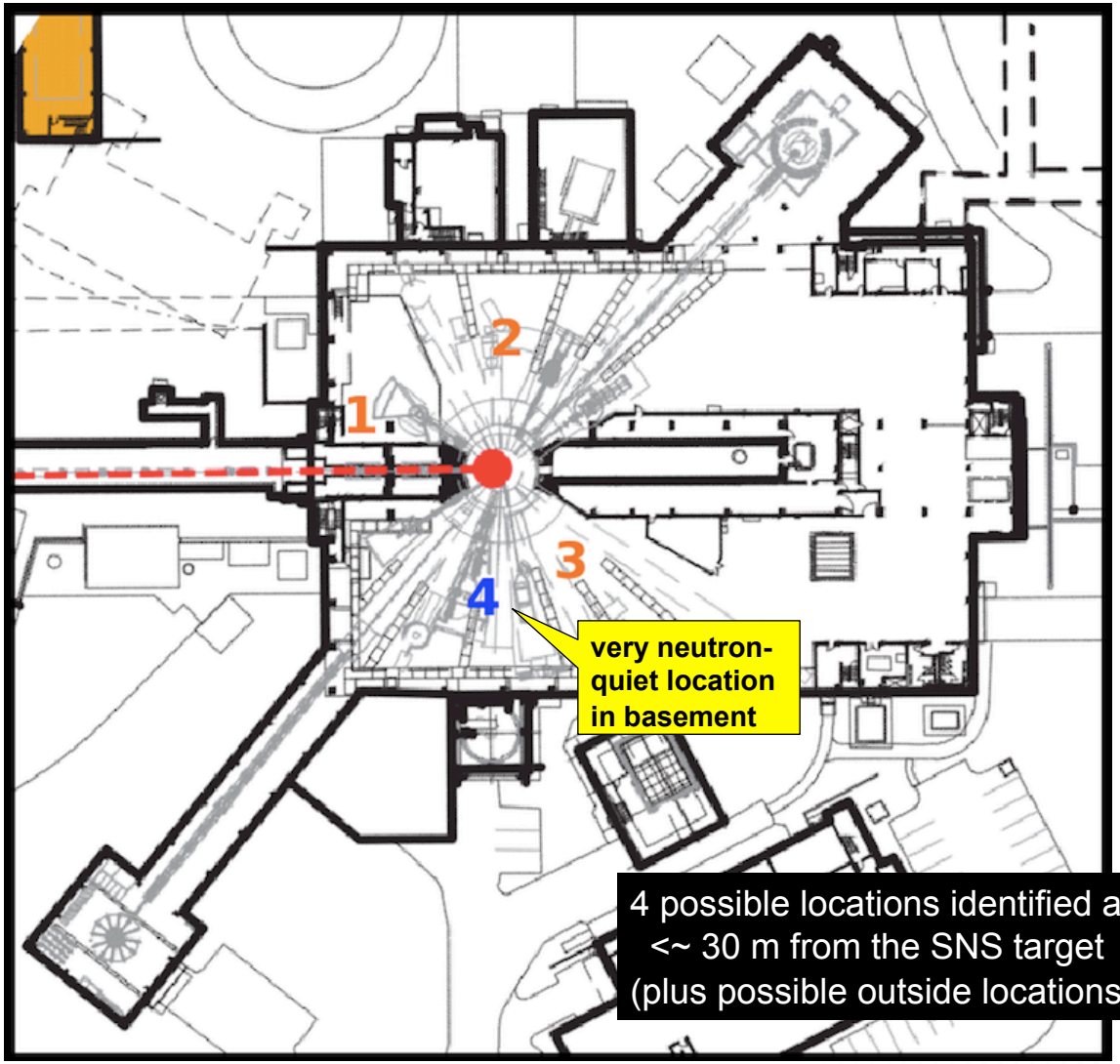


- High Intensity (10^7/s/cm^2 @ 20m)
- Multiple Neutrino Flavors: ν_e, (anti)ν_μ
- Ideal Energy: Below Kaon Threshold
- Complete Stopping: Position
- Ideal Time Structure (Short Pulses)
- ORNL/SNS support.



The SNS is the cleanest, most intense neutrino source for a first observation of coherent elastic neutrino nuclear scattering (CEνNS).

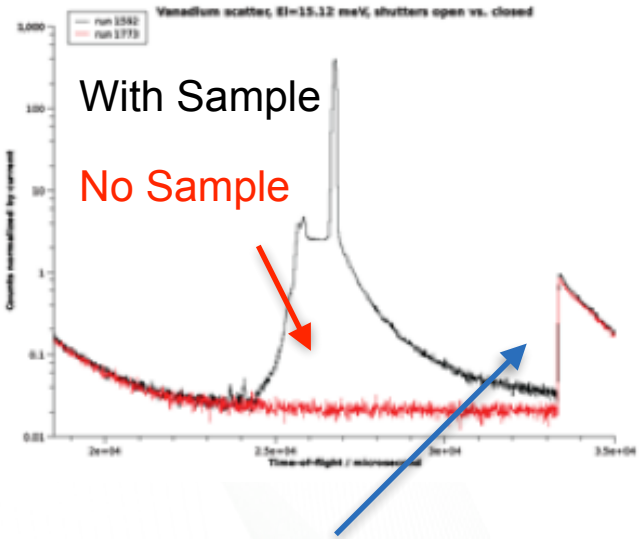
SNS Target Building



Dominant Backgrounds for CENNS Measurement at the SNS

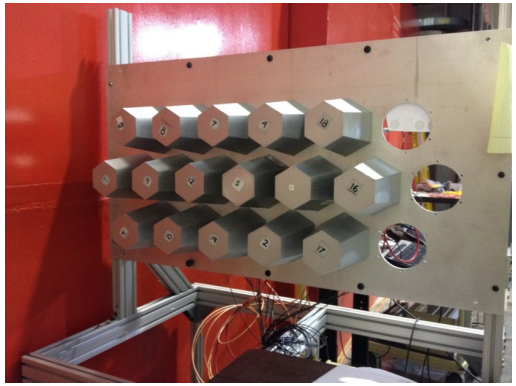
- As with all Decay at Rest Pion Stopping neutrino sources, beam related fast neutrons are the dominant unknown and the most difficult to disentangle from neutrino signal, i.e. in time with the beam.
- As of August 2013, precious little known about the fast-neutron backgrounds at the SNS.
  - Biologically safe: time-averaged rates within twice the natural background rate.
  - Some SNS instruments see prompt "flashes" possibly attributed to a variety of sources:
    - Beam losses in the beam transfer line to the target hall.
    - Fast-neutrons originating at the target and punching through the monolith shielding.
    - Lower energy neutrons scattering from one instrument beam line (secondary shutters, choppers,etc) to another instrument.
    - Other sources…
- Open questions about the fast-neutrons:
  - What is the timing structure (as compared to the beam on target timing)?
  - What it the energy spectrum of these fast-neutrons?
  - What is the variation of the intensity at different locations within the SNS target building.

SNS HYSPEC Instrument



Prompt Flash is a hint of Significant Fast-Neutron Backgrounds

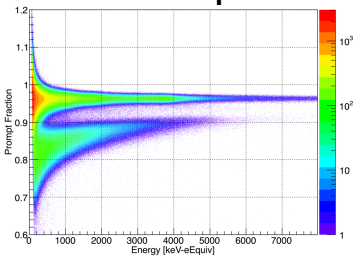
Fast-Neutron Detectors Deployed @ SNS

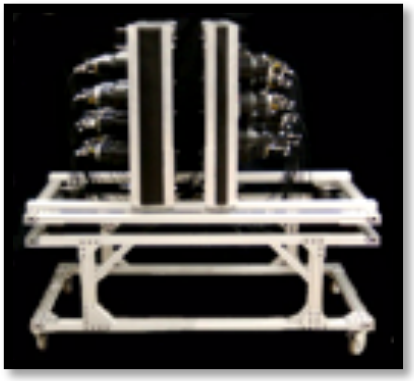


ORNL

Single Cell Detectors

- Arrays of EJ-301:1.5 liter (16), 5 liter (4)
- Neutron/Gamma Discrimination
- <1 ns timing
- Pulse-Height "Unfolded" Neutron Spectrum

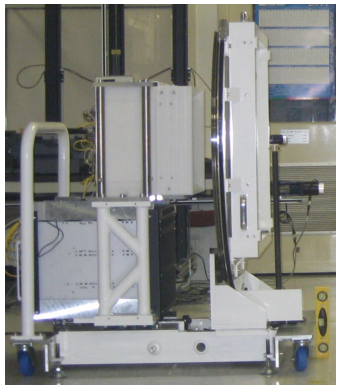




Sandia

Scatter Camera

- Two Planes of EJ-309 Cells
- Neutron/Gamma Discrimination
- <1 ns timing
- Time-of-Flight Neutron Spectrum
- Kinematic Imaging with Iterative Reconstruction
- Double Scatter Inefficiency

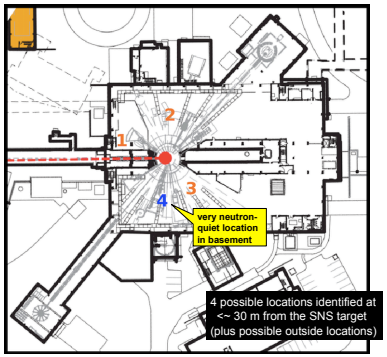


ORNL

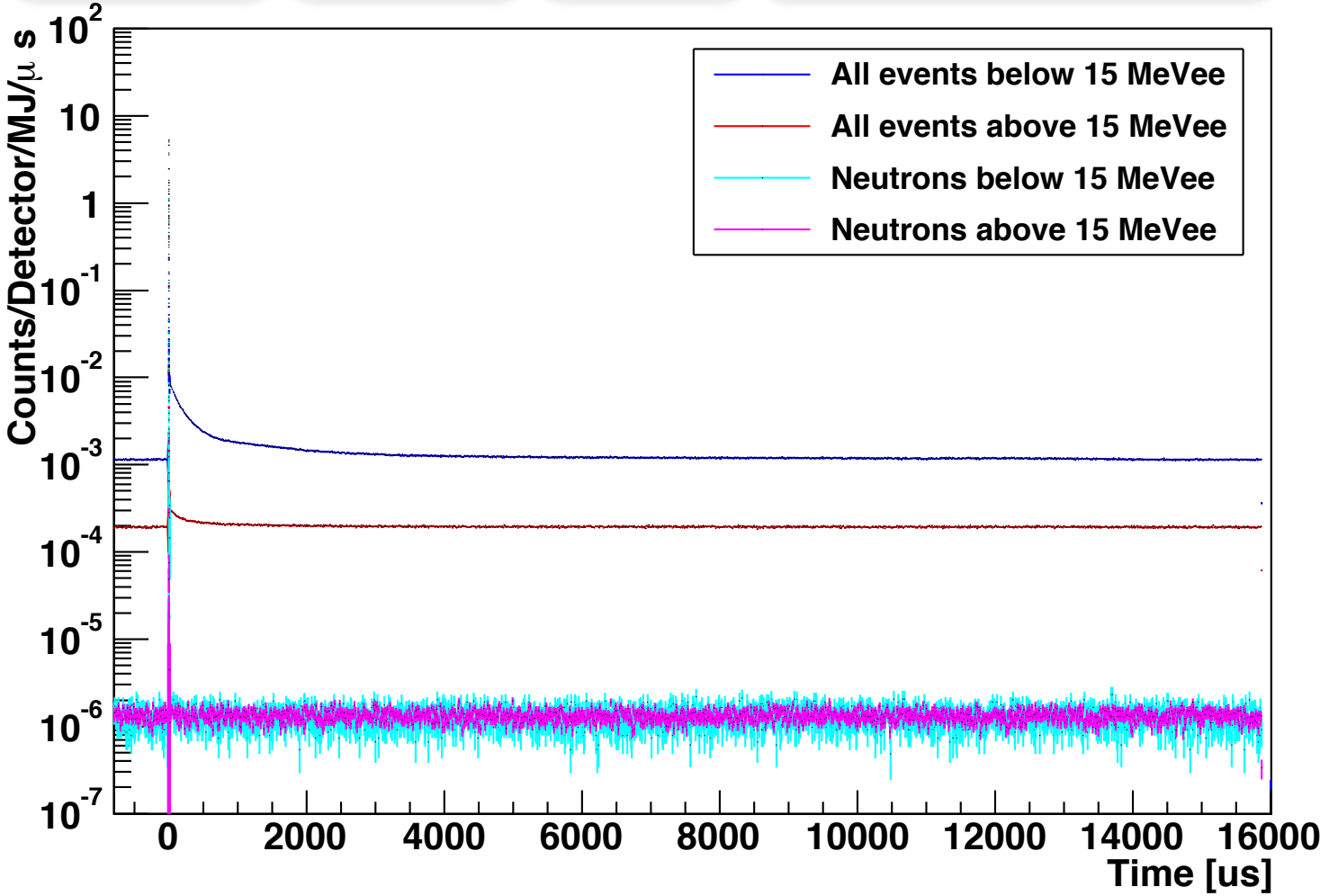
Coded-Aperture Imager

- 24x24 Pixelated Array of PSD Plastic EJ-299-34
- Neutron/Gamma Discrimination
- <1 ns timing
- Imaging via Linear Transformation
- Efficient Coded Mask (50% Open)
- Limited Spectral Information

Initial Observation of Intense Flash

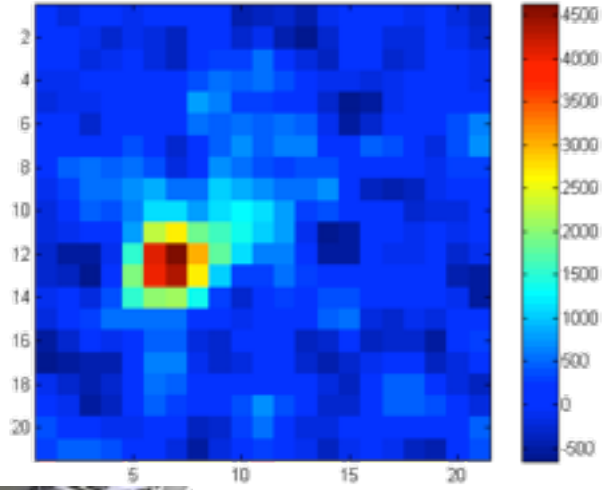


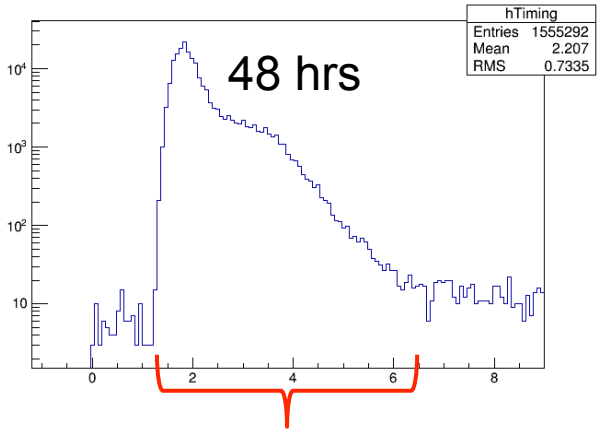
Linac Pulse 800 μs	Extraction 1.3 μs	Muon 10 μs	Delayed 16+ ms

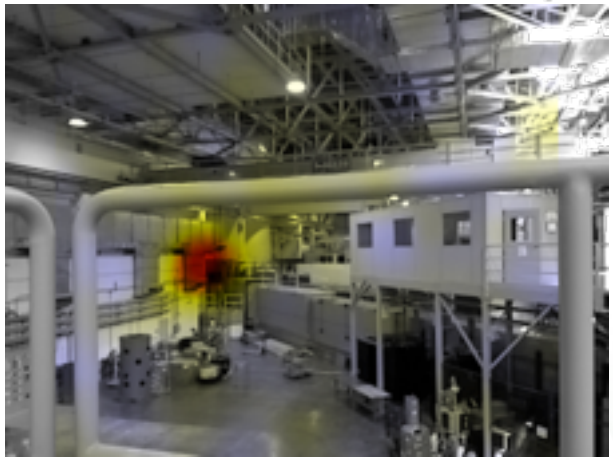


In BL14a, Intense Burst of fast neutrons 10^5 above continuum

Coded-Aperture Imager

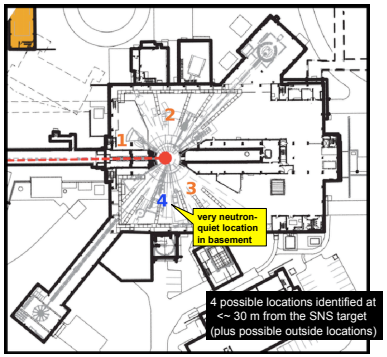


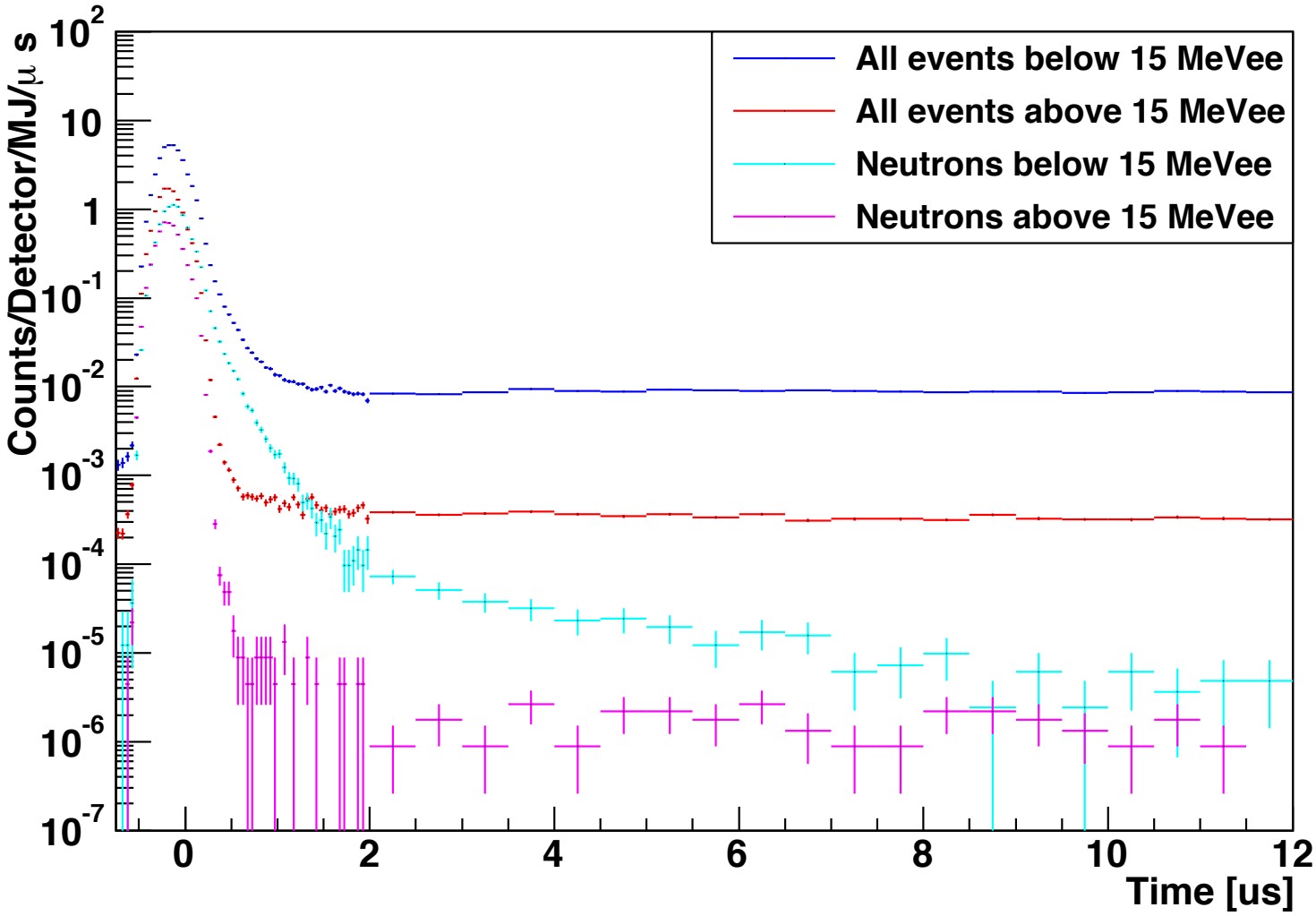




High-energy fast-neutrons penetrate a gap in the SNS shielding at beam line 11.

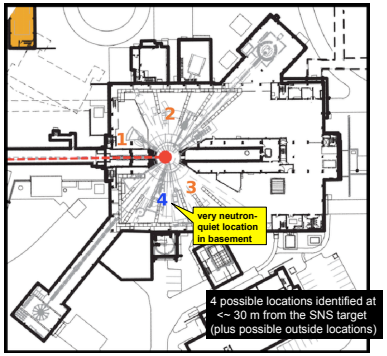
Time Structure of Fast-Neutrons

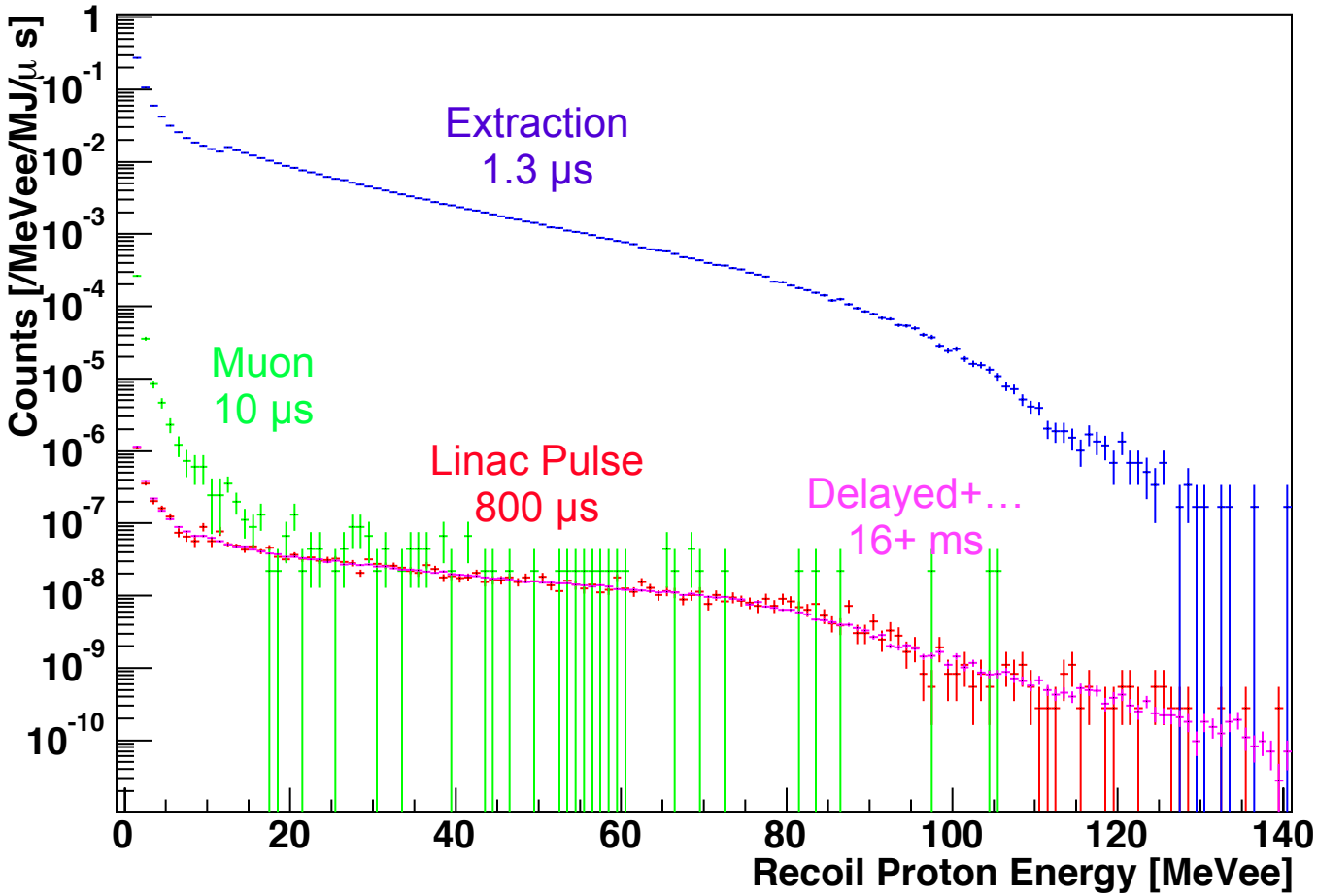




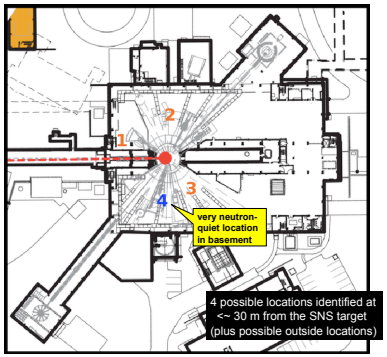
OAK RIDGE National Laboratory

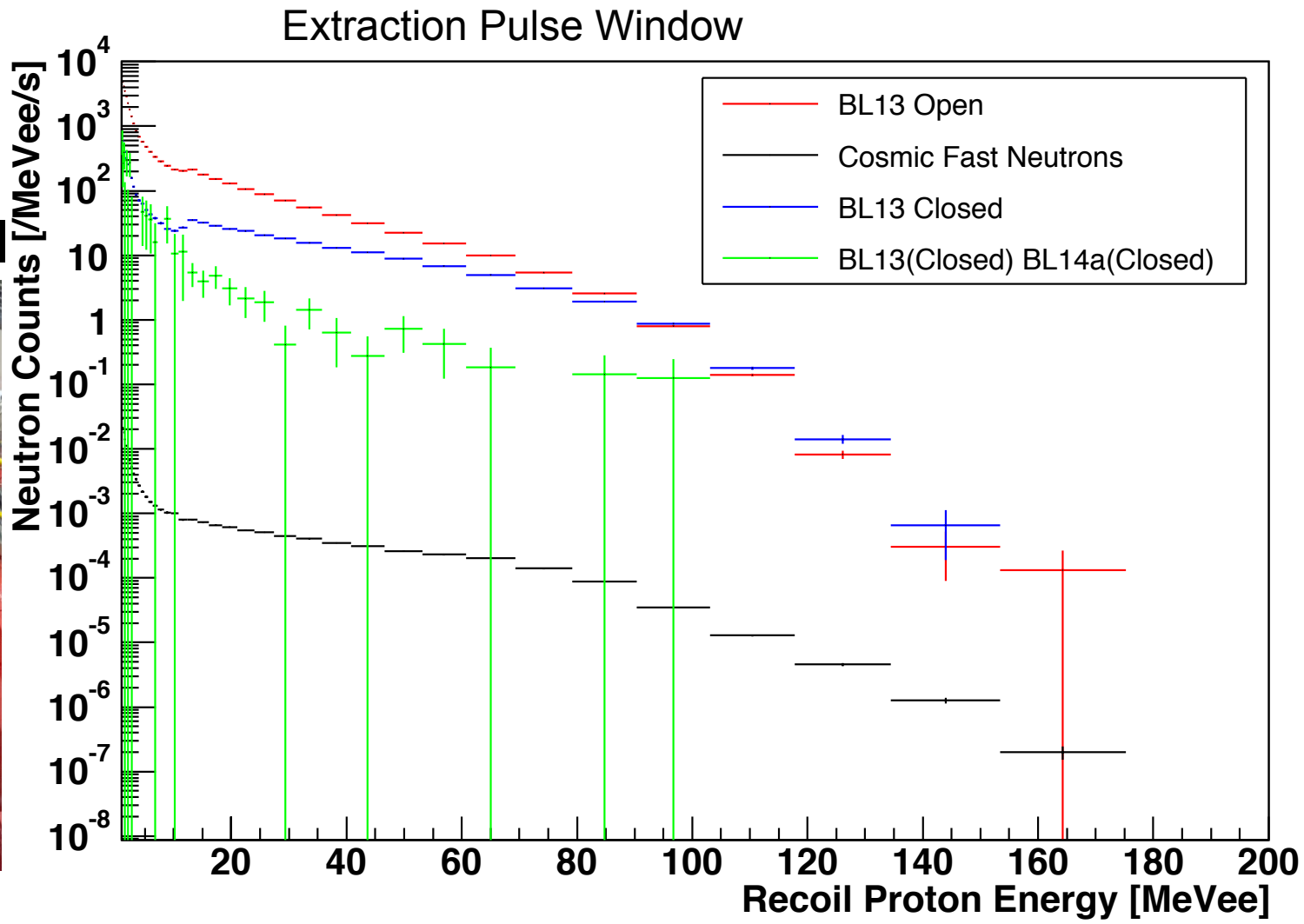
Light-Yield Spectrum





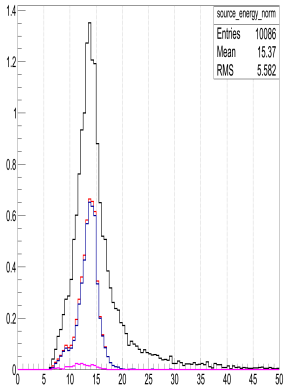
Varying Operational Conditions

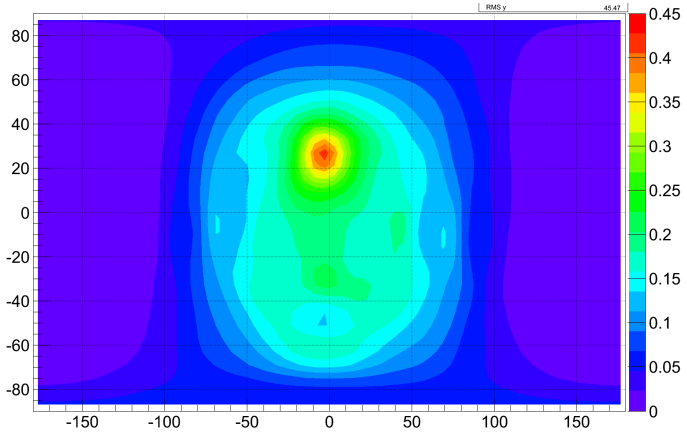




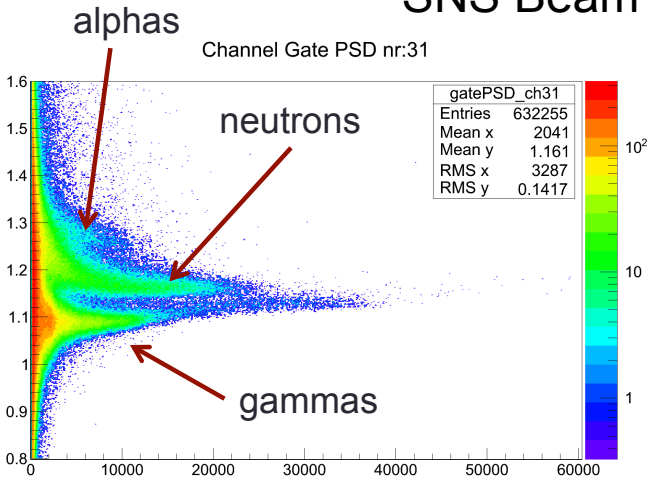
Scatter Imaging BL14a

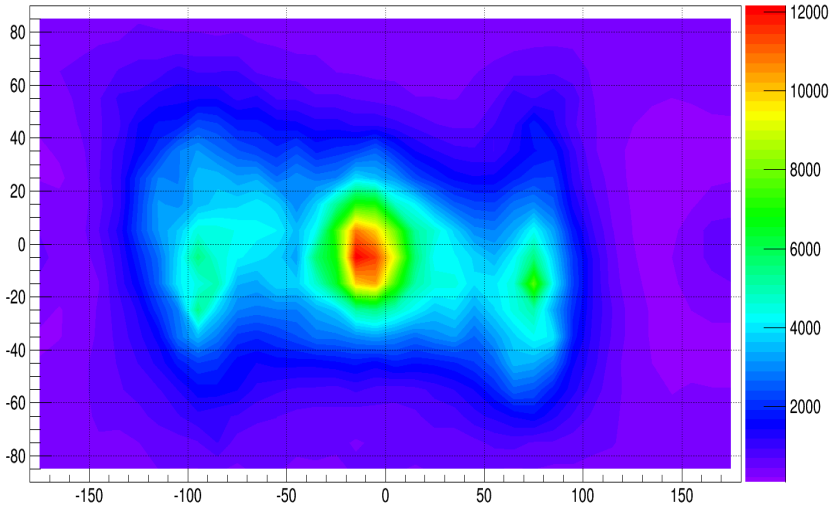
DT Calibrations at BL14a





SNS Beam On at BL14a

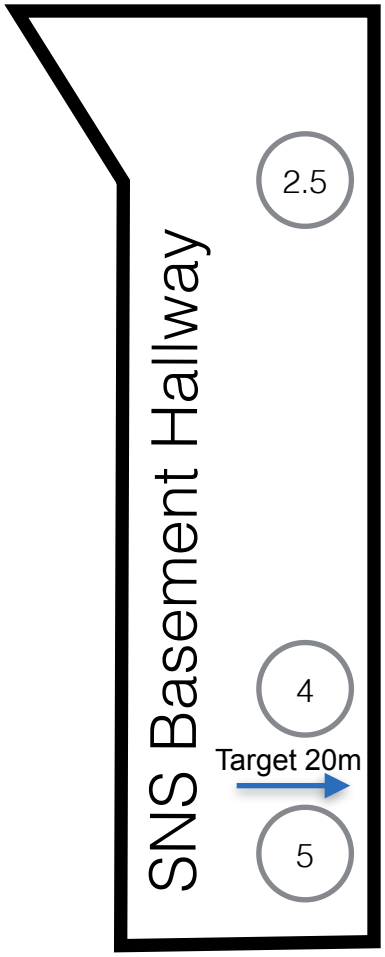




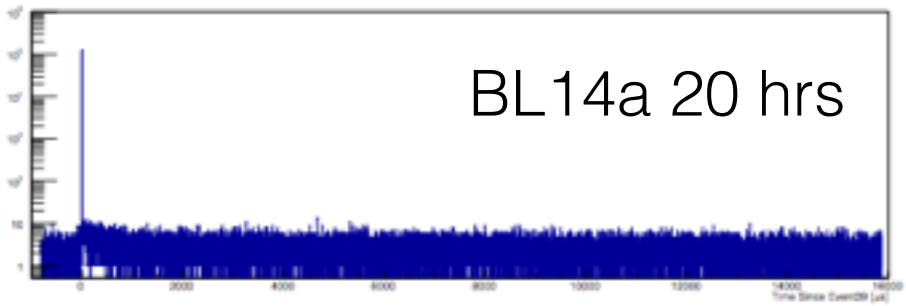
Belkis Cabrera-Palmer, Mark Gerling, David Reyna (Sandia)

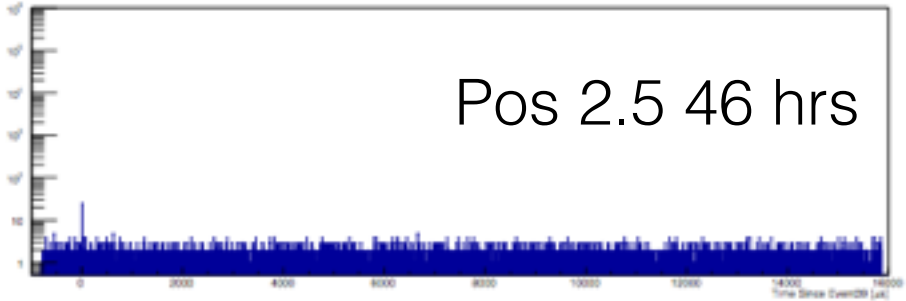
SNS Basement

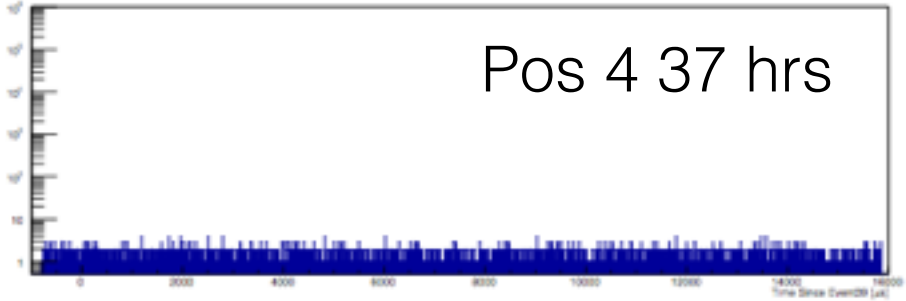
- 5 Liter EJ-301 Cells
- Compact and Cart Portable

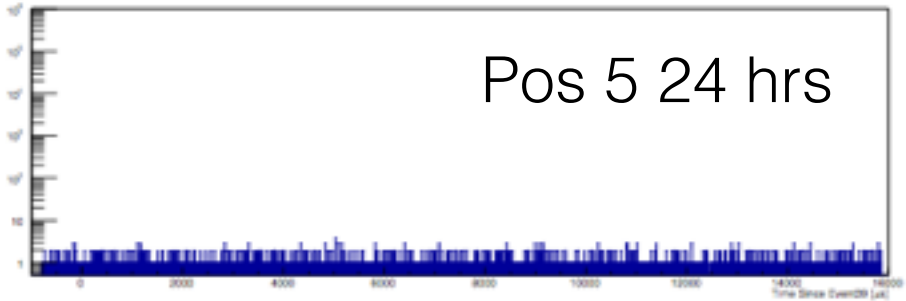


SNS Beam Power ~1 MW

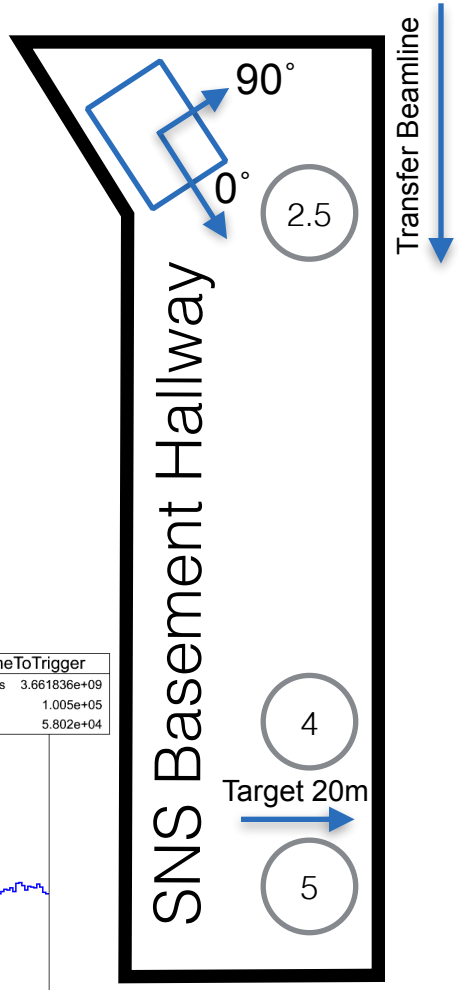


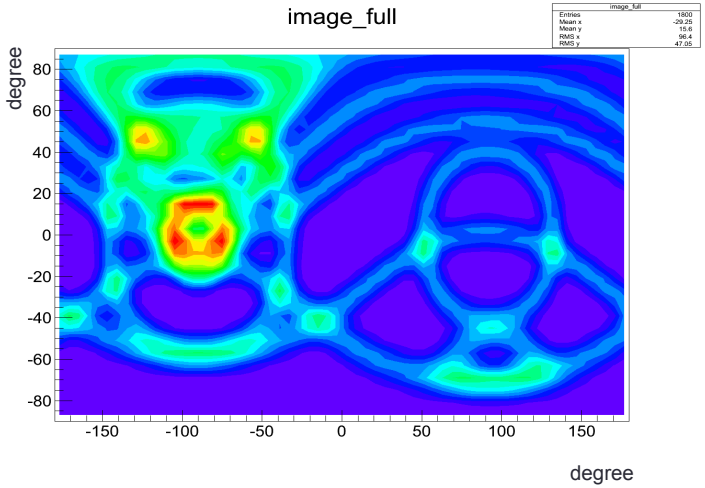




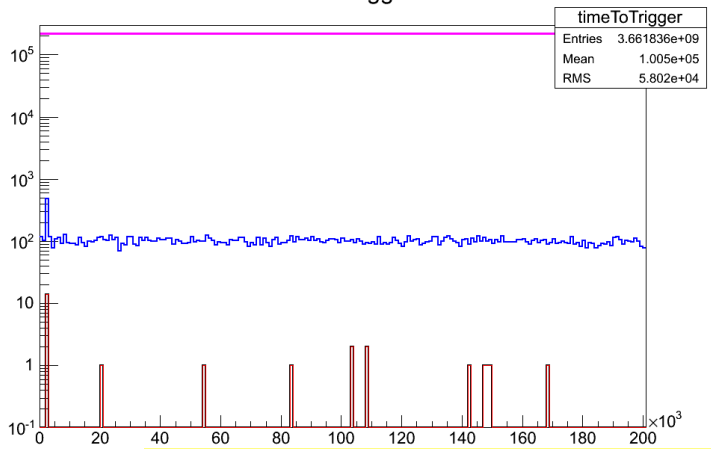


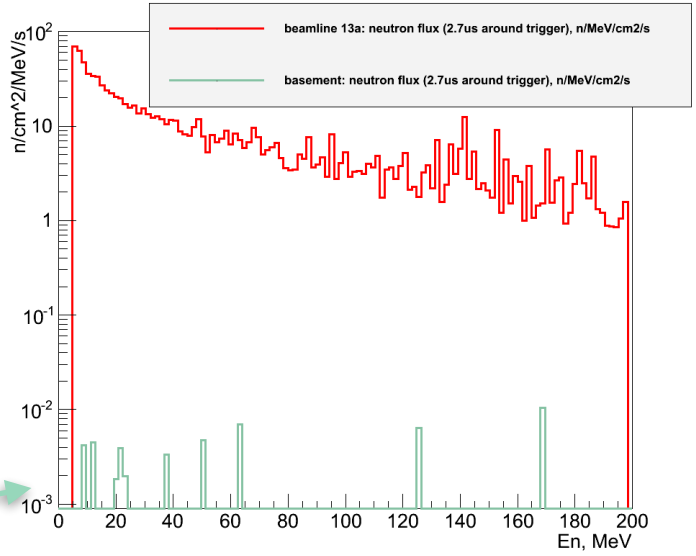
Sandia Scatter Camera at Pos 2.5





timeToTrigger





SNS Basement is a nice quiet place for a CEνNS experiment.

OAK RIDGE National Laboratory

Summary

- COHERENT measurements of backgrounds at the Spallation Neutron Source are well underway to support a future coherent elastic neutrino-nuclear scattering experiment.
- Significant fluxes of fast-neutrons are observed on the target hall floor in at least two measured locations. Two other locations are planned Fall 2014.
- Measurements in the SNS basement show significant reduction in these backgrounds within 20 meters of the SNS target where instruments are presently installed for a neutrino-induced neutron measurement.
- SNS Basement hallway could be a feasible location for a first observation CEνNS measurement.

Acknowledgements

- Many thanks to the Spallation Neutron Source scientific and technical staff for their support and the cooperation of Basic Energy Sciences: Erik Iverson, John Galambos and many others.
- ORNL efforts funded by ORNL SEED Laboratory Directed Research and Development: Donald Hornback, Yuri Efremenko, Justin Raybern
- Sandia efforts funded by SNL Laboratory Directed Research and Development: Belkis Cabrera-Palmer, Mark Gerling, David Reyna.
- Many contributions from our collaborators: Nicole Fields (University of Chicago)

COHERENT SNS

J. Adam, D. Akimov, P. Barbeau, P. Barton, A. Bolozdyna, B. Cabrera-Palmer, J. Collar, Robert Cooper, Ren Cooper, D. Dean, Y. Efremenko, S. Elliott, N. Fields, M. Foxe, A. Galindo-Uribarri, M. Gerling, M. Green, G. Green, D. Hornback, T. Hossbach, E. Iverson, A. Khromov, S. Klein, A. Kumpan, W. Lu, D. Markoff, M. McIntyre, P. Mueller, J. Newby, J. Orrell, S. Penttila, G. Perumpilly, D. Radford, J. Raybern, H. Ray, D. Reyna, G. Rich, D. Rimal, K. Scholberg, B. Scholz, S. Suchyta, R. Tayloe, K. Vetter, C.-H. Yu

Duke UNIVERSITY · OAK RIDGE National Laboratory · TUNL · Pacific Northwest NATIONAL LABORATORY · North Carolina Central University · Los Alamos NATIONAL LABORATORY · Sandia National Laboratories · UF UNIVERSITY of FLORIDA · THE UNIVERSITY OF CHICAGO · OAK RIDGE National Laboratory