Testing Monte Carlo Simulations for Neutron Scattering in MoNA

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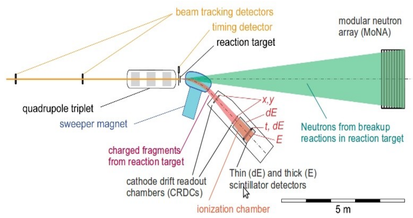
The MoNA Collaboration

MoNA (Modular Neutron Array) Collaboration: 8 undergraduate institutions (including Westmont) and Michigan State University, funded primarily by the NSF and NNSA.
Research Focus: Determining ground and excited state properties of exotic neutron-rich nuclei near the neutron dripline

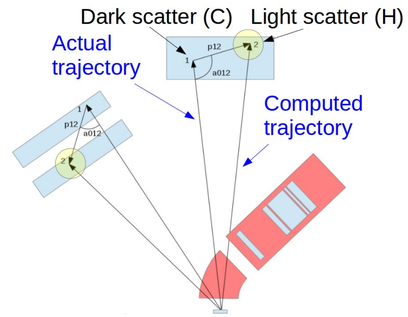
MoNA and LISA scintillator arrays, N2 vault at NSCL



Schematic of the N2 vault detector set up for a typical experiment

LANL Experiment Motivation

Reliance on Simulations: Monte Carlo simulations provide an important tool for nuclear physics research, both in preparing for experiments, and in interpreting experimental data. The MoNA collaboration has become increasingly dependent on simulations, especially for distinguishing between three-body decay, sequential 2n decay, and ^{0}dineutron decay.



Comparison between actual scattering trajectories (taking dark scattering into account) and computed trajectories in MoNA (blue on right) & LISA (blue on left)

The Goal: To observe single neutron scattering in MoNA using a high flux, well-defined neutron beam (at LANSCE). The dataset will be compared with Monte Carlo simulations in order to better gauge the accuracy of simulations for experiments conducted at NSCL using MoNA and LISA.

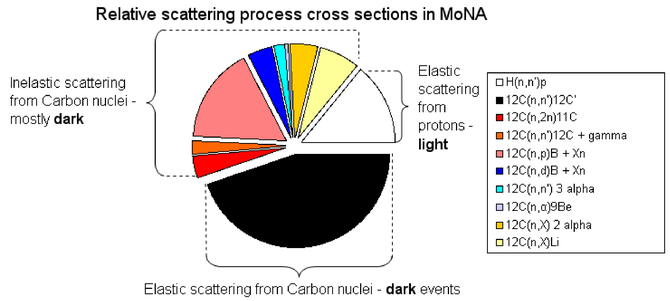


Illustration of the estimated contributions of the various scattering channels to the production of light in the scintillator

Preparations

Planning: The experiment we proposed in May has been approved and is scheduled for December 4th through 11th (2015).

Details:

-3mm beam spot

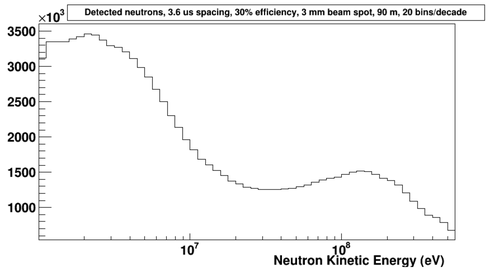
-16 MoNA bars in 3 geometries

-deterctors in 90m shed (4FP15L flight path) at LANSCE

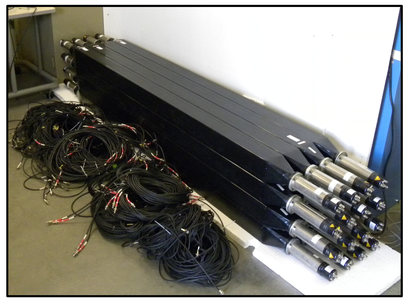
-7 days of beam time

-17kHz detector trigger rate

-3.6μs pulse spacing



Estimated detected neutrons per day as a function of neutron energy, for a 3mm beam, entering the 90m station (the array efficiency is assumed to be 30%)

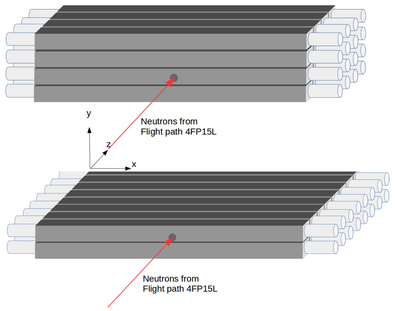


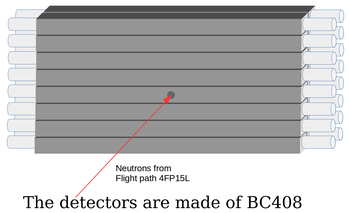
The Move: This summer we packaged, shipped, and unpacked 16 of the MoNA scintillator detector bars. We then tested them for damage, and found none.

Left: The Monet array (16 MoNA bars) at LANL after a safe arrival

Simulations

Three Geometries: 4x4, 8x2 and 2x8



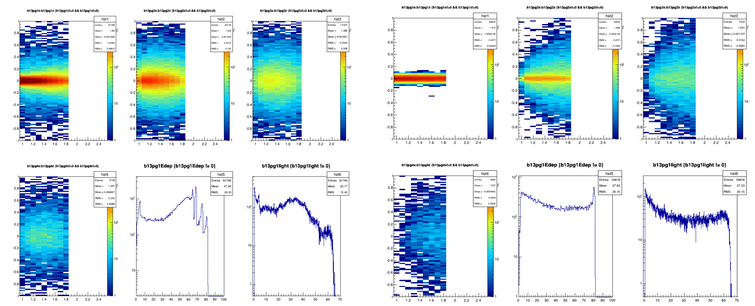


The detectors are made of BC408 scintillator, which contains Carbon and Hydrogen.

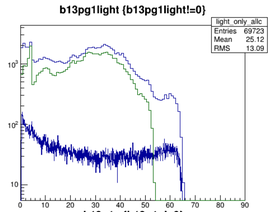
How They Work: STMONA, a code package developed by MoNA collaborators, generates the incident particles (produces a ROOT file with information about each particle's energy and trajectory). This file is fed into Geant4, a simulations toolkit, that feeds the particles through the detectors and produces another file with information about how the particles scatter. We can alter parameters regarding experimental set up, and we can select for specific scattering crossections.

Results

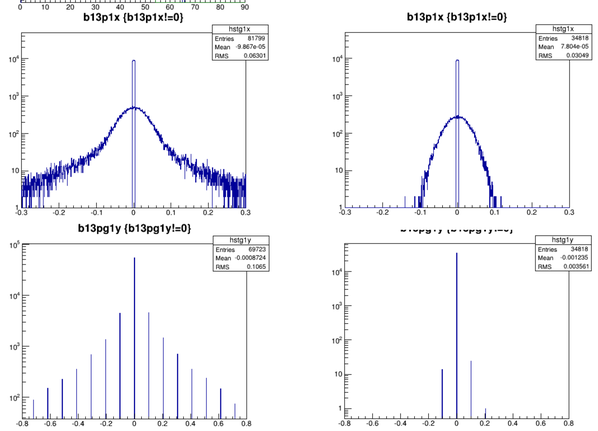
Simulated Data: We have modified the simulations to observe the contributions from individual cross section channels, to better understand how much light different types of scattering produce. One primary concern is to better understand dark scattering and its affect on neutron trajectory resolution. Another concern is how much light is produced by Carbon scattering.



Left: plots of scattering in the entire MoNA array (viewed from above with the beam entering from the left and all cross sections (four plots showing the events within the array for the 1st-4th neutron hits, energy deposited and light deposited))
Right: plots of Hydrogen elastic scattering



Left: total predicted light produced by Hydrogen Carbon scattering. Below: plots demonstrating loss of resolution owing to dark scattering. Below left: entire BC408 array
Below right: Hydrogen scattering alone



Moving Forward: We will continue on site preparations and simulations leading up to the experiment in December. We hope to characterize our detectors with both simulations and experimental data. This experiment will inform all of our preparation and analysis at NSCL (and soon, FRIB).

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