Neutron dEtector with Xn Tracking (NEXT)

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and the NEXT collaboration

Introduction:

The production of heavy nuclei which approach the neutron dripline, reveals the need for improved neutron detection. NEXT sets out to achieve this with the capability of pulse shaped discrimination and an energy resolution improvement by a factor of at least 5 compared to current detectors.

NEXT, with segmented scintillators in a rectangular geometry coupled with photosensitive devices (Figure 1), will provide accurate energy measurements alongside positioning capabilities for these heavy nuclei. NEXT ultimately allows for the study of unbound neutron states following beta-delayed neutron emission.

Figure 1: Experimental setup used recently showing multiple NEXT modules in an array.

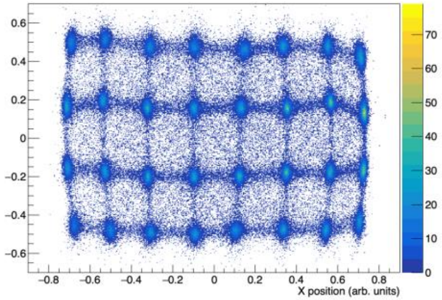


Figure 2: An experimental position plot using a Cobalt-60 source.

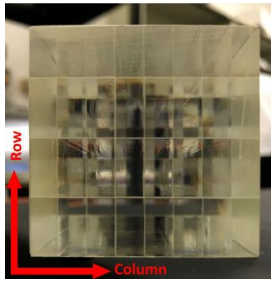


Figure 3: NEXT scintillators.

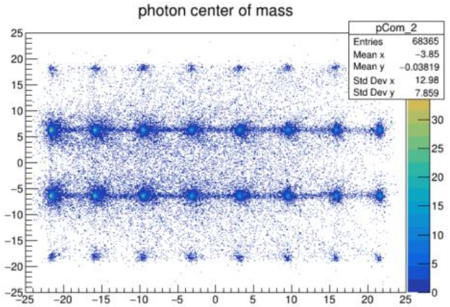
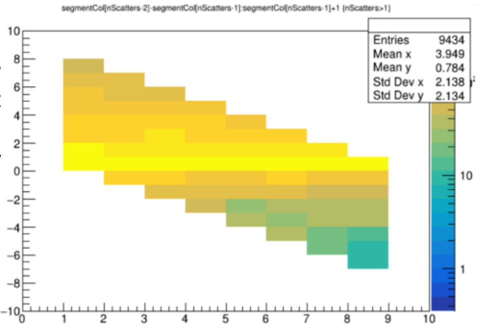


Figure 4: A simulated position plot using a neutron source.

Procedure:

In order to understand the effectiveness of NEXT, a Geant4 based simulation software (NextSim) was implemented. NextSim tracks individual particles and stores pertinent information to the primary particle until it leaves or is absorbed by the material defined in the simulation space. I created a macro to be use with ROOT (an analysis framework) to plot the scattering patterns (Figures 4, 5 & 6) as well as calculate various scattering statistics. 100,000 Neutrons for each 1 MeV increment from 1-10 MeV as well as 100,000 gamma rays from 0.1-6 MeV were simulated.

Figure 5: Scatter layer difference between first and second scatter of 1MeV gamma-rays. This plot was produced from the command line in Root.



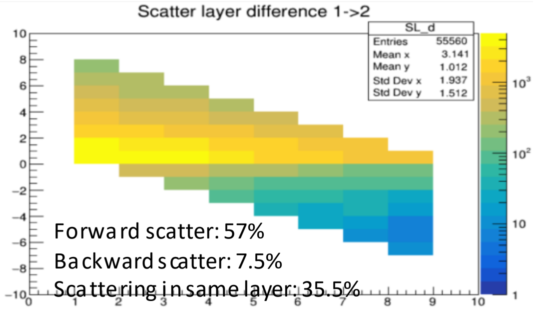


Figure 6: A plot showing the difference in segment between first and second scatter of 1MeV neutrons. In the bottom left corner are statistics produced with my root macro.

Results/Conclusion:

Generally, neutrons are more difficult to detect at higher energies. As neutrons approached 10MeV, interactions inside the simulation space decreased from 72.9% to 36%. This increase in energy also caused a 9% increase in forward scattered neutrons from 57% at 1 MeV to a maximum of 66% at 8 MeV.

Gamma-rays are even less likely to interact than neutrons at equal energy. As gamma-rays approached 6 MeV, forward scattering increas -ed from 49% at 100 keV to a maximum of 57.6% at 5 MeV. Gammas interacting with the detector volume space in the simulation decreased from 49.9% at 100 keV to 12.9% at 6 MeV. In conclusion, a direct correlation between energy and forward scatter can be observed in higher statistic simulations.

Future Work:

Future work will be based upon improving NEXTSim. The main focus will be to fully interpret how accurate these plots and any further plot representations will be based on NEXTSim's definition of physical processes (i.e. photon scattering), and obtain relative efficiency curves based on energy of primary particles.

References:
[1] Heideman, J et. al, NIM Section A; Vol. 946: 162528, Dec. 01, 2019.
[2] Thornsberry et al., NEXTSim, Oct. 6, 2019, github

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