# Calibration and Detection Using the Large Area Neutron Array

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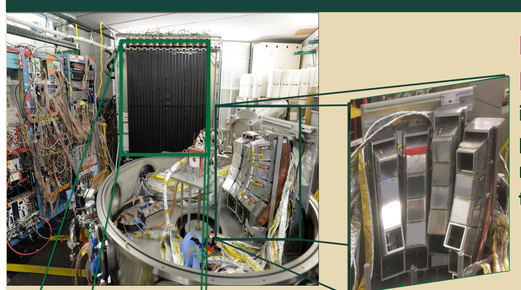
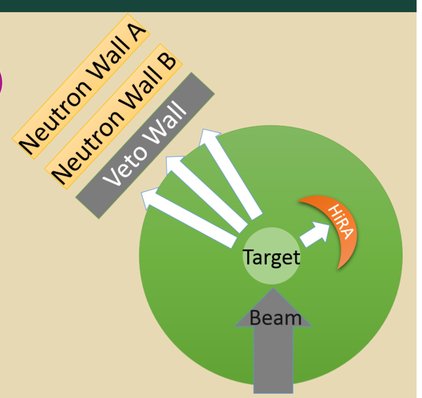
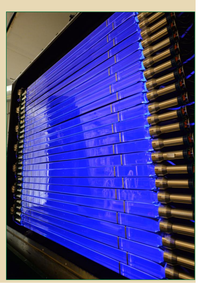
## HiRA and LANA



**HiRA (High Resolution Array)** is a modular charged particle detector made of Si-CsI telescopes.

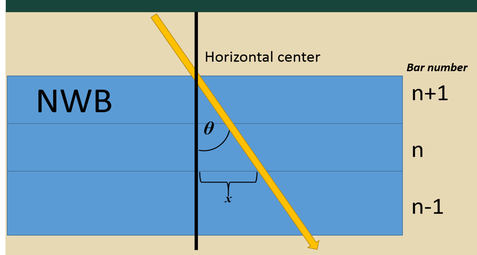



**LANA (Large Area Neutron Array),** also known the Neutron Walls, are two arrays of 24 bars filled with scintillating fluid (Ne213) and photo-multiplying tubes (PMTs) on each side of each bar used to detect neutrons via secondary interactions.



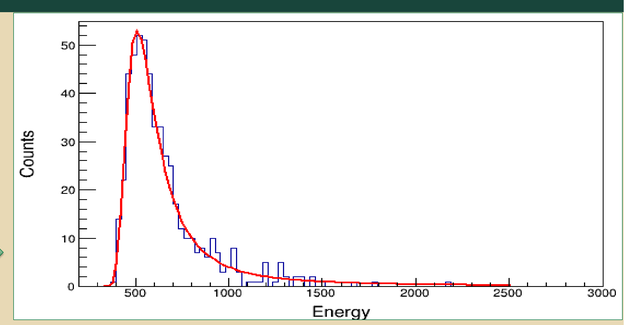
**Veto Wall** is an array of 24 plastic scintillating detectors for charged particles that is paired with LANA to veto charged particles.

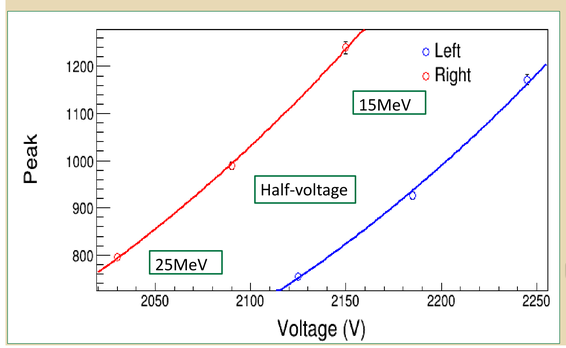
## Cosmic Ray Analysis



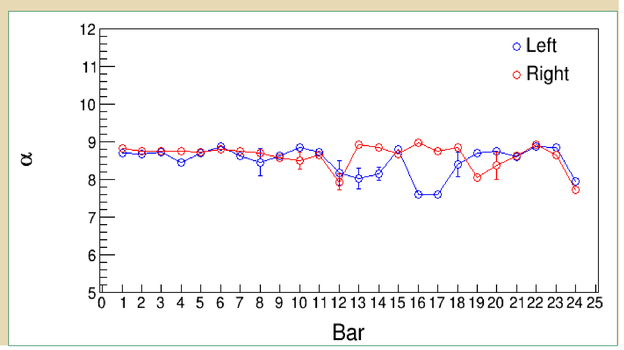

We can calibrate the gains of the PMTs using ~12MeV cosmic ray background.

We determine the signal response due to cosmic rays in each PMT using a Landau fit.

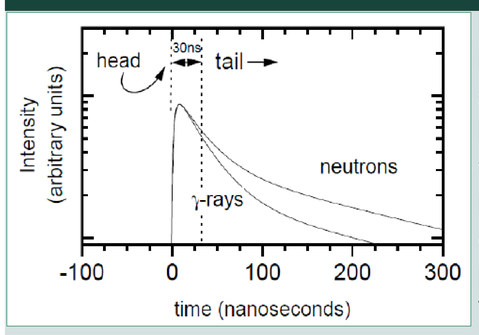


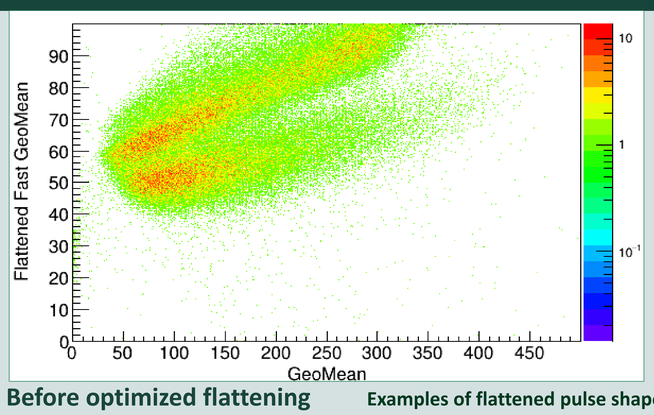

We expect PMTs to follow $g = b\,V^{\alpha}$, where g is gain and V is voltage.



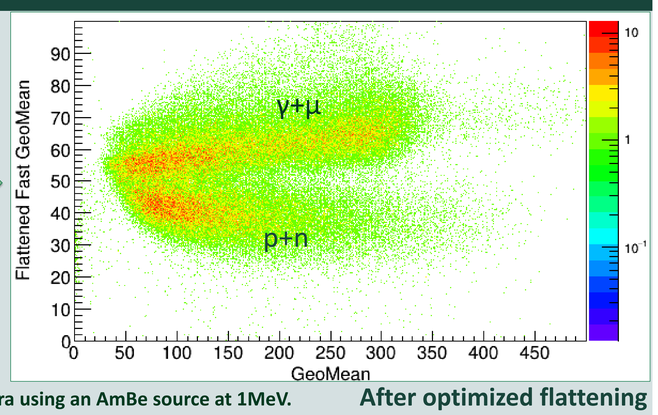

## Using Pulse Shape Discrimination to Identify Particles




Particles, such as neutrons, yield signals with longer tails than γ-rays. We can use this to discriminate particles in LANA. This method is called pulse shape identification (PSD) [1].



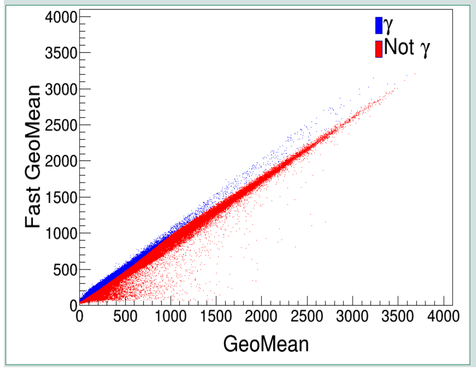

**Before optimized flattening**




**After optimized flattening**

**Examples of flattened pulse shape spectra using an AmBe source at 1MeV.**

**Pulse shape spectrum**

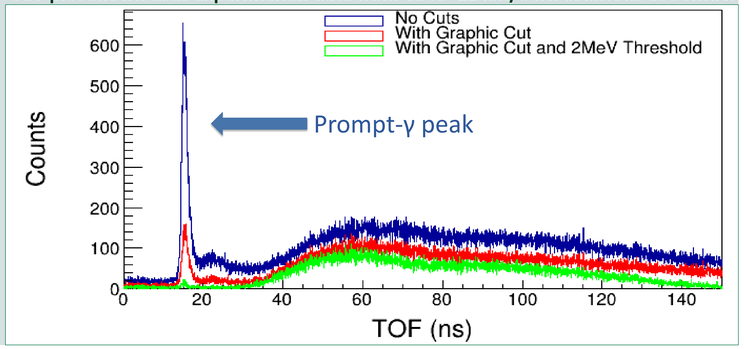



To make a reasonable graphic cut, we can flatten the pulse shape spectrum. This procedure's flattening fraction may be calibrated to give us a better identification spectrum by rotating horizontally for a graphic cut.

flattened fastGeoMean = fastGeoMean -x(GeoMean), for some flattening fraction, x that can be optimized.

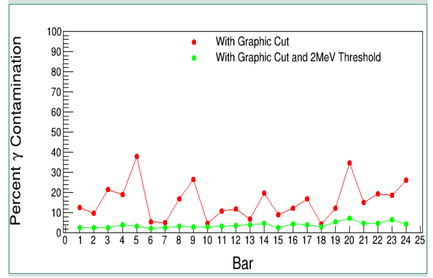
Time of flight (TOF) analysis of the prompt-γ peak is one measure of evaluating success of identification. At low energies, contamination is higher, so a small energy threshold improves identification.

**TOF plot shown uses experimental data from Ca48+124Sn/64Ni collisions at 56MeV.**




## LANA & Probing Symmetry Energy

LANA has been characterized via left/right gain matching and used to discriminate between particles successfully. Using a low energy threshold, we further improved the success of the identification.




## References

[1] Daniel Coupland. *Probing the Nuclear Symmetry Energy with Heavy Ion Collisions.* PhD thesis, Michigan State University ,2013.
[2] A large-area, position-sensitive neutron detector with neutron/gamma-ray discrimination capabilities; P.D. Zecher, A. Galonsky, J.J. Kruse, S.J. Gaff, J. Ottarson, J. Wang, F. Deak, A. Horvath, A. Kiss, Z. Seres, K. Ieki, Y. Iwata, H. Schelin, Nucl. Instrum. and Meth. A **401** (1997) 329.