Improved particle identification with the FAUST array

M. B. Chapman, P. Cammarata, S. Behling, and S. J. Yennello

One current method for particle identification with the FAUST [1] array utilizes a ΔE-E technique for isotopic particle identification. A new method is proposed to separate the detection of Light Charged Particles (LCPs) and lighter Intermediate Mass Fragments (IMFs) from the heavier IMFs. This will be accomplished by using Pulse Shape Discrimination [2] on the CsI photodiode signal to identify LCPs and light IMF, while gaining the Si for detecting heavier IMFs via ΔE-E analysis. The analog signal from the photodiode will be digitized with a flash Analog to Digital Converter (ADC). This technique can be further enhanced with the inclusion of a machine learning algorithm to train the computer to identify the isotopes based on rise time and full pulse shape analog input. The machine learning algorithm will be based on a dimensional reduction package [3] written in the statistical programming language R [4]. One major hurdle in implementing such a technique is the need to model both the detector and electronic response accurately. This is desired both to determine the time resolution required to digitize the CsI signal as well as for input data to train the machine learning algorithm. It is important to note that the algorithm can also be trained with experimental data.

A Geant4 model of the entire detector array has been created and simulations are ongoing utilizing the Eos supercomputer at the Texas A&M Super Computing Facility [5]. Fig. 1 is a ΔE-E plot created with data captured from the completed Geant4 simulation. Fig. 2 is an image of FAUST capture from inside Geant4. The electronics simulation is a work in progress. Collaboration is under way with the pre-amp manufacturer [6] to model the electronics' response utilizing the Simulation Program with Integrated Circuit Emphasis(SPICE) [7]. The simulation will be executed from a virtual machine with a root script to manage the simulated input data and the electronics output signals.

Two FAUST style Si-CsI telescope detectors have been built. They will be used for a control experiment for comparison with the simulation. The electronics for the planned experiment are still being finalized. A dual flash ADC method might prove to be the best way to digitize the analog pulse from the pre-amp, but the complexity makes it more difficult. The advantage of using two flash ADCs is the ability to capture the picosecond resolution rise time while also capture the microsecond fall time. If the simulation data can be shown to be reliable then the same experimental data will be used for development of the machine learning algorithm.

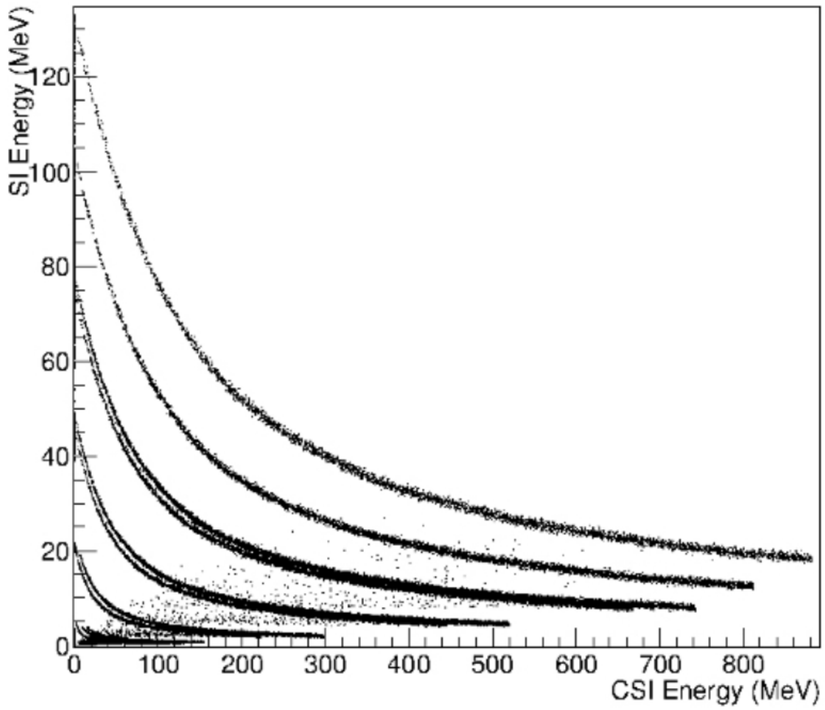

FIG. 1. A simulated ΔE-E plot from a typical ring A FAUST detector.

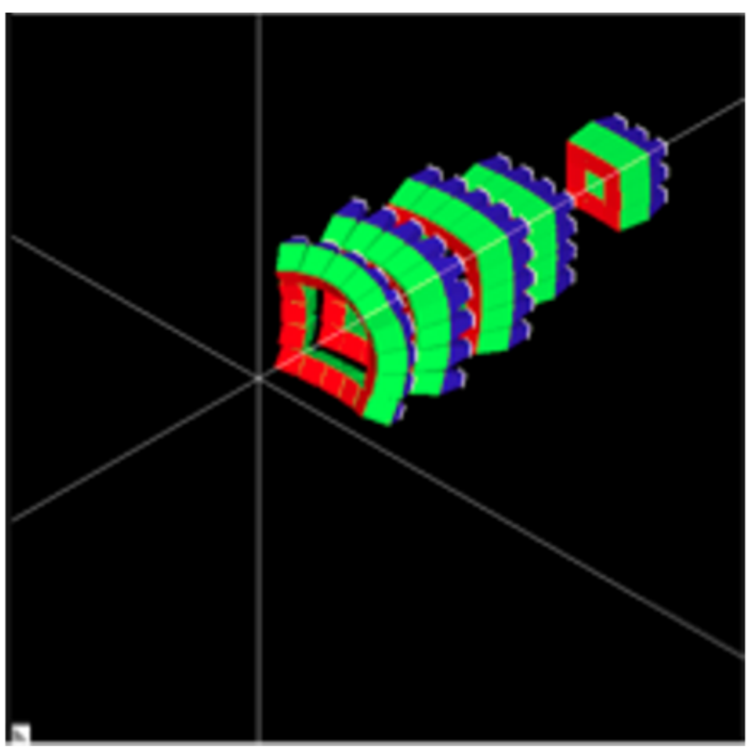

FIG. 2. The FAUST detector array modeled inside Geant4.

Special Acknowledgements

I would like to thank Larry May for his mathematics help with the 3D geometry required for the simulation. I would also like to thank Andrew Zarrella for his help in verifying some of the physics used in the Geant4 simulation and his help with the construction of the Si-CsI telescope.

[1] F. Gimeno-Nogues *et al.*, Nucl. Instrum. Methods Phys. Res. **A309**, 94 (1997).
[2] R. Laforest *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (1997-1998), p. II-1
[3] S. Weisberg, J. Statistical Software **7**, 1 (2002).
[4] *R: A Language and Environment for Statistical Computing* (R Foundation for Statistical Computing, Vienna, Austria, 2013)
[5] T.A.S. Faculty, Eos an IBM iDataplex Cluster (http://sc.tamu.edu/)
[6] D. Todd, RIS Corp (http://www.ris-corp.com/)
[7] SPICE, Simulation Program with Integrated Circuit Emphasis; (http://bwrcs.eecs.berkele.edu/Classes/IcBook/SPICE)