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Calibration of a Fusion Experiment to Investigate the Nuclear Caloric Curve

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INTRODUCTION

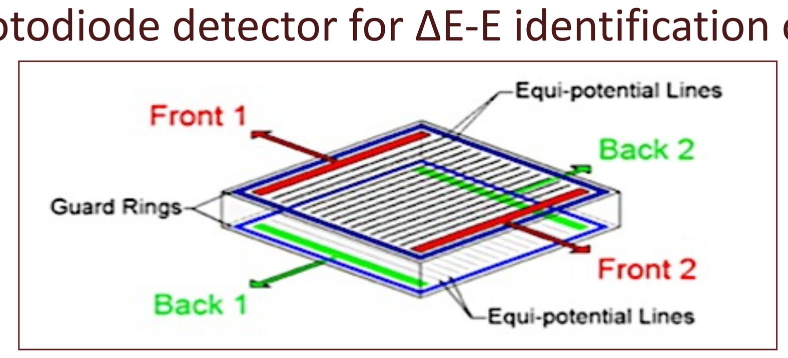
In order to investigate the nuclear equation of state (EoS), the relation between two thermodynamic quantities can be examined. The correlation between the temperature and excitation energy of a nucleus, also known as the caloric curve, has been previously observed in peripheral heavy-ion collisions [1-3] to exhibit a dependence on the neutron-proton asymmetry. To further investigate this result, fusion reactions (^{78}Kr + ^{12}C and ^{86}Kr + ^{12}C) were measured; the beam energy was varied in the range 15-35 MeV/u in order to vary the excitation energy. The light charged particles (LCPs) evaporated from the compound nucleus were measured in the Si-CsI(TI)/PD detector array FAUST (Forward Array Using Silicon Technology). The LCPs carry information about the temperature. The calibration of FAUST will be described in this presentation.

THE FUSION REACTIONS

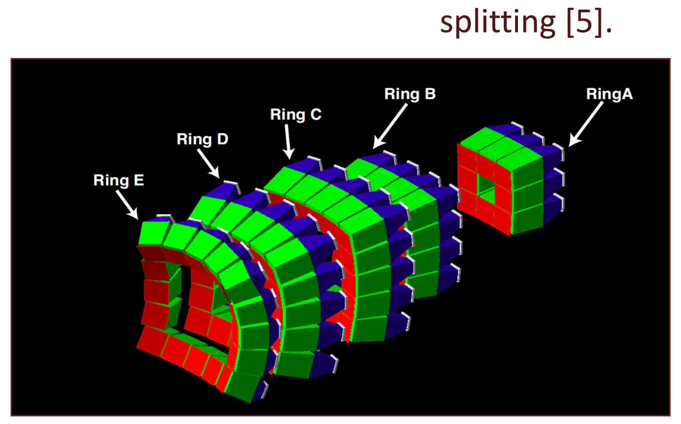
- ^{78}Kr + ^{12}C ^{86}Kr + ^{12}C
- Beam Energies E/A = 15, 25, 35 MeV/u
- E*/A = 1.3 , 2.0 MeV, and 2.8 MeV for ^{86}Kr (For ^{78}Kr, ~10% higher)
- (N-Z)/A: ^{86}Kr = 0.163 ^{78}Kr = 0.070

EXPERIMENTAL CONFIGURATION

- Forward Array Using Silicon Technology (FAUST): 68 ΔE-E telescopes [4]
- Position-sensitive Dual-Axis Dual-Lateral (DADL) silicon diode detector backed by a CsI(TI)-photodiode detector for ΔE-E identification of LCPs [5].



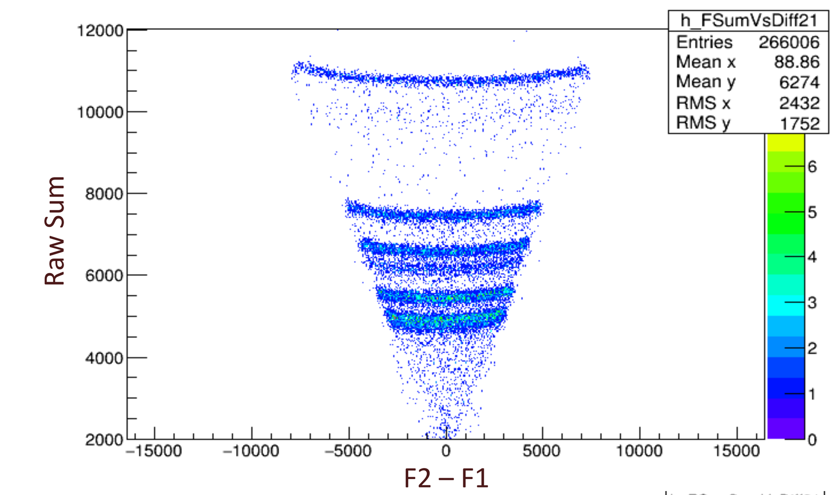
Schematic of DADL, showing the equipotential lines on the uniformly resistive surface, which allows the position to be determined by charge splitting [5].



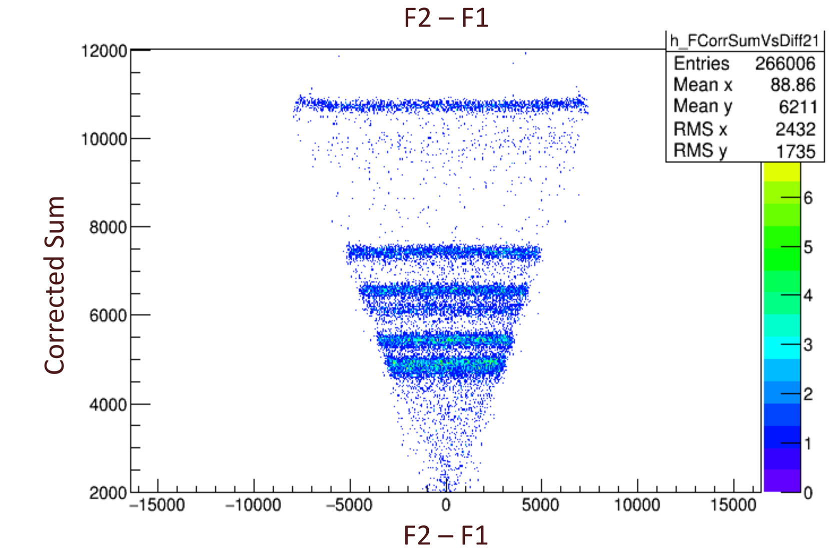
FAUST: Measures Light Charged Particles Position-Sensitive $1.6° \leq \theta \leq 45°$

POSITION CORRECTION

The addition (Raw Sum) of the two front (or two back signals) represent the total amount of energy deposited in the silicon detector. The difference (F2 - F1) of the two front (or back) signals represents the relative 1D-position of the hit on the detector. When the sum vs. the difference of the front (or back) signals were plotted, a 2D histogram was generated. The lines in these histograms should be linear and horizontal, since the energy deposited by each particle should not be dependent on the position of the incident particle hit.
Since these lines were clearly curved, rather than straight, it was concluded that the response of the silicon detectors was not completely linear as a function of position on the detector face. In order to take full advantage of the resolution of the detector, a position-dependent correction was applied to the raw energies before energy calibration. Each of the lines were fit quadratically in order to correct for the curvature of these lines. This process was implemented on the fronts and backs of all the detectors in rings A,B, C, D, and E of FAUST.

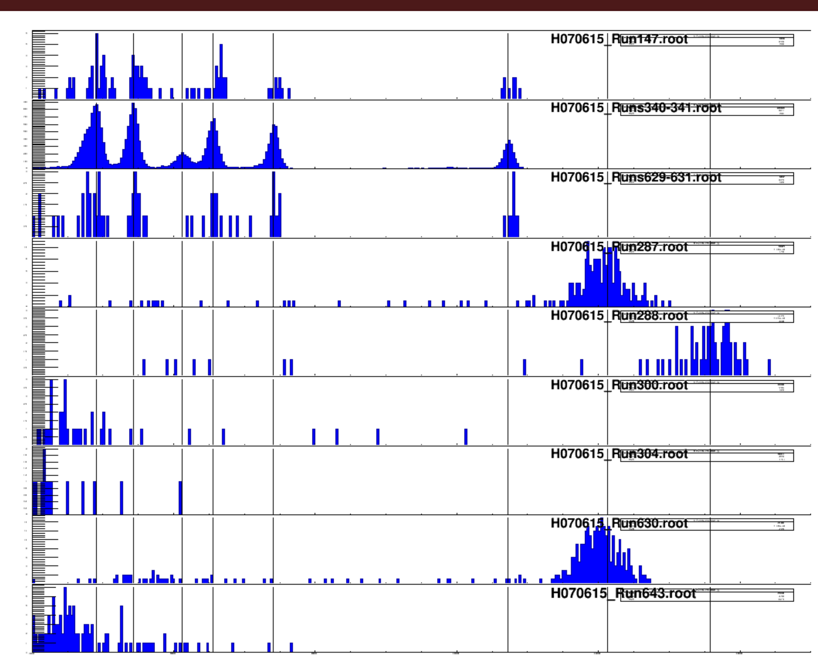


The uncorrected sum vs. difference for particle energies deposited in the front of detector 21.

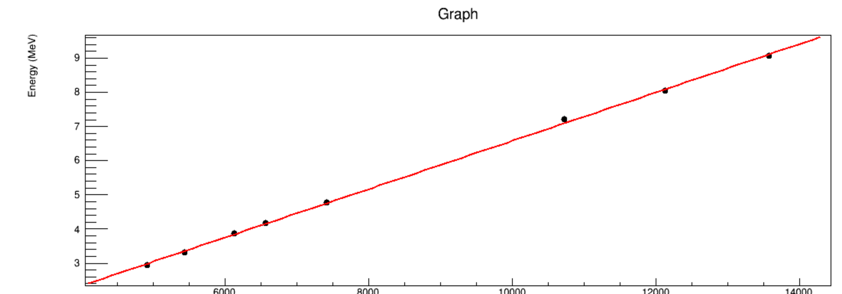


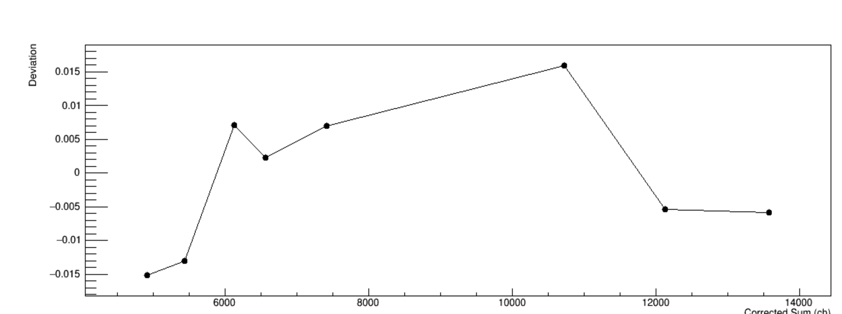
The corrected sum vs. difference for particle energies deposited in the front of detector 21 after implementation of the position-dependent correction to the energy deposition.

ENERGY CALIBRATION



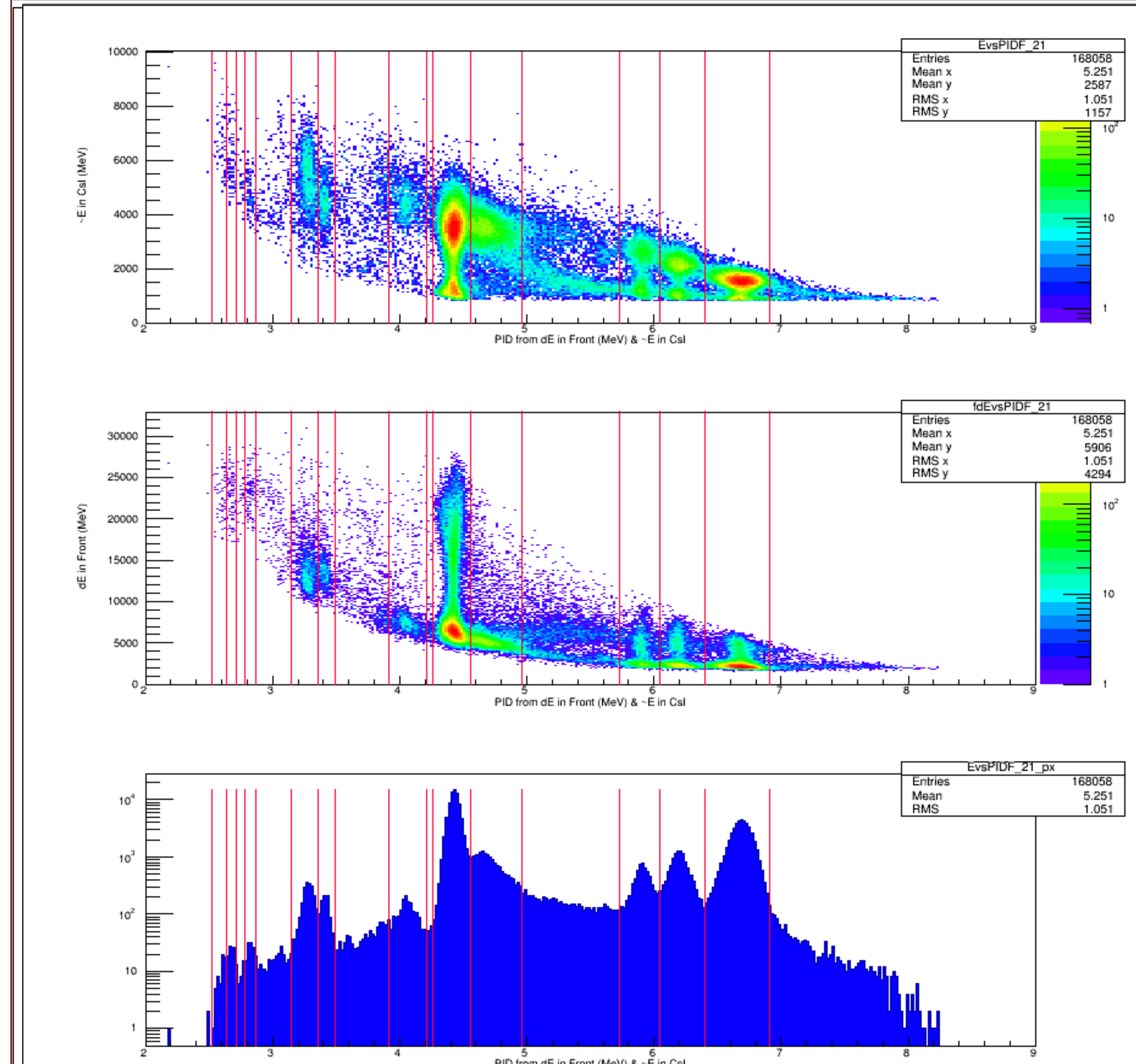
The number of counts vs. corrected energy sum for the front of detector 21. Plotting several runs allowed us to determine that the location of these energy peaks did not change significantly with time.





Top Plot- The energy (MeV) vs. corrected sum (ch) for the front of detector 21.
Bottom Plot- The deviation vs. corrected sum (ch).

PID CUTS

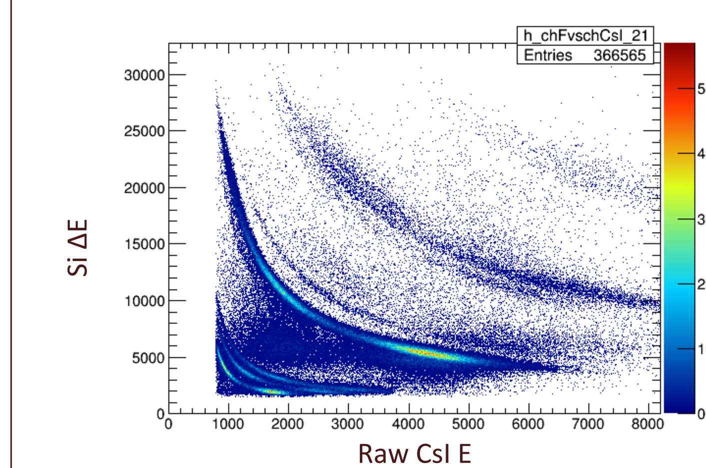


PARTICLE IDENTIFICATION (PID)

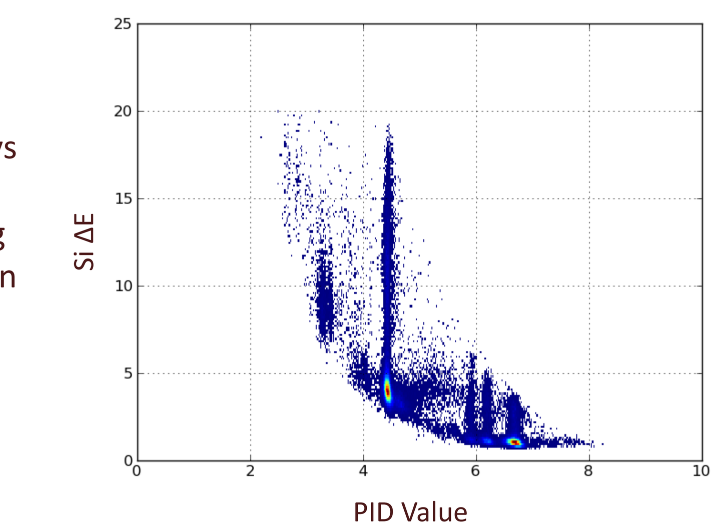
- A parameterized formula, based on the Bethe-Bloch equation, was used to straighten the PID lines measured with the dE-E technique.

$$PID = b * \log(x_0) - \log(b * \Delta E) - (b-1)\log(E + x_1 * \Delta E)$$

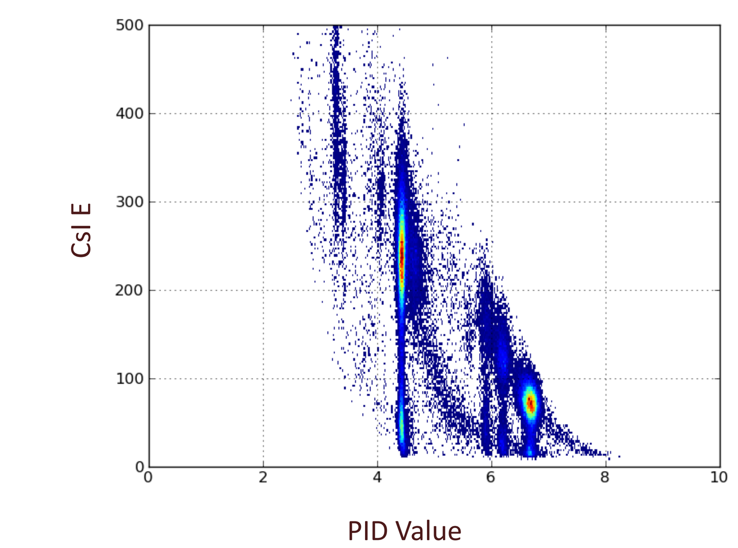
Where b is defined as: $b = x_2 - x_3 * \frac{\Delta E}{x_4}$



The ΔE (silicon front) vs. E (raw CsI signal) for the front of detector 21 from runs 223-285.



Detector 21 front for runs 223-285 Si ΔE vs PID Value, demonstrating the linearization of data achievable via the PID equation.



Detector 21 front for runs 223-285 CsI E vs PID Value

FUTURE

- The particle identification (PID) and PID cuts described in this presentation are ongoing.
- Once the PID is completed, the next step is the energy calibration of the CsI detectors (based on the silicon detector energy calibration and the PID).
- Once all of the calibrations have been completed, the impact of the asymmetry energy term of the nuclear equation of state will be further investigated.

ACKNOWLEDGEMENTS

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