Characterizing the Light Response of the CsI(Tl) Crystals in the HiRA Detector to Low-Energy Charged Particles

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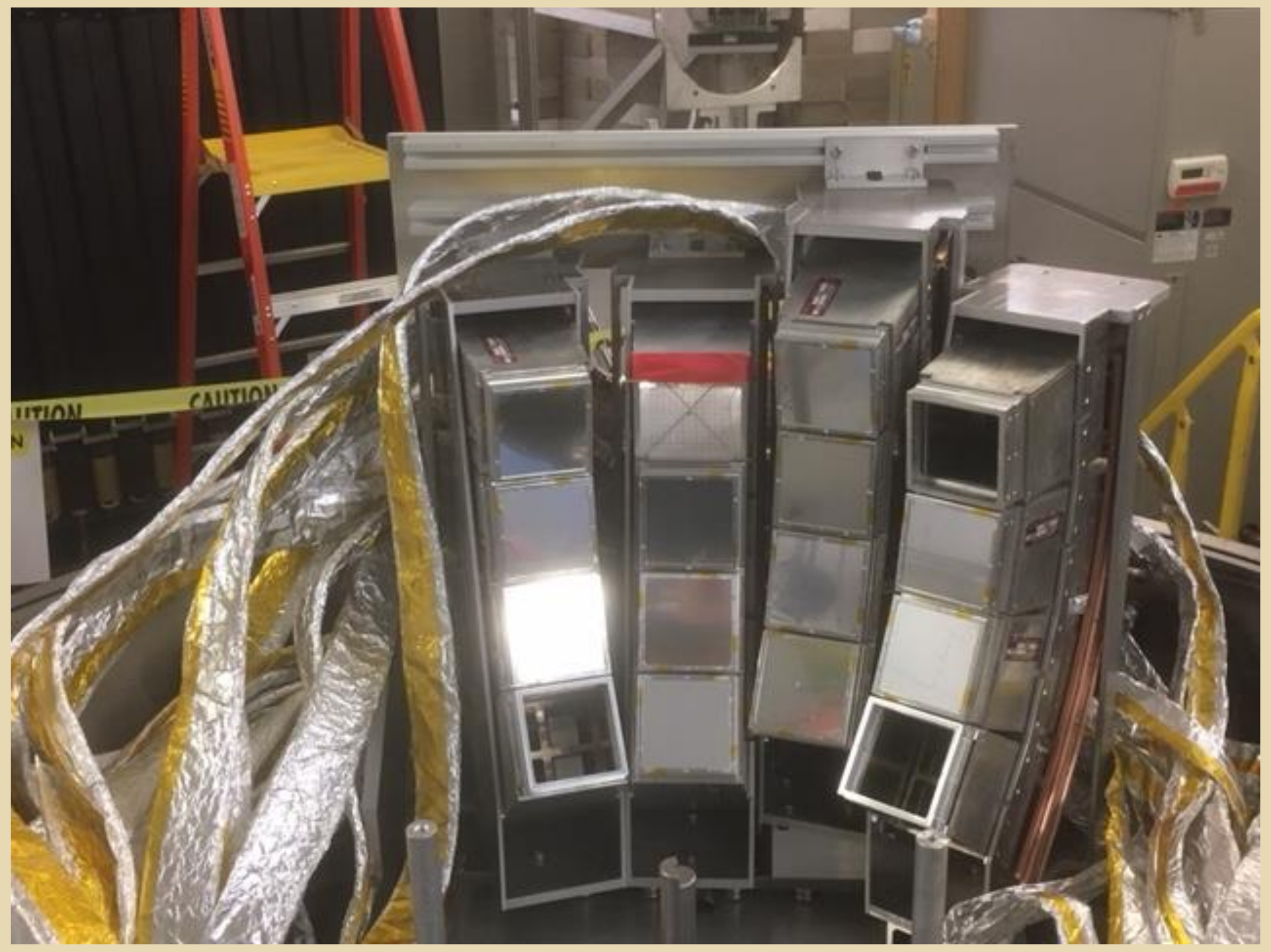
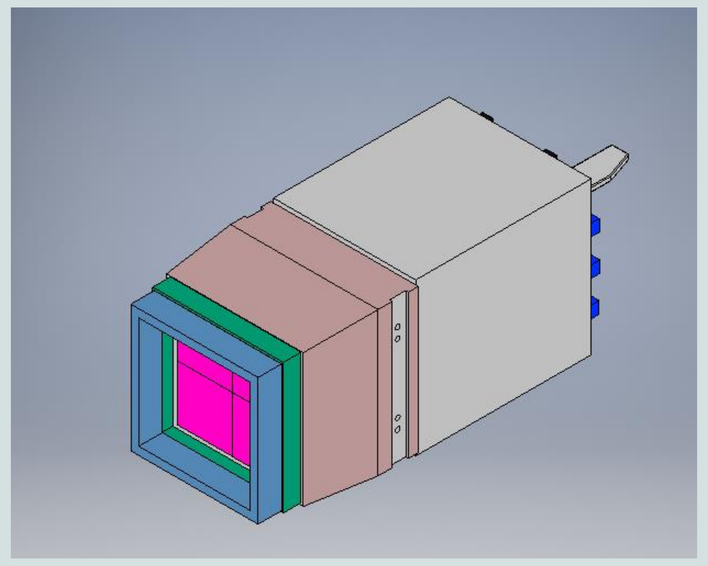
Introduction/Background

- HiRA (High Resolution Array) is a charged particle detector which consists of multiple Si-CsI(Tl) telescopes.
  - HiRA has a modular setup

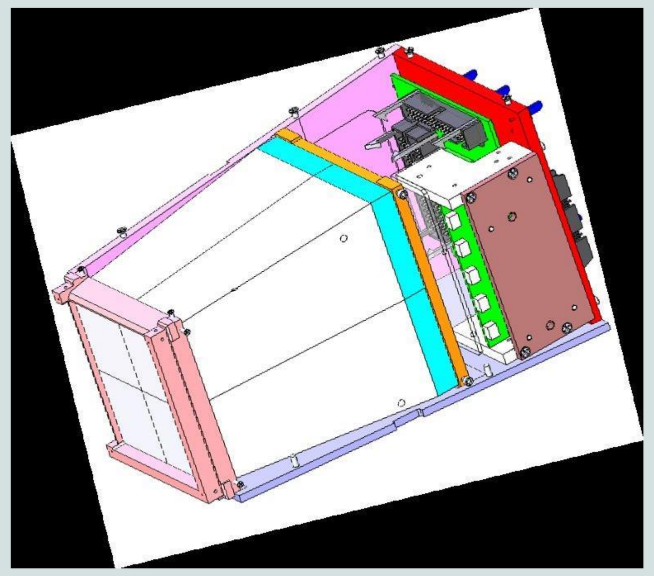


Upgraded HiRA Detector

- HiRA telescopes have been modified to have 10 cm long CsI crystals instead of 4 cm long crystals.



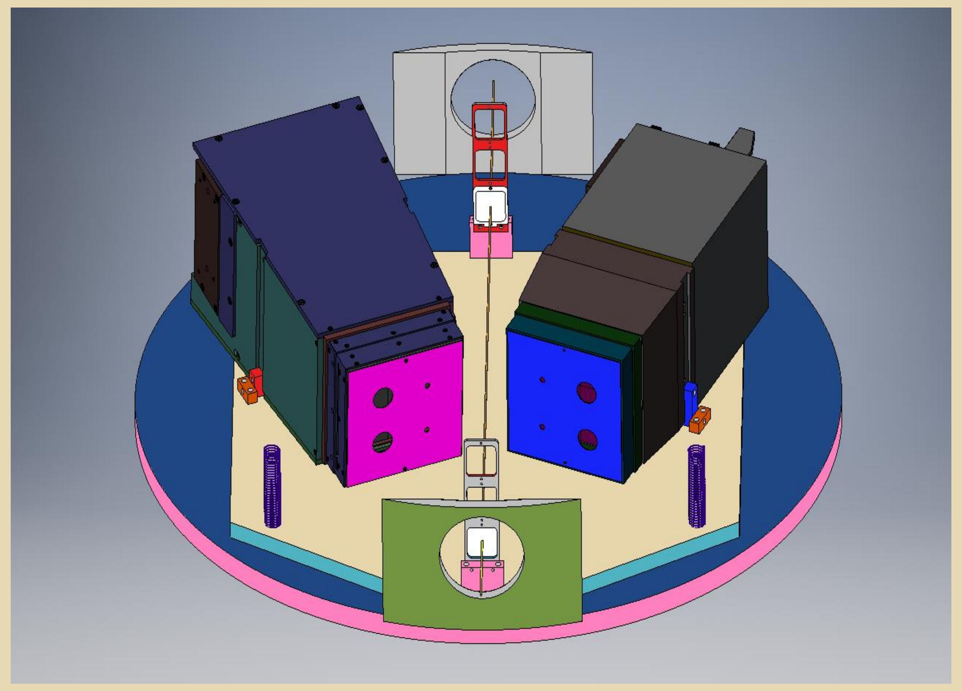
Old HiRA (4-cm long crystals)

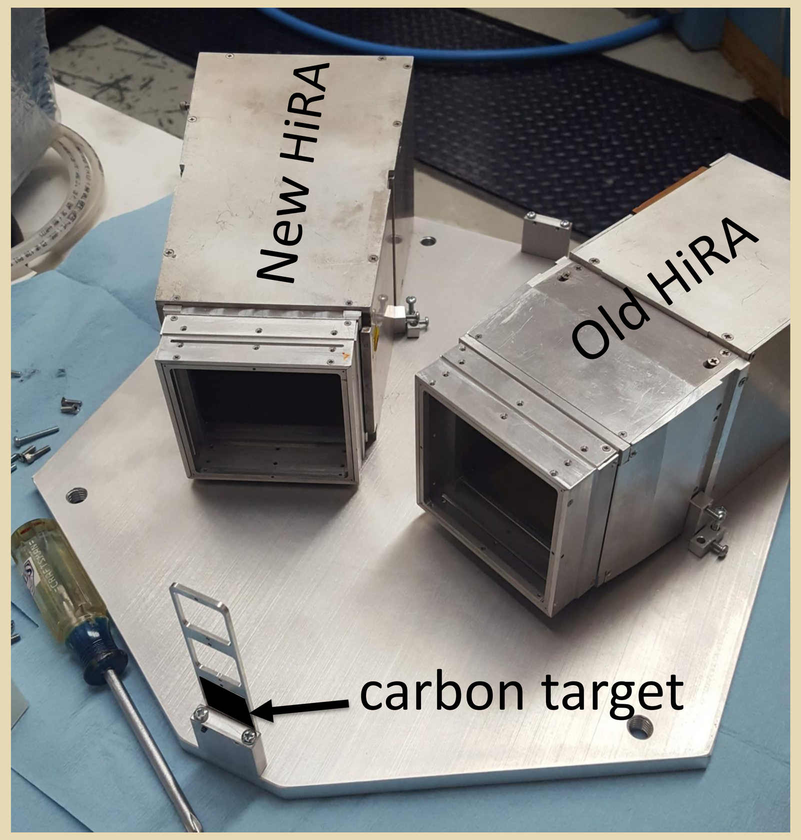


New HiRA (10-cm long crystals)

- In order to compare the two HiRA telescopes, the silicon strips were removed and we studied the light response of the two different length crystals to low energy [around 10 MeV] protons, deuterons, and alpha particles.
- Autodesk Inventor was used to model both HiRA telescopes as well as the experimental setup.

Experiment at Western Michigan University





- Experiment conducted at Western Michigan University (WMU).
- Old and new HiRA were placed in a vacuum chamber, and a carbon-12 target along with a low energy beam were used to elastically scattering protons, deuterons, and alphas.
- LISE++ was used to predict the energies of the particles at the entrance of the detectors.

Relativistic Rutherford Scattering

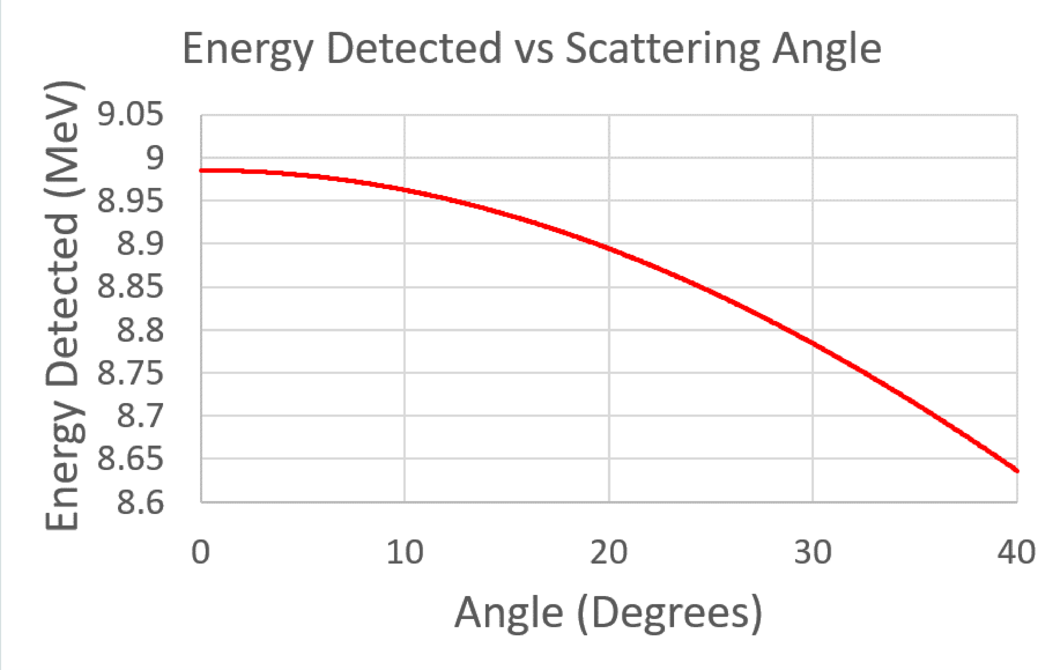


Figure 1: This is a graph of the energy at the entrance of the detector vs. the angle the particle scattered at. The shape of this graph depends on the target material/thickness and beam energy. This one is for carbon with a 0.44 µm thickness and a 9.00 MeV beam.

- Detector can not be placed directly in front of the beam because the intensity would be to high and this would overload the readout system.
- We needed a way to redirect the particles, which is why we are using low energy beams and a target (in this case carbon-12 [around 0.44 microns thick]).
- The incoming beam will elastically scatter off of the carbon nuclei, but now we need a way to determine the energy loss from the scattering.
- The energy loss of the particle will be different depending on the angle it scatters (see figure 4), so we used LISE++ to predict the energies of the particles at the entrance of the detectors.

Conclusion

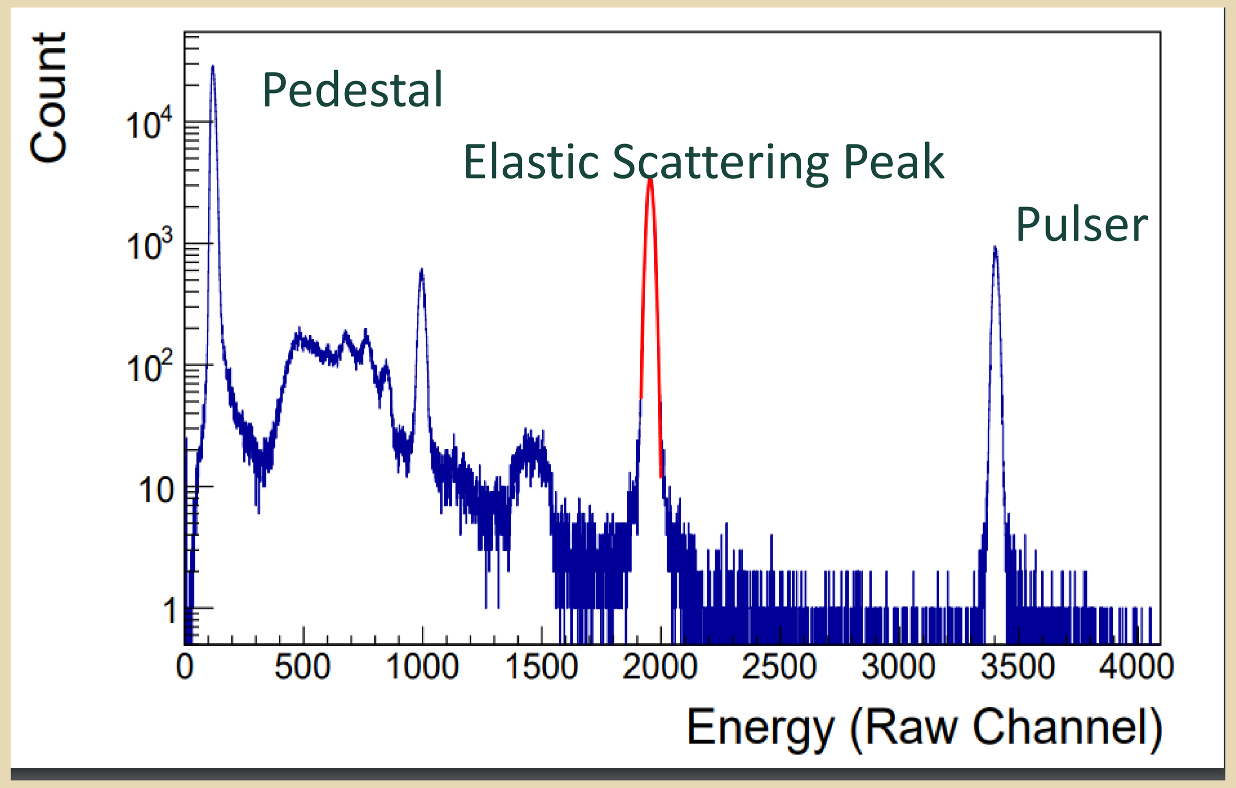


Figure 2: This is the raw data collected for a 9 MeV proton beam for one of the crystals in HiRA 4 with a Gaussian fit on the elastic scattering peak.

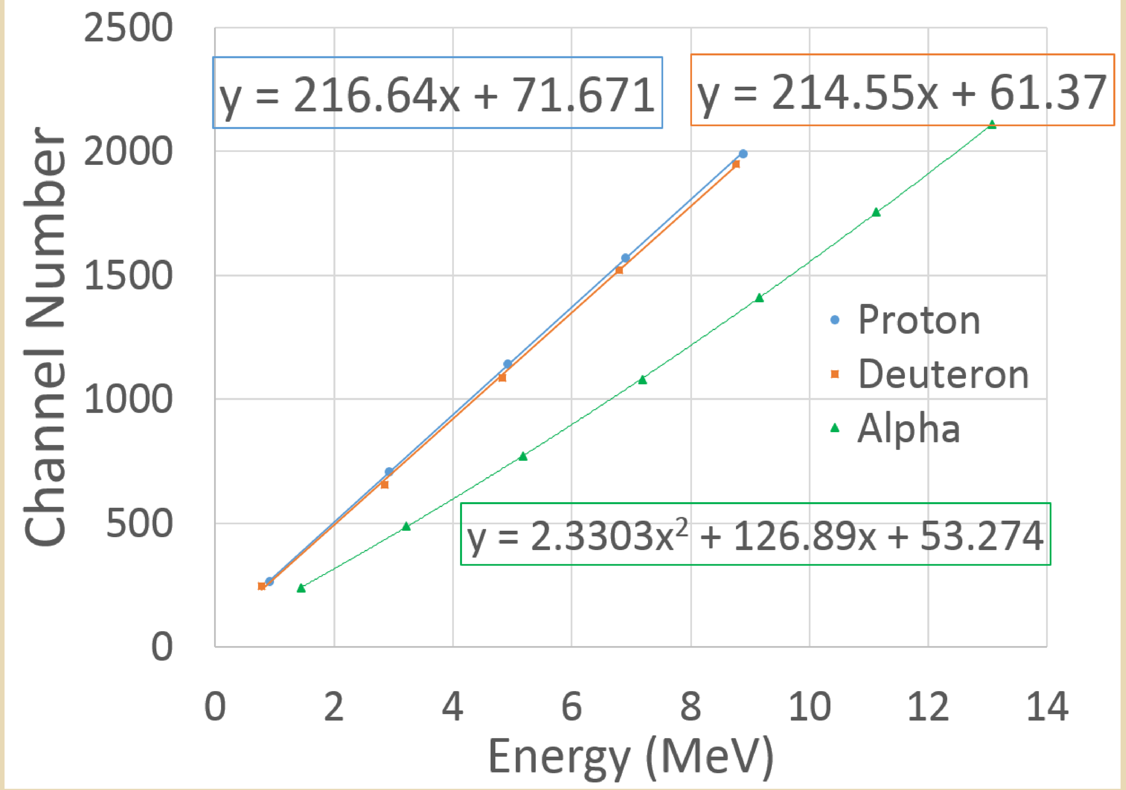


Figure 3: This is a graph (for the same crystal), of the channel number vs. the corresponding energy value for all 3 particles. The slope of the equations for proton and deuteron will give the Ch.#/1MeV, and since alpha has a non-linear relation the entire fitting function is used for calibration.

- The light response of the CsI(Tl) crystals appear to have a linear relationship and HiRA can now be used to effectively study nuclear physics experiments.

References

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2. LISE++ Nuclear Physics Program, O.B. Tarasov, D. Bazin, NIM B 266 (2008) 4657-4664

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NSCL

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