CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

Development of the Focal Plane Detection System for the Future Gas-Filled Separator

Presented by: Erin R. Bertelsen, Dickinson State University

Mentor: Dmitriy A. Mayorov*, Cyclotron Institute, Texas A&M University

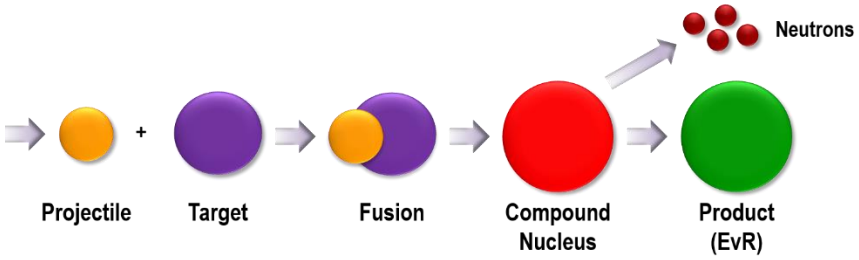
Advisor: Prof. Charles M. Folden III, Cyclotron Institute, Texas A&M University

August 7, 2015

Present address: Los Alamos National Laboratory

Introduction

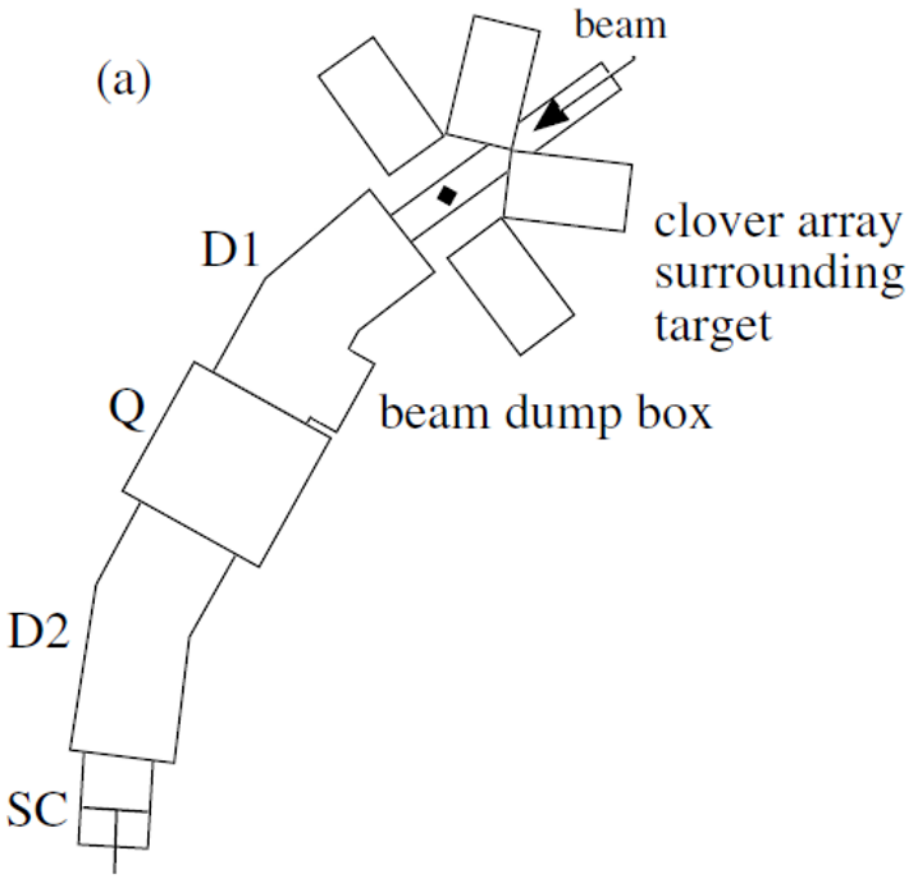
- MARS (Momentum Achromat Recoil Spectrometer) has been used for several years
  - Not designed for the purpose of the experiments within the group
- Want to study the chemical and physical properties of heavy elements (Z ≥ 90) produced by fusion-evaporation reactions



Example: $^{40}Ar + ^{165}Ho \rightarrow ^{205}At \rightarrow 4n + ^{201}At$

AGGIE – Al Ghiorso's Gas-Ion Experiment

- Separator formerly known as SASSYER at Yale University
- Future gas-filled separator at the Cyclotron Institute
- Higher efficiency



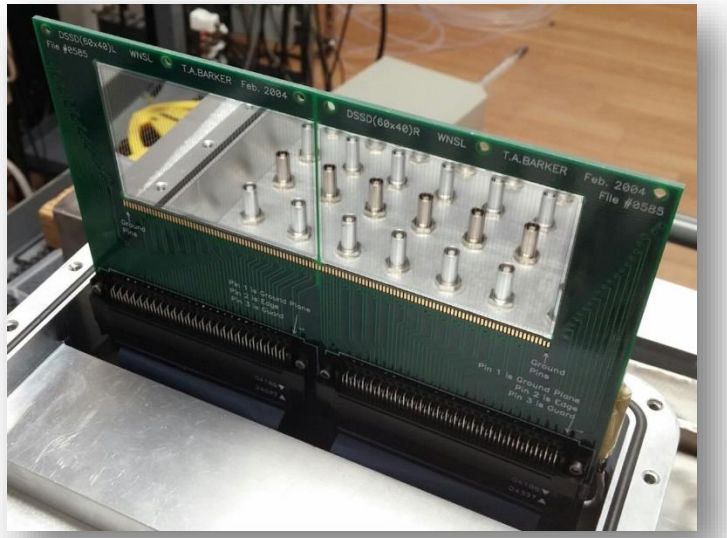
J. J. Ressler *et al.*, Nucl. Instrum. Meth. B **204**, 141 (2003).

A. Ghiorso, J. Radioan. Nucl. Ch. **124**, 407 (1988).

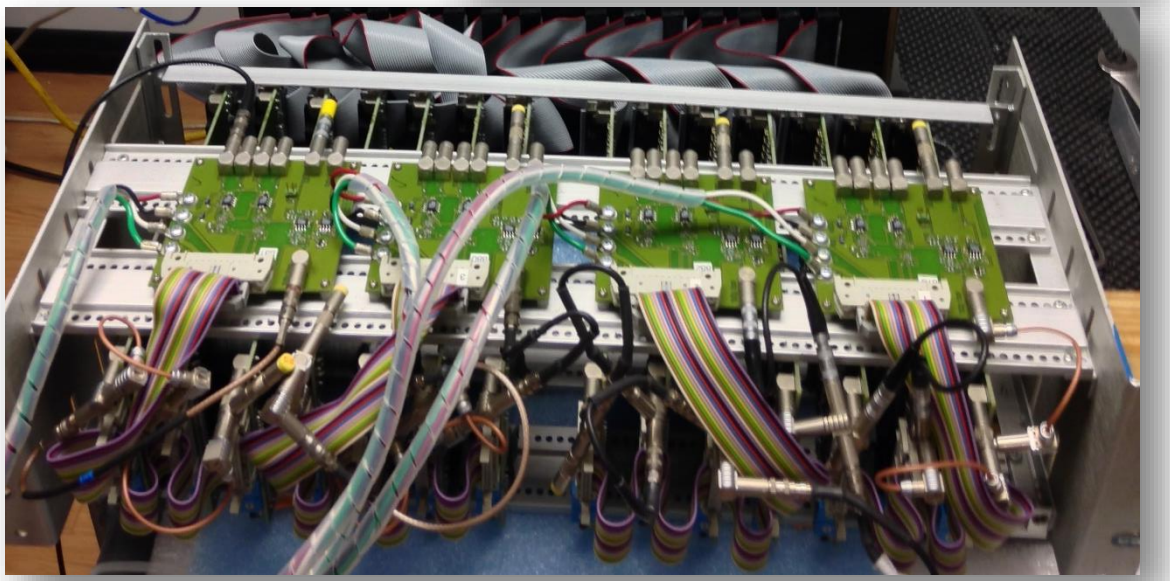
Goal

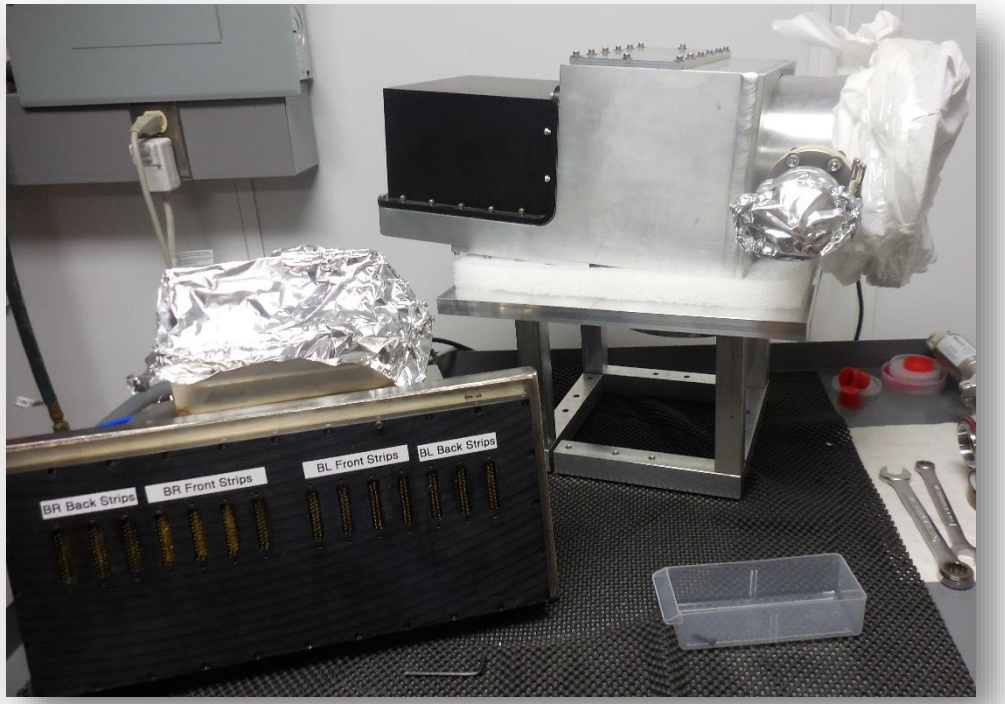
- Implementation of a multiplexed focal plane detection system
  - Assemble
  - Test and troubleshoot
  - Determine signal pathways
  - Interface with existing DAQ
  - Determine energy resolution parameters

Initial Status



- Attach transition boards
  - DSSDs
  - Vacuum chamber
  - Multiplexing bin





Focal Plane Si Detectors

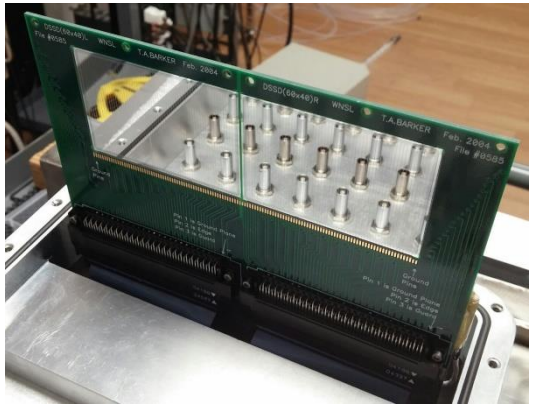
- Interested in the alpha decay of the products
  - Si detectors well-suited for this purpose
- Ionizing radiation produces electron-hole pairs
- Collected charge proportional to the deposited kinetic energy of the incident particle
- Ideal for charged particle detection
- Provide good energy resolution
- Position sensitive
  - Necessary to correlate detected events
  - Search for implantation signal followed by a decay signal

Focal Plane Si Detectors

Previous Detector – PSSD (Position-Sensitive Silicon Detector)

- 16 vertical strips, each 3 mm wide
- 50 mm x 50 mm active area
- Horizontal position determined by strip number
- Vertical position determined by resistive charge division

New Detectors – DSSDs (Double-Sided Silicon Strip Detectors)



- 100 strips per detector, each 1 mm wide
  - 60 front vertical strips
  - 40 back horizontal strips
  - Crossing of strips produce 4800 pixels
  - Position resolution 6x better than before
- Larger detection area
  - 120 mm x 40 mm
- No position calibration
- Gives two signals for each hit

Signal Read-Out Electronics

- Fourteen 16-channel multiplexers (MUX-16) used
- Perform numerous functions for all 16 input channels
  - Preamplifier
  - Shaper
  - Leading-edge discriminator
- Controlled by four “MUX drivers”
  - Serve as a signal bus
- Multiplexed system is beneficial
  - Fewer modules needed for the 200 total channels

Signal Read-Out Electronics

threshold

gain/polarity

ID

MUX-bus

reject-signal

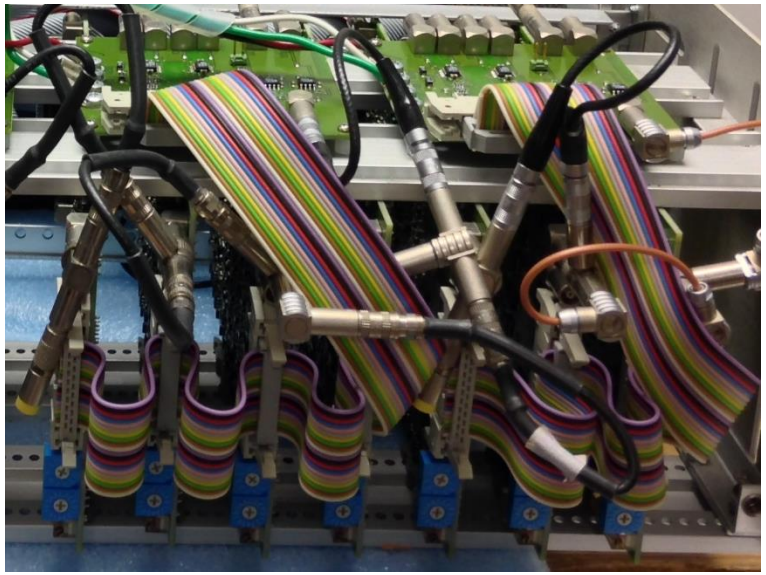
trigger-bus

detector bias

16 detector signals in

pulser in

Signal Read-Out Electronics

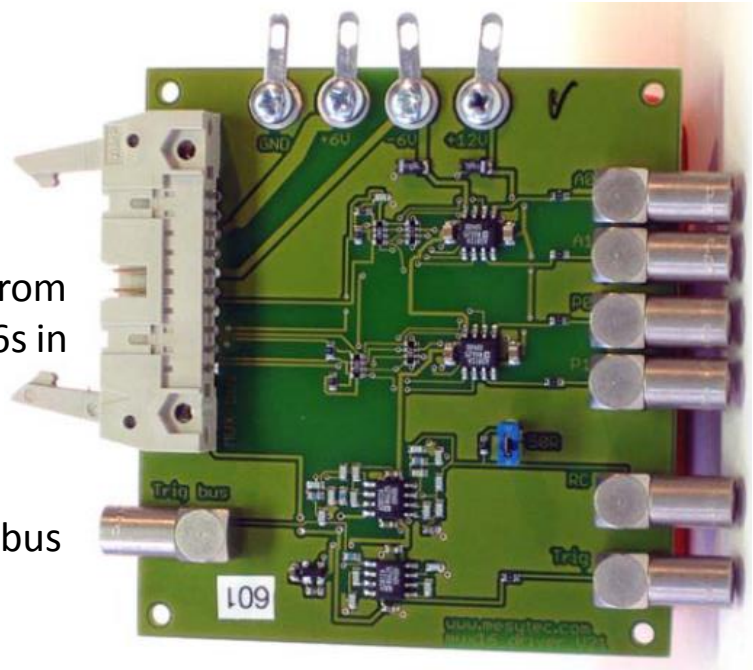


Chained MUX boards connected to MUX driver

Power supply

Signals from MUX-16s in

Trigger-bus



Primary amplitude

Secondary amplitude

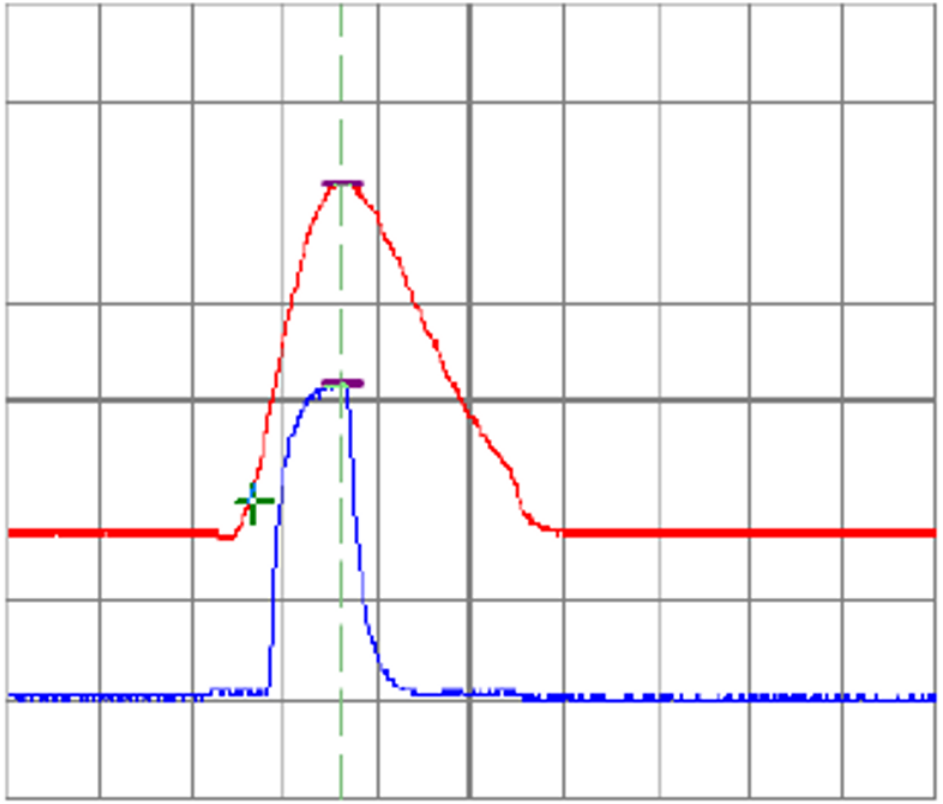
Primary position

Secondary position

Remote control

Trigger output

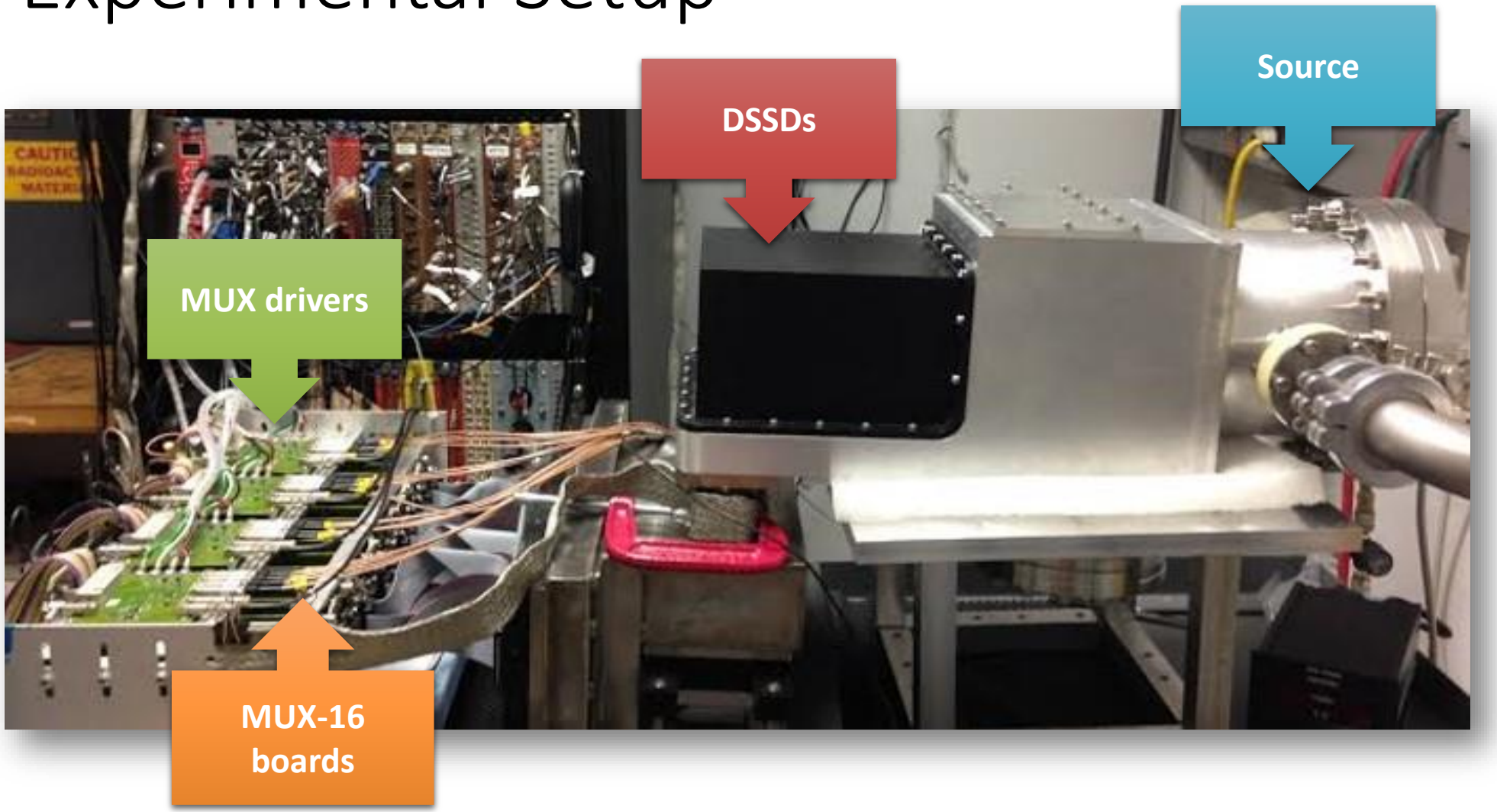
Signal Read-Out Electronics



Output signals (Y=1 V, X=500 ns). Shaper (energy) output signal is shown in red. Position output signal is shown in blue. Graph obtained from Mesytec MUX-16 manual.

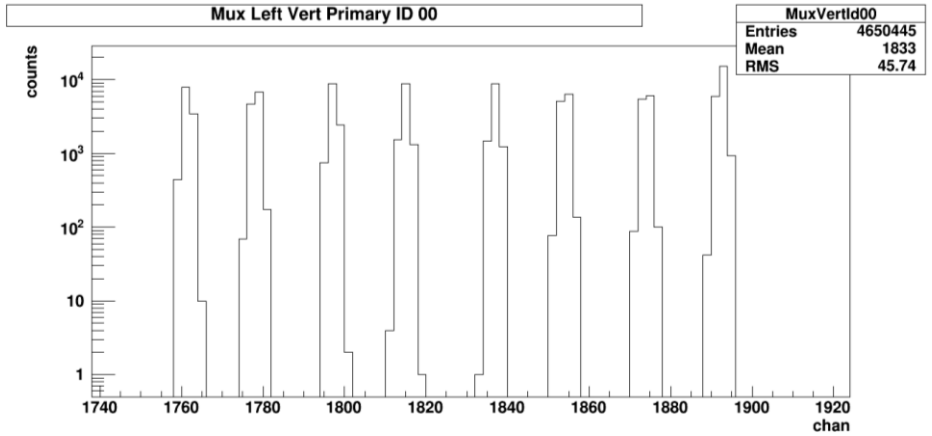
Output signals using a pulser (Y=500 mV, X=400 ns). Shaper output signal is shown in yellow. Position output signal is shown in purple. The signal gate, initiated by the trigger on the MUX driver, is shown in green. *Photo courtesy of D. A. Mayorov.*

Experimental Setup

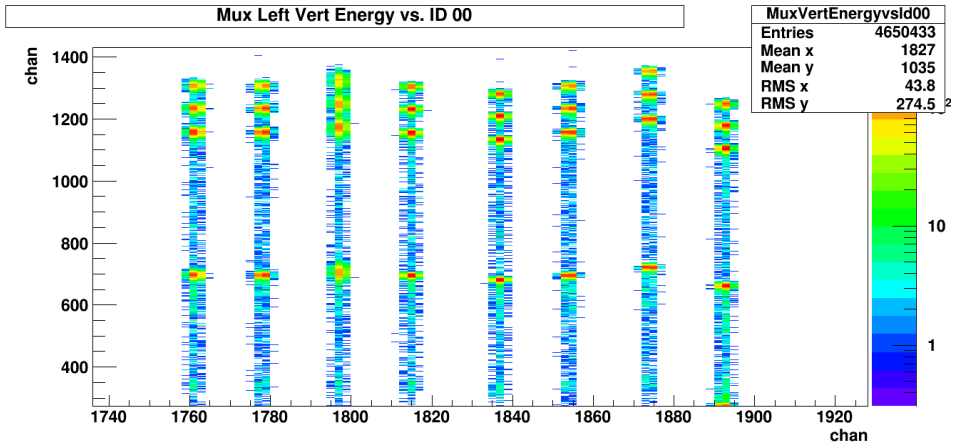


CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

DSSD Performance

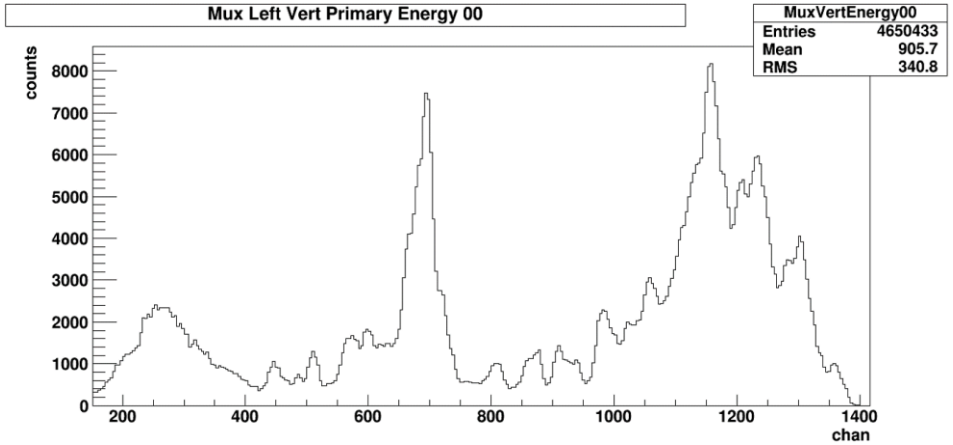


Primary position (identification) spectrum of vertical strips 28-35 on the front left detector. The range correlates to the strip number.

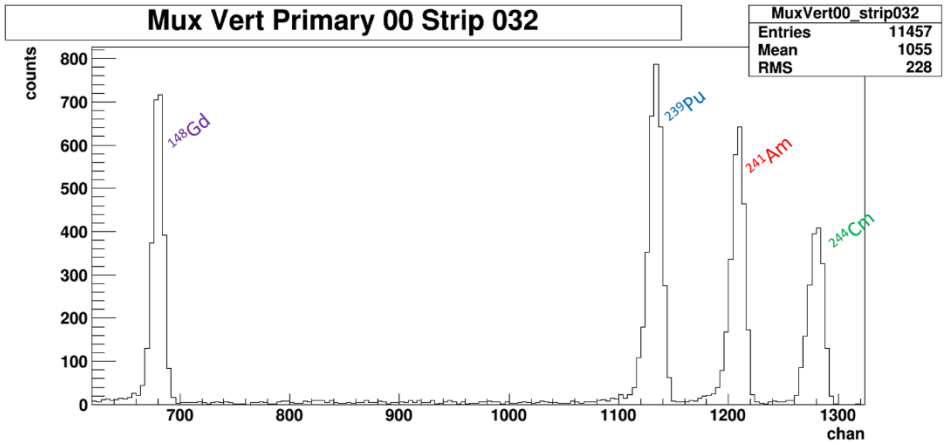


Energy vs. Channel ID. Alpha energies present can be seen on the individual vertical strips 28-35 on the front of the left detector. The isotopes present, in order of increasing energy, are ^{148}Gd, ^{239}Pu, ^{241}Am, and ^{244}Cm.

DSSD Performance

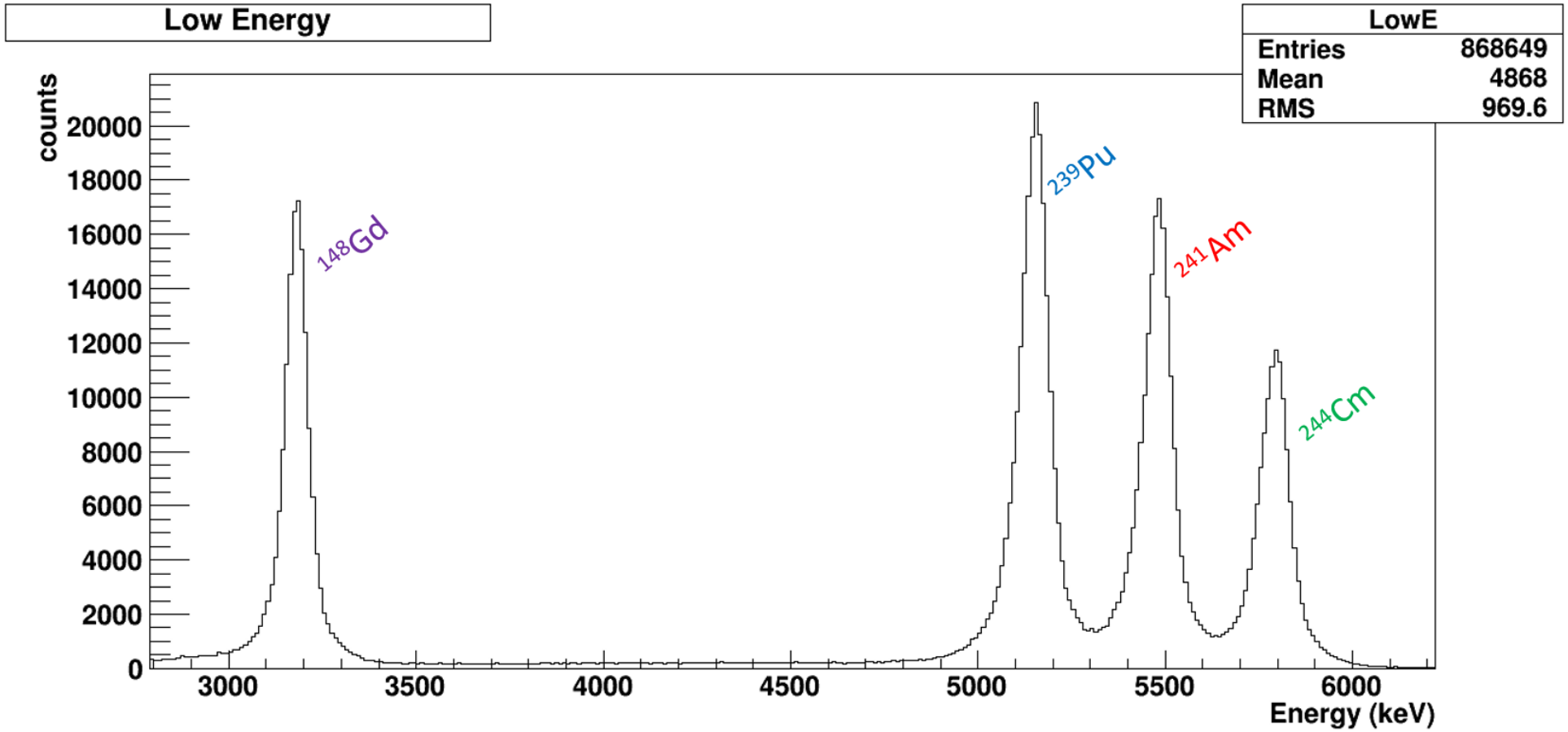


Combined energy spectrum. This shows overlapping energies from all 60 strips of the front side on the left detector. Gain mismatch is likely responsible for the broad distribution of detected events.



Energy spectrum of a single strip. The four alpha peaks can be seen for vertical strip 32 on the front of the left detector after extraction from the combined energy spectrum. The FWHM are: ^{148}Gd 51.14 keV, ^{239}Pu 59.96 keV, ^{241}Am 59.61 keV, and ^{244}Cm 64.26 keV.

DSSD Performance



Calibrated total energy spectrum. The energy spectra of the front vertical strips on both detectors can be seen as a whole. The FWHM are: ^{148}Gd 78.41 keV, ^{239}Pu 93.47 keV, ^{241}Am 97.38 keV, and ^{244}Cm 91.24 keV.

Challenges

- Increased complexity
- Some strips are not producing signals
- Poor energy resolution
- Noise reduction
- Determine if position ranges drift

Future Work

- Addition of a chiller
  - Cool DSSDs to improve energy resolution
- Determine which strips are dead
- Install AGGIE

Conclusions

- Detection system is fundamentally working
- Better position sensitivity
  - Vertical and horizontal positions known without calibration
- Larger detection area

CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Award Number DE-FG02-12ER41869/DE-SC0008126. Additionally, this work was supported by the National Science Foundation Graduate Research Fellowship under Grant Number PHY-1263281.

A special thank you to Dmitriy A. Mayorov and Professor Charles M. Folden III for their patience, guidance, and expertise during this summer research experience.