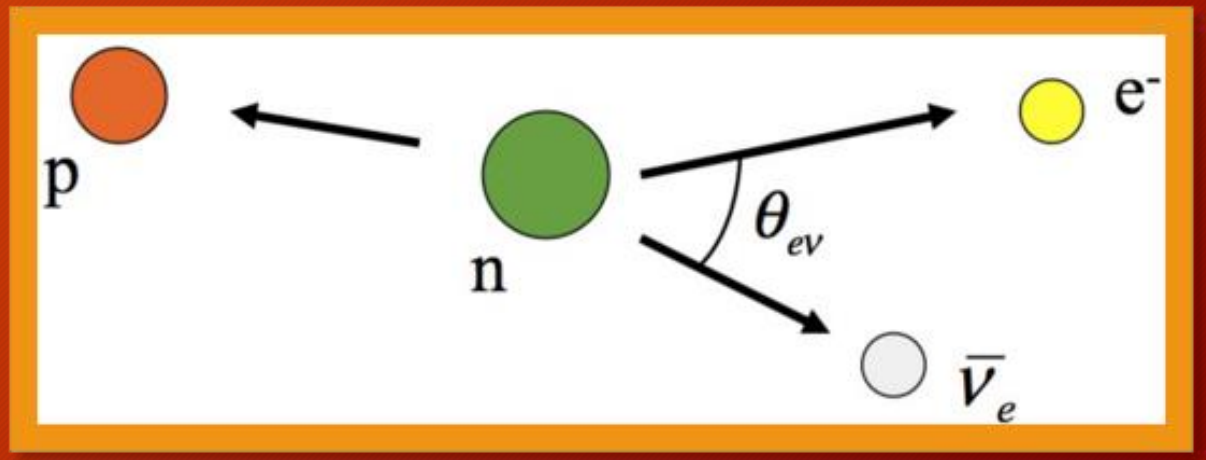
Characterization of Segmented Semiconductor Detectors for Neutron Beta Decay

By: August Mendelsohn for the Nab Collaboration

Overview

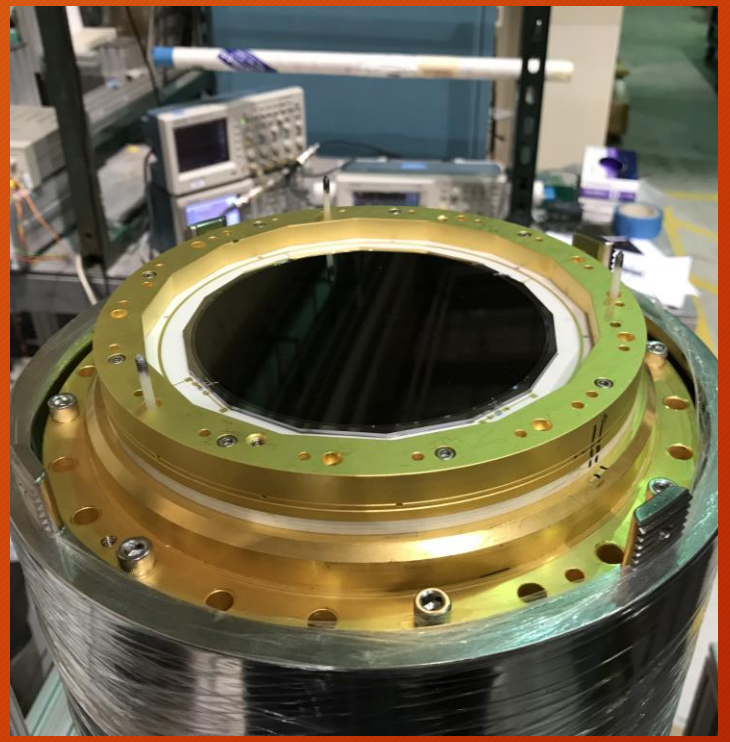
- The Nab Experiment
- Unique setup at Manitoba
- Calibration/Optimization
- Summary/Future Work

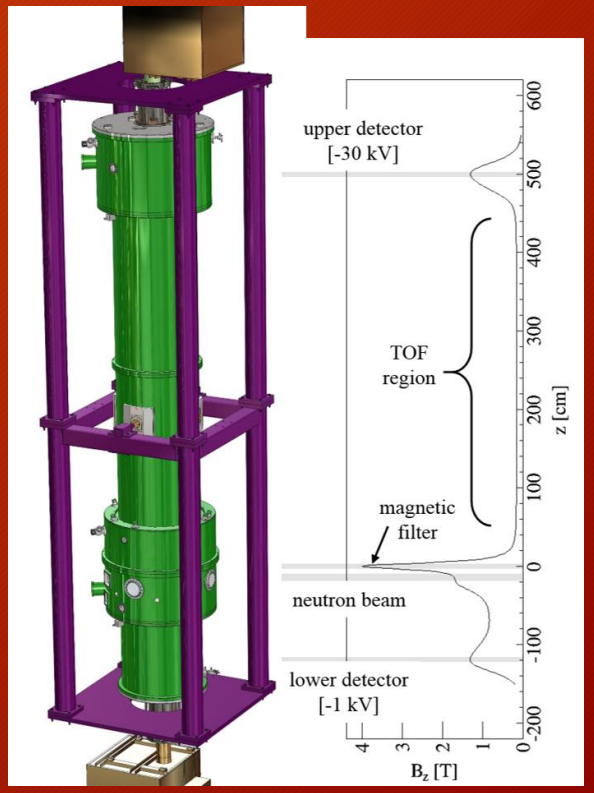


The Nab Experiment and Motivation

- Neutron-a-b
  - Beta decay to probe CKM unitarity
  - 26' ToF spectrometer
  - Segmented silicon diode detectors to collect decay products
- Motivation
  - Calibration of detection electronics

Credit: Dr. Leah Broussard

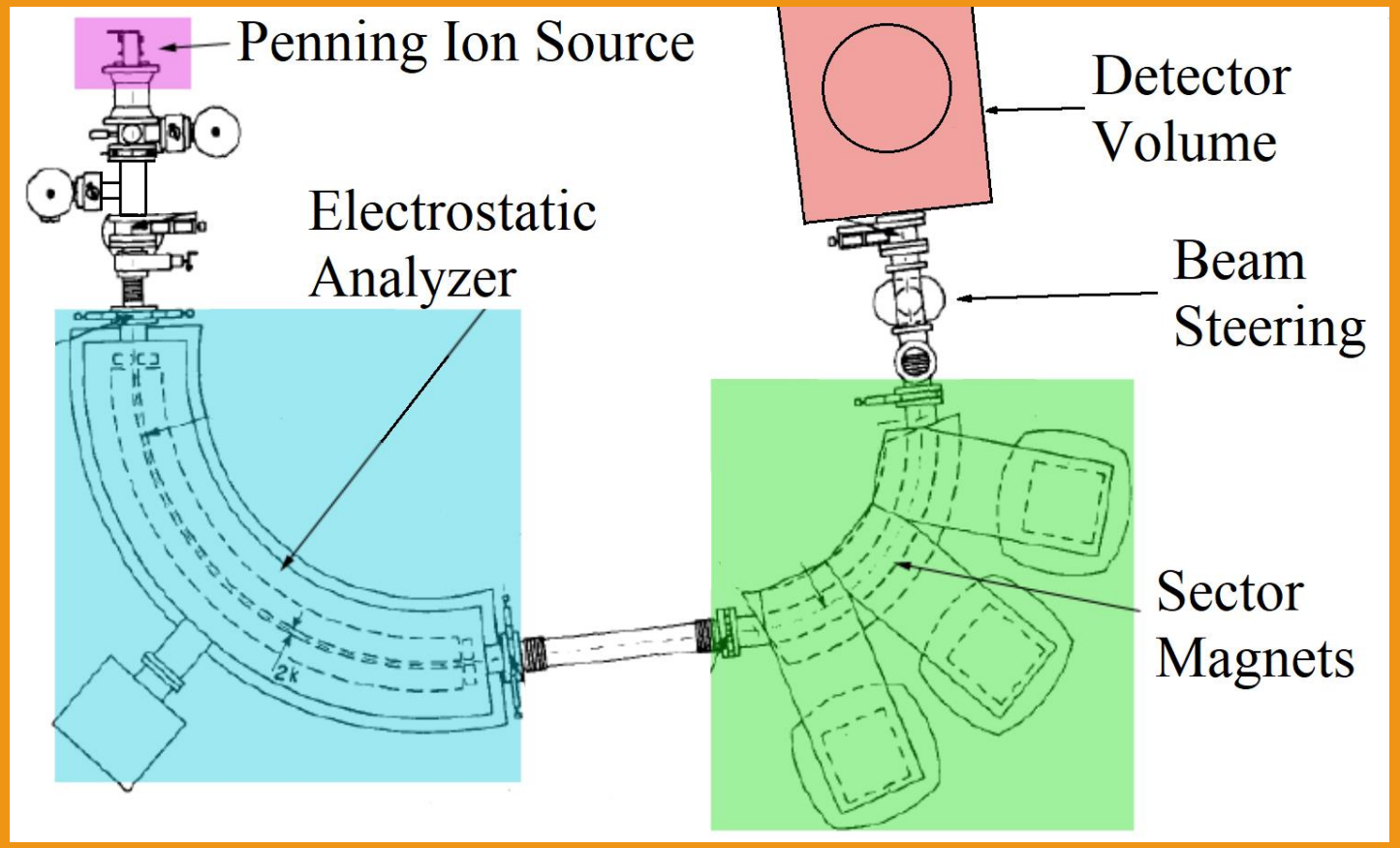


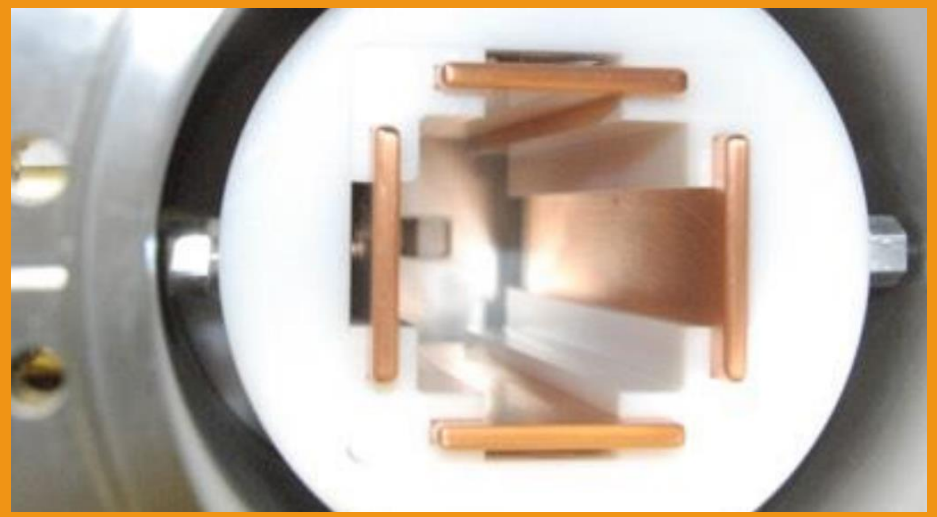


Courtesy of the Nab Collaboration

The Manitoba II Proton Source

D. Harrison M.Sc Thesis (2013) modified





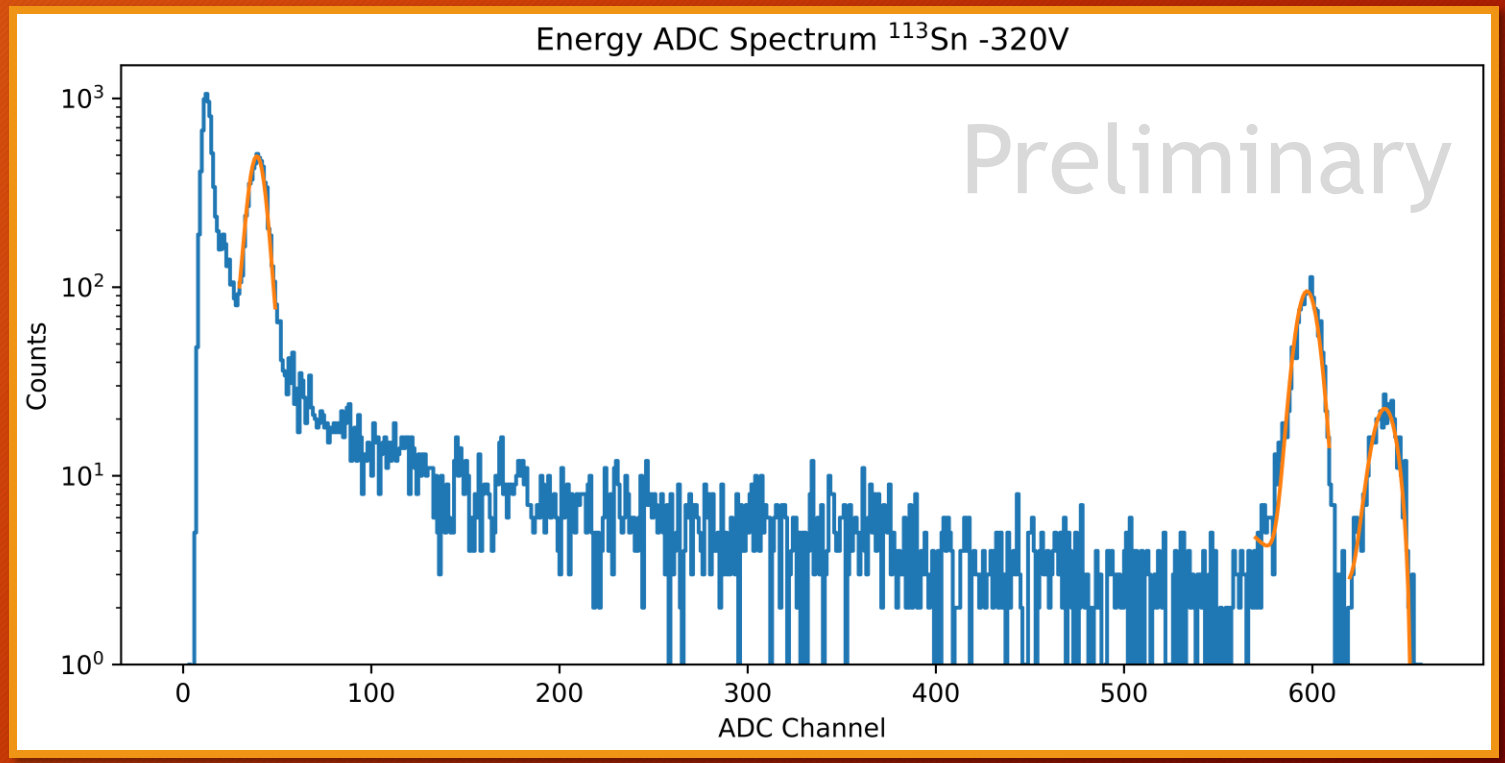
Courtesy of R. Mammei

Energy Calibration

- Used 113Sn and 109Cd to calibrate for 30 KeV protons and up to 1Mev electrons

Energy Calibration

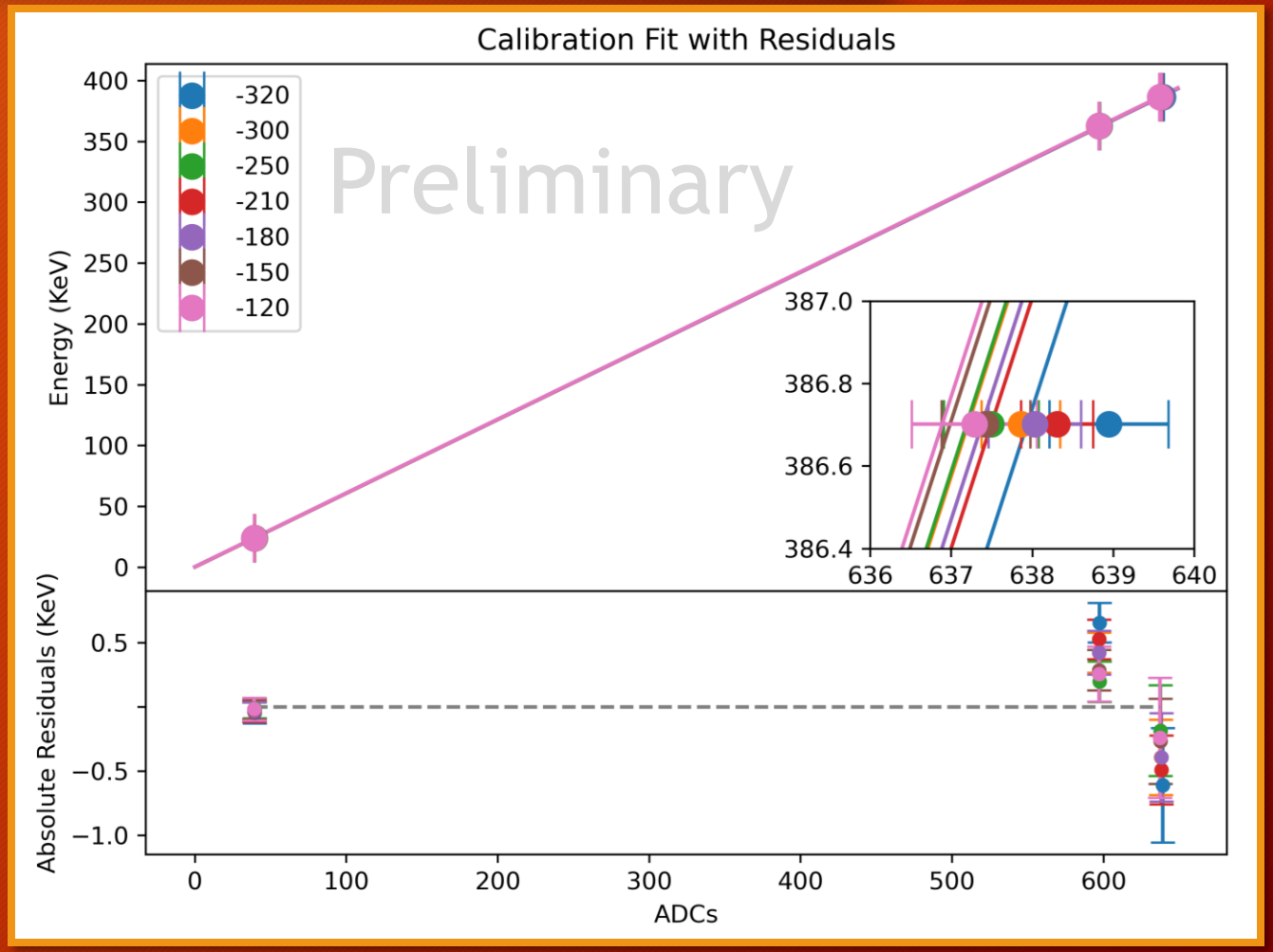
- Convert between ADC (arb) units to KeV
- Using known X-ray and Conversion electron peaks
- Corroborate using NIST e-star data to account for losses through mylar foil



Energy Calibration vs. Detector Bias

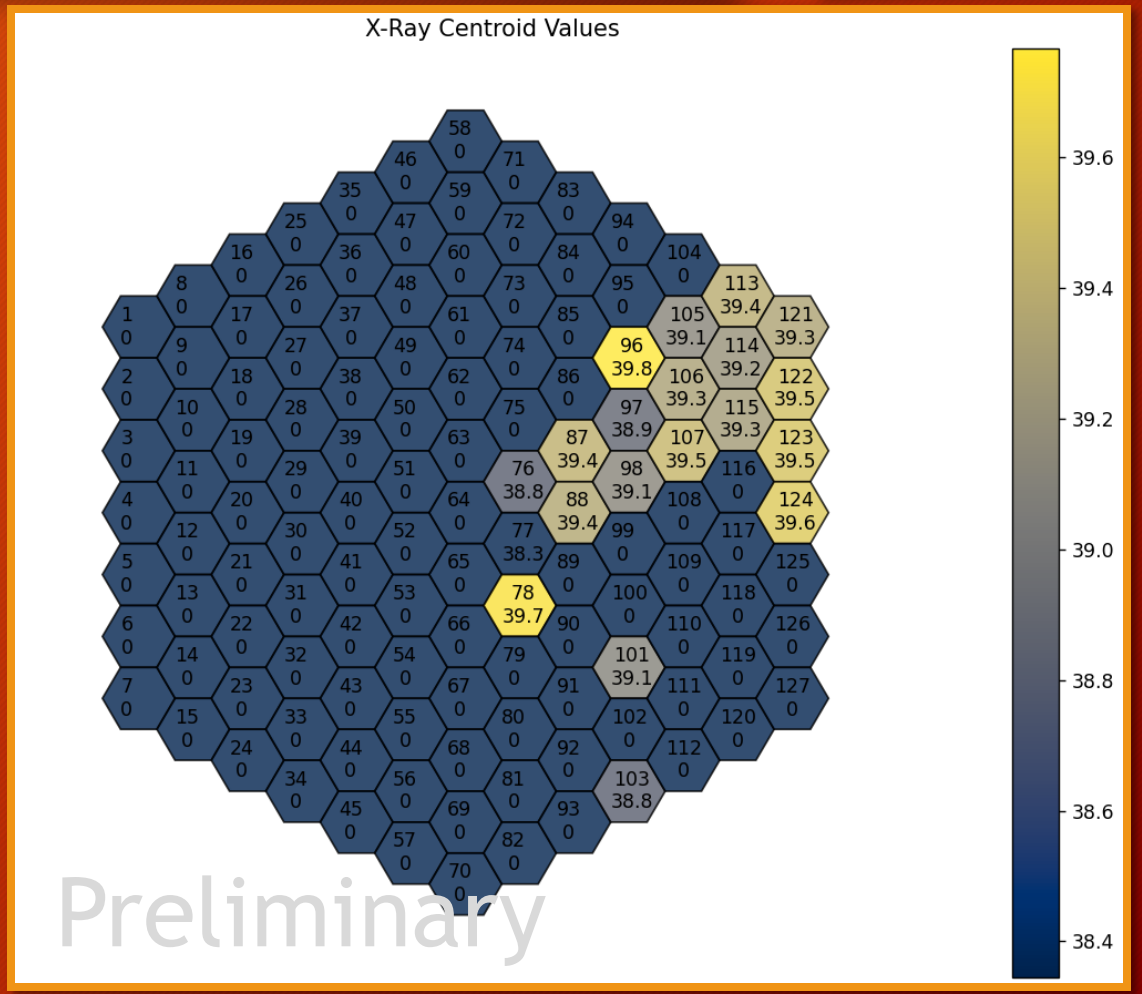
- Remarkably consistent over a range of 200V
- Y-intercept decreases with bias magnitude, slopes remain similar
- Further study needed

Approx 0.6KeV/ADC + 0.4KeV



Peak Centroid vs. Detector Pixel

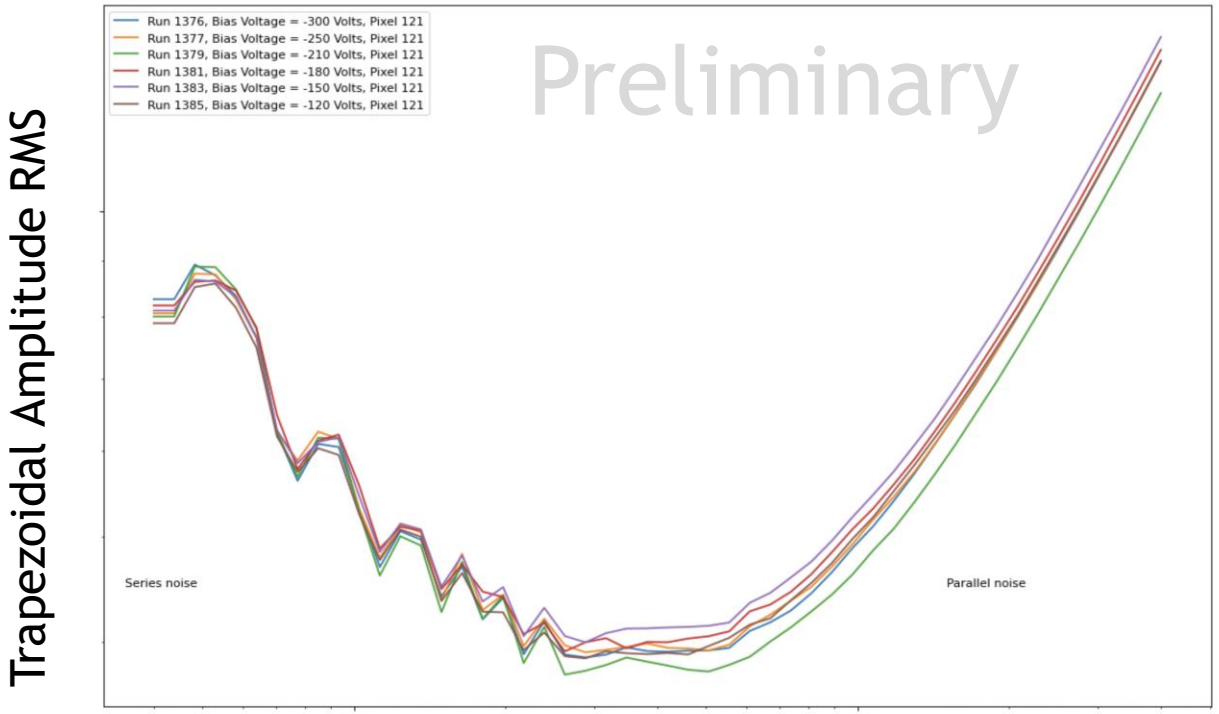
- Only powered a subset of pixels
- No significant relationship with detector symmetry
- May be due to individual gain stages for each pixel



ENC vs Filter Rise Time

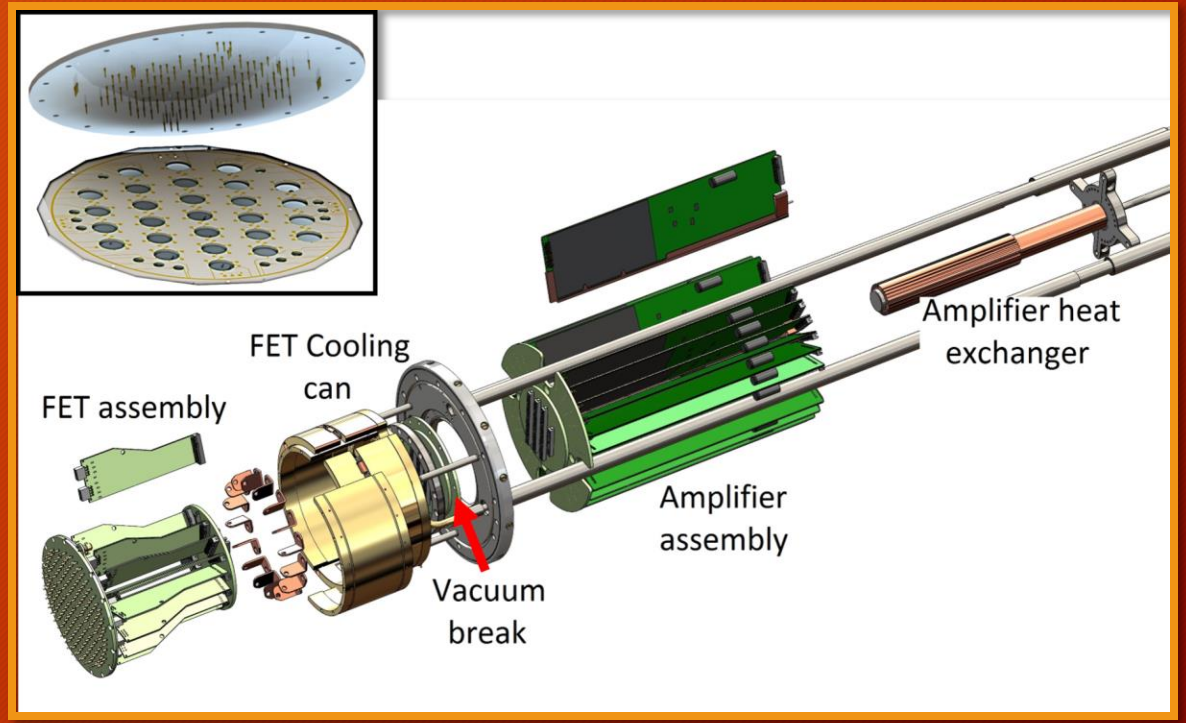
- Proportional to the FWHM
- Used a Pulser to characterize
- DAQ uses a double trapezoidal filter to convolve waveforms

Credit to Billy Mcray at NCSU for these results



Summary

- Characterization with known X-rays and conversion electrons
- Calibration is stable with detector bias
- Spatial dependance for a given bias voltage is limited

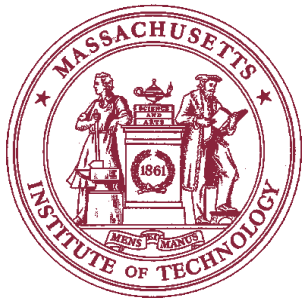


Courtesy of the Nab Collaboration

Concurrent and Future Work

- See Session PL: Neutron Physics II: Precision Neutron Decay on Sunday to see further talks on:
  - Detector simulations (Leendert Hayen)
  - A test stand for the detector systems (Michelle Gervais)
  - In-situ calibration (Jin Ha Choi)
  - And a few more!
- Currently continuing effort to calibrate detectors at ORNL via a custom test stand
- Ongoing analysis of the data collected at Manitoba

The Nab Collaboration



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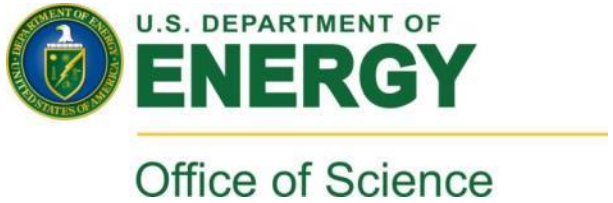
Main project funding:



Noise Contributions

- Want to reduce typical noise contributions
  - Thermal (Johnson) noise
    - Temperature and detector bias are coupled
    - Use of LN2 to achieve temperatures of 120°K
  - Shot noise – FET amplifier