Pulse Shape Discrimination Using a Regular Silicon Detector

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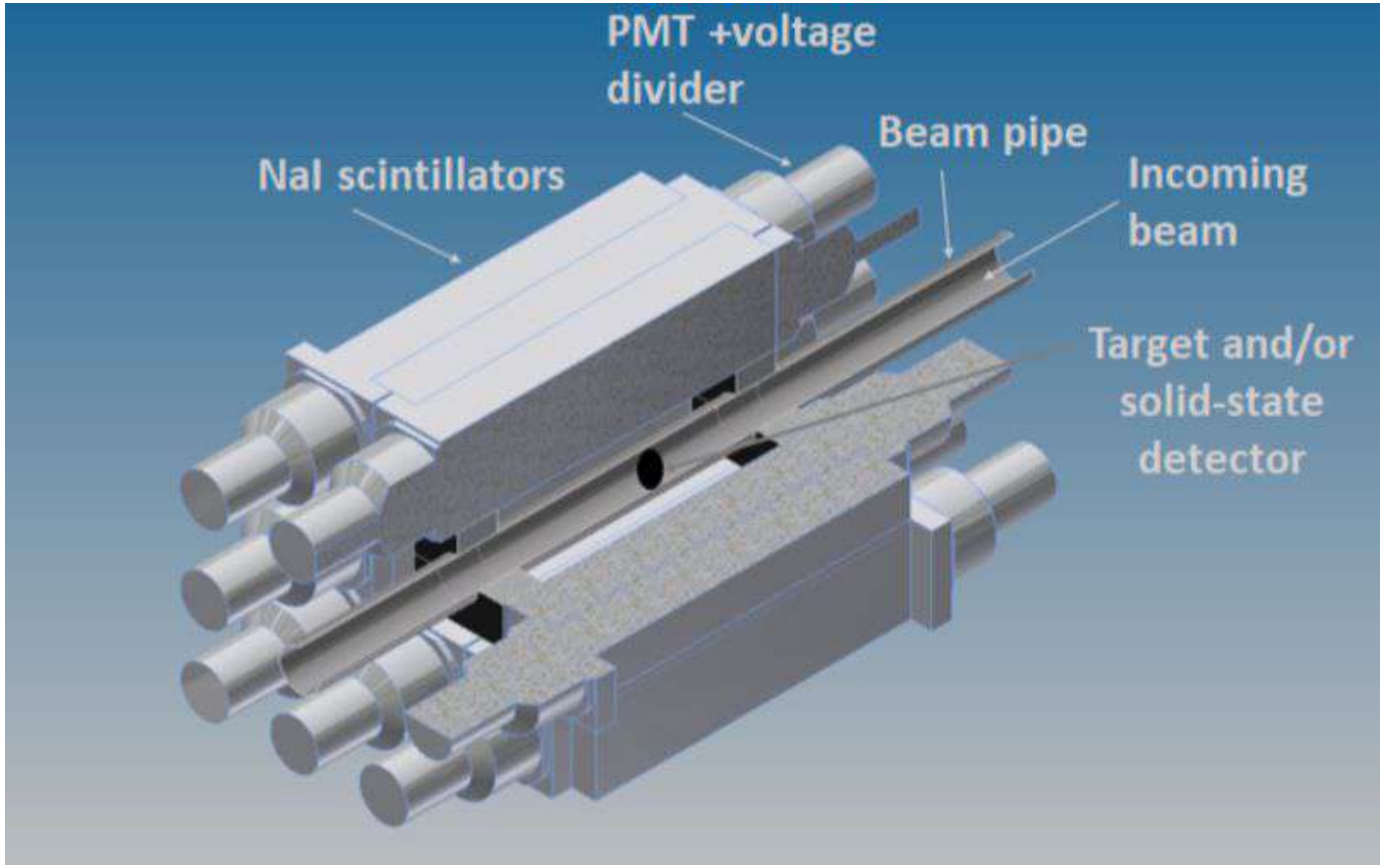
Motivation

- TexNAAM detector
  - Targeting (α,d) transfer reactions
- Looking for coincidences between γ and d

Particle ID will be needed to distinguish between produced deuterons and scattered protons



Particle Identification

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ΔE, E

- Uses a thin and thick detector
- Requires punchthrough
  - Need very thin detector at low energies
  - 100 µm silicon has deuteron punch-through of ~4.2 MeV

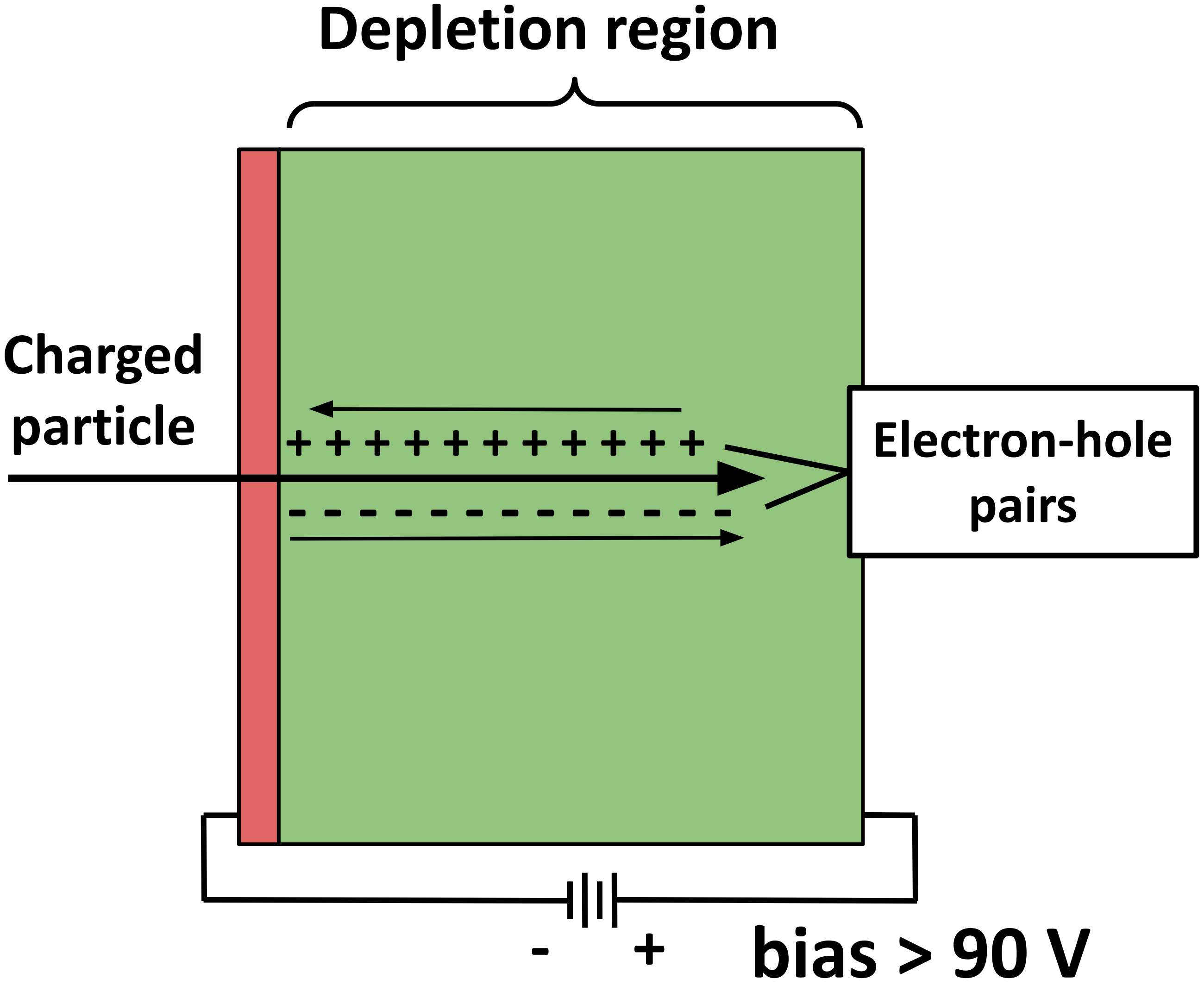
Pulse Shape Discrimination (PSD)

- Single detector
- Works best with Neutron Transmutation Doped (NTD) detectors
  - Expensive
  - Maximum thickness
- We can use ordinary silicon instead

We will demonstrate that PSD with an ordinary silicon detector can distinguish protons and deuterons down to 6 MeV

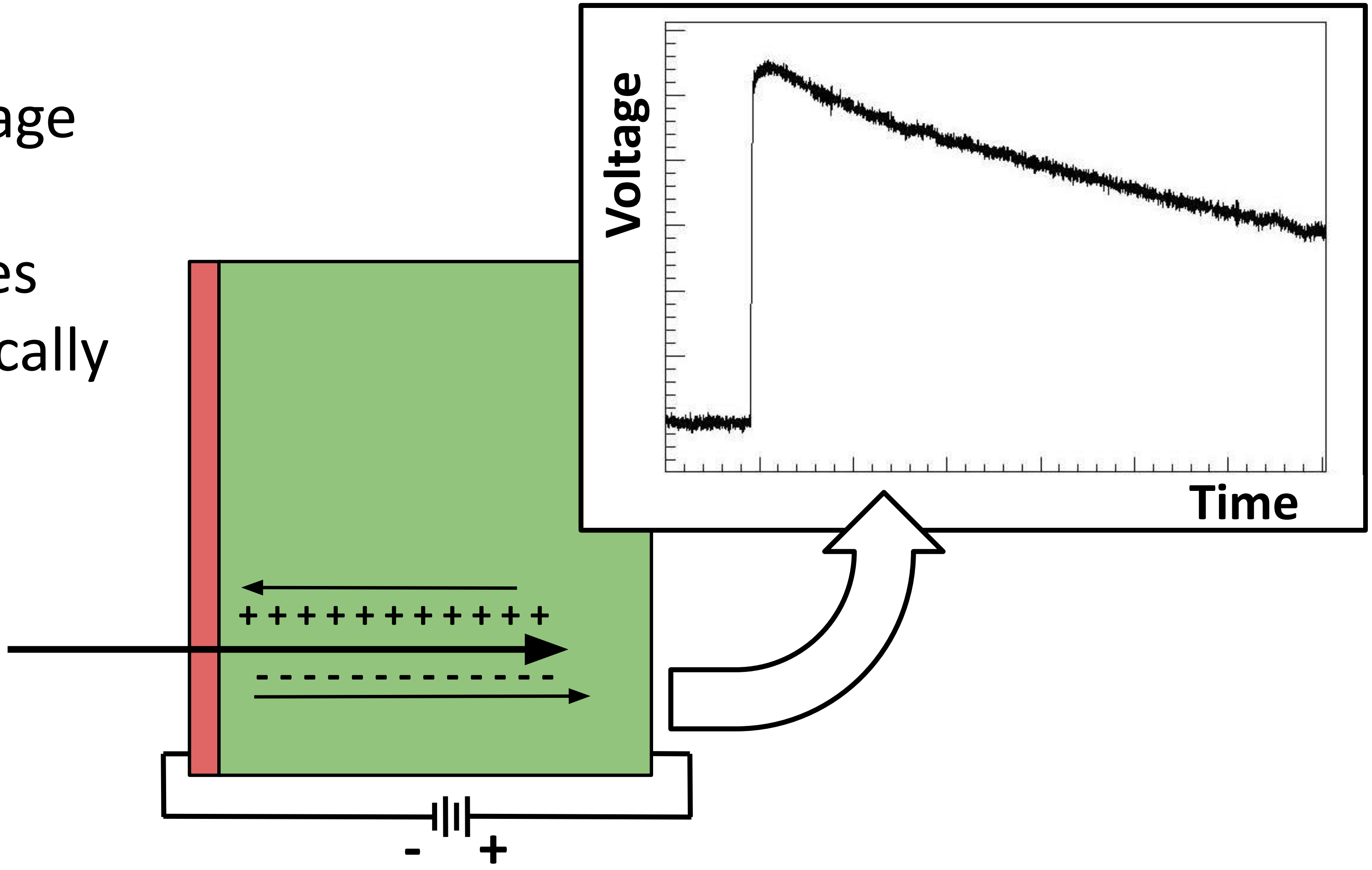
Silicon Detectors

- Charged particles produce electron-hole pairs in the silicon detector
- Applied voltage drifts electrons and holes in opposite directions



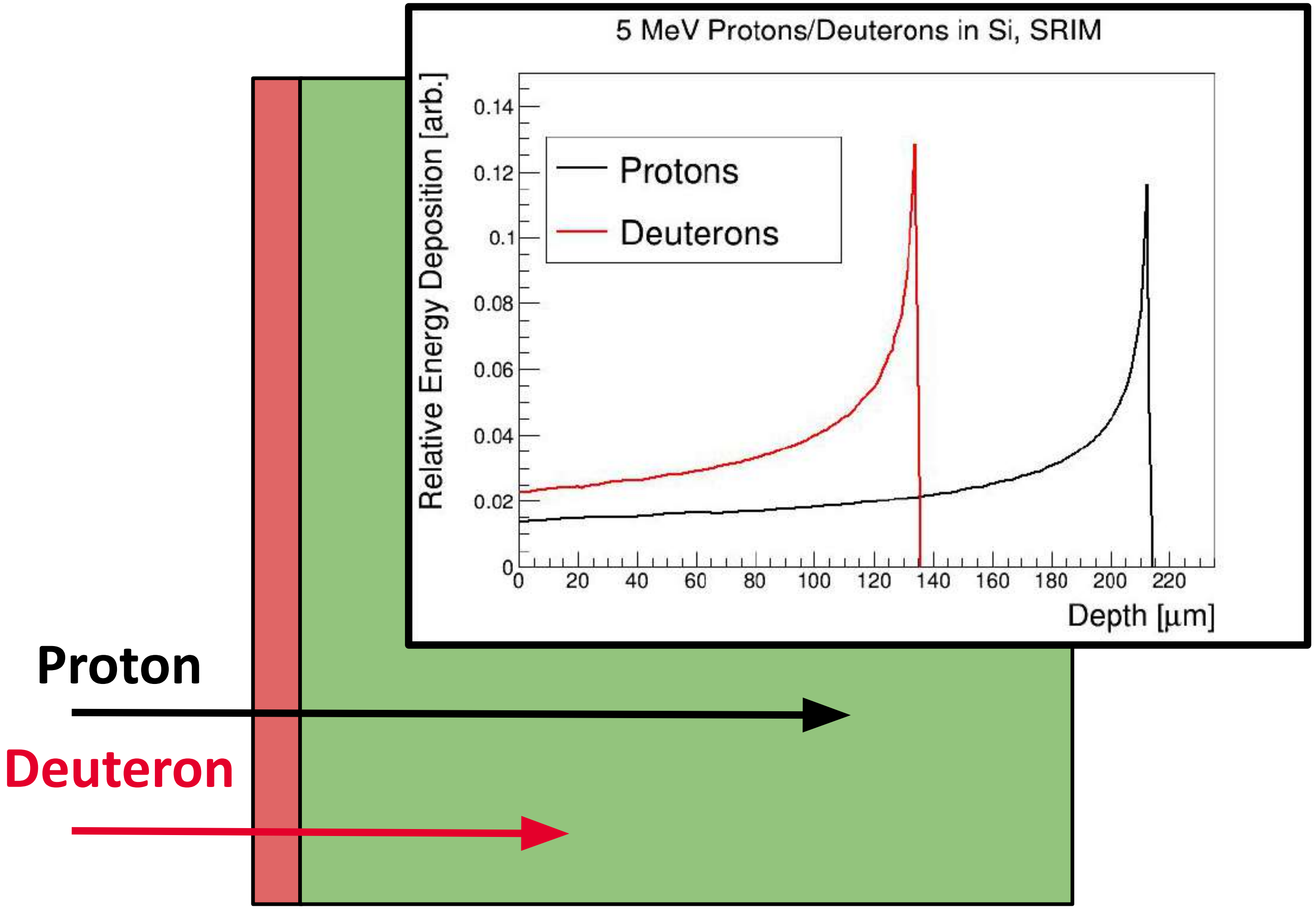
Silicon Detectors

- As charges collect, a voltage signal is produced
- PSD requires that particles enter on the rear (electrically negative) side
- Pulse height ⇨ energy
- Pulse shape ⇨ range



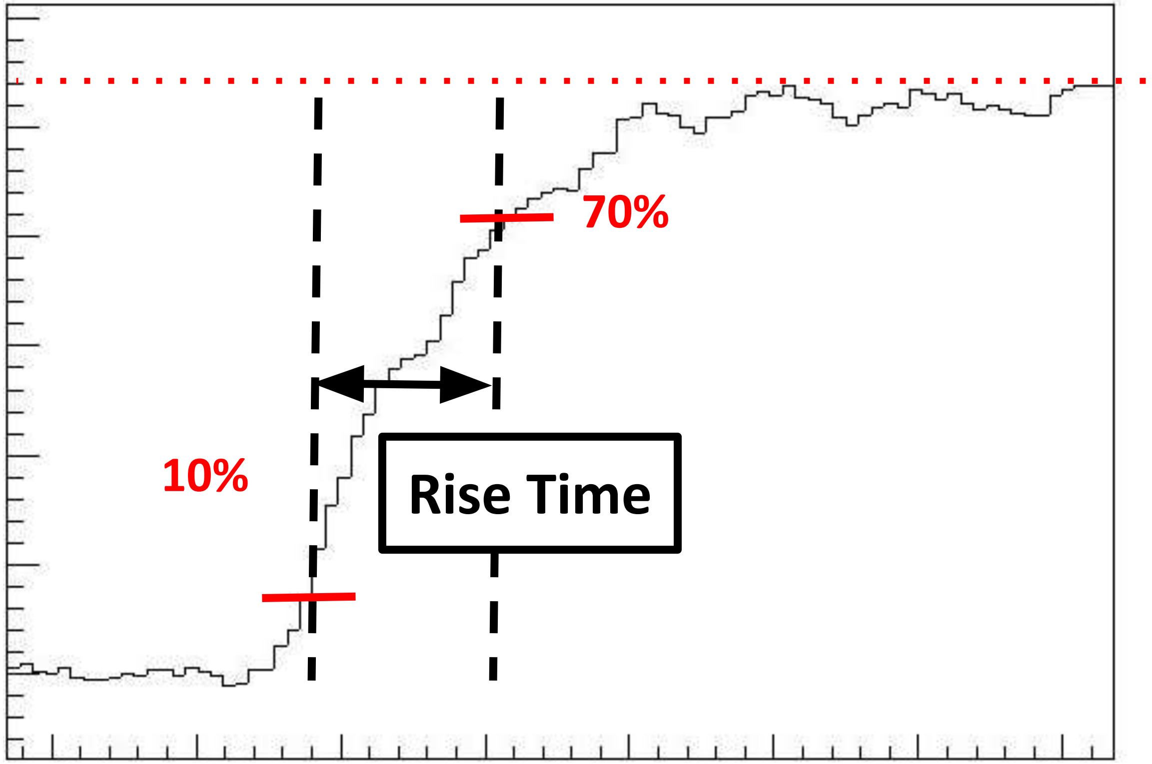
Silicon Detectors

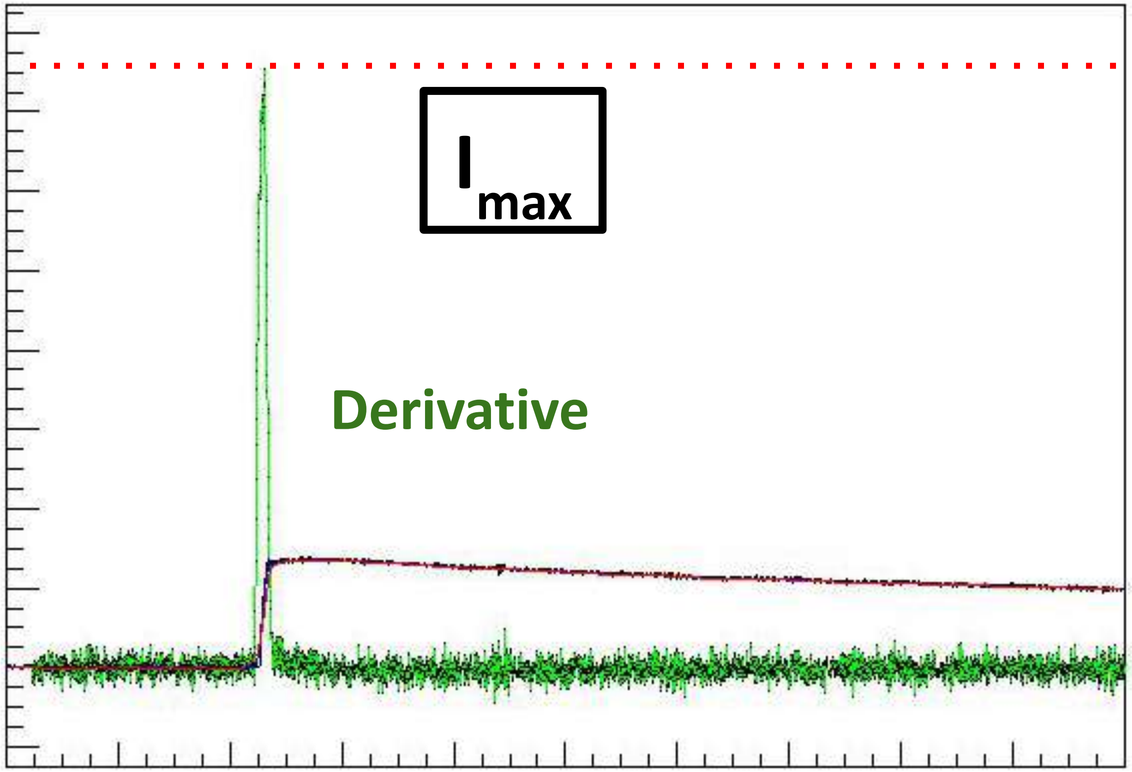
For a given energy, different particles have different ranges, resulting in distinct pulse shapes



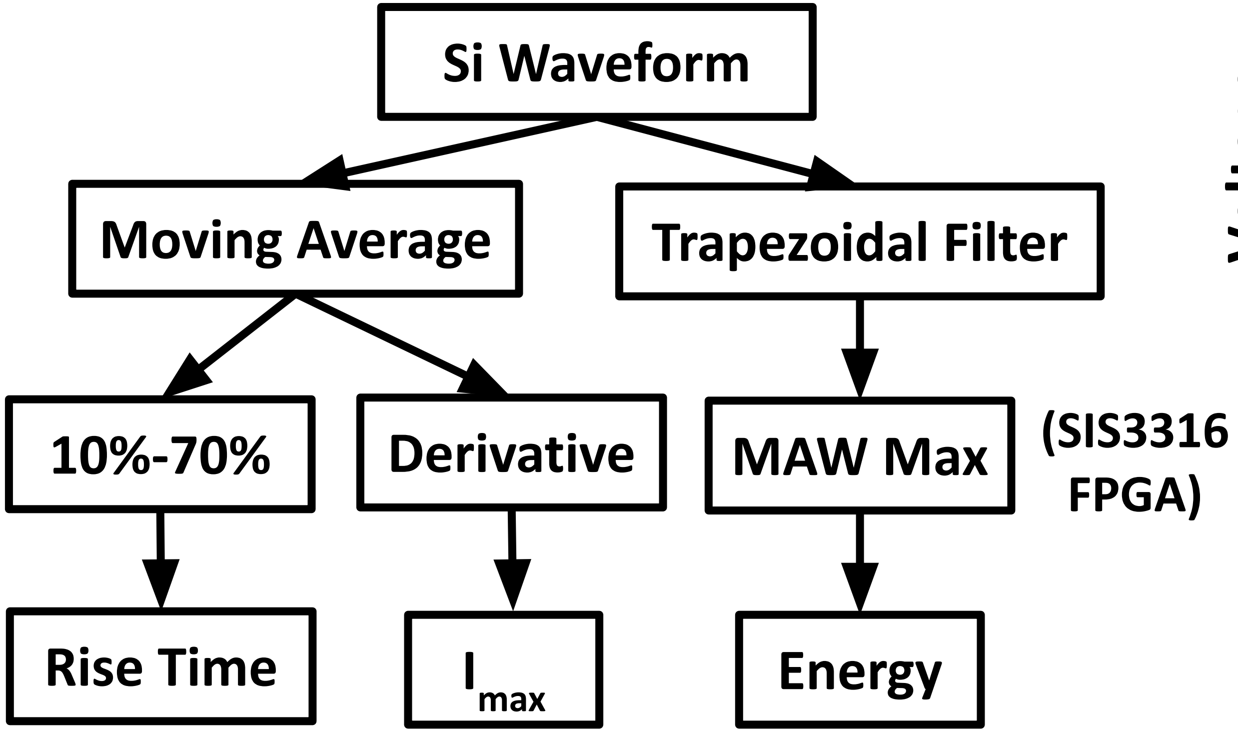
Rise Time and I_{max}

Both rise time and maximum current (I_{max}) correlate to particle range

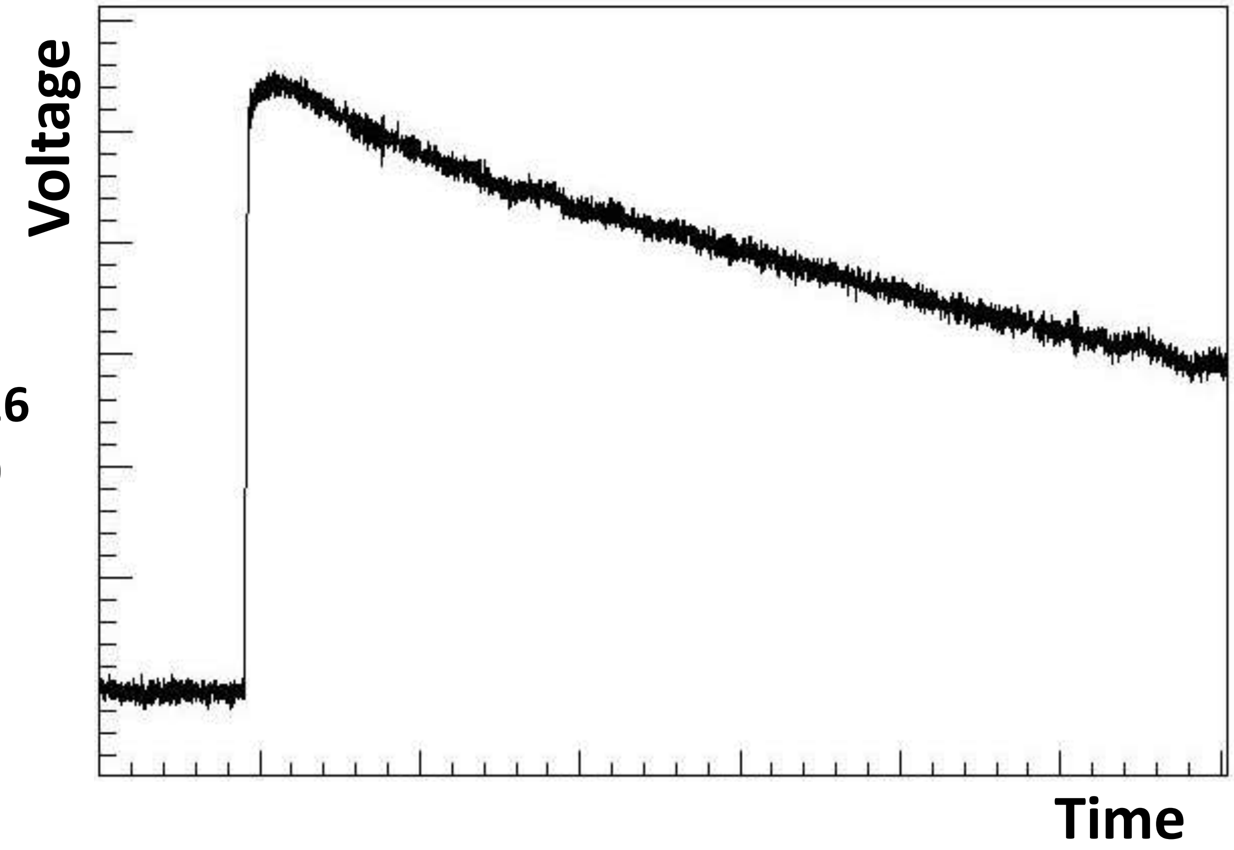




Voltage Signal Processing



Typical Si Waveform

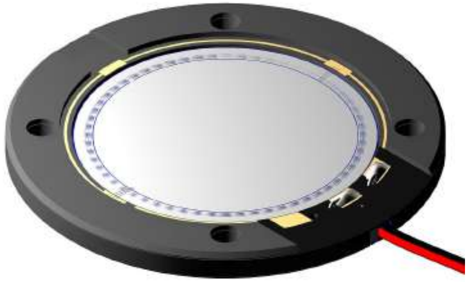


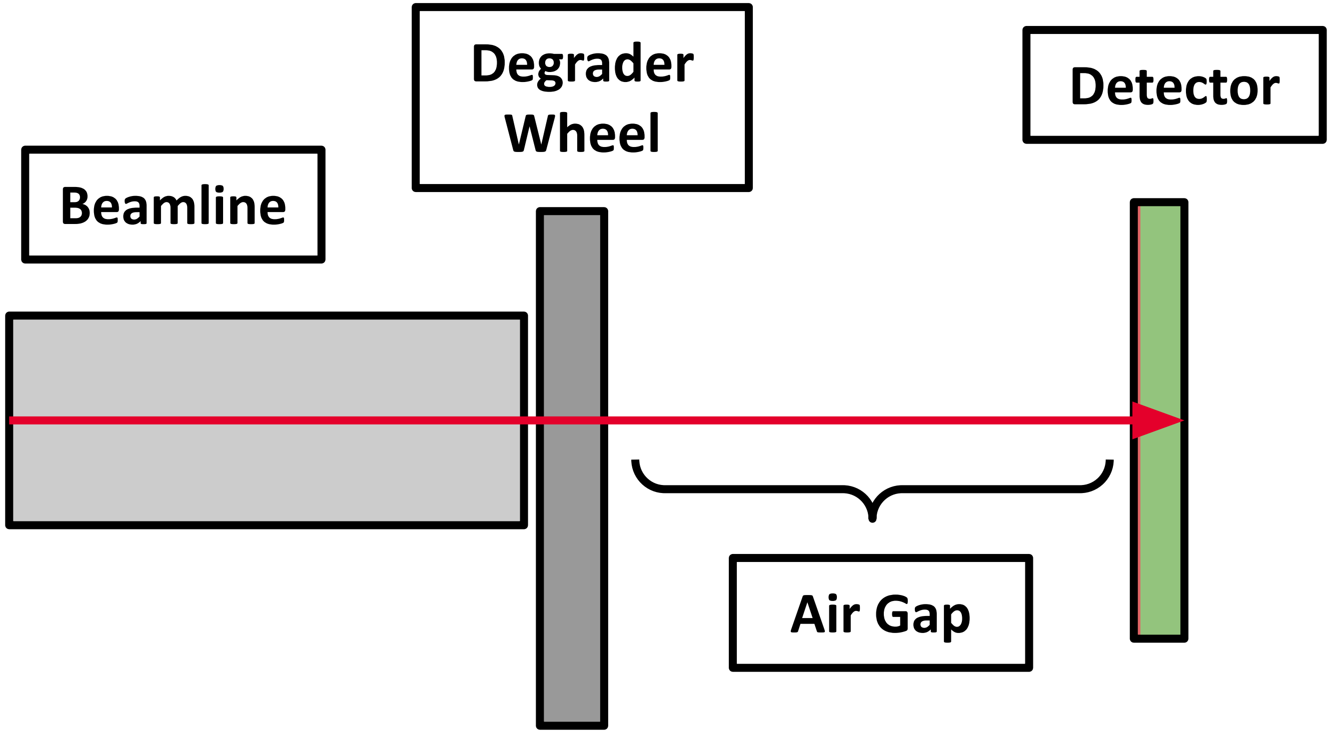
Experimental Setup

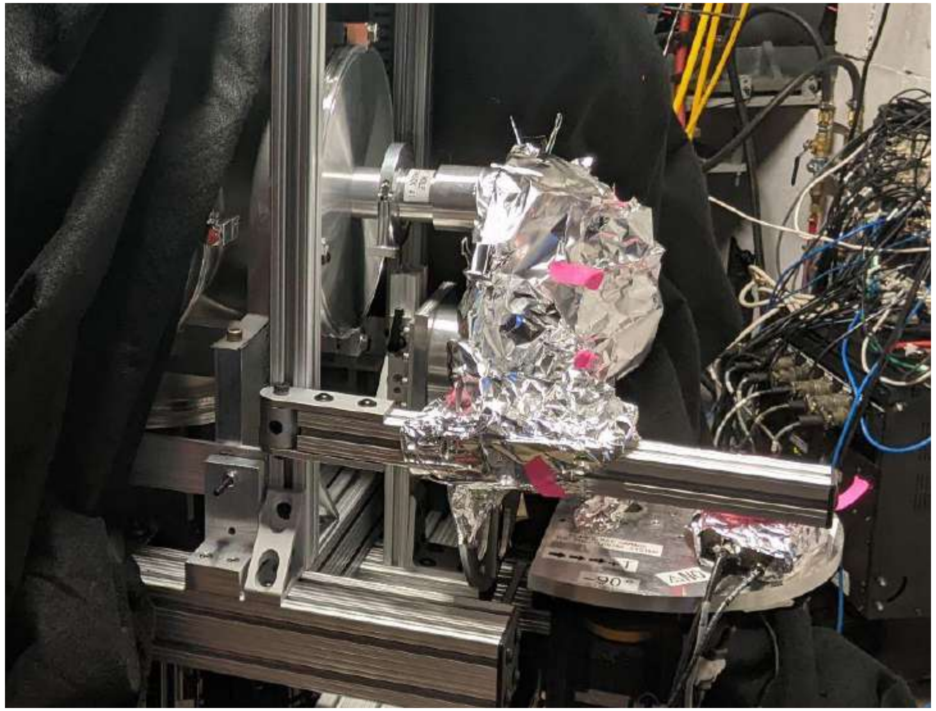
- K150
- In air
- 10 MeV protons and deuterons

Micron MSD026-1500

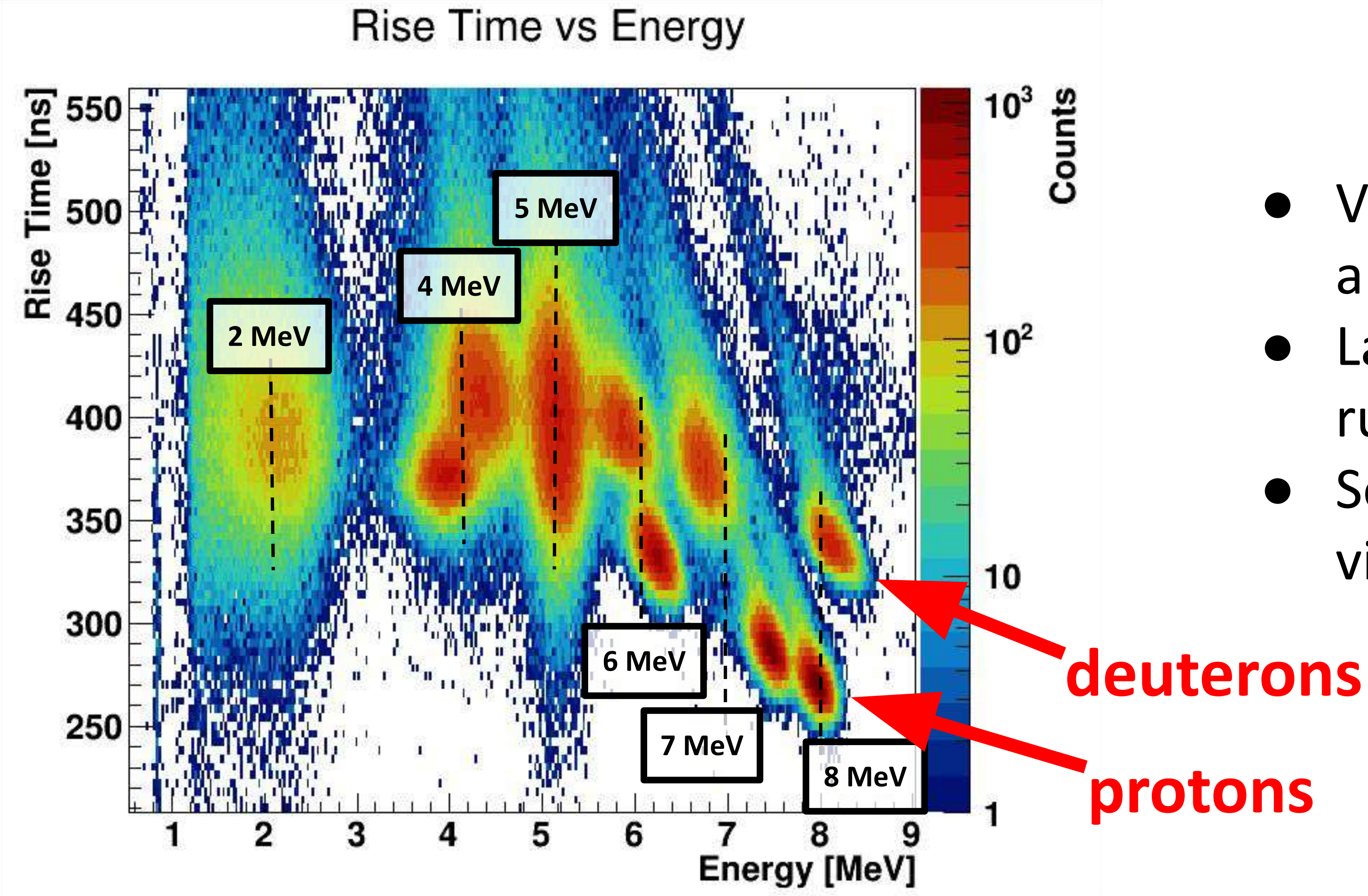
Bias at 110 V







Rise Time



- Very clear separation above 6 MeV
- Large noise in 5 MeV run kills separation
- Some separation still visible at 4 MeV

Rise Time Figure of Merit

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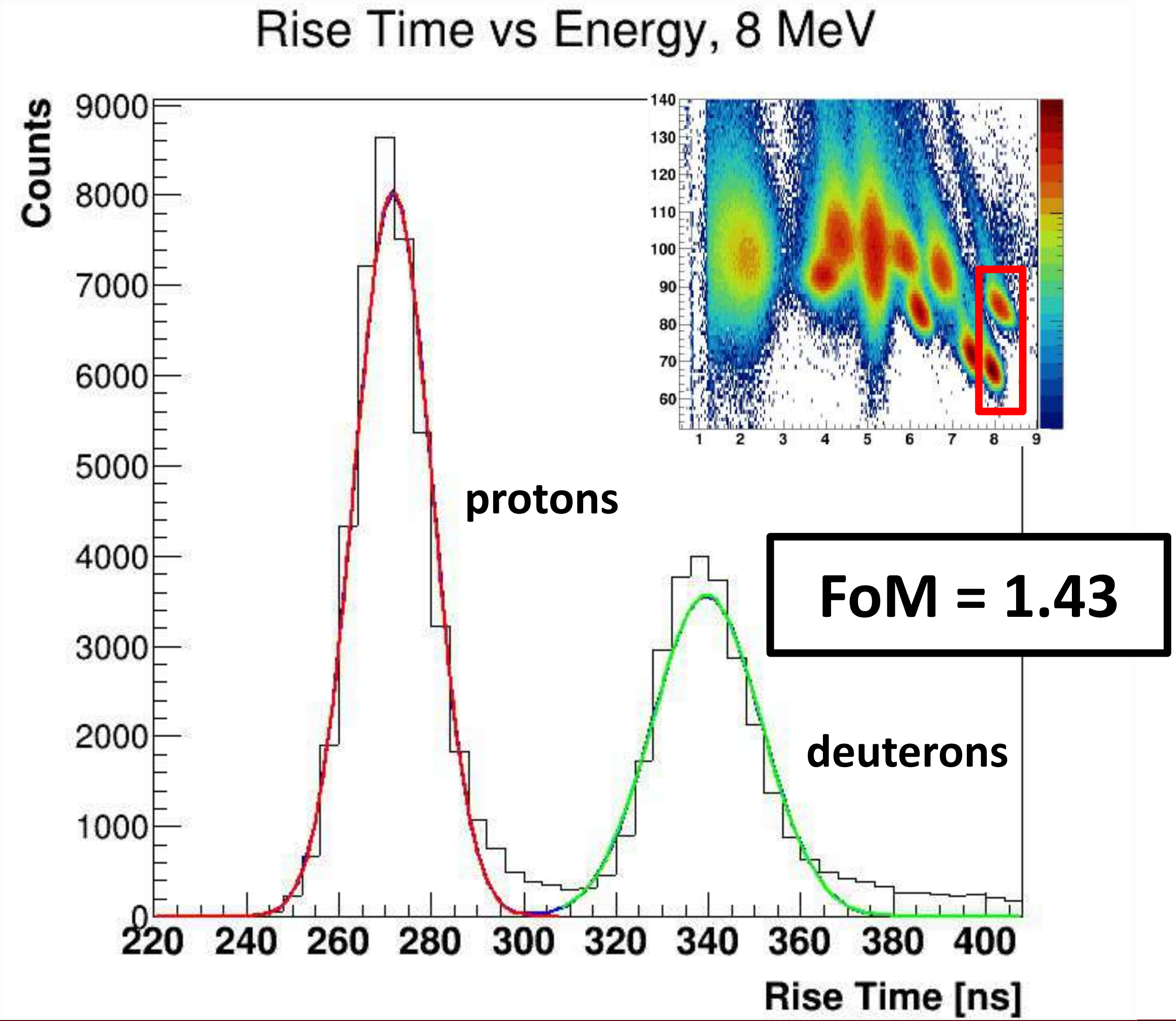
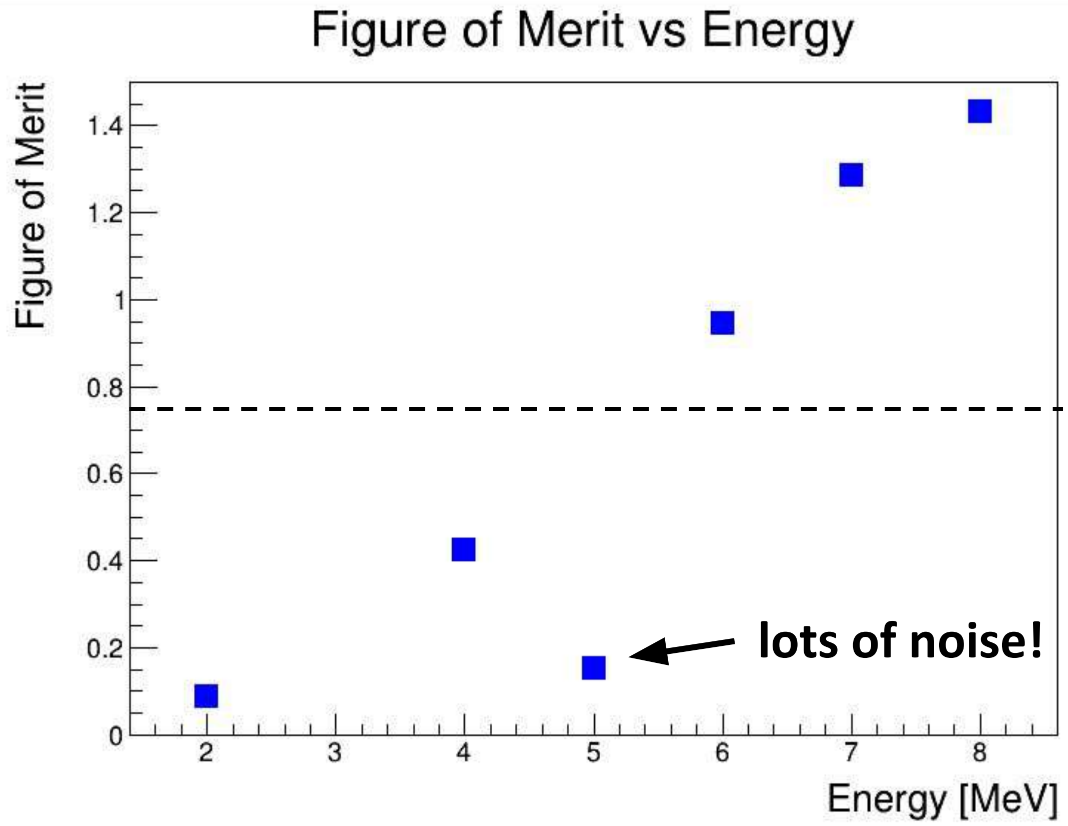
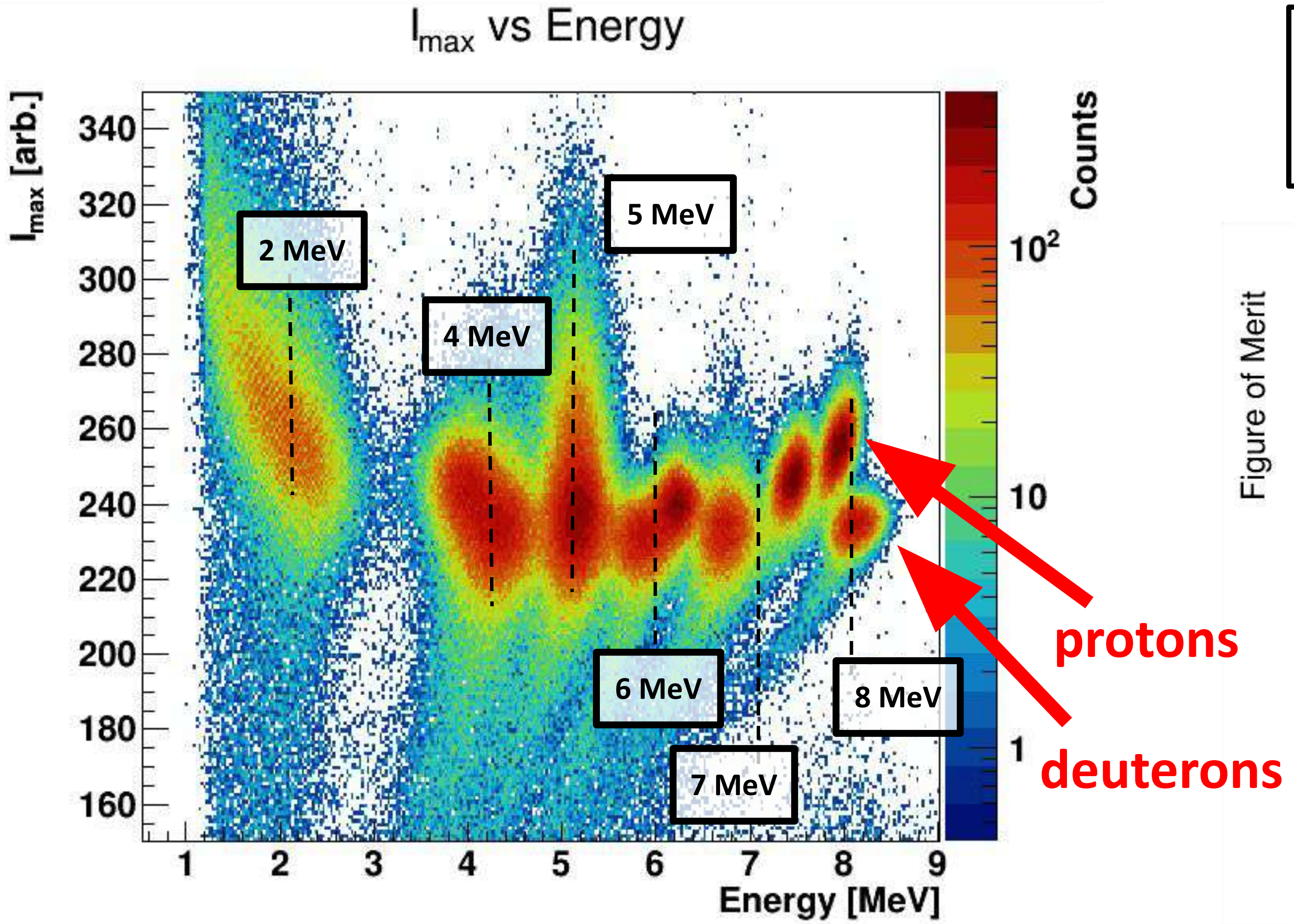


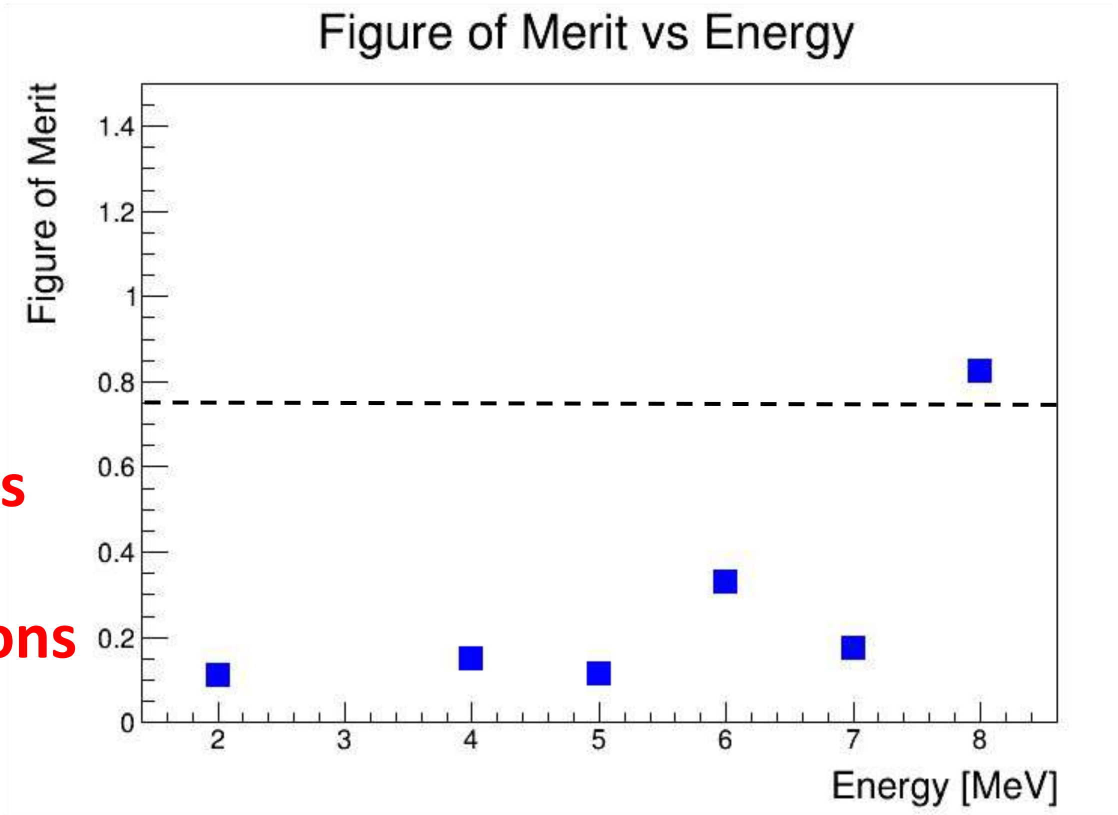
Figure of Merit quantifies the separation of two peaks



Maximum Current (I_{max})



Clearly, rise time is the superior metric



Future Steps

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Current Performance

- No NTD silicon necessary
  - Cheap
  - Large thickness
- Middle energy ranges
  - 5 MeV < E < 10 MeV

Future Improvements

- Algorithm adjustments could improve resolution
  - Polynomial smoothing
- Vacuum chamber
  - Shields from noise
- Lower bias voltage
  - Decrease drift velocity leading to better pulse shapes

Thank you!

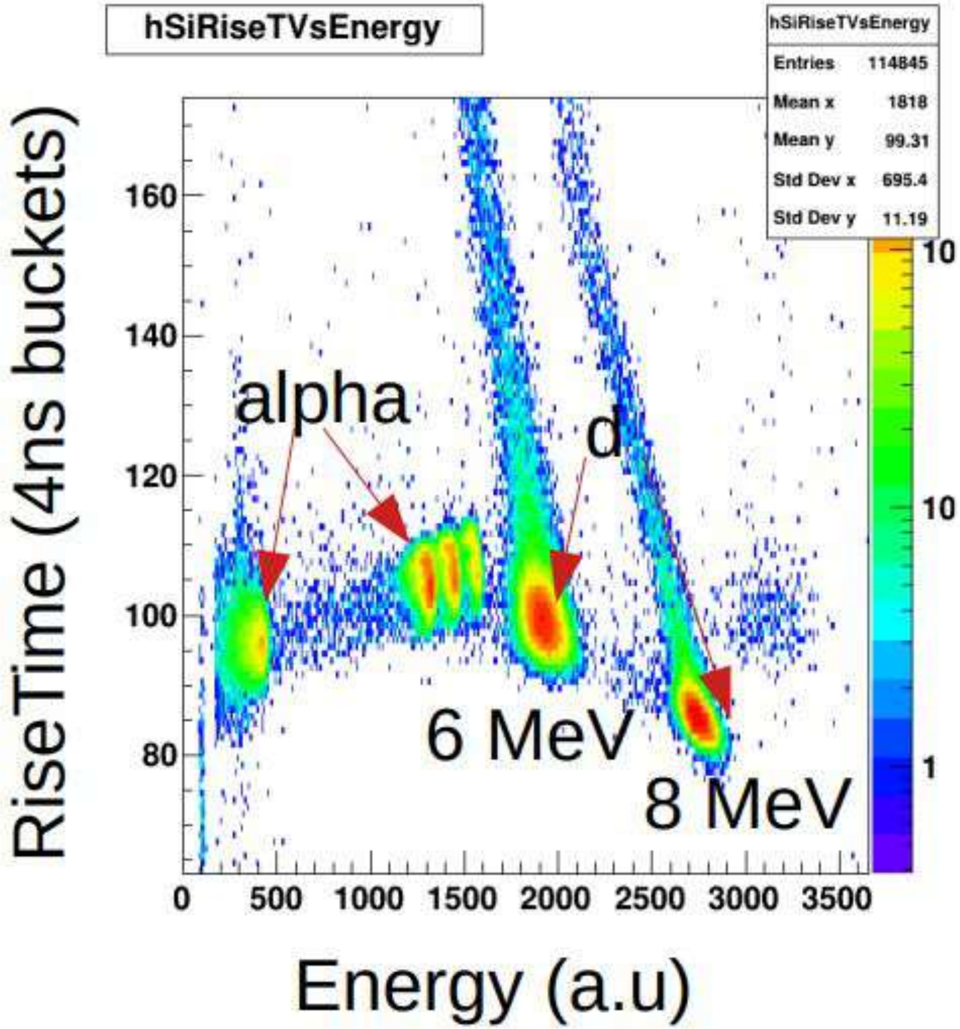
Special thanks to Dr. Rogachev, Marina, and Yevgen

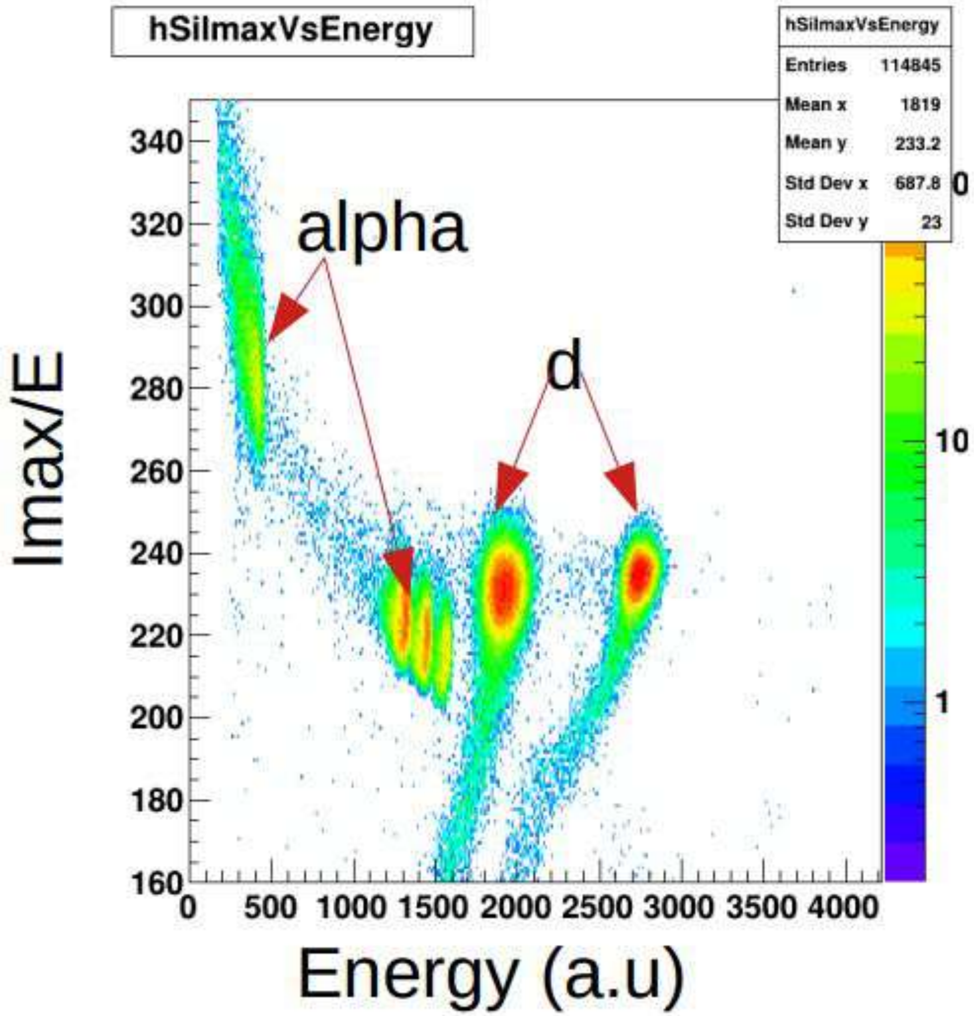
Questions?

Backup Slides

Alpha Particles?

Taken from Marina's slides



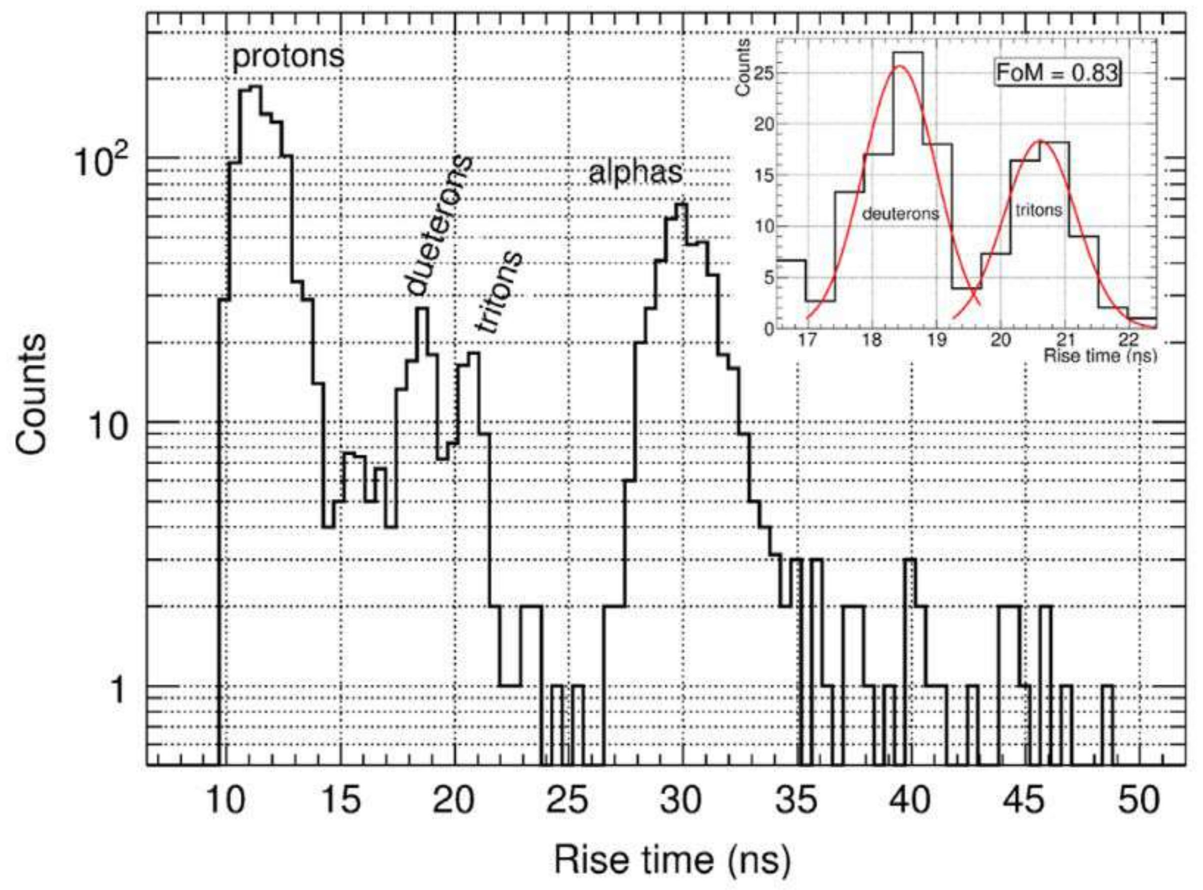


Comparing with Papers

Digital pulse-shape analysis with a TRACE early silicon prototype

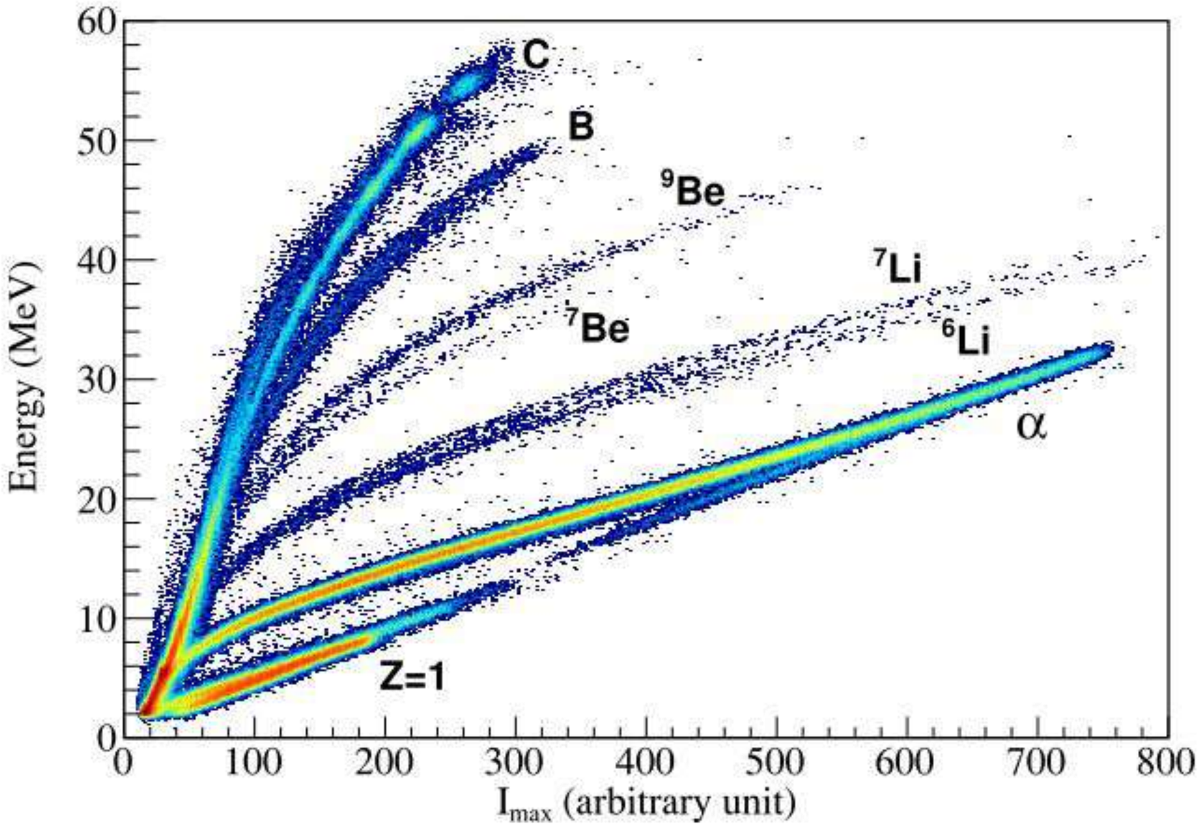
D. Mengoni [a,b,*], J.A. Dueñas [c], M. Assié [d], C. Boiano [e], P.R. John [a,b], R.J. Aliaga [f], D. Beaumel [d], S. Capra [e], A. Gadea [g], V. Gonzáles [h], A. Gottardo [i], L. Grassi [a,b], V. Herrero-Bosch [f], T. Houdy [j], I. Martel [c], V.V. Parkar [k], R. Perez-Vidal [g], A. Pullia [e], E. Sanchis [h], A. Triossi [i], J.J. Valiente Dobón [i]

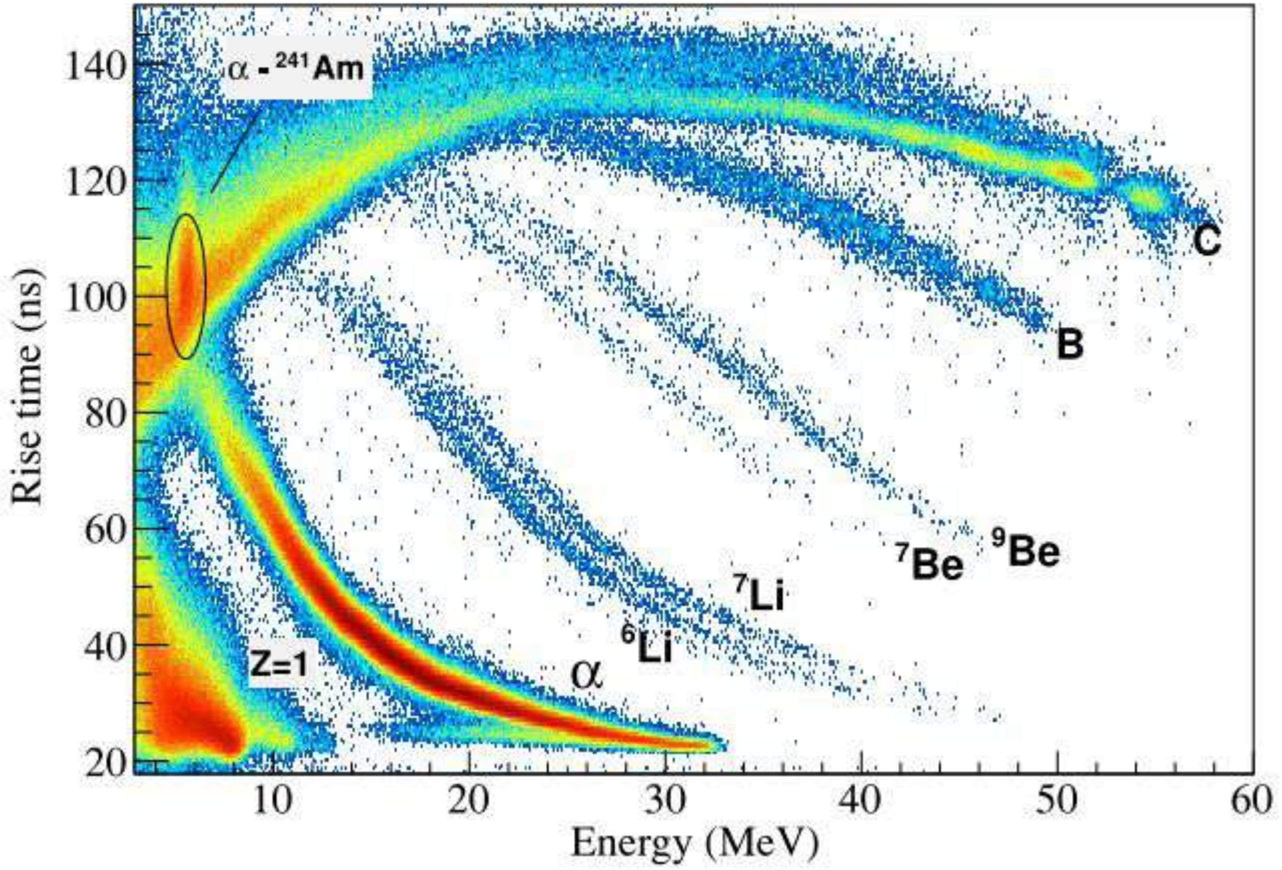
Mengoni et al. were able to get proton, deuteron, triton, and alpha separation at 4 MeV



Comparing with Papers

Isotopic identification using Pulse Shape Analysis of current signals from silicon detectors: Recent results from the FAZIA collaboration





Cover Image