Pulse Shape Discrimination Using a Regular Silicon Detector

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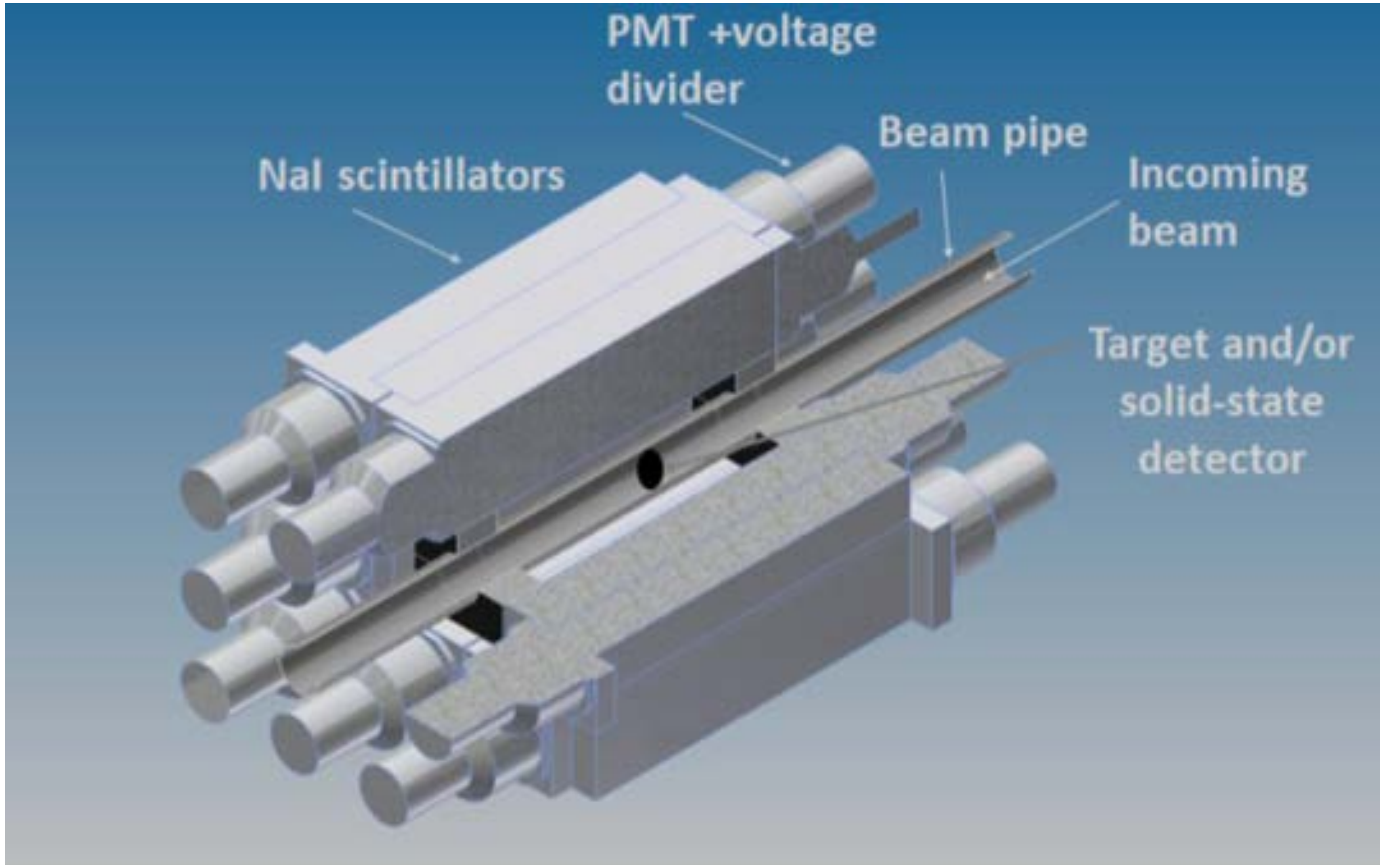
Motivation

- 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

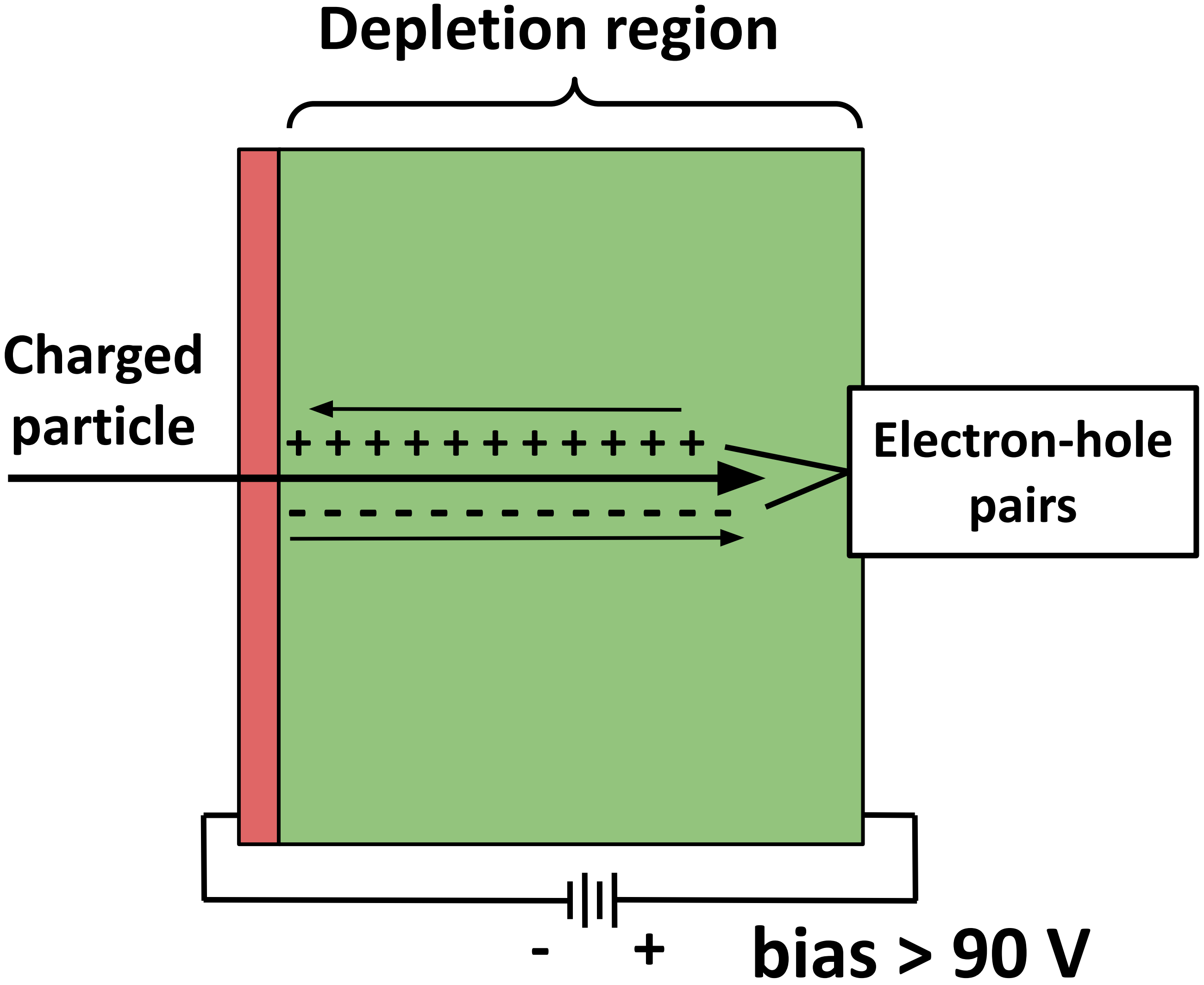
Pulse Shape Discrimination (PSD)

- 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

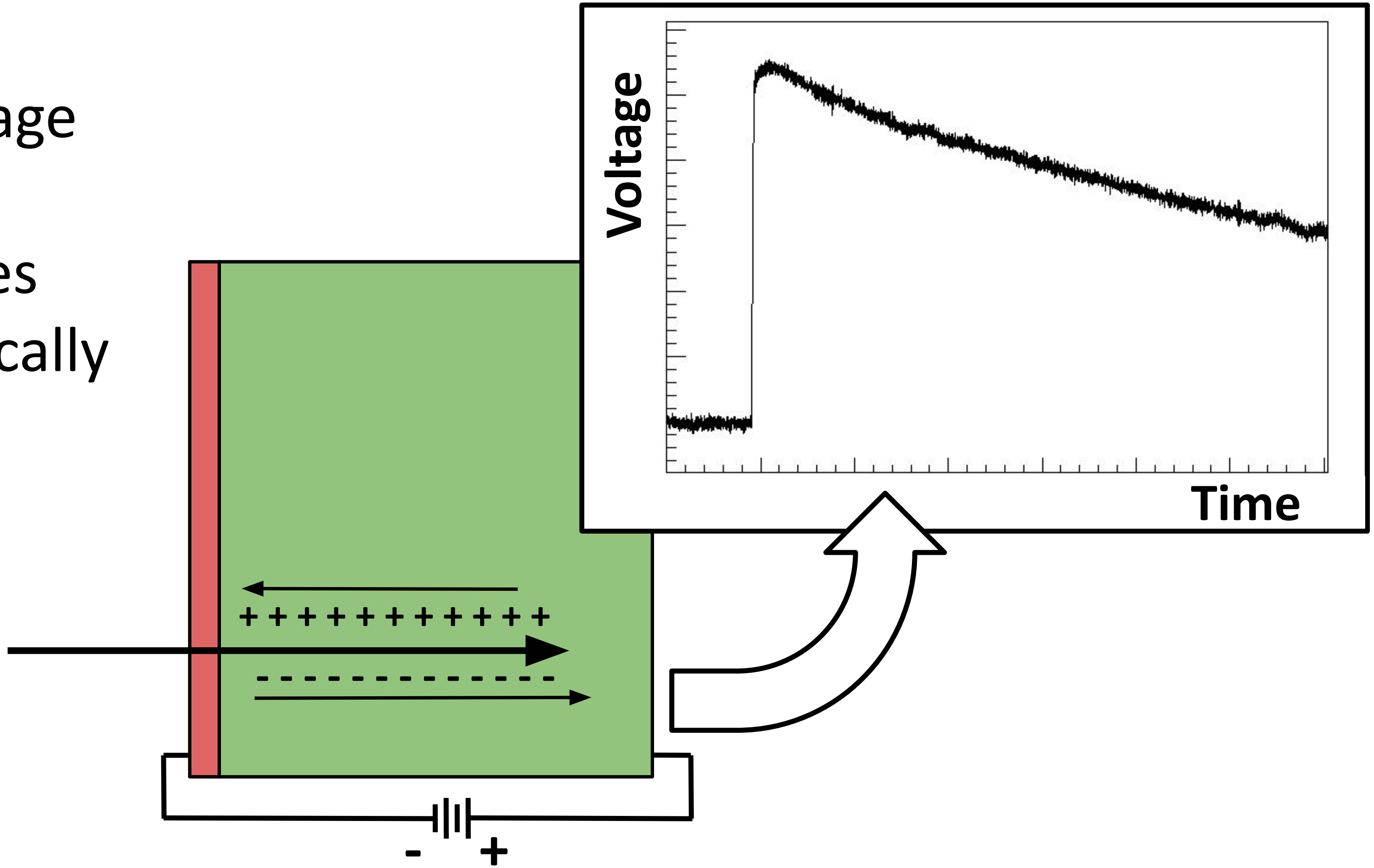
Silicon Detectors

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



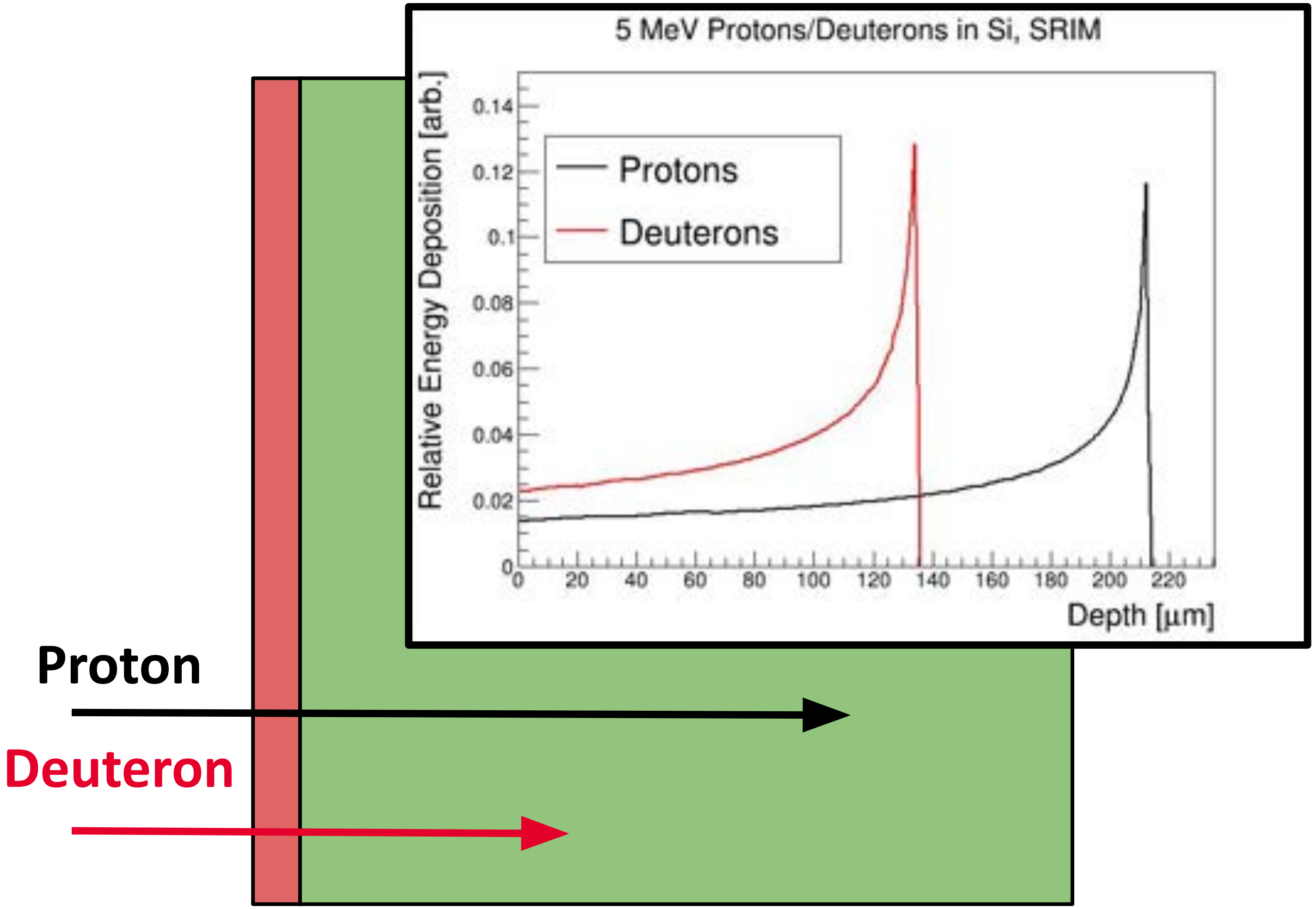
Silicon Detectors

- 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



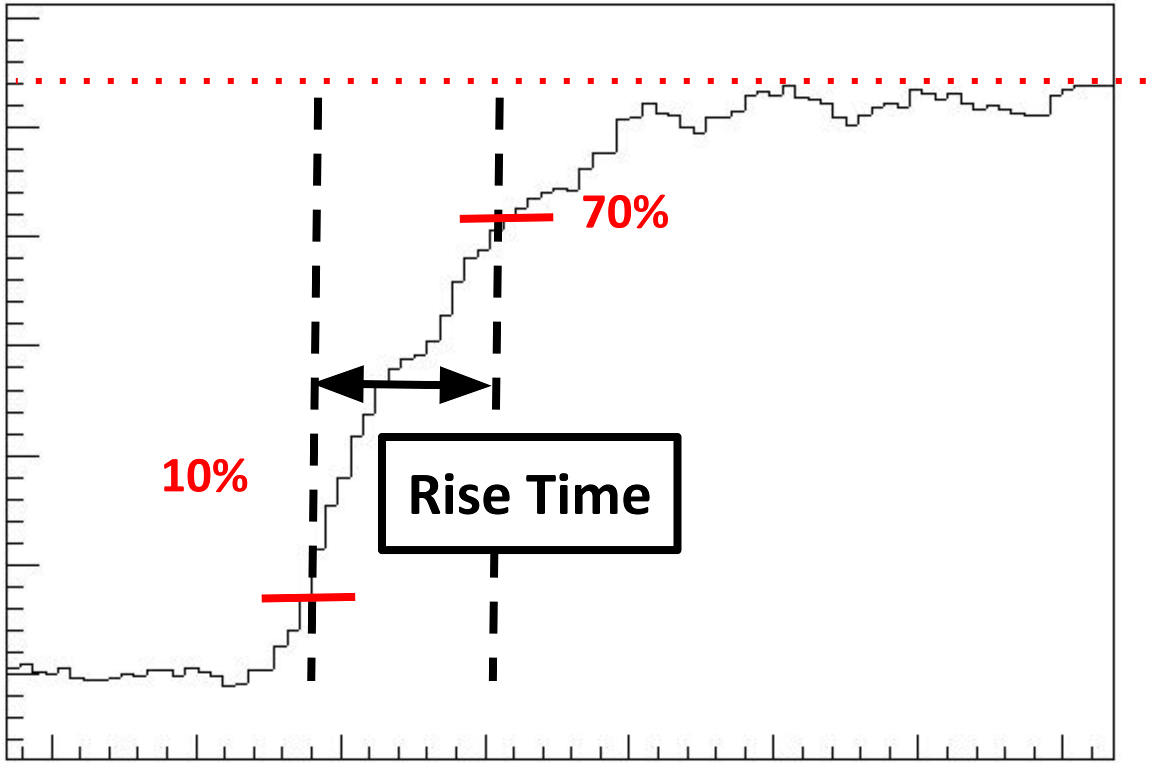
Silicon Detectors

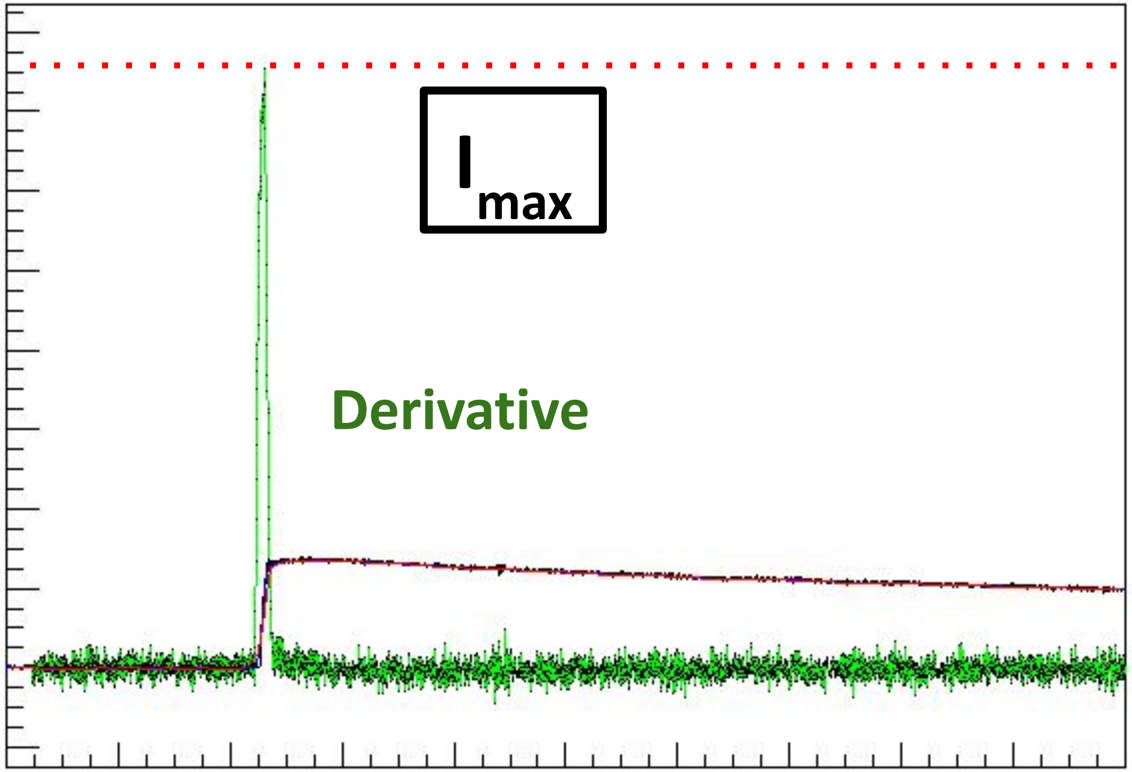
For a given energy, different particles have different ranges, resulting in distinct pulse shapes



Rise Time and I_{max}

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





Voltage Signal Processing

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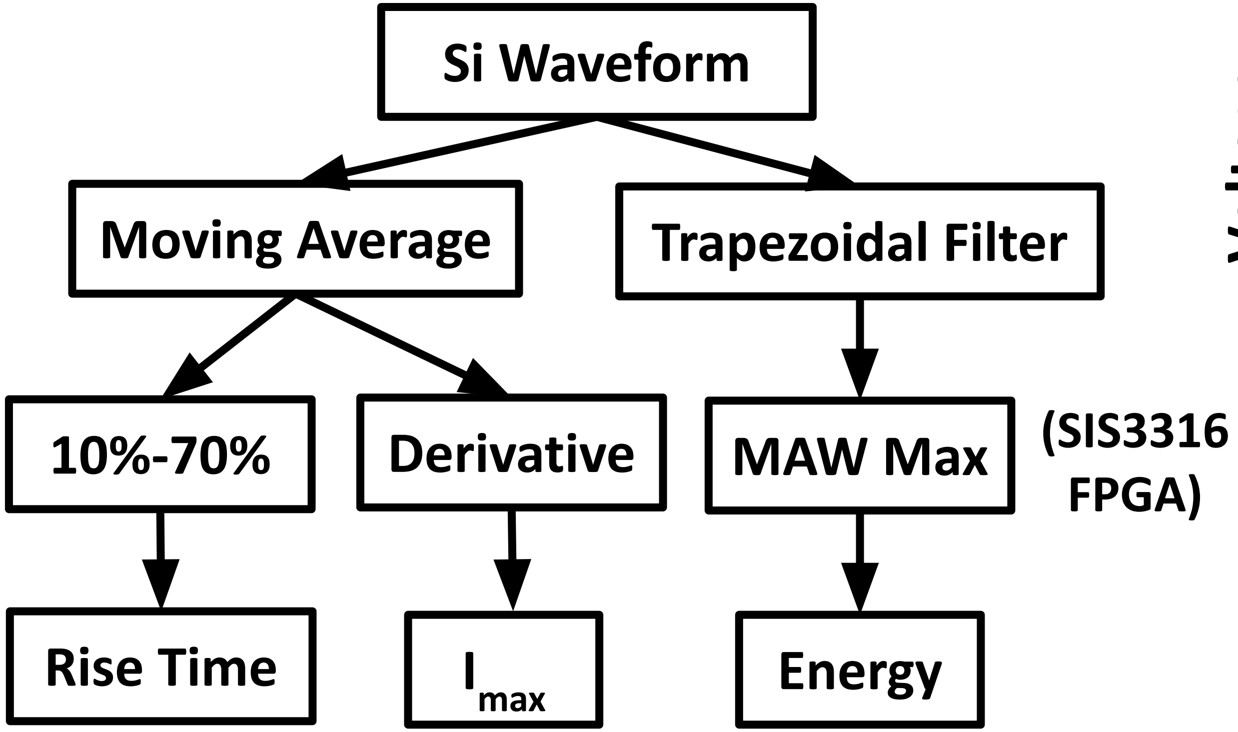
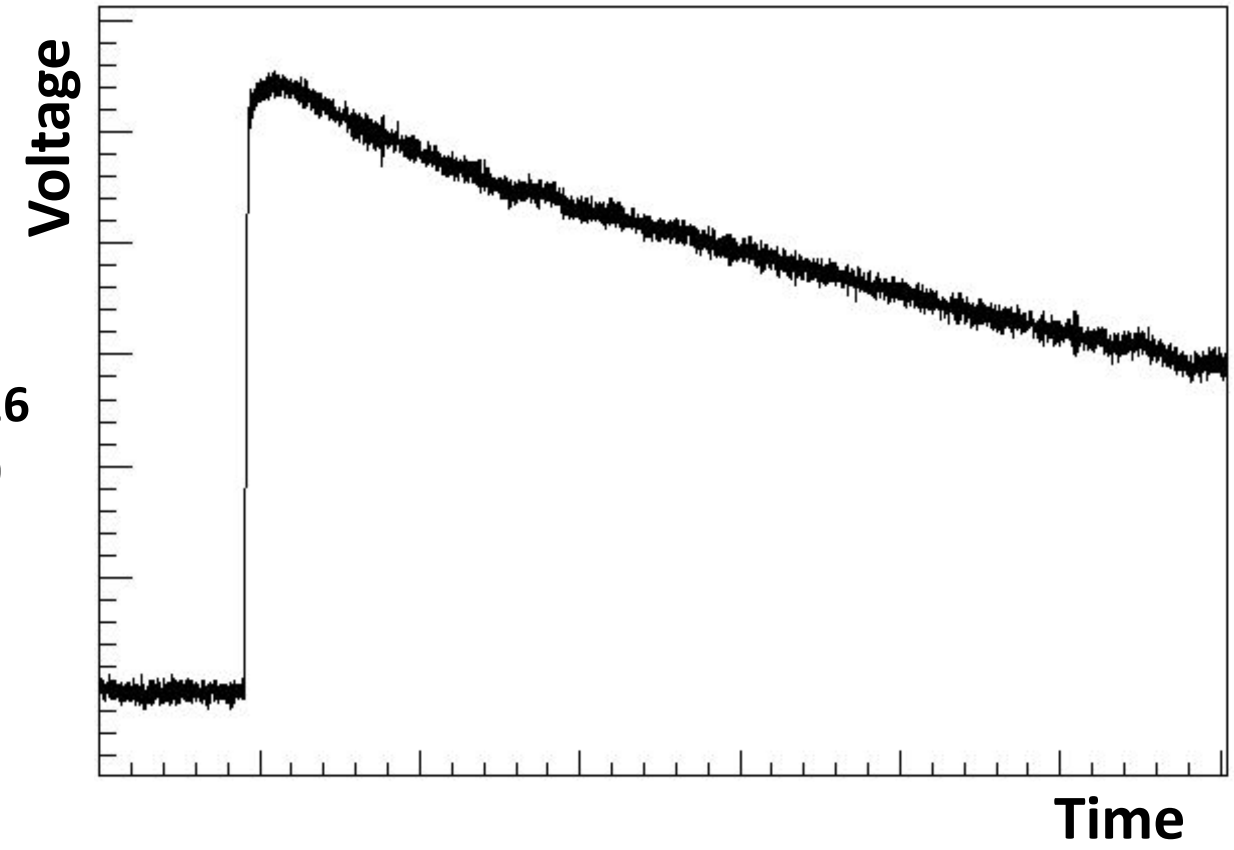


Typical Si Waveform

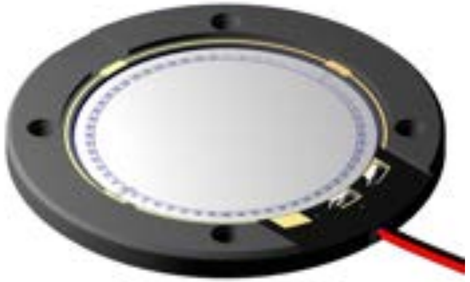


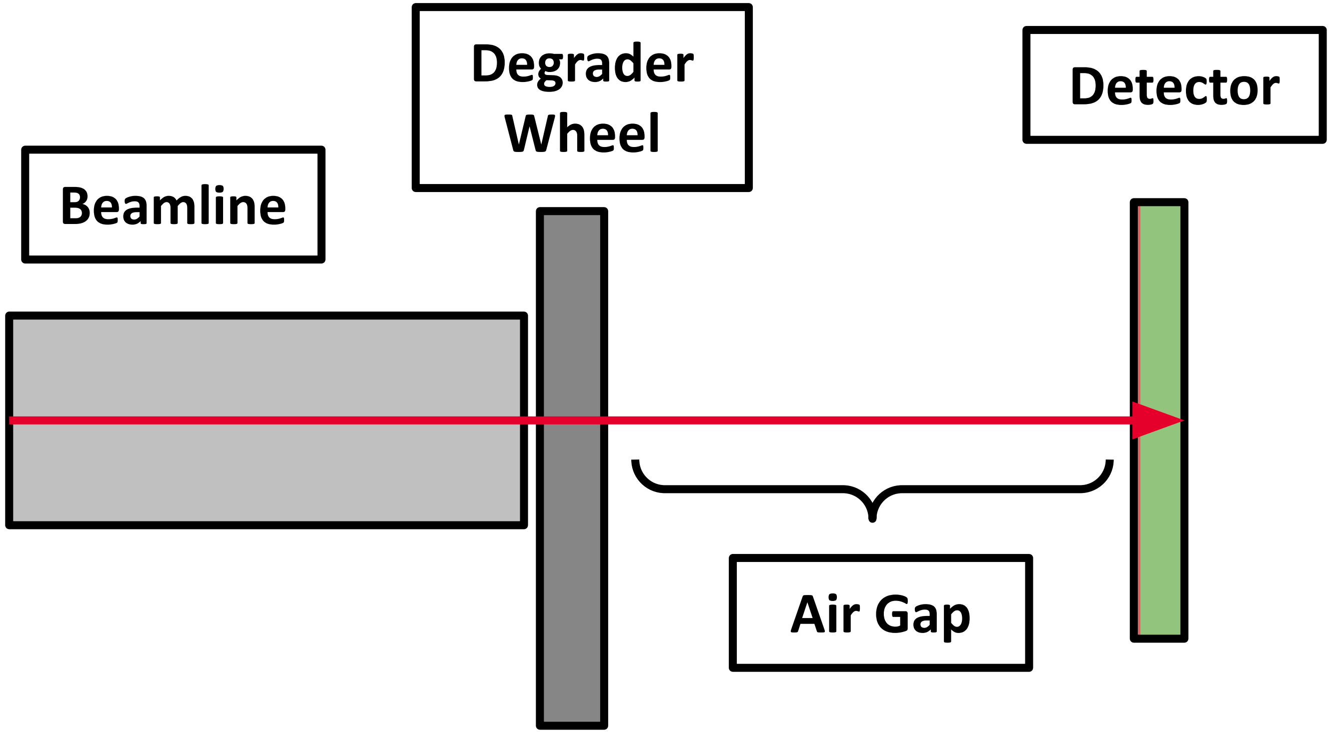
Experimental Setup

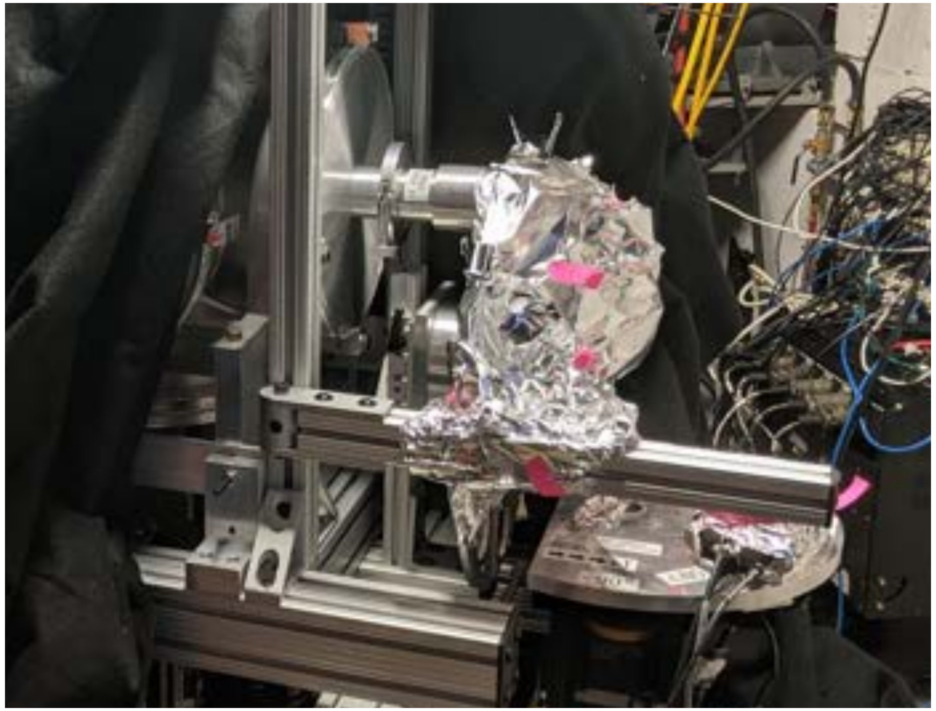
- K150
- In air
- 10 MeV protons and deuterons

Micron MSD026-1500

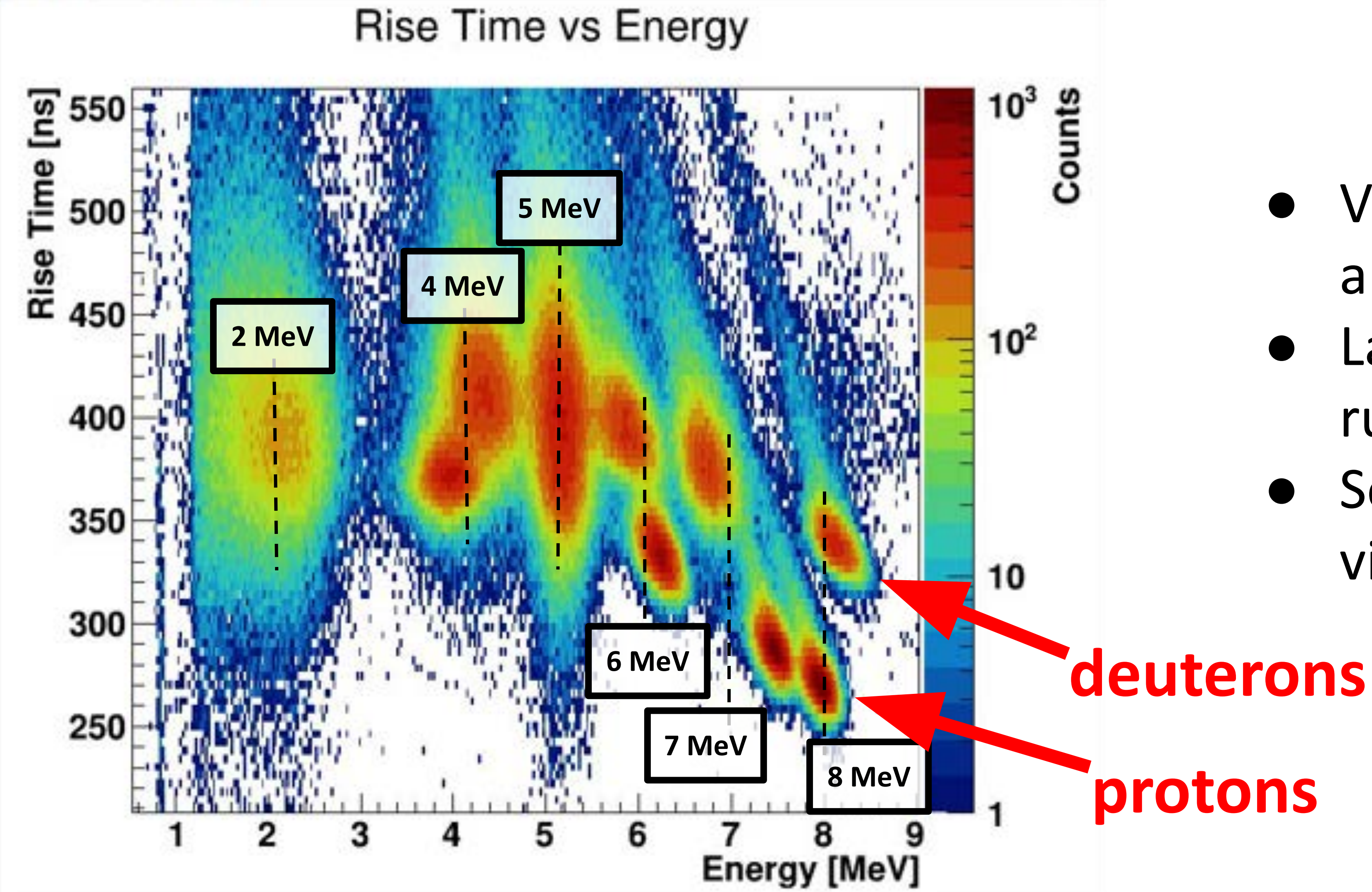
Bias at 110 V







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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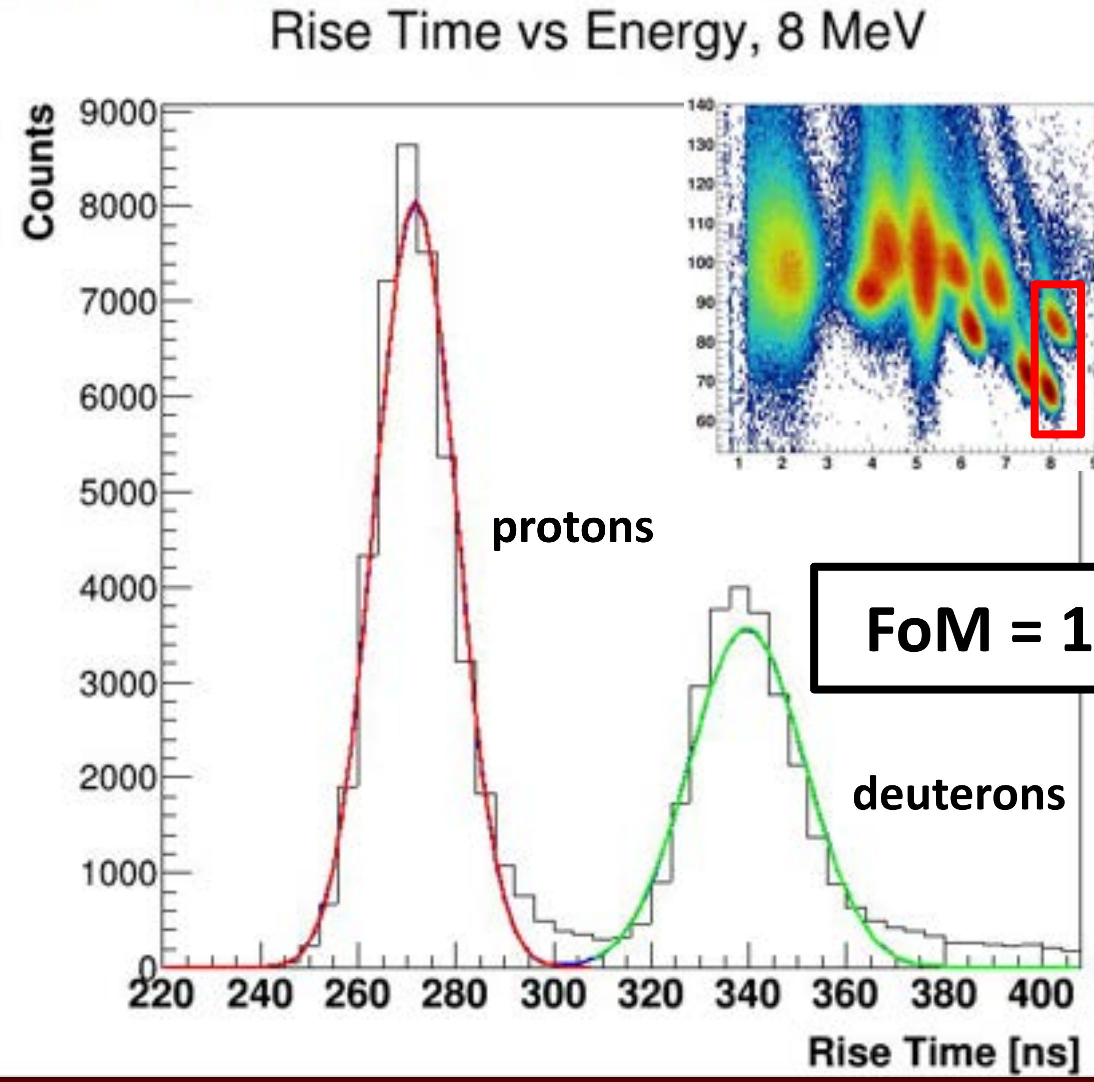
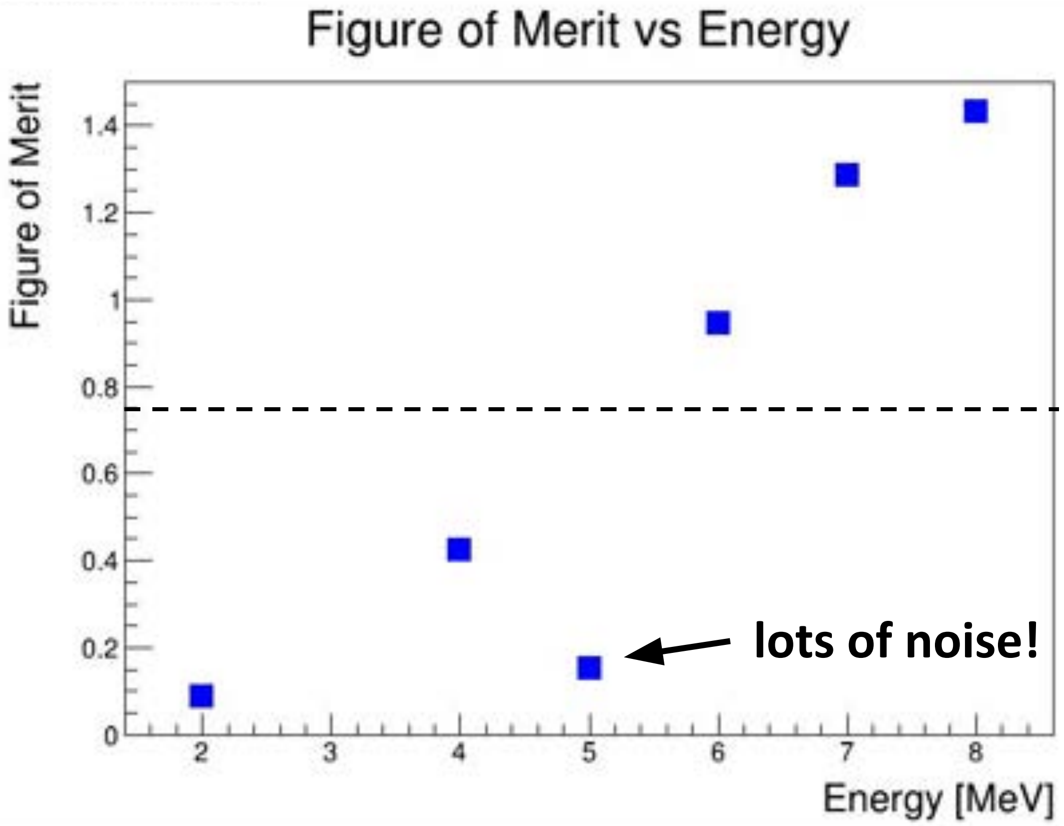
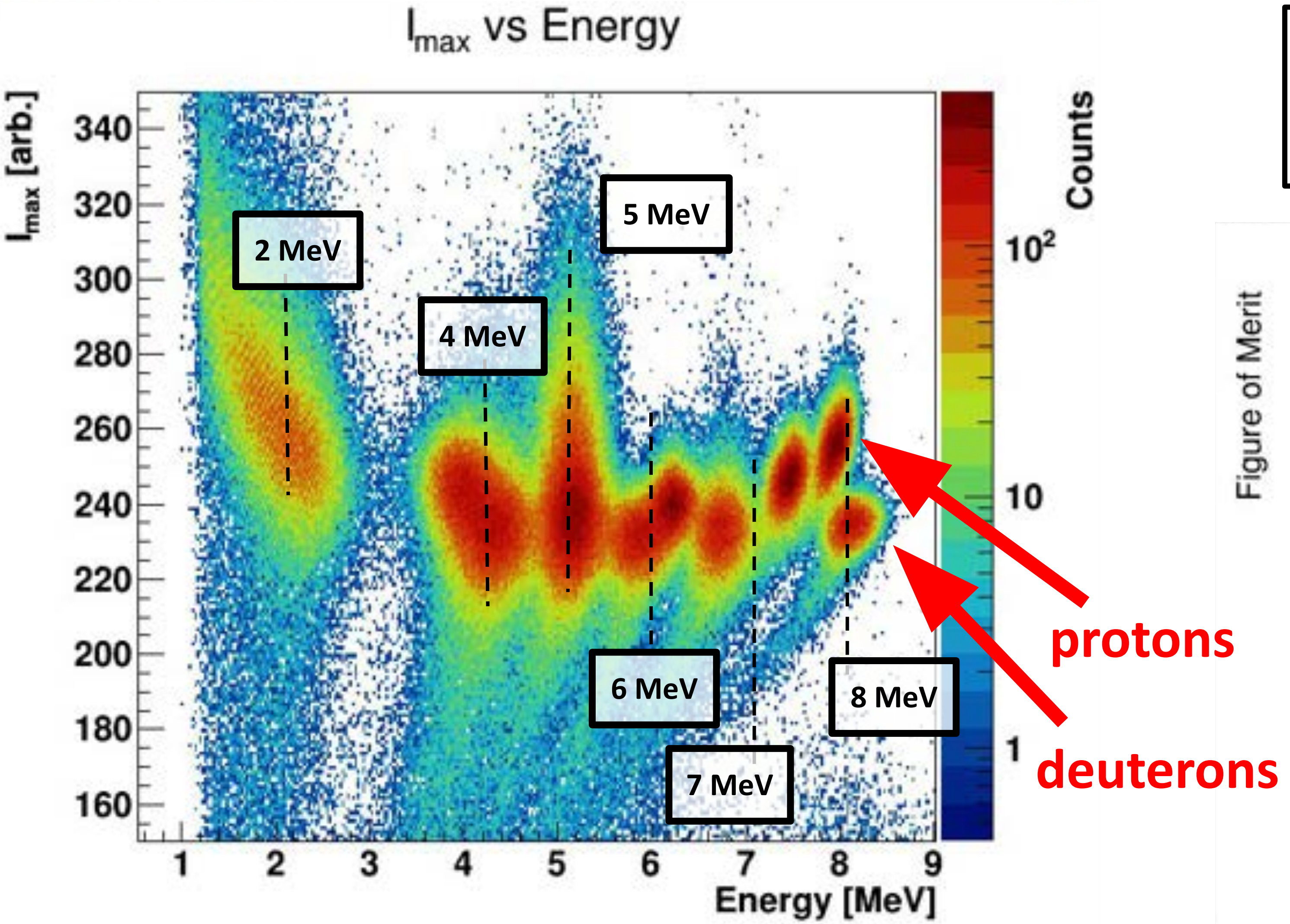


FoM = 1.43

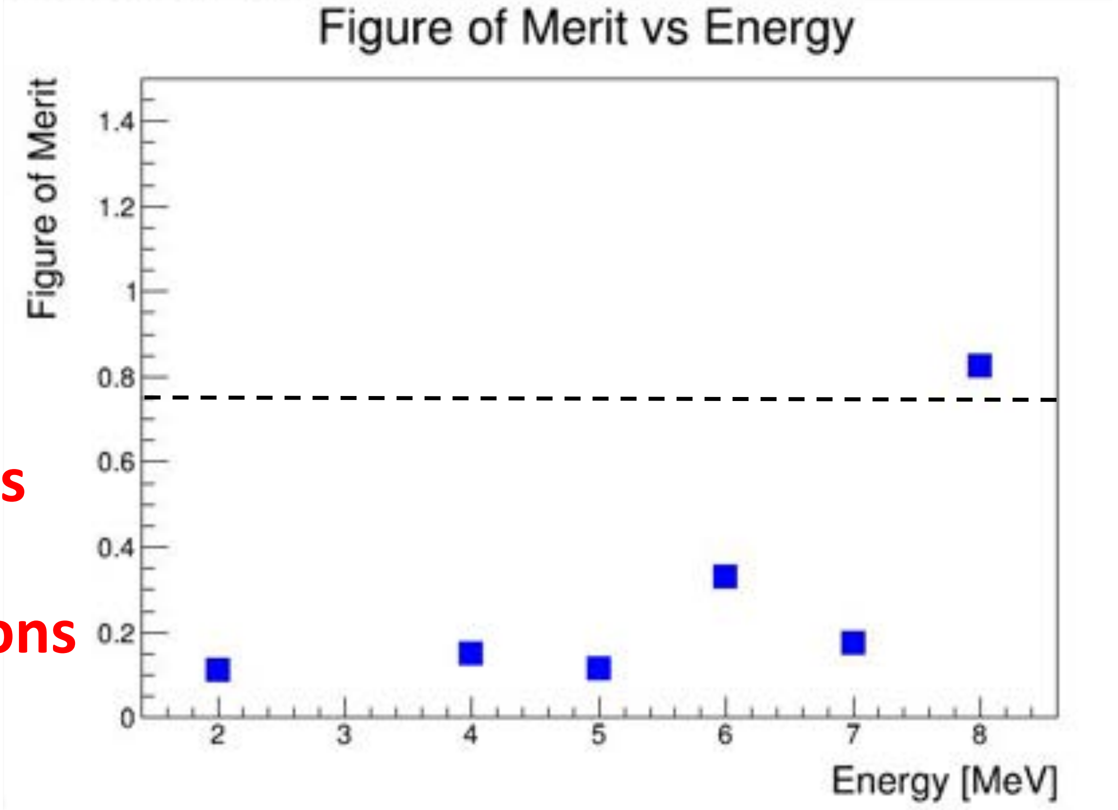
Figure of Merit quantifies the separation of two peaks



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
  - Increase drift velocity leading to better pulse shapes

Thank you!

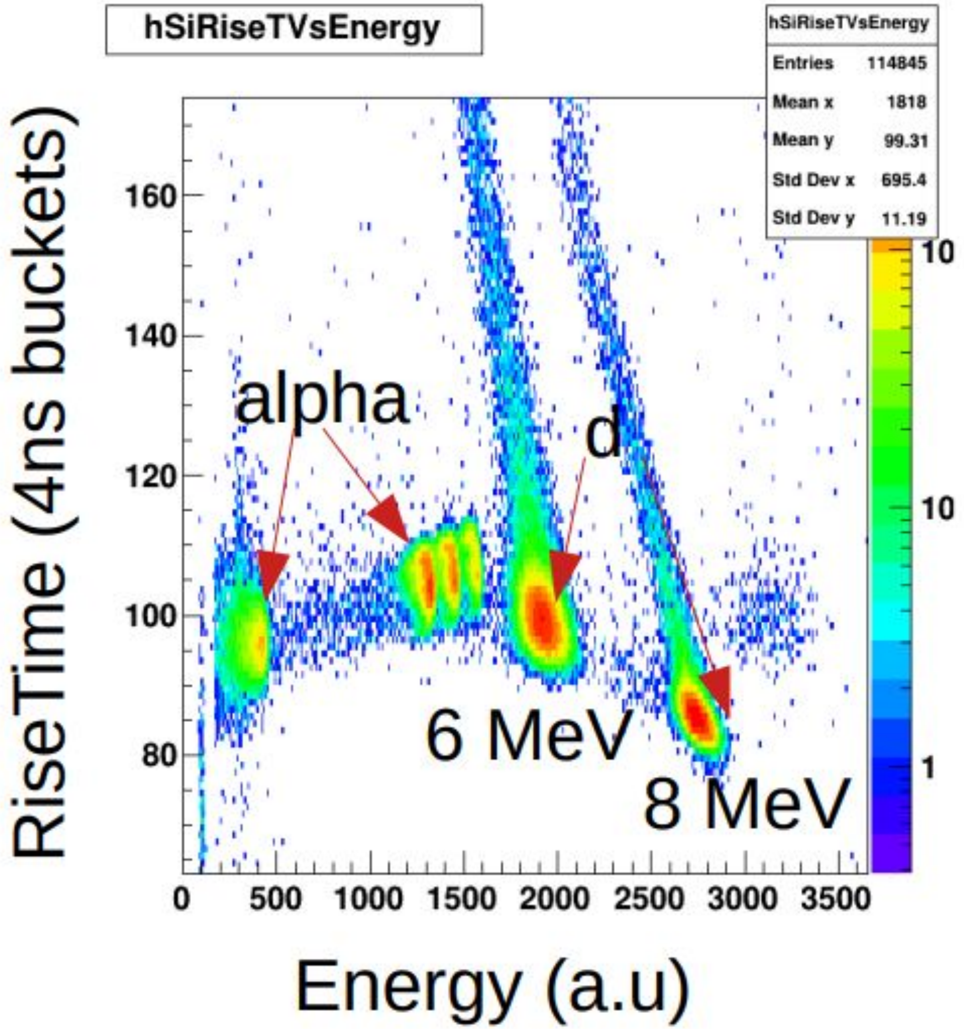
Special thanks to Dr. Rogachev, Marina, and Yevgen

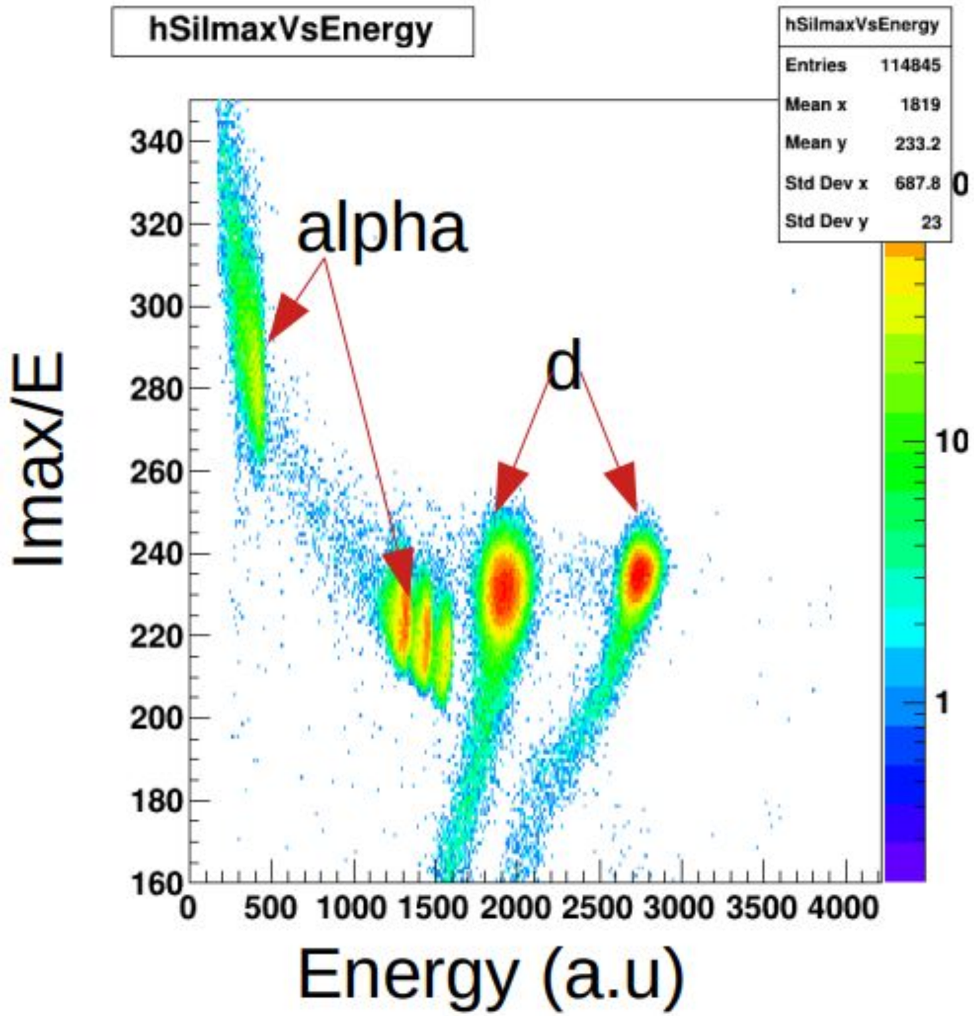
Questions?

Backup Slides

Alpha Particles?

Taken from Marina's slides





Comparing with Papers

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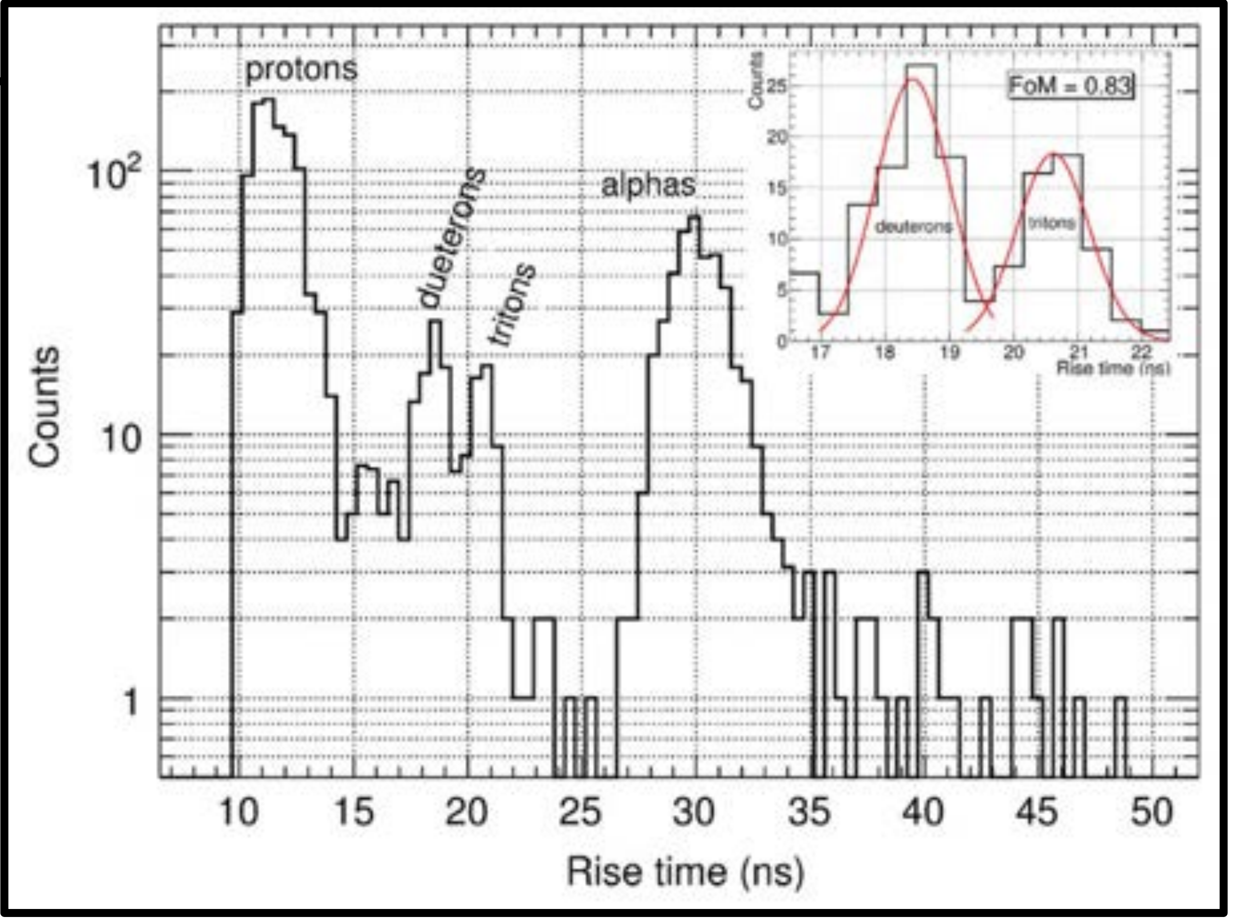
Digital pulse-shape analysis with a TRACE early silicon prototype

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

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