Initial Results on Charge and Velocity Discrimination for Heavy Ions using Silicon Timepix Detectors

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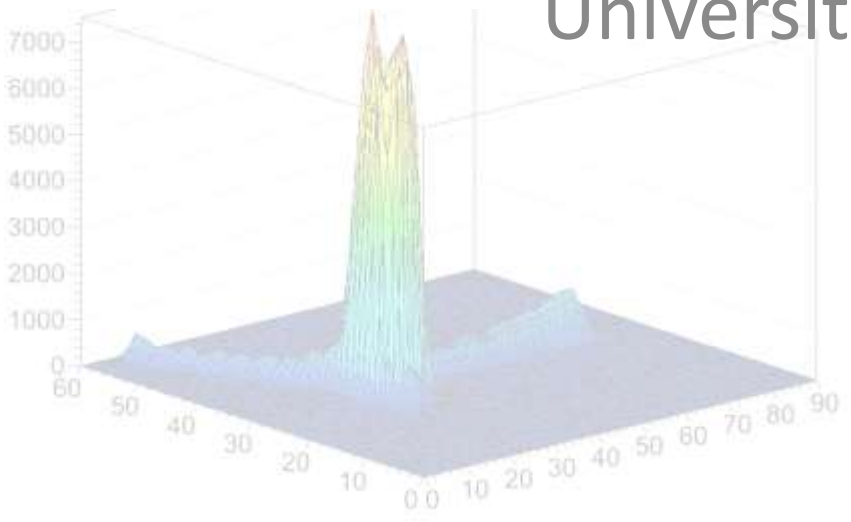

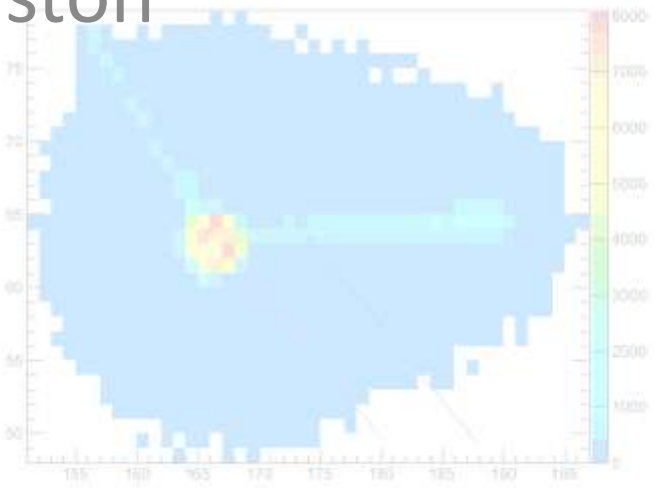

Collaborators

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Why try to resolve *z* and *ν*

Timepix telescope stacks are viable so why try to use a single layer detector for particle ID?

The end goal is to allow Si Timepix detectors to be used as monitors on manned spacecraft

The combination of low-power and space-constrained environments imposes limitations on power, data processing, and hardware envelope

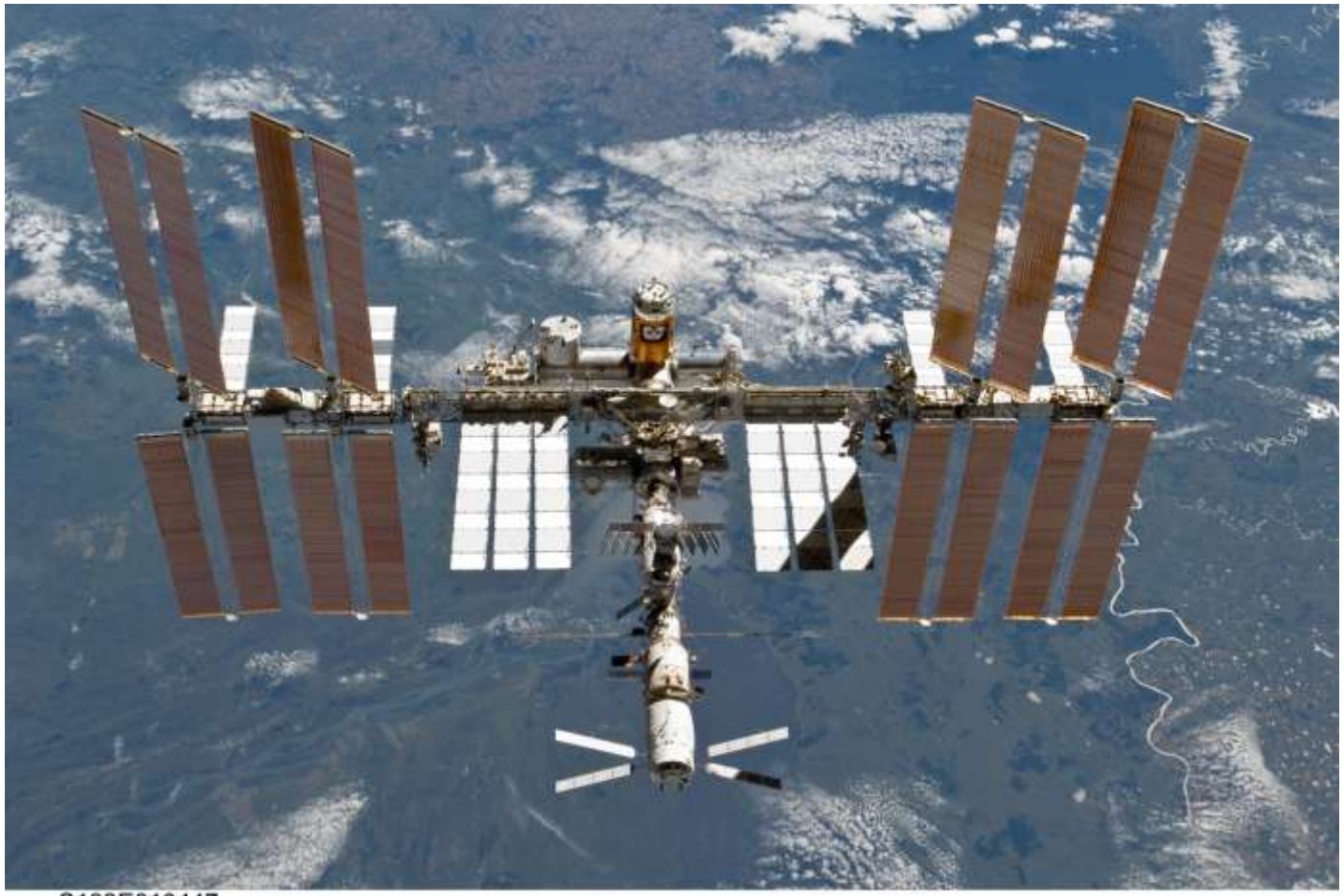
Further, the extraction of particle field information allows several dose endpoints

Silicon Timepix Detectors

Timpix based devices are relatively low power, compact, robust, and have a large dynamic range

Silicon detectors provide data from a well-characterized material and provide a wide range of response to ionizing radiation from photons through heavy ions

Current Applications



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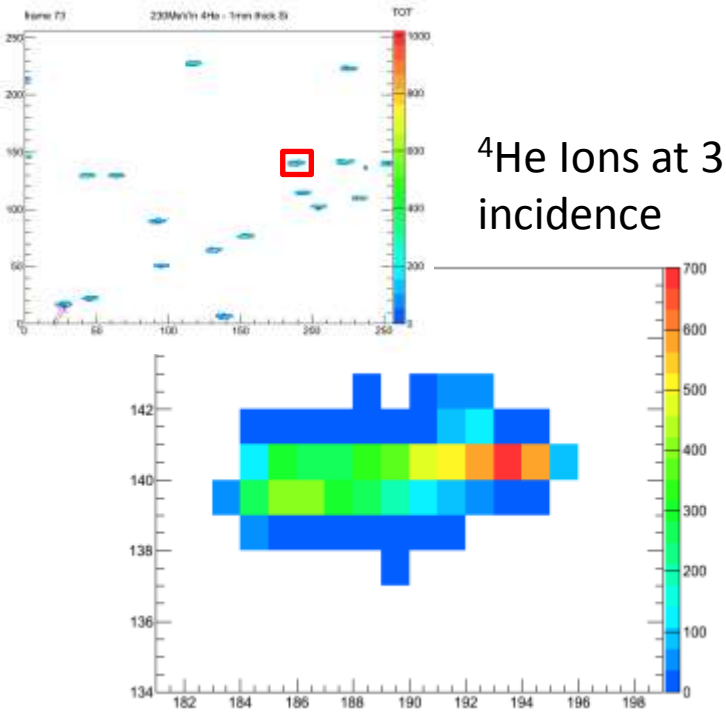
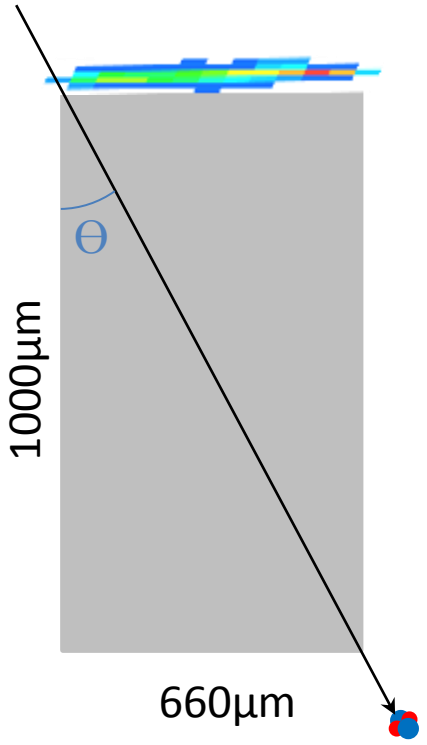
Basic Dosimetry with Timepix

LET calculation from calibrated ToT data

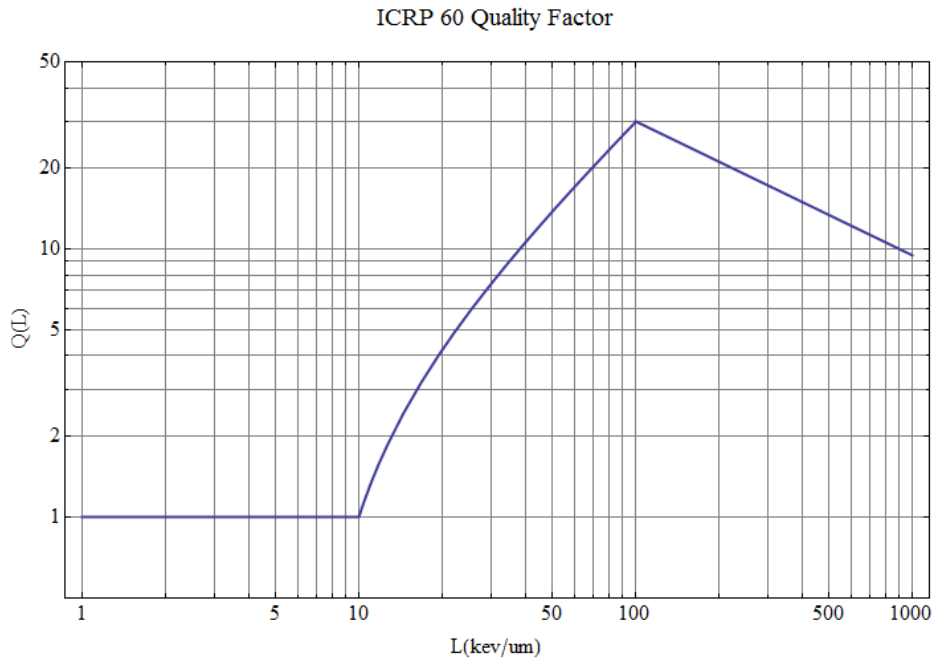
- Sum energy in cluster
- Calculate angle of track



^{4}He Ions at 30° incidence



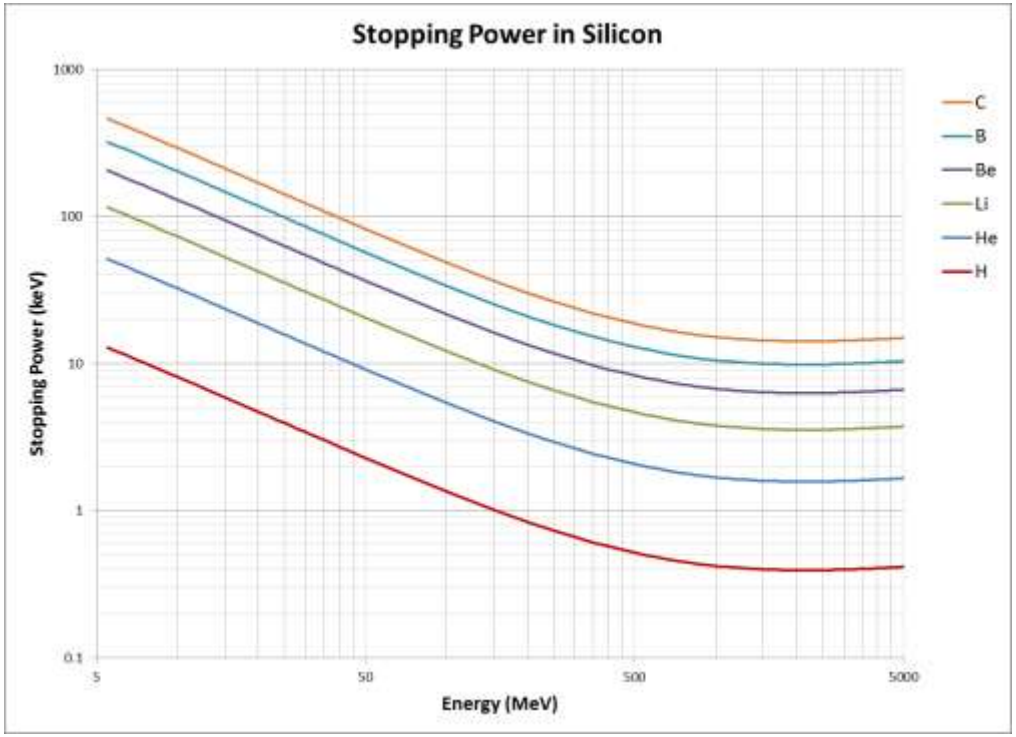
Basic Dosimetry with Timepix



The resulting LET can allow dose equivalent estimates based on the ICRP60 defined Q factor

But this is still tied to a specific endpoint

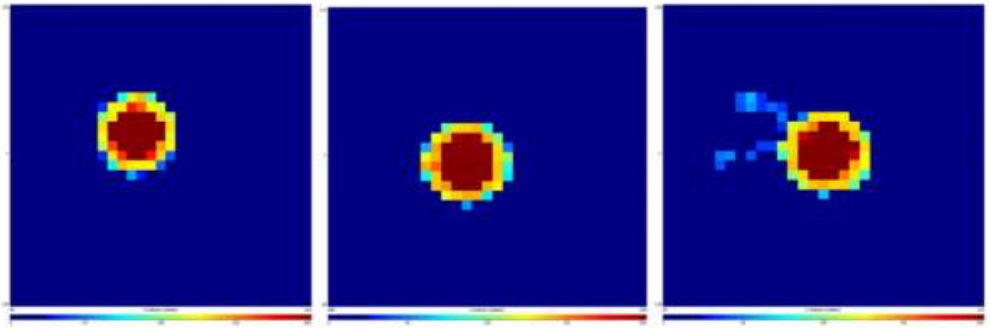
From LET to z^2/β^2



The ratio of charge to velocity can be extracted from stopping power estimates

This allows some differentiation based on assumption of the environment

Separation of z and β with δ-rays



100 MeV/A ^{16}O (86.85 keV/um)

180 MeV/A ^{20}Ne (90.08 keV/um)

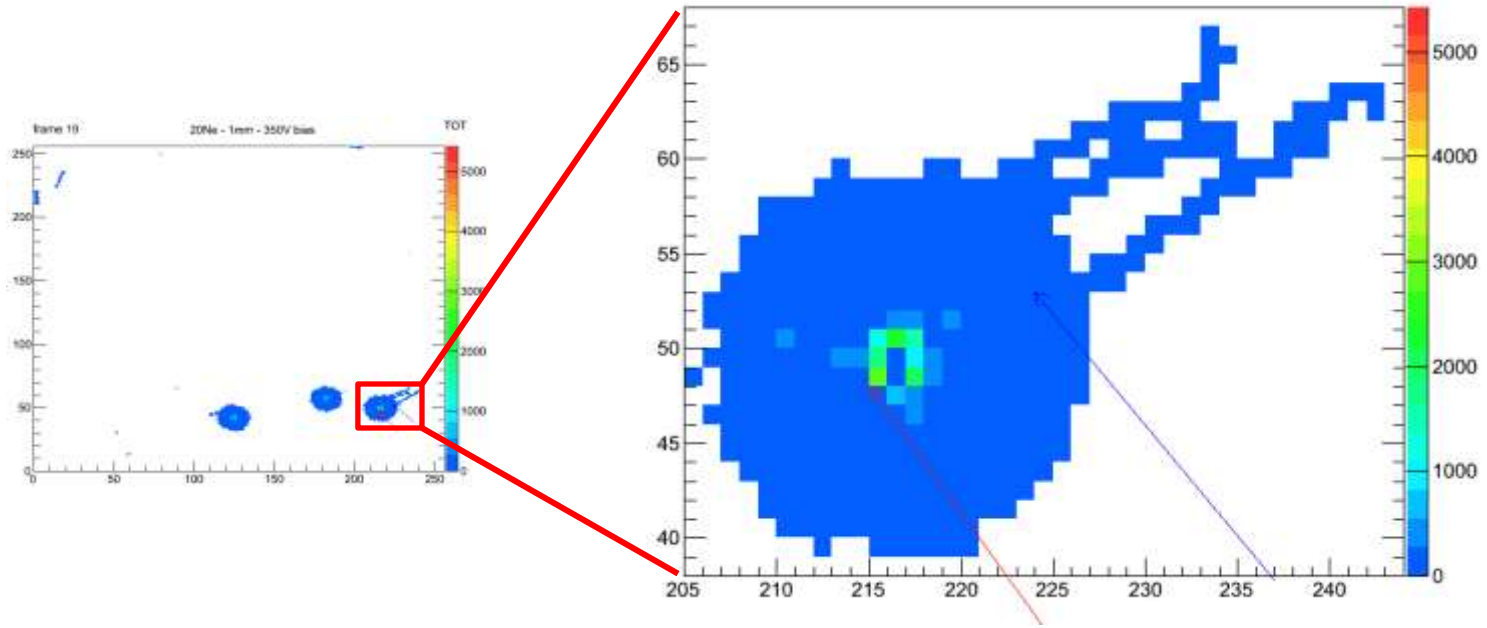
600 MeV/A ^{28}Si (95.15 keV/um)

The spectrum of the delta rays produced during ionization is influenced by ion charge

This leads to the following questions:

- Can we identify delta rays with the Si Timepix?
- If so, how can we characterize the δ-ray spectrum?

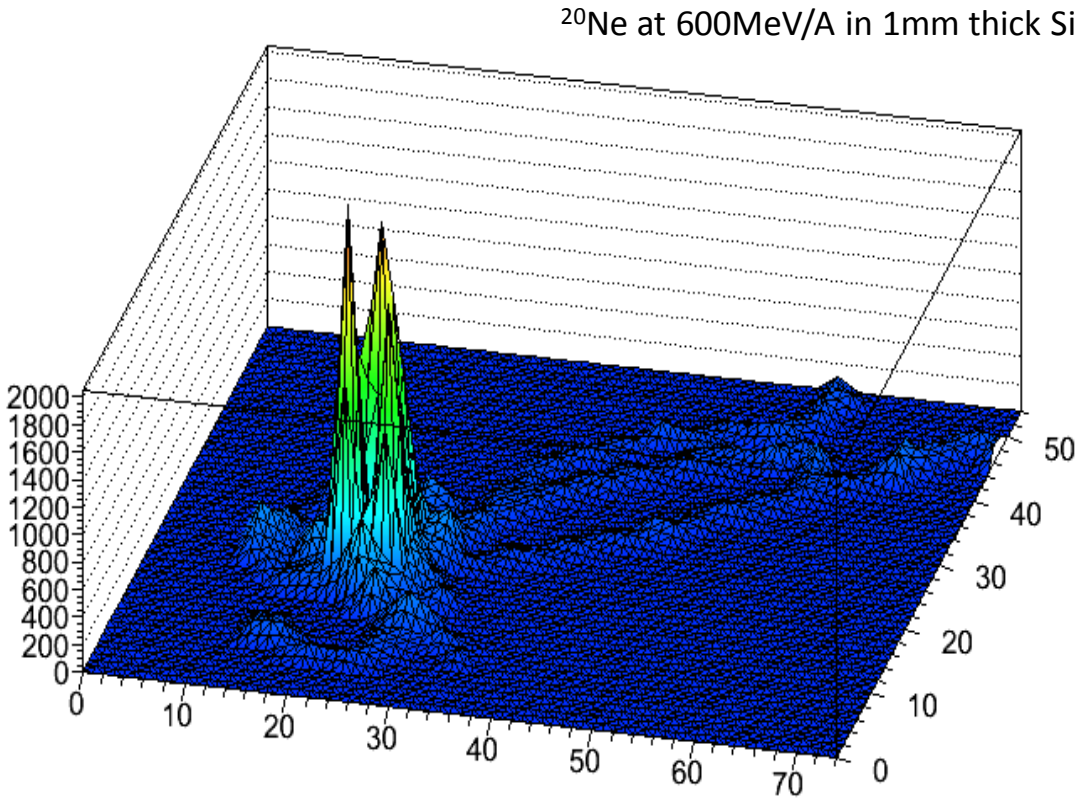
δ-ray detection with Si Timepix



Higher energy delta rays can be identified and the range can be estimated for those tracks

Lower energy delta rays show up as a broad, low count/energy base on the pixel cluster

δ-ray detection with Si Timepix

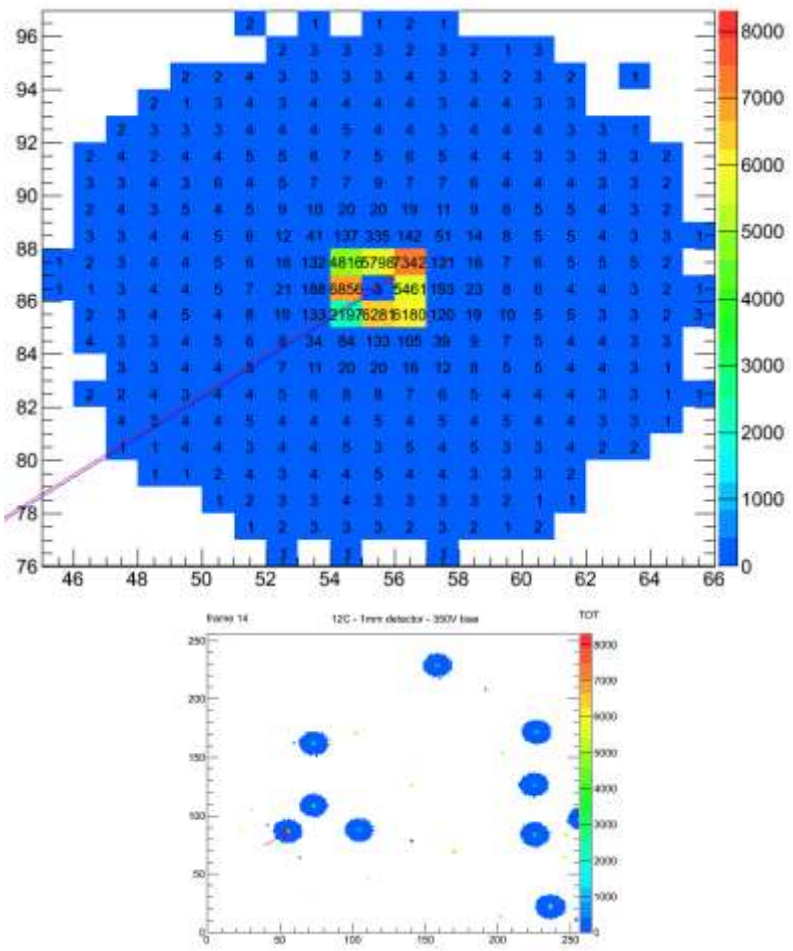


Delta ray production is visible in the cluster patterns in Timepix data

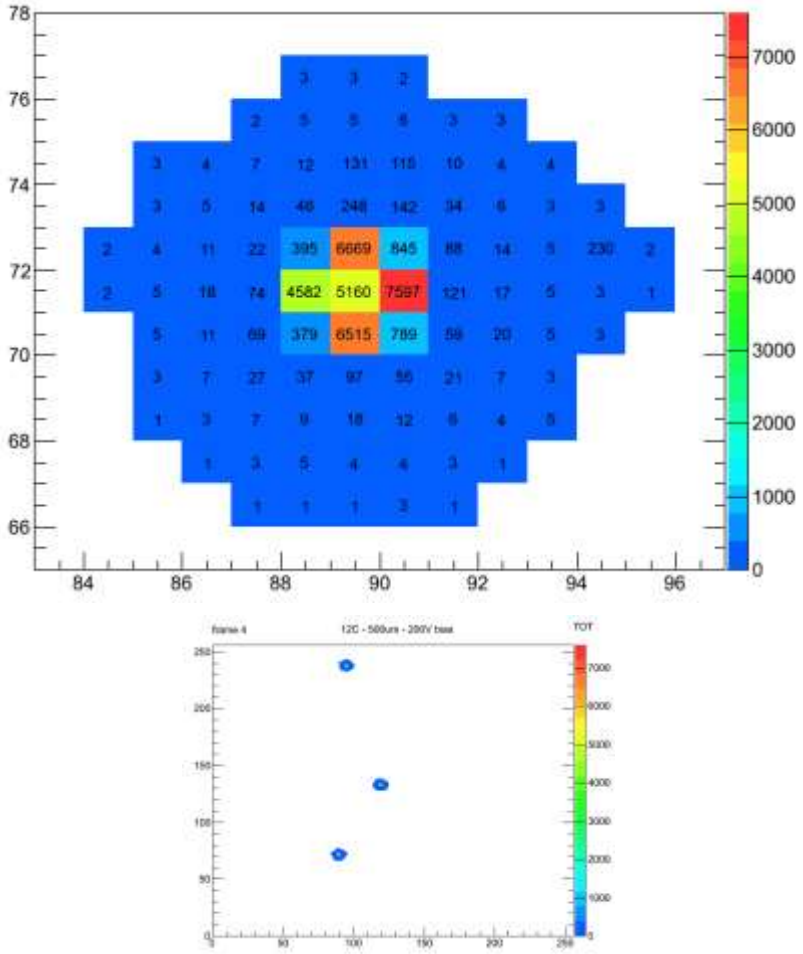
Thicker sensors show the effects more dramatically

Effect of Si Detector Thickness

100MeV/A ^{12}C
350V bias in 1mm thick Si Detector



100MeV/A ^{12}C
200V bias in 500µm thick Si Detector



Limits on resolution of *z* and *v*

Much of our existing forward work deals with this question

Increasing incidence angle resolution

Using range and radial energy distribution to increase resolution in δ-ray spectra

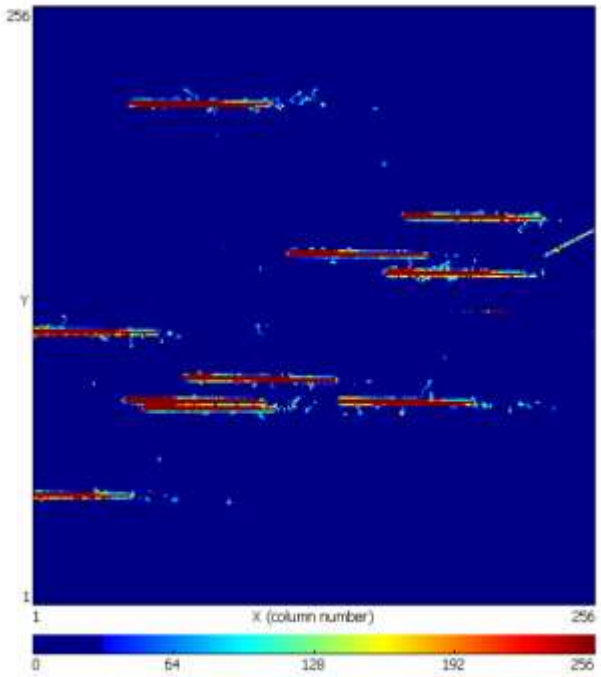
KE (MeV/u)=	100.00	180.00	230.00	290.00	350.00	400.00	430.00	500.00	600.00	650.00	800.00
He (KeV/mm)	5.42	3.60	3.09								
He (KeV)	231.14	433.00	566.81								
C (KeV/mm)	48.74	32.43	27.81	24.32	22.02	20.63	19.96				
C (KeV)	231.19	433.09	566.94	735.32	912.18	1066.04	1161.19				
N (KeV/mm)	66.34	44.14	37.85	33.10	29.97	28.09	27.17				
N (KeV)	231.19	433.10	566.95	735.33	912.20	1066.06	1161.21				
O (KeV/mm)	86.85	57.65	49.43	43.24	39.15	36.68	35.49				
O (KeV)	231.19	433.10	566.95	735.34	912.21	1066.08	1161.23				
Ne (KeV/mm)	135.38	90.08	77.24	67.56	61.17	57.32			48.55		
Ne (KeV)	231.20	433.11	566.96	735.36	912.25	1066.10			1740.46		
Si (KeV/mm)	265.35	176.55	151.39	132.41	119.89	112.35			95.15		87.18
Si (KeV)	231.20	433.12	566.97	735.37	912.25	1066.12			1740.51		2509.10
Ar (KeV/mm)		*291.85		218.88		185.71				153.11	
Ar (KeV)		433.13		735.38		1066.14				1923.86	
Fe (KeV/mm)		*608.92		*456.68		387.48		351.51			
Fe (KeV)		433.13		735.39		1066.15		1391.58			

Calculated dE/dx

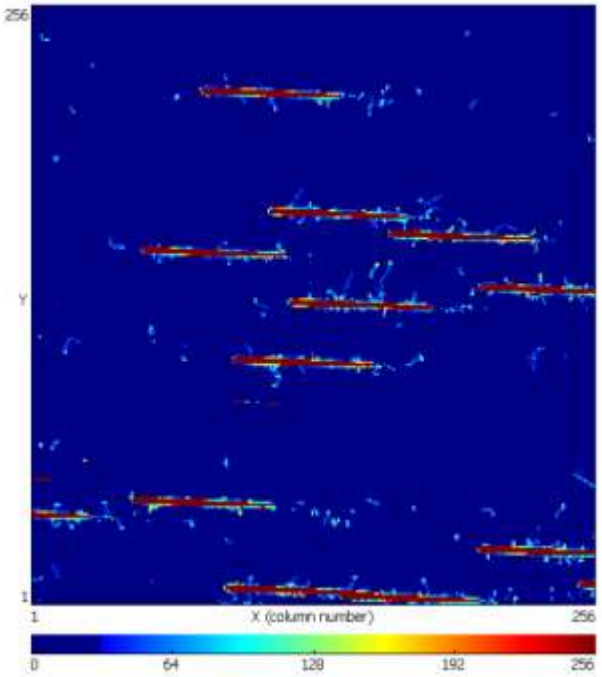
Maximum theoretical δ-ray energy

Summary

180 MeV/A ^{12}C



430 MeV/A ^{16}O



Si Timepix sensors are capable of distinguishing higher energy delta rays from the core ion track

The extraction and use of the delta ray spectrum on a per-cluster basis is promising for identification of heavy ion z and *v*

Thank you for your attention!