Advanced Electronics for the SONTRAC Neutron Spectrometer

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NASA

Goddard SPACE FLIGHT CENTER

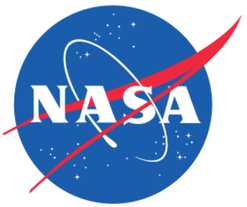
Acronyms

ASIC – Application Specific Integrated Circuit

FPGA – Field Programmable Gate Array

SiPM – Silicon Photomultiplier

SONTRAC – SOlar Neutron TRACking



SOlar Neutron TRACking (SONTRAC) Team

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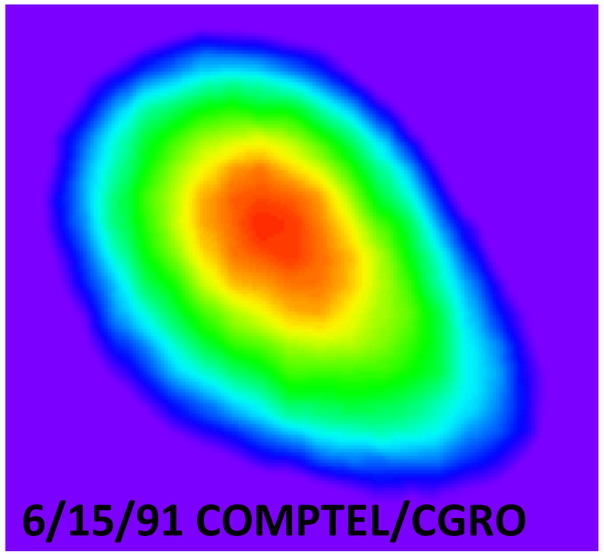
To be presented by George Suarez Martinez at the 2019 IEEE Nuclear Science Symposium (NSS) and Medical Imaging Conference (MIC), Manchester, United Kingdom, October 26 to November 2, 2019.

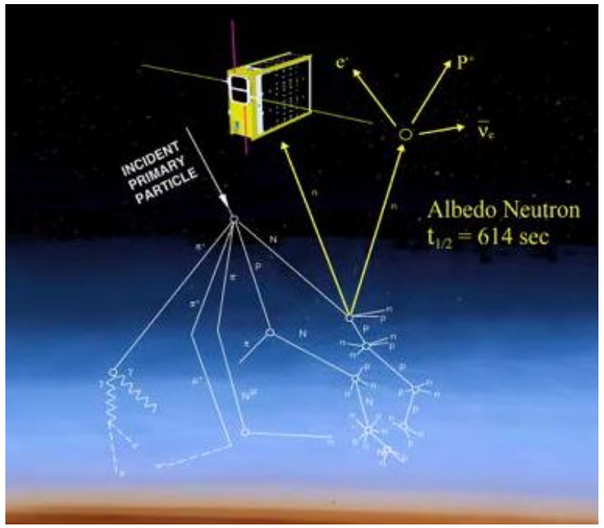
Background

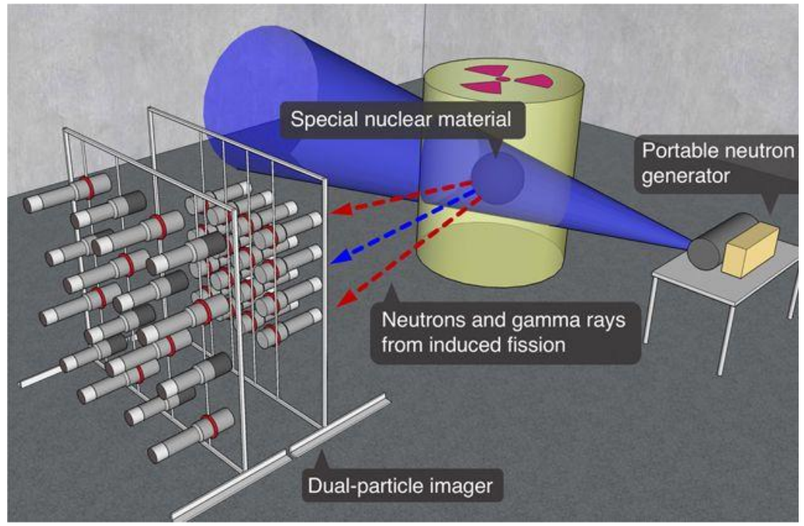
Measure:

- Albedo neutrons
- Solar Neutrons

Major interest in small instruments for CubeSats







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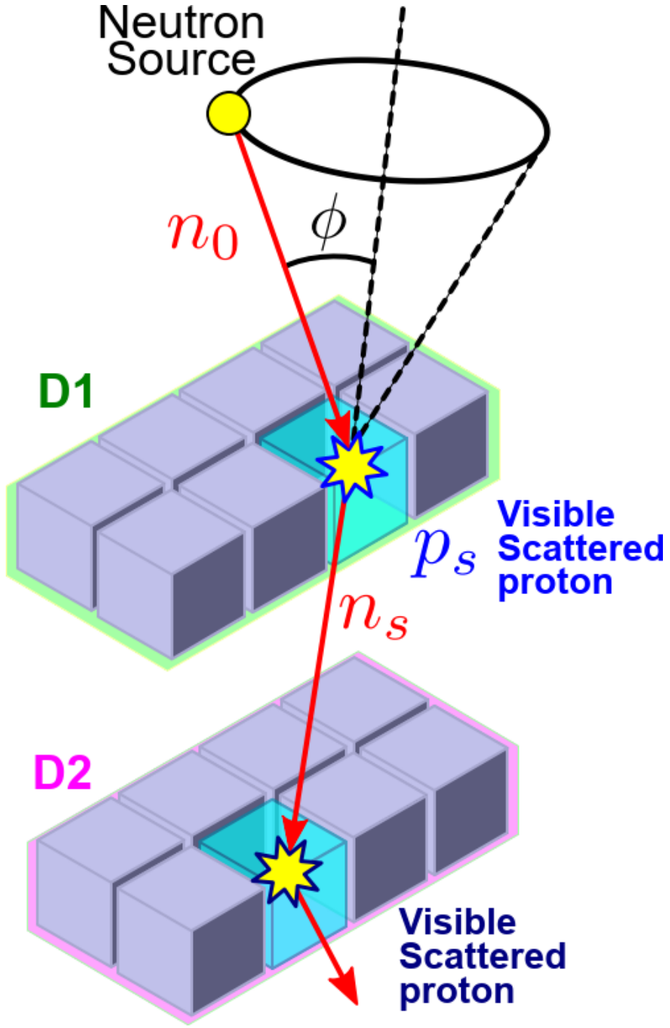
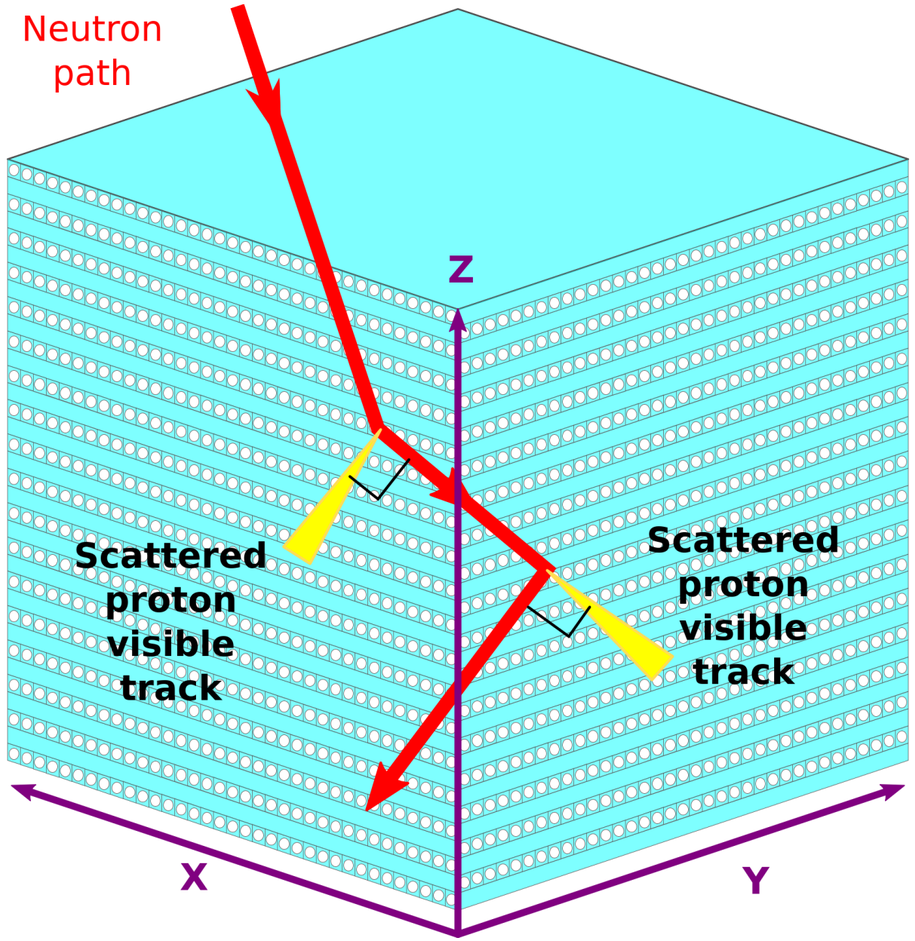
SONTRAC 3D Neutron Spectrometer



Double scatter

Measure both energy and direction.



Neutron Imaging

To be presented by George Suarez Martinez at the 2019 IEEE Nuclear Science Symposium (NSS) and Medical Imaging Conference (MIC), Manchester, United Kingdom, October 26 to November 2, 2019.

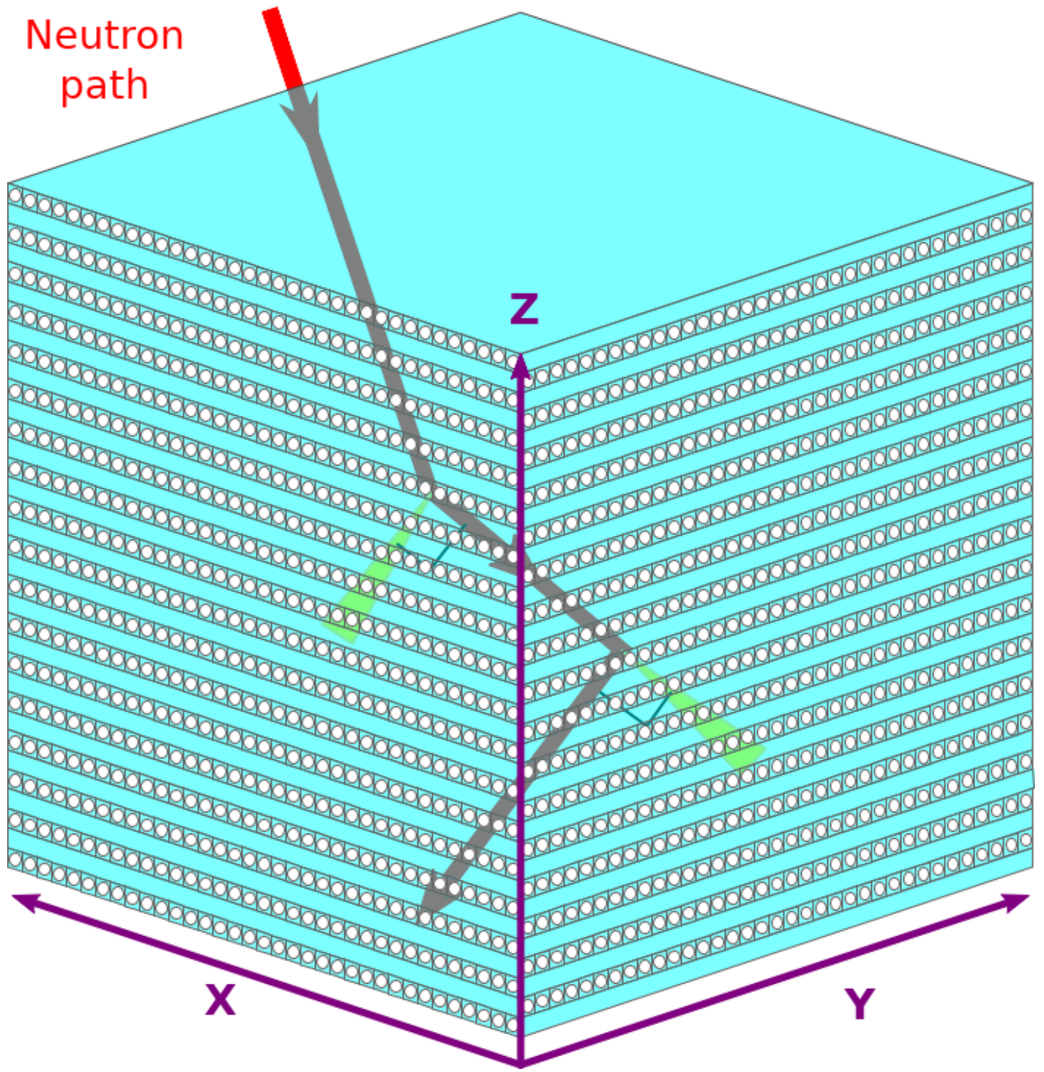
SONTRAC 3D Neutron Spectrometer

Current design:

- 5cm cube with 1.36mm fibers built at the University of New Hampshire.
- Read by 1mm SiPMs with 1.36mm pitch

Problem:

- Reading all the fibers requires 32x32x2 = 2048 channels!
- Impractical for small instruments targeting small satellites (e.g. CubeSats)



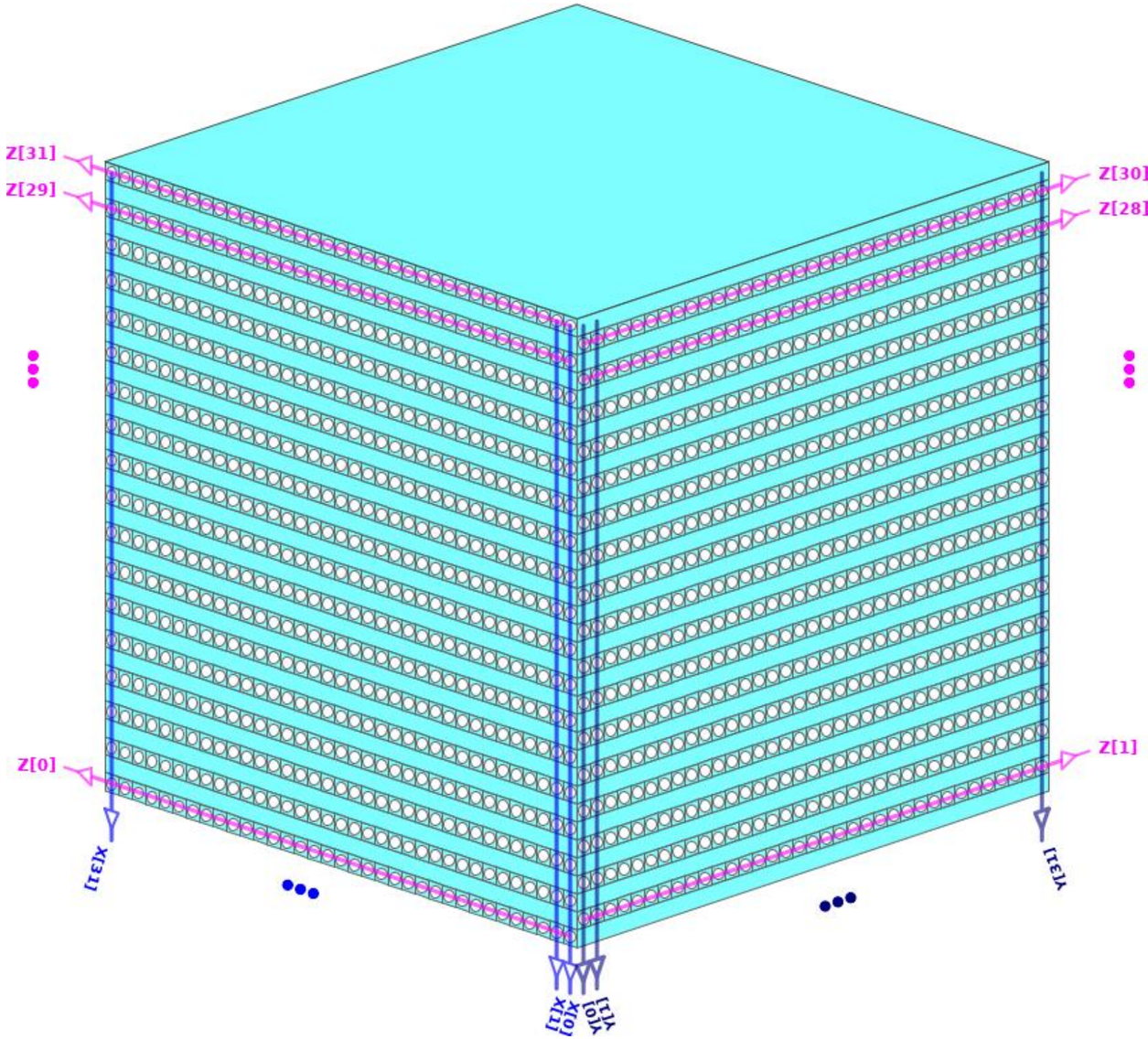
SONTRAC 3D Neutron Spectrometer

Possible solution:

- Strip readout (1D Projections)
- Only need 32x3 = 96 channels
- Events are encoded in strips
- Reconstruction needed

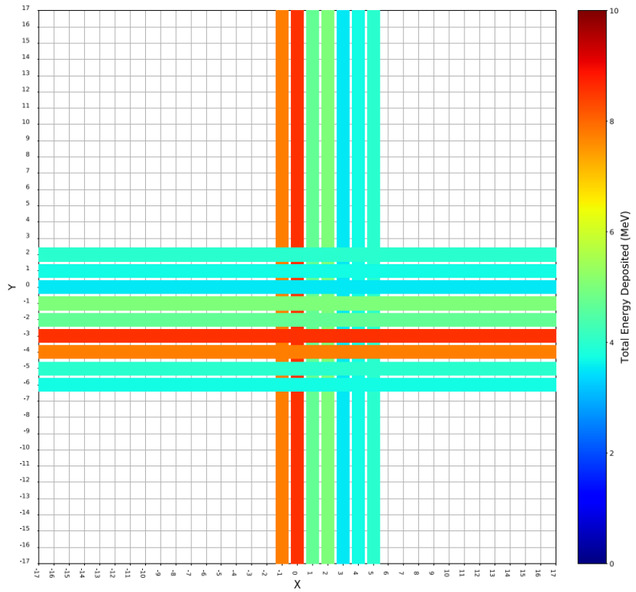
Main limitation:

- Some events will be ambiguous (more on this later).

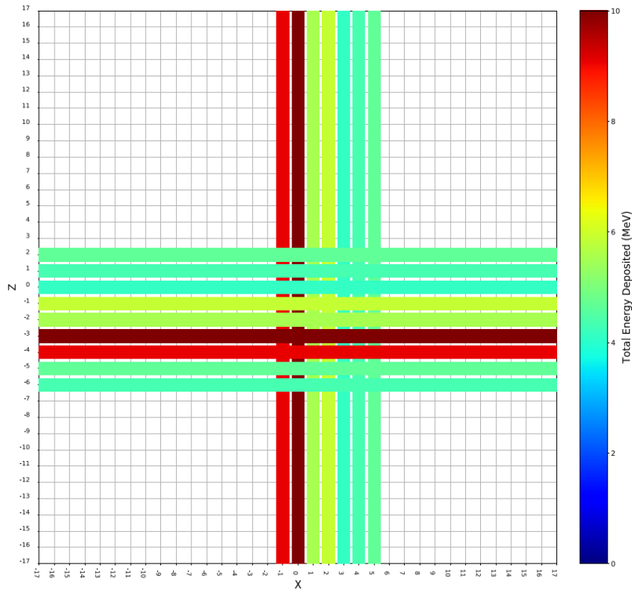


SONTRAC 3D Neutron Spectrometer

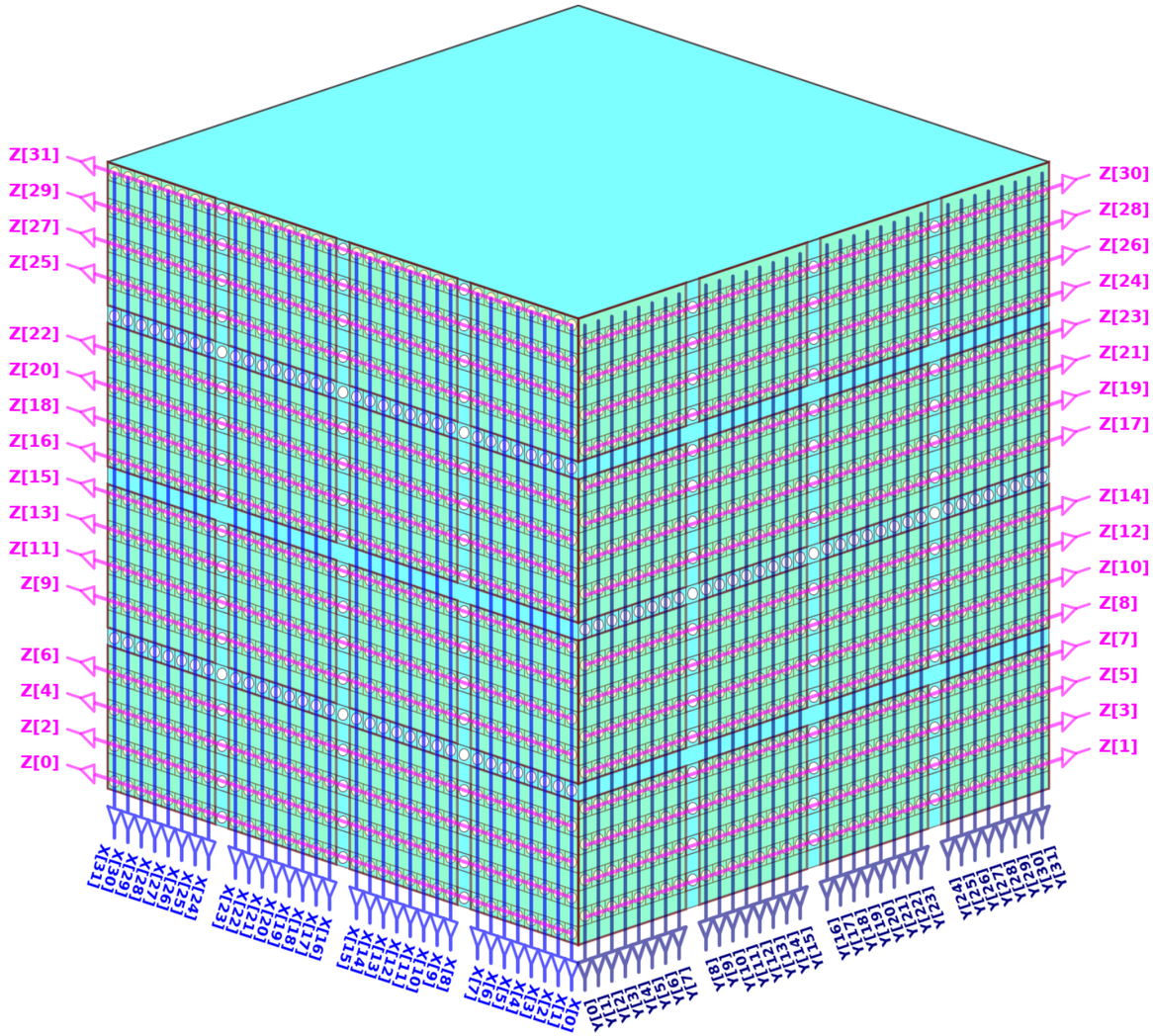
- Three 1D projections are needed
- X, Y are vertical strips
- Z is formed by horizontal strips



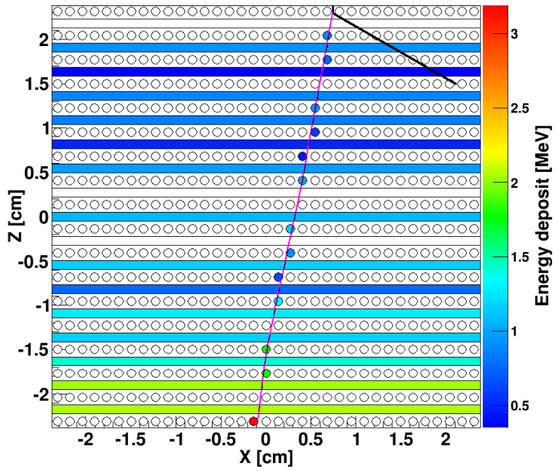
X vs Y

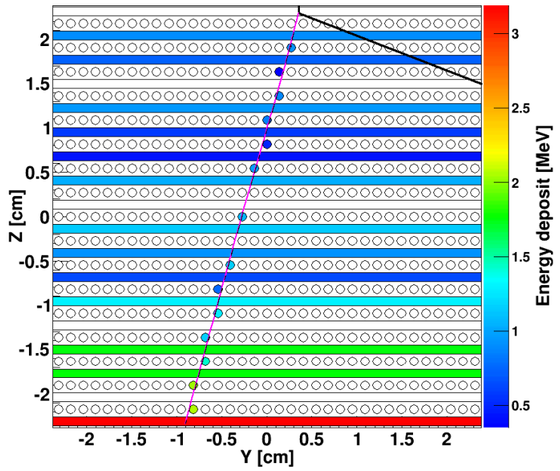


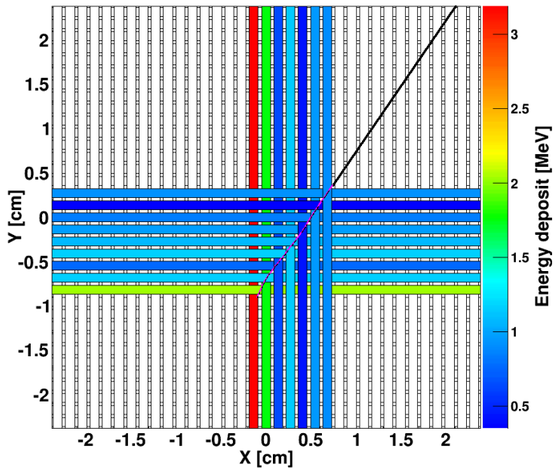
X vs Z



SONTRAC - Track Reconstruction Single Scatter





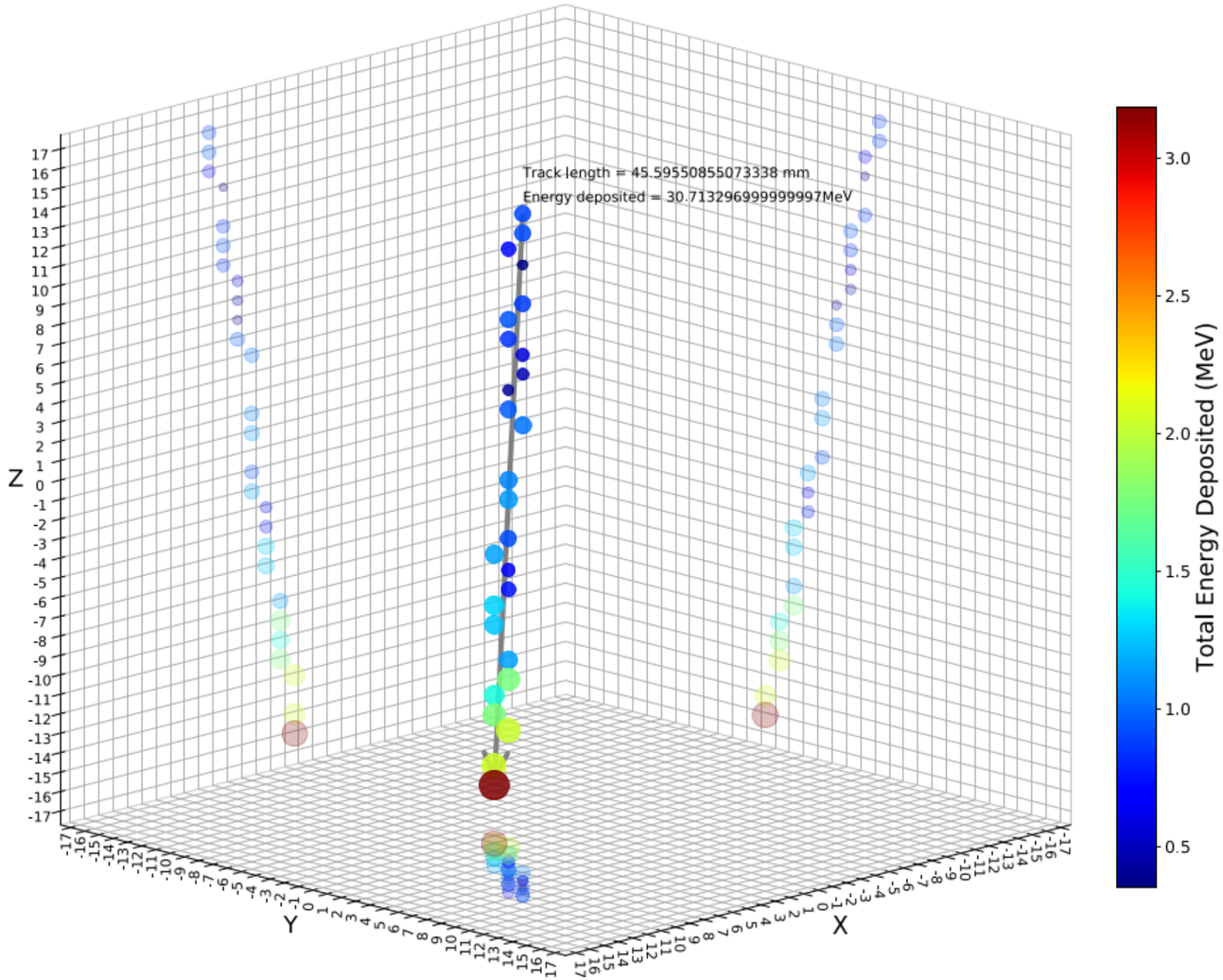


Neutron: E_{ini} = 91.42 MeV
E_{fin} = 8.38 MeV

1st proton: E = 83.05 MeV
hit fibers = 27 (13 pairs)
track length = 48.77 mm
tot. E_{loss} = 30.71 MeV

2nd proton: E = 0.00 MeV
hit fibers = 0 (0 pairs)
track length = 0.00 mm
tot. E_{loss} = 0.00 MeV

Epoxy E_{loss} = 47.87 MeV



Geant4 simulation (double scatter)
Dr. Alessandro Bruno/NASA GSFC

Reconstruction

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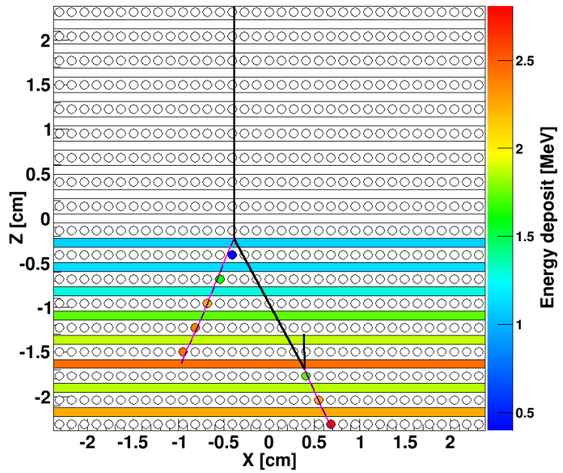
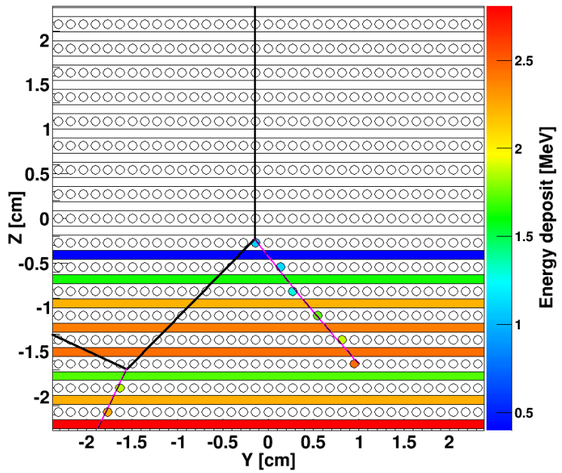
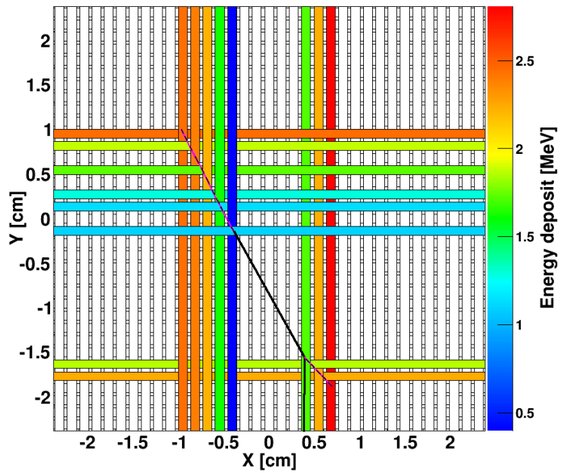
SONTRAC - Track Reconstruction Double Scatter





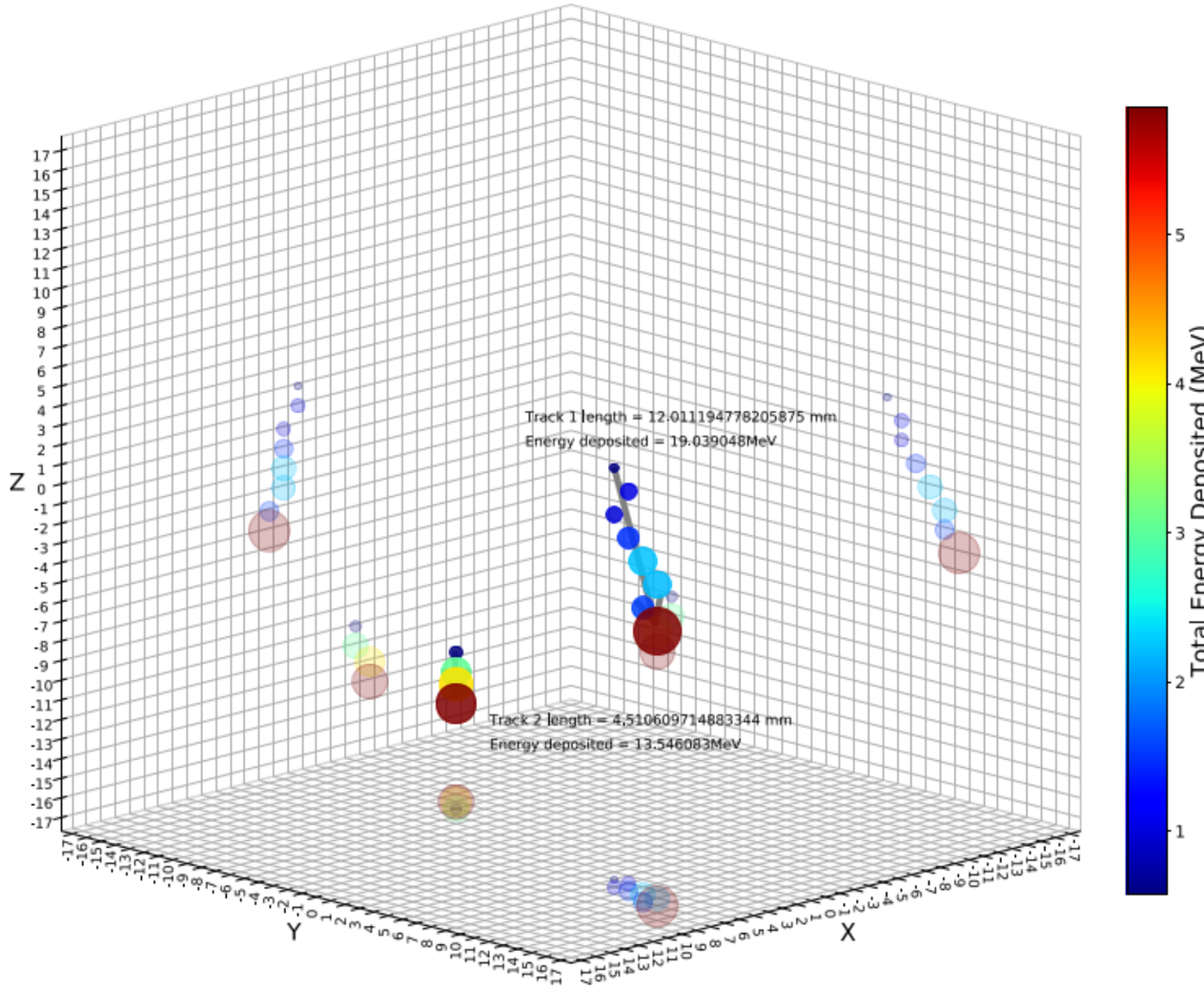


Neutron: E_{ini} = 91.42 MeV
E_{fin} = 18.17 MeV

1st proton: E = 51.39 MeV
hit fibers = 11 (5 pairs)
track length = 18.99 mm
tot. E_{loss} = 18.65 MeV

2nd proton: E = 36.70 MeV
hit fibers = 5 (2 pairs)
track length = 7.99 mm
tot. E_{loss} = 10.86 MeV

Epoxy E_{loss} = 37.31 MeV



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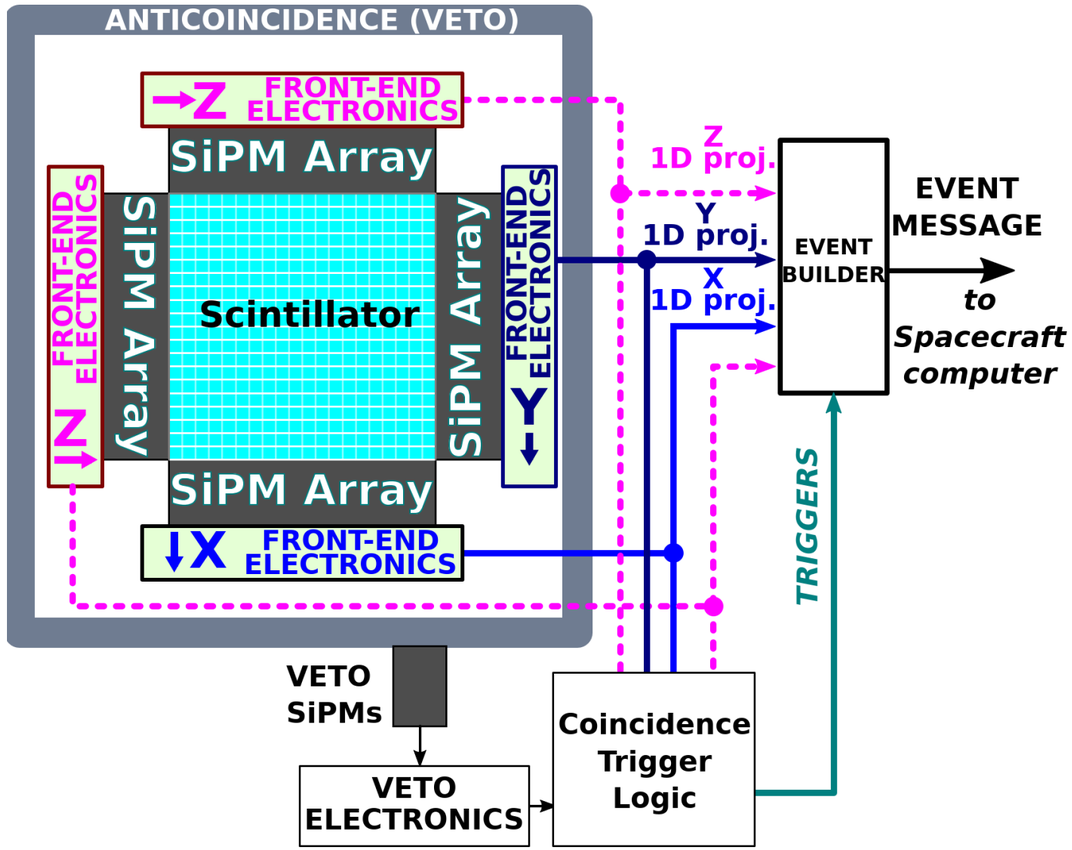
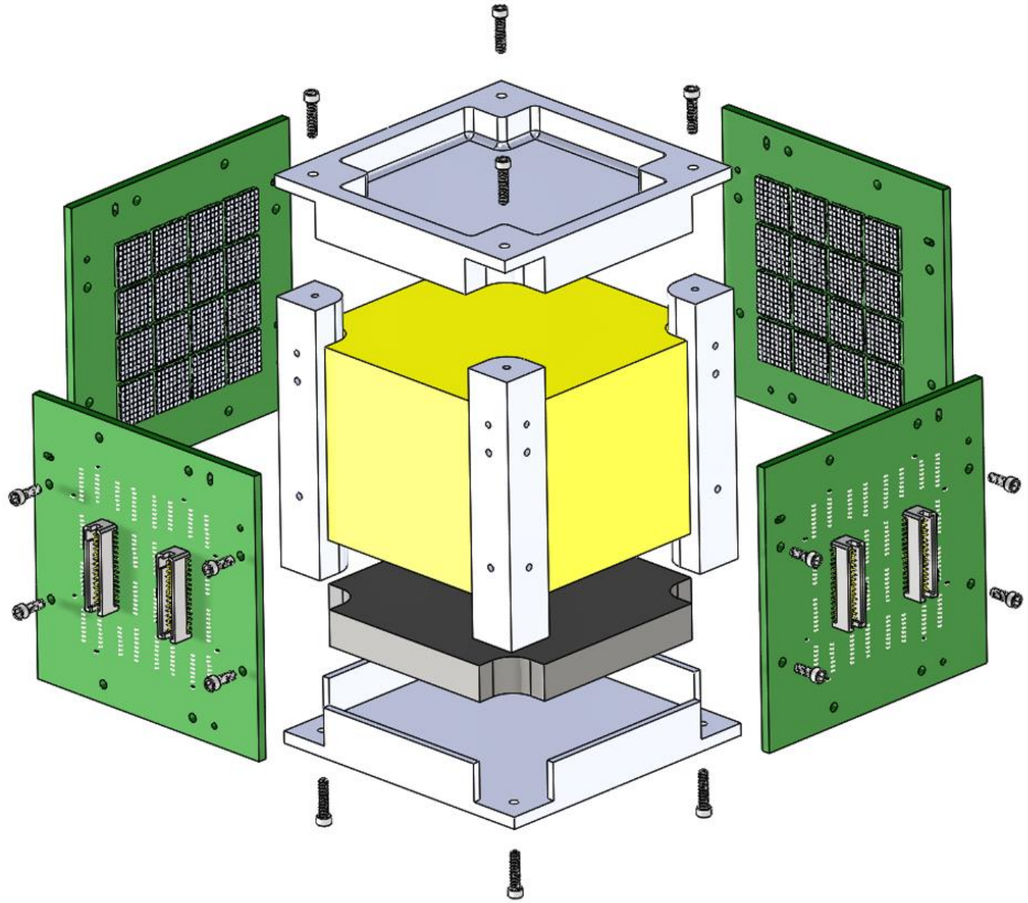
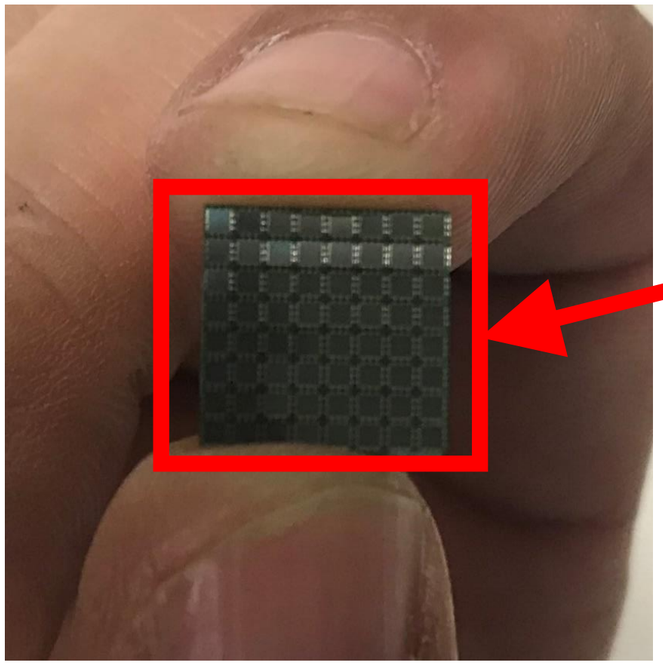


Instrument Concept

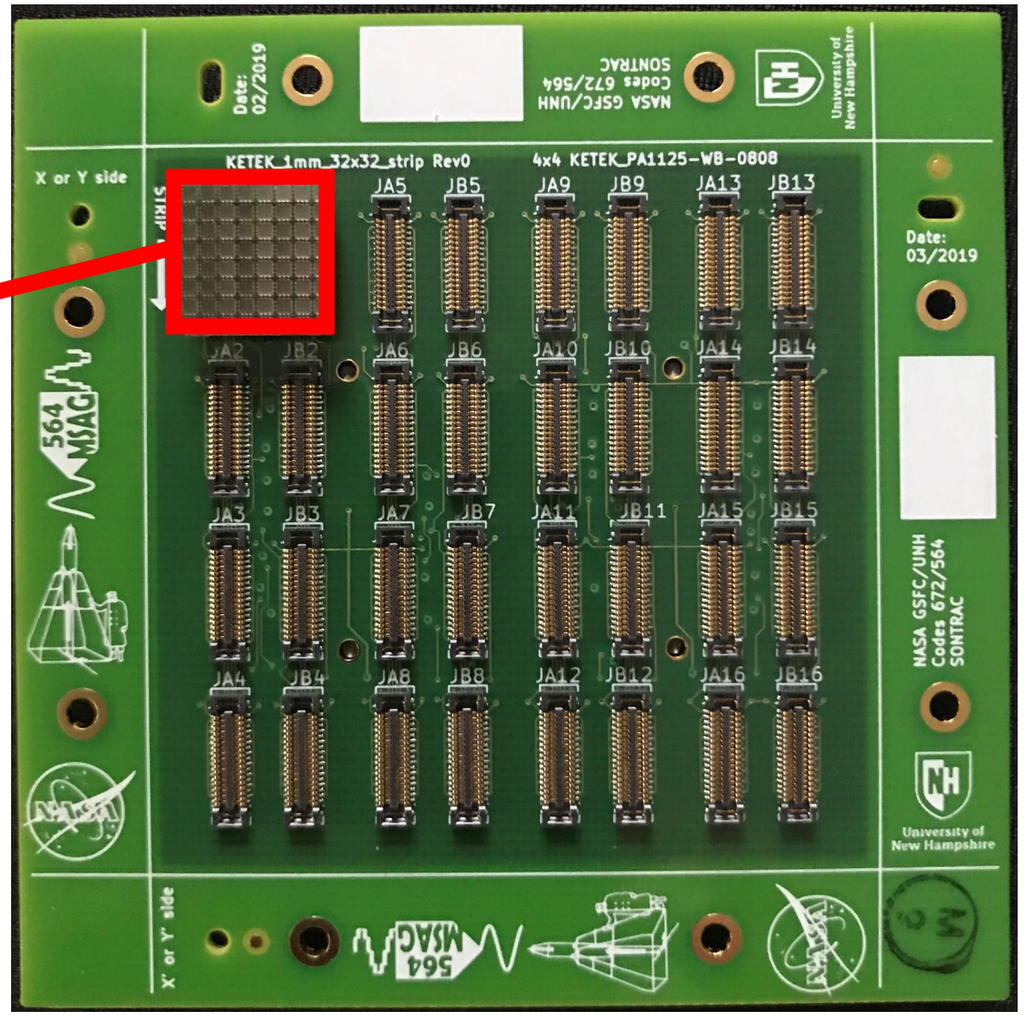


Fiber bundle with SiPM array boards (Mechanical)

SONTRAC – SiPM boards

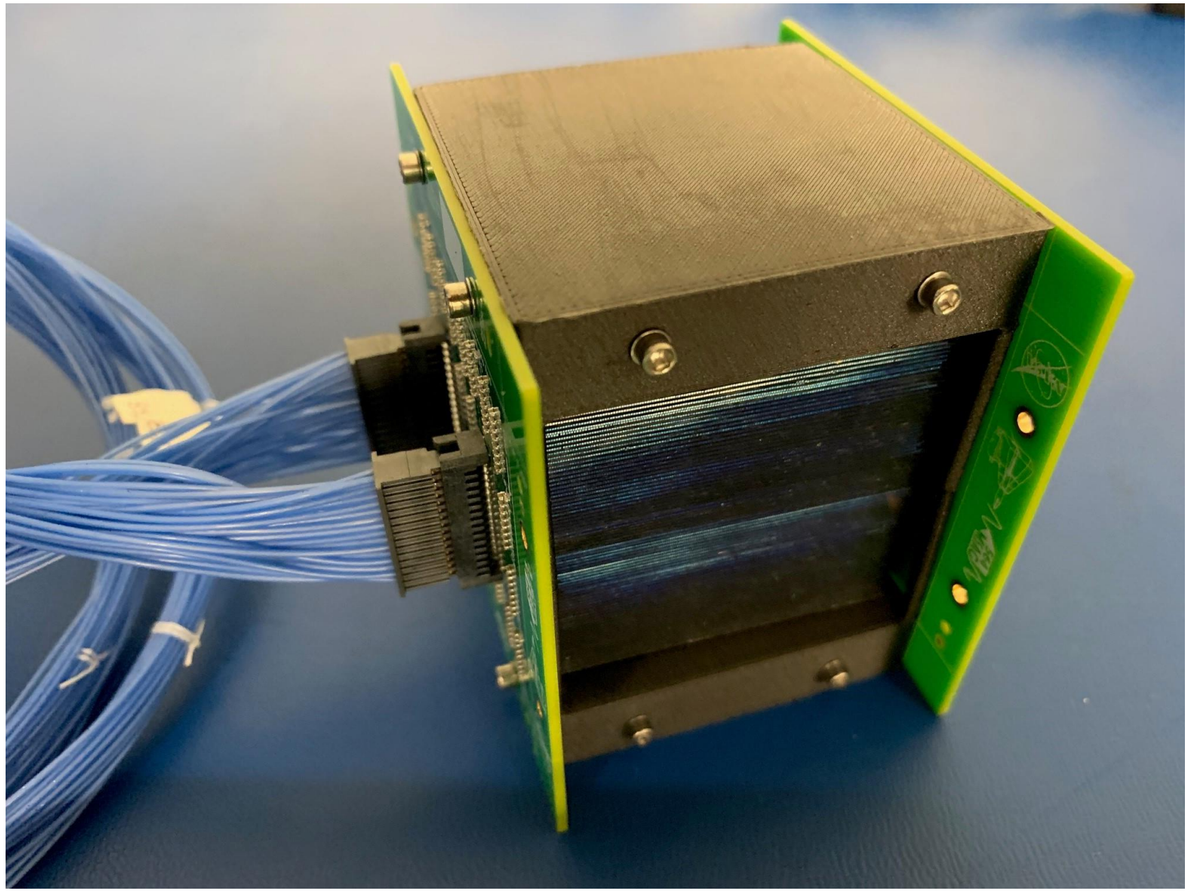


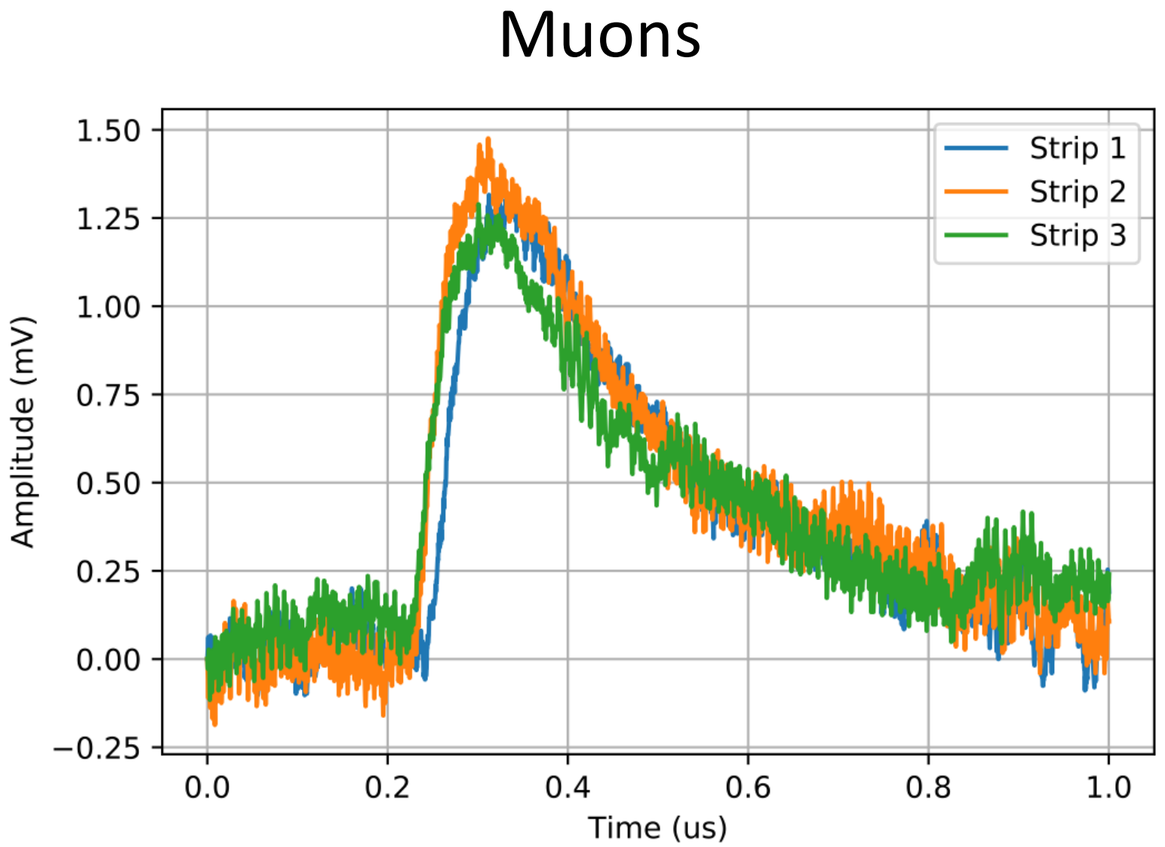
1mm 8x8 SiPM arrays



1mm 32x32 Strip Board

SONTRAC – Prototyping with 300 µm Fiber Bundle





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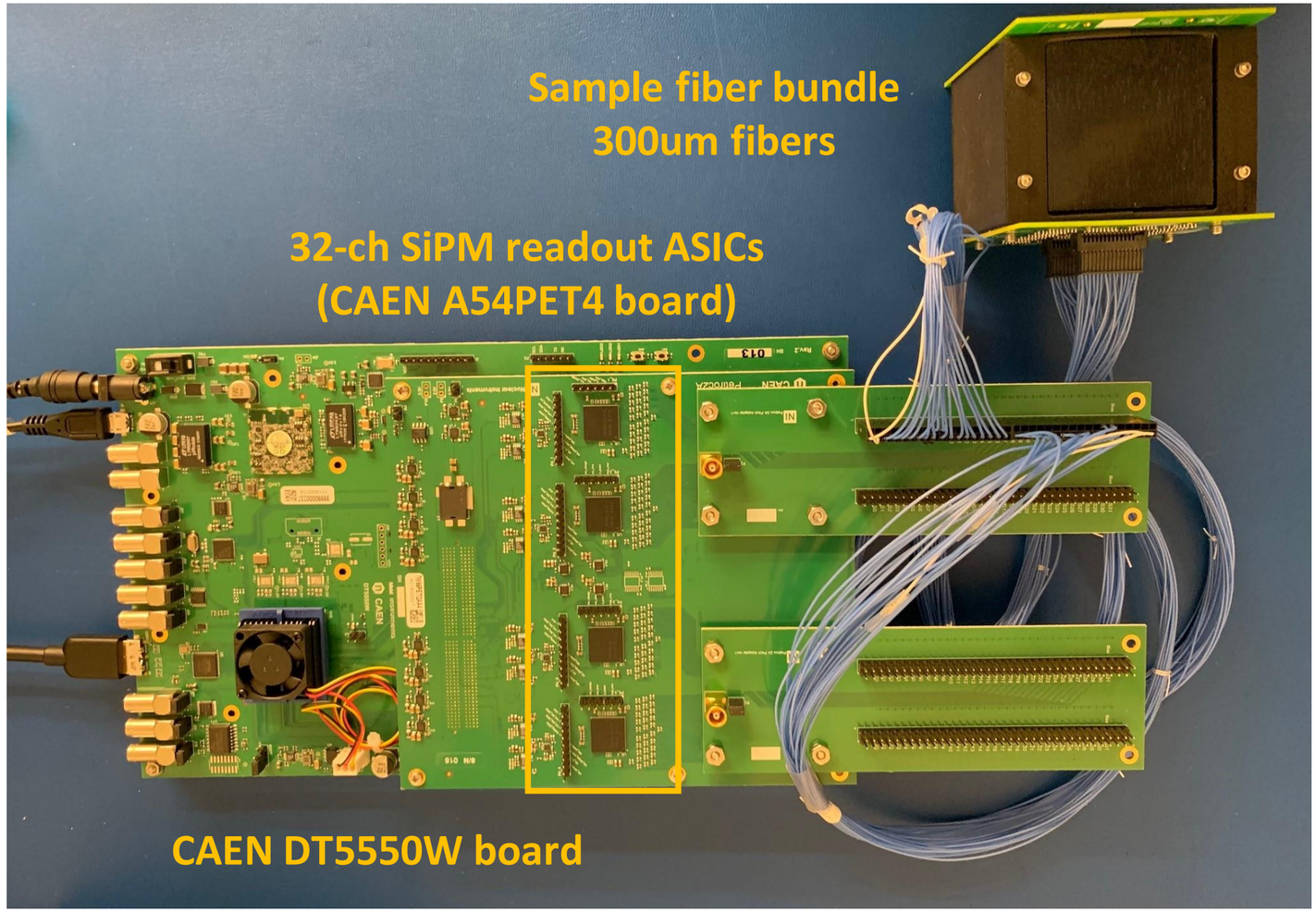
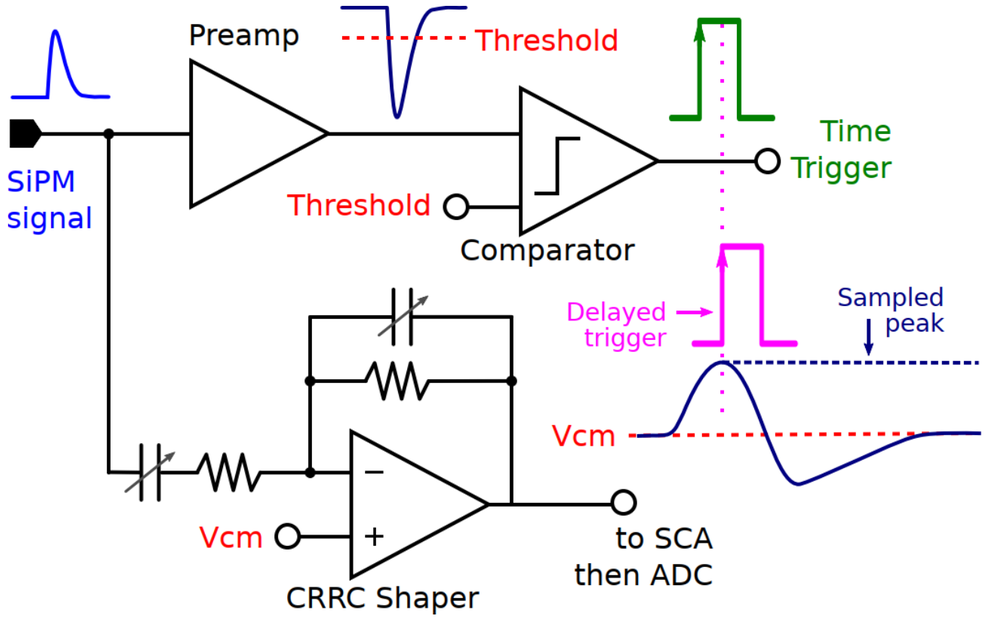
SONTRAC – Readout CAEN DT5550W with Petiroc2 chips

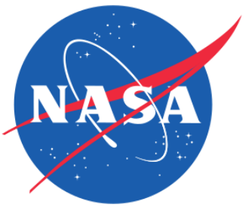


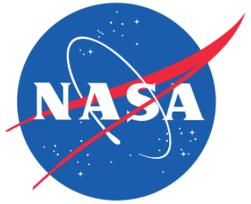


Petiroc2 ASIC channel

Future Work

- Evaluate 5cm fiber bundle science model with SiPMs configured as strips using Muons.
- Prepare for accelerator run in 2020.
- Explore smaller pitch (1.2mm) Hamamatsu 1mm SiPMs.
- Explore ASICs with 64-channels such as the PETsys TOFPET2ET and Weeroc Triroc 1A ASICs.
- Custom design with readout ASICs and FPGA.





Q&A