BERKELEY LAB

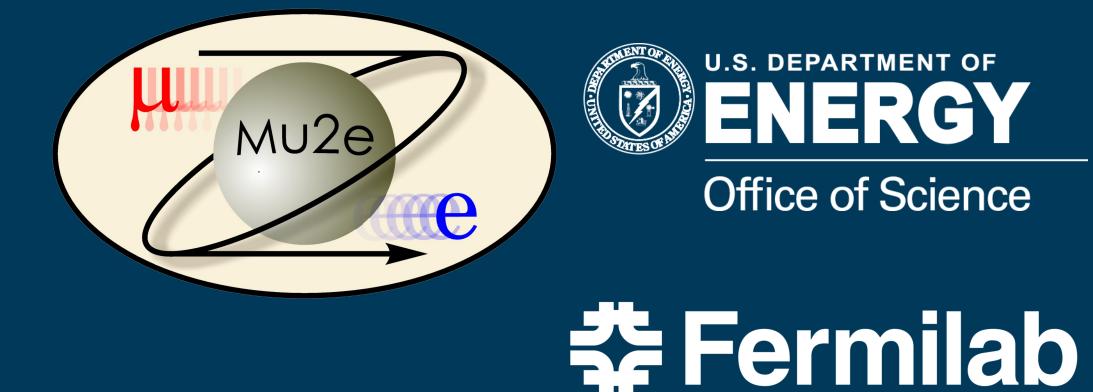
Front-end electronics for the Mu2e tracker

<70W)

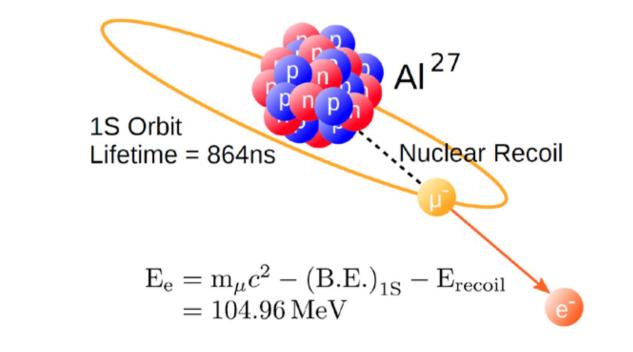


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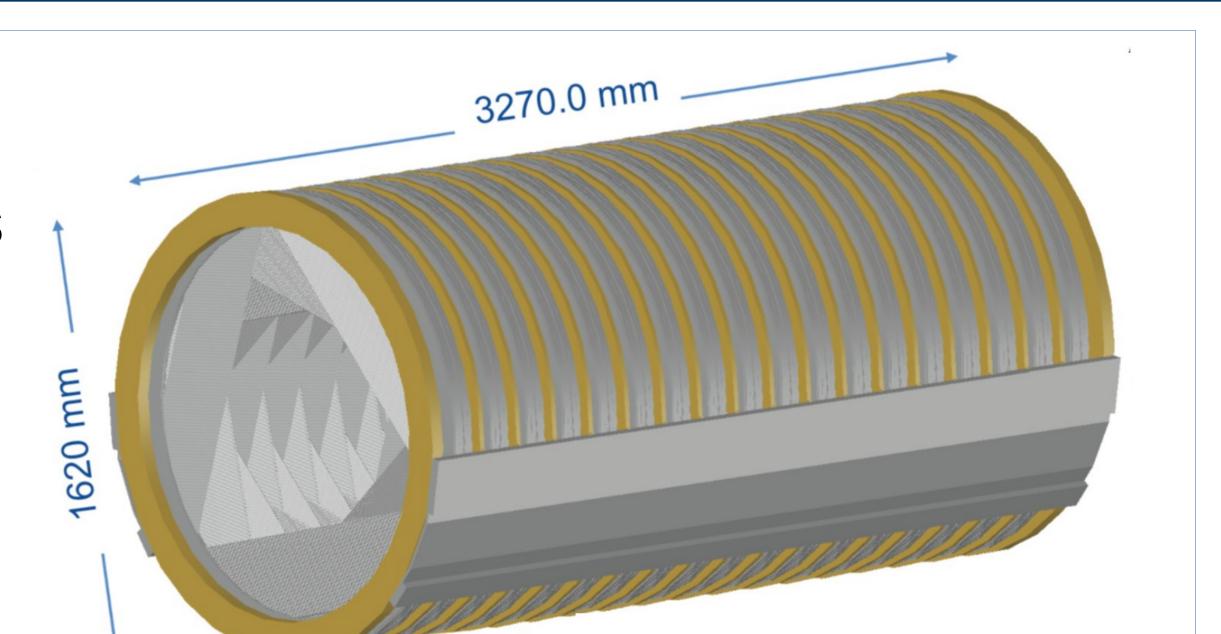


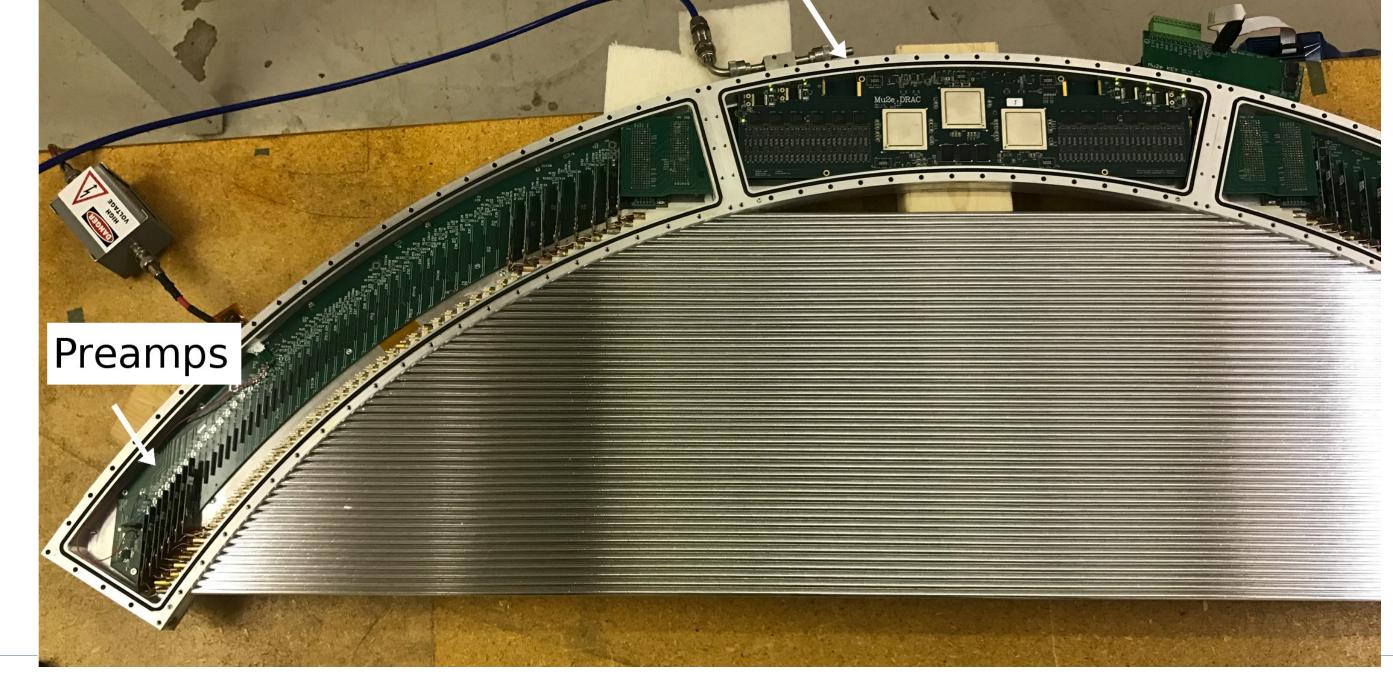
Overview

The Mu2e experiment will search for charged lepton flavor violating muon to electron conversion with a sensitivity four orders of magnitude better than previous experiments. The signature of this process is a 105 MeV/c electron, which will be detected using a cylindrical straw tube tracker, consisting of ~21,000 low mass straws grouped into panels of 96 straws each.

DRAC: Digitizer, Readout, Assembler and Controller

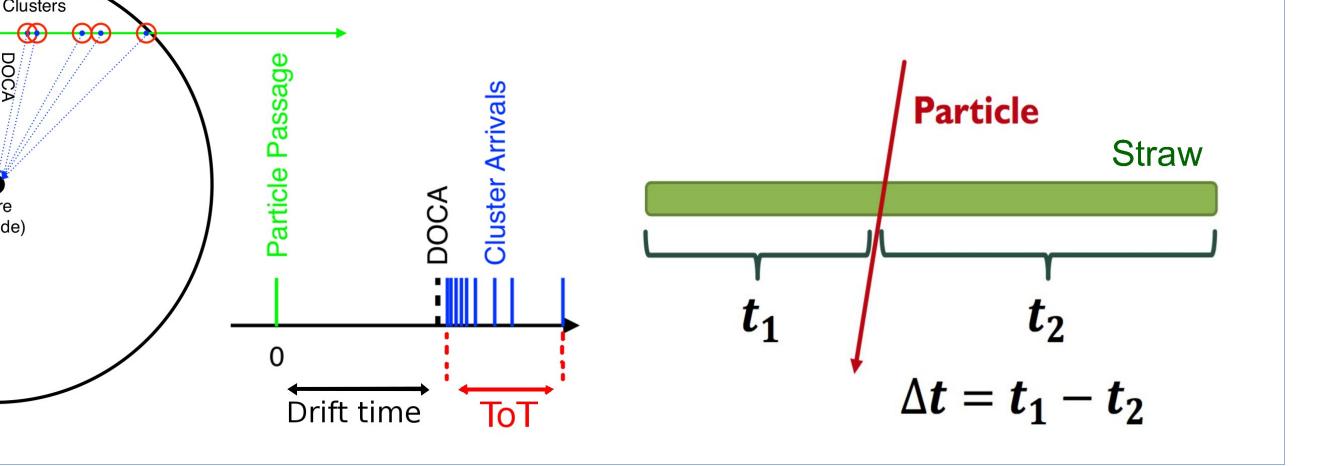
Front end electronics housed in the





- outer part of each panel Preamps on each end of straw • Single digitizer and readout board per panel (DRAC) Measure radial and longitudinal
- position of track in each hit straw, time over-threshold, digitized waveform • Total power usage ~50W (requirement

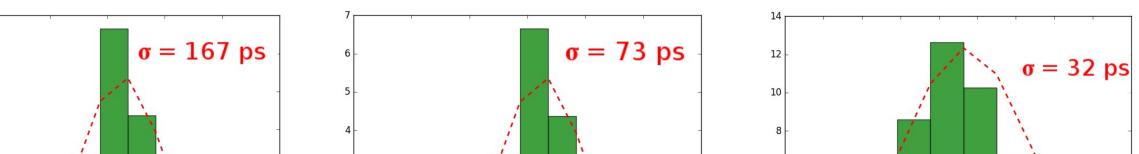
The Mu2e tracker consists of 36 circular planes each containing 6 panels of 96 straws



DRAC



- Firmware TDC uses multiple delay chains to increase precision
- balance resource usage vs resolution – 96 TDCs with 70 ps resolution in each MPF300 FPGA



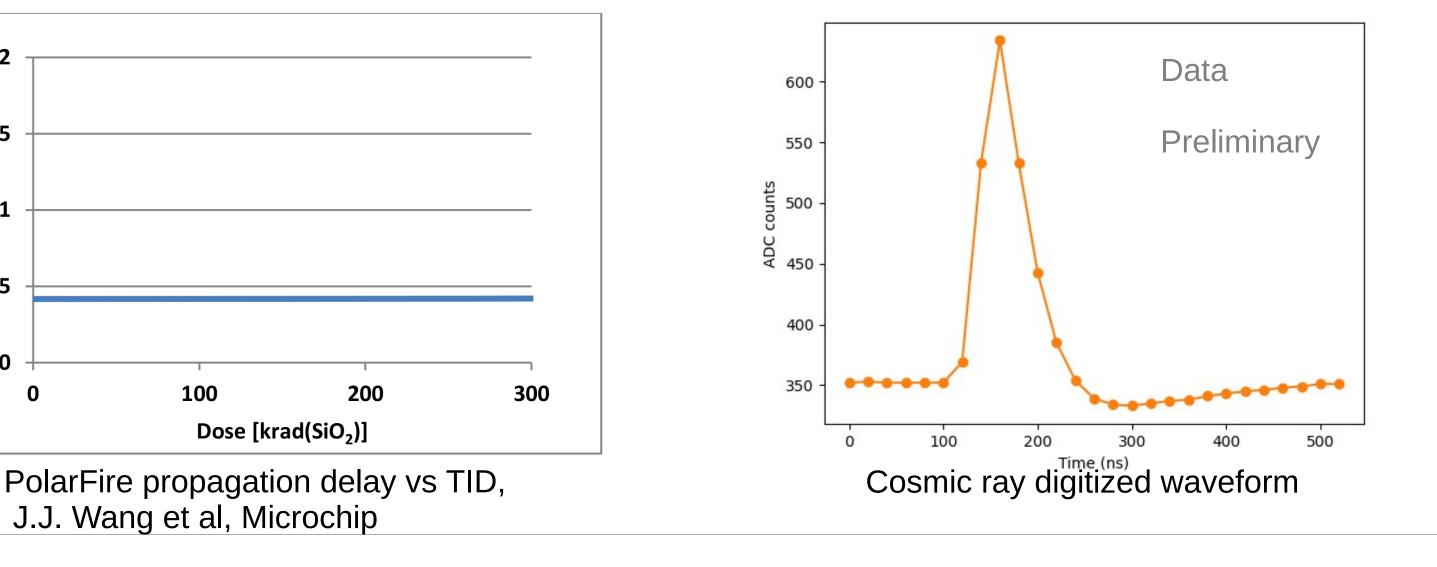
Preamplifiers

- Each instruments two straws
- Signal shaping and baseline restoration
- Per-channel threshold / gain adjustment
- Remote HV disconnect
- Charge injection for calibration

- 3x Microchip PolarFire FPGAs – configuration memory immune to SEE
- timing performance not sensitive to TID precision firmware TDCs
- remotely programmable
- 4 GB of DDR3 memory for data buffering Pre-event building to sort and count hits 2 Gbps optical fiber connection to TDAQ over VTRx transceiver

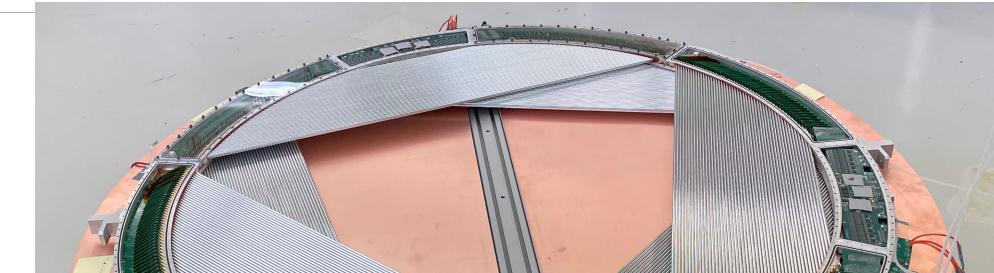
Δt (ns) Δt (ns) Firmware TDC resolution with 1 chain (left), 3 chains (center), and 8 chains (right) • 50 MHz ADCs

digitized waveform for proton hit rejection

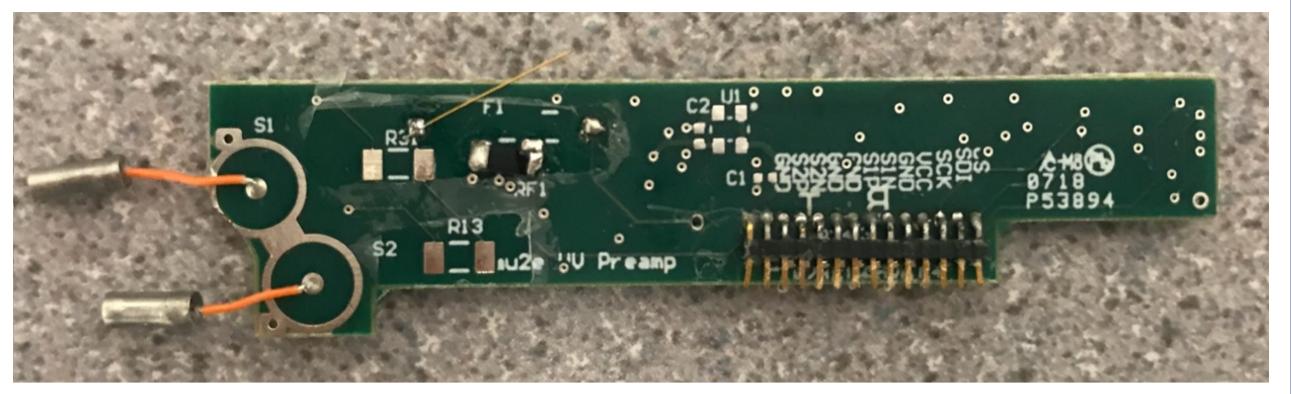


Performance

Straw hit resolution and efficiency demonstrated



Custom straw connector

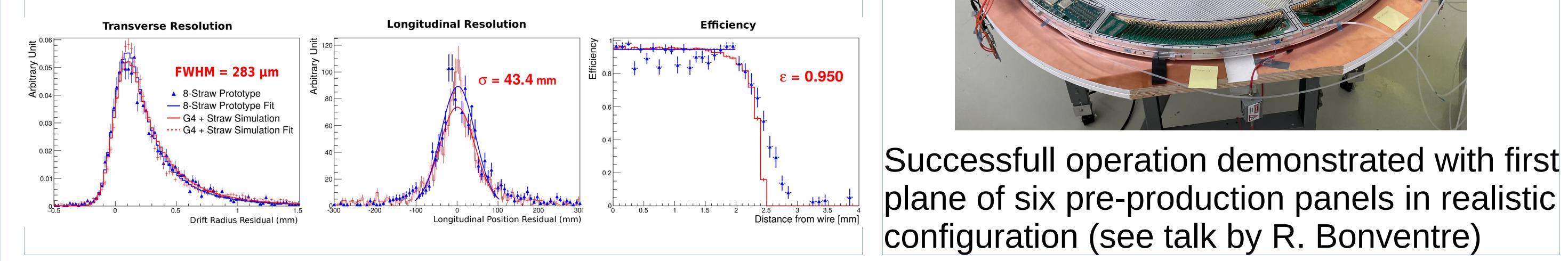


Radiation testing

- Radiation testing of DRAC, preamps and components
- TID: 200 kRad (15x expected)
- NIEL: 2e13 n/cm²1 MeV eq. (12x expected) from McClellan reactor
- SEE: 1e11 p/cm² from 100 MeV/c

proton beam

with cosmic ray data from prototypes



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MICROCHIP

PolarFire

 No latchups or power failures seen • No noticeable changes in operating parameters

SEE test setup at Northwestern Medicine Hospital

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