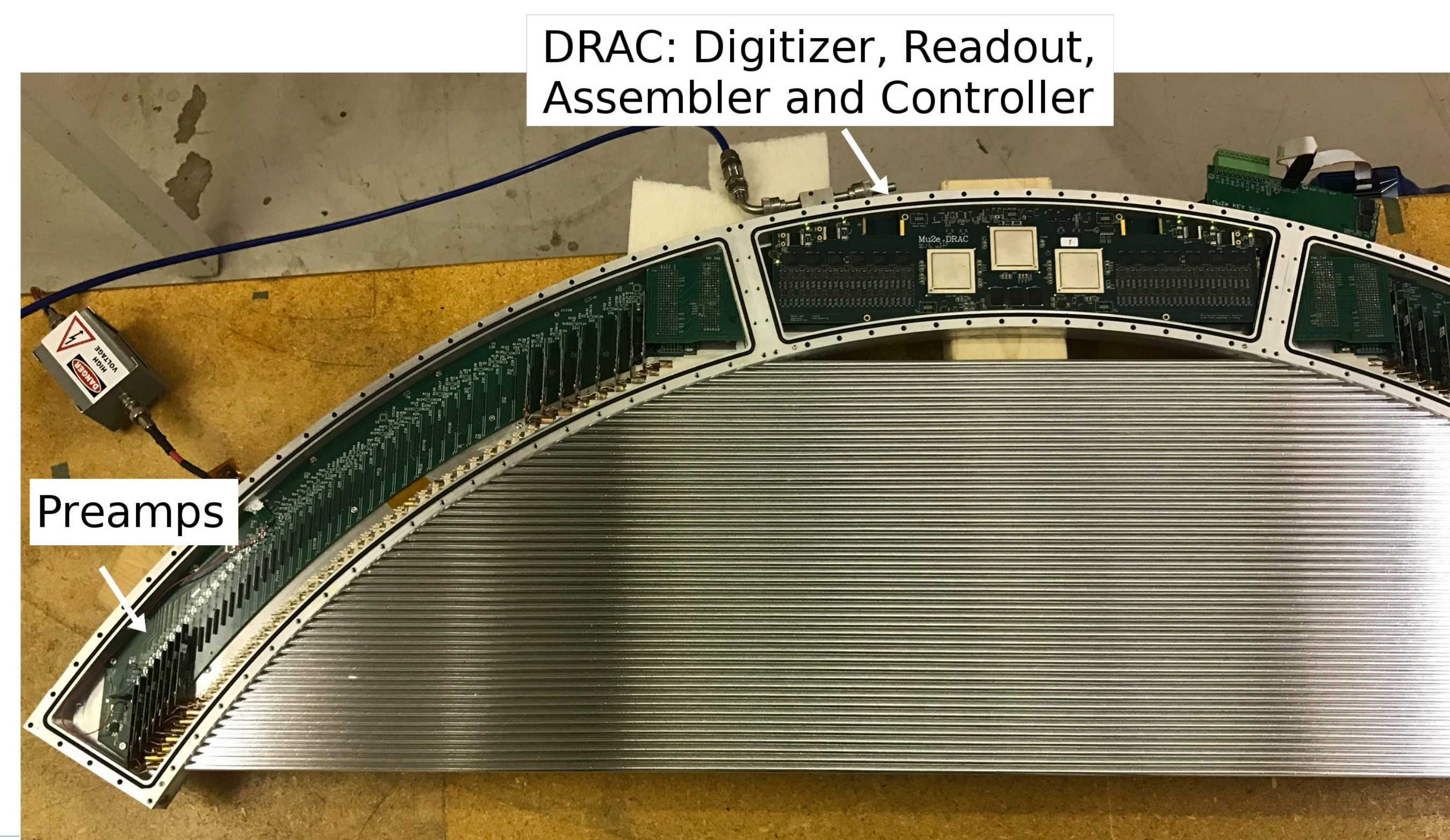
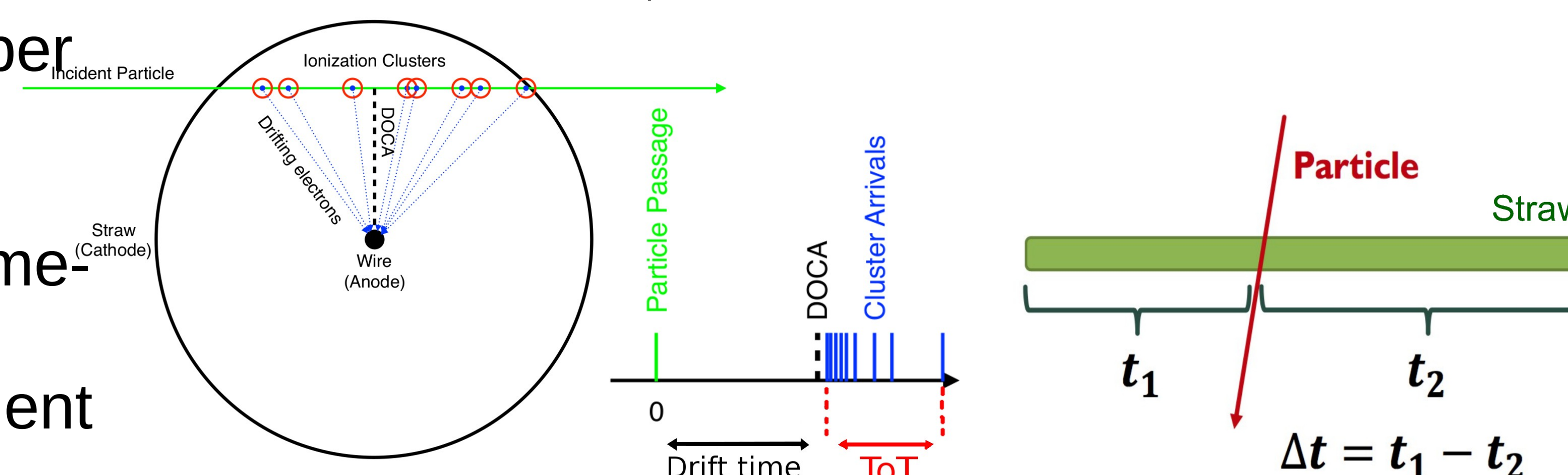


Overview

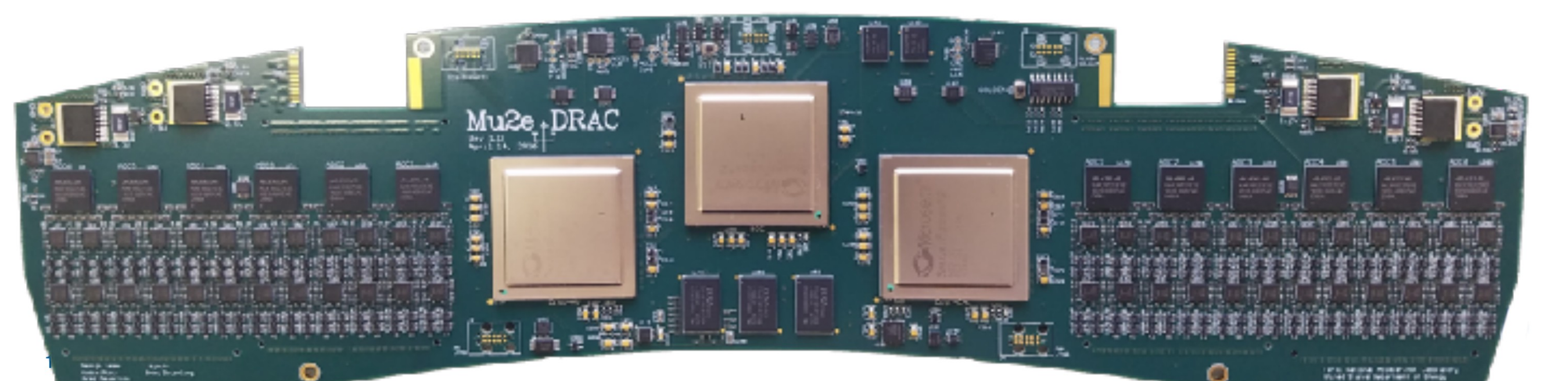
The Mu2e experiment will search for charged lepton flavor violating muon to electron conversion with a sensitivity four orders of magnitude better than previous experiments. The signature of this process is a 105 MeV/c electron, which will be detected using a cylindrical straw tube tracker, consisting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



- 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 <70W)

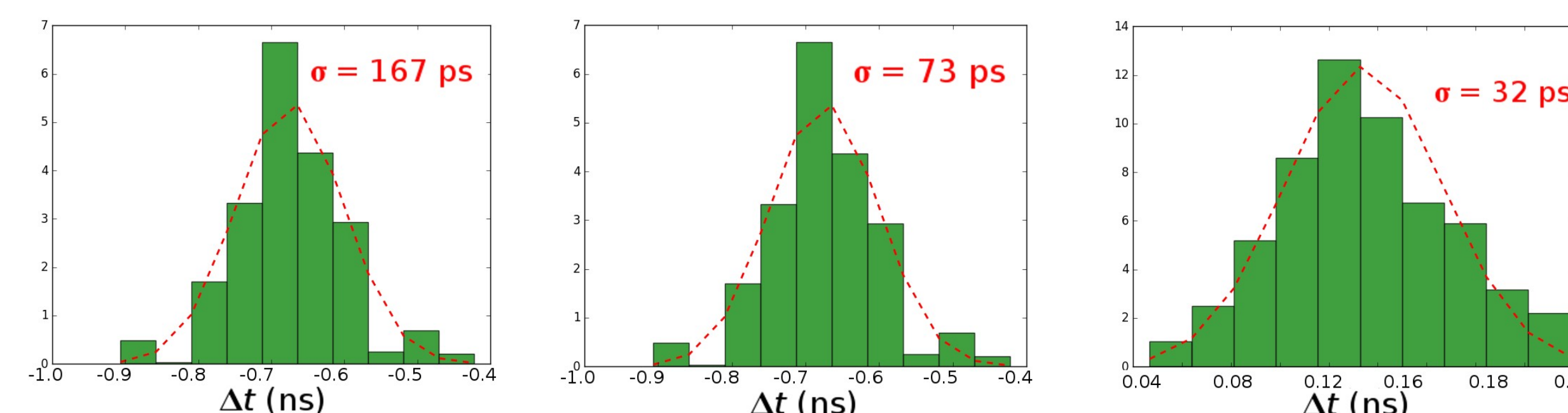


DRAC



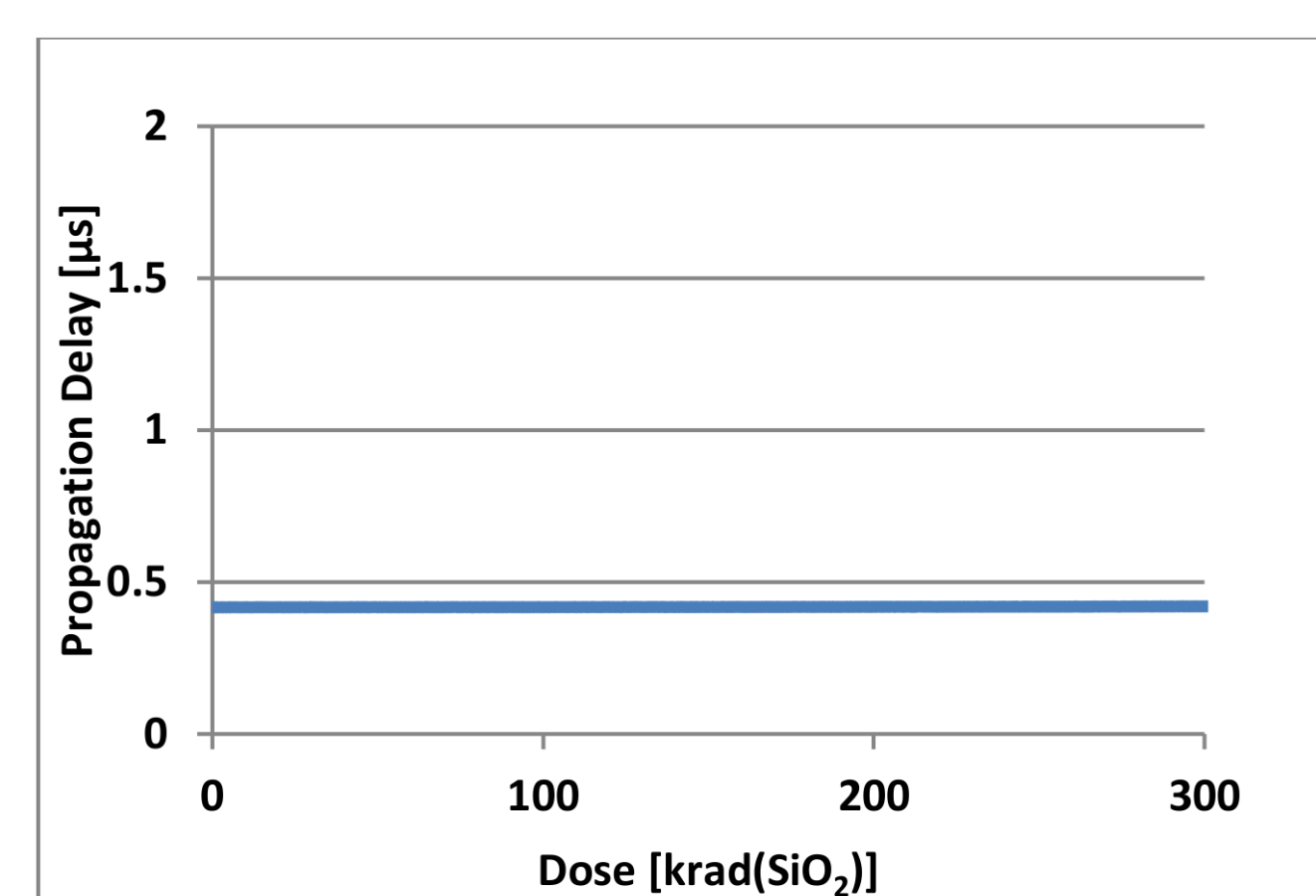
- 3x Microchip PolarFire FPGAs
 - configuration memory immune to SEE
 - timing performance not sensitive to TID
 - precision firmware TDCs
 - remotely programmable
- 4 GB of DDR3 memory for data buffering
- Pre-event building to sort and count hits
- 2 Gbps optical fiber connection to TDAQ over VTRx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

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

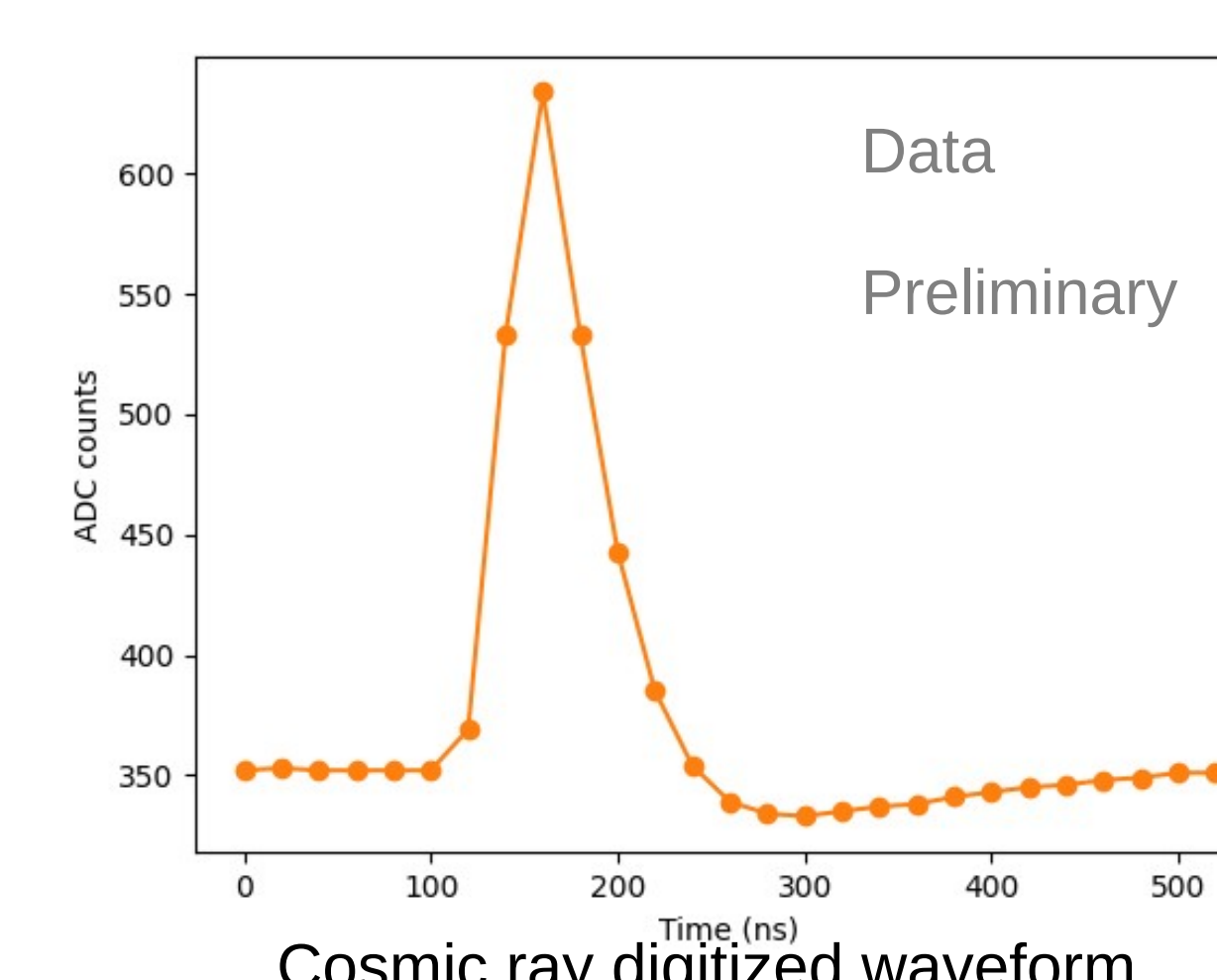


Firmware TDC resolution with 1 chain (left), 3 chains (center), and 8 chains (right)

- 50 MHz ADCs
 - digitized waveform for proton hit rejection



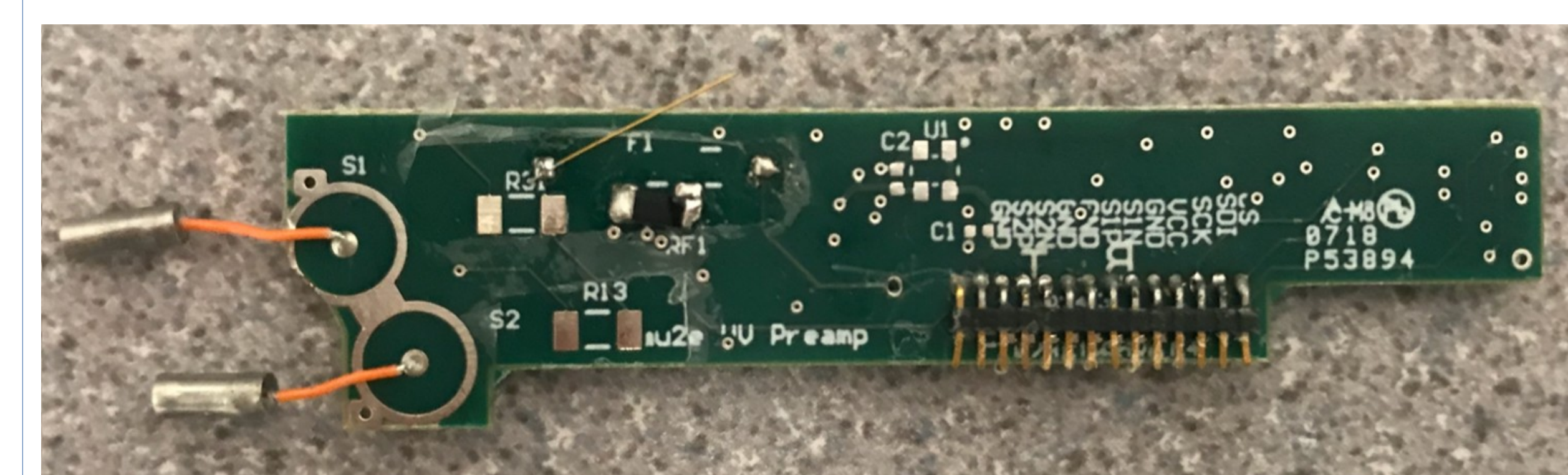
PolarFire propagation delay vs TID, J.J. Wang et al, Microchip



Cosmic ray digitized waveform

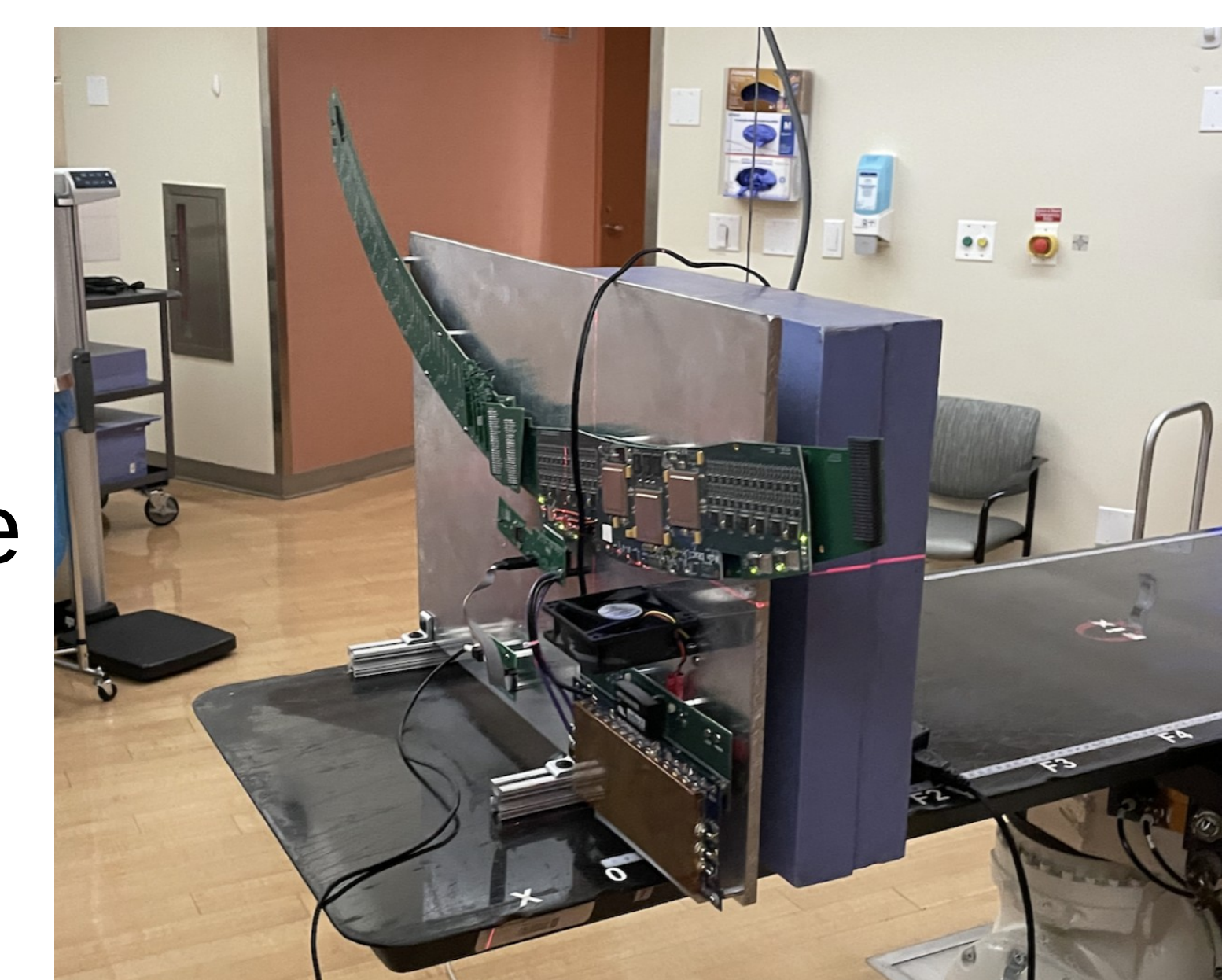
Preamplifiers

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



Radiation testing

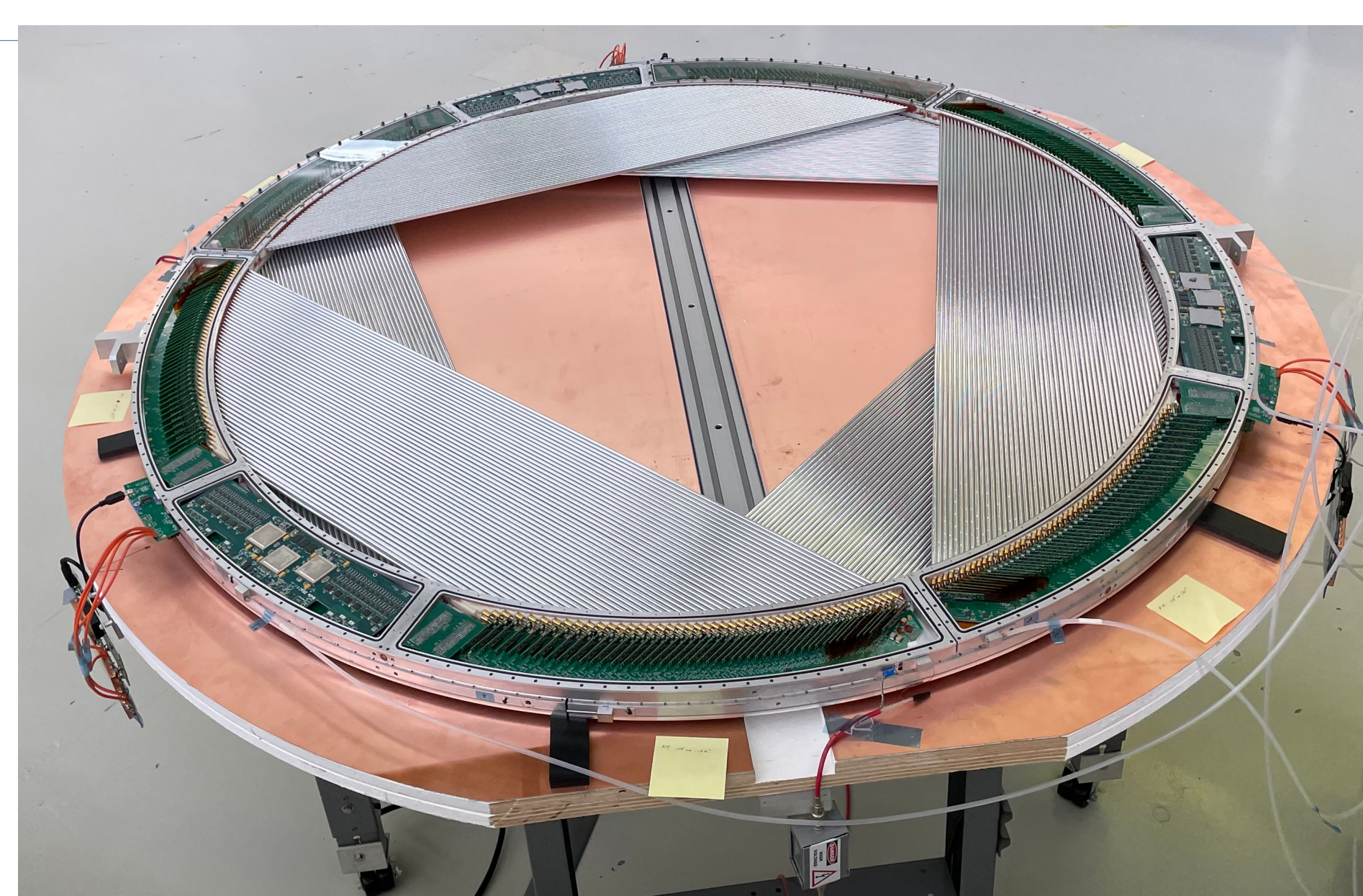
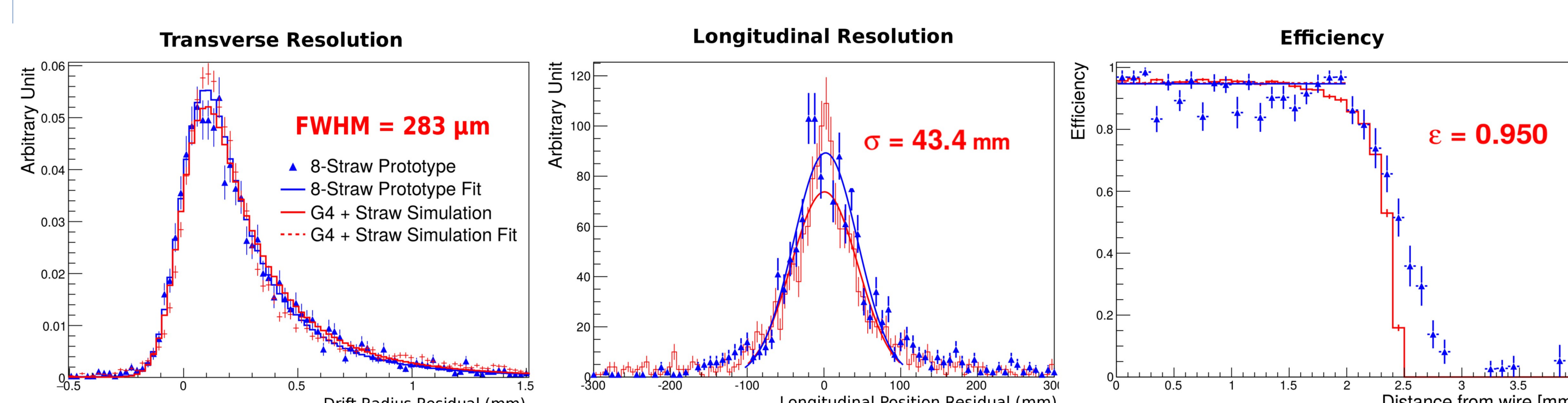
- Radiation testing of DRAC, preamps and components
 - TID: 200 kRad (15x expected)
 - NIEL: 2e13 n/cm² 1 MeV eq. (12x expected) from McClellan reactor
 - SEE: 1e11 p/cm² from 100 MeV/c proton beam
- No latchups or power failures seen
- No noticeable changes in operating parameters



SEE test setup at Northwestern Medicine Hospital

Performance

Straw hit resolution and efficiency demonstrated with cosmic ray data from prototypes



Successful operation demonstrated with first plane of six pre-production panels in realistic configuration (see talk by R. Bonventre)