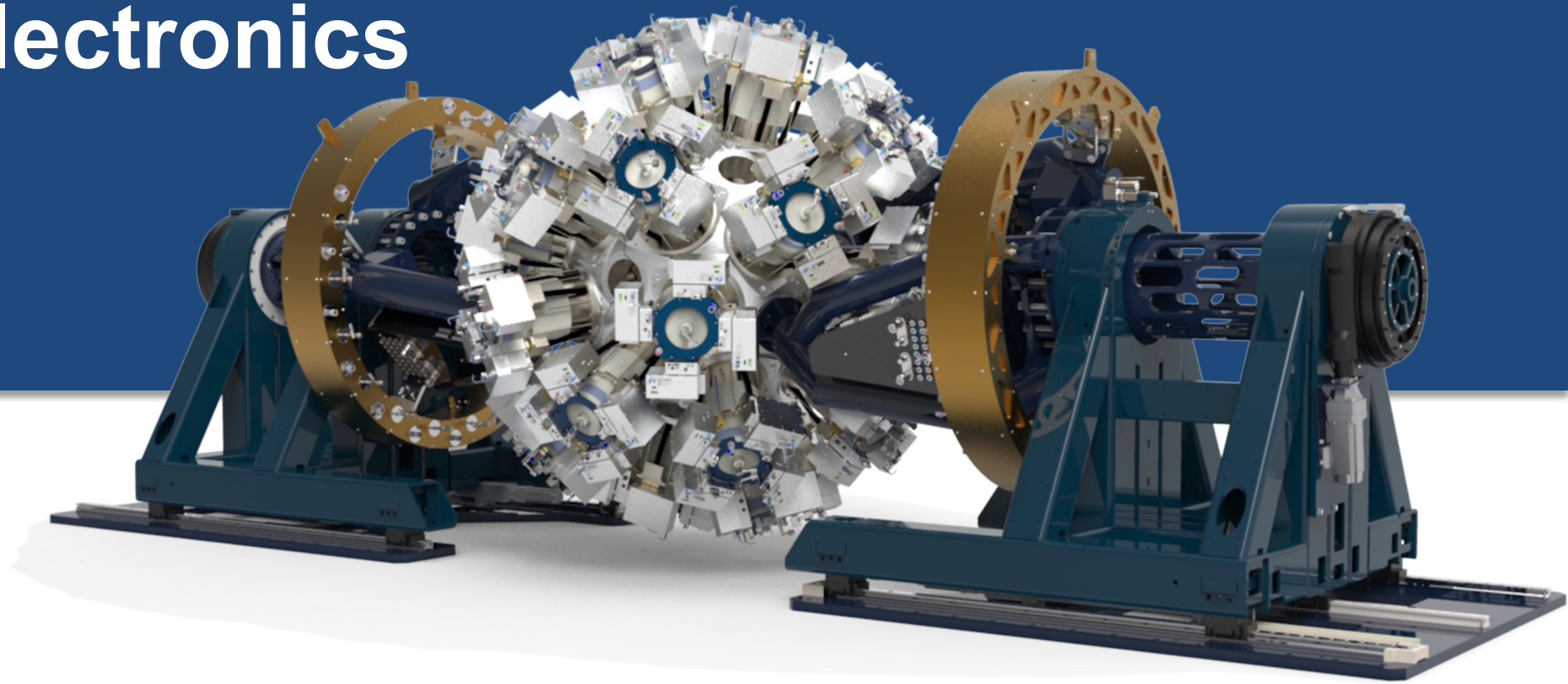
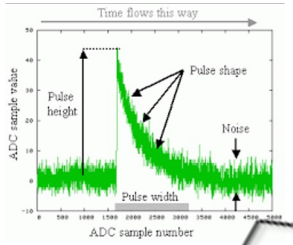
GRETA Electronics

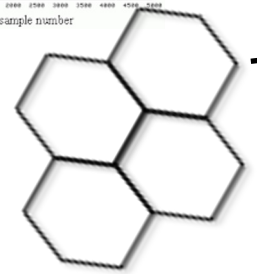


Electronics Scope and Key Capabilities



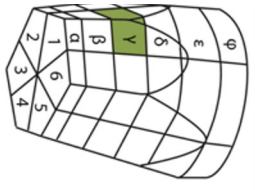
DM: Provide digitized signal waveforms at 100MHz & determine the gamma-ray interaction points

SFB: Provide real-time and continuous determination of energy and time for each gamma-ray event



Quad Detector

Key Interface



Detector Interface Box (DIB)

Digitizer Module (DM)

100Gb/s

DM 100Gb/s

DM 100Gb/s

DM 100Gb/s

Signal Filter Board (SFB)

25 GbE

Network Switch

Computing Systems

Key Interface

Forward Buffers

10GbE

Trigger Routers

Timing Module

System Trigger

1 GbE

Slow Control & Monitoring

Ancillary Systems includes Cu and FO Cables, Power Distribution Rack Chassis

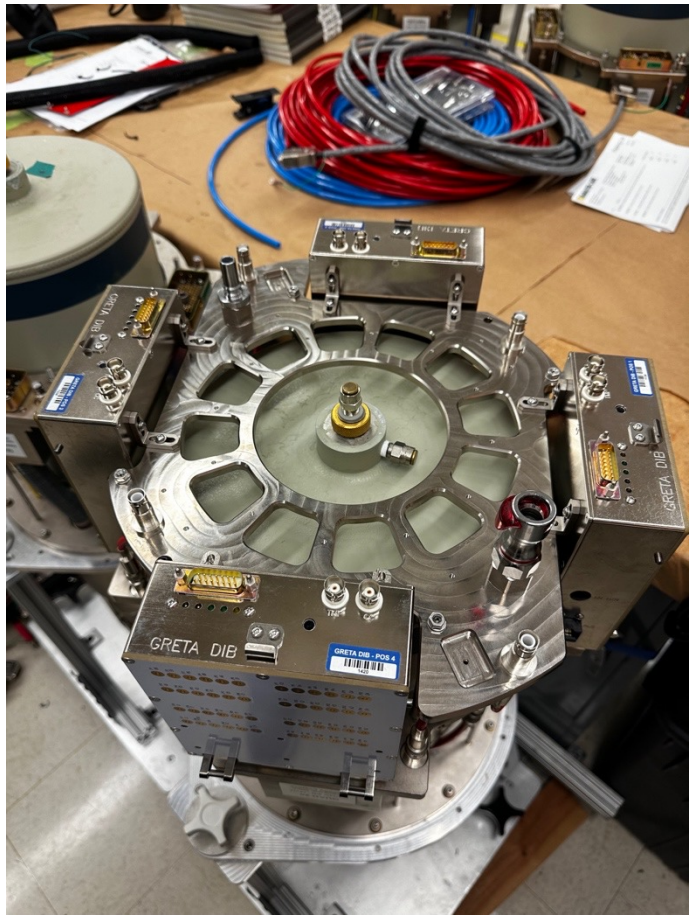
TTC: Provides system synchronization and timestamps for all triggered events

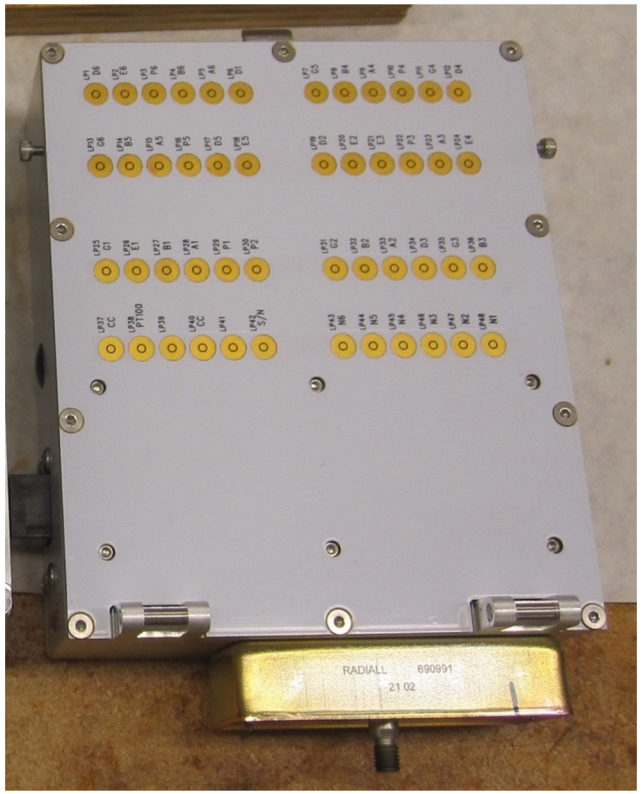
External Detectors / Accelerator Clocks

ALL: Provide high data transfer bandwidth appropriate to support the needs of the experimental trigger rates

Detector Interface Box

- Interface between Detector and Digitizer Module
- Routes Power to the Detector, Temperature monitor, Analog Core Contact output

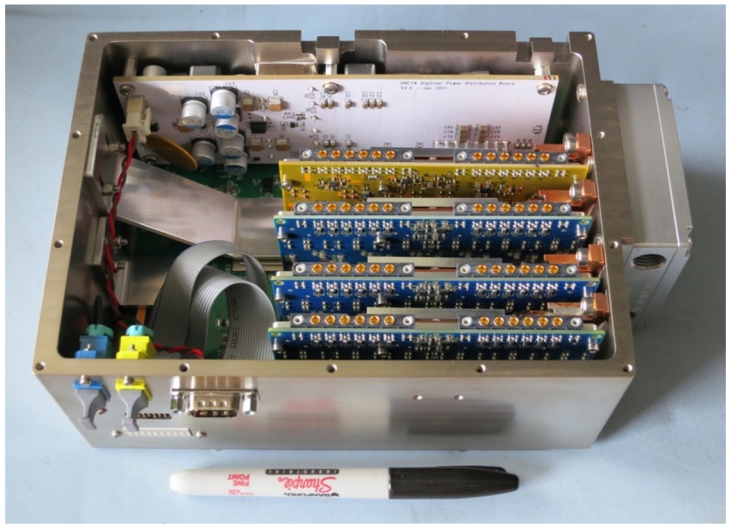


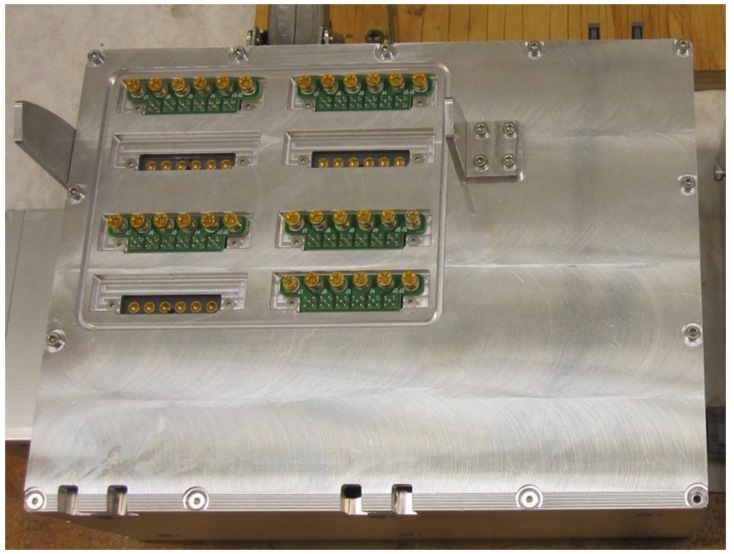


Digitizer Module

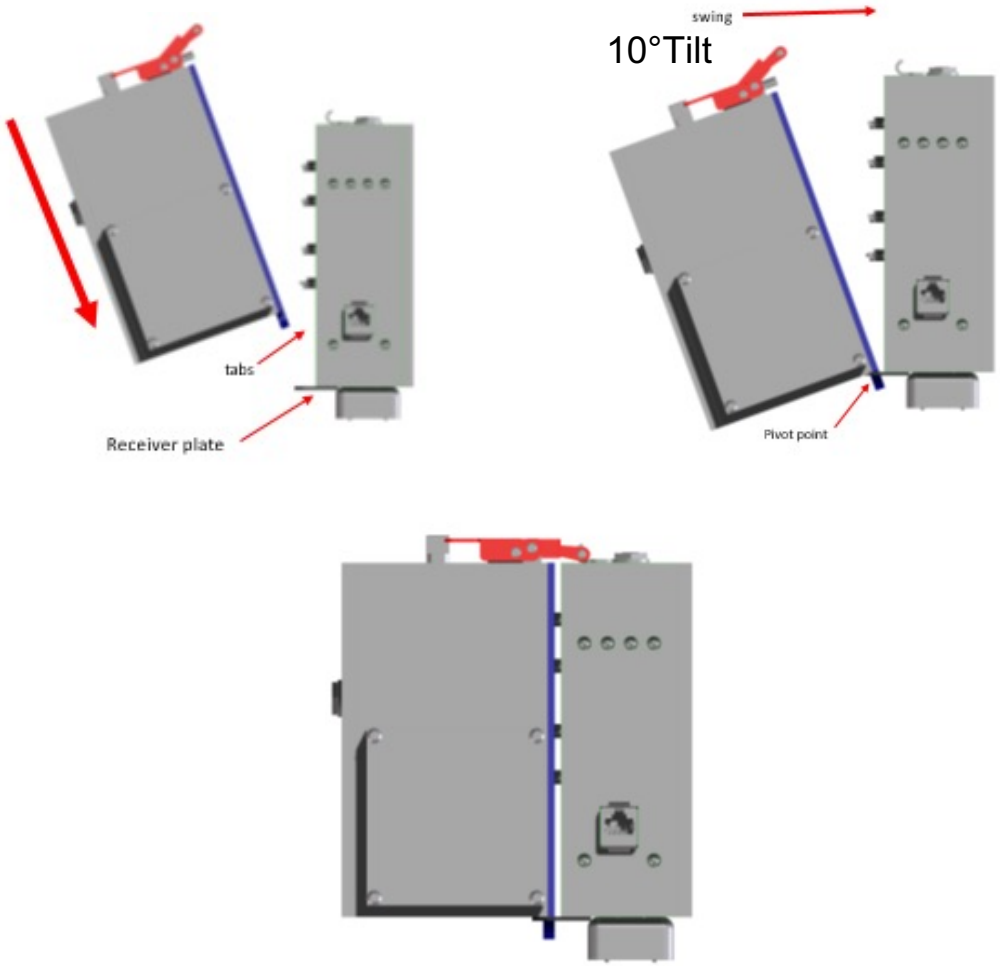
- Digitize the detector signals and streams them to the Signal Filter Board
- 40 (36 segments + 4 gain ranges for the core contact, all LTC2194) 100MHz 16-bit digitizers, selected to minimize integral and differential non-linearity) – organized on 3x12-channel segment boards and a CC board
- 300 MHz CC ADC for triggering (fast timing signal) – outputs trigger primitives (TS of LEDs) to the trigger system
- Receives 48-bit global clock from the timing system
- 100 Mb data output (10 x 10Gb) on proprietary protocol over 16-strand MTP fiber cable – **all** ADC data + metadata (e.g. TS) is streamed from the DM units
- 10 Gb control link allows “scope mode” – computer-based oscilloscope capability

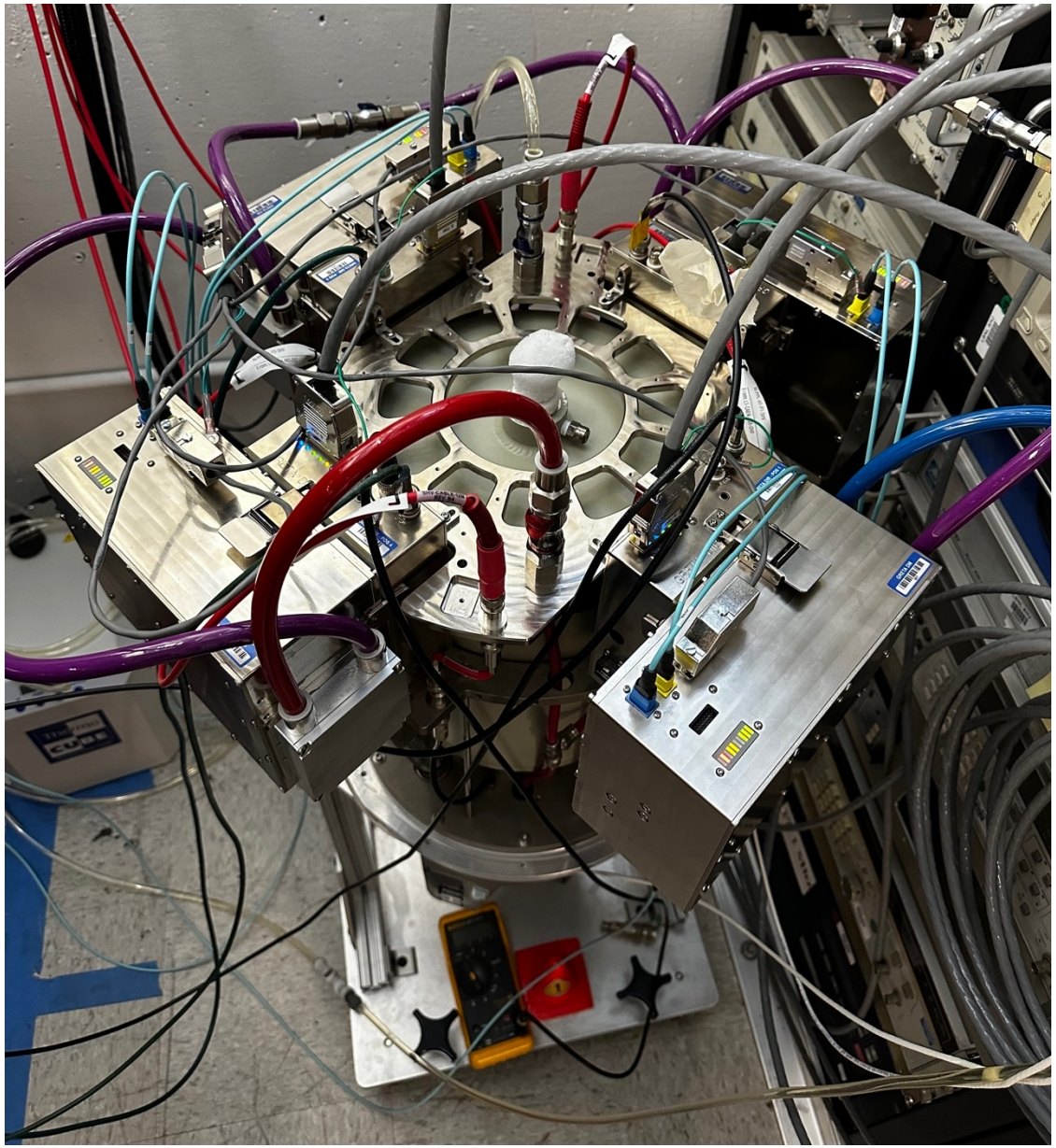
- Cooled by dedicated glycol cooling loop via cooling block





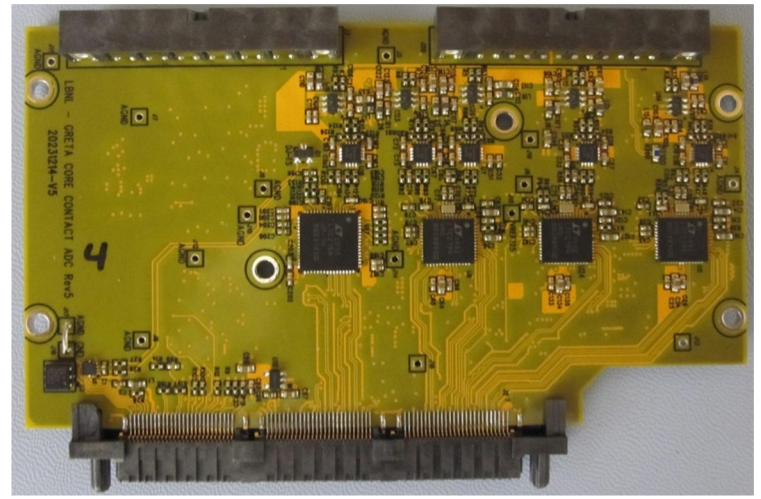
Digitizer Module Installation Scheme

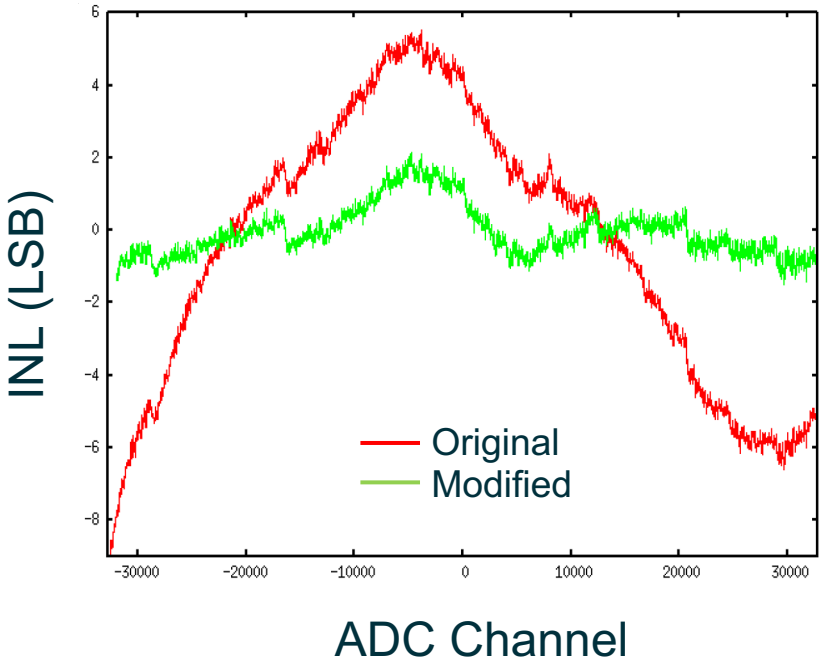




Digitizer Module – Core Contact Board

- Discovered an integral linearity issue on the core contact board
  - Anti-alias filter
  - Input impedance change for out of range ADC channels
  - Intra ADC crosstalk for out of range ADC channels
- Core contact is digitized in 5 ADC channels
  - 4x Data Acquisition with different gains
  - 1x Fast trigger ADC
- Redesigned board
  - Added input buffer amplifier
  - Added additional ADC chip (chip use single channel)
- INL significantly improved
  - Original (+5.3,-6.3 LSB) (red trace)
  - Modified (+1.8,-1.2 LSB) (green trace)
  - Spec <= +/- 2 LSB



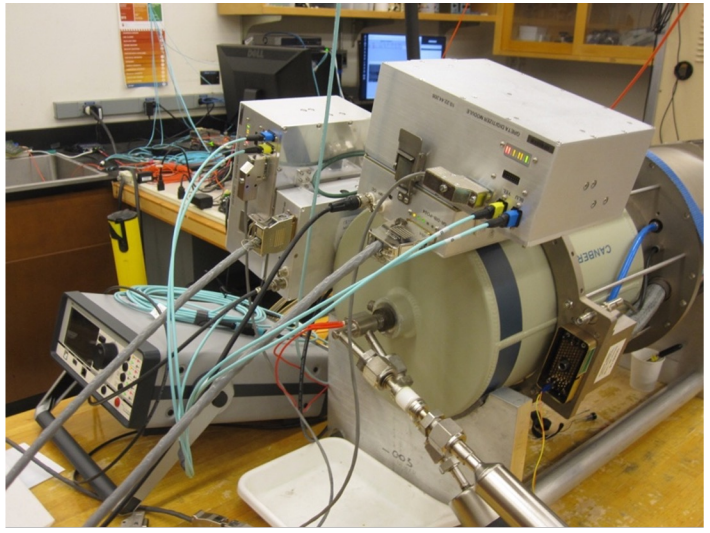


Digitizer Module Core Contact Performance

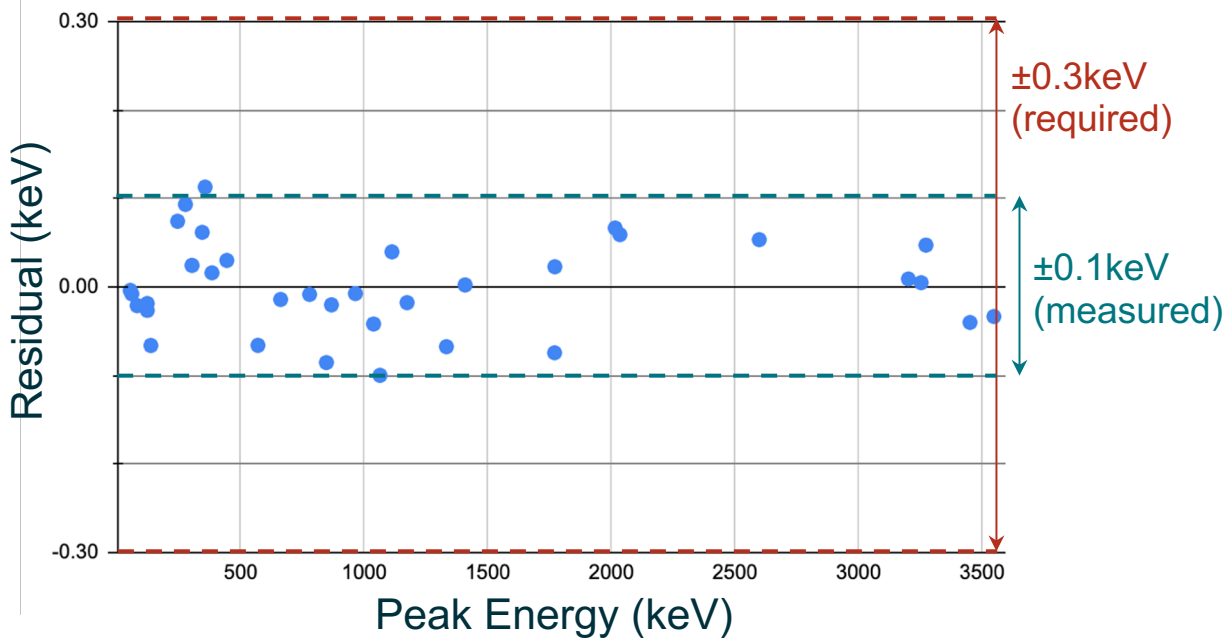
Energy Resolution

Peak (@ rate)	FWHM [keV]	Req. [keV]
60 keV (1 kHz)	1.361±0.001	<= 1.4
1332 keV (1 kHz)	2.314±0.006	<= 2.5
1332 keV (50 kHz)	3.08±0.01	<= 3.5

Measurements carried out with production hardware and firmware (including SFB)



Energy Calibration Residuals

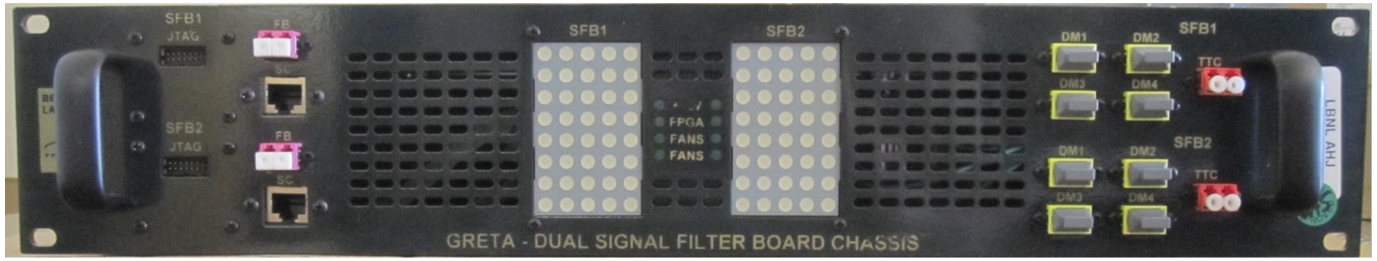


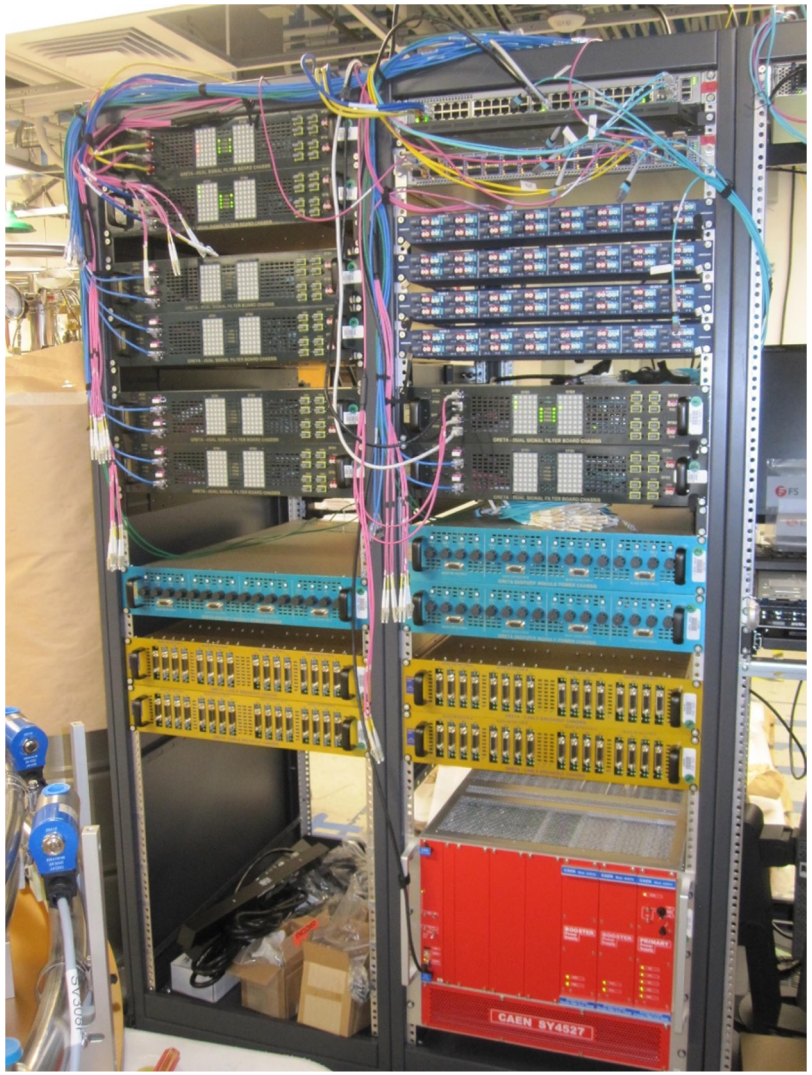
Measured: ± 0.1 keV
Spec: ± 0.3 keV (over 10 MeV)

- Testing also confirms that the Digitizer Module meets temperature stability requirements
  - Gain is stable to <= 0.03% across full range over 12 hours, or ±2°C temperature change

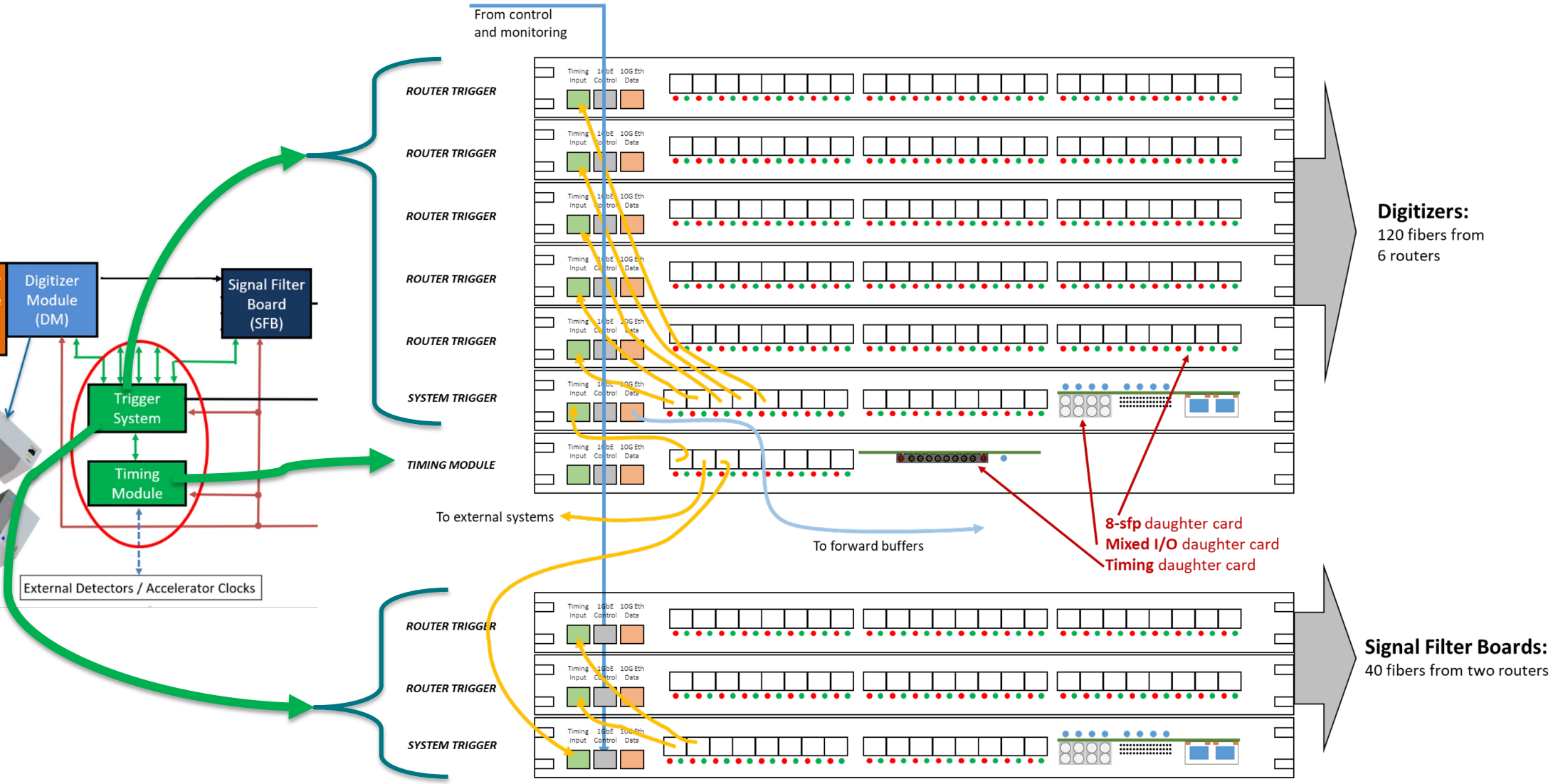
Signal Filter Board

- Receives detector ADC data, runs digital filter to extract energy and timing information and select waveform snippets
- On trigger validations, routes the data to the forward buffer with compressed waveforms as UDP datagrams (25 Gb interface)
- Based on off-the-shelf Hi-Tech FPGA board with Xilinx Virtex Ultrascale FPGA
- One FPGA per Quad module; packed as 2u units serving two Quads





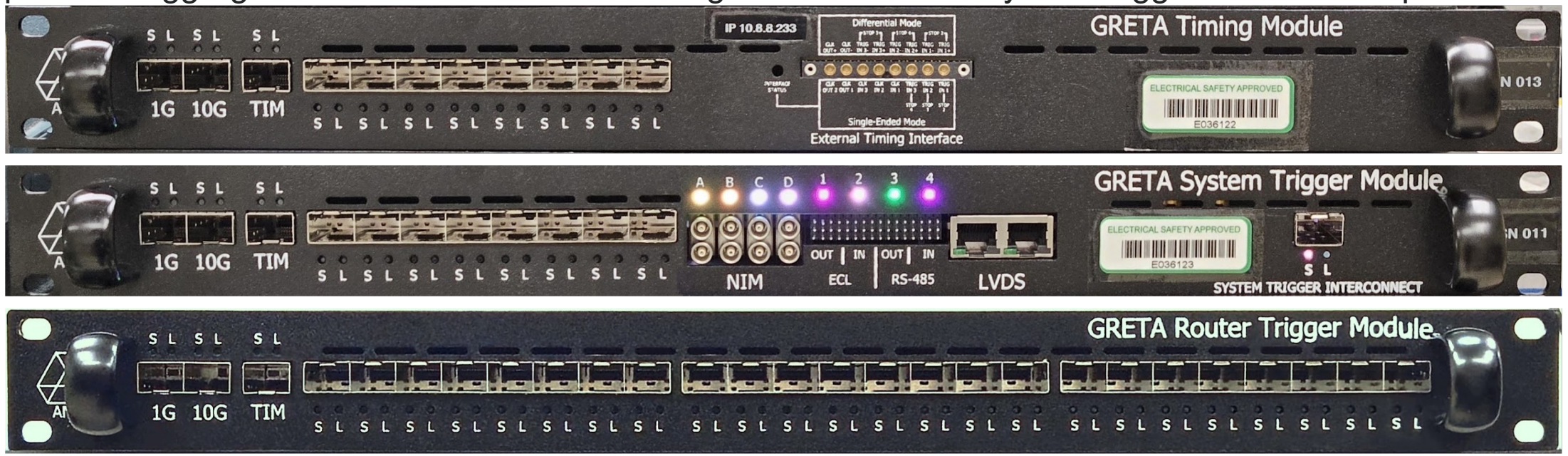
System Components – Trigger System Detail



System Components – Module Overview

One design, 3 configurations using 4 FMC plug in cards:

- **Timing Module:** Provides the source of clock throughout the system, as well as clock interface for external detectors.
- **System Trigger Module:** Distributes clock from timing master to the routers and provides trigger logic for SFB and Digitizer systems. Also provides trigger diagnostics and summary data via its 10GBPS Ethernet interface
- **Router Trigger Module:** Provides fanout of timing and trigger to the digitizer and SFB endpoints. Also provides aggregation of event information being sent back to the system trigger from the endpoints



Ancillary Systems

- Digitizer Module Power Supplies
  - TDK Lambda power supplies – 4 Quads in 2u chassis
- Cable Breakout Chassis
  - Receive and distribute LV from CAEN modules; provide interlocks and AC power for fans and LN bayonet heater
- Detector HV (and LV)
  - CAEN HV and LV cards, individually floating HV channels
- Custom fiber plant
  - Includes custom fiber breakout units (passive) and spider cables