Calorimeter Insert Prototype Test at RHIC

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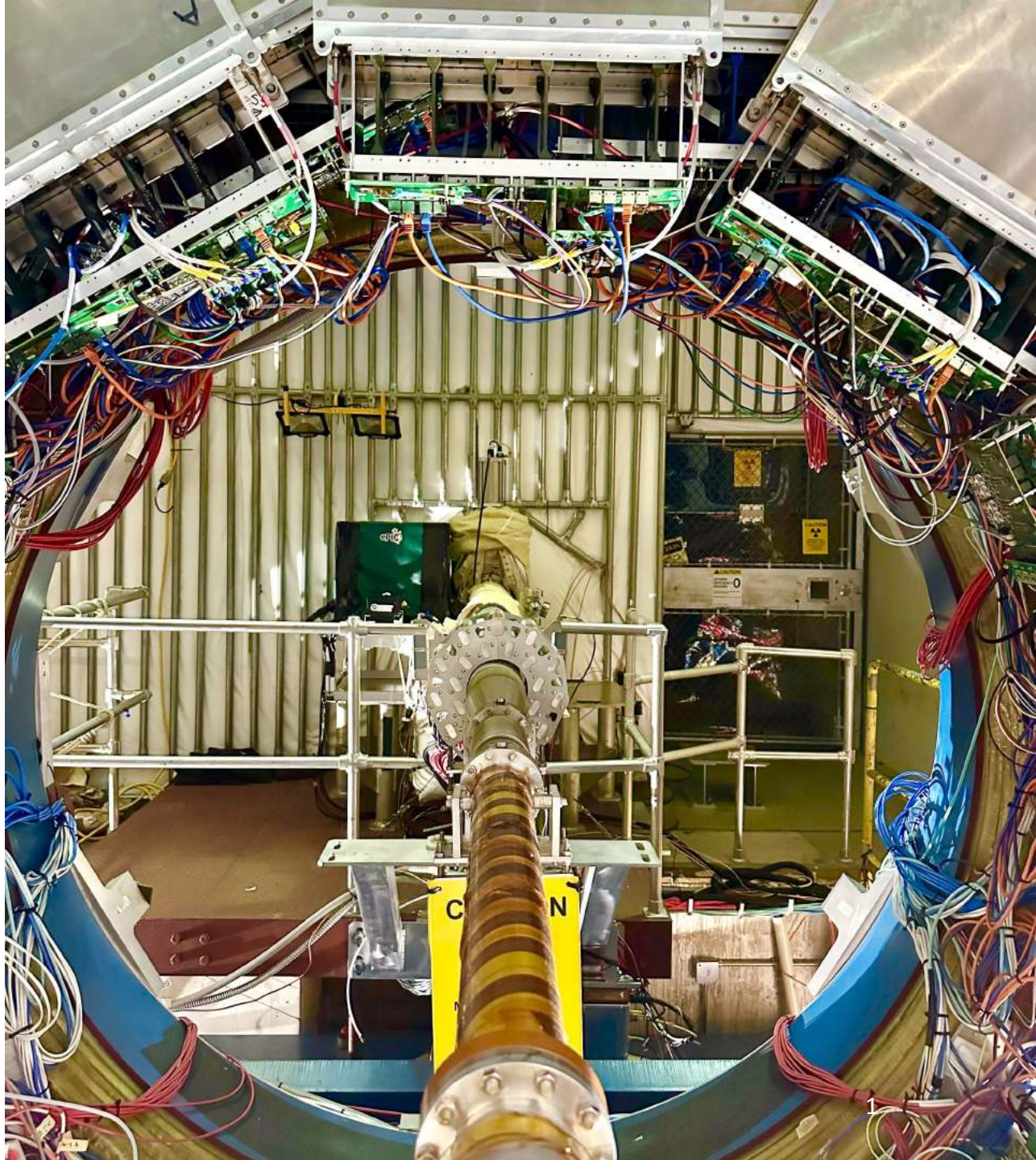
3/13/24

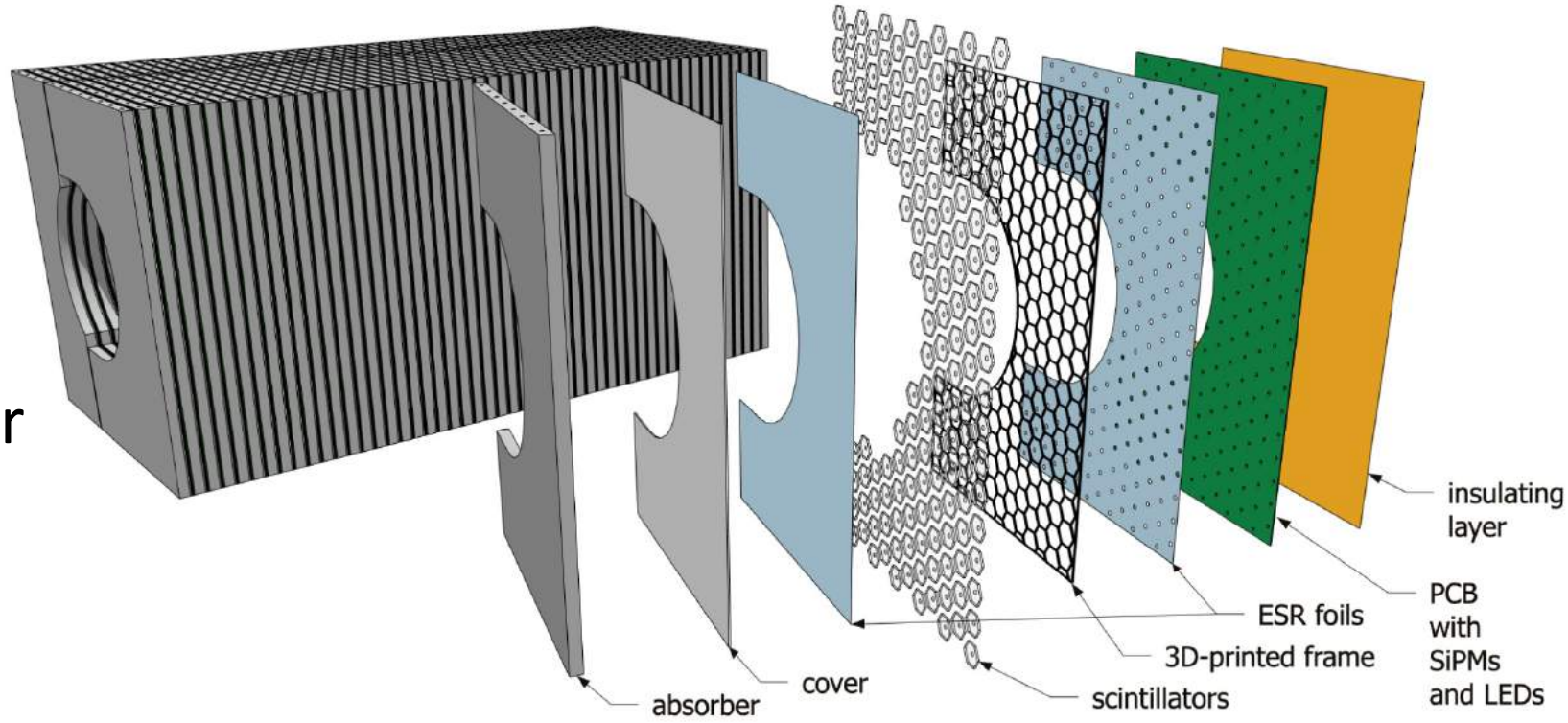


Overview

- Background and previous tests
- Gen II Prototype for HG-CALI
- Initial installation at STAR
- Upgrade plans

Background

- Continuation of studies for developing CALI, a high granularity SiPM-on-tile sampling calorimeter
- Same technology will be used in the ZDC



A high-granularity calorimeter insert based on SiPM-on-tile technology at the future Electron-Ion Collider

Miguel Arratia [a], Kenneth Barish [a], Liam Blanchard [a], Huan Z. Huang [b], Zhongling Ji [b], Bishnu Karki [a], Owen Long [a], Ryan Milton [a b], Ananya Paul [a], Sebouh J. Paul [a], Sean Preins [a], Barak Schmookler [a], Oleg Tsai [b], Zhiwan Xu [b]

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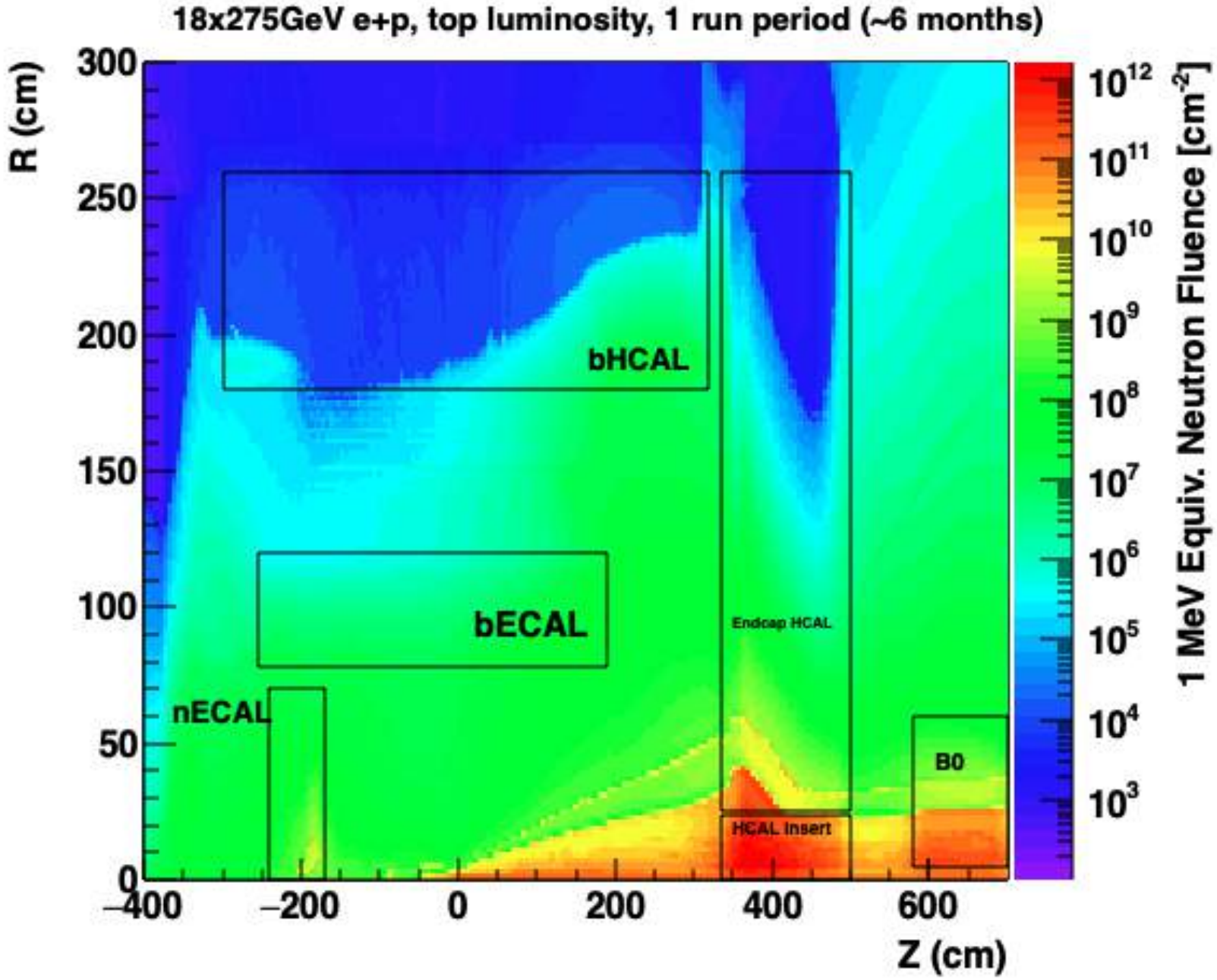
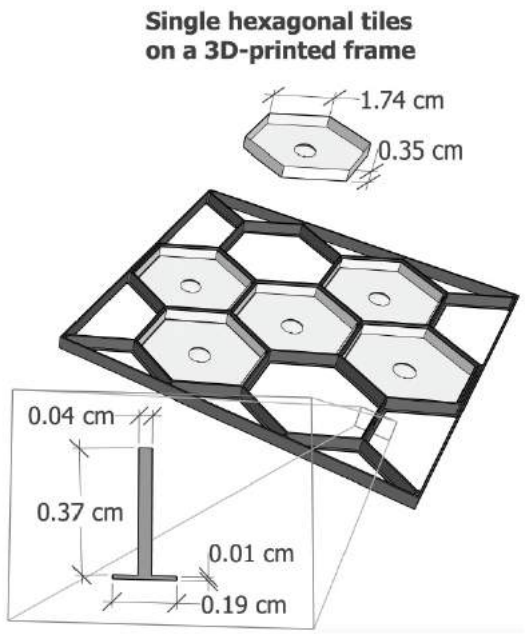
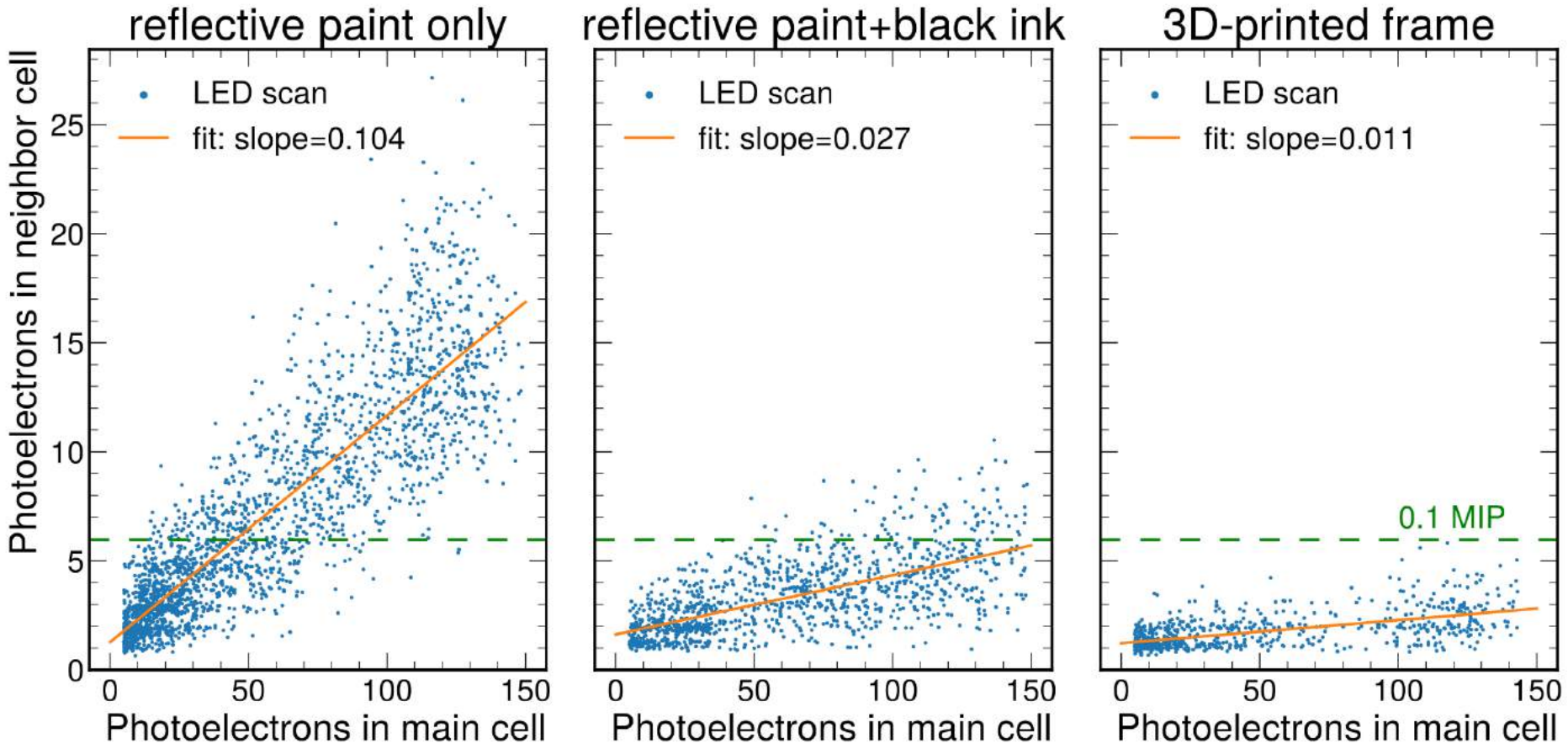
- CALI will receive the largest radiation dose in ePIC
- Effects of radiation damage to SiPMs and annealing needs to be studied
- Current test at STAR will be informed by upcoming UC Davis irradiation test







- Benchtop tests studied light yield and timing resolution of SiPM-on-tile configuration
- Validated new method of segmenting tiles with 3D-printed frames

Studies of time resolution, light yield, and crosstalk using SiPM-on-tile calorimetry for the future Electron-Ion Collider

Miguel Arratia[1,2], Luis Garabito Ruiz[1], Jiajun Huang[1], Sebouh J. Paul[1], Sean Preins[1] and Miguel Rodriguez[1]

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Gen I Prototype

- Gen I Prototype was tested at Jefferson Lab Hall D pair spectrometer in January 2023
- Consisted of 40 channels, 10 layers of iron absorbers / SiPM-on-tile boards

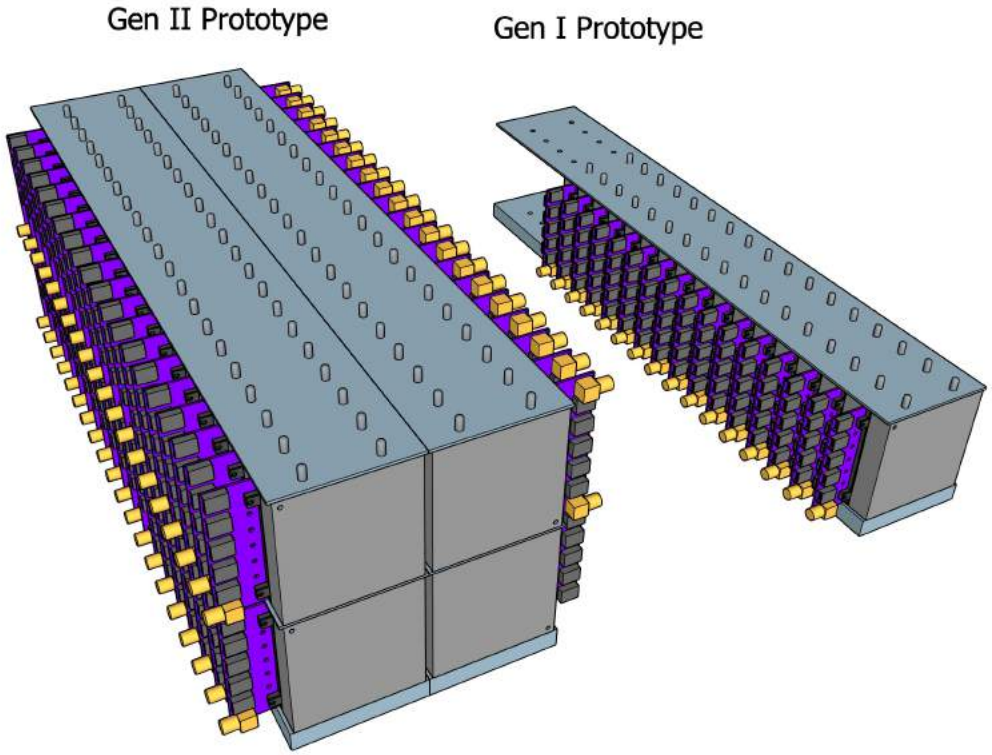
Article

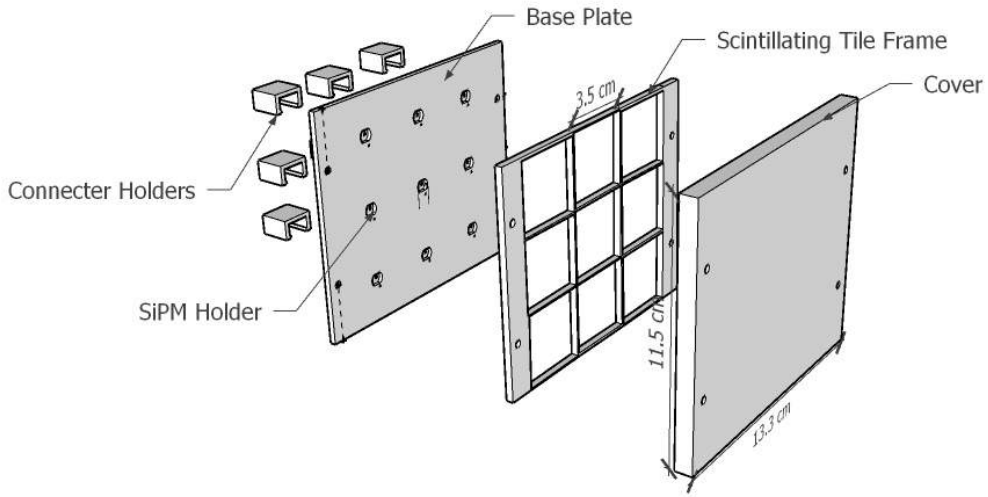
Beam Test of the First Prototype of SiPM-on-Tile Calorimeter Insert for the EIC Using 4 GeV Positrons at Jefferson Laboratory

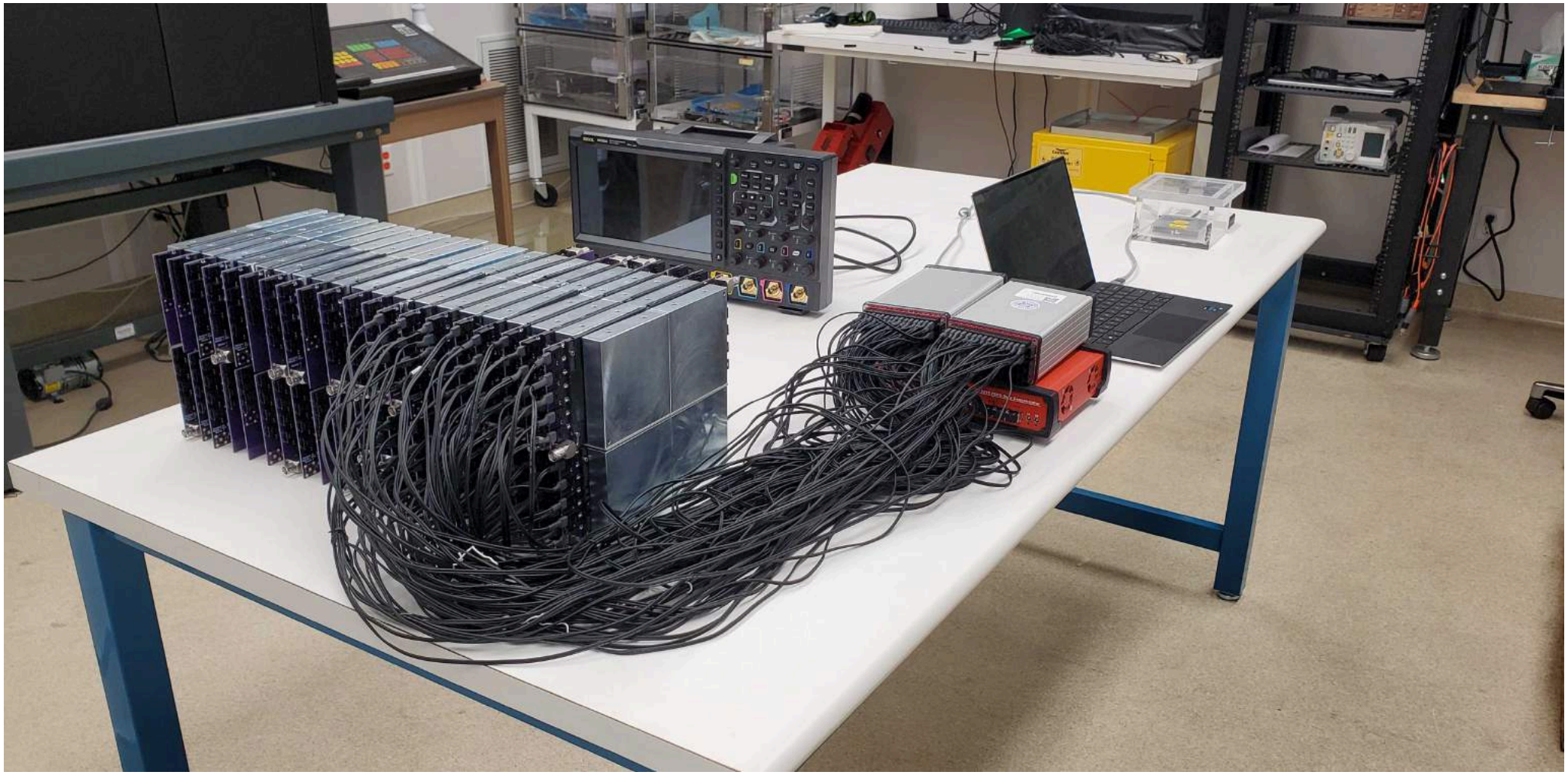
Miguel Arratia [1,2,*], Bruce Bagby[1], Peter Carney[1], Jiajun Huang[1], Ryan Milton[1], Sebouh J. Paul[1], Sean Preins[1], Miguel Rodriguez[1] and Weibin Zhang[1]

Gen II Prototype

- Gen II prototype consists of ~300 channels, 20 iron layers
- Same blocks and mechanical design as ZDC
- Has three hodoscope layers in front
- Installed in the east side of STAR at RHIC, within $3.2 < \eta < 3.6$ range to emulate CALI conditions in ePIC





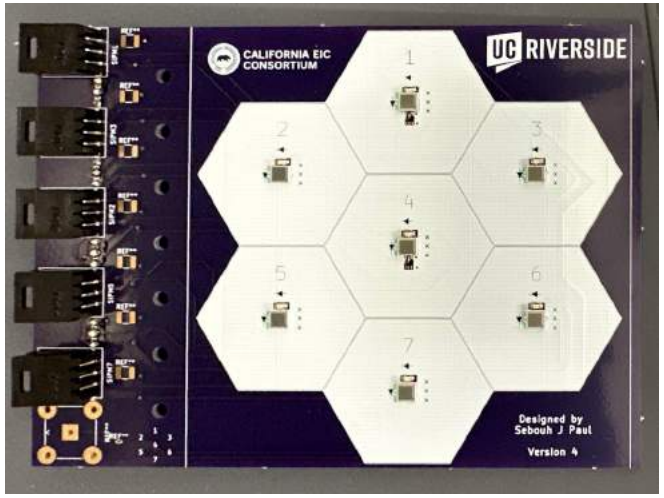


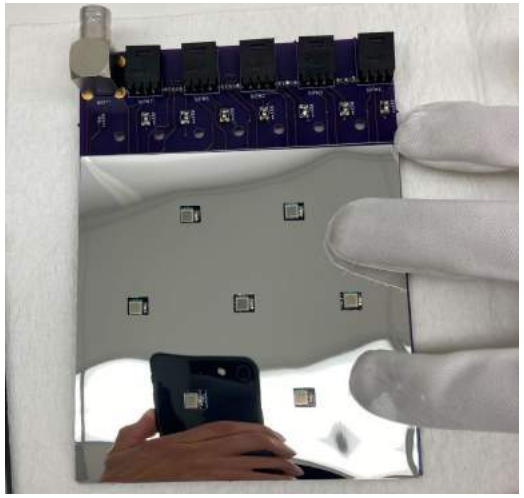
- Base plate, dividing plates, and scintillating tiles are machined in-house
- Consists of high granularity hexagonal tiles in front, larger granularity square tiles in rear
- All 302 channels have been tested with cosmics at UCR

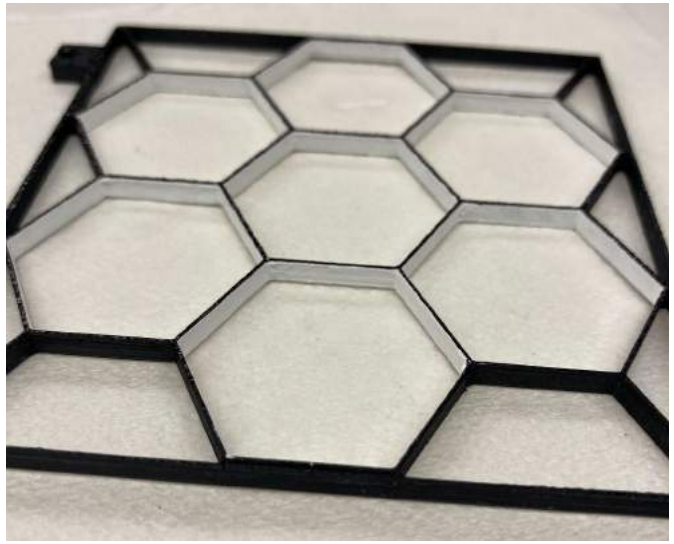
- FERS-5200 front-end readout system provides SiPM bias and digitization for 64 channels each

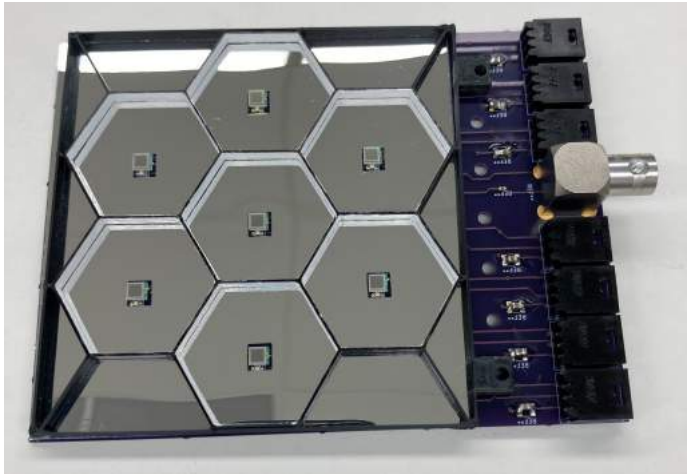
- Data is collected across multiple boards by a DT5215 concentrator and sent to DAQ laptop via USB

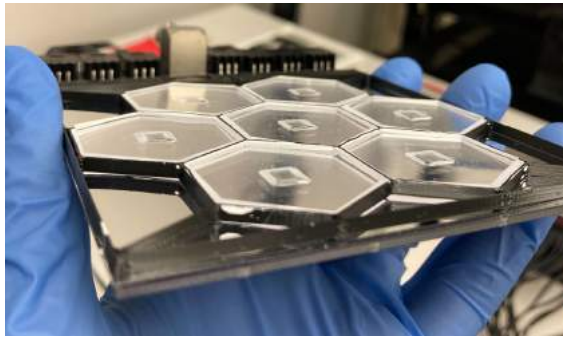
Constructing Prototype Layers

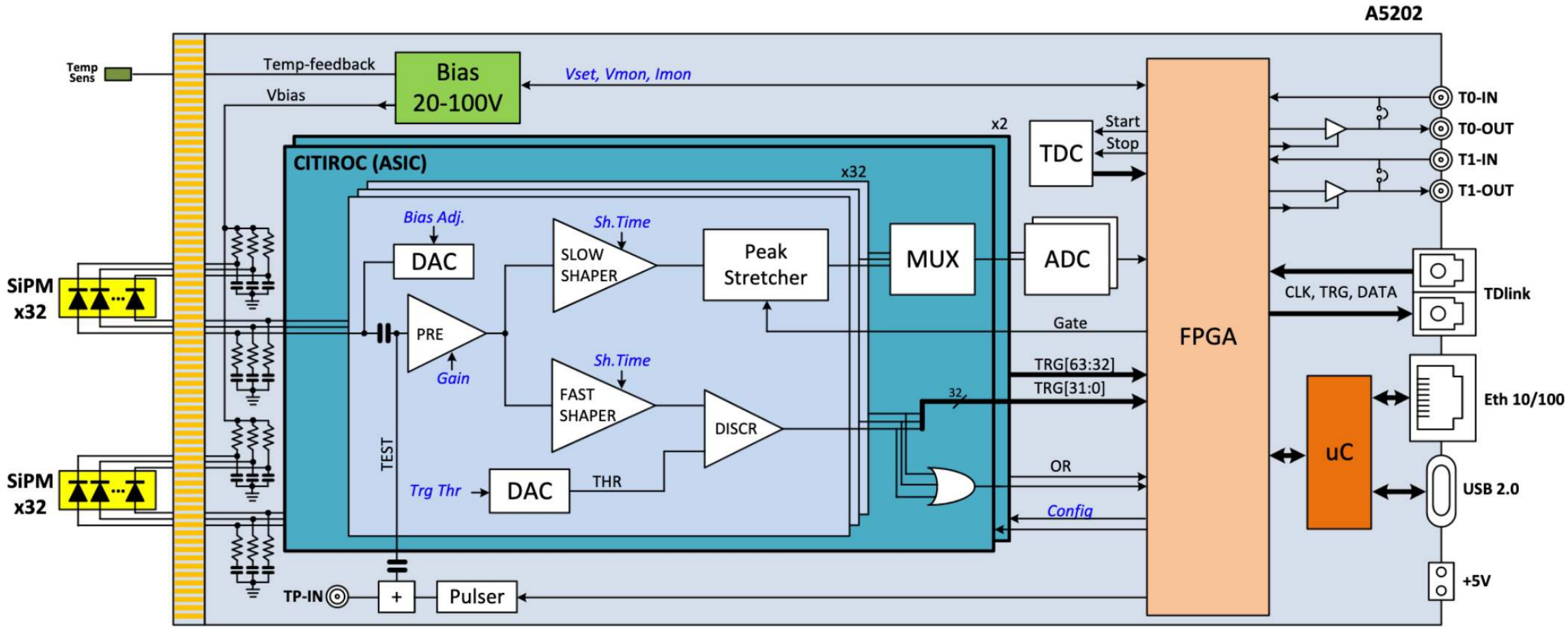










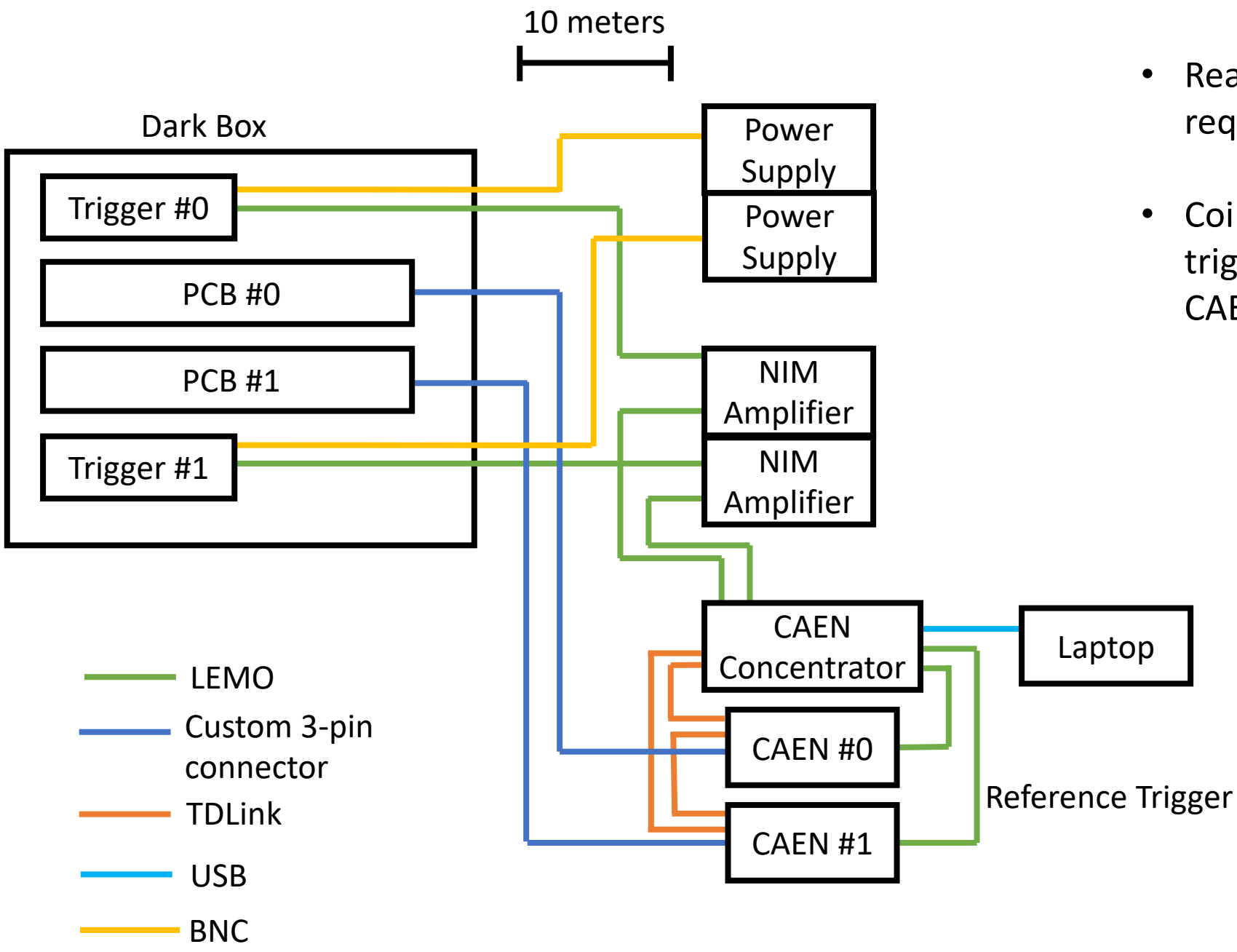


CITIROC 1A chip

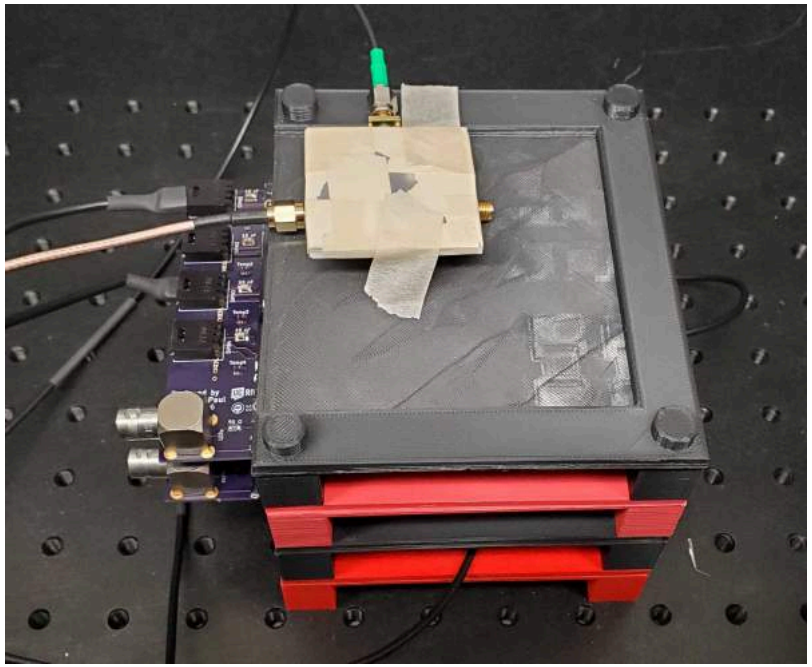
- 13-bit A/D conversion
- Systematic conversion time ~ 10 µs
- Max. trigger rate ~ 100 kHz

Janus Parameters

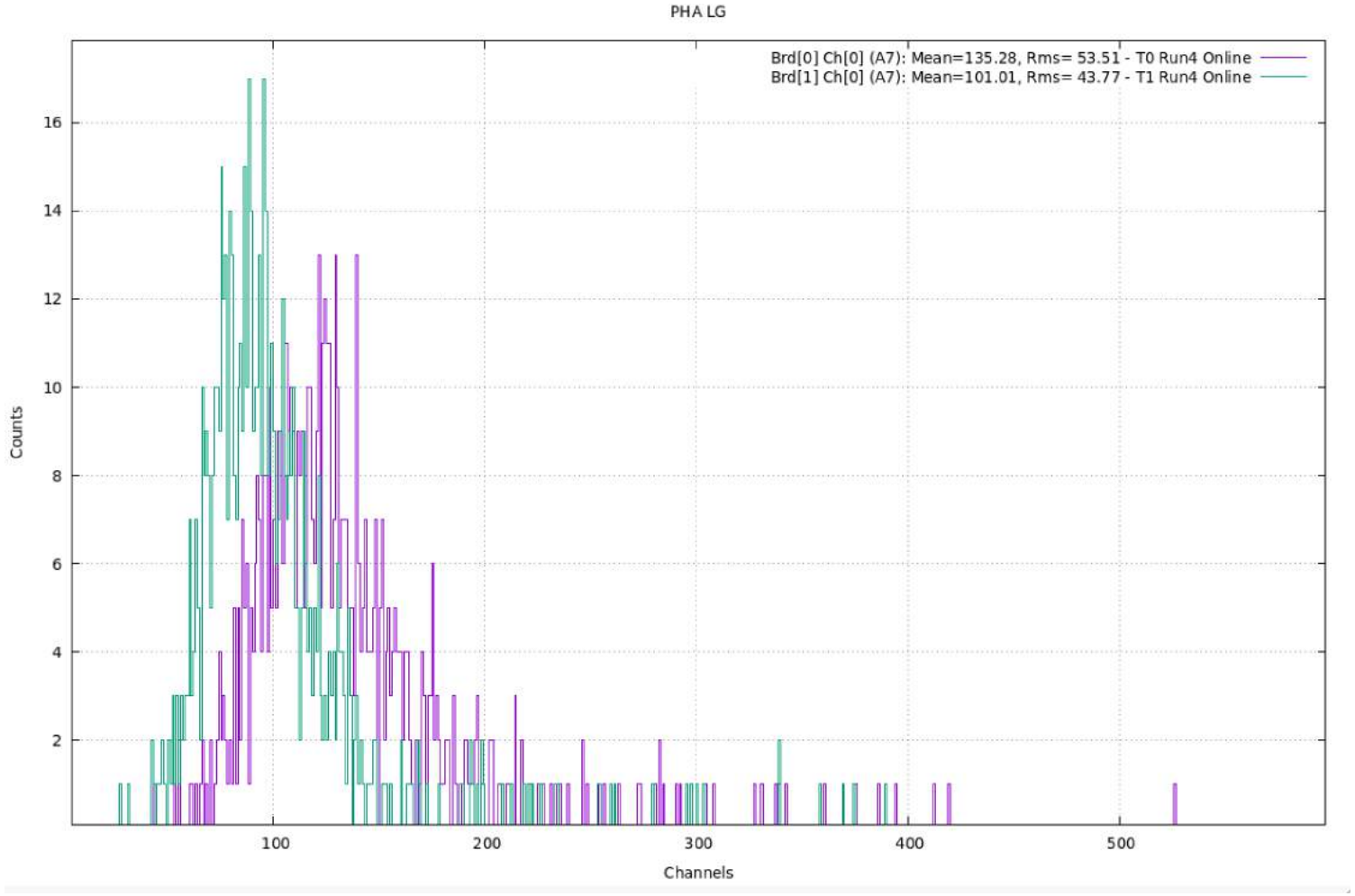
- Acquisition mode = SPECTROSCOPY
- Low Gain = 50
- Shaping Time = 25 ns
- Hold Delay = 100 ns



- Reading multiple CAEN units requires an external trigger system
- Coincidence test with two external trigger tiles, recording across two CAEN units

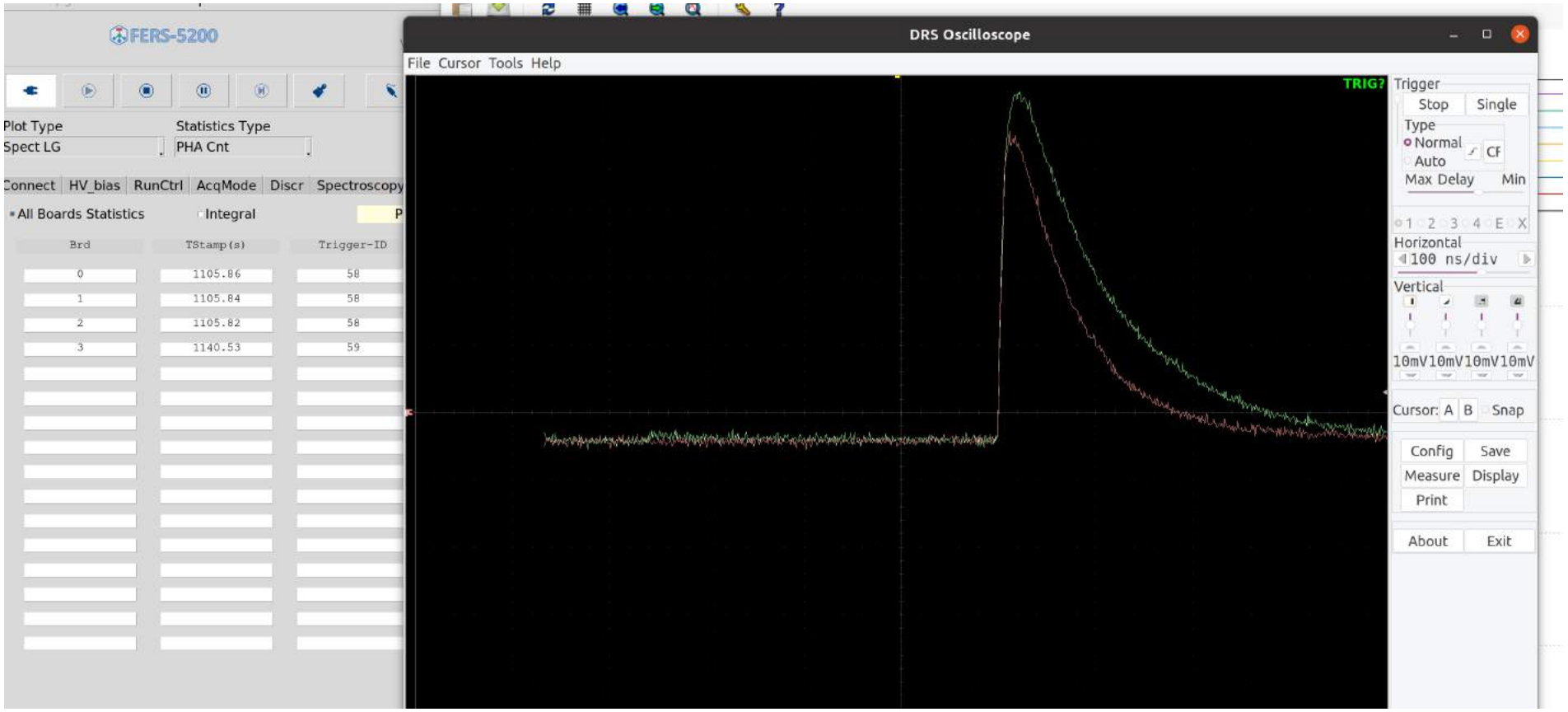


- Cosmic ray landaus measured, triggered on external tiles, with 10-meter-long cables
- Demonstrates external triggers can synchronize data collection across multiple CAEN units

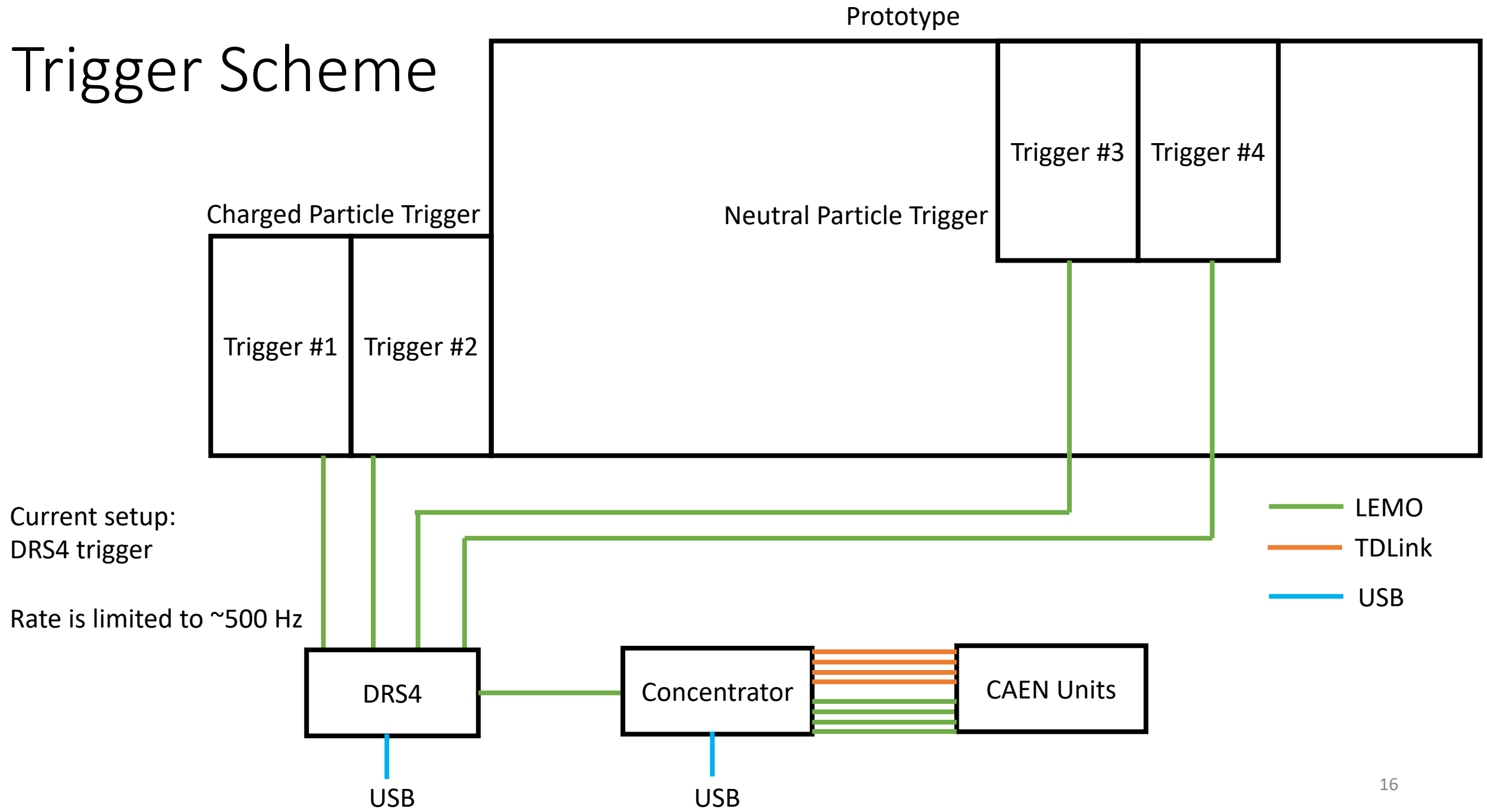


- Two trigger tiles currently installed at max shower position inside prototype, act as neutral particle trigger
- Two more trigger tiles will be installed in front to act as charged particle trigger

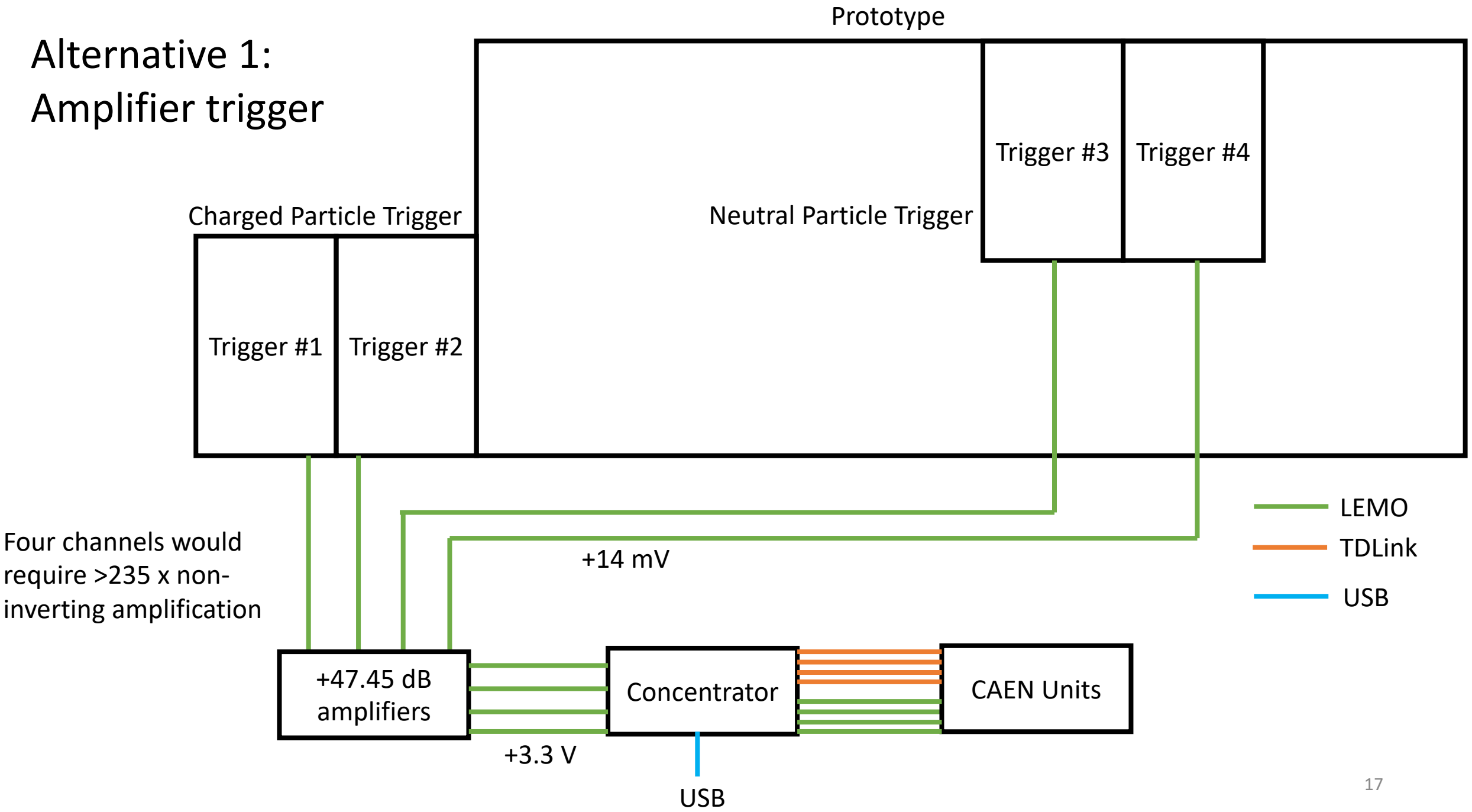
- External trigger scheme was modified to come from DRS4 evaluation board
- Reads four channels, trigger logic can be modified in-situ from external DAQ laptop
- Rate is limited to ~500 Hz



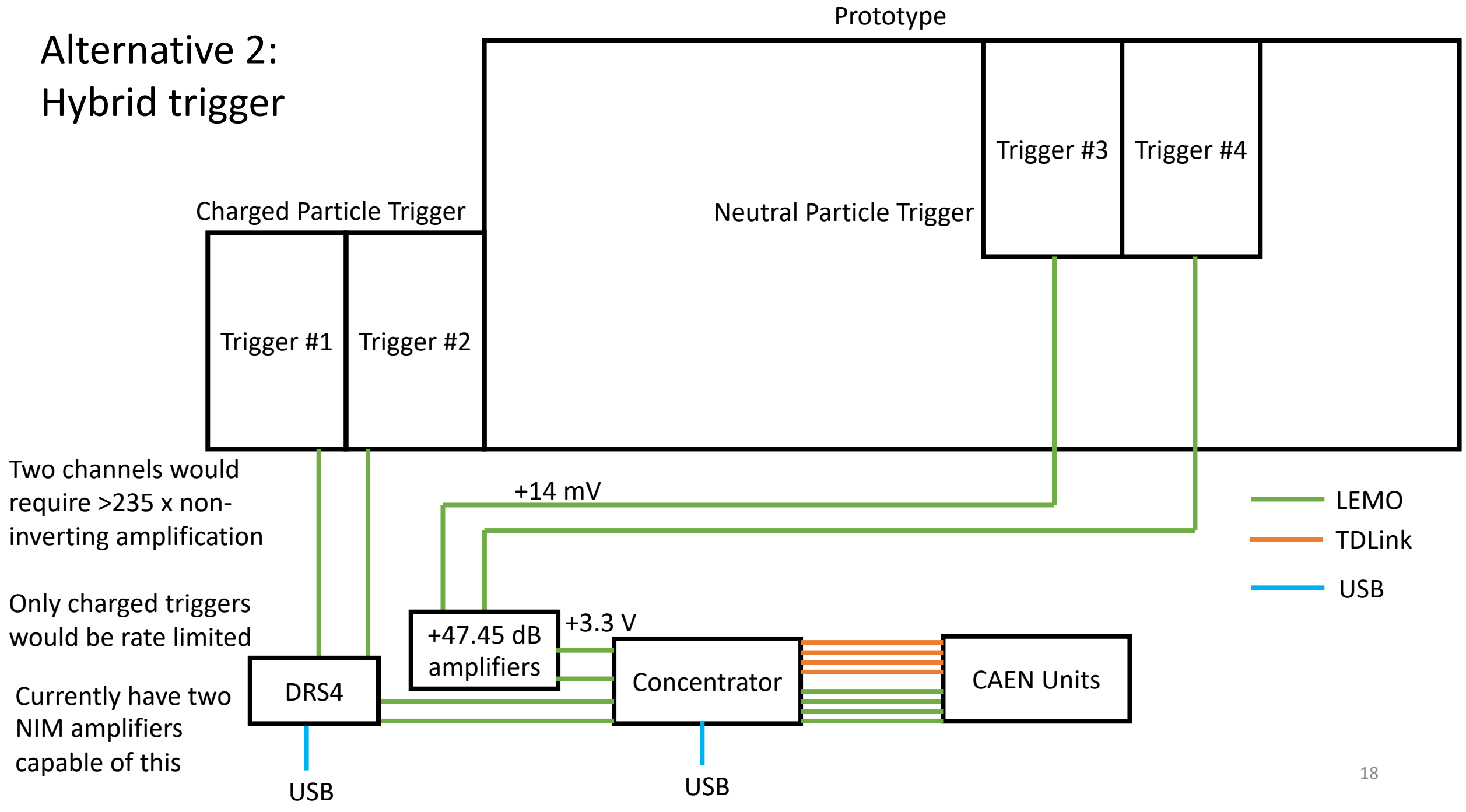
Trigger Scheme



Alternative 1: Amplifier trigger



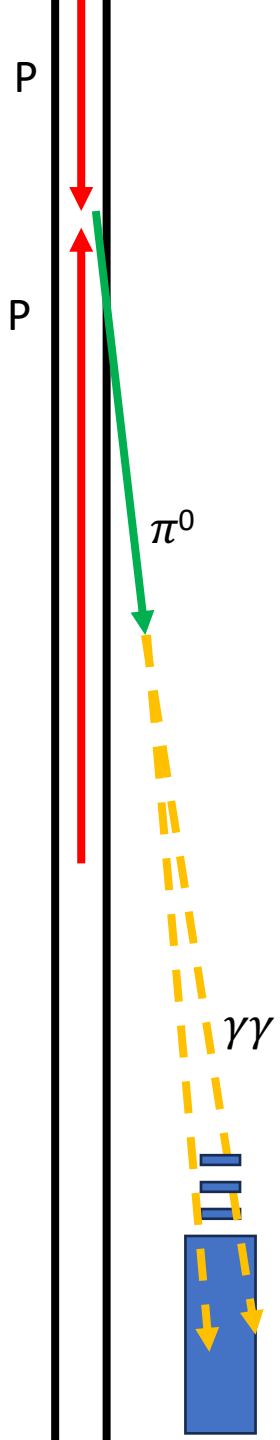
Alternative 2: Hybrid trigger

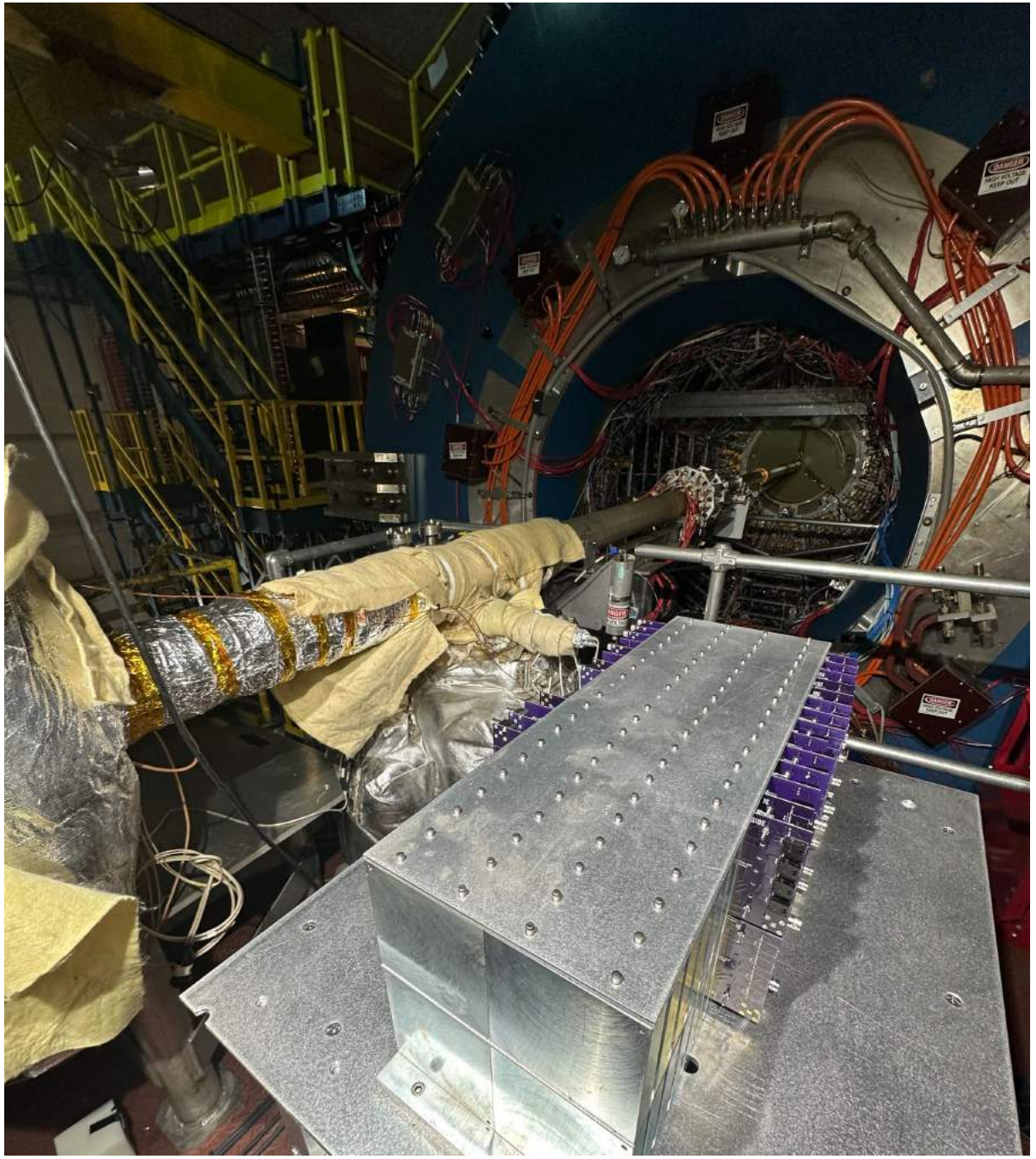


- Installed in STAR on Feb 23-28

Goals:

- Demonstrate in-situ calibration and operation under realistic radiation fluence
- Channel-by-channel calibration using MIPs
- Calibration with pi0 from pp collisions
- Monitor stability of physics quantities over time





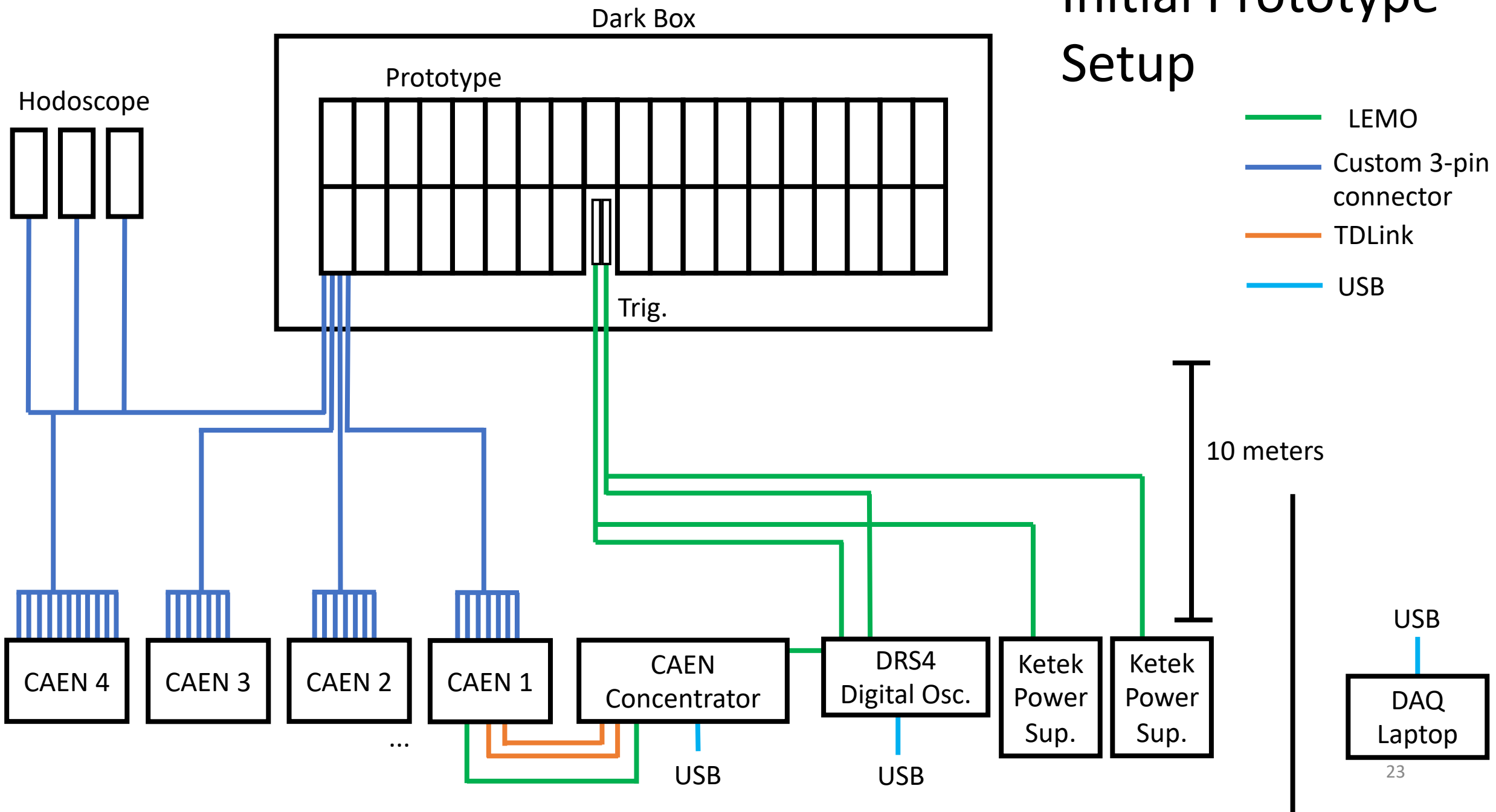
- Will receive particles from interaction region of pp collisions with minimal material in front
- Last chance to run any realistic test at RHIC
- Neutron fluence will be determined from simulations and SiPM current

- Dark box consists of black-out canvas mounted over an 80-20 frame
- Hodoscope layers are encased in 3D-printed plastic, sufficiently light-tight

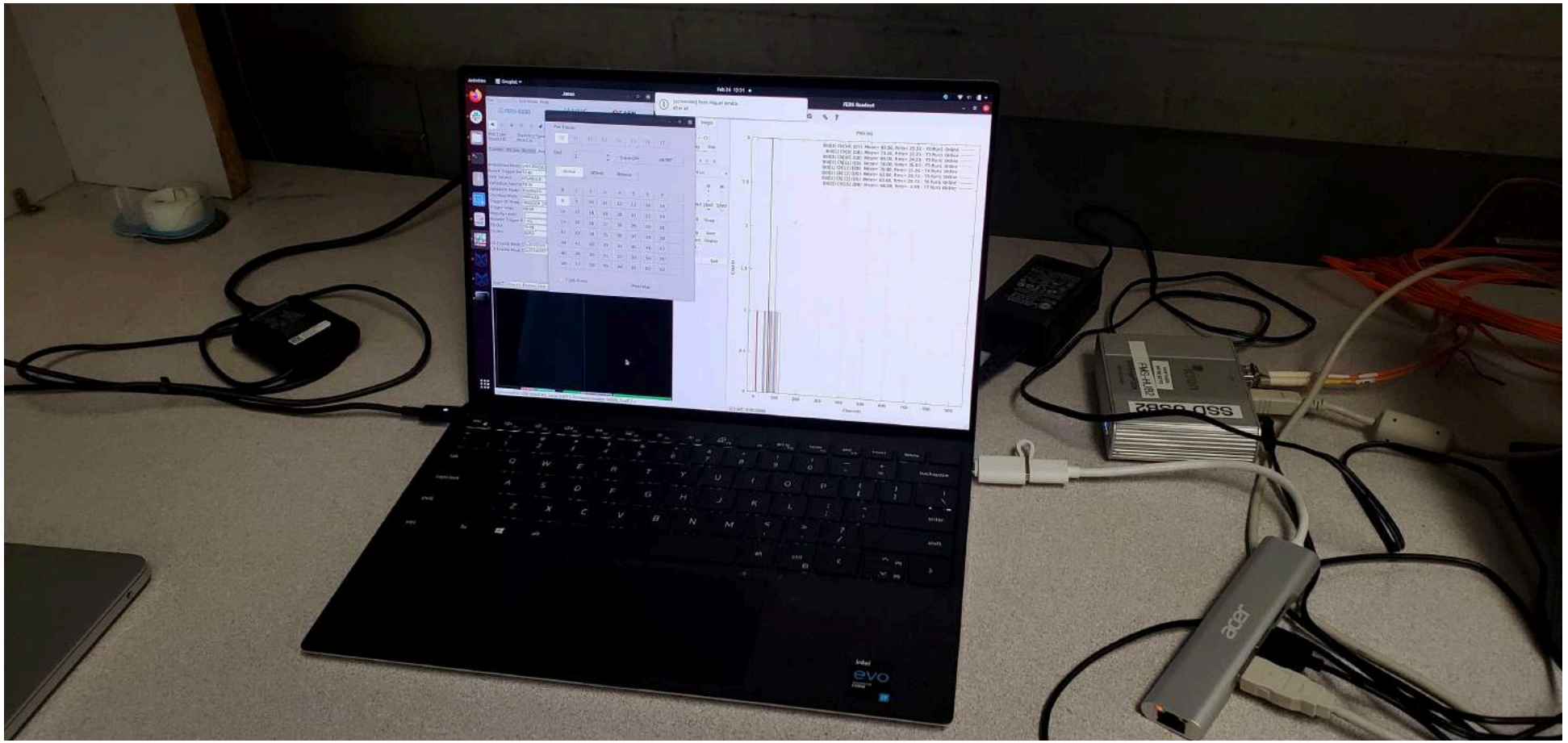
- PCBs require custom 3-pin cables, 25 were completed for the initial installation
- The channels were spread across the four CAEN units to continue testing our DAQ system

10 meters away from prototype

Initial Prototype Setup



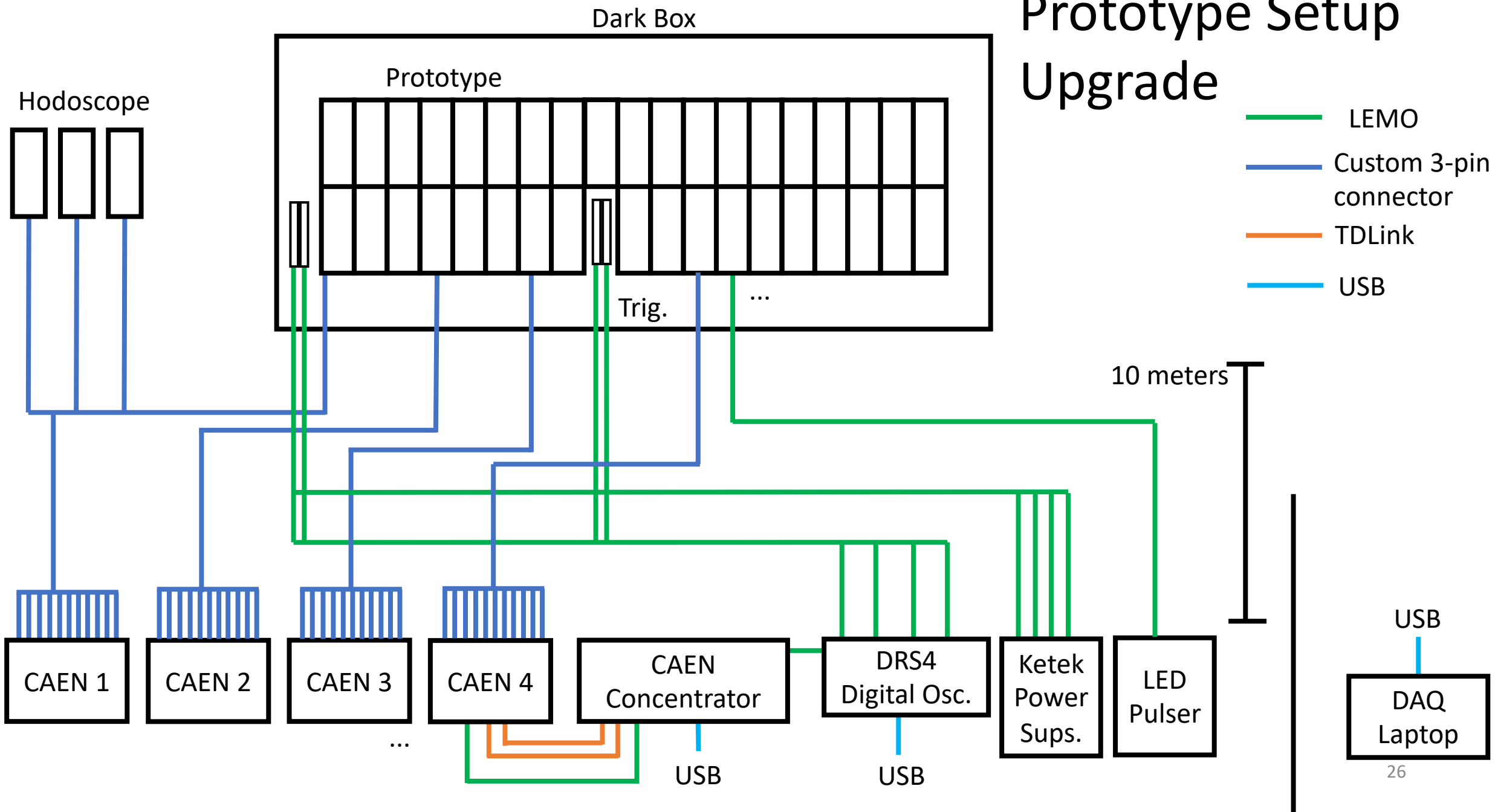
- DAQ system is entirely decoupled from STAR



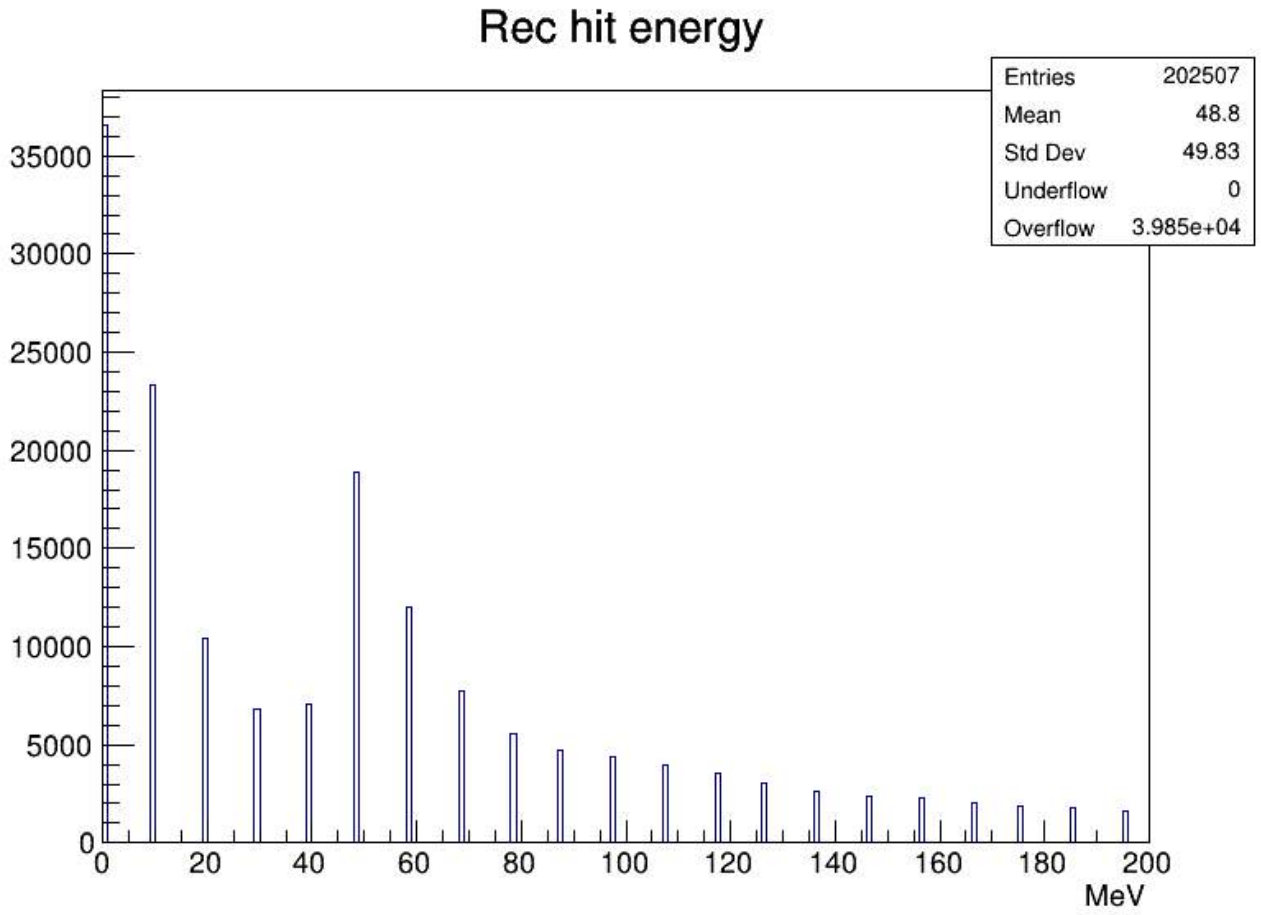
Upgrade Plans

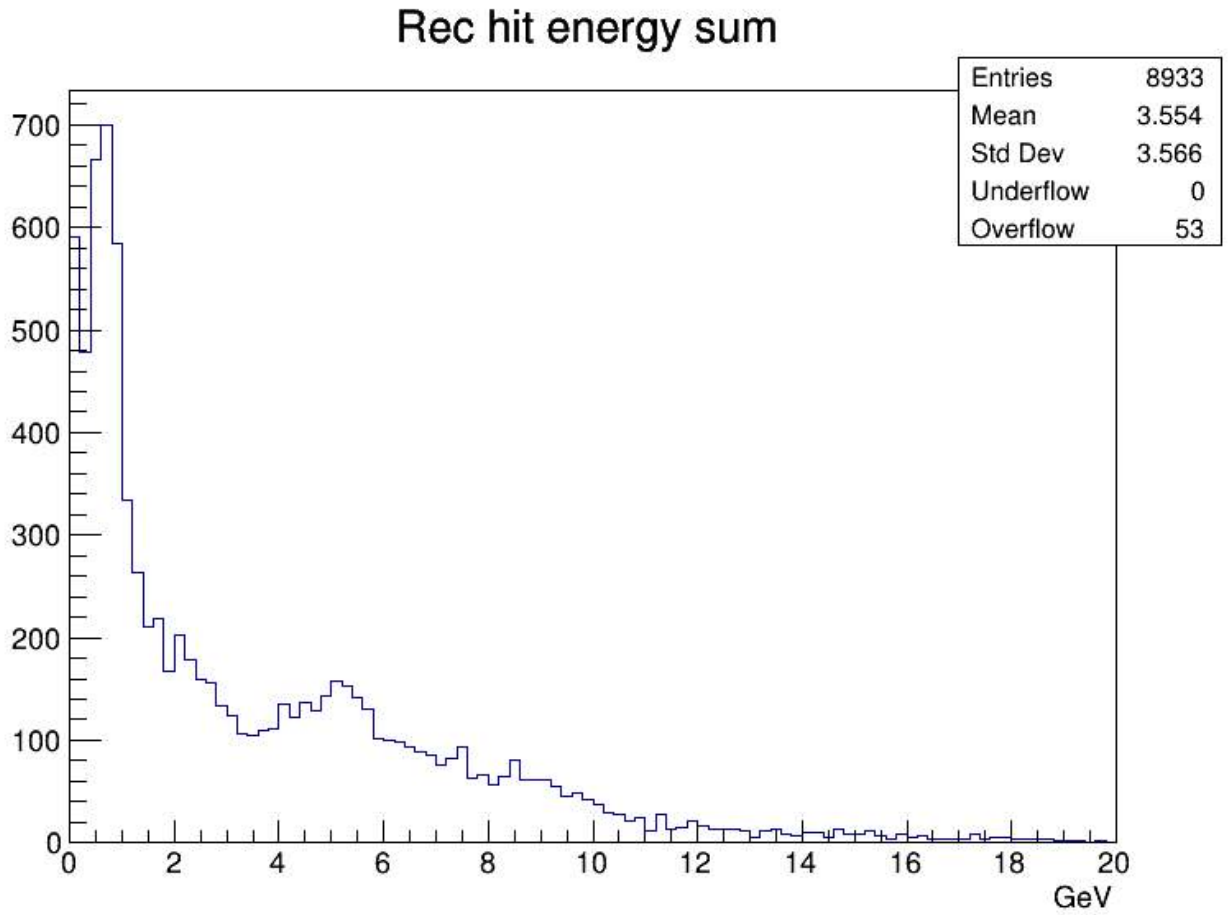
- Install remaining layers (will require ~80 model 14160 1315PS SiPMs)
- Construct and install cables
- Install 2-3 more DAQ CAEN units
- Install 2 trigger tiles in front for charged particle trigger
- Add current monitor for individual SiPMs to monitor radiation damage

Prototype Setup Upgrade

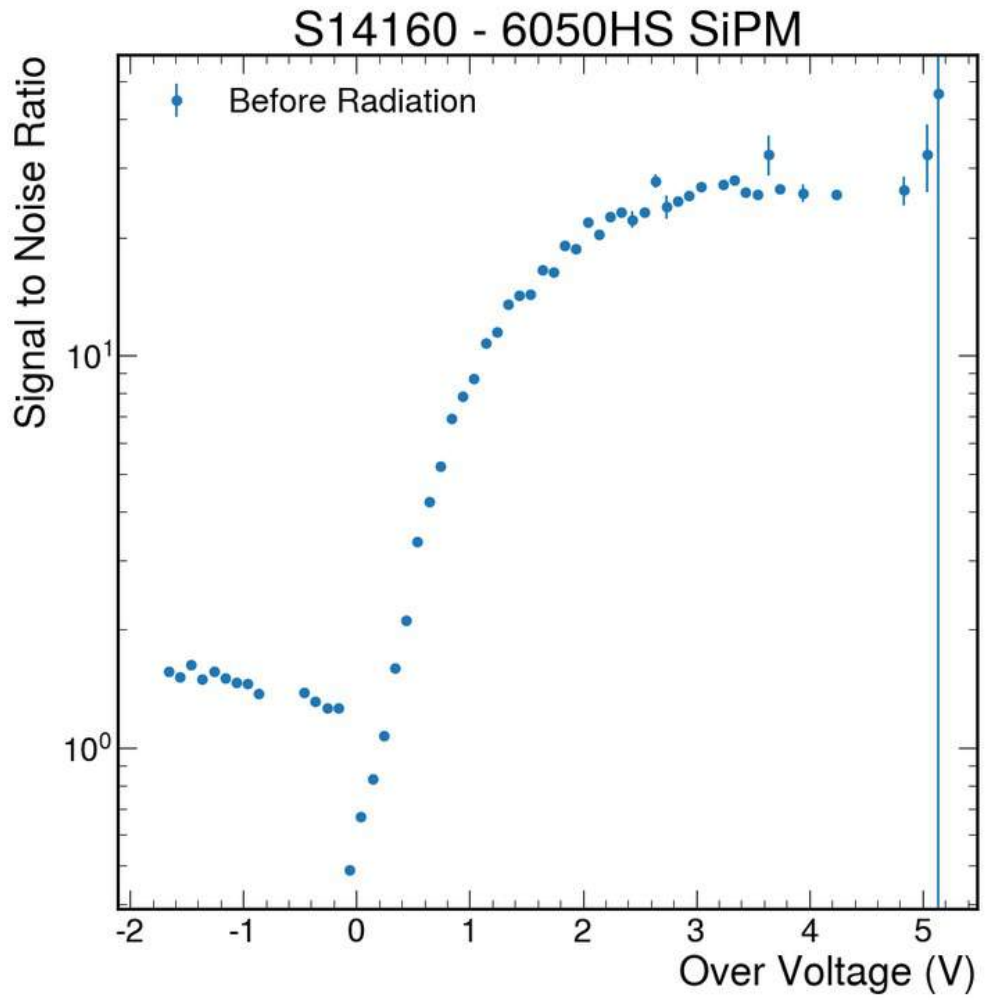


Various physics quantities will be monitored over time



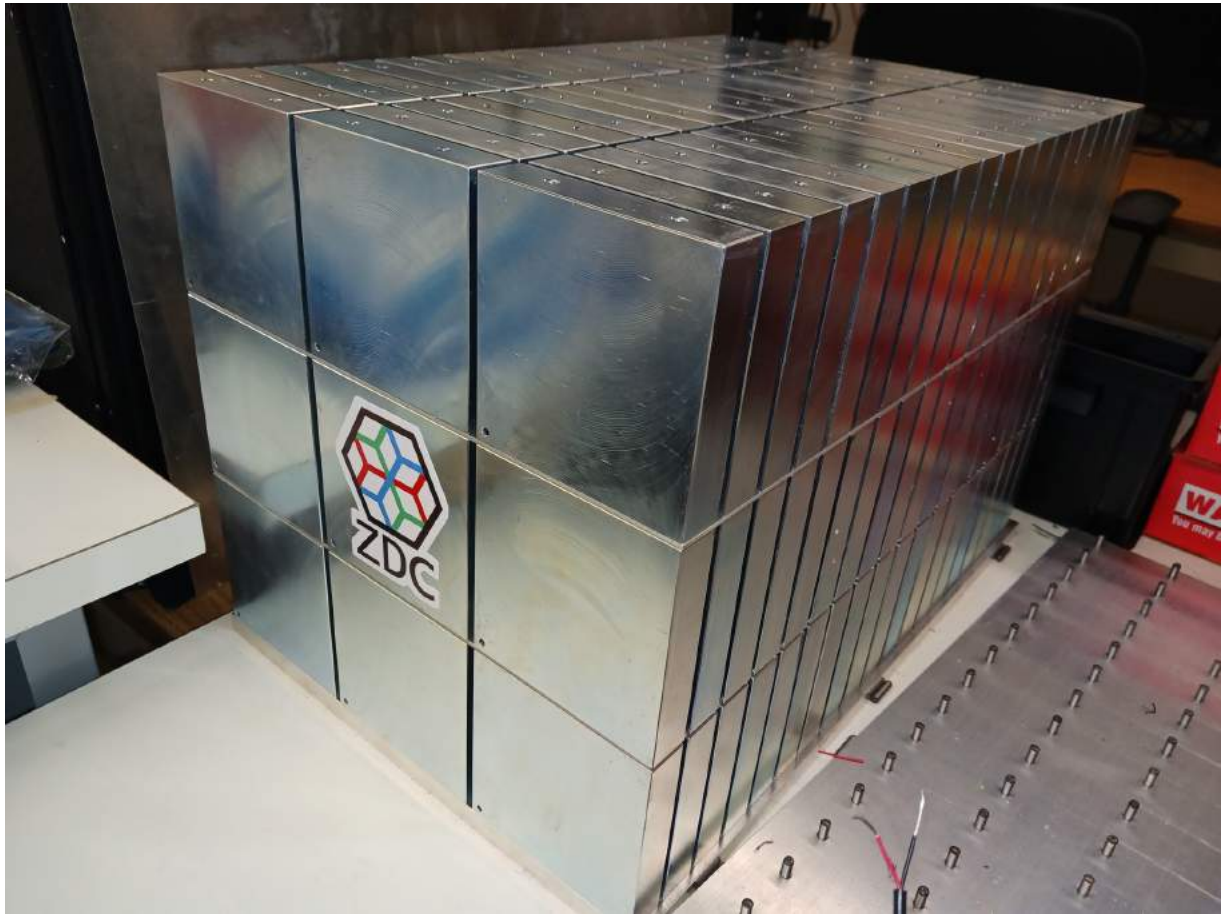


Between pp and Au-Au runs, we will remove the SiPMs, anneal them, reinstall them, and run them as long as possible



Gen III Prototype

- Plan to test Gen III prototype at JLab and FNAL
- Will consist of ~600 channels
- Validate mechanical structure for ZDC, continue prototyping studies



Thank you!