HRS Detector Package for PREX-II/CREX

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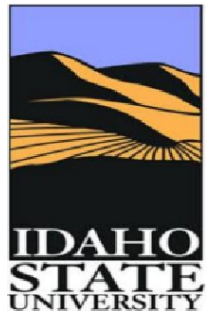
Nov 11 - 12, 2018

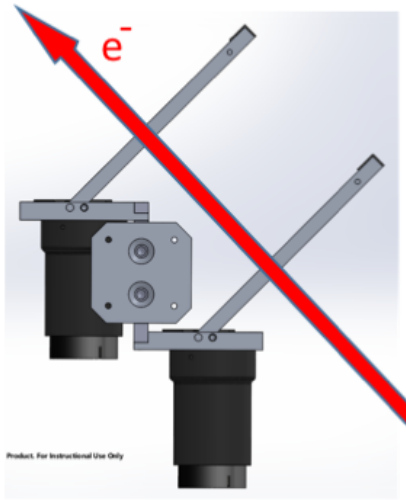


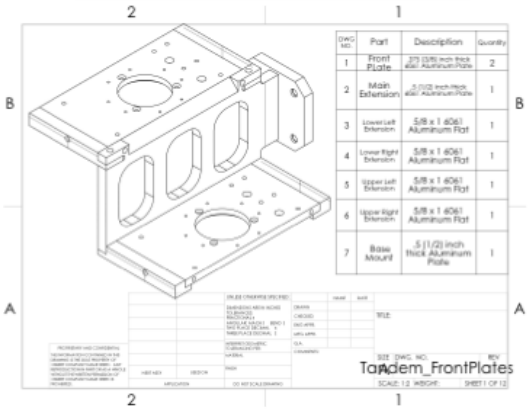
HRS Detector Package for PREX-II/CREX

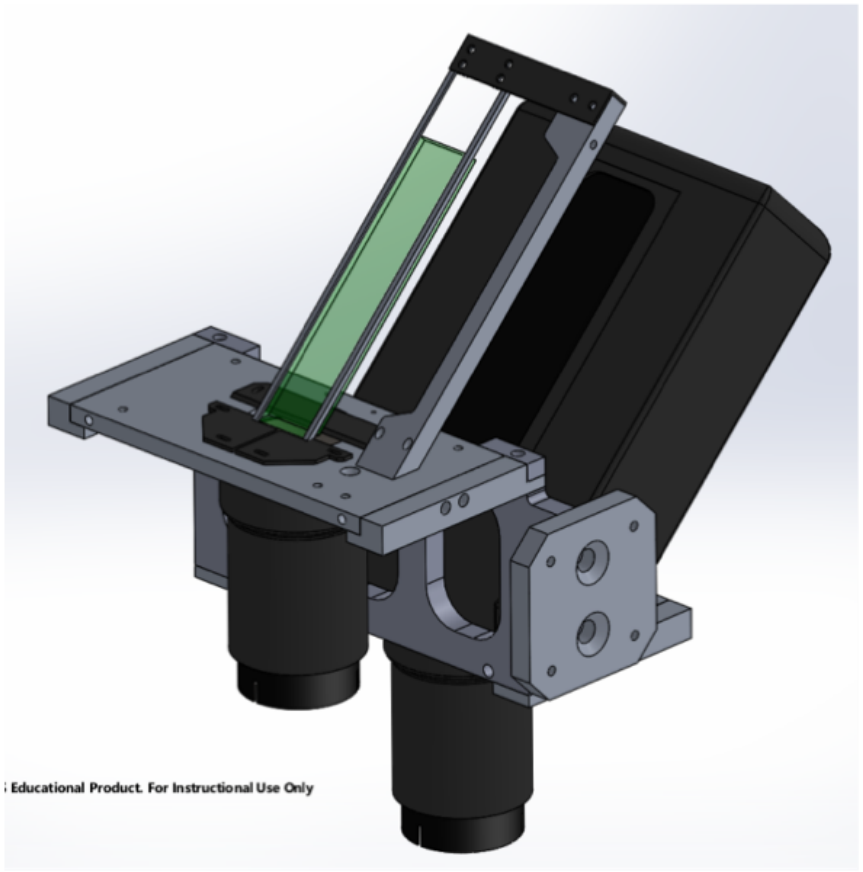
Talk Outline:

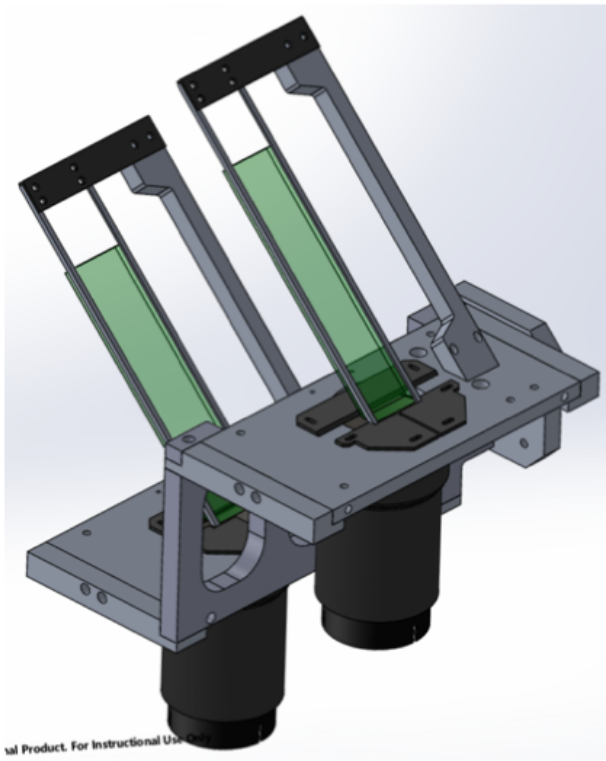
- Main Detector Design
- Motion Control System
- GEM System Progress
- HRS Detector Package
- PMT Linearity
- SLAC Testbeam and Jlab Pre-staging
- Summary

Main Integrating Tandem Detector Design



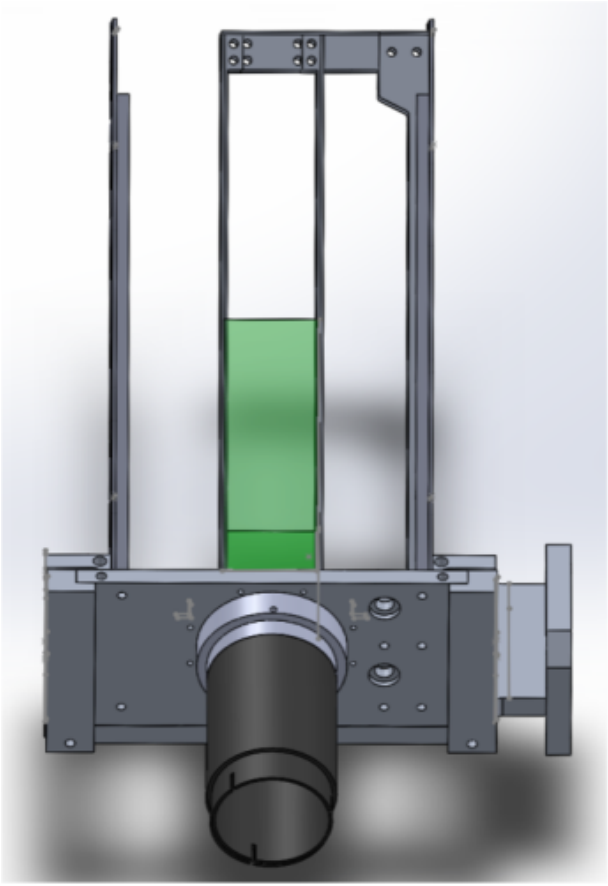




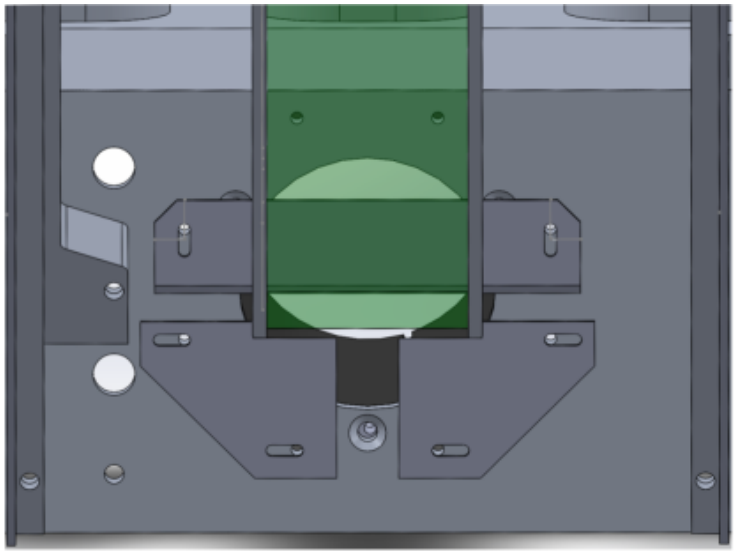


- PREX-II/CREX main detector design based on UMass Design-3.
- Rotatable tandem mount designed and prototype constructed
- New design has shorter quartz rails and incorporates mu-metal shields and 3D printed ABS-plastic enclosure with Kapton or Tedlar windows

Quartz Geometry Plans (Preliminary)



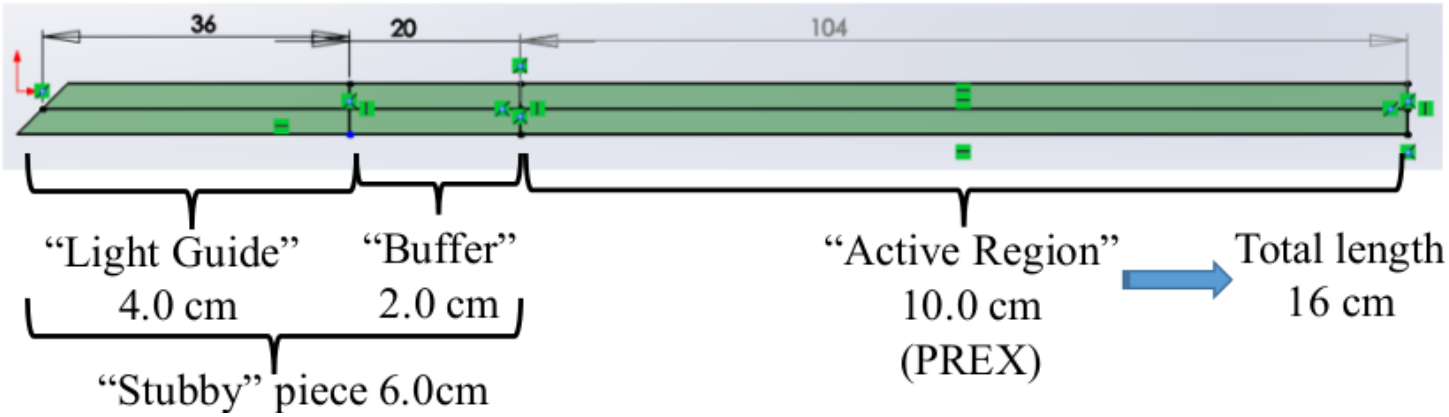
Beam's view. Note "stubby" quartz installed upstream, "full" quartz downstream – for illustrative purposes



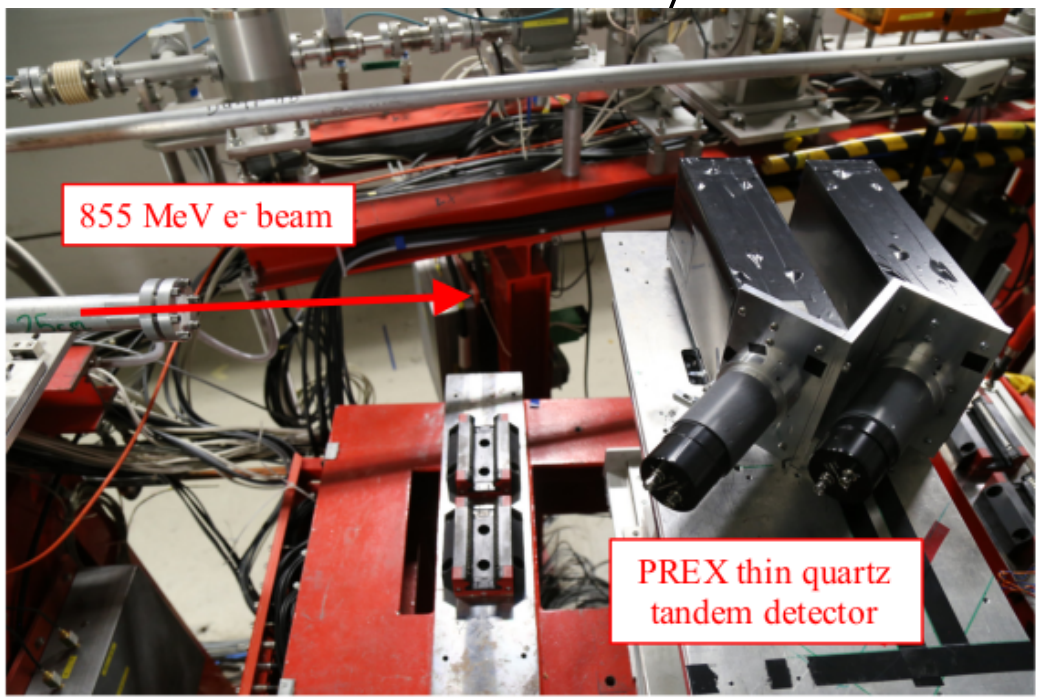
Top view showing quartz-rail supports (at PMT end). No light guides or wrapping will be used.

- PREX-I quartz was 3.5 cm wide by 16 cm long by 6 mm/10 mm thick
- PREX-II and CREX quartz could be same geometry as PREX-I
- Design can accommodate up to 4.8 cm wide quartz piece

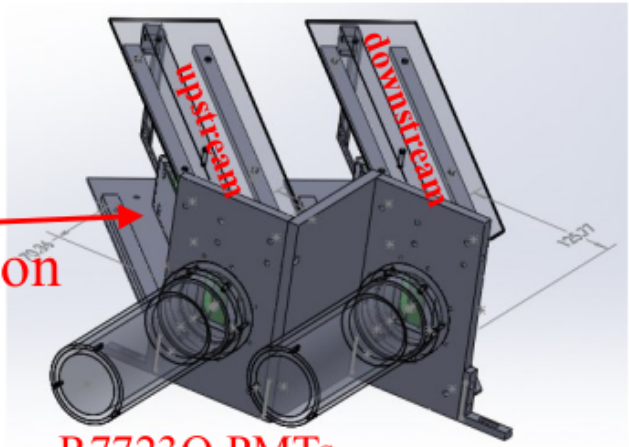
Preliminary proposed quartz geometry idea



PREX/CREX Tandem mount Tests



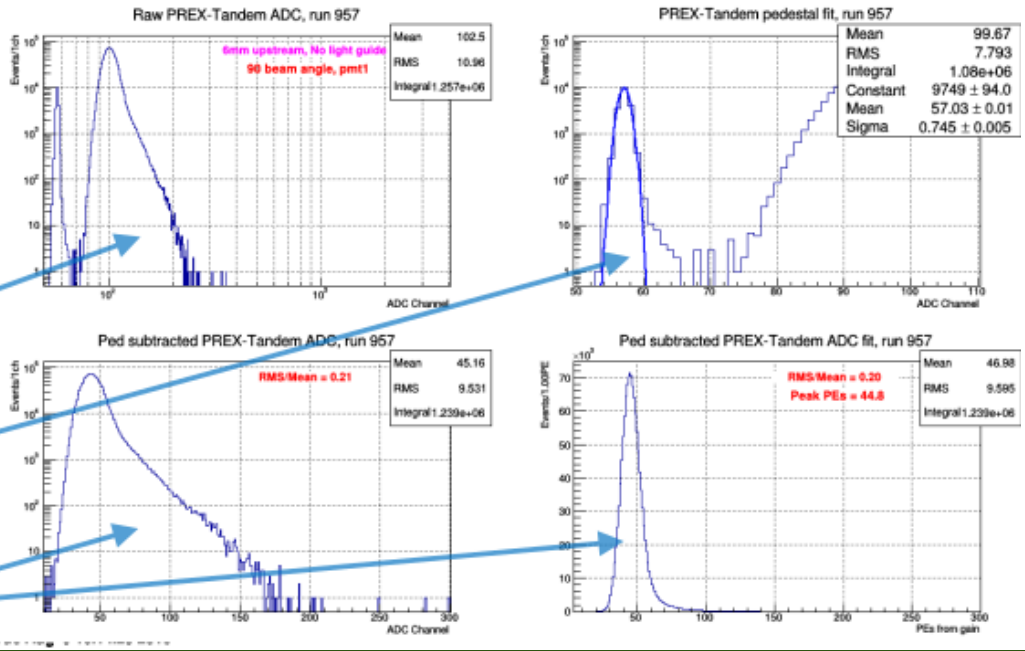
Spectrosil2000 thicknesses: 10mm and 6mm / 6mm and 10mm



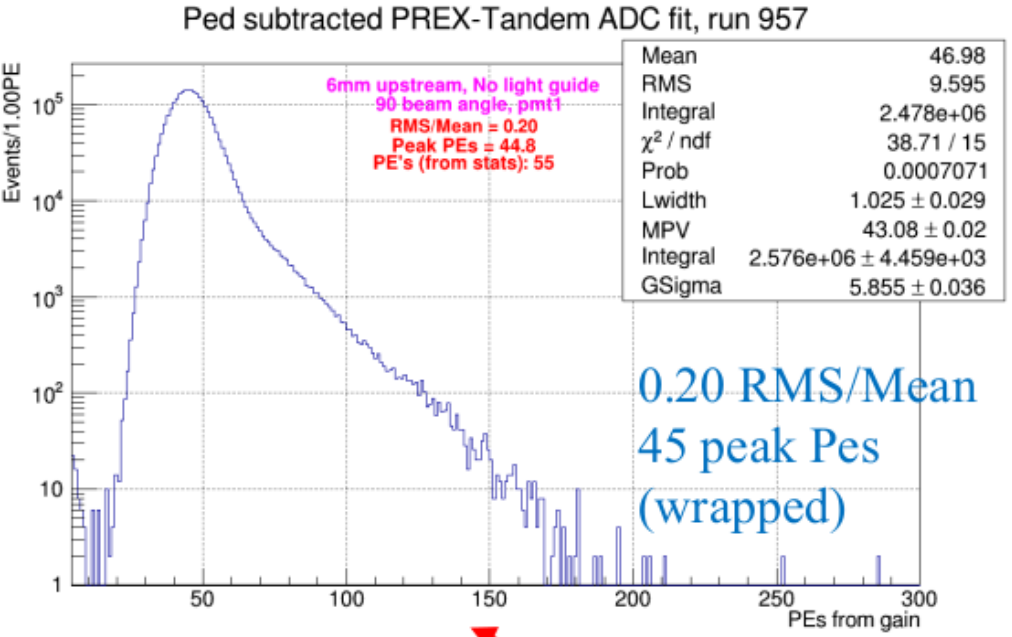
e- beam Centered on quartz at ~90°

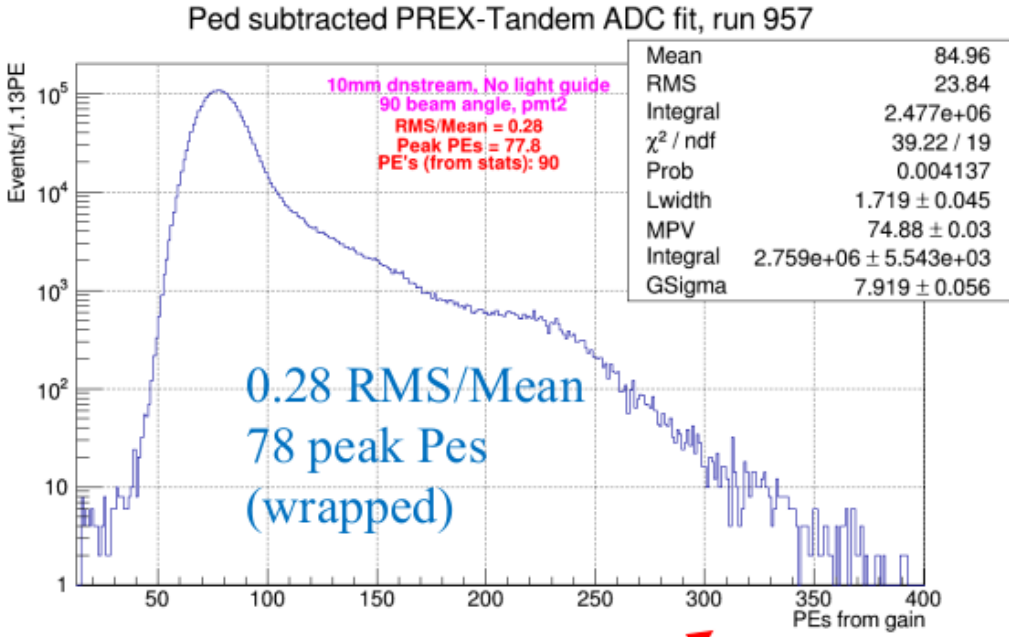
R7723Q PMTs

- Quartz spacing same as for rotary tandem mount (~16 cm)
- Used two Hamamatsu R7723Q pmts
- Quartz is wrapped with 1 mil Al. Mylar
- Took runs for each quartz thickness upstream and downstream
- Example raw data, pedestal fit, and ped-corrected ADC and PE dists



6 mm/10 mm Tandem Testbeam Results



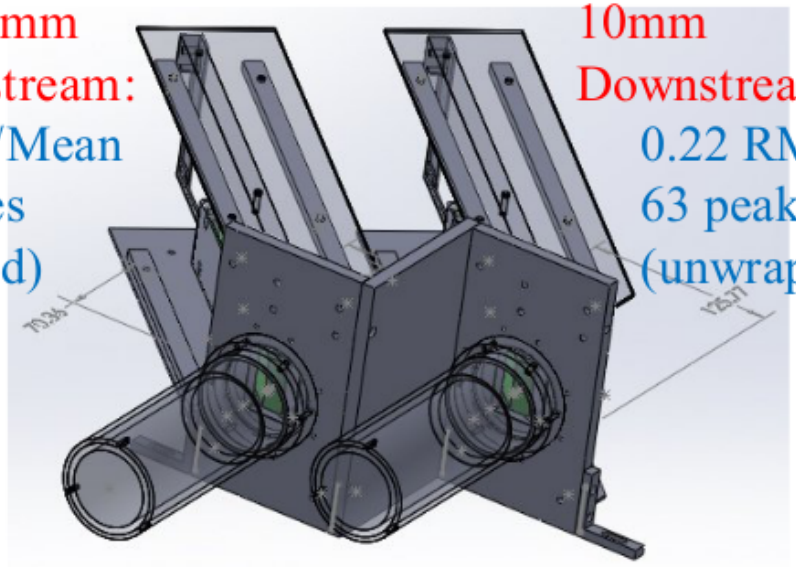


- PEs converted from ADC units using PMT gains

- Peak PE's from Langau fit parameters did not agree with PE's from gain; fits were poor and very sensitive to fit domain around peak

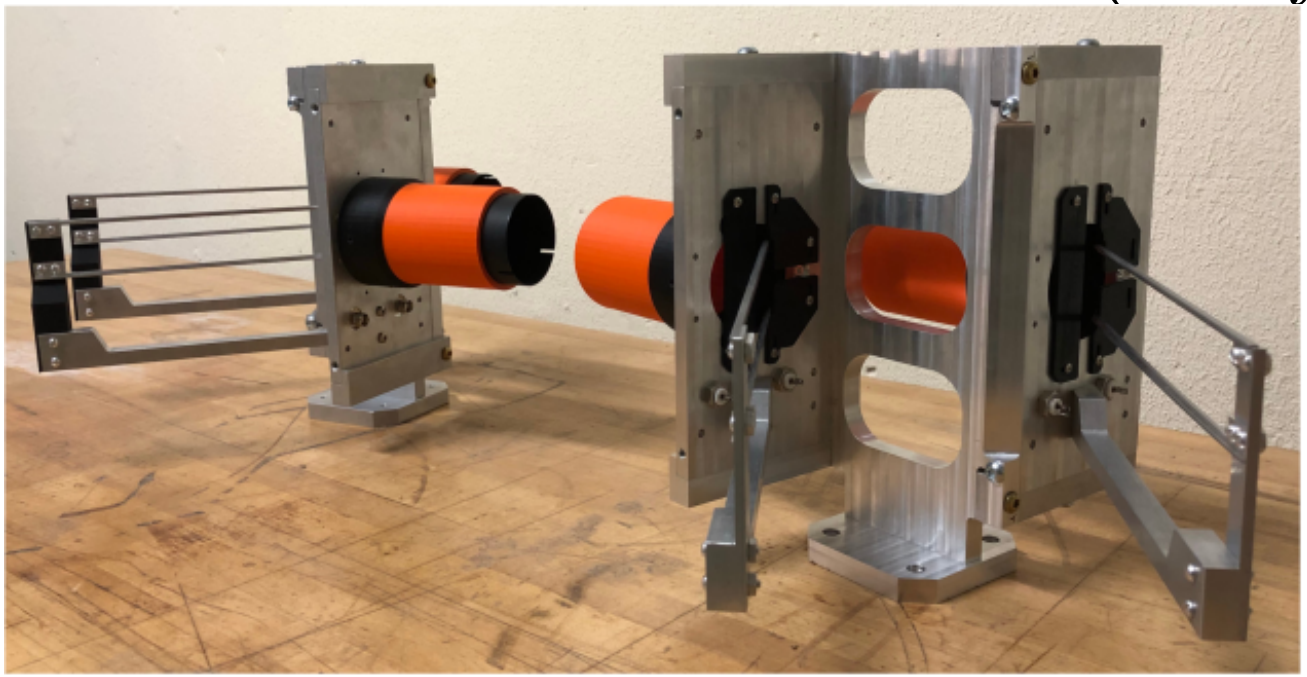
6mm Upstream:
0.19 RMS/Mean
35 peak Pes
(unwrapped)

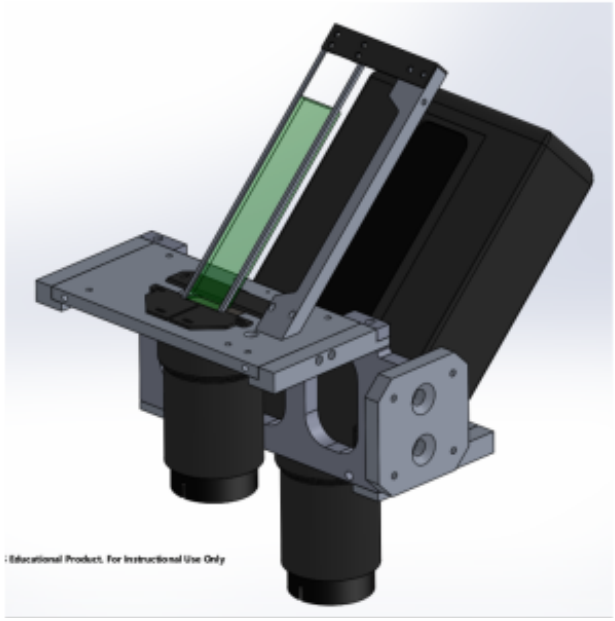
10mm Downstream:
0.22 RMS/Mean
63 peak PEs
(unwrapped)



- Uncertainty in PMT gains at 5% level

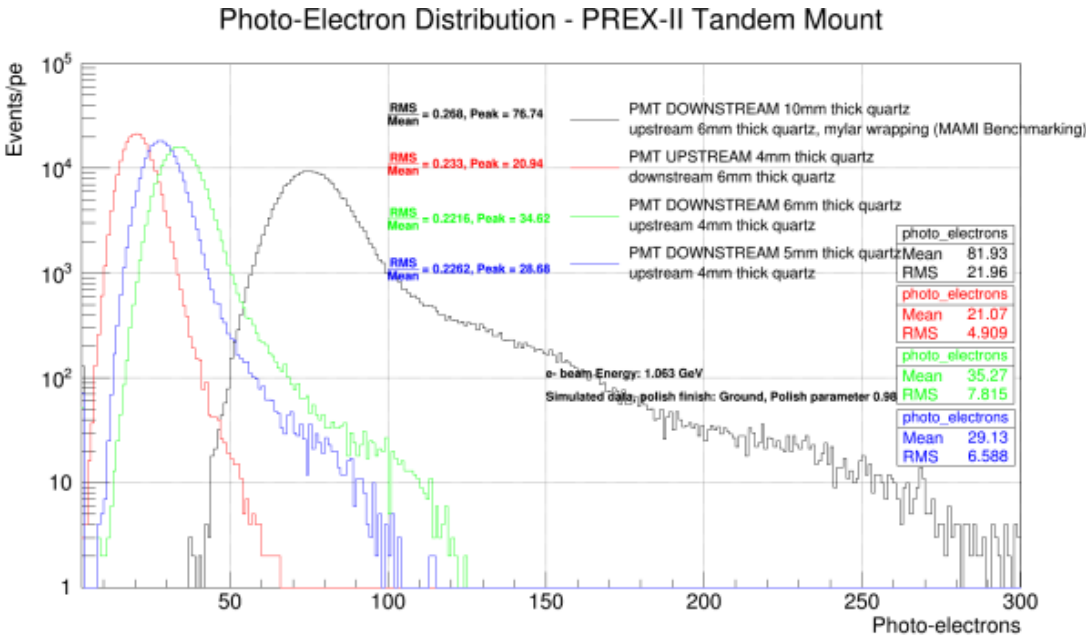
Built Tandem Detectors (nearly complete)

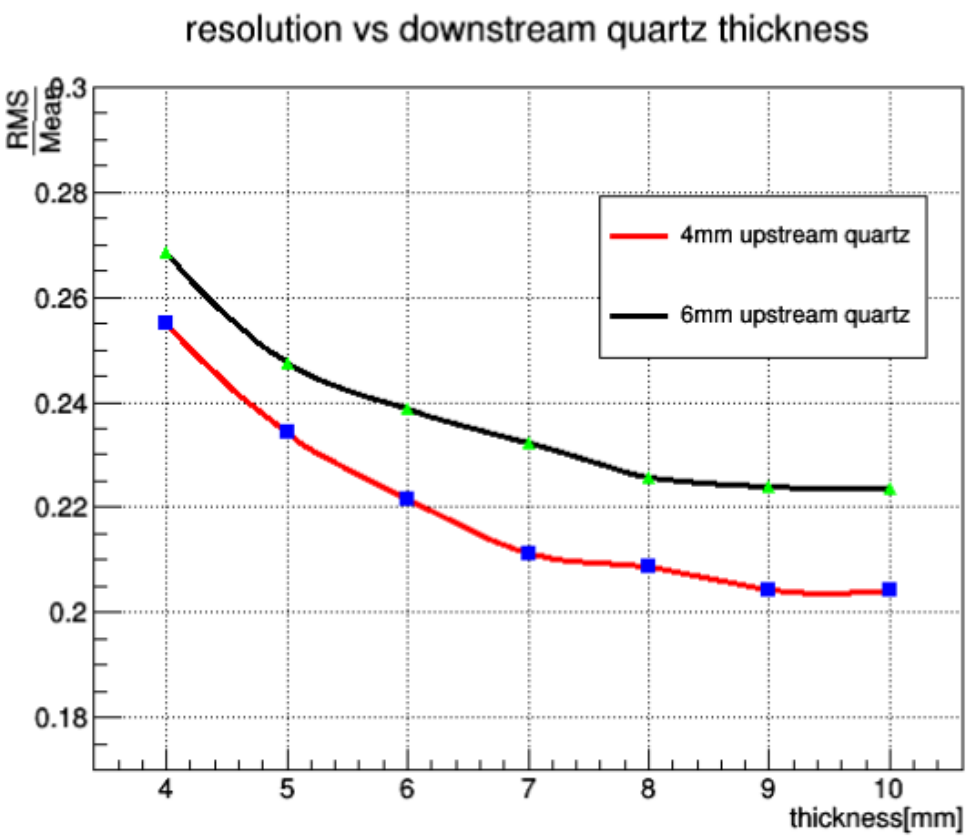


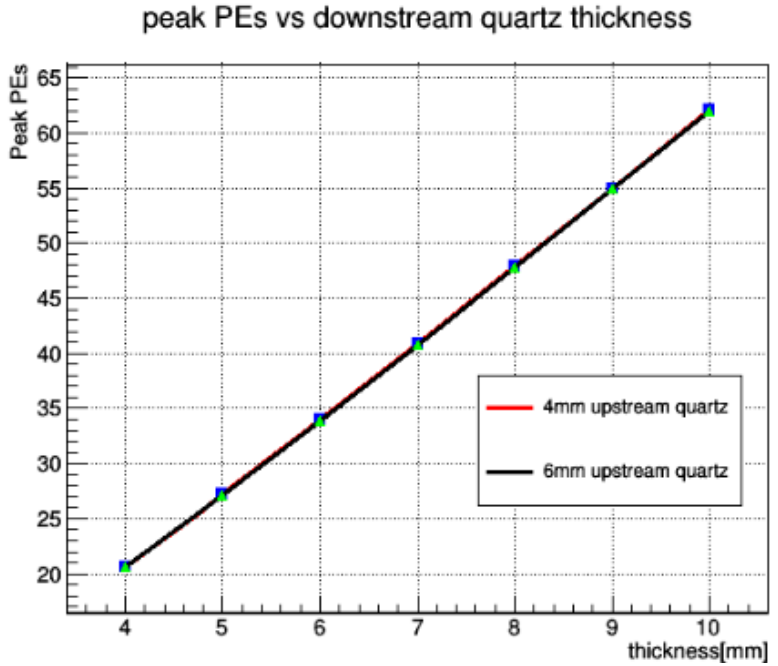


Exploring thinner quartz configurations

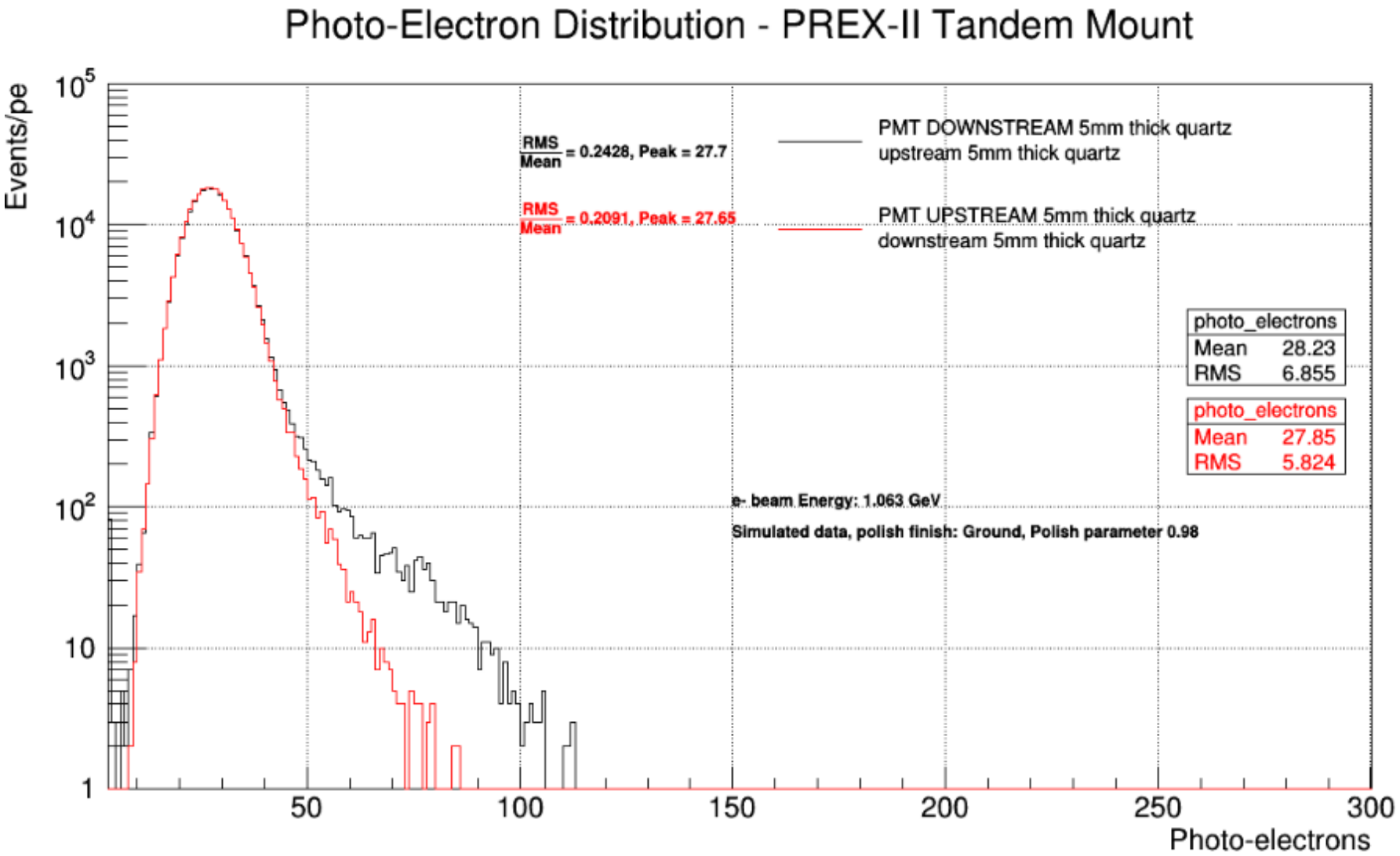
- 6 and 10 mm give too much light for PREX (linearity considerations)
- 5 mm thick for both up- and down-stream looks promising







5 mm thick Quartz Simulation Results



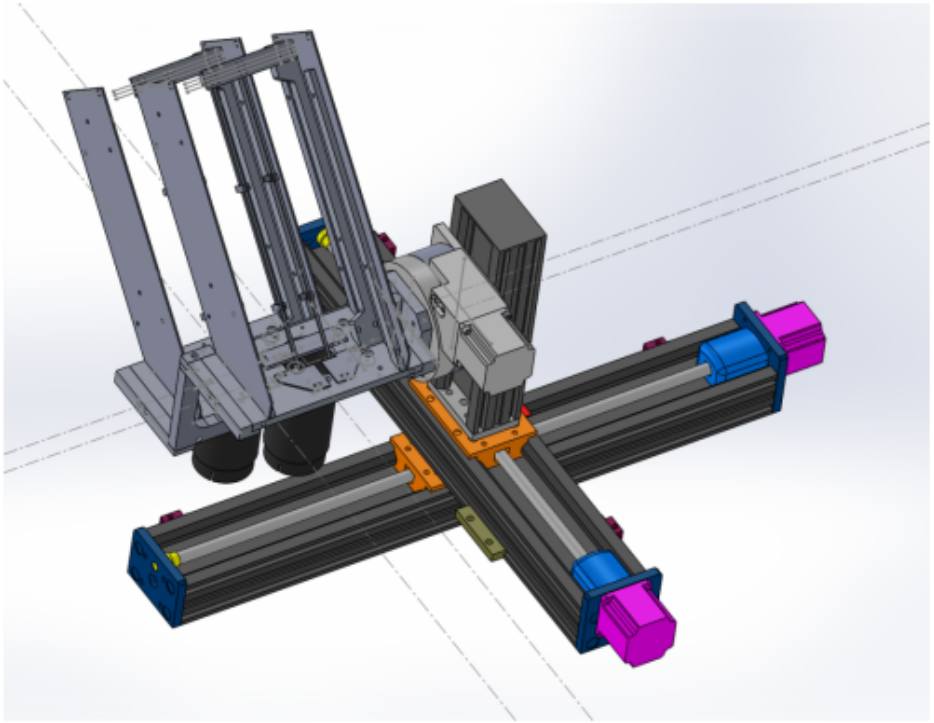
- Upstream quartz 5 mm thick: 28 PEs with 21% resolution
- Downstream quartz 5 mm thick: 28 PEs with 24% resolution

Main Detector Components List: What we have & what is needed

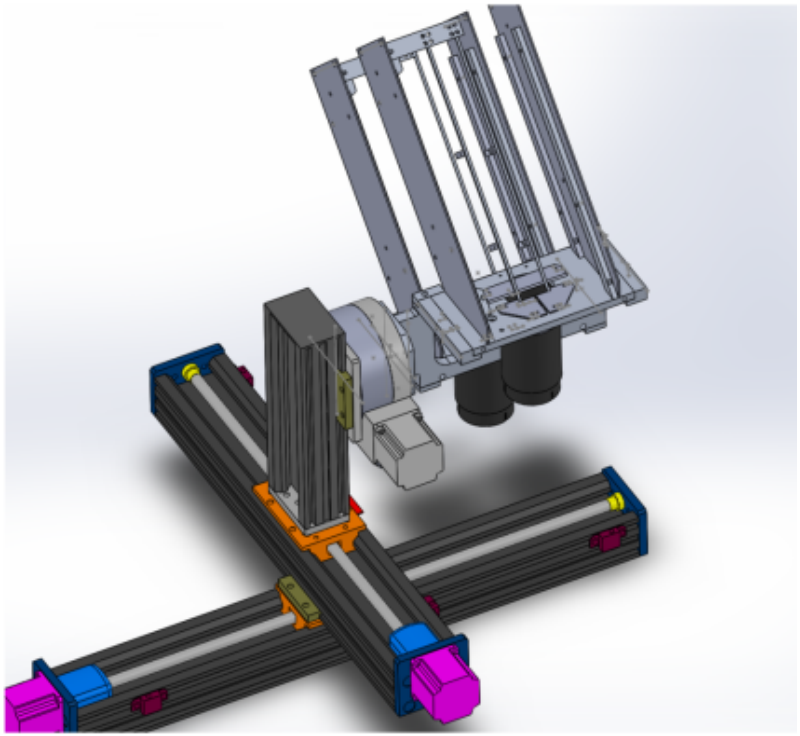
- Left and right arm tandem mounts complete
- Have 4 R7723Q PMTs with characterized gain and linearity; need 4 to 6 more for A_T detectors and spares (SBU and JLab have some -- $2k each if we need to buy any)
- Have 4 mu-metal shields for PMTs; SBU purchased 4 more for A_T detectors.
- Quartz geometry finalized for main and A_T detectors. Will use 5 mm by 35 mm by 160 mm; two pieces purchased this fall in time for SLAC testbeam in December. 6 more pieces (minimum) needed; cost per piece expected to be between $1k - 1.5k. Total cost: $6k - $9k
- We also need to purchase the "stubby" quartz pieces (for alignment validation during commissioning). Total cost is expected to be ~$2k - $3k
- Total cost of Main and A_T detector components still to purchase: $9k - $12k in quartz and ~$8k in PMTs. Purchases will be initiated this January; lead-times are ~2 months

Prototype Tandem Mount (Degrees of Freedom)

RHRS



LHRS



- *X*, *Y*, and θ degrees of freedom for main detectors
- Velmex 5 and 15" BiSlides for x and y motion, respectively (from PREX-I, we've found 15" sliders but not 15" and no controllers or cables)
- Velmex rotary stages (have one, *need another*)
- Transducers for position feedback (have 8 from PREX-I)
- A_T dets will each use 2" and 4" Velmex Xslides (have 4 from PREX-I)

Motion System Needs

- Stepper motor controllers: need 7 channels per arm at $500/channel. ISU and Manitoba are providing 8 channels each; purchases have been made--will have by end of November
- Have two 15" BiSlides in hand. Need two 5" BiSlides. ISU and Manitoba providing these; purchases have been made
- Need two rotary stages. ISU and Manitoba are each providing one; purchase has been made Have 4 mu-metal shields for PMTs; SBU purchased 4 more for A_T detectors.
- Quartz geometry finalized for main and A_T detectors. Will use 5 mm by 35 mm by 160 mm; two pieces purchased this fall in time for SLAC testbeam in December. 6 more pieces (minimum) needed; cost per piece expected to be between $1k - 1.5k. Total cost: $6k - $9k
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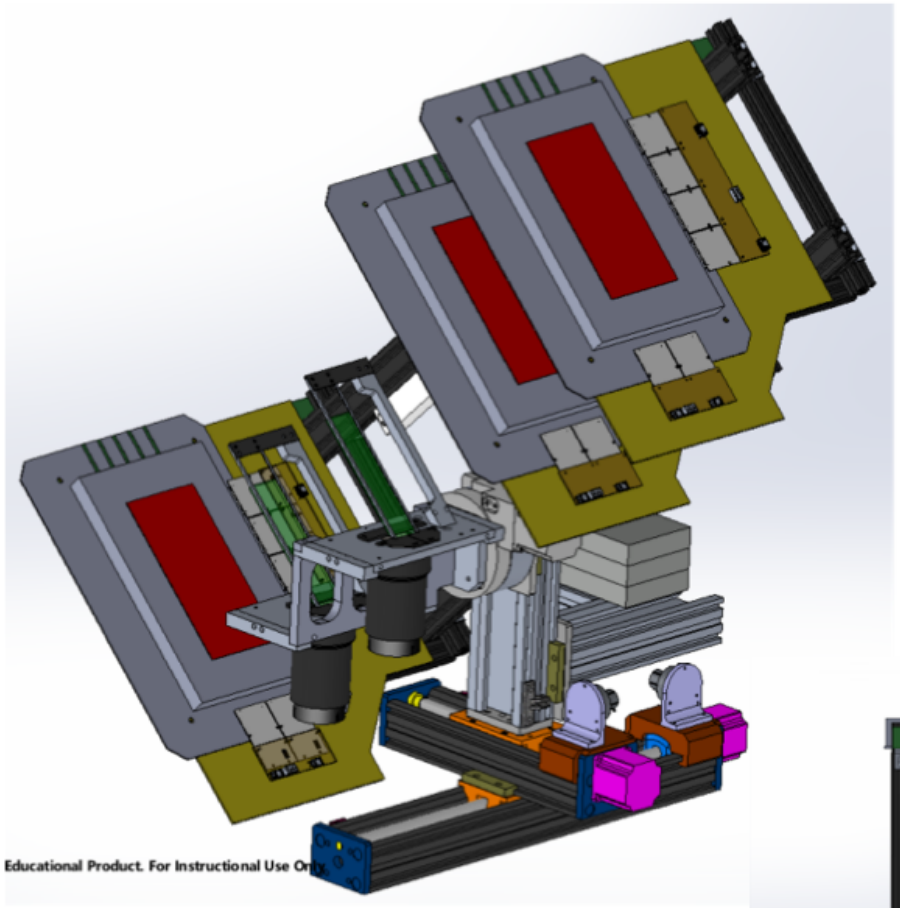
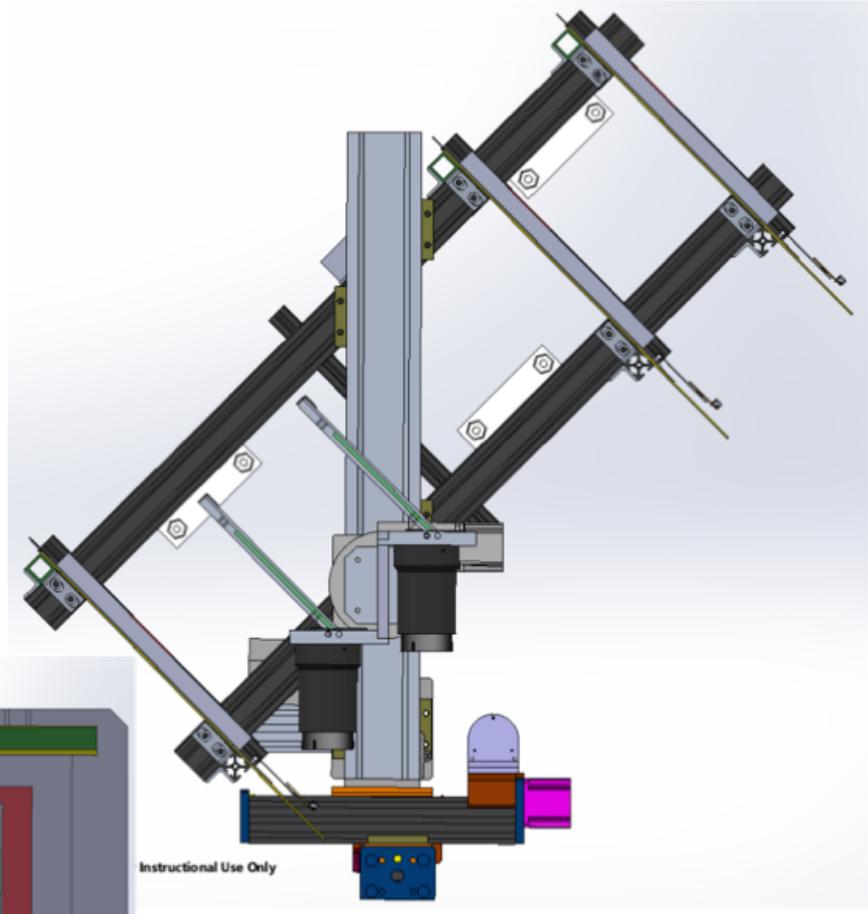
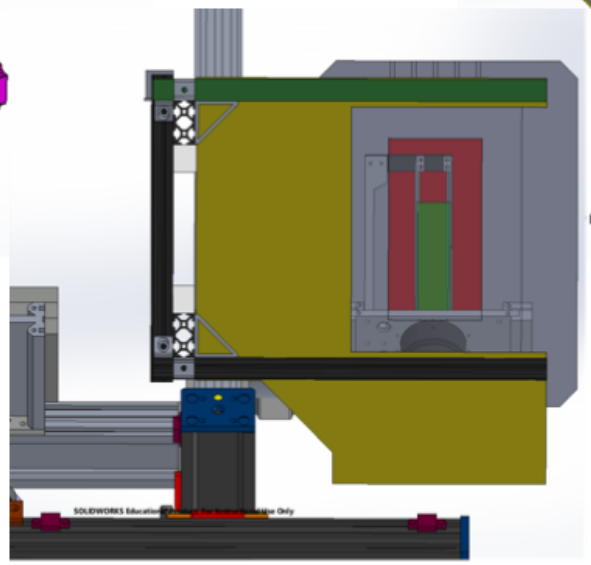
RHRS Tandem Quartz Mount with GEMs

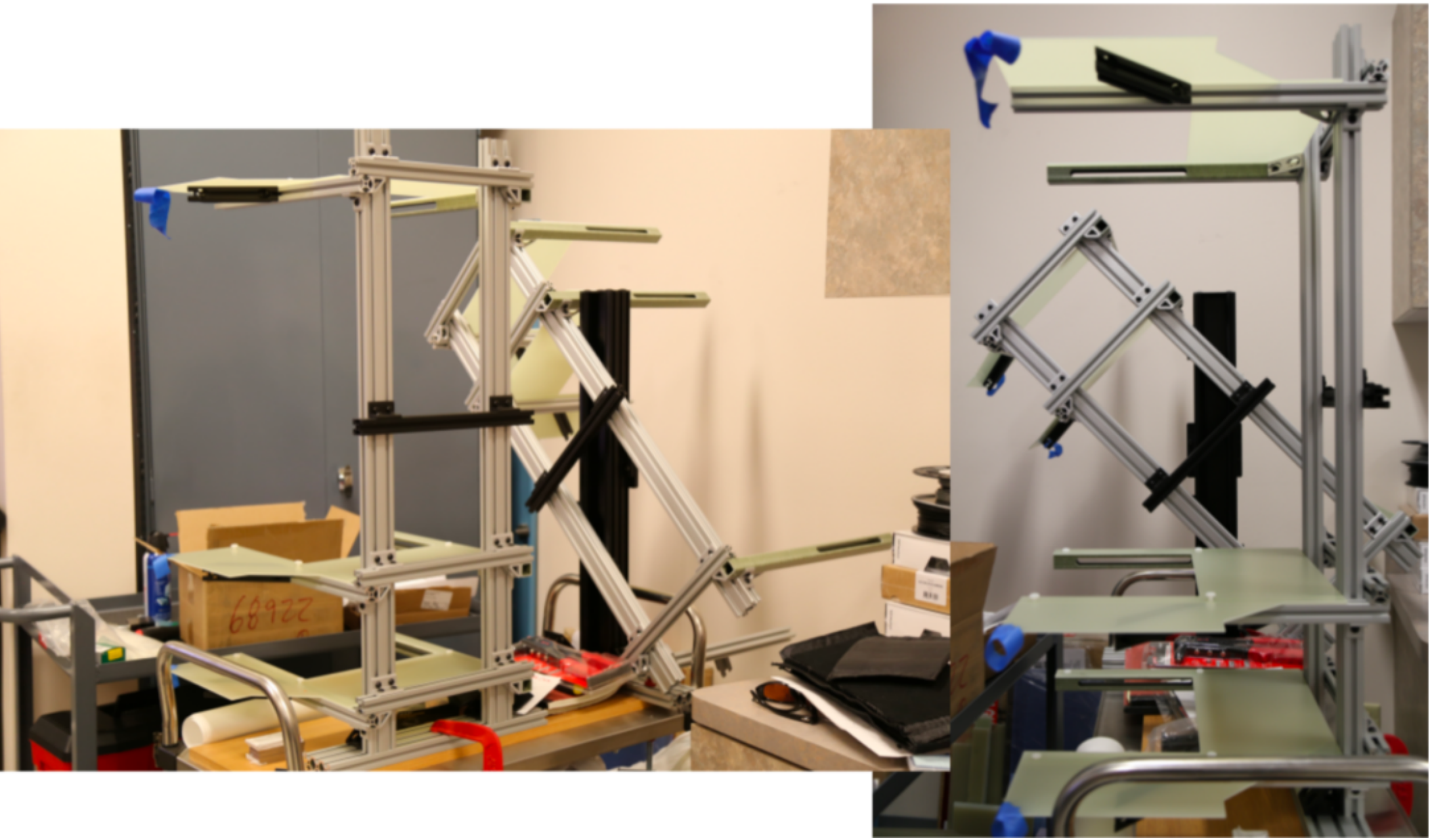




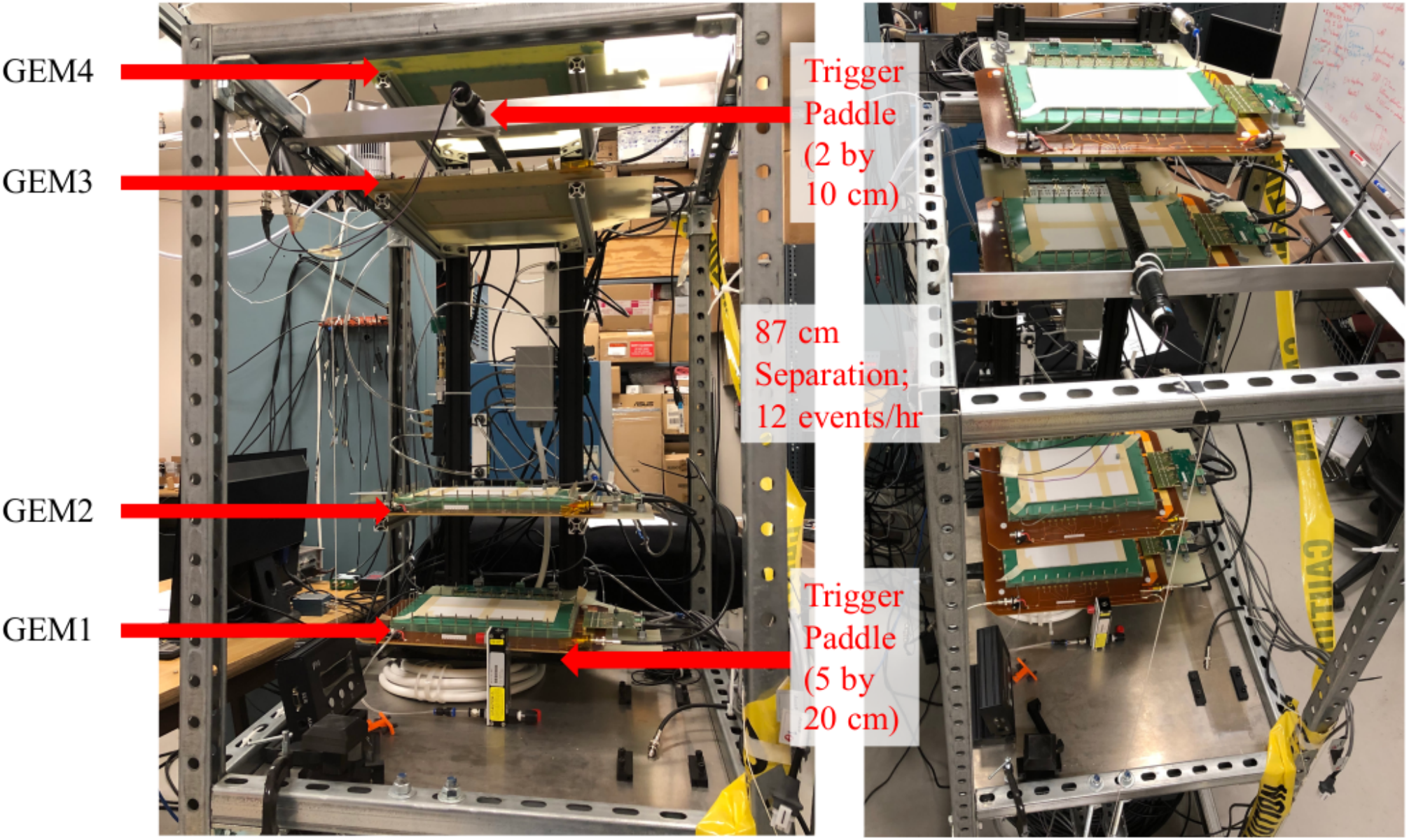


Electron's view (from below)

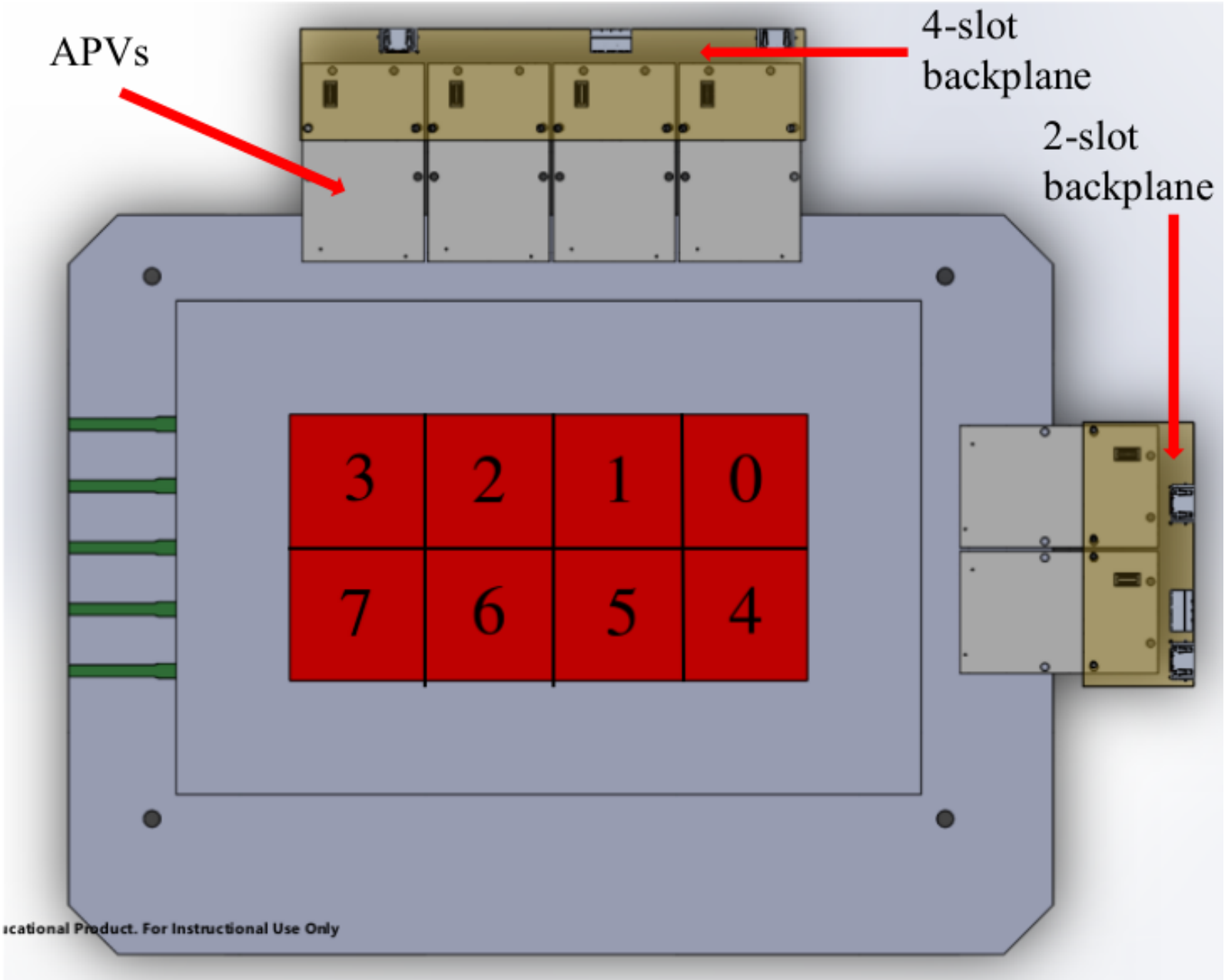
Main DetectorStands



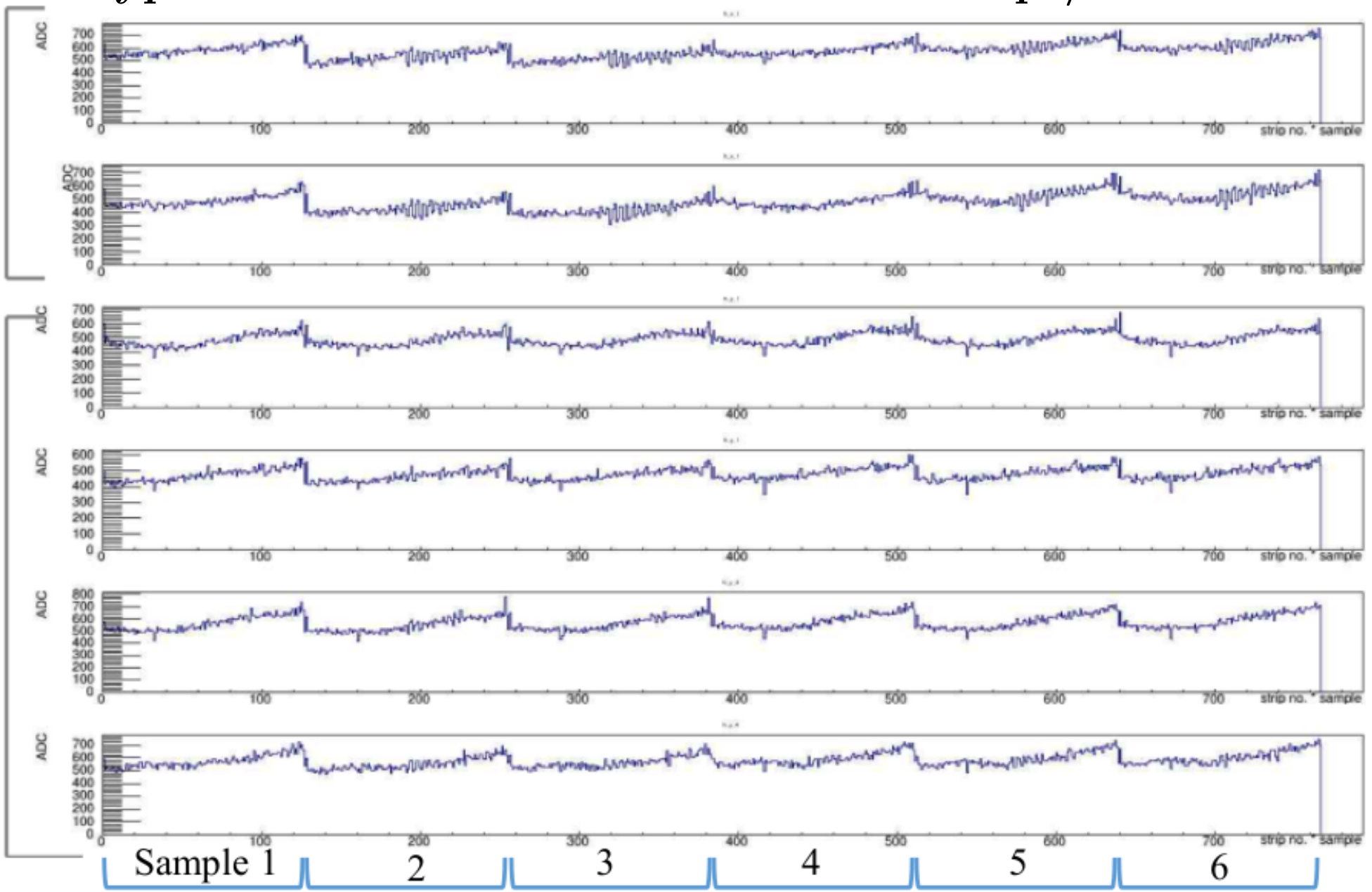
ISU Cosmic-ray Test Stand



GEM Chamber Layout

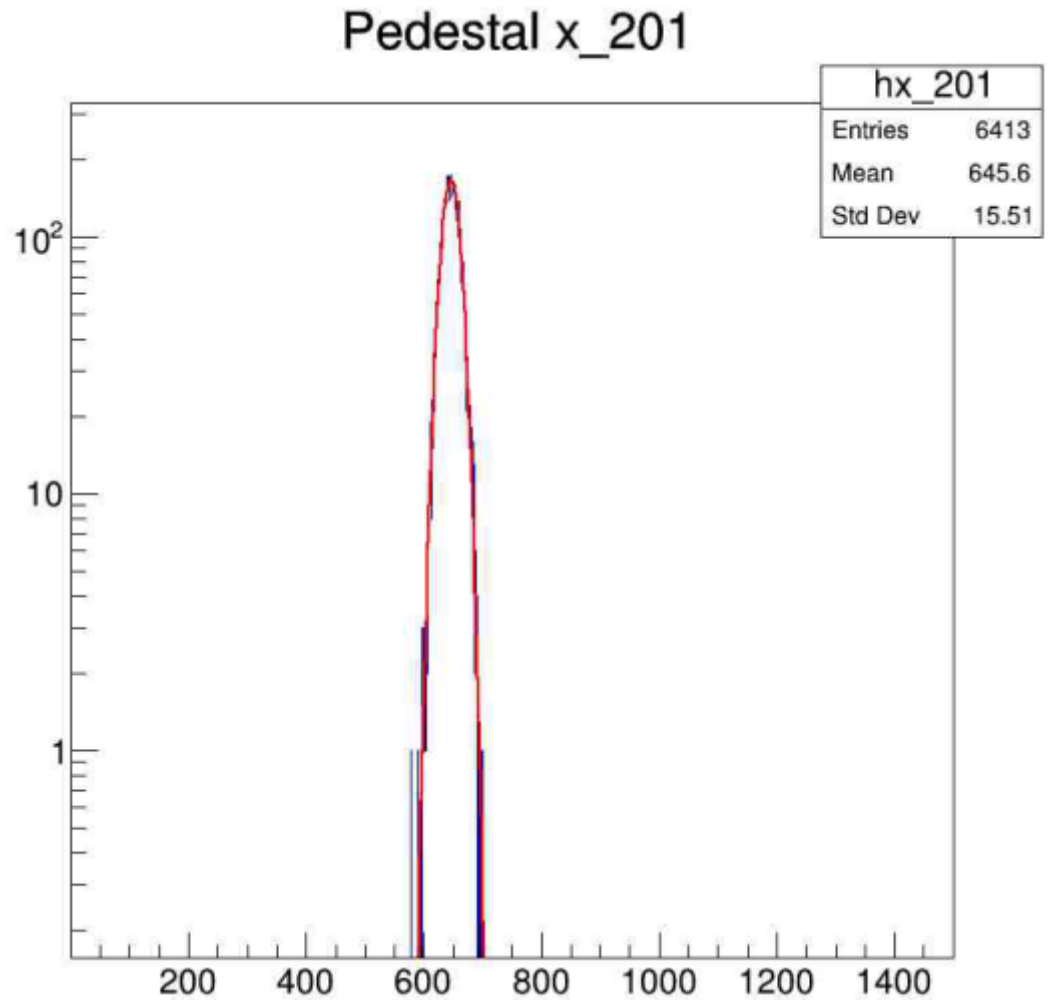


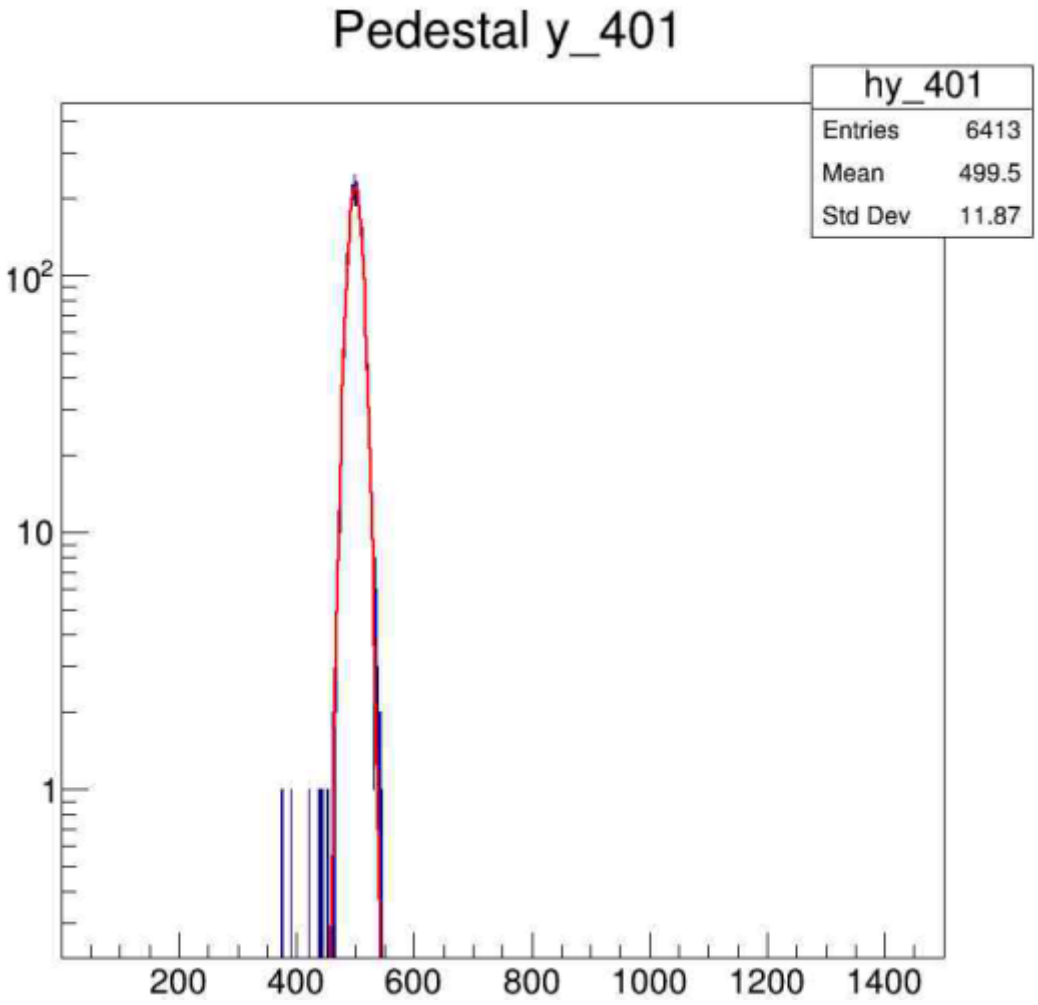
Typical GEM Pedestals: All readout strips/wires



Readout 128 strips per APV card every 25 ns: 6 APVs per GEM, 768 samples per APV per event

Sample Pedestal with Fit

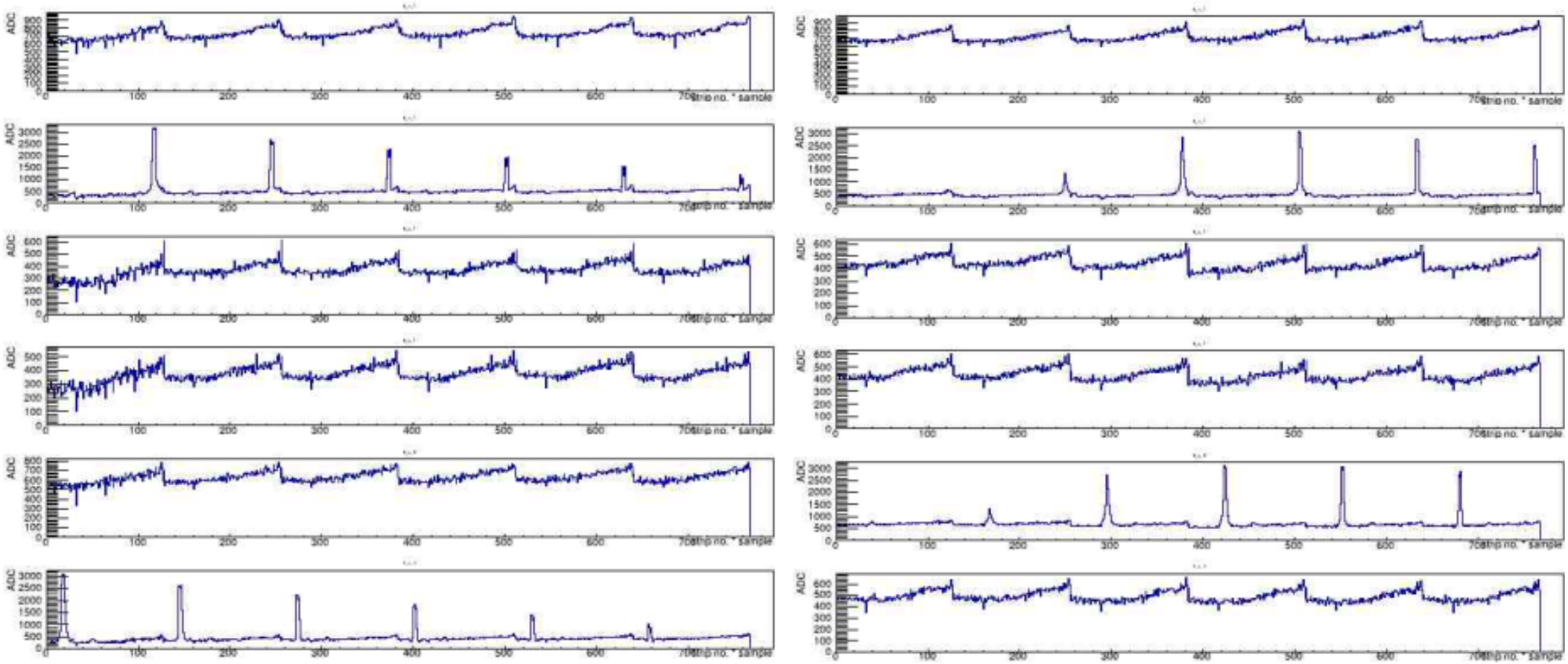




Cosmic data: Trigger Latency Scan

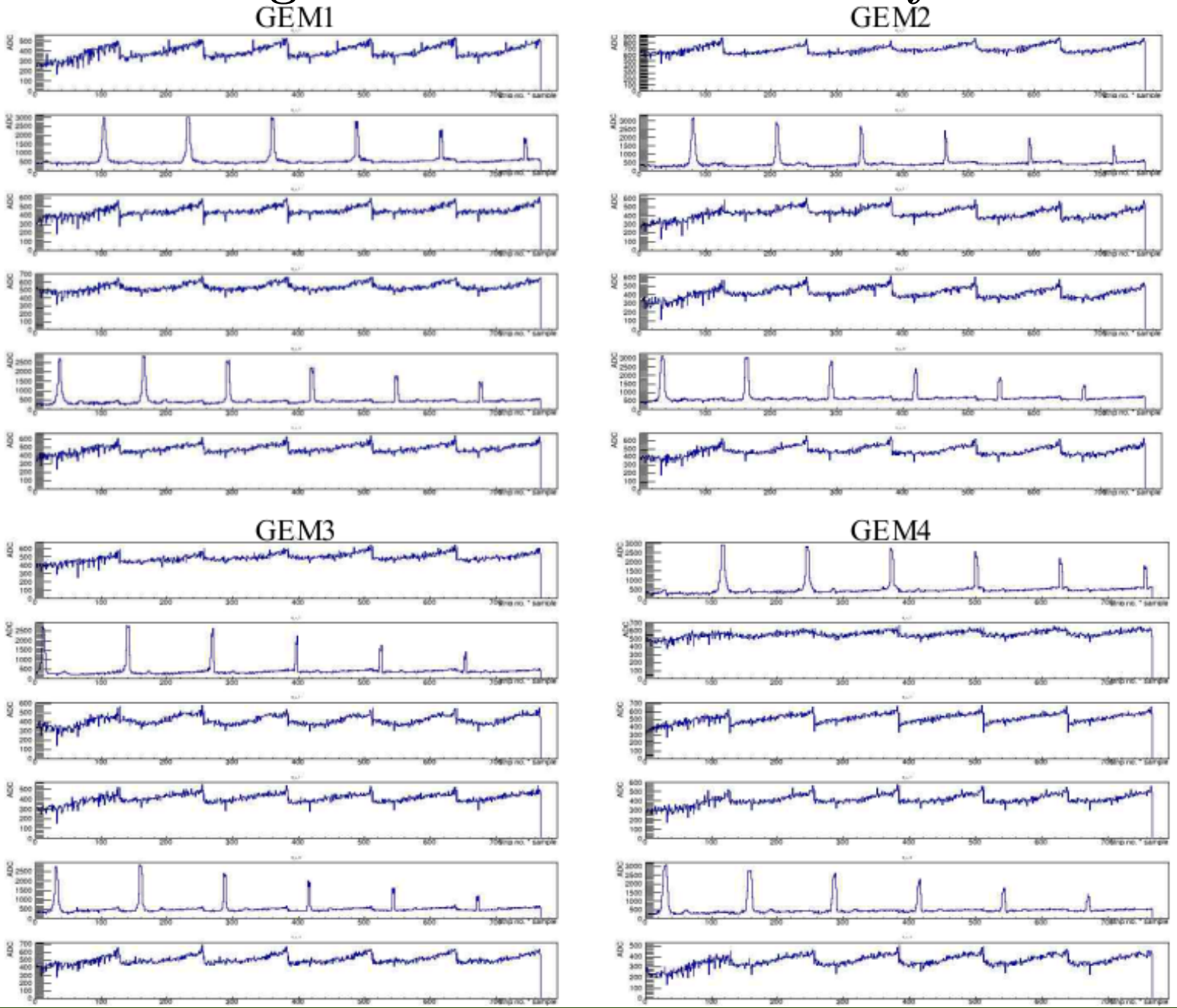
Latency = 22 (a little late)

Latency = 24 (a little early)

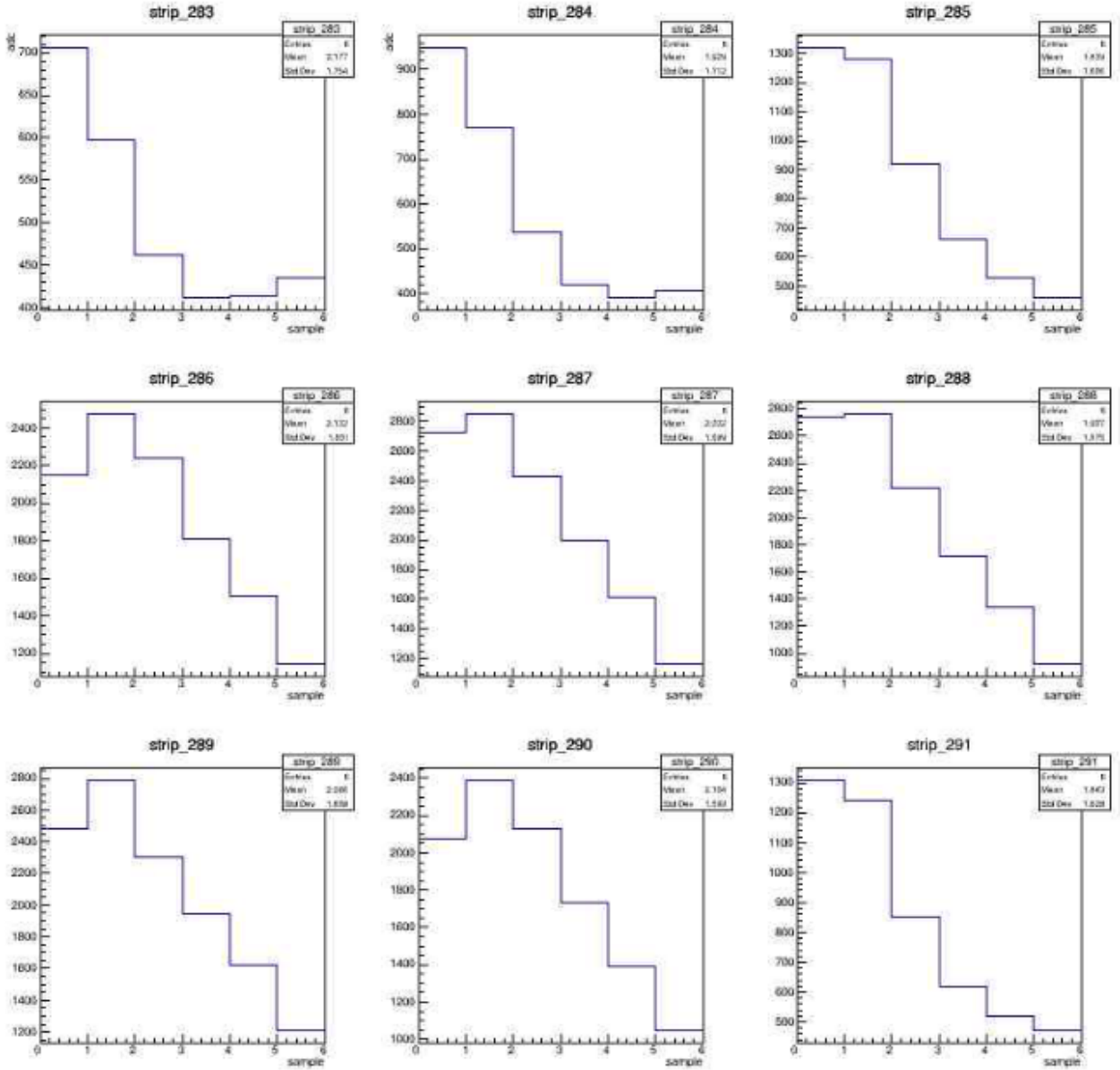


Latency of 23 is just right

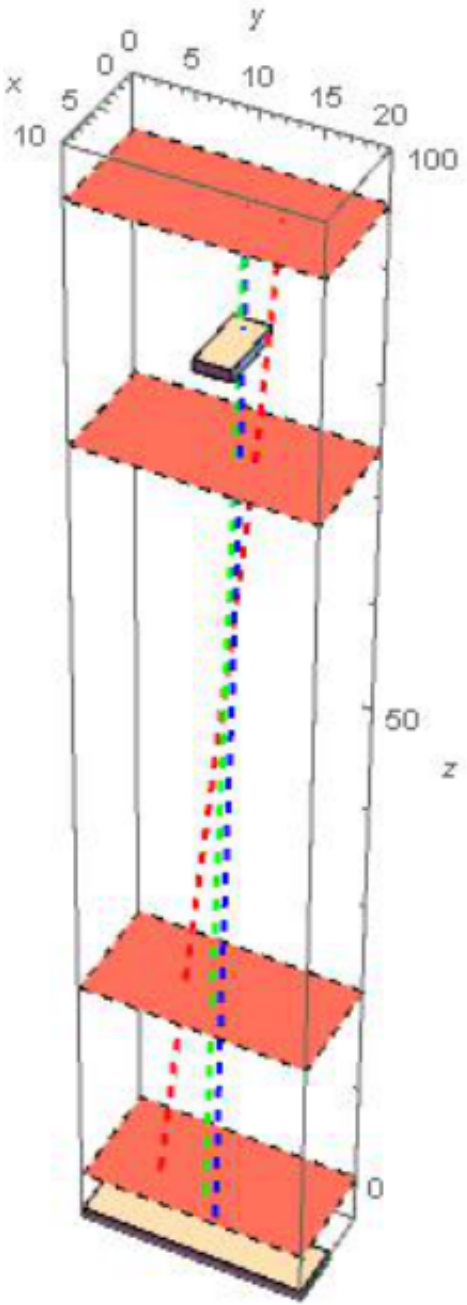
Single Cosmic Event: Latency = 23

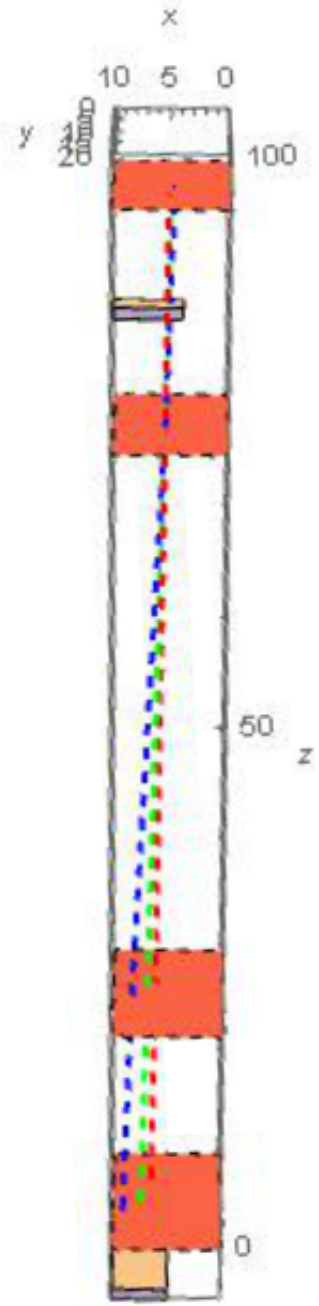


Cosmic Event, Latency = 23: 6 Samples on individual wires (raw data)



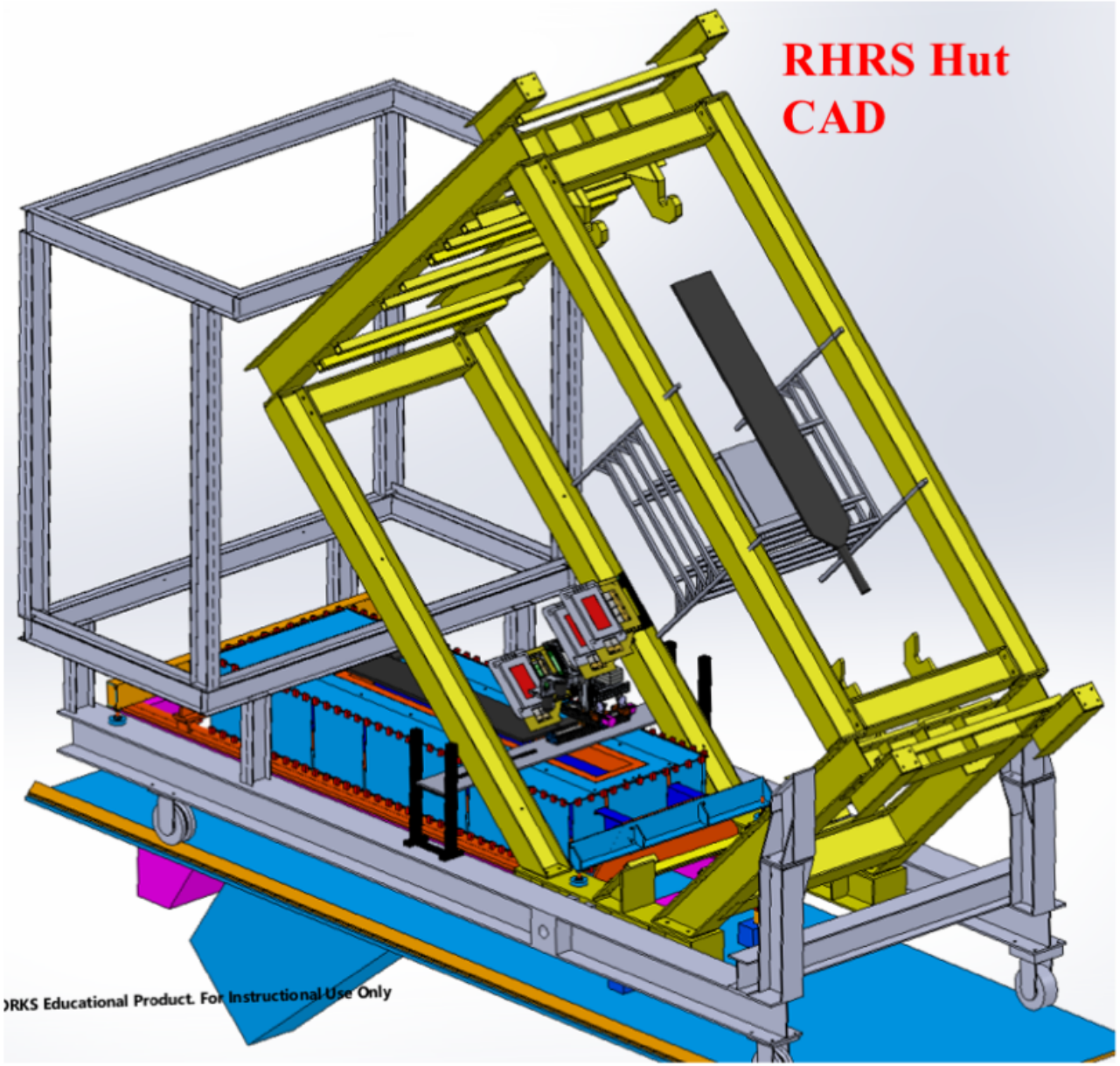
Cosmic Event Tracks





HRS Detector Package for PREX-II/CREX

- All HRS standard detector packages removed except for VDCs: No S1, S2, Cerenkov, or Calorimeter
- For event-mode operation: Use S3 (or S0) for triggering
- Additional array of large GEMs from UVA group installed above PREX detector package
- A_T detector not shown: will mount just above small GEMs
- Plan to reuse same hardware and mounting/installation concept developed for PREX-I



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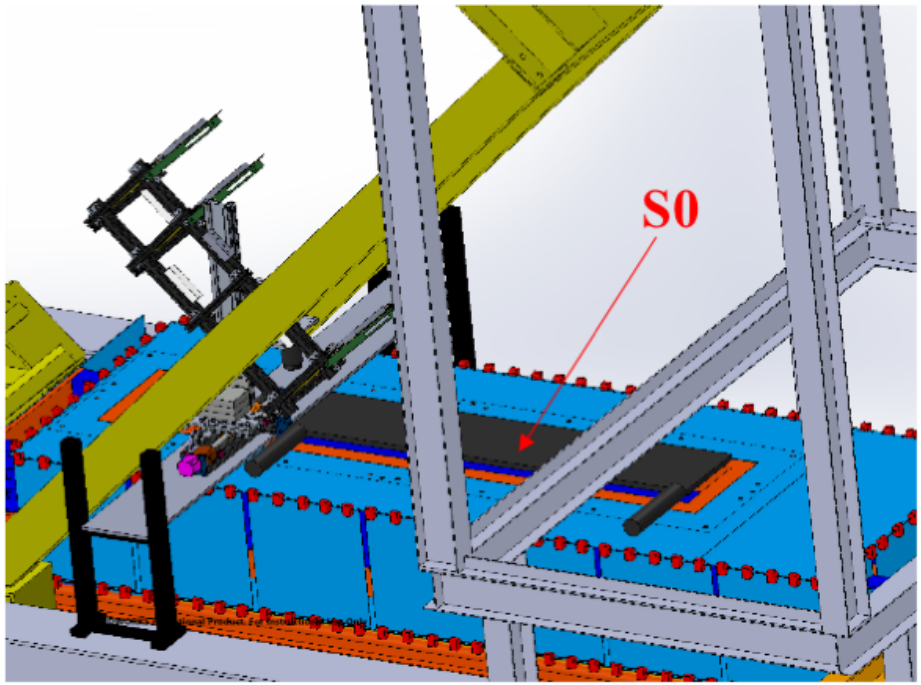
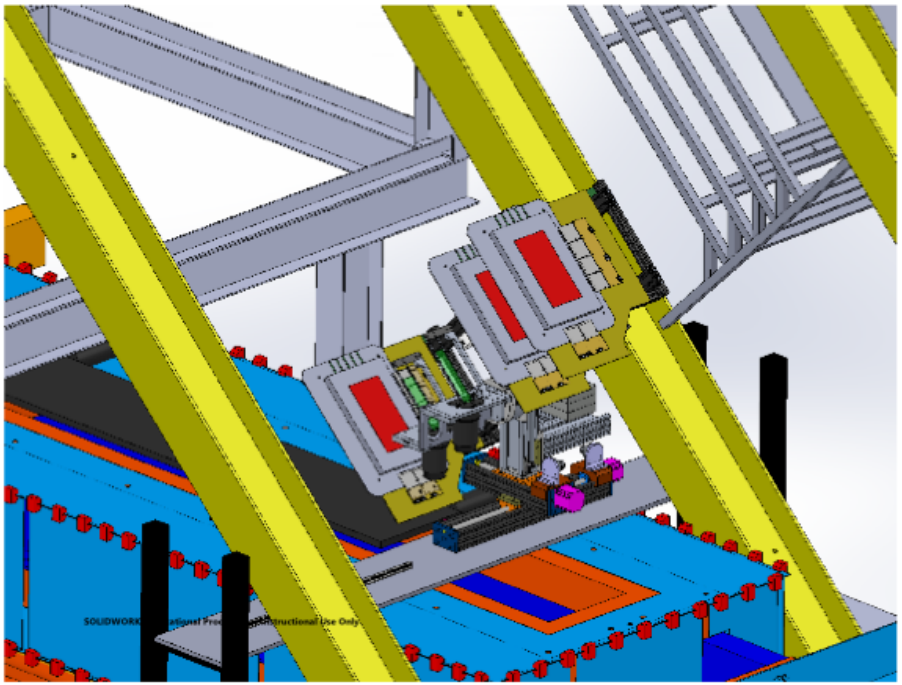
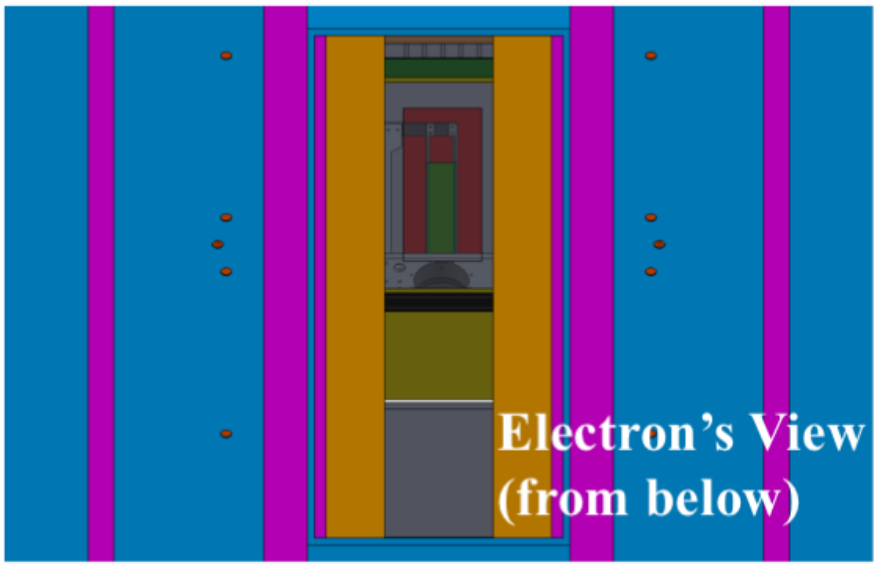
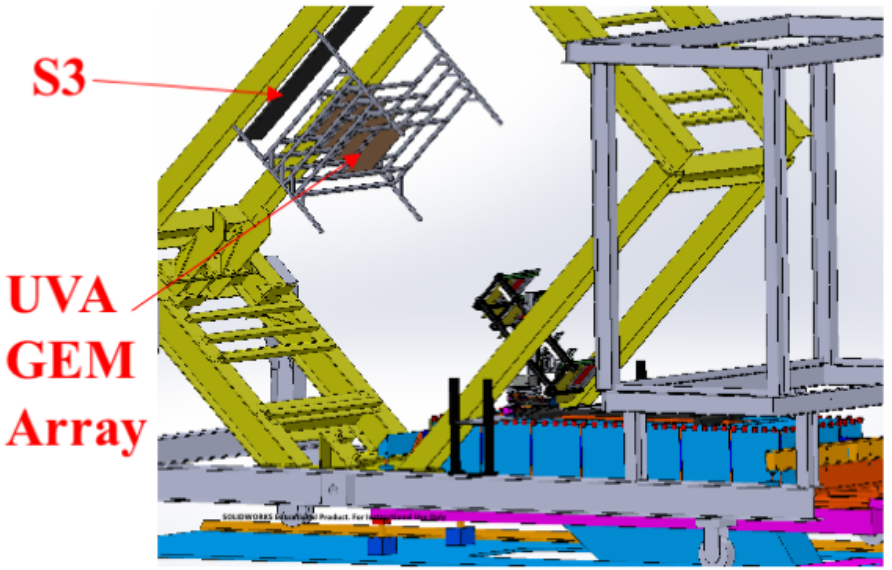


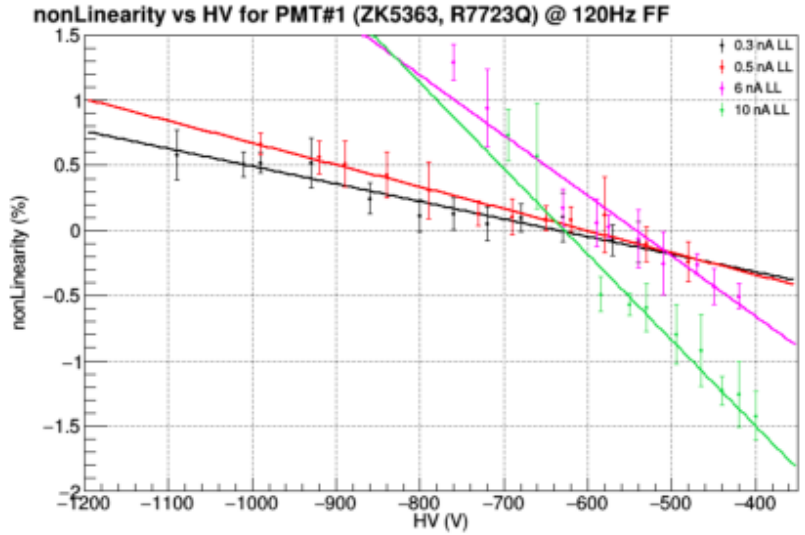




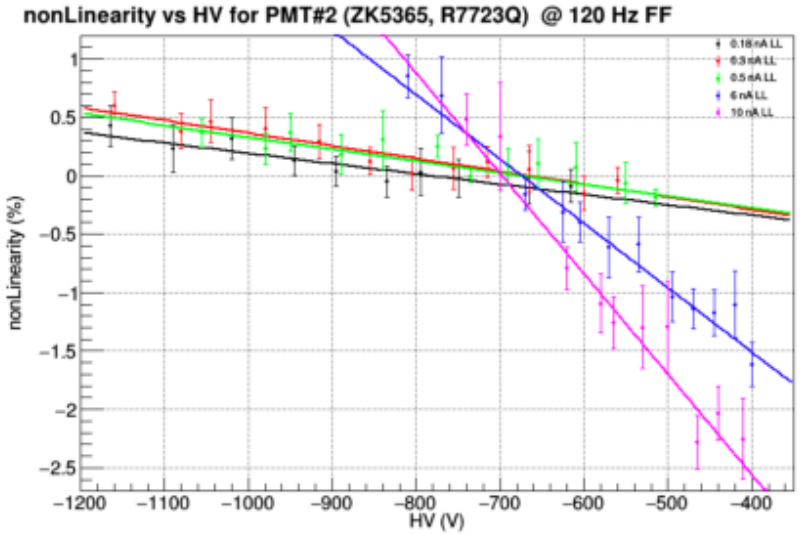


PMT Linearity at 120 Hz Flipping for various LLs

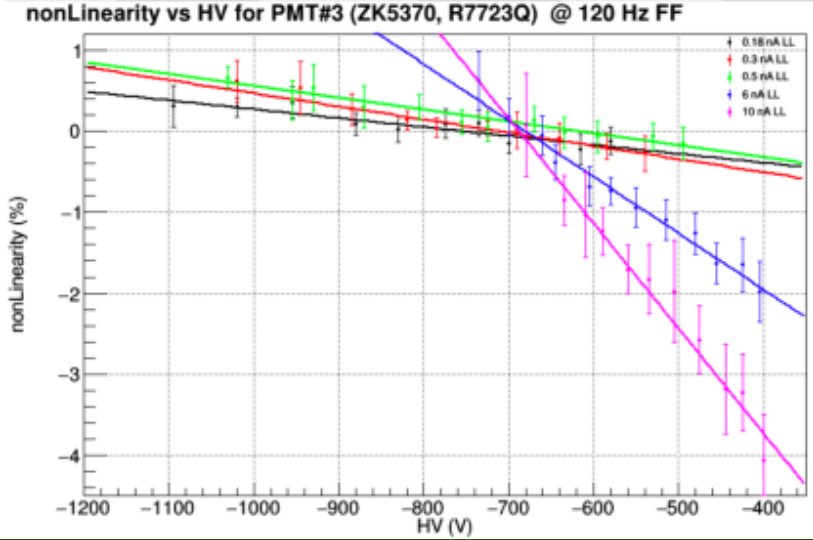
LL	0.3 nA	0.5 nA	6 nA	10 nA
HV_{max}	1090 V	990 V	760 V	695 V
$I_{anodemax}$	24.52 µA	25.08 µA	66.07 µA	66.00 µA



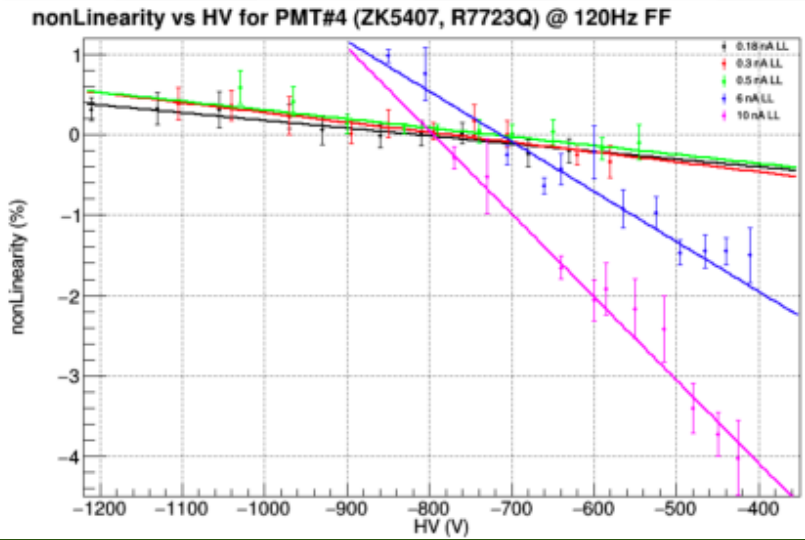
LL	0.18 nA	0.3 nA	0.5 nA	6 nA	10 nA
HV_{max}	1165 V	1160 V	1055 V	810 V	740 V
$I_{anodemax}$	15.01 µA	24.80 µA	24.68 µA	67.31 µA	66.30 µA



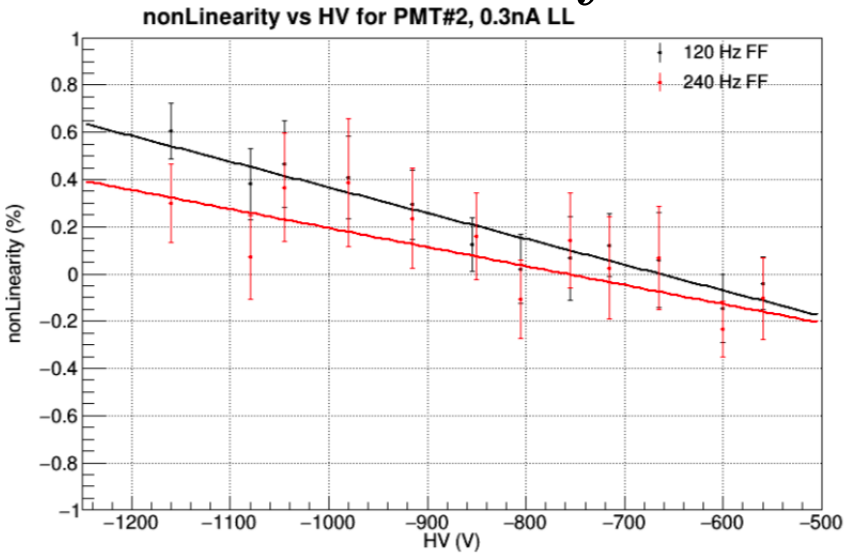
LL	0.18 nA	0.3 nA	0.5 nA	6 nA	10 nA
HV_{max}	1095 V	1020 V	1030 V	735 V	680 V
$I_{anodemax}$	14.90 µA	15.04 µA	24.50 µA	48.80 µA	49.69 µA

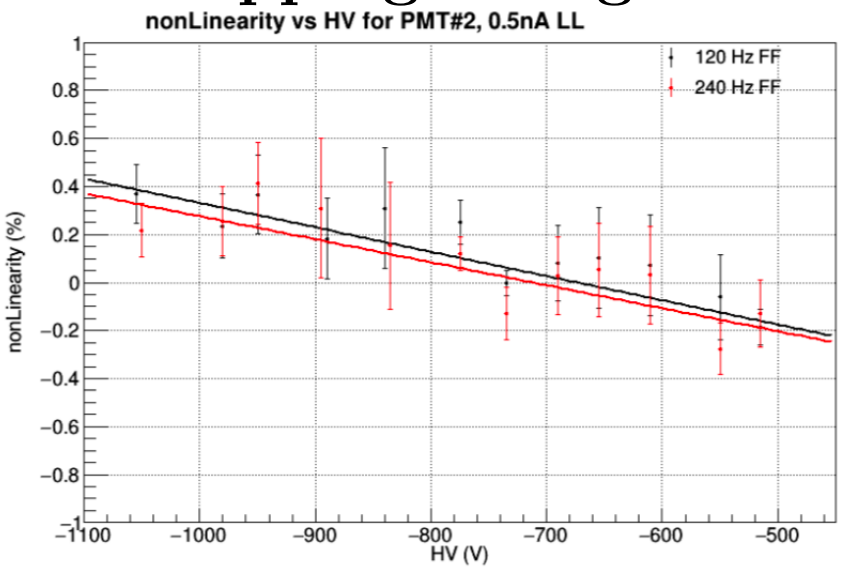


LL	0.18 nA	0.3 nA	0.5 nA	6 nA	10 nA
HV_{max}	1210 V	1105 V	1030 V	850 V	770 V
$I_{anodemax}$	14.74 µA	14.47 µA	14.88 µA	65.34 µA	67.00 µA

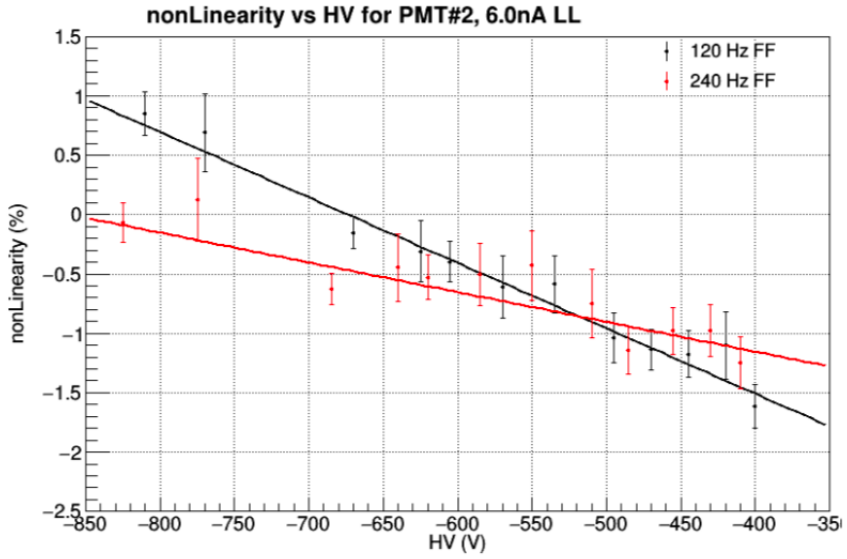


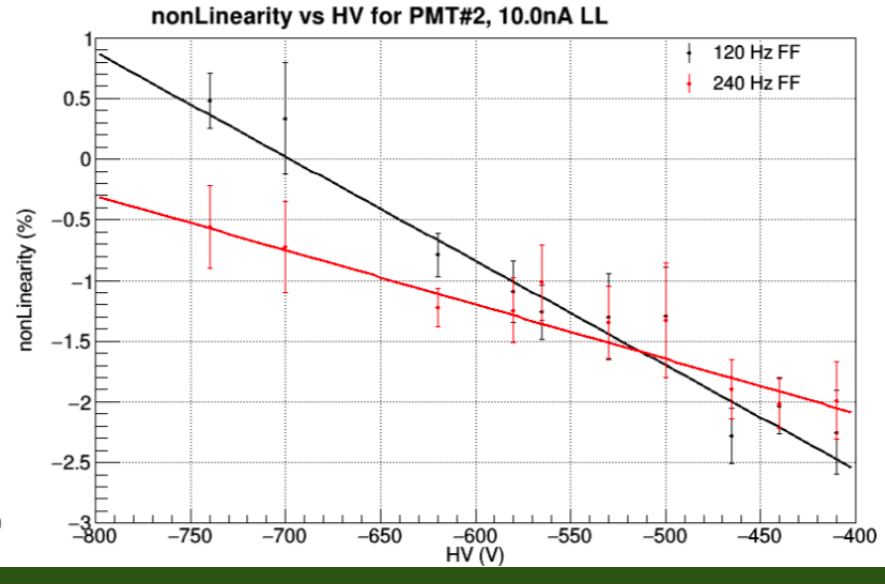
Inconsistency for 240 Hz Flipping at high LLs





Above two results were shown in previous meeting





Details of the Inconsistency and Plans to Address it

- For the lower (CREX) light levels, measurements are very consistent for 30, 120, and 240 Hz flipping for all PMTs

- For the higher (PREX) light levels, measurements are inconsistent between 20/120 and 240 Hz. Why? Here are some potential plans to understand and correct this problem:

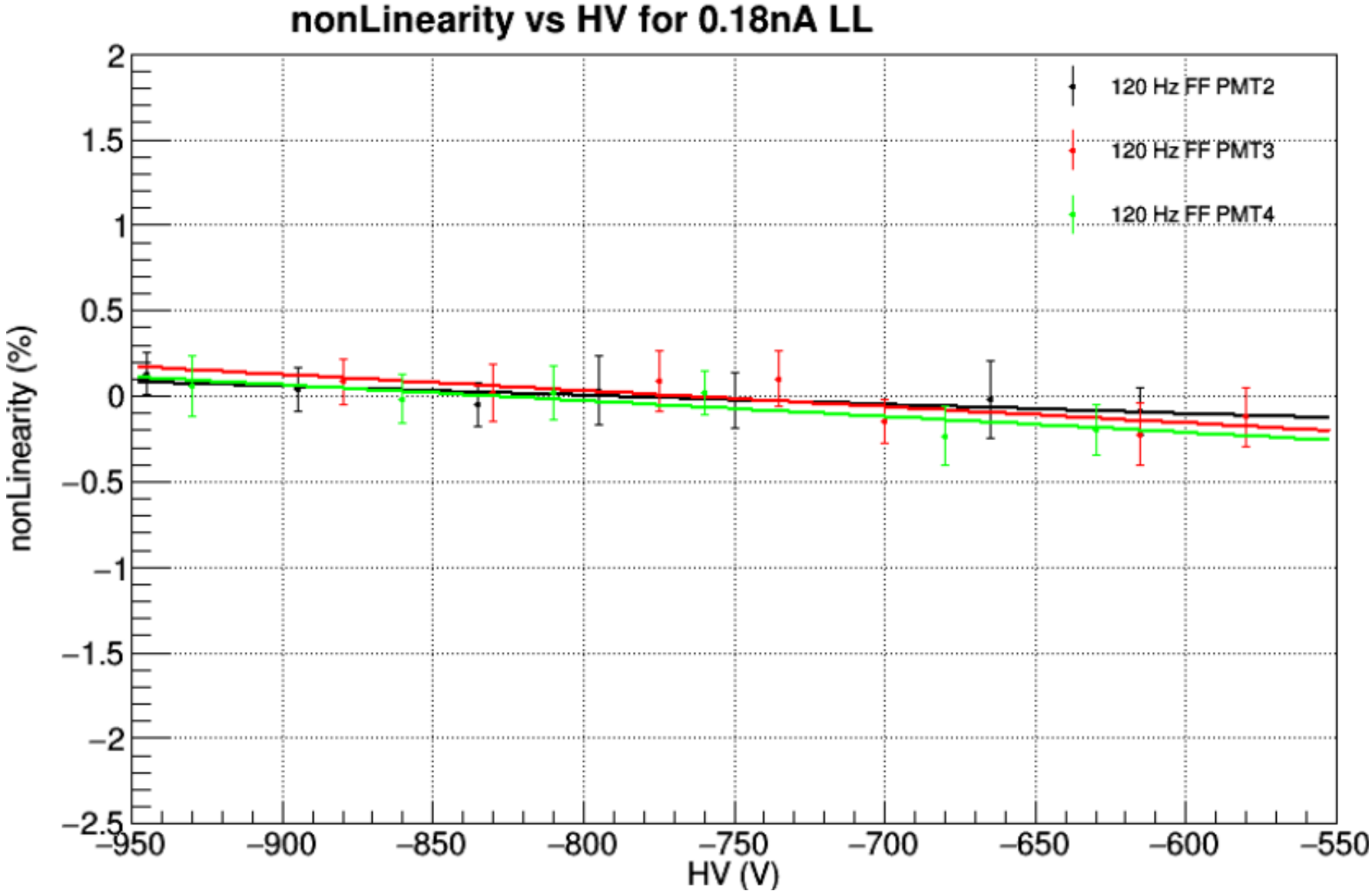
  - We may be driving the flashing LED too hard. Too large of a forward bias can cause much increased rise and fall times which could potentially cause this problem. We will lower the amplitude for the flashing LED—which will lower the size of the asymmetry we measure (currently using ~3% asymmetry for measurements)

  - We will scan through larger t_{settle} times (we already started this, but so far no change)

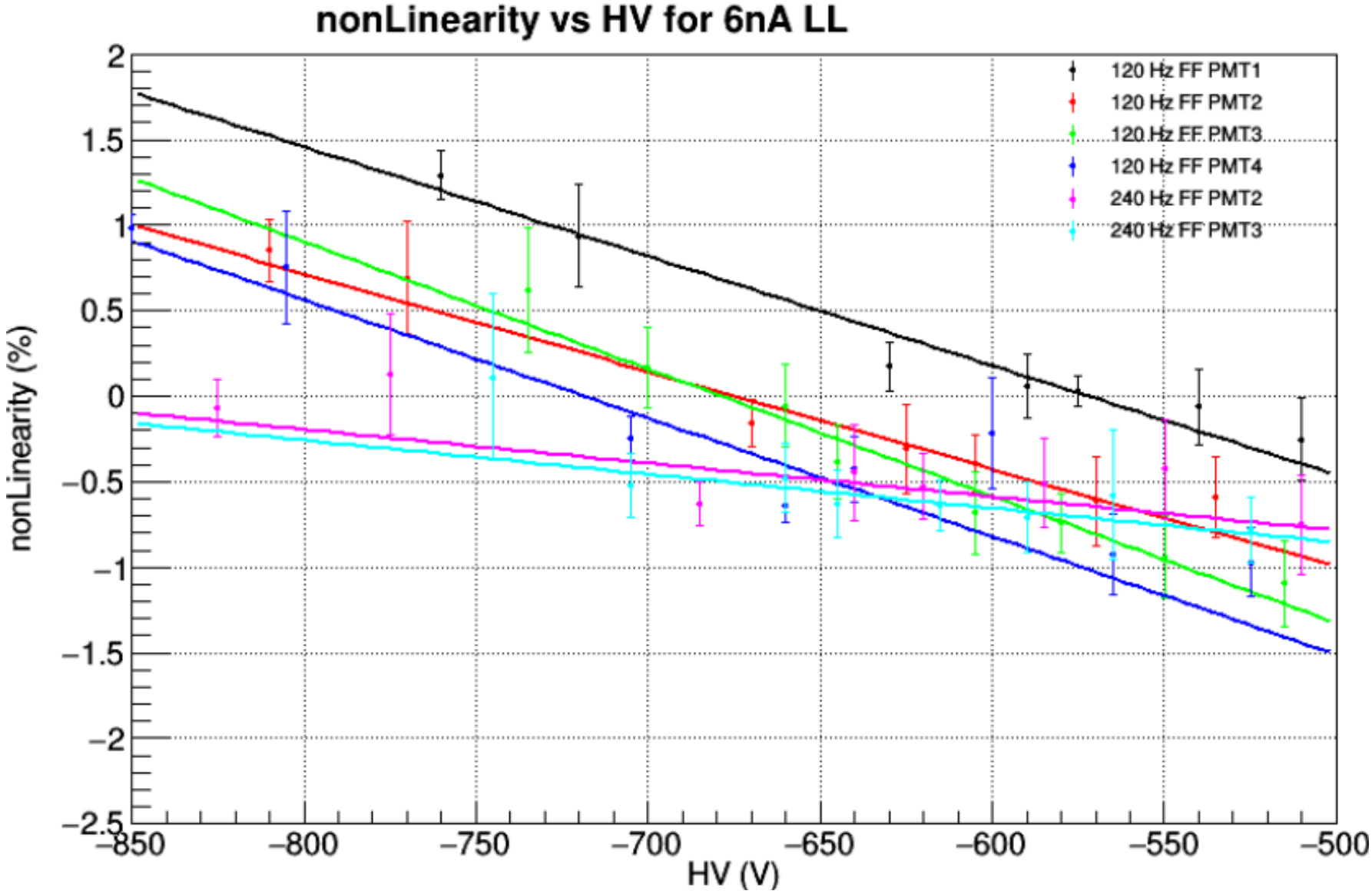
  - We will examine 480 Hz flipping and perhaps something between 120 and 240 Hz

  - Could be that our measurement technique breaks down at higher frequencies due to LED instabilities (thermal or otherwise?). If this is the case then we may need to develop an alternative technique that does not involve flashing an LED such as using a chopper wheel and a lock in amplifier. We may eventually need this for MOLLER

Latest CREX expected LL: 28PEs*e*30MHz = 0.13 nA

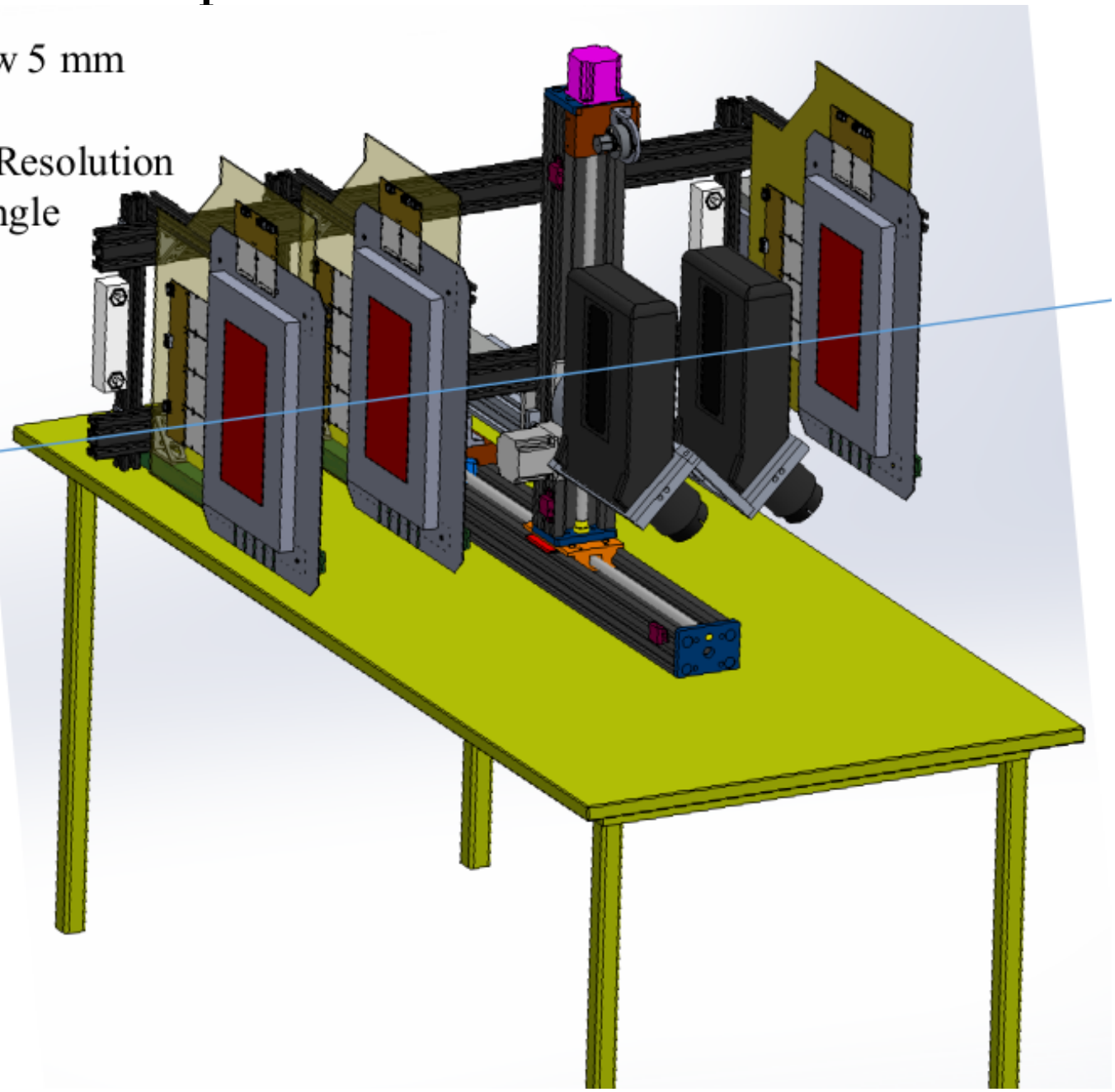


Latest PREX expected LL: 28PEs*e*1.5GHz = 6.7 nA

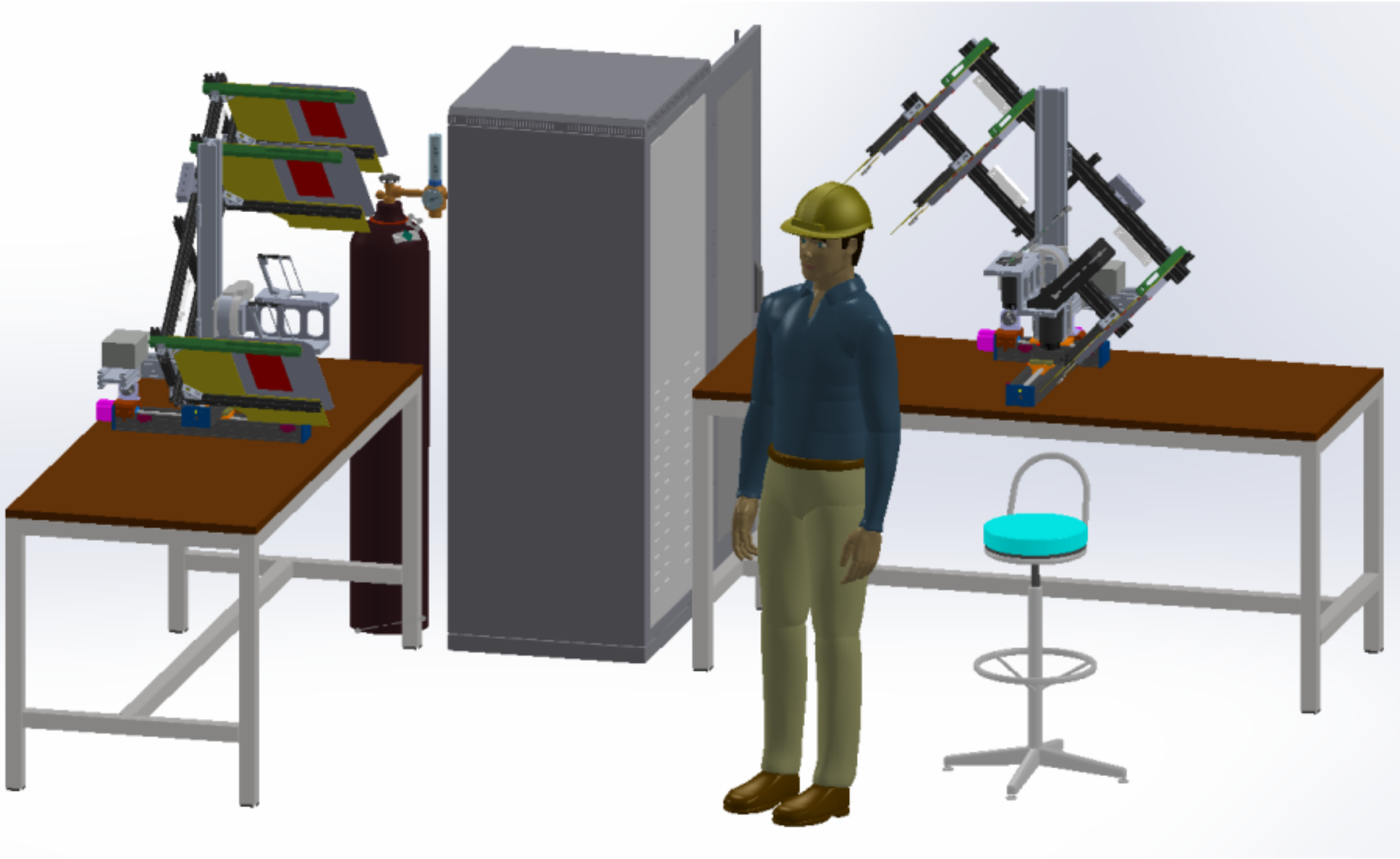


PREX Setup for SLAC Testbeam: Dec 6 - 12

- Plan to test new 5 mm thick quartz
  - ➢ PE yields and Resolution
  - ➢ Position and angle scans



Pre-staging Setup at JLab this Winter



Summary

- PREX-II/CREX main detector design complete
  - Detectors for both arms constructed and ready
  - Quartz geometry has been finalized: 5 mm by 35 mm by 160 mm
  - Will use bare, unwrapped quartz and no light guide
  - Will benchmark simulations for 5 mm thick quartz at SLAC next month
- GEM stands for main detectors complete
- Motion control software/GUI is nearly complete
- GEM readout system and analysis software development well underway; working hard to be ready for testbeam
- Linearity measurement issue at high flip frequencies under investigation