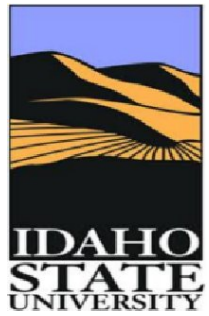
# HRS Detector Package for PREX-II/CREX

Dustin McNulty
Idaho State University
*mcnulty@jlab.org*

Feb 25, 2018

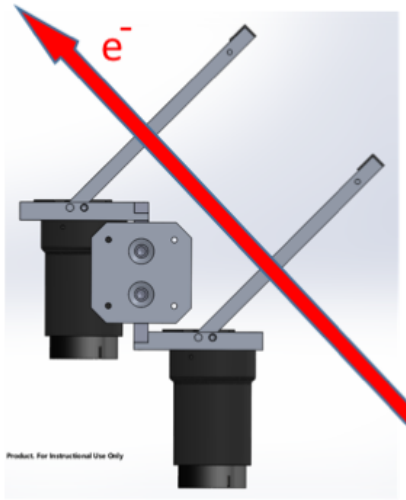



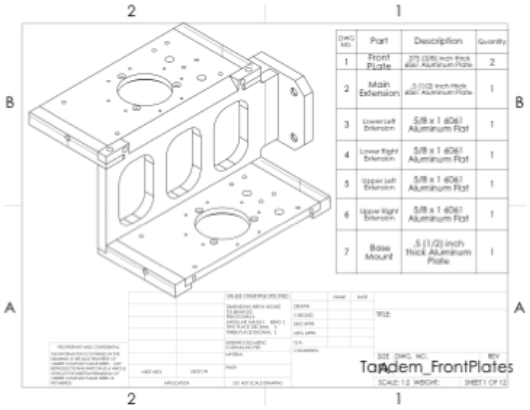
# HRS Detector Package for PREX-II/CREX

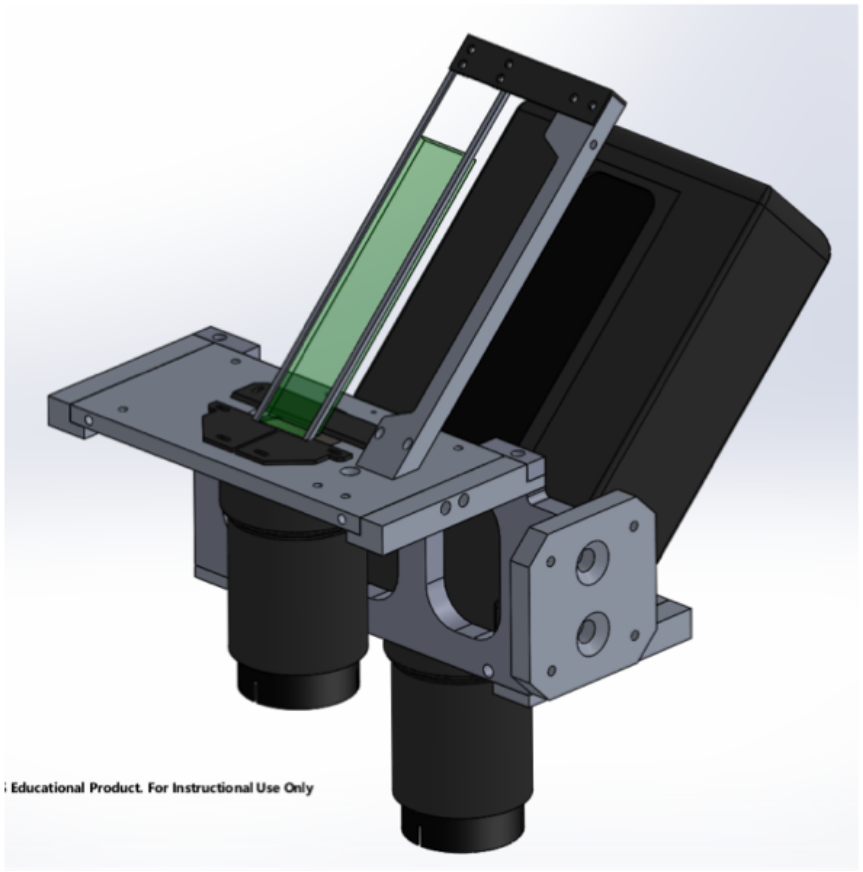
Talk Outline:

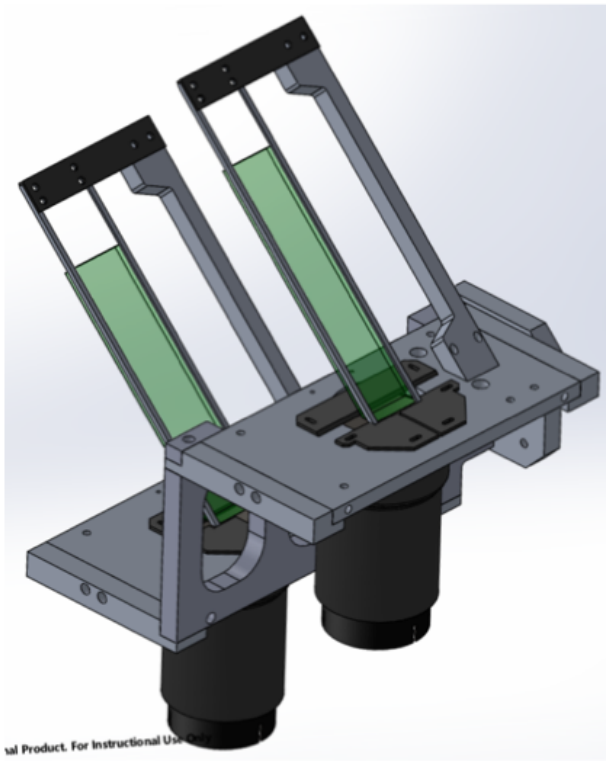
- Tandem Detector Design Update
- GEM Tracking System Update
- GEM Stand with Tandem Mount Update
- HRS Detector Package
- Summary and Future Work

# Main Integrating Tandem Detector Design



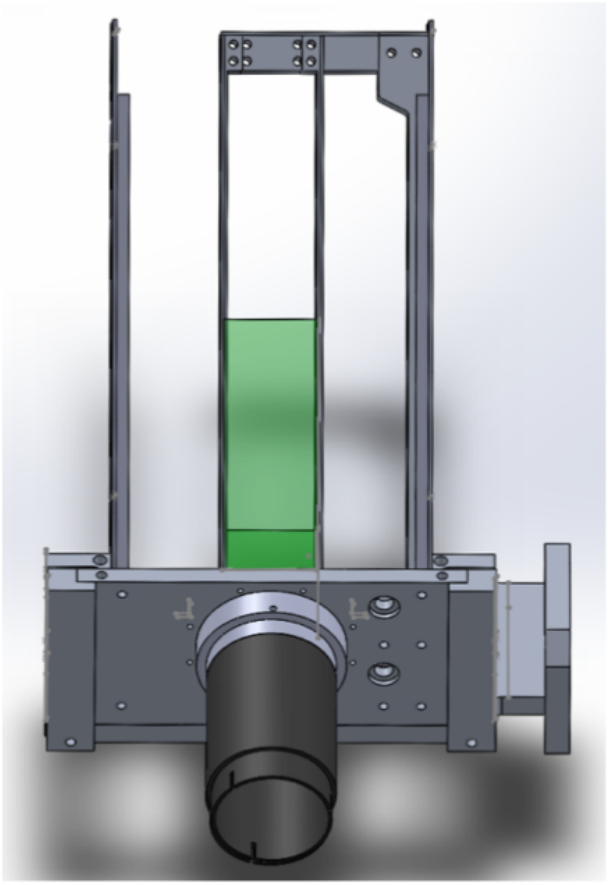



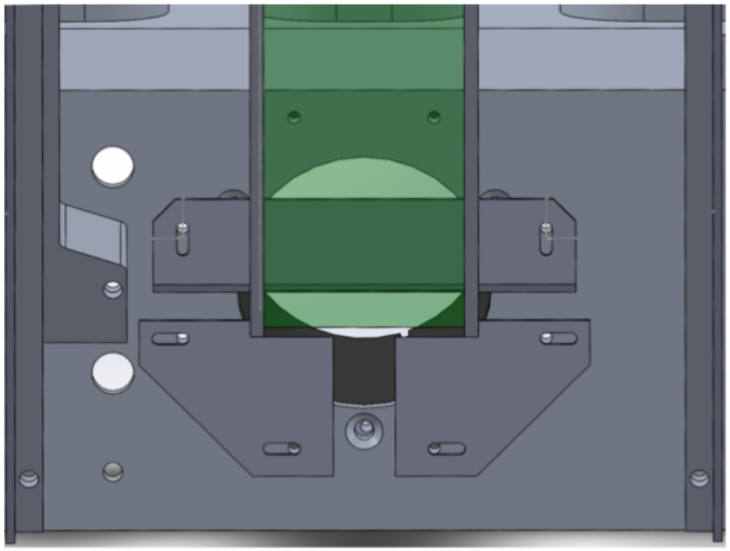



- PREX-II/CREX main detector design based on UMass Design-3.
- Rotatable tandem mount designed and prototype constructed
- New design has shorter quartz rails and incorporates mu-metal shields and 3D printed ABS-plastic enclosure with Kapton or Tedlar windows

# Quartz Geometry Plans (Preliminary)



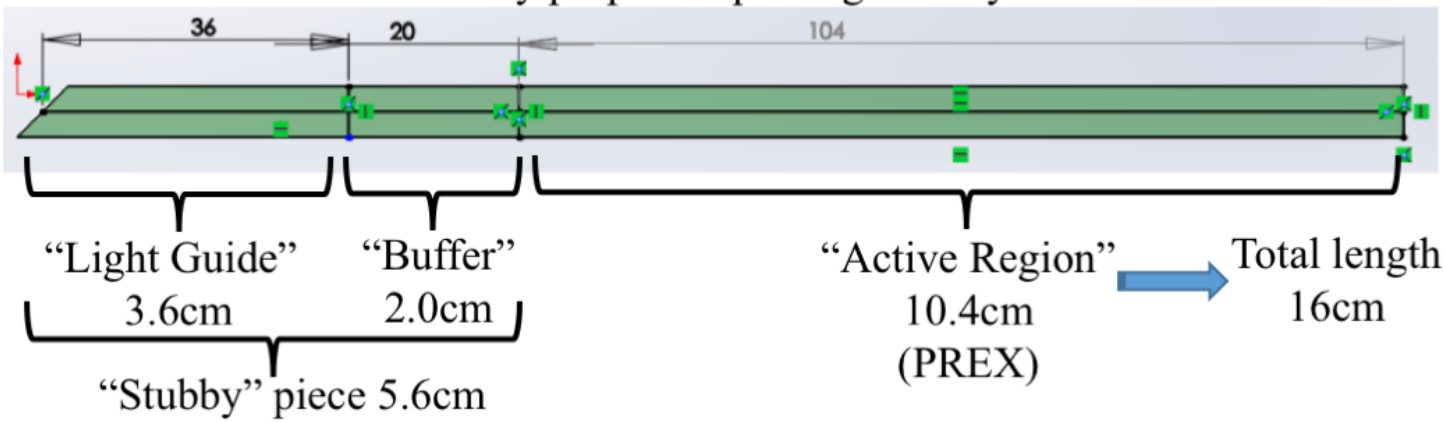
Beam's view. Note "stubby" quartz installed upstream, "full" quartz downstream – for illustrative purposes



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

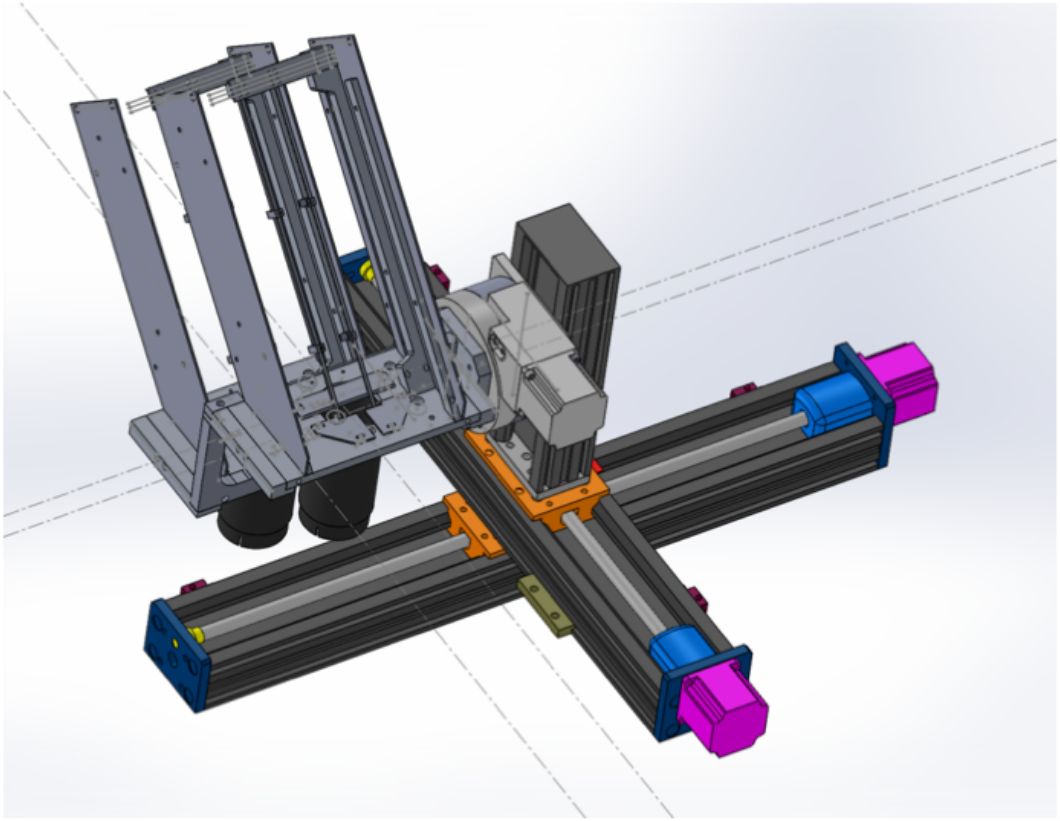
- PREX-I quartz was 3.5 cm wide by 16 cm long by 6 mm/10 mm thick
- PREX-II and CREX quartz could be same geometry as PREX-I
- Design can accommodate up to 4.8 cm wide quartz piece

Preliminary proposed quartz geometry idea

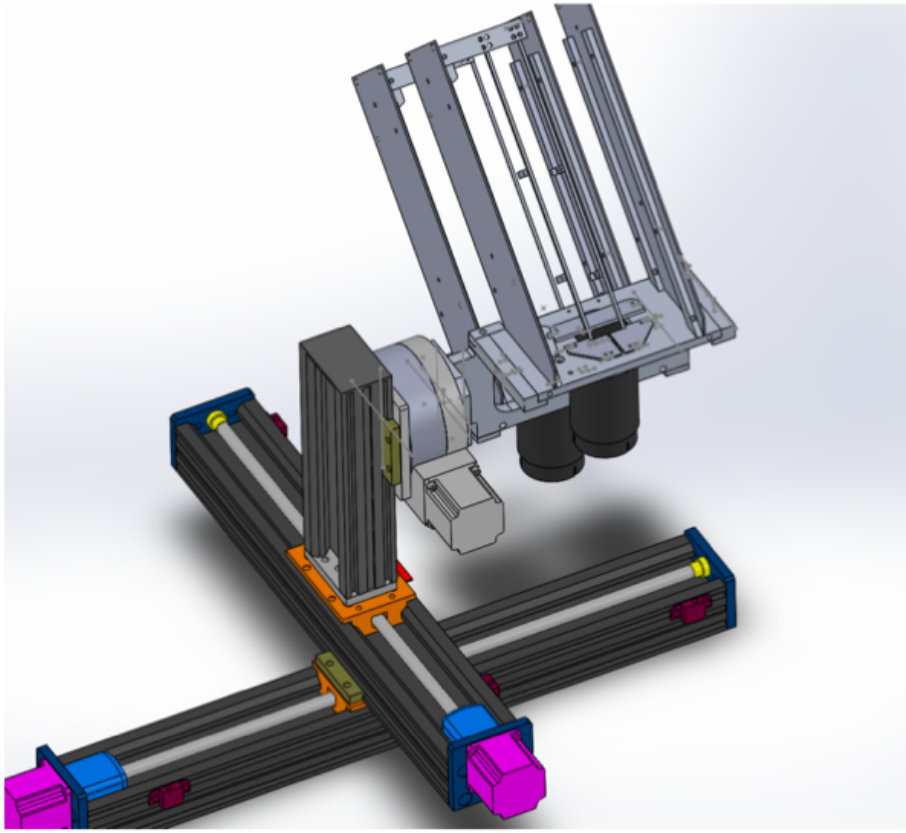


# Prototype Tandem Mount (Degrees of Freedom)

RHRS

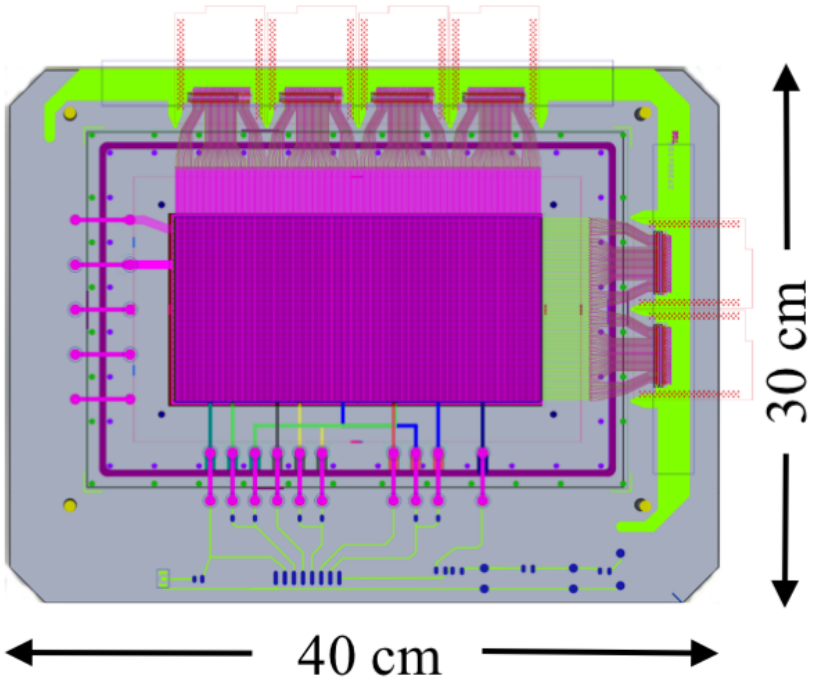


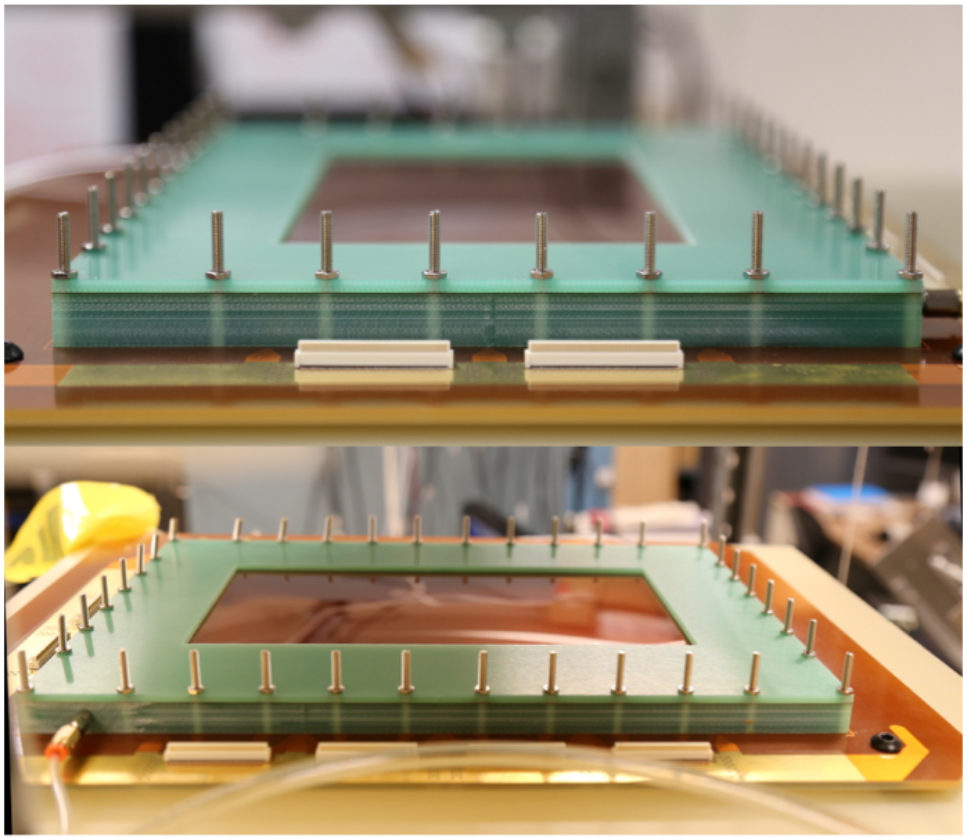
LHRS



- *X*, *Y*, and $\theta$ degrees of freedom
- Velmex 5 and 10 inch travel sliders (so far, from PREX-I, we've found 5" sliders but not 10" and no controllers or cables yet…)
- Velmex rotary stages (have one, *need another*)

# PREX/CREX "small" 10x20 cm$^2$ GEM trackers

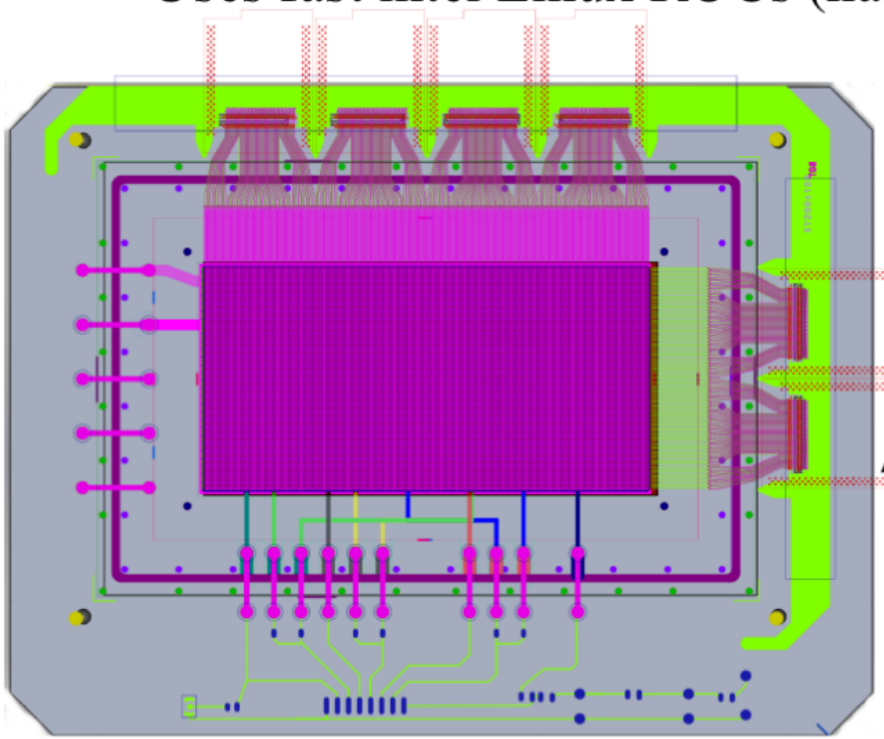


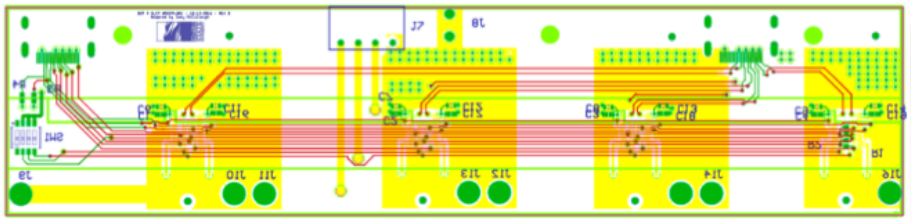



- Custom CERN 10 cm by 20 cm active area triple GEM chambers
  - 400$\mu$m pitch x/y, 4 + 2 Panasonic 130pin Readout connectors
  - Standard GEM spacing D-3mm-G1-2mm-G2-2mm-G3-2mm-RO
  - Standard HV filter circuit: uses CERN ceramic resistor
- Readout scheme based on INFN/UVA SBS rear-tracker:
  APV25FE ➟ backplane PCB ➟ VME MPD

# GEM Readout Plans

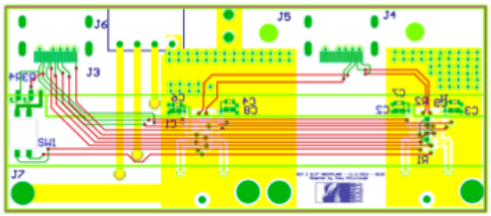
- GEM readout scheme based on INFN/UVA SBS rear-tracker system:
  - Uses APV25FE rev4.1 cards (have 55 in-hand); each chamber requires 6 APVs
  - Requires new 4-slot and 2-slot "backplane" PCBs (have 36 in-hand)
  - Backplanes buss analog-out signals to MPD and pass digital ctrl signals to APVs
  - Have 6 VME MPDs (Multi-Purpose Digitizers); require 2 for each arm
  - Uses fast intel Linux ROCs (have 3 in-hand: GE XVB601); require 1 for each arm





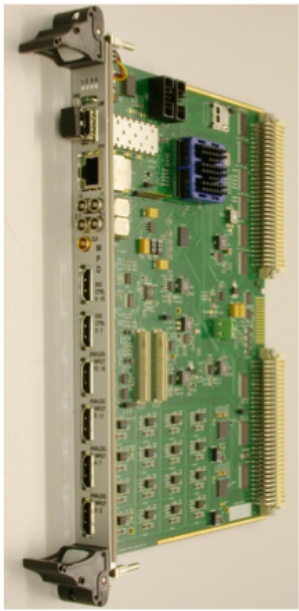
4-slot backplane

APV rev4.1



2-slot backplane

APVs mount directly to Panasonics on GEM readout board—amplifies and multiplexes output



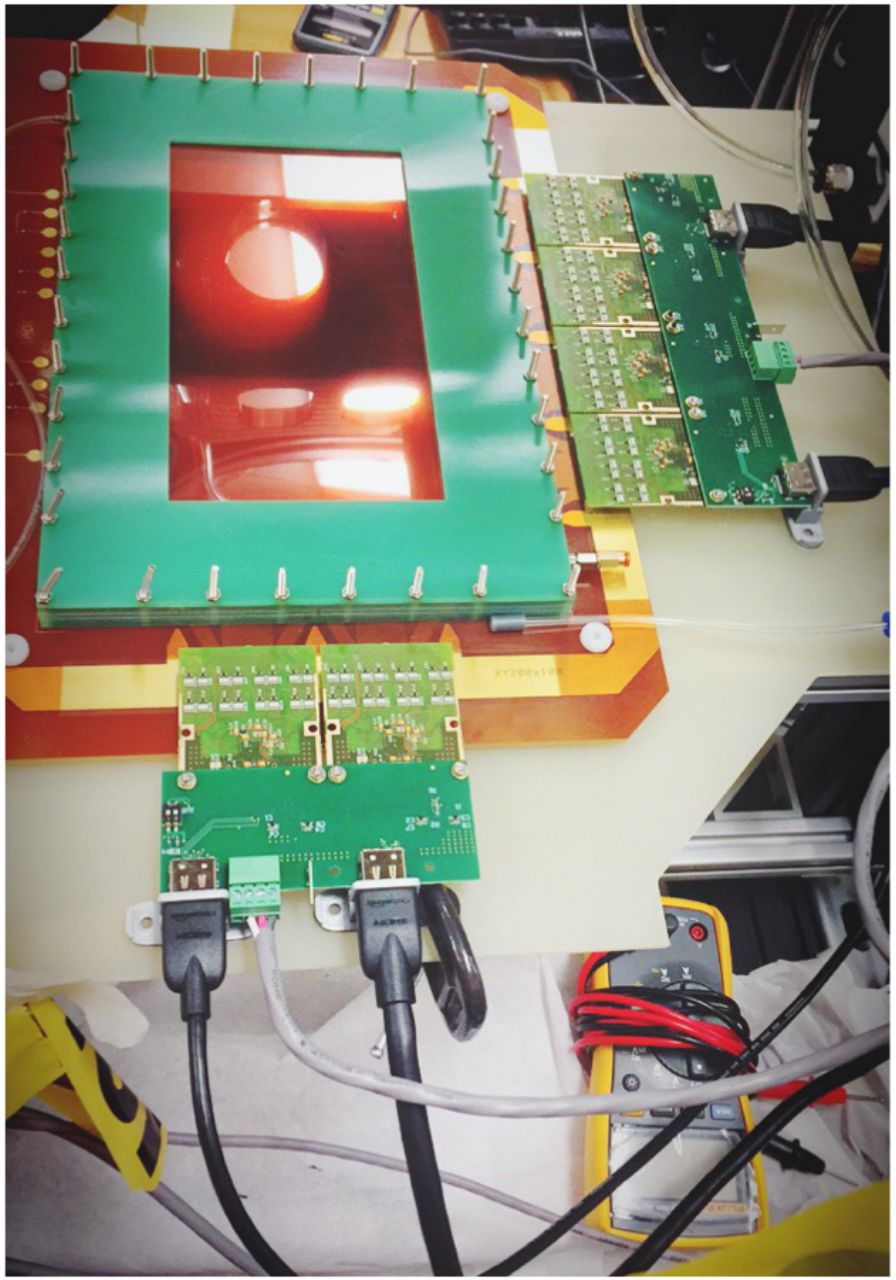
MPD rev4: Handles 16 APVs

- Getting much advice and help from Paolo Musico and INFN group, Kondo Gnanvo, Chris Cuevas, Nilanga Liyanage, and Alexandre Camsonne

# GEM DAQ Plans

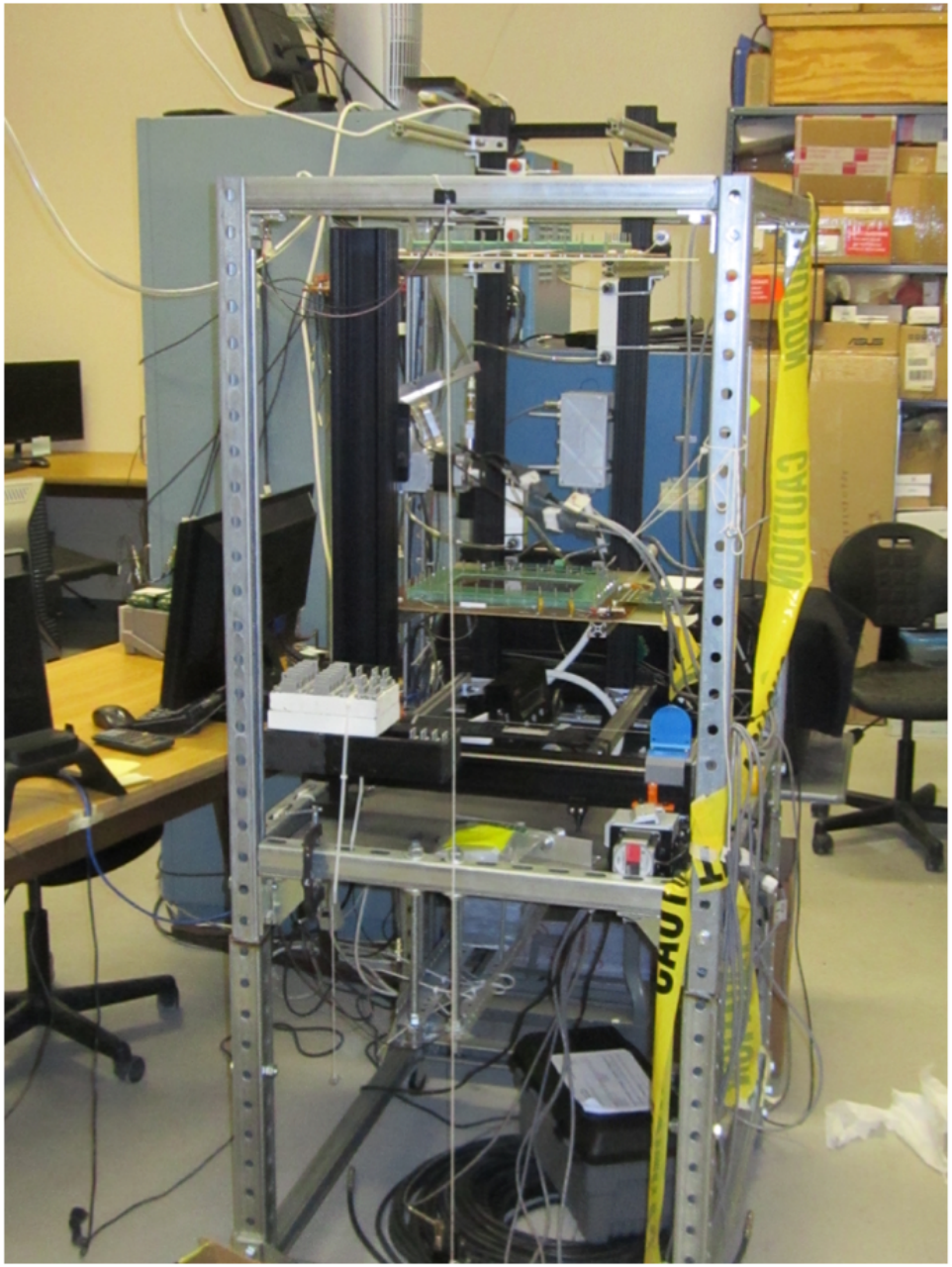
- Each arm requires one VME crate with fast linux ROC and at least three other available slots; I am currently using two Dawn 4-slot VME crates
- Each arm will need a trigger interrupt module and 2 MPDs; currently using SIS3610 and a CEAN V965 QDC for triggering interrupts
  (*we will likely want JLab TIs for this*)
- Using CODA 2.6.2 with MPD drivers and support from JLab DAQ group
- Planning to use 6 – 10 meter long high speed HDMI cables for analog and digital signals
- Each arm will need a CAEN N1470 HV NIM module (or equivalent) with 3 available channels; I currently have one HV module. *We will need an HV supply for the other arm—Nilanga mentioned we could use the UVA GEMs HV supply*
- Each arm will need LV power supply with 5.0, 2.5 and 1.25 V; I have one already built and plan to build another

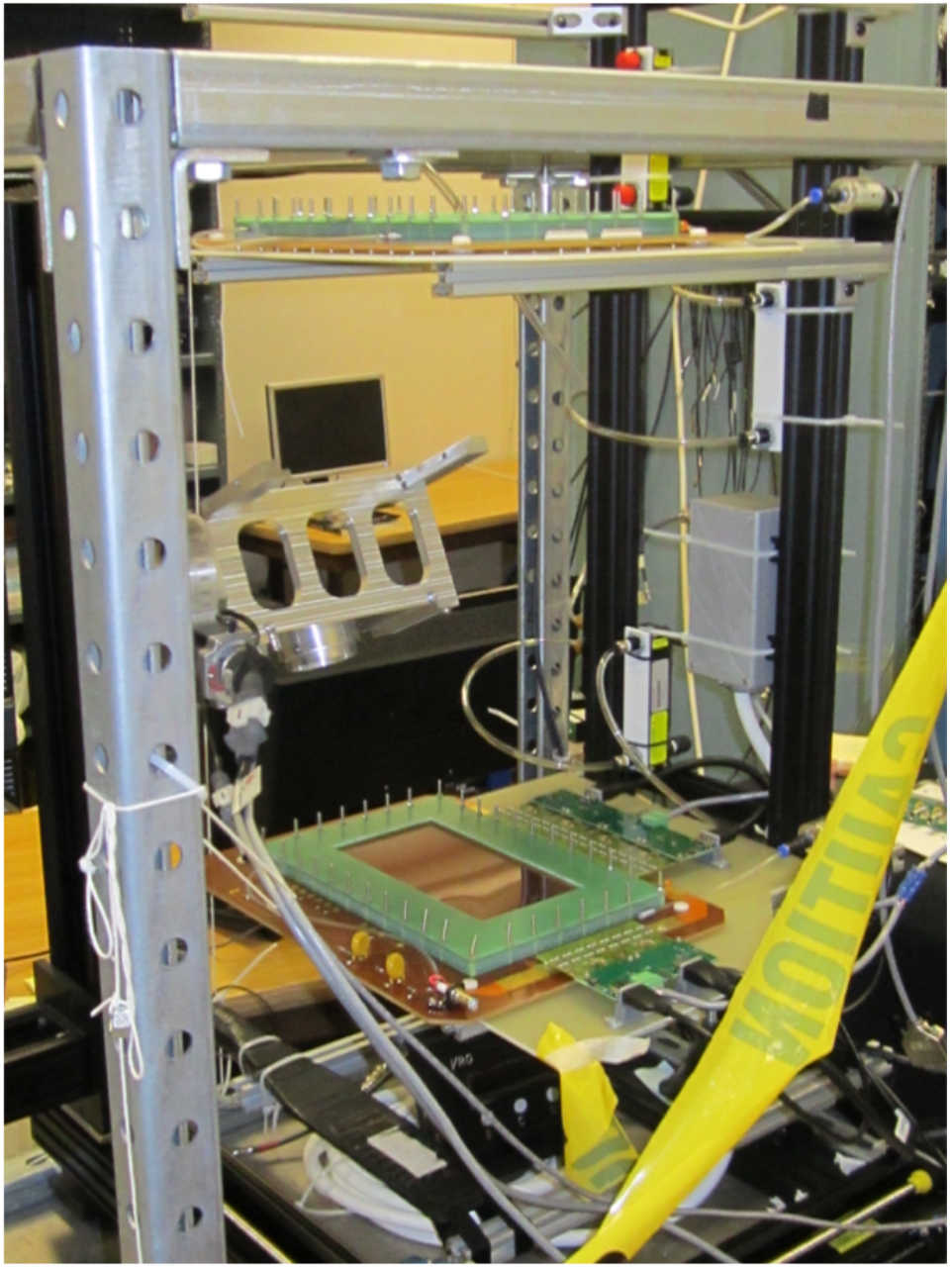
# GEM DAQ Progress



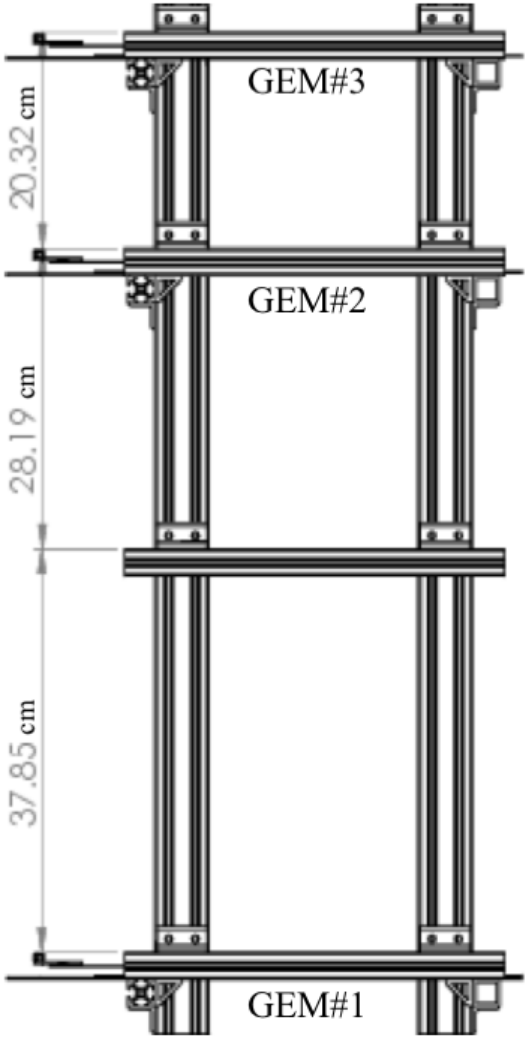
- One GEM complete with readout electronics chain: APV ↔ backplanes (HDMI) ↔ MPD
- Discovered $I^2C$ addressing problem with backplanes; fixed with small jumper-wire
- Working with B. Moffit on CODA VME drivers specific for our setup – using v965 QDC or SIS3610 for triggering backplane interrupts
- CODA MPD system is up and running with one GEM (so far); can now take data; next step is to modify Danning's decoder to work with our setup (underway)
- Found out at SBS meeting that there is a VME readout firmware problem with the factory MPDs. Paolo has fixed and given me instructions on how to update our MPD firmware
- Also met with Danning about understanding his apv config file, how to test the APV configuration, set the clock phase, $I^2C$ speed,…

# Cosmic Stand





# GEM Chamber Mounting Concept




Aluminum ladder-frame

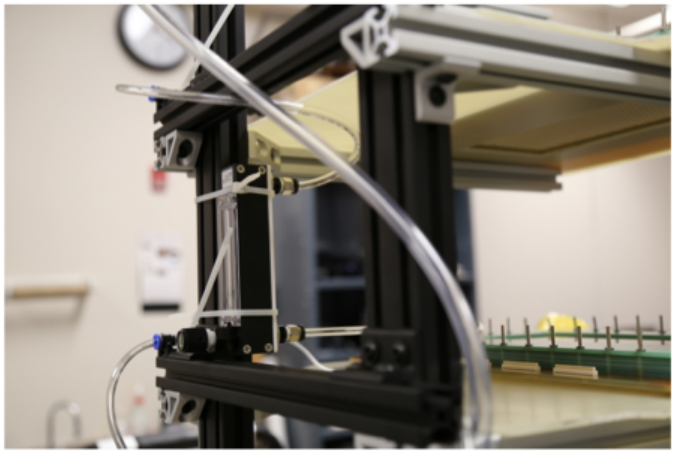
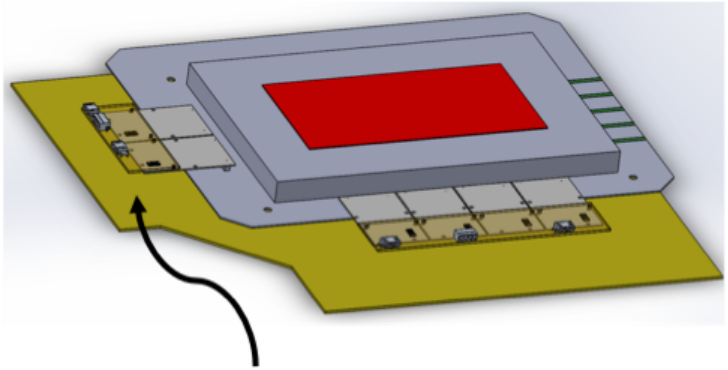
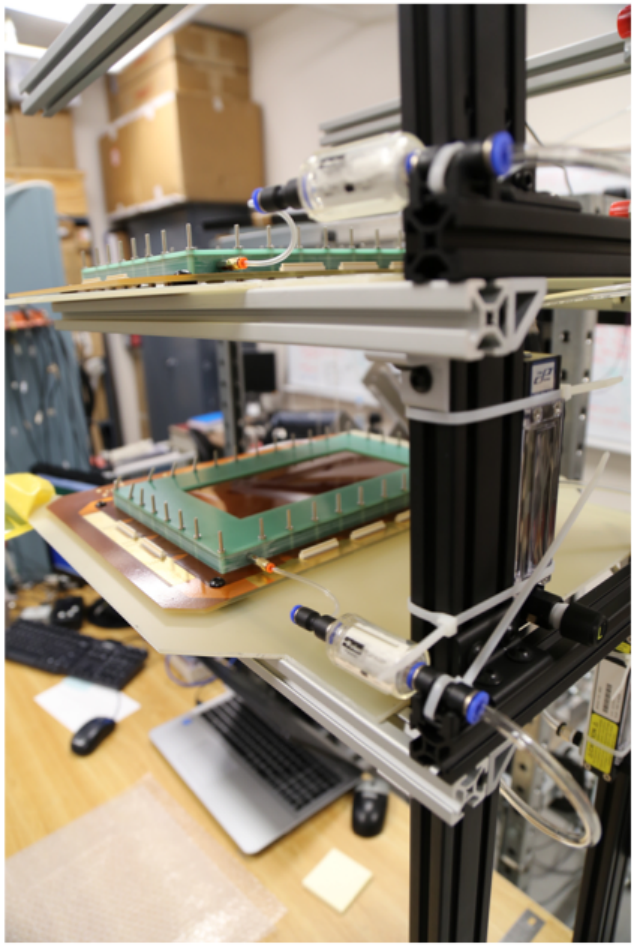


Photo showing rail support brackets



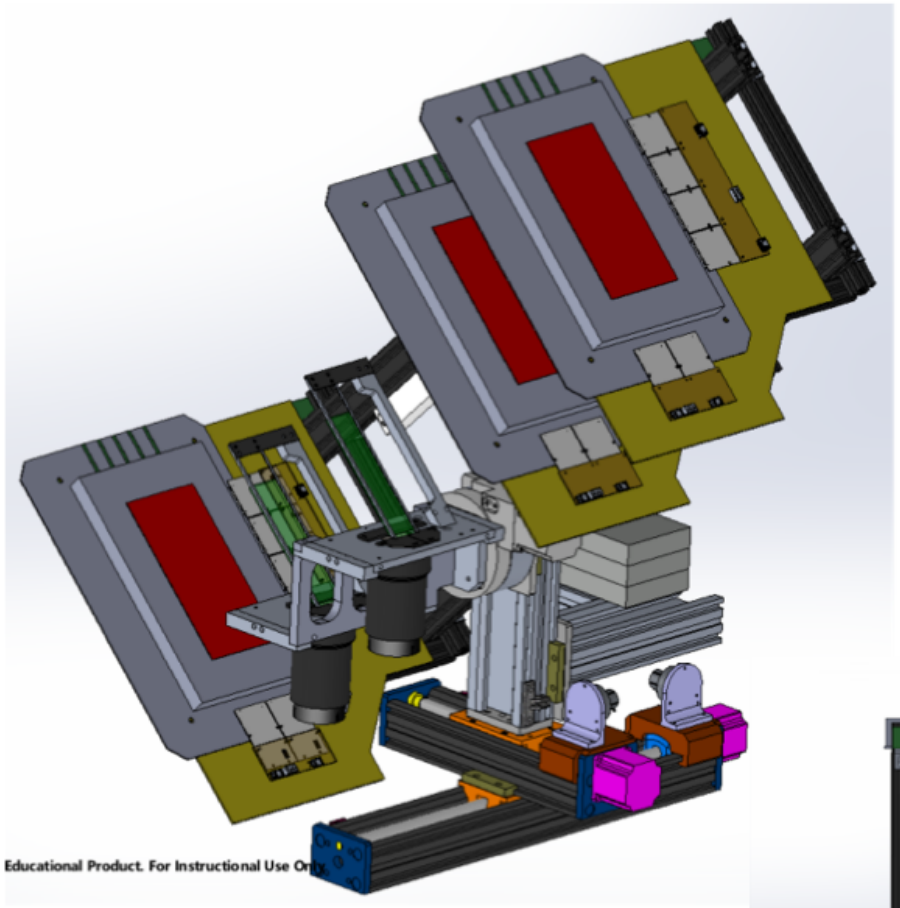
G10 platforms (1/16 in. thick) for GEMs: supports readout electronics

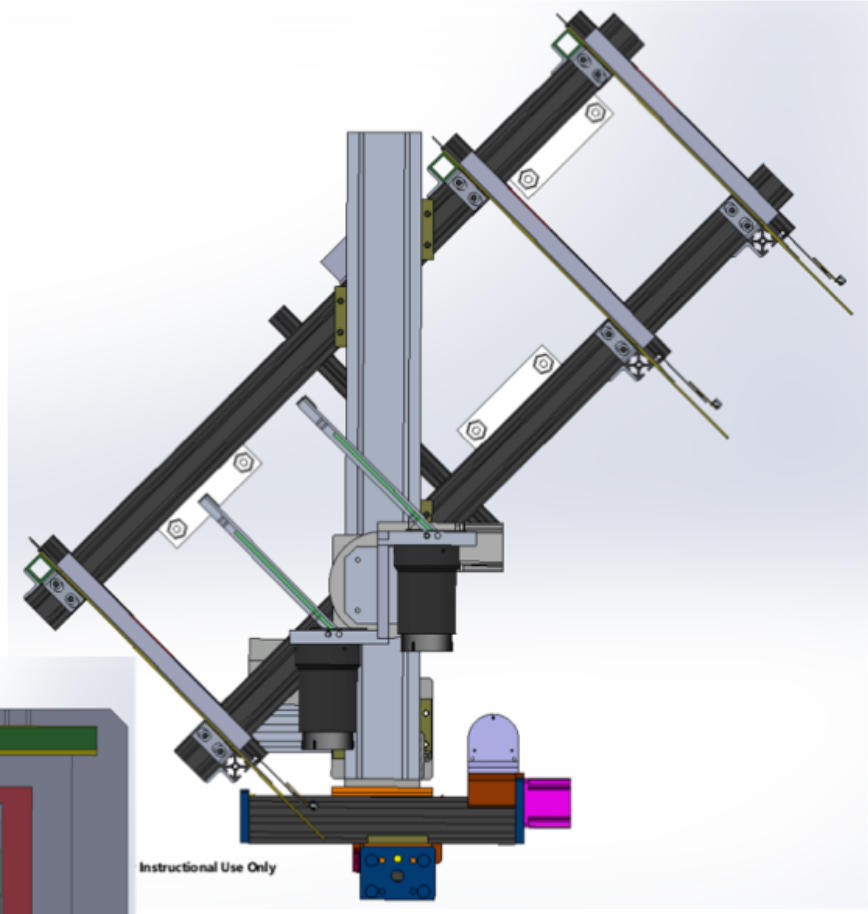


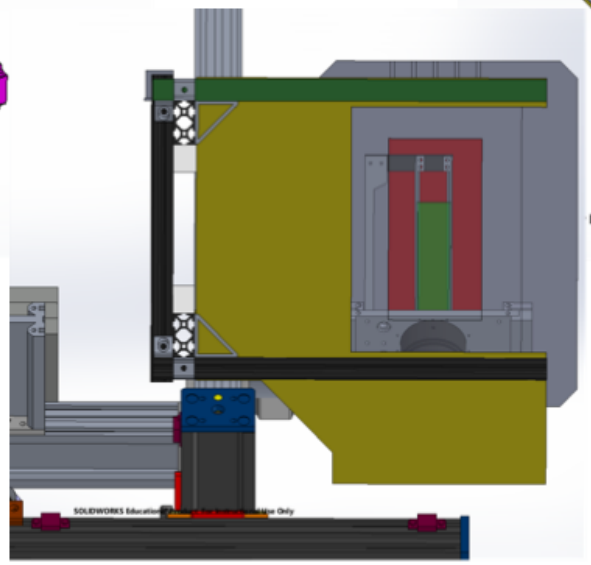
Two Chambers installed; gas flowing

- 1" Extruded aluminum framing system for GEM mount
- Each arm will use three GEM chambers: one upstream and two downstream of quartz
- GEM ladder-frame mounts to Velmex slider post using cleats

# RHRS Tandem Quartz Mount with GEMs

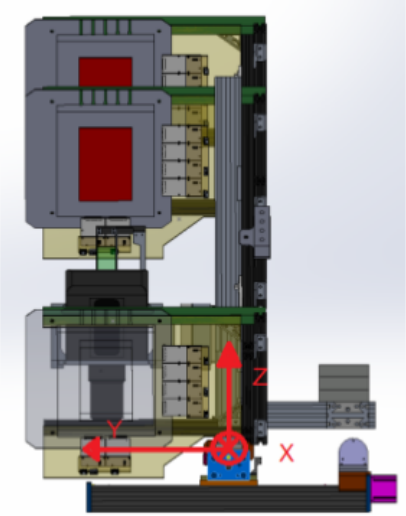


Electron's view (from below)

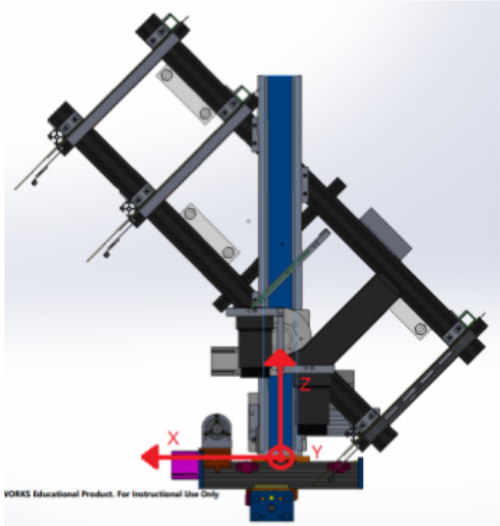
# HRS Detector Package Torque Analysis

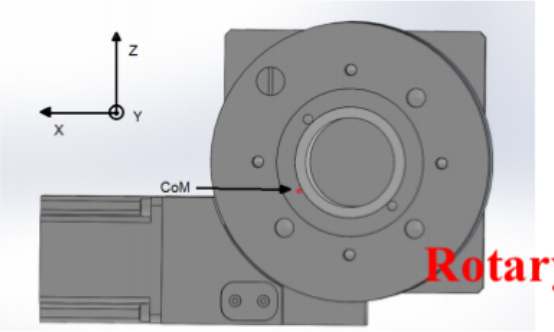


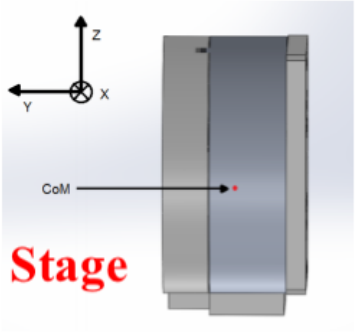

Using HRS hut coordinate system

- Origin defined at the center of the 5-inch travel (top) slider platform.

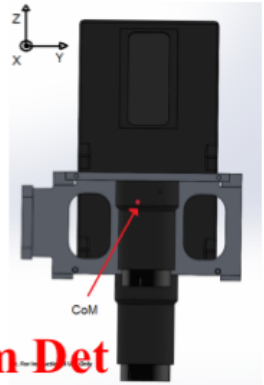
Center of Mass Analysis



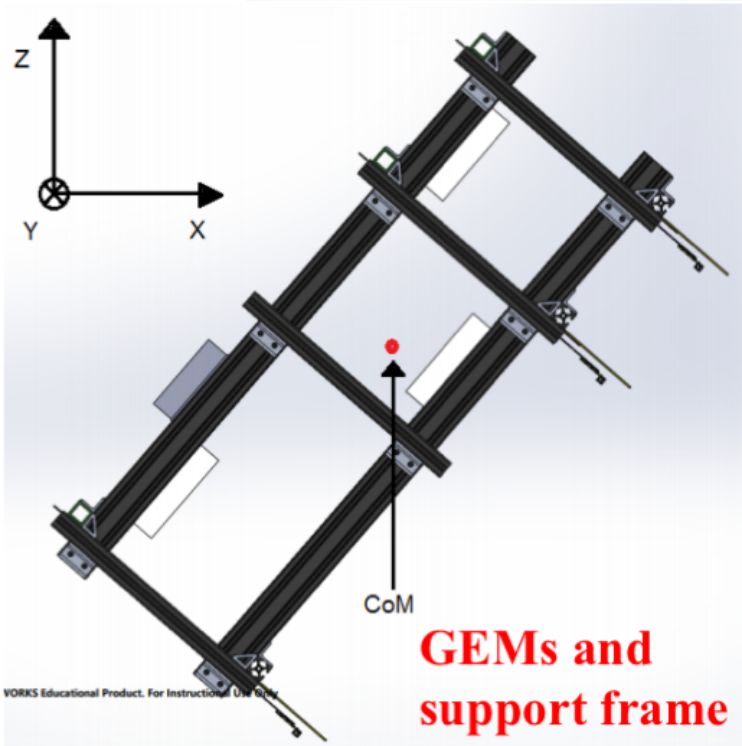




Rotary Stage

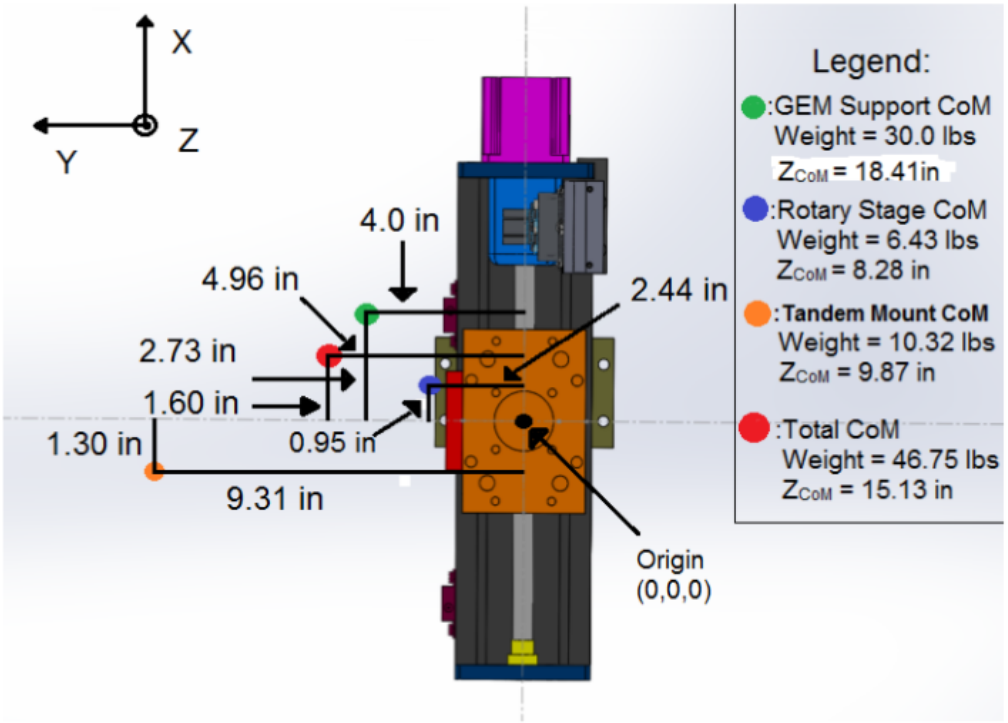




Tandem Det



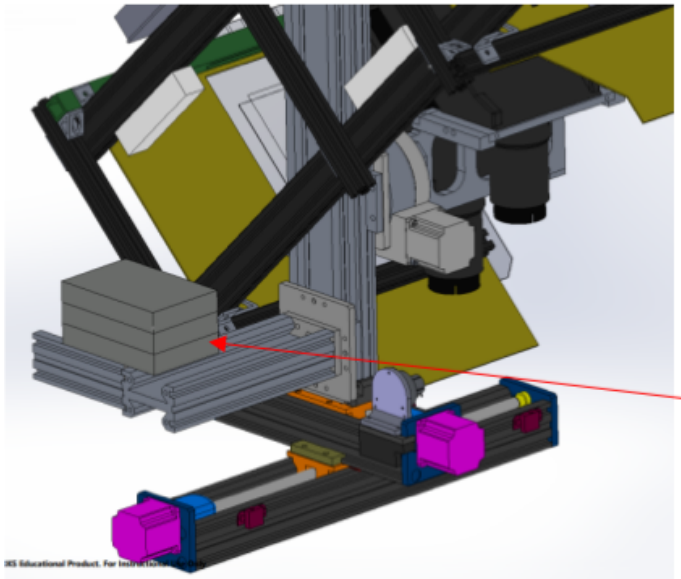

GEMs and support frame

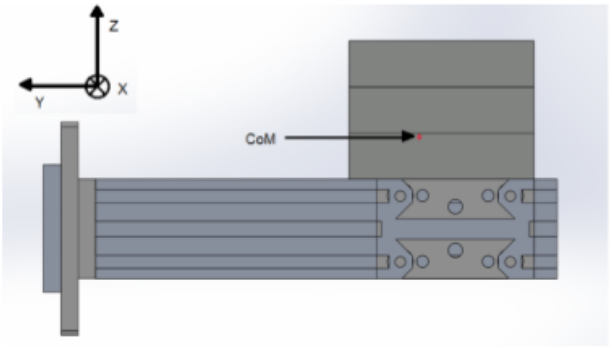
# HRS Detector Package Torque Analysis

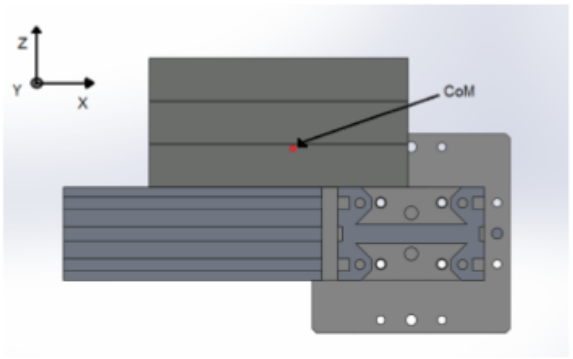



| Dot Color | Assembly | Weight (lbs) | Torque around y-axis (in-lbs) | Torque around x-axis (in-lbs) |
|---|---|---|---|---|
| Green | GEM Support Frame | 30.0 | 81.90 | -120.0 |
| Blue | Rotary Stage | 6.43 | 6.11 | -15.69 |
| Orange | Tandem Quartz Mount | 10.32 | -13.42 | -96.08 |
| **Red** | **Total Detector Package** | **46.75** | **74.59** | **-231.77** |

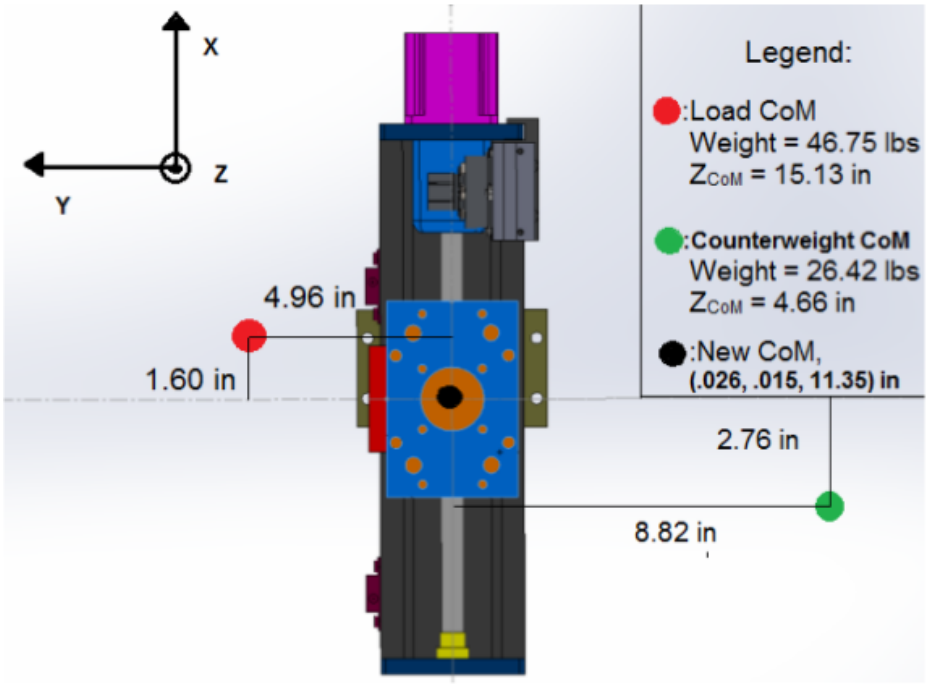
# HRS Detector Package Torque Analysis





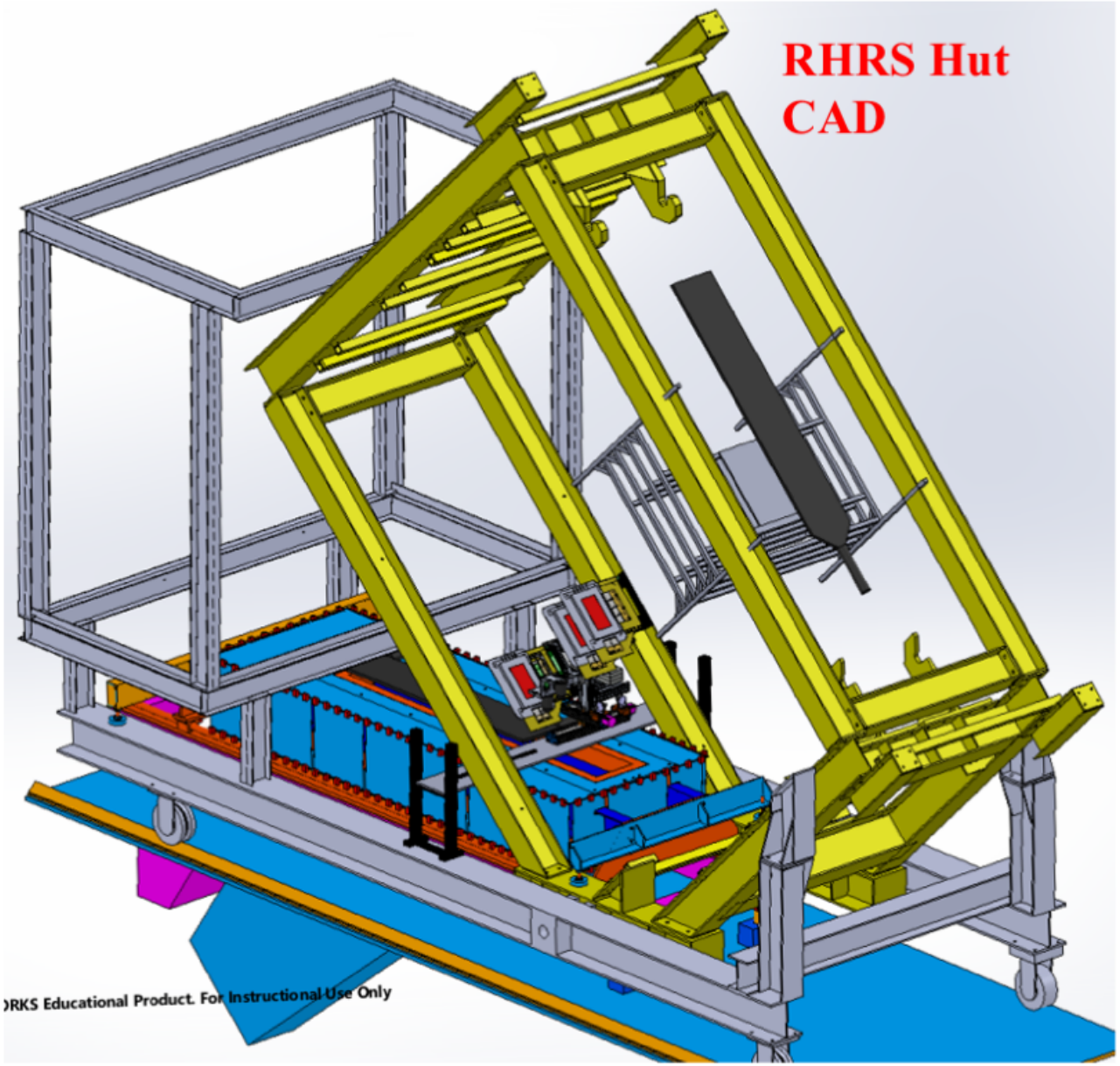

**Counter weight (+ supports): 26.4 lbs**



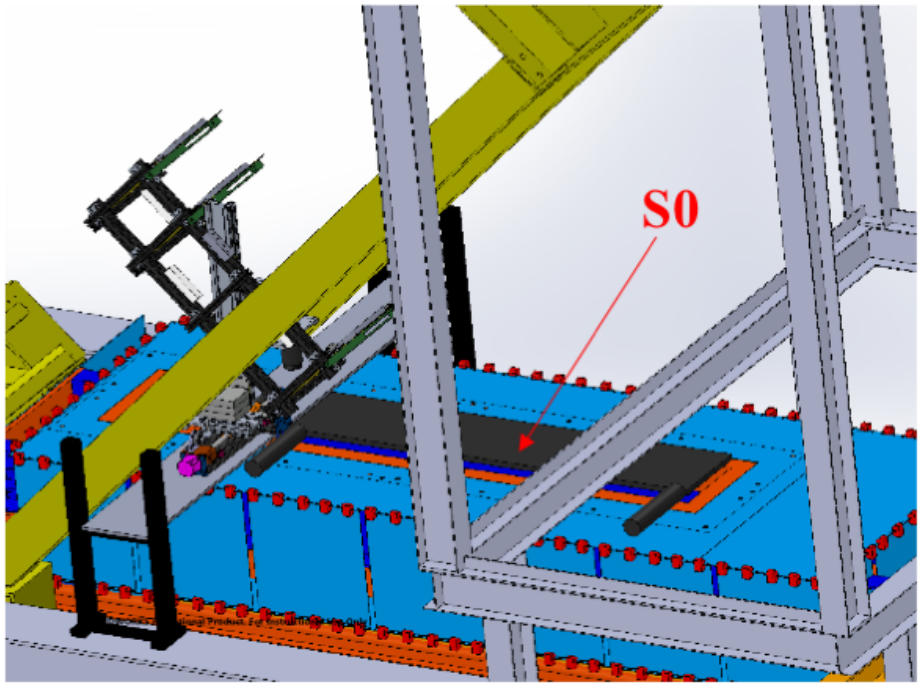

- Using the new center of mass location and new load (old load + counterweight) of **73.17 lbs**, net torques were calculated.
- Net Torque about X-axis: (0.015 in)*(73.17 lbs) = **1.10 in-lbs**
- Net Torque about Y-axis: (0.026 in)*(73.17 lbs) = **1.90 in-lbs**
- Net Total Torque: $((1.10)^2+(1.90)^2)^{1/2}$ = **2.19 in-lbs**

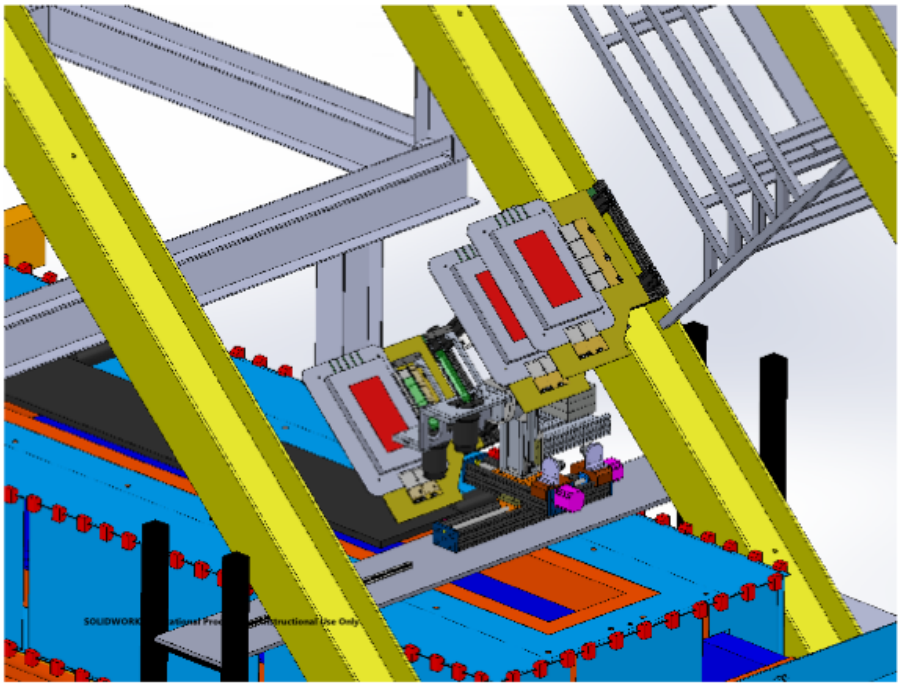
# HRS Detector Package for PREX-II/CREX

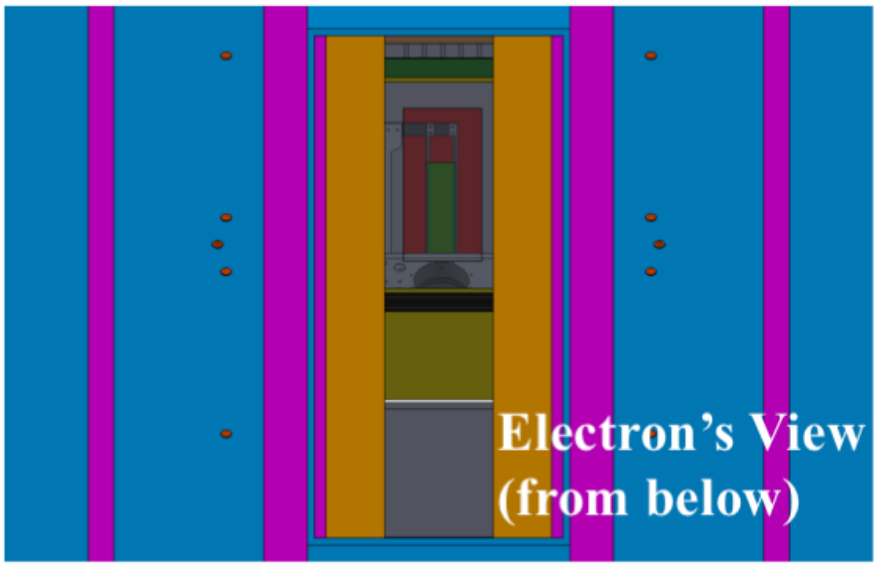
- All HRS standard detector packages removed except for VDCs: No S1, S2, Cerenkov, or Calorimeter
- For event-mode operation: Use S3 (or S0) for triggering
- Additional array of large GEMs from UVA group installed above PREX detector package
- A_T detector not shown: will mount just above small GEMs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

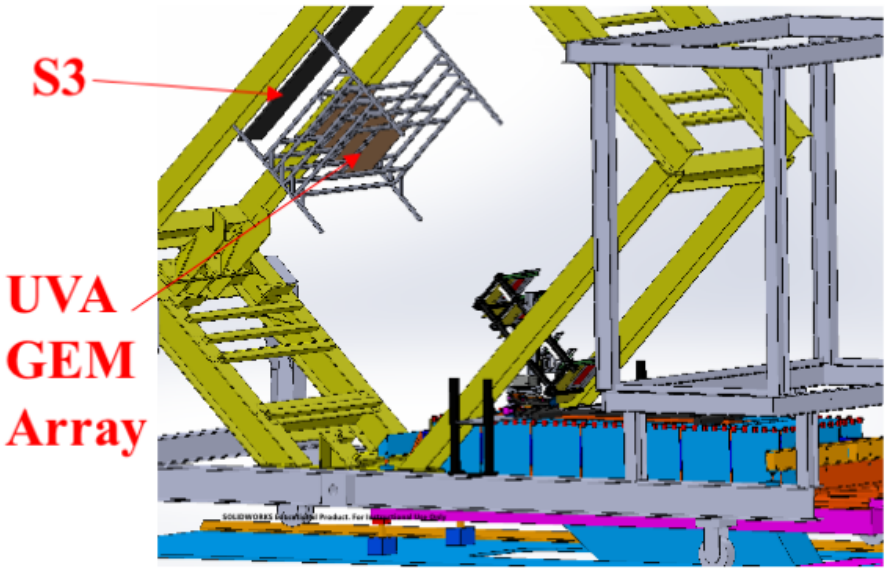


# HRS Detector Package for PREX-II/CREX





# Main Detector Summary

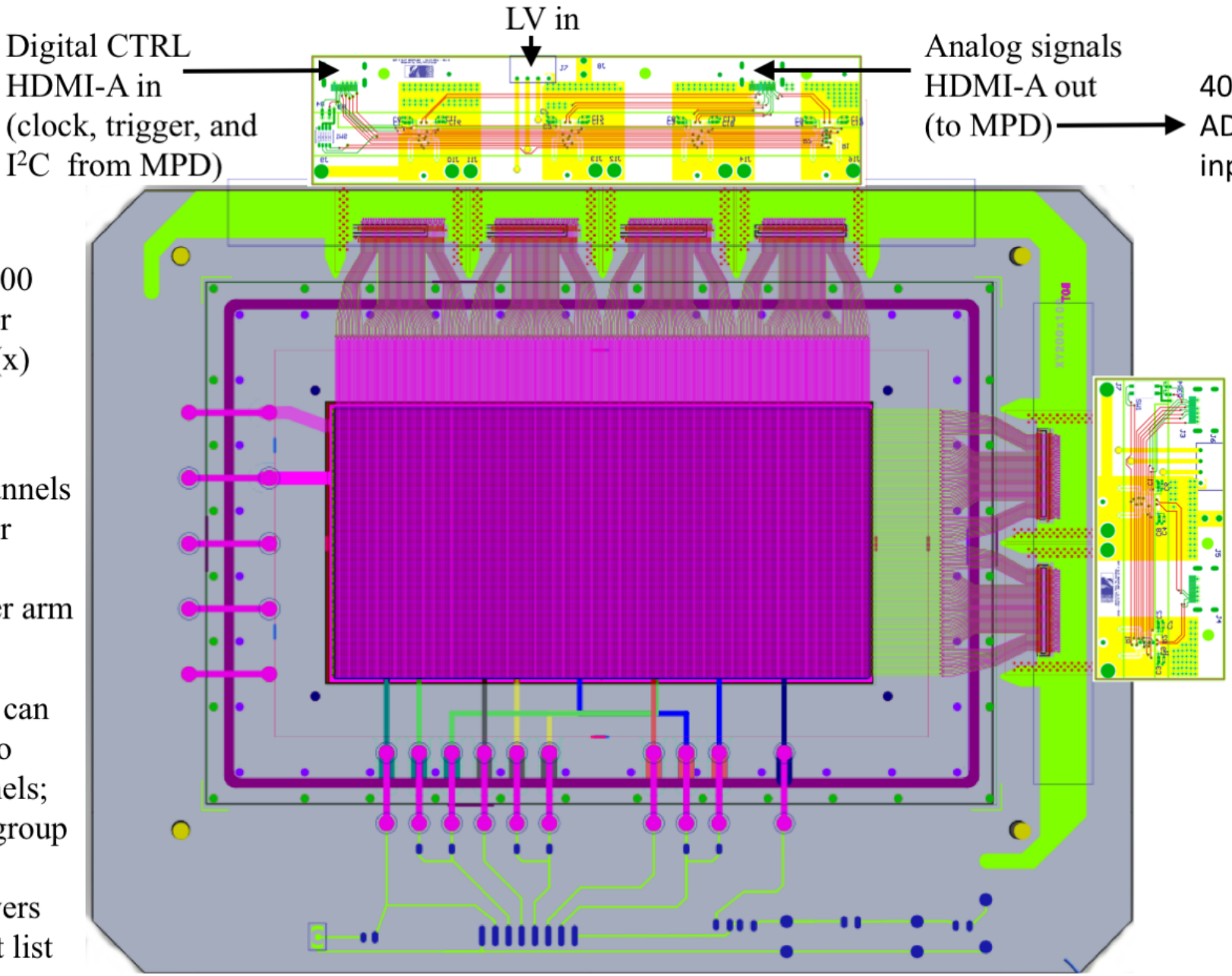
- PREX-II/CREX main detector design essentially complete
  - Waiting for *final* PREX-II and CREX focal-plane footprints before finalizing quartz geometry
  - Will use bare, unwrapped quartz and no light guide
  - Rotary tandem mount concept vetted: Left arm tandem detector constructed and in cosmic test-stand
- Main detector PE yields and relative widths measured at MAMI for 6mm and 10mm thick tandem configuration
  - For unwrapped quartz, 6mm gives 37 peak PEs with 20% RMS/Mean; 10mm (downstream) gives 65 peak PEs with 28% RMS/Mean
  - Expected focal plane rates times these peak PE calibrations give PMT photocathode light levels–so we can prepare each PMT for optimal linearity–Devi will give progress update

# GEM Summary

- "Small" GEM tracking system development well underway
  - 5 assembled and tested GEM chambers in hand (*need at least one more chamber*)
  - All readout electronics in hand: 55 APVs, 6 MPDs, 20 two-slot and 16 four-slot backplanes
  - GEM mounting concept developed and prototype built
  - HV circuits assembled and burn-in procedure completed
  - CODA DAQ with MPD drivers established; communicating with APVs and acquiring raw data; working on decoder now; will start exploring basic functionality and cosmic-ray/source tests soon
- Thanks to ISU parity group: Carlos Bula-Villarreal, Devi-Adhikari, Joey McCullough, Daniel Sluder, and Brady Lowe

# Extra Slides

# GEM Readout




125 x 4 = 500 channels for dispersive (x) direction

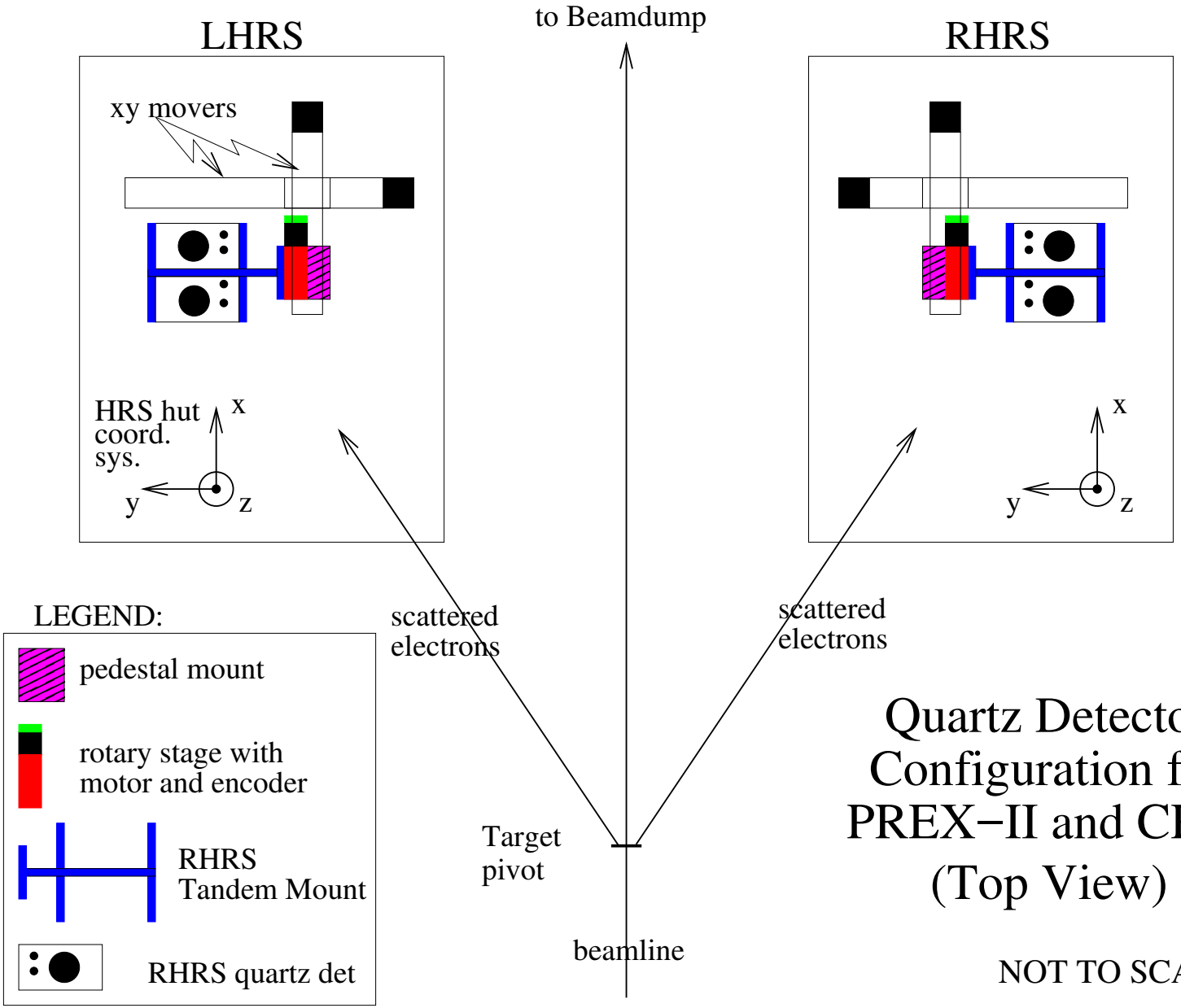
750 x/y channels per chamber gives 3000 channels per arm

Each MPD can handle up to 2000 channels; Jlab DAQ group support for CODA drivers and readout list

125 x 2 = 250 channels for transverse (y) direction

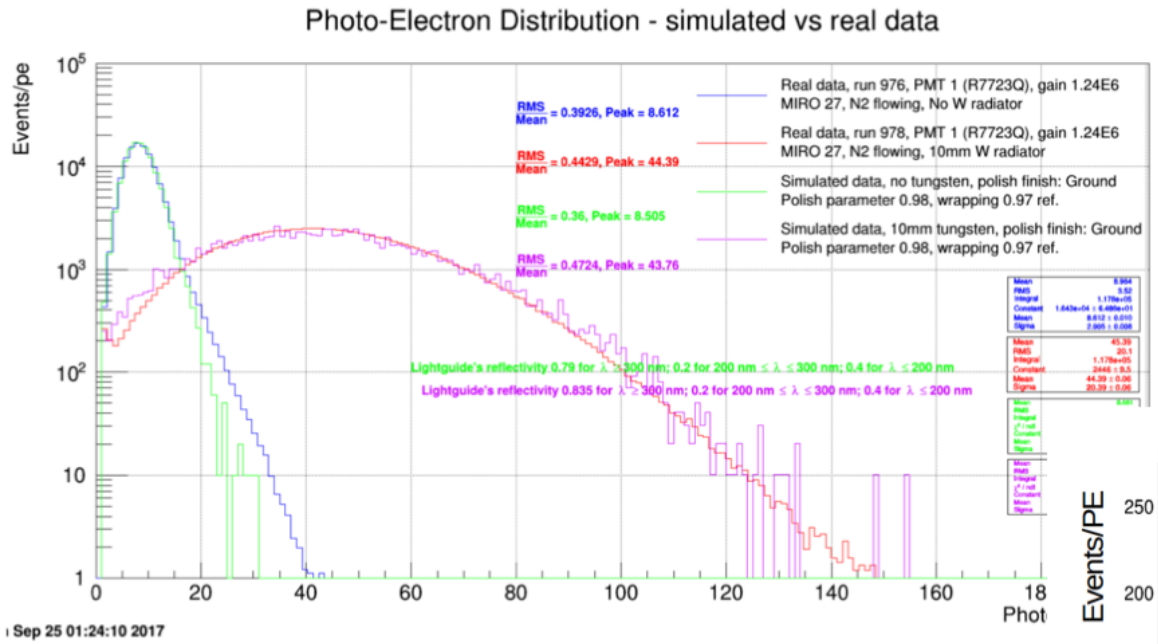
Use analog patch panels to combine signals from two 2-slot backplanes – allows for efficient use of MPD inputs

# Detector Configuration in HRS (Top View)



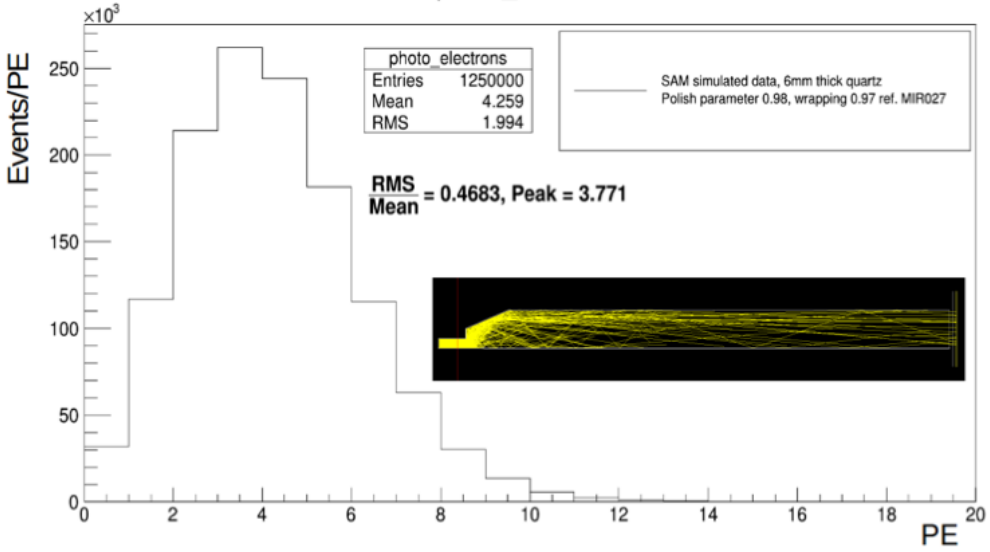
# Reduced SAM quartz thickness; same LG

## 2016 SAMs' PE distributions, MIRO27 lightguide




- Quartz thicknes reduced from 13mm to 6mm. Dimensions are now: 2.0x2.6x0.6 $cm^3$

photo_electrons




- <PE> reduces by factor of 2 and resolution increases from 40% to 50%