PREX/CREX Main Detectors and GEM Trackers

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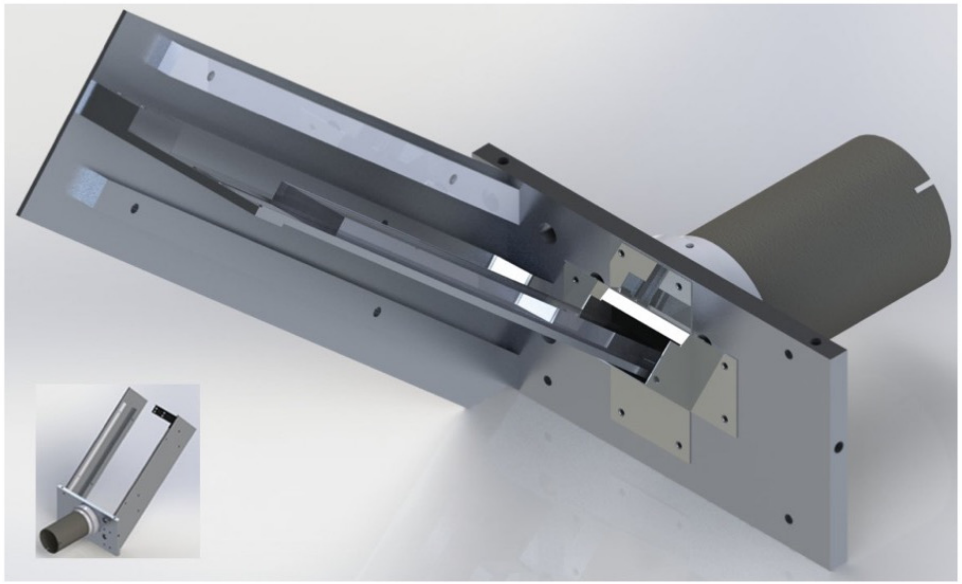
March 4, 2017

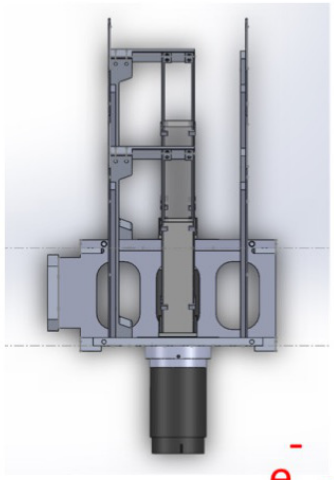
PREX/CREX Main Detectors and GEM Trackers

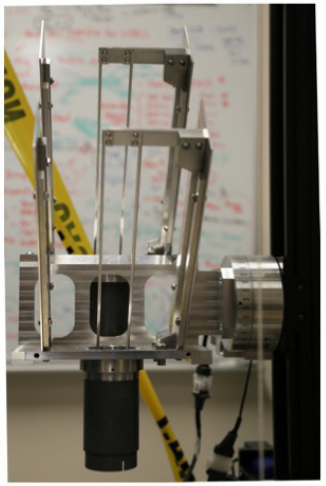
Outline

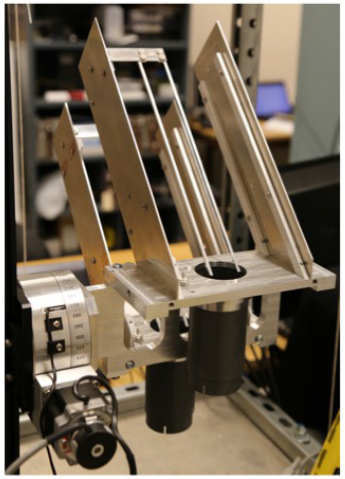
- Main Integrating Detector design and HRS mount
  - Tandem thin quartz Detectors
  - Sliders with rotary stage mount
- PREX-II/CREX Tandem Detector Testbeam Results
- SAM Testbeam Results
- PREX-II "Small" GEM Tracking System
  - CERN 10x20 cm^2 GEMs
  - HRS mount
  - Readout system
- Quartz Geometry Idea
- Finalizing Detector Design
- Summaries and Future Work

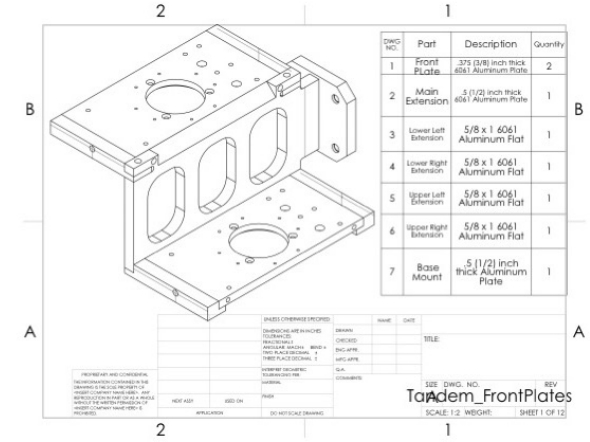
Main Integrating Detectors and Tandem Mount

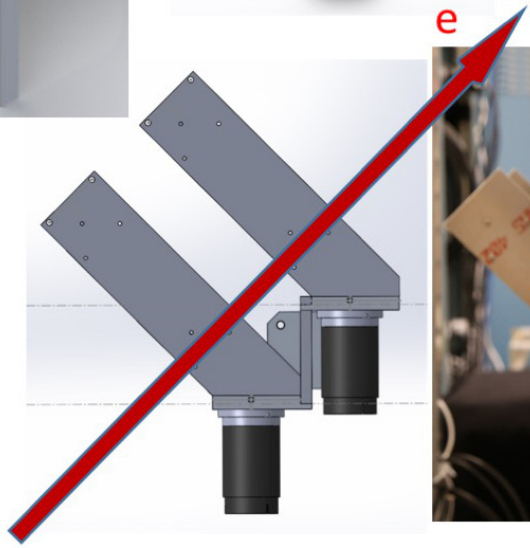


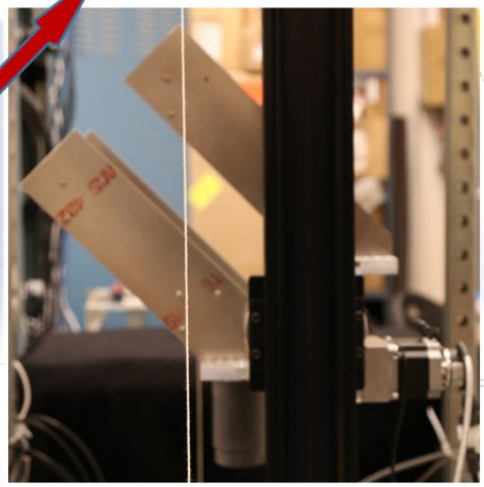






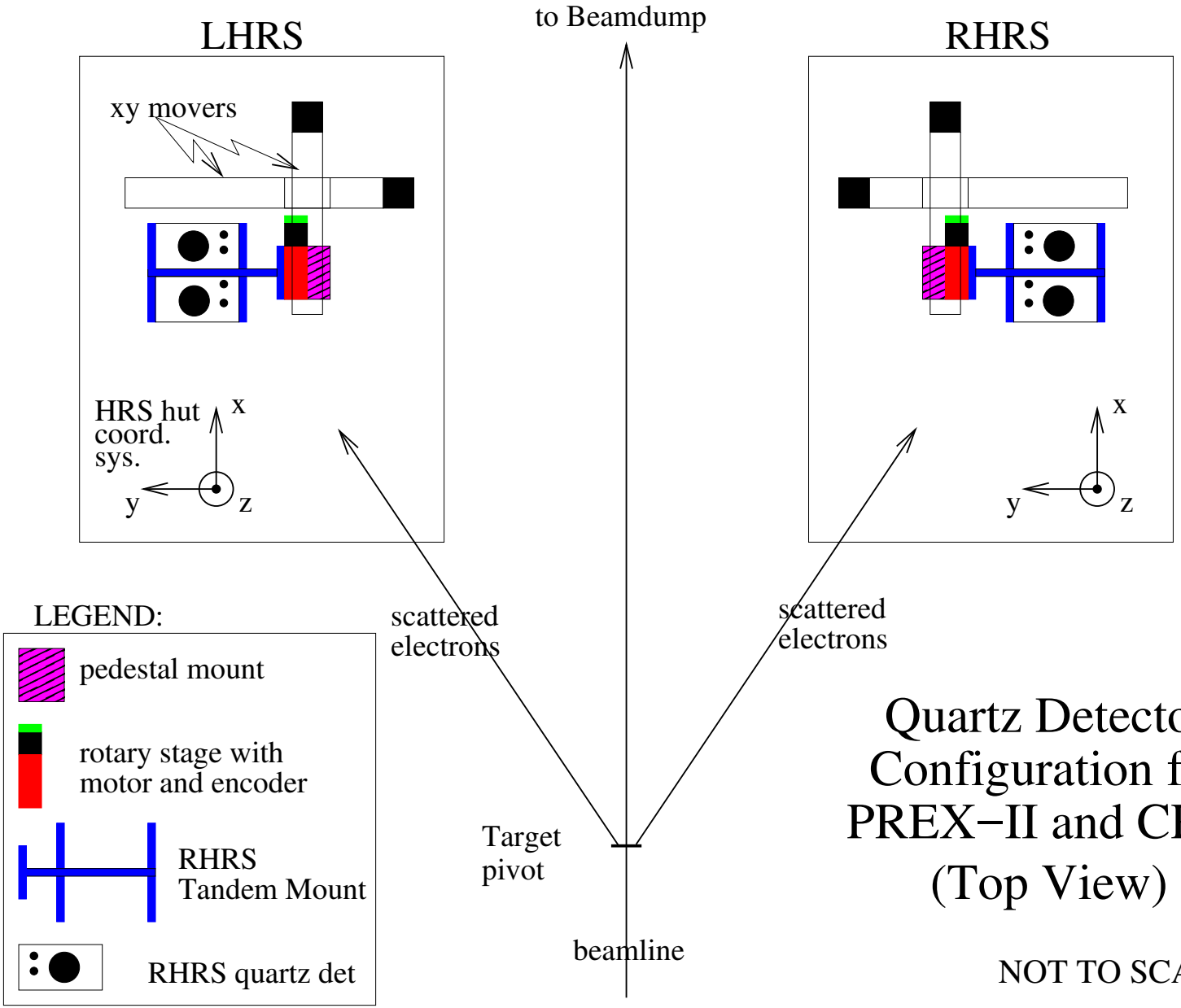






- PREX-II/CREX main detector design based on UMass Design3.
- Can accommodate up to ~5cm wide rectangular quartz piece (for CREX)
- Rotatable tandem mount designed and prototype constructed

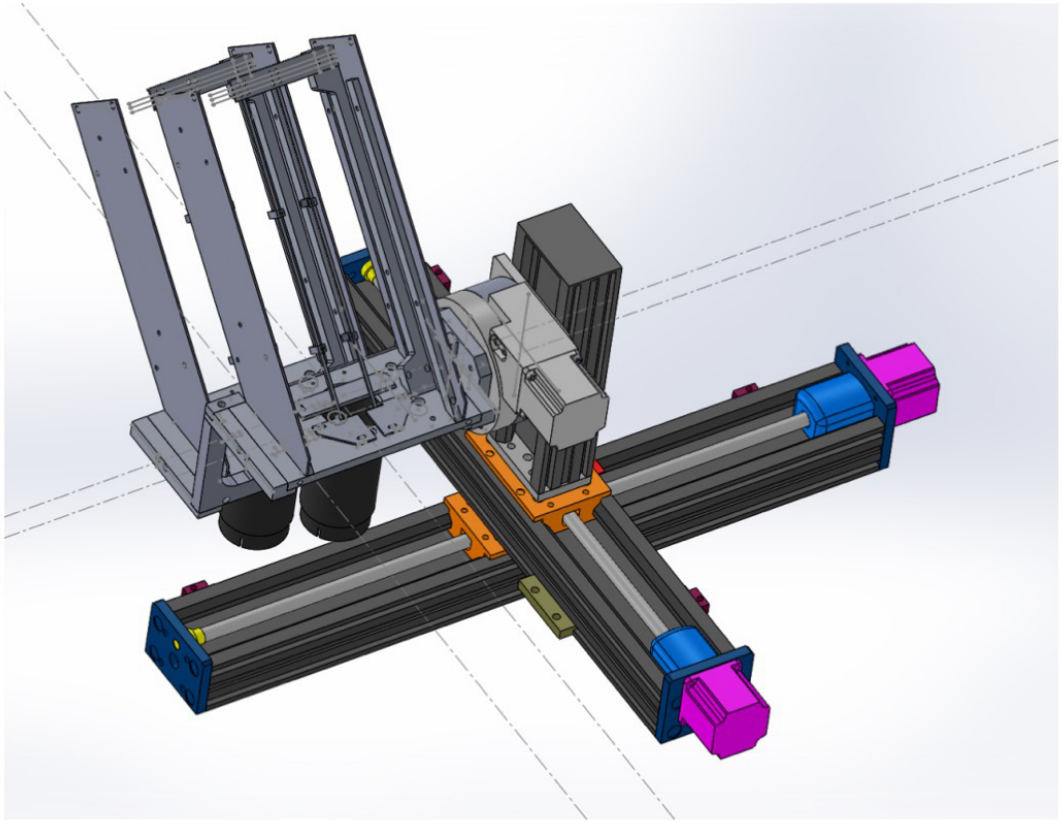
Detector Configuration in HRS (Top View)



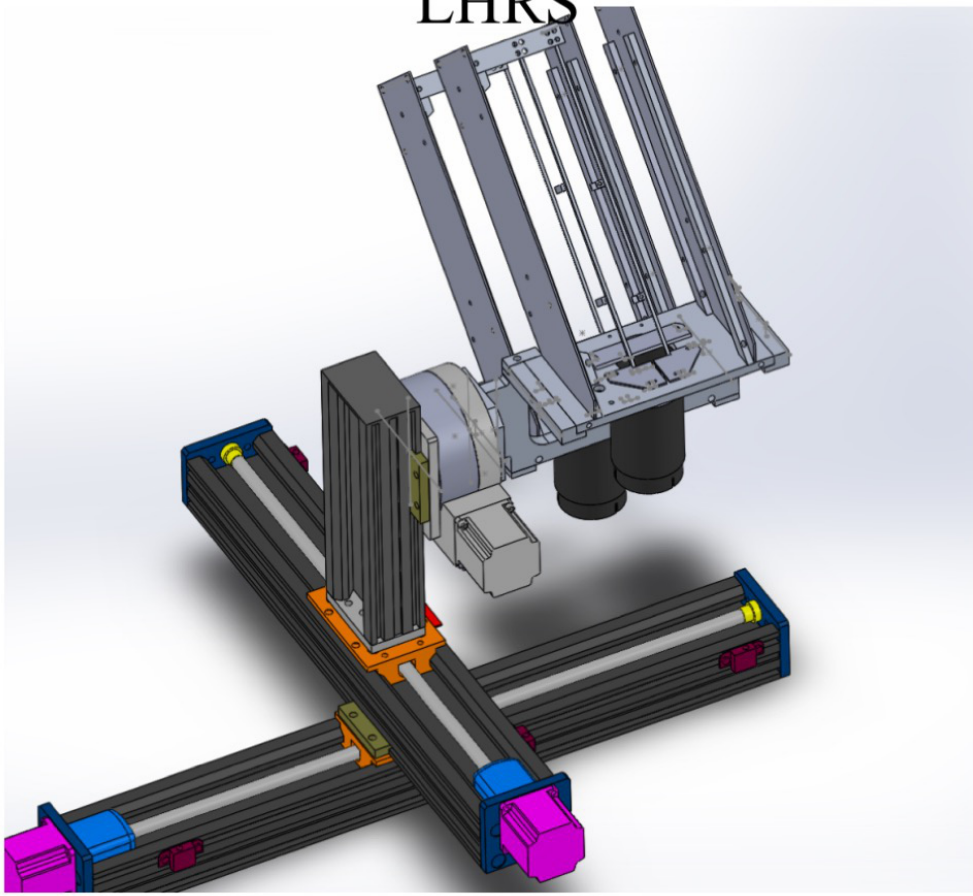
Quartz Detector Configuration for PREX−II and CREX (Top View)

RHRS and LHRS Tandem Rotary Mount CAD

RHRS



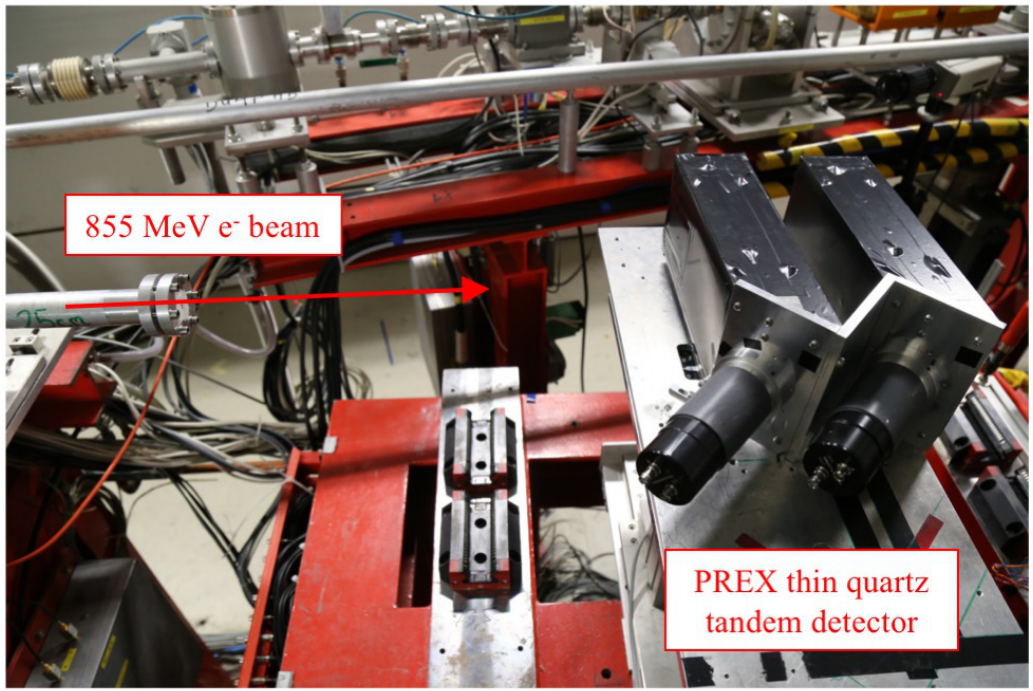
LHRS

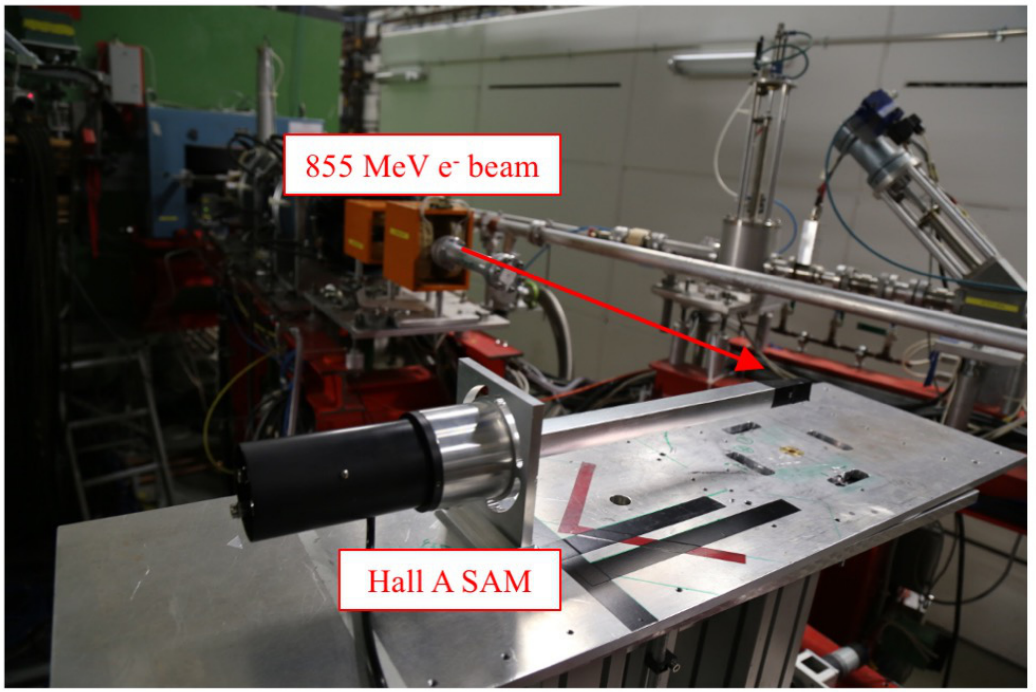


- *X*, *Y*, and θ degrees of freedom
- Velmex 5 and 10 inch travel sliders (Jack has from PREX-I) and rotary stage (have one, need another)

MAMI testbeam May 24-27, 2016

- ¾ shift total for PREX/CREX and SAM tests

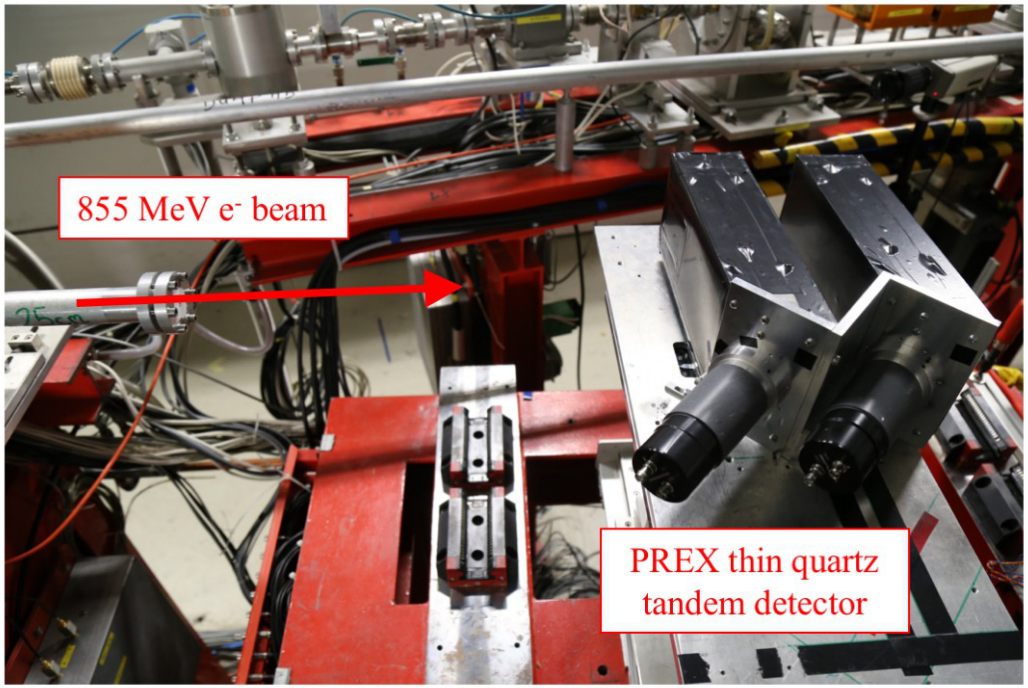




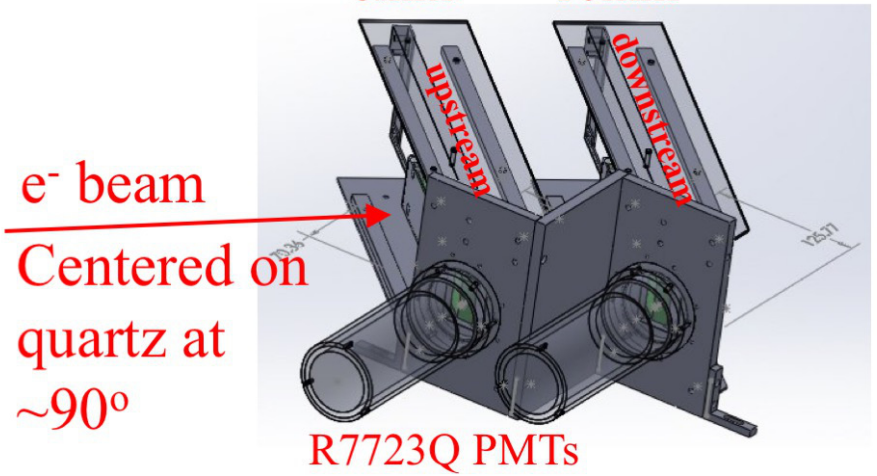
- 6mm and 10mm Tandem mount
- Near normal e- incidence

- Final SAM detector PE yield studies:
  - Miro27 and UVS light-guides
  - With and without 1cm tungsten pre-radiator

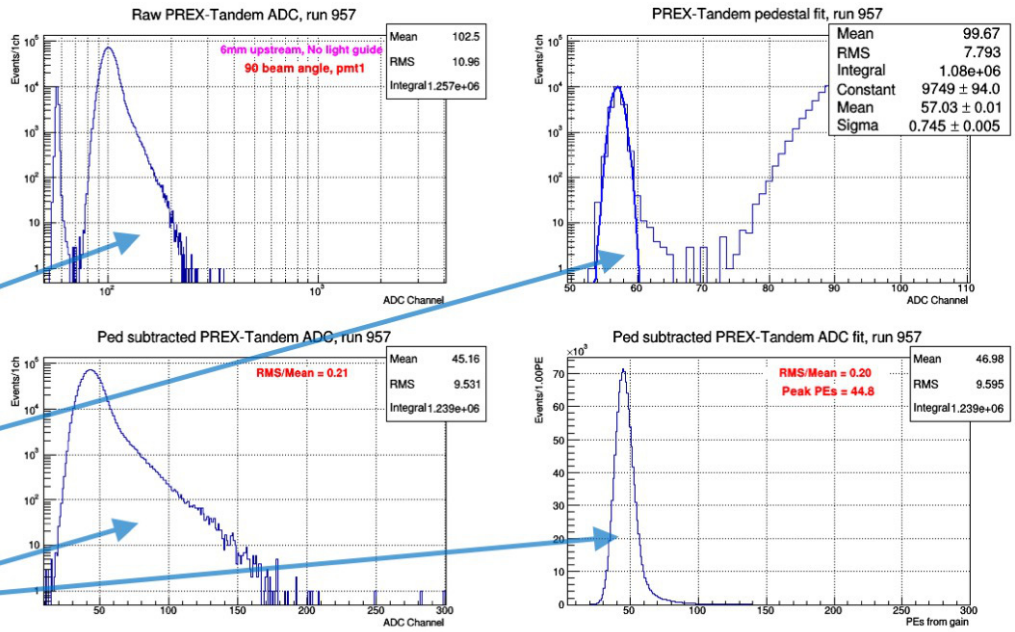
PREX/CREX Tandem mount Tests



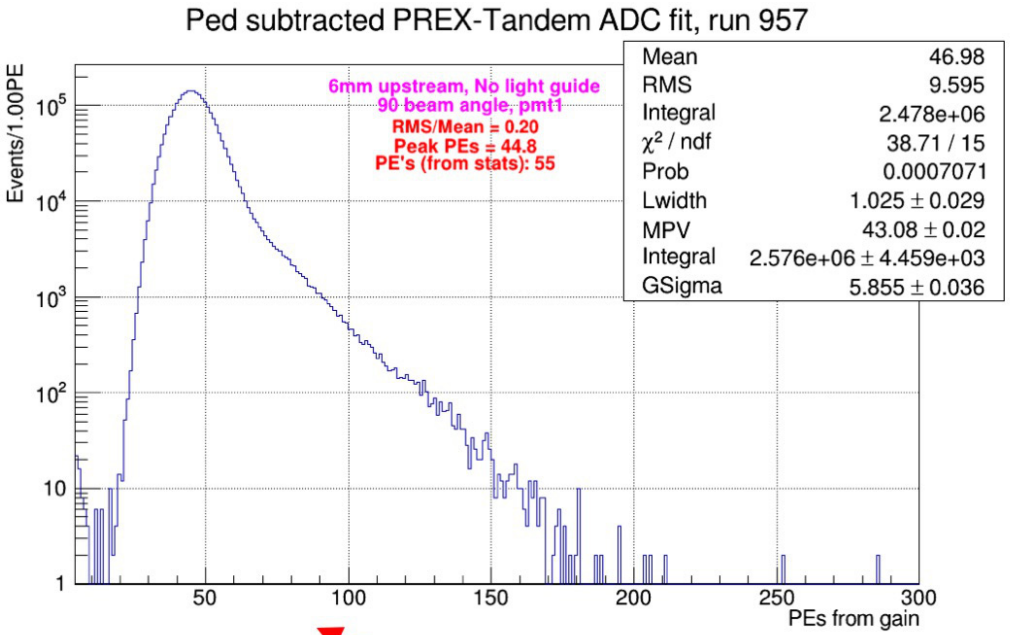
Spectrosil2000 thicknesses: 10mm 6mm and 6mm 10mm

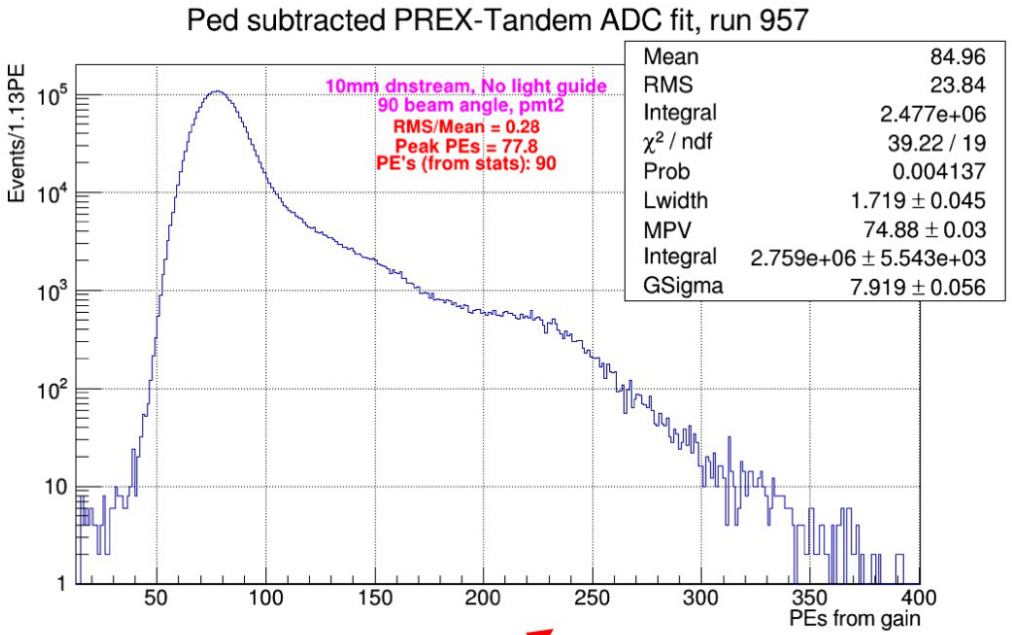


- Quartz spacing same as for rotary tandem mount (~16 cm)
- Used two Hamamatsu R7723Q pmts
- Quartz is wrapped with 1 mil Al. Mylar
- Took runs for each quartz thickness upstream and downstream
- Example raw data, pedestal fit, and ped-corrected ADC and PE dists



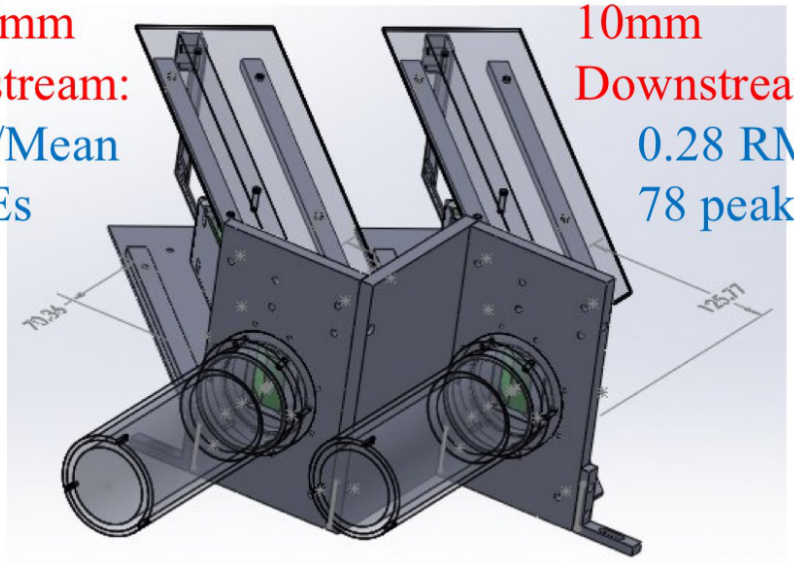
6 mm/10 mm Tandem Testbeam Results





- PEs converted from ADC units using PMT gains

6mm Upstream:
0.20 RMS/Mean
45 peak PEs

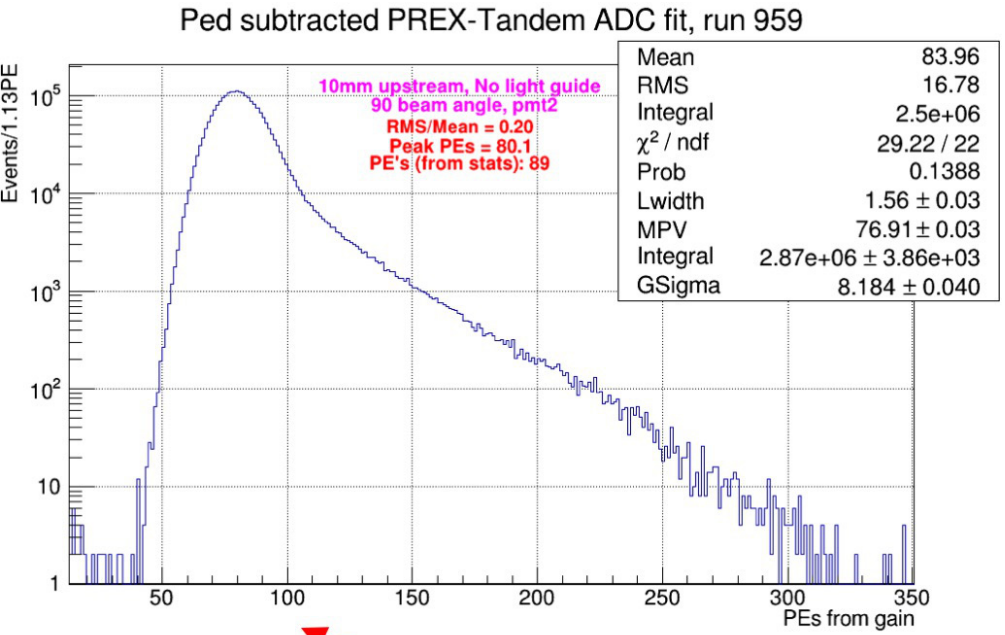


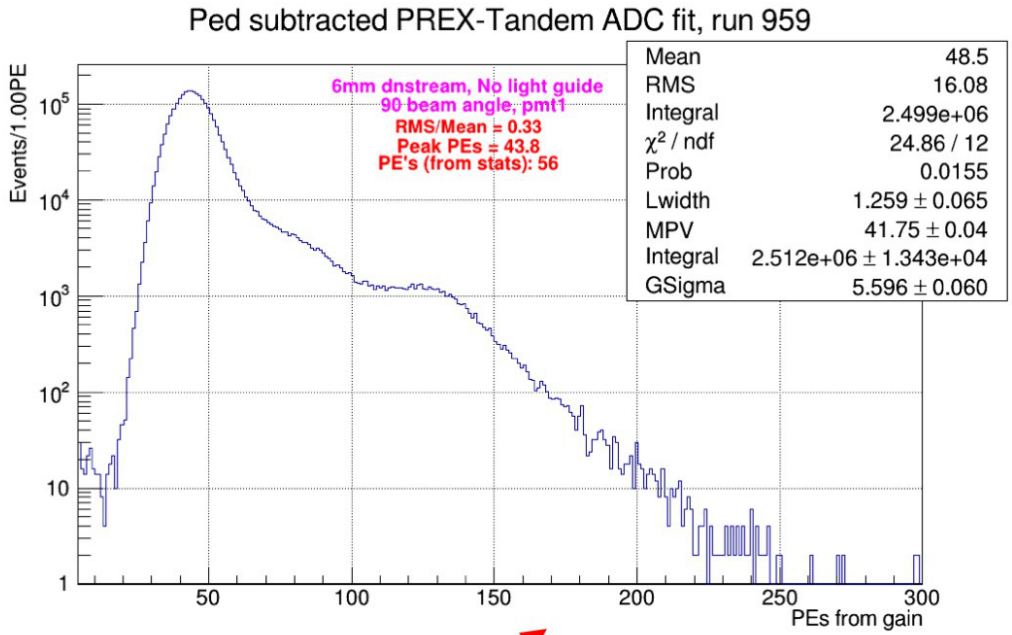
10mm Downstream:
0.28 RMS/Mean
78 peak PEs

- 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

- Uncertainty in PMT gains between 5 – 10%

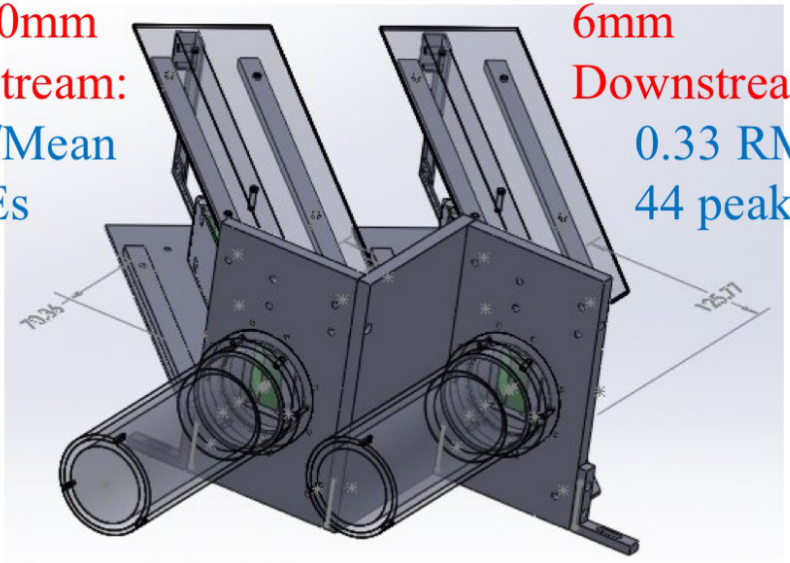
10 mm/6 mm Tandem Testbeam Results



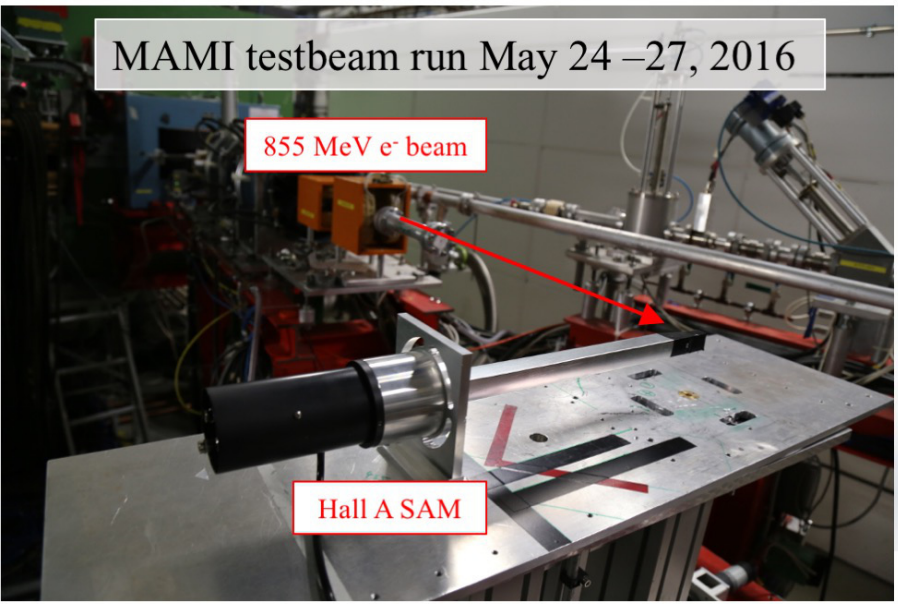


10mm Upstream:
0.20 RMS/Mean
80 peak PEs

6mm Downstream:
0.33 RMS/Mean
44 peak PEs



Final SAM Design and 2016 Testbeam



- Final SAM detector PE yield studies:
  - MiroSilver27 and UVS light-guides
  - With and without 1cm tungsten pre-radiator

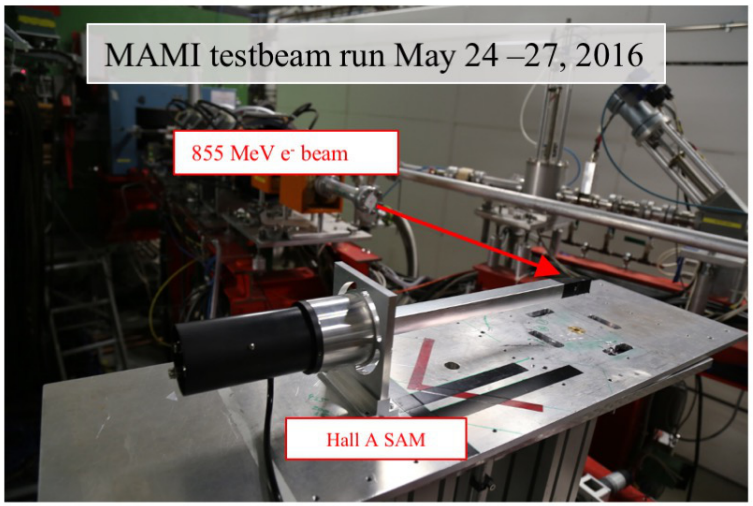
Assembled & Installed in Hall A Fall 2015

Final SAM detector

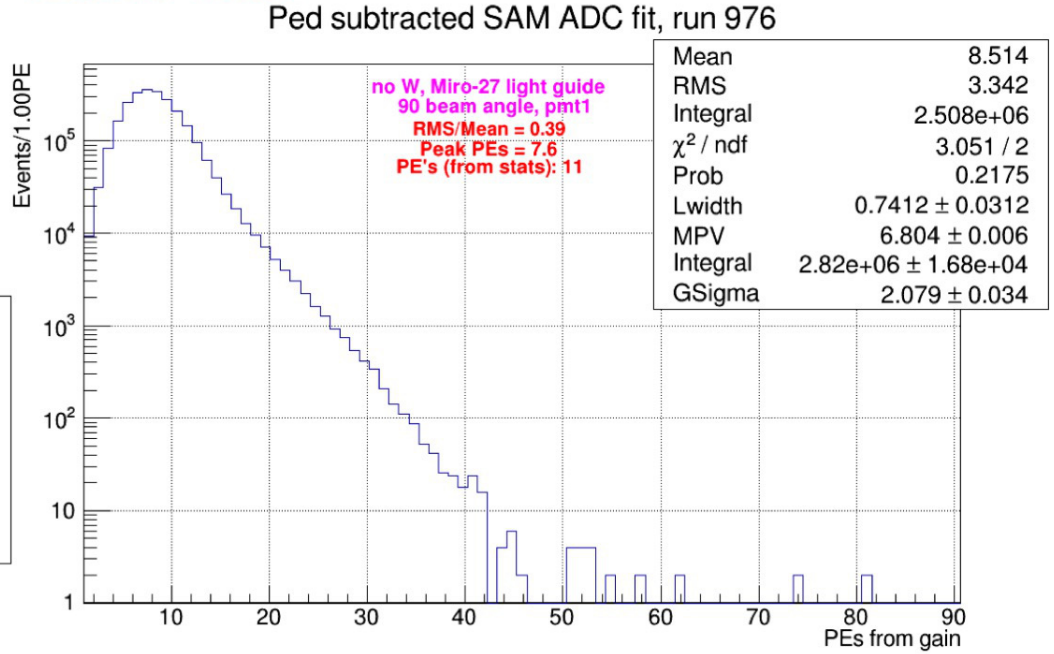
- Quartz: 33 x 20 x 13 mm^3
- Miro27 LG: 36 x 2.6 x 2.1 cm^3
- Optimized 1-bounce funnel mirror
- Unity or high-gain R375 2” PMTs
- Use of pre-radiator not decided
- Dry-air inlet and outlet ports
- Custom flange adapter for easy de-install/re-install (radcon permitting)

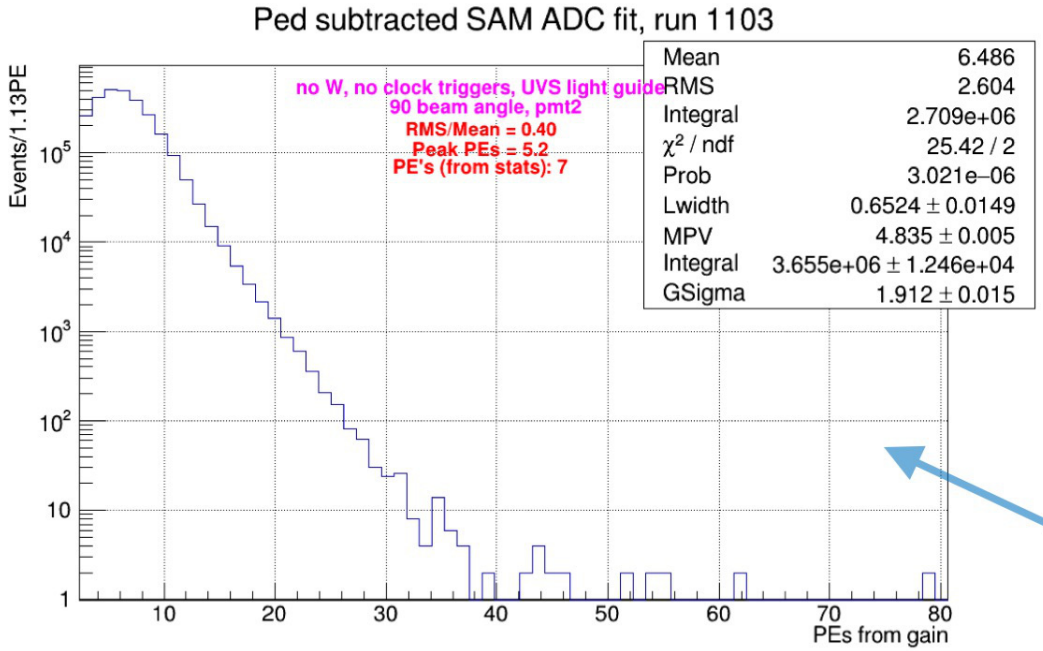
Small Angle Monitors:
Detect ~0.5° target scattering

SAM PE Yield & LG Testbeam Study: Miro-silver27 vs Anolux UVS (no tungsten)



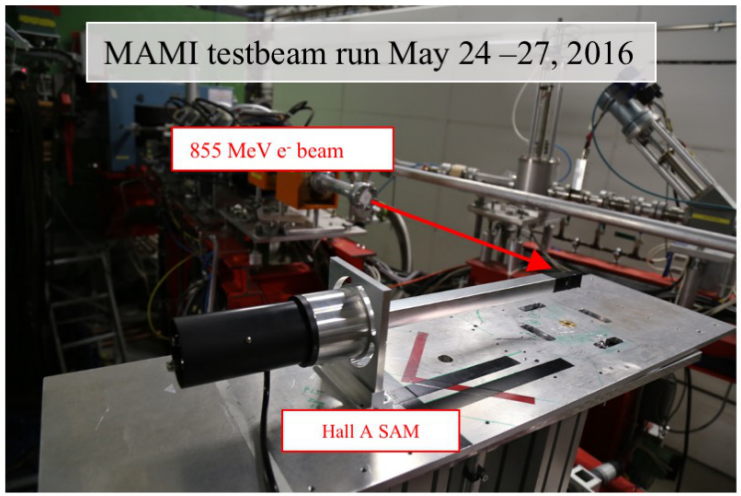
- Miro-silver27, no tungsten, N_2 gas flowing: ~7 - 8 peak PEs (using PMT gain) with 39% relative width



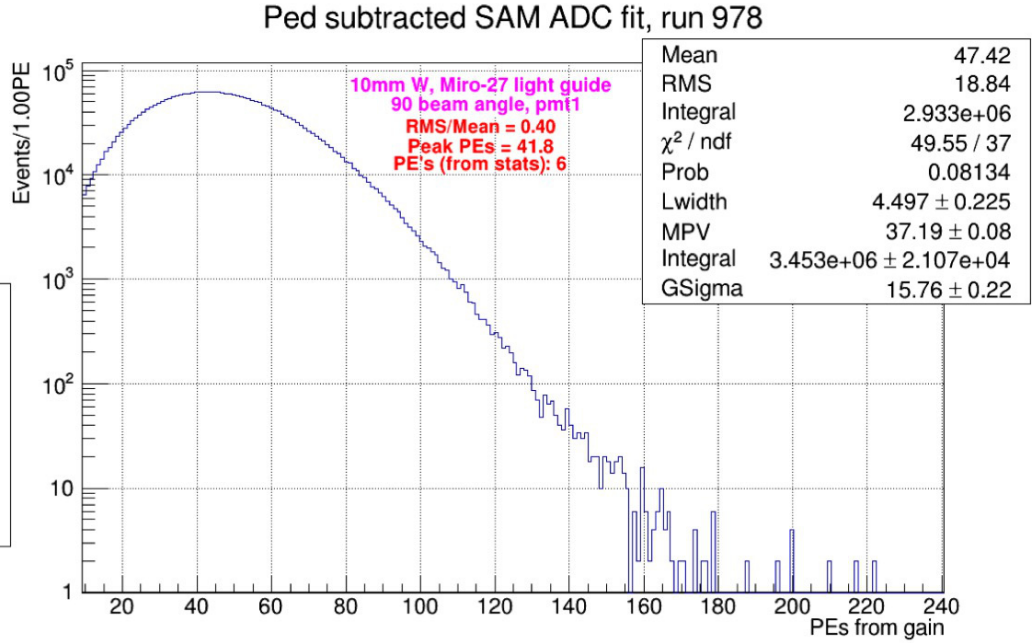


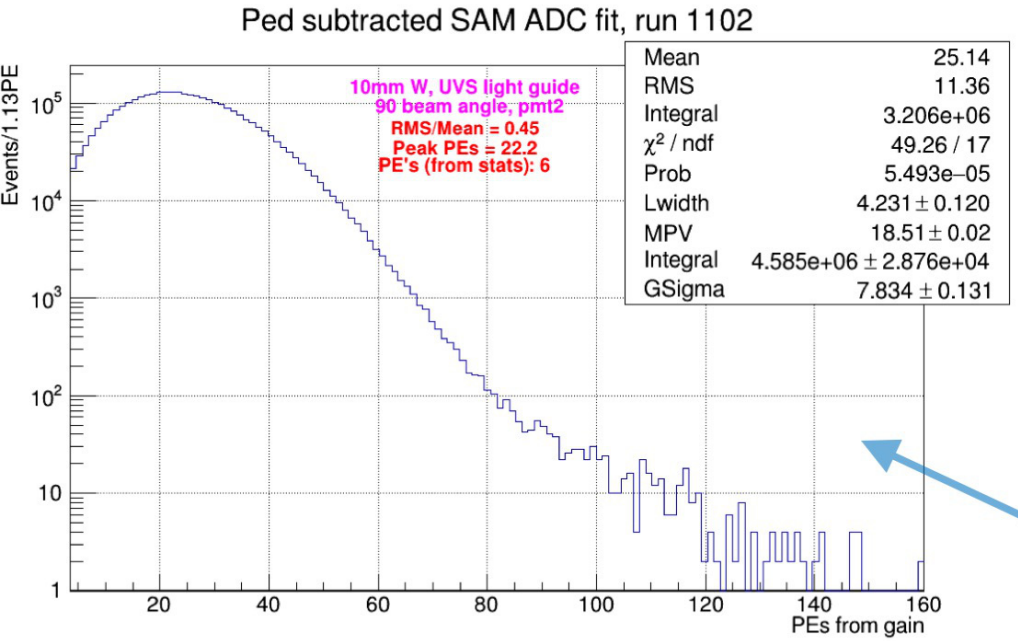
- Anolux UVS, no tungsten, N_2 gas flowing, and no clock-triggers: ~5 peak PEs (using PMT gain) with 40% relative width

SAM PE Yield & LG Testbeam Study: Miro-silver27 vs Anolux UVS (w/ tungsten)



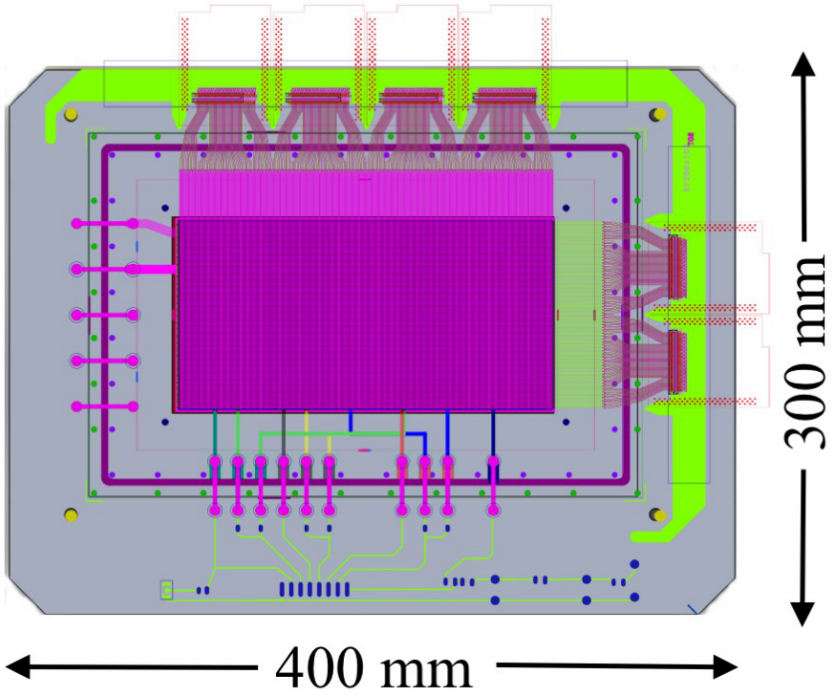
- Miro-silver27, w/ 10mm tungsten, N_2 gas flowing: ~42 peak PEs (using PMT gain) with 40% relative width

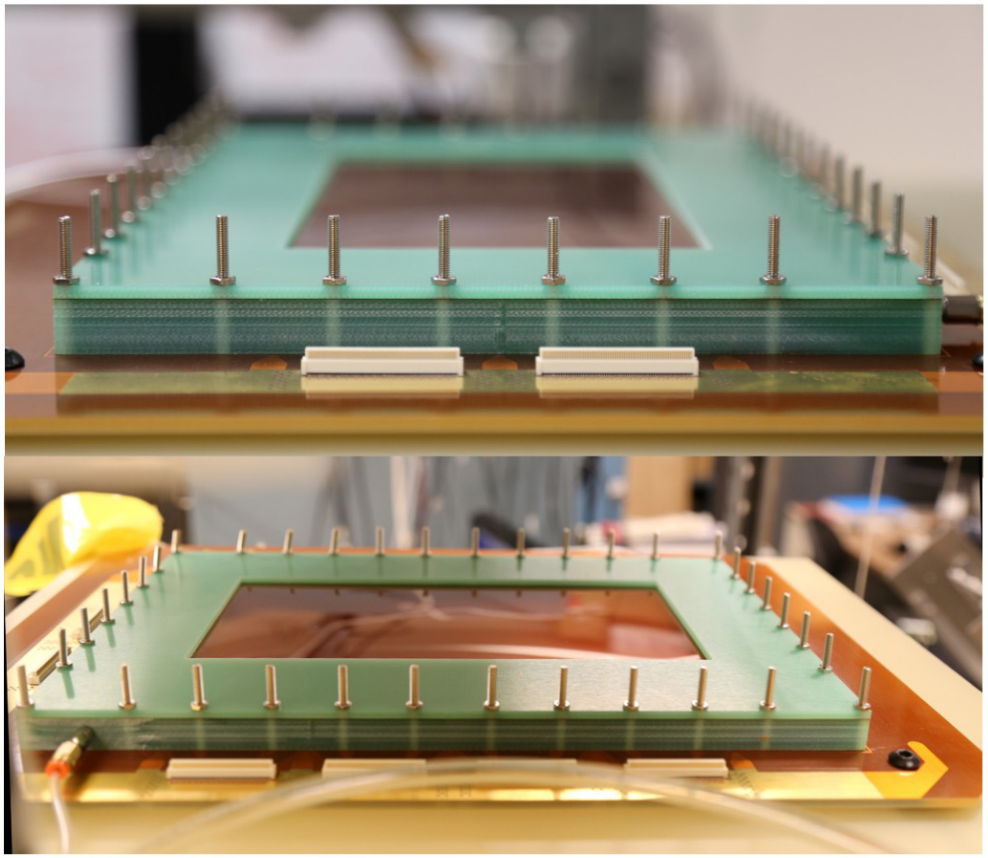




- Anolux UVS, w/ tungsten, N_2 gas flowing: ~22 peak PEs (using PMT gain) with 45% relative width

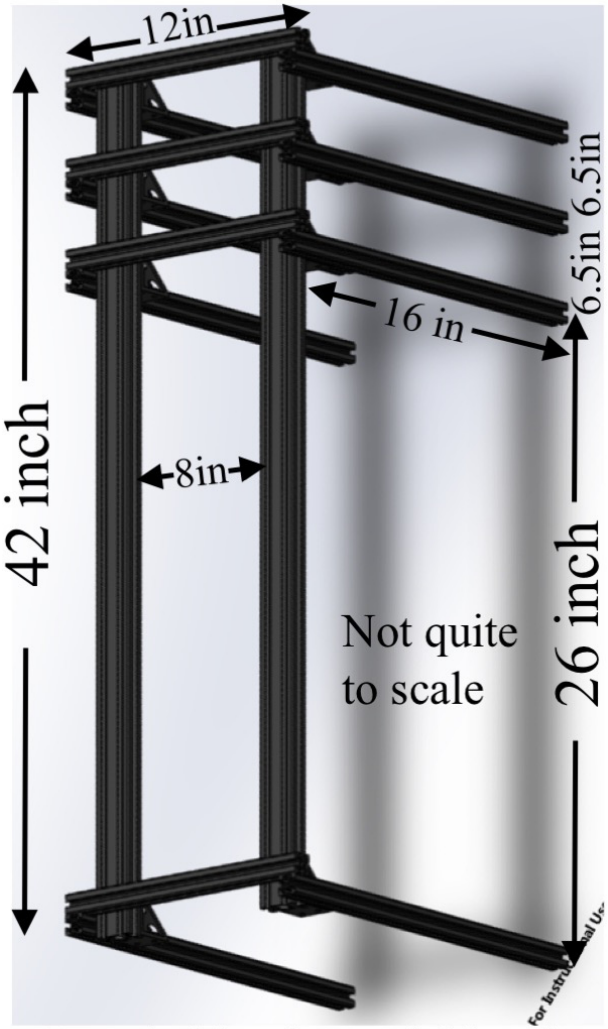
PREX/CREX "small" 10x20 cm^2 GEM trackers





- Custom CERN 10 cm X 20 cm active area triple GEM chambers
  - 400μm pitch x/y, 4 + 2 Panasonic 130pin Readout connectors
  - Standard GEM spacing D-3mm-G1-2mm-G2-2mm-G3-2mm-RO
  - GEM frames are 2mm thick and 2cm wide
  - Standard HV filter circuit
- Readout scheme based on INFN: APV25FE-->backplane->MPD

GEM Chamber Mounting Concept



Bare ladder-frame (old ver)

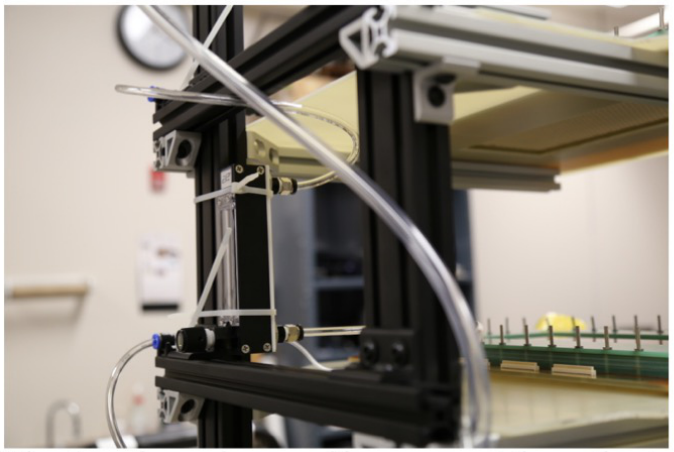
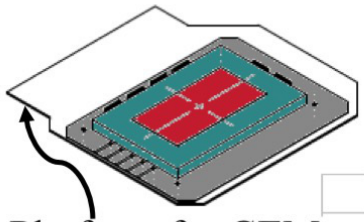
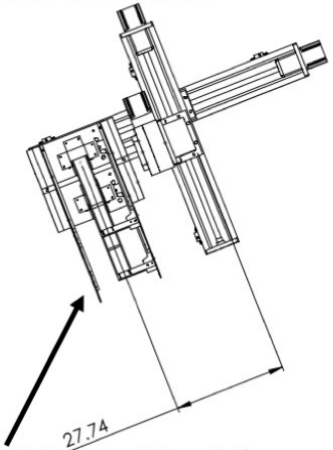
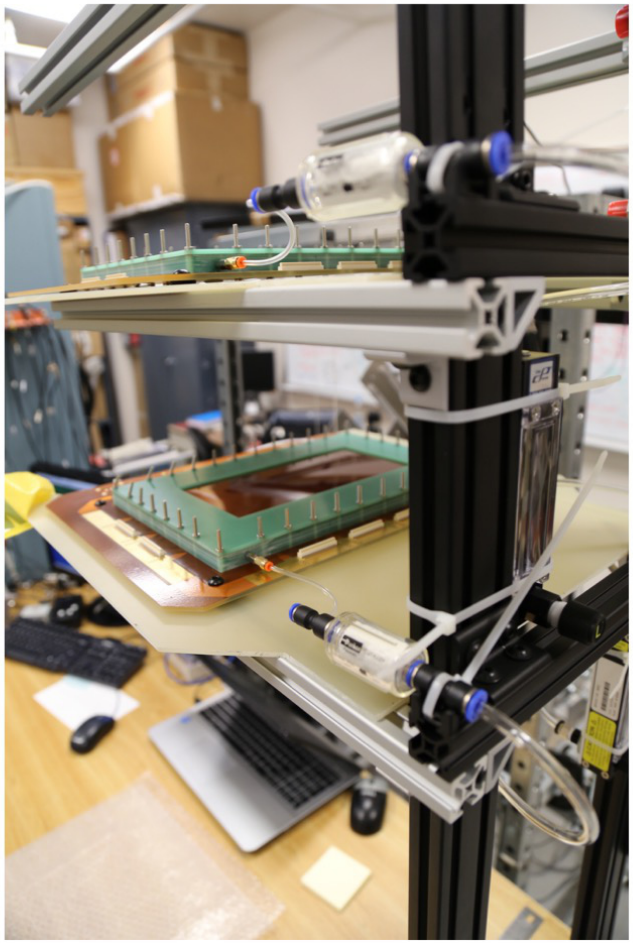


Photo showing rail support brackets


Platform for GEMs

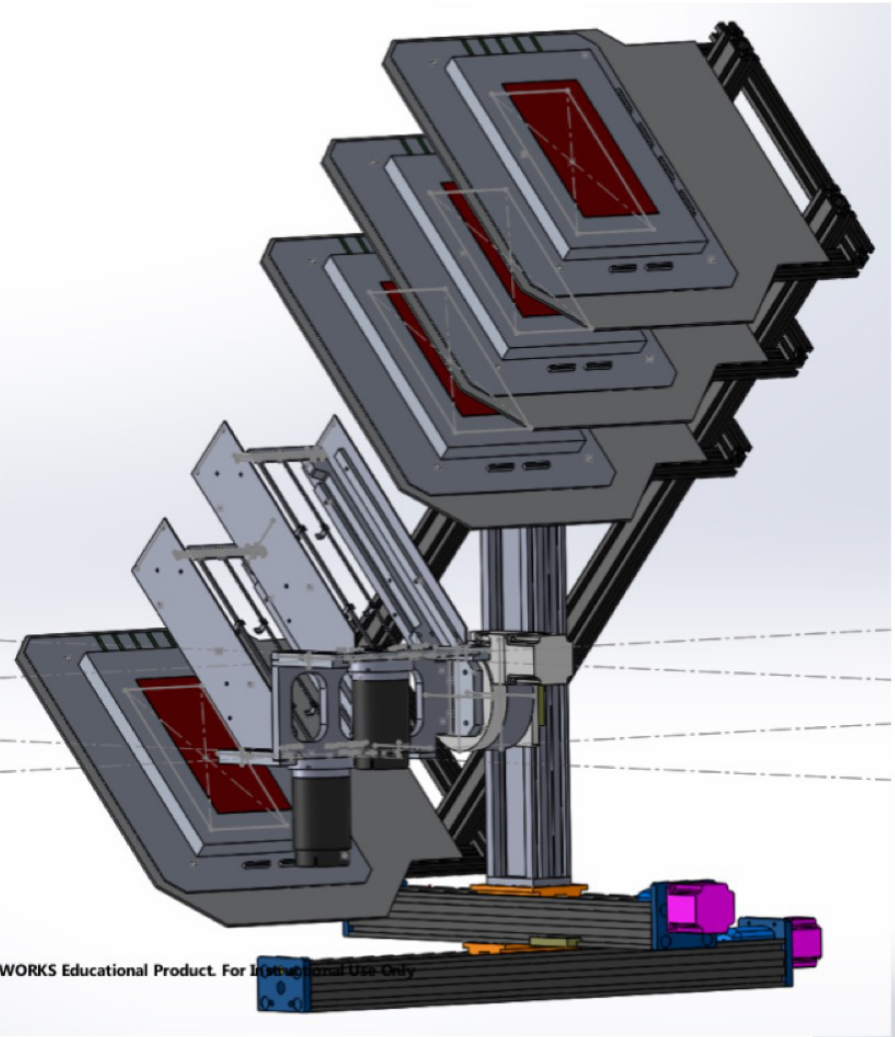


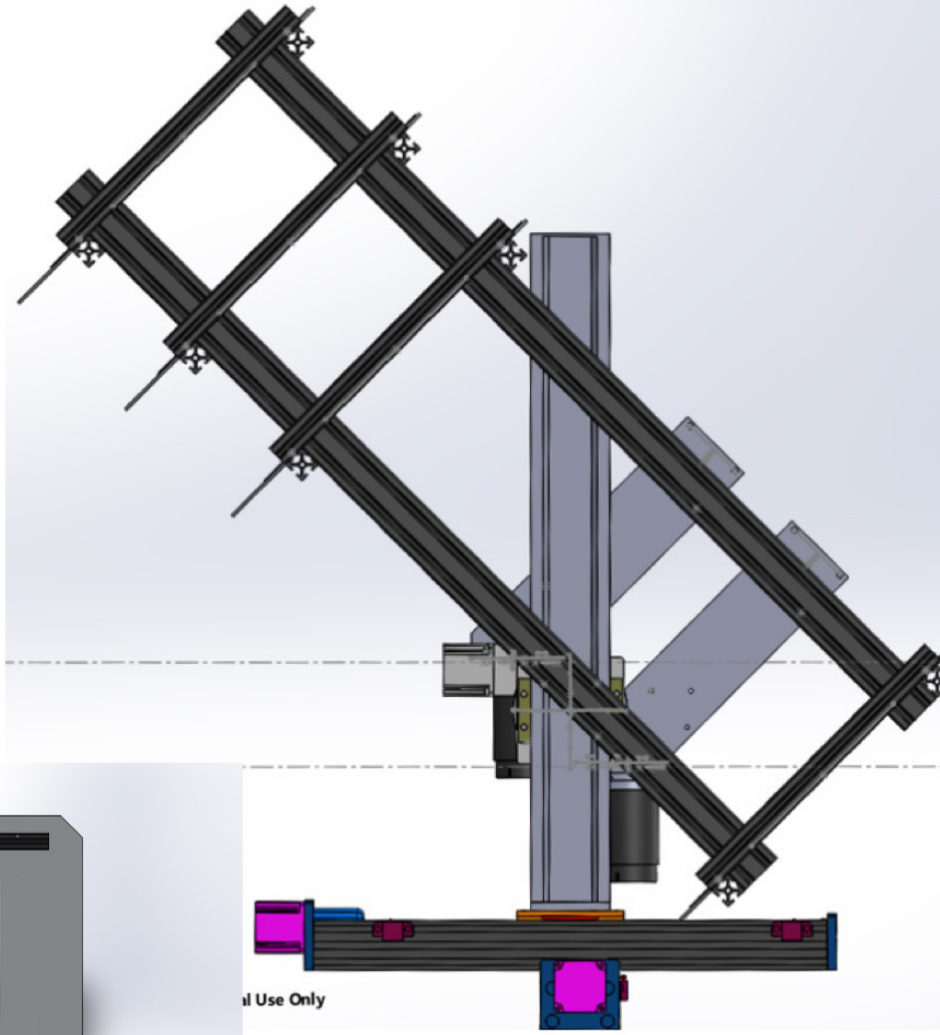
Tandem Mount Top View

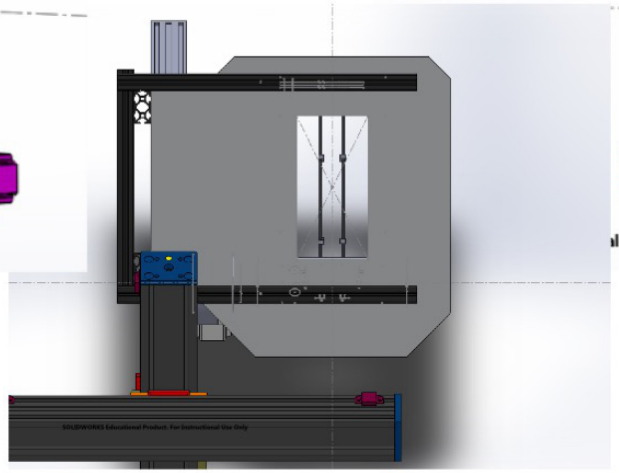

2 Chambers installed; gas flowing

- Extruded aluminum mounting system for GEMs; not finalized yet
- Chambers mounted to 1/8” thick G10 FR4 platform (w/10x20 area cutout)
- GEM ladder-frame mounts to Velmex slider post using cleats

RHRS Tandem Quartz Mount with GEMs

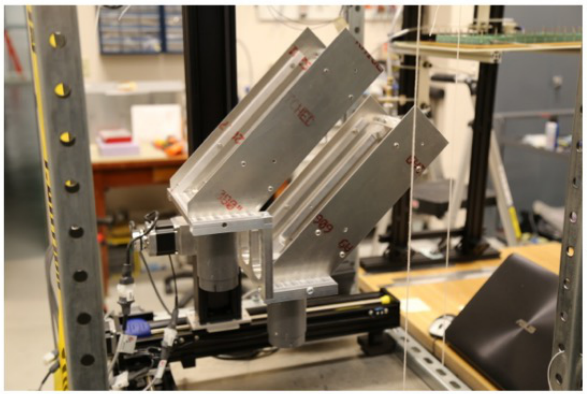


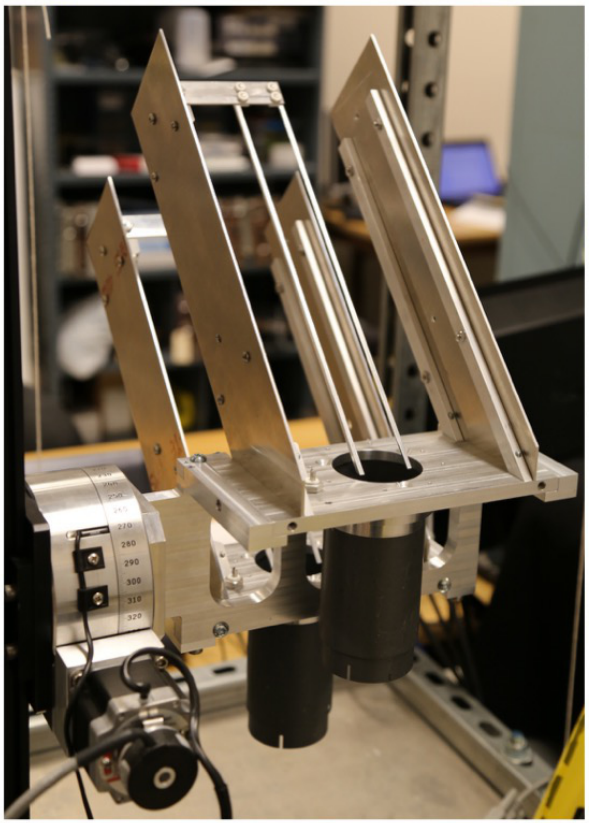




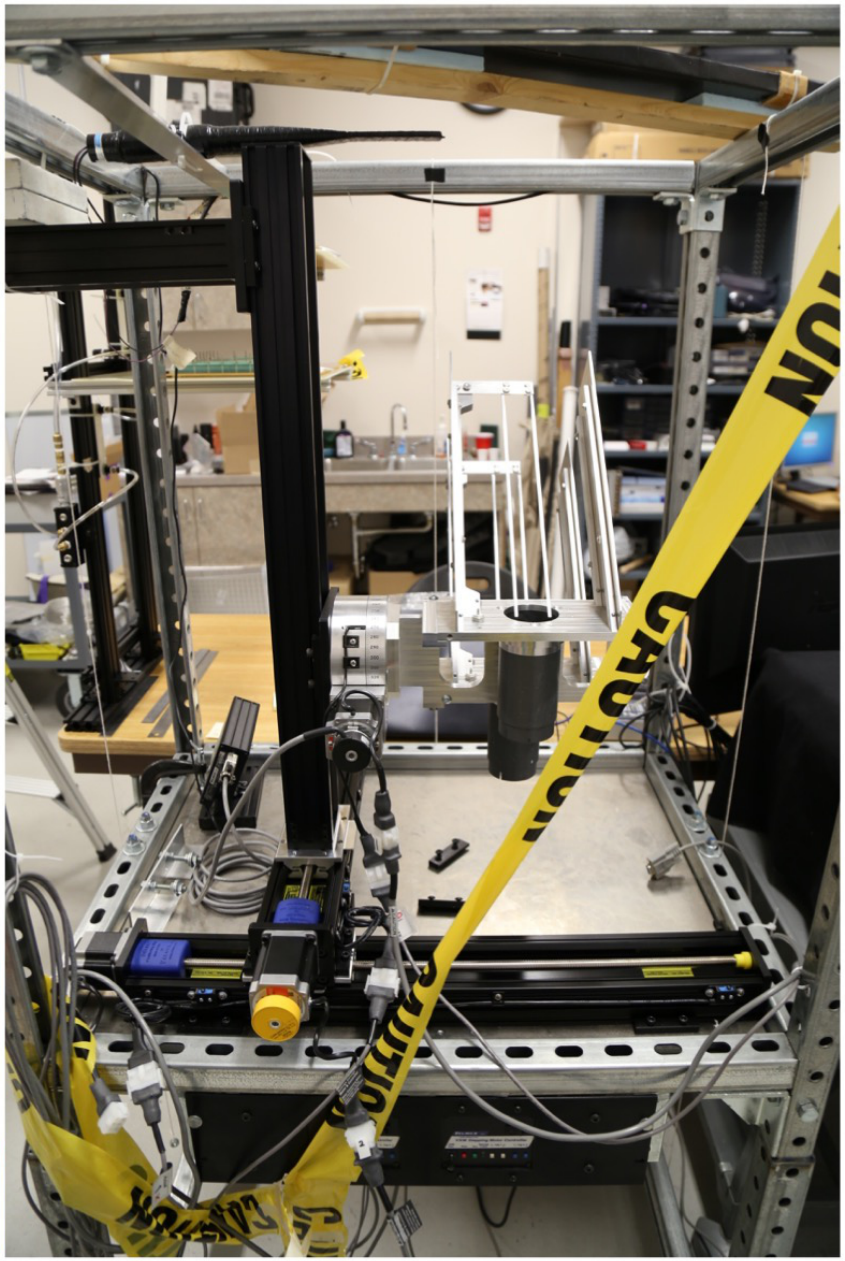
Beam's view (from below)

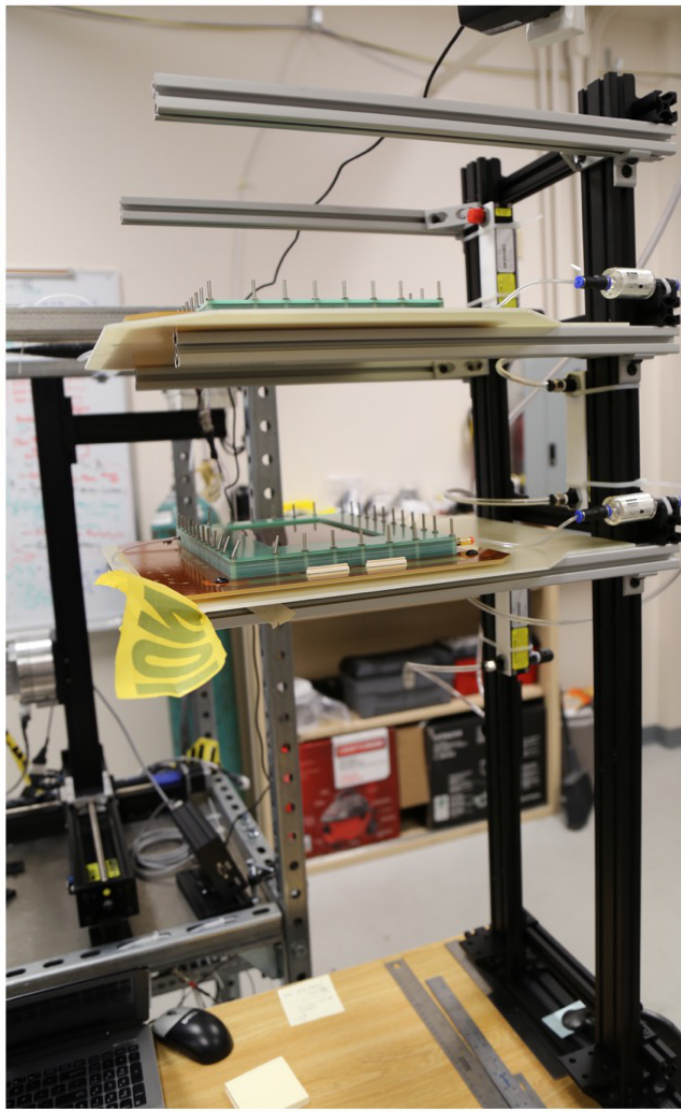
Prototype Development at ISU





Prototype LHRS Tandem mount

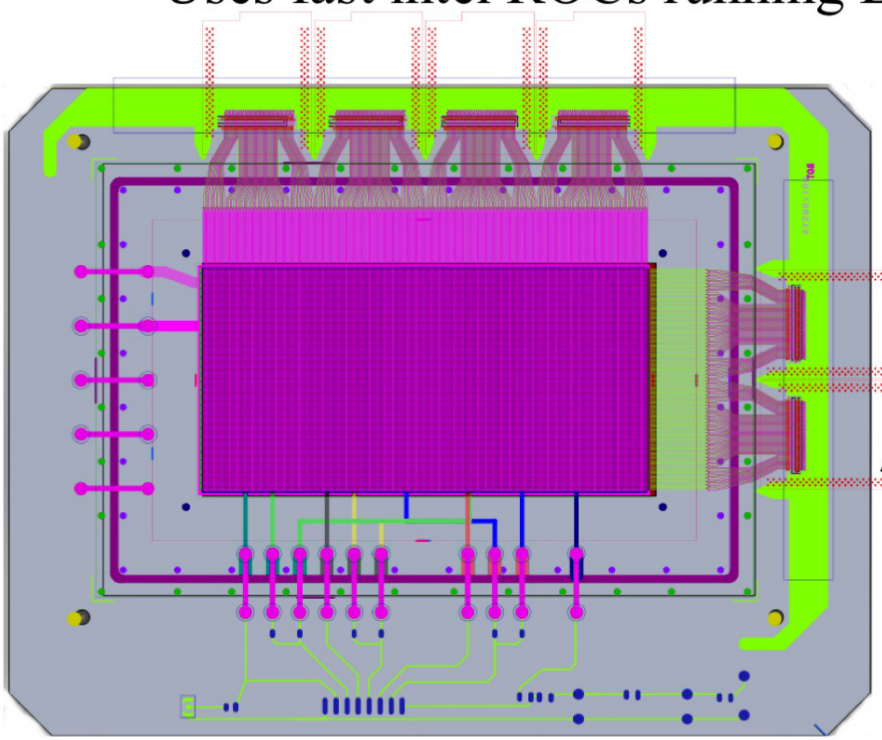


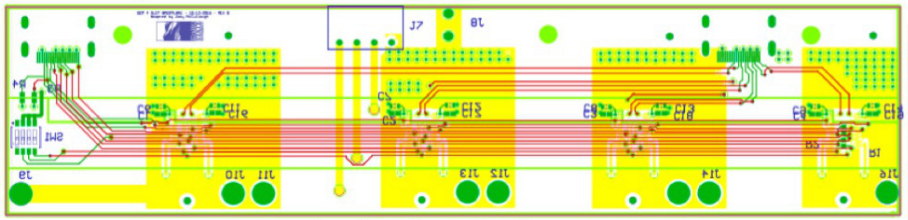


Prototype GEM stand
(under construction)

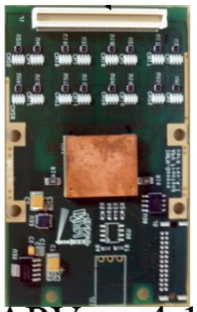
GEM Readout Plans

- GEM readout scheme based on INFN/UVA SBS front-tracker system:
  - Uses APV25FE rev4.1 cards (have 55 in hand); each chamber needs 6 APVs
  - Requires new 4-slot and 2-slot "backplane" PCBs (designed and in production)
  - 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 ROCs running Linux (have 3 in hand: GE model XVB601)

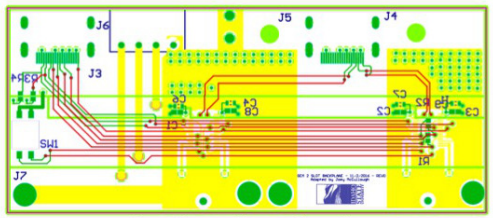




4-slot backplane

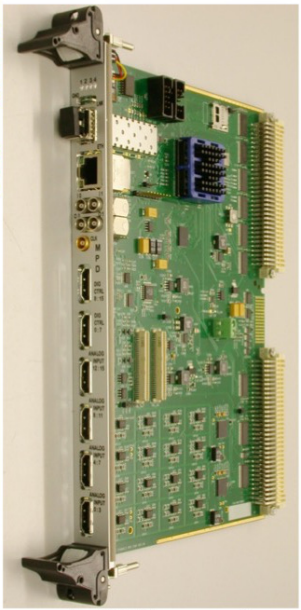


APV rev4.1



2-slot backplane

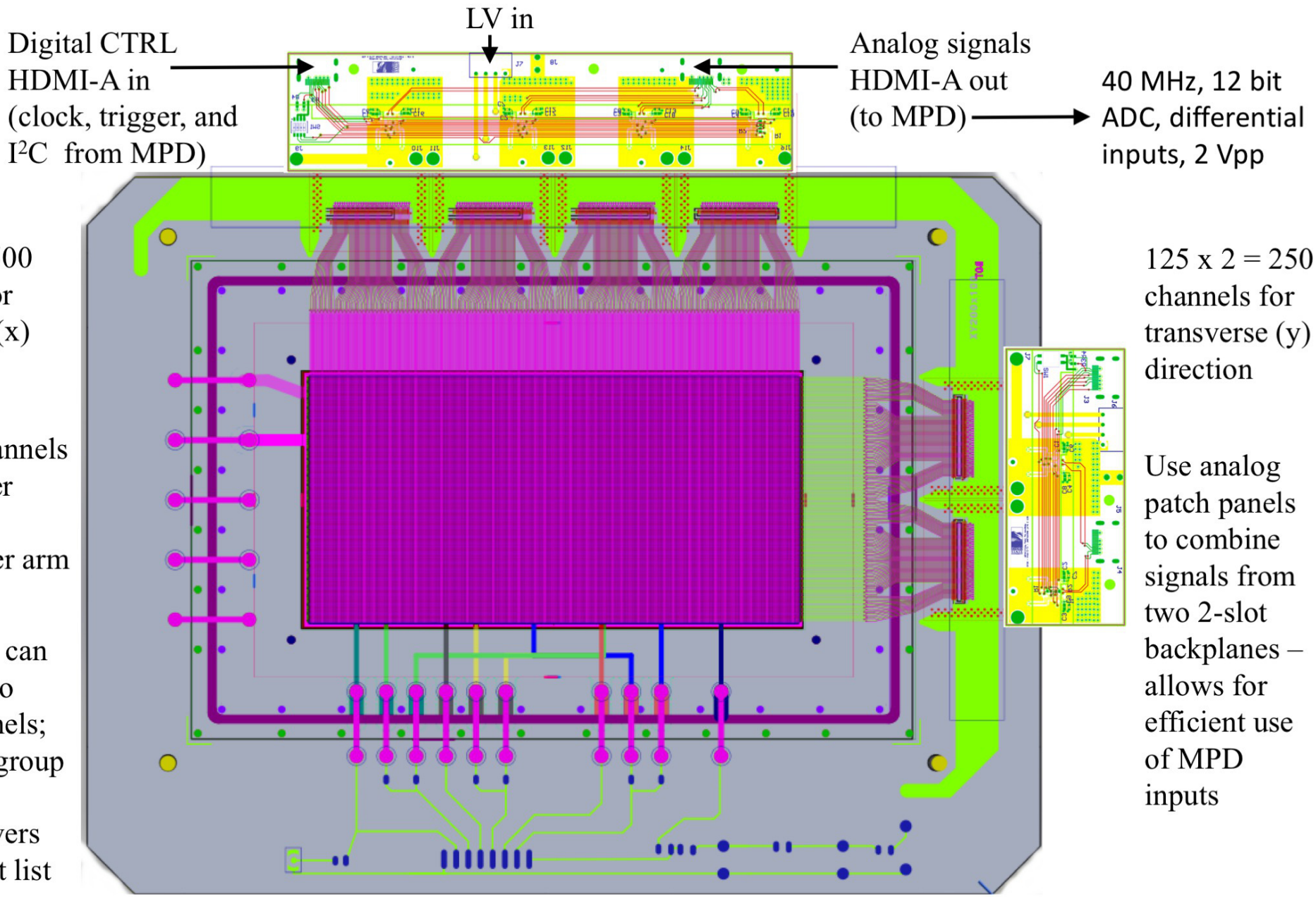
APVs mount directly to Panasonics on GEM readout board—amplifies and multiplexes output



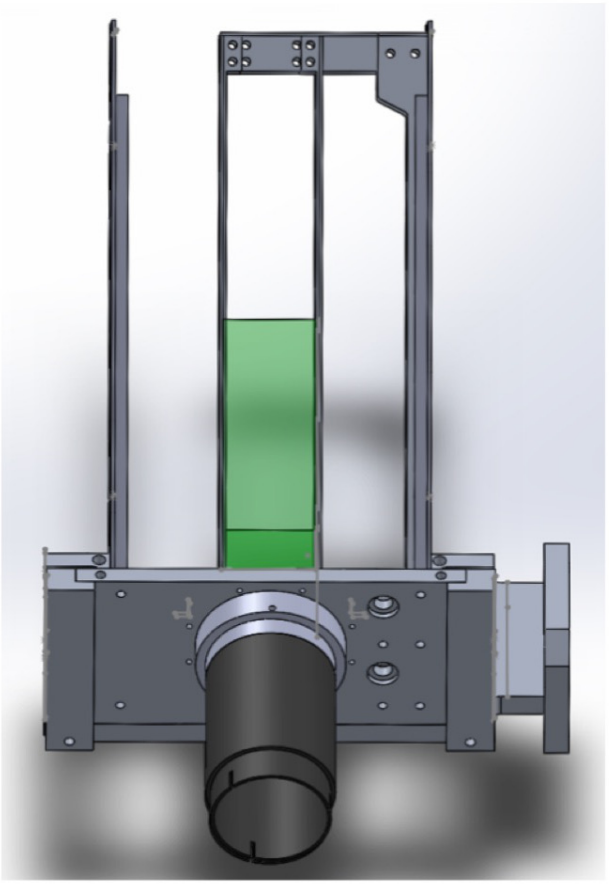
MPD rev4: Handles 16 APVs

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

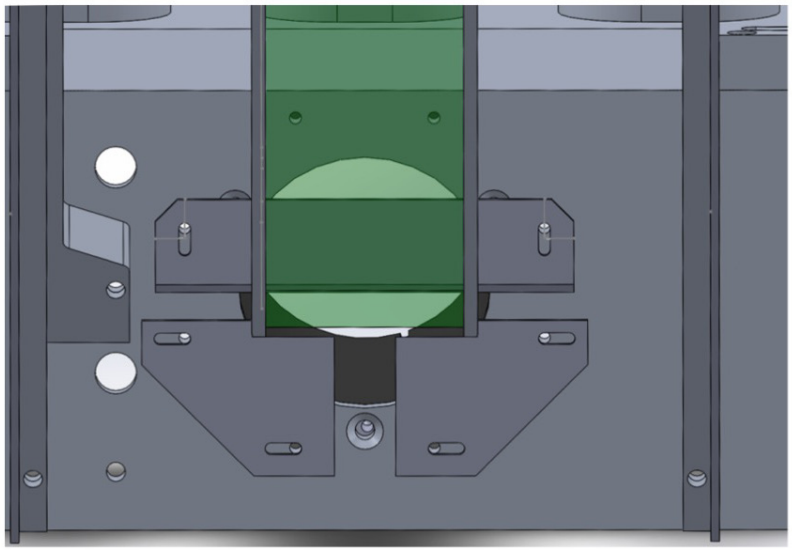
GEM Readout


LV in
Digital CTRL
HDMI-A in
(clock, trigger, and
I²C from MPD)
Analog signals
HDMI-A out
(to MPD)
40 MHz, 12 bit
ADC, differential
inputs, 2 Vpp
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

Quartz Geometry Idea

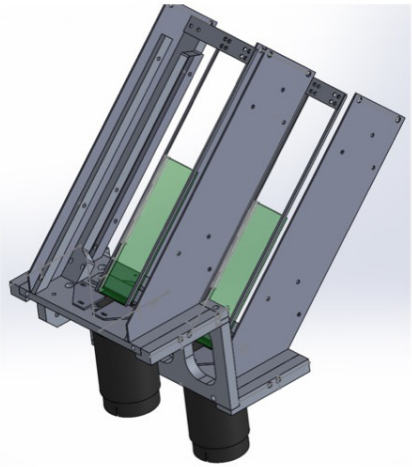


Beam's view. Note "stubby" quartz installed upstream, full quartz downstream – for illustrative purposes

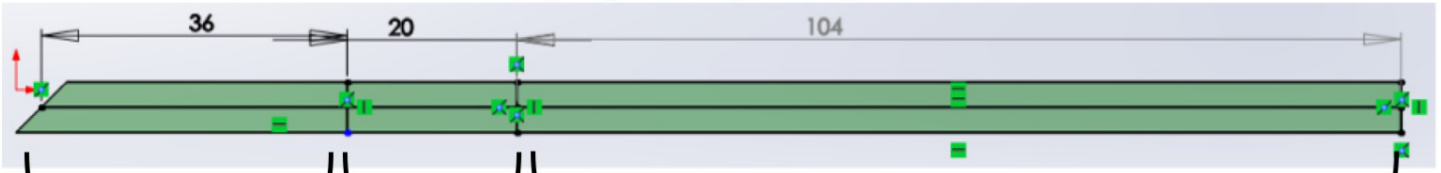


Top view showing new quartz-rail supports (at PMT end). No more LGs here.

- 48mm wide quartz shown. This is widest we can go with 2" PMT (but maybe not necessary now for CREX)



Preliminary proposed quartz geometry



"Light Guide" 3.6cm

"Buffer" 2.0cm

"Stubby" piece 5.6cm

"Active Region" 10.4cm (PREX)

Total length 16cm

- New info: Maybe able to re-use PREX-I quartz for PREX-II AND CREX!

Upcoming Plans for Finalizing Detector Design

- Will shorten quartz rails and side-walls
- Thinking to redesign side-walls – may replace aluminum with 3D-printed plastic
- Question: Do we want μ-metal PMT shields?
- Also thinking about how to make detector more easily light-tight without using gobs of tape–will facilitate quicker turn-around time for re-configuring quartz arrangement
- We may want thinner quartz (or ND filter) for PREX based on preliminary non-linearity measurements: 40 PEs/e^- at 1 GHz gives 6.4 nA light level on photo-cathode; so far, $\leq$ 3nA LL gives best results (see next talk)

Main Detector Summary

- PREX-II/CREX main detector design near complete
  - Still waiting for CREX focal plane footprint
  - Rotary tandem mount concept ∼vetted
- Main detector PE yields and relative widths measured at MAMI for 6mm/10mm thick tandem
  - For al. mylar wrapped quartz, 6mm gives 45 PEs with 20% rel. width; 10mm gives 80 PEs
  - Note that during 2015 MAMI testbeam, 6mm (unwrapped) gave 40 PEs with 19% rel. width (benchmarked with MC)

SAM Summary

- SAM PE yields studied for final SAM design (the one currently installed in Hall A)
  - Examined two LG materials w/ and w/out W pre-radiator
  - Miro-silver27 (LG used in Hall A SAM) gave 7.6 PEs/e^-; ~120 nA LL on cathode at 100GHz
  - Anolux UVS LG gave only 5.2 PEs (unexepected result based on reflectivity measurements)
  - PE yields increase 5-fold using pre-radiator with no significant degradation in rel. width
  - May install W pre-radiators in SAMs this summer

GEM Summary

- "Small" GEM tracking system development underway
  - 5 assembled and tested GEM chambers in hand
  - Readout electronics in hand (55 APVs, 6 MPDs), and in production (20 2-slot and 15 4-slot backplanes)
  - Preliminary GEM mounting concept developed and prototype under construction
  - Plans to start HV burn-in procedure next week, assemble HV divider circuit and start to test rudimentary functionality
  - Hope to get backplanes from vendor within month or so; start to assemble full readout chain, establish MPD DAQ and eventually cosmic tests over summer
- Thanks to ISU parity group: Carlos Bula-Villarreal, Devi-Adhikari, Joey McCullough, Daniel Sluder, Royal Cole, and Chase Juneau