eRD-3

Status Report (Q4 FY17 and Q1 FY 18)

Fast and Lightweight

EIC Integrated Tracking System

Barrel MicroMegas (MM)

And

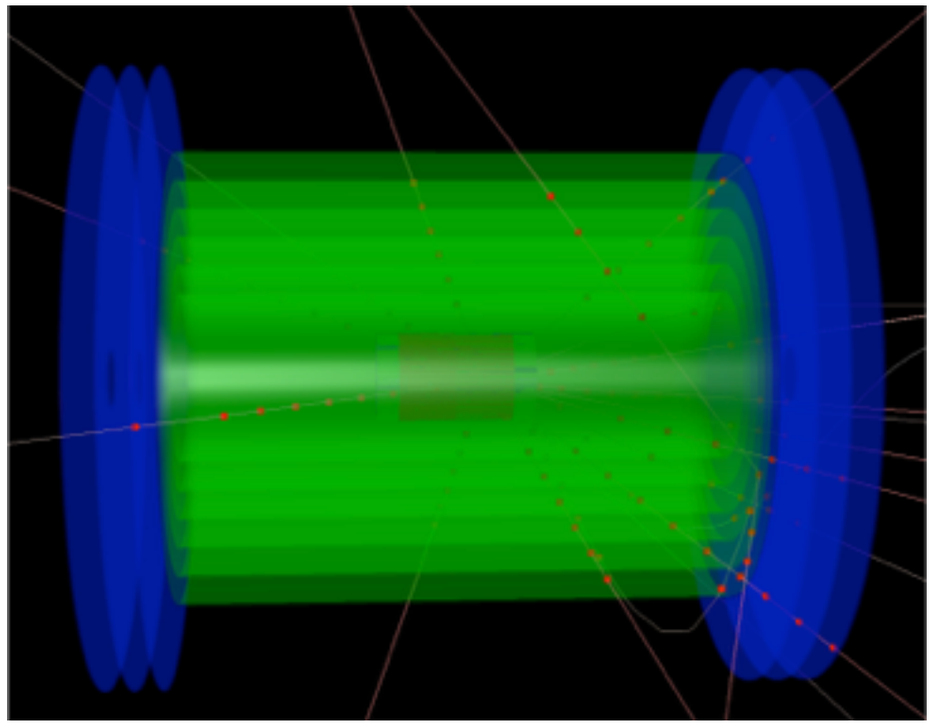
Forward Triple- Gas Electron Multiplier (GEM)

Franck Sabatie (PI), Maxence Vandenbroucke

Bernd Surrow (PI), Matt Posik

Outline

- Introduction
- R&D Program Status
  - Forward GEM tracking
  - Barrel MM tracking
- R&D Program Plans
  - Forward GEM tracking
  - Barrel MM tracking
- Summary



Introduction

Overview of eRD3 Effort

- This R&D concentrates on a dedicated tracking system based on micro-pattern technology, which focuses on the design and development of fast and lightweight detectors.
  - **Barrel tracking system** based on MM detectors manufactured as cylindrical shell elements.
  - **Rear/Forward tracking system** based on triple-GEM detectors manufactured as planar segments (partly in Collaboration with eRD6).
- Main **generic R&D** goals of eRD3
  - Commercial fabrication of critical detector elements.
  - Utilization of lightweight materials.
  - Test and characterizations of curved 2D MM and commercial GEM detectors.
  - Design and test of new common chip readout system employing CLAS12 DREAM chip.
- Completion of generic eRD3 goals will lead to full merging of efforts into eRD6.

EIC Detector R&D

Progress Report FY18

Project ID: eRD3

Project Name: Design and assembly of fast and lightweight forward tracking prototype systems for an EIC

Period Reported: July 2017 – December 2017 (Status)

Project Leaders:
Professor Bernd Surrow and Dr. Matt Posik (Temple University) / Dr. Franck Sabatie (Saclay)

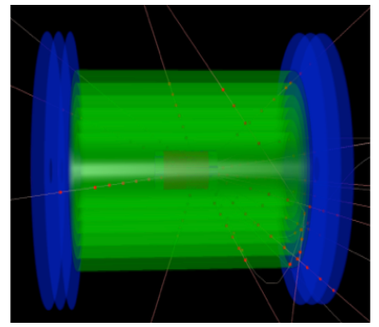
Date: December 29, 2017

Applicant Address: Temple University
Department of Physics
Science Education and Research Center
1925 North 12th Street
Philadelphia, PA, 19122

Contact Person: Professor Bernd Surrow and Dr. Matt Posik

Email: surrow@temple.edu and posik@temple.edu

Phone: 215-204-7644

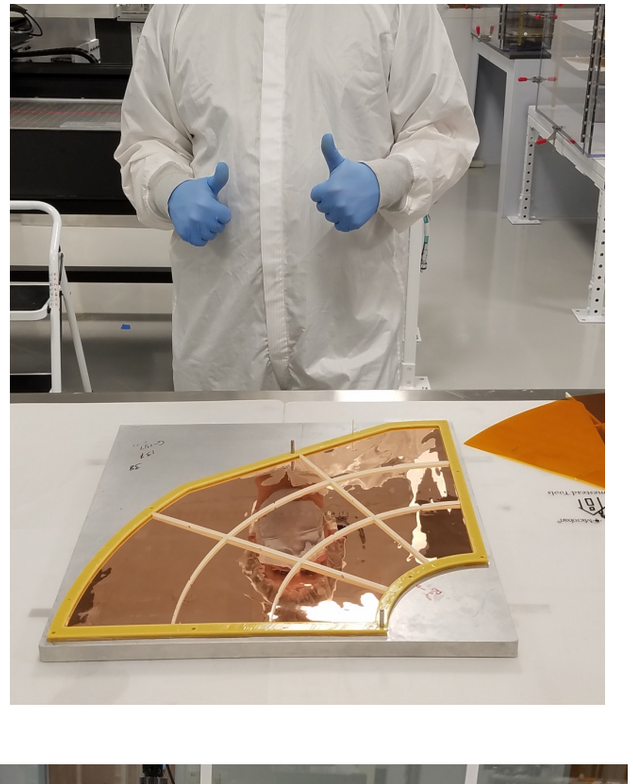


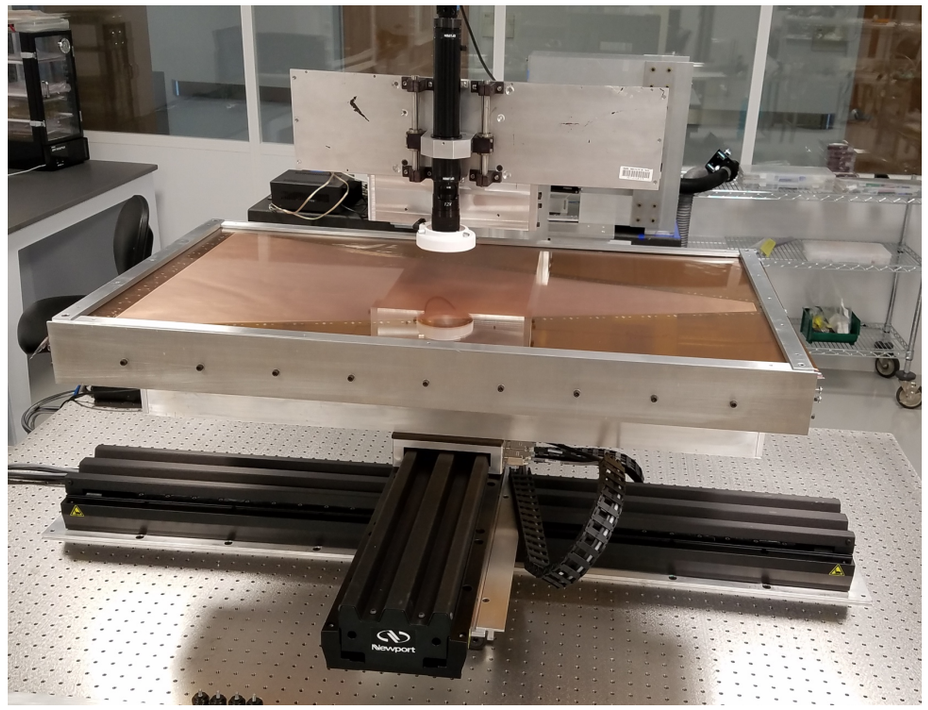
Introduction

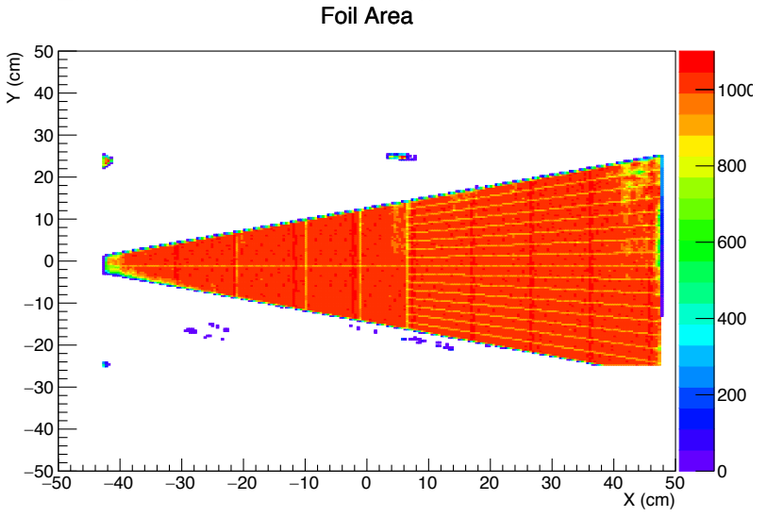
Highlights of the triple-GEM R&D program

- CCD optical GEM scanner assembly and commissioning completed.
  - All commercial (Tech-Etch) 40 cm x 40 cm foils have been scanned.
  - Successful scanning of EIC GEM foil, developed by eRD3 and eRD6.
  - First scans of eRD6 Cr-GEM foils.
- GEM N_2 storage boxes have been completed.
- Completed assembly of two triple-GEM detector prototypes
  - Both detectors were built using commercial elements

  i.e. GEM, HV, and readout foils
  - One detector was built using **Kapton spacer rings**
  - The other detector built using **G10 spacer grids**.
- Beginning detector characterization with cosmics.

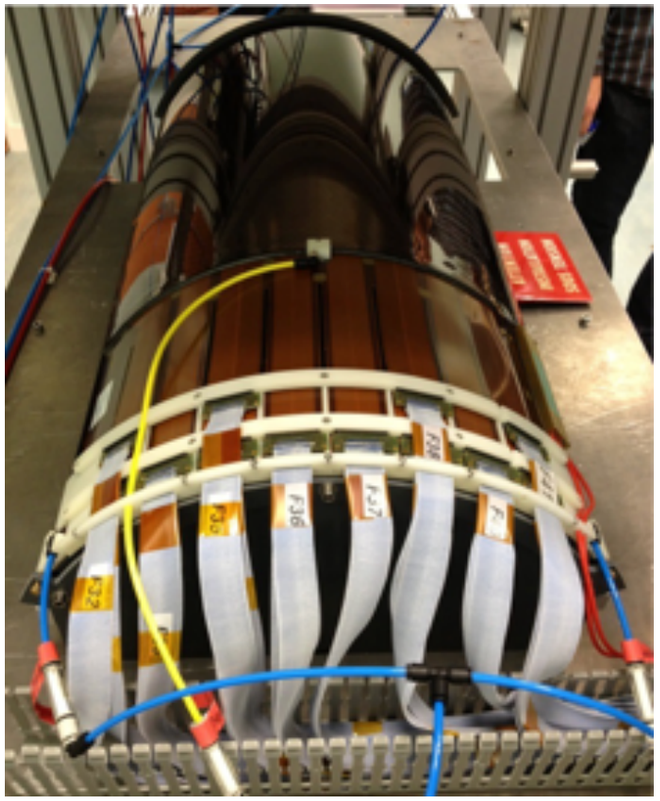




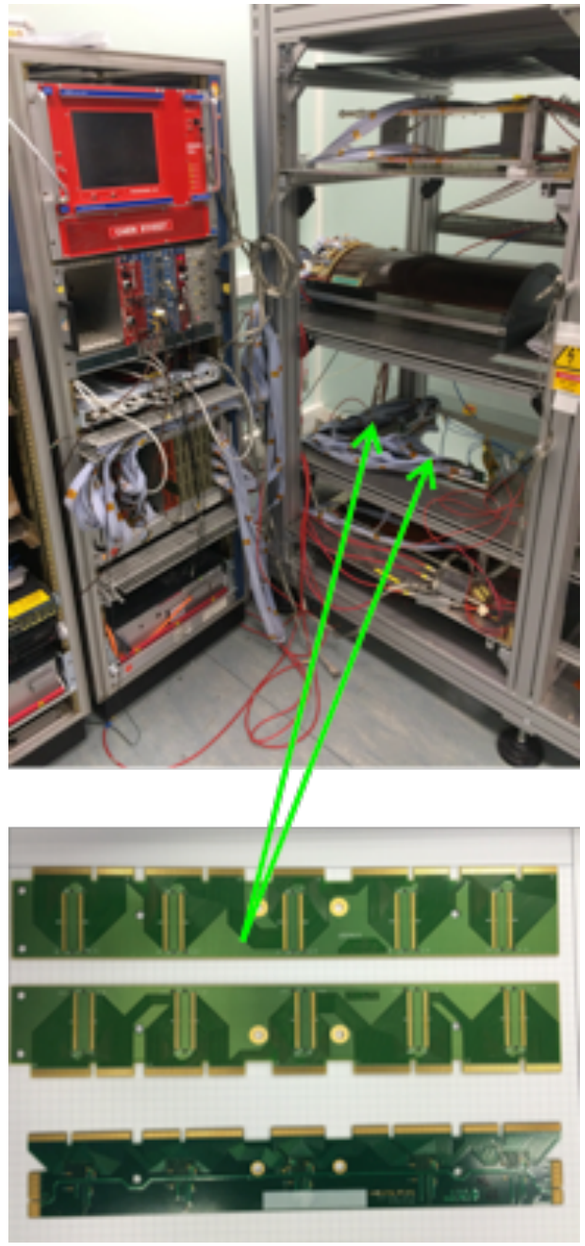


Introduction

Highlights of the MM R&D program



- 2D MM design ongoing.
  - No funding to complete.
- Further testing of the MM 1D prototype detectors and triple-GEM detectors with the DREAM chip readout.
- Component list for the DREAM chip DAQ setup at Temple is available, but no funding to proceed.
- Modular DREAM chip development as previously reported.



Introduction

International MPGD 2017 Conference and RD51 Collaboration Meeting

- eRD3 R&D progress was last presented at MPGD 2017.
  - Proceedings paper in preparation (deadline Feb. 28th).
- MPGD Took place May 22-26 2017 at Temple University.
- Strong eRD3/6 involvement:
  - Local committee member institutions:

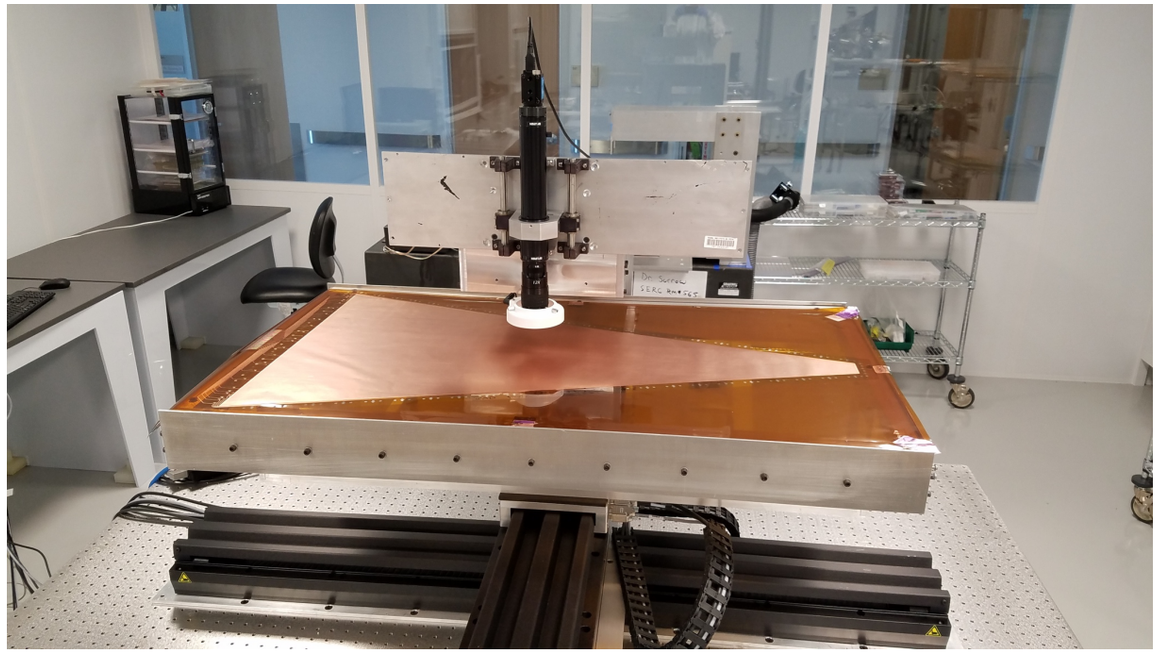
BNL/Florida Institute of Technology/Stony Brook University/Temple University/University of Virginia/Yale University.

- The selection of eRD3/6 to host the conference shows a strong recognition of EIC R&D program.
  - *"In recent years, we have seen a growing and impactful community participating in MPGD established in the US."*
    —S. Dalla Torre, MPGD 2017

Status: GEM Tracking

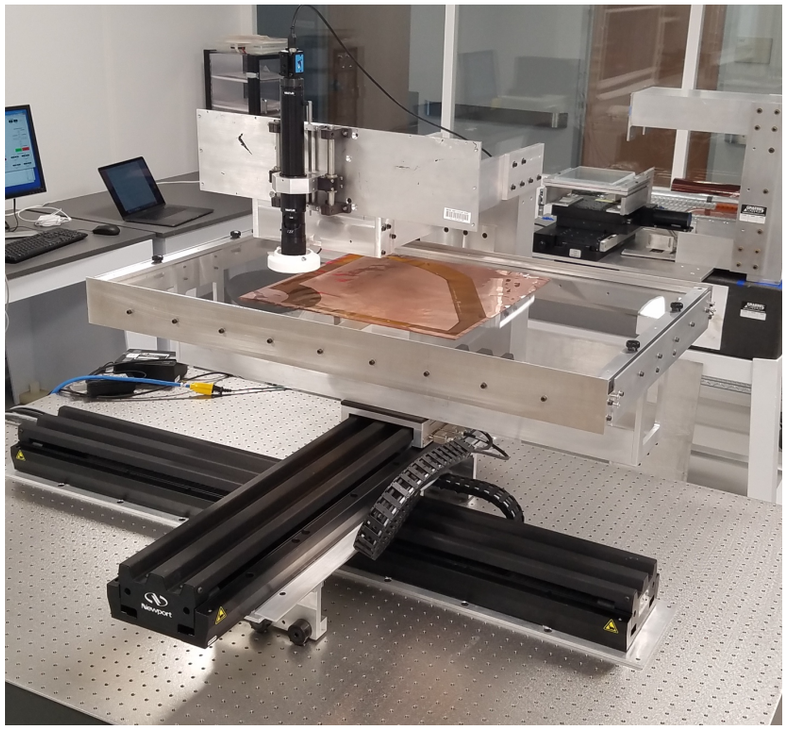
GEM CCD Scanner

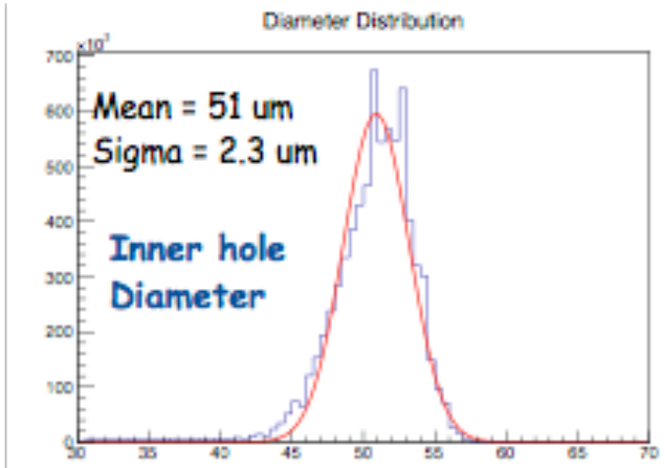
- CCD scanner assembly completed and commissioned.
- Switched bottom bed from plexiglass to thick glass to minimize sagging.
- Several different types of foils have been scanned
  - CERN/Tech-Etch GEMs (10 cm x 10 cm)
  - Tech-Etch GEMs (~ 40 cm x 40 cm)
  - Cr-GEMs (10 cm x1 0 cm)
  - EIC prototype GEM (~ 60 cm x 100 cm)

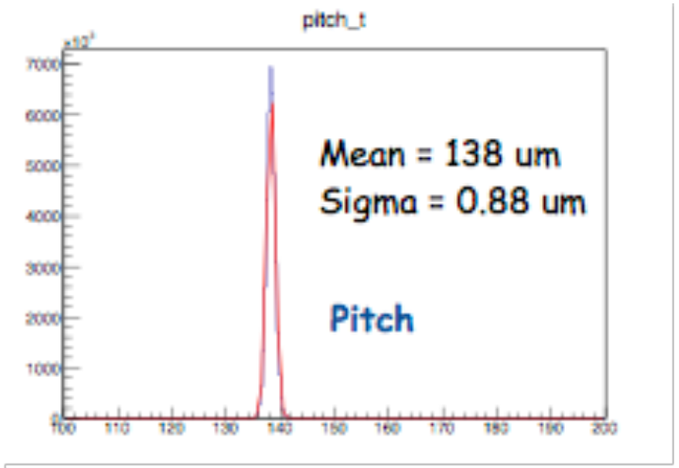


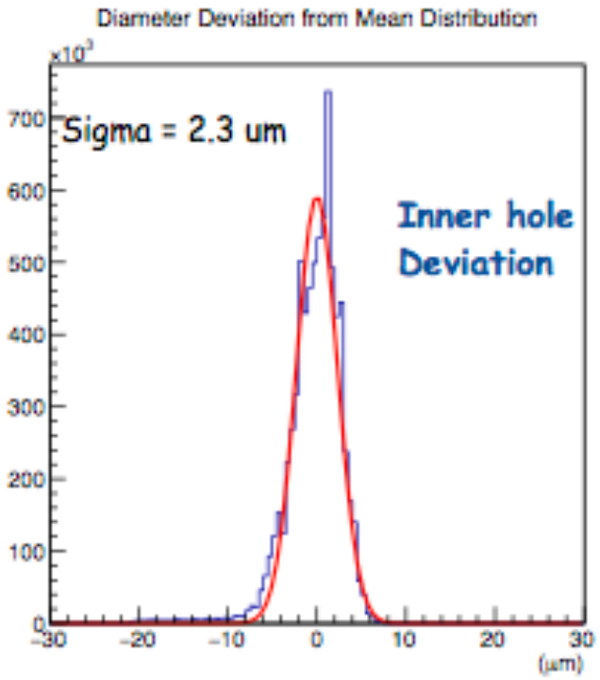
Status: GEM Tracking

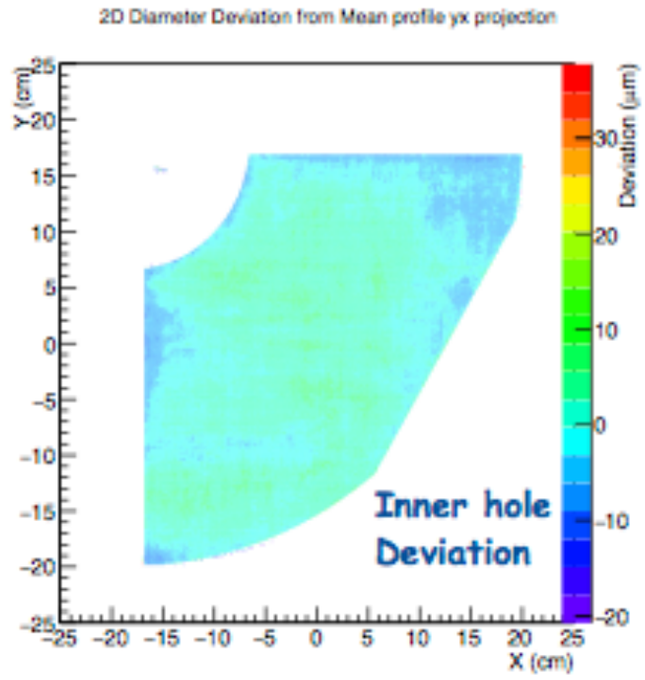
GEM CCD Scanner – 40 cm x 40 cm







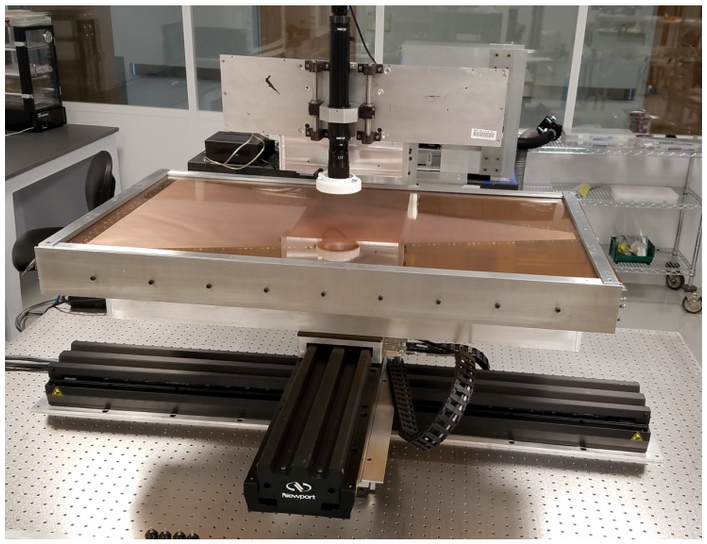


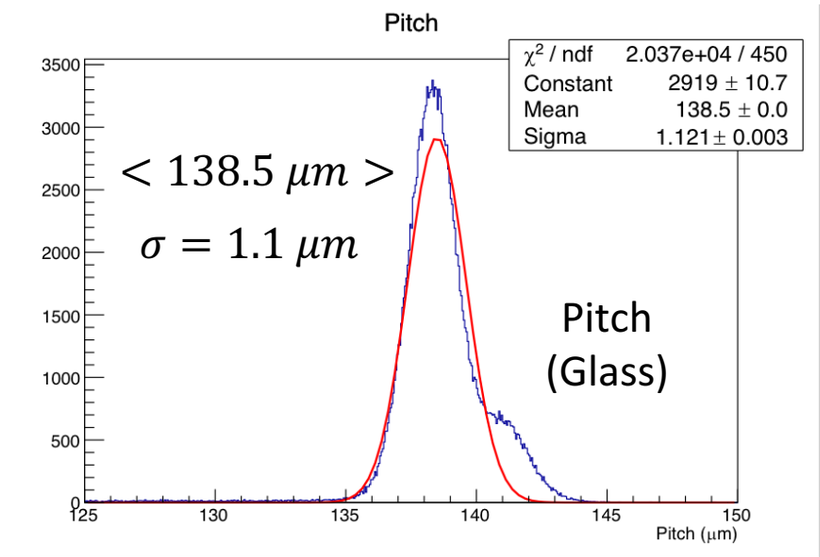


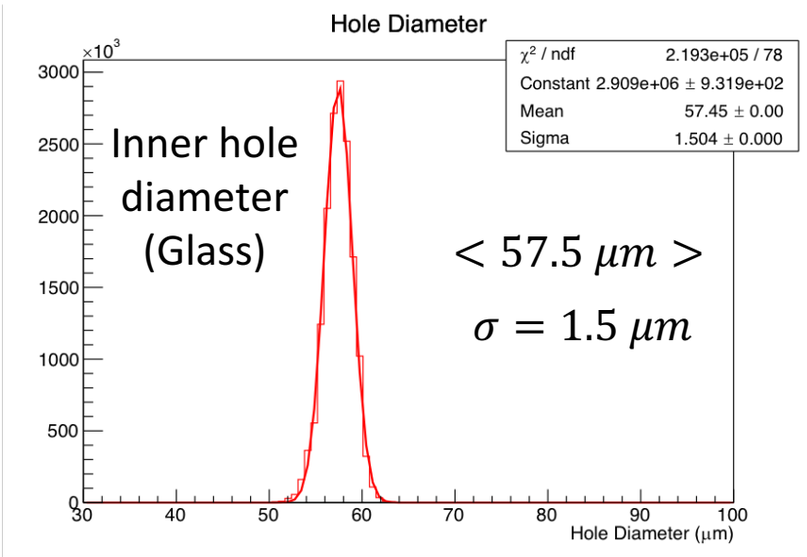
- All 12 Tech-Etch foils have now been scanned.
- Image analysis of those foils is on-going.

Status: GEM Tracking

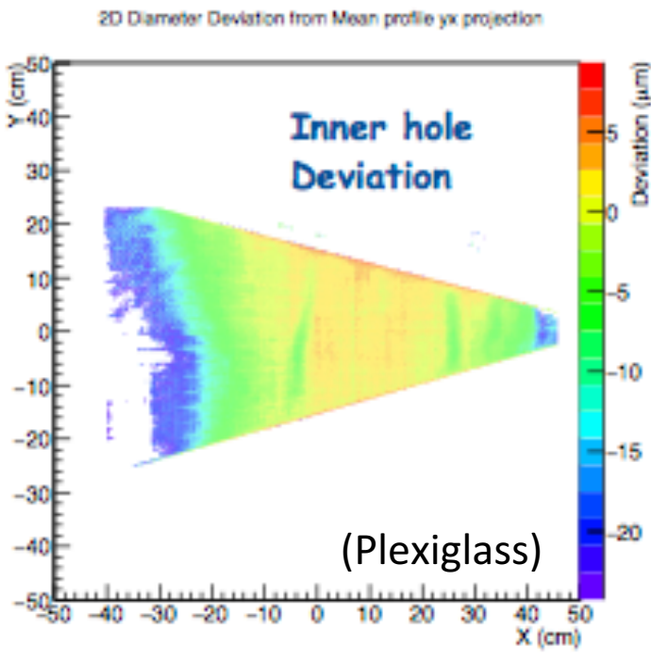
GEM CCD Scanner – EIC Prototype GEM

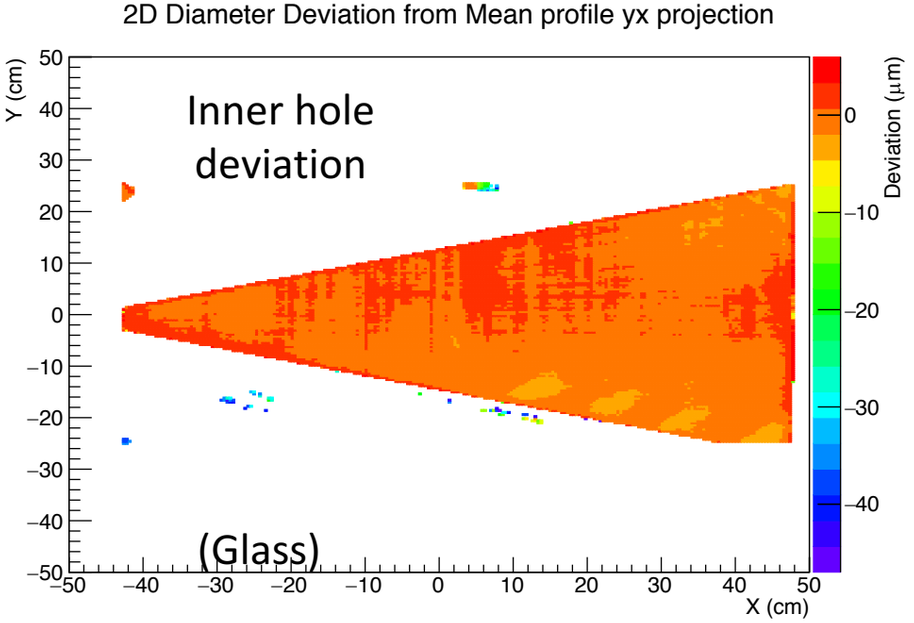






- eRD6 sent us a “bad” EIC prototype foil to scan (60 cm x 100 cm).
  - Initial scan was done with the foil resting on a plexiglass bed.
  - Plexiglass bed sagged which lead to camera loosing focus near the edges of the foil .
  - Scan was redone with thicker glass bed to minimize sagging.
- Geometrical values appear good.
- Double peak structure is seen in the pitch distribution.



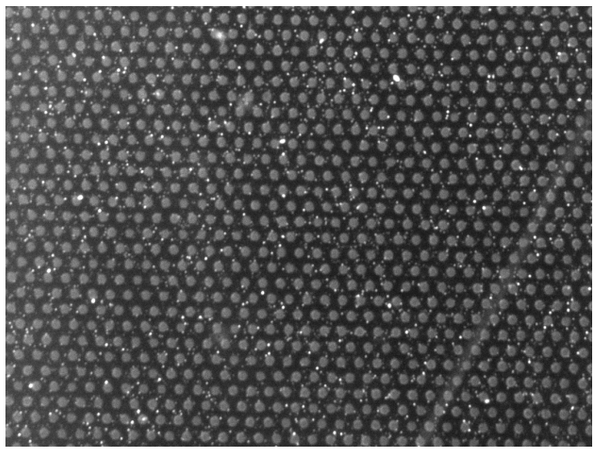


Status: GEM Tracking

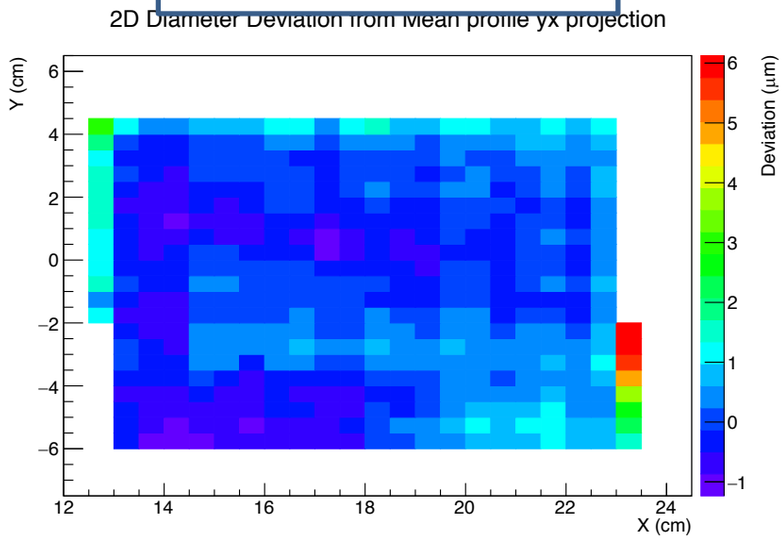
GEM CCD Scanner – Cr-GEM Scans

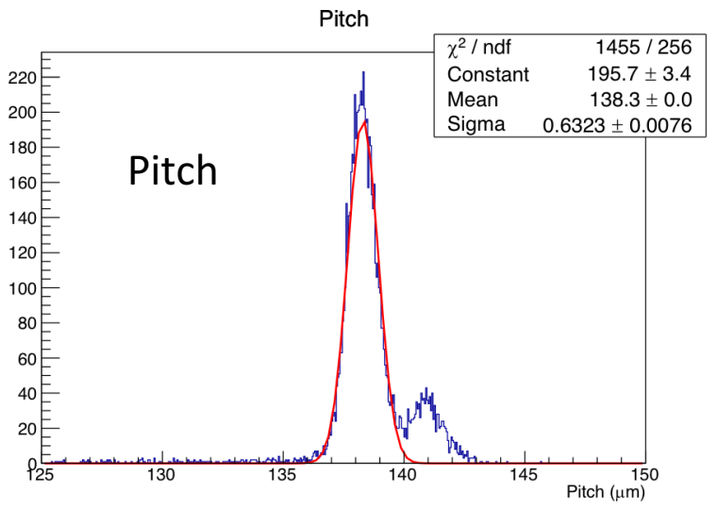
- eRD6 allowed us to scan a couple Cr-GEMs
- Outer hole diameters could not be scanned
  - Lack of copper layer(s) led to poorly illuminated CCD image.
  - Increasing camera gain helped, but resulted in a lot of noise.
  - Outer hole images contained areas of high reflectivity which made analysis difficult.
- Inner diameter and pitch looked good and showed good uniformity across the foil.
- Double pitch structure also seen in Cr-GEM scans.

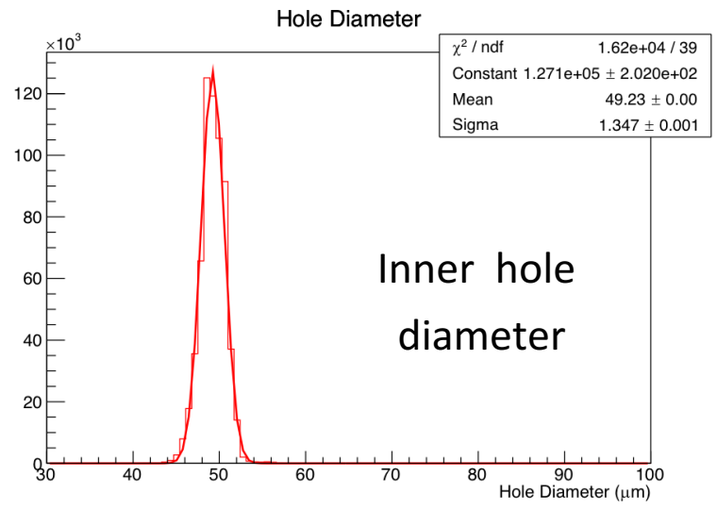
Outer diameter CCD image



Inner hole Deviation



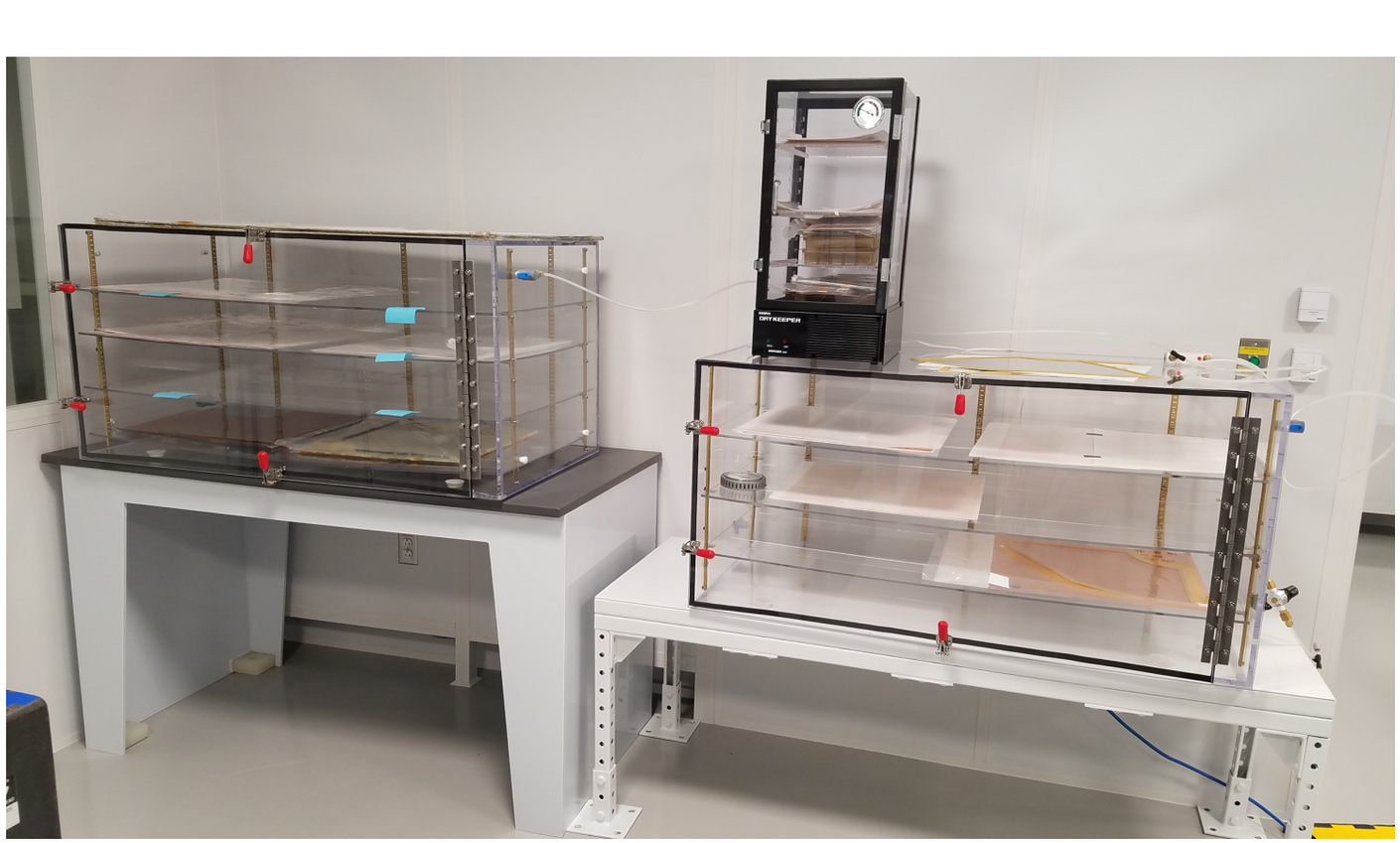


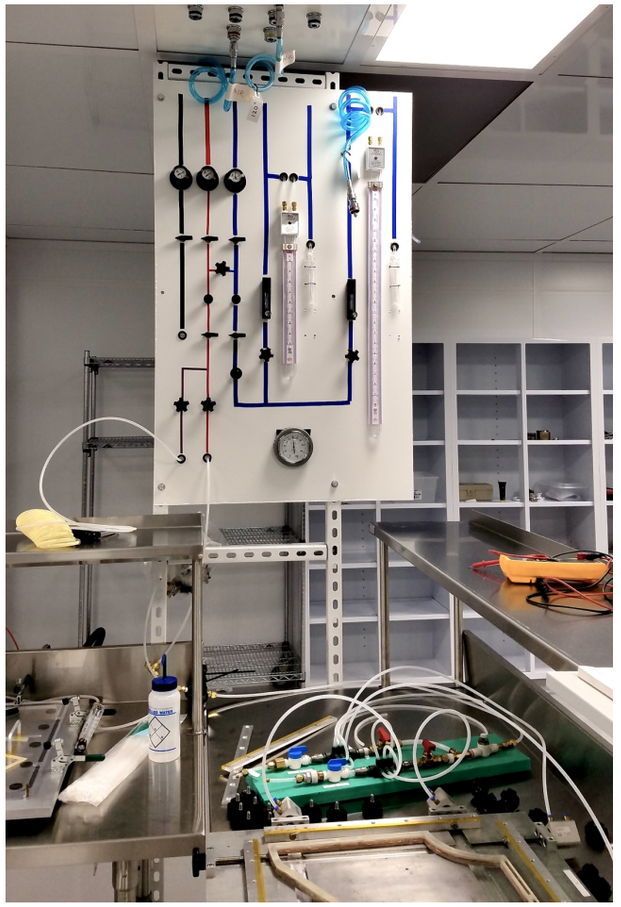


Status: GEM Tracking

MPGD Cleanroom Facilities

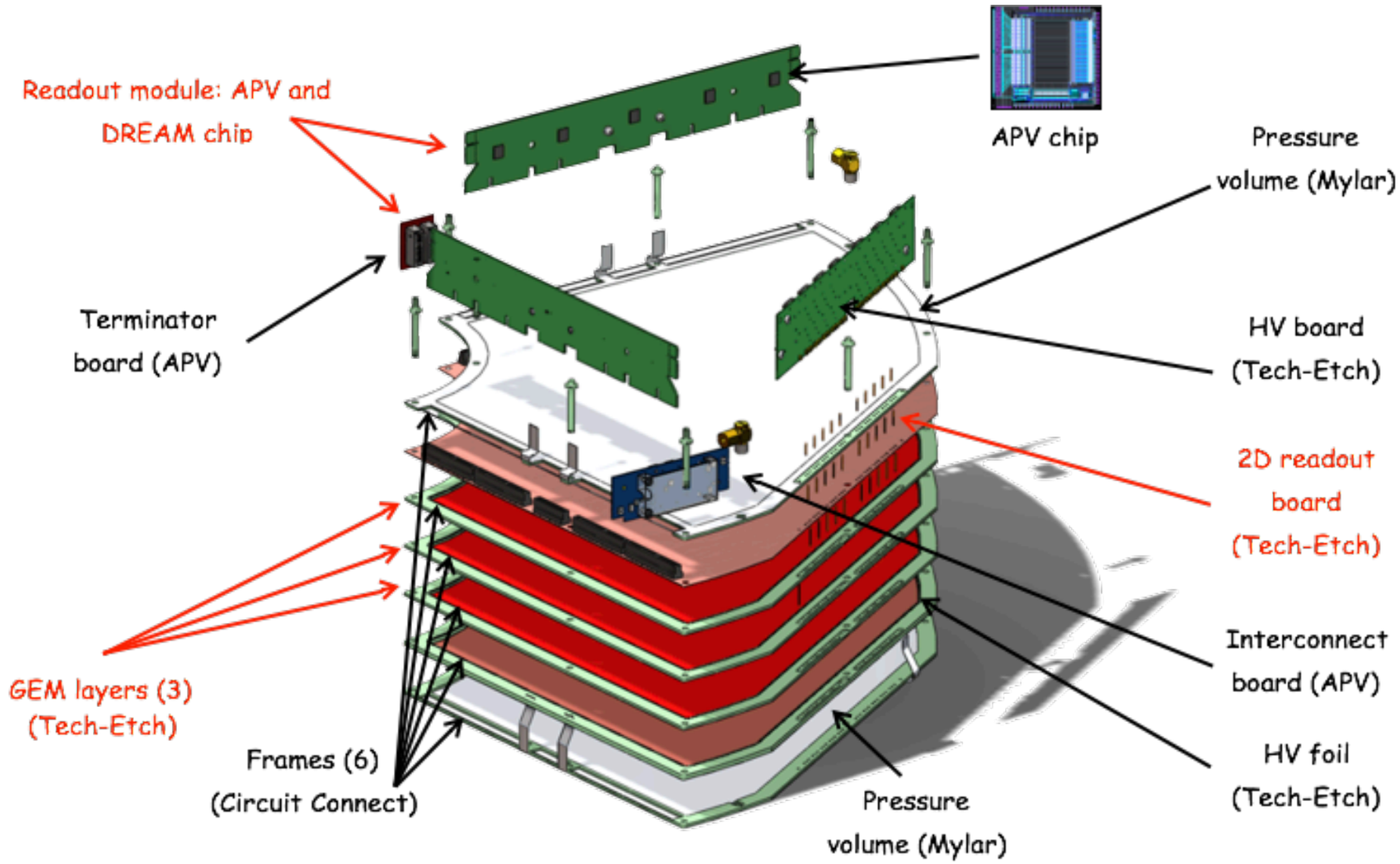
- Assembly and installation of two large GEM storage boxes has been completed.
- Boxes are flushed with N_2, from newly installed Gas distribution panel, to provide a dry environment.
- Large enough to accommodate 60 cm x 100 cm GEMs.
- Adjustable shelving allows storage of partially assembled detectors of various designs.
- Was the last step needed before assembly of triple-GEM prototypes.





Status: GEM Tracking

Triple-GEM Detector Prototypes: Overview



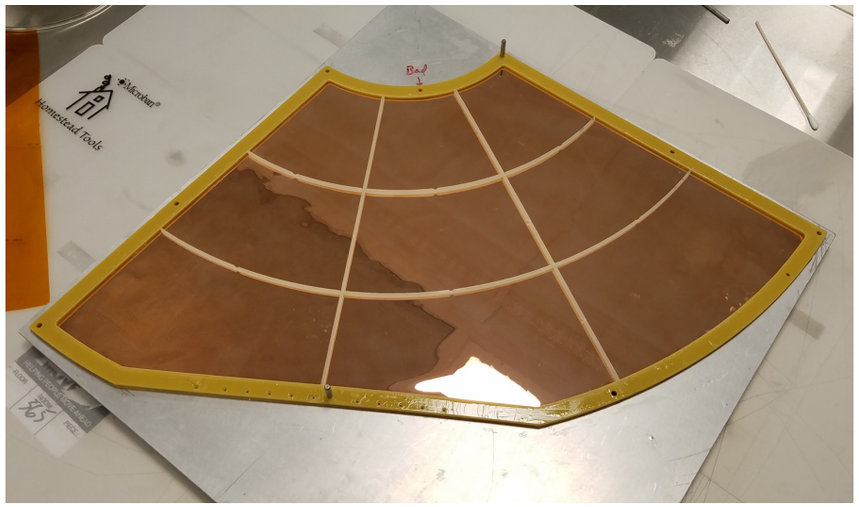
Prototype Concepts:

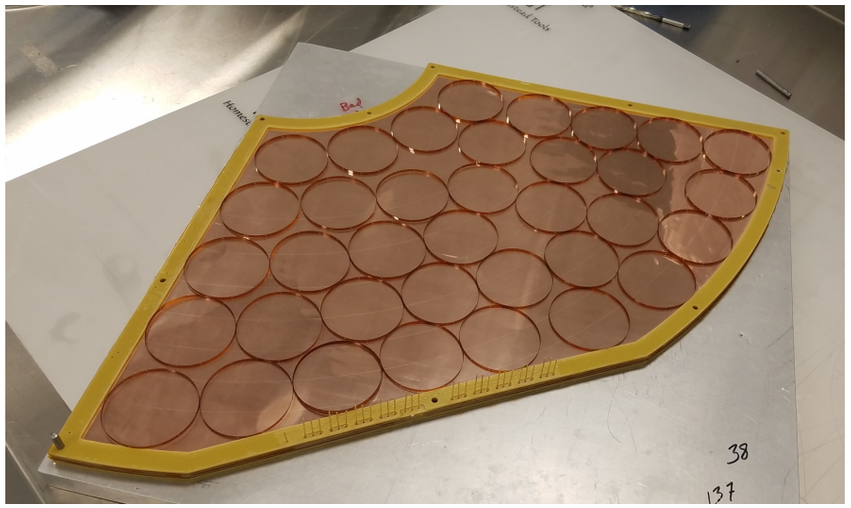
1. Commercially produced materials.
2. Kapton spacer rings
3. DREAM chip implementation

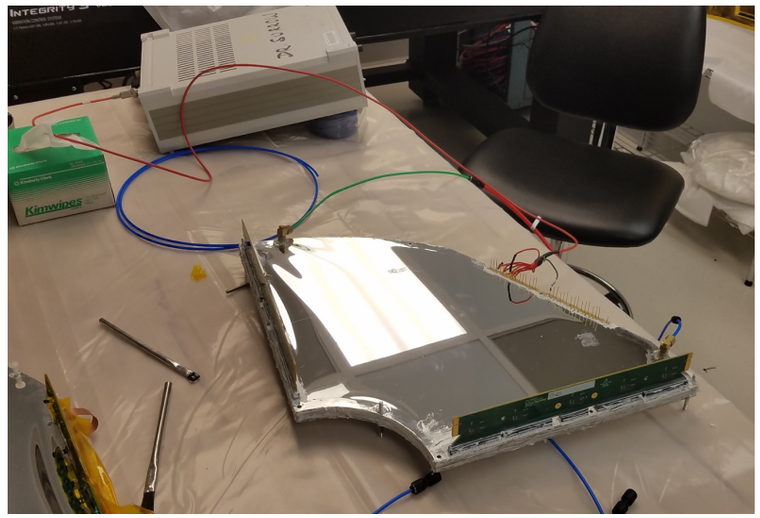
Status: GEM Tracking

Triple-GEM Detector Prototypes - Assembly

- Two triple-GEM detectors have now been assembled using Tech-Etch produced
  - GEM foils
  - HV foils
  - 2D readout foils
- One detector was built using Kapton spacer rings.
- The other detector was built using more traditional G10 spacer grids.



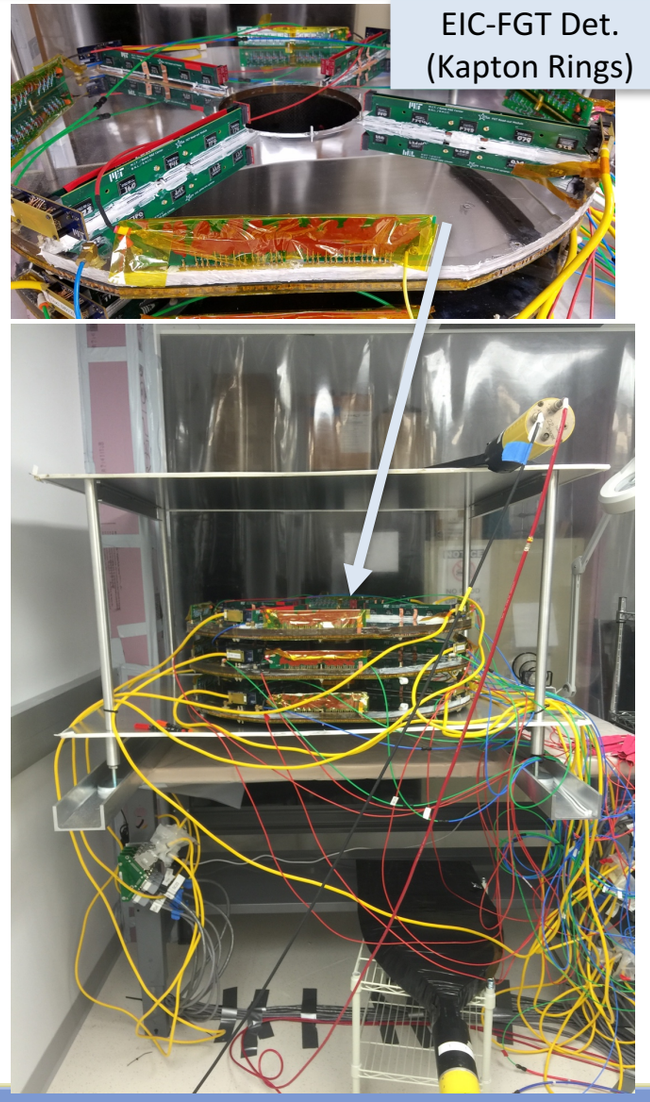




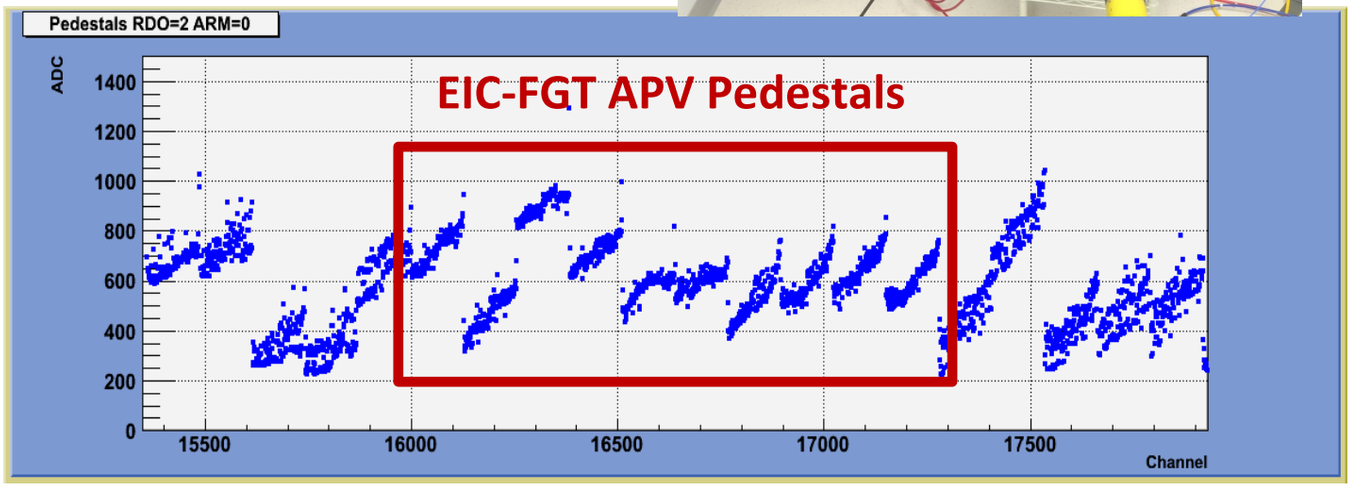
Status: GEM Tracking

Triple-GEM Detector Prototypes - Tests

- Leakage current of both detectors was measured and found to be satisfactory.
- No signs of charging up were found after about a day.
- The Kapton ring based detector showed larger current as compared to STAR FGT reference detector.
- Spacer grid detector is being implemented into the test stack.
- 10 APV chip pedestals from Kapton ring detector measured and look good.
- Preparing for cosmic ray characterization of the detectors.



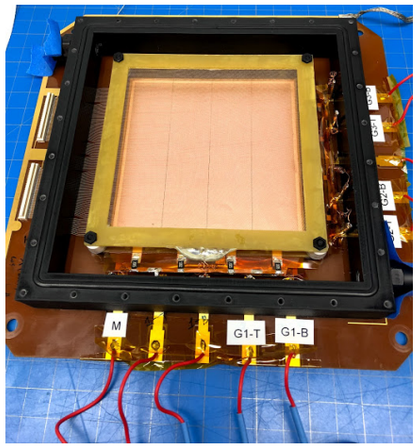
Det.	Voltage (kV)	Current (μA)
STAR FGT	3.2	3.1
EIC FGT (Kapton Ring)	3.2	5.4



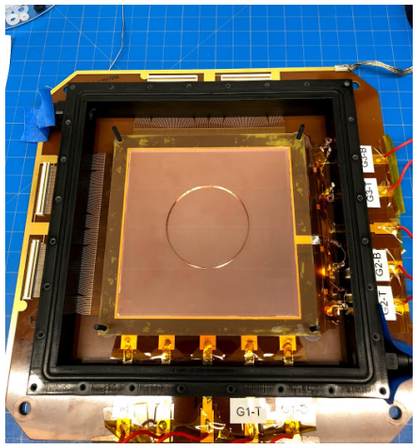
Status: GEM Tracking

Triple-GEM Detector Prototypes - Tests

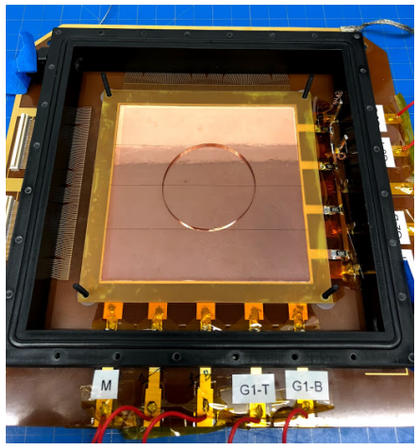
- Kapton rings were also sent to BNL for X-ray scan to test their EM distortions.
- Early initial results are in (very preliminary) → Thanks to Bob Azmoun for the measurement!
- Tested on 4-GEM + COMPASS readout.
- 4 “zero event” rings are clearly seen.
- One ring moved to upper-right corner.
- More work needed to attempt Kapton ring optimization and comparisons to dead area produced by spacer grids.
- Further characterization through this data and upcoming Temple cosmic data.



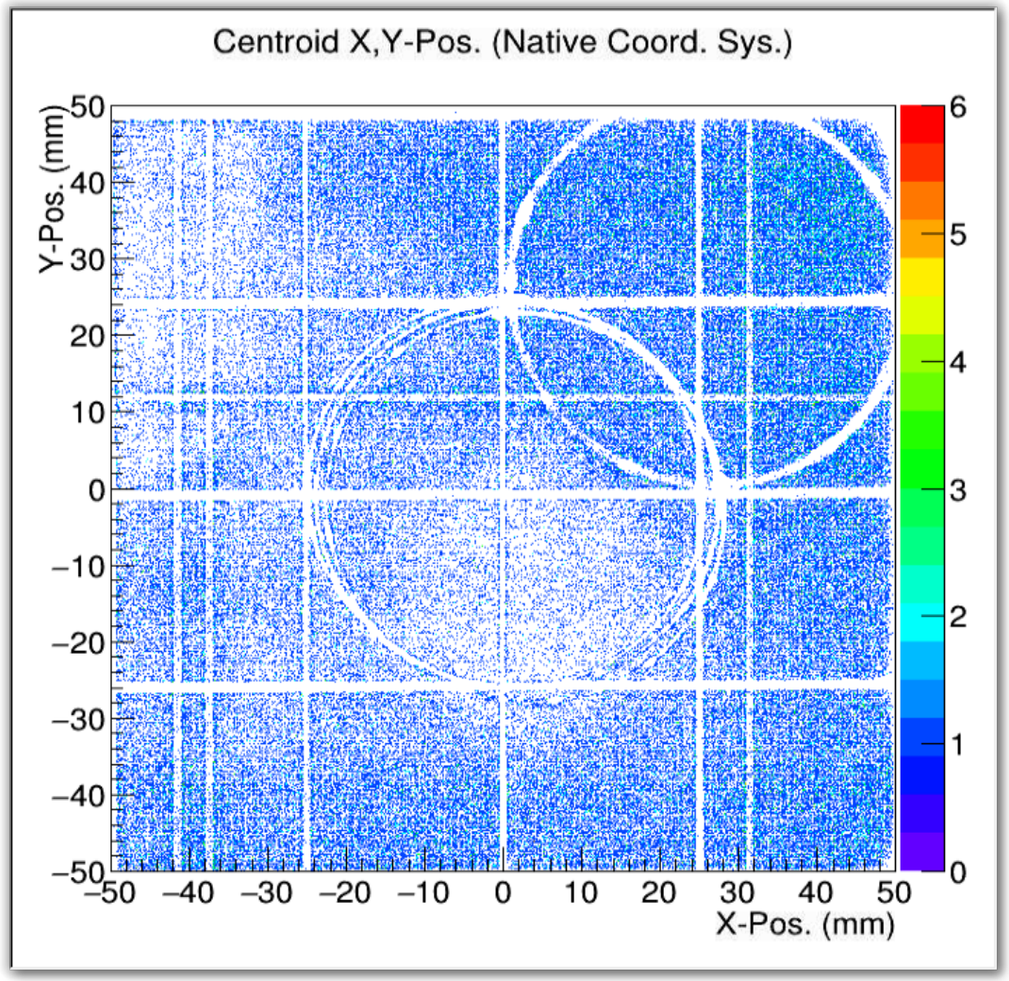
Mesh&GEM1/DG



GEM2/TG1



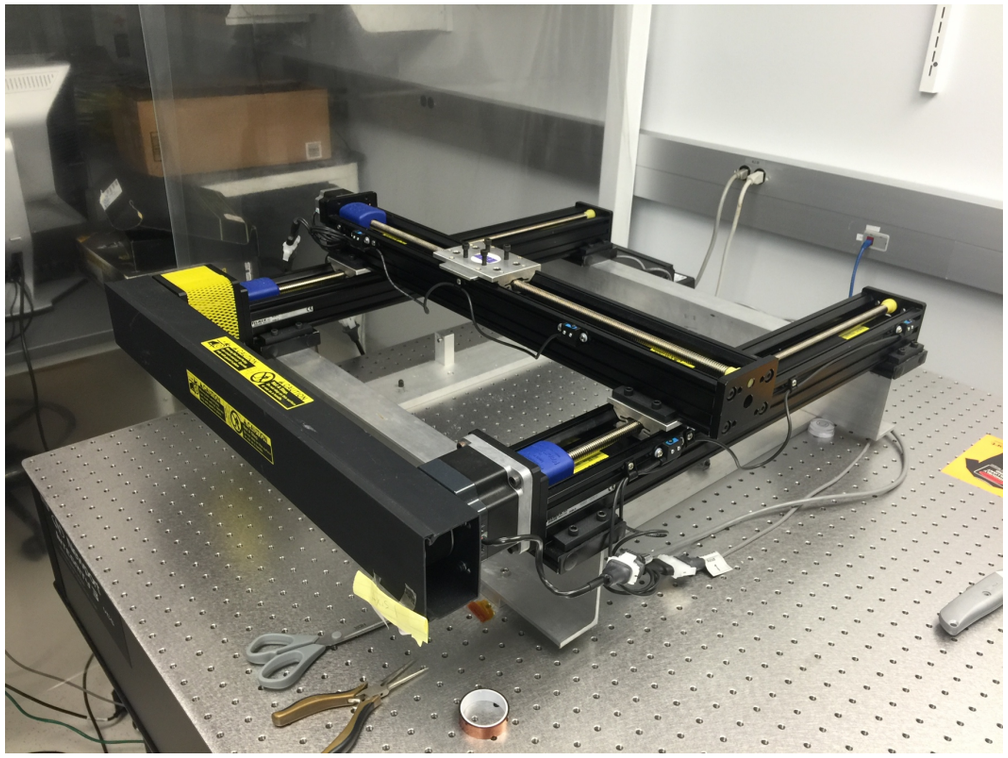
GEM3/TG2



Status: GEM Tracking

Fe-55 Scanning / X-ray Gun

- Use X-Y gantry with Fe-55 source to measure gains and energy resolution as a function of foil area.
- No shielding needed.
- Current X-Y gantry capable of scanning detectors up to 40 cm x 40 cm.
- X-Y gantry built on 4’ x 6’ optical table located inside the GEM detector lab cleanroom.

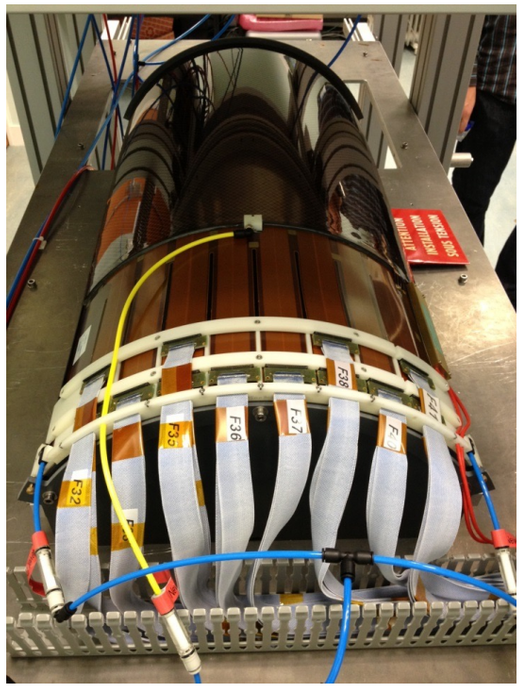


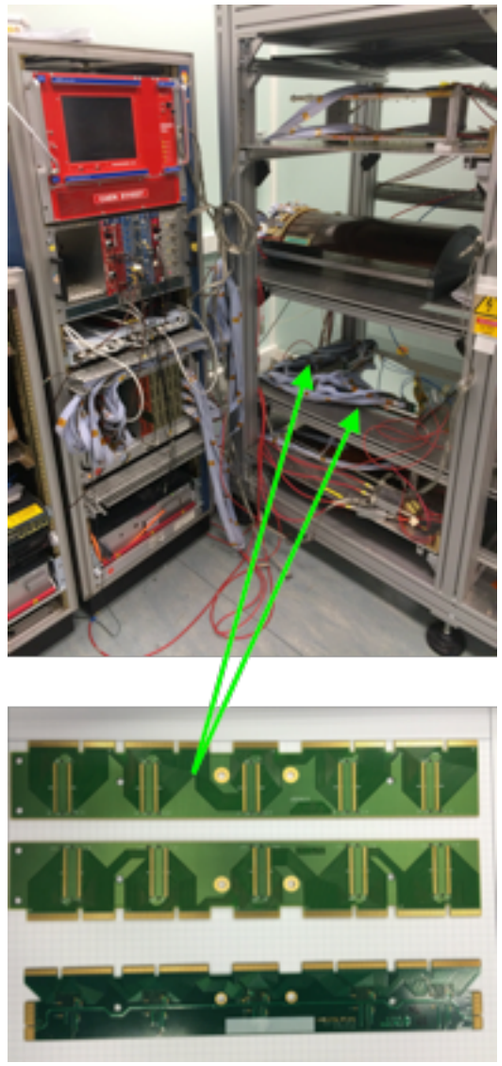
- Mini X-ray gun will be used to provide gain and efficiency measurements.
  - Au target
  - 50 kV / 80 μA
- Will have x-ray gun “spray” entire triple-GEM area
- Need radiation enclosure to operate.
- Design Pb-plywood box with interlock system.
- Enclosure should be large (~ 1.5 m long) enough to accommodate large triple-GEM detectors.

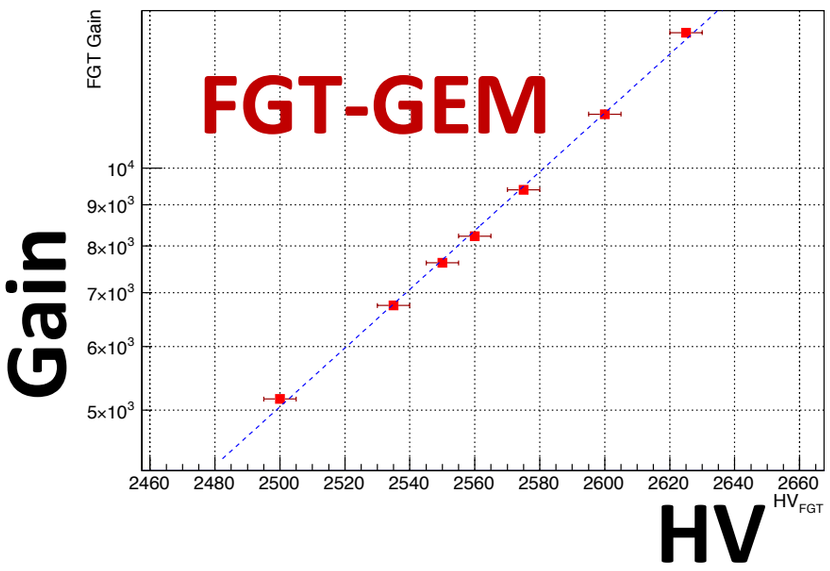
Status: Barrel MM Tracking

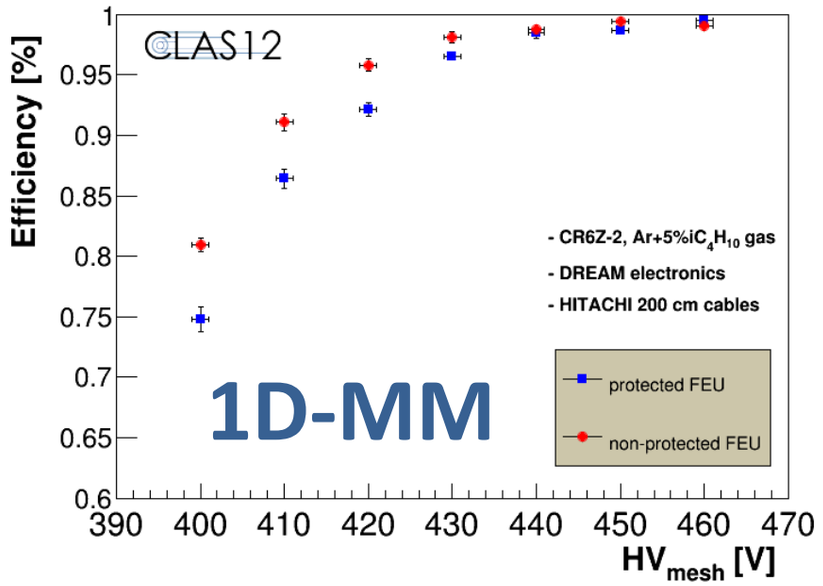
DREAM chip readout system: MM/GEM

- Further testing of the MM 1D prototype detectors and triple-GEM detectors with the DREAM chip readout.
- Component list for the Dream chip DAQ setup at Temple available, but no funding to proceed.
- Modular DREAM chip development as reported earlier.





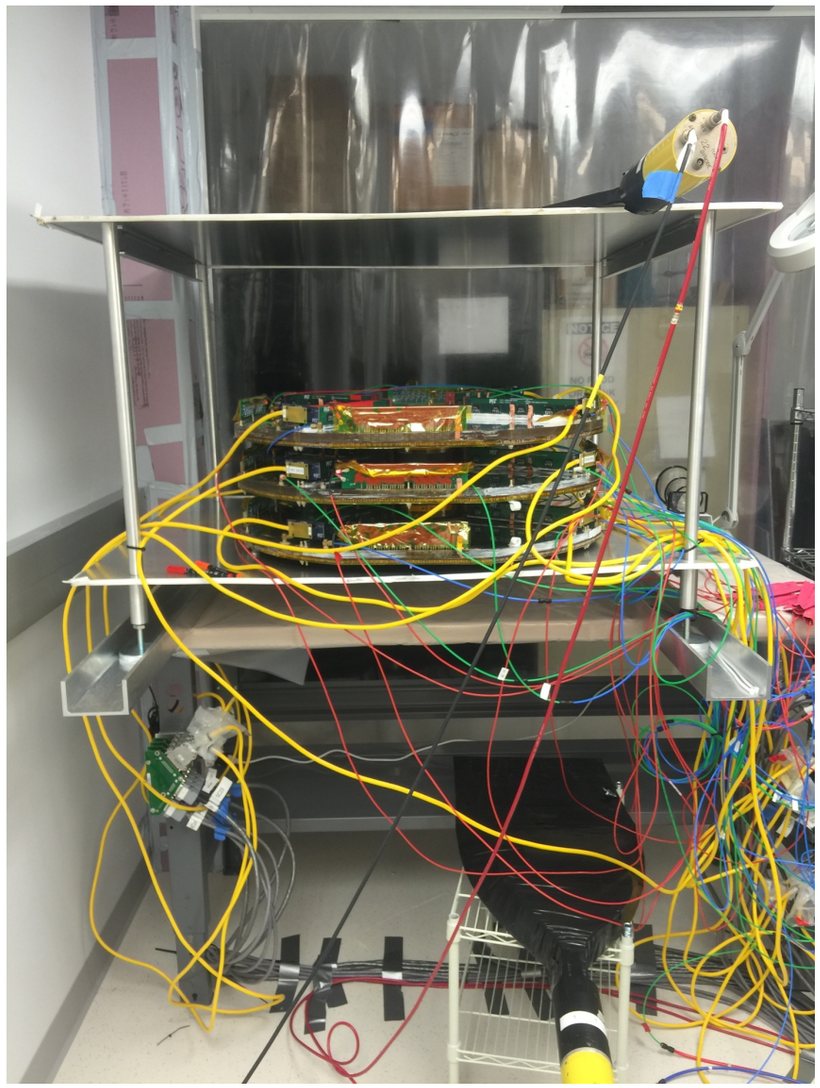




Plans: GEM Tracking

GEM Tracking

- Integrate both prototype GEM detectors into STAR FGT DAQ
- Characterize prototype GEM foils using
  - Cosmic rays
  - Fe-55 source
  - X-ray gun
- Cosmic ray trigger has already been implemented in STAR FGT DAQ.
- Currently modifying/updating STAR FGT code to analyze cosmics data.
- Anticipated FY19 Request
  - 50% postdoc – finish data taking/ x-ray gun commissioning.
  - Misc. equipment



Plans: GEM Tracking

40 cm x 40 cm GEM Time Line

- ✓ All materials acquired and all GEM foils tested and ready to be stretched.
- ✓ Gas distribution system installed.
- ✓ Soldering of multi-pin connectors to 2D readout foil.
- ✓ GEM frame cleaning process established and commissioned.
- ✓ GEM stretching, gluing, soldering, and stack assembly procedure in place.
- ✓ GEM storage boxes completed and installed.
- ✓ Stretching and gluing of GEM, HV, and readout foils.
- ✓ Assembly of triple-GEM detectors (2).
- ❑ Begin testing
  - ✓ Leakage current
  - ○ **Cosmics** – trigger, analysis code, mapping …
  - ○ 55Fe
  - ○ X-ray gun

Time Line

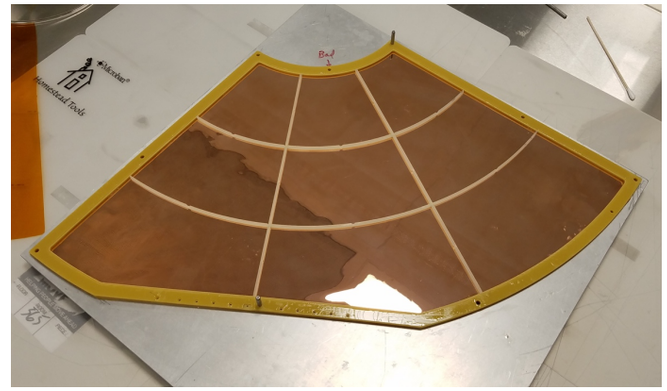
Done
Previous meetings

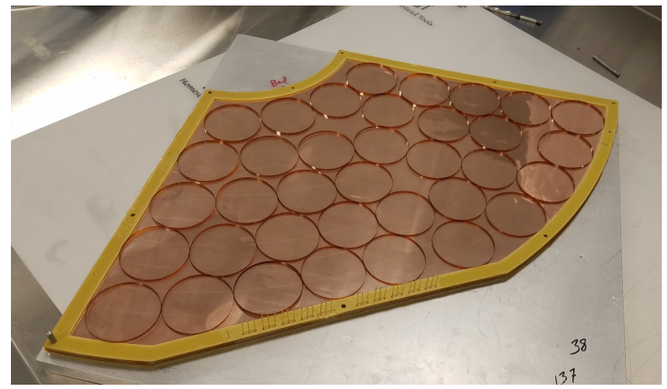
Done

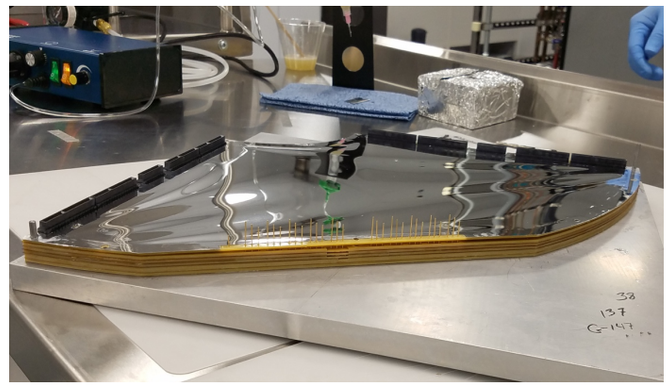
In progress

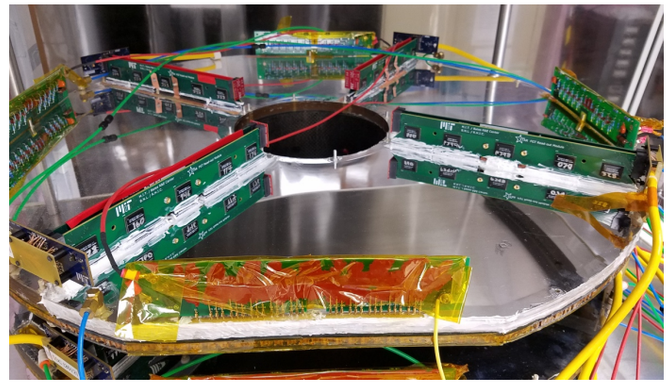
Summer 2018

Winter 2018





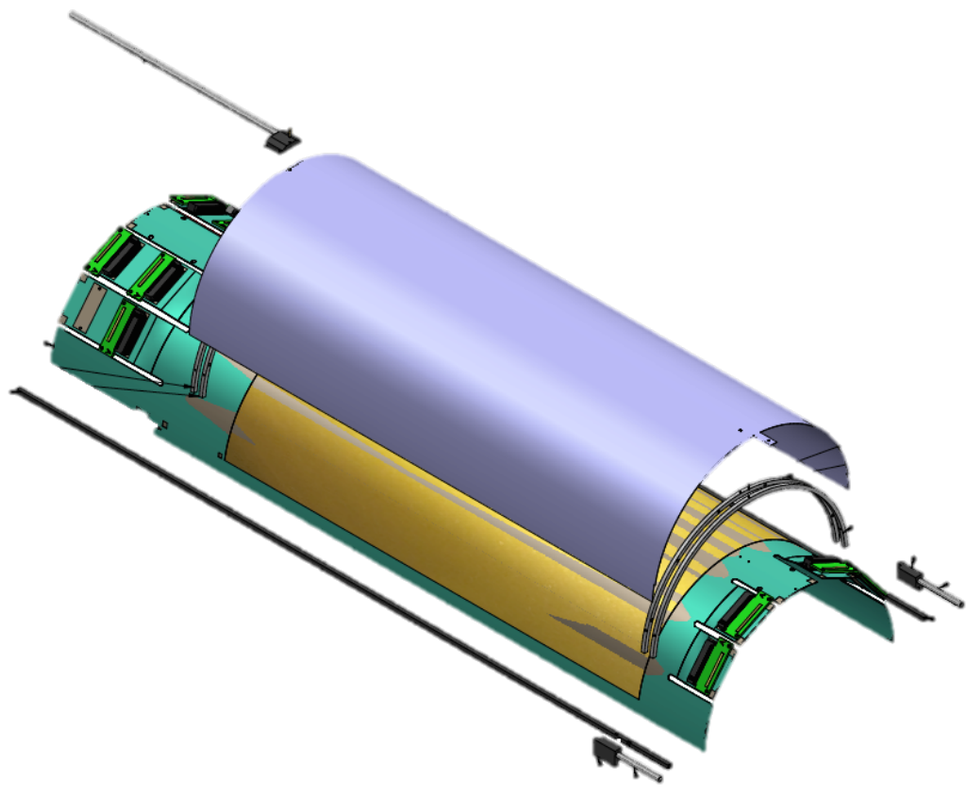


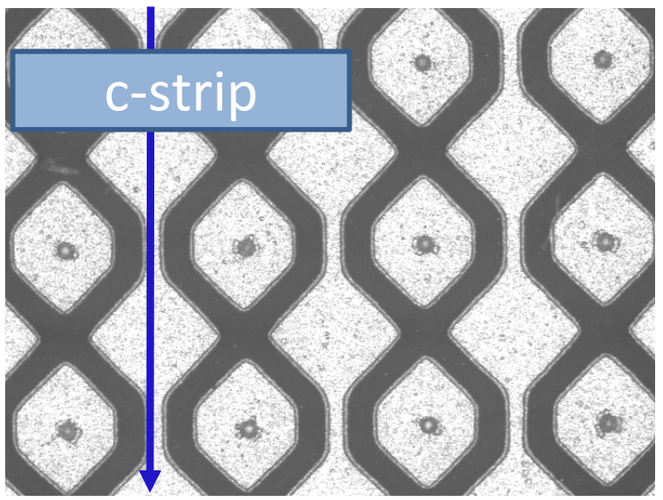


Plans: Barrel MM Tracking

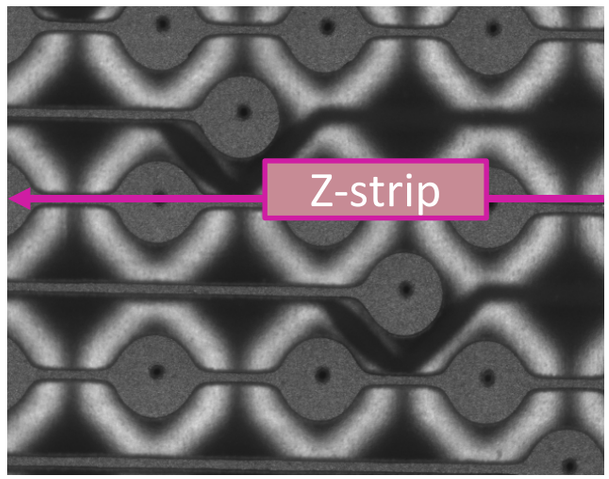
Barrel MM

- **Main goals:**
  - Complete 2D MM barrel design
  - Order components and assemble
  - Test and characterize the detector.





Top readout pattern



Bottom readout pattern

Summary

Summary

- **Forward GEM tracking**
  - CCD scanner built and commissioned
  - All twelve Tech-Etch foils have been scanned (image analysis ongoing)
  - CCD scanner used outside of generic eRD3 R&D
    - Cr-GEM
    - EIC prototype GEM
  - Large N_2 GEM storage box assembly completed.
  - Two triple-GEM prototypes have been built
    - Kapton spacer rings
    - G10 spacer grids
  - Leakage current measurements completed.
  - Starting triple-GEM characteristic via cosmics
- **Barrel MicroMegas tracking**
  - Awaiting funding to
    - Design and build 2D MM cylindrical shell.
    - Setup DREAM chip DAQ at Temple University.