Status Report (Q4 FY15 / Q1 FY16)

Fast and lightweight

EIC integrated tracking system

Barrel MicroMegas

&

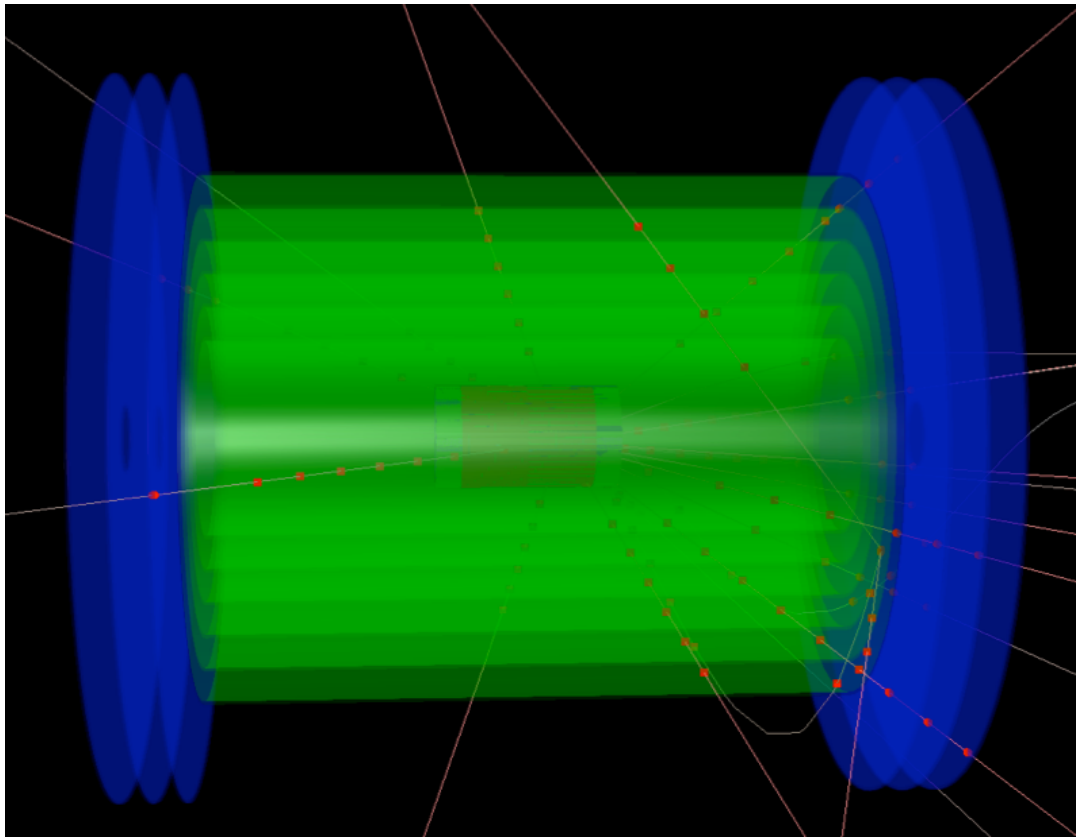
Forward Triple-GEM

Franck Sabatie (PI),
Maxence Vandenbroucke

Matt Posik,
Bernd Surrow (PI)

Outline

- Introduction
- R&D program: Status
  - ☆ (1) Forward GEM tracking
  - ☆ (2) Barrel MicroMegas tracking
- Plans
  - ☆ (1) Forward GEM tracking
  - ☆ (2) Barrel MicroMegas tracking
- Planned budget request - Summer FY16
- Summary



Introduction

Overview of eRD3 effort

- R&D effort focuses on intermediate tracking system:
  - Barrel tracking system based on MicroMegas detectors (Dedicated barrel / curved MM EIC R&D program) manufactured as cylindrical shell elements and
  - Rear / Forward tracking system based on triple-GEM detectors manufactured as planar segments (Collaboration with eRD6 FIT/UVA)
- R&D effort - Main strategy:
  - Design and assembly of large cylindrical MicroMegas detector elements and large planar triple-GEM detectors
  - Test and characterization of MicroMegas and triple-GEM prototype detectors
  - Design and test of new, common chip readout system employing CLAS12 'DREAM' chip development, ideally suited for micro-pattern detectors
  - Utilization of light-weight materials
  - Development and commercial fabrication of various critical detector elements
  - European/US collaborative effort on EIC detector development (CEA Saclay, and Temple University)

EIC Detector R&D Progress Report

Project ID: eRD3

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

Period Reported: July 01, 2015 – December 31, 2015 (Status)

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

Date: December 31, 2015

Applicant Address: Temple University
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Philadelphia, PA, 19122

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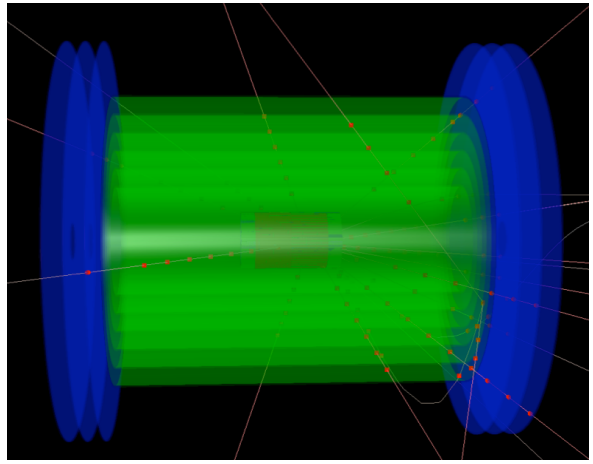

Introduction

Highlights of triple-GEM R&D program

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Optical and electrical performance of commercially manufactured large GEM foils

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ABSTRACT

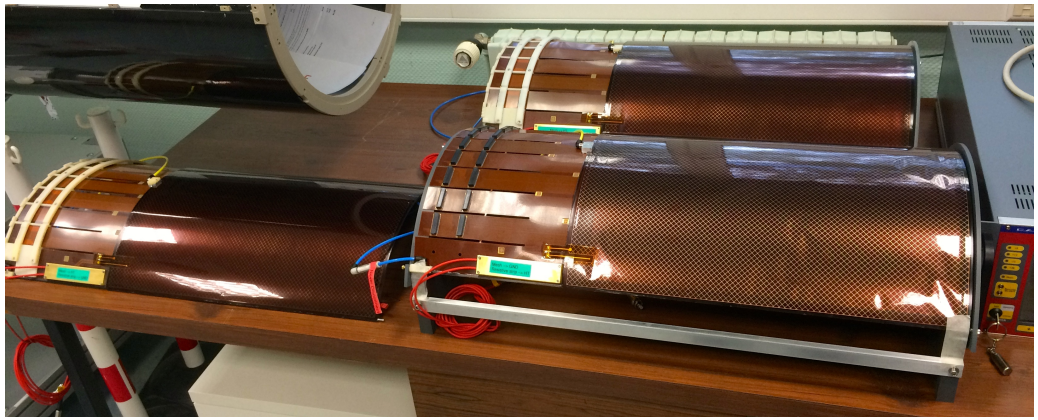
With interest in large area GEM foils increasing and CERN being the only main distributor, keeping up with the demand for GEM foils will be difficult. Thus the commercialization of GEMs is being established by Tech-Etch of Plymouth, MA, USA using single-mask techniques. We report here on the first of a two step quality verification of the commercially produced 10×10 cm^2 and 40×40 cm^2 GEM foils, which includes characterizing their electrical and geometrical properties. We have found that the Tech-Etch foils display excellent electrical properties, as well as uniform and consistent hole diameters comparable to established foils produced by CERN.

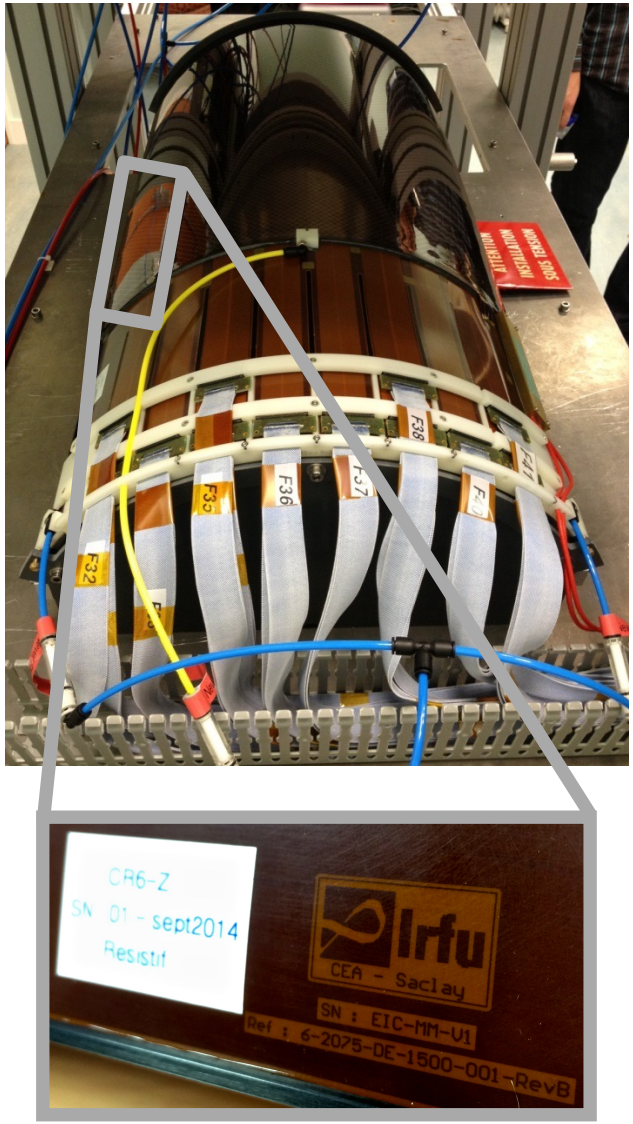
- Paper published in NIM: DOI: 10.1016/j.nima.2015.08.048
- Strong encouragement by editor/referee to publish respective gain source measurements in follow-up publication
- Presented and submitted proceedings to IEEE 2015 Conference: arXiv:1511.08693
- Successful integration of DREAM chip into triple-GEM detector
- Completion of EIC common GEM foil
- Path forward for large area GEM foil CCD scanner setup
- Ongoing ordering of single-mask triple-GEM detector components (Employing STAR FGT size)

Introduction

- Highlights of MicroMegas R&D program
  - Continue with MicroMegas R&D program
  - MicroMegas z and c-barrel testing/characterization with

    cosmic-rays





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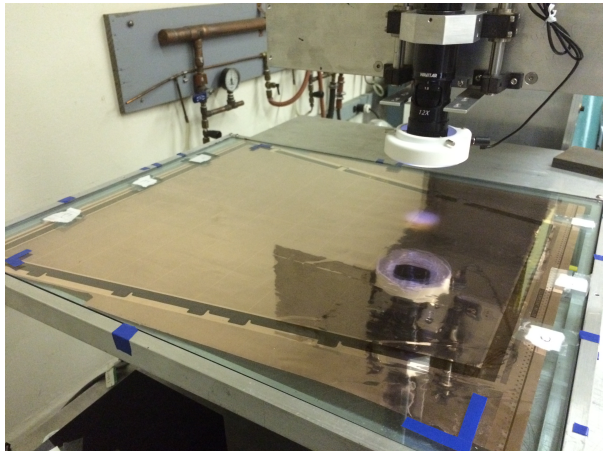
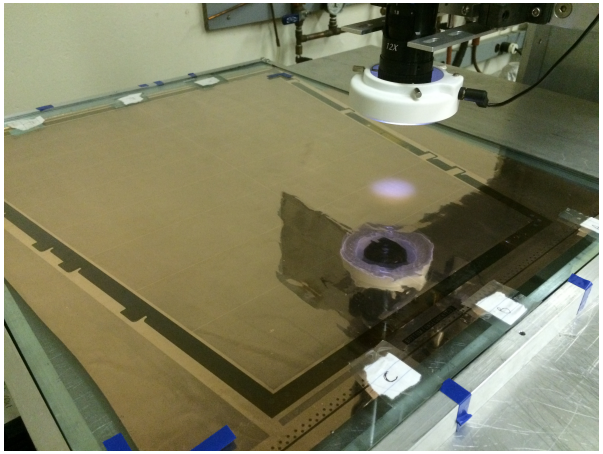
Status - Forward GEM Tracking

Tech-Etch Large Area GEM Foil Development

- Currently finishing optimizing large area 50 cm x 50 cm GEM foils
- Main goal is to have Tech-Etch extend their GEM foil production from 50cm to ~ 1m long
- There are two possible ways for this could happen
  1. Secure floor space and upgrade their production facilities (i.e. etching baths etc.) to accommodate larger foils
  2. See if Tech-Etch could employ a curved foil etching technique that was used at CERN. This could allow for larger foils without the need to upgrade facilities.
- **Major concern**: **Tech-Etch is not sure there is an actual market for large area GEM foils**





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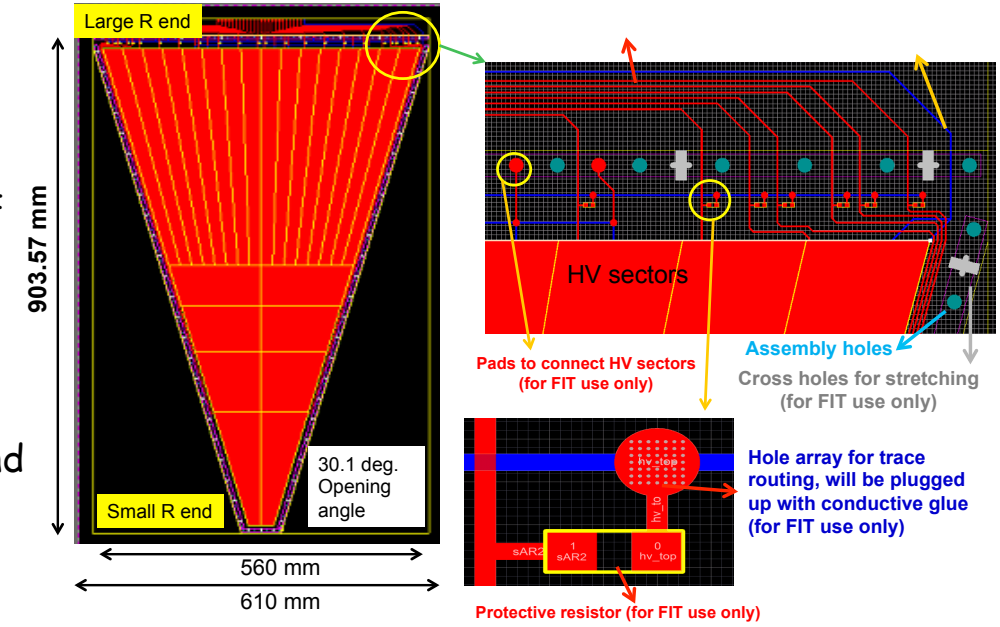
Status - Forward GEM Tracking

- Large EIC segment design
  - Finalized design of large, **dedicated EIC triple-GEM segment** of ~50 X 100cm^2 in collaboration with Florida Institute of Technology and University of Virginia
  - Commercial production of very large GEM foils and 2D readout foils of ~50 X 120cm^2



EIC common foil design drawn by Aiwu Zhang (FIT, EIC postdoc)

  - Coordination meetings with Tech-Etch Inc. incl. CERN, FIT, and UVa (GEM foils / 2D readout foils)
  - Last step profiting from EIC R&D program ➜ Enormous benefit to wider nuclear and particle physics community!

- TU group: Looking into scaling down the design to ~50 cm in length to allow Tech-Etch prototypes

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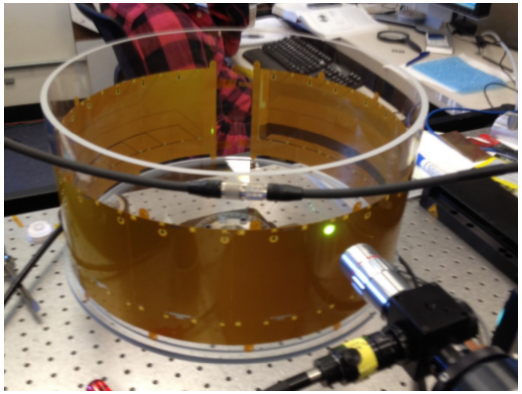
Status - Forward GEM Tracking

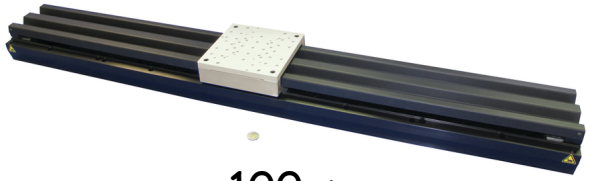
Large Area GEM CCD Scanner

- Urgently needed: Upgrade of CCD scanner at Temple University to accommodate large GEM foils
- LBL visit in September 2014: Looked into Tube scanner idea (C. Haber et al.)
- Also looked into large area 2D linear scanner
- Discussions with Newport engineers about possible options in Q1 FY16
- Decided to pursue large area 2D linear scanner: cheaper and imaging software can be re-used

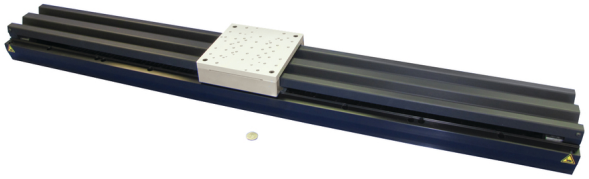
Tube scanner option



Large 2D Linear Scanner



100cm



80cm

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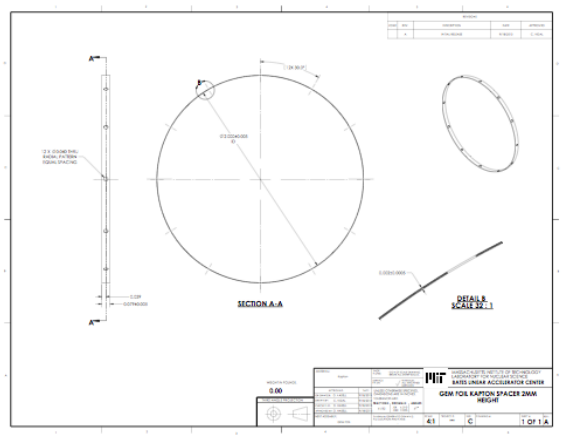
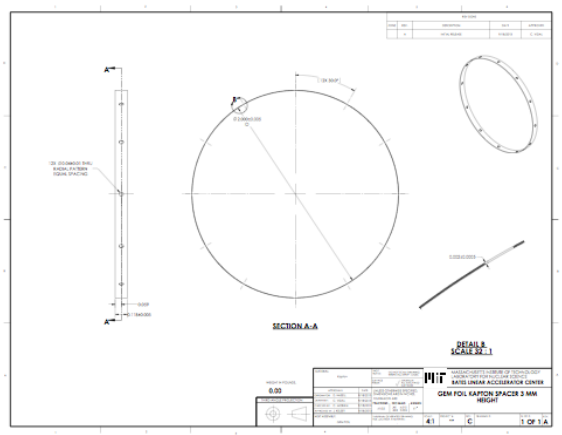
Status - Forward GEM Tracking

Assembly of Tech-Etch Single-Mask 40 X 40cm^2 detectors

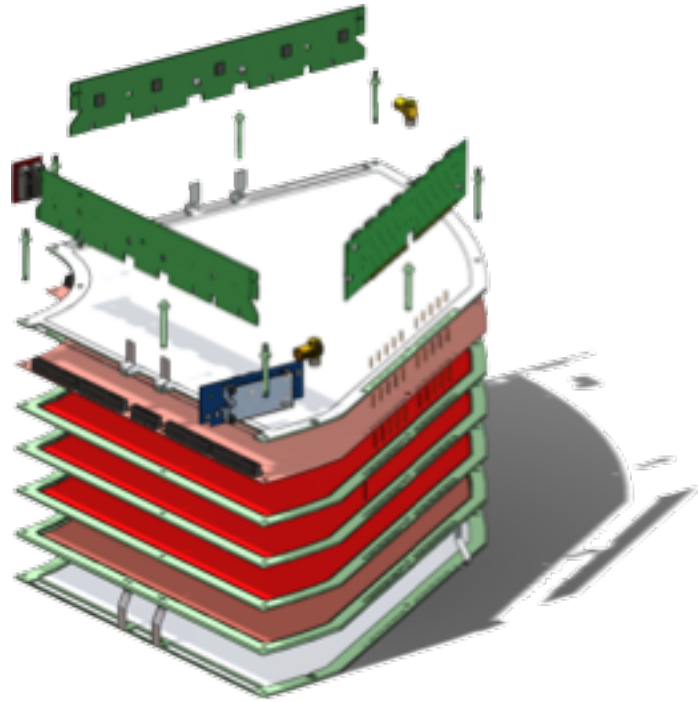
- ☑ Complete FEE (APV25-S1) / DAQ system operational
- ☑ 9 Single-mask foils **received** from Tech-Etch (currently under QA analysis)
- ☑ 3 HV foils **received** from Tech-Etch
- ☑ 3 2D readout foils **received** from Tech-Etch
- ☑ Tooling for assembly and testing
- ☐ Beginning ordering process for spacer ring material (**Kapton**)
- ☐ Missing hardware items: Frames



(a)



(b)



Kapton Rings

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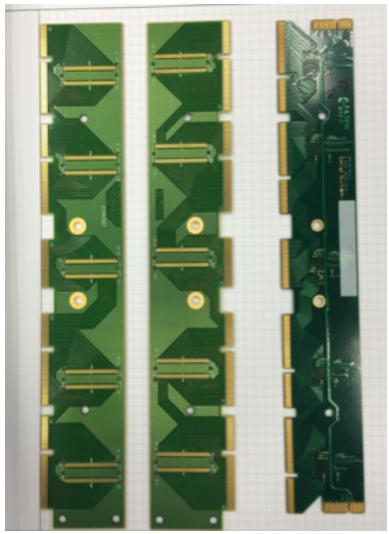
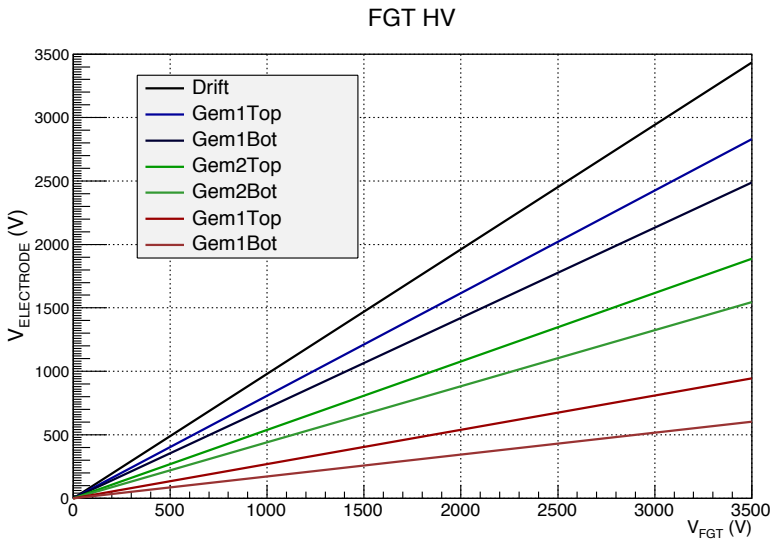
Status - Forward GEM Tracking

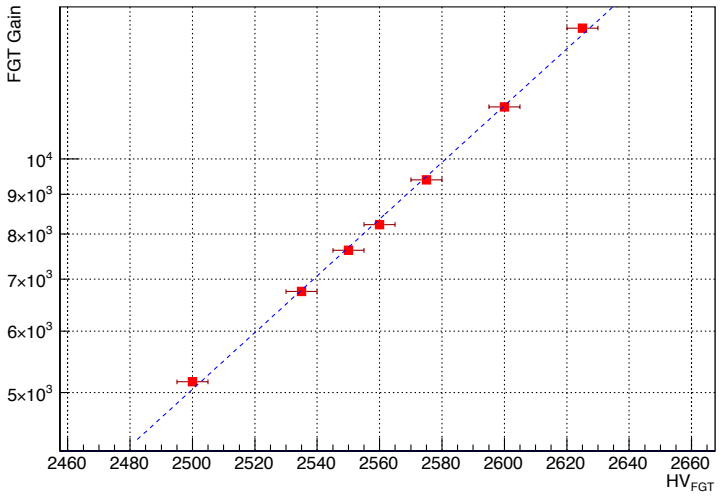
Triple-GEM Detector DREAM Chip Integration

- Saclay successfully designed and built transition cards to connect a FGT quarter section to their DREAM FEE
- Newly fabricated FGT-DREAM cards will take the place of FGT-APV cards
- FGT triple-GEM detector refitted with FGT-DREAM card and characterized via 55-Fe source **(Ar/iCH10 95/05)**
- Shows good gain characteristics
- Triple-GEM detector gains larger than 10^4 for V > 2500 V



FGT-DREAM cards (left), FGT-APV card (right)





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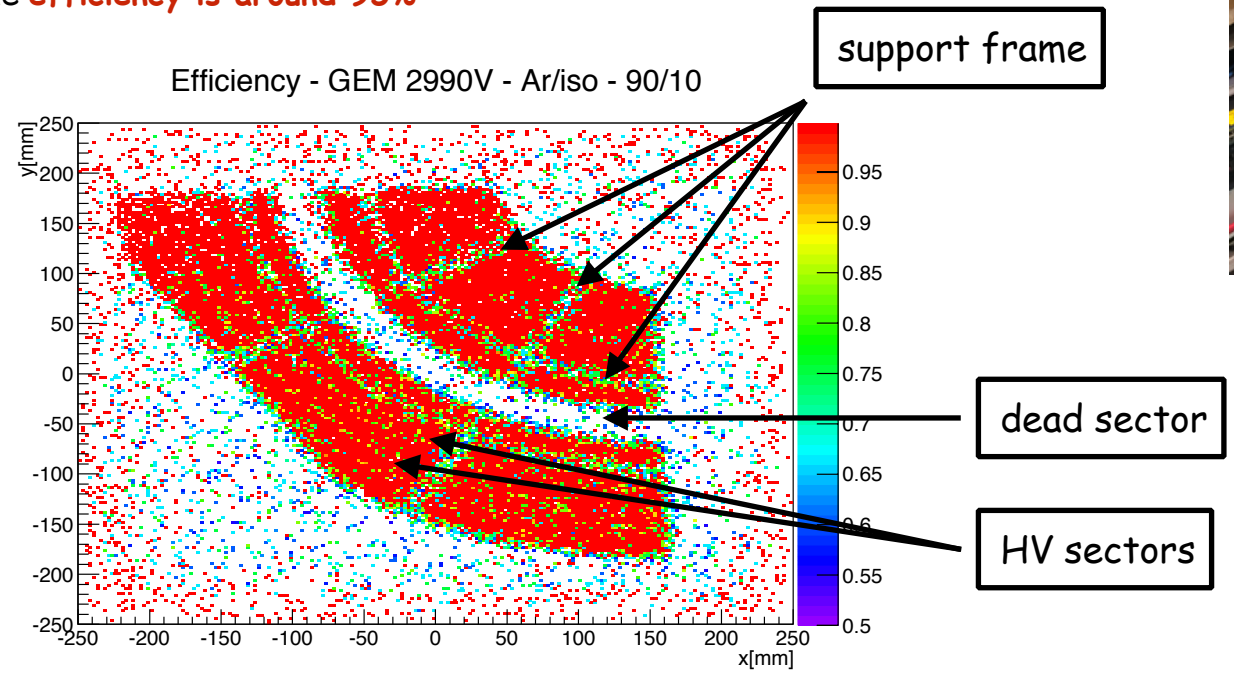
Status - Forward GEM Tracking

Triple-GEM Detector DREAM Chip Integration

- Saclay's **cosmic-ray test** stand was also used to characterize the FGT with DREAM chip readout
- Initial results look very promising (even with known mapping issues)
- Discarding the less effective areas due to GEM supports/ HV sector lines, the **efficiency is around 95%**



Cosmic-ray test stand

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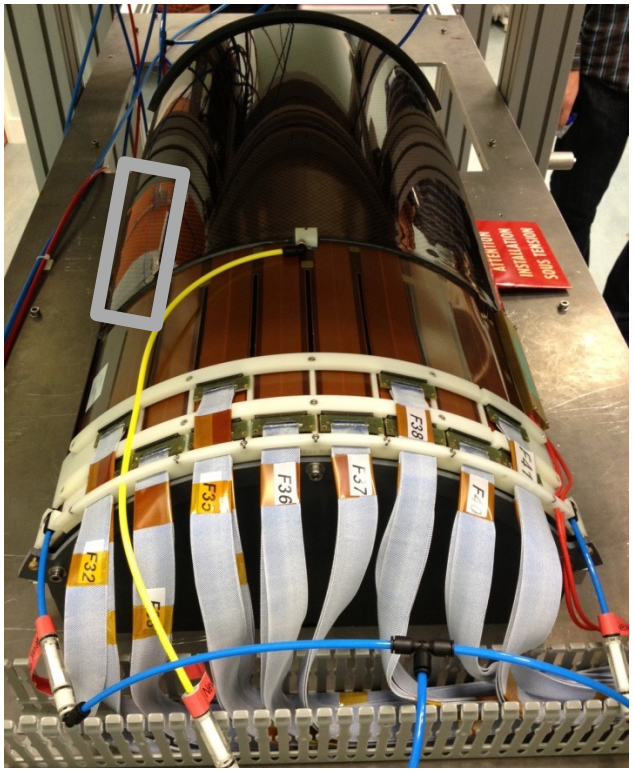
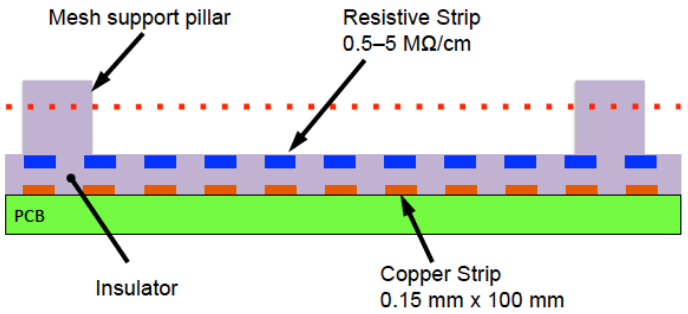
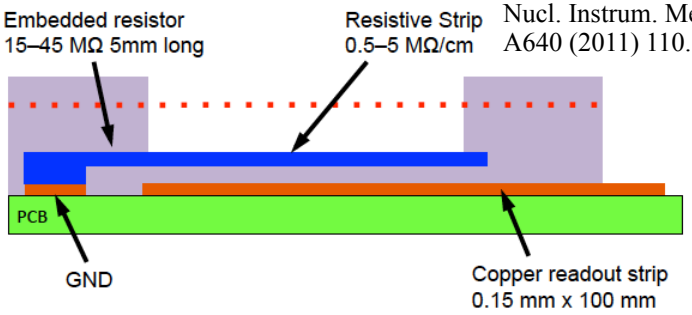
Status - Barrel MicroMegas tracking

Introduction

- Curved MicroMegas for barrel based on carbon structure glued on thin PCB
- Idea validated for CLAS12 tracker
- Need to increase size: PCB size, mesh tension, capacitance and gain homogeneity
- Transition to resistive technology for MicroMegas detectors / No measurable sparking







T. Alexopoulos et al., Nucl. Instrum. Meth. A640 (2011) 110.

- First dedicated EIC large radius resistive 1D (Z) MM prototype (EIC-MM-V1) with 37x45cm^2
- 120 degree section, R=22.5cm, L=45cm

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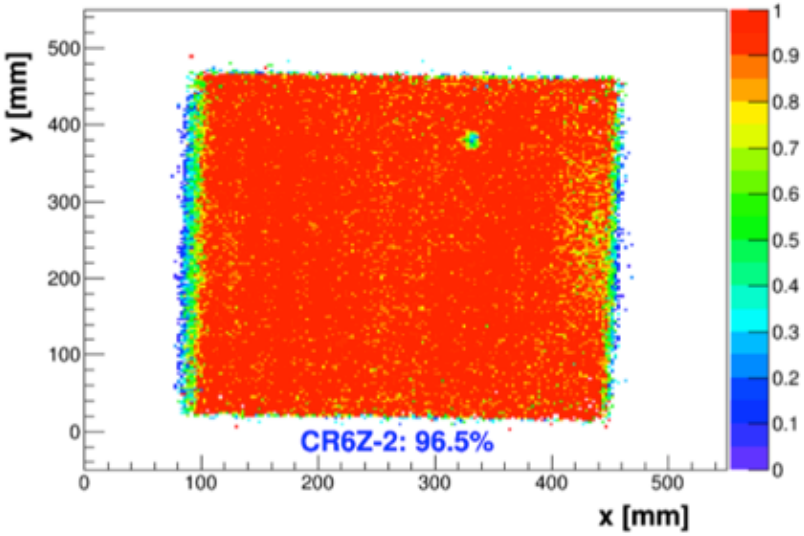
Status - Barrel MicroMegas tracking

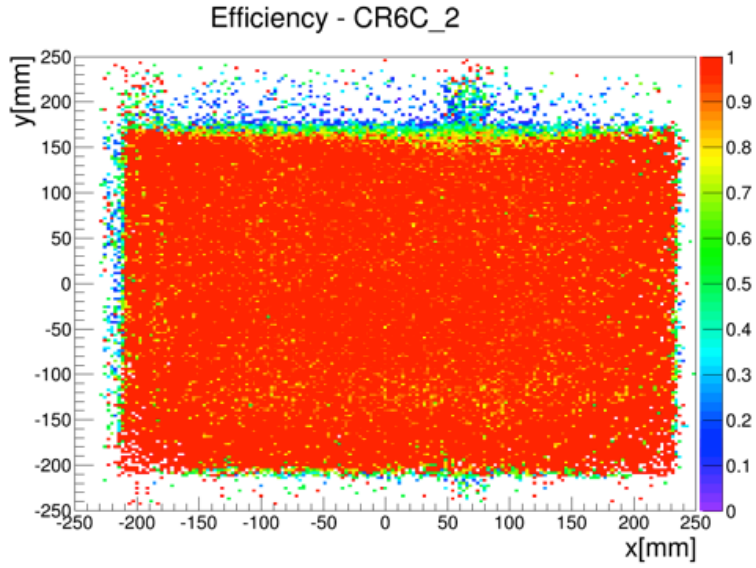
- Further testing of C and Z-layer resistive prototype and cosmic-ray testing
  - Continue characterizing both 1D prototypes
  - Both C and Z barrels have:
  - spatial resolution better than 200 um
  - Timing resolution ~20 ns

Z-Barrel



~97% Efficient

C-Barrel



~98% Efficient

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Plans - Forward GEM Tracking

- Continuation of Large GEM Development at Tech-Etch
  - Produce a scaled down version of large EIC foil for production at Tech-Etch
  - Continue work with Tech-Etch to expand GEM size to larger size of ≳ 1m (order EIC foils)
- Assembly and characterization of single-mask triple-GEM detectors (40 cm x40 cm)
  - Perform electrical/optical QA on 9 40 cm x 40 cm GEM foils to be used in 3 triple-GEM detectors **(currently in progress)**
  - Assemble 3 detectors using spacer rings to reduce dead material
  - Characterize the detector using 55-Fe source (need to purchase), X-ray gun (acquired), and cosmic-rays (setup and commissioned)
- Build shielding enclosure to use mini x-ray gun using available scanner
- Build large area GEM CCD scanner
  - In discussions with Newport engineers on design, purchase of the **large linear stages (100 cm and 75 cm) and motion controller being made soon / Waiting for FY16 funds!**
- Continuation of testing DREAM chip readout with triple-GEM detector

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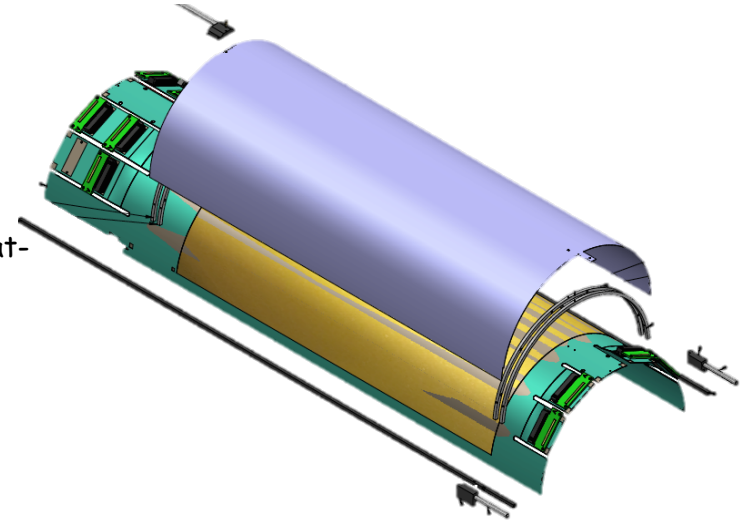
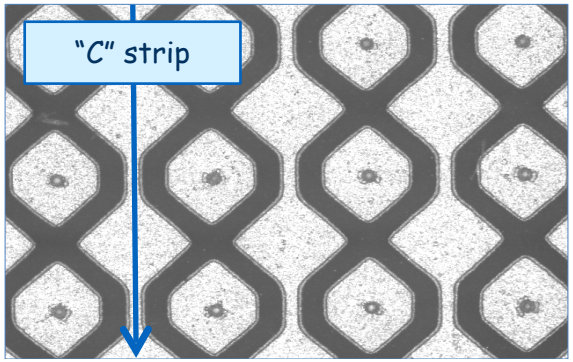
Plans - Barrel MicroMegas tracking

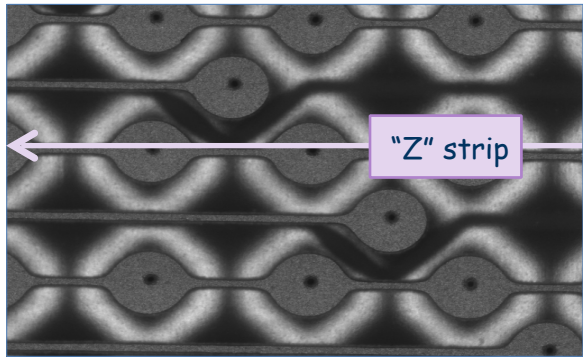
2D curved resistive prototype, C-Z pattern

- Minimization of dead material with respect to 1D detectors
- Tailored for high-flux experiments (resistive)
- Next technological step after 1D-curved-resistive, 2D-curved-metallic and 2D-flat-resistive
- Will profit from experience with CLAS12, Asacusa AMT and Mcube





Read-out pattern (top)



Read-out pattern (bottom)

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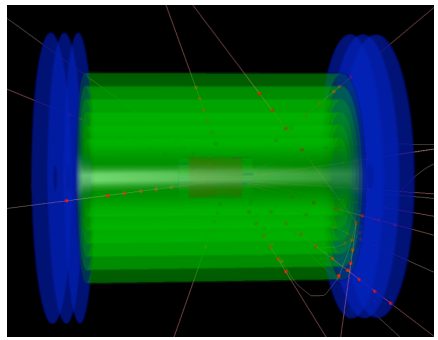
Planned budget request - Summer FY16

- Approximate budget request for FY17 = $150k focusing on:
  - Support for one post-doc (2nd year)
  - Travel
  - Building safety enclosure for mini X-ray tube
  - Ordering scaled down EIC foils from Tech-Etch
  - Development of 2D MicroMega at Saclay

Summary / Outlook

Summary / Outlook

- Forward GEM tracking
  - Successful commercial single-mask production of large GEM foils / Critical characterization of leakage current and optical uniformity at Temple University
  - Upgrade of CCD scanner has started
  - Assembly of single-mask detectors and X-ray scan
  - Large EIC GEM foil design completed
  - Successful integration of DREAM chip into triple-GEM detector. Initial results very promising (~95% efficient)
- Barrel MicroMegas tracking
  - Successful assembly + test of large radius resistive MM detector (1D-Z / 1D-C) using DREAM chip FEE / DAQ
  - Design and assembly of 2D MM - Critical step to complete R&D program
- Simulations
  - Dedicated farm at Temple University for computing cluster to be used for EIC simulations / Cloud computing configuration in preparation



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