Status Report (Q2 FY16 / Q3 FY16) and Proposal (FY17)

Fast and lightweight

EIC integrated tracking system

Barrel MicroMegas (MM)

&

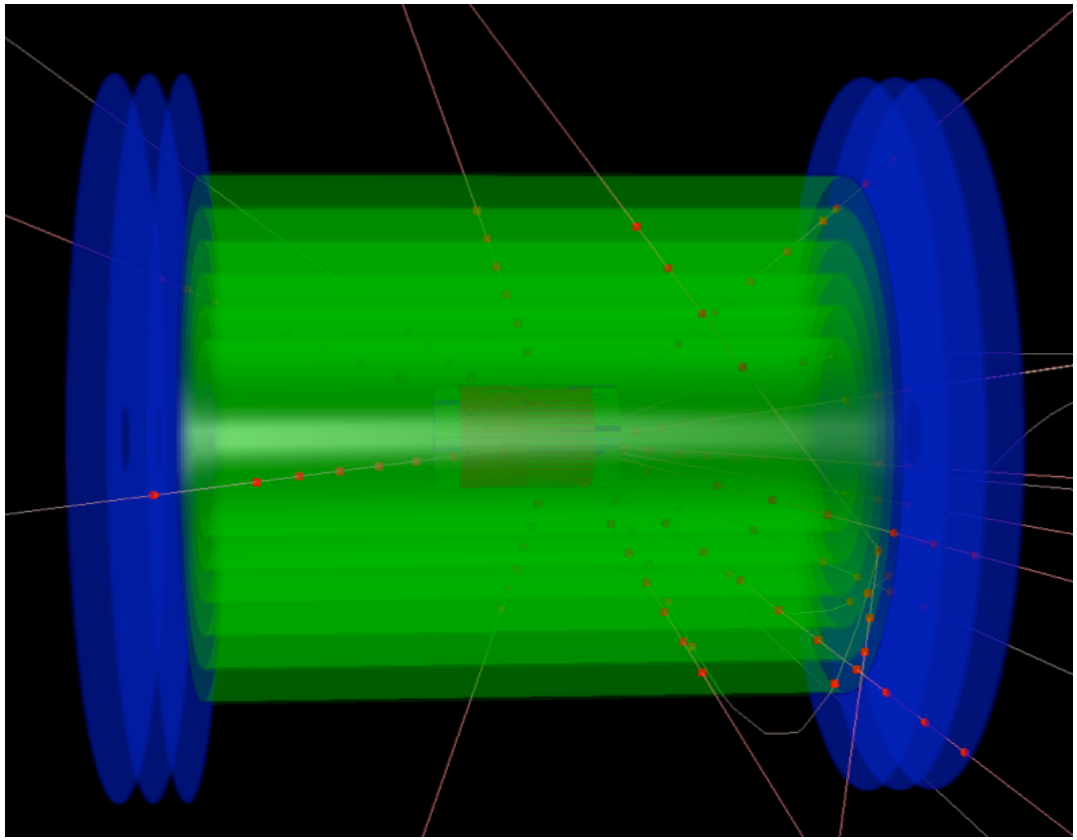
Forward Triple - Gas Electron Multiplier (GEM)

Franck Sabatie (PI),
Maxence Vandenbroucke

Matt Posik,
Bernd Surrow (PI)

Outline

- Introduction
- Generic R&D program: Status
  - (1) Forward GEM tracking
  - (2) Barrel MM tracking
- Generic R&D program: Plans
  - (1) Forward GEM tracking
  - (2) Barrel MM tracking
- Targeted R&D program eRD3/6: Plans
- Budget request FY17
- Summary



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Introduction

Overview of eRD3 effort

- R&D effort focuses on intermediate tracking system:
  - Barrel tracking system based on MM 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) - Merging efforts!
- R&D effort - Main strategy:
  - Design and assembly of large cylindrical MM 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
  - Utilization of light-weight materials
  - Development and commercial fabrication of various critical detector elements
  - Move from generic R&D phase (eRD3: Status report and proposal) to targeted R&D phase in collaboration with eRD6 (eRD3/6: "Slash" document)

eRD3: generic R&D

EIC Detector R&D

Progress Report and Proposal

Project ID: eRD3

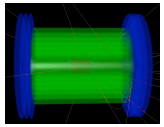
Project Name: Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC

Period Reported: January 01, 2016 – June 30, 2016 (Status) / October 01, 2016 - September 30, 2017 (Proposal)

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

Date: June 15, 2016

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



Contact Person: Professor Bernd Surrow

Email: surrow@temple.edu

Phone: 215-204-7644

eRD3/6: targeted R&D

Project Name: eRD3/eRD6, Proposal for targeted detector R&D towards an EIC detector

Project Leader:
Brookhaven National Lab: Craig Woody
Florida Tech: Marcus Hohlmann
INFN Trieste: Silvia Dalla Torre
Stony Brook University: Klaus Dehmelt, Thomas Hemmick
Temple University: Bernd Surrow
Saclay: Franck Sabatie
University of Virginia: Kondo Gnanvo, Nilanga Liyanage
WIS: Alexander Milov
Yale University: Richard Majka, Nikolai Smirnov
Date: June, 2016

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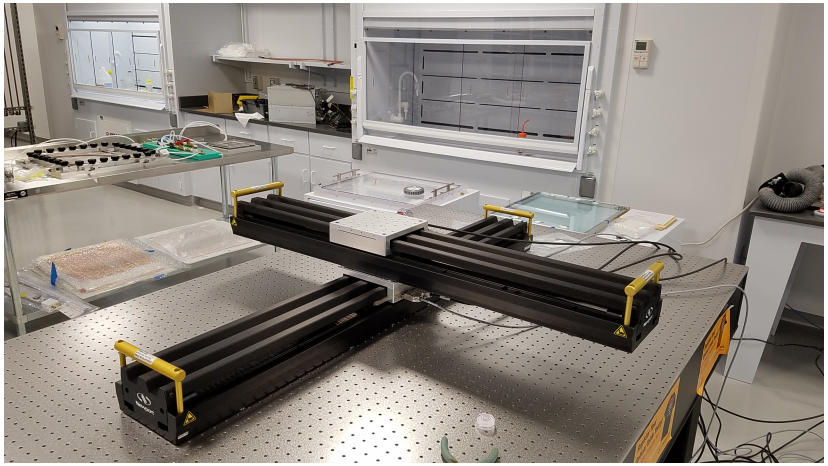
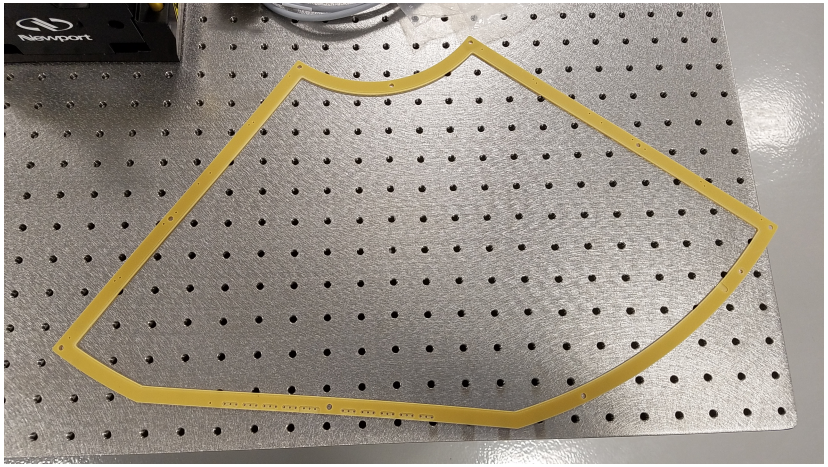
Introduction

Highlights of triple-GEM R&D program

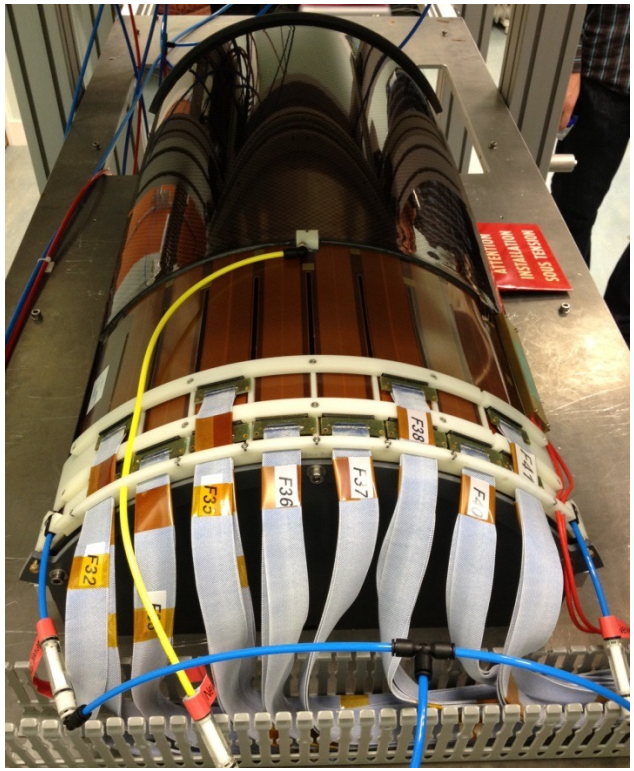
- New mechanical engineer (James Wilhelmi) fully supported by Temple University, College of Science and Technology in support of Nuclear and Particle Physics experiment programs including Micro-pattern detector lab
- FY16 funds became only available in spring 2016 after January 2016 status report resulting in delay of various component orders which have been exclusively placed with US vendors:
  - All single-mask GEM foils, HV foils, 2D readout foils and frames. Still waiting on Kapton spacer rings and soldering of SAMTEC multi-pin connectors to 2D readout foils
  - Hire of new postdoc (Dr. Amilkar Quintero) in spring 2016 (50% on EIC R&D subcontract together with Dr. Matt Posik at 50% level - Remaining support from DOE base grant and Temple University)
- New CCD scanner in progress: Newport linear stages received and tested / Mechanical design completed by James Wilhelmi and machining of parts at Temple University started



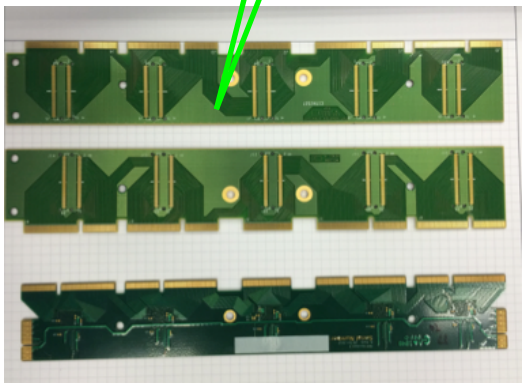


Introduction

- Highlights of MM R&D program



- Further testing of MM 1D prototype detectors and triple-GEM prototype detector with DREAM chip readout / Analysis of data of triple-GEM detector (Mapping as reported earlier!) requires help from new postdoc who was only hired in spring 2016 due to delay of FY16 funding
- Component list for DREAM-chip DAQ setup at Temple University available
- Modular DREAM chip development
- 2D MM design ongoing



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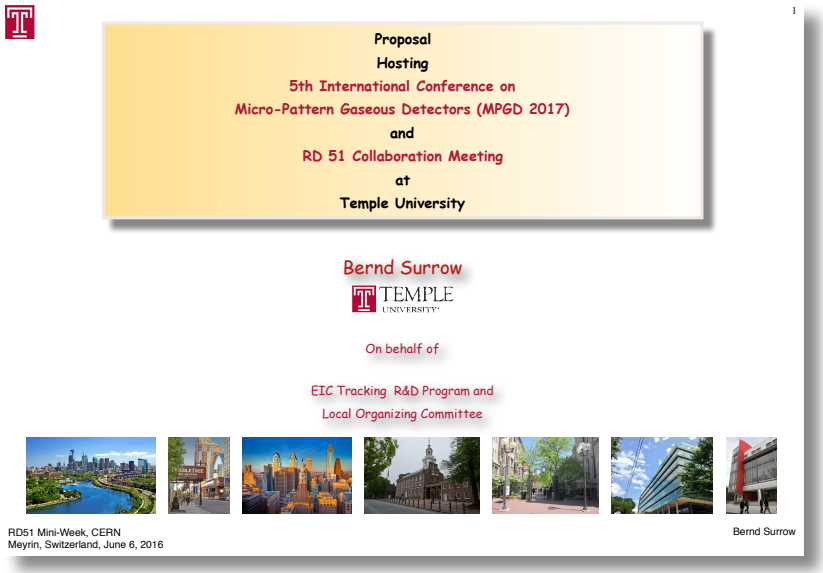
Introduction

International MPGD 2017 Conference / RD51 Collaboration Meeting

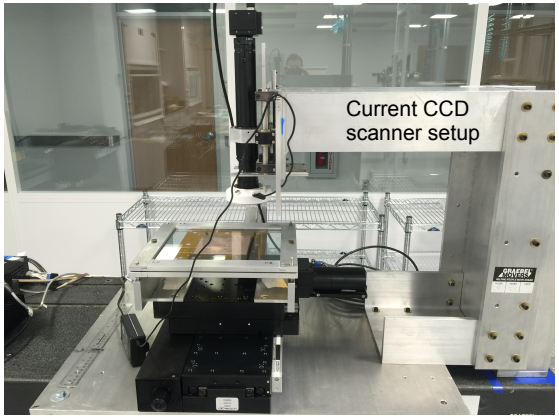
- Proposal was submitted to International Advisory Committee of the MPGD Conference series to host the 5th International Conference on Micro-Pattern Detectors (MPGD 2017) at Temple University
- Local organizing committee: Member institutions: BNL (Craig Woody) / Florida Institute of Technology (Marcus Hohlmann and Aiwu Zhang) / Stony Brook University (Tom Hemmick, Klaus Dehmelt) / Temple University (Matt Posik, Amilkar Quintero and Bernd Surrow) / University of Virginia (Kondo Gnanvo and Nilanga Liyanage) / Yale University (Dick Majka and Nikolai Smirnov)
- Date: Monday, May 22, 2017 - Friday, May 26, 2017
- eRD3/6 programs are looking forward to host MPGD2017 ⇒ Strong recognition of EIC R&D program!

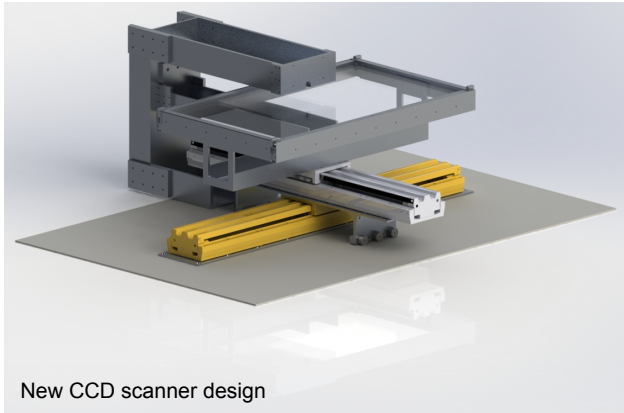


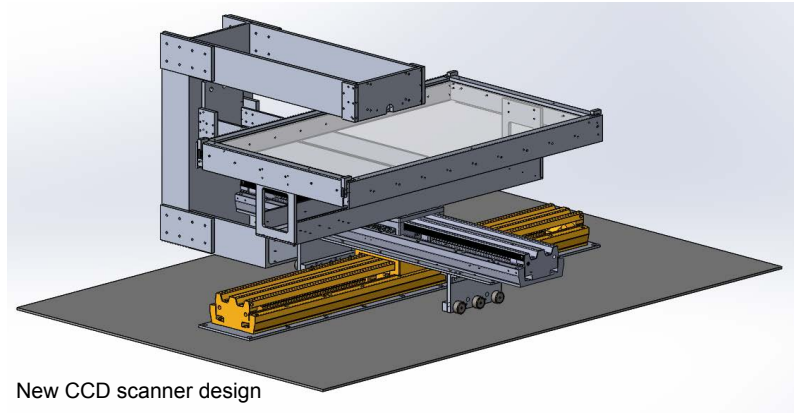
Ioannis Giomataris, June 14, 2016: “Today the International advisory committee gathered and discussed the two proposals for the organization of next MPGD2017. After a wide and tight review of the two proposals the decision was favorable to PHILADELPHIA-Temple University project, which is proposed by you and your collaborators.”

Status - Forward GEM Tracking / Generic R&D

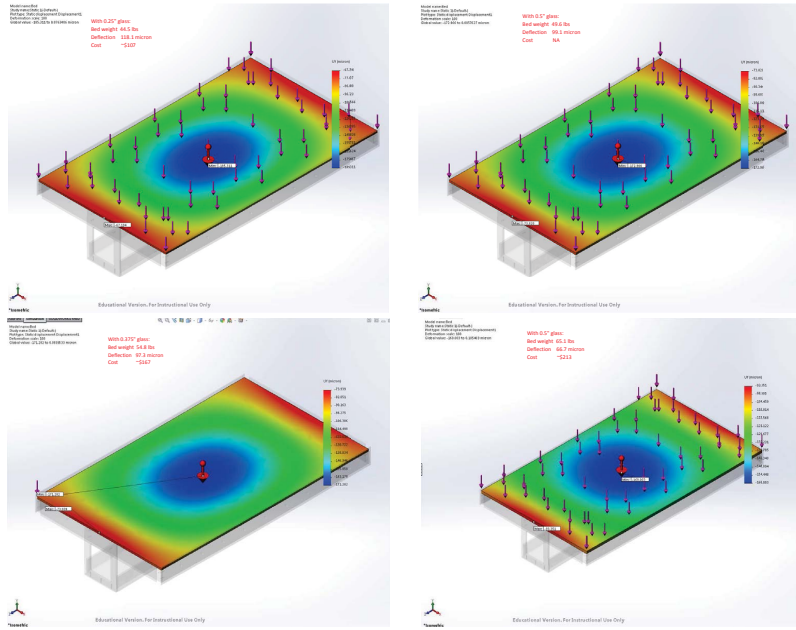
GEM CCD Scanner (1)







- Design of new CCD scanner in TU Micro-Pattern Clean Room facility completed by James Wilhelmi based on SolidWorks including simulation of glass deflection
- Conceptual idea similar to prior setup based on glass sandwich support, top and bottom light with fixed new CCD camera under MatLab control
- Significant extension in size to allow scans of GEM foils of size of max. ~60cm / ~120cm
- Machining of all parts started in Temple University Physics Department machine shop



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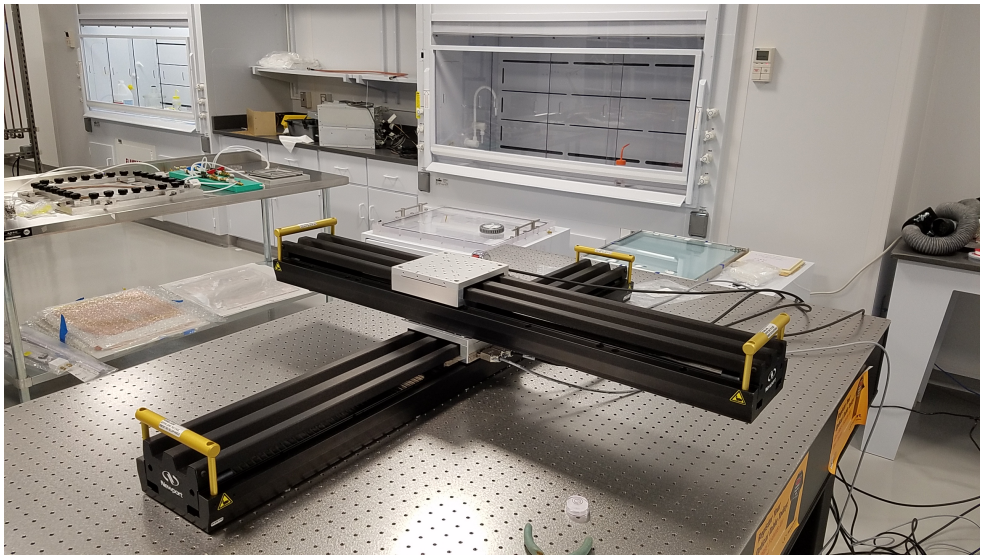
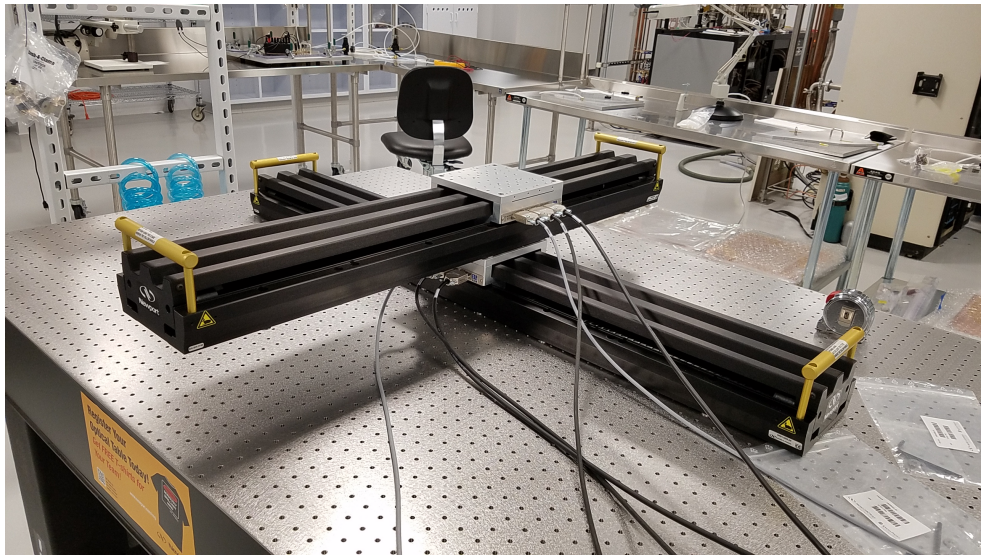
Status - Forward GEM Tracking / Generic R&D

GEM CCD Scanner (2)





- Obtained and tested Newport linear stages located on a 4' X 6' optical table (TU CST support) inside the TU Micro-Pattern Clean Room facility
- Specifications of high precision Newport linear stages: On axis accuracy: ±12.5μm / Minimum incremental motion: 0.02μm / Bi-direction repeatability: ±0.5μm / Resolution 0.005μm
- CCD scanner will be mounted on top of 4' X 6' optical table
- Delivery of new CCD camera expected during the week of July 4, 2016

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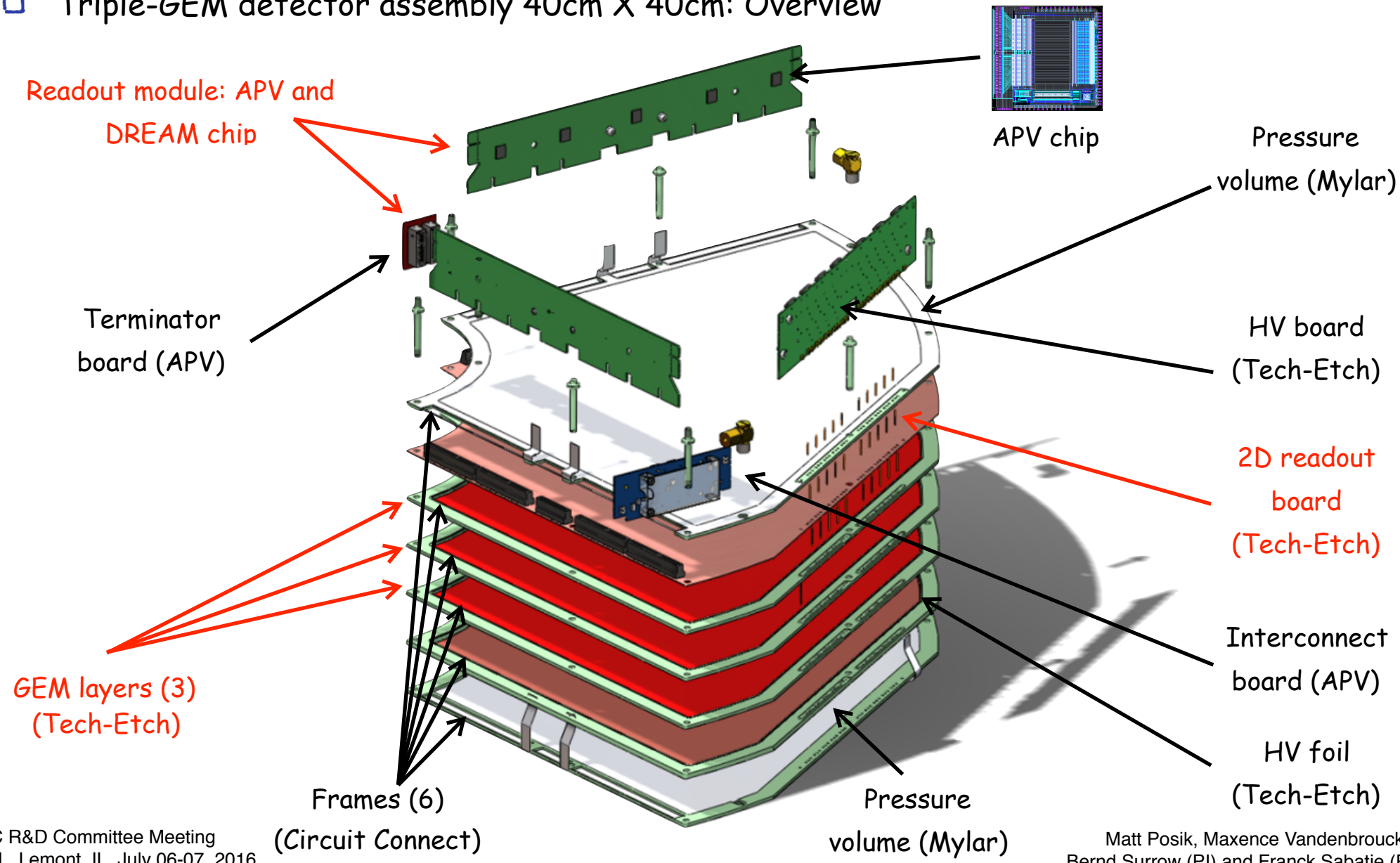
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: Overview



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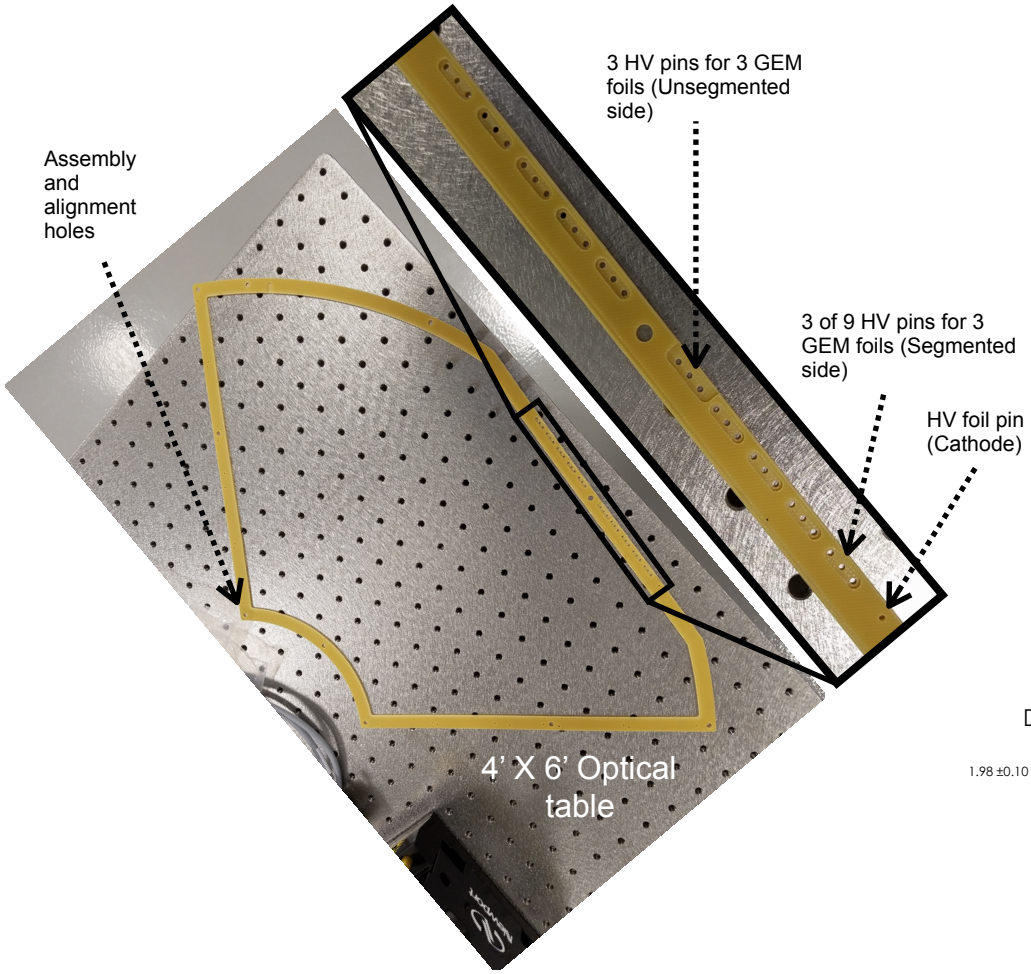
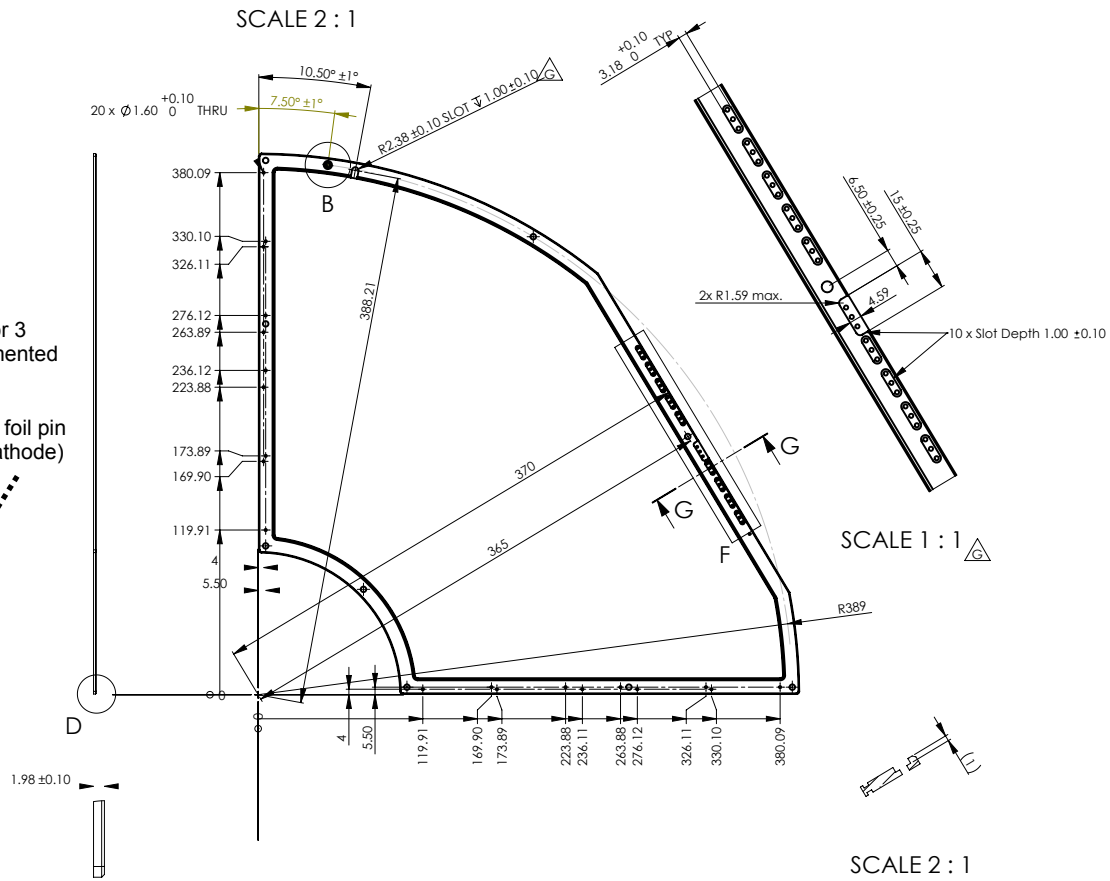
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: Frames





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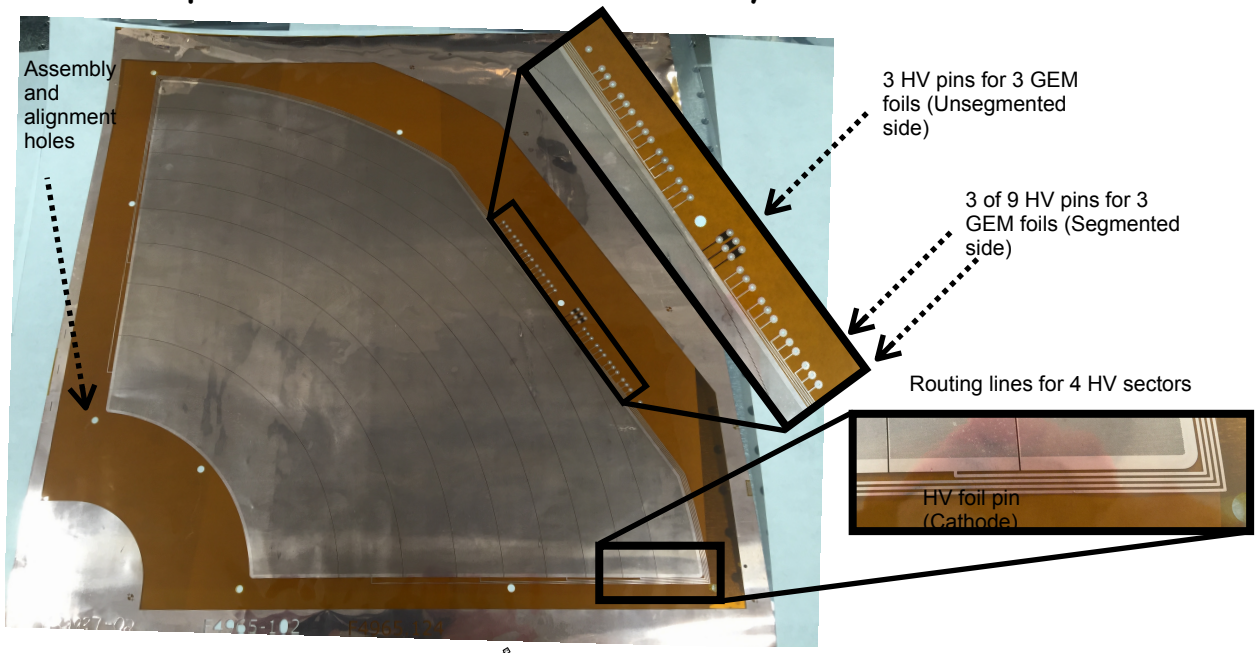
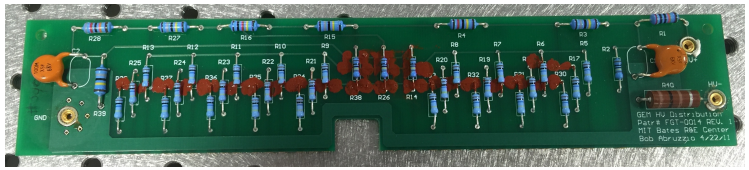
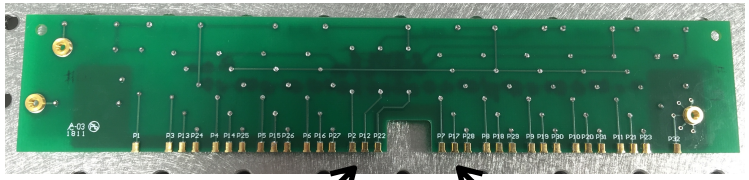
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: GEM foils



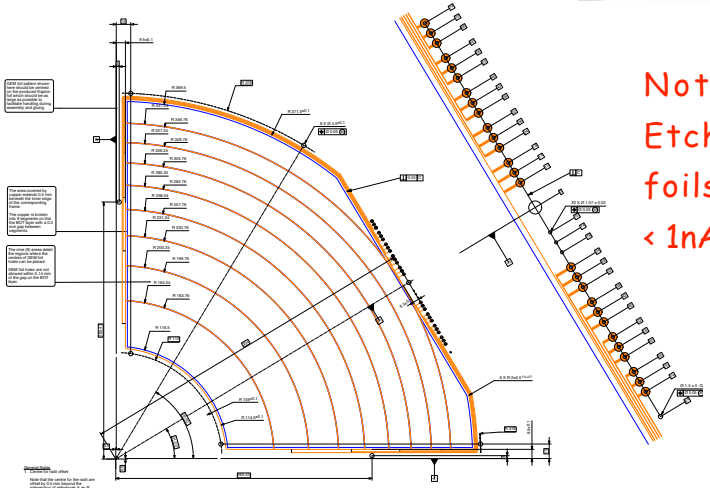
HV boards



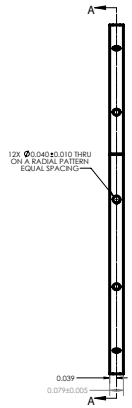


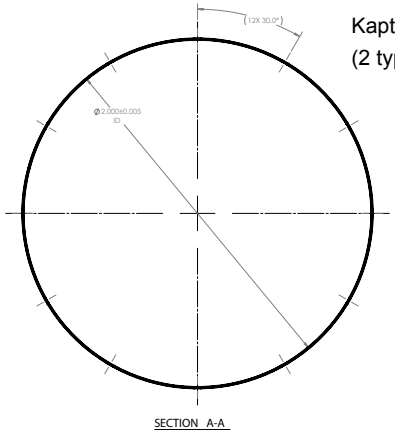
3 HV pins for 3 GEM foils (Unsegmented side)

3 of 9 HV pins for 3 GEM foils (Segmented side)

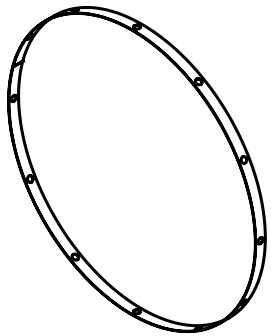


Note: All Tech-Etch, single-mask foils tested with < 1nA up to 550V





Kapton rings: 2”
(2 types, 2mm and 3mm)



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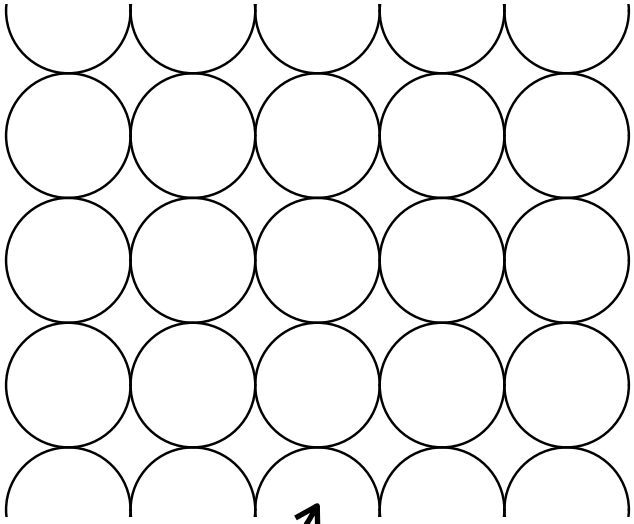
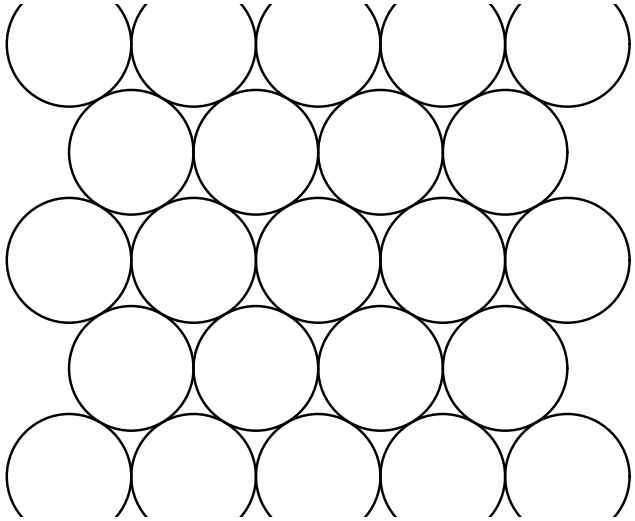
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: Possible Kapton ring arrangements

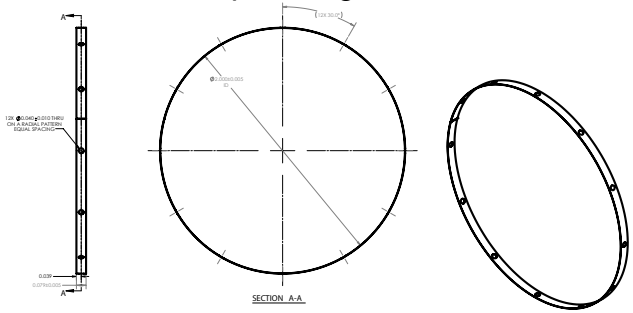


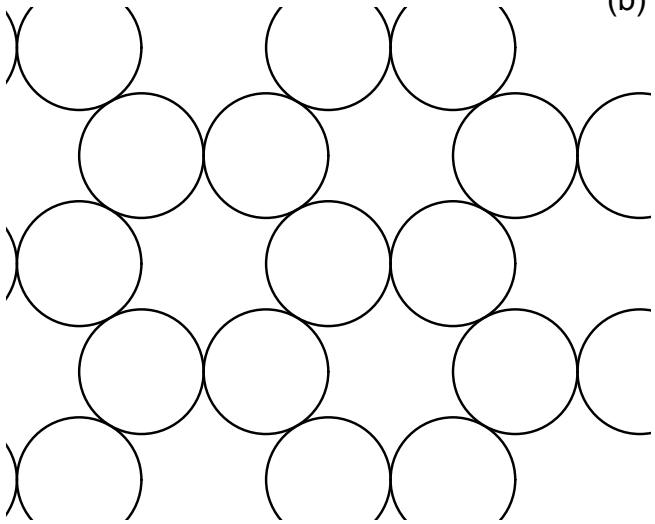
(a)



(b)

Kapton rings: 2”





(c)

Note: Final arrangements not decided yet!

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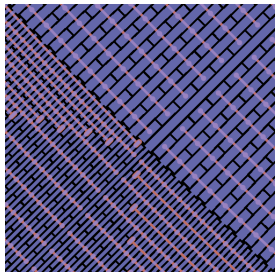
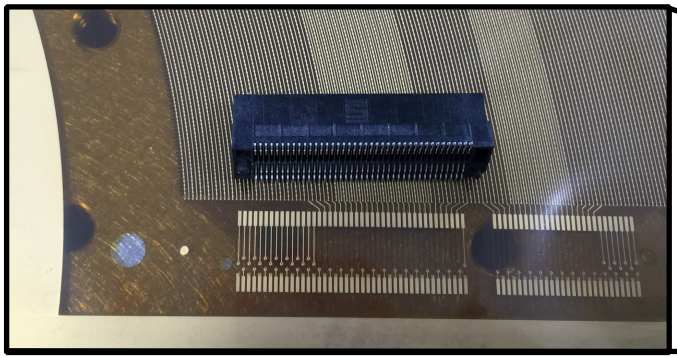
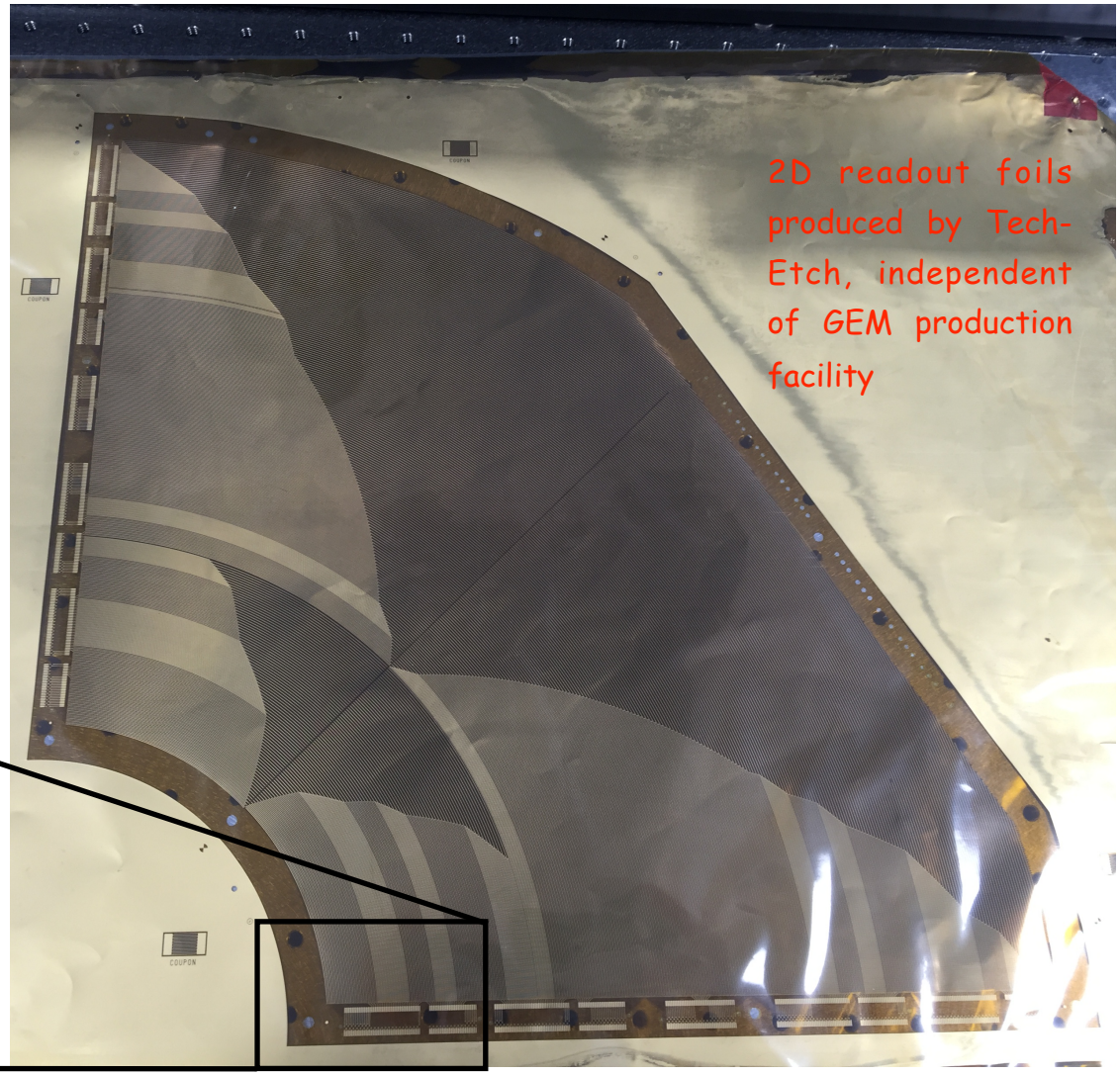
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: 2D readout foils / FEE
  - r-φ symmetry for 2D readout layer
  - Lines at constant φ angle read out separately
  - Pads at constant r (BLUE) connected and readout separately
  - Routing lines in orange
  - Connection to SAMTEC multi-pin connector connected to APV / DREAM readout module
  - Capacitance measurement for each channel (1280) planned (Keithley Electrometer)







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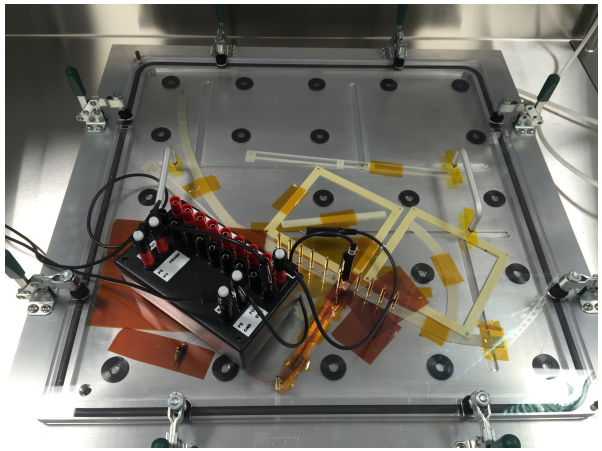
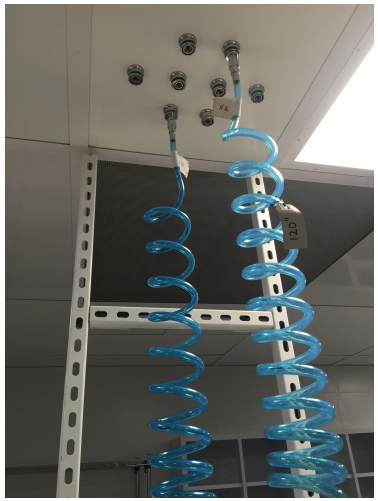
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: Tooling 1

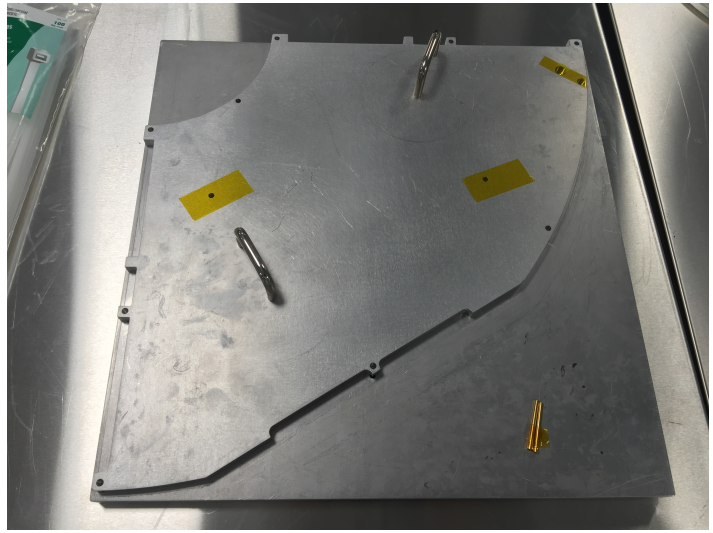


GEM nitrogen box / N_2 enclosure



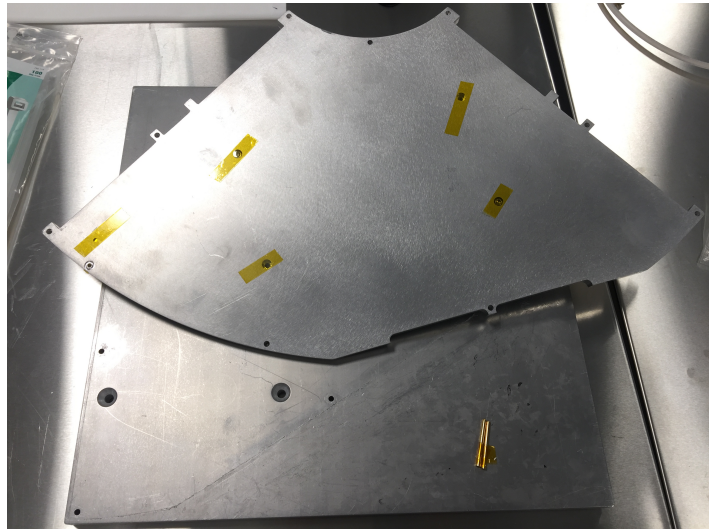
New gas distribution inside TU Micro-Pattern clean-room facility with manometer for gas flow tests / Panel in preparation

Assembly tool with gas flow cover (Top)



ISEG precision power supply and current measurement

Assembly tool with gas flow cover (Bottom)



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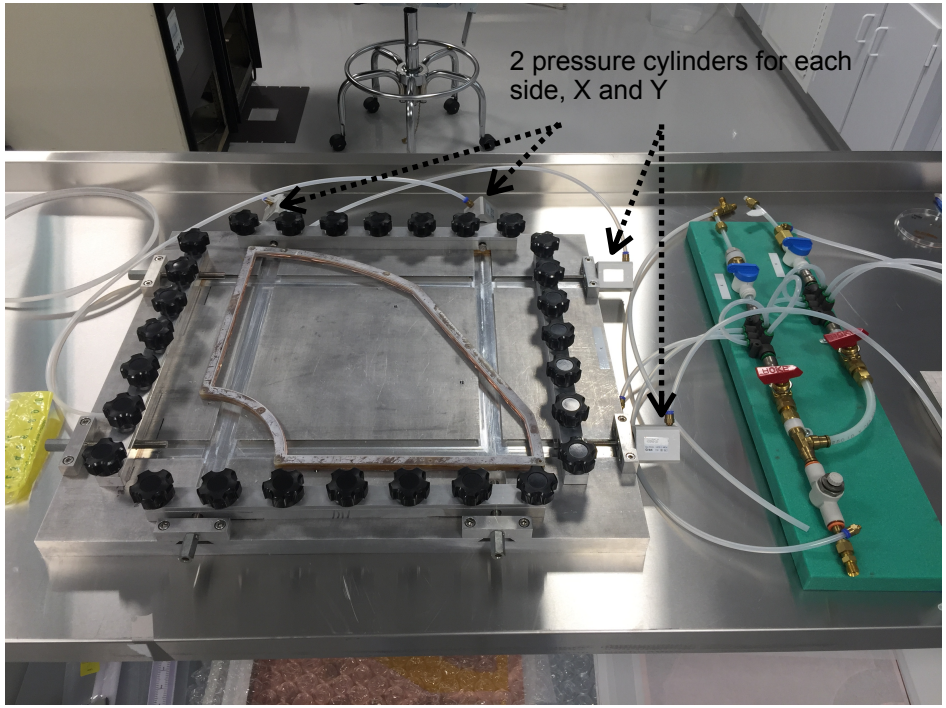
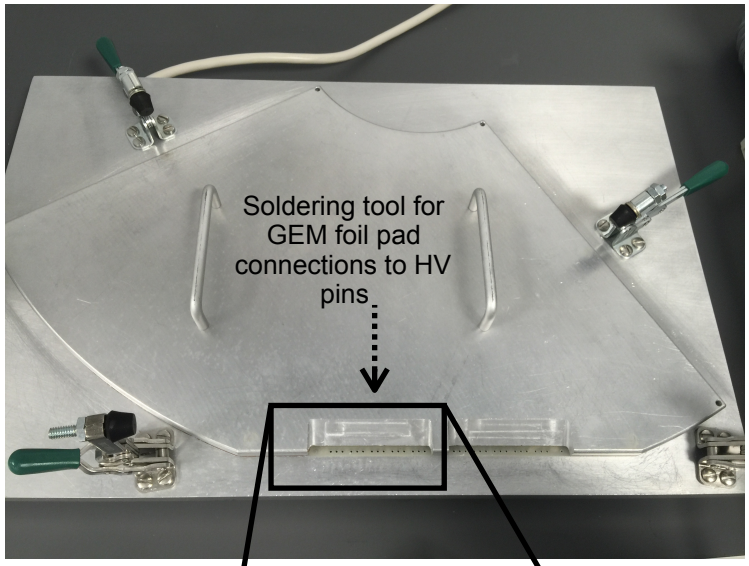
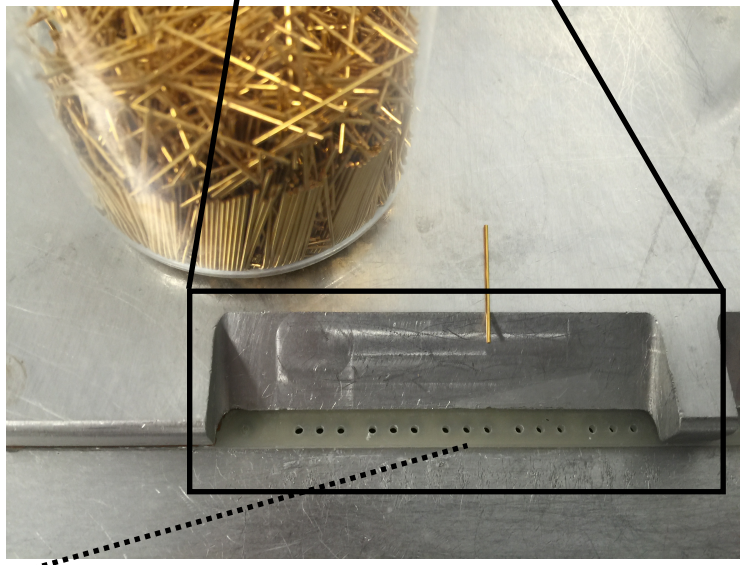
Status - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm: Tooling 2

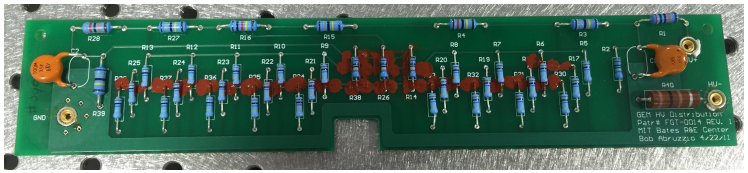


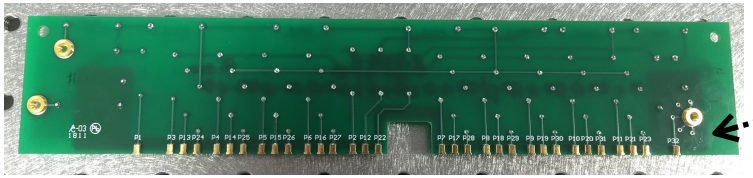
Stretching tool





HV boards





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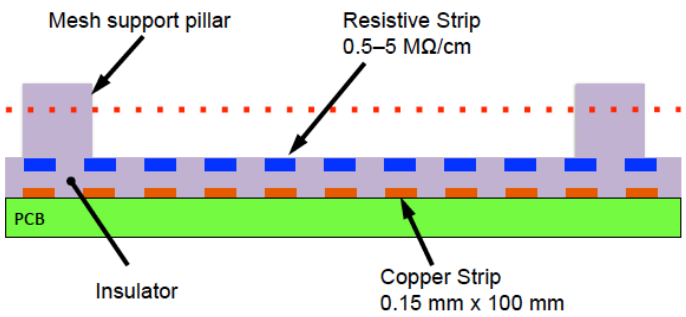
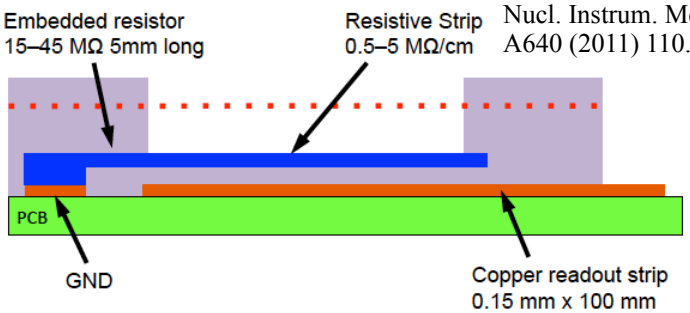
Bernd Surrow (PI) and Franck Sabatie (PI)

Status - Barrel MM tracking / Generic R&D

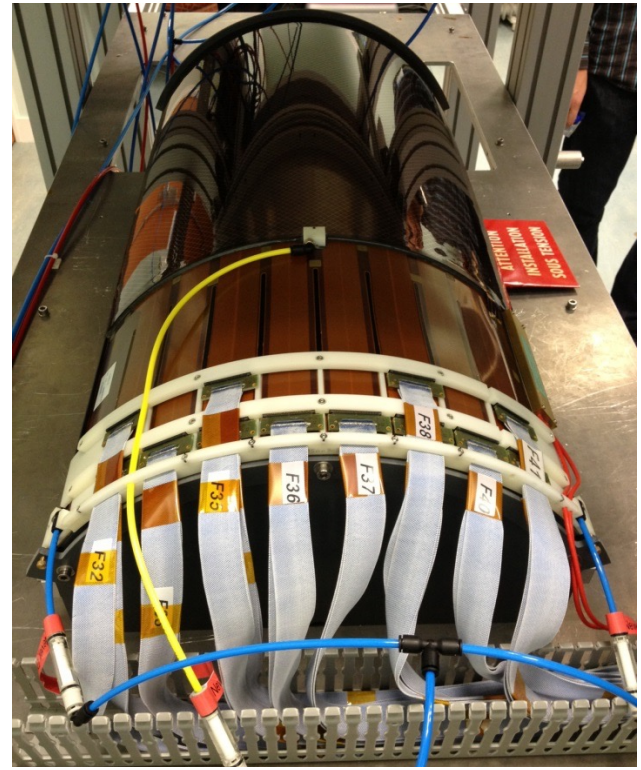
Overview

- 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 120 degree section, R=22.5cm, L=45cm
- Further extensive cosmic-ray testing / Analysis in progress
- Next: 2D design (C / Z)

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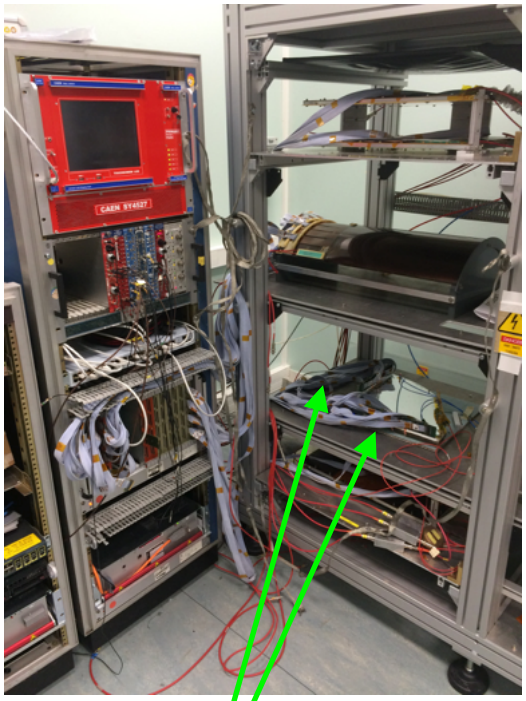
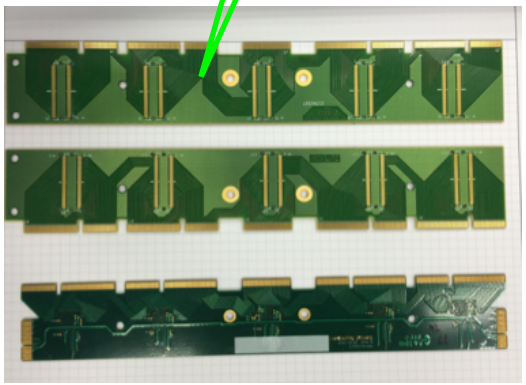
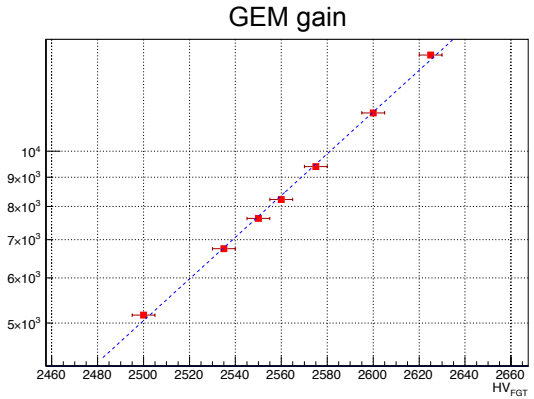
Bernd Surrow (PI) and Franck Sabatie (PI)

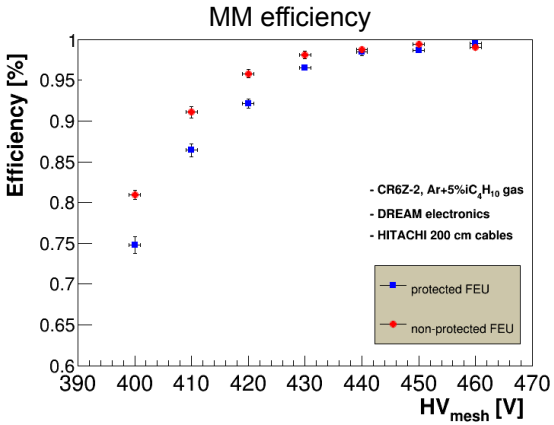
Status - Barrel MM tracking / Generic R&D

- DREAM chip readout system: MM / GEM
  - Saclay successfully designed and built transition cards to connect a FGT quarter section to their DREAM DAQ system
  - Further development of modular DREAM readout system (Analog solution!)
  - Triple-GEM test inside Saclay cosmic-ray test-stand (Mapping needs to be sorted out with help of new postdoc!)
  - Further testing of 1D MM prototypes
  - Design of MM 2D prototypes ongoing





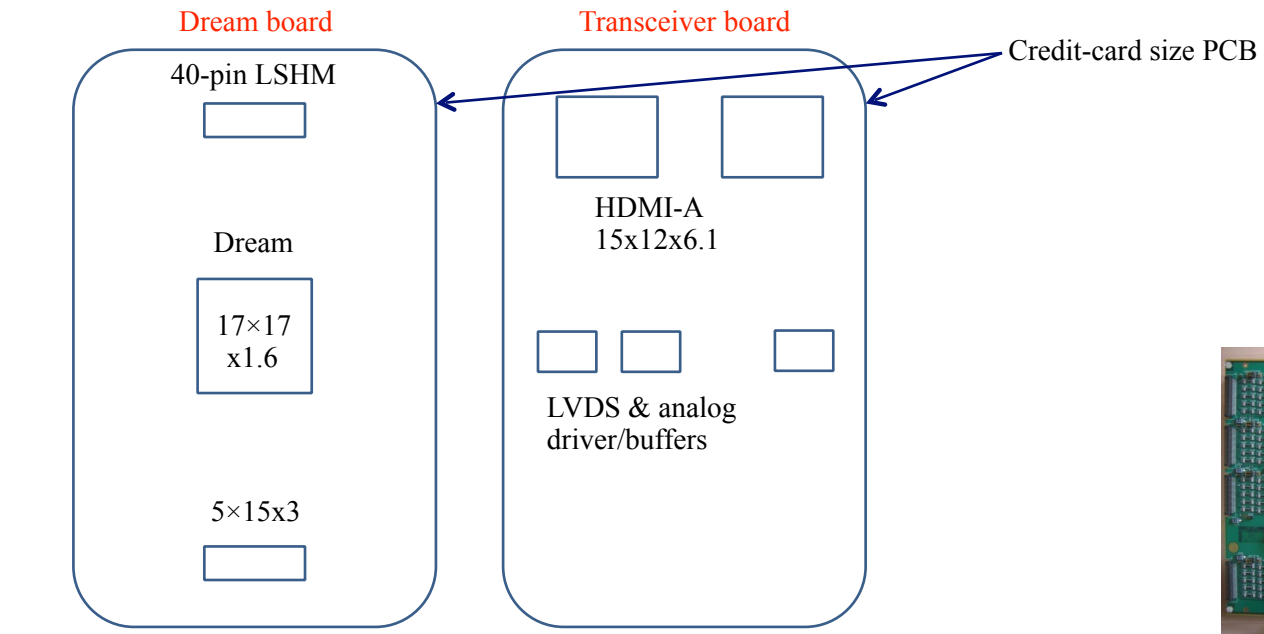




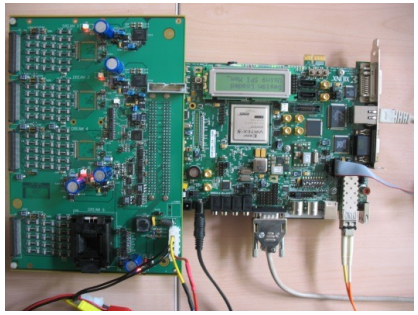
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

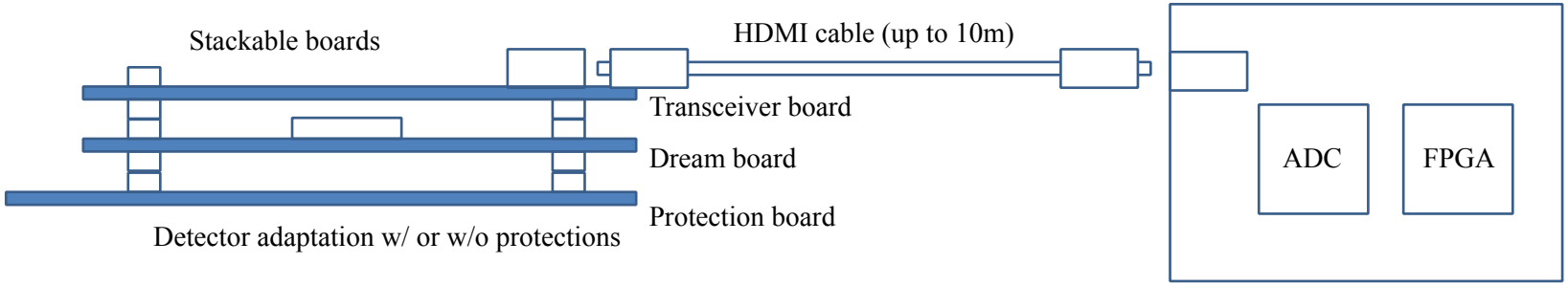
Status - Barrel MM tracking / Generic R&D

- Layout of modular DREAM DAQ system: Analog VFE solution
  - Analogue VFE boards produced
  - Basic functionality tested
  - Next:
    - Detector readout
    - Mixed solution



DAQ board
(E.g. Dream test bench)



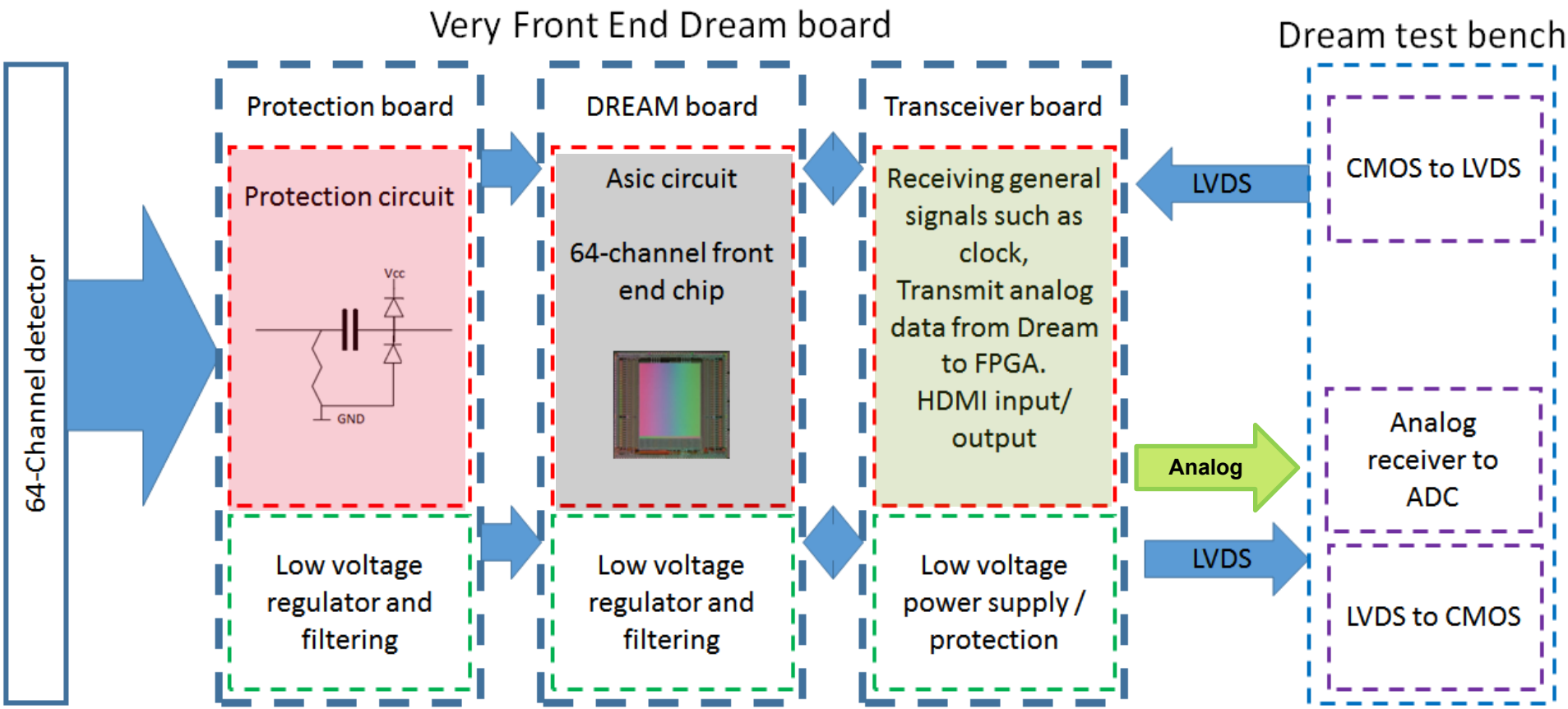


Test bench has already functionalities to control Dream-based analogue VFE

Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Status - Barrel MM tracking / Generic R&D

- VFE Layout

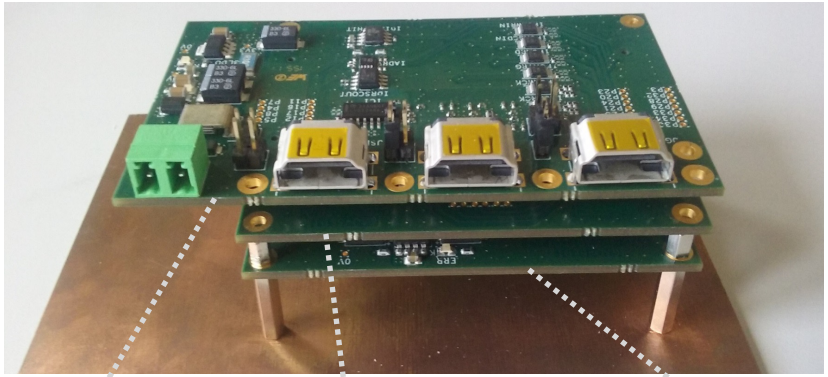


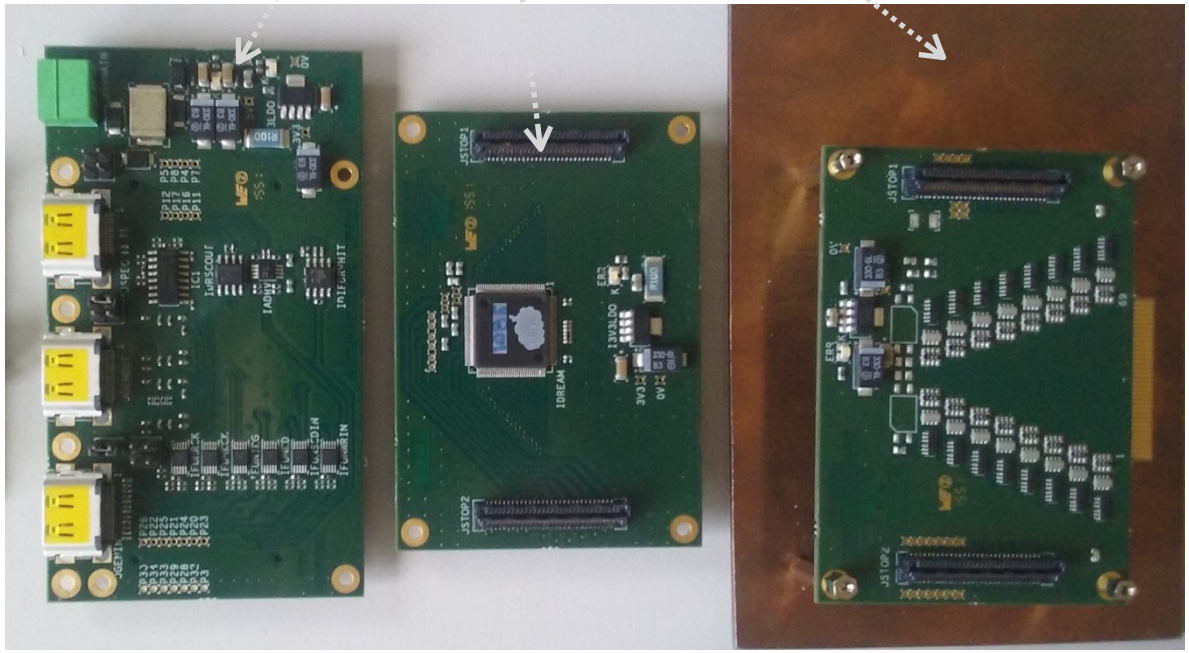
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Status - Barrel MM tracking / Generic R&D

- VFE Test Setup: 3 stackable cards

Stack



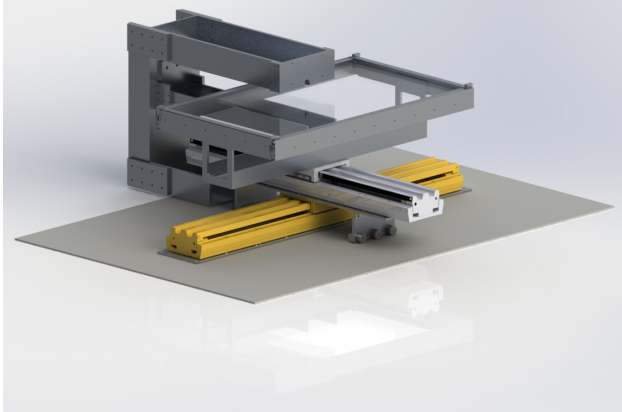


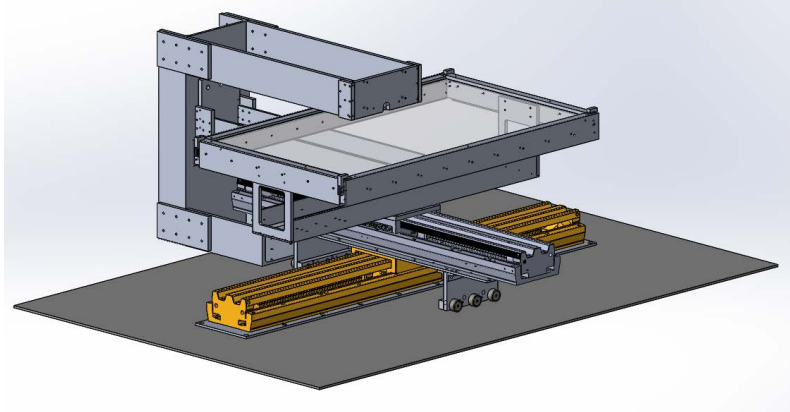
Transceiver Board Dream Board Protection Board

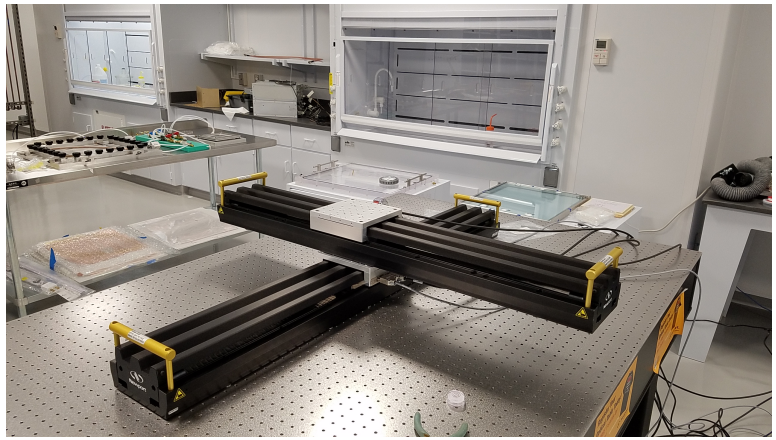
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - Forward GEM Tracking / Generic R&D

- CCD scanner
  - Machining of all parts (~90) underway / Projected completion by end of August 2016
  - Assembly and setup in September 2016
  - Test scan expected in late fall 2016
  - Starting in late fall 2016:
    - Samples: 40cm X 40cm foils (EIC) / 50cm X 50cm (ALICE) and larger EIC prototype (CERN) in collaboration with FIT and UVA
    - Other samples: CMS large foils - Independent optical probe of gain uniformity in collaboration with CMS / CERN
    - New large storage unit for GEM foils (~120cm (L) X ~60cm (D) X ~60cm (H)) in preparation by James Wilhelmi and TU Physics Department machine shop - Expected completion August 2017!
    - Require at least 2 undergraduate students supported by TU CST operating completed CCD scanner
    - Publication of results!







Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - Forward GEM Tracking / Generic R&D

- Triple-GEM detector assembly 40cm X 40cm
  - Component preparation:
    1. GEM foils: All tested and ready to be stretched
    2. 2D readout foils available together with SAMTEC connectors. Soldering to be done by Proxy Inc.
  - Stretching of GEM foils, HV foils and 2D readout foils with leakage current test after each assembly step
  - Stacking and assembly of triple-GEM chamber
  - Gas flow and gas leak tests
  - Cosmic-ray testing

Timeline

June 2016

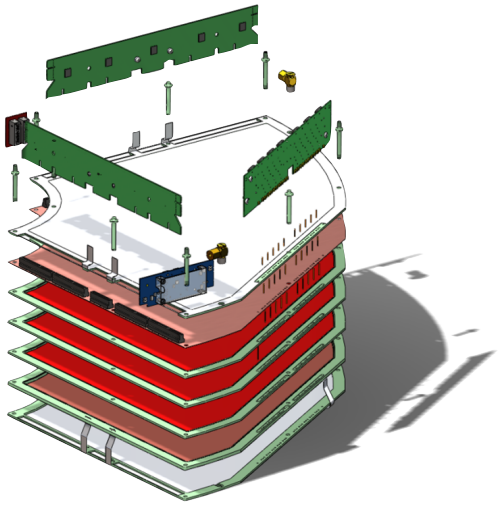
August 2016

August 2016

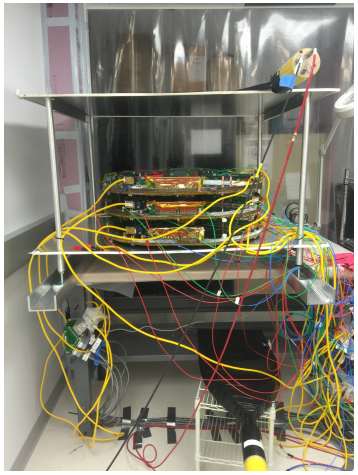
October 2016

December 2016

Spring 2017



Commissioned cosmic-ray test stand

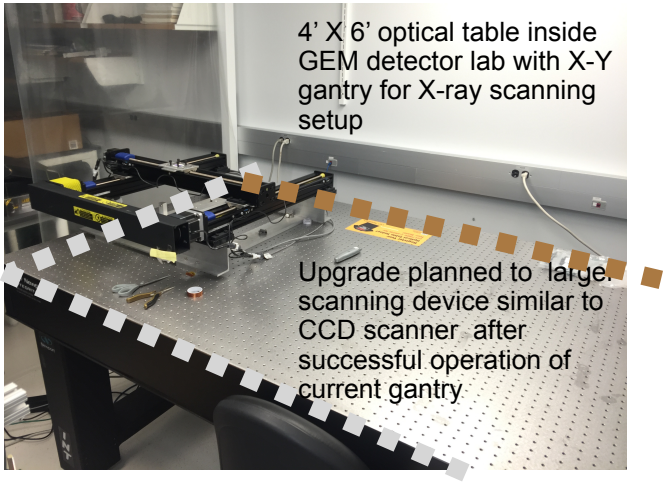


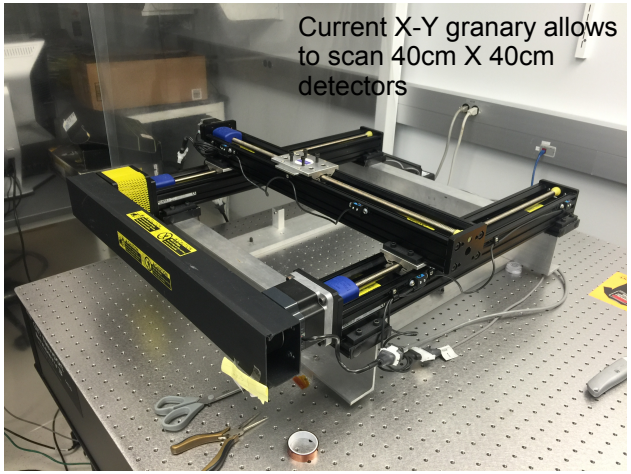
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

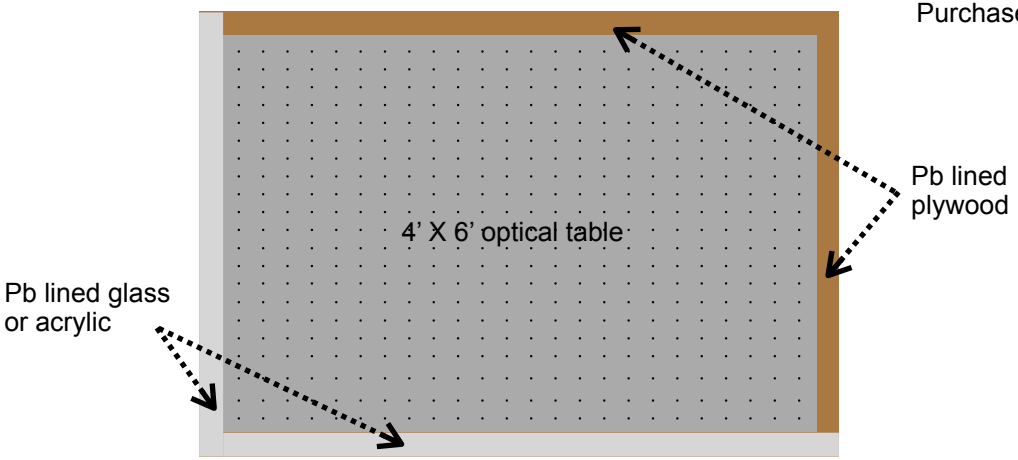
Plans - Forward GEM Tracking / Generic R&D

- X-ray enclosure
  - Design work and assembly by James Wilhelmi
  - Material based on combination of Pb-lined glass or acrylic and plywood (Nelco Inc.) mounted on detector lab 4' X 6' optical table
  - Design requires approval by TU Health Services group

Purchased X-ray gun







Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - Forward GEM Tracking / Generic R&D

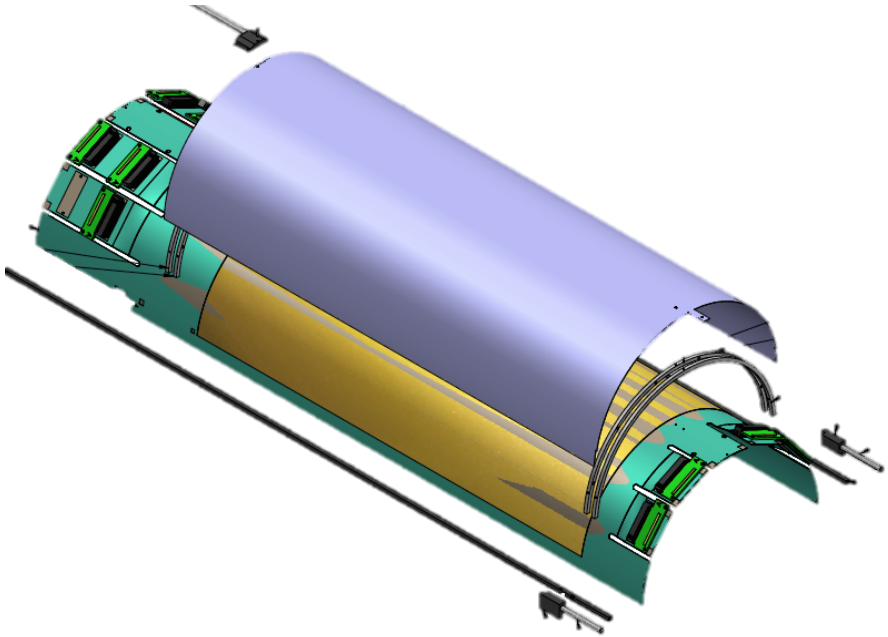
- Commercial component development
  - GEM foils: Tech-Etch Inc. (Continuation of effort of GEM foils will depend on large scale orders - Paused for the moment as directed by Board of Directors and President)
  - HV foils: Tech-Etch Inc. - Continuing!
  - 2D readout foils: Tech-Etch Inc. - Continuing!
  - 2D readout foil / connector soldering: Proxy Inc.
  - Readout module (APV) / Passive DREAM readout card: Sierra Circuits Inc.
  - Frames: Circuit Connect Inc.
  - Kapton rings: Potomac Photonics Inc.

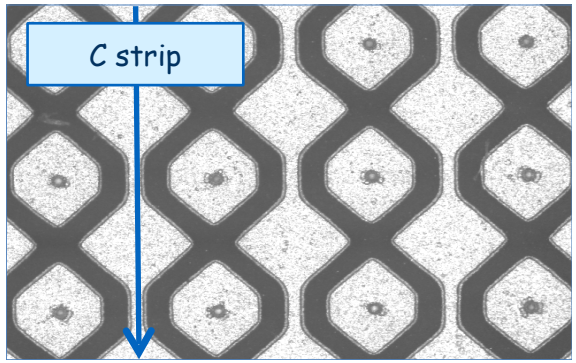
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - Barrel MM tracking / Generic R&D

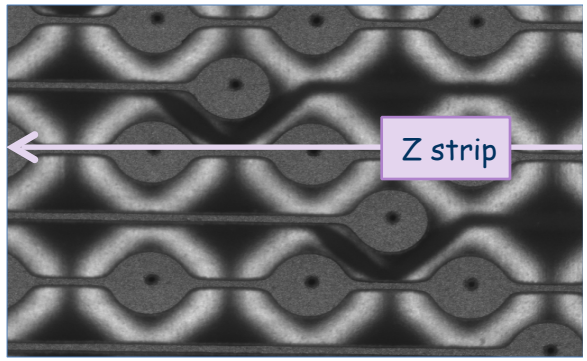
Barrel MM effort

- Main goal for FY17 - 2D design completion
- Next technological step after 1D-curved-resistive, 2D-curved-metallic and 2D-flat-resistive
- Will profit from experience with CLAS12, Asacusa AMT and Mcube
- Complete design of 2D MM prototype detectors followed by ordering of components, assembly and testing





Read-out pattern (top)

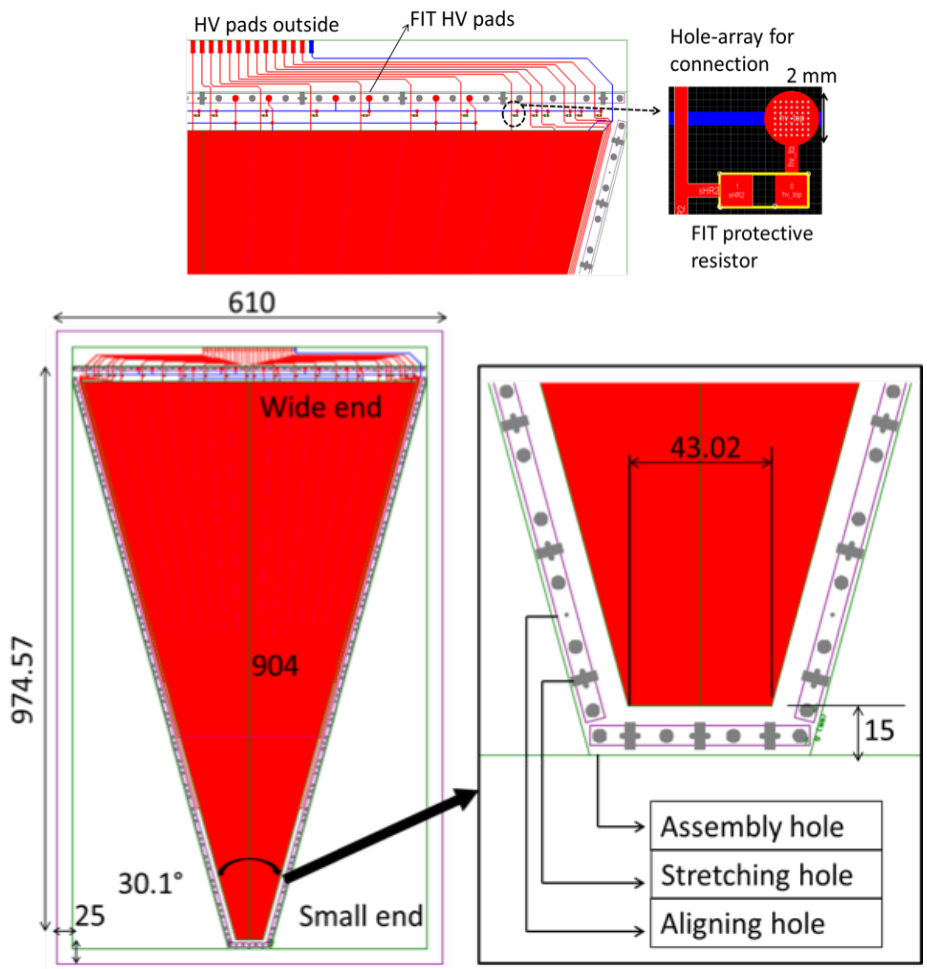


Read-out pattern (bottom)

Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - GEM & MM / Targeted R&D eRD3/6

- Forward GEM effort
  - Acquire component for large sector assembly using different assembly technique and spacer setup compared to FIT and UVA as presented earlier
  - Prepare various new tooling components locally at Temple University
  - Need: 3 GEM foils / 1 2D readout foil / 1 HV foil / 6 sets of frames / Tooling / Labor and machining
  - Visit at UVA for information exchange on July 19, 2016



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

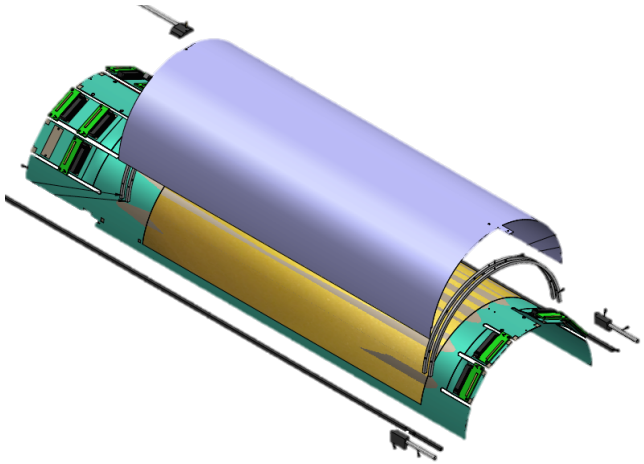
Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - GEM & MM / Targeted R&D eRD3/6

- Barrel MM effort

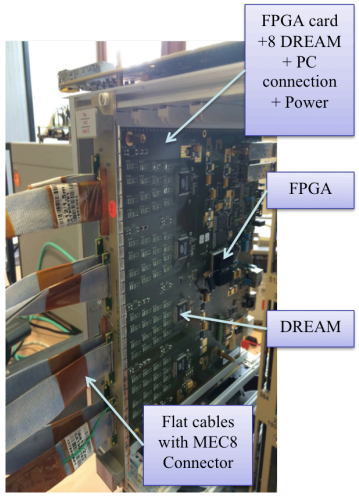
Timeline

- Ordering of components, assembly and testing (Generic R&D) — FY 17



- Testing — FY 18

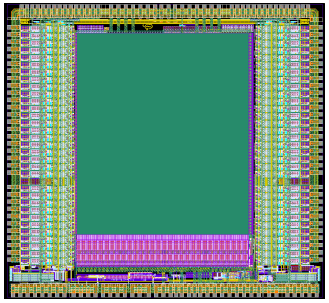
- Preparation of standalone DREAM-chip based DAQ system at Temple University — FY 17

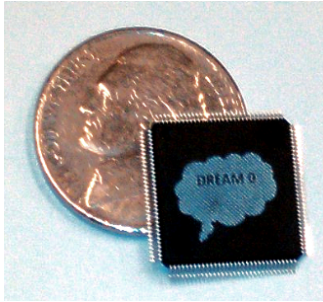


Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Plans - GEM & MM / Targeted R&D eRD3/6

- DREAM chip readout development
  - Reminder: Dream ASICs have been solely used so far in an off-detector front-end configuration
    - 1 to 2m long micro-coaxial cables to transport bare signals from detectors to the front-end
    - Increased noise due to cable capacitances
    - Noise pick-up is not excluded despite cable shielding
  - Goal: Implement a modular Dream-based Very-Front-End (VFE) system to provide various modular configuration for EIC R&D programs (MM / GEM) - Critical beyond APV / SRS system
    - Analog VFE contains only Dream ASIC
      - Remote ADC and digital electronics housed on off-detector front-ends or even on backend electronics
      - Develop a solution for long distance (3, 5, 10m) transmission line for the Dream differential analog output signal
    - Mixed analog-digital VFE contains Dream ASIC and ADC (and possibly some digital signal processing means)
    - Study synchronization (clock-trigger) and control signal distribution
  - Outcome: Improve S/N ratio and Dream-based trigger efficiency





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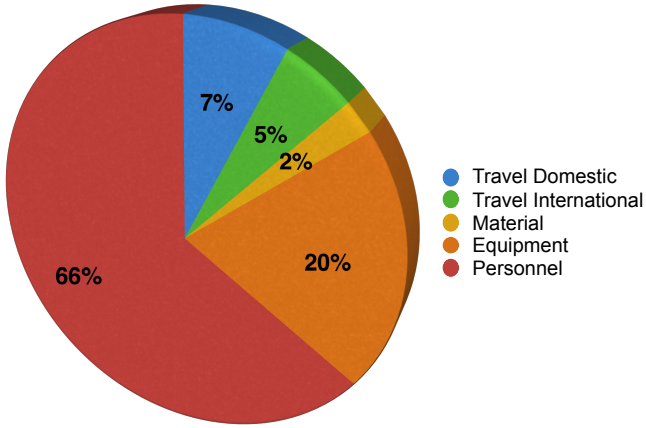
Bernd Surrow (PI) and Franck Sabatie (PI)

Budget request FY17 / Generic R&D

Generic R&D

- Highest priority: Continued (2nd year) postdoc support
- Travel support: $8,250 (Domestic) + $5,600 (International)
- Material: $2,500 (Triple-GEM assembly)
- Equipment: $22,000 (MM 2D $12,000 / X-ray enclosure $10,000)
- Total: $161,732 (Incl. 56% overhead)

DOE EIC R&D / eRD3 - Dr. Bernd Surrow (PI) (Temple University)	
	FY 2017
PERSONNEL	
Post Docs	$56,368
Fringe Benefits	
29.9% on Post Doc	$16,854
Total Personnel	$73,222
Travel - Domestic	$8,250
Travel - International	$5,600
Material	$2,500
Equipment	$22,000
OTHER:	
Total Direct Costs	$111,572
Modified Total Direct Costs (MTDC)	$89,572
F&A: On-Campus Overhead 56%	$50,160
Total Project Costs	$161,732

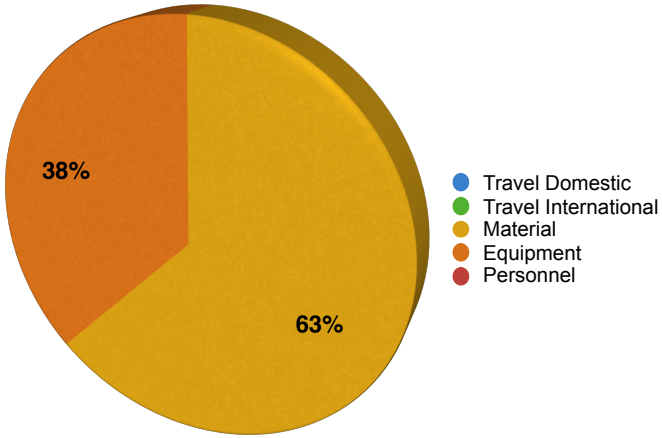


Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Budget request FY17 / Targeted R&D eRD3/6

- Target R&D request
  - Material: $20,000 (3 GEM foils / 1 2D readout foil / 1 HV foil / 6 sets of frames / Tooling / Labor and machining)
  - Equipment: $12,000 (DREAM-chip readout system)
  - Total: $43,000 (Incl. 56% overhead)

DOE EIC R&D / eRD3/6 - Dr. Bernd Surrow (PI) (Temple University)	
	FY 2017
PERSONNEL	
Post Docs	$0
Fringe Benefits	
29.9% on Post Doc	$0
Total Personnel	$0
Travel - Domestic	$0
Travel - International	$0
Material	$20,000
Equipment	$12,000
OTHER:	
Total Direct Costs	$32,000
Modified Total Direct Costs (MTDC)	$20,000
F&A: On-Campus Overhead 56%	$11,200
Total Project Costs	$43,200



Total (Generic and Targeted R&D): $204,742 (Incl. 56% overhead)

Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Timeline

R&D schedule

- Critical items:

  Manpower (Postdoc and undergraduate students) and procurement of components

- Assumptions:

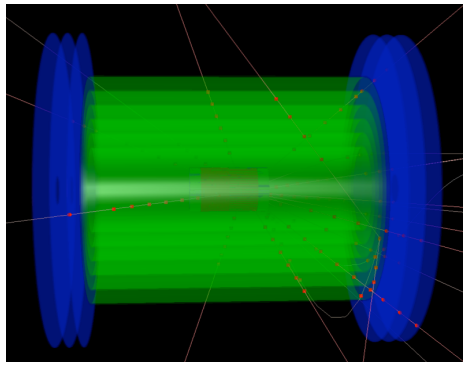
  At least two undergraduate students from TU CST URP program and availability of FY17 funding in April 2017

EIC R&D Forward and Barrel R&D Schedule eRD3 (Generic R&D) and eRD3/6 (Targeted R&D)	Time in Months for FY 2017											
Items	10	11	12	1	2	3	4	5	6	7	8	9
(1) Forward triple-GEM R&D:												
40 X 40cm^2: Component preparation (Generic R&D)	■											
40 X 40cm^2: Assembly Large GEM foil storage unit (Generic R&D)	■											
40 X 40cm^2: Operation of Large GEM foil storage unit (Generic R&D)		■										
40 X 40cm^2: Stretching of foils (Generic R&D)	■	■										
40 X 40cm^2: Stacking of frames (Generic R&D)		■	■	■								
40 X 40cm^2: Gas flow and gas leak tests (Generic R&D)				■	■							
40 X 40cm^2: Cosmic-ray testing (Generic R&D)						■	■	■	■	■	■	■
CCD scanner: Assembly (Generic R&D)	■	■										
CCD scanner: Test scan (Generic R&D)			■	■								
CCD scanner: Scans of various large foils (ALICE / CMS / EIC) (Generic R&D)					■	■	■	■	■	■	■	■
X-ray enclosure: Complete design (Generic R&D)	■	■	■									
X-ray enclosure: Procurement of parts (Generic R&D)							■	■				
X-ray enclosure: Assembly (Generic R&D)									■	■		
X-ray enclosure: Operation (Generic R&D)											■	■
EIC sector: Acquire components / New tooling (Targeted R&D)									■	■	■	■
(2) Barrel MicroMegas R&D:												
2D MM: Design of prototype (Generic R&D)	■	■	■	■								
2D MM: Procurement (Generic R&D)							■	■				
2D MM: Testing (Generic R&D)									■	■	■	■
DREAM: TU GEM readout system design (Targeted R&D)	■	■										
DREAM: TU GEM readout system procurement (Targeted R&D)							■	■				
DREAM: TU GEM readout system assembly and test (Targeted R&D)									■	■	■	■
DREAM: Development of modular readout (Targeted R&D)	■	■	■	■	■	■	■	■	■	■	■	■

Matt Posik, Maxence Vandenbroucke,
Bernd Surrow (PI) and Franck Sabatie (PI)

Summary / Outlook

- Summary / Outlook
  - Forward GEM tracking
    - Generic R&D:
      - Acquired majority of components and prepared tooling for 40cm X 40cm assembly / Assembly over next 1/2 year
      - Design of CCD scanner completed / machining of parts started / Assembly and testing over next 1/2 year
      - Design of X-ray enclosure started / Urgently needed for operation of existing X-ray gun
    - Targeted R&D: Order components for large EIC sector segment by spring 2017 followed by assembly
  - Barrel MicroMegas tracking
    - Generic R&D: Design and assembly of 2D MM - Critical step to complete R&D program
    - Targeted R&D: Dream chip readout system
  - Fully merge eRD3/6 efforts beyond generic R&D programs
  - 5th International Conference on Micro-Pattern Detectors (MPGD2017) at Temple University: Strong recognition of EIC R&D program
    - Organization by eRD3/6 gas detector groups
    - Date: May 22-26, 2017



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