The STAR Forward GEM Tracker (FGT)

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(On behalf of the STAR Collaboration)

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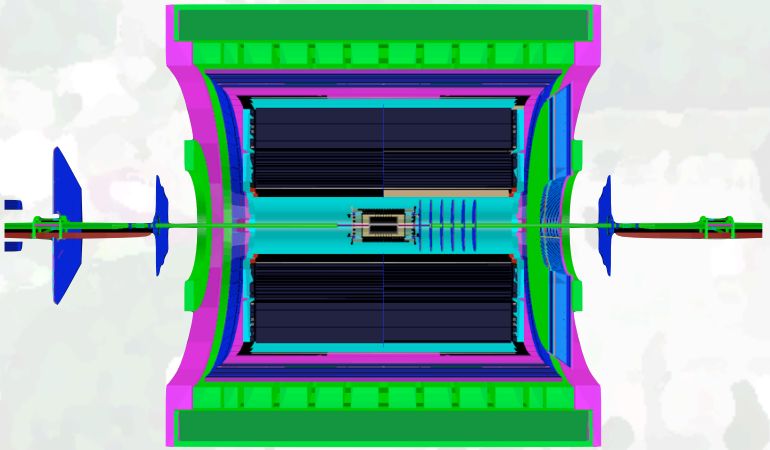
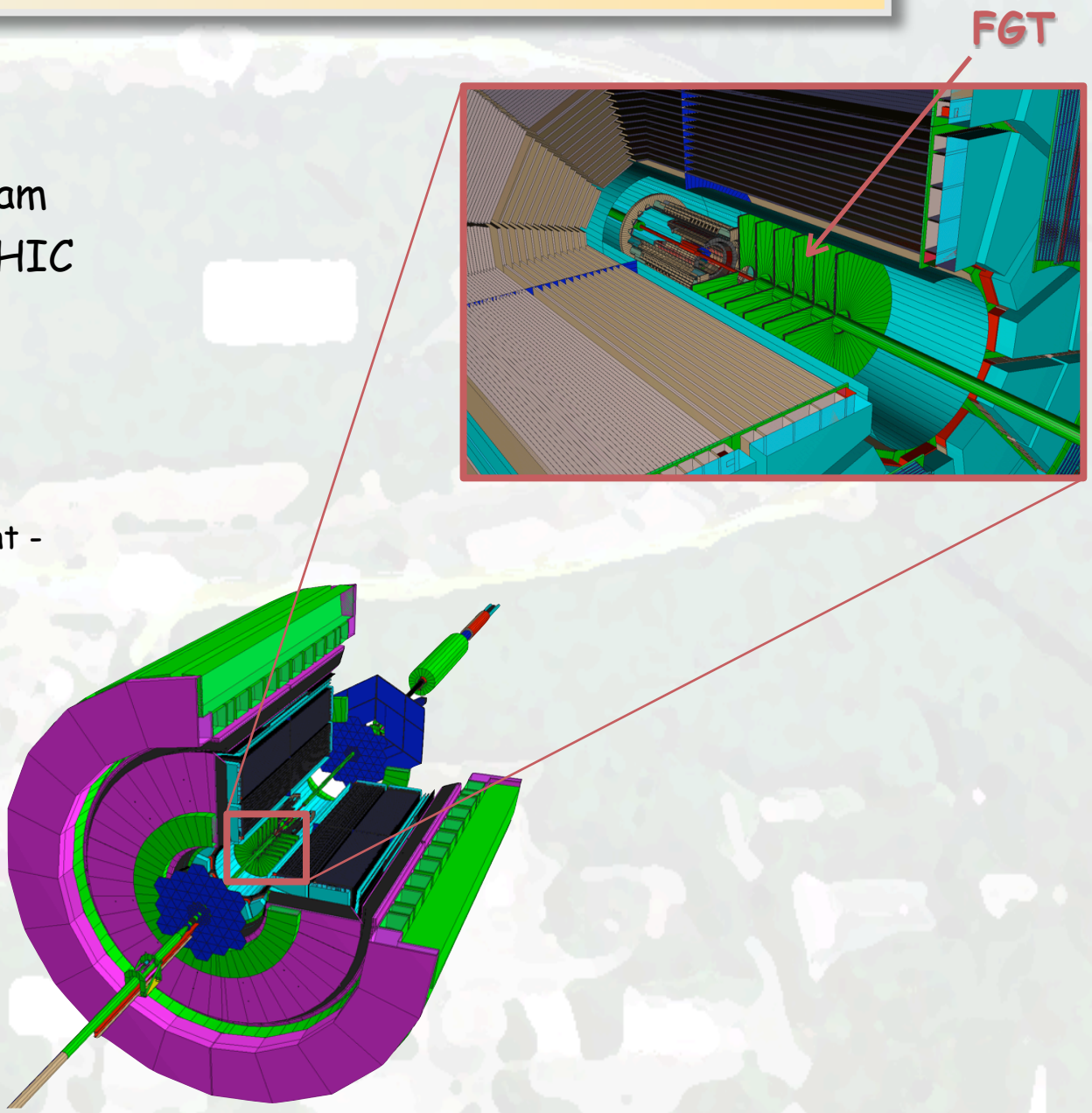


Outline

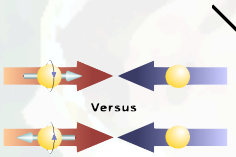
- Physics motivation - W program in polarized pp collisions at RHIC
- FGT Technical Realization
  - Triple-GEM detector development - R&D
  - Mechanical design
  - Front-End Electronics
- Summary



FGT Physics motivation - W program

Quark / Anti-Quark Polarization - W production

$$\Delta d + \bar{u} \rightarrow W^-$$
$$\Delta \bar{u} + d \rightarrow W^-$$



$$W^{\mp}$$

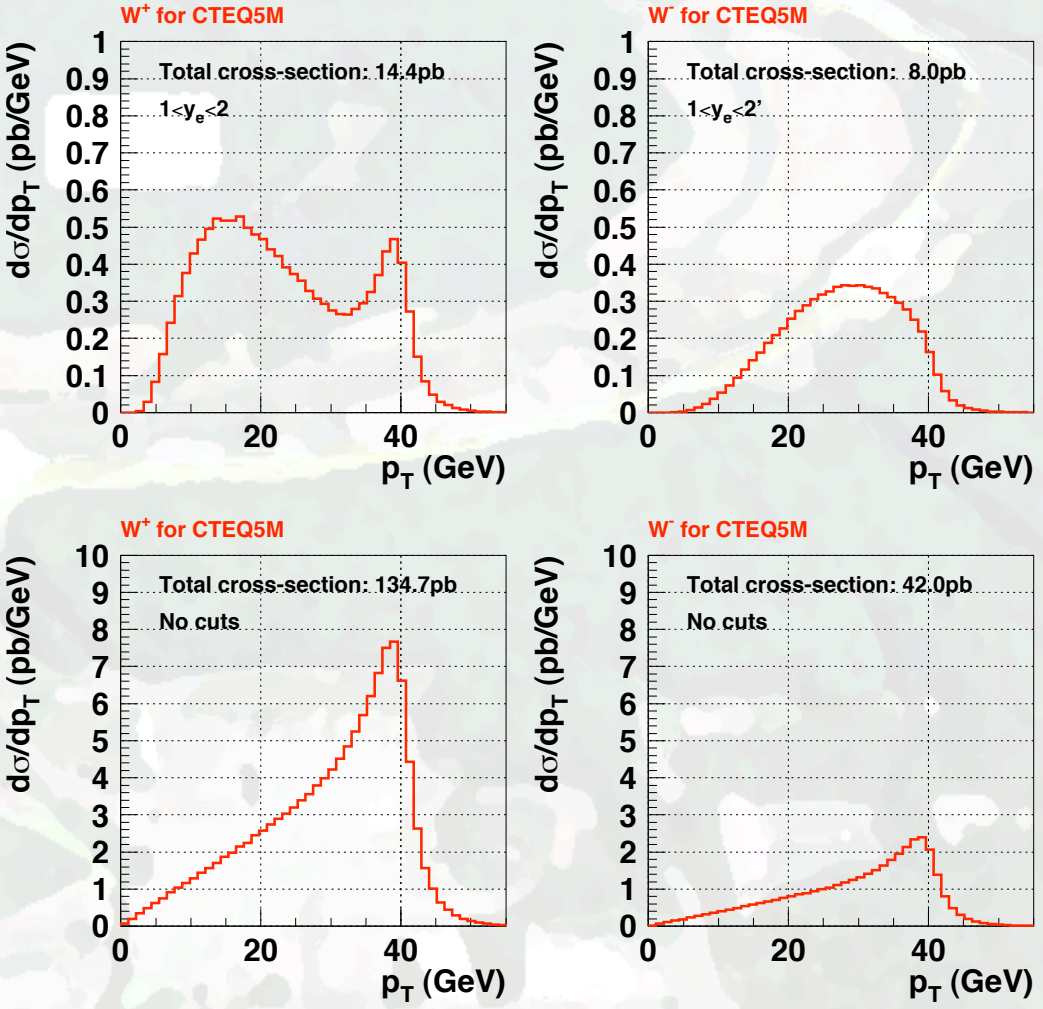
$$W^- \rightarrow e^- + \bar{\nu}_e$$

$$A_L^W = \frac{1}{P}\frac{N^+(W) \quad N^-(W)}{N^+(W) \quad N^-(W)}$$

$$W^+ \rightarrow e^+ + \nu_e$$

$$\Delta \bar{d} + u \rightarrow W^+$$
$$\Delta u + \bar{d} \rightarrow W^+$$

RHICBOS W simulation at 500GeV CME



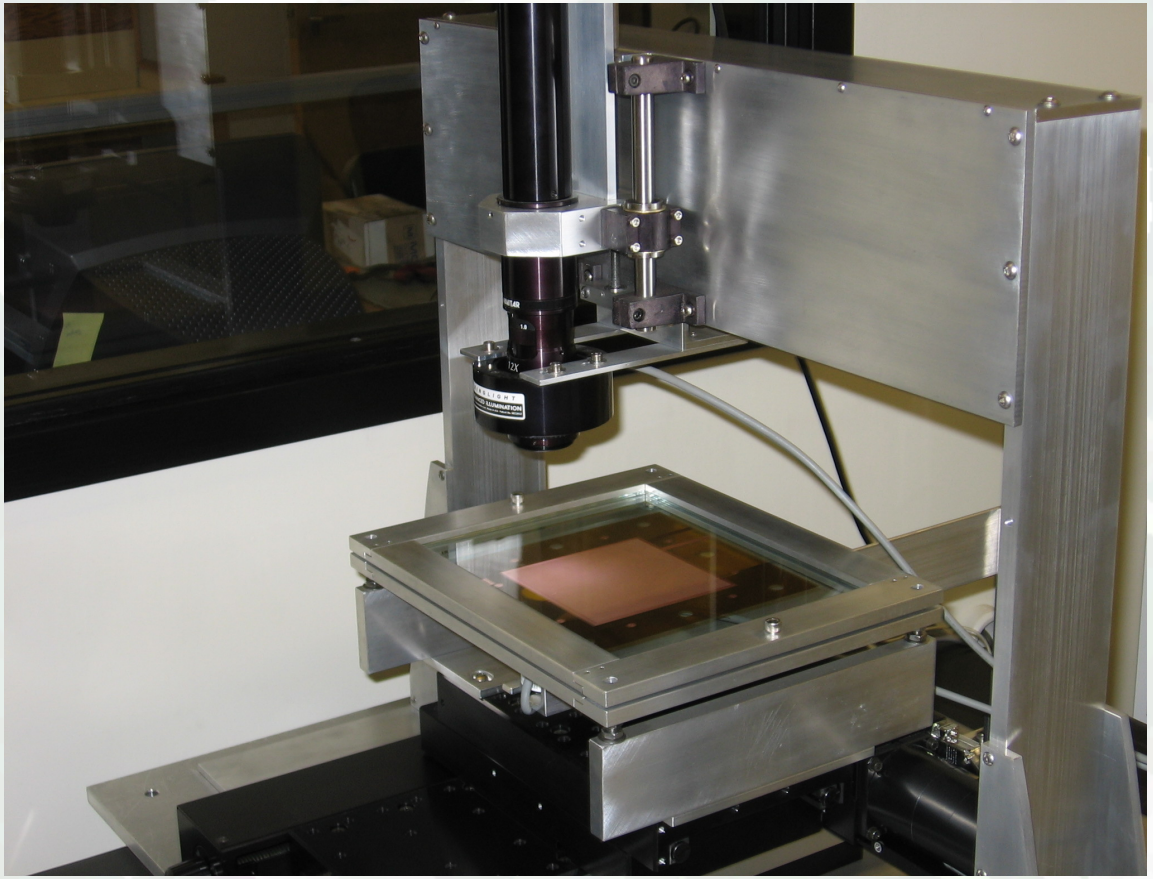
- Key signature: High p_T lepton (e^-/e^+ or μ^-/μ^+) (Max. $M_W/2$) - Selection of W^-/W^+ : Charge sign discrimination of high p_T lepton
- Required: Lepton/Hadron discrimination

FGT Technical realization

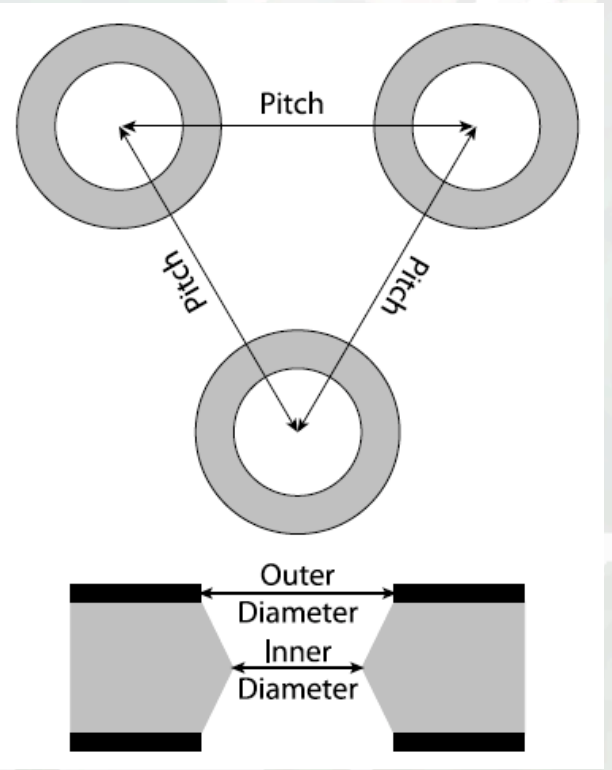
- SBIR proposal
  - SBIR: Small Business Innovation Research: US Government (DOE) funded program
    - ☑ Phase I: Explore feasibility of innovative concepts with award of up to $100k
    - ☑ Phase II: Principal R&D effort with award of up to $750k
    - ☐ Phase III: Commercial application
  - SBIR: Collaborative effort of Tech-Etch Inc. with BNL, MIT and Yale University - Production of GEM foils
    - ☐ Develop optimized production process for small (10cm X 10cm) and larger GEM foils
    - ☐ Investigate a variety of materials
    - ☐ Study post production handling: Cleaning, surface treatment and storage
  - New SBIR proposal: 2D readout board using chemical etching : Recently approved!

FGT Technical realization

- Optical scans (1)



- 2D scanning table with CCD camera - fully automated
- Scan GEM foils to measure hole diameter (inner and outer) and pitch

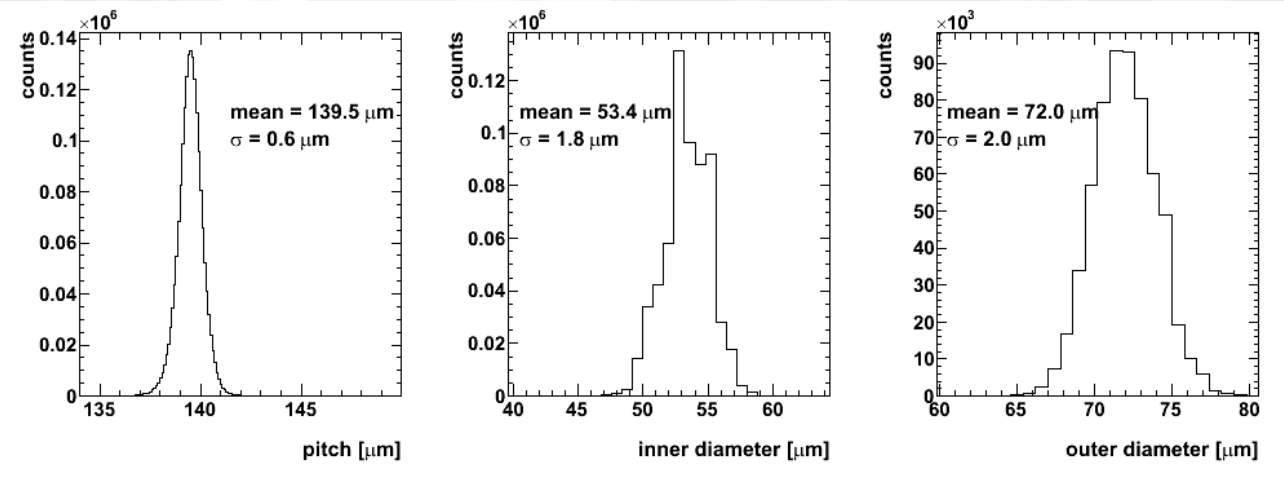


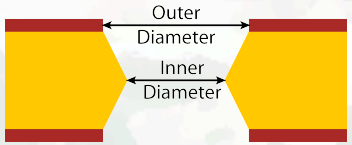
- Check for defects:
  - Missing holes, enlarged holes, dirt in holes and etching defects

FGT Technical realization

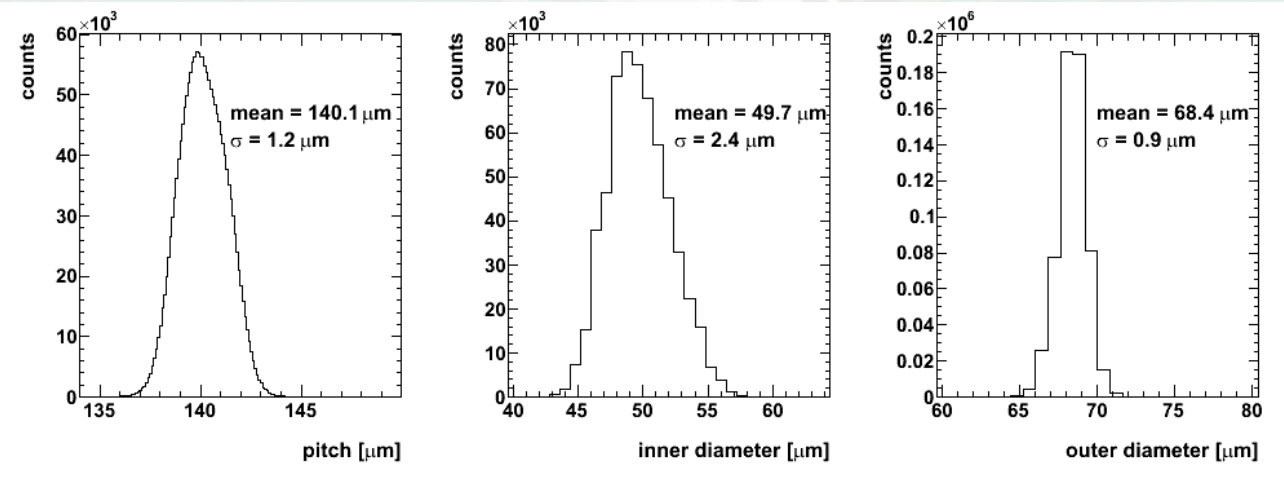
- Optical scans (2)

Tech-Etch





CERN

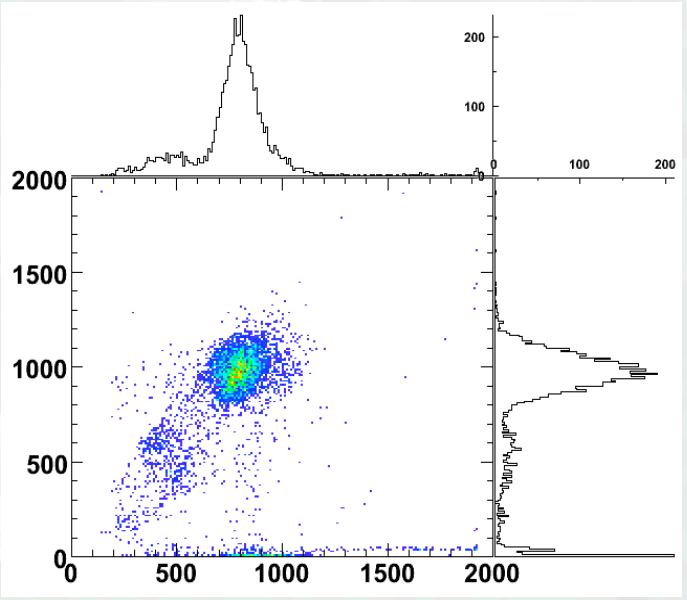


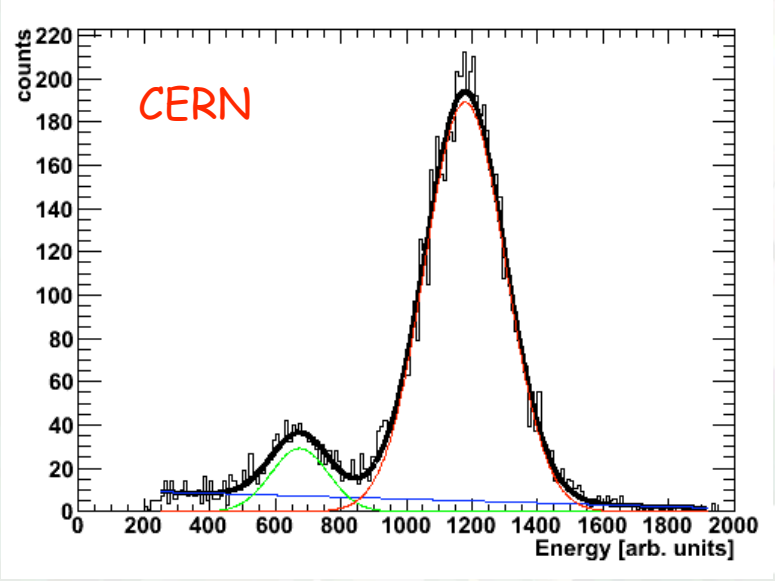
- Geometrical parameters are similar for Tech-Etch and CERN foils (10cm X 10cm samples)

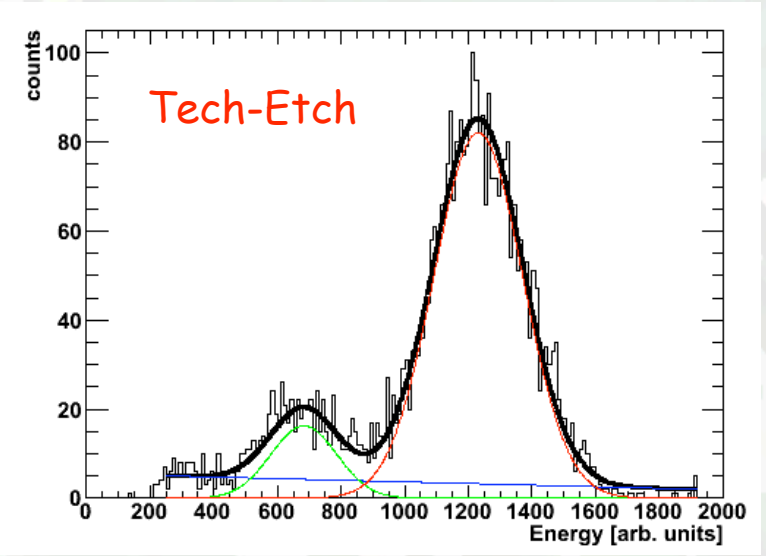
FGT Technical realization

- Source tests
  - Two identical detectors, one with CERN foils, one using Tech-Etch foils
  - Both detectors give reasonable X-Ray spectrum using ^{55}Fe source with comparable energy resolution (~20%)

Correlation of X-Y readout plane

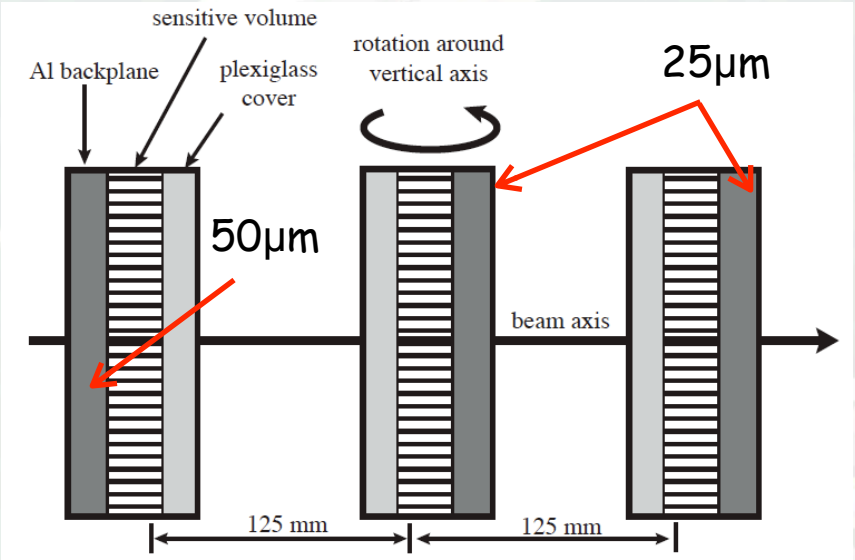


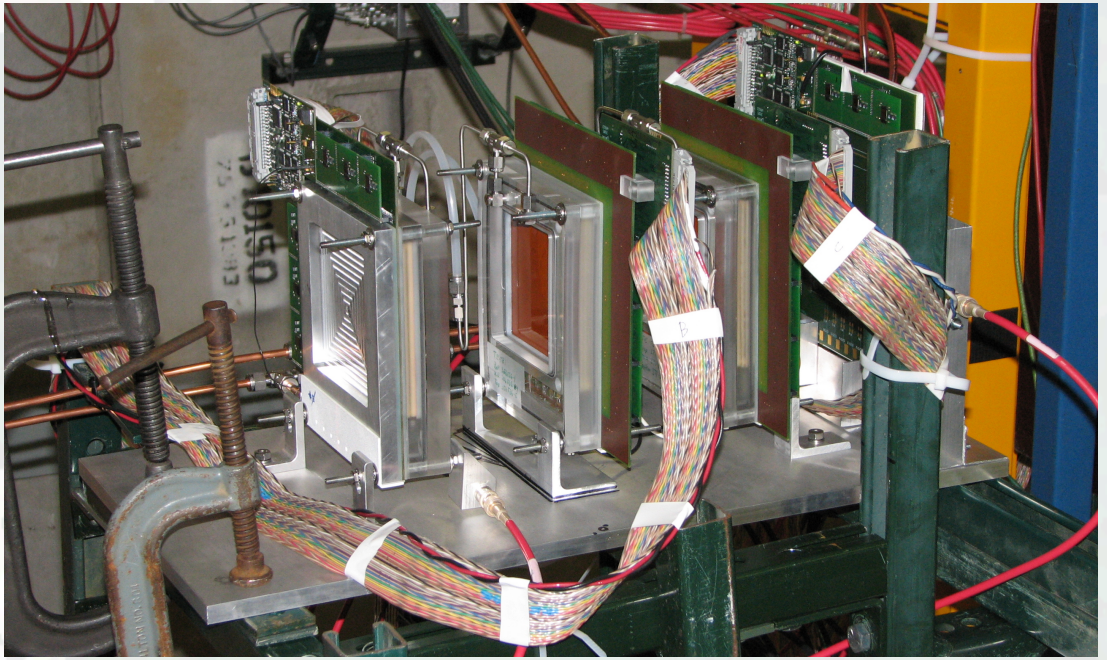




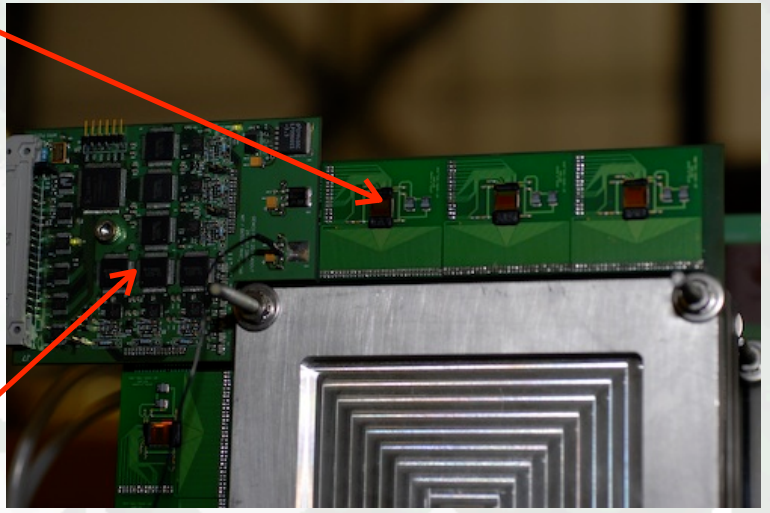
FGT Technical realization

- Testbeam results (1)





APV25-S1



FPGA Readout System

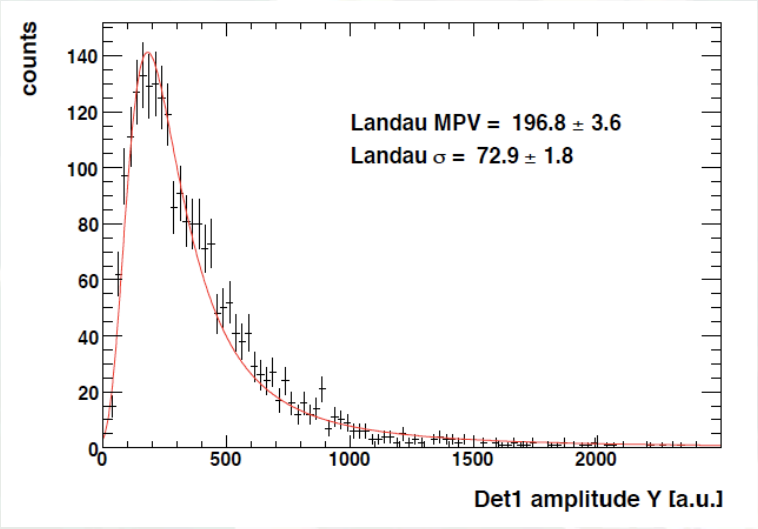
- FNAL Meson Test Beam Facility: Data taking with

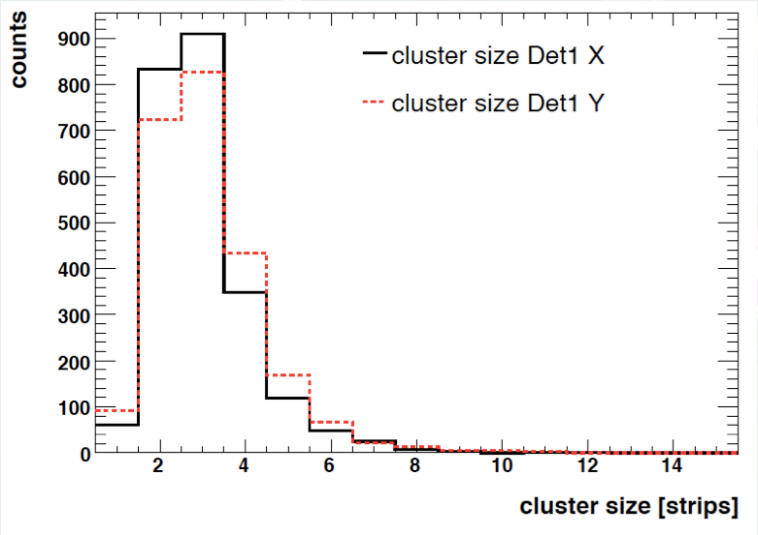
  4GeV-32GeV unseparated secondary beam and

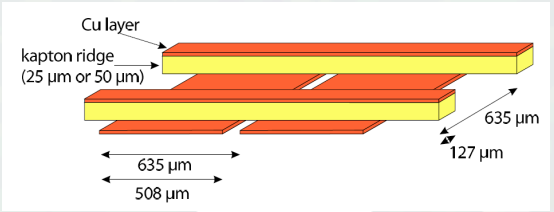
  120GeV primary proton beam

FGT Technical realization

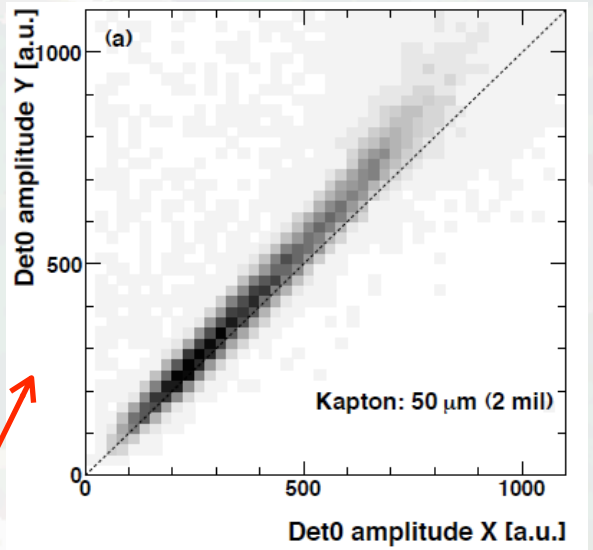
Testbeam results (2)

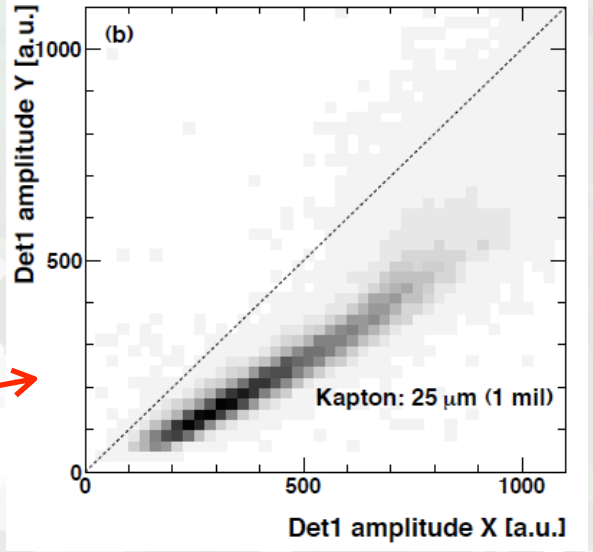






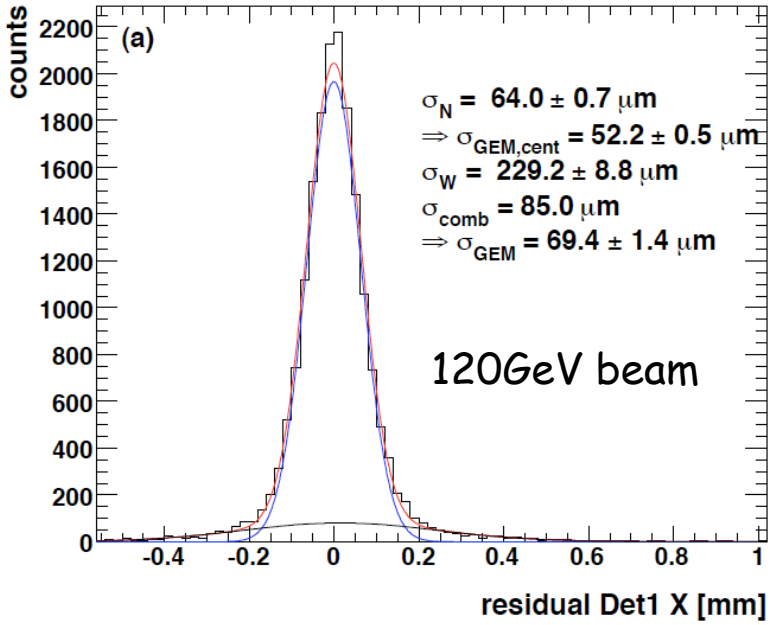
- Cluster charge follows expected distribution
- Two version of readout board (50µm and 25µm)

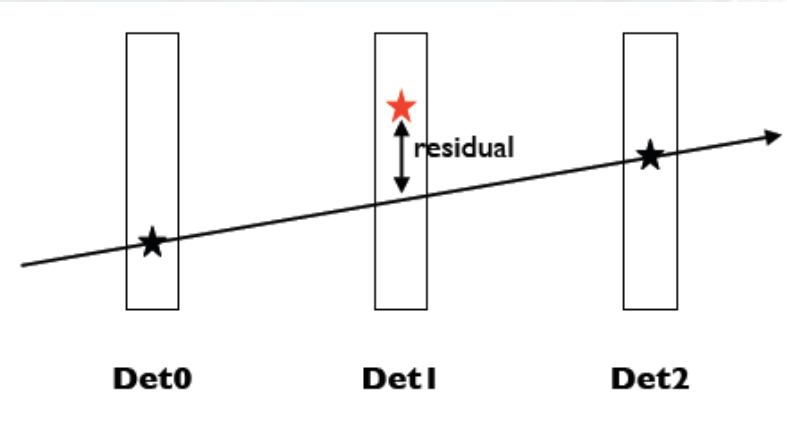


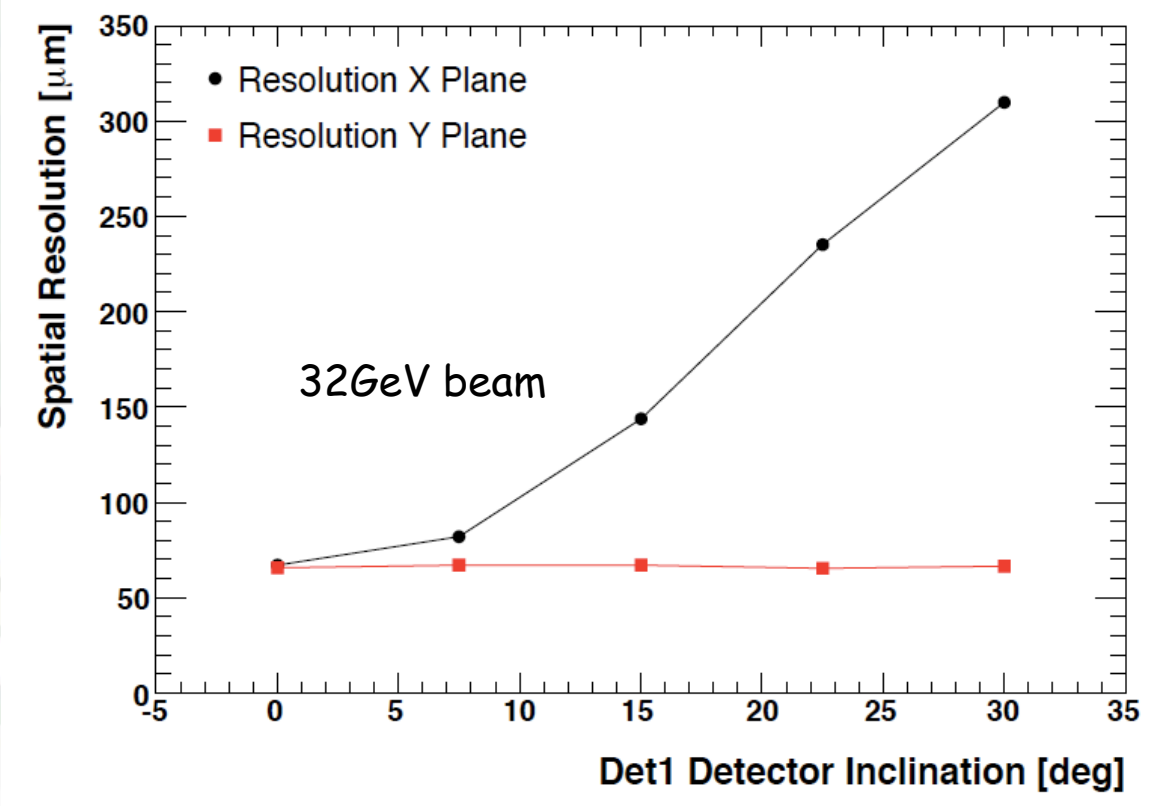


FGT Technical realization

- Testbeam results (3)



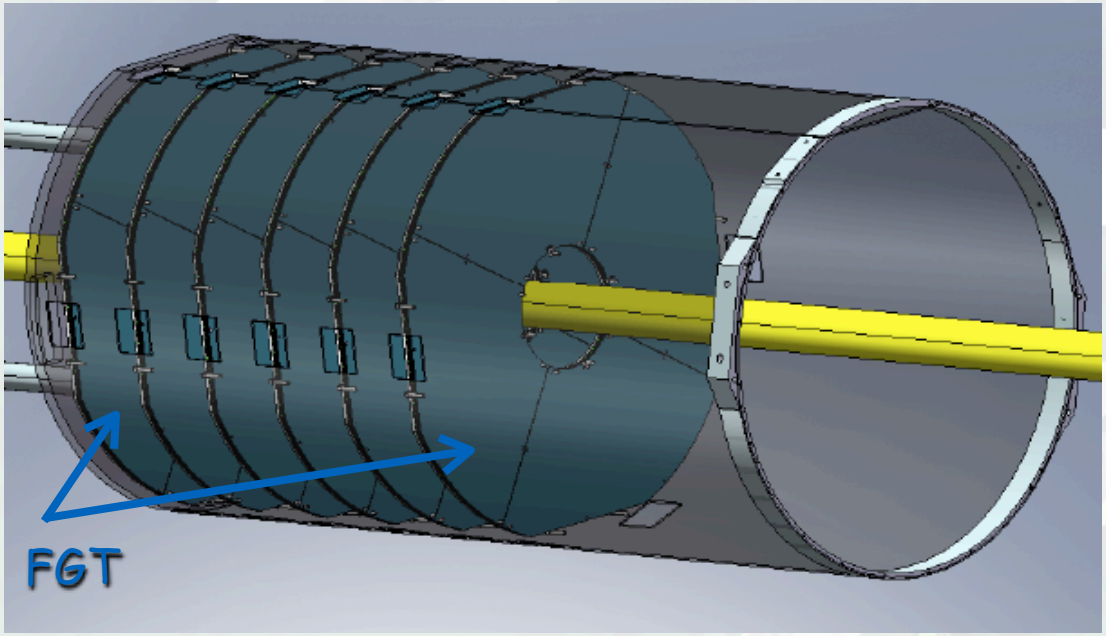


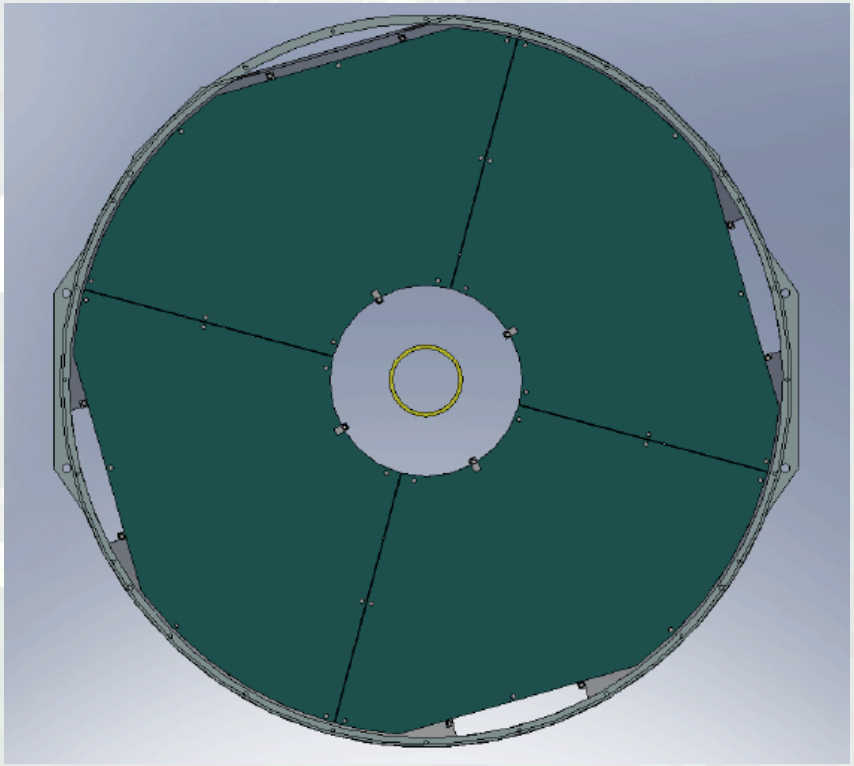


- Study of inclination by up to 30°: Only X (horizontal) resolution is affected, not so for Y (vertical) coordinate as expected!

FGT Technical realization

- Layout

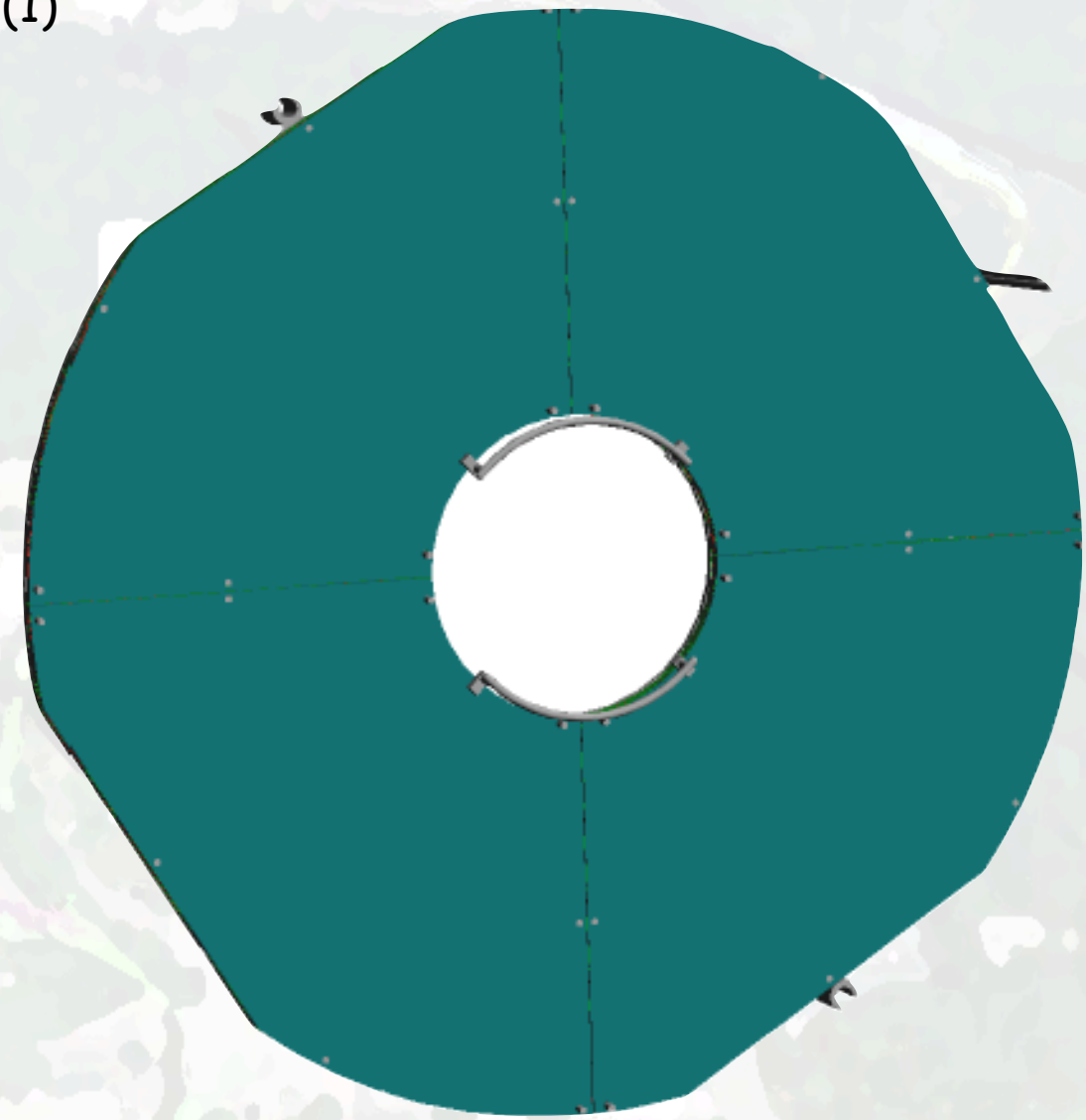




- FGT: 6 light-weight disks
- Each disk consists of 4 triple-GEM chambers (Quarter sections)
- Procurement and assembly of full quarter section prototype in preparation

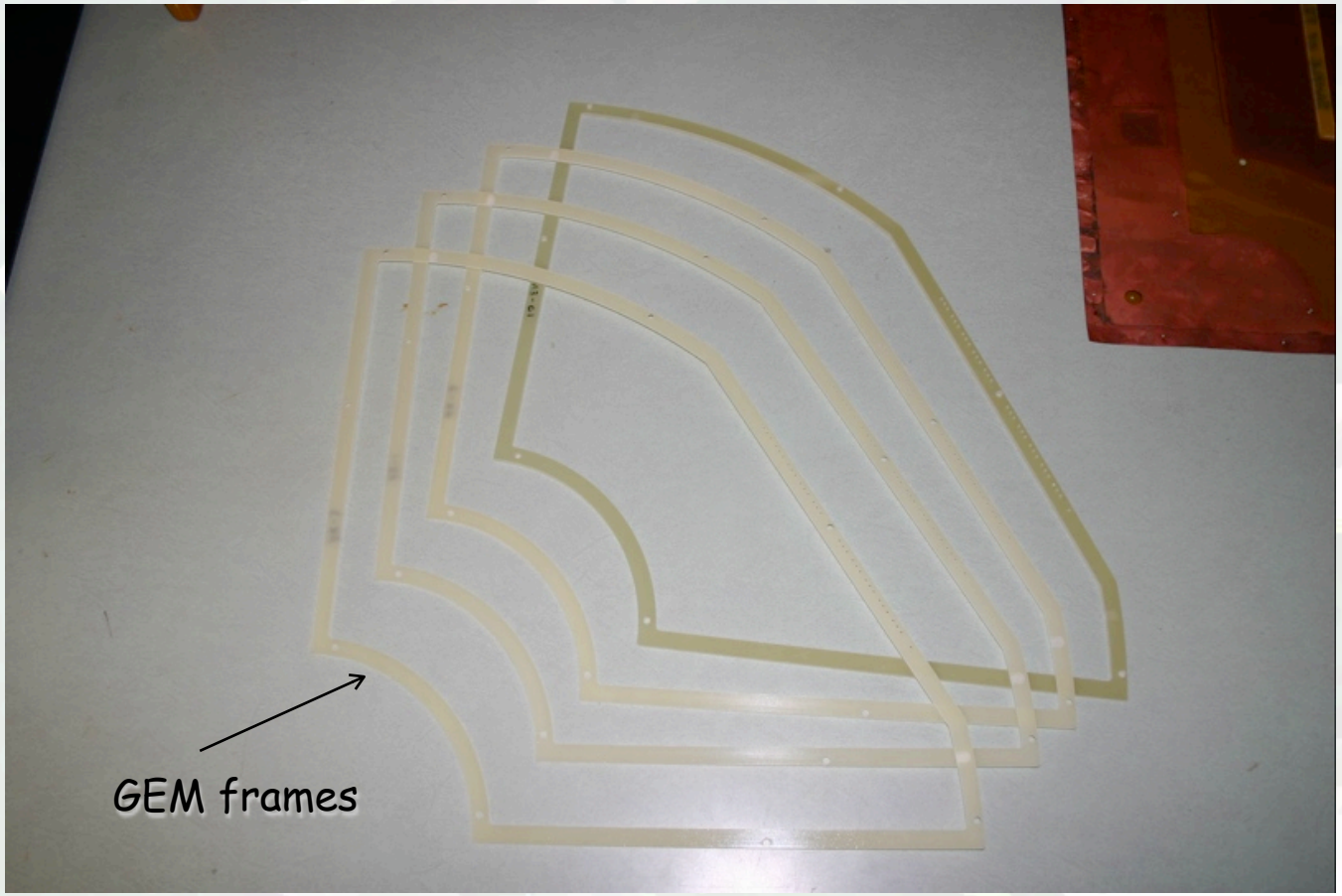
FGT Technical realization

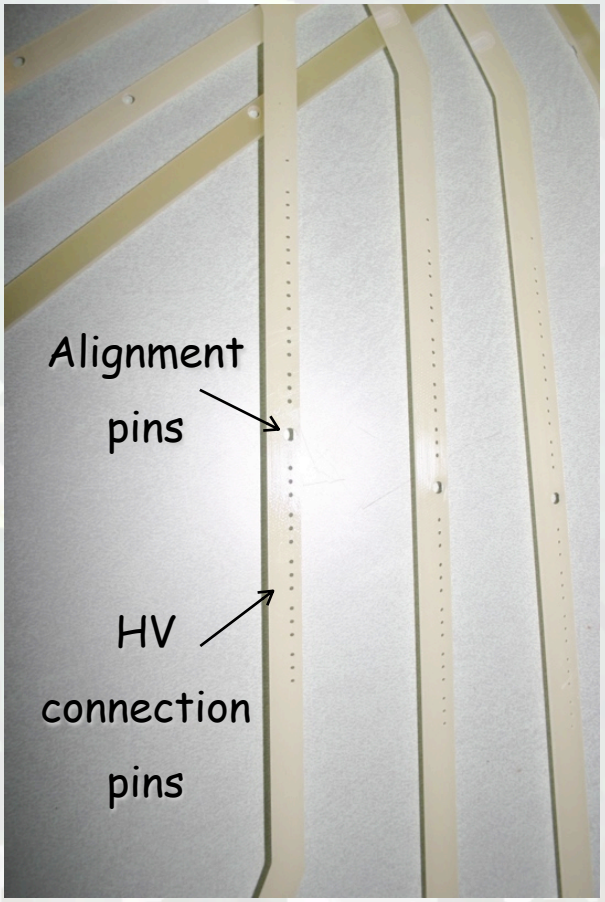
- Triple-GEM: Quarter section design (1)
  - Single disk
    - 5mm Nomex honeycomb
    - 0.25mm FR4 skins
    - Pins used as part of assembly and alignment
  - GEM quadrant
    - Pins define position
    - Pins preserve shape
  - Gas manifolds and rails



FGT Technical realization

- Triple-GEM: Quarter section design (2)

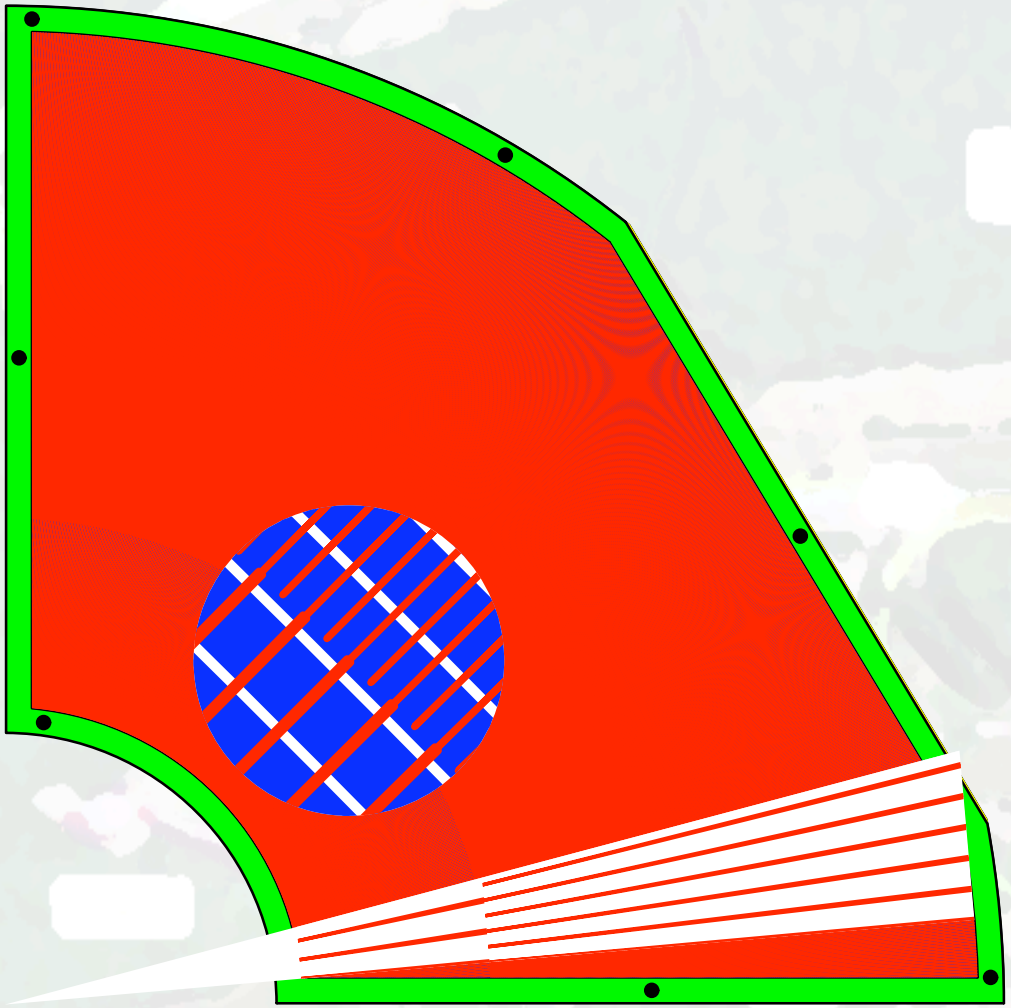




- Dimensions close to final design (WSC dimensions)
- Verify mechanical detail
- Develop stretching and assembly fixtures / Test flatness of GEM foils

FGT Technical realization

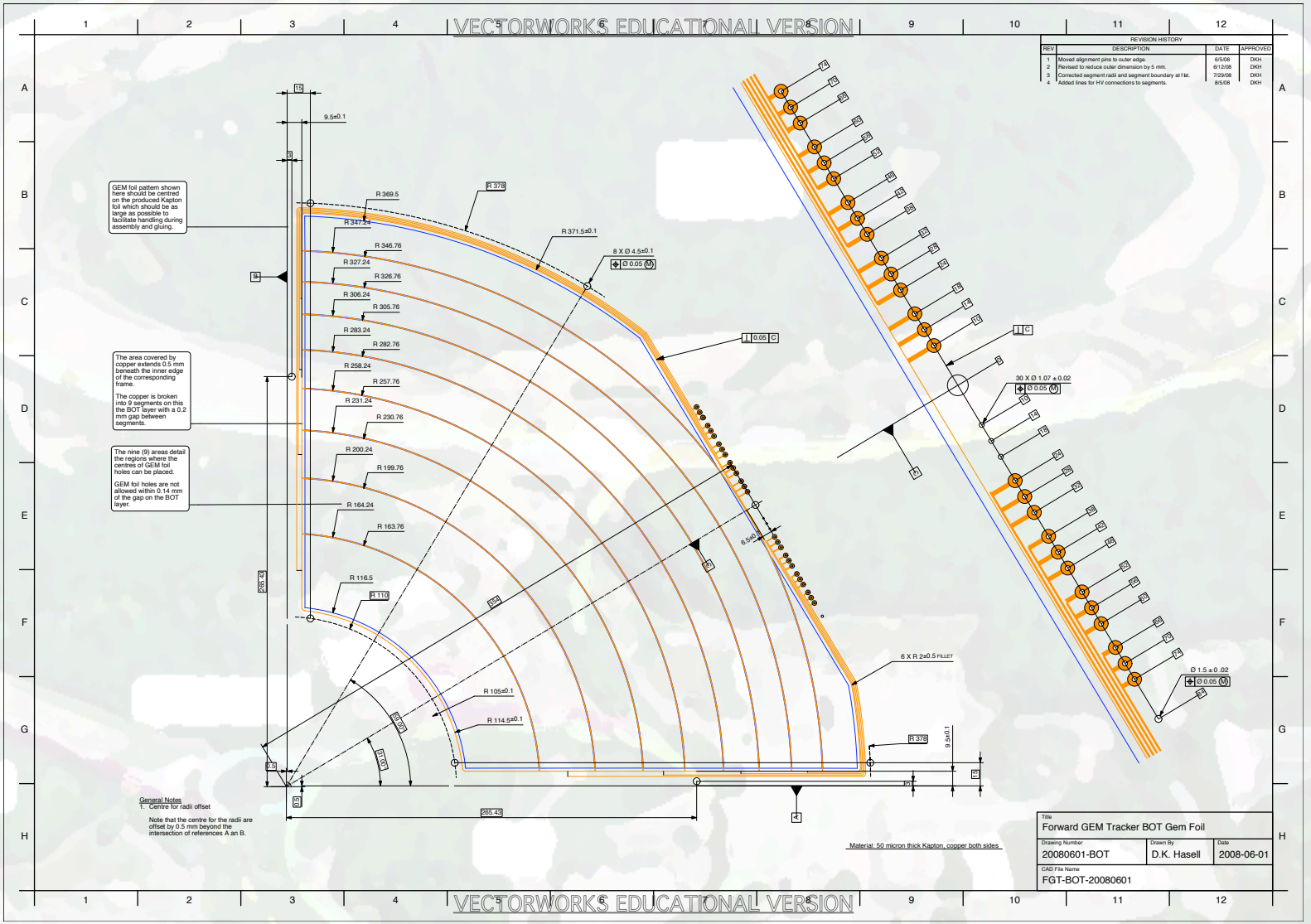
- Triple-GEM: Quarter section design (3)



- 50 μm Kapton
  - Copper on both sides
  - Laser etching exposes bottom layer
- Top layer
  - Φ-readout layer
  - Alternate lines end at 18.8cm
  - Pitch: 300-600 μm
  - Line width: 80-120μm
- Bottom layer
  - R-readout layer
  - Pitch: 800μm
  - Line width: 700μm

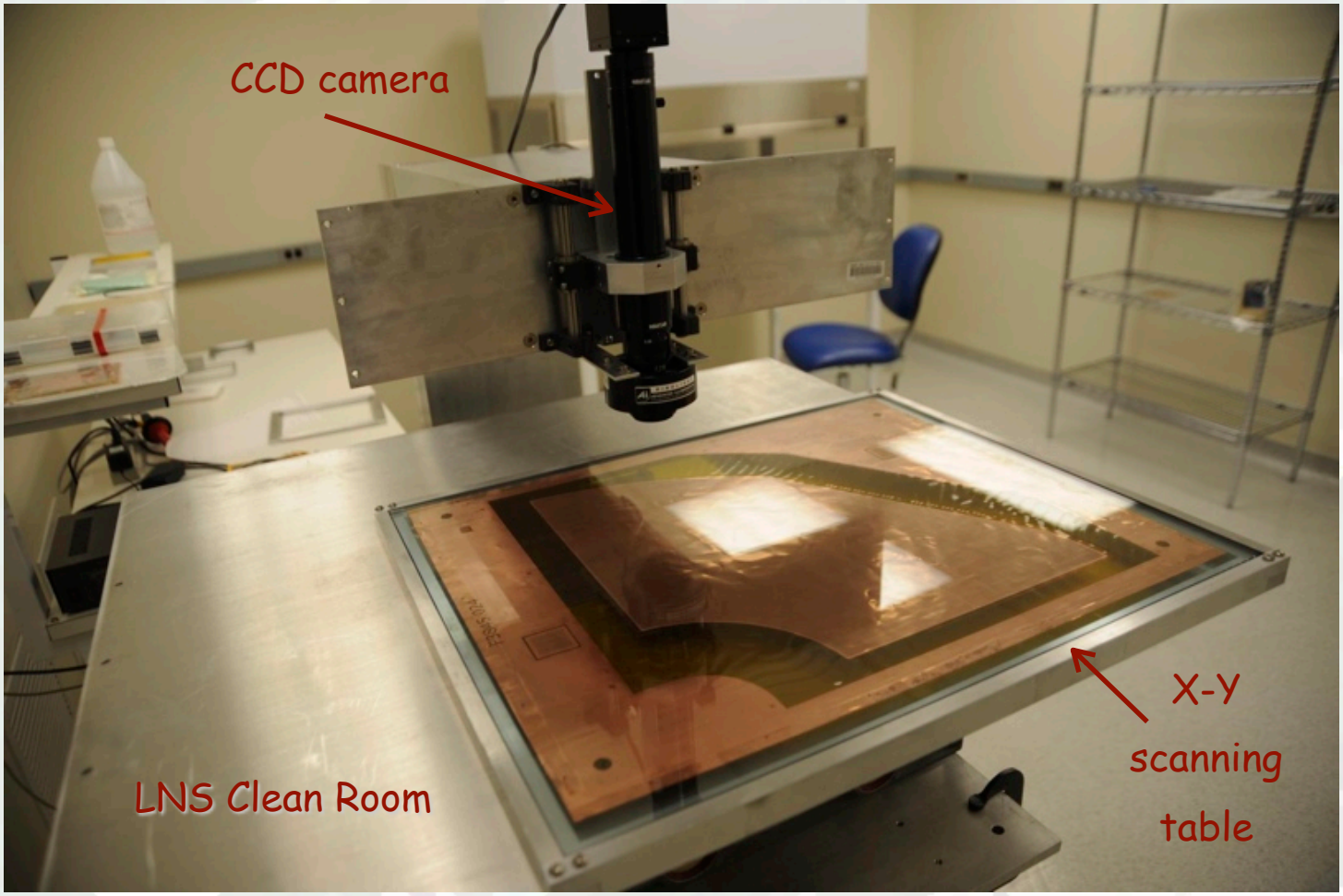
FGT Technical realization

Triple-GEM: GEM foil design



FGT Technical realization

- Triple-GEM: GEM foil testing (1)



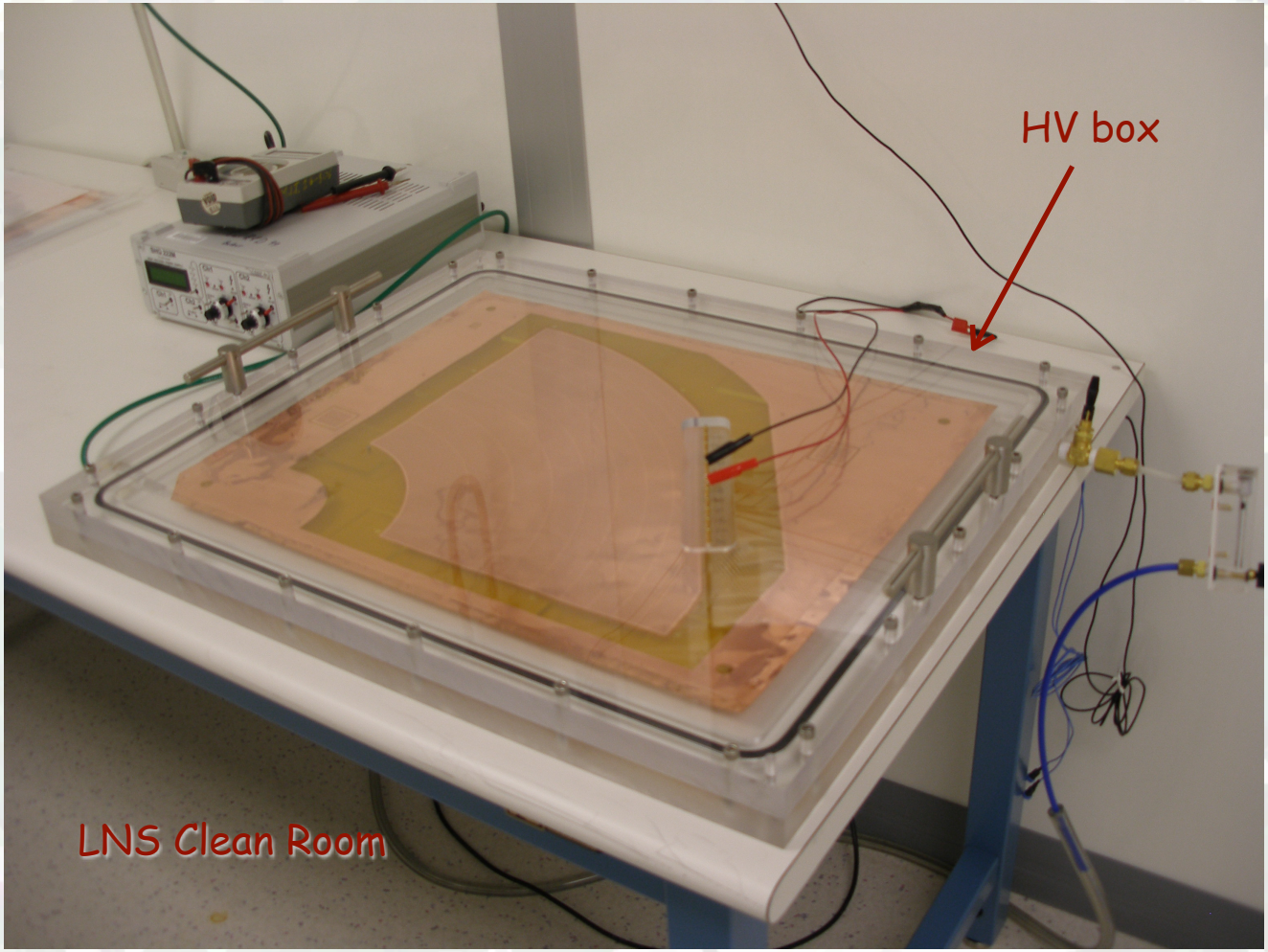
CCD camera setup for optical GEM foil scans

Optical scans:

- Measure inner and outer hole diameter / Uniformity across full surface (Important for gain uniformity) - Ongoing
- Systematic Tech-Etch and CERN comparison

FGT Technical realization

- Triple-GEM: GEM foil testing (2)

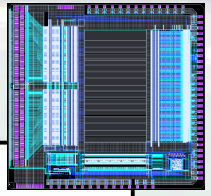


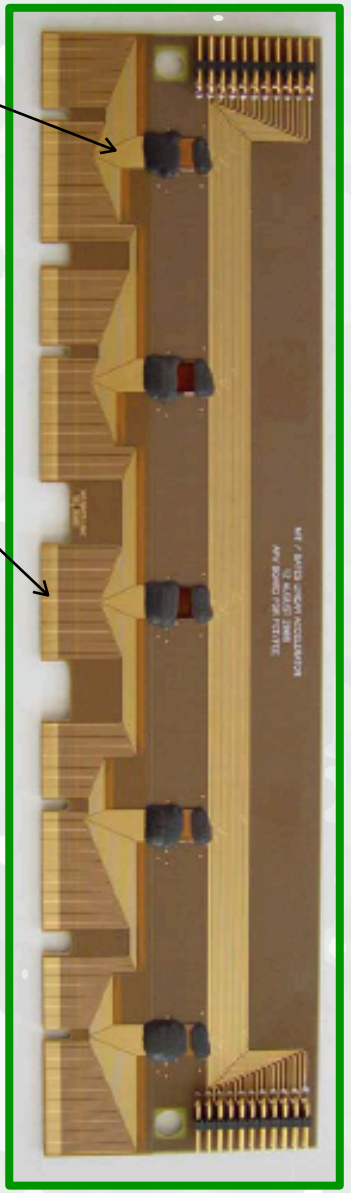
HV box for GEM foil leakage current tests

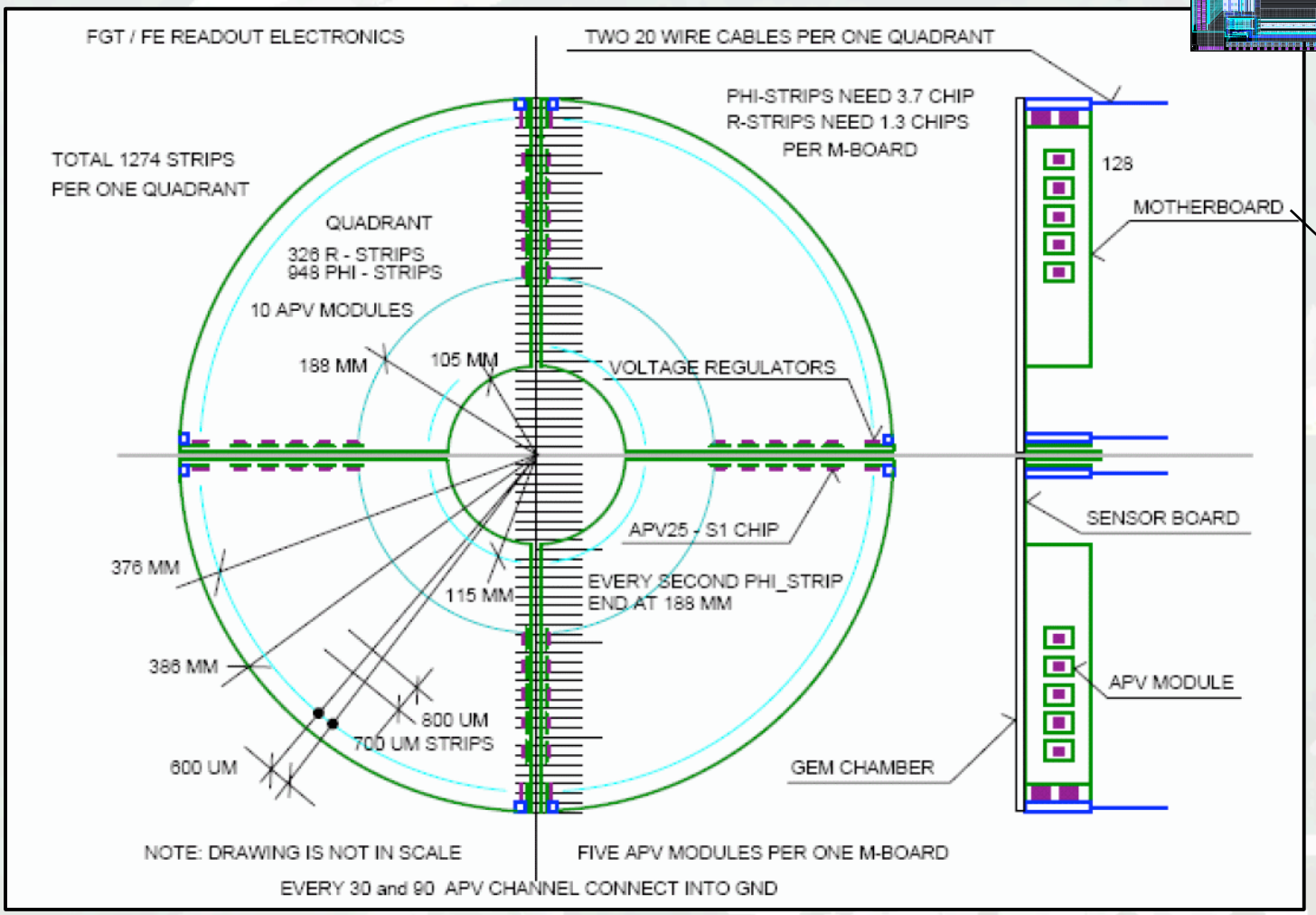
FGT Technical realization

FEE: Overview

APV25-S1 chips







Summary

- Milestones / Schedule
  - Goal: Complete FGT construction in ~fall 2010 followed by full system test and subsequent full installation in ~summer 2011

    ⇒ Ready for anticipated first long 500GeV polarized pp run in FY12
  - Review: Successful review January 2008 / Beginning of construction funds FY08

- New SBIR initiatives in collaboration with Tech-Etch Inc.:
  - Commercial fabrication using chemical etching of 2D readout board: Recently approved
  - In preparation: Large GEM foil production (~1X1 m^2) using single-mask etching - Strong impact for various future applications in Nuclear and Particle Physics / Major RD51 focus