UTA GEM DHCAL Update

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LCWS2007, DESY

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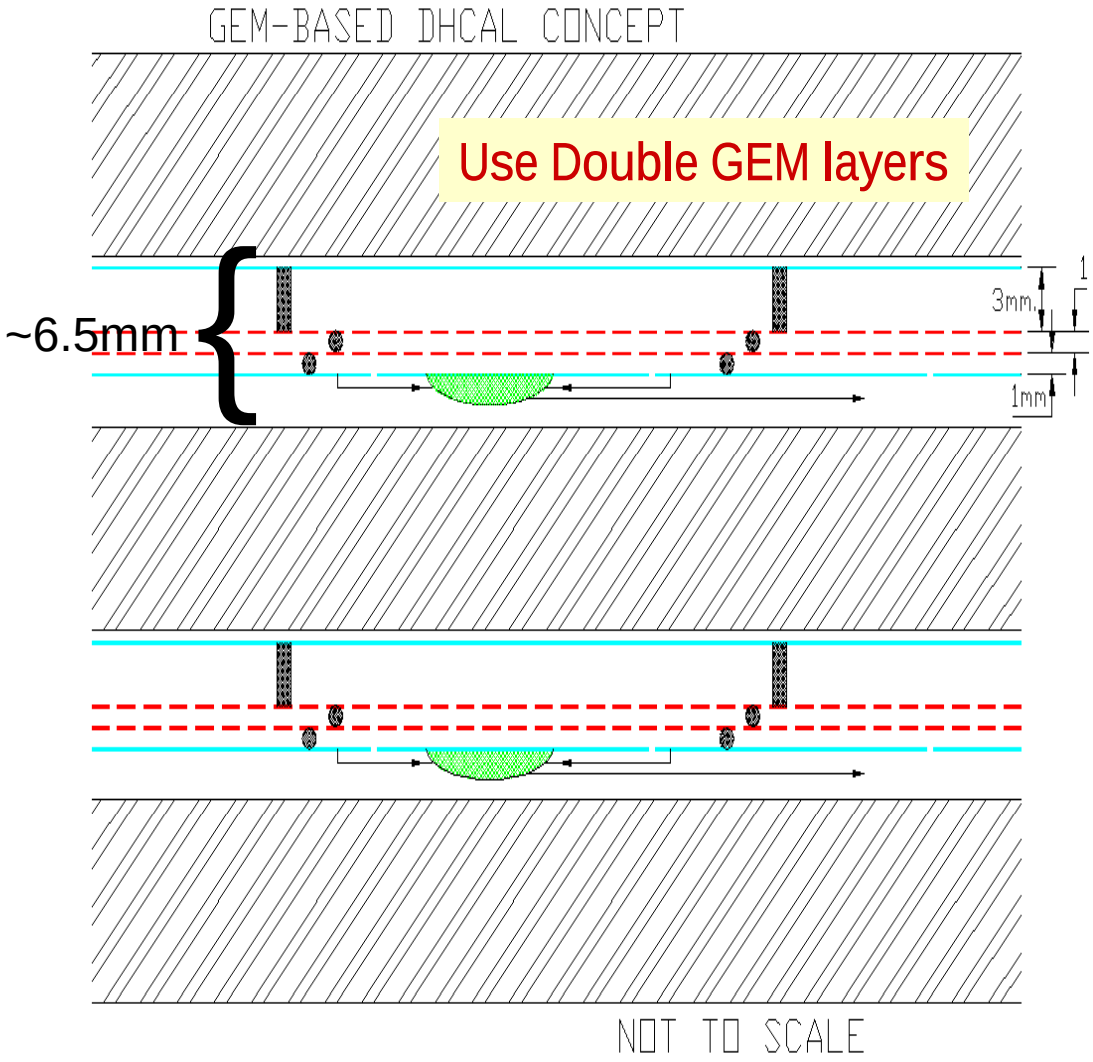
For GEM/DHCAL Group

- Introduction
- 30cmx30cm Prototype GEM chamber Development
- Beam Test Activities
- What next?
- Conclusions

Why GEM's?

- Flexible configurations: allows small anode pads for high granularity
- Robust: survives ~10^{12} particles/mm^2 with no changes
- Fast: based on electron collection, ~few ns rise time
- Short recovery time ➔ can handle high rates
- Uses simple gas (Argon/CO_2) – no long-term issues
- Runs at low HV (~400V across a foil)
- Stable operation

GEM-based Digital Calorimeter Concept



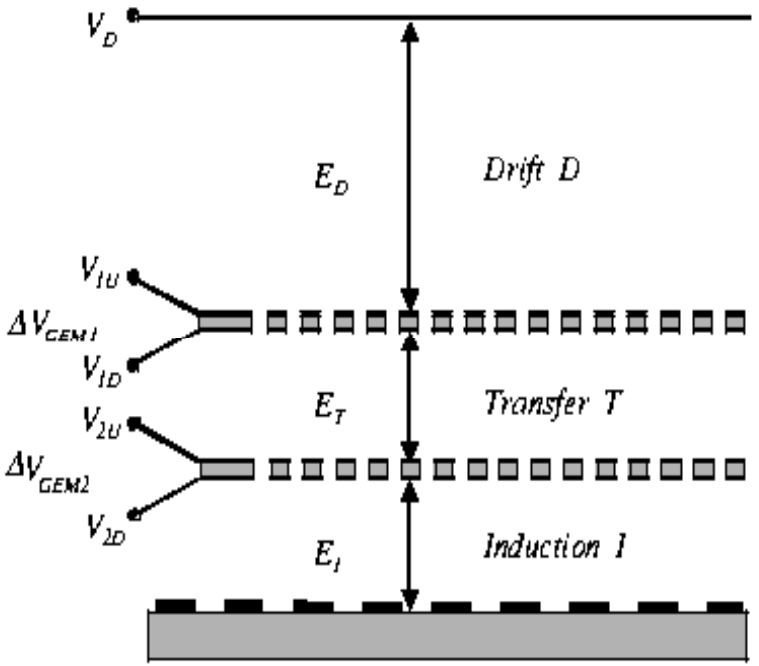


Fig. 1: Schematics of a double-GEM detector.

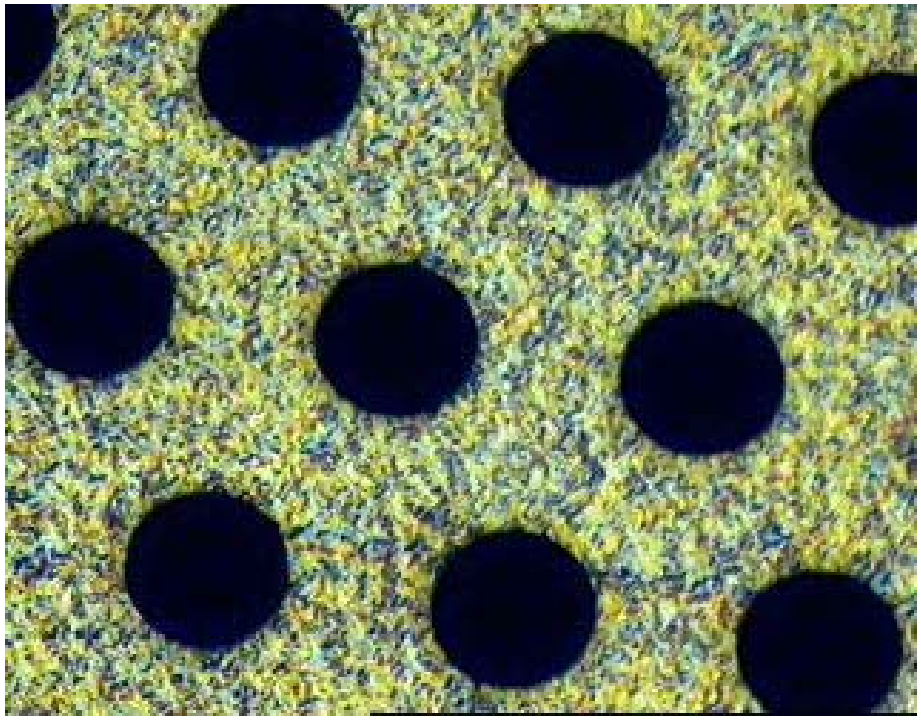
GEM Foils From 3M

- 30cm x 30cm foils made with three types of coating:
  - Bare copper
  - “organic polymer” coating
  - gold plating
- HV tests made on all three types
  - Prefer to use the uncoated foils
- All 30cm x 30cm chambers built w/ uncoated foils
- 3M is setting up a formal internal project to develop larger foils for the $1m^3$ prototype stack
  - $30x30cm^2$ foil did not require 3M process modification

30cm x 30cm 3M GEM foils

12 HV sectors on one side of each foil.

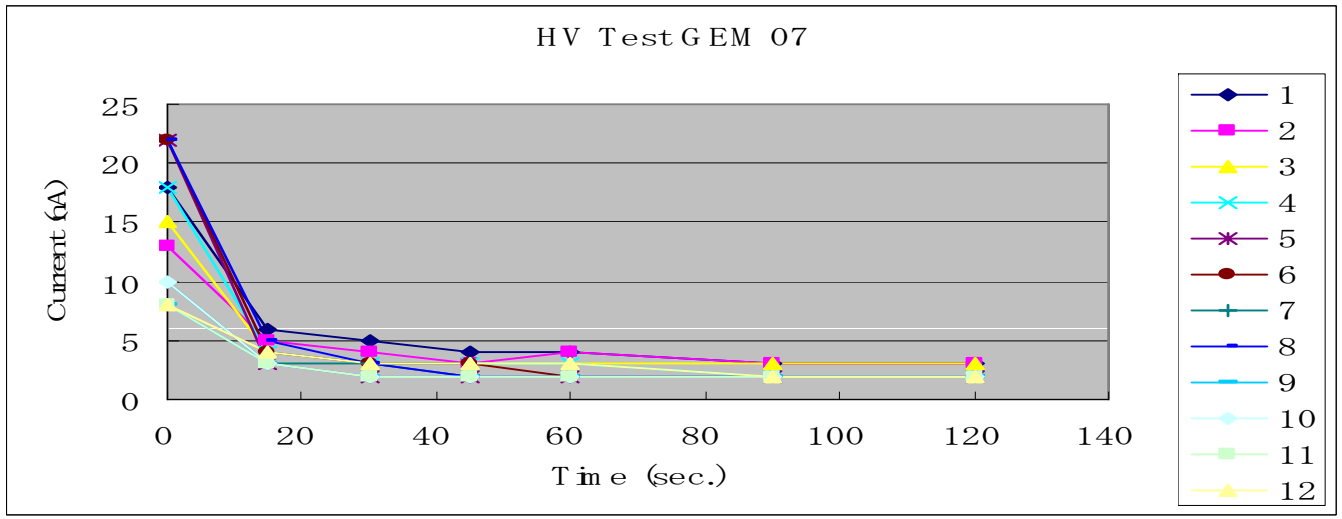
Magnified section of a 3M GEM foil.



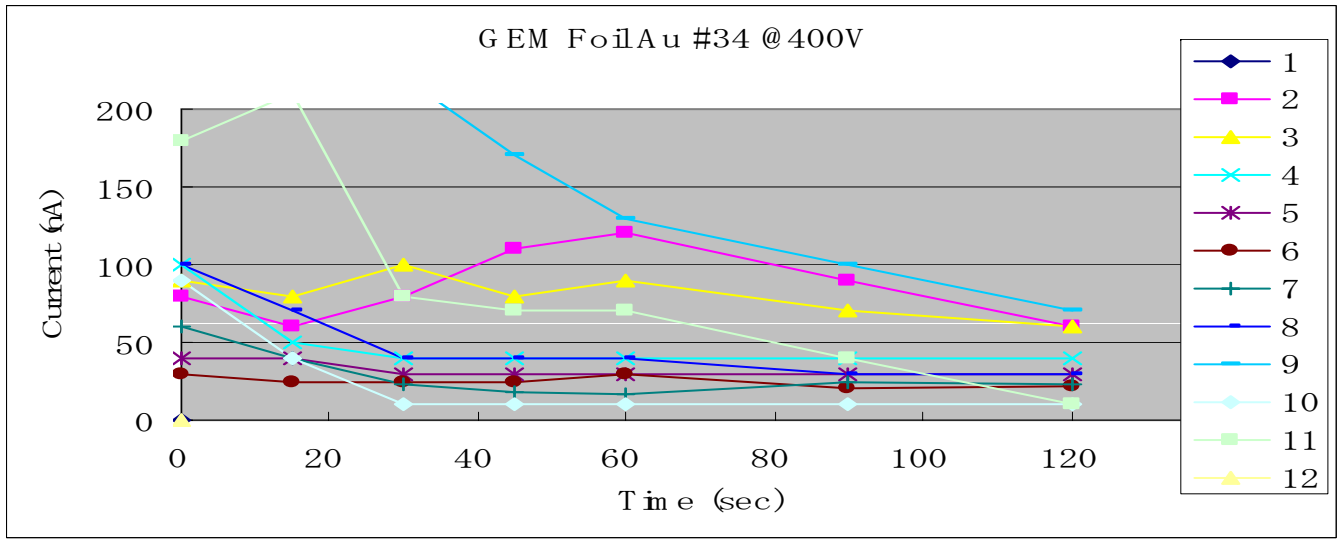
30cm x 30cm GEM Chamber Development

- Foils HV tested and certified
- Jigs made to mount foils, stack chamber.
- Multilayer 30cmx30cm anode board made to work w/ Fermilab QPA02-based preamp cards

HV Tests on 30cmx30cm 3M GEM foils

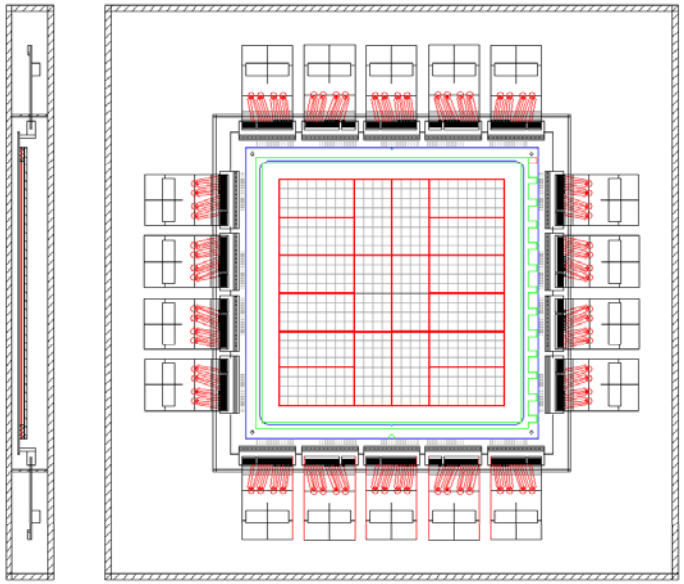


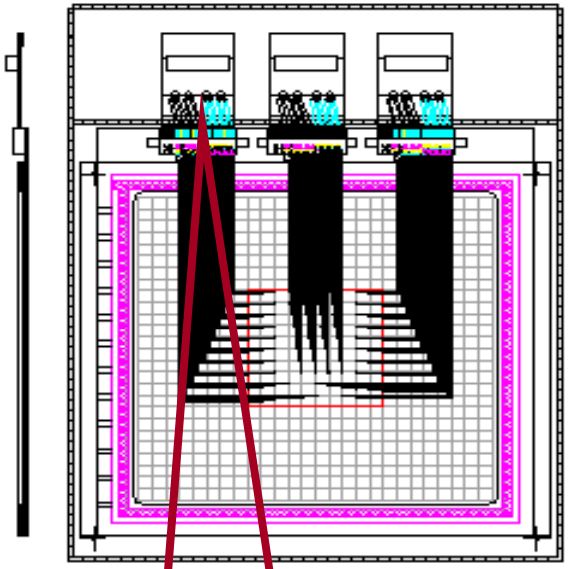
Uncoated foils settle at below 5nA in less than 1 min



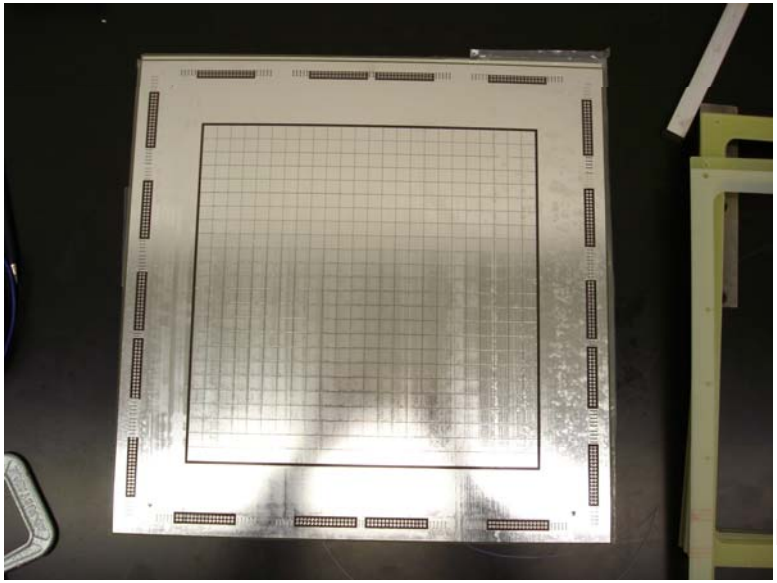
Au coated foils settle at 20 – 70nA and take longer to settle

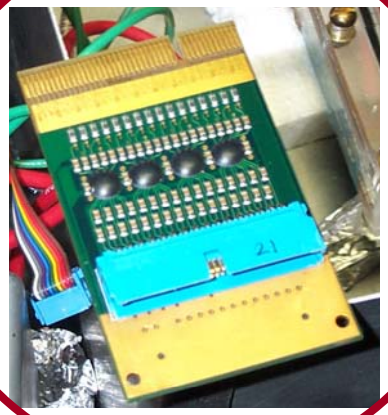
Anode Board & Preamp for 30cm x 30cm Chamber





Preamps configured to read 96 pads in the center





Use 32 channel FNAL preamps

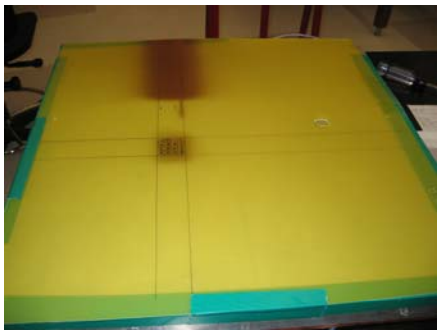
30cm x 30cm GEM Chamber Development

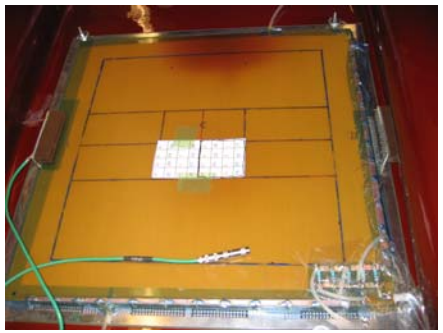
- Foils HV tested and certified
- Jigs made to mount foils, stack chamber.
- Multilayer 30cmx30cm anode board made to work w/ Fermilab QPA02-based preamp cards
- Verify aspects of chamber operation:
  - Stability
  - pulse characteristics (cf. 10cm x 10cm chamber using CERN foils)
- Exposed a 30cmx30cm chamber to 10MeV electron beams at Korea/KAERI beam tests in May, 2006
- Exposed to 8GeV π and 120GeV protons at FNAL – MTBF in Mar. – Apr. 2007

UTA GEM Chamber in KAERI Electron Beam

- e^- beam: 10^{10} particles in 30ps pulse ~every 43μs
- Scans 4cmx60cm area every 2 seconds

4-pad area (2cm x 2cm) exposed to scanning beams for ~2000 sec
➔~ 1.6 x 10^{-2} mC/mm^2





G10 boards in the exposed area discolorized.
But no damage to the GEM foils
➔Chamber operates normal even after this

MTBF Run Goals

- Measure the MiP using protons at 120GeV
- Measure chamber efficiencies and gains
- Measure Pad Occupancy
- Measure cross talk and noise rates
- Measure the uniformity of the chamber responses
- Measure rate capabilities of the chamber

GEM MTBF Runs

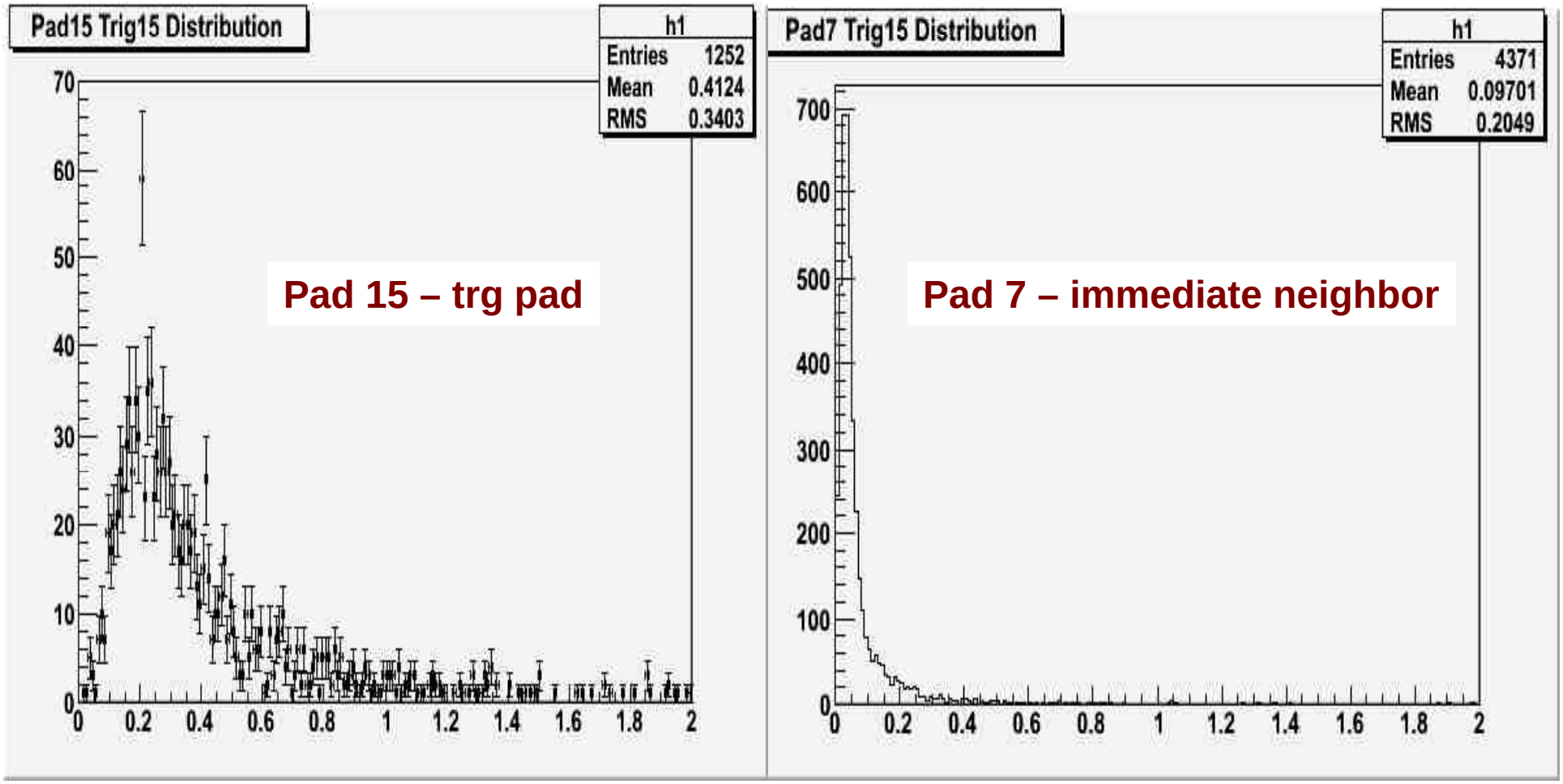
- As a secondary: Mar. 21 – Mar. 27, 2007
  - Joint run with ChangWon National University, Korea
  - Run behind a straw tube detector group
  - 8 GeV mixed beams
  - Trigger counter timing completed
  - Commissioned the detector and readout system
  - Running as a secondary puts large restrictions on operations
- As the primary: Apr. 4 – 10, 2007
  - Beam: 120GeV proton alone
  - Chamber analog signal patched outside the enclosure

GEM Beam Test Detector Setup

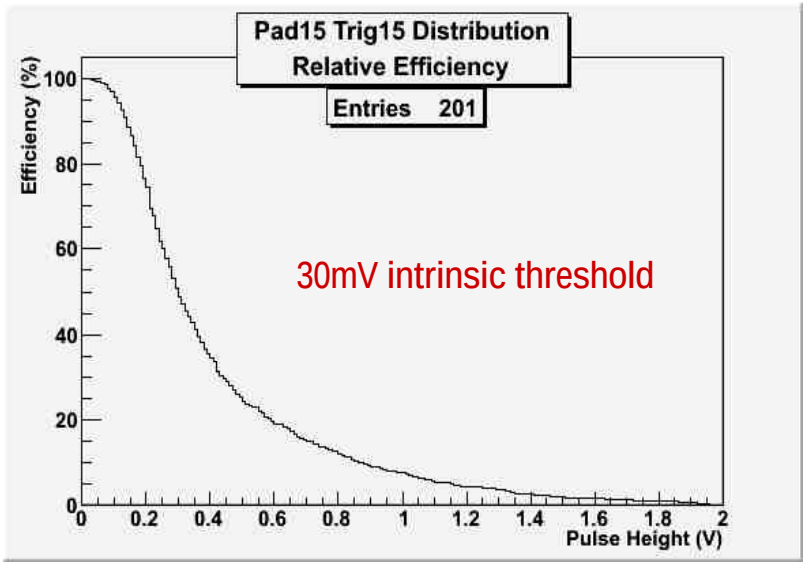
Trigger Types

- Beam Trigger – 5Fold scintillation counters
  - Three 1cmx1cm finger counters, 10cm apart, are located in front of the setup
  - Two 19cmx19cm counters envelop the chamber active area, separated by about 3m's
    - One counter located about 40cm upstream of the chamber and the other about 2.5 m downstream of the chamber
  - Coincidence of all 5 counters defines a beam spot less than or equal to 1cmx1cm ➔ The size of one readout pad
- GEM Chamber self trigger
  - Use negative chamber output
  - Threshold set at 30mV
- Beam constrained chamber trigger formed of 5F*GEM: 6Fold
  - Allows to look at data from neighboring pads while triggering on the pad centered at the beam

120GeV Proton – Triggered pad & Neighbor, X-Talk measurement



Some GEM Results



- At the bench test using Sr90 source
  - W/ 40mV threshold ➔ 95% MiP efficiency observed
    - Consistent with our simulation study
  - Multiplicity: ~ 1.27
- From the beam test, the initial measurements on 1cmx1cm pad
  - ~90% on the center 1cmx1cm pad when beam is well constrained on the pad
    - Corrections for multi particle events in the 200ns trigger gate needed
  - Initial measurement of the cross talk rates
    - In the two neighboring pads ➔ <25% but need to clean up results
  - Initial studies on double proton events show about 20% double proton events
  - Initial noise rate measurement : <0.2Hz

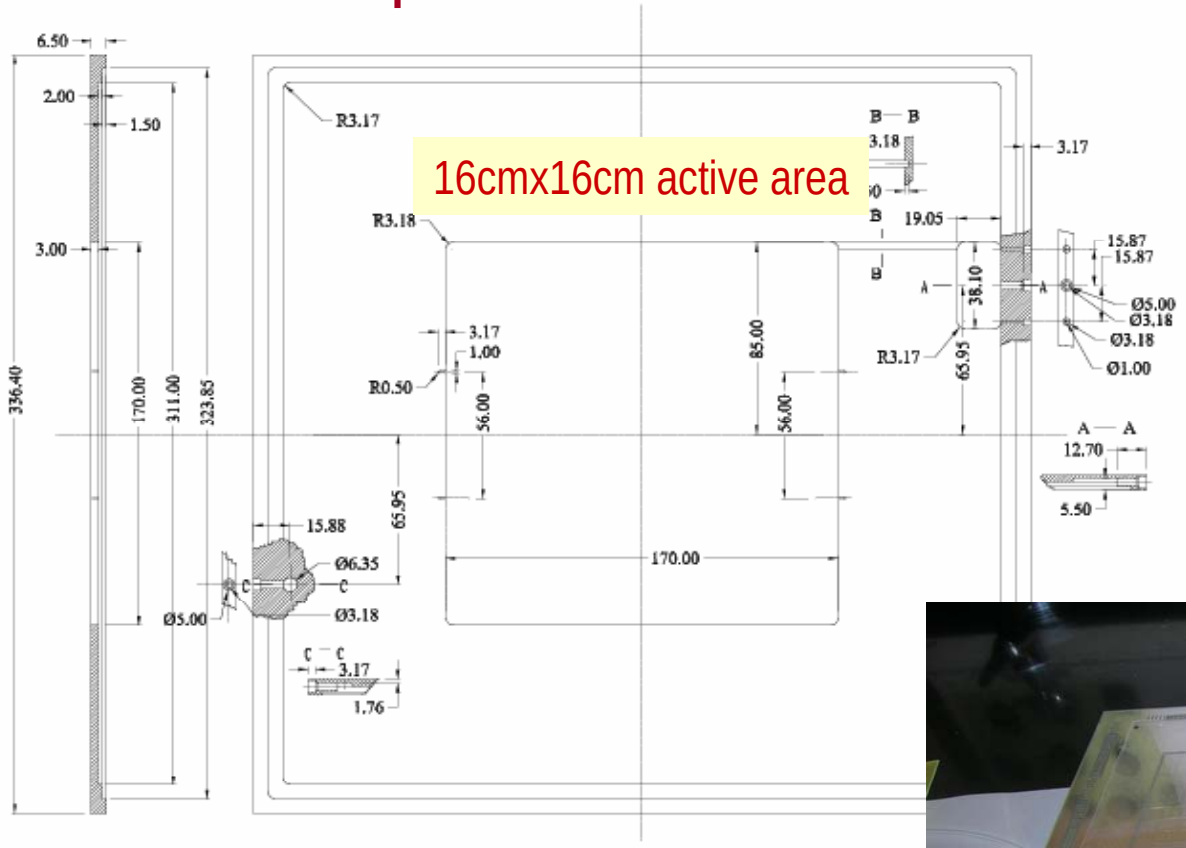
MTBF Beam Test Experience

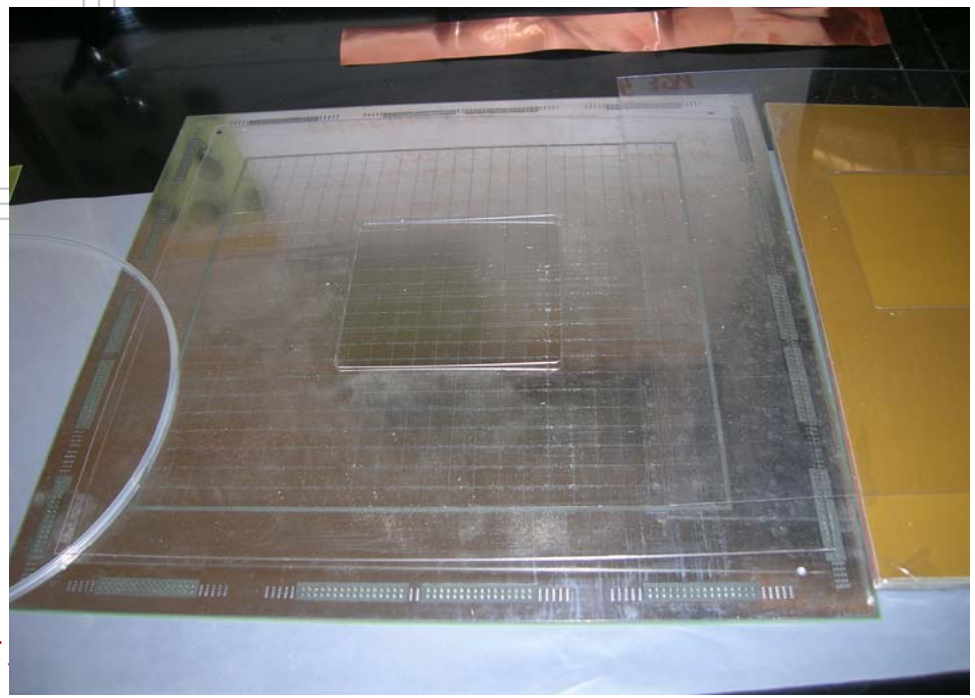
- 120GeV P and 8GeV pion tunes established
  - 120GeV P: Beam spot size at the MT6-2C dump
    - σ_x: 11.5mm, σ_y: 9.1mm
    - Rate: Can vary in a wide range
    - Can go as high as radiation safety allows
  - 8GeV mixed beam: Did not measure beam spot size but seems to be about 2 – 3 times larger than 120GeV protons
    - Rate: over 4kHz at the 10cmx10cm TOF paddle right behind our detector
- Beam available for 12 hours 6am – 6pm
  - One 6 sec spill with 4s flat-top/min ➔ 5% program limit
  - Shot setups
    - Recycler transfer: Some interruptions (<3 – 5 times in 12 hr period) of 10~20 min each
    - HEP Shot: over 1.5 hrs each but avoided during the 12 hr period
- A lot more pleasant environment than before
- Many standard Fermilab logic modules failed to function correctly

Vertical Slice Test

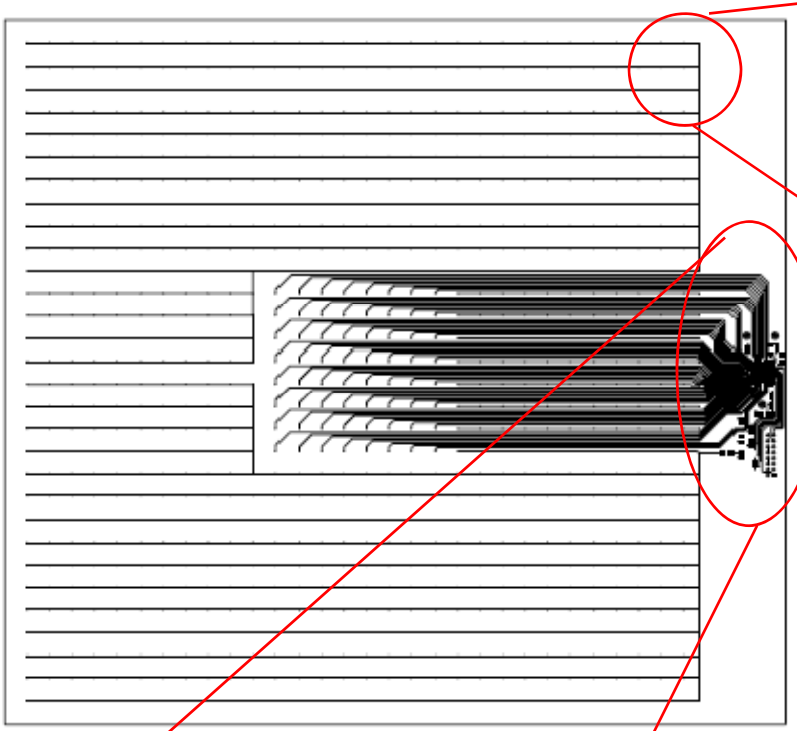
- Completed the beam telescope
  - Already used for GEM chamber characteristics run
- Construction of 16x16 cm^2 active area chambers
  - 4 sets of 3M GEM foils HV tested and certified
    - For 4 chamber construction (2 w/ DCAL and 2 w/ kPix)
  - Delrin frames for all four chambers in hand
  - Interface boards for 20cmx20cm FEB+PB to 30cmx30cm chamber structure designed and produced
  - Awaiting for FEB+PB arrivals

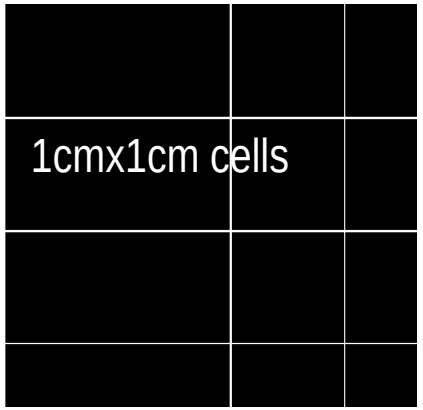
DCAL Chip 16cm x16cm Slice Test Chamber

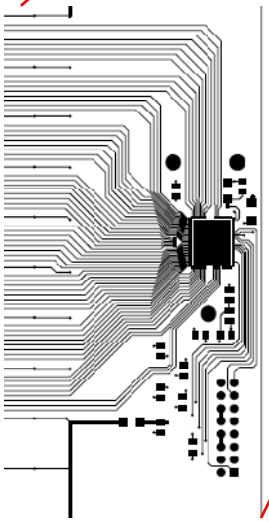


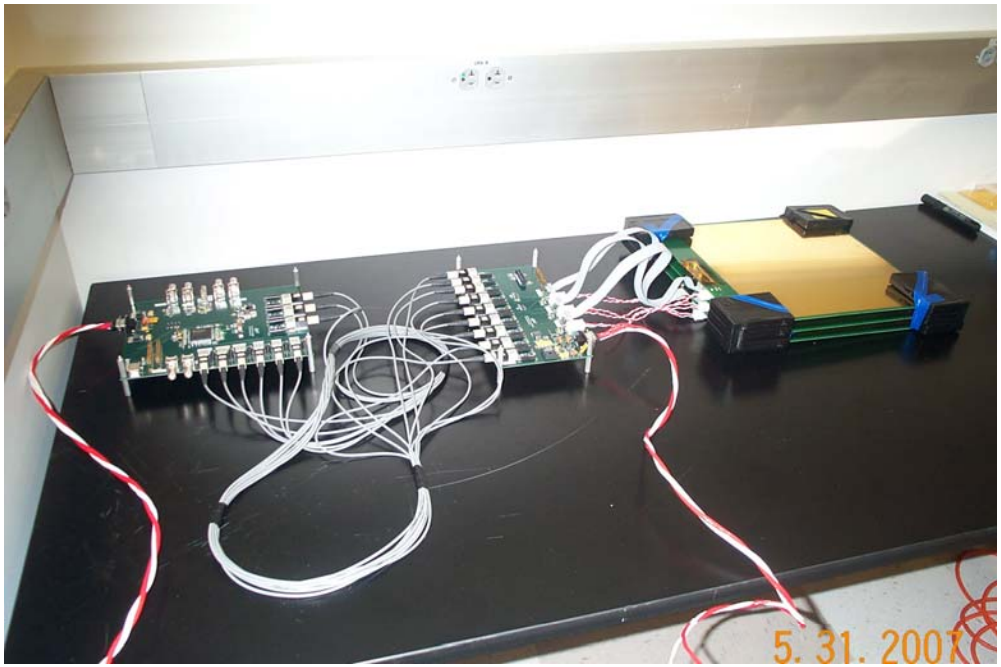


GEM FEB for Analog KPix Chip









June

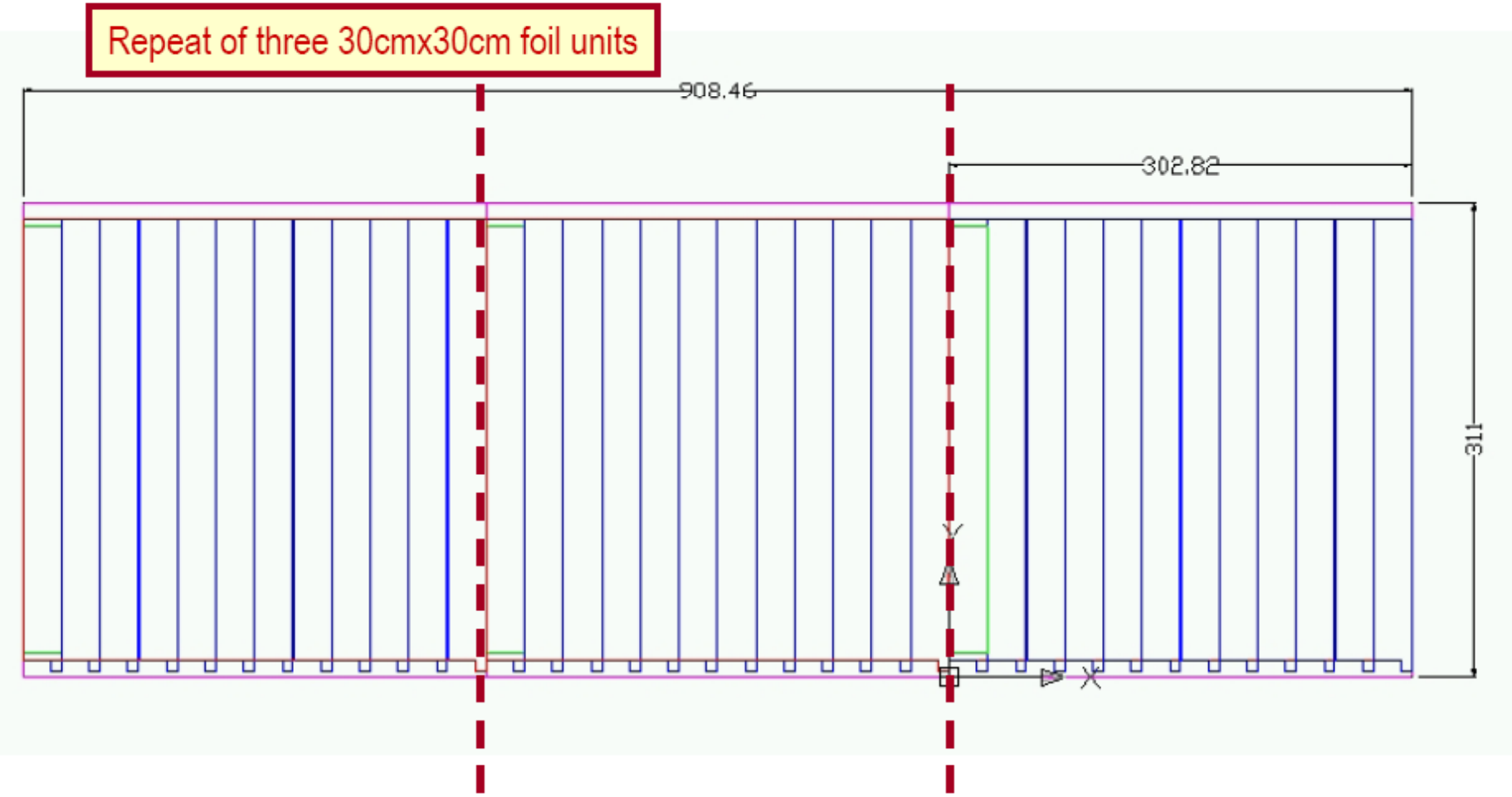
What next?

- Late 2007/early 2008
  - First set of 30cmx1m large GEM foils delivered
  - Construct and test large scale unit boards (30cmx1m)
  - Start producing GEM chambers for $1m^3$ prototype if funding allows
  - Numerous tests, including beam tests for chamber properties, as the large chambers get produced

3M Long (1mx30cm) GEM Foils

- We are working with 3M to develop larger foils for the $1m^3$ prototype stack
- Minimally modified new artwork (masks) deriving from the 30cm x 30cm foil development
- Small area needed for re-registration as foil moves through etching station.
  - Anticipate first sample in late ’07.
- First long chamber construction will occur after characterization and certification of the foils

Proposed Initial 3M 30cmx100cm Foil Design



Can be produced in 6 weeks after the final specification

What next?

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  - First set of 30cmx1m large GEM foils delivered
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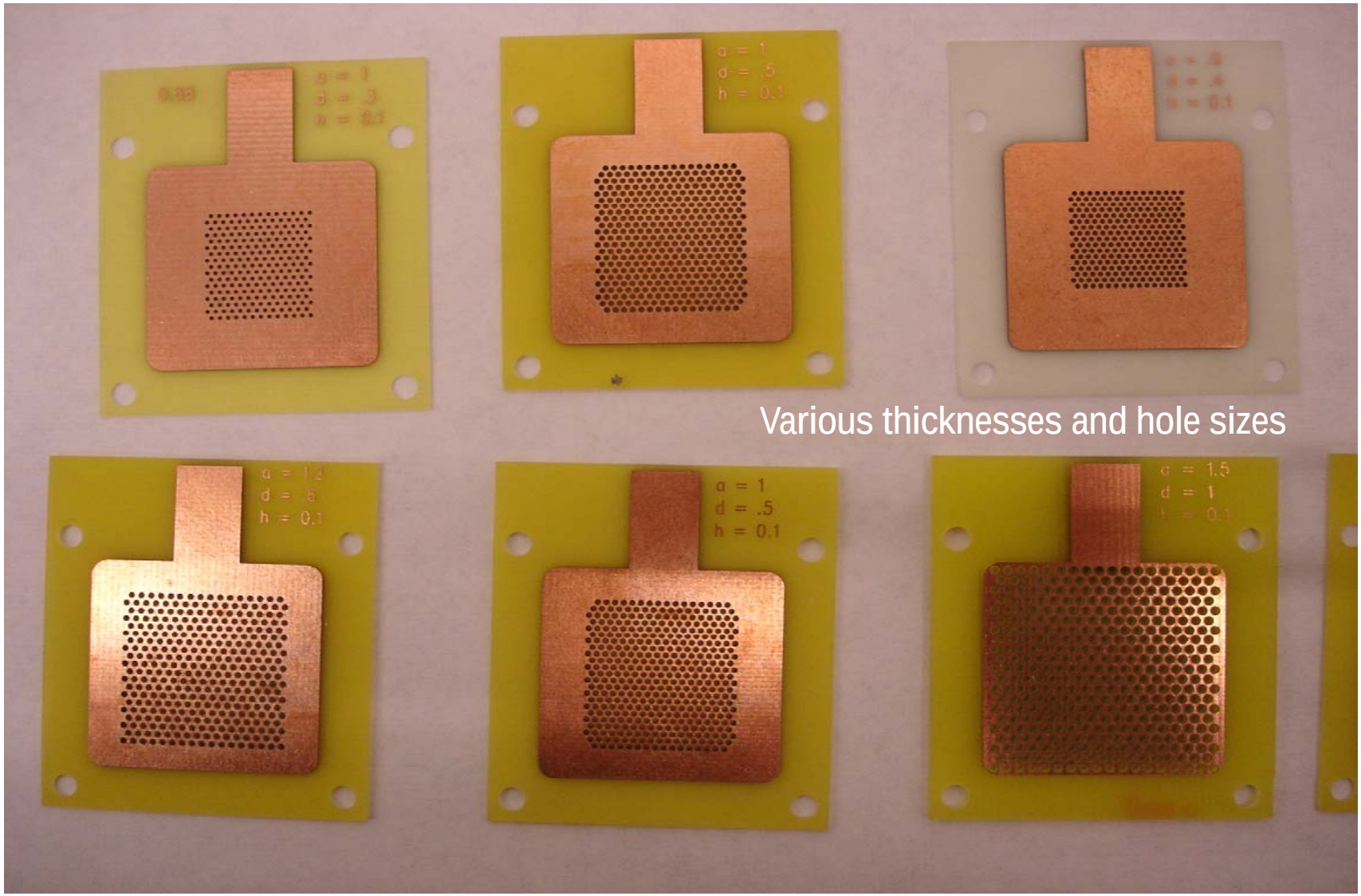
  - Start producing GEM chambers for $1m^3$ prototype if funding allows
  - Numerous tests, including beam tests for chamber properties, as the large chambers get produced
  - Develop TGEM “boards” and a prototype chamber

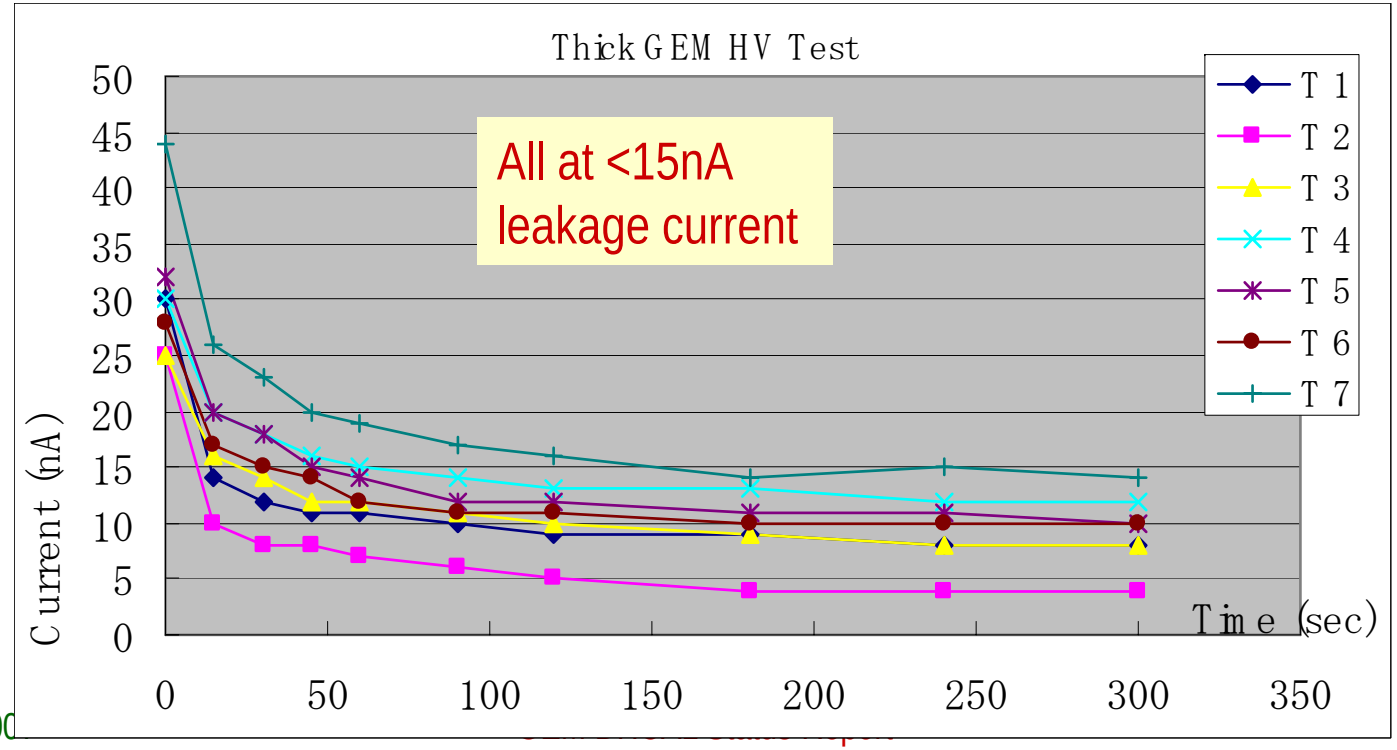
Samples of Thick GEM (TGEM)

Higher gains than thin GEMs and lower production cost ….



TGEM HV Test Results

ThickGEM ID	0	15	30	45	60	90	120	180	240	300	Voltage(V)
T 1	30	14	12	11	11	10	9	9	8	8	1000
T 2	25	10	8	8	7	6	5	4	4	4	1000
T 3	25	16	14	12	12	11	10	9	8	8	1700
T 4	30	20	18	16	15	14	13	13	12	12	1700
T 5	32	20	18	15	14	12	12	11	11	10	1700
T 6	28	17	15	14	12	11	11	10	10	10	1700
T 7	44	26	23	20	19	17	16	14	15	14	2000



What next?

- Late 2007 – Mid 2008
  - Construct and test large scale unit boards (30cmx1m)
  - Start producing GEM chambers for $1m^3$ prototype if funding allows
  - Numerous tests, including beam tests for chamber properties, as the large chambers get produced
  - Develop TGEM “boards” and prototype chamber
- Mid 2008 -2009
  - Complete $1m^3$ GEM stack construction
  - Beam test w/ full depth (40 layers) GEM DHCAL

Conclusions

- Significant progress made in 30cmx30cm GEM chamber construction, characterization and tests
- Chamber characteristics test done Mar. – Apr. 07
  - Data analyses in progress
- Electronics slice test to start in July 2007
- Larger foil (30cmx1m) development for “unit chamber” on going with 3M
  - First set of foils to be available late 2007 ➔ Unit chambers in early 2008
- $1m^3$ prototype test w/ GEM in late 2008 - 2009 w/ available funding
- Thick GEM development and prototype chamber construction in progress