UTA GEM DHCAL Progress

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IHEP, Beijing

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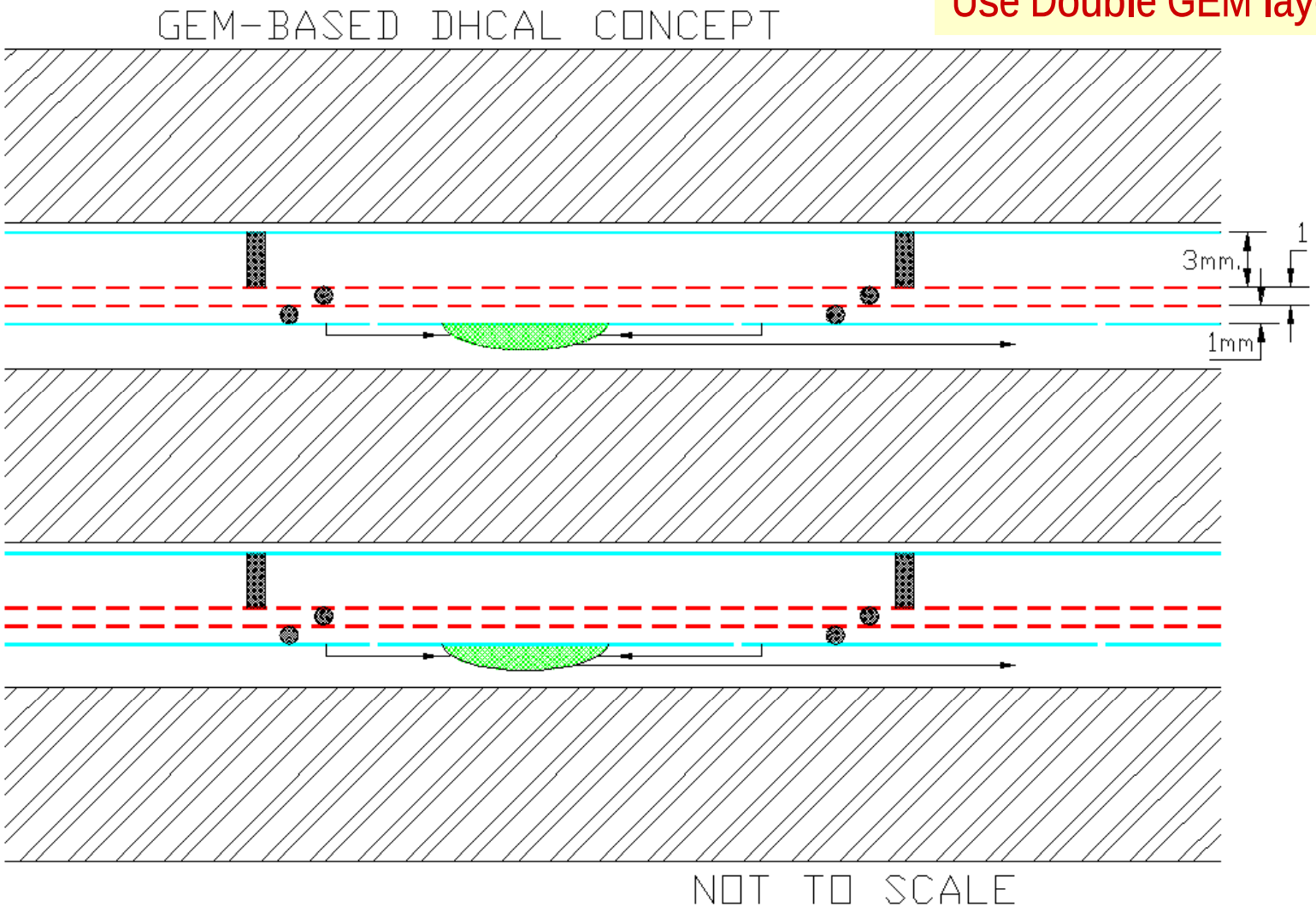
- Introduction
- 30cmx30cm Prototype GEM chamber Development
- KAERI electron beam exposure
- What next?
- Conclusions

Why GEM's?

- Flexible configurations: allows small anode pads for high granularity
  - Advantageous for PFA calorimeter
- Robust: survives ~10^{12} particles/mm^2 with no changes.
- Fast: based on electron collection, ~few ns rise time.
- Uses simple gas (Argon/CO2) – no long-term issues.
- Runs at low HV (~400V across a foil) but with high gains (~100 per foil)
- Stable operation

GEM-based Digital Calorimeter Concept

Use Double GEM layers



GEM – Operation

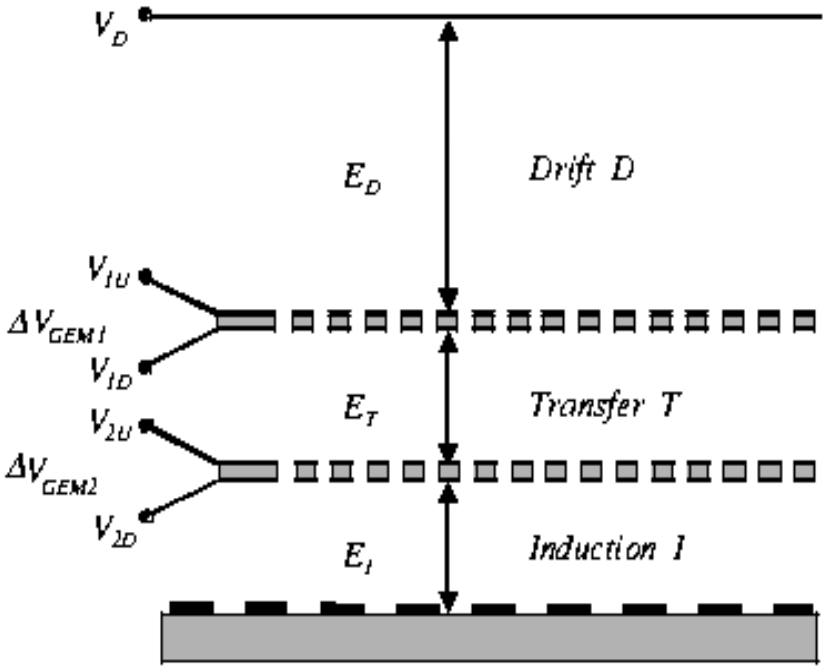


Fig. 1: Schematics of a double-GEM detector.

-2100V

ΔV ~400V

ΔV ~400V

0V

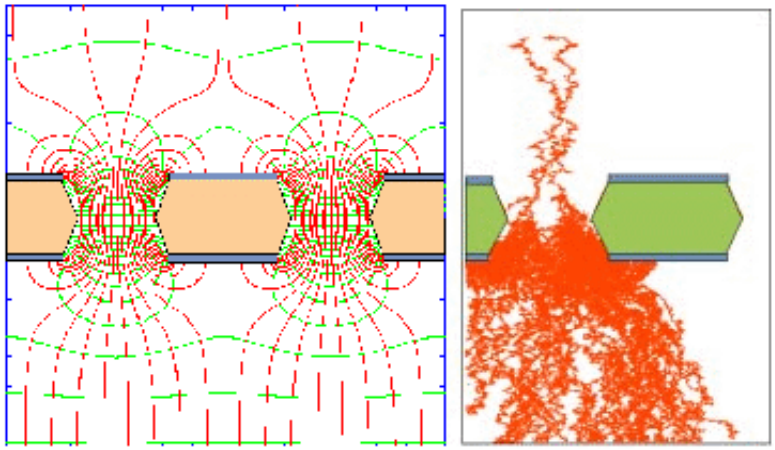


Fig. 15(a) Electric Field and (b) an avalanche across a GEM channel

Coupled with a drift electrode above and a readout electrode below, it acts as a highly performing microparticle detector. The essential and advantageous feature of this detector is that amplification and detection are decoupled, and the readout is at zero potential. Permitting charge transfer to a second amplification device, this opens up the possibility of using a GEM in tandem with an MSGC or a second GEM.

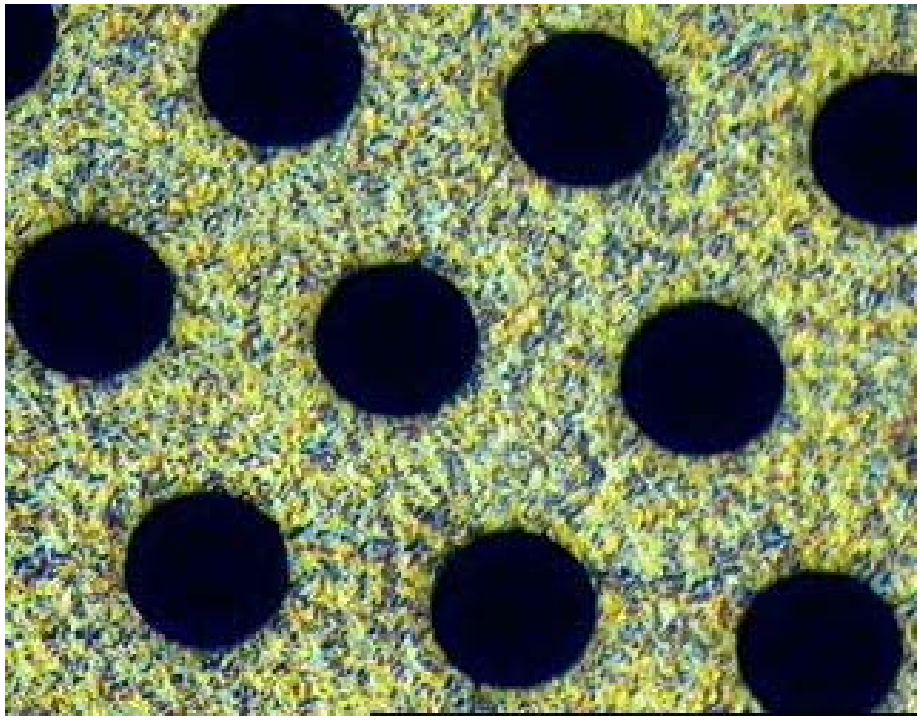
GEM Foils From 3M

- 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.

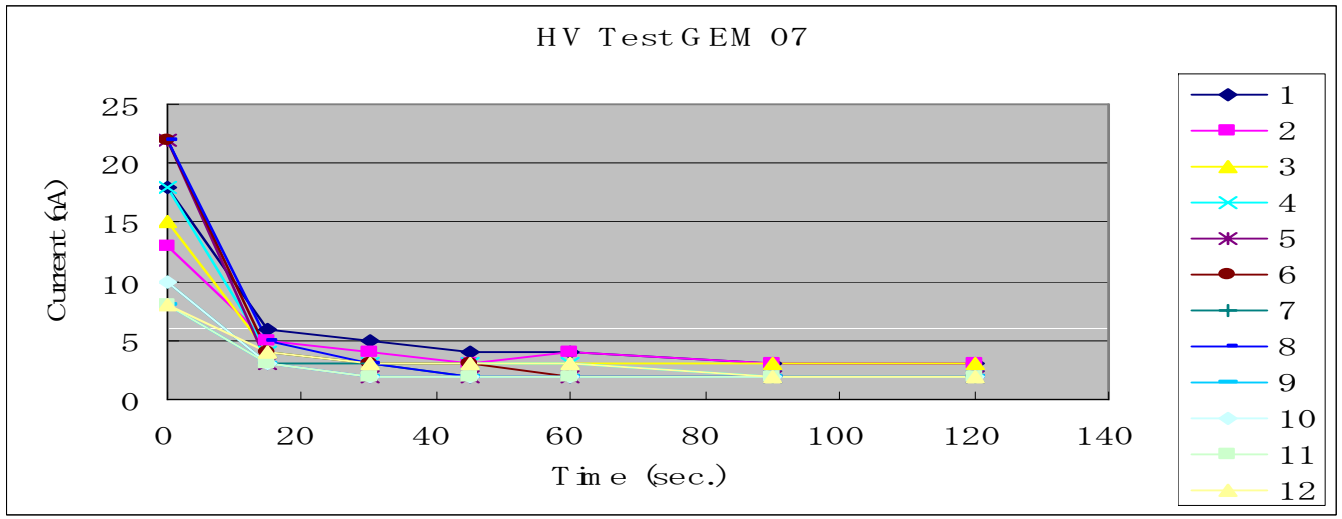
Magnified section of a 3M GEM foil.



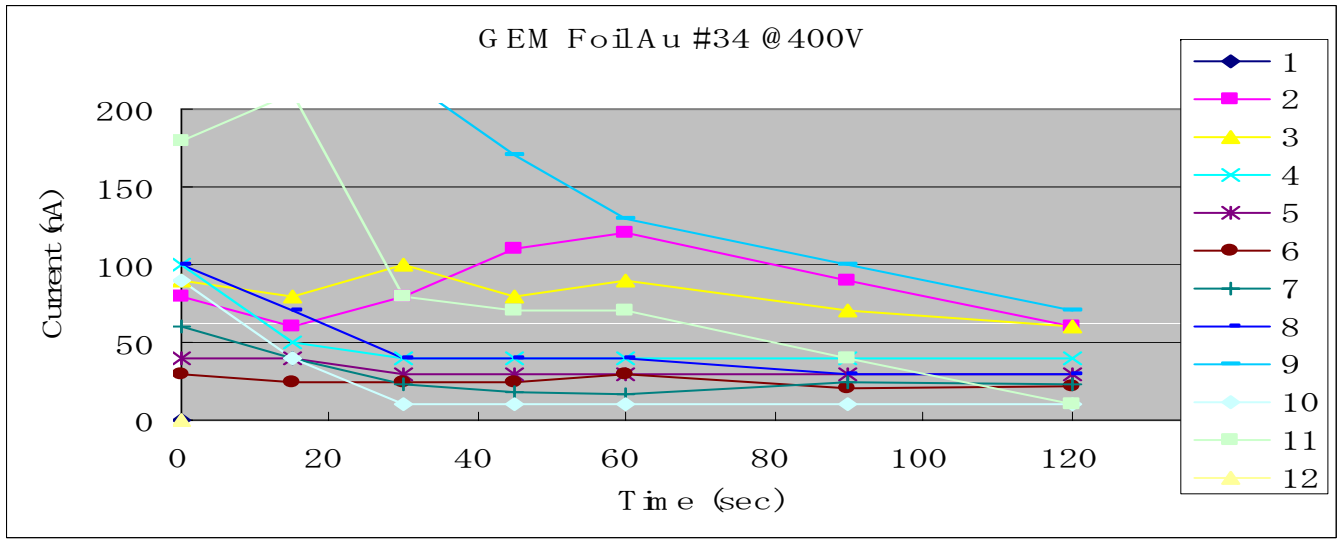
30cm x 30cm GEM Chamber Development

- Foils HV tested and certified
- Jigs made to mount foils, stack chamber

HV Tests on 30cmx30cm 3M GEM foils



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



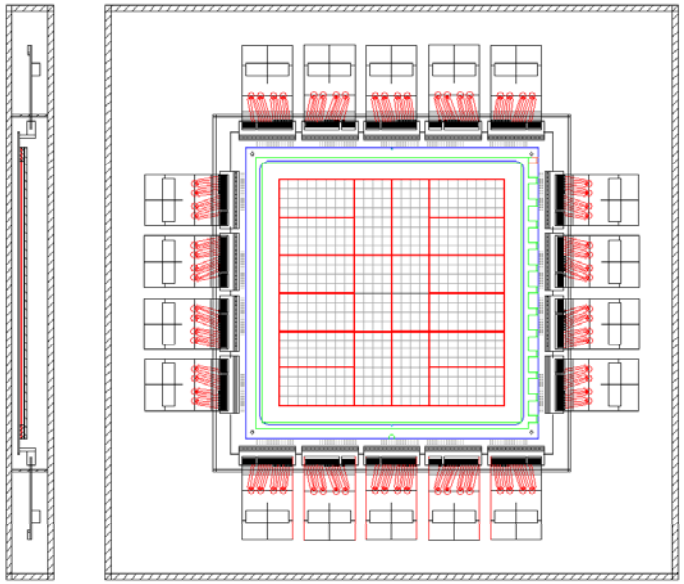
Au coated foils settle at 20 – 70nA and take longer to settle

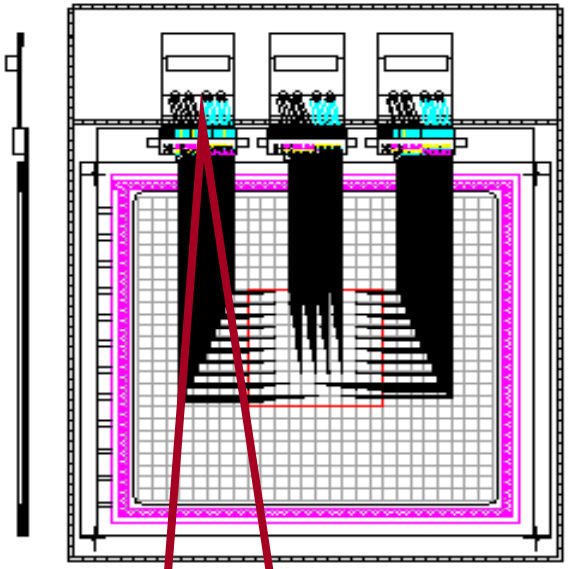
GEM 30cmx30cm Foil Mounting Jig

30cm x 30cm GEM Chamber Development

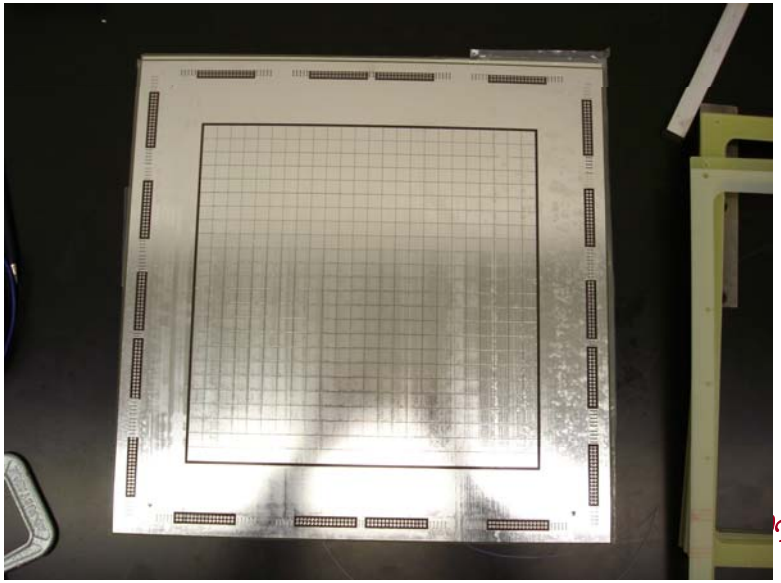
- Foils HV tested and certified
- Jigs made to mount foils, stack chamber.
- Multilayer 30cmx30cm anode board made to work w/ Fermilab QPA02-based preamp cards

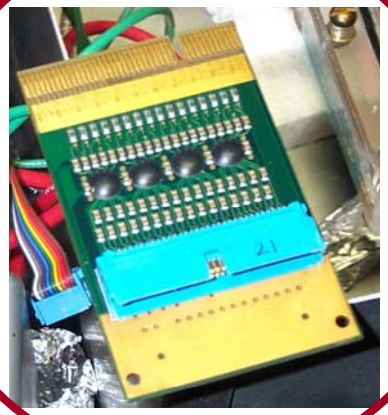
Anode Board & Preamp for 30cm x 30cm Chamber





Anode boards designed to read 96 pads in the center



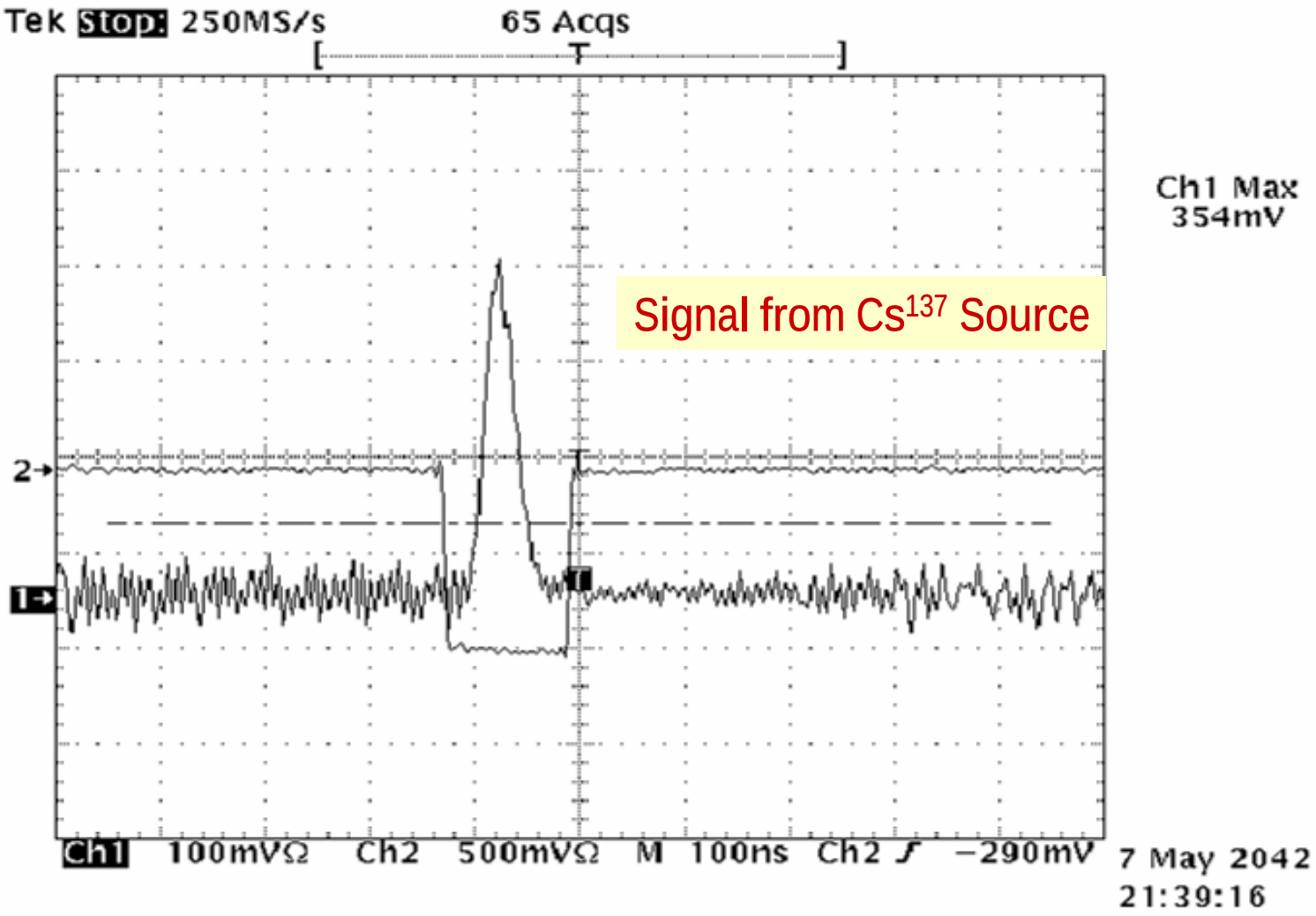


Use 32 channel FNAL preamps

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)

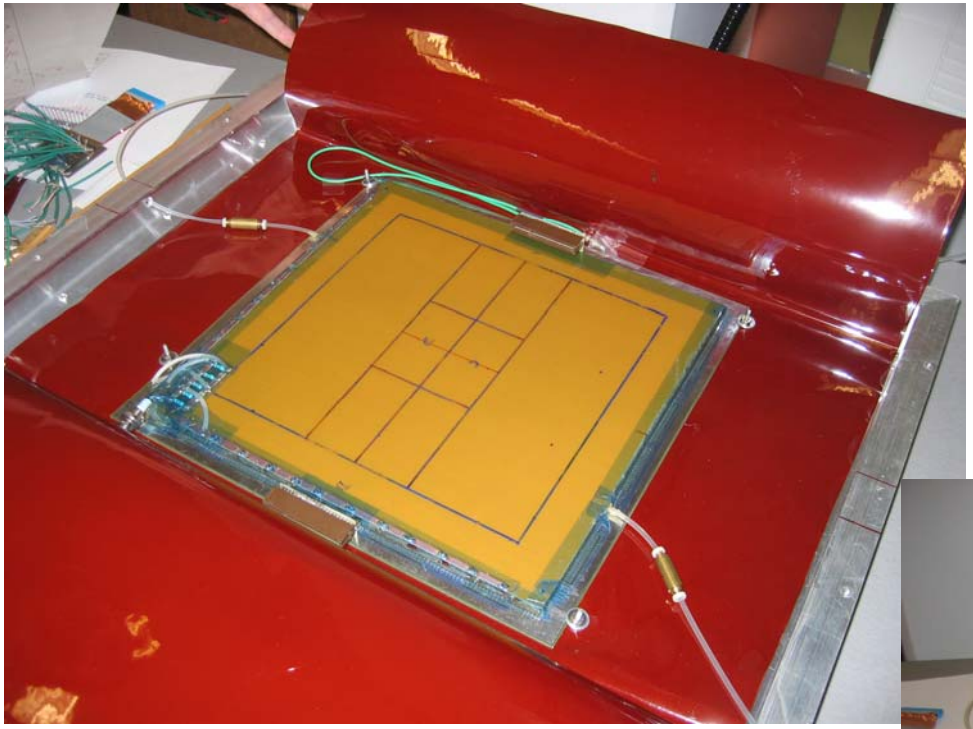
30cmx30cm D-GEM Detector Signal



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 to 10MeV electron beams at Korea/KAERI beam tests in May

30cm x 30cm GEM Chamber for KAERI Beam Exposure



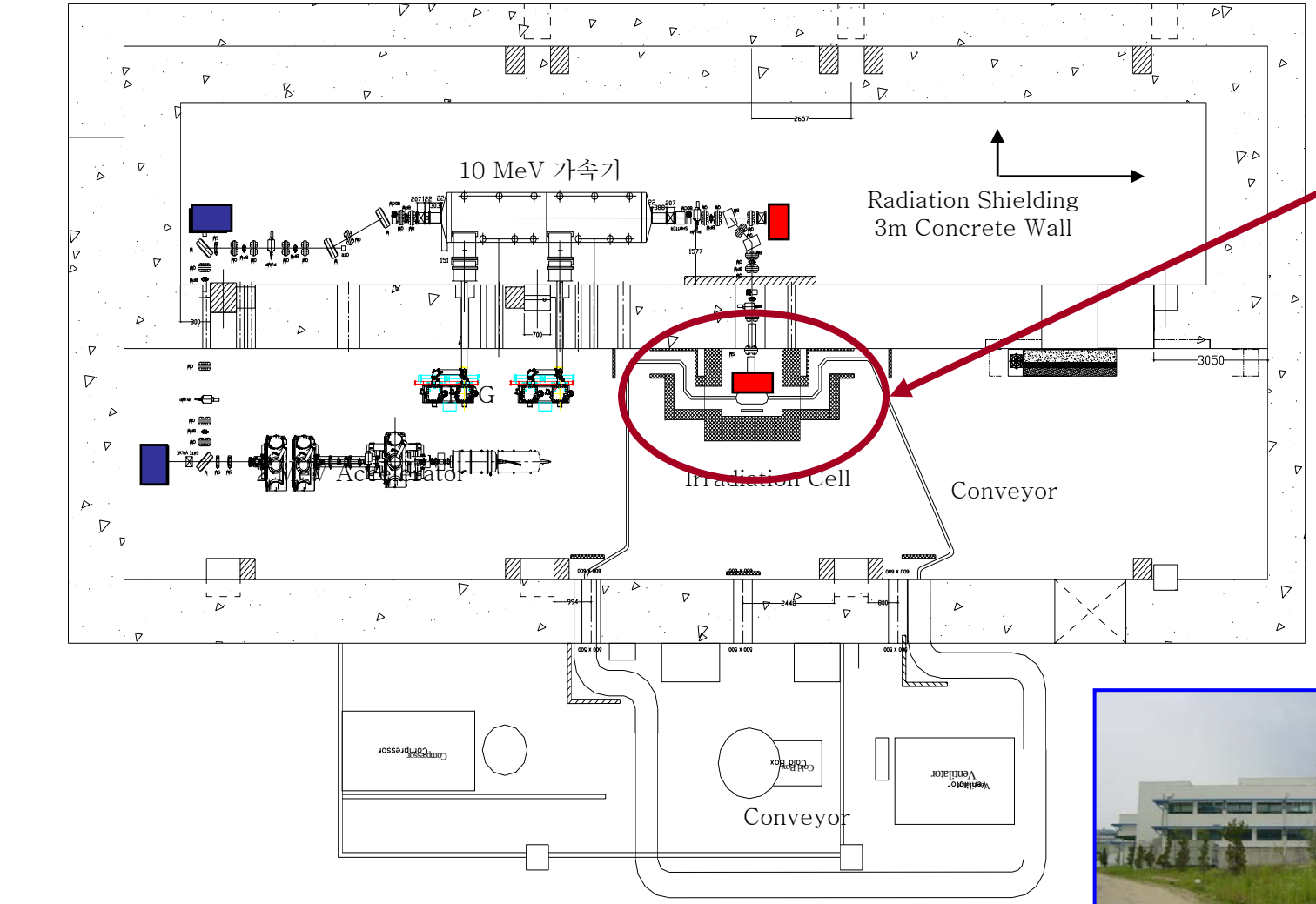
KAERI Low-Med E Exposure Facility

0.3~2 MeV

2~10 MeV

지하 : 330평
지상 : 170평

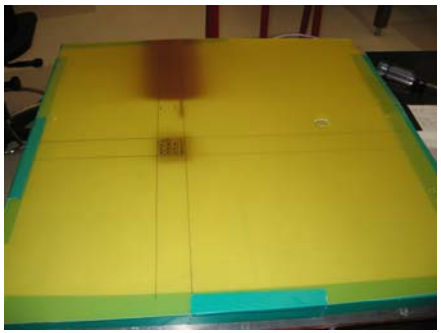
총 면적 : 500평

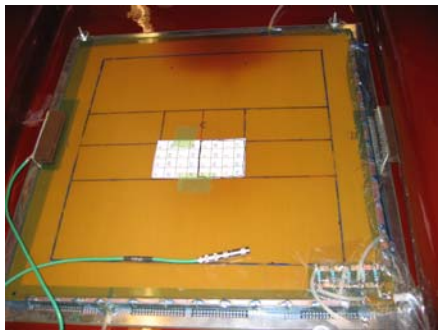


UTA GEM Chamber in KAERI Electron Beam

- 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 beam for ~2000 sec.





G10 boards in the exposed area discolorized.
But no damage to the GEM foils

UTA GEM-DHCAL Beam Exposure

- In collaboration with Changwon National University, Korea
- Beam scans ~600mm x 40mm area every 2 sec, with 30ps pulse of 10^{10} e^-/pulse over a 5 cm^2 area ➔ ~10^9 e^-/sec on an anode pad
- Total exposure ~2000sec
  - Estimate ~2 x 10^{12} e^-/pad (~ 1.6 x 10^{-2} mC/mm^2) accumulation
  - GEM chamber continued normal operation.

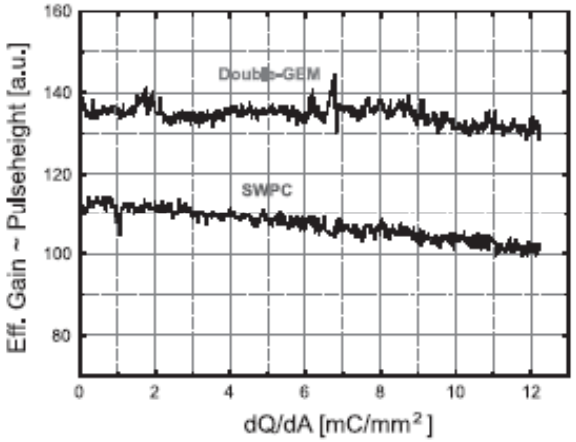
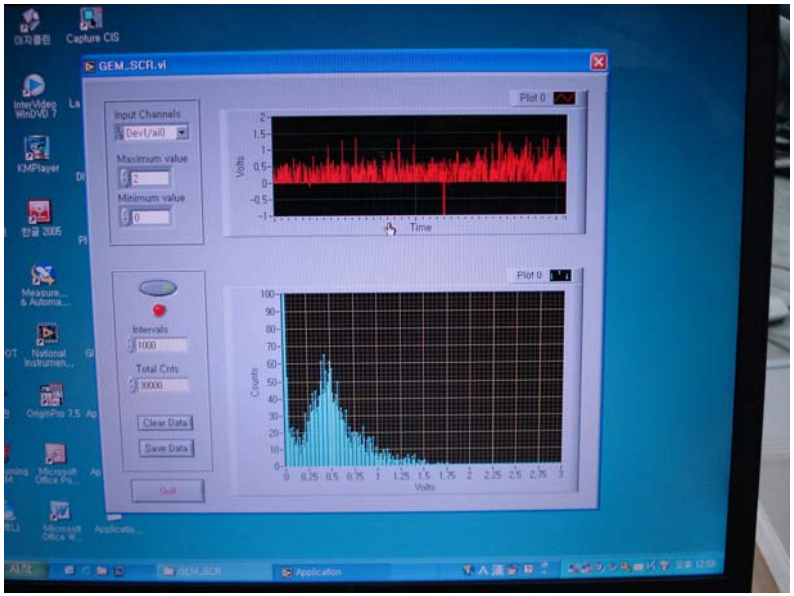


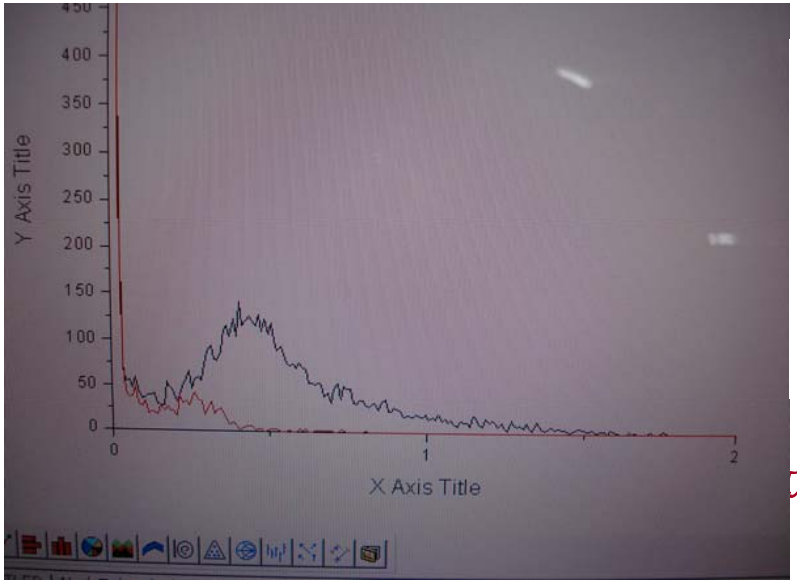
Fig. 3. Previous aging measurement of a double-GEM detector with $Ar–CO_2$ (70:30): effective gain versus accumulated charge dQ/dA.

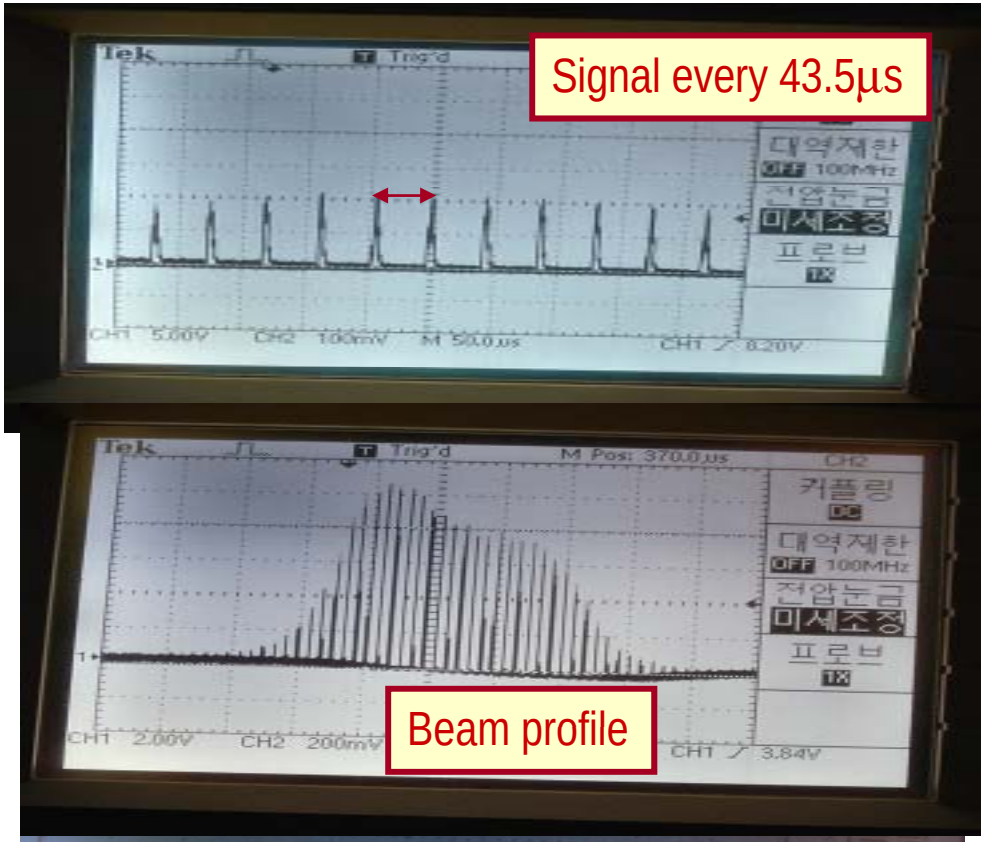
- Much above total hits/10y/pad at ILC
- Much below any damage region for decrease in gain.

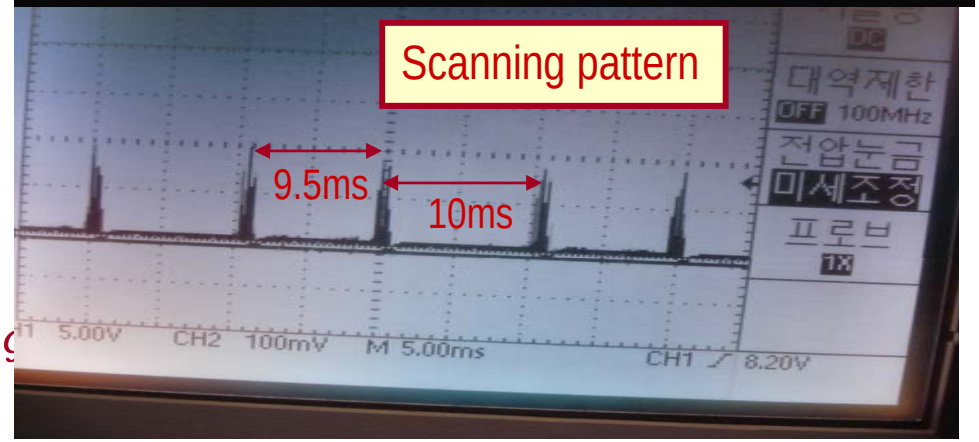
KAERI Beam Exposure Results

CNU Chamber Labview output



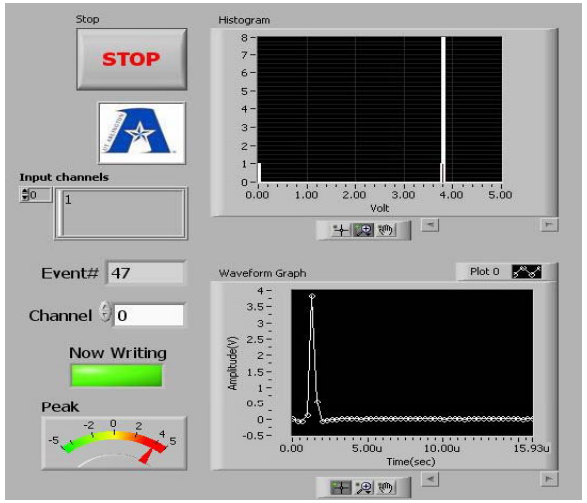




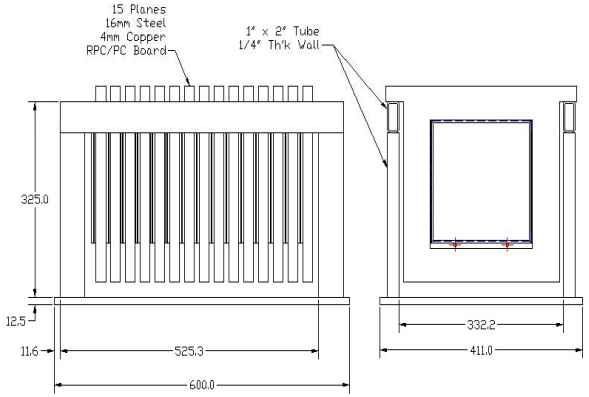


What next?

- Mid Mar. 2007: Chamber characteristics run at FNAL
  - Joint MOU w/ CNU (imaging) and LTU (ILC Tracking) submitted
  - MiP, efficiencies, gains, pad occupancies, rate capabilities, etc
  - One 30cmx30cm chamber
    - Use FNAL preamp+100channel PCI based ADC+LabView DAQ software
    - Will be used for lab testing and cosmic runs after TB

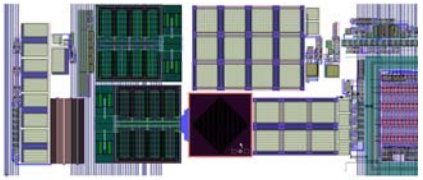


- Early summer 2007: Electronics slice test at FNAL
  - Joint with RPC DHCAL group at ANL
  - Read out using DCAL chips, followed by kPix chips later
  - Use two 30cmx30cm chambers each



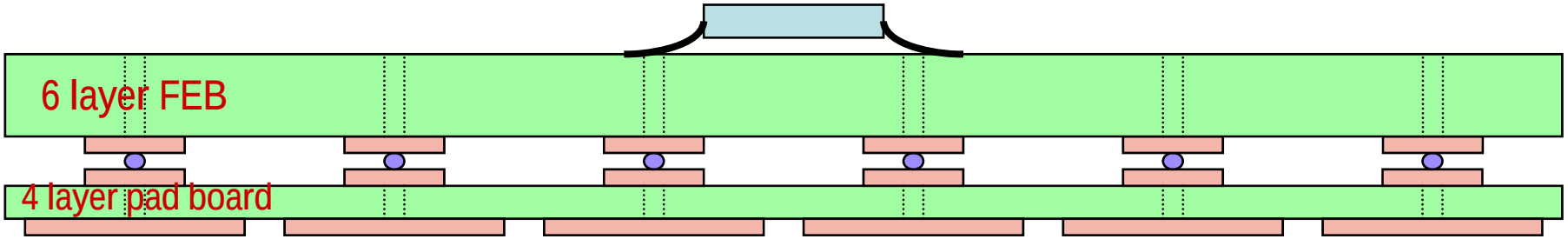
GEM-DHCAL Readout

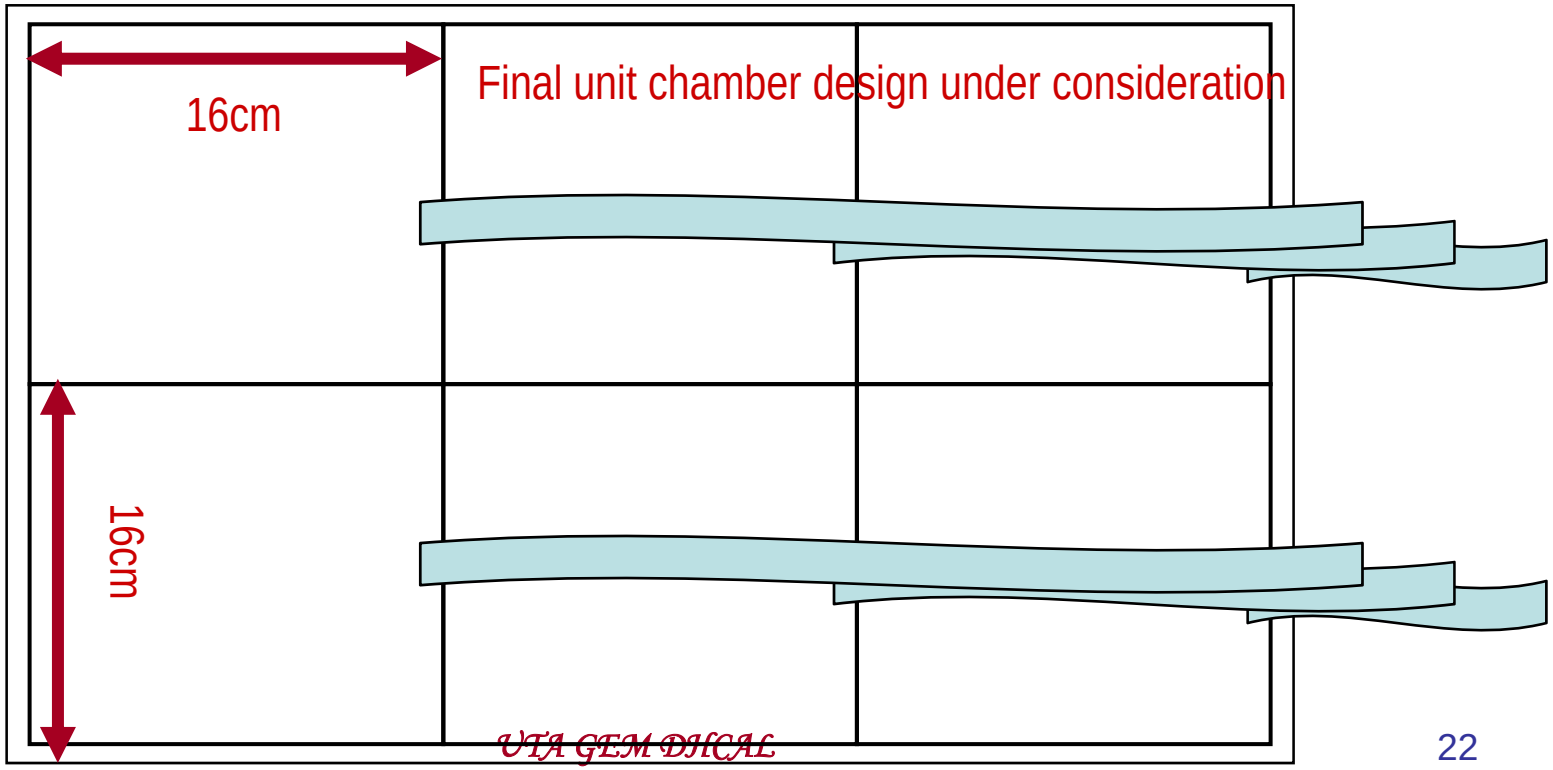
- Chip-based readout for individual/multiple chamber beam tests and 1m^3 stack.
  - DCAL (ANL/Fermilab) – test on the production version in its final stretch
    - Digital output w/ 2 gains to accommodate both RPC and GEM
  - KPiX (SLAC) – 64 ch V4 chips under test at SLAC
    - Analog output w/ 2 gains to accommodate GEM
    - Developed for Si/W Ecal



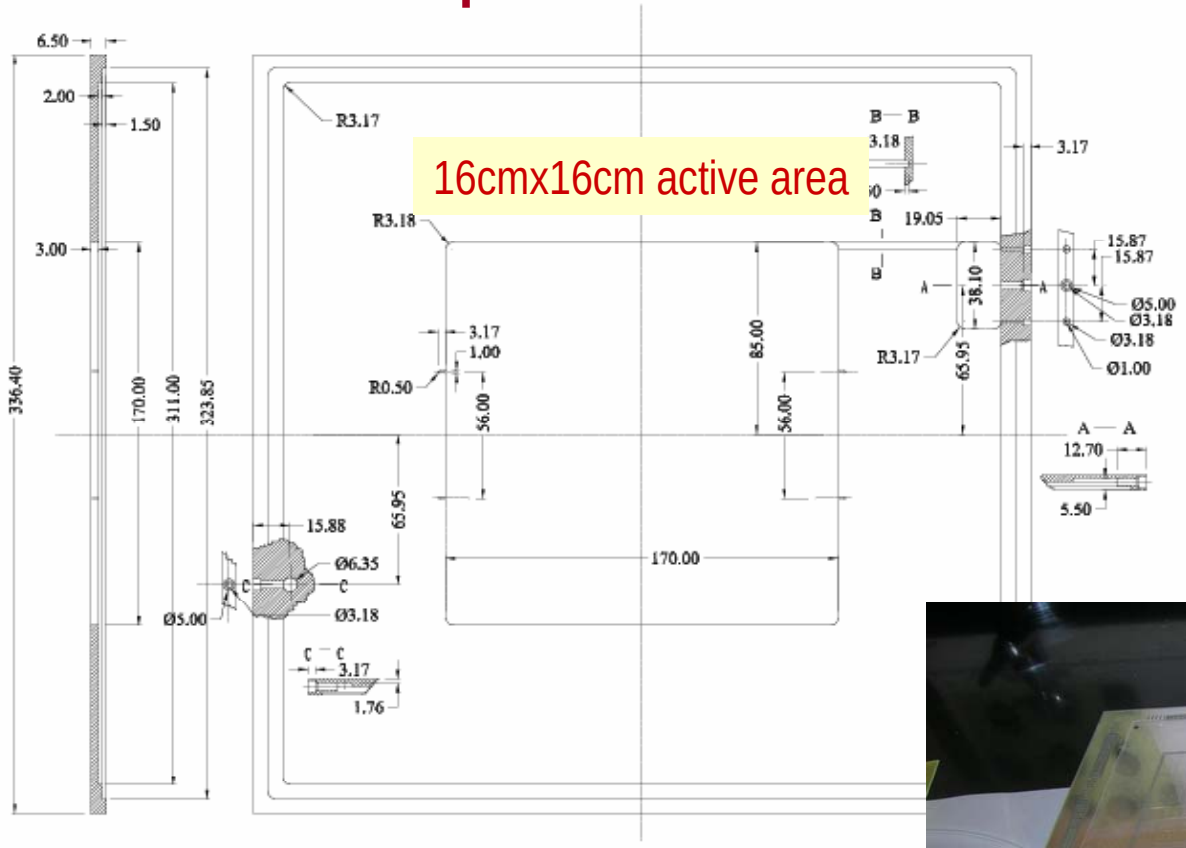
- 1m^3 stack will have 400,000 channels and [illegible] ILC Digital Hadron Calorimeter will have $\mathcal{O}(10^8)$ channels.

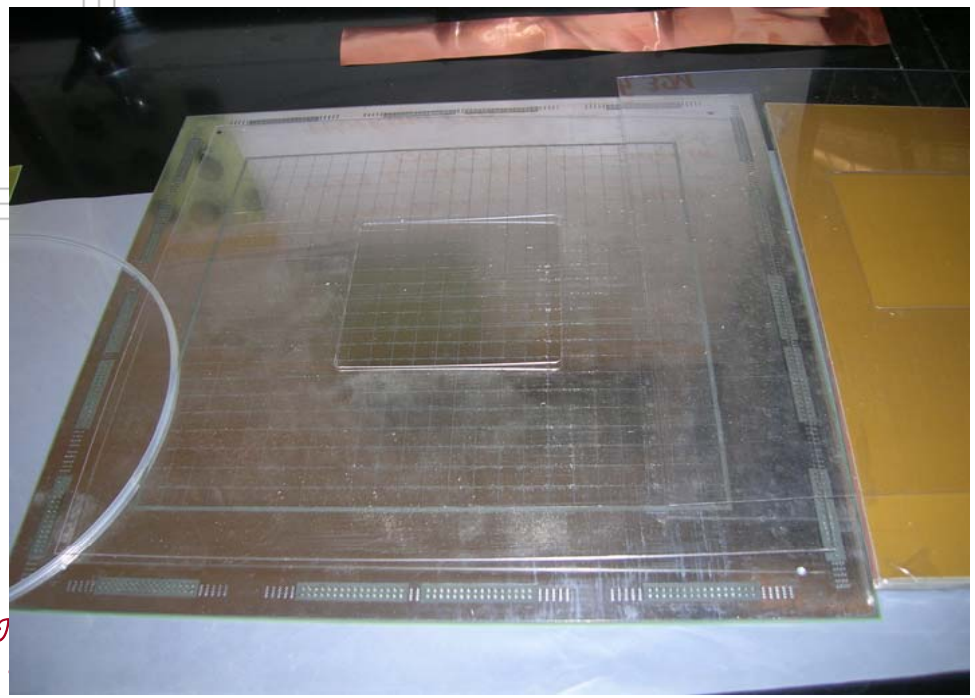
GEM/RPC Pad+FEB for DCAL Chip



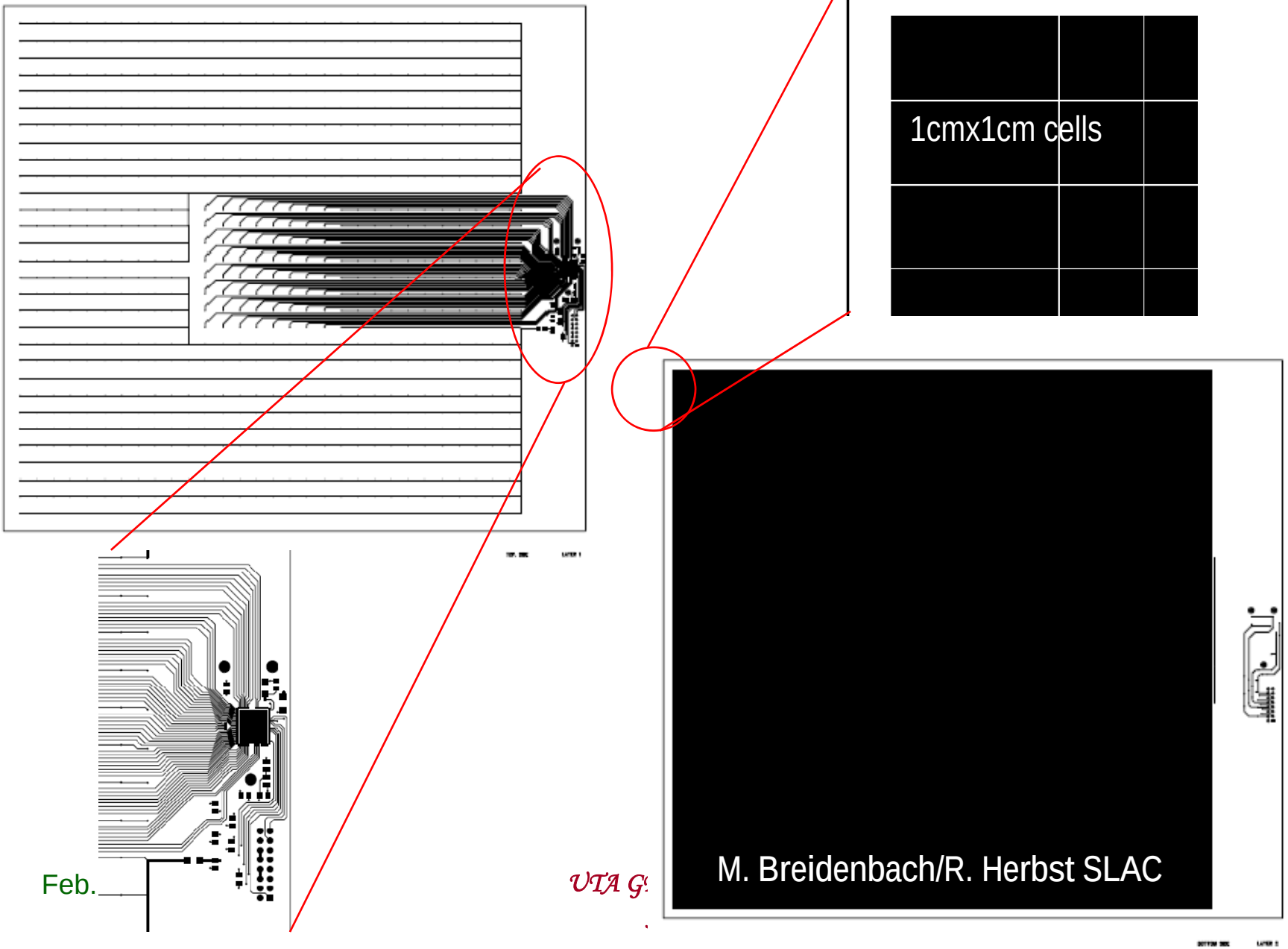


DCAL Chip 16cm x16cm Slice Test Chamber

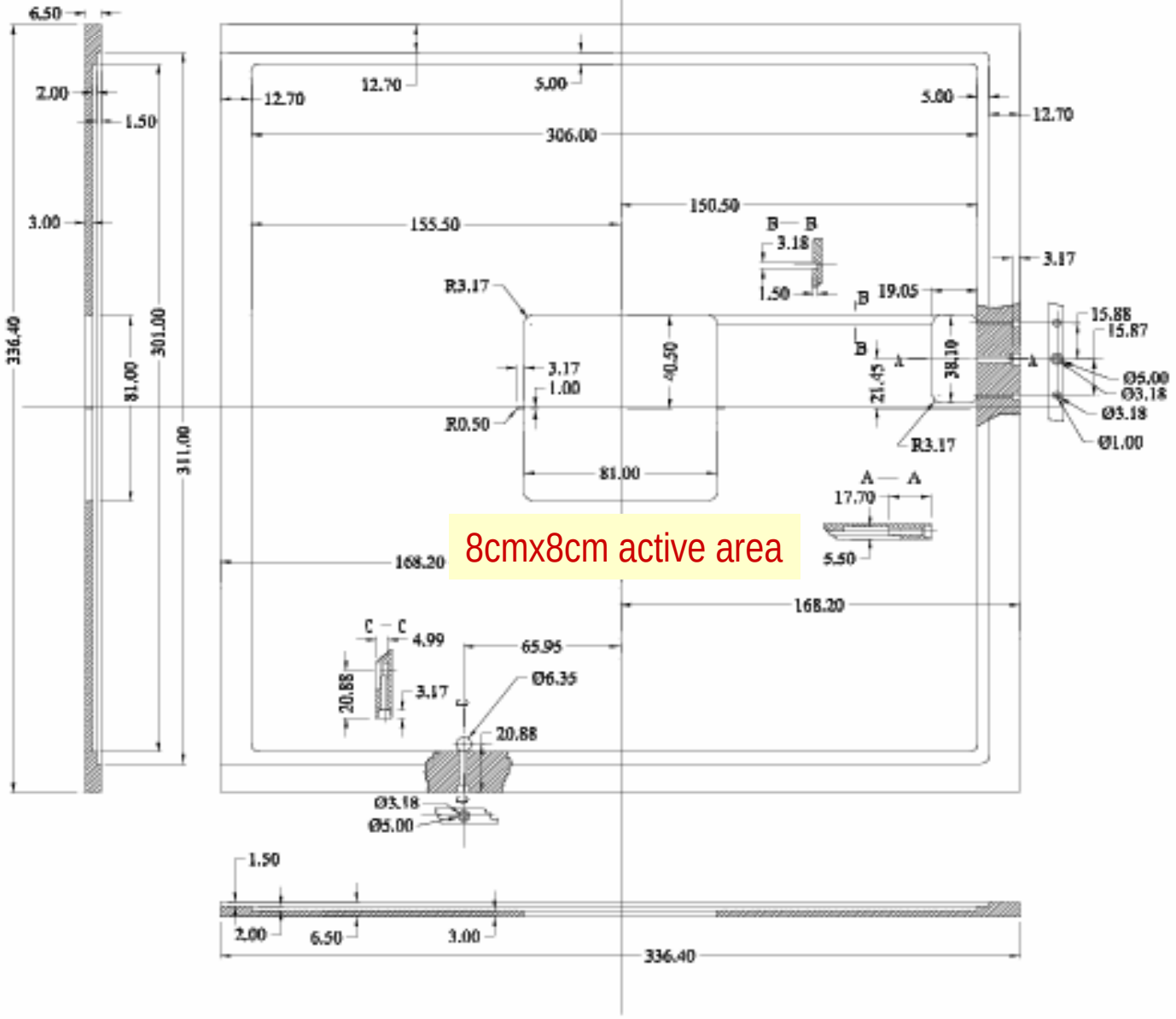




GEM FEB for KPix Chip



kPix Chip 8cmx8cm Slice Test Chamber



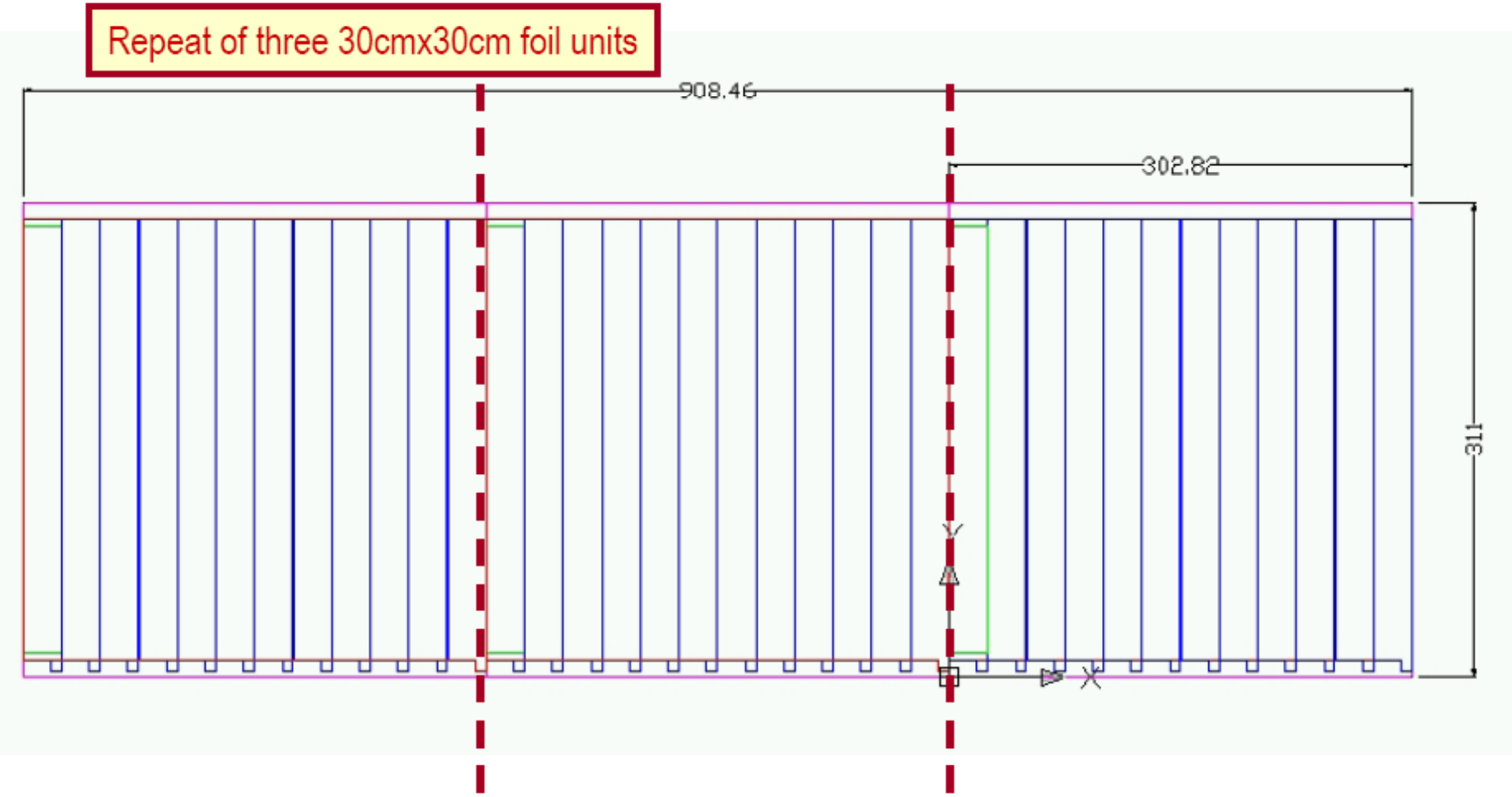
What next?

- Late 2007/early 2008
  - Construct large scale unit boards (30cmx1m)
  - Test unit boards
  - 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 (90cmx30cm) 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 summer ’07.
- First long chamber construction will follow the electronics slice test at Fermilab, in fall ‘07.

Proposed Initial 3M 30cmx100cm Foil Design



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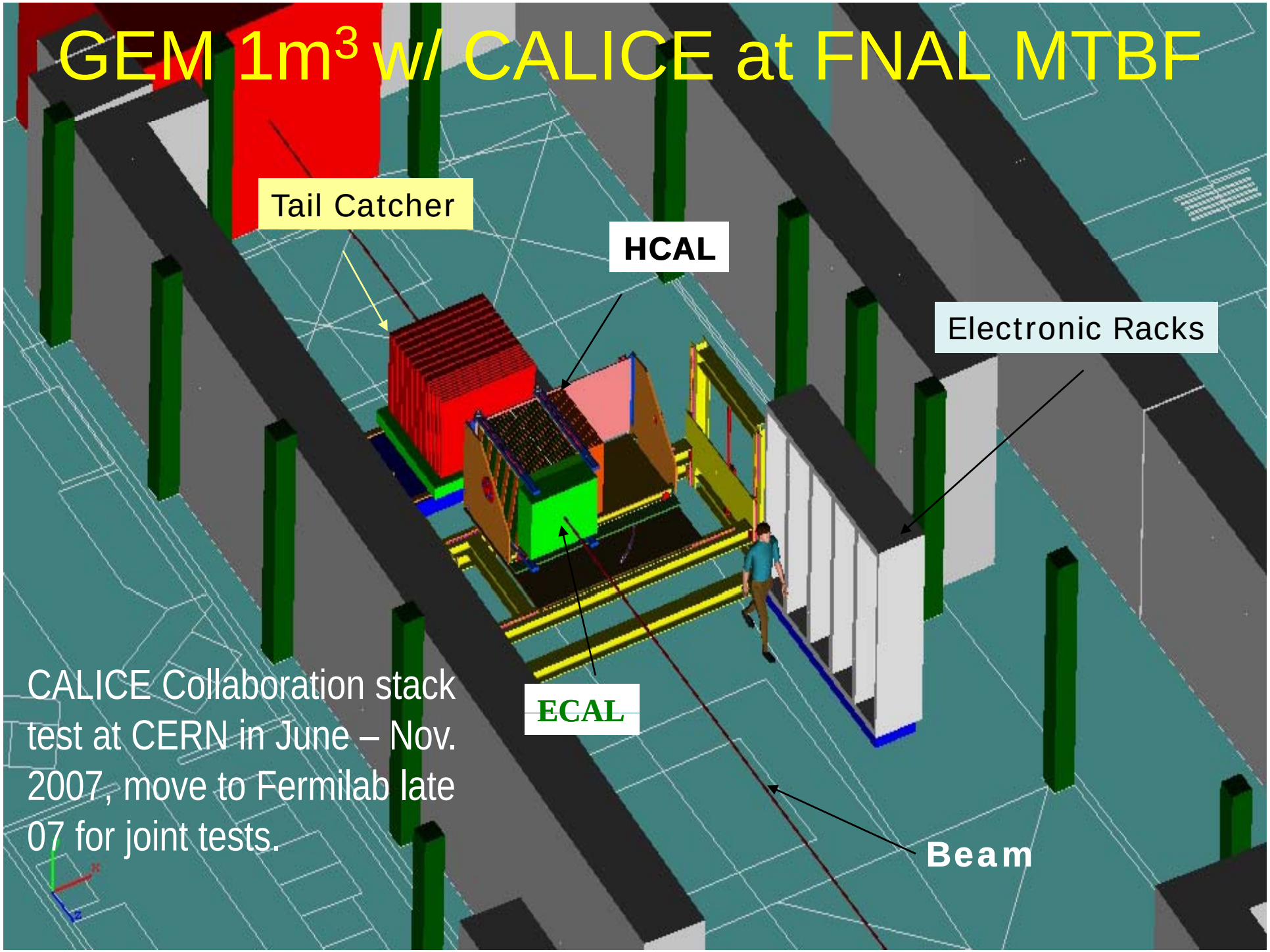
  - Construct large scale unit boards (30cmx1m)
  - Test unit boards
  - Start producing GEM chambers for $1m^3$ prototype if funding allows
  - Numerous tests, including beam tests for chamber properties, as the large chambers get produced
- Mid – late 2008
  - Completion of $1m^3$ stack
  - Beam test w/ full depth (40 layers) in late 2008

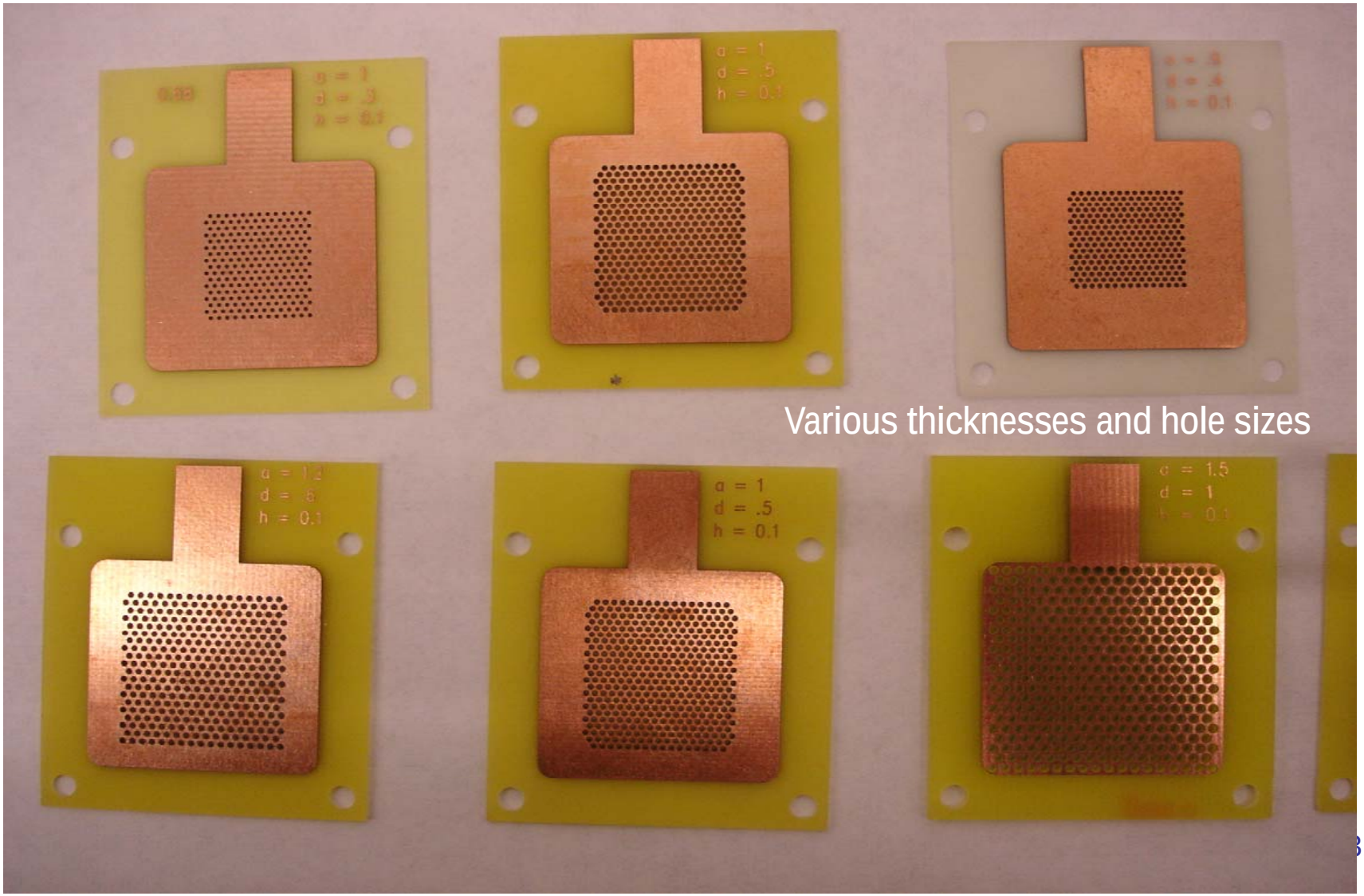
GEM $1m^3$ w/ CALICE at FNAL MTBF



CALICE Collaboration stack test at CERN in June – Nov. 2007, move to Fermilab late 07 for joint tests.

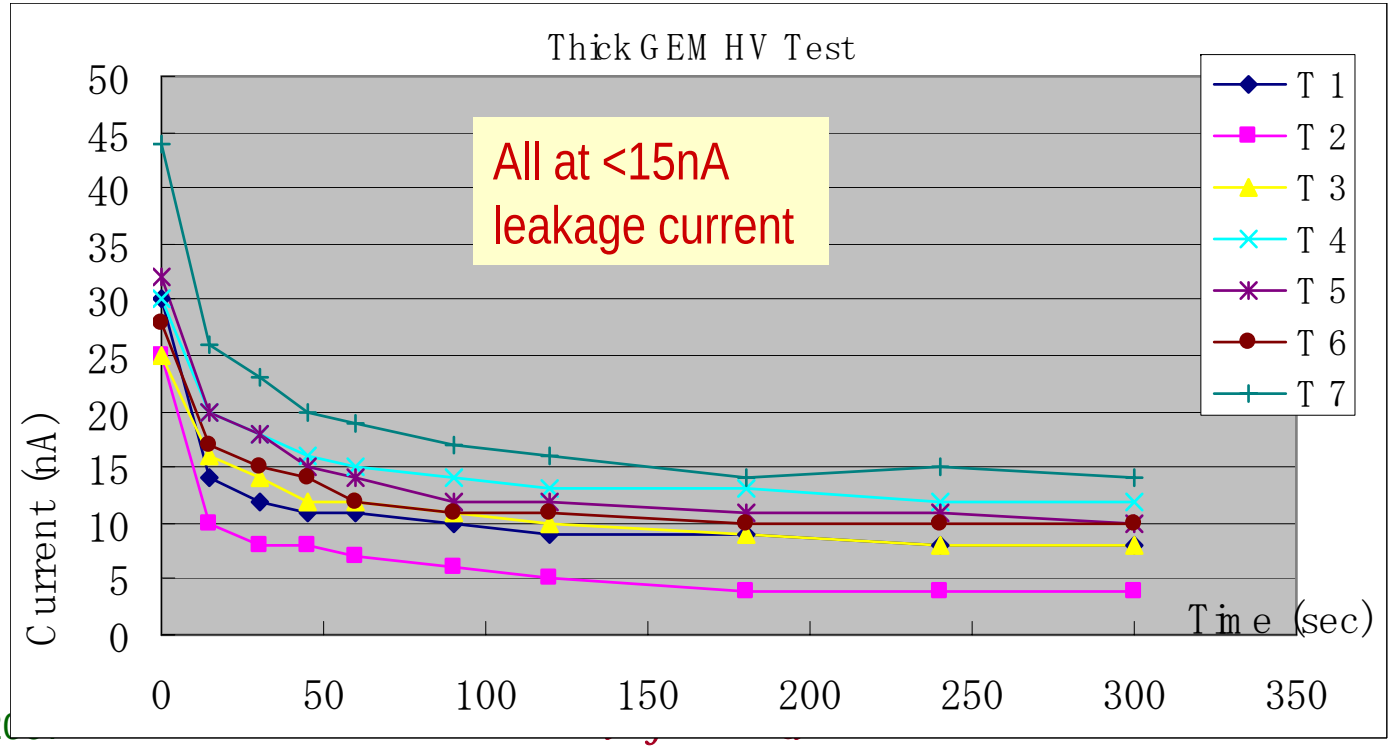
Samples of Thick GEM (TGEM)

Higher gains than thin GEMs and lower production cost ….

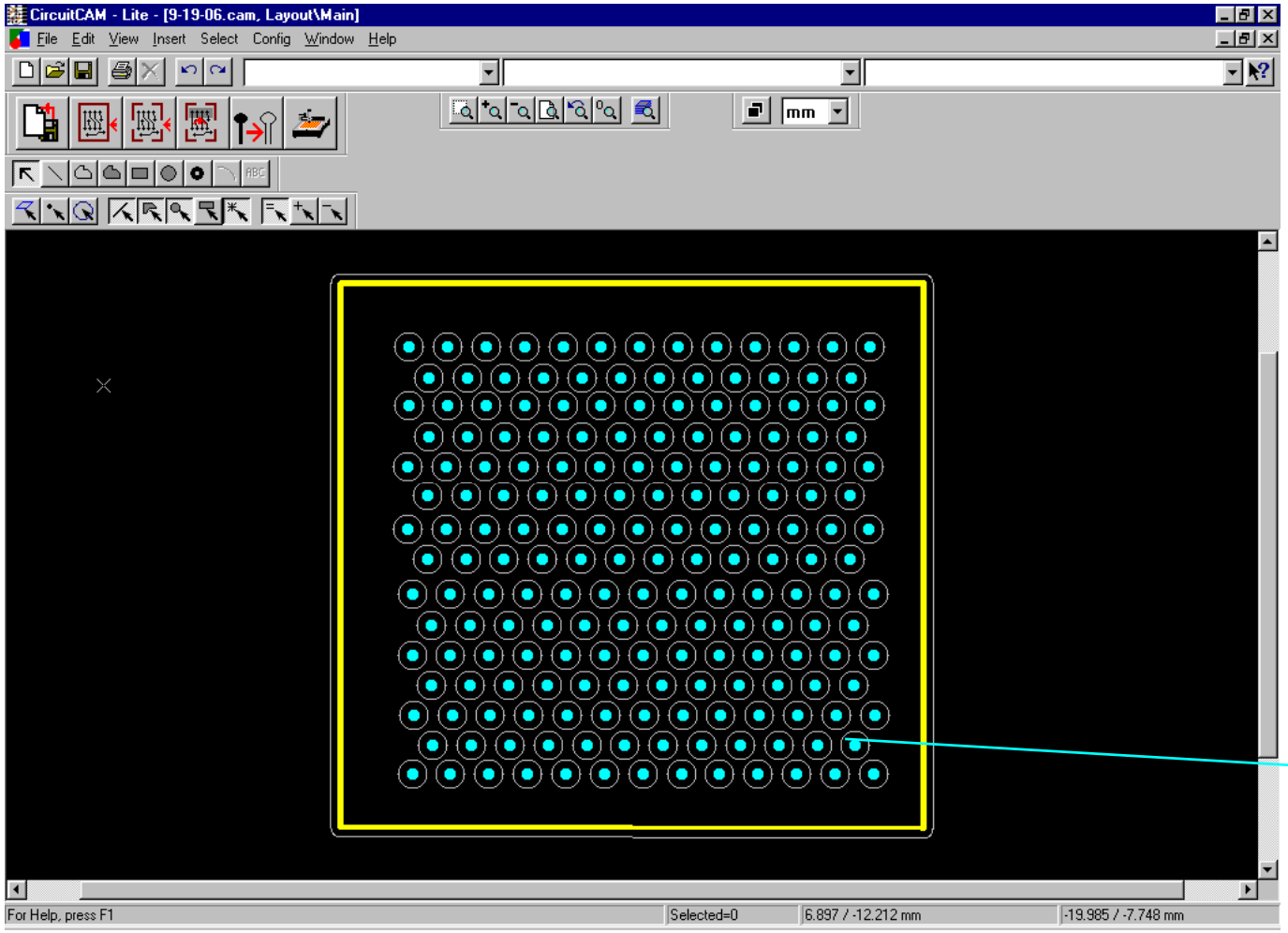


TGEM HV Test Results

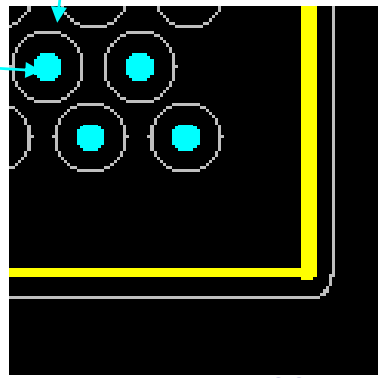
ThickGEM ID	0	15	30	45	60	90	120	180	240	300	Voltage(V)
T 1	30	14	12	11	11	10	9	9	8	8	1000
T 2	25	10	8	8	7	6	5	4	4	4	1000
T 3	25	16	14	12	12	11	10	9	8	8	1700
T 4	30	20	18	16	15	14	13	13	12	12	1700
T 5	32	20	18	15	14	12	12	11	11	10	1700
T 6	28	17	15	14	12	11	11	10	10	10	1700
T 7	44	26	23	20	19	17	16	14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



TGEM Development at UTA



0.5mm inner,
0.7mm outer



Conclusions

- UTA 30cmx30cm chamber built and exposed to low energi electron beam in May 2006
- First operation of the chamber in the beam
- Sebmitted MOU for joint chamber characteristics test on mid Mar. 7
- Electronics slice test to start in summer 07
- Larger foil (30cmx1m) for unit chamber development on going with 3M
- Firsd set to be available summer 07
- 1m3 prototype test in 2008 w/ available