UTA GEM DHCAL Progress

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For GEM/DHCAL Group

June 2006

- Introduction
- 30cmx30cm 3M GEM Foils
- 30cmx30cm Prototype GEM chamber
- KAERI electron beam exposure
- What next?
- Conclusions

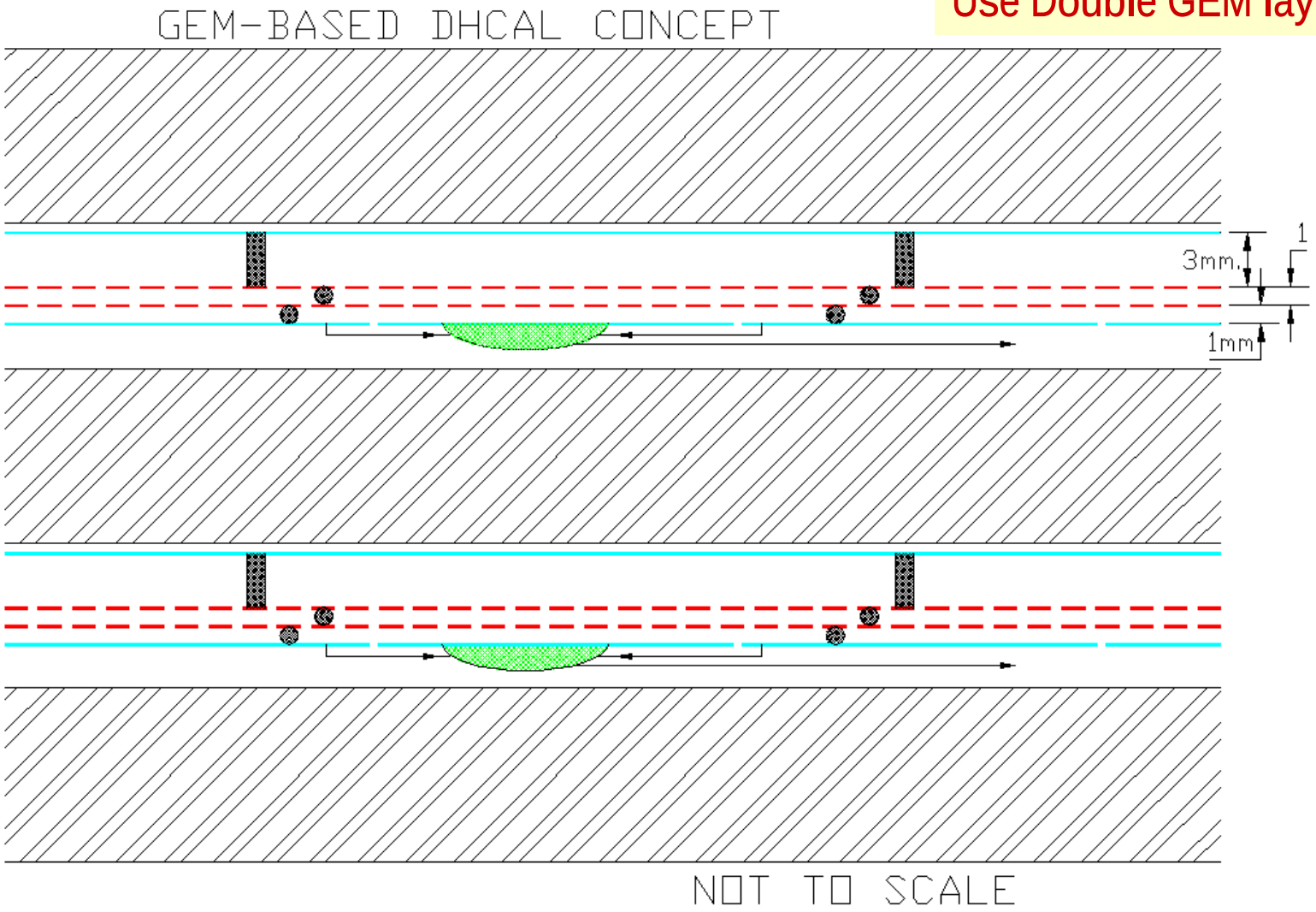
* UTA, U.Washington, Changwon Nat.U., Tsinghua U.

Why GEM's?

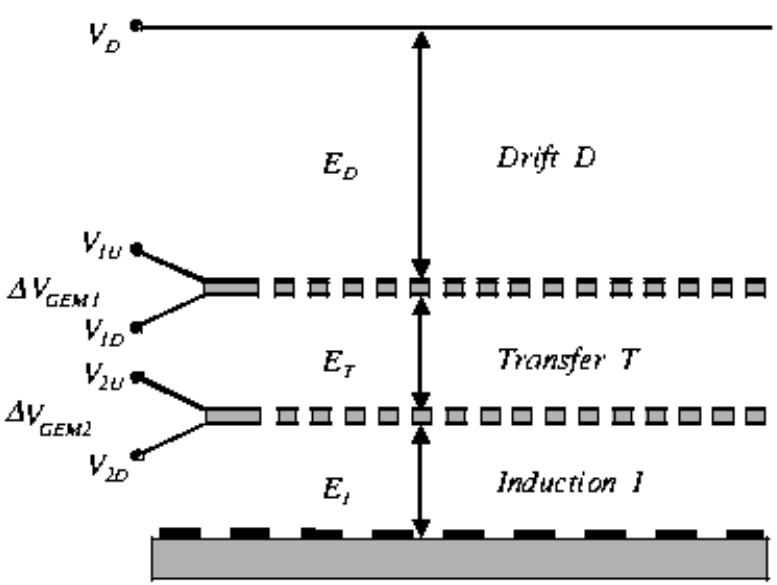
- Flexible configurations: allows small anode pads for high granularity.
- Robust: survives ~10^{12} particles/mm^2 with no changes.
- Fast: based on electron collection, ~few ns rise time.
- Uses simple gas (Argon/CO2) – no long-term issues.
- Runs at low HV (~400V across a foil).
- Stable operation.

GEM-based Digital Calorimeter Concept

Use Double GEM layers



GEM – Operation



-2100V

ΔV ~400V

ΔV ~400V

0V

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

GEM Foils From 3M

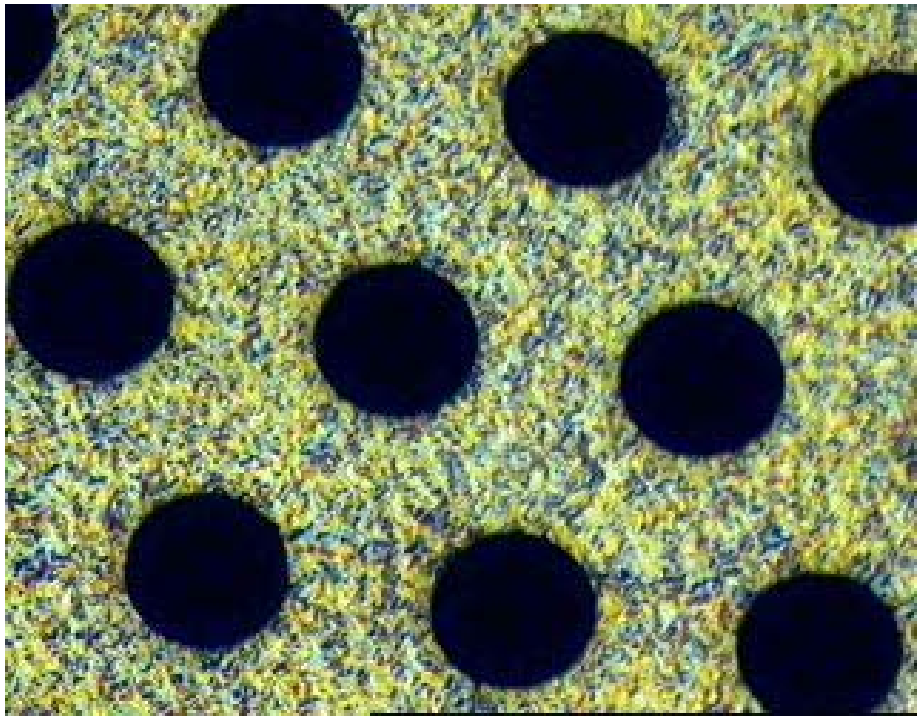
- 30cm x 30cm foils made with three types of coating:
  - Bare copper
  - “organic polymer” coating
  - gold plating
- HV tests made on all three types
  - Prefer to use the uncoated foils.
- New 30cm x 30cm chambers will be built w/ uncoated foils
- 3M is setting up a formal internal project to develop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

30cm x 30cm 3M GEM foils

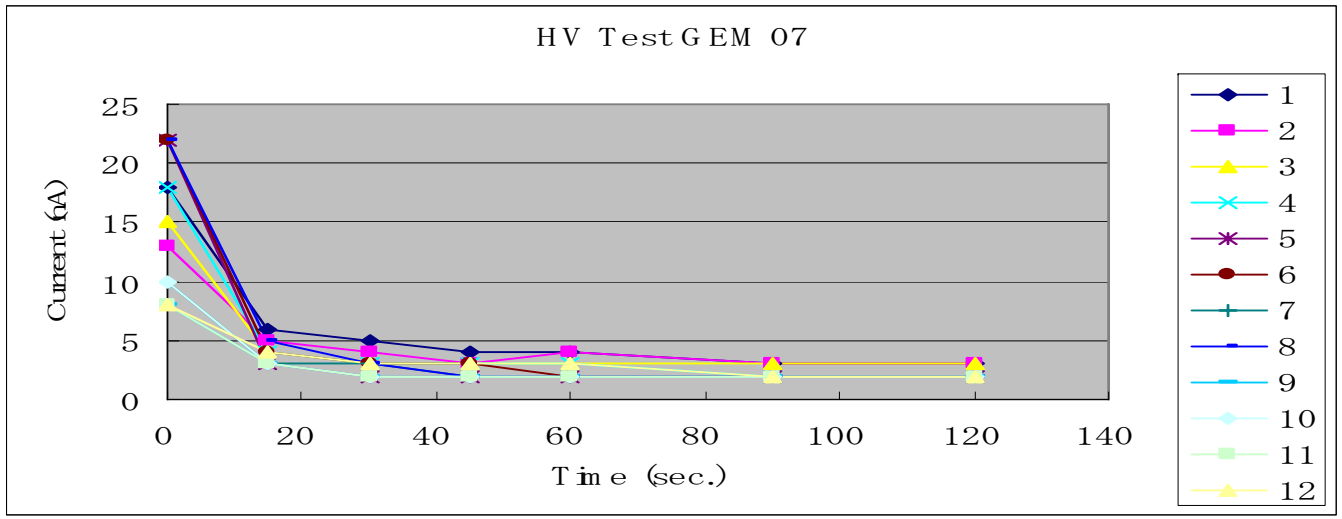
12 HV sectors on one side of each foil.

HV Sector Boundary

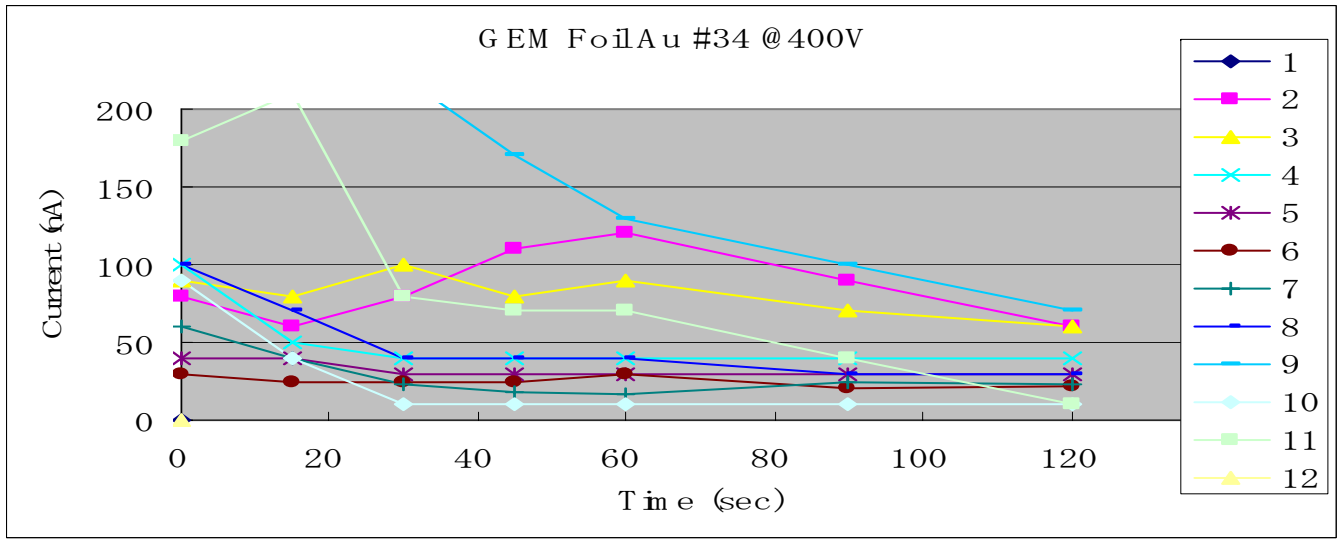
Magnified section of a 3M GEM foil.



HV Tests on 30cmx30cm 3M GEM foils



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



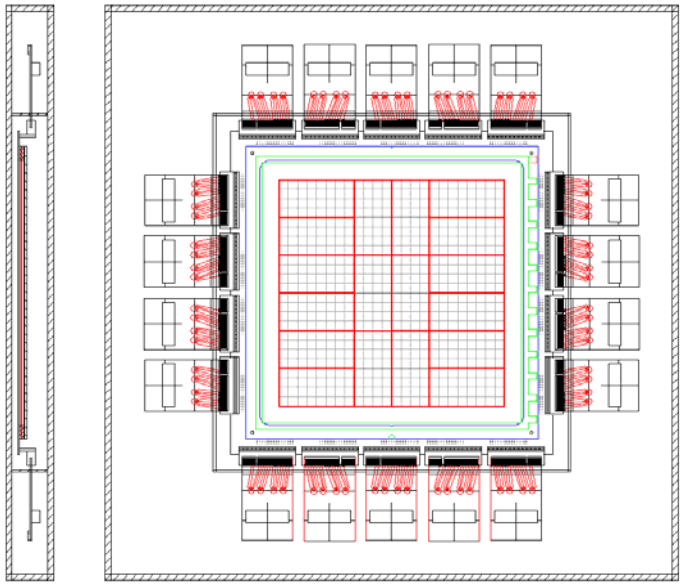
Au coated foils settle at 20 – 70nA and take longer to settle

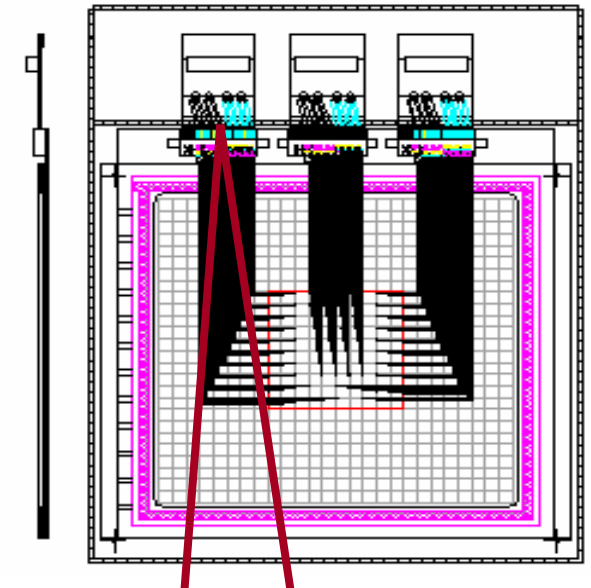
30cm x 30cm GEM Chamber Development

- Foils HV tested and certified
- Jigs made to mount foils, stack chamber.
- Initial 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 at 10MeV electron beams at Korea/KAERI beam tests in May

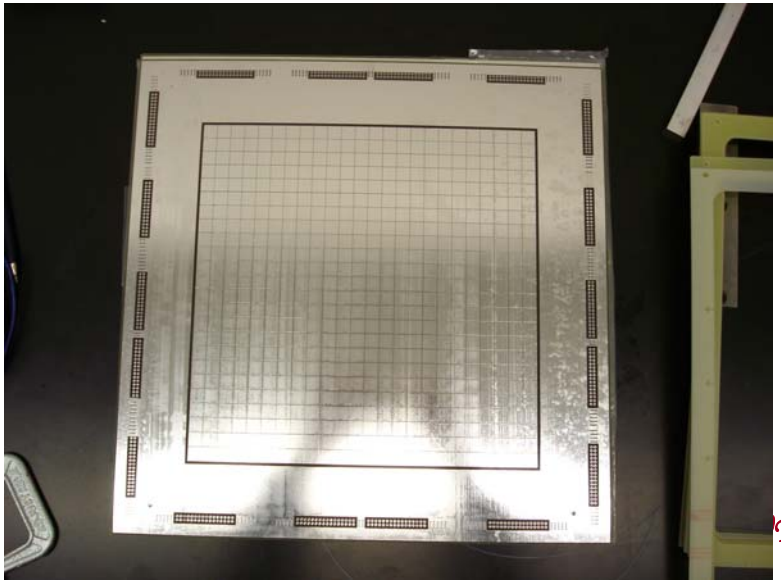
GEM Foil Frame Mounting Jig

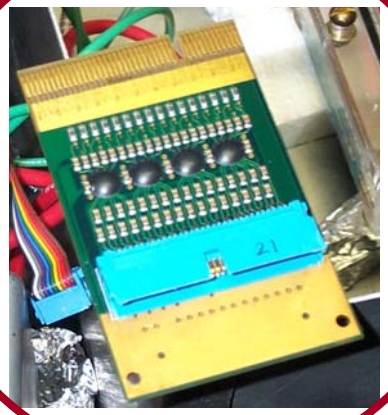
Anode Board & Preamp for 30cm x 30cm Chamber





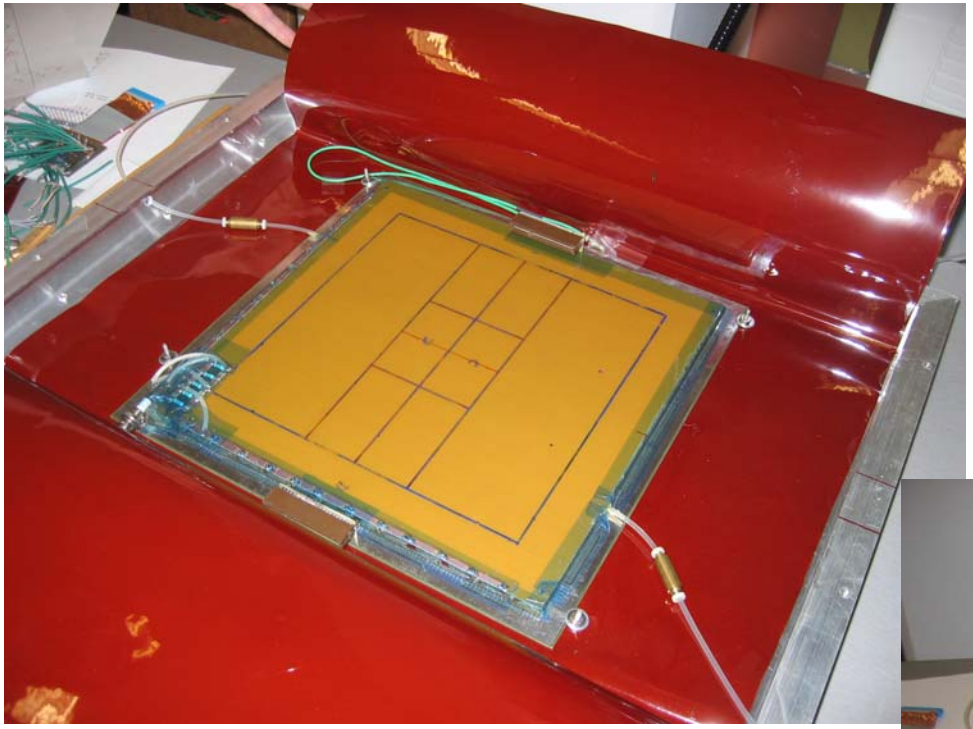
Anode boards designed to read 96 pads in the center



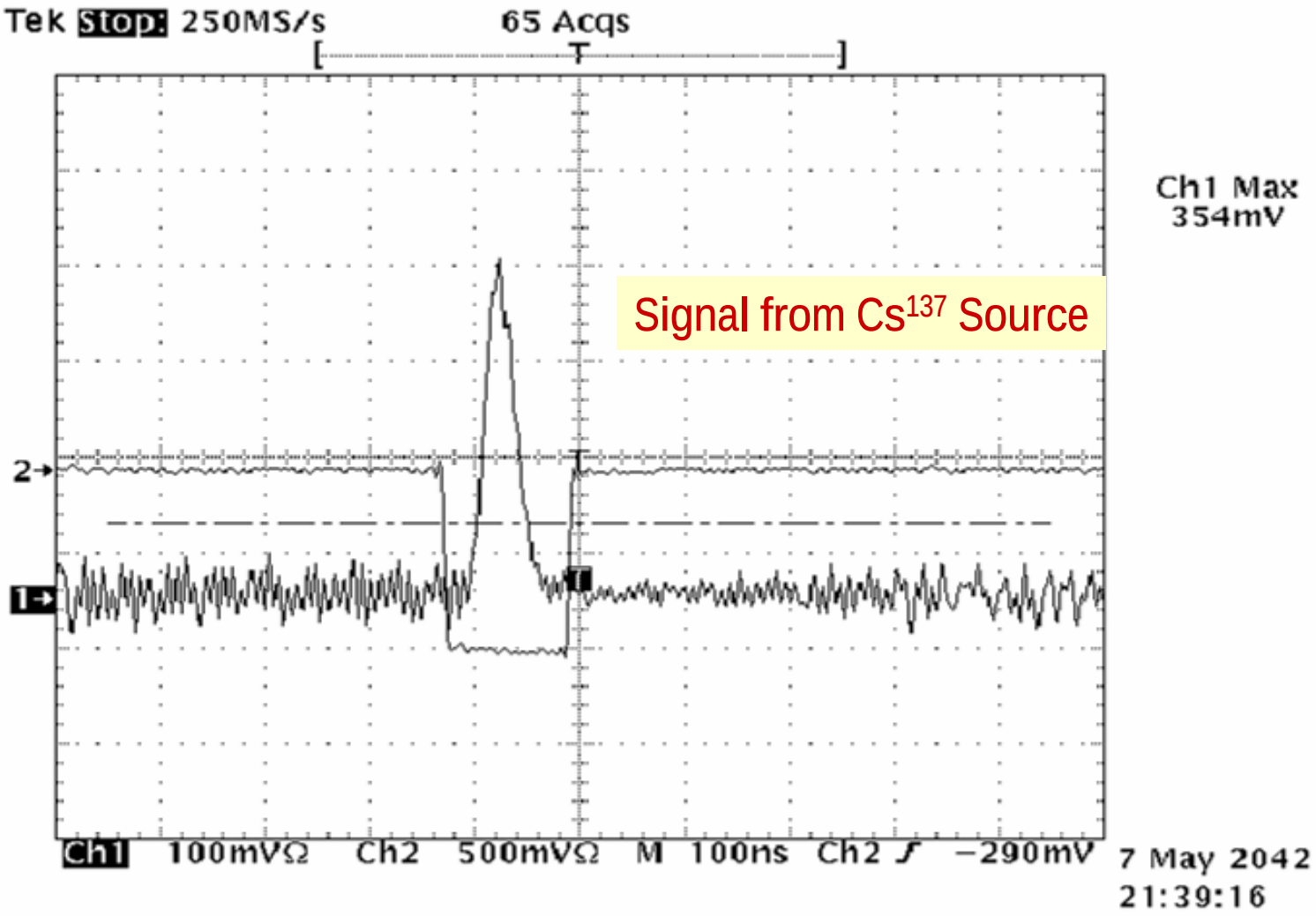


Use 32 channel FNAL preamps

30cm x 30cm GEM Chamber for KAERI Beam Exposure



30cmx30cm D-GEM Detector Signal



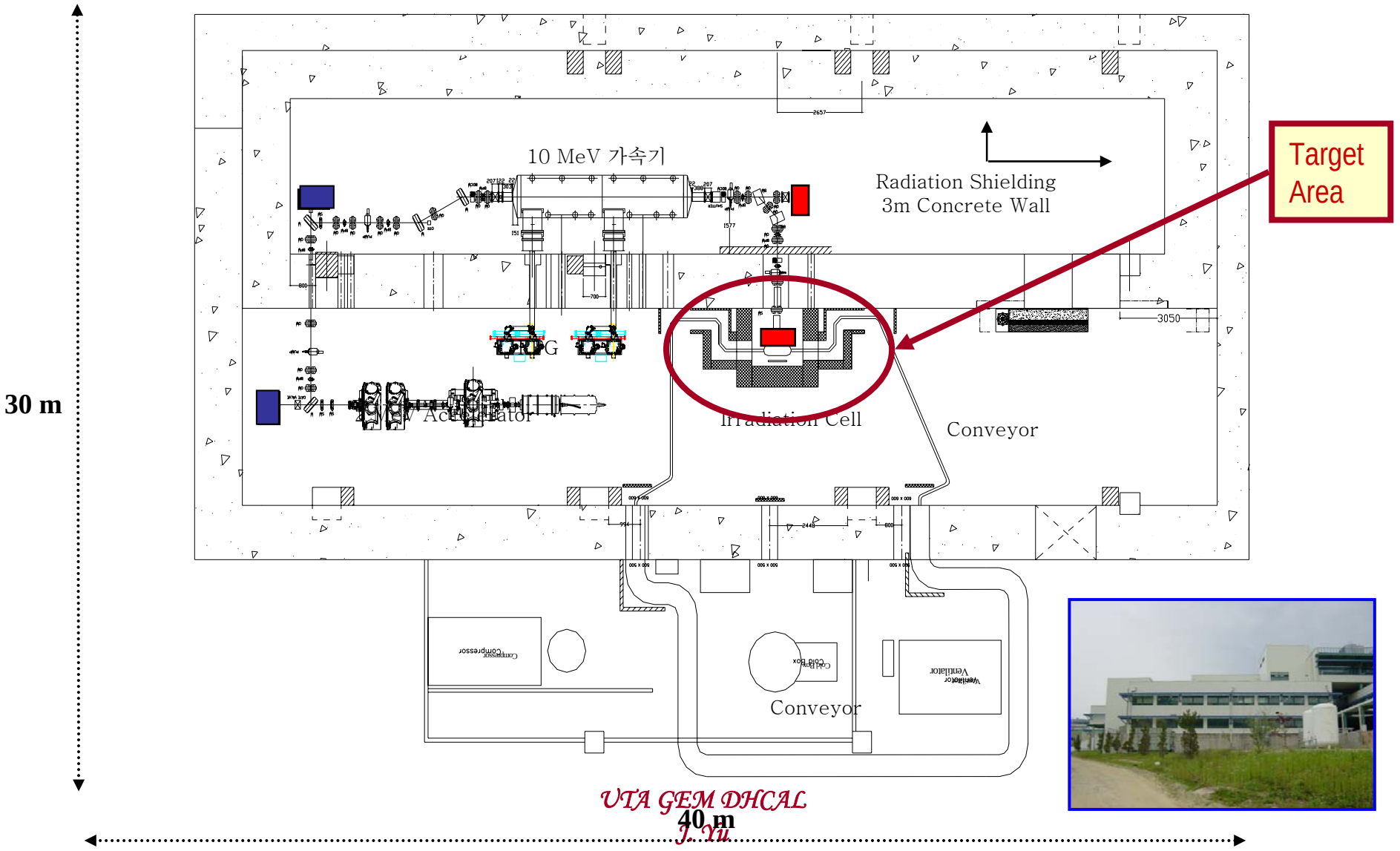
KAERI Low-Med E Exposure Facility

0.3~2 MeV

2~10 MeV

지하 : 330평
지상 : 170평

총 면적 : 500평

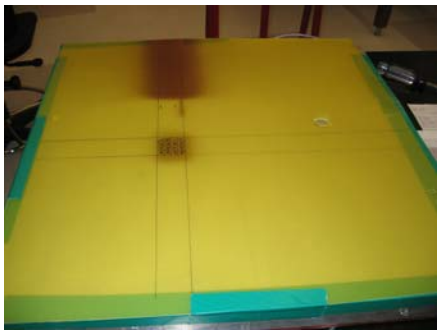


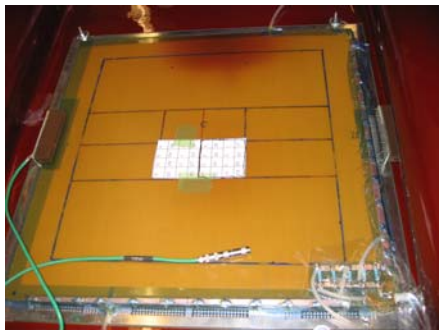
UTA GEM Chamber in KAERI Electron Beam

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

- 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.

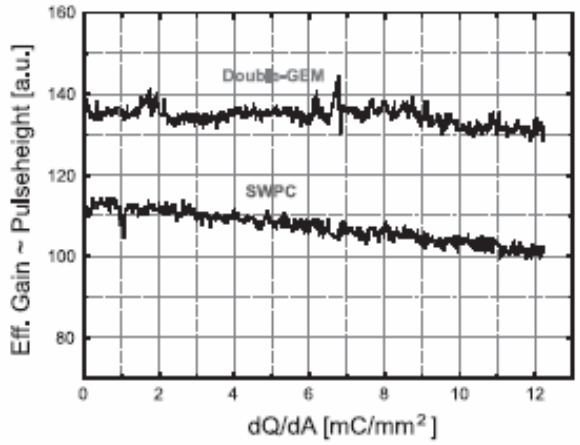


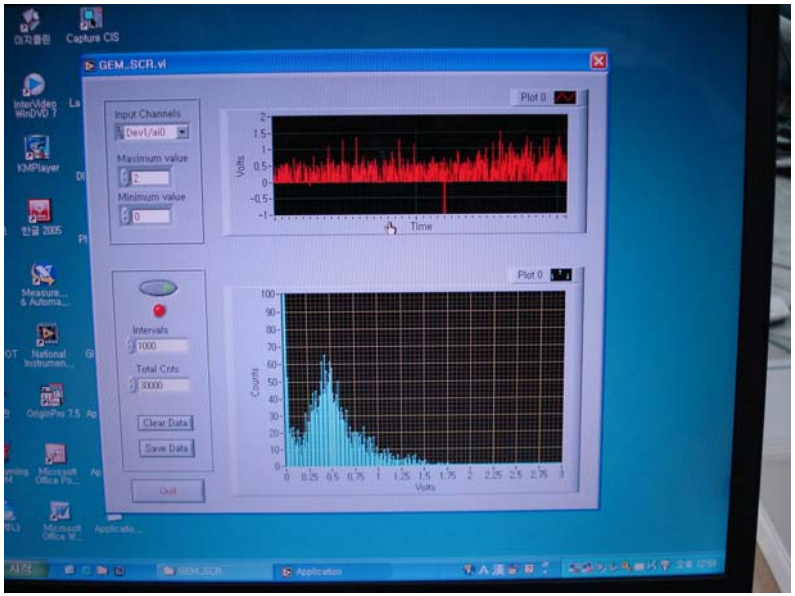
Fig. 3. Previous aging measurement of a double-GEM detector with Ar–CO_2 (70:30): effective gain versus accumulated charge dQ/dA.

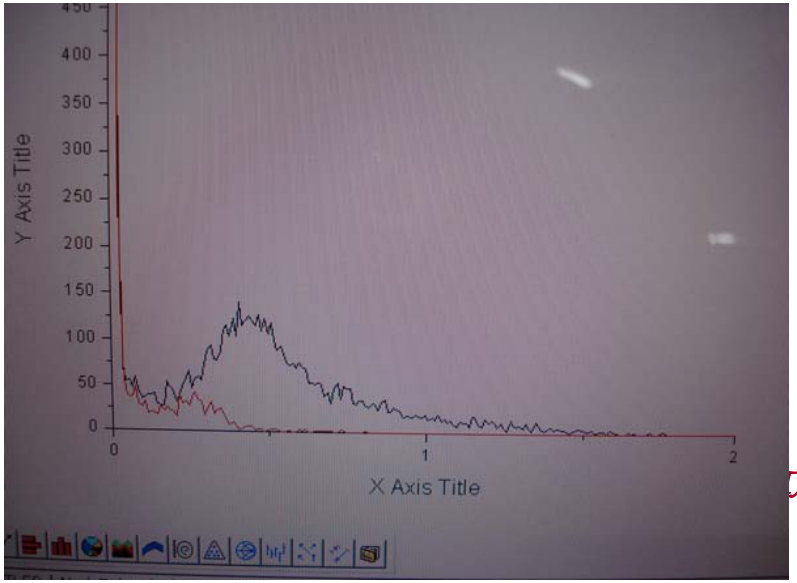
- Much above total hits/10y/pad at ILC

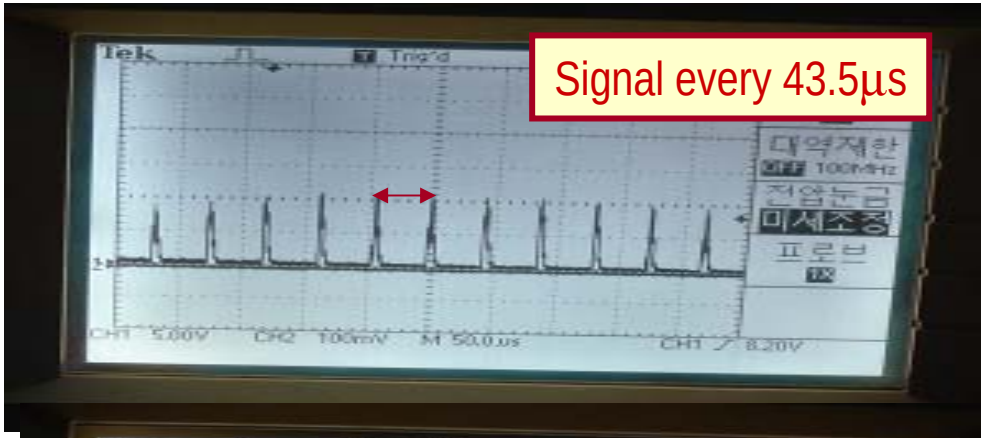
- Much below any damage region for decrease in gain.

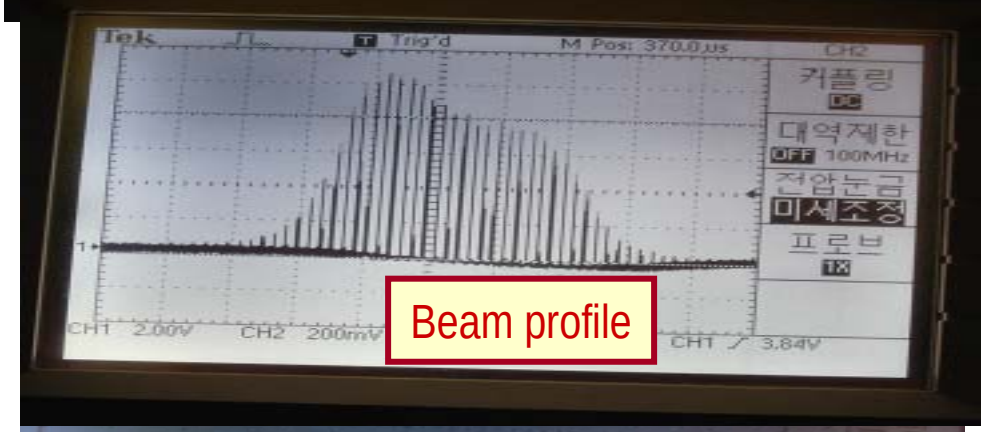
KAERI Beam Exposure Results

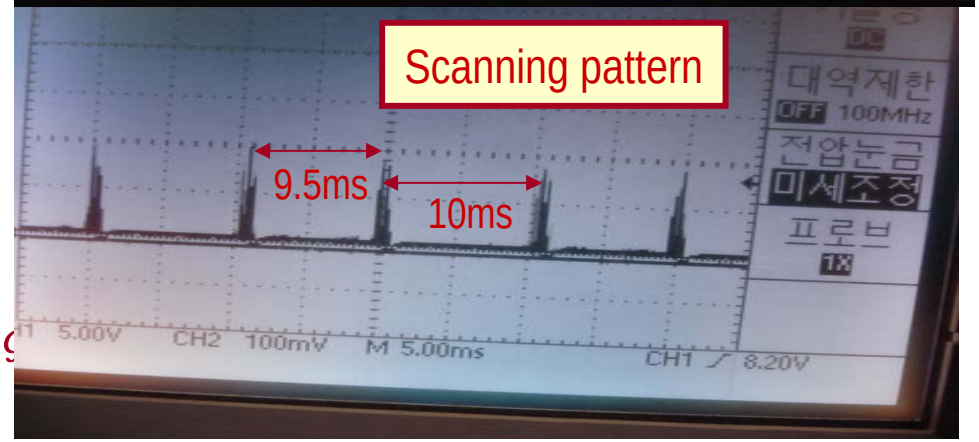
CNU Chamber Labview output











What next?

- Fall 2006: Prototype test at FNAL
  - Much reasonable beam intensity
  - Two additional 30cmx30cm chambers
    - Use FNAL preamp+100channel PCI based ADC
- Early 2007: Slice test at FNAL
  - Joint with RPC
  - Read out using DCAL and kPix chips
  - Use two 30cmx30cm chambers
  - Working on developing 1mx30cm foils for sections of $1m^3$ prototype
    - If 3M develops larger foils in time, we might try them out.

What next?

- Mid 2007
  - Large anode board test
  - Start producing GEM chambers for $1m^3$ prototype if funding allows
  - Numerous tests, including beam tests, as the large chambers get produced
- Late 2007/early 2008
  - Completion of $1m^3$ stack
  - Beam test w/ full depth in 2008

Conclusions

- UTA 30cmx30cm chamber built and exposed to low energy electron beam in May 2006
  - First operation of the chamber in the beam
- Larger foil (30cmx1m) development on going with 3M
  - First set available in Fall 06
- Additional beam tests in Fall 06 and early 07
  - Decision on readout chip expected after slice test
- $1m^3$ prototype test in 2008 w/ available funding