UTA GEM DHCAL Progress

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For GEM/DHCAL Group
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• Introduction
• 30cmx30cm 3M GEM Foils
• 30cmx30cm Prototype GEM chamber
• KAERIC electron beam exposure
• What next?
• Conclusions
Why GEM’s?

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

Use Double GEM layers
GEM – Operation

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.

Magnified section of a 3M GEM foil.

HV Sector Boundary
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 30cm x 30cm anode board made to work with 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

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30cmx30cm D-GEM Detector Signal

Signal from Cs$^{137}$ Source
KAERI Low-Med E Exposure Facility

- **0.3~2 MeV**
- **2~10 MeV**

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<th>Style</th>
<th>Description</th>
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<td>0.3~2 MeV</td>
<td>Blue</td>
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<tr>
<td>2~10 MeV</td>
<td>Red</td>
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**Specifications:**
- Underground: 330 m²
- Aboveground: 170 m²
- Total Area: 500 m²

- **Target Area**
- **3m Concrete Wall**
- **Conveyor**
- **10 MeV Accelerator**
- **Radiation Shielding**
- **Irradiation Cell**

Visual representation includes:
- **Ventilator**
- **Compressor**
- **Cold Box**
- **UTA GEM DHCAL**
- **KAERI Low-Med E Exposure Facility**

[Map of KAERI Low-Med E Exposure Facility]
UTA GEM Chamber in KAERI Electron Beam

e beam: $10^{10}$ particles in 30ps pulse
~every 43µs
Scans 4cmx6cm 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 $\Rightarrow$ ~$10^9$ e-/sec on an anode pad.

- Total exposure ~2000sec

$\Rightarrow$ Estimate ~2 x $10^{12}$ e-/pad (~ 1.6 x $10^{-2}$ mC/mm$^2$) accumulation

$\Rightarrow$ GEM chamber continued normal operation.

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

- Much below any damage region for decrease in gain.

Fig. 3. Previous aging measurement of a double-GEM detector with Ar–CO$_2$ (70:30): effective gain versus accumulated charge $dQ/dA$. 

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KAERI Beam Exposure Results

CNU Chamber Labview output

Signal every 43.5µs

Beam profile

Scanning pattern

9.5ms 10ms
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 1m³ prototype if funding allows
  - Numerous tests, including beam tests, as the large chambers get produced

• **Late 2007/early 2008**
  - Completion of 1m³ 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