Mass Production of GEMs (Chicago/Purdue/3M)

Aging of mass produced GEMS (Purdue)

Operation of GEMS in Negative Ion Gases (Purdue/Temple/WSU)

Towards mass production of MICROMEGAS (Purdue/3M)

Jun Miyamoto, Ian Shipsey
Purdue University
**GEM:** holes separated by an insulator

**Micromegas:** a micromesured sputter ion-milled \( \mu \text{m} \) thick insulating diaphragms

Slide stolen from P. Colas Amsterdam Tracking meeting March 31 2003
First Mass Production of Gas Electron Multipliers
(3M Proprietary Flex Circuit Fabrication Technique)

• **3M** Reel-to-reel process, rolls of 16”x16” templates of detachable GEMs in any pattern.
• Batch of 1,980 GEMs produced end ’02 and tested at Chicago/Purdue Spring ’03
• Now widely inspected/tested elsewhere: CERN/Novosibirsk/NASA Goddard/BNL etc.

Single roll of
~1,000 GEMS

3M GEm
$\Delta E/E = 16\%$

P. Barbeau & J. Collar (Chicago)
J. Miyamoto, & I. Shipsey (Purdue)

Preliminary studies performance is equivalent to CERN GEMs, cost potentially lower

Novosibirsk gain curve in P-10 gas
### Summary Comparison CERN and 3M GEM

<table>
<thead>
<tr>
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<th>3M GEM</th>
<th>CERN GEM</th>
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<tbody>
<tr>
<td>$I_{\text{leak}}$</td>
<td>$0.02 \text{nA/cm}^2 @ 600\text{V in air at} \quad 40% \text{R.H.}$</td>
<td>$0.005 \text{nA/cm}^2 @ 500\text{V in N}_2$</td>
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<tr>
<td>Gain</td>
<td>$\sim 1,000 @ 500\text{V Ar/CO}_2 \ 7:3$</td>
<td>$\sim 1,000 @ 500\text{V Ar/CO}_2 \ 7:3$</td>
</tr>
<tr>
<td>$\Delta E/E$</td>
<td>$\sim 16%$ (9%)</td>
<td>$\sim 18%$ (typical)</td>
</tr>
<tr>
<td>$\Delta G(x,y)/G(x,y)$</td>
<td>$0.9$</td>
<td>$0/9$</td>
</tr>
<tr>
<td>Electron Transparency</td>
<td>$0.9$</td>
<td>$0.6$</td>
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<tr>
<td>Ion Transparency</td>
<td></td>
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<tr>
<td>Ion Feedback</td>
<td>$0.1$ at G=$20$ \quad E_{\text{drift}}=150\text{V/cm}$</td>
<td>$0.08 \quad E_{\text{drift}}=150\text{V/cm}$</td>
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| Ageing                       | $To be measured$                            | $25 \text{mC/mm}^2$ Triple GEM @ Purdue (2000)$

First mass production of $\sim 2,000$ GEMs Preliminary studies performance is equivalent to GEMs made at CERN. See hep-ex/0304013 & Imaging 2003 proceedings. An ageing study had yet to be done....

Table from I.Shipsey ALCW Cornell, July ‘03
First Aging Study of a Single 3M GEM

X-ray beam parallel to the GEM surface homogenous irradiation over a large area: provides a more realistic aging simulation (NEW)

First Aging Study of a Single 3M GEM

Ambient conditions (P,T) gas quality & X-ray tube stability are accounted for with a single wire proportional monitor chamber in the same gas system receiving beam from the same X-ray tube.

Spectra are obtained without pile up via an absorber & reduction in the X-ray current.
Pulse height of monitor chamber and a single GEM with time

(The fluctuations in gain are due to changes in atmospheric pressure.)
Energy resolution remains constant throughout the experiment.

Beginning of ageing study

After 400 hours of irradiation

Gas Gain

5.4 keV X-ray peak

Gas Gain

Total accumulated charge 2.5 mC/mm² (corresponds to ~16,000 years at a LC [ref Lepeltier]).
Leakage current remains in the region expected for a normally functioning GEM throughout the period of irradiation. This stability of the insulator is crucial for its performance.
New Application:
3M GEMs for Negative Ion TPC

Single stage gains up to ~1,000

(He mixtures also tested)
Towards Development of Mass Produced MICROMEGAS

3M Flex Circuit Fabrication Technique better suited to GEMS than MICROMEGAS but worth a try…

(Micromegas are harder to make because they are effectively GEMs with one layer of conductor and most of the insulator removed)
Development of mass produced MICROMEGAS

November-December 2003

Drawing (two views)

Reality

Kapton pillar (tapered on right)
Successful operation in Ar-DME gas but the performance (energy resolution) is inferior to a traditional MICROMEGAS presumably due to an observed (severe) lack of uniformity and imperfections in the micromesh.

3M believe they know how to cure this and a new batch of micromesh foils is expected in the next few weeks.
Mass produced GEMs now tested by a variety of groups
performance similar to CERN GEMS (Chicago/Purdue/3M)

Mass produced GEMs are radiation hard (Purdue). Need
other groups to confirm this result.

GEMs operate in negative ion gases
(Purdue/ Temple/ WSU)

The first steps towards successful mass production of a
MICROMEGAS have been taken. In our opinion most
of the challenges still lie ahead. However, we are cautiously
optimistic. More news (hopefully) in a few weeks.
(Purdue/3M)