Results of QC of large size GEM detector based on Korean GEM foil for future upgrades of the CMS muon system

Inseok Yoon on behalf of the CMS Collaboration

Seoul National University

5th, July, 2018
ICHEP 2018 at Seoul
Table of Contents

The CMS Phase-II muon detector upgrade

GEM detector technology

KCMS & Mecaro consortium

Single-mask & double-mask technique comparison

Foil quality validation with CMS GE1/1 detector
   Gain and its uniformity
   Rate capability
   Radiation hardness

Conclusion & summary
The CMS Phase-II muon detector upgrade

- As luminosity upgrade of LHC is scheduled, detector capability should be upgraded to maintain trigger performances.
- Detectors based on GEM technology, GE1/1, GE2/1, and ME0, are planned to be installed.
  - TDR of CMS Phase-II muon detector upgrade for detail.
GEM detector technology

- Avalanche occurs at micro holes which are filled with high density electric fields.
- Why GEM technology is chosen for the CMS Phase-II upgrade?
  - High rate capability.
  - Hardness to radiation.
  - Thin.
KCMS & Mecaro consortium

- KCMS has made the consortium with Mecaro to produce large size GEM foil since 2012.
  - The current supply of GEM foil can’t satisfy the demand.
  - To be a second supplier for the CMS Phase-II upgrade.
- Mecaro produces GEM foil with double-mask technique.
  - Inner(outer) hole diameter = 50(70) µm, pitch = 140 µm.
  - Production rate: 10 foils/week.
  - Maximum producible foil size: 1300mm × 610mm.
### Single-mask & double-mask comparison

<table>
<thead>
<tr>
<th></th>
<th>Single-mask</th>
<th>Double-mask</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production process</strong></td>
<td><img src="image" alt="Single-mask production process" /></td>
<td><img src="image" alt="Double-mask production process" /></td>
</tr>
<tr>
<td><strong>Production speed</strong></td>
<td>Slow</td>
<td>Fast</td>
</tr>
<tr>
<td><strong>Necessity of mask alignment</strong></td>
<td>No (film)</td>
<td>Crucial (glass)</td>
</tr>
<tr>
<td><strong>Cost of necessary machines</strong></td>
<td>Cheap</td>
<td>Expensive</td>
</tr>
<tr>
<td><strong>Hole shape</strong></td>
<td>Asymmetric</td>
<td>Symmetric</td>
</tr>
</tbody>
</table>

- Mecaro alignment capability: residual misalignment $< 3 \mu m$.
- Inkyu’s talk for the detail of GEM foil production at Mecaro.
Foil quality validation with CMS GE1/1 detector

- To validate the quality of Mecaro foils, three CMS GE1/1 detectors are assembled with Mecaro foils.
- Triple GEM detector with mechanical foil stretching. Single line HV with voltage divider.
- Validation of cleaning capability of Mecaro is still ongoing.
  - For proper operation, Mecaro foils should be cleaned again at CERN.
- Once cleaned again, Mecaro foils work well.
Gain and its uniformity

- Gain: $2 - 5 \times 10^4$ at $700 \mu A$, gain variance: $10.2 - 16.2\%$
  - Consistent with the results of the detectors based CERN foils.
Rate capability

- Gain remains stable x-ray flux up to $1 \times 10^5 \text{Hz/mm}^2$.
  - Enough capability for the Phase-II upgrade.
  - Gain drops at very high flux because of voltage drop at high protection resistance.
Radiation hardness

- No gain degradation due to aging is observed up to $34 \text{mC/cm}^2$.
  - It corresponds to 113 years of GE2/1 and 1.2 years of ME0 detector operation at HL-LHC.
- Yonghoon’s poster for detail.
Conclusion & Summary

• KCMS & Mecaro consortium produces large size GEM foil with double-mask technique for the CMS Phase-II muon detector upgrade.
• Foil quality validation is ongoing by assembling CMS GE1/1 detectors and measuring properties.
• Once foils are cleaned again at CERN, Mecaro foils work fine in terms of gain, gain uniformity, rate capability and radiation hardness.
• Foil cleaning capability of Mecaro is being reviewed now.
• KCMS & Mecaro consortium will contribute to not only the CMS Phase-II muon upgrade but also other experiments by supplying the large size GEM foils.