GEM Activities at USTC

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Outline

• Introduction: GEM detectors

• Self-stretching GEM assembly
  – NS2 technique

• 30cm*30cm GEM R&D

• Large-area GEM stretching studies

• 50cm*100cm GEM design and prototyping
  – Towards SoLID GEM

• GEM readout electronics

• Summary and plans
GEM Detectors

- Gas Electron Multiplier (GEM) detectors
  - electrons released in primary ionization are multiplied through small holes on GEM foils and finally collected on the anode plane.
- A low-mass and cost-effective solution to high-precision and large-area tracking at high-rate large-scale experiments such as SoLID.
NS2 Technique

- A new GEM assembly method developed at CERN for the CMS GEM project.
- Main focus of large-size GEM detector R&D at USTC

- No gluing, assembly easy and fast, highly efficient and labor saving
- No inner spacers, no dead areas, smooth gas flow
- Complete re-opening possible, full detector re-cleaning possible, highly replaceable and repairable, reduced cost
30cm *30cm GEM R&D
• Intensive R&D on NS2 technique through 30cm*30cm GEM prototyping. Modifications and improvements to NS2.

GEM layer assembly

Main frame assembly

GEM foil stretching and whole Chamber assembly
Testing

X-Ray -> GEM -> Pre-Amplifier -> Shaper1

- Shaper2
- Disc.
- Scaler

- HV
- Pico-ammeter
- MCA
Gain vs. HV

- Clear exponential dependence of gain on high voltage
- Can reach a gain of $10^4$ at 4000V
Response Uniformity

Gain at different sectors

Energy resolution at different sectors

Uniformity $\sim 11\%$

Uniformity $\sim 5.3\%$

Good uniformity observed

Note: uniformity = RMS/Mean
GEM Stretching Simulation

- Simulated displacement of stretched triple GEM foils (0.5m*1m) with HV applied.

- Maximum GEM displacement ~ 150um when tensioned at ~0.3kg/cm per GEM
- Tensioning more doesn’t help too much in further reducing displacement.
GEM Stretching Measurement

Tensions applied to GEM:
- ~0.48kg/cm @ long side
- ~0.39kg/cm @ short side

GEM extension:
- ~1.3mm @ long side
- ~0.7mm @ short side

Valuable input for GEM tension determination and choice
Towards SoLID GEM:
50cm *100cm GEM
Design

- Main components in the design
  - GEM electrodes
  - GEM foil stretching components
  - Drift and readout electrodes
  - Main frame
Prototyping (I)

• A full-size mechanical mock-up of a 0.5m*1m GEM detector
  – to validate the mechanical design
  – to gain experience in large-size GEM stretching and detector assembly
Prototyping (II)

• Assembling an actual 0.5m*1m GEM prototype
Response Uniformity

0.5m*1m GEM

Gain at different sectors

Energy resolution at different sectors

Uniformity ~ 51%
~ 11%

Much worse than 30cm*30cm GEM

Uniformity ~ 11%
~ 5.3%

Note: uniformity = RMS/Mean
• Large gain variations arose from chamber deformation under tension from GEM stretching and gas flowing.

• Gain uniformity improved by reinforcing the mechanic supporting frame and readout board.

\( \approx 32\% \quad \approx 10\% \)
Design optimization

• Optimized 0.5m*1m GEM design based on results from prototyping and simulation.
  – Reinforced supporting frames
  – Segmented GEM clamping to better accommodate GEM extension when stretched
  – ...

![Diagram of GEM design]
GEM Readout Development

- Developed a GEM readout system based on the INFN APV25 hybrid.
- Tested and characterized the readout system

- The developer will graduate soon. Need to identify a successor to keep the work going.
APV25-MPD Readout

• Redesigned the FPC connector of APV25 hybrid to improve the grounding so as to reduce noise.

• Have gotten the APV25-MPD system working by upgrading the MPD firmware. Detailed tests underway.
Summary and Plans

• Active large-size-GEM R&D at USTC on both detectors and readout in the past year.
  – An important milestone achieved: successful first prototyping of 0.5m*1m GEM detectors using an improved self-stretching technique.

• Near-term plans
  – Further optimize 0.5m*1m GEM detector design through more simulation and prototyping
  – Test GEM detector prototypes using APV25-MPD readout