A Improved Self-Stretching GEM Assembly Technique
— Sliding Self-Stretching

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Introduction

• Gas Electron Multiplier (GEM) is one of the most popular micro-pattern gaseous detectors

• Advantages of GEM detectors
  – High rate capability (up to 1MHz/cm²)
  – Good position resolution (~100μm)
  – Low mass and low cost
Large-size GEM

• A low-mass and cost-effective solution to high-precision and large-area tracking at high-rate and large-scale experiments such as CMS and SoLID.
  
  – Key: large-size (~1 m²) GEM assembly
Assembly time for one chamber ~ 1 week! And impossible to reopen for repairs. Have to find an alternative technique.
Self-Stretching Assembly

- A purely mechanical GEM assembly technique developed at CERN for the CMS GEM upgrade project.
  
  - 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
Self-Stretching R&D

• Intensive R&D on self-stretching technique by 30cm*30cm GEM prototyping.
• Modifications and improvements to original self-stretching.
GEM X-ray Test

- X-Ray
- GEM
- Pre-Amplifier
- Shaper1
- Disc.
- Scalor
- Shaper2
- HV
- Pico-ammeter
- MCA
• Clear exponential dependence of gain on high voltage
• Can reach a gain of $10^4$ at 4000V
Response Uniformity

Gain in different sectors

Energy resolution in different sectors

Uniformity ~ 11%

Resolution <20% @ 8 keV, Uniformity ~ 5.3%

Good uniformity observed

Note: uniformity = RMS/Mean
Going for Larger Size

• Assembling an 0.5m*1m GEM with self-stretching technique.
Uniformity in Large Area

0.5m*1m: 51%  v.s. 30cm*30cm: 11%

- The uniformity of the 0.5m*1m GEM is much worse than that of the 30cm*30cm GEMs.
Issues with Self-Stretching

Stretching screws are locked by outside frame when inner frame moves following GEM foil displacement due to tension. The locked screws would also have O rings stressed too much causing gas leaks.
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:
- ~2.5 mm @ long side
- ~1.0 mm @ short side

Valuable input in GEM tension determination
Improving Self-Stretching

• Lots of effort put in optimizing the design of the 1m*0.5m self-stretched GEM:
  – Reinforced supporting frames
  – Segmented GEM clamping ➔ sliding self-stretching
A Close-up of Sliding Self-Stretching

GEM foils can now move freely up to 5mm with respect to the main frame.
Sliding Self-Stretched GEM

• High quality GEM stretching with no visual wrinkles.
• Very good gain uniformity ~ 15%, comparable to 30 cm x 30 cm!
2D X-ray Imaging
Summary

• Active R&D on self-stretching GEM assembly at USTC in the past few years.
• Improved the original self-stretching technique by segmenting GEM foil clamping to allow room for GEM displacement
  – sliding self-stretching
• Built a 0.5m*1m GEM prototype with sliding self-stretching technique
  • Very good uniformity over large area
MPGD lab @ USTC

- Central gas supply
- A class-10000 clean room
- A general-purpose work station and a large-area regular work bench
- Three detector testing areas