Construction and first commissioning of the self-stretched gas electron multiplier (GEM) detector

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Outline

Motivation
   Time, cost, and construction environment

Construction
   GEM foil stretching and framing by IR thermal method
   Mechanical self-stretching design

Characterization
   First signal under X-ray
   Gain measurements and rate plateaus

Future Work
   Construction and testing of the Compact Muon Solenoid
   GEM detectors
Motivation

Time

• Previous methods of construction and foil stretching were measured in days.

• With new assembly techniques complete detectors can be manufactured in hours.

Large Scale Production

• In order for the design to be viable for mass production the required infrastructure was reduced to a minimum.

• Assembly now only requires a clean room facility.
Contrasting Foil Stretching Techniques

Low cost GEM stretching using IR heating

Mechanical Self-Stretching
Redesigned Frame

New design integrates the drift and readout into the frame to provide a gas volume with the assistance of an O-ring.

Previous frame style was a single piece coated in glued to seal the gas volume.
Difficulties in Construction

The screws that secure the foil stack deformed the readout board and compromised the gas volume.

Without the inclusion of corner screws reaching a uniform tightening became more difficult as you move away from the center of the foils.
Solutions

Applying voltage under air

- In order to confirm that the foils for our detector are parallel to each other we apply voltage between the foils under air.

- If we are unable to reach the normal operating voltage between foils then we have identified a problem.
Possible Improvements

Electrical connection to the foils is made using springs. The problem is that properly securing the springs to their points of contact and the foils is extremely difficult. There is also no way to check that connection is made once you place the foil stack.

One of the major issues with mass production will be achieving uniform tightening of the foils with precision.

This spring broke from its solder point.
First Commissioning

Two arrangements for testing due to the thickness of our frame pieces

Must pass through our readout and GEM foils to reach the drift gap

Vertical setup allows us to reach the drift region through minimal material
The blue channel is displaying information directly from the pre-amplifier.

While the red channel is our linear amplifier.
These signals were recorded while operating the detector at 4200 volts and irradiating with the Amptek Mini-X portable X-ray source.
Rate Plateau

Rate plateau

![Graph showing rate plateau with voltage (V) on the x-axis and count rate (Hz) on the y-axis. The graph includes data points for measurements at different voltage levels, with distinct lines for different positions (X2 and Y2).]
Gain Curves

Gain vs. Voltage(V)

Gain

Voltage(V)

Gain Y2
Gain X2
Conclusion

What is the point?

Now that this design has been proven effective and successful we can move on to a larger scale.

- We will now scale up our design to be used in the CMS experiment at CERN.

- Once we have shown that this we can properly scale this design up to the size required we will experiment with zig-zag readout structures.