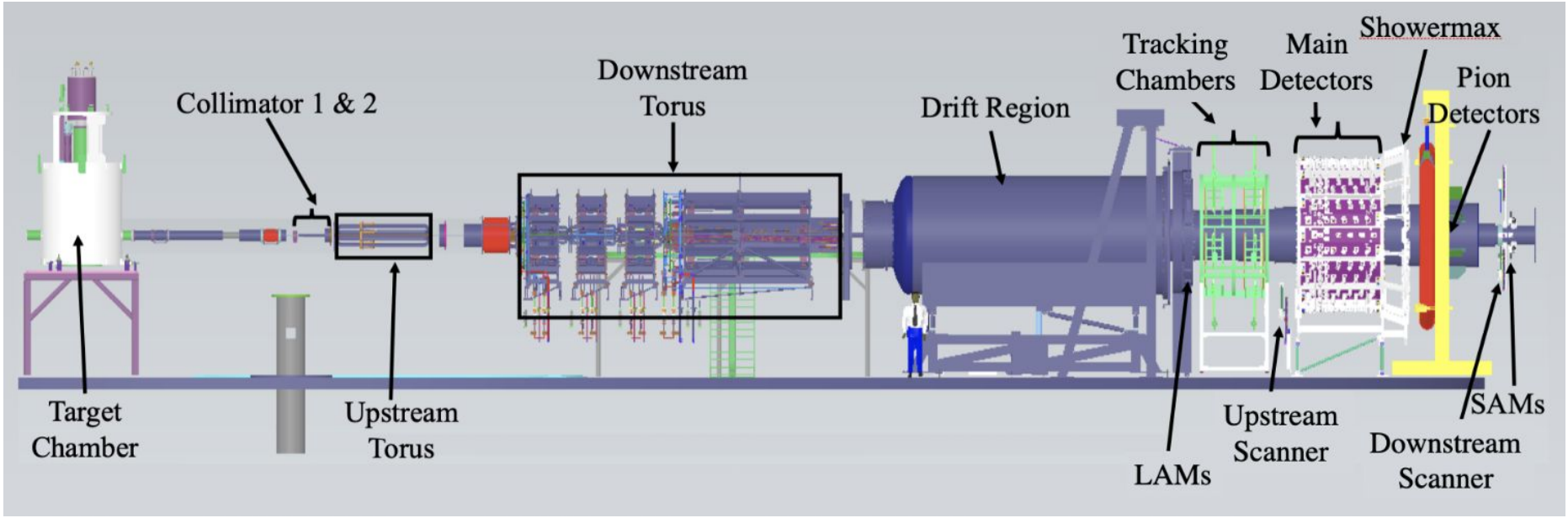
Designing and production of GEM modules for the MOLLER experiment

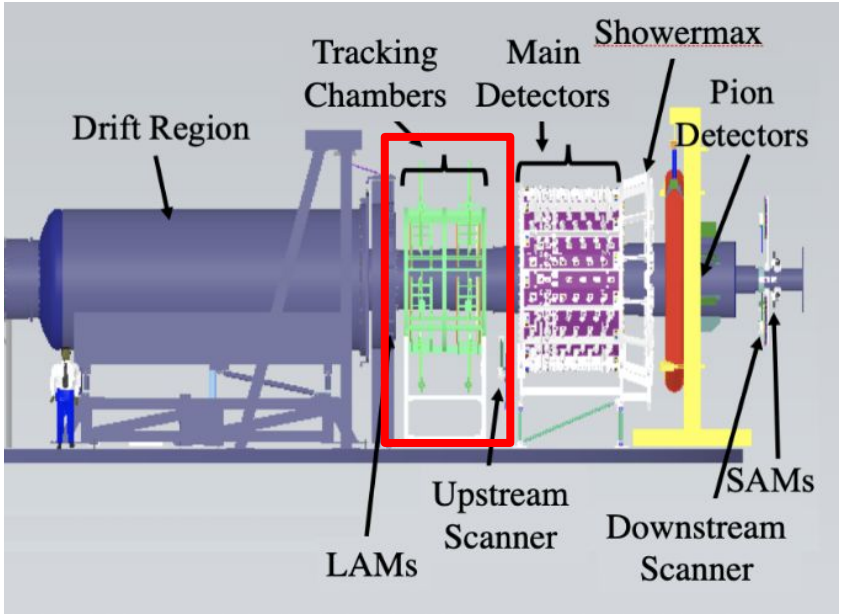
Jaydeep Datta, Zuhal Seyma Demiroglu, Abhay Deshpande, Brynna Moran, James Shirk

MOLLER experiment

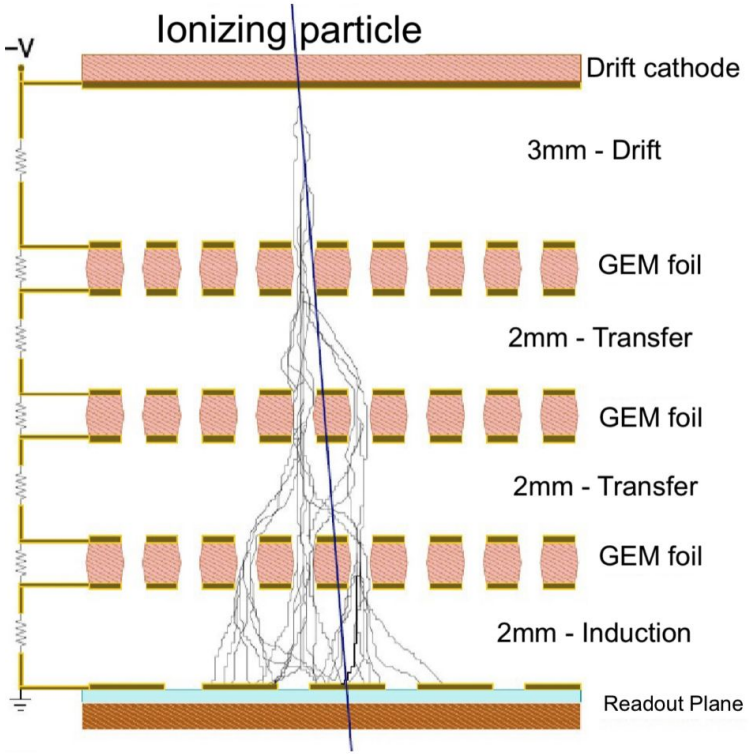


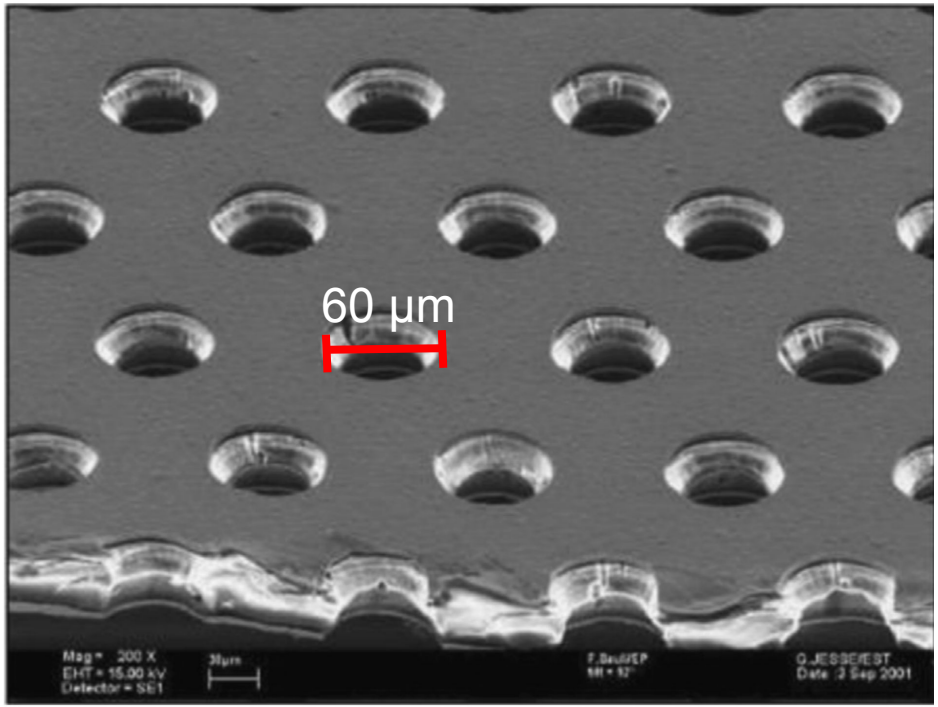
MOLLER beamline

- Need tracking detector with:
  - High rate capability
  - High efficiency
  - High position (and angular) resolution
- Needs to:
  - Verify acceptance of magnets
  - Verify main (quartz) detector acceptance
  - Check if quartz detector light output is position dependent

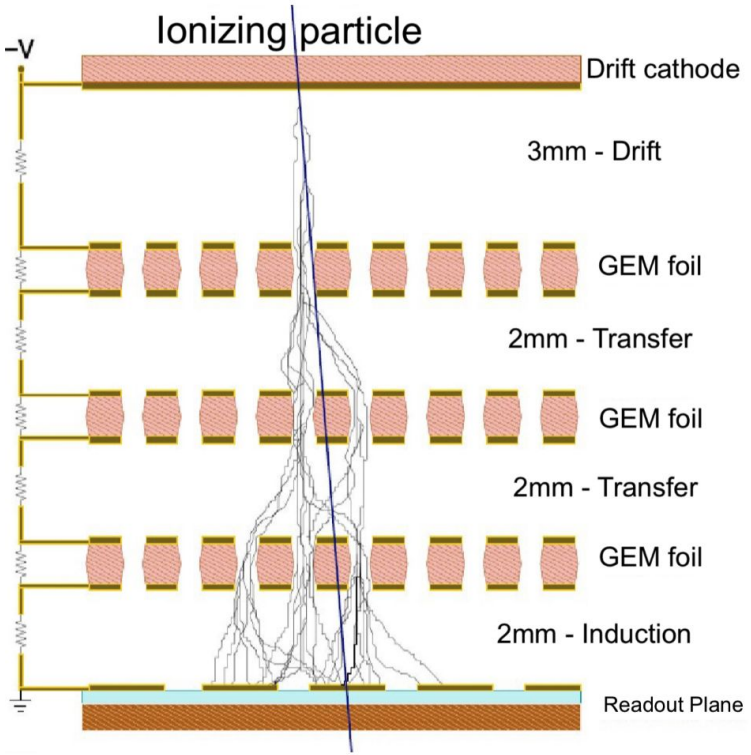


GEM Technology



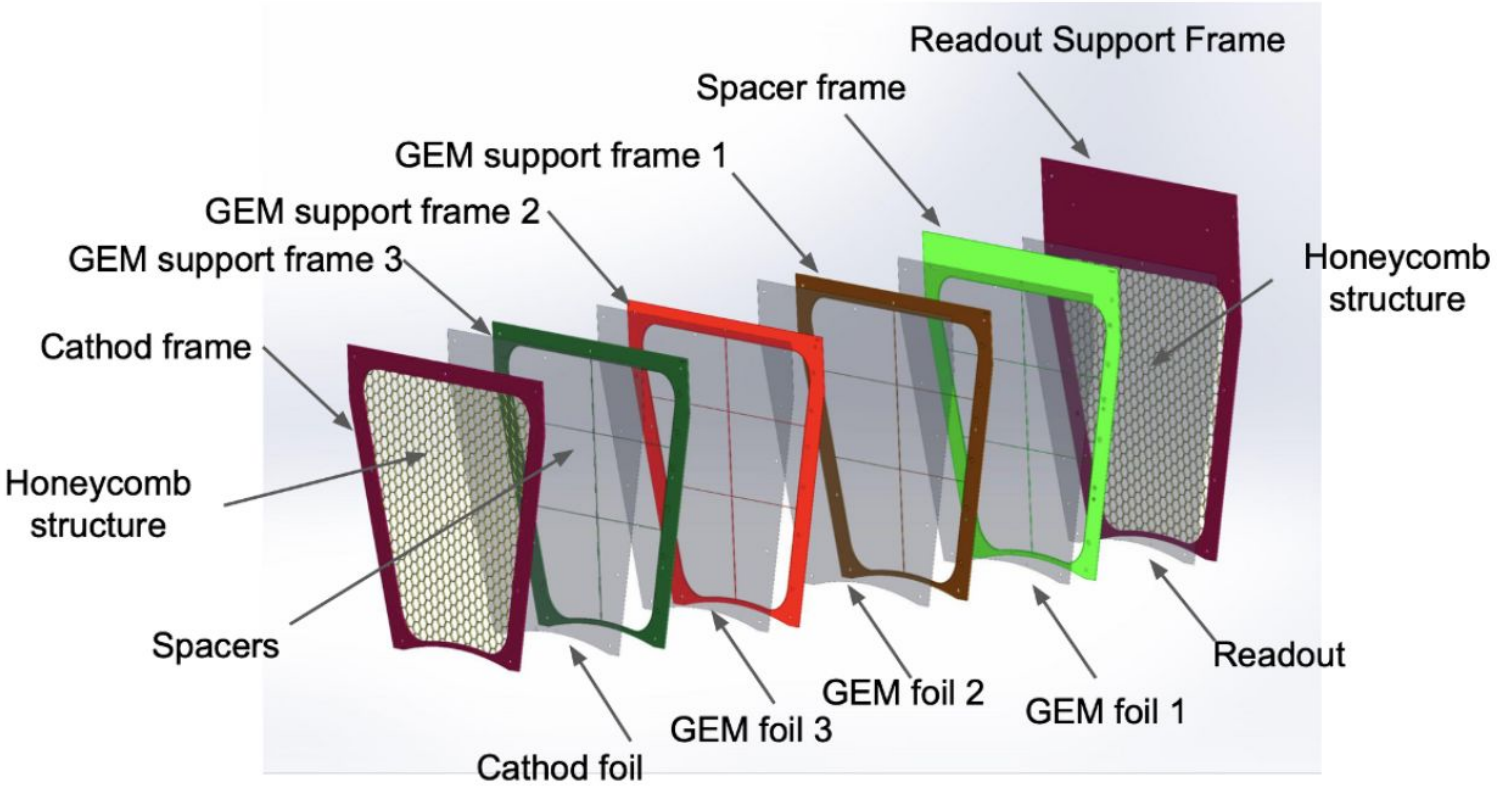


GEM Technology



- GEMs have:
  - High rate capability (>100 MHz/cm^2)
  - High efficiency (> 95%)
  - High position and angular resolution
    - Based on readout design but ~ < 80μm
  - Large area at moderate cost
    - 1.4 m^2 covered in experiment

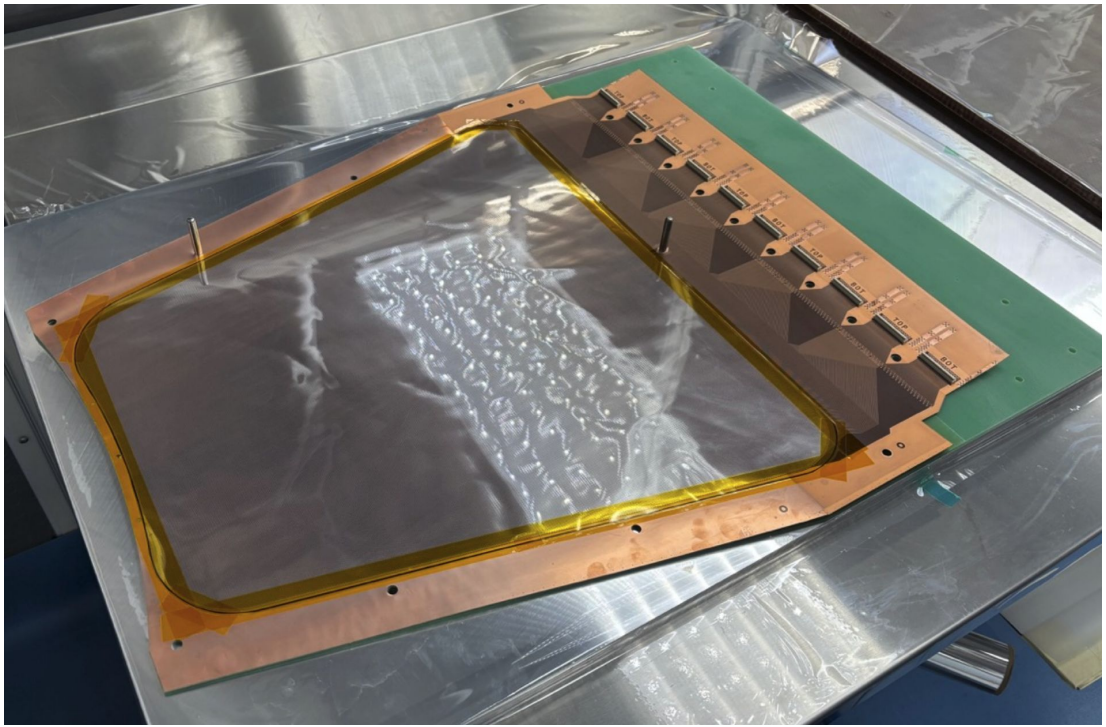
GEM CAD blowout



- GEMs must be assembled in clean rooms
- Clean room was built in basement of SBU

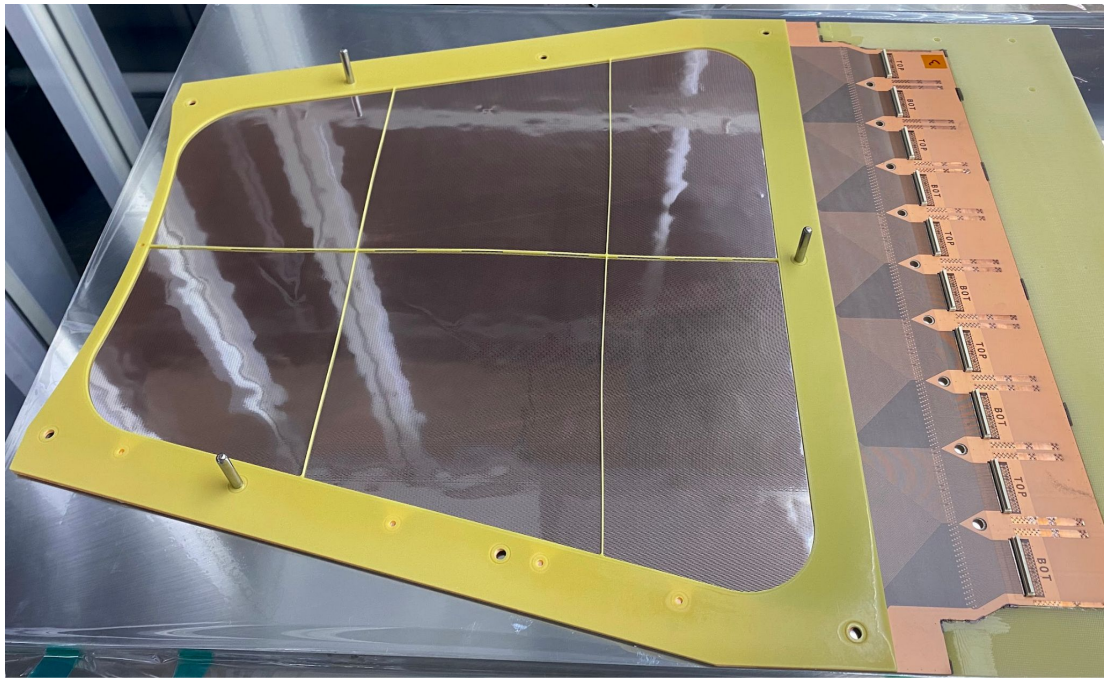
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors



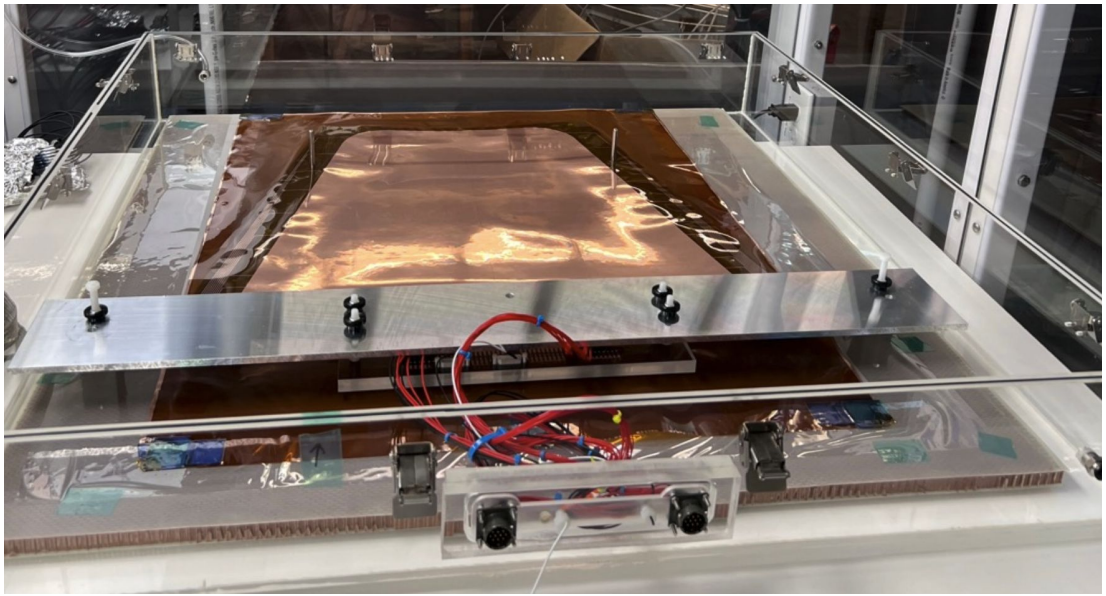
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors



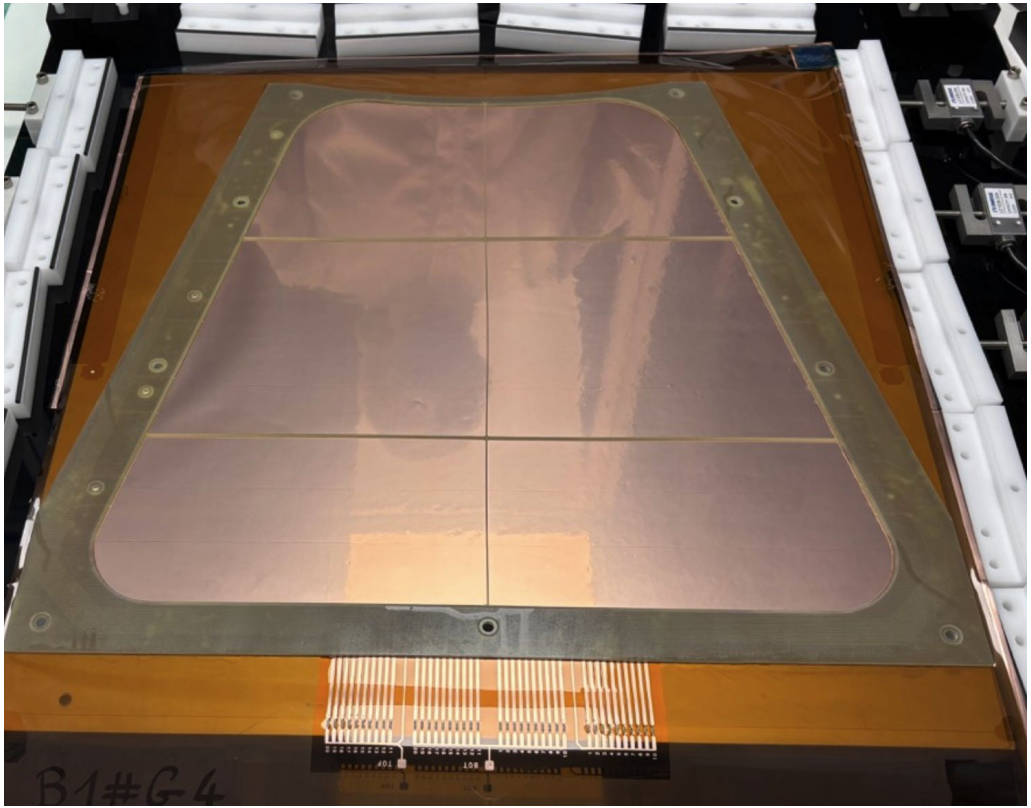
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors



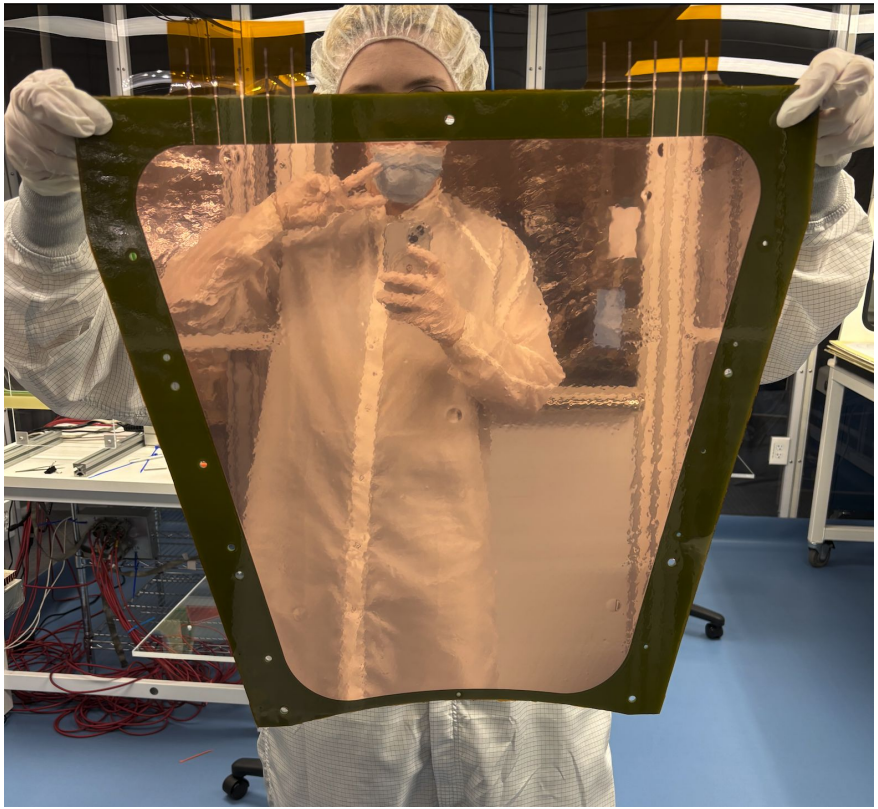
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors



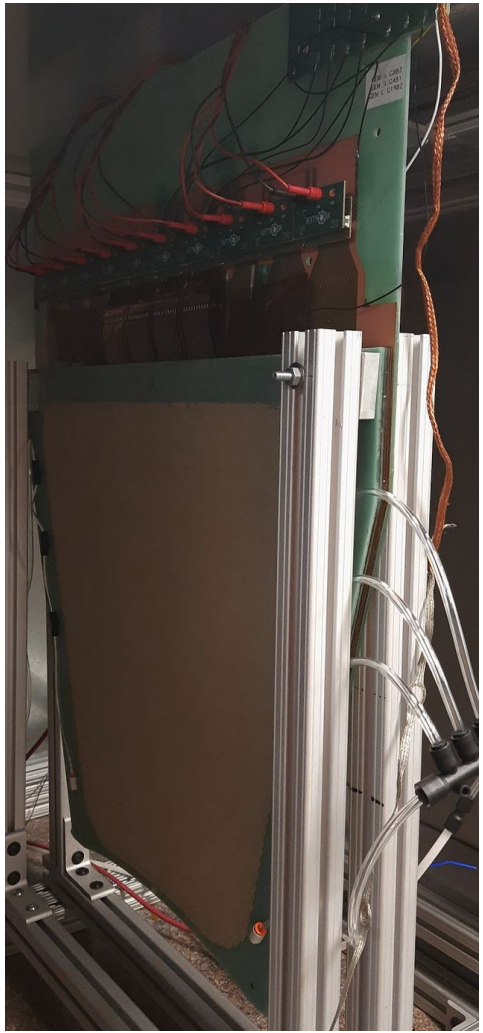
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors

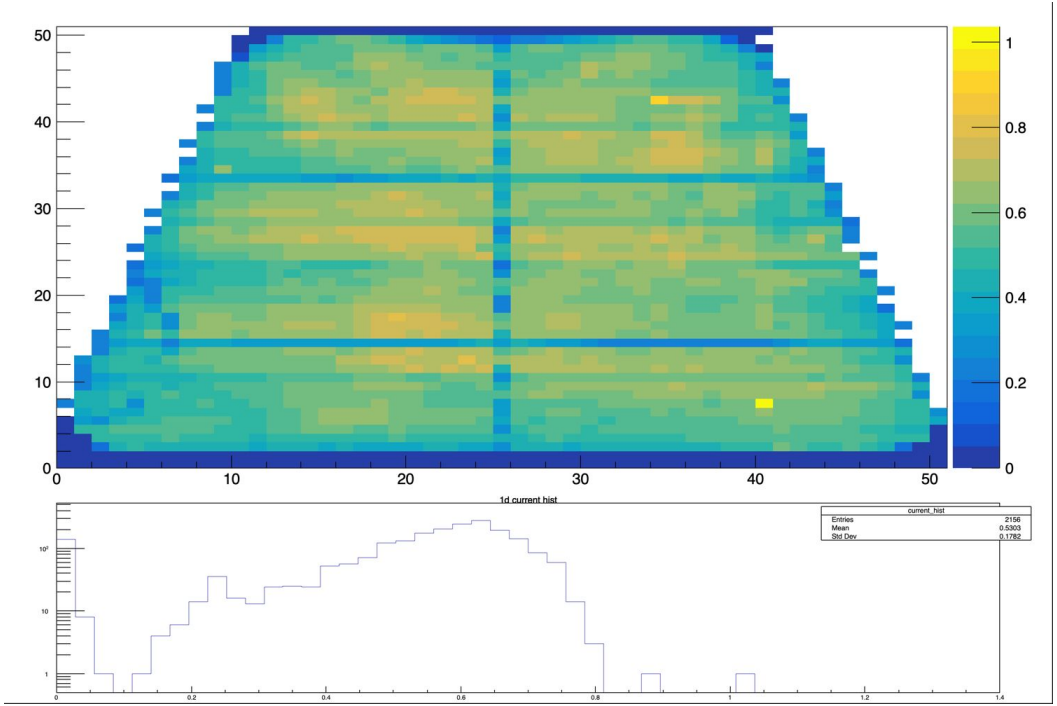


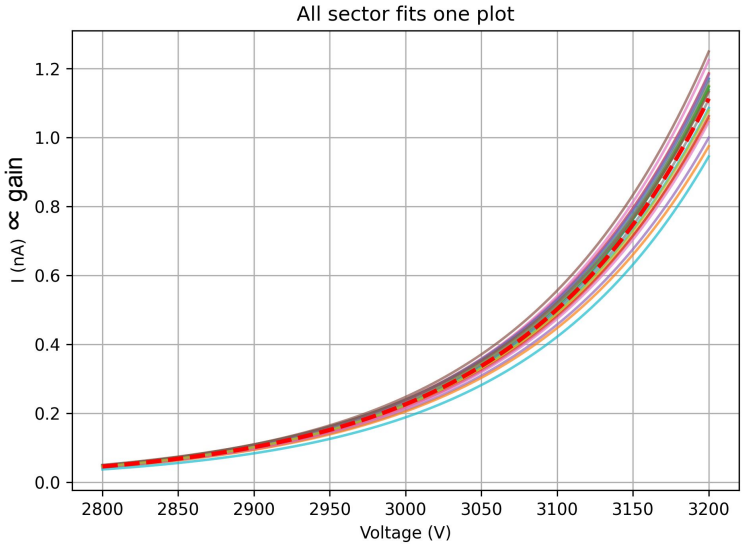
Steps to assemble GEM module

1. Glue readout to backing
2. Glue spacer onto readout
3. HV test GEM
4. Attach GEM to frame and framed GEM to readout
5. Repeat step 4 three times
6. Glue cathode
7. Test detectors



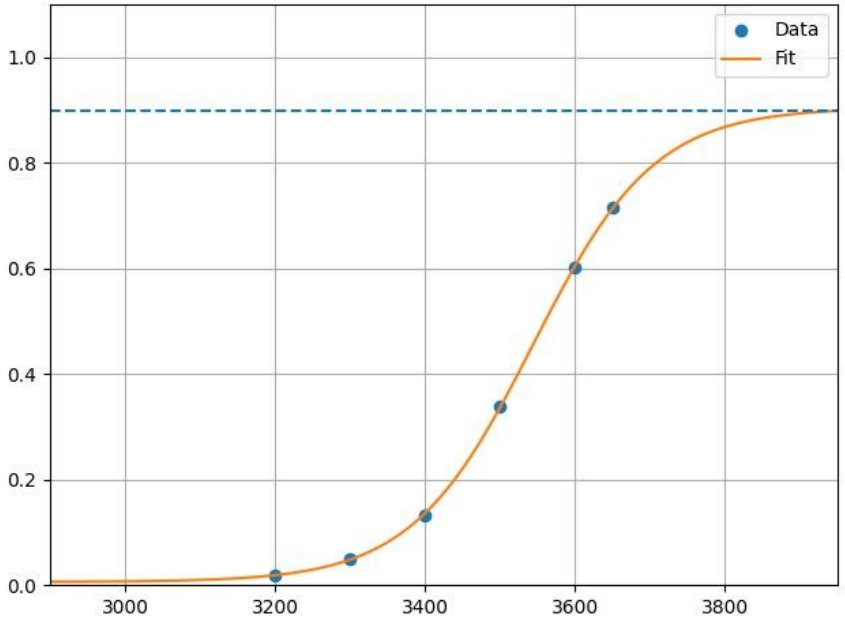
Gain uniformity check



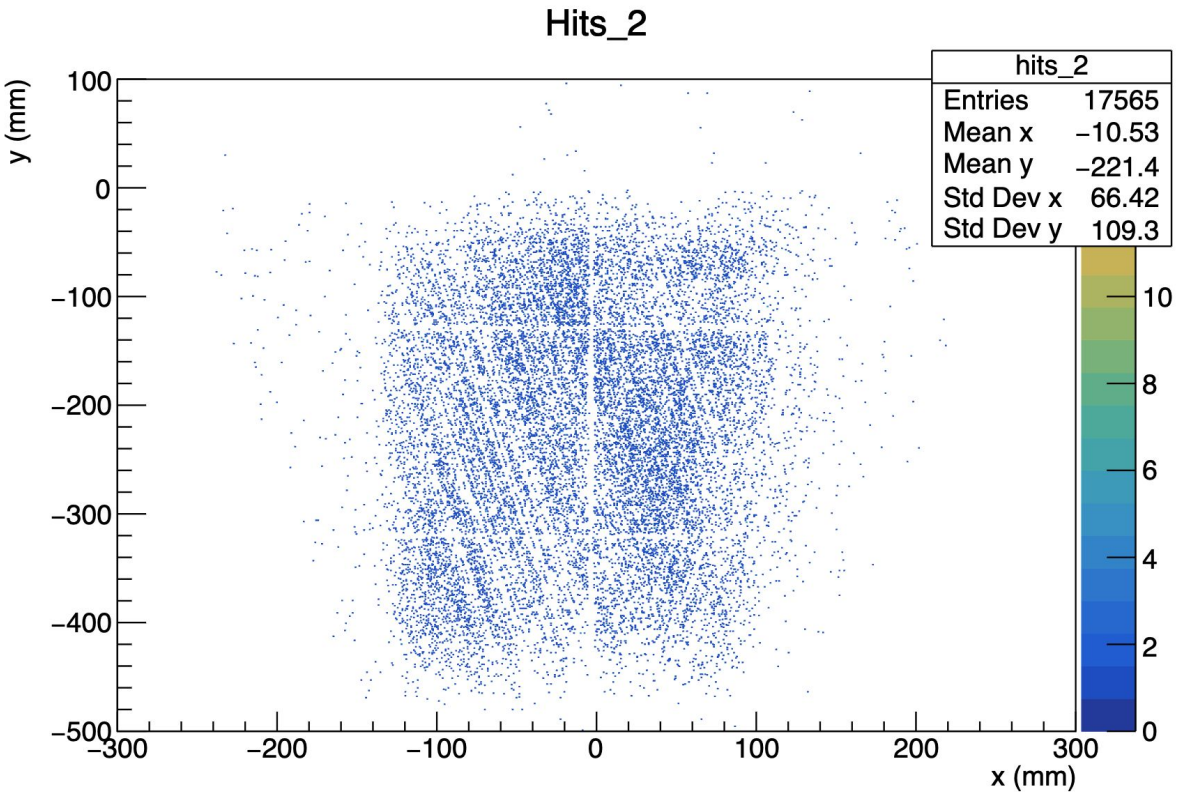


Efficiency Measurement

- We measure the efficiency of the detector as a function of voltage applied to the HV divider
- Gives us information about what voltage to run the detector at during the experiment



Hit maps



- By clustering events we can reconstruct the position of the particle
- See area of the scintillator used to trigger the detectors
- See fewer counts in the area the ribs occupy

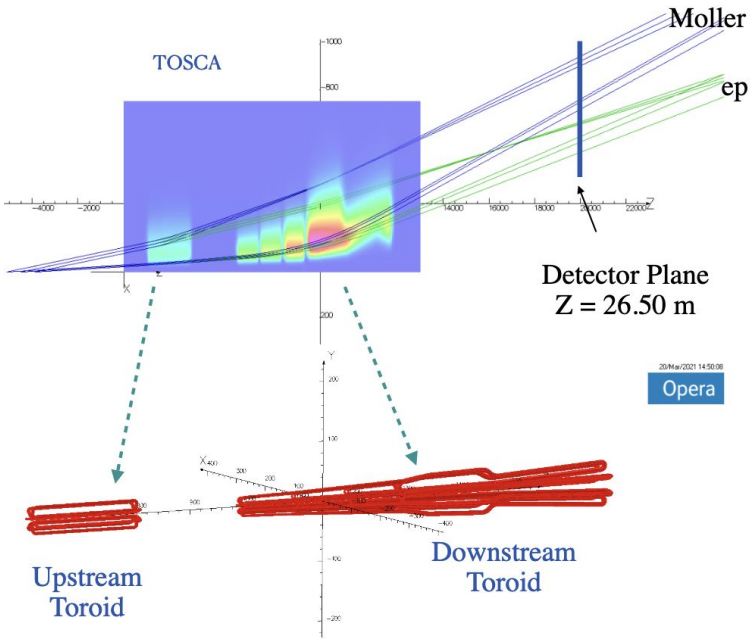
Conclusion

- SBU is building 14 large area triple GEM detectors for the MOLLER experiment
- These detectors are going to be used at lower beam current and lower energies to verify kinematics of experiment
- SBU has built 3 prototypes and 5 production modules

Backup slides

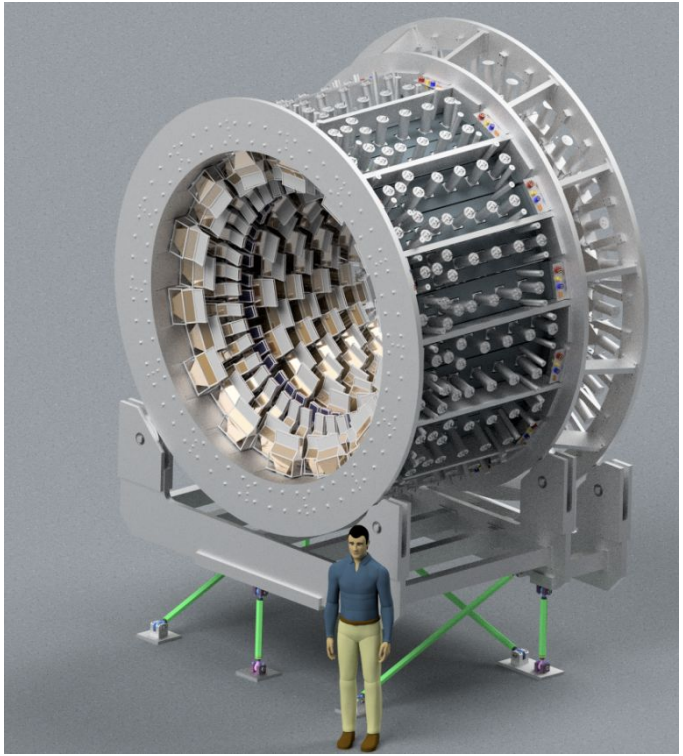
Why do we need tracking detectors?

1. Verify acceptance of toroid magnets
2. Verify main (quartz) detector acceptance
3. Check if light output of quartz is position dependent
4. Study backgrounds



Why do we need tracking detectors?

1. Verify acceptance of toroid magnets
2. Verify main (quartz) detector acceptance
3. Check if light output of quartz is position dependent
4. Study backgrounds



$$\mathcal{A} \equiv \frac{mG_F}{\sqrt{2}\pi\alpha} \frac{4E\sin^2\theta}{(3+\cos^2\theta)^2}$$

Why do we need tracking detectors?

1. Verify acceptance of toroid magnets
2. Verify main (quartz) detector acceptance
3. Check if light output of quartz is position dependent
4. Study backgrounds

Why do we need tracking detectors?

1. Verify acceptance of toroid magnets
2. Verify main (quartz) detector acceptance
3. Check if light output of quartz is position dependent
4. Study backgrounds