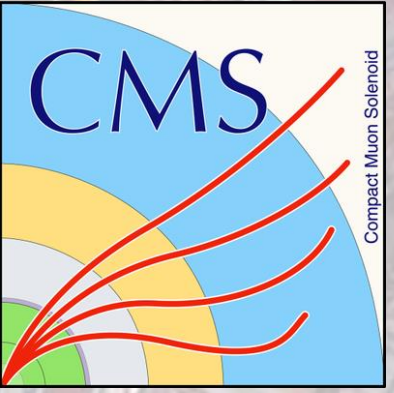


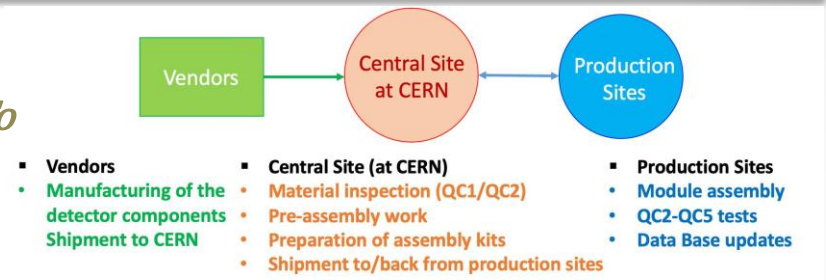
Progress of CMS GE2/1 GEM end-cap muon system upgrade

Peking University

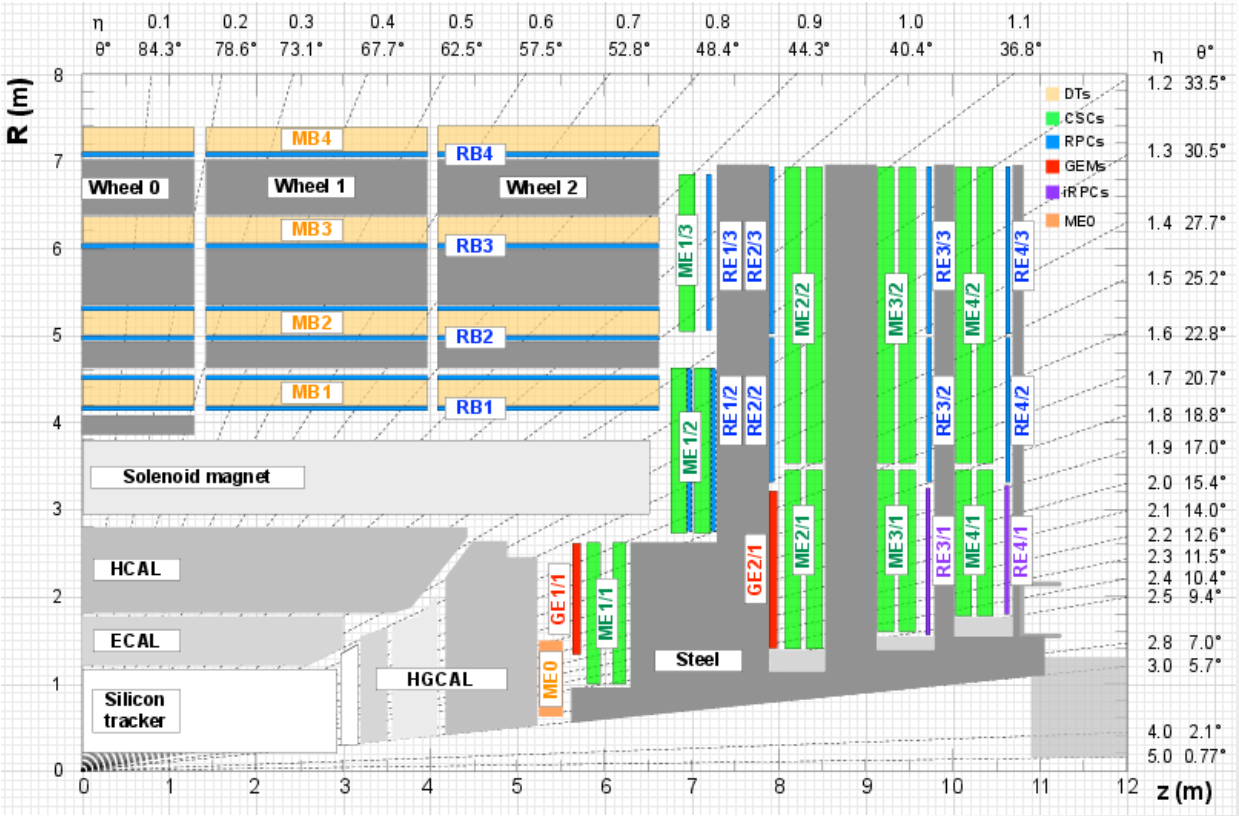
Contents

1. Overview of CMS GE2/1 GEM upgrade project

- *The Large Hadron Collider (LHC) is being improved to higher instantaneous luminosity. To maintains the detector's sensitivity for electroweak scale physics, upgrade of the detector is necessary.*

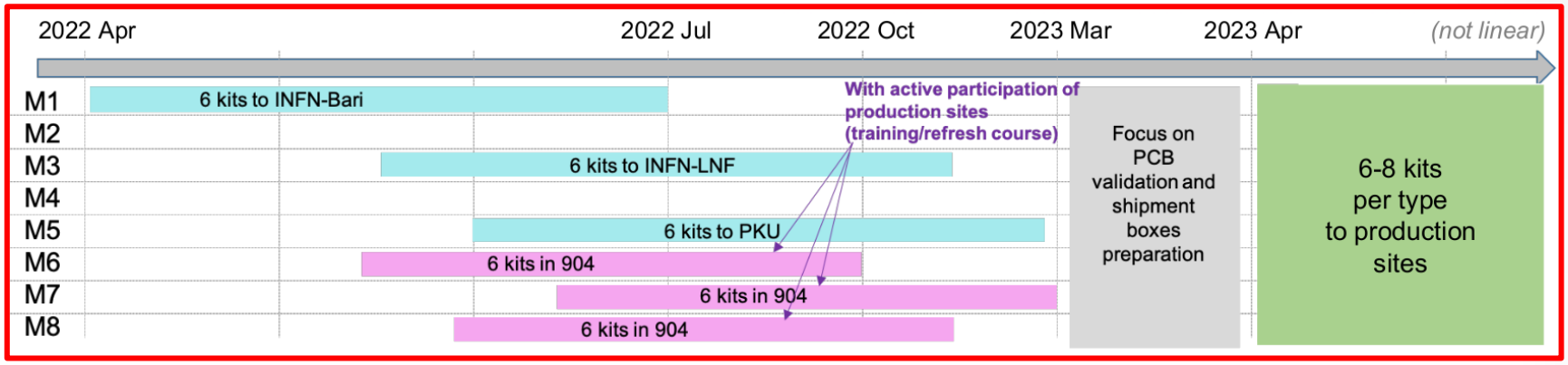


- The use of gas electron multiplier (GEM) technology in the endcap muon station will help to maintain or even improve the forward muon triggering and reconstruction in the region | η | > 1.6 in the face of high luminosity.

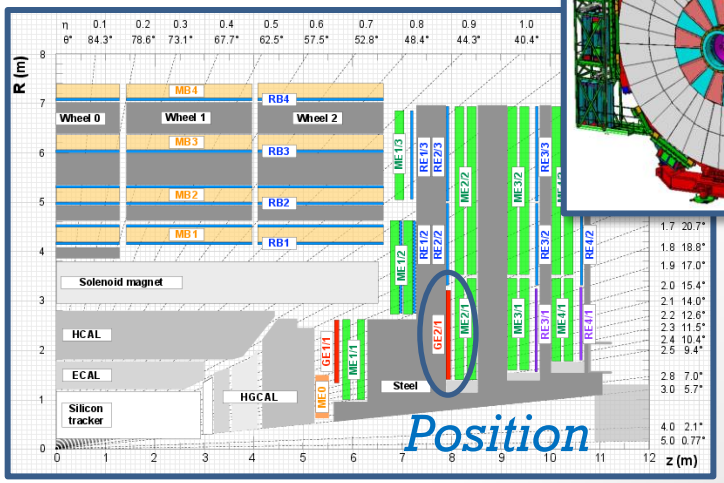


1. Overview of CMS GE2/1 GEM upgrade project

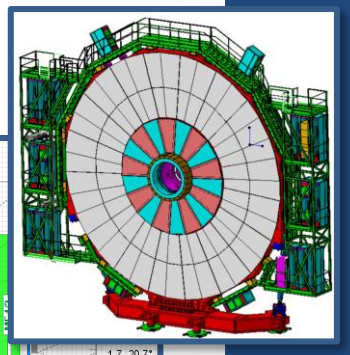
Timeline



Installation



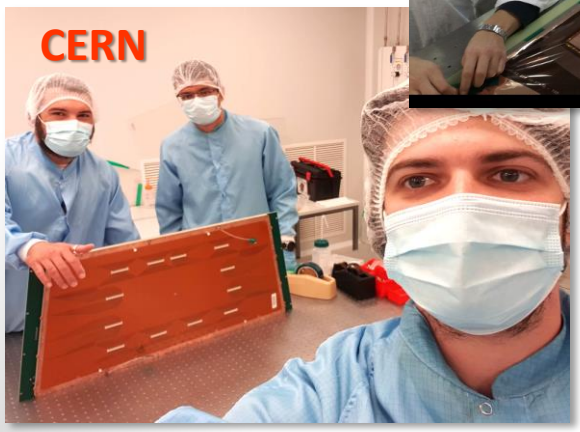
Position



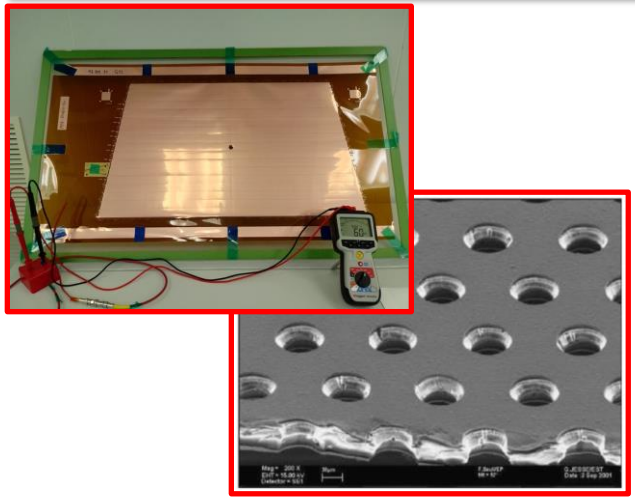
1. Overview of CMS GE2/1 GEM upgrade project

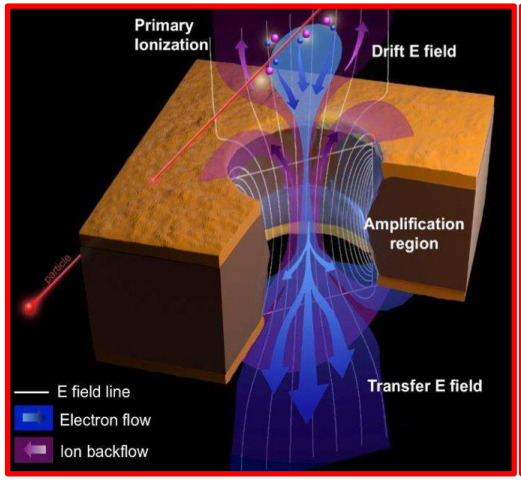
- Three production sites have taken part in the project:
  - M1 construction in Bari
  - M3 construction in Frascati
  - M5 construction in PKU

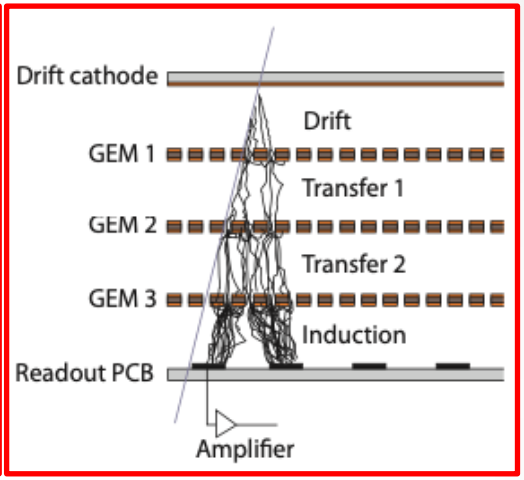
+ CERN



2. GE2/1 GEM detector design



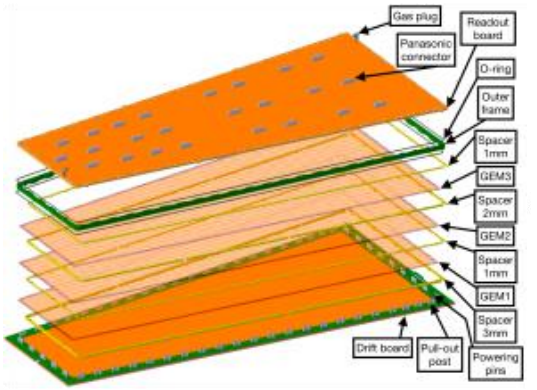




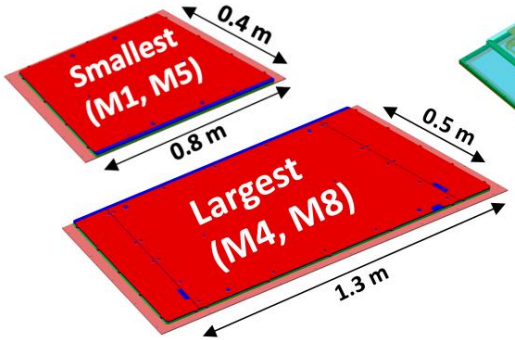
GEM foil is a thin insulating polymer foil, metallized on each side, with many small opening channels all the way through. The foil is originally realized on a 25 µm thick polymer, sandwiched between 18 µm thick copper electrodes; the etching pattern has parallel rows of 70 µm wide holes 100 µm apart. With 200 V applied, the maximum field strength in the channel can reaches 40 kV/cm. Electrons released by ionization in the upper gas volume drift into the channels, avalanche in the high field region and leave towards the electrode in the lower volume, ions generated in the avalanche drift along the central field lines, avoiding charging up problems.

2. GE2/1 GEM detector design

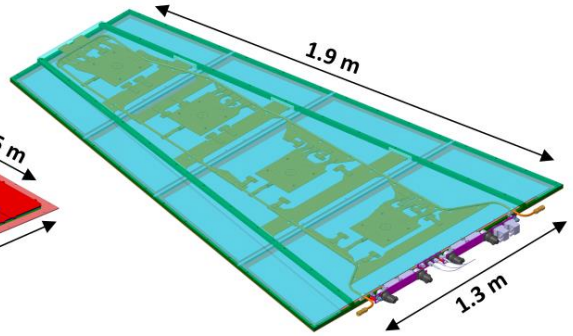
- Triple-GEM technology (same as GE1/1)
- The full system: 72 GE2/1 chambers (36 per end-cap)
  - 4 triple-GEM modules per chamber = 288 modules in total
  - The chambers are arranged in two layers
- Two different types of chambers
  - On-Yoke= FRONT-type (module types M1-M4)
  - Off-Yoke= BACK-type (module types M5-M8)



Layout in triple GEM detector (GE1/1 as an example)



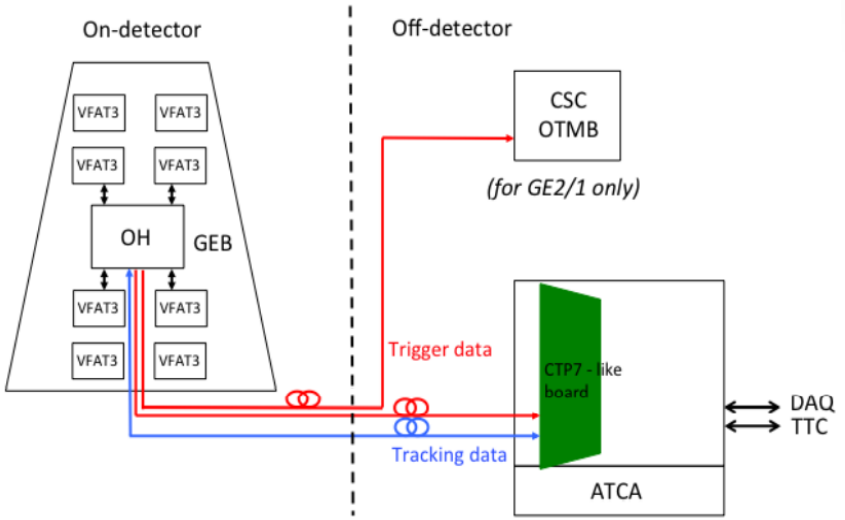
8 slightly different triple-GEM modules (M1 to M8)

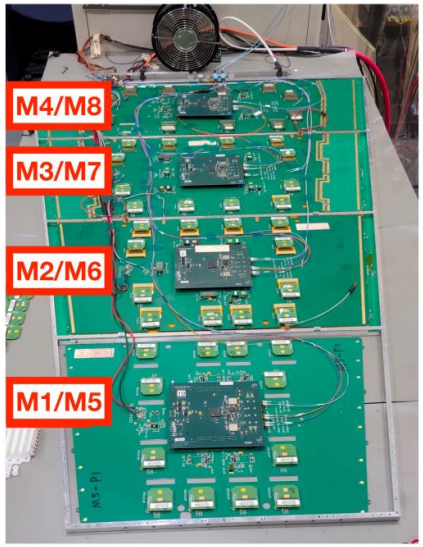


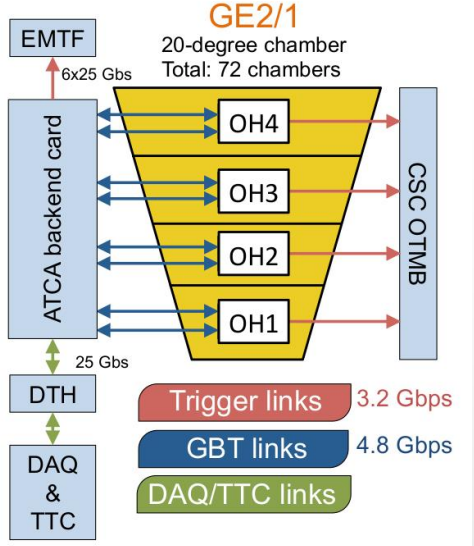
Off-Yoke (M1 to M4) and On-Yoke (M5 to M8) chambers

2. GE2/1 GEM detector design

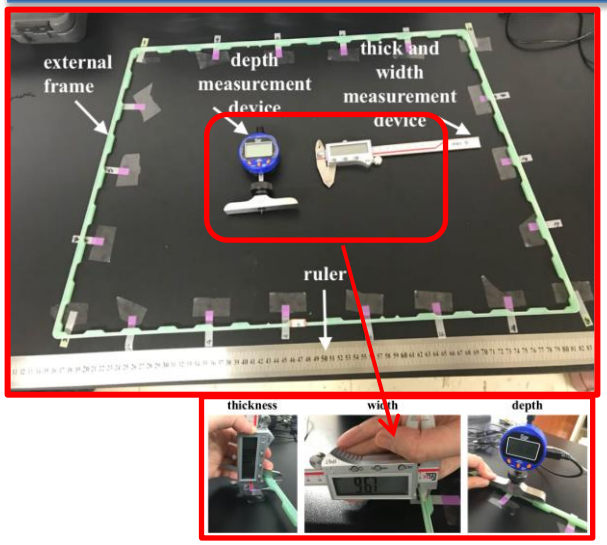
The readout electronics is connected to the electrodes of the GEM chamber through the readout board. The VFAT is mounted on the GEM Electronics Board (GEB) and is connected to the readout board through a flex PCB connector. The GEB distributes power to all boards mounted on it and hosts the Optohyrbid (OH), which further reads out the data from the VFATs. The OH converts the electrical signals to an optical signal and sends this to the back-end ATCA card.



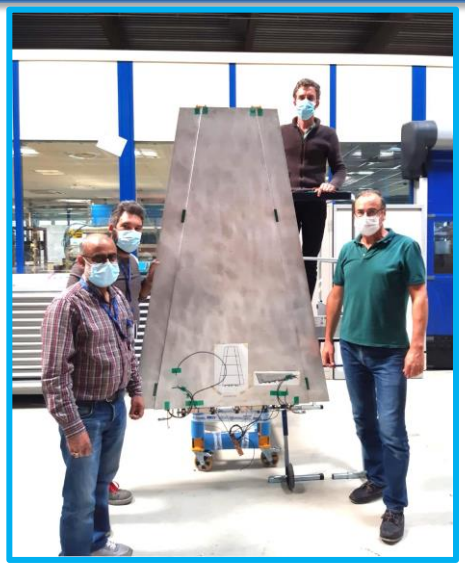




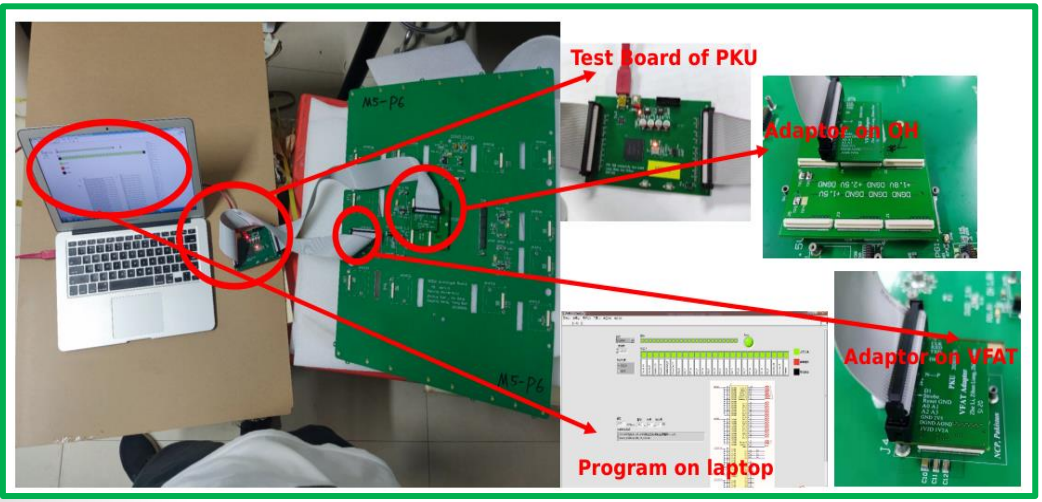
3. Progress and status of China group



External frame (M1-M8): produced and tested in China, an important component for gas tightness of GEM chamber. Production is completed.



Super module supporting structure: produce in China, a structure used to hold GEM modules together.



The GEB, designed by Peking University, distributes power and provides the interface for all front-end electronics on GE2/1, is radiation-tolerant and magnetic-tolerant by design. Providing current and temperature monitoring of the DC-DC converters, fixed to the readout board and read out through the OH.
Now the design, production, quality control of GE2/1 GEBs are completed in China.

4. 1st batch of 6 GEM assembly and test at PKU

CERN

- QC 1: material inspection
- QC 2: GEM foils test (fast + long)

Production sites (e.g. PKU)

- QC 2: GEM foils test (fast)
- Assembly preparation + Assembly
- QC 3: gas leak test
- QC 4: HV test
- QC 5: gas gain calibration

CERN

- QC 6: HV stability test
- QC 7: electronics connectivity test
- QC 8: cosmic ray test

4. 1st batch of 6 GEM assembly and test at PKU

Assembly check list

Clean and test GEM foils

Make up GEM stack

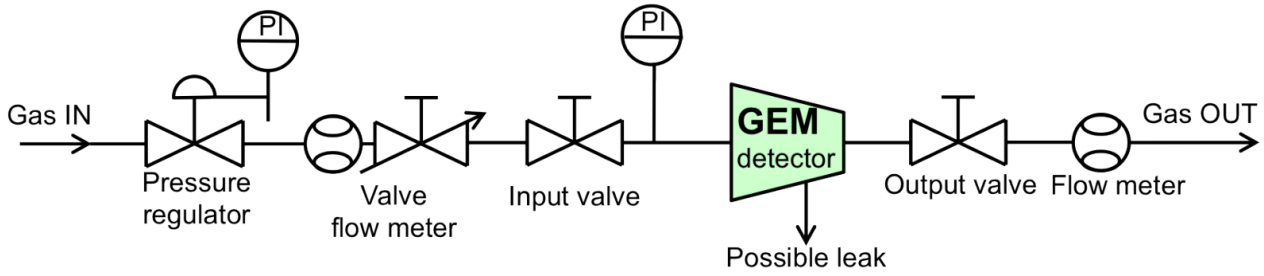
Mount GEM stack on drift board

Mount readout board

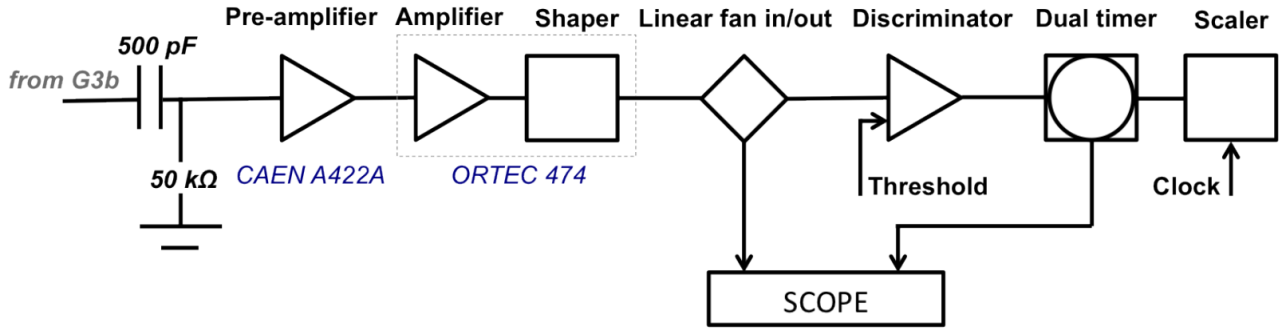
Closure, Done!!

4. 1st batch of 6 GEM assembly and test at PKU

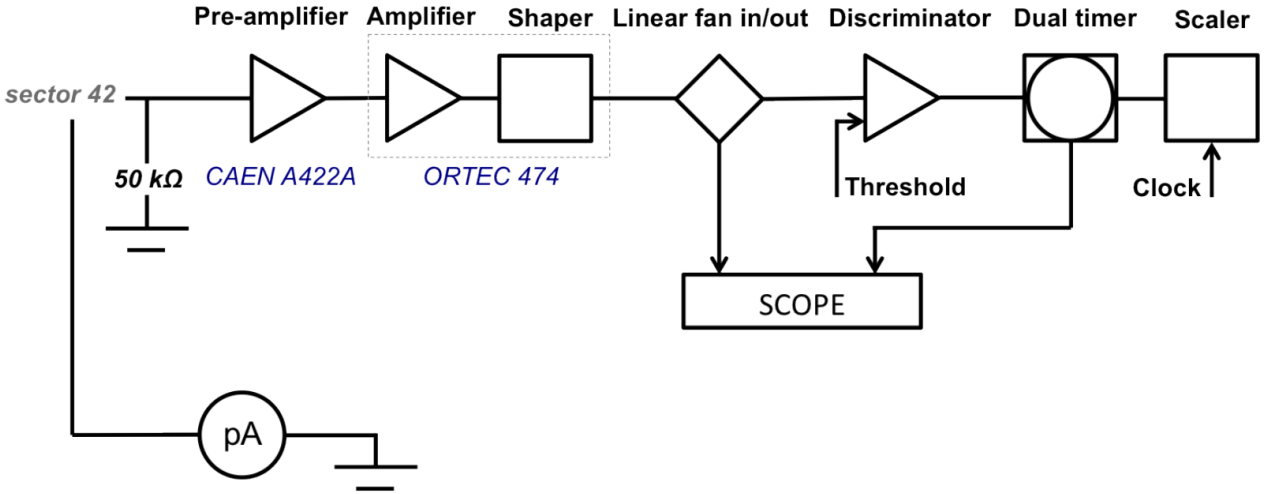
QC3



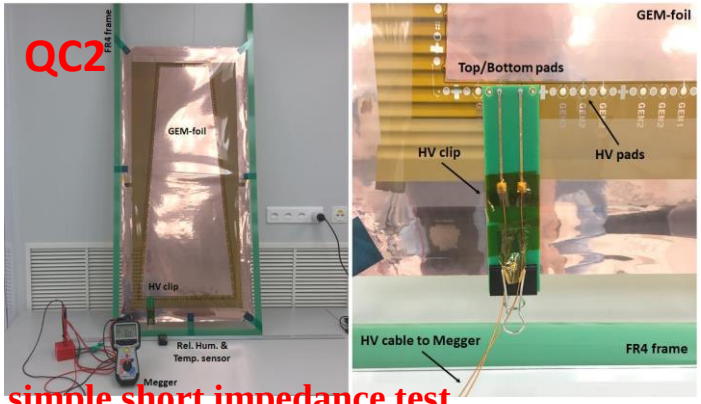
QC4



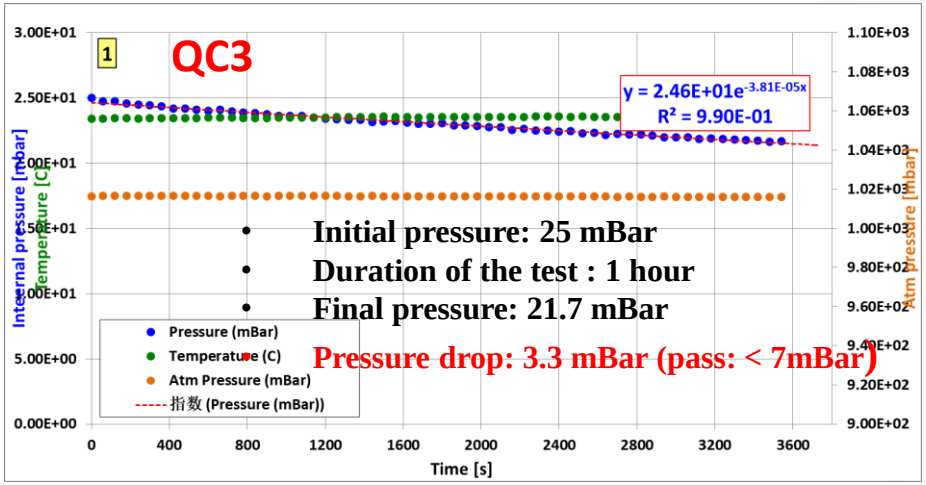
QC5



4. 1st batch of 6 GEM assembly and test at PKU

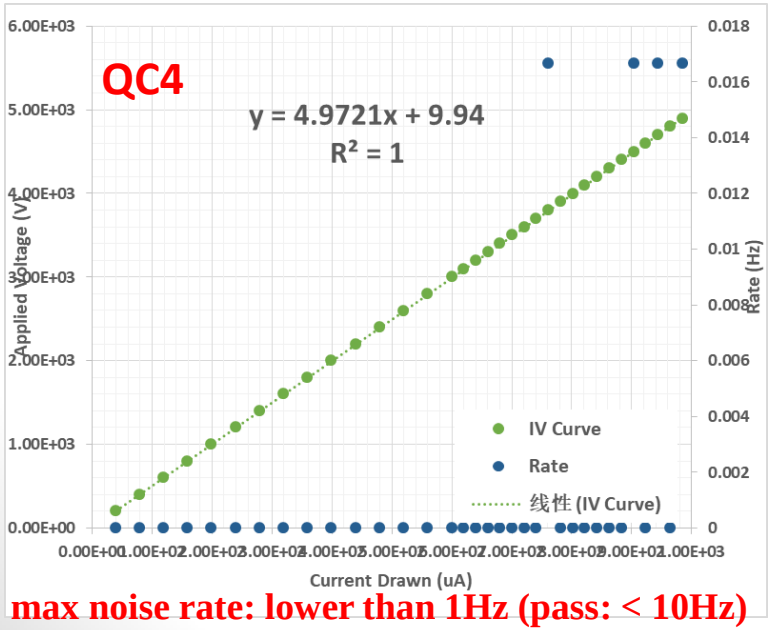


simple short impedance test

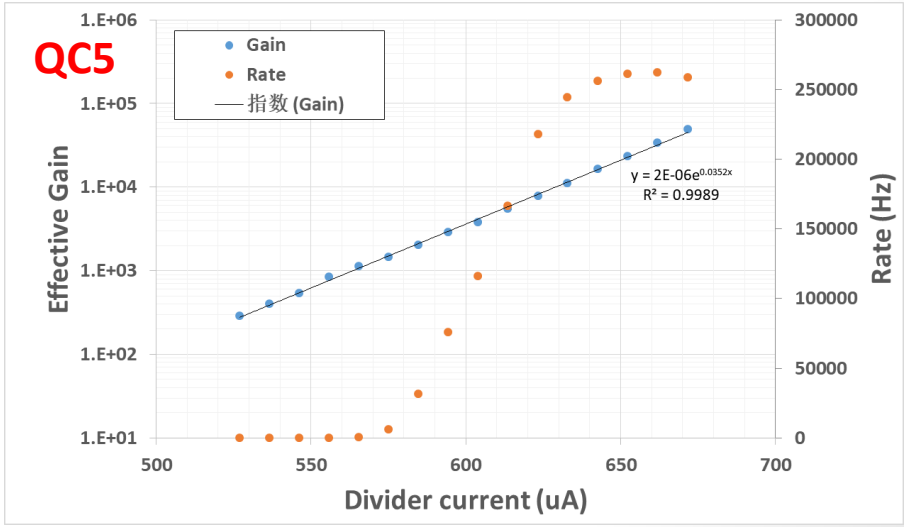


- Initial pressure: 25 mBar
- Duration of the test : 1 hour
- Final pressure: 21.7 mBar

Pressure drop: 3.3 mBar (pass: < 7mBar)



max noise rate: lower than 1Hz (pass: < 10Hz)



effective gas gain test with X-ray (stage1 at PKU)

4. 1st batch of 6 GEM assembly and test at PKU

- The assembly of the first batch of GE2/1 M5 is completed.
- All the M5 GEMs will be tested and sent back to CERN for further testing.
- Preparation for the next batch of GE2/1 M5 is going on.

5. Summary

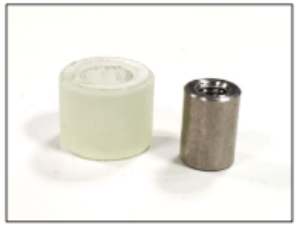
- The work for the first batch of GE2/1 M5 at PKU site is done.
- PKU site is preparing for the next batch of GE2/1 M5.
- PKU site also makes effort on the ME0 GEM project.
- The GEM detector is promising and PKU site is continuing to study on it, planning to build up a cosmic ray detector system with GEM.

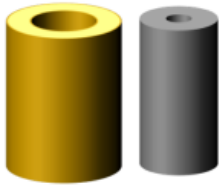
End

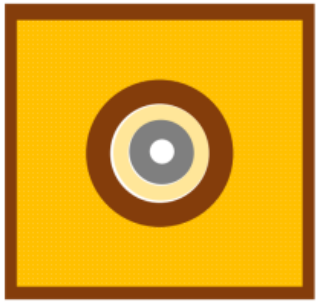
Thank you

Backup

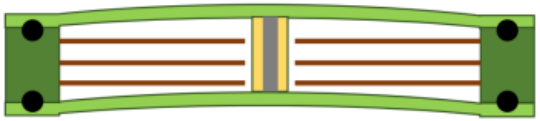
→ A new components was introduced to replace the pillars:
→ the inner FR4 rings



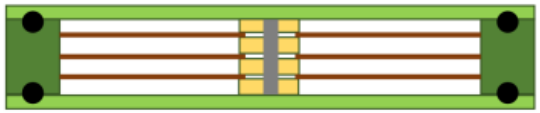


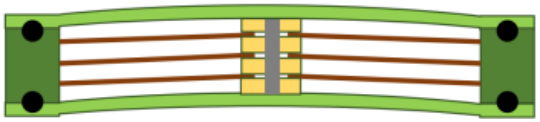


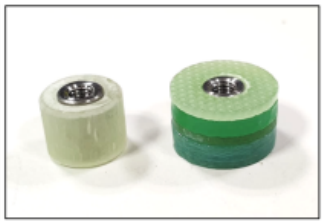
Baseline

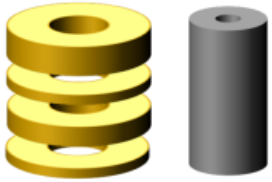


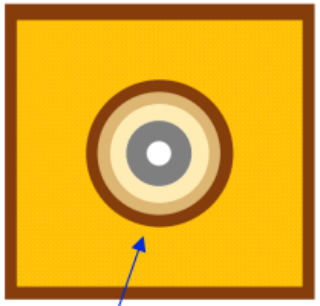
New idea **The inner ring structure keep the foils together, even with bending**











Inner are larger than the holes in the foil

→ The inner rings helps to secure the gap between all the electrodes, not only DRIFT and RO
→ In case of significant bending, the foils follow the PCB shape, maintaining gap integrity
→ The concept was **successfully tested** on 8 modules and then adopted as the new baseline