Development and performance of large-scale triple GEM detectors for CMS

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On behalf of CMS GEM Collaboration

Outline

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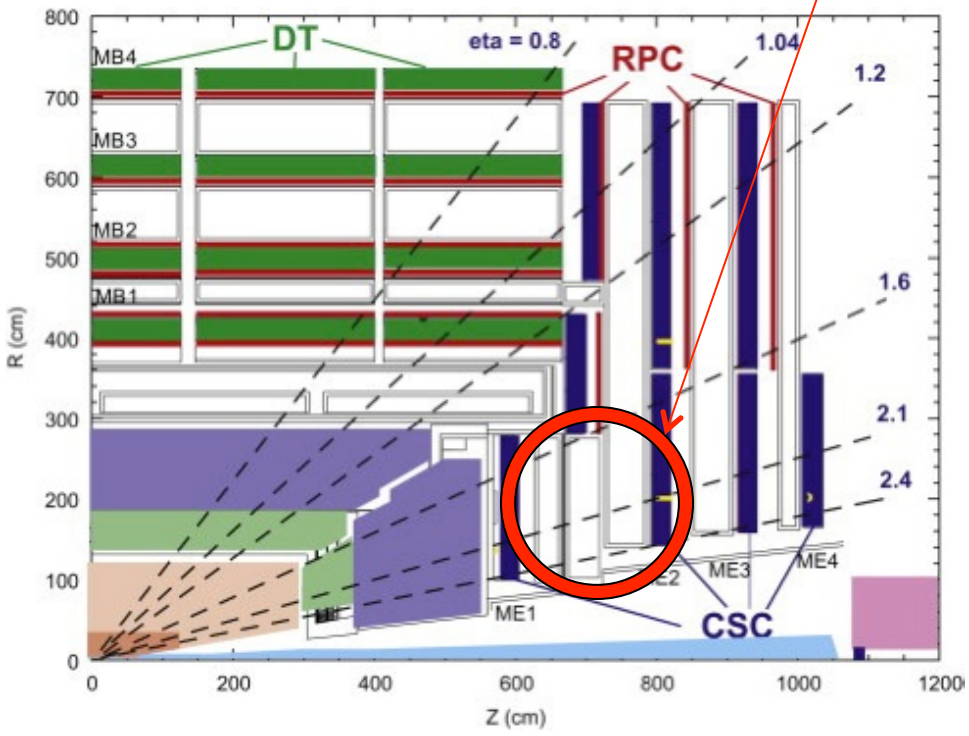
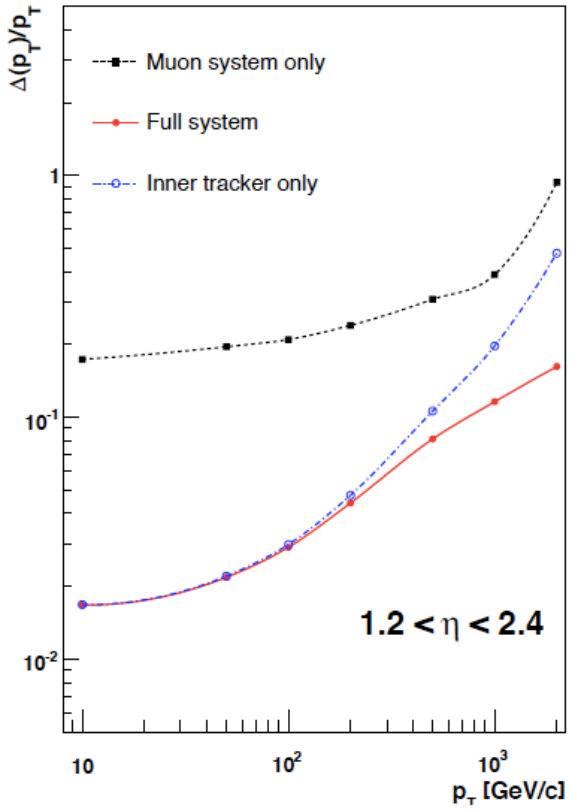
- Motivations
- Proposed GEM CMS Layout
- Results :
  - Simulation
  - Test beam results
  - Uniformity study
  - Aging study

Motivations

- CMS was designed to have a highly full redundant muon system
- CMS is presently lacking redundancy in the region 1.5<η< 2.4





Motivations

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CMS GEM collaboration:

Equip the high-η region with GEM chambers to cope with the high

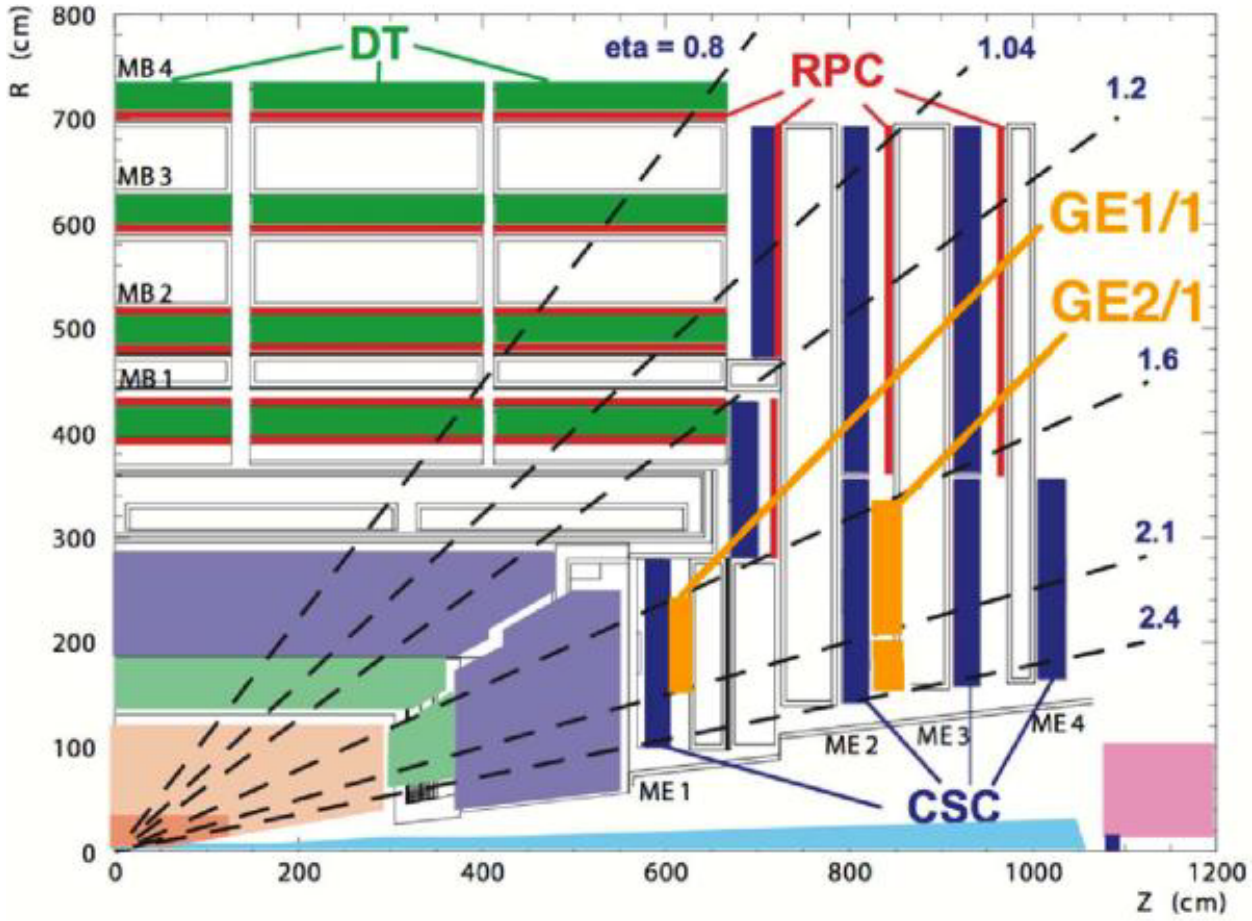
Luminosity and pileup conditions:

→ Improve muon momentum resolution

→ Provide highly efficient muon triggering (in high PU environment)

→ Improve reconstruction capabilities (complement GEM with existing CSC stations)

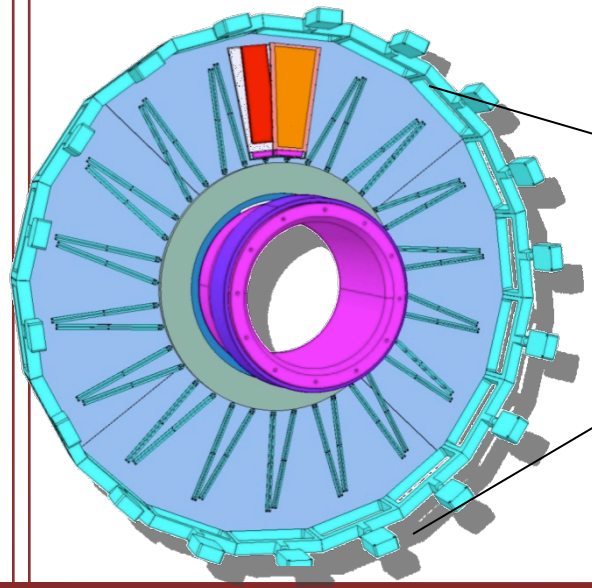
Proposed Layout

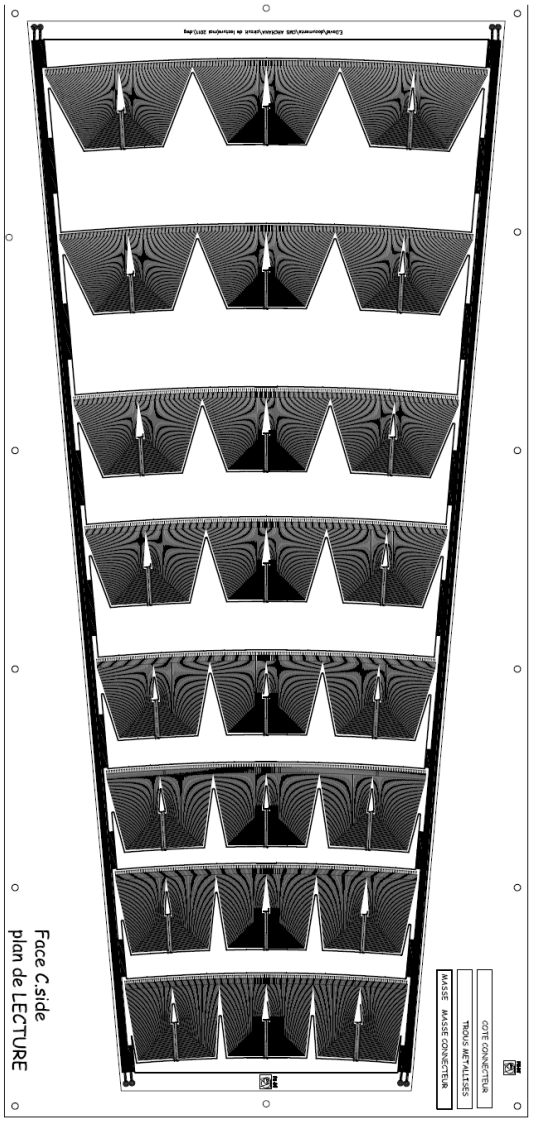


GE: GEM stations

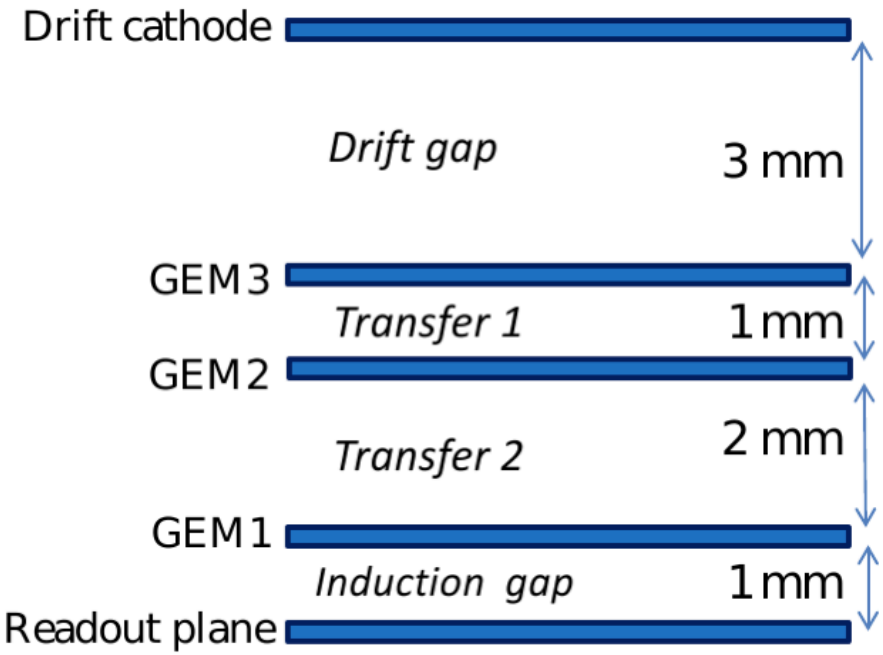
Proposed Layout

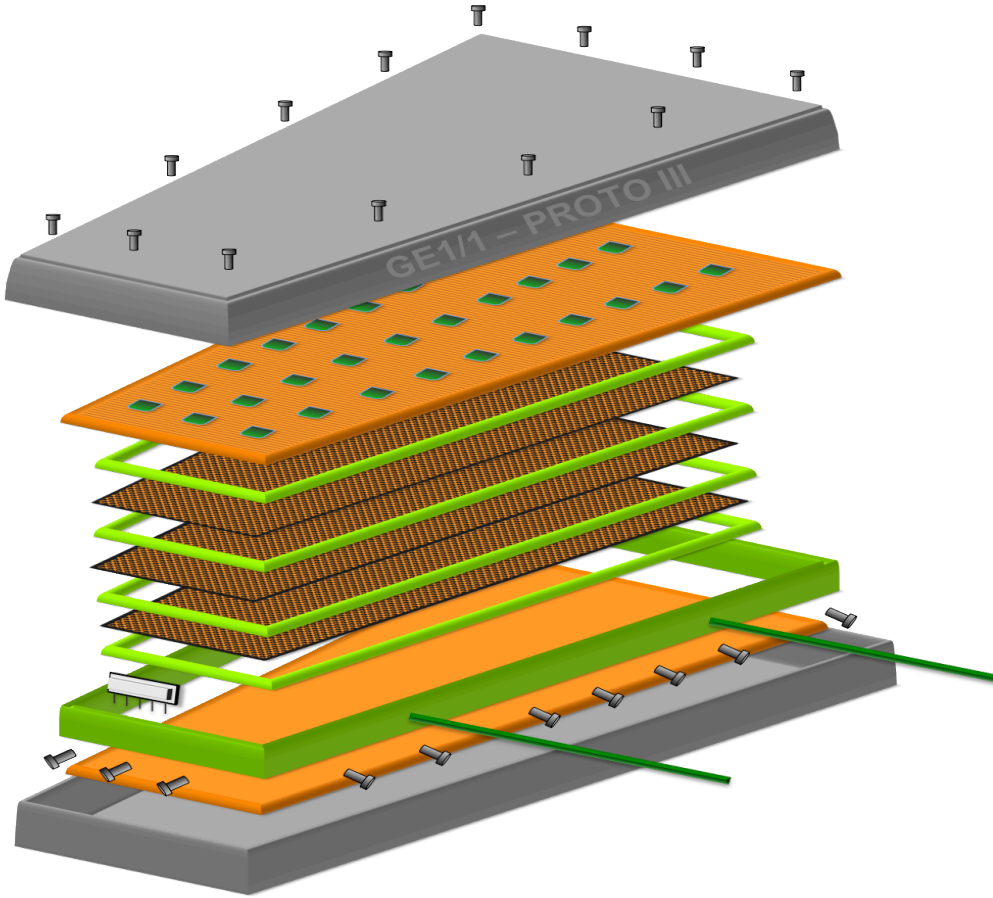
- Super Chambers (SC) equipped with triple GEMs
- each SC is a double readout layer
- Pitch from 0.6 to 1.2 mm





Proposed Layout: Super Chambers





Large size Triple-GEM chamber (Super Chamber)

Proposal validation

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- Extensive simulation (standalone and CMSSW)
- Beam/X-ray tests of real size super chambers
- Aging studies

In the following, results are summarized

Prelim. Results of simulation

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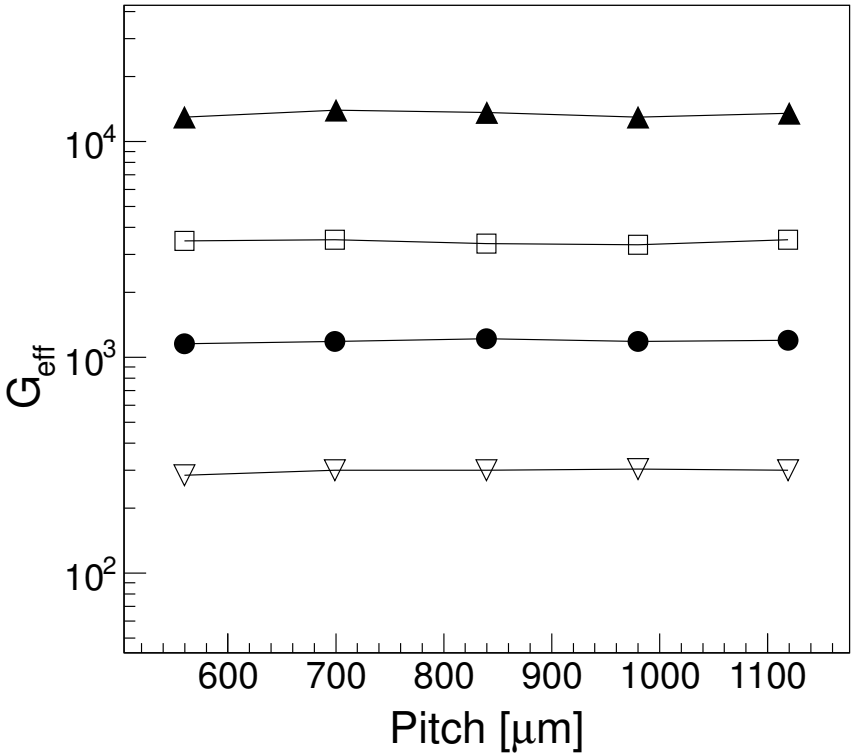
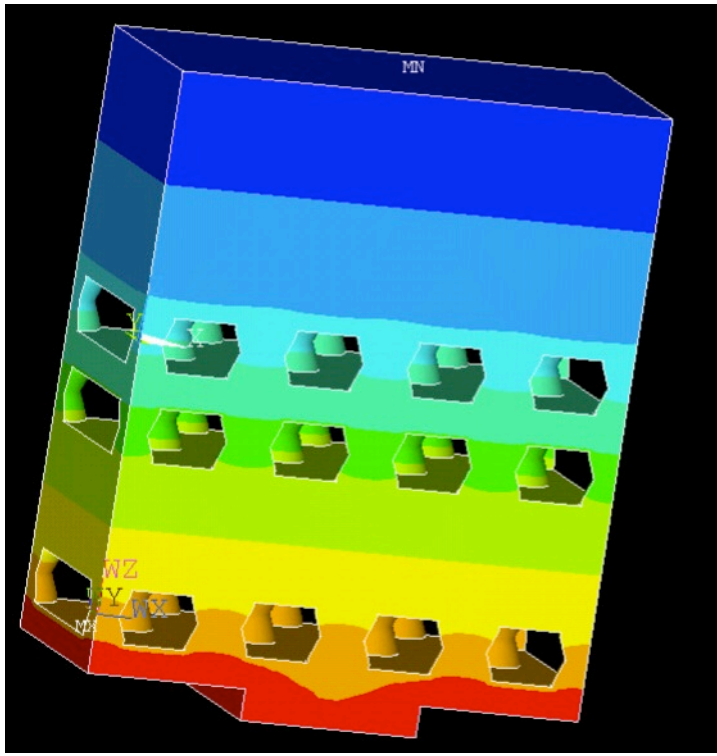
Full chain: ANSYS+GARFIELD
Four different voltages are shown

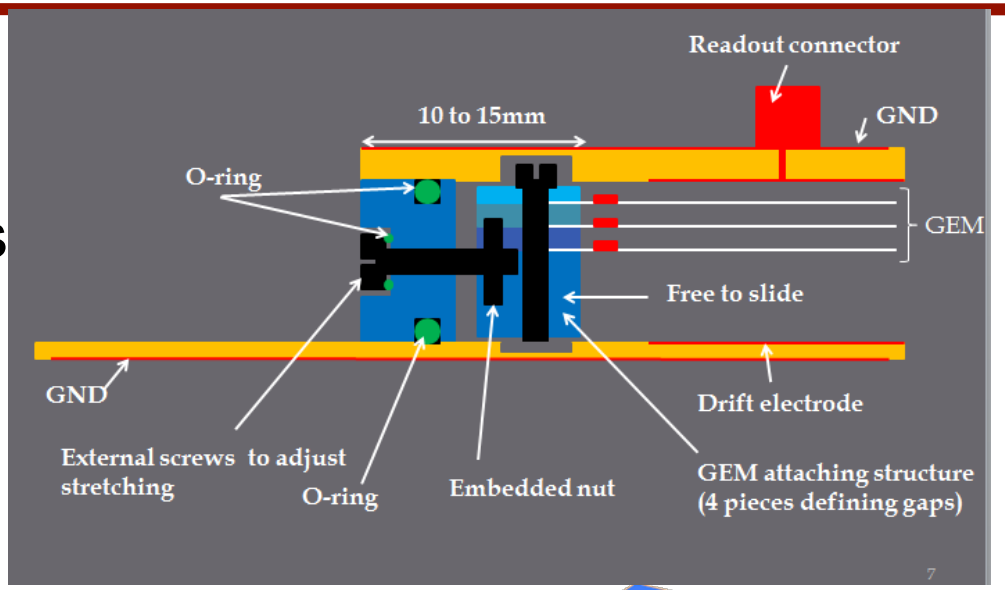




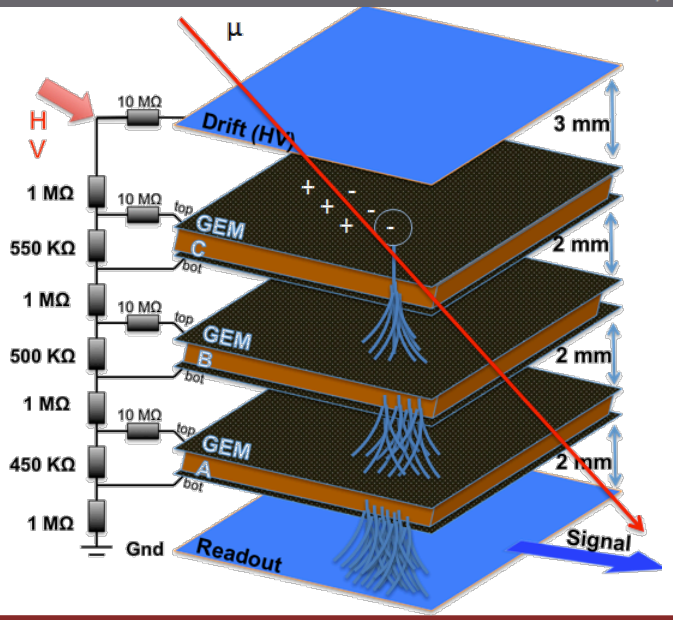
Uniform (less than 10% variation) effective gain versus pitch.

Super Chamber assembly

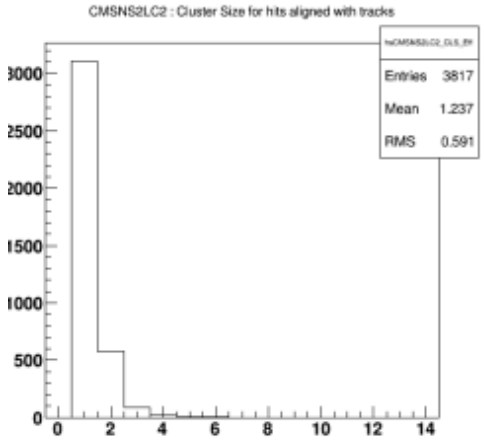
New assembly technique:
no stress on GEM, no spacers

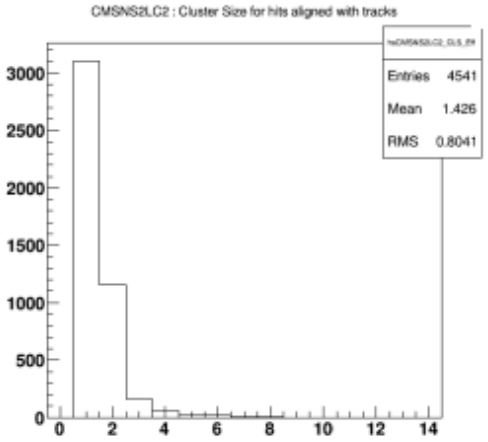


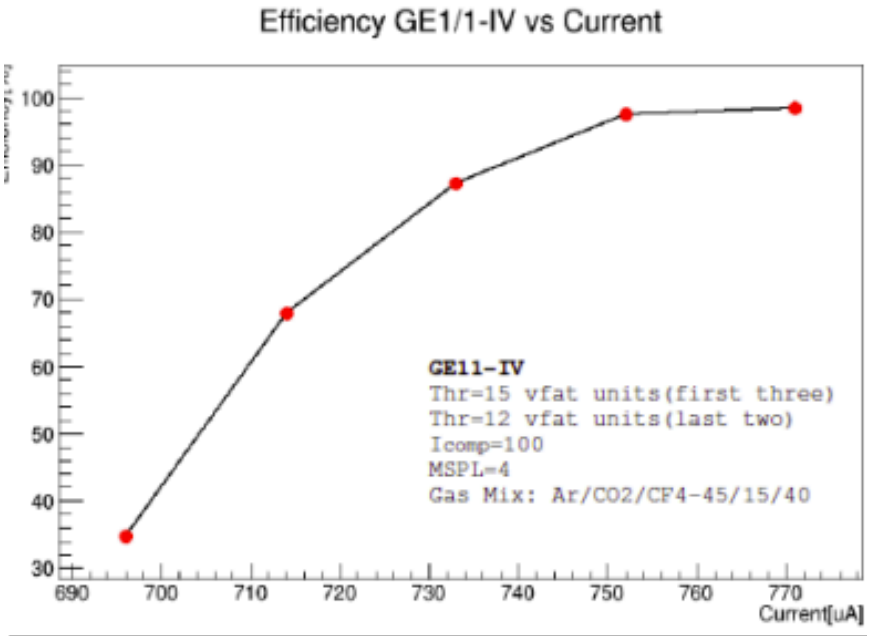
HV distributed via a divider



Prelim. Beam test results (VFAT chips)



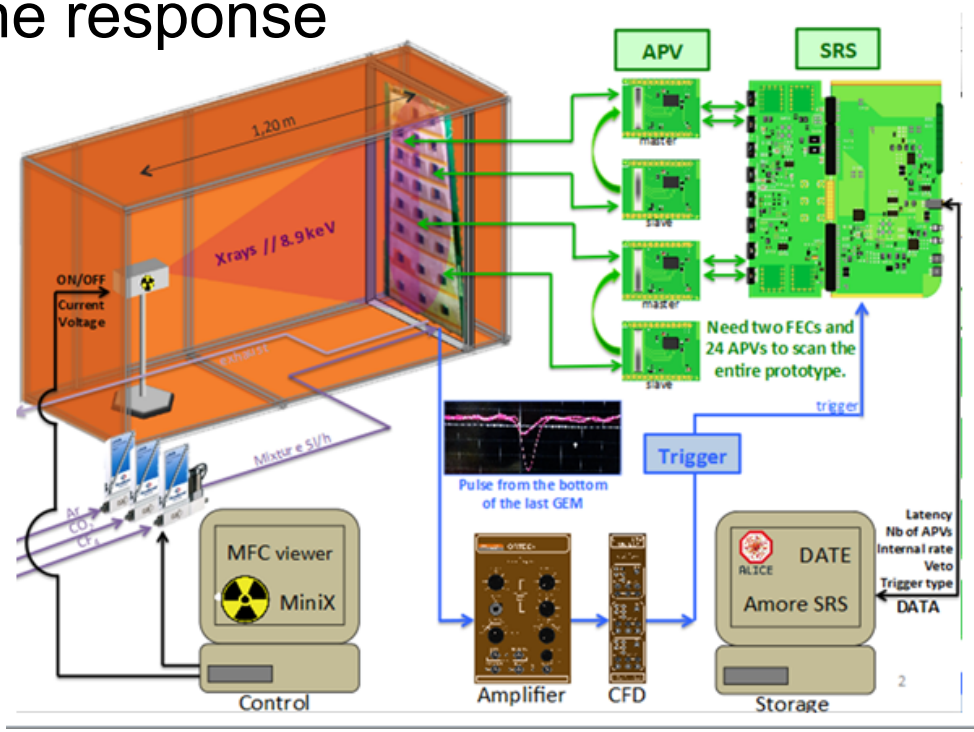




- November 2012
- Full size chambers tested
- 98% efficiency is reached
- Cluster size 1.2-1.5 strips
- SRS (analog chip) data is being processed

Gain uniformity measurement

- Chamber is illuminated with X-ray
- Signal collected on strips (APV channels)
- Look at the uniformity of the response



Gain uniformity measurement

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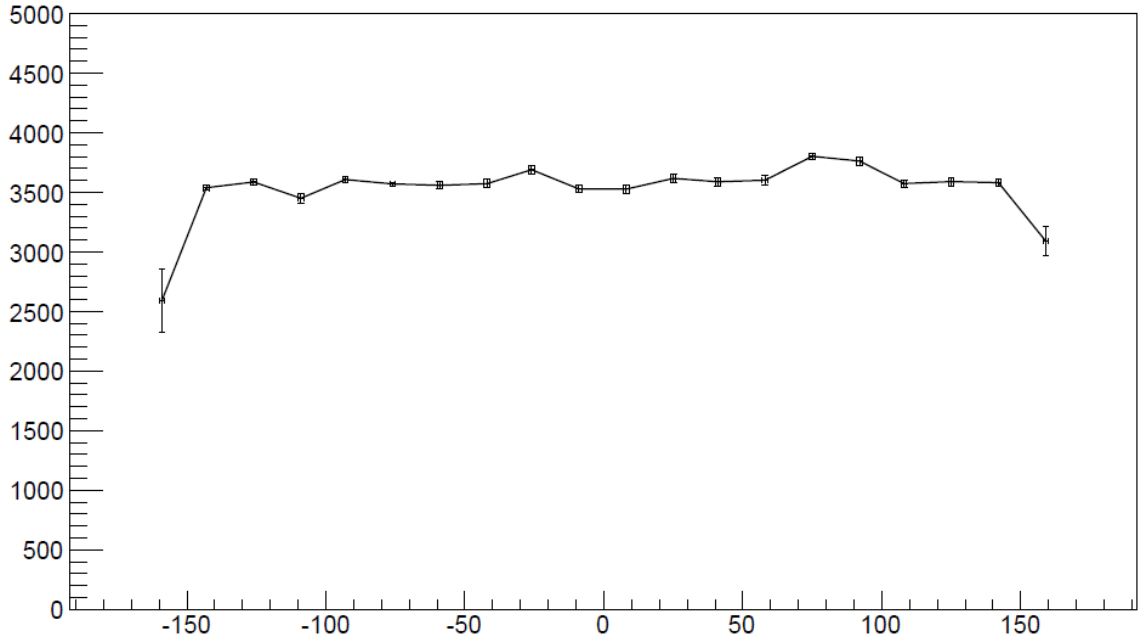
Charge recorded (ADC counts) across the strips of the SC



Less than 15% gain variations observed across the strips

Gain uniformity measurement

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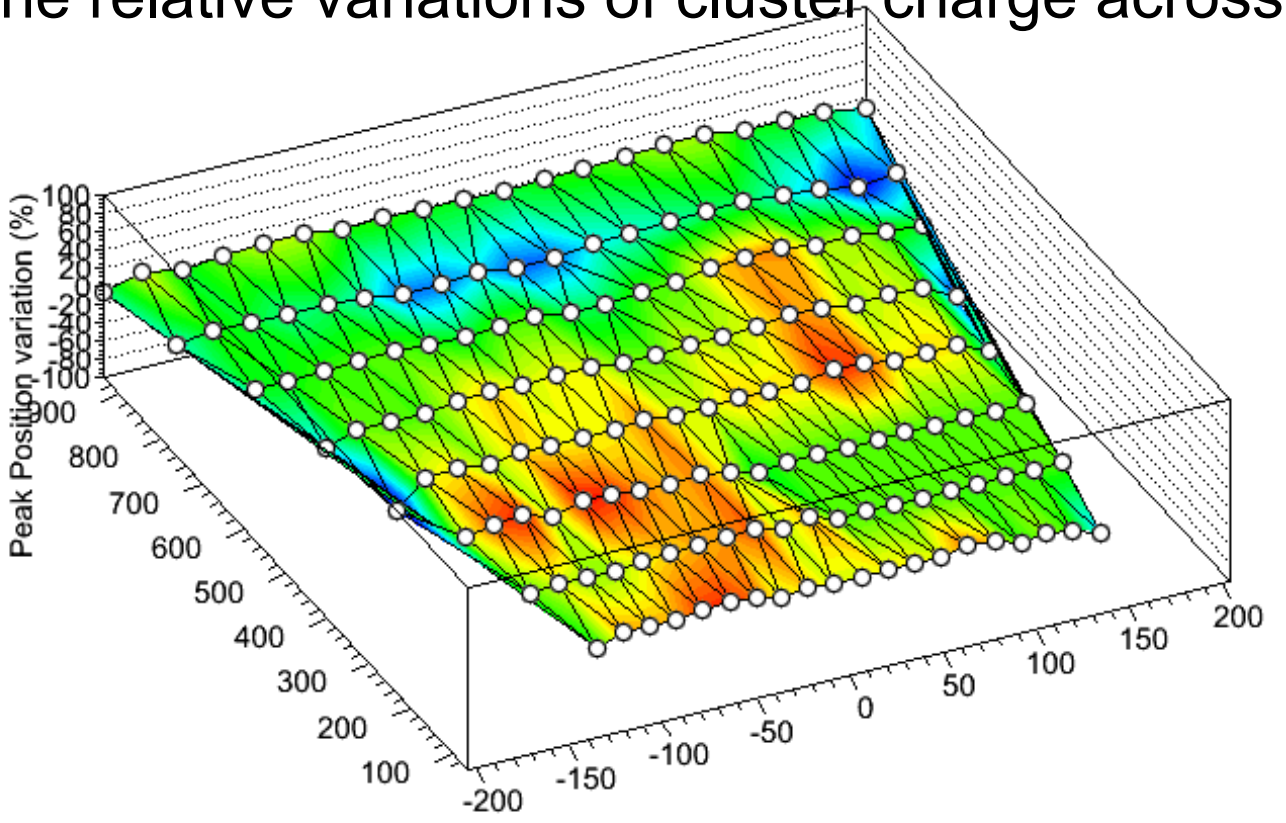
Measure the relative variations of cluster charge across the chamb



Less than 15% gain variations observed across the whole area

Aging studies

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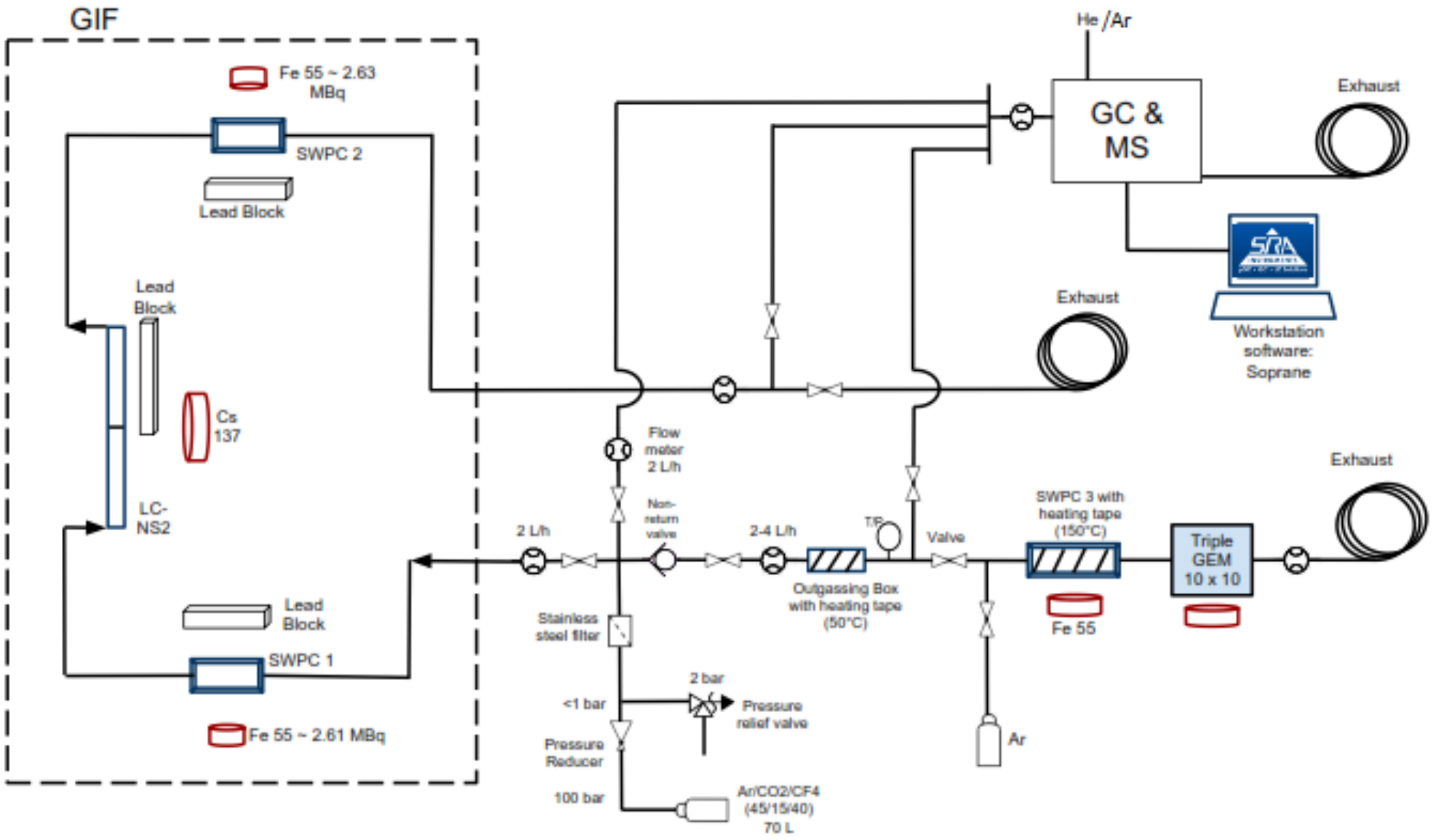
- Perform aging test for long term operation of triple-GEM
- Using GIF (Gamma Irradiation Facility) at CERN
- Using ^{137}Cs source providing up to 566 GBq
- Single Wire chambers are used as control chambers
- Gas Chromatograph is used for gas composition analysis

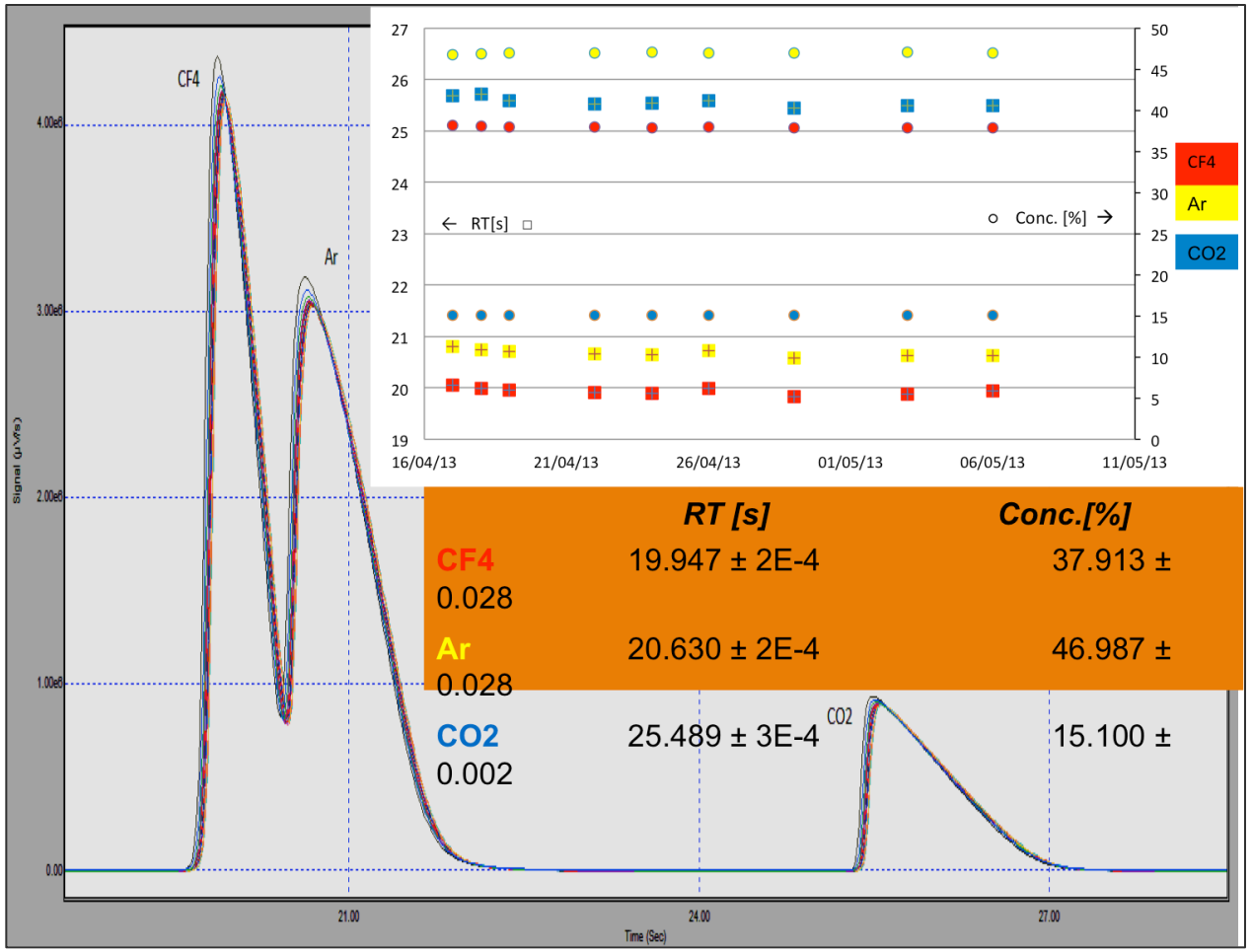
Aging studies (setup)



Aging studies

- Complete super chamber tested (3072 readout channels)
  - ❑ Ar(45%)-CO_2(15%)-CF_4(40%)
  - ❑ Effective Gain: 10^4
- Continuous monitoring of SC response

Aging studies



Continuous gas analysis

Aging studies

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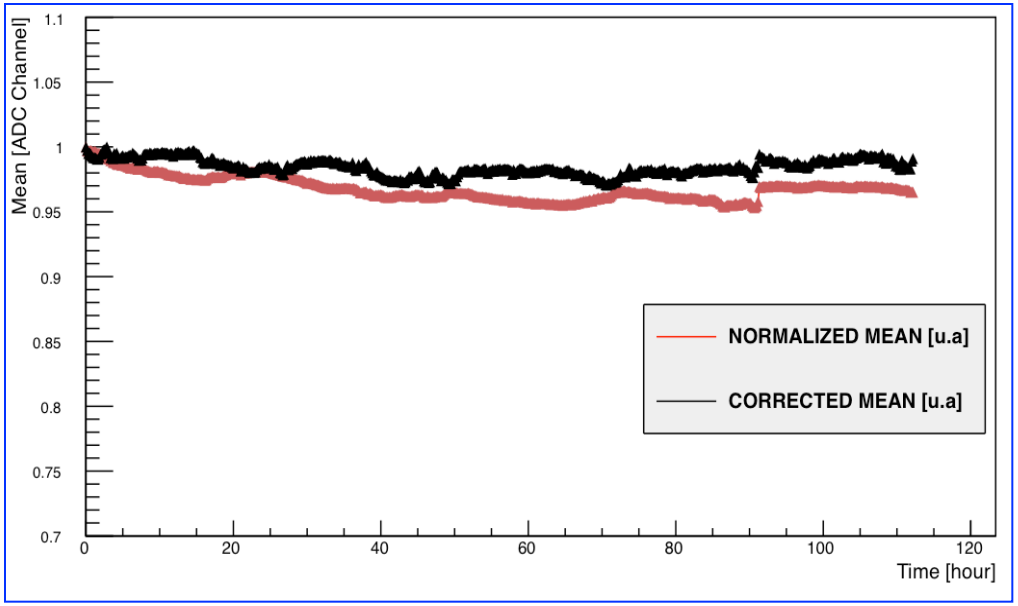
ADC counts



- Use correlation between gains of wire chamber and GEM
- Compute the corrected (independent of T/P variations)gain of the GEM

Summary

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- R&D program demonstrated very promising capabilitie for large-area GEMs that are suitable for high η region
  - ➢ 98% detection capabilities
  - ➢ Uniform response achieved
  - ➢ Ongoing aging test shows no degradation
- More ongoing simulation and data analysis effort

More information:

- **Christopher Armaingaud** ***"Gain Uniformity tests on full scale triple GEM detectors for CMS high Eta upgrade"*** poster at this conference
- **Jeremie Merlin** "***Aging studies for large triple-GEM detectors for the CMS Endcap***" poster at this conference
- **Michel Tytgat** "***Status of the Triple-GEM Project for the Upgrade of the CMS Muon System"*** presented at this conference