106° Congresso Nazionale Società Italiana di Fisica

ME0 project for the Triple-GEM upgrade of the CMS muon spectrometer upgrade

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On behalf of CMS Muon Group

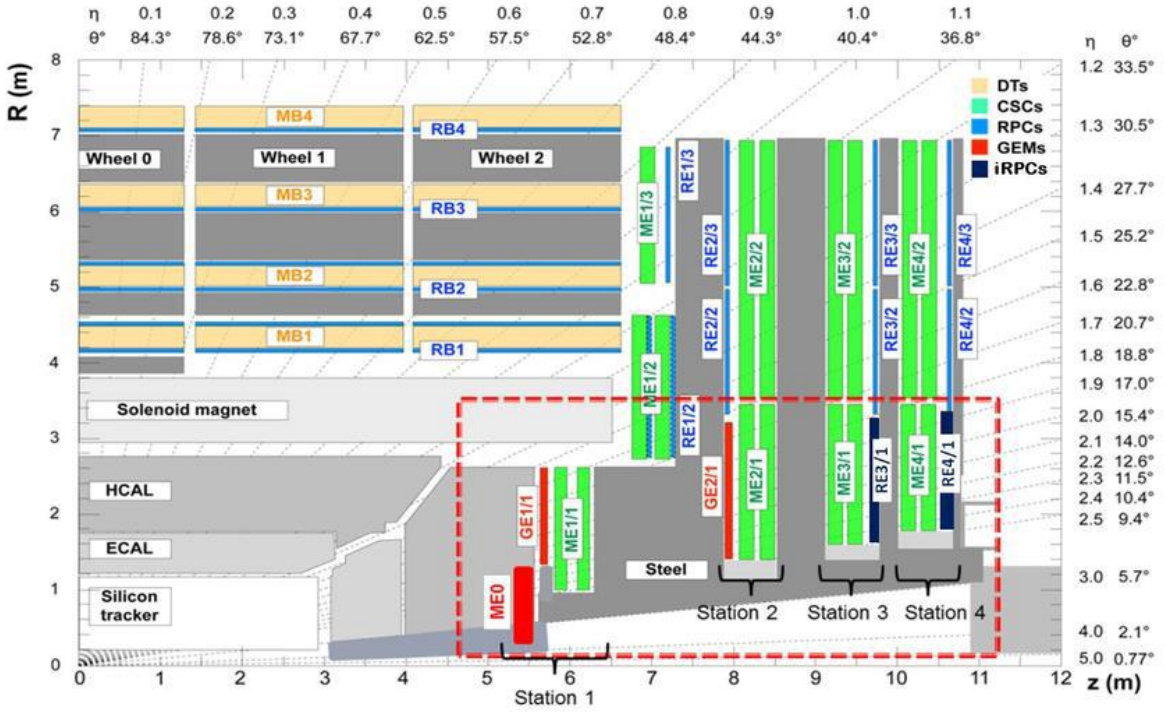
CMS muon upgrade for High-Luminosity LHC

Luminosity

$10^{34} cm^{-2} s^{-1}$

HL-LHC upgrade

$5 - 7 \times 10^{34} cm^{-2} s^{-1}$



Higher discovery potential

But

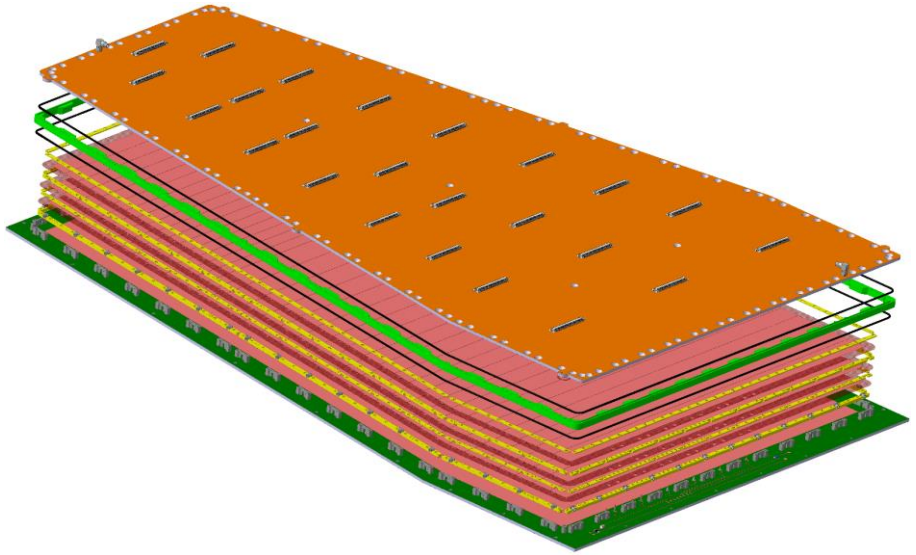
Also

- Higher Event Pile-Up
- Higher background (photons, electrons, neutrons)

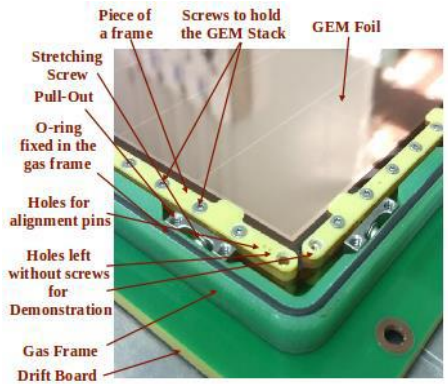
GEM Detector Mechanical Design

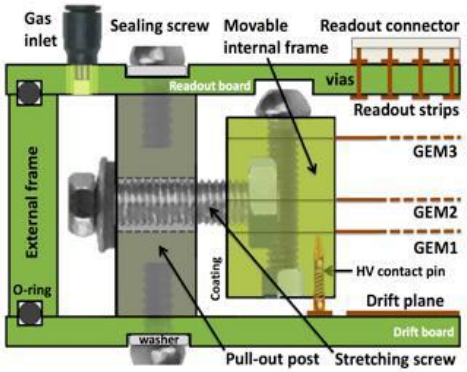
Self-stretching technique

- Avoid using spacers (loss of active area)
- Avoid using glues (possible contamination and premature aging)



- Glass-epoxy internal frame to ensure the gap distancing
- Glass-epoxy external frame+O-ring to ensure gas tightness

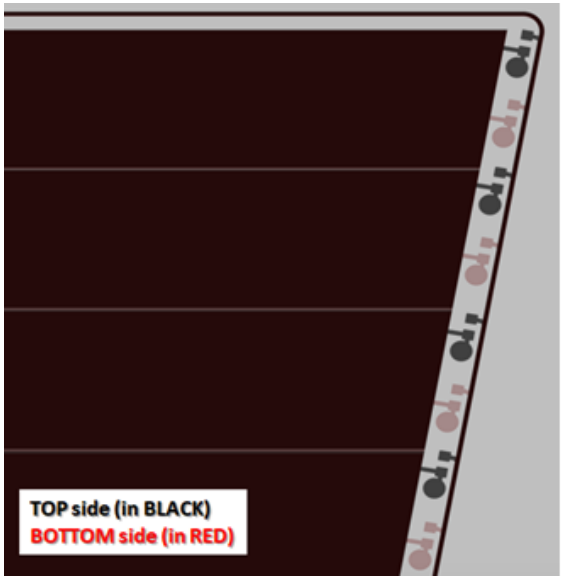




ME0 Detector Mechanical Design

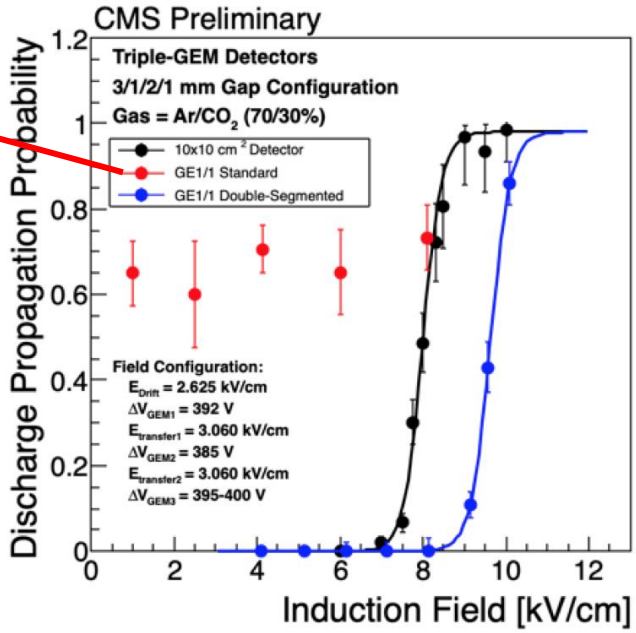
Foils double segmentation

- The foil (≈ 0.3m^2) is divided in 29 sectors (≈ 100 cm^2)
- Protector resistors on both top and bottom sectors still uder discussion (see next slides)



Part of the discharge mitigation strategy

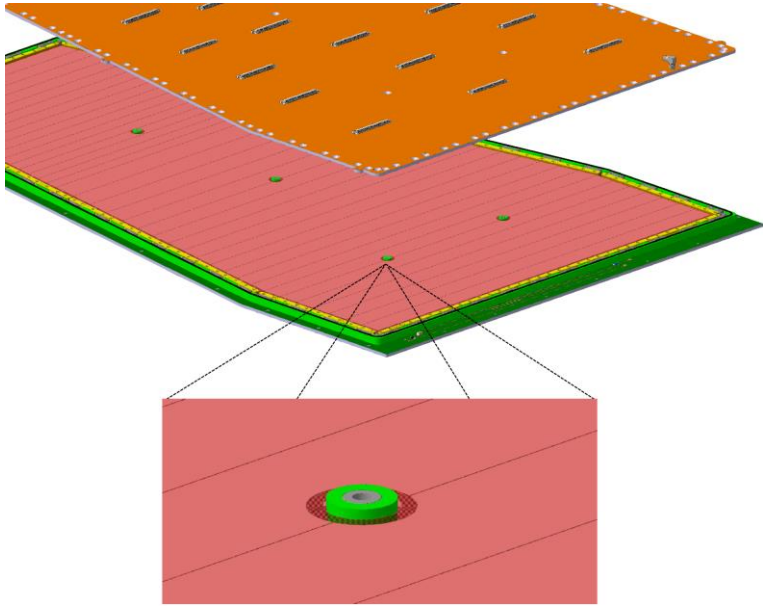
Only the top side segmented



Reducing the gaps capacitance reduces the probabilty that a discharge in the foil propagate to readout board and damage the eletronics

See also:
https://indico.cern.ch/event/757322/contributions/3396501/attachments/1839468/3015160/JMerlin_MPGD2019_Discharge_Study_V1_23042019.pdf

ME0 Detector Mechanical Design



Internal distance holders (Pillars)

- GE1/1 production revealed that the gain uniformity can be improved (GE1/1 is good but not best)
- Placing pillars sacrifice ≈ 1.3% of the active area
- But improves the gain uniformity

GE1/1 mass production chambers average gain uniformity (σ/μ)

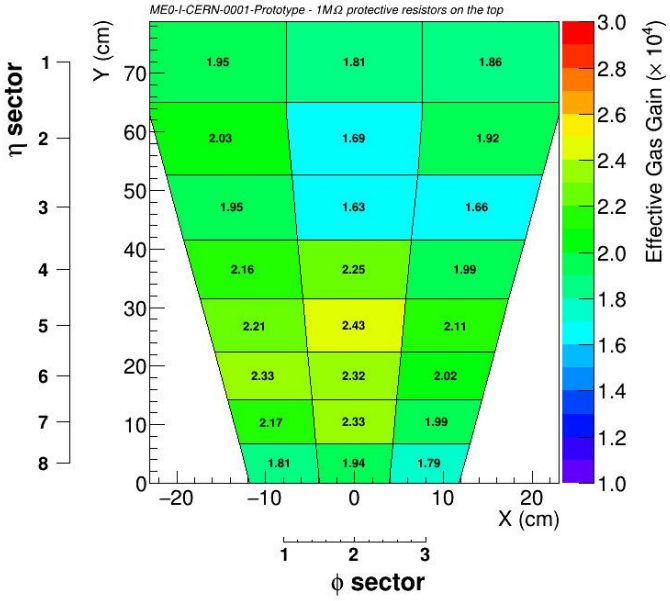
25%

ME0-I-CERN-0001-Proto

11%

ME0-I-CERN-0002-Protc

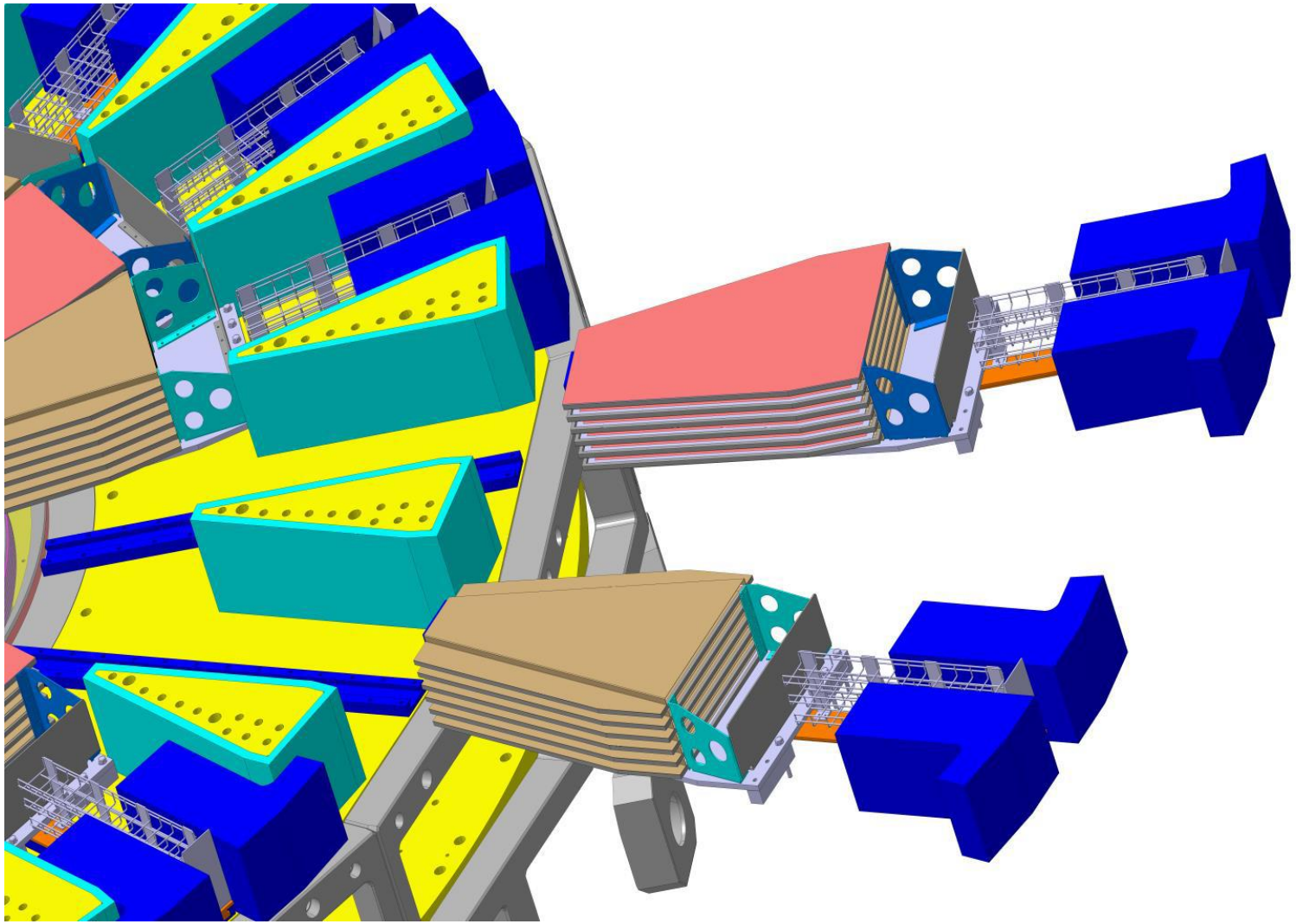
13%



See also:

https://iopscience.iop.org/article/10.1088/1748-0221/15/08/C08002

Six ME0 module stack design



ME0 background particle environment

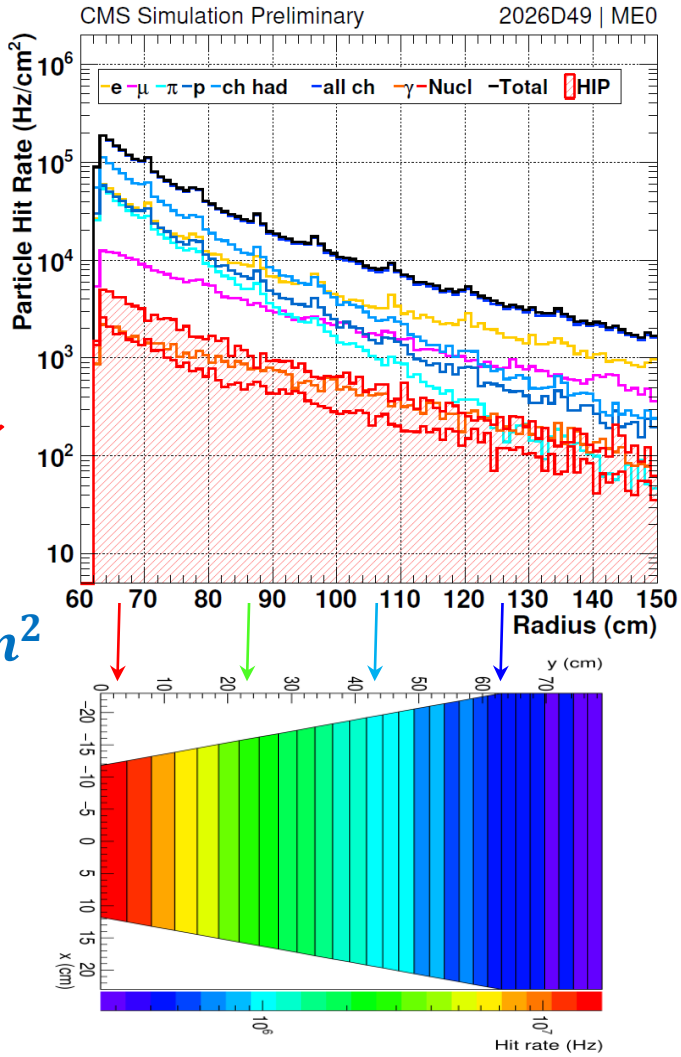
- Highest hit rate: $144\ kHz/cm^2$
- Average hit rate: $21\ kHz/cm^2$

HIP -> Heavely Ionizing Particle
Patricle which deposits >30 keV in the detector

- Highest HIP hit rate: $4\ kHz/cm^2$
- Average HIP hit rate: $1.7\ kHz/cm^2$

Most likely trigger discharges

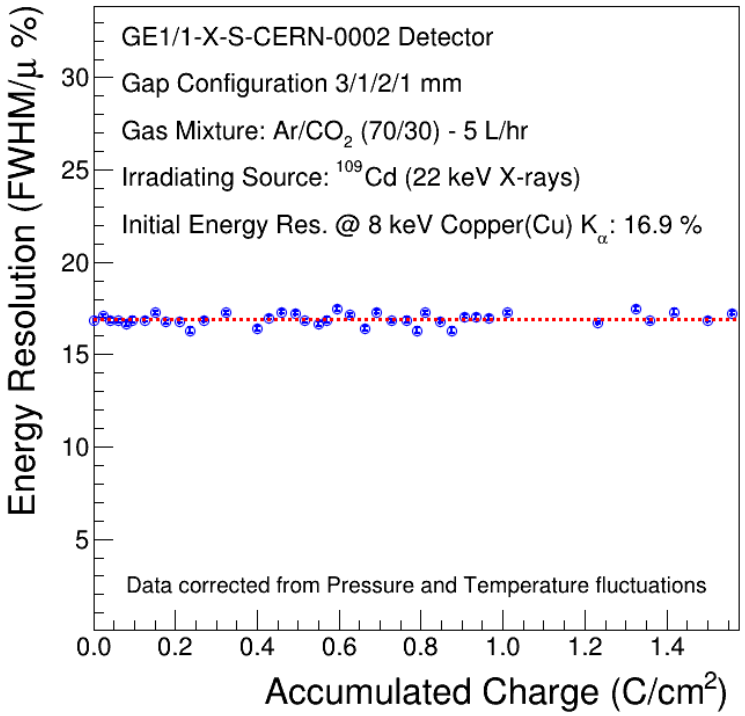
- Collected charge in the hottest region: $7.9\ C/cm^2$

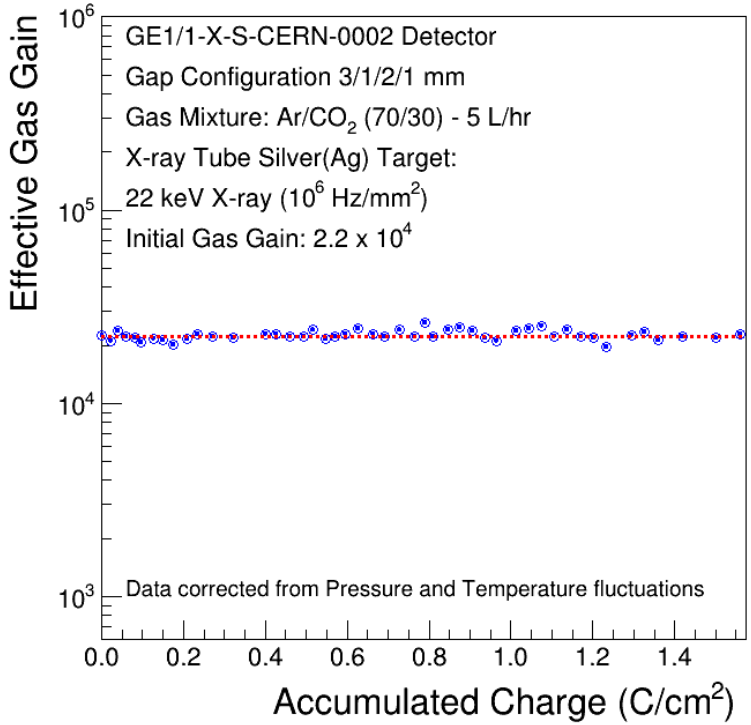


See also:

- https://indico.cern.ch/event/918611/contributions/3864586/attachments/2041443/3419415/20200519_Ph2Workshop_ME0Bkg.pdf
- https://indico.cern.ch/event/918611/contributions/3864578/attachments/2041245/3418747/GEM_Workshop_INSEOK_200519.pdf
- https://indico.cern.ch/event/918611/contributions/3864577/attachments/2040951/3418120/FFallavollita_CMS_GEM_Workshop_20200518.pdf

Aging studies for ME0

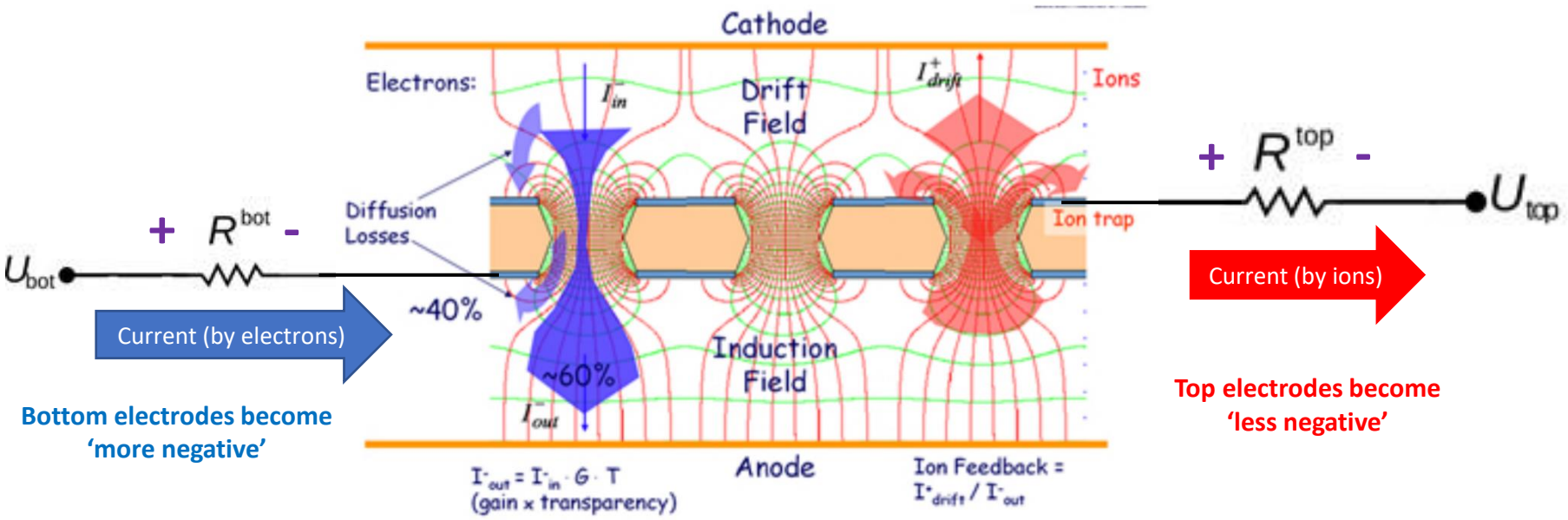




- **GEM detectors design validated up to $1.56\ C/cm^2$**
- **Test still ongoing to reach the goal of $7.9\ C/cm^2$**
- **Advanced aging studies revealed the radiation hardness of GEMs also in presence of HIPs and gas pollutants**

See also:
https://indico.cern.ch/event/843258/contributions/3610749/attachments/1929418/3195281/06_Fiorina.pdf

Rate Capability for ME0

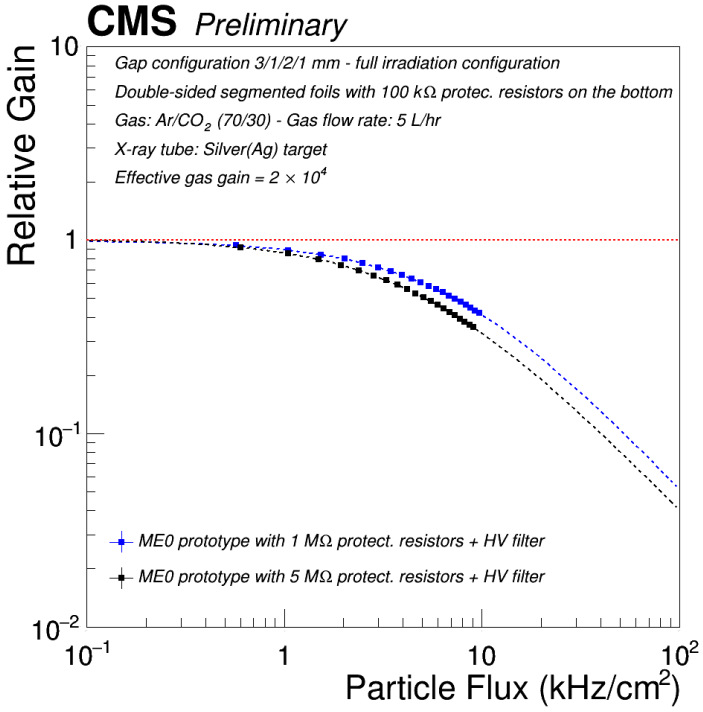


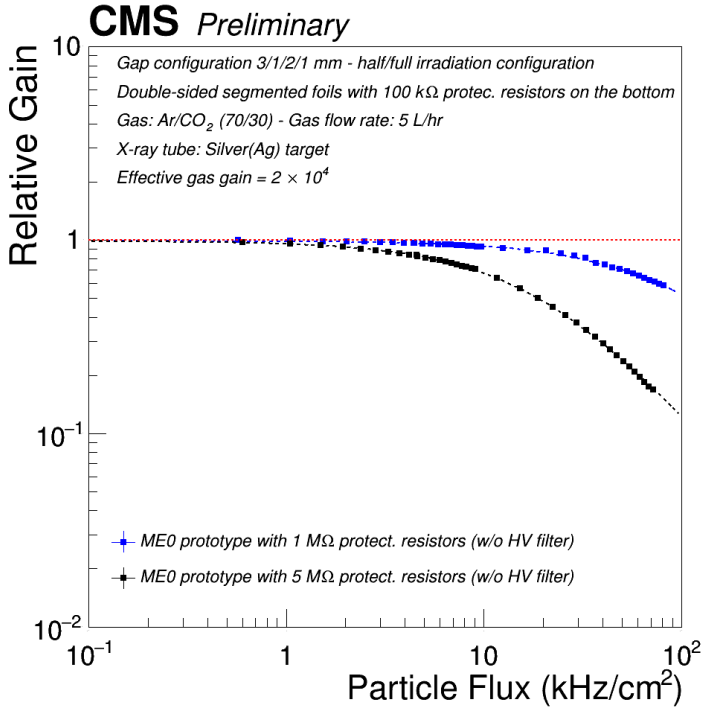
- Increasing of the gaps fields (enached electron extracion)
- Reducing of the Amplification field (loss of gain)

Top current is usually higher (ions are cathced easier) but this strongly depends on the RESISTOR

--> GEM foils lose gain under intense irradiation

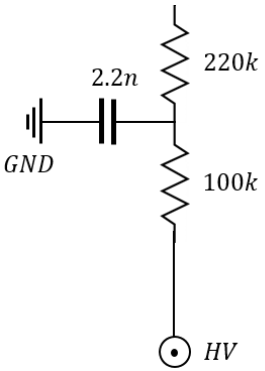
Rate Capability for ME0





Target rate:
$150\ kHz/cm^2$

ME0 prototypes with 1 - 5 MΩ on top and 100 kΩ on bottom



- **The prototypes can't work efficiently in these configurations (lower resistor are needed)**
- **Removing the HV filter (or changing it) can help**
- **Still room for improvement, new tests ongoing**

Conclusion

- Production will start 2021/2022 i.e. We still have 1 year of R&D
- Structural changes in the design imporved the gain uniformity and mitigated the discharges effects
- Due to the incredibly harsh particle environment rate capability and aging are critical issues

Aging tests are on going and they will reach the goal in time for mass production

Rate capability studies are more delicate:

- Need to develop knowledge in the field
- Time and effort for prototyping and testing new solutions