Study of GEM chambers under neutron irradiation

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Outline

- Goal
- GEM chamber tests
- Materials to be tested
- Types of tests on the materials
- Test conditions
- Possible irradiation facilities
- Important parameters
- Conclusions

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Goal

- Reproduce the conditions that the chamber will undergo at CMS, with respect to neutrons.
- The chamber will be in similar conditions as in CMS (HV, gas mixture, cooling system).
- Study the neutron irradiation effect on the GEM chambers performance.
- Observe the modification of the chamber's materials properties.
- It will be necessary to perform tests before and after irradiating the chamber and the material samples.

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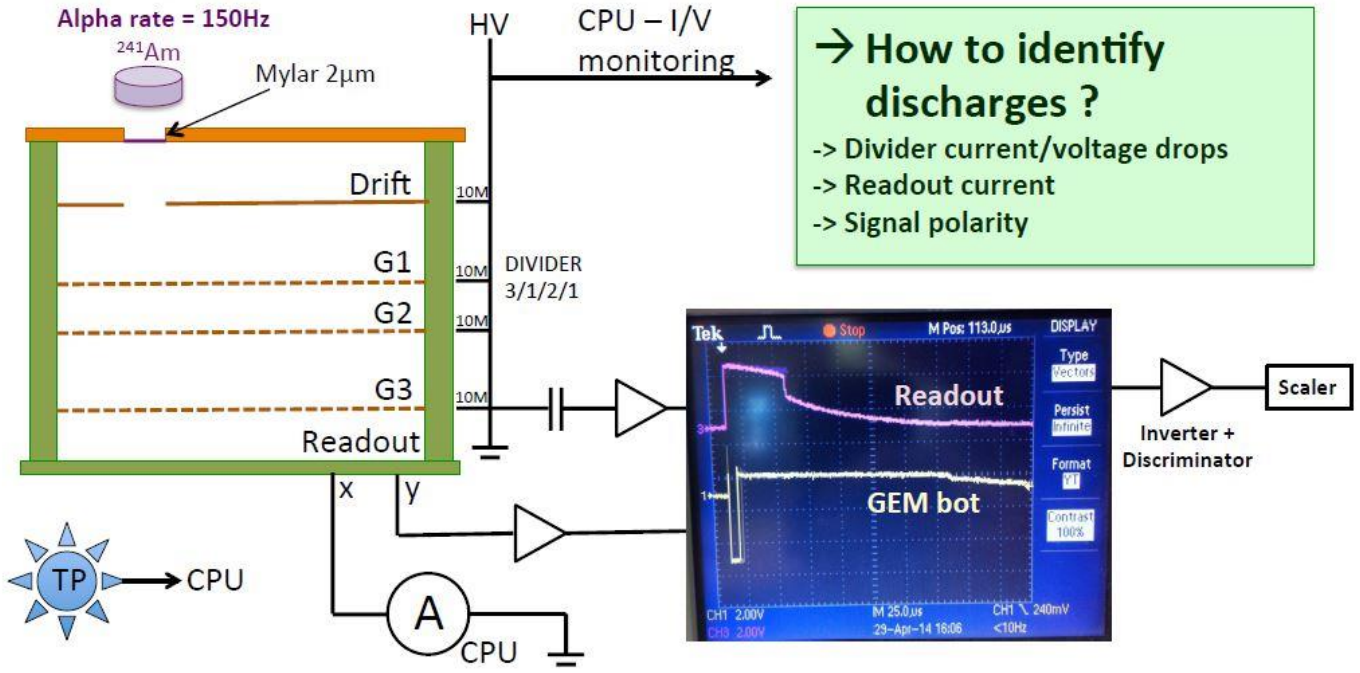
GEM chamber tests

- Research on GEM's irradiated with neutrons has previously been done.
  - Croci, G. (n.d.). *Development and Characterization of Micro-Pattern Gaseous Detectors for HEP applications and beyond*.
- Discharge probability test
  - Similar to the test done at RD5
  - How to identify discharges?
    - Jeremie's previous talk
    - Alternatives



J. Merlin https://indico.cern.ch/event/324982/contribution/3/material/slides/0.pdf

GEM chamber tests

- Sensitivity test
  - Detector needs to be operational
  - The acquisition time can be obtained from simulations.
  - A large amount of events will be necessary to have good statistics.
- Stability test
  - Observe if the detector performs well after being irradiated during a specific amount of time.
- Deexcitation test
  - Study for how long do we continue to observe particles after there is no source irradiating

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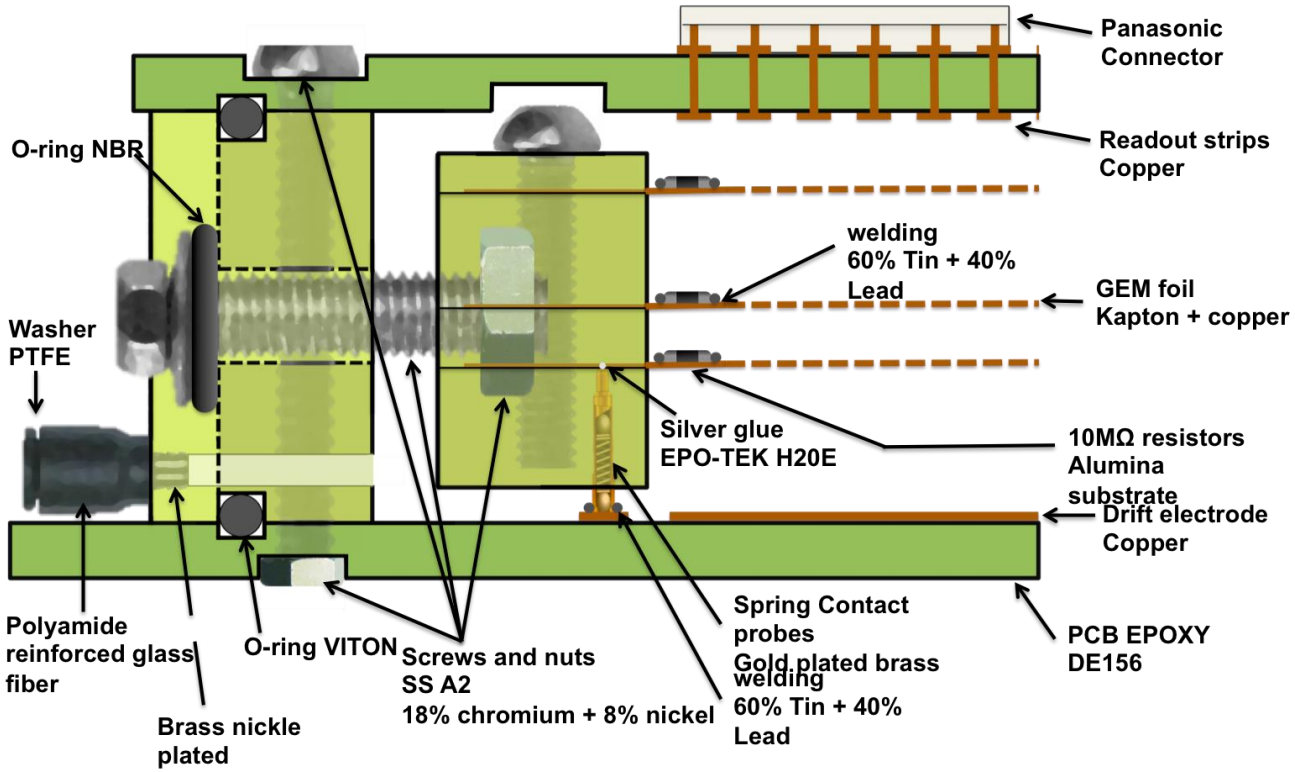
Materials tested



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Materials tested

- Many materials have been tested at CERN already. See the “CERN Yellow Book” Compilation of Radiation Damage Test Data.
- Some new materials need to be tested.
  - Polyurethane Novoverne used as an electric insulator (electric properties).
  - Scotch weld EC100 glue and Scotch weld activator AC11, used to glue the Viton O-rings (mechanical properties).
  - Ceramic resistors 10 MΩ alumina substrate (electric properties).
- It will be interesting to reproduce and compare the results of materials previously studied with the results obtained from new tests.

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Types of tests

- Materials will need to be tested before and after irradiation.
- Mechanical tests
  - Standard traction, bending and shear tests for those materials submitted to mechanical stresses.. Need to have an important amount of samples in order to have acceptable results.
  - Glues will be tested also following standard methods.
- Electric tests
  - Electric insulating properties of both the PU and the film layer on top of the PCB must be measured.
  - According to literature conductance and capacitance of resistors varies with frequency. This will need to be measured.

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Test conditions

- Two types of test, active or passive.
- GEM chamber must undergo an active test (HV, gas mixture, cooling system).
  - Some facilities have expressed their concern to use our gas mixture
- Materials can be tested with a passive test
- Due to the dimensions of the chamber (almost $1m^2$) it will not be possible to homogenously irradiate the whole chamber.
- If thermal neutrons are used the chamber will probably be too radioactive to handle.
- We are in the process of studying how neutrons react with other materials
- How to properly reproduce CMS conditions?

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Test conditions

CMS Muon System background ($L = 10^{34}$ $cm^{-2}s^{-1}$)

Region	Neutrons		Photons			Charged	
	Flux ($cm^{-2}s^{-1}$) Max	Fluence (cm^{-2}) Max	Flux ($cm^{-2}s^{-1}$) Max	Fluence (cm^{-2}) Max	Dose (Gy) Max	Flux ($cm^{-2}s^{-1}$) Max	Fluence (cm^{-2}) Max
GE1/1	$5,6 \times 10^{3}$	$2,8 \times 10^{10}$	$2,5 \times 10^{3}$	$1,3 \times 10^{10}$	$5,6 \times 10^{-2}$	$1,2 \times 10^{2}$	$6,0 \times 10^{8}$
GE2/1	$1,3 \times 10^{4}$	$6,5 \times 10^{10}$	$3,9 \times 10^{3}$	$2,0 \times 10^{10}$	$8,7 \times 10^{-2}$	$5,0 \times 10^{1}$	$2,5 \times 10^{8}$
ME0	2.8×10^{6}	$1,4 \times 10^{13}$	6.0×10^{7}	$3,0 \times 10^{14}$	$1,3 \times 10^{3}$	$8,2 \times 10^{6}$	$4,1 \times 10^{13}$
RE3/1	$1,9 \times 10^{4}$	$9,5 \times 10^{10}$	$3,8 \times 10^{3}$	$2,0 \times 10^{10}$	$8,5 \times 10^{-2}$	$2,6 \times 10^{1}$	$1,3 \times 10^{8}$
RE4/1	$1,1 \times 10^{4}$	$5,5 \times 10^{10}$	$9,3 \times 10^{3}$	$4,7 \times 10^{10}$	$2,1 \times 10^{-1}$	$1,6 \times 10^{2}$	$8,0 \times 10^{8}$

- Fluence is calculated for 1 y LHC = 5×10^{6} s
- Dose in air calculated with 1 MeV γ

Possible overestimation due to:
- Forward Calorimeter not implemented
- Post LS1 Shielding not implemented

For an estimation for HL LHC (5×10^{34} $cm^{-2}s^{-1}$) the values in the table must be multiplied by a factor 5

S. Constantini , https://indico.cern.ch/conferenceDisplay.py?confId=288056
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ILARIA VAI - GEM WORKSHOP VIII - DAQ HARDWARE MEETING

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Possible irradiation facilities

- Lena (Pavia, Italy)
- Enea (Casaccia , Italy)
- Enea (Frascati, Italy)
- PSI (Switzerland), only thermal electrons. Very Expensive to build a system for a big GEM chamber
- Louvain la Neuve (France)
- TSL (Uppsala, Sweden)
- Laboratoire Léon Brillouin CEA (France). Possible geometry constraints
- Institut Laue-Langevin (France).
- PRISMA (Germany). Not yet possible, they are planning to have a special facility to irradiate gas detectors.
- NCBJ (Poland).

Important parameters

- Dimensions
- High voltage
- Gas mixture
- Cooling system
- Activation of the materials.

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Conclusions

- Most of the materials will be tested (re-tested)
- Which facility should be used?
  - Geometric, HV, gas and cooling system constraints
  - Economic constraints
  - Type of beam constraints
- Design tests to study the evolution of electric and mechanical properties of the materials.
- We are still at a very preliminary stage

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All suggestions will be appreciated

Thank you for your attention