Ageing and high rate studies on resistive Micromegas at the CERN Gamma Irradiation Facility

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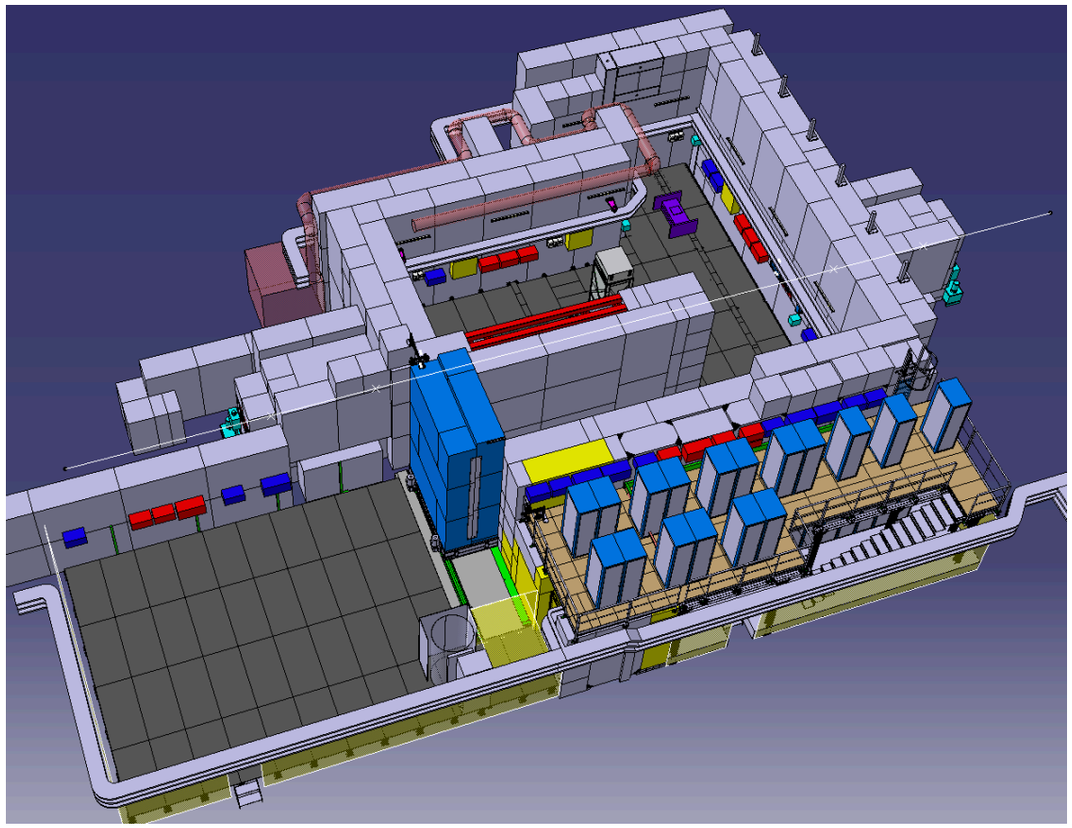
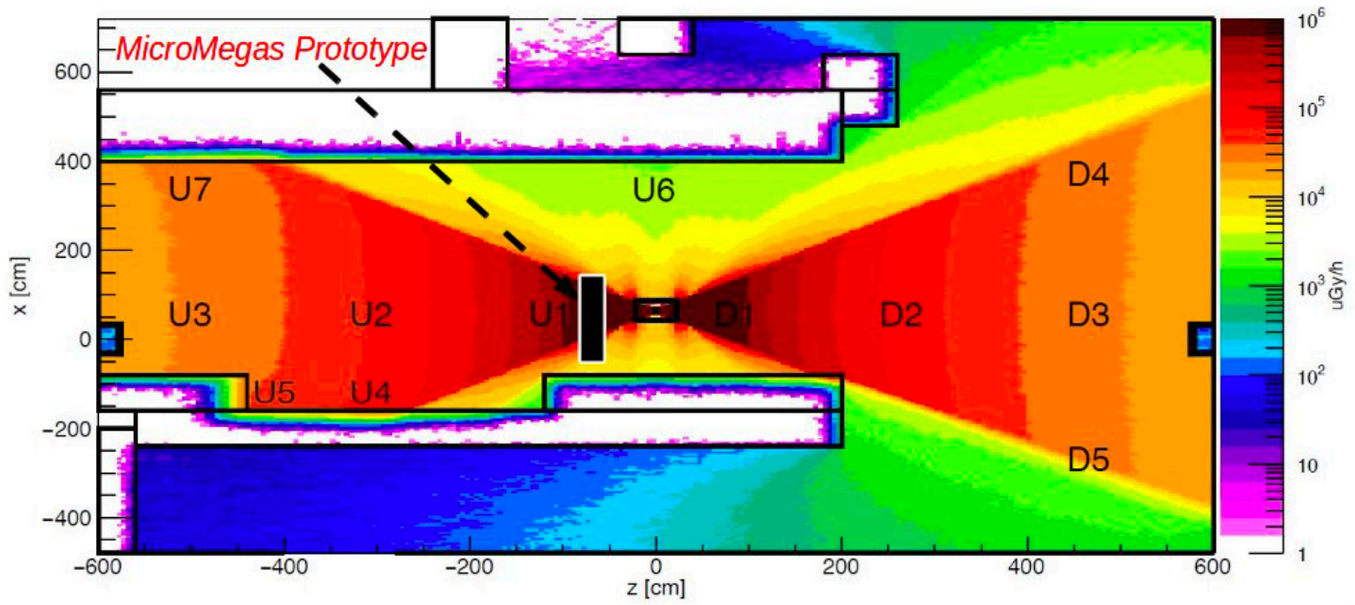
Gamma Irradiation Facility (GIF++) as ageing facility

Detector response to long term irradiation and high rate capability are key elements for new muons detectors especially in view of High-Luminosity LHC

- GIF++ at CERN combines a high intensity photon source (14 TBq Cesium source) with a muon beam
- The source produces 662 keV photons (50% of the flux, the other 50% are about equally distributed between ≈100 keV and 662 keV)
- The particle flux can be modified, with absorbers filters shielding the source



A current of about $5*10^7$ photons/cm^2 is expected at the reference position closest to the source



D:Pfeiffer et al:, "The radiation field in the Gamma Irradiation Facility GIF++ at CERN", arXiv:1611.00299v1

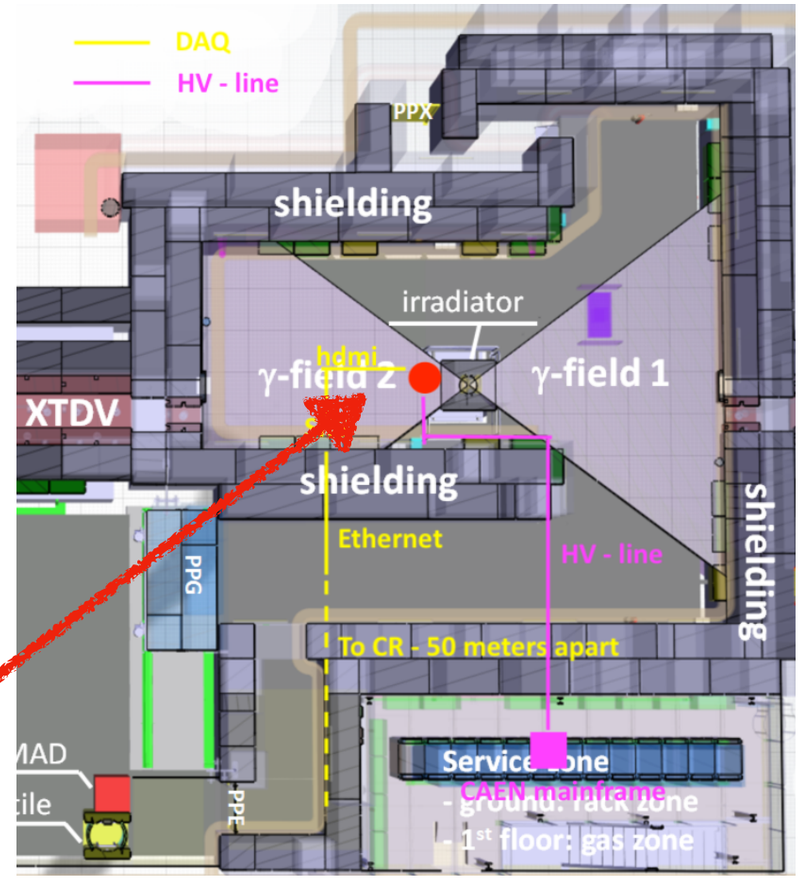
Description of the setup

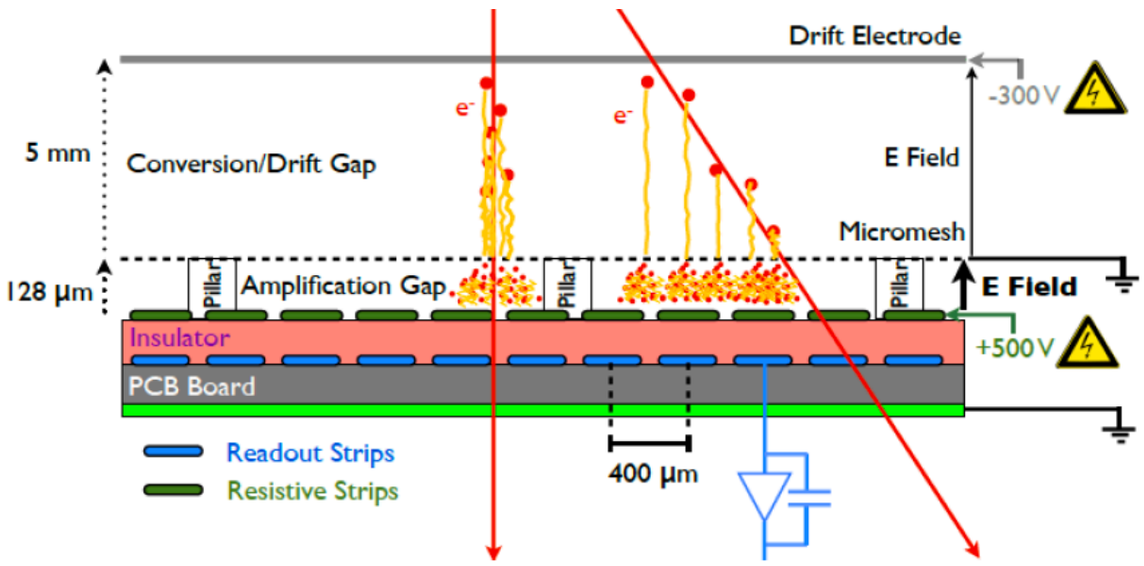
Two *bulk* resistive Micromegas prototypes (T5, T8) have been installed in GIF++ in 2015:

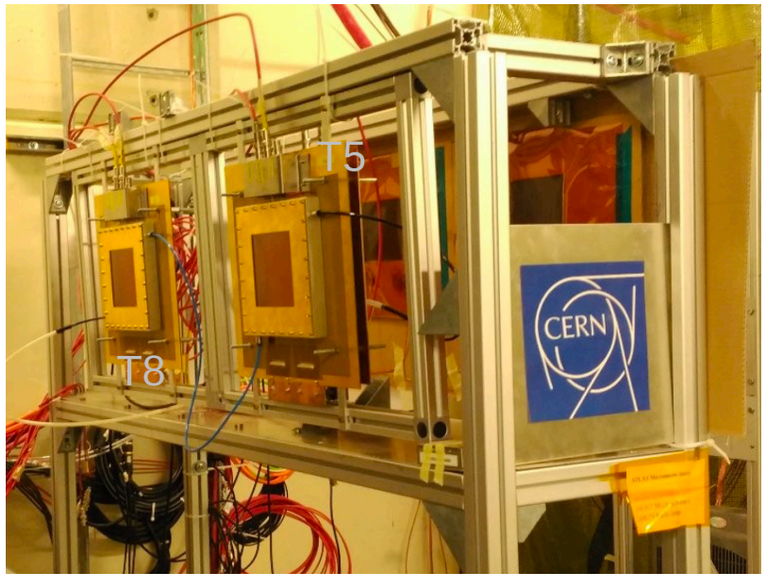
- Active area of 10x10 cm²
- 5 mm drift, ~100 μm amplification gaps
- The copper readout strips (pitch 0.4 mm) are covered by a 50 μm thick Kapton foil carrying resistive strips (0.5-1 MΩ/cm²)
- Mesh consisting of 18 μm wires, with opening of 45 μm

The aim was to accumulate at least 0.2 C/cm² (equivalent to ~10 years for inner muon detectors at HL-LHC) to evaluate the impact of long term irradiation on the detector

The setup has been mounted as close as possibile to the source to maximise the photon rate

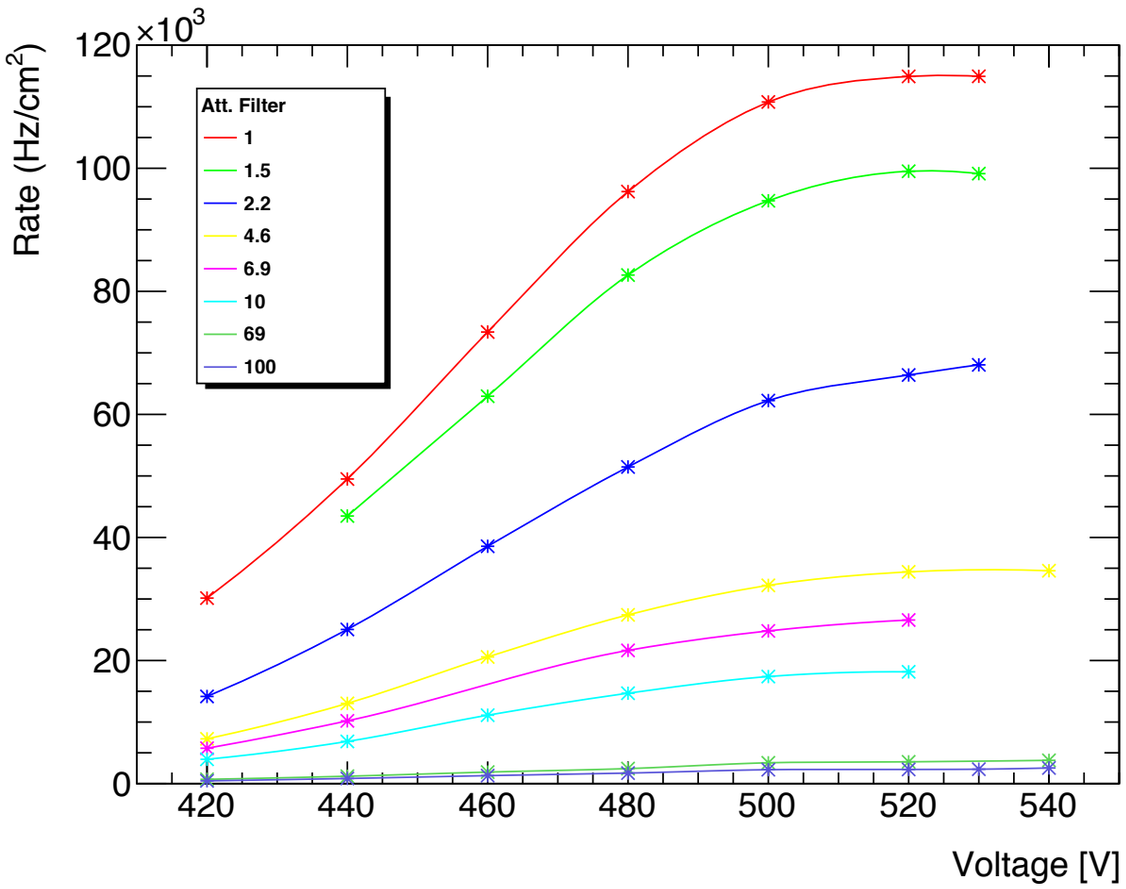






Particle rate estimation and sensitivity to photons

- Estimation of the particle rate has been performed by counting single photon conversions in the gas
- Geant4 simulation of the expected particle rate seen by the detectors has been performed
- A sensitivity of ~1.7*10^{-3} has been measured, in good agreement with the simulation accounting for the GIF++ source and detector structure

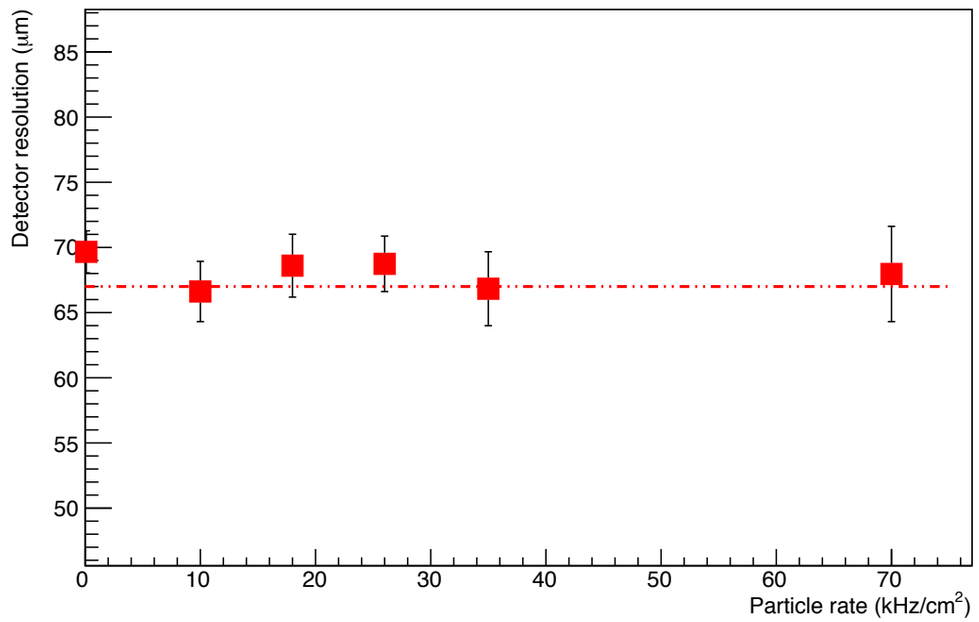


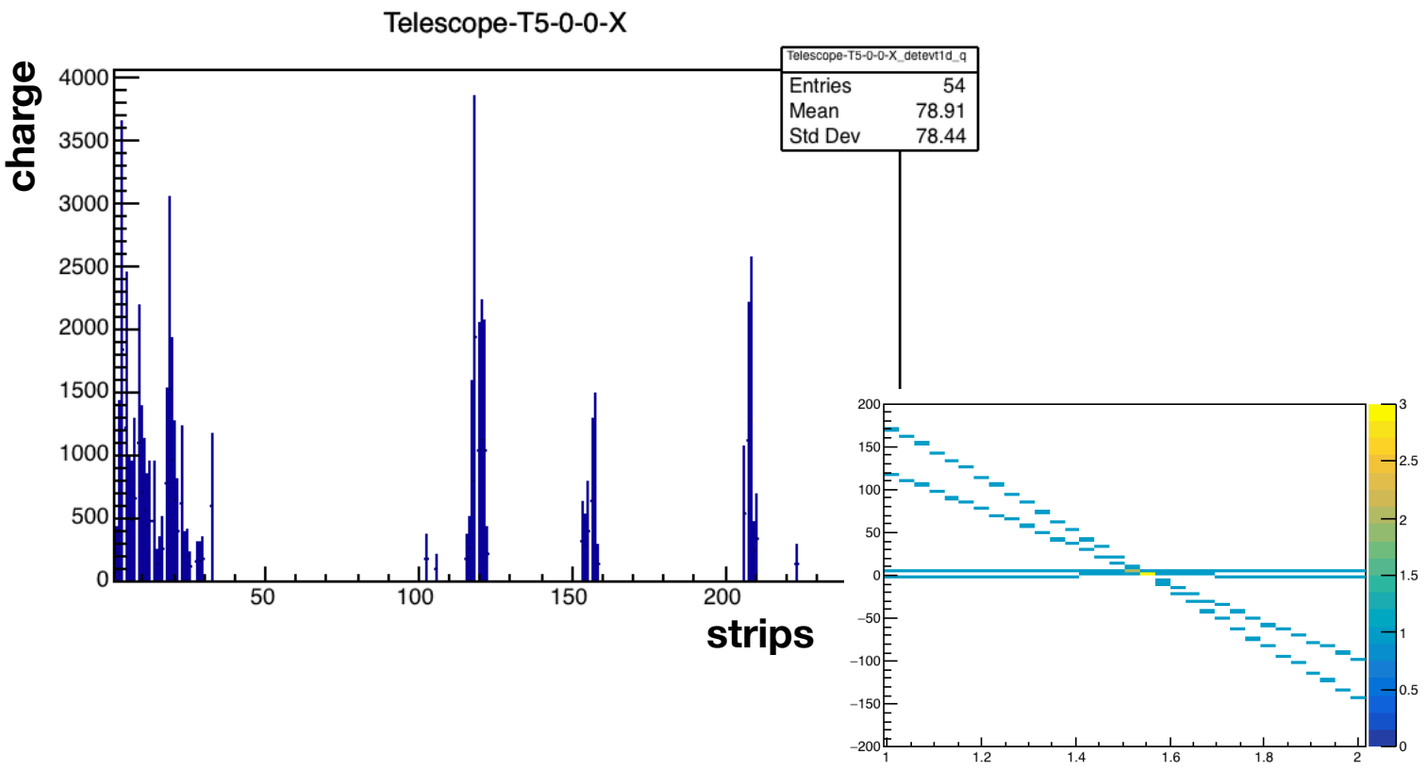
Att factor	Rate from detector	Simulation	**Sensitivity**
1	115000	7.70E+07	0.001494
1.5	99130	5.21E+07	0.001901
2.2	68052	3.73E+07	0.001827
4.6	34590	1.88E+07	0.001839
10	18158	1.06E+07	0.001712
100	2536	1.49E+06	0.001699

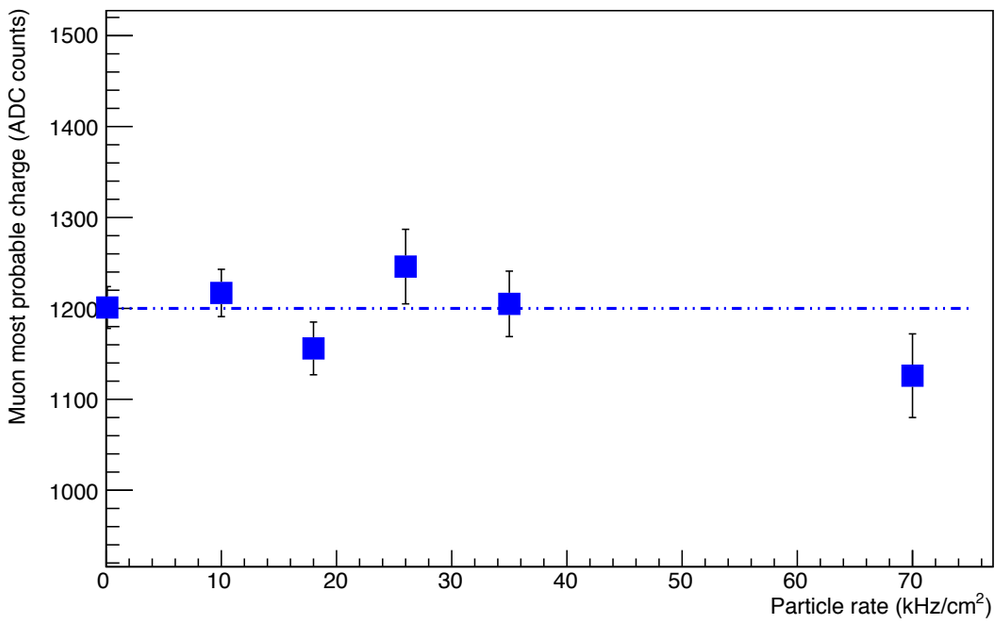
Detector performance at high rate

The detector performance has been studied in a high rate photon background in combination with a muon beam

- The Hough transform has been used to identify muons in the photon background
- The resolution and the most-probable-value of the muon cluster charge have been studied
- **No sign of performance degradation is observed up to 70 kHz/cm²**

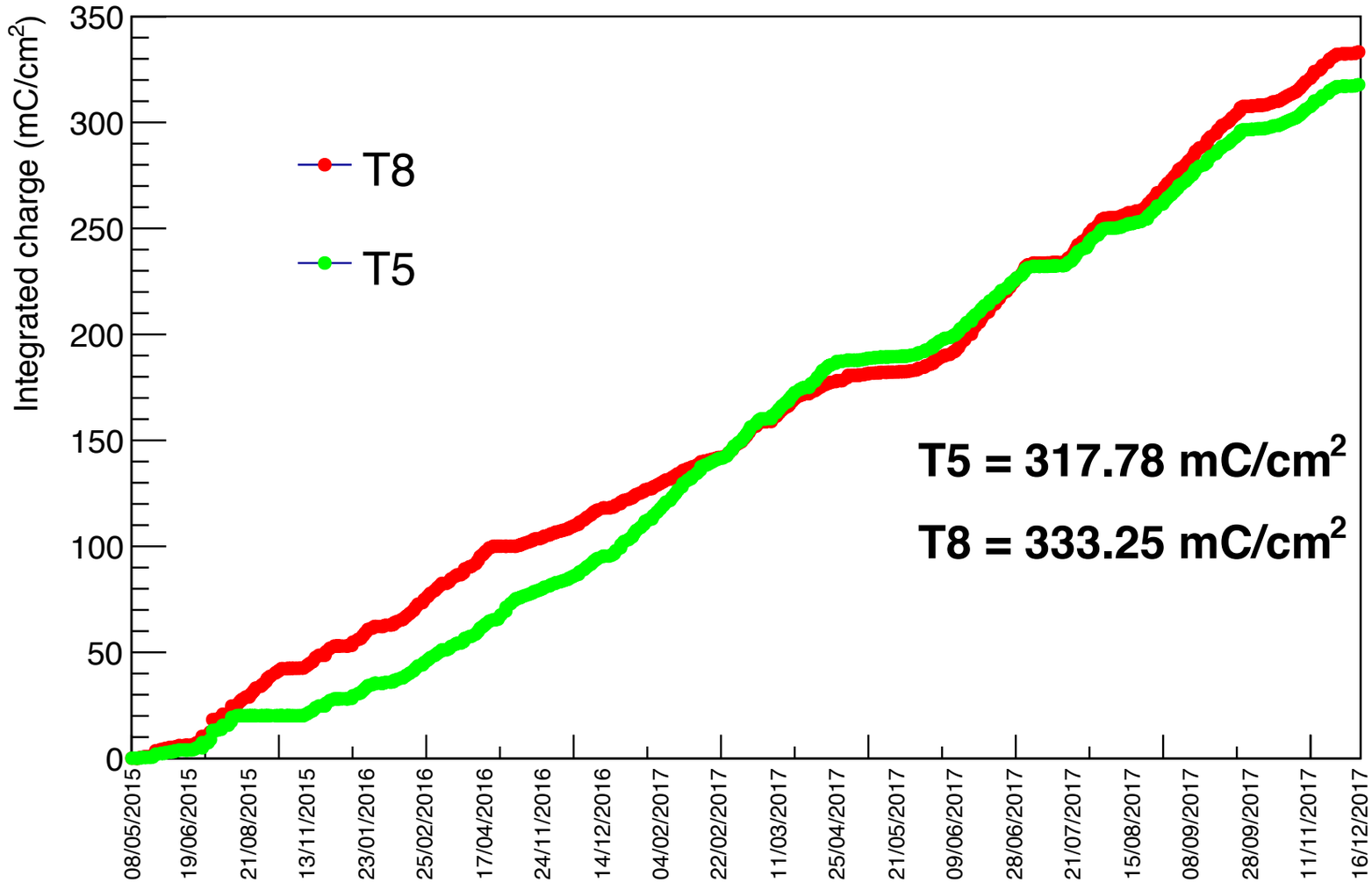






Long term irradiation

Accumulated charge has been estimated monitoring the current on the detectors



More than 0.3 C/cm² have been collected since May 2015

Performance tests have been performed in May 2017 (after 0.2 C/cm²) and January 2018 (after 0.3 C/cm²)

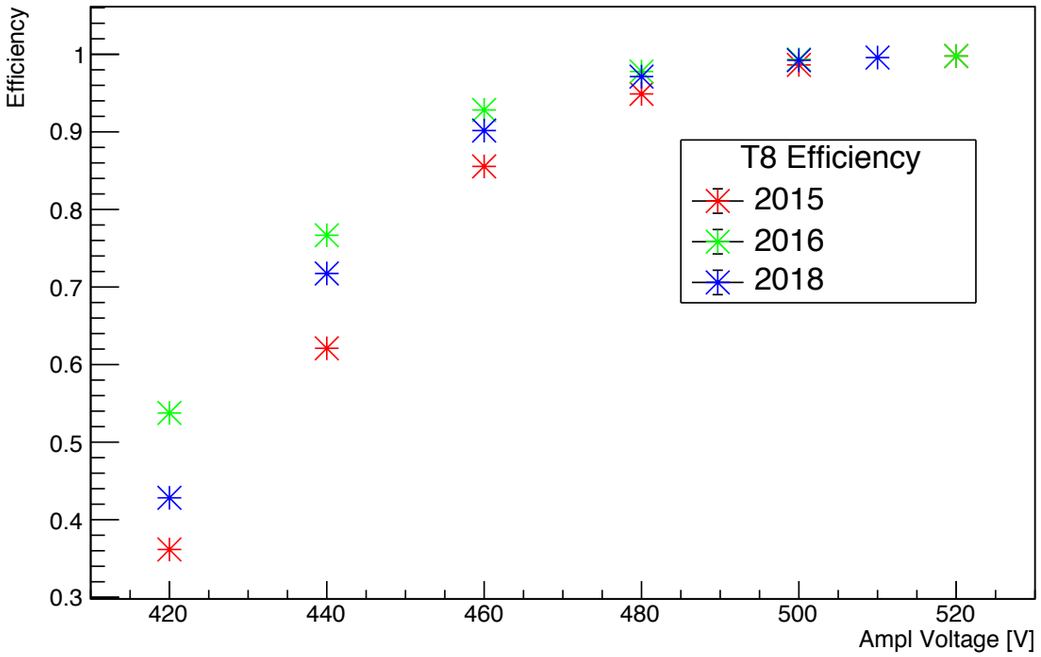
Efficiency before, during and after irradiation

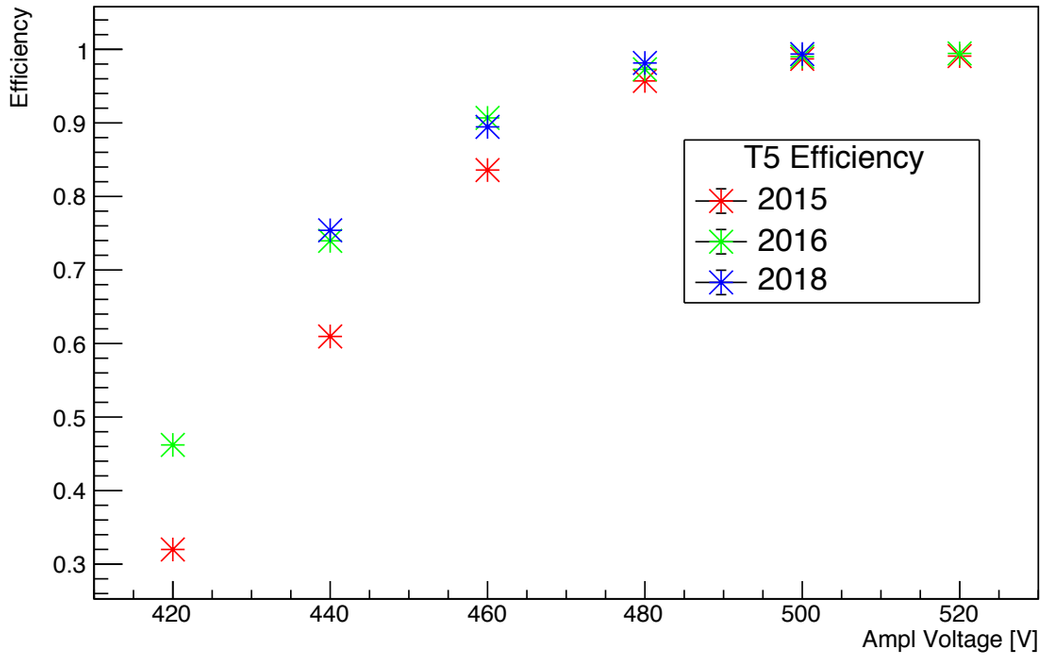
The efficiency of the detectors has been measured by means of cosmic muons in the lab and in test-beams.

The efficiency is defined by the presence of a cluster of strips with a signal around the expected muon position as obtained from the tracking chambers

Results show:

- No reduction of the detector efficiency
- No reduction of the working point





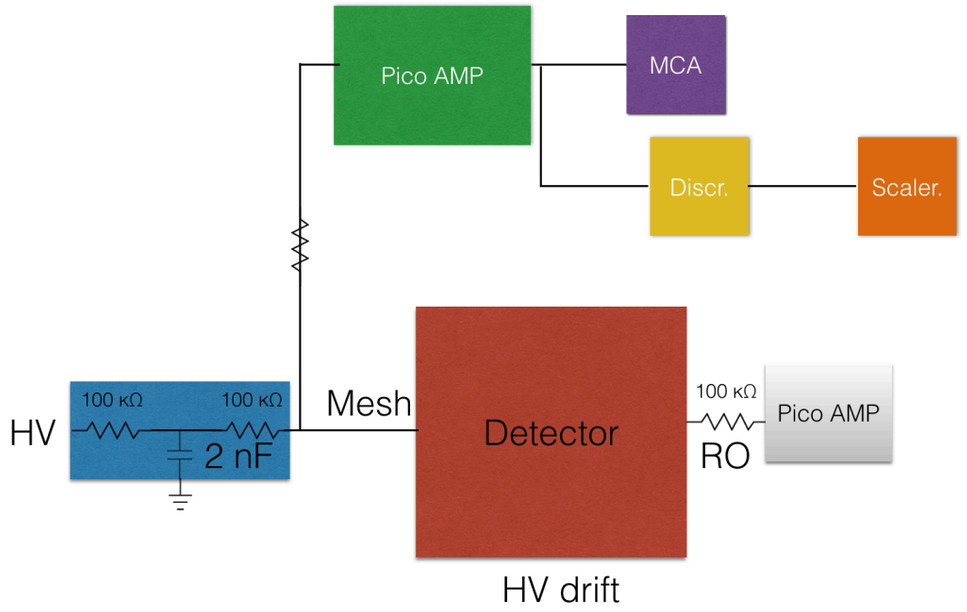
Detector gain before, during and after irradiation

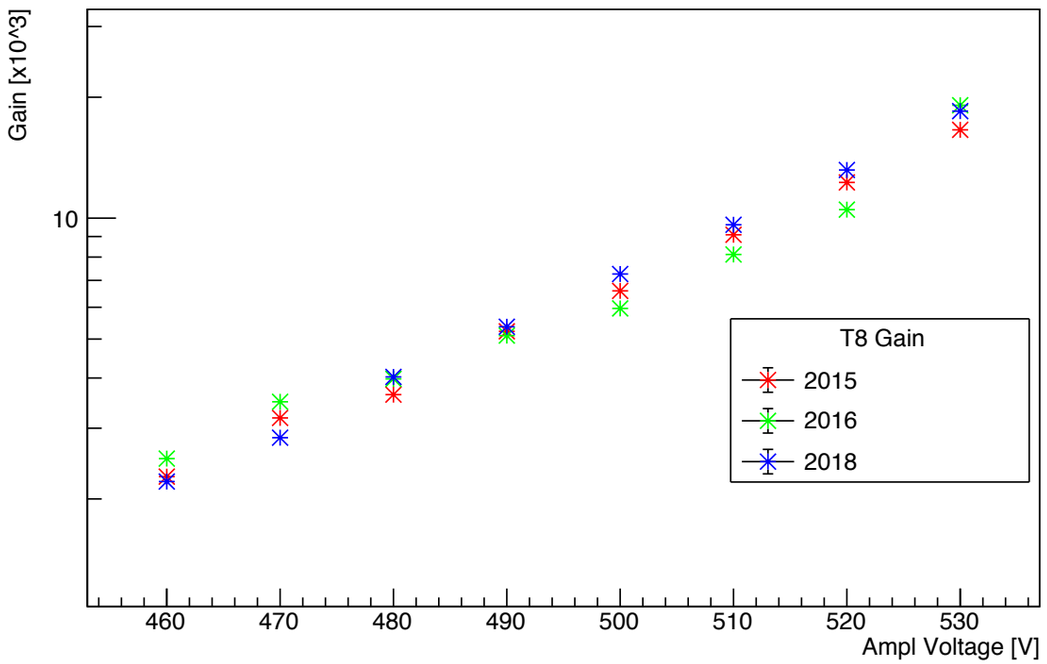
Gain measurements carried with ^{55}Fe sources in 2015, 2017, 2018:

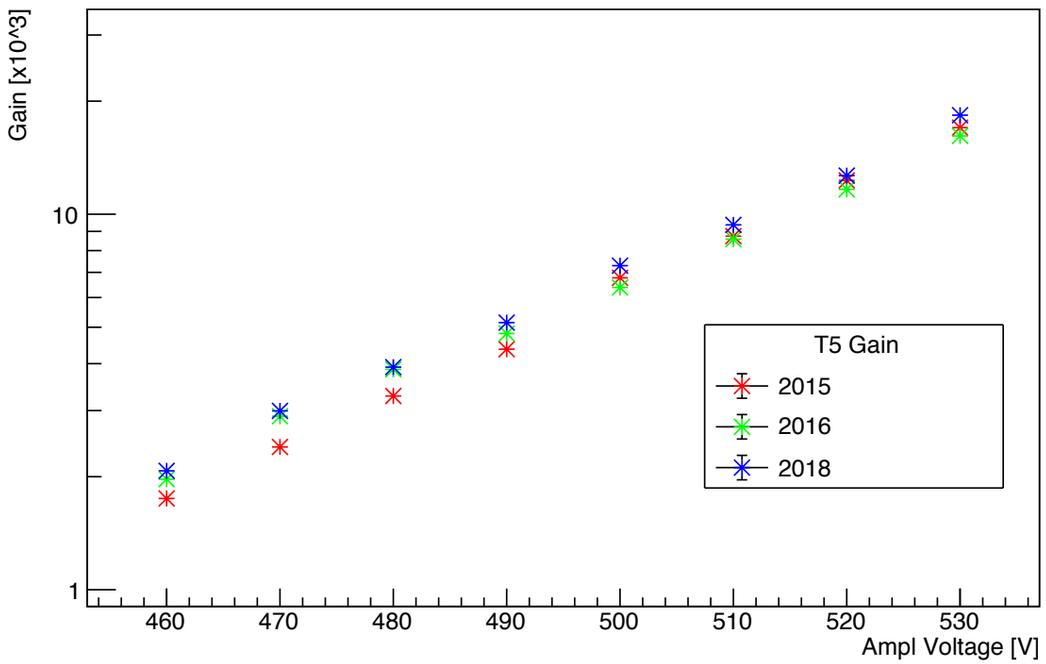
- HV supplied to drift electrode and mesh
- Current read from readout strips
- Trigger rate obtained from mesh signals (~300k/cm^2)

Results show:

- No reduction of the gain throughout the irradiation period







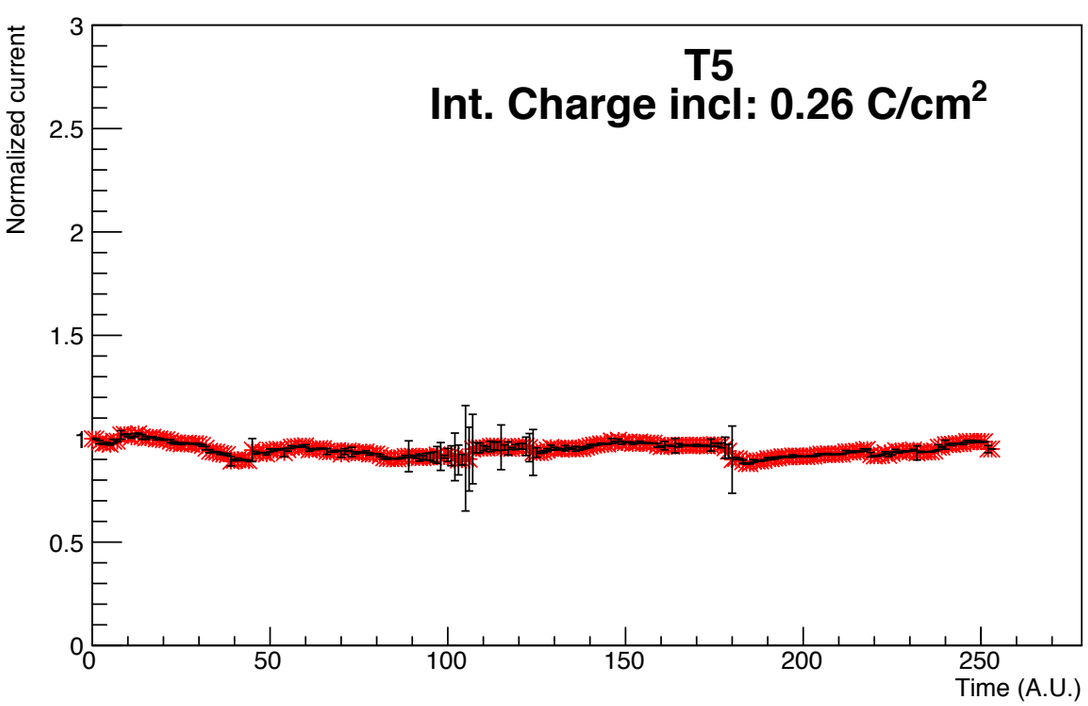
Current monitoring

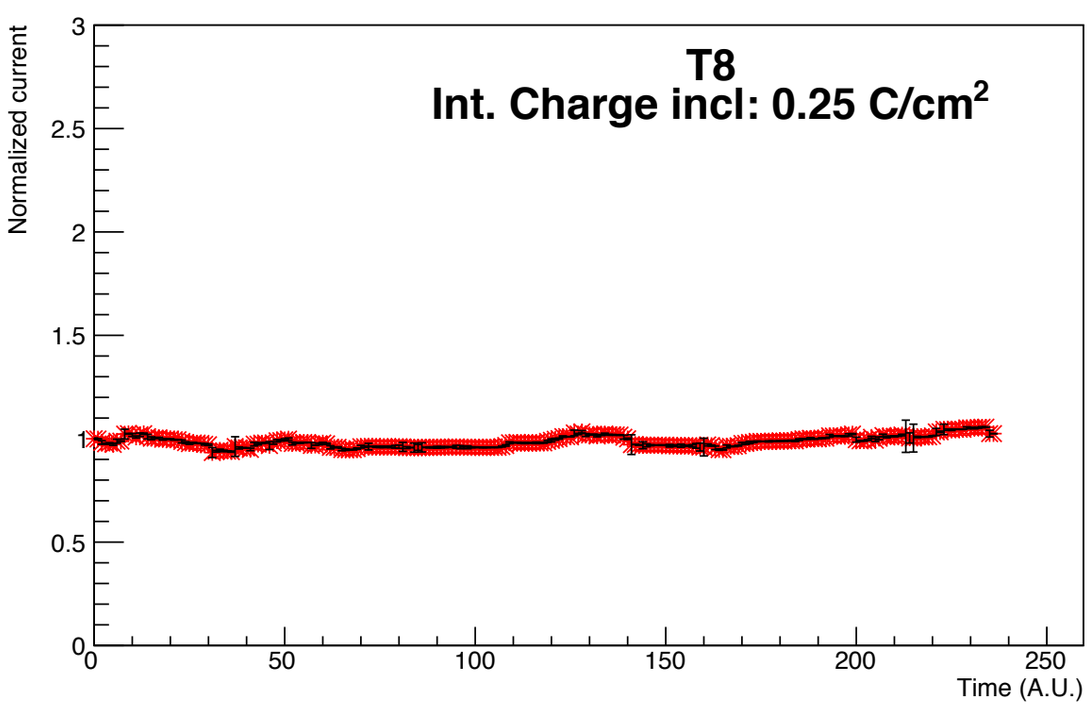
The current has been monitored:

- Detector position has been changed several times because of test-beams, tests in the lab, facility needs
- Irradiation time intervals where conditions are unchanged (same position/distance) are considered
- Current of about 2 μA with source fully open and at detector working point

Results show:

- Current is stable during the whole period





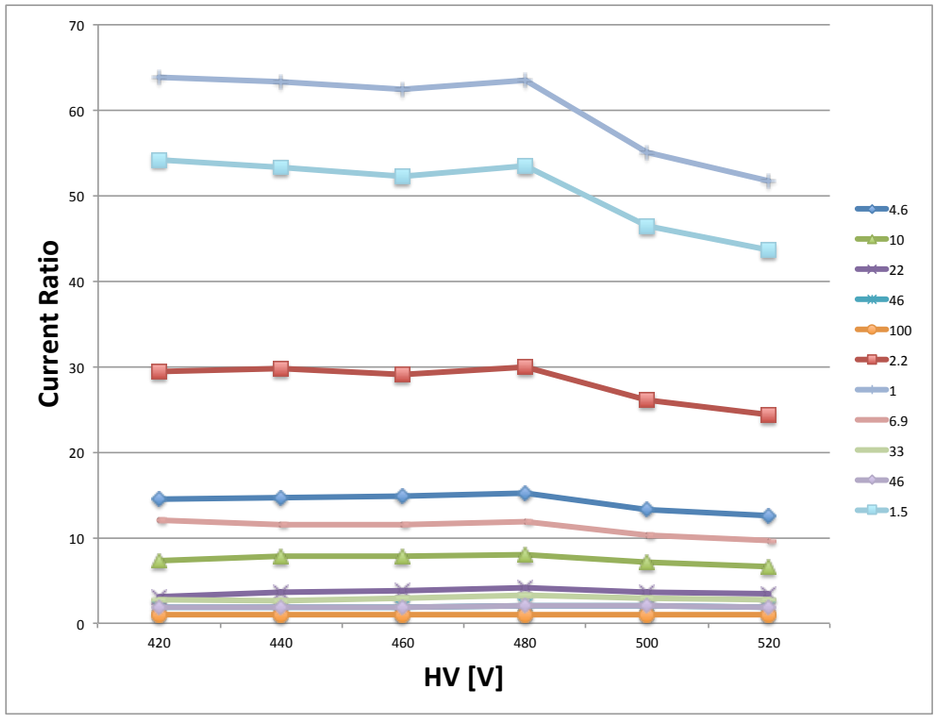
Conclusions

Two *bulk* resistive strips Micromegas prototypes have been exposed to intense photon source since 2015 at GIF++ facility at CERN:

- A sensitivity of $1.7*10^{-3}$ to the GIF++ photon spectrum has been obtained by comparing the converted photons with the simulated flux reaching the detectors
- Spatial resolution and cluster charge distributions have been measured under different background rates ranging from 0 to 70 kHz/cm^2
- 0.3 C/cm^2 has been collected in total
- Detector efficiency to muons and gain have been measured three times, once before irradiation, once after accumulation 0.2 C/cm^2 and finally after 0.3 C/cm^2: no detectable degradation of the performance has been observed
- Current behaviour over time does not show variations throughout the whole irradiation period
- Similar study on Micromegas prototype has been performed* with similar outcome

*) J. Galan et al., Aging studies of Micromegas prototypes for the HL-LHC, JINST 7 (2012) C01041

Backup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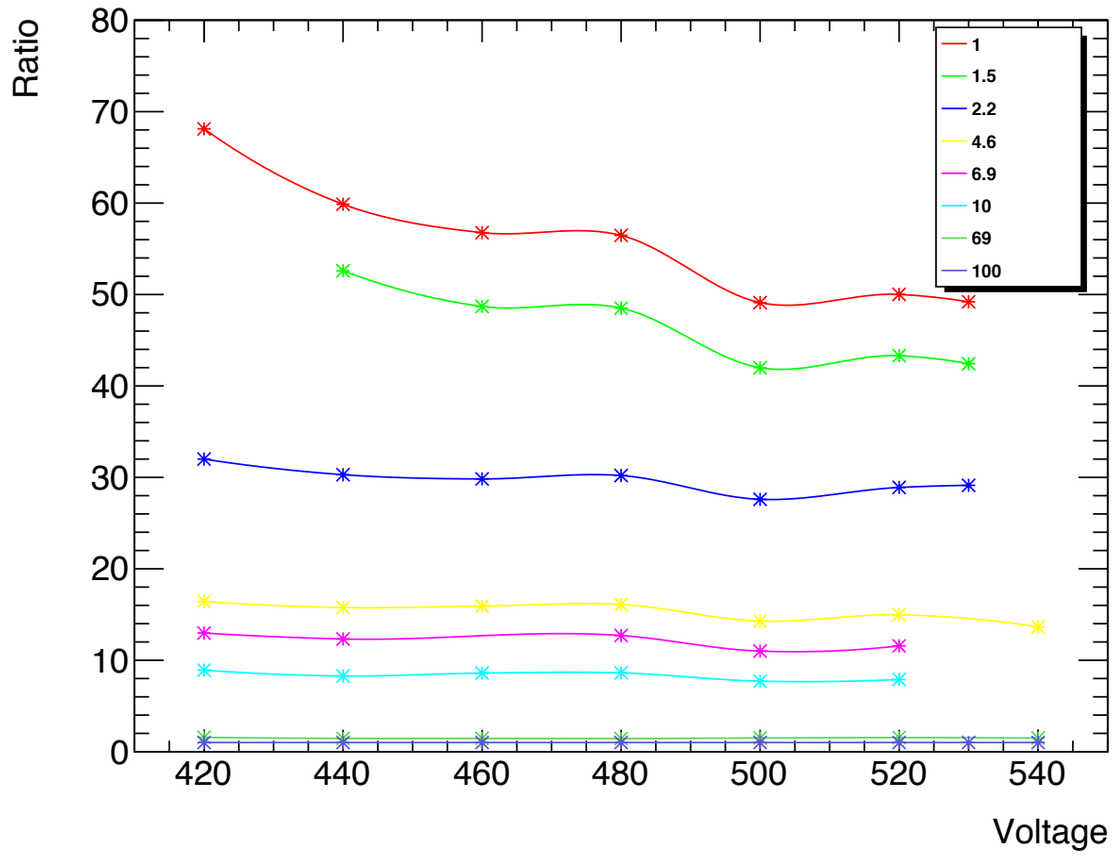
HV [V]
4.6
10
22
46
100
2.2
1
6.9
33
46
1.5


Ratio
Voltage
1
1.5
2.2
4.6
6.9
10
69
100