Radiation studies on resistive bulk-micromegas chambers at the CERN Gamma Irradiation Facility

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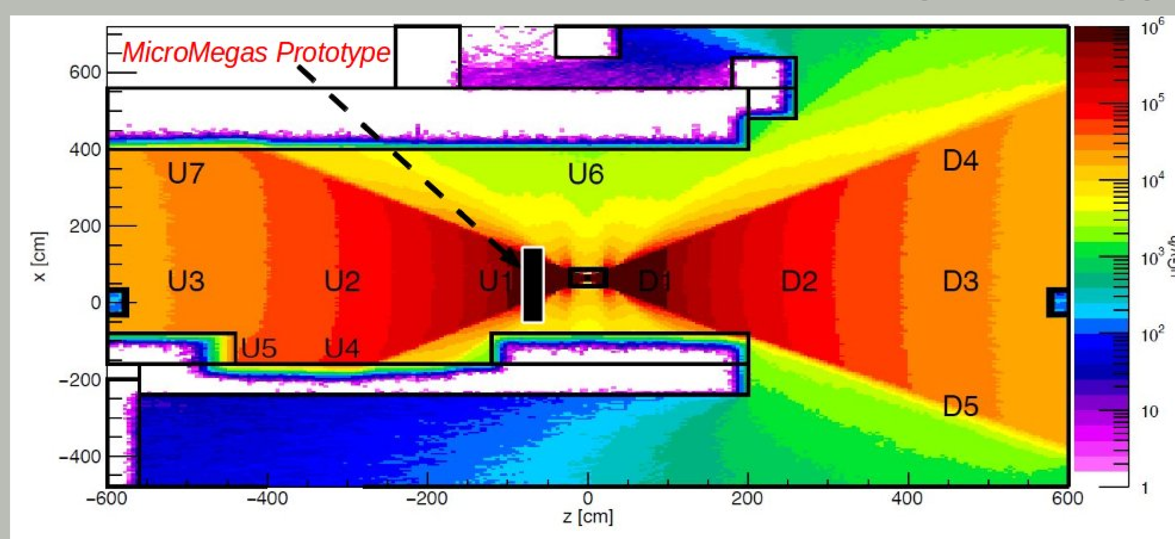
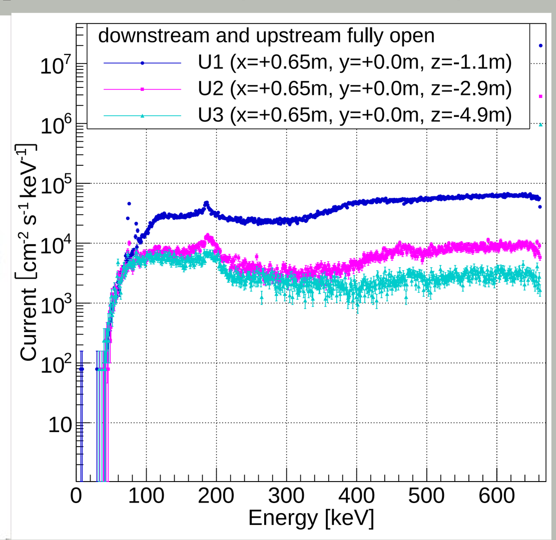
Abstract

Two *resistive bulk-micromegas chambers* were installed in May 2015 at GIF++ exposed to an intense γ irradiation with the aim to study the detector behavior under high irradiation and long-term aging. The results of the detector performance after this long-term irradiation period will be presented.

Gamma Irradiation Facility (GIF++) at CERN

Located in the north area of the SPS accelerator at CERN **[1]**
Unique place where **high energy charged particle beams** (mainly muons) are combined with a flux of **high energy photons** *(662 KeV)*





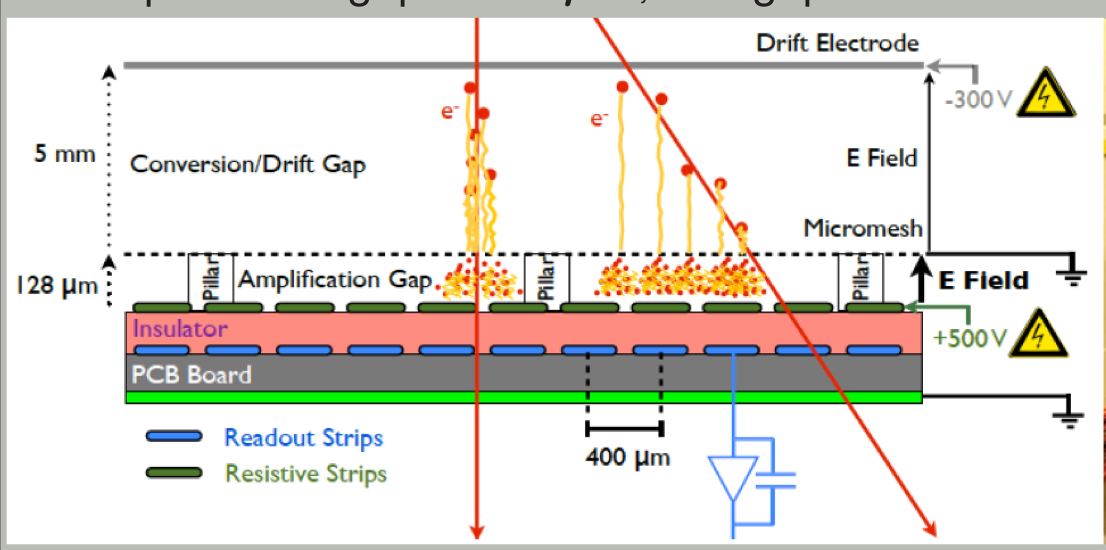
The high source activity, **^{137}Cs**, produces a **very intense background gamma field** allowing to accumulate doses equivalent to **High Luminosity LHC (HL-LHC)** experimental conditions in a reasonable time

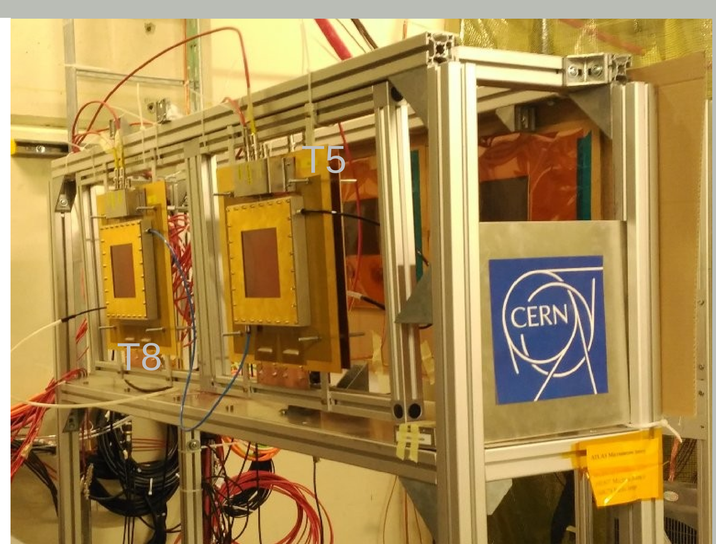
Measurements and simulations (*Geant4*) of the **photon field** were provided **[1]** and used as benchmarks for our measurements

Filter system permits the attenuation of the photon rate in several steps to reach **attenuation factors** of several orders of magnitude ($\sim 10^4$ - 10^5)

Description of the MicroMegas used in GIF++

- Two **resistive bulk-micromegas** chambers (T5 & T8) **[2]** built at CERN
  - Active area of **10x10 cm^2**
  - Single readout plane with strip pitch **400μm** and strip width **300μm**
  - Readout strips covered with a **50μm** thick Kapton foil carrying high resistivity ($\sim$1MΩ/sq) carbon strips $\rightarrow$ *spark protection*
  - Mesh consisting of **18μm** diameter wires with **64μm** pitch
  - Amplification gap of **128μm**, drift gap of 5 mm





Data-taking and Working Conditions

Data acquired with **APV-25** front-end ASICs **[3]** and RD51 Scalable Readout System (**SRS**)**[4]**

Data-taking varying attenuation filters and amplification voltages

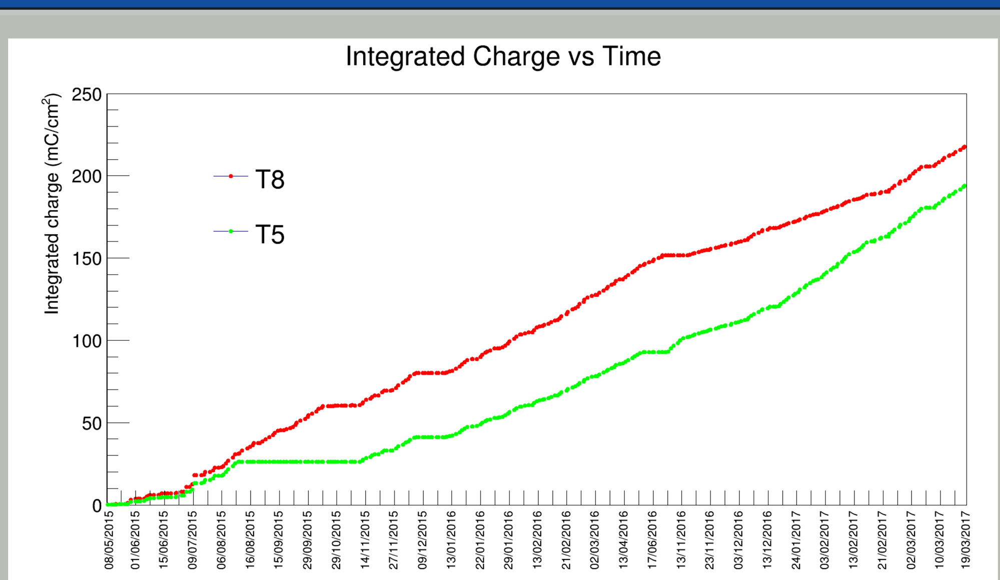
- **Att. Factors:** 1, 2.2, 4.6, 10, ..., 100
- **Amplification Voltage Scan:** 420-540 V
- **Drift Field:** 600 V/cm
- Source **ON/OFF** + Muon Beam

Working conditions:

- **Gas:** ArCO_2 93**%**, 7**%**, **Gas Flow:** 5 l/h

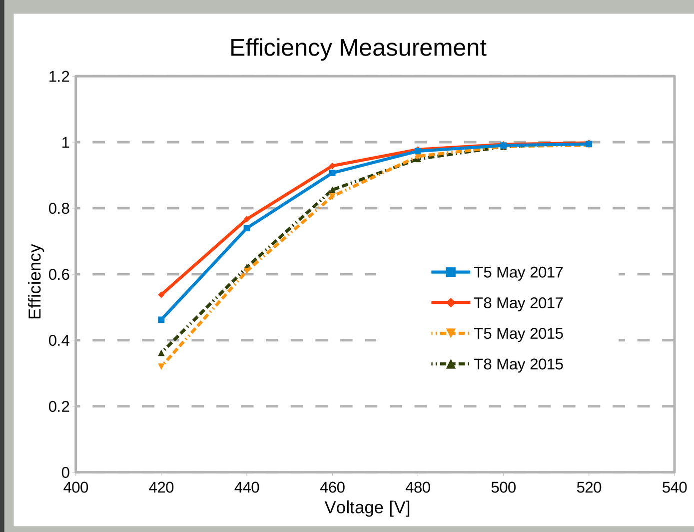
Integrated Charge

After **~2 years** of exposure to an intense γ irradiation the desired accumulated charge of more than **0.2 C/cm^2** has been reached for one of the two chambers; *the equivalent charge expected after 10 years of* ***HL-LHC*** *operation*



Chambers exposed at GIF++ from May 2015 to March 2017

Efficiency Measurement



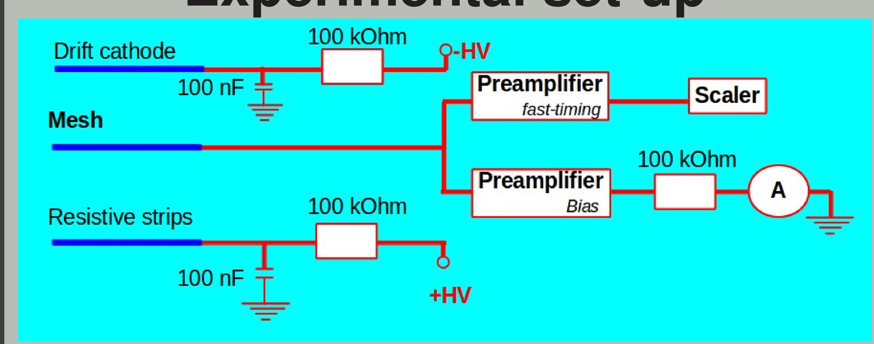
The efficiency is measured with respect to the reference detectors using **muon tracks**

- **May 2015:** muons from cosmic rays in the *RD51 GDD lab*
- **May 2017:** GIF++ muon beam
- Both datasets reach full efficiency at 500V
- Voltage was not corrected by T, P and H
- No degradation of the efficiency due to irradiation observed

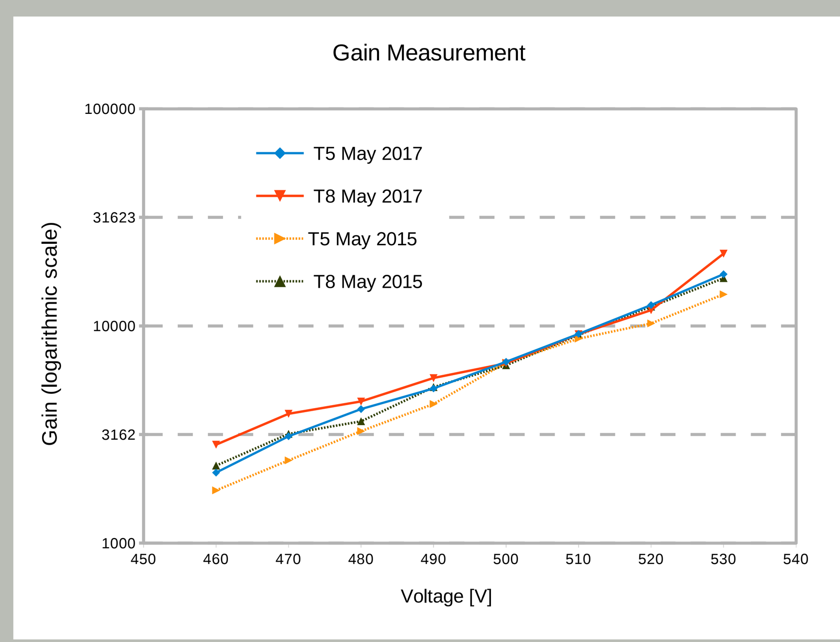
Gain Measurement

Gain measurements were conducted on the T5 and T8 chambers using an ^{55}Fe source in the *RD51 GDD lab*

Experimental set-up



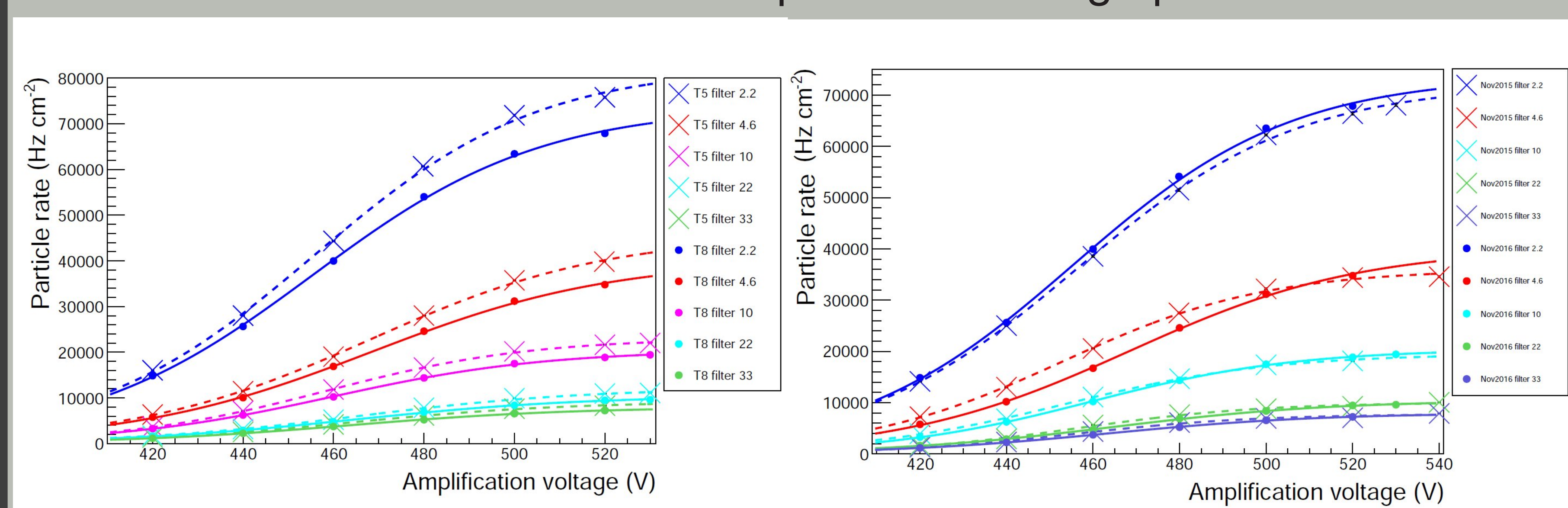
$$\textbf{Gain} = \frac{Current\ from\ the\ mesh}{\gamma\ conversion\ Rate\ x\ q_{e^-}\ x\ N_{e\ per\ \gamma}}$$



- No significant changes on the gain are observed for any of the two chambers $\rightarrow$ No degradation of the gain due to irradiation observed

Particle Rate and Detector Sensitivity

Particle rate as a function of the amplification voltage per att. factor



- **Left figure:** November 2016 data-taking for *T5* and *T8*
- **Right figure:** comparison of Nov. 2015 and 2016 data-takings for *T8*

The **detector sensitivity** is extracted from the measured particle rate from the fully efficient region **@ 520 V** and the photon current at **U1** and is estimated to be $\sim$**3x10^{-3}**. This agrees with the Geant4 simulations which include the resistive bulk-micromegas chambers

Conclusions

The efficiency, gain and particle rate measurements have been presented. After two years of irradiation at GIF++ **no aging effects** have been observed in either of the two chambers. This confirms earlier results obtained in a γ ray exposure at CEA Saclay **[5]**.

References

[1] ***D.Pfeiffer et al.***, *arXiv:1611.00299v1*
[2] ***T. Alexopoulos et al.***, *Nucl. Instr. Meth. Phys. Res. A 640 (2011) 110-118*
[3] ***M .Raymond et al.***, *IEEE Nucl. Sci. Symp. Conf. Rec. 2 (2000), 9/113*
[4] ***S. Martoiu et al.***, *JINST 8 (2013) C03015*
[5] ***J. Galán et al.***, *JINST 7 (2012) C01041*

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