

Performance Studies under High Irradiation of Resistive Bulk-MicroMegas Chambers @ the CERN GIF++



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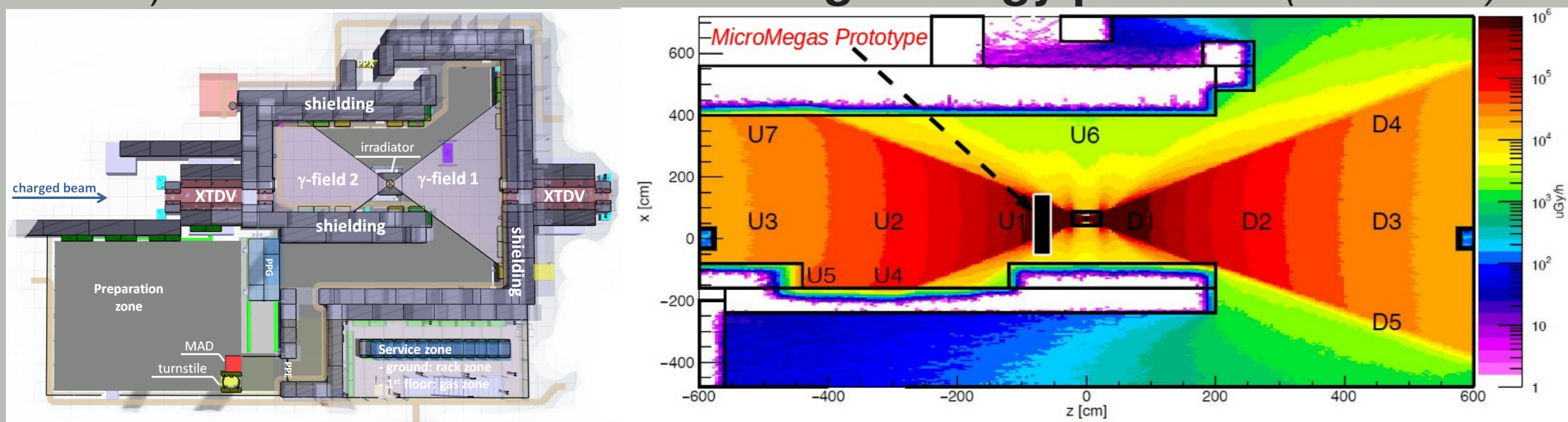
Abstract

Radiation studies on two **resistive bulk-micromegas chambers** produced at the CERN are shown. The chambers have been installed at the CERN Gamma Irradiation Facility (GIF++) exposed to an intense gamma irradiation with the aim of carrying out a **long-term ageing study** in order to evaluate the detector behaviour under high irradiation.

Gamma Irradiation Facility (GIF++) at CERN

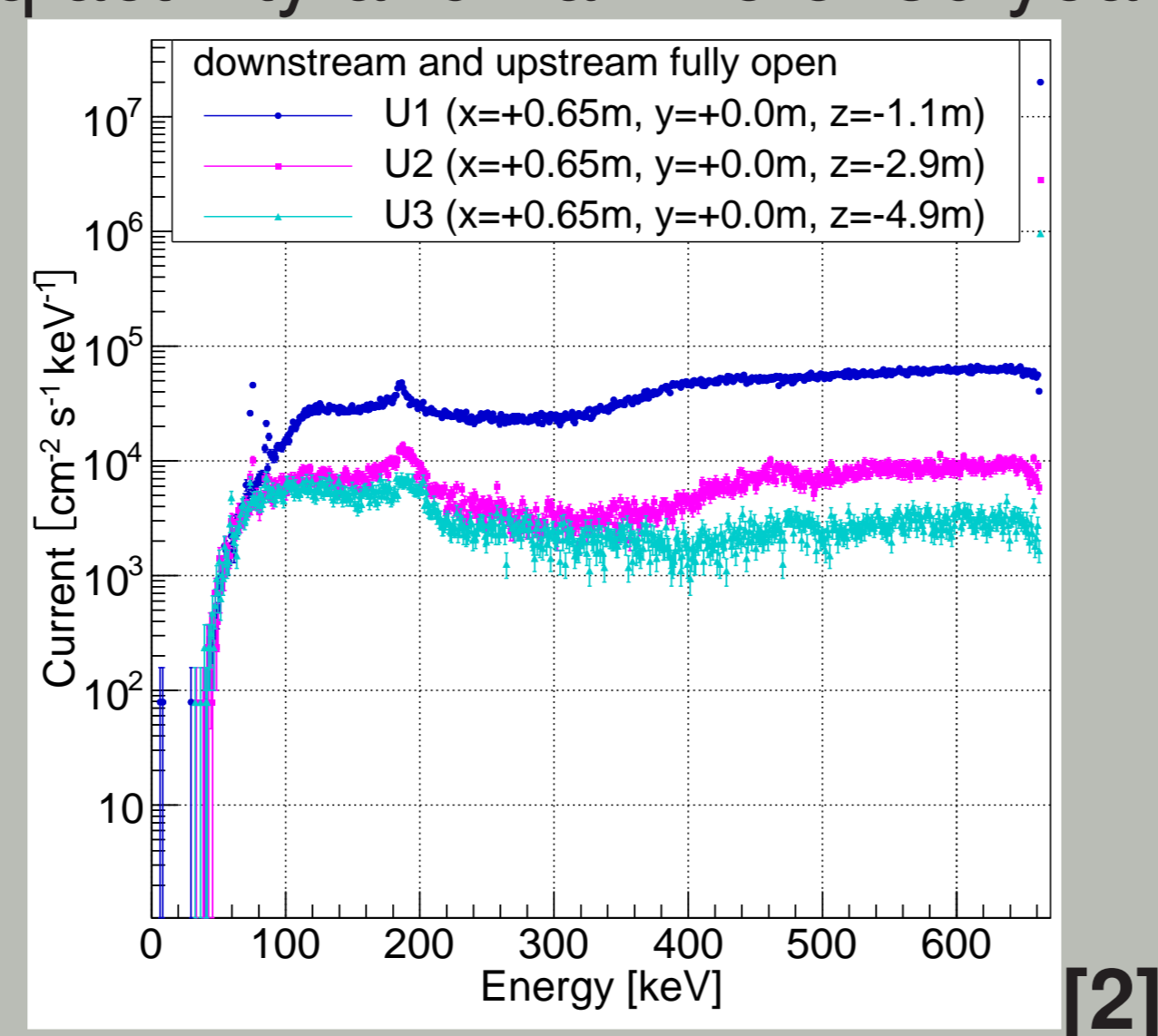
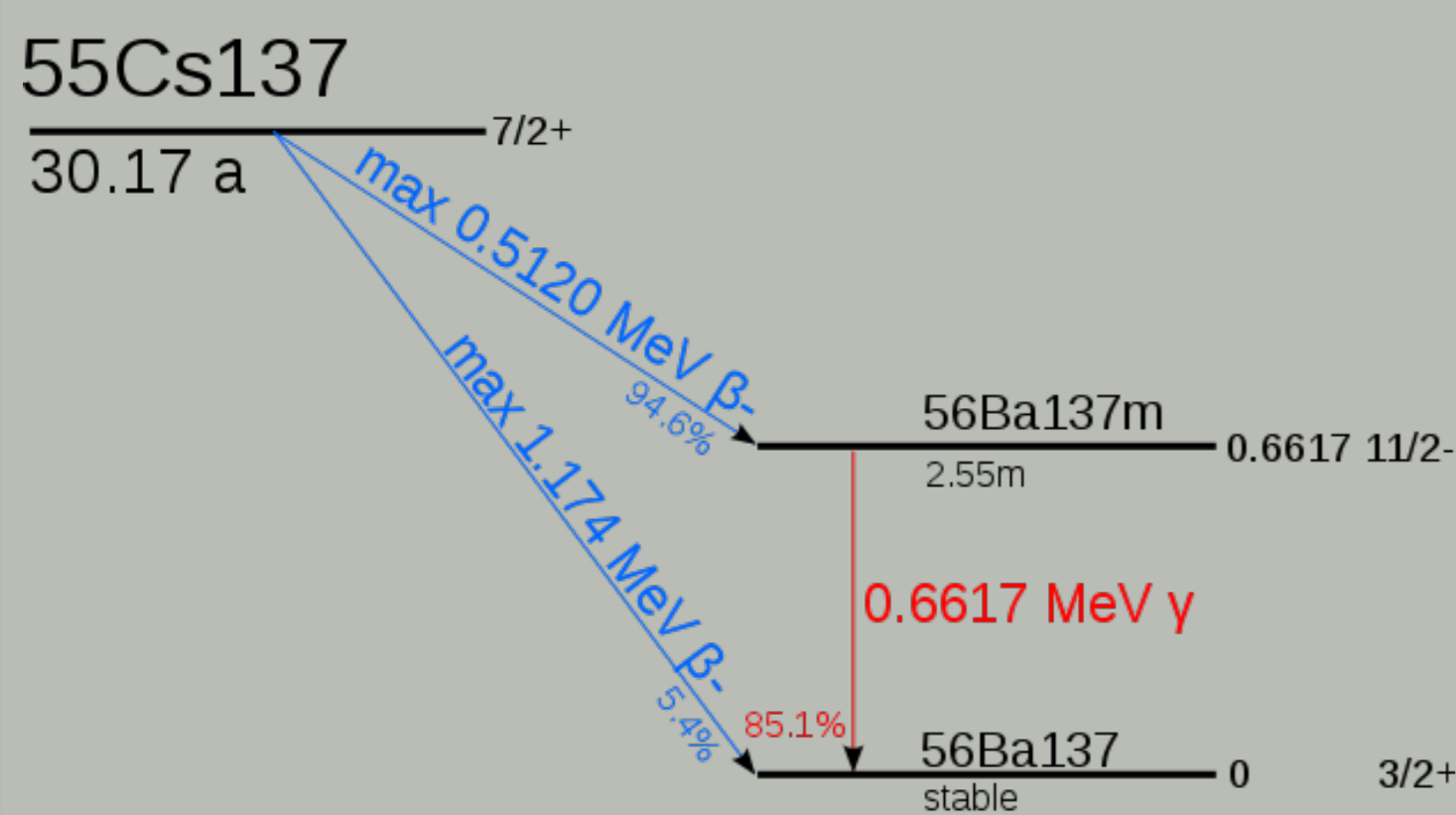
Located in the north area of the SPS accelerator at CERN [1]

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 produces a **very intense background gamma field** allowing to accumulate doses equivalent to **High Luminosity LHC (HL-LHC)** experimental conditions in a reasonable time

- γ radiation ionizes via **photoelectric effect, compton scattering or pair-production**
- Compton scattering: principal mechanism for 0.1-10 MeV (**main @ GIF++**)
- ¹³⁷Cs: source of irradiation with 14 TBq activity and half-life of 30 years

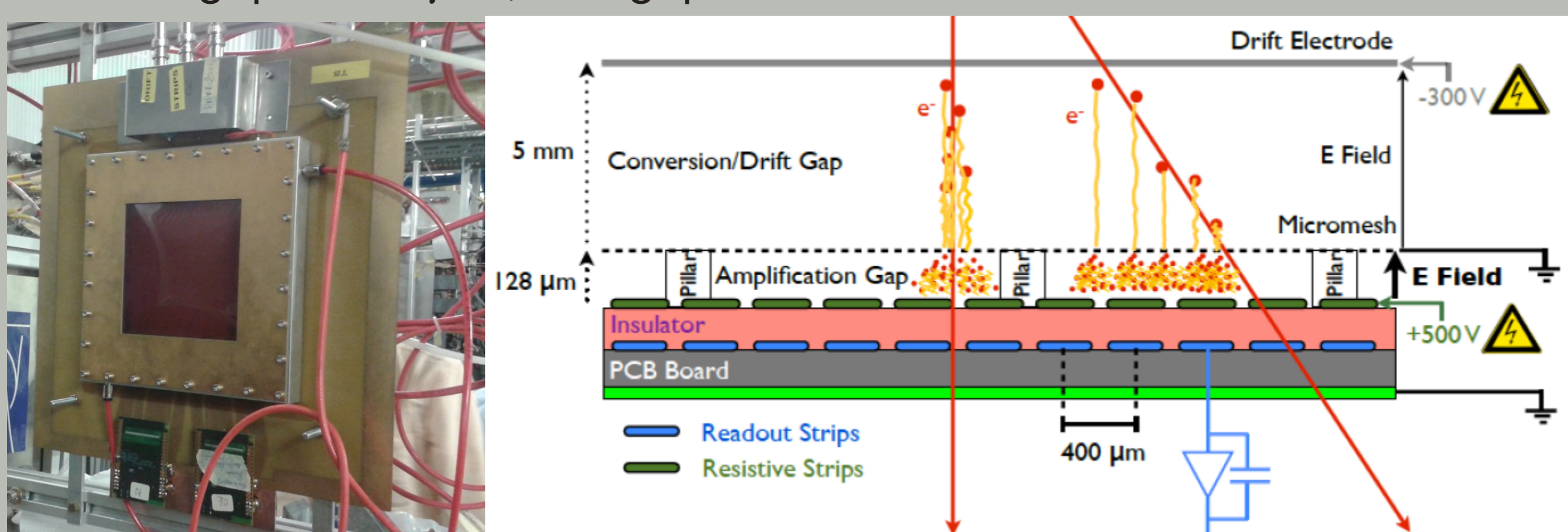


^{137m}Ba emits **gamma rays** with a main photon peak at **662 keV**

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)** [3]
 - Active area of **10x10 cm²**
 - Single readout plane with strip pitch **400 μm** and strip width **300 μm**
 - Readout strips covered with a **50 μm** thick Kapton foil carrying high resistivity ($\sim 1\text{M}\Omega/\text{sq}$) carbon strips → **spark protection**
 - Mesh consisting of **18 μm** diameter wires with **64 μm** pitch
 - Amplification gap of **128 μm**, drift gap of 5 mm



Data-taking and Working Conditions

Data acquired with **APV-25** front-end ASICs [4] and RD51 Scalable Readout System (SRS)[5]

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: ArCO₂ 93%, 7%, Gas Flow: 5 l/h

Hit Rate and Detector Sensitivity

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

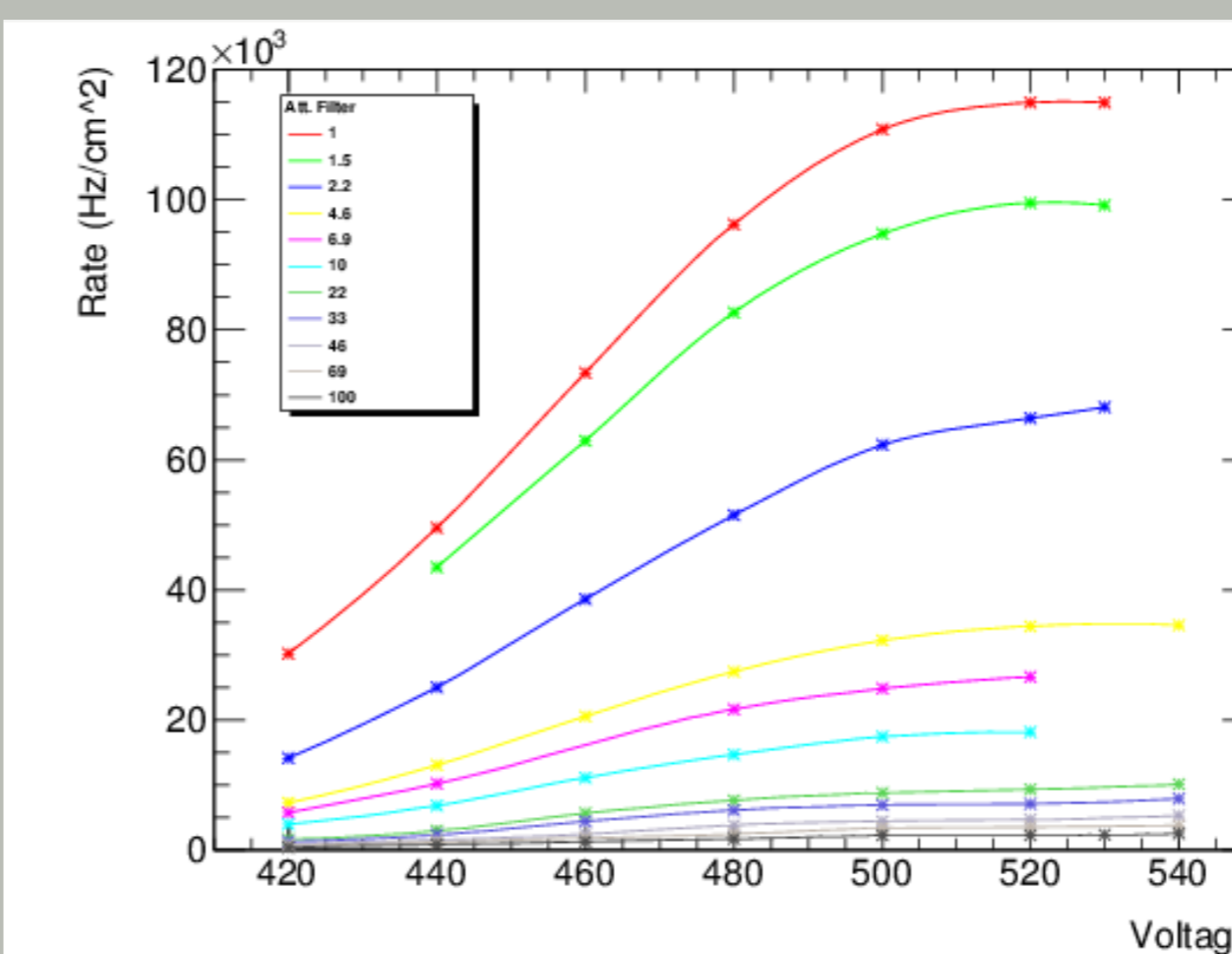


Table 1: Summary of expected and measured particle rate

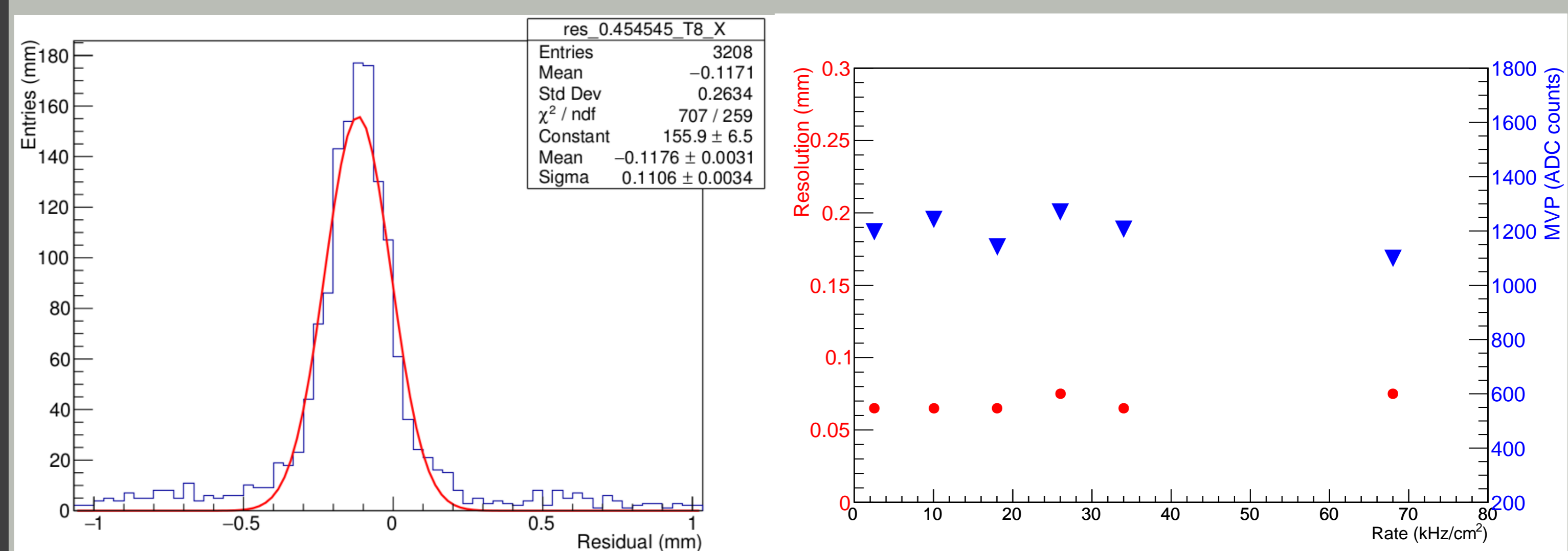
Attenuation		Rate (Hz/cm ²)		Sensitivity
nominal	measured	γ flux	measured rate	
2.2	2.2	2.00E+07	6.80E+04	3.40E-03
4.6	4.5	9.75E+06	3.40E+04	3.49E-03
6.9			2.60E+04	
10	8.8	4.98E+06	1.80E+04	3.62E-03
22			1.00E+04	
33			7.90E+03	
46			5.30E+03	
69			3.70E+03	
100	72	6.00E+05	2.50E+03	4.16E-03

At 520 V full efficiency, the hit rate is extracted from the plateau

Tracking with muon beam

Muon tracks distinguished from photons using the *Hough transform* [6] Cluster position difference between T5 and T8 fitted with a Gaussian:

$$\text{Resolution} = \frac{\sigma_{\text{fitted}}}{\sqrt{2}}$$

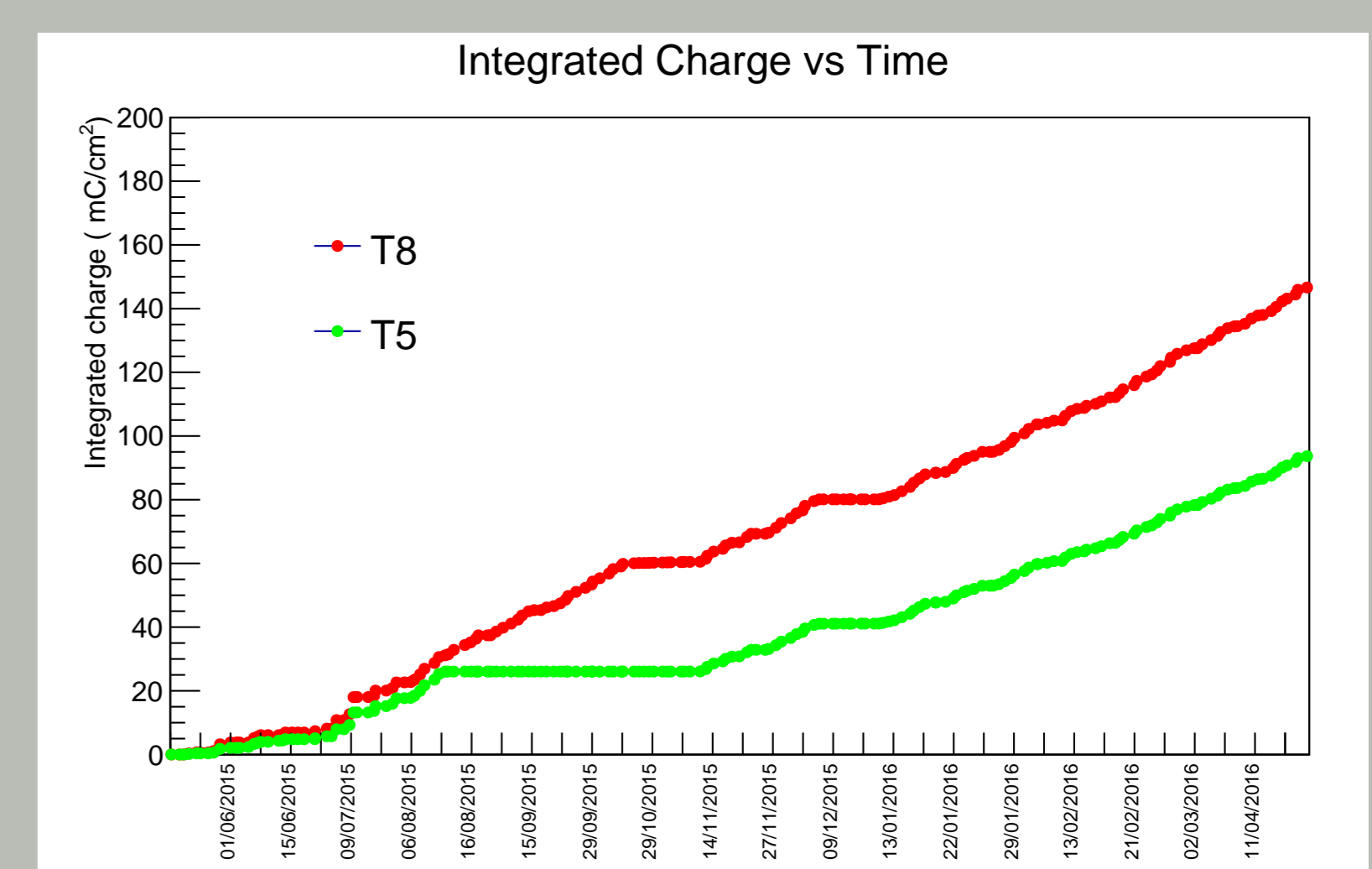


- Resolution stable up to **68 kHz/cm²** (4 times more than the expected rate during the **HL-LHC**)
- The **most probable value (MPV)** of the cluster charge is also shown and is constant up to this very high photon flux

Summary and Plans

Ageing studies are mandatory to assess the capability of the detectors to handle the rate and level of radiation at the **HL-LHC**

The goal is to accumulate more than **0.2 C/cm²**, the equivalent charge expected after 10 years of **HL-LHC** operation, and evaluate the detector performance



Chambers exposed at GIF++ more than 10 months

References

- [1] M. R. Jäkel et al., CERN GIF++, PoS (TIPP2014) 102
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- [4] M. Raymond et al., IEEE Nucl. Sci. Symp. Conf. Rec. 2 (2000), 9/113
- [5] S. Martoiu et al., JINST 8 C03015 (2013)
- [6] P. V. Chough, Inc Proc. Int. Conf. on High Energy Accelerators and Instrumentation, 1959