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Performance studies under high irradiation and ageing properties of resistive bulk Micromegas chambers at the new CERN Gamma Irradiation Facility

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ABSTRACT

Resistive bulk Micromegas chambers, produced at CERN, have been installed at the new CERN Gamma Irradiation Facility (GIF++) in order to study the effects of ageing and to evaluate the detector behaviour under high irradiation. The chambers have an active area of $10 \times 10\ cm^2$, strip pitch of 400 μm and an amplification gap of 128 μm. We present the detector performance as a function of the background rate of up to 20 MHz/cm^2.

1. Introduction

Two resistive bulk Micromegas detectors (called T5 and T8) with an active area of $10 \times 10\ cm^2$ have been installed in the new Gamma Irradiation Facility (GIF++) [1] at CERN, in May 2015, for long term ageing studies. These detectors consist of a single readout plane with a strip pitch of 400 μm and a strip width of 300 μm. The readout strips are covered with a 50 μm thick Kapton foil carrying high resistivity (~1 MΩ/sq) carbon strips as spark protection. The mesh, consisting of 18 μm diameter wires with a pitch of 64 μm, is embedded in the supporting pillars providing the amplification gap of 128 μm [2].

In this paper we report the detector performance after nine months of high intensity photon irradiation. For these studies the detectors were operated with an Ar:CO_2 93:7 mixture at atmospheric pressure and a field of 600 V/cm in the 5 mm drift gap. The anode voltage for the amplification region on the resistive strips was varying from 420–540 V according to the studies and the mesh was grounded.

2. The new Gamma Irradiation Facility (GIF++)

The new GIF++ is placed in the north area of the Super Proton Synchroton (SPS) accelarator in the H4 beam line in Prevessin at CERN (Fig. 1). The source of the irradiation is ^{137}Cs with an activity of about 16 TBq and a half-life of about 30 years. In 95% of the cases it decays by beta emission to a metastable nuclear isomer of barium (^{137m}Ba) while the remainder populates the ground state of stable ^{137}Ba. The metastable ^{137m}Ba having a half-life of about 153 s emits gamma rays with a main photon peak of 662 keV.

The flux of the gamma rays can be tuned by a system of filters that can be set independently for the two γ-field regions as denoted in Fig. 1. Fig. 2 shows the simulated photon current of the gamma particles when the source is fully open [3]. The Micromegas detectors are placed in the position U1, about 1 m from the source.

The high gamma flux (up to $4.4 \times 10^7\ Hz/cm^2$) allows us to perform fast studies, e.g., of detector occupancy and rate capability as a function gamma background but also to study cumulative effects like detector ageing for extended exposure time. Moreover, using the H4 beam, the response of the detectors to pions or muons can be studied as a function of the high intensity gamma background.

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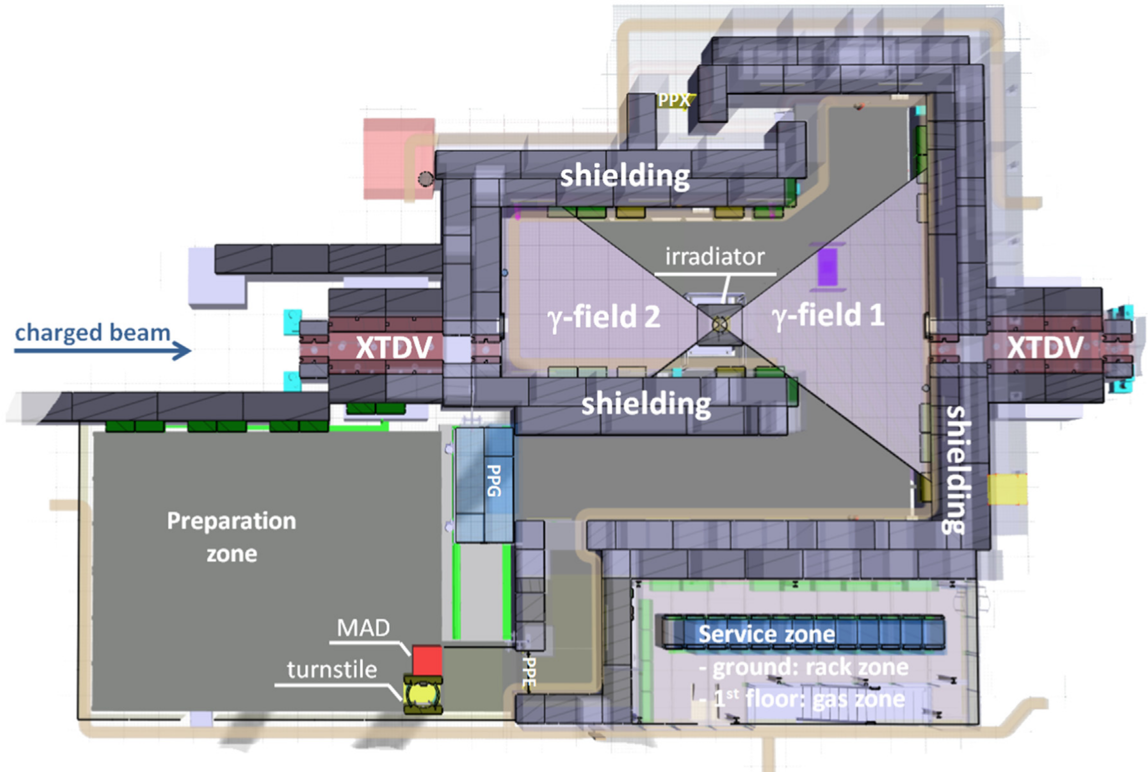

Fig. 1. Layout of the new Gamma Irradiation Facility.

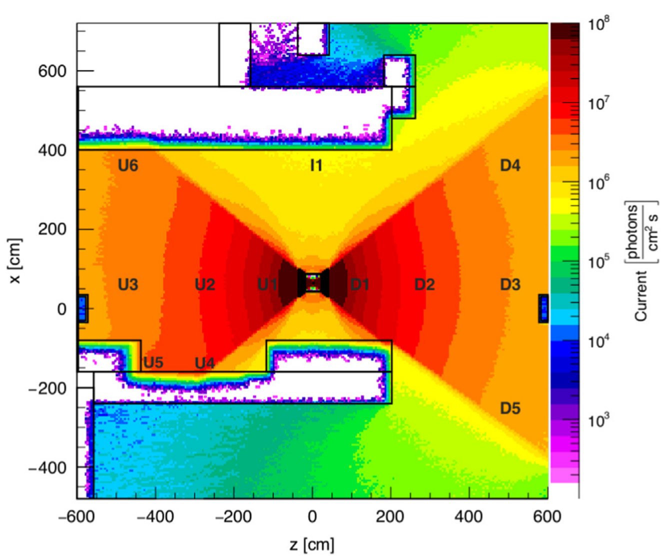

Fig. 2. Simulation of the photon current with the source fully open. Photons are emitted in two cones with an opening angle of $\pm 37°$ into the upstream (U) and downstream (D) regions.

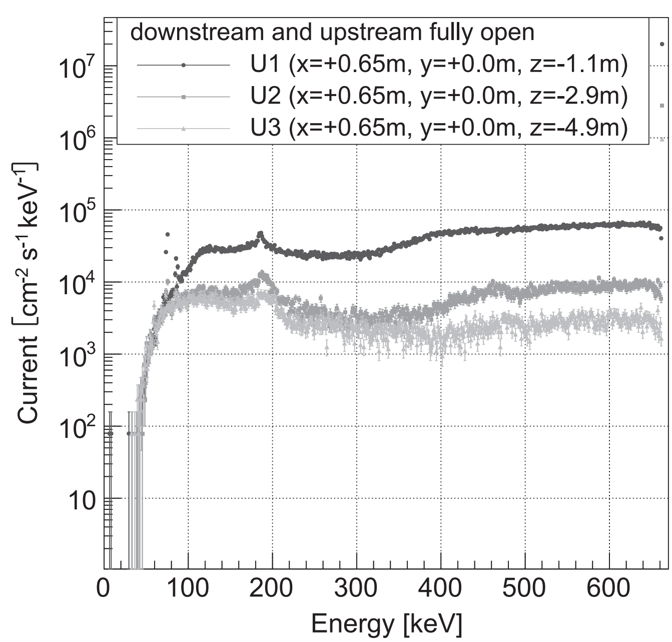

Fig. 3. Energy spectrum of photons as a function of the photon current, at the upstream positions U1, U2 and U3. The Micromegas chambers are placed at the U1 position.

3. Energy deposition and spectrum in Micromegas detectors at GIF++

Gamma radiation as it passes through matter ionizes via three processes: the photoelectric effect, Compton scattering, and pair production. The photoelectric effect is the dominant process for γ with energies below 50 keV. The Compton scattering is the principle mechanism for energy ranges 0.1–10 MeV and it is the main dominant process in GIF++, while the pair production becomes important at energies above 5 MeV.

Fig. 3 shows the simulated energy spectrum of the photons as a function of the flux at the different upstream positions [3].

Using the source referenced in [3] one resistive bulk Micromegas detector was simulated with Geant 4 ~1 m from the source. Fig. 4 shows the energy deposited by different processes in this detector when the source is fully open. The main contribution comes from the recoiled electrons of the Compton scattering that are detected by the detector.