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The Compact Muon Solenoid Experiment

CMS Performance Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

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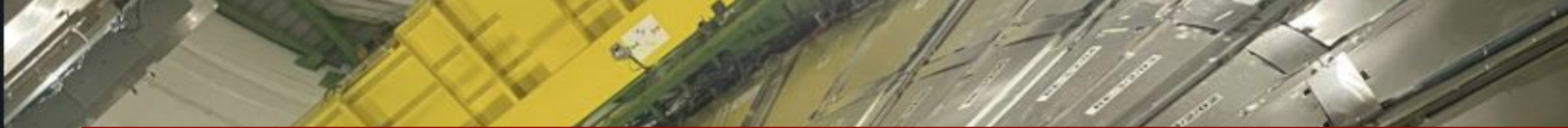
iRPC for the CMS Phase 2 Upgrade: GIF++ results

CMS Collaboration

Abstract

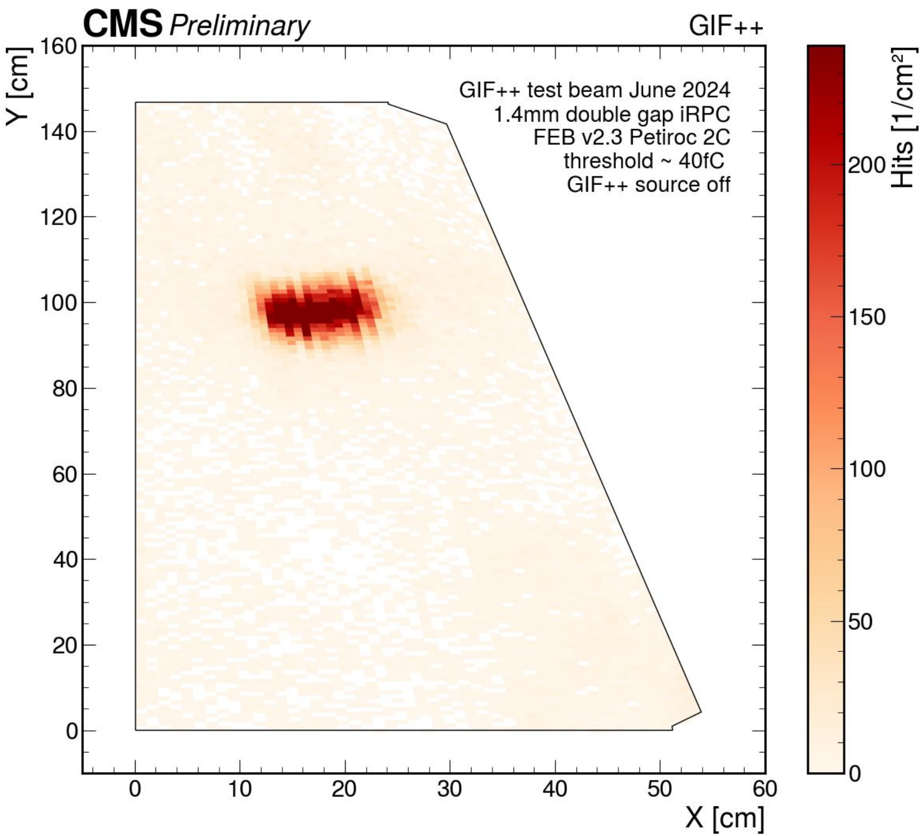
Results from the GIF++ irradiation tests done on iRPC.



iRPC for the CMS Phase 2 Upgrade:
GIF++ results

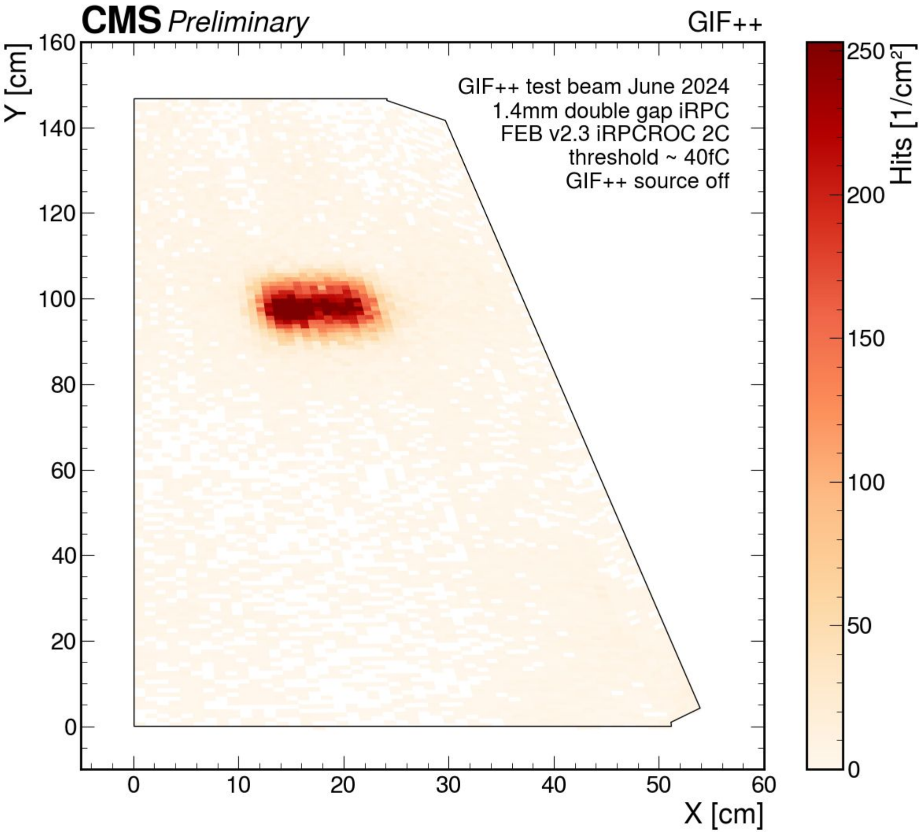
CMS Collaboration
cms-dpg-conveners-rpc@cern.ch

hit profile plot



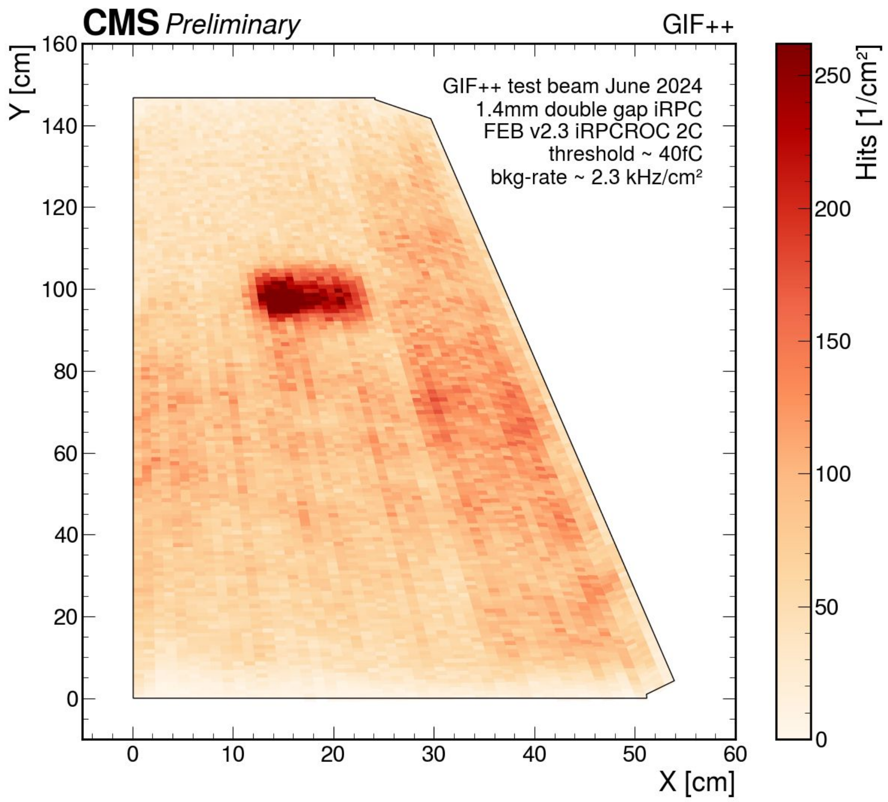
The figure shows a 2D hit profile of the number of muon hits in the strips of the 1.4 mm double gap iRPC production chamber with data taken at the Gamma Irradiation Facility (GIF++). The X- and Y-coordinates of a hit are calculated using the iRPC chamber geometry, based on the hitted strip and the position of the hit along it. The iRPC detector uses a front-end electronics board (FEB) with ASIC iRPCROC version 2C, optimized for RPC use at low charge threshold. The data are collected at a high voltage of 7035 V over the iRPC detector gaps. This is the working point of this detector with the GIF++ gamma radiation source off, and a charge threshold of the iRPCROC around 40 fC.

hit profile plot



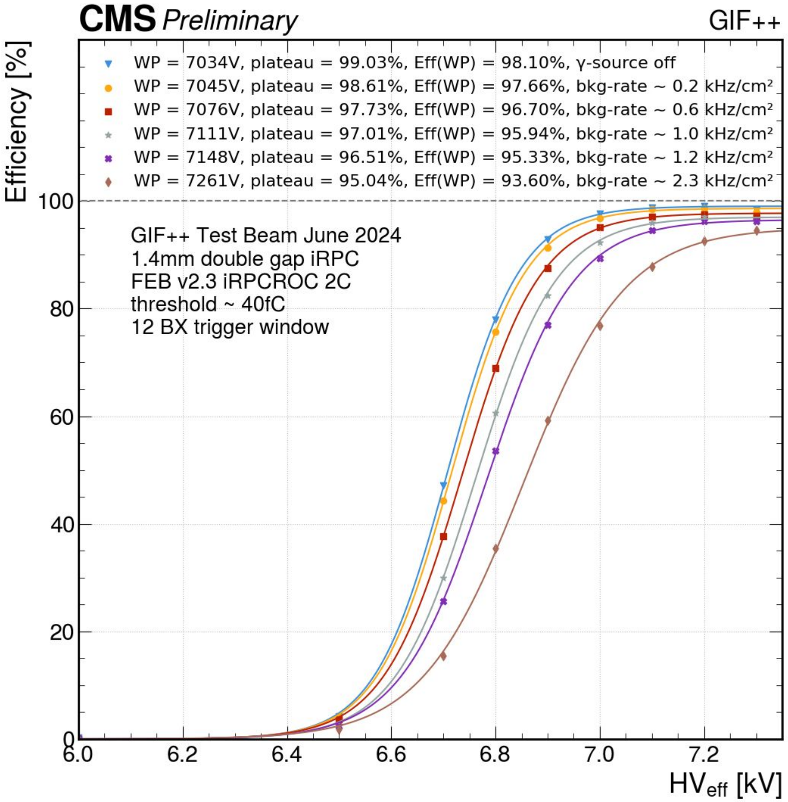
The figure shows a 2D hit profile of the number of muon hits in the strips of the 1.4 mm double gap iRPC production chamber with data taken at the Gamma Irradiation Facility (GIF++). The X- and Y-coordinates of a hit are calculated using the iRPC chamber geometry, based on the hitted strip and the position of the hit along it. The position of hits along each strip is aligned offline. The iRPC detector uses a front-end electronics board (FEB) with ASIC iRPCROC version 2C, optimized for RPC use at low charge threshold. The data are collected at a high voltage of 7035 V over the iRPC detector gaps. This is the working point of this detector with the GIF++ gamma radiation source off, and a charge threshold of the iRPCROC around 40 fC.

hit profile plot



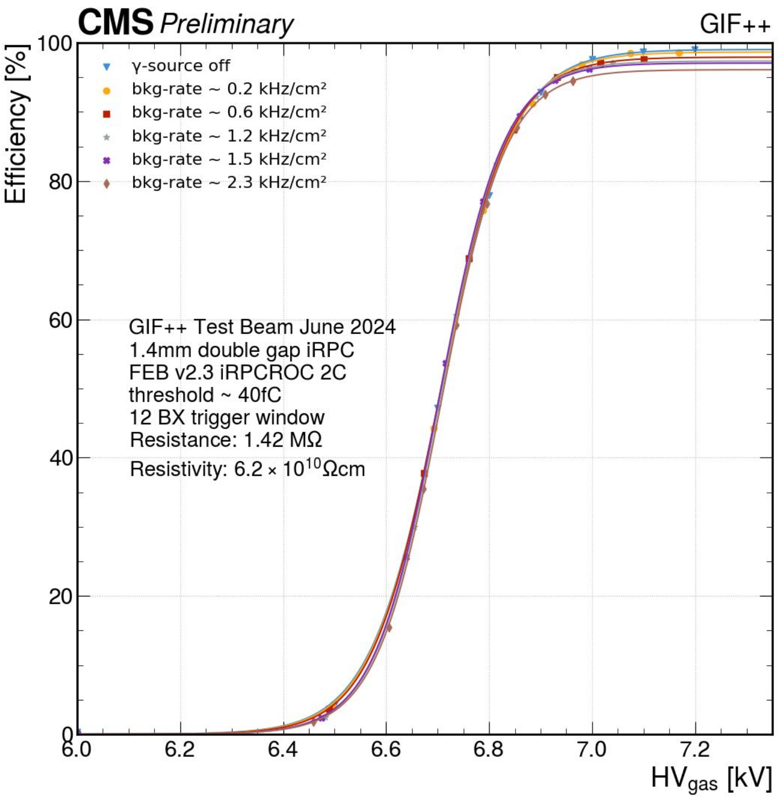
The figure shows a 2D hit profile of all hits inside the muon window in the strips of the 1.4 mm double gap iRPC production chamber with data taken at the Gamma Irradiation Facility (GIF++). The X- and Y-coordinates of a hit are calculated using the iRPC chamber geometry, based on the hitted strip and the position of the hit along it. The position of hits along each strip is aligned offline. The iRPC detector uses a front-end electronics board (FEB) with ASIC iRPCROC version 2C, optimized for RPC use at low charge threshold. The data are collected at a high voltage of 7261 V over the iRPC detector gaps. This is the working point of this iRPC detector with the GIF++ gamma radiation flux through the detector in the order of 2.3 kHz/cm² photons and a charge threshold of the iRPCROC around 40 fC. In the top-left region of the detector (X < 30cm and Y > 80cm) the detector was obstructed from the GIF++ source which explains the lower hit rate in this region.

Muon detection efficiency



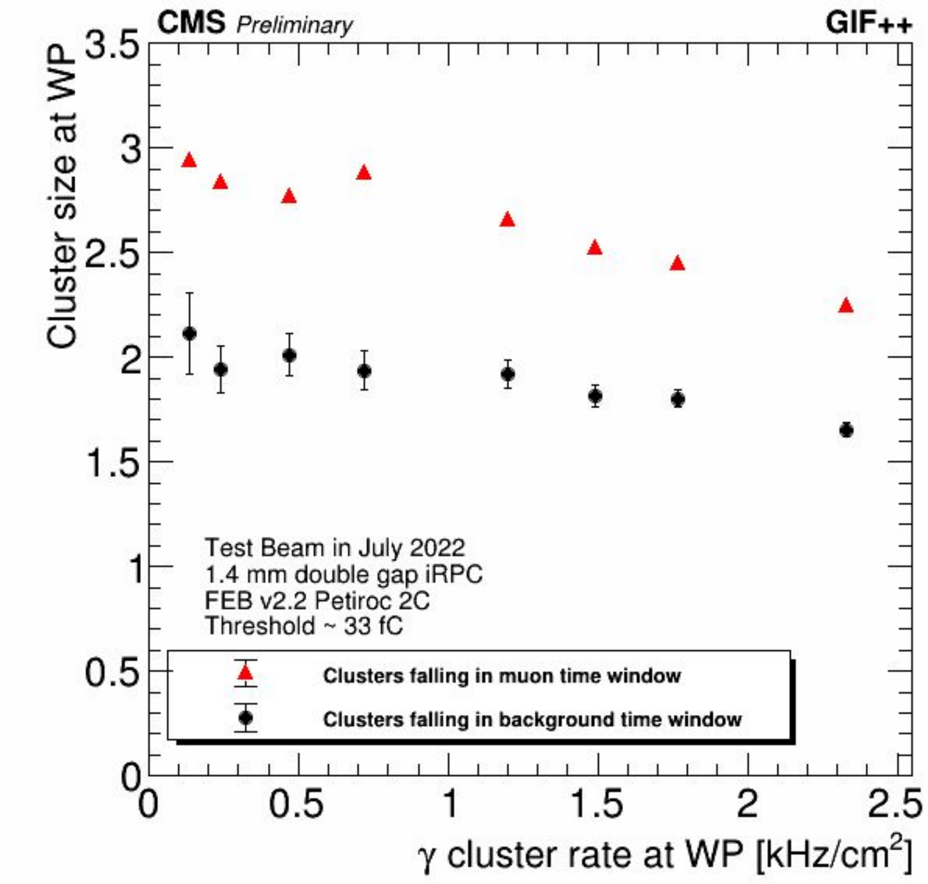
The figure shows the efficiency of the 1.4mm double gap iRPC detector with data taken at the Gamma Irradiation Facility (GIF++) in terms of the effective high voltage (HV_{eff}). The efficiencies are measured with a trigger window of 12 bunch crossings per orbit at various GIF++ gamma irradiation rates, and with a charge threshold of ~ 40fC of the iRPC detector. The detector efficiency at each high voltage is defined as the ratio of the number of triggered events with a detected muon to the total number of triggered events, corrected by the efficiency of noise. A detected muon is considered as at least one hit within the scintillator projected area and within the expected time range of the muon passing the detector after triggering. The high voltage working point is defined as 120V higher than the knee of the fitted efficiency curve to maximize efficiency at a lowest possible high voltage.

Muon detection efficiency, ohmic correction



The figure shows the efficiency of the 1.4mm double gap iRPC detector with data taken at the Gamma Irradiation Facility (GIF++) in terms of the ohmic corrected high voltage over the iRPC gas (HV_{gas}). The ohmic correction is applied following $HV_{gas} = HV_{eff} - IR$. Here I is the current over the iRPC gaps and R is the resistance measured from a χ^2 goodness of fit that minimizes the efficiency curve HV shift of all background rates. The measured resistance for the iRPC detector is 1.42 MΩ and resistivity is $6.2 \times 10^{10}\,\Omega$cm. The efficiencies are measured with a trigger window of 12 bunch crossings per orbit at various GIF++ gamma irradiation rates, and with a charge threshold of ~ 40fC of the iRPC detector.

cluster size per background rate



The figure shows the cluster size for the collected events that are outside muon window (mostly gammas) and inside muon window (mostly muons) at working point as a function of gamma background rates. The statistical uncertainty on the cluster size is not visible for the muons because it is very small. The data is collected at the GIF++ facility during the July 2022 test beams. The 13 TBq Cs^{137} is used as gamma source to mimic the background, and the new front-end electronics (FEB v2.2) with Petiroc 2C ASIC was used.