

Longevity Study on the CMS Resistive Plate Chambers for HL-LHC

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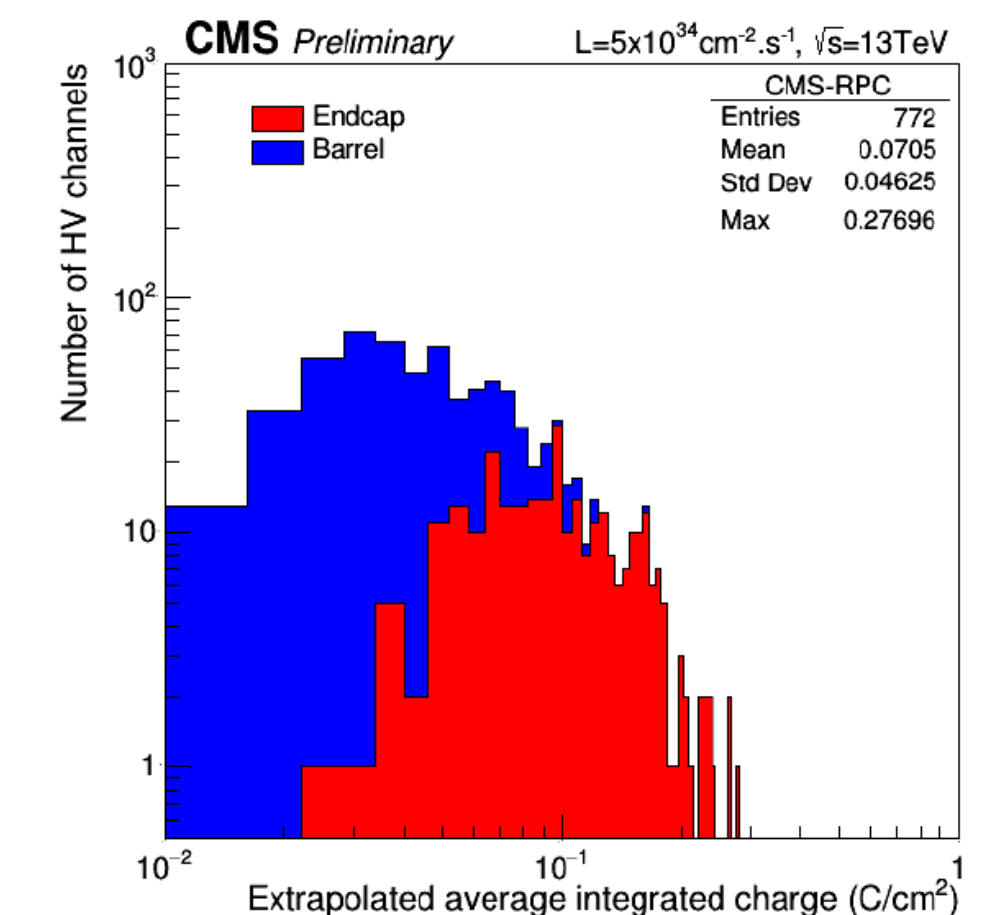
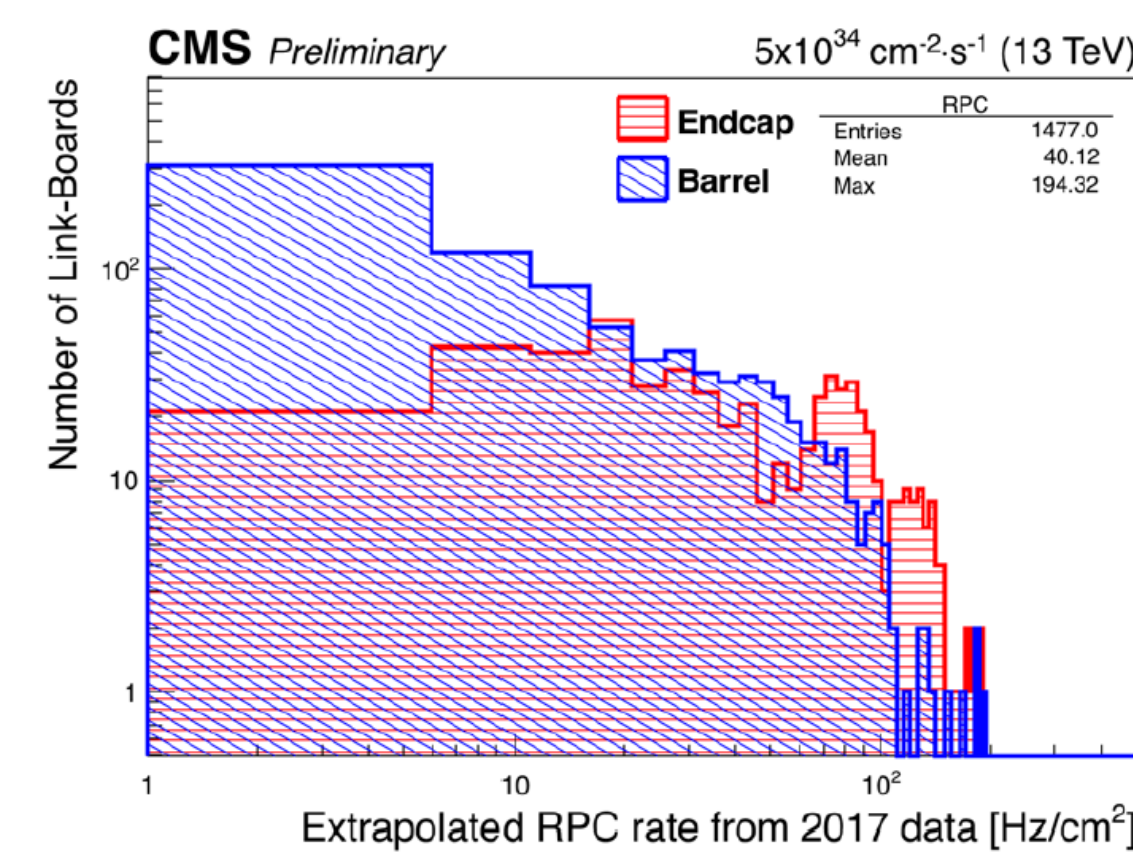


PDS12: The 12th International Conference on Position Sensitive Detectors

1. Abstract

The CMS Resistive Plate Chambers (RPC) system has been certified for 10 years of LHC operation [1]. In the next years, during the High luminosity LHC (HL-LHC) phase, the LHC instantaneous luminosity will increase to factor five more than the nominal LHC luminosity. This will subject the present CMS RPC system to high background rates and operating conditions much higher with respect those for which the detectors have been designed. Those conditions could affect the detector properties and introduce a non-recoverable aging effects. A dedicated longevity test is set up in the CERN Gamma Irradiation Facility (GIF++) to study if the present RPC detectors can survive the hard background conditions during the HL-LHC running period. During the irradiation test, the RPC detectors are exposed to a high gamma radiation for a long period and the detector main parameters are monitored as a function of the integrated charge. The results of the irradiation test after having collected a sufficient amount of the expected integrated charge will be presented.

2. The expected Conditions at HL- LHC



- Based on the data collected by CMS during LHC Run II and assuming a linear dependence of the background rates as a function of the instantaneous luminosity, the expected background rates and integrated charge at HL-LHC will be about **600 Hz/cm²** and **840 mC/cm²**, respectively (including a safety factor of three).

3. Longevity Setup

- The Longevity Setup (Fig.1) consists of four spare RPC chambers, two endcap chambers of type RE2 and RE4 which are continuously irradiated and two non-irradiated chambers of the same type are installed to be used as reference.

Periodic measurements are performed on both the irradiated and reference chambers:

- the detector parameters such as dark current, noise rate, current and count rates at several background conditions
- the detector performance is studied at different irradiation fluxes when the muon beam at GIF++ is available.
- few times per year measurement of the bakelite resistivity.

- The integrated charge collected from the beginning of irradiation are about **788 and 458 mC/cm²** for RE2 and RE4 chambers respectively as shown in Fig. 2 that correspond to approximately 94 % and 55% of the expected integrated charges at HL-LHC [2].

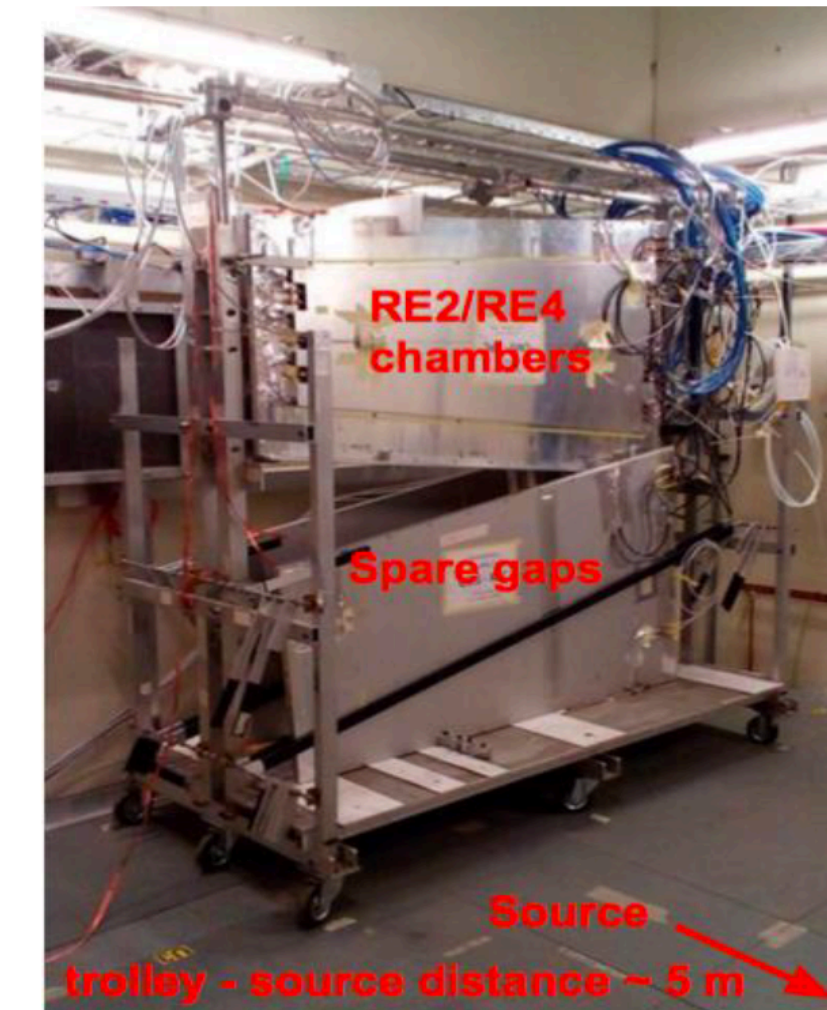


Fig. 1

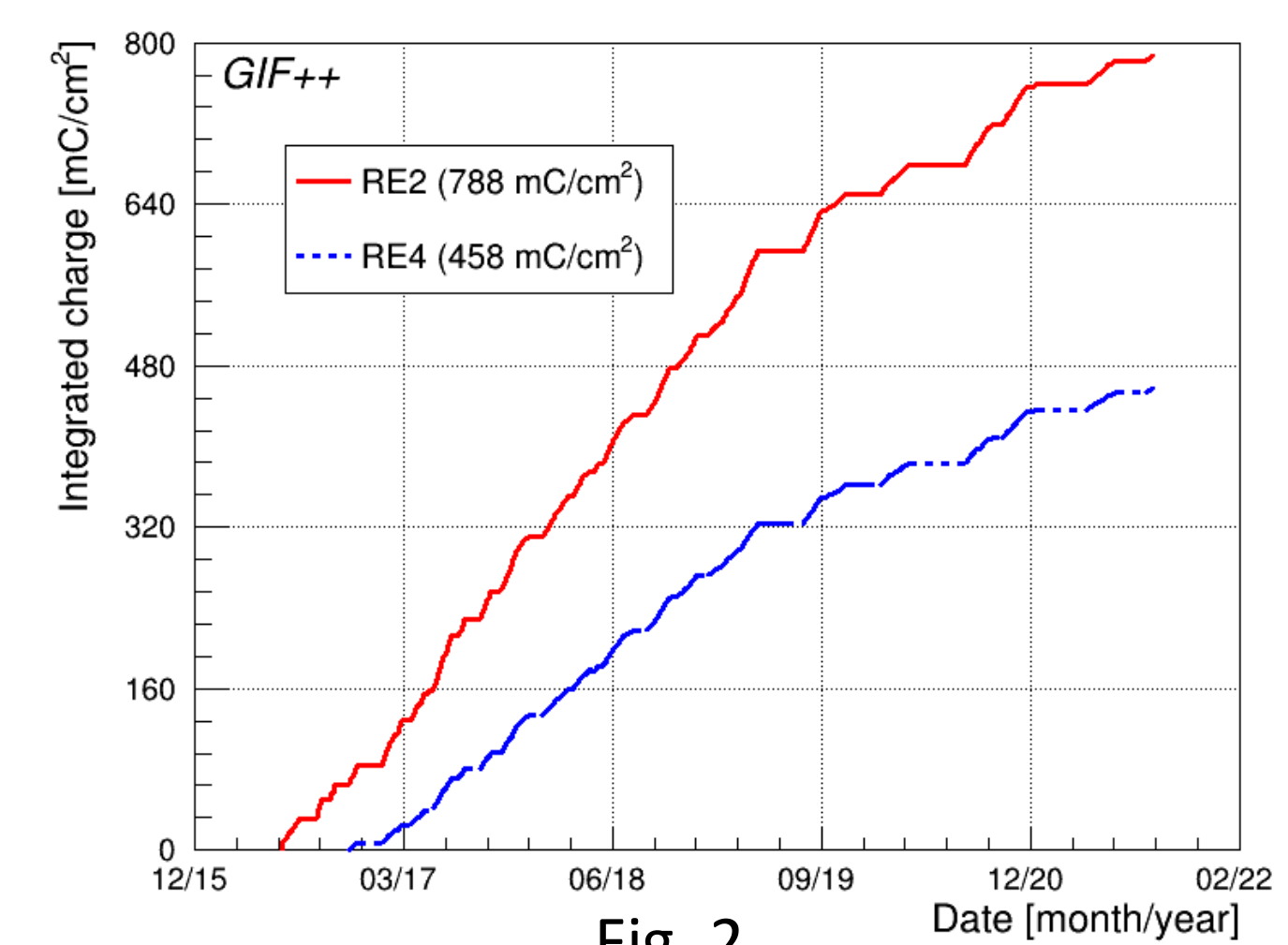
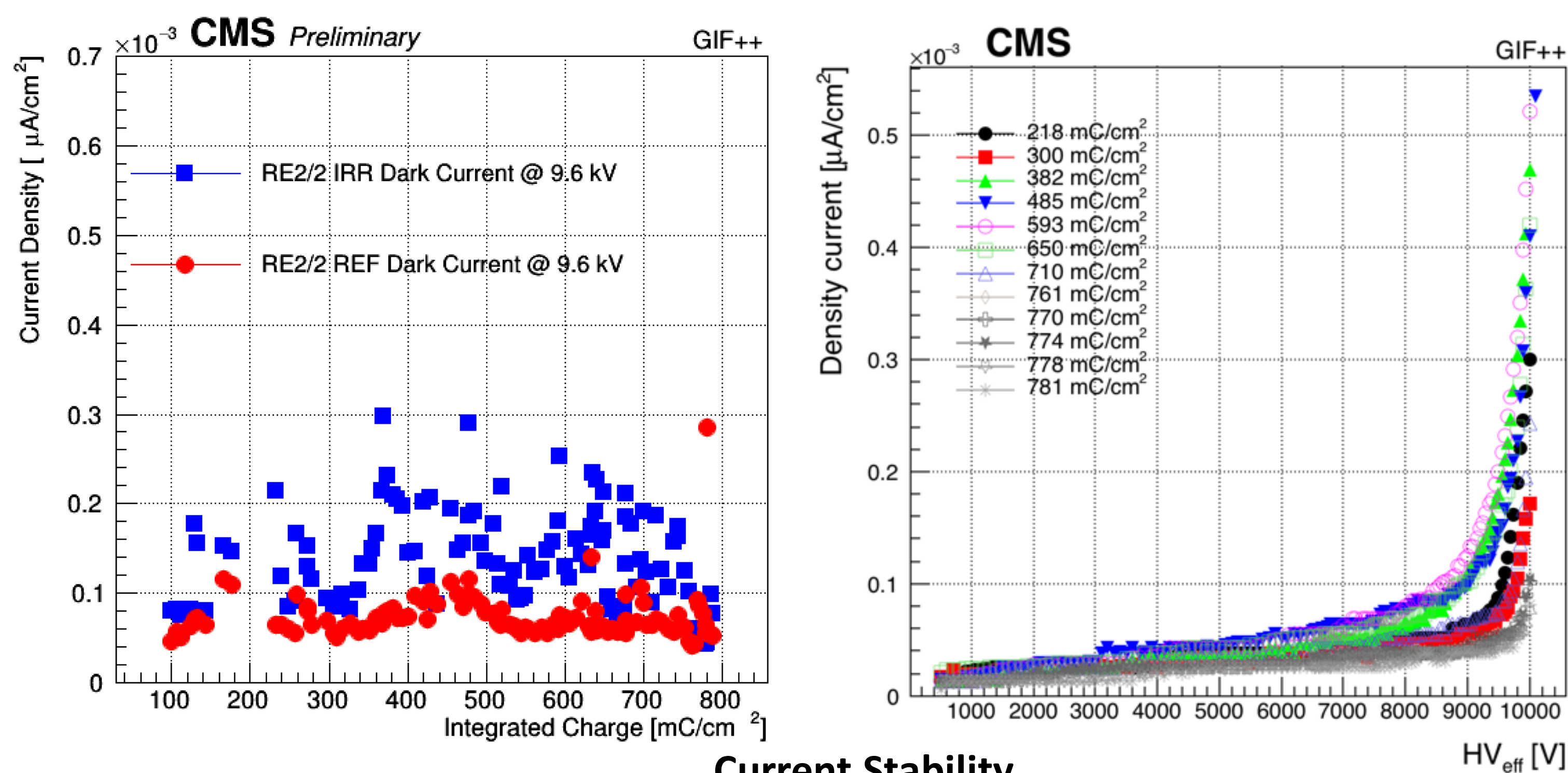


Fig. 2

4. Results

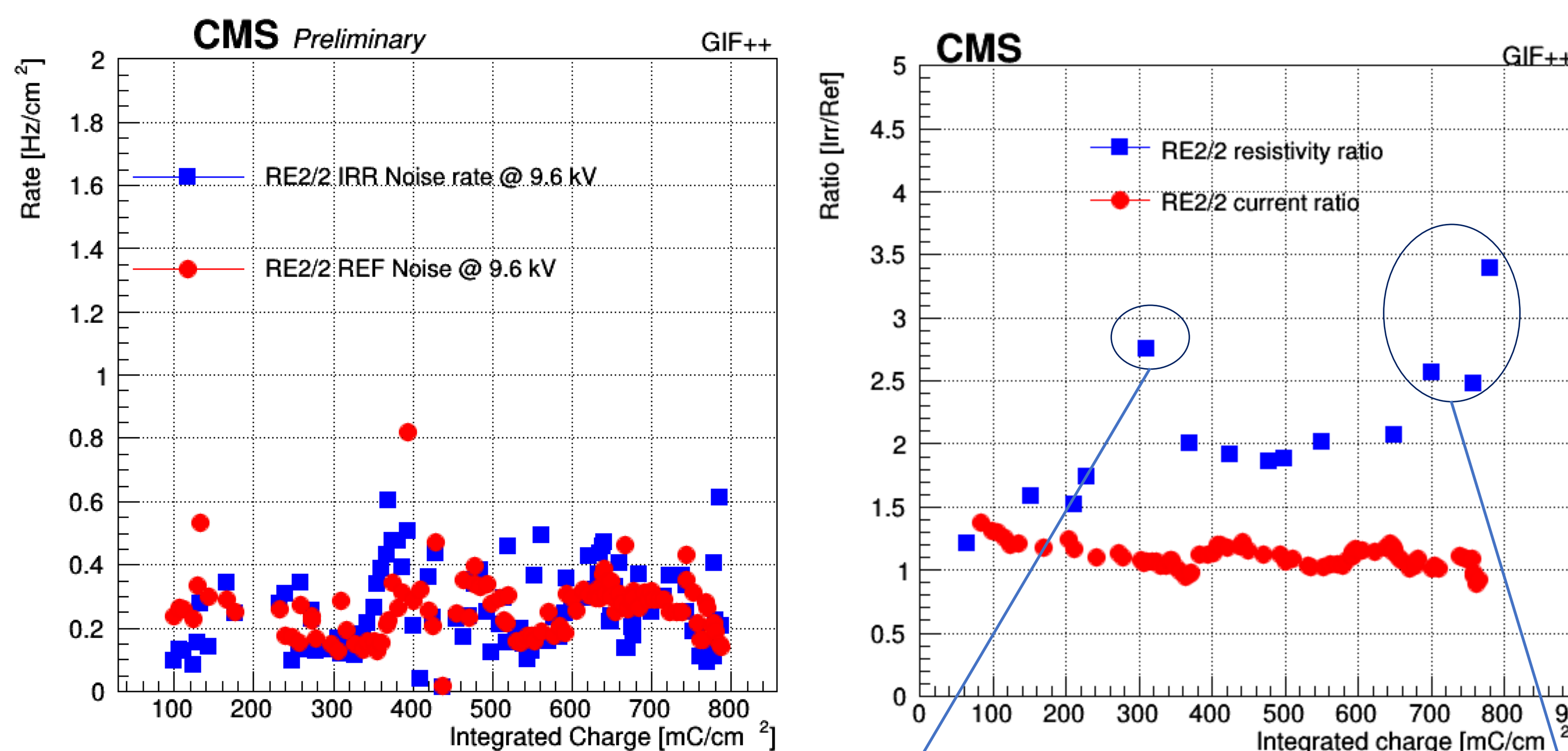
4.1 Detector Parameters Monitoring

- The stability of the dark current is one of the key parameters to spot any aging effects [3].



Current Stability

- The dark current is almost stable since the beginning of irradiation.



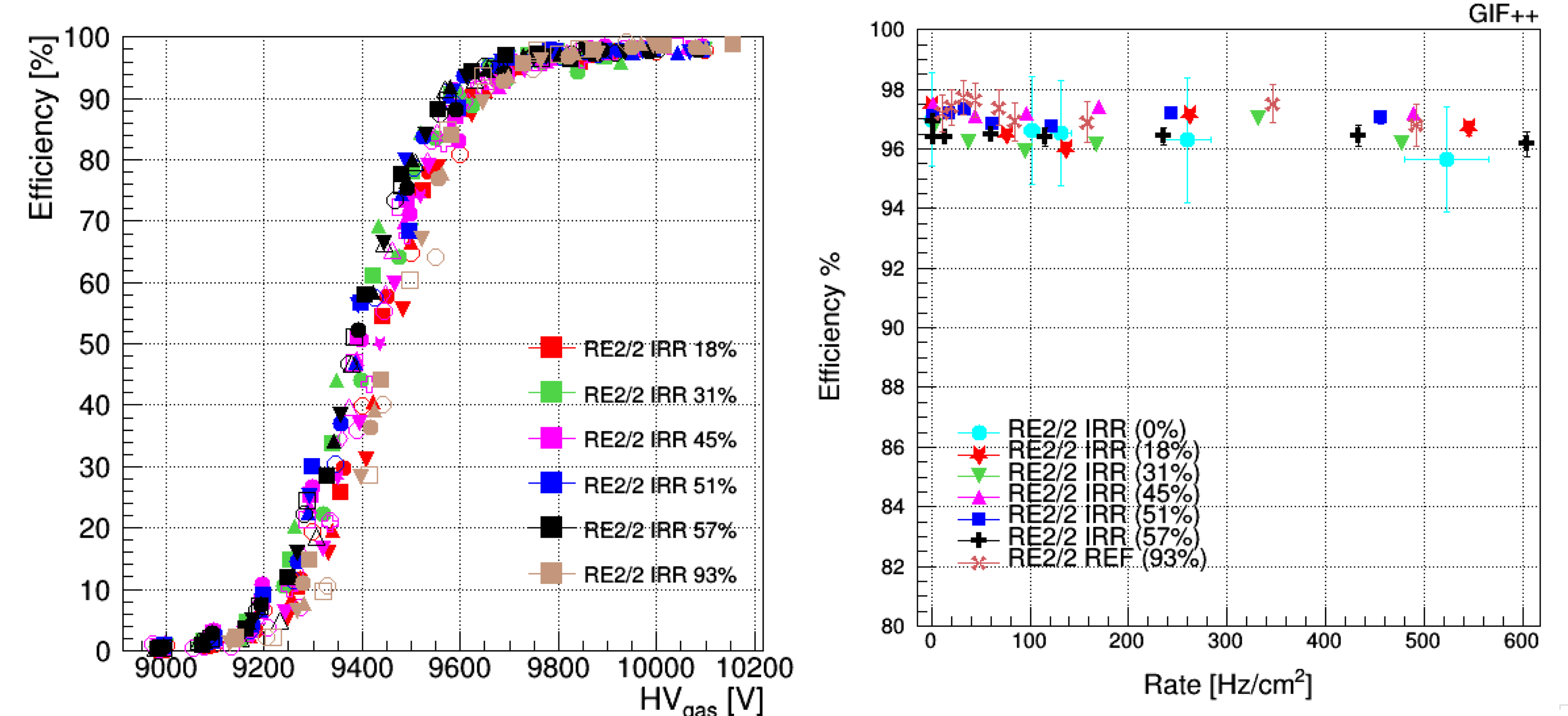
Average Noise Rate

Resistivity & Current Ratio

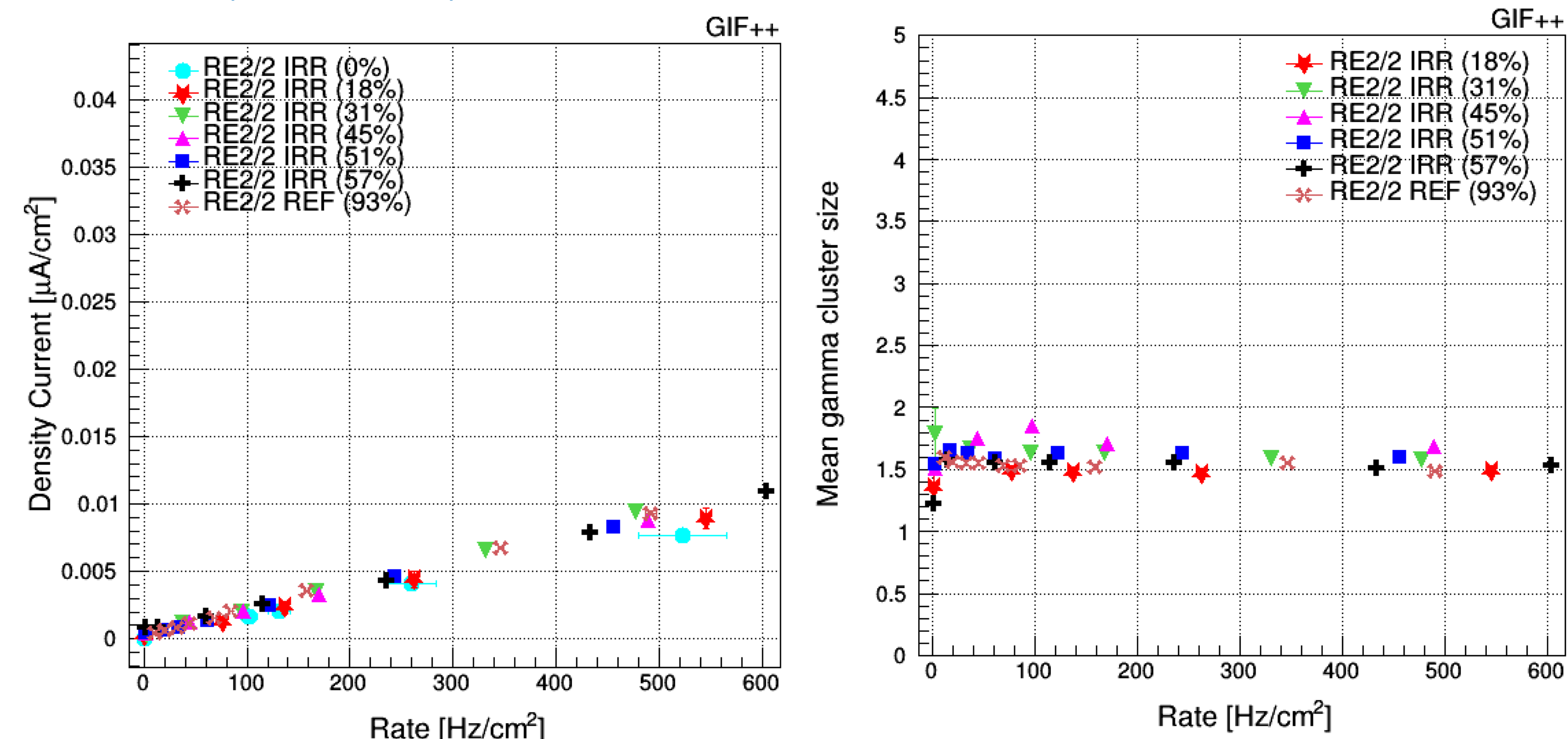
* The resistivity increase observed in irradiated chamber relative to reference chamber due to low gas humidity during this irradiation period.

4.2 Detector Performance Monitoring

- The detector performance has been measured during test beams before irradiation and at different periods of irradiation.



- Stable Efficiency at different background rate and different Integrated charge.
- Efficiency at WP remains stable in time up to the maximum expected rate (600 Hz/cm²)



- Stable average charge & Gamma cluster size at different Integrate charge up to the maximum expected rate (600 Hz/cm²).

✓ No Evidence of any aging effect has been observed

References

- CMS Collaboration, *The CMS experiment at the CERN LHC*, JINST 3 (2008) S08004. doi:10.1088/1748-0221/3/08/S08004.
- CMS Collaboration, *The Phase-2 Upgrade of the CMS Muon Detectors*, CERN-LHCC-2017-012, CMS-TDR-016, (2017).
- R.Aly on behalf of the CMS Muon Group. "Aging Study on Resistive Plate Chambers of the CMS Muon Detector for HL-LHC". JINST 15, (2020), arXiv:2005.11397v2. Doi:https://iopscience.iop.org/article/10.1088/1748-0221/15/11/C11002.