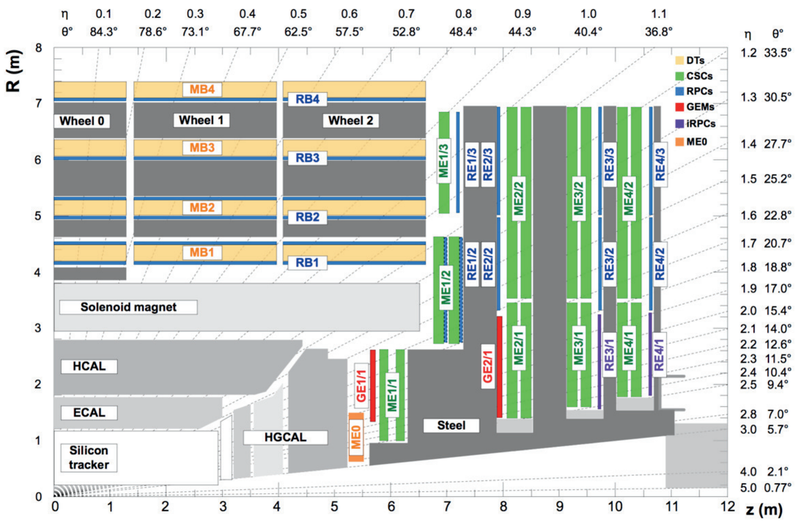
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# CMS RPC system consolidation and upgrade for the LHC Phase-II programme

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## Introduction

The Phase-II upgrade of the Large Hadron Collider (LHC), known as High Luminosity (HL)-LHC, will increase proton-proton collision luminosity to 5-7 x $10^{34}$ $cm^{-2}s^{-1}$ [1]. To cope with the increased interaction rate, the Compact Muon Solenoid (CMS) is undergoing significant upgrades in the existing systems and adding new detectors. Resistive Plate Chambers (RPC), parallel plate gaseous detectors in the CMS barrel (480) and endcap (576) Muon System are crucial for triggering due to their excellent timing resolution. For HL-LHC, RPC will get upgraded electronics and an acceptance extension to the forward region. This includes installing 72 improved RPC (iRPC) detectors in the region 1.8 < |η| < 2.4, challenging for muon reconstruction due to high background rates and a highly non-uniform magnetic field. This poster shows the maintenance procedures of the existing RPC detector and the activities in the view of Phase-II Upgrade of CMS for HL-LHC era.



Schematic longitudinal view of one quarter of the CMS detector with the different subsystems which compose the Muon Detector for Phase-II Upgrade

## Gas leak repairs

Since Run I (2011), leaks have appeared in barrel RPC chambers due to a bad batch of gas pipes, which degraded differently from those installed in the endcap chambers. These leaks degrade efficiency (if air goes inside the gaps) and emit greenhouse gases, as RPC gas mixture contain over 95% of $C_2H_2F_4$. Consequently, 217 chambers are either directly or indirectly deactivated due to leaks. During the Year-End Technical Stop (YETS) 2023/2024, a new permanent procedure was tested in CMS, involving full chamber extraction and leak repair on-site.

Three openings (back, middle, and front chamber), each measuring 14-20 x 3 $cm^2$, are milled on the side of the chamber to access gas connections. The gap inlets are connected to T-unions (middle and front) and L-unions (back) via Tygon pipes. The existing pipe is left inside the chamber, while a new V0 pipe (radiation certified) connects to the T and L unions and extends to the service box in front of the chamber. Ten chambers were successfully repaired so far, with leak rate measurements indicating no detectable leaks years after the intervention, and efficiency comparable to that measured before the leaks developed. The procedure is ready for massive application.


Extraction of one Drift Tubes+RPC package, allowing the leak repair [3]


New V0 pipes (in blue) installed after chamber repair, going to the new service box.

## Installation of iRPC chambers

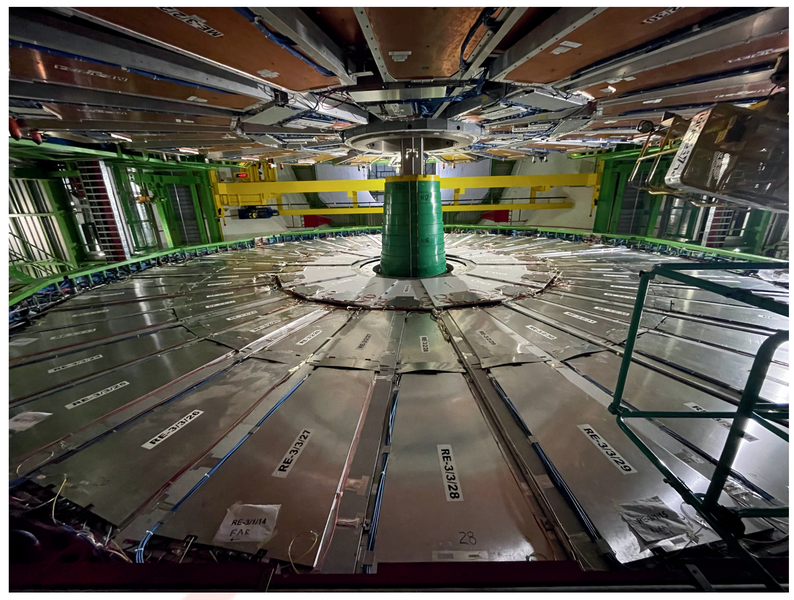
To improve the performance of the muon trigger and reconstruction in the forward region of CMS, 72 new improved Resistive Plate Chambers are being installed in stations 3 and 4 of the Muon System. Preparation for this work during YETS (Year-End Technical Stop) 2023/2024 included the installation of mounting brackets to attach the chambers in the even sectors directly to the return yoke (on-yoke chambers). In contrast, the chambers in the odd sectors are installed off-yoke by attaching to the even-sector chamber using a mounting bracket.

During YETS 2024/2025, the first two disks were installed in stations 3 and 4 of the negative endcap of CMS. Beforehand, fine-tuning was carried out using full-size chambers to ensure the correct positioning of the mounting brackets for the installation of all chambers. This procedure proved to be both efficient and fast. The services, including high- and low-voltage power, gas, water cooling, and optical fibers for temperature monitoring and signal readout, were installed, connected, and successfully tested, enabling the full commissioning of 36 iRPC chambers.


RPC team with the first mass production chamber installed in CMS during YETS 2024/2025 [4]



RE-3/1/01 chamber with the signatures of the team [4]



18 iRPC chambers installed in station -4 in CMS: the white ones in the innermost ring (bottom disk) [5]


Moment of chamber installation in the bracket while lifted by the crane [4]

## Conclusion

The maintenance and upgrade of Resistive Plate Chambers (RPCs) in the CMS Muon System are critical steps in preparing for the High-Luminosity LHC Phase-II. The successful installation of the first two iRPC disks, comprising 36 chambers during YETS 2024/2025, provides a solid foundation for the upcoming installation of the remaining 36 chambers during the next access period. Additionally, the new gas leak repair procedure has demonstrated an effective way to recover chambers that were powered off due to high leak rates. The team also took advantage of the access during the first weeks of Long Shutdown 3 (LS3) to remove the two demonstrators and prepare the mechanical brackets for the installation of 18 chambers in the +3 disk. These advancements ensure the CMS detector's readiness to handle increased luminosity and maintain high performance, significantly enhancing its muon trigger and reconstruction capabilities.

## References

[1] CMS Collaboration (2017), The Phase-2 Upgrade of the CMS Muon Detectors, CMS-TDR-016, https://cds.cern.ch/record/228318.
[2] E. Asilar, A. Dimitrov (2025), Hi-Lumi iRPC Muon Chambers Installed in CMS in Record Time, https://cms.cern/news/hi-lumi-irpc-muon-chambers-installed-cms-record-time.
[3] ASILAR, E. CMS RPC Barrel – Gas pipe maintenance – YETS 2025. CERN, 2025. Available at: https://cds.cern.ch/record/2922016.
[4] ASILAR, E. CMS iRPC RE-3/1 installation – YETS 2025. CERN, 2025. Available at: https://cds.cern.ch/record/2922015.
[5] ASILAR, E. CMS iRPC RE-4/1 installation – YETS 2025. CERN, 2025. Available at: https://cds.cern.ch/record/2925269.

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