CMS RPC Upgrade Program

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Abstract

The LHC will be upgraded in several phases that will allow significant expansion of its physics program. The luminosity of the accelerator is expected to exceed $5 \times 10^{34} cm^{-2} s^{-1}$. In order to sustain the harsher conditions and to help maintaining good trigger efficiency and performance the Resistive Plate Chambers (RPC) system of the CMS experiment will be upgraded. The present RPC system would continue to operate, and it would be upgraded with new Link Boards system. In addition, the coverage of the RPC system would be increased up to pseudo rapidity of 2.4 by installing a new generation of improved RPCs (iRPCs). Their design and configuration are optimized to sustain higher rates and hence to survive the harsh background condition during HL-LHC operation. The iRPC are equipped with newly developed electronics designed to read out the detectors from both sides, allowing in this way a good spatial resolution along the strips O(cm). The status of the upgrade project is presented.

CMS RPC Upgrade

Figure **??** presents a quadrant of the CMS Muon system, showing DT chambers (yellow), RPCs (light blue), and CSCs (green). The locations of new forward muon detectors for the HL-LHC project are indicated in red for Gas Electron Multiplier (GEM) stations (ME0, GE1/1, and GE2/1) and violet for improved RPC stations (RE3/1 and RE4/1).

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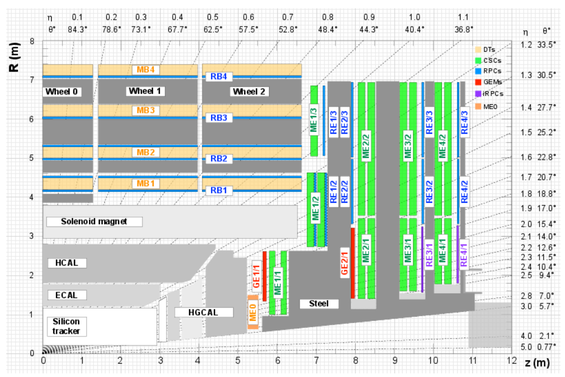

Figure 1: CMS Muon system for the Phase-2 Upgrade.

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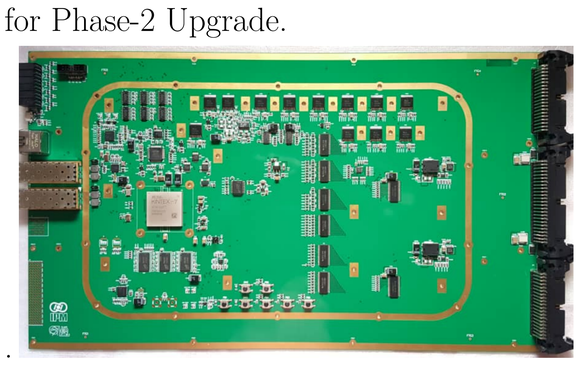
New Link System

In the CMS experiment, the RPC chambers are readout, controlled and monitored through the Link System, which consists of 1592 electronics boards, divided in two kinds, known as the Link boards (LBs) and Control Boards (CBs), LBs can work as Master LB of Slave LB.

The HL-LHC high rates will required an increase of the available TX bandwidth and time readout time resolution. The new link system is being developed around the use of modern components and FPGAs (Field Programmable Gate Array), following a radation hard design. The data transmission rate between the new Link system and CMS back-end electronics increases to 10.24 Gbps and resolution of the Muon hit time improves to 1.5 ns, close to the RPC chamber instrinsic resolution, which is achieved by implementeing a high resolution 96-channel Time-to-Digital Converter (TDC) in the link board FPGA. Each TDC channel comprised of 16 bins where each bin had a time scale of one sixteenth of the 25 ns. The experimental results showed that there existed a 1.56 ns resolution for the implemented TDC channels. The high speed data transmittions in obtained by the use of a GTX transceivers of the FPGA, plus preprocessing of data before sending to the GTX transmitter.

Figure 2: A RPC Link Board prototype for Phase-2 Upgrade.



Conclusion

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iRPC FEB

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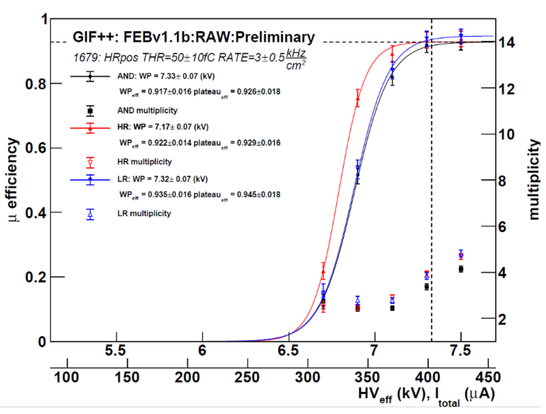
Figure 3: A capition for iRPC FEB.



This plot shows s-curves with dependencies of Muon Efficiency versus High Voltage Effective (HVeff) for the second version of FEB with PETIROC2B (FEBv1b). Also, this slide showing the mean value of multiplicity for each side. AND efficiency showing without crosstalk impact. Data was taking during GIF++ (ATT=3.3) cosmic tests (September-November 2019). Scintillators placed in the HR of the chamber and covered about 20cm. This setup includes three protected with leads scintillators inside GIF++ (without outside scintillators) HR: 500-480=20DACu. (50±10fC)

LR: 500-480=20DACu (50±10fC)

HIGH VOLTAGE EFFECTIVE (X-axis)

Effective HV takes into account the change in pressure and temperature with respect to an HV reference value V0 at given pressure P0 and temperature T0.

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Readout and Control Electronics

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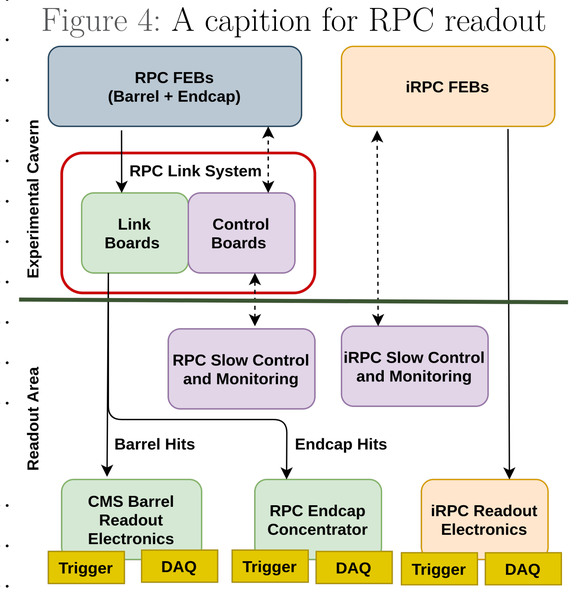
Figure 4: A capition for RPC readout



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Demonstrator

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References

[1, 2, 3, 4]

[1] Albert Einstein. “Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]”. In: *Annalen der Physik* 322.10 (1905), pp. 891–921.

[2] Albert Einstein. “Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]”. In: *Annalen der Physik*