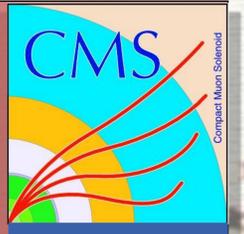




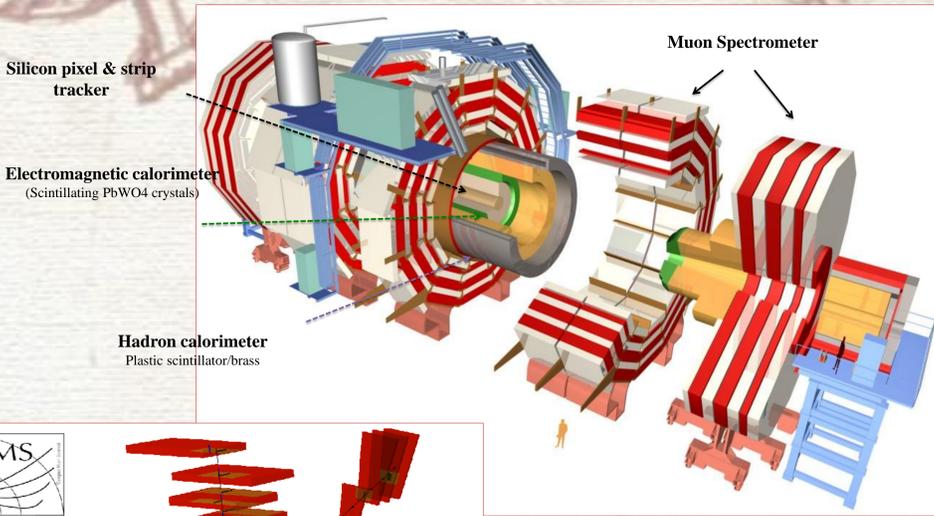
Operation, performance and upgrade of the CMS Resistive Plate Chamber system at LHC



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on behalf of the CMS Collaboration

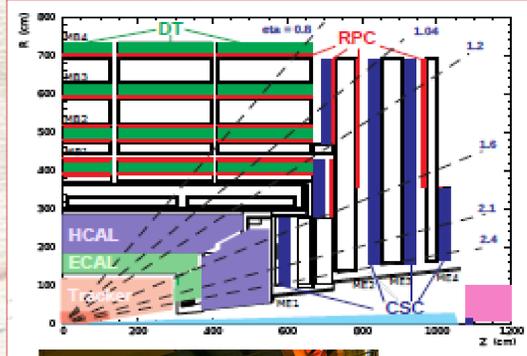
The CMS detector



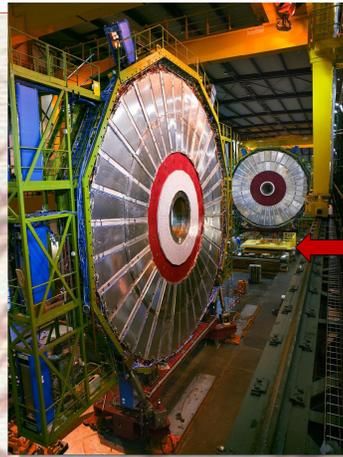
Weight: 12000 tonnes
Length: 21.6 m
Diameter: 15 m
Magnetic field: 3.8 T

Event display with 4 muons, the RPC hits (in black) are shown explicitly. Not all the event content is shown (CSC hits are suppressed)

The Resistive Plate Chamber system



- covers $0 < |\eta| < 1.6$
- 912 chambers (480 in barrel and 432 in endcap)
- Double gaps gas chamber: 2 mm gas width
- 110000 electronic channels and 300 m² of active area
- Bakelite bulk resistivity: $\rho = 2-5 \times 10^{10} \Omega\text{cm}$
- Strip width: $2 \div 4 \text{ cm}$.
- Gas mixture: C₂H₂F₄ / isoC₄H₁₀ / SF₆ 96.2/3.5/0.3 (40% of humidity)
- Operated in avalanche mode



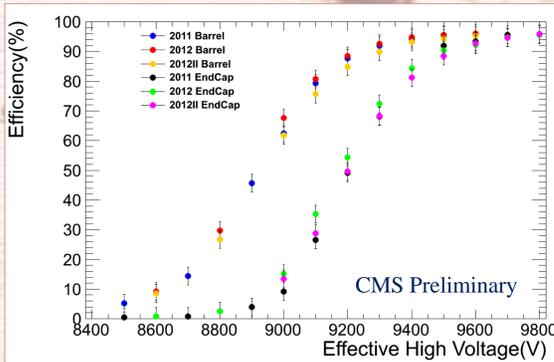
Endcap

Barrel

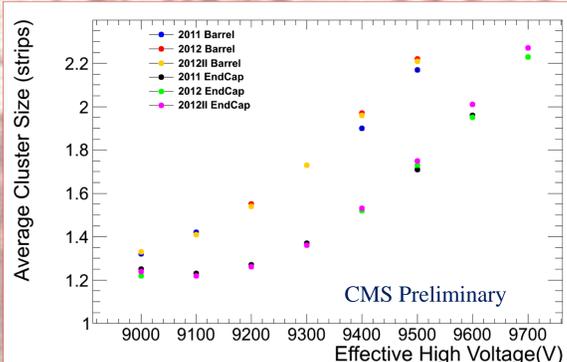


RPC working point calibration

At the beginning of 2011, and twice in 2012, an **HV scan** was done in order to study the chambers Working Points and to monitor in time the performance.

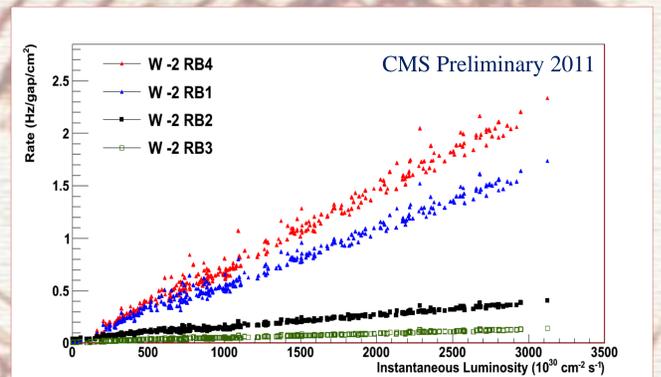


Barrel and Endcap Average Efficiency vs effective HV (reference pressure 965 mbar). Same detector conditions for the 3 HV Scans (thresholds, gas, pressure, correction algorithm)



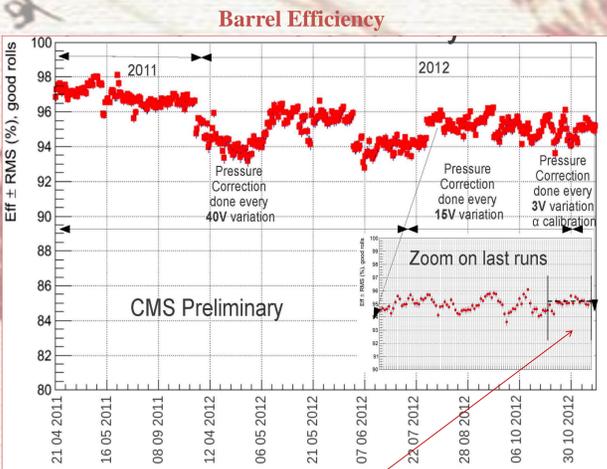
Average Cluster Size vs effective HV, for Barrel and Endcap. The similarity of the curves demonstrates the stability of the system, and that no aging effect has been observed

Radial distribution of the rate in the Barrel



RPC background rate as a function of the instantaneous luminosity, for four radial stations of Barrel wheel W-2. Outermost station affected mainly by neutron background, innermost mainly affected by particles coming from the vertex.

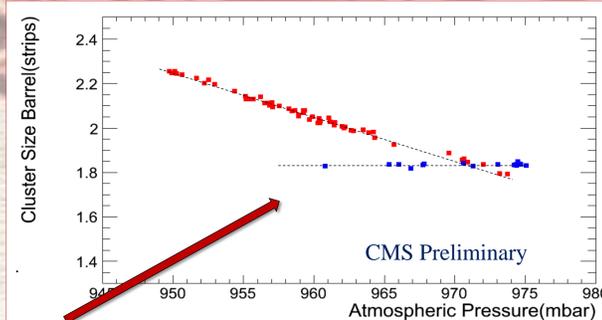
Keeping the working point stable...



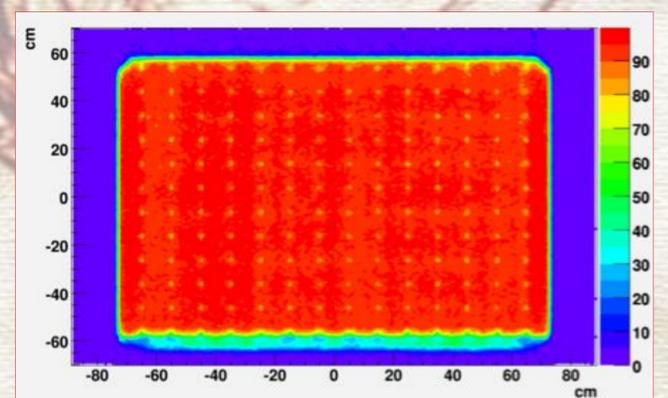
Fully automatic P-correction and α -factor ($\alpha = 0.8$)
RPC average efficiency stable within $\pm 0.5\%$

$$HV_{app} = HV_{eff} \left(1 - \alpha + \alpha \frac{P}{P_0} \right)$$

Barrel Cluster Size vs. atmospheric pressure



Red, early 2011 data, a linear correlation between the cluster size and atmospheric pressure, can be observed
Blue, late 2012 data, the cluster size is stable at ~ 1.85 and the correlation disappeared



Muon radiography: the chamber efficiency can be studied in details, with a resolution of $\approx 1\text{cm}^2$. In few chambers, the stability in time of inefficient zones is under observation. **No degradation observed up to now.**

Conclusions

The CMS **RPC systems is operating extremely well**, delivering good data for physics: After 3 years of LHC running with increasing instantaneous luminosity and 6 years from the end of construction, the **detector performance** is within specifications both for triggering and as a reconstruction system:

- ✓ Excellent synchronization and efficiency of the trigger system.
- ✓ RPC performance is stable without any degradation observed.
- ✓ Background measurements are within expectation. No significant issues for running at nominal luminosity.