Operations and Performance of the CMS RPC Muon System at LHC

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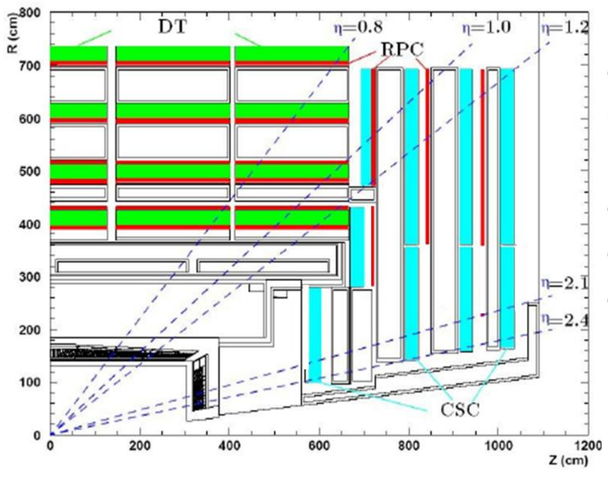
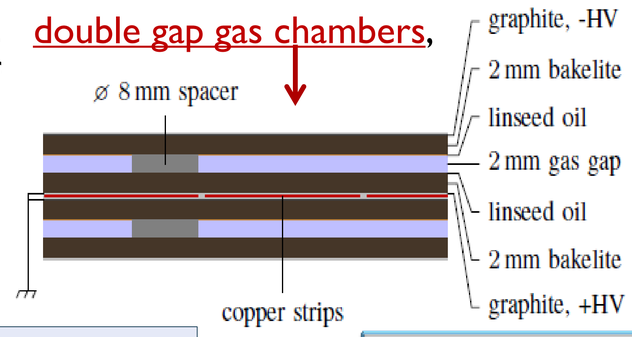
The Compact Muon Solenoid (CMS) experiment is one of the two general-purpose detectors observing at the CERN Large Hadron Collider (LHC). CMS combines three different gaseous detector technologies to trigger and reconstruct muons: Drift Tube (DTs) in the barrel region ($|\eta| < 1.2$), Cathode Strip Chambers (CSCs) in the endcaps ($0.9 < |\eta| < 2.4$) , and Resistive Plate Chambers (RPCs) in both regions, as dedicated muon trigger. We will report on the operations and performance of the RPC system after two years of LHC running with increasing instantaneous luminosity. Special attention will be given to the stability of the system and to the working point calibration procedures.

Resistive Plate Chamber System



- The RPC subdetector consists of 912 double gap gas chambers, covering $|\eta| < 1.6$, for an active area of ~2953 m^2.
- They are characterized by a time resolution of 3 ns, crucial for unambiguous bunch crossing assignment. and a spatial resolution of ~ 1cm.



RPC info	
Bakelite thickness	2 mm
Bulk resistivity	1-2 10^{10} Ω cm
Gas mixtures	96.2%C2H2F4 + 3.5%C4H10 + 0.3%SF6
Operating HV	9.4 – 9.8 kV

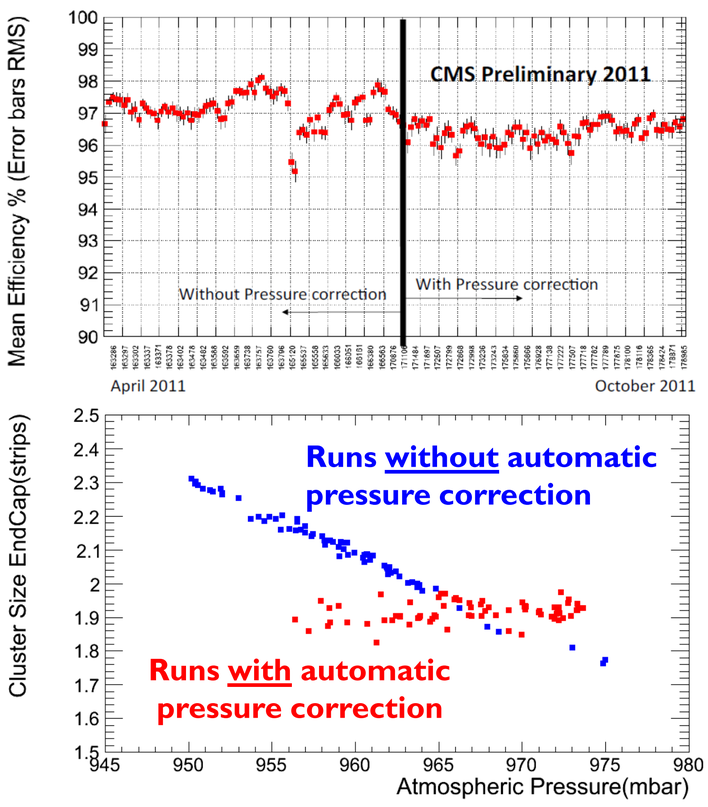
CMS Operation Requirements

Efficiency > 95%	Mean cluster size ≤ 2 strips
Time resolution ≤ 3 ns	Rate capability ≥ 1 kHz/cm2
	Operation plateau > 300 V
	# Streamers < 10%

[1] CMS Collaboration, J. Instrum., vol. 3, p. S08004, 2008, doi:10.1088/1748-0221/3/08/S08004.
[2] L. Evans and P. Bryant, J. Instrum., vol. 3, p. S08001, 2008, doi:10.1088/1748-0221/3/08/S08001.
[3] CMS Collaboration, CERN-LHCC-97-032; CMS-TDR-003. (1997)
[4] R. Santonico and R. Cardarelli, Nucl. Inst. Meth. vol. 187, p. 377 (1981), doi:10.1016/0029- 554X(81)90363-3.
[5] M.Abbrescia et al., Nucl. Inst.Meth.A 359 (1995) 603.
[6] S.Costantini, et al., CMSIN-2010/002 (2010).

Detector Stability

Since July 2011 automatic temperature and pressure corrections.



Variation of the environmental pressure P and the temperature T inside the CMS cavern used to rescale effective voltage (Hv_{eff}):

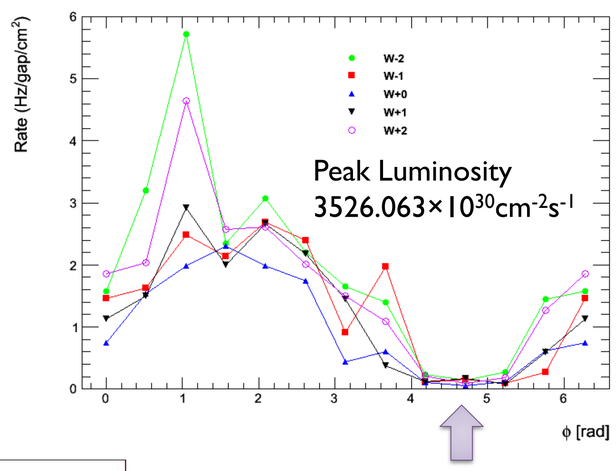
$$HV_{eff}(P,T) = HV \cdot \frac{P_0}{P} \cdot \frac{T}{T_0}$$

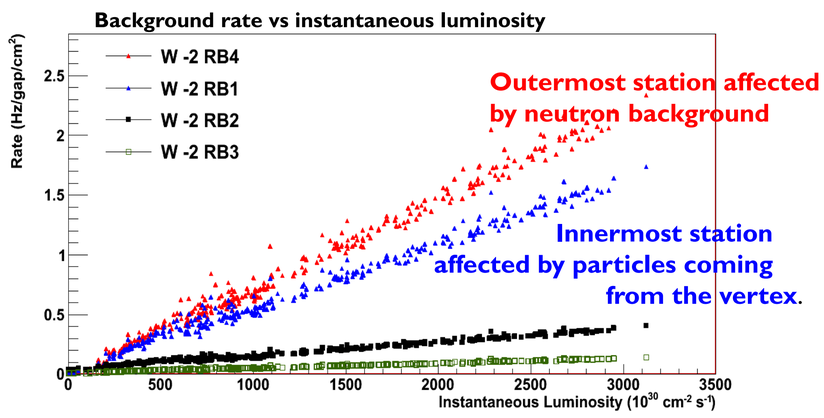
reference values:
P_0 = 965 mbar and T_0 = 293 K.

In 2011 proton-proton data, an increased stability, with reduced fluctuations is observed in cluster size and efficiency studies, after the correction is applied.

Radiation Background

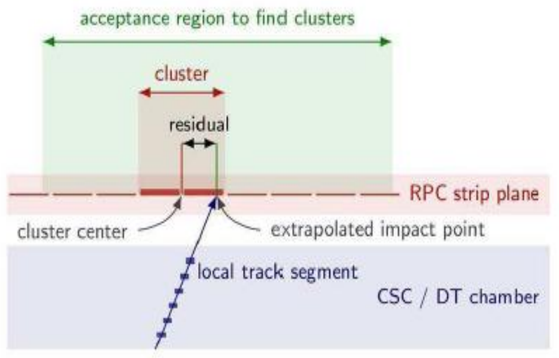
Radiation background levels are an important parameter for the overall performance of the system. High background levels could affect negatively RPC trigger performance Radiation background is studied as function of R, Z and ϕ as well as function of increasing luminosity. Results are in good qualitative agreement with the other two muon subsystems (DT and CSC).





Radiation background, for a given run, as function of ϕ, for all Barrel wheels (W-2 - W+2.) Bottom sectors are less affected by neutron background due to the cavern floor shielding.

Working Point Calibration: HV Scan

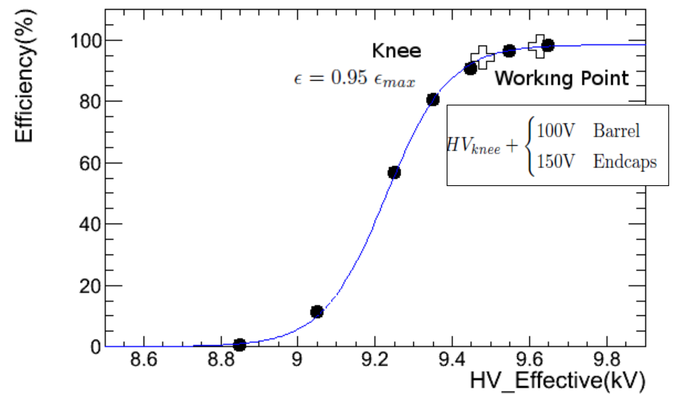


Efficiency Calculation Method

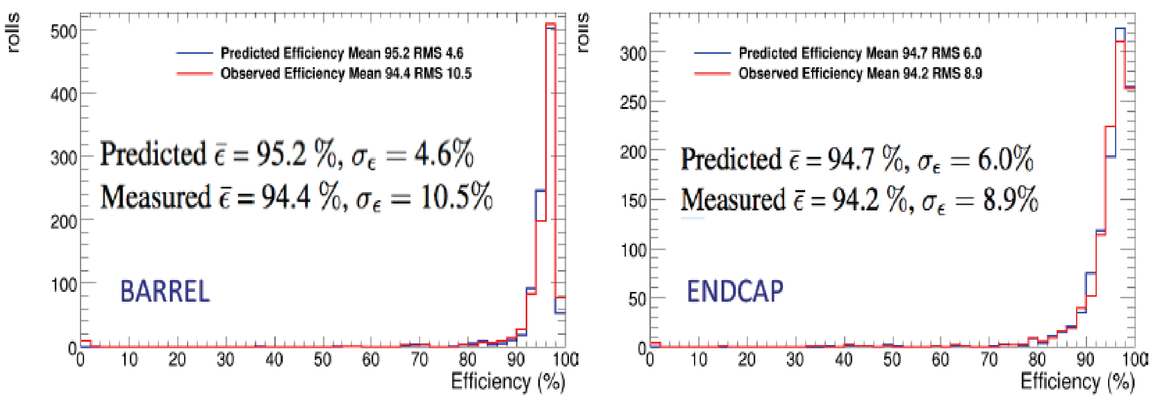
- Linear extrapolation of every track segment in DTs and CSCs toward the associated RPC strip plane
- matched to the cluster (a strip or a set of contiguous strips) closest to the extrapolated impact point

This method provides both a measure for the **efficiency** and, through the **residuals,** for the spatial resolution.

$$\epsilon = \frac{\epsilon_{max}}{1 + e^{-s(HV_{eff} - HV_{\epsilon=\frac{\epsilon_{max}}{2}})}}$$

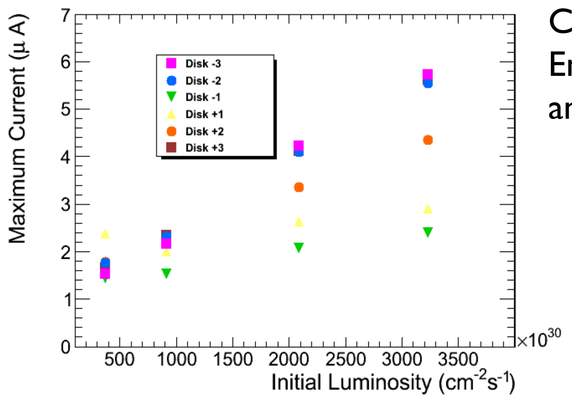


A high voltage scan was performed during early 2011 collision data was recorded at 11 different HV settings during a series of dedicated runs to define the optimal operating voltage for each chamber.

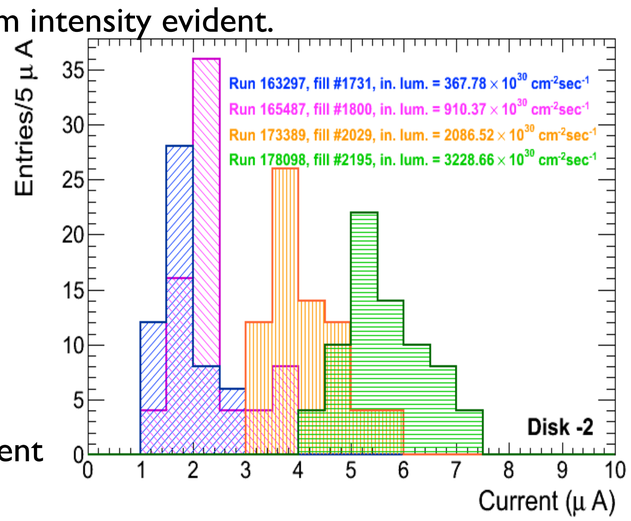


Study is being repeated for 2012 operation.

Current vs. Luminosity



Current distribution shift vs. luminosity for a single Endcap station (Disk-2). Correlation between current and beam intensity evident.



Maximum current registered for each Endcap station vs. Luminosity.
8-fold increase luminosity →4μA increase in current

Conclusions: Overall Performance in 2011

Data loss for RPC	19 pb^{-1} – 0.37%
Overall operating channels	98.4%
Average efficiency	95%
Average cluster size	< 2
Average rate (3 ·10^{33} cm^{-2} s^{-1})	1.3 Hz/cm^2
Average intrinsic noise (no-beam)	~ 0.1 Hz/cm^2
Average current (no-beam)	~ 1 μA
Average current (with beam)	~ 1.5 μA
Temperature	< 21.5 °C