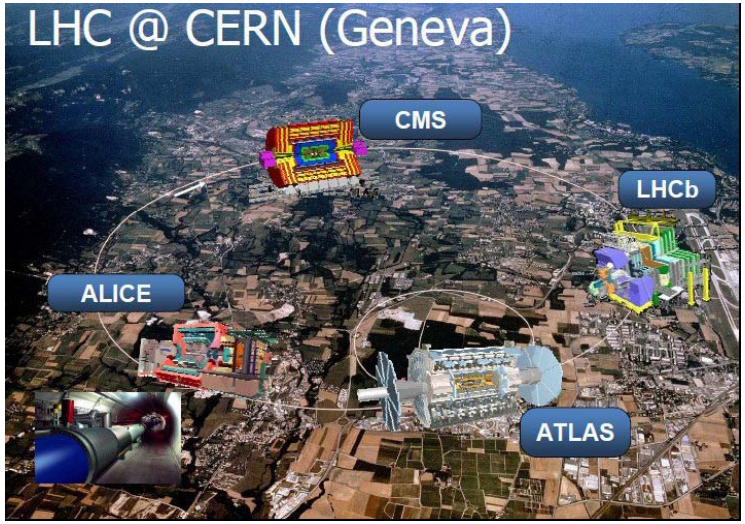
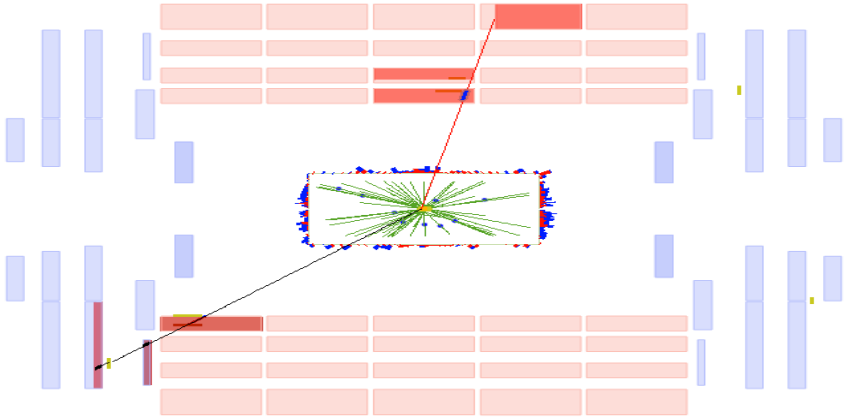
Calibration of the RPC working voltage in the CMS experiment



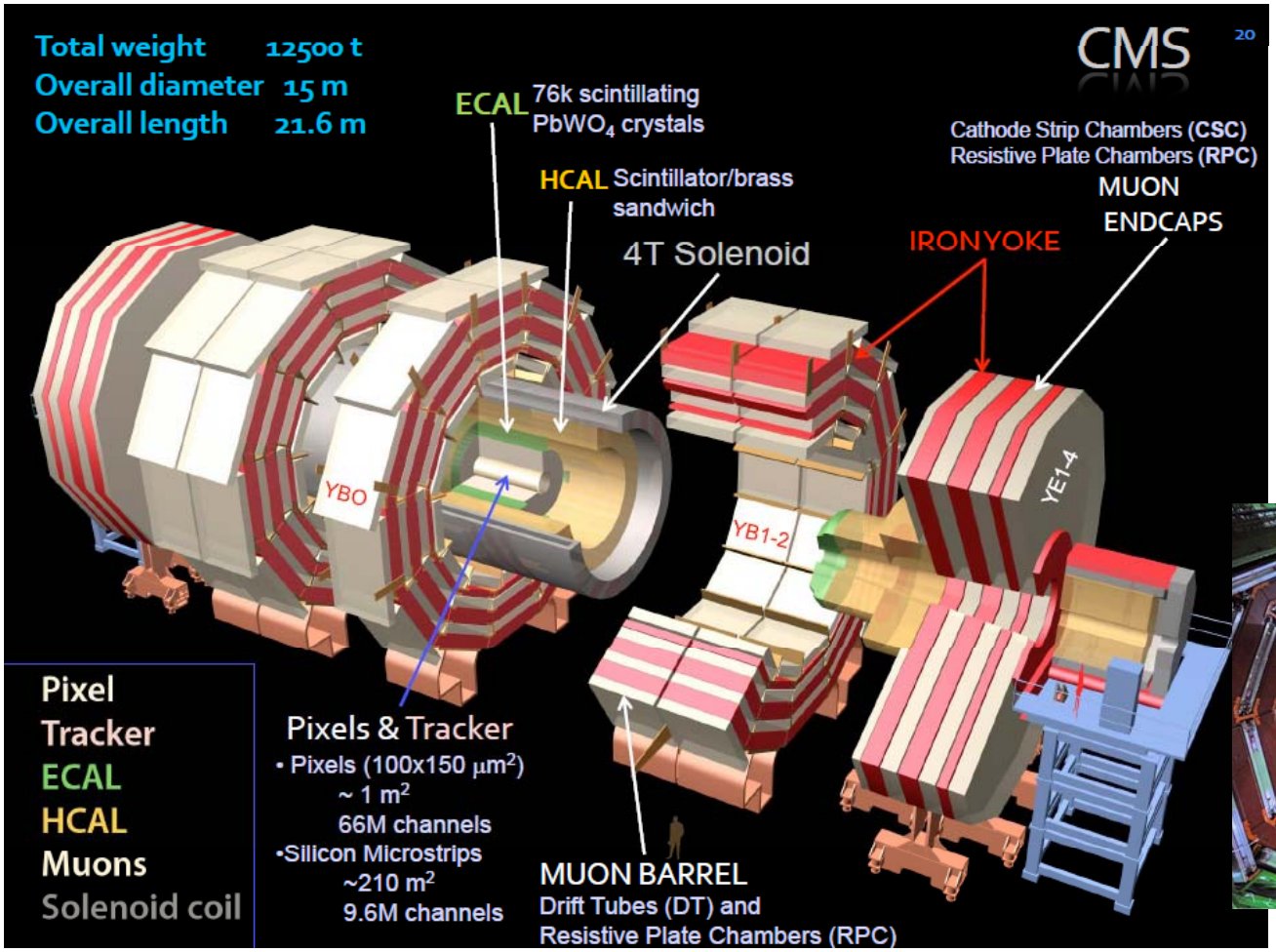


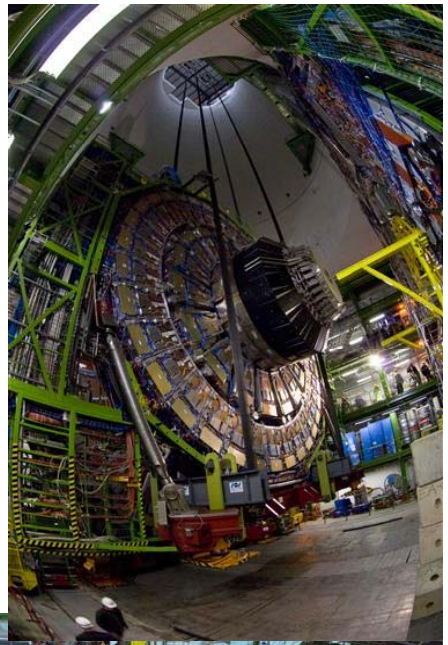
Silvia Costantini
Ghent University

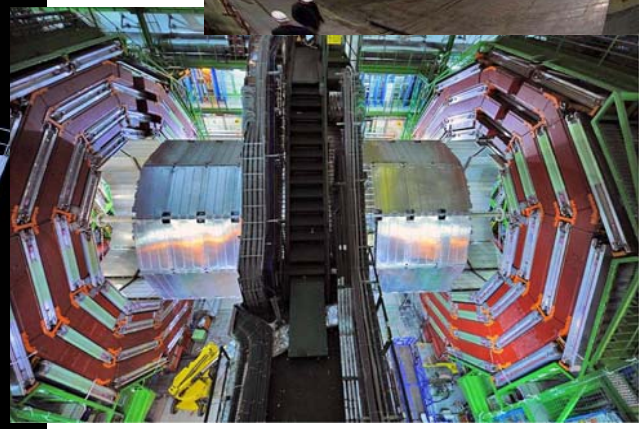
on behalf of the CMS Collaboration

The CMS Collaboration

~3400 scientists and engineers (including ~840 students) from 173 institutes in 40 countries







http://cms.cern.ch

LHC/CMS operations pp@√s=7TeV 2011

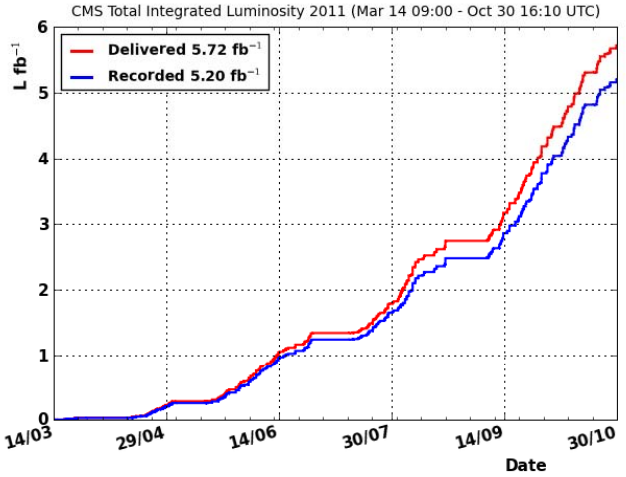
5.72 fb^{-1} delivered by LHC and **5.20 fb^{-1}** recorded by CMS

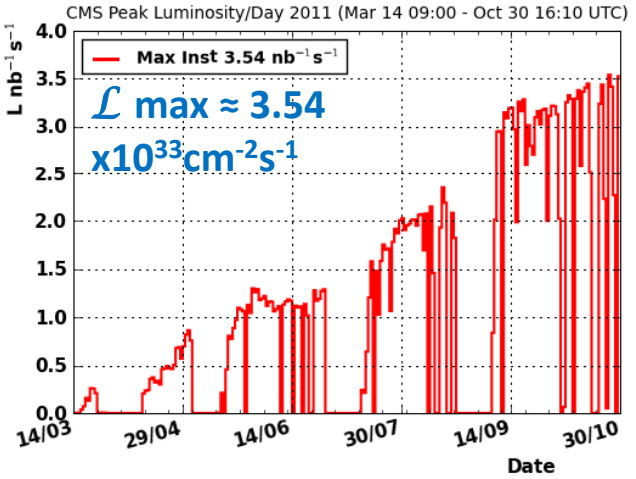
2010 @ 7 TeV : ~36 pb^{-1}

Overall data taking efficiency **~91%.**

Average fraction of operational channels per subsystem >98%

RPC	98.4
CSC	98.3
DT	99.4
HF	99.9
HE	100.0
HB	99.9
ES	95.9
EE	98.6
EB	99.1
STRIP	97.8
PIXEL	96.9





- **Instantaneous luminosity above $3.5 \cdot 10^{33}$ cm^{-2}s^{-1}**

Certified data for physics: **Golden 93%, Muon 96%**.

The CMS RPCs

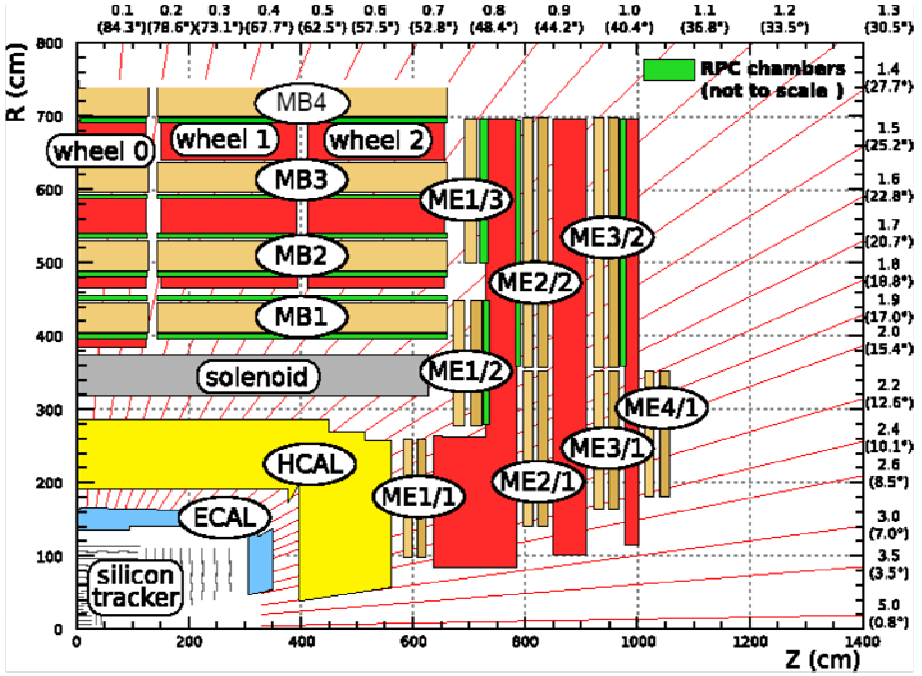
Dedicated trigger system both in the Barrel and in the Endcap

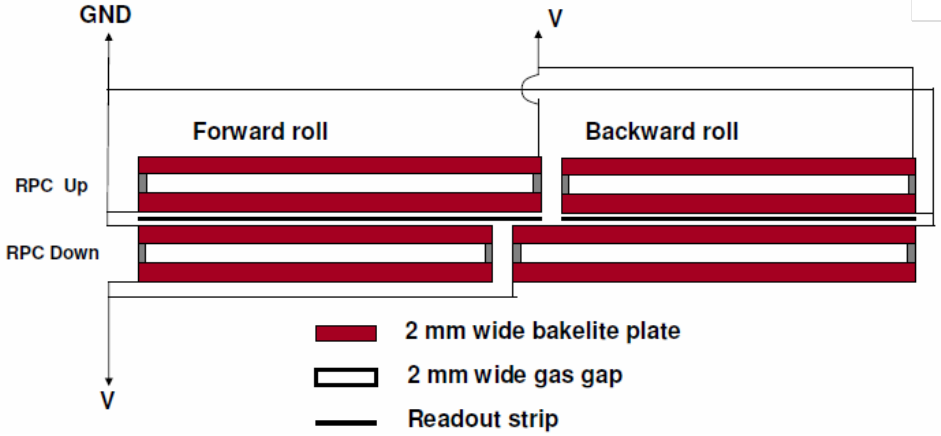
- Double gap chambers
- Single readout plane (strip)
- Operated in avalanche mode
- Gas mixture:
  - 95.2% $C_2H_2F_4$
  - 4.5% iC_4H_{10}
  - 0.3% SF_6
- HV:

-RPCs were operated at one HV in 2010

-Individual WPs chosen in 2011 (see later)

- Time resolution: ~ 3ns





912 = **480** Barrel chambers + **432** Endcap chambers

109608 = **68136** Barrel strips + **41472** Endcap strips

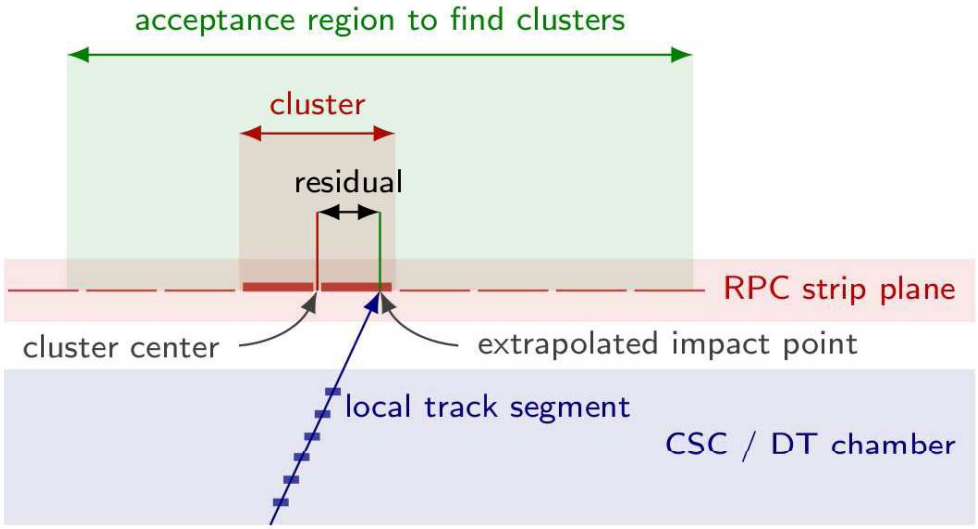
Coverage up to $|\eta| < 1.6$

$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$

Barrel and Endcap chambers have different geometries and have been built in different construction sites with different construction techniques

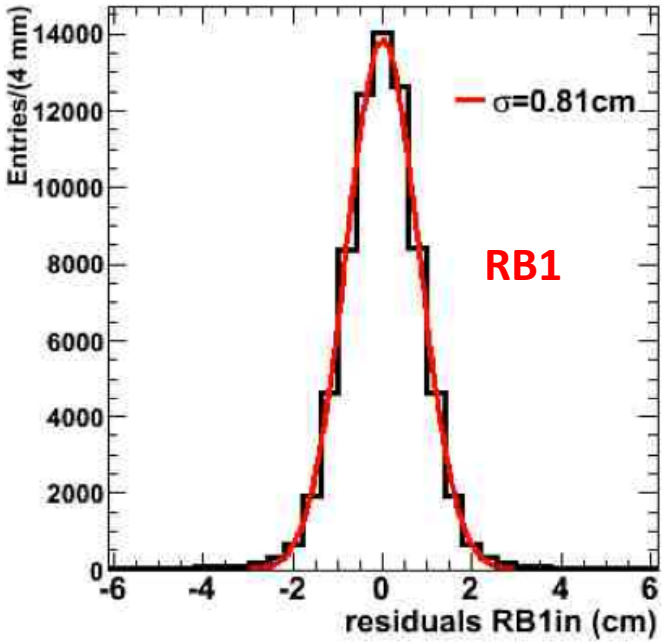
Resolution and Efficiency studies: the method

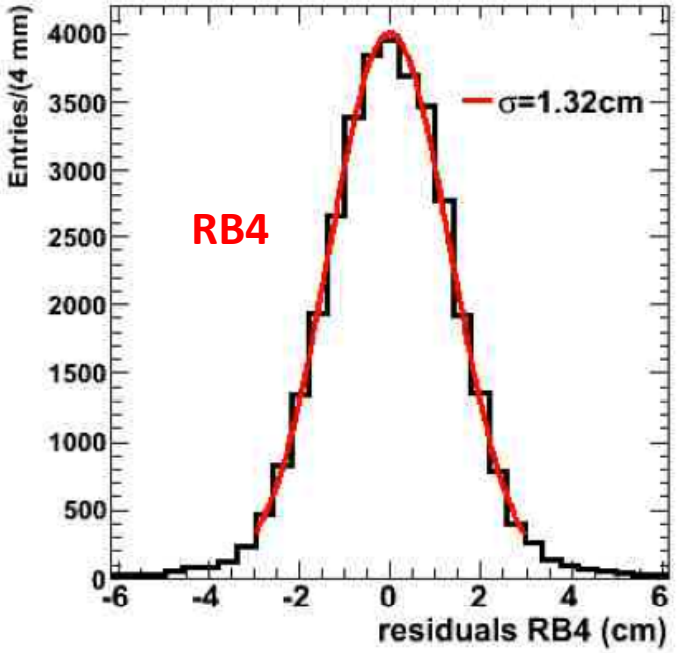
- The same method is used to measure the spatial resolution (through the residuals) and the efficiency
- DT/CSC reconstructed segments are extrapolated to RPC strip planes and used to measure the efficiency to find an RPC hit ("probe") in the acceptance region around the extrapolated point
- Efficiency defined independently of final physics "objects", making use of DT/CSC segments of muon tracks (as "tags")
- New method: only DT/CSC segments associated to track hits are used



Spatial resolution

- In the range 0.8 – 1.3 cm, both for Barrel and Endcap
- Increasing with increasing strip pitch values, from the inner to the outer detector layers





HV Scan

- One of the main RPC efforts in 2011
- **Define the optimal operating HV for each chamber**

- 11 HV points: 8.5 - 9.7 kV with HV(P,T) correction already applied:

$$HV\_effective = HV \cdot P_0/P \cdot T/T_0$$

$(P_0 = 965$ mbar, $T_0 = 293$ K)

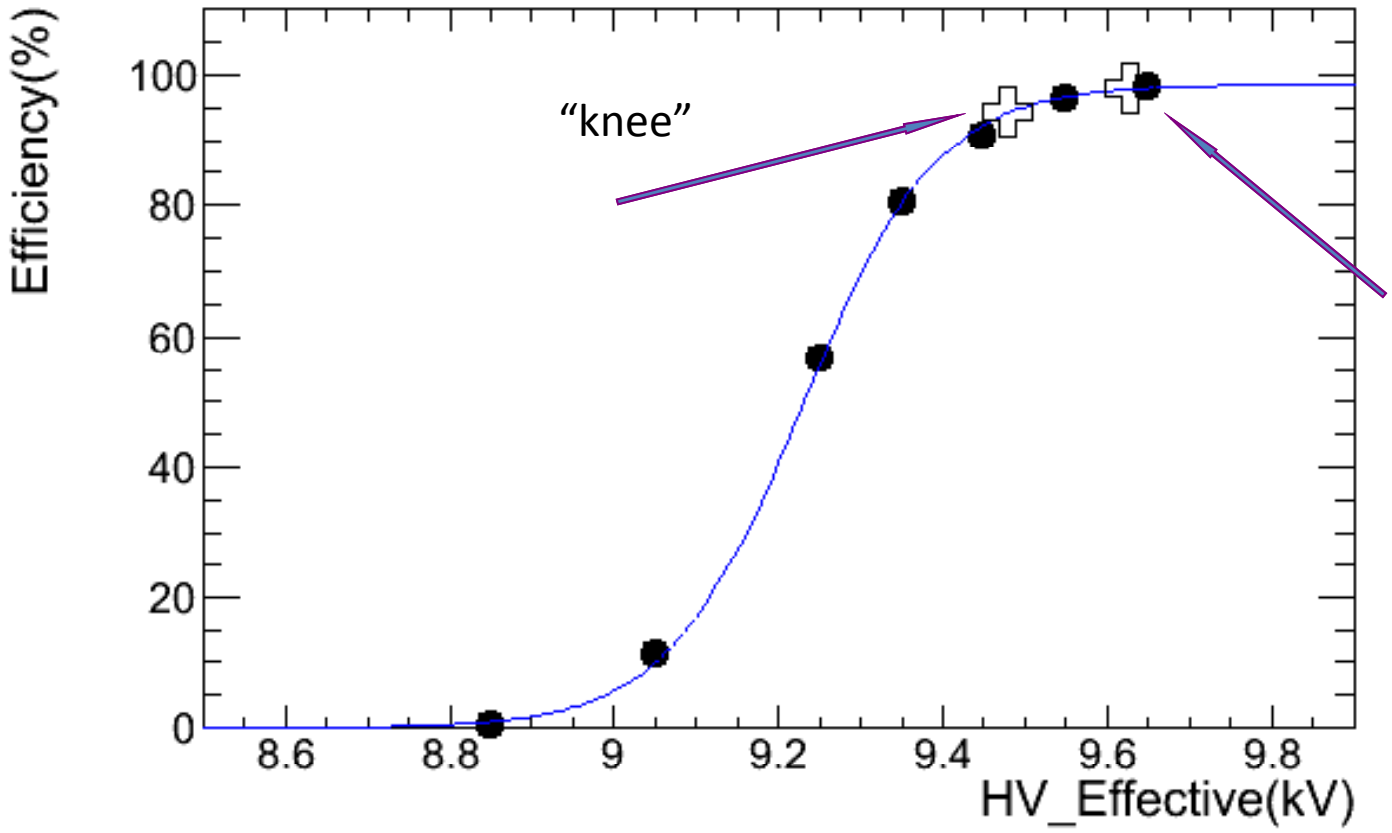
Example: ~10 mbar ←→ ~1% P variation ←→ ~ 100 V difference

- Efficiency dependence on HV: sigmoidal shape

$$\epsilon = \frac{\epsilon_{\max}}{1 + e^{-\lambda(HV_{eff} - HV_{50\%})}}$$

Example: P > P0 → HV_eff < HV → lower efficiency, lower cluster size

Efficiency vs. HV_Effective
Typical RPC (endcap) chamber



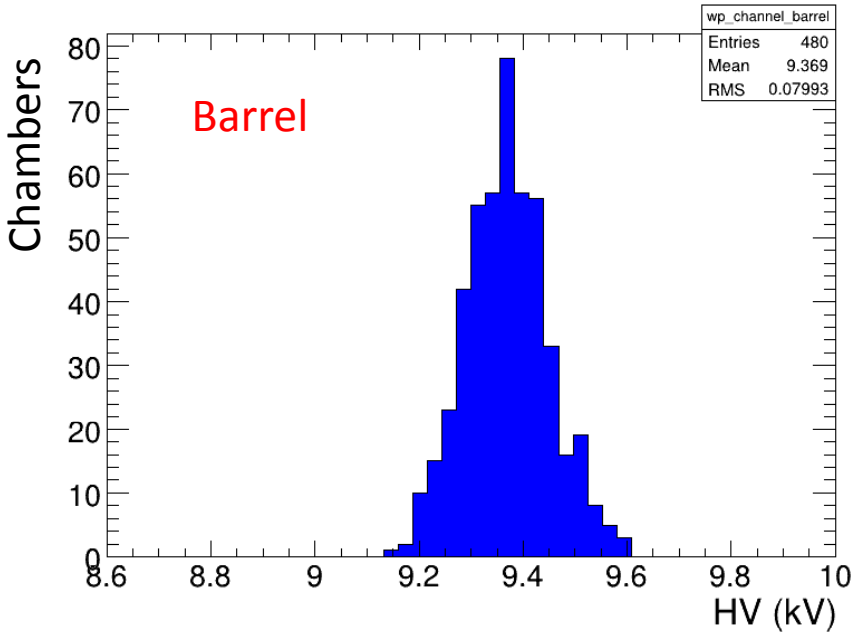
Working Point

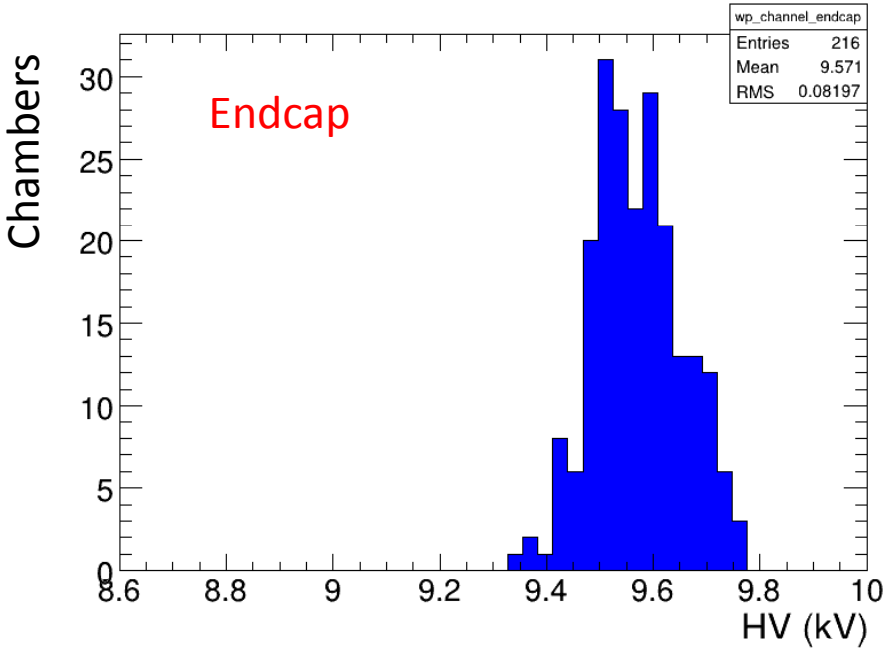
WP = knee +
100 V (barrel)
150 V (endcap)

- "knee": HV where 95% of the asymptotic efficiency value is reached
- Working Point (WP) can be defined taking into account the trigger algorithms in the barrel and endcap

Working Points for Barrel and EndCap

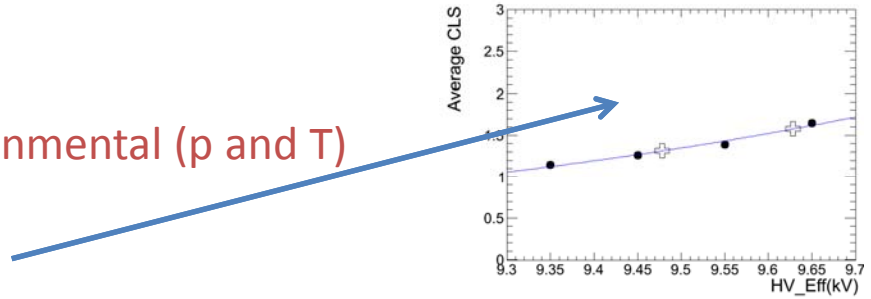
Note: since different chambers are fed by the same HV channel, a procedure of "averaging" in choosing the WPs was applied





Working Point has to be chosen carefully:

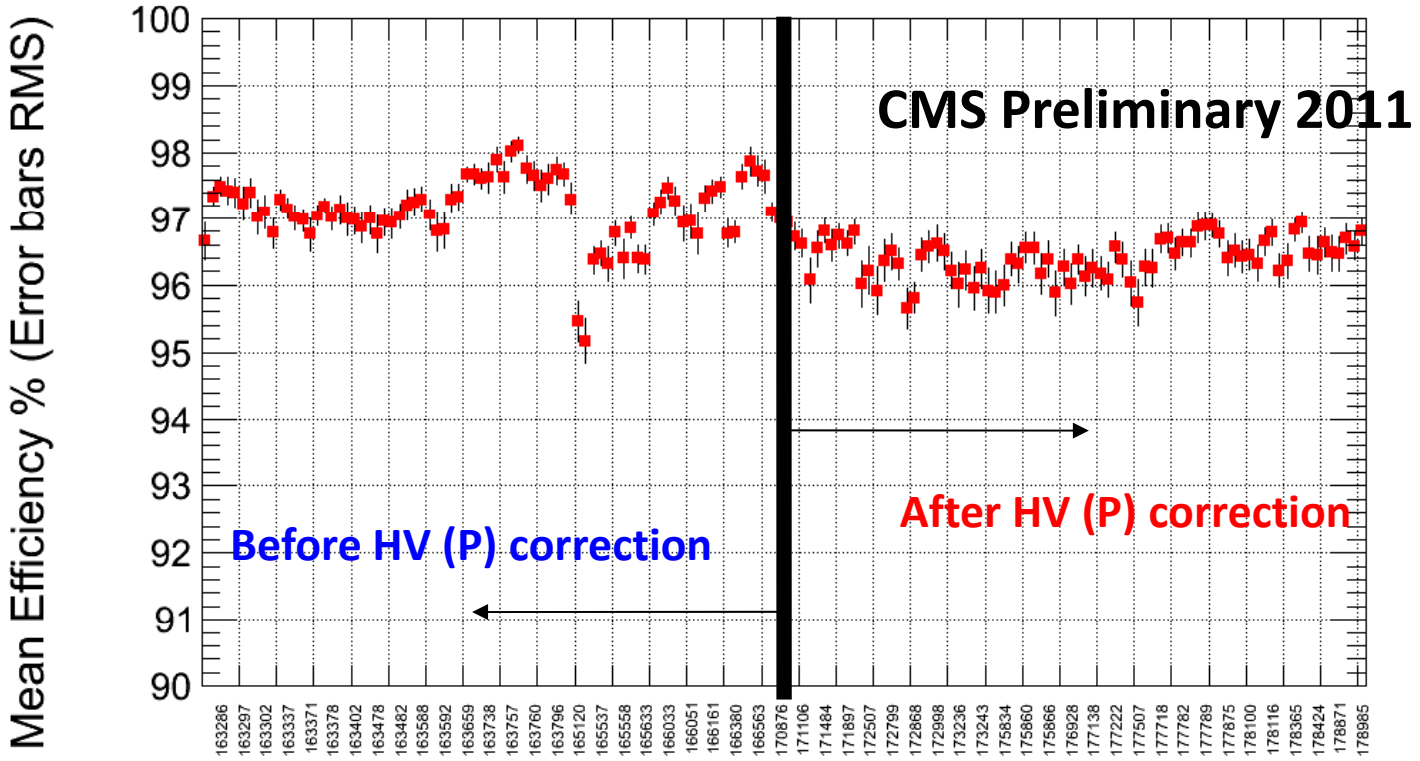
a. Beyond the knee to assure high efficiency
b. In the plateau to be less sensitive to environmental (p and T) variations;
c. Not too high not to increase cluster size



Data taking details

- Negligible amount of data loss due to RPC HV calibration: ~3 pb^{-1} out of **5.72 fb^{-1}**
- Each point has needed only ~30' of low-luminosity collision data (**10^{30} - 10^{31} $cm^{-2}s^{-1}$**)
- Dedicated data stream ('RPC Monitoring stream") containing ad-hoc info from RPC, CSC, DT and L1 trigger (RPC Digis and RecHits, DT Digis and 4DSegments, CSC 4DSegments, L1 Regional Candidates, L1 GMT), with negligible event size

RPC average Hit Efficiency vs. time
Efficiency stability (Barrel)



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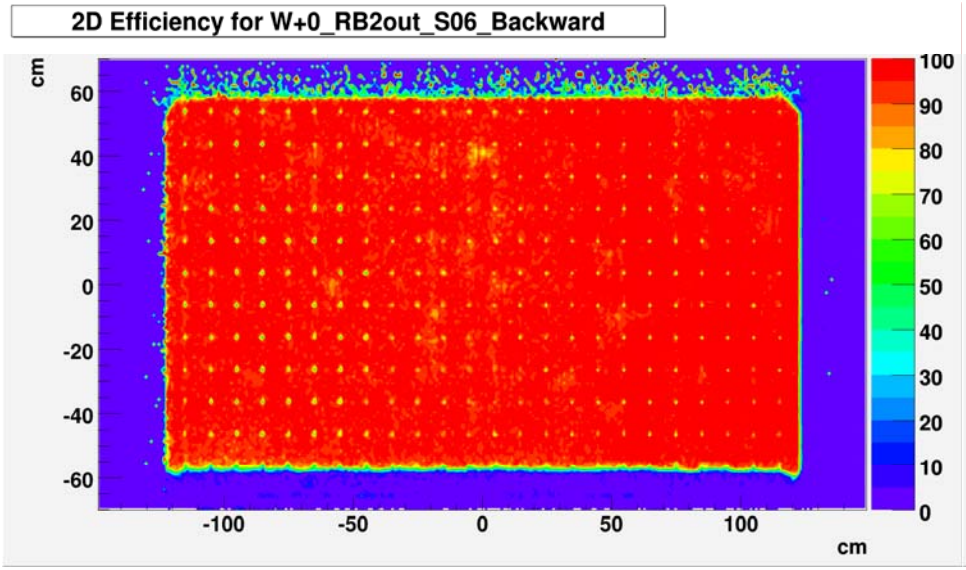
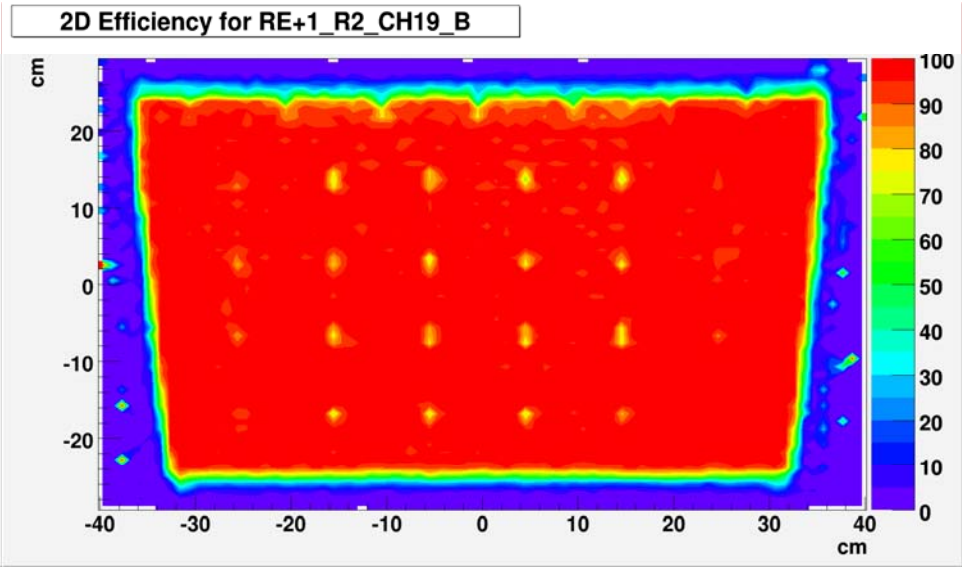
- After HV(P) correction: fluctuations reduced to ± ~0.5 %.
- Stability vs. time and pressure
- Chambers with known hardware problems are excluded
- New method under validation: results are preliminary

Efficiency uniformity

- Local efficiency maps, left: Barrel chamber, right: Endcap chamber
- Low efficiency points correspond to the location of the spacers in the gas gaps

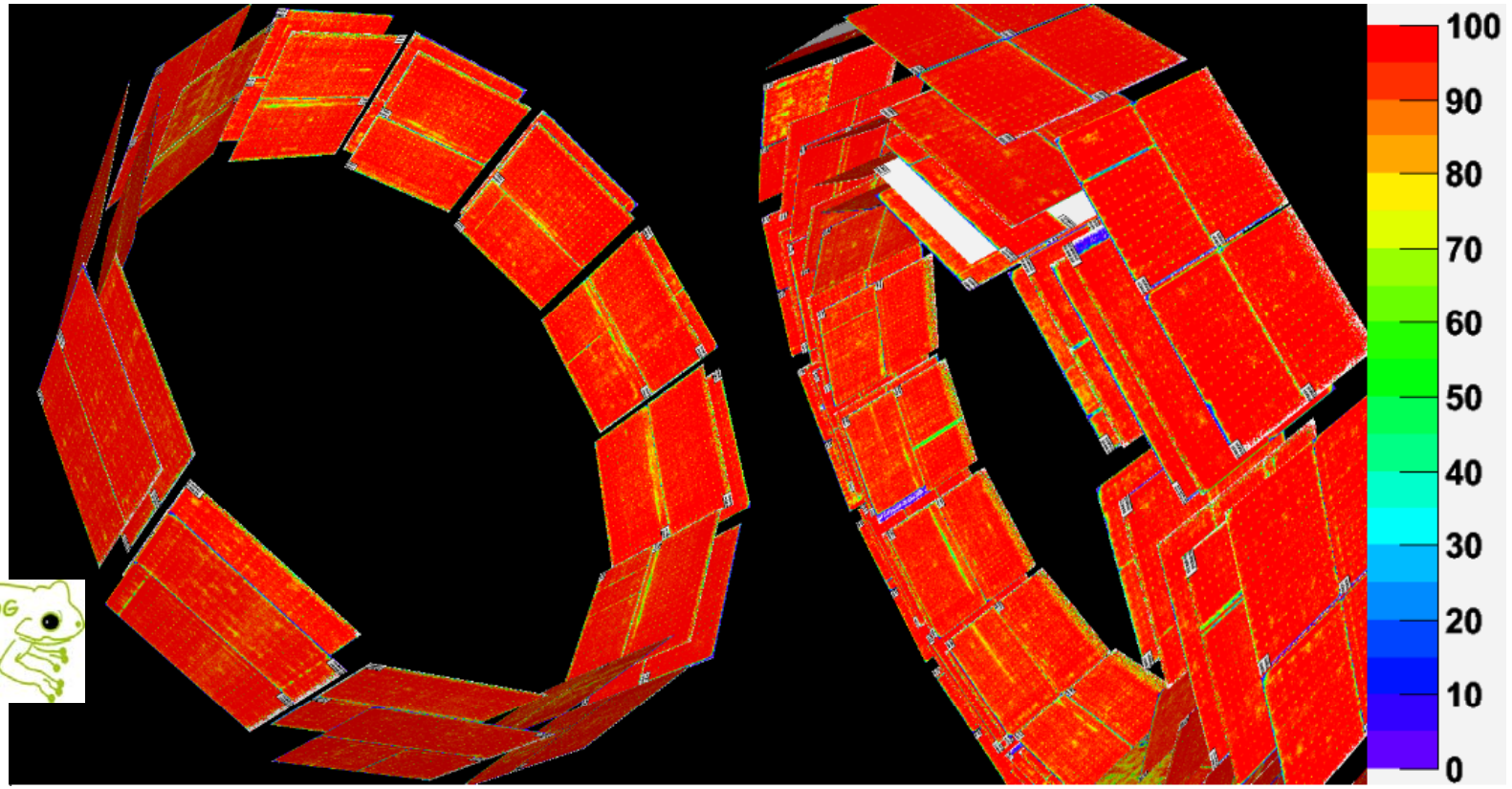




3D efficiency maps

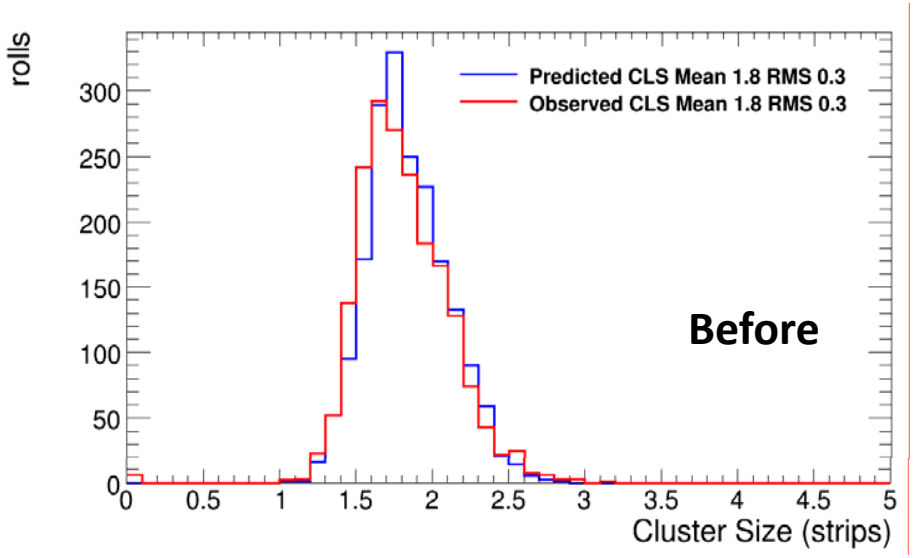
CMS Preliminary 2011

- Left: Barrel Wheel, 2 innermost radial layers
- Right: Barrel Wheel, 5 radial layers (except RB4)

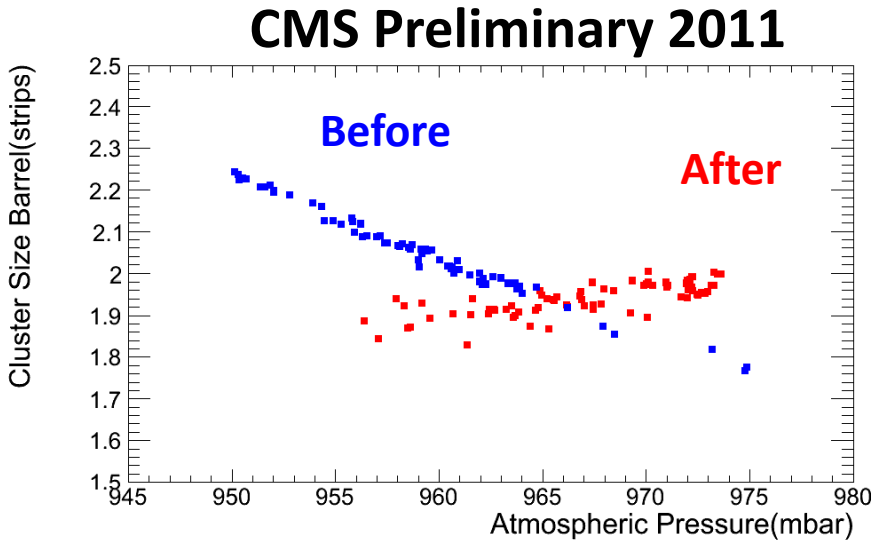


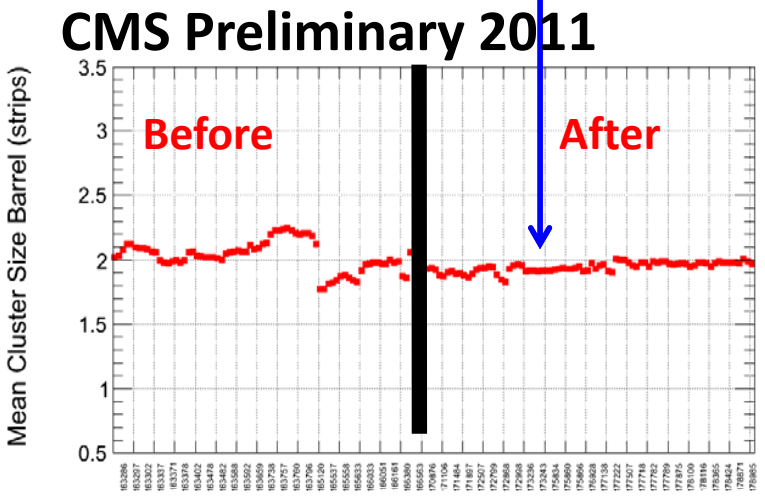
Yellow lines: joints in-between double gaps.
Lower efficiency regions due to masked or dead strips are shown in blue/yellow.
Chambers off are represented in white.

Automatic HV(P) correction: cluster size stability



- Top: Cluster size at WP, before correction
- Bottom: comparison Before/After for Barrel
- Correction performed from July 2011
- HV dependence on P automatically taken into account





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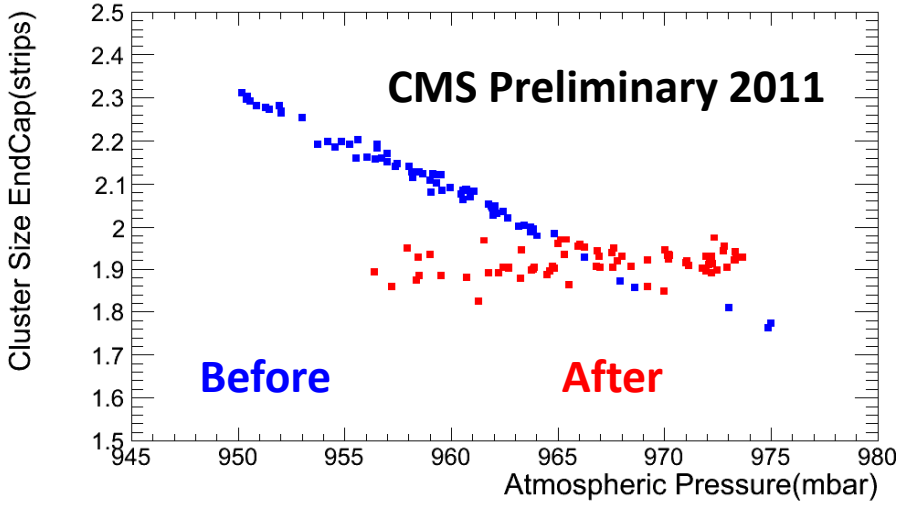
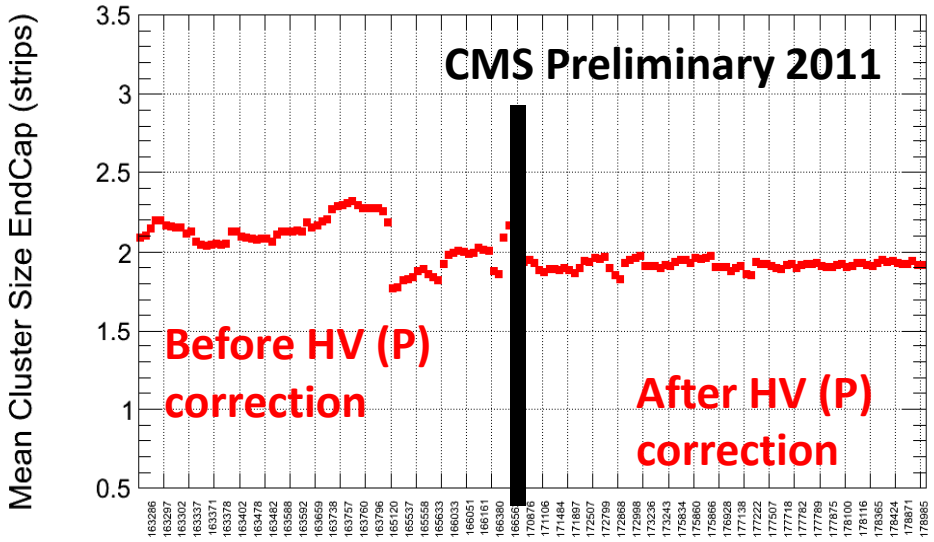
Cluster Size stability: Endcap



Blue: Runs without automatic HV(P) Correction

Red: Runs with automatic HV(P) correction

- The system is more stable after the automatic HV (P) rescaling
- Hint of over-correction?



April 2011 October 2011

Summary and outlook

- HV scan has been extremely effective: optimal operating HV for each chamber
- Will be performed again in 2012 (only 3 pb^{-1} lost in 2011)

- New method for calculating the efficiency
  - Average efficiency ~ **95%-96 %** (results are still preliminary)
  - Efficiency stable w.r.t. pressure and time

- Automatic HV(P) correction in place since July 2011
  - Before HV(P) correction: ±**1%** efficiency fluctuations due to pressure variation in the CMS cavern.
  - After HV(P) correction: efficiency fluctuations reduced to ± ~**0.5%**