"First results on the CMS RPC system using the 2007 and 2008 cosmic ray data "

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on behalf of the CMS RPC Collaboration

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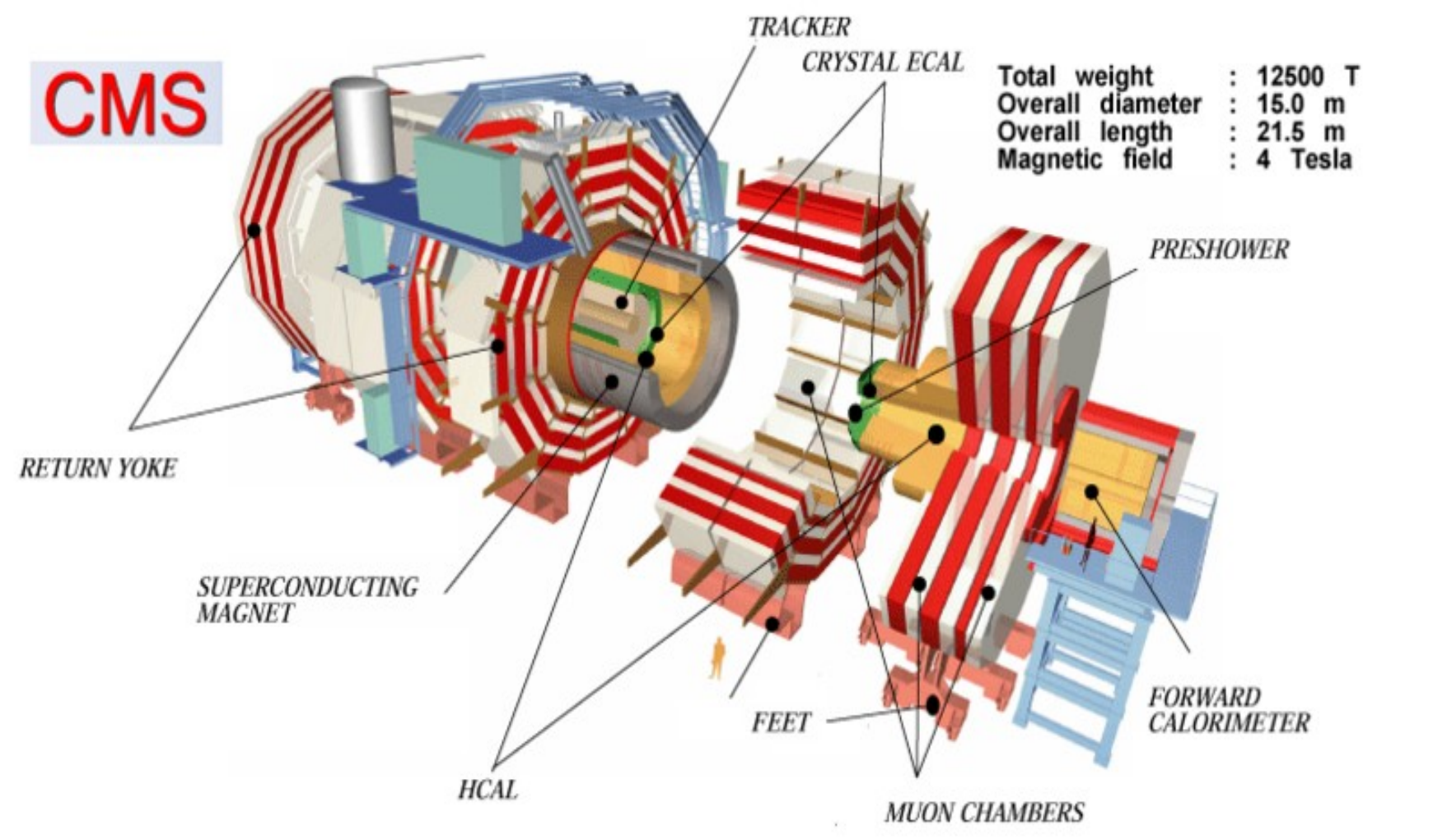
INFN Sezione di Napoli
Università degli Studi di Napoli "Federico II"

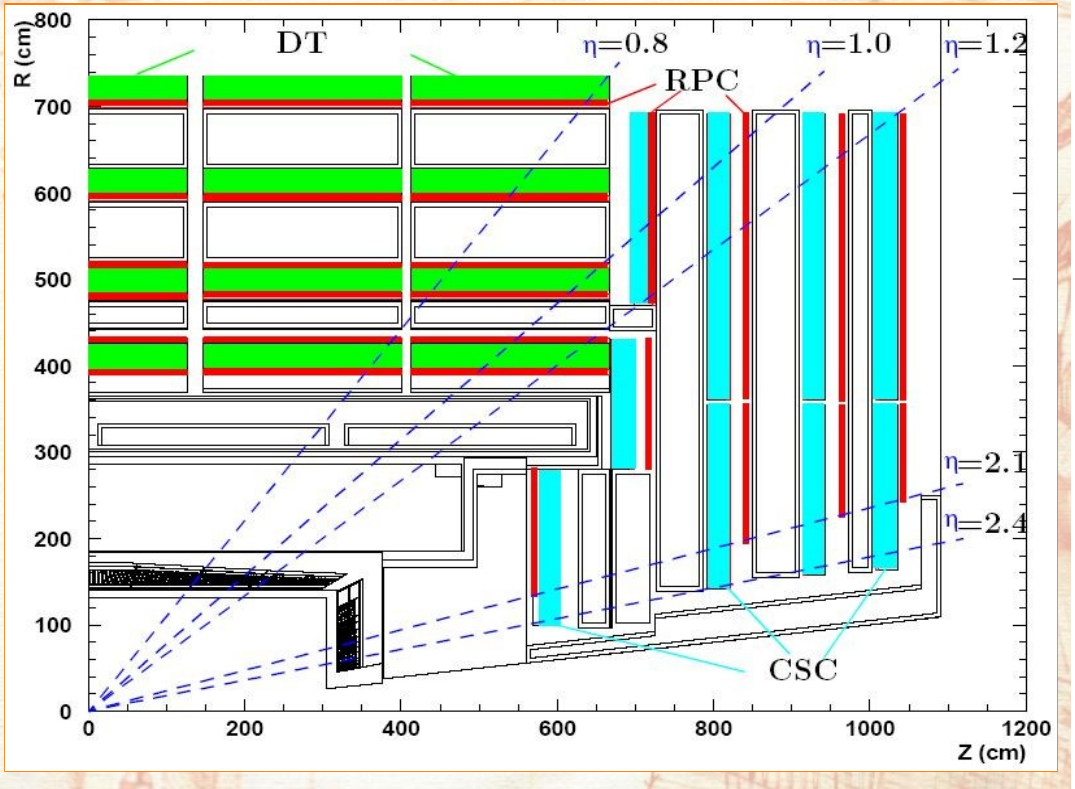
CMS Detector



The Muon System

- The **muon system** must fulfill the job of: muon trigger and identification and momentum measurement

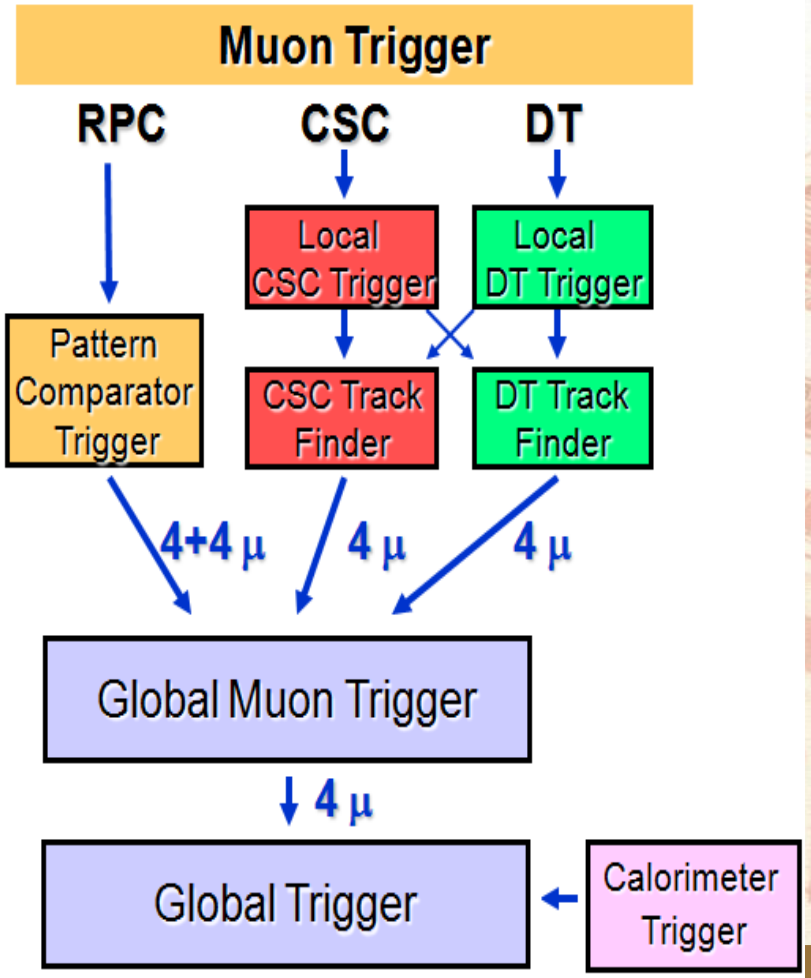
Barrel and Endcap angular coverage



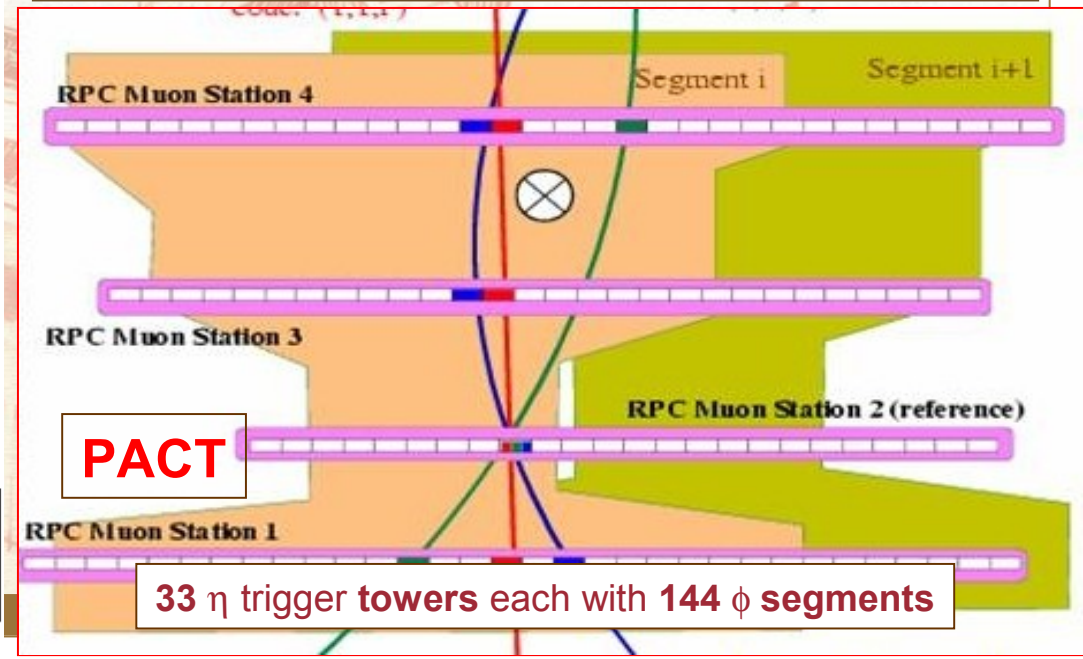
- **250 DTs** are installed in the barrel, where the track occupancy and the residual magnetic field are low.
- In the endcaps, **540 CSCs** are installed to cope with high particle rates and large residual magnetic field
- Trigger redundancy is assured by the use of **RPCs** in both sections of the detector **(480+432)**.

The Muon Trigger

- **Muon Trigger:** combination of fast trigger detector (RPC) and precise spatial resolution detectors (DT and CSC)

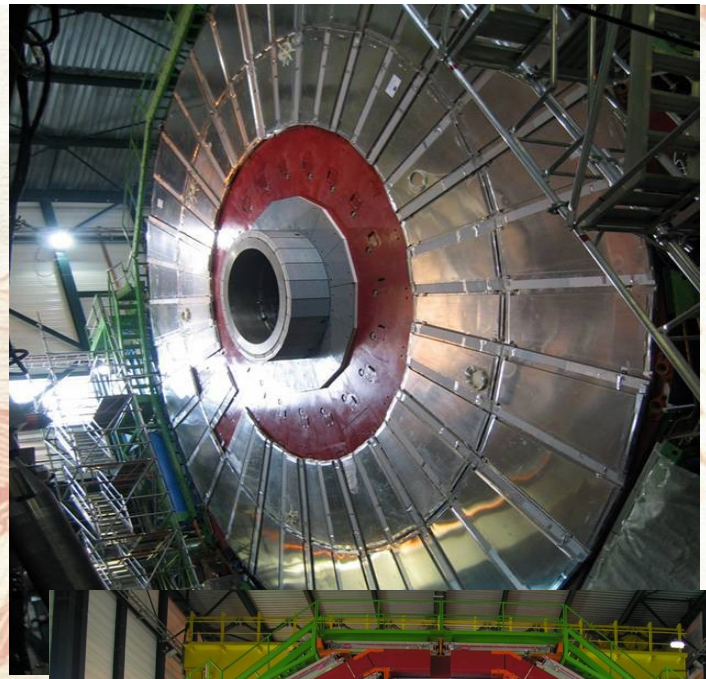


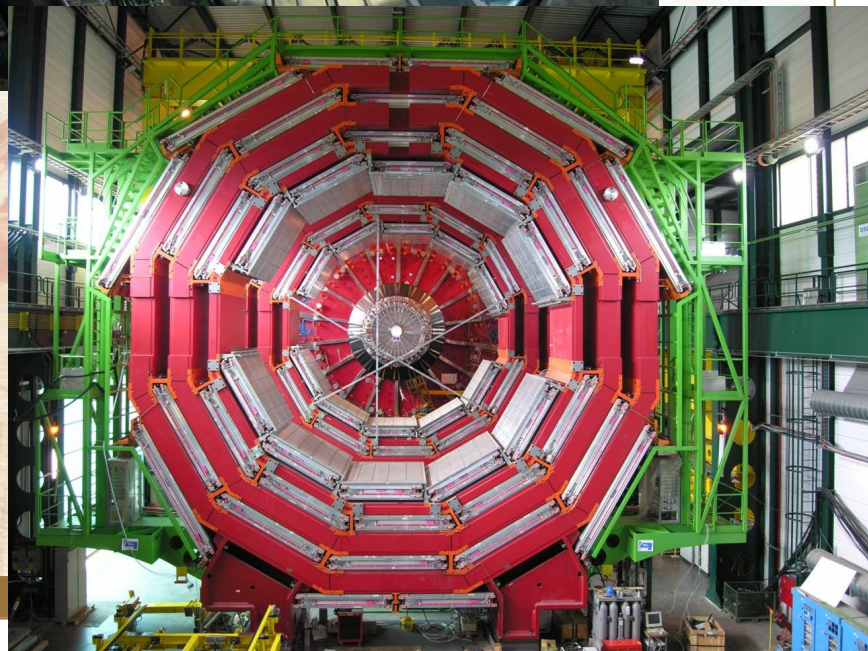
The **RPC PACT** is based on the spatial and temporal coincidence of hits in 3 (low quality) or 4 (high quality) RPC muon stations. The pattern of hit strips is then compared to predefined patterns corresponding to various p_T



The CMS RPC system

- The **RPC system** confers robustness and redundancy to the muon trigger.
- 6 layers of RPCs are embedded in the barrel iron yoke closely following the DT segmentation. The layers are dodecagons with 2π coverage. The chambers are rectangular and strips run parallel to the beam
- The forward region is instrumented with four layers of RPCs covering up to η= 2.1. The chambers have trapezoidal shape and the strips run along the radial direction.
- **A total of 480 + 432 RPC chambers at startup.**



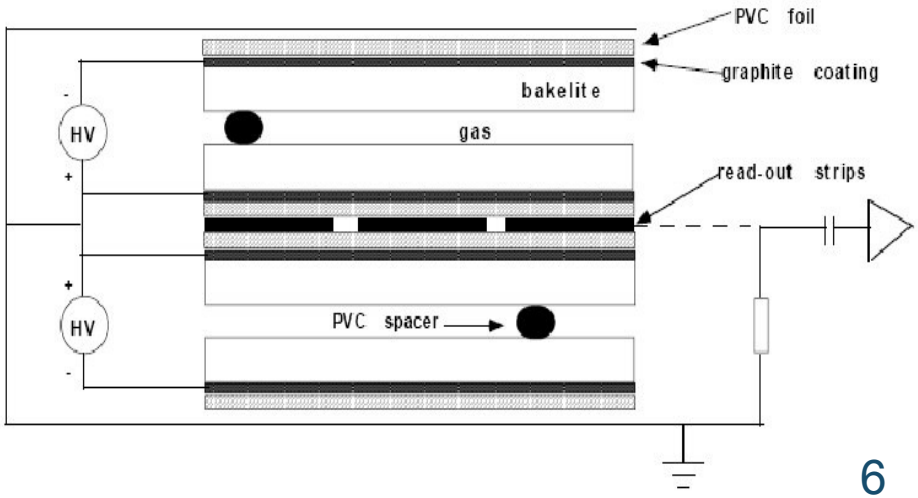


The CMS RPC system

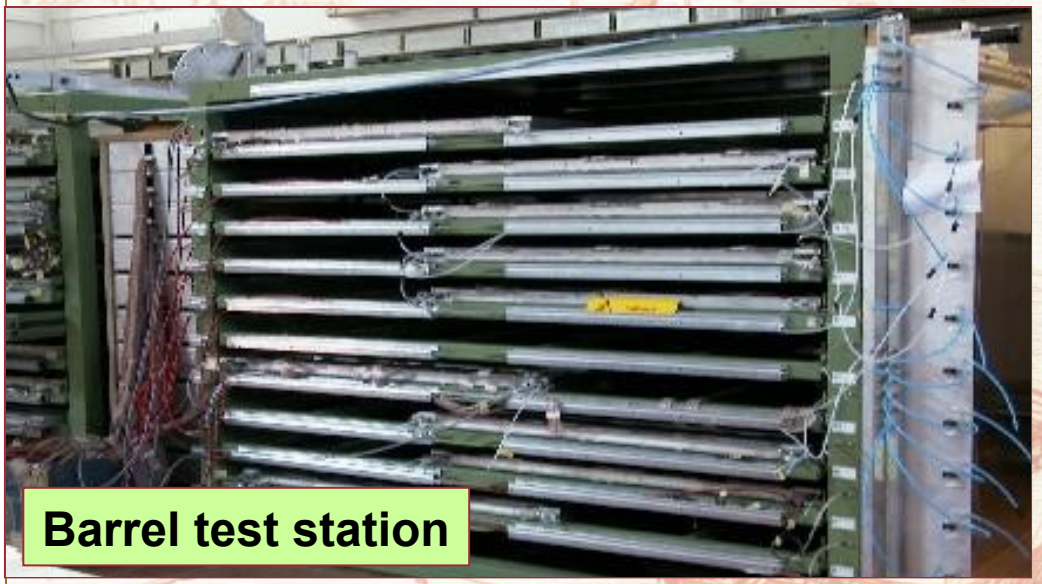
- Double gap design
- 2mm gaps
- Common pick-up aluminum strips between the gaps (~96/chamber)
- Bakelite resistivity 10^{10} Ωcm
- Operated in avalanche mode (Operating HV = 9.2kV)
- Used gas mixture: 96.2% $C_2H_2F_4$, 3.5% i–C_4H_{10}, 0.3% SF_6.

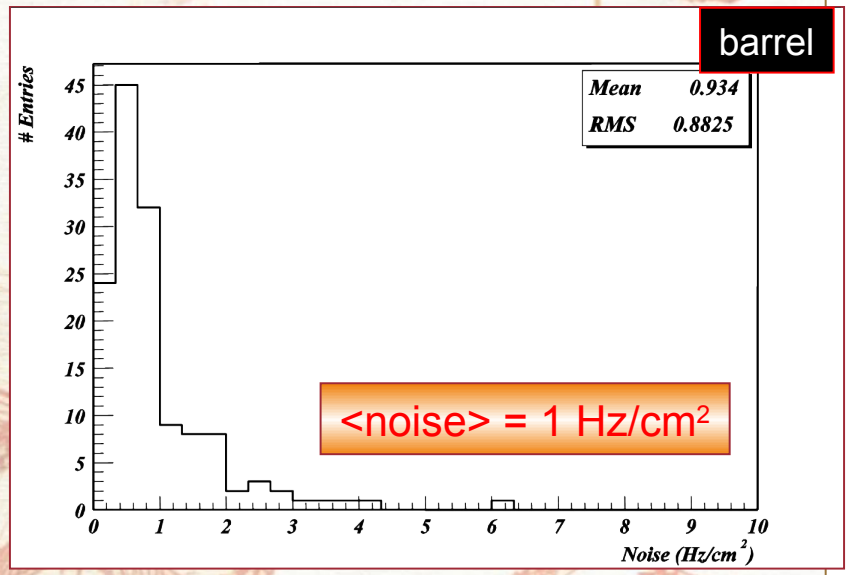
CMS requirements for RPCs

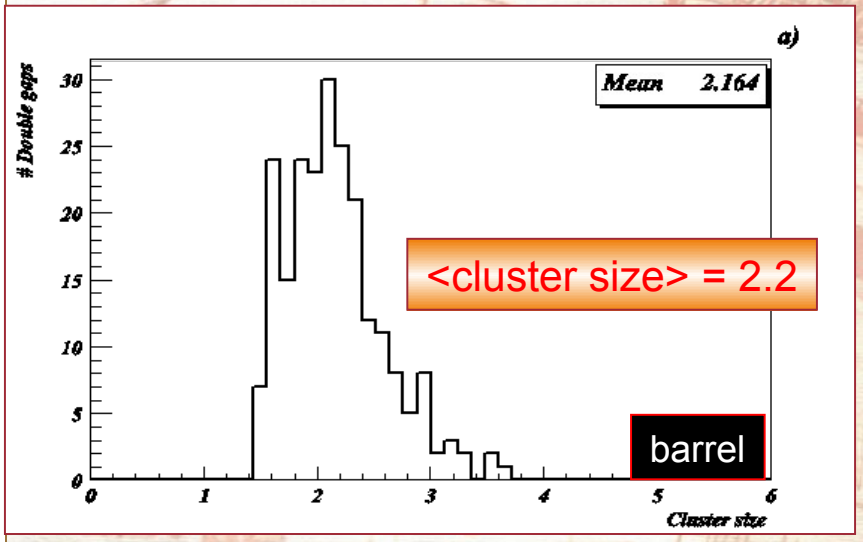
Efficiency	> 95%
Time resolution	≤ 3 ns
Average cluster size	≤2 strips
Rate capability	≥ 1 kHz/cm^2
Power consumption	< 2-3 W/m^2
Operation plateau	> 300 V
# Streamers	< 10%

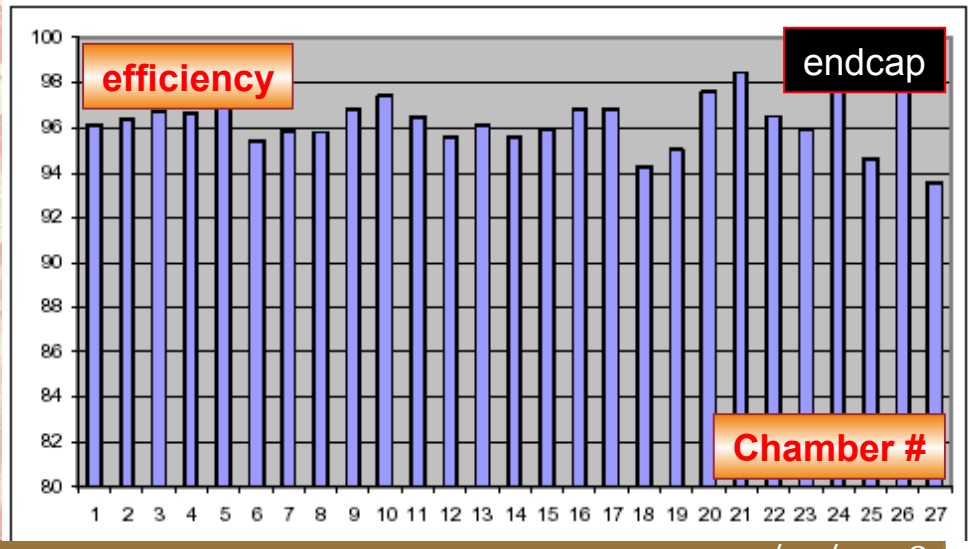


RPC production & test









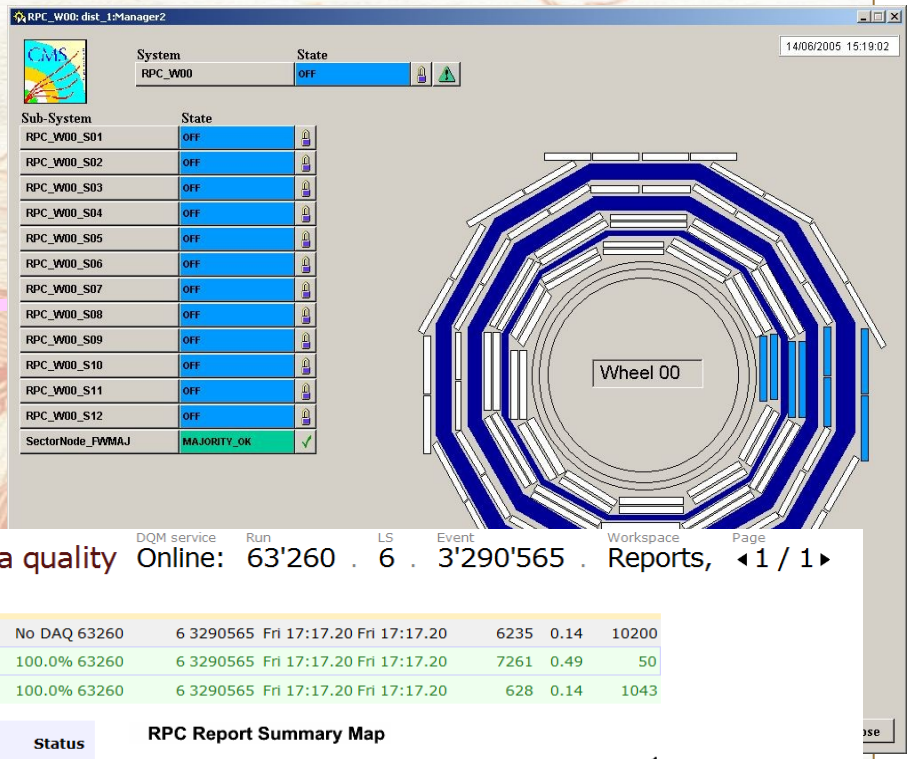
Monitoring software
DCS & DQM systems

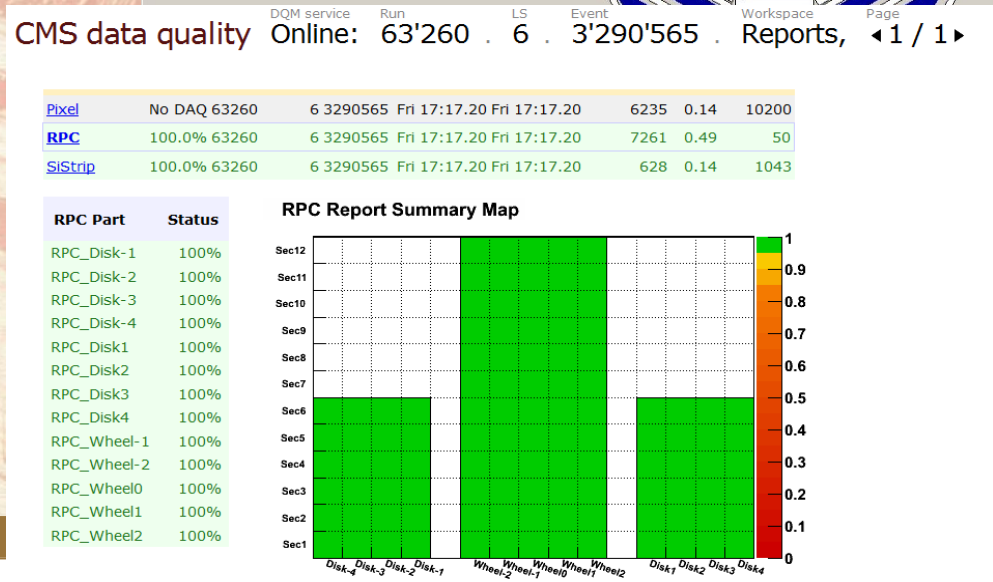
- The **Detector Control System** (DCS) is responsible for controlling and monitoring detector services and environmental variables, takes actions to maintain the detector stability and ensures high quality data
- For RPCs:HV (~ 900 channels) and LV (~1800 channels) systems, environmental parameters (320 T sensors) Gas system (~20 sensors) -> 10k datapoints .

The **Data Quality Monitoring** (DQM):
-data consistency and quality
-correct detector functioning (on/off line)

RPC DQM: A set of dedicated tasks monitor all information about the detector necessary to promptly spot problematic channels

- Occupancy, cluster size and multiplicity, synchronization, efficiency, data integrity, etc.
- >10k histograms on web GUI
- A hierarchical structure divides shifter (summary) from expert histogram layouts for refined analysis.

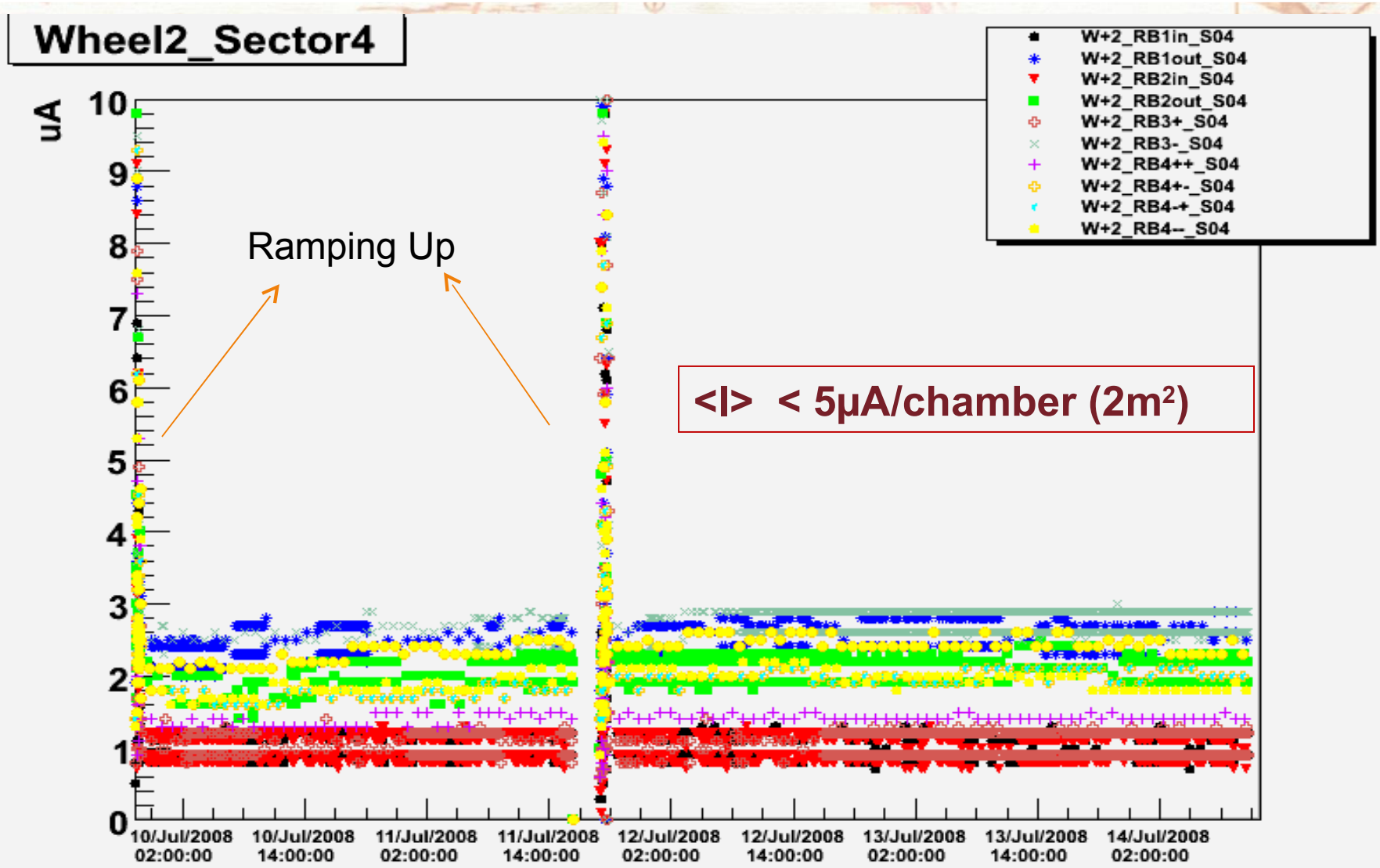




Data Taking with Cosmics 2007/2008

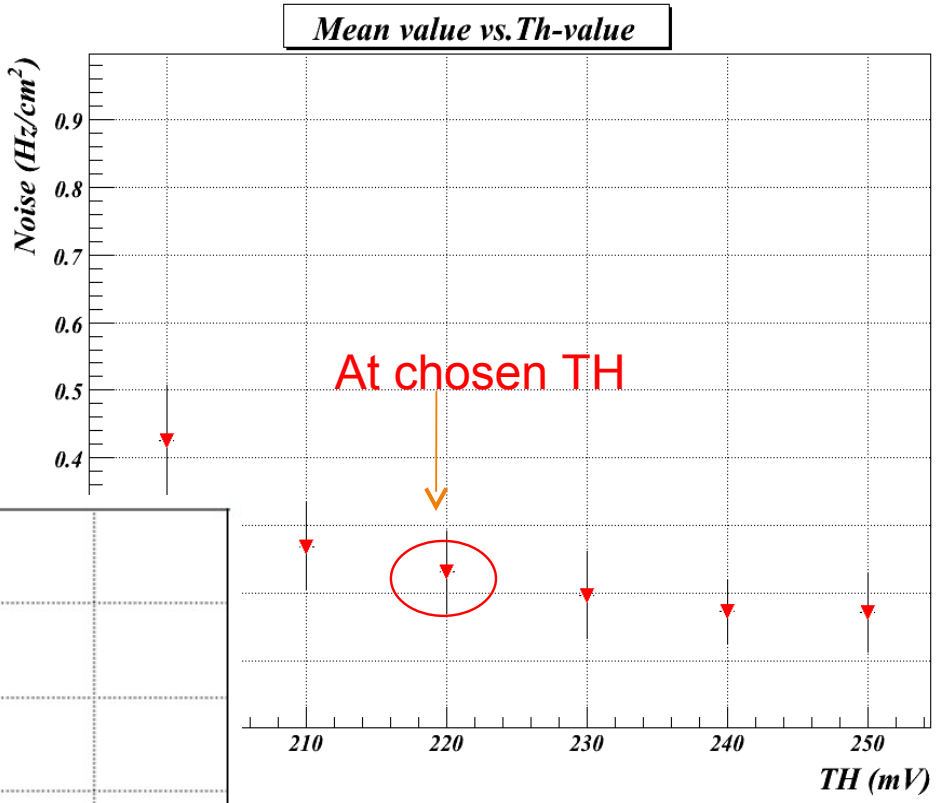
- During the last 2 years CMS performed numerous "Global Runs", i.e. periods of data taking with cosmics
- The whole RPC system was commissioned using this data
  - In the specific, here we'll present the results obtained during Cruzet1->4
  - Several millions of cosmics have been collected during this period
- Detector configuration varied over the interval of time considered
  - During Cruzet 1 20% of the barrel chambers participated to data taking
  - At present – configuration during Cruzet4 – all barrel sectors are readout as well as the forward chambers in the positive side
- Final HV, LV and Gas systems were in place as well as the final DAQ software, DCS, and DQM implemented for the detector readout and control.
- A study of the RPC performances will here be presented focused on the parameters listed previously.

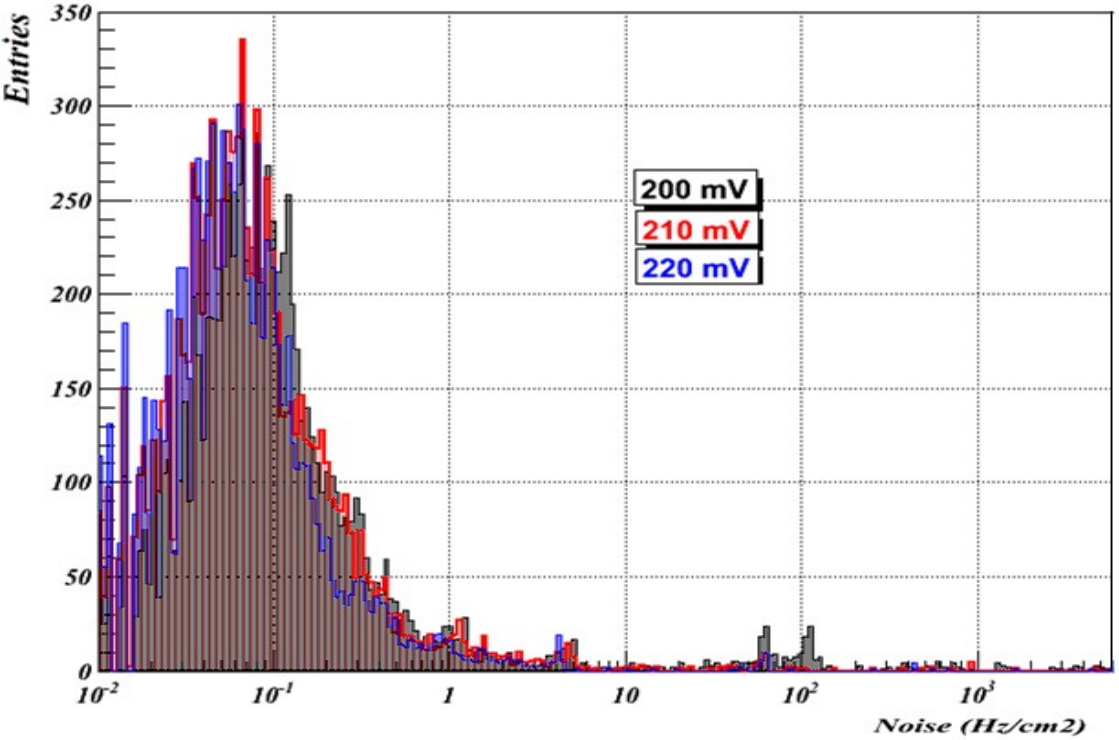
Current studies



Noise studies

- The RPC trigger configuration allows a maximum signal rate of 50Hz/cm²
- Gamma & neutron background is 20Hz/cm² in the barrel
- 2 sources of information to consider
  - Event data (occupancy rate from read out)
  - Non–event data (noisy strips masking)

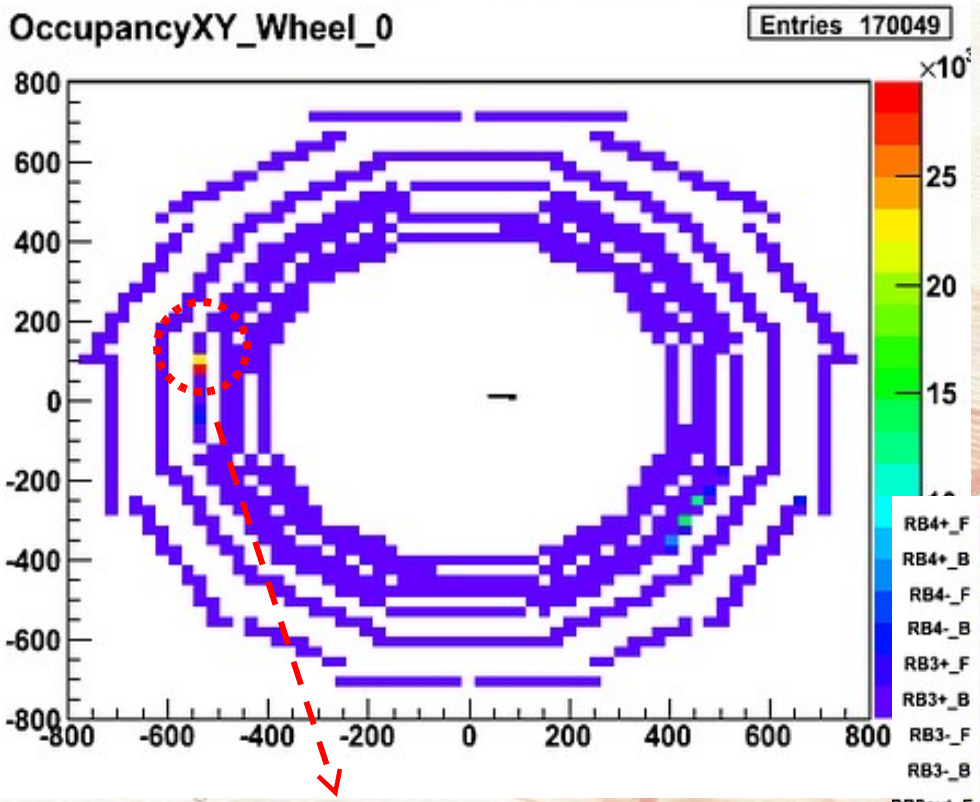




The noise rate was studied for different thresholds

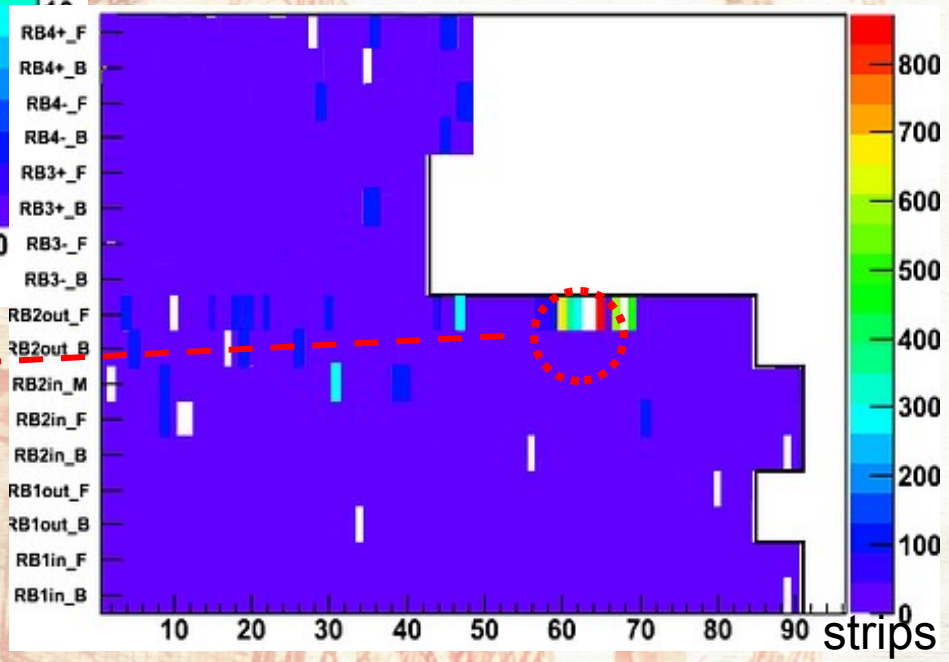
Noise < 1Hz/cm². Better than what measured at the test stations

Occupancy



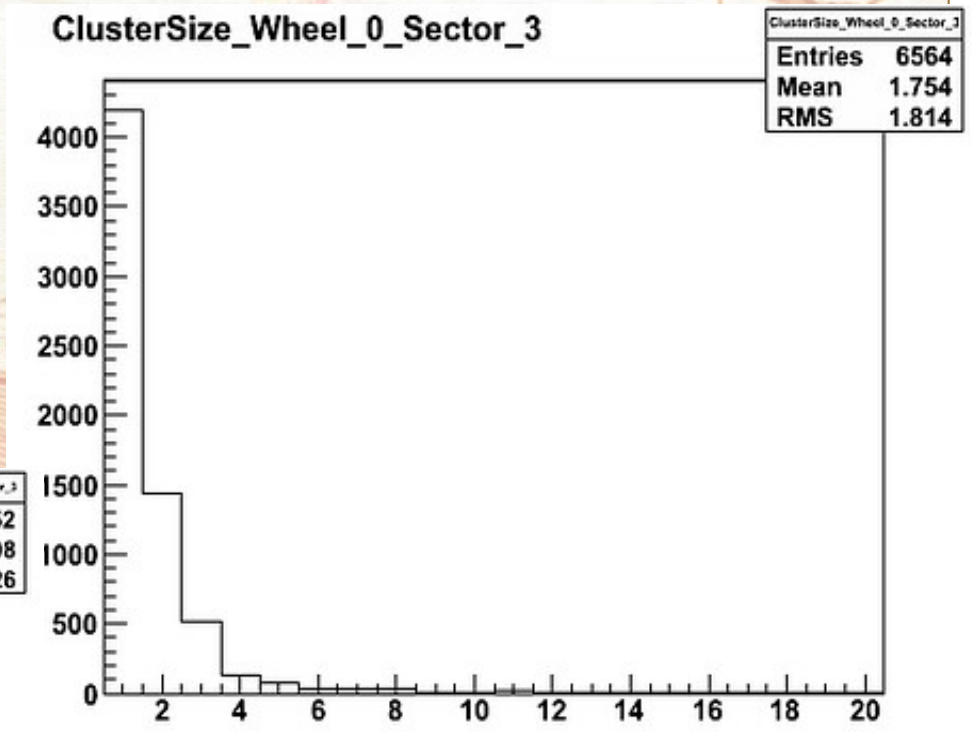
White zones correspond to masked or dead strips

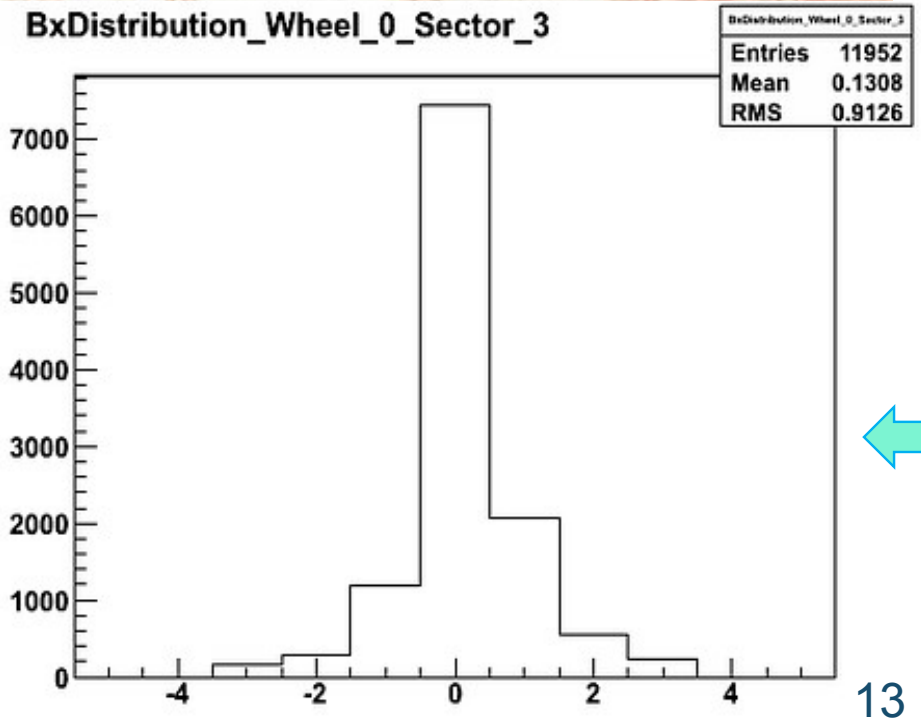
Noisy strips



Cluster size & BX distribution

Cluster size <2 insures a low number of ghost hits and the required momentum resolution

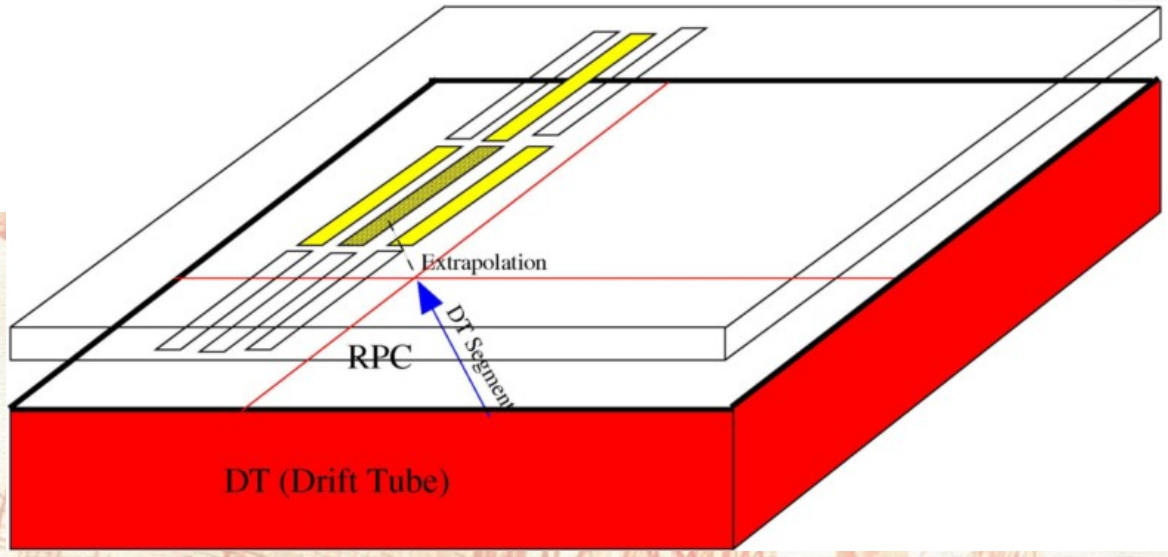




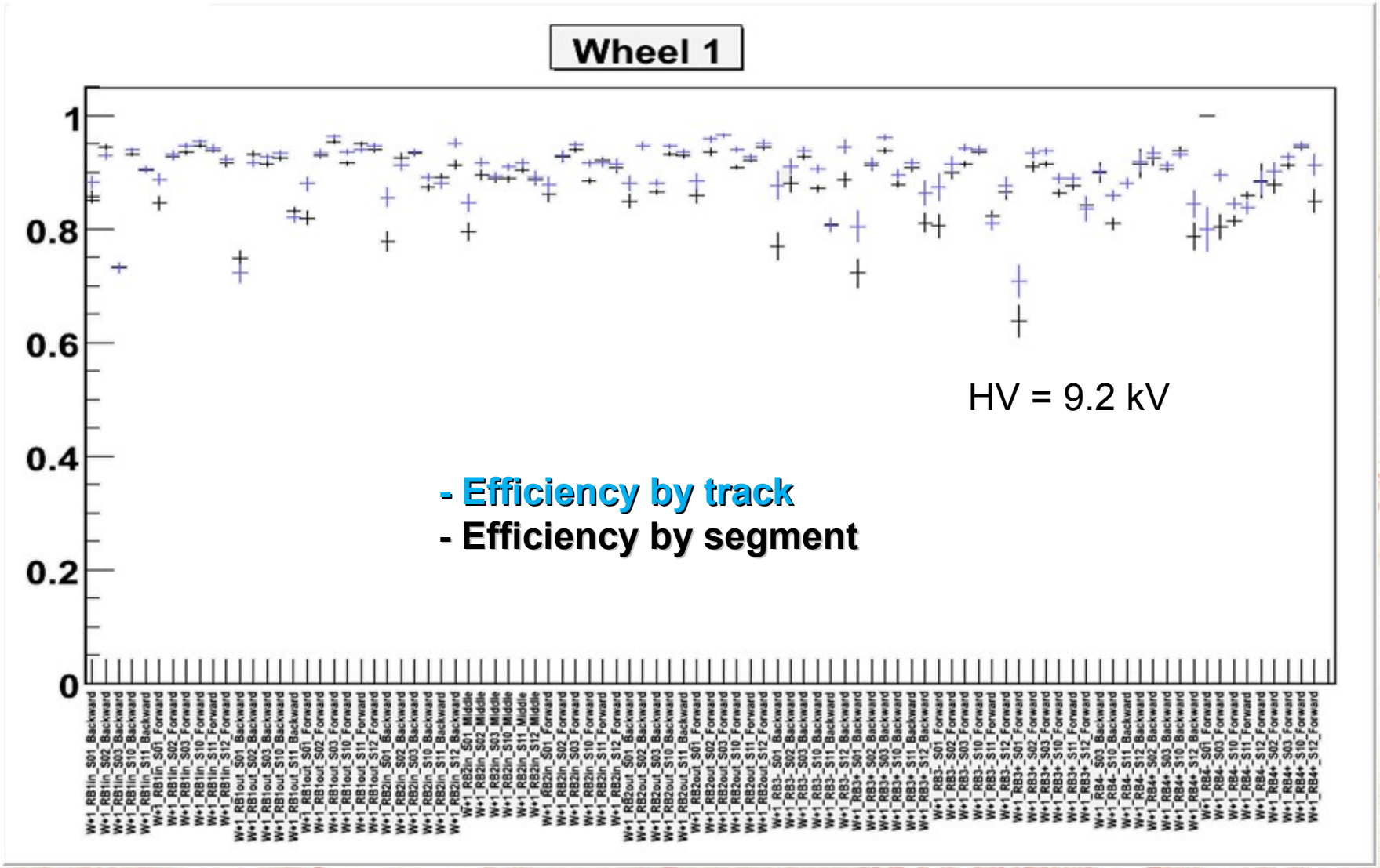
1 Bunch Crossing (Bx) = 25ns
- Initial synchronization is computed on cable/fiber length and assuming vertical muons
- Specific algorithms are then applied
- Synchronized all RPC chamber.s Then synchronized RPCs with DTs.

RPC Efficiency studies

- Information coming from all 3 independent muon systems was used to performed muon detection efficiency studies. 2 different algorithms are currently used.
  - Muon tracks:
    - RPC impact point extrapolated from the muon tracks reconstructed using DT and CSC chambers.
  - Drift Tube/or Cathode Strip Camber Segment extrapolation
    - RPC impact point extrapolated from the segment reconstructed in the DT or CSC chambers (no request about track)



Track reconstruction & Segment extrapolation

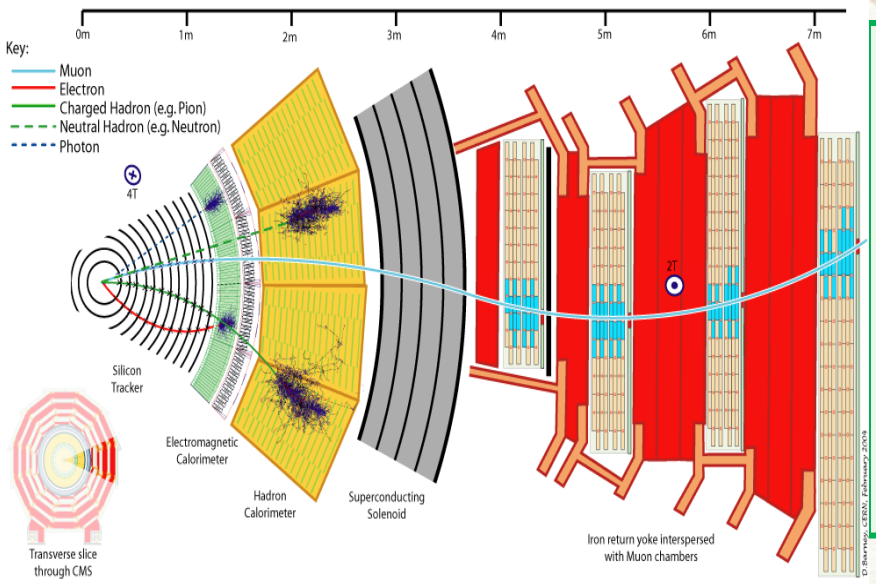


Conclusions

- CMS has been running as a whole for more than 1 year.
- All subdetectors are now included
- Hundreds of millions cosmic taken
- RPCs are working well
- Results obtain are inside the requirements
- Efficiency >>>90% at 9.2kV
- Noise rates are well below 1Hz/cm^2
- Average cluster size >2
- The detector was synchronized for cosmic muons, while synchronization for beam collisions is still ongoing

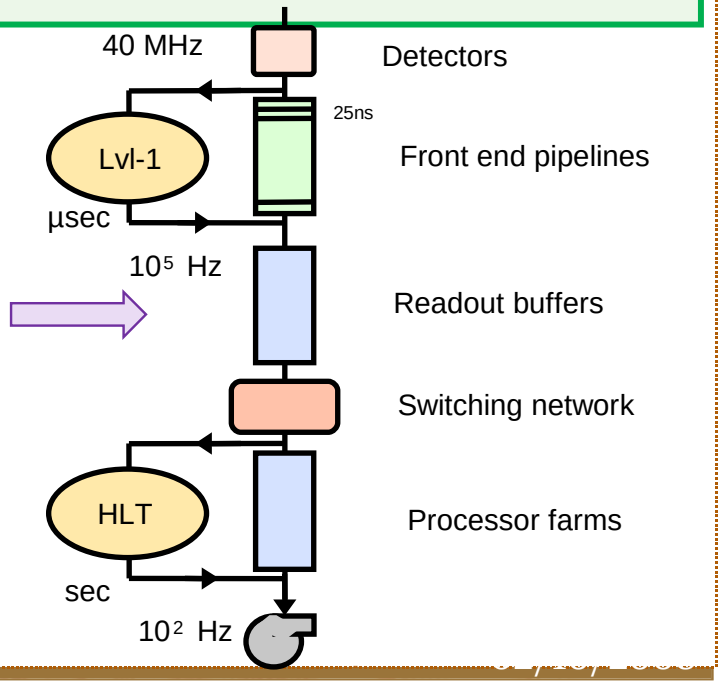
- BACKUP

CMS Detector

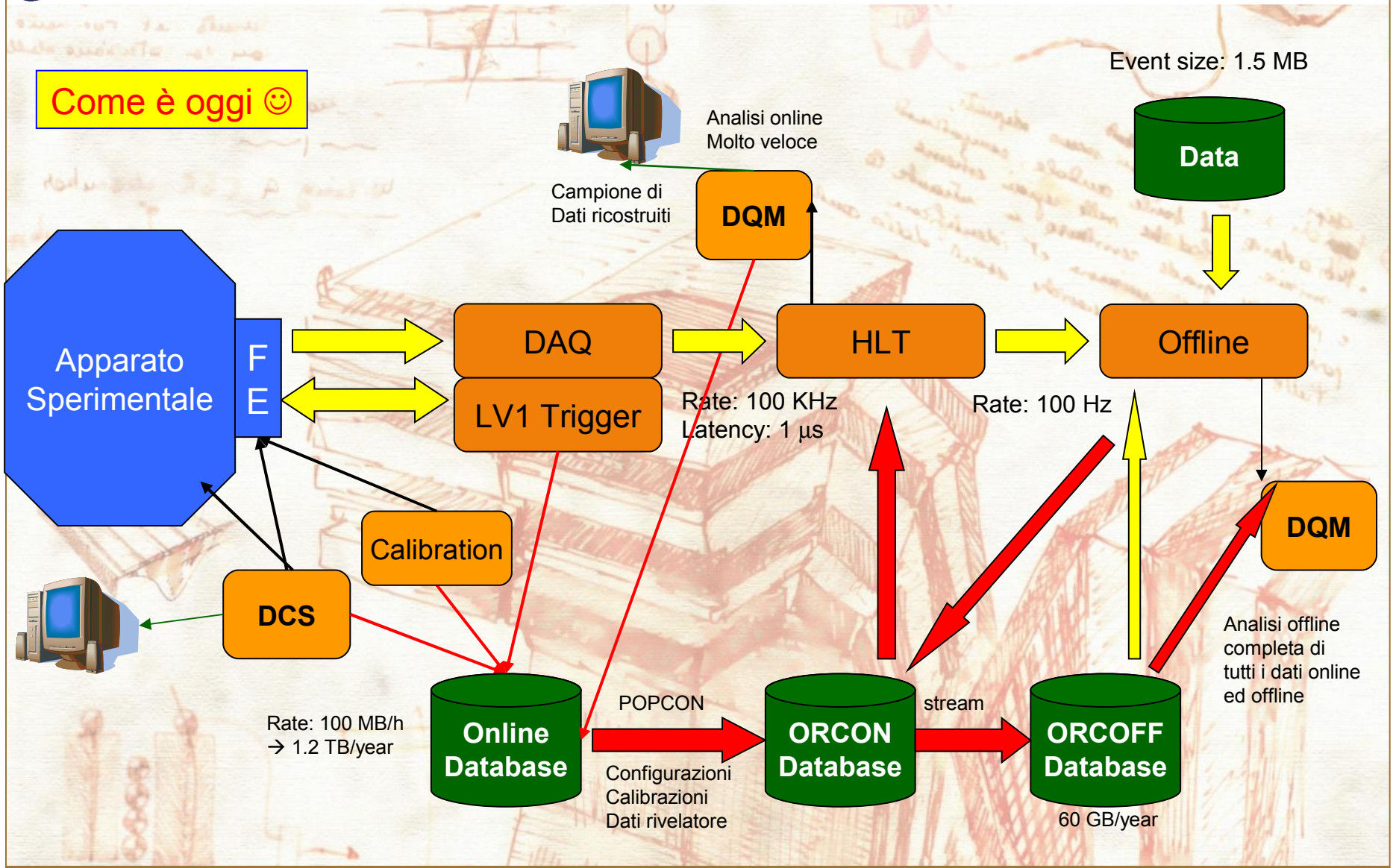


- General purpose detector optimized for the search of SM Higgs between 90GeV/c^2 – 1TeV/c^2
- Heart of the detector is a 4T superconducting solenoid magnet
- The magnetic field configuration influences the entire detector design
  - The return field is large enough to saturate 1.8 m of iron (1.8 T), hence allowing the integration of four muon stations.
  - The inner tracker and calorimeters are accommodated inside the magnet coil.

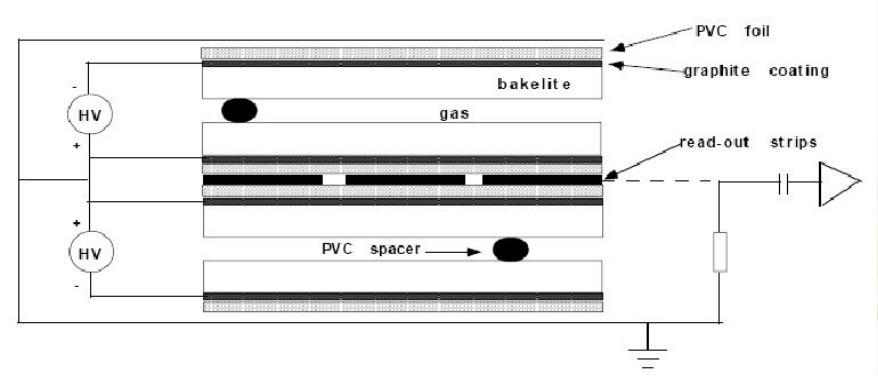
- The **CMS Trigger** has the difficult task of the event selection
  - 40MHz – 100 TB/s 102 Hz – 100MB/s
- The Muon Trigger of CMS uses three kinds of muon detectors: DT, CSC and RPC.
- DTs and CSCs have good spatial resolution (~10/100 μm) for muon track position and momentum measurements.
- RPCs have superior time resolution (few ns). Mainly dedicated to the trigger for providing unambiguous identification of the bunch crossing. They're also used in muon track reconstruction and muon p_t estimation.



ONline & OFFline



The CMS RPC system



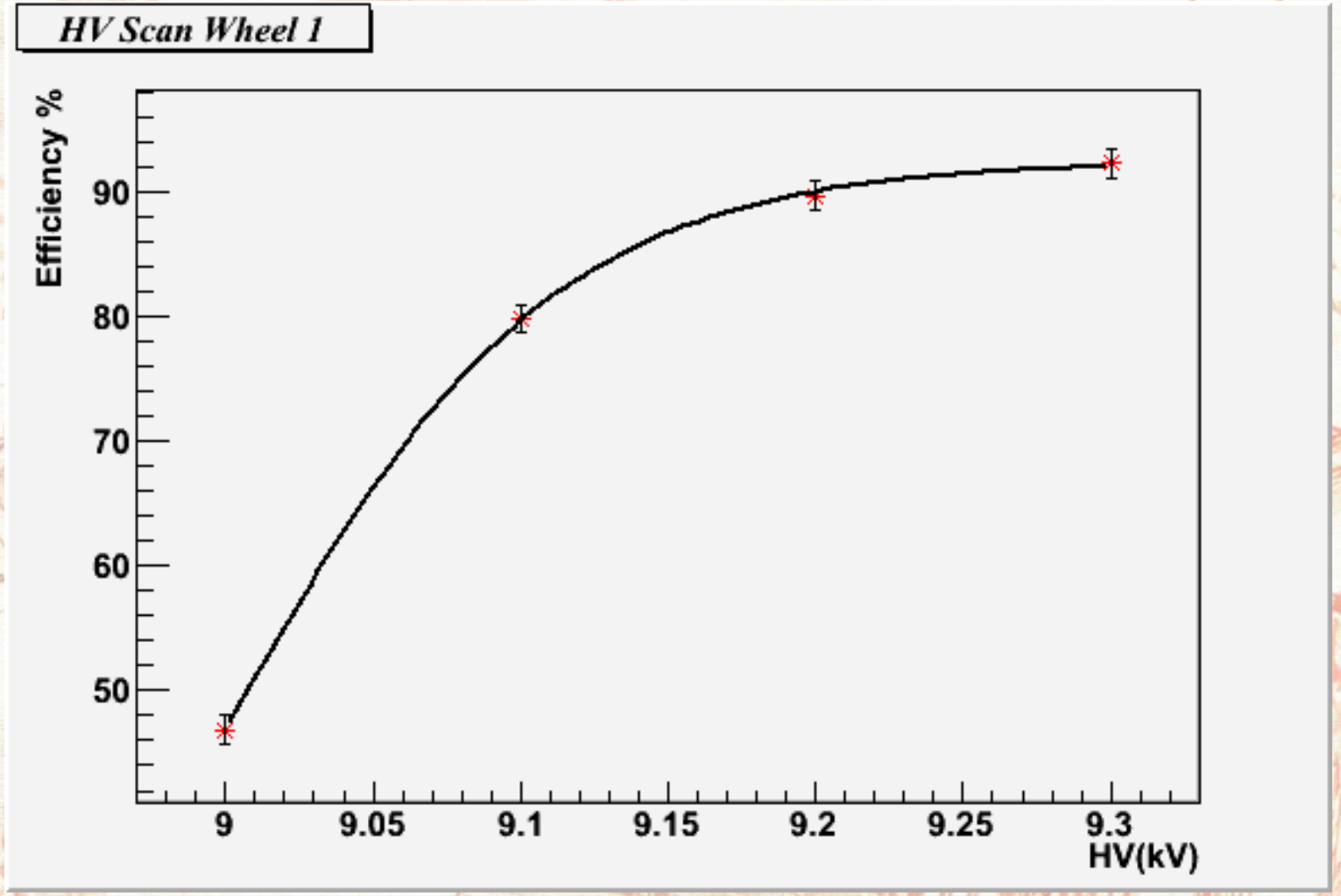
- Double gap design
  - Efficiency is the OR of single gap efficiencies
- 2mm gaps
  - Influences the time resolution
- Bakelite resistivity 10^{10} Ωcm
  - Determines rate capability
  - higher resistivity -> bigger dead time
  - Lower resistivity ->lower effective voltage across the gas gap
- Operated in avalanche mode
  - Determines rate capability
  - higher resistivity -> bigger dead time
  - Lower resistivity ->lower effective voltage across the gas gap

- Used gas mixture: 96.2% $C_2H_2F_4$,3.5% i–C_4H_{10}, 0.3% SF_6.
  - gas cluster size ~ 5 -> maximizes useful signal
  - SF_6 -> improves plateau by 200V

CMS requirements for RPCs

Efficiency	> 95%
Time resolution	≤ 3 ns
Average cluster size	≤2 strips
Rate capability	≥ 1 kHz/cm²
Power consumption	< 2-3 W/m²
Operation plateau	> 300 V
# Streamers	< 10%

HV Efficiency Scan with Segment extrapolation



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