The RPC System for the CMS Experiment

The CMS RPC collaboration

Forward Detector

Peking University, Beijing **China**
KODEL, Seoul, **S. Korea**
PAEC and NCP, Islamabad, **Pakistan**
CERN, Geneva, **Switzerland**

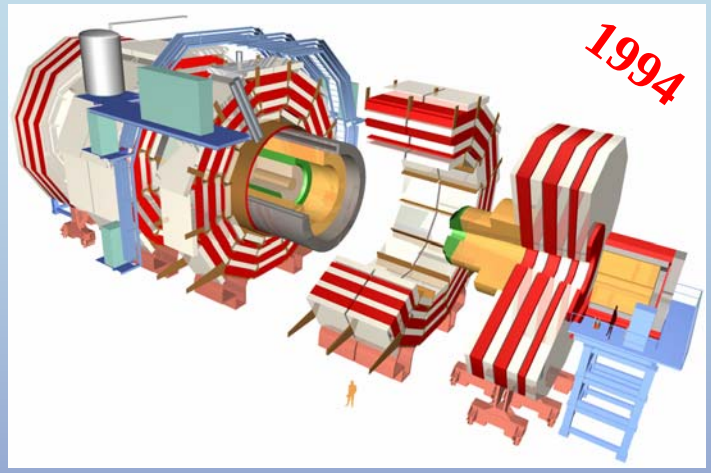
Trigger Electronics

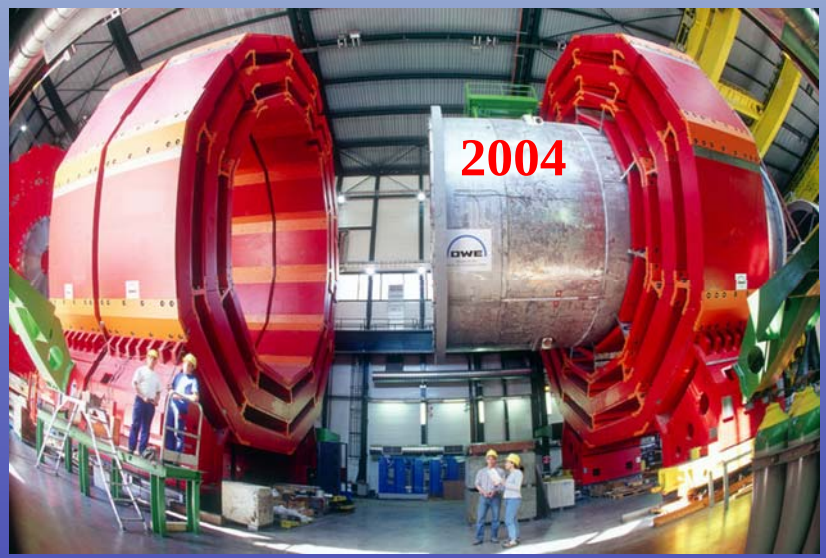
Warsaw University, **Poland**
Warsaw Univ. of Tech., **Poland**
Soltan Institute for Nuclear Studies, Warsaw, **Poland**
University of Technology, Lappeenranta. **Finland**
Sez. INFN, **Bari**, Italy

Barrel Detector

INRNE, BAS, Sofia, Bulgaria & University of Sofia, **Bulgaria**
Laboratori Nazionali di Frascati dell'INFN, **Frascati**
Dipart. Interateneo di Fisica and Sez. INFN, **Bari**, Italy
Dipart. di Fisica and Sez. INFN, **Napoli**, Italy
Dipart. di Fisica Nucleare e Teorica and Sez.INFN, **Pavia**, Italy

The CMS design





The **μ system** is located outside of the coil.

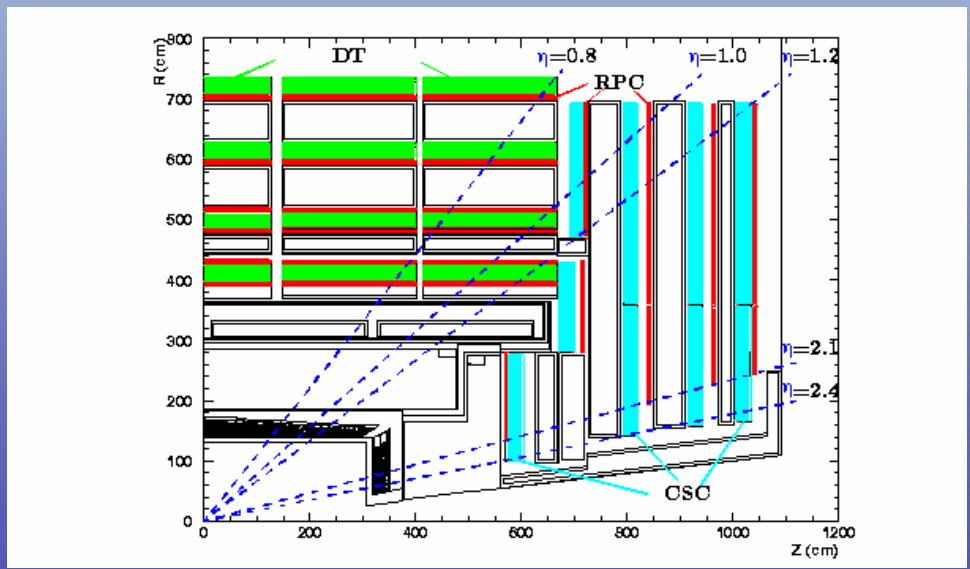
It consists of 4 μ stations interleaved with the iron return yoke plates: MB1-4 in the barrel and RE1-4 in the forward.

The stations are grouped into **5 wheels** around the beam line in the barrel and in **4 disks/end** (the 4th is descoped), perpendicular to the beam line, in the forward.

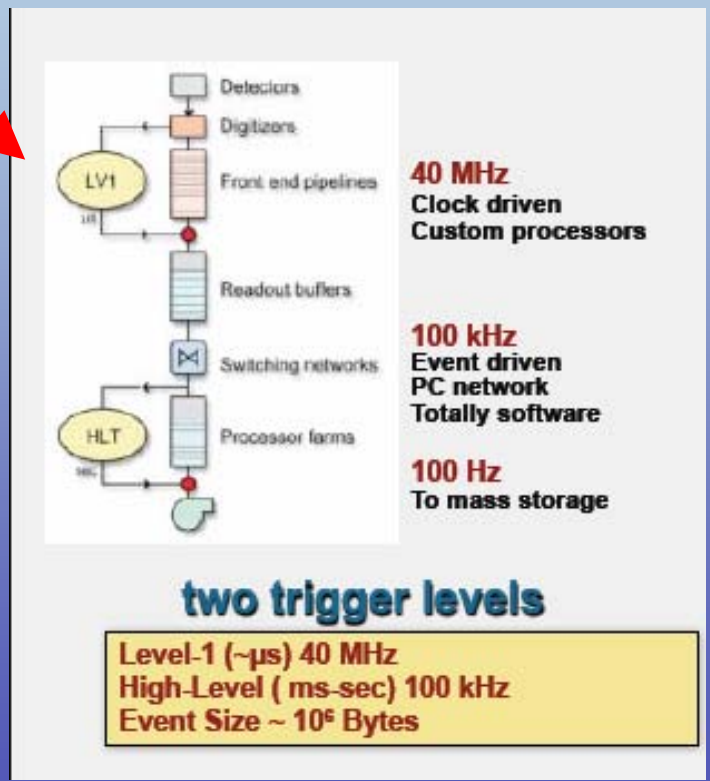
The CMS muon trigger

μ trigger consists of 2 complementary and independent systems **DT or CSC & RPC** for:

- identification of muons
- measurement of their transverse momentum
- bunch crossing assignment



The most difficult task for any experiment at LHC: the **event selection!**



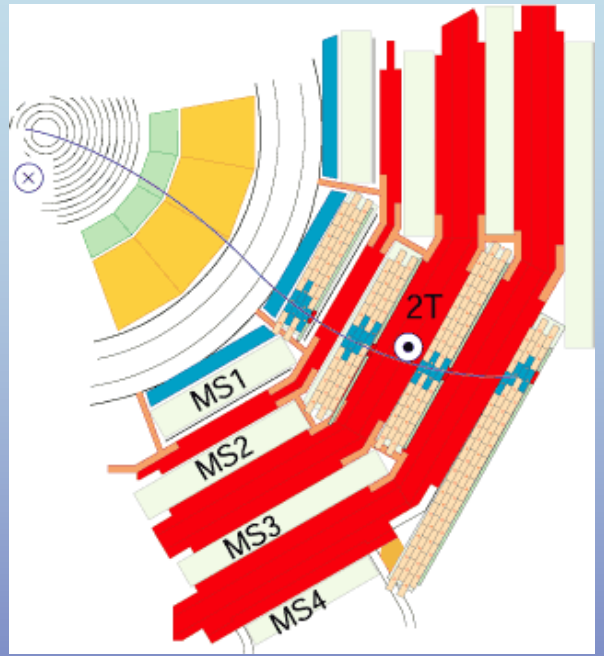
The CMS muon trigger….con't

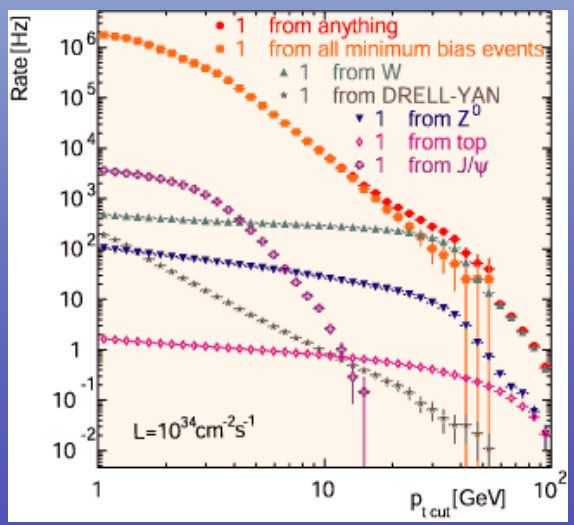
Muons are expected to provide clean signature

The **momentum measurement** relays on the bending of charged tracks in the magnetic field produced by the coil.

The solenoid field of CMS bends tracks in the (r,ϕ) plane perpendicular to the beam axis.

A reduction of the trigger muon rate can be done requesting that the transverse momentum of the muons exceeds a certain threshold.



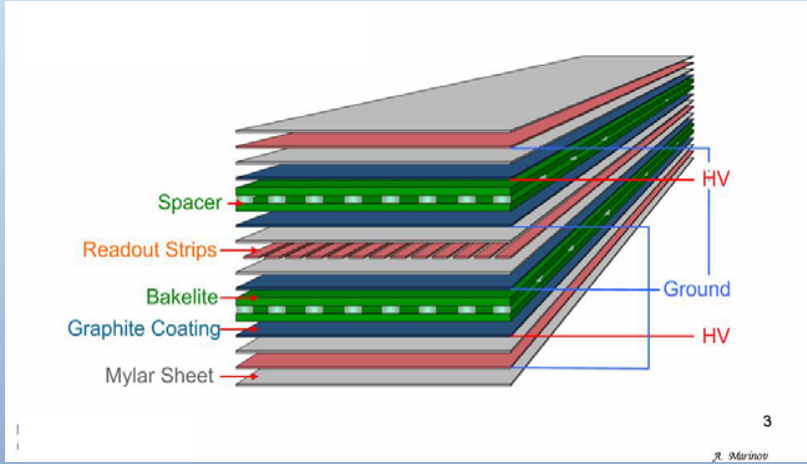


The RPC system

The **p_t assignment** is accomplished by the trigger processor, the PAC, that compare the observed patterns of hits with predefined ones, each corresponding to a p_t value.

High RPC's time resolution (about 1 ns) and a perfect **synchronization** is required to assign the muon to the proper bunch crossing.

The CMS RPC design



- **Double gaps** 2 mm width
- **Bakelite** bulk resistivity ρ = 2-5 x 10^{10} Ωcm
- Gas mixture: 96.2% $C_2H_2F_4$+3.5%isoC_4H_{10}+0.3 SF_6
- Operated in **avalanche mode**

Barrel Station

Forward Station

- **912 stations**
- **4632 sheets of bakelite**
- **total surface 3500 m^2**
- **150.000 electronic channels**

Status of Barrel production

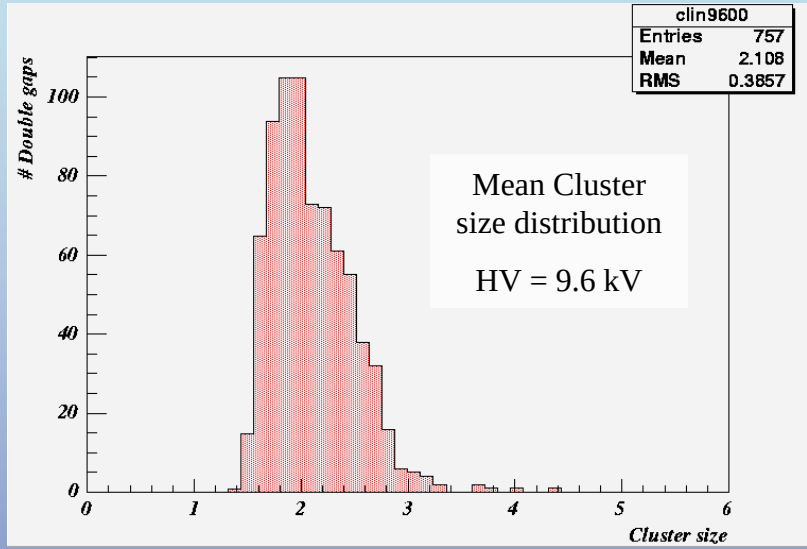
Production & test: 100% completed

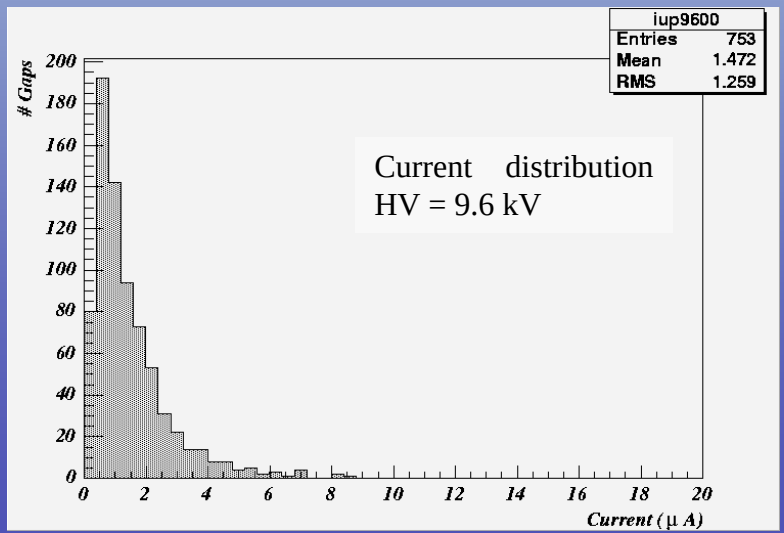
- 480 chambers **assembled**
- 480 chambers **tested** with cosmic rays
- **All accepted chambers** satisfy the CMS requirement:

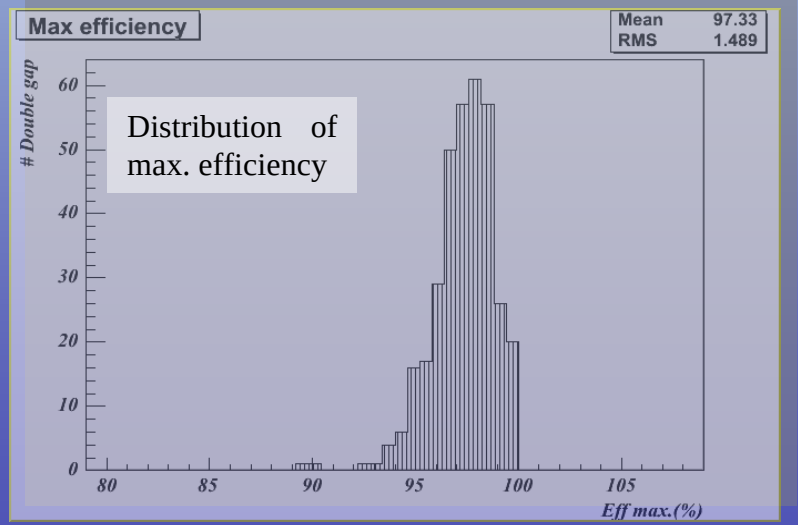
<noise> < 1 Hz/ cm^2

<cluster size> = 2.1 strips

<efficiency> = 97.3 %





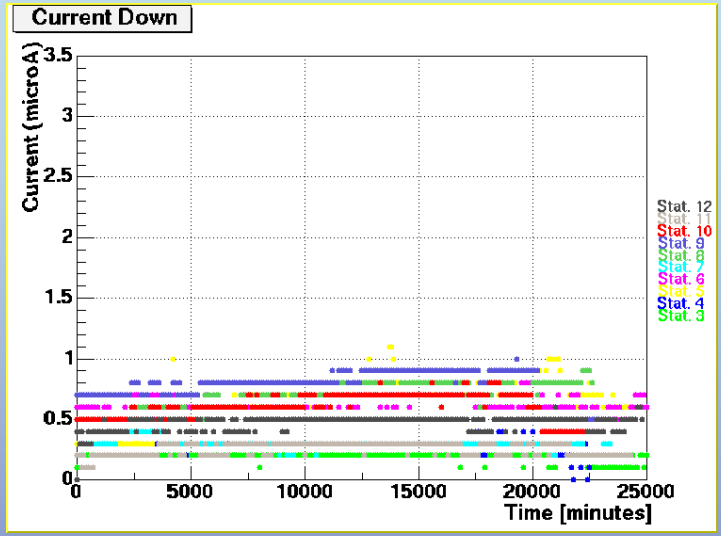


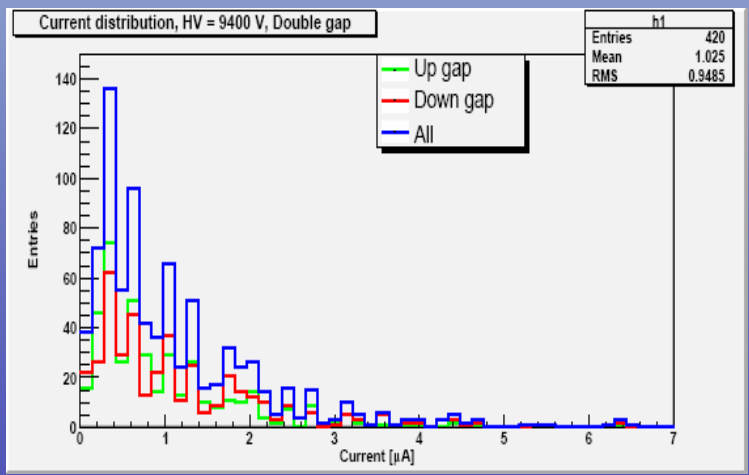
Status of Barrel installation

Commissioning & Installation: 58% **completed**

- The stability of the current is monitored for about 20 days.
- Functionality tests are done before and after the installation in the coil.

430 chambers **certified** → 90 % completed

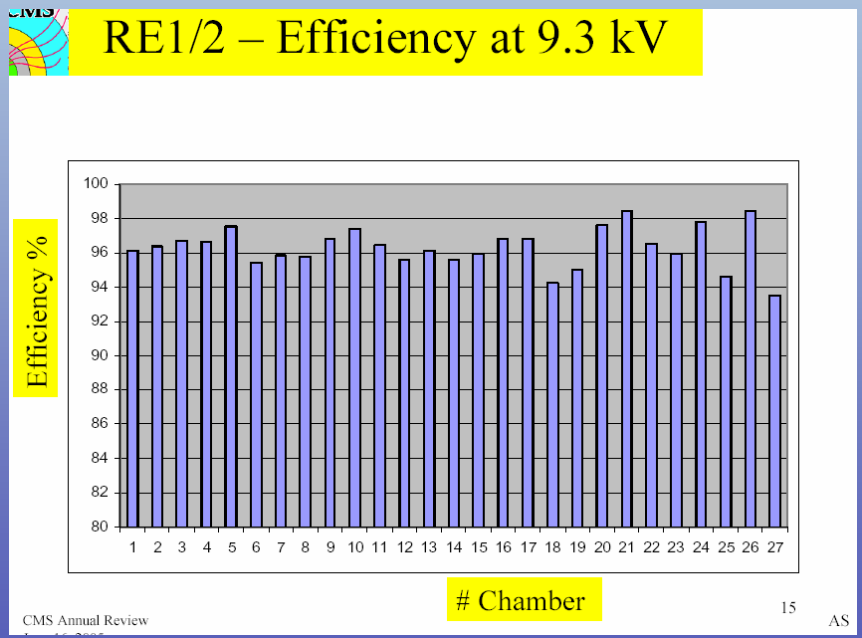


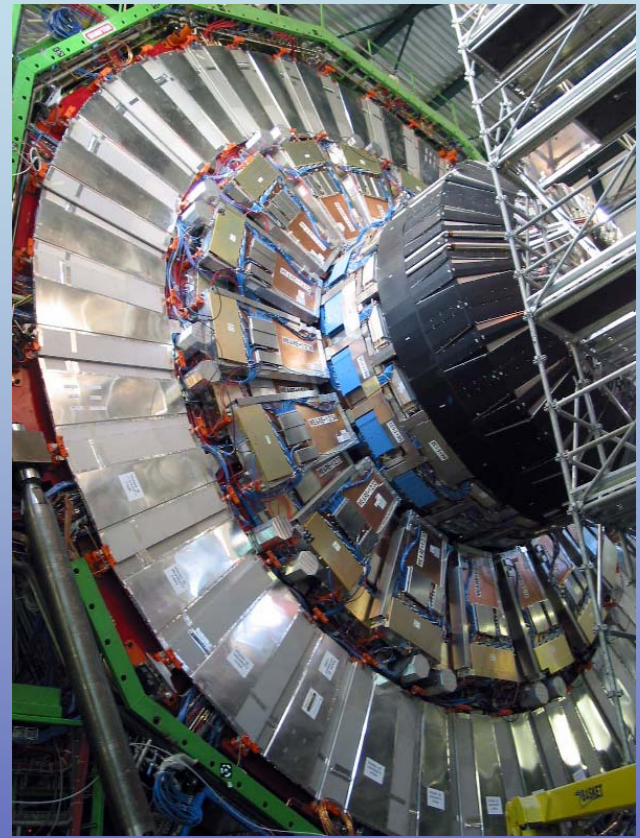


Status of RPC Forward

Production & Test: 67 % completed

- 288 chambers **assembled** and **tested** with cosmic muons





Installation: 46% completed

- Y+1 RE1 and RE2 and RE3.
- Y-1 RE1

MTCC: Magnet Test and Cosmic Challenge

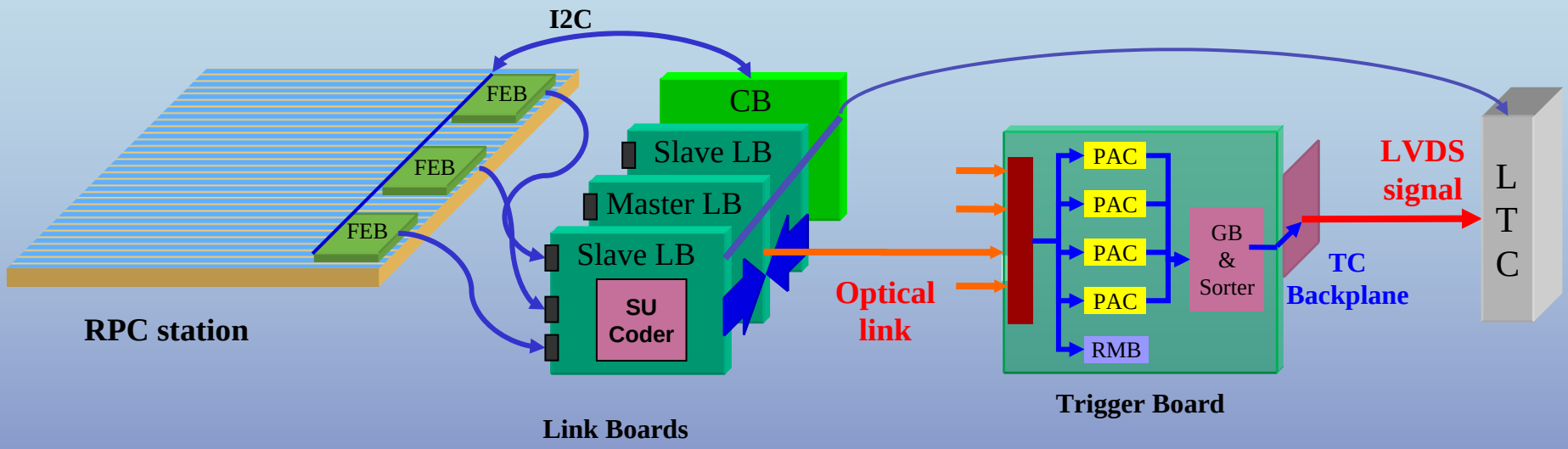
August - October 2006

- Check functionality of the magnet: cooling, power supply and control systems
- Field mapping
- Test μ alignment system
- Installation validation
- Read out detector & synchronization
- **Commission detector**
- **Commission cosmic trigger**

RPC system

- **Barrel:** Two sectors of W +2 & one sector of W+1
- **Endcap**: 1 station of Y+1

The read out chain



- **The CMS Trigger logic** is optimized for muon tracks coming from the vertex. Not adequate for cosmic muons !!

- This requirement is crucial for the commissioning and debugging of the whole apparatus.

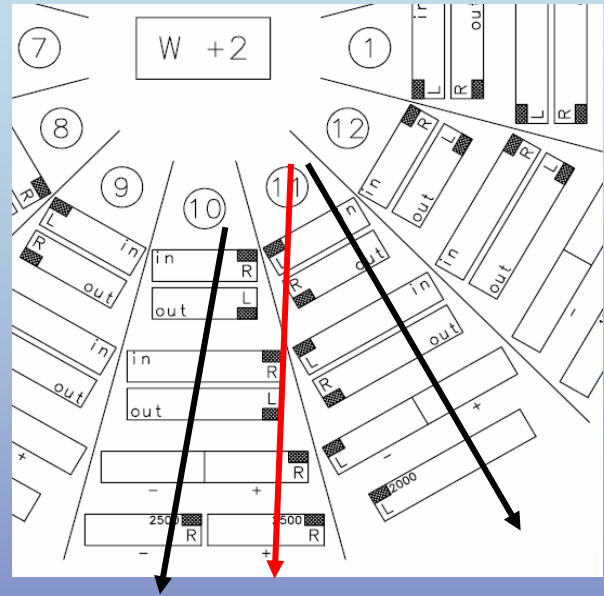
RPC Technical Trigger

Development and test of an alternative RPC technical trigger (RBC) for cosmic muons. The **RBC** electronics provide sector trigger with selectable majority level from 1/6 to 6/6.

The reliability of this electronics studied during MTTC.

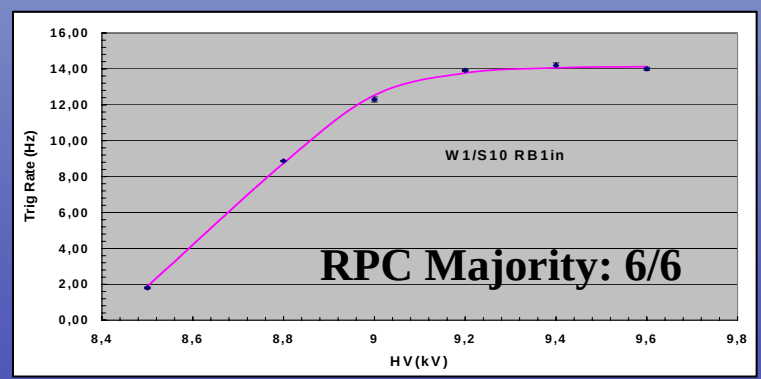
Goals are:

- study of the RPC performance
- give the trigger to the other sub detectors



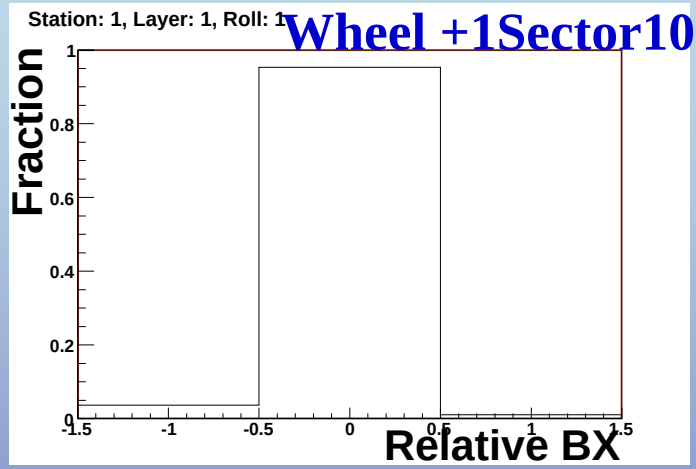
W+1: **Sect. 10** → **RBC1**

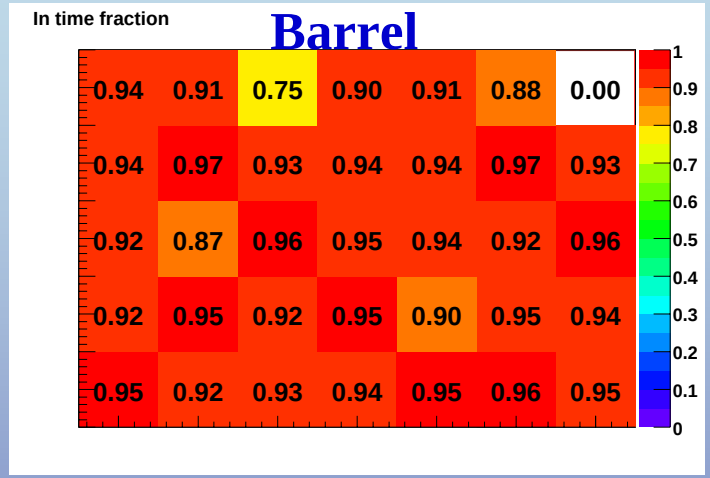
W+2: **Sect. 10**, **Sect. 11** → OR → **RBC2**

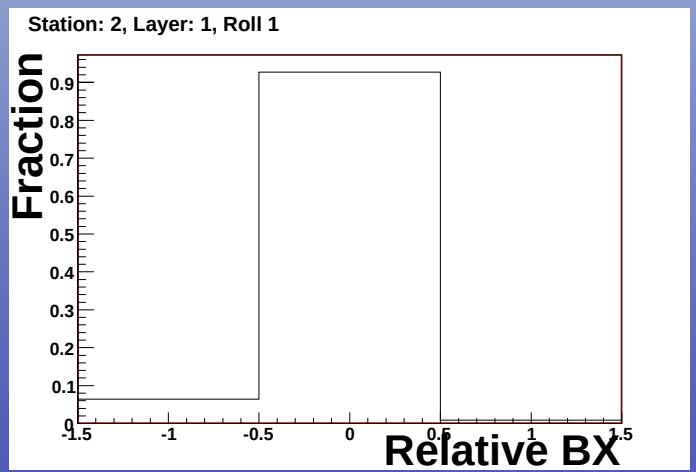


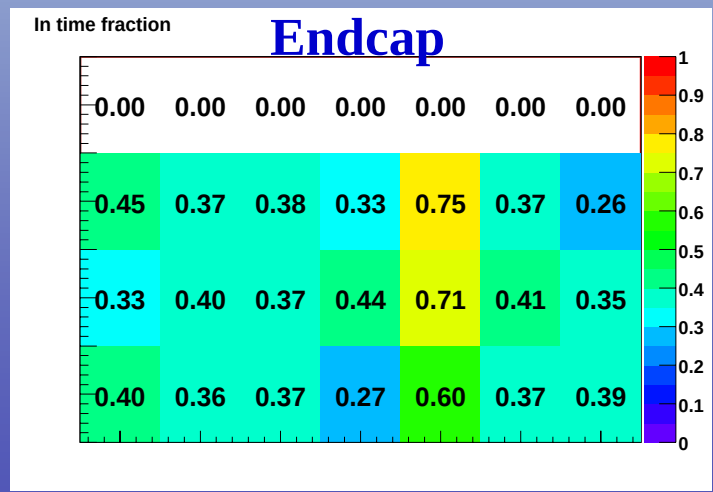
5/6 - trigger rate ~30 Hz per wheel
6/6 - trigger rate ~13 Hz per wheel

Synchronization

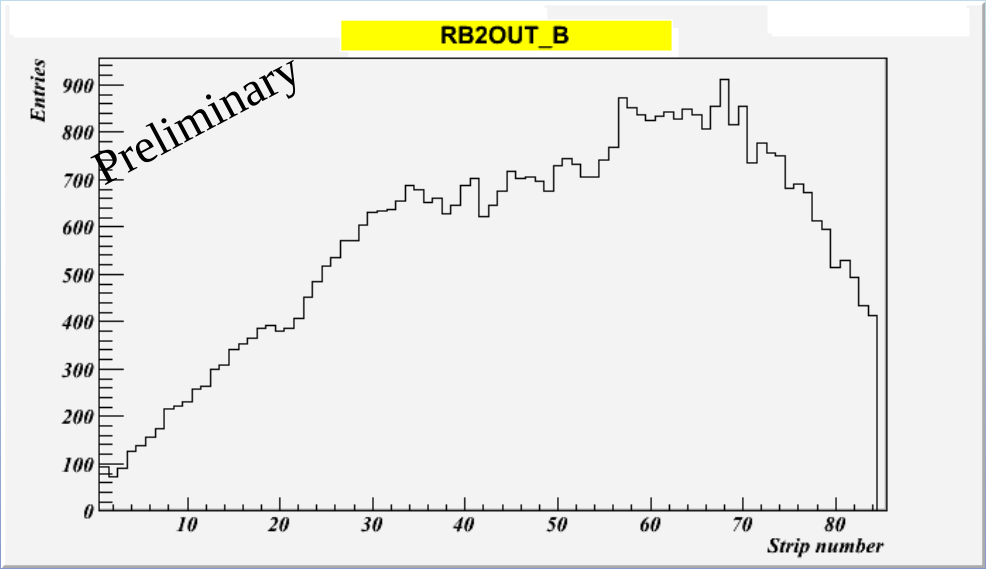






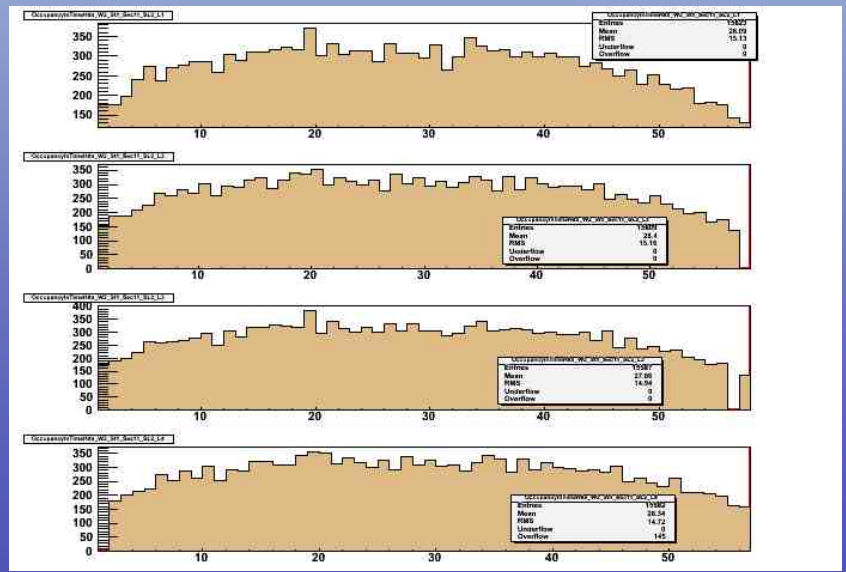


RPC & DT occupancy



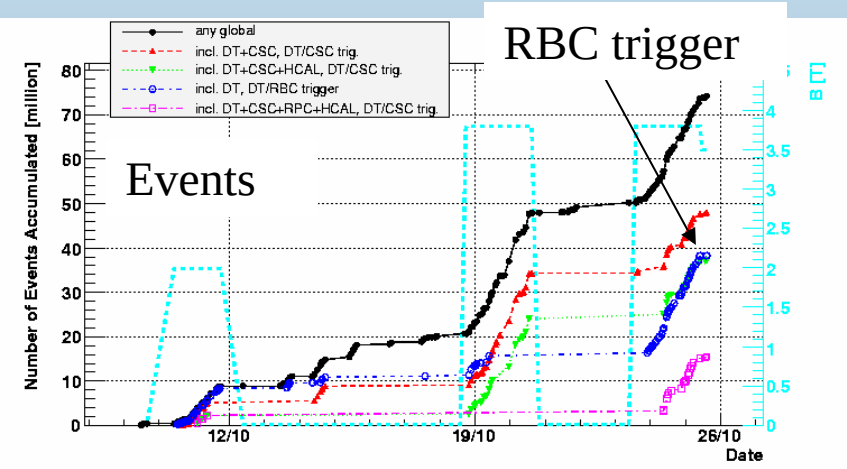
RPC occupancy triggered by DT

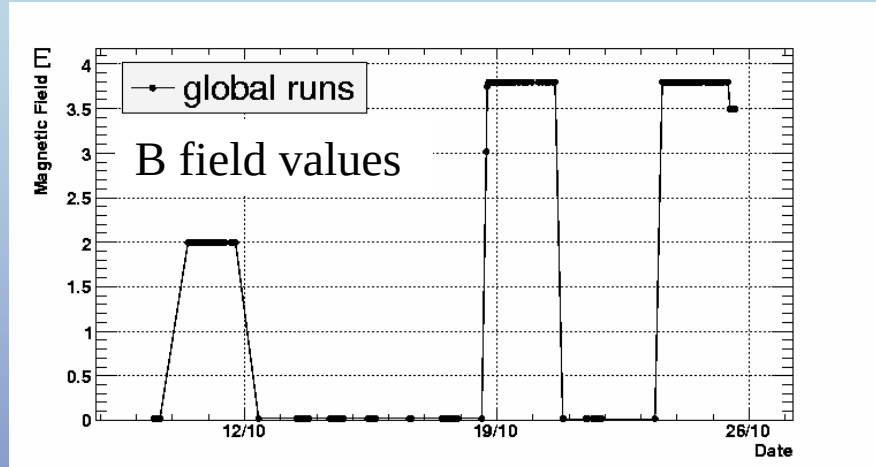
DT occupancy triggered by RPC



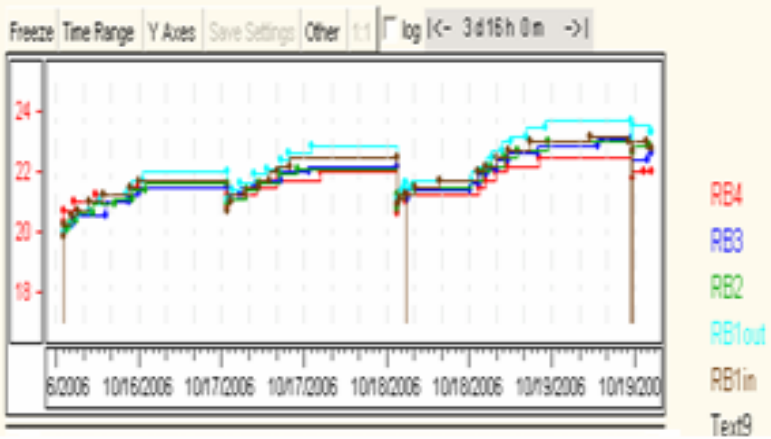
Running conditions

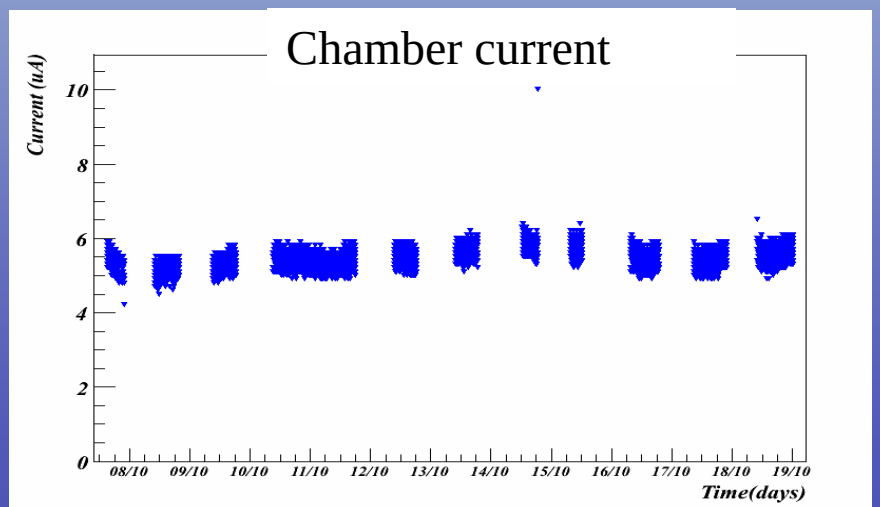
Environmental and detector parameter have been continuously monitored



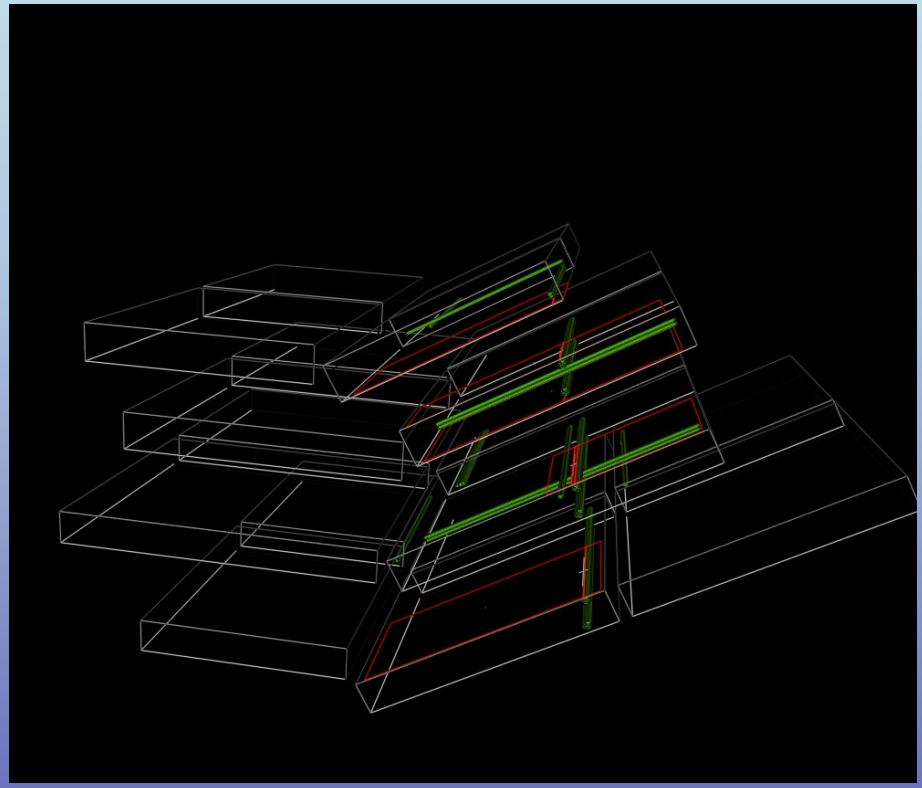


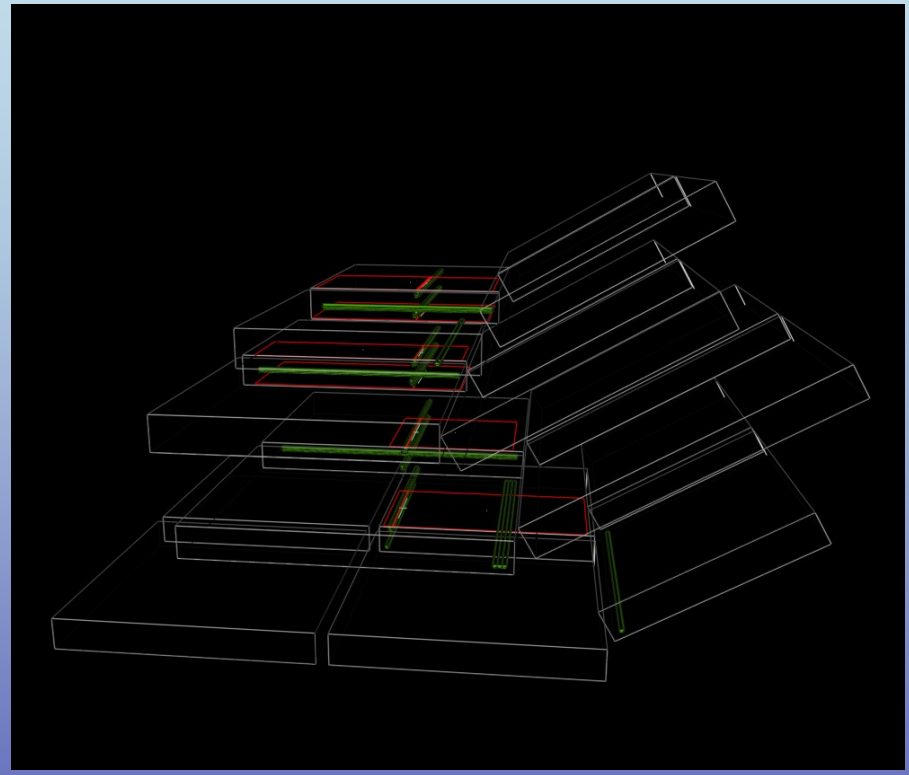
Chamber temperature





Event display

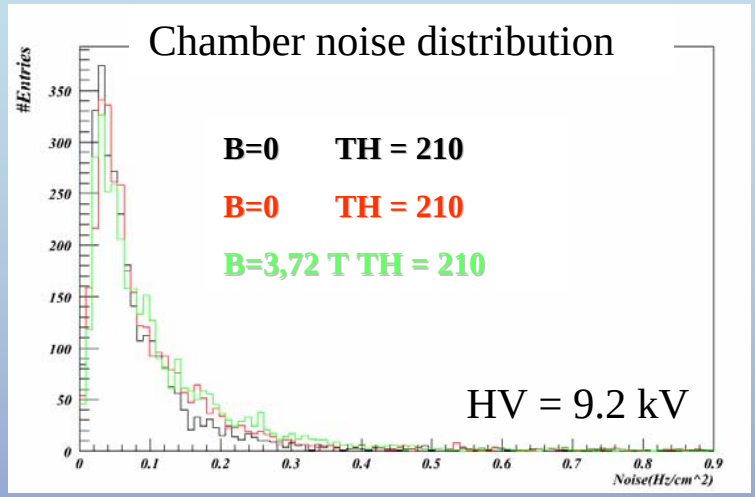


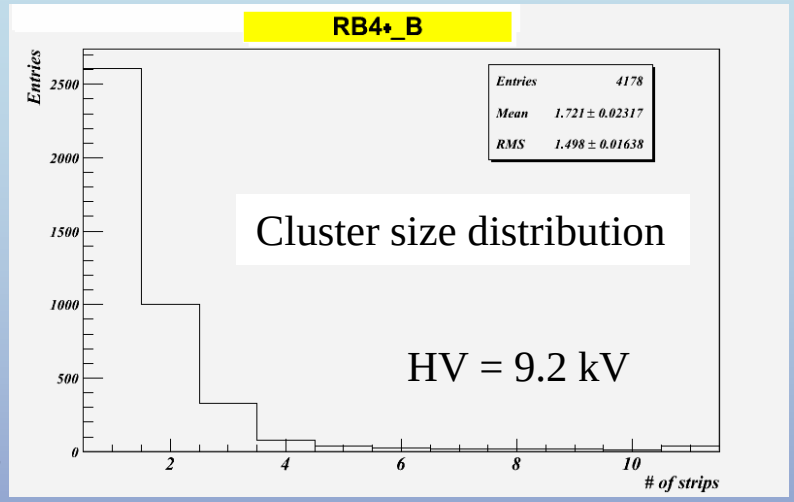


Muon offline reconstruction: RPC strips fired in **red** and DT in **green**

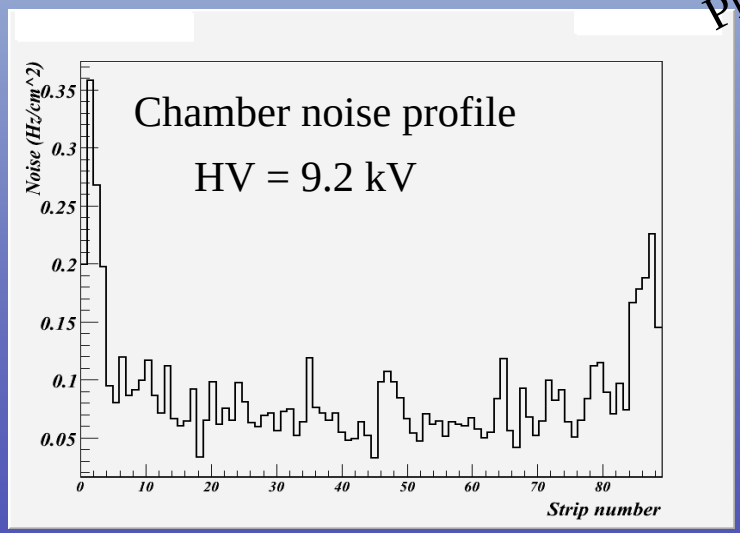
Many successfully reconstructed μ observed!!!

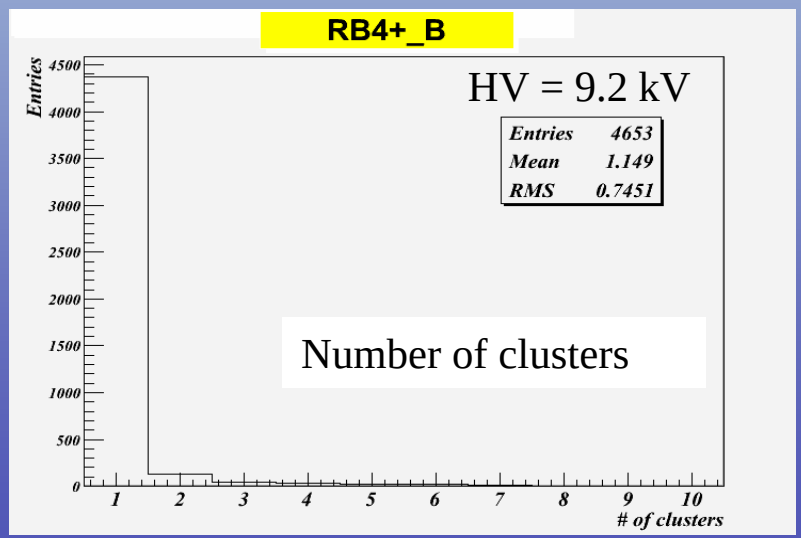
Data Quality Monitor





Preliminary

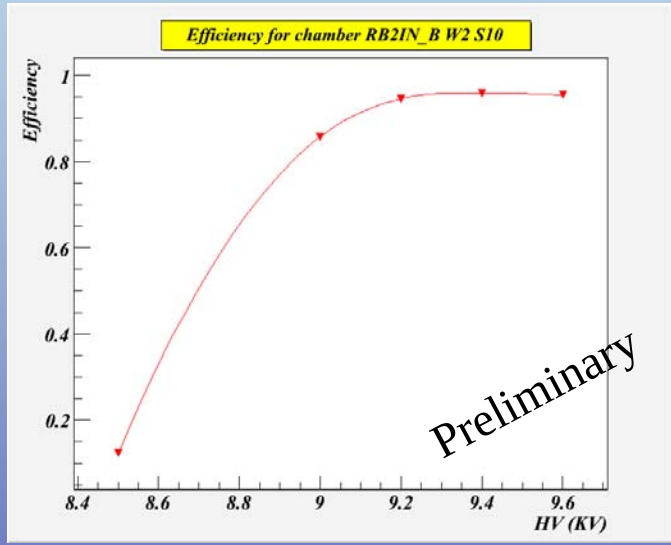




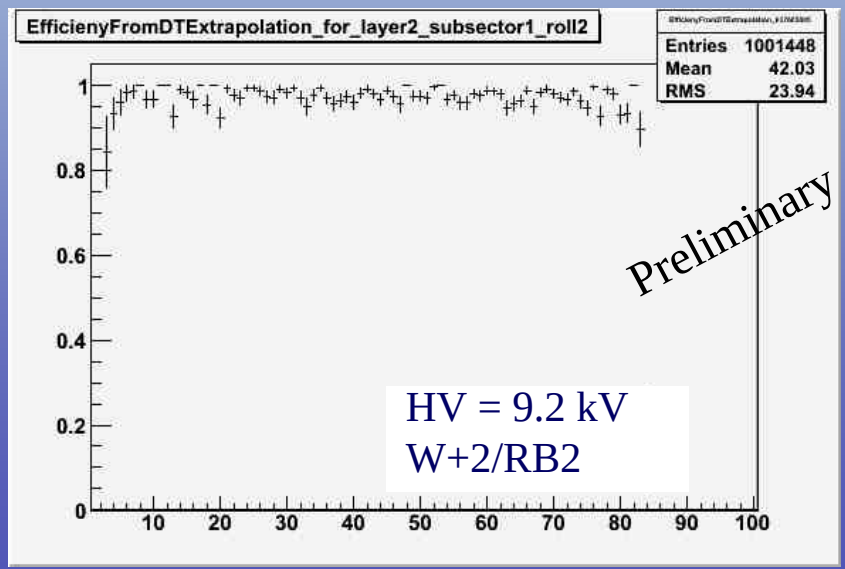
DT Local segment reconstruction

The μ impact point on the RPC have been evaluated by reconstruction of the DT segment

Chamber global efficiency

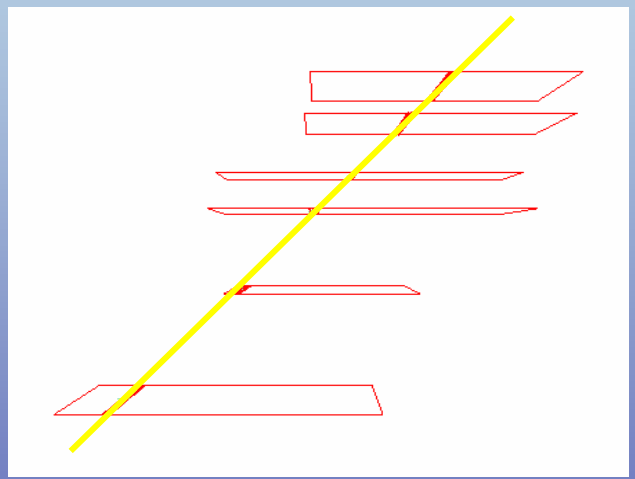


Chamber Local efficiency

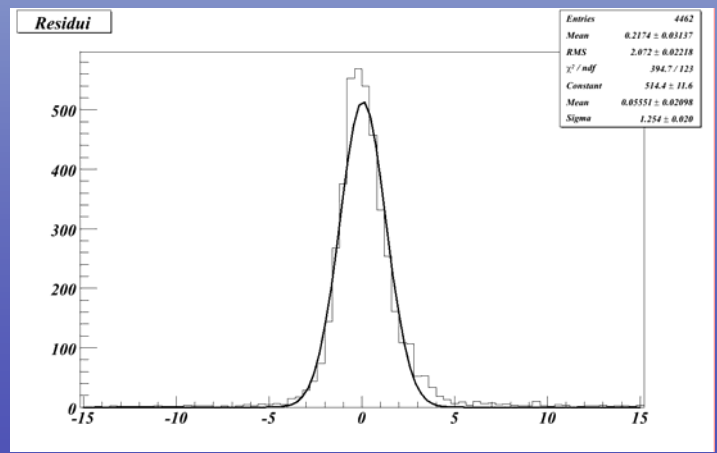


Muon stand alone reconstruction

Alternative method: μ events can be reconstructed using only the RPC stations with a linear fit of fired strips position.



Preliminary



Spatial resolution ~ 1.2 cm evaluated using the residual distribution (distance between muon impact point and the nearest cluster center).

Conclusion

- ✓ Installation of the CMS RPC system is well advanced.
- ✓ Chambers performance certificated through cosmic rays telescopes.
- ✓ Three barrel sectors and one forward slide successfully operated during the MTCC at CERN.
- ✓ RPC based Technical Trigger for cosmic muon developed and tested successfully.
- ✓ Chamber performance according to expectation and to CMS requirement
- ✓ Cosmic muons reconstructed to study local and global chamber efficiency.

However only 4 % of the detector operated during the MTTC …still a long way to catch the goal !!!