The CMS Drift Tube Chambers:
commissioning, operation and performance.

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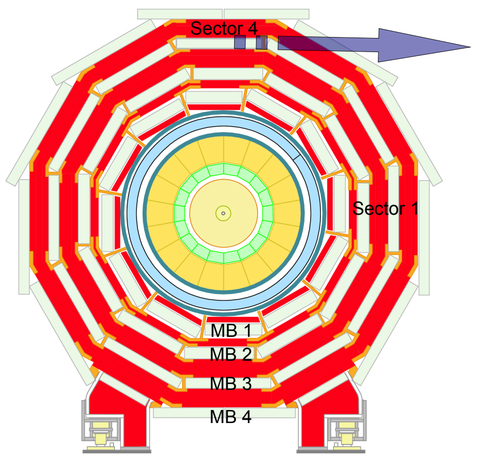
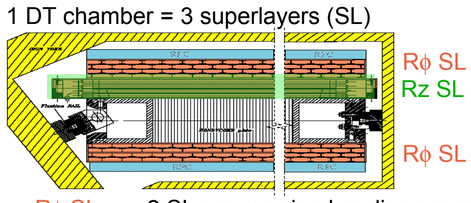
The CMS Drift Tube System

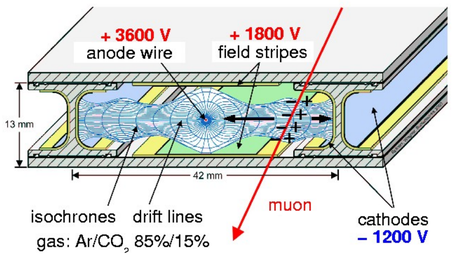


1 DT chamber = 3 superlayers (SL)



- Rϕ SLs → 2 SLs measuring bending coordinate
- Rz SL → 1 SL measuring the track angle w.r.t.beam line

1 SL = 4 layers of drift cells



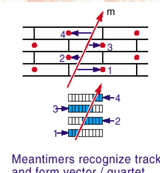
The design of the Compact Muon Solenoid (CMS) is based on the **large superconducting solenoid** providing a **3.8T magnetic field**. This allows independent tracking inside (Si tracker) and outside (muon spectrometer) the coil.

The **muon spectrometer in the iron return yoke** must provide:

- good p_T resolution at high transverse momenta (goal $\sigma(p_T)/p_T$ ~ 10% @ 1TeV/c)
- reliable and robust trigger: **p_T standalone measurement @ Level-1** and **High Level Trigger** and precise Bunch Crossing (BX) assignment

The barrel **Drift Tubes** (DT) (**$|\eta| < 1.2$**) are composed by 4 station of chambers (250 chambers, $O(10^5)$ chanels). Each chamber is composed by 12 layers of drift cells. This structure allows to:

- reconstruct track segments in each chamber improving the resolution w.r.t. single cell
- minimize the effect of soft δ-rays and neutron background
- self-trigger in the chamber (mean-timer technique).



Meantimers recognize tracks and form vector / quartet.

$$\frac{(t_1+t_3)}{2}+t_2=T_{MAX}$$

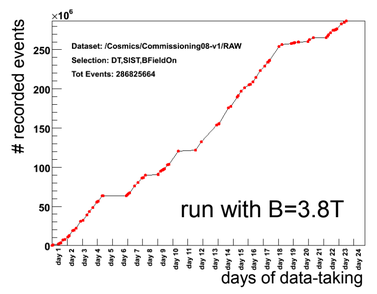
meantimer

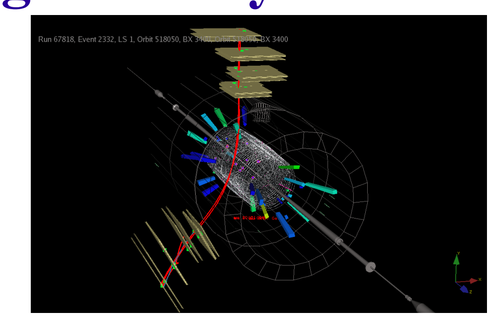
Commissioning of the System

Cosmic Ray Data Taking

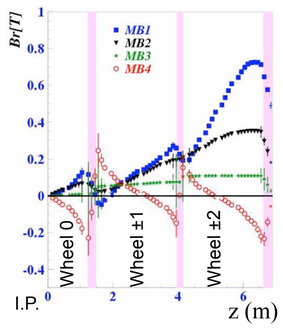
The commissioning activity started in 2005, in parallel with the installation of the detector. It mainly consisted of the acquisition of cosmic ray data. The first phase was dedicated to the standalone test of parts of the DT system. Starting with the Magnet Test & Cosmic Challenge in 2006 various integration tests with the other CMS subsystems have been carried out.

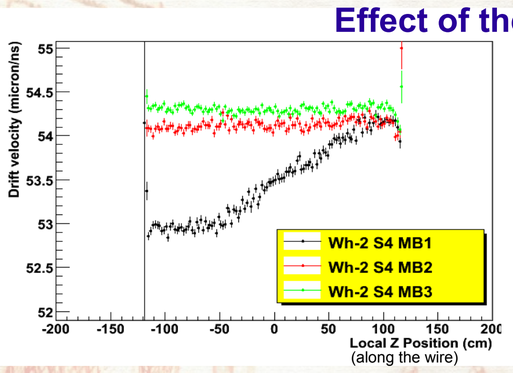
The **DT system provided several hundred millions of triggers to CMS**. The data collected during these integration tests represent a valuable datasets for a deep understanding of the detector before collisions.





Effect of the Stray Magnetic Field on the Chambers





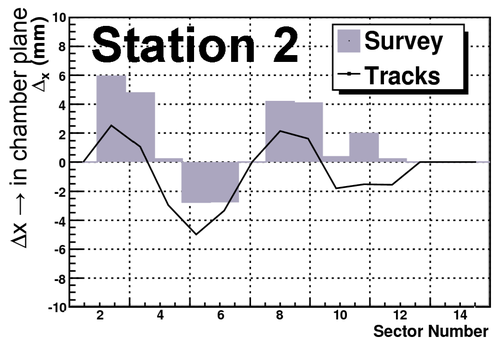
The understanding of the magnetic field in the iron return yoke is essential to exploit full tracking capabilities:

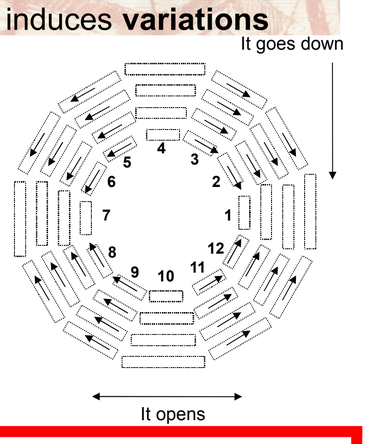
- **~ 300M events collected in ~ 3 weeks** in 2008 **with full magnetic** field and all CMS sub-detectors.

The **residual magnetic field in the chamber volume** mainly affects the MB1 chambers in the most external wheels (high pseudorapidity) where the presence of a radial component B_r induces **variations of the drift-velocity up to 2%**.

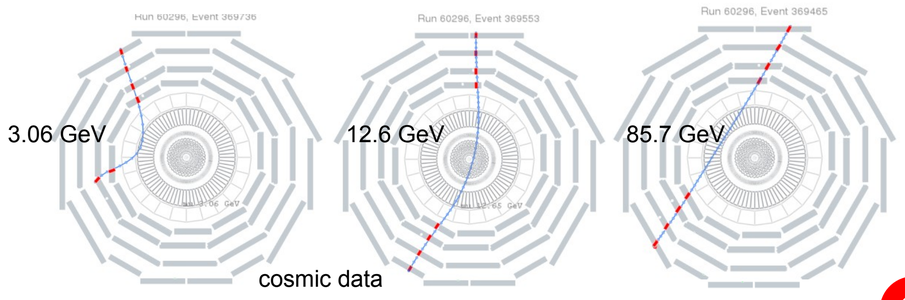
Chamber Alignment

The commissioning data have been used to study the alignment of the chambers and of their relative alignment with respect to the tracker.
A **gravitational sag of the iron wheels** has been determined. The relative offset between photogrammetry surveys and track alignment is due to a global rotation of the muon system w.r.t. the central tracker. The measurements are used to correct the geometry used for reconstruction.





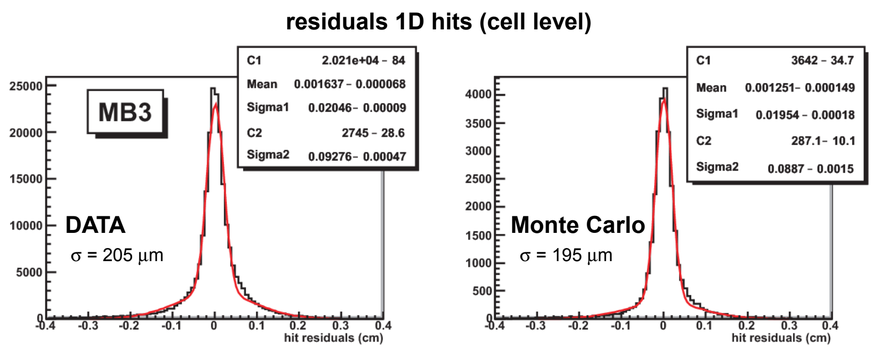
Performance



The cosmic data acquired during the tests of the chambers have also been used for the **commissioning** of the **muon reconstruction** algorithms:

- local reconstruction (track segments at chamber level)
- muon track fitting:
  - Standalone = spectrometer only
  - Global = spectrometer + Si tracker

The products of the local reconstruction are used as input to the kalman-filter algorithm used for the track fit.



DT Chamber Performance

Resolution:

- 1D hits (cell level): **σ_x ~ 200 μm**
- 3D segments (chamber level): σ_x ~ 70 μm σ_ϕ ~ 0.5 mrad in Rϕ projection

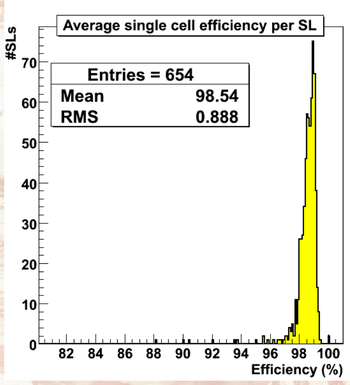
Efficiency:

- single cell efficiency **> 98 %**

Noise:

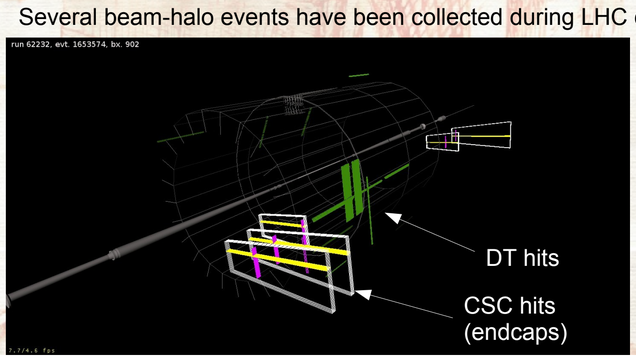
- random noise: 20-30 noisy channels / 170k (noise rate > 500Hz)

The **agreement** between **data** and **MonteCarlo** looks **satisfactory**.

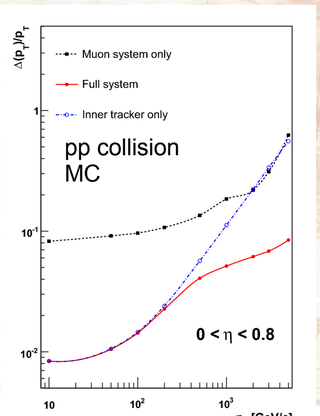


Muons from beam-halo

Several beam-halo events have been collected during LHC commissioning.



Muon Momentum Resolution



The **contribution of the muon-spectrometer to the momentum resolution becomes important at very high p_T (>200 GeV)** thanks to the larger lever arm w.r.t. the central tracker.
The Standalone reconstruction is also used in the Level-2 trigger selection in the CMS High Level Trigger.

The understanding of the commissioning data will play a key role for the achievement of the design performance