Muon Identification & Muon Commissioning

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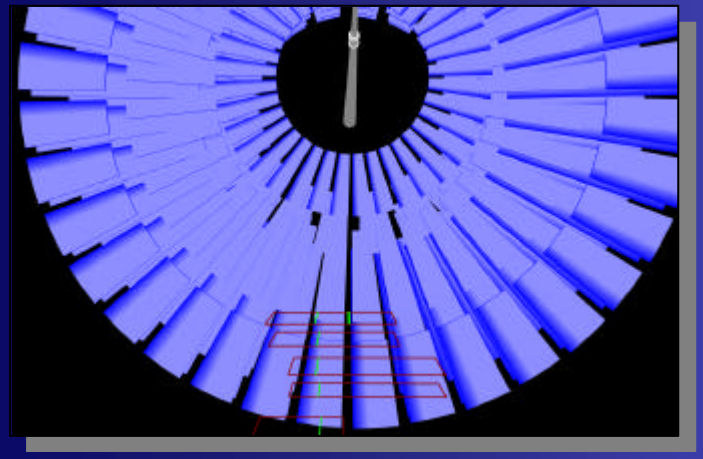
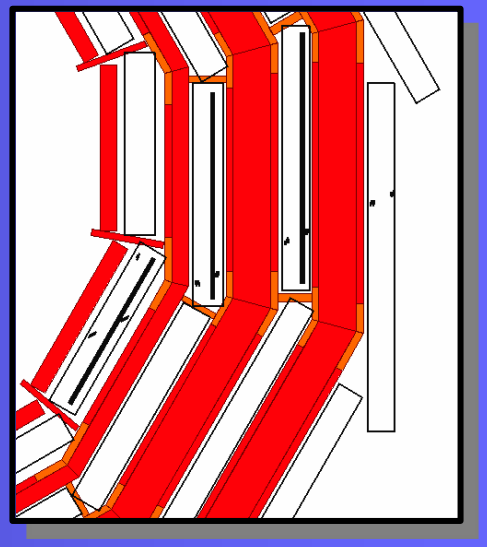


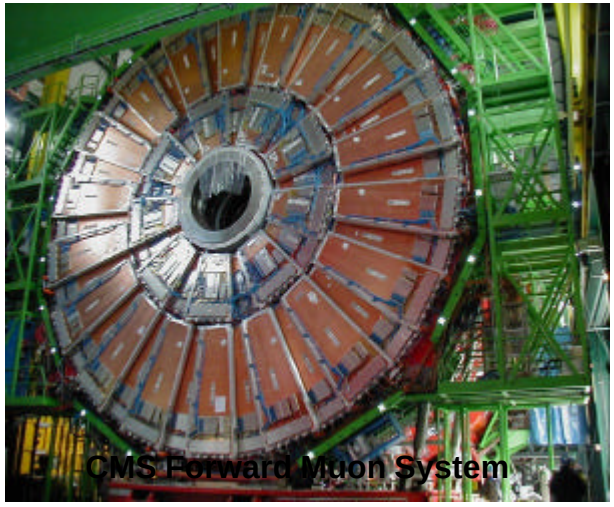


Outline

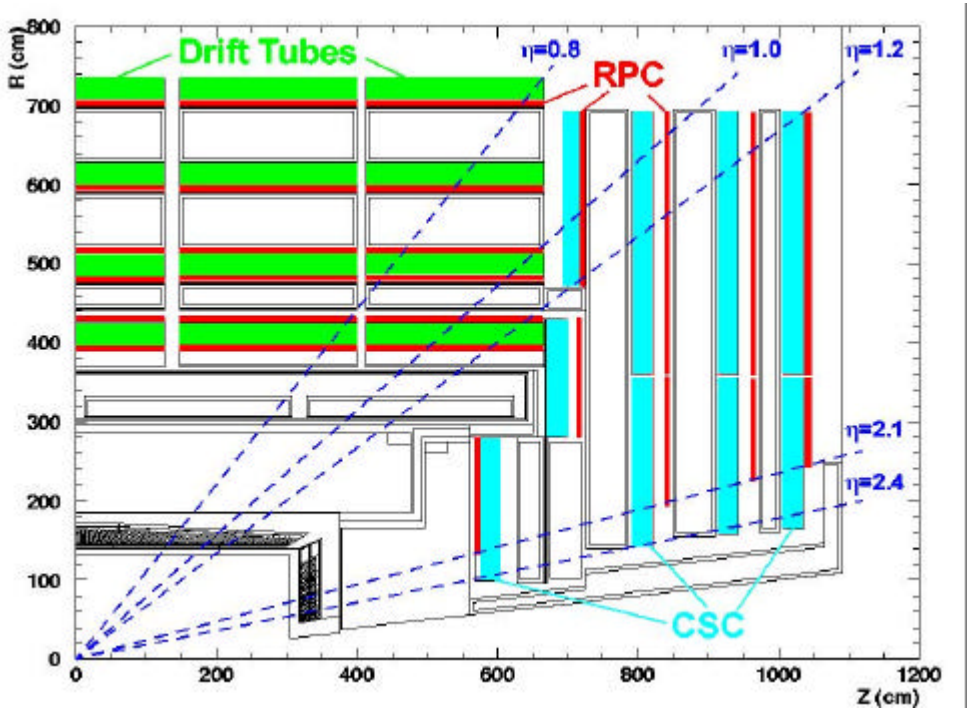
- Overview muon HW & SW groups
- Muon Identification

- Muon Commissioning
  1. DETECTORS
     - Subsystem (CSC, DT, RPC) commissioning
     - Integration in CMS, Concept of global runs
  2. RECONSTRUCTION SOFTWARE
     - DPG activities


CMS Muon Barrel System


CMS Forward Muon System

CMS Muon System

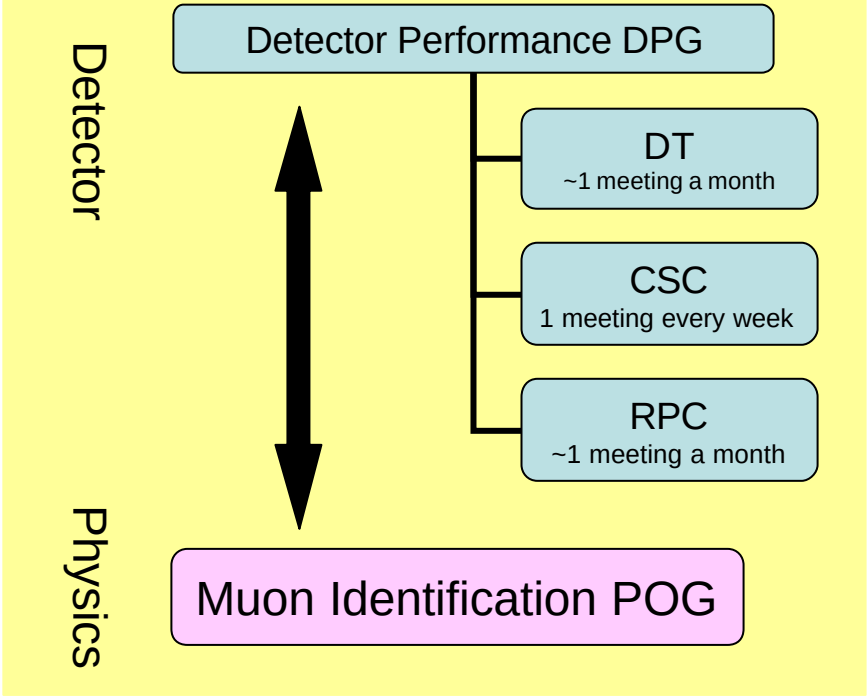


Muon Barrel 0 < |h| < 1.2

- 5 barrel wheels, iron return yoke for the solenoid magnet
- Almost no B-field
- 250 Drift Tube (DT) Chambers
- 480 Resistive Plate Chambers (RPC)

Forward Muon 0.9 < |h| < 2.4

- Arranged in 2 x 3 disks
- 4 muon stations in 2/3 rings
- Inhomogenous field with B<1.2 T
- 250 Cathode Strip Chambers (CSC)
- 483 Resistive Plate Chambers (RPC)



Offline Muon Reconstruction

Offline reconstruction algorithms provide in CMSSW_1_6_0:

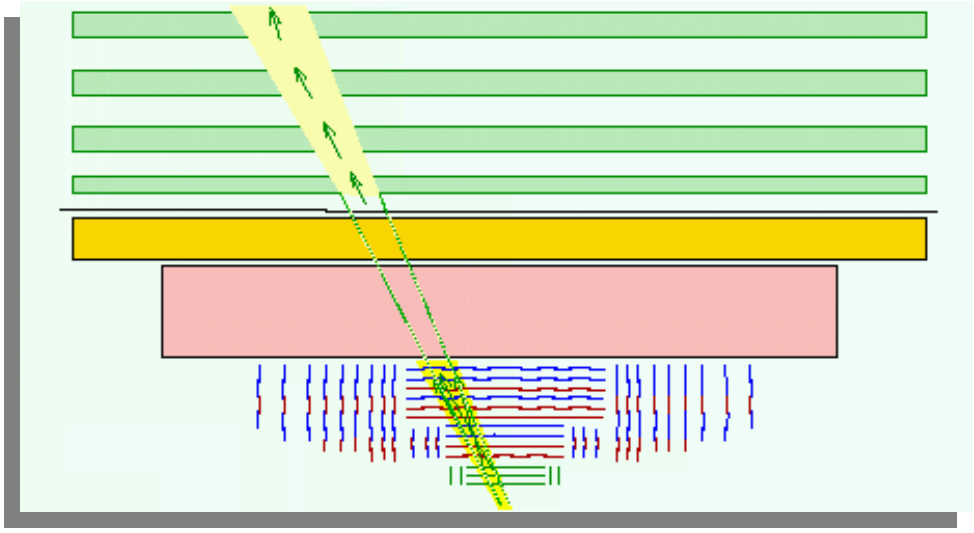
- Standalone Muon (STA)
  - → Muon spectrometer only
- Global Muon
  - → Muon + tracker

- Muon Identification
  - → Compatibility of tracker track with muon hypothesis

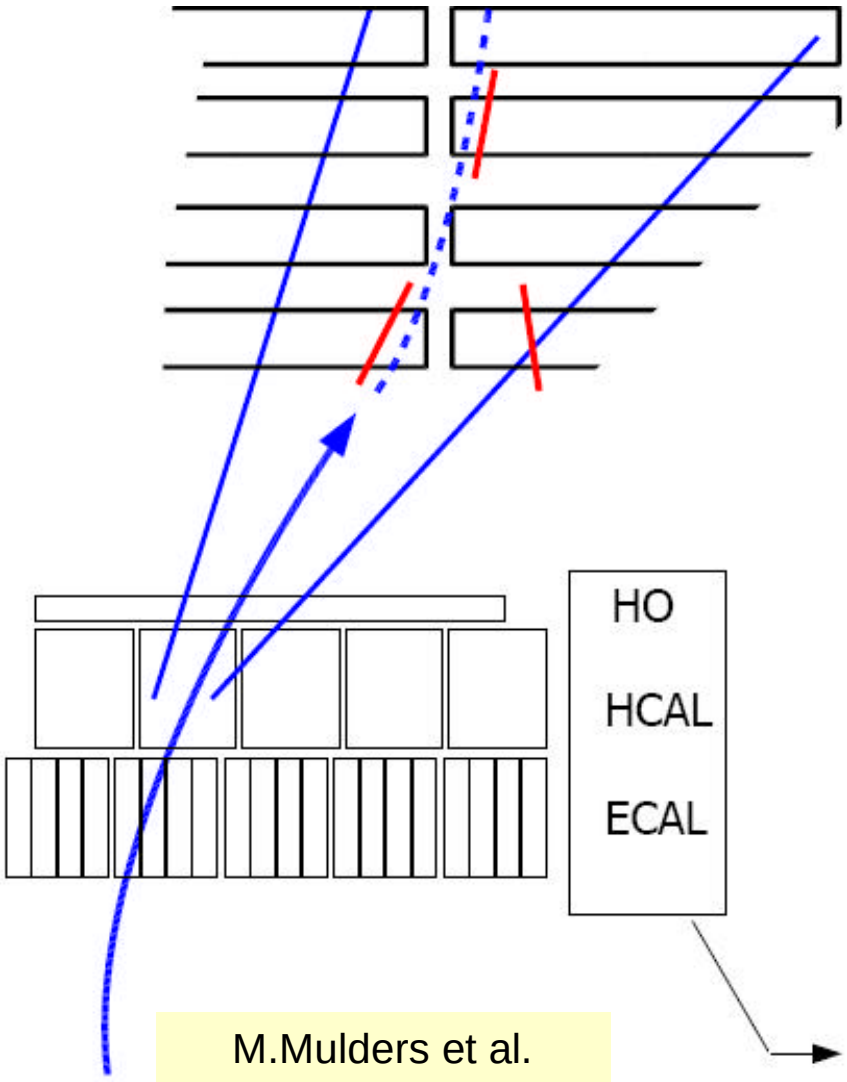
M.Mulders et al.

- Muon Isolation
  - → Calorimeters and tracks

Workshop on POG Commissioning on 12/09/2007, see http://indico.cern.ch/conferenceDisplay.py?confId=20353



TrackerMuon Information



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Information provided for each track:

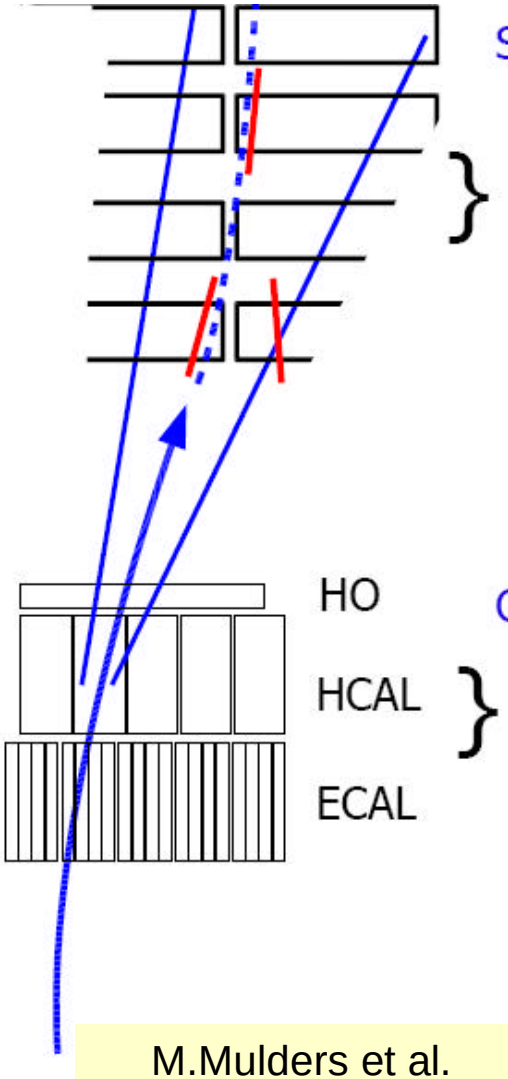
- Each layer:
  - Matched chambers in each layer, compatible with extrapolation...
    - Distance to edge (x,y) + errors
    - Slopes dx/dz, dy/dz + errors
    - Muon Segments in chamber
      - Positions x,y + errors
      - Slopes dx/dz, dy/dz + errors
- 'Arbitration' information, which segment is closest to which extrapolated track...

[available as of 1_5_0 , 1_6_0]

Lots of complex, nested information
--> need to summarize for user ...

Energy deposited in crossed cells; 1x1 cone, or 3x3 cone (also useful for MET corr.)

Approach 1: Muon Compatibility



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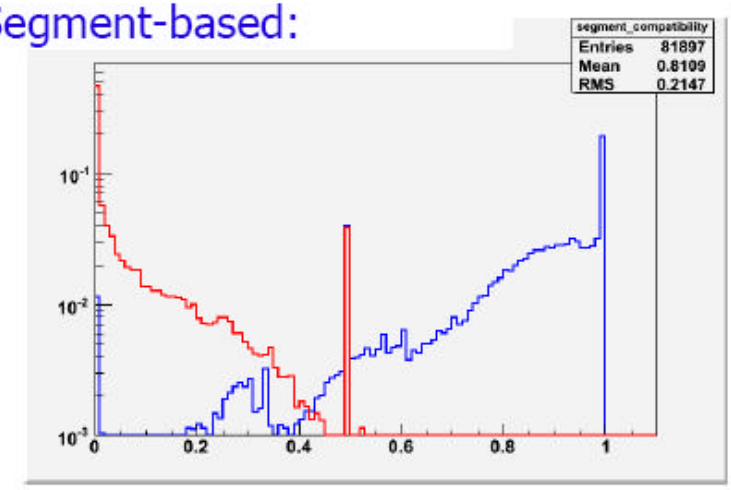
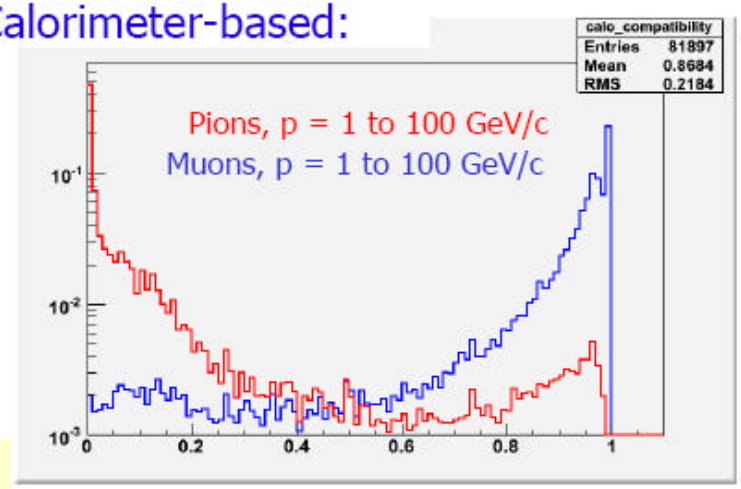
Segment-based:



Calorimeter-based:



A la PTDR
CMS note 2006/10

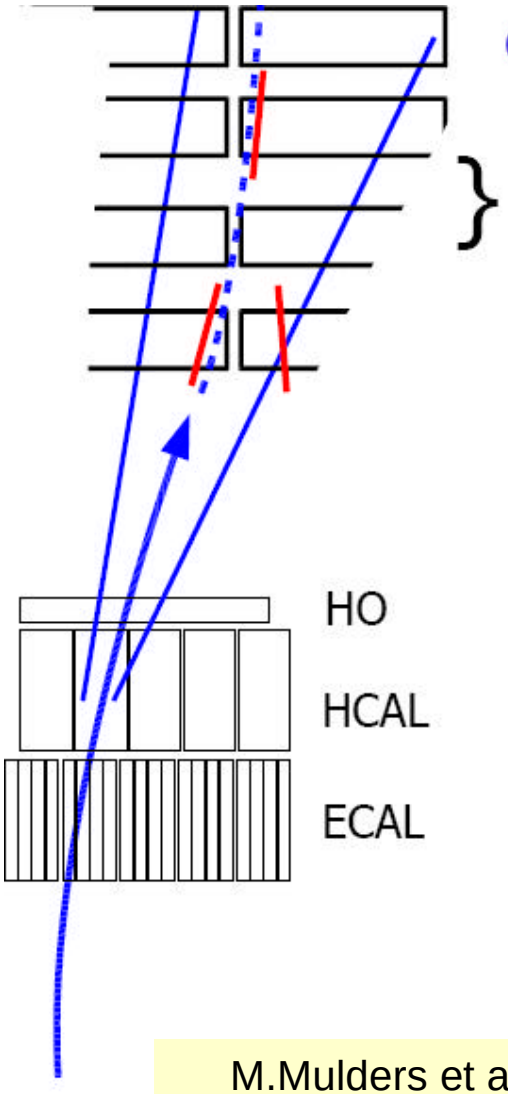
Discriminating variable, more weight to outer layers, uses all info

- Based on segments, not hits
- New: lenient on missing segments close to chamber edge

Purity based on likelihood ratio from MC templates of energy

- Improved eta bins
- Correction vs eta in bins
- 2D Energy templates vs pT of track

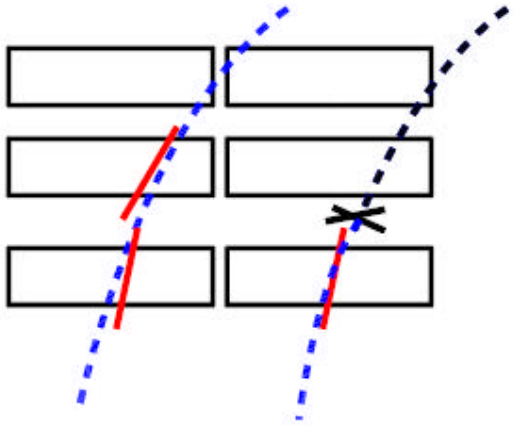
Approach 2: Cut-Based Selection



Only using segment information:

- At least 2 associated segments. Require segment in last station with extrapolation >3 sigma inside
- Loose: | X(seg) – X(extrap) | < Max(3σ, 3 cm)
- Tight: same, in local X and Y

"last station algorithm"



--> this station not required

--> last required station: good discrimination

--> first station: not so good discrimination

(real system has 4 stations)

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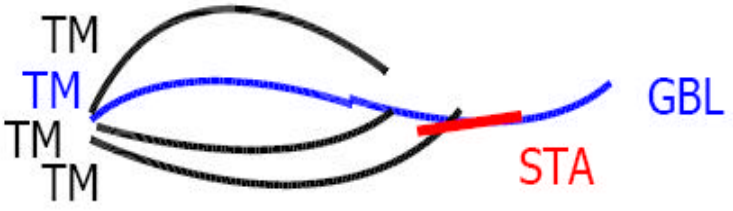
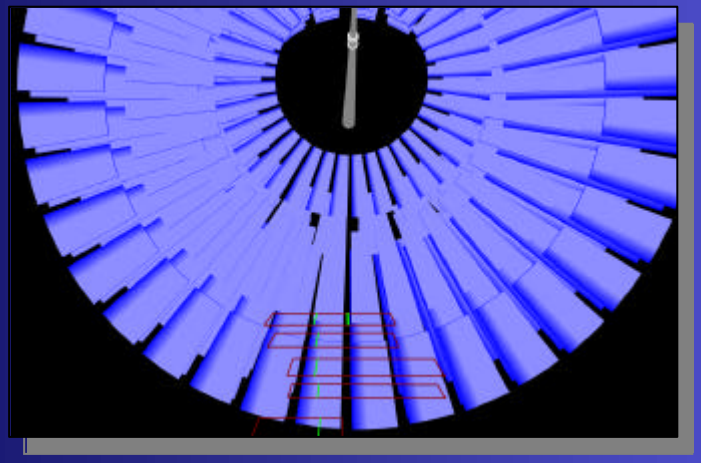
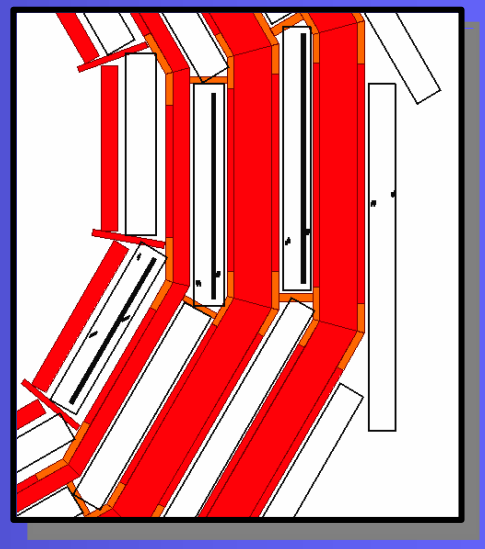
Tracker Muon ™



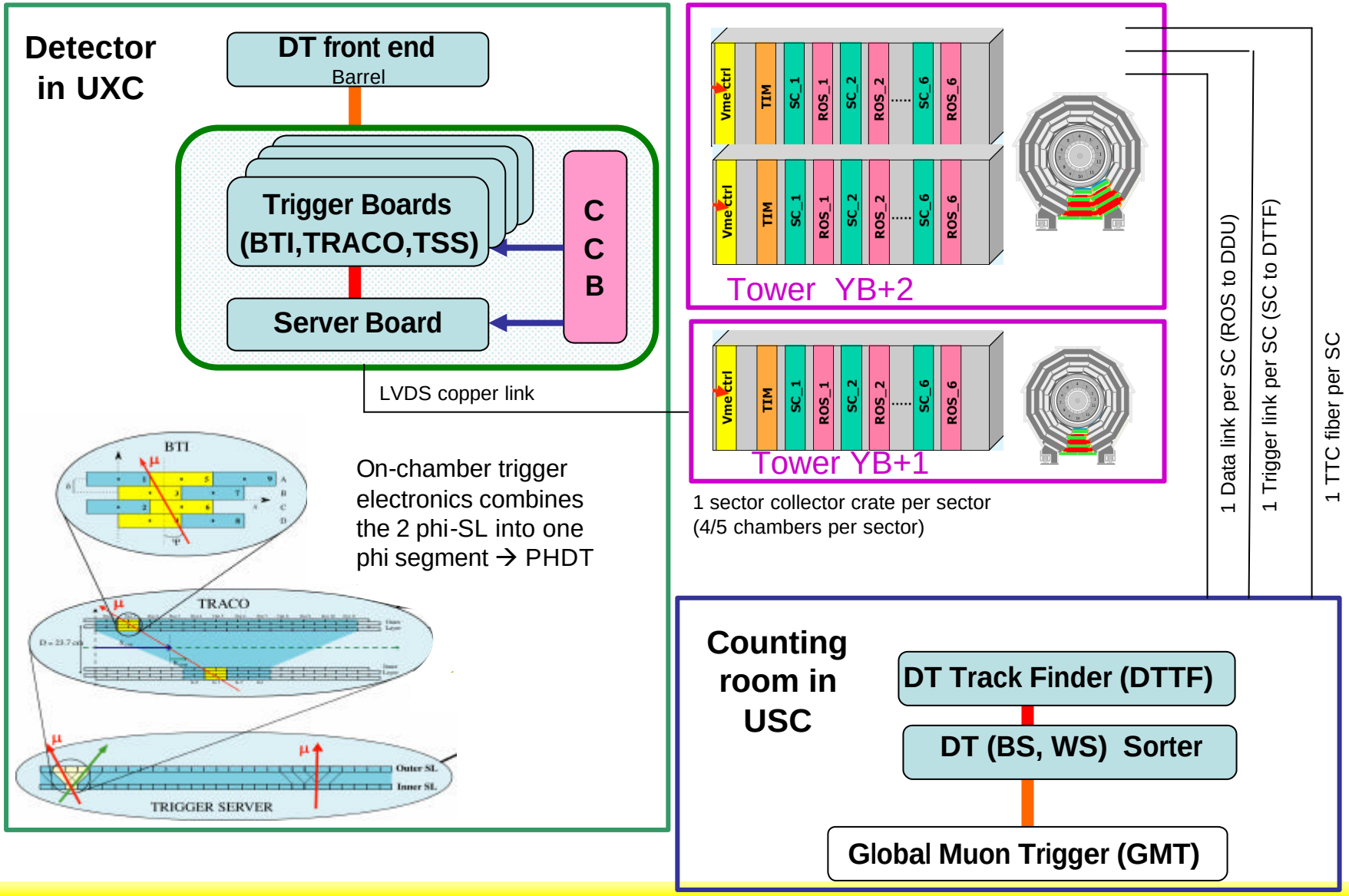
- TrackerMuons available as of 1_5_0
- Example as of 1_6_0, see
  - Twiki: http://twiki.cern.ch/twiki/bin/view/CMS/TRackerMuons
  - FWLite example: in RecoMuon/MuonIdentification/test/MuonSelectionExample.cxx
- First comparison with global muons
  - TM potentially more efficient at low p_T
  - Should allow to distinguish punch-though π
  - "Last station" logic (missing segments) is a useful new handle to improve muon ID
- Still learning and improving!
- Beware of tighter cuts in 1_6_x, studying looser settings for 1_7_x
- Goal for 1_7_x: to provide a single merged collection on muons and define user functions to select tighter subsets

Commissiong of CMS Muon System





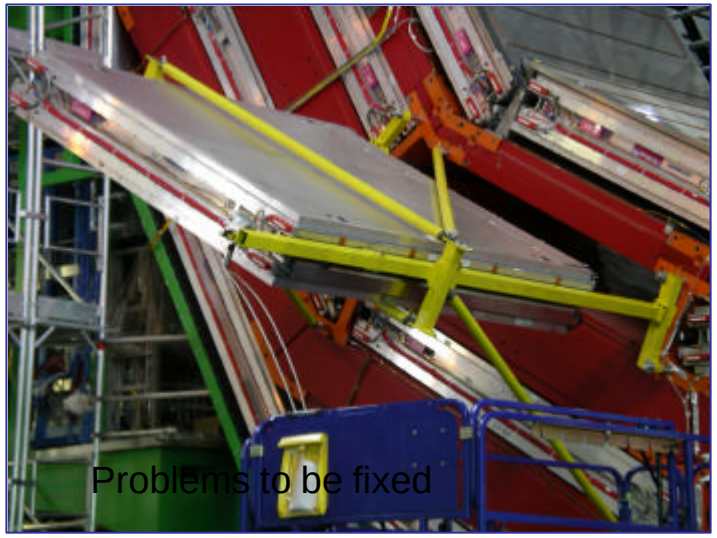
Commissioning of DT Electronics

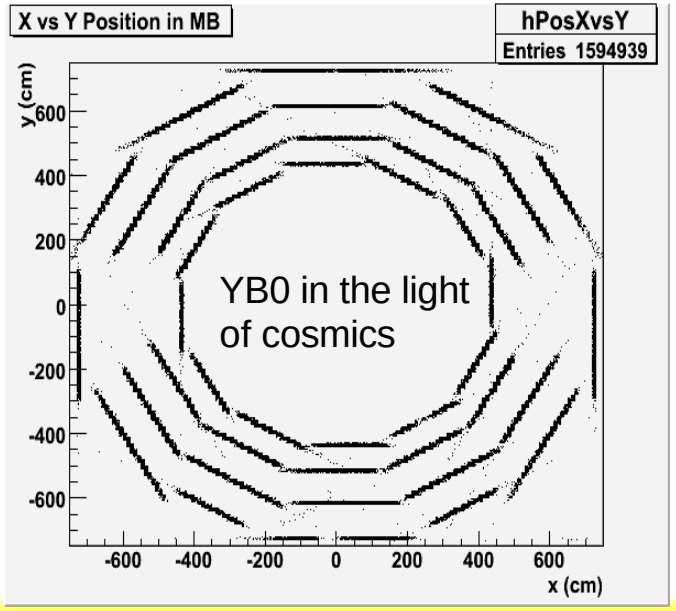


DT Wheel Commissioning

- All chambers **installed** (except 8, MB2/MB3 in sectors 1/7 of YB-1 and YB-2)
- Under long term HV test (Final cables UXC / Provisional SX5)
- Wheels connected to gas & cooling (partly provisional)
- Commissioning activities ongoing at SX5 & cavern (**YB0, YB-1, YB+1** almost completed, **YB-2, YB+2** ongoing).
- Schedule: We loose access to YB0, only restricted access periods for movable wheels

- Commissioning of wheels includes:
  - 4-5 chambers per sector. 1-2 sectors at the time
  - On- and off-chamber electronics
  - Configuration and monitoring via DCS (minicrate, SC, ROS)
  - Trigger "high end" (DTTF, BS, WS) used as a tool
  - DQM



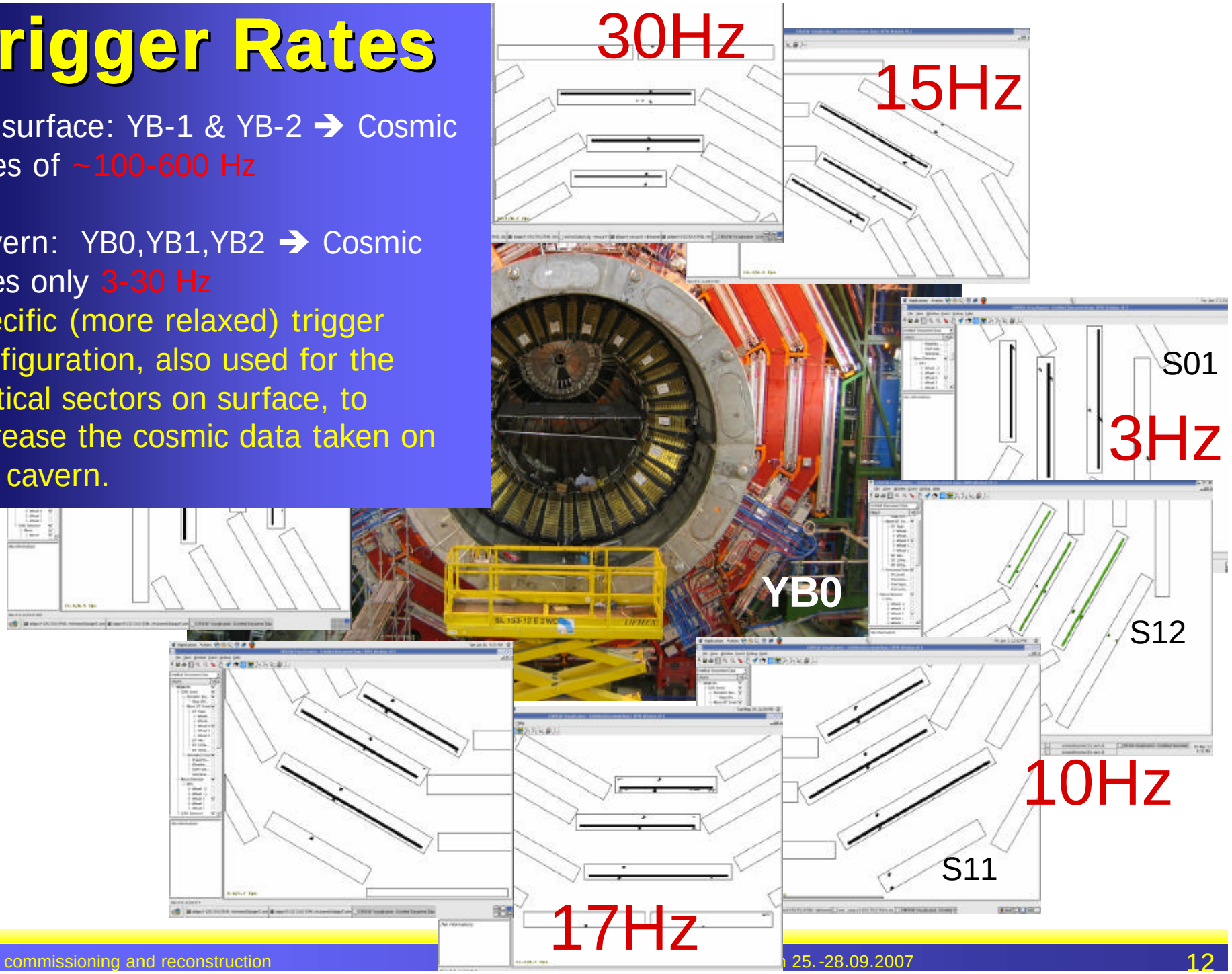


Trigger Rates

On surface: YB-1 & YB-2 ➔ Cosmic rates of ~100-600 Hz

Cavern: YB0,YB1,YB2 ➔ Cosmic rates only 3-30 Hz

Specific (more relaxed) trigger configuration, also used for the vertical sectors on surface, to increase the cosmic data taken on the cavern.



Wheel Data Analysis

- **Goals:**
  - Certify performance of chamber, read out and local trigger
  - Learn and check the tools (reco-software, geometry, database, calibration…). First step to be prepared for the operation and calibration of the whole detector.

- The first analysis step ➔ The online DQM run by shift-crew
- A more detailed offline analysis based on the available DQM tasks on higher level objects. A DPG-crew of people involved on the effort. (CMSSW 1_4_5)
  - Producing noise channels database
  - Global Tzero (tTrig) calibration database
  - Relative Tzeros calibration (from TestPulse runs)
  - Digi information (ocupancies, single cell timeboxes)
  - Local trigger (BX, qualities)
  - 4D Segments reconstruction (Resolutions, single cell efficiency, track reconstruction efficiencies)
  - Cross checks between chamber and local trigger (Trigger efficiencies)
- Summary plots available on a web page:

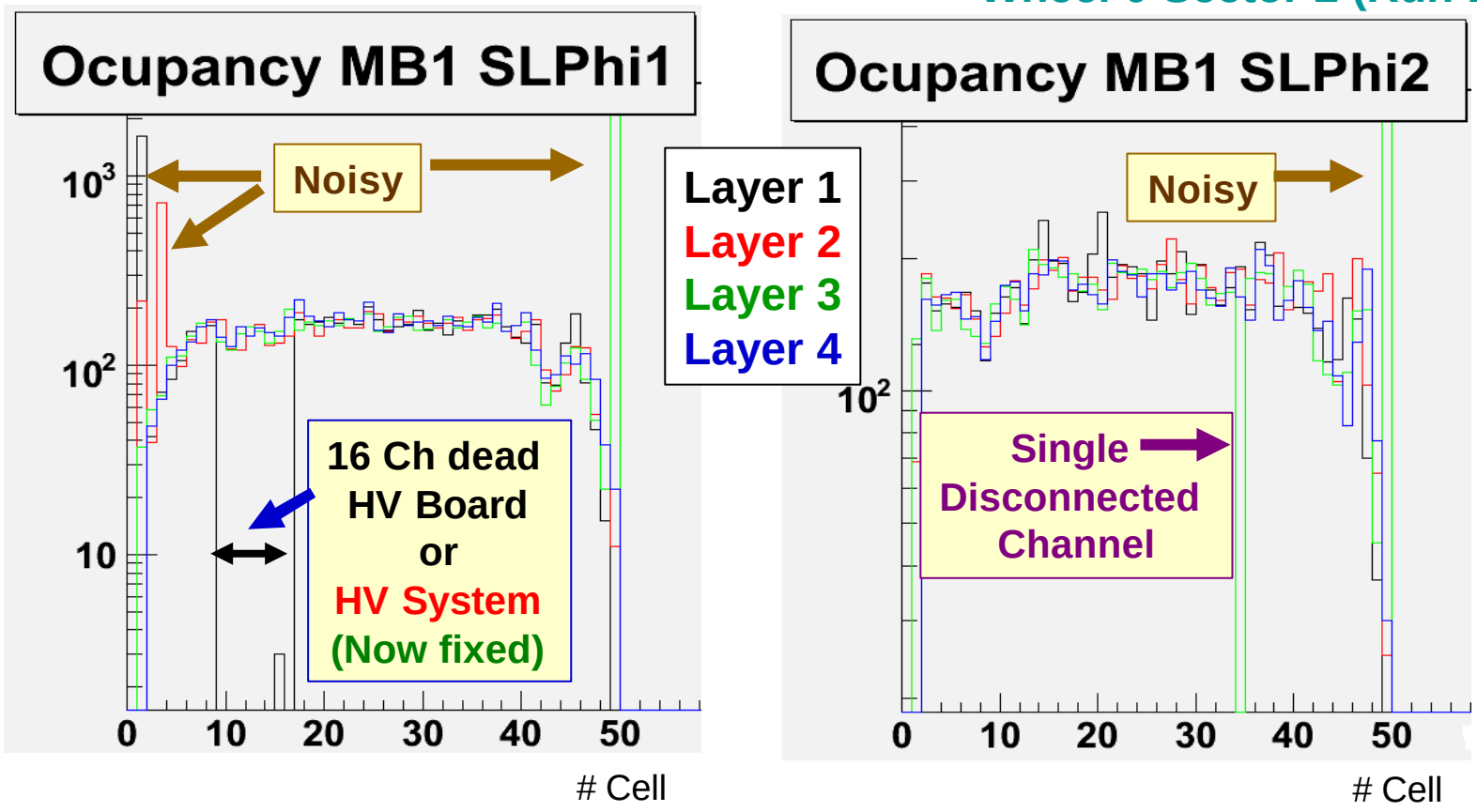
  http://cmsdoc.cern.ch/cms/MUON/dt/sx5/Results/WheelComm/

Occupancies

Simple check based on digis

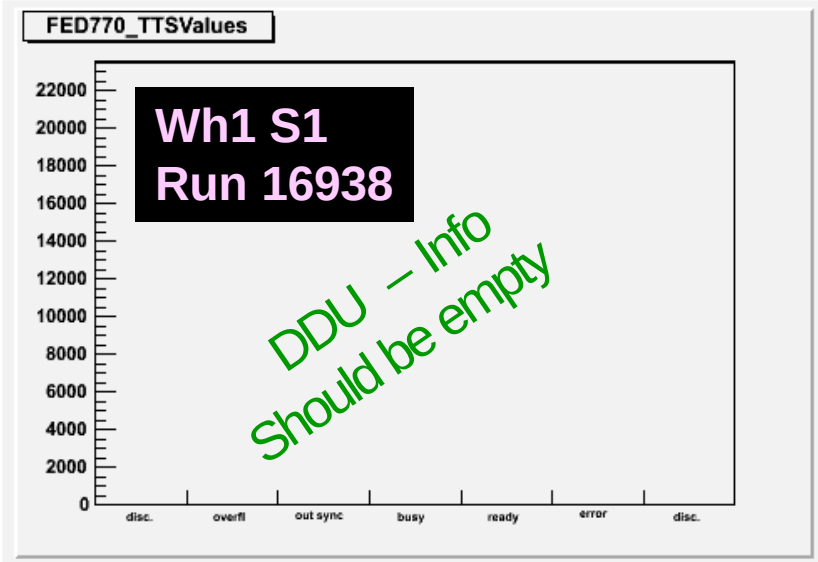
To detect: dead channels, noisy channels, HV problems

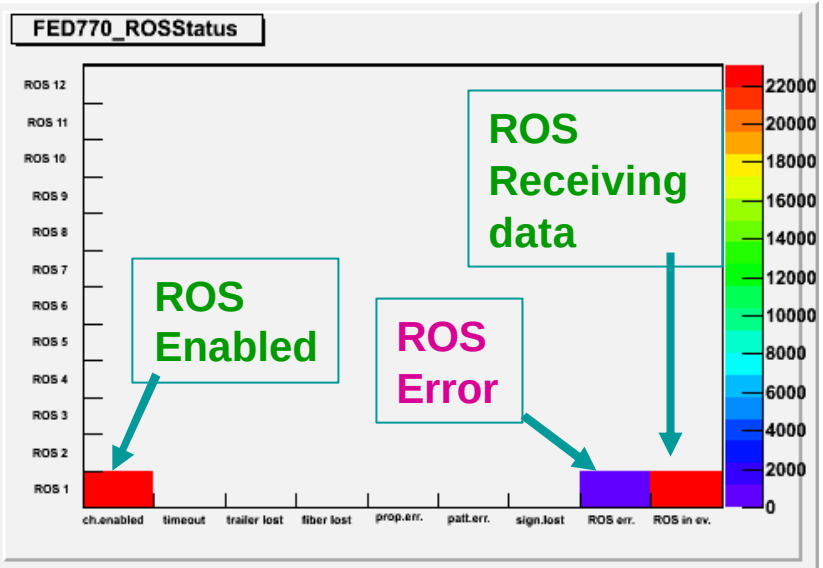
Wheel 0 Sector 2 (Run 12952)

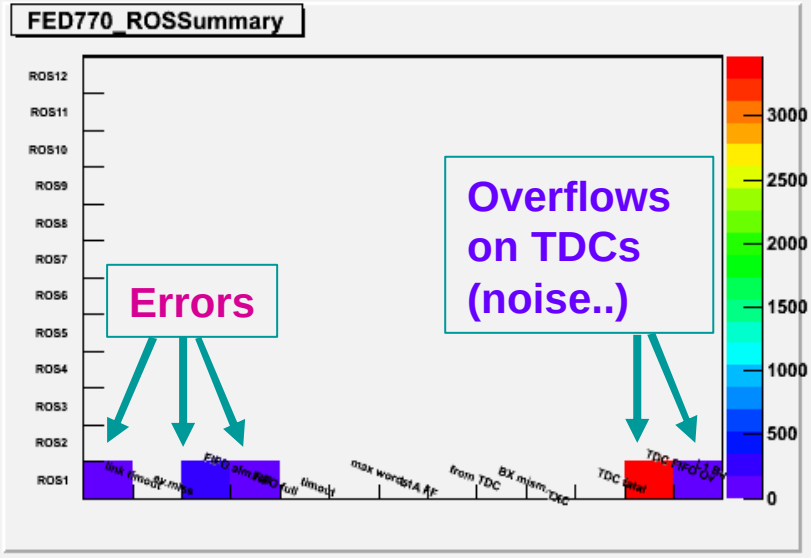


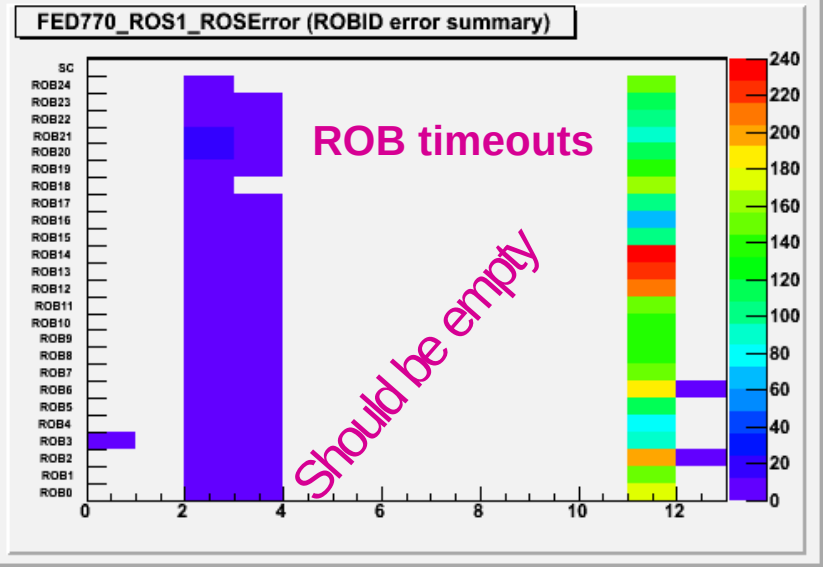
A new source of noise found when taking data underground (low trigger rates, possibly related to LV powering) → under study

Example for Data Integrity

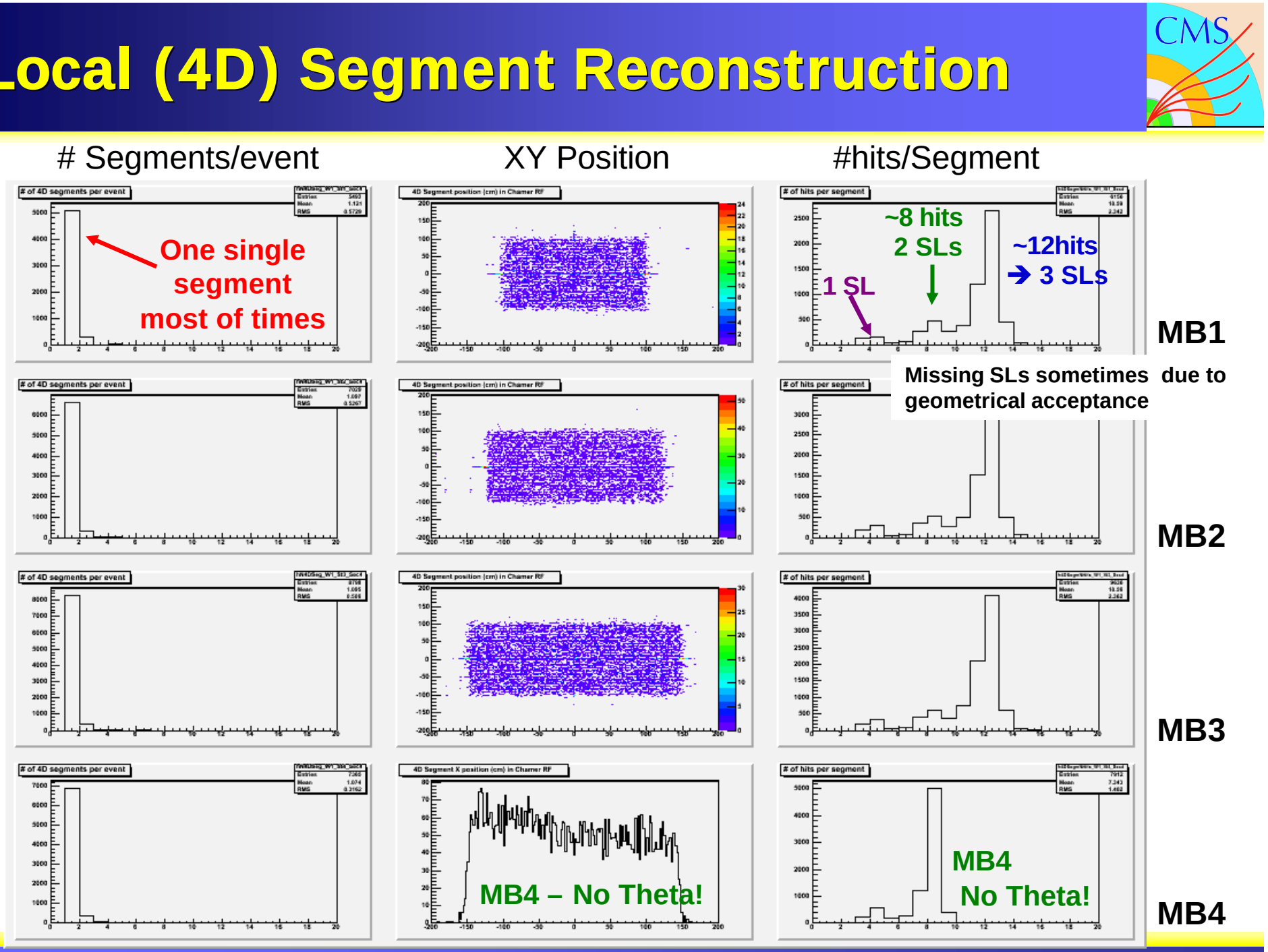








Local (4D) Segment Reconstruction



CMSSW Issues for DT

- CMSSW_1_4_5 :
  - Frozen version extensively used since June in online DQM & off-line cosmic data analyses (stability is a must to guaranteed uniformity of results,ect...)
  - Extensive tests /debug on real data performed; calibration procedures developed/tested in real data environment

- CMSSW_1_6_0 :
  - Used in recent (August) GlobalRun analysis tests
  - Final digi2raw->raw2digi code (some fixing needed for simul.data)
  - Used for tests of global muon reconstruction on real data; databases handling on full Wheel/Detector scale
  - First implementation of out-of-time particle refitting

- CMSSW_1_7_0 (last open release due October 2nd)
  - Final geometry updates (few MB4 geometry fixing needed based on real data analysis, found in agreement with engineering drawings) Final certification (Overlaps checks) ongoing

RPC Detectors

Resistive Plate Chambers in CMS are → Digital Detectors

The output is the address of the fired strip

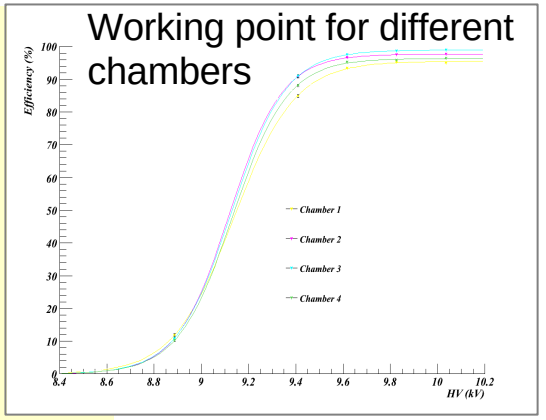
Assigned to a bunch crossing

→ No Calibration Needed

Coarse space resolution (~1 cm)

→ Minor effects on due to Mis-Alignment

Important: RPC working point, sensitive to T, p, gas composition



Working point kept below plateau to reduce ageing

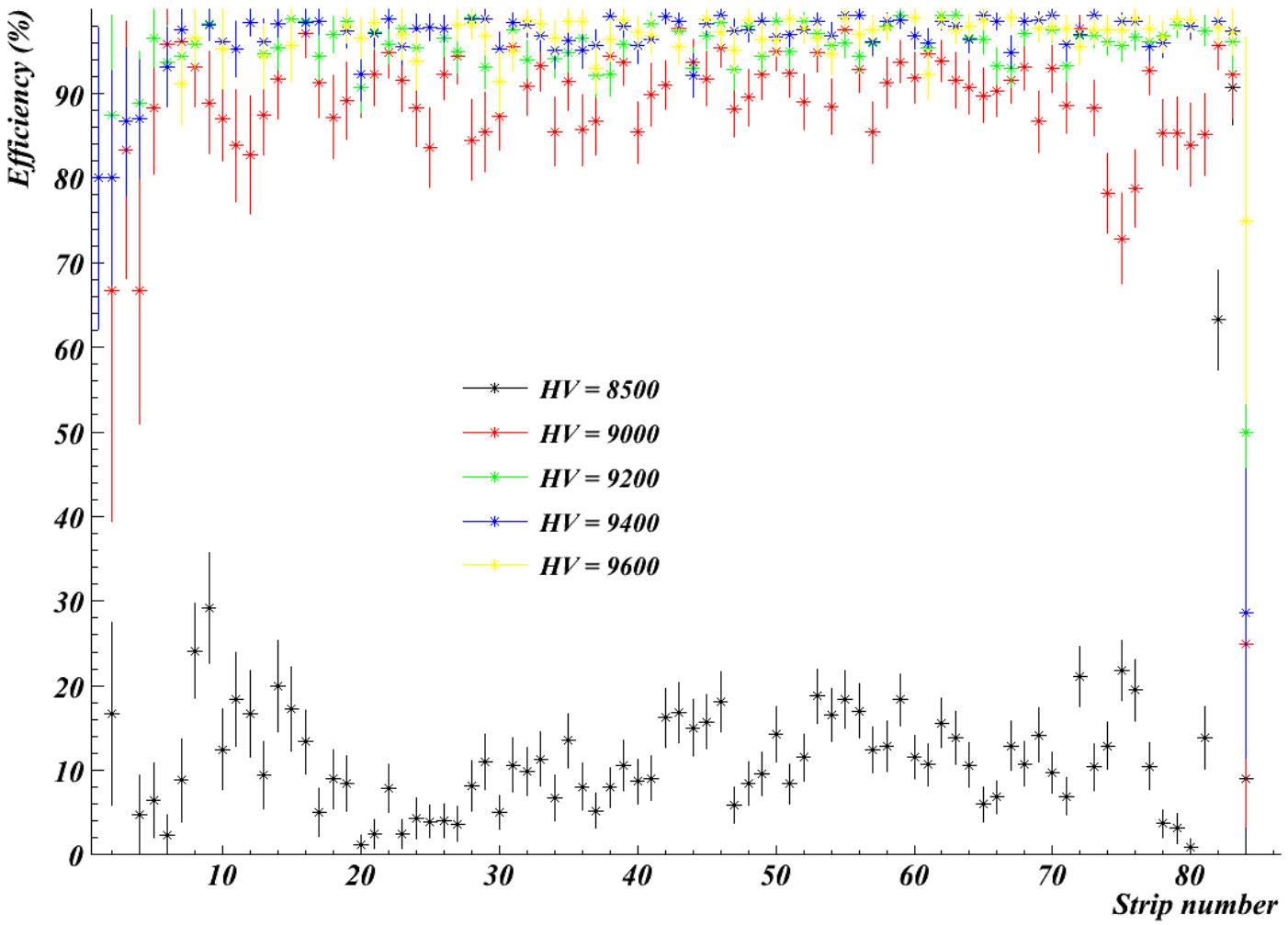
Commissioning:

- Verify I-V curves after installation (measured during production)
- Check hardware

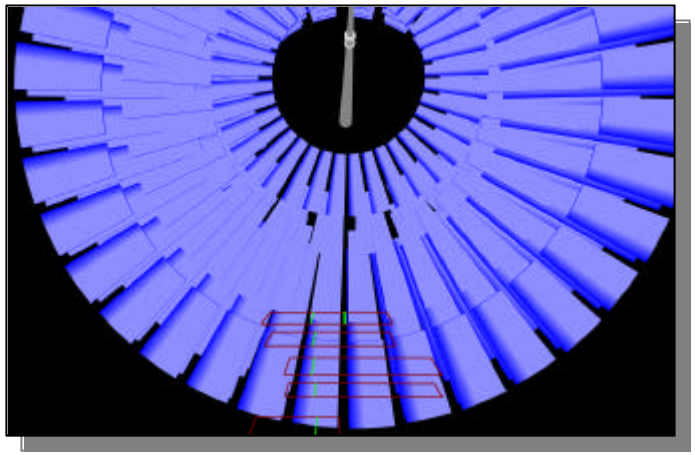
- Barrel RPC are worked on first, end-cap RPC afterwards (small comm. team, late installation of end-cap RPC)

- After lowering: link boards (readout) and trigger board added underground (in process). Test barrel chambers with ½ wheel granularity.

Local Efficiency Using DT Extrapolation



RPC Global Data & SW



- Vertical test post-July GR:
  - Data transmission to trigger and triggering → OK
  - Readout and data recording → OK
  - Unpacking and local reconstruction → OK

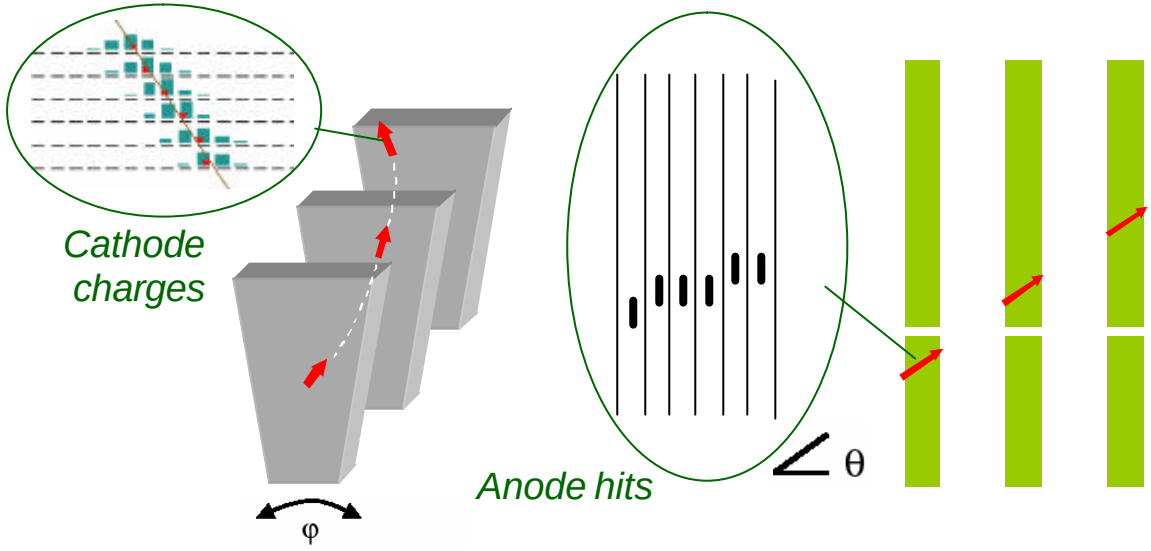
- Data Quality Monitoring and Reconstruction
  - DT Segment extrapolation for barrel efficiency calculation → OK
  - CSC Segment extrapolation → Ongoing
  - RPC muon stand-alone reconstruction for commissioning data → to be done
  - Integration with conditions DB, for RPC performance studies → ongoing

- A bug in counting and assigning RPC fixed → TeV muon reconstruction OK now

M.Maggi

CSC Trigger

CSC trigger is based on (fast) anodes (ALCT) AND (slow) cathodes
ALCT: 2...4 out of 6 wire planes are required

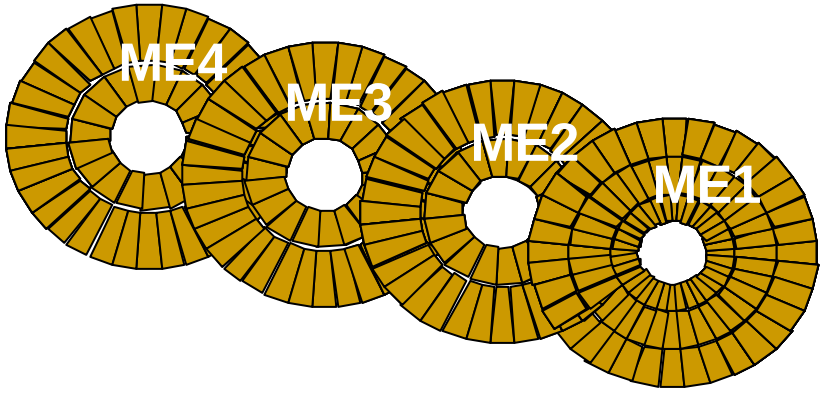


Default ALCT collision pattern defines envelope pointing to IP:

```
Layer 0 xxx
Layer 1  xx
Layer 2   x
Layer 3   xx
Layer 4   xxx
Layer 5   xxx
```

Sector Processor (TF): any coincidence of 2 stations OR single chamber (e.g. ME1)

Synch levels: chamber → station to station → CSC/DT



CSC Commissioning

- Locations: YE Plus end-cap = underground, YE Minus end-cap = surface
- **Commissioning concept:**
  - Commissioning of YE+ (again) underground, after lowering, with "slice test" similar to surface but now with final services (issues: LV, gas, cooling).
  - Final commissioning of YE- stations on the surface. No time after lowering.
- **Scope of underground slice test:** provide cosmics triggers to GMT/GT, data read-out to Global DAQ, and commission online systems
  - Main problem for underground activities: delay in cooling, presently "not before late October". Chambers switched on only for short periods with cont. temperature monitoring. Implications on commissioning and GR.
  - Present focus on YB+2: Trigger Sect.1 on stations ME+2 and ME+3. Big 10° chambers: ME+2/2/3-8, ME+3/2/3-8. Small 20° chambers: ME+2/2-4, ME+3/2/2-4
- **GREA** (August GR): Successful integration with two TTC partitions (ME+ and TF) read out by Global DAQ. CSC-TF under control of Trigger Supervisor. External trigger from Global Trigger. “Empty” CSC events since chambers are off.
- **GRES** (September GR): plan to participate with some YB+2 chambers could not be realized due to bad gas conditions. Will try with test patterns.

CSC Unpacking and DIGIs

A.Tumanov, J.Hauser, R.Wikinson

- The format of the raw data has changed drastically since last year, reflecting major improvements in the readout firmware and track finder
  - Unpacker must deal with two format (2006 or 2007 +)

- Much progress has been made, but task is not finished yet
  - Anode wire information completely reformatted → done
  - TMB format changes more modest → intended to finish before Oct.2nd

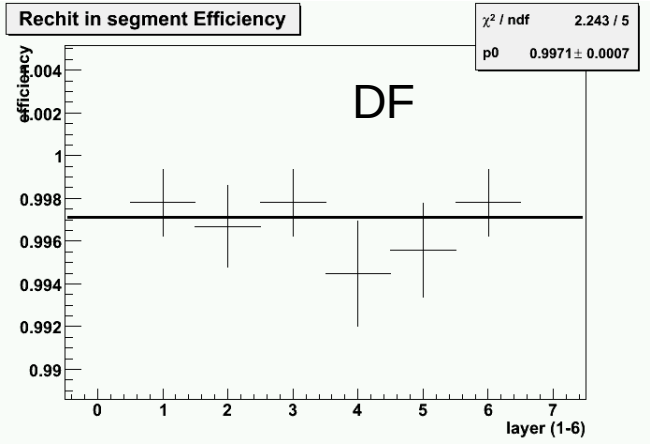
- Note that old unpacker has been thoroughly degugged since 1_4_X
- Major bug in packer code (digi2raw) fixed, in DT code too
  - Very large memory leak
  - Quite important for HLT studies

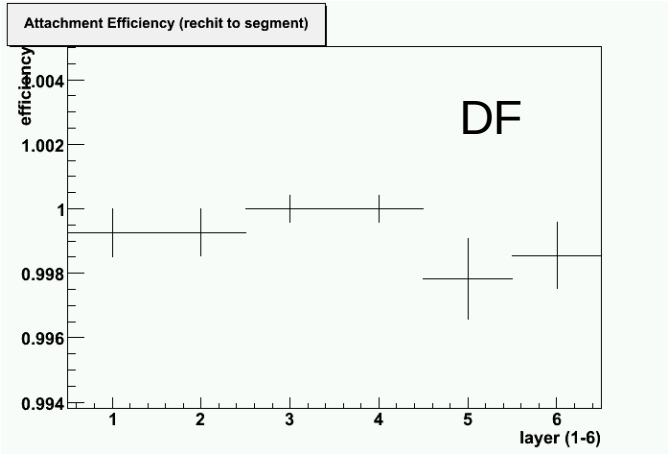
To get new unpacking use 1_5_X or later → recommended for data. MTCC data being re-processed. CSA uses 1_5_x

Does not work for MC produced with CMSSW 1_3_1 (Spring production).

CSC Local Reconstruction

- New RecHit routine released: CSCRecHitB is default CSC hit package since 1_5_2 (RecHitB uses detector calibration while RecHit does not)
- Three local reco algorithms were developed to replace the old SK algorithm (algorithm can be chosen in cfg). They were extensively validated and compared by many people in July, see
  - https://twiki.cern.ch/twiki/bin/view/CMS/CSCDPGVettingLocalReconstruction
  - Choosen: DF





SW studies extensively uses MTCC data → reprocessing initiated since raw MTCC data cannot be reconstructed with present CMSSW versions 1_4_X…1_6_X

- Reasons for change: access to calibration DB and constants (~40 MB calib data per event), reconstruction speed and performance

D.Fortin, I.Bloch, S.Stoynev, E.James, T.Cox, M.Schmitt

CSC Geometry

- Major update for 1_4_x/1_5_x
  - Involved signficant rewriting the C++ code, though interfaces have a similar appearance
  - Re-defined the basis of the local coordinate system to be the chamber frames (solid and well-measured, holds alignment pins), rather than the gas volume, which is what GEANT cares most about.
  - No common geometric center → consequences for several analysis codes, quickly resolved. Non-trivial updates to the values of chamber constants and some additions and corrections to make the description more detailed and accurate. This work continues into 17x (break backward compatibility slightly)
- Extensive collection (64 pages) of information on CSC geometry, see http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=17946
- Should be transparent to the "user" of CSC

Consequences:

- 131 data cannot be reconstructed with 1_4_x/1_5_x

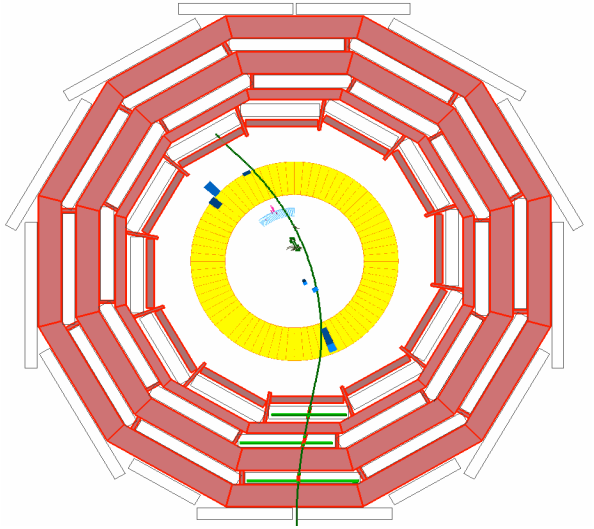
MTCC reprocessing uses 1_5_x in reconstruction step

Outlook

- Finish commissioning surface and underground. Integration in CMS

- Milestones:
  - Global run end December 2007 (all three muon subsystems) and B=off
  - Muon reconstruction and muon identification with 1_7_x

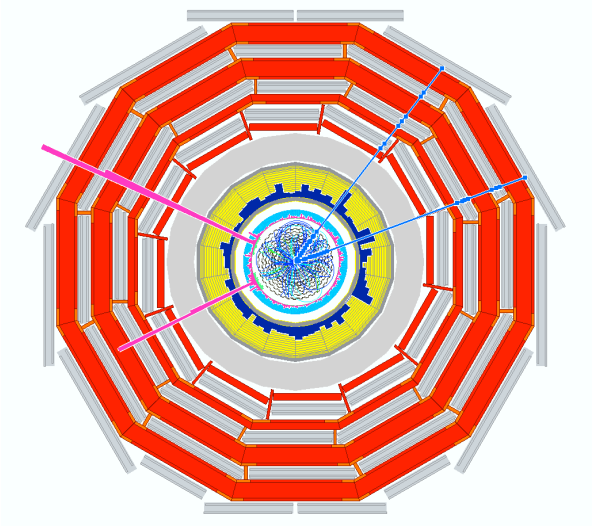
  - Cosmic Global run with B=4T~April 2008



Real data 2006

Finally….

From cosmics to pp



(Still) simulation