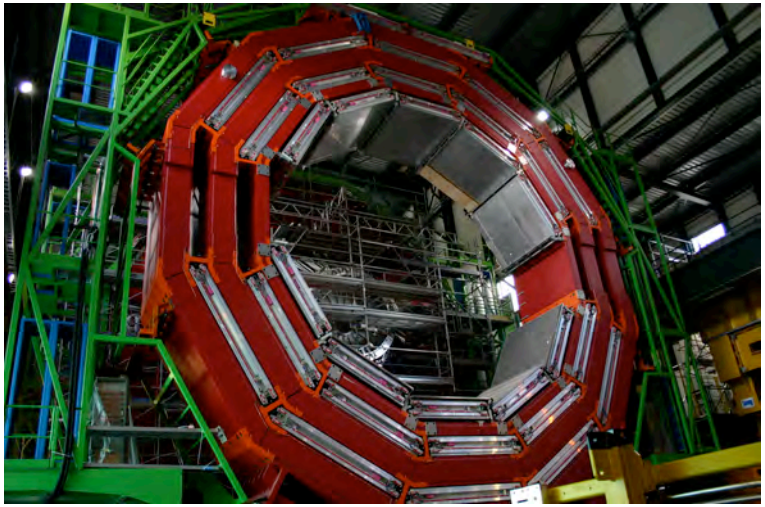
DT Chamber Commissioning



Kerstin Hoepfner, RWTH Aachen & CERN CMM

For the commissioning team

Commissioning Procedures

Commissioning contains several steps:

1. Cabling of the chamber connecting LV, RO, TRG, clock, DCS. Hand-made connections!
2. Test on-chamber readout and trigger electronics with dedicated procedures
   - Several ROB and TRB testing procedures
   - If errors are found commissioners try to fix it (success depends on experience with electronics).
   - No fix → leave chamber to Franco and/or move to next one
3. Take testpulses TP fed directly to FEB, no wire test
4. Cosmics data taking test performance of all cells + readout
   - 3 (MB1,2,3) and 2 (MB4) configurations, respectively
   - Depending on chamber orientation, data taking rates ~80 - 500 Hz
5. Data analysis and diagnostics
   - ISR chamber traveller is the reference, see http://dt-sx5.web.cern.ch/dt-sx5/
   - Calibration (t0 and tTrig)
   - Analysis and diagnostic with Hanytheta run

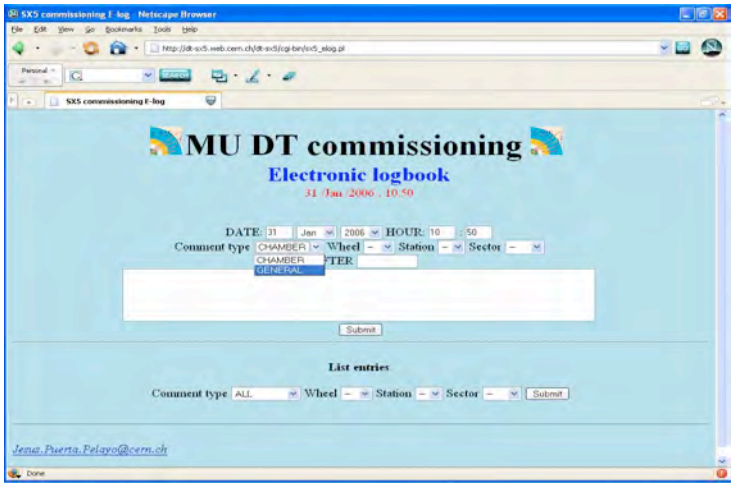
Required time and manpower: a team of 2 people is needed, manage 1-2 chambers per day (depends on cabling time, chamber performance, data taking time)

Now we operate 2 set-up's in parallel with 3 people on shift.

E-Tools for Logging

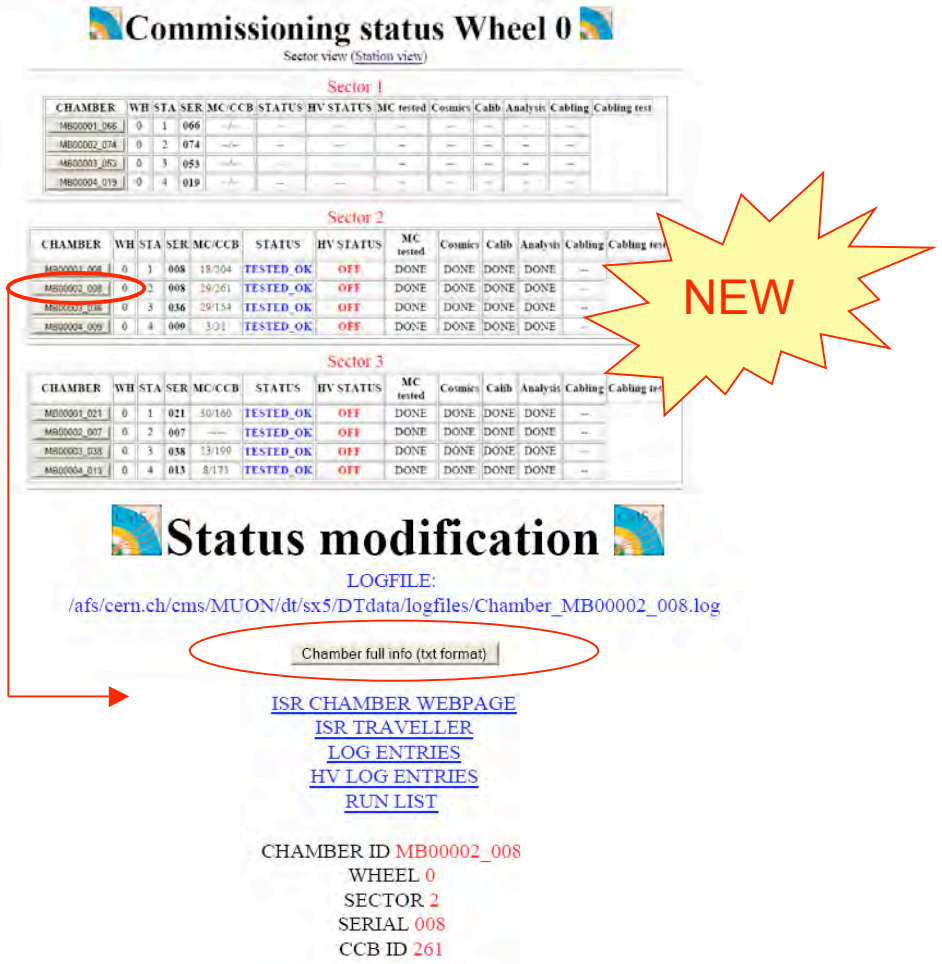
- Since beginning 2006 use of electronics tools to ease the communication between CERN shifts and off-site analysis (e-logbook, e-runlist)

  http://dt-sx5.web.cern.ch/dt-sx5/



Please use these tools and give feedback if they do not serve their purpose

Jesus



Commissiong Team & Organisation

- **Commissioning crew** continues to grow (20 potential shifters):
  Michael Sowa, Tiziano Rovelli, Chiara Mariotti, Gianluca Cerminara, Enrico Conti, Andrea Parenti, Gianni Siroli, Marco Zanetti, Francesca Cavallo, Pierluigi Zotto, Jesus Puerta, Marcos Fernandez, Marina Giunta, Ezio Torasso, Andrea Perrotta, Stefano Marcellini, Philipp Biallass, Emanuel Jacobi, Maria Chamizo, Carlos Villanueva, Kerstin Hoepfner, Franco Gonella

- Some Comments:
  - All lab's participate in commissioning. Interest by collaboration is good.
  - Spring commissioning sometimes conflicted with SX5 infrastructure work and 2 weeks shifts got cancelled. No overall impact due to availability of 2.set-up.
  - Looking to the future: YB-1 and YB-2 will be constraint in time. Requires both set-up's with good reliability and fast feedback BEFORE the cabling of the wheels begins…
  - For commissioning of the vertical sectors (underground) a 3.set-up is recommended.

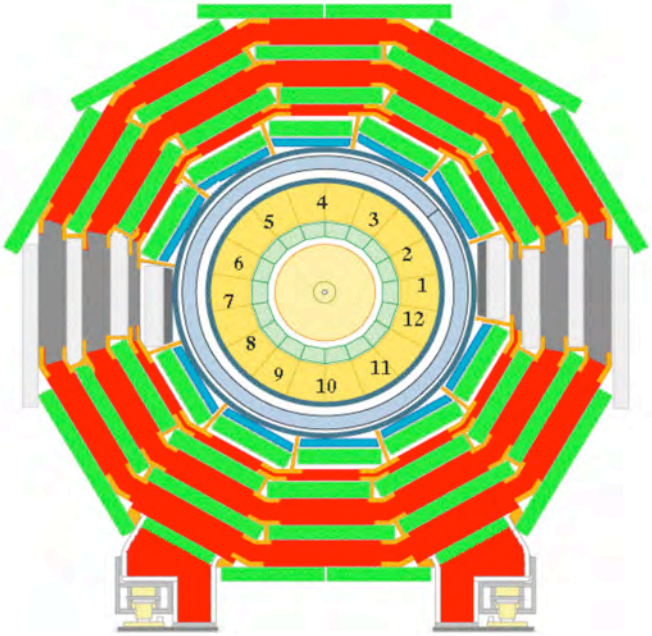
Which Sectors Do We Deal With

- **Commissioning periods per wheel:**
  - **YB+2** 09/05/05 – 02/09/05: 4 months, 40 chambers, 1 shifter, start-up effects
  - **YB+1** 19/09/05 – 19/12/05: 3 months, 42 chambers, 2 shifters
  - **YB0** 16/03/06 – 19/05/05: (2 weeks cancelled): 1.5 months, 32 chambers, second set-up became available end April 05, then 3 shifters
  - **YB-1** 17/05/05 – 26/05/05: 1.5 weeks, 10 chambers, 3 shifters

- **Which sectors can be commissioned**

Best **commissioning** rate achieved: 6 chambers per week for **trained shifters**

Vertical sectors S01, S07 will be installed and commissioned underground.



Commissioning Status 02.06.2006

Following chambers are completed:

- **YB+2** all possible surface chambers (except vertical ones S01, S07).
- **YB+1** all possible surface chambers.
- **YB0**: Chambers commissioned in sectors S02, S03, S06, S08, S09 (except MB4 not installed), S10, S11 (except MB4 not installed), S12
  Status see: http://dt-sx5.web.cern.ch/dt-sx5/cgi-bin/comm_status_sector.pl?wheel=0
  Sector S04, S05 installed mid May but not yet commissioned.
- **YB-1**: Chambers commissioned in S10, S11 (MB1, MB2), MB4 S08, MB4 S12.
  Status see: http://dt-sx5.web.cern.ch/dt-sx5/cgi-bin/comm_status_ sector.pl?wheel=-1
- **YB-2**: Chambers in S10, S11 are installed but not commissioned.

50% of all DT chambers are commissioned

Now we break for MTCC.

Results are in
http://cmsdoc.cern.ch/cms/MUON/dt/sx5/Results/ and in
http://cms.pd.infn.it/commissioning/Results/

Interventions Due To Chamber Problems

124 chambers (= 50% of the total) commissioned so far.

Interventions due to chamber problems:

- 1 chamber (YB+2 MB3 S09) uninstalled to fix a HV problem (wire discharge, HVB replaced)
- 1 chamber (YB0 MB3 S06) uninstalled to fix a LV short in theta-SL FE-cover
- 2 chambers failed pre-installation tests (YB+1 MB4/10, MB4). One was due to a broken ground fork that was fixed with installed chamber in place. The other chamber failed HV pre-install test and went back to ISR for repair.
- 1 chamber (YB+2 MB1 S04) with many noisy channels, fixed by disconnecting the slow ctrl cable shield from splitter board ground

Summary:

Intervention	Number of chambers	Fraction of all 124 chambers
Chambers to be un-installed for repair	2	2%
Chambers failing SX5 pre-installation test	2	2%
Minor interventions (noise, FEB)	1	1%

- No HV problems after long time operation observed! Commissioning is mainly a test of the on-chamber readout electronics.

→ Small number of repairs shows the success of the ISR training, testing, repair and commissioning. Thanks to the ISR team!

Minicrate Interventions [Chamber Units]

Wheel	Total No. MC commissioned	Major interventions			Minor interventions		
		Chamber commiss.	Cabling	Percentage of both	Chamber commiss.	Cabling	Percentage of both
YB+2	42	2	3	12%	7	5	29%
YB+1	42	4	1	12%	10	3	31%
YB 0	31	1	To do	3%	2	To do	6%

Intervention type	YB+2		YB+1		YB0	
	Chamber commiss.	Cabling	Chamber commiss.	Cabling	Chamber commiss.	Cabling
TRB replaced + fixes	2	4	8	0	1	To be done
Cabling errors and minor fixes	2	2	3	3	2	
Link board replaced	2	-	-	1	-	
ROB replaced	-	-	1	-	-	
FEB replaced + fixes	-	2	1	-	-	
ROS link board replaced	1	-	-	-	-	
Noise	2	-	1	-	-	

Minicrate Interventions [Component Units]

Check, the fraction of exchanged components. Without repairs at the ISR and pre-installation tests. Only repairs during chambers commissioning and cabling test. No cabling test in YB0 yet.

Intervention type	No. of this component	**YB+2**		**YB+1**		**YB0**	
	YB+2, +1, 0 124 chambers	Chamber + Cabling	Percentage of total no.	Chamber + Cabling	Percentage of total no.	Chamber	Percentage of total no.
TRB replaced + fixes	252	6	2.3%	8	3.2%	1	0.4%
Cabling errors and minor fixes	124	4	3.2%	6	4.8%	2	1.6%
Link board replaced	124	2	1.6%	1	0.8%	-	-
ROB replaced	252	-	-	1	0.4%	-	-
FEB replaced	~2020	2	0.1%	1	0.05%	-	-
ROS link board replaced	124	1	0.8%	-	-	-	-
Noise	124	2	1.6%	1	0.8%	-	-

Summary: 15 TRB = 6% (out of which 3 were a MAJOR intervention)

3 Link boards = 2.4%, 1 ROB = 0.4%

Major: 1 ROS link board, 3 TRB, 1 ROB connector re-crimped, 1 ROB output, 1 FEB

Comments to Interventions

- The number of interventions due to chamber problems is very low. In particular, no long term HV problems are observed. Commissioning appears to be mainly a test of the minicrate and to some extend of the cable connection.
- The fraction of MAJOR interventions (also true for minor) due to minicrate problems has decreased from YB+2, +1 (12%) to YB0 (3%). Normalized to the number of MC, not the number of components (many boards in a MC)!!
- Roughly 1/3 of minicrate interventions are serious and concern the overall MC functionality. About 2/3 are minor interventions like cabling errors, broken connectors, replacement of board affecting only 16 channels, etc.
- Most interventions fix some channels, rarely we would have lost a whole chamber (just 2 cases).
- Various kinds of problems are found during MC testing at the ISR, chamber commissioning and when testing chambers with final cabling. The problems are different and indicate that the different testing steps are necessary. In YB+2 some problems were overlooked during chamber commissioning, indicating the missing experience of the shifters at the beginning. Also YB+2 chambers were installed without minicrate and the MC were attached later. For YB+1 this has improved.
- Understanding and fixing minicrate problems requires the presence of Franco.

Analysis of Commissioning Data

- Main tool to study chamber performance is the Run Monitor (ORCA based), used by the shifter in quasi-online mode. To check:
  - Occupancy for every layer should be flat. All working cells should perform with similar efficiency. Dead cells to be compared with chamber traveller (prod. site + ISR)
  - Timeboxes for every cells.
  - Testpulse analysis and writing of t0 files.
- New DQM is under development (Marco Z.)

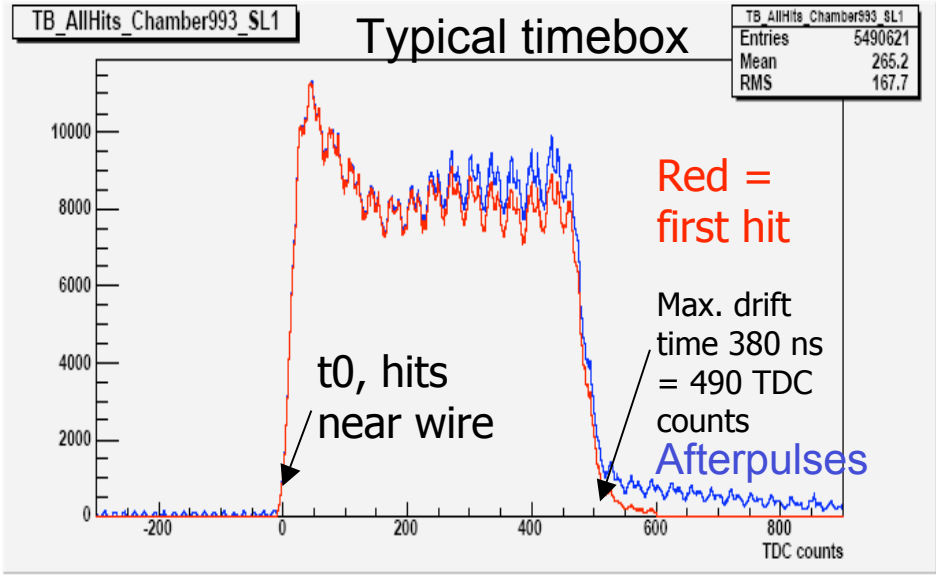
- Offline analysis structure has been set-up and experience was gained with the analysis of YB+2, YB+1 data. For YB+2 data response came too late. For YB+1 better, e.g. configuration problem in MB4 was seen and fixed. Several observed effects are understood by now. For YB0 feedback is provided before cabling but still after the data taking.

- Most chambers are performing well but some effects were found which had/have to be understood: swapped connectors, synch.noise, noise, many afterpulses…

Timebox Analysis

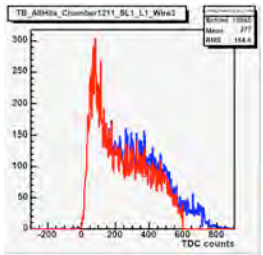
Shifters run (online) the diagnostics to verify chambers performance. Check:

- Disconnected channels (0 entries)
- Noise (hits with tDrift<0)
- Dead channels (few entries)
- Afterpulses (2nd hits with tDrift>0 and the 1st hits within the TMax and 2TMax. Ratio FirstHits/AfterPulses should be < 0.5)
- Quality of timeboxes (tail/belly, head/belly)

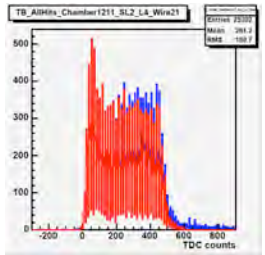


Timebox diagnostics: head: 0-190 counts, belly: 190-320, tail: 520-640

- Efficient tool to spot problems in HV.
- Examples of problems we found and cured:
  missing cathode voltage, bad gas mixture, problems in individual cells compare to chamber traveller, swapped TP cables (in TP run), noise and grounding problems



Missing cathode



Noise

Efficiencies

- Efficiencies are an important parameter to check chamber performance. Can only be checked offline through track reconstruction. Occasionally finds effects not seen with the online monitoring → fast feedback is essential.

Reconstruction efficiency $\varepsilon_{Rn} = N_n/NEvent$

With: NEvent = number of triggered events

N_n = number of events with at least one track reconstructed in both Φ superlayers, with at least n points (n = 4, …,8)

Local cell efficiency $\varepsilon_c = Nh/Ntrack$

With Nh = subset of Ntrack where hits are found within the considered cell or its 2 neighbours.

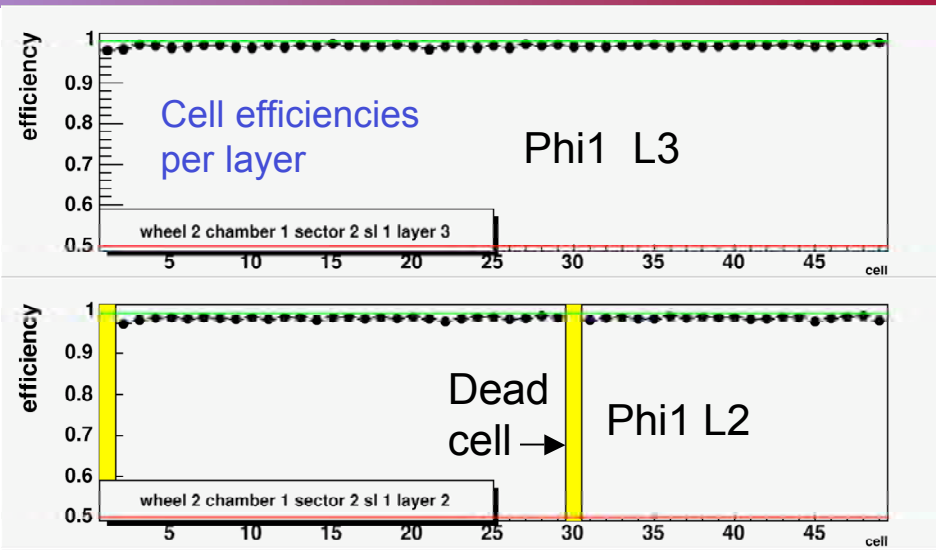
Ntrack = number of tracks reconstructed in both Φ superlayers, with at least 5 points (for Φ cells), or in Θ superlayer, with at least 3 points (for Θ cells), and traversing the considered cell.

- "Local efficiency" and "reconstruction efficiency" give complementary information. For example (seen in YB+2 MB4/1) raw hit occupancy is uniform but first 8 channels of $\Phi 1$ lack tracks → wrong hardware connections. Cannot be seen with Run Monitor.
- Local cell efficiencies are almost 100%. Very small (known) inefficiencies near the I-beams.
- Reconstruction efficiencies are typically ~90%, independent of the sector (respectively chamber inclination) and station number.

Efficiencies

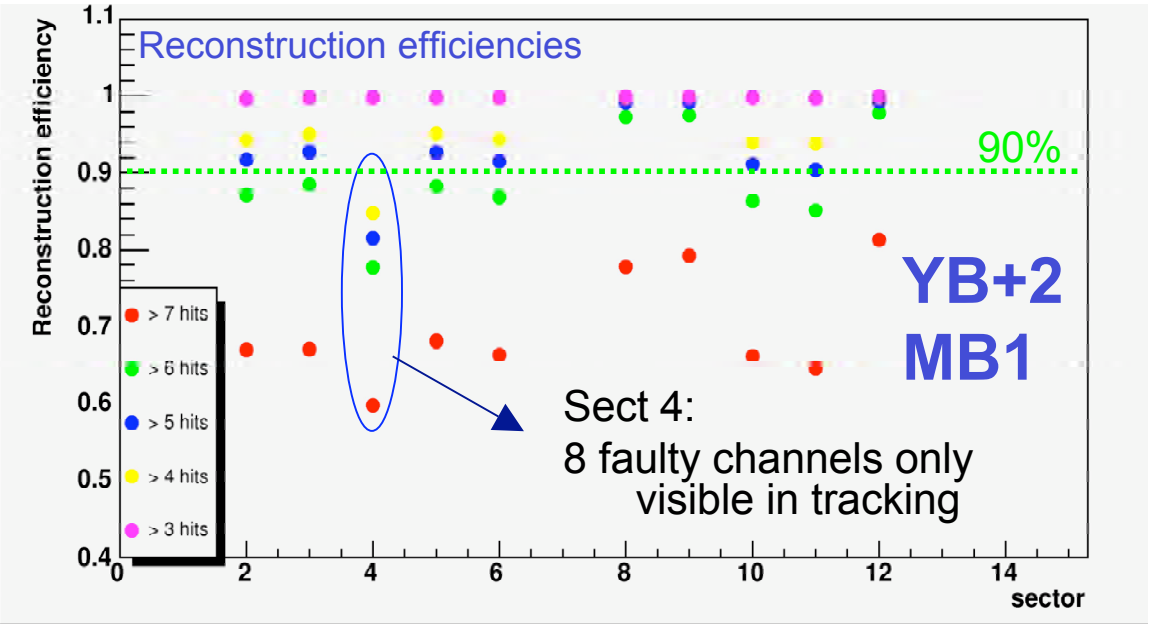
Local Cell Efficiencies

- Efficiency of good cells is usually better than ~99%
- Some examples (other layers look the same)



Reconstruction efficiency

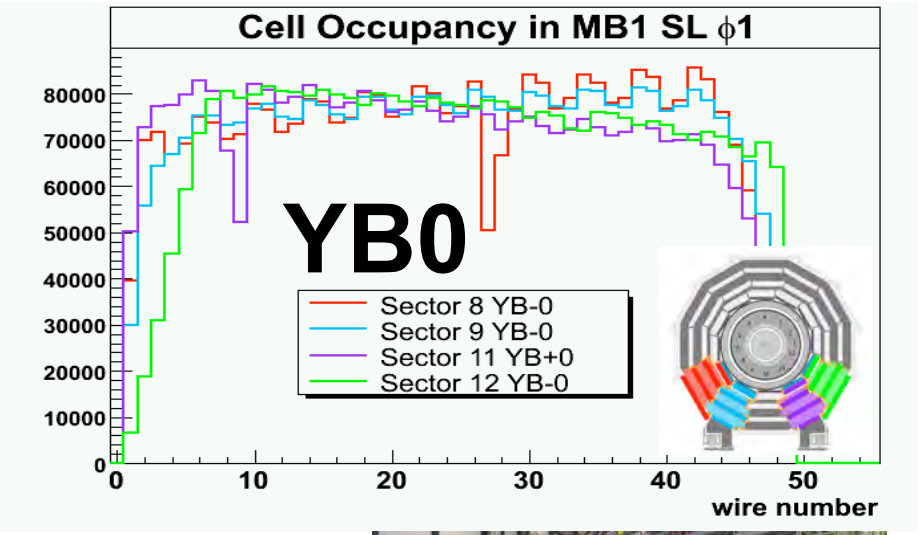
- Use HanyTheta whenever available. HHandHL (Default) for MB4.
- Value depends on required number of hits:
  - ~95% for 4 hits
  - ~89% for 6 hits
  - See also Francesca's talk last DT session 14/03/06.



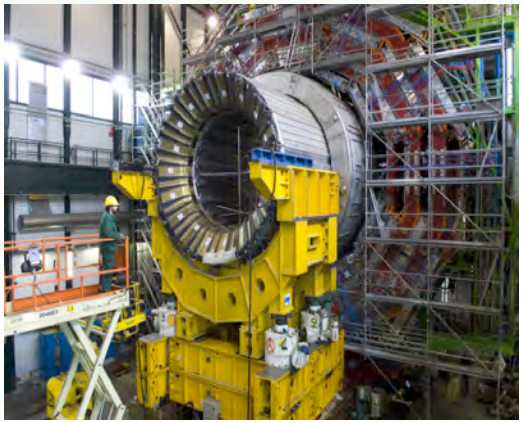
Francesca, Anna

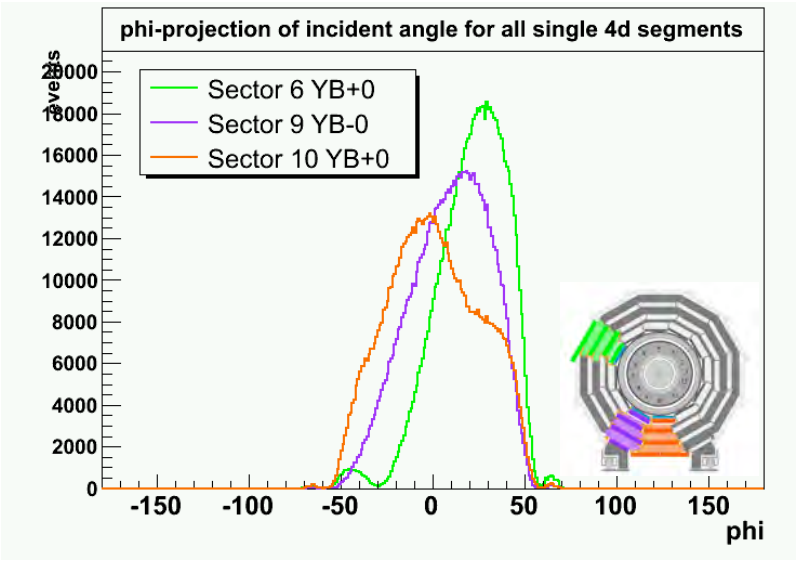
Occupancies and Shielding Effects (YB0)

Occupancies show effects related to open wheel configuration and shielding.
Allows for interesting studies.



The occupancy decreases steadily due to shielding of HB/solenoid, more so for strongly inclined sectors.





Strongly inclined chambers (S06) cover less track angles.
For S10 as a horizontal chamber one would expect symmetric distribution. But the MB1 S10 is not centered and thus shielded asymmetrically by the solenoid/HB

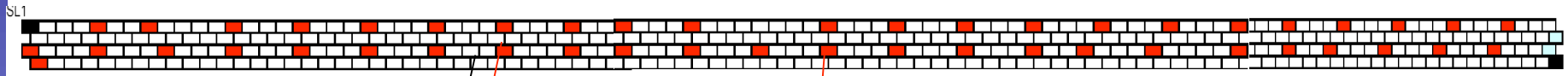
Emanuel

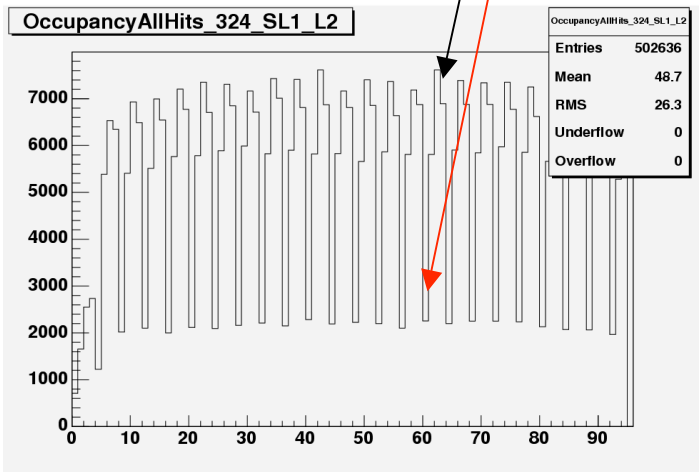
Correction of MB4 Trigger Config Files

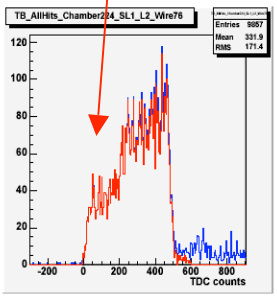
Another example how offline analysis spotted a problem. Here: trigger configuration for MB4.

Giorgia

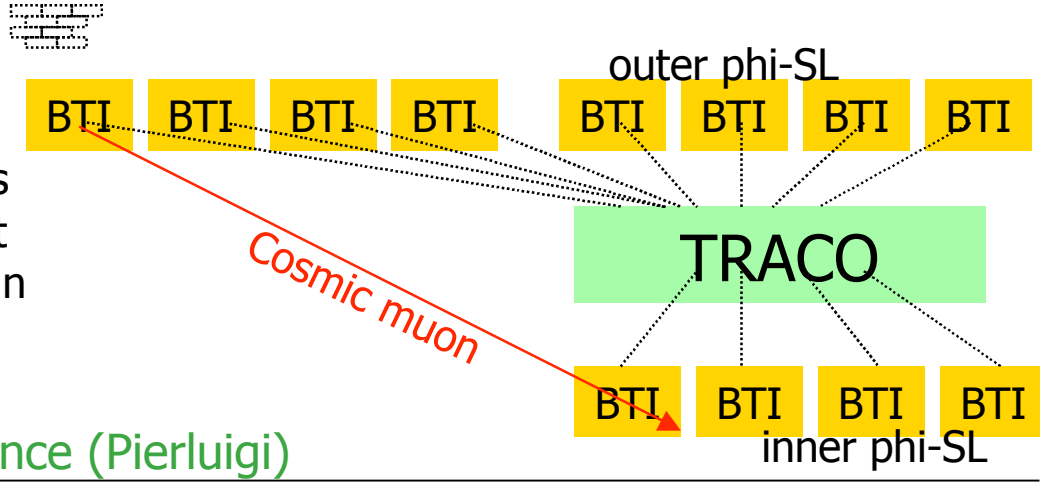
Analysis of MB4 YB+2 in inclined sectors showed strong pattern in occupancy.







Cells with a distorted TDC spectrum, distributed according to a regular pattern.
Occupancy drops in the cells with distorted time boxes



Reason: angular acceptance of BTI was not sufficient to cope with the large shift between both phi SL (2 cells = 8.4 cm) in MB4. TRACO did not correlate segments between two outermost BTI.

Fixed by increasing angular acceptance (Pierluigi)

Summary And Outlook

- By now, 50% of all DT chambers are commissioned (YB+2, +1, 0 (exc.S04,05)!
- We gained lots of experience in terms of chamber behaviour, understanding new problems, stability of the test system and offline analysis of data.
- Commissioning is a big task. Thanks to commissioning team!

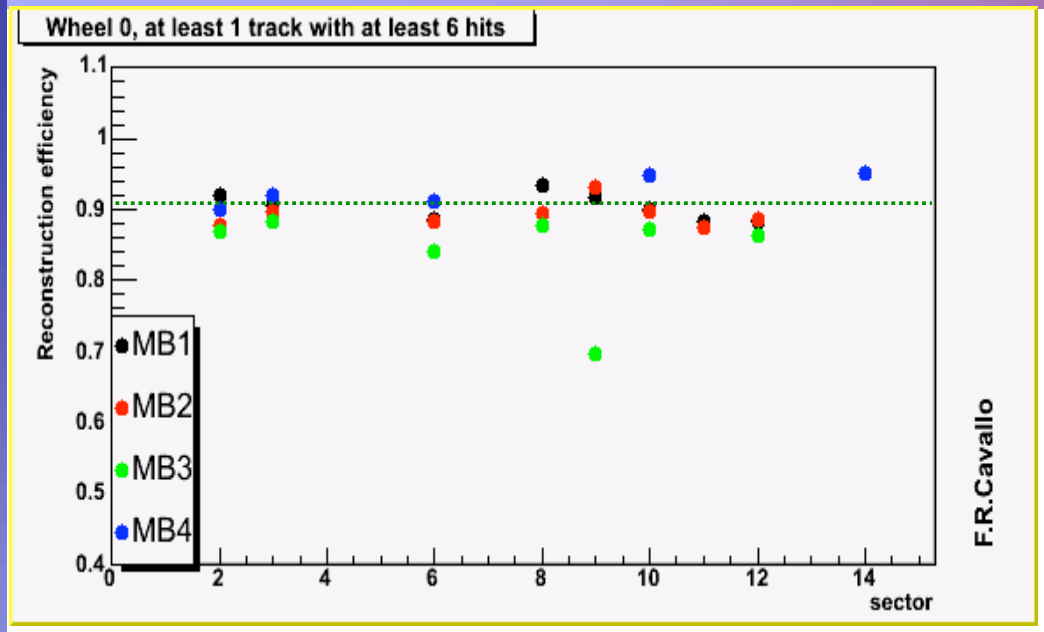
- Chambers are working well. No long-term HV problem observed.
- About ~30% of minicrates need intervention (major + minor). Fraction of major intervention is acceptable (12%) and went down from YB+2,+1 to YB0. Variety of problems, no single components which stands out.
- A few new dead cells were found.

- Chambers for MTCC are commissioned and operating well.

- Commissioning of YB-1, -2 in fall 2006 is time-critical. Requires fast analysis feed-back since cabling will follow chamber commissioning soon.

SPARES

Reconstruction Efficiencies per Chamber



Francesca, Anna

Trigger: HAnyTheta, whenever available, for MB1, MB2, MB3; HHandHL or Default for MB4

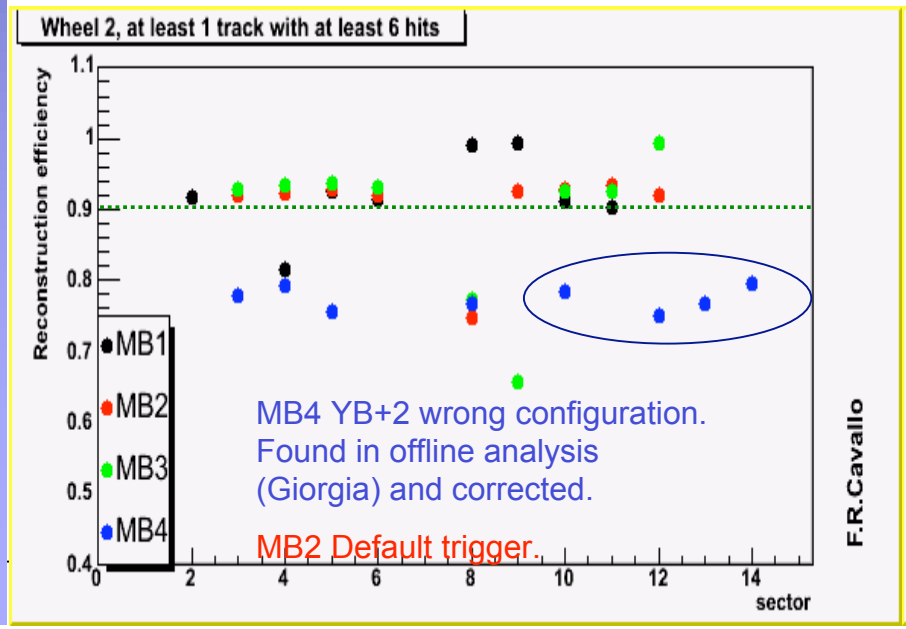
Local track reconstruction and tree production with ORCA_8_7_1 (P.Ronchese)

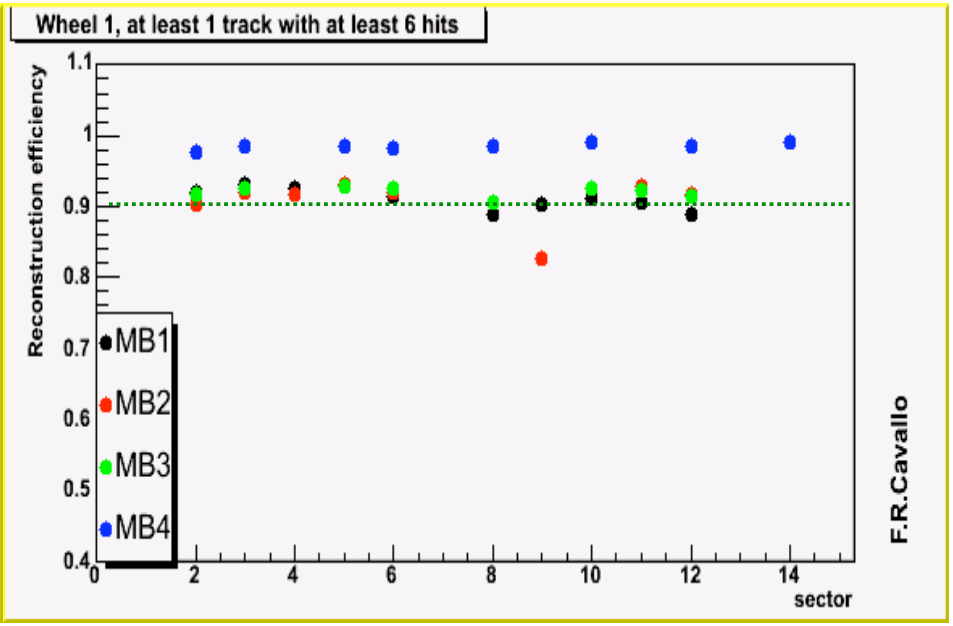
Constant *vdrift* (T*max* = 492 TDC counts)

Constant error associated to each hit (300 mm)

TP correction (compensation for delay found between the 2 TP lines:~20% of the chambers) (A. Meneguzzo)

t0 event by event determination (A. Meneguzzo)





Trigger Rates per Sector

- Trigger rates depend on configuration and sector. Actually these are DAQ rates

Sector	HHandHL [Hz]			Hanytheta [Hz]			Default [Hz]		
	MB1	MB2	MB3	MB1	MB2	MB3	MB1	MB2	MB3
S02	100	110	180	130	160	240	155	200	250
S03	160	210	-	225	280	420	260	340	480
S06	85	130	170	120	170	230	170	220	260
S08	85	95	100	120	140	150	145	160	175
S09	160	165	195	240	250	260	290	305	310
S10	100	180	190	140	230	260	170	-	300
S11	80	120	135	120	150	120	140	185	250
S12	80	100	100	125	140	150	165	160	170

- Trigger configurations:
  - HHandHL: High-High (4-4 hits) or High-Low (4-3 hits) correlated in both phi SLs
  - Hanytheta: HH + HL + H_uncorrelated if confirmed by theta SL (not for MB4)
  - Default: HH + HL + H_uncorrelated

Minicrate Interventions During Commissioning

- **YB+2:** 2 major (5%) + 7 minor interventions (16%) out of 42 MC in total

Franco

  - MB3 S12, MB1 S04 noise problems
  - MB2 S08 link board replaced (problem on primary port)
  - MB2 S05 problem on parallel interface: capton cable changed. Bad ROB output: ROS link board changed (MAJOR).
  - MB1 S05 clock connector broken (during commissioning): link board replaced
  - MB1 S02 signal connector on MC unplugged and fixed.
  - MB4 S02 correlation between phi1 and phi2 on TRB0 not working. TRB replaced (MAJOR)
  - MB3 S02 MC could not be ramped up, missing crimping on LV box: fixed.
  - MB3 S03 Unable to configure BTI on TRB3. TRB replaced. Bad trace on TRB2: TRB replaced

  Note: many chambers tested on site before commissioning (installed without MC)

- **YB+1:** 4 major (10%) + 10 minor interventions (24%) out of 42 MC
  - MB2 S12 replaced TRB (failed boundary scan)
  - MB1 S11 bad trace on 2 TRB (bad connection of capton cable)
  - MB3 S10 replaced 2 TRB and 1 ROB (1 channel disconnected)
  - MB2 S02 bad slowctrl theta connection: splitter board changed, labelled cabling
  - MB2 S08, MB2 S11, MB3 S03, MB1 S04 bad trace, replaced TRB
  - MB4 S04 noise problem
  - MB2 S06, MB4 S10 dipswitch TRB -> replaced TRB (2 MAJOR)
  - MB2 S06 manca soglia su una feb -> replaced 1 FEB (MAJOR)
  - MB4 S03 re-crimped connector for TP
  - MB2 S05 ROB connector badly crimped -> re-crimped (MAJOR)

Minicrate Interventions During Commissioning

Continuation of previous page

Franco

- **YB0:** 1 major (3%) + 2 minor interventions (6%) out of 31 MC
  - All surface sectors except S04, S05. LV problem in MB3 S06 is listed as chamber problem.
  - MB2 S11 bad rob output: bad connection → repaired (MAJOR)
  - MB1 S11 bad trace, TRB replaced.
  - MB2 S06 swap TP cables

- **YB-1:** 1 major (10%) + 1 minor intervention (10%) out of 10 MC
  - No intervention happened yet in YB-1. Still to be done. Not part of summary table.
  - MB3 S10 CCB needs to be replaced
  - MB1 S10 FEB-09 has double counts → to be checked

Interventions During Cabling Test

Franco

- **YB+2** (42 chambers): 3 major (7%) + 5 minor (12%)
  - Cabling: 1 cable readout: changed
  - Minicrate:
    - 1 dipswitch TRB: repaired (MAJOR)
    - 1 jumper traco TRB: repaired (MAJOR)
    - 1 parallel interface TRB: TRB changed
    - 3 bad TRB trigger output: TRB changed
    - 1 bad connection mc link board: repaired. (MAJOR: **very serious: no communication with mc, chamber lost**)
  - Chamber: 2 bad fast mask (on one FEB)
- **YB+1** (40 chambers): 1 major (2%) + 3 minor (7%)
  - Note: MB4_9/11 partially tested during commissioning (done with final cabling for feet chambers). MB1 S02, 03, 05 to be tested.
  - Cabling: 1 cable tr: changed
  - Minicrate: 1 ROB link board (bad output first theta ROS): changed
  - Chamber:
    - 1 bad Tmean theta: splitter board changed (bad connector)
    - 1 bad PADC output (problem in connector): repaired