

CERN-RRB-2008-096

16 April 2008

# Status of the LHCb Experiment

LHCb RRB at CERN

16 April 2008

on behalf of the LHCb Collaboration

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CERN

and

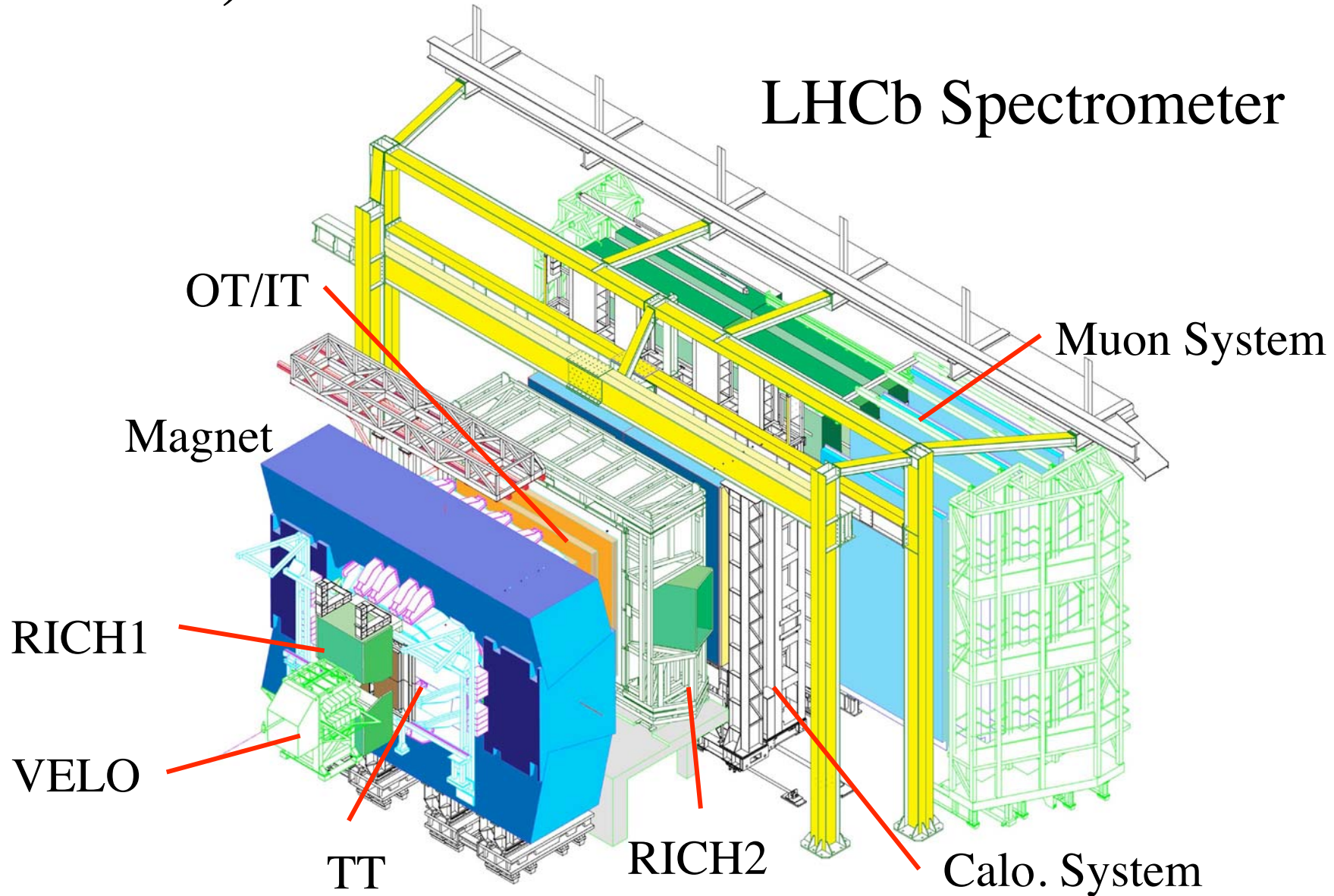
EPFL



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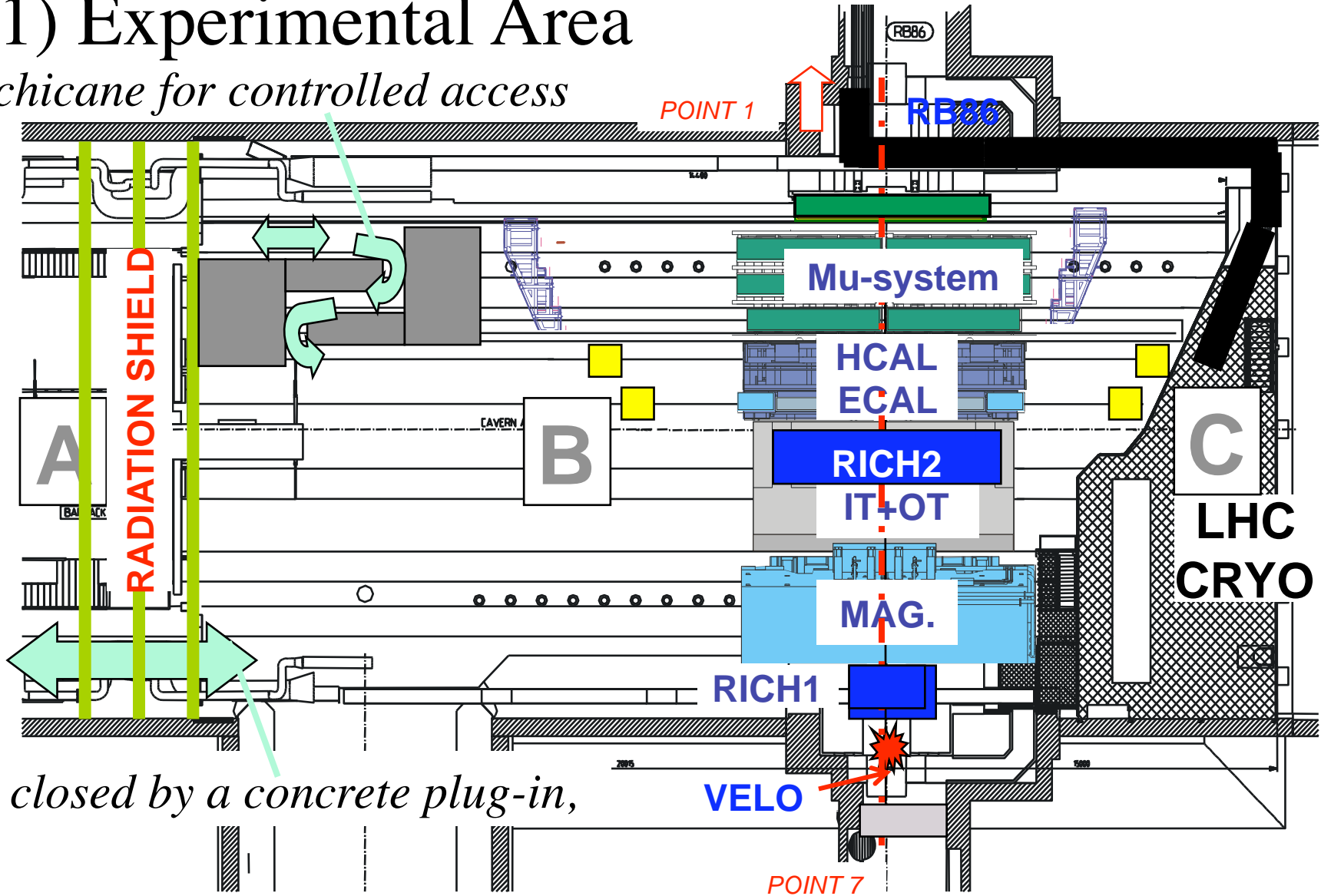
- I) Construction and Installation
- II) Early Physics
- III) Cost and Funding
- IV) Collaboration Issues
- V) Conclusions

# I) Construction and Installation



# 1) Experimental Area

*chicane for controlled access*



Service infrastructure installed and safety system operational.

# Delay in completing the shielding wall → 30 Apr 08



All the cooling pipes going through the chicane of the wall had to be replaced between the end of December and beginning of January due to the poor welding quality.  
-detector installation and commissioning work also affected-

## 2) Beam Pipe and Magnet

Vacuum pipe and VELO vacuum tank fully commissioned last autumn and ready to be used.  
(currently filled with ultra pure Ne)

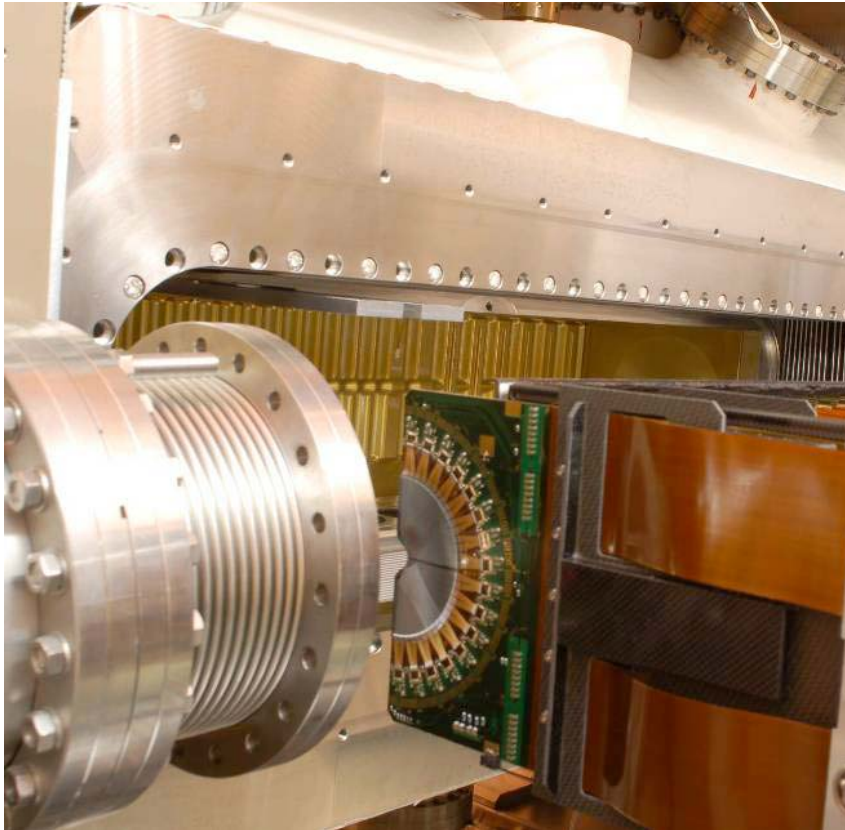
Recently evacuated once more and vacuum quality remains good.

Beam Condition Monitors, produced by the Dortmund group (based on diamond detectors) installed around the beam pipe.

Magnet fully commissioned and the control has been tested from the CERN Control Centre.

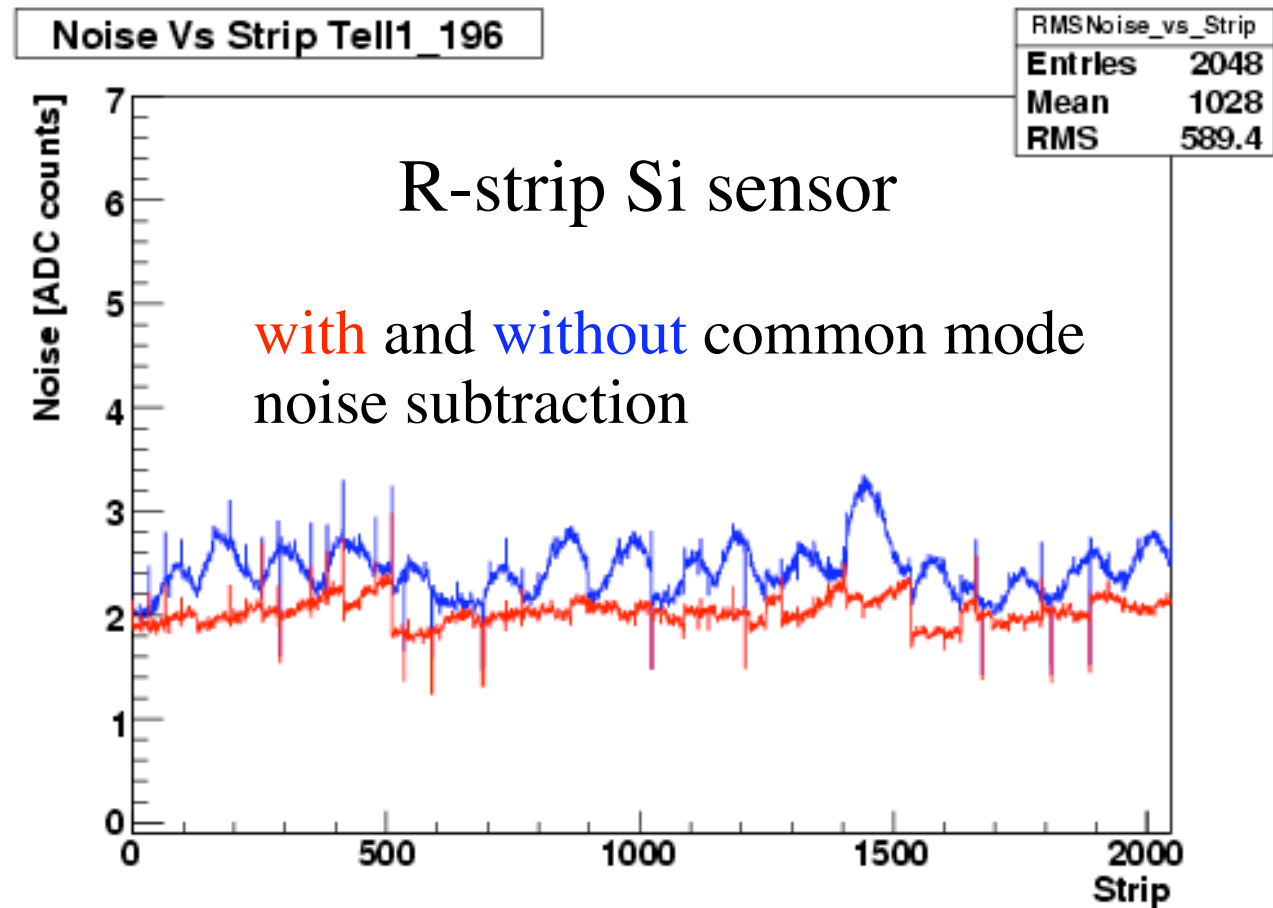
### 3) VErtex LOcator (funded by CH, DE, GB, NL)

Both detector halves successfully **installed**.



Commissioning is in progress: somewhat slower since not many modules can be switched on simultaneously, if not under vacuum.

But making good progress.  
 $S/N > 20$  achieved!

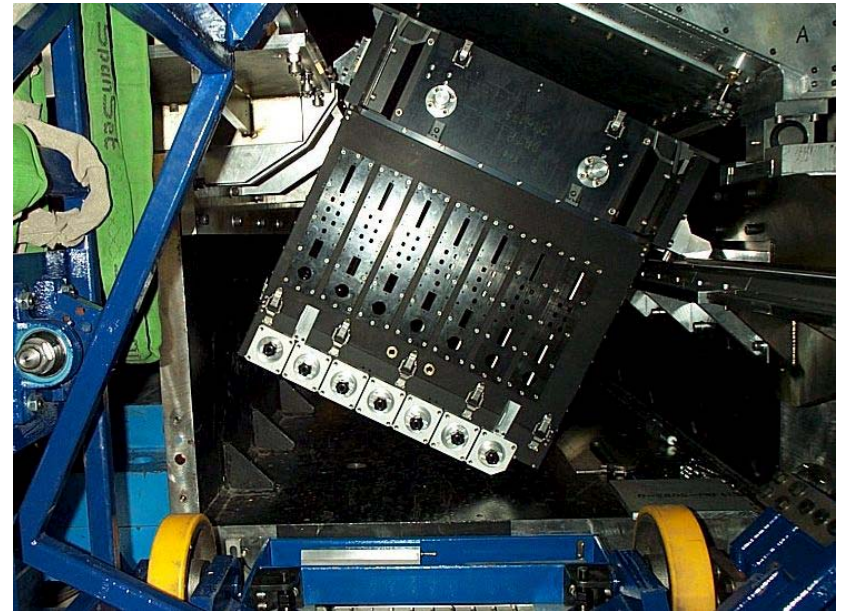


#### 4) RICH (funded by CERN, CF, GB, IT)

RICH-1: remaining parts are now **all at CERN**, quartz windows, photon funnels and lower HPD box.



*Photon funnel with B field distortion monitoring system mounted*

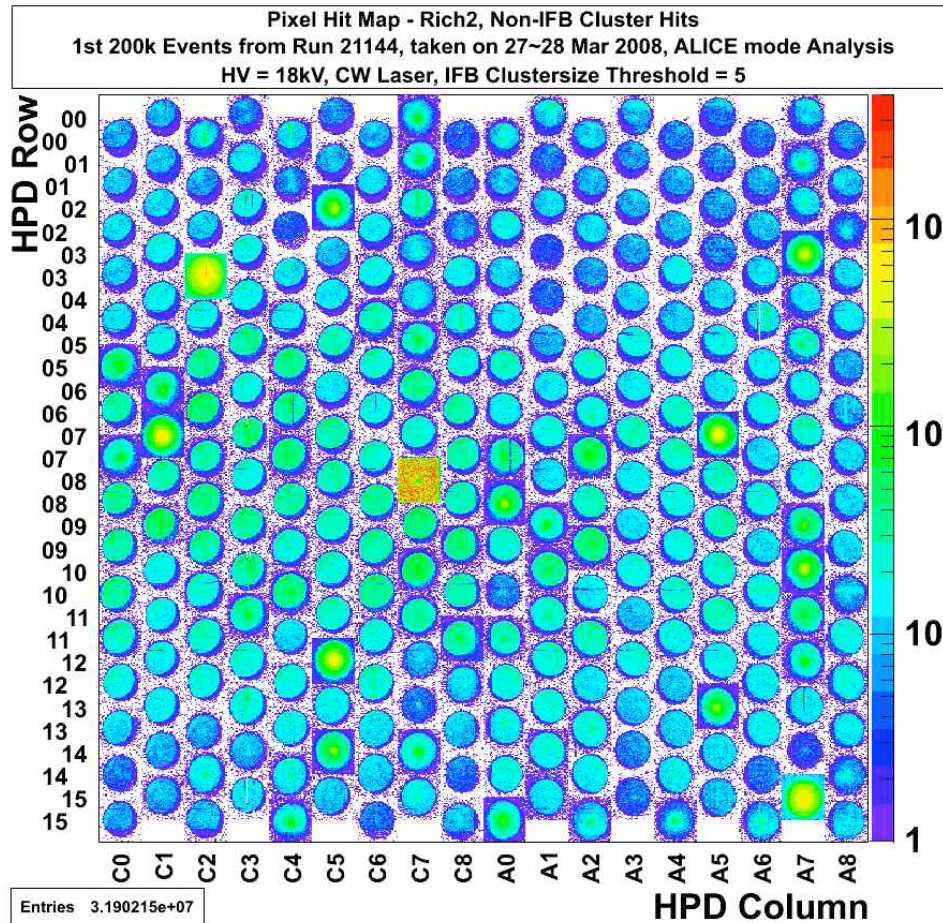


*RICH-1 lower HPD box test insertion*

Installation will be completed by the end of April

HPD commissioning for the upper box started: **all HPDs OK**

# RICH-2: Completed and commissioning in progress 17 HPD's replaced



*Hits from 200k events with  
CW laser*

NB:

$10^2$  A total of  $\sim 300$ k pixels.

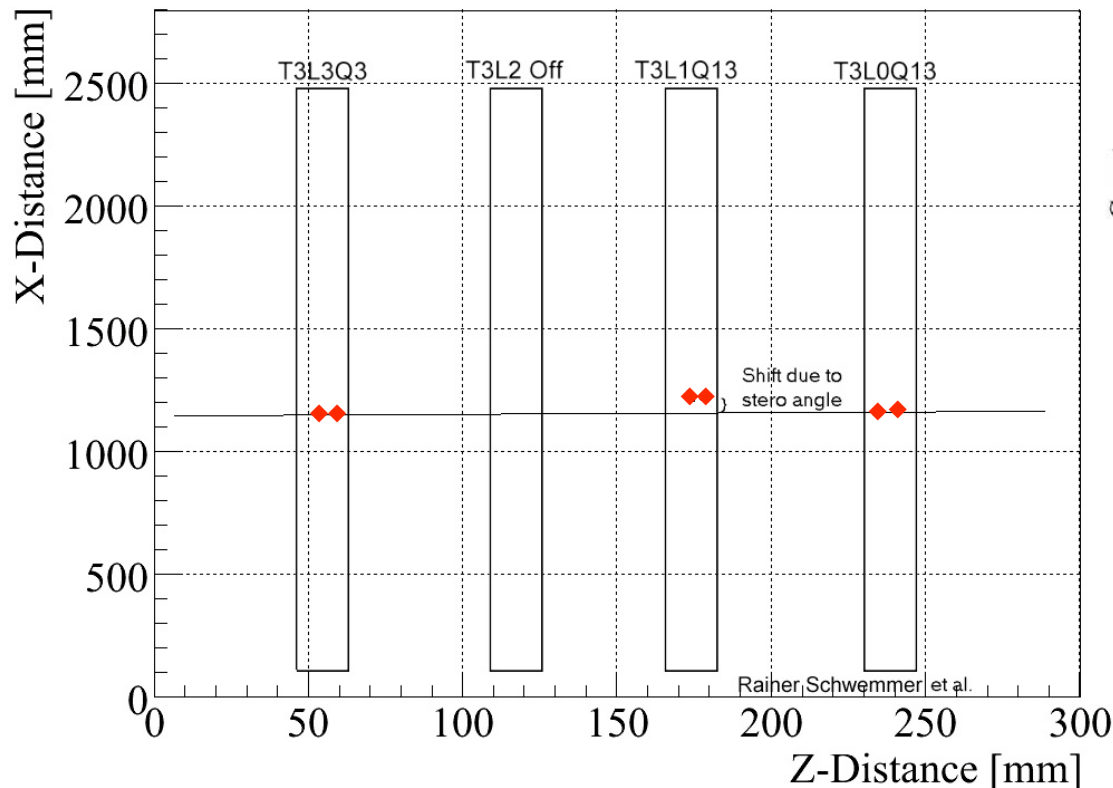
No threshold tuning yet.

$10$  Log-scale colour coding.

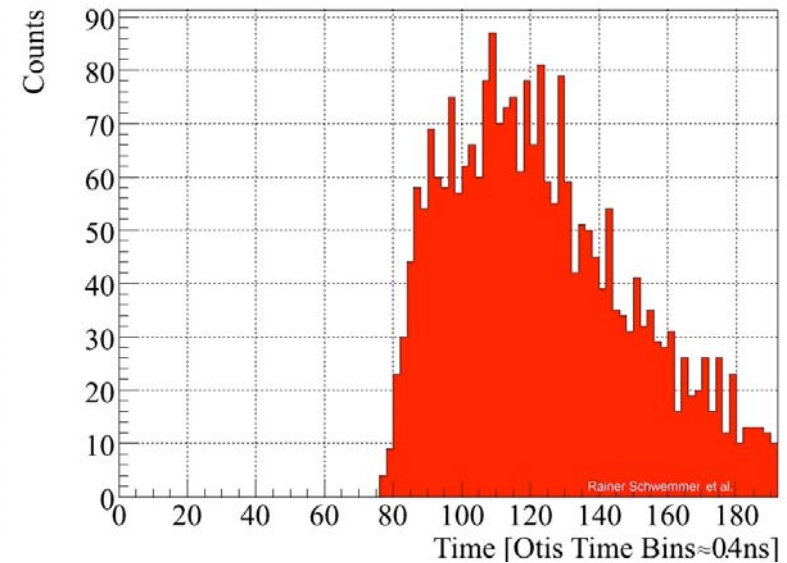
$1$  A few more HPDs may need to be replaced during the 2008/09 shut down.

## 5) Outer Tracker (funded by CERN, CF, CN, DE, NL, PL)

- detector installation completed + 80% of the FE electronics boxes installed (100% by the end of April)
- commissioning with cosmic muons (special trigger)

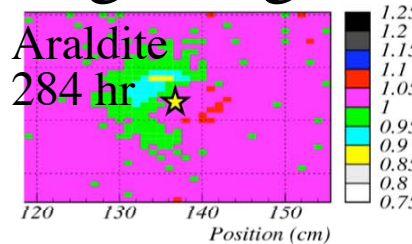
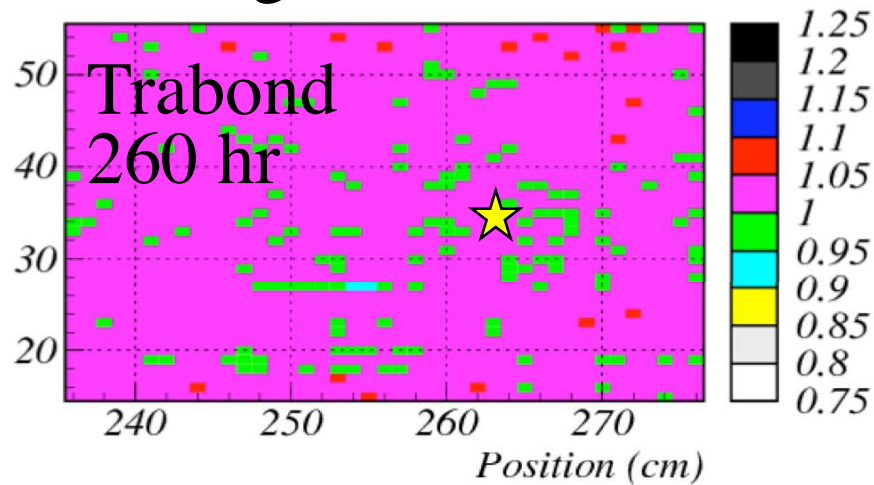


*a track in the horizontal plane*



*drift time distribution*

One long module with identical material to the production module, except using Trabond rather than Araldite, produced and being tested: so far no clear sign of gain loss seen.



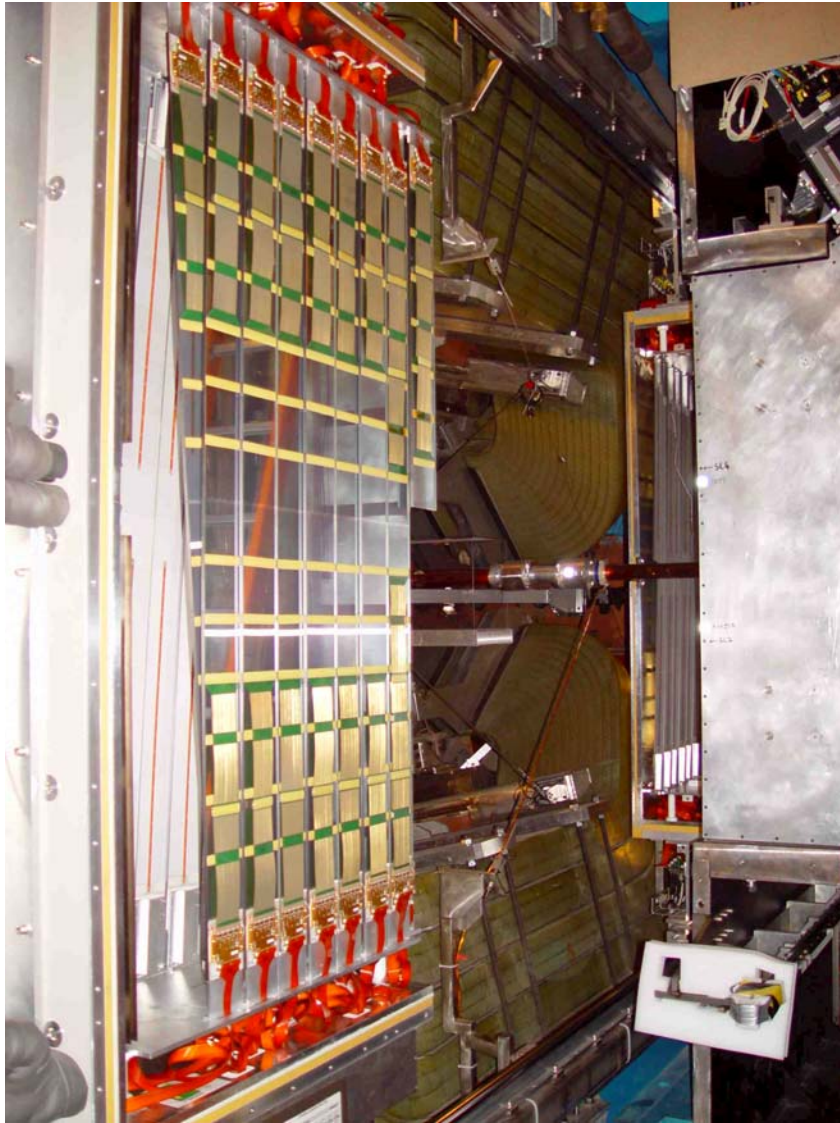
Cause of gain loss identified

Heat treatment in-situ has started: 2 C-frames heated.

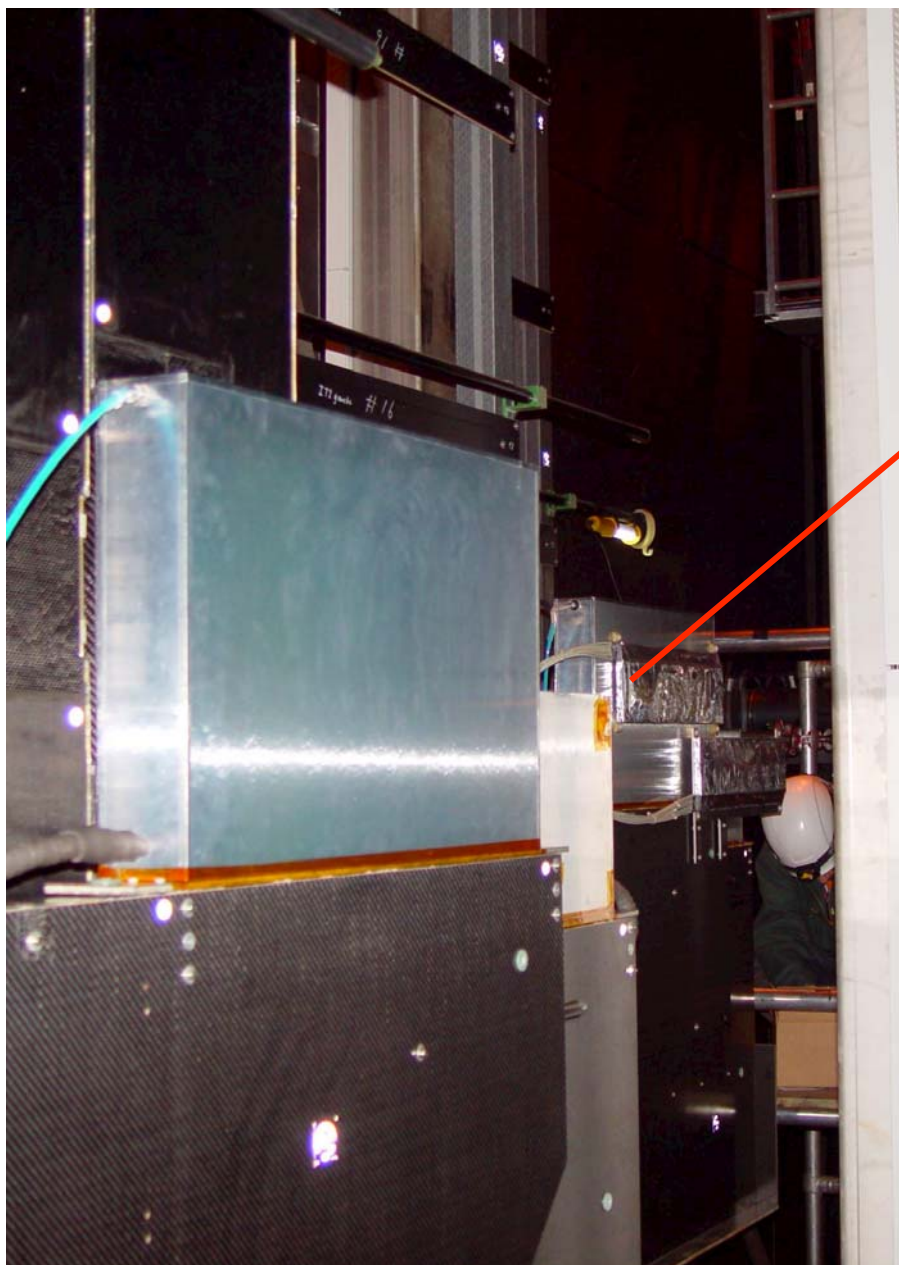


~4 C-frames by the end of April  
In-situ gain measurements with source in progress

## 6) Silicon Tracker (funded by CERN, CH, DE, ES, UA)



TT Si sensor ladders  
A side 100% installed  
and tested  
few connection problems  
being fixed  
C side 80% installed  
test in progress



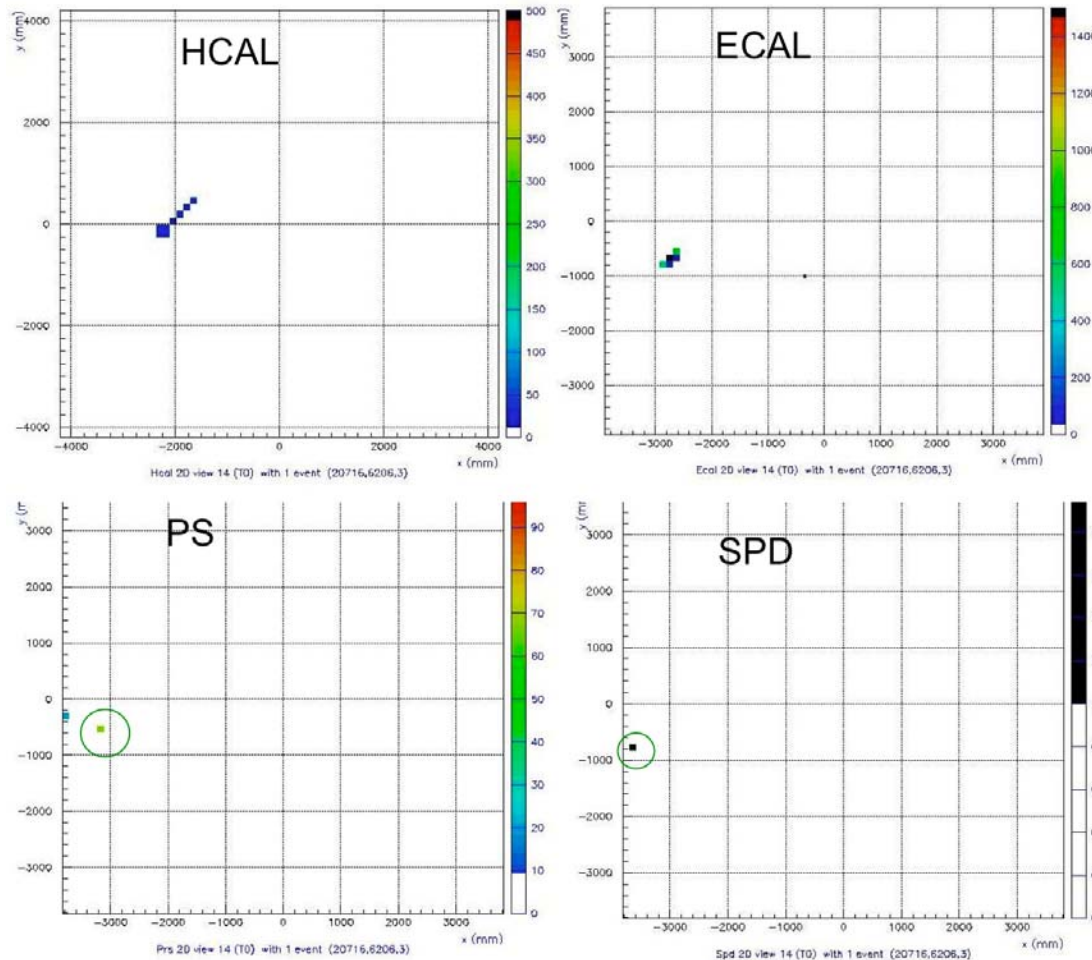
All IT sensor boxes (12)  
installed and connection test  
started.  
-two already tested-

Radiation Monitoring System  
Four very thin metal foil  
detectors (made by the  
Ukrainian group) installed in  
front of IT boxes of T2.

# 7) Calorimeter System (funded by CERN, CF, ES, FR, RO, RU, UA)

All the detector and electronics installed and cabled.

Commissioning well advanced.



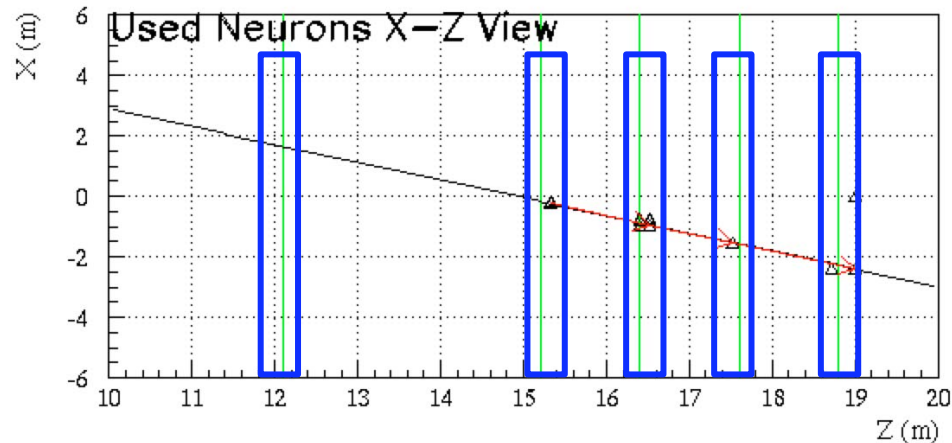
*Cosmic ray seen by the all four detectors of the Calo system*

**Calo system is now able to provide L0 cosmic signal for the global commissioning.**

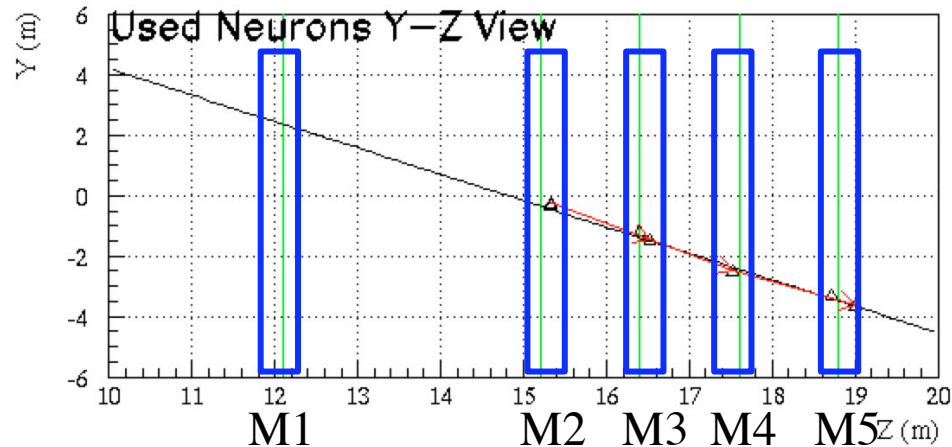
## 9) Muon System (funded by CERN, CF, IT, RU)

All MWPCs installed for M2-M5

Commissioning work in progress: connection, timing, HV, readout, etc.



L0 cosmic signal with  
M4-M5 coincidence  
→ clean cosmic ray with  
low number of hits



Muon system is now able  
to provide L0 cosmic  
signal for the  
global commissioning.

Installation of the infrastructure for the M1 wall, i.e. gas pipes and cables are in progress.



Cable chains installed.



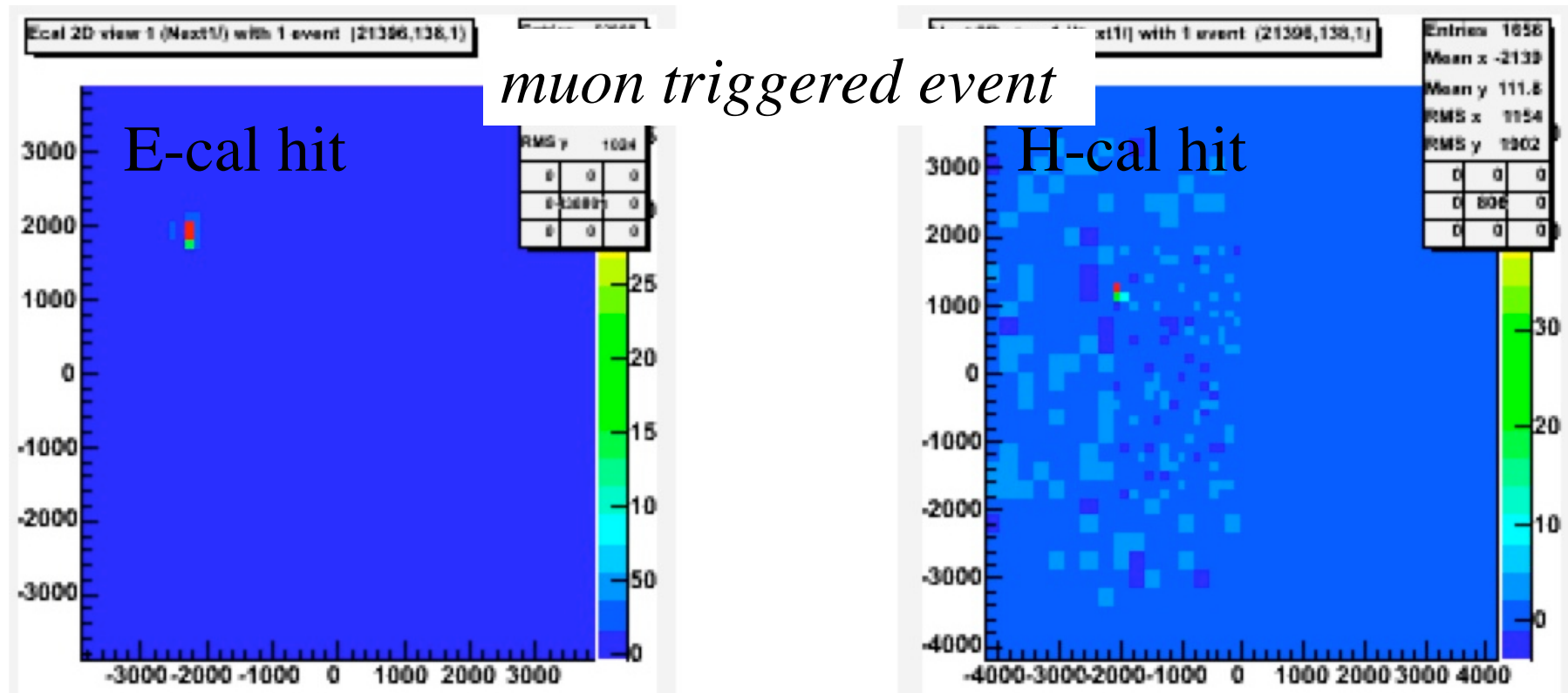
After the installation of the signal cables, mount as many chambers as possible.

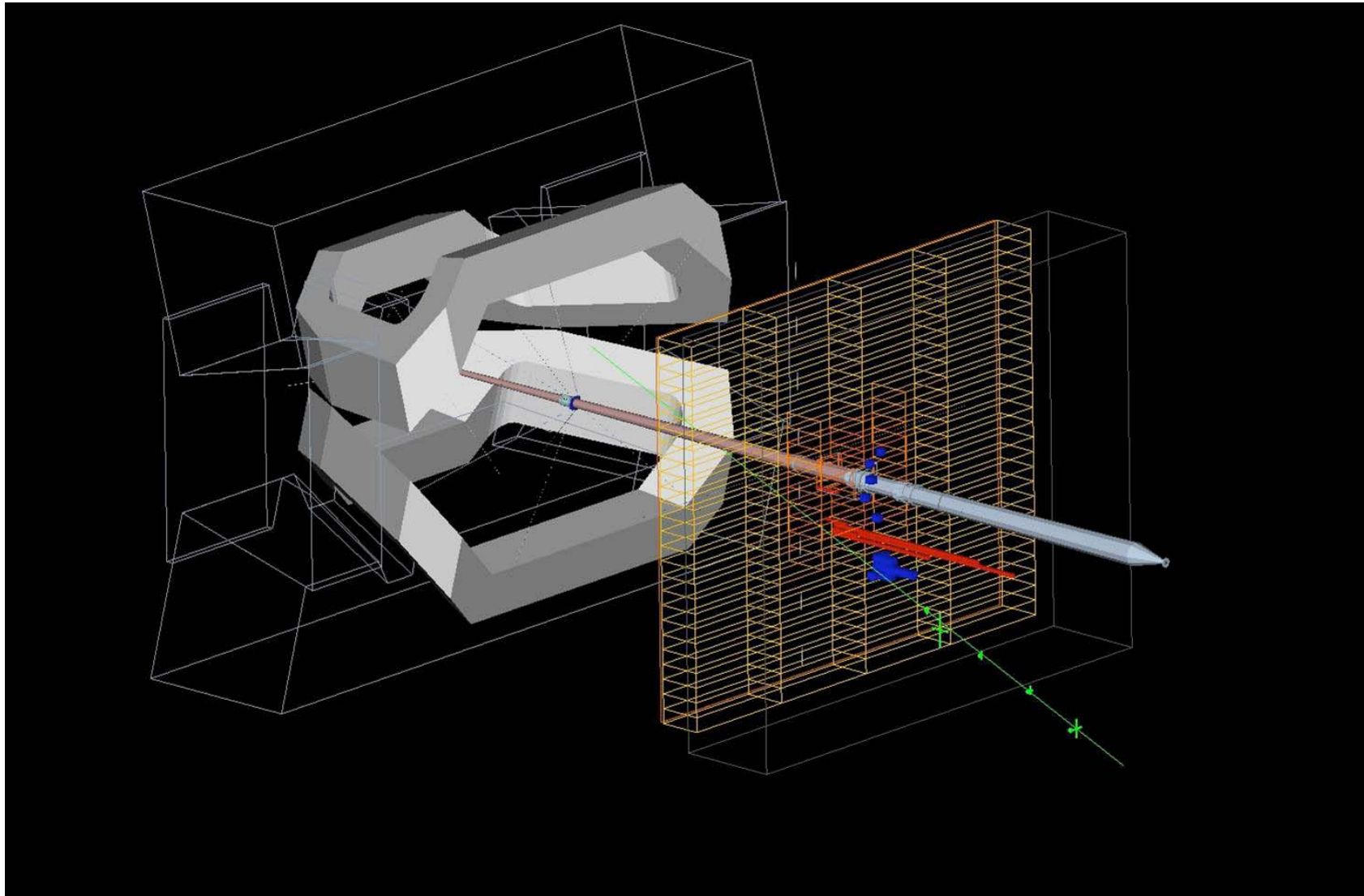
# 10) Trigger and Online

(funded by CERN, CF, CH, DE, FR, ES, GB, IT, NL)

All the Level-0 trigger boards in hand, being commissioned

In the global commissioning, Level-0 decision was made based on Calo or Muon L-0 cosmic signals and readout most of the detector subsystems (some are electronics only)

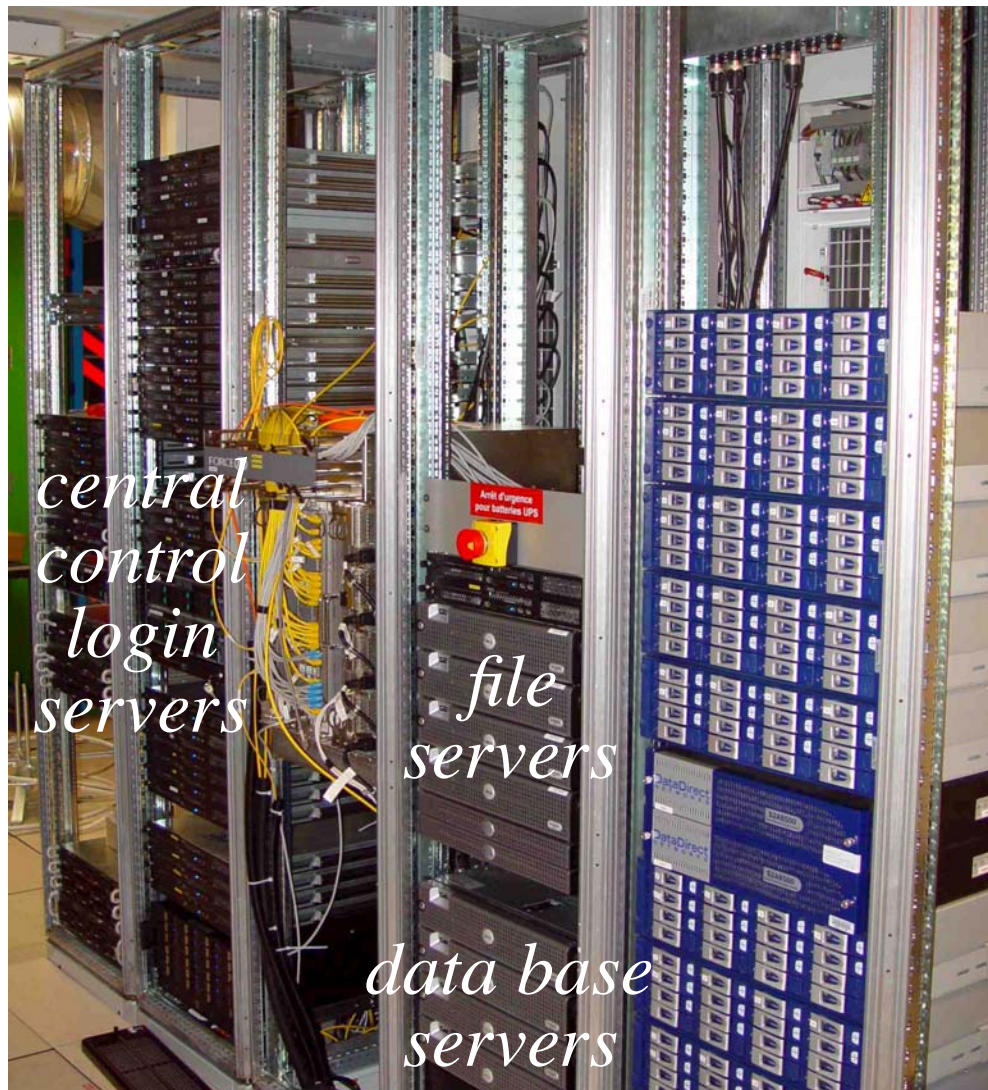




*3D event display for an L0 muon triggered event*

Next step is to include OT.

# Online system @ surface



*central  
control  
login  
servers*

*file  
servers*

*data base  
servers*

*control/LOG  
network*

*disk array  
(110×500GB)*

## Online System

Consolidating the installed equipment.

Starting with 20% of network switch and CPU farm capacity.

The rest to be purchased toward the end of 2008 for the 2009 run.

# Integration and improvement of online and control software through regular global commissioning.



control room @ surface

# 11) Computing

## Physics quality software in place

Event reconstruction ready for real data,  
track finding found to be robust against misalignment.

Tracking framework is now identical for offline and HLT.

Measured B field implemented and ready for test.

## LHCb Common Computing Readiness Challenge

Simulating real data taking situation with four experiments

IP8-control-room → Tier-0 → Tier-1's

with nominal DAQ rate = 35 kB/event @ 2 kHz: 70 MB/sec

alternating 6 hours on 6 hours off (50% duty cycle)

start event reconstruction automatically @ Tier-1

successfully executed

## II) Early Physics

Discussion on more concrete plan for the [first physics](#) with very few data, including a case for  $< 1 \text{ pb}^{-1}$ , has started.

After initial calibration and alignment,  
some physics can be done with  $< 10^8$  Min.Bias events  
→ No HLT required

inclusive “low  $p_T$ ” physics  
particle ratios  $+/-$ ,  $\pi/K/p$ ,  $\Lambda/\bar{\Lambda}$  vs  $d\eta dp_T$   
 $\Lambda$  polarization  
hyperon production

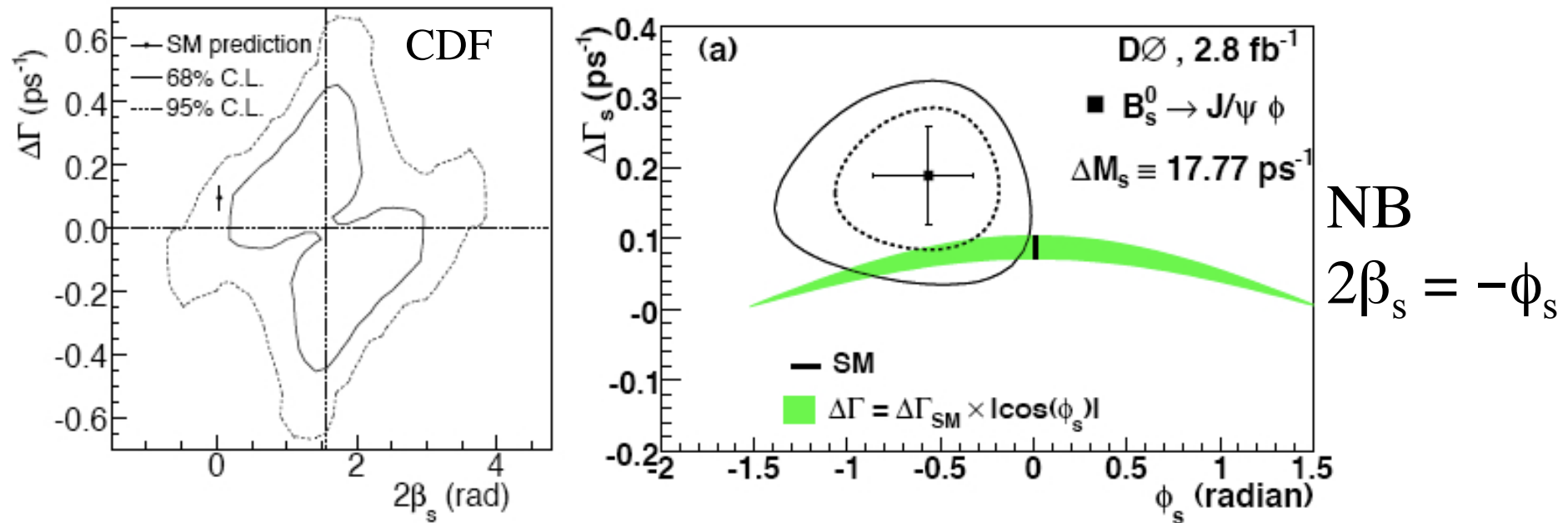
inclusive  $J/\psi$  for c and b production  
and exclusive  $D^0 \rightarrow K^- \pi^+$  and  $D^+ \rightarrow K^- \pi^+ \pi^+$   
-those channels are also useful for momentum and  
PID calibration-

Physics with exclusive B decays requires HLT  
 $5\sigma$  observation of “rare” decays needs up to  $2 \text{ pb}^{-1}$

Lumi( $\text{pb}^{-1}$ )	Channel	MinBias events
0.009	$B_d \rightarrow D^{*-} \mu^+ \nu$	$9.0 \cdot 10^8$
0.039	$B_u \rightarrow J/\psi(\mu^+ \mu^-) K^+$	$3.9 \cdot 10^9$
0.046	$B_d \rightarrow D^+ \pi^-$	$4.6 \cdot 10^9$
0.062	$B_d \rightarrow J/\psi(\mu^+ \mu^-) K^{*0}$	$6.2 \cdot 10^9$
0.418	$B_d \rightarrow K^+ \pi^-$	$4.2 \cdot 10^{10}$
0.427	$B_s \rightarrow J/\psi(\mu^+ \mu^-) \phi$	$4.3 \cdot 10^{10}$
0.500	$B_s \rightarrow D_s^- \pi^+$	$5.0 \cdot 10^{10}$
1.176	$B_d \rightarrow K^* \gamma$	$1.2 \cdot 10^{11}$
1.490	$B_s \rightarrow K^+ K^-$	$1.5 \cdot 10^{11}$
2.101	$B_d \rightarrow \pi^+ \pi^-$	$2.1 \cdot 10^{11}$

And with more data...

CDF and D0 studied time dependent CP asymmetries in  $B_s \rightarrow J/\psi \phi$ : very small in the standard model



NB: If there were indeed New Physics as suggested by M. Bona et al. (arXiv:0803.0659), who combined all the CDF and D0 results, LHCb would see a  $5\sigma$  observation of  $\cancel{CP}$  in  $B_s \rightarrow J/\psi \phi$  with  $\sim 200 \text{ pb}^{-1}$ , i.e. 10% of nominal year of data.

# III) Cost and Funding

No change since the last RRB in October 2007

i.e.

Cost: 75.341 MCHF

Funding: Fully funded, with the second instalment from US-NSF for the extra contribution to the CPU's via Syracuse (200 kUSD) expected by Nov 2008

## -Issue of the VELO full replacement detectors

As already presented during the last RRB,  
100% of 42 sensor modules needed after  $\int Ldt = 6 \text{ fb}^{-1}$   
due to the irradiation (cf. nominal LHCb physics  $10 \text{ fb}^{-1}$ )

50% of them (21 modules) already required as spares  
in case of a severe beam related accident, covered by  
VELO groups

Remaining 50% can be considered as a common item  
according to the MoU for M&O, Annex 7

Annex 7 : LHCb Common Items for M&O Costs

For M&O costs, the following subsystems shall be treated as Common items:-

The Magnet  
Infrastructure  
Data Handling (DAQ & DCS)  
plus other items as listed in Annex 9 below.

If radiation damage necessitates the replacement of certain detectors, these detectors  
may become a Common Item regarding M&O.

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## -Our proposal:

Share the investment cost for the 21 modules (496 kCHF), pro rata, over 5 years (corresponds to 4.5% increase of M&O Cat. A )

Item	Cost (kCHF)
Si	180
Pitch adapter	70
Hybrids	65
TPG substrates	38
Kapton flat cables	23
Other items (transport, additional tooling, etc.)	120

**NB:**

A document including the cost estimate submitted and endorsed by LHCC

**NB:** after  $\int L dt = 6 \text{ fb}^{-1}$

Si sensors and detector bases will be activated  
may need to follow lengthy radiation safety procedures  
for the replacement operation: e.g. cool down period,  
limited working hours, restricted working space, etc.

→ replacement operation might take longer than  
the normal annual shutdown period...

pre-mounted two detector halves would be an advantage  
would require two new detector bases with cables etc.

Decision to be taken in future once we have a better  
knowledge of the irradiation at LHC and of shutdown  
scenario, and if required, funding method would then  
need to be discussed

## -Issue on the replacement for UX85/3

(3rd Be section of the beam pipe)

Leaks due to the non-conformal Be material

Fixed currently by varnishing and operational

However, no long term guarantee under irradiation

→ CERN vacuum group (AT-VAC) has requested to procure replacement piece

Investigation being continued in collaboration with AT-VAC

-finally responsible for the procurement and operation-

Current indication is:

procurement could be possible

within the available funds from CERN

# IV) Collaboration issues

## New collaborator: Moscow State University, Russia

3 PhD's and PhD students

Team leader: P. Ermolov

Area of contribution:

Muon and VELO, where manpower needed

Additional Tier-2 activity

**NB**

Russia: in the LHCb experiment since the beginning

CORE contribution, 2.5 MCHF

Crucial role in the detector construction for

Muon (PNPI), Calo (BINP, IHEP, INR, ITEP)

and Radiation Calculation (BINP)

Computing (Tier-2 federation) and physics

# New management will take over from 1 May 2008

Spokesperson:

Andrey Golutvin, Imperial College (since 4/2008) and ITEP

Deputy Spokesperson:

Andreas Schopper, CERN

Technical Coordinator

Werner Witzeling, CERN

Resource Coordinator

Olav Ullaland, CERN

} unchanged

# V) Conclusions

- 1) All the subsystems needed for the 2008 run have been installed, except 1/4 of TT ladders and RICH-1 mechanics (quartz windows, photon funnels and the lower HPD box). Expected to be complete by the end of April.
- 2) M1 installation will continue as long as possible.
- 3) Commissioning work is in progress and Level-0 trigger now provides cosmic muons (with Calo- or Muon system).
- 4) Preparation for early physics is underway.
- 5) Eagerly looking forward to the first data in summer.
- 6) VELO replacement modules for beyond  $6 \text{ fb}^{-1}$  needs from the collaboration 496 kCHF. LHCb would like the RRB to agree in principle to the pro rata share of this, spread over the coming 5 years, i.e. 4.5% of M&O Cat.A.