

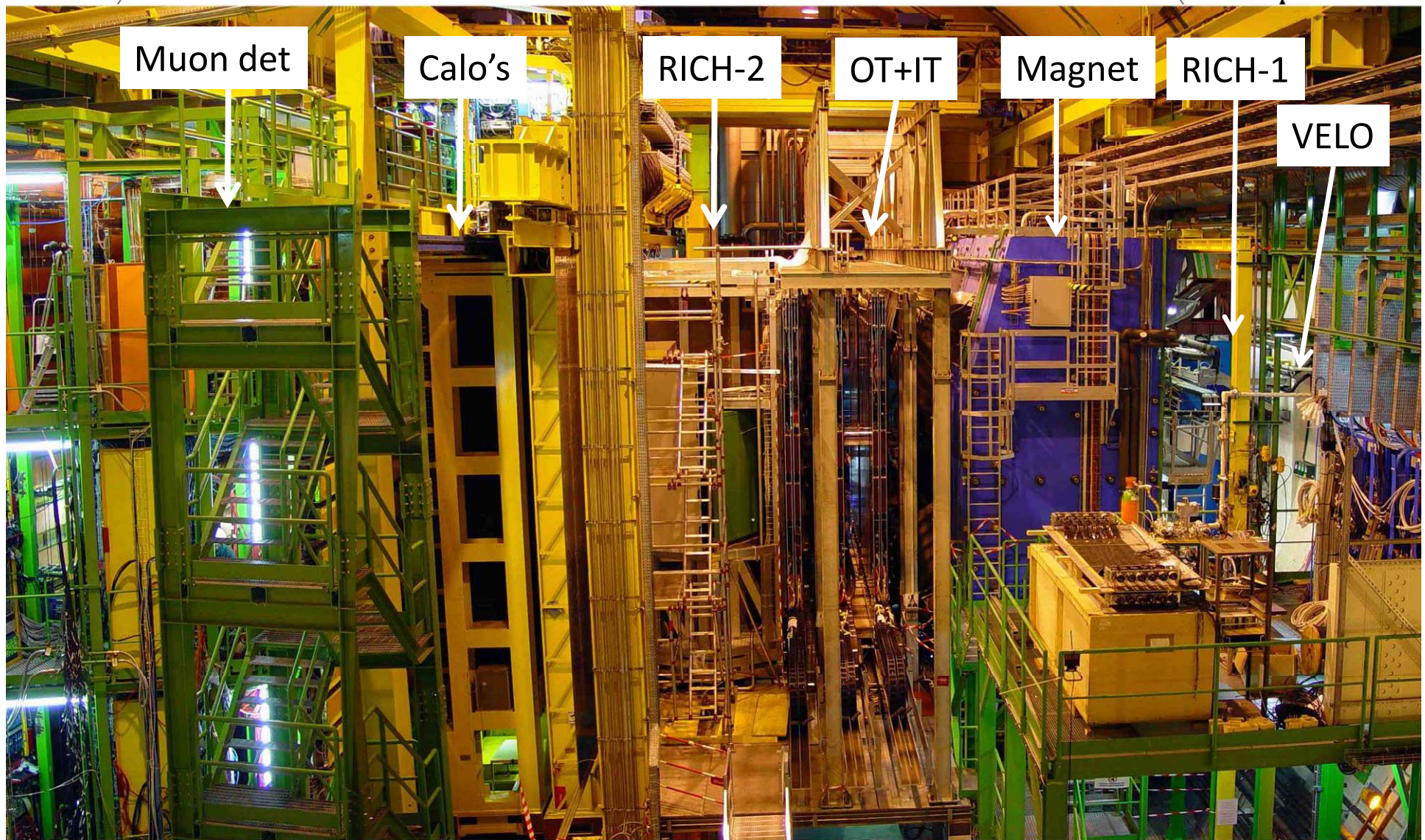
# *Status of LHCb*

*Andrei Golutvin ( Imperial & ITEP & CERN )  
On behalf of the LHCb collaboration*

## **Outline:**

- *Installation*
- *Commissioning*
- *Main physics objectives*
- *Preparation for physics with 2008 data*
- *Collaboration matters*

# *The LHCb Detector*

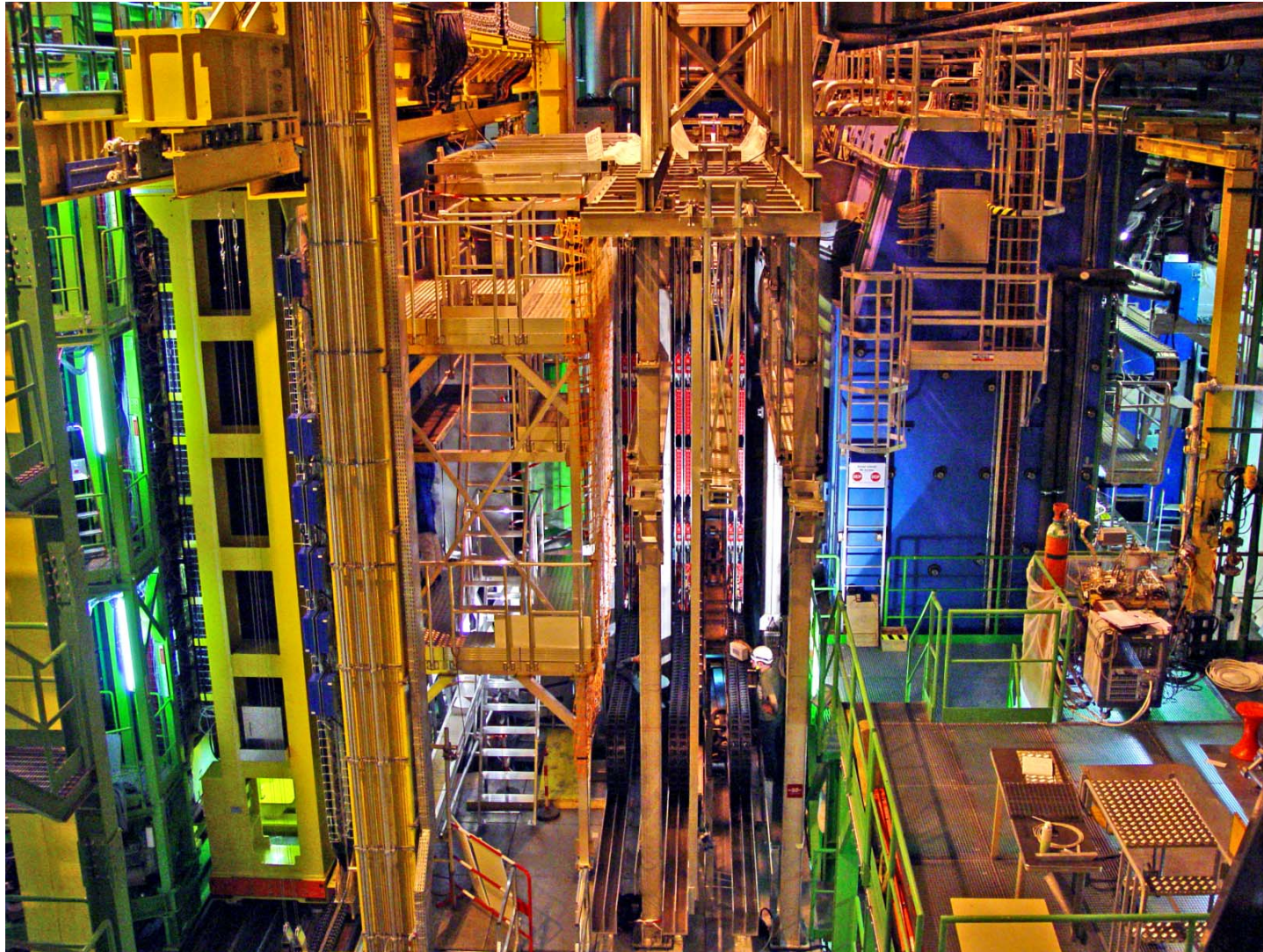


*Installation is complete*

LHC July 2008



*Since 18 June LHCb is in the nominal position  
waiting for the first data*





# *Shielding wall completed*



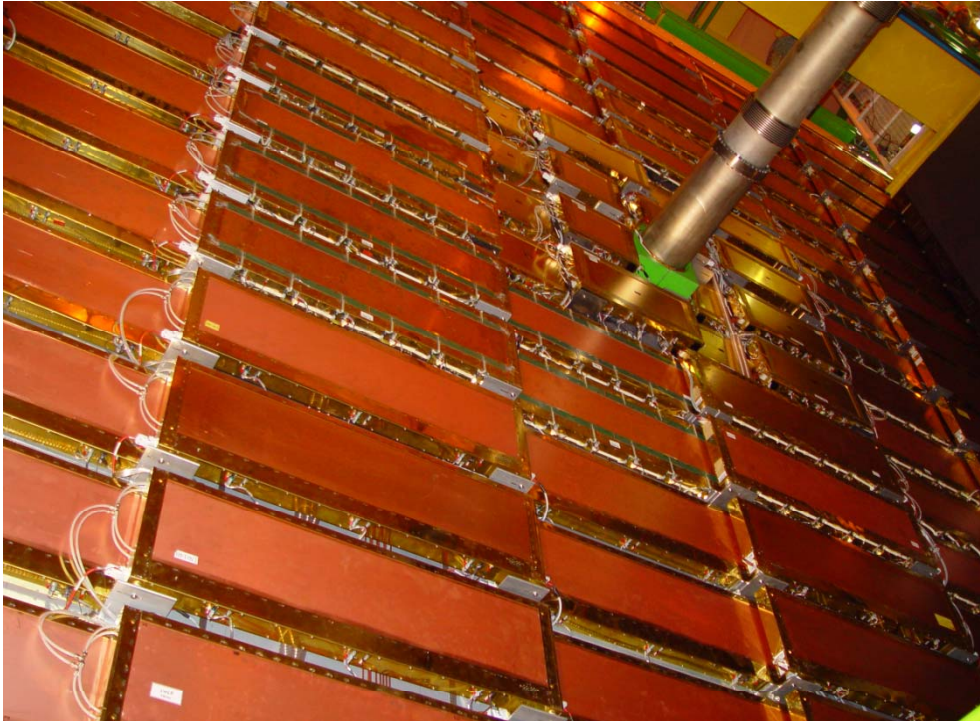
Radiation Shield – 15<sup>th</sup> layer – Installation of the last concrete block (7.5 t)

*DBS “Egyptians” are also famous painters*

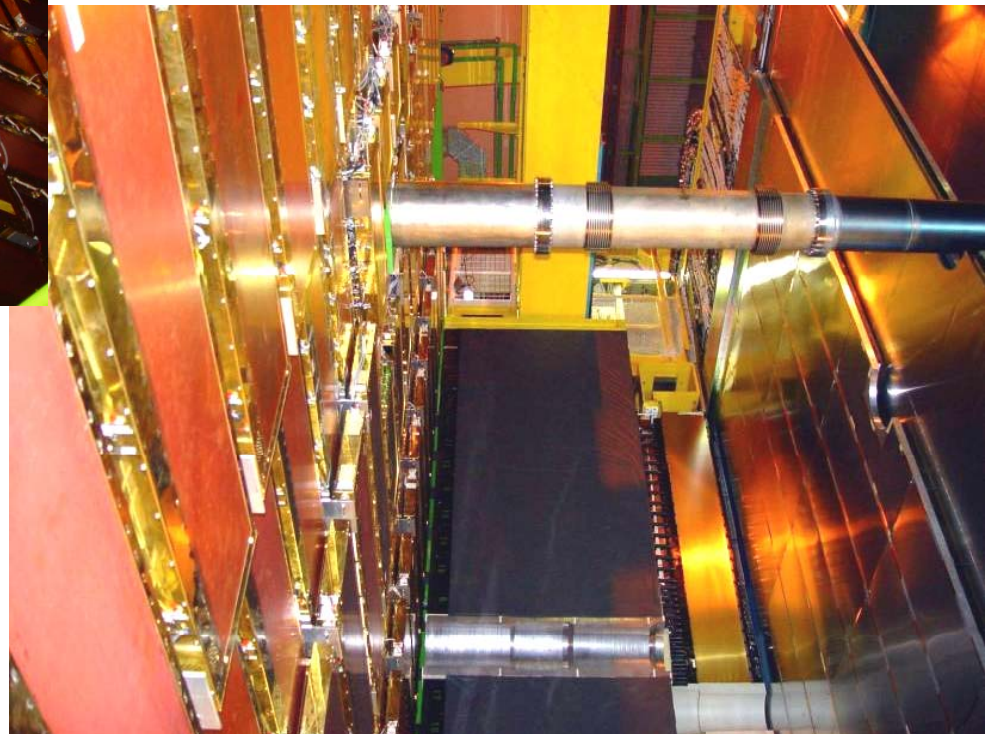
Photo : P.VALLET

07 May 2008 - 15:45

# *Muon detector closed*



*Between Muon Station 2 and RICH 2*





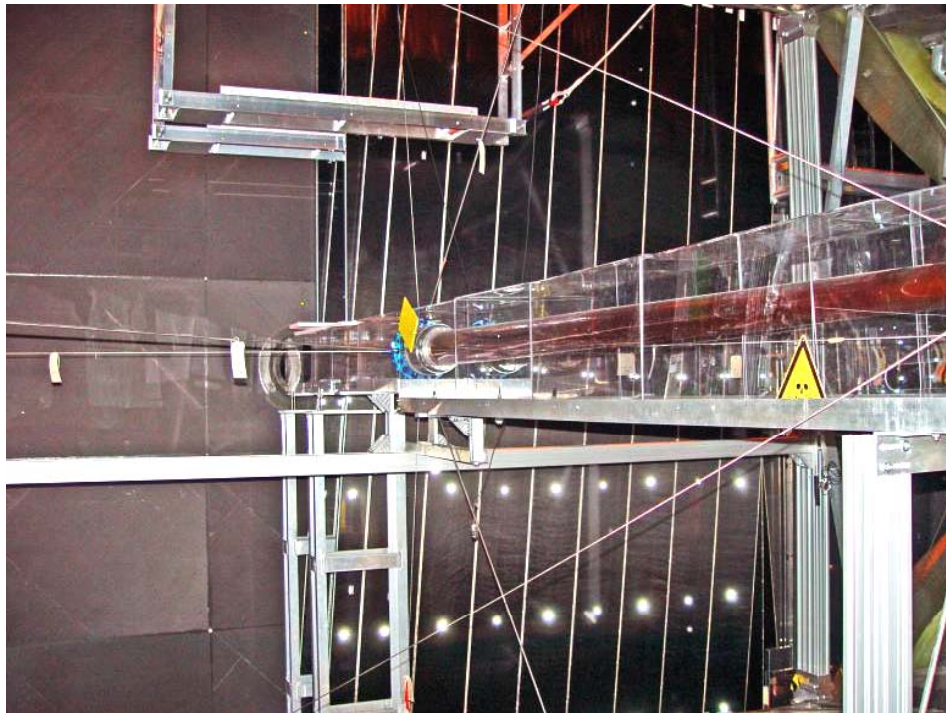


*ECAL closed*

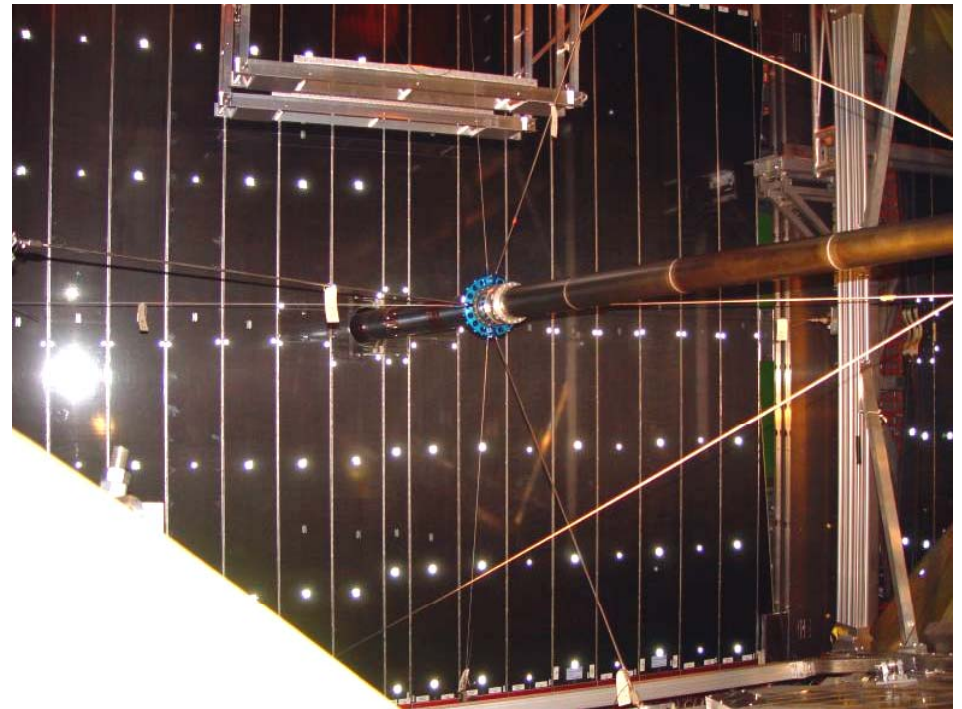


## *Removal of the Beam Pipe protection (Be section)*

*Beam Pipe with protection and two  
OT station closed*



*Beam Pipe protection removed*





## *Many thanks to the CERN support team*

*Thanks to all sub detector installation responsible and the experimental area team, the experiment has been installed in a very efficient and smooth way!*



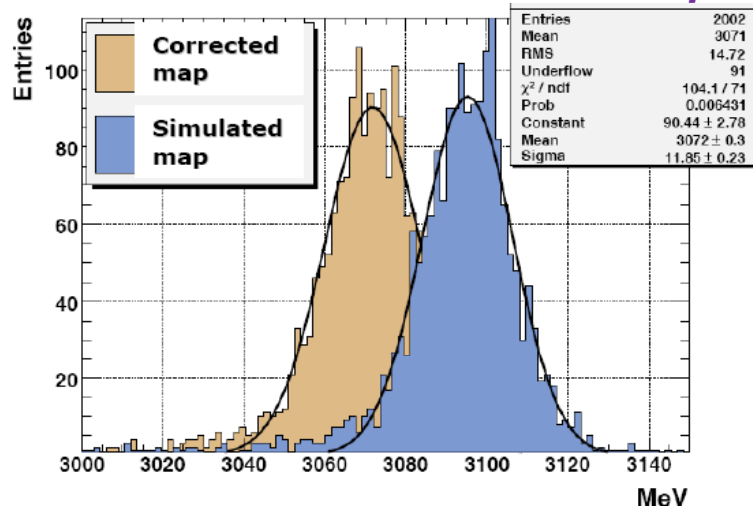
LHCC July 2008



# ***Status of the SubDetectors commissioning***

# Magnet

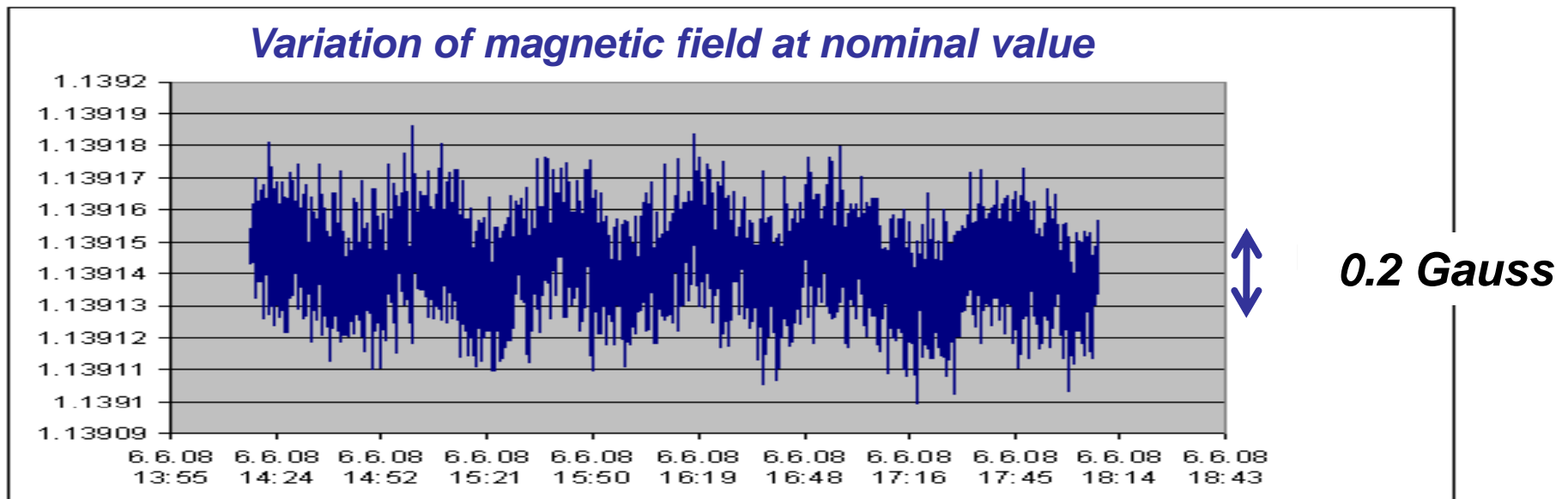
## Warm dipole magnet



*Effect of magnetic field variation on physics:  
for “golden” peaks  $\delta M$  scales with  $\delta B$*

*~30 Gauss difference between magnetic fields  
would lead to ~30 MeV shift in reconstructed  
 $J/\psi$  mass*

## Measured stability of the LHCb magnetic field (for both polarities)



LHCC July 2008



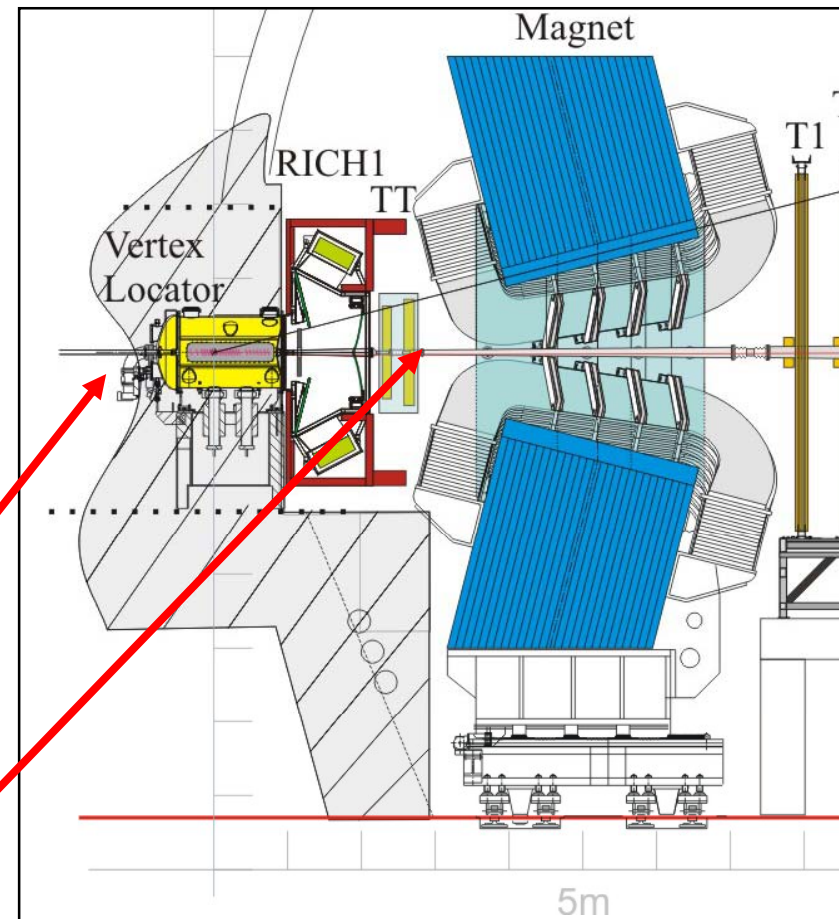
# Beam Condition Monitor

## **Hardware fully installed and tested**

- ❑ 16 CVD diamond sensors, subdivided in 2 stations (BCM-D and BCM-U 8mm  $\times$  8mm active surface)
- ❑ Successful in-situ test of all 16 diamond sensors with a  $^{90}\text{Sr}$  source
- ❑ Successful system test at full B field strength of spectrometer magnet

*BCM-U at 2130 mm upstream from IP,  
inner radius of sensitive area: 48 mm*

*BCM-D at 2765 mm downstream from IP,  
inner radius of sensitive area: 36 mm*

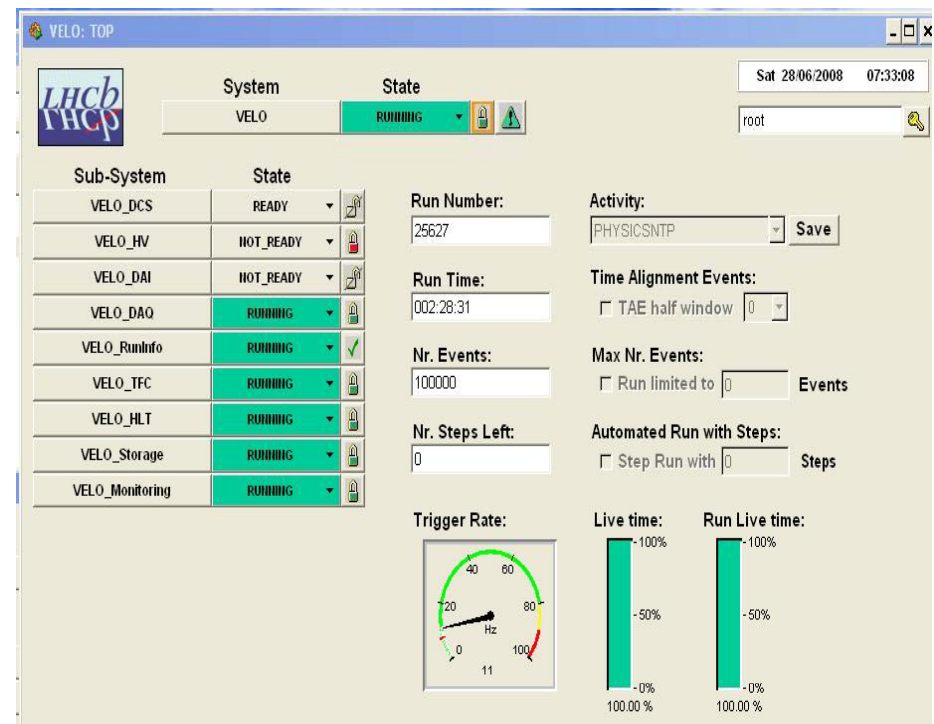


# VELO

*21 pairs of Si sensors arranged in 2 halves; each pair consists of one sensor with R- and one sensor with  $\phi$ - strips*

- ❑ Since last LHCC:
  - Both VELO halves independently commissioned
    - ✓ Total system noise as expected
  - CO2 cooling system fully commissioned
    - ✓ Operated under full load at -25C
    - ✓ Setting point will be -5C for 2008
      - Minimizing effects of thermal cycling
- ❑ VELO turned on fully for first time (24 June) after beam pipe evacuation

- ❑ >100000 events collected
- ❑ Rates of > 10kHz achieved
  - With 8 nodes in event builder





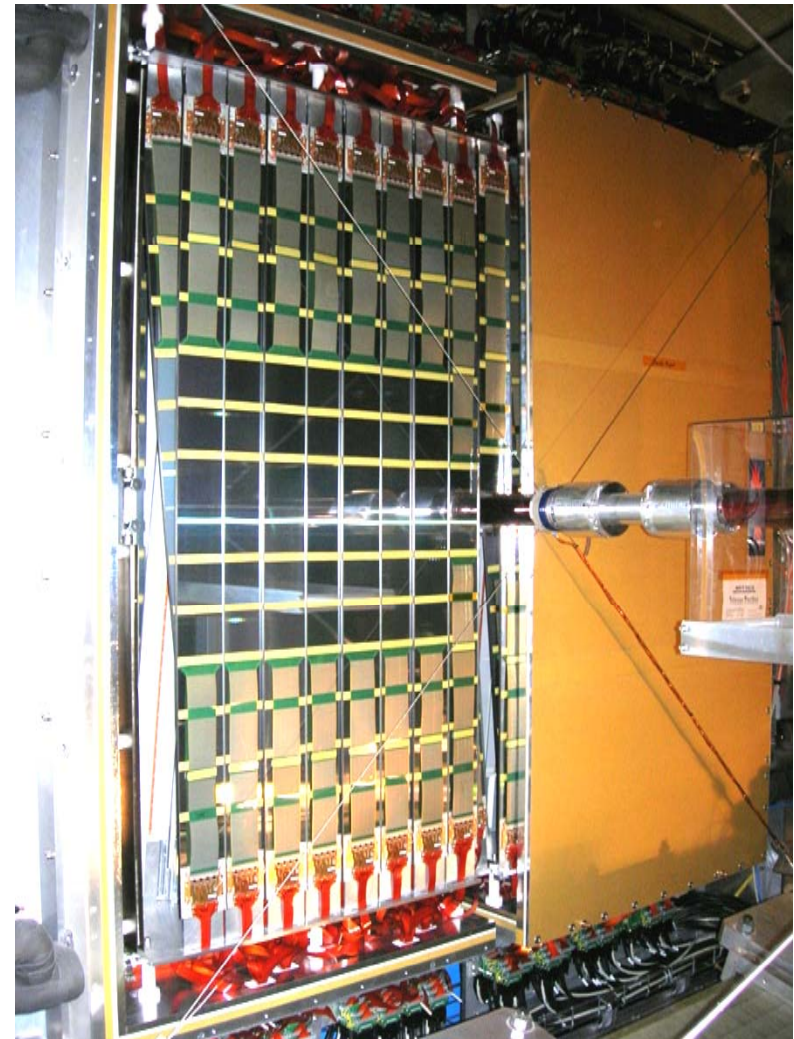
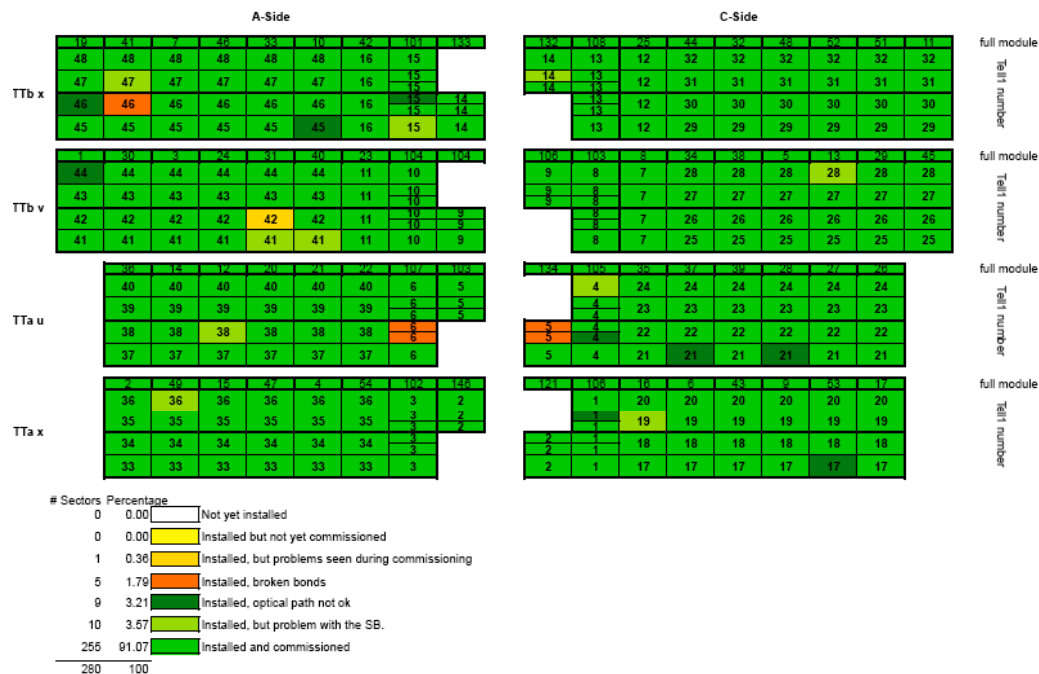
# VELO ISSUES

- ❑ **Strategy for power up and closing**
  - *Monitoring critical*
  
- ❑ **Detector Channels** - *only 0.3% problematic (0.5% design spec)*
  - ✓ *Due to non-availability of LV power supplies and TELL1 readout boards ~3% of channels still to be commissioned*
  
- ❑ **Spare/Replacement VELO**
  - *modules under construction at Liverpool since 1 week*
  - *Production completed in April 2010*
  - *Discussion with NIKHEF/CERN on building remaining mechanics to ease installation*

# Silicon Tracker – Trigger Tracker

*TT covers area of 1.4×1.2 m<sup>2</sup>; 4 stereo layers with ladders consisting of 3 or 4 chained Si- sensors with strip pitch 183 micron; 143k channels*

- ❑ All modules + service boxes installed
- ❑ Detector surveyed with magnet on
- ❑ Detector cooled to operating  $T = 0^\circ \text{C}$
- ❑ 91% of channels commissioned
- ❑ Remaining faults under investigation

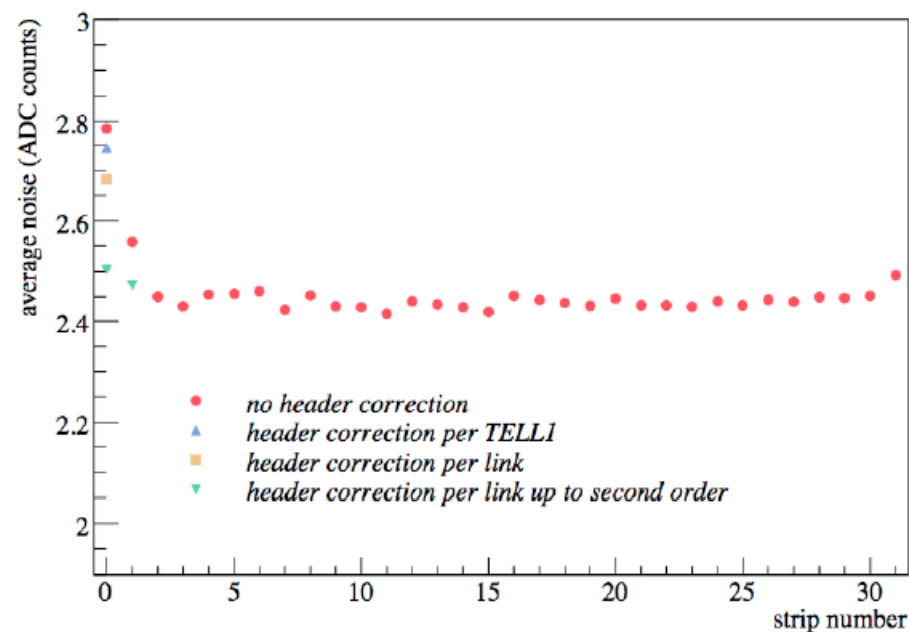




# Silicon Tracker – Inner Tracker

*3 stations with 4 boxes each arranged around beam pipe; each box has 4 stereo layers  
x-u-v-x, modules with one or two chained Si-sensors; strip pitch 198 micron; 130k  
channels*

- ☐ *Detector closed + surveyed*
- ☐ *Detector cooled to operating  $T \sim 0^\circ \text{C}$*
- ☐ *98.5 % of channels working*
- ☐ *Preparing software/hardware for time alignment with beam gas:*
  - ✓ *participating in cosmic running*
  - ✓ *setting cluster thresholds in TELL1*
  - ✓ *tuning TELL1 algorithms*



# Outer Tracker – OT

*Three stations with each 4 stereo layers of straw tubes 5 mm diameter and 5m length; 55k channels*

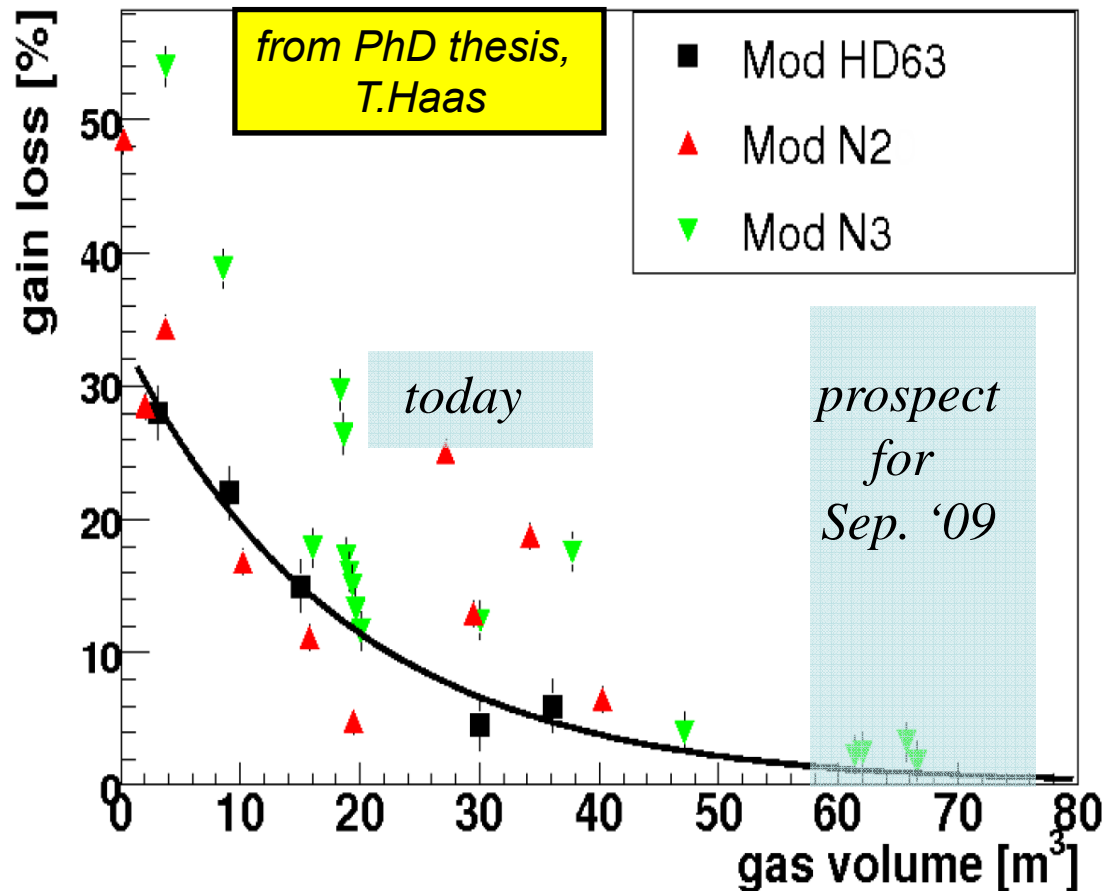
- ☐ *All detector modules installed*
- ☐ *All FE Electronics installed*
- ☐ *All TELL1 operational*
- ☐ *Detector positioned and surveyed*

- ☐ *C-side commissioning (with test-pulses) completed*
- ☐ *A-side commissioning on-going*
- ☐ *HV, LV, Gas and Cooling control operational*
- ☐ *OT readout time aligned (using CALO cosmic trigger)*
- ☐ *Cosmic data acquired, preliminary tracking !*



# Gain Loss Prevention

## Effects of Gas Flushing



**Heating modules during flashing also helps**

□ Warming up in situ will be completed during winter shutdown; Not critical for 2008 Run

**Assuming constant gas flow of 0.8V/h**

# RICH

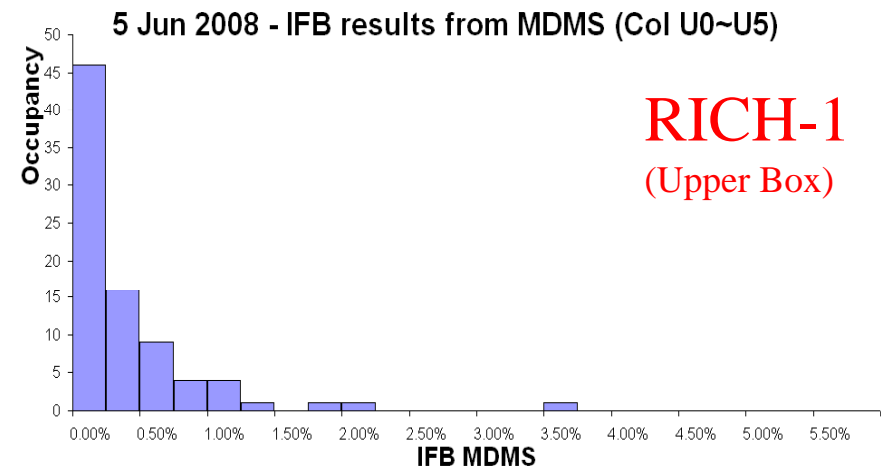
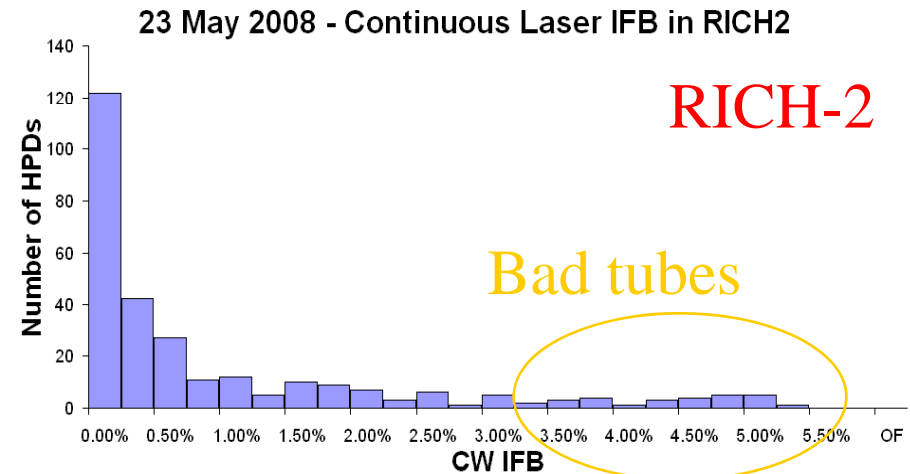
*RICH1 and RICH2 with 3 radiators covers momentum range 2-100 GeV; RICH1: 5cm aerogel with  $n=1.03$  & 4m<sup>3</sup> C<sub>4</sub>F<sub>10</sub> with  $n=1.0014$ ; RICH2: 100m<sup>3</sup> CF<sub>4</sub> with  $n=1.0005$ ; ~500 HPD to readout*

- ☐ *RICH-2 has been powered under HV for ~9 months. The detector routinely runs 24 hours of the day with minimal intervention.*
- ☐ *Readout through LHCb data acquisition runs smoothly. RICH-2 was the first detector to be integrated into the LHCb DAQ framework.*
- ☐ *A dedicated pulsed laser system to provide a synchronized source of photons gives timing across RICH-2 to be typically better than  $\pm 2\text{ns}$  across all channels, separately on each side of RICH-2.*
- ☐ *The RICH-2 magnetic calibration system successfully maps changes in magnetic field to a precision of significantly better than 1 HPD pixel.*
- ☐ *RICH-1 was completed by the beginning of June. The system was largely up and running at full HV within 2 weeks. Data are read out under central DAQ control. RICH-1 is now powered up under HV routinely.*
- ☐ *The RICH-1 magnetic calibration system works successfully and data to map HPD magnetic distortions are currently being analysed.*
- ☐ *In summary, the RICH detectors are ready for LHC collisions.*



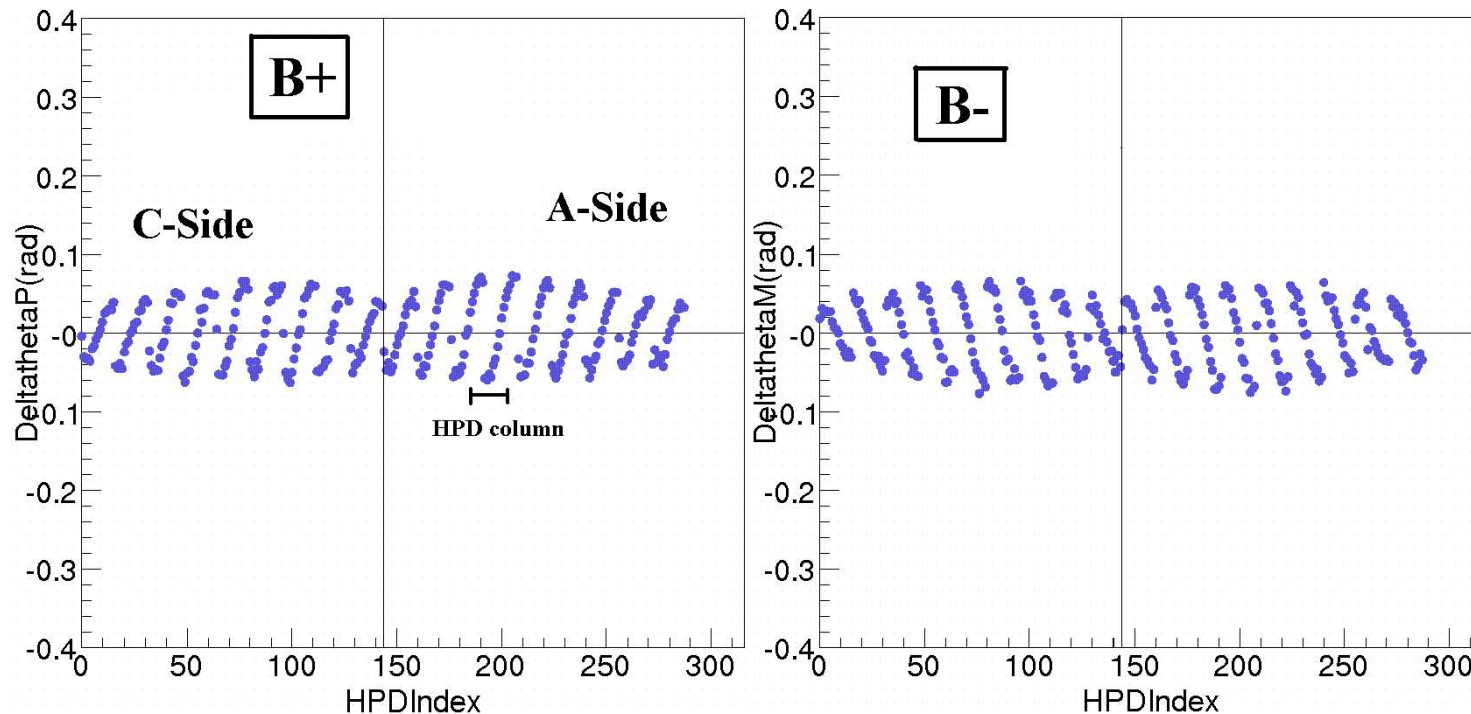
# HPD status

- ❑ Problems seen with vacuum quality for some tubes  
→ cannot take full 20 kV
- ❑ Correlated to high ion-feedback rate (measured by looking for large hit clusters)
- ❑ At present appears to be a problem of the early HPD batches: RICH-2 (populated first) has had 19 tubes replaced / 288  
11 more showing problems  
RICH-1 tubes have low ion-feedback rate, only few > 1%
- ❑ Discussions with vendor (DEP-Photonis) for repair ongoing



# Magnetic field test

- ✓ Readout of full RICH-2 with (B+,0, B-) using projected test pattern
- ✓ Minor distortion of HPD images due to B-field clearly seen  
Very uniform response over RICH-2, maximum distortion  $\approx 1$  pixel  
Consistent with predictions from simulation, easy to correct

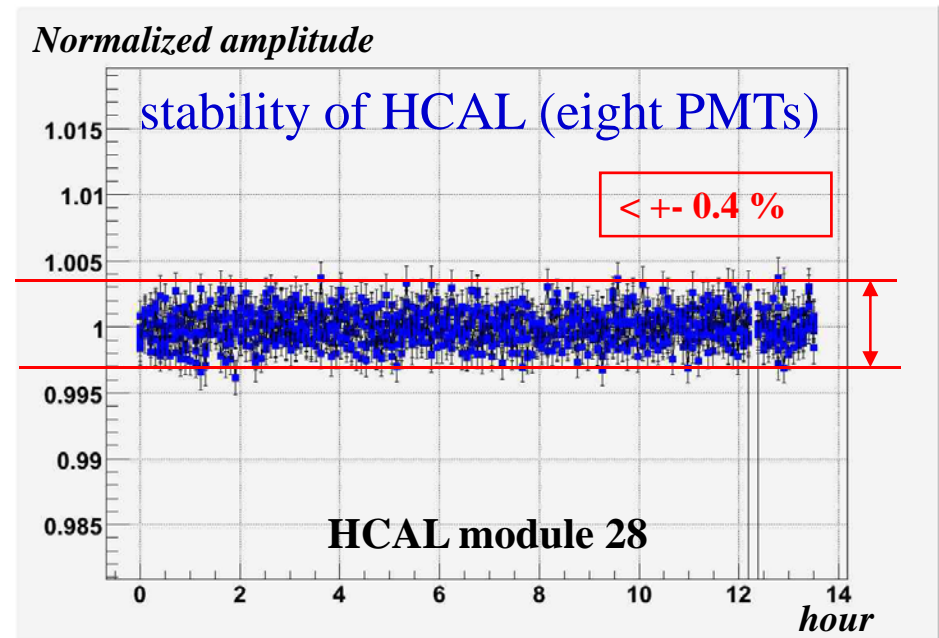
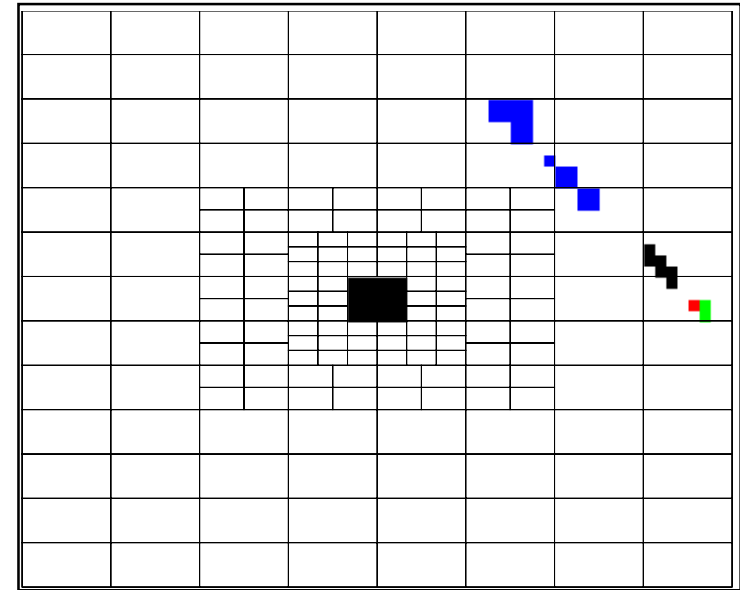




# Calorimeters

*PS/SPD: 12k scint. tiles readout by WLS; ECAL: 6k shashlik cells; HCAL: TILE Calo, 1.5k channels*

- ✓ *System is complete*
- ✓ *HCAL calibration with Cesium source will be performed in the next weeks*
- ✓ *Calorimeters cosmic triggers delivered to LHCb regularly*
- ✓ *HCAL – ECAL – PS – SPD commissioned using cosmics*  
*Time alignment ~3ns achieved*
- ✓ *L0 calorimeter trigger being commissioned*
- ✓ *Stability of the PMT gain being monitored using LED system*



# Muon

*Arranged in 5 SuperLayers; M1 consists of 24 triple GEM chambers;  
M2-M5 consists of 1100 MWPCs*

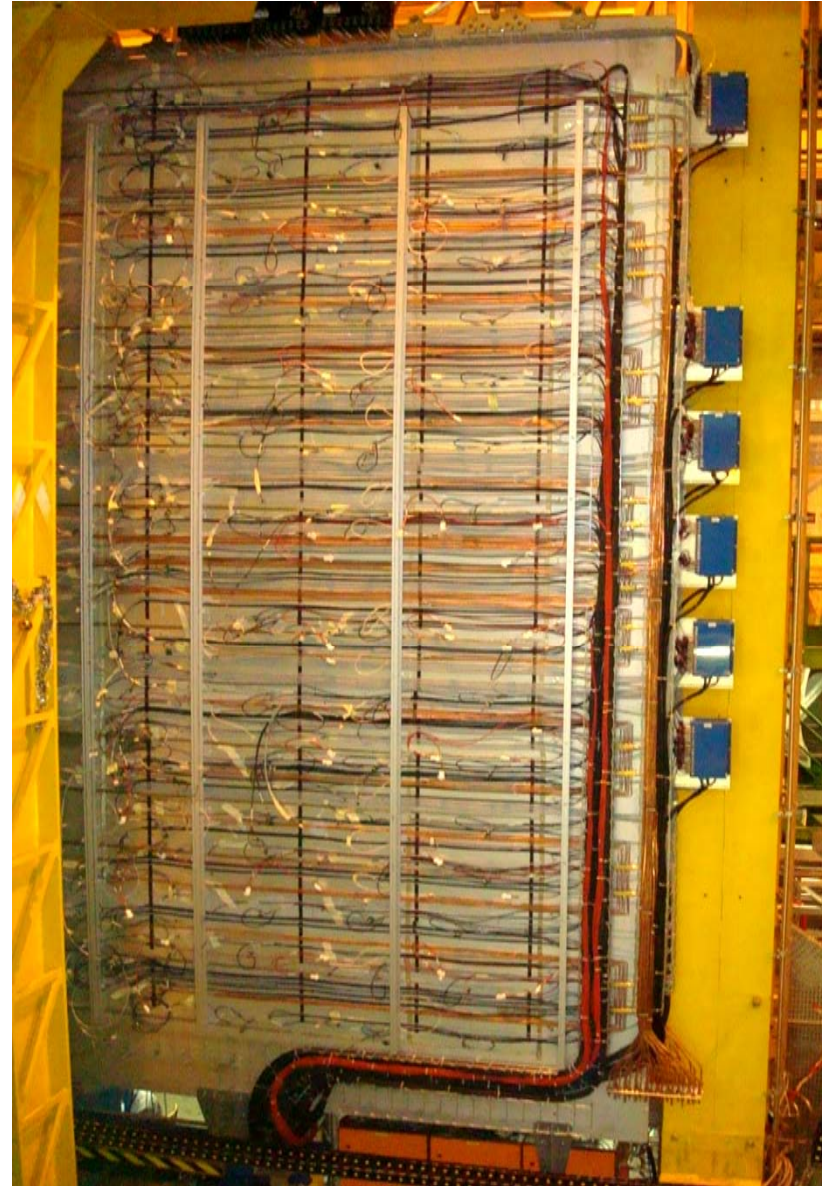
- ☐ *Chamber alignment completed. All chambers are within  $\pm 1$  mm of their nominal position*
- ☐ *Stations M2-M5 successfully closed*
- ☐ *Connectivity tests and time alignment completed  
(~0.5% bad channels)  
Debugging is ongoing*
- ☐ *M1 will not be completed for 2008 Run. Not needed for low luminosity*





# M1 status

- ✓ *Mechanics completed*
  - *Walls, chambers support rails, moving system, cable chains*
- ✓ *Work on services ongoing:*
  - *Gas piping: On wall piping completed*  
*Flexibles being cleaned*
  - *Cabling: ~80% of cables installed*  
*~60% of connectors mounted*
- ✓ *Some GEM chambers may be installed before zone is closed*
- ✓ *Completion of installation and commissioning in the next winter shutdown*



# Online

- ❑ *Overall the system is in good shape*
- ❑ *The commissioning is progressing well. The hardware that was foreseen for 2008 is installed and operational: ~15% of network and HLT farm capacity, corresponding to 100 1U servers containing 16 computing cores each*
- ❑ *The system is regularly in use for all Subdetector commissioning and global commissioning efforts*
- ❑ *Online configuration is redundant for 2008 goals*

# *Concerns and actions to be taken*

## ☐ *TELL1 readout boards*

- *Quality of vias connection of the PCB boards*
- *Organize repairs and start mini-production of spares with a different company*

## ☐ *CAEN Low Voltage supplies*

- *Delays with delivery*

## ☐ *Cooling plastic turbines for the power supplies (tolerant to magnetic field)*

- *Mechanical defects*
- *Repairs and new production has to be organized*



# *Global Commissioning*

- ❑ *Cosmic data are being taken*

*All detectors are put together for cosmic readout*

*CALO, Muon and Outer Tracker time aligned*

*ST will be the next → this week is a global commissioning week*

- ❑ *Continue time alignment with Beam gas events when available*

- ❑ *Regular operation of LHCb as a whole*

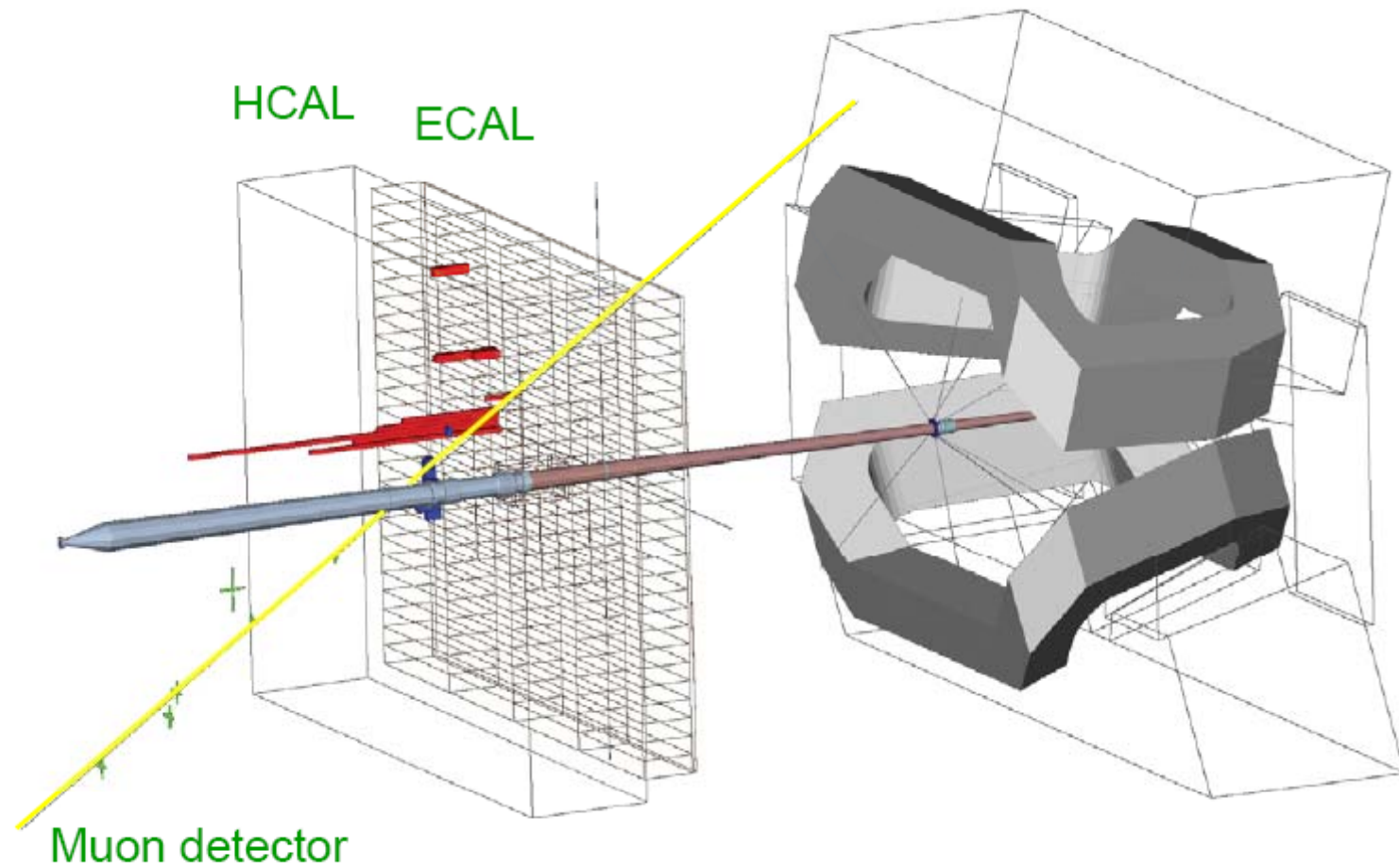
*Day time / working days*

*24 hours a day, 7 days a week*

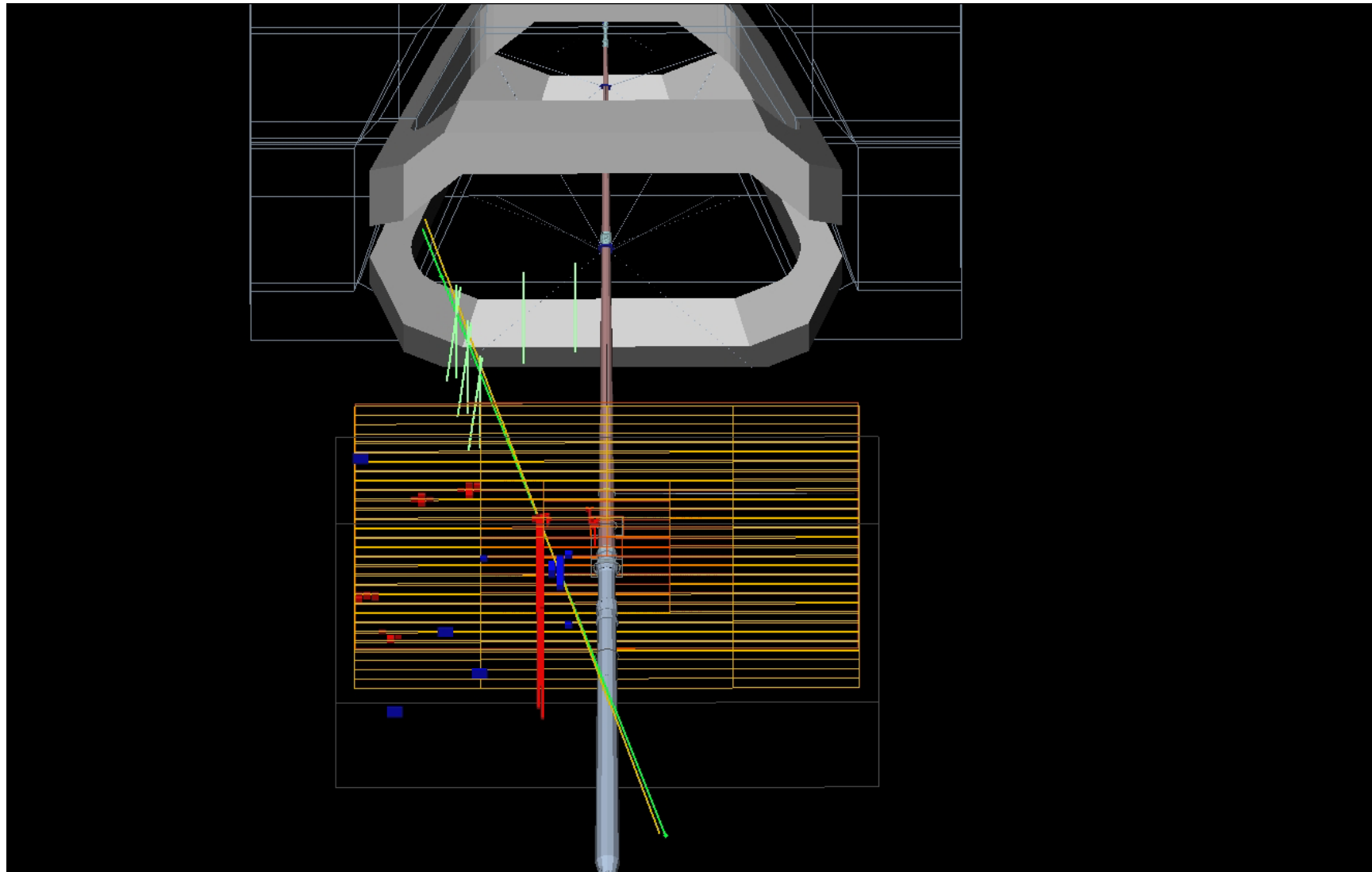
*second half of July*

*end of July*

# *LHCb cosmic rays: Muon + HCAL + ECAL*



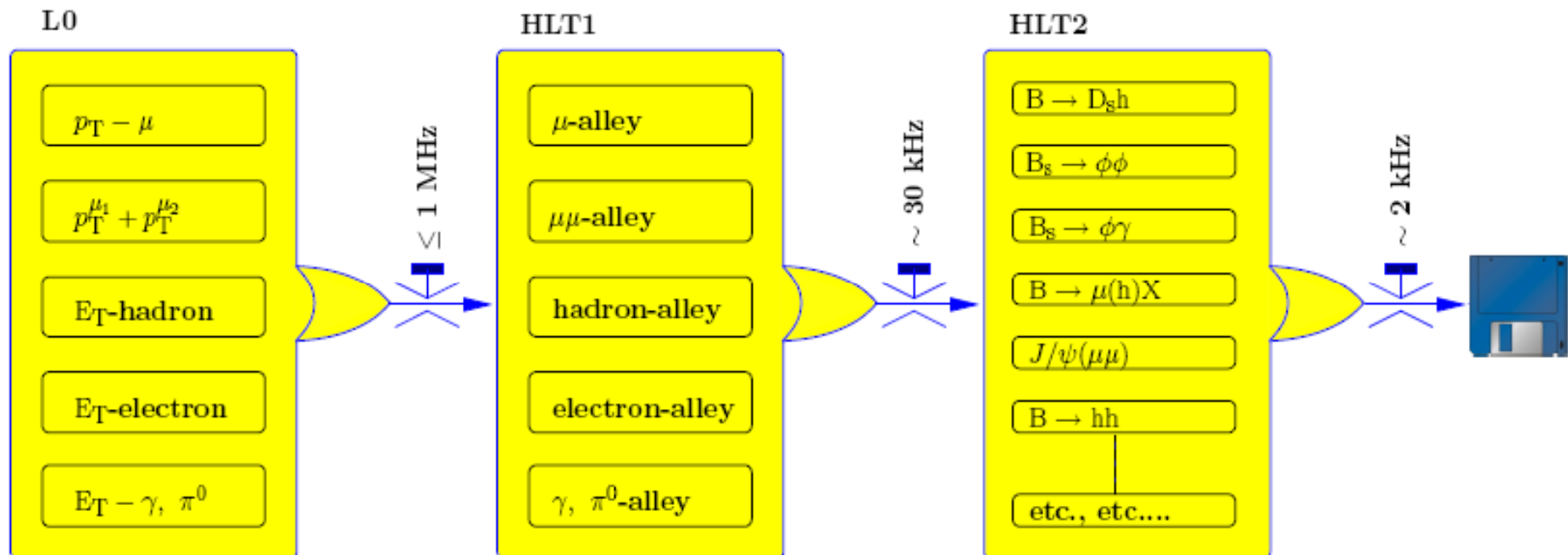
# *LHCb cosmic rays: Outer Tracker + HCAL + ECAL*





# Nominal Trigger Flow Reminder

- ❑ *L0: Trigger on  $E_t^{\text{hadron}} \lesssim 3.5$ ,  $E_t^{e,\gamma,\pi} \lesssim 2.5$  and  $p_t^{\mu\mu\mu} \lesssim 1$  GeV*
- ❑ *HLT1: Confirm L0 objects (with  $T$ , VELO, and optionally IP – cut)*
- ❑ *HLT2: Full pattern recognition, exclusive and inclusive B-reconstruction*



# Main Physics Objectives

## Search for New Physics in CP-violation and Rare Decays

### Key Measurements

Accuracy in 1 nominal year  
(2 fb<sup>-1</sup>)

#### □ In CP – violation

✓ $\phi_s$	0.023
✓ $\gamma$ in trees	4.5°
✓ $\gamma$ in loops	10°

#### □ In Rare Decays

✓ $B \rightarrow K^* \mu \mu$	$\sigma(s_0) = 0.5 \text{ GeV}^2$
✓ $B_s \rightarrow \mu \mu$	3 $\sigma$ measurement down to SM prediction
✓ Polarization of photon in radiative penguin decays	$\sigma(A\Delta) = 0.2$ (in $B_s \rightarrow \phi \gamma$ )

# Assumptions for 2008 Run

- ❑ Start "Physics" with first 10TeV collisions
  - ✓ 2x2, i.e. 2 bunches on 2 bunches, each experiment sees 1 colliding pair
- ❑ Increase luminosity gradually (zero external crossing angle)
  - ✓ push bunch charges:  $4 \times 10^{10} \rightarrow 9 \times 10^{10}$  protons/bunch
  - ✓ push number of bunches: 43x43, then 156x156
- ❑ Target luminosities (for  $9 \times 10^{10}$  protons per bunch,  $\beta^* = 6\text{m}$ ):

<u>Scheme</u>	<u>coll. pairs</u>	<u>non-coll. bunches</u>	<u>Lumi at IP8</u>
2x2	1	1	$1.7 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$
43x43	19	24	$3.3 \times 10^{30}$
<b>156x156</b>	<b>68</b>	<b>88</b>	<b><math>1.2 \times 10^{31}</math></b>
		(per beam)	

- ❑ Expected integrated luminosity in 2008:  $\sim 5 \text{ pb}^{-1}$
- ❑ Conditions per Xing in 2008 are similar to the nominal conditions;  
Rate is down by  $> 25 \rightarrow$  adequate to installed CPU power ( $\sim 15\%$ )



# First Triggers

## **L0 $E_t^{\text{hadron}}$ (commissioned)**

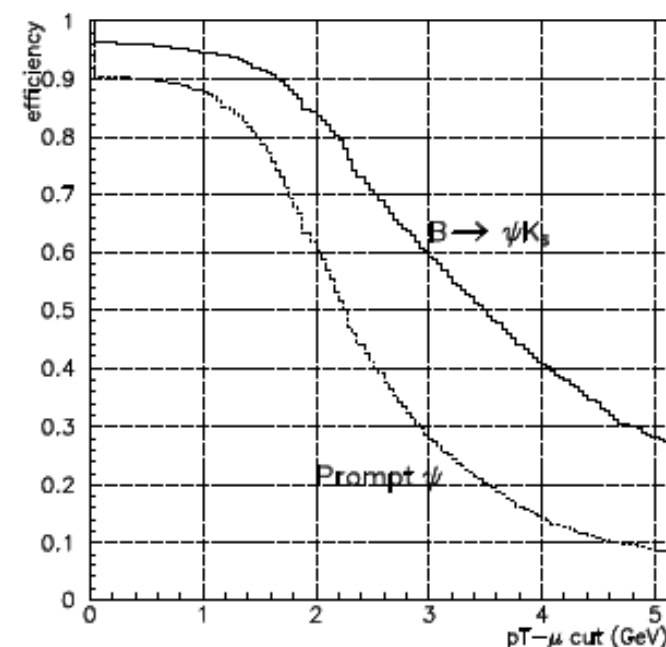
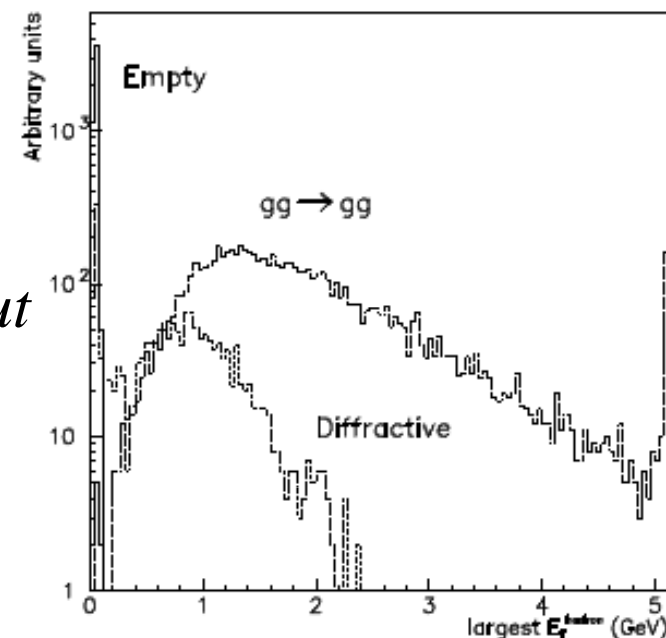
- ✓ No-beam rate – few Hz, with 0.5 GeV  $E_t$  cut
- ✓ Ideal “minimum bias” trigger

## **Single $\mu$ - trigger (commissioned)**

- ✓ Other  $\mu$  un-biased (in dimuon events)
- ✓ Needs only M2-M5 information, possibly add T-stations
- ✓ Large efficiency for dimuon events (requires 1 out 2  $\mu$ )

1/70k events will contain a (prompt)  $J/\psi \rightarrow \mu\mu$  in LHCb acceptance. Expected rate 6  $J/\psi \rightarrow \mu\mu$  / s

**Add hadron/e/ $\gamma$  triggers as more detectors (VELO, T, ST) are shaken down**



# Steps towards key measurements

## □ *PID is important for all*

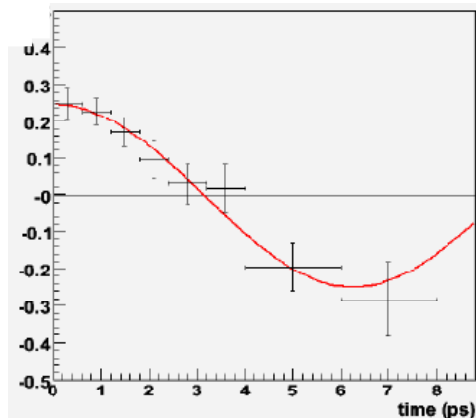
*Plenty of  $K_S$  and  $\Lambda$  in  $10^8$  min. bias events. 95% purities achievable with kinematical and vertex cuts alone  $\rightarrow$  clean & unbiased sample for PID studies*

*$J/\psi$  trigger on single  $\mu$  with  $P_T$  cut  $\rightarrow$  one muon unbiased for PID studies*

## □ *For $\beta_s$*

***For  $5\text{pb}^{-1}$  we expect 330  $B_s \rightarrow J/\psi\phi$ ,  
2.3k  $B^0 \rightarrow J/\psi K^*$  and 23k  $B^0 \rightarrow D^*\mu\nu$  events***

*Oscillation plot  
made with 3pb  
 $B^0 \rightarrow D^*\mu\nu$   
(kaon tag; signal)*



- Study prompt time resolution with prompt component
- Tagging studies with flavor specific modes
- Exercise fit machinery with  $B \rightarrow J/\psi K^*$

# Steps towards key measurements

## □ For the angle $\gamma$

Significant samples should be available once  $\mu P_T$  & / or hadron trigger is operational

Channel	Yield / 5 pb <sup>-1</sup>
$B \rightarrow D(K\pi)X$	31k
$B^+ \rightarrow D(K\pi)\pi^+$	1700

- Optimize thresholds to boost charm from prompt production
- Study vertex / mass resolutions and lifetimes for  $D(B) \rightarrow hh$  modes
- Study background environment with accumulated sample of  $B \rightarrow D(K\pi)\pi$  (control sample for the ADS method)

## □ For $B_s \rightarrow \mu\mu$ (We try to make fast measurement)

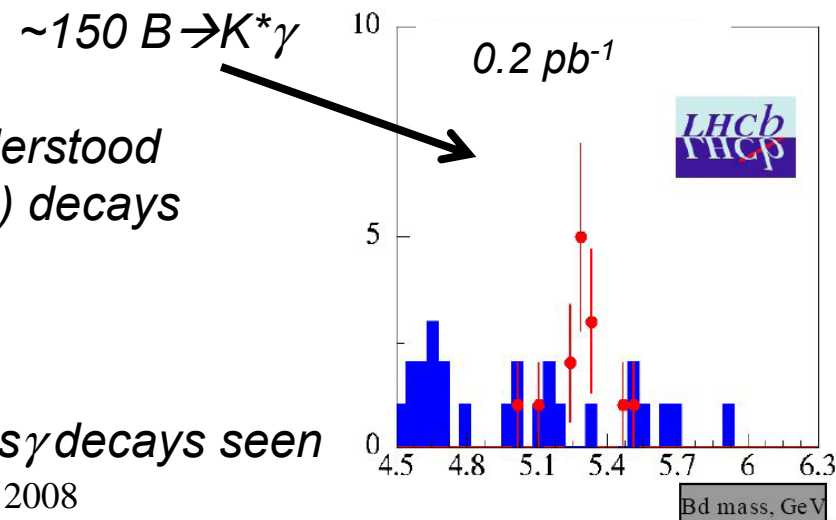
- Methods for calibrating mass, PID and selection demonstrated

## □ For $B - K^*\mu\mu$

- Muon efficiency at low momentum understood
- Experience with angular fits from  $\psi(2S)$  decays of similar topology

## □ For Radiative penguin decays

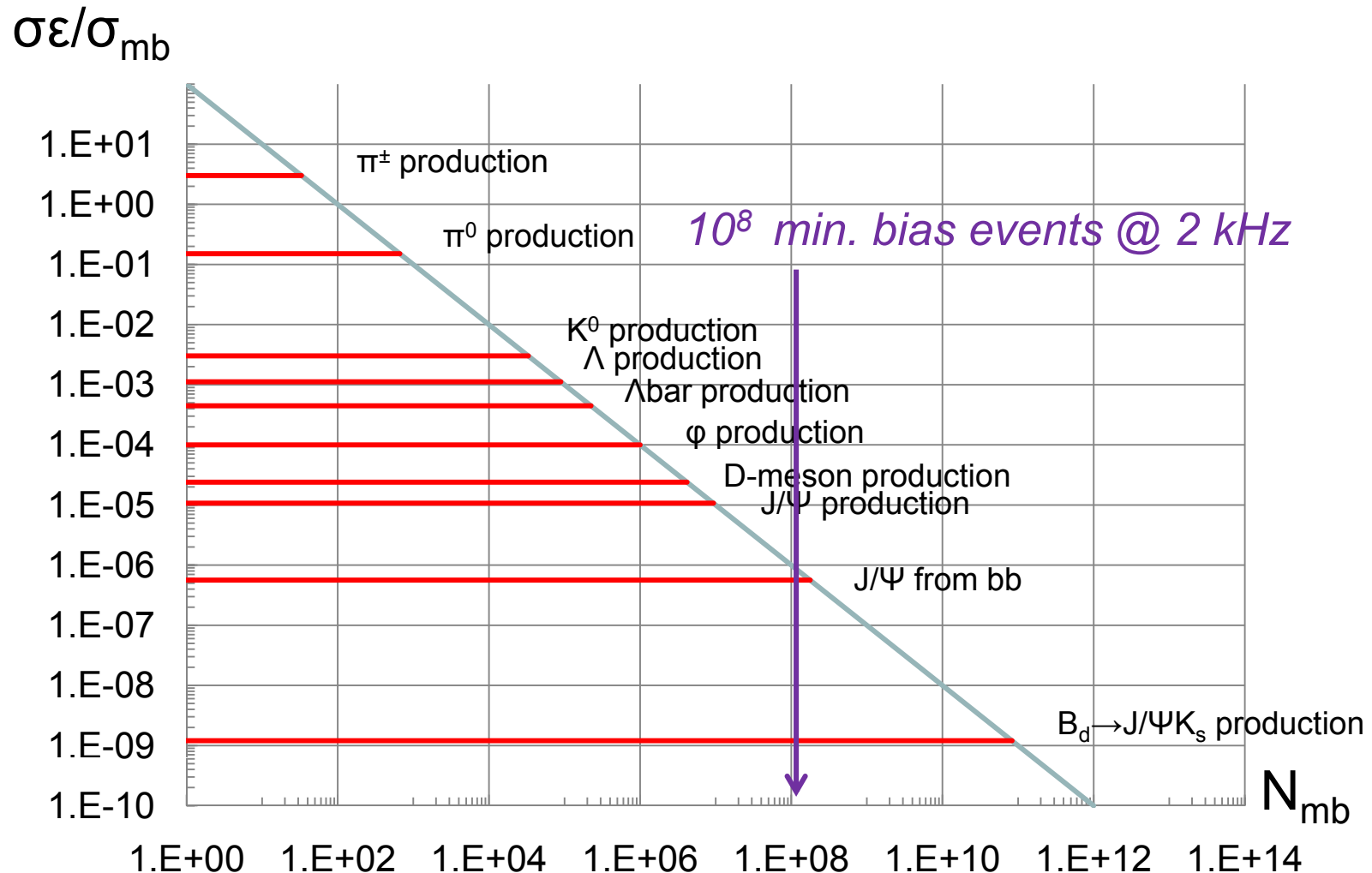
- Calorimeter is calibrated and first  $b \rightarrow s\gamma$  decays seen



LHCC July 2008



# Possible 2008 topics for the 1<sup>st</sup> paper

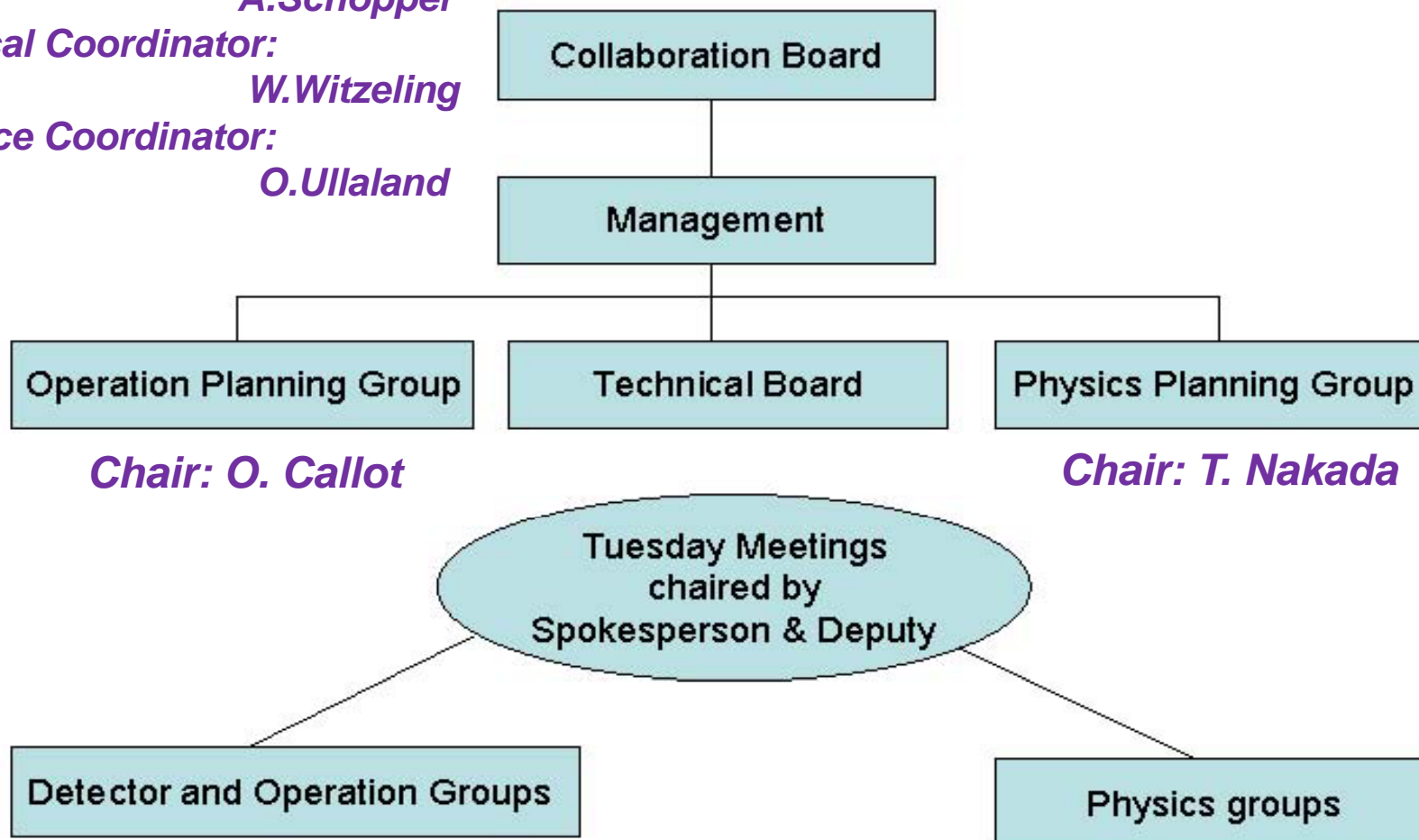


# Collaboration Matters

## Management:

**Spokesperson:** A.Golutvin  
**Deputy:** A.Schopper  
**Technical Coordinator:** W.Witzeling  
**Resource Coordinator:** O.Ullaland

**CB Chair:** E. Aslanides



# Physics groups

## CP-violation

**Convener: Guy Wilkinson**

**Deputy: Marta Calvi**

*(with particular responsibility for tagging and proper time)*

**Coordinators of the key measurements:**

$\phi_s$  O. Leroy

$\gamma$  in loops V. Vagnoni

$\gamma$  in trees J. Libby

## Rare Decays

**Convener: Ulrik Egede**

**Coordinators of the key measurements:**

$B_s \rightarrow \mu\mu$  F. Teubert

$B \rightarrow K^*\mu\mu$  M. Patel

$B \rightarrow X\gamma$  I. Belyaev

## Flavor Physics

*(very 1<sup>st</sup> measurements)*

**Convener:**

**Olivier Schneider**

**Coordinators:**

**Soft QCD** M. Schmelling  
*1<sup>st</sup> phys with min. bias*

**Quarkonium and B** P. Robbe  
*1<sup>st</sup> phys. with J/ $\psi$*

**EW physics** T. Shears

**Higgs and exotica**

C. Matteuzzi

**Direct LUMI measurement**

J. Panman



# *Conclusion*

- ❑ *LHCb is ready to take data*
- ❑ *We are looking forward to work on first data during next LHCC in September*

# ***Spare Slides***

# Main Physics Objective

***LHCb is designed to search for New Physics in CP-violation and Rare Decays***

***In CP-violation sensitivity of UT approach is limited by theory:***

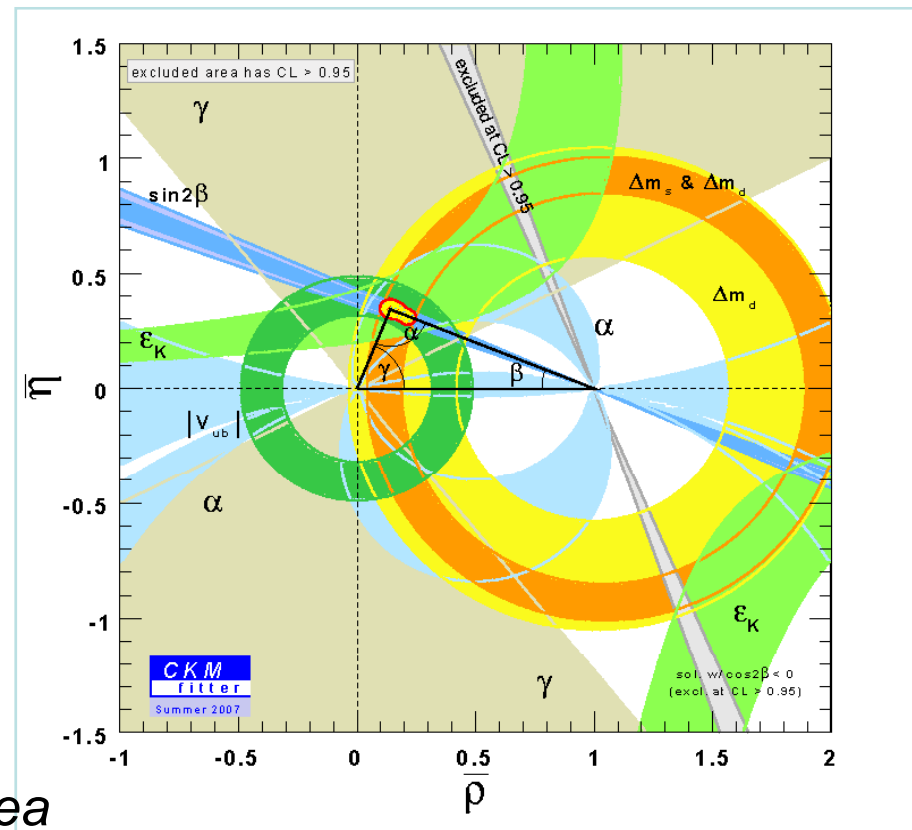
- Extraction of  $|V_{ub}|$
- Lattice calculation of

$$\xi^2 = \frac{\hat{B}_{B_s} f_{B_s}^2}{\hat{B}_{B_d} f_{B_d}^2}$$

***and experiment: angle  $\gamma$***

***In Rare Decays sensitivity is limited by experimental statistics***

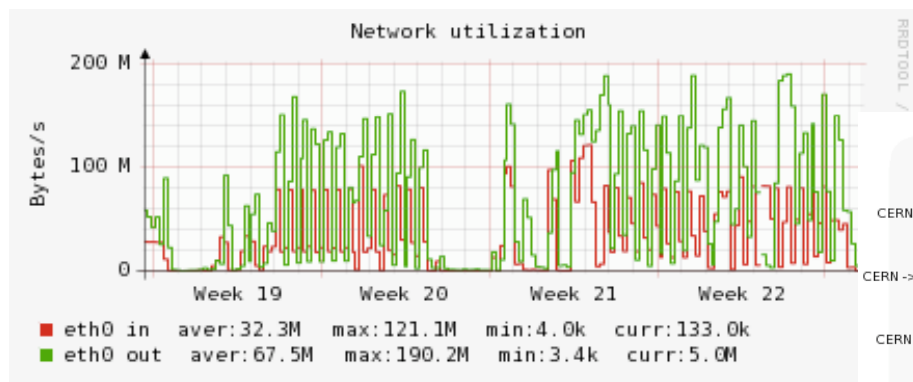
*CDF/ D0 are reaching an interesting area*



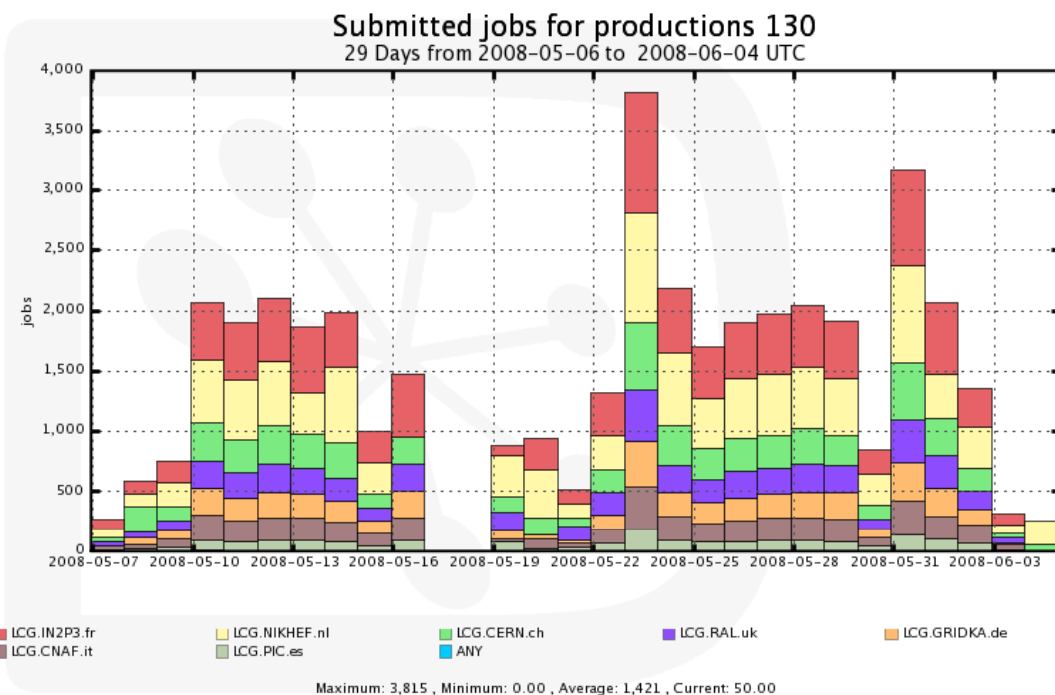
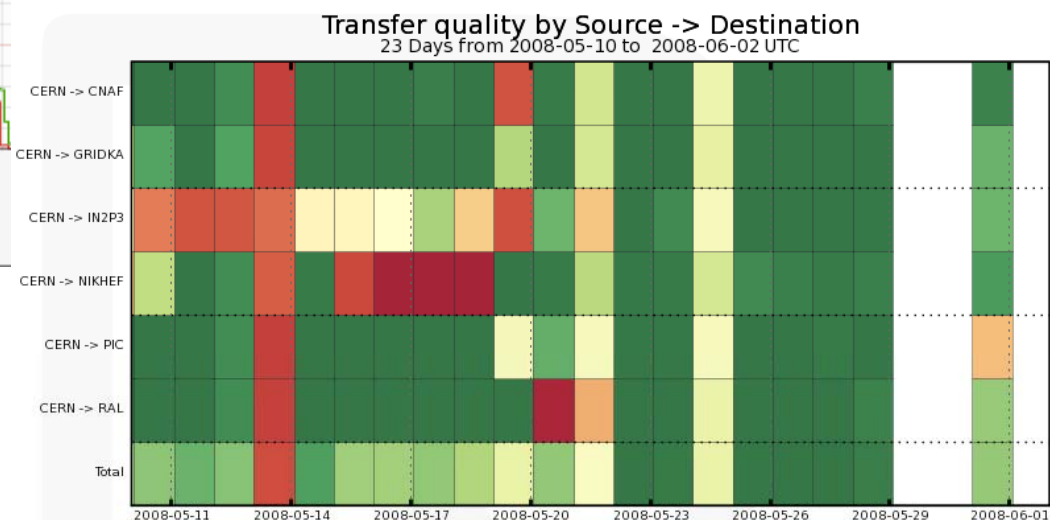
# Core Software and Computing

- Core Software
  - Following latest developments in LCG-AA
  - Waiting for final versions of Physics Applications
- Computing: preparing for real data - CCRC'08
  - Cf presentation at the LCG mini-review yesterday
  - From pit to DST (transfer + reconstruction + stripping)
    - Using simulated raw data (50,000 evts, 1.6 GB files)
  - Transfers:
    - 41,000 files transferred at nominal rate (70 MB/s for 50% of time)
  - Reconstruction:
    - One job submitted per file (no retry)
    - Problems dominated by file access problems at Tier1s
      - Very good response from sites and developers
      - Problems being ironed out
  - Stripping
    - Similar to reconstruction
    - Shown issues with LHCb bookkeeping handling (being reworked)





RRDTool /



Site	Fraction (%)
CERN	14
FZK	11
IN2P3	25
CNAF	9
NIKHEF/SARA	26
PIC	4
RAL	11