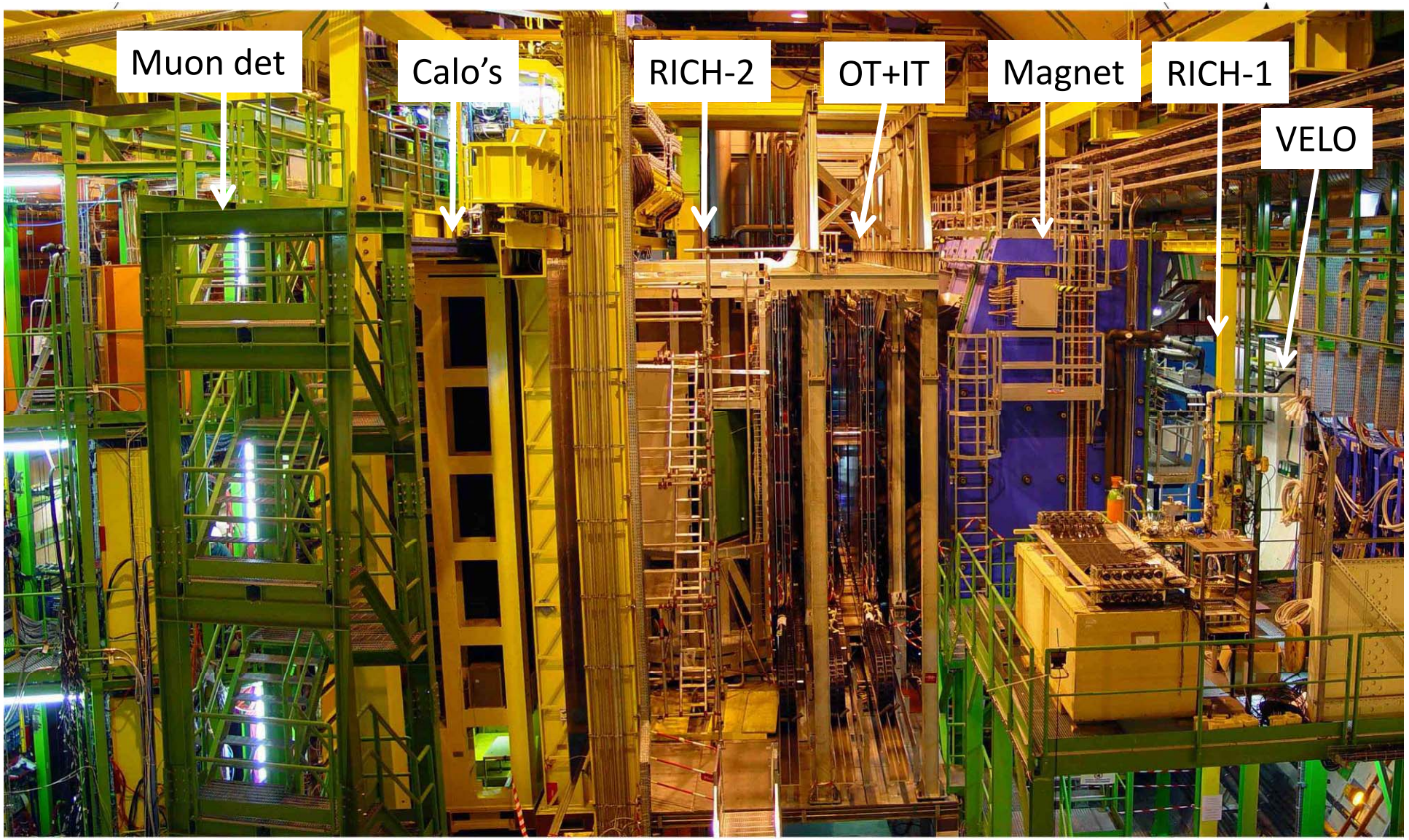
Status of LHCb

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

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

Shielding wall completed

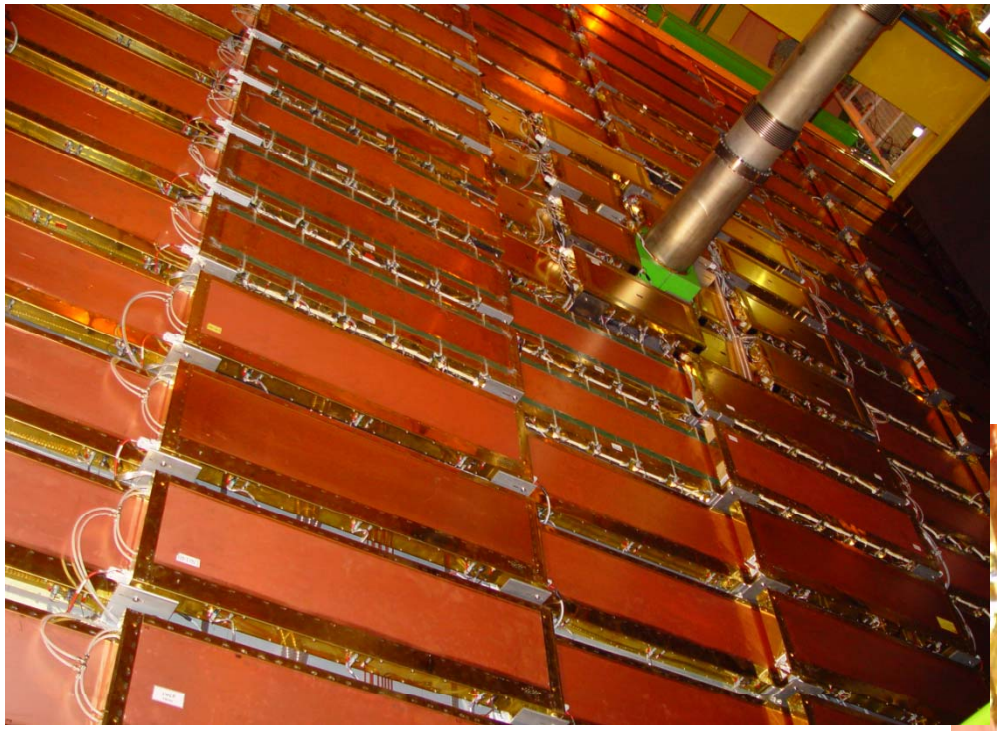
Radiation Shield – 15th layer – Installation of the last concrete block (7.5 t)

DBS "Egyptians" are also famous painters

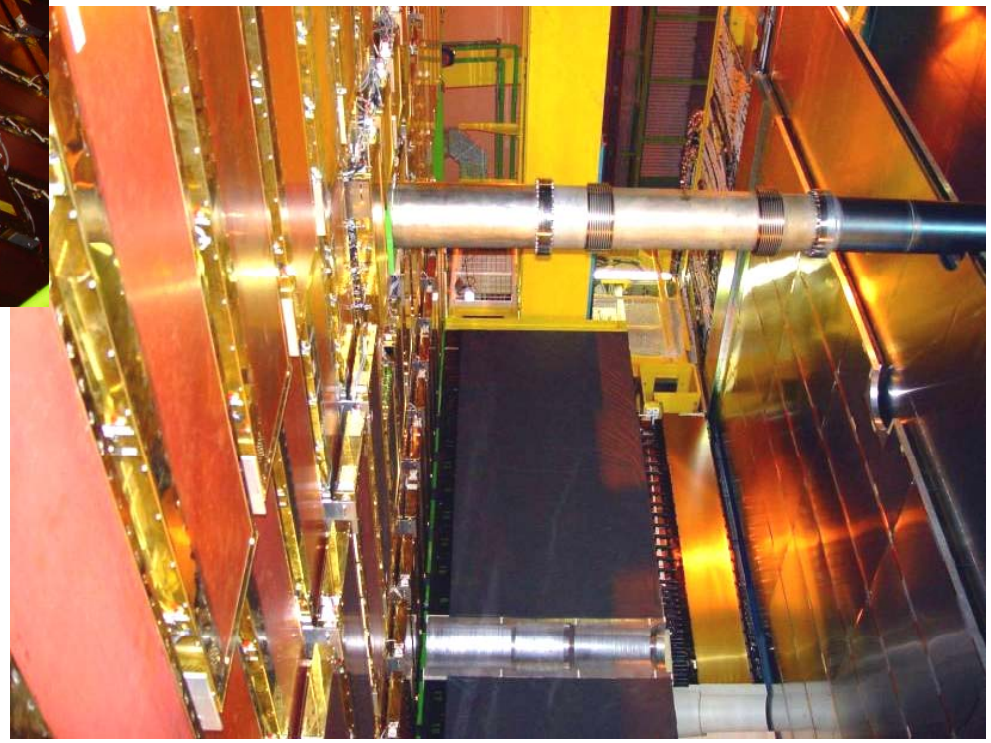
Photo : P.VALLET

07 May 2008 - 15:45

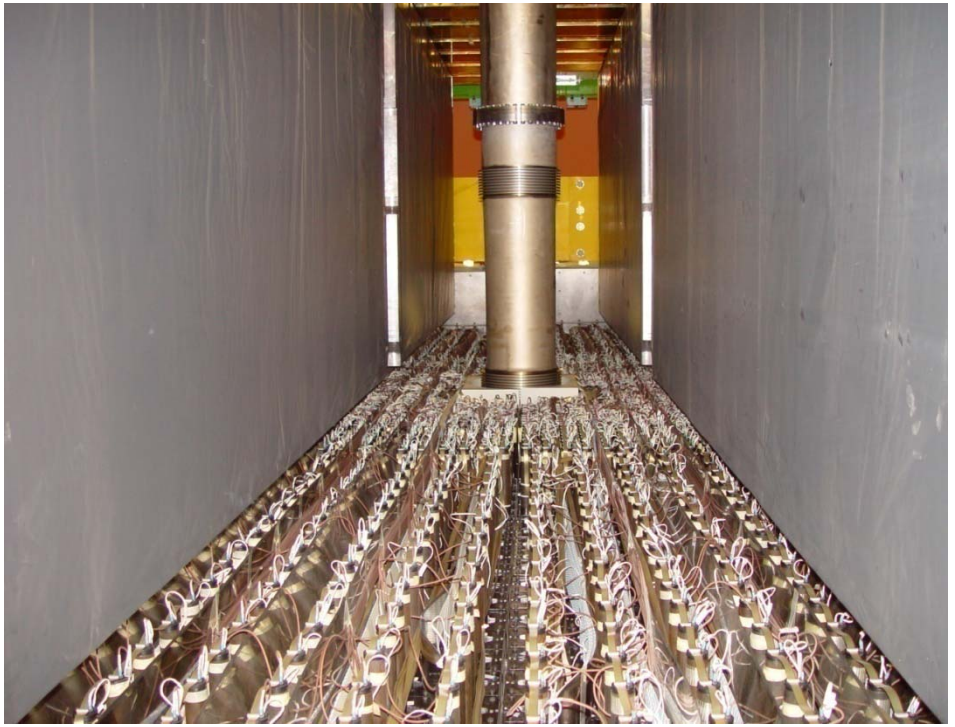
Muon detector closed



Between Muon Station 2 and RICH 2

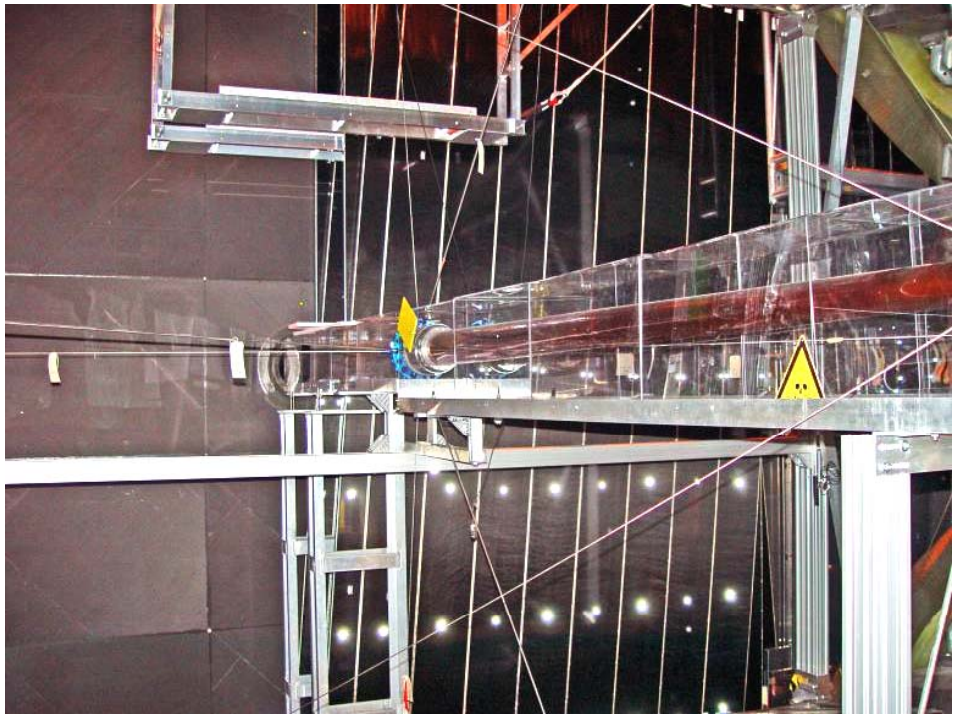


ECAL closed

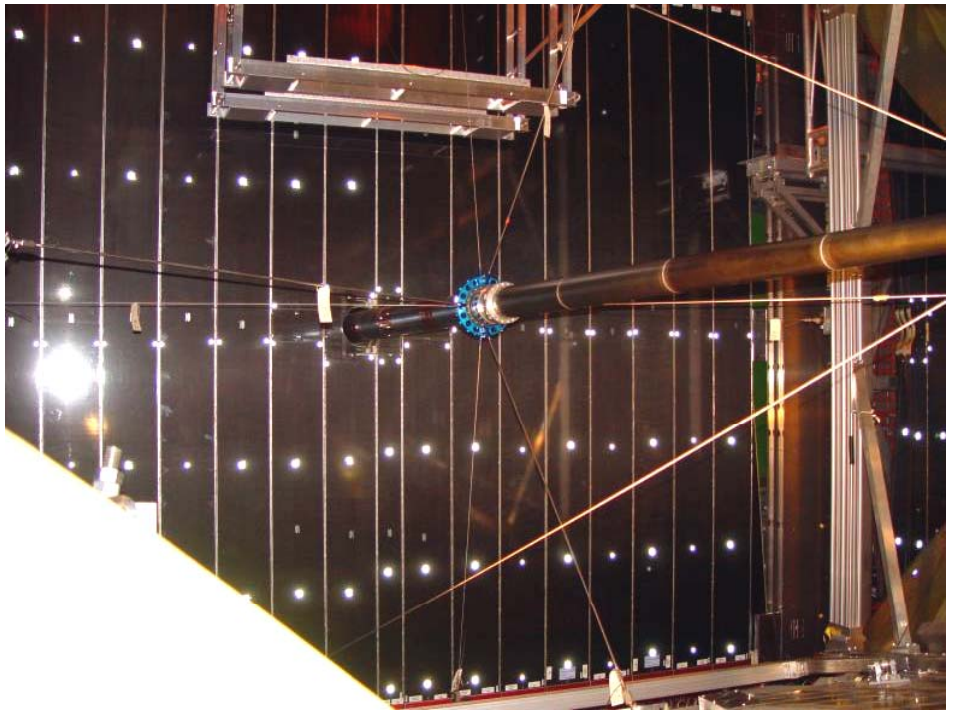


Removal of the Beam Pipe protection (Be section)

Beam Pipe with protection and two OT station closed



Beam Pipe protection removed



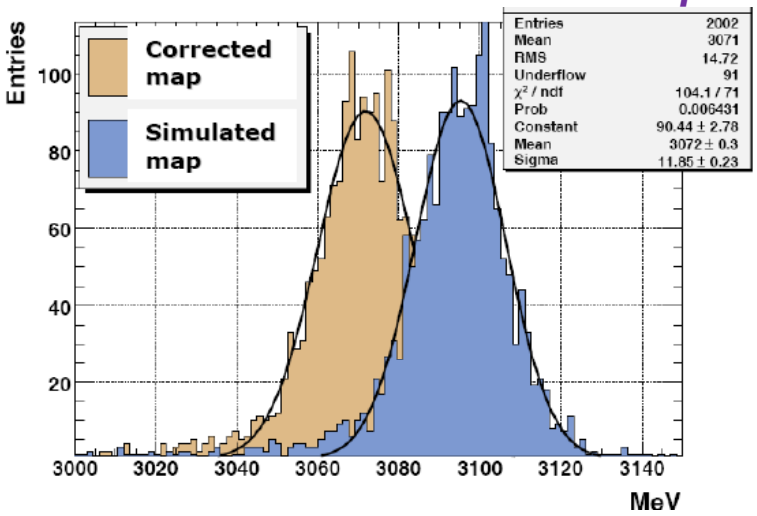
Many thanks to the CERN support team

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

Status of the SubDetectors commissioning

Magnet

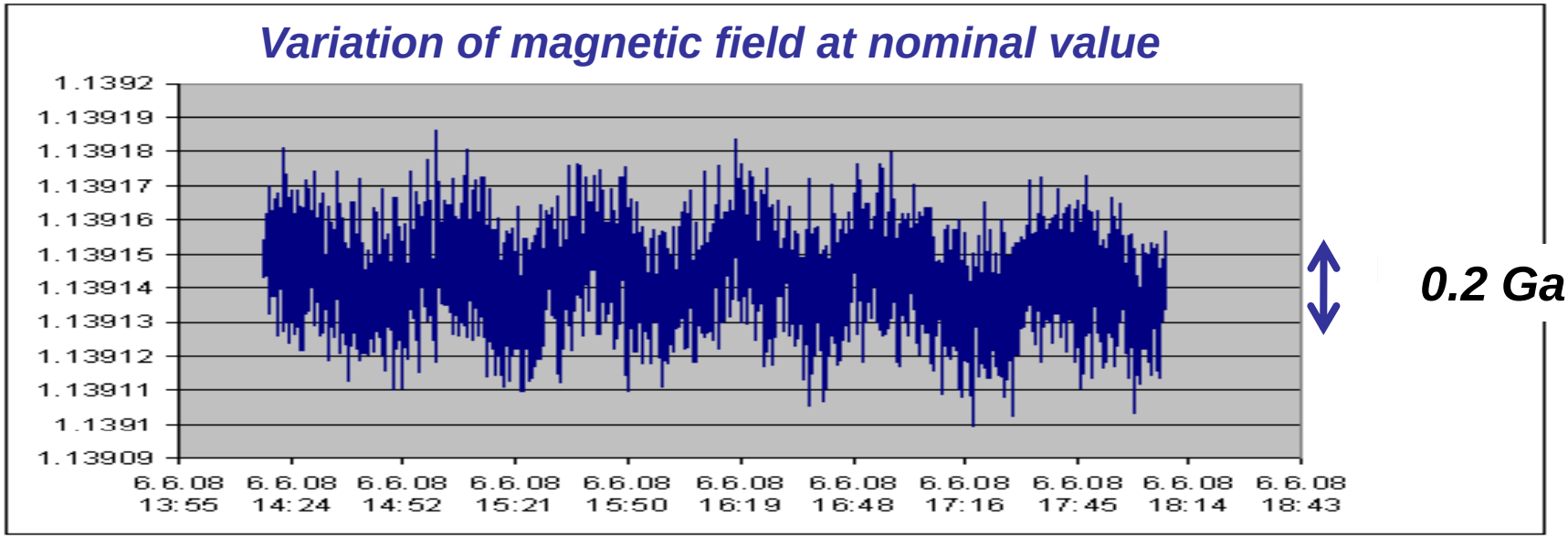
Warm dipole magnet



Effect of magnetic field variation on physics: for "golden" peaks δM scales with δB

~30 Gauss difference between magnetic fields would lead to ~30 MeV shift in reconstructed J/ ψ mass

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



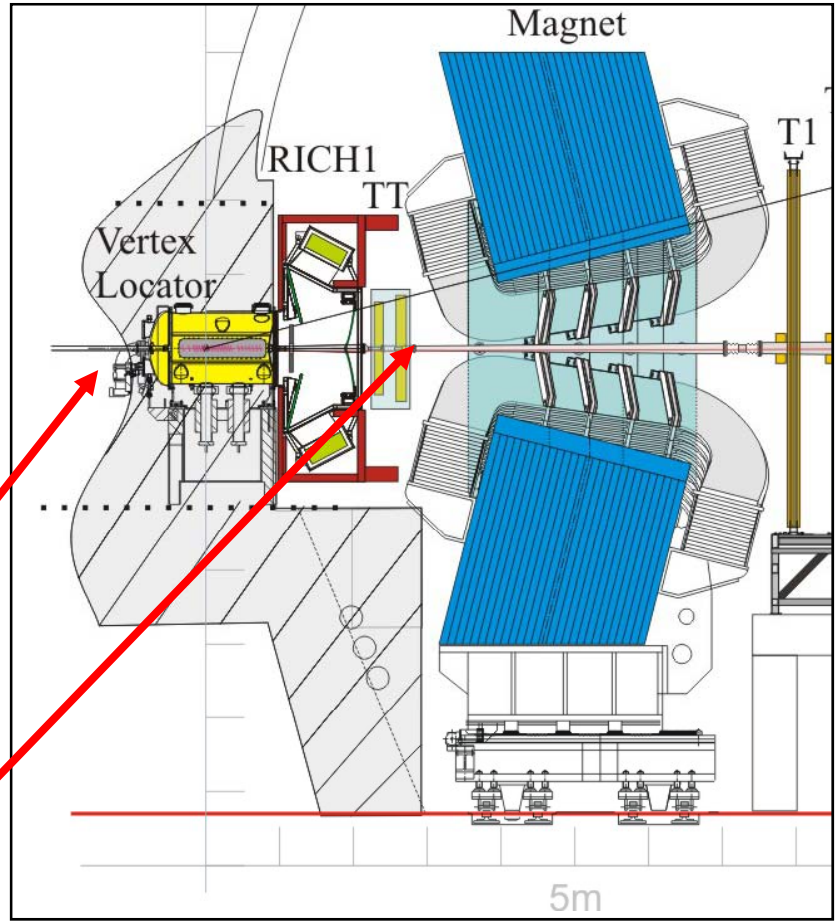
Beam Condition Monitor

Hardware fully installed and tested

- *16 CVD diamond sensors, subdivided in 2 stations (BCM-D and BCM-U 8mm × 8mm active surface)*
- *Successful in-situ test of all 16 diamond sensors with a ^{90}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

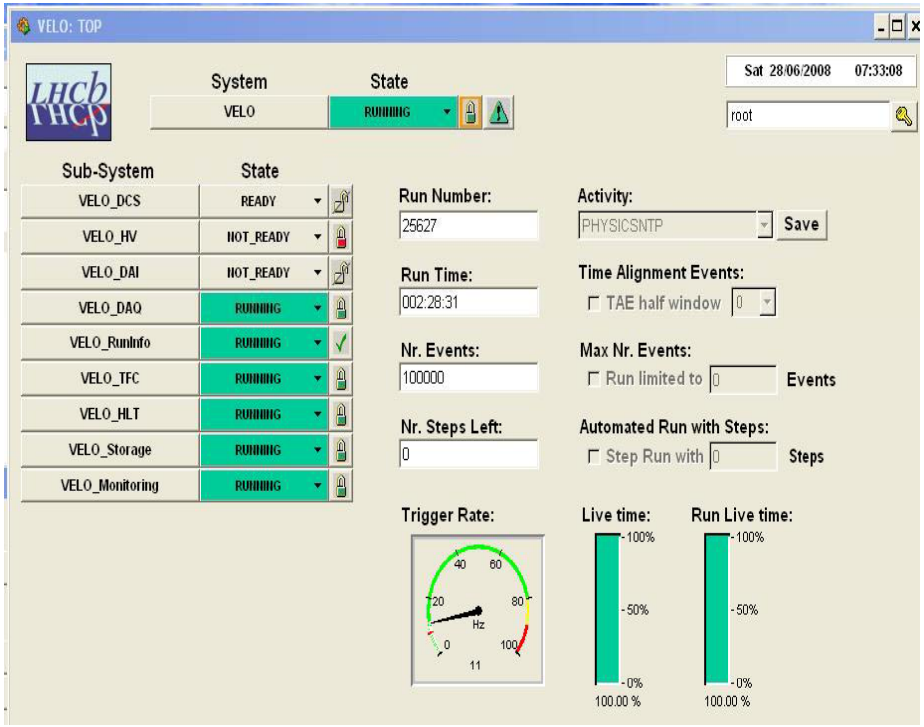


VELO

21 pairs of Si sensors arranged in 2 halves; each pair consists of one sensor with R- and one sensor with φ- 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*
      - *Miminimizing 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*

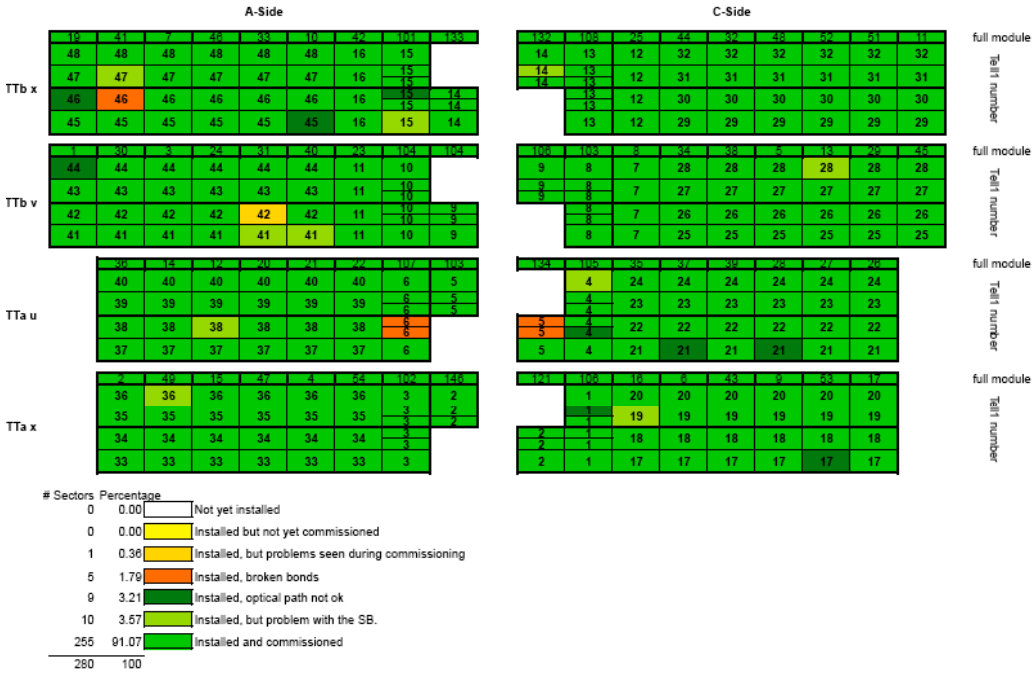
- ***Detector Channels*** *- only 0.3% problematic (0.5% design spec)*
  - ✓ *Due to non-availability of LV power supplies and TELL1 readout boards ~3% of channels still to be commissioned*

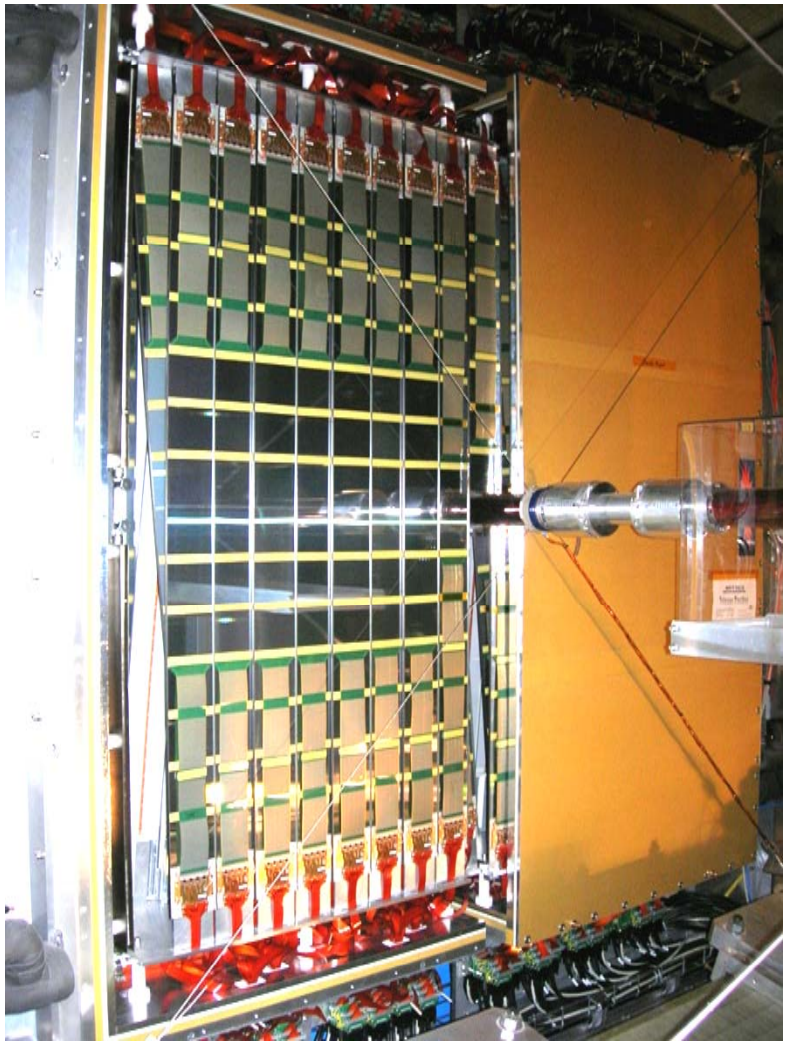
- ***Spare/Replacement VELO***
  - *modules under construction at Liverpool since 1 week*
  - *Production completed in April 2010*
  - *Discussion with NIKHEF/CERN on building remaining mechanics to ease installation*

Silicon Tracker – Trigger Tracker

TT covers area of 1.4×1.2 m2; 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 = 0º C*
- *91% of channels commissioned*
- *Remaining faults under investigation*

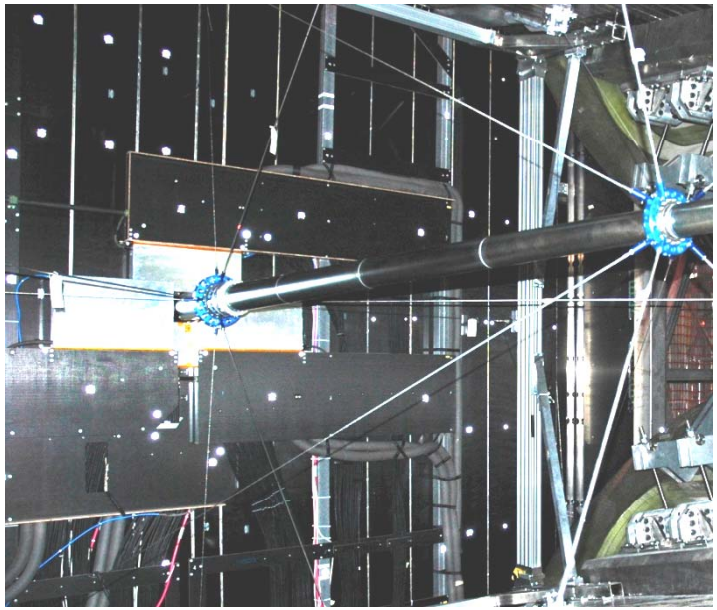


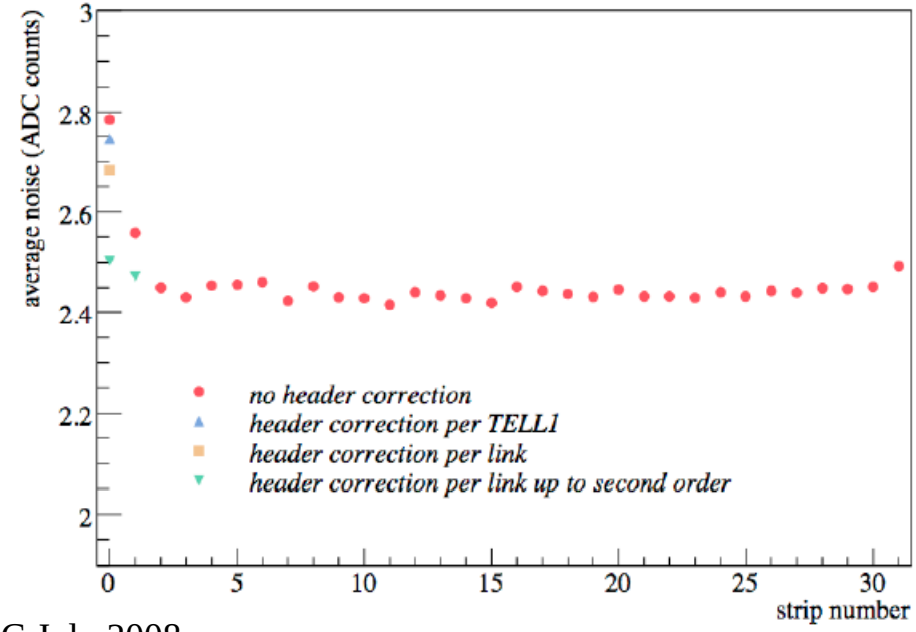


Silicon Tracker – Inner Tracker

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 ~ 0º 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

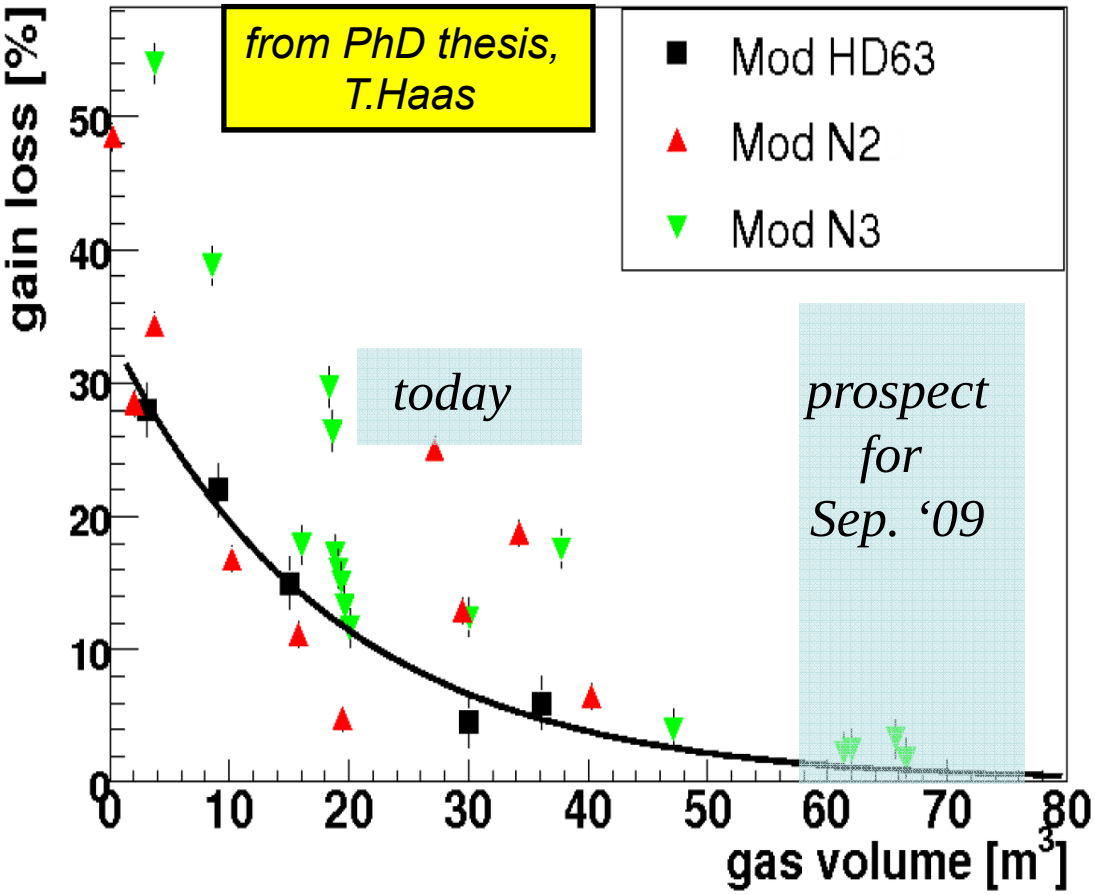
Three stations with each 4 stereo layers of straw tubes 5 mm diameter and 5m length; 55k channels

- *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

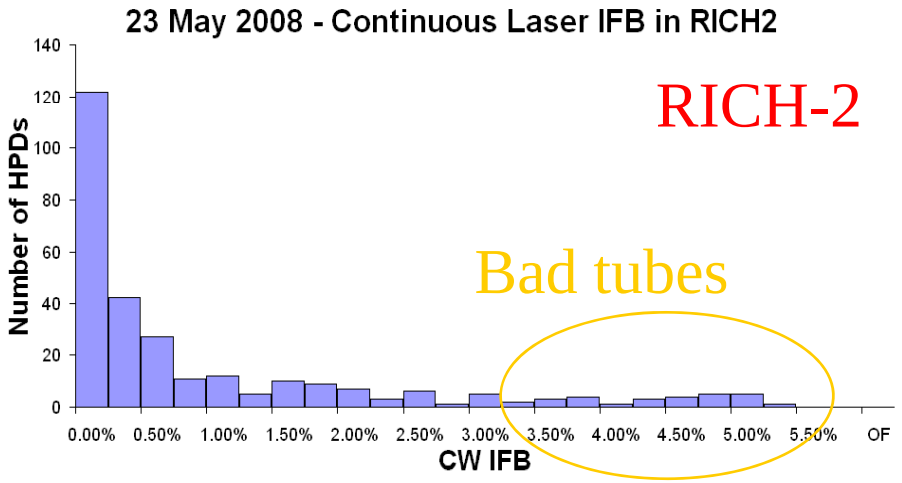
RICH

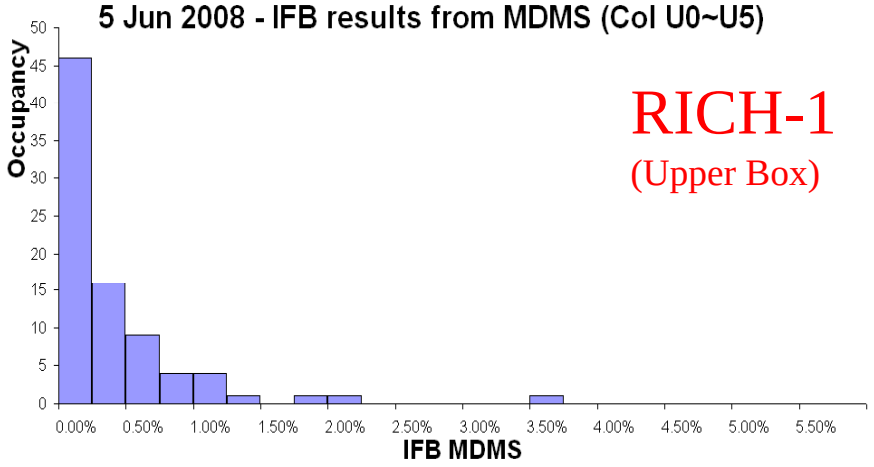
RICH1 and RICH2 with 3 radiators covers momentum range 2-100 GeV; RICH1: 5cm aerogel with n=1.03 & 4m^3 C4F10 with n=1.0014; RICH2: 100m^3 CF4 with n=1.0005; ~500 HPD to readout

- *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 +-2ns 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

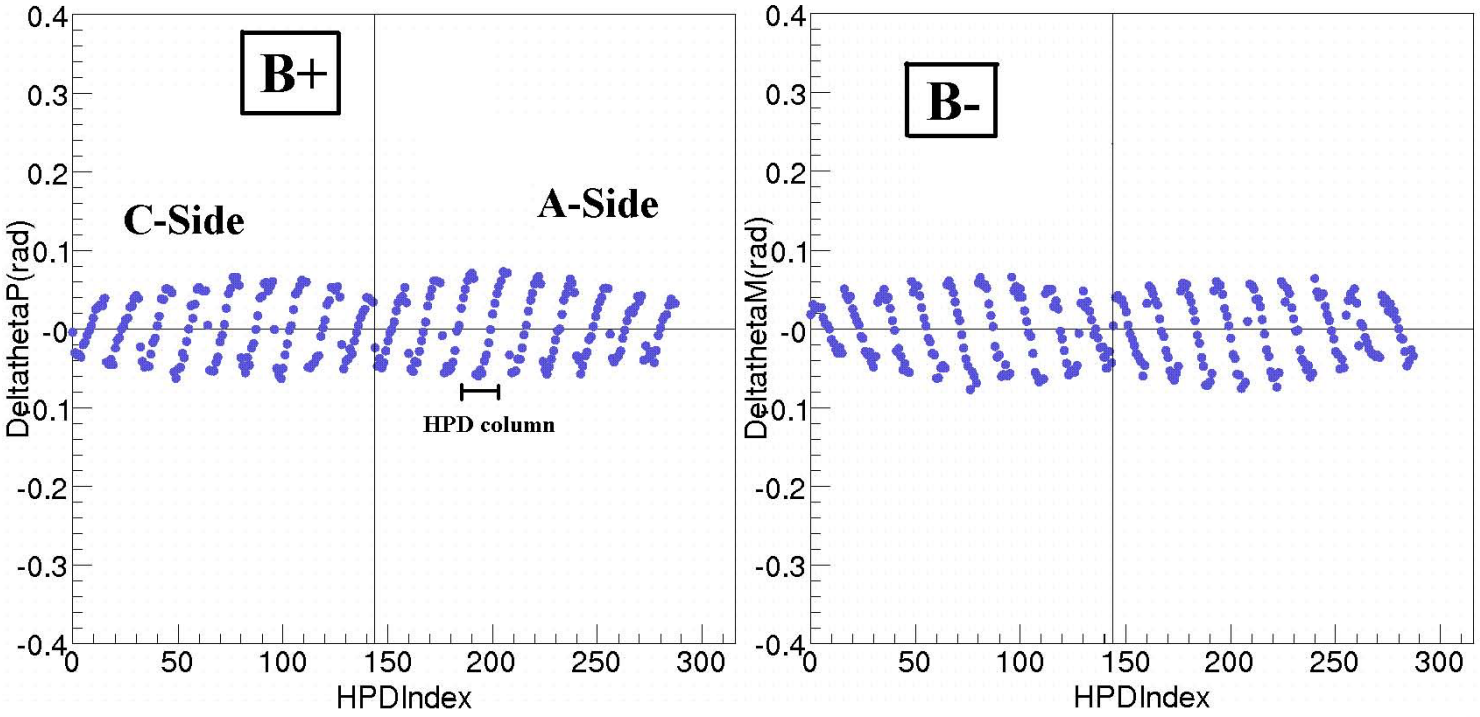
- *Problems seen with vacuum quality for some tubes*
  → cannot take full 20 kV
- *Correlated to high ion-feedback rate (measured by looking for large hit clusters)*
- *At present appears to be a problem of the early HPD batches: RICH-2 (populated first) has had 19 tubes replaced / 288*
  11 more showing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





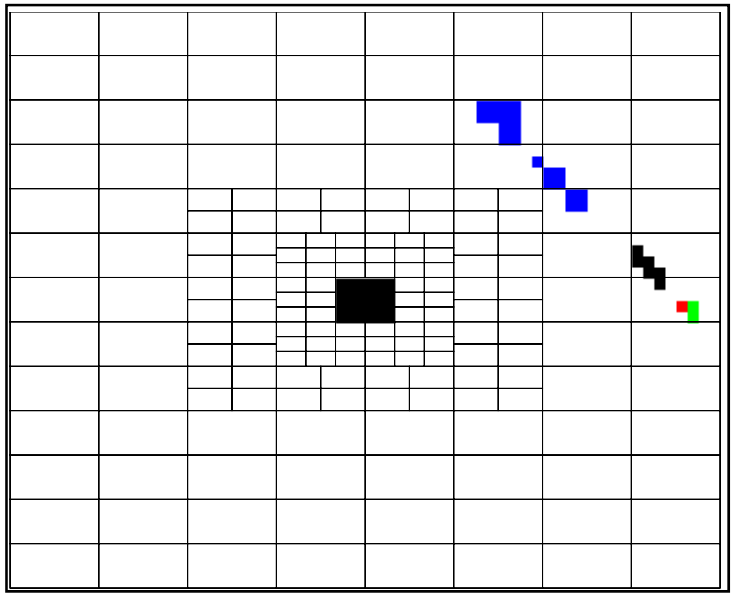
Magnetic field test

- ✓ *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 ≈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*

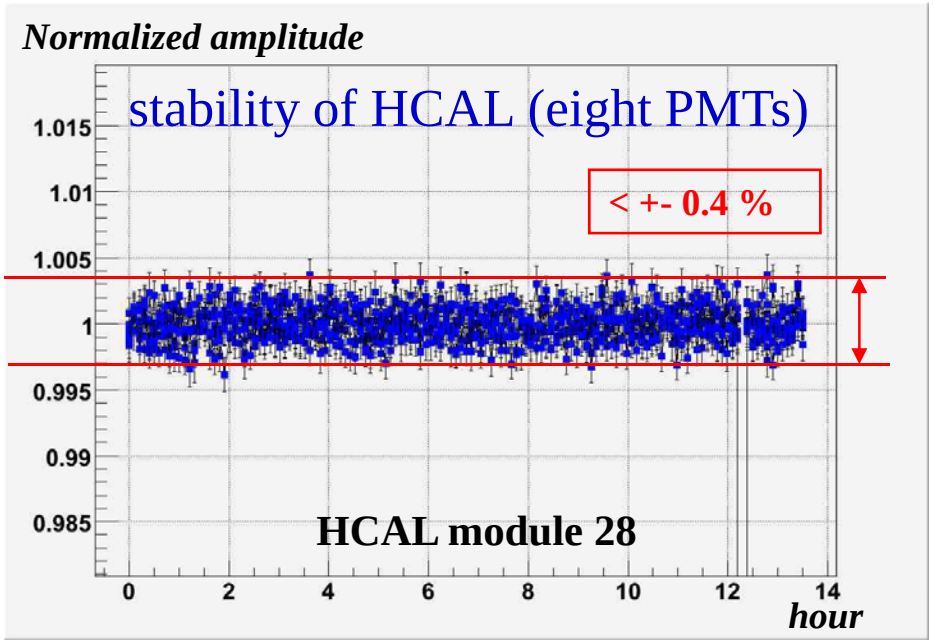
✓ *HCAL calibration with Cesium source will be performed in the next weeks*

✓ *Calorimeters cosmic triggers delivered to LHCb regurlarly*

✓ *HCAL – ECAL – PS – SPD commissioned using cosmics*
Time alignment ~3ns achieved

✓ *L0 calorimeter trigger being commisioned*

✓ *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 ± 1 mm of their nominal position*

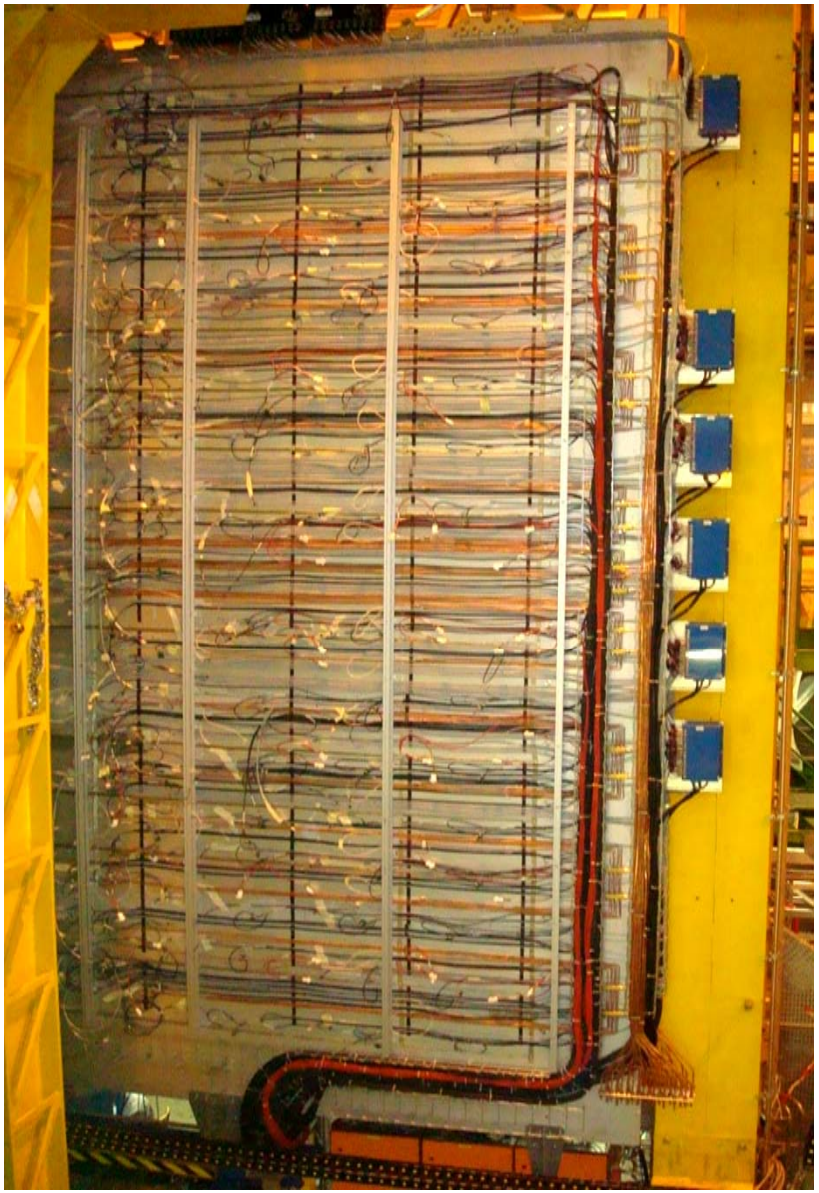
- *Stations M2-M5 successfully closed*

- *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*

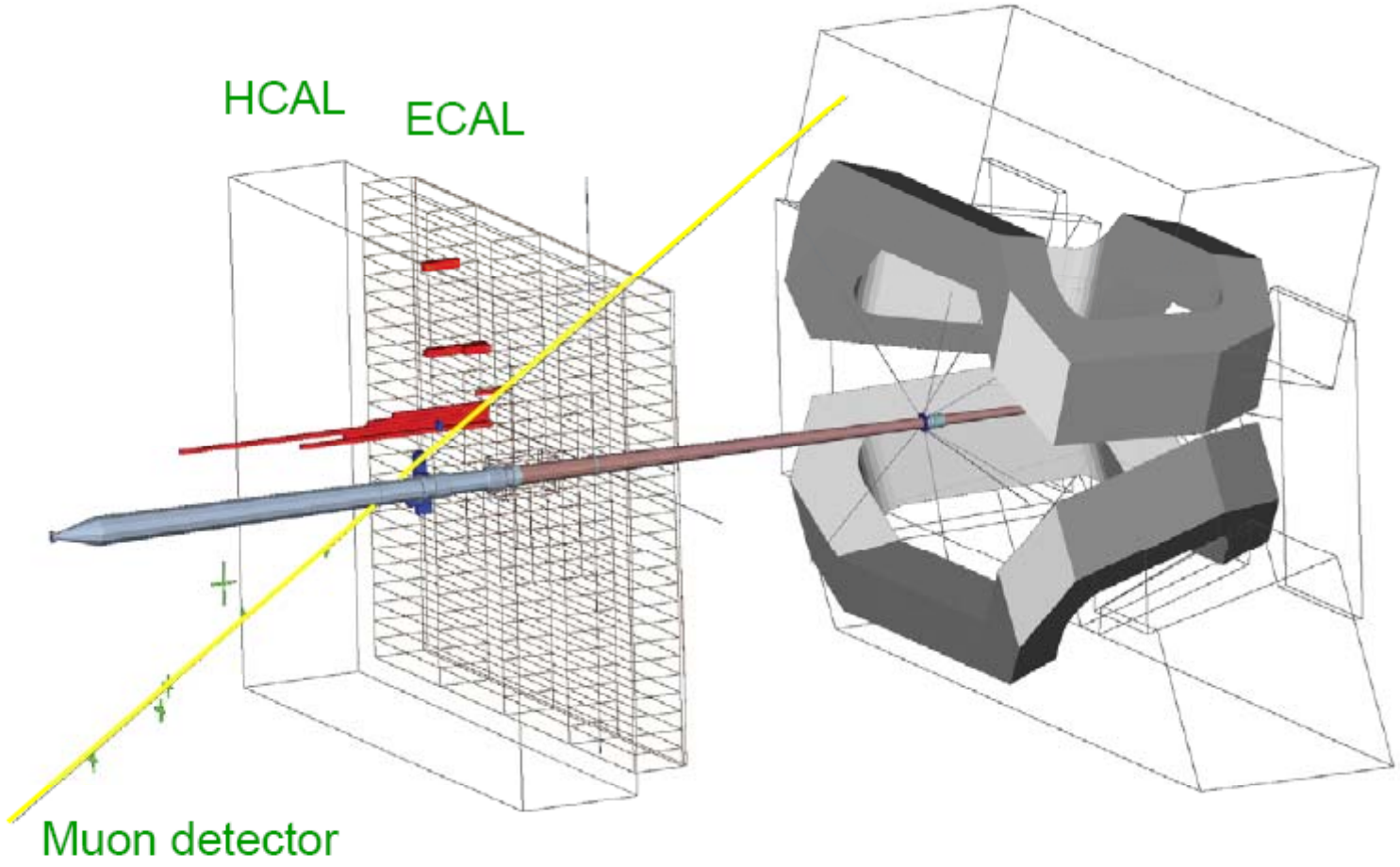
  All detectors are put together for cosmic readout
  CALO, Muon and Outer Tracker time aligned
  ST will be the next → this week is a global commissioning week

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

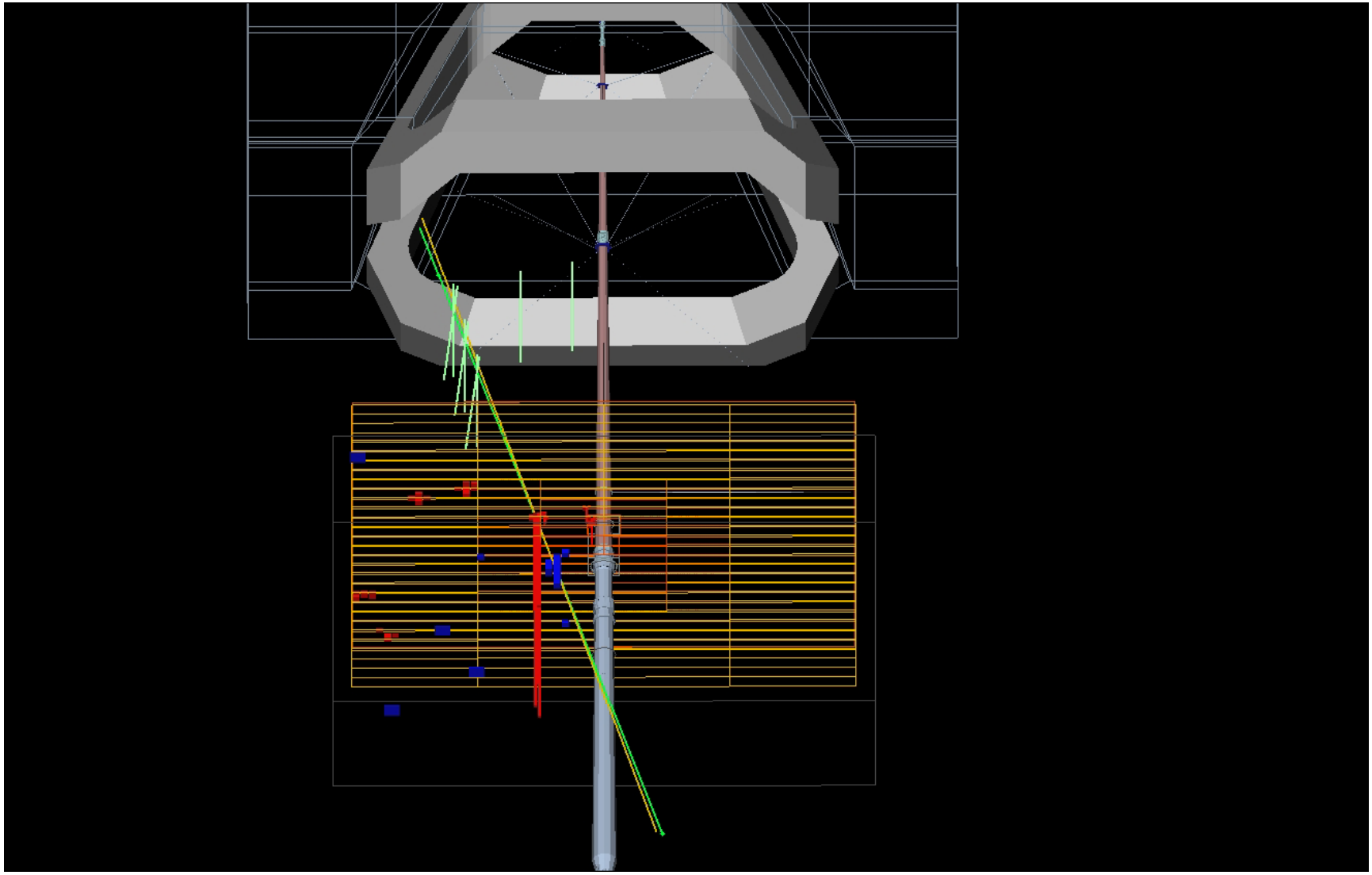
- *Regular operation of LHCb as a whole*

Day time / working days	*second half of July*
24 hours a day, 7 days a week	*end of July*

LHCb cosmic rays: Muon + HCAL + ECAL



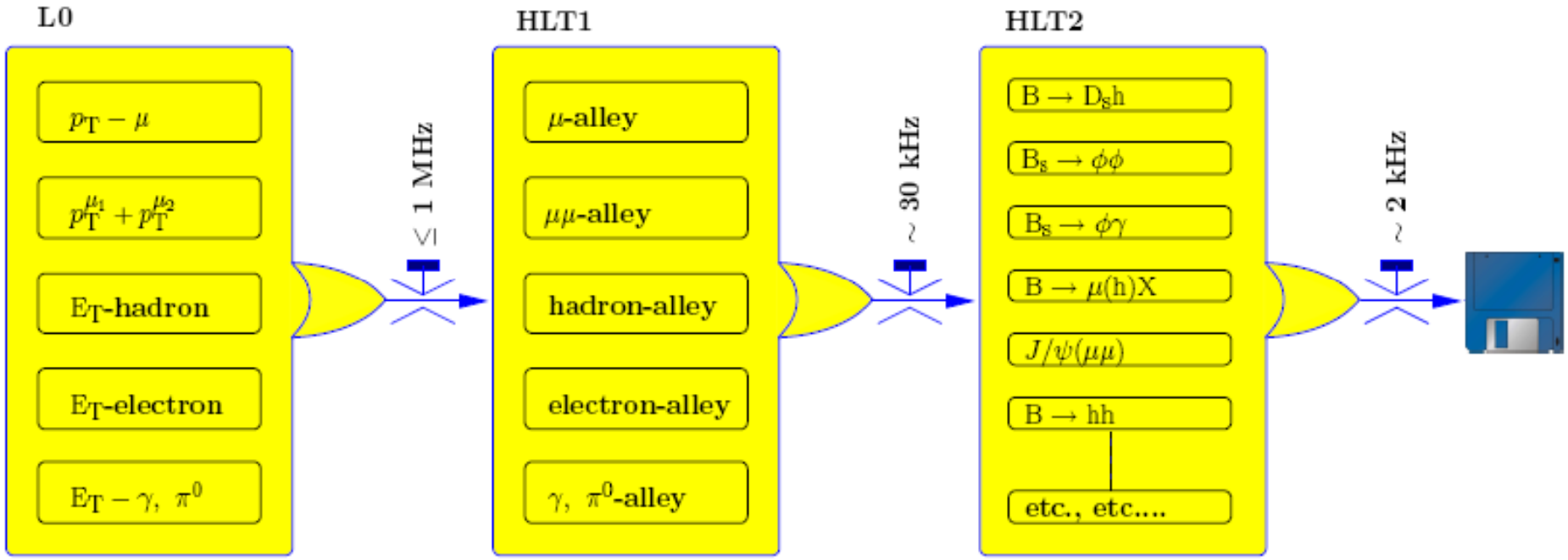
LHCb cosmic rays: Outer Tracker + HCAL + ECAL



Nominal Trigger Flow Reminder

- *L0: Trigger on $E_t^{hadron} > 3.5$, $E_t^{e,\gamma,\pi} > 2.5$ and $p_t^{\mu\,\mu\mu} > 1$ 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 ($2\ fb^{-1}$)
❑ *In CP – violation*	
✓ ϕ_s	0.023
✓ γ *in trees*	4.5°
✓ γ *in loops*	10°
❑ *In Rare Decays*	
✓ $B \rightarrow K^* \mu\mu$	$\sigma(s0) = 0.5\ GeV^2$
✓ $B_s \rightarrow \mu\mu$	3σ *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: $4\times10^{10} \rightarrow 9\times10^{10}$ protons/bunch*
  - ✓ *push number of bunches: 43x43, then 156x156*
- *Target luminosities (for 9×10^{10} protons per bunch, $\beta^* = 6m$):*

Scheme	*coll. pairs*	*non-coll. bunches*	*Lumi at IP8*
2x2	*1*	*1*	*1.7×10^{29} cm^{-2} s^{-1}*
43x43	*19*	*24*	*3.3×10^{30}*
156x156	***68***	***88***	***1.2×10^{31}***
		(per beam)	

- *Expected integrated luminosity in 2008: ~5 pb^{-1}*

- *Conditions per Xing in 2008 are similar to the nominal conditions;*

  Rate is down by > 25 → adequate to installed CPU power (~15%)

First Triggers

L0 E_t^{hadron} (commissioned)

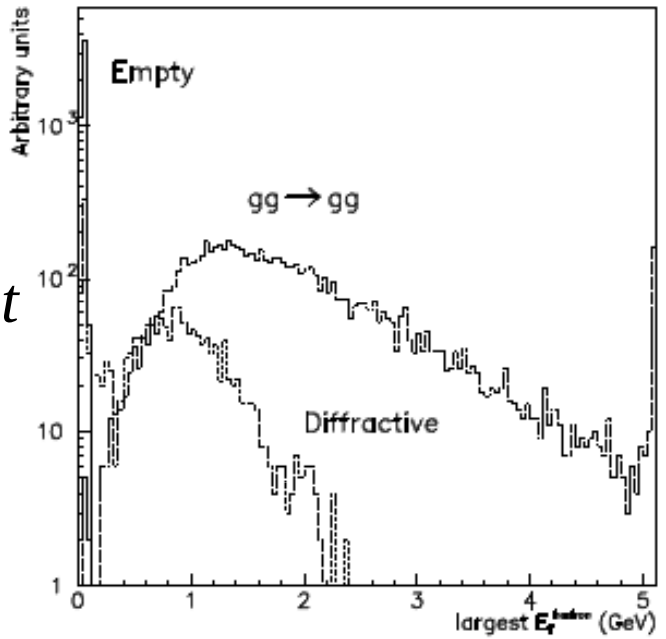
- ✓ *No-beam rate – few Hz, with 0.5 GeV Et cut*
- ✓ *Ideal "minimum bias" trigger*

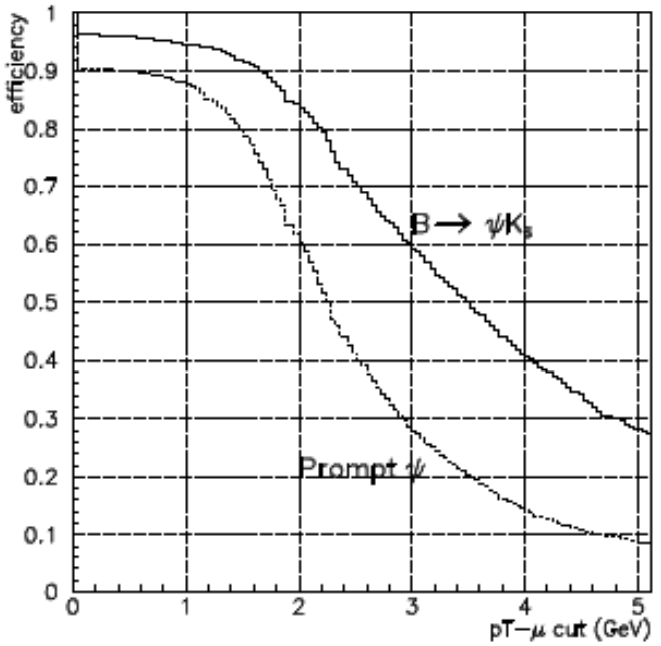
Single μ - trigger (commissioned)

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

1/70k events will contain a (prompt) J/ψ→μμ in LHCb acceptance. Expected rate 6 J/ψ→μμ / s

Add hadron/e/γ triggers as more detectors (VELO, T, ST) are shaken down





Steps towards key measurements

- ***PID is important for all***

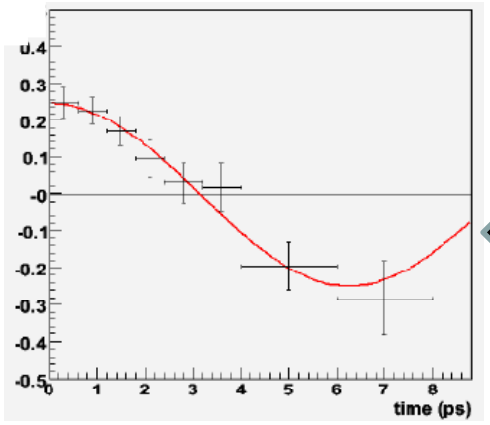
Plenty of K_s and Λ in 10^8 min. bias events. 95% purities achievable with kinematical and vertex cuts alone → clean & unbiased sample for PID studies

J/ψ trigger on single μ with P_T cut → one muon unbiased for PID studies

- ***For β_s***

For 5pb^{-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 γ***

Significant samples should be available once μ P_T & / or hadron trigger is operational

Channel	Yield / 5 pb^{-1}
B→D(Kπ)X	31k
B^+→D(Kπ)π^+	1700

- Optimize thresholds to boost charm from prompt production

- Study vertex / mass resolutions and lifetimes for D(B)→ hh modes

- Study background environment with accumulated sample of B→D(Kπ)π (control sample for the ADS method)

❑ ***For B_s→ $\mu\mu$ (We try to make fast measurement)***

- Methods for calibrating mass, PID and selection demonstrated

~150 B→Kγ*

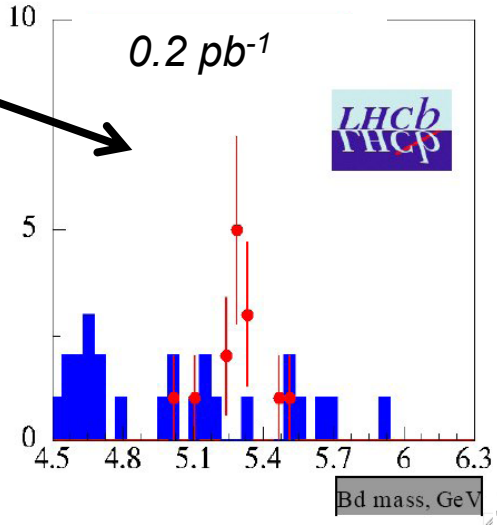
❑ ***For B – K*$\mu\mu$***

- Muon efficiency at low momentum understood

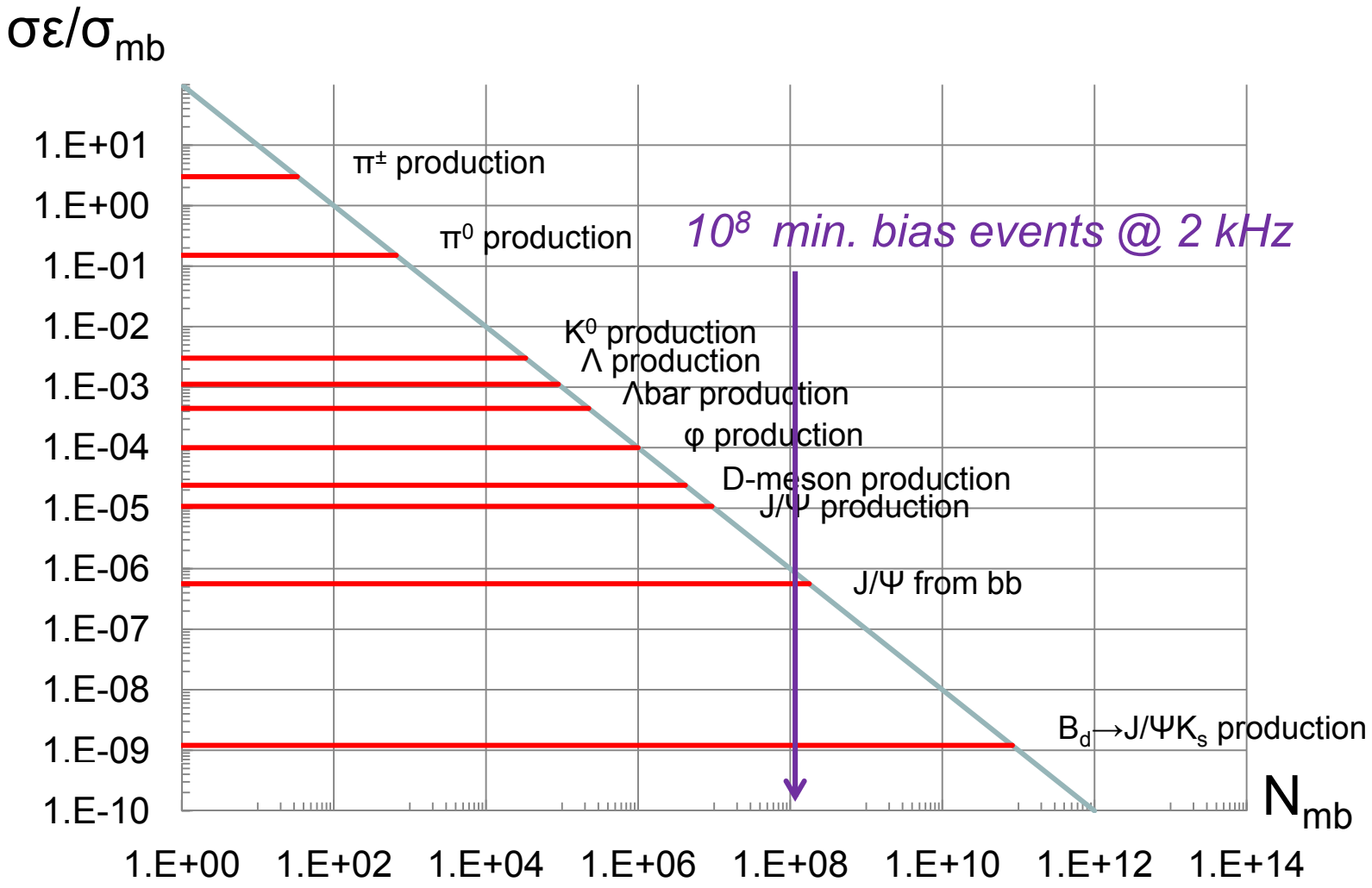
- Experience with angular fits from ψ(2S) decays of similar topology

❑ ***For Radiative penguin decays***

- Calorimeter is calibrated and first b → sγ decays seen



Possible 2008 topics for the 1st paper

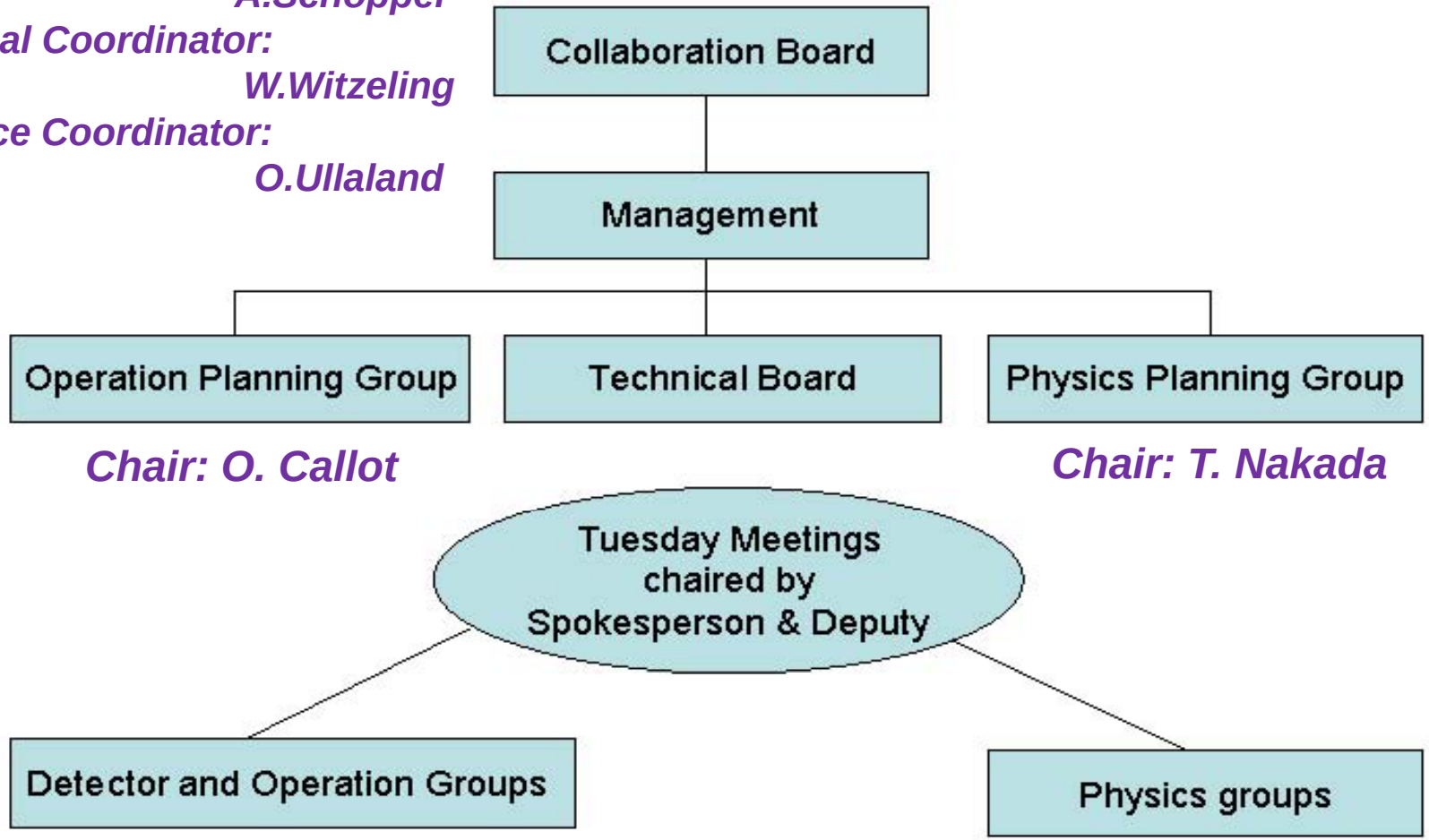


Collaboration Matters

Management:

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

CB Chair: ***E. Aslanides***



Chair: O. Callot

Chair: T. Nakada

Physics groups

CP-violation

Convener: Guy Wilkinson
Deputy: Marta Calvi
(with particular responsibility for tagging and proper time)

Coordinators of the key measurements:

ϕ_s *O. Leroy*

γ ***in loops*** *V. Vagnoni*

γ ***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 1st measurements)
Convener:
Olivier Schneider

Coordinators:

Soft QCD *M. Schmelling*
1st phys with min. bias

Quarkonium and B *P.Robbe*
1st phys. with J/ψ

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

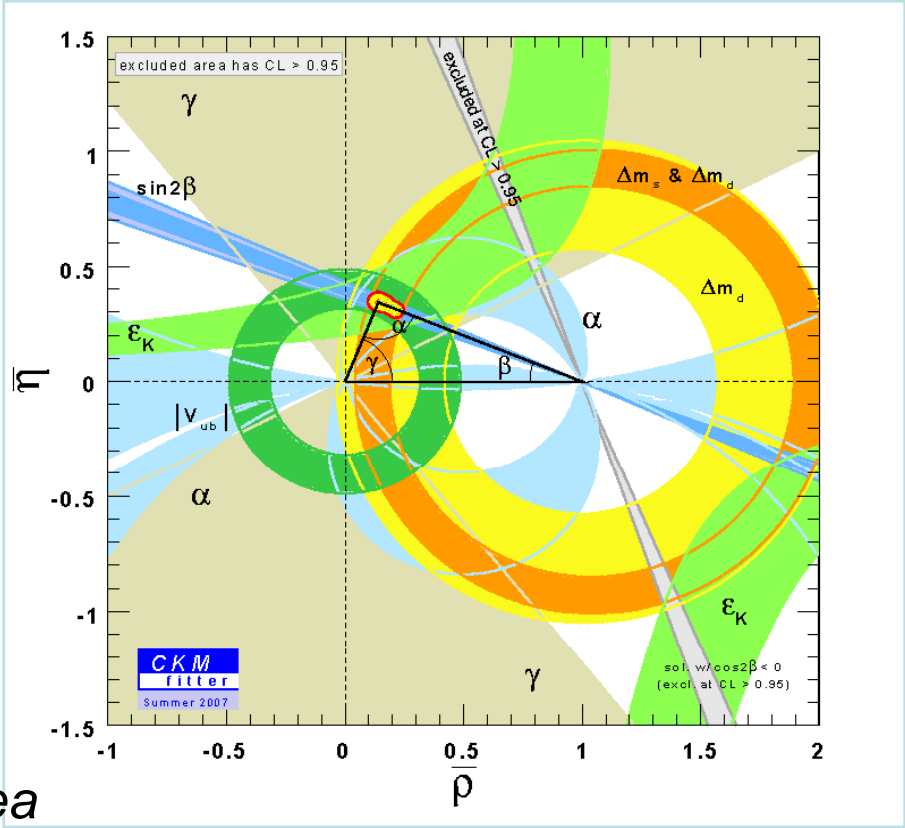
In CP-violation sensitivity of UT approach is limited by theory:

- *Extraction of |Vub|*
- *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* γ

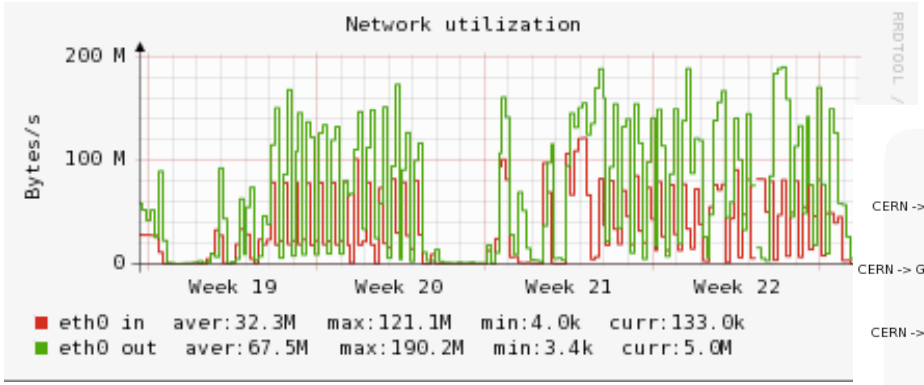
In Rare Decays sensitivity is limited by experimental statistics

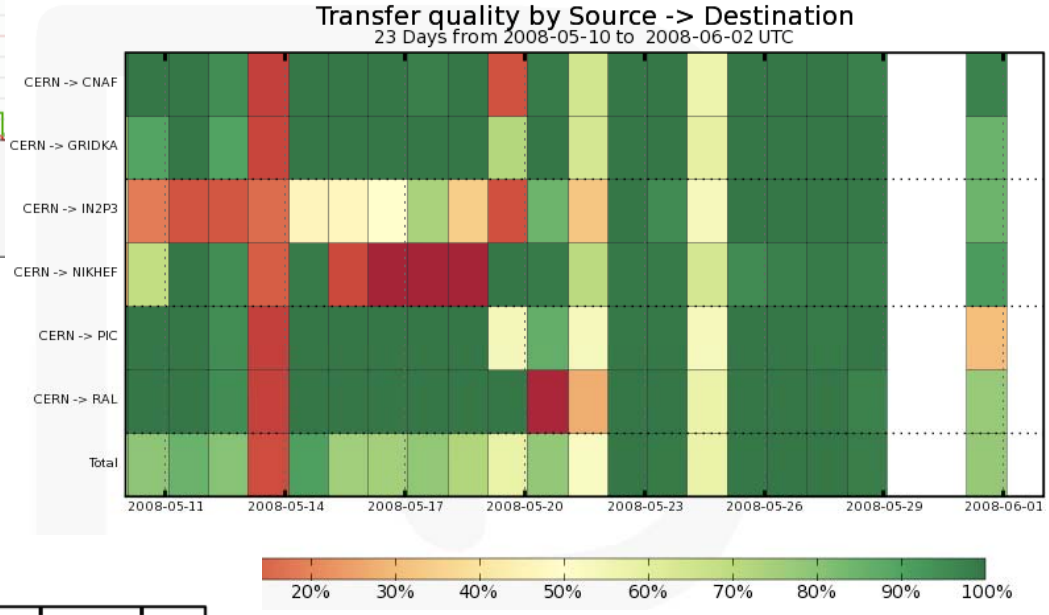
CDF/ D0 are reaching an interesting area

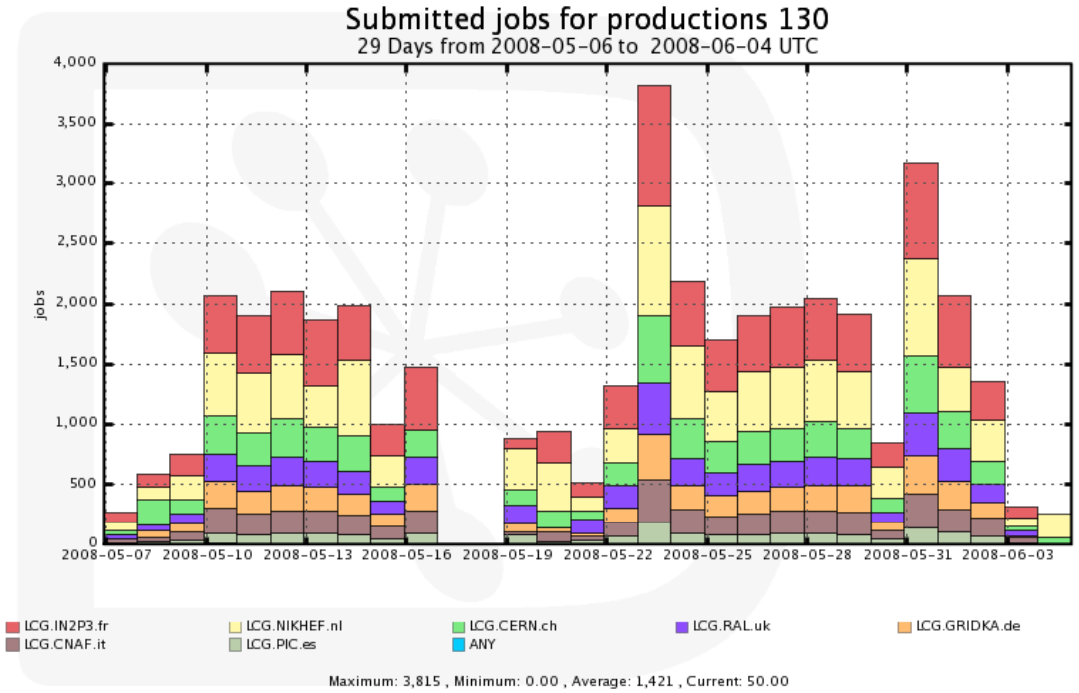


Core Software and Computing

- 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)







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