Lake Louise Winter Institute
18th-23rd February 2008
Alberta, Canada

Status of the LHCb detector

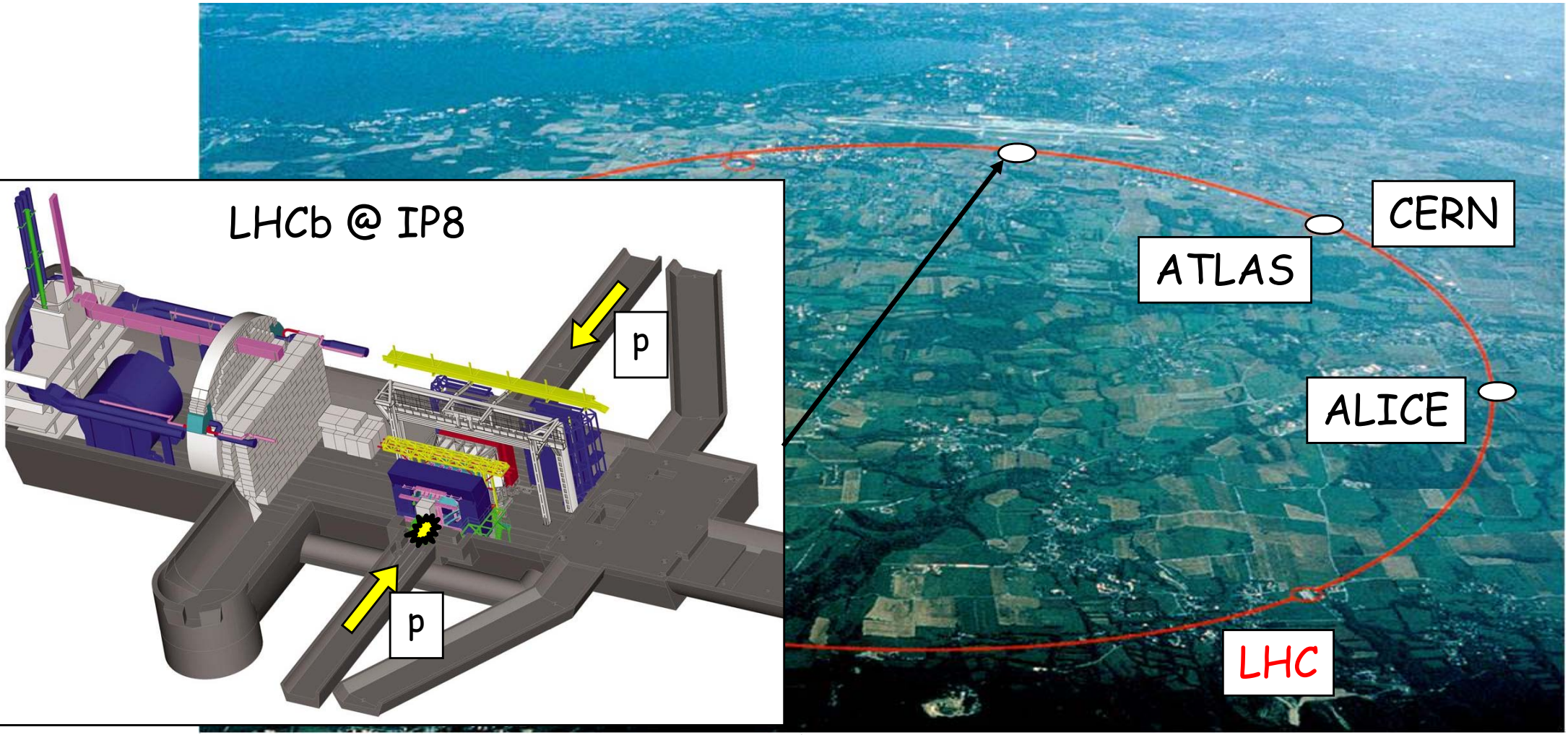
Pablo Vázquez

USC
UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

On behalf of the LHCb collaboration

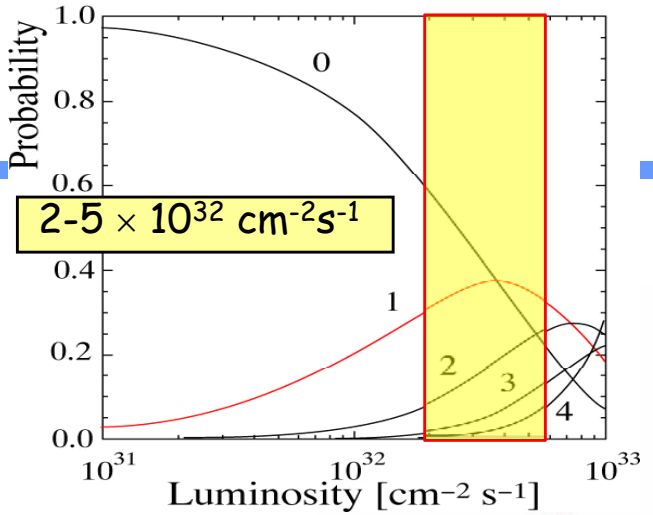
Introduction

- LHCb is the dedicated B physics experiment at the LHC devoted to the precision study of CP violation and rare decays
- Collaboration of more than 600 people from 48 institutes and 14 countries



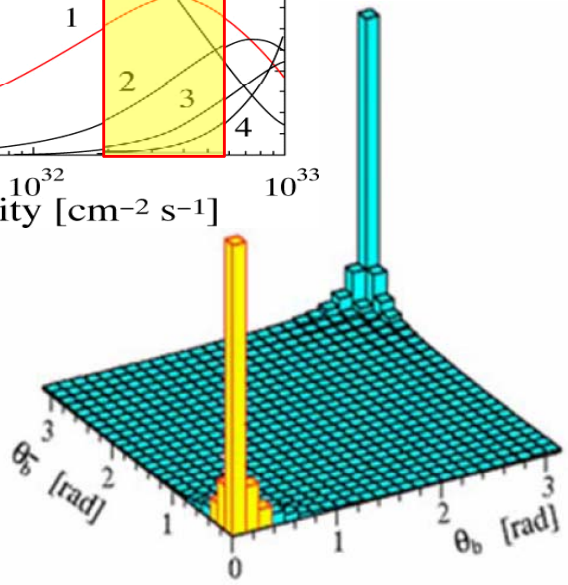
The LHCb experiment

- High $\sigma_{b\bar{b}}$ at pp collisions at $\sqrt{s}$ = 14TeV
- Multiple interactions suppressed
  - To improve primary-secondary vertex separation
- Access to B_s [$b\bar{s}$] meson with huge statistics
  - Even though $LHCb_{lumi} = LHC_{lumi} / 50$
- Flavor tagging capability
  - Correlated $b/\bar{b}$ production
  - High p_T accompanying $\mu^{\pm}$, $K^{\pm}$
- Precision vertexing
  - VELO detector
- Very good tracking performance
  - Dipole field + tracking detectors
- Excellent K/π separation
  - High resolution RICH detectors



$2\text{-}5 \times 10^{32}$ cm^{-2}s^{-1}

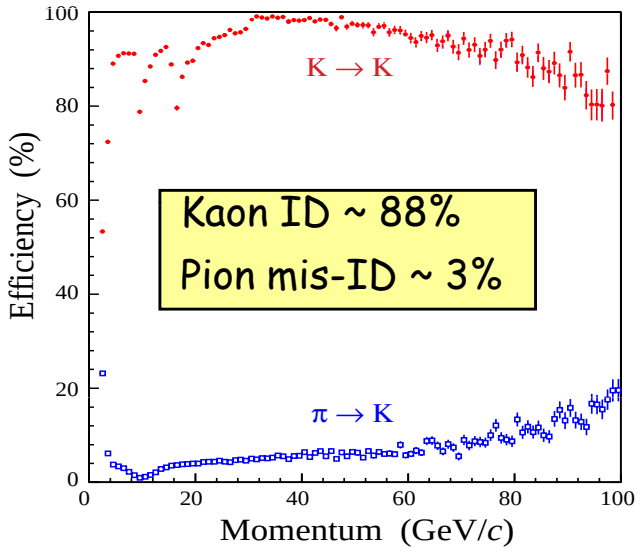
10^{12} B hadrons/year



σ_{IP} ~ 30μm

B ~ 4Tm

δp/p ~ 0.4%



Kaon ID ~ 88%

Pion mis-ID ~ 3%

Physics

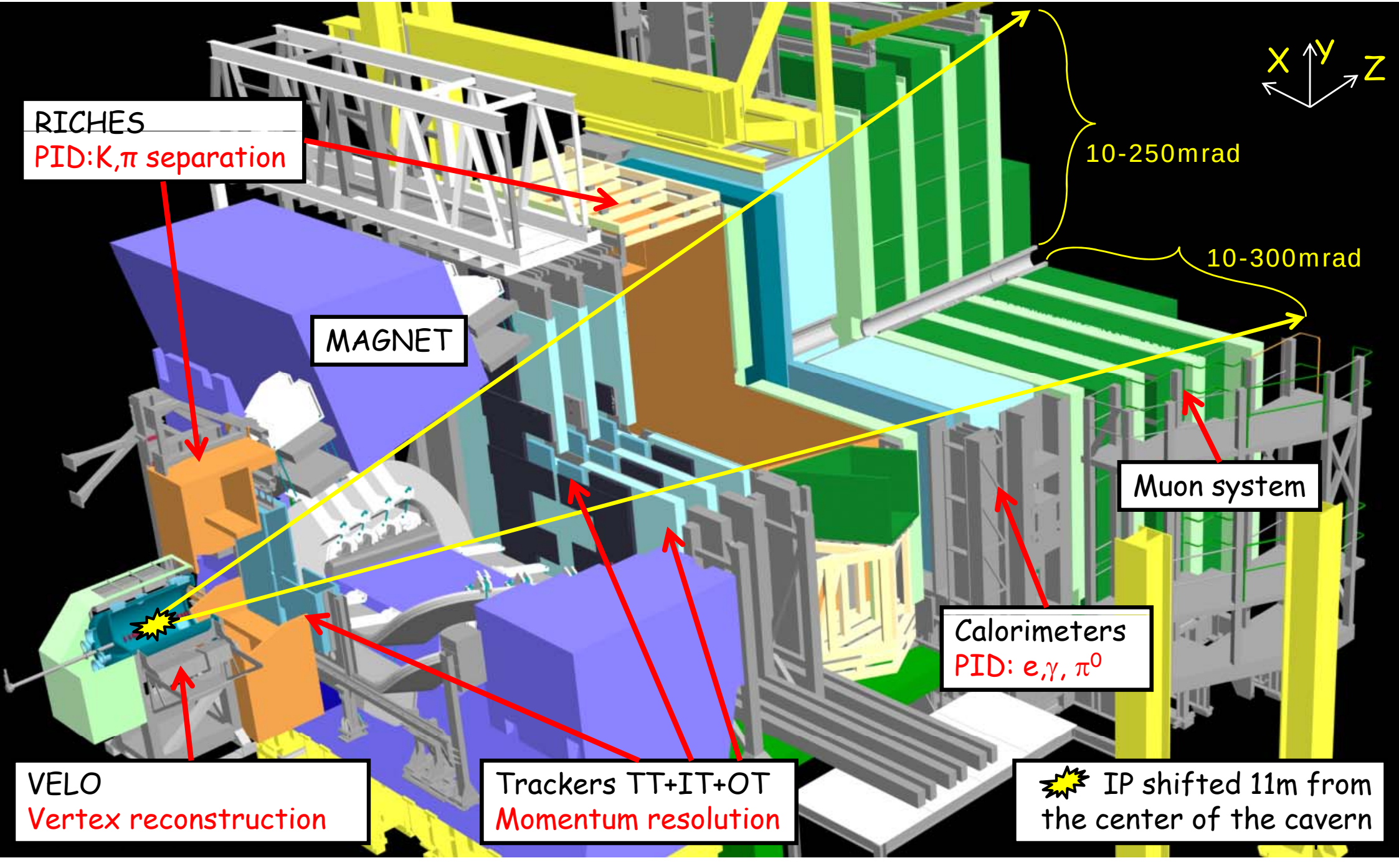
- Precision study of CP violation in the b-quark sector
  - Measurement of neutral meson oscillations:
    - ⇨ Frequency (ΔM) and CP-violating phase (ϕ_s)
      - Example: $B_s \rightarrow J/\psi\, \Phi$
  - Measurement of quark mixing phases (β, γ, β_s) with improved precision arising from fermion mass mechanisms and test CKM matrix
    - Examples: $B_s \rightarrow D_s^+ K^-$; $B^0, B_s \rightarrow K^+K^-, K^+\pi^-, \pi^+\pi^-$; $B_s \rightarrow \Phi\Phi$

See Vladimir Gligorov talk

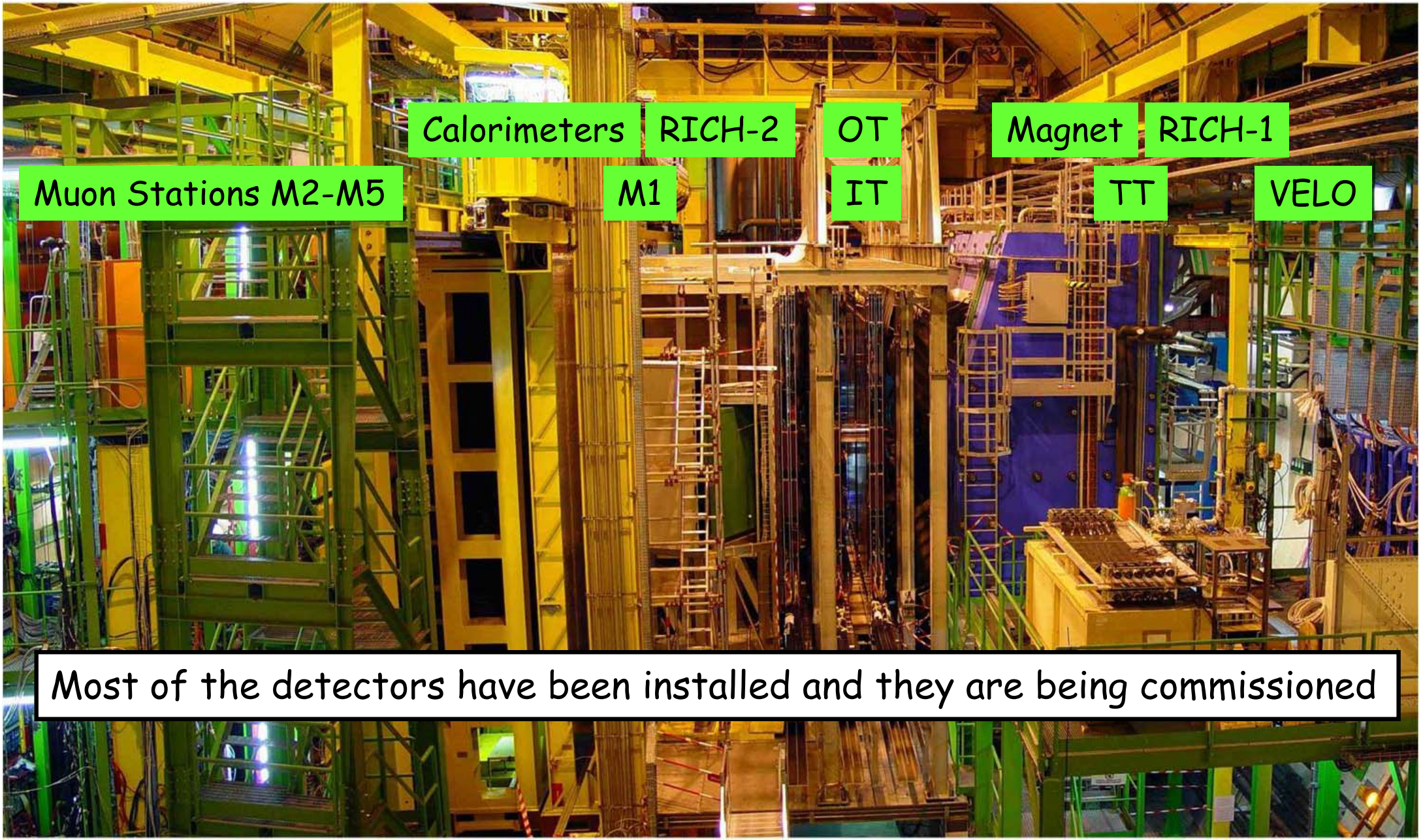
- Study of rare B mesons decays
  - Testing Flavour-Changing Neutral Currents ($b \rightarrow s$)
    - ⇨ Suppressed in the Standard Model, New Physics?
  - Experimental observables: ratios, asymmetries, branching ratios to leptons
    - ⇨ $b \rightarrow s\mu\mu$
      - Example: $B_s \rightarrow \mu^+\mu^-$
    - ⇨ $b \rightarrow s\gamma$ Radiative decays
      - Example: $B_s \rightarrow \Phi\gamma$
    - ⇨ $b \rightarrow sll$
      - Example: $B \rightarrow K^*\mu\mu$

See Jose Angel Hernando talk

The LHCb detector



The detector in the cavern



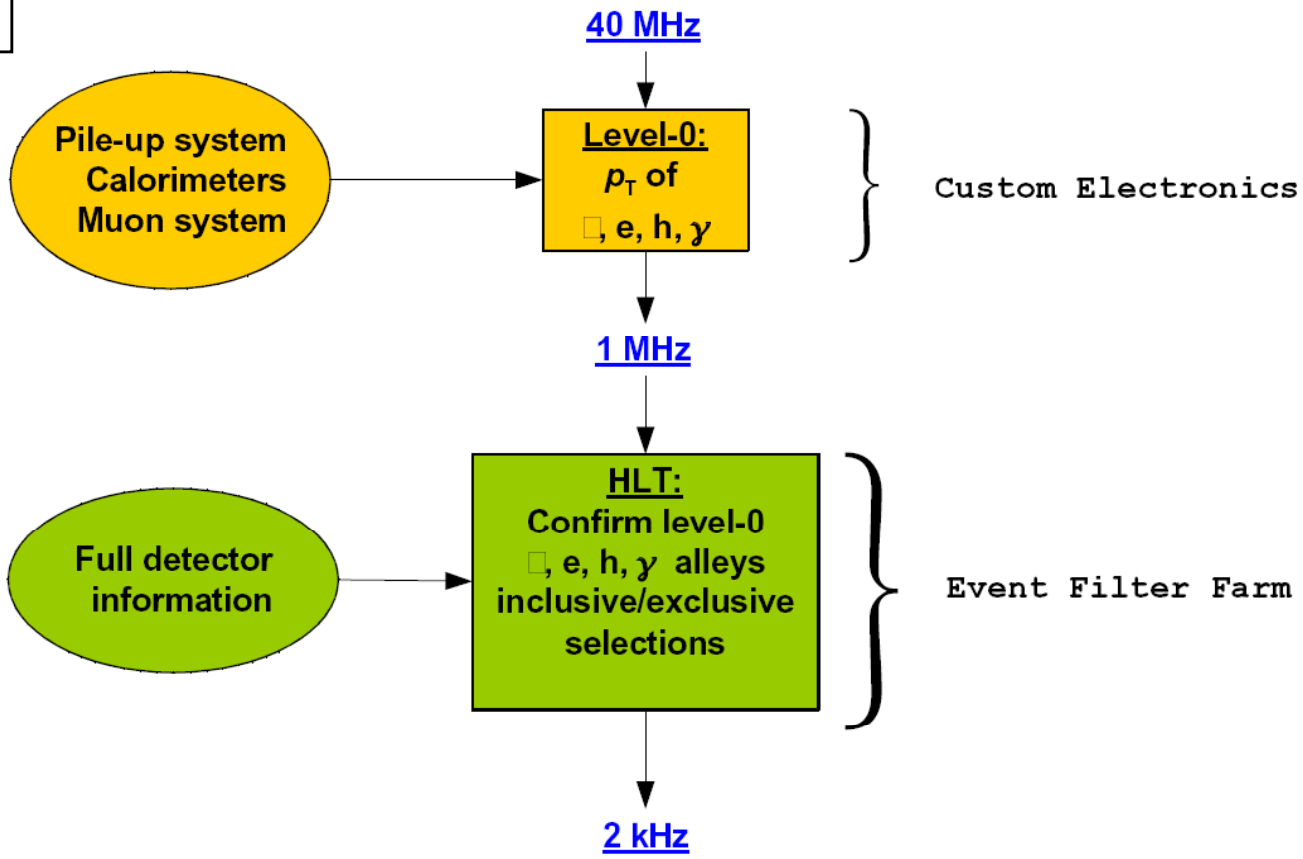
Most of the detectors have been installed and they are being commissioned

Trigger

- Sampling @ 40MHz → L0-Trigger (hardware) @ 1MHz → HLT (software) @ 2KHz

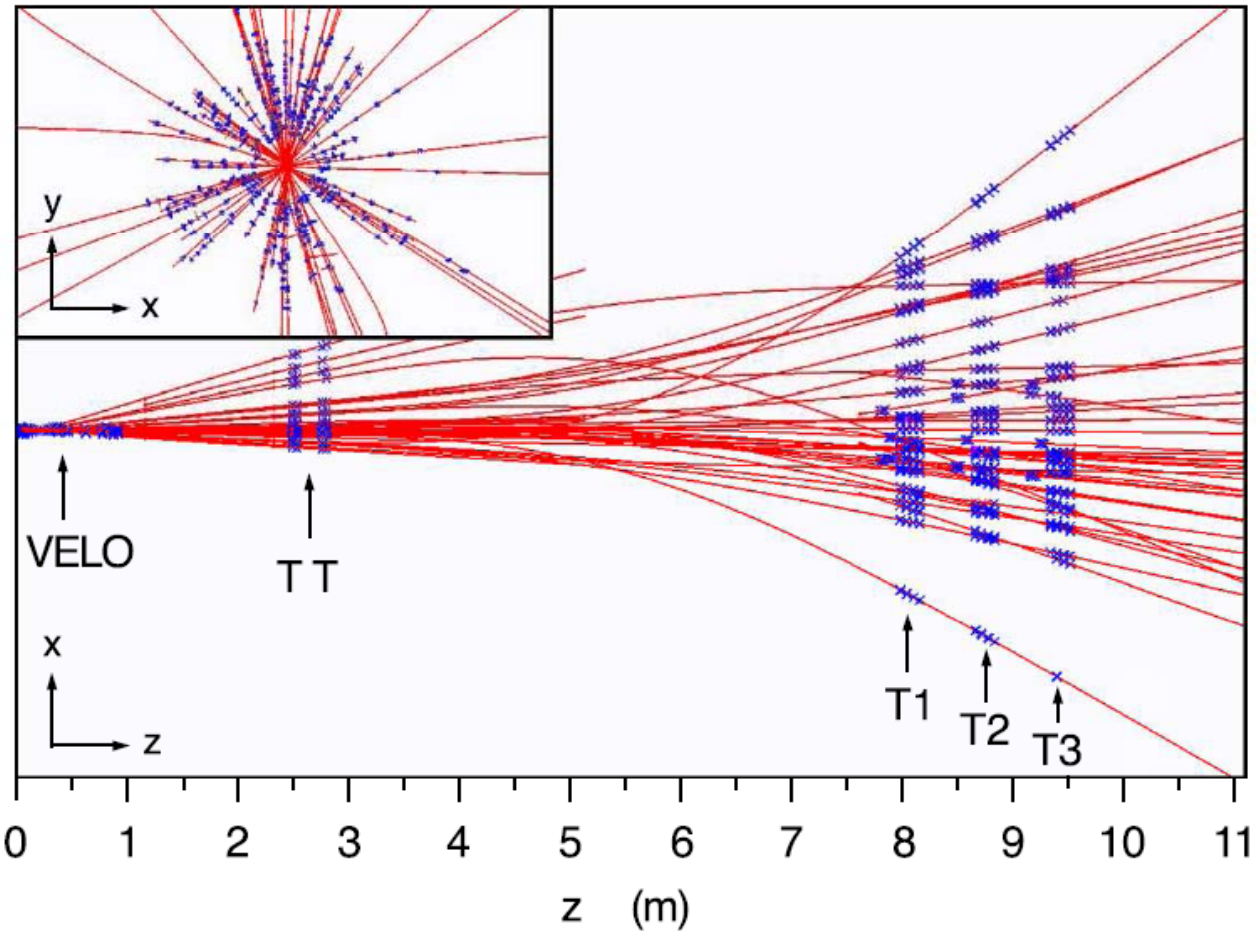
- High p_T of decay products
  - Large B mass
- Displaced secondary vertex
  - Long decay path for b lifetime

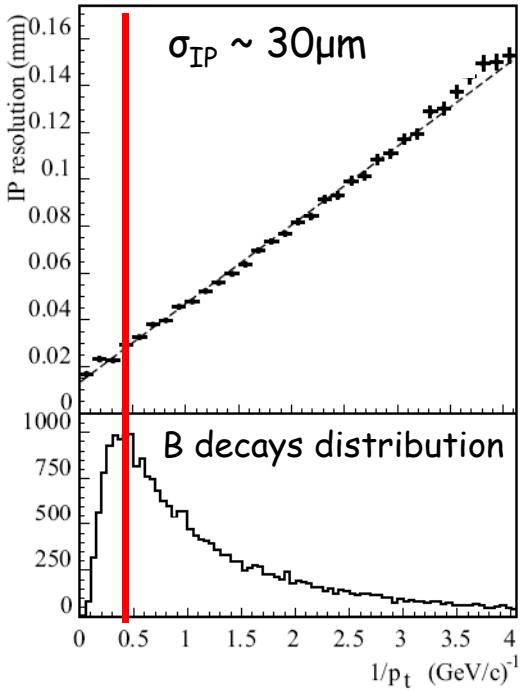
- L0-Trigger
  - Most boards PileUp, L0-Calo, L0-Muon, L0-Decicion Unit produced and installed
- High Level Trigger
  - First complete software release October 07
  - Only 20% of CPUs in the farm are needed for the 1st year of data taking

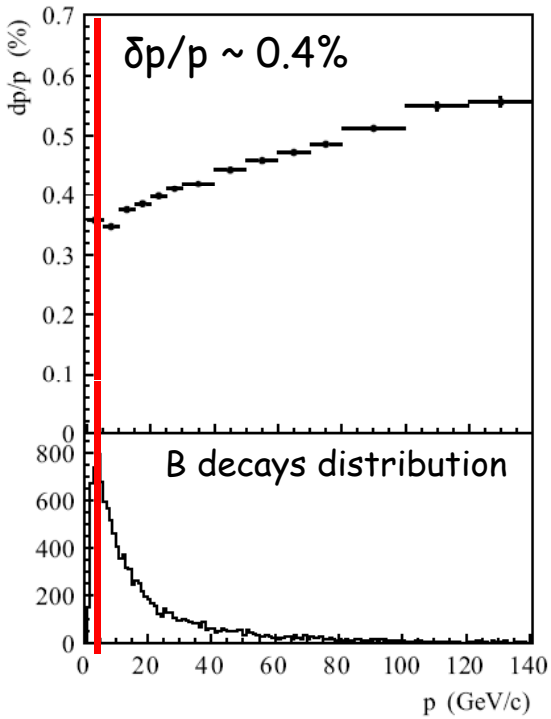


Tracking system

- Provide tracks and momentum with high precision
- Upstream of magnet: VELO + TT
- Dowstream of magnet: IT + OT





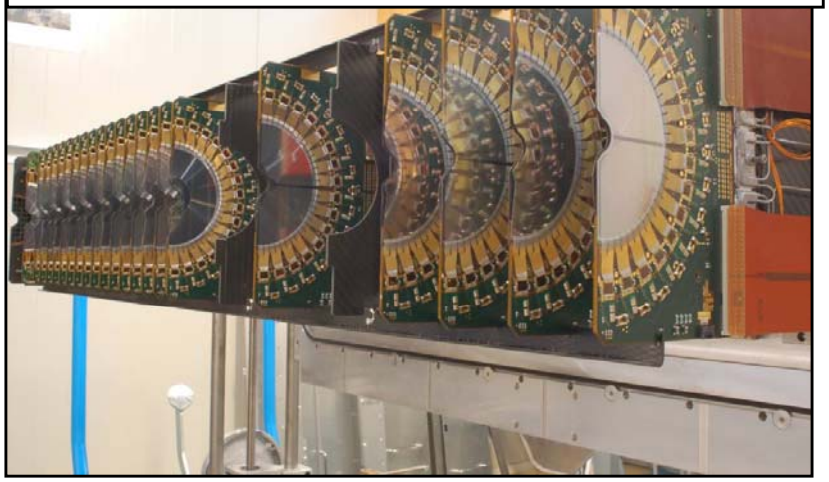


VELO and TT

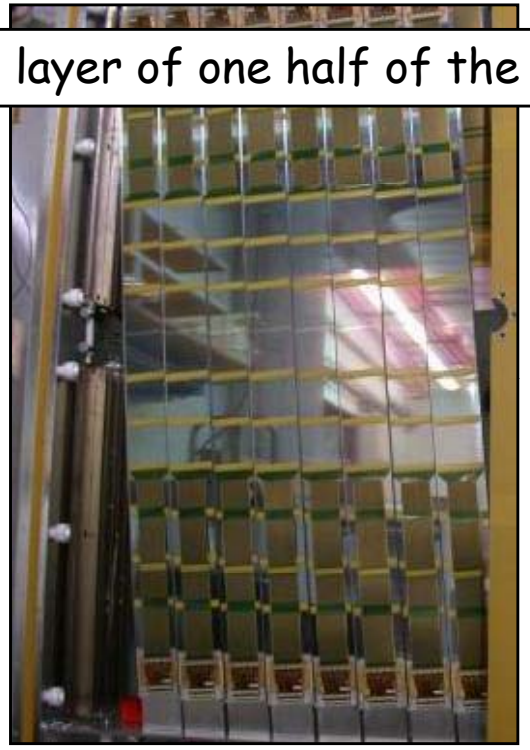
- VELO
- 21 stations equipped with R- and Ø-measuring silicon sensors
- Primary vertex resolution
  - 10μm (R-axis), 50μm (Z-axis)
- Silicon sensors sit in secondary vacuum
- Detector installed and participating in global commissioning

- TT
- 4 layers at 0°,±5° with 200μm pitch silicon sensors
- Single hit resolution
  - 50μm
- Support installed, modules in Feb-March

21 stations of one half of the VELO

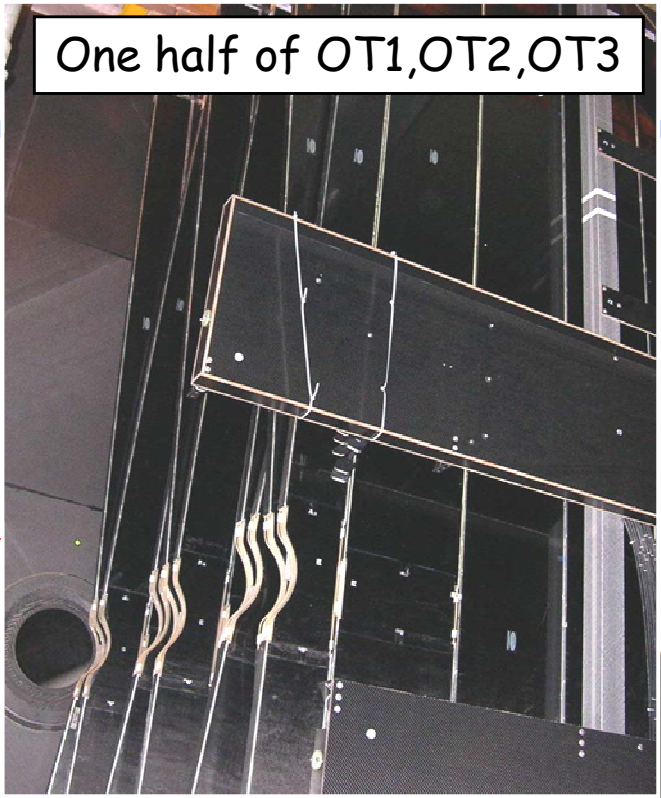


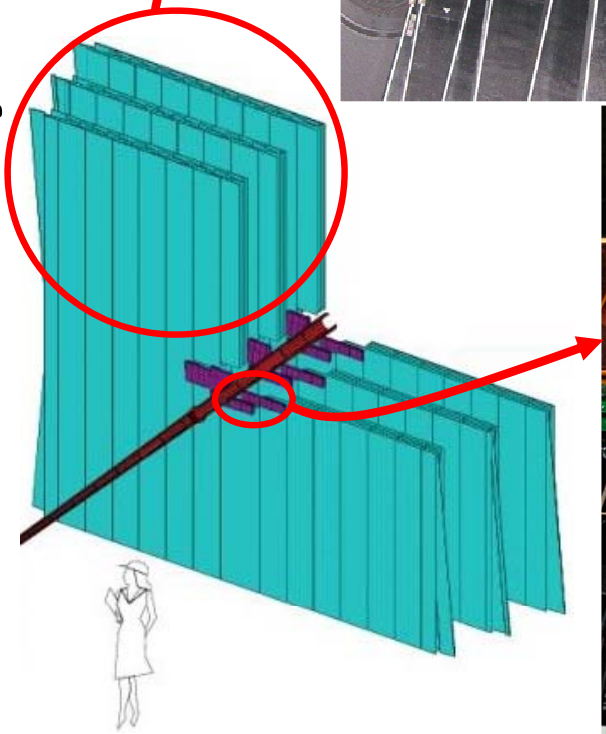
1 layer of one half of the TT

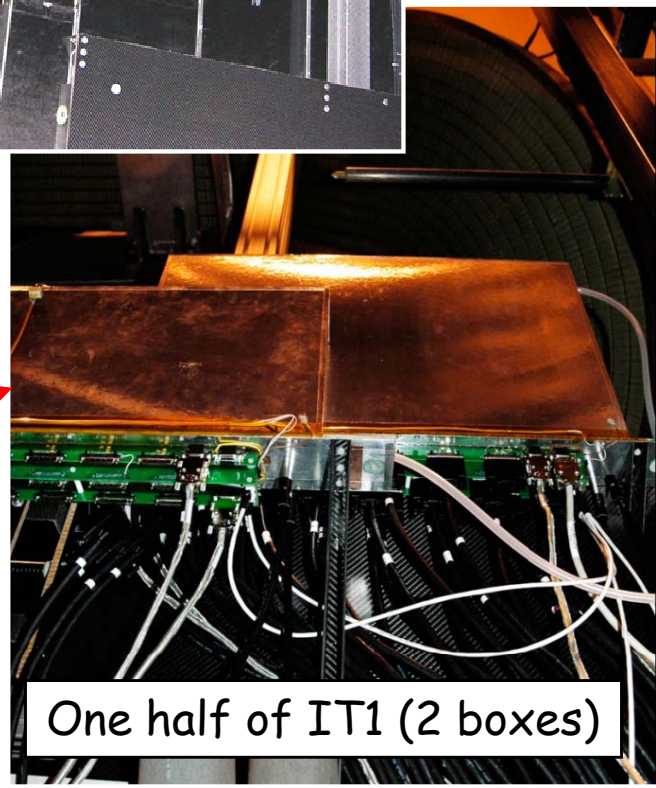


IT and OT

- 3 tracking stations equipped with silicon sensors in the inner part (IT) and drift time tubes in the outer part (OT)
- 4 layers at 0°,±5°
- IT boxes around the beam pipe covers ~2% of acceptance with ~20% of tracks
- Pitch ~200μm for IT, ~3mm for OT
- Supports installed
- Modules installed for OT, IT finish in March
- Commissioning OT with cosmics



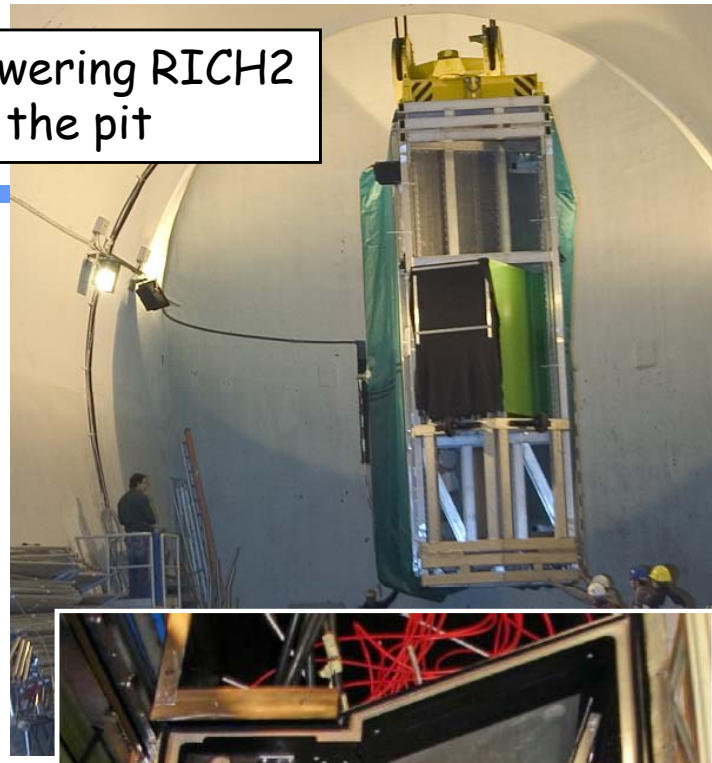




RICH system

- Provide K,π separation
  - Cherenkov angle resolution 1.66 mrad
- RICH1 indentifies particles ~1-60 GeV
  - Upstream of magnet
  - Radiators: aerogel + C_4F_{10}
- RICH2 indentifies particles ~15 to 100 GeV
  - Downstream of magnet
  - Radiator: CF_4
- Hybrid Photo Detectors (HPD)
  - Pixel readout
- RICH1, structure and mirrors installed, HPDs in March
- RICH2 completely installed and participating in the global commissioning

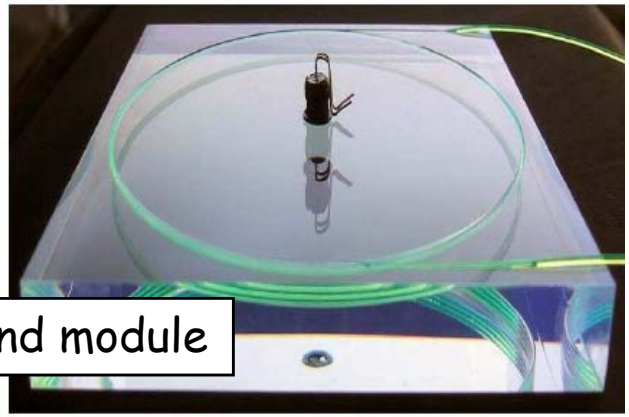
Lowering RICH2 to the pit

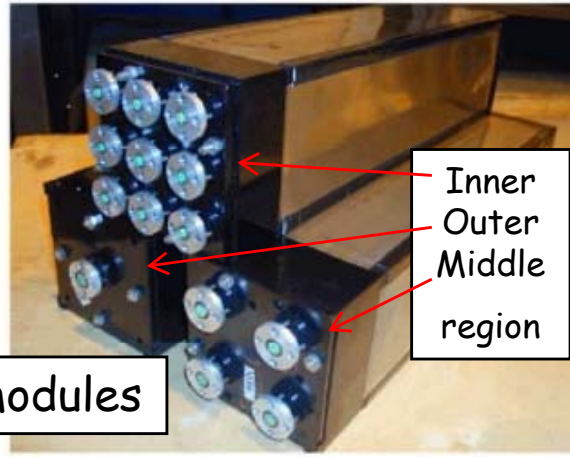


RICH1: spherical & flat mirrors

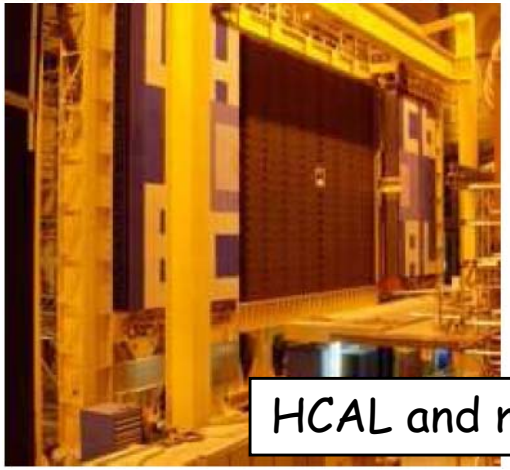
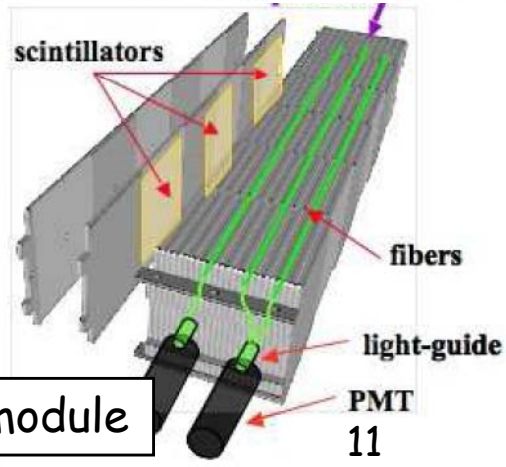
Calorimeters

- Provide particle indentification
- Select high E_T hadron, electron and photon candidates for L0-trigger
- SPD/PS + ECAL + HCAL
- Scintillation light is transmitted to a PMT by wavelength-shifting (WLS) fibers
- All installed and cabled
- ECAL, HCAL being commissioned
  - Using cosmics & LED



SPD/PS and module

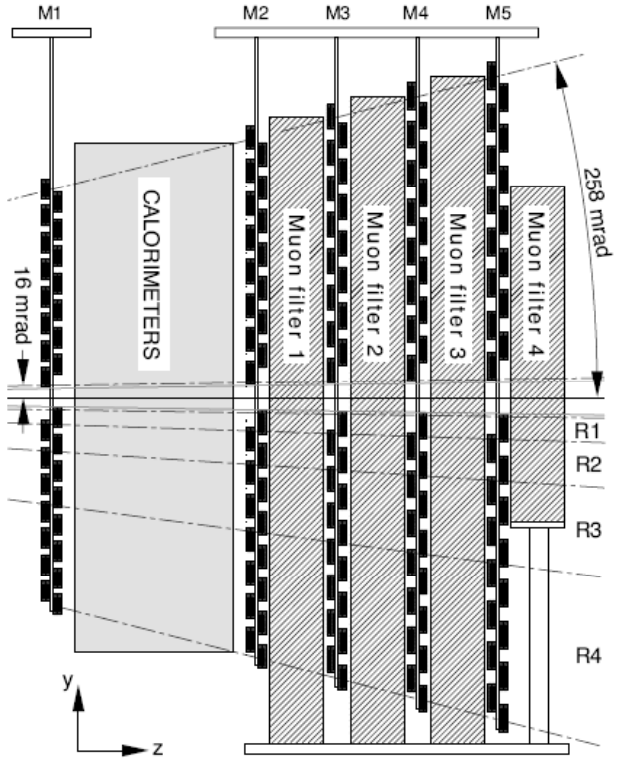
ECAL and modules

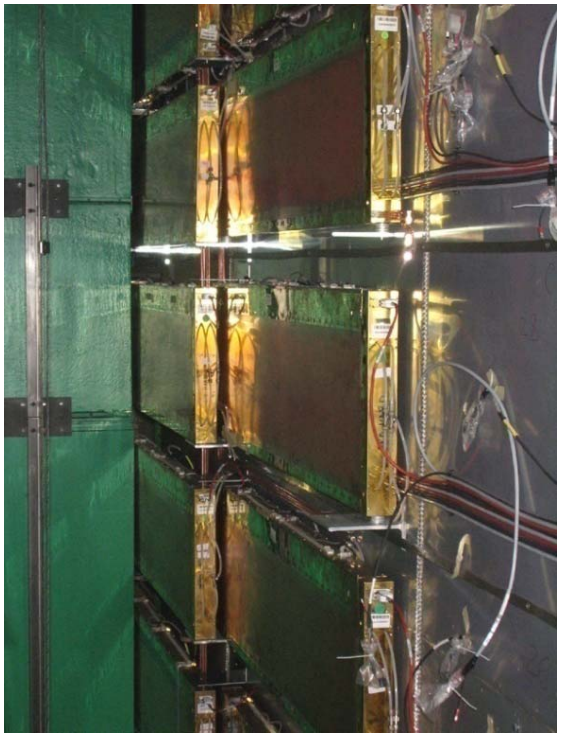



HCAL and module

Muon system

- 5 stations provide fast information for the high p_T for L0 trigger and muon indentification for High Level Trigger and offline
- Readout technology
  - Multi Wire Proportional Chamber
  - Triple-GEM for M1-R1
  - All produced; some 3-GEM services ready by April
- M1 station structure to be installed in May
- M2-5 completed and participating in the global commissioning





LHCb upgrade

- LHCb is designed to run at an average luminosity of 2×10^{32} cm^{-2}s^{-1}
  - After 5 years of data taking a data sample of 10 fb^{-1} will be collected
    - ⇨ Enough to make a first observation of rare decays $B_s \rightarrow \mu^+\mu^-$ down to SM prediction and improve CKM angle γ by a factor 5
  - To continue will not be very profitable as statistical precision increases very slowly
- An upgraded LHCb running at ~2×10^{33} cm^{-2}s^{-1} would collect ~100 fb^{-1}
  - Does not require SuperLHC but it is compatible with it
- A Working Group has been created to investigate the LHCb upgrading option
  - Expression of Interest for an LHCb upgrade is in preparation
  - R&D program to evaluate the required technologies
    - ⇨ Trigger decision in the farm
    - ⇨ All detectors to be readout @ 40MHz
    - ⇨ New FEE design
      - Profit from common LHC development
    - ⇨ Only Si detectors need be replaced

Conclusion

- Installation of LHCb is almost complete
  - Structures are in place
  - Remaining sensitive elements and services to be finished by March
- Most of detectors are being commissioned
  - Using cosmics where possible, otherwise LED or test pulses
  - Global data taking started
- After 13 years of work … the experiment will be ready for first LHC beam