LHCb

- Une expérience dédiée à la violation de CP au LHC
  - mesure de précision dans le domaine des mésons beaux et charmés

Les hadrons beaux

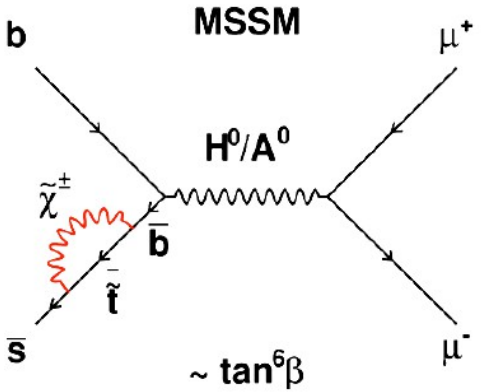
Les mésons neutres : B^0 / B_d ($b\bar{d}$) et B_s ($b\bar{s}$)

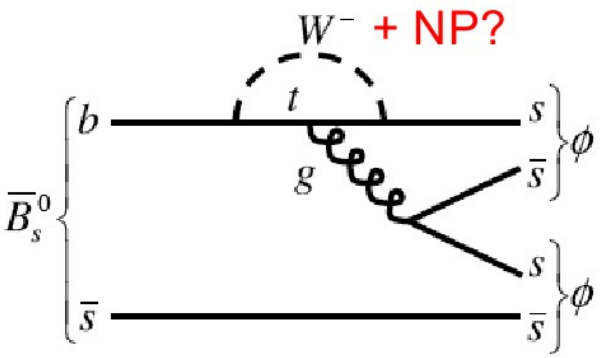
- → oscillent comme les kaons
- mais plus rapidement
- → masse :
- B_d = 5.3 GeV/c^2
- B_d = 5.4 GeV/c^2
- → durée de vie : $\tau = 1.5\ 10^{-12}$ s
- D = ~ 1 cm

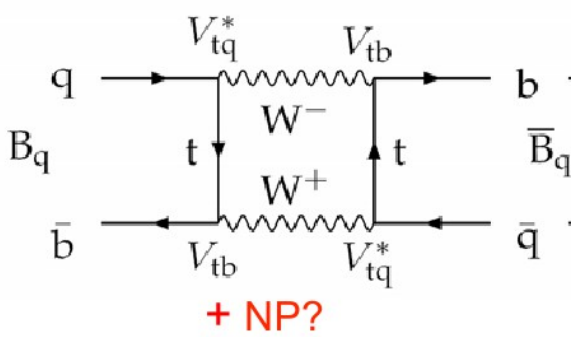
LHCb : a dedicated flavour physics experiment at LHC

ATLAS & CMS search for direct production of new states

LHCb designed to see their indirect effect on charm & beauty decays via virtual production in loop diagrams







Des particules encore inconnues pourraient se manifester dans les processus de désintégrations des hadrons B.

Les réactions observées seraient donc différentes de celles prévues par le Modèle Standard.

Les mesures de précisions faites à LHCb devraient permettre de mesurer ces différences et de mettre en évidence ces nouvelles particules.

Beauty and Charm production at LHC

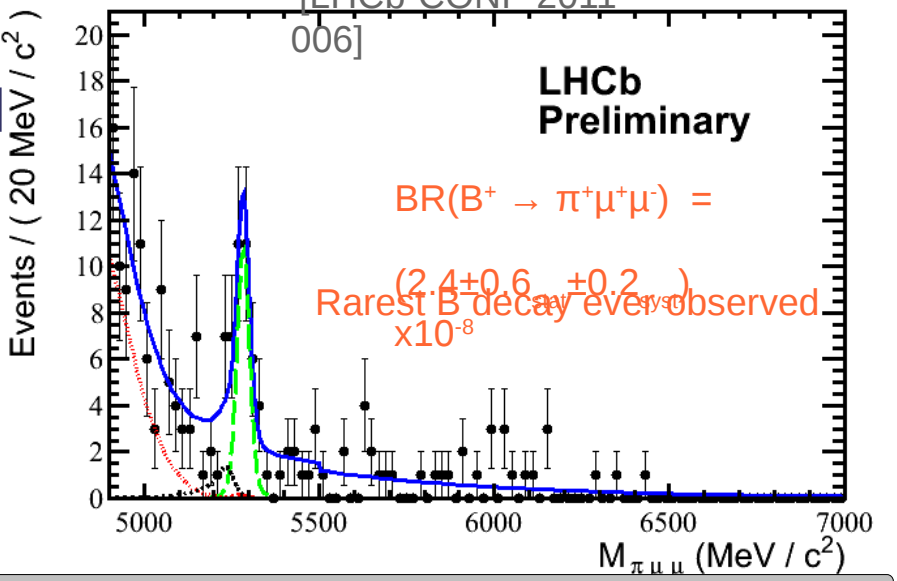
LHC is a Flavor Factory, @ 7 TeV :

- σ(pp → cc X) = ~ 6 mb [LHCb-CONF-2010-013]
- σ(pp → bb X) = ~0.3 mb [PLB 694 (2010) 209]
- B factories : σ(e+e- → bb)@Y(4S) = ~ 1 nb

Challenging background condition :

- σ(pp →X)inel = 60 mb [JINST 7 (2012) P01010]

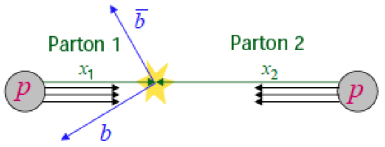
[LHCb-CONF-2011-006]

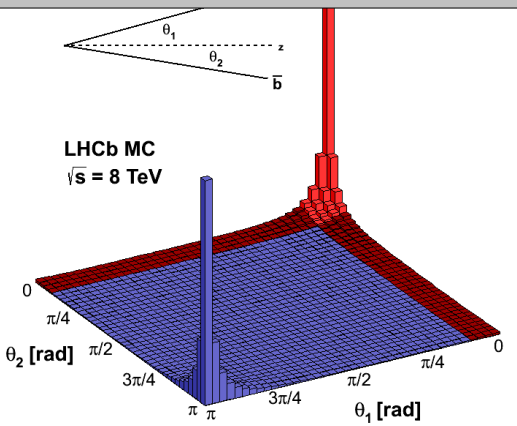


Le LHC est une usine à B : beaucoup de quark b sont produits (~ 1 paire $b\bar{b}$ toutes les 200 collisions).

A très haute énergie comme celle des collisions au LHC, les quarks b sont produits préférentiellement à petit angle (proche des faisceaux)

bb/cc pairs are produced predominantly in the forward or backward directions



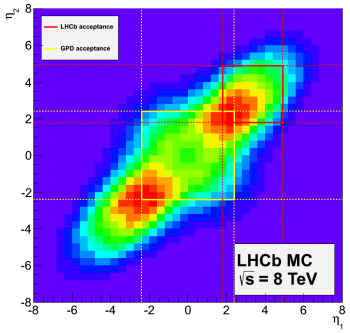


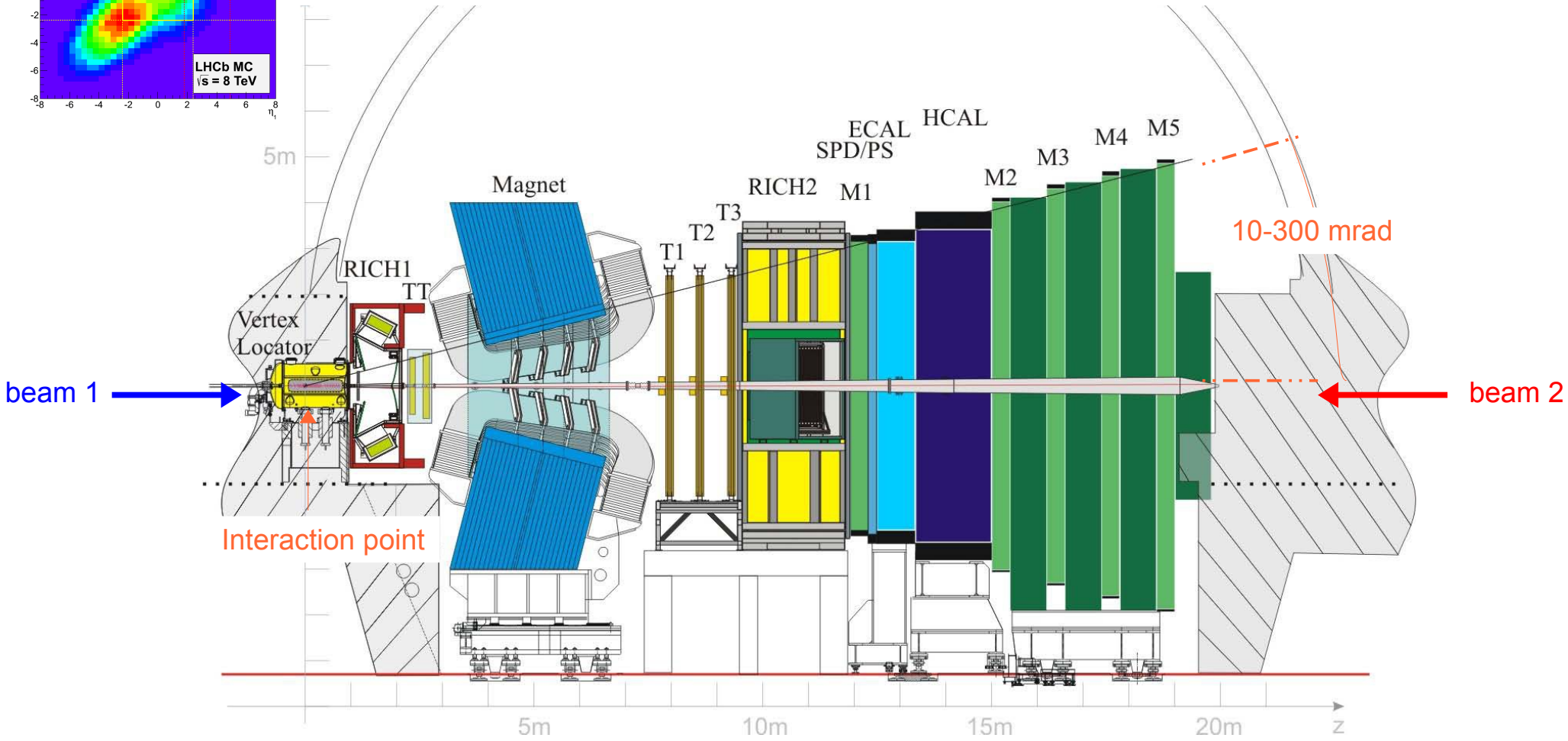
The LHCb Collaboration

LHCb : a forward spectrometer

B forward-peaked production → LHCb is a forward spectrometer

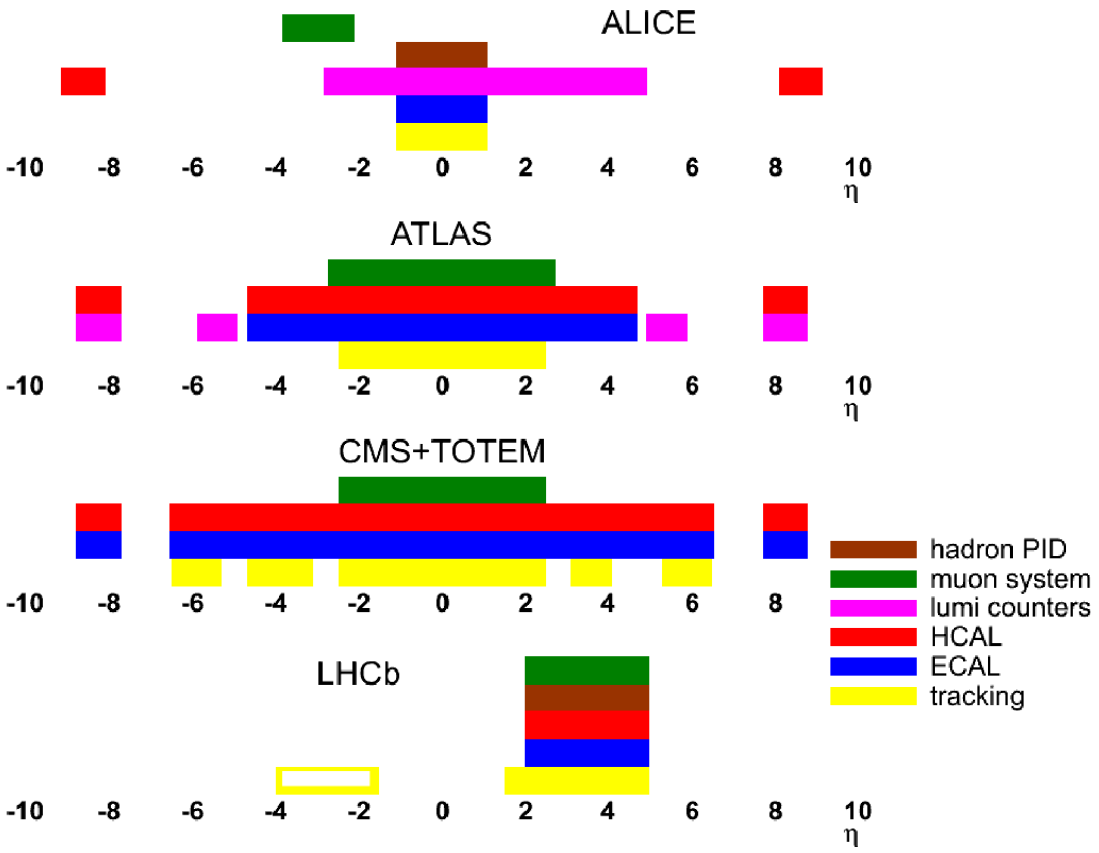
(operating in collider mode)

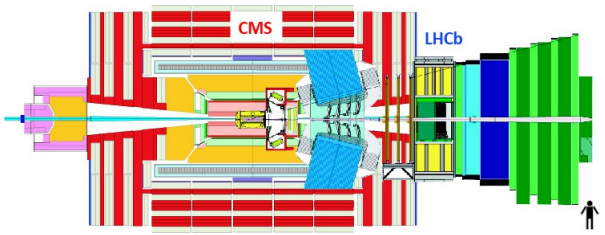




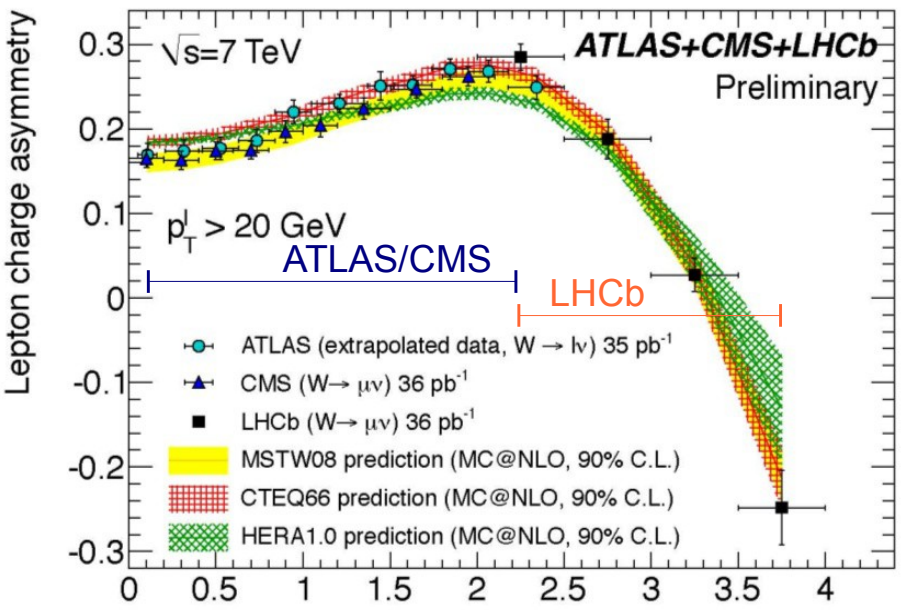
LHCb : a forward spectrometer

With unique rapidity coverage at LHC → complementary measurements

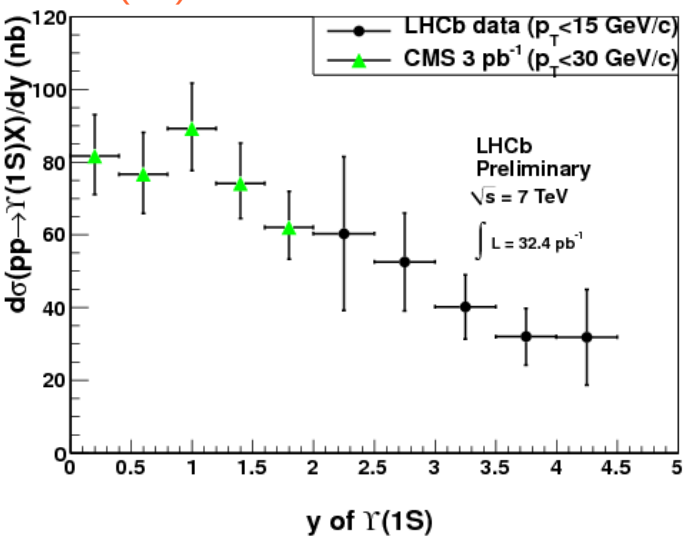




W charge asymmetry

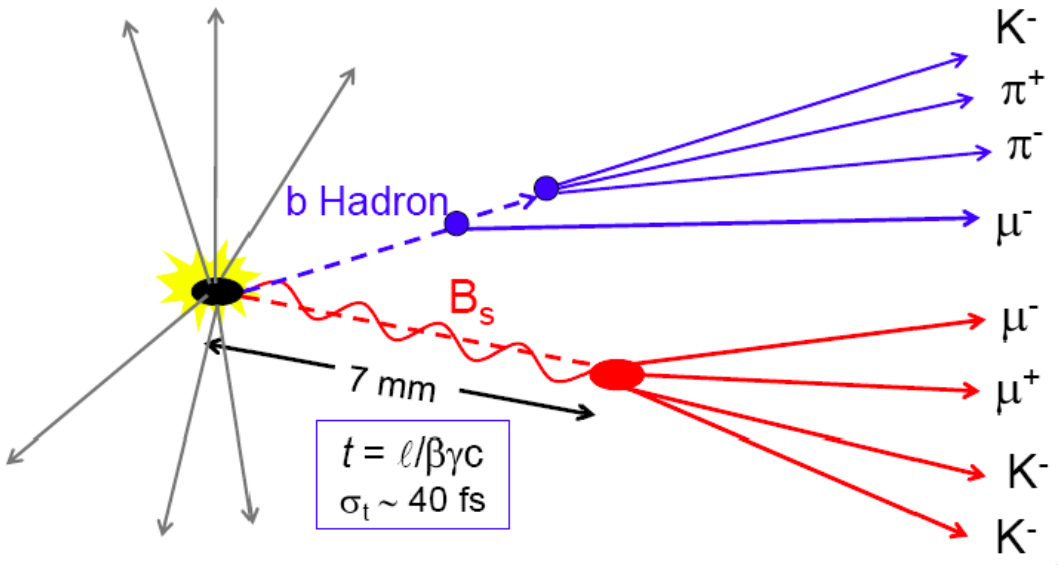


Υ(1S) differential cross section



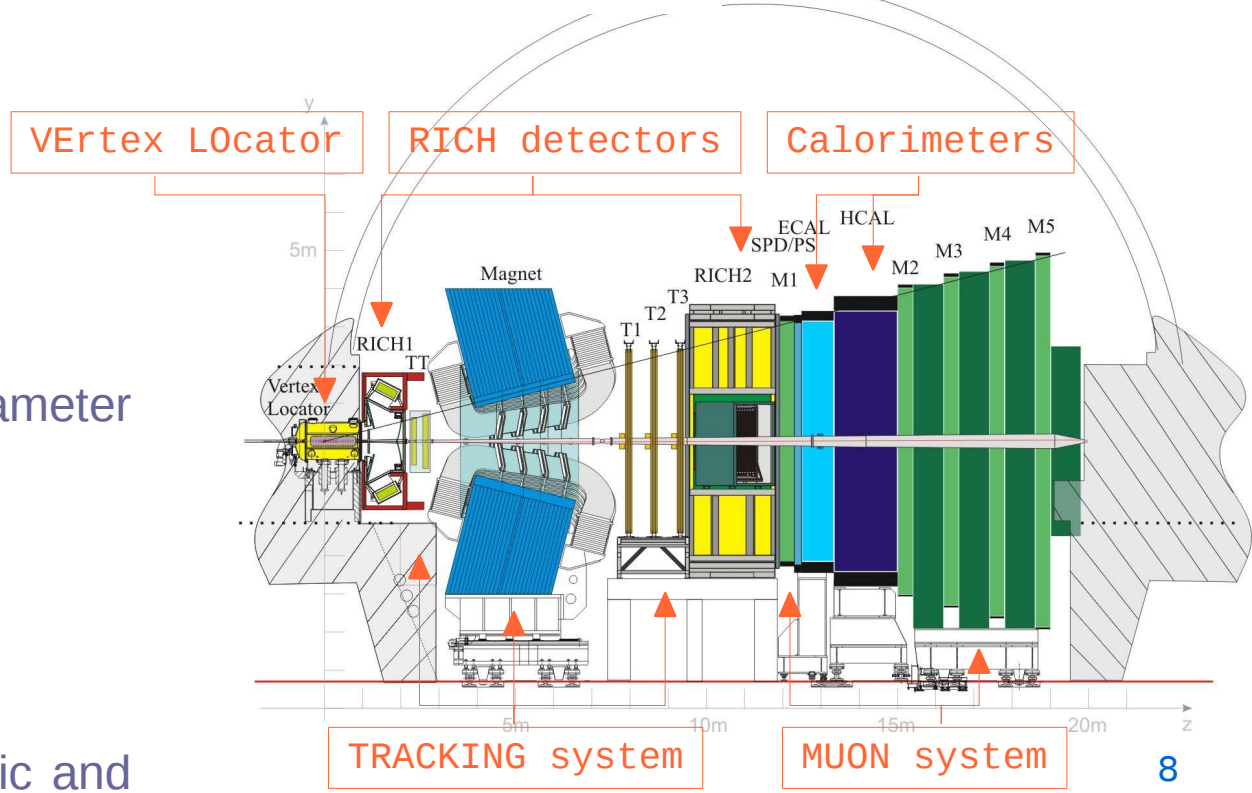
LHCb : a forward spectrometer optimised for heavy flavors

Typical topology :

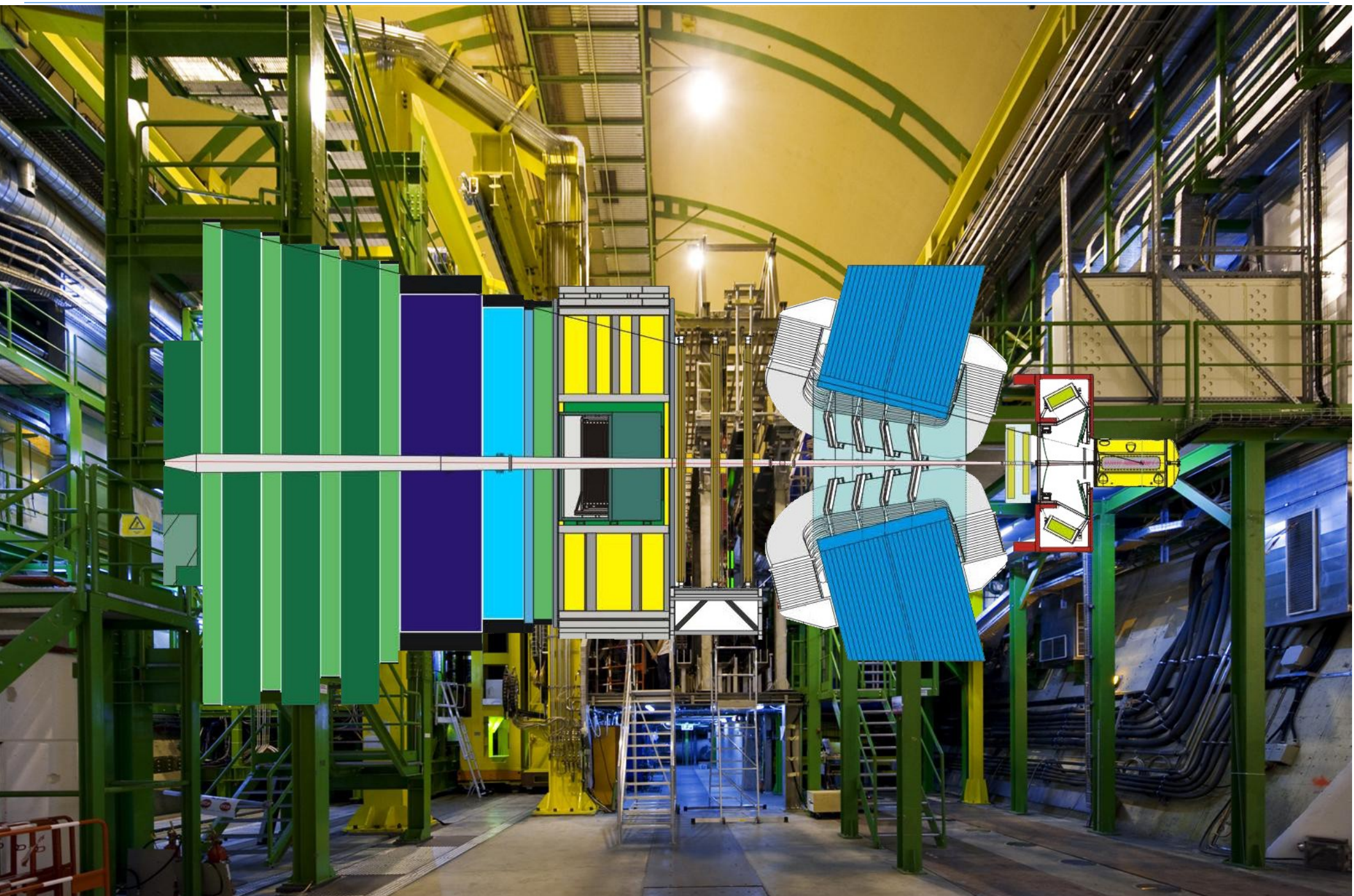


Key features :

- Resolve fast BS oscillation
  - → excellent vertex resolution
- Background reduction :
  - → very good impact parameter resolution
  - → good mass resolution
  - → good particle identification (K/π)
- Collect high statistics :
  - → efficient trigger for both hadronic and

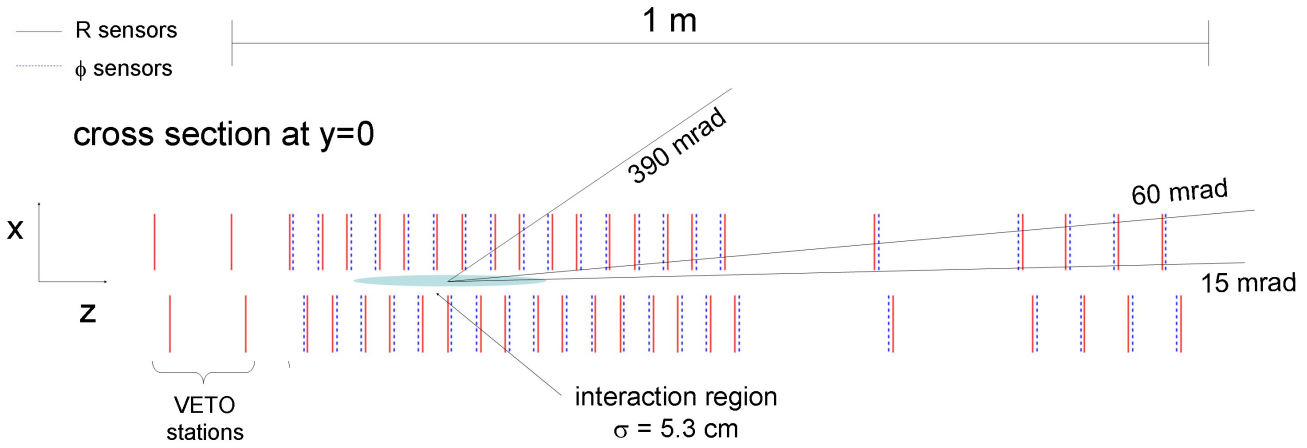


LHCb detector

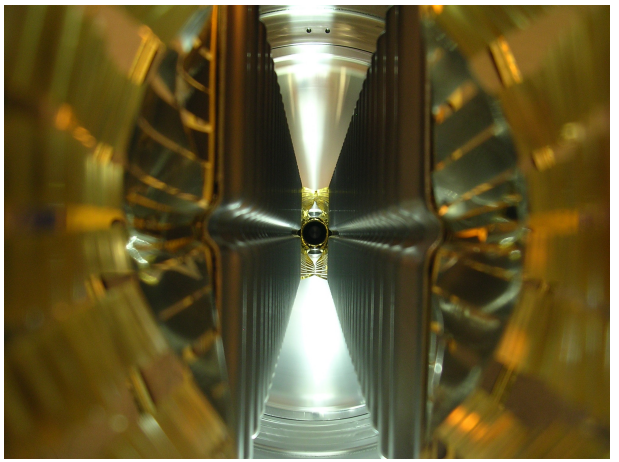


Vertex detection : the VErtex LOcator (VELO)

Reconstruction of primary and decay vertices, track seeds, + trigger input



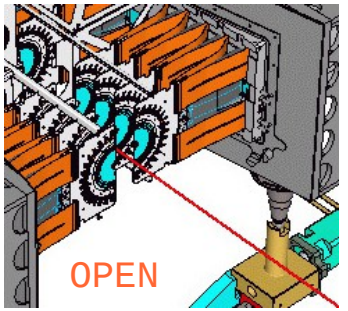
The VELO seen by the LHC beams

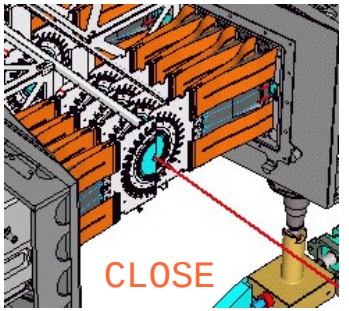


21 modules of R-Φ sensors

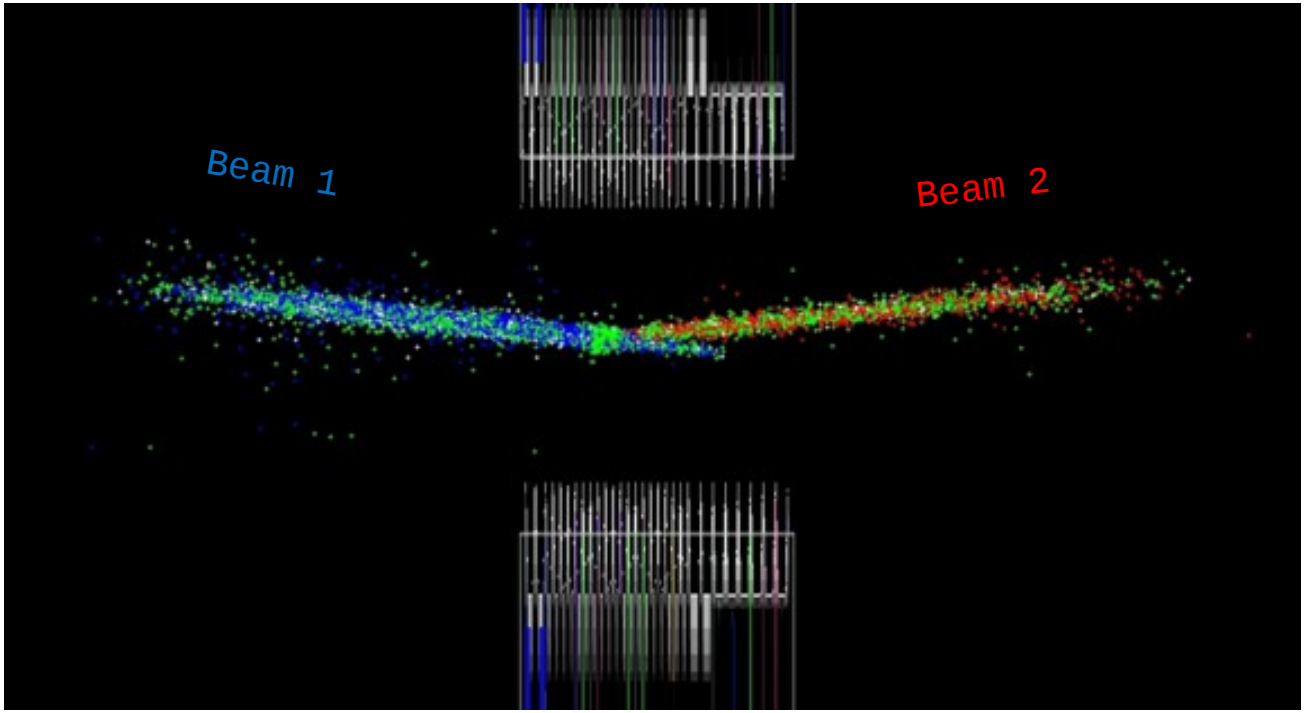
Movable device (retracted for safety during beam injection) :

- 35 mm from beam out of physics
- 8 mm from beam during physics





Vertex detection : performances



[PLB **693** 69]

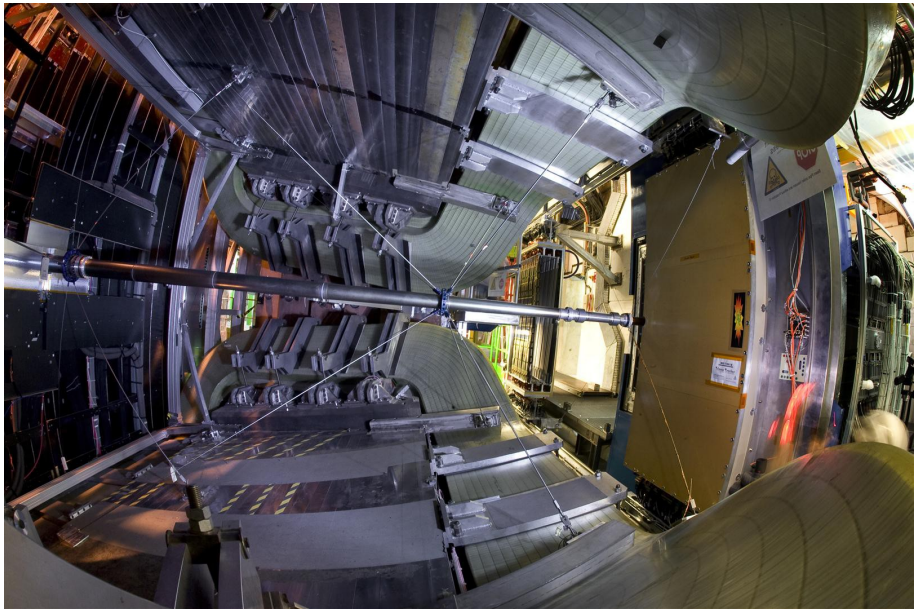
Reconstructed beam-gaz vertices (used for luminosity measurement)

The Tracking System

System :

- 1 tracking station before magnet (TT) :
  - → 4 layers of Si-Strips sensors
- Magnet
  - → ∫Bdl = ~ 4 Tm ; polarity switched regularly
- 3 tracking stations after magnet,
- 4 layers each split into:
  - → Inner Tracker (Si-sensors)
  - → Outer Tracker (straw tube)

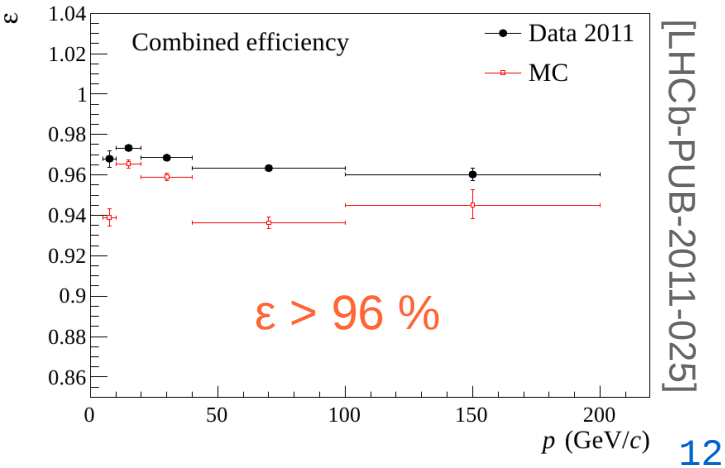
T1 TT



Track finding :

- Long tracks : high-momentum tracks traversing the full LHCb tracking setup
  - → combine track seeds in VELO and T-stations and add TT hits
  - → measured with highest precision
  - → most numerous in the main LHCb acceptance

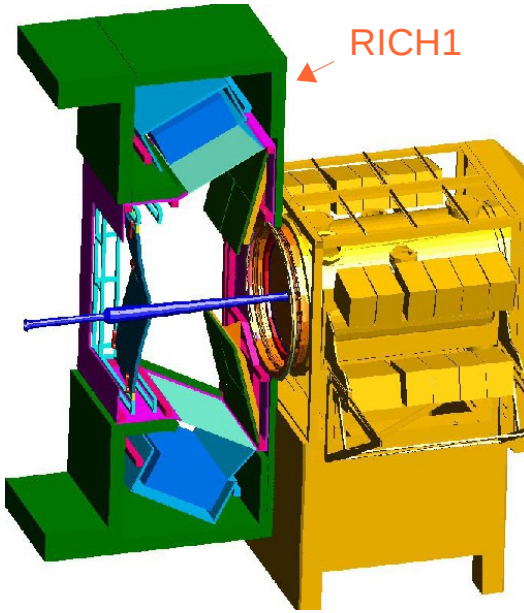
Track finding efficiency



[LHCb-PUB-2011-025]

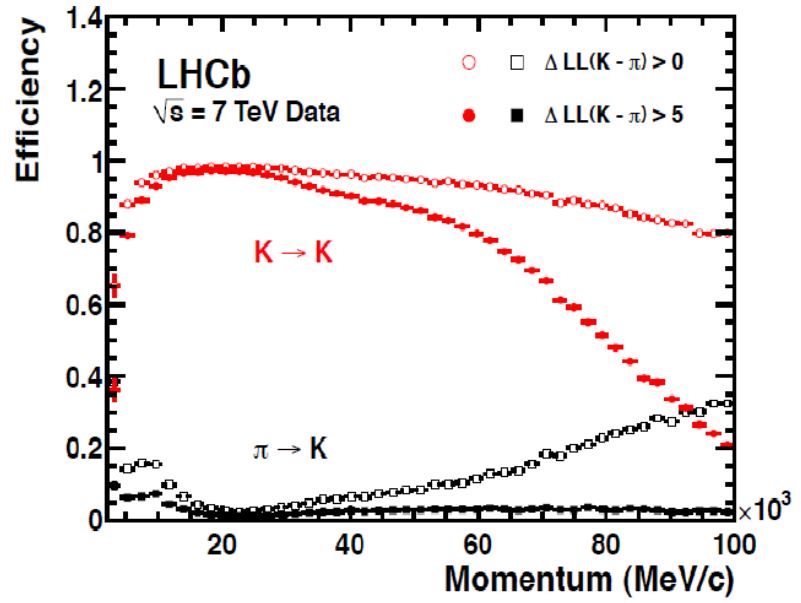
Particle identification : the RICH detectors

K/π separation over the full 1-100 GeV/c range



The detectors :

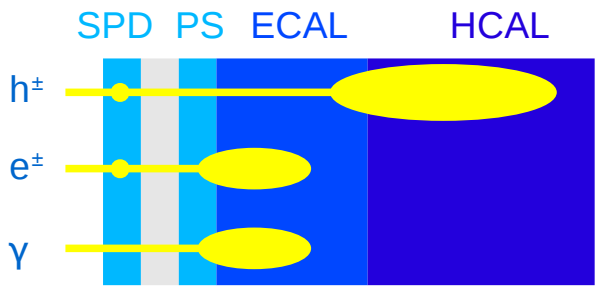
- RICH1 :
  - → full angular acceptance
  - → covers low momentum range : 1-60 GeV/c
  - → aerogel & C4F10 radiators
- RICH2 :
  - → limited angular acceptance (~±15 → ~±100 mrad)
  - → high momentum range : ~15 GeV/c - > 100 GeV/c
  - → CF4 radiator
- Hybrid Photon Detectors (HPDs)
  - → 500 each with 1024 pixels
  - → High efficiency, low noise

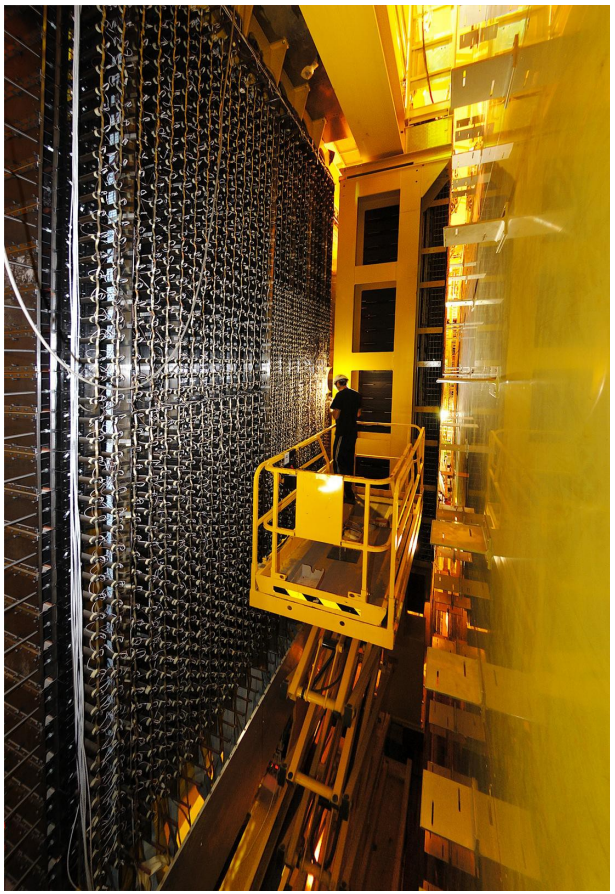


Performances

- ε ≈ 95 % for 5% π-K misID probability
- performances well described by simulation

Particle identification : the calorimeters





The ECAL detector

Scintillator Pad Detector / PreShower :

- robust e/γ and e/hadron separation
- single layer scintillator tiles separated by Pb sheet (2.5 X0)
- ε(e±) = 90% for 5% e-hadron MisID

Electromagnetic CALorimeter :

- e and γ energy measurement
- trigger on electromagnetic decay channels
- Pb plates / scintillator tiles (25 X0)
- σ(E)/E = 10%/√E(GeV) + 1% (nominal)

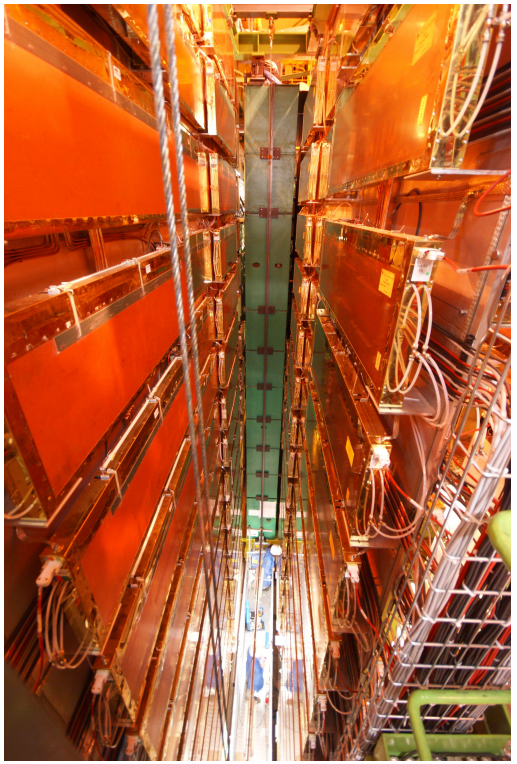
Hadronic CALorimeter :

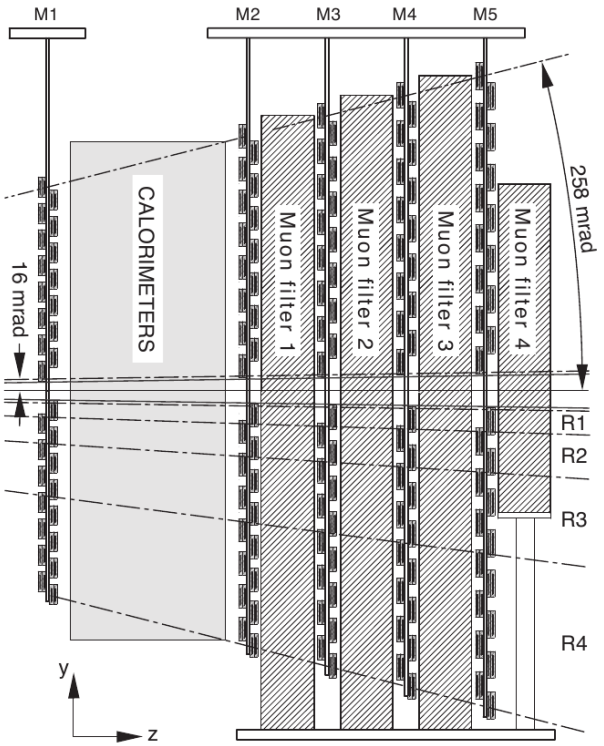
- energy measurement for hadron
- trigger on hadronic decay channels
- Fe plates / scintillator tiles
- σ(E)/E = 69%/√E(GeV) + 9% (nominal), moderate but enough for triggering

Particle identification : the muon system

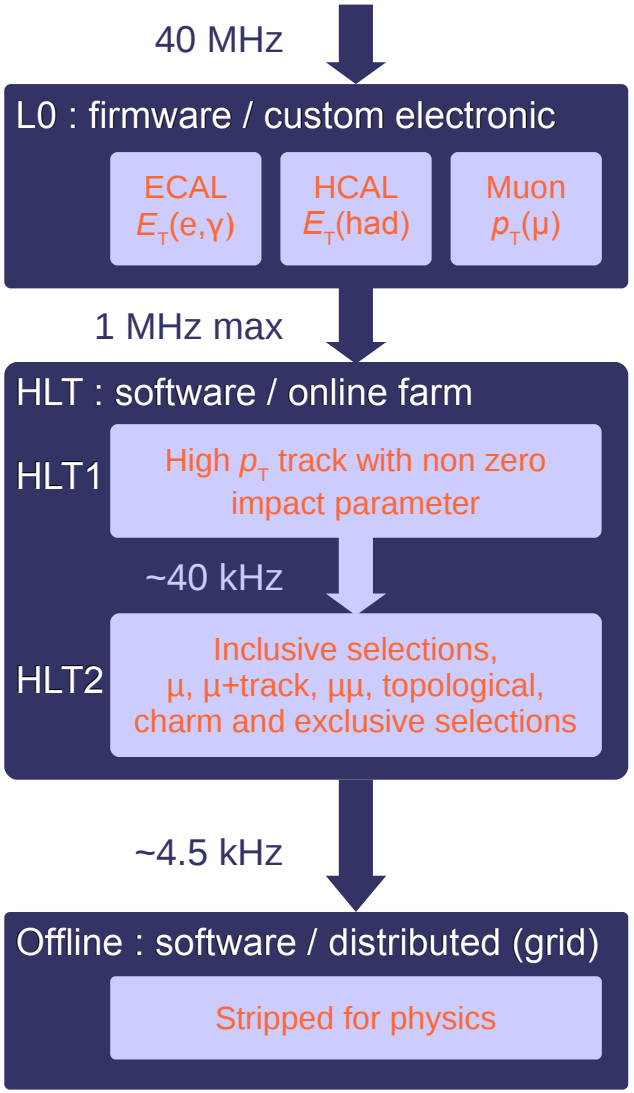
5 stations interleaved with iron absorbers

- muon identification
- trigger on muonic decay channels
- Muon ID ε(μ) = 97 % for 1-3% π-μ MisID





Trigger & stripping



L0 : custom electronic @40Mhz, 4 μs latency

- search for high-pT μ, e, γ, hadron candidates
  - → pT(μ)>1.4; ET(e/γ)>2.7; ET(hadron)>3.6 [GeV]

HLT : software trigger

- ~ 30000 tasks in parallel on ~1500 nodes
- HLT1 : add Impact Parameters cuts
- HLT2 : global event reconstruction tuned for HLT

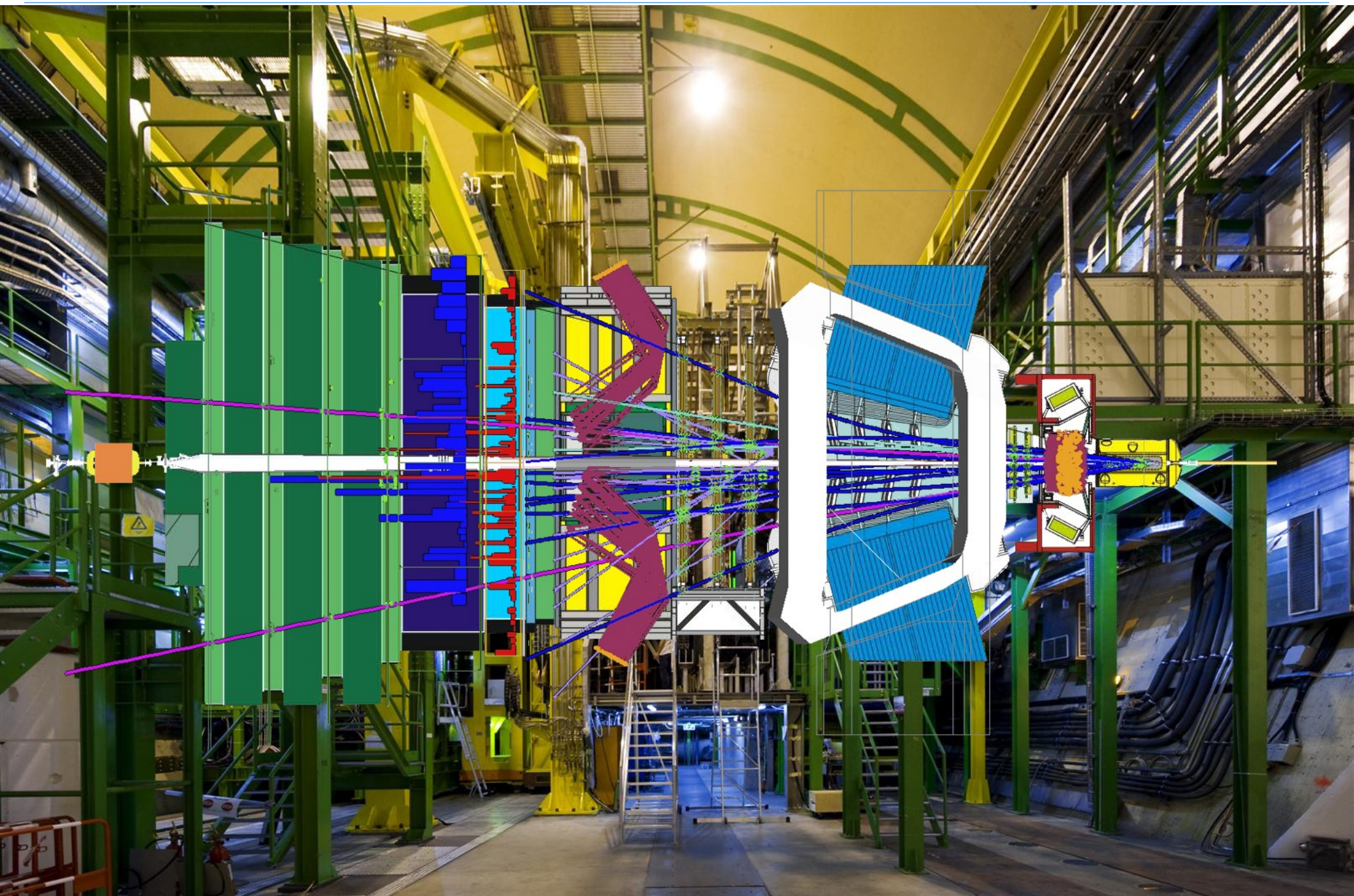
Efficiencies :

- di-muons channels : ~ 90 %
- multi-body hadronic final states : 30 %
- cf. H. Dijkstra's talk

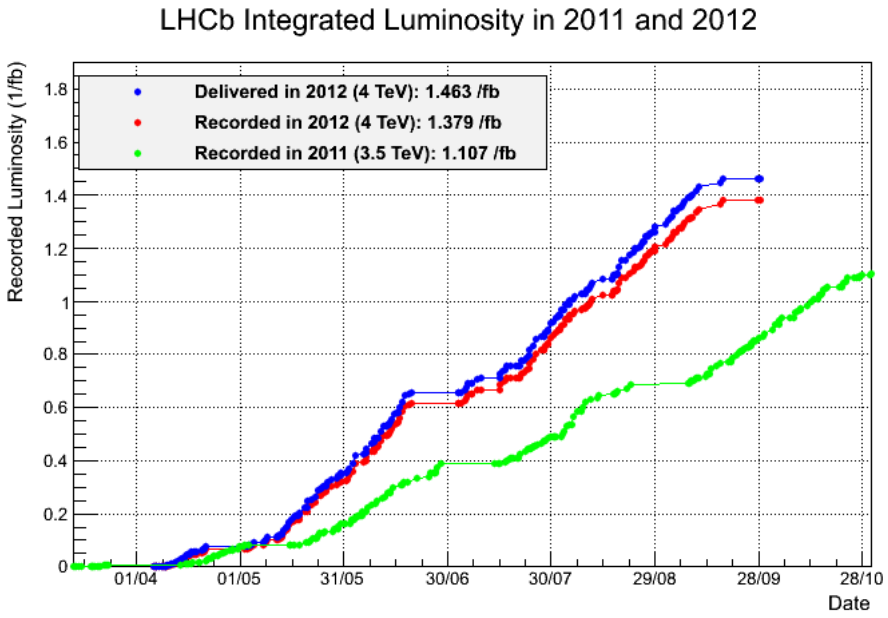
Offline : ~1010 events, 700 TB recorded/year

- centralized stripping selections to reduces to samples with 0(107) events for individual analyses

LHCb Operation

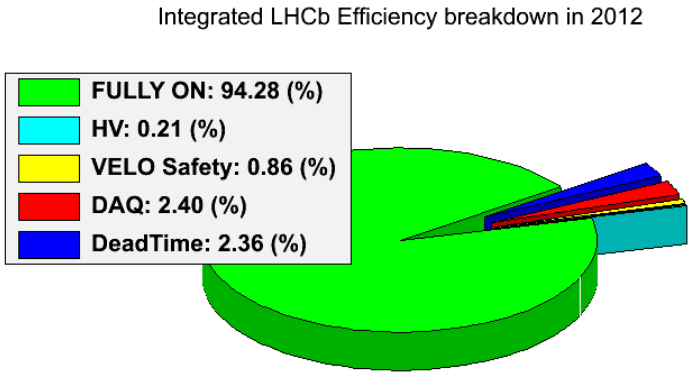


Data Taking



Recorded Luminosity :

- 2010 : 37 pb-1 @ 7 TeV
- 2011 : 1 fb-1 @ 7 TeV
- 2012 : aim at 2.2 fb-1 @ 8 TeV
- (as of end of September : 1.4 fb-1)
  - → expect σ(bb) increased by ~15% w.r.t 7TeV



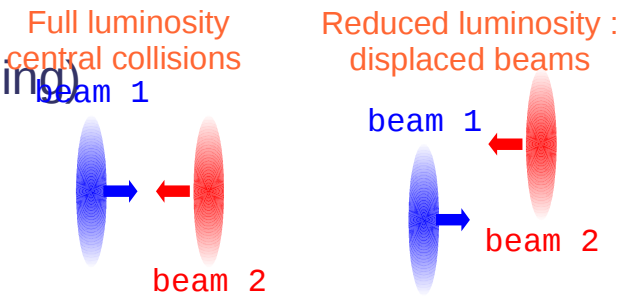
Efficiencies :

- > 90 % data taking efficiency
- ~99 % working detector channels
- > 99% of recorded data good for analysis

Luminosity

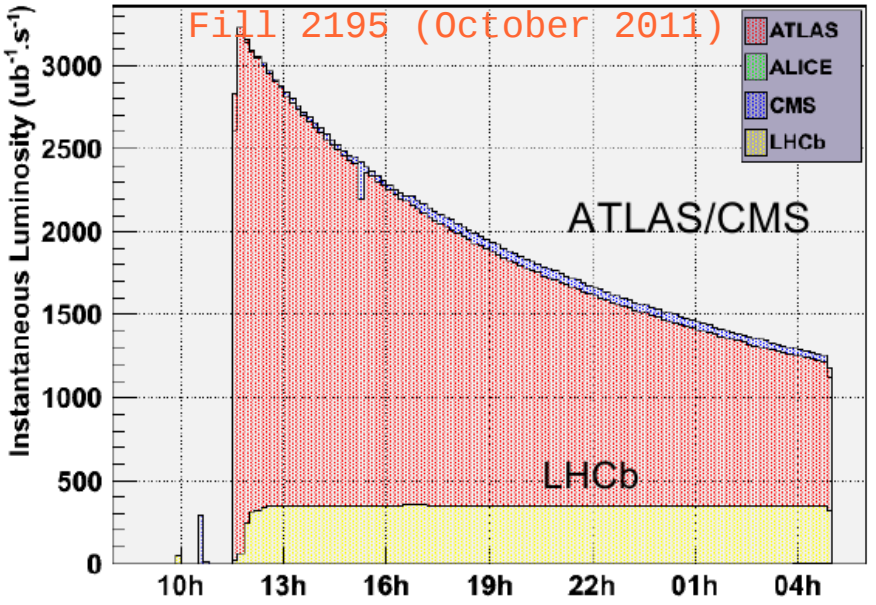
LHCb designed luminosity :

- Linst = 2x1032 cm-2s-1 with μ=0.4 (# of visible pp int./crossing)
- Precision physics depending on vertex structure
  - → easier in a low-pileup environment

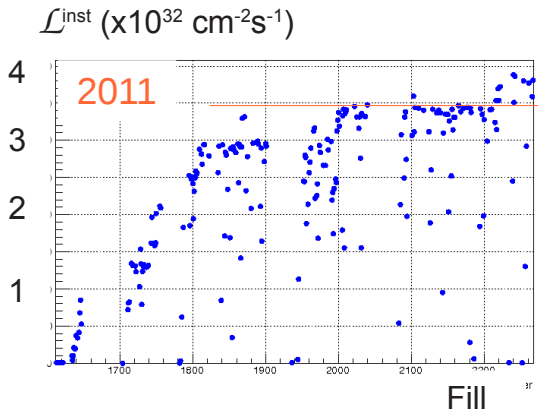


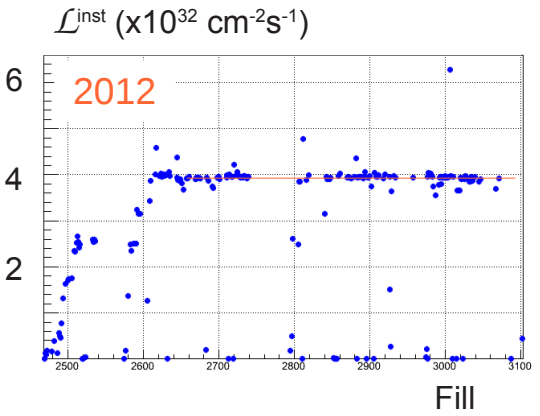
Luminosity levelling at LHCb

- run with constant luminosity
  - → beam overlap adjusted regularly
- automatic procedure between LHC&LHCb



2011 & 2012 instantaneous luminosities :





2011 : $\mathcal{L}^{inst}$ = ~ 3.5x10^{32} cm^{-2}s^{-1}, μ = ~1.5

2012 : $\mathcal{L}^{inst}$ = ~ 4.0x10^{32} cm^{-2}s^{-1}, μ = ~1.7

2012 novelties

Optimisation of data acquisition :

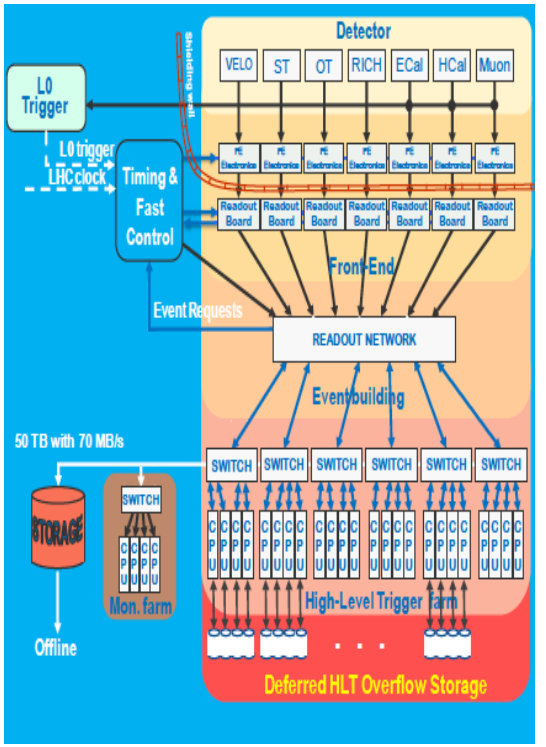
- L0 rate from 925 kHz to 975 kHz
- allow to run at higher luminosity

Deferred HLT triggering :a

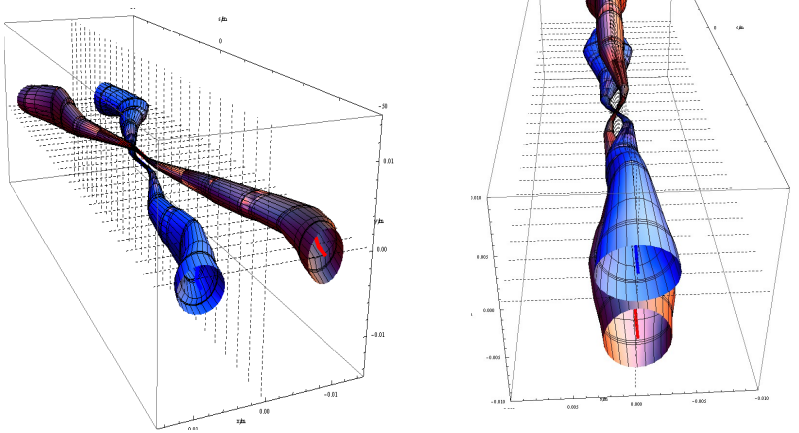
- the HLT processing of a fraction (20%) of the L0 rate is deferred
- deferred event are written to disk and processed by the HLT in the inter-fill gap
- equivalent to 20% gain in CPU power

LHC optics :

- beams crossing angle change from horizontal plane in 2011 to vertical plane in 2012
- decoupled from LHCb magnet polarity change (H bending)
- minimize systematic effects



2011 2012



Conclusions

LHCb detector achievements :

- excellent vertex resolution
- great tracking performances
- robust particle identification
- flexible and efficient trigger

LHCb operation :

- smooth and efficient
- sustain luminosity higher than designed value

LHCb able to deliver high-quality physics results

- ~70 submitted papers
- world's best measurements of many important physics parameters
- upgrade activities launched

Thank you for your attention

Détecteur de muons

Reconstruction de vertex