LHCb detector performance

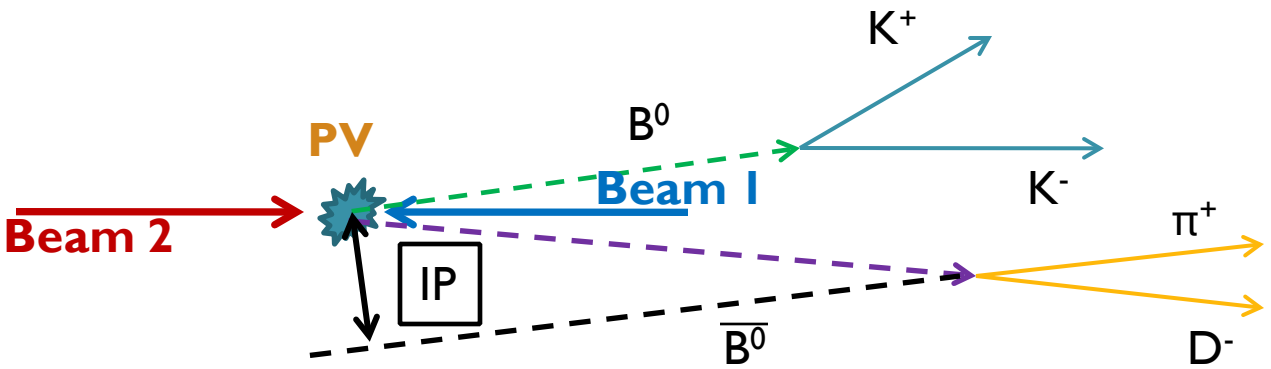
22 July 2011

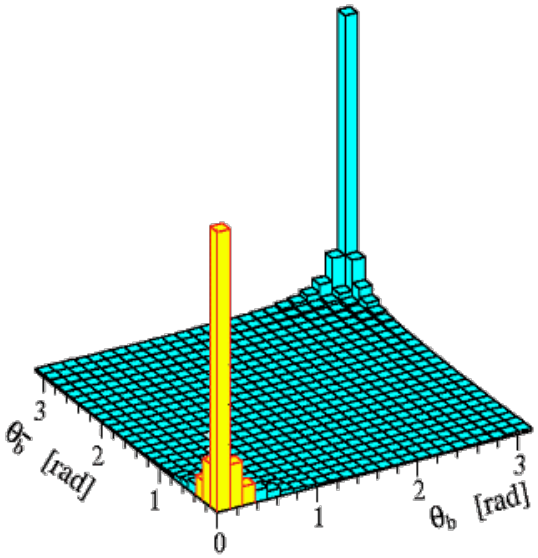
Martin van Beuzekom

On behalf of the LHCb collaboration

- Overview of LHCb
- Operations
- Vertexing, Tracking & Alignment
- Particle Identification
- Summary / Outlook

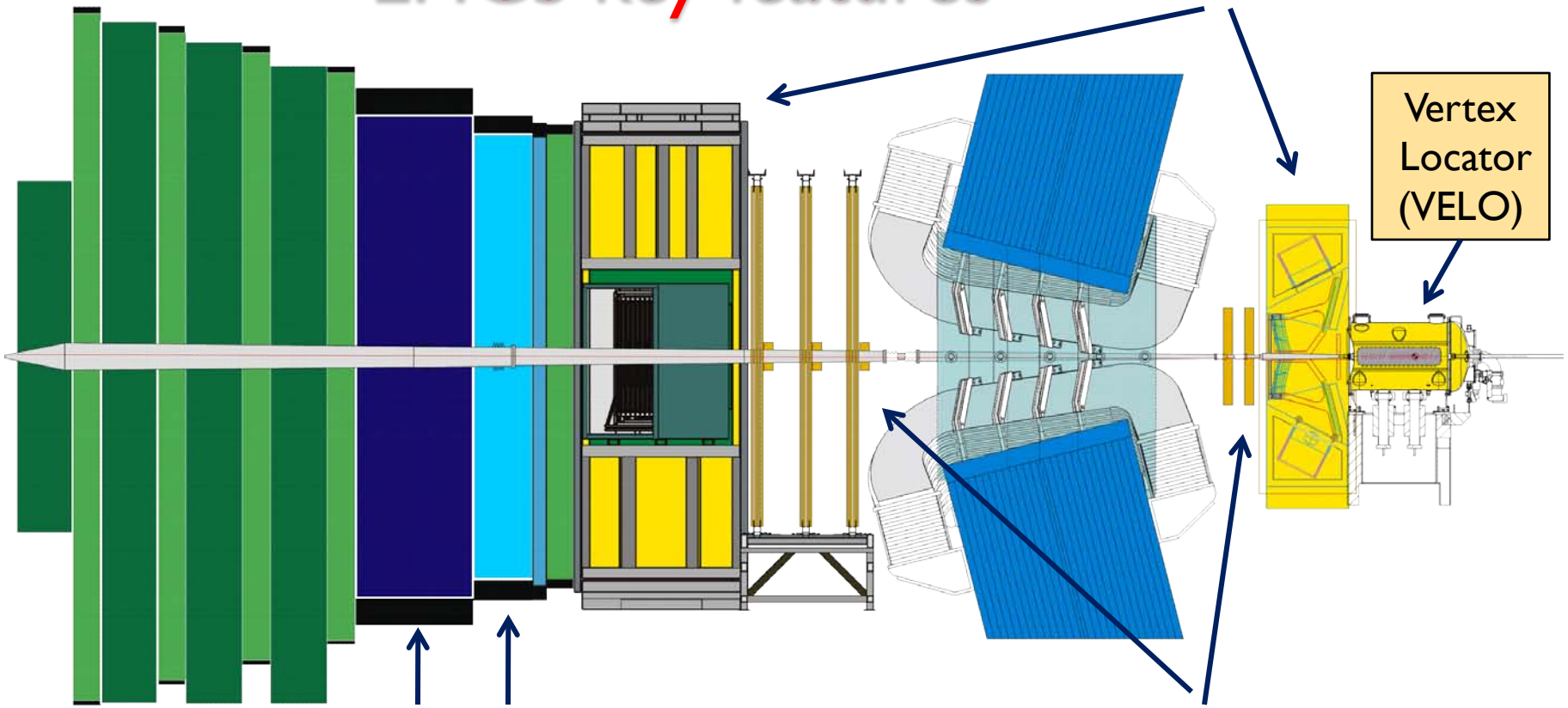
Introduction to LHCb





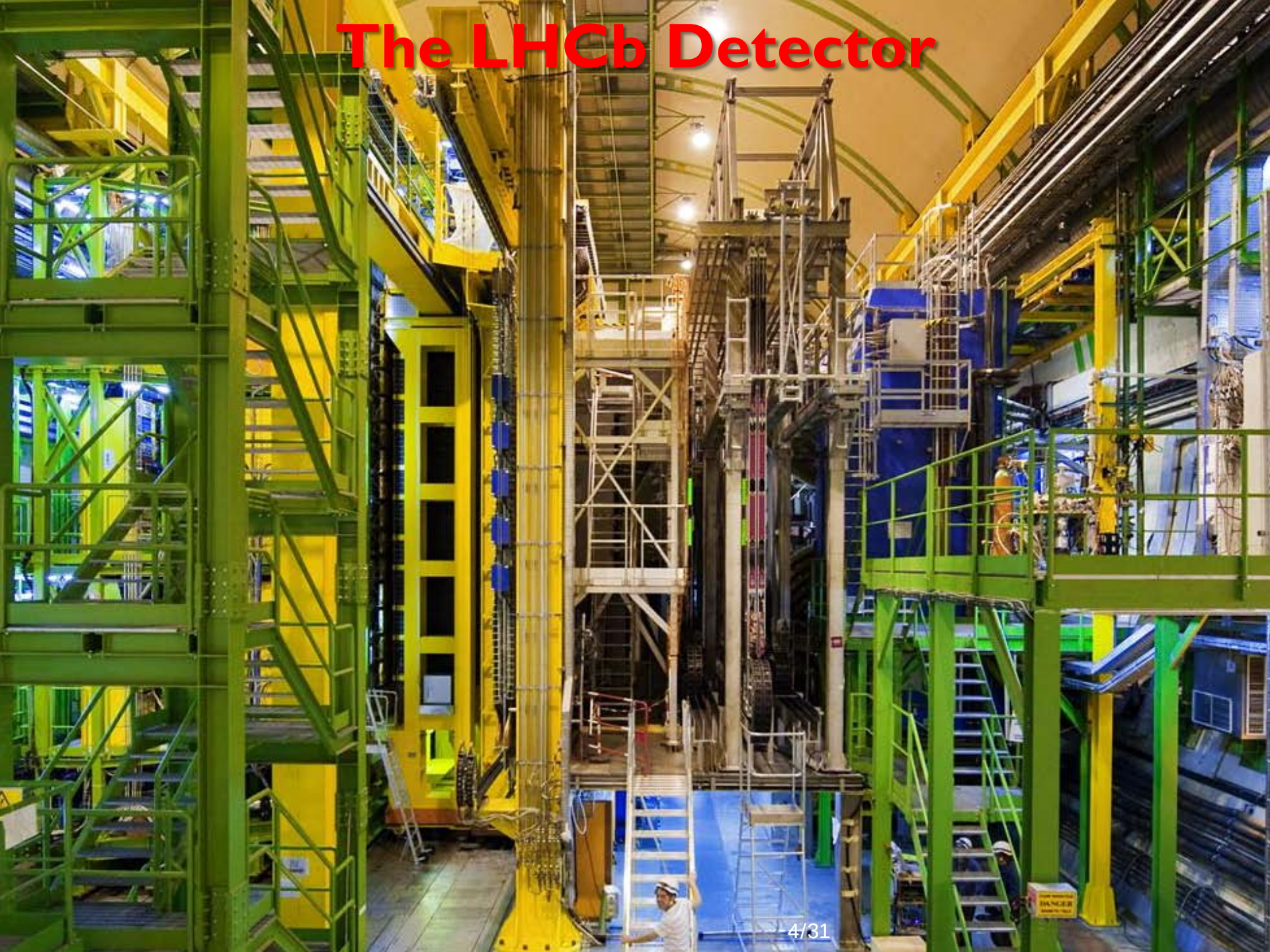
- LHCb dedicated to
  - CP violation and rare decays in the B-system
  - Search for new Physics
- Forward spectrometer ($1.9 < \eta < 4.9$)
- Only 2% of solid angle, but captures 27% of heavy quark production cross-section

LHCb key features

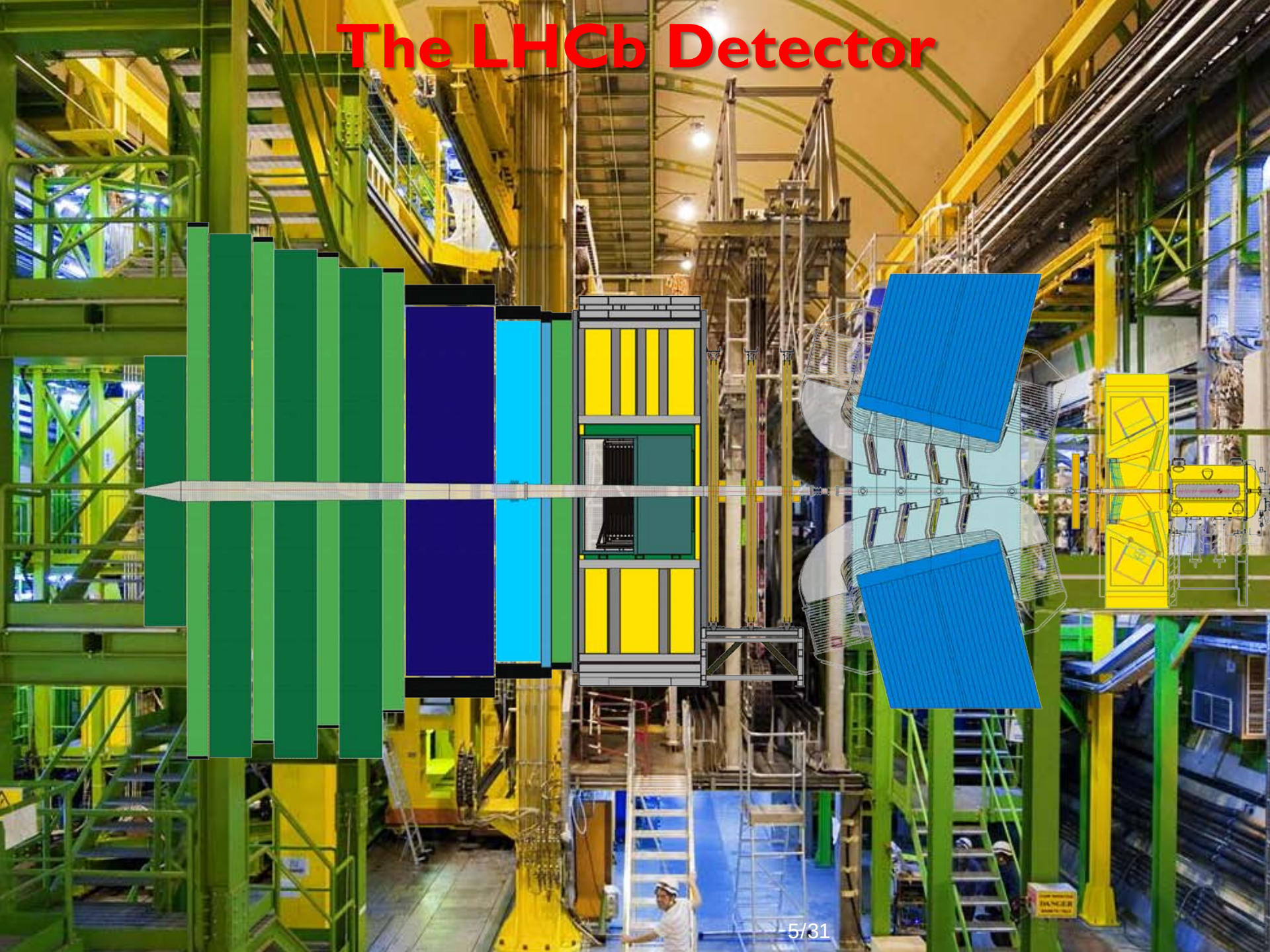


- Accurate vertexing
- Excellent mass resolution
- Particle Identification over large momentum range
- High performance trigger

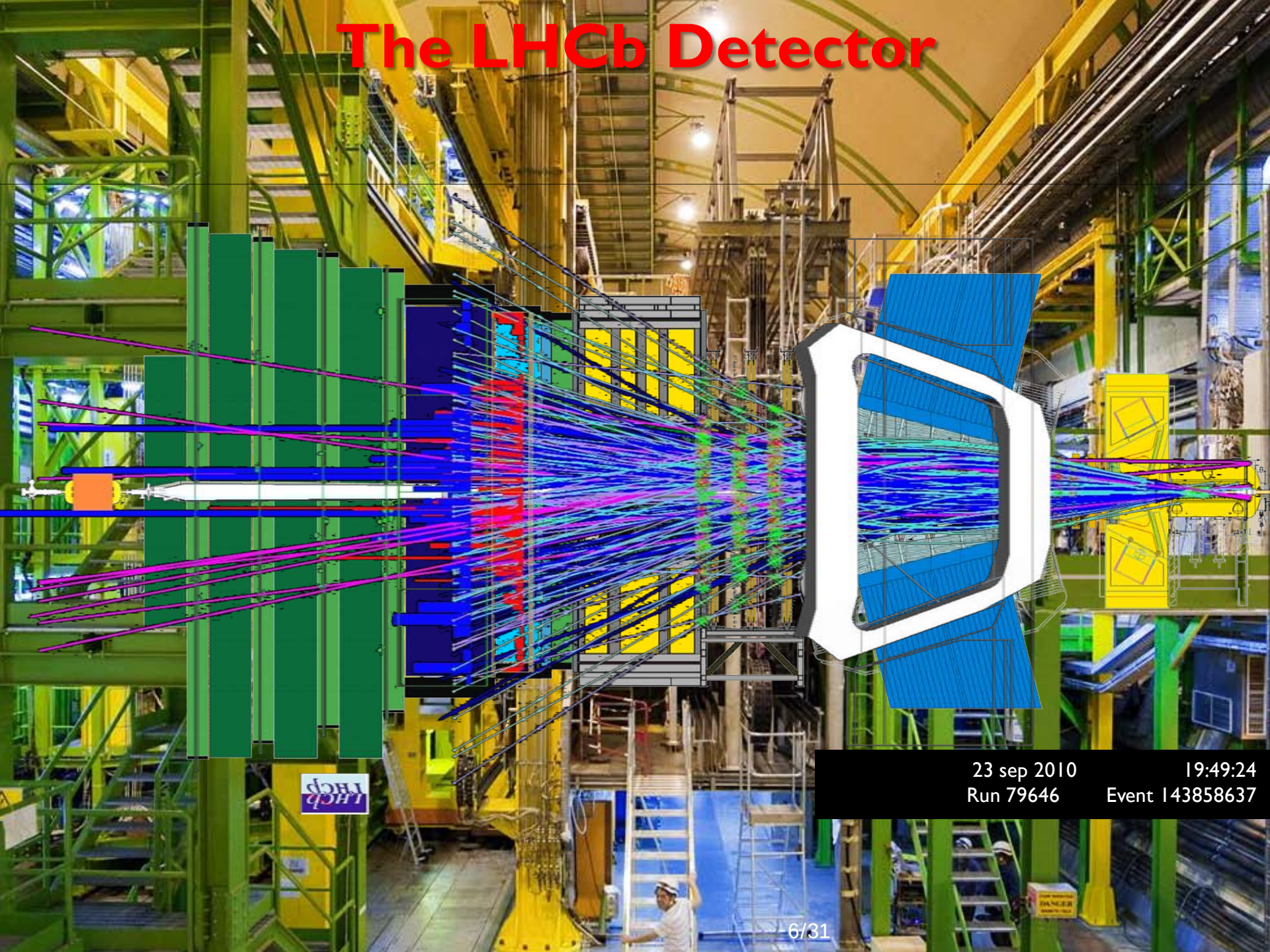
The LHCb Detector



The LHCb Detector

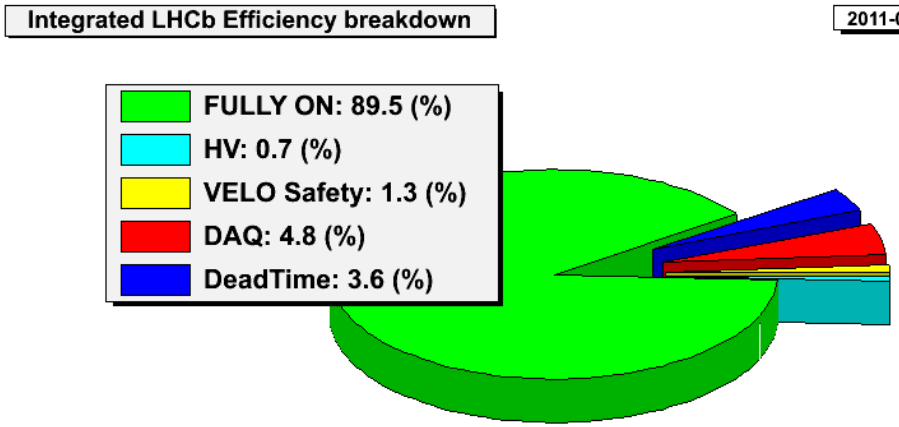


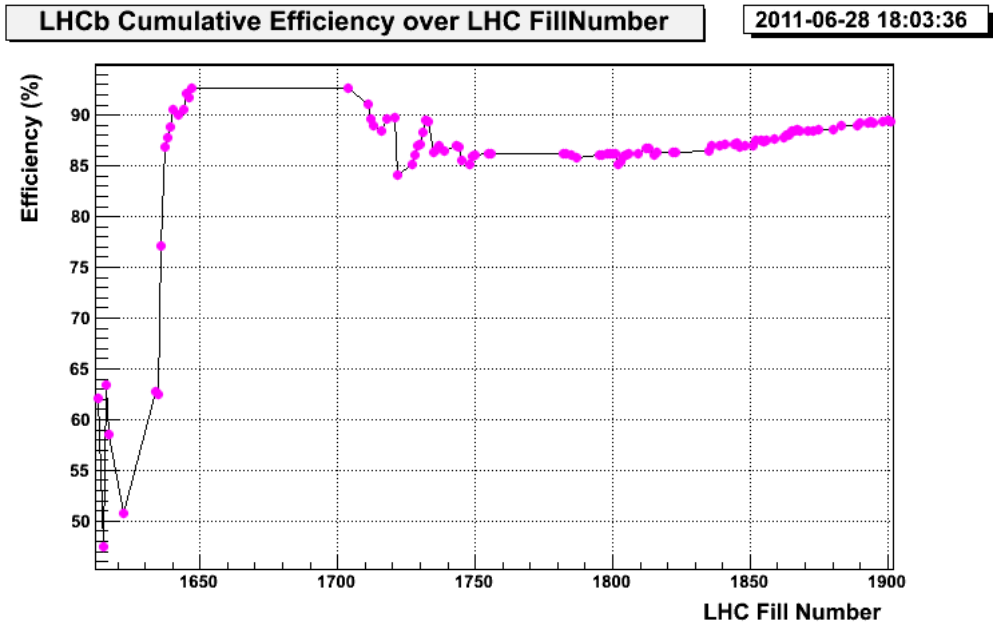
The LHCb Detector



Detector efficiencies

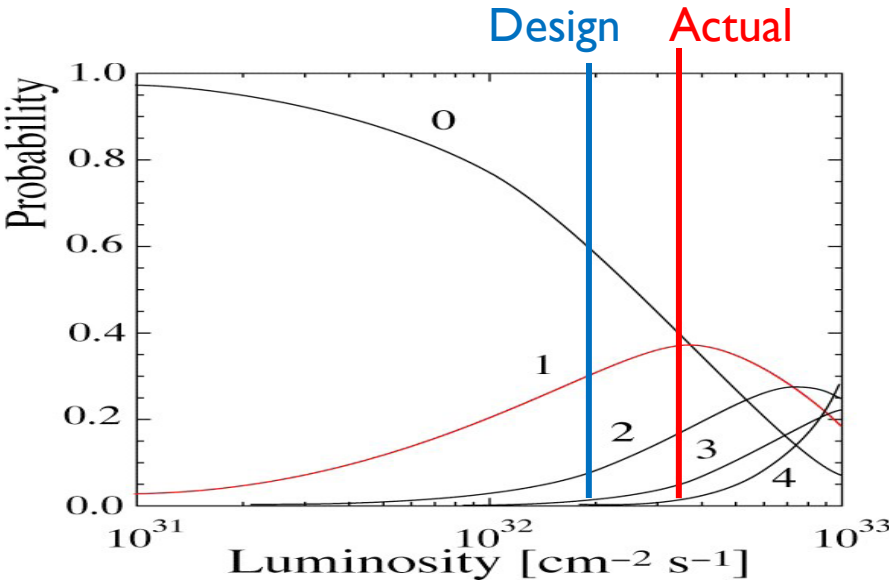
- Sub-detector efficiencies are high
  - Mainly loss due to dead channels
- Overall efficiency > 90 % for physics quality data
  - DAQ is halted if small fraction of detector not OK
  - Dead-time
- Cumulative efficiency ~ 90%
  - And going up!

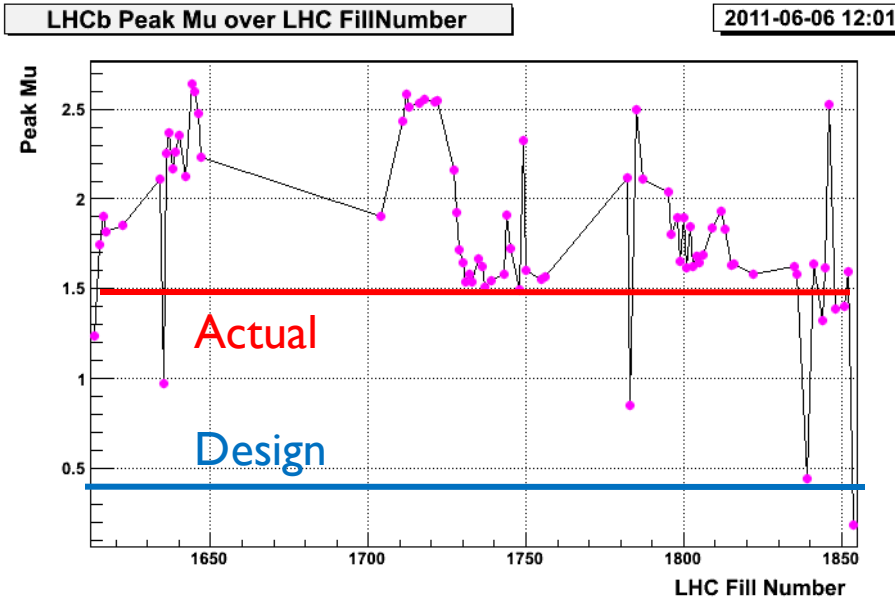




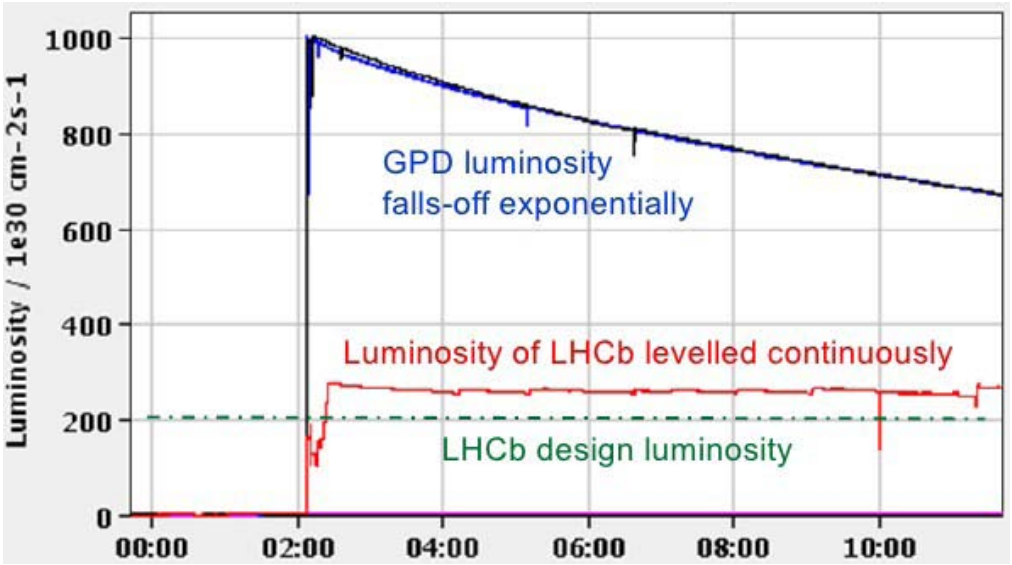
High luminosity running

- LHCb is designed to run at L = 2.10^{32}
- We run at 3.5 10^{32}
- With half the number of bunches in LHC !
- Price to pay is large pile-up
- -> average # of simultaneous PP interactions
  1.5 instead of design value of 0.4
- Sub-detectors performing okay at high lumi.
  - Occupancies for sub-detectors at the limit
  - Aging the detector at higher speed
- Trigger farm can cope with these busy event



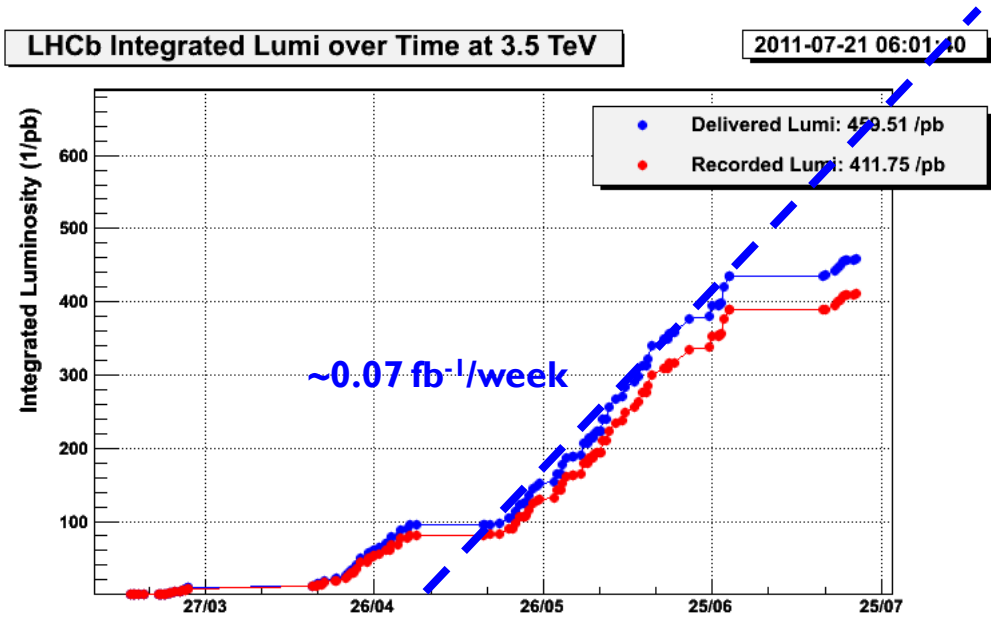


Running conditions



- Luminosity leveling by beam steering
- LHCb at max. luminosity during the whole fill

- 37.5 pb^{-1} collected in 2010
- ~400 pb^{-1} so far in 2011
  - Rate ~ 1 pb^{-1} / hour during fill
- expect >1 fb^{-1} this year



Trigger

Level-0 hardware trigger

- High P_t μ, e, γ, and hadron candidates
  - Typical thresholds μ ~1GeV/c, h,e,γ 3-4 GeV/c
- Output rate max 1.1 MHz
  - Currently ~750 kHz

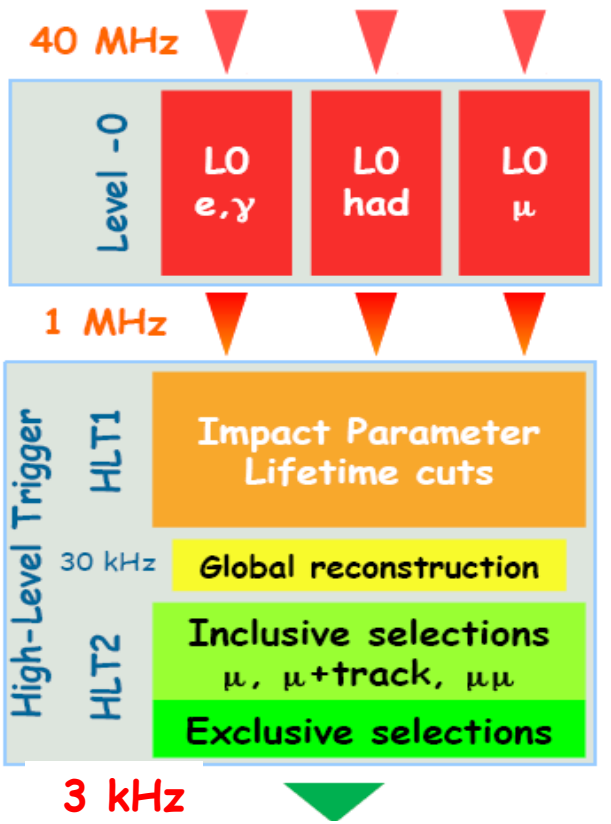
High level trigger (14k CPU cores)

HLT1:

- Add tracking info
- Large IP tracks, lifetime cuts

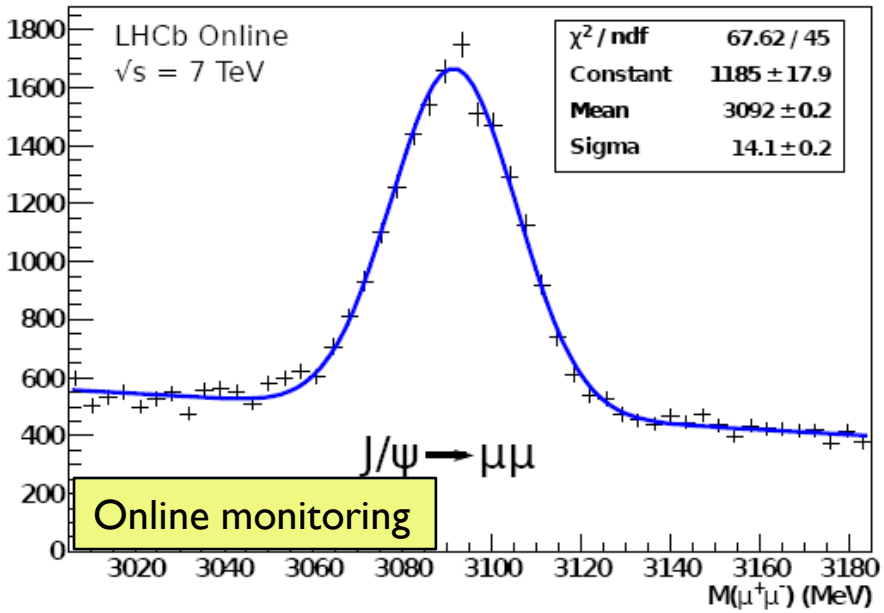
HLT2:

- Global reconstruction
- Inclusive and exclusive selection
- Output rate 3kHz
- L0xHLT efficiency



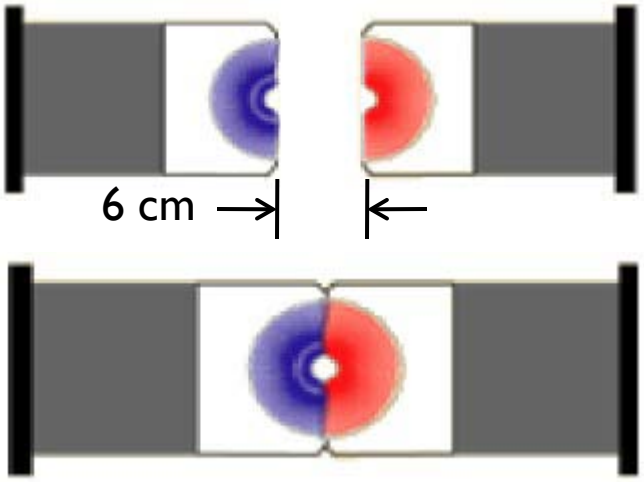
	Muon trigger (J/ψ)	Hadron trigger (D^0)
Data	94.9±0.2%	60±4%
MC	93.3±0.2%	66%

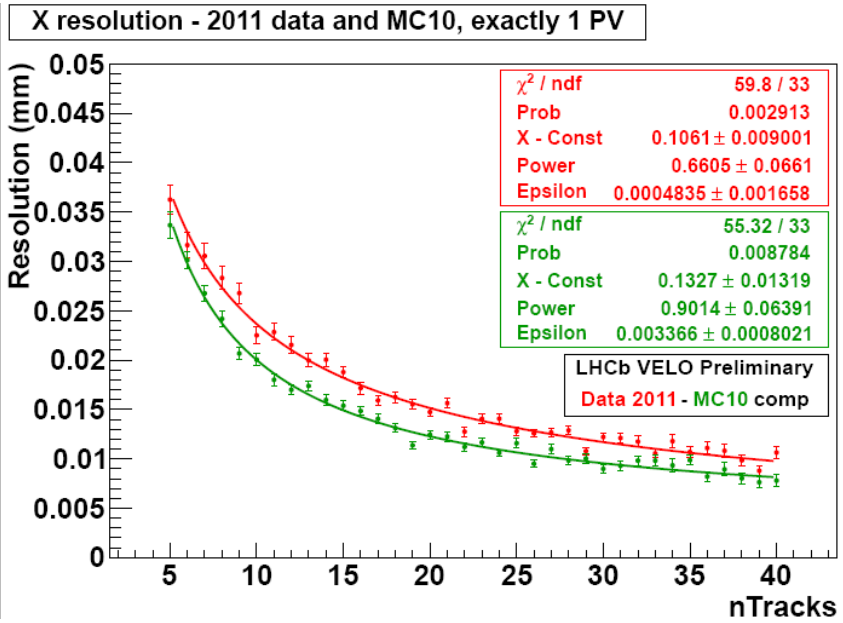
or performance

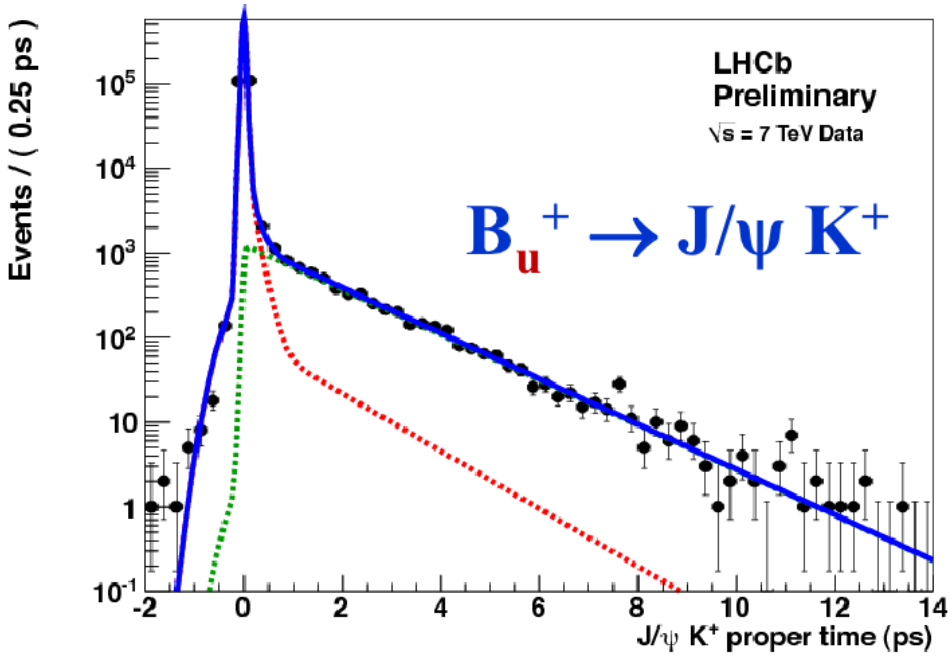


Vertex reconstruction

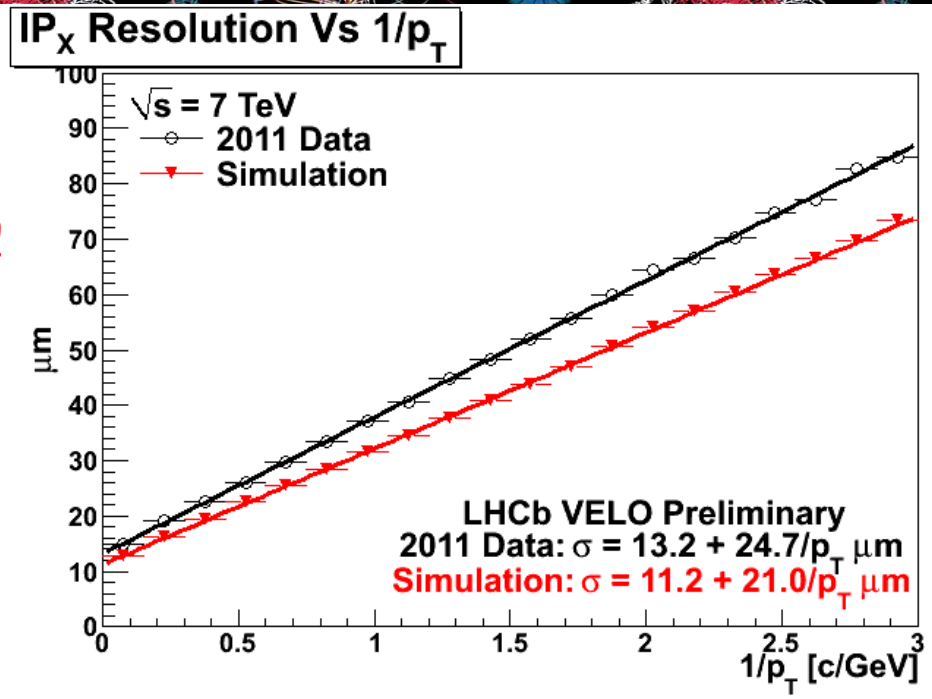
- VELO only 8mm from LHC beams during data taking
- Retracted by ±3 cm in between fills
- Primary vertex resolution for 25 tracks
- σ_x , σ_y = ~13 μm σ_z = ~ 70 μm
- Proper-time resolution $\sigma_t \approx 50$ fs
- Compare to B lifetimes: $\tau_B \approx 1500$ fs
- Measured lifetimes compatible with PDG values



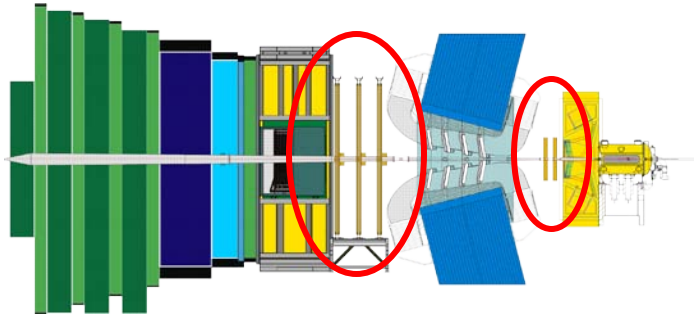




IP resolution



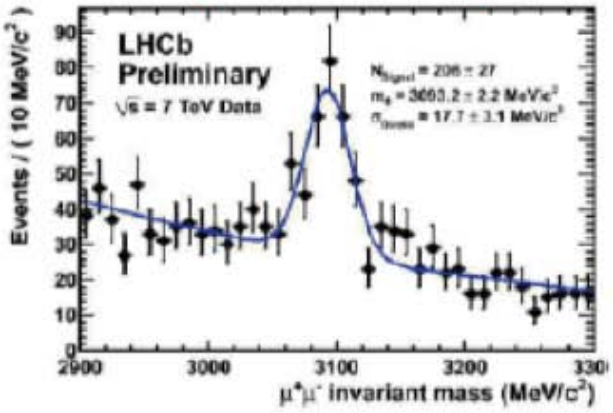
- Very good Impact Parameter resolution!
- Still significant discrepancy w.r.t. MC
- IP slope due to multiple scattering
- Too much material in VELO?
  - No big discrepancies found
- Too little material in MC?
  - Complex shape of 'beam pipe'
- Also investigating multiple scattering modeling in Geant4
- Not conclusive yet



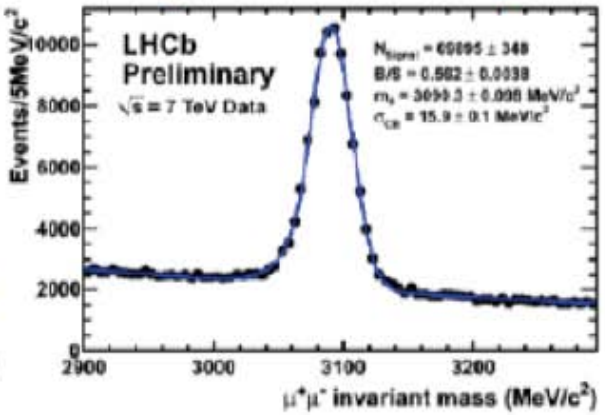
Tracking & Alignment

- Tracking stations before and after (empty) magnet
  - Long arm
- Excellent mass resolution

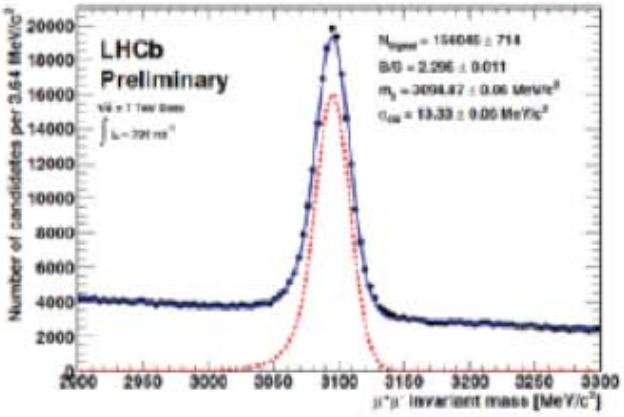
May: σ ~ 18 MeV/c²



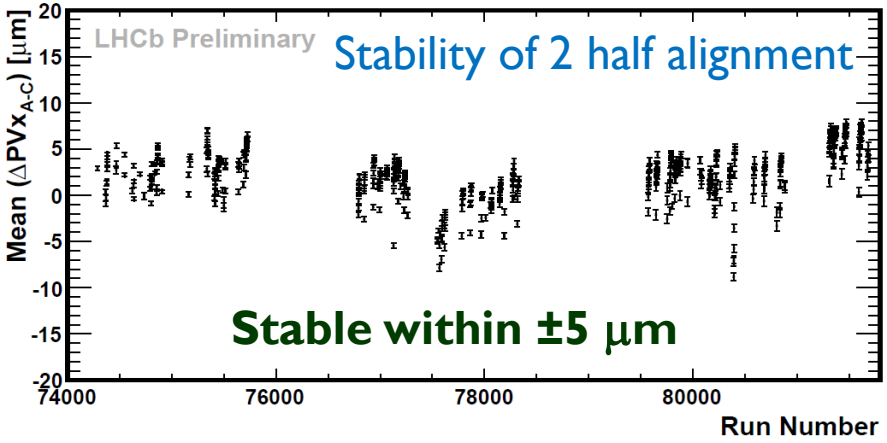
August: σ ~ 16 MeV/c²



November: σ ~ 13 MeV/c²

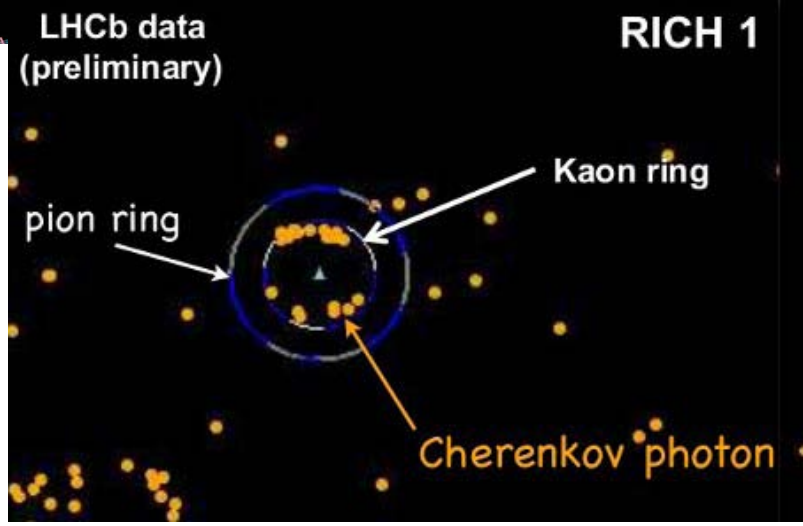


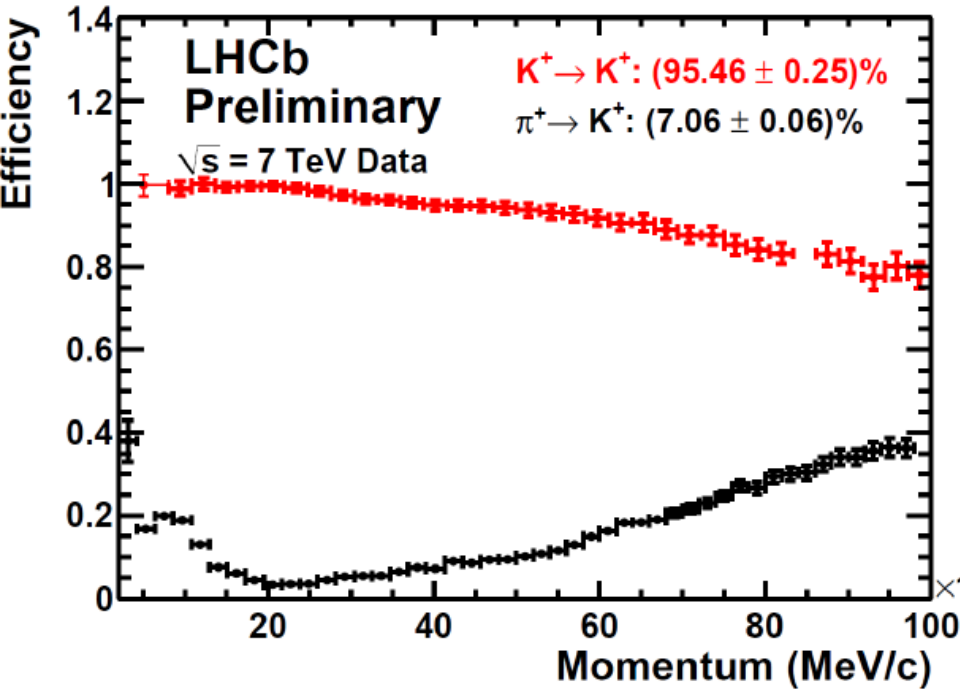
1) VELO internal alignment
2) Y-alignment of Si. detectors before and after magnet
3) Align Spectrometer



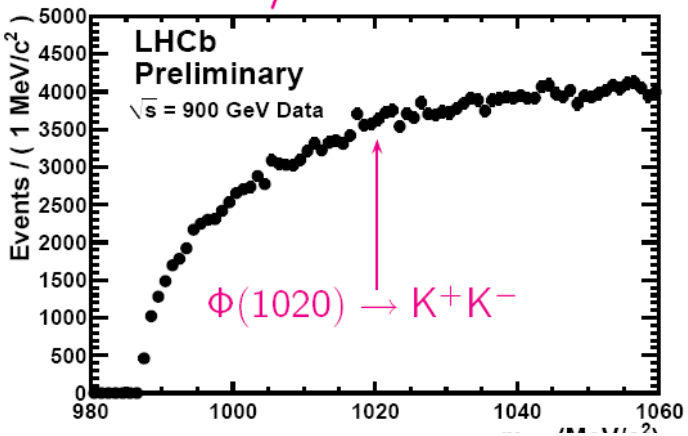
Particle identification

- π/K separation
- two RICH detectors with three radiators to cover 100 GeV/c momentum range
- photon-detection in pixel-HPDs
- performance close to simulation for all momenta

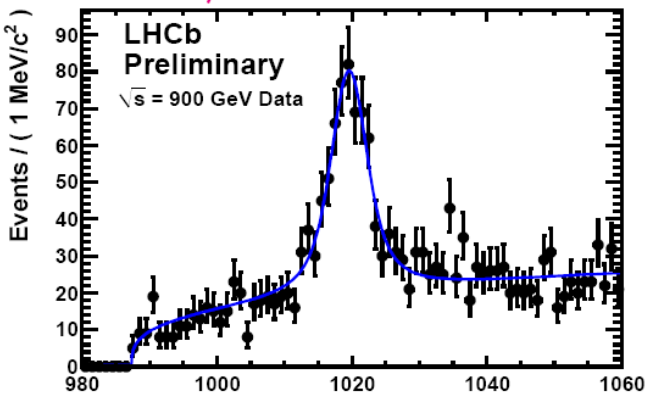




w/o RICH PID

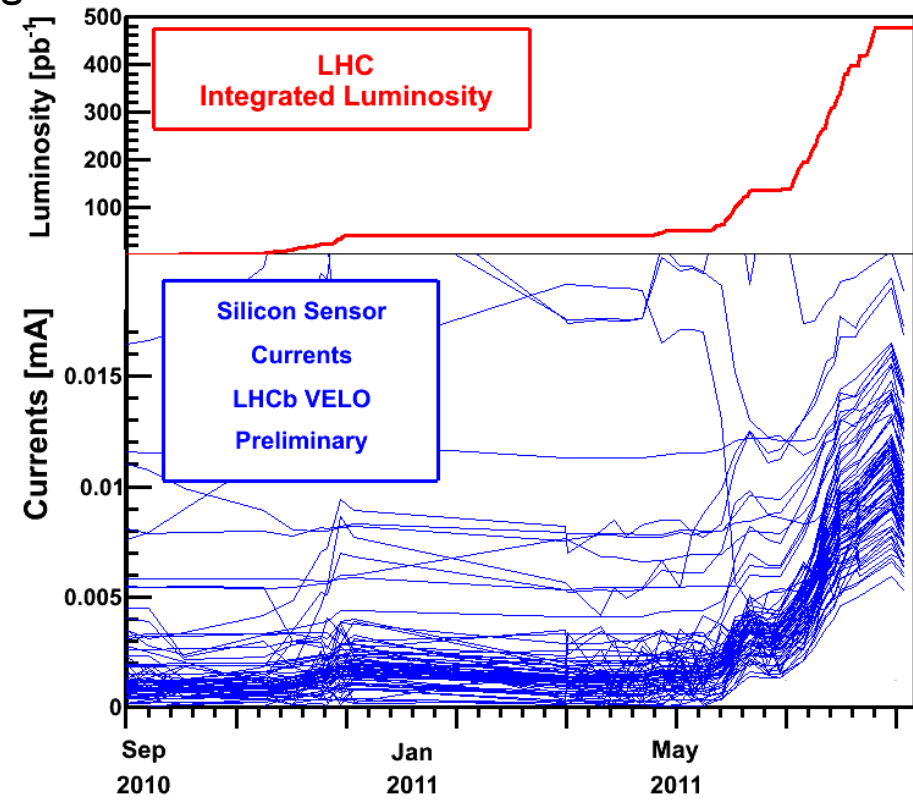


w/ RICH PID



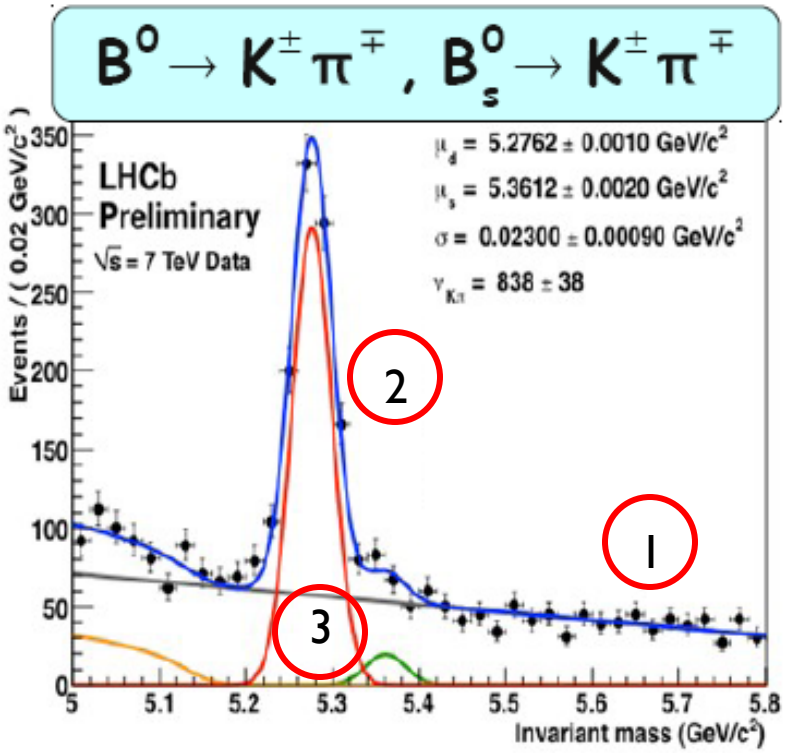
Outlook: Radiation damage

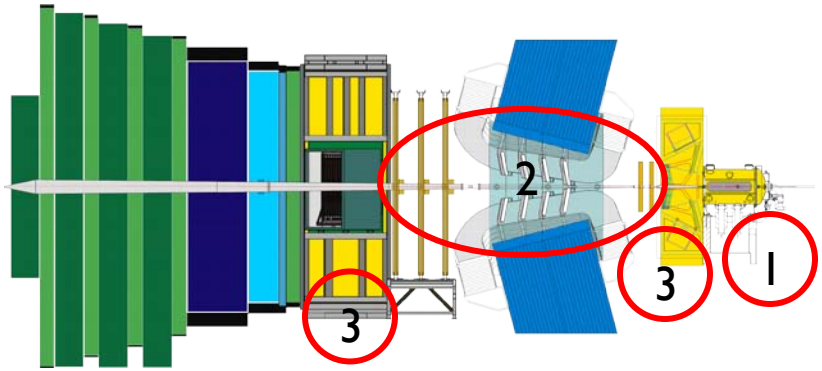
- Running at twice the luminosity -> aging double speed
- Collect 1 pb^{-1} per hour, VELO designed for 6 fb^{-1}
  - Tip of sensor at 8 mm from beam
  - Current VELO will reach end of life before upgrade
  - Replacement being built, ready end 2011
- Detector exposed to ~0.5 fb^{-1}
  - -> clearly see effects of radiation damage
- Silicon leakage current increase
  - within expectation (error bars still large)
- Type inversion of sensors with low initial depletion voltage



See poster of Christian Färber on Radiation Damage @ LHC for details

Summary: key performance in one plot





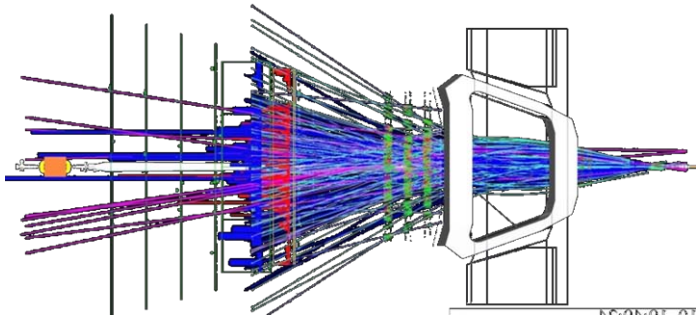
1) VELO proper time resolution-> low background

2) Tracking stations
-> excellent mass resolution

3) Two RICH detectors
-> Particle Identification
-> distinguish Kπ from KK, ππ

Summary / Outlook

- LHCb is running very successfully at twice the design luminosity
- And 4 times the number of visible interaction per bunch crossing
- Collected >450 pb^{-1}
- Data-taking efficiency ~ 90% and going up
- Excellent mass and proper time resolution, and PID
- Hence producing very nice physics results
  - Quite a few "world best" results already
- Signs of radiation damage/aging visible
  - Within expectation



- Also working on upgrade, see Burkhard Schmidt's talk later today

Thank you