LHCb Tracking system and its performance

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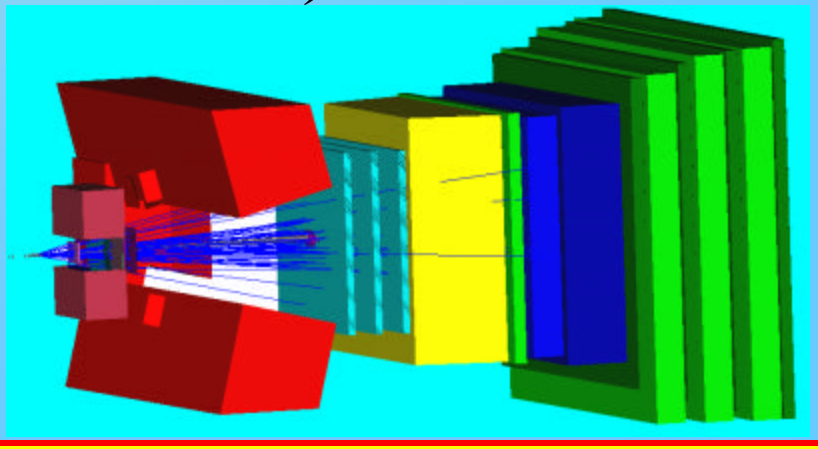
(On behalf of the LHCb collaboration)

Outline:

- The LHCb detector
- Tracking sub detectors
- Tracking performances
- Conclusion

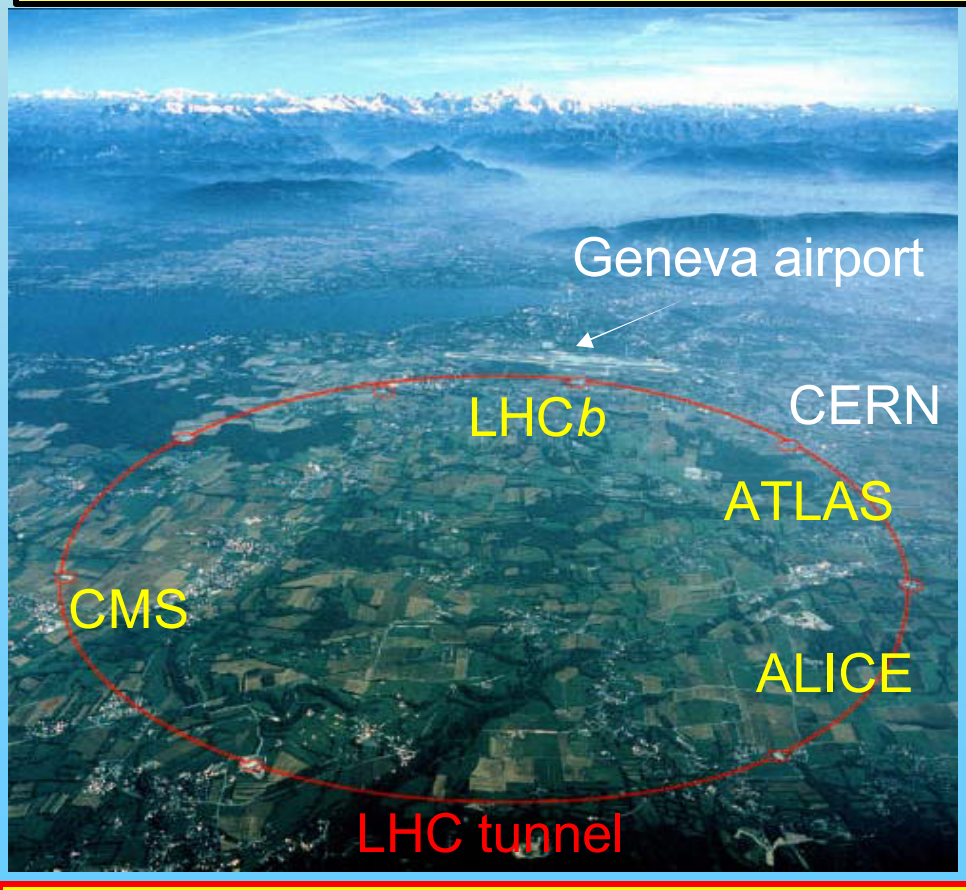


The Large Hadron Collider (LHC)

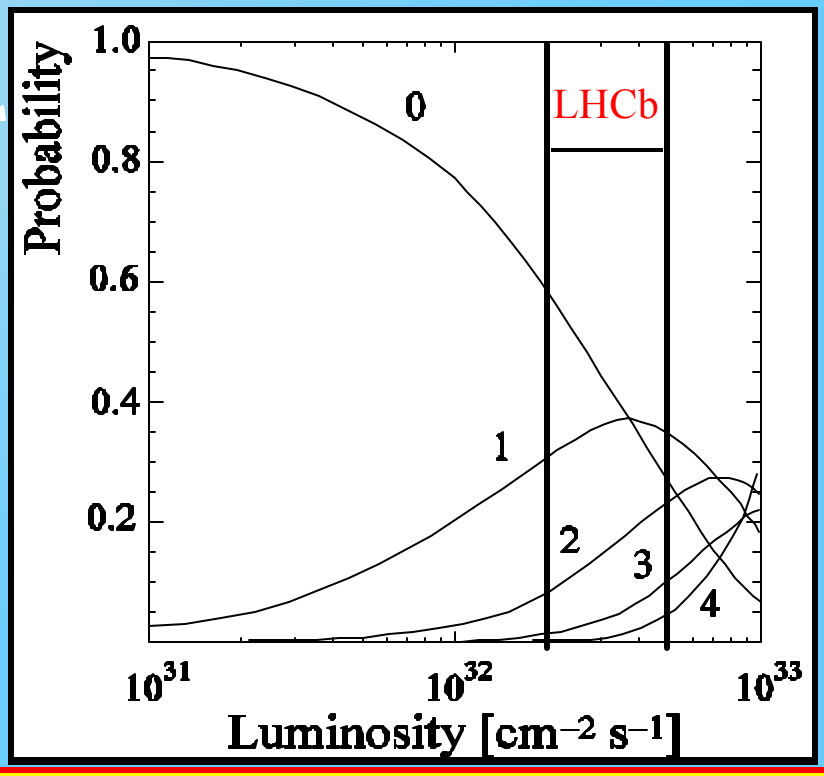
Start: Summer 2007

LHC
p-p collisions with 14 TeV
Bunch crossing @ 40MHz (25 ns)

LHCb:
L ~ 2 .10^{32} $cm^{-2}s^{-1}$ (mostly single interactions)
~ 14 Million collisions per second
1 in 160 collisions is B physics

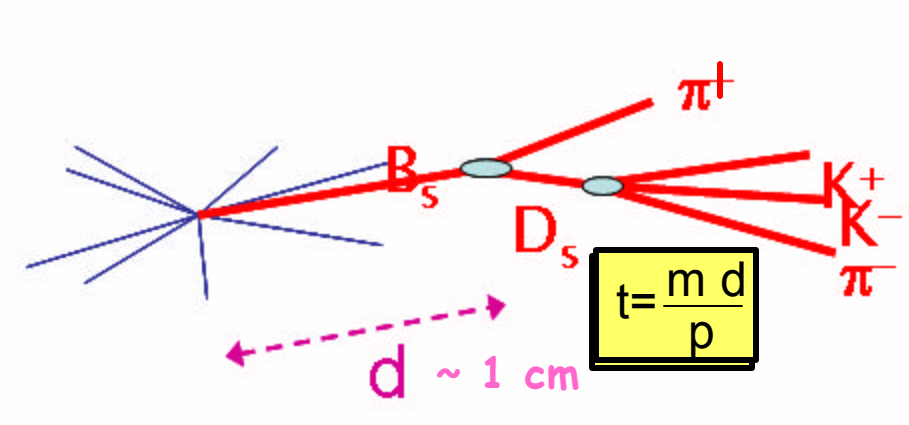


Inelastic pp collisions/crossing



Physics motivations

Example: $B_s \rightarrow D_s \pi$

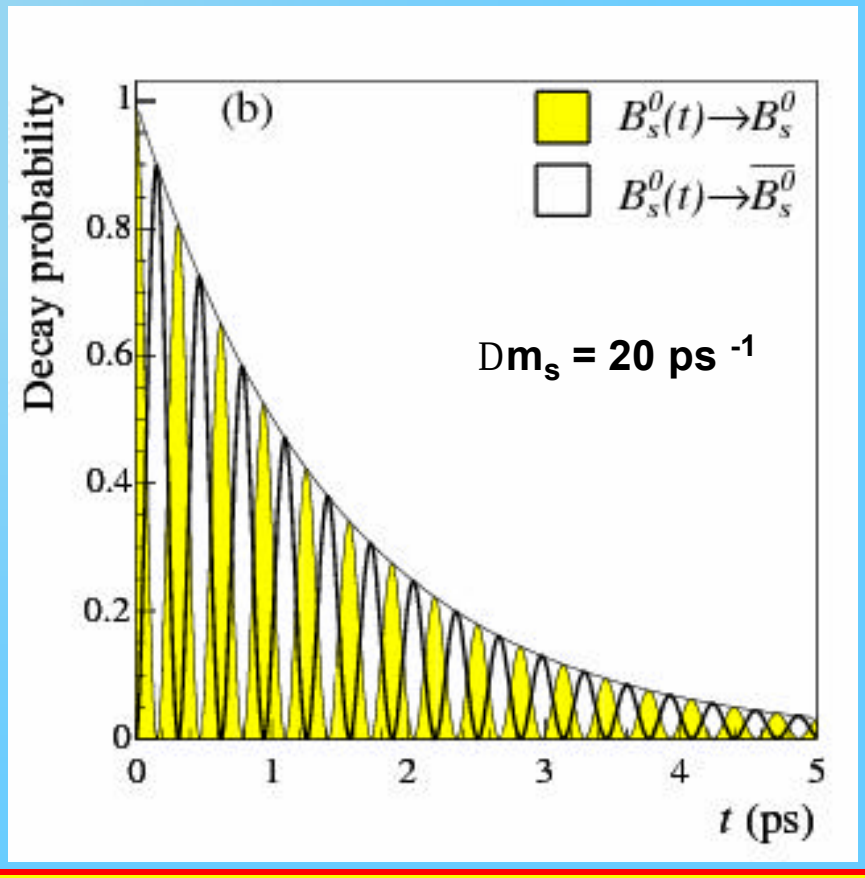


Bs oscillation

To measure Δm_s you need

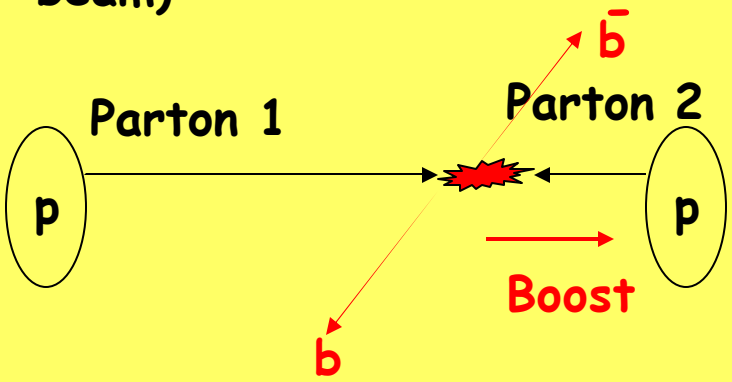
- Good vertex resolution

- Good proper time resolution



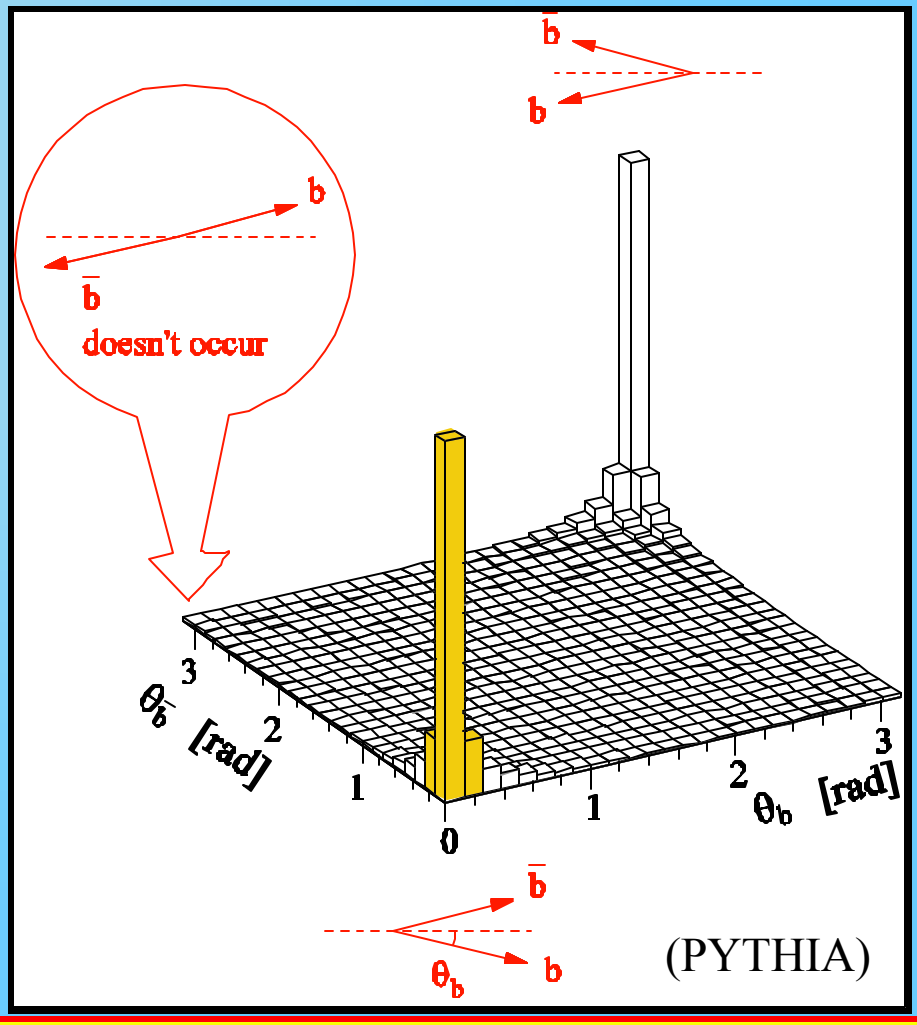
B production

- B hadrons are mostly produced in the forward direction (along the beam)

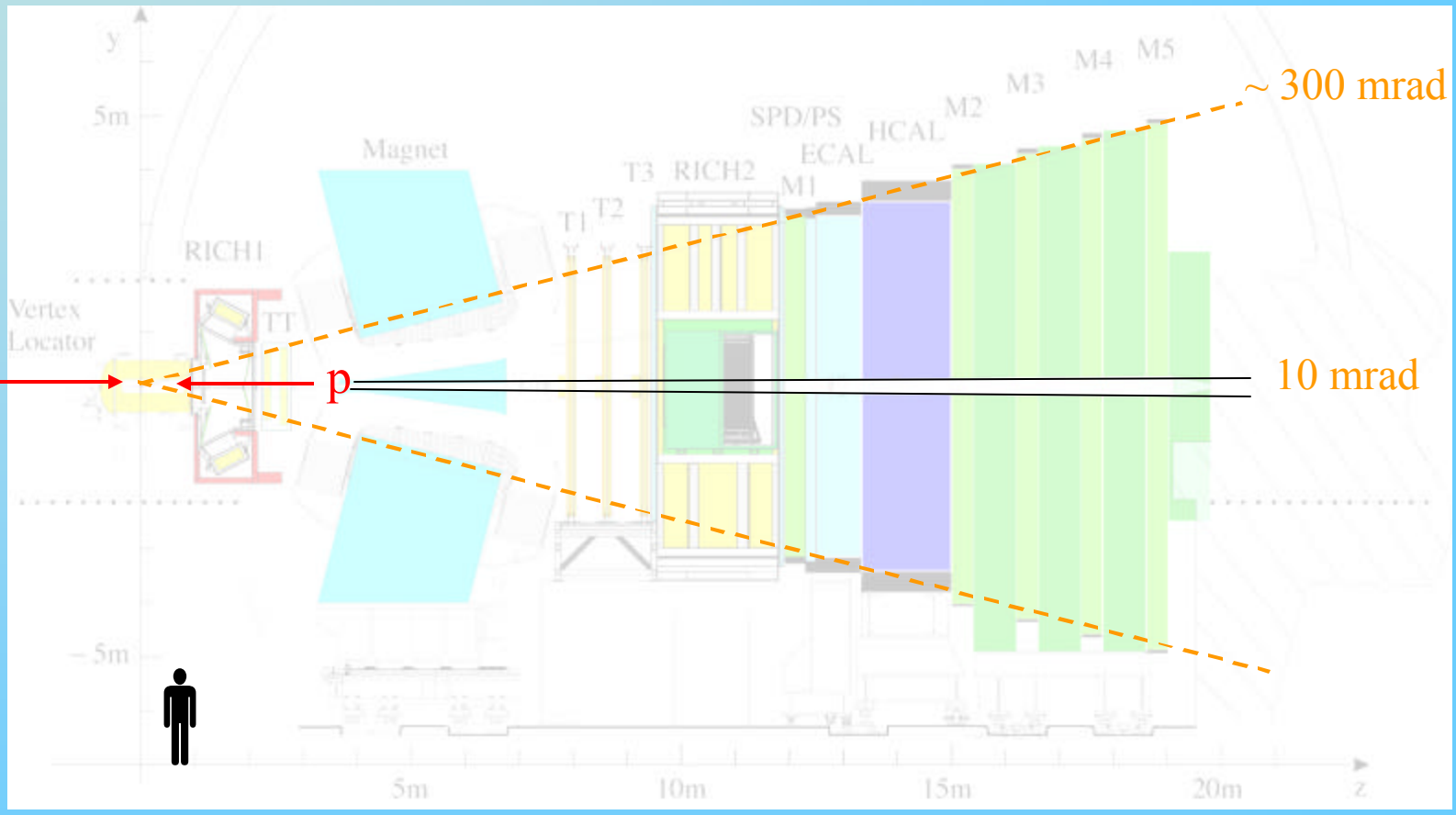


- Choose a forward spectrometer 10–300 mrad
- Both b and $\bar{b}$ in the acceptance: important to tag the B flavour at production.

b–$\bar{b}$ correlation

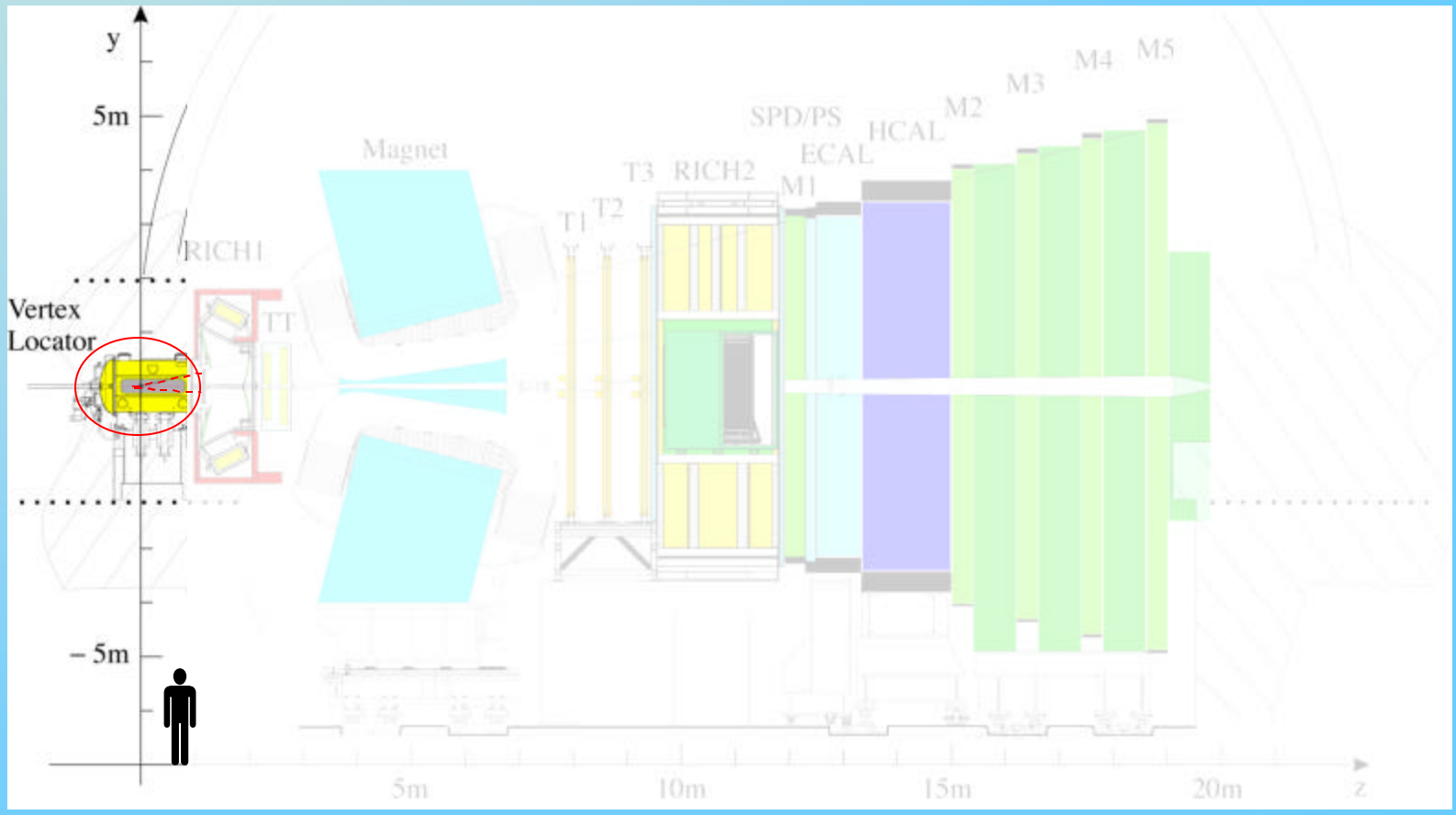


LHCb Detector



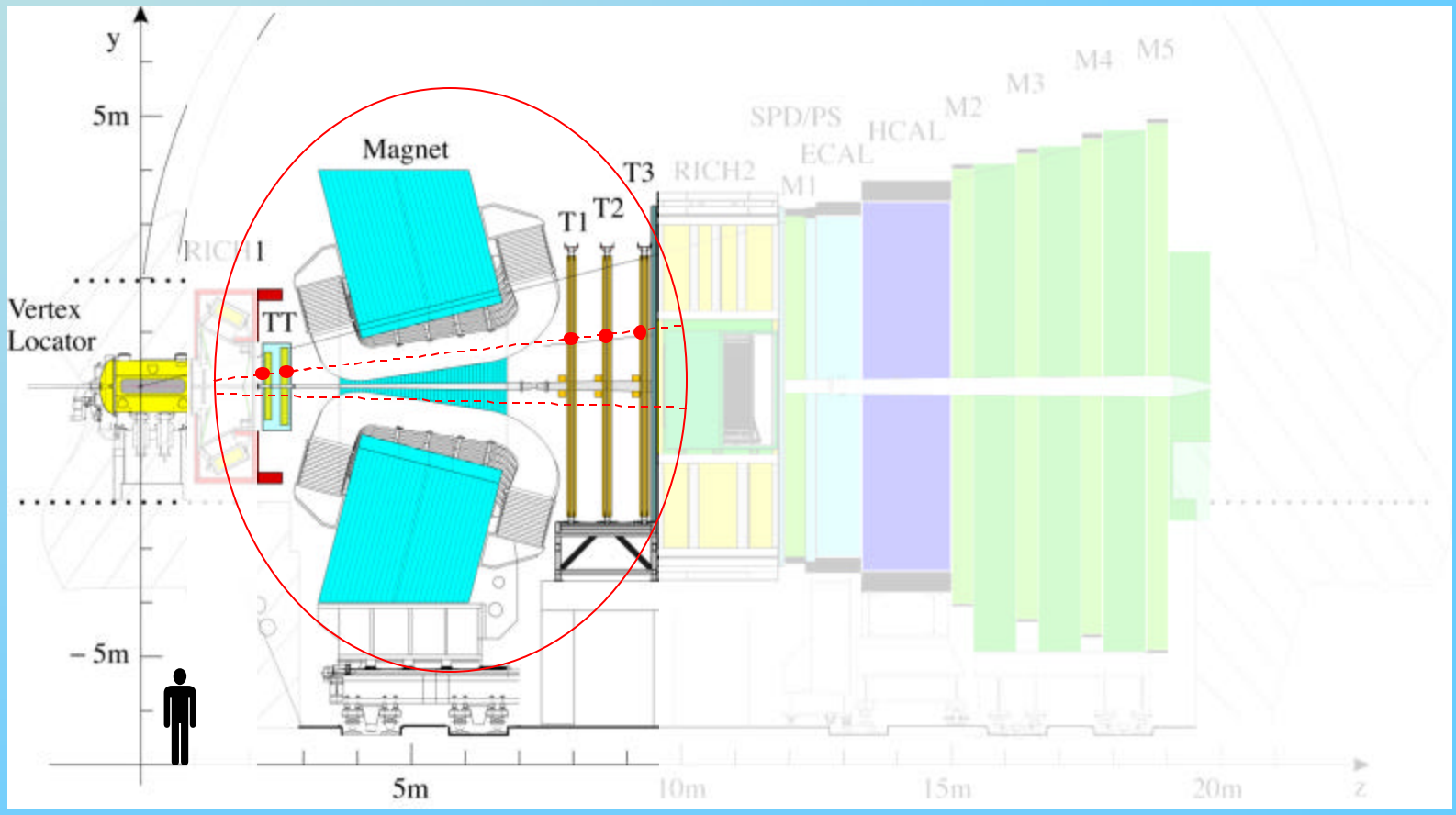
Forward spectrometer (running in pp collider mode)

LHCb Detector



Vertex locator around the interaction region

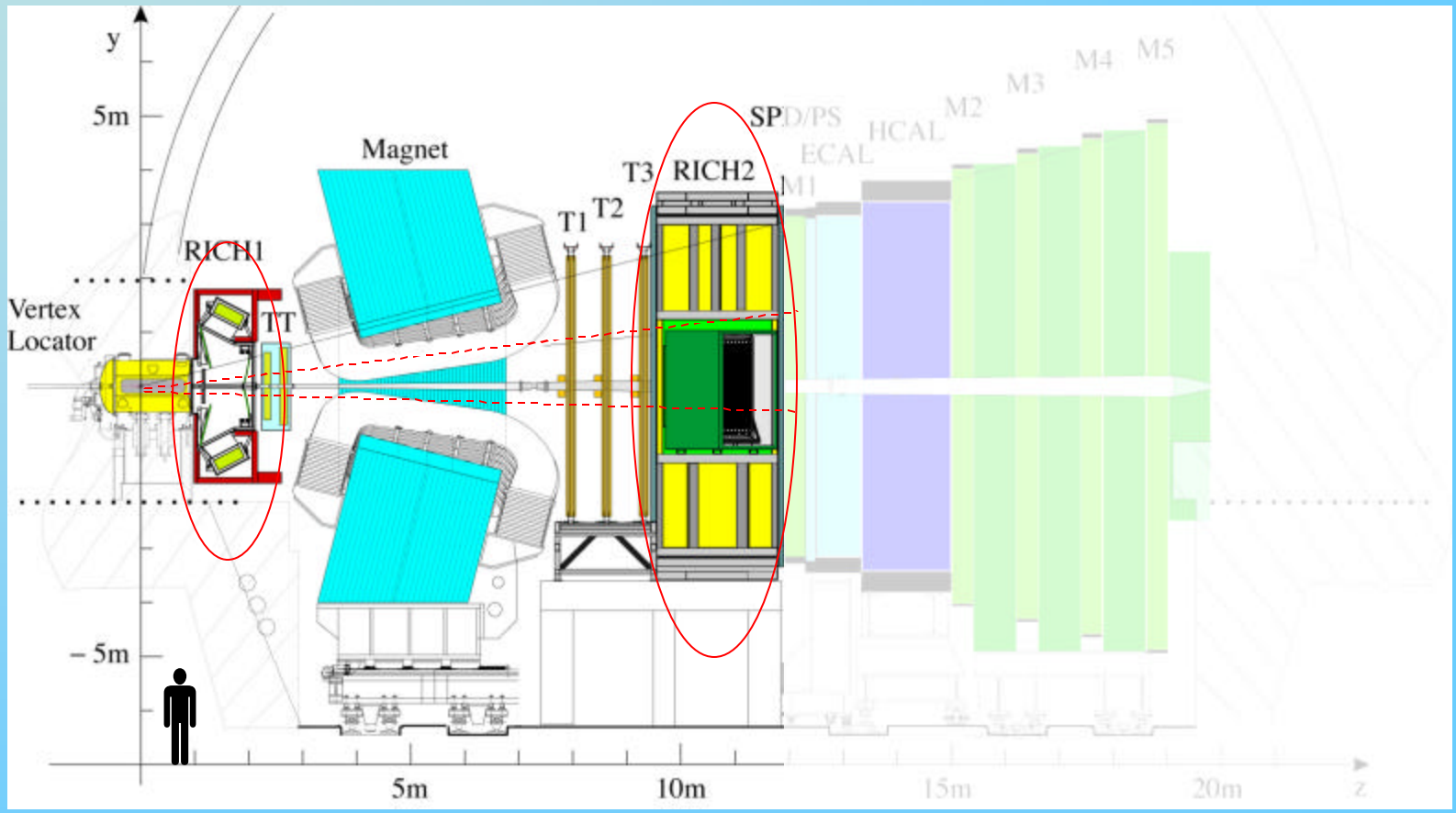
LHCb Detector



Tracking system and dipole magnet to measure angles and momenta Dp/p ~ 0.4 %

Magnetic field regularly reversed to reduce experimental systematics

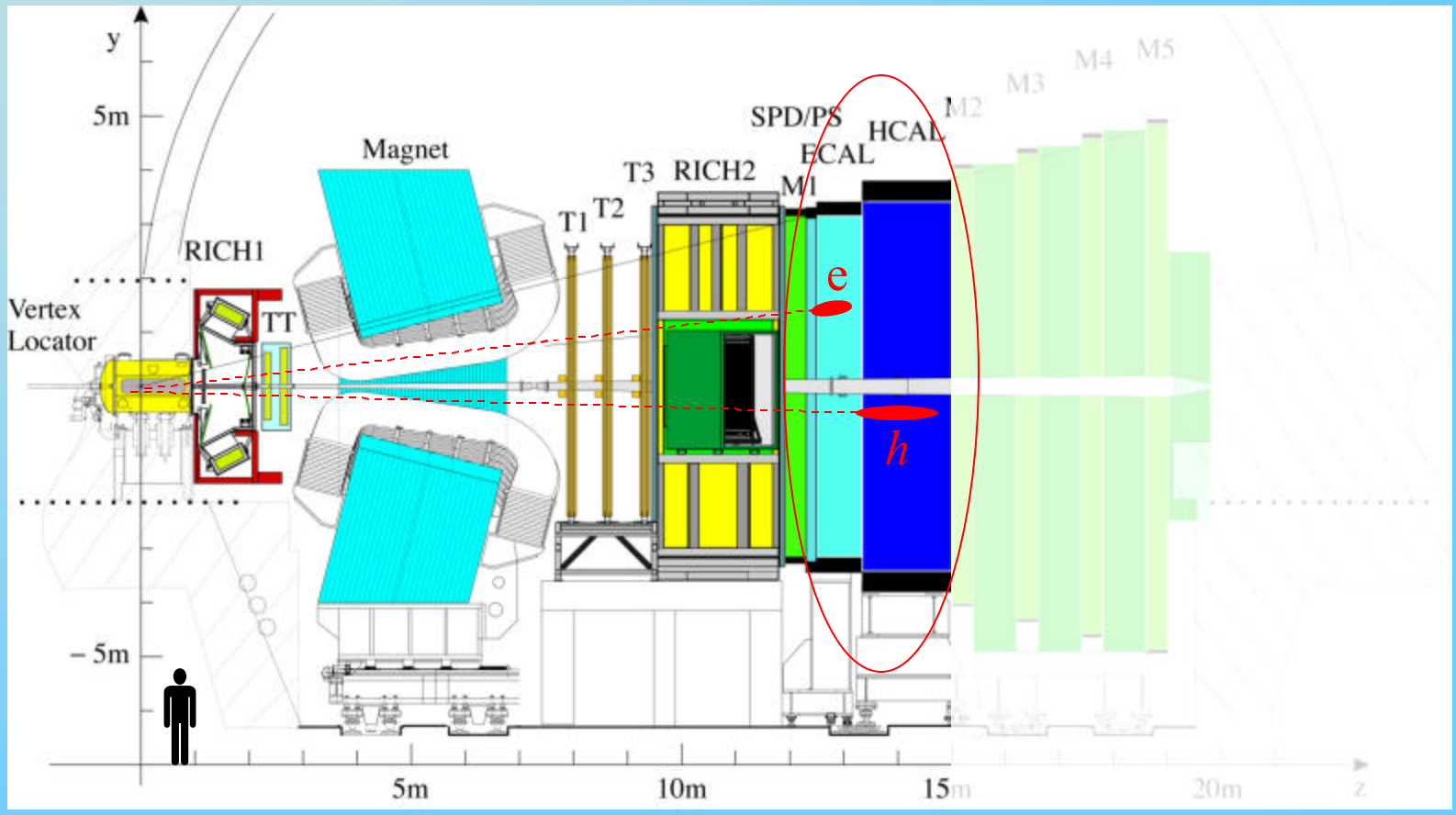
LHCb Detector



Two **RICH** detectors for charged hadron identification

Provide > **3**σ $\pi \setminus \kappa$ separation for 3 < p < 80 GeV

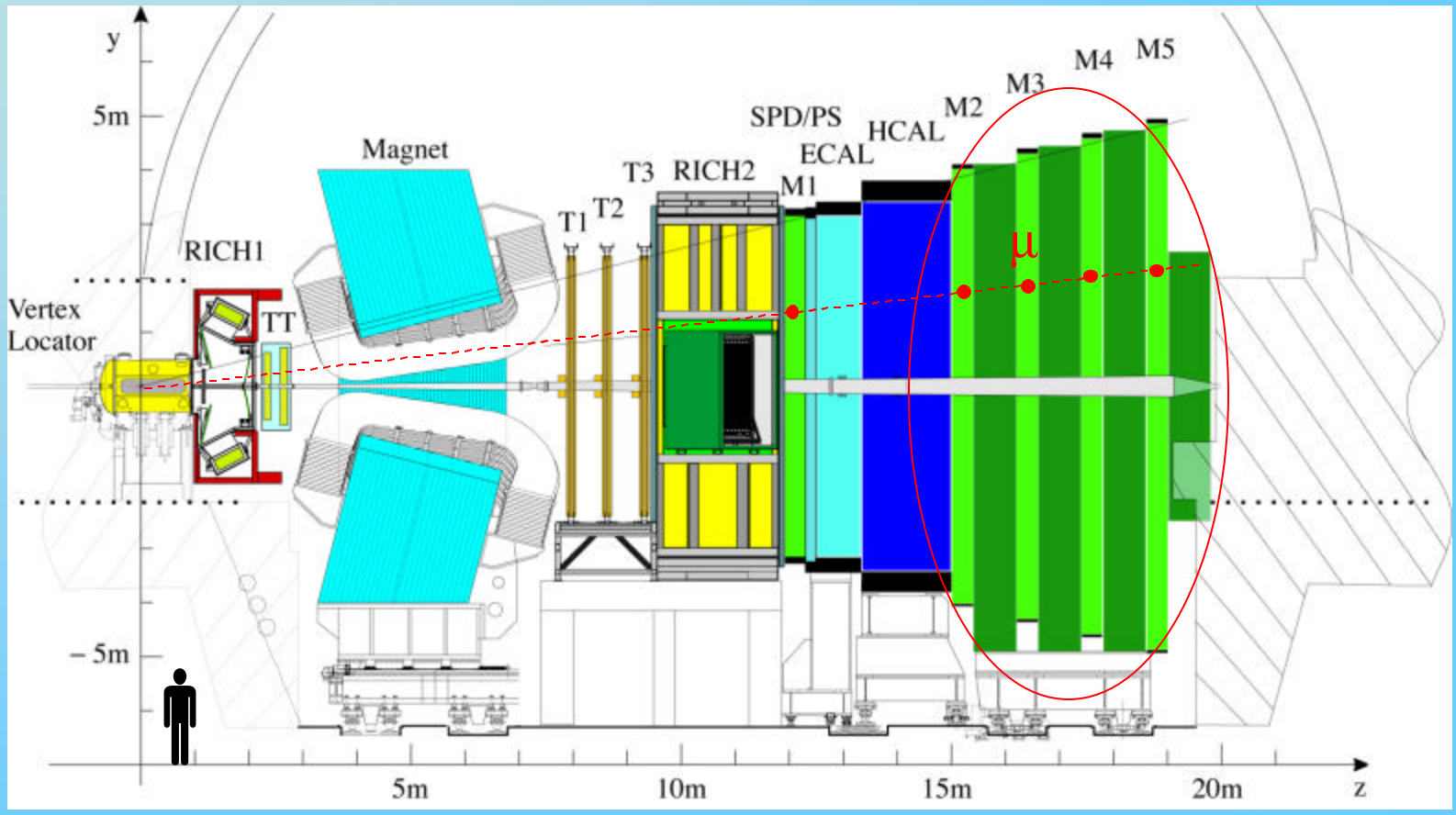
LHCb Detector



Calorimeter system to identify electrons, hadrons and neutrals

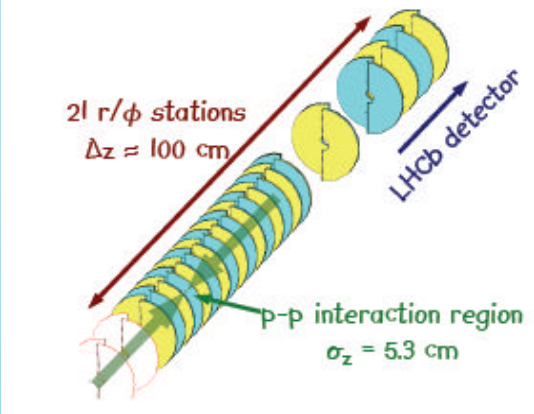
Important for the first level of the trigger

LHCb Detector



Muon system to identify muons, also used in first level of trigger

The Vertex Locator (VeLo)



Vertex Locator:

- 21 stations Single Silicon R/φ sensors.
- Occupancy 0.5%

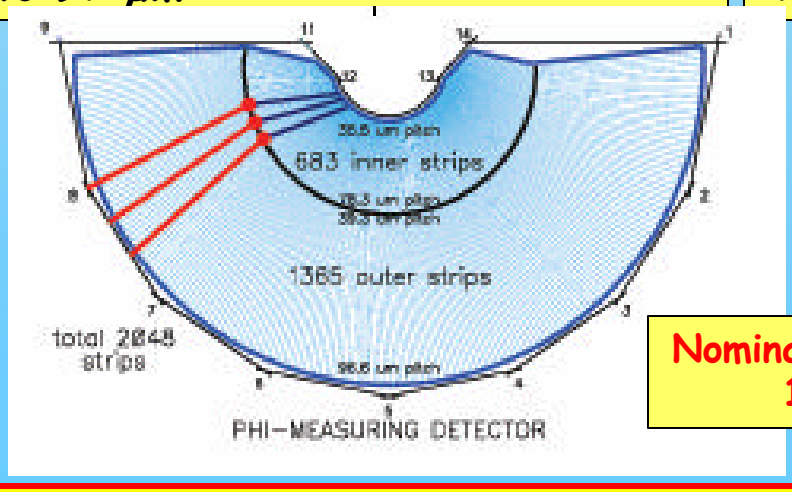
Optimized for ⇒ Trigger application: R/φ geometry for fast 2D tracking in rz plane

⇒ Main tracking upstream

⇒ Precise reconstruction of decay vertices

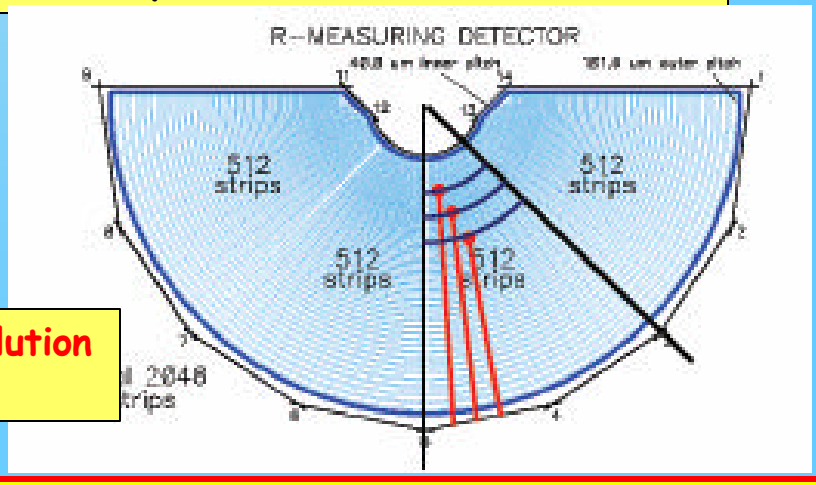
φ Sensors

- 2048 Strip divided inner/outer region
- Strip pitch increases with radius from 36 μm to 97 μm



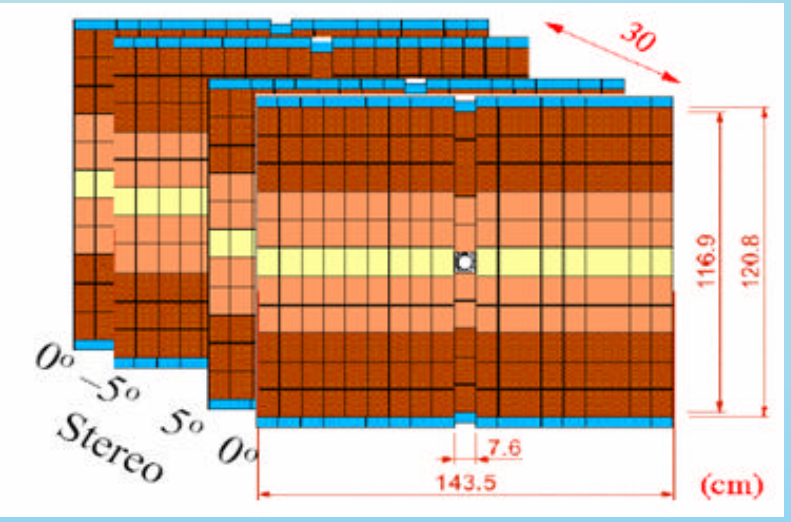
r Sensors

- 2048 Strip divided into 45° sectors
- Strip pitch increases with radius from 40 μm to 100 μm

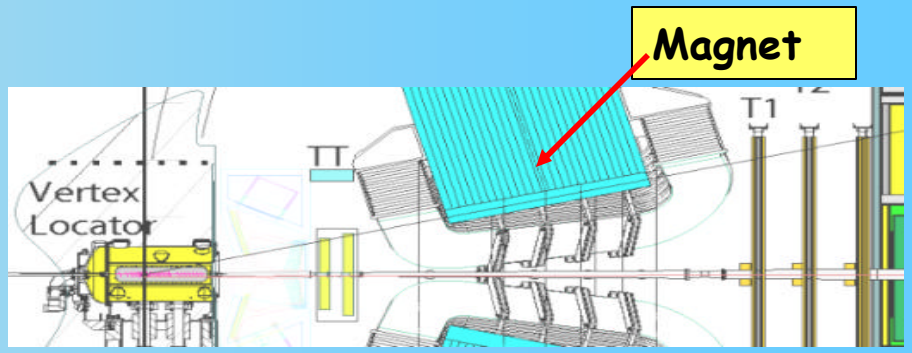


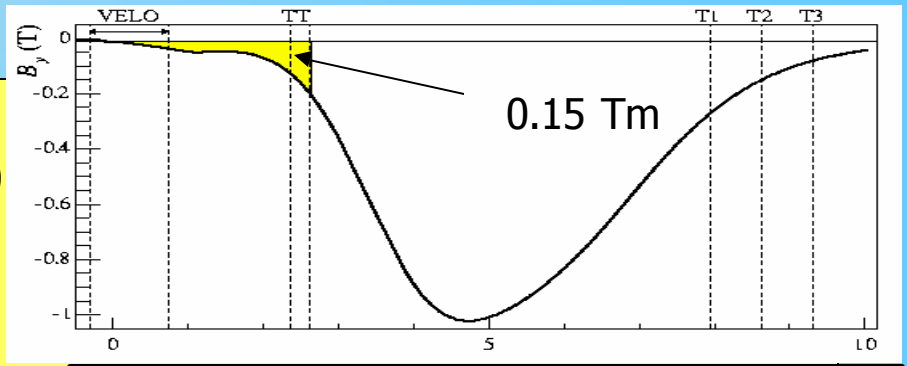
Nominal resolution 10 μm

The Trigger Tracker (TT)



Used in Trigger decision.
Estimate of momentum



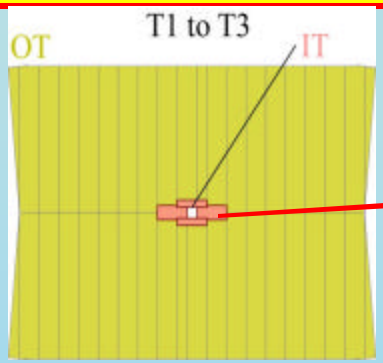


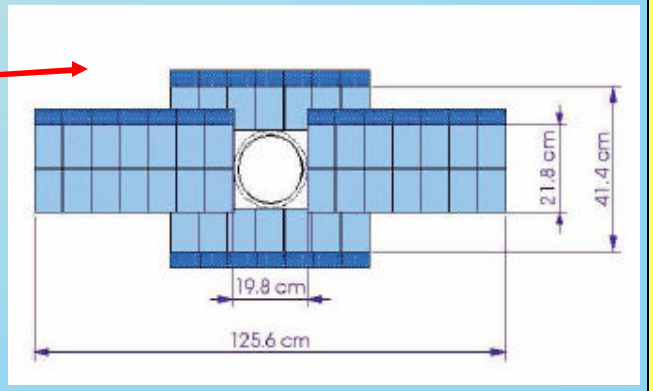
Trigger Tracker

- Silicon micro strip detector (full acceptance)
- 4 layers (0°,+5°,-5°,0°) - 30 cm split
- Layer made of sensors 11 cm by 7.8 cm
- Max occupancy 2%
- Strip pitch 183 μm.
- Nominal Resolution 50 μm

VELO-TT tracking: 30%
$\delta p_T/p_T$ at p_T=3 GeV

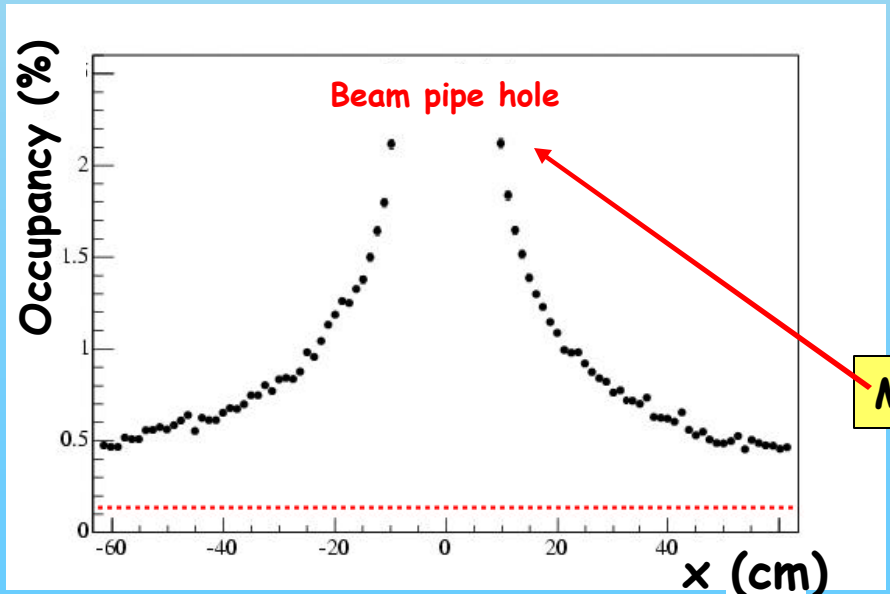
The Inner Tracker (IT)





Inner Tracker

- Silicon micro strip detector
- Innermost part of 3 stations after magnet
- 3 stations (T1-T3) with 4 layers each (0°,+5°,-5°,0°).
- ~125 cm width ; ~ 40 cm height
- 2% of the tracker station surface contains 20% of Tracks.
- Boxes: 320 /410 μm thick silicon
- 198 μm strip pitch.
- Nominal resolution is below 50 μm



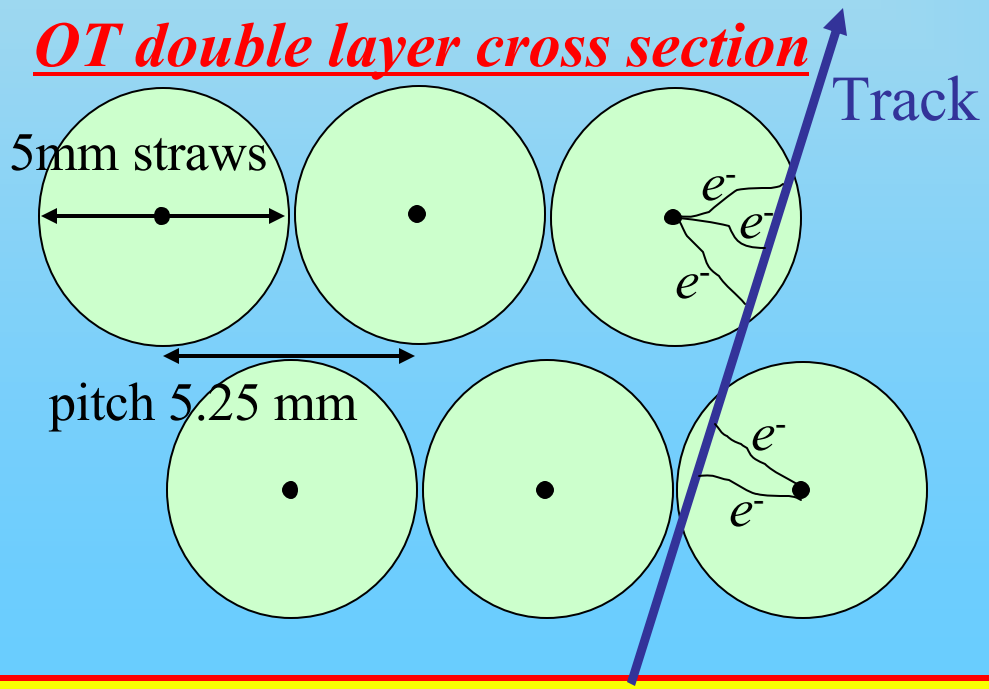
Max occupancy in IT ~ 2.3 %

The Outer Tracker (OT)

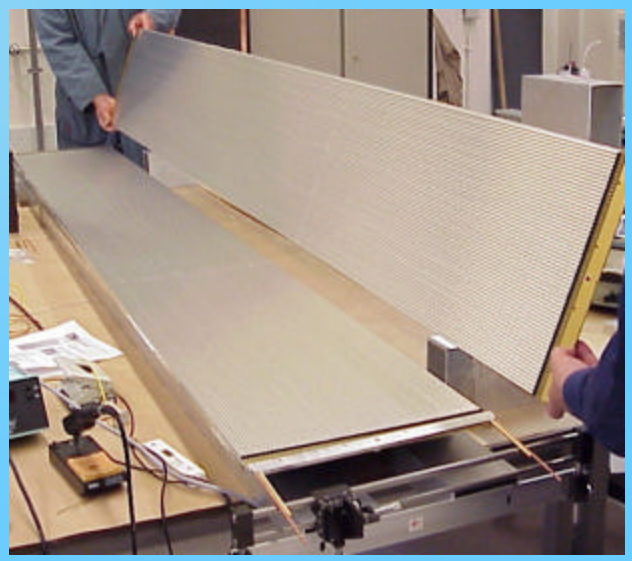
Outer Tracker

- 3 stations (T1-T3) with 4 double layers (0°,+5°,-5°,0°).
- 5 mm straws.
- Drift gas (Ar(70)/CO_2(30)) → Signal collection < 75 ns.
- 25 ns beam crossing → spillover from previous and next spills.
- Straws are 2.4 m long

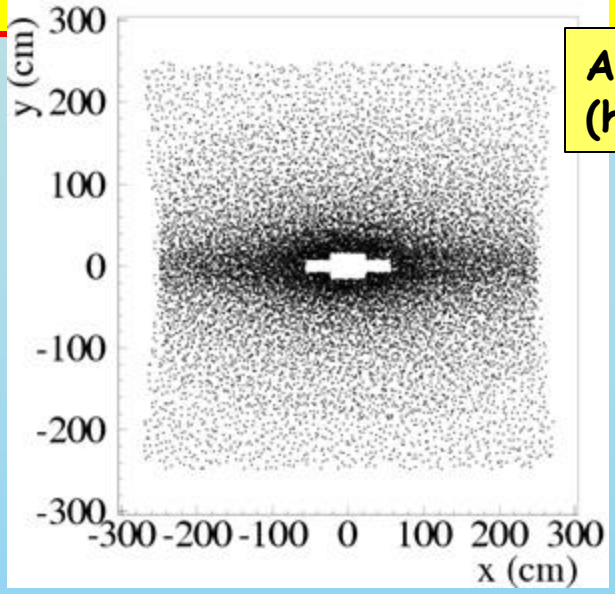
OT double layer cross section



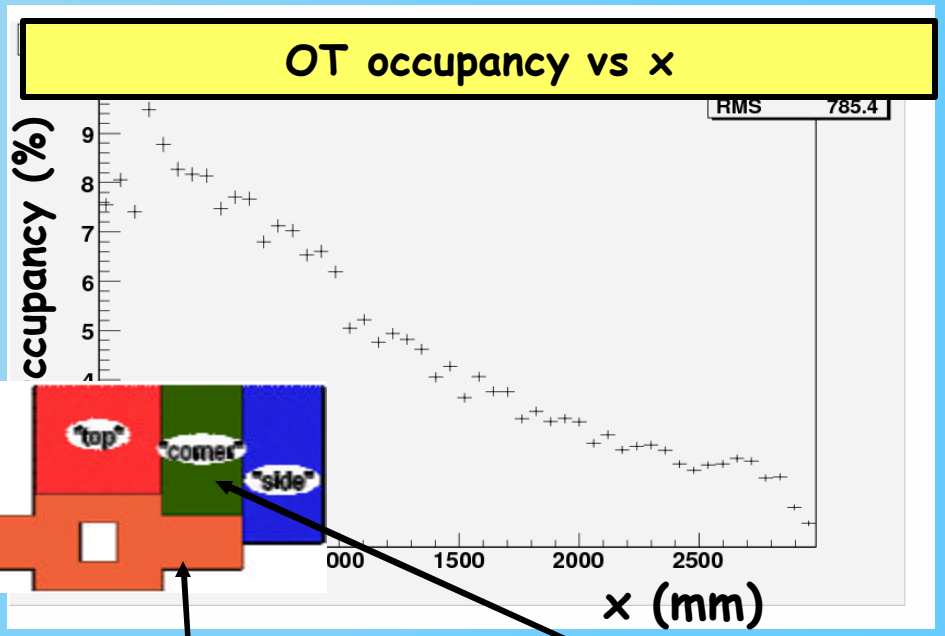
Module Production at NIKHEF



The Outer Tracker (OT)



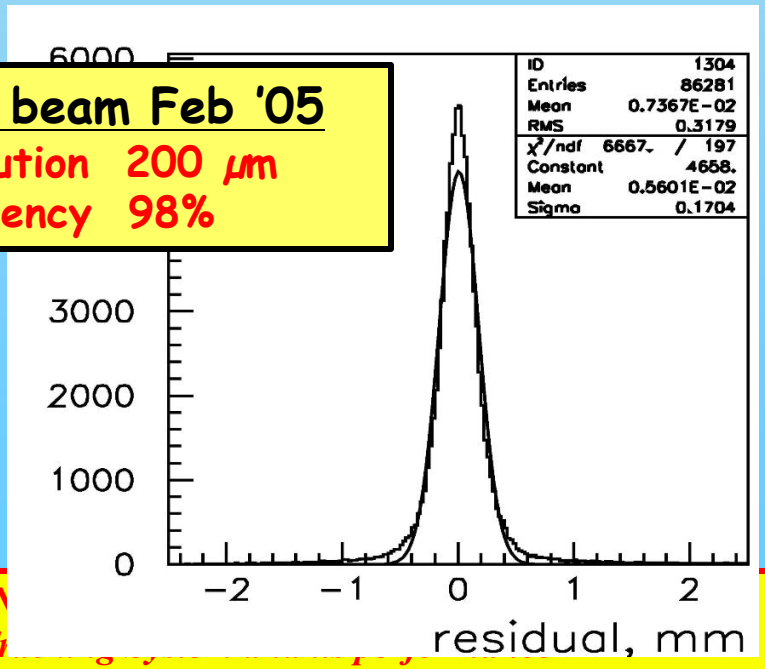
Average occupancy in OT ~ 4.5 %
(hottest region ~ 9 %)



OT

IT

Test beam Feb '05
Resolution 200 μm
Efficiency 98%

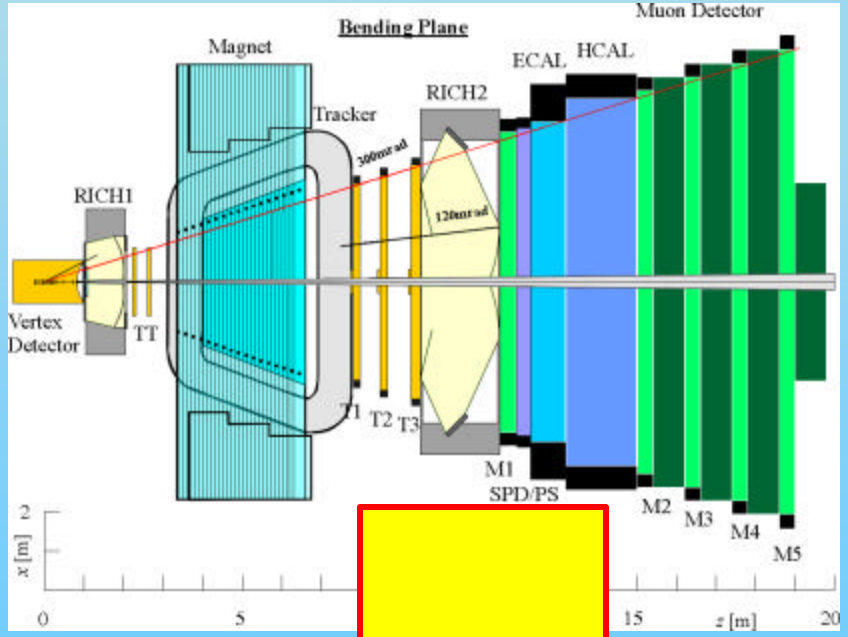


Tracking Environment

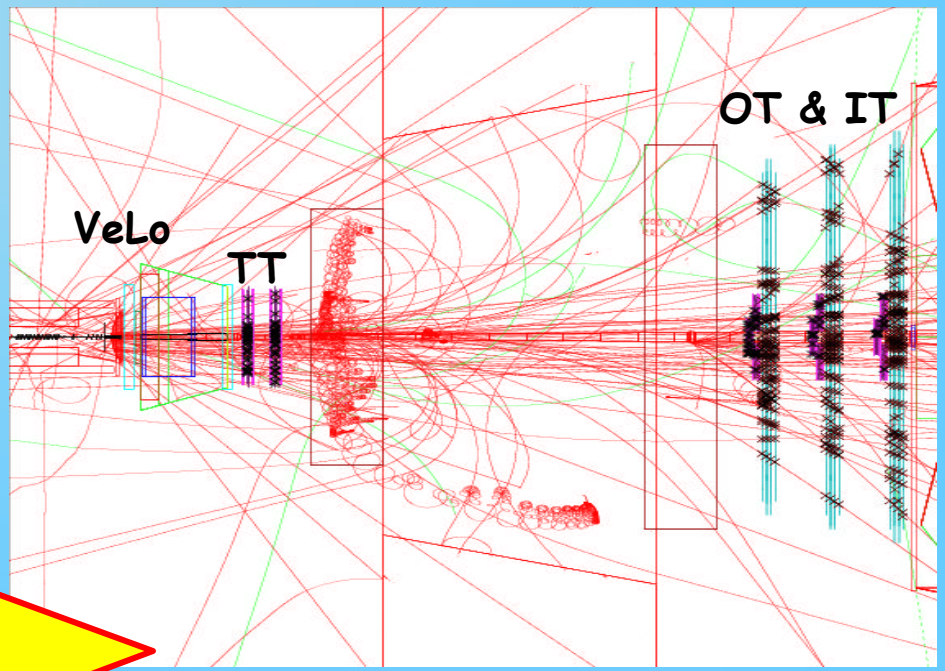
LHCb challenging enviroment for Tracking

- 50 primary particles per event
- Particle see 40% of a radiation length up to RICH2

⇒ Multiple scattering
⇒ Secondary Particles

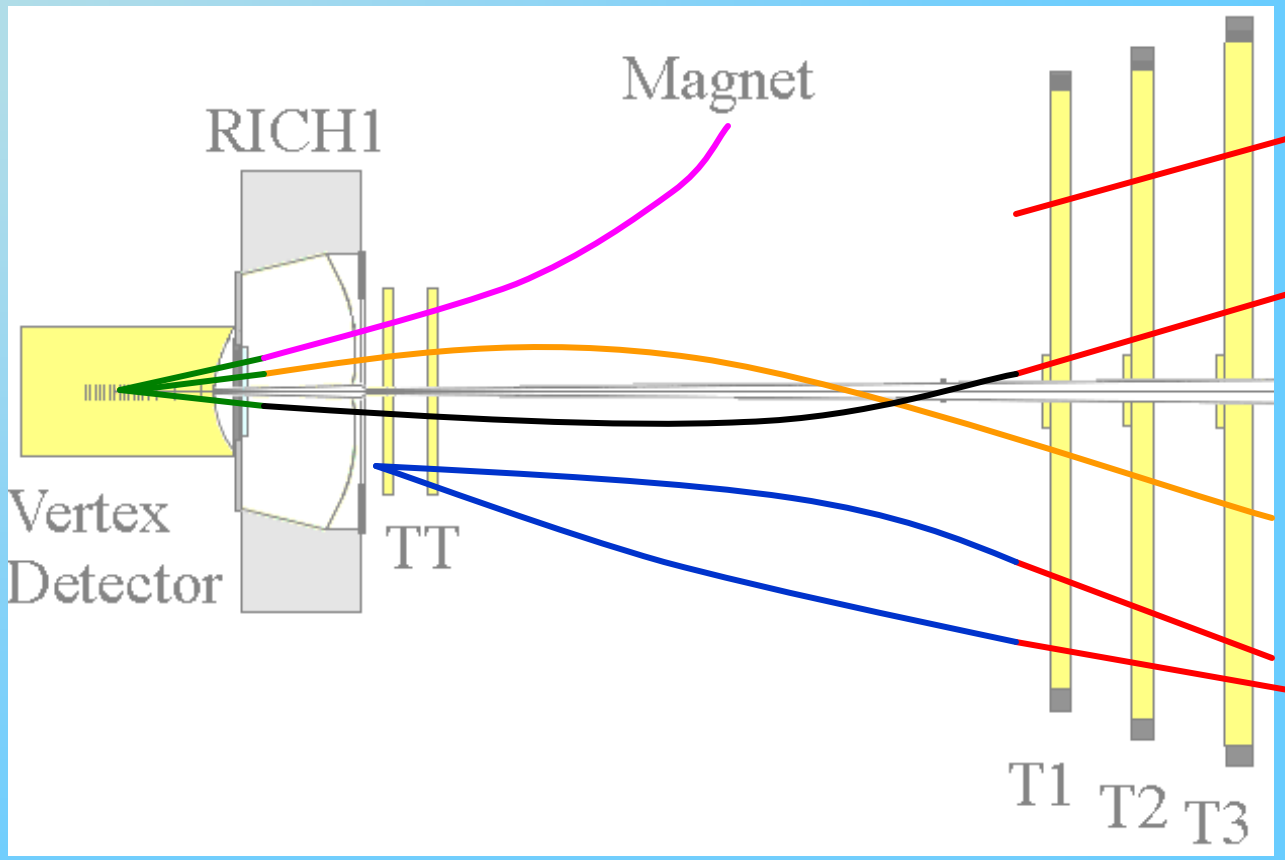


GEANT SIMULATION

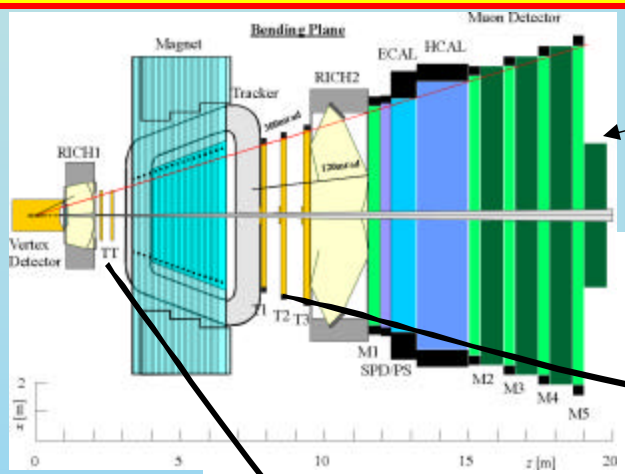


Tracking strategy

Velo tracks
Forward tracks
Seed tracks
Matched tracks
upstream tracks
downstream tracks



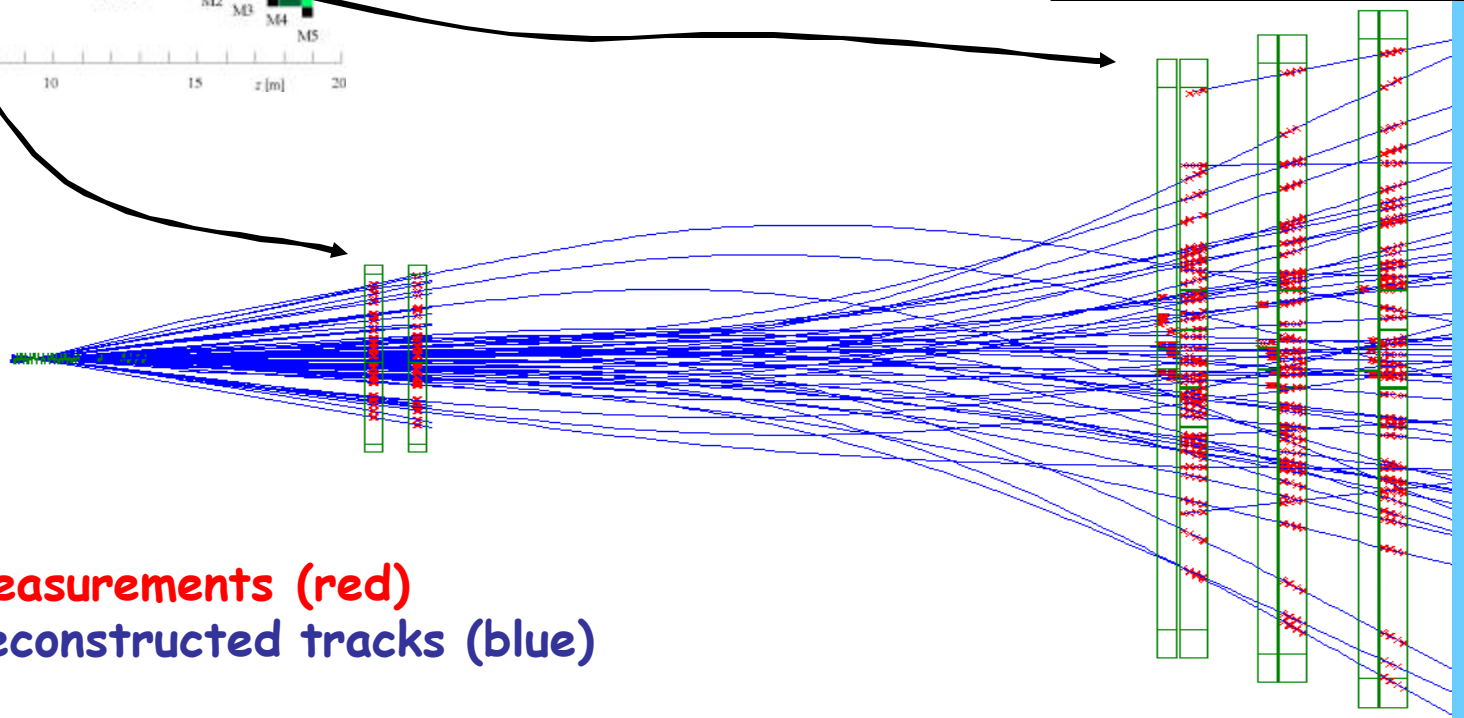
Results



LHCb detector

A typical B event:

- 26 long tracks
- 11 upstream tracks
- 4 downstream tracks
- 5 seed/T tracks
- 26 VELO tracks

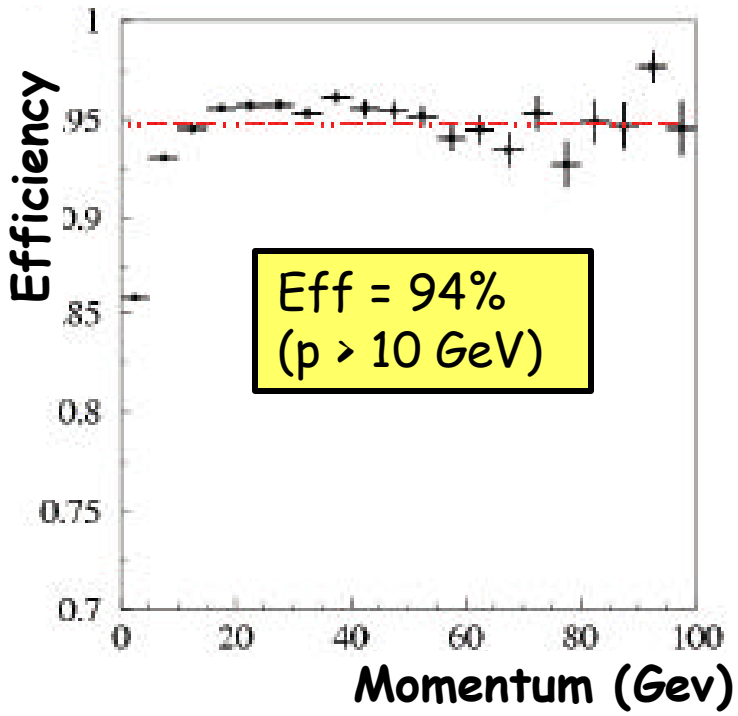


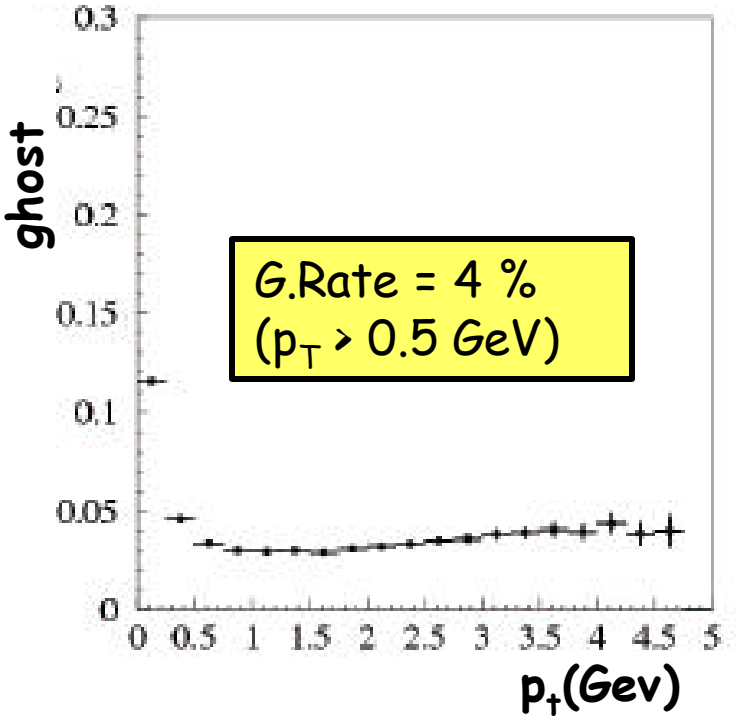
Measurements (red)

Reconstructed tracks (blue)

Performances
Overall reconstruction

Monitoring Quality:
Efficiency = #Correct/#True
Ghost rate = #Ghosts/(#Correct+#Ghosts)

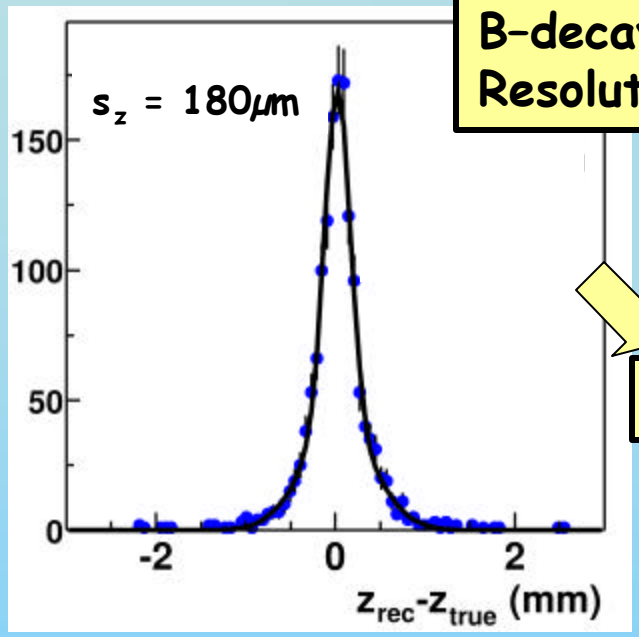




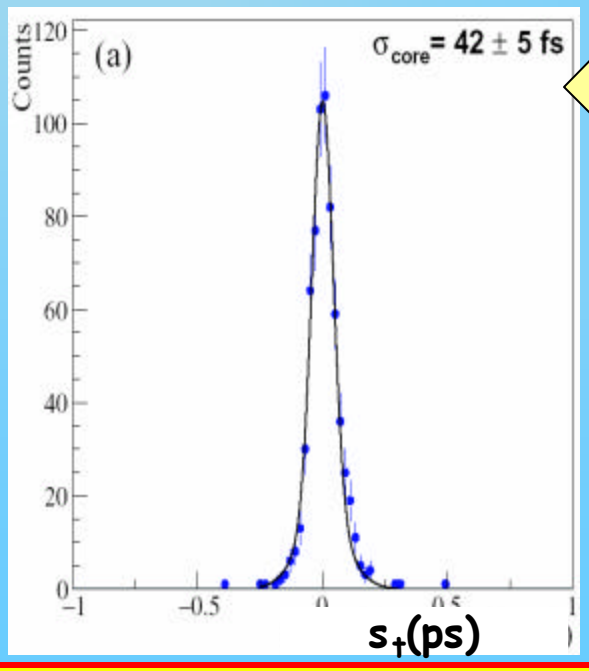
Performances

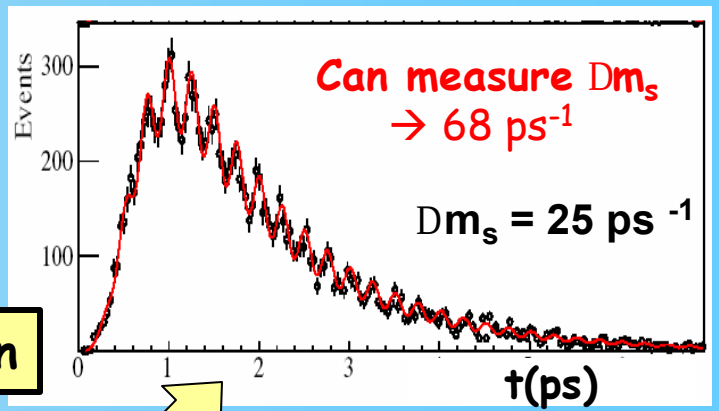
Δm_s

B-decay Vertex Resolution



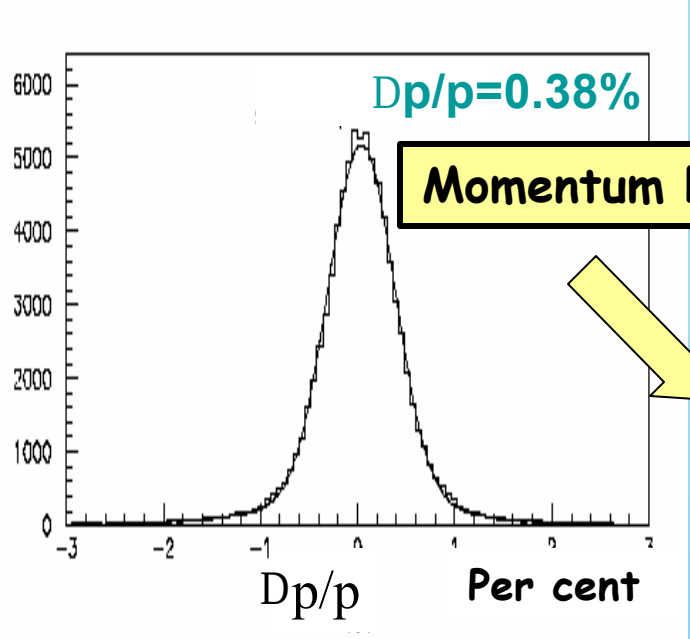
Proper time resolution





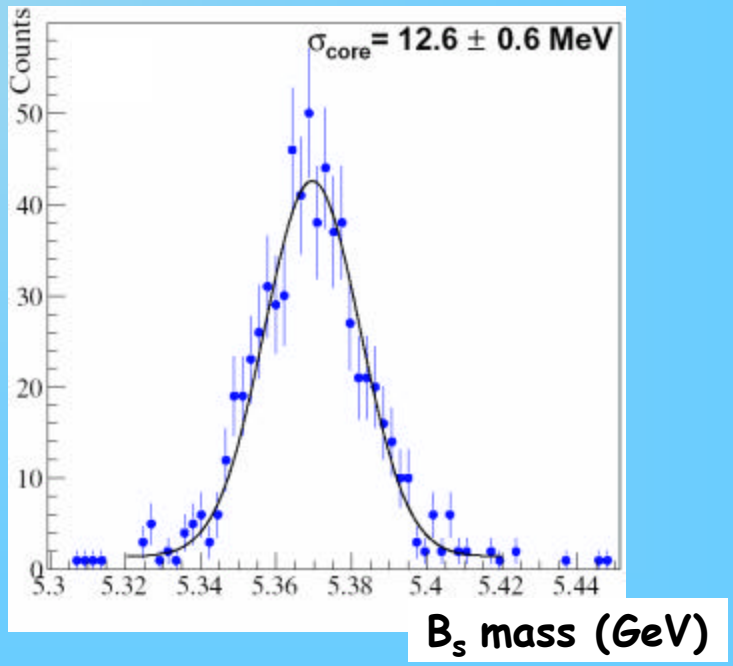
Performances

B_s mass



Momentum Resolution

B_s mass (GeV)



Summary

Construction of LHCb tracking system is advancing:

- Velo ⟹ Towards Commisioning test June 2006
- IT & TT ⟹ Delivery and testing of Sensors ongoing.
- Outer Tracker ⟹ Module Production Finished. Installation is starting.

Expected Tracking performances

- Efficiency 94 %
- Ghost rate 4 %
- Momentum Resolution 0.38 %
- Vertex Resolution 180 μm
- Proper time resolution 42 fs
- Δm_s can be measured $\rightarrow$ 68 ps^{-1}

2006: Major Challenge is Installation.
2007: Ready for physics

Back Up Slides

Tracking and Alignment

Next challenge for the Reconstruction Software: **Misalignment**

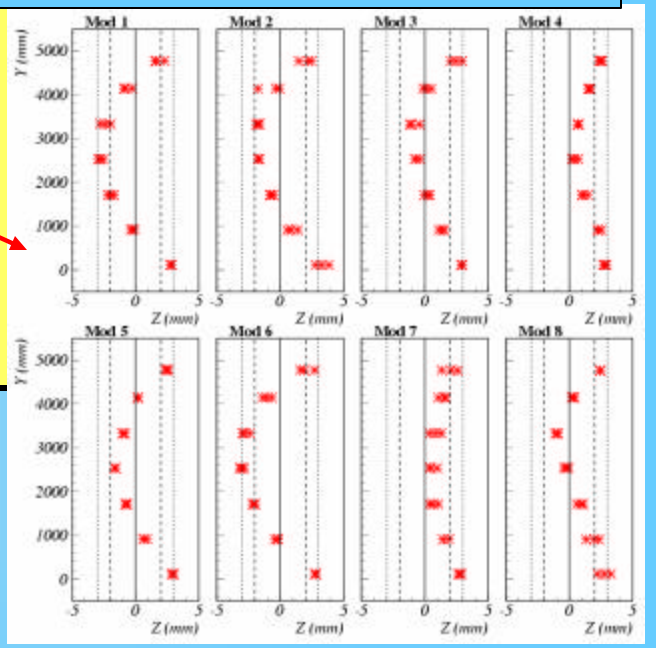
- **Needs: Tracking in a realistic enviroment**

Misalignment, tilted geometry and/or deformed detector should not spoil tracking performaces.

- **Ideas: Trajectories**

A Track's Trajectory is locally defined as a Parabola
Any Detector shape can be approximated as a Parabola

"banana-shaped" Outer Tracker modules



B field Resolution