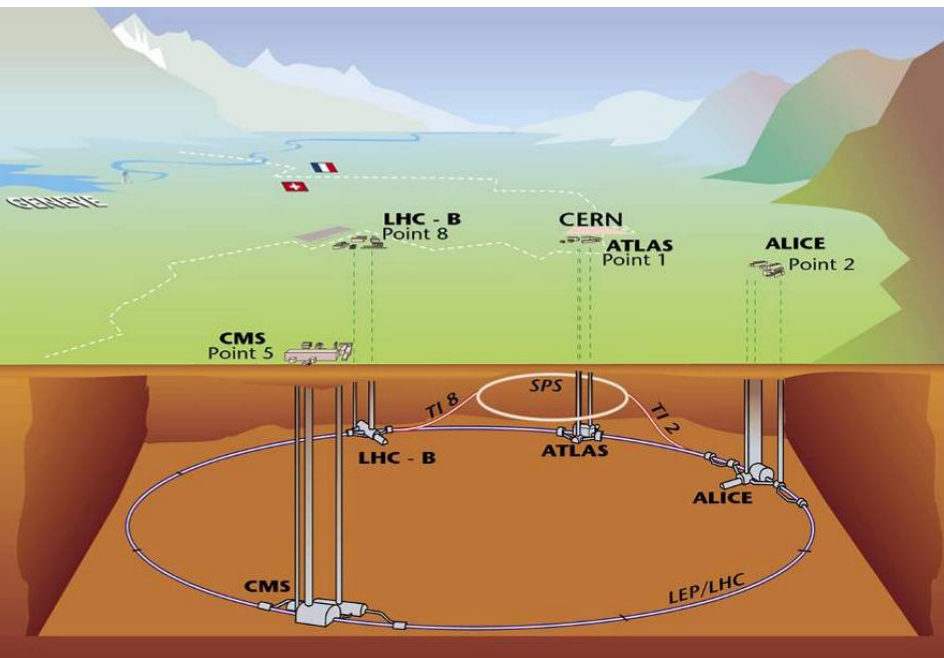


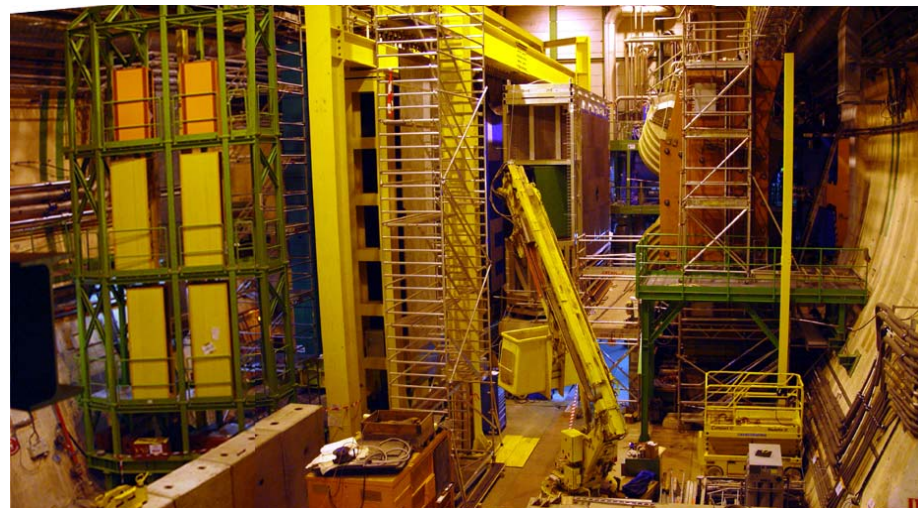


The LHCb Tracking System

Jeroen van Hunen



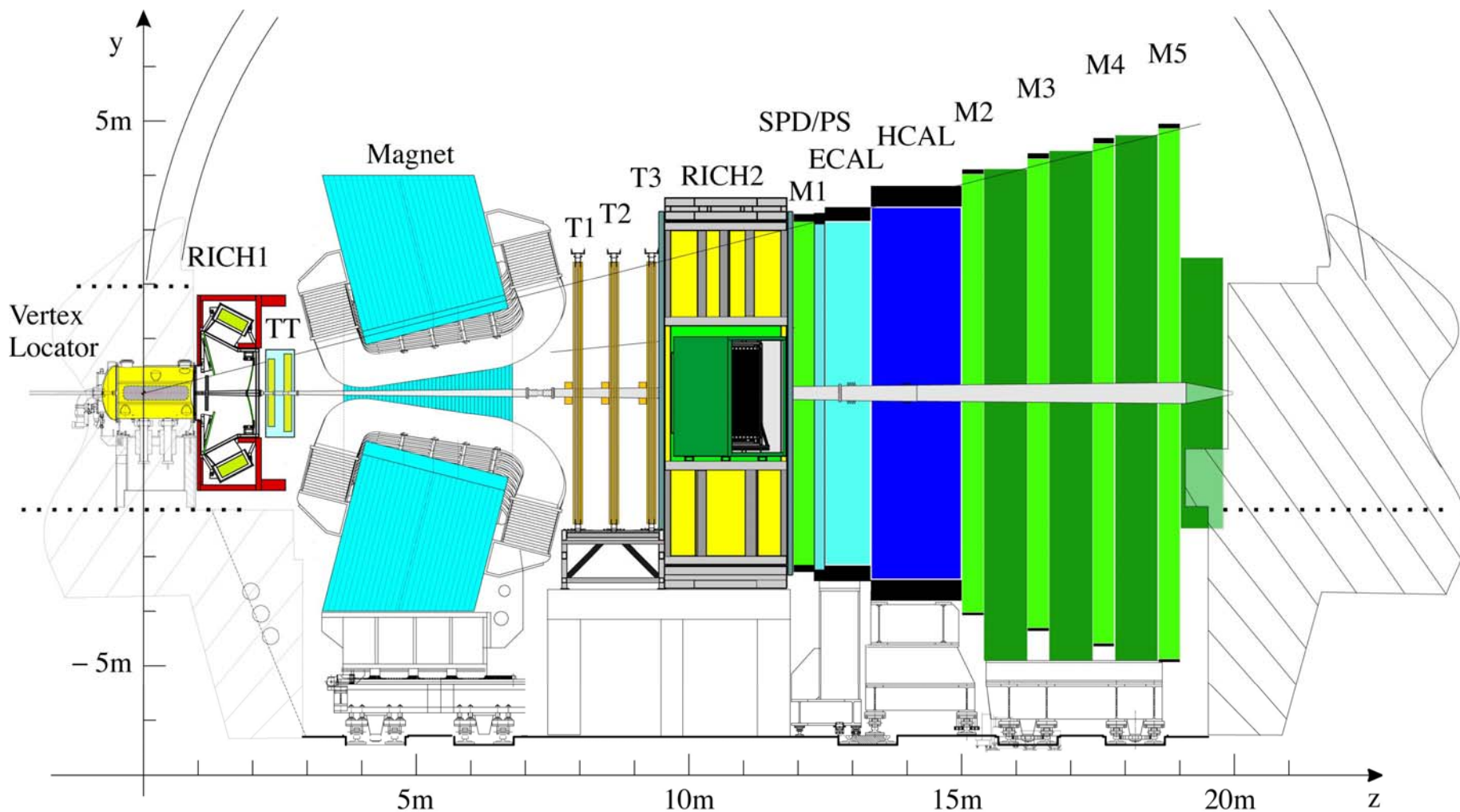
LHCb at Point 8 : a lot of activity!

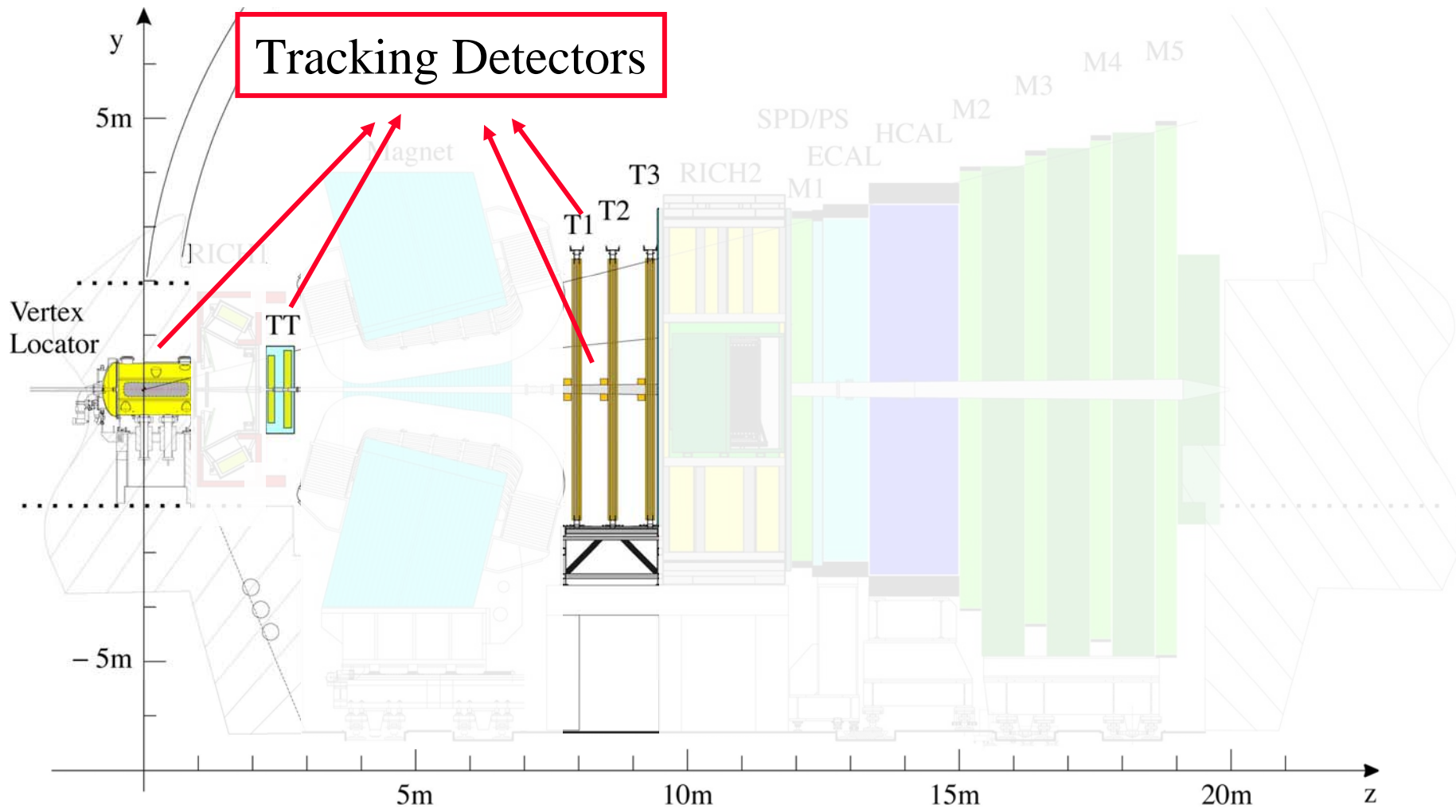


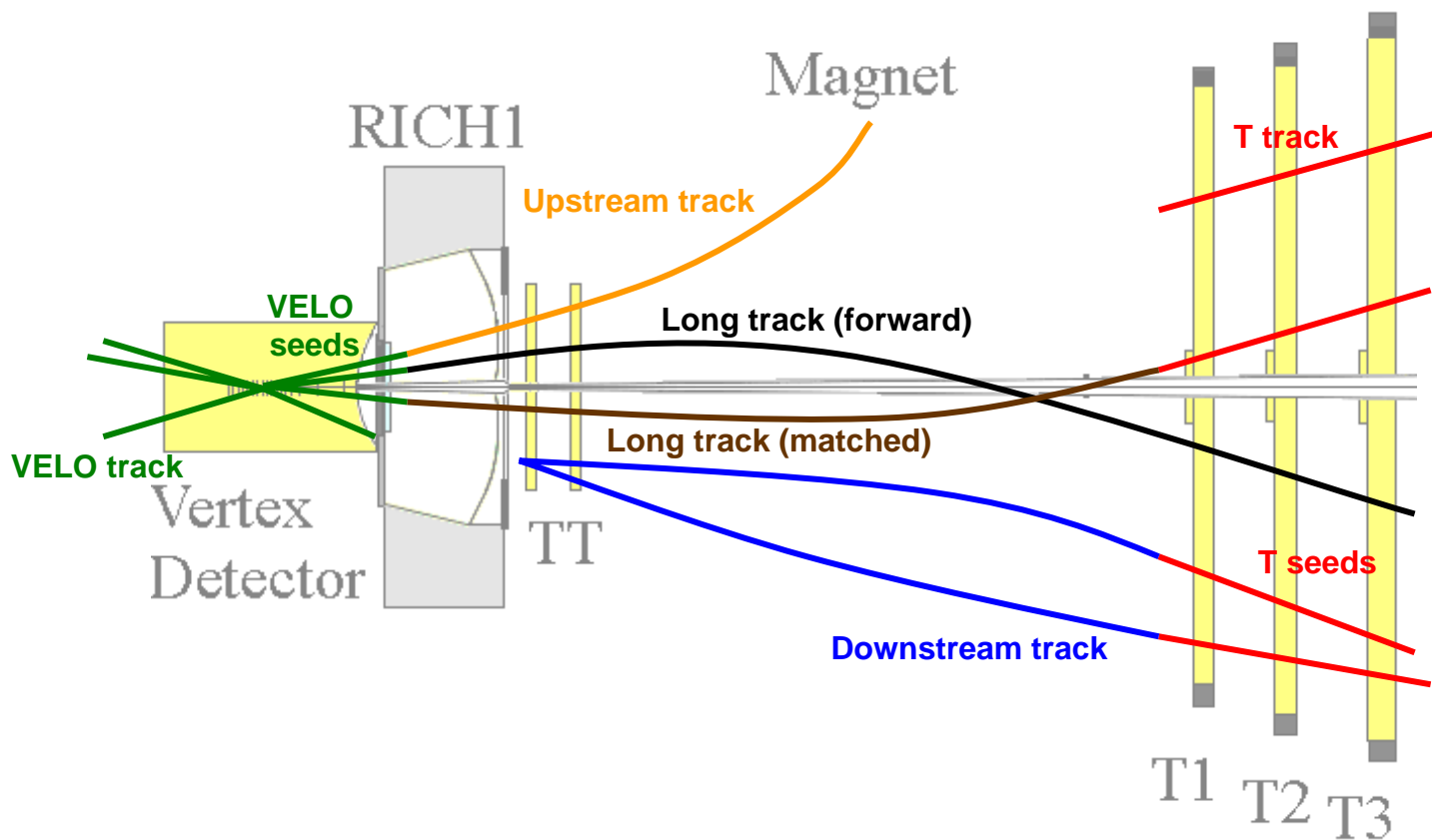
LHCb : a B-physics experiment that is being constructed for :

- ⇒ Precision measurements of the CP-violation parameters
- ⇒ Rare B-decays

→ The CP parameters and rare decays are sensitive to physics beyond the standard Model

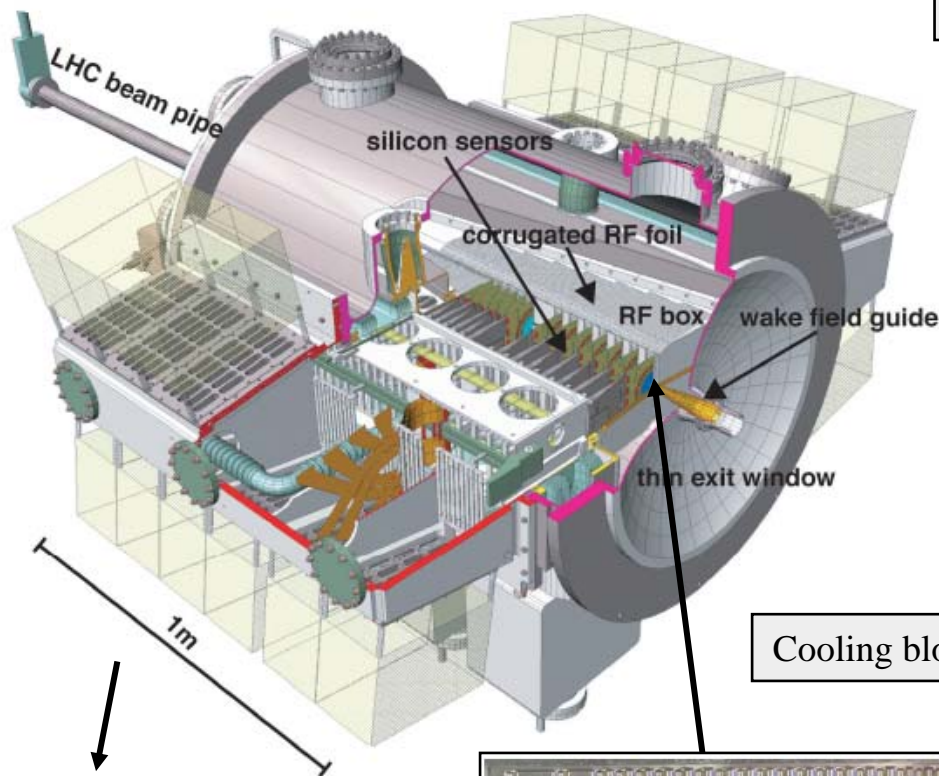






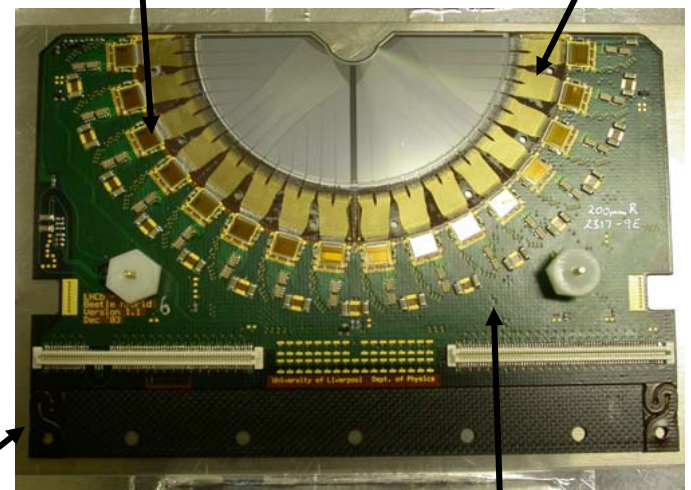
- Long tracks** ⇒ highest quality for physics (good IP & p resolution)
- Downstream tracks** ⇒ needed for efficient K_S finding (good p resolution)
- Upstream tracks** ⇒ lower p, worse p resolution, but useful for RICH1 pattern recognition
- T tracks** ⇒ useful for RICH2 pattern recognition
- VELO tracks** ⇒ useful for primary vertex reconstruction (good IP resolution)

The VERtex LOcator (VELO)



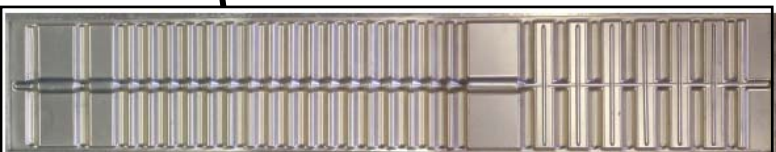
Front end : Beetle (0.25μm CMOS)

Pitch Adapter



Cooling block

Carbon fiber substrate with laminated kapton circuit

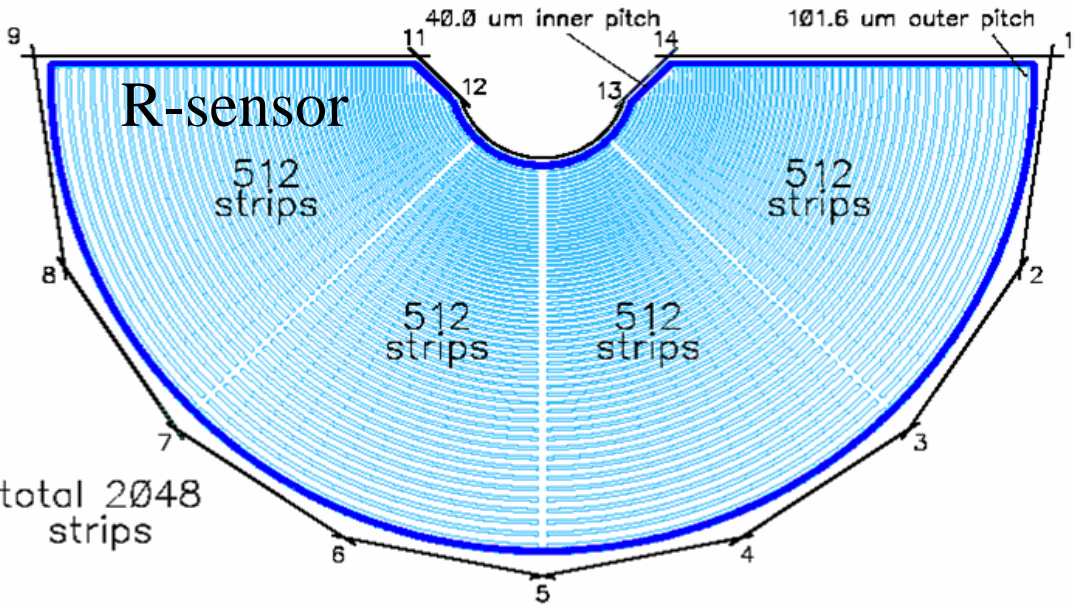
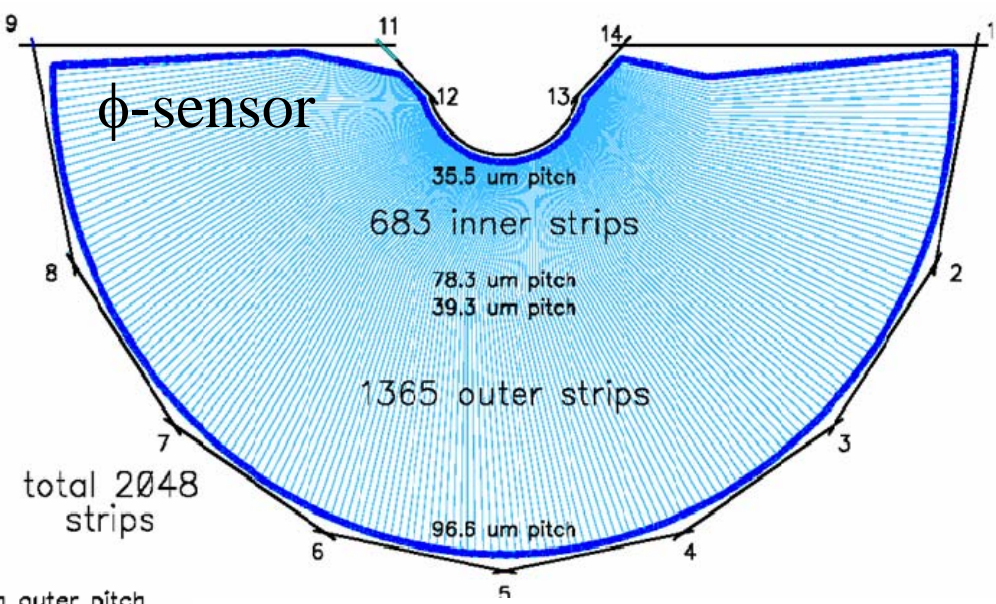


Al foil of 300μm to separate primary (beam) and secondary vacuum

VERtex LOcator (VELO) vacuum tank at LHCb (P8)

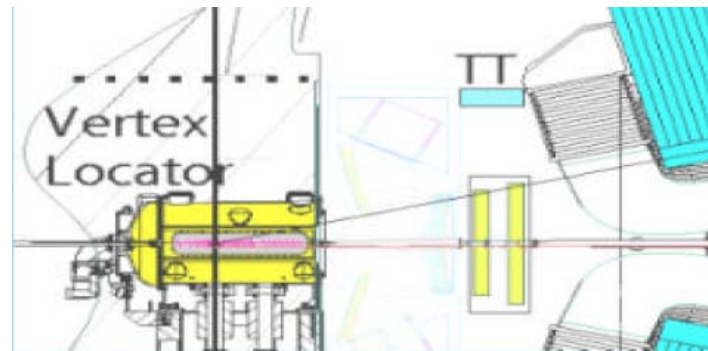
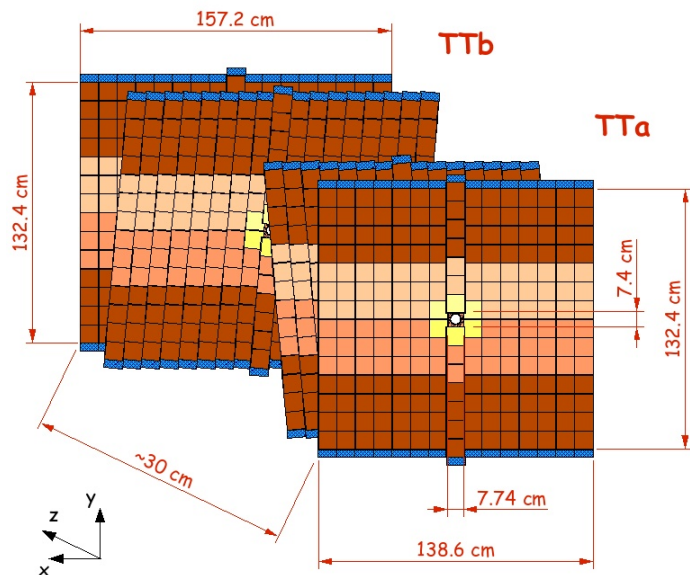


- n^+ in n-bulk sensors
- second metal layer for signal routing
- 2048 micro strips per sensor
- 40 – 100 μm pitch
- 300 μm thick

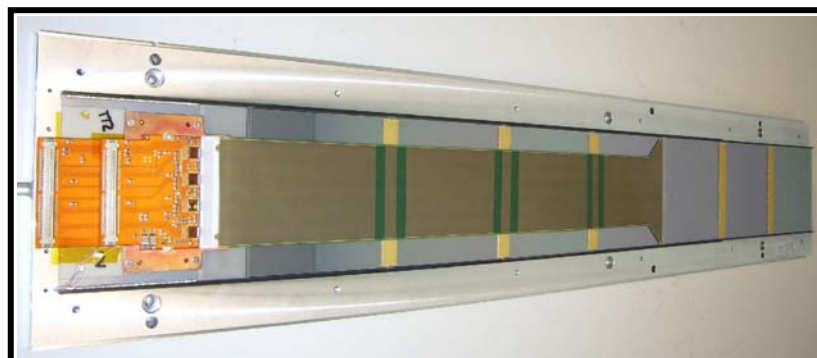


- 21 tracking stations in total (4 half discs per station, 2ϕ and $2R$)
- Radiation environment:
 - $R=8\text{mm}$: 1.3×10^{14} neq/cm²/year
 - $R=42\text{mm}$: 5×10^{12} neq/cm²/year
- The modules need to be replaced after 3 - 4 years.

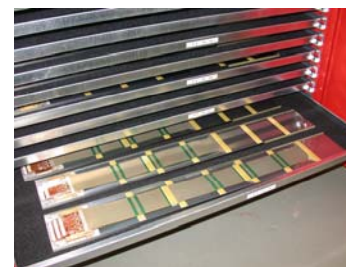
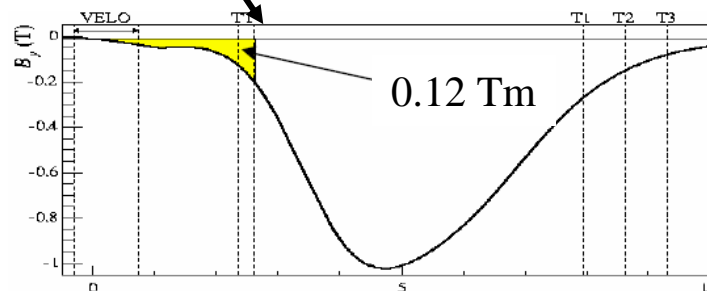
Status: 8 'pre-series' modules produced.



TT = Station before the magnet. Used in the trigger for momentum estimate. (small field between magnet and velo)

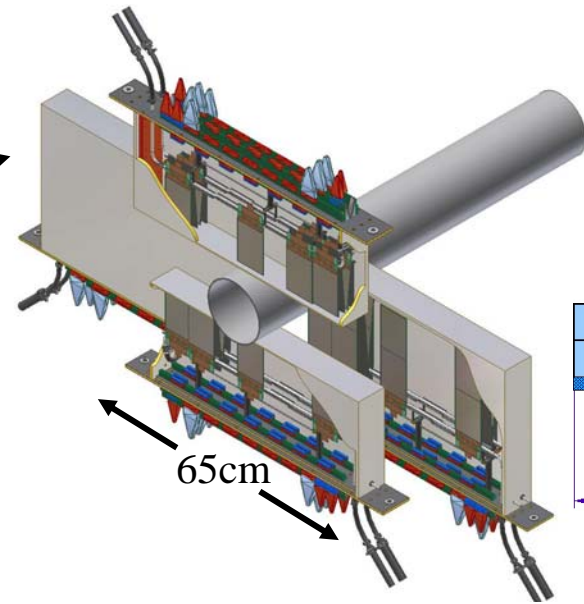
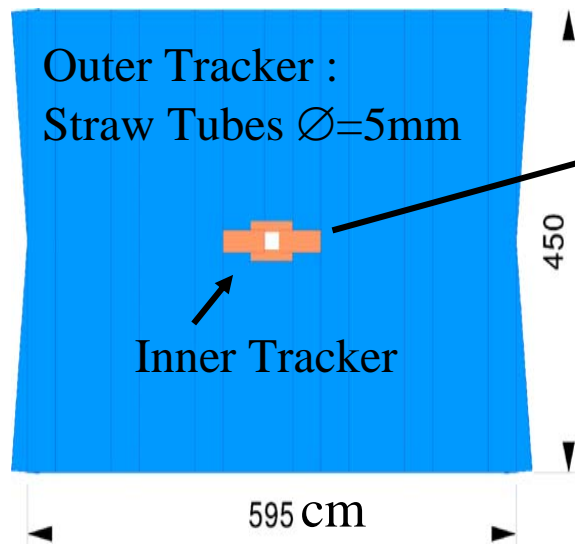


- Silicon sensors : $9.4 \times 9.6 \text{ cm}^2$, $500 \mu\text{m}$ thick
- Long modules of 14 sensors, with max 4 sensors per front-end (Beetle) $\Rightarrow 55 \text{ pF}$
- Long Kapton cables : front-end \leftrightarrow sensors

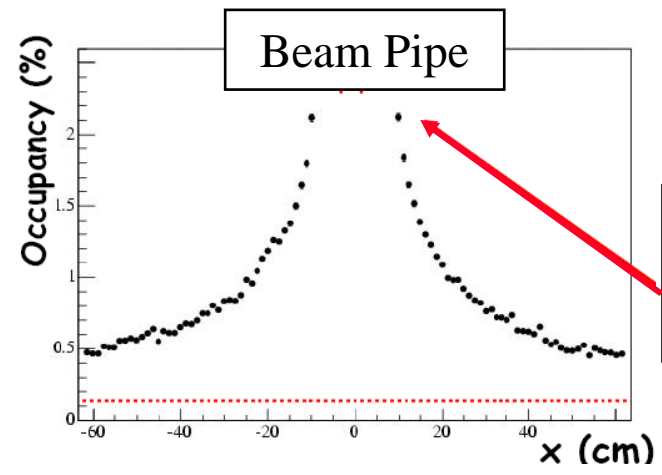
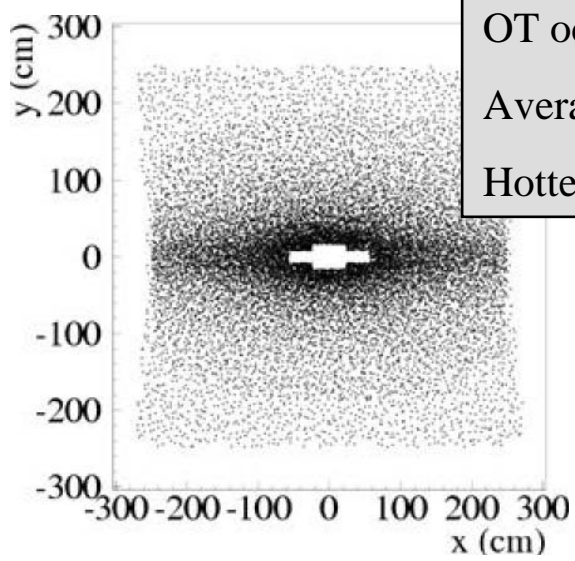
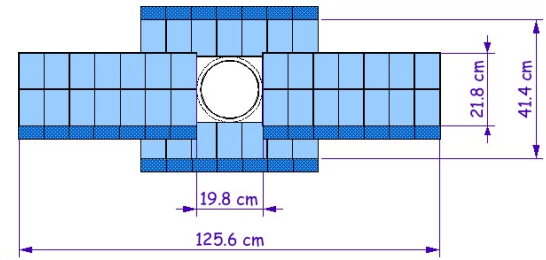


80 half modules in production, several are fully completed and tested.

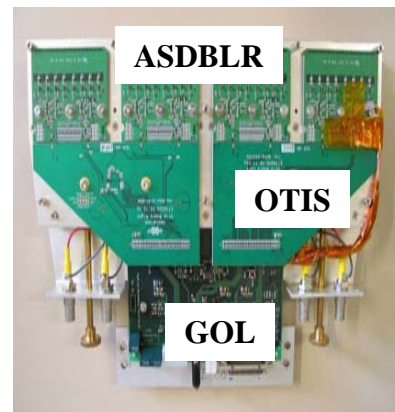
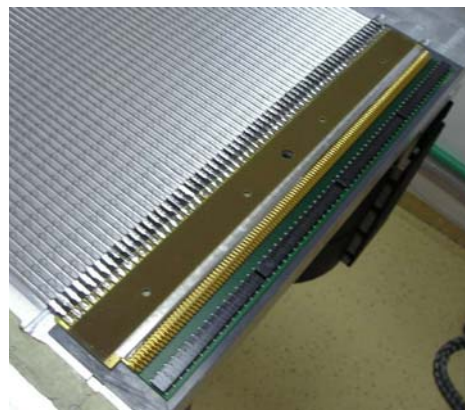
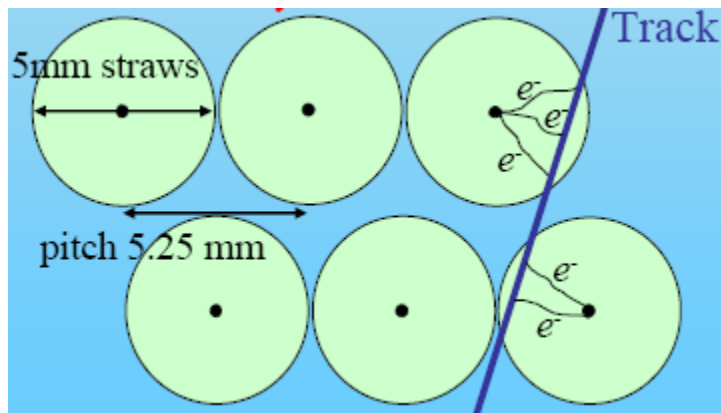
The Outer and Inner Tracker



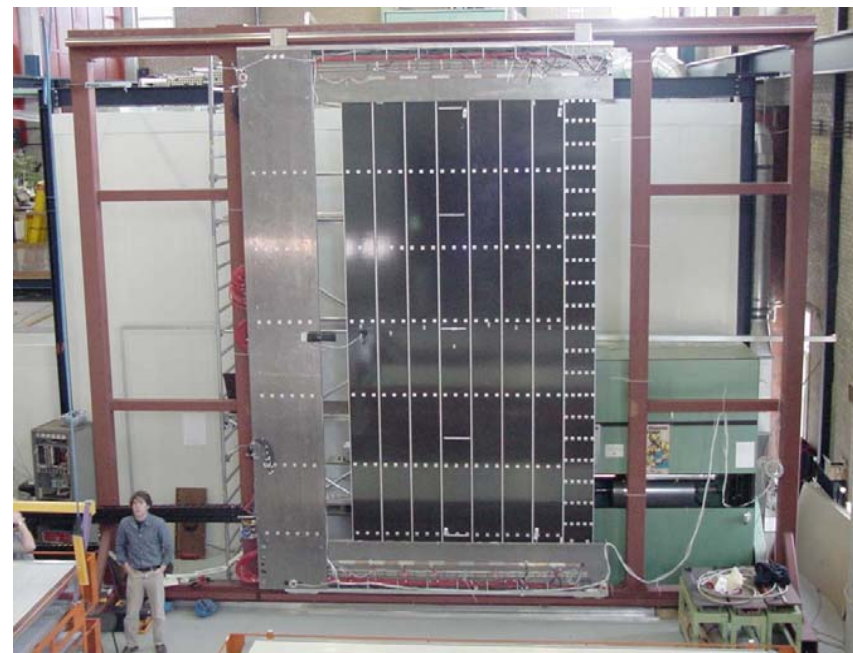
Inner Tracker :
Silicon micro strip
198 μm pitch



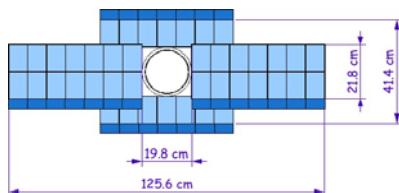
IT occupancy,
hottest region :
2.3%



- 3 stations (T1 – T3) with 4 layers of straws ($0^\circ, -5^\circ, 5^\circ, 0^\circ$) each.
 - Drift gas : Ar(0.7)/CO₂(0.3). Drift time is 45ns for 2.5mm.
 - The straws are 2.4 meter long
 - Wire is W/Au.
- ⇒ All modules have been produced, installation at P8 in June/July this year



Silicon sensor: p in n-bulk, 198 μ m pitch, 420 μ m and 300 μ m thick, 7.8 \times 11cm².



1mm thick Carbon sandwich (2 \times 2 uni-directional carbon with Airex)

25 μ m kapton isolation

Kapton hybrid

Beetle (0.25 μ m CMOS) front-end

Alumina Pitch adapter with Au strips

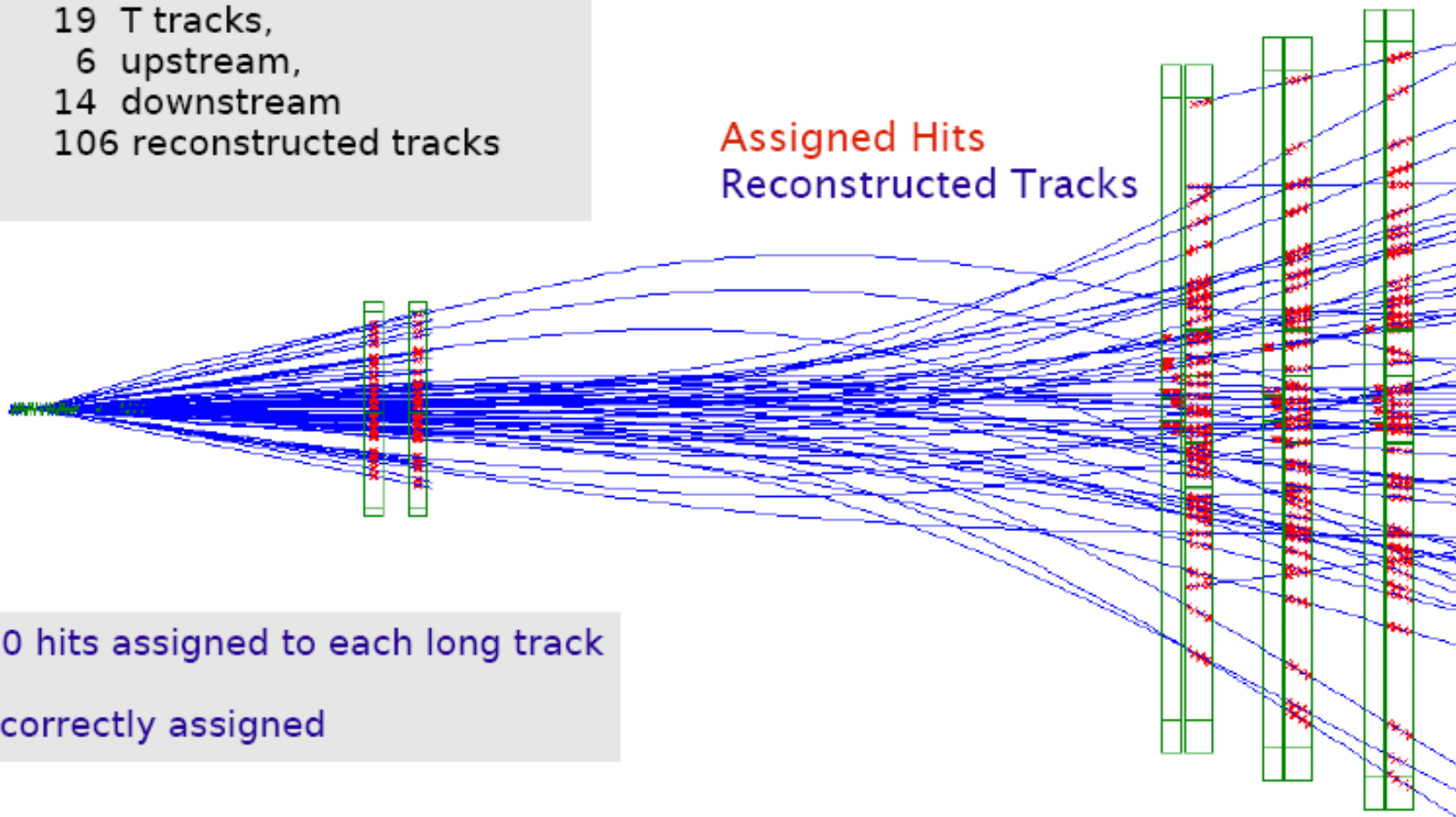


One of the three IT stations

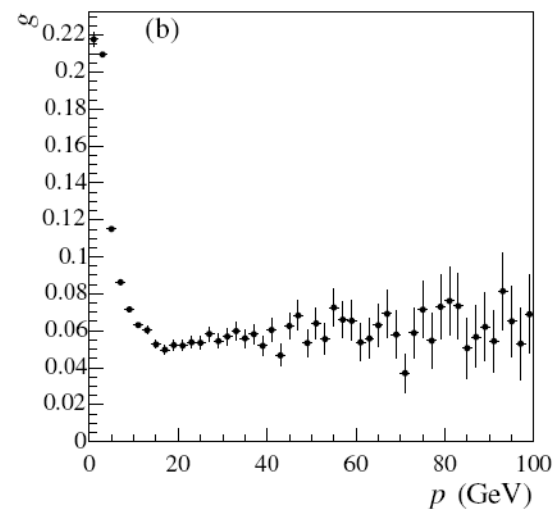
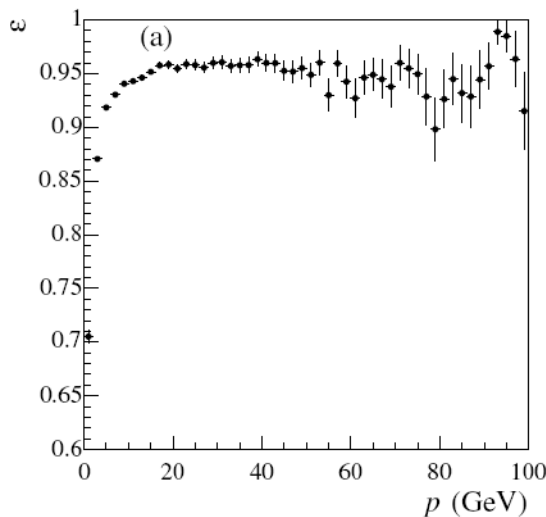
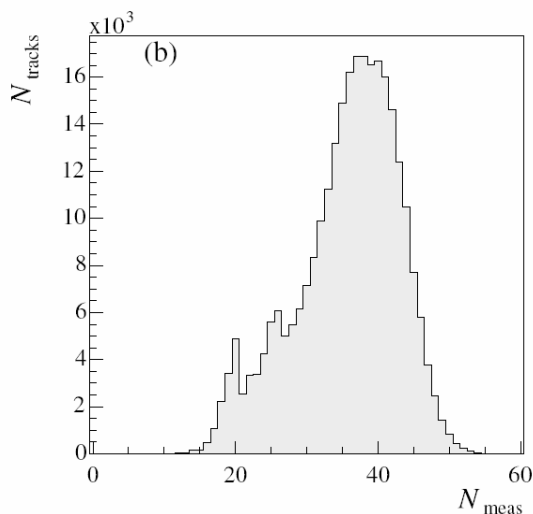


- 3 stations (T1 – T3) with 4 detector boxes per station.
- 4 Silicon layers per box, 28 modules (with one or two sensors each)
- 336 modules in total : 60 built and tested

Average # of tracks in b-events:
 34 VELO,
 33 long,
 19 T tracks,
 6 upstream,
 14 downstream
Total 106 reconstructed tracks

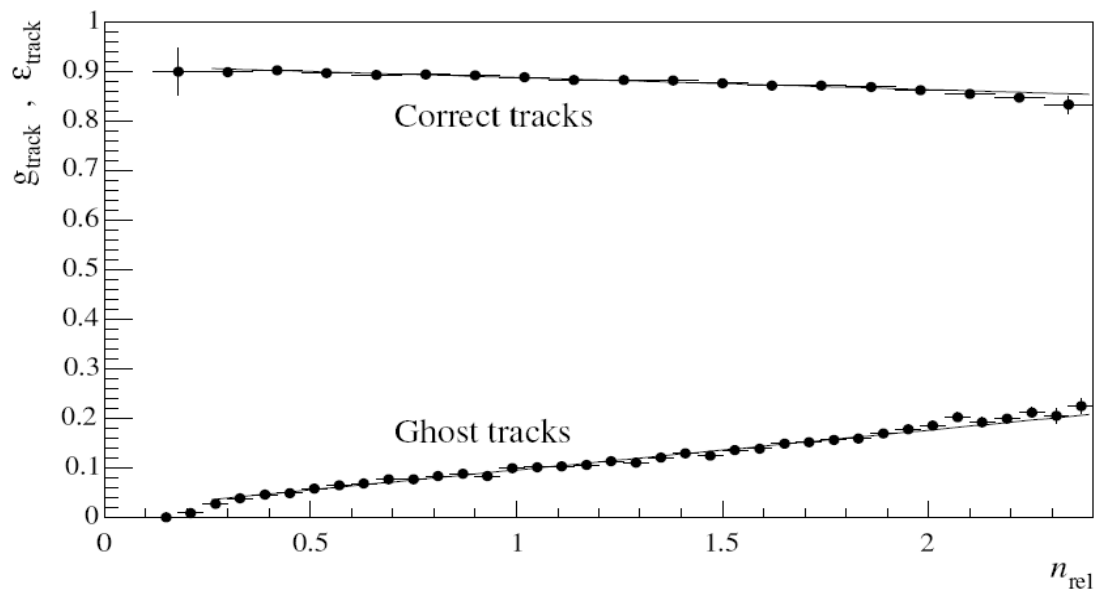


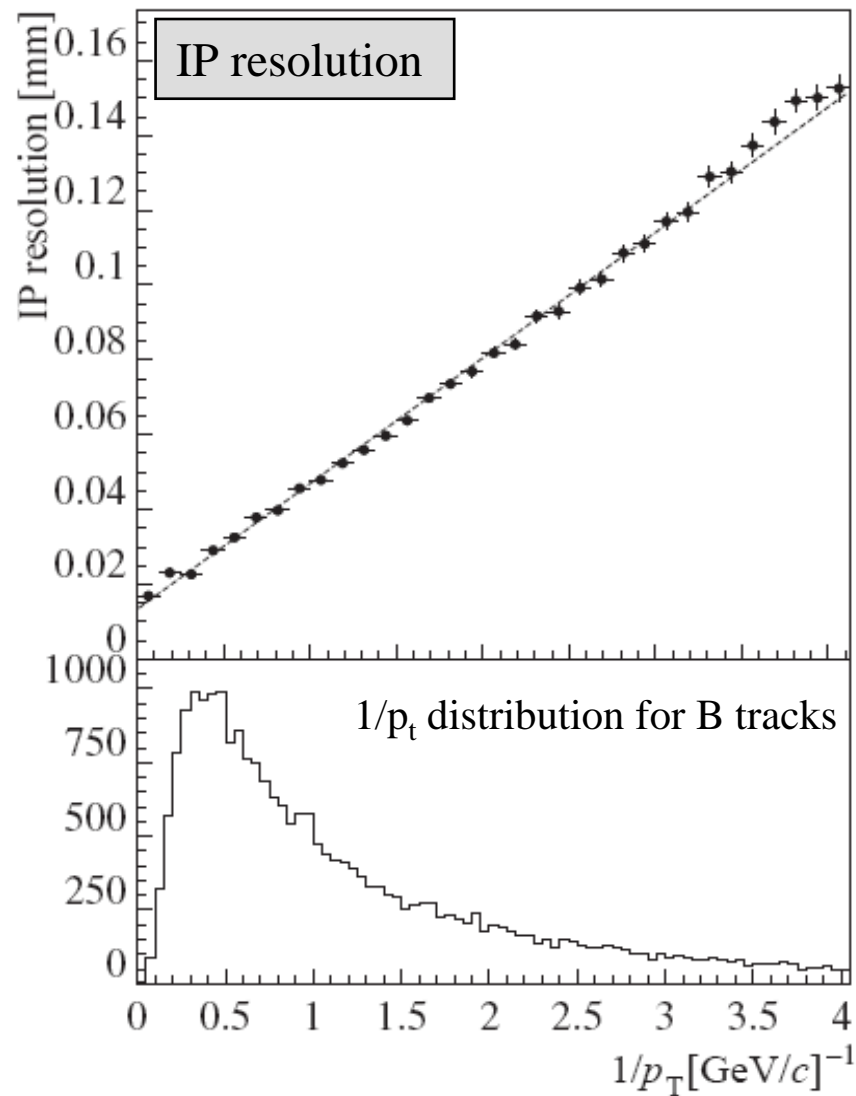
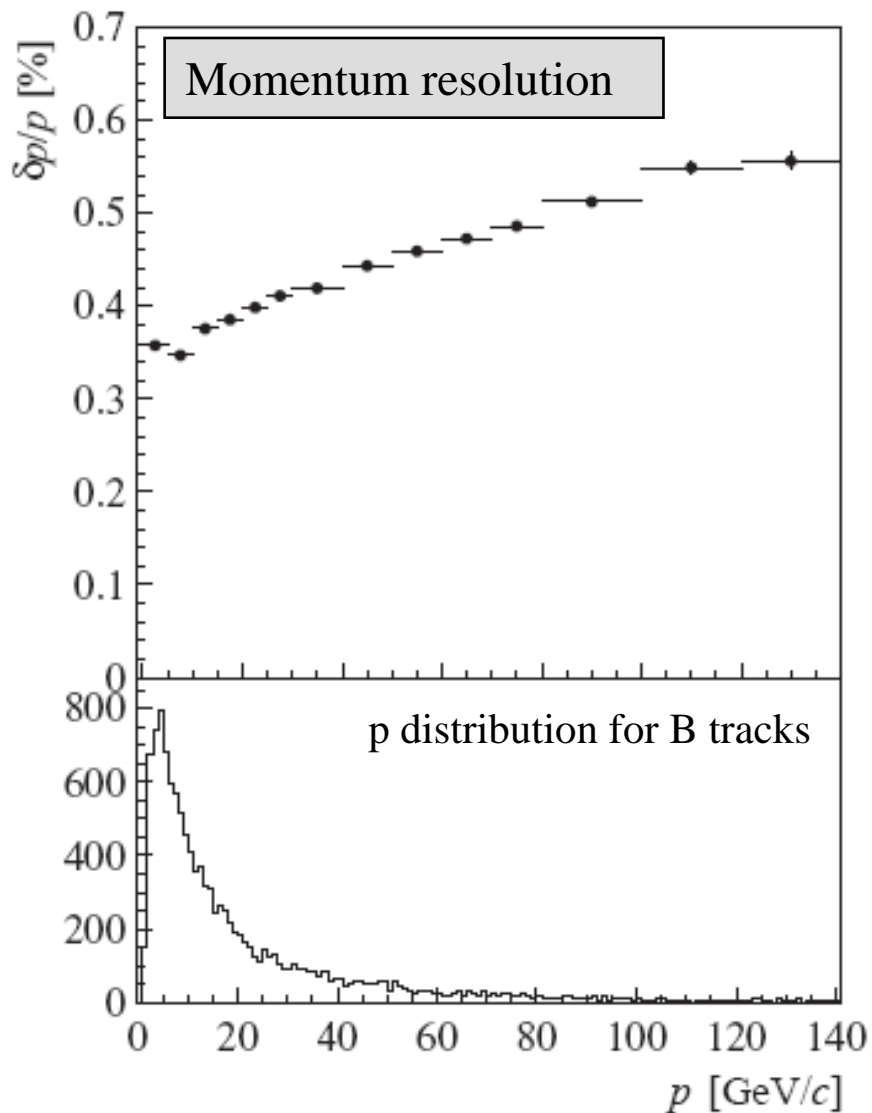
20 to 50 hits assigned to each long track
 98.7% correctly assigned

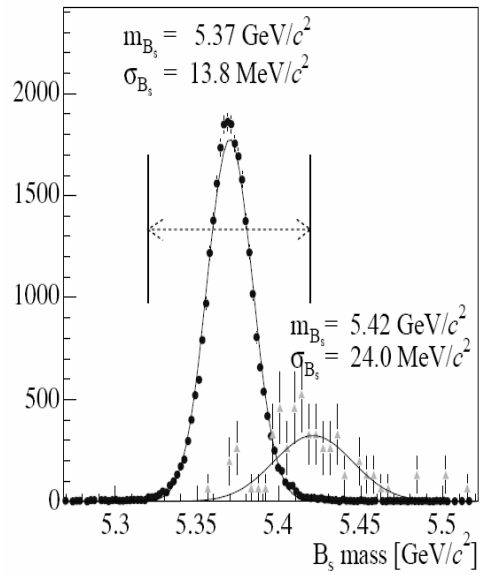
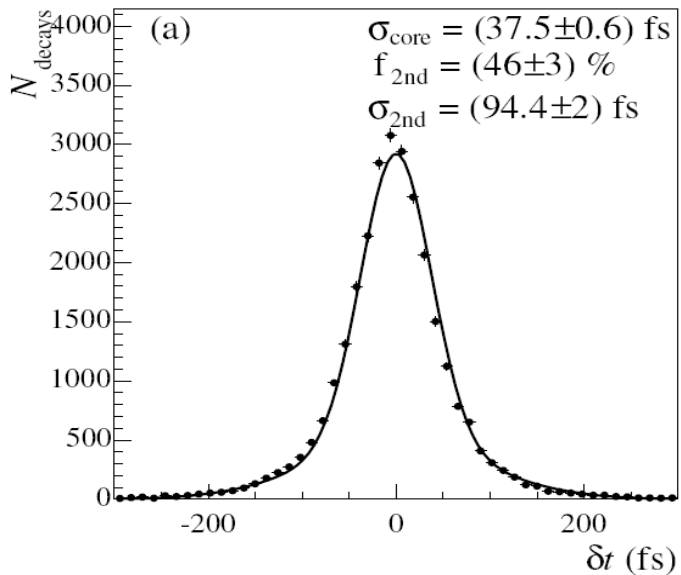
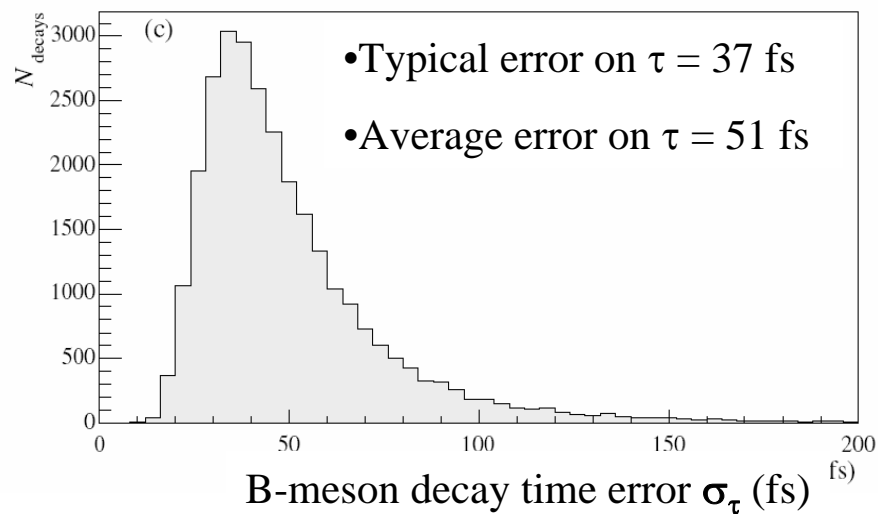
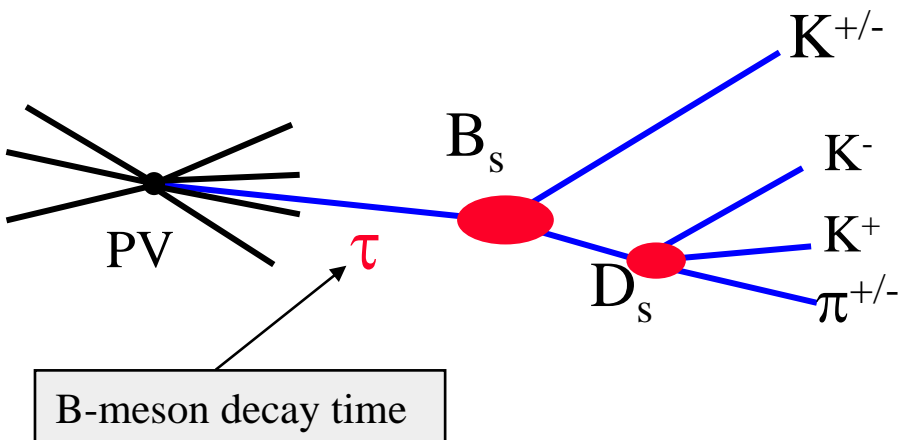


Long tracks

- Typically 38 measurements per track
- Efficiency $> 95\%$ for $p > 12\text{GeV}$
- Ghost rate $< 7\%$ for $p > 12\text{GeV}$
- For twice the event multiplicity the efficiency drops by 4% and ghost rate increases by 7%







• B_s mass resolution = 14 MeV
 • Decay time resolution = 37 fs

This excellent decay time resolution is needed to resolve the fast $B_s^0 \leftrightarrow \bar{B}_s^0$ oscillations.

Construction of the LHCb tracking system well advanced

- **Vertex Locator: 8 ‘pre-series’ modules produced (need 84 half modules)**
- **Trigger Tracker: 80 half modules in production (need 128)**
- **Outer Tracker: All modules produced**
- **Inner Tracker: 100 modules produced & 60 are fully tested (need 336)**

Expected performance : tracking efficiency > 95% while the ghost rate remains below 7% (for $p > 12$ GeV)

B-meson decay time resolution is 37fs

Looking forward to real data!