First experience and results with the LHCb Silicon Tracker

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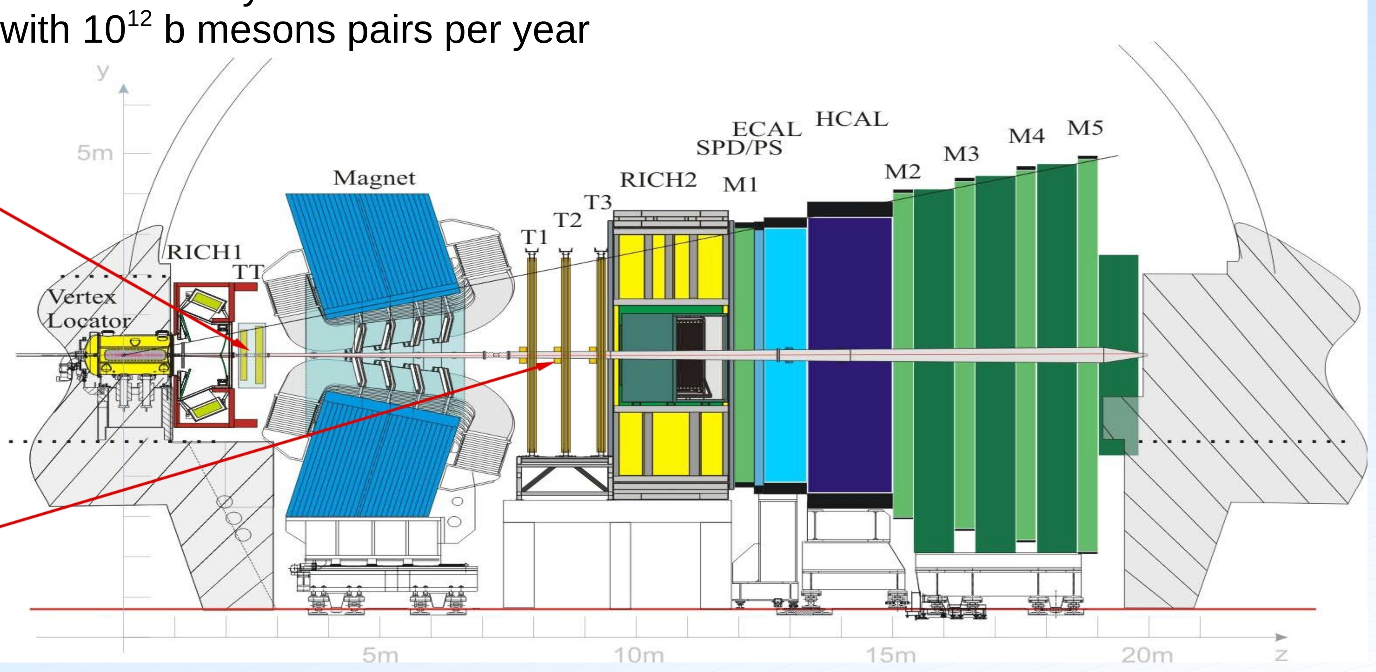
The LHCb Experiment

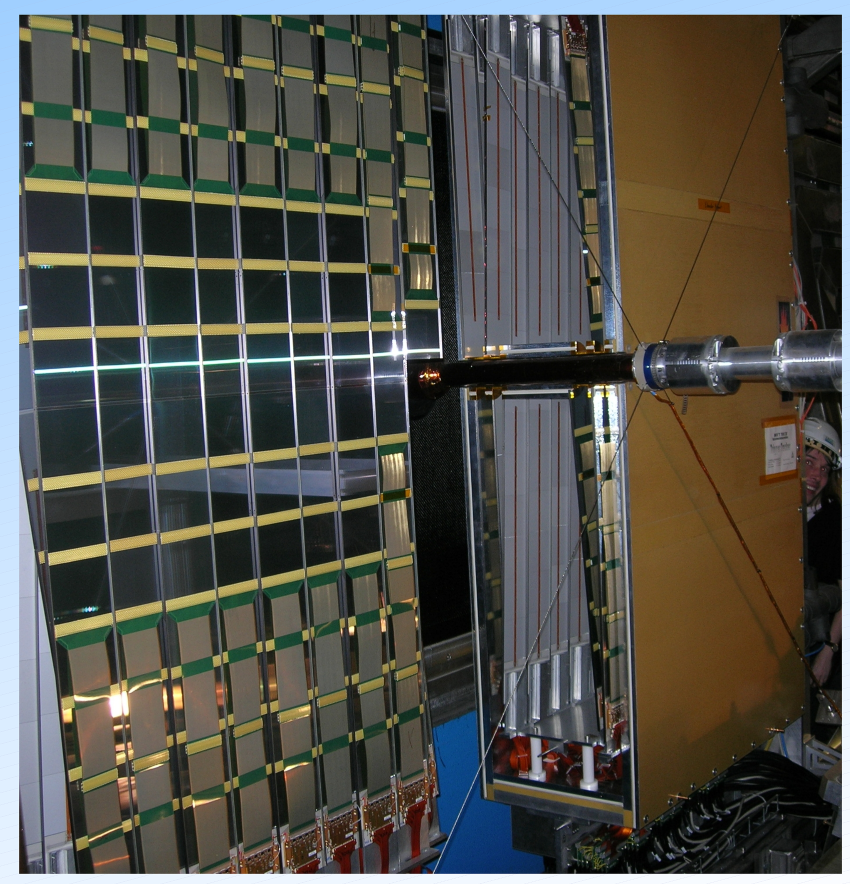
- Single-arm forward spectrometer dedicated to B-Physics with an acceptance of 15-300 mrad
- pp collision at 14 TeV with a luminosity of $2 \times 10^{32}\ cm^{-2}s^{-1}$
- All b species produced, with 10^{12} b mesons pairs per year

Tracker Turicensis
- Covers an area of 8 m^2
- 140K readout channels

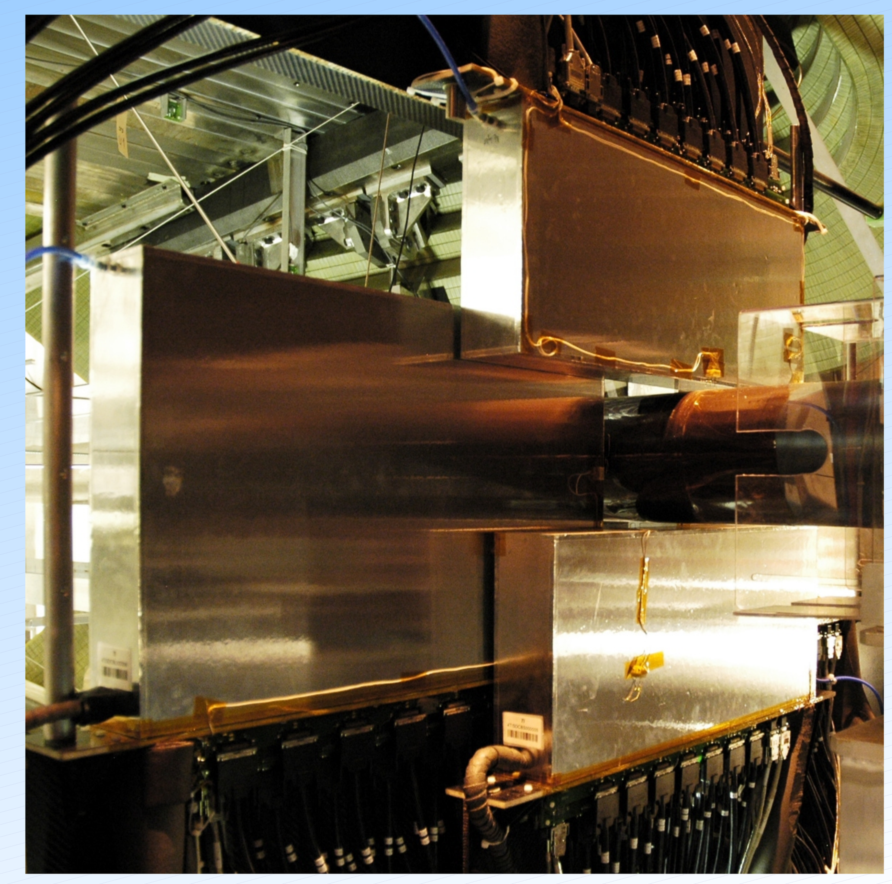
Inner Tracker
- Covers an area of 4 m^2
- 130K readout channels



Tracker Turicensis



Inner Tracker

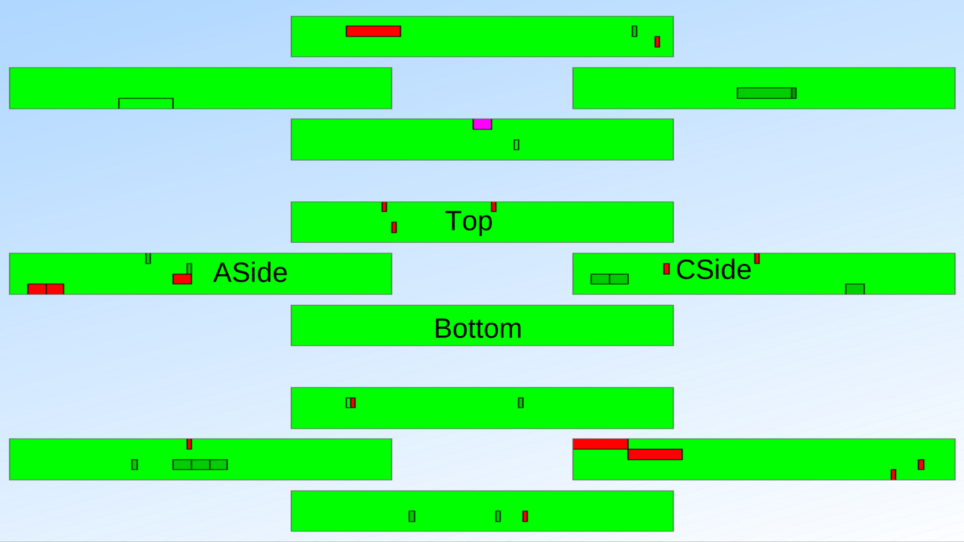


Silicon Tracker Status

Inner Tracker Status

96.7% of the Inner Tracker is fully working
1.7% is noisy
1.6% is dead

- module/beetle/port is dead
- very large noise
- large noise
- minor issue, like lower testpulse
- PCN go out of sync



Tracker Turicensis Status

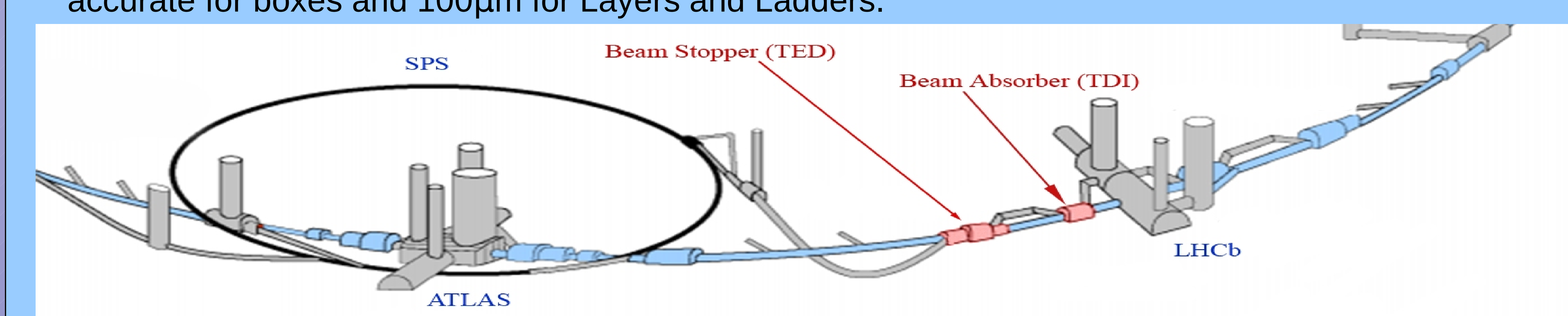
99% of the TT is fully working

- broken bonds
- HV problems
- optical path or acquisition board not ok
- problem with the SB
- commissioned

Status of August 2008 (Time of TED data taking)
The majority of problems are fixed for the runs of 2009-2010.

TED Data

- This is the main data-set so far. The particles are produced by dumping injection test bunched in a tungsten absorber 300m 'behind' LHCb.
- TED events are high multiplicity events, with an occupancy 20 times greater than in normal physics.
- It has been used for the spatial alignment of IT and TT, beyond the survey results that is 500µm accurate for boxes and 100µm for Layers and Ladders.

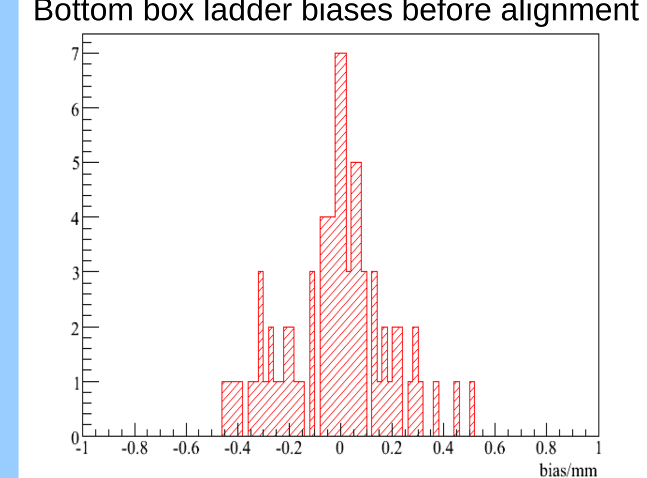


IT Alignment Results

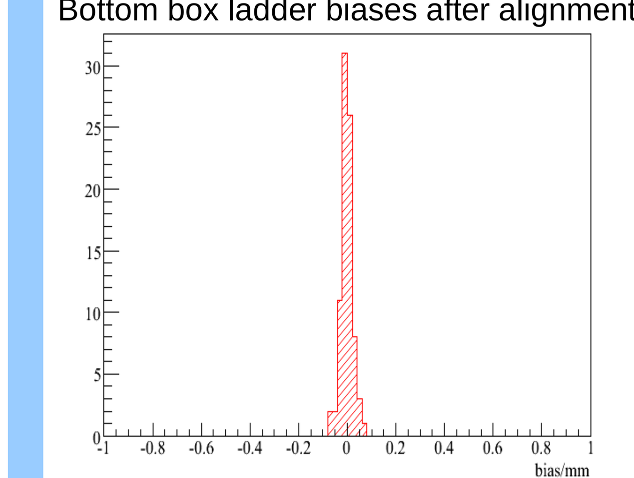
IT alignment has been performed using the generic tracking algorithm. The starting database is the detector survey together with a pre-alignment based on histogramming of residuals. Below is the effect of the complete alignment procedure on the biases of the Inner Tracker ladders.

Survey → Pre-Alignment using histograms → Alignment

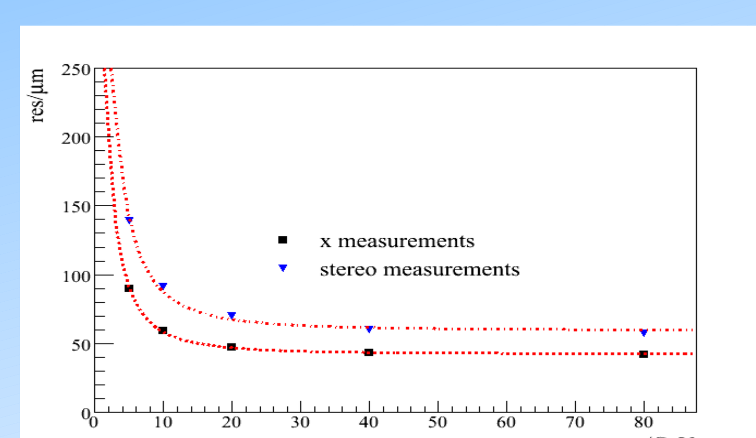
Bottom box ladder biases before alignment



Bottom box ladder biases after alignment



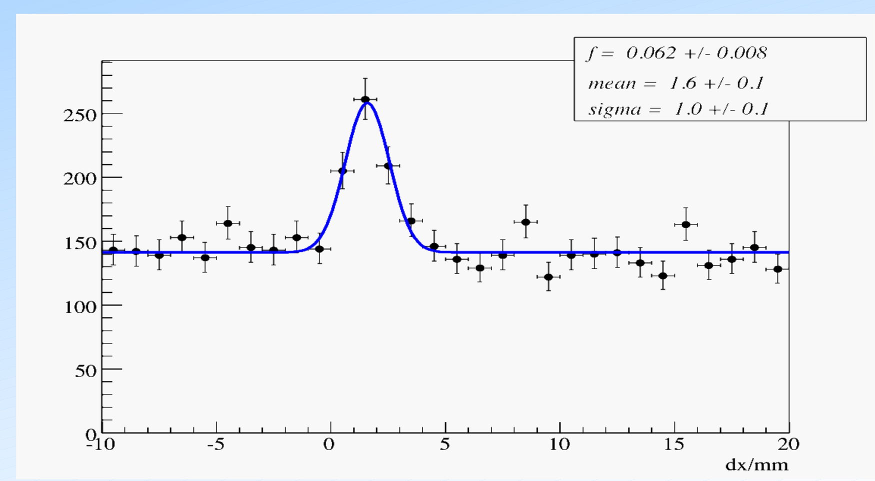
Momentum estimate



- Using Monte-Carlo, one can link the resolution with the momentum of the particles.
- Given that the obtained residuals are in the 100µm for X Layers and 150µm range for U/V Layers, this corresponds to particles of 5-6 GeV in momentum.
- The lower resolution for stereo measurements in the plot is due to only having 6 stereo layers versus 12 for x measurements.

Track confirmation by TT

- Studying the residuals of the tracks reconstructed by the IT generic tracking algorithm in the Tracker Turicensis confirms that 'real' tracks have been reconstructed.



TED Reconstruction

CreateITClusters → ITGenericTracking → TrackEventFilter → TrackContainerCleaner → TrackCompetition → TrackMonitor

IT Generic Algorithm

Find Tracks in the x-z plane

- Find a pair of hits in two different stations.
- Apply cuts on the line's parameters.
- If the line passes the cut, the hits are searched in a window around the line.
- If several compatible hits are found, then the candidate is split.
- Once the tracks are built, those with too few hits are discarded.
- The optimal estimates of the x-z track parameters is obtained using a least square fit on the hits.

Add the stereo layers information

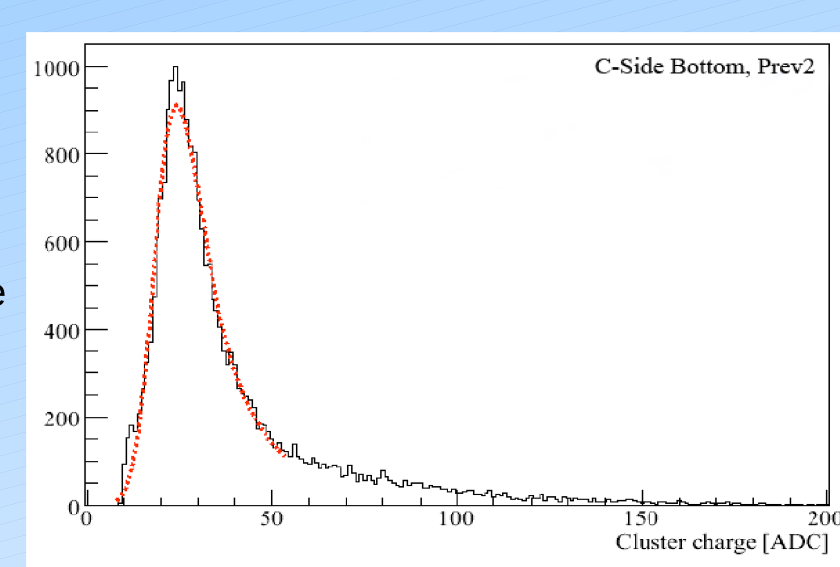
- All stereo hits consistent with the x-z track are collected.
- Each of these hits is converted into a y position information. The hit is checked to be compatible with the physical boundaries of the hit channel.
- The y-z tracks are built using the same steps as in x-z.

Algorithm performances

- The performance of the algorithm is evaluated using Monte-Carlo.
- For top and bottom boxes, the efficiency is of 98% with a ghost rate of 0.8% for an occupancy of 1.7%.
- For side boxes, the efficiency is of 81% with a ghost rate of 6.2% for an occupancy of 4%.

TT Time Alignment

- The charge deposit in the TT detector corresponds to a Landau curve, as shown on the plot.
- The observed signal over noise ratio is 13, which is a little lower than the expected value of 15.
- A timing scan is made to find the delay between the LHC clock and trigger in the frontend electronics.
- For each scan, the most probable value for the cluster charge is measured using a Landau fit.



- This most probable value is then ploted against the applied delay.
- A second order shaper function is used to find the maximum, and it is given as :

$$f = A \cdot e^{-x} \cdot (x^2/2 - x^3/6)$$

with $x = (t - t_0)/t_{rise}$

- The plots show the $tmax$ which is the time a the maximum, mpv, which is the most probable value and rem which is the remaining fraction of the signal 25ns past maximum for the four quarters of the TT.