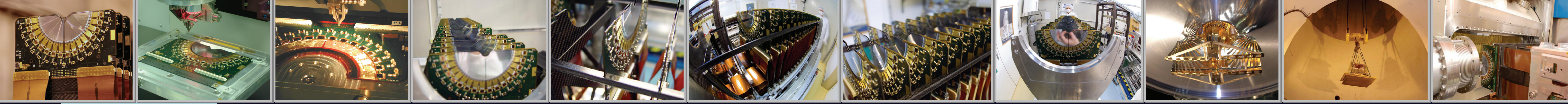
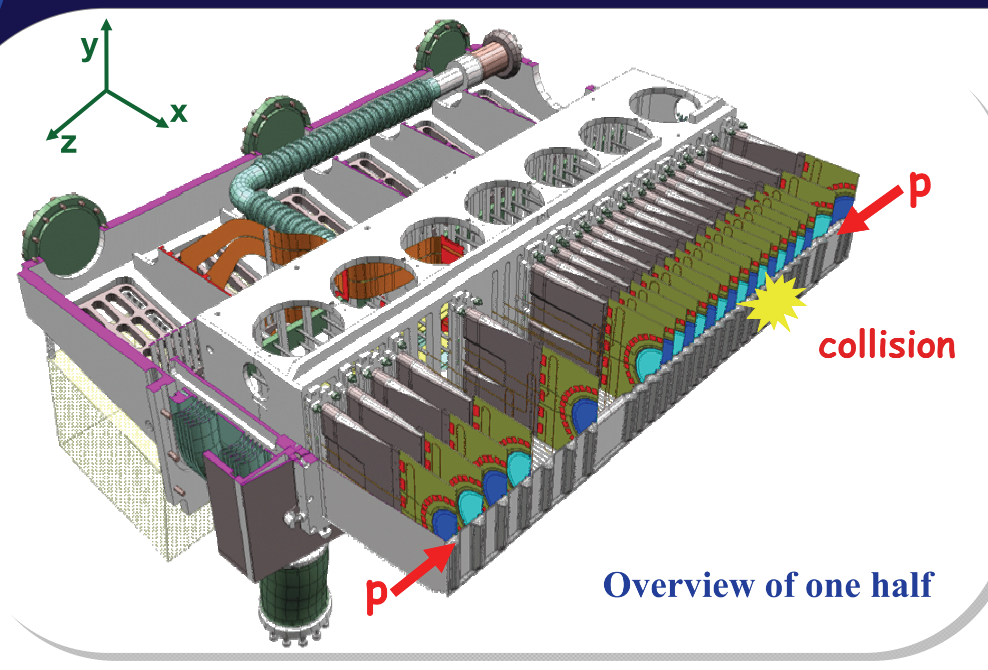


First Results from the LHCb Vertex Locator

Silvia Borghi for the LHCb VELO group

University of Glasgow



Overview of one half

Detector description and operational results

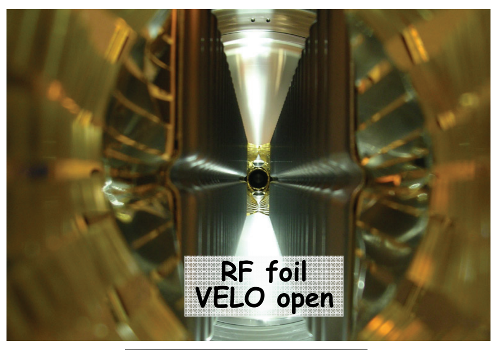
LHCb is a dedicated experiment to study New Physics in the decays of beauty and charm hadrons at the LHC at CERN.

The VELO is the silicon detector surrounding the interaction point, and is the vertex detector at the LHC that is closest to an interaction point: located only 7 mm from the LHC beam during normal operation. The detector will operate in an extreme and highly non-uniform radiation environment.

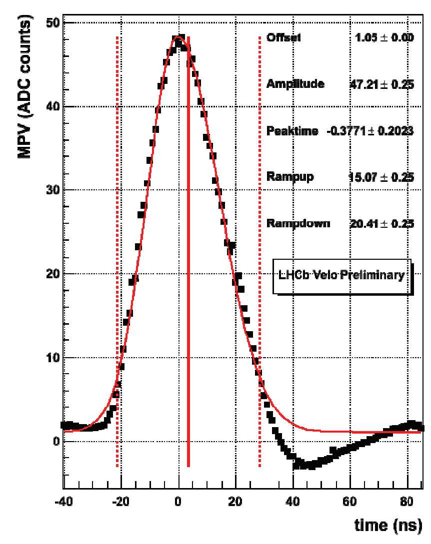
The VELO consists of two retractable detector halves with 21 silicon micro-strip tracking modules each.

A module is composed of two n+-on-n 300 micron thick half disc sensors with R-measuring and Phi-measuring micro-strip geometry, mounted on a carbon fibre support paddle.

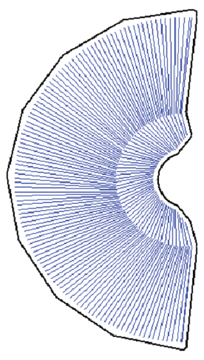
The detectors are operated in vacuum and a bi-phase $C0_2$ cooling system is used. The LHC beam vacuum is separated from the detector vacuum by 300 µm thick aluminium RF foils mounted on each half. In order to cover the full azimuthal acceptance and for alignment issues, the RF foils are corrugated in a way that allows the sensors of the two detector halves to overlap.



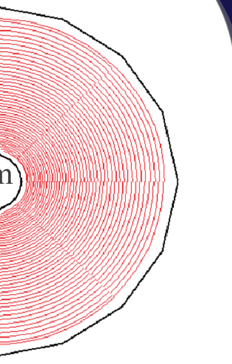
Time alignment within 2 ns



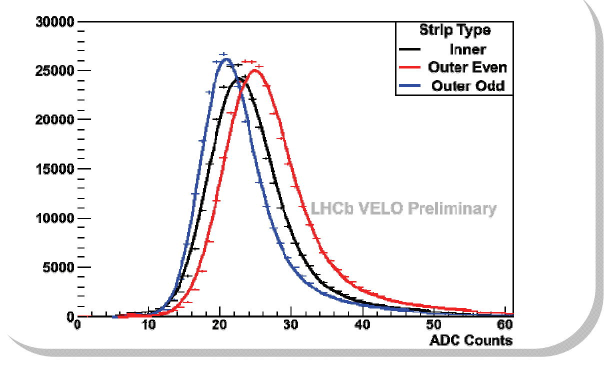
R-φ design

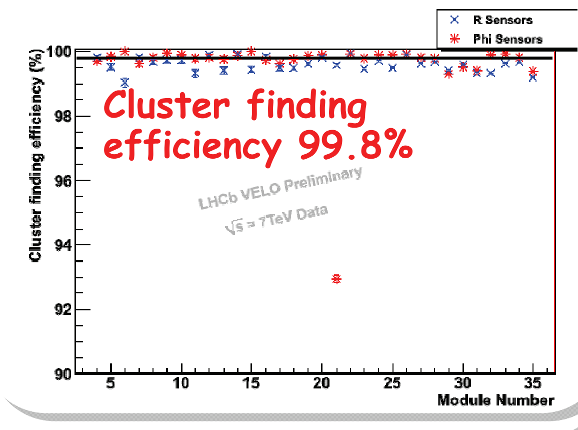


- 2048 strips
- 42 R-Φ pairs
- 172k channels
- pitch= 40-100 µm
- 40MHz clock
- DAQ: ~1MHz
- r_{active} = 8.2 mm

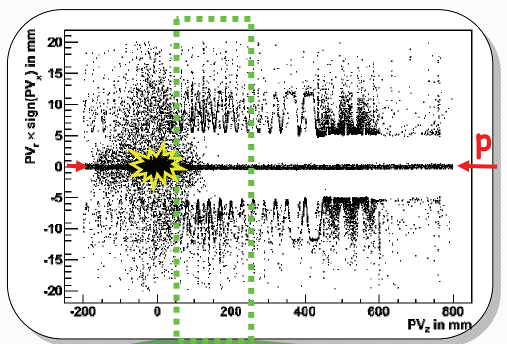


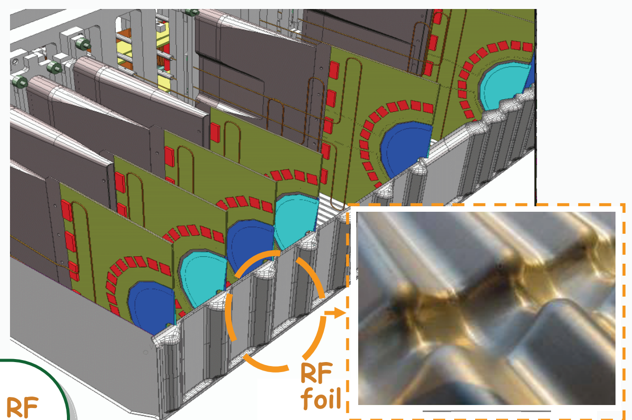
Signal to noise ratio of 20:1

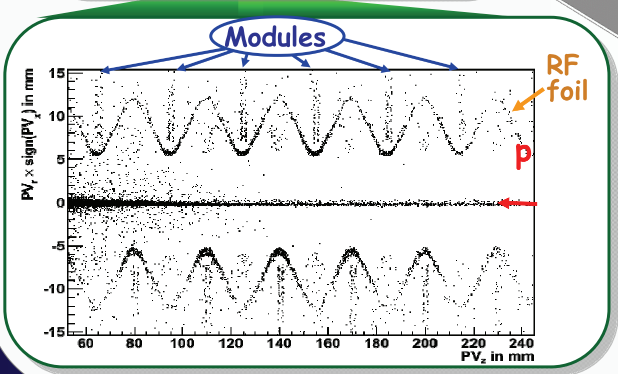




Material Imaging by reconstructed PV vertex





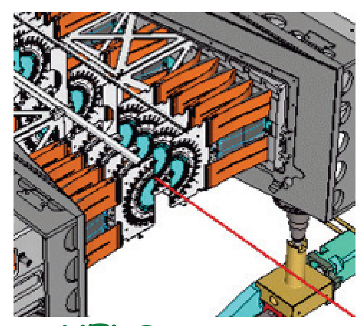


In these plots one can identify some sensors and the RF foil that separates the detector vacuum from the LHC beam vacuum.

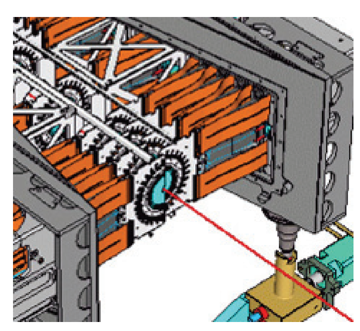
Closing Procedure

During physics running conditions of the LHC machine, the sensors are operated at 7 mm from the beam. Since the required LHC aperture increases during injection and machine studies the detector halves are then retracted by ~30 mm. The halves are inserted for each fill of the LHC once stable beams are obtained. The detector is centred around the LHC beam during the insertion.

This is achieved with a precise motion system capable of positioning the VELO in the x- and y -directions with an accuracy of 10 µm. The online imaging of the beams is provided by fast tracking and vertexing algorithms, also used to determine the motion steps and final detector position around the interaction point.

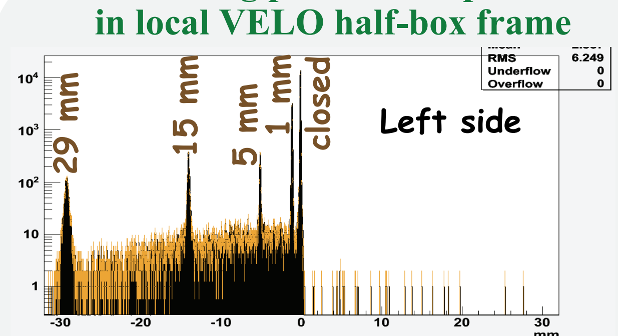


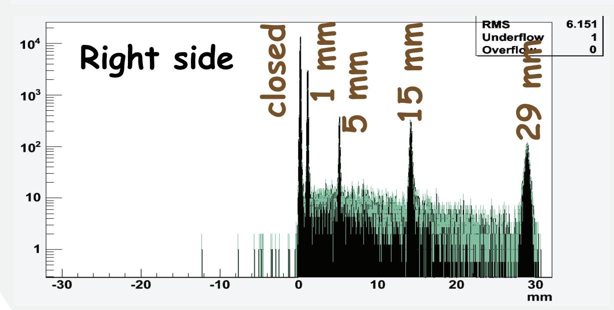
VELO open at injection and MD



VELO closed with stable beams

Monitoring plots: beam position in local VELO half-box frame





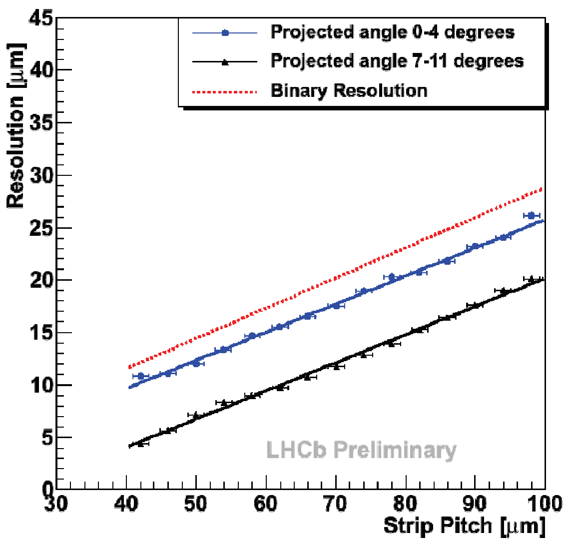
Detector performance

Hit resolution

The hit resolution depends on the strip pitch and on the projected angle.

The projected angle is the angle between the track and the strip in the plane perpendicular to the sensor.

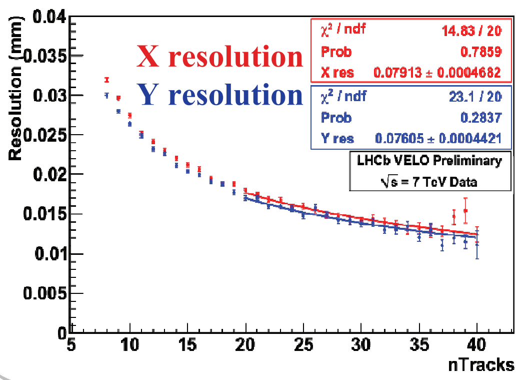
Best hit resolution: 4 µm

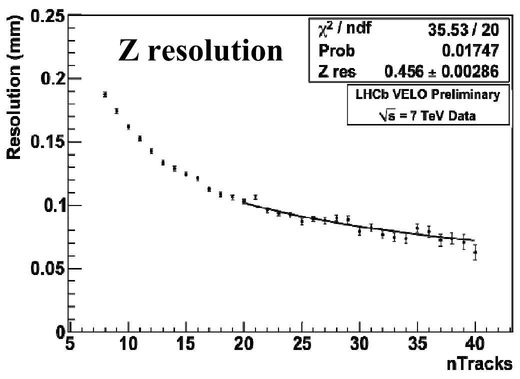


Primary Vertex resolution

- Measure resolution by randomly splitting track sample in two
- Compare split vertices of equal multiplicity
- Method validated with Monte Carlo

PV resolution with 25 tracks/vertex σ(x,y,z) = (16,15,90) µm



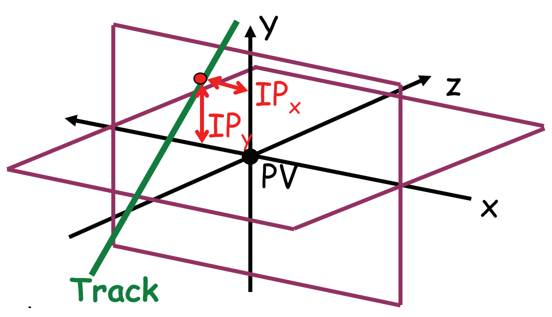


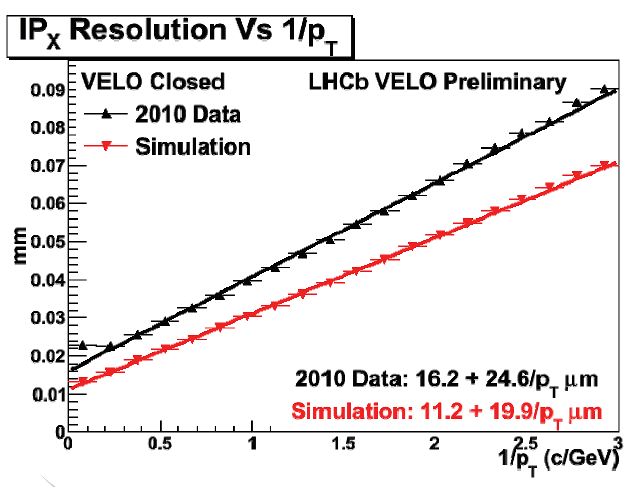
Impact Parameter resolution

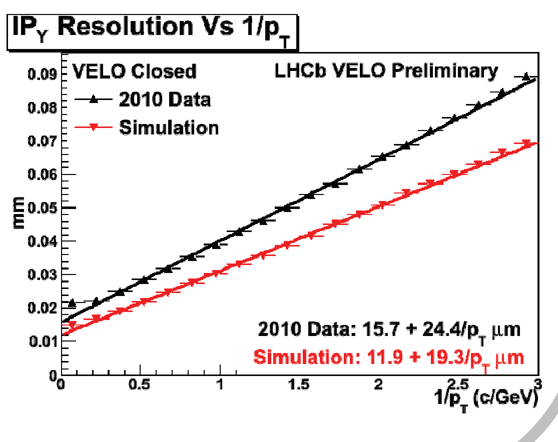
IP is defined as the closest distance of each track to the primary vertex

- Measure x and y component of IP
- Assume all tracks originate from PV
- Measure resolution as spread of IP distribution

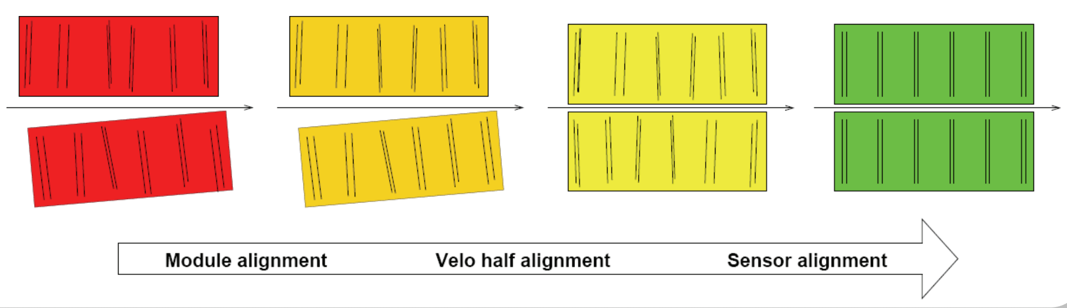
IP resolution up to 20 µm for the highest p_T bins







Spatial Alignment



The VELO alignment uses two different methods:

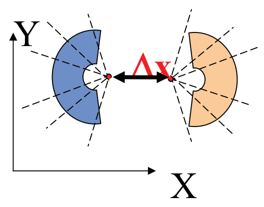
First method

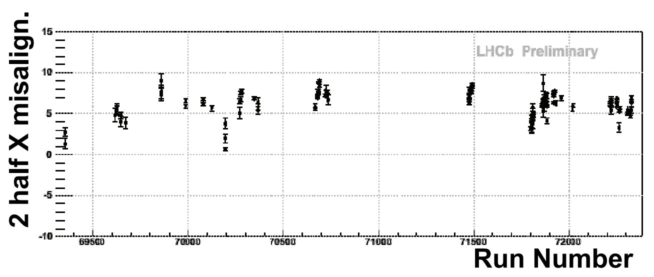
- Relative alignment of sensors: fit to residual distribution
- Module alignment: Millepede algorithm with linear track fit
- VELO half alignment: align with primary vertices from the halves and with tracks crossing the overlap region

Second method

- Global χ2 minimisation based on Kalman track fit residuals.

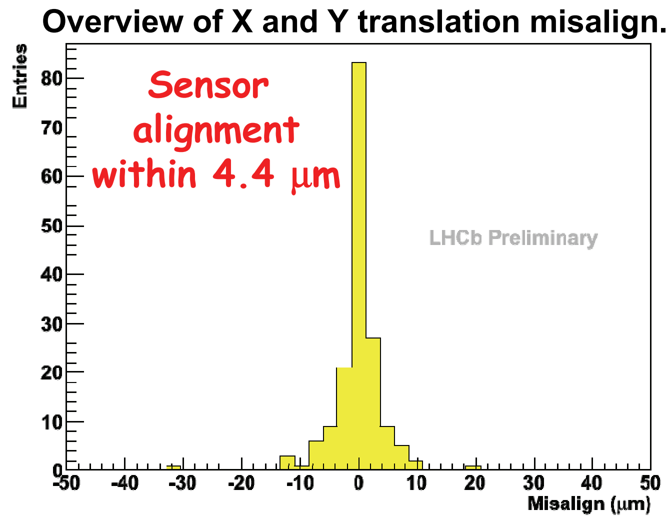
Stability evaluated by the distance of PV evaluated with tracks in the left or Right side.





Stability run-to-run of the 2 half alignment: (x,y) = (±5, ±3)µm

Monitoring of x and y translation alignment for the R and Φ sensors



$$\text{residual (R sens)} = -\Delta x \cos\phi_{track} + \Delta y \sin\phi_{track}$$

$$\text{residual}(\Phi \text{ sens}) = \Delta x \sin\phi_{track} + \Delta y \cos\phi_{track} + \Delta\gamma\, r_{track}$$