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FSP LHCb
Erforschung von Universum und Materie

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Understanding the Alignment of LHCb's Scintillating Fibre Tracker

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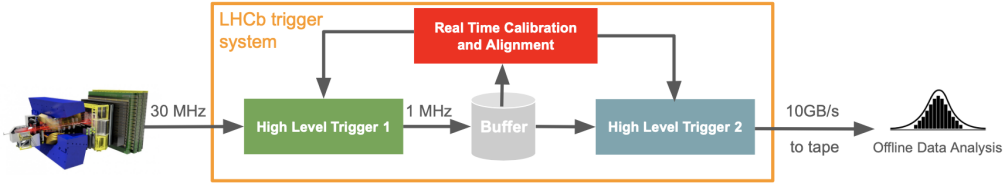
Overview

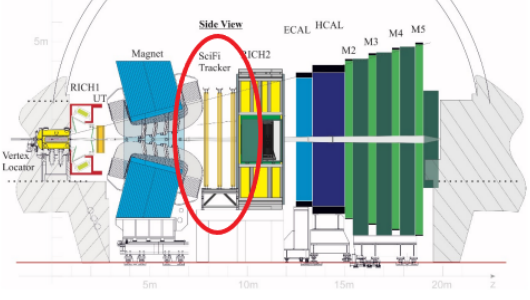
- The SciFi Detector Upgrade
- Importance of the SciFi and Alignment
- Understanding first alignments on 2022 data

Importance of alignments

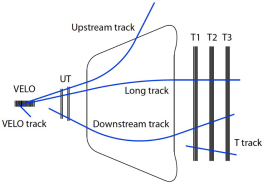
- Alignment is part of the LHCb trigger system
- Physics performance tied to alignment performance
- with optimal alignment:
  - → remove systematic biases for asymmetry measurements
  - best possible mass resolution



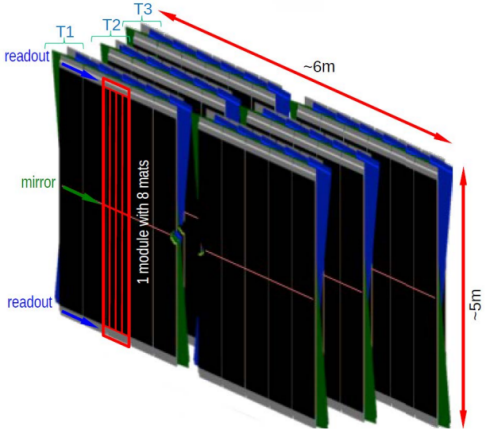
LHCb upgraded with the SciFi



- Consists of 3 stations: T1, T2, T3
- 4 layers per station: X1, U, V, X2
- replaces former IT and OT to cope with the increased instantaneous luminosity
- crucial part of tracking system



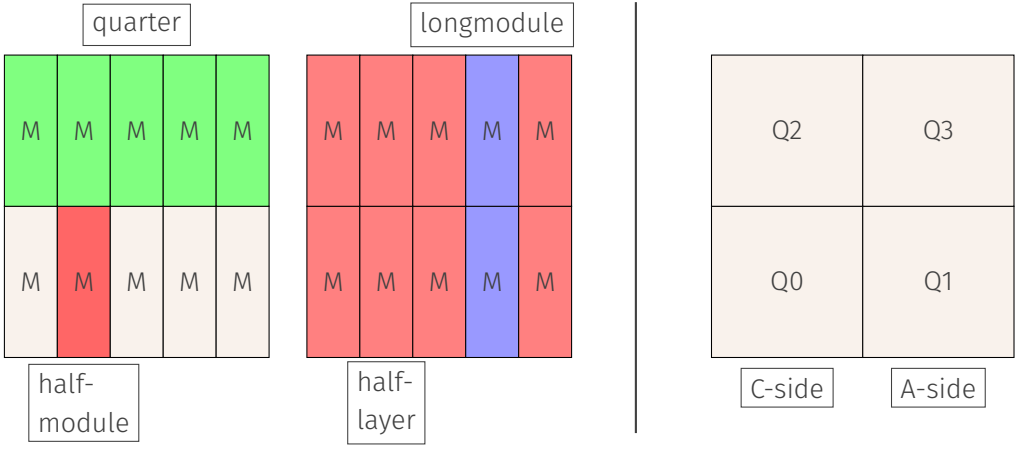
The Scintillating Fibre Tracker



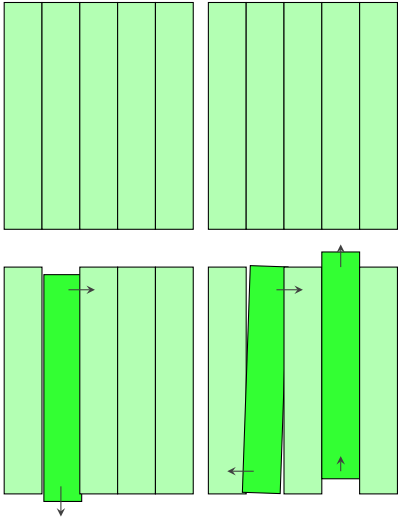
- Front two stations have 5 modules per side
- Back station has 6 modules on each side
- U, V layers have a **∓5 deg** stereo angle respectively
- → used for determining y-position of tracks by comparing hitposition at different angles

SciFi terminology

layers are divided into two halves commonly labeled as A-side and C-side



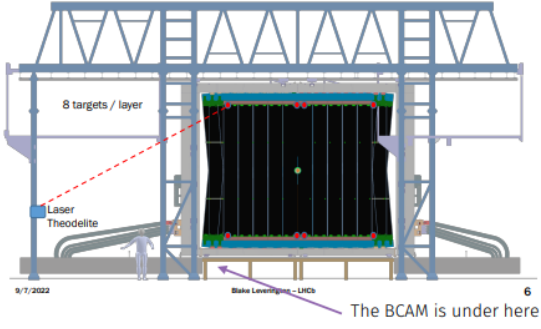
What is Alignment and why do we need it?



- top: ideal detector, bottom: physical detector
- Surveys are used to find the rotation and position of each detector component
- Are used as starting positions for software alignment
- Building tracks accurately requires positions in reconstruction to be as similar as possible to real positions

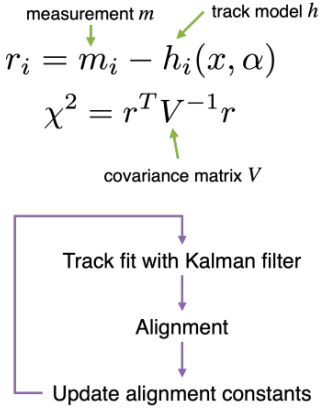
The survey: what is it and the different types

- measure distance of some points on the detector with a laser



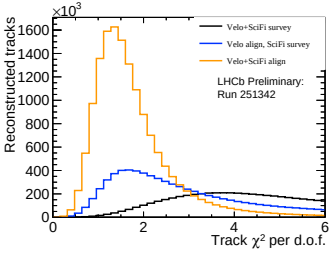
- 2022: photogrammetry was recorded in assembly hall → not quite perfect
- 2023: photogrammetry will be recorded in cavern
- relative angles and positions between points are compared to simulation
- layer survey: performed in the cavern on the layer in the front in closed state (both halves together)
- module survey: performed inside assembly hall using reflective stickers keeping track of all positions

Alignment: track fits with the Kalman Filter



- Use survey information as starting point
- aligning the detector by minimizing the residuals of the track hits
- basically a χ^2 minimization problem with alignment parameters α
- Why Kalman Filter?
  - easily models material interactions as well as multiple scattering
- propagation of nodes, minimization, smooth error sizes by back propagation

Alignment versions in use

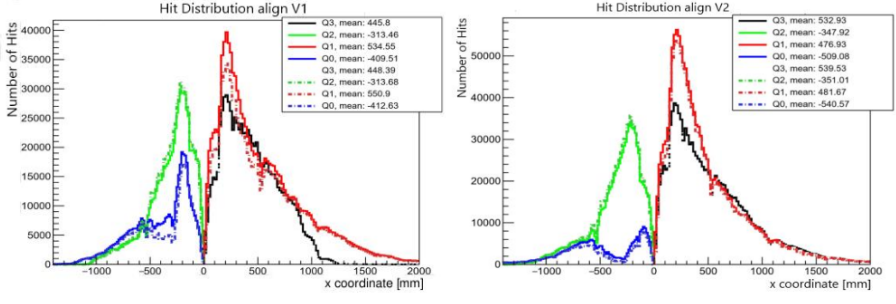


- V1: First ever SciFi alignments for the upgraded LHCb detector
- Using early tracks from comissioning
- use full length modules
- alignable degrees of freedom: Tx Rz (x translation, rotation around z →beam pipe axis)

- V2: Updated alignment version with what we learned from V1
- aligned using half modules
- uses newest time alignment

Hit distribution per quarter in V1 and V2 alignment

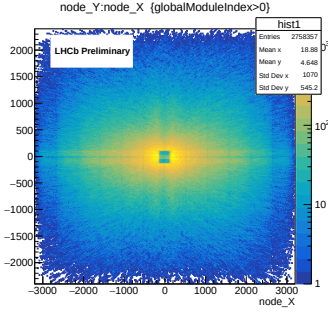
- Improvements to V2 visible on A-side, losing some performance on C-side
- Alignment performance difference in each quarter → seperately analyse quarters!
- $\chi 2$ per quarter can provide more insights about alignment performance in each detector part
  - analysis of each quarter seperately makes finding possible issues easier

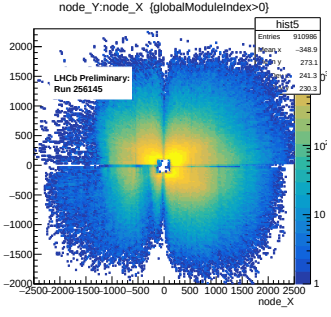


Track hits comparison of V2 and simulation

- MC: hits on **reconstructed** tracks fill whole detector
- data: filling tracks into A-side → good!

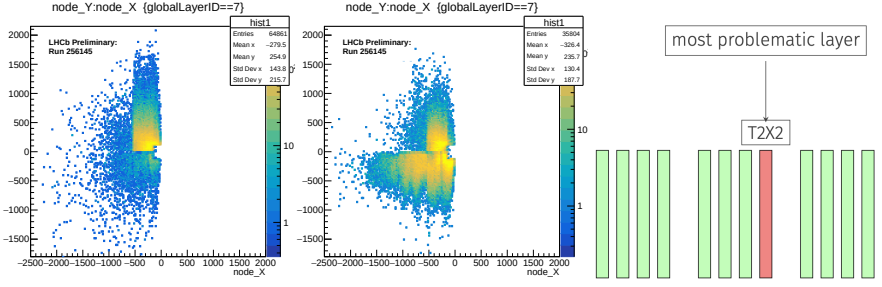
→ scan C-side quarters for possible issues in distinct layers





New Q0 positions in T2X2 layer

- Changes based on V2 alignment positions
- test incremental shifts of position/rotation until we found an improvement
- rotations are with regard to the local frame of the module
- positions: translations relative to the nominal position for each module
- V2 alignment has only few tracks in Q0 because parts of the SciFi are too far out of alignment



Summary

- Trying to solve a puzzle on unexpected lower number of alignment tracks on the C-side
- Source of complications: SciFi parts too far out of alignment to be correctly updated
- → Varying the positions and rotations of Q0 modules yielded more tracks in more modules
- Feeding this back into tracking alignment to get the fine tuning right
- new survey/photogrammetry in progress to improve alignment starting conditions this year

Thank you for your attention!