Understanding the alignment of LHCb's SciFi Tracker

Nils Breer*, Sophie Hollitt, Johannes Albrecht

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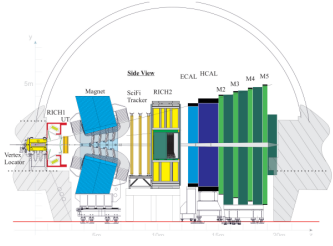
Technische Universität Dortmund, Fakultät Physik

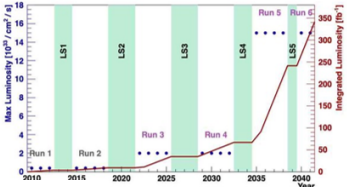
Overview

- The SciFi Detector Upgrade
- Alignment how to
- Analysis of SciFi quarters

The Scintillating Fibre Tracker

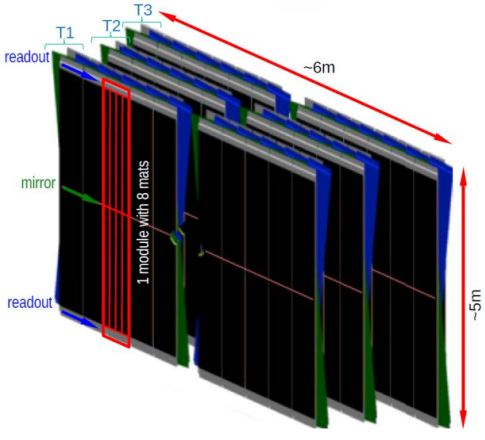


(a)



- Higher luminosity
  - detector must operate well with expected radiation damage
- detector readout electronics need to operate at 40 MHz, 25ns usable time per collision
- tracking efficiency and hit detection improvements aim for about 98% hit detection rate

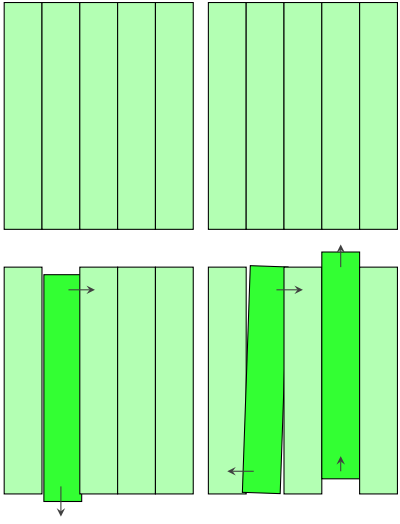
The Scintillating Fibre Tracker



- single detector type vs. IT + OT
- less timing information needed for readout
- less detector material
  - less multiple scattering and material interactions
- SiPM technology improvements yield better resolution and speed

Abbildung: Visualization of the SciFi tracking

What is Alignment?



- 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 (this talk!)

Alignment: track fits with the Kalman Filter

measurement m track model h

$$r_i = m_i - h_i(x, \alpha)$$

$$\chi^2 = r^T V^{-1} r$$

covariance matrix V

- Minimise χ^2 with respect to the track parameters for the track fit
- Minimise χ^2 with respect to the alignment parameters α during the alignment
- Update the alignment constants α and repeat until convergence criterium

Alignment versions in use

V1:

- use full length Modules
- alignable degrees of freedom: Tx Rz (x translation, rotation around z →beam pipe axis)

lowμ:

- use half modules
- uses VELO alignment on run 256145 data
- μ = look it up

V2:

- newest alignment version
- half modules (top half and bottom half)
- uses newest time alignment
- utilizes VELO alignment from run 256145
- $\mu \approx 2.26$ (value taken from run database)

Why analyse the quarters separately?

- perfomance in each quarter might be very different from one another
- $\rightarrow \chi^2$ per layer might be different from χ^2 per quarter
- v2 alignment shows improvements from v1 alignment but not across the whole SciFi
- find and resolve possible issues is easier

Summary of Metrics from alignments in Quarter 0

This hints that something is not right in Q0

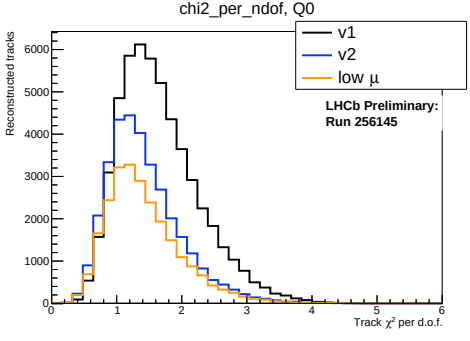


Abbildung: track χ^2 per dof comparing each alignment for Quarter 0.

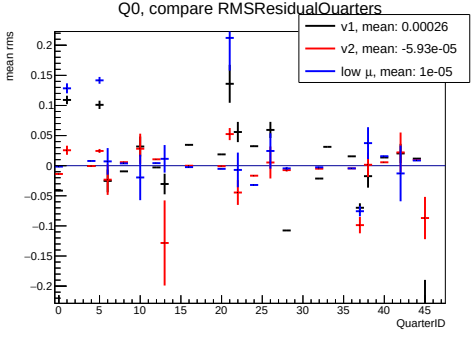


Abbildung: Residual in each module for each alignment in Quarter 0.

Summary of Metrics from alignments in Quarter 1

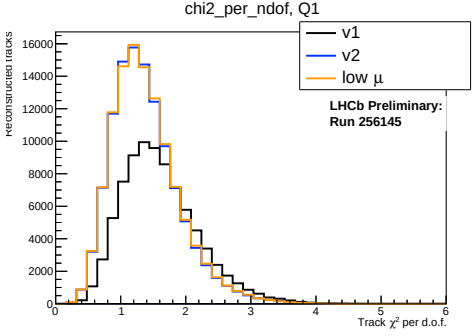


Abbildung: track χ^2 per dof comparing each alignment for Quarter 1.

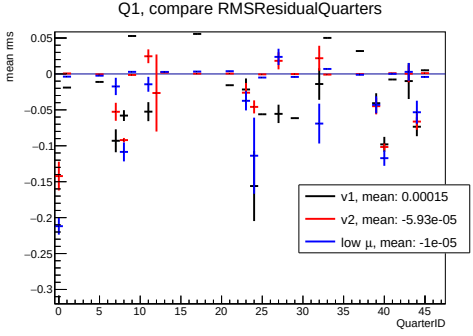


Abbildung: Residual in each module for each alignment in Quarter 1.

Summary of Metrics from alignments in Quarter 2

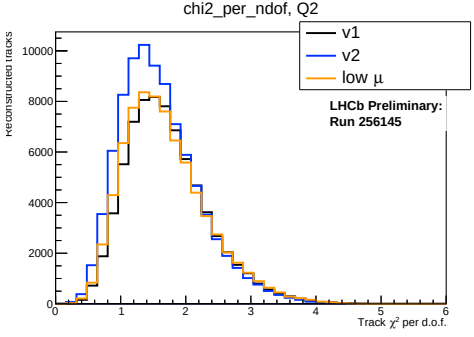


Abbildung: track χ^2 per dof comparing each alignment for Quarter 2.

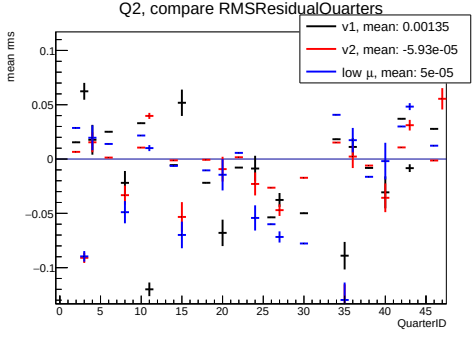


Abbildung: Residual in each module for each alignment in Quarter 2.

Summary of Metrics from alignments in Quarter 3

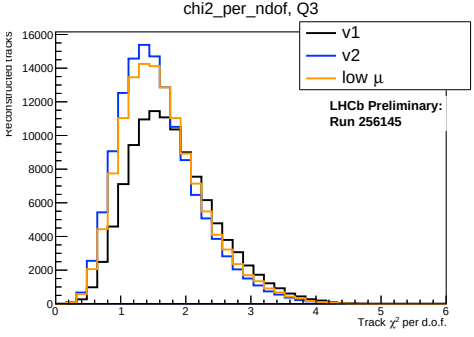


Abbildung: track χ^2 per dof comparing each alignment for Quarter 3.

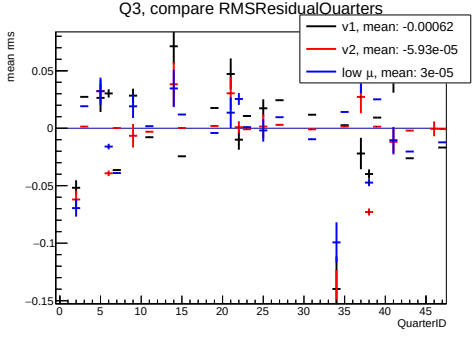


Abbildung: Residual in each module for each alignment in Quarter 3.

Conclusion

- text

Sources

- SciFi Conference Talk:
https://twiki.cern.ch/twiki/pub/LHCb/SciFiConference/fee_2018.pdf
- LHCb SciFi: From performance requirements to an operational detector:
https://indico.cern.ch/event/1163878/