technische universität dortmund

FSP LHCb
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Global alignment of the LHCb SciFi Tracker and Vertex Locator

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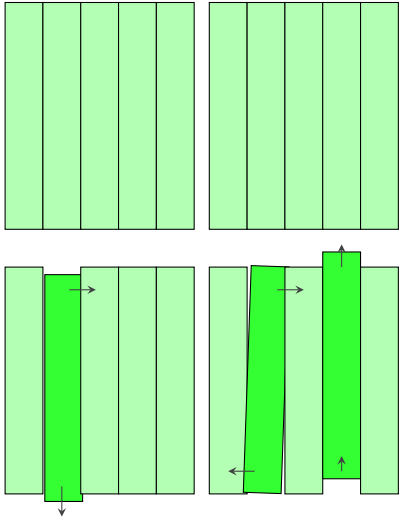
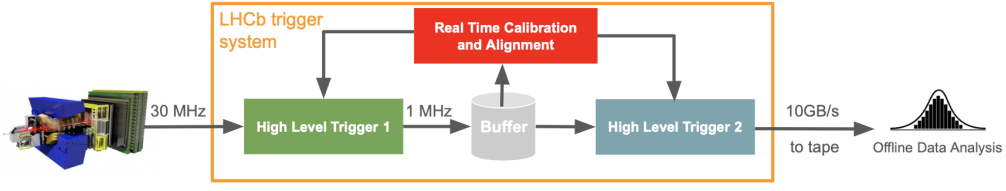
Why do we need detector alignment?



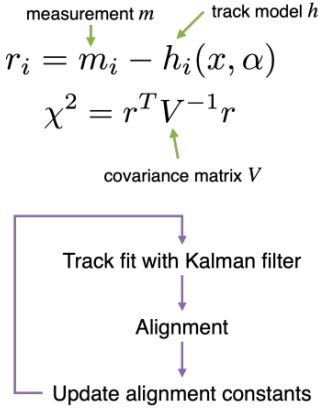
- Track reconstruction accurately requires positions in reconstruction to be as similar as possible to real positions
- Top: ideal detector, bottom: physical detector
- Surveys are used to find the rotation and position of each detector component
- Input for alignment are surveyed measurements of detector positions
- Alignment goal: achieve the best precision in the detector position

Importance of alignments

- Alignment is part of the LHCb trigger system
- Physics performance tied to alignment performance
- Good quality alignment contributes to:
  - → remove systematic biases for asymmetry measurements
  - Best possible mass resolution

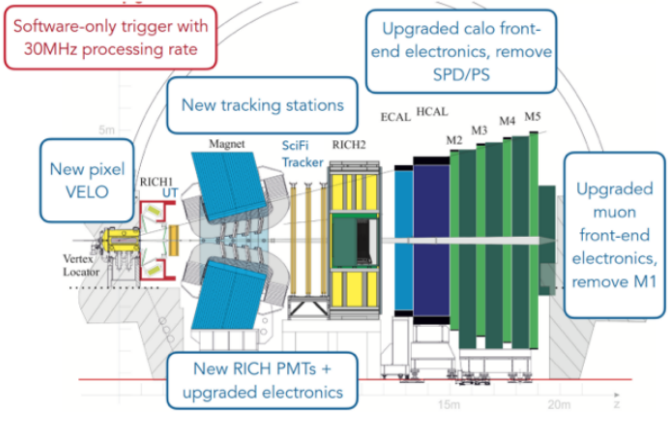


Tracking alignment: track fit using Kalman filter

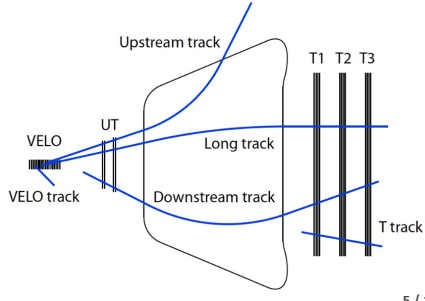


- Starting positions: positions from laser scans of detector objects (survey)
- Alignment: χ^2 minimization of track residuals
- $$\frac{d\chi^2}{d\alpha} = 2A^T V^{-1} r \quad (1)$$
- Add measurements one-by-one to fit
- Prediction of next measurement →minimize residuals →redo until track complete
- Why Kalman Filter?
  - Easily models material interactions as well as multiple scattering

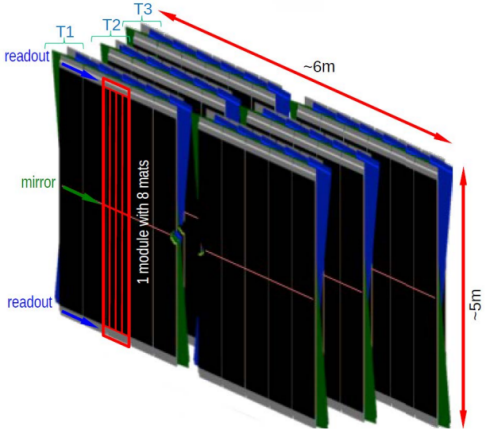
The Run 3 LHCb detector



- Brand new detector to maintain physics performance at more radiation harsh environment
- UT was not present during 2022-23 data taking →focus on SciFi and VELO



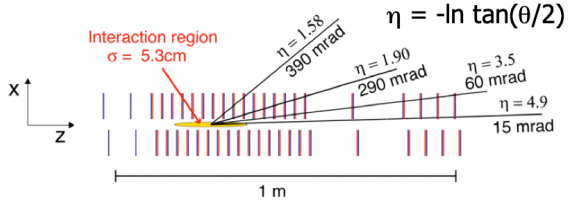
The Scintillating Fibre Tracker

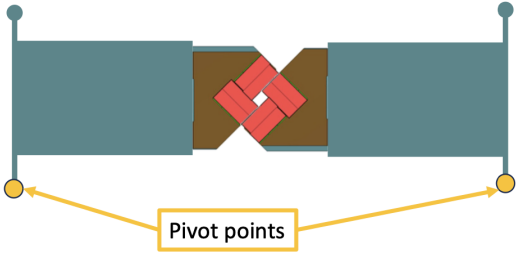


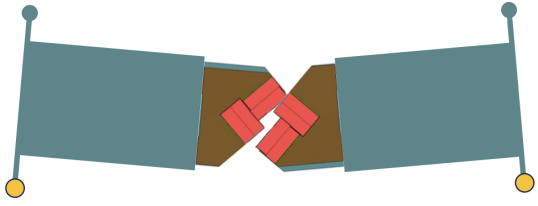
- 5 modules per side except for back T-station has 6
- X1, X2-layers are vertical and only yield x-position information
- U, V layers have a ∓5degree stereo angle respectively
  - → Used for determining y-position of tracks by comparing hitposition at different angles

VELO geometry

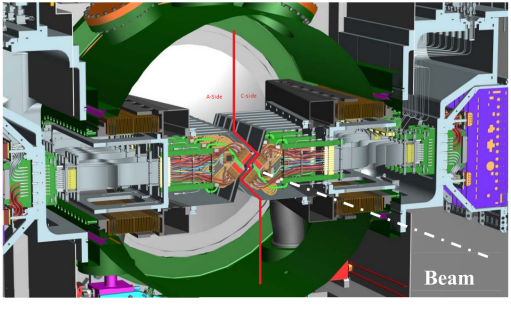
- Rotation Rz leading to shifts in x and y
- Half alignment sensitive to x shift
- Global movement in y
- Can not be corrected for by half alignment

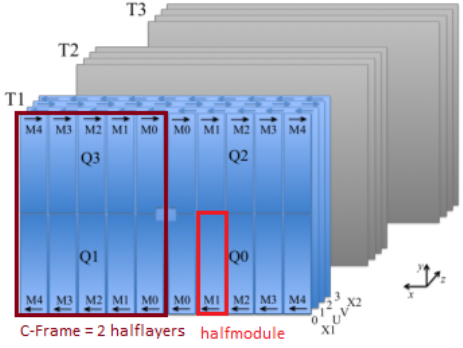




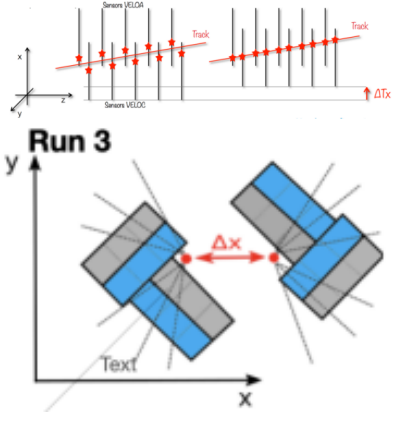


Alignables for the global alignment

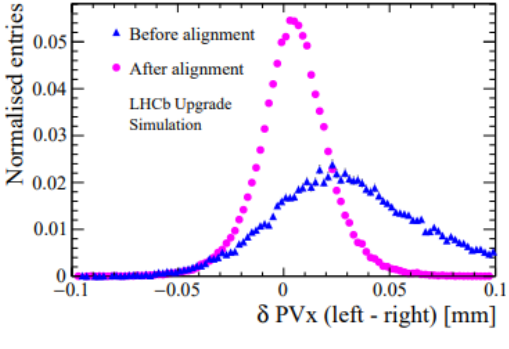




VELO ALignment



- Align VELO in Tx to move modules where track is expected

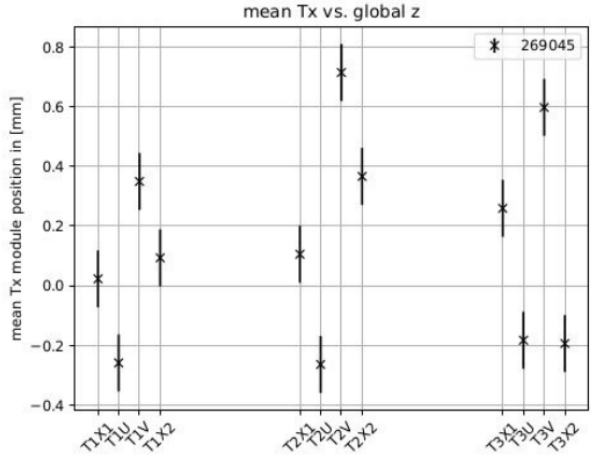


Global alignment and motivation

Global alignment

- Alignment of the VELO and SciFi simultaneously
- Motivation for global alignment
  - we can do the alignment seperately but ideally best alignment we achieve is the global one
  - Understanding the interplay between tracking systems
  - Rotations inside the VELO →weak modes inside SciFi (VELO twisting)

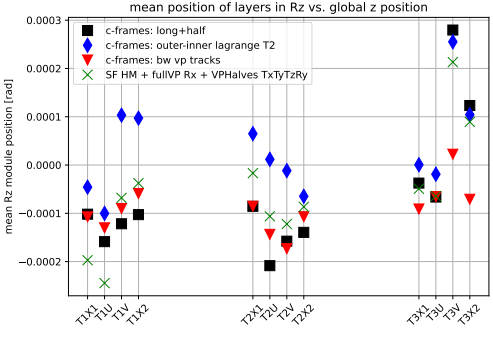
SciFi alignment status and issues



- SciFi alignment is quite good already but there are some underlying problems
- Shift of SciFi layers larger than expected from survey
- Zig-zag pattern comes from global VELO Rx rotation
- Similar pattern in SciFi Tz →entangled problem between Tx and Tz

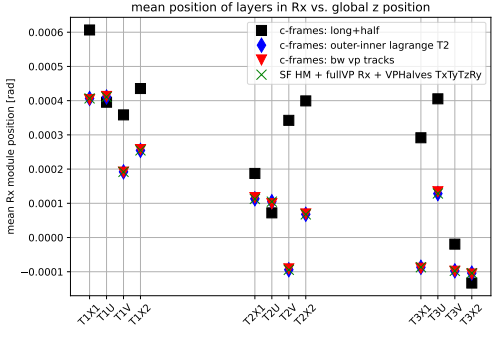
Comparison to global alignment tests

	C-FRames	Halfmodules	full VELO	VELO halves
DoF	RxRz	TxRxRz	RxRz	TxTyTz



- Black: first align Longmodules then Halfmodules
- Blue: constraining (X1|X2) and (U|V) layers
- Red: added backwards VELO tracks
- Green: only Rx in full VELO alignment

global alignment: rotation studies



- Observe rotation around Rx through T-stations →inconsistent bending of the layers
- This effect only shows when running SciFi and VELO together

Outcome of the study and next steps

- ongoing investigation of zig-zag pattern with VELO Rx

→similar pattern in Tz →cannot fix one without the other

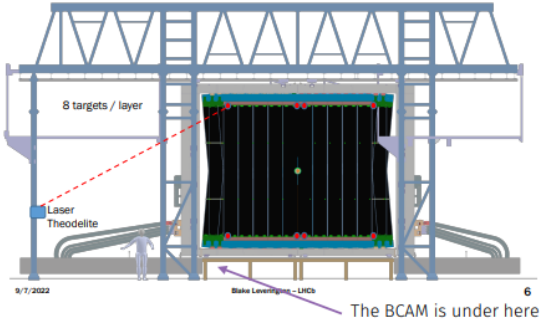
- global VELO Rx might be overthrown by survey constrains acting on Rx →Rx not being picked up in the alignment
- Testing different survey uncertanties to study the impact on global VELO rotation
- Testing different settings in the alignment on stereo layers in Tx
- make sure VELO Rx is being picked up in the alignment
- Include the VELO+ SciFi configuration during data-takin

Summary

- global alignment improving the position of the T-stations
- survey constraints might counteract the global VELO Rx
- A lot more tests to do until data taking which look promising
- **Thank you for your attention!**

The survey: what is it and the different types

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



- Layer survey: find corners of layers
- Module survey: reflective stickers, calculate module plane
- Compare survey to simulation