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# Global Alignment of the SciFi and the VELO (DPG titel einfuegen)

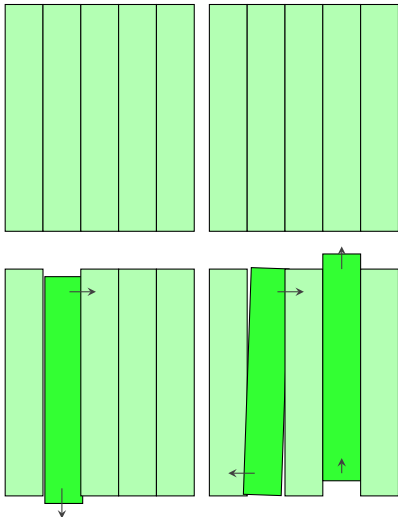
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**Nils Breer**, Biljana Mitreska, Sophie Hollitt, Johannes Albrecht

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## 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
- → Starting positions for software alignment
- Building tracks accurately requires positions in reconstruction to be as similar as possible to real positions

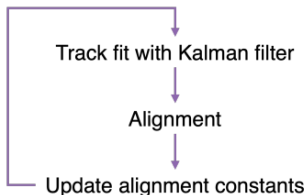
## Alignment: track fits with the Kalman Filter (maybe backup)

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

measurement  $m$       track model  $h$

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

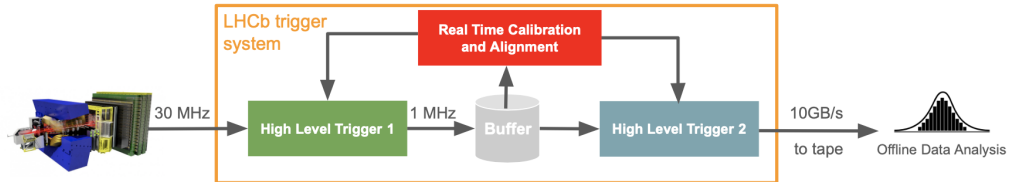
covariance matrix  $V$



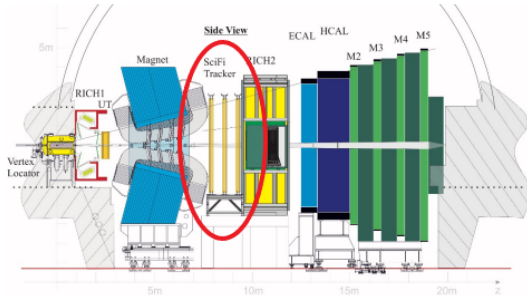
- Starting positions: positions from laser scans of detector objects (survey)
- Alignment:  $\chi^2$  minimization of track residuals
- Add measurements one-by-one to fit
- Prediction of next measurement → minimize residuals → redo until track complete
- Why Kalman Filter?
  - easily models material interactions as well as multiple scattering

## Importance of alignments

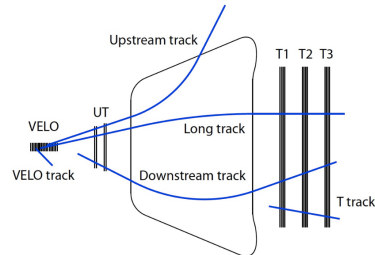
- Alignment is part of the LHCb trigger system
- Physics performance tied to alignment performance
- with optimal alignment:
  - → remove systematic biases for asymmetry measurements
  - Best possible mass resolution



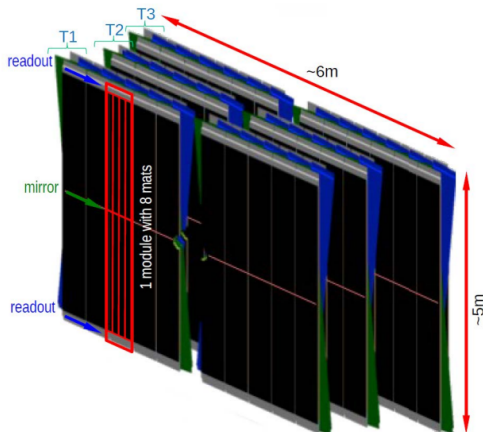
## LHCb upgraded with the SciFi



- 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



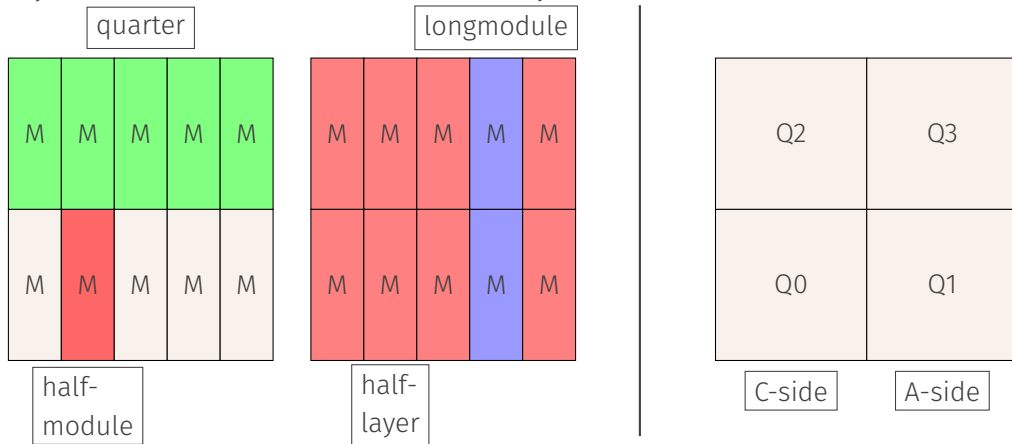
## The Scintillating Fibre Tracker



- Front two stations have 5 modules per side
- Back station has 6 modules on each side
- U, V layers have a  $\pm 5^\circ$  stereo angle respectively
- → Used for determining y-position of tracks by comparing hitposition at different angles

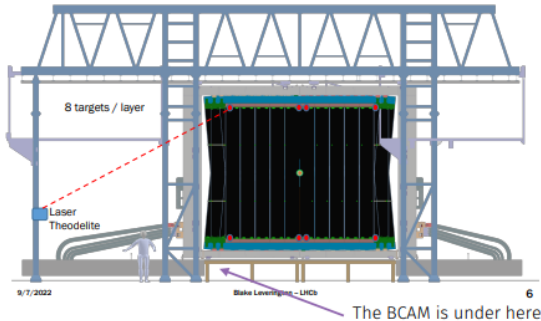
## SciFi terminology (confusing for some people)

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



## The survey: what is it and the different types (maybe backup material)

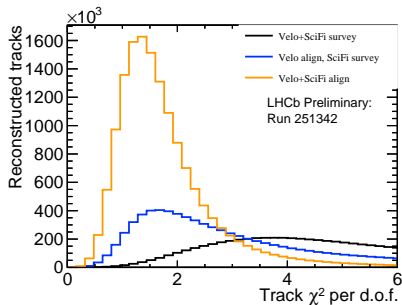
- Measure distance of some points on the detector with a laser



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



## Alignment versions development in 2022 (maybe exchange with something more recent)



- V1: First ever alignments after upgrade
- Using first data sets
- Starting configuration: long modules, Tx Rz

- V2: Improved configuration from V1
- Half modules, Tx Rz, new time alignment

## Global Alignment and motivation

- what is global alignment?
  - alignment of the velo and the scifi together to understand the interplay in comparison to only SciFi
- why is it a good idea to do it?
  - open VELO might be a problem for other tracking stations like UT, SciFi and Muon
  - VELO is twisted between fron and back -> introduces potential biases

## problems miguel told me

- problem A

## plots about layer positions

- zig zag pattern
- dip in T2 is weird
- look at my plots and deduce the differences between configs (what happens when introduce Frames or Long layers or lagrange constraints or different dofs)

## maybe also show module positions

- make it easier to understand when looking at the plot

## Summary

- Source of complications: SciFi parts too far out of alignment to be correctly updated, corrected now with new alignment version and photogrammetry
- Correct module positions by hand: working procedure for singular low-efficiency modules
- stability tests show no substantial difference in alignment quality from magnet polarity
- sufficient statistics: **150 $\mu$ m** movement; rerun manually if this is exceeded

## Backup

### Loose Tracking config and D0 selection

```

1 #####
2 # (c) Copyright 2022 CERN for the benefit of the LHCb Collaboration #
3 # #
4 # This software is distributed under the terms of the GNU General Public #
5 # Licence version 3 (GPL Version 3), copied verbatim in the file "COPYING". #
6 # #
7 # In applying this licence, CERN does not waive the privileges and immunities #
8 # granted to it by virtue of its status as an Intergovernmental Organization #
9 # or submit itself to any jurisdiction. #
10 #####
11 from PyConf.Algorithms import (PrForwardTrackingVelo, PrMatchNN)
12 from Moore import options, run_reconstruction
13 from RecoConf.standalone import standalone_hlt2_light_reco_without_UT
14 from RecoConf.hlt2_tracking import (
15     make_PrKalmanFilter_noUT_tracks,
16     make_TrackBestTrackCreator_tracks,
17 )
18 from RecoConf.early_data import (
19     get_loose_PrForwardTrackingVelo_params,
20     get_loose_PrMatchNN_params,
21     get_loose_PrKalmanFilter_params,
22     get_loose_TrackBestTrackCreator_params,
23 )
24 with PrForwardTrackingVelo.bind(**get_loose_PrForwardTrackingVelo_params()), \
25     PrMatchNN.bind(**get_loose_PrMatchNN_params()), \
26     make_PrKalmanFilter_noUT_tracks.bind(**get_loose_PrKalmanFilter_params()), \
27     make_TrackBestTrackCreator_tracks.bind(**get_loose_TrackBestTrackCreator_params()):
28     run_reconstruction(options, standalone_hlt2_light_reco_without_UT)

```

$p_{\text{min}} = 800 \text{ MeV}$

pion, kaon required to have min pt and  
IPCut =  $60 \mu\text{m}$

mass hypothesis [1760 MeV, 1960 MeV]

vertex  $\chi^2 < 10$

## Backup: stability dataset

- Dataset contains magnet-up and magnet-down samples from 2022 labeled as "good" from EMTF

- Good: > 90% of datalinks are good
- Includes runs from fills: 8489, 8491, 8496

List of randomly chosen runs: 255949, 256030, 256145, 256159, 256163, 256272, 256278, 256290

- V3 Alignment from tag (loose tracking, half module alignment TxTz + Mat alignment, back layer fixed) from conditions database