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SciFi reconstruction and alignment

Nils Breer on behalf of the SciFi alignment and Reconstruction team

SciFi general at 108th LHCb week - 5th june 2023

Reconstruction and alignment overview

● Big SciFi alignment team this year

● Working in close contact with SciFi hit efficiency, timing, survey, data quality, sim+reco, RTA and early measurements

Thanks everyone for your support and feedback!

People working with SciFi align and calibration

- Fred Blanc
- Jessy Daniel
- Zehua Xu
- Emmy Gabriel
- Louis Henry
- Nils Breer
- Giulia Tuci
- Laurent Dufour

- Blake Leverington
- Wouter Hulsbergen
- Izaac Sanderswood
- Maria Vieites Diaz
- Mark Waterlaat
- Sophie Hollitt
- Miguel Ruiz Diaz
- Biljana Mitreska

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Overview of the topics

SciFi simulation and reconstruction

- Weekly group meeting: Monday, 13:15h

- Mailing list: lhcb-upgrade-ft-software

Alignment and Calibration

- Weekly group meeting: Tuesday, 11:00h

- Mailing list: lhcb-scifi-alignment-calib

Twiki

- Updates since last LHCb week
  - 2022 SciFi checks:
    - VELO drift studies
    - V3 SciFi alignment
    - V^0 studies of alignment versions
    - Stability measurements
  - Checks for 2023 alignments:
    - Survey and photogrammetry
    - Loose tracking and open VELO alignment
    - New module constraint in progress

Software and operations
  - Readout map development
  - Run control

2022 VELO drift
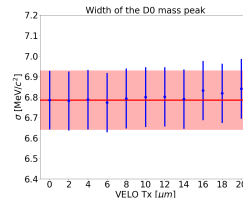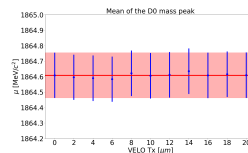

Fill 8387

LHCb internal
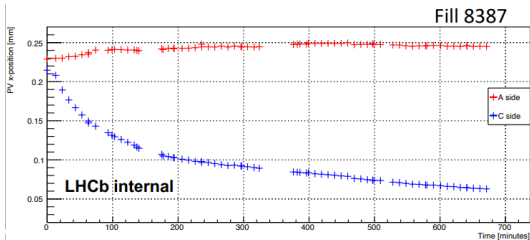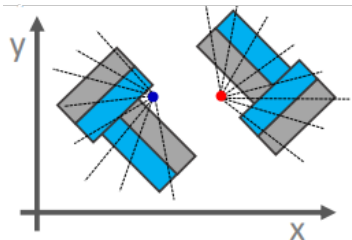
- The VELO drift has been confirmed with monitoring, alignment and material scan

- After the closing, C-side starts rotating around y with pivot point at around 850 mm

- Complications:
  - Start of drift unpredictable
  - Drift amount differs over time

Also see Florian's slides
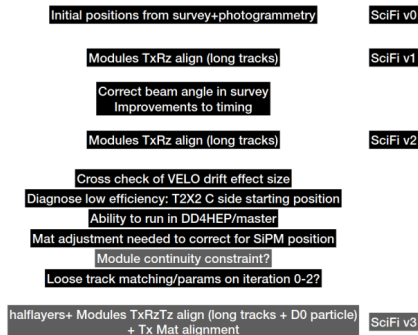
VELO drift impact for SciFi alignment on 2022 data

- Goal: estimate impact of VELO movement on reconstructed mass

- DoFs: Tx, Rz long modules aligned

- Data set: $B^0 \rightarrow D^*\pi$ and $D_0 \rightarrow K\pi$

- Outcome: the mean value of the mass is consistent.

- Resolution: got slightly worse but still within a standard deviation

Thanks to Miguel!

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SciFi

SciFi alignment with 2022 data

from Sophie's slides

- Half modules to better correct for suboptimal starting conditions
- Beam angle fix + better fine timing
- Low efficiency C-side → improved starting conditions
- Mats need to correct for SiPM positions
- Loose track matching/params in first iterations yield performance boost
- Final v3: TxTzRz, halflayers + modules, long tracks to D0 particles + Tx mat alignment

Overview of alignment v3 module

- Starts from 2022 SciFi survey positions unless otherwise marked
- DD4Hep + PrKalman tracking
- Run on 600k events (increased from 200k)
  - All modules have sufficient statistics to align
- Aligns in Tz degree of freedom (new since v2)
- Uses loose tracking mode (see setup) and PatPV3D
- Uses D0 particle information (see Selections)
- Constrained average Tx, Tz in SciFi backlayer
  - Ideally allows us to compare alignments with shared momentum scale reference, prevent changes from curvature bias
  - But this scale is not necessarily correct
- These alignments shown consider modules only: mat alignment performed as a seperate step

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How do module/mat alignments work together?

AlignV9:
Module x only
No z correction to survey
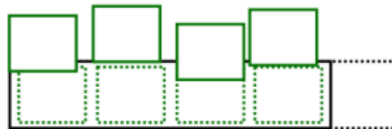
AlignV9 + mats:
Module x only
Mats x and z adjustment
all z correction handled by mats (unphysical)
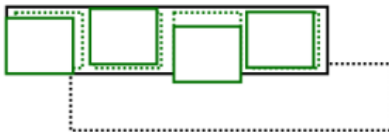
SciFi v3
Module motion in x and z
Mats in x and z
Largest efficiency improvement is from module component!

from

N.Breer

Mat alignment and the real SciFi

- Real mats are glued together wth very fine tolerance/quality control (≈50 μm), but prelim mat alignment sees movement up to 1,5 mm
  - "mat alignment" moves the mats in software to match the best hit position in tracking
    - Depends on module alignment quality
    - Depends on relative position of glued SiPM readouts relative to mats
  - Long term goal SciFi team: correct for hit positions in readout without moving mat material in simulation
    - Understand rotations in survey positions that may produce z movement in reconstruction
    - Understand true variations in SiPM positions
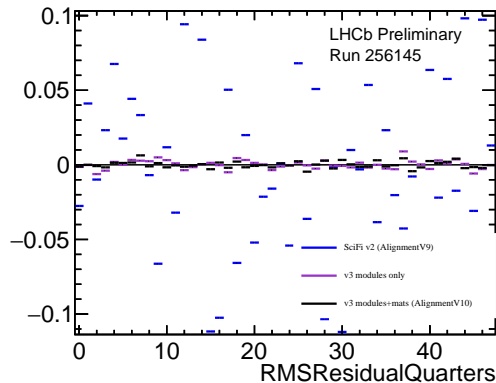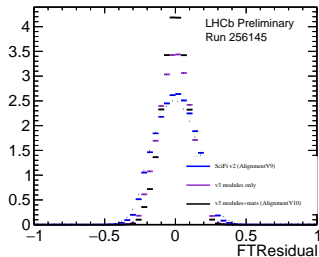 - In the short term: offline mat alignment to improve reconstruction

Performance of v3 alignment on 2022 data
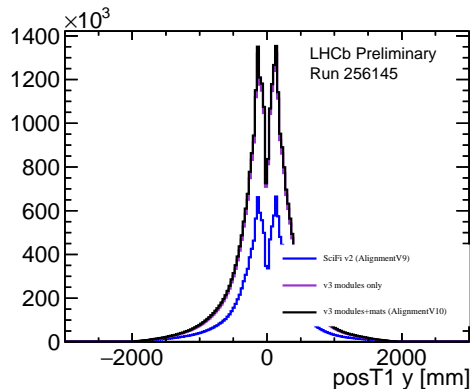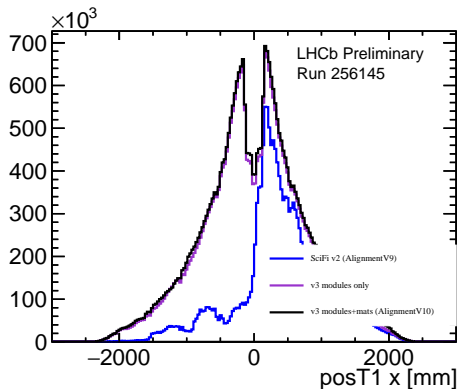
Performance of v3 alignment on 2022 data
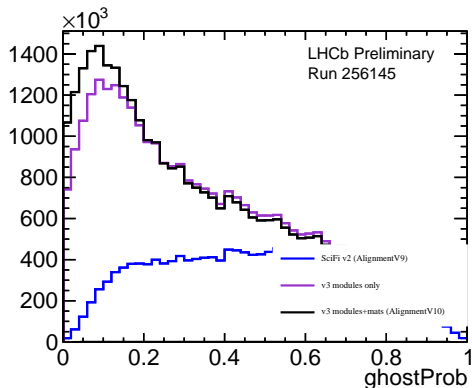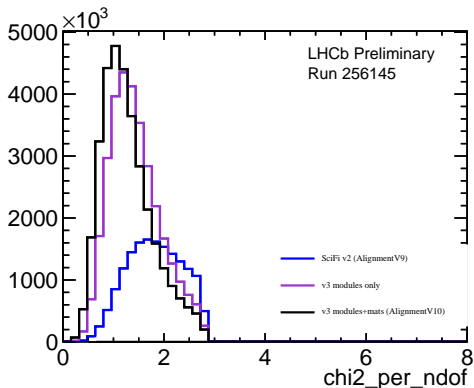
Performance of v3 alignment on 2022 data

Residual std. dev:

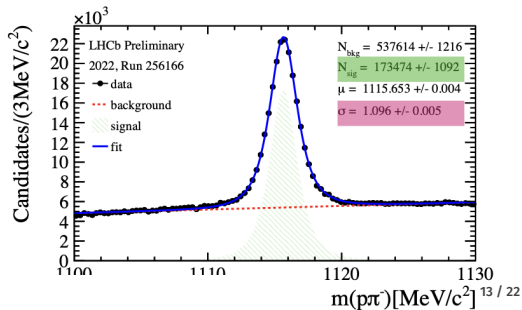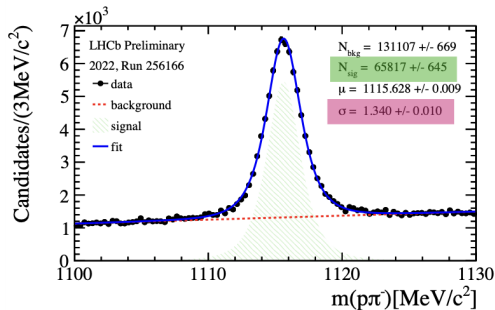- AlignmentV9: 0.137

- v3 modules: 0.110

- AlignmentV10: 0.096

Λ^0 decays in different alignment versions

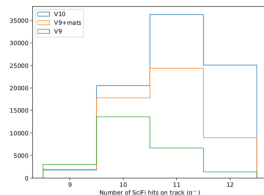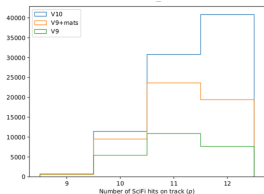Candidates: $\Lambda_0 \rightarrow p\pi^-/\overline{\Lambda}_0 \rightarrow \bar{p}\pi+$

Huge improvements in signal yields (x2 from v9 to v10)
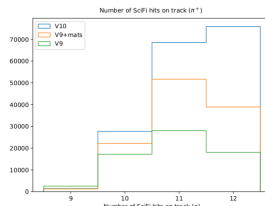
Slightly improve mass peak resolution

Lukas' slides

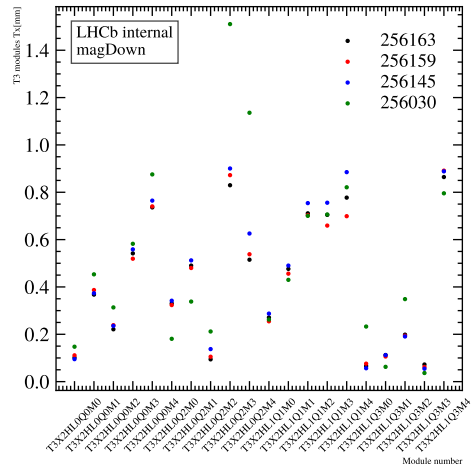# Λ^0 decays: SciFi hits per track on s-weighted data

- Huge improvement on reconstructed tracks with 10, 11, 12 hits

- Significantly higher average number of SciFi hits on tracks from version to version

- We also see a significant charge asymmetry in Λ decays

Lukas' slides

Stability cross check on 2022 data
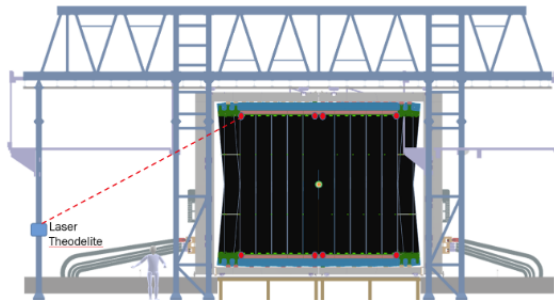
Exemplary plot for T3X2

- Showing translation in x vs module number

- MD run comparison

- runs from same fill yield consistent results

- run 256030 without fine timing worse as expected → newer runs clearly better!

- Most translations are within 1 mm which is expected from survey measurements

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SciFi

Survey and Photogrammetry for 2023
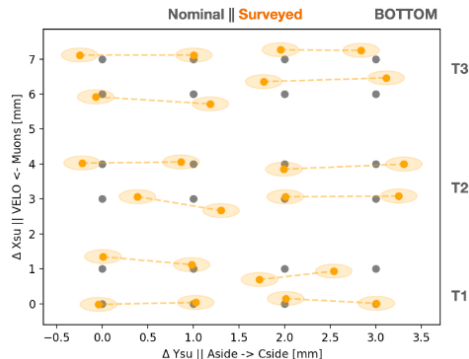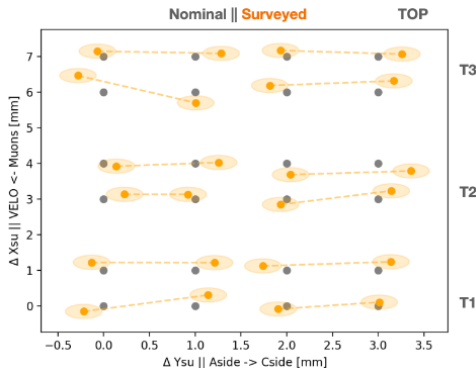

8 targets / layer

Laser
Theodelite

Big thanks to Maria, Blake, Pascal S, Rodolphe
and the whole survey team!

- Survey taken: feb 20th - march 9th
- 4 measurement points per C-frame at corners
- Target: keep inner modules as close to nominal as possible, outer edges can move as needed
- Summary: 450 microns in Z, most frames within 200 microns from nominal
- 400 microns in X, 1.5 mm in Y
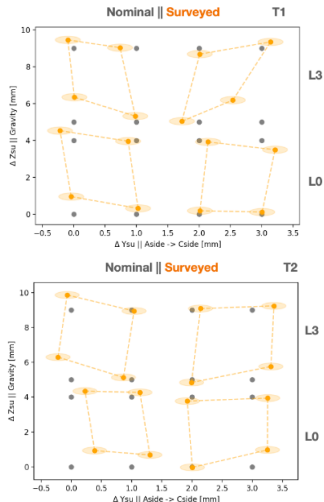- On average 400 - 600 microns in Y, 50 - 200 microns in the center region
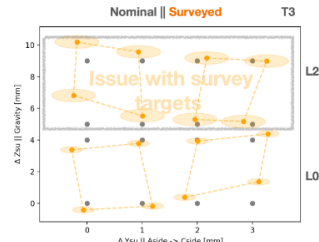
Survey and Photogrammetry for 2023

- Top/bottom view of the respective edges ±2,5 m above/below beam pipe
- 200 µm survey uncertainty
- T1, T2: outer layers surveyed →L0 and L3

Survey and Photogrammetry for 2023

- T3: L0 and L2 surveyed (L3 targets in RICH volume)

- T3L2 measured between L1 and L2 with smaller targets

- Possible movement during measurement

Readout Map adaptations

Rewrite the FTReadoutMap in order to get deactivated links from Conditions

Merged   Louis Henry requested to merge `lohenry-rewriteReadout` into `master` 1 month ago

```
sourceIDs: [ # List of source IDs in order in which they come.
#T1L0O1_D1   T1L0O1_D2   T1L0O1_D3   T1L0O1_D3   T1L0O3_D1   T1L0O3_D2   T1L0O3_D2   T1L0O3_D3   T1L0O3_D3
14608      , 14610    , 14611    , 14612    , 14613    , 14640    , 14642    , 14643    , 14644    , 14645    ,
```

```
LinkMap: [ # SiPM corresponding FTChannelIDs, arranged in [bankNumber][nbLinksPrBank]
#T1L0O1_D1
#T1L0O1M0D00   T1L0O1M0D01   T1L0O1M0D02   T1L0O1M0D03   T1L0O1M0D04   T1L0O1M0D05   T1L0O1M0D06
278528      , 278656    , 278784    , 278912    , 279552    , 279680    , 279808    ,
```

Big thanks to Louis!

- Readout map → Cabling Map
- Automatic fetching of deactivated links
→ Deactivate links without changing readout map!
- 2022: no active link map
- →empty events
- LHCb!4129 improved flexibility
- 2023: allows to ignore dynamic link deactivation if no active link found

SciFi online alignment

- SciFi alignment was added in the run control MooreOnline!232 and Alignment!378

- Detector elements and alignment adapted for DD4Hep: Detector!363 and Alignment!364

- Next is to work on the online monitoring and estimate thresholds for automatic update while data taking

- runs with recent mu scans (from 2023) used for evaluating the SciFi half modules alignment: Run 264400 : mu 6,71
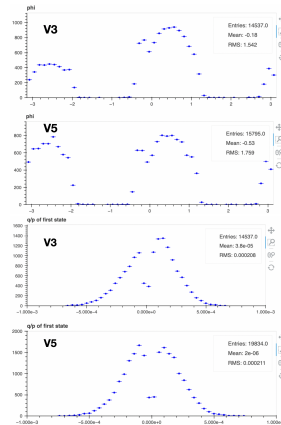
SciFi alignment with 2023 data

- Several configurations ran aligning the HalfModules: TxRxRz + average Tz constraint
- Translations in x within 1mm
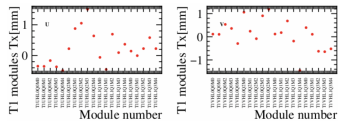
- Rotations in x within 1 mrad
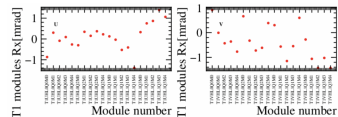
- New version of the module alignment (v5) was created based on this

Outlook

Alignment outlook in the coming months:

- Alignment stability and magnet up vs. magnet down tests in 2022 data (also later 2023 data)

- Dedicated MC studies for 2023 conditions and using what we have learned from 2022

- Continuing work with new data, commissioning SciFi alignment and the online alignment system

- Estimate SciFi alignment accuracy needed to trigger automatic update of constant and automatic alignment monitoring

sim+reco outlook:

- Effort on Boole code modernization

- Louis writing a note on cluster resolution

- Louis also writing a definitive document about clusterization, encoding and decoding