ALIGNMENT AND CONDITIONS DATA

Silvia Borghi, Chris Burr, Lucia Grillo,
Biljana Mitreska, Chris Parkes

AIDA-2020 WP3 final meeting - 23 April 2020

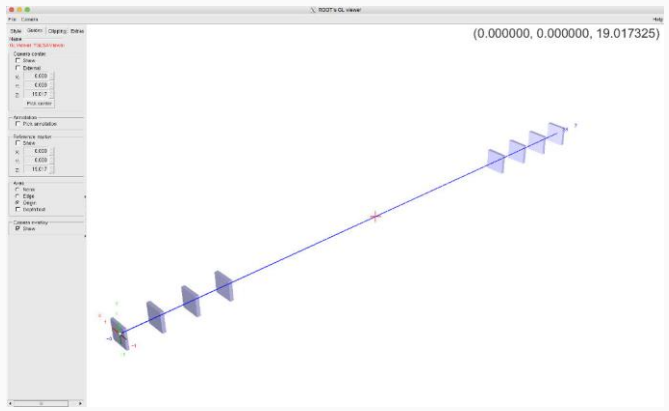
Outline

- Alignment Toolkit development
- Application of the alignment toolkit to a test beam facility
- LHCb alignment development

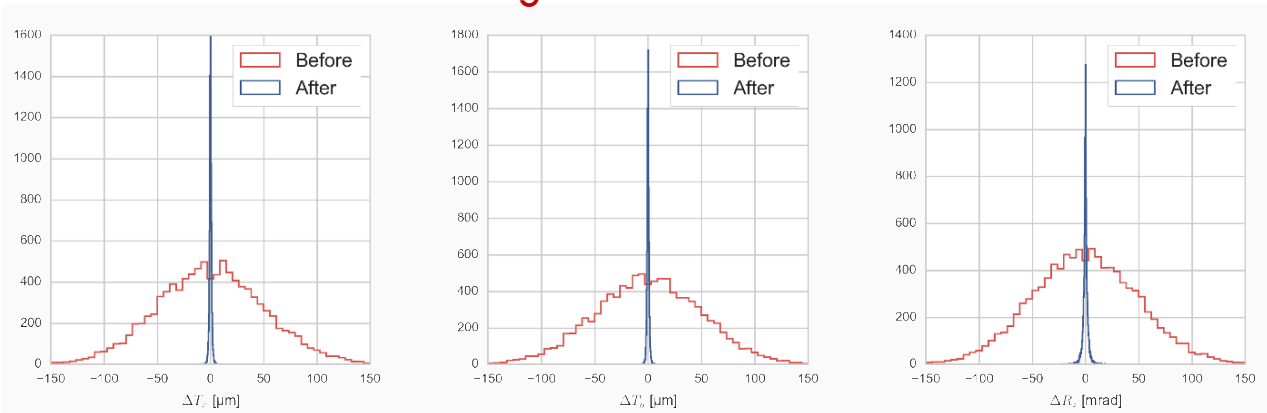
Running prototype for Alignment toolkit

- Based on BACH software package developed as part of the original AIDA project.
- Project in GitHub (https://github.com/chrisburr/Bach)
- Added the integration to the DD4hep toolkit for the detector description
- Validation aligning a “LHCb timepix telescope” like geometry using toy studies

Geometry



Alignment constants



Alignment constants for plane 3 before and after alignment for 1000 different alignment scenarios

Running prototype for Alignment toolkit

- https://cds.cern.ch/record/2243542
- Milestone 40
- Abstract

  This milestone report documents the modifications made to the Bach software package in order to provide a prototype alignment package with tight integration to the DD4hep toolkit.

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDA-2020

MILESTONE REPORT

RUNNING PROTOTYPE FOR ALIGNMENT TOOLKIT

MILESTONE: MS40

Document identifier:	AIDA-2020-MS40
Due date of milestone:	End of Month 21 (January 2017)
Report release date:	31/01/2017
Work package:	WP3: Advanced Software
Lead beneficiary:	UNIMAN
Document status:	Final

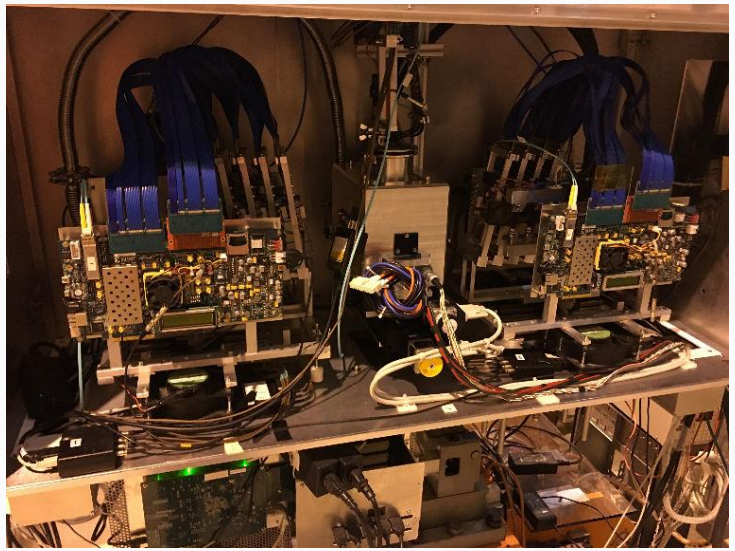
Abstract:

This milestone report documents the modifications made to the Bach software package in order to provide a prototype alignment package with tight integration to the DD4hep toolkit.

Alignment Toolkit

- The alignment toolkit is fully functional and can be used with DD4hep geometries to extract alignment conditions
- Used extensively in LHCb testbeams for upgrade:
  - Timepix telescope at CERN
    - Comprised of 8 timepix sensors
    - Sensors can be rotated around x/y to improve resolution/charge sharing
    - Remotely movable (Tx/Ty/Ry) DuT can be placed between the arms
  - Velopix telescope at Fermilab
    - Comprised of velopix sensors (+ DuT)
- Other users: LHC beamgas vertex group and MICE (Muon Ionising Cooling Experiment)

Timepix telescope



Velopix telescope

Alignment Toolkit

- https://cds.cern.ch/record/2315367
- Deliverable D3.3
- Abstract

The BACH alignment toolkit developed during the first AIDA project has been expanded to use the DD4hep software framework for managing the detector description and conditions data. It is now able to extract alignment corrections for more complex geometries, and without the need to create a custom definition of the detector for use with BACH.

AIDA 2020

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDA-2020

DELIVERABLE REPORT

ALIGNMENT TOOLKIT

DELIVERABLE: D3.3

Document identifier:	AIDA-2020-D3.3
Due date of deliverable:	End of Month 36 (April 2018)
Report release date:	27/04/2018
Work package:	WP3: Advanced Software
Lead beneficiary:	UNIMAN
Document status:	Final

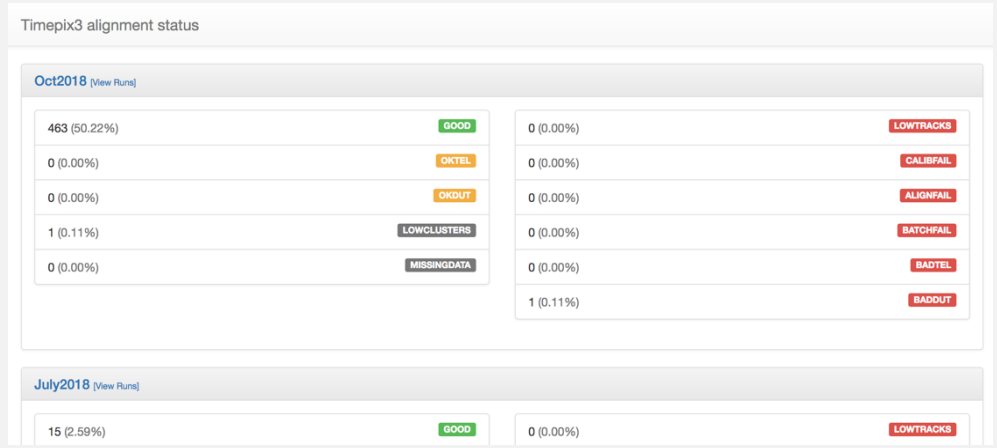
Abstract:

The BACH alignment toolkit developed during the first AIDA project has been expanded to use the DD4hep software framework for managing the detector description and conditions data. It is now able to extract alignment corrections for more complex geometries, and without the need to create a custom definition of the detector for use with BACH.

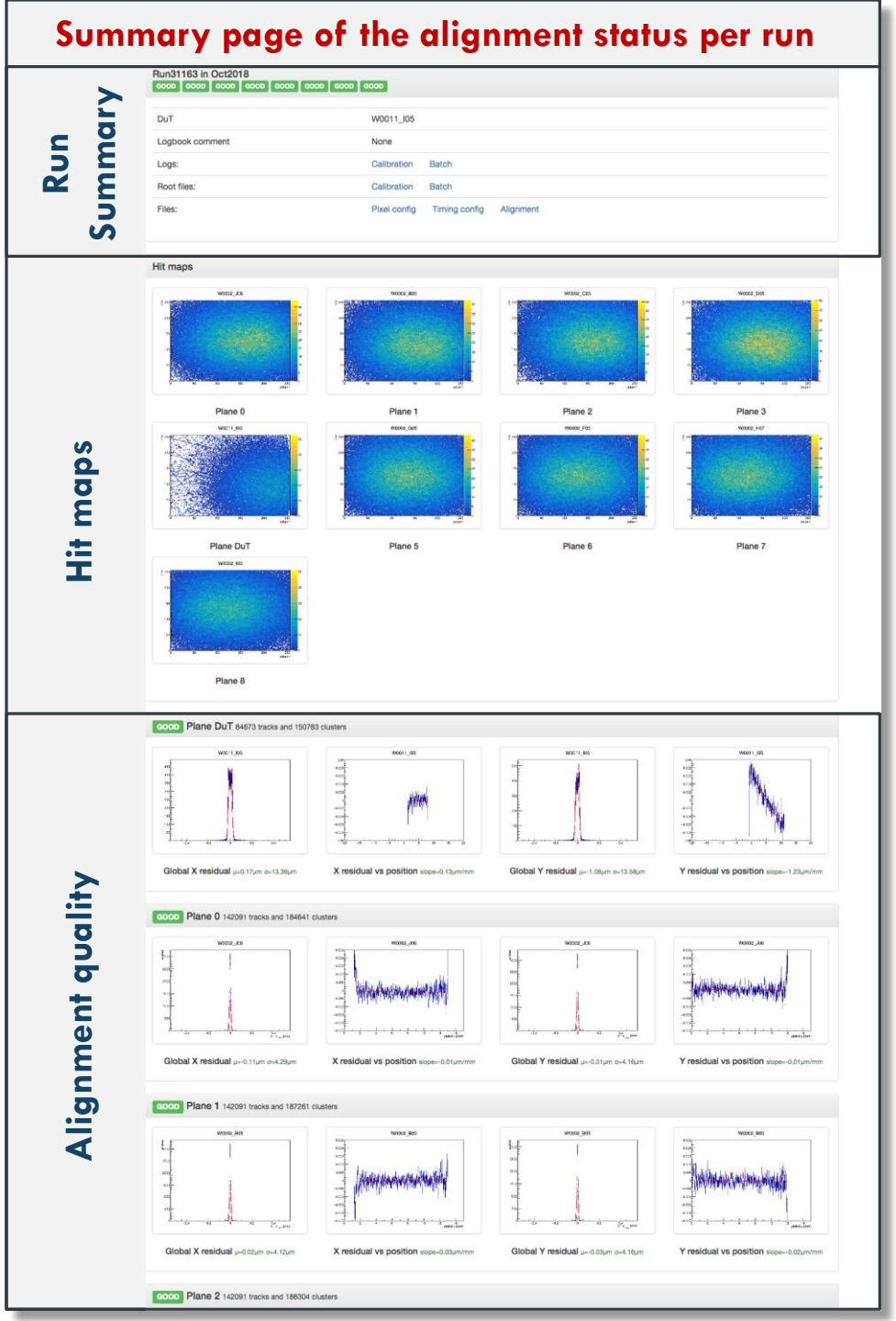
Application of alignment toolkit

- Extendently used in the LHCb testbeam with a timepix telescope.
- Thousands of datasets have been successfully aligned.
- Web application to monitoring the status and the quality of the alignment using Python's flask framework was developed.

Summary of the alignment status for all runs



Summary page of the alignment status per run



Application of alignment toolkit to an external tracker

- https://cds.cern.ch/record/2664996
- Milestone 89
- Abstract

It is essential to use software alignment techniques to get the best possible performance out of modern high-resolution detectors. The BACH alignment toolkit provides tools for performing track-based alignment. It was developed during the original AIDA project and has been extended during AIDA- 2020. The software in BACH has been applied to the LHCb VELO Timepix3 telescope to align many thousands of datasets collected over multiple years. It was originally planned to apply this software to the external PCMAG tracker (Deliverable 15.2) but this has not been possible due to delays in the construction of the tracker. The application of the software to multiple test beam configurations for testing a range of detector systems has demonstrated the applicability of the software to real detector systems and benefitted detector R&D for several major experiments.

AIDA 2020

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDA-2020

MILESTONE REPORT

APPLICATION OF ALIGNMENT TOOLKIT TO AN EXTERNAL TRACKER

MILESTONE: MS89

Document identifier:	AIDA2020-MS89
Due date of milestone:	End of Month 44 (December 2018)
Report release date:	21/12/2018
Work package:	WP3: Advanced Software
Lead beneficiary:	DESY
Document status:	Final

Abstract:

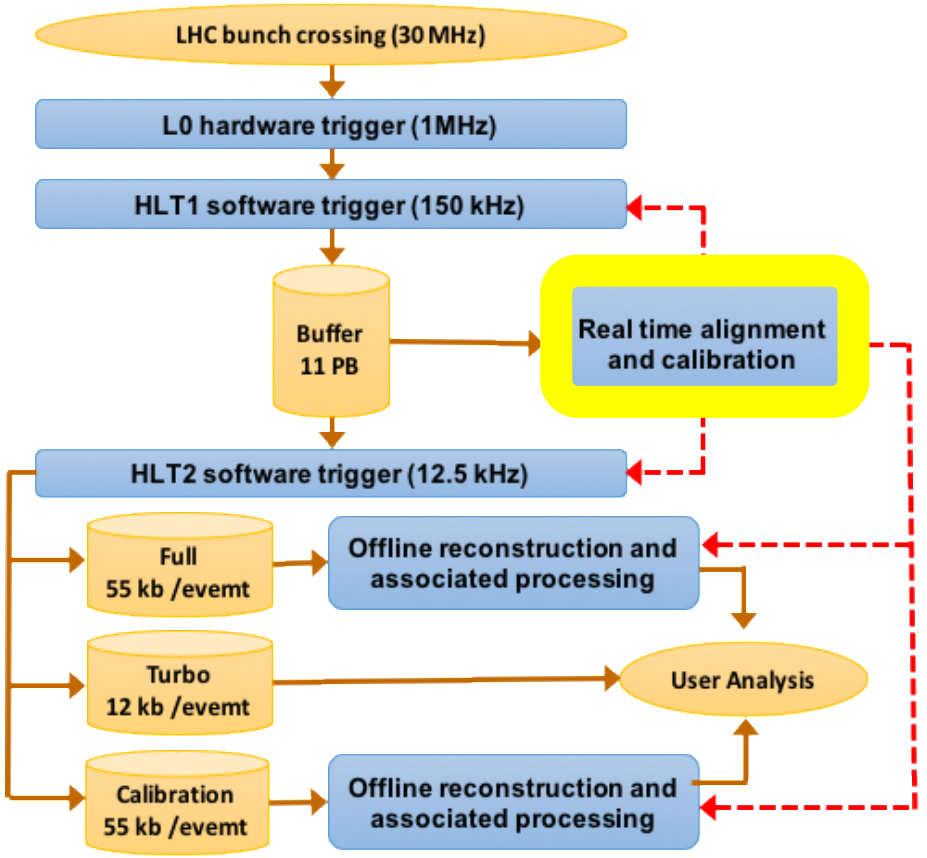
It is essential to use software alignment techniques to get the best possible performance out of modern high-resolution detectors. The BACH alignment toolkit provides tools for performing track-based alignment. It was developed during the original AIDA project and has been extended during AIDA-2020. The software in BACH has been applied to the LHCb VELO Timepix3 telescope to align many thousands of datasets collected over multiple years. It was originally planned to apply this software to the external PCMAG tracker (Deliverable 15.2) but this has not been possible due to delays in the construction of the tracker. The application of the software to multiple test beam configurations for testing a range of detector systems has demonstrated the applicability of the software to real detector systems and benefitted detector R&D for several major experiments.

Real-time alignment at LHCb

JINST 14 (2019) P04013

- In Run2, a innovative real-time alignment procedure was developed
- Alignment of the full tracking system (VELO, UT, OT, IT) runs automatically in few minutes at the beginning of the fill.
  - Reconstruction is parallelized across ~1700 nodes of the online farm and the minimization is performed in a single node
  - Several thousands of elements are aligned.
  - Update of the constants if they are significantly different
- The full detector alignment is available in the second stage of the software trigger: one of the key elements to have the same online and offline performance

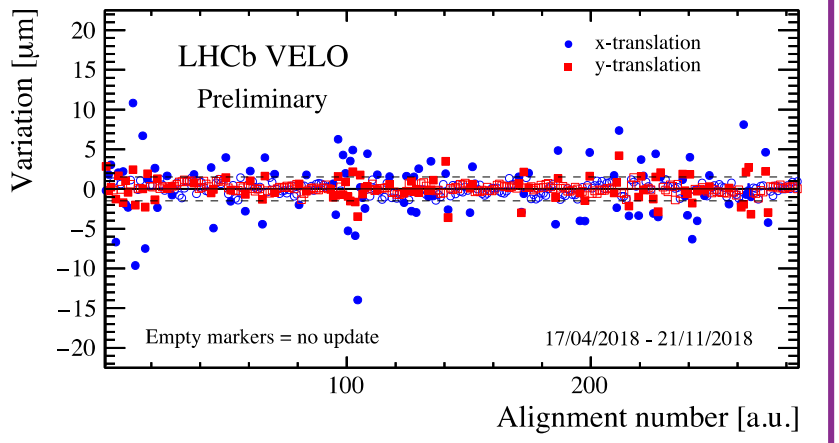
Run2 data taking strategy

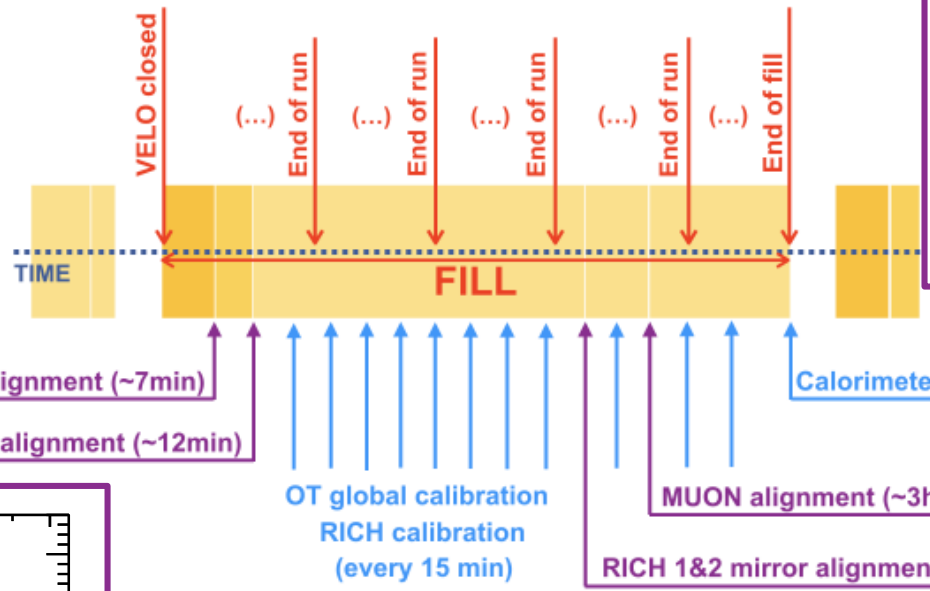


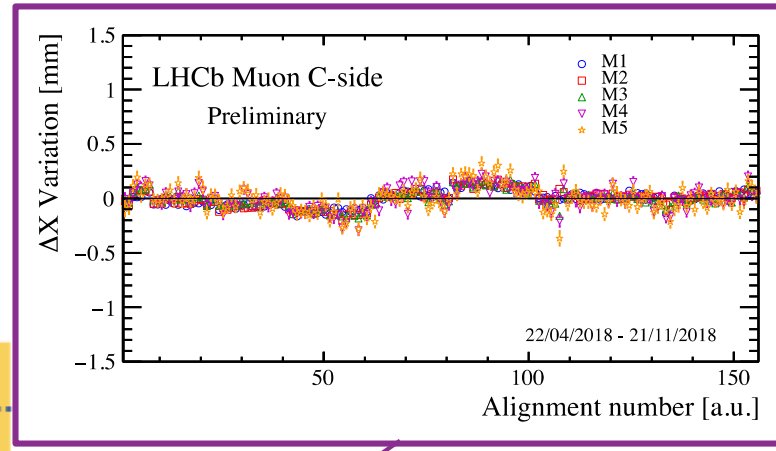
LHCb alignment stability in Run 2

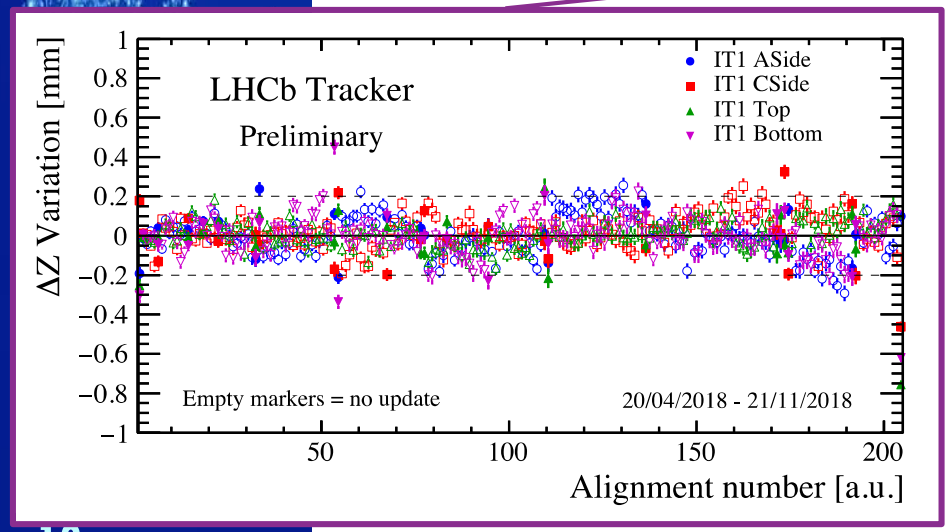
LHCb-FIGURE-2019-015

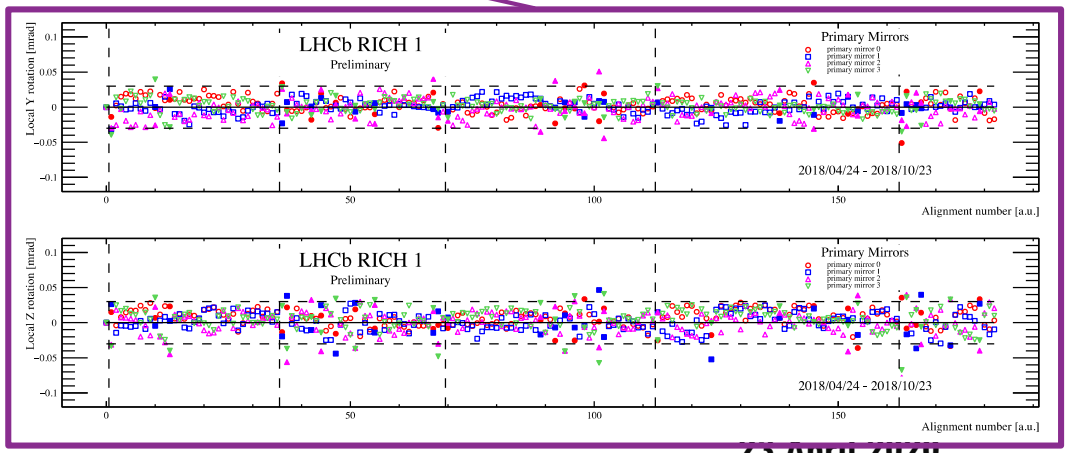
- Run smoothly during Run 2 data taking









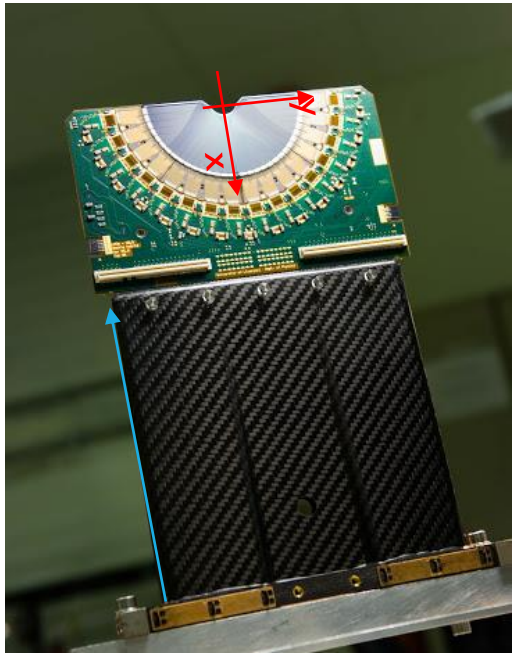


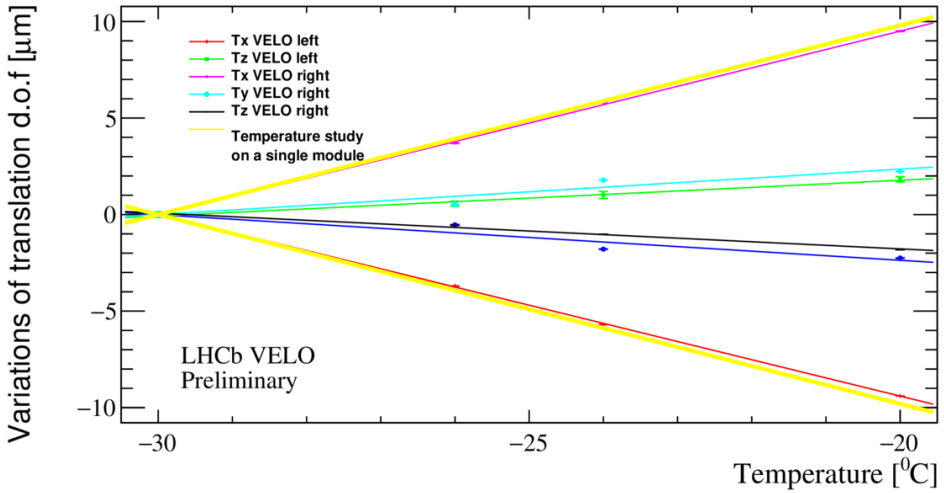
Alignment Variation vs Temperature

- Metrology measurements of the module position were performed before Run1 data taking at the ambient temperature
- The operation temperature of the VELO is -30°.
- This results in a shrinking of the module carbon fiber support, of about 1 micron per degree (result of measurement performed in laboratory on a single module).
- A dedicate temperature scan at 4 steps (-30°, -26°, -24°, -20°) was performed at the end of Run 2 data taking.
- Software tracking alignment allows to evaluate the variation of the module position as function of the temperature for x, y, z translations and rotations

Tx variation vs the temperature is compatible with the measurement on the single module.

The other dofs variations are within the alignment accuracy.

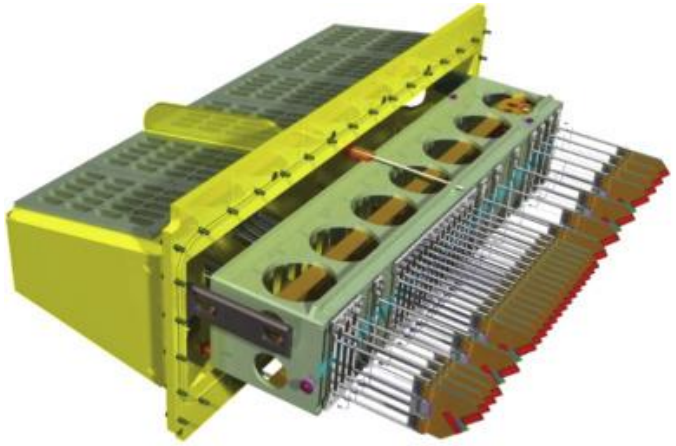




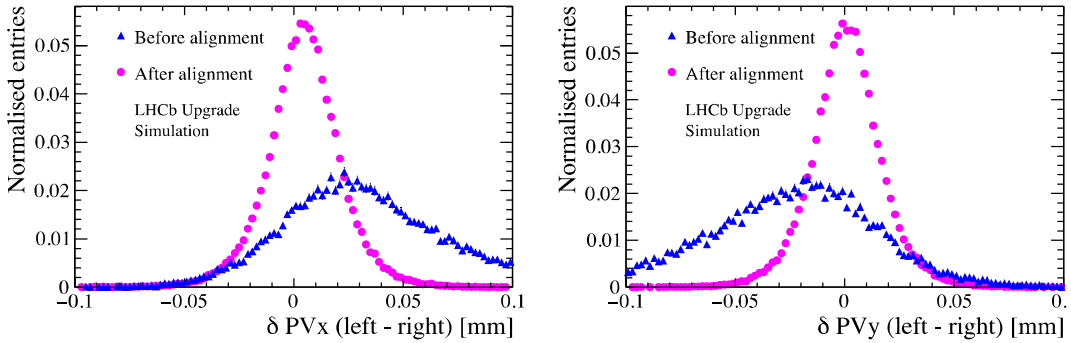
LHCb-FIGURE-2019-001

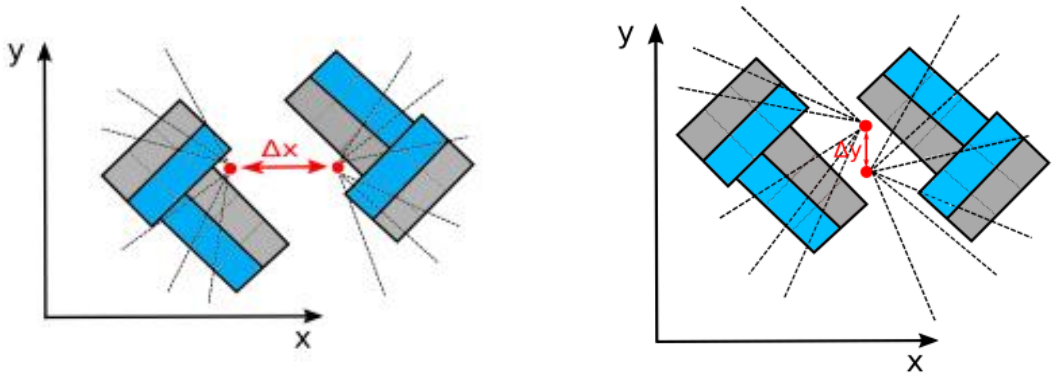
LHCb alignment study for Run 3

- During LS2, LHCb has a major upgrade, replacing all the subdetectors of the tracking (VELO, UT, SciFi)
- The trigger will be exclusively a software trigger
- Similar Run 2 real-time alignment procedure will be used in Run 3
- Study of the alignment performance of each subdetector are ongoing
  - Optimization of the configuration
  - Study of alignment weak modes
  - Monitoring
  - Evaluation of the accuracy



VELO alignment monitoring





LHCb-FIGURE-2019-003

Conclusion

- Real-time Alignment in LHCb run smoothly during the full Run 2
- Alignment was used to study the VELO module position dependency as a function of the operation temperature.
- Study of the alignment for the LHCb upgrade detector for Run 3 are ongoing.
- Alignment Toolkit with tight integration to the DD4hep toolkit has been provided.
- Alignment toolkit has been extended used for LHCb test beams for the LHCb upgrade detector study