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MILESTONE REPORT

RUNNING PROTOTYPE FOR ALIGNMENT TOOLKIT

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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.
AIDA-2020 Consortium, 2017
For more information on AIDA-2020, its partners and contributors please see www.cern.ch/AIDA2020

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### Delivery Slip

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Executive summary

A prototype alignment package has been produced that is capable of correcting misalignments in DD4hep geometries. This work has been based on the BACH alignment package produced in the earlier AIDA project. Preliminary validation has been performed to show the true alignment can successfully be recovered and future work will perform additional validation and further improve the integration with DD4hep.

1. INTRODUCTION

Experiments in high energy physics depend upon the accurate measurement of the trajectories of particles passing through detectors in order to calculate a wide range of physical quantities. In order to allow these quantities to be reconstructed with the greatest precision the exact position of the detector elements must be computed. The alignment constants describing this exact position are typically calculated in software by minimising the track residual, that is the difference between the position of the detected hit and the intercept of the fitted track. An overview of alignment methods used in high energy physics can be found in [1].

The BACH alignment package [2] was developed during the first AIDA project and provides a complete standalone package for the reconstruction of data in telescope-like detectors, including: simulation, clustering, pattern recognition, track fitting and alignment. The minimisation is performed using MILLEPEDE [3]. The package has been used for the AIDA Timepix telescope [4] and is being considered for use by the LHC beam gas vertex group and the Muon Ionisation Cooling Experiment (MICE).

DD4hep [5] is software framework designed to provide a comprehensive solution for the detector description of high energy physics experiments. Despite BACH providing everything required for the reconstruction of data, integration with DD4hep allows for more advanced usage, such as arbitrarily nested detector elements and integration with other packages supported by DD4hep such as GEANT4 [6]. This milestone document describes the status of the current prototype.

2. ALIGNMENT PACKAGE

The BACH alignment package is described in the software manual [2] and AIDA deliverable report[7]. Development of the software has been moved to GitHub and the latest version can be obtained from the git repository (https://github.com/chrisburr/Bach).

In order to facilitate the integration, the package has been converted into a DD4hep plugin which is executed using geoPluginRun. The geometry is no longer specified using BACH’s custom XML format and is instead specified using the standard driver/XML and alignment constants are loaded and applied using the DDAlign package.

To facilitate testing the updated package the AIDA timepix telescope geometry was used with simulated data to test if the detector positions are successfully recovered after introducing random misalignments to the system. Figure 1 shows the displacement of the detector planes from their true position before and after performing the alignment procedure for 1000 simulated experiments.
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Fig. 1 Difference between the position of a detector element and the true position in x (left) and y (right). The blue points show the positions simulated with random misalignments. The green points show the position after running the alignment package.

3. CONCLUSIONS AND FUTURE WORK

A prototype plugin has been produced allowing the BACH alignment package to be easily used by high energy physics experiments using the DD4hep framework. Initial validation shows the software can successfully compute alignment constants to accurately recover the positions of the detector elements. Future work will focus on improving and validating the integration with DD4hep and verifying the functionality of DDAlign package as well as use it to study alignment strategies for the ILD detector.

4. REFERENCES

## ANNEX: GLOSSARY

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<tr>
<th>Acronym</th>
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<td>BACH</td>
<td>Basic Alignment and reconstruction Chain. A software package developed in AIDA for alignment of telescope-style detectors, and applied to the alignment of the AIDA LHCb Timepix telescope.</td>
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<tr>
<td>Timepix</td>
<td>An Application Specific Integrated Circuit (ASIC) for use with high spatial resolution semi-conductor detectors. It is used in the AIDA LHCb Timepix Telescope.</td>
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<tr>
<td>DD4hep</td>
<td>Detector Description for HEP</td>
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<td>DDAign</td>
<td>Alignment component of DD4hep</td>
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