T 61: Methods in Particle Physics III (Tracking)

Time: Wednesday 16:15–18:15 Location: VG 4.101

T 61.1 Wed 16:15 VG 4.101

Performance of the SciFi tracker alignment in 2024 — •Nils Breer, Biljana Mitreska, and Johannes Albrecht — TU Dortmund University, Germany

Alignment and calibration form a crucial part of the LHCb trigger system and are responsible for ensuring the best possible physics performance. The positions of the SciFi tracker need to be monitored over time using the track-based alignment software in order to find potential biases and disentangle effects coming from other tracking systems.

In 2024 the global alignment is performed utilising all of LHCb's tracking detectors. The SciFi alignment constants are analysed on a set of runs for multiple configurations as well as the stability over time of the SciFi tracker in order to validate the performance on 2024 data.

In this talk, studies on the alignment of the outermost modules of the SciFi will be presented alongside results on the performance achieved by the global alignment.

T 61.2 Wed 16:30 VG 4.101

SciFi Threshold Calibration — •Dhruvanshu Parmar[1], Xiaoxue Han[2], and Mikhail Mikhasenko[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Ruprecht-Karls-Universität, Heidelberg, Germany

The Scintillating Fiber tracker (SciFi) at LHCb, operational since 2022, is the main tracker positioned downstream of the dipole magnet. Aided by upstream trackers, SciFi detects charged particles and precisely measures their momentum and trajectory with high accuracy. It consists of three stations, each composed of 5-meter high modules containing scintillating fiber mats. The ends of the tracker modules include readout boxes equipped with silicon photomultiplier sensors (SiPMs) that collect photons generated by particle interactions with the scintillating fibers. Analog signals from SiPM channels are processed by comparing them to a set of three "comparator" thresholds to discriminate signals from dark noise. Adjusting these thresholds is critical for a high hit efficiency, a low fake track rate and sustainable bandwidth. This talk summarizes the utilization of the Light Injection System (LIS) for calibrating the comparator thresholds for the full system of 524k SiPM channels and 1.5M comparators. Accurate time alignment for optimizing LIS performance and full calibration procedure of fitting SiPM spectra will be discussed. Finally, challenges faced with LIS calibration and strategies to address them will be highlighted.

T 61.3 Wed 16:45 VG 4.101

Studies of alignment systems for the LHCb Upgrade II downstream tracker — •Todor Todorov, Ksenia Solovieva, and Marco Gersabeck — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany

For the LHCb Upgrade II in Long Shutdown 4 the instantaneous luminosity is planned to increase by at least a factor of 5 with respect to current operation. The increase in detector occupancy and pileup will be beyond the capabilities of the current scintillating fibers (SciFi) sensors utilised in the downstream tracker of the LHCb detector. A new hybrid tracker will be installed, the Mighty Tracker, which will consist of six layers of silicon pixel sensors in the most occupied regions near the beam pipe and of an improved SciFi in the remaining areas. An active hardware alignment system will be beneficial for the physics performance of LHCb but it will have to adhere to strict space and material budget constraints. A study of alignment requirements and of early prototype systems capable of fulfilling those within the above-mentioned constraints is presented.

T 61.4 Wed 17:00 VG 4.101

Track Based Software Alignment using the General Triplet Track Fit — •David Fritz, Tamasi Kar, Abhirikshma Nandi, and André Schöning — Physikalisches Institut, Universität Heidelberg, Germany

Modern particle physics experiments require very high precision and the accurate alignment of tracking detectors. While optical surveillance systems provide an initial reference, track-based software alignment is essential for achieving optimal physics performance.

A new alignment procedure based on the General Triplet Track Fit (GTTF) [1] is introduced, enabling the simultaneous determination of track and alignment parameters. The GTTF is a novel, non-iterative, triplet-based track fit that accounts for both hit uncertainties and multiple scattering effects. Its high parallelizability and scalability make it particularly well-suited for online alignment using hardware accelerators such as FPGAs or GPUs.

This talk will provide an overview of the GTTF-based alignment in the context of standard track based alignment procedures. Additionally, results from the GTTF-based alignment for a use case - the Mu3e Pixel Detector - will also be presented.

[1] A. Schöning, 2024, A General Track Fit based on Triplets, arXiv:2406.05240

T 61.5 Wed 17:15 VG 4.101

Studies of a New Track Fitting Algorithm for the ATLAS Event Filter — Abhirikshma Nandi[1], •André Schöning[1], Sebastian Dittmeier[1], and Christof Sauer[2] — [1]Physikalisches Institut, Universität Heidelberg, Heidelberg, Germany — [2]CERN, Geneva, Switzerland

The ATLAS experiment is going through a comprehensive set of upgrades in preparation for data taking at the High-Luminosity Large Hadron Collider. The Trigger and Data Acquisition (TDAQ) systems are being upgraded to handle an increased trigger rate and run more sophisticated algorithms online to retain performance in the face of increased event complexity.

The ATLAS Event Filter (EF) - running on commercial, potentially heterogeneous computing hardware - has to provide the second level of filtering, reducing the Level-0 trigger rate of 1 MHz to 10 KHz for storage. To this end, it is required to perform track reconstruction (EF Tracking) for the entire Inner Tracker (ITk) at a maximum rate of 150 kHz.

A new, parallelizable track fit, based on triplets of hits, is being studied for EF Tracking - with the aim to gain from parallel hardware, like GPUs. The General Triplet Track Fit (GTTF) is a generalization of the Multiple Scattering-only triplet fit, developed originally for the Mu3e experiment, by including hit uncertainties. The results from the studies of the GTTF will be summarized along with an overview of the work in the broader context of the EF Tracking project.

T 61.6 Wed 17:30 VG 4.101

Online Track Reconstruction for the Mu3e Experiment — •Haris Avudaiyappan Murugan — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Germany

The Mu3e experiment aims to find or exclude the lepton flavour violating decay of a positive muon to two positrons and an electron with a branching fraction sensitivity of 10^{-16}. To observe such a rare event, we require a tracking detector from custom-designed High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) together with timing detectors made from scintillating fibre and tiles for the experiment. The detector will be streaming up to 1 TBit/s of data to the filter farm composed of graphics processing units (GPUs), in which the data rate is reduced to less than 100 MB/s and this filtered data is stored for later analysis. This reduction can be achieved by selecting potential signal events with two positrons and one electron originating from a single vertex through online track and vertex reconstruction on the GPU. The misalignment of the thin pixel tracking detectors can affect the precision of track reconstruction. Track-based alignment algorithm requires constraints from global parameters of the actual position of the pixels which can be measured using a camera alignment system. By calibrating the track reconstruction and histogramming the momentum of tracks on the GPU, the searches can be extended to observe potential two-body decays of the muon.

T 61.7 Wed 17:45 VG 4.101

Tracking efficiency studies for LHCb in Run 3 — •Rowina Caspary[1], Michel de Cian[1], Peilian Li[2], and Maurice Morgenthaler[1] — [1]Physikalisches Institut, Heidelberg University — [2]University of Chinese Academy of Sciences (UCAS)

The LHCb experiment is dedicated but not limited to the precision measurement of particles containing b- and c-quarks. It has been collecting data with an upgraded detector and a novel software-only trigger framework since 2022 at an instantaneous luminosity up to

$2 \times 10^{33}\mathrm{cm}^{-1}\mathrm{s}^{-1}$at $\sqrt{s} = 13.6$ TeV.
The correct evaluation of the track reconstruction efficiency is essential for many high-precision measurements. A tag-and-probe method is developed to estimate the track reconstruction efficiency of each tracker using muonic tracks from $J/\psi \rightarrow \mu\mu$ decays, where hits from other detector systems are used to reconstruct the probe tracks. Discrepancies of the measured track reconstruction efficiency between simulation and data are evaluated, examined and corrected deliberately, taking into account various effects due to misalignment and inefficiency of the sub-detectors. An agreement between simulation and data at the subpercent level is achieved over almost the entire phase space and for all tracking sub detectors, which illustrates the excellent understanding of the upgraded LHCb detector and its reconstruction sequences. This talk presents the results of the tracking efficiency methods in 2024 data and according systematic uncertainties.

T 61.8 Wed 18:00 VG 4.101

The Resolution Study of the New Scintillating Fiber Tracker of the LHCb Detector — •Ya Zhao — Physics Institute, Heidelberg University, Germany

The LHCb experiment started data-taking in 2022 with the upgraded tracking system including Vertex Locator(Velo), Upstream Tracker(UT) and Scintillating Fiber Tracker(SciFi). The hit resolution of SciFi is an essential part of its performance. An analysis of SciFi hit resolution was performed using 2024 dataset with latest alignment condition. The strategy to calculate hit resolution and the relationships between hit resolution and SciFi layers, track momentum, track slopes will be presented. The results of hit resolution measurement will provide SciFi hit errors for Kalman Filter to improve tracking performance. The long track momentum resolution is a key metric to evaluate the performance of the tracking system of LHCb. It can be estimated from the mass resolution of reconstructed Jpsi2mumu candidates. The approach and result of long track momentum resolution using 2024 dataset will be presented.