

Duration: May 2021-August 2021 (3 FTE-months)

Project: Implement hashing-based particle track reconstruction in ACTS

In 2027, the High Luminosity Large Hadron Collider (HL-LHC) is expected to start taking data. It will have roughly an order of magnitude more than the luminosity of the current LHC, and with this the possibility of discovering new physics raises significantly. The particle tracking algorithms currently used in the ATLAS and CMS experiments will no longer be adequate with dealing with the much larger luminosity of the HL-LHC, where particle tracking will be a much more complex task. To address this, several efforts are being made to engineer novel particle tracking algorithms. One in particular is “Similarity hashing for charged particle tracking” (Amrouche et al, 2019, IEEE). In addition to its applications for particle tracking/reconstruction, similarity hashing has also seen a variety of other applications, including being used in Spotify to optimize memory storage.

We will work on implementing similarity hashing techniques using the Approximate Nearest Neighbors (ANN) search method using C++ and Python into the ACTS project at CERN. We will begin by implementing a hashing technique that groups sections of a 3D detector layout into “buckets”, which will register particle tracks. We will then implement the ANN search method to be able to quickly identify the common origins of clusters of these tracks, which then can be extended to performing particle tracking reconstruction. The minimization of search complexity in identifying track hits is a tool which will be invaluable to data collection at the HL-LHC. After identifying particle track clusters using the ANN method, we will then use existing Kalman Filters to focus on these clusters to comprehensively perform track reconstruction. As a final step, we plan on tuning parameters to optimize both the complexity of the algorithm as well as the track reconstruction performance, and maximizing the extent to which our code can be parallelized. If time allows, we will implement an extension to this project in which the track reconstruction is performed with neural networks instead of Kalman filters. I will perform these tasks under the supervision of Dr. Louis-Guillaume Gagnon (UC Berkeley) and Prof Heather Gray (UC Berkeley, LBNL).

Timeline

- Phase 1 (weeks 1-3):
Closely read the method's journal article. Discuss with the Uni. of Geneva & CERN groups. Run & understand the existing proof-of-concept code.
- Phase 2 (weeks 4-7): Port the "Approximate nearest neighbor" hashing algorithm in c++ within ACTS.
- Phase 3 (weeks 8-10): Obtain a first end-to-end pipeline in ACTS by implementing Kalman Filter-based track reconstruction within regions identified by the hashing algorithm previously implemented
- Phase 4 (weeks 11-12): As time allows, perform some tuning of the various algorithm parameters. Prepare a presentation.
- Stretch goal: Implementing neural network-based track reconstruction within regions identified by the hashing algorithm previously implemented.