Time Information in Track Reconstruction for Future Colliders

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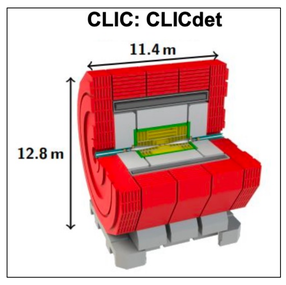
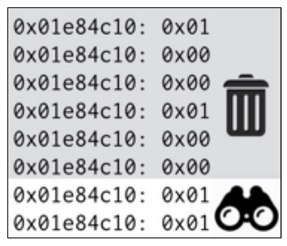
Track reconstruction

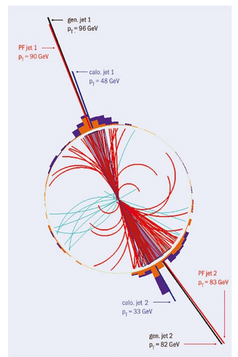
Data's journey in HEP:



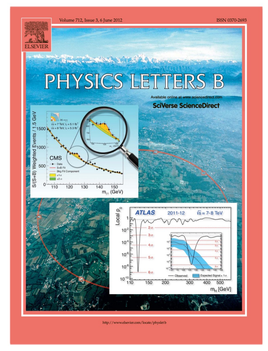
Detector



Trigger



Track reconstruction



Analysis

Precise track reconstruction is one of the most important process interpreting the data from detector in collider experiments such as for the proposed high energy electron–positron collider Compact Linear Collider (CLIC).

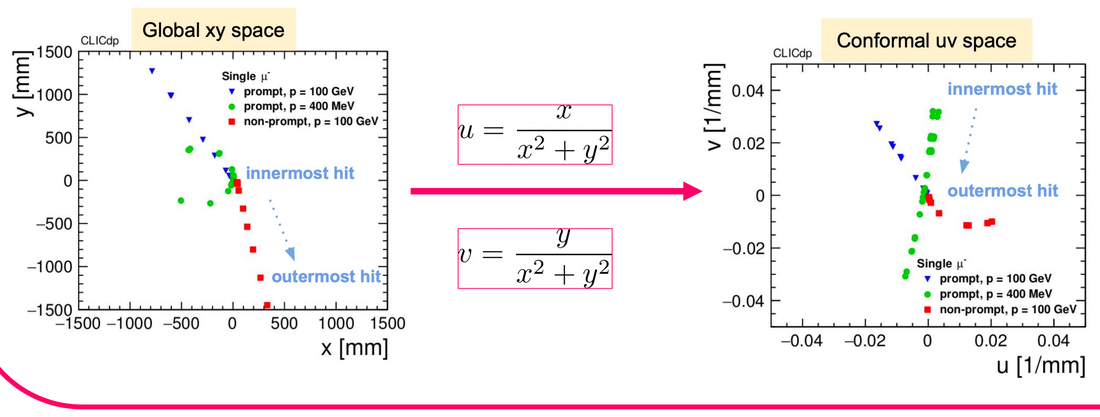
The journey of raw data to physics results goes like below:
After a collision, particles leave tracks on the detector. With a trigger, an initial selection of events to record is made. Then the triggered data are reconstructed to particles. Finally, physics results are obtained through analysis.

Daniel Saunders, iCSC 2016 - Data Reconstruction in Modern Particle Physics (Lecture 1/2)
Raffaela Langer, CERN Summer student program 2016, Including time information in conformal tracking for future colliders

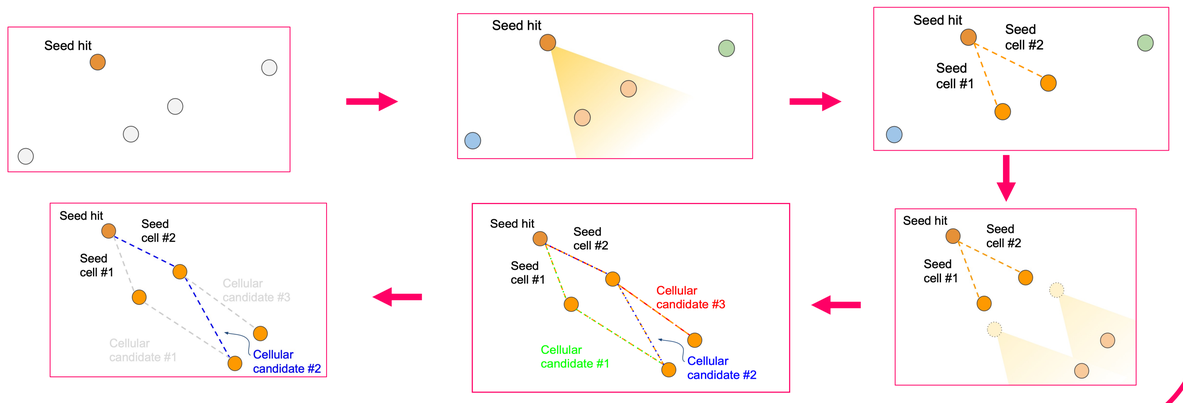
Conformal tracking

The reconstruction algorithm used here is called Conformal Tracking. It is essentially a cellular automaton-based track finding in conformal space. The conformal mapping method is important because that circles passing through the origin of a coordinate system xy can be translated into straight lines in a new coordinate uv.

Conformal mapping:



Cellualr automaton:



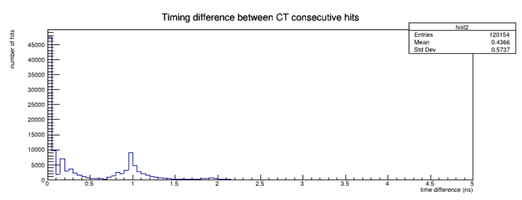
Erica Brondolin, ECFA Higgs Factories, 4th May 2022, Conformal Tracking for future e+e- colliders

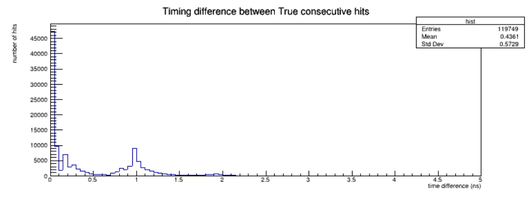
Time information

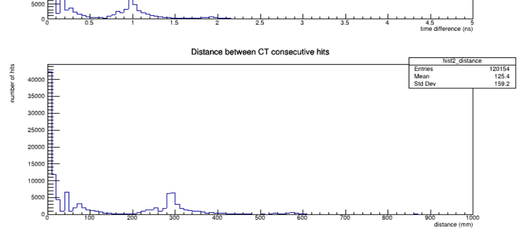
Based on the Conformal tracking algorithm, we are trying to include the timing of each hit left by the particles on trackers. Hopefully, this can improve the reconstruction efficiency, run time and distinguishability of overlay tracks. In the code, we have set a variable called "MaxTimeDifference" which is the upper limit of timing difference between the seed hit and a neighbor hit for the neighbor hit to be taken into cosideration as a track candidate. This MaxTimeDifference happens everytime when a seed hit is finding the next hit in the track by looping over its neighbor. Currently, we are trying to estimate the value of an effective MaxTimeDifference.

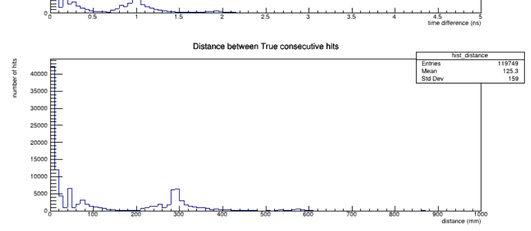
Estimating MaxTimeDifference: with overlay

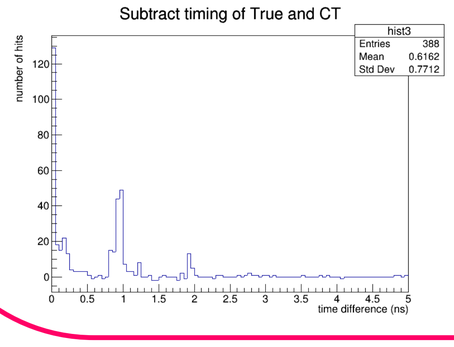
To find a reasonable value for MaxTimeDifference, we collected all the hit time intervals of True tracks and Conformal tracking reconstructed tracks. (overaly refers to tracks leave by background events)





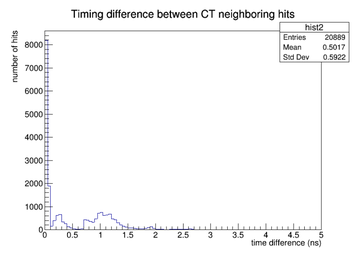


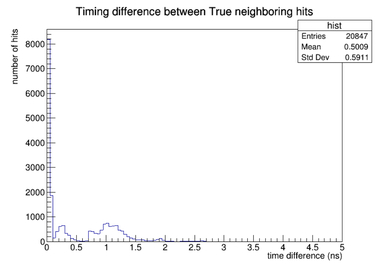


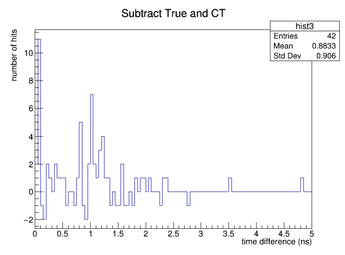


From the timing histograms, we can see that a reasonable time cut can be set at 2ns. Also, the peaks correspond to different parts of tracker, therefore we can also set specific value of MaxTimeDifference for different parts of detector.

Estimating MaxTimeDifference: without overlay

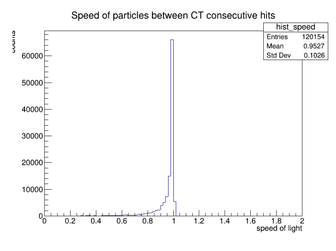


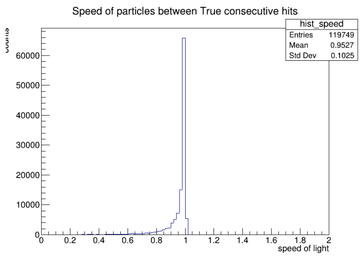


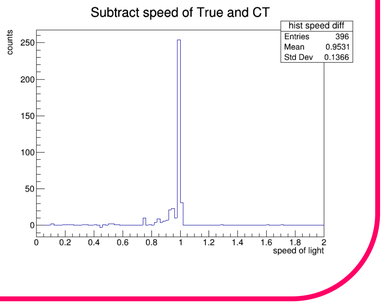


Speed cut

Using the time difference and distance between consecutive hit tracks to estimate the speed of particles between hits and estimating a reasonable value for speed cut.







Outlook

- Validate the efficiency improvement of the algorithm using validation software package.
- Find the most efficient value of time cut or speed cut.
- Improve the distinguishablility of overlay events.