Triggering For High-Multiplicity Events In *pp* Events In ATLAS.

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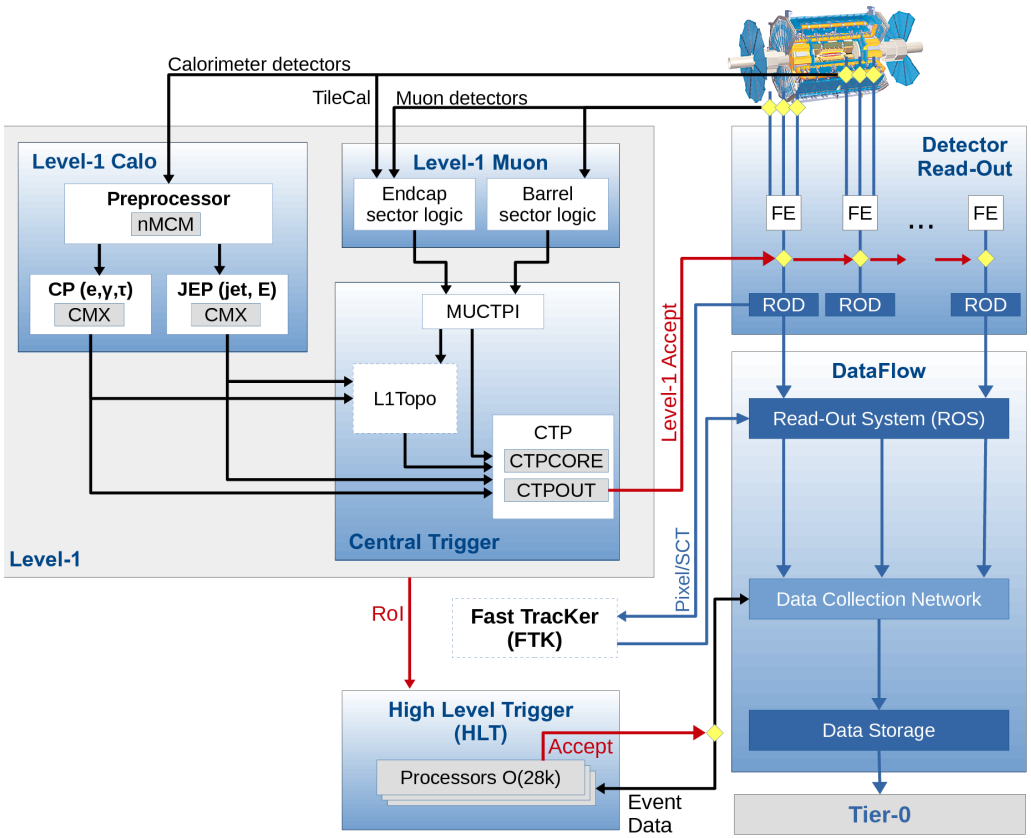
ATLAS Trigger System

The ATLAS trigger system consists of two stages:



- Level 1 (L1) trigger: Consists of hardware. Max. 100 kHz recording rate
- High Level Trigger (HLT): Software trigger operates from a large farm of about 40,000 CPU cores.
  $\Rightarrow$ Consume plenty of resources.
  Recording rate $\sim$ 1.2 kHz.

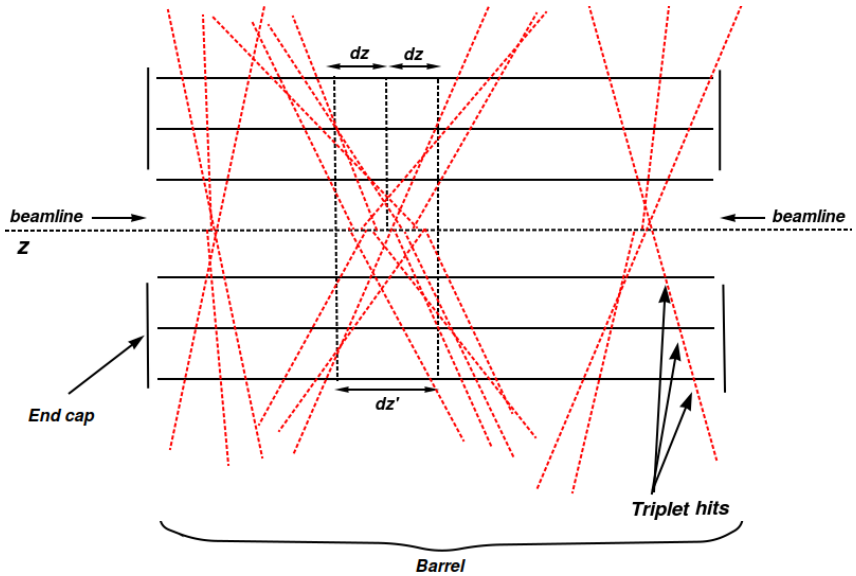
The selected events are then passed on to a data storage system for offline analysis.

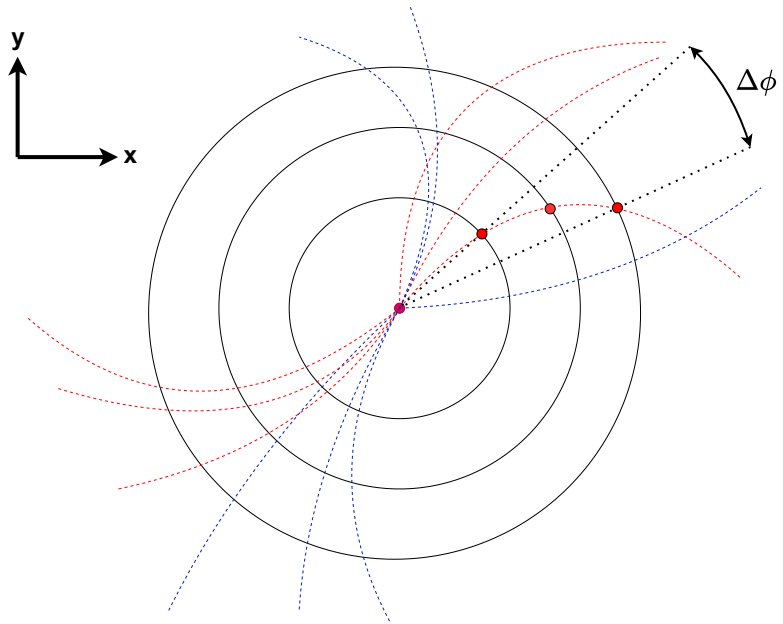
ZFinder

The ATLAS trigger ZFinder is an algorithm for finding an approximation of the z-position of the collision vertices without reconstructing charged particle tracks.

- Uses extrapolations of approximate helix lines through mulitplets of signal points from the tracking detectors.
- Provides the count (weight or multiplicity) of lines from signal points extrapolations to the vertex z position along beamline.
- Can be optimised for low, medium, and high pileup conditions to precisely estimate vertex position.
- Using two parameters that are tuned to data taking conditions and momentum range are histogram bin width, Δz, and allowed angular window $\Delta\phi$ for the three hits respectively.
- Will be used for High-Multiplicity Trigger (HMT) for the upcoming Run 3 high-luminosity pp and p-Pb to save resources without losing the efficiency.

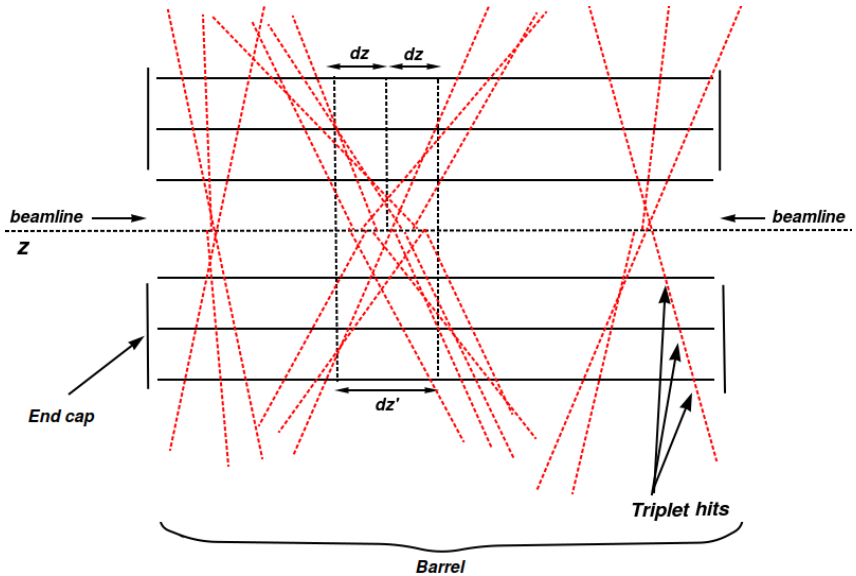
Illustrations

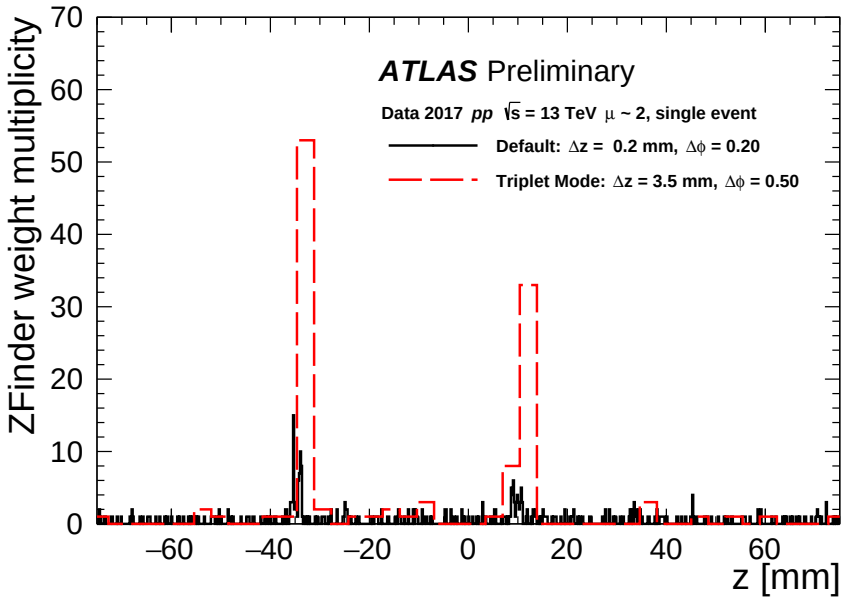




Left figure illustrates the longitudinal view of the collision inside ATLAS pixel detector with the barrel and end cap on both sides. Red-dashed lines are z-axis projection of extrapolation from the signal hits in the pixel-barrel detector to the vertex location. Narrow Δz bins can cause vertex split. Right figure illustrates the transverse view of the collision and the meaning of the $\Delta\phi$ parameter. Lower p_{T} particles are bent harder in magnetic field, so increasing $\Delta\phi$ means accepting more low p_{T} particles.

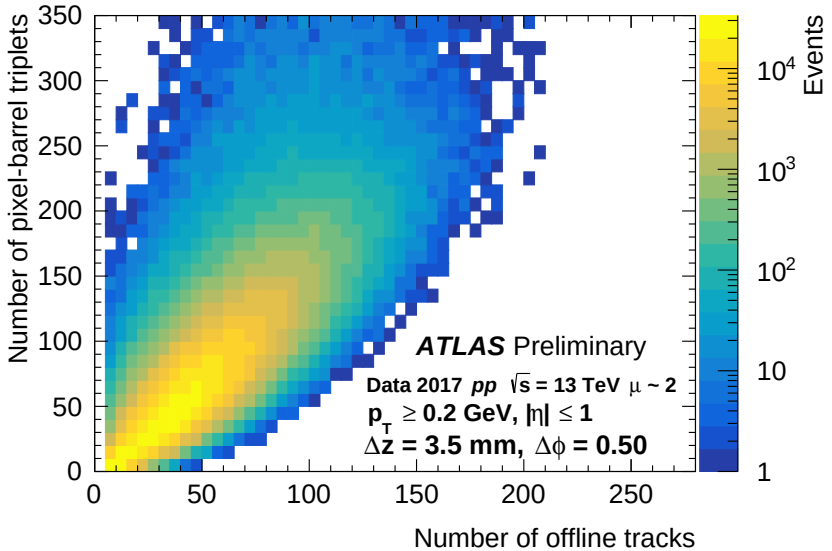
Counting Lines Into Histogram

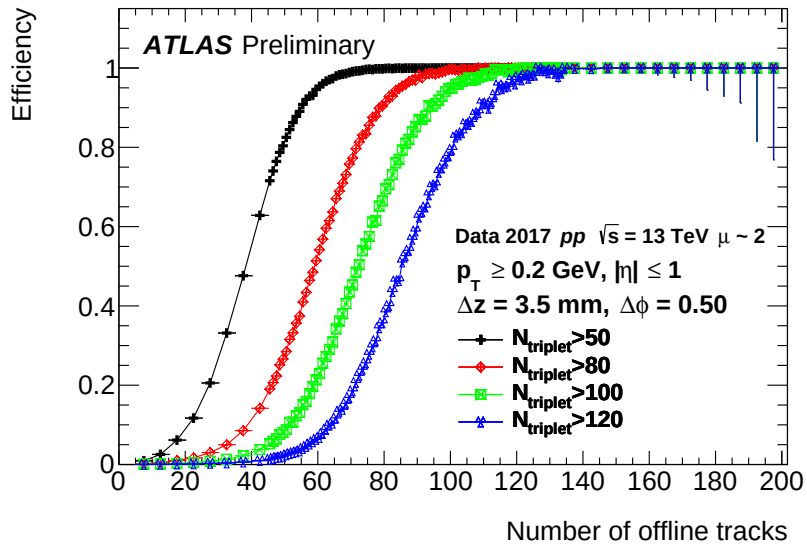




The ZFinder counts each extrapolated line that belongs to certain z position into a histogram bin. The histogram is the results of running the algorithm for a one event with two sets of parameters, default for high pile-up pp running conditions (black, dotted) and one with parameters optimised for low pile-up (red line) that uses triplets from the pixel barrel and larger values of $\Delta z = 3.5$ mm and $\Delta\phi$=0.5. The later gives better signal (value at peak) to noise (value around the peak) ratio.

Some Results

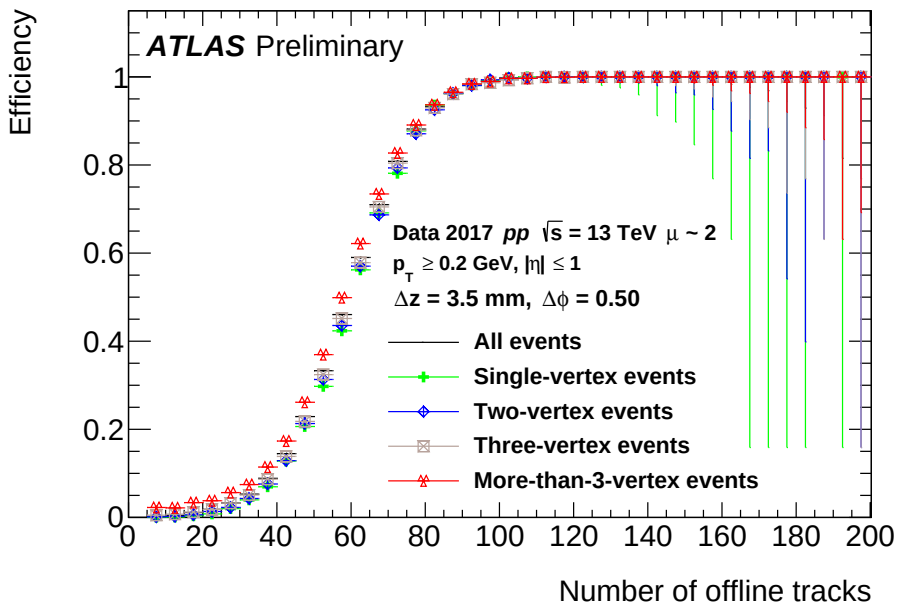




Left: Correlation of the number of triplets in the largest peak found by the Z-Finder algorithm in an event versus the number of charged particle tracks in an event of $p_{\mathrm{T}} > 0.2$ GeV and $|\eta| < 1$.

Right: The efficiencies as functions of number of offline tracks for various number of pixel-barrel triplets (N_{triplet}) thresholds.

Summary And Outlook



References to the figure and plots:

- *JINST 15 (2020) P100*
- HLT Tracking Public Results

- In Run 3, this algorithm will used for HMT in ATLAS.
- The efficiency plot on the left shows that the performance is good regardless of the pile-up.
- Therefore the ZFinder will save resources without losing the efficiency.