Performance of Track Reconstruction at the CMS High-Level Trigger in 2022 data

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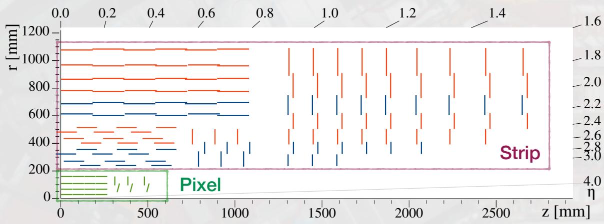
The CMS tracker

The CMS inner tracking system, which measures the trajectories of charged particles, consists of silicon pixel and strip detectors.



In preparation for Run 3 of the LHC, a refurbished innermost barrel pixel layer (BPix L1) was installed.

Tracking at the High-Level Trigger in Run 3

The CMS High-Level Trigger (HLT) runs a version of the full event reconstruction optimized for fast processing. Since the start of Run 3, the HLT makes use of a heterogeneous computing farm.

In Run 3, HLT tracking is based on a single iteration of the Combinational Kalman Filter, seeded by pixel tracks reconstructed by the Patatrack algorithm, which can be offloaded to GPUs [1-3].

To be used as seeds, Patatrack pixel tracks are required to:

- Be built with at least three pixel hits
- Have transverse momentum $p_T > 0.3$ GeV
- Be consistent with a leading pixel vertex

Pixel vertices from primary interactions are reconstructed at the HLT from pixel tracks with at least four hits and $p_T > 0.5$ GeV. The vertex with largest summed p_T^2 is the primary vertex (PV).

Detector conditions during data taking

The performance is measured in data recorded at $\sqrt{s} = 13.6$ TeV in 2022, using runs taken shortly before and shortly after the first Technical Stop (TS1) of the LHC, when several updates in detector conditions took place: Increase of BPix L1 reverse bias high voltage (HV) from 150 V to 300 V, with a corresponding update of the pixel cluster position estimator (CPE), as well as a new pixel detector gain calibration and a new tracker alignment.

Validation w.r.t. offline tracking

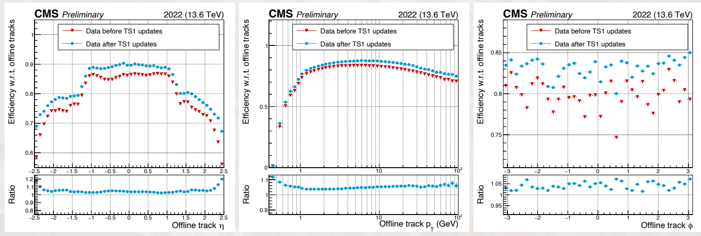
The HLT tracking efficiency and fake rate measured in data are defined with respect to offline tracks, produced by the full offline event reconstruction, which satisfy high-purity track quality criteria. Both HLT and offline tracks are required to have:

- Transverse momentum $p_T > 0.9$ GeV
- Transverse impact parameter w.r.t. PV $|d_{xy}| < 2.5$ cm
- Longitudinal impact parameter w.r.t. PV $|d_z| < 0.1$ cm

Matching between HLT tracks and offline tracks is performed by requiring an angular distance between them of $\Delta R < 0.002$.

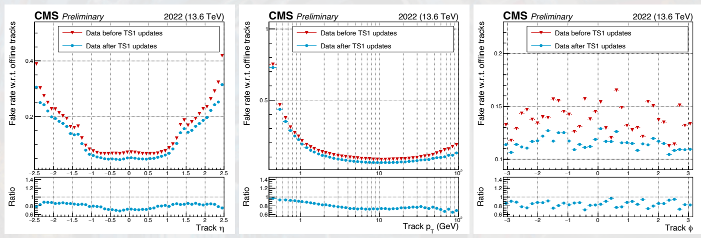
Efficiency

The HLT tracking efficiency w.r.t. offline is defined as the fraction of selected offline tracks matched to a selected HLT track.



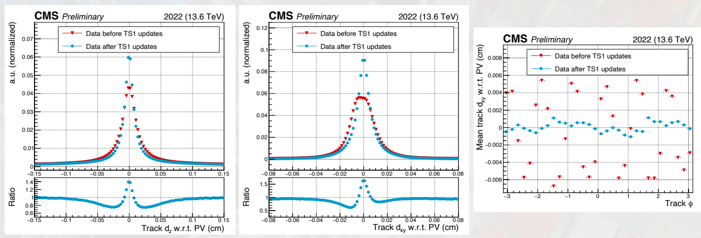
Fake rate

The HLT tracking fake rate w.r.t. offline is defined as the fraction of selected HLT tracks not matched to a selected offline track.



Impact parameters

Track longitudinal and transverse impact parameters are sensitive to the tracker alignment and calibration [4].



Performance is recovered by the BPix L1 HV increase and pixel CPE updates, which include an adjusted Lorentz angle calibration.

References

[1] CMS Collaboration, *Performance of Track Reconstruction at the CMS High-Level Trigger in 2022 data*, CMS Detector Performance Note CMS-DP-2023-028, 2022.

[2] CMS Collaboration, *Performance of Run-3 HLT Track Reconstruction*, CMS Detector Performance Note CMS-DP-2022-014, 2022.

[3] A. Bocci, V. Innocente, M. Kortelainen, F. Pantaleo, M. Rovere, *Heterogeneous Reconstruction of Tracks and Primary Vertices With the CMS Pixel Tracker*, arXiv:2008.13461 [physics.ins-det], DOI:10.3389/fdata.2020.601728, published in: Front.Big Data 3 (2020), 601728.

[4] CMS Collaboration, Strategies and performance of the CMS silicon tracker alignment during LHC Run 2, arXiv:2111.08757 [physics.ins-det], DOI:10.1016/j.nima.2022.166795, published in: Nucl. Instrum. Methods A 1037 (2022) 166795.