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Tracking challenges at HL-LHC

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Summary. — The high-luminosity upgrade of the LHC (HL-LHC) in 2026 will provide new challenges to the tracking detectors. In ATLAS the current inner detector will be replaced by a whole silicon Inner Tracker (ITk). The increase of the istantaneous luminosity at HL-LHC will lead to a mean number of additional p-p interactions from 140 to 200. To cope with this dense pile-up environment, an accurate reconstruction and selection of tracks and an efficient rejection of pile-up jets are crucial. The expected performance of the ITk will be presented.

1. – Introduction

The HL-LHC will be operative during the second half of 2026 and will probably deliver data for almost 15 years, resulting in an integrated luminosity of about $4000\,\mathrm{fb}^{-1}$, providing an order of magnitude more data than what would be collected during Run 2. To achieve this goal, the delivered istantaneous luminosity is required to be within $5\cdot10^{34}$ and $7.5\cdot10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, leading to an average number of proton-proton interactions per bunch crossing, $\langle\mu\rangle$, between 140 and 200. The existing ATLAS Inner Detector plays a fundamental role in the ATLAS physic programme (reconstruction of the trajectories of charged particles, identification of primary and secondary vertices, particle identification, hard-scatter vertex identification and pile-up suppression, jet energy and missing transverse energy measurement), but it was not designed to operate under the harsh HL-LHC conditions in terms of radiation damage, bandwidth saturation, detector occupancy and tracking performance. It will be replaced by a whole silicon tracker, called Inner Tracker, ITk, which will extend the pseudorapidity coverage from $|\eta| < 2.5$ to $|\eta| < 4.0$ and will guarantee equal or better performance with respect to the current one. The ITk barrel will consist of 5 Pixel layers spanning a radius from 39 mm to 345 mm with respect to the beam axis and 4 Strip layers extending up to 1000 mm. The end-cap region will be made of 6 Pixel rings on each side, mounted on independent supports at different radii and positions along the beam axis (from 1308 mm to 3000 mm). The candidate Pixel barrel layouts, ITk Extended and ITk Inclined, are made of 14 longitudinal modules mounted on linear stuctures placed parallel or inclined with respect to the beam axis. Further details can be found in [1-3].

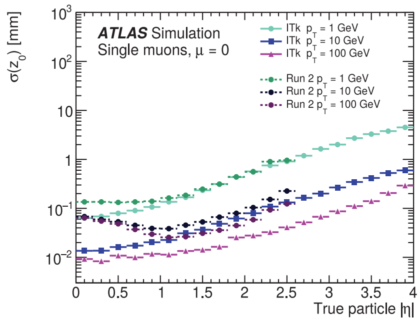

Fig. 1. – Resolutions on z_0 track parameter as a function of true track η for single muons with p_T of 1, 10, or 100 GeV, for $\langle\mu\rangle = 0$. Results for Run 2 are shown for comparison [2].

2. – ITk performance at HL-LHC

This section presents a brief review of the expected performance of ITk at HL-LHC.

2·1. *Tracking performance.* – ATLAS uses five parameters to fully define a track: the particle charge divided by the transverse momentum, q/p_T, the longitudinal and transverse impact parameters, z_0 and d_0, the polar and azimuthal angles, θ and ϕ. Figure 1 shows the z_0 resolution of the tracks, obtained from simulation by comparing their reconstructed to truth value. The resolution is better for ITk than Run 2 in the whole p_T spectra. This is mainly due to the decreased pixel pitch in the z direction from 250 μm to 50 μm, resulting in charge sharing being present also for central tracks.

2·2. *Jet/E_T^{miss} performance.* – Tracks, and their vertex association information, can be used to mitigate pile-up effects in the jet and E_T^{miss} reconstruction. The extension from the current $|\eta| < 2.5$ to $|\eta| < 4.0$ of the ATLAS tracker acceptance will enable to apply Run 2 track-based pile-up suppression methods [4] for jets in the very forward region to reject jets due to pile-up interactions. The E_T^{miss}, being computed from high-p_T physics objects and tracks originating from the hard-scatter vertex and not associated to any of the reconstructed objects, is very sensitive to pile-up contamination. Figure 2 shows the E_T^{miss} resolution as a function of the number of reconstructed primary vertices for different tracker acceptances. The resolution is about 30% better when using tracks up to $|\eta| = 4.0$. This is primarily due to the removal of forward pile-up jets.

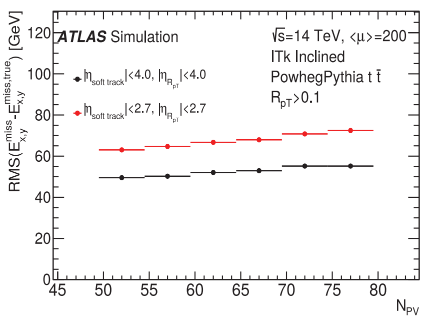

Fig. 2. – The resolutions of the E_T^{miss} for the $|\eta| > 2.7$ and $|\eta| < 4.0$ ITk acceptance ranges for $t\bar{t}$ events with $\langle\mu\rangle = 200$, as a function of the number of reconstructed primary vertices [2].

REFERENCES

[1] The ATLAS Collaboration, *ATLAS Phase-II Upgrade Scoping Document*, CERN-LHCC-2015-020, LHCC-G-166, https://cds.cern.ch/record/2055248.
[2] The ATLAS Collaboration, *Technical Design Report for the ATLAS Inner Tracker Strip Detector*, CERN-LHCC-2017-005, ATLAS-TDR-025, https://cds.cern.ch/record/2257755.
[3] The ATLAS Collaboration, *Expected Performance of the ATLAS Inner Tracker at the High-Luminosity LHC*, ATL-PHYS-PUB-2016-025, https://cds.cern.ch/record/2222304.
[4] The ATLAS Collaboration, *Tagging and suppression of pileup jets with the ATLAS detector*, ATLAS-CONF-2014-018, https://cds.cern.ch/record/1700870.