Tracking challenges at HL-LHC

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 with a whole silicon tracker consisting of a five barrel layer Pixel detector surrounded by a four barrel layer Strip detector, called Inner Tracker, ITk.

The delivered instantaneous luminosity under HL-LHC conditions is expected to be in the range 5·10^34 to 7.5·10^34 cm^-2 s^-1 [1]. This leads to a very high number of additional proton-proton interactions, called pile-up, with a mean value of interaction per bunch crossing, \( \langle p_\text{up} \rangle \), from 140 up to 200 [2]. To cope with this dense pile-up environment, an accurate reconstruction and selection of tracks and an efficient rejection of pile-up jets is crucial. The expected performance of the HL-LHC ATLAS Inner Tracker with respect to the current one will be reviewed.

The ITk is an all-silicon tracker with an extended acceptance up to |\( \eta \)|<4. It will adopt two different technologies: silicon Pixel and silicon Strip detectors. The candidate layouts are based on two Pixel barrel designs, characterised by linear structures (staves) oriented parallel or inclined with respect to the beam axis, a common Strip detector layout and the same design for the Pixel endcap, made of independent rings of different sizes placed at different radii and positions along the beam axis.

The ITK extended coverage will improve, among others, the reconstruction and identification of the vertices in the event, the reconstruction of large \( \eta \) leptons and the pileup jet suppression by applying jet vertex tagging techniques also to forward jets.

The expected performance of the ATLAS ITk layouts under HL-LHC conditions has been presented; The ITk is expected to have better tracking resolutions than Run 2 Inner Tracker; The ITk Inclined layout shows a better track efficiency in the high \( \eta \) region with respect to the Extended one; The track efficiency is independent of \( \langle p_\text{up} \rangle \) in the range 40 – 260 for all \( \eta \) ranges; The lower ROC curve for the ITk Inclined layout in the forward region is reflected by a non-negligible enhancement in the \( E_{\text{miss}} \) resolution with respect to the ITk Extended layout. The extended \( \eta \) acceptance of the ITk leads to a significant improvement in the \( E_{\text{miss}} \) resolution even in a dense pileup environment.

Conclusions

Acknowledgements

I would like to express my sincere acknowledgement to my colleagues from the ITk Layout Task Force. A special mention goes to Marianna Testa, LNF, and to Claudia Gemme, INFN – Gen.

References:
[4] ITk-2017-001