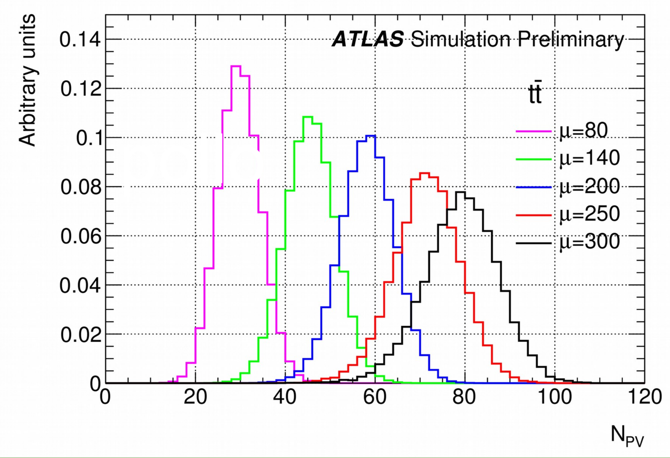
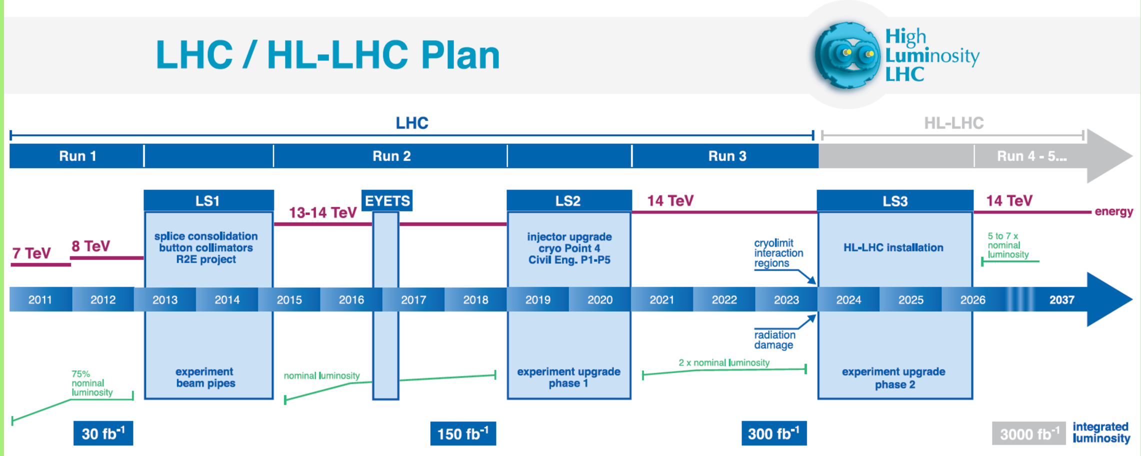
XVI IFAE Poster Session, Sessione Nuove Tecnologie
April 19th-21st 2017, TRIESTE

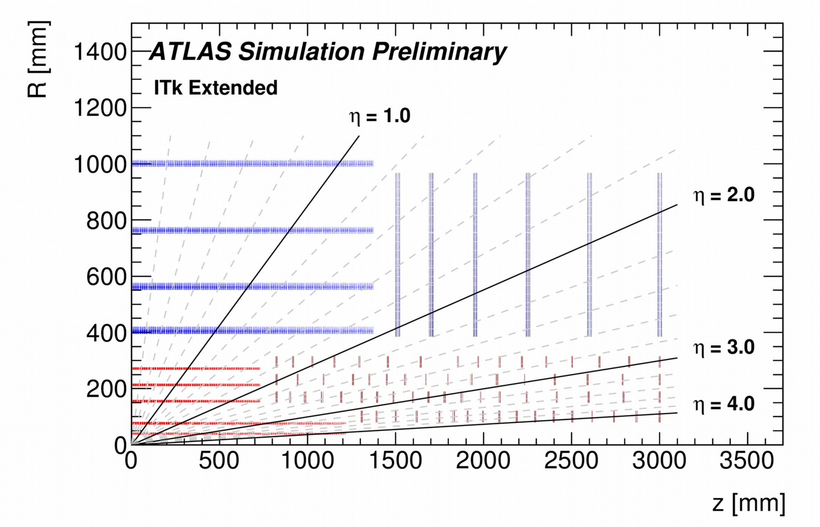
Tracking challenges at HL-LHC

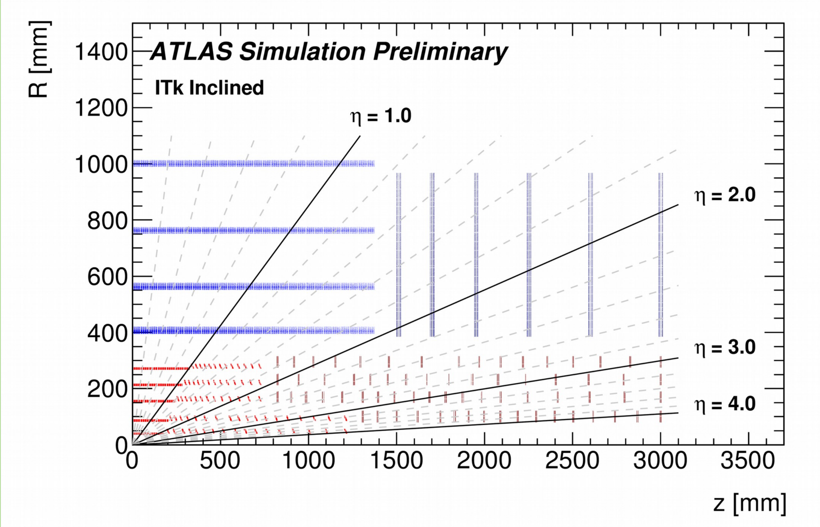


The high luminosity upgrade of the LHC (HL-LHC) in 2026 will provide new challenges to the tracking detectors. In ATLAS the current inner detector will be replaced with a whole silicon tracker consisting of a five barrel layer Pixel detector surrounded by a four barrel layer Strip detector, called Inner Tracker, ITk.
The delivered istantaneous luminosity under HL-LHC conditions is expected to be in the range $5{\cdot}10^{34}$ to $7.5{\cdot}10^{34}$ $cm^{-2}s^{-1}$ **[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, <μ>, 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.

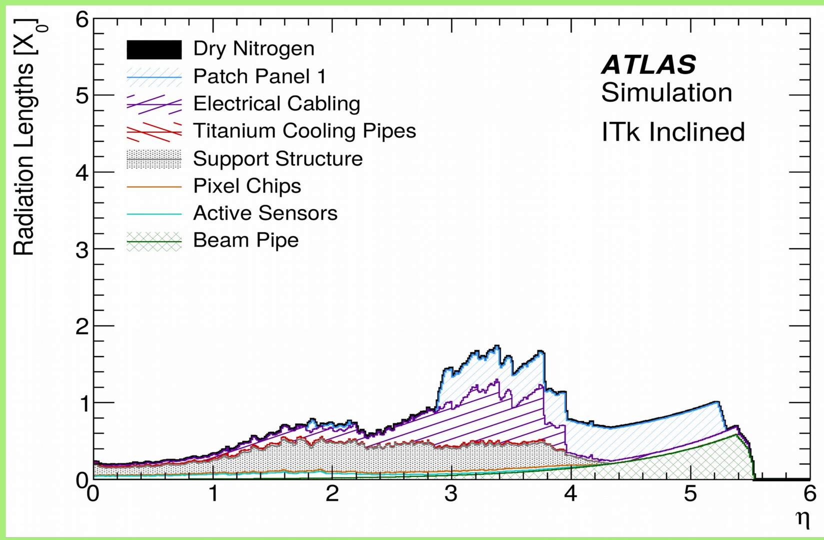


The ATLAS Inner Tracker, ITk

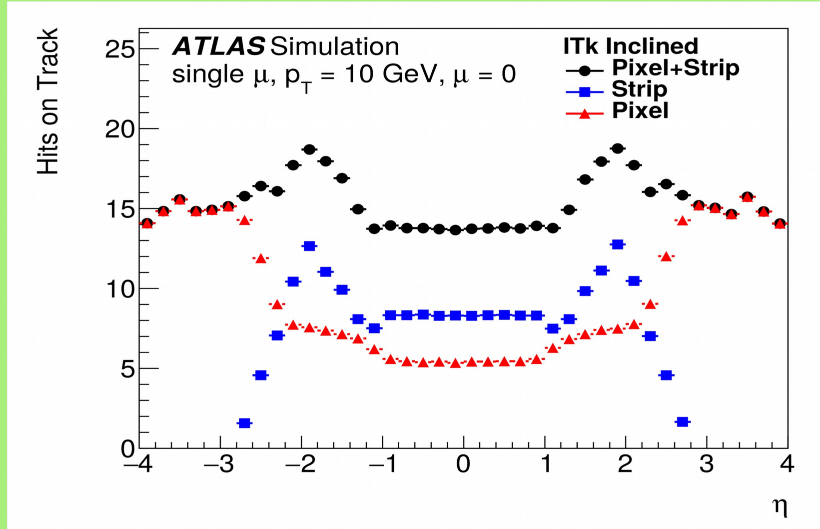




The two candidate ITk layouts: the **Extended** (left) and the **Inclined** (right) pixel barrel layouts. The Pixel tracker is in **red**, the Strip tracker is in **blue** **[3]**.



Radiation length X_0 versus η for the ITk Inclined layout.

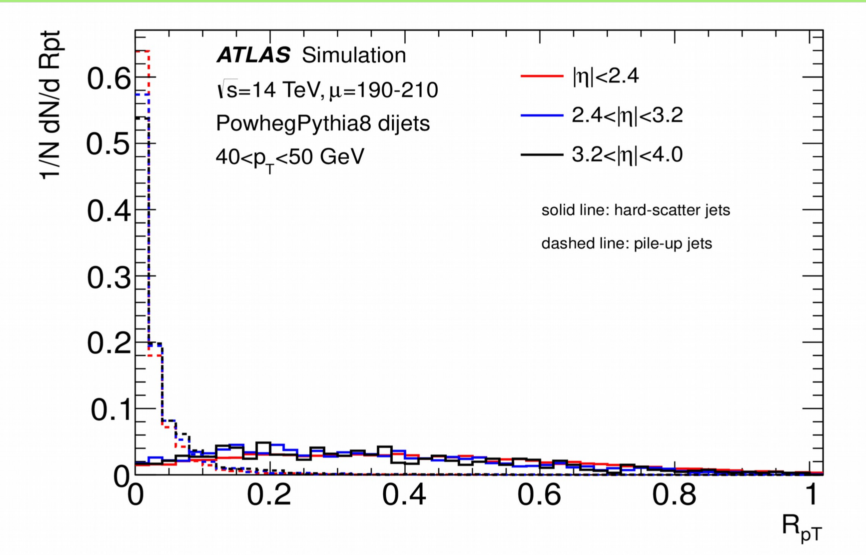


Mean number of hits per track versus η for single muons with p_T=10 GeV for the ITk Inclined layout.

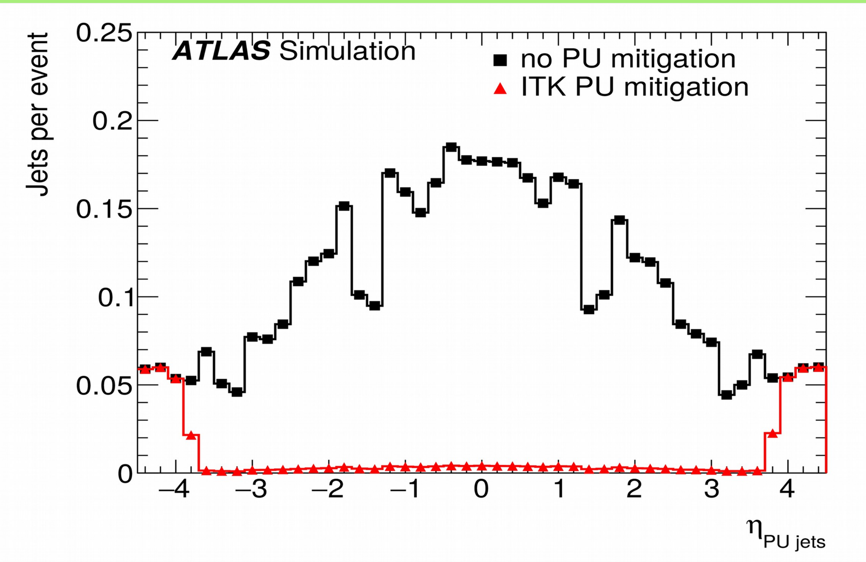
The ITk is an **all-silicon tracker** with an **extended acceptance** up to |η|<4. It will adopt two different technologies: silicon Pixel and silicon Strip detectors. The candidate layouts are based on two Pixel barrel designs, characterised by linear structures (staves) oriented **parallel** or **inclined** 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 η leptons and the pileup jet suppression by applying jet vertex tagging techniques also to forward jets.

Pileup suppression with ITk

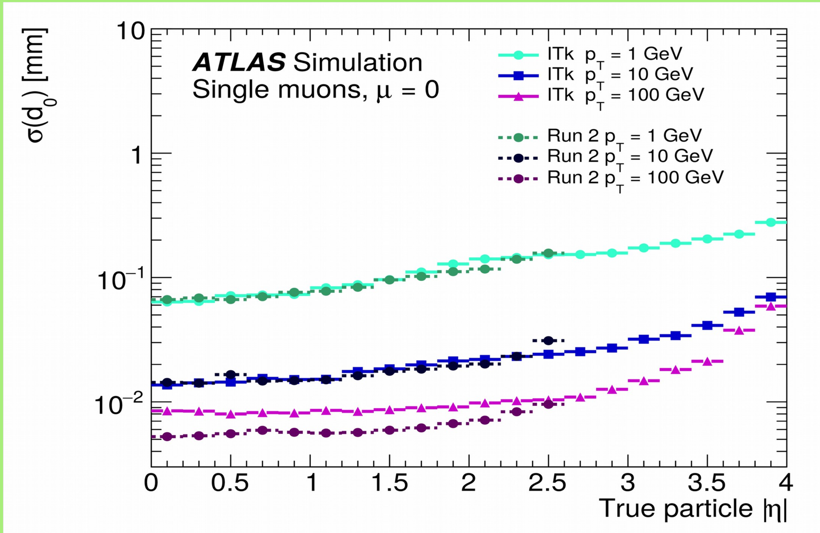


R_{pT} distribution for hard-scatter and pile-up jets with 40<p_T<50 GeV in different η regions **[1]**. Small values of R_{pT} are very likely to correspond to pileup jets.

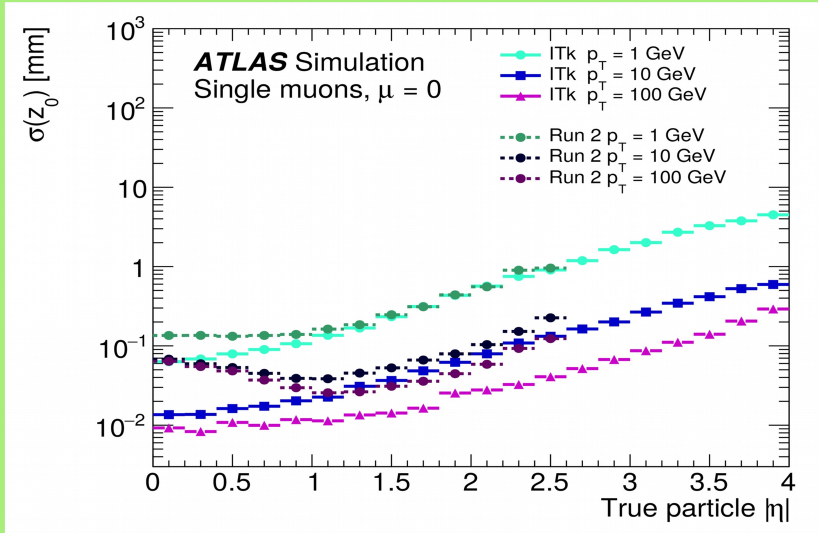


Number of pileup jets per event with and without R_{pT} cut in the extended ITk coverage **[1]**.

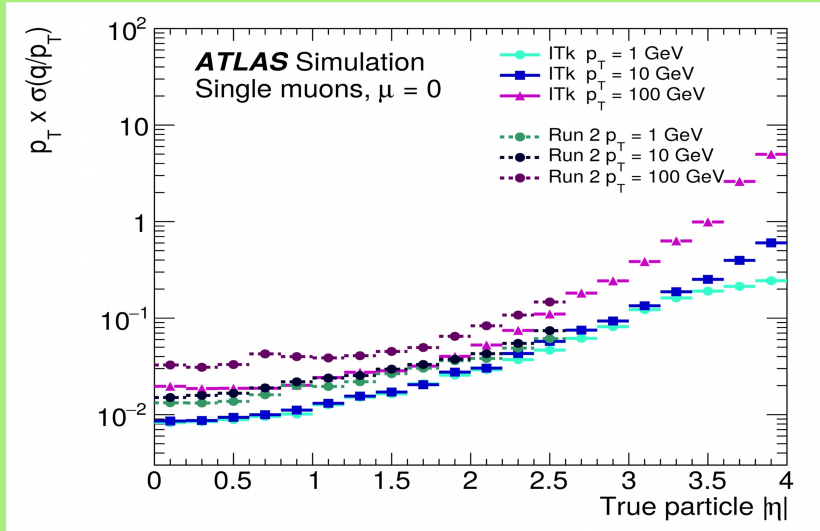
ITk tracking performance at HL-LHC



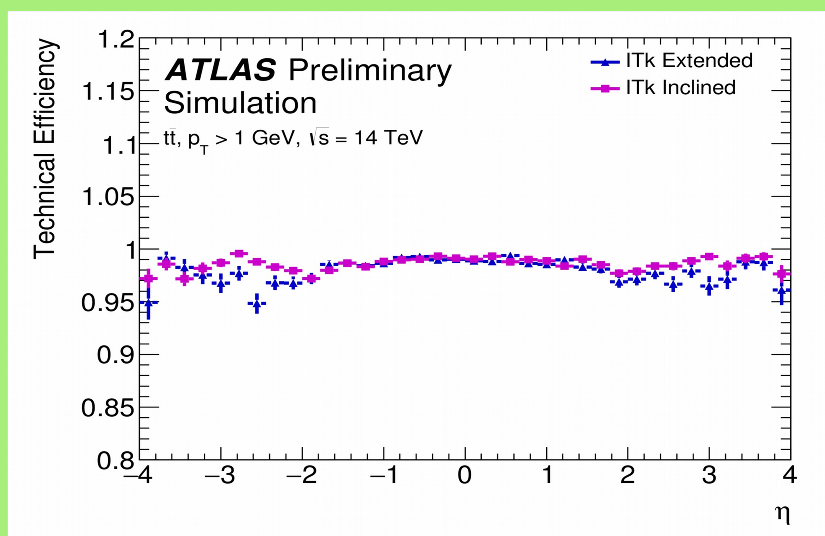
Resolution of the transverse impact parameter d_0



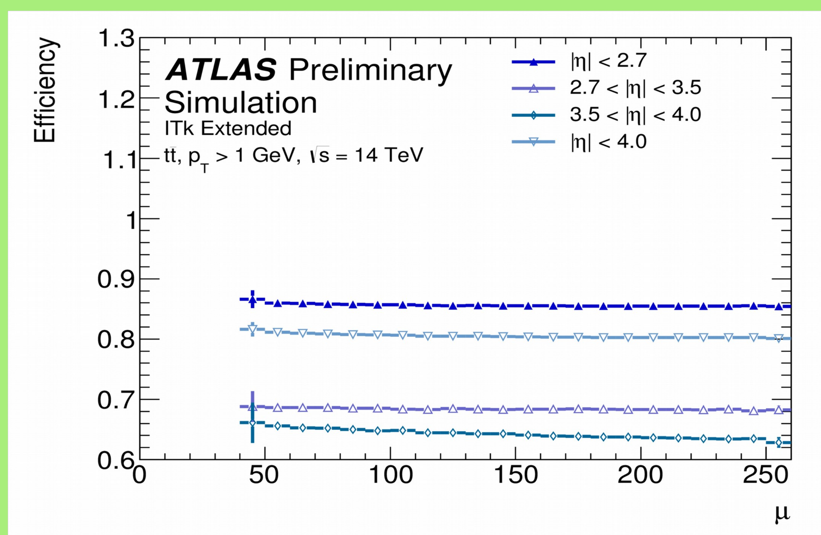
Resolution of the longitudinal impact parameter z_0

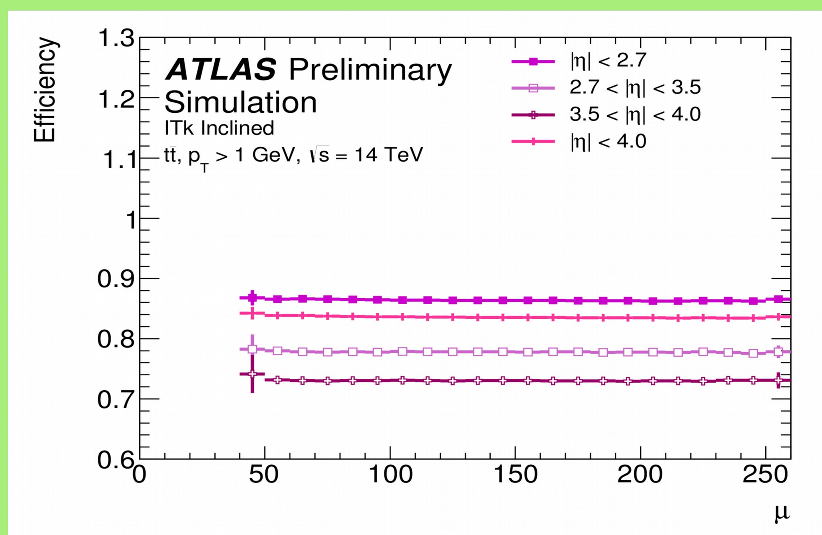


Resolution of the charge to the momentum q/p_T



Technical efficiency for the two ITk layouts

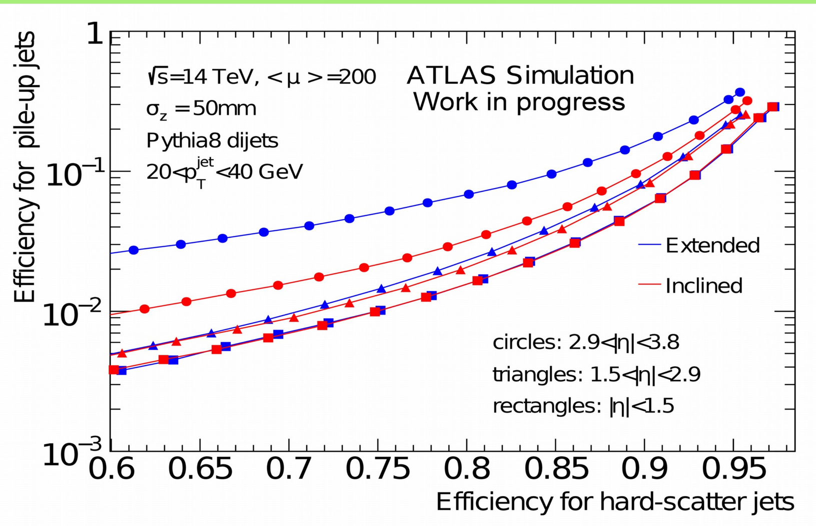




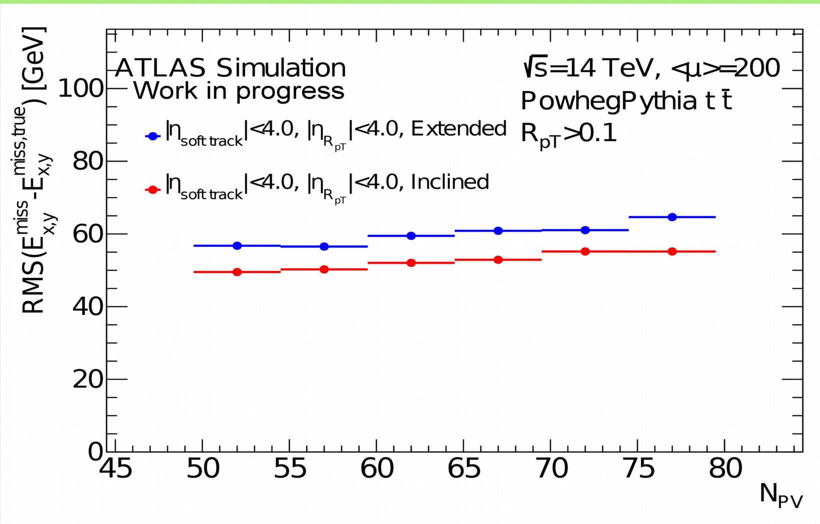
Track efficiency versus μ in bins of η for the **Extended** (left) and **Inclined** (right) ITk layouts

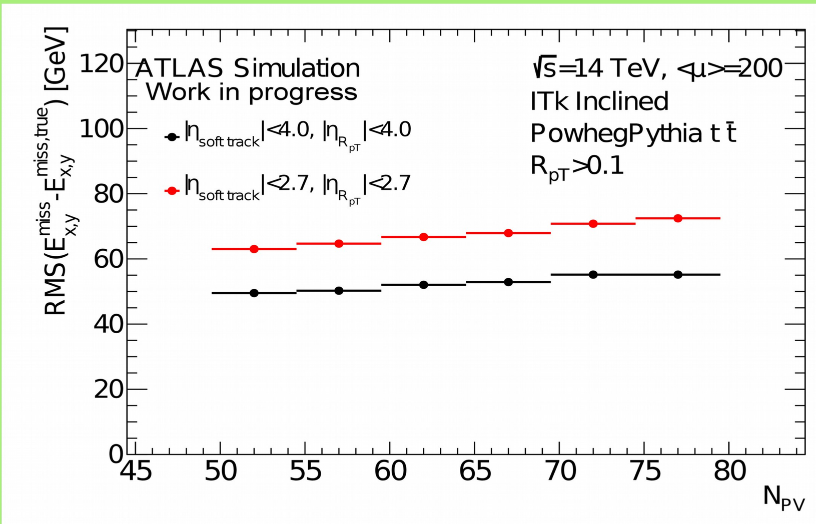
The most decisive Figures of Merit for the tracking performance are the resolutions of the tracking parameters and the track reconstruction efficiencies. The resolutions are shown in bins of the p_T of the tracks for both ITk Inclined and Run 2 Inner Detector configurations for single muons at <μ>=0. The efficiencies for tracks with p_T>1 GeV in tt events for both ITk Extended and Inclined are presented versus η (μ=0) and μ in bins of η **[4]**.

Jet and E_T^{miss} performance with ITk



ROC curves in different η regions for jets with 20<p_T<40 GeV using R_{pT} discriminant. The tracks used in the R_{pT} calculation have p_T>1 GeV.





Resolutions of the **x** and **y** components of the E_T^{miss} for the ITk Extended (**blue**) and Inclined (**red**) layouts (left) and in the η<2.7 (**red**) and η<4.0 (**black**) of the ITk Inclined layout acceptance regions as a function of the number of reconstructed primary vertices, N_{PV}.

The E_T^{miss} is computed as the negative of the sum of **x** (**y**) component of the momenta of high-p_T physics objects in the event and the tracks originating from the hard-scatter vertex and not associated to any of the reconstructed objects. E_T^{miss} performance is evaluated through its resolution, here presented versus N_{PV} for different ITk layouts and acceptance. The resolution strongly benefits from a good pileup jet suppression. This is evident by looking at the efficiency for pileup jets as a function of the efficiency for hard-scatter jets (**ROC curves**), here presented for the two ITk layouts in η bins.

Conclusions

- 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 η region with respect to the Extended one;
- The track efficiency is independent of <μ> in the range 40 – 260 for all η ranges;
- The lower ROC curve for the ITk Inclined layout in the forward η region is reflected by a non-negligible enhancement in the E_T^{miss} resolution with respect to the ITk Extended layout.
- The extended η acceptance of the ITk leads to a significant improvement in the E_T^{miss} resolution even in a dense pileup environment;

Acknowledgements

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References:

[1] CERN-LHCC-2015-020
[2] PLOT-UPGRADE-2014-003
[3] ATL-PHYS-PUB-2016-025
[4] IDTR-2017-001