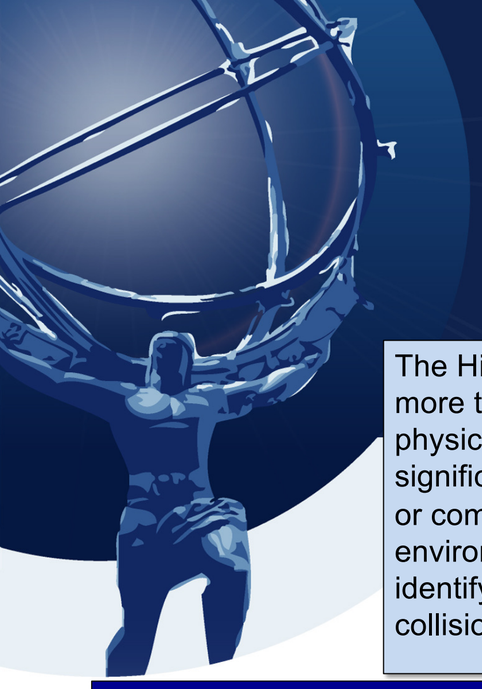
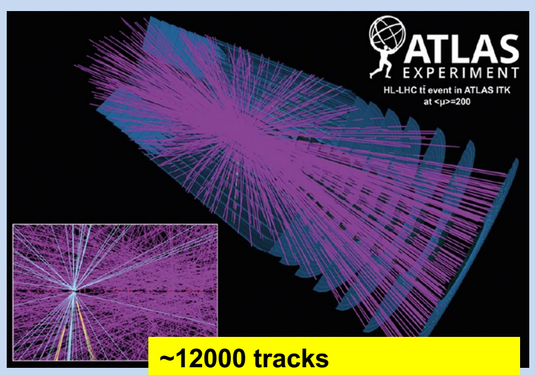


PM2022 - 15th Pisa Meeting on Advanced Detectors

Expected reconstruction performance with the new ATLAS Inner Tracker at the High-Luminosity LHC

The High Luminosity-Large Hadron Collider is expected to start in 2029 and to provide an integrated luminosity of 4000 fb^{-1} in ten year, about a factor 20 more than what was collected so far. This high statistics will allow to perform precise measurements in the Higgs sector and improve searches of new physics at the TeV scale. The luminosity needed is L ~7.5 10^{34} cm^{-2} s^{-1}, corresponding to ~200 additional proton-proton pile-up interactions, which can significantly degrade the reconstruction performances. To face such harsh environment some sub-detectors of the ATLAS experiment will be upgraded or completely substituted. The current Inner Detector will be replaced with a new all-silicon Inner Tracker (ITk) designed to face the challenging environment associated with the high number of collisions per bunch crossing. In this poster an overview of the ITk performance to reconstruct and identify high-level objects will be shown. A particular focus will be given to the pile-up jets tagging and the impact of the spatial density of the number of collisions per bunch crossing

New Inner Tracker (ITk) at HL-LHC



~12000 tracks in the tracker acceptance (each 25 nsec)

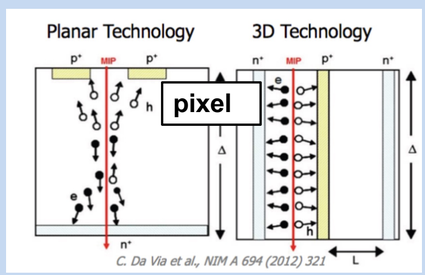
Motivation: To face the harsh environment at HL-LHC, the current inner detector will be replaced with a new full-silicon Inner Tracker (ITk).

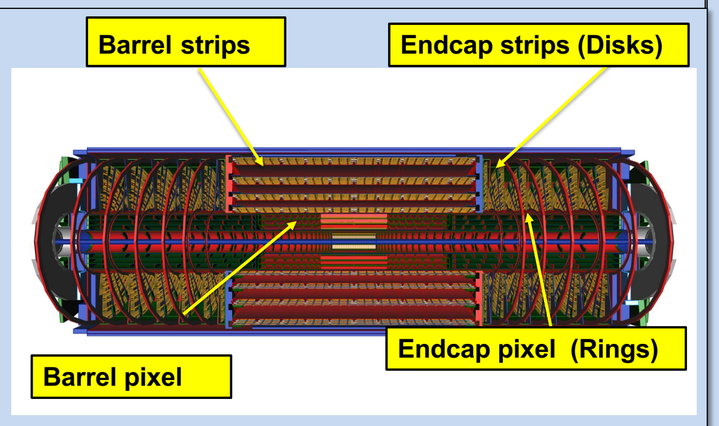
Finer segmentation
- More and smaller channels
- All silicon inner tracker with strips and pixel
- Extension up to $|\eta| < 4$

Increase radiation hardness: new sensors & front-end

CERN-LHCC-2017-005, ITk Strip TDR
CERN-LHCC-2017-021, ITkPixel TDR

Sensor Technology
- Pixel, 13m^2
  - 3D for the inner most layer
  - Planar elsewhere
  - pitch size 50 x 50 μm^2 except 25 x 100 μm50 x 50 μm for barrel most inner layer
- Strip: 165m^2, planar n-in-p



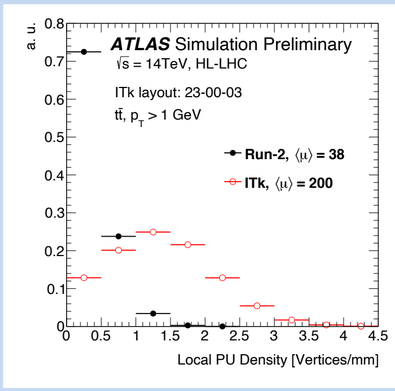


Radiation hardness:
~ 2×10^{16} (2×10^{15}) n_{eq}/cm^2 for Pixel (Strips)

HL-LHC Pile-up conditions

- Larger average number of pile-up interaction per bunch crossing
- Larger **pile-up density =** fraction of events where a vertex is reconstructed within 0.1 mm of the true hard-scatter position in the longitudinal direction

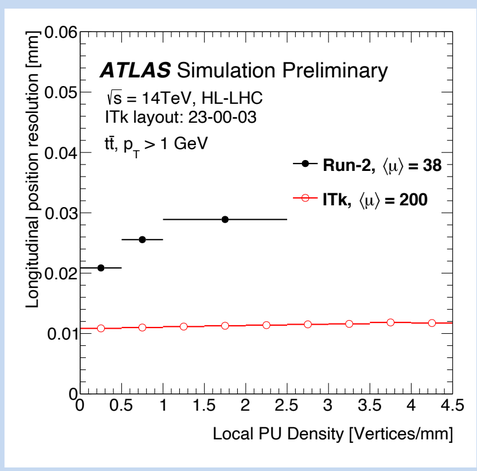
→ Impact on reconstruction and identification of high level objects

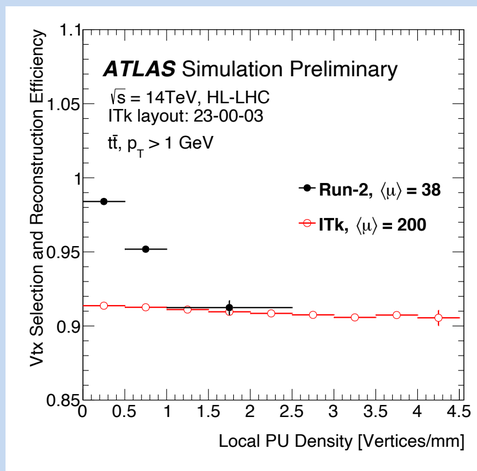


Vertexing

ATL-PHYS-PUB-2021-024

- Vertices reconstructed through an Adaptive Multi-Vertex Finder algorithm
- Primary vertex identified as the reconstructed vertex with the largest $\Sigma\, p^2_T$ of associated tracks
- Efficiency and resolution stable against pile-up density

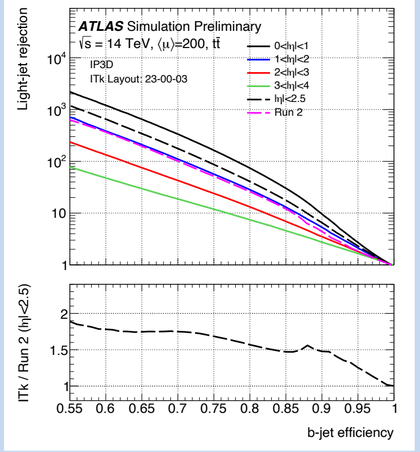




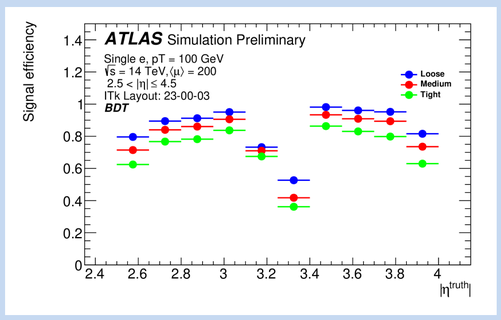
B-Tagging, Electrons, γ conversion

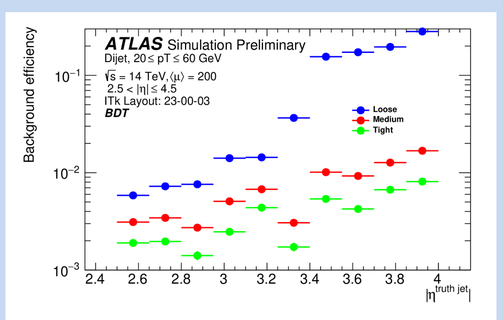
ATL-PHYS-PUB-2021-024

- *Several* **b-tagging** algorithms developed
- The IP3D alg. exploits the large d_0, z_0 of tracks from *b*-hadron decay products
- Improved performance wrt Run2 due in particular to the d_0 and z_0 resolution improved respectively up to a factor 1.2(2) and up to a factor 2(4) for 2(100) GeV muons
- Deterioration at large $|\eta|$ due to increased material crossed

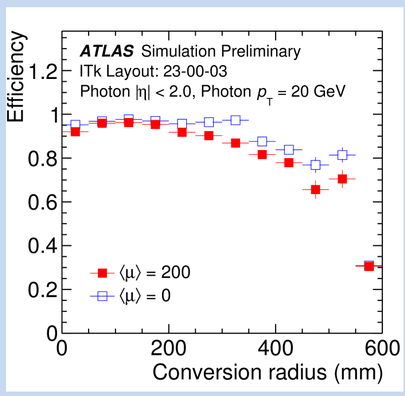


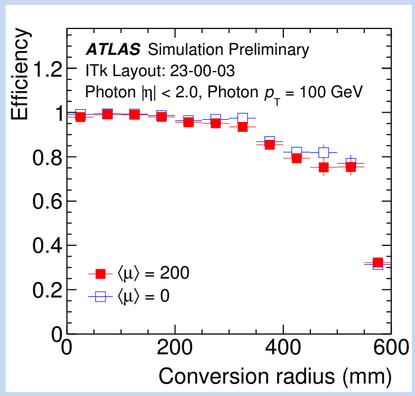
- **Electrons** and **photon conversion** reconstruction and identification (ID) based on on several tracking and calorimeter variables
- ITk enables reconstruction and ID of **electrons** in the forward region





- **Photon conversion** reconstruction efficiency above 80% up to the first ITk strip layer at R = 400 mm

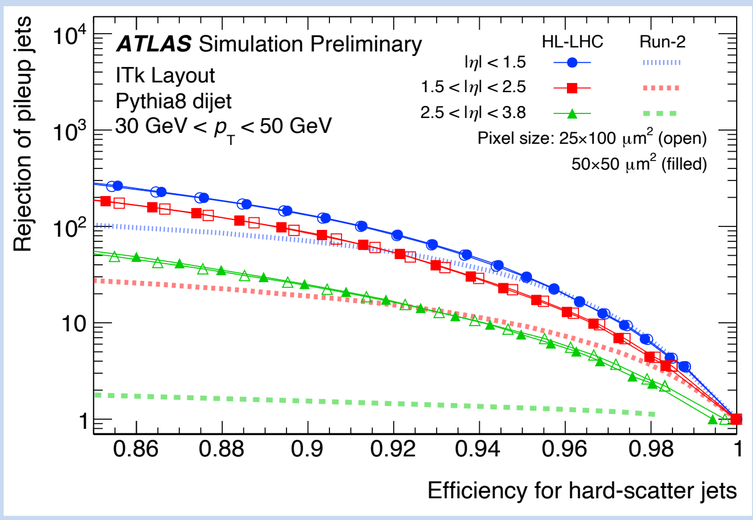




Pile-up Jet suppression

ATL-PHYS-PUB-2019-014

- Crucial to assign tracks to the primary vertex
- Rely on z_0 resolution, improved by up to a factor 2(4) for 2(100) GeV muons thanks to the smaller pixel pitch, 25 × 100 or 50 × 50 μm² for ITk, 50 × 250 μm² for the current ID
- Similar performances expected with the final chosen pixel pitch
- Deterioration at large $|\eta|$ due to increased material crossed



Impact of different HL-LHC conditions

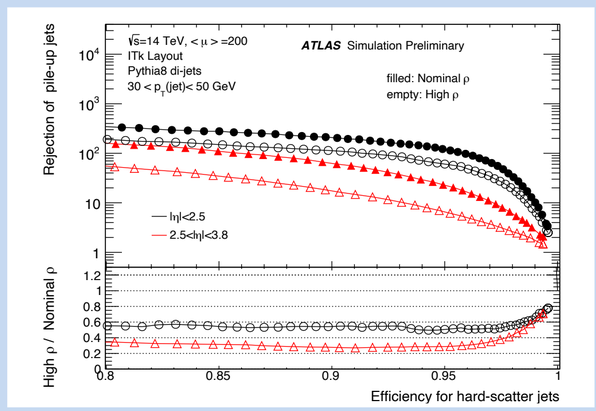
ATL-PHYS-PUB-2021-023

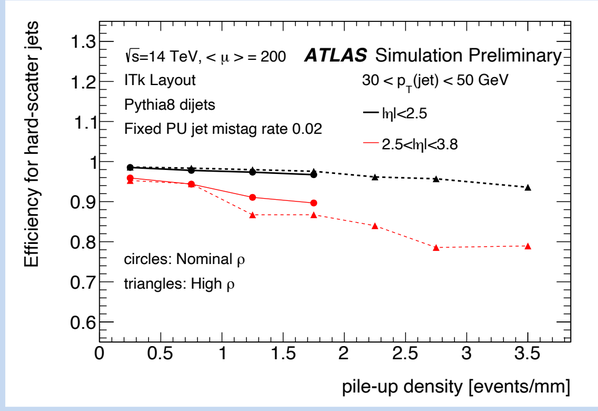
- Several **HL-LHC configurations** to mitigate risks and reduce costs

→ Impact on the luminous region, the pileup conditions and luminosity

Parameter	Baseline	Flat	8b+4e	200 MHz	No CCs
z_{RMS} at start of leveling [mm]	47	49	49	54	37
z_{RMS} at end of leveling [mm]	41	39	42	44	29
Peak instantaneous luminosity [$\times 10^{34}$ $cm^{-1}s^{-2}$]	7.5	7.5	5.5	7.5	7.5
Peak pileup density at start of leveling [mm^{-1}]	1.62	1.56	1.58	1.48	2.13
Peak pileup density at end of leveling [mm^{-1}]	1.95	2.02	1.88	1.93	2.73
Effective pileup density over fill [mm^{-1}]	1.20	1.20	1.17	1.08	1.58
Yearly integrated luminosity [fb^{-1}/160 days]	326	340	243	304	293

Pile-up Jet tagging:
- Up to 20% efficiency deterioration in the forward region at typical working points.
- Expected improvement using time information from the new High Granularity Time Detector





Marianna Testa, for the ATLAS Collaboration