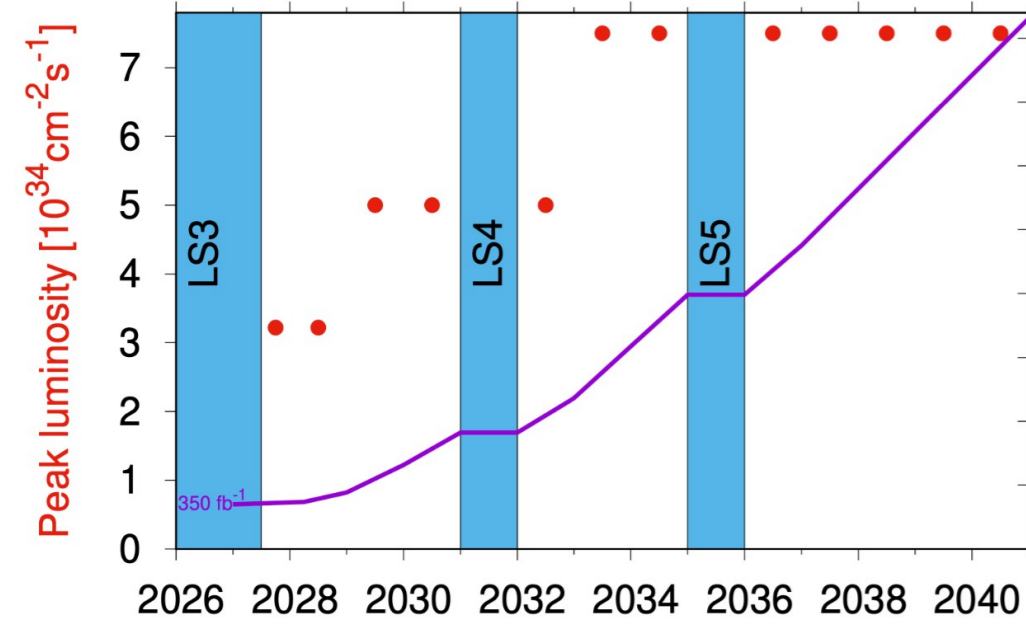
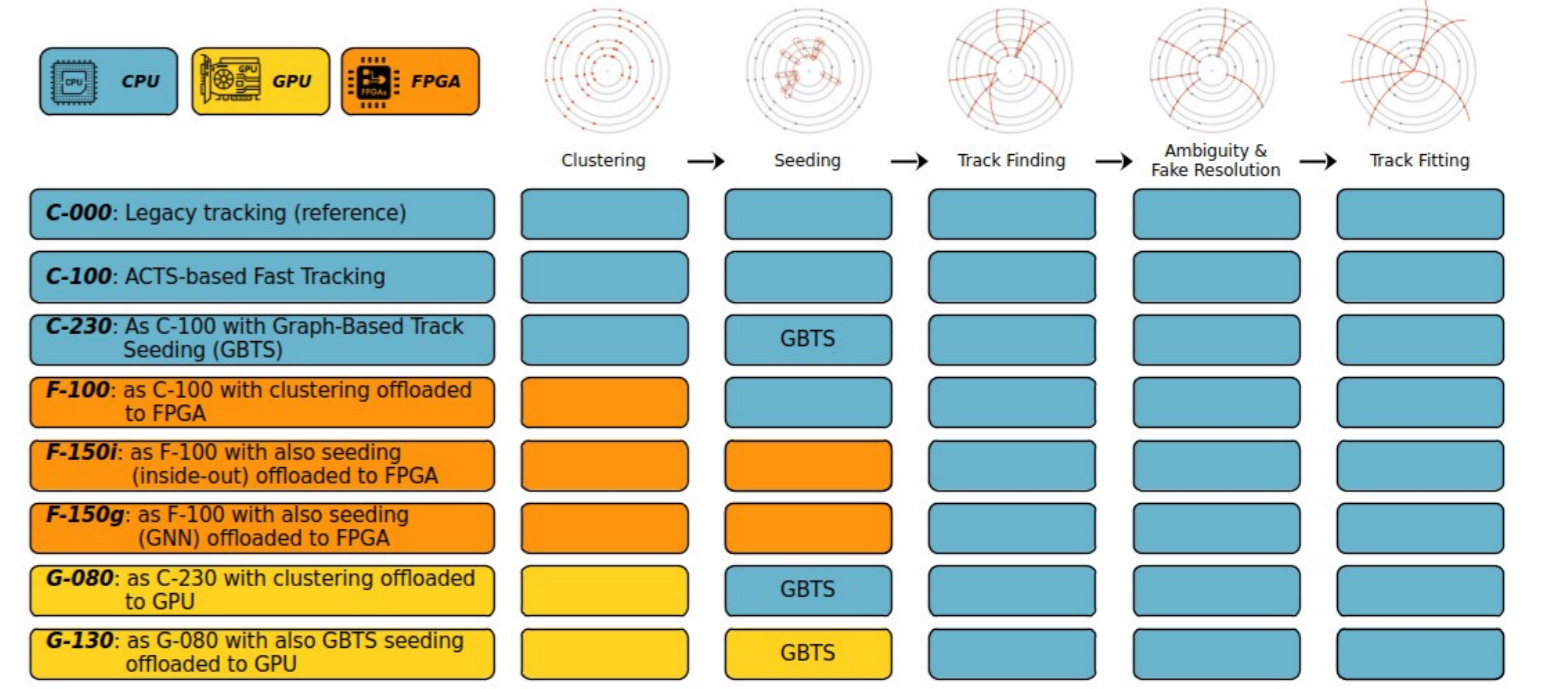


EF Tracking for the Phase-II Upgrade of the ATLAS Experiment



Projected HL-LHC luminosity profile. The highest pile-up of 200 to be reached in Run 5 (2033) [1]

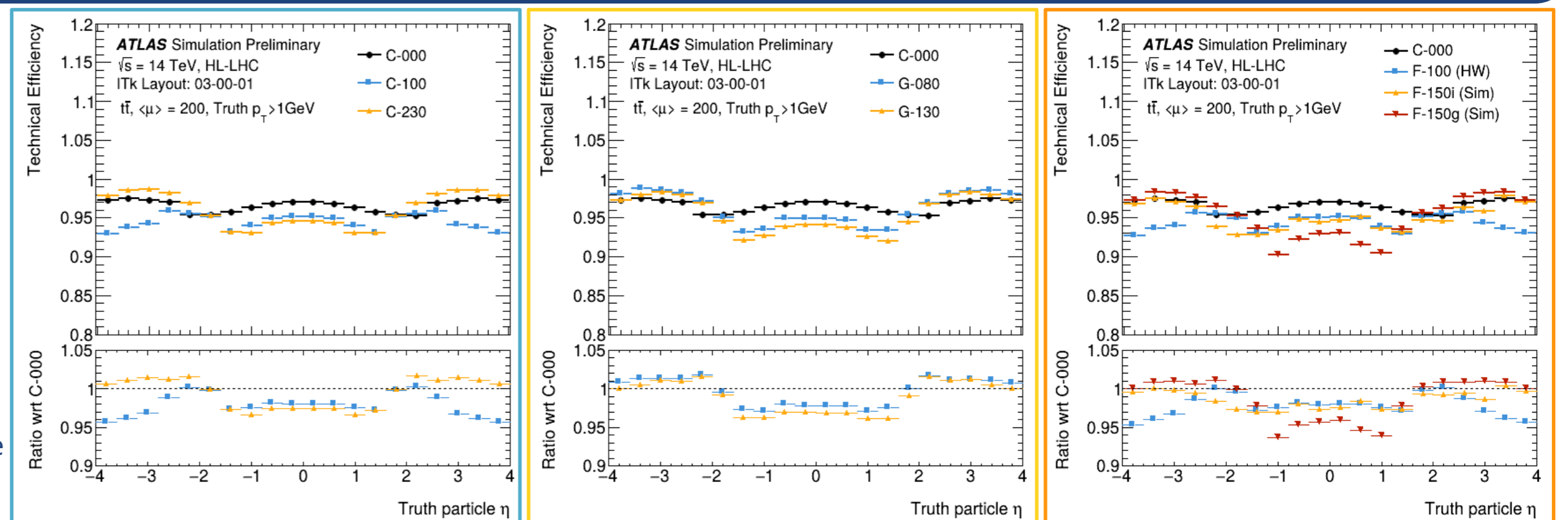
- At High Luminosity LHC (HL-LHC), extremely **challenging pile-up conditions** → Major upgrade of the ATLAS Inner Tracker and Trigger and Data Acquisition (TDAQ) System [1]
- Event Filter (EF) System: **processing farm of commodity hardware (CPU, GPU, FPGA)** [2, 3] to select events to reduce the final output rate
- Roughly **80% of the computing power** of the EF System is dedicated to track reconstruction
- Tracking performance is critical** to keep rate low and achieve the ATLAS HL-LHC physics goals



Overview of the tracking "pipelines" [2, 3], highlighting the steps and the hardware they run on

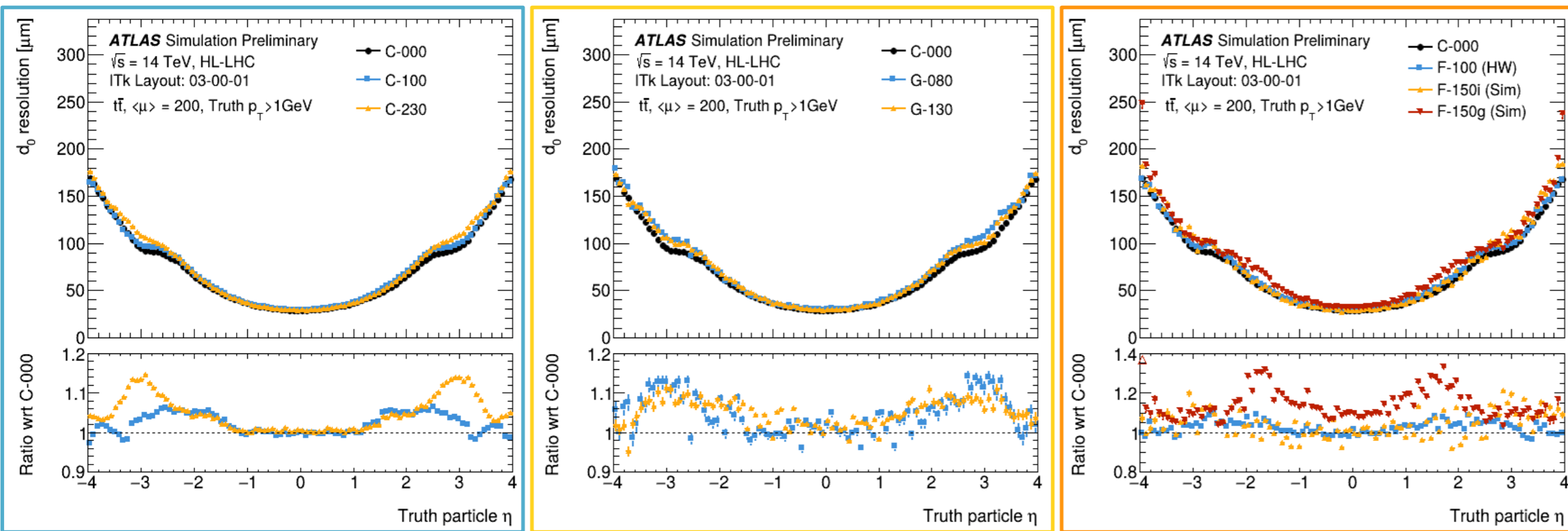
Tracking Efficiency

- Important for object identification and isolation
- "Technical" efficiency = fraction of "reconstructable" truth particles from Hard Scattering, matched to reconstructed tracks [4]
- All pipelines → **similar performance to C-000**
- drop in barrel due to simplified seeding in fast tracking (not using strip space points)
- Graph-Based Track Seeding (GBTS) pipelines: drop in the barrel due to preliminary graph configurations (missed layer hits), while gain in forward region



Comparison of the technical efficiencies [4] as a function of truth η for the various pipelines with respect to legacy tracking (C-000)

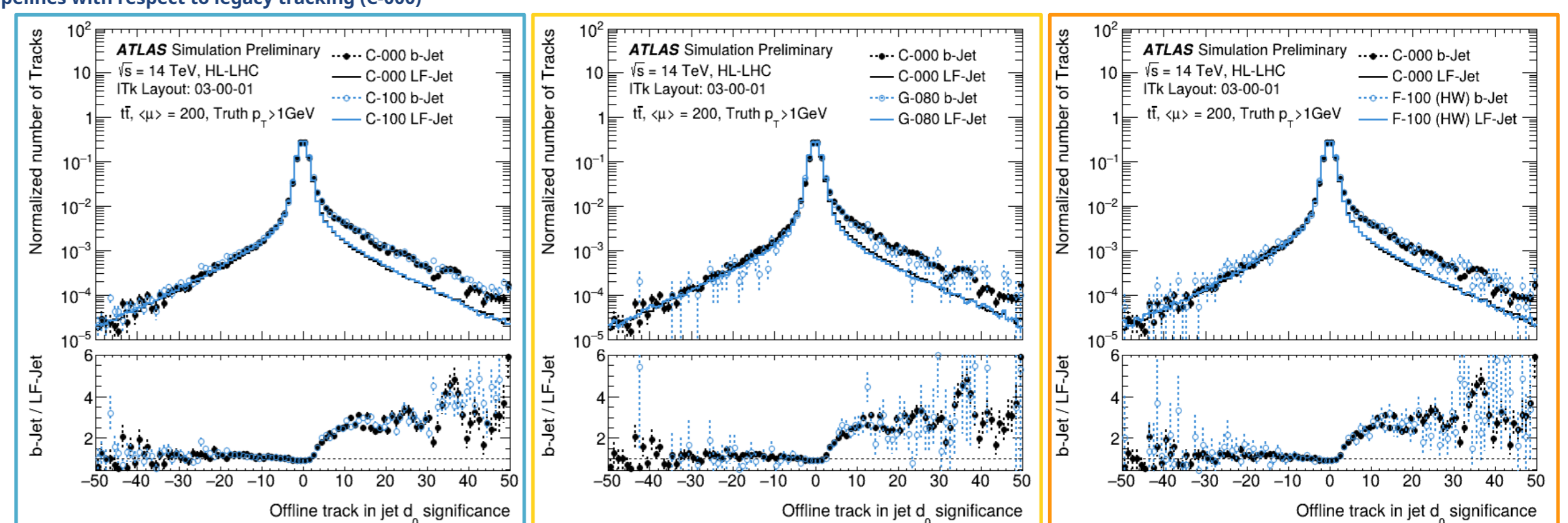
Transverse impact parameter resolution & B-hadron signatures



Comparison of the d_0 resolution as a function of truth η for the various pipelines with respect to legacy tracking (C-000)

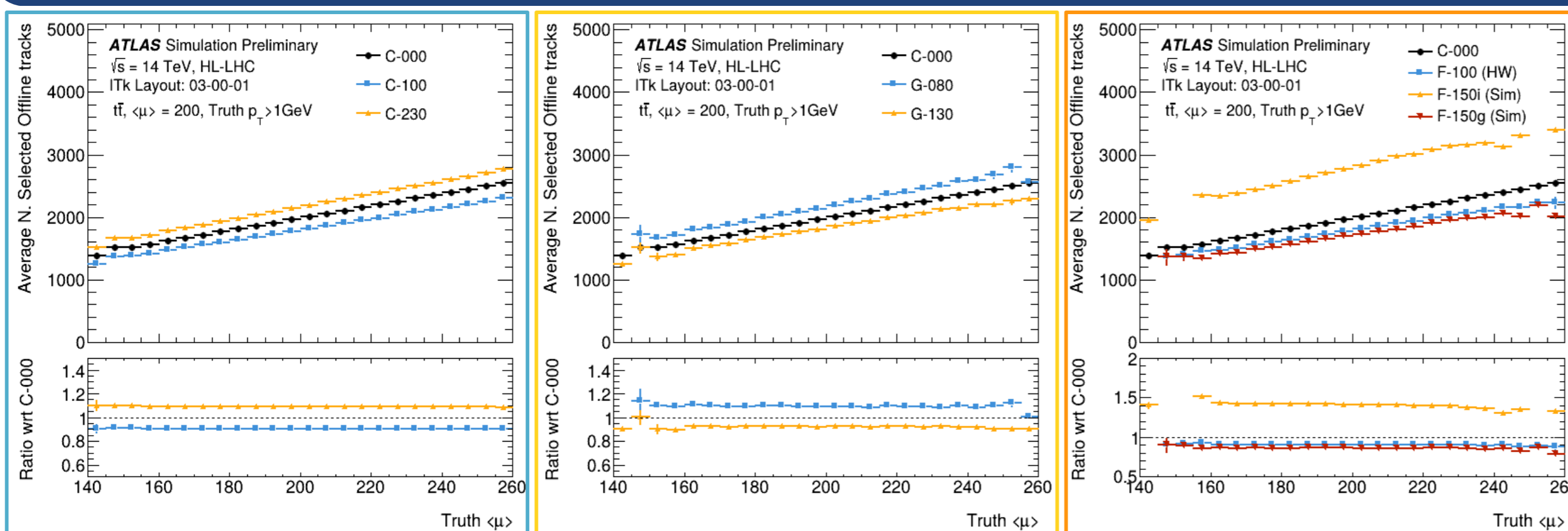
- Core requirement for evaluation of pipeline performance
- Transverse (d_0) **impact parameters resolution** particularly crucial for heavy hadron signatures
- Almost all pipelines have resolutions **within a factor of 2 to that of C-000**
- Resolutions also evaluated separately for different signatures and fixed p_T [2,3]
- Further pipeline optimisation is still in progress

- Heavy hadron signatures** → crucial role in ATLAS HL-LHC trigger
- d_0 **significance** = (signed) $d_0 / \sigma(d_0)$, for reconstructed tracks in jets originating from **Light Flavor (LF) and B-Hadrons**
- Asymmetric distribution for b-jets due to secondary vertex for d_0 in the direction along the b-jet axis
- Sufficient **separation between LF- and b-jet tracks** for positive values of the d_0 significance
- enough d_0 resolution to guarantee e.g. satisfactory performance of **b-tagging algorithms**



Comparison of the d_0 significance for tracks in jets from Light Flavor (LF) and b-hadrons for the various pipelines with respect to legacy tracking (C-000)

Robustness against increasing pile-up



Comparison of the of the average number of reconstructed tracks as a function of truth $\langle\mu\rangle$ for the various pipelines with respect to legacy tracking (C-000)

- Expected **linearity for track multiplicity vs pile-up**
- Non-linearity associated to the reconstruction of **fake or duplicated tracks**
- Deviation from C-000: different efficiency in reconstructing tracks from pile-up (non Hard Scattering) events
- Generally **linear dependency for all pipelines**
- Inclusive **fake and duplicate rates measured <1%**
- Extensive R&D** over the past years to design a heterogeneous EF Tracking farm
- Remarkable tracking performance** achieved across all proposed technologies