Fatras integration for ATLAS fast simulation at HL-LHC

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on behalf of the ATLAS Computing Activity

Fast ATLAS Track Simulation (FATRAS) utilizes simplified detector geometry and parameterized interactions for fast simulation of charged particle propagation

Physics modeling / CPU benchmarking

- Q3 — **Legacy FATRAS** Physics Validation
- Q4
- 2024 Q1
- Q2
- Q3 — **Legacy FATRAS** Ready for Run 3, **ActsFatras** Integrated
- Q4
- 2025 Q1 — **ActsFatras** Physics Validation
- Q2
- Q3
- Q4
- 2026 Q1
- Q2 — **ActsFatras** Ready for Run 4

Legacy FATRAS[1]

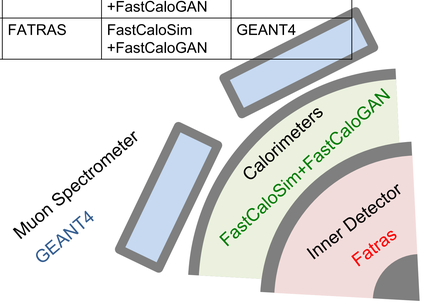
- Run 3, not MT-compatible
- Reproduce GEANT4 for key observables monitored in physics validation to within 10%
- Reduces the CPU time by ~ a factor of 10

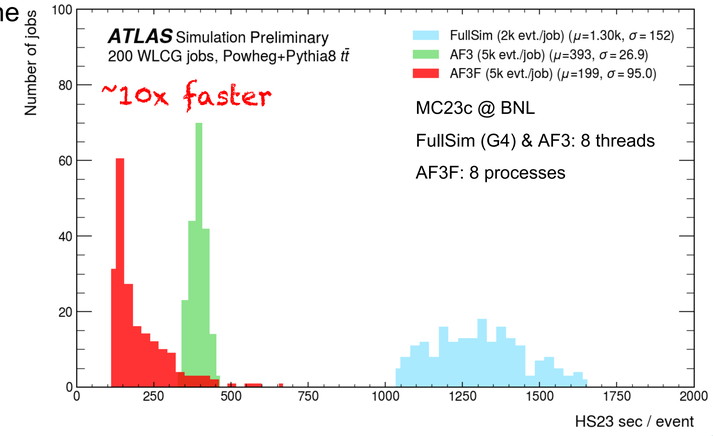
ActsFatras

- Run 4, MT safe
- ACTS[2] (A Common Tracking Software) based FATRAS
- Proof-of-principle running of all key simulation processes

Integrated into ATLAS fast simulation pipeline

	ID	Calorimeters	Muon
FullSim	GEANT4	GEANT4	GEANT4
AF3	GEANT4	FastCaloSim +FastCaloGAN	GEANT4
AF3F	FATRAS	FastCaloSim +FastCaloGAN	GEANT4





FATRAS reproduces GEANT4 with ~10% accuracy

Ongoing work to improve the physics modeling performance of FATRAS to be within ~1% of the GEANT4 for ATLAS physics analyses uses

EM physics

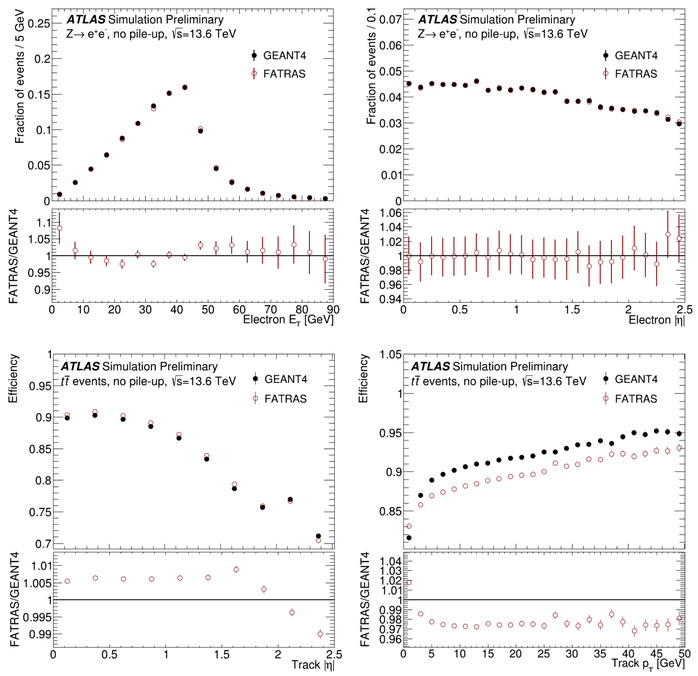
- Keep working on the improvement
- In particular, the photon conversion model, which known to be problematic

Transverse impact parameter (d_0) resolution

- ~10% larger than GEANT4 at large η
- The mis-modeling is due to **FATRAS's inability to simulate rare hadronic interactions**, which yield tracks with large impact parameters.

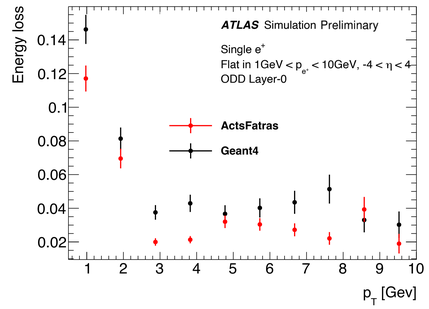
Track reconstruction efficiency

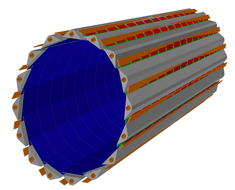
- Within 3% vs p_T
  too high @ low p_T
  too low @ p_T > 2GeV
- Within 1% vs η



Fast algorithms to parameterize material effects

- Ionization: Bethe-Bloch
- Radiation loss: Bethe-Heitler
- Multiple Coulomb scattering: Gaussian mixture model
- Hadronic interactions: parameterized from data simulated with GEANT4 ➪ use GEANT4 simulation directly





Innermost layer (Layer-0) of the ODD pixel system at a radius of 36 mm

ActsFatras physics modeling performance study

- Using standalone ACTS
- The Open Data Detector[3] (ODD)
- In Layer-0, ActsFatras E_{loss} is lower by 20%
- Under investigation

1. The fast ATLAS track simulation (FATRAS), ATL-SOFT-PUB-2008-001, ATL-COM-SOFT-2008-002, 3, 2008
2. Gumpert, C & Salzburger, A & Kiehn, M & Hrdinka, J & Calace, N. (2017). ACTS: from ATLAS software towards a common track reconstruction software. Journal of Physics: Conference Series. 898. 042011. 10.1088/1742-6596/898/4/042011.
3. The Open Data Detector Tracking System, Paul Gessinger-Befurt *et al* 2023 *J. Phys.: Conf. Ser.* **2438** 012110