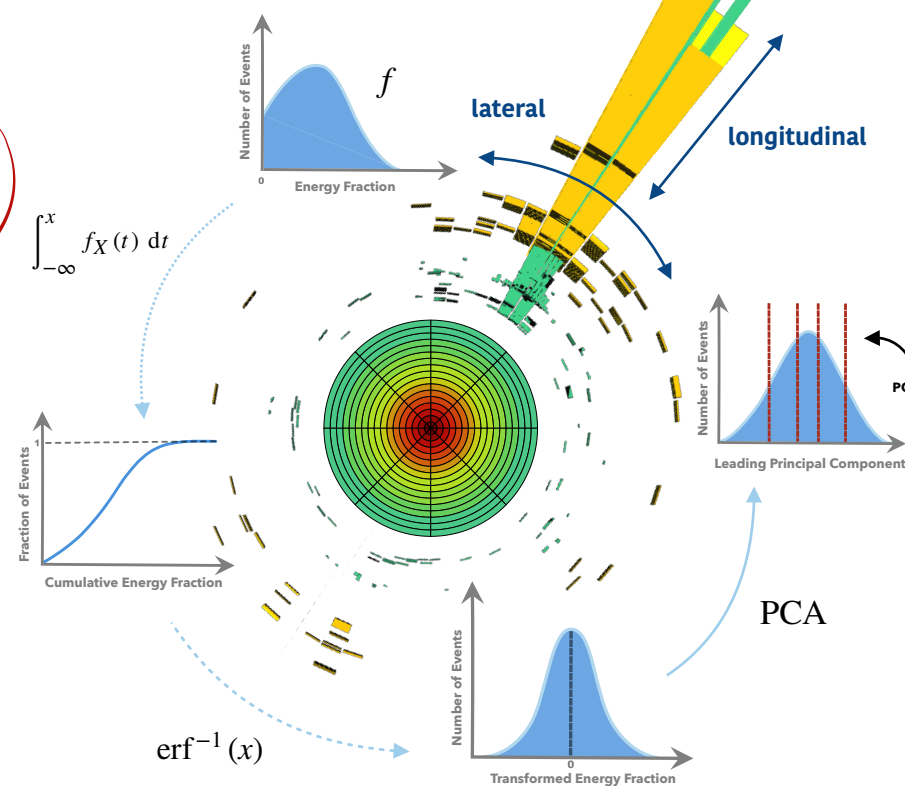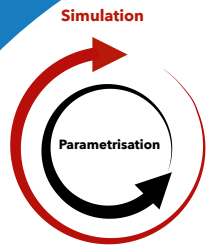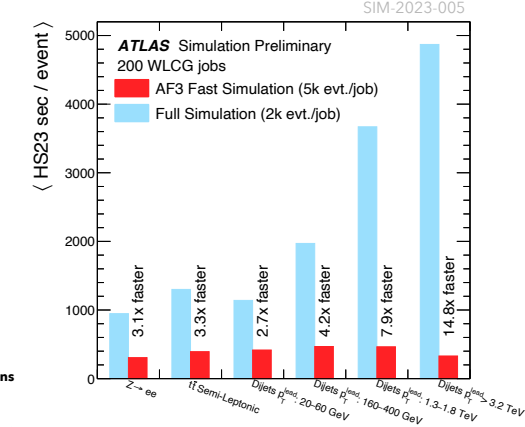# AtlFast3: Fast Simulation in ATLAS for LHC Run 3 and beyond

ACAT 2024, Stony Brook University, 11th-15th March 2024

Motivation

Significant R&D required to keep up with rising CPU needs for Run 3 and beyond

Most CPU consumption spent on MC detector simulation with **80-90% used for simulation of the calorimeter**

Strategy

Two distinct approaches of shower generation:

FastCaloSimV2

- Parametrised modelling using Geant4 single photon, electron and pion samples
- Parametrisation in 17 logarithmically spaced energy bins from 64 MeV to 4 TeV and 100 linearly spaced bins in $|\eta|$ from 0 to 5
- Separate parametrisation of **longitudinal** and **lateral** shower development
- Decorrelate energy in layers using **Principal Component Analysis (PCA)**
- Average lateral energy distribution parametrised as 2D probability functions

FastCaloGAN

- Wasserstein **Generative Adversarial Networks** (GANs) trained on each of the 100 bins in $|\eta|$ and conditioned on truth momentum
- Trained to reproduce voxels and energies in layers as well as total energy in single step
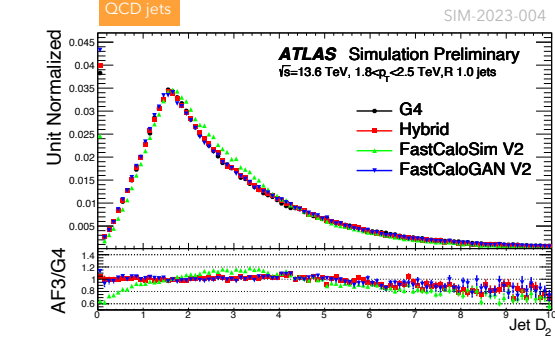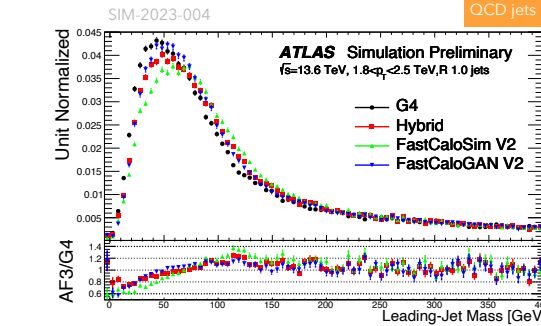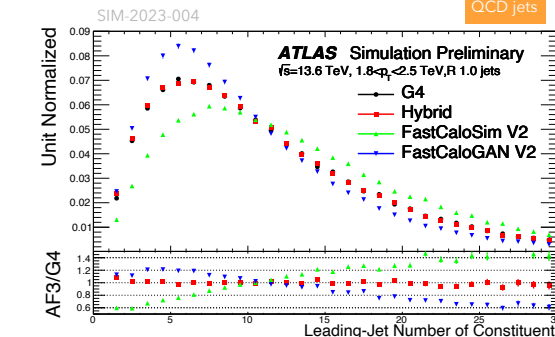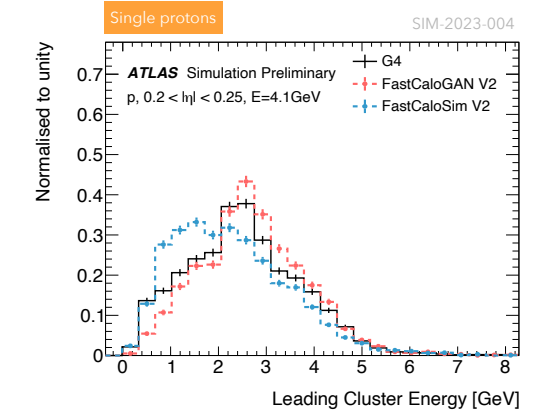- Total of 300 GANs to cover full detector region

CPU Performance

3 - 15x speed-up in simulation time with respect to Geant4, depending on the physics process

Physics Performance

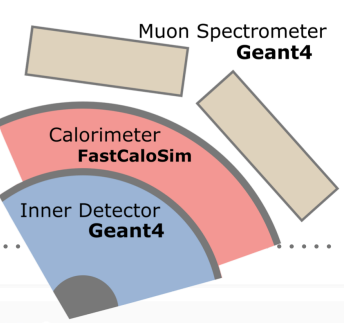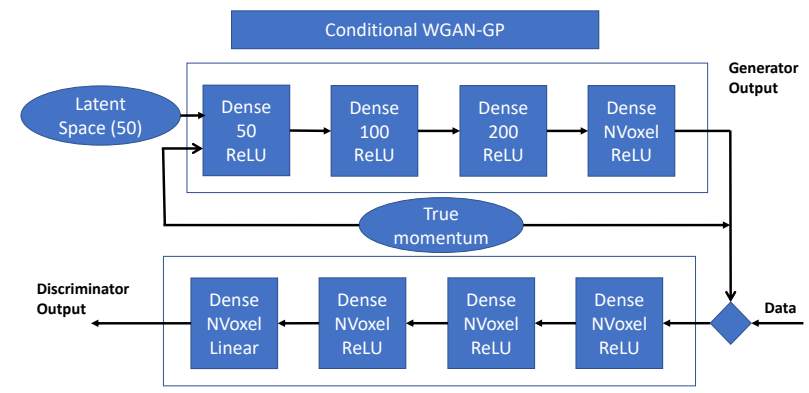Hybrid approach offers excellent physics performance!

Conclusion

- AtlFast3 is the **state-of-the-art fast simulation in ATLAS** and able to simulate broad range of physics processes with high precision
- AtlFast3 provides **significant improvements in physics performance** compared to predecessor
- Simulation time in AtlFast3 completely dominated by full simulation of the Inner Detector

Joshua Falco Beirer (CERN), on behalf of the ATLAS collaboration