**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

Previous fast simulation tool AFII limited in physics performance

**Strategy**

AtIFast3 consists of two distinct approaches of shower generation:

- **FastCaloSimV2**
  - Parametrised modelling using Geant4 single photon, electron and pion samples
  - Parametrization in logarithmically spaced energy bins from 64 MeV to 4 TeV and linearly spaced bins in |η| from 0 to 5
  - Separate parametrisation of longitudinal and lateral shower development
  - Energy deposits highly correlated between layers
  - Decorrelate 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 |η| 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
  - Used for hadrons in the intermediate energy range

**Results**

- **Leading jet mass in Z → ll decays**
  - Reconstructed Z mass from Z → ll decays
  - Associated muon segments in Z → ll decays

- **Leading jet $p_T$**
  - Leading jet number of constituents

**Conclusions**

- AtIFast3 is the state-of-the-art fast simulation in ATLAS and able to simulate broad range of physics processes with high precision
- AtIFast3 provides significant improvements in physics performance compared to AF2
- AtIFast3 requires 80% less CPU time compared to Geant4
- Simulation time in AtIFast3 completely dominated by full simulation of the inner detector