Deep Generative Models for Fast Shower Simulation with the ATLAS Experiment

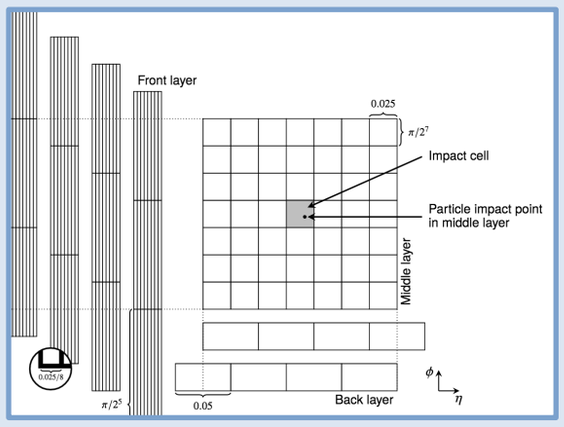
ATL-SOFT-PUB-2018-001

Full simulation of the ATLAS Calorimeter is CPU intensive
Current fast simulation methods trade accuracy for speed
Replace expensive simulation with fast deep generative models
Can train a single network conditioned on particle energy and trajectory
GANs and VAEs are studied to reproduce the simulation of photons in Geant4

ATLAS Calorimeter

- Complex geometry
- Comprises layers of cells
- Energy deposits per cell

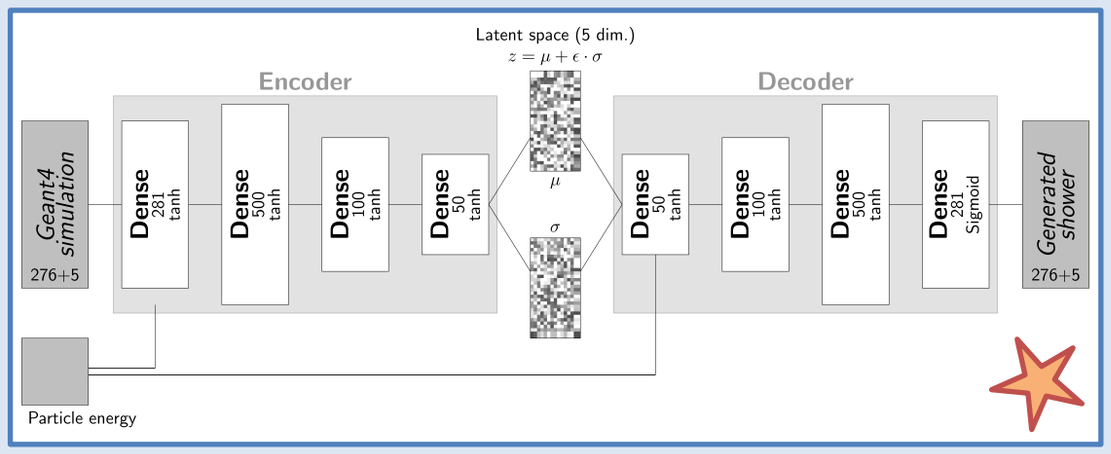
- Focus on single photons
- Only in range
  $0.2 < |\eta| < 0.25$



Methodology

Single photon G4 events $E_\gamma \in \{2..262\}$ GeV → **Learn Shower Simulation VAE or WGAN** → **Fast Shower Generation**

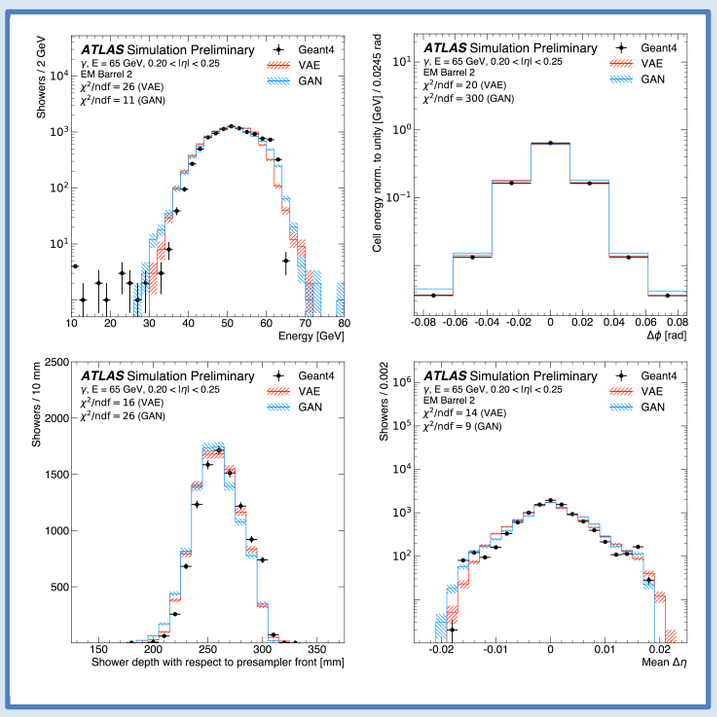
Variational Auto-Encoders



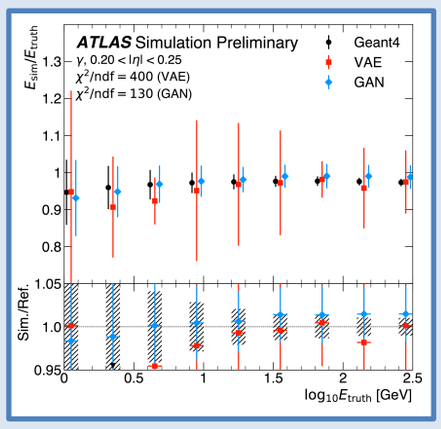
- Encode showers into reduced dimension Latent Space
- Decoder converts back to full dimension of shower
- Train the best representation of all showers in LS
- Use random sampling in LS to generate new showers

Results from 2018

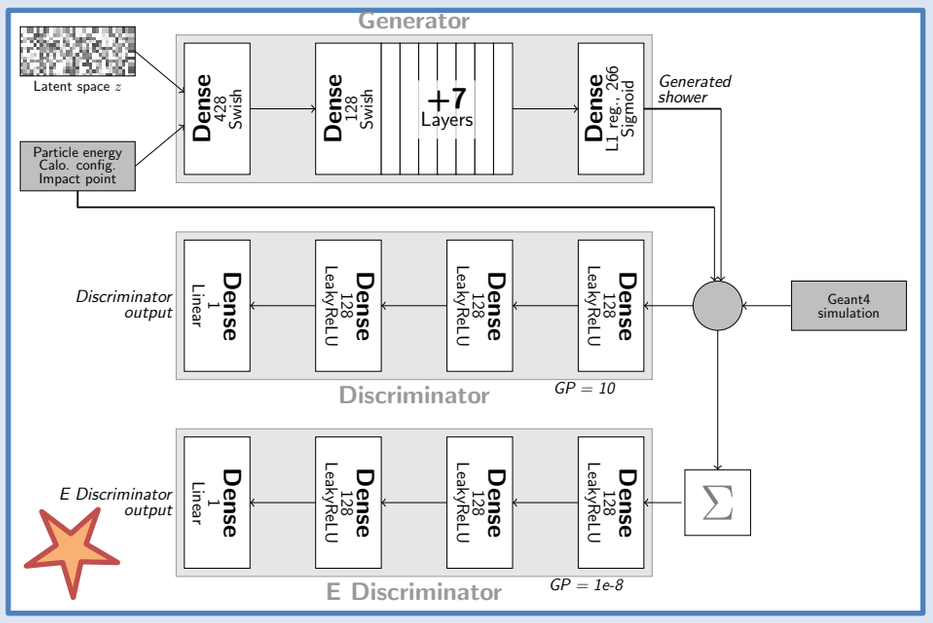
[1]



- Compare **WGAN** and **VAE** to Geant4
- Performance is generally good
- Total Energy of shower not great

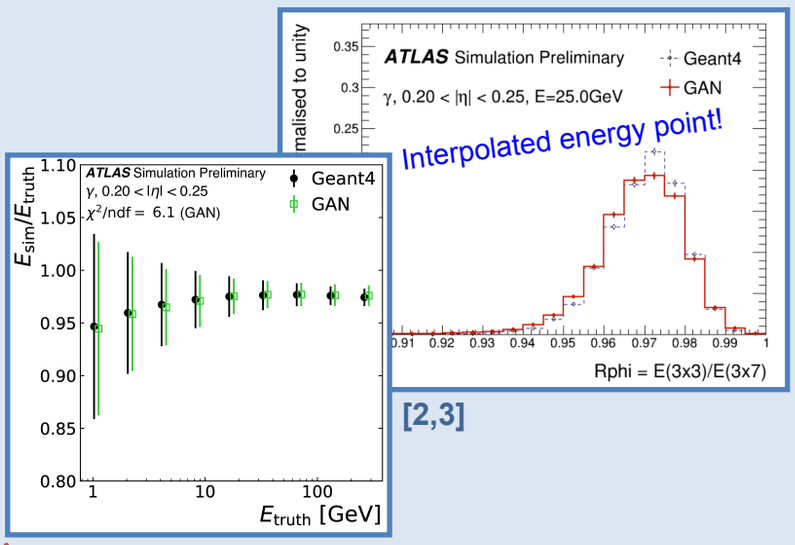


Generative Adversarial Networks



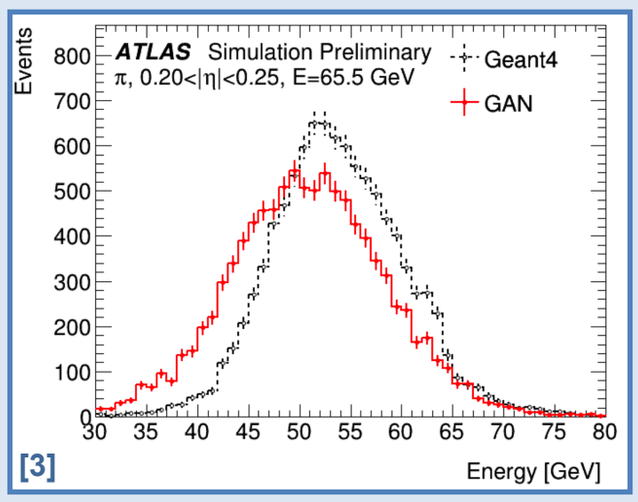
- Train generator and a critic
- Generator produces new showers from noise as input
- Critic identifies showers from Geant4 or generator
- Back and forth game, AI supervising AI

New and Improved!



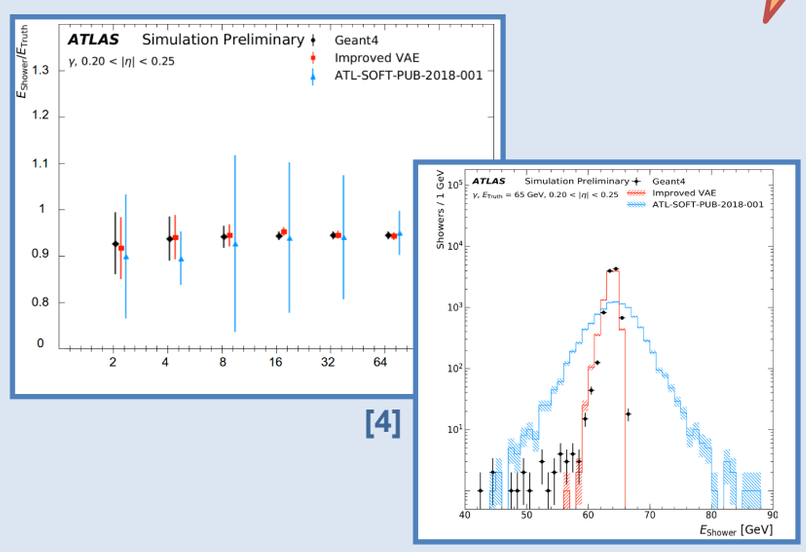
[2,3]

Total Energy critic in optimised **WGAN**
Condition on particle position



[3]

First look at **Pions** using a WGAN
Trained on hits instead of cells



[4]

Optimised **VAE** trained on relative energies per cell and layer

[1] ATL-SOFT-PUB-2018-001 [2] ATL-PLOT-SIM-2019-004 [3] ATL-PLOT-SIM-2019-006 [4] ATL-PLOT-SIM-2019-007

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