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Reusability

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LPCC Fast Detector Simulation
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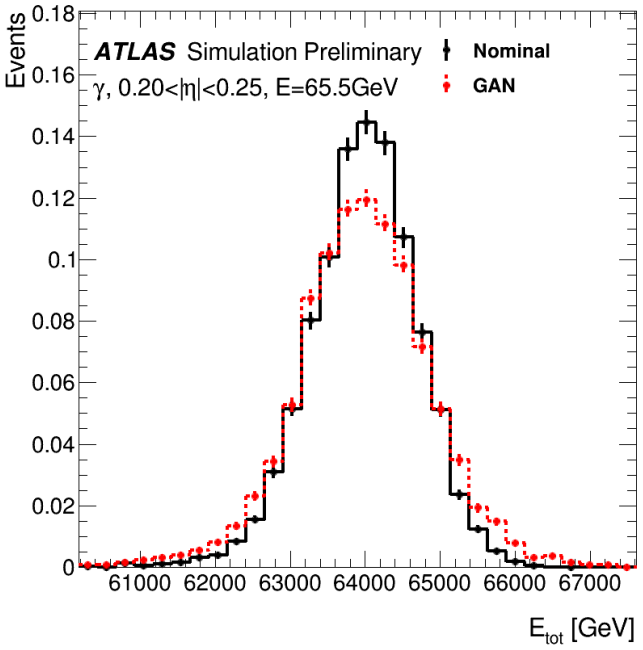
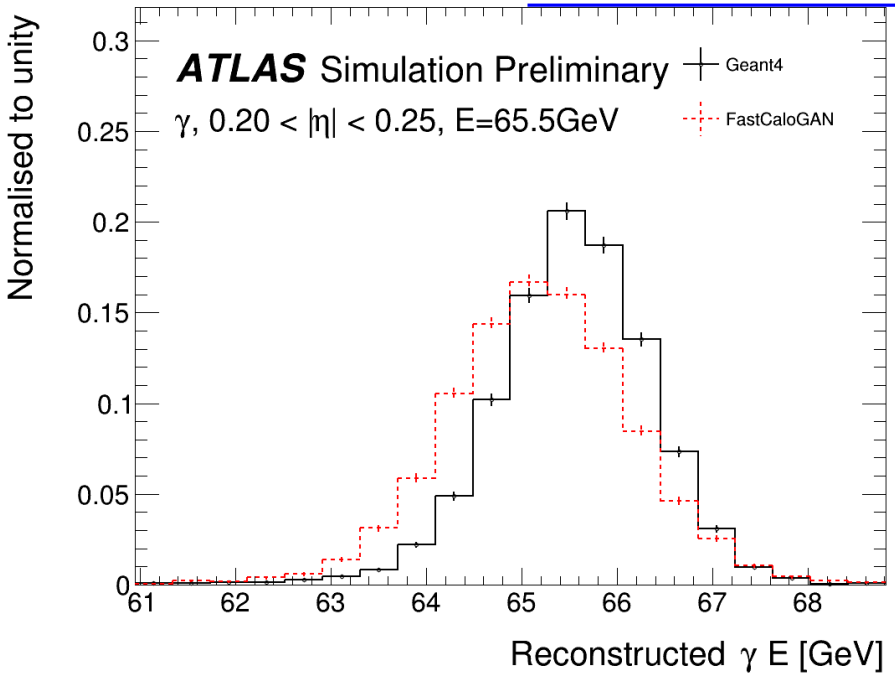
Lessons learned

- Are there any valuable lessons to be learnt by others?
  - Fast simulation is difficult, years are required to achieve high performance and many small effects, very experiment specific, must be considered
  - ML tools are now mature and can be considered as valid alternatives to classical methods
  - So far, ML tools were limited more by physics effects that required time to be understood than ML itself (models, HPO, pre-processing strategy).
  - More in general, validation can require a long time (ML training time << validation time)

Example of physics limitation

ATL-SOFT-PUB-2020-006

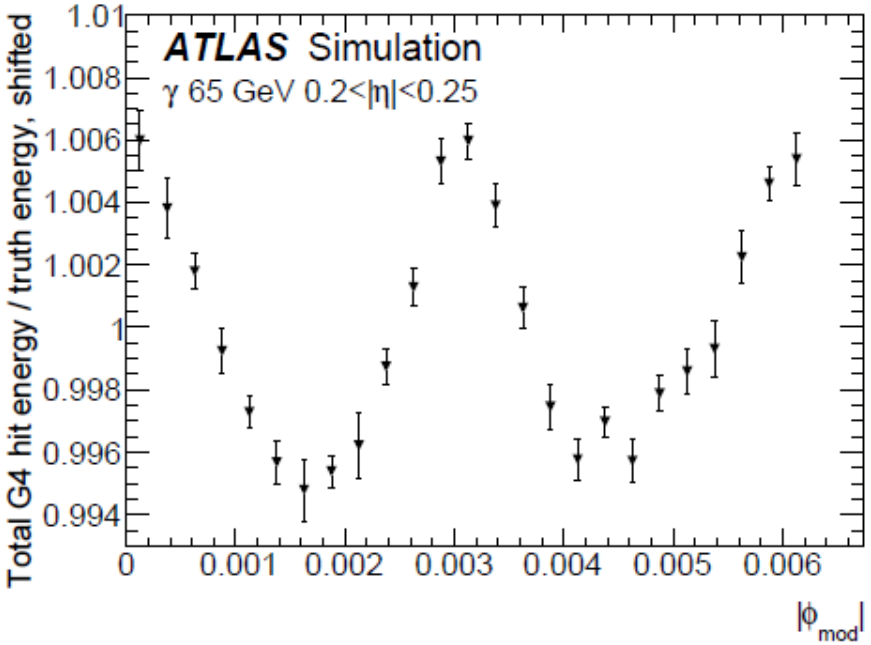


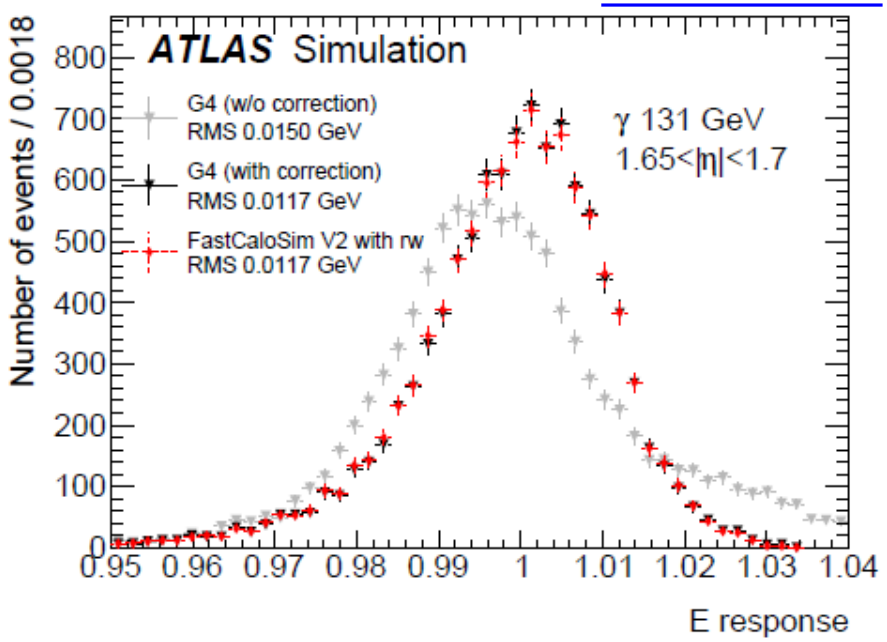


- GANs learn the input distribution correctly but after simulation and reconstruction a shift in energy was observed
- Problem identified in an missing energy correction that needs to be applied to the training sample

Accordion effect

SIMU-2018-04





- The accordion structure result in an energy response that depends on the phi position of the shower
- This result in a correction that must be applied to the training sample so that a model (FCSV2 or GAN) can produce the correct energy response

Re-use

- Tools which can be reused?
  - The use of voxelisation, which is detector dependent, makes both FCSV2 and ML tools rather independent on the detector so they could be re-used by other experiments
    - The voxelisation and the inference would need to be detector specific

Unsuccessful ideas

- Maybe some ideas have failed for your detectors (or parts of it) and it can be useful to others?
  - Training a model on the lateral shape distributions for each layer/pca instead of saving them as 2D histogram did not work
  - Voxels perform better than cells:
    - GAN at cell level did not perform as well as FastCaloGAN using voxels
    - VAE also saw a significant improvement going from cells to voxels
  - Normalisation is crucial, without a normalisation strategy no approach works (FCSV2, GAN or VAE)
  - Conditioning GANs on phiMod did not work, nor trying to have them predict the longitudinal position of the hits in a layer
    - Lesson: don’t make the model more complex than it should be and factorise different problems

Collaborations

- What are your plans, maybe there is room for collaboration?
  - We will keep developing classical and ML based fast calorimeter simulations
  - Classical tools and the approach developed for FCSV2 may be used by other experiment, especially those focussing on e/gammas
  - We are publishing the voxelised inputs files used to train the GANs used in AF3 on the CERN OpenData
  - The FastCaloGAN code is already available on zenodo, any contribution from the community is welcome
  - FCSV2 code is also in an open GitLab repository