Deep Generative models for calorimeter simulations

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CERN Openlab Summer Programme

16th of August 2018

Outline

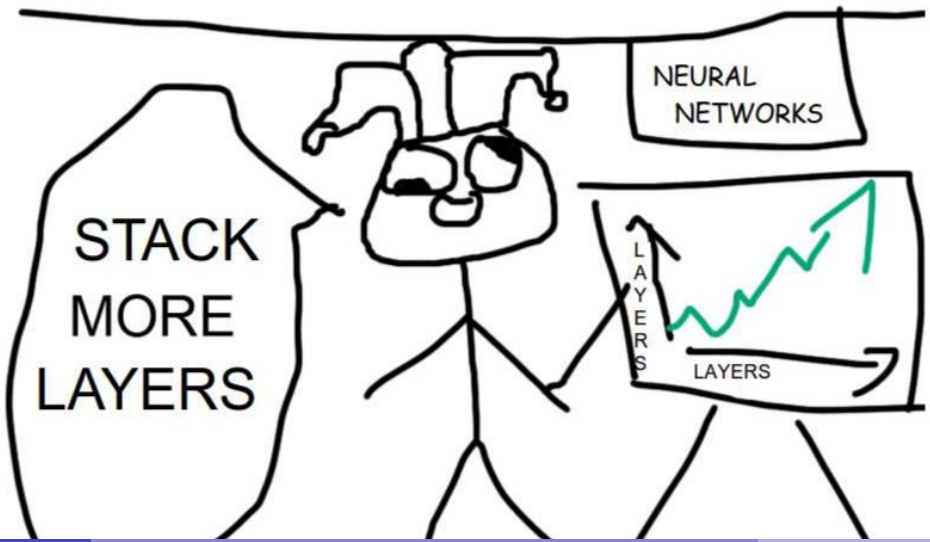
Why neural networks?

- Geant4: incredibly accurate simulator but can be slow;

- recently certain types of neural networks have been able to model and "simulate" data;
- Deep NNs show themselves as a very powerful and precise tool in many applications;

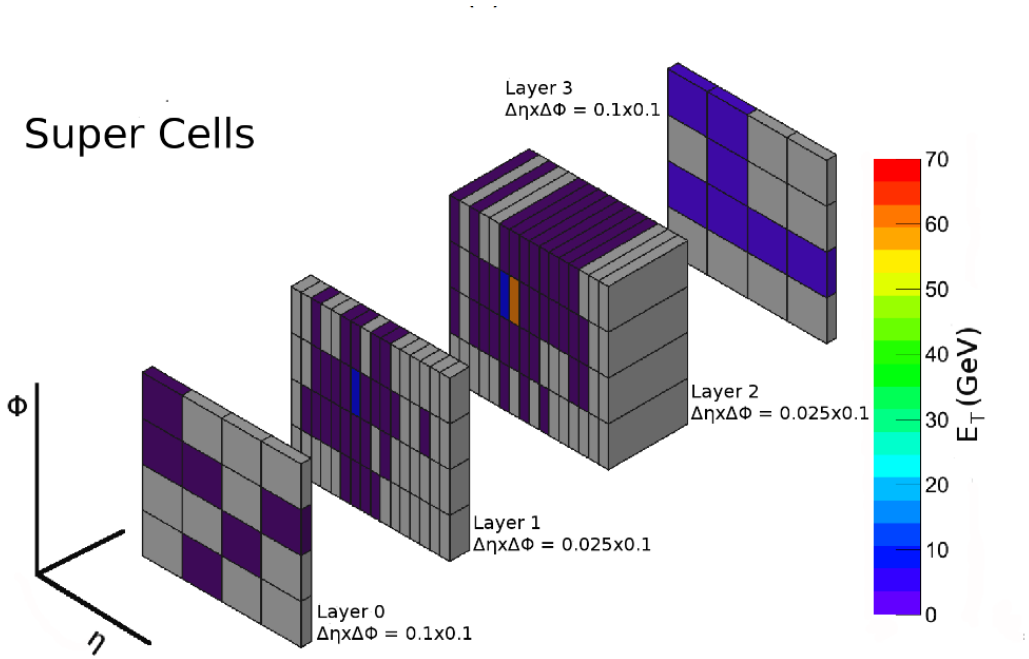
Why neural networks?

- Geant4: incredibly accurate simulator but can be slow; NNs are fast!
- recently certain types of neural networks have been able to model and "simulate" data;
- Deep NNs show themselves as a very powerful and precise tool in many applications; We can build on recent phenomenological work [1] and ATLAS work [2] but we want to develop this further!
- Deep learning is fun!

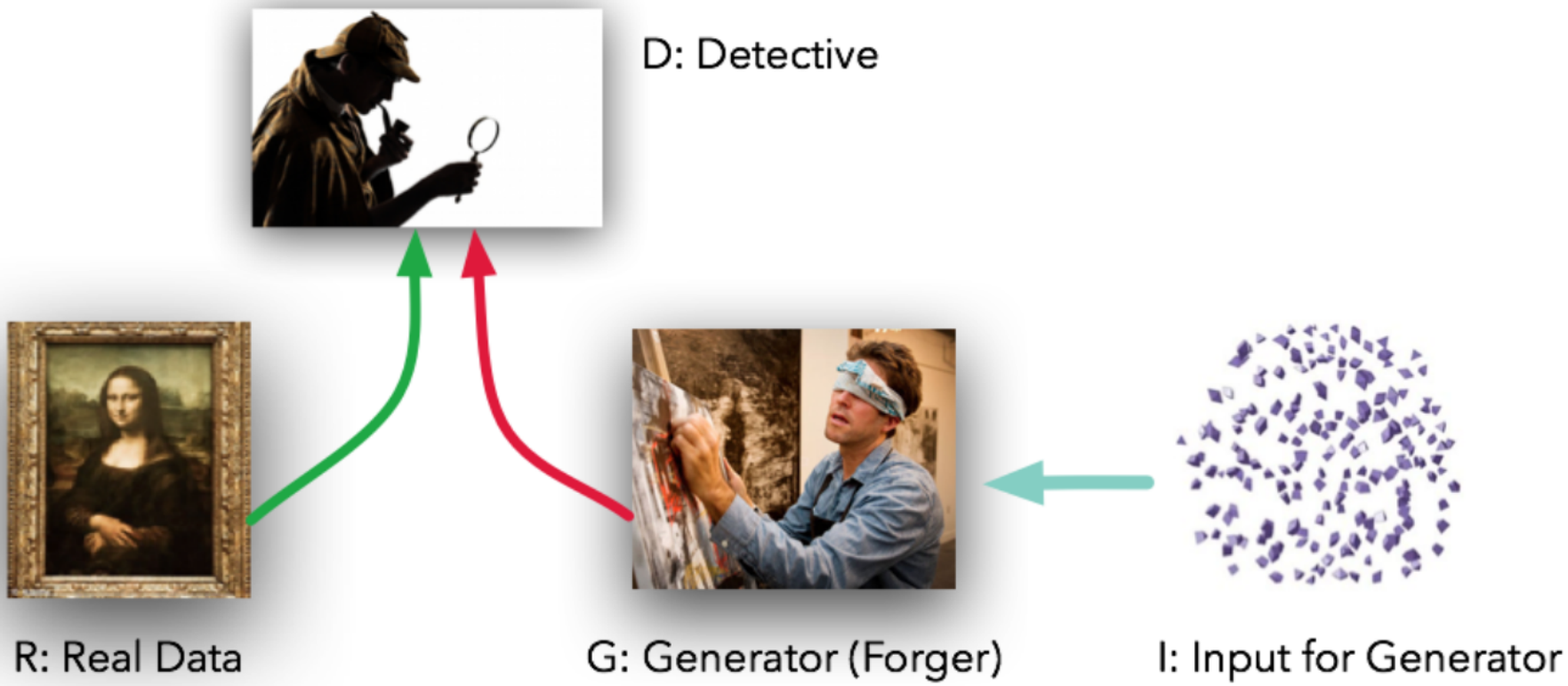


The task

- ATLAS Calorimeter is like a 3D image, composed of several layers of images. But each image has different pixel sizes;
- Particles incident on the calorimeter deposit energy in the cells (this is what Geant simulates);
- Considering these cells as image pixels we can try to generate them with a neural network.

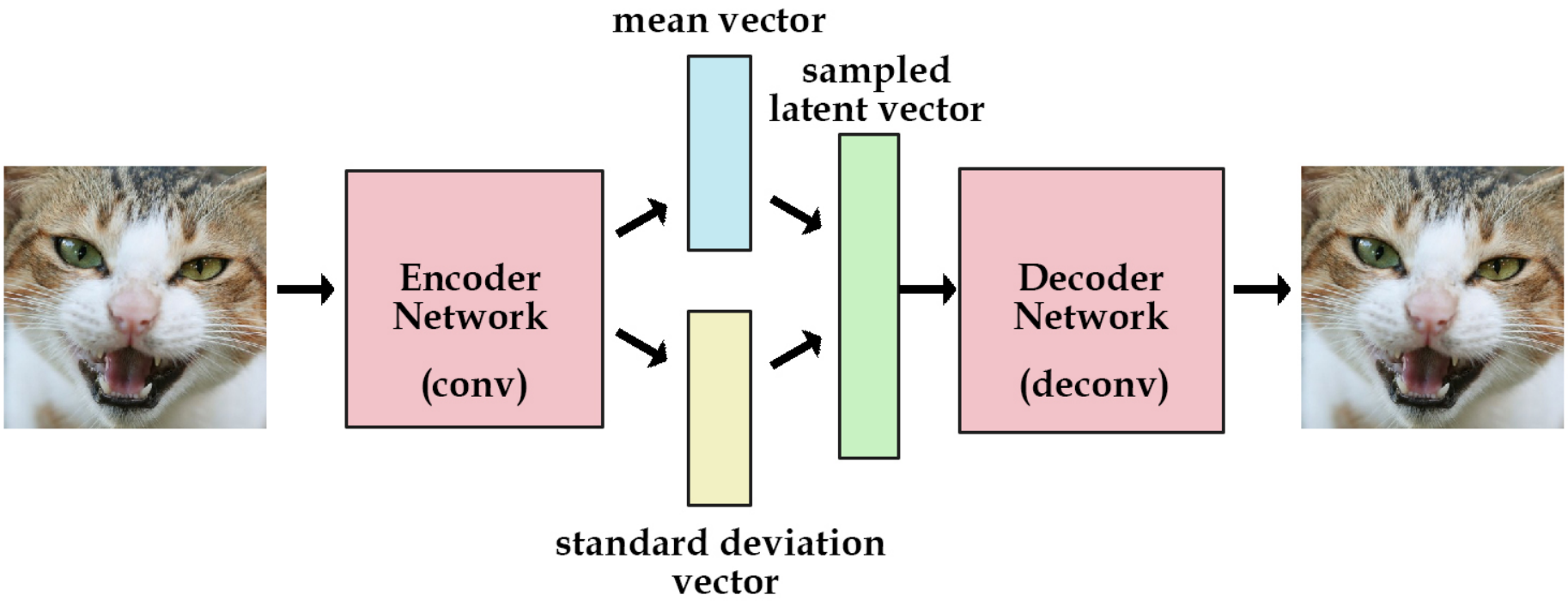


GANs

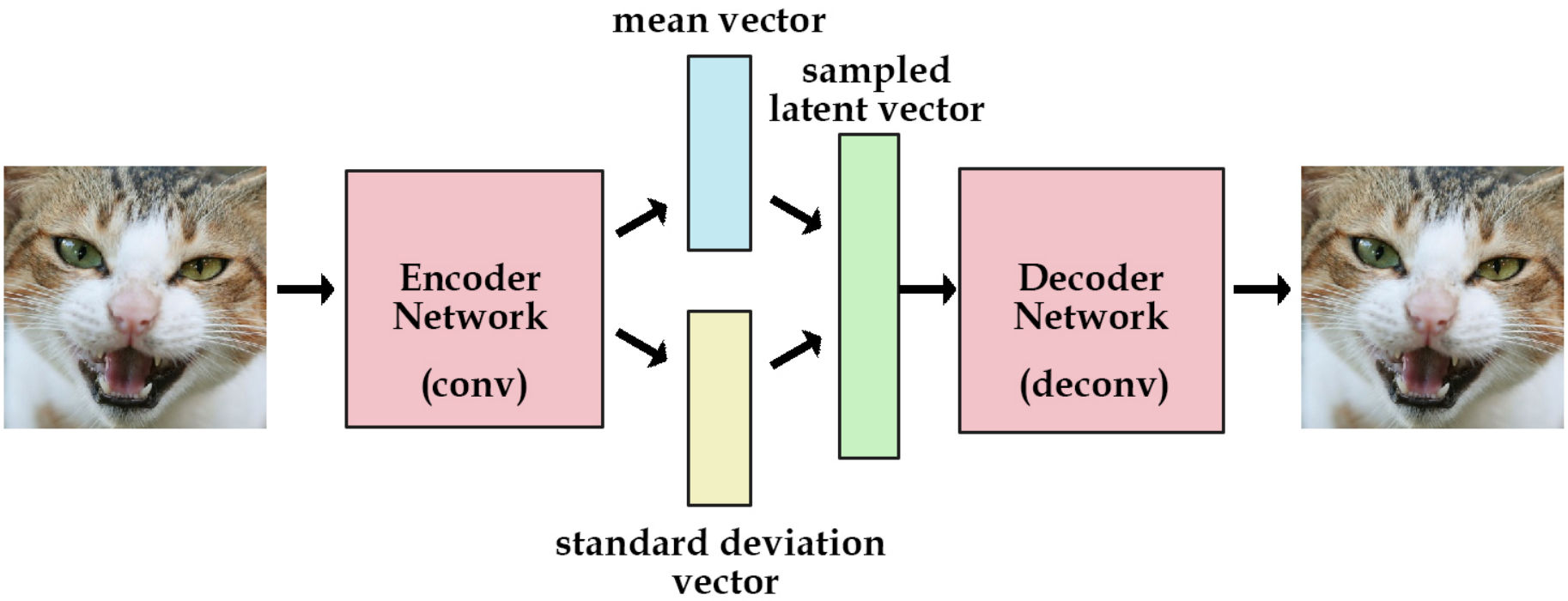


$$\min_G \max_D \mathbb{E} \log D(x) + \mathbb{E} \log(1 - D(G(z))$$

VAEs


mean vector
sampled
latent vector
Encoder
Network
(conv)
Decoder
Network
(deconv)
standard deviation
vector

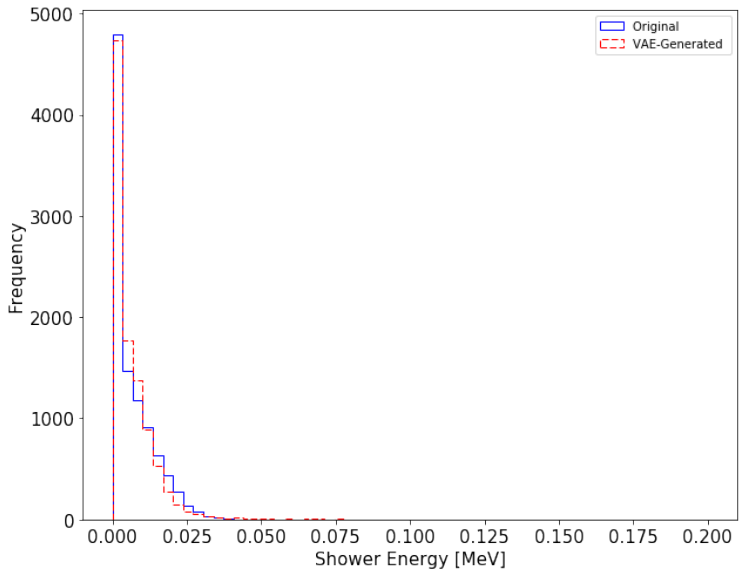
VAEs

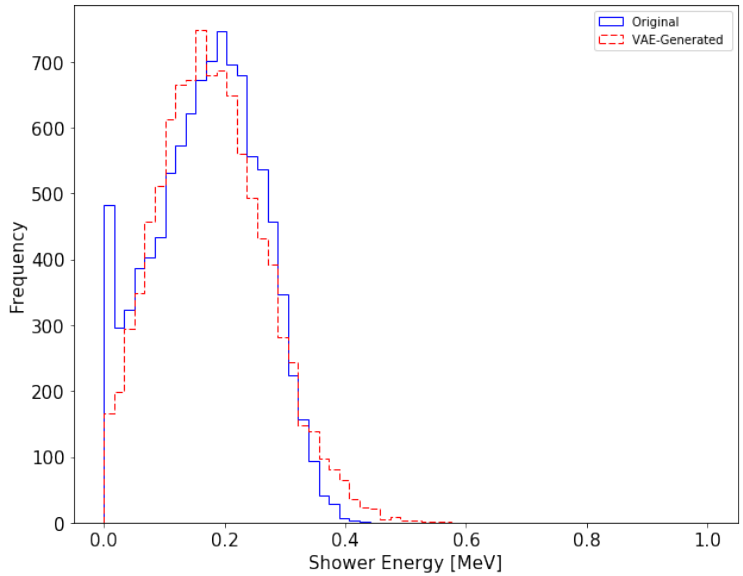


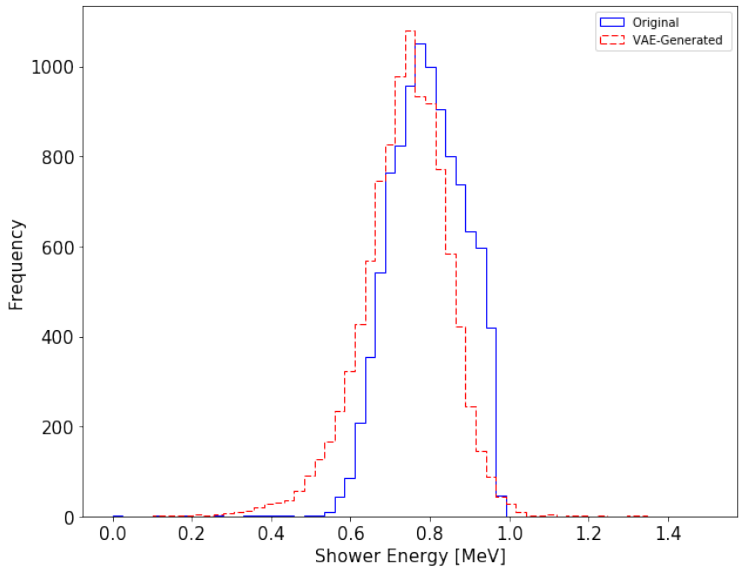
We're doing the same thing with flattened Calo images!

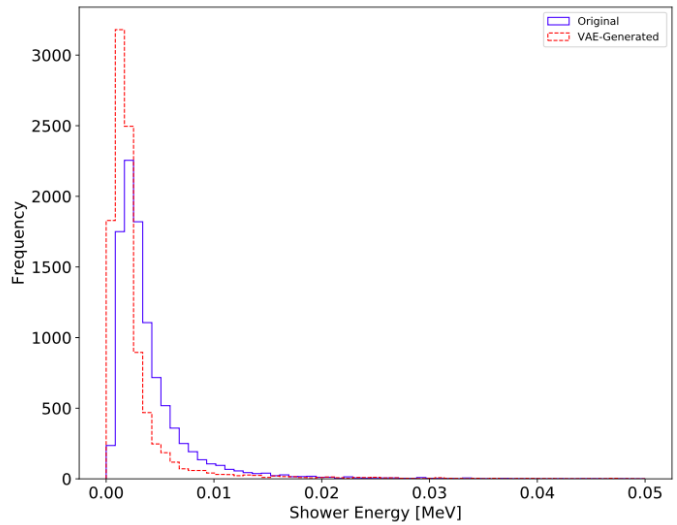
Results for VAE

Histograms of the total energy distributions for layers 1-4



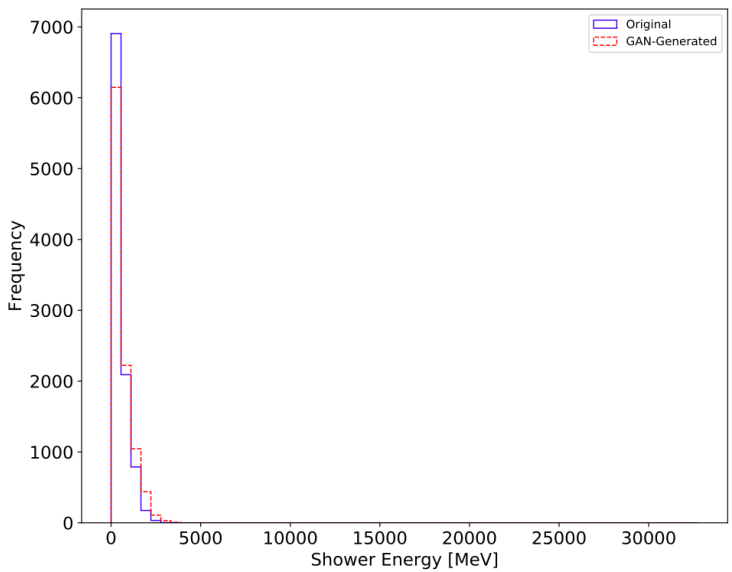


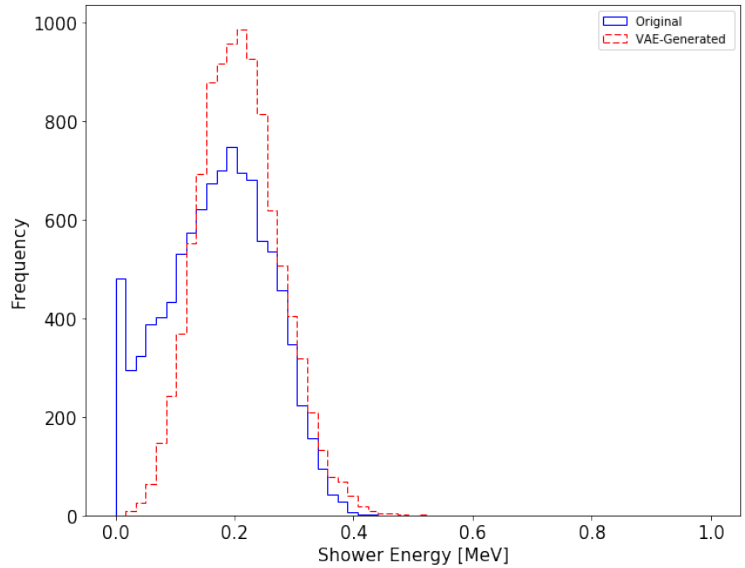


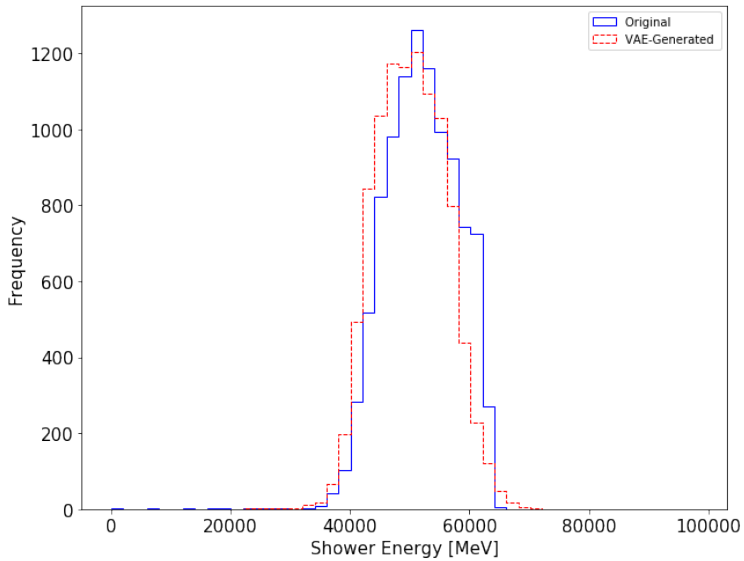


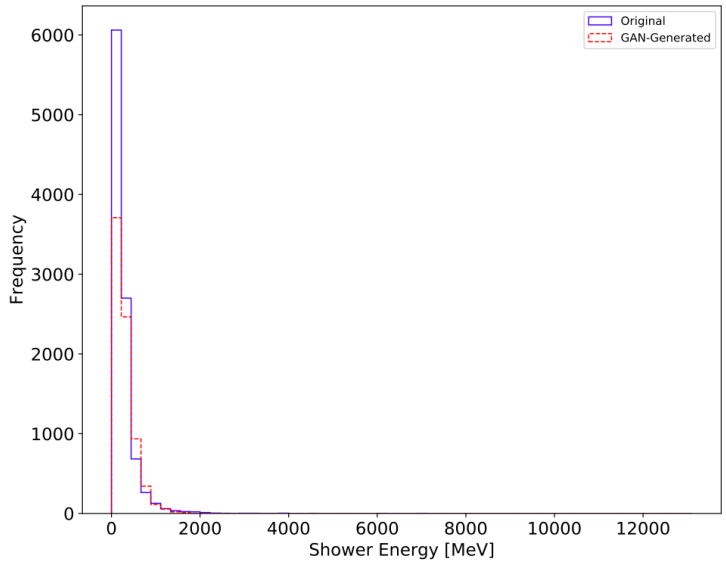
Results for GANs

Histograms of the total energy distributions for layers 1-4









Results and Future Work

The results we've got so far:

- GANs and VAEs show a strong potential as a tool for shower simulations;
- They may allow to speed up the simulation process significantly.

Future work will focus on:

- Considering the correlations between layers;
- Increasing precision of the model.

If you have any questions, you can contact me:

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- Over Telegram: @Saigetsu

Thanks for your attention!