



The ATLAS detector as a muon fixed-target experiment: using generative models to simulate muonic force carriers

CERN openlab summer student Lightning Talks

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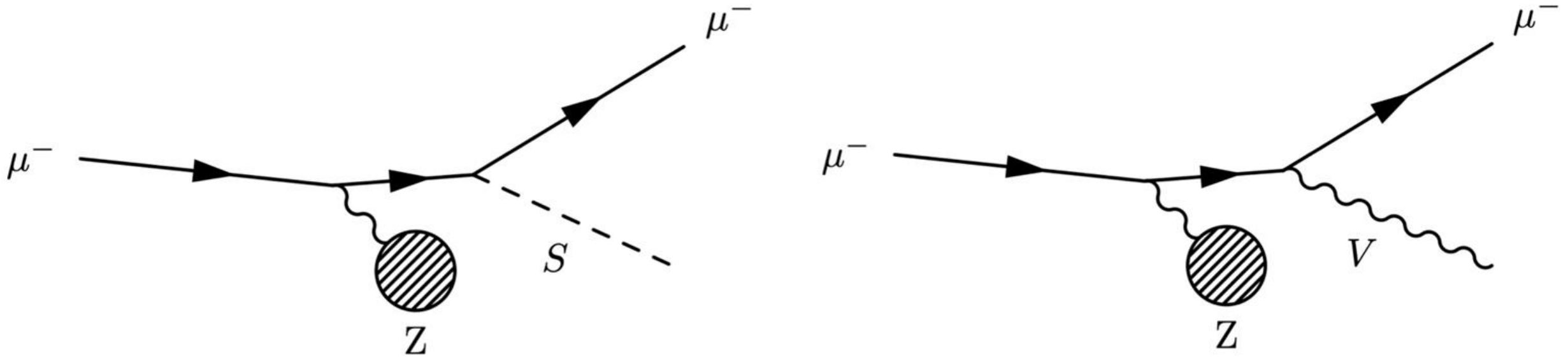
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Experiment Description



[1] Y. Kahn et al. M3: A New Muon Missing Momentum Experiment to Probe $(g - 2)\mu$ and Dark Matter at Fermilab, Journal of High Energy Physics 2018 (9)

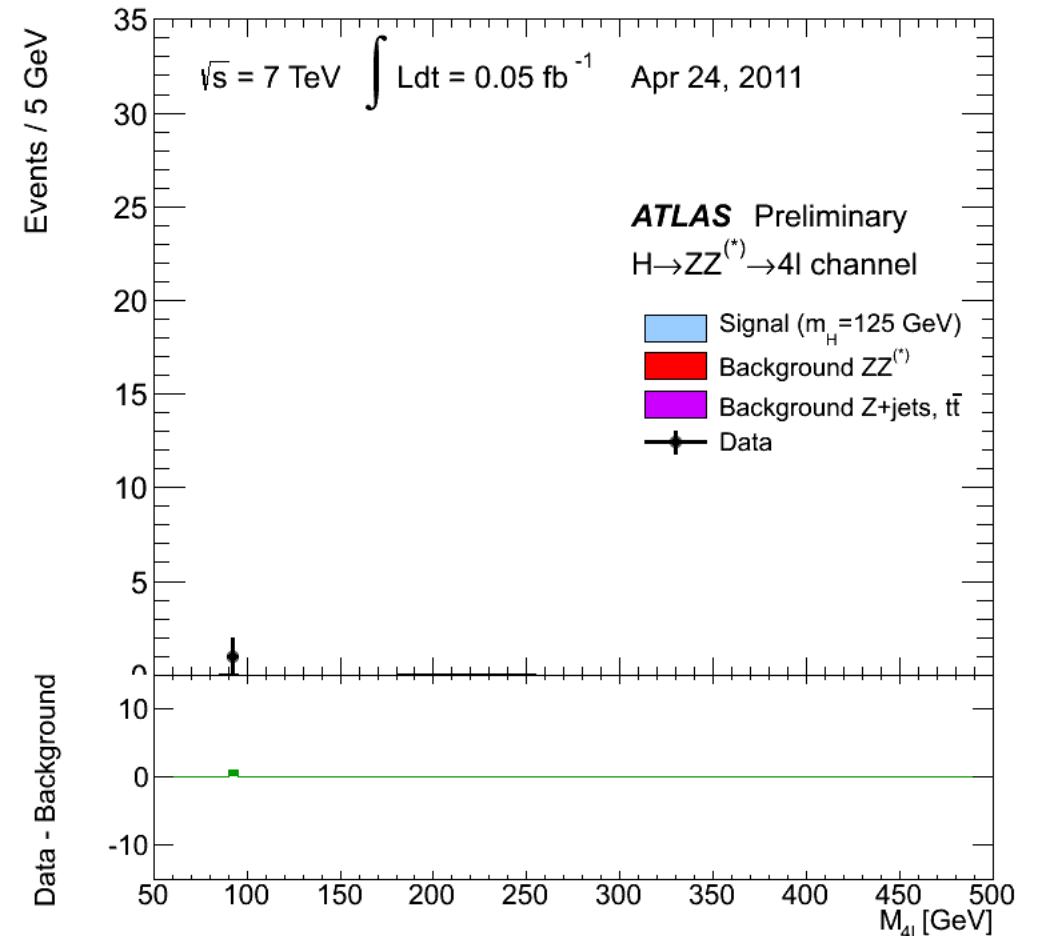
Analysis Process

Higgs Boson example

Most decisions in the LHC are based on a study of simulation. Since the concept of blind analysis in principle does not allow looking at the shape of the signal in the data until the end of the analysis.

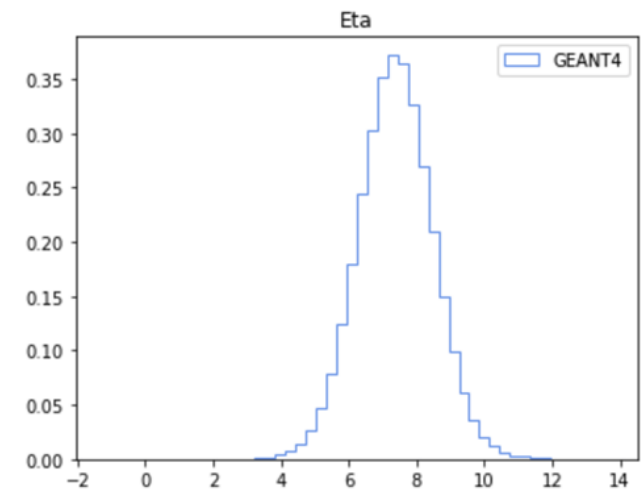
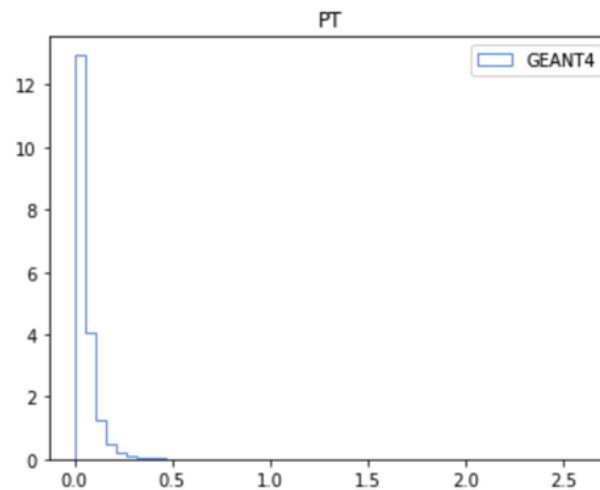
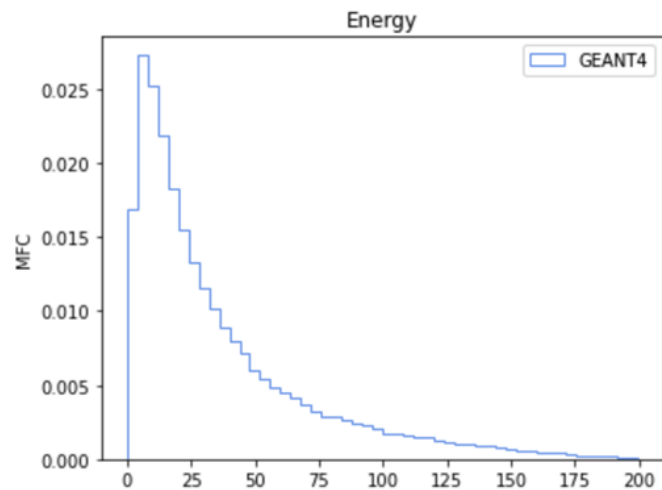
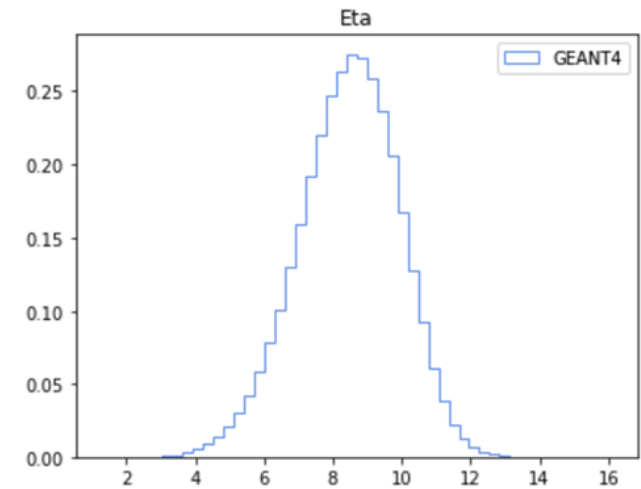
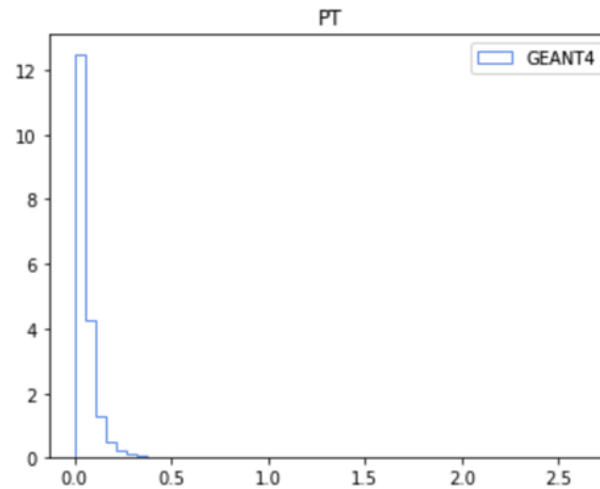
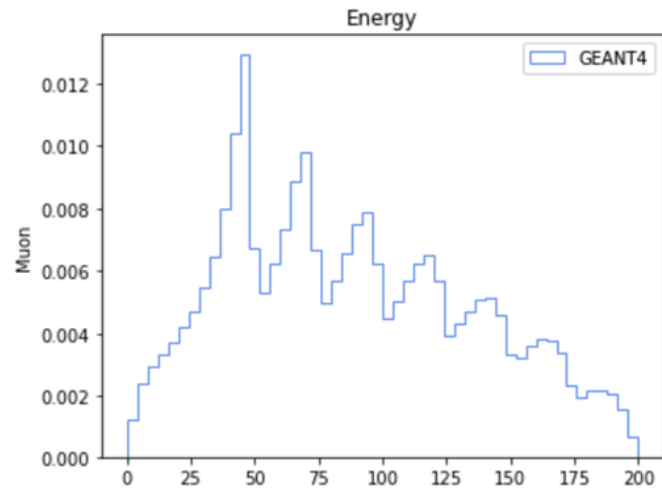
In particular, the simulation was needed to consider the noise at the discovery of the Higgs boson.

Basically, we subtract everything that we know and check the results.

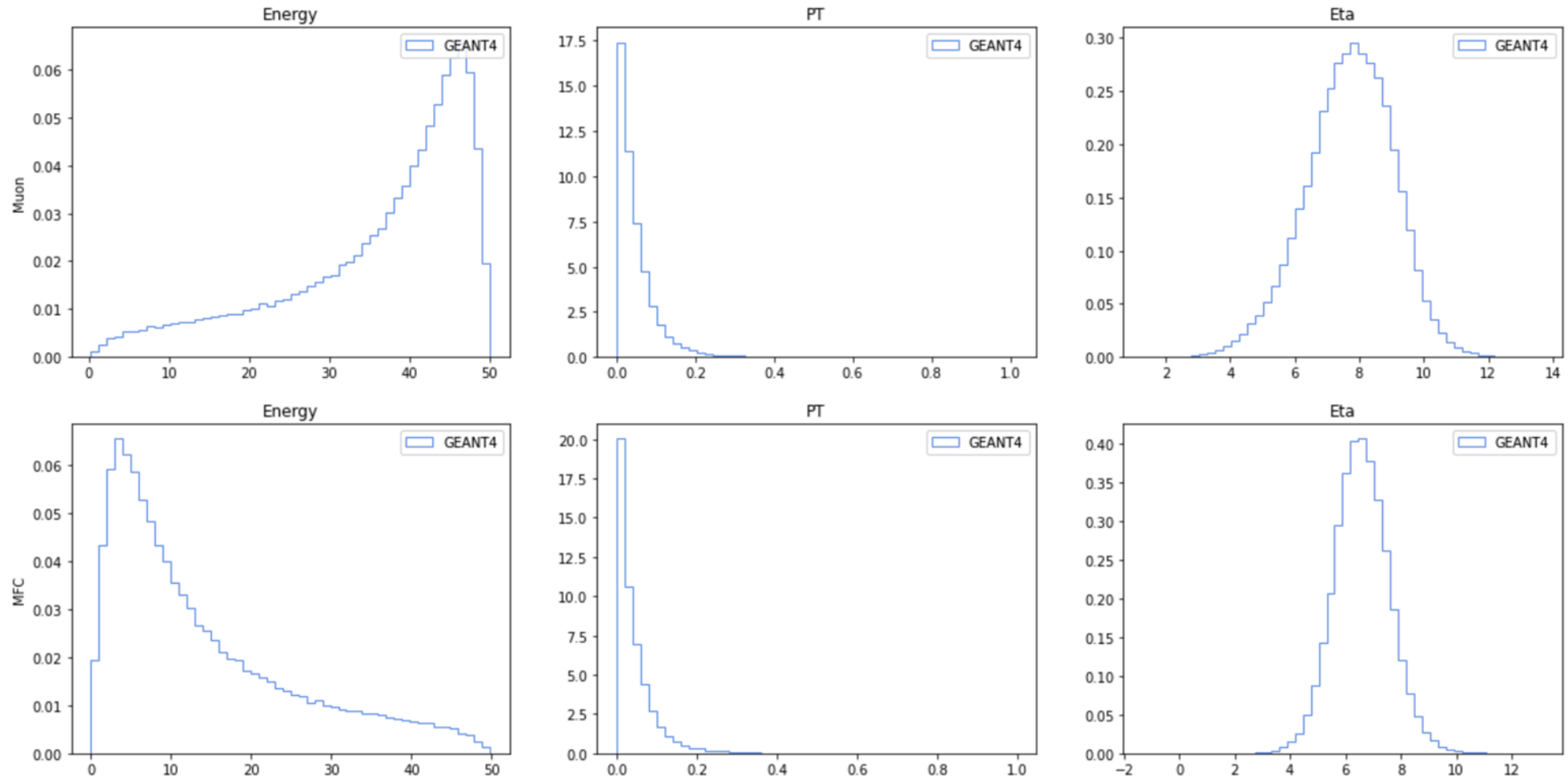


Data

7 datasets from 50 GeV to 200 GeV



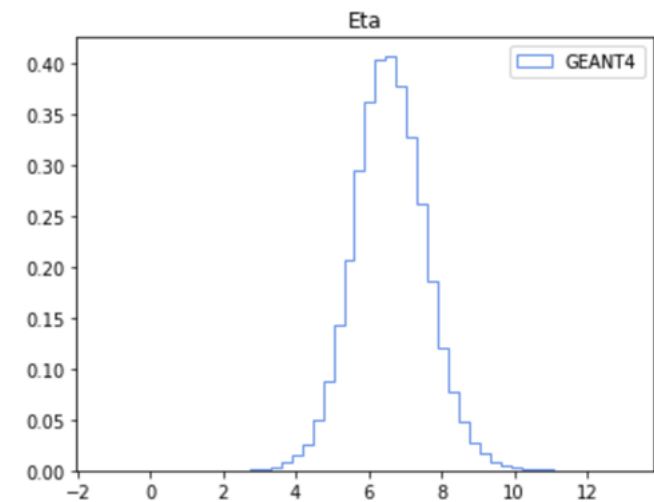
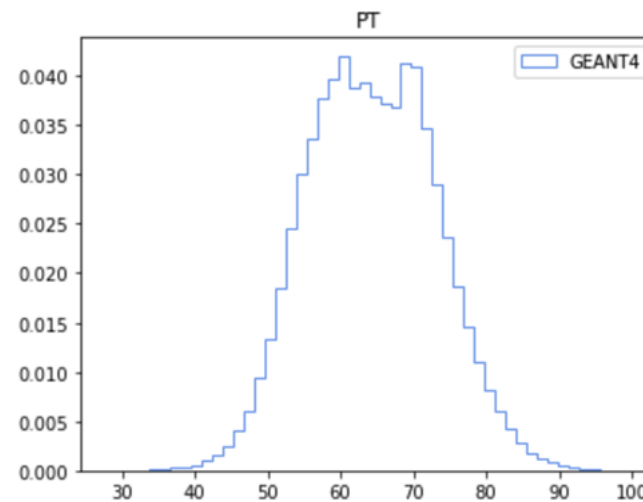
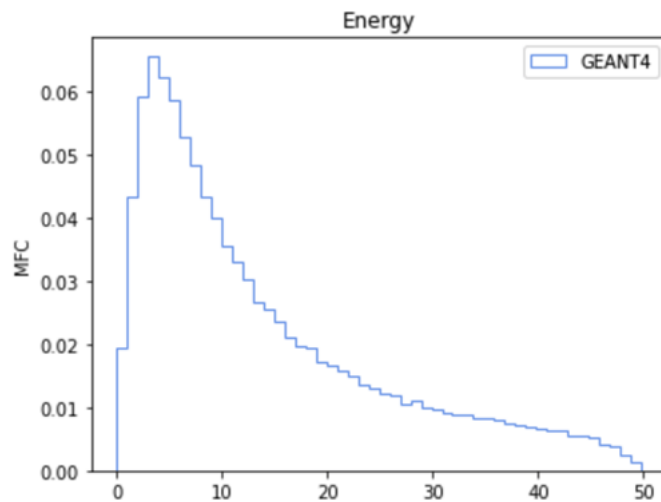
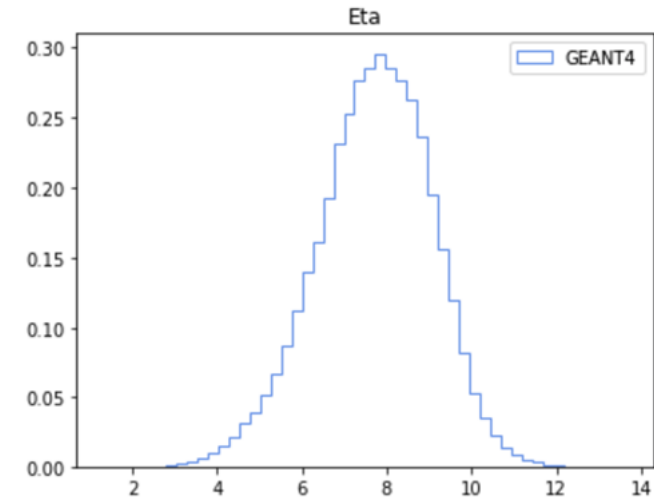
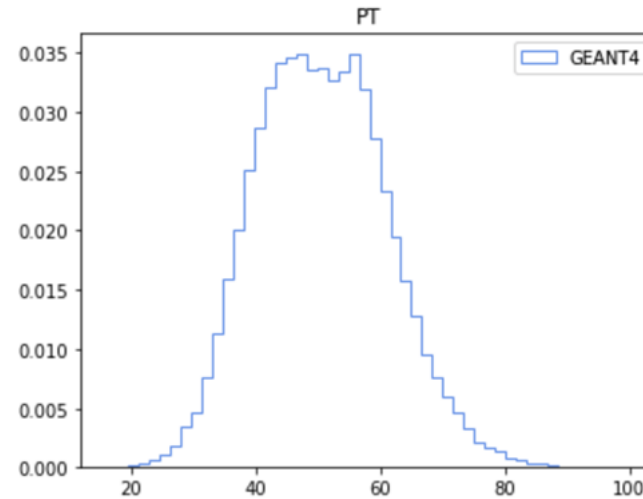
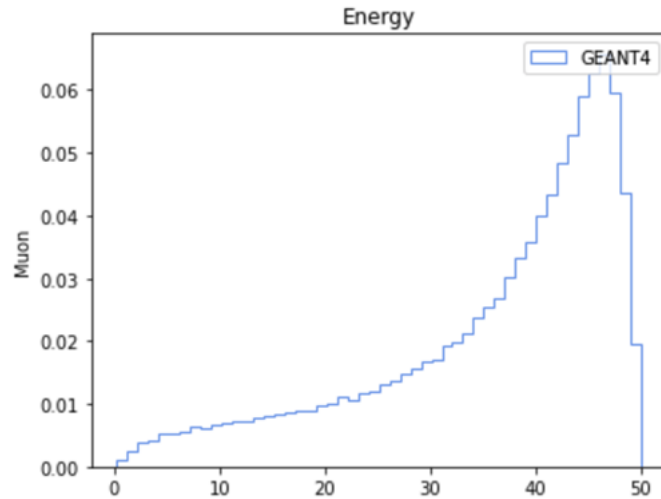
Data: 50 GeV dataset



Transformed Data

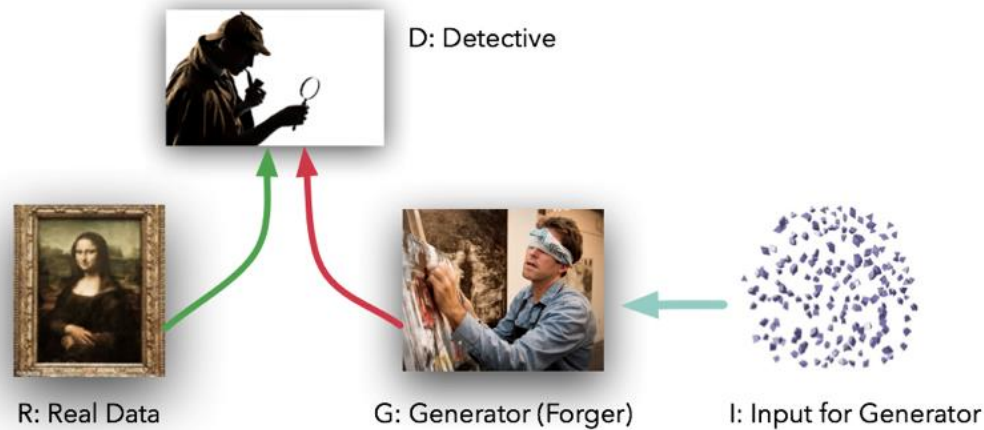
$$\mu : P_T^{scaled} = 100 \cdot P_T^{0.2}$$

$$\text{MFC} : P_T^{scaled} = 100 \cdot P_T^{0.124}$$



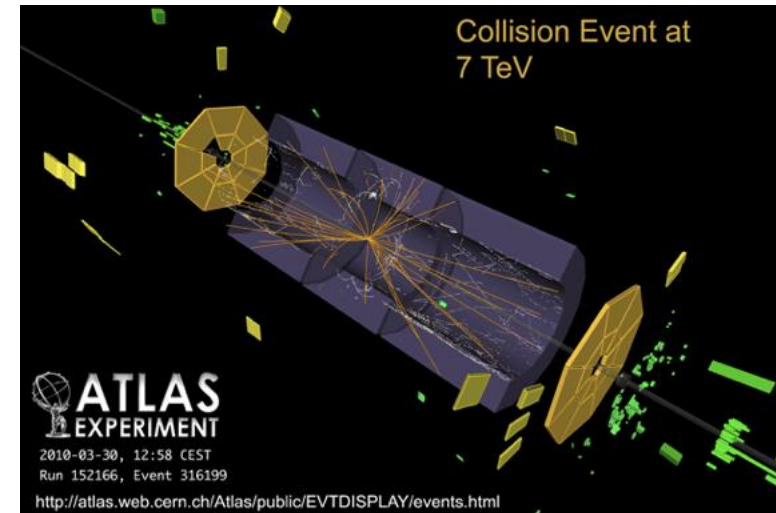
Generative Models

Generative Adversarial Networks (GANs)



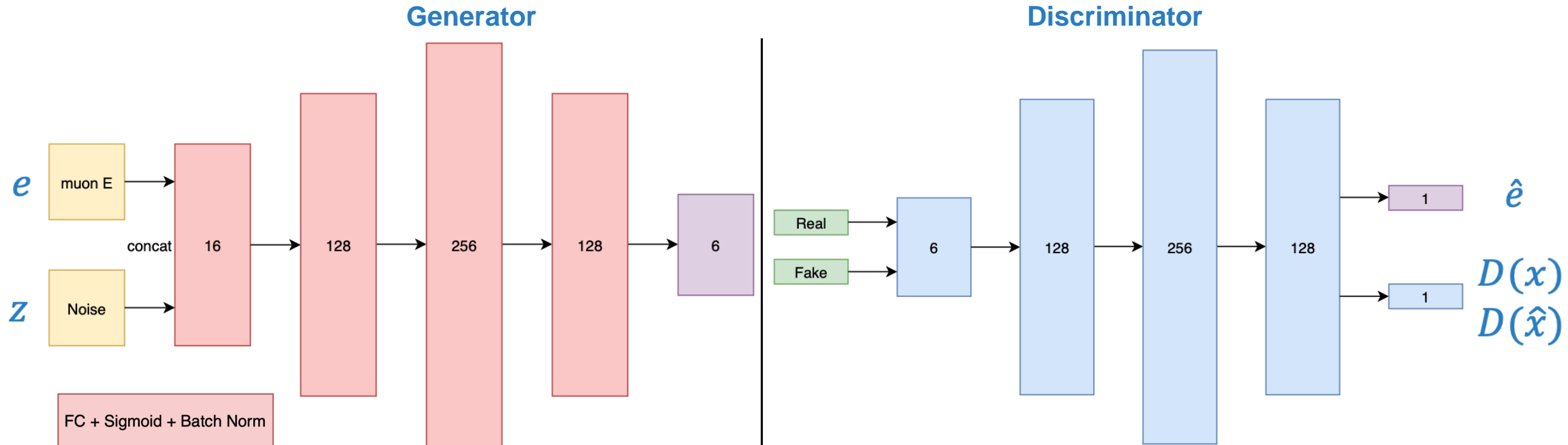
We can try to use the recent concept of Generative Adversarial Network, that can be characterised by the interplay between a forger and a detective.

At the Large Hadron Collider, nature is an artist. We need to learn how to fake these paintings.



MFC GAN Architecture Features

Conditional GAN

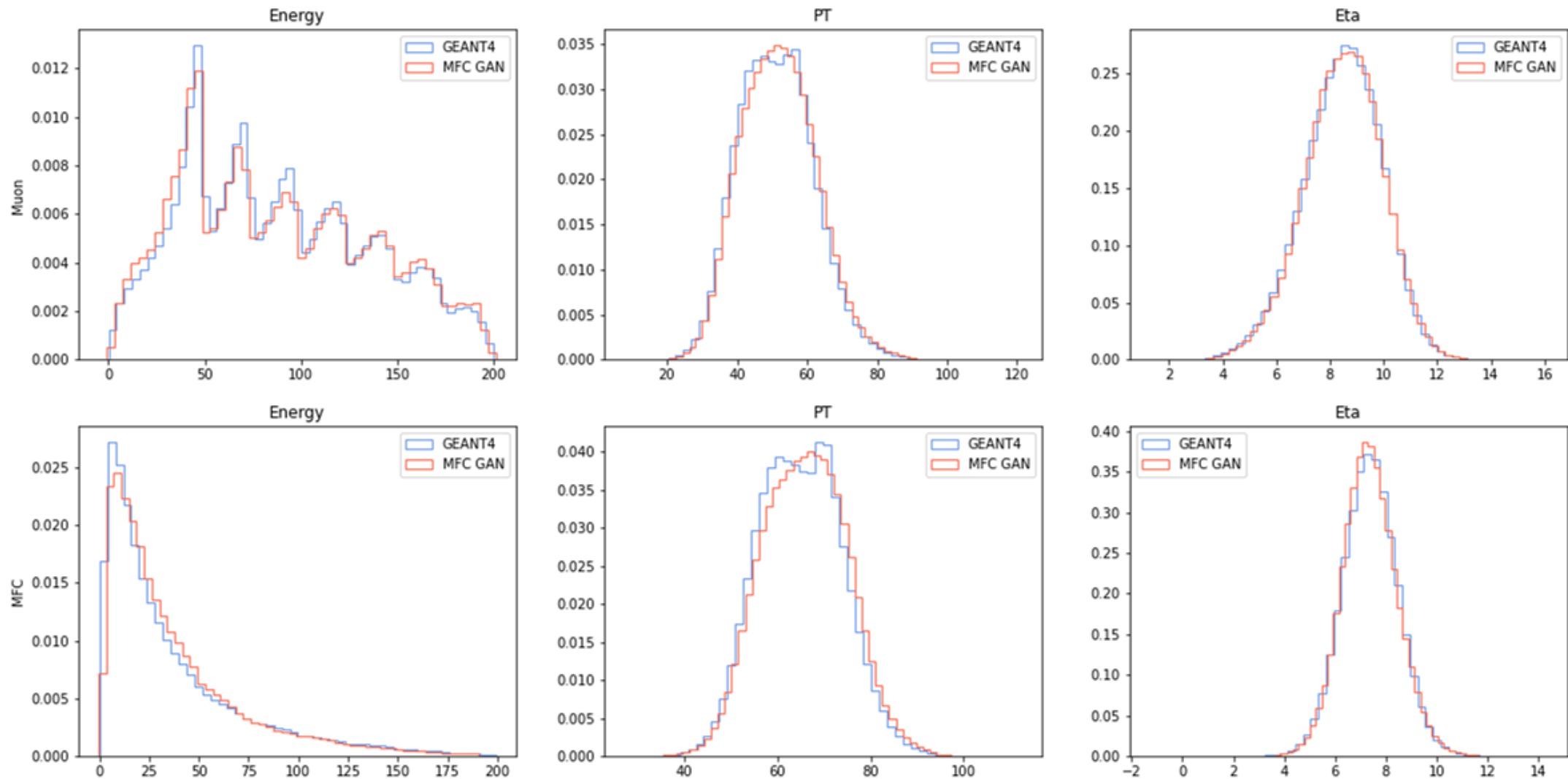


$$\hat{x} = G(e, z), \text{ where } z \sim \mathcal{N}(0, 1)$$

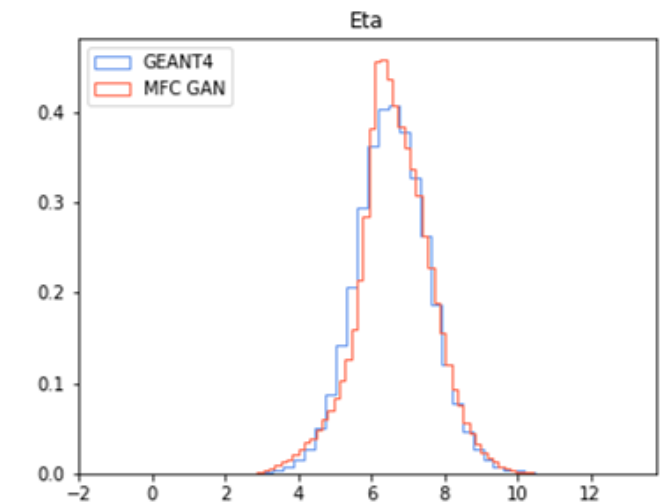
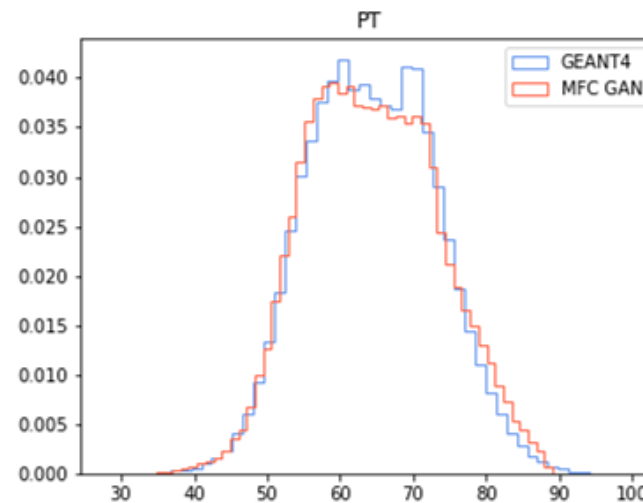
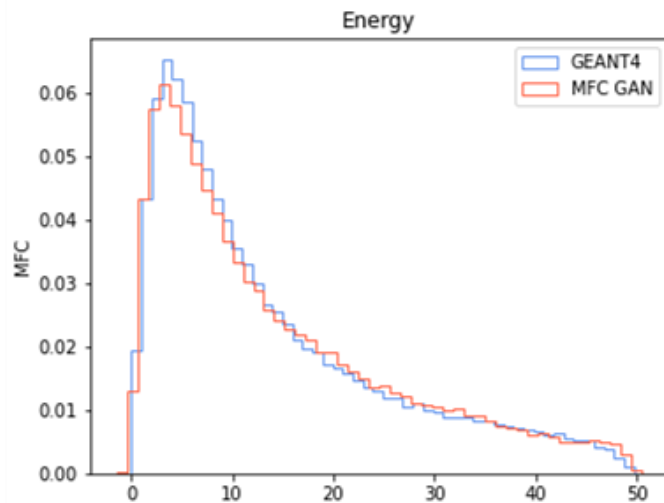
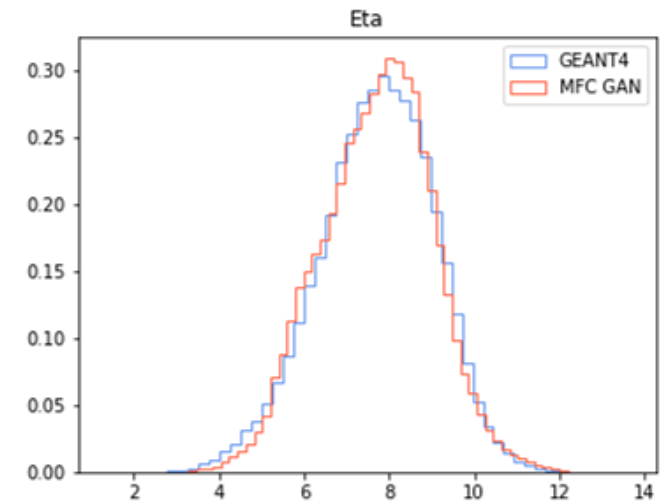
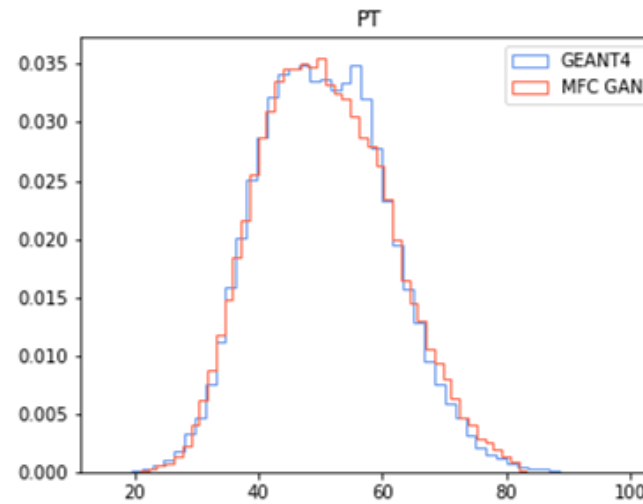
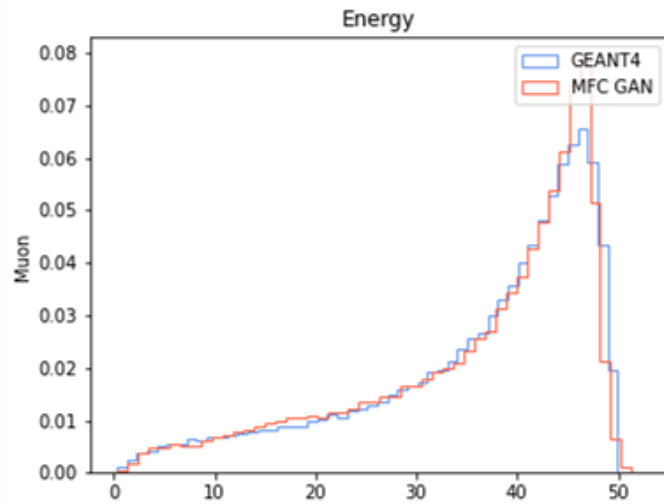
$$L_G = -\frac{1}{2} \mathbb{E}_{\hat{x} \sim \mathbb{P}_{fake}} \log(D(\hat{x}))$$

$$L_D = -\frac{1}{2} \mathbb{E}_{x \sim \mathbb{P}_{real}} \log(D(x)) - \frac{1}{2} \mathbb{E}_{x \sim \mathbb{P}_{fake}} \log(1 - D(\hat{x})) + \lambda \cdot (\text{MSE}(e, \hat{e}) + (\sigma(e) - \sigma(\hat{e}))^2)$$

Results full dataset



Results single dataset





QUESTIONS?

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