# Transcoding between two distributions with GANDALF

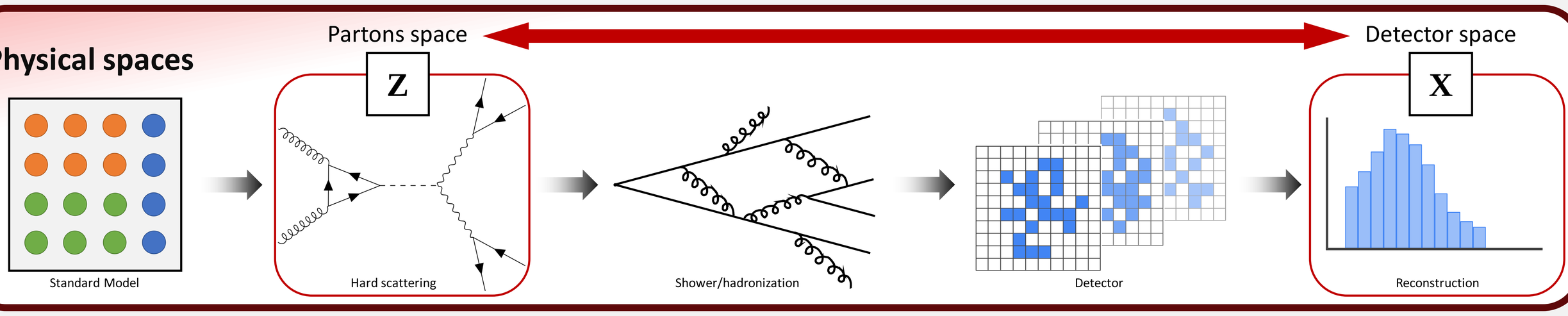
UNIVERSITÉ DE GENÈVE

## Introduction

GANDALF is a *Generalised Autoencoder Network for Density Aware Learning of Four-momentum*.

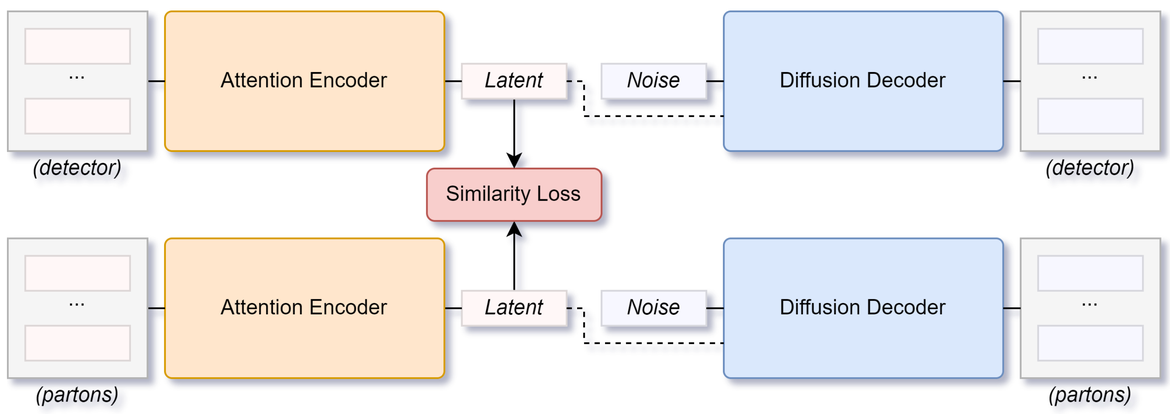
- It aims at transcoding four-momentum from a theory space (*partons*) to an observation space (*detector*) and vice versa.
- It uses state-of-the-art deep learning methods such as the attention mechanism and denoising diffusion models.

## Physical spaces

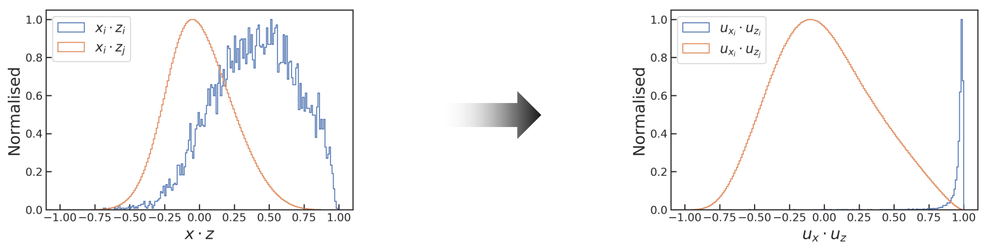



## GANDALF

- Attention encoders
  → Transform each particle considering every other particles.
- Common latent representation
  → Detector and partons data share the same latent encodings.
- Diffusion decoders
  → Gradually conditionally transform random noise towards actual data.



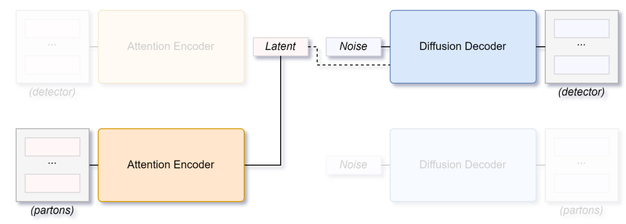

The encoders are able to bring the pairs much closer in the latent space!



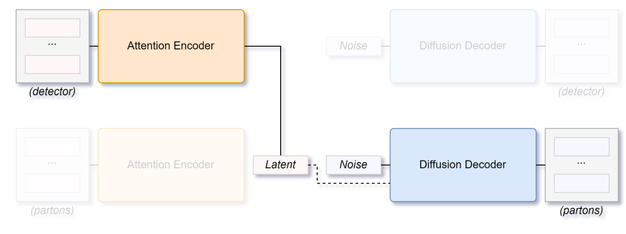

## In more details

Once trained the network can:

- Generate new detector samples from the theory

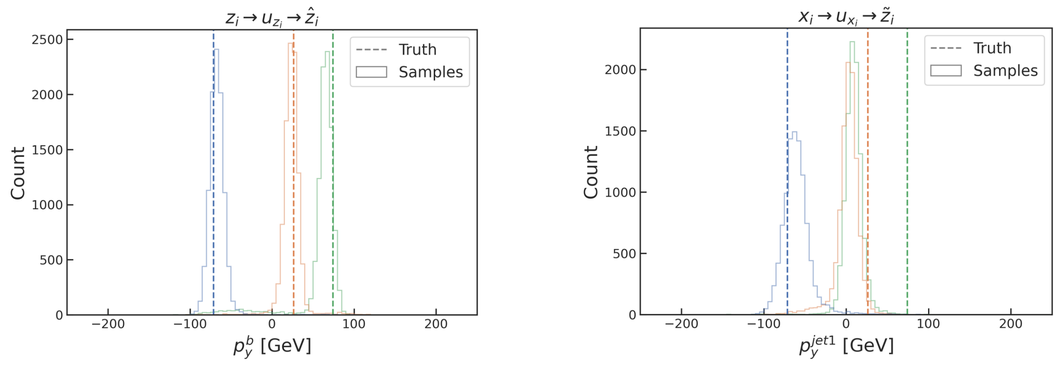



- Unfold the theory from the detector observations



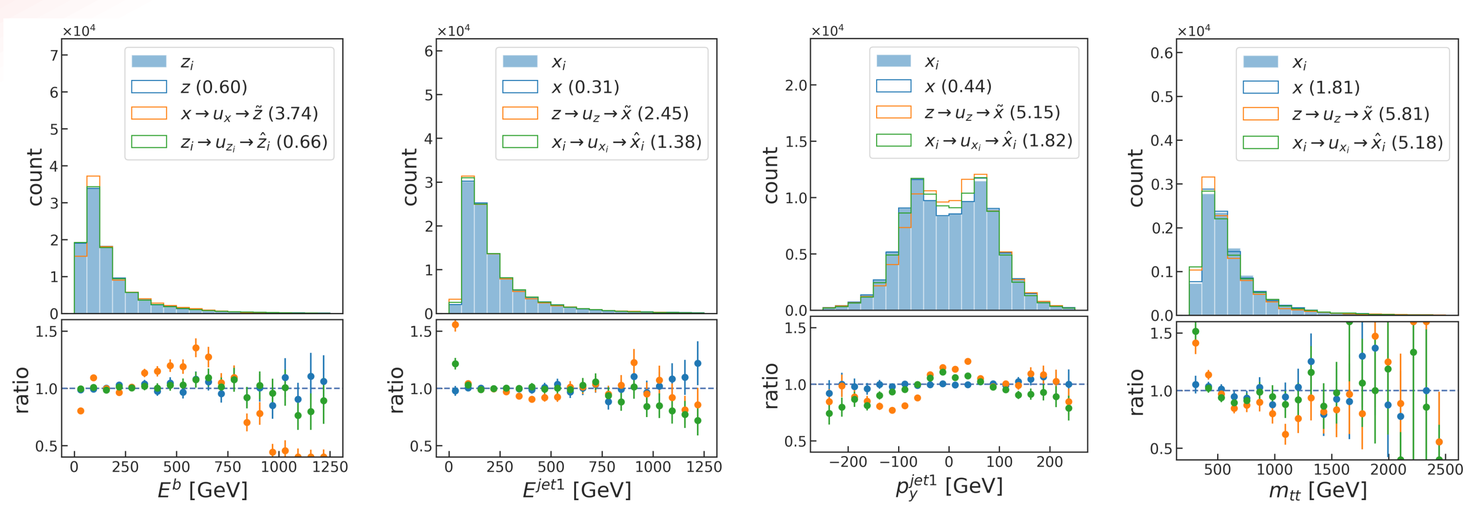

The data is highly stochastic just as the conditional diffusion samples.

- Reconstruction (left) is well learnt.
- Transcoding (right) still shows some slight mismodelling.




## Distributions

We focus on double top quarks production in proton–proton collisions subsequently decaying into b-quarks and W-bosons which in turn decay into a pair of light leptons and a pair of light quarks: $pp \to t\bar{t} \to e^- \bar{\nu}_e \, b\bar{b} \, u\bar{d}$




Both for reconstruction and transcoding, the distributions of the four-momenta match well with respect to the Kolmogorov-Smirnov distance to the truth (in parenthesis).

## References


- Guillaume Quétant et al. *Turbo-Sim: a generalised generative model with a physical latent space.* 2021. arXiv: 2112.10629
- Slava Voloshynovskiy et al. *Information bottleneck through variational glasses*. 2019. arXiv: 1912.00830
- Jessica N. Howard et al. *Foundations of a Fast, Data-Driven, Machine-Learned Simulator*. 2021. arXiv: 2101.08944



**Guillaume Quétant, Mariia Drozdova, Vitaliy Kinakh, Tobias Golling, Slava Voloshynovskiy**

*Contact: guillaume.quetant@unige.ch*


*Data Science Day 2022*