

MODELING HADRONIZATION USING MACHINE LEARNING

RBSM Summer School

Tony Menzo

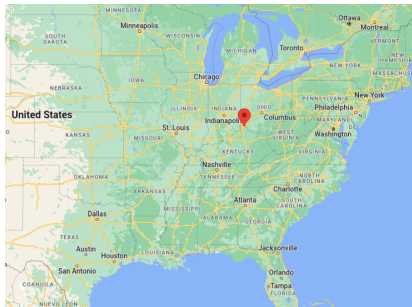
University of Cincinnati

July 28, 2022

Based on [2203.04983](#) with Phil Ilten, Ahmed Youssef, and Jure Zupan

Me 😊

- I grew up in Columbus, Ohio
→ undergrad at The Ohio State University
- 3rd year PhD student at the University of Cincinnati



My dog Wilson →

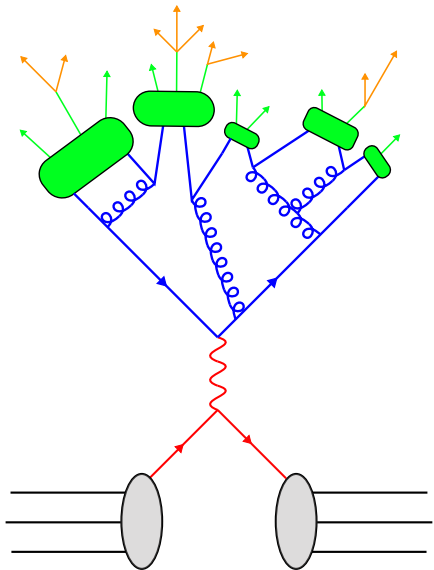
Event generators

For example Pythia,
Herwig, etc...

The simulation is ordered
according to the magnitude
of momentum transfer:

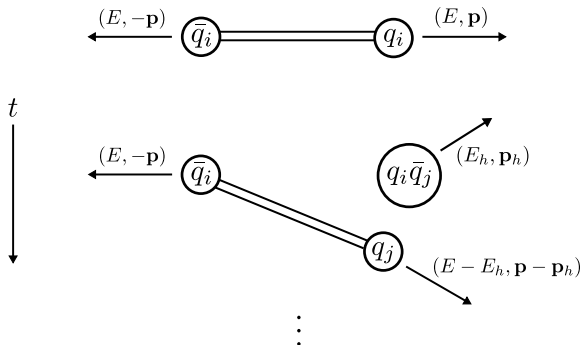
1. **Hard interaction**
2. **Parton Showers**
3. **Hadronization***
4. **Unstable particle decay**

★ ‘Out of the box’
hadronization models are
typically within 20-50% of
observations



Lund Model: *Classical* model of hadronization utilizing string picture. Assume large separations

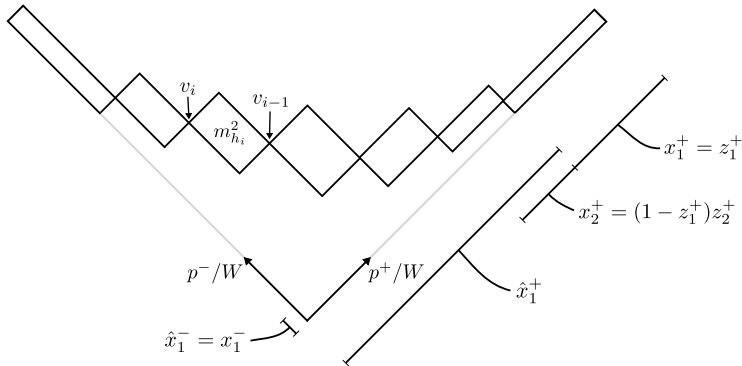
$$V_{\text{Lund}} = \kappa r$$



- Two inputs: mass of hadron m_h and longitudinal momentum fraction z . Left-right symmetric Lund fragmentation function:

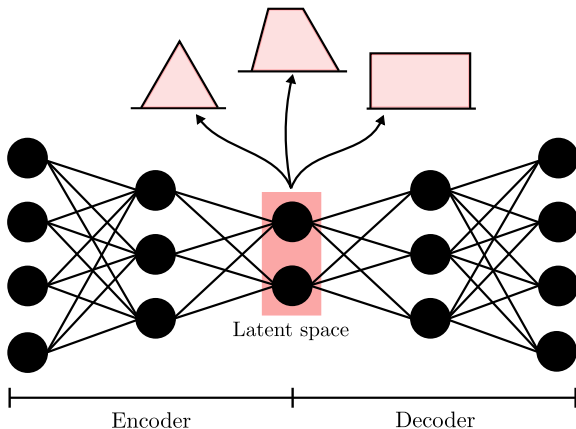
$$f(z)dz \propto \frac{(1-z)^a}{z} \exp\left(-b\frac{m_h^2}{z}\right) dz$$

where a and b are fit parameters.

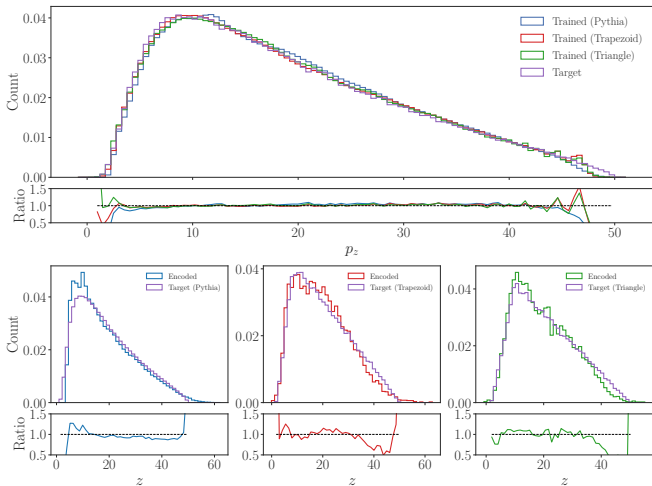


Sliced-Wasserstein Autoencoder (SWAE)

In essence we need to generate random variables from distributions whose form we don't know analytically

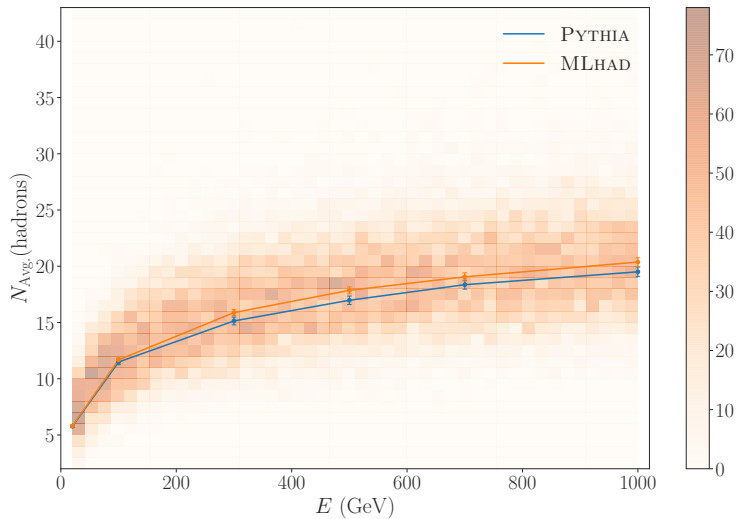


SWAE-trained models: p_z



Pion first emission z -component of momentum distribution compared with encoder/decoder results from three SWAE-trained models.

Scaling with energy



Future

Goal: create a phenomenological model of hadronization utilizing data

- Requires a slight shift in mindset: training on global observables and matching to full hadronization events.
- Generalize machine learning algorithm: Need to implement multidimensional training on correlated random variables

MILHAD

The logo for MILHAD features the letters in a bold, black, serif font. The letter 'D' is significantly larger than the others. Green decorative elements include a diagonal line with an arrow pointing left across the top of the letters, several green coiled spring-like lines, and several green branching lines extending from the right side of the 'D'.

All the code written for this project is publically available at:

<https://gitlab.com/uchep/mlhad>

Thank you ☺