

# Empirically Trained Hadronic Event Regenerator

Evan McClellan

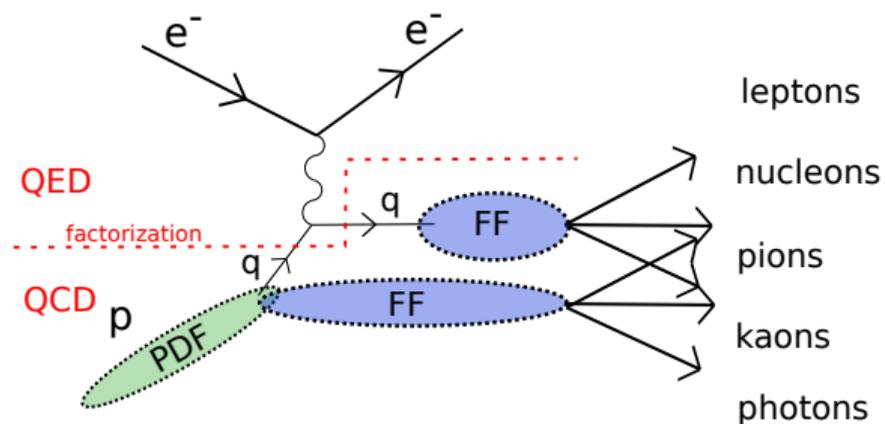
July 9th, 2019

ETHER

The logo consists of the word "ETHER" in a bold, grey, sans-serif font. Each letter has a small, dark grey rectangular box embedded within it, containing a word. The word "empirically" is inside the 'E', "trained" is inside the 'T', "heuristic" is inside the 'H', "hadronic" is inside the 'R' (the second one), "event" is inside the 'E', and "regenerator" is inside the 'R'.

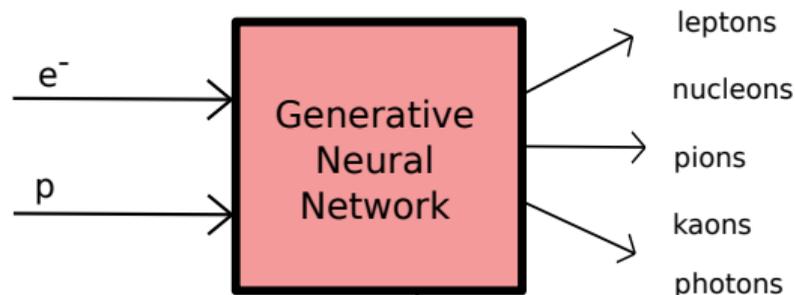
# Hadronic Event Generators

- PYTHIA
- HERWIG
- ISAJET
- Sherpa
  
- Inputs:
  - ▶ PDFs (QCD)
  - ▶ FFs (QCD)
  - ▶ Factorization
  - ▶ QED
  
  - ▶ Tune to match experiment...



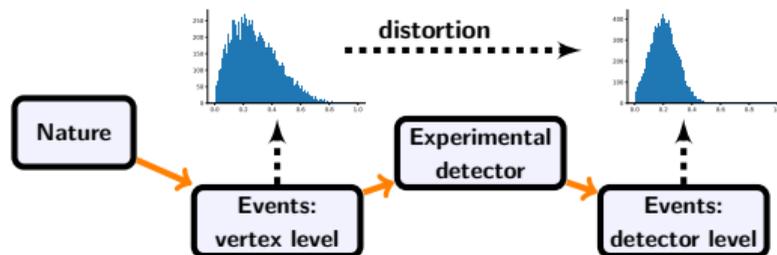
# ETHER: An Agnostic Event Generator

- No theory input on vertex interactions
- Generative Adversarial Networks (GANs)
- Inputs: electron and proton
- Outputs: long-lived (detectable) particles
- Train generator against existing data
  
- Leverage recent major advances in Generative Machine Learning

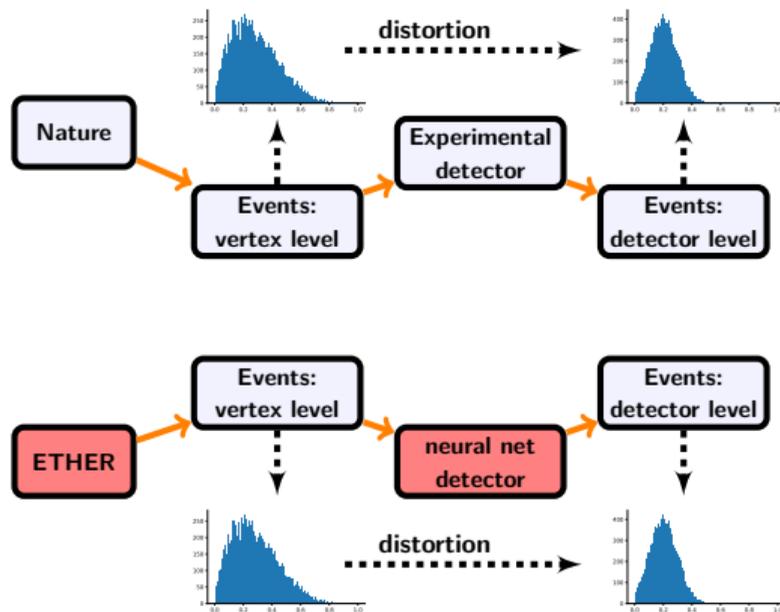


ENGINEERING TIP:  
WHEN YOU DO A TASK BY HAND,  
YOU CAN TECHNICALLY SAY YOU  
TRAINED A NEURAL NET TO DO IT.

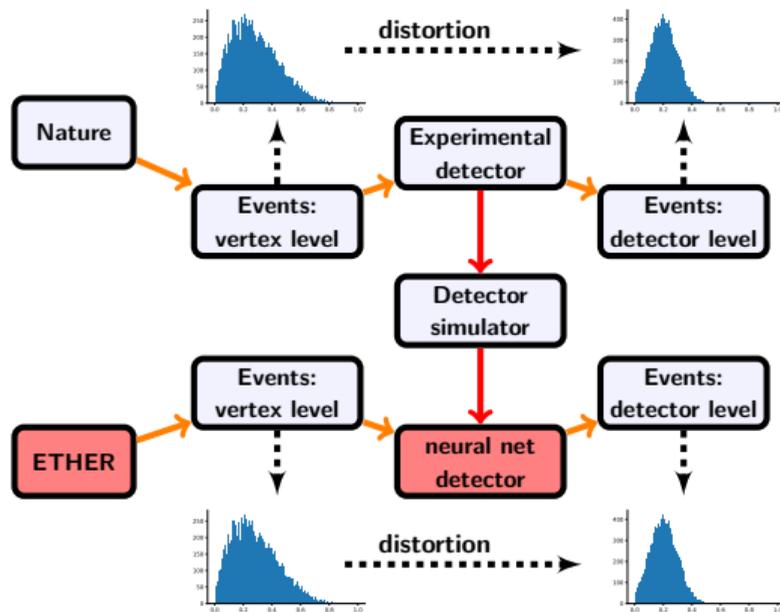
# ETHER Flowchart



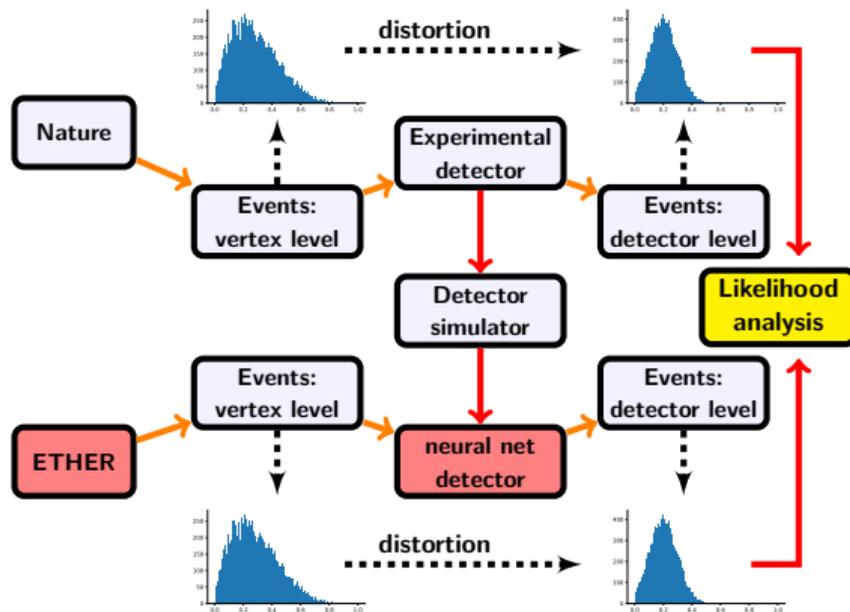
# ETHER Flowchart



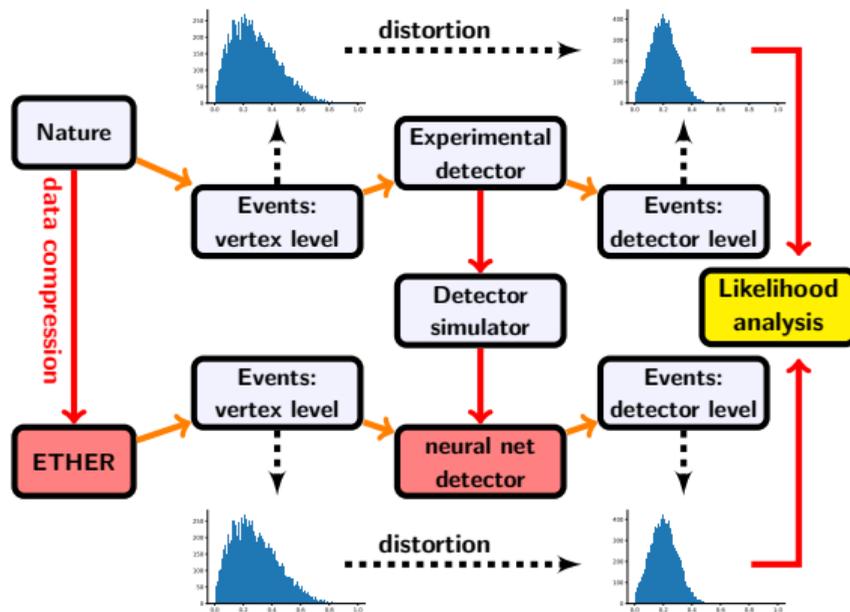
# ETHER Flowchart



# ETHER Flowchart



# ETHER Flowchart



## Old Dominion University

- Yaohang Li
- Yasir Awadh Alanzi

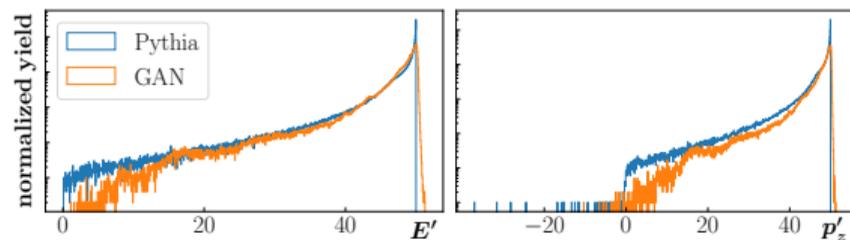
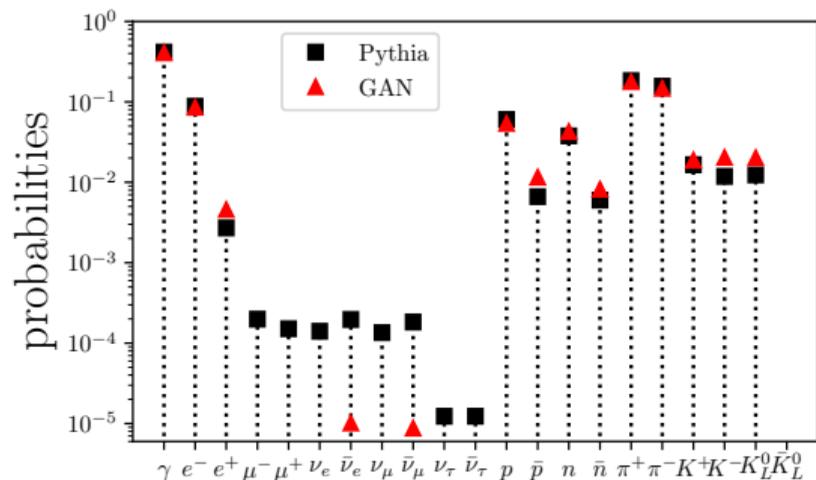
## Davidson College

- Michelle Kuchera
- Raghuram Ramanujan
- Ryan Strauss
- Evan Pritchard
- Michael Robertson

## Jefferson Lab

Nobuo Sato   Wally Melnitchouk   Tianbo Liu   Evan McClellan   Luisa Velasco

## Dual GAN



## Full Exclusive Event

- R&D on data representation and GAN architecture for full exclusive events
- R&D: make generators *conditional* on  $\sqrt{s}$
- **Challenges:**
  - ▶ Variable number of particles
  - ▶ Discrete (PID) and continuous (4-vector) variables

## Simpler, Inclusive Final States

- Develop inclusive GANs for specific reactions
- One GAN per final state:
  - ▶  $p(e, e')X$
  - ▶  $p(e, e'\pi^+)X$
  - ▶  $p(e, e'\pi^+\pi^-)X$
  - ▶ ...
- R&D: make generators *conditional* on  $\sqrt{s}$