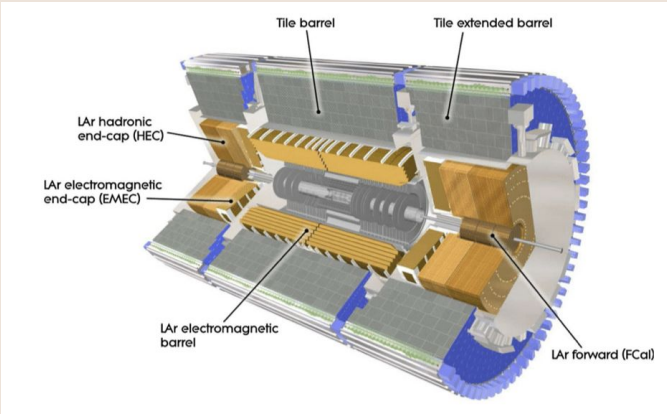
A Machine Learning Approach to Local Hadronic Calibration in the ATLAS Calorimeters

Madison Howard

Problem Overview

- Physics object reconstruction in ATLAS
  - Final-state objects
- Correcting for effects of...
  - non-compensating calorimeter response to hadrons
  - Accidental signal losses
  - Inactive material

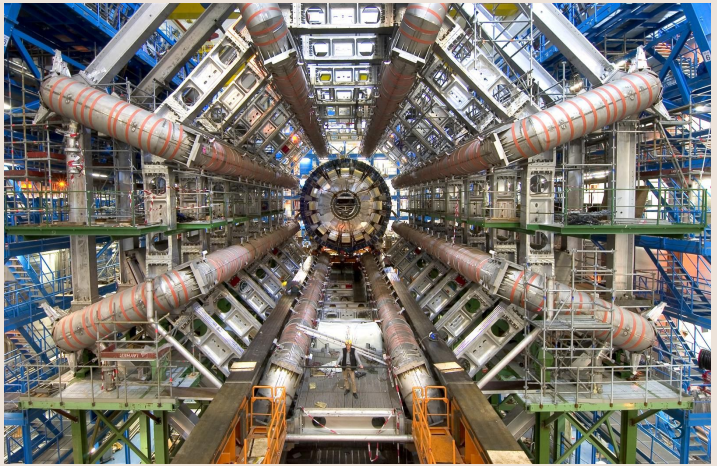


https://arxiv.org/abs/1603.02934

General Project Goal

Develop and configure a ML framework to

- Improve topo-cluster classification
- Develop a calibration function
  - shift the topo-cluster signal to the expected *true* energy
- Test single step calibration without explicit classification



Machine Learning: Why?

- Local Hadronic Cell Weighting
  - a tool to get calibrated jets at particle level
  - receive cell weights to correct for the invisible energy deposits of hadrons
  - not very good at lower energies

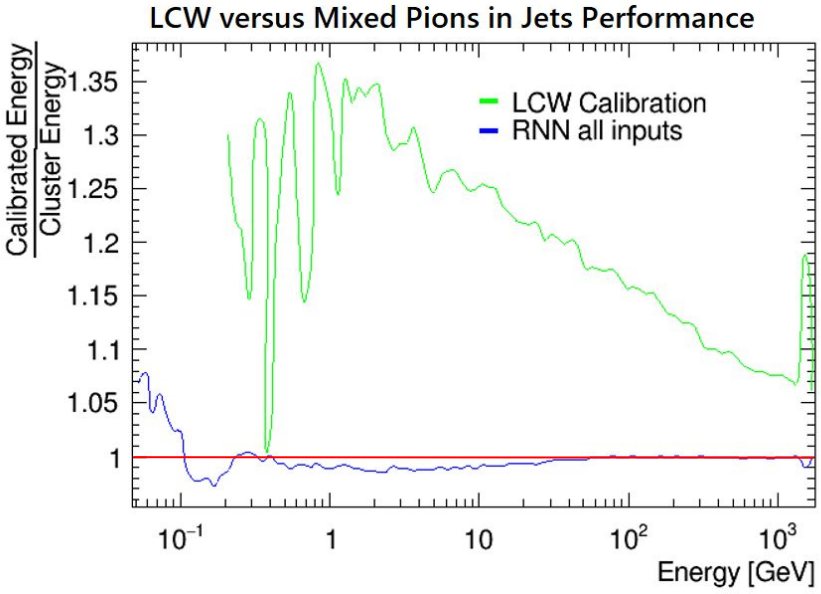


Figure 1: LCW versus Mixed Pions in Jets Performance

What does that actually mean?

- **Energy**
- Statistics
- Visualization

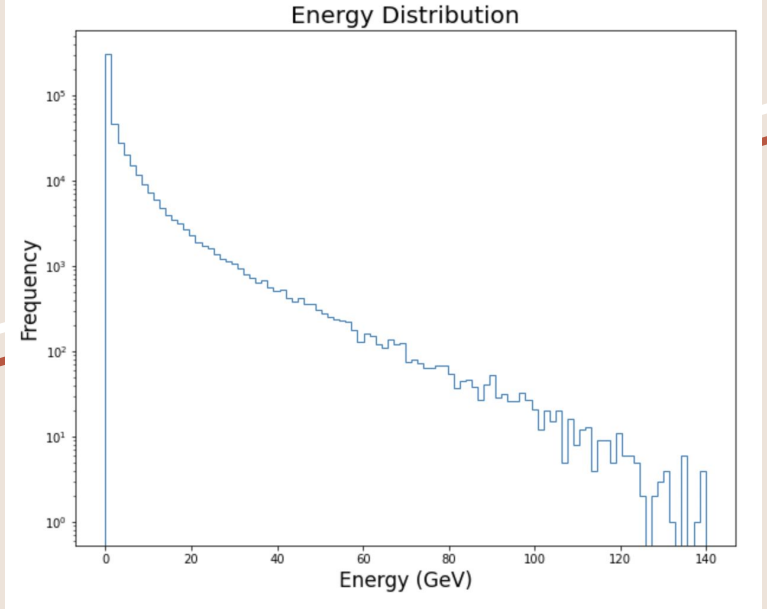


Figure 1: Energy Distribution

What does that actually mean?

- Energy
- **Statistics**
- Visualization

What does that actually mean?

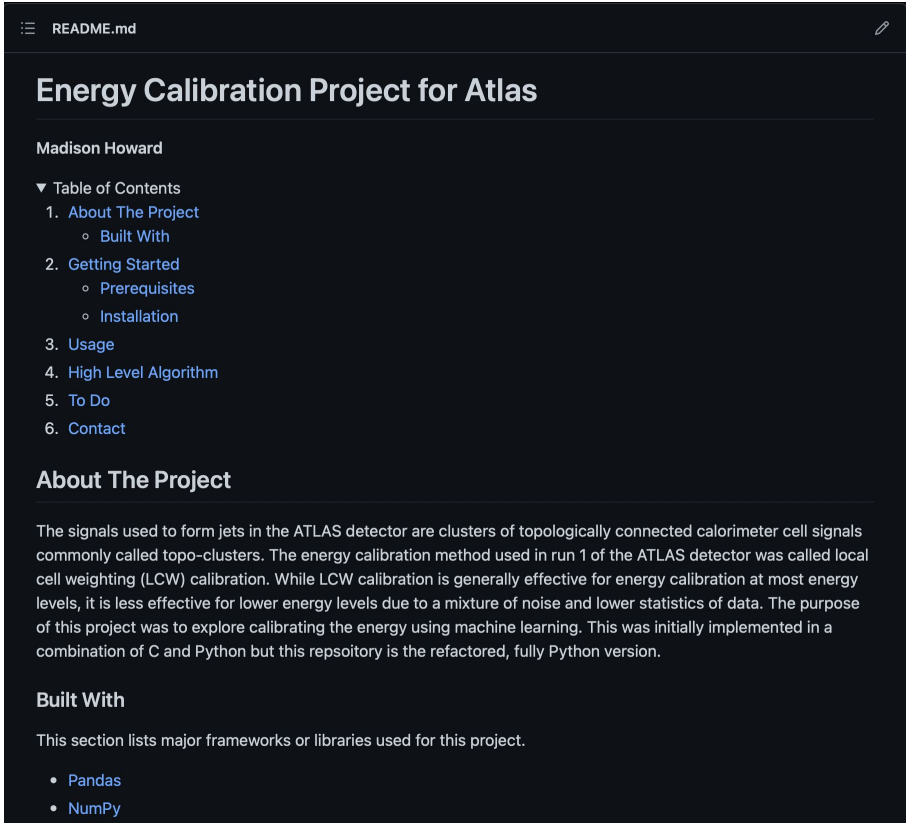
- Energy
- Statistics
- **Visualization**

Loss Functions, Inputs and Optimization Algorithms

- Loss Functions Metrics
  - Mean Absolute Percentage Error (MAPE) vs Mean Absolute Error (MAE)
- Chaσ_t^2ing Inputs
  -
- Optimization Algorithms
  - Adam

Software Development

- From C to Python
  - Documentation
  - Data handler class
    - Cuts, inputs, normalization
    - automated
  - Boost Histogram
- https://github.com/madihowa/EnergyCalibration



README.md

Energy Calibration Project for Atlas

Madison Howard

▼ Table of Contents

1. About The Project
   - Built With
2. Getting Started
   - Prerequisites
   - Installation
3. Usage
4. High Level Algorithm
5. To Do
6. Contact

About The Project

The signals used to form jets in the ATLAS detector are clusters of topologically connected calorimeter cell signals commonly called topo-clusters. The energy calibration method used in run 1 of the ATLAS detector was called local cell weighting (LCW) calibration. While LCW calibration is generally effective for energy calibration at most energy levels, it is less effective for lower energy levels due to a mixture of noise and lower statistics of data. The purpose of this project was to explore calibrating the energy using machine learning. This was initially implemented in a combination of C and Python but this repsoitory is the refactored, fully Python version.

Built With

This section lists major frameworks or libraries used for this project.

- Pandas
- NumPy

Figure 1: Screenshot of GitHub README.md

Network Architecture

- 9 inputs
- 2 hidden layers
  - 1024 nodes each
- Rectified linear activation function

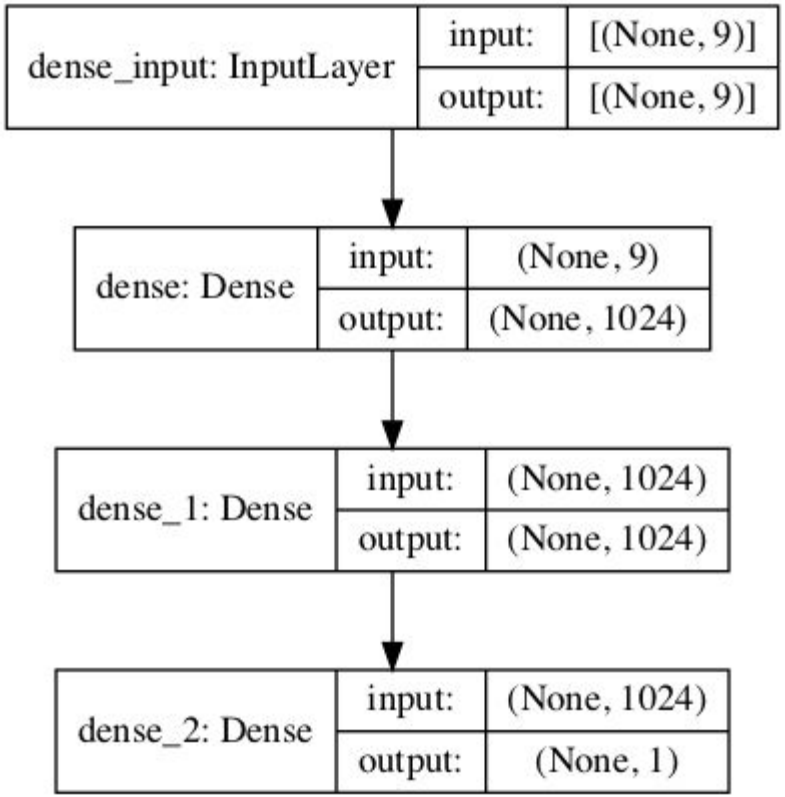


Figure 1: NN Architecture for Energy Calibration

Plotting

Before:

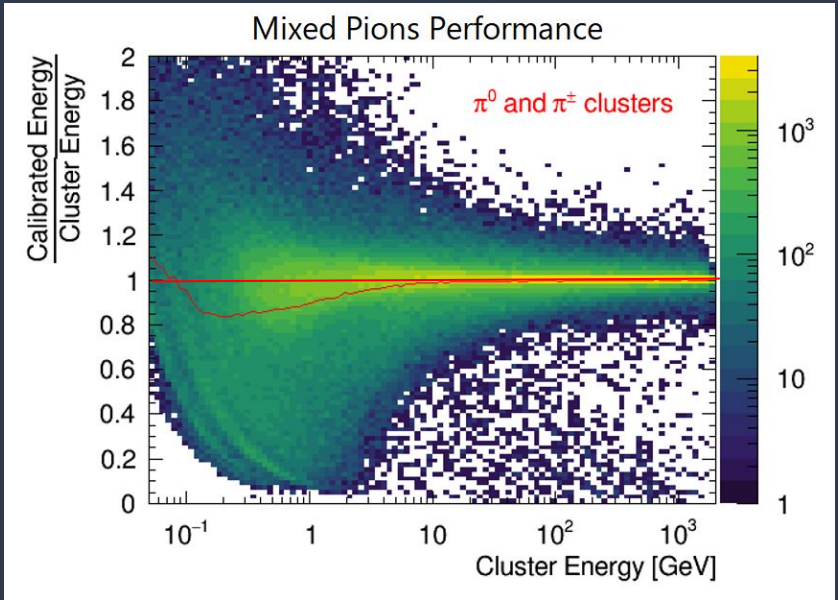


Figure 1: Results of NN at start of the summer

After:

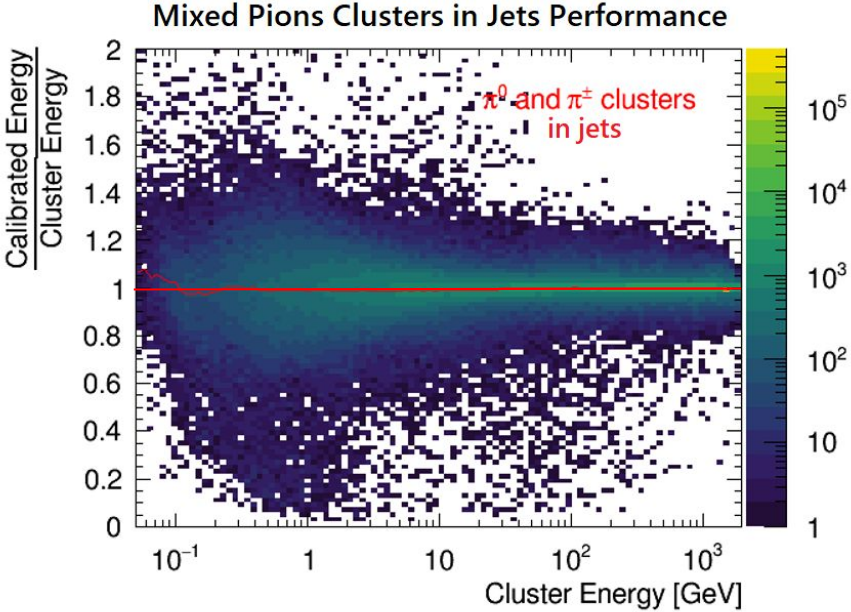


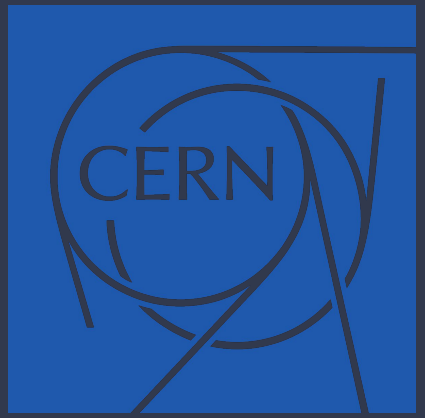
Figure 2: Results of NN at end of the summer

Future Work

- Jet Data
- Fall semester

Acknowledgments

- National Science Foundation
- CERN
- ATLAS Collaboration
- University of Michigan



Questions?