BHCal Machine Learning Energy Calibration Update

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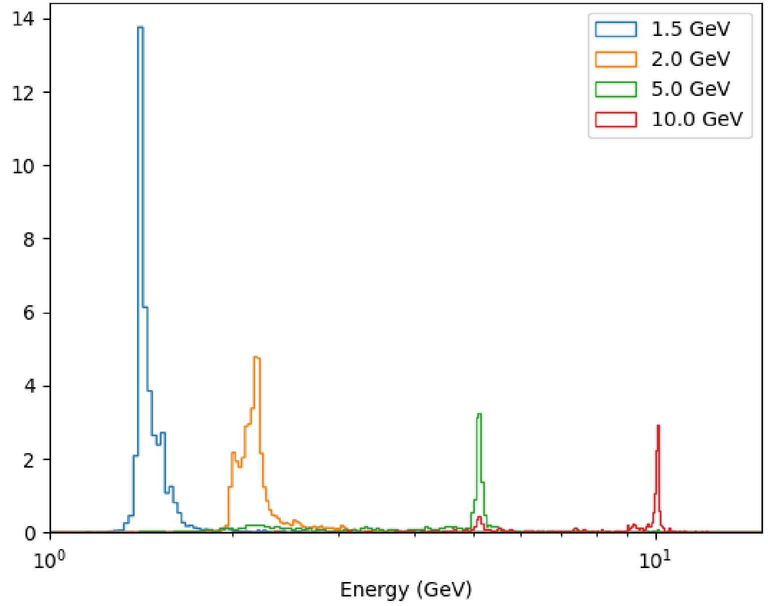
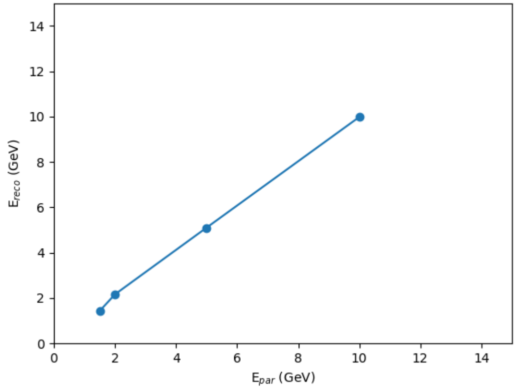
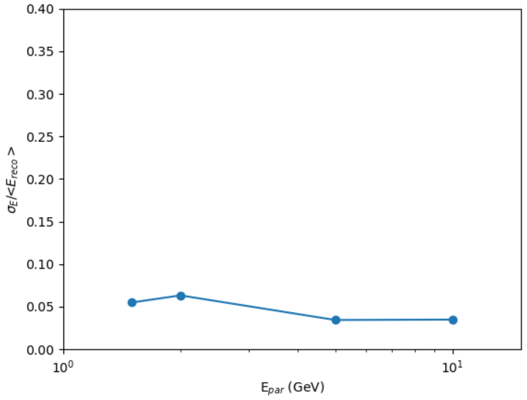
Refresher on Current Status

- Used a custom PyTorch Multilayer Perceptron to try and do calibration for single particle neutrons
- Resolutions were “unbelievably” small (with irregular distributions) – need a way to verify machine learning solution is trustworthy







How to check if we can trust the ML solution?

- Train with a continuous energy distribution (from DIS simulation campaign) to provide a more realistic input that doesn't allow the neural network to hone in on "classification problem" results
- Perform a careful uncertainty analysis on the NN performance

- Because I am in many ways still very inexperienced with BNL physics and the EIC simulation, took quite a lot of time to learn how to make appropriate training files for the first step…

Training File Generation

- Thanks x1000 to Derek for a tremendous amount of help learning how he generated the old training files and figuring out a new way

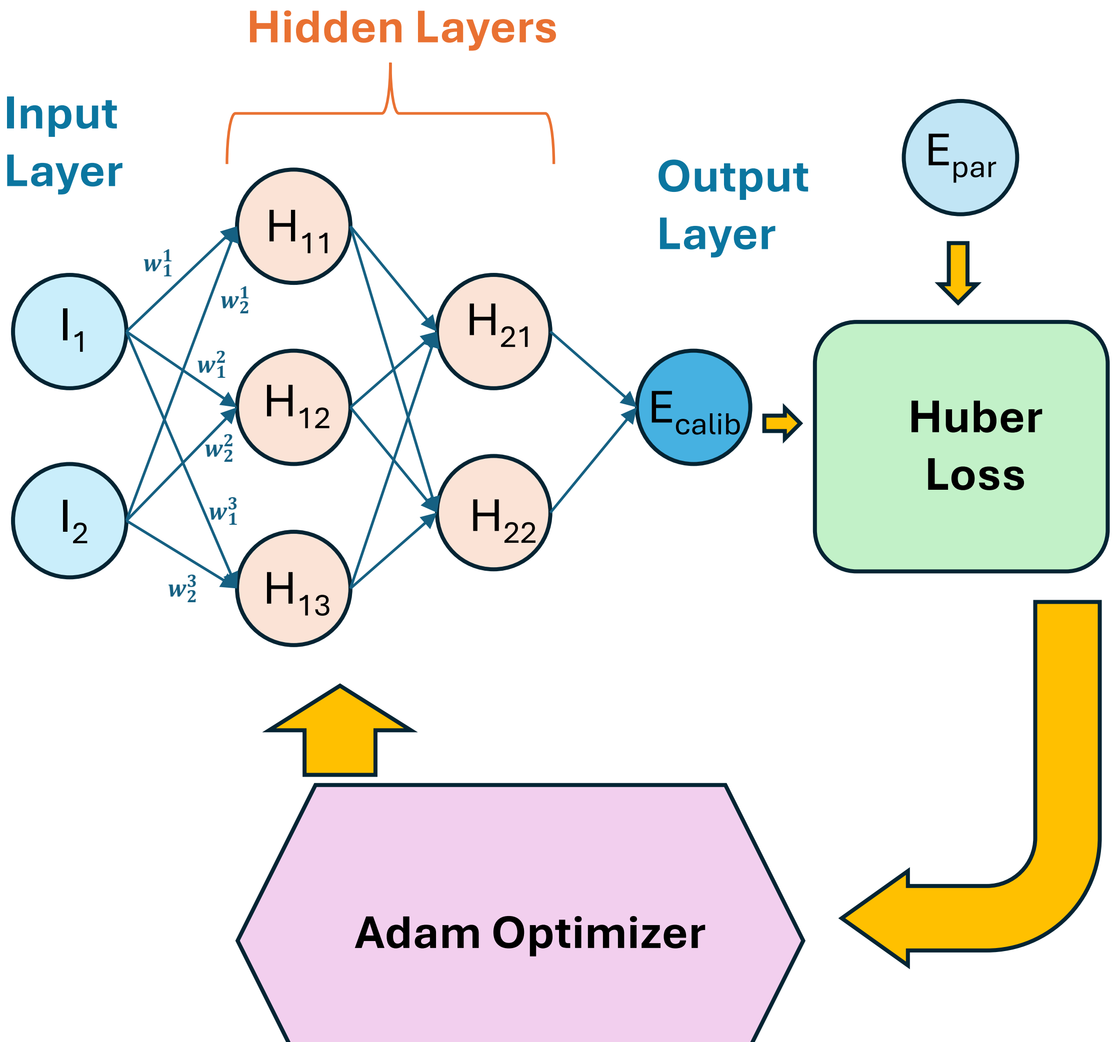
- Use DIS simulation campaign with appropriate Q2, eta, etc.
- Loop through particle-cluster associations, identify clusters in BHCal, EMCal, ScFi, Imaging, and fill training tuple for each particle-cluster pairing

New Training Files

- **Network Inputs:**
- Mass
- PDG
- Kinetic Energy (“cheating on the test”)
- BHCal: nClusters, Cluster energy, # hits, eta, phi, time
- EMCal: nClusters, Cluster energy, # hits, eta, phi, time (for each layer)
- ScFi: nClusters, Cluster energy, # hits, eta, phi, time (for each layer)
- Image: nClusters, Cluster energy, # hits, eta, phi, time (for each layer)

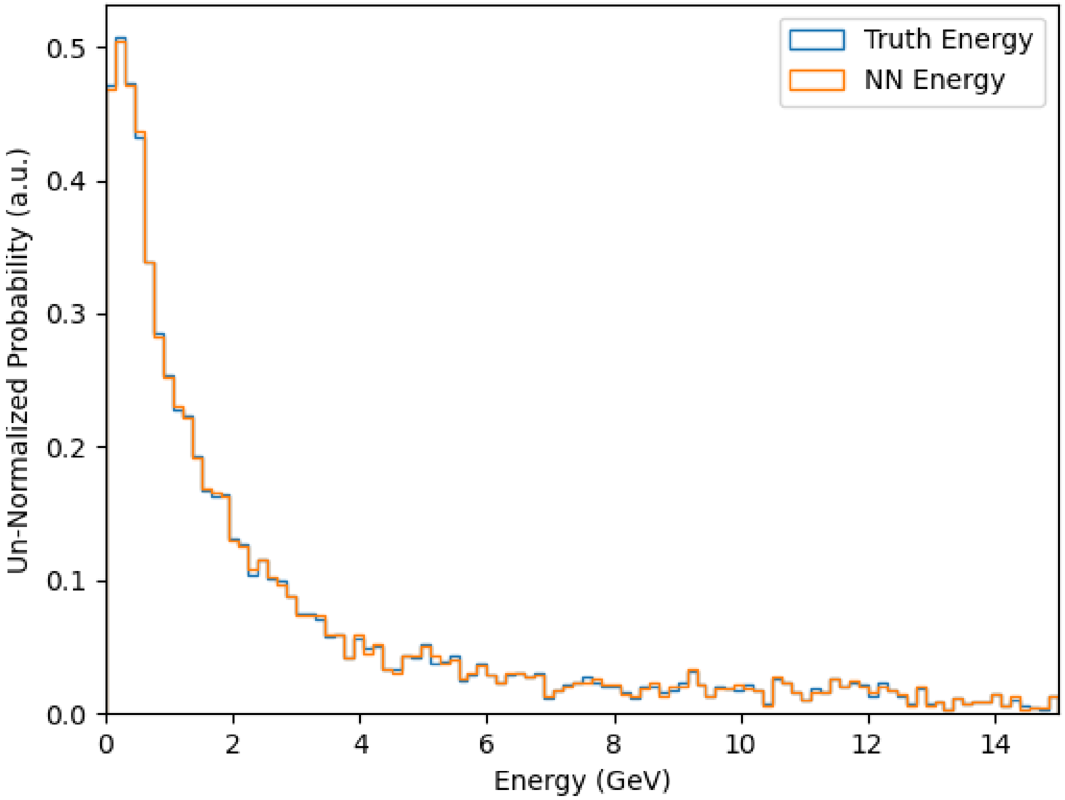
- **Network Outputs:**
- Total Energy

Architecture Details



- "Dense/Fully-connected" network
- 128-512 neurons in first of 3-6 hidden layers, "reverse pyramid" structure

“Proof of Principle” Results



- Does not reflect expected level of neural network performance
- Just that we can now produce a (reasonable?) continuous energy spectra training file
- And that the neural network can handle the input and perfectly produce the total energy when given the “cheat sheet” of the kinetic energy and mass
- Performance without “cheat sheet” not worth showing yet but we can now make faster progress towards a meaningful result

Next Steps

- Take off the training wheels and see how well the network reproduces the training data
- Figure out a way to examine resolutions – train on continuous spectrum and then test with single particle energies?
- Start on careful analysis of machine learning systematics