BHCAL Energy Calibration using Machine Learning

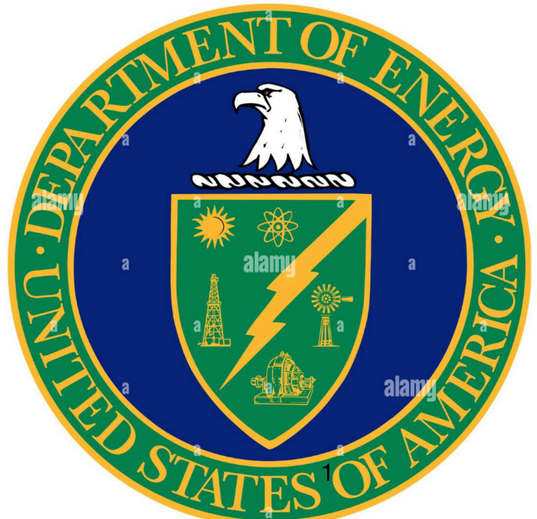
(ePIC BHCAL Meeting)

Churamani Paudel

With

(**Prof. David Ruth**)

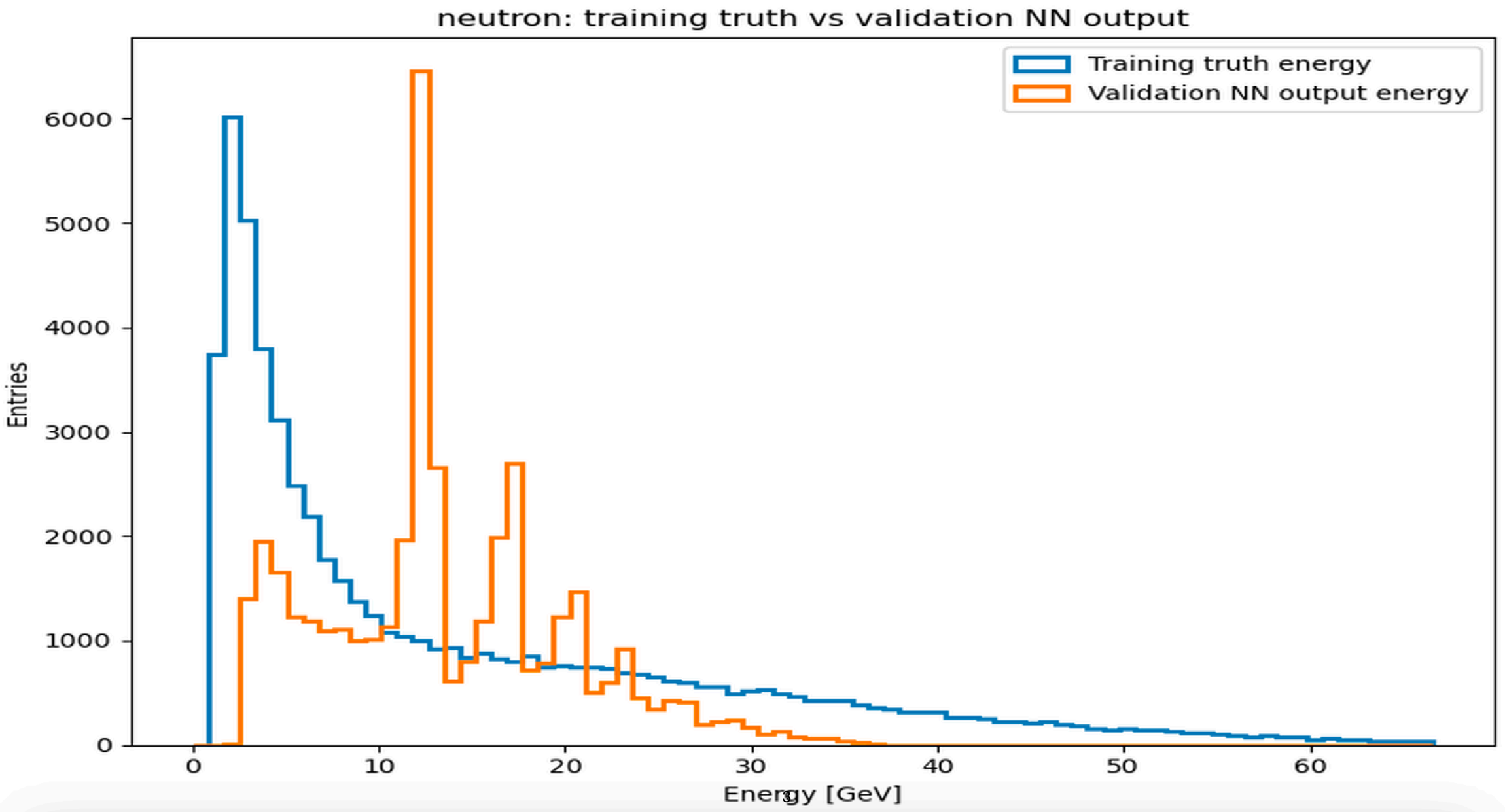
New Mexico State University



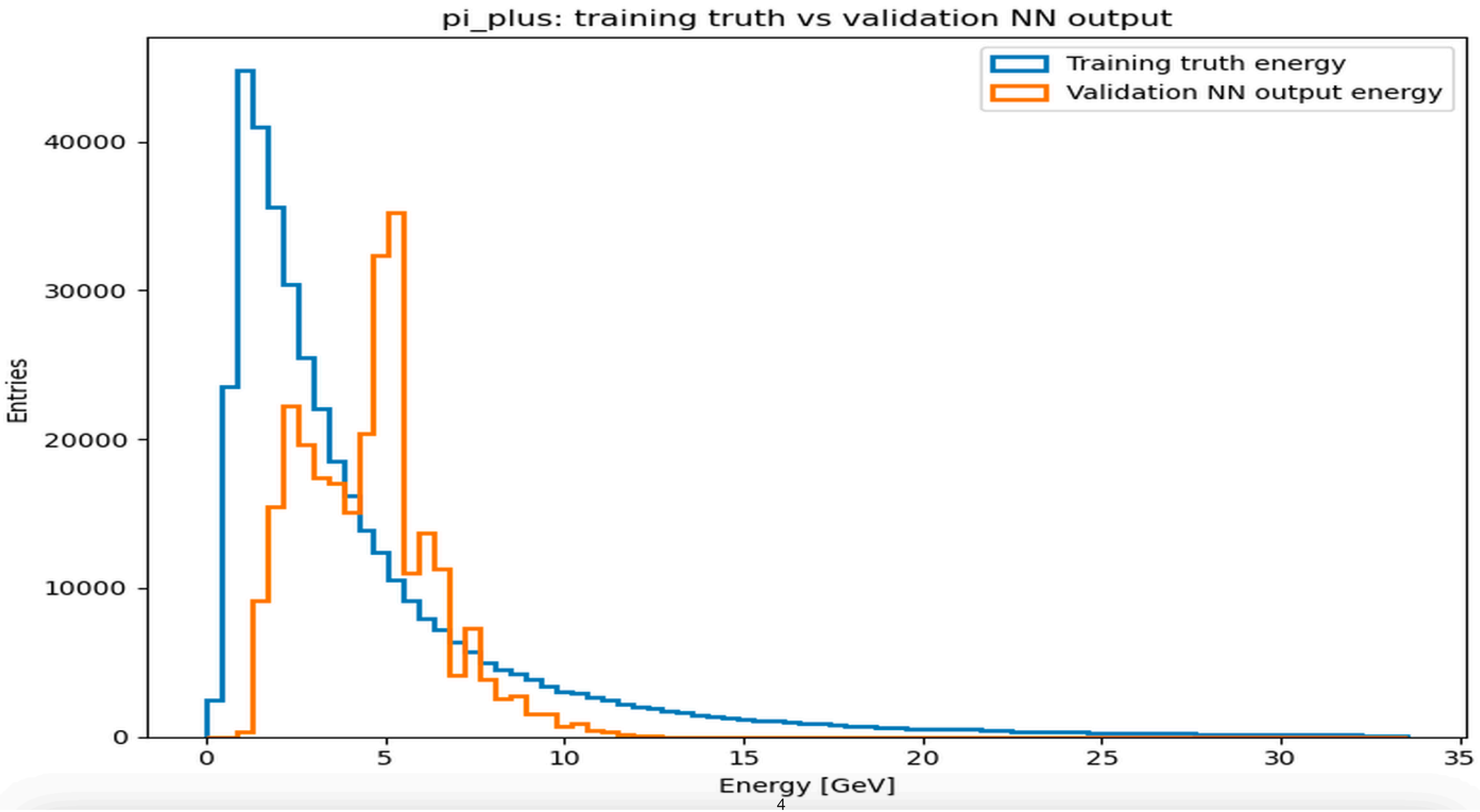
Motivation

- Test a machine-learning-based energy calibration workflow for the BHCal.
- Produce a training tuple with:
  - MC truth particle information
  - reconstructed BHCal cluster information
- Train a PyTorch multilayer perceptron to predict the true particle energy.
- Immediate goal:
  - Check whether the network behaves reasonably with the new continuous DIS training file.
- Main validation check:
  - Compare training truth-energy spectra with validation network-output energy spectra.
- Show performance separately for different particle species:
  - neutrons
  - pions

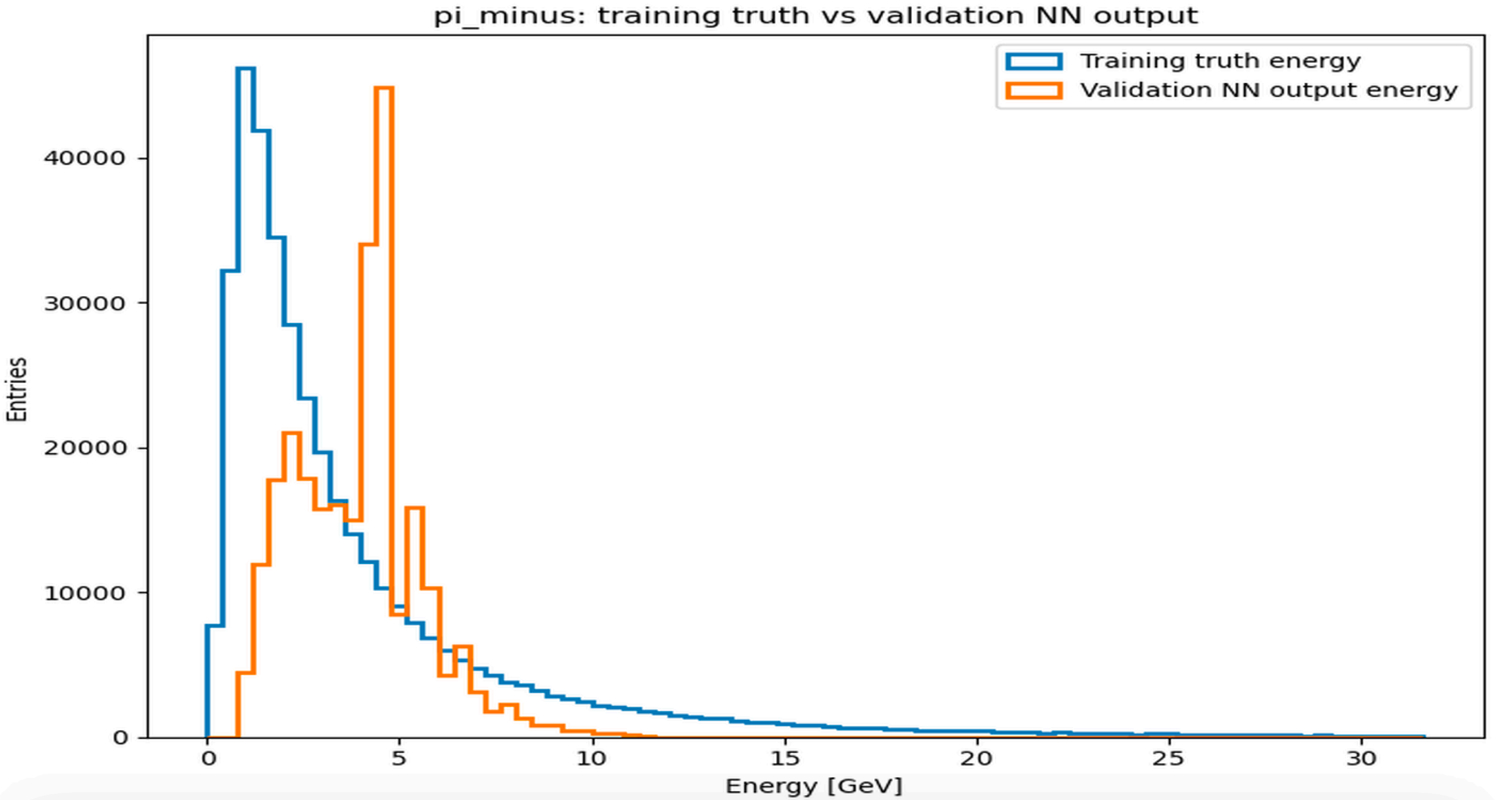
Neutron: Truth Energy vs Network Output Energy



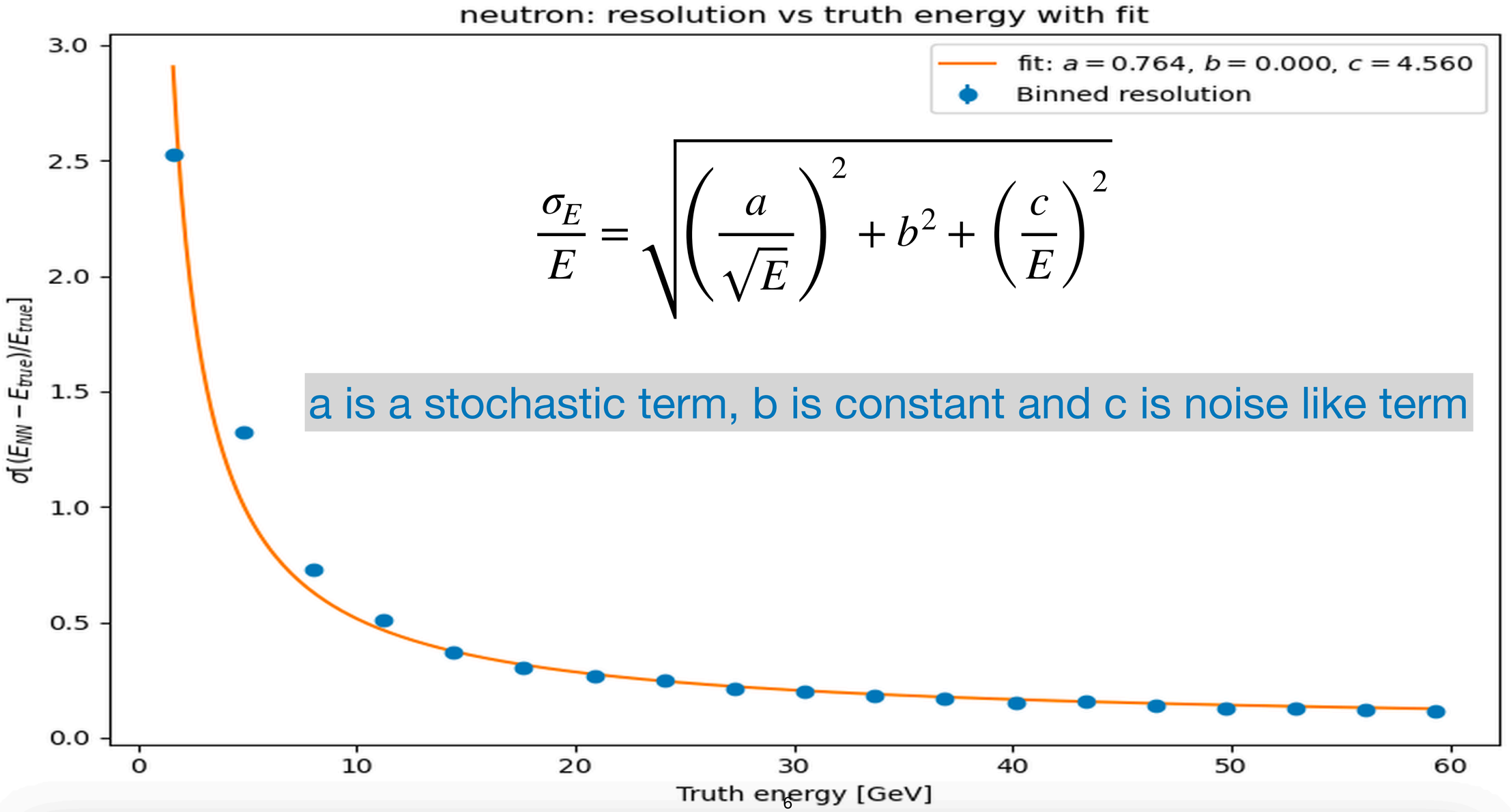
Pi_plus: Truth Energy vs Network Output Energy



Pi_minus: Truth Energy vs Network Output Energy



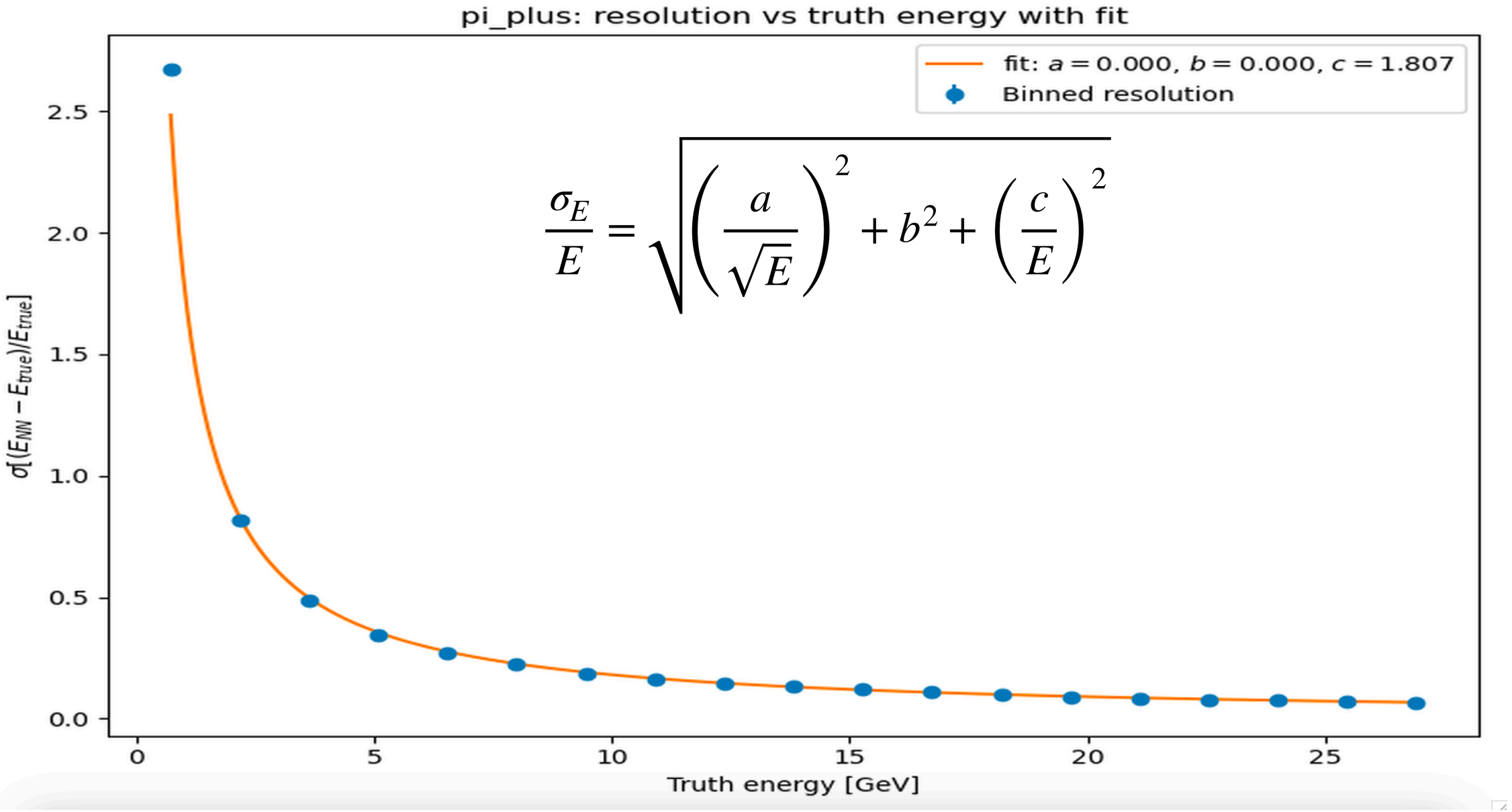
Calorimeter Resolution for neutron (Network Performance)



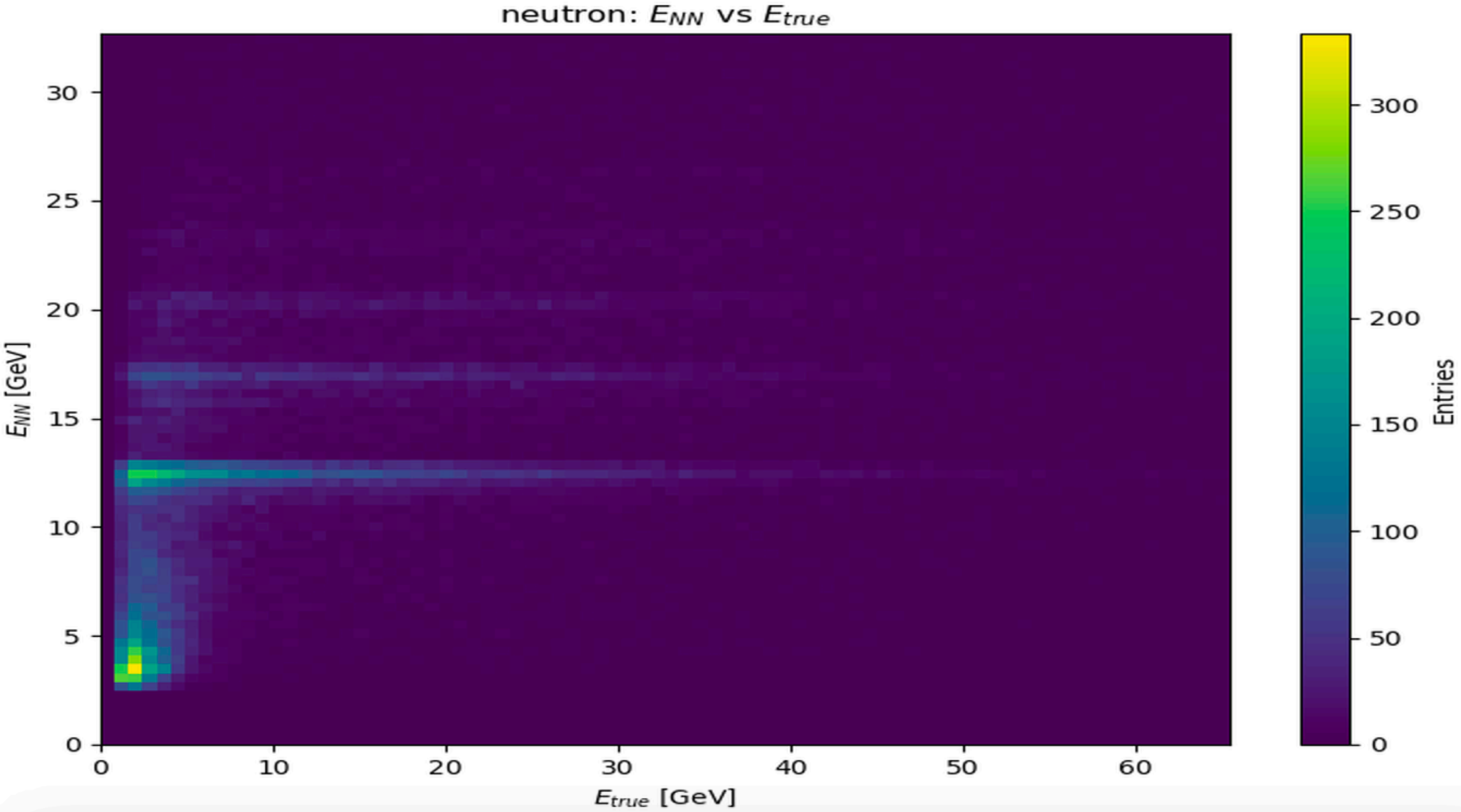
$$\frac{\sigma_E}{E} = \sqrt{\left(\frac{a}{\sqrt{E}}\right)^2 + b^2 + \left(\frac{c}{E}\right)^2}$$

a is a stochastic term, b is constant and c is noise like term

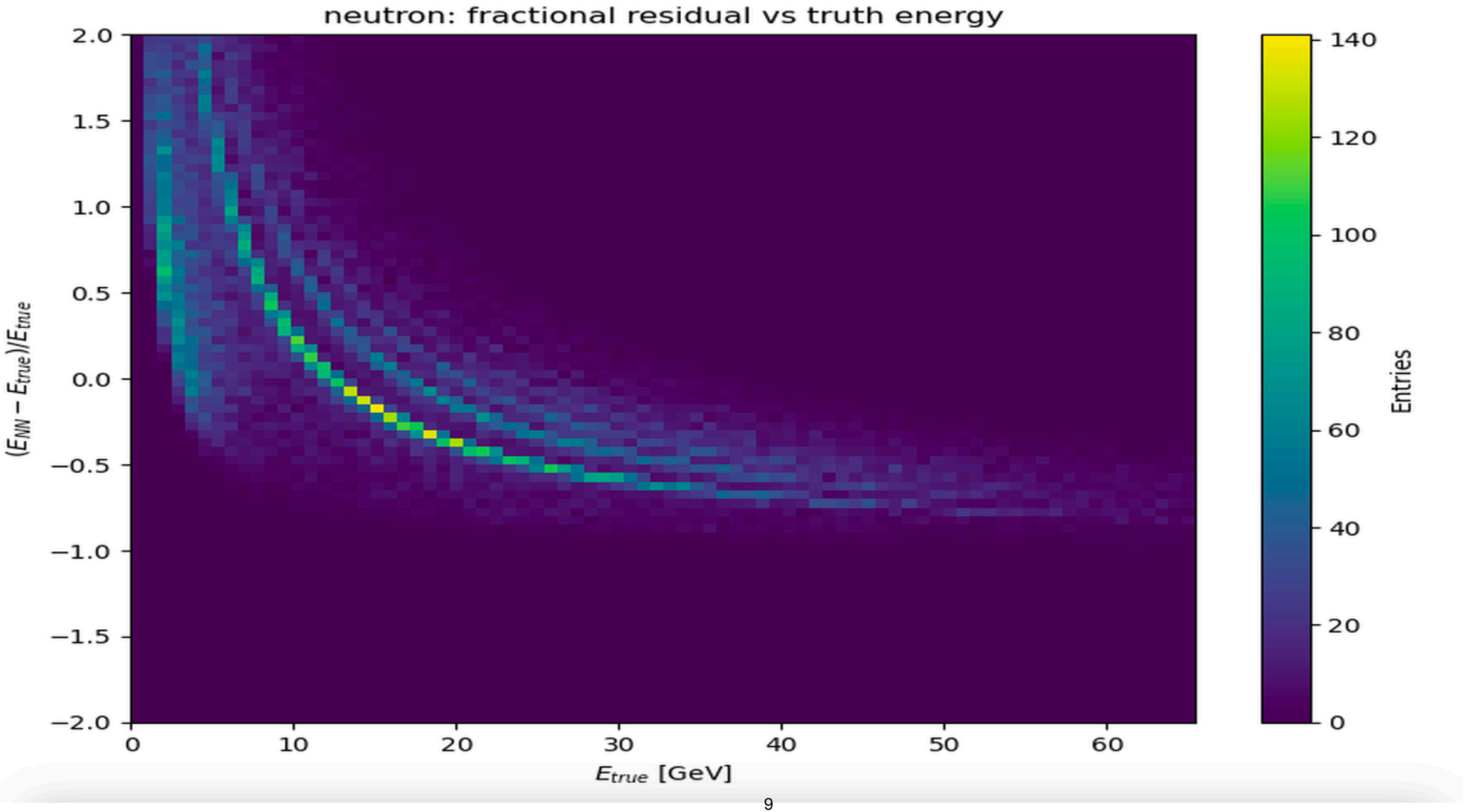
Calorimeter Resolution for pi_plus(Network Performance)



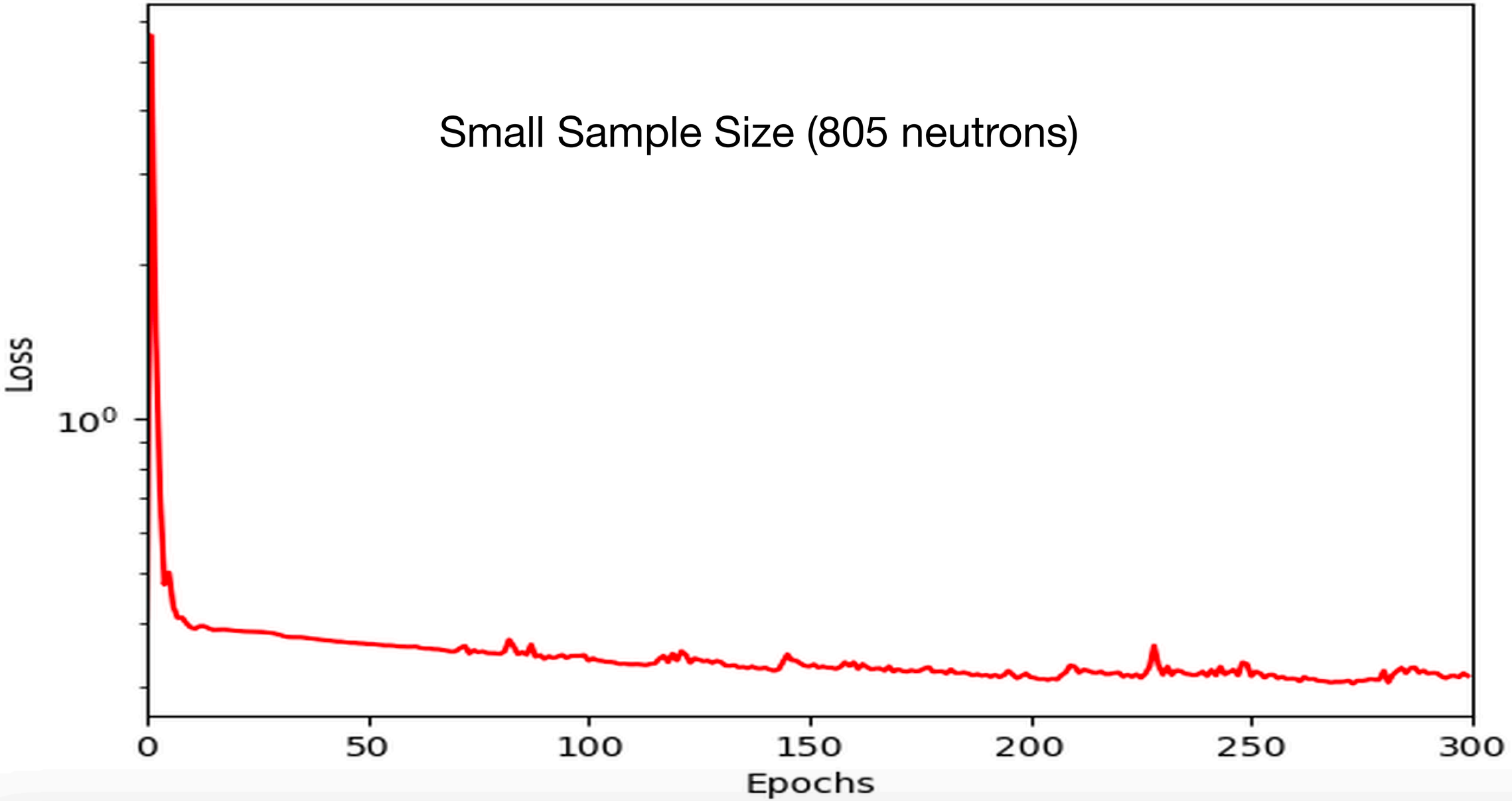
E(NN) vs E(True) for neutron



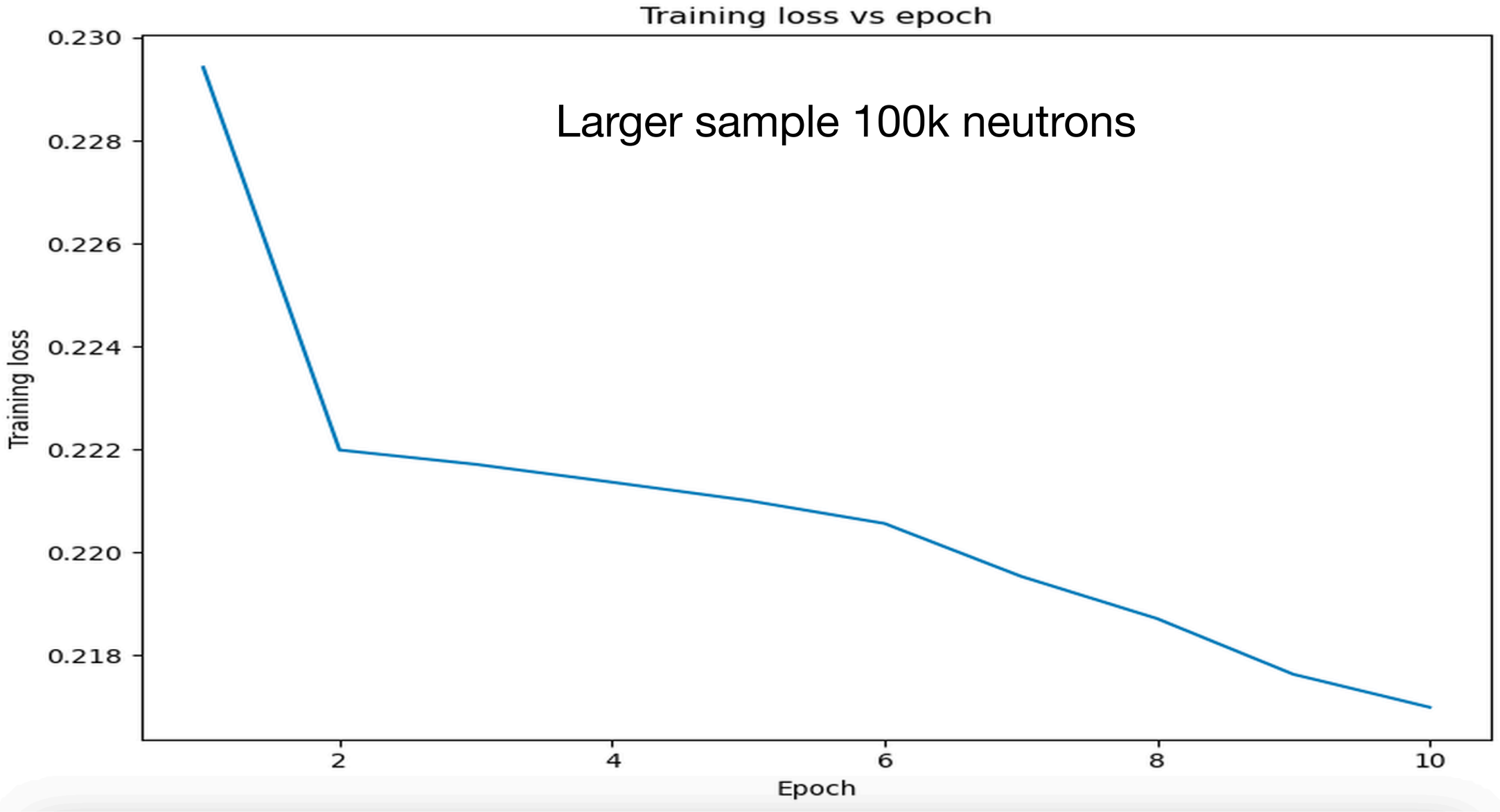
Fractional residual vs truth energy: neutron



Training Loss vs Epoch



Training Loss vs Epoch



Summary

- The PyTorch MLP code was adopted to read the new training file and run successfully
- The current results show that the ML pipeline is working end-to-end: tuple production, training, validation, and plotting. These results are useful as a first network-performance study using the continuous DIS sample.
- Use single-particle samples to extract the true BHCal energy resolution.

- Improve training with larger statistics and longer optimized training.
- Validate the trained model on independent single-particle simulation campaigns

Backup

E(NN) vs E(True) for pi_plus