BHCal Energy Calibration MLP Update

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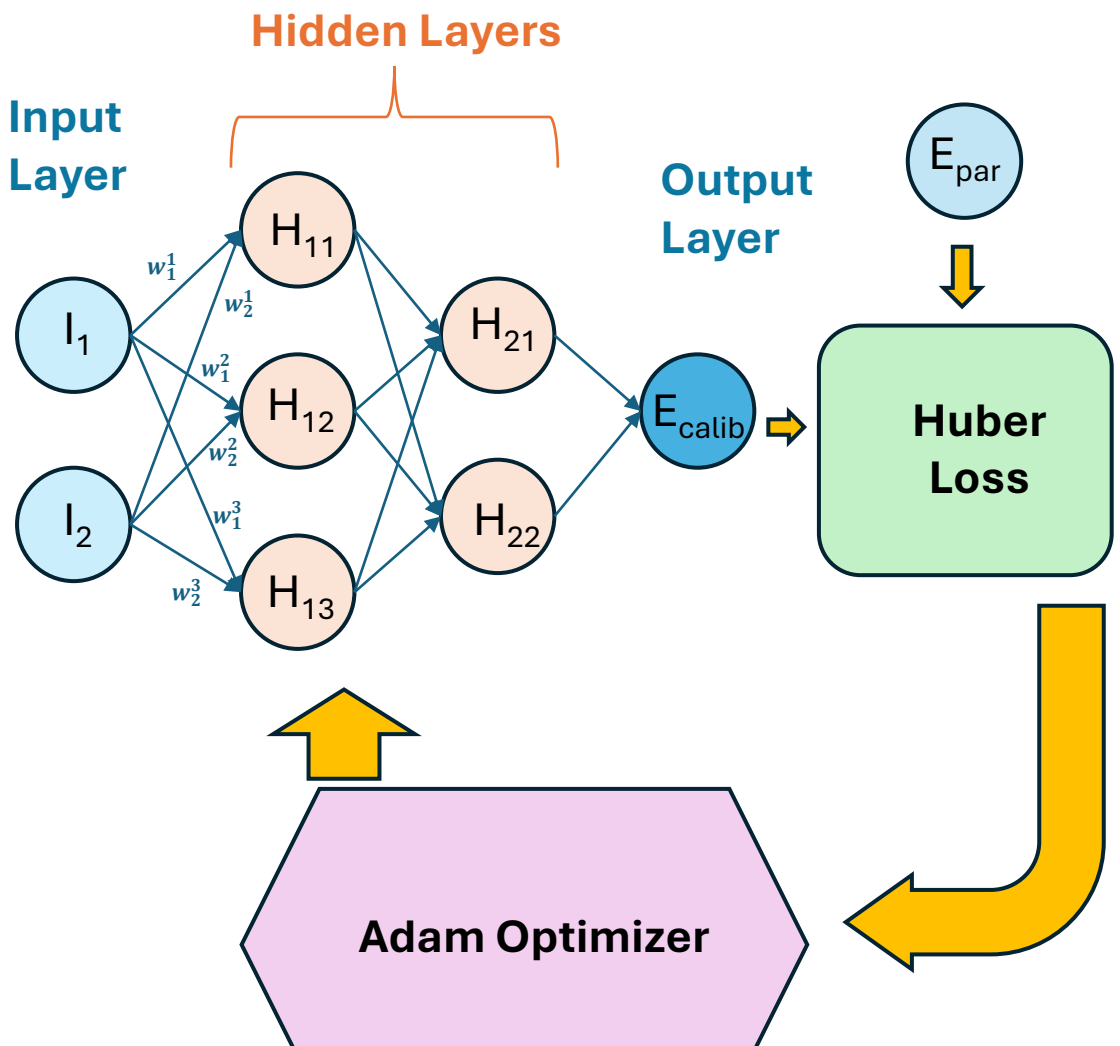
Refresher: Why bother with this?

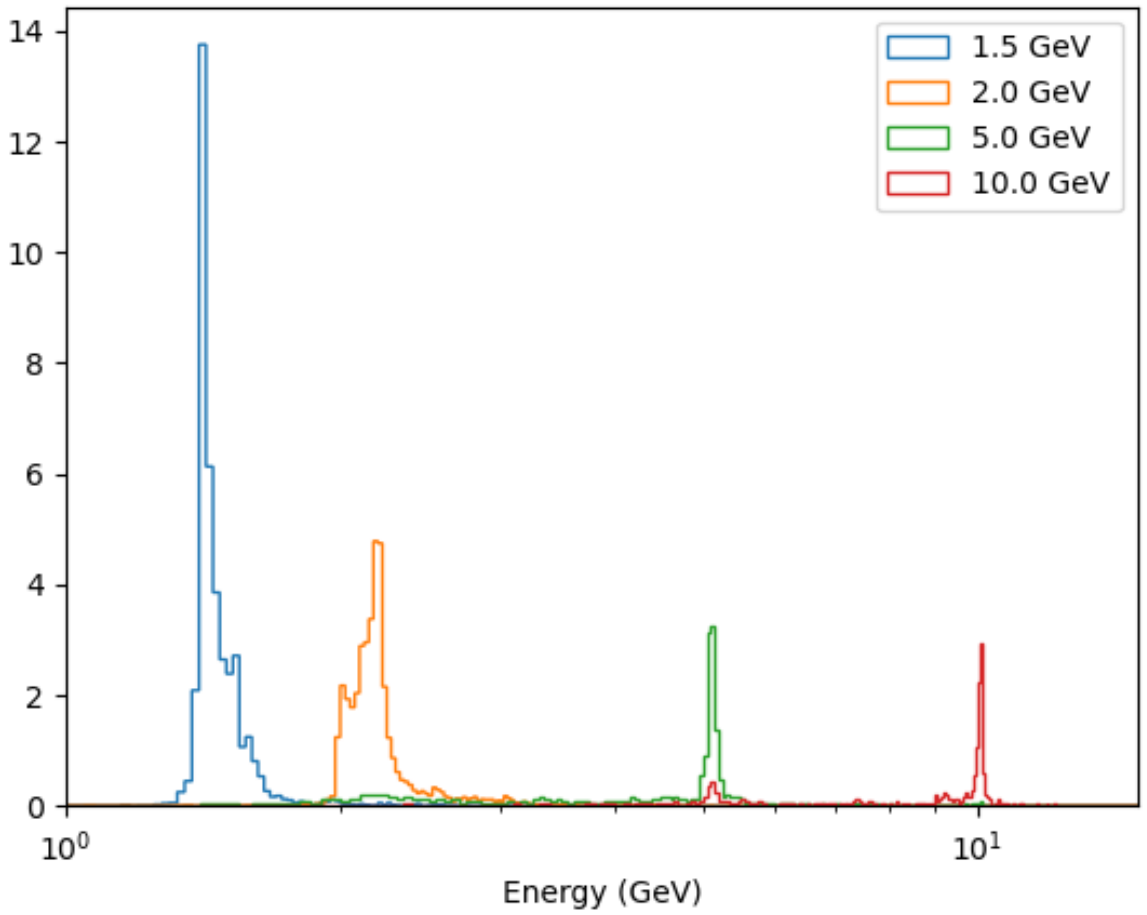
- Evidence that a tuned neural network can probably outperform the simple method of calibration, especially at low energies (See Jan Vanek's slides)
- Previous machine-learning solutions (TMVA) were limited by lack of options for improving the network and tuning the hyperparameters
- Multilayer Perceptron (MLP) – good "swiss army knife" neural network type
- New PyTorch MLP developed at UNH in spring, initial tuning done by Olaiya and Nathaly

Architecture Details



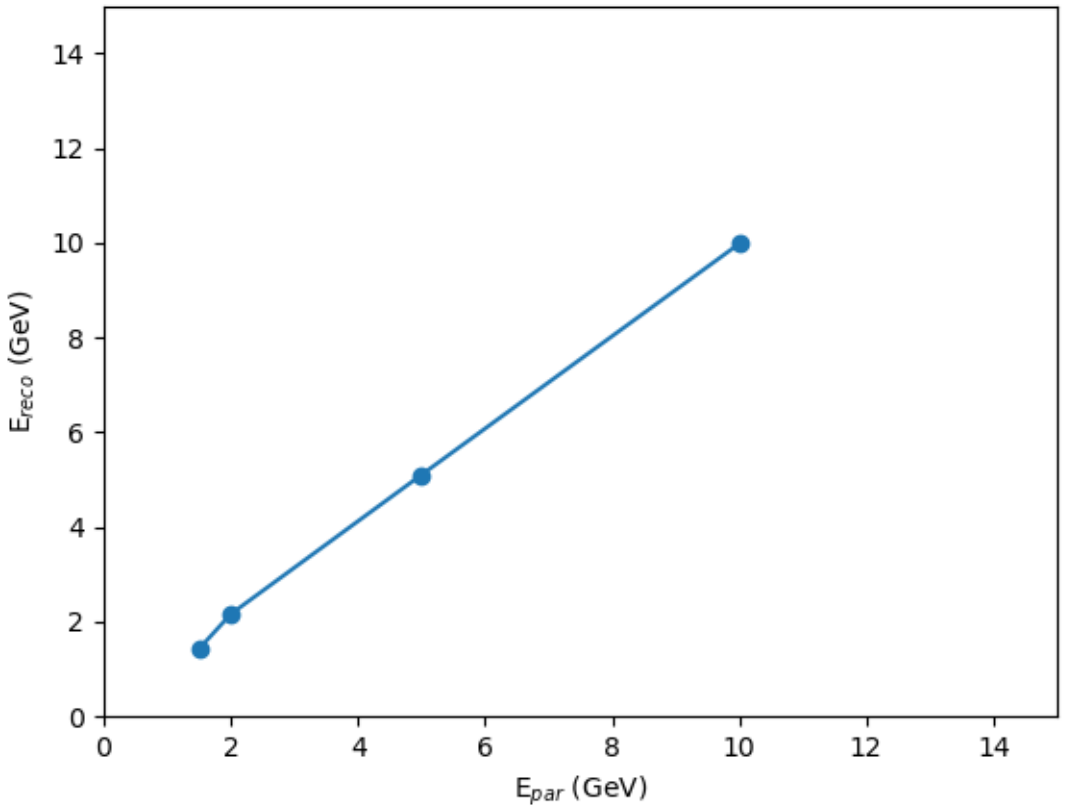
- "Dense/Fully-connected" network
- 128-512 neurons in first of 3-6 hidden layers, "reverse pyramid" structure
- **Training Inputs:** eLeadBEMC, eSumScFiLayer(1-12), eSumImageLayer(1-6)
- **Training Output:** ePar
- New modifications: implemented feature scaling (to handle broader range of energies) and Batch Normalization

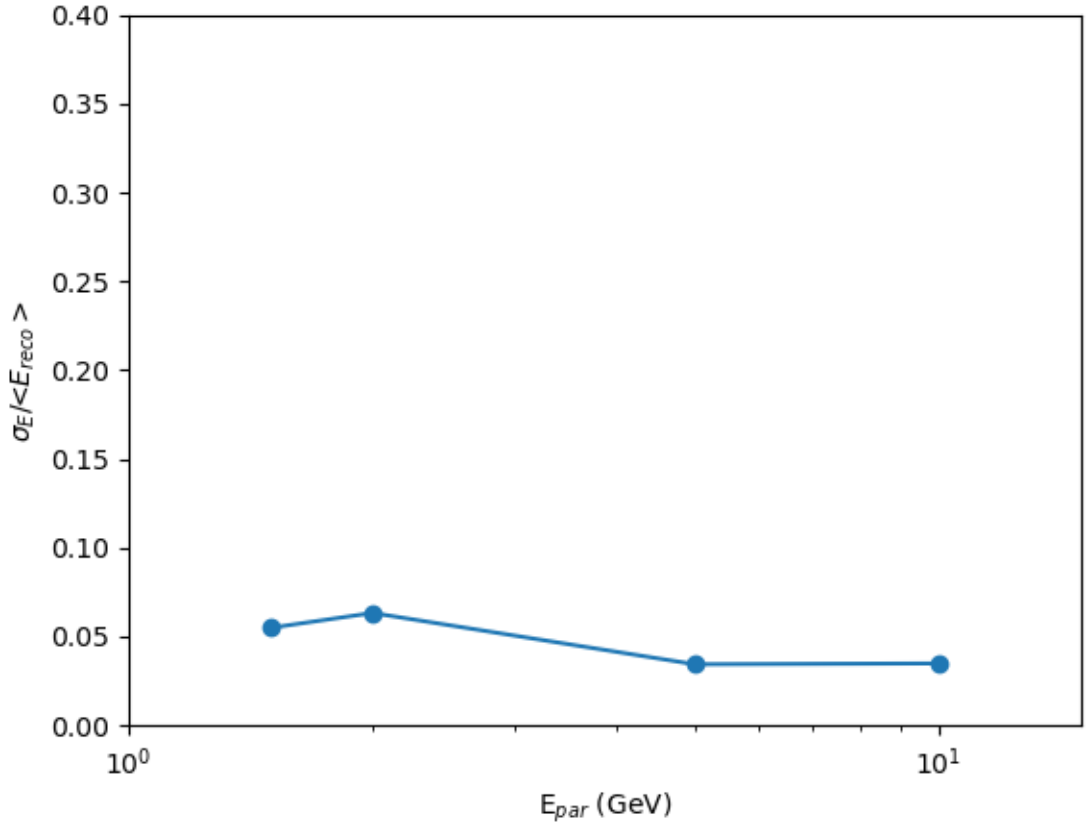
Current Neutron Output



- Training: 25.08.0 Simulation Campaign
- Some unphysical “wrong energy contamination” remaining
- Some of the peaks have longer tails
- But, resolution and linearity are massively improved from TMVA neural networks
- Note: some peaks are smaller, I think because the test/train breakdown is random with no consideration for energies, so sometimes you get well-trained peaks with a small number of events in the test set and vice versa

Current Neutron Output





Next Steps

- Several undergrads working with me have just start working on tuning hyperparameters
- Network should improve tremendously over the coming weeks
- Need to start training with continuous distributions instead of single energies