Energy Reconstruction in NOvA with Regression Convolutional Neural Networks (CNN)

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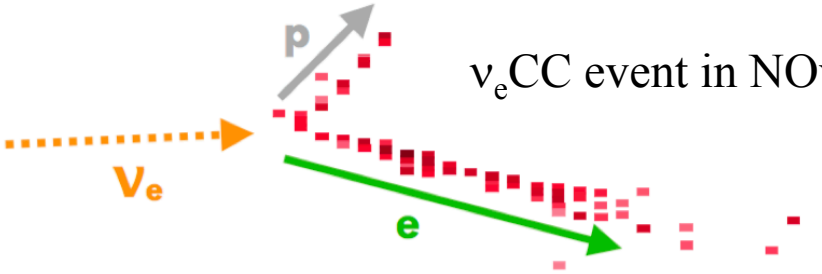
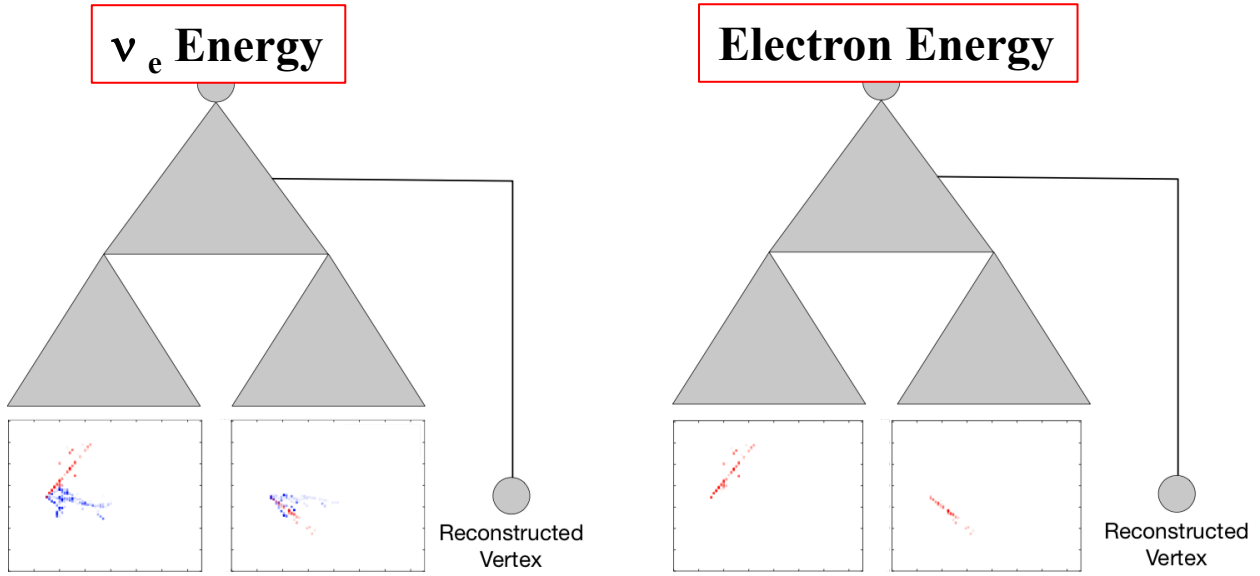
- CNNs have demonstrated success in **classification** problems such as event identification in NOvA and other neutrino experiments
- We propose a **regression** CNN based method to reconstruct ν_e energy and electron energy at NOvA
- Can be extended to other reconstruction tasks



ν_eCC event in NOvA Detector

Neural Network architecture:



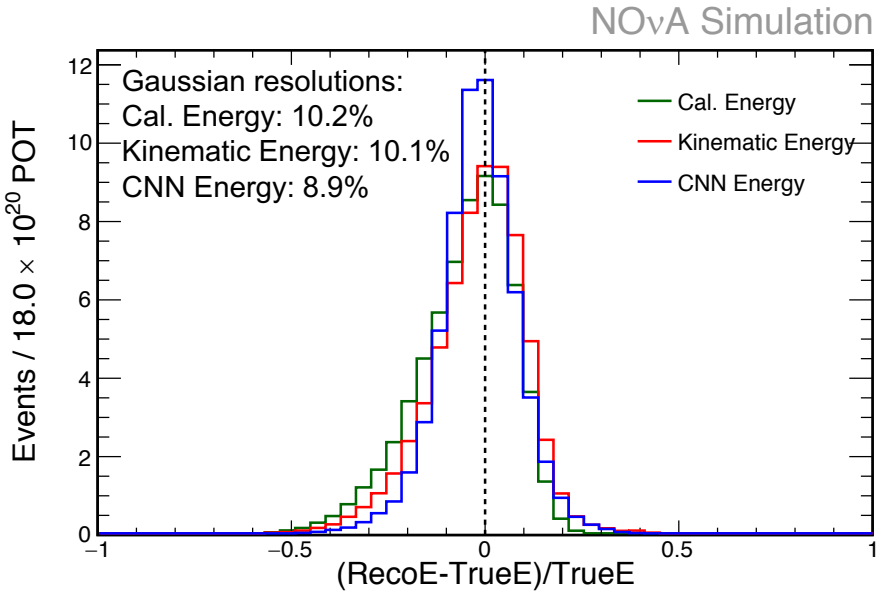
Key Features

- Raw detector pixel map inputs
- Linear output for continuous variables
- Choose loss function to optimize resolution and prevent large impacts from outliers
- Hyperparameter optimization software SHERPA used
- Flat neutrino flux training to reduce energy dependent bias

Loss function: $L(\mathbf{W}, \{\mathbf{x}_i, y_i\}_{i=1}^n) = \frac{1}{n}\sum_{i=1}^{n} |\frac{f_{\mathbf{W}}(\mathbf{x}_i) - y_i}{y_i}|$

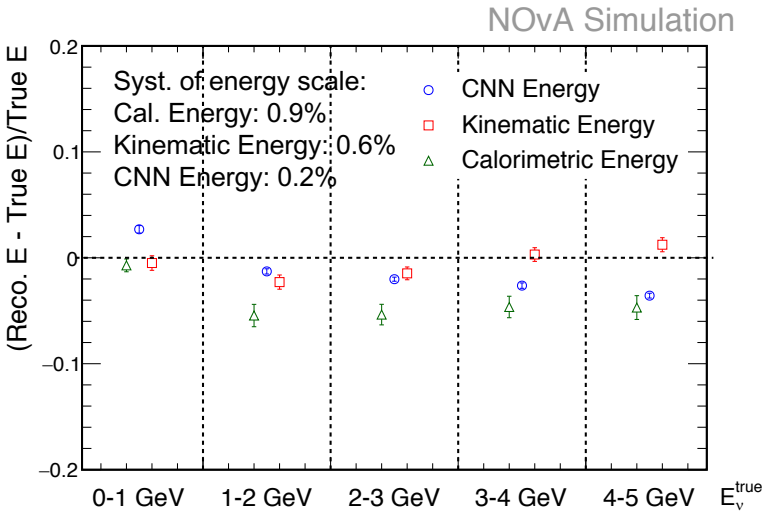
Regression Convolutional Neural Network for ν_e CC and Electron Energy

- Compared with kinematics-based energy reconstruction, Regression CNN shows a better resolution
- Regression CNN energy shows comparable or less true energy dependent bias
- Also shows smaller systematic uncertainties from the simulation of neutrino interactions (GENIE reweighting)

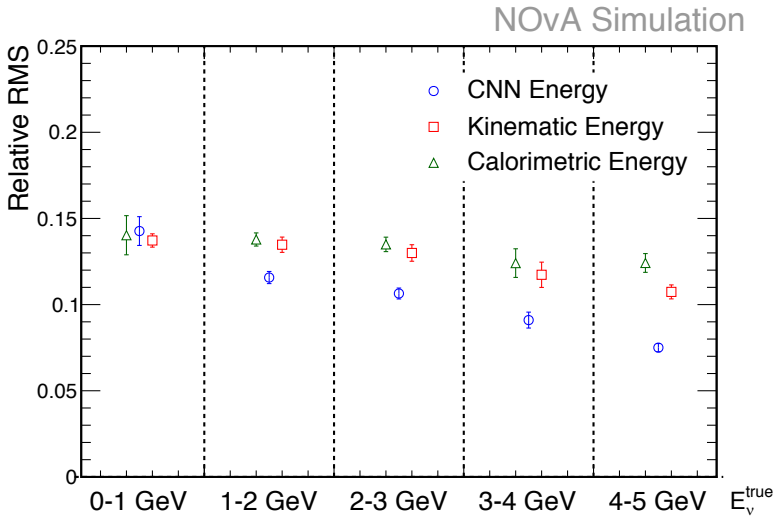


Electron Neutrino Energy

Reco. $E_{\nu e}$ Energy Scale vs. True $E_{\nu e}$



Reco. $E_{\nu e}$ Resolution vs. True $E_{\nu e}$



Error bars represent systematic uncertainties evaluated by GENIE reweighting