Neutrino energy reconstruction using machine learning technique

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Outline

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Motivation

- We check the viability of using machine learning algorithm (MLA) in reconstructing the neutrino energy.
- Neutrino Energy reconstruction has several challenges for example- missing energy, FSI, nuclear effects.
- For training the MLA we use data samples generated from two neutrino event generators viz. GENIE and GiBUU.
- The best result obtained is for a combined data sample from both the neutrino event generators.
- We also compare it with the traditional calorimetric method of neutrino energy reconstruction.

Analysis

- We have selected two nuclear targets: Argon(A=40) and Hydrogen(A=1).
- An inclusive data sample (ν_{μ} -Ar, H) of 1 million statistics is generated with the DUNE (ND & FD) flux.
- The Final State Particles (FSI) data as obtained from GENIE and GiBUU is given as an input to MLA for predicting the neutrino energy.
- We have calculated the ratio of Ar/H in order to quantify nuclear effects in Ar.



Calorimetric technique

• Applying the calorimetric approach i.e. summing up all the outgoing particles, E_{ν}^{Calor} (reconstructed neutrino energy), can be calculated as-

$$E_{\nu}^{Calor} = E_{lep} + \sum_{i} T_{i}^{nuc} + \epsilon_{nuc} + \sum_{m} E_{m}$$
(1)

• where E_{lep} is the outgoing final state charged lepton's energy, T_i^{nuc} is the kinetic energies of the outgoing nucleons(i.e. the protons and/or neutrons), their corresponding separation energies represented as ϵ_{nuc} and total energy of any other particle produced represented as E_m .

Machine learning technique

- Here we are using linear regression model which comes under supervised learning to train our algorithm.
- We divide our data sample into training and testing sample. 70% of the data sample is used to train the model and 30% is used for testing.
- The features for our algorithm are momenta(p_x, p_y, p_z), energy(p_0), mass of the particles in the final state.

Muon survival probability for Argon



Figure 1 : A comparison of muon survival probability calculated using calorimetric and linear regression technique as a function of reconstructed neutrino energy.

Muon survival probability for Hydrogen



Figure 2 : A comparison of muon survival probability calculated using calorimetric and linear regression technique as a function of reconstructed neutrino energy.

Probability Ratio: Ar/H



Figure 3 : Ratio of survival probability Ar/H. Left panel represents results from GENIE and right panel represents result from GiBUU.

Probability Ratio Ar/H: GENIE+GiBUU



Figure 4 : Ratio of survival probability Ar/H after combining data from GENIE and GiBUU represented by green solid circles.

Thank you

