Neutron-antineutron oscillation sensitivity study at DUNE

Justin Wheeler, Carthage College – SULI Intern

FERMILAB-POSTER-24-0204-LBNF-STUDENT

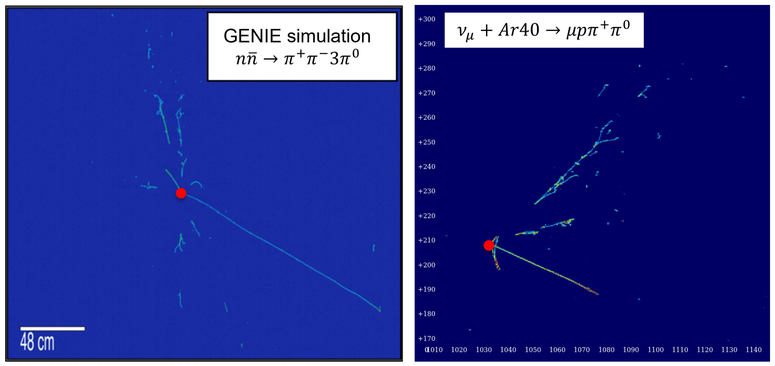
Motivation

- Baryon asymmetry of the universe motivates baryon number violating process (BNV) search
- The Deep Underground Neutrino Experiment (DUNE) will be a new neutrino observatory and nucleon decay detector
- DUNE investigates spontaneous conversion of a neutron to an antineutron $(n \to \bar{n})$ bound in argon nuclei
- This analysis uses DUNE Far Detector simulations

Signal/Background Features

Antineutron annihilation

Atmospheric ν interaction



DUNE Far Detector simulation

- $n \to \bar{n}$ is signal in this study
- Post-oscillation, antineutron annihilates with nucleon
- Product particles are mostly pions in many directions
- Atmospheric neutrinos are dominant background for $n \to \bar{n}$ search
- Product particles exhibit preferential direction

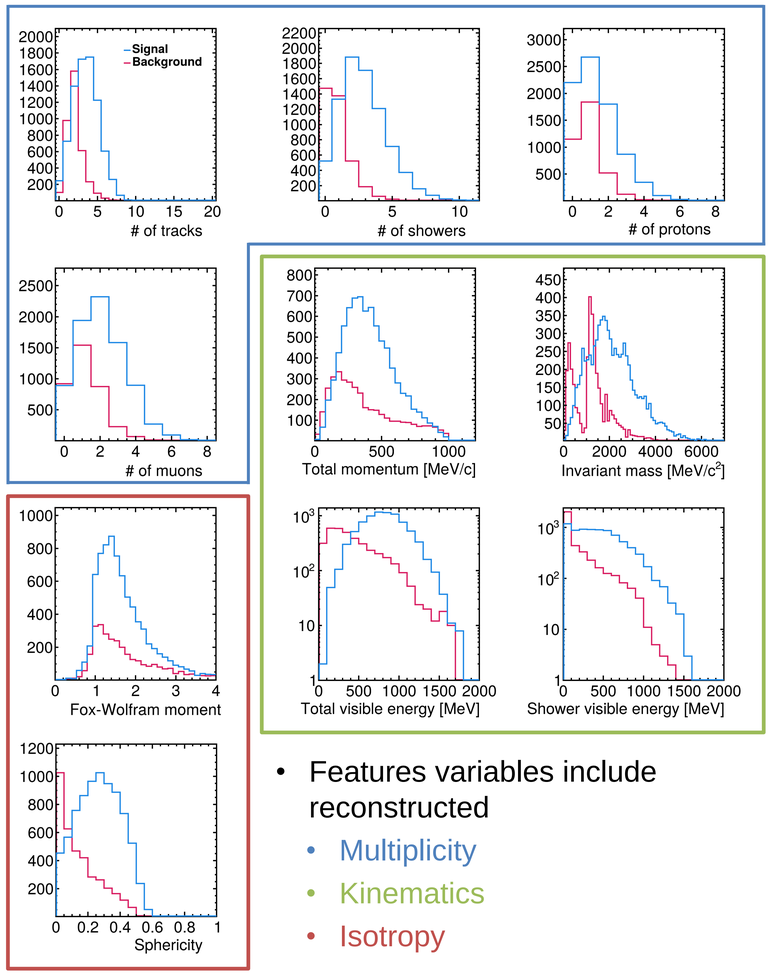
Contact: jwheeler1@carthage.edu

linkedin.com/in/justin-wheeler88/

Classification Pre-cuts

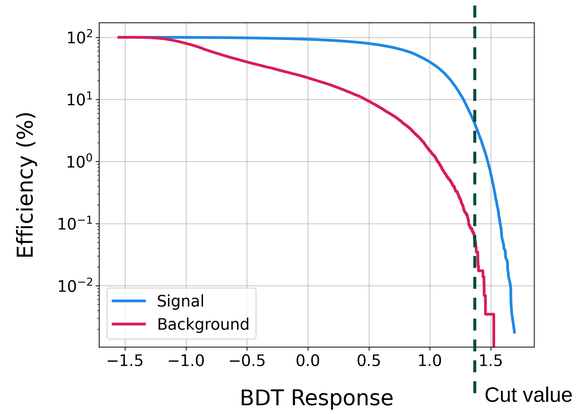
- 100k simulated signal and background events
- Reject all events with
  - < 2 reconstructed particles
  - > 980 MeV total reconstructed momentum
  - > 1800 MeV total visible energy

Feature Variables



- Features variables include reconstructed
  - Multiplicity
  - Kinematics
  - Isotropy

Preliminary Results



- Currently have a 3.0% signal efficiency at 99.98% background rejection
- Corresponds to 90% C.L. free $n \to \bar{n}$ lifetime limit of 5.16×10^8 s with 400 kton·yr exposure of DUNE Far Detector (without systematic uncertainty analysis)

Future Work

- Experiment with BDT parameters to prevent overtraining
- Experiment different input feature variables
- Optimize an analysis cut towards best sensitivity

Acknowledgements

- I would like to thank my supervisor, Dr. Linyan Wan, for her mentorship and support during my internship

- This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.
- This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).