Neutron-antineutron oscillation sim/reco needs

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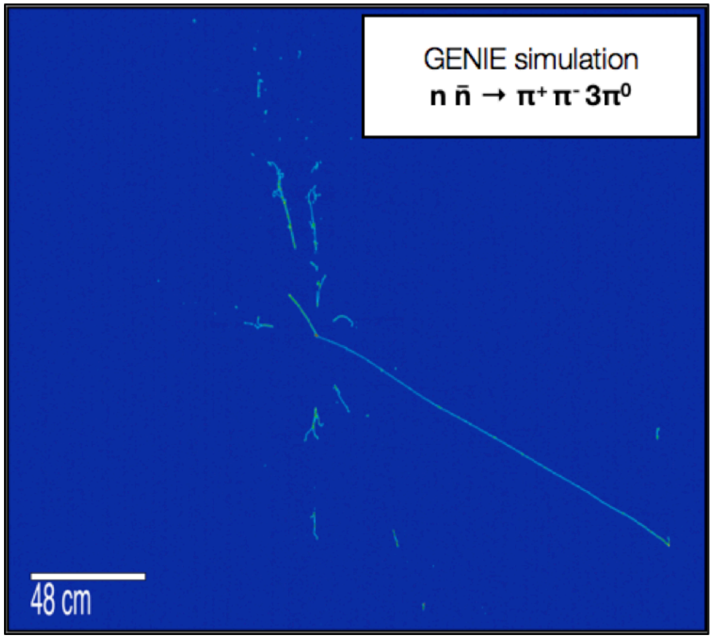
Neutron-antineutron oscillation in DUNE

Search for rare, baryon-number violating signature.

Anticipated background contributions from atmospheric neutrinos.

Signature/topology is visually striking: “star event” → Use a trained CNN to differentiate n-nbar events from atmospheric neutrino events.



For more details on analysis method, results, and current status, see yesterday’s talk by Yuyang Zhou:

https://indico.fnal.gov/event/15181/session/2/contribution/11/material/slides/0.pdf

Neutron-antineutron oscillation in DUNE

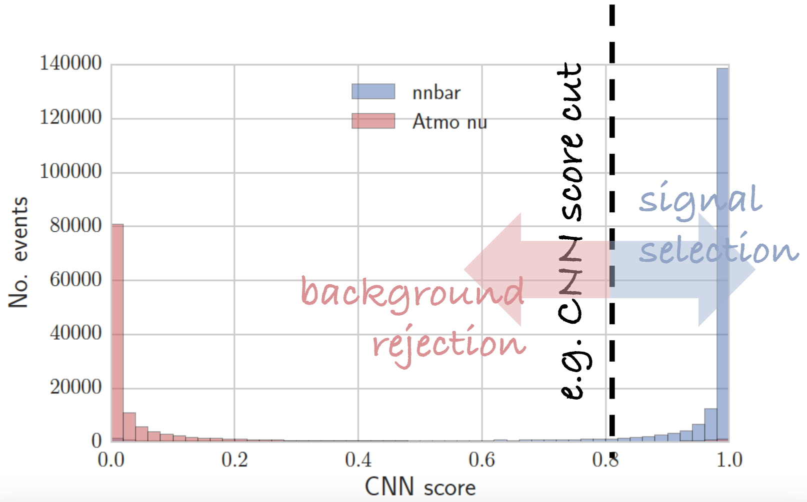
Results:

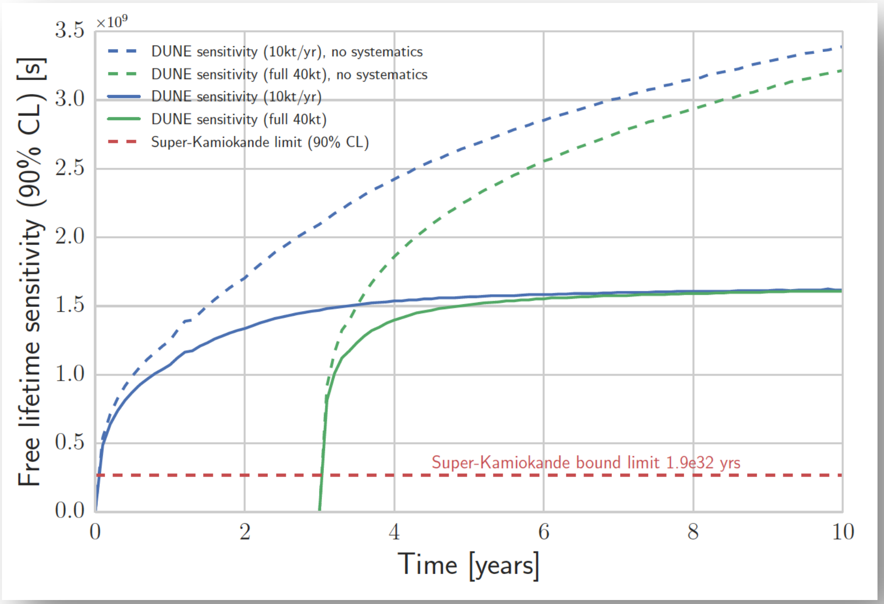
Network training results show excellent signal vs. background separation.

Optimized score cut yields 14% signal efficiency and 99.997% background rejection efficiency →

DUNE sensitivity is 5x better than the existing bound from Super-Kamiokande (leading world limit on this process).

Systematic uncertainties:
largely educated guesses based on Super-K search





Simulation needs

Systematic uncertainty assumptions are in need of further work and studies to validate/better quantify.

Signal simulation uncertainties:
- nuclear suppression factor for bound-neutron oscillation
- final state branching fractions and final state interactions within the nucleus

Background simulation uncertainties:
- atmospheric neutrino fluxes
- neutrino cross-sections, including nuclear effects and final state interactions within the nucleus

Selection efficiency:
- ROI selection efficiency
- finite statistics size of sample used for training and inference
- backgrounds from other detector activity (e.g. cosmics)

Detector response:
- gain variation
- field non-uniformity
- electron lifetime
- noise levels

Simulation needs

Systematic uncertainty assumptions are in need of further work and studies to validate/ better quantify.

Signal simulation uncertainties:

- nuclear suppression factor for bound-neutron oscillation *from theory; can quote bound lifetime*
- final state branching fractions and final state interactions within the nucleus *J. Barrow et al.*

Background simulation uncertainties:

- atmospheric neutrino fluxes ~ *well-characterized*
- neutrino cross-sections, including nuclear effects and final state interactions within the nucleus ~ *well-characterized*
- backgrounds from other detector activity (e.g. cosmics)

Selection efficiency:

- APA and ROI selection
- finite statistics of samples used for training and inference

Detector response:

- gain variation
- field non-uniformity
- electron lifetime
- noise levels
- data reduction scheme

need dedicated studies → more event samples!

processing ~~Reconstruction~~ needs

- Very minimal reconstruction needs (we use recob::Wire after deconvolution and before hit finding), and then apply APA/ROI selection and feed images to CNN.
- However, it might be useful to study different zero suppression/data reduction schemes → deconvolution; and effects of different ROI selection (threshold based, after deconvolution).

For each MC systematic variation, will need:

- ~200,000 n-nbar events and ~200,000 atmospheric neutrino events (for inference)
- 4,000 jobs x 5,000 events/job, on grid, taking about 5,000 hrs per sample, and 200-500 GB per sample

For additional backgrounds studies, will need

- Cosmogenic simulations (10x expected data statistics?)