MicroBooNE Data Fitting & Analysis

Savannah King

10 June 2019

MicroBooNE

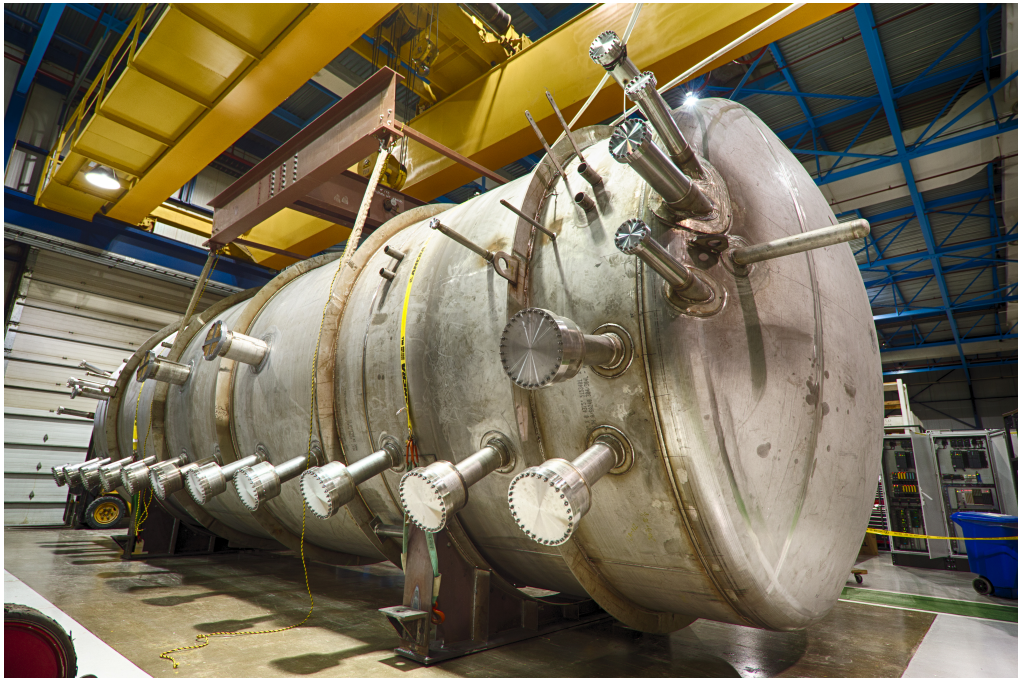

Figure: MicroBooNE cryostat

Micro Booster Neutrino Experiment

- 170 ton LArTPC (liquid argon time projection chamber) in the Booster Neutrino Beam (BNB)
- Utilizes extremely cold liquid argon (87K) to observe trails of ionized electrons produced by charged particles in the detector
- Began collecting neutrino beam data in October 2015

Goals & the Low Energy Excess

- MiniBoone & Liquid Scintillator Neutrino Detector (LSND) experiments observed an excess of electron-like events at low energy
- Origin of excess is still unknown but possibly due to the presence of a sterile neutrino that amplifies the $(\nu_\mu \rightarrow \nu_e)$ oscillation
- Goal of MicroBooNE is to investigate this excess of events by utilizing the ability of liquid argon time projection chambers (LArTPC) to perform electron/photon separation

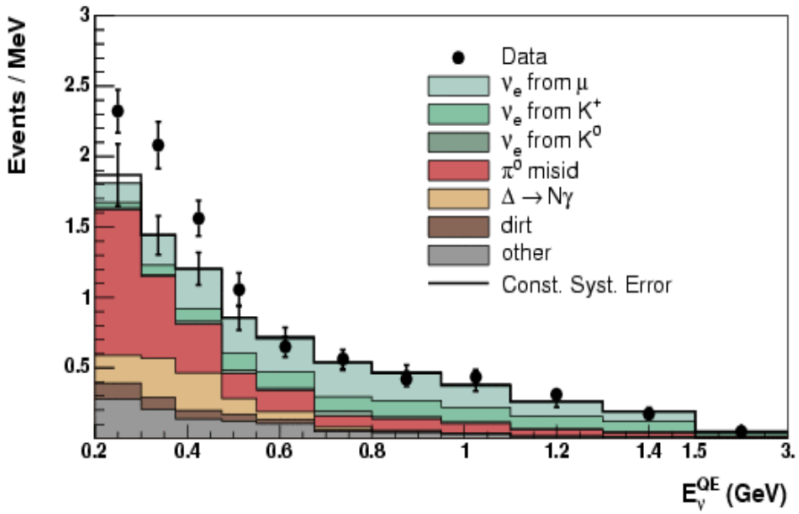

Figure: MiniBooNE low energy excess

SBNfit

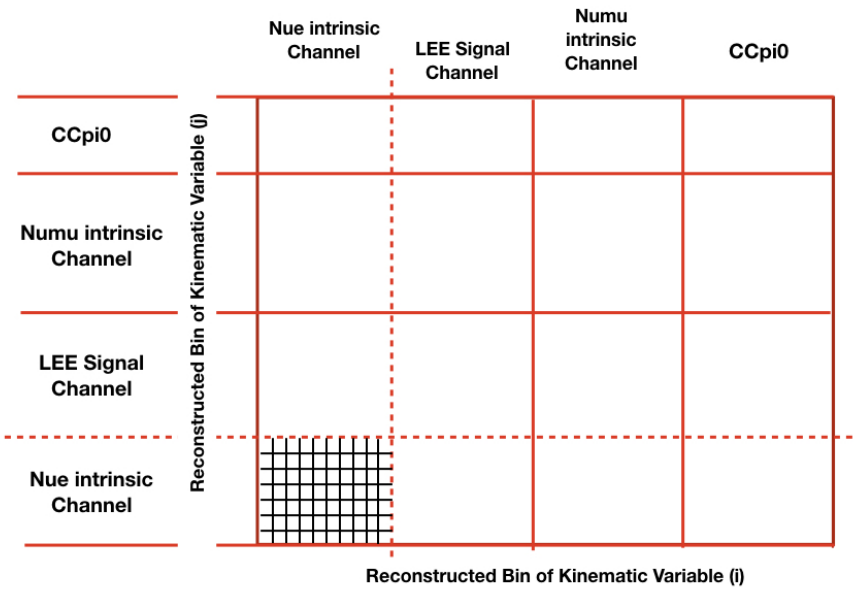

Figure: Representation of a covarience matrix calculated in SBNfit

- Data fitting framework for sterile decays at SBN facilities (SBND, MicroBooNE, ICARUS)
- Allows the fitting of multiple modes, detectors, and channels simultaneously
  - Modes: Neutrino/antineutrino, etc.
  - Detectors: MicroBooNE, MiniBooNE, ICARUS, DUNE, etc.
  - Channels: Physically observable selections (ccpi0, ν_μ, ν_e, etc.)

Calculations in SBNfit

$$E_{ij}^{sys} = \frac{1}{N}\sum_{k}^{N}(N_i^{CV} - N_i^k)(N_j^{CV} - N_j^k)$$

Equation: Calculating a covariance matrix, where N is the total number of variations, N_j is the value in the i-th bin of the k-th variation and N_i is that of the central value.

$$\chi^2 = \sum_{l,k=1}^{M}(N_k - N_k^{null})E_{kl}^{-1}(N_l - N_l^{null})$$

Equation: χ^2 calculation, where M is the total number of bins and E^{-1} is the inverse of the covariance matrix associated with the null hypothesis

Project Goals

- Learn the implementation of SBNFit
- Develop new algorithms for analyzing and fitting data and evaluate the new implementation using toy data
  - Incorporate systematic uncertainties represented by the nuisance parameters into SBNfit by modifying the χ^2 calculation
  - New algorithms will improve data fitting & sensitivity analysis for the SBN experiments
- Begin adapting software to run on supercomputers

References

[1] Fermilab, MicroBooNE liquid-argon time projection chamber & MicroBooNE Physics, https://microboone.fnal.gov.

[2] N. Foppiani, Search for a Low Energy Excess in MicroBooNE, 14 May 2019, arXiv:1905.05325v1 [hep-ex].

[3] D. Cianci, A. Furmanski, G. Karagiorgi, & M. Ross-Lonergan, Prospects of Light Sterile Neutrino Oscillation and CP Violation Searches at the Fermilab Short Baseline Neutrino Facility, 6 Feb 2017, arXiv:1702.01758v1 [hep-ph].

[4] M. Ross-Lonergan, SBNfit, https://github.com/markrosslonergan/whipping_star.