A preliminary investigation into determining $CC0\pi$ cross-section sensitivities in SBND

Rhiannon Jones
University of Liverpool
School of Physical Sciences
rjones@hep.ph.liv.ac.uk
1st year PhD report

April 26, 2017

Abstract

Random stuff

1. Introduction

Neutrino physics is at the core of current high energy research. The standard model of particle physics explains many elements of the physical nature of our universe, though we now know that it does not cover everything. If neutrinos were to be described by the standard model they would be massless, but this was proved not to be the case when the Super-Kamiokande experiment observed neutrino flavour oscillations find reference. Neutrino research provided the first confirmation of the existence of physics beyond the standard model.

Future, long-baseline, neutrino experiments such as the Deep Underground Neutrino Experiment (DUNE) and Hyper-Kamiokande (Hyper-K) are hoping to investigate some of the most fundamental questions we are still asking: Why does the universe constist of matter, and not anti-matter? What is the neutrino mass heirarchy?

Neutrino research is an extremely active field. Optimising the current and future detectors to maximise the accuracy of all interaction anaylses is a crucial step towards obtaining concrete answers to these questions.

1.1. Neutrino interactions

Due to the elusive nature of the neutrino, directly observing one in a detector isn't possible. It is therefore necessary to infer their existence from particles produced when they interact. Since this process relies upon the reconstruction capability of the experiment, purpose-built detectors have been constructed to maximise the efficiency of neutrino reconstruction.

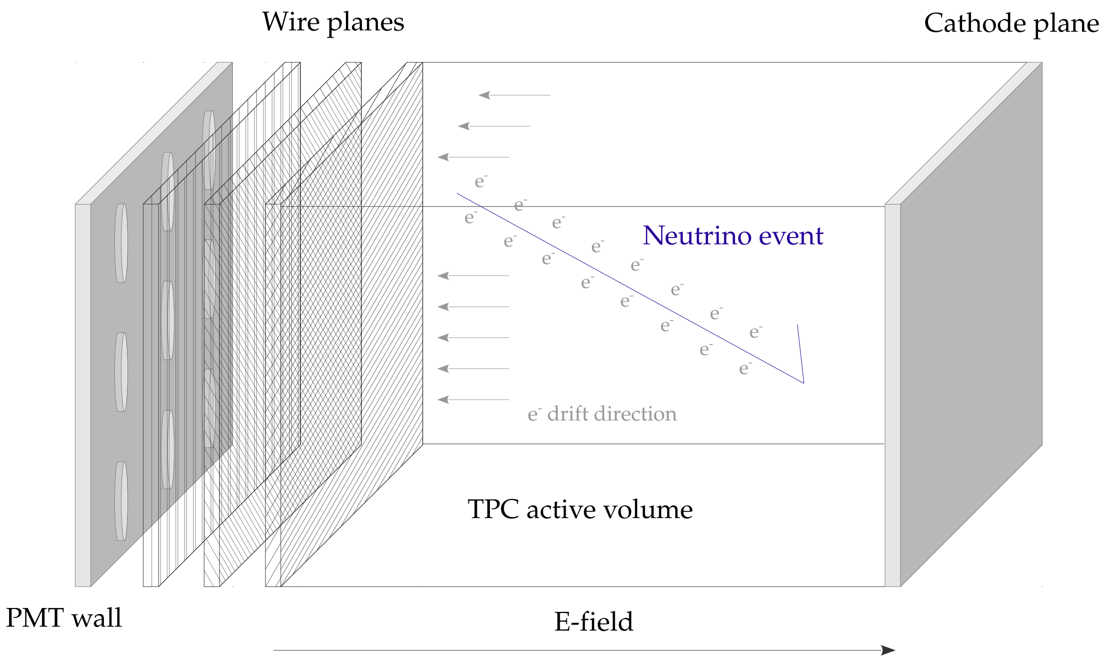
1.2. GENIE

GENIE is the world leading neutrino interaction generator.

1.3. Cross-sections

- Why?
  - Simulation
  - GENIE
- Historical
- Current knowledge
- Needs for future
  - LArTPCs
  - Statistics

Process		No. Events
	ν_μ Events	
CC 0 π	$\nu_\mu N \rightarrow \mu + Np$	3,551,830
CC 1 $\pi^\pm$	$\nu_\mu N \rightarrow \mu + nucleons + 1\pi^\pm$	1,161,610
CC $\geq 2\pi^\pm$	$\nu_\mu N \rightarrow \mu + nucleons + \geq 2\pi^\pm$	97,929
CC $\geq 1\pi^0$	$\nu_\mu N \rightarrow \mu + nucleons + \geq 1\pi^0$	497,963
NC 0 π	$\nu_\mu N \rightarrow nucleons$	1,371,070
NC 1 $\pi^\pm$	$\nu_\mu N \rightarrow nucleons + 1\pi^\pm$	260,924
NC $\geq 2\pi^\pm$	$\nu_\mu N \rightarrow nucleons + \geq 2\pi^\pm$	31,940
NC $\geq 1\pi^0$	$\nu_\mu N \rightarrow nucleons + \geq 1\pi^0$	358,443
Total ν_μ & ν_e events		7,251,948



1.4. SBND

- LArTPC general functionality
- LArTPC resolution benefits
- Comparison with other detector materials
  - Example event display?
- SBND specifics

  - Dimensions
  - Beamline
  - Flux
  - Statistics
- Cross-section precision capabilites

1.5. GENIE-Professor global fits

2. Neutrino Interaction Phenomenology in the few-GeV Energy Range

2.1. Dominant topologies

2.2. Golden channel

2.3. Signal

2.4. Potential backgrounds

2.5. Maybe some results here?

3. Theory and Recent Measurements of CC0π Cross-Section

3.1. Cross-sections

Inc. equations

3.2. Method

3.3. Unfolding

3.4. Results

Plots and cross-section values

4. A Global Fit of CC0π Data

4.1. Experiments involved

4.2. Process

4.3. Results

5. Prospects for a CC0π Measurement at SBND and Sensitivity Esimates

5.1. SBND sensitivity

5.2. Future

6. Discussion

References