Precise Measurement of Pion Cross-section

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1. Motivation : Why Pion interaction?

For neutrino experiment:
If a secondary τe generated by neutrino interaction is absorbed by nuclei, such τe is not detected. This becomes major backgrounds for νe appearance, and the energy spectrum of CCQE νe events would be distorted. Thus, precise measurements of τe interaction is necessary for the precise measurement of the oscillation parameters.

For nucleon decay experiment:
τe interaction also plays a key role to nucleon decay. This is because that for Kν interaction, π and K0 are generated by neutrino nucleon decay. This is because that for Kν interaction also plays a key role to evaluate the MC simulation of e and m mode, and could determine how much fraction of the τe should interact in the nucleus.

2. Experimental setup

TRIUMF Acc.

Oct1/2010-Nov30/2010
>480MeV/c proton from cycl.
>π+ beam at M11
>P0: 150-375MeV/c
>Trig rate(S0&S1): <30Hz
>Selection/Detection efficiency
Systematic uncertainty study
γs
Cx like
Inel. scattering like
Fraction of π in each momentum
Track reconstruction and Analysis
Rmip
Ch
16NaIs for Config.B to measure

Harpischord: Miniature of T2K FGD consists of 1cm square scintillator with WLS coupled to MPPC. 15layers of 32(x) x 32(y) channels.

We took data with 2 configurations.

3. PIaV-O detector

1.5 mm square x 60cm length scint. fib. 16layers of 32(x) x 32(y) 1024fib in total. 8 x 8 fib. coupled to 1 MAPMT. MAPMT is coupled to FEB.

To measure absorption and charge exchange cross-section separately. NaI (crystal size: 5cm x 5cm x 15cm) detectors are installed to detect vs from m mode decays. 15NaIs for Config.A 16NaIs for Config.B 15NaIs for Config.B, Harpsichord has~1.5mm lead plates in between each layer.

4. Hit level analysis

Before track reconstruction is implemented, we needed to verify our data. Also, the result of this study will be compared with results from track reconstruction, and check the systematic uncertainty on both results.

Selection of Absorption/Cx candidate
1. Incoming mip particle should be in inside 20 fiber (out of 32)
2. Clean event selection
3. Number of layers which incoming mip particle went through: 3-<15
4. Total PE > 600 p.e. (mip hit ~12p.e.)
5. Total PE of mip range hits of large hits (Rmip>25)

Abs/Cx like
Absorption like
neg. scattering like
Rejection
Abs/Cx like
Scatt. like
Abs/Cx like

Example of distributions for 250 MeV/c mode

5. Status and TO DO

>Fraction of selected events and penetrated events as a function of incoming m momentum (right plot).
>Selection/Detection efficiency, is not corrected.
>(Need MC simulation)
>Fraction of in each momentum setting is corrected by fitting the distributions.
>(Need to develop better method using Cheerenkov detector)
>After the robust selection cuts, the statistical uncertainty is ~5% for Cx like events. Cx data have >20%. uncertainty.
>Next thing to do
>Use Harpsichord data to see Cx event
>MC development
>MC based on G4
>Implement NEUT τ interaction into G4 code
>Develop PIaV-O-Harpischord integrated MC
>Efficiency check for the hit-level analysis
>Track reconstruction and Analysis
>Get cross section
>Systematic uncertainty study
>Analysis of number of ejected nucleon after absorption which is not simulated in current NEUT
>Prepare for next beam test in May/June 2011
>Install water layer

6. Summary

>Precise measurements of τe interaction are necessary for the precise measurement of the oscillation parameters since the uncertainty of pion interaction is one of major sources of systematic uncertainty for neutrino beam flux and spectrum measurement.
>This measurement also contribute verification of MC simulation to nucleon decay experiment.
>From Oct.1 to Nov.30, 2010, we performed an experiment to measure the pion interaction cross section at TRIUMF M11 beam line.
>For the experiment, two new detectors are developed: one in Kyoto and the other one in TRIUMF.
>Hit level analysis is performed to check data quality. Even after the strict cuts, we still have enough statistics (statistical uncertainty ~5%).
>Wrap up the result within 1year including the result from next beam time from May 2011.