Neutrino reaction in N^* and Δ resonance region

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The neutrino induced meson production through nucleon resonances is the main mechanism in GeV neutrino reaction. Precise understanding of the reaction is crucial to extract neutrino physics from the long base line neutrino and the atmospheric neutrino. We have developed a coupled channel reaction model of electroweak meson production reactions by extending the ANL-Osaka DCC model of $\pi N, \gamma N \to \pi N, \eta N, KY$ reactions[1].

In developing model of pion production, a common procedure is to adjust model parameters to fit the ANL and BNL total cross section data of $\nu_\mu N \to \mu^- \pi N$. Those currently available data are extracted from $\nu_\mu d \to \mu^- \pi NN$ assuming quasifree mechanism. We have studied the νd reaction including final state interaction(FSI) from NN and πN rescattering[2]. The analysis of the momentum distribution of spectator nucleon shows significant reduction of the spectra due to the FSI. A recipe to extract νN cross section from νd observable is proposed for possible future experiments.

The angular distribution of pion in neutrino-nucleon reaction can be generally written as

$$\frac{d\sigma}{dE_l d\Omega_l d\Omega^*_\pi} = \frac{|\boldsymbol{k}_l|}{|\boldsymbol{k}_\nu|}\frac{G_F^2}{4\pi^2}(A + B\cos\phi^*_\pi + C\cos 2\phi^*_\pi + D\sin\phi^*_\pi + E\sin 2\phi^*_\pi),$$

where ϕ^*_π is the angle between lepton and hadron scattering plane. The coefficients A, B, C, D and E are function of pion angle θ^*, invariant mass W and momentum transfer Q^2. The coefficients D and E depending on $\sin\phi^*_\pi$ are parity and time-reversal odd terms due to parity violation in weak interaction and hadronic final state interactions. We have investigated in detail the angular distribution of the pion with the state-of-the-art models for electroweak pion production reactions[3]. The charged current and neutral current reactions in addition to the electron scattering are studied with the SL-model[4], ANL-Osaka model[1] and the HNV[5] model. Various aspects of the models, such as the implementation of unitarity, show up in the angular distribution of the pion. The ANL-Osaka model beyond the $\Delta(1232)$ region is further examined against available data[6]. The angular distribution of pion is parametrized by the mean value of spherical harmonics. $< Y_{lm} >= [\int d\Omega_\pi \frac{d\sigma}{dW d\Omega_\pi} Y^*_{lm}]/[\int d\Omega_\pi \frac{d\sigma}{dW d\Omega_\pi} Y^*_{00}]$. The ANL-Osaka model gives reasonable description of the W dependence(Fig. 1). It is recommended that the Monte Carlo event generators used in analyzing neutrino oscillation experiments have to be confronted with predictions of available 'realistic' models[1, 4, 5].

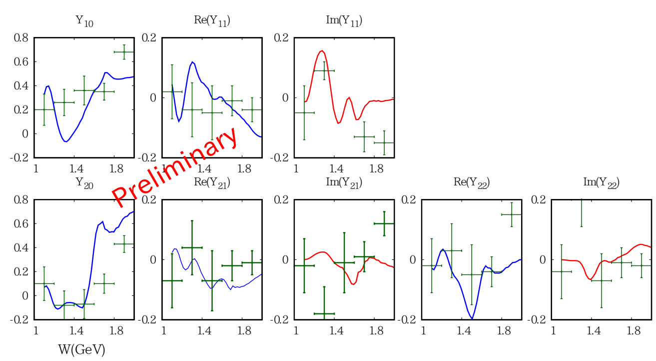

Figure 1: $< Y_{lm} >$ of $\bar{\nu}_\mu p \to \mu^+ p \pi^-$. Solid curves are obtained with ANL-Osaka model[1] at $E_\nu = 20GeV$. Data are from [7].

References

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