PROCEEDINGS OF SCIENCE

Construction of new hybrid CC1π^+ sample for the SK detector error estimation

Guang Yang[1]†, Shunichi Mine[2], Thomas Mueller[3] for the T2K collaboration

[1] *State University of New York at Stony Brook, Stony Brook, NY, USA*
[2] *University of California at Irvine, Irvine, CA, USA*
[3] *Ecole Polytechnique, IN2P3-CNRS, France*
†*E-mail:* guang.yang.1@stonybrook.edu

In the energy region of the T2K (Tokai to Kamioka) beam, which is peaked around 0.6 GeV, Charged Current 1 π^+ production (CC1π^+) is a dominant channel besides Charged Current Quasi-elastic (CCQE) interaction. Consequently, T2K plans to include CC1π^+ channel as a signal channel. An evaluation of the Super Kamiokande detector related systematic errors on CC1π^+ needs to be done. A new hybrid sample is constructed, as it was successfully used for the evaluation of neutral current π^0 background in the SK detector in previous oscillation analyses. In this proceeding, we describe how the atmospheric neutrino data in SK enabled the construction of a CC1π^+ hybrid sample and the possibility to apply the results to the systematic error estimation.

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T2K is a long-baseline neutrino oscillation experiment using Super Kamiokande (SK) detector as its far detector. Latest T2K results reveal a two sigma non-zero δ_{CP} value and a mixing angle θ_{23} that indicates maximal mixing. T2K has included the CC1π^+ channel with the pion below Cherenkov threshold in water by tagging an extra decay electron. To gain further significance of the measurements, we would like to add the CC1π^+ events in which the charged pion momentum is above the Cherenkov threshold. We need to evaluate all the systematic errors related to this new channel.

One important systematic is the SK detector related uncertainty. This is the first attempt to estimate the SK detector error including the visible π^+ ring. For this purpose, we constructed new hybrid sample by referring the existing hybrid π^0 samples. The purpose of employing the hybrid sample is to address the SK detector systematics coming from uncertainties involving light scattering and absorption in water, light reflection at the inner wall, angular dependence of the PMT response, and so on. We construct both data and MC samples and compare the detection efficiencies to estimate the systematic error.

The steps of constructing the hybrid CC1π+ sample are: 1. Select single muon-like ring events in the atmospheric neutrino data or MC at SK for the hybrid data or MC samples, respectively. 2. Extract the true kinematics from the T2K CC1π^+ MC. 3. Match the kinematics between the T2K CC1π+ MC true muon and the SK reconstructed muon data or MC rings. In order to match the kinematic, spin of the muon ring is allowed to match the direction. Run number is assigned to MC based on data. 4. Generate a charged pion event with detector simulation based on the T2K MC true information. Dark noise is tuned off in order to avoid double counting. 5. Merge the MC charged pion event and the muon data or MC event. 6. Apply reconstruction on both the merged hybrid CC1π^+ data and MC samples.

The data and MC hybrid samples are processed through the selections in the T2K analysis and the selection efficiencies are compared. Events in the hybrid sample that pass a series of cuts are considered as the numerator and events that with true wall distance greater 200 cm are considered as the denominator. Fig. 1 shows the comparison of the remaining efficiency for the data and MC hybrid samples. The cuts in order are fiducial + containing (FCFV), ring number, muon and pion like, muon-like ring momentum and number of decays cuts. The biggest discrepancy comes from the cut of number of rings, which can still be covered by the statistical error. The discrepancy between the data and MC samples is considered as a SK detector systematic error, which will be incorporated into the T2K oscillation analysis.

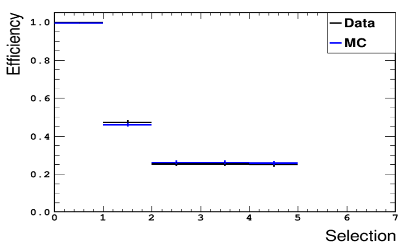

Figure 1: Remaining efficiency comparison between the hybrid data and MC samples. On the X axis, 0 = FCFV, 1 = ring number, 2 = muon/pion likelihood, 3 = muon-like momentum, 4 = decay number.