Measurement of the Muon Neutrino Spectrum at the Near Detector T2K

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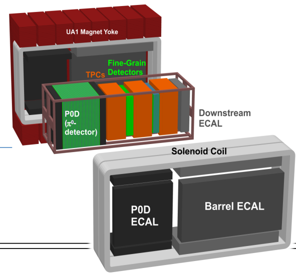
We present the **T2K near detector constraint** on the ν_e **appearance** and ν_μ **disappearance** analyses using data collected up to **April 11th, 2013**. **Charged-current** (CC) ν_μ **interactions** are used to constrain the uncertainties on the **flux** and **cross section** parameters that are propagated to Super-K. A selection of CC events is separated into a charged current without pions (**CC0π**), charged current single pion (**CC1π+**) and a **CC Others** samples, based on the **post-nucleus final state.**

The T2K Experiment and the ND280 Detector

T2K is a long baseline neutrino oscillation experiment designed to measure the neutrino oscillation parameters θ_{13}, Δm^2_{32} and $\sin^2\theta_{32}$, and neutrino cross sections. An intense ν_μ **beam** is produced in J-PARC and directed to the far detector **Super-Kamiokande**.

The near detector ND280 samples the **unoscillated** ν_μ beam.



ND280 tracker:
- 2 active target Fine Grained Detectors (**FGDs**)
- 3 Time Projection Chambers (**TPCs**)
- A 0.2T magnetic field allows **momentum** and **charge** measurements.

CC Event Selection with CC0π, CC1π+ and CC Others Sub-Samples

Event Selection

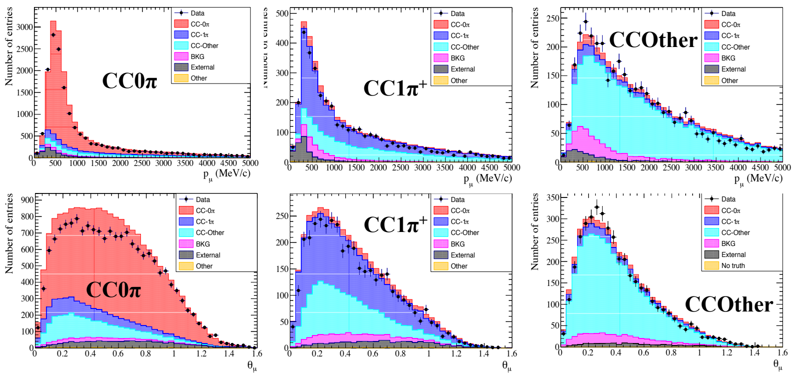
The CC event selection requires a **negative charged muon-like track** starting in the FGD fiducial volume.

- **CC inclusive** sample divided into enriched samples:
  - **CC0π:** no $\pi^{+/-/0}$ in the event
  - **CC1π+:** no $\pi^{-/0}$, presence of $1\pi^+$ in the event
  - **CCOthers:** at least 1 $\pi^{-/0}$, or more that $1\pi^+$ in the event

π+-like is selected by **TPC** Particle identification (PID), **Michel –like** delayed activity (Michel electron tagging) and **FGD** PID

π−-like is selected by **TPC** PID

π0-like is selected by $e^{+/-}$ tagging with **TPC** PID



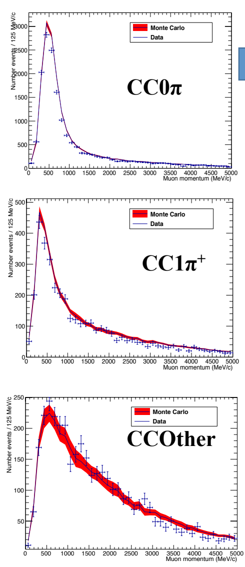
$$Purity^{CC-X} = \frac{Nevts^{true-CC-X}_{CC-X-sample}}{Nevts_{CC-X-sample}}$$

$$\varepsilon^{CC-X} = \frac{Nevts^{true-CC-X}_{CC-X-Sample}}{Nevts^{true-CC-X}_{events-generated-in-FGD-FV}}$$

CC-X	CC-0π	CC-π+	CC-Other
ε^{CC-X}	50.1 %	29.5 %	35.2 %
$Purity^{CC-X}$	72.6 %	49.4%	73.8%

Detector Systematic Uncertainties

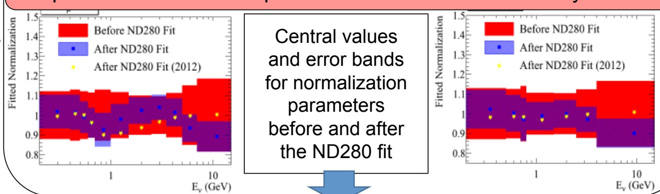
B Field distorsion	TPC Tracking efficiency
TPC-FGD matching efficiency	TPC Charge missidentification
TPC Momentum scale	***TPC Momentum resolution***
TPC Quality cut	Michel electron efficiency
FGD Mass	***Out of Fiducial Volume***
Pile-up	Sand muon
TPC PID	FGD PID
FGD tracking efficiency	***Pion secondary interaction***



Systematic errors are estimated with several control samples: cosmic rays, upstream muons, etc..

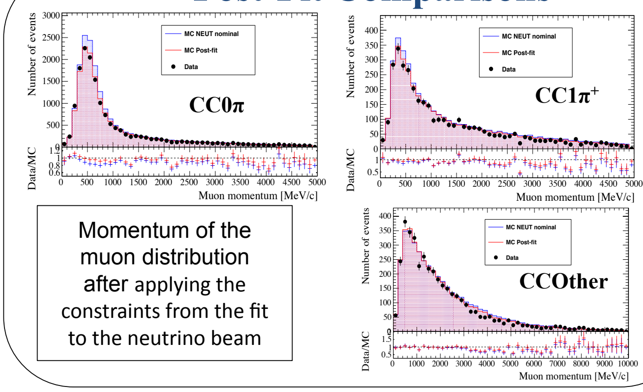
Fit of Neutrino Beam Flux

Use constrained parameters and uncertainties to predict the Super-Kamiokande samples used for the oscillation analysis



Central values and error bands for normalization parameters before and after the ND280 fit

Post-Fit Comparisons



Momentum of the muon distribution after applying the constraints from the fit to the neutrino beam