Measuring the ν_μ CC0π cross section on lead at the T2K near detector

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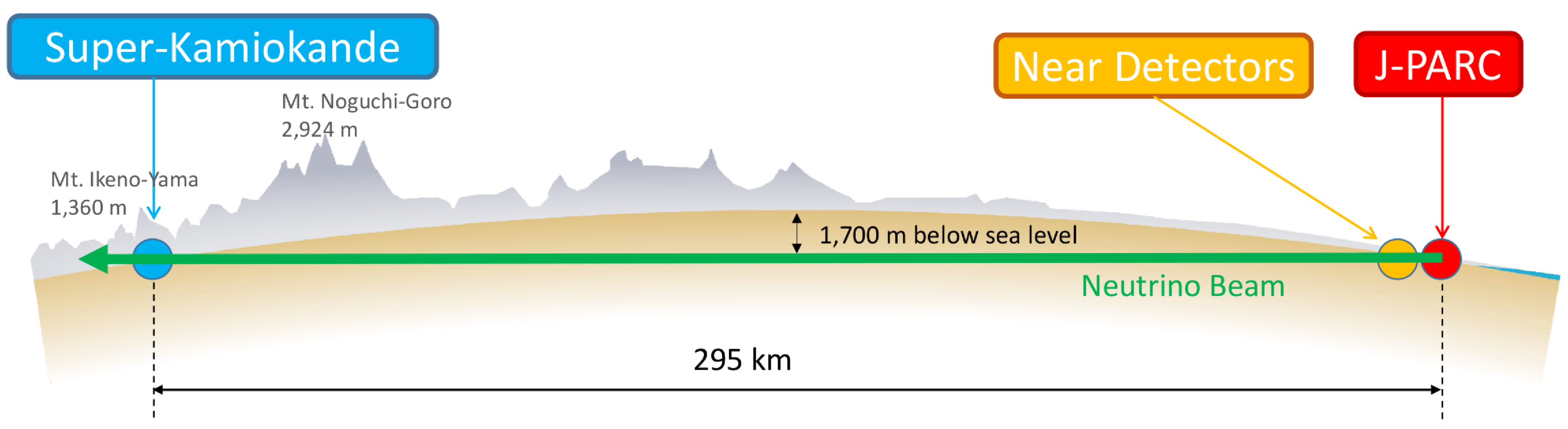
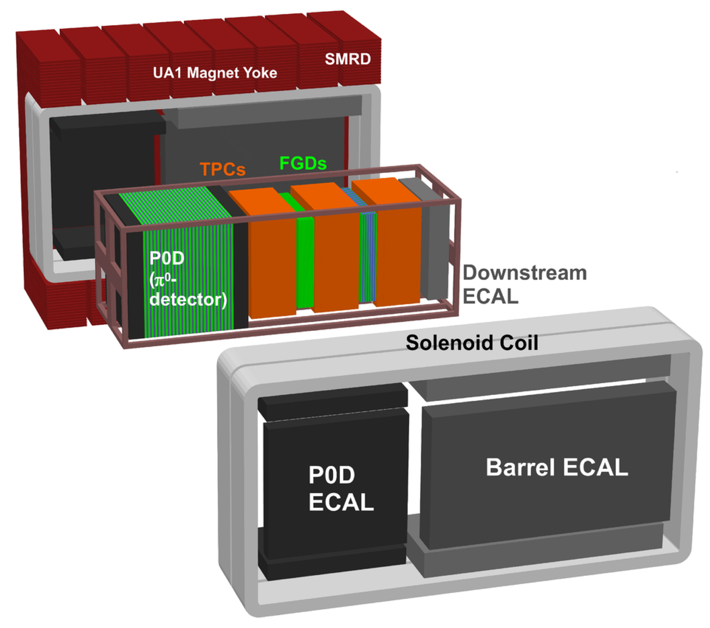


❖**Accelerator, long-baseline** neutrino experiment located in Japan [1].
❖**Neutrino beam** with energy peak at 0.6 GeV.
❖Two main detector stations: **near detectors (ND280 and INGRID)** located at 280 m and **Super-Kamiokande** at 295 km from the beam target.
❖Goals: Measure the parameters of neutrino oscillations and understand neutrino interactions with nuclei

❖Former **UA1/Nomad** magnet: magnetic field of 0.2T to measure particle momenta and charges. Partially instrumented with scintillators (**SMRD**) for the measurement of the muon momenta from their ranges in iron.

❖π^0 detector (**P0D**): water/brass or lead layers interleaved with scintillator (carbon) layers.



❖Tracker: 2 **FGDs** of plastic scintillator layers (FGD2: scintillator/water layers), 3 **TPCs** particle tracking, momentum and charge measurement and particle ID

❖**ECAL:** scintillator/lead layers to improve track/shower separation

1. Motivation

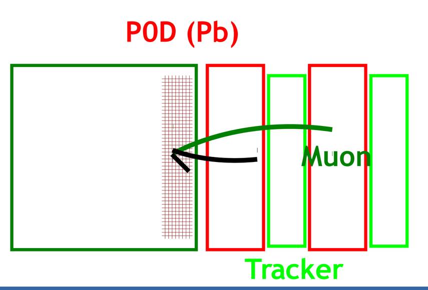
❖Investigate the effect of the nuclear environment on CC0π interactions (1 muon + no mesons + any number of nucleons) in the low energy region.

❖Understand the A-dependence of the neutrino-nucleus cross section in the perspective of argon-target experiments.

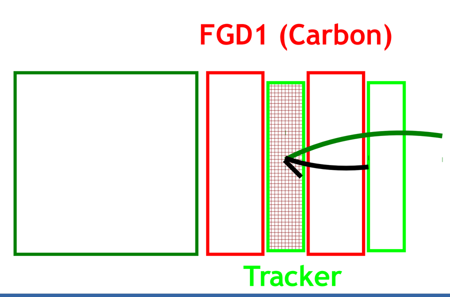
❖The measurement can help discriminate between different models of both initial state nucleons and final state interactions.

2. Selection strategy

❖Analysis combines the information from two sections of ND280 detector: P0D and Tracker (FGD & TPC)
❖Developed inter-detector reconstruction algorithms to improve the efficiency of selecting neutrino interactions in P0D and Tracker



1) At least 1 P0D-TPC track
2) Find highest momentum negative track in P0D and Tracker
3) Track quality + fiducial volume cut (P0D)
4) Upstream P0D tracks veto cut
5) Muon likelihood cut



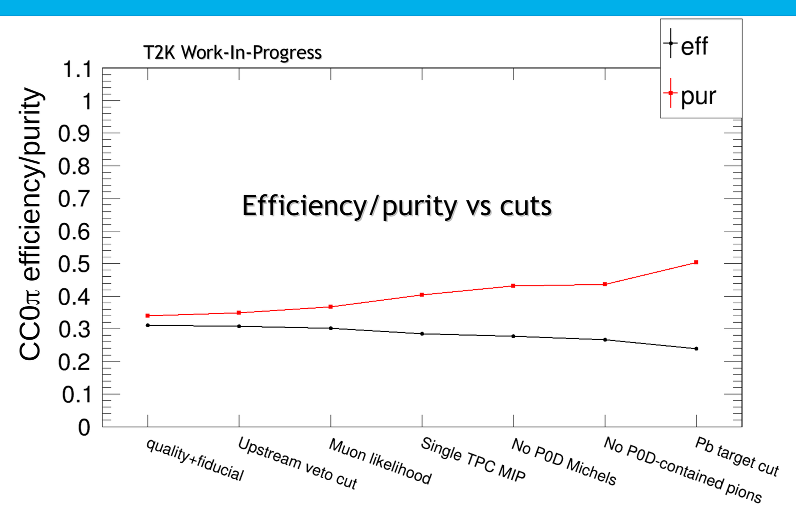
1) Find highest momentum negative track in TPC/ FGD1
2) Track quality + fiducial volume cut (FGD1)
3) Muon and proton likelihood cut (TPC)
4) No Michel electrons
5) ECAL particle identification cut
6) ECAL π^0 veto cut
7) Time of flight cut

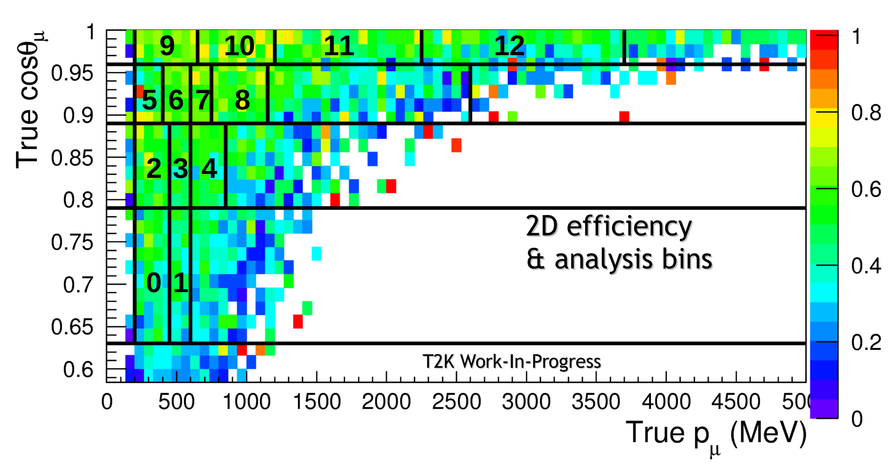
1 TPC MIP
No Michel electrons

>1 TPC MIP

CC0π on Pb (signal) | **CC1π & CC Other** | **CC0π on Carbon**

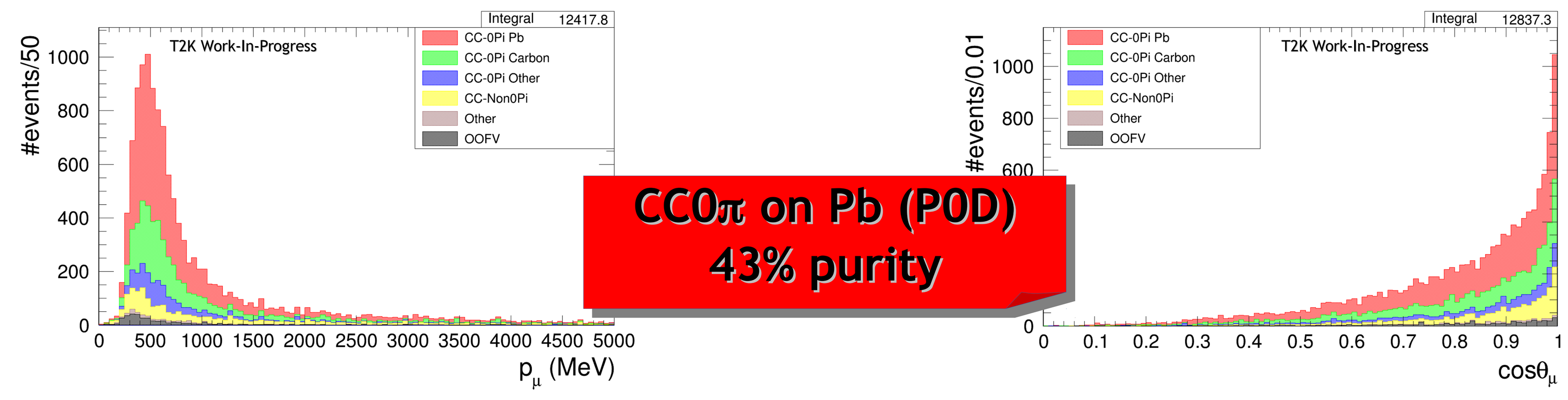
3. Efficiency, purity and binning





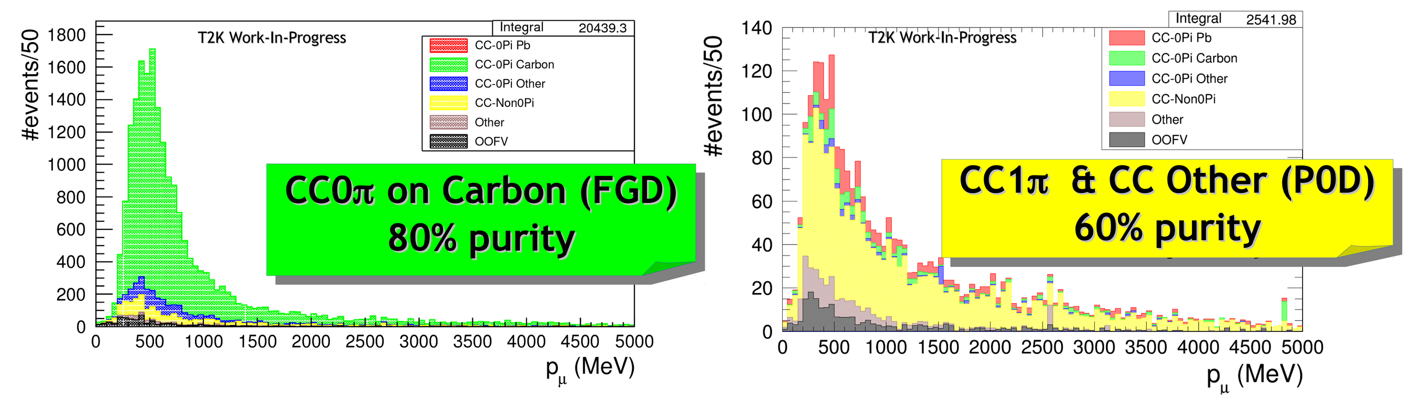
4. Selection results and systematic errors

❖Reconstructed muon momenta (p_μ) and cosine of the angle ($\cos\theta_\mu$) for the signal sample



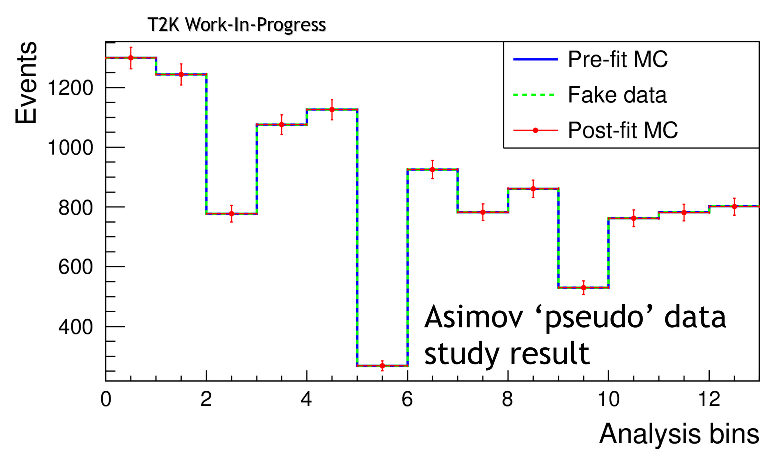
❖Composition of the signal sample and sideband samples:

CC0π on Pb	42.72%
CC0π on Carbon	28.79%
CC1π + CC Other	13.92%
CC0π on other targets	8.26%
Other	1.50%
out FV	4.81%



❖Systematic errors:
- Detector simulation: P0D and Tracker related uncertainties and their correlations
- Flux modelling
- Cross section model uncertainties

5. Cross-section extraction



❖Measurement of the cross section in the bins of true muon momentum and cos θ_μ.

❖Simultaneous fit of three samples: CC0π on lead, CC0π on Carbon and CC1π + CC Other using maximum likelihood fitter [2].

❖Detector, flux, cross section model systematic uncertainties are implemented as nuissance parameters. Correlations are taken into account via covariance matrices.

$$N_i=\sum_{j=1}^{Nbins}\left(c_j N_j^{CC-0\pi,Pb,MC}+d_j N_j^{CC-0\pi,Carbon,MC}+\sum_{k=1}^{Nbg} N_j^{bg\ k,MC}\prod_a^{model} w(a)_j^k\right)\times S_{ij}\times r_i^{Det}\times\sum_n^{E_\nu} f_n^i$$

$$\chi^2=\chi^2_{stat}+\chi^2_{syst}\qquad \chi^2_{syst}=(\vec{p}-\vec{p}_{prior})(V^{syst}_{cov})^{-1}(\vec{p}-\vec{p}_{prior})$$

6. Future plans

❖Fit validation and 'pseudo' data studies. Finalizing the measurement of the differential CC0π Pb cross section.
❖Comparisons of the predictions of various models for heavy target neutrino interactions with NUISSANCE.
❖Possible Pb/Carbon CC0π ratio measurement.

References

[1] Nucl.Instrum.Meth. A659 (2011) 106-135
[2] Phys. Rev. D 93, 112012 (2016), arXiv:1802.05078

Acknowledgements

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