Imperial College London

T2K

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for the T2K Collaboration

ND280

Science & Technology Facilities Council

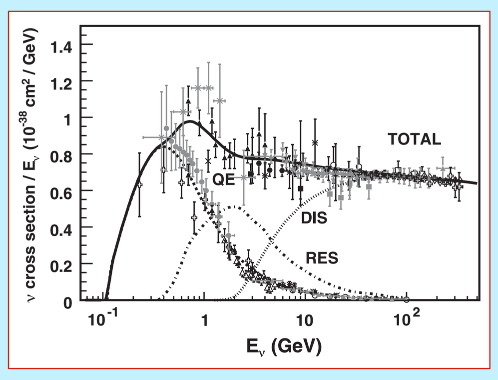
MEASURING THE ν_e CC INCLUSIVE CROSS-SECTION AT THE GEV-SCALE USING ND280, THE T2K NEAR DETECTOR

ν_e CROSS-SECTIONS ARE IMPORTANT

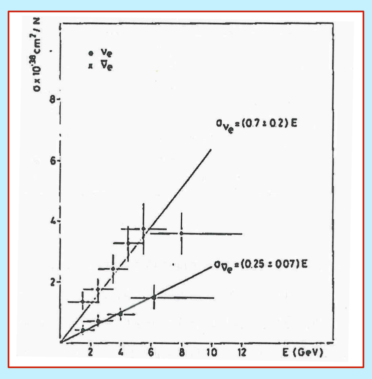
Long baseline oscillation experiments are searching for CP violation.

$\nu_\mu \rightarrow \nu_e$ oscillation is a golden channel for this.

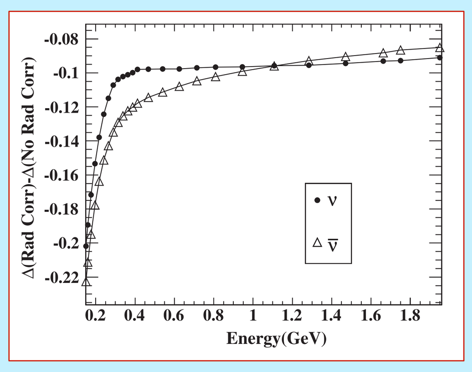
We need to understand differences between ν_μ and ν_e cross-sections!

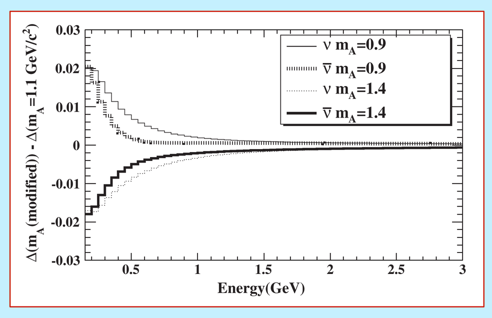


Lots of ν_μ cross-section measurements…
(Rev.Mod.Phys., 84:1307, 2012)



…but only Gargamelle results for ν_e.
(Nucl.Phys.B, 133(2), 1978)



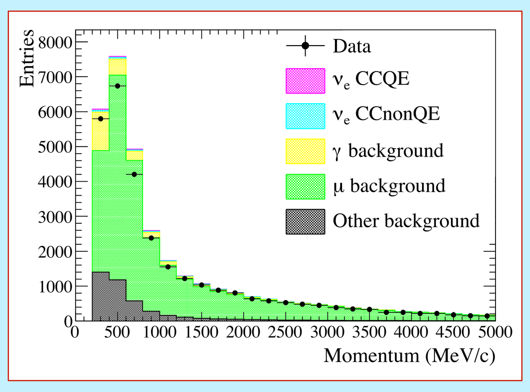


Many theoretical differences exist between ν_μ and ν_e cross-sections.
(PRD 86, 053003, 2012)

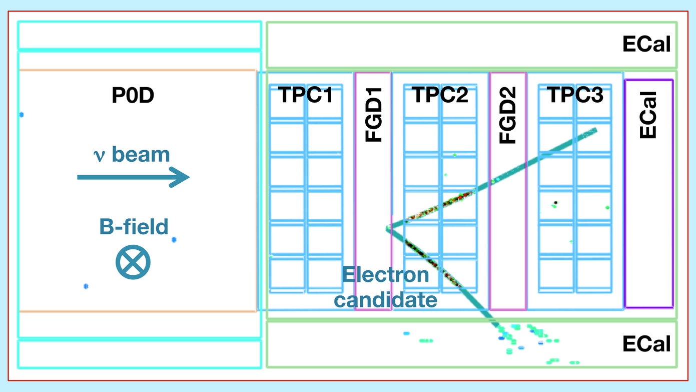
These need to be constrained by data!

EVENT SELECTION

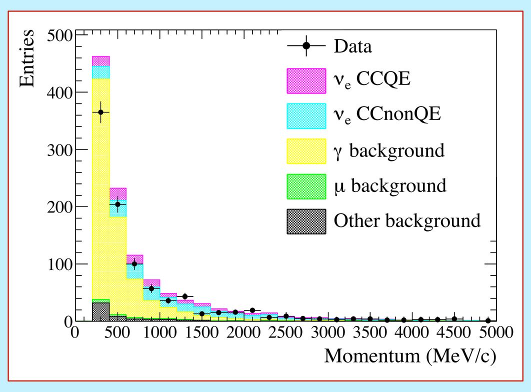
1) Start with highest momentum negative track in active plastic scintillator target, FGD1.



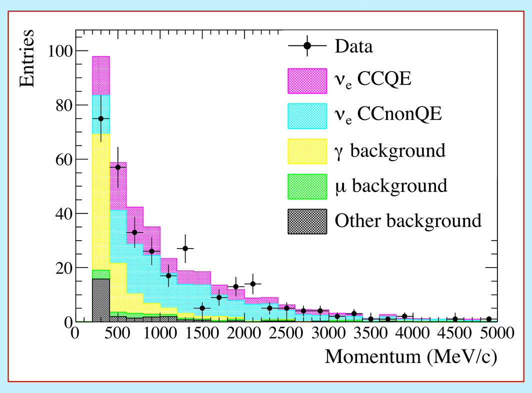
Typical data event entering the ν_e sample. Electron candidate starts in upstream Fine Grained Detector (FGD1).



2) Select electrons using TPCs (dE/dx) and ECals (shape and charge). Reject 99.9% of μ^-.



3) Veto $\gamma \rightarrow e^+e^-$ conversions to achieve 65% CC ν_e purity.

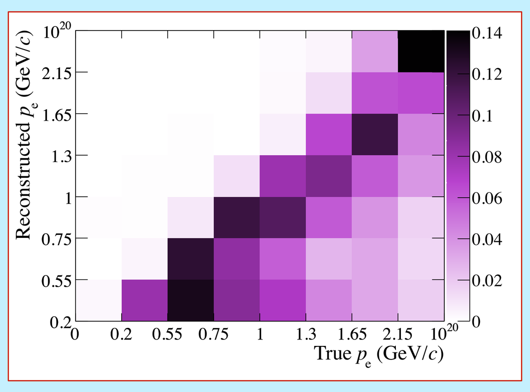


UNFOLDING

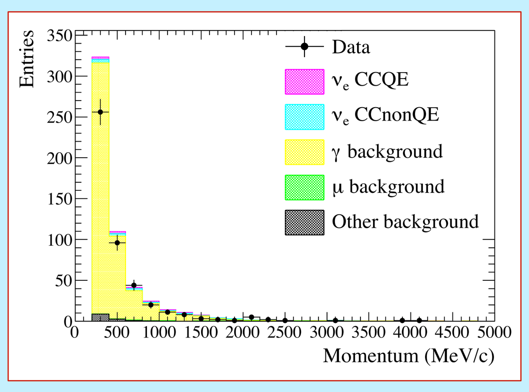
Use Bayesian unfolding to estimate true distribution.

$$P(t_k|r_j) = \frac{P(r_j|t_k)P(t_k)}{\sum_{\alpha=1}^{n_t} P(r_j|t_\alpha)P(t_\alpha)} \qquad N_{t_k} = \frac{1}{\epsilon_{t_k}} \sum_{j=1}^{n_r} P(t_k|r_j)(N^{\mathrm{meas}}_{r_j} - B_{r_j})$$

Smearing matrices relate true and reconstructed information. Bremsstrahlung affects momentum reconstruction.



Constrain background using sample of $\gamma \rightarrow e^+e^-$ conversions. Constrain background from out of fiducial volume in (p,θ) bins.

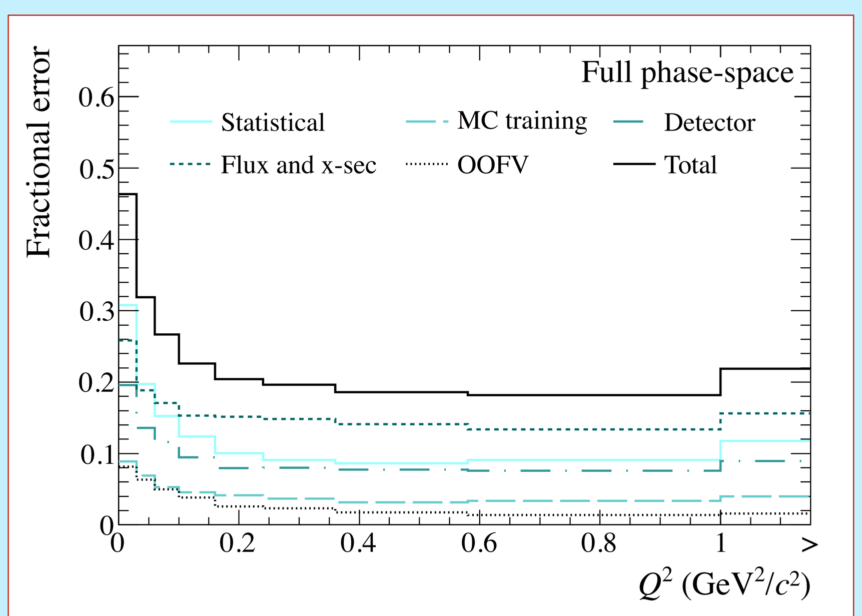


SYSTEMATICS

Summary

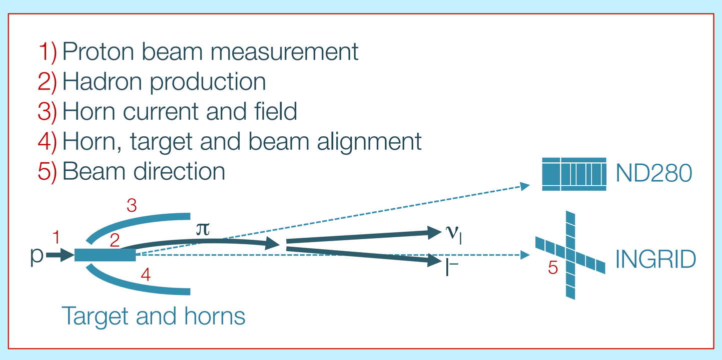
Use covariance matrix method with 1000 throws.

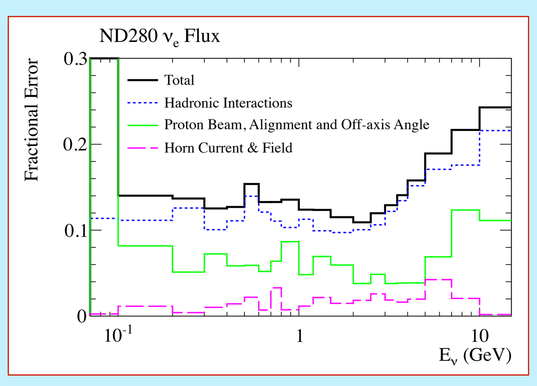
Dominant uncertainties on total cross-section are
- Flux (12.9%)
- Data statistics (8.7%)
- Detector systematics (8.4%)



Flux

Constrain 5 sources of uncertainty using beam measurements and NA61 hadron production data.





Detector

All ND280 uncertainties are constrained by data.

Separate systematics cover
- FGDs
- TPCs
- ECals
- External interactions

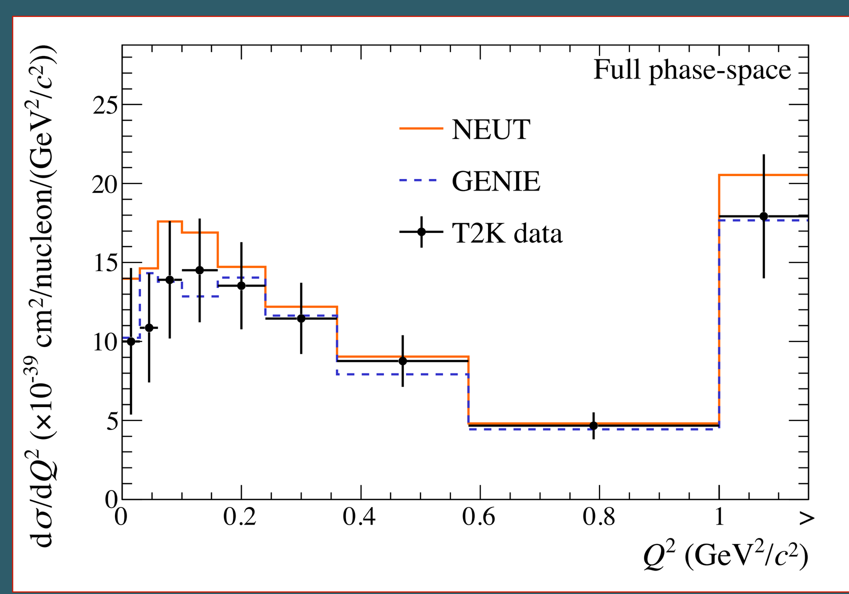
Uncertainty on number of target nucleons is 0.67%.

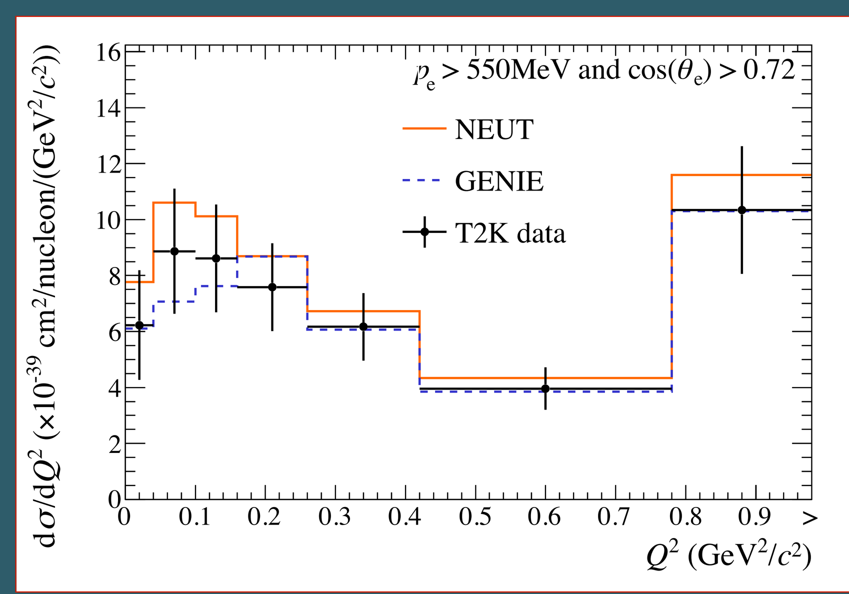
RESULTS

Selection is not sensitive to low momentum and high angle tracks. Unfolding into these regions depends on the MC model (NEUT). Present two results – with and without unfolding into unseen region. These are the first GeV-scale ν_e cross-section results since Gargamelle!

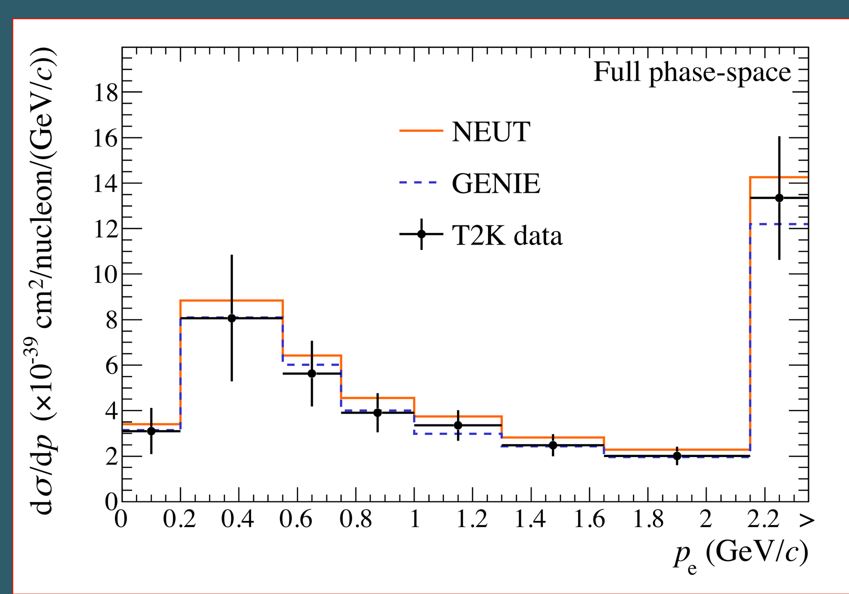
Q^2

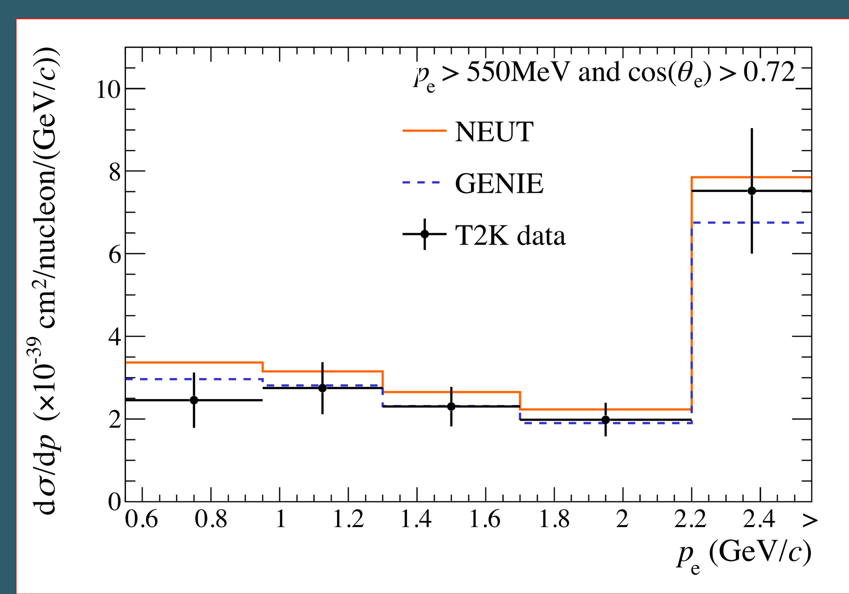
Four-momentum transfer from lepton to hadron system



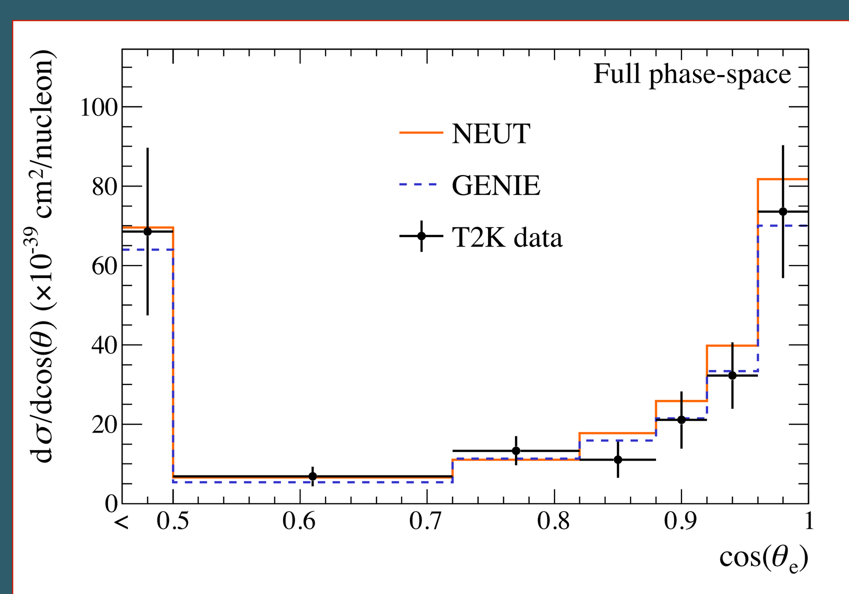


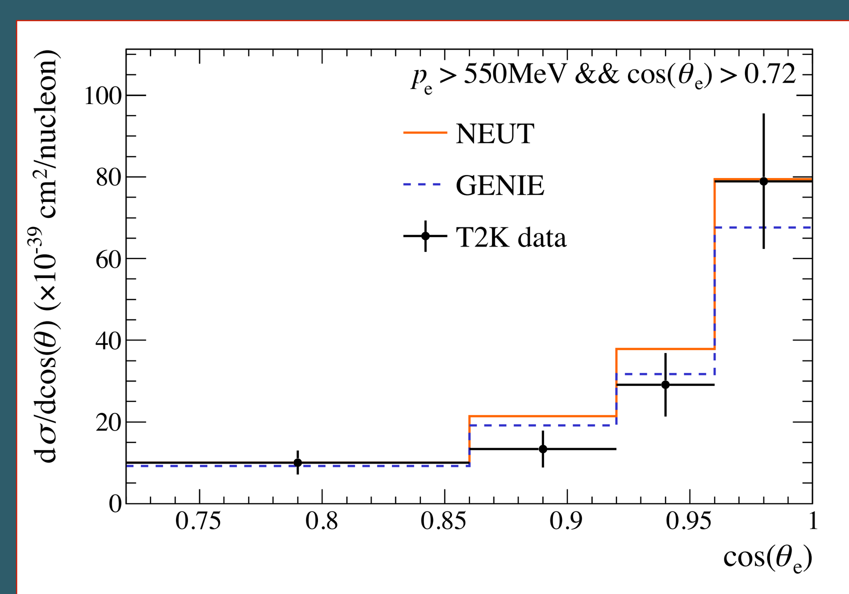
Electron momentum



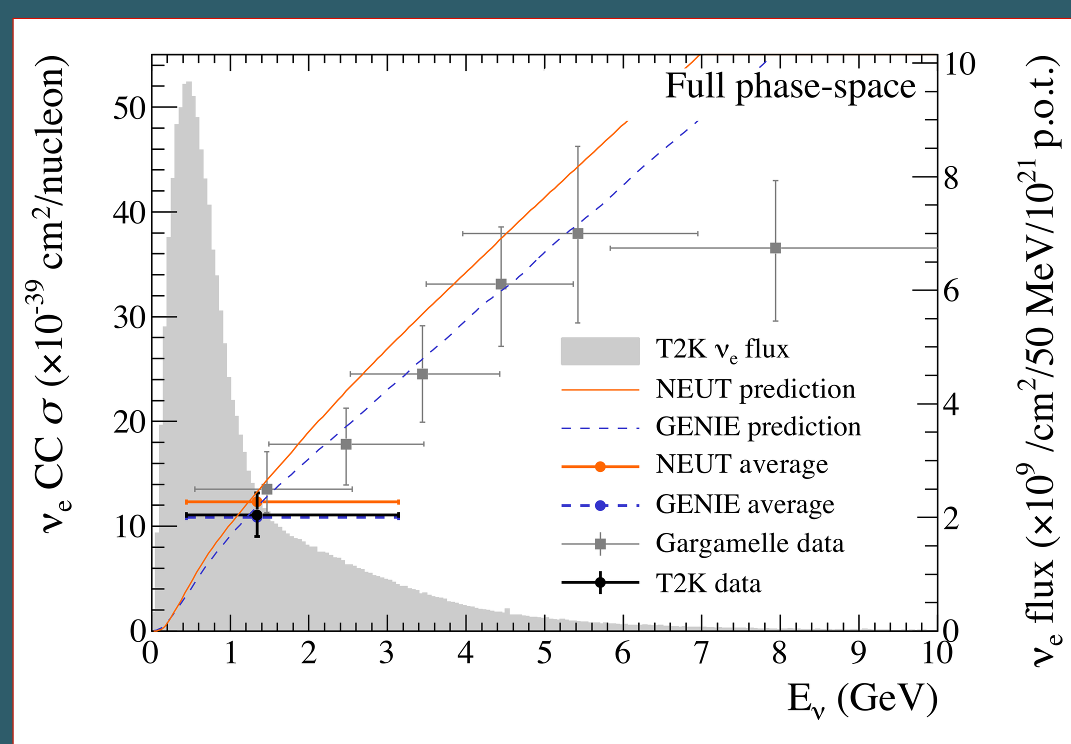


Electron angle





Total ν_e CC inclusive cross-section



MC predictions from interaction generators NEUT v5.1.4.2 and GENIE v2.6.4.

FUTURE PROSPECTS

Many exciting analyses planned:
- CCQE-enhanced selection to give ν_e CCQE cross-section as a function of E_ν
- Running T2K in anti-neutrino mode will give anti-ν_e cross-sections
- ν_μ/ν_e cross-section ratio measurement will benefit from cancelling of many systematic uncertainties.