A first search for sterile neutrinos with the T2K near detector

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Reactor and Gallium anomalies

Anomalies observed in the last few years that can be explained assuming non standard ν_e disappearance:

Reactor anomaly [1]
Gallium anomaly [2][3]

Compatible with the oscillation $\nu_e \rightarrow \nu_s$

No hints of $\nu_\mu \rightarrow \nu_s$ oscillations [4]

[1] T.Mueller,D.Lhuillier,M.Fallot,A.Letourneau,S.Cormon,etal.,Phys.Rev.C83,054615(2011), arXiv:1101.2663
[2] P. Anselmann et al., Phys. Lett. B685, 47 (2010), arXiv:1001.2731
[3] J. N. Abdurashitov et al., Phys. Rev. C80, 015807 (2009), arXiv:0901.2200
[4] MiniBooNE, SciBooNE collaborations, Phys. Rev. D86.052009, arXiv:1208.0322

3+1 Model

Add a sterile neutrino that doesn't interact via W/Z exchange but can oscillate with standard neutrinos

$$\nu_\alpha = \sum_{k=1}^{4} U_{\alpha k} \nu_k$$

Δm^2_{14} around 1eV^2 is responsible for short baseline oscillations

U is the unitary 4x4 matrix

Assume no ν_μ disappearence and ν_e appearance ($U_{\mu 4} = 0$)

$$\sin^2 2\theta_{ee} = 4|U^2_{e4}|\left(1 - |U^2_{e4}|\right)$$

$$P_{\nu_e \rightarrow \nu_e} = 1 - \sin^2 2\theta_{ee} \cdot \sin^2\left(\frac{1.267 \Delta m^2_{41} L_\nu}{E} \frac{\mathrm{GeV}}{\mathrm{eV}^2 \mathrm{km}}\right)$$

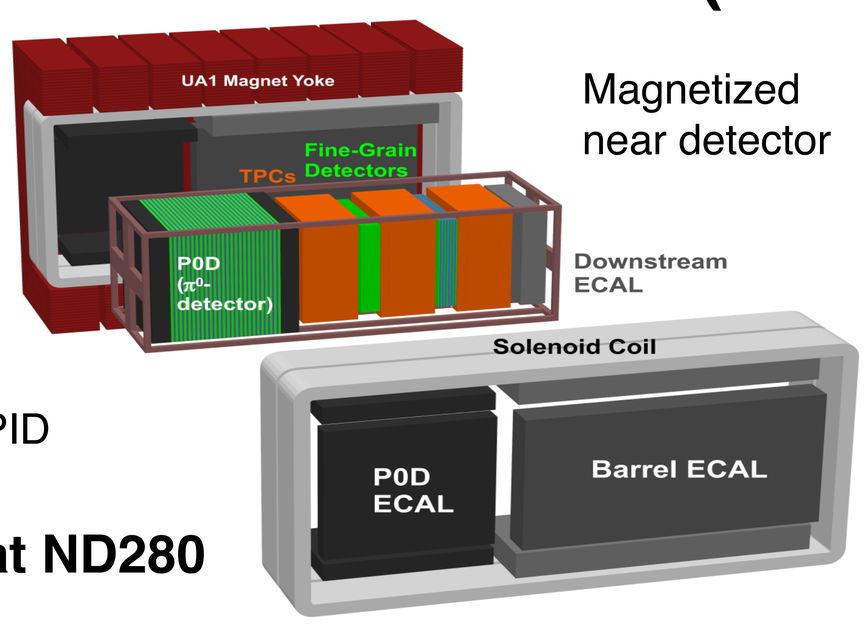
T2K Near Detector (ND280)

Short baseline: 280m from the production target

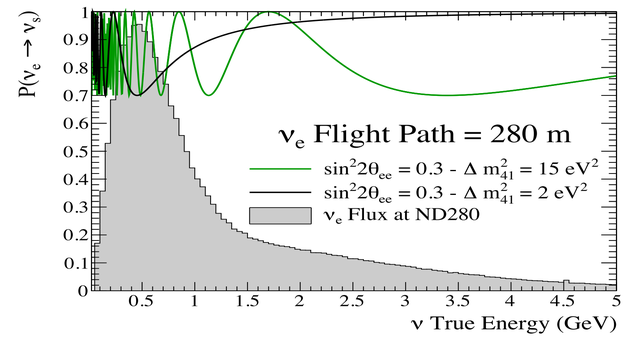
Fine Grained Detectors give active mass for neutrino interactions

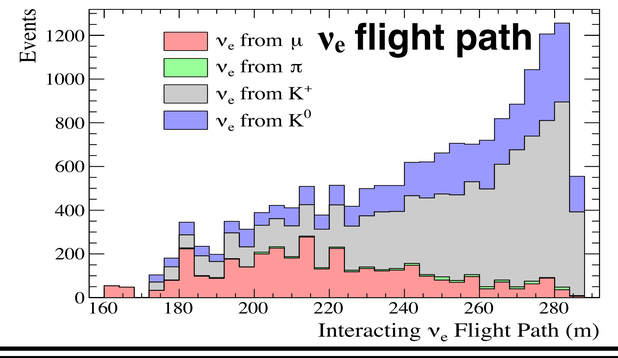
Electrons are selected using the TPC and the electromagnetic calorimeter PID

Search for ν_e disappearance at ND280



Magnetized near detector

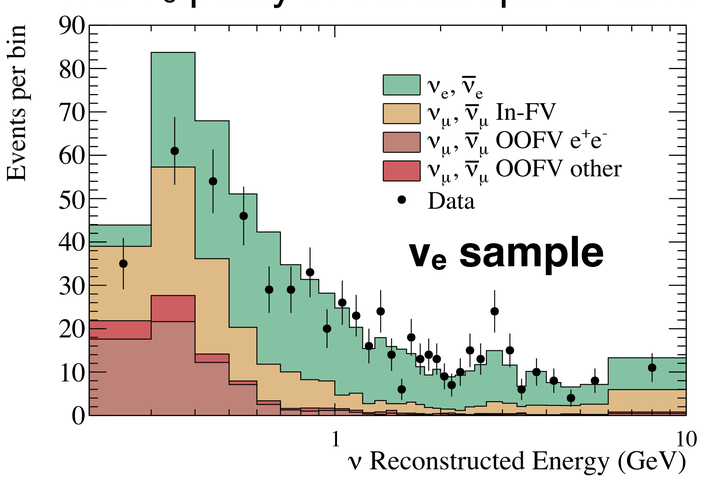


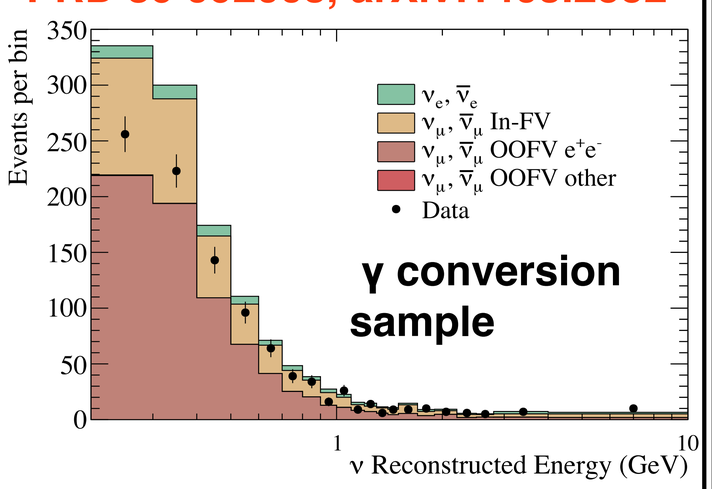


75% of the ν_e comes from kaon decays

Expected distributions

The ν_e purity in the sample is 68% **PRD 89 092003, arXiv:1403.2552**





ν_e candidates (Data) = 614
ν_e candidates (MC) = 681.8

γ candidates (Data) = 989
γ candidates (MC) = 1149.7

92% of events in the control sample are from γ conversion (main ν_e Bkg)

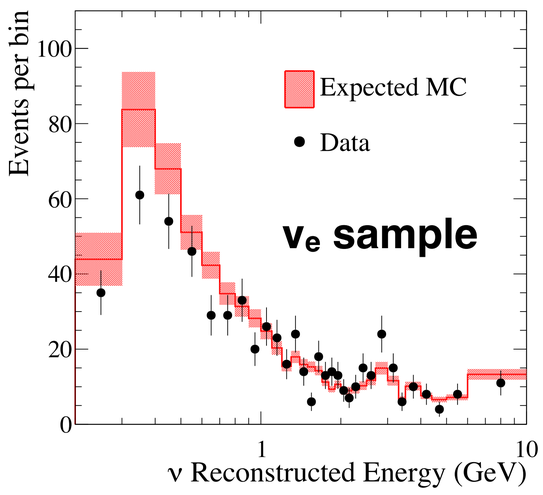
Out of fiducial volume (OOFV) component is measured "in situ"

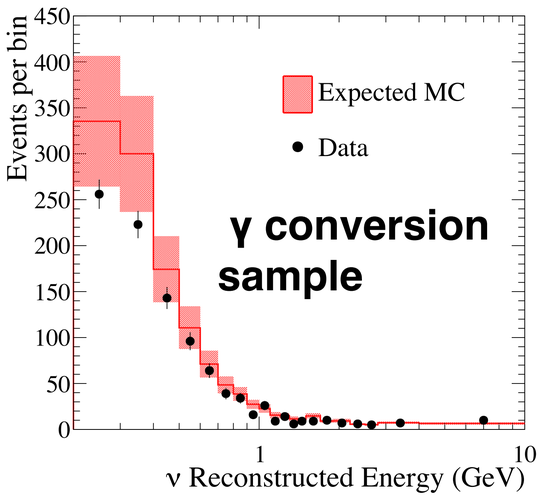
Systematic uncertainties

Flux, cross section and detector systematics

The ND280 ν_μ sample is used to constrain the systematic parameters

Total systematic variation on the No. of ν_e events is 8%

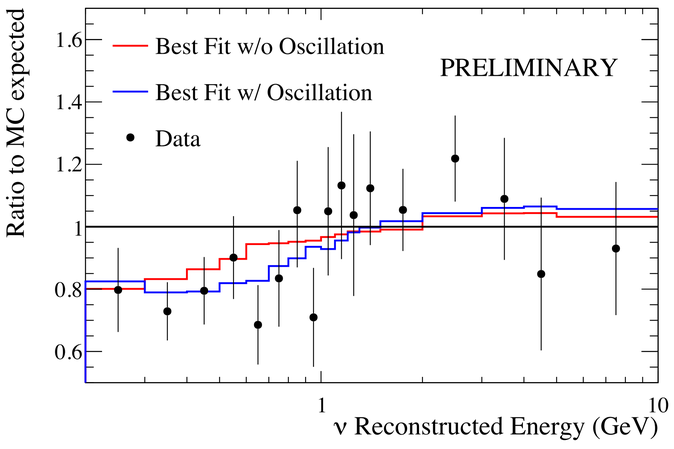




Results

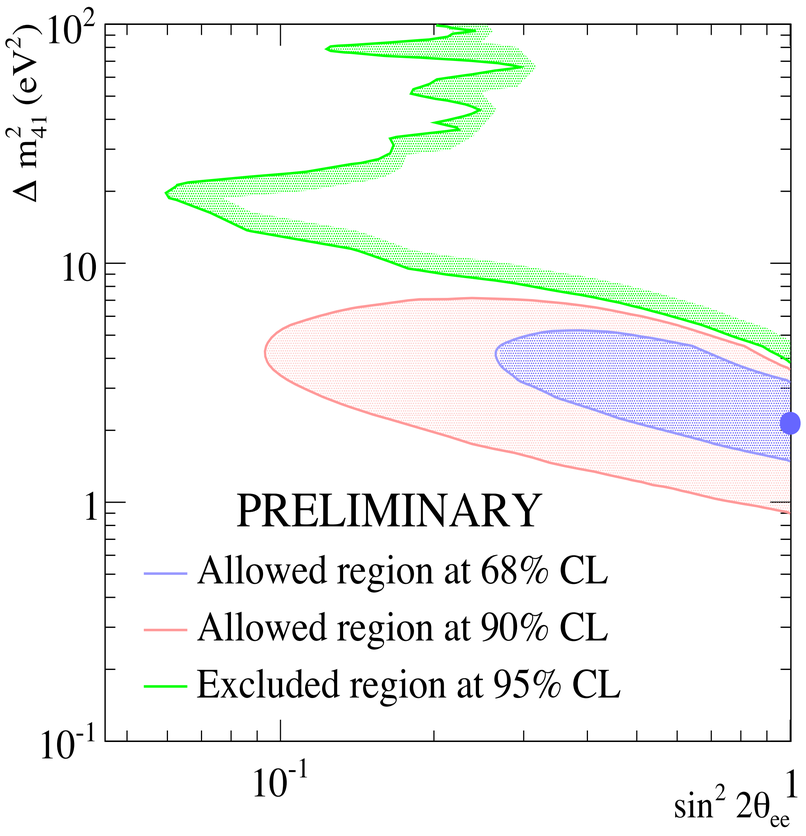
Log-likelihood ratio method

55 nuisance parameters



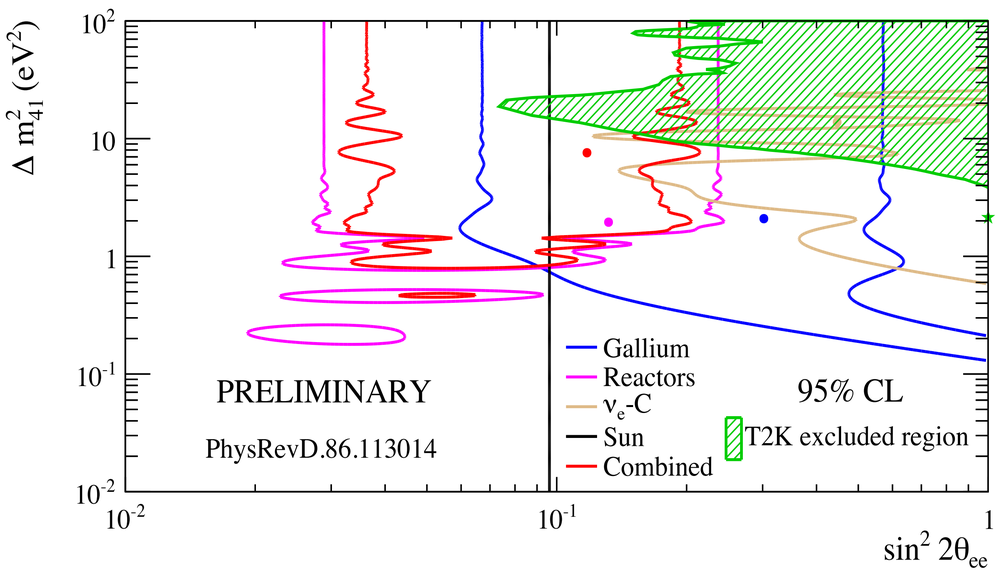
Confidence intervals built with Feldman-Cousins

P-value of non oscillation hypothesis is 6.069%



Best-fit parameters:
$\sin^2 2\theta_{ee} = 1$ $\Delta m^2_{41} = 2.14$ eV^2

6x10^{20} protons on target, only 8% of the T2K goal



Large part of the gallium anomaly at $\Delta m^2_{41} > 10$ eV^2 as well as some part of the reactor anomaly ($10 < \Delta m^2_{41} < 30$ eV^2) are rejected at 95%CL