Role of DUNE near detector to reduce Systematic Uncertainty

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Based on: Ghosh, Goswami, Raut, Eur. Phys. J. C **76**, 114 (2016)

ND Report

Detector Configuration taken from:

LBNE-INDIA

Proposal of Indian Institutions and Fermilab Collaboration for Participation in the Long-Baseline Neutrino Experiment at Fermilab

(*A Proposal to Design and Build a High-Resolution Near Detector and to Contribute to the Liquid Argon Far Detector*)

to

Department of Atomic Energy and

Department of Science and Technology

Government of India

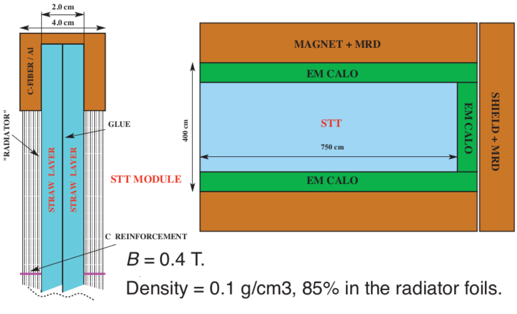
Edited by

Brajesh Choudhary, Raj Gandhi, Sanjib R. Mishra, Shekhar Mishra and James Strait

Indian Institutions and Fermilab Collaboration

12 December 2012

The Near Detector



- An active straw tube tracker (STT)
- Surrounded by an electromagnetic calorimeter (ECAL)
- All embedded inside a dipole magnet

Detector Characteristics

- Mass: 5 tons, 459 m from source
- Muon(electron) detection efficiency: 95%(50%)
- The NC background rejection efficiency of 20%
- The energy resolution for electrons (muons) is $6\%/\sqrt{E(GeV)}$ (37 MeV)

Aim

- The main role of ND is to reduce the systematic error of FD
- We study how much improvement in the physics sensitivity once ND is added with FD

To compare sensitivity between (i) only FD and (ii) FD+ND

Treatment of Systematics

2 pull variables

- signal normalization (affect the scaling of the events)
- background normalization

Systematics ate incorporated by varying the test events:

$$M_i^{(th)}(\vec{p}_{th}) \;=\; N_i^{(th)}(\vec{p}_{th})\left[1+\sum_k \xi_k \pi^k\right]$$

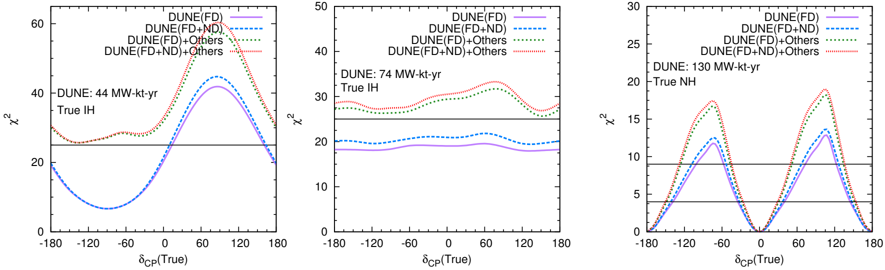
where π are the 1σ error of the pull variable ξ with $k=2$.

Analysis Method

- ND and FD are treated as separate experiments having same systematics
- Then we calculate $\chi^2_{\rm FD}$ and $\chi^2_{\rm eff} \equiv \chi^2({\rm FD} \oplus {\rm ND})$

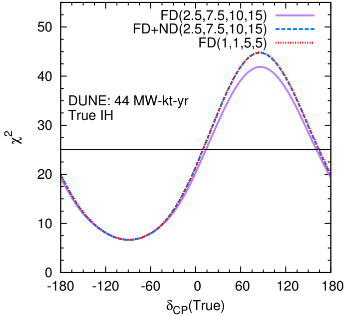
Systematic error	only FD/only ND
ν_e app signal	2.5%
ν_μ disapp signal	7.5%
ν_e app background	10%
ν_μ disapp background	15%

Sensitivity Results



- Left: Hierarchy, Middle: Octant, Right: CP
- FD: 10 kt, 1300 km

Improvements in the systematics



Systematic error	only FD	FD+ND
ν_e app signal	2.5%	1%
ν_μ disapp signal	7.5%	1%
ν_e app background	10%	5%
ν_μ disapp background	15%	5%

Summary

- Inclusion of ND improve the systematics by 13 - 50%
- Effect is more in the region where sensitivity is high

Future Project: Comparative study for all possible ND options

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Thank You