Group Meeting 30/11/2017

D. Vargas

Study of the reconstructed neutrino energy

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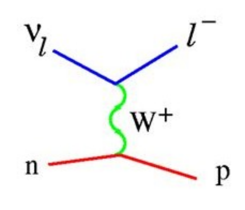
Introduction

T2K and NEUT

Using the NEUT simulation code, the reaction studied was:

- $\nu_\mu \rightarrow {}^{12}$C

CCQE or CC0π



T2K

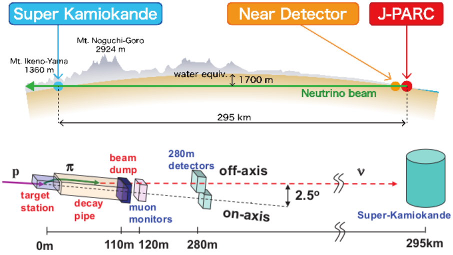
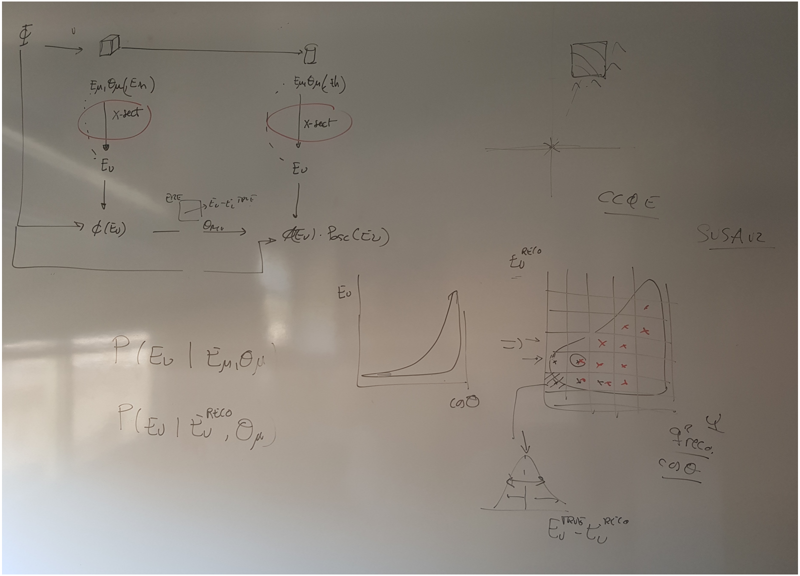


Figure 4.8: Schematic representation of the T2K configuration.

- $L_{near} = 280$ m;
- $L_{far} = 295$ km.

Introduction

Motivation



Reconstructed neutrino energy

Equation for the reconstructed neutrino energy (E_ν^{rec}) for CCQE

Reconstructed neutrino energy (E_ν^{rec}):

$$E_\nu^{rec} = \frac{2(M_n - E_B)E_\mu - (E_B^2 + M_\mu^2 - 2M_nE_B + \Delta M^2)}{2(M_n - E_B - E_\mu + |\vec{k_\mu}|cos\theta_\mu)} \quad (1)$$

$$\Delta M^2 = M_n^2 - M_p^2$$

$$E_\mu = \sqrt{|\vec{k_\mu}|^2 + M_\mu^2}$$

- $M_n = 939.565379$ MeV;
- $M_p = 938.272046$ MeV;
- $M_\mu = 105.6583715$ MeV;
- $E_B = 24$ MeV.

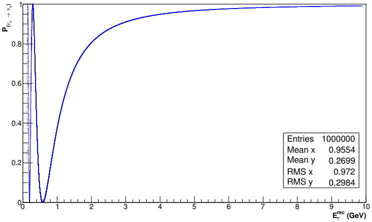
Reconstructed neutrino energy

Equation for oscillation probability

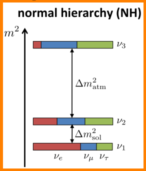
ν_μ probability of disappearance:

$$P_{\mu\mu} \equiv P_{(\nu_\mu \to \nu_\mu)} = 1 - sen^2(2\,\theta_{23})\, sen^2\left(1.267\,\frac{\Delta M^2_{32}\,L_{far}}{E_\nu^{true}}\right) \qquad (2)$$

- $sen^2(2\,\theta_{23}) \approx 1$
- $\Delta M^2_{32} = 2.44 \times 10^{-3}\ \mathrm{eV}^2$.

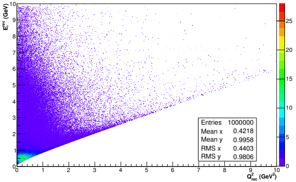


Important!!!

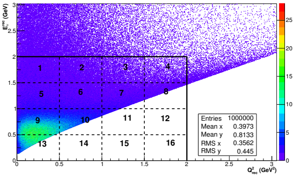


Reconstructed neutrino energy

E_ν^{rec} dependency with Q^2_{rec}



(a)



(b)

Figure 1: (a) Reconstructed neutrino energy vs. transfered momentum and (b) matrix.

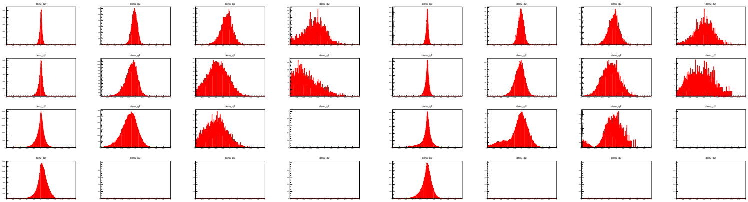
Transfered momentum:

$$Q^2_{rec} = 2\,E_\nu^{rec}\,(E_\mu - |\vec{k_\mu}|\cos\theta_\mu) - M^2_\mu \qquad (3)$$

matrix with bins of 0.5 GeV for E_ν^{rec} and 0.5 GeV for Q^2_{rec}

Reconstructed neutrino energy

E_ν^{rec} dependency with Q^2_{rec}

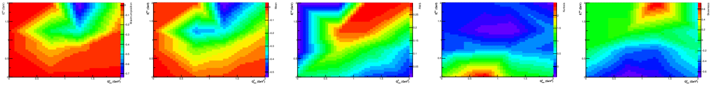


(a) (b)

Figure 2: (a) No. of ν_μ events vs. $1 - (E_\nu^{rec}/E_\nu^{true})$ for each block of the matrix and (b) appalling probability of disappearance of the ν_μ.

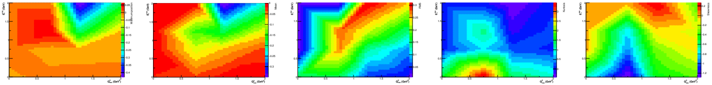
Reconstructed neutrino energy

E_ν^{rec} dependency with Q^2_{rec}



(a) (b) (c) (d) (e)

Figure 3: Data of each distribution (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.

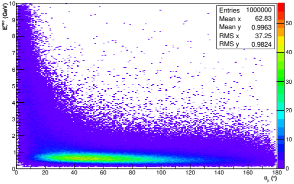


(a) (b) (c) (d) (e)

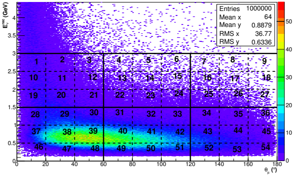
Figure 4: Comparison data of each distribution appalling probability of disappearance of the ν_μ (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.

Reconstructed neutrino energy

E_ν^{rec} dependency with θ_μ



(a)



(b)

Figure 5: (a) Reconstructed neutrino energy vs. muon angle and (b) matrix.

Muon angle:

$$\theta_\mu = \arccos\left(\frac{\vec{P_\nu} * \vec{P_\mu}}{P_\nu\, P_\mu}\right) \quad (4)$$

Matrix with bins of 0.5 GeV for E_ν^{rec} and 20° for θ_μ.

Reconstructed neutrino energy

E_ν^{rec} dependency with θ_μ

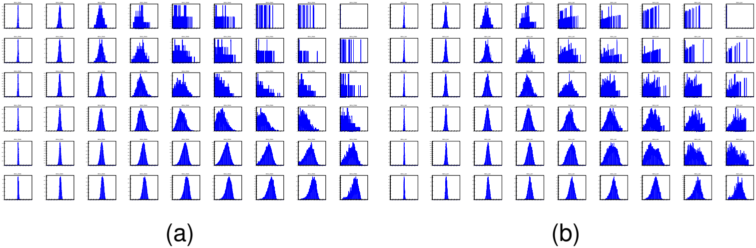
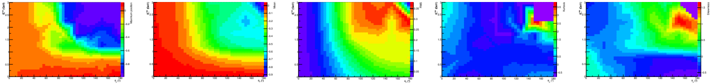


Figure 6: (a) No. of ν_μ events vs. $1 - (E_\nu^{rec}/E_\nu^{true})$ for each block of the matrix and (b) appalling probability of disappearance of the ν_μ.

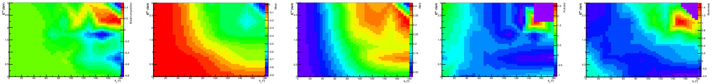
Reconstructed neutrino energy

E_ν^{rec} dependency with θ_μ



(a) (b) (c) (d) (e)

Figure 7: Data of each distribution (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.



(a) (b) (c) (d) (e)

Figure 8: Comparison data of each distribution appalling probability of disappearance of the ν_μ (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.

Super Scaling Approach (SuSA)

Equation for the scaling variable (ψ')

Scaling variable:

$$\psi' \equiv \frac{1}{\sqrt{\xi_F}} \frac{\lambda' - \tau'}{\sqrt{(1+\lambda')\tau' + \kappa\sqrt{\tau'(\tau'+1)}}} \quad (5)$$

$$\xi_F = \sqrt{1+\eta_F^2} - 1;$$

$$\eta_F = \frac{k_F}{M_N} << 1;$$

$$k_F = 228\ MeV;$$

$$\kappa = \frac{q}{(2M_N)};$$

$$q = \sqrt{|\vec{k_\mu}|^2 + E_\nu^{true2} - 2\,|\vec{k_\mu}|\,E_\nu^{true}\,cos\theta_\mu}$$

$$\lambda' = \frac{\omega'}{(2M_N)};$$

$$\omega' = \omega - E_{shift};$$

$$\omega = E_\nu^{true} - E_\mu$$

$$E_{shift} = 20\ MeV;$$

$$\tau' = \kappa^2 - \lambda'^2.$$

The energy shift E_{shift}, is introduced in the theoretical description to account phenomenologically for the shift observed in the QE peak $\left(\omega = \frac{|Q^2|}{2\ M_N}\right)$ when the cross section is plotted as a function of ω.

ψ' dependency with θ_n

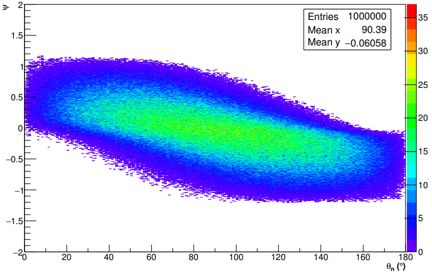


Figure 9: Scaling variable dependency with the neutron angle.

Neutron angle:

$$\theta_n = \arccos\left(\frac{\vec{P_\nu} * \vec{P_n}}{P_\nu\, P_n}\right) \qquad (6)$$

Super Scaling Approach (SuSA)

ψ' dependency with $\sqrt{s}$

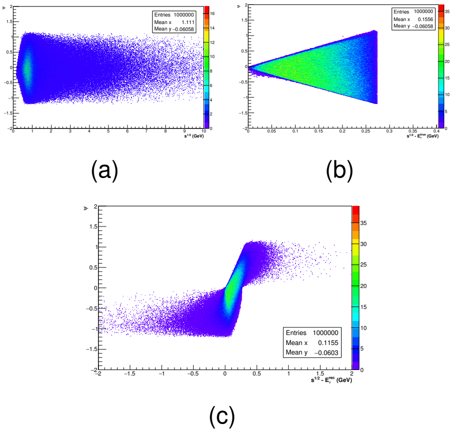


Figure 10: Scaling variable dependency with (a) the energy of the center of mass (b) the energy of the center of mass and (c).

Energy of the center of mass:

$$\sqrt{s} = E_\nu^{true} - P_n \tag{7}$$

Super Scaling Approach (SuSA)

ψ' dependency with Q^2_{rec}

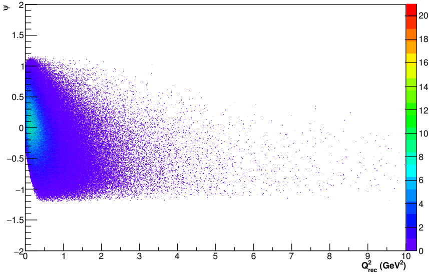


Figure 11: Scaling variable dependency with the transfered momentum.

Transfered momentum:

$$Q^2_{rec} = 2\,E_\nu^{rec}\,(E_\mu - |\vec{k_\mu}|\cos\theta_\mu) - M_\mu^2 \quad (8)$$

Reconstructed neutrino energy and SuSA

E_ν^{rec} dependency with ψ'

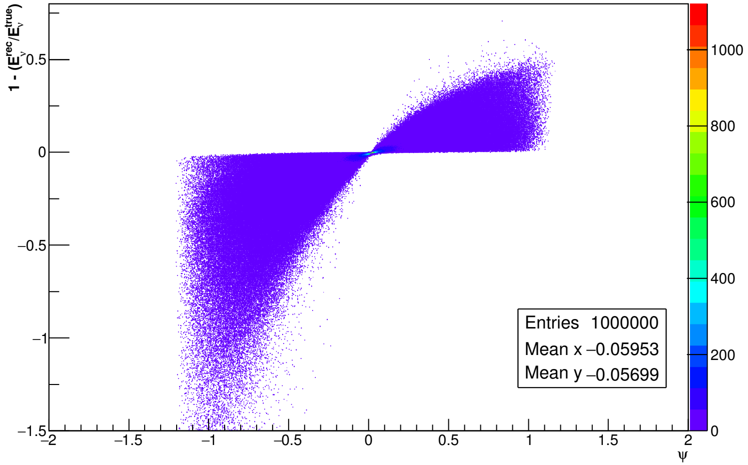


Figure 12: $1 - (E_\nu^{rec}/E_\nu^{true})$ vs. ψ.

Reconstructed neutrino energy and SuSA

E_ν^{rec} dependency with ψ'

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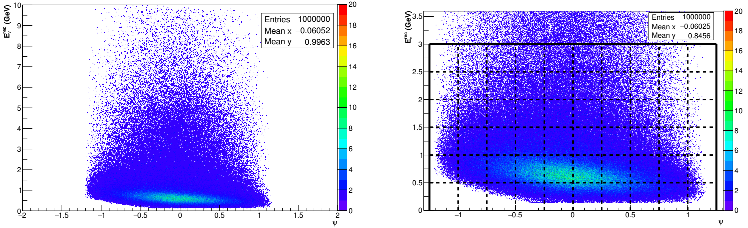
E_ν^{rec} vs. Q^2_{rec}
E_ν^{rec} vs. θ_μ
Super Scaling Approach (SuSA)
E_ν^{rec} vs. ψ'



(a) (b)

Figure 13: (a) Reconstructed neutrino energy vs. scaling variable, (b) matrix with bins of 0.5 GeV for E_ν^{rec} and 0.25 for the scaling variable.

Reconstructed neutrino energy and SuSA

E_ν^{rec} dependency with ψ'

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Introduction

Reconstructed neutrino energy

E_ν^{rec} vs. Q^2_{rec}

E_ν^{rec} vs. θ_μ

Super Scaling Approach (SuSA)

E_ν^{rec} vs. ψ'

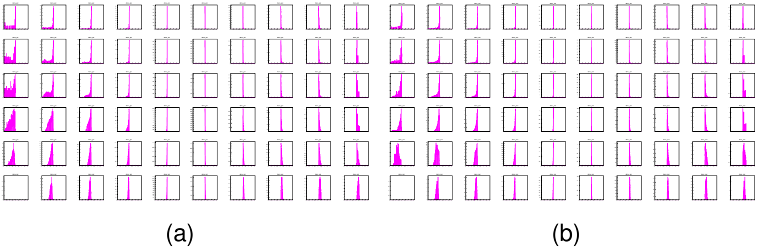
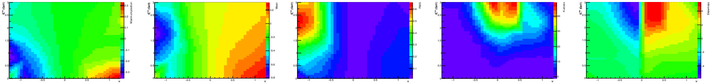


Figure 14: (a) No. of ν_μ events vs. $1 - (E_\nu^{rec}/E_\nu^{true})$ for each block of the matrix and (b) appalling probability of disappearance of the ν_μ.

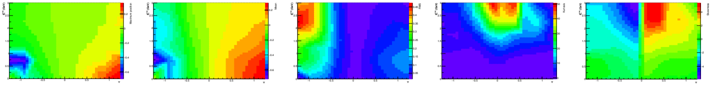
Reconstructed neutrino energy and SuSA

E_ν^{rec} dependency with ψ'



(a) (b) (c) (d) (e)

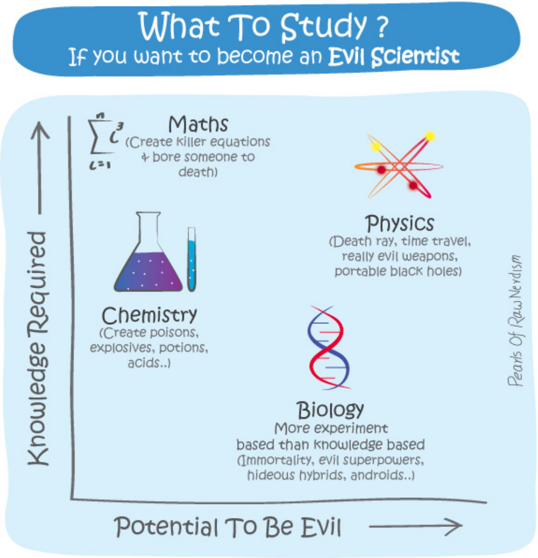
Figure 15: Data of each distribution (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.



(a) (b) (c) (d) (e)

Figure 16: Comparison data of each distribution appalling probability of disappearance of the ν_μ (a) Maximum position, (b) Mean, (c) RMS, (d) Kurtosis, (e) Skewmess.

Thank you!!!


What To Study ?
If you want to become an Evil Scientist
Knowledge Required
Maths
(Create killer equations & bore someone to death)
Physics
(Death ray, time travel, really evil weapons, portable black holes)
Chemistry
(Create poisons, explosives, potions, acids..)
Biology
More experiment based than knowledge based
(Immortality, evil superpowers, hideous hybrids, androids..)
Pearls Of Raw Nerdism
Potential To Be Evil