CC1π^+ Selection for 4π acceptance

ND280 Selection Development Working Group meeting

Danaisis Vargas Oliva

dvargas@ifae.es

Institute of High Energy Physics - IFAE

Tokai to Kamioka - T2K

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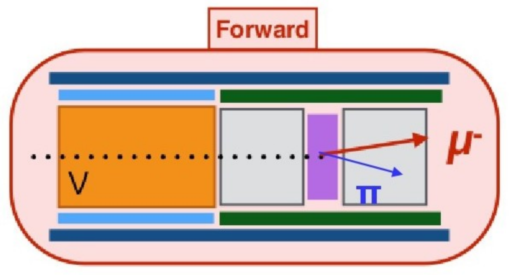
Institut de Física d'Altes Energies

Selection Criteria

numuCC4piMultiPi

Using the two selection:

1. Event quality data,
2. >0 tracks,
3. Sort TPC tracks,
4. Quality and Fiducial cut,
5. TPC veto,
6. Muon PID cut,
7. Pion PID cut,



CC0π (FWD, BWD, HAFWD and HABWD)

Reject events with:

- $\pi^{\pm}$ in TPCs,
- $e^{\pm}$ in TPCs,
- ME FGD,
- π FGD,

CC1π (FWD, BWD, HAFWD and HABWD)

Reject events with:

- π^- in TPCs,
- $e^{\pm}$ in TPCs,

Select events with either:

- $(\pi^+ + ME)$ in TPCs $= 1$
- ME$=0$ and $\pi^+(inTPC + inFGD) = 1$.

CCOther (FWD, BWD, HAFWD and HABWD)

Select events with either:

- $\geq 1e^{\pm}$ in TPCs,
- $\geq \pi-$ in TPCs,
- $> 1(\pi^+ + ME)$ in TPCs,

1. nd280Highland2 v2r27
2. Production 6B

I will be looking only FWD for now!!!
And only the $1/54$ of the total data.

Run No.	files
run6b_mag_neut.root	air (2,3 and 4) $+$ water (2 and 4)
run6b_data.root	from 00004000 to 00009999

Table 1: Runs used for test.

Muon Kinematics

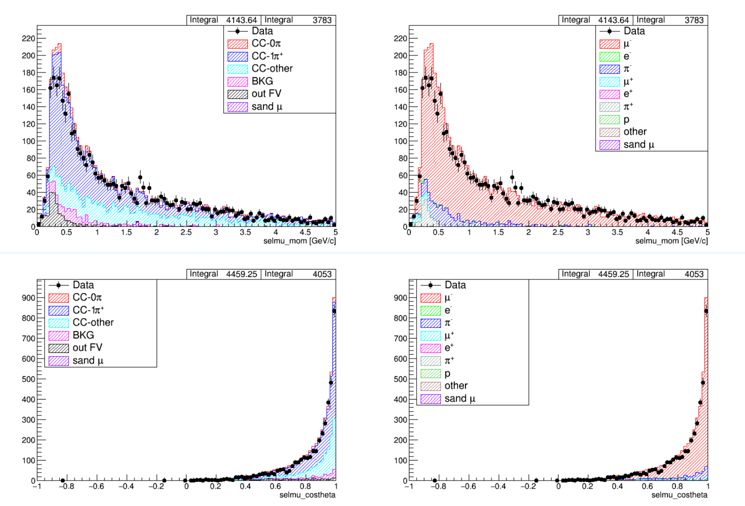


Figure 1: Muon momentum distribution according topology (top left) and particle (top right) level. Muon cosine of theta distribution for the CC1π^+ according topology (bottom left) and particle (bottom right) level. For CC1π^+.

Muon Kinematics

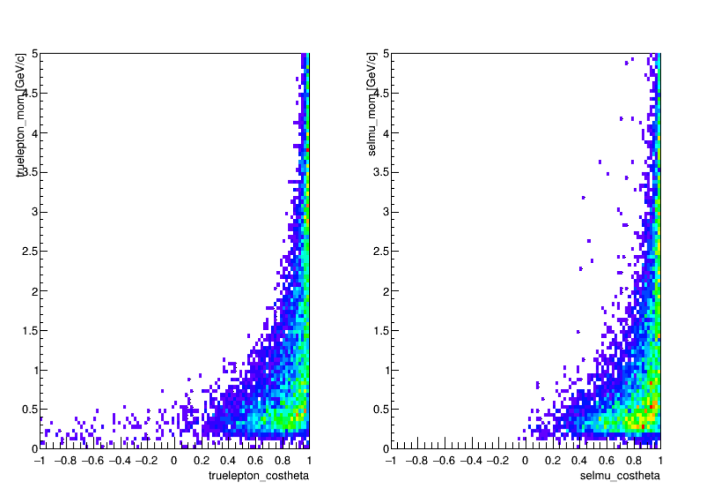


Figure 2: Muon momentum vs muon cosine of theta, for reconstructed variables (left) and true variables (right). For CC1π^{+}.

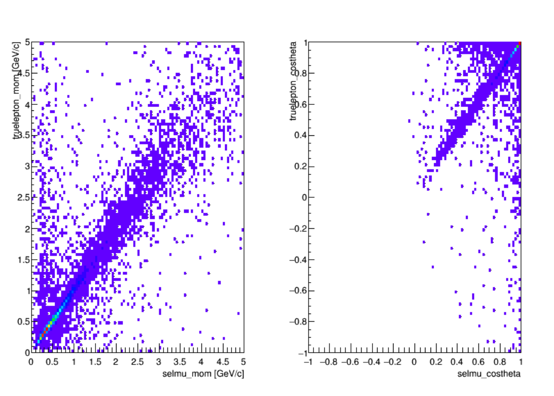


Figure 3: correlation between reconstructed and true muon momentum (left) and reconstructed and true muon cosine of muon theta (right). For CC1π^+.

Muon Kinematics

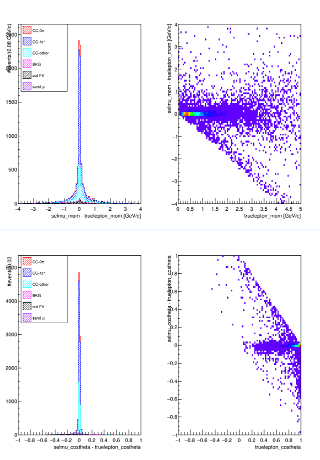


Figure 4: Difference between reconstructed and true muon momentum (top left), difference between reconstructed and true muon momentum vs. true muon momentum (top right), difference between reconstructed and true muon cosine of theta (bottom left), difference between reconstructed and true muon cosine of theta vs. true muon cosine of theta (bottom right). For CC1π^+.

Pion Kinematics

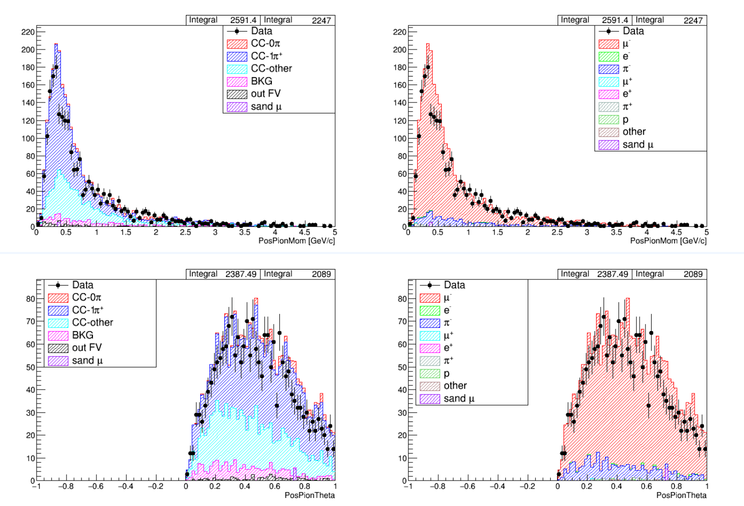


Figure 5: Pion momentum distribution according topology (top left) and particle (top right) level. Pion cosine of theta distribution for the CC1π^+ according topology (bottom left) and particle (bottom right) level. For CC1π^+.

Pion Kinematics

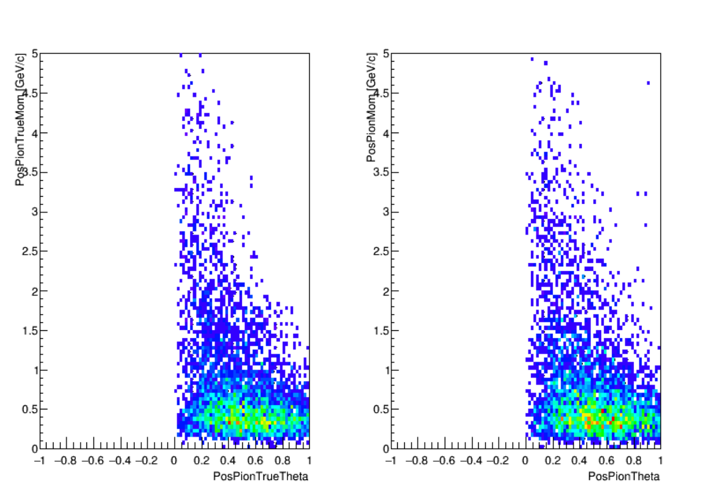


Figure 6: Pion momentum vs pion cosine of theta, for reconstructed variables (left) and true variables (right). For $CC1\pi^+$.

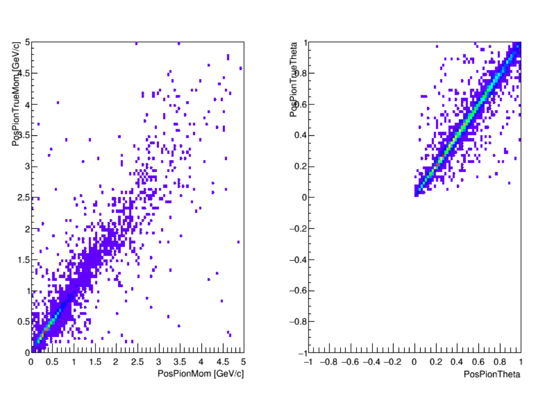


Figure 7: correlation between reconstructed and true pion momentum (left) and reconstructed and true pion cosine of muon theta (right). For CC1π^+.

Pion Kinematics

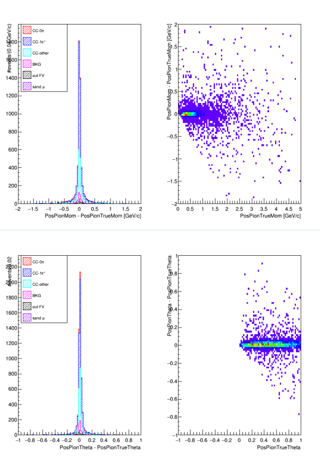


Figure 8: Difference between reconstructed and true pion momentum (top left), difference between reconstructed and true pion momentum vs. true muon momentum (top right), difference between reconstructed and true pion cosine of theta (bottom left), difference between reconstructed and true pion cosine of theta vs. true muon cosine of theta (bottom right). For CC1π^+.

Muon vs. Pion Kinematics

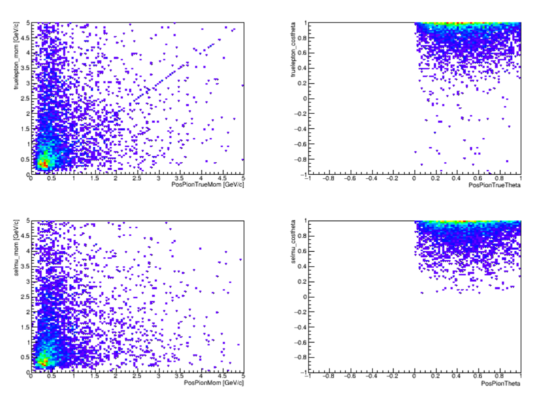


Figure 9: Relationship between muon and pion momentum (left) and muon and pion cosine of theta (right). For $CC1\pi^+$.

Neutrino Kinematics

$$E_{RecoMB} = \frac{m_\mu^2 + m_\pi^2 - 2m_N(E_\mu + E_\pi) + 2p_\mu \cdot p_\pi}{2(E_\mu + E_\pi - |\mathbf{p}_\mu| cos\Theta_{\nu,\mu} - |\mathbf{p}_\pi| cos\Theta_{\nu,\pi} - m_N)}$$

$$E_{RecoMBapproach} = \frac{m_\mu^2 + m_\pi^2 - 2m_N(E_\mu + E_\pi) + 2p_\mu \cdot p_\pi}{2(E_\mu + E_\pi - |\mathbf{p}_\mu| cos\Theta_{\nu,\mu} - m_N)}$$

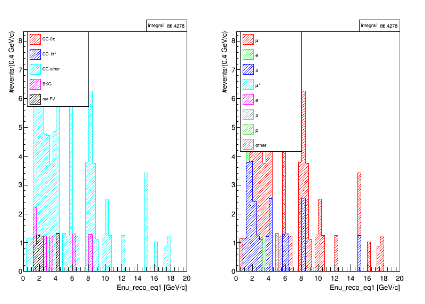


Figure 10: Reconstructed neutrino energy using E_ν^{RecoMB} for topology (left) and particle (right). For CC1π^+.

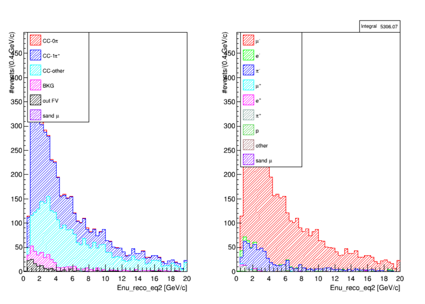


Figure 11: Reconstructed neutrino energy using $E_\nu^{RecoMBapproach}$ for topology (left) and particle (right). For CC1π^+.

Neutrino Kinematics

$$E_{RecoMB} = \frac{m_\mu^2 + m_\pi^2 - 2m_N(E_\mu + E_\pi) + 2p_\mu \cdot p_\pi}{2(E_\mu + E_\pi - |\mathbf{p}_\mu| cos\Theta_{\nu,\mu} - |\mathbf{p}_\pi| cos\Theta_{\nu,\pi} - m_N)}$$

$$E_{RecoMBapproach} = \frac{m_\mu^2 + m_\pi^2 - 2m_N(E_\mu + E_\pi) + 2p_\mu \cdot p_\pi}{2(E_\mu + E_\pi - |\mathbf{p}_\mu| cos\Theta_{\nu,\mu} - m_N)}$$

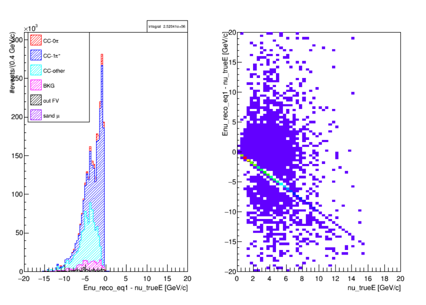


Figure 12: Difference between reconstructed and true neutrino energy using E_ν^{RecoMB} for topology (left) and particle (right). For CC1π^+.

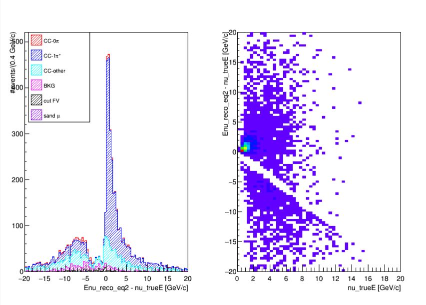


Figure 13: Difference between reconstructed and true neutrino energy using $E_\nu^{RecoMBapproach}$ for topology (left) and particle (right). For CC1π^+.

MOMENTUM TRANSFER

$$Q^2 = -q^2 = (p_\mu - p_\nu)^2$$

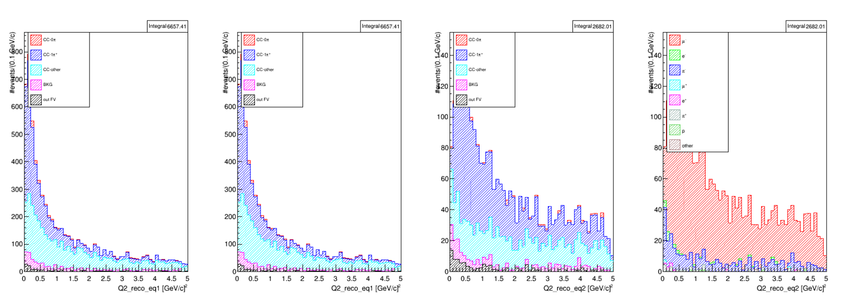
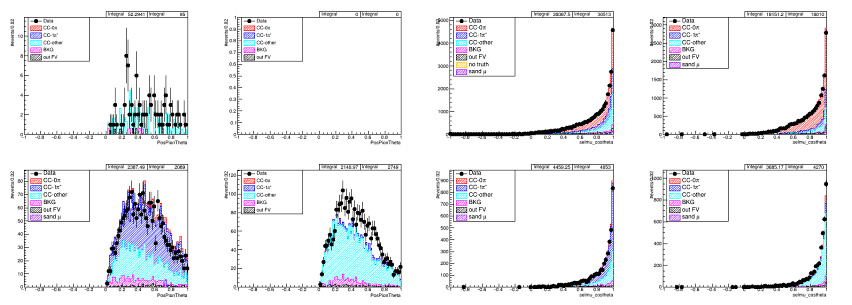
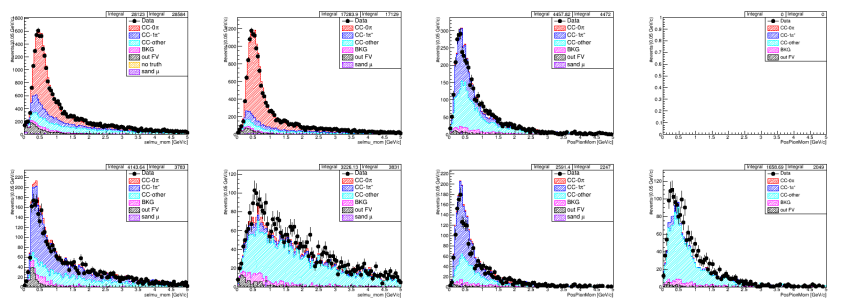


Figure 14: Transfered momentum according topology (top left) and reaction (top right) level. For CC1π^+.

CC1π^+ Selection





Purity

Particle	Purity
μ^-	91.118139
μ^+	0.54582733
e^-	1.0173905
e^+	0.39296155
π^-	4.824405
π^+	1.4363479
p	0.50102443
other	0.073644815
no thruth	0.0015120787
sand μ	0.08874779

Table 2: True sample purity (in %) of the particle.

Reaction	Purity
CCQE	41.391876
2p2h	6.3699333
RES	23.311735
DIS	16.397918
COH	2.0000215
NC	2.3842028
$CC - \bar{\nu}_\mu$	0.53935444
$CC - \nu_e, CC - \bar{\nu}_e$	0.19664012
other	0
out FV	7.3180599
no truth	0.0015120787
sand μ	0.08874779

Table 3: True sample purity (in %) of the reaction.

Efficiency

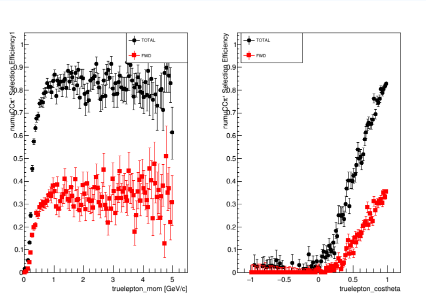


Figure 15: True muon momentum (left) and muon cosine of theta (right) efficiency, for CC1π^+ with its vertex in FGD1 FV. Colors indicate contribution from different directions: forward (red) and total (black).

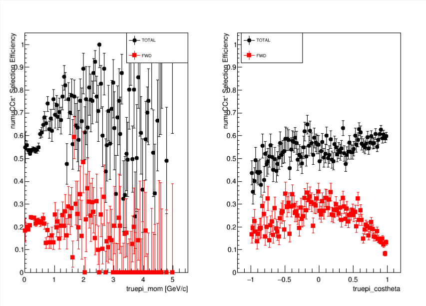


Figure 16: True pion momentum (left) and pion cosine of theta (right) efficiency for CC1π^+ with its vertex in FGD1 FV. Colors indicate contribution from different directions: forward (red) and total (black).

SUMMARY

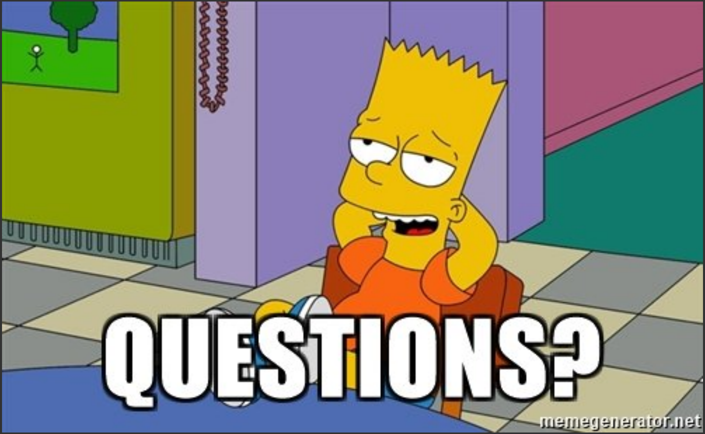
Until now:

1. The numuCC4piMultiPiAnalysis package has been implemented in highland2.
2. The selection of numuCC1π^+ is working.

For the next weeks:

1. Include the variables of the proton (for a complementary study (numuCC1$\pi^+ +$ *Np*) that Stéphanie Bron is going start).
2. Improve the π PID cut.

Thank you!



and Suggestions.