Update for Produced Neutrino Energy Spectra

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Motivation

The energy spectra of the produced neutrinos are necessary for the cross section measurement. I produced the spectra for ν_τ, ν_μ, and ν_e with the E872 MC.

As a cross check for these spectra, I will compare them with data from the E613 experiment. The following differences in the two data sets must be considered.

- E613 used 400 GeV protons vs. our 800 GeV protons

- E613 neutrinos are produced by D particles only, not D_s.

Procedure

- First I need the spectra for prompt (only from D particles) ν_μ and ν_e from 400 GeV protons.

- E613 provides an energy spectrum for their interacted neutrinos. I must extract the energy spectrum for the produced neutrino interactions.

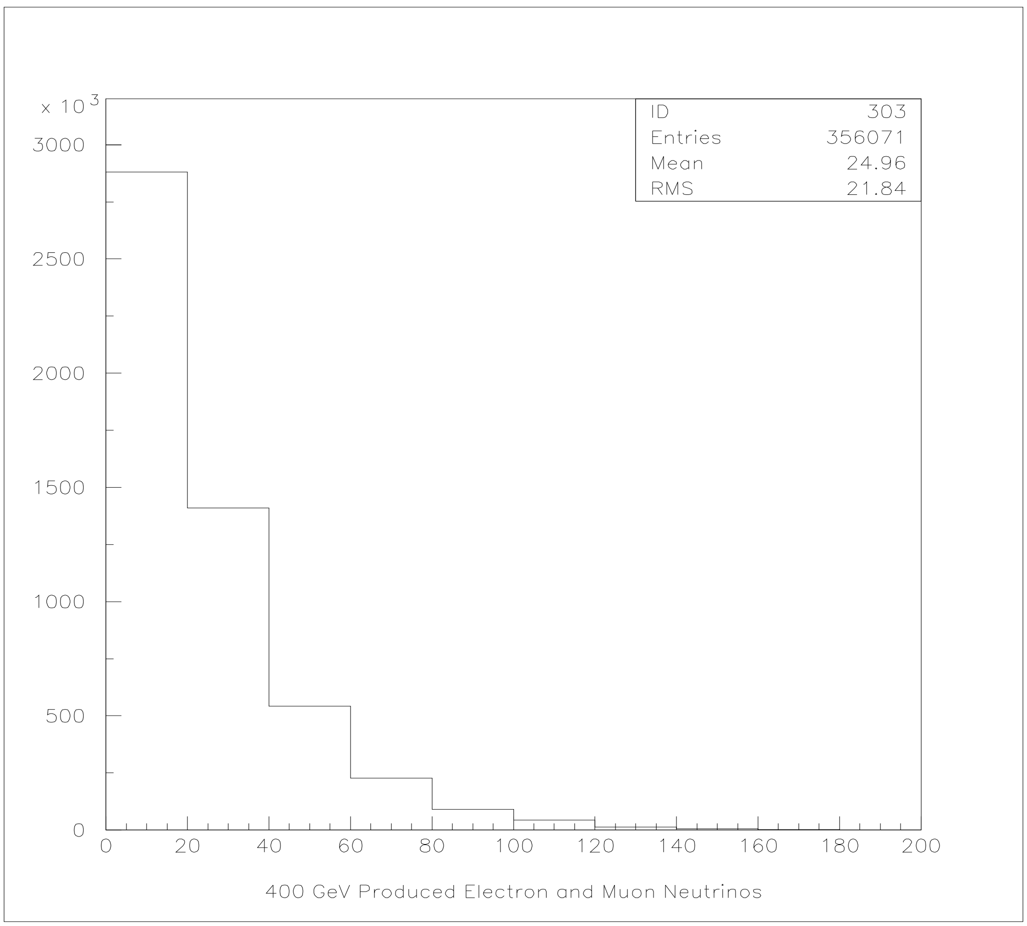
- In both experiments, the charm production cross section is parameterized with:

$$\frac{d^2\sigma}{dx_F dp_T^2} \propto e^{-bp_T}(1 - x_F)^n \tag{1}$$

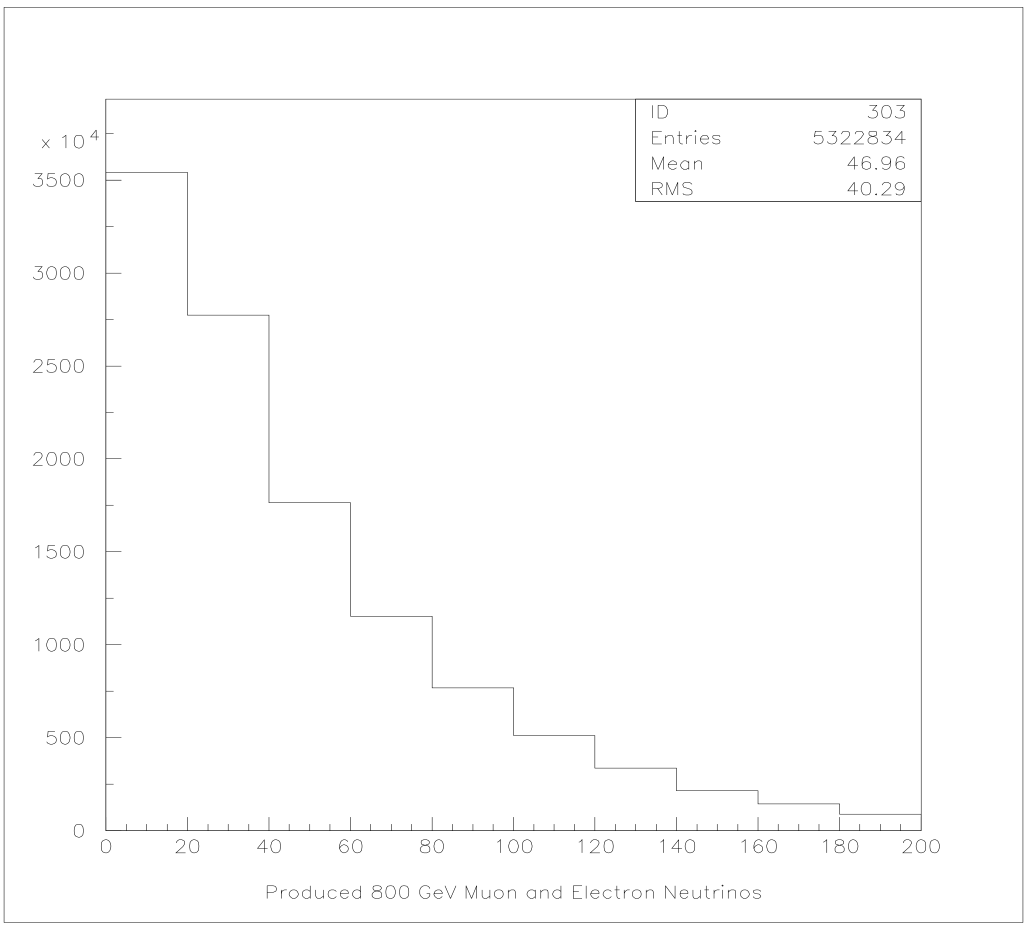
  In order to compare the data to our Monte Carlo, the ranges of x_F and p_T must overlap. I must check the range of x_F and p_T for each experiment.

Monte Carlo Results

The resulting produced neutrino energy spectrum from the E872 Monte Carlo with 400 GeV protons:



Comparing this to the 800 GeV neutrino energy spectrum, the main difference is the 400 GeV spectrum has more low energy neutrinos, which is what you would expect.



E613 Energy Spectrum Results

E613 provides an energy spectrum for the interacted neutrinos:

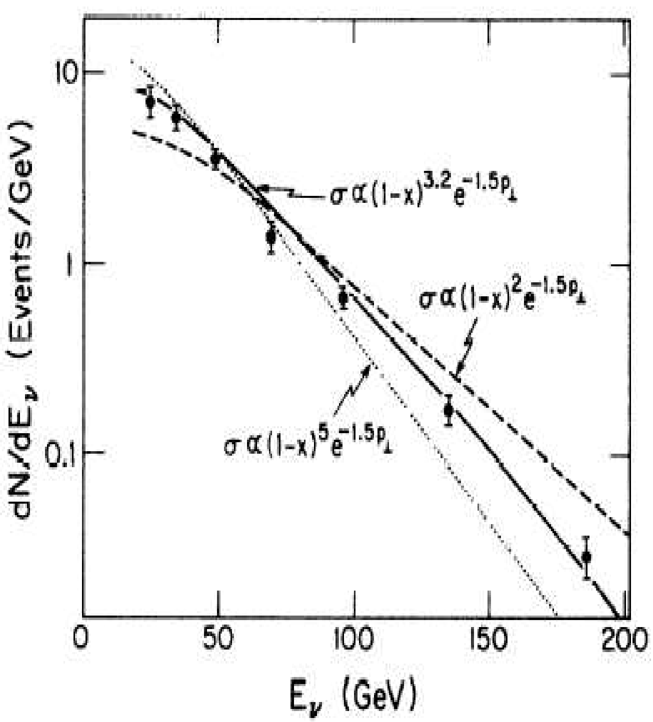


FIG. 20. Energy distribution dN/dE_ν of the measured prompt $\nu_\mu+\bar{\nu}_\mu+\nu_e+\bar{\nu}_e$ event rate per 10^{16} protons. The solid line represents the best fit to a $D\bar{D}$ production model (including detector acceptance) with $n=3.2$ and $b=1.5$. The dotted (dashed) line shows the spectra generated for $n=5$ ($n=2$).

E613 fits their interacted neutrino spectrum with the following function:

$$\frac{dN}{dE_\nu} = S \int 2\pi E_\nu \frac{d^3\sigma}{dp_\nu} \sin\theta_\nu d\theta_\nu \qquad (2)$$

where the integral is over their acceptance angle, S is the effective ν cross section in Pb, and

$$\frac{d^3\sigma}{dp_\nu} = B_{\Gamma_{D\to\nu}} \int \frac{dx}{x} \alpha \int \frac{dE_D}{E_\nu} \left(2E_D \frac{d^3\sigma}{dp_D^3} \right) \qquad (3)$$

where

$$\frac{d^2\sigma}{dp_D^3} \propto e^{-bp_T}(1 - x_F)^n \text{ and } \alpha = \left(\frac{1}{\Gamma_{D\to\nu}} \frac{d\Gamma_{D\to\nu}}{dx} \right) \qquad (4)$$

If I can take the interaction term, S, out of this integral and integrate it over the E872 acceptance instead of the E613 acceptance, I should get $\frac{dN}{dE_\nu}$ as a function of E_ν for E613's produced neutrinos. This should look similar to my produced neutrinos. Currently I am still working on this, as it is not a trivial integral.

Checking x_F and p_T Ranges

In order to check the E872 ranges for these variables, I can use the distributions that the Monte Carlo uses, which I found in nuemugen.sf.

$$x_F = \left(1 - \text{ran\_num}\left(\frac{1}{x_F n + 1}\right)\right) \tag{5}$$

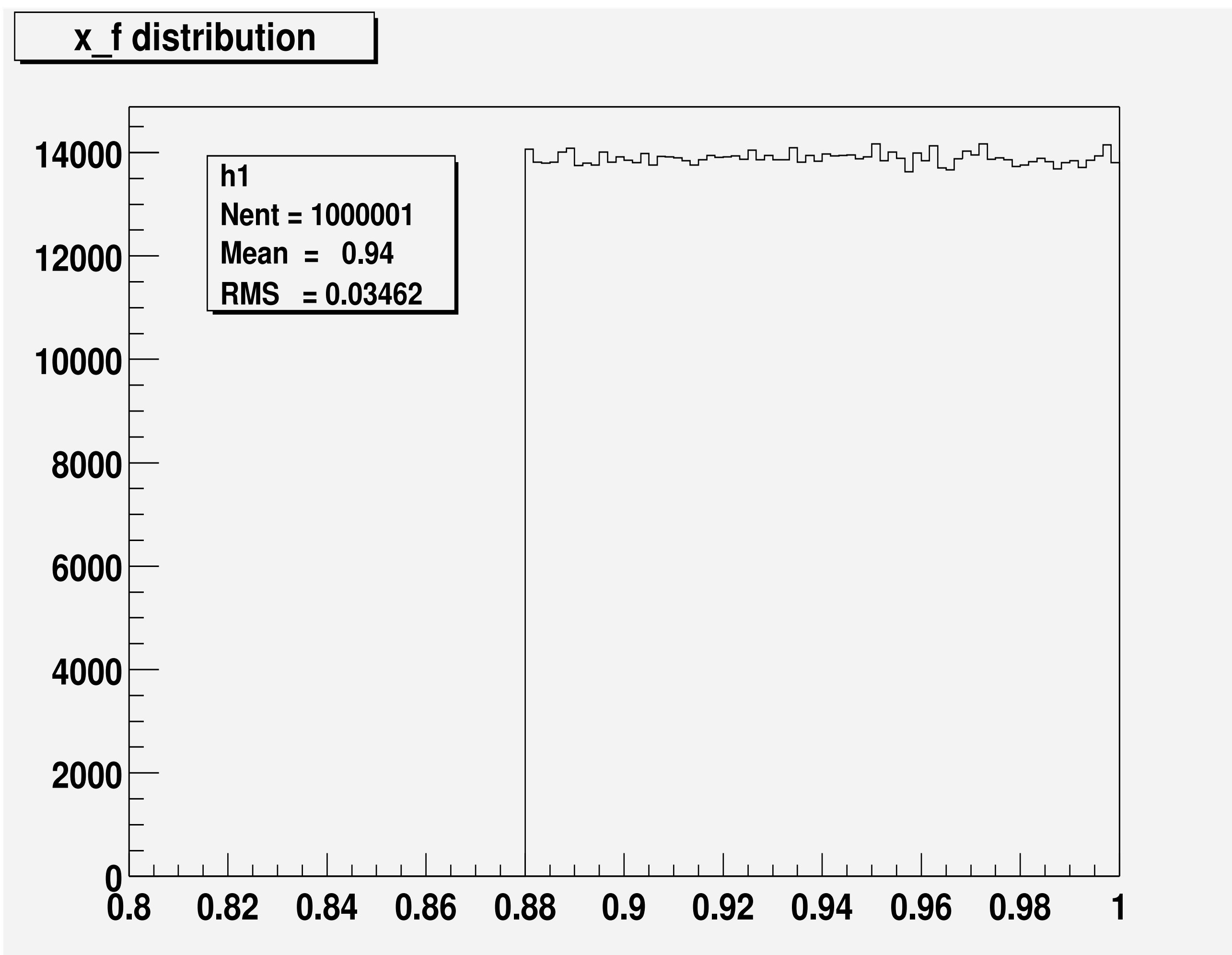
where $x_F n$ is the central value, which is an input to mymc.ctl,

$$x_F n = 7.4 \pm 0.6 \text{ and } n = 7.7 \pm 1.4 \tag{6}$$

which implies that our central value of x_F is:

$$x_F = 0.96 \pm 0.2 \tag{7}$$

and the x_F distribution is:



Should our x_F distribution look different?

For p_T:

$$p_T = \left| \frac{\text{e872\_gaussian}}{\sqrt{2 \cdot p_t b}} \right| \quad (8)$$

where e872_gaussian is a random number based on a gaussian distribution and

$$p_T b = 0.94 \pm 0.06 \text{ and } b = 0.8 \pm 0.2 \quad (9)$$

which implies that our central value of p_T is:

$$p_T = 1.2 \pm 0.3 \quad (10)$$

Shouldn't our p_T be smaller?

I am not sure how to extract the range of x_F and p_T from the information given in the paper, which is:

- A plot of $\frac{dN}{dE_\nu}$ as a function of E_ν for produced neutrinos
- A plot of $\frac{dN}{dp_T^2}$ as a function of p_T for produced neutrinos
- A function to fit each of these plots

I am still working on this.

Future Work

- Complete integration of their fit function without the interaction term and with E872 acceptance instead of E613 acceptance

- Find the ranges for x_F and p_T for the E613 experiment

- Understand the E872 x_F and p_T distributions