Can we estimate the ν_e flux with the measured μ^+ rate?

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Abstract

Milind suggested that measurement of the $\overline{\nu}_\mu$ flux via reconstructed μ^+ in CC interactions could be used to estimate the ν_e flux if $\mu^+ \rightarrow e^+\overline{\nu}_\mu\nu_e$ is a significant fraction of $\overline{\nu}_\mu$ production. Based on a study with GNUMI, this suggestion is not totally crazy.

1 Initial study and results

If $\mu^+ \rightarrow e^+\overline{\nu}_\mu\nu_e$ is a substantial contribution to the $\overline{\nu}_\mu$ flux, then measurement of μ^+ in the near detector could give us a handle on the ν_e flux. Figures 1 and 2 show that the only contribution from muon decays occurs at less than 10 GeV and attains $\sim 15\%$ of the total ν_μ flux based on GNUMI R15. For antineutrino energies less than 20 GeV, the $\overline{\nu}_\mu$ flux is dominated by $\overline{\nu}_\mu$ from π^- decays. If the $\overline{\nu}_\mu$ from pions in the 10-20 GeV range can be used to estimate the pion-produced $\overline{\nu}_\mu$ spectrum at < 10 GeV, then the method might work. The extrapolation to the < 10 GeV range would require some input from simulation. Based on Jeff Hartnell's studies [1], it looks possible.

For completeness, I show the composition of the $\overline{\nu}_\mu$, ν_e and $\overline{\nu}_e$ fluxes in Figures 3, 4, 5, and 6. In Figure 7, the expected $\overline{\nu}_\mu$ and ν_e energy spectra extrapolated to the center of the front of the near detector are compared. Note the difference of $\sim 17\%$ in the relative $\overline{\nu}_\mu$ and ν_e fluxes that strike the near detector.

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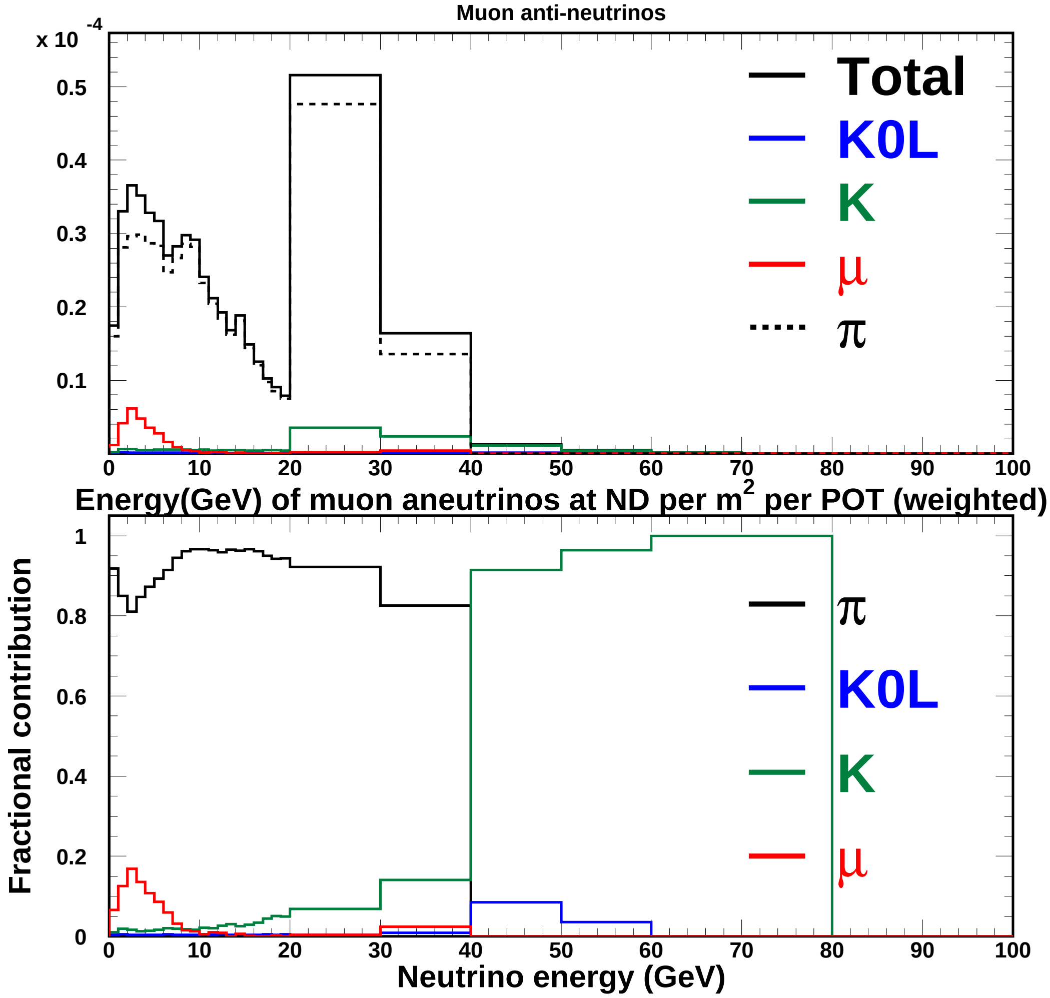

Figure 1: Upper: The total flux (solid black line) as a function of energy of $\overline{\nu}_\mu$ at the near detector. The contribution from pion, K0L, kaon and muon decays is indicated by the black dashed, dark blue, green and red lines, respectively. Lower: The fractional contribution to the neutrino flux as a function of energy from pions (black), K0L (dark blue), kaons (green) and muons (red). See Ref. [2].

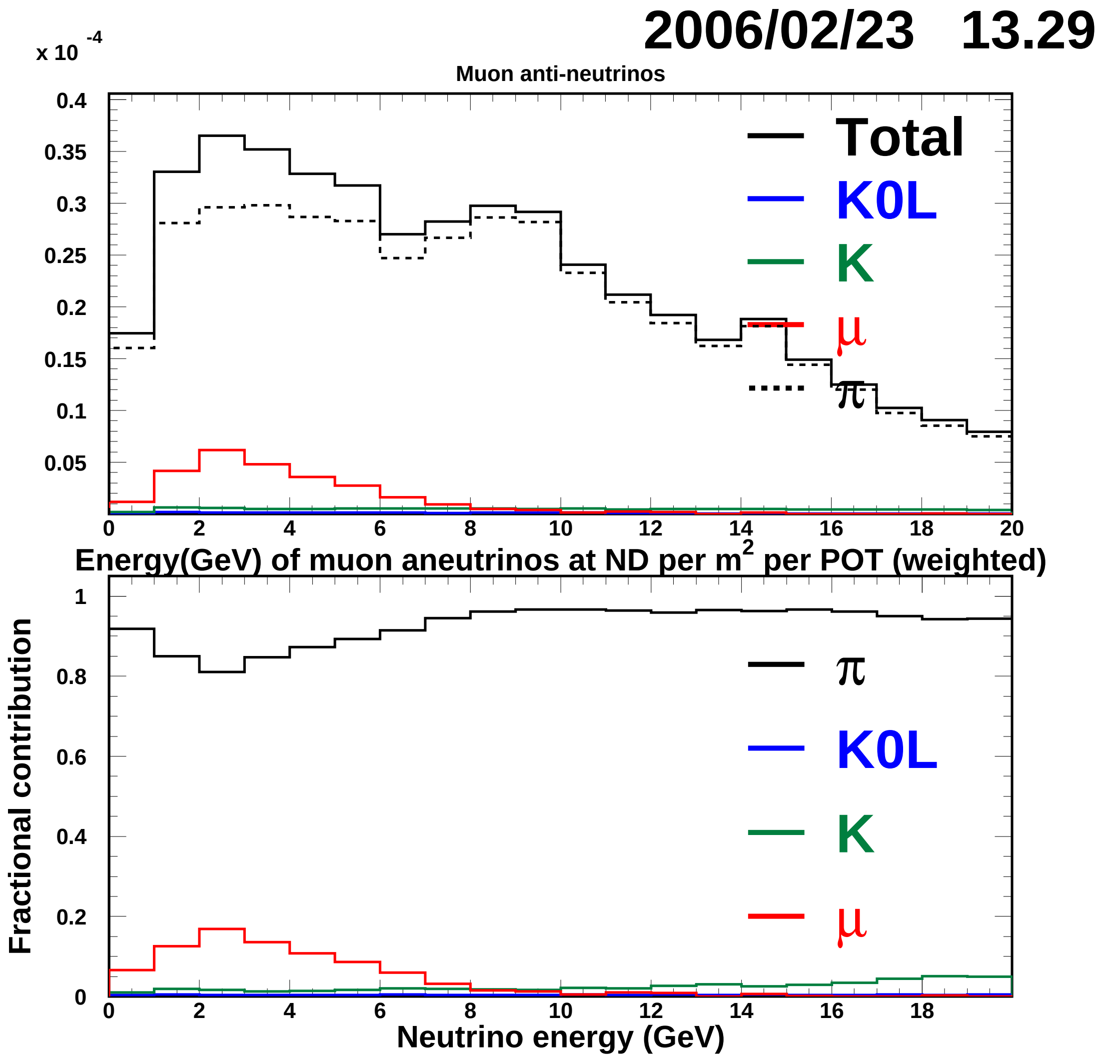

Figure 2: Same as Figure 1 but with linear ordinate and restricted to $E_\nu < 20$ GeV. See Ref. [2].

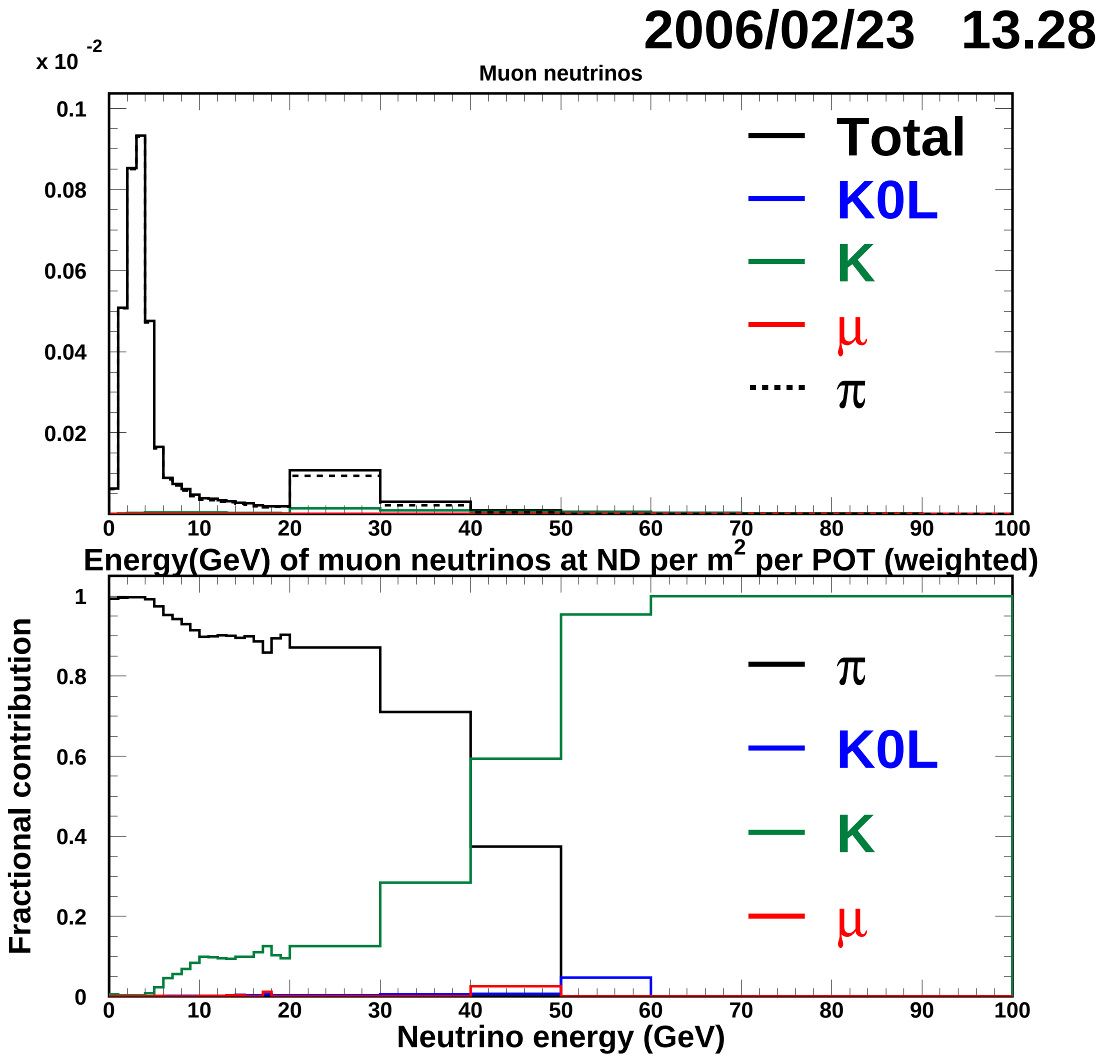

Figure 3: Upper: The total flux (solid black line) as a function of energy of ν_μ at the near detector. The contribution from pion, K0L, kaon and muon decays is indicated by the black dashed, dark blue, green and red lines, respectively. Lower: The fractional contribution to the neutrino flux as a function of energy from pions (black), K0L (dark blue), kaons (green) and muons (red). See Ref. [2].

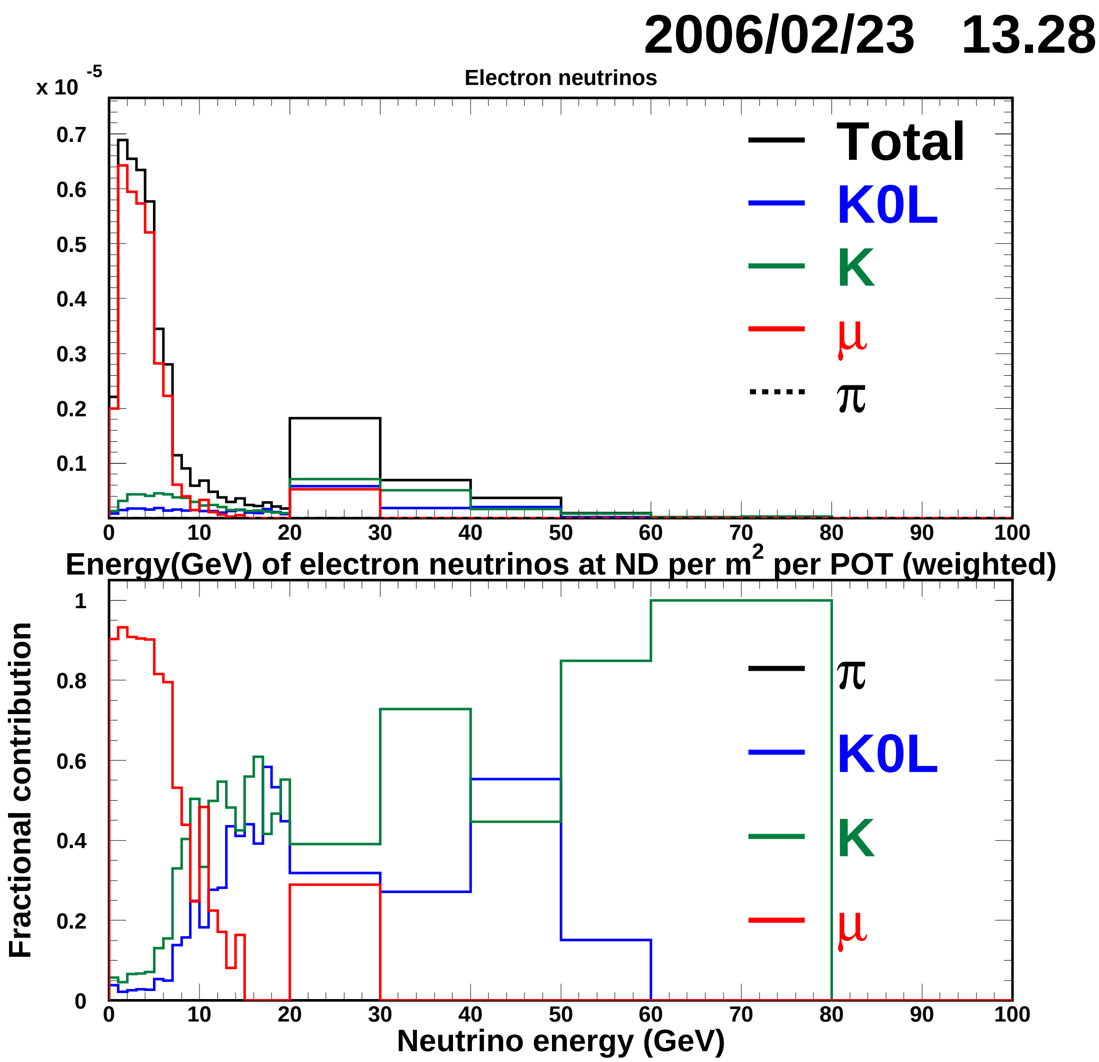

Figure 4: Upper: The total flux (solid black line) as a function of energy of ν_e at the near detector. The contribution from pion, K0L, kaon and muon decays is indicated by the black dashed, dark blue, green and red lines, respectively. Lower: The fractional contribution to the neutrino flux as a function of energy from pions (black), K0L (dark blue), kaons (green) and muons (red). See Ref. [2].

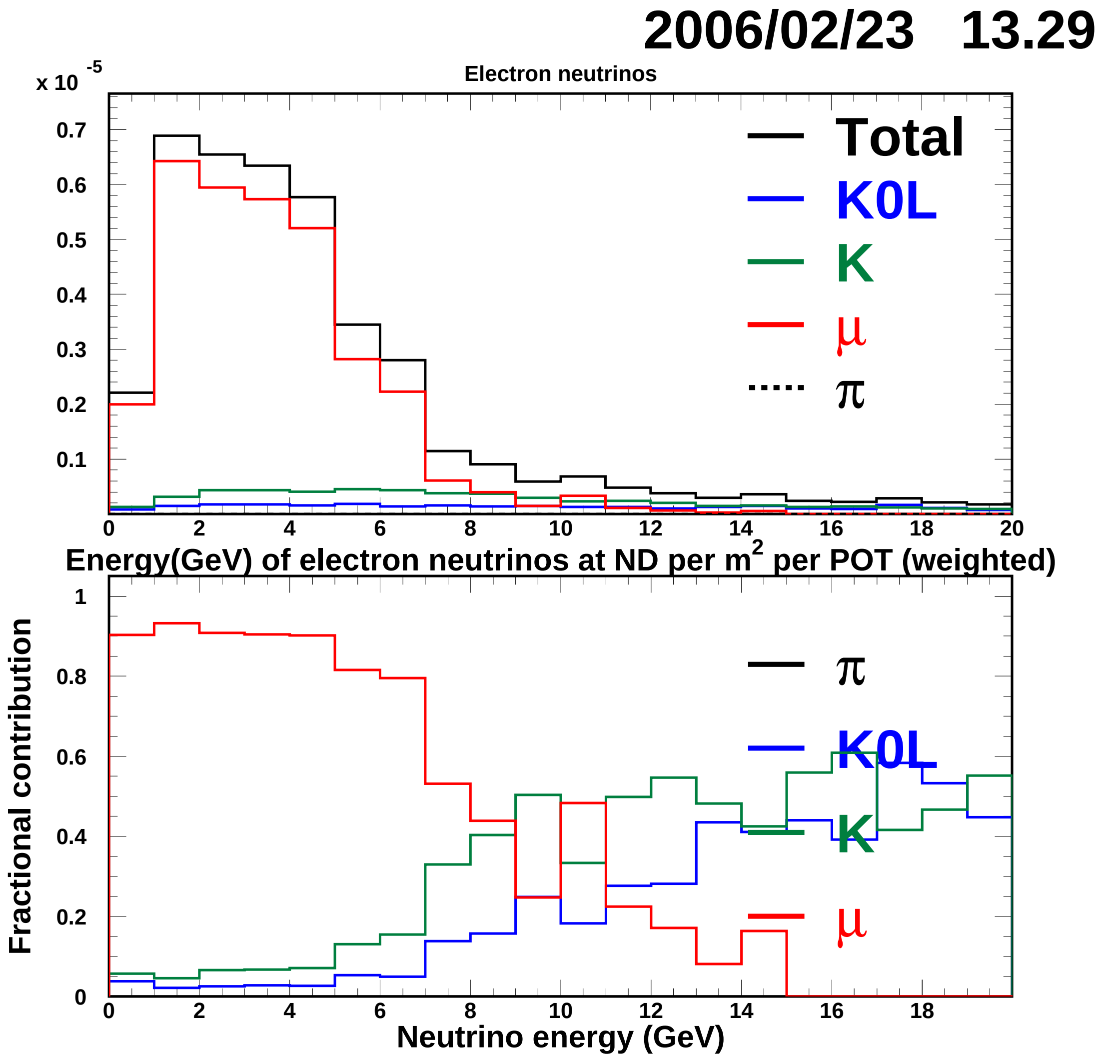

Figure 5: Same as Figure 4 but with linear ordinate and restricted to $E_\nu < 20$ GeV. See Ref. [2].

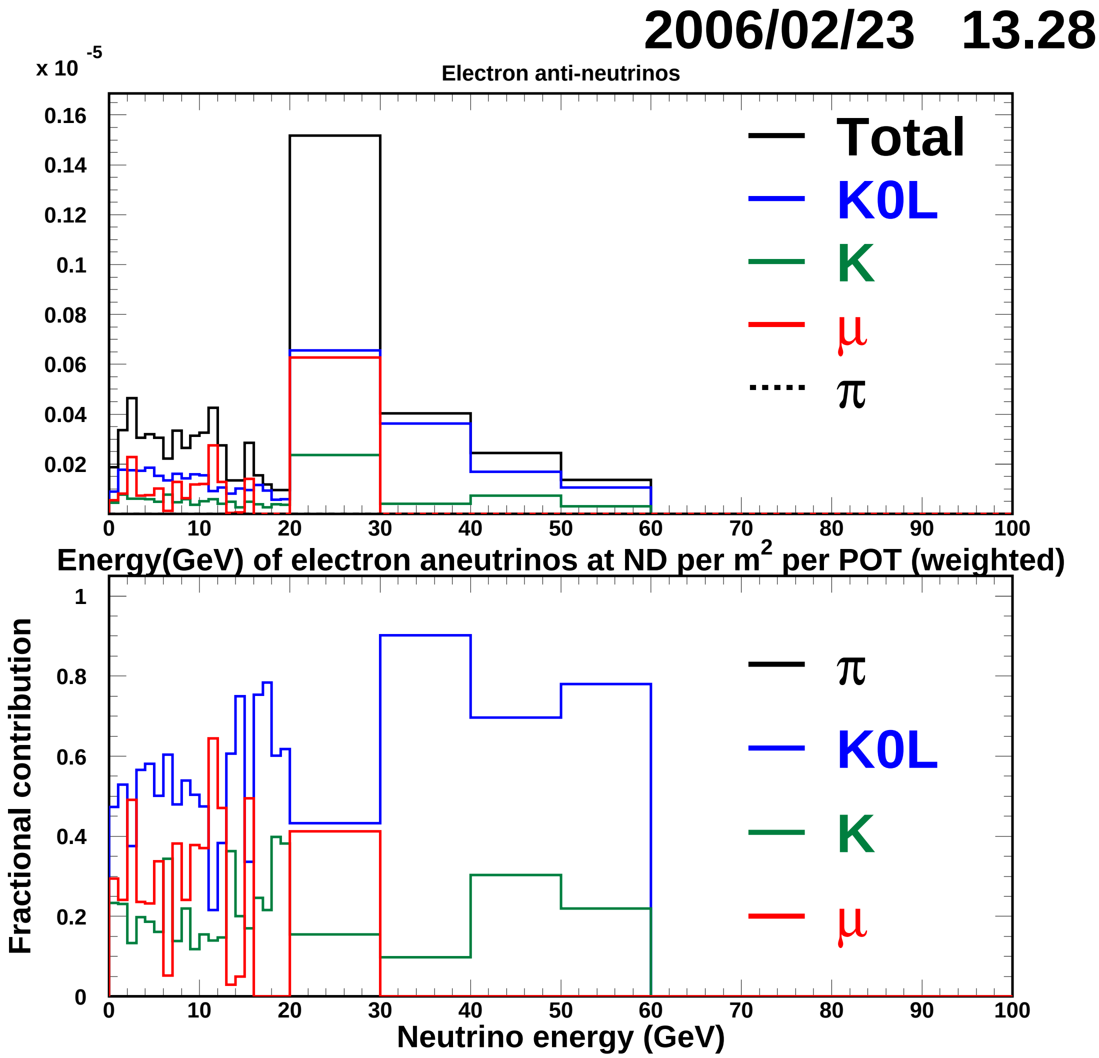

Figure 6: Upper: The total flux (solid black line) as a function of energy of $\overline{\nu}_e$ at the near detector. The contribution from pion, K0L, kaon and muon decays is indicated by the black dashed, dark blue, green and red lines, respectively. Lower: The fractional contribution to the neutrino flux as a function of energy from pions (black), K0L (dark blue), kaons (green) and muons (red). See Ref. [2].

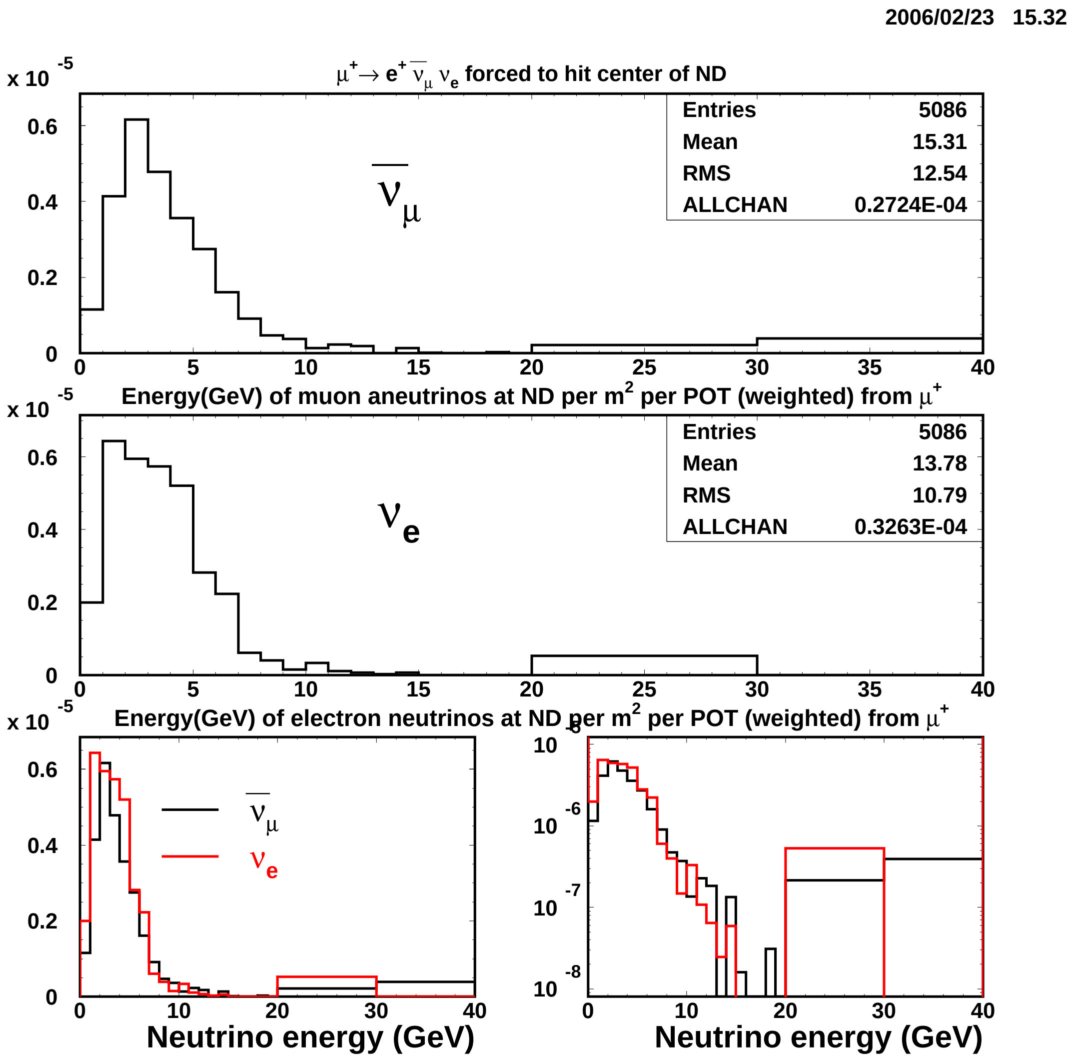

Figure 7: Upper: $\overline{\nu}_\mu$ flux as a function of energy at the near detector. Middle: ν_e flux as a function of energy at the near detector. Bottom: The two distributions are overlaid on linear (left) and logarithmic (right) scales. See Ref. [2].

References

[1] Jeff Hartnell, "A preliminary look at Anti-neutrinos in the Near detector", MINOS-doc-1409-v1, Presentation at January 2006 MINOS collaboration meeting.

[2] All plots were made with GNUMI R15 for the LE beam so they don't have the latest and greatest information about the beams. The gross features probably don't change much.