A Document Describing How the On and Off Axis Near Detectors for NOvA and MINOS sample the NuMI beam during a Variety of Beam Modes

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Abstract

This note summarises the spectra observed at the NOvA and MINOS near detectors during a variety of beam modes, with a breakdown of how they sample hadron production off the NuMI target. It attempts to provide a resource for those attempting to weigh the merits of running the NuMI beam in alternative beam modes, with a particular focus on those interested in reweighting hadron production from the NuMI target.

1 Introduction

In the previous incarnation of the NuMI beam data/Monte Carlo agreement at MINERvA and the MINOS Near Detector (ND) has been poor before using a system of "beam reweighting" to alter the predicted neutrino flux within horn focusing and hadron production constraints [1]. Key to this method was the use of multiple NuMI beam modes so as to both sample different regions of hadron production phase space, and perhaps most importantly to cancel detector effects in the final fit to the short baseline data to create the beam reweighting.

Additionaly in the previous incarnation of the NuMI beam a similiar technique called decomposition [2] was used by MINOS in its electron neutrino appearance analysis to data driven constraints on numi beam electron neutrino rates, an important backgroun to any electron neutrino analysis in the NuMI beam.

This document attempts to provide a resource for those attempting to weigh the merits of running the new NuMI beam in alternative beam modes, with a particular focus on those interested in reweighting hadron production from the NuMI target.

2 Method

The following plots are made using low threshold nova period FLUGG2008 flux mc, Cross sections are from GEANT, and normalization is to 1 kiloton year assuming 700kw running. Neutrino energies and probability of passing through the centre of each of the NOvA and MINOS ND is acheived using a parent information based reweighting that takes adavantage of the isotropic nature of pion and kaon decay[3].

3 CC ν_μ Spectra at the MINOS and NOvA Near Detectors

Figures 1, 2, 3, 4, 5, and 6 show CC ν_μ Spectra at the MINOS and NOvA Near Detectors for horn on and horn off running.

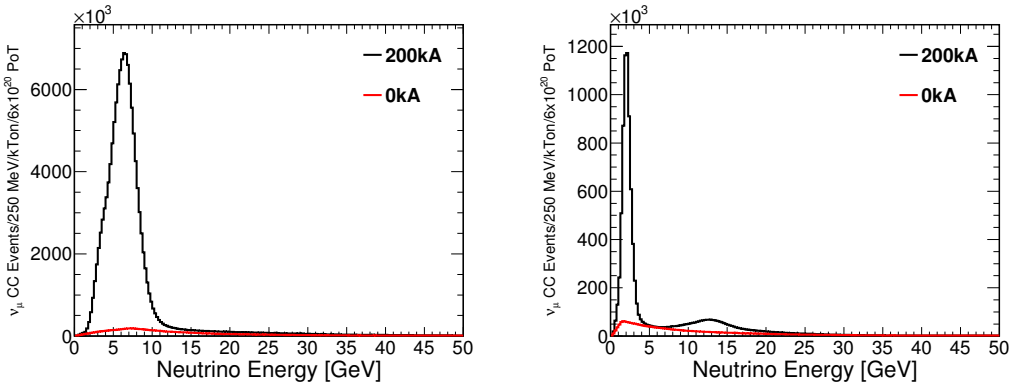

Figure 1: CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running.

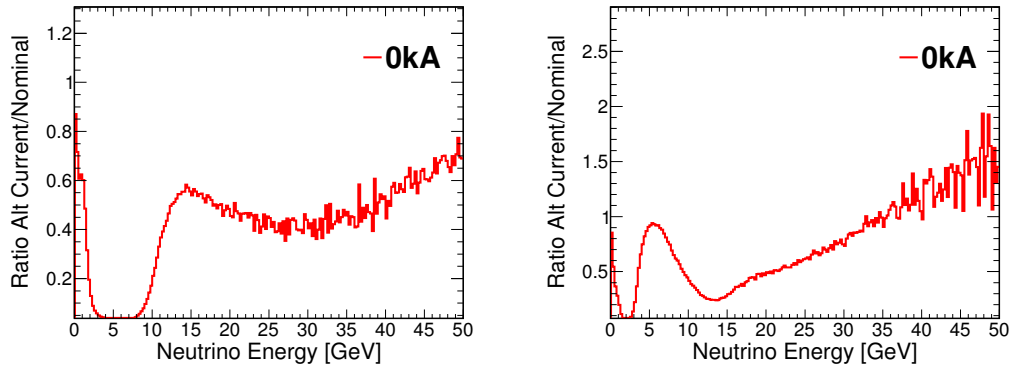

Figure 2: Ratio of CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running.

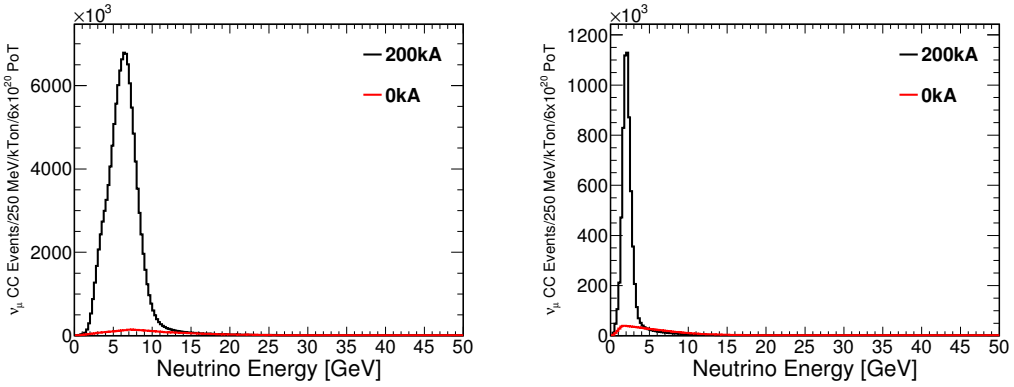

Figure 3: CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running. ν_μ where the original hadron produced off the NuMi target was a pion are shown

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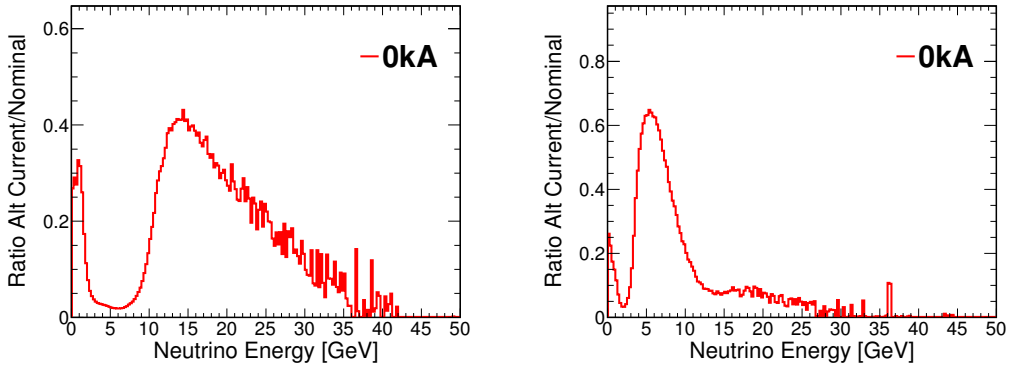

Figure 4: Ratio of CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running. ν_μ where the original hadron produced off the NuMi target was a pion are shown.

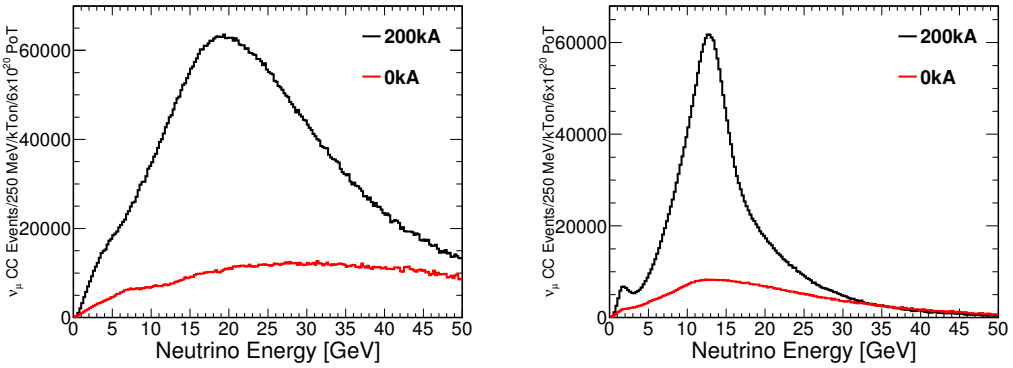

Figure 5: CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running. ν_μ where the original hadron produced off the NuMi target was a kaon are shown.

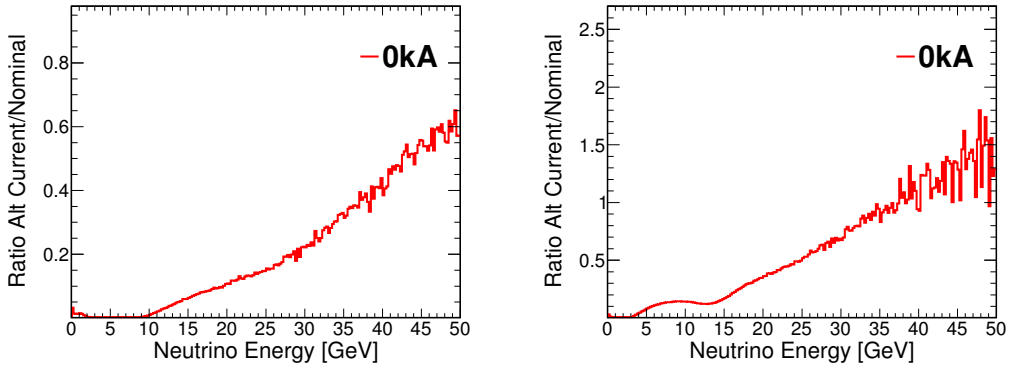

Figure 6: Ratio of CC ν_μ spectra at the MINOS and NOvA Near Detectors for horn on and horn off running. ν_μ where the original hadron produced off the NuMi target was a kaon are shown.

4 Hadron Production Phase Space Sampled at the MINOS and NOvA Near Detectors

Figures 7, 8, 9, and 10 show transverse momentum and feynman X distributions for hadrons as they leave the target and which eventualy produce a CC ν_μ event in the MINOS ND during horn on and horn off running.

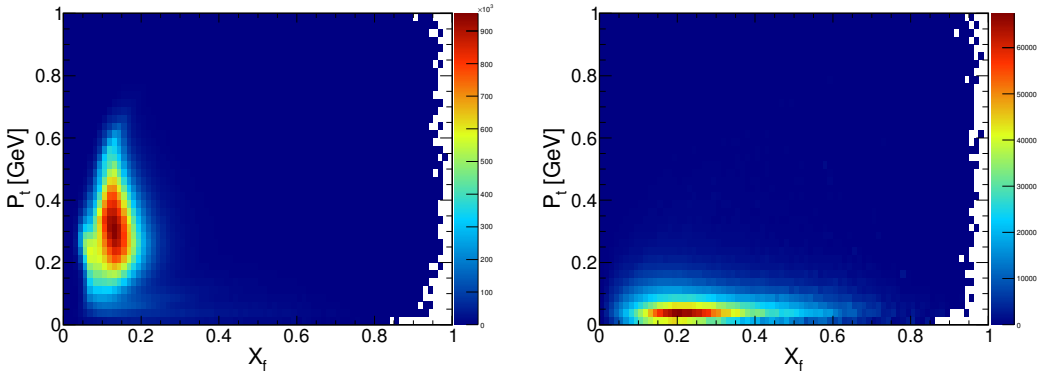

Figure 7: Pion transverse momentum and feynman X distributions for hadrons as they leave the target and which eventualy produce a CC ν_μ event in the MINOS ND during horn on (left) and horn off (right) running.

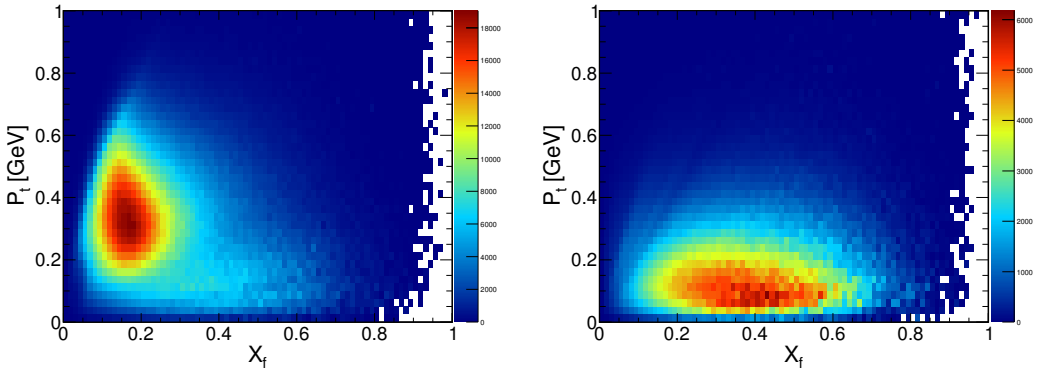

Figure 8: Kaon transverse momentum and feynman X distributions for hadrons as they leave the target and which eventualy produce a CC ν_μ event in the MINOS ND during horn on (left) and horn off (right) running.

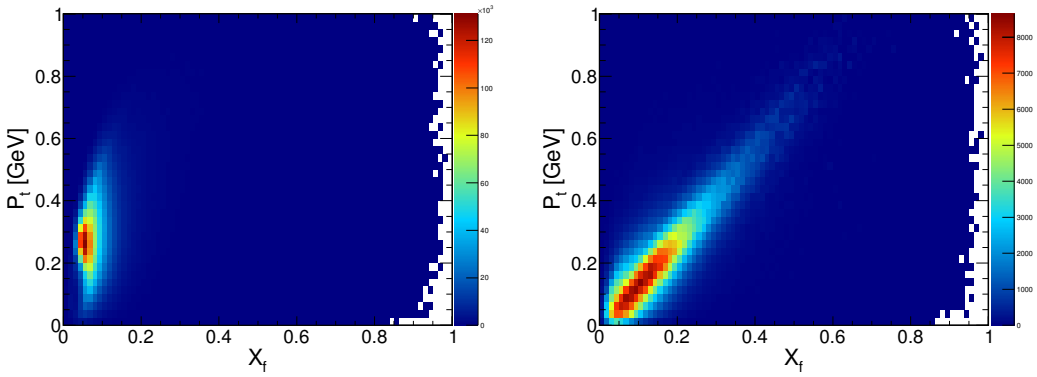

Figure 9: Pion transverse momentum and feynman X distributions for hadrons as they leave the target and which eventualy produce a CC ν_μ event in the NOvA ND during horn on (left) and horn off (right) running.

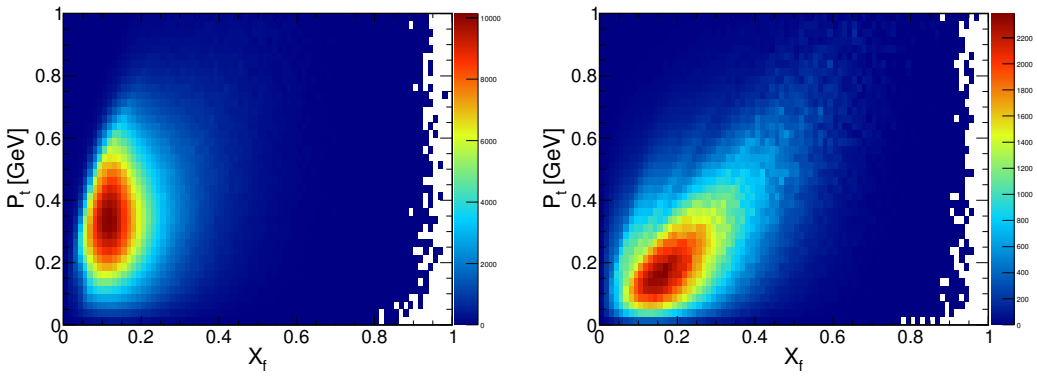

Figure 10: Kaon transverse momentum and feynman X distributions for hadrons as they leave the target and which eventualy produce a CC ν_μ event in the NOvA ND during horn on (left) and horn off (right) running.

References

[1] *Beam Fit Position Paper*, Mark Dorman, MINOS-doc-7146

[2] *Near Detector Beam Decomposition for the 3rd nue analysis*, Joao Coelho, MINOS-doc-7986

[3] *Neutrino Beam Simulation using PAW with Weighted Monte Carlo*, John Urish, MINOS-doc-109.