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Measurement of the NuMI Neutrino Flux Using the Accompanying Muon Beam

To further our understanding of neutrino interactions, it is desirable to measure
absolute cross sections on nucleon and nuclear targets. Many past neutrino experiments have measured relative cross sections due to a lack of precise measurements of the incident neutrino flux, normalizing to better established reaction processes, such as quasielastic neutrino-nucleon scattering. Absolute neutrino cross sections, in contrast, are determined via $\sigma(\nu) = N(\nu)/\varphi(\nu)$, where the numerator is the measured number of neutrino interactions in a neutrino detector and the denominator is the flux of incident neutrinos, measured independently. The NuMI beam line has 3 muon monitors which can be used to, indirectly, measure the neutrino flux. The muon flux is related to the neutrino flux because one muon is produced for every muon neutrino in $\pi^- \to \mu\nu(\mu)$ and $K^\pm \to \mu\nu(\mu)$ decays. We measure the neutrino flux generated by the NuMI beam line by measuring the daughter muon flux produced in pion and kaon decays. This is an in-situ flux measurement and is completely independent of the observed neutrino interaction rate in a neutrino detector.
The muon monitoring system consists of 3 arrays of 81 helium filled ionization
chambers located approximately 720m downstream of the target. Muons must have a
minimum energy of sim4, 10 and 20 GeV to penetrate muon monitor 1, 2 and, 3, respectively, providing sensitivity to the neutrino flux above $E(\nu) = 1.6$ GeV. Furthermore, the kinematic distributions of mesons producing neutrinos can be studied by moving the meson production target longitudinally and by varying the current through the focusing horns. These studies provide a mechanism to measure of the muon spectrum which is directly related to the parent pion and kaon flux off of the NuMI target and, in turn, the neutrino flux. The two current experiments utilizing the NuMI beam, MINOS and MINERA, can use this independently determined flux to measure neutrino cross-sections via $\sigma(\nu) = N(\nu)/\varphi(\nu)$, where the numerator is the number of neutrino events seen in the MINOS Near Detector and MINERA Detector. We will present the measurement of the NuMI neutrino flux obtained from the muon monitoring system.

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