FINAL STRANGE ASYMMETRY RESULTS FROM NuTeV

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The measurement of the difference between the strange and antistrange quark distributions from dimuon events recorded by the NuTeV experiment at Fermilab, utilizing the first complete NLO QCD description of the process is presented. Dimuon events, resulting from the semi-muonic decay of charmed particles produced in charged current neutrino interactions, allow direct study of the strange quark content of the nucleon. NuTeV's sign selected beam produced uniquely pure samples of neutrino and antineutrino initiated dimuon events, allowing independent measurement of the strange and antistrange quark distributions.

Dimuons, $\nu_\mu - N$ and $\overline{\nu}_\mu - N$ charged current events including two oppositely charged muons in the final state, are a unique data sample with which to isolate the strange and antistrange content of the nucleon[1]. These events occur in charm production from charged current (CC) interactions with strange (or down) quarks. Approximately 10% of the time the charmed hadrons decay semi-muonically, clearly distinguishing dimuons from other charged current interactions.

The NuTeV experiment was executed during Fermilab's 1996-97 fixed target run, and recorded 5163 ν and 1380 $\overline{\nu}$ dimuon events with a highly pure sign selected beam at reconstructed neutrino energies ranging from 20-400 GeV. The a priori knowledge of whether an event was the result of a neutrino or antineutrino interaction allows independent extraction of the strange and antistrange seas.

Several models exist which predict an asymmetry between the momentum distributions $xs(x)$ and $x\overline{s}(x)$[2,3,4,5,6]. Until now there has been little experimental constraint on such an asymmetry[7], leading to much phenomenological speculation [8,10,9,11,12], most recently in the context of the NuTeV $\sin^2\theta_W$ measurement[13], found to be 3σ above the world av-

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erage. An asymmetry in the strange and antistrange seas, assumed to be zero in the NuTeV analysis, would affect the measured value of $\sin^2\theta_W$. $S^- \equiv \int_0^1 xs(x) - x\overline{s}(x)dx$, would need to be approximately $+0.0068$[14,15] to bring the NuTeV measurement to the world average.

The measurement presented here represents the first extraction of the strange and antistrange sea distributions with a complete NLO QCD model differential in all variables required to describe event acceptance[16]. This model, coupled with NuTeV's uniquely pure neutrino and antineutrino data samples provides the ability to measure the nature and size of any asymmetry directly.

The NuTeV dimuon data has been condensed into a model independent forward dimuon cross section table[17,18]. This table is defined to be the cross section of charm produced dimuon events in iron such that the muon from the semileptonic charm decay has energy greater than 5 GeV. The cross section was extracted in a model independent way, and has been corrected for detector smearing effects and the background due to semileptonic π and K decays. The cross section data is available for public use.

As is described in more detail in reference 19, the strange sea is extracted by performing a χ^2 fit of the acceptance corrected dimuon cross section to the table data The following expression illustrates the components making up this fit:

$$\frac{d\sigma_{charm}}{dxdy} \cdot B_c \otimes \mathcal{N} \otimes \mathcal{A} = \boxed{\text{fit}} \Rightarrow \frac{d\sigma_{2\mu}}{dxdy} \tag{1}$$

Where model parameters in components on the left side of $= \boxed{\text{fit}} \Rightarrow$ are varied to find the best χ^2 to the cross section table values, $\frac{d\sigma_{2\mu}}{dxdy}$. $\frac{d\sigma_{charm}}{dxdy}$ is the NLO neutrino charm production cross section[20], dependent on the strange/antistrange sea and charm mass. B_c is the charm semileptonic branching ratio, for which value of 0.099 ± 0.012, from FNAL E-531 data[21], is used. $\mathcal{N}$ is the correction for nuclear effects, dependent on , x, Q^2, atomic number (in this case for iron), and struck quark pdf[22].

$\mathcal{A}$ is a kinematic acceptance correction accounting for the 5 GeV cut on the energy of the charm decay muon. $\mathcal{A}$ depends on E_ν, y, x, as well as charm fragmentation and, at NLO, charm mass. A Monte Carlo simulation of dimuon events employing the DISCO[16] charm cross section model was used to calculate $\mathcal{A}$ in each cross section table bin.

Fits are based on the CTEQ6M pdf set[23], and a modified version of the EVLCTEQ evolution package which accommodates $s(x) \neq \overline{s}(x)$ is used. The strange sea is described with a parameterization[24] which enforces $\int s(x) - \overline{s}(x)dx = 0$ by finding where $s^-(x) \equiv s(x) - \overline{s}(x)$ crosses zero, x_0, such that that be the case. The nonstrange pdf's are held constant, and treated as external constraints. The total momentum sum rule is maintained by slightly rescaling the size of the gluon distribution to balance any increase or decrease in the size of xs^+.

A good fit to the table, with a χ^2 of 38.2/37.8 DOF is achieved. The overall size of the strange and antistrange seas resulting from the fit, $\eta \equiv \frac{S^+}{U+D}$ of 0.061 ± 0.001 (stat) ± 0.006 (syst) ± 0.013 (external) agrees well with past measurements. If left to vary in our fits, we obtain a charm mass of 1.41 ± 0.10 (stat) ± 0.08 (syst) ± 0.12 (external) GeV.

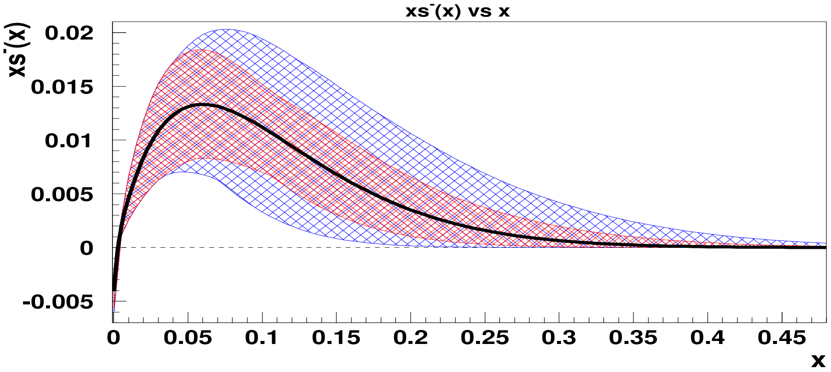

Figure 1. $xs^-(x)$ vs x at $Q^2 = 16$ GeV^2. Outer band is combined errors, inner band is without B_c uncertainty.

Figure 1 shows the shape of $xs^-(x)$ resulting from the fit, with the outer error band indicating the combined error on the measurement. The inner error band shows the uncertainty without including the error due to B_c. We find that $xs^-(x)$ tends positive at moderate x, such that S^- is 0.00196 ± 0.0046 (stat) ± 0.0045 (syst) ± 0.00119 (external).

The data prefers an asymmetry which satisfies the flavor sum rule by forcing $s^-(x)$ to spike negative below an x_0 of 0.004, where it is unconstrained by NuTeV data. If one chooses to fix the crossing point at higher values of x_0, as suggested by some theoretical models, one finds the asymmetry shrinks with increasing x_0 at the expense of χ^2. Figure 2 shows the results of three fits where x_0 was fixed at increasing values of x, and the sum rule was satisfied by solving for one of the other shape parameters. As the crossing point reaches $x_0 = 0.15$ the asymmetry virtually disappears, however the χ^2 grows to 53.4/38.8 DOF.

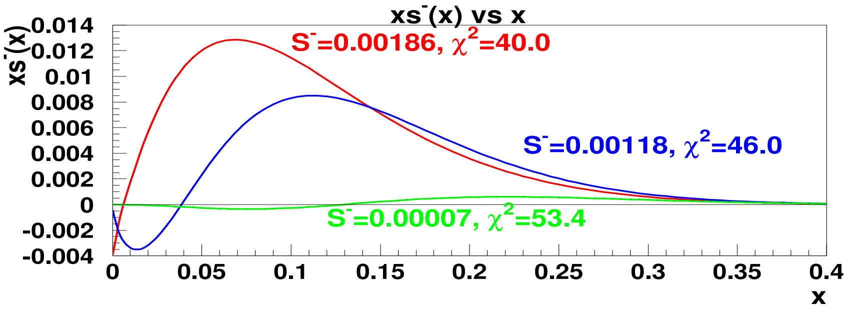

Figure 2. xs^- for x_0 of 0.01, 0.05, and 0.15. χ^2's are labeled, with a DOF of 38.8.

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