MEASURING $\bar{u}/\bar{d}$ IN THE PROTON: FERMILAB E866

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Abstract. Experiment E866, conducted at the Fermi National Accelerator Laboratory, is a high statistics experiment to measure $\bar{u}(x)/\bar{d}(x)$ in the proton over a wide range of x. Preliminary results are shown for the ratio of the Drell-Yan cross sections $\sigma^{pd}/2\sigma^{pp}$. These results confirm the conclusions of both the NMC and NA51 collaborations that there is an $\bar{u}/\bar{d}$ asymmetry in the proton sea.

REVIEW OF ASYMMETRY MEASUREMENTS

The first indication of an asymmetry in the quark sea of the proton was found by using the Gottfried Sum Rule [1] to interpret the DIS data taken by the NMC Collaboration. Assuming isospin symmetry the Gottfried Sum Rule can be written in terms of parton distribution functions to give

$$I_{GSR} = \frac{1}{3} - \frac{2}{3}\int_0^1 \left(\bar{d}_p(x) - \bar{u}_p(x)\right) dx. \tag{1}$$

Therefore $I_{GSR} = 1/3$ if the proton sea is flavor symmetric with respect to the up and down quark flavors.

The NMC Collaboration measured deep inelastic muon scattering on hydrogen and deuterium targets and determined [2] $I_{GSR} = 0.235 \pm 0.026$. There are several possible explanations why the NMC result differs from the expected I_{GSR} value of 1/3, however the most likely explanation is an up, down flavor asymmetry in the proton sea.

Dimuon production via the Drell-Yan mechanism can be used to investigate the question of flavor asymmetry in the nucleon sea. The proton-nucleon Drell-Yan cross section can be written in terms of parton distribution functions as

$$\sigma^{pN} \propto \sum_i e_i^2 \left[q_i(x_1)\bar{q}_i(x_2) + q_i(x_2)\bar{q}_i(x_1)\right] \tag{2}$$

with the subscripts 1 and 2 denoting the beam and target parton respectively.

The NA51 collaboration [3] made the first definitive observation of an asymmetry in the proton sea by comparing the Drell-Yan yields from protons incident on hydrogen and deuterium targets to measure $\sigma^{pd}/2\sigma^{pp}$. NA51 determined $\bar{u}/\bar{d}$ for only a single average value of x.

$$\frac{\bar{u}(x)}{\bar{d}(x)} = 0.51 \pm 0.04 \pm 0.05 \quad \text{at} \quad x = 0.18. \tag{3}$$

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The goal of the E866 experiment is to measure the ratio of Drell-Yan cross sections $\sigma^{pd}/2\sigma^{pp}$ to the order of 1% accuracy for $0.05 \leq x \leq 0.15$ and with lesser statistical accuracy out to $x \simeq 0.3$. Furthermore, it is our goal to then use this measurement to determine $\bar{u}(x)/\bar{d}(x)$ over this range of x.

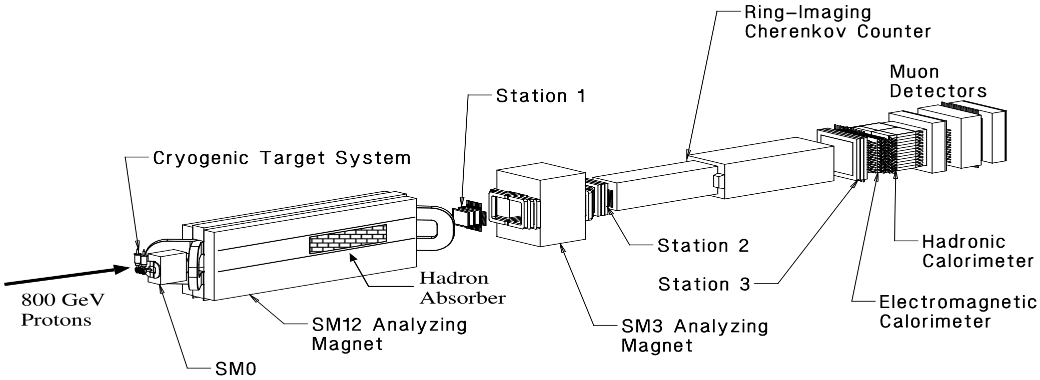

FIGURE 1. The E605/E772/E789/E866 Spectrometer.

The E866 spectrometer [4] is a forward x_F, high mass dimuon spectrometer. Dimuon yields were measured from 800 GeV protons interacting with liquid hydrogen, liquid deuterium and empty flask targets. Three different current settings were used for the magnets SM0 and SM12 in order to shift the acceptance of the spectrometer to record data in low, intermediate, and high mass regions.

PRELIMINARY RESULTS

A preliminary analysis of each of the three data sets has been completed. Figure 2 shows the mass spectra of all three data sets as well as the high mass data set alone. To extract only the Drell-Yan events, cuts were made in the mass spectra to exclude the J/ψ, ψ' and Υ resonances.

The preliminary ratio of the deuterium to hydrogen Drell-Yan cross sections is shown in figure 2 as a function of x_2 for the high mass data set. The high mass data set was chosen for this analysis since it does not suffer from several systematic effects that still need to be corrected in the other data sets. In this plot our data points are compared with common parameterizations of the proton (weighted by the acceptance of our spectrometer). Also plotted is a curve based on CTEQ4M [5], where we have modified the parameterization

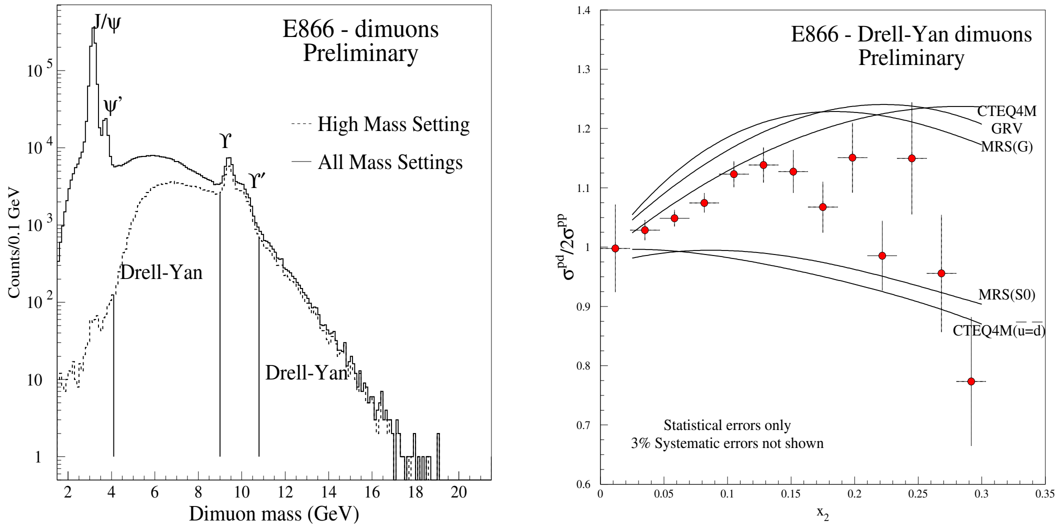

FIGURE 2. Preliminary dimuon mass spectra and cross section ratio from the $\bar{u}/\bar{d}$ run.

to force $\bar{u}_p = \bar{d}_p \equiv (\bar{u}_p + \bar{d}_p)/2$. The error bars show only the statistical uncertainty; an additional systematic uncertainty of about 3% is not shown.

If we assume that $x_1 \gg x_2$ then Eq. 2 yields a simple approximation to $\bar{u}/\bar{d}$.

$$\left.\frac{\sigma^{pd}}{2\sigma^{pp}}\right|_{x_1 \gg x_2} \approx \frac{1}{2}\left(1 + \frac{\bar{d}(x)}{\bar{u}(x)}\right) \tag{4}$$

However, a significant portion of the data is near $x_1 \approx x_2$. Thus calculating $\bar{u}/\bar{d}$ is more difficult and is model dependent.

CONCLUSION

The goal of E866 should be achieved after a full analysis of the data. The preliminary results from FNAL E866 confirm both the NMC evidence that $\bar{u}_p \neq \bar{d}_p$ and the NA51 result that $\bar{d}_p > \bar{u}_p$. Our data for $x > 0.2$ do not agree with common parameterizations of the proton.

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