Progress in probing flavor asymmetry of antiquarks in protons in the E906/SeaQuest experiment at Fermilab

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E906/SeaQuest is a Drell–Yan experiment at Fermi National Accelerator Laboratory (Fermilab). SeaQuest aims to measure the flavor asymmetry of antiquarks ($\bar{d}/\bar{u}$) in protons at large Bjorken x more accurately than the E866 experiment, which is the Drell–Yan experiment conducted previously at Fermilab.[1)] The flavor asymmetry is derived from the ratio of the Drell–Yan cross sections in proton-proton (pp) and proton-deuteron (pd) reactions, as shown below:

$$\frac{\sigma^{pd}}{2\sigma^{pp}} \sim \frac{1}{2}\left[1+\frac{\bar{d}}{\bar{u}}\right]. \quad (1)$$

We use a 120-GeV proton beam extracted from Fermilab Main Injector and liquid hydrogen and deuterium as targets. Carbon, iron, and tungsten are also used as targets for measuring nuclear effects on the parton distribution. The Drell–Yan process creates a $\mu^+\mu^-$ pair, and therefore the muons are measured to count the number of Drell–Yan events. SeaQuest acquired data for 10 months in 2013 and 2014 (called "Run 2").

Data acquired over two months of the data were analyzed as an initial step. Results of the analyzed data and prospects are discussed in this report.

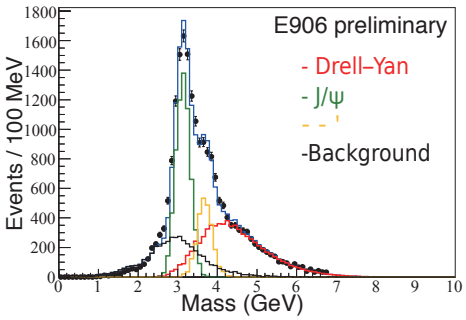

Fig. 1. Reconstructed di-muon mass distribution with all the targets (black points). It is fitted with four components (red, green, yellow, and black lines).

We succeeded in reconstructing the mass distribution of di-muons with all the targets as shown in Fig. 1. The mass distribution was fitted with four components, Drell–Yan events, J/ψ events, ψ' events, and random backgrounds. The distribution shapes of the Drell–Yan, J/ψ, and ψ' events were simulated, while that of random backgrounds was estimated using real data. The experimental data ware fitted reasonably well to simulated events and estimated backgrounds, which suggests the detectors and the algorithm of di-muon reconstruction work as expected. The Drell–Yan events were selected with a di-muon cut-off mass of 4.2 GeV. We evaluated the cross-section ratio using the yields of the Drell–Yan events in the pp and pd interactions. The flavor asymmetry ($\bar{d}/\bar{u}$) was derived from the cross-section ratio using Eq. 1. The magnitude and systematic error of $\bar{d}/\bar{u}$ are currently being evaluated. Thus, Fig. 2 shows only the statistical errors of $\bar{d}/\bar{u}$

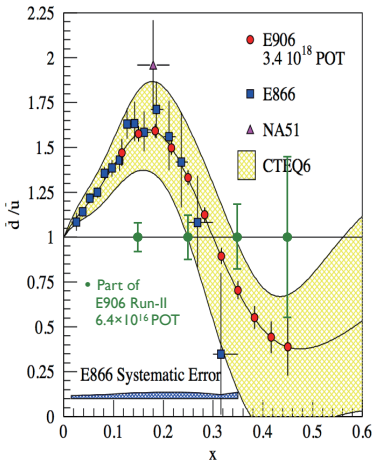

Fig. 2. Plot of $\bar{d}/\bar{u}$ vs Bjorken x obtained by E866 (blue points), and the size of statistical errors expected in the SeaQuest experiment (red points) and that obtained using the analyzed data (green points).

using the analyzed data, together with the previous measurement results. The amount of analyzed data at small x is approximately the same as that of the E866 data.

We started acquiring another set of data for two years in November 2014. After data acquisition, we will obtain 20 times more statistics than the set of data we analyzed. The result that will be obtained using in the SeaQuest experiment will considerably improve the understanding of the internal structure of protons.

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References

1) E.A. Hawker et al.: E866/NuSea, Phys. Rev. Lett. 80, 3715 (1998)