Progress of Drell–Yan experiment by SeaQuest at Fermilab

K. Nagai,[*1,*2] Y. Goto,[*2] Y. Kunisada[*1] Y. Miyachi,[*3] S. Miyasaka,[*1] K. Nakano,[*1] S. Nara,[*3] S. Sawada,[*2,*4] T.-A. Shibata,[*1,*2] S. Tamamushi[*1] for the E906/SeaQuest Collaboration

The E906/SeaQuest experiment is a Drell–Yan experiment at Fermi National Accelerator Laboratory (Fermilab). SeaQuest aims to accurately measure the flavor asymmetry of antiquarks ($\bar{d}/\bar{u}$) in the proton at large Bjorken x ($0.1 \lesssim x \lesssim 0.45$). E866 measured the flavor asymmetry around Bjorken $x \sim 0.3$. E866 indicated that the flavor asymmetry decreases in that region, although the uncertainty was large.[1)] The behavior has not been reproduced by any theory. The measurement by SeaQuest will improve the understanding of the internal structure of the proton.

The flavor asymmetry is derived from the ratio of proton-proton and proton-deuteron Drell–Yan cross sections. SeaQuest uses a 120-GeV proton beam extracted from Fermilab Main Injector and liquid target of hydrogen and deuterium. A pair of μ^- and μ^+ is created in the Drell–Yan process. It passes through a focusing magnet, which is located right behind the targets. The muon pair is detected by four tracking stations (Stations 1, 2, 3, and 4). Stations 1, 2, and 3 consist of drift chambers and hodoscopes. Station 4 consists of proportional tubes and hodoscopes. Station 4 is located behind a hadron absorber and is used for the identification of the muons. Another magnet is placed between Station 1 and Station 2 in order to determine muon momenta. We reconstruct the muon momenta using hit positions measured at the four stations.

SeaQuest acquired 0.8×10^{18} beam protons on target for 20 months from 2013 to 2015. It started acquiring another set of data in October 2015. In total, we will accumulate 3.4×10^{18} beam protons on target.

Two months' data acquired in 2014 are used to perform the data analysis. We successfully reconstructed the invariant-mass (M) distribution of muon pairs.[2)] The Drell–Yan events were selected with $M > 4.2$ GeV. Figure 1 shows the z-vertex distribution of muon pairs. The hydrogen and deuteron targets are located at $z = -150$ cm through -100 cm, and a beam dump, which is the iron core of the focusing magnet, is located at $z = 0$ cm through 500 cm. The closed circles in Fig. 1 are all the muon pairs in the real data. The open circles at $z < -50$ cm are the muon pairs that originate from the target, and the open circles at $z > -50$ cm are the muon pairs that originate from the beam dump. The muon pairs around $z = -50$ cm are discarded because the z-vertices are highly inaccurate and it cannot be determined where the muon pairs originated from. The open circles are consistent with the distributions estimated by the simulation (the solid lines) well except for the upstream region ($z \sim -200$ cm).

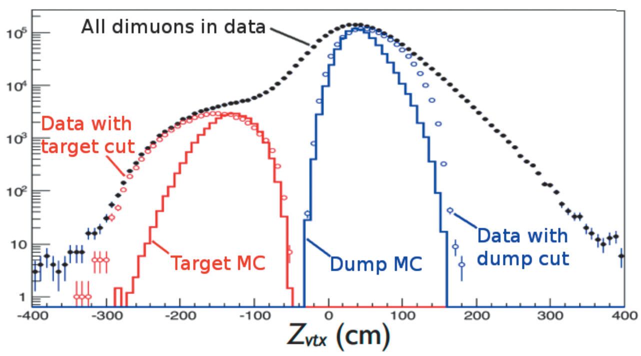

Fig. 1. The z-vertex distribution of muon pairs whose invariant masses are larger than 4.2 GeV/c^2. The circles show z-vertex distribution of the muon pairs in real data. The solid lines are estimated z-vertex distributions of muon pairs from target (red line) and that of muon pairs from dump (blue line) in the simulation.

The z-vertex of muon pairs from the target in the real data distributes around $z = -160$ cm, which is slightly more upstream than the actual target position ($-150 < z < -100$ cm). This is because the calibration of the magnetic field is not accurate by 2%. It has been tuned.

A very preliminary result of the flavor asymmetry was derived using the two months of data. The systematic uncertainty is large at present, mostly arising from the beam-intensity dependence of measurement efficiencies. We are improving the analysis method to minimize the systematic uncertainty.

References

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*1 Graduate School of Science and Engineering, Tokyo Institute of Technology
*2 RIKEN Nishina Center
*3 Faculty of Science, Yamagata University
*4 Institute of Particle and Nuclear Studies, KEK