Measurement of the Light Anti-quark Asymmetry of the Nucleon at the 120 GeV Fermilab Main Injector

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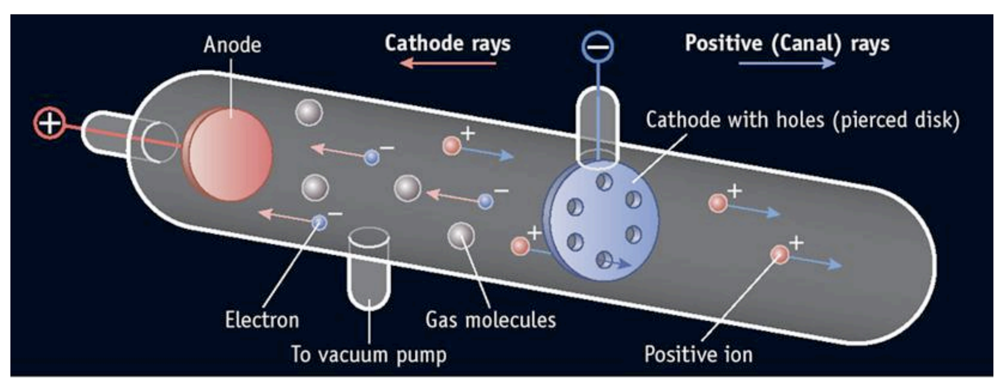
For Fermilab E-906/SeaQuest

Abstract

Fermilab experiment E-906/ SeaQuest will use the Drell-Yan (D-Y) process to extend our knowledge of the antiquark structure of the nucleon. By measuring the D-Y cross section of a proton colliding with liquid hydrogen and deuterium targets it is possible to extract the anti-down to anti-up asymmetry within the nucleon. Because of the increase in the D-Y cross section and decrease in background rates, the Fermilab 120 GeV Main Injector will allow the d-bar/u-bar measurements made by Fermilab E-866/NuSea at 800 GeV to be extended to values of Bjorken-x up to 0.5. The kinematics are chosen so that the quark comes from the beam proton and the anti-quark comes from the target; they annihilate via the D-Y process into a di-muon pair. The detector is optimized for detecting di-muons and consists of a two-magnet focusing spectrometer with four detector stations. The fast level-one trigger will interrogate eight hodoscope planes. Wire and drift chambers will be used to reconstruct particle trajectories to separate events originating in the target from those originating from a magnetized beam dump just downstream of the target. Measurements will also be made with protons colliding with solid nuclear targets.

Introduction

The journey of the proton has been a long and arduous path. The first characteristics, of the proton, noted by Eugen Goldstein's canal rays experiments, showed that there were positively charged particles within the structure of the atom.



From this initial experiment to what we have learned and seen today, our familiarities with the proton has grown exponentially. Compared to just having a positive charge, we have now shown, proven from experiments, that the proton consists of valence quarks, sea quarks, and gluons. The SeaQuest team will attempt to expand upon these premises to further our knowledge of the proton, and thus learn more about the world around us and ultimately the universe.

The Drell-Yan Process

The Drell-Yan Process consists of one hadron containing a quark colliding with another hadron containing an antiquark to produce a virtual photon. This virtual photon will then decay into a lepton-antilepton pair.

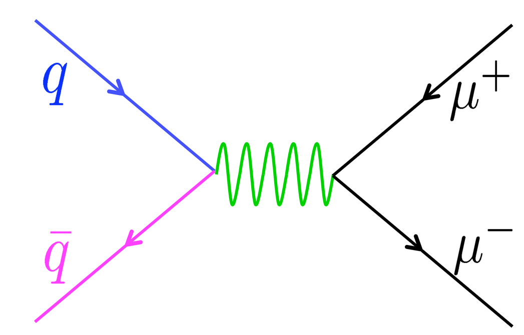
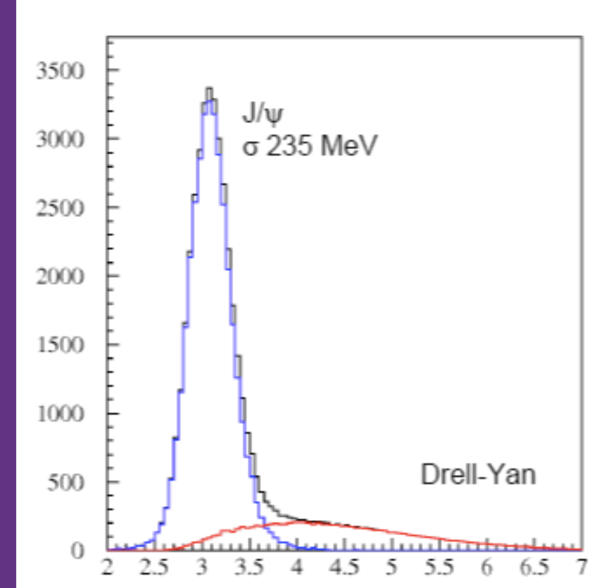


Figure 1: *A Feynman Diagram of the Drell-Yan Process*

$$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha^2}{9x_1x_2}\frac{1}{s}\sum e^2\left[\bar{q}_t(x_t)q_b(x_b) + q_t(x_t)\bar{q}_b(x_b)\right]$$

In order to get the antiquark ratio, measurements of the Drell-Yan cross section ratio from the proton-proton target to the proton deuterium target.

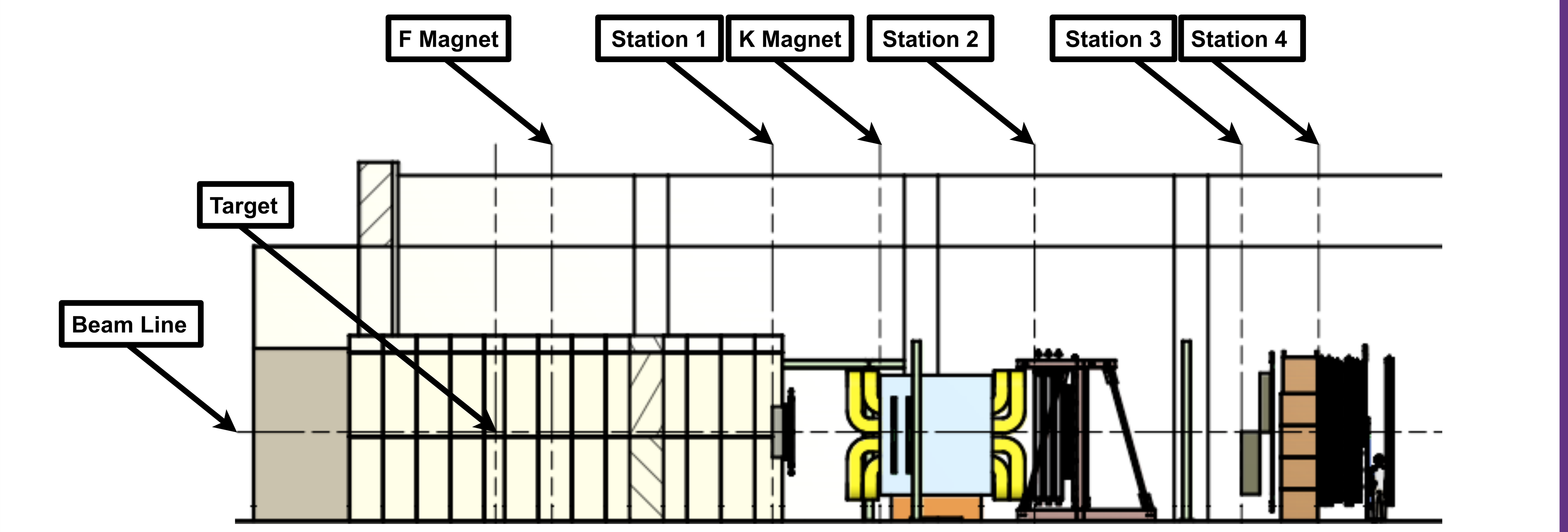
Why the Change In Energy?



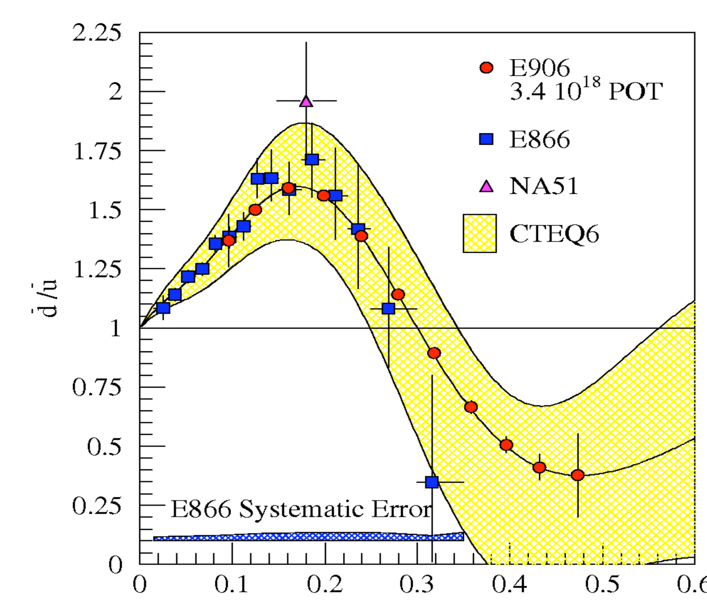
The graph above shows the J/Psi (blue) and the Drell-Yan (red) production rates.

By making use of the Fermilab Main Injector SeaQuest will be able to gain an approximate increase of 50x in statistics over E866/ NuSea. This comes from J/Psi background rates scaling inversely with energy, allowing the use of higher luminosity. Drell-Yan cross-sections also scale inversely with energy, another factor of 7x the luminosity.

Experiment Hall, Side View

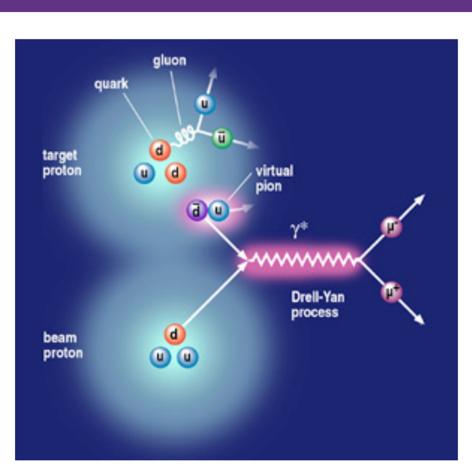


With the increase in the number of Drell-Yan events recorded, the results will determine the anti quark ratio to a higher x. This will permit the refinement of parton distribution function calculations demonstrated by the CTEQ6 values below. The uncertainties that SeaQuest will have above x of 0.2 will place stronger constraints on the different phenomenological results.



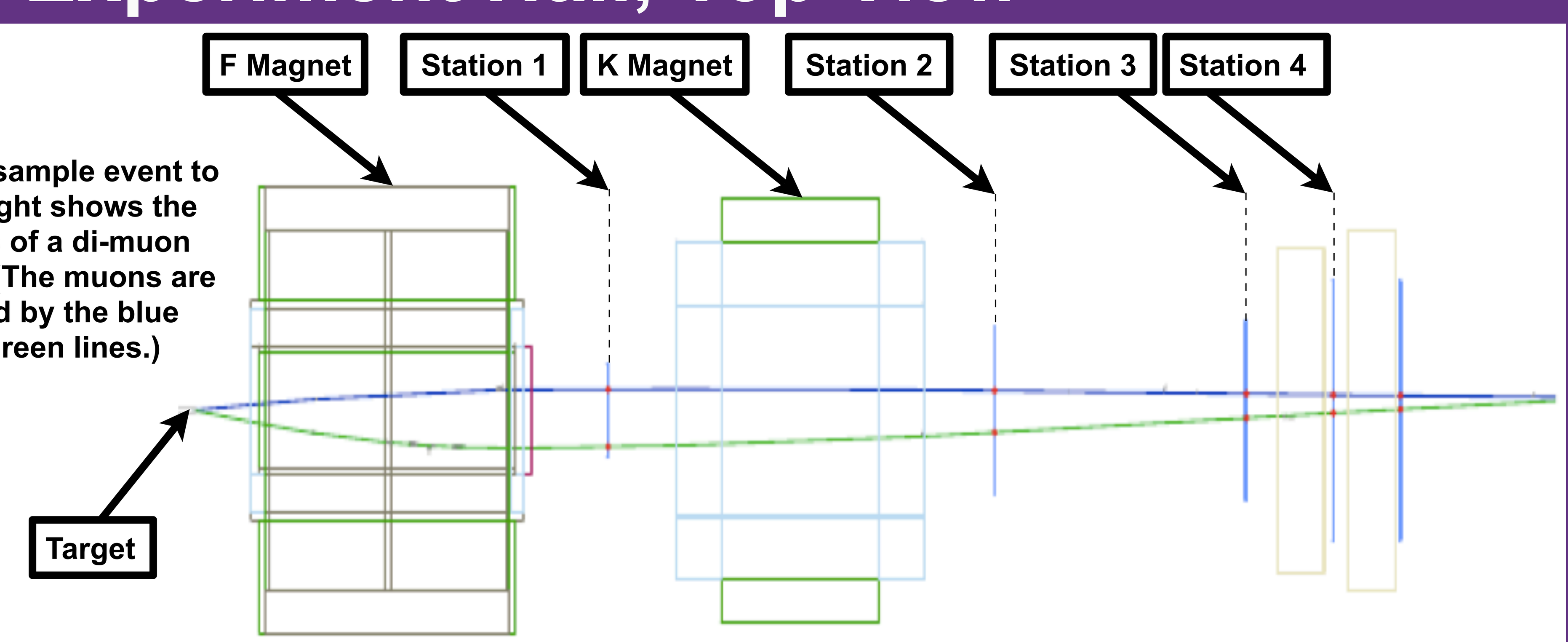
The experiment E-906/SeaQuest will build upon these results and extend the Bjorken-x range of approximately $x \approx 0.5$

Experiment Hall, Top View



The di-muon pair produced by the Drell-Yan process (shown above) will be seen by our detector.

This sample event to the right shows the paths of a di-muon pair. (The muons are traced by the blue and green lines.)



Conclusion

Collaborators all across the globe are currently in the process of detector construction and software development. SeaQuest is expected to have low-ratebeam in September to start data collection in late 2010.

Fermilab

Collaboration Information

Abilene Christian University
Academia Sinica
Argonne National Laboratory
University of Colorado
Fermi National Accelerator Laboratory
University of Illinois
KEK
Kyoto University
Ling-Tung University
Los Alamos National Lab
University of Maryland
University of Michigan
National Kaohsiung Norma
RIKEN
Rutgers University
Texas A & M University
Thomas Jefferson National Accelerator Facility
Tokyo Tech
Yamagata University

SeaQuest E906

Acknowledgments

This research is funded in part by the U.S. Department of Energy under grants DE-PS02_09ER09-02, DE-FG03-94ER40860-16, Fermi National Accelerator Laboratory, and the ACU Research Council.