SeaQuest Experiment at Fermilab

The Fermilab E-906/SeaQuest experiment is part of a series of fixed target Drell-Yan experiments designed to measure the antiquark structure of the nucleon and the modifications to that structure when the nucleon is embedded in a nucleus. Its principal goal is to extend the landmark measurement of the sea flavor asymmetry $\bar{d}(x)/\bar{u}(x)$ in the proton made by its predecessor, E866, to the high-*x* regime. SeaQuest provides unique access to the vanishing sea quark density at high *x* via the luminosity and beam energy of the Fermilab Main Injector and the innate sensitivity of the Drell-Yan process to antiquarks. The experiment will also measure Drell–Yan from nuclear targets, to address the puzzle of the as-yet unobserved EMC effect in Drell–Yan and to learn more about parton energy loss in cold nuclear matter.

Figure 1 illustrates the Drell-Yan process in the proton-proton collision. An energetic quark in the beam proton collides with an antiquark in the target proton, forming a high-mass virtual photon, which subsequently decays into a pair of energetic $\mu^+$and μ^-. By comparing the Drell-Yan cross section ratio of p+d over p+p collisions, one could deduce the quantity $\bar{d}(x)/\bar{u}(x)$ in the proton.

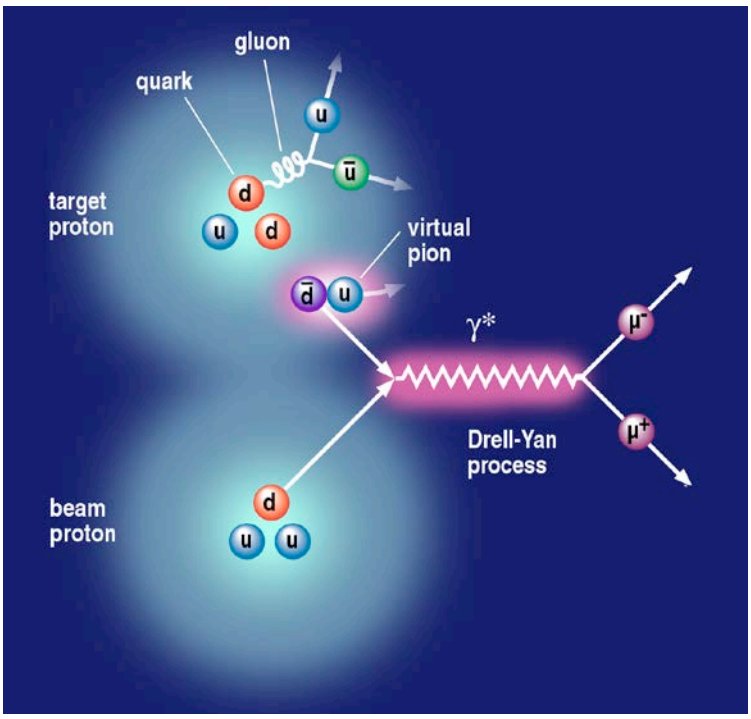

Figure 1: A cartoon to illustrate how one could measure the antiquark content in the proton using the Drell-Yan process. The proton consists of three valence quarks (uud), illustrated by the beam proton. The proton can also emit a pion (π^+ in this case), which contains $u\bar{d}$, as shown for the target proton. The Drell-Yan process involves an annihilation of a quark in the proton beam with a sea antiquark in the target, forming a virtual photon (γ^*). One can determine $\bar{d}/\bar{u}$ by measuring the properties of the muon pairs from the decay of the vitual photon.

The SeaQuest experiment uses the high-intensity 120 GeV proton beam from the Fermilab Main Injector, as shown in Figure 2. A new spectrometer designed to measure pairs of energetic muons with high-rate capability has been constructured, as shown in Figure 3a. The UIUC group, consisting of Prof. Naomi Makins and Jen-Chieh Peng, postdocs Markus Diefenthaler and Andrew Chen, graduate students Bryan Dannowitz, Jason Dove, Bryan Kerns, Evan McClellan, and Shivangi Prasad, and several undergraduate

students, has been involved in several different areas including hodoscope, offline software, trigger system, and chamber gas system. After some initial commissioning runs, SeaQuest started taking physics data in March 2014. Figure 3b shows the preliminary result of the dimuon mass spectrum obtained in a few days of data. The Drell-Yan events, together with the J/ψ events, are clearly observed.

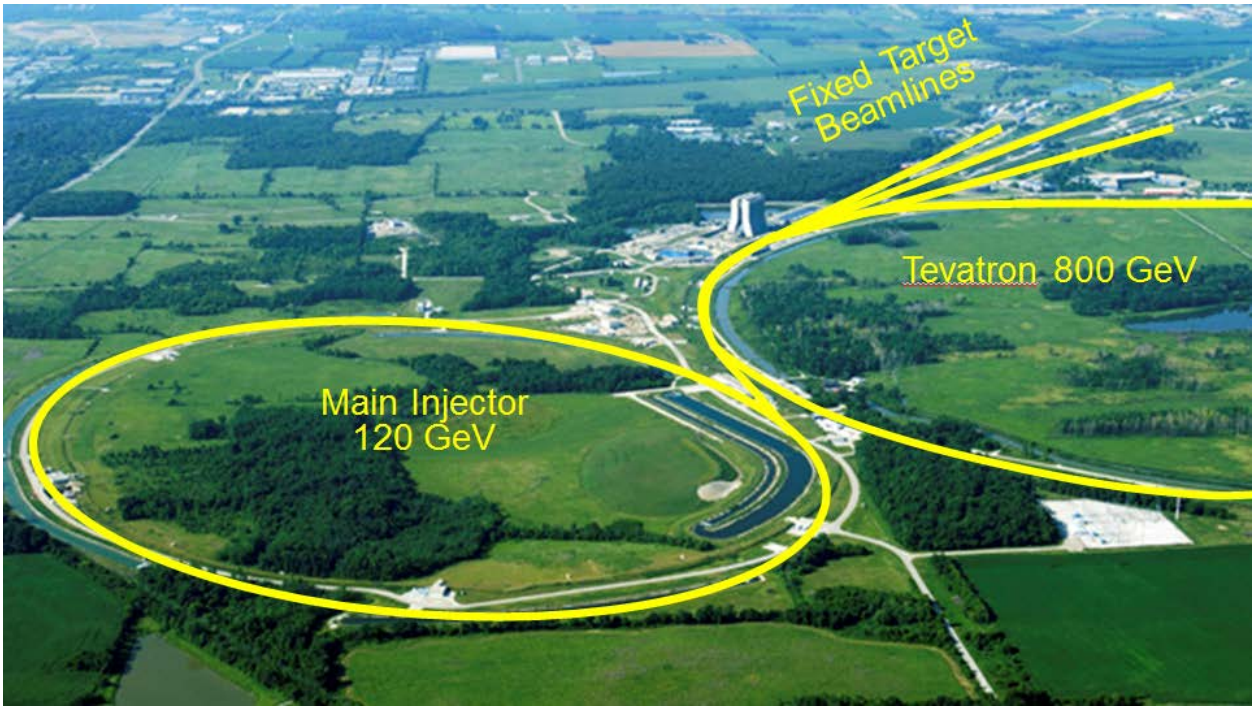

Figure 2: Photo of the Fermilab 120 GeV Main Injector ring and the beams lines for extracted proton beams. SeaQuest experiement utilizes the proton beam in the Meson beamline.

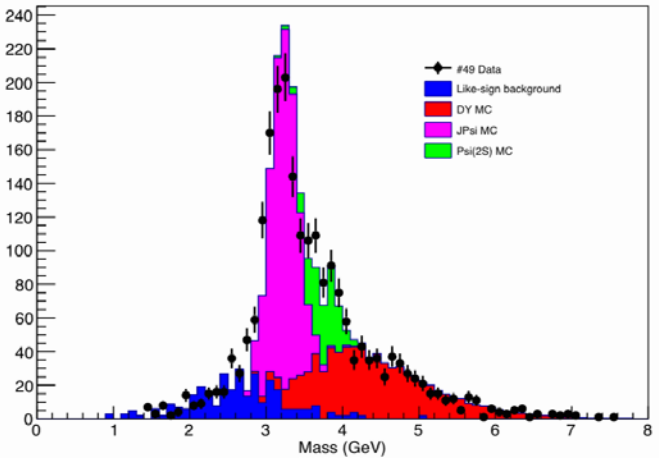

Figure 3: a) The SeaQuest apparatus. Two large magnets focus the muon pairs horizontally, and their momenta are measured by arrays of hodoscopes and wire chambers. b) Preliminary result from SeaQuest showing the dimuon mass spectrum obtained in a few days of data taking.

The SeaQuest experiment will continue to take data until the summer of 2017. Figure 4 shows the anticipated sensitivity in the measurement of $\bar{d}(x)/\bar{u}(x)$ when the experiment is completed.

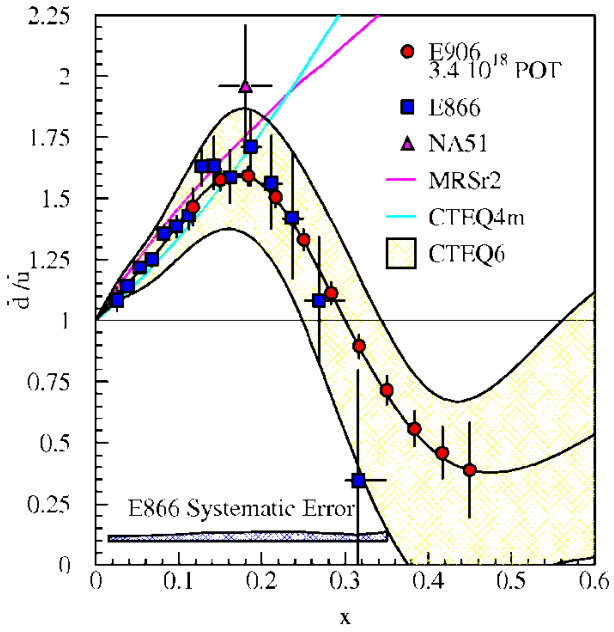

Figure 4: Expected statistical accuracy of $\bar{d}(x)/\bar{u}(x)$ for SeaQuest (E906), shown as the red points. The results from the previous E866 experiment (blue points) are also shown for comparison.