Exploring the Light Anti-Quark Flavor Asymmetry in the Nucleon Sea using Semi Inclusive Charged Pion Production in Hall C

A Letter of Intent for PAC50

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Abstract

This letter of intent aims at the possibility of realizing previously proposed measurement PR12-06-111 that uses SIDIS reactions $(e, e'\pi^{\pm})$ on hydrogen and deuterium targets in the kinematic range $0.1 < x < 0.48$, $1.2 < Q^2 < 4.3$ $(\mathrm{GeV/c})^2$ and $0.3 < z < 0.7$ in Hall C at Jefferson lab with a 11 GeV e^- beam. The charged pion yield ratio could be sensitive to $\overline{d}(x)/\overline{u}(x)$ and $\overline{d}(x) - \overline{u}(x)$ which will shed light on the non-perturbative mechanisms that are responsible for generating the proton sea. The precise measurement of these yield ratios can provide data in the high-x region using a different process and Q^2 region as compared to previous Drell-Yan measurements. In light of recent results from SeaQuest experiment [1], a decades worth of advances in extracting precise fragmentation functions, and an opportunistic overlap in kinematic phase space with approved experiment E12-06-104, the revival of this measurement is timely and necessary in enriching our understanding of the nucleon anti-quark structure.

1 Introduction

Understanding the flavor composition of the nucleon sea is one of the central goals of hadronic physics. Worldwide experimental and theoretical efforts over the past few decades have given us a wealth of information on the sea structure, in particular the anti-quark structure of the nucleon. Independent processes such as Drell-Yan [2, 3] and Semi-Inclusive Deep Inelastic Scattering (SIDIS) have been used as powerful tools to probe the anti-quark structure of the nucleon. Recent Drell-Yan measurements conducted by the SeaQuest experiment at Fermilab reported an excess of $\overline{d}(x)$ compared to $\overline{u}(x)$ over a broad kinematic range in Bjorken-x [1] with higher statistical precision compared to the NuSea experiment [4]. These measurements indicate a non-perturbative mechanism other than gluon splitting that generates the excess. Alternatively, by measuring the charged pion yield ratio from Semi-Inclusive Deep-Inelastic Scattering (SIDIS) on hydrogen and deuterium targets, the HERMES collaboration reported[5] results on $\overline{d}(x)-\overline{u}(x)$ with a 27.5 GeV positron beam on hydrogen and deuterium targets. These results are in agreement with NuSea results although with modest precision. These results indicated an alternative in extracting the anti-quark flavor asymmetry of the nucleon sea with a different process (SIDIS) as compared to Drell-Yan, although in a different Q^2 region. This letter of intent seeks to realize the measurements first proposed in PR12-06-111[6], now that the SeaQuest experiment [1] has published first result on $\bar{d}(x)/\bar{u}(x)$, and there has been over a decades worth of advances in extracting precise fragmentation functions. The purpose of these measurements are two-fold:

- To explore the region $0.1 < x < 0.25$ using SIDIS to establish consistency with previous Drell-Yan measurements.
- To explore the high-x ($0.25 < x < 0.4$) region where there is apparent tension between NuSea and SeaQuest results.

In order to accomplish this, the previously proposed measurement in Hall C (PR12-06-111) uses SIDIS reactions $(e, e'\pi^{\pm})$ on hydrogen and deuterium targets in the kinematic range

- 11 GeV e^- beam
- $0.1 < x < 0.48$
- $1.2 < Q^2 < 4.3$ (GeV/c)^2
- $0.3 < z < 0.7$

2 Motivation

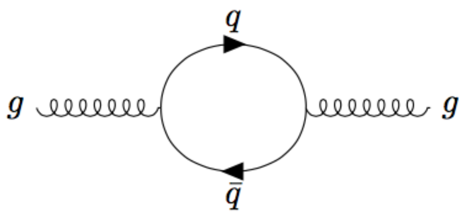

Figure 1: Feynman diagram of gluon splitting

Although no known symmetry constraint requires them to be the same, until the early 1990's it was assumed that the nucleon sea is light quark flavor symmetric: $\bar{u}(x) = \bar{d}(x)$ in the proton. As gluons do not couple to a particular flavor and the masses of u and d quarks are similar and small compared to the Λ_{QCD} scale, a flavor symmetric nucleon sea was thought to be generated from a pure perturbative process such as gluon splitting (shown in Figure 1). Subsequent experiments showed that the nucleon sea is not just flavor asymmetric but must have a non-perturbative origin.

The Gottfried Sum Rule is a generalized sum rule in QCD which offers insight into the structure of the nucleon [7]. This sum rule assumes that the proton and the neutron's quark distributions are related by charge symmetry i.e. the up quark distributions in the proton are identical to the down quark distributions in the neutron and vice versa (i.e. $u_p(x) = d_n(x)$ and $d_p(x) = u_n(x)$). It also assumes that the nucleon is made up of only the light quarks (u, d and s) and the strange quark distributions are the same in the proton and the neutron. In such a case, one can take the difference in the proton and neutron leading order structure functions (assuming strange quark distributions are the same) and perform the Gottfried integral S_G to obtain:

$$S_G = \frac{1}{3} + \int_0^1 \frac{2}{3}(\bar{u}^p(x) - \bar{d}^p(x))dx. \tag{1}$$

A purely perturbative origin of the nucleon sea would imply that $\int_0^1 \bar{u}(x)dx$ and $\int_0^1 \bar{d}(x)dx$ distributions in the proton are identical, thus reducing the Gottfried integral S_G to 1/3. Any significant deviation from this value reflects a non-perturbative contribution.

In 1991, the NMC (New Muon Collaboration) experiment at CERN published an evaluation of the Gottfried sum rule [8, 9]. The experiment used a 90 GeV and 280 GeV muon beam incident on liquid hydrogen and liquid deuterium targets[1]. They reported a value of $S_G = \int_{0.004}^{0.8}(F_2^p - F_2^n)dx/x = 0.221 \pm 0.008(\text{stat}) \pm 0.019(\text{syst})$ at a value of $Q^2 = 4\ \text{GeV}^2$. The values for $F_2^p - F_2^n$ were extrapolated on either ends of x and a total integral of $S_G = \int_0^1 \frac{1}{x}(F_2^p - F_2^n)dx = 0.235 \pm 0.026$ was reported. This was the first clear evidence of a violation of the Gottfried sum rule. It was also suggested that perhaps the assumed charge symmetry could be broken [10, 11] or that there is a non negligible contribution from the small-x region. It was suggested by Ellis and Stirling that one could take advantage of the Drell-Yan process to disentangle the two possible scenarios (non-symmetric sea parton distributions and isospin symmetry breaking) reported by the NMC experiment [12]. The NA51 experiment performed at CERN measured the Drell-Yan reaction cross sections with a 450 GeV/c proton beam on liquid hydrogen and liquid deuterium targets and obtained [13]:

$$\left.\frac{\bar{d}}{\bar{u}}\right|_{\langle x=0.18\rangle} = 1.96 \pm 0.15(\text{stat}) + 0.19(\text{syst}) \tag{2}$$

The E866/NuSea experiment was the first to measure an x-dependence of the ratio $\bar{d}(x)/\bar{u}(x)$ over a range $0.015 < x < 0.35$ [14, 4]. The experiment used the 800 GeV proton beam extracted from the Tevatron at Fermilab along with liquid hydrogen and liquid deuterium targets. Approximately 360,000 Drell-Yan dimuon pairs remained after analysis cuts on the data. The data from this experiment put several tight constraints on non-perturbative models that attempt to explain the origin of the nucleon sea. Plots of the ratio of cross sections $\sigma_{pd}/2\sigma_{pp}$ (left) and $\bar{d}(x)/\bar{u}(x)$ (right) show two prominent features. The ratio seems to rise up until $x \approx 0.18$ and surprisingly starts falling down to a value below 1 (with limited statistical precision) near $x \approx 0.25$. After the quantity $\bar{d}(x)/\bar{u}(x)$ is extracted, the value of $\bar{d}(x) + \bar{u}(x)$ is taken from parameterizations and the quantity $\bar{d}(x) - \bar{u}(x)$ is calculated. The quantity $\bar{d}(x) - \bar{u}(x)$ is essentially the non-perturbative asymmetric sea contribution[2].

The results from NuSea experiment for $\bar{d}(x)/\bar{u}(x)$ and $\bar{d}(x) - \bar{u}(x)$ (later confirmed by HERMES with limited statistical precision [5]) put constraints on models that attempt to explain the nucleon sea and the observed flavor asymmetry. Initially, the sea was assumed to be generated perturbatively by gluon splitting. Field and Feynman suggested that the presence of an "additional" valence u quark in a proton could lead to the suppression of the gluon splitting to $u\bar{u}$ relative to $d\bar{d}$ due to Pauli blocking [15]. Ross and Sachradja reported that the

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[1] Since there are no free neutron targets, experiments typically use a deuterium target and a hydrogen target and then subtract the proton part and nuclear effects in deuterium.

[2] There could also be a non-perturbative symmetric sea component as in case of the meson cloud model where a virtual π^0 cloud contains an equal amount of $u\bar{u}$ and $d\bar{d}$.

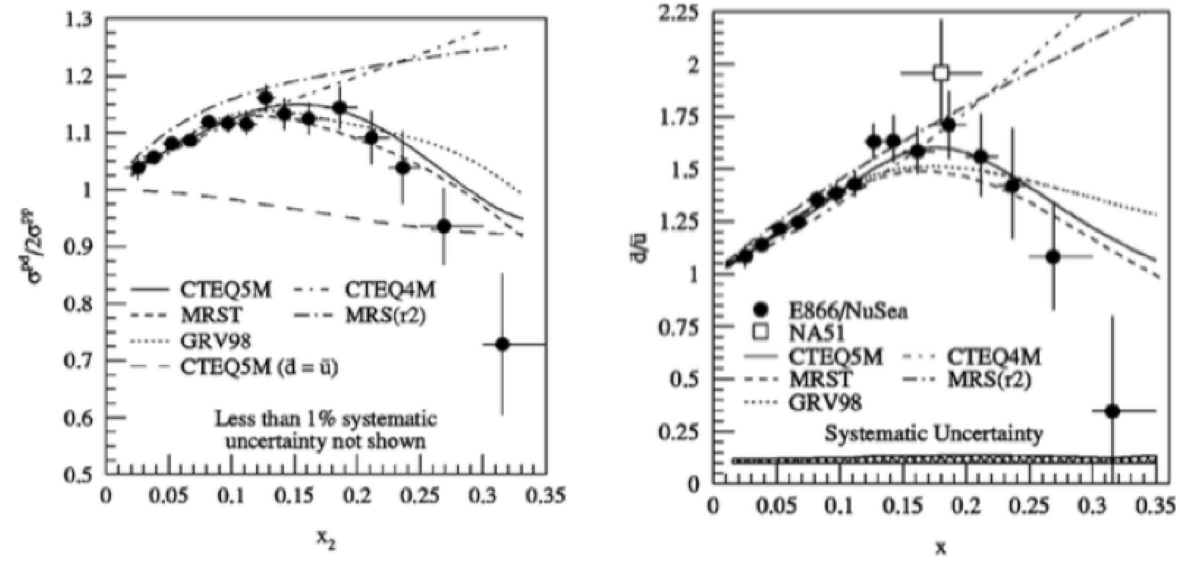


Figure 2: Results from E866 experiment [14]. Left plot shows the ratio of cross sections $\sigma_{pd}(x)/2\sigma_{pp}(x)$ and the right plot shows the extracted ratio $\bar{d}(x)/\bar{u}(x)$ [4].

perturbative contribution to the $\bar{d}(x) - \bar{u}(x)$ is very small [16] and argued that by taking the parameterizations suggested by Field and Feynman in [15] Pauli blocking is not important. A purely perturbative mechanism is unable to account for the flavor asymmetry observed by NuSea. Therefore, this asymmetry must be of a non-perturbative origin. Several theoretical models were proposed to explain the origin of the nucleon sea as well as the flavor asymmetry. For example, the pion cloud model rewrites the proton (under the one meson approximation) as a linear combination of several different fluctuations of baryon virtual meson Fock states. If p_0 is the bare proton with a symmetric sea, the proton can be written as

$$|p\rangle = \alpha\,|p_0\rangle + \beta\,|p_0\pi^0\rangle + \gamma\,|n\pi^+\rangle + \delta\,|\Delta^{++}\pi^-\rangle + \ldots \tag{3}$$

If one were to consider the Clebsch-Gordan coefficients of different baryon virtual meson Fock states, the lower energy state $|n\pi^+\rangle$ has a larger Clebsch-Gordan coefficient than the higher energy state $|\Delta^{++}\pi^-\rangle$. One would expect a $\bar{d} > \bar{u}$ for SeaQuest's x range but cannot intuitively imagine an overturn of the ratio at $x \approx 0.25$. The meson cloud model predicts an overturn at a later value due to a shift in the mechanism where $|\Delta^{++}\pi^-\rangle$ dominates $|n\pi^+\rangle$ although not at $x \approx 0.25$ [17]. The meson cloud model (π, ω, ρ etc.) which incorporates other baryon virtual

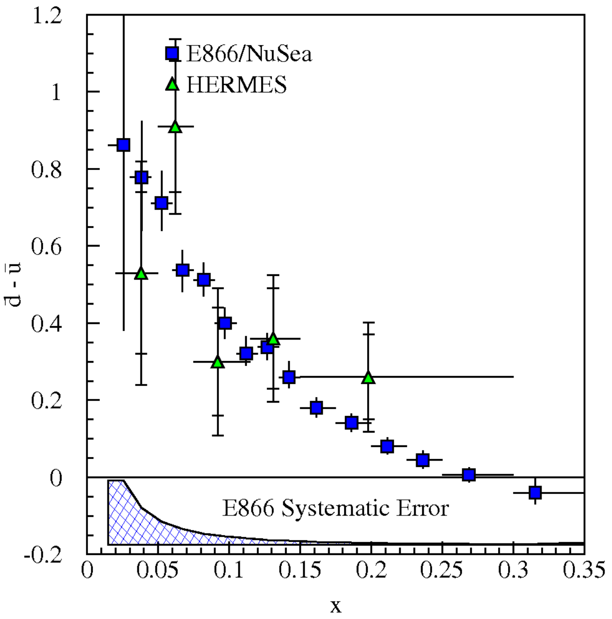


Figure 3: Results from the NuSea [14, 4] and HERMES [5] experiments for $\bar{d}(x) - \bar{u}(x)$.

meson Fock states is able to somewhat reproduce the $\bar{d}(x) - \bar{u}(x)$ difference (Fig 3) but predicts that the ratio will cross 1 at a larger value of x compared to NuSea [18, 19]. Also, another challenge in this model is to find the exact place to truncate the hadronic expression in Equation 3. Furthermore, some analyses report results that suggest a delicate balance between several competing mechanisms that include a $\pi\Delta$, πN and a parameterized Pauli blocking component [20]. Chiral perturbation theory suggests that the constituent quarks couple to goldstone bosons ($u \longrightarrow d\pi^+$ and $d \longrightarrow u\pi^-$) and that the excess of $\bar{d}$ is simply due to the presence of an 'extra' u constituent quark [21]. The prediction for this model falls short in explaining all the asymmetry. The statistical parton distributions model, which considers the nucleon as a gas of massless partons (quarks, antiquarks and gluons) in equilibrium at a given temperature in a finite volume, predict a monotonic increase in the $\bar{d}(x)/\bar{u}(x)$ ratio [22]. The ratio $\bar{d}(x)/\bar{u}(x)$ is shown for several other non-perturbative models such as Chiral Quark model [23], Chiral Quark Soliton model [24] and Instanton induced models [25]. While some models are able to reproduce $\bar{d}(x) - \bar{u}(x)$, they are unable to predict the surprising overturn and drop below unity in the ratio (with limited statistical precision) observed at $x \approx 0.25$ by NuSea. It is evident that higher precision data is needed in the range $0.15 < x < 0.45$ region to map out the overturn at $x \approx 0.18$ and confirm the seeming drop below unity at $x \approx 0.25$.

2.1 Recent results from SeaQuest

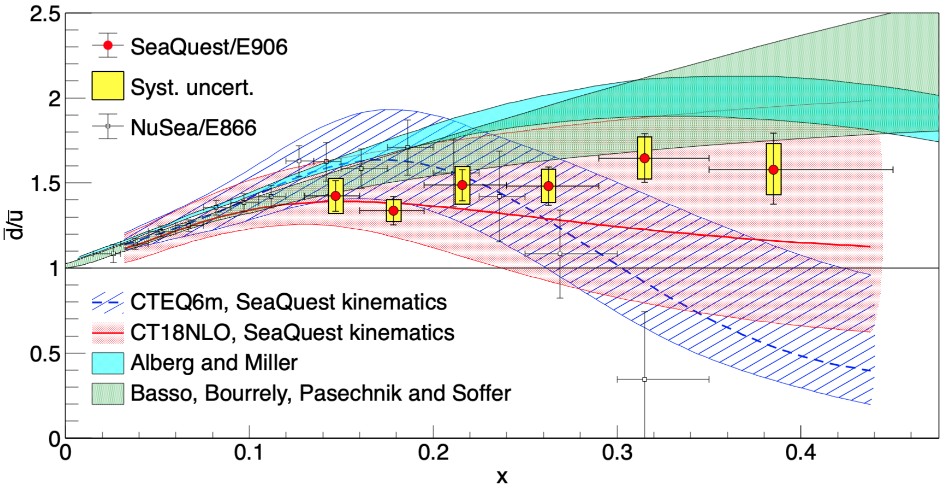


Figure 4: $\overline{d}(x)/\overline{u}(x)$ vs x_T plot along with PDF predictions from CTEQ6m, CT18NLO and predictions by Alberg and Miller (cyan band) [26] and Basso et al (green band) [27].

SeaQuest is a fixed target experiment that takes advantage of the Drell-Yan process to access the nucleon anti-quark structure [28]. The experiment used a 120 GeV proton beam extracted from the Main Injector at Fermilab to collide with liquid hydrogen and deuterium targets. SeaQuest probed the region $0.1 < x < 0.45$ with higher statistical precision compared to the previous Drell-Yan experiment, NuSea. Figure 4 shows the ratio $\overline{d}(x)/\overline{u}(x)$ as a function of x_T which are recent results published by SeaQuest. Some observations regarding the data points:

- SeaQuest data points are consistently above unity for all x_T.
- There is a tension between the NuSea and SeaQuest data sets as the trend of data points particularly at higher $x_T \geq 0.25$ are quite different.

2.2 Accessing Anti-Quark Flavor Asymmetry using SIDIS

The consistency between different physical hard scattering processes can provide important validity of factorization in QCD as well as using SIDIS reactions to access anti-quark distributions via electroproduction. The HERMES collaboration reported a LO $x - z$ factorization in the kinematic region $1.33 < Q^2 < 4.88$ (GeV/c)^{2}and $W > 2.0$ GeV. The ratio $(\overline{d} - \overline{u})/(u - d)$ as a function z in five different bins of x is shown in Fig5. The data show no dependence on z indicating that a LO $x - z$ analysis approach can be used as a first look at the data. Two LO analysis methods (Method I and Method II) were described in PR12-006-111 as a way to extract the light anti-quark flavor asymmetry. The two methods are also summarized briefly in Sec. 4. The final result for the light sea quark asymmetry will undoubtedly require a global analysis requiring constraints from multiple experiments, higher order corrections, etc.

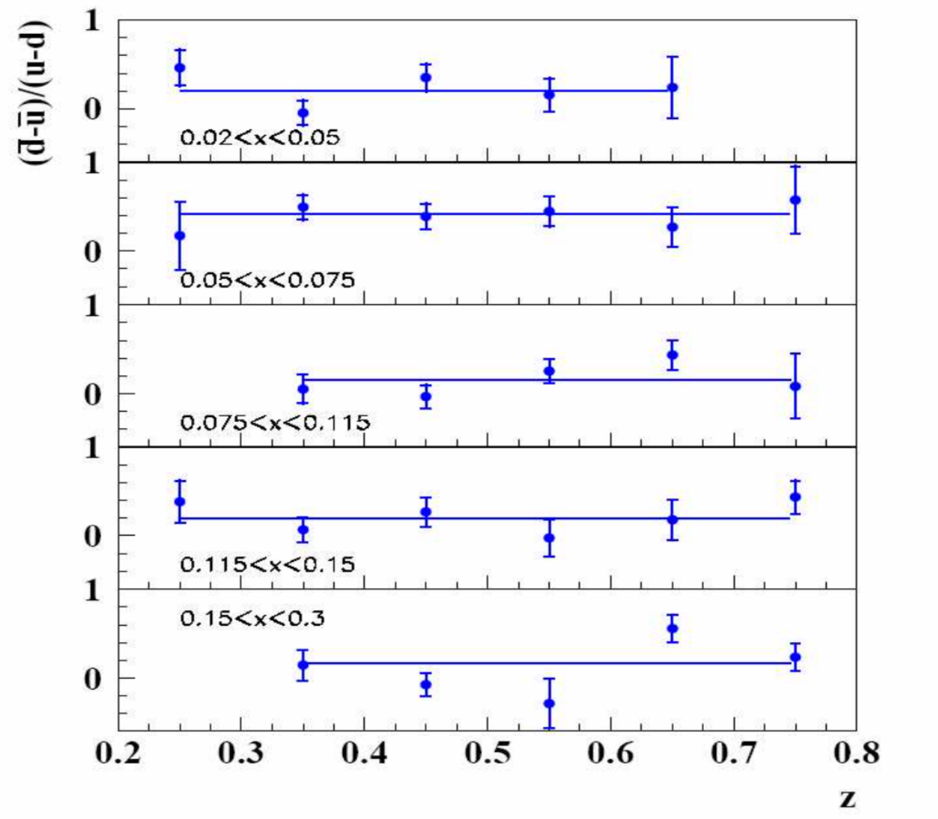
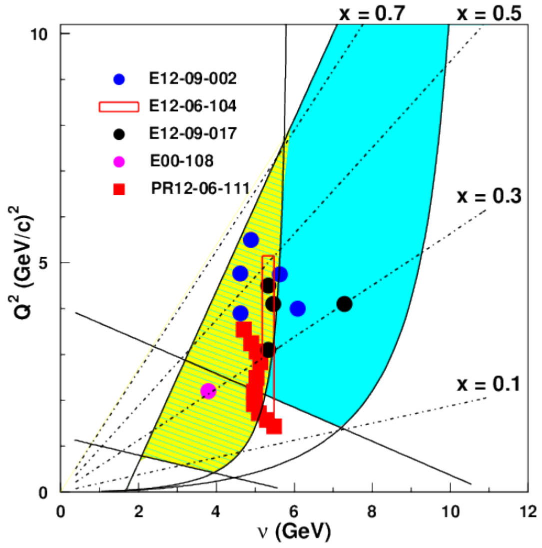


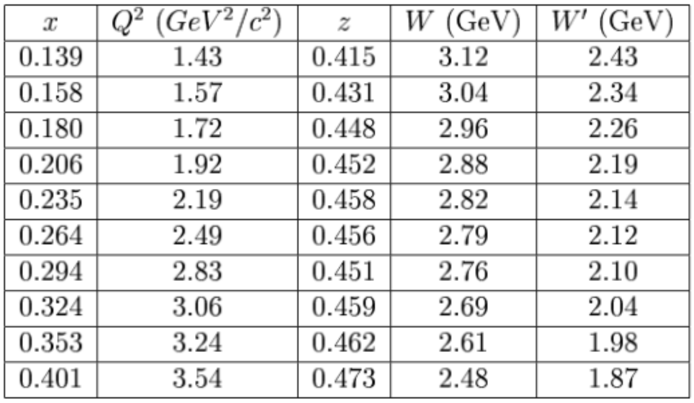
Figure 5: Evidence of factorization from HERMES. The ratio $(\overline{d} - \overline{u})/(u - d)$ as a function of z in five bins of x [5].

3 Tentative Run Plan

The primary goal of this experiment is to explore the light sea quark asymmetry at moderate x to elucidate the apparent tension from the new E906 results with those from E866 at large x. As can be seen in Fig. 4 the region of interest begins at $x \approx 0.25$. However, data at lower x, where E866 and E906 are in relatively good agreement, will be important to demonstrate the light anti-quark asymmetry extracted from SIDIS is consistent with that from Drell-Yan.



(a) Updated phase space plot of ν vs Q^2 for various Hall C SIDIS experiments. Black points represent E12-09-017 = PT-SIDIS, blue points represent E12-09-002=CSV, and the open red box indicates planned kinematics for E12-06-104. The previously proposed kinematics from PR12-06-111 are shown with solid red squares.



x	Q^2 (GeV^2/c^2)	z	W (GeV)	W' (GeV)
0.139	1.43	0.415	3.12	2.43
0.158	1.57	0.431	3.04	2.34
0.180	1.72	0.448	2.96	2.26
0.206	1.92	0.452	2.88	2.19
0.235	2.19	0.458	2.82	2.14
0.264	2.49	0.456	2.79	2.12
0.294	2.83	0.451	2.76	2.10
0.324	3.06	0.459	2.69	2.04
0.353	3.24	0.462	2.61	1.98
0.401	3.54	0.473	2.48	1.87

(b) Table of previously proposed kinematics for PR12-06-111.

Figure 6: a) The red squares show the kinematics from PR12-06-111. Note the overlap with E12-06-104, which will measure $R = \sigma_L/\sigma_T$ in SIDIS in Hall C. E12-06-104 will make measurements at multiple beam energies, so the statistics at each point will likely be lower than required for a flavor-asymmetry measurement. In addition, a flavor asymmetry measurement requires measurements on both H and D, while E12-06-104 only includes both hydrogen and deuterium targets at x=0.2.

Fig. 6 (upper) shows the phase space for charged pion SIDIS experiments that have been or will be performed in Hall C, along with that from the deferred PR12-06-111. It is of note that the phase space for the deferred, earlier proposal is very similar to that for the E12-06-104 ("Measurement of the Ratio $R = \sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering), which has not yet run. We list in Table 1 the kinematics listed in the E12-06-14 proposal.

x	Q^2	Target(s)	Comment
0.15	1.5	LH2	one z value
0.20	**2.0**	**LH2, LD2**	z **scan**
0.30	**3.0**	**LH2**	p_T **scan**
0.40	**4.0**	**LH2**	z **scan**
0.50	5.0	LH2	one z value

Table 1: Table of kinematics from E12-06-104. Those in **bold** represent settings that would fit well with the goals of this letter.

Significant overhead, commissioning, and setup time would be saved if it were possible for this experiment to run at the same time as E12-06-104. Assuming such running is feasible, the $x = 0.2$, 0.3, and 0.4 kinematics would fit well with our experimental goals. However some comments are in order:

- Since it is an L-T separation, E12-06-104 will require several beam energies. This experiment only requires data at the largest beam energy, 11 GeV.
- This experiment will require SIDIS data for π^+ and π^- production from both hydrogen and deuterium. E12-06-104 will take data on both pion charge states, but only at $x = 0.2$ will it use both LH2 and LD2 targets.
- In general, we will require very high statistical (and systematic) precision to be sensitive to the light anti-quark asymmetry. As such, we would require longer run times at all settings.

Although the final result for the light sea quark asymmetry will undoubtedly require a global analysis requiring constraints from multiple experiments, higher order corrections, etc., it is informative to use the leading formulas from PR-06-111 to explore the sensitivity this precision measurement of charged pions in SIDIS will provide. The result of this exercise is shown by the green triangle points in Fig. 7. For these projections, we have assumed 100,000 (200,000) π^+ and π^- events from LH2 and 200,000 (400,000) events from LD2 at x=0.2, 0.3 (x=0.4). Scaling the time required from the estimates from E12-06-104, we estimate that it would take about 405 hours (17 days) of production to achieve the precision noted. Note that about 20% of the needed time would be in common with E12-06-104 if both experiments were to run simultaneously. Note that these projections include only statistical uncertainties - systematic uncertainties will be explored in the full proposal.

4 Addressing concerns from PAC30 report

1. PAC comment: Both techniques (termed "Method 1" and "Method 2") for the sea-flavor asymmetry measurement rely critically on the assumptions detailed in Equations 17 and 18 of the proposal: that all four "favored" pion fragmentation functions are equal, and the same for the four "disfavored" functions. These symmetries are true in the limit of perfectly-factorized fragmentation in the current-quark regime: i.e., when the fragmentation process depends only on the nature of the struck quark, and has no "memory" of the target remnant. However, though the Lund Monte Carlo has been shown (by CLAS) to reproduce well the pion multiplicities in the $W < 3.2$ GeV (e.g. Fig. 6 of the proposal, though a different Monte Carlo was used for that comparison), the same Lund Monte Carlo suggests that considerable breaking of these symmetries exists at the $W > 3.2$ GeV kinematics of the

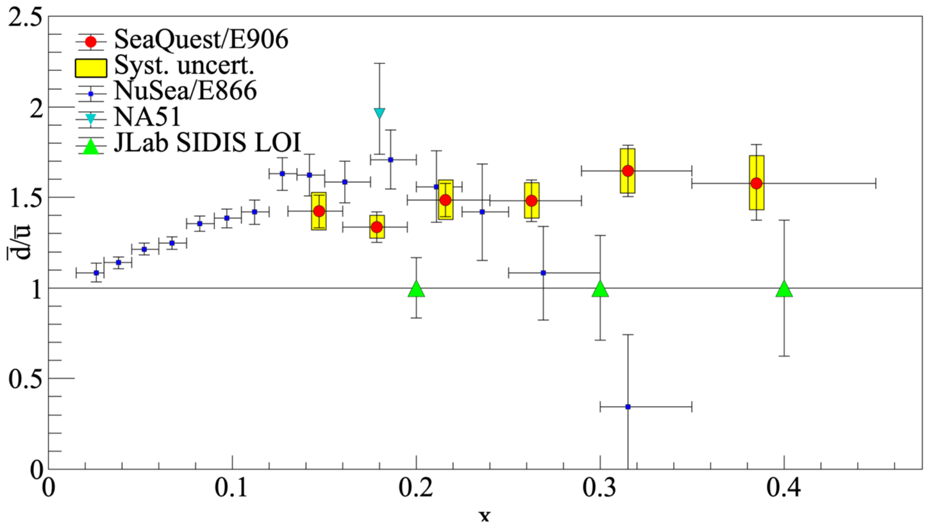


Figure 7: Results of $\overline{d}(x)/\overline{u}(x)$ from NA51 (cyan upside down triangles) [13], E866 experiment [14] (black circles), SeaQuest (red circles) [1] and JLAB SIDIS projections (green triangles) if data is collected at E12-06-104 kinematics.

HERMES experiment, and becomes worse at lower W. Unlike the measurements proposed here, the pion multiplicities are strongly dominated by u-quark fragmentation, and so are quite insensitive to the symmetries of Eqs. 17 and 18. HERMES is presently engaged in the analysis of $\overline{d}(x)/\overline{u}(x)$and $d_v(x)/u_v(x)$ using precisely the techniques proposed here and the high-statistics dataset collected over 10 years of running. Even with $W > 3.2$ GeV, the analysis is confronting systematic effects in the data that appear to reflect the symmetry-breakings suggested by the Lund Monte Carlo. Until the HERMES analysis, at higher W, reaches a conclusion in the next 2 – 3 years (i.e. quantifying the influence of these symmetry-breakings in various kinematic regions), it is simply unclear whether or not this SIDIS technique will work at anywhere near the projected accuracy of the proposed measurement at modest values of W. It is simply premature to endorse the proposed experiment before these findings are released. Further, experiment E-04-114, conditionally-approved for Hall A, will perform the same experiment proposed here at more restricted but similar kinematics, notably 2.5 < W < 3.1 GeV. Those data offer another opportunity to explore the feasibility of this technique. Finally, the proponents are encouraged to explore the possibility of using this technique at CLAS12, where the open geometry removes the W < 3.2 GeV restriction.

Response: Note here that Method -I in PR12-06-111 refers to the analysis where one uses the ratio of PDFs $\frac{\bar{u}+\bar{d}}{u+d}$ as input to extract the ratio of unfavored to favored fragmentation function from the deuterium SIDIS yields. This ratio of fragmentation functions can then be used to extract the anti-quark asymmetry along with the proton and neutron SIDIS yields. Similarly, Method -II also relies on input PDFs but the yield ratios obtained from data are such that the fragmentation functions cancel in the ratios. Moreover, one of the yield ratios used in this method provides a clean handle on NLO analysis.

The fragmentation function fits [29] that included the HERMES results showed ∼ 10% isospin symmetry violation (ISV) both in LO and NLO analysis. The 10% ISV favored by these fits is driven primarily by the HERMES data which were deemed to have insufficient precision. These data were also insufficient to extract any z dependence of the ISV [30].

The HERMES results on the extraction of d_v/u_v found large contamination by the target remnant at $z < 0.3$. The systematic uncertainties were also found to be too large. The HERMES analysis suggested that future high statistics experiments should have a multi-dimensional approach to extract meaningful results [30].

All of this points to the urgent need for high statistics data with good control over systematic uncertainties as would be possible with this proposed experiment. It would also allow the multi-dimensional approach advocated by the HERMES collaboration.

2. PAC comment: Fig. 28 of the proposal compares the projected accuracy of the proposed $\overline{d}(x)/\overline{u}(x)$measurement to that of Drell-Yan experiment E906, which is expected to run in 2009 at Fermilab. As E906 will provide greater accuracy and kinematic coverage, the proposal states that its primary purpose is to cross-check the anticipated Drell-Yan result, via a different technique with entirely different systematic issues and at much lower Q^2. However, when HERMES ceases data-taking in mid-2007, it will have collected more than 25 times the statistics of the 1996 data used in its published $\overline{d}(x)/\overline{u}(x)$measurement(shown in Fig.27). Though the final HERMES results will beat lower x than those proposed here, comparing them with the E866 measurement may provide a sufficient cross-check between the SIDIS and Drell-Yan techniques (and information on the scale- dependence). It is advisable to wait for the next HERMES release of $\overline{d}(x)/\overline{u}(x)$to see whether further precision from the SIDIS technique is needed.

   Response: The SeaQuest experiment has finished recording data and has now published results from the first half of its data. These results are shown in Fig. 4 and should be compared to the accuracy of this proposal, shown in Fig. 28 and reproduced here as Fig. 8. The E12-06-111 proposal states that its primary purpose is to cross-check the anticipated Drell-Yan result, via a different technique with entirely different systematic issues and at much lower Q^2. The HERMES experiment has used SIDIS to extract $\bar{d}(x) - \bar{u}(x)$ [5]. The HERMES data generally confirm the low-x behavior of the SeaQuest and NuSea (E866) data, albeit with limited statistical precision. The HERMES data and NuSea data are shown in Fig. 3.

   Thus, the issue remains unresolved and more data using different techniques are much needed.

3. PAC comment: Section 2.7 suggests that measurements of kaon SIDIS can provide information on the flavor- dependence of the kaon fragmentation functions, and even on the quark substructure of the kaon itself. However, these assertions are based on the symmetries presented in Equations 31–33 between the various kaon fragmentation functions, and these postulated symmetry-relations are impossible. The simplest illustration is equating the fragmentation function for u → K+ to that for s → K+. This relation requires that the probabilities for the "pickup" of an s or u quark from string-breaking is the same. Even at LEP energies, a strangeness-suppression factor of order 1/3 damps the creation of $s\bar{s}$ pairs as compared with uu or dd (e.g. the default value of the strangeness-suppression parameter PARJ(2) in PYTHIA is 0.3).

   Response: We intend to just focus on the pion data only.

5 Summary

This letter of intent aims at realizing PR12-06-111 that uses SIDIS reactions $(e, e'\pi^{\pm})$ on hydrogen and deuterium targets in the kinematic range $0.1 < x < 0.48$, $1.2 < Q^2 < 4.3$ (GeV/c)^2 and $0.3 < z < 0.7$ in Hall C at Jefferson lab with a 11 GeV e^- beam. The charged pion yield ratio is

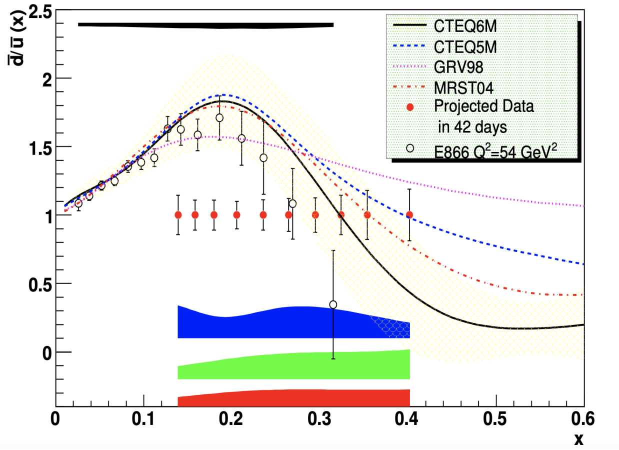


Figure 8: The projected uncertainties in the extraction of $\bar{d}/\bar{u}$ in Hall C with a 11 GeV/c incident electron beam. The published E866 [14, 4] results are plotted for comparison. The red band shows the target related uncertainties. The green band shows the charge related uncertainties and fragmentation ratio related uncertainties. The blue band shows the uncertainties due to PDF input in forming $\bar{d}/\bar{u}$. This figure is reproduced directly from Fig. 28 of the E12-06-111 [6].

sensitive to $\overline{d}(x)/\overline{u}(x)$ and $\overline{d}(x)-\overline{u}(x)$ which are key variables that shed light on various possible non-perturbative mechanisms that generate the nucleon sea as well as the anti-quark flavor asymmetry. The precise measurement of these ratios will provide data in the high-x region using a different process and Q^2 region as compared to previous Drell-Yan measurements. After results from various experiments (HERMES, NuSea and SeaQuest), a high statistics data sample with good control over systematic uncertainties using SIDIS reactions will provide an independent study of the region of overlap with previous Drell-Yan measurements. These advancements point to the urgent need for high statistics data with good control over systematic uncertainties as would be possible with this proposed experiment. It would also allow the multi-dimensional approach used by most global analysis efforts.

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