

# UPDATE to E12-09-007; Studies of partonic distributions using semi-inclusive production of Kaons

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## Abstract

We propose to measure multiplicities and longitudinal double spin asymmetries for pions ( $\pi^+$ ,  $\pi^-$ ,  $\pi^0$ ) and kaons ( $K^+$ ,  $K^-$ ,  $K_s^0$ ) in Semi-Inclusive Deep Inelastic Scattering (SIDIS) from hydrogen and deuterium. The data will be used to extract the individual contributions of quarks and anti-quarks to the nucleon spin, in addition to measuring the x-dependence of the strange parton distribution function (PDF) and constraining the global fits used to obtain the fragmentation functions (FF).

The experiment will use CLAS12 detector in Hall B to measure scattered electrons and produced hadrons in coincidence. The experiment requires the use of a Ring Imaging Cherenkov (RICH) to replace the refurbished low threshold Cherenkov counter for a successful charged kaon identification over the whole momentum range. Two running conditions will be needed. The first one involves unpolarized beam and targets for multiplicity and strange PDF measurements. The second one uses both polarized beam and targets for the flavor decomposition. The measurements will cover the x-range from  $0.05 < x < 0.7$ .

The experiment, run alone requires 136 days to complete in Hall B assuming a luminosity of  $10^{35} \text{ cm}^{-2}\text{s}^{-1}$  and 11 GeV electron beam. A total of 56 days will be used for the unpolarized configuration and 80 days will be needed for the polarized measurements. However, the unpolarized part can run together with the approved experiment E12-07-104, reducing the beam time request by 30 days. The polarized part can run together with the E12-06-109 and E12-07-107 experiments, further reducing the beam time request by 80 days. The additional beam time requested is 26 days due to the statistical requirements of multi-dimensional binning.

## I. PHYSICS CASE

Until recently, inclusive measurements have provided most of the current knowledge of nucleon spin structure. However, they are only sensitive to the sum of the quark and antiquark distribution functions because the scattering cross section depends on the squared charge of the quarks and antiquarks. The polarization of the individual flavors is only accessible in fits to inclusive data where additional assumptions are used such as SU(3) symmetry for the sea quarks. Accessing in more direct way the contributions from individual quarks and antiquarks can be achieved when hadrons are detected in the final state in addition to the scattered lepton. This method is called "flavor tagging" where the statistical correlation between the struck quark and the produced hadron "fragmentation function" is a key ingredient. HERMES experiment was pioneering in such measurements [1]. The extracted distributions  $\Delta u(x)$  and  $\Delta d(x)$  are consistent with inclusive results, but have better precision. The sea distributions were extracted separately for the first time and were found to be consistent with zero. The strange sea was found to be slightly positive but consistent with zero while the inclusive measurements yielded a negative value. An alternative method, the so-called isoscalar method was used to extract the strange sea distributions [2]. The result was found consistent with the five flavor decomposition with improved precision. The advantage of such method is its simplicity (isoscalar target), minimal assumptions and control of the systematic errors related to fragmentation functions. COMPASS [3] extended the measured region by an order of magnitude towards small  $x$ . Their results for individual quarks helicity distribution were found in qualitative agreement with HERMES measurements.

Very good progress has been made toward a complete understanding of the contributions of individual quarks to the nucleon spin. However, the associated uncertainties remain important, especially in the sea sector ( $\Delta\bar{u}$ ,  $\Delta\bar{d}$ ,  $\Delta s$  and  $\Delta\bar{s}$ ). One can take advantage from the high luminosity of JLab 12 GeV upgrade to improve the statistical precision especially in the kaon sector. Special attention should be given to  $K^-$  since it is a purely sea object, which will allow us to avoid the u-quark dominance. The authors in Ref. [4] suggested that measuring  $A_{1p}^{K^-}$  is of particular interest because of its sensitivity to  $\Delta\bar{u} - \Delta\bar{d}$ . It provides an excellent test for models which successfully describe the unpolarized densities  $\bar{u} - \bar{d}$ . Two of such models are the Chiral Quark Soliton Model ( $\chi QSM$ ) [4], which is based on an effective theory where baryons appear as soliton solutions of the Chiral Lagrangian. The second one is a meson cloud model [5] that describes the nucleon as a bare nucleon and a cloud of virtual mesons. The two models have very distinct predictions for  $\Delta\bar{u} - \Delta\bar{d}$ . Both HERMES and COMPASS measured  $\Delta\bar{u} - \Delta\bar{d}$ . While HERMES data tend to prefer flavor symmetry, COMPASS seems to indicate that  $\Delta\bar{u} - \Delta\bar{d}$  is slightly positive, about 1.5 standard deviations from zero. Both experiments observed no difference between  $\Delta s$  and  $\Delta\bar{s}$ . However, no decisive conclusion can be made due to the lack of statistical precision. A recent global next-to-leading order analysis [6] of DIS, SIDIS, and preliminary RHIC data gives rise to a robust pattern for the sea polarization, clearly deviating from SU(3) symmetry. With the anticipated precision of the proposed measurements, one can clearly validate one, if any, of the existing models.

Important ingredients in the flavor decomposition method are fragmentation functions (FFs). The knowledge of fragmentation functions has been rapidly evolving, following the path of parton densities, however without attaining yet their precisions. Up to recently, most of the information used to determine FFs comes essentially from electron-positron annihilation into charged hadrons. These data are precise and clean since they do not depend on parton densities. However, they do not give any information on how to disentangle the quark from antiquark fragmentation as they refer to the charge sum for certain hadron species such as  $(\pi^+ + \pi^-)$ . The information on how the individual quark fragments into hadrons depends crucially on the tagging techniques and the underlying assumptions implemented in the Monte-Carlo generator used. Fortunately, in the last few years several measurements coming from both proton-proton collisions and deep-inelastic lepton-nucleon scattering have matured enough as to yield complementary information on the fragmentation process with competing precision [7–11]. These measurements were the main driver for excellent improvement of the FF parameterizations [12] where less stringent assumptions on the flavor asymmetry of FFs are made. The proposed

measurements can contribute tremendously to this database with high quality multiplicity data for various hadron species ( $\pi^+$ ,  $\pi^-$ ,  $\pi^0$ ,  $K^+$ ,  $K^-$ ,  $K_s^0$ ) off proton and deuteron. The high luminosity will allow us to perform multi-dimensional binning ( $x$ ,  $z$ ,  $Q^2$ ,  $P_T$  and  $\phi$ ) checking for example the  $Q^2$  evolution of FFs. The same data can be used to reduce the systematic uncertainties in the extraction of the polarized parton distribution functions. It can also be used as was done recently by HERMES to determine the shape of the strange parton density distribution checking the assumption used in the parameterization about  $s = \bar{s} \propto (\bar{u} + \bar{d})/2$ .

## II. EXPERIMENTAL OBSERVABLES

### A. Formalism for unpolarized deuteron target: Multiplicities and Strange PDFs

At the leading order of QCD and for unpolarized SIDIS, the cross section for hadron production at a given  $x$ ,  $Q^2$  and  $z$ , normalized to the corresponding inclusive cross section takes the factorized form

$$\frac{d\sigma^h(x, Q^2, z, p_t, \phi)/dx dQ^2 dz dp_t d\phi}{d\sigma^{DIS}(x, Q^2)/dx dQ^2} = \frac{dN^h(x, Q^2, z, p_t, \phi)}{dN^{DIS}(x, Q^2)} = \frac{\sum_q e_q^2 q(x, Q^2) D_q^h(z, p_t, \phi, Q^2)}{\sum_q e_q^2 q(x, Q^2)} \quad (1)$$

where  $q$  is the parton distribution function for a quark of a flavor  $q$ ,  $e_q$  is its charge and  $D_q^h$  is the fragmentation function.  $z = E_h/\nu$  is the fraction of the photon energy  $\nu$  carried by the hadron of energy  $E_h$ ,  $p_t$  is the hadron transverse momentum and  $\phi$  is its azimuthal angle. In the following the  $p_t$  and  $\phi$  dependence is omitted for simplicity. For deuterium; an isoscalar target, the fragmentation functions become isospin independent. By assuming isospin symmetry between proton and neutron, the strange PDF to be identical for both nucleons and charge conjugation invariance in the fragmentation functions, the multiplicity of Eq. (1) for a final product ( $H$ ) takes the following form

$$\frac{dN^H(x, Q^2)}{dN^{DIS}(x, Q^2)} = \frac{Q(x, Q^2) \int D_{NS}^H(z, Q^2) dz + S(x, Q^2) \int D_S^H(z, Q^2) dz}{5Q(x, Q^2) + 2S(x, Q^2)} \quad (2)$$

where  $H = K^+ + K^-$ ,  $H = \pi^+ + \pi^-$  or  $H = K_s^0$ . The sum of non strange and strange PDFs are  $Q = u + \bar{u} + d + \bar{d}$  and  $S = s + \bar{s}$  respectively. Furthermore,  $D_{NS}^H = 4D_u^H + D_d^H$  and  $D_S^H = 2D_s^H$  are the non strange and strange FFs respectively. In the denominator of Eq. (2), the term  $2S(x, Q^2)$  is at the most 1% ( $0.05 < x < 0.075$ ) of the  $5Q(x, Q^2)$  term, therefore one can safely drop it from the previous equation

$$\frac{dN^H(x, Q^2)}{dN^{DIS}(x, Q^2)} = \frac{Q(x, Q^2) \int D_{NS}^H(z, Q^2) dz + S(x, Q^2) \int D_S^H(z, Q^2) dz}{5Q(x, Q^2)} \quad (3)$$

If we contemplate carefully Eq. (3), we realize that once we are in the region where the sum of the strange parton distribution functions  $S(x)$  vanishes, the multiplicity becomes independent of  $x$

$$\frac{dN^H(x, Q^2)}{dN^{DIS}(x, Q^2)} = \frac{\int D_{NS}^H(z, Q^2) dz}{5} \quad (4)$$

Once in that region, one can extract the  $Q^2$  dependence of the non strange fragmentation function from the measured multiplicities.

### B. Formalism for polarized deuteron target: Asymmetries and Strange helicity distributions

In a similar way as for the unpolarized case, the leading order double spin asymmetry (photon-nucleon) for SIDIS can be expressed as

$$A_1^h(x, Q^2, z) = \sum_q \mathcal{P}_q^h(x, Q^2, z) \frac{\Delta q(x, Q^2)}{q(x, Q^2)} \quad (5)$$

where the expression for the purity is

$$\mathcal{P}_q^h(x, Q^2, z) = \frac{e_q^2 q(x, Q^2) D_q^h(z, Q^2)}{\sum_q e_q^2 q(x, Q^2) D_q^h(z, Q^2)} \quad (6)$$

The concept of purity can be generalized to inclusive scattering by setting the fragmentation function to unity in the expression of purity of Eq. (6). Moreover it can be applied to different targets (proton, deuteron) and hadron species (pions, kaons and more). Now, when using isoscalar target such as deuterium, and limiting the produced hadrons to be either  $H = K^+ + K^-$ ,  $H = \pi^+ + \pi^-$  or  $H = K_s^0$ , in addition to the assumption of isospin symmetry between proton and neutron and charge conjugation invariance in the fragmentation functions ( $D_u^H = D_{\bar{u}}^H$ ,  $D_d^H = D_{\bar{d}}^H$ ,  $D_s^H = D_{\bar{s}}^H$ ), the purity formalism simplifies to a linear relationship between the measured double spin asymmetries and the total non strange and strange quark helicity distributions. This relationship can be expressed as follow

$$\begin{pmatrix} A_d(x, Q^2) \\ A_d^H(x, Q^2) \end{pmatrix} = C_R \begin{pmatrix} \mathcal{P}_{NS}(x, Q^2) & \mathcal{P}_S(x, Q^2) \\ \mathcal{P}_{NS}^H(x, Q^2) & \mathcal{P}_S^H(x, Q^2) \end{pmatrix} \begin{pmatrix} \Delta Q(x, Q^2)/Q(x, Q^2) \\ \Delta S(x, Q^2)/S(x, Q^2) \end{pmatrix}. \quad (7)$$

The inclusive purities  $\mathcal{P}_{NS}$  and  $\mathcal{P}_S$  are functions of PDFs. The purities for the SIDIS asymmetries are functions of PDFs and FFs integrated over the measured range of  $z$  values.  $C_R$  in Eq. 7 is a kinematic factor. To solve Eq. 7, one needs to measure both the inclusive and semi inclusive asymmetries in addition to the inclusive and semi inclusive purities. The semi inclusive purities can be determined directly from the unpolarized multiplicities described earlier. While the inclusive ones need the input from the PDFs parameterizations. In the case of non strange PDFs, one can rely on the existing parameterizations. However, one should be cautious for the strange PDFs. Luckily their contributions to the inclusive purities are quite small making them marginally sensitive to strange PDFs input.

### C. Formalism for polarized proton and deuteron targets: flavor decomposition

One can write Eq. (5) in a matrix form

$$\vec{\mathcal{A}}(x, Q^2) = \mathcal{P}(x, Q^2) \cdot \vec{\mathcal{Q}}(x, Q^2) \quad (8)$$

The measured asymmetries in different bins in  $(x, Q^2)$  are elements of the vector  $\vec{\mathcal{A}}$

$$\vec{\mathcal{A}}(x, Q^2) = (A_{1p}, A_{1p}^{\pi^+}, A_{1p}^{\pi^-}, A_{1p}^{K^+}, A_{1p}^{K^-}, A_{1p}^{K_s^0}, A_{1d}, A_{1d}^{\pi^+}, A_{1d}^{\pi^-}, A_{1d}^{K^+}, A_{1d}^{K^-}, A_{1d}^{K_s^0}) \quad (9)$$

The matrix  $\mathcal{P}(x, Q^2)$  contains the purities for the proton and deuteron, while the vector  $\vec{\mathcal{Q}}(x, Q^2)$  contains the quark and anti-quark polarizations:

$$\vec{\mathcal{Q}}(x, Q^2) = \left( \frac{\Delta u}{u}, \frac{\Delta d}{d}, \frac{\Delta s}{s}, \frac{\Delta \bar{u}}{\bar{u}}, \frac{\Delta \bar{d}}{\bar{d}}, \frac{\Delta \bar{s}}{\bar{s}} \right) \quad (10)$$

As shown in Eq. 6, the purities depend on the unpolarized PDFs and the fragmentation functions. For the fragmentation functions, one can constrain them using measured pion and kaon multiplicities in the same kinematical range from unpolarized proton and deuteron data. Eq. 8 becomes a set of equations evaluated in all  $(x, Q^2)$  bins. They can be solved to give the vector  $\vec{\mathcal{Q}}(x, Q^2)$  by  $\chi^2$  minimization accounting for the correlations between the various asymmetries.

### III. EXPERIMENTAL OVERVIEW

The proposed experiment will use the upgraded CLAS12 spectrometer with the low threshold Cherenkov counter replaced by a RICH detector. In the baseline design of CLAS12, particle identification (PID) in the forward detector is obtained by using the high threshold Cherenkov counter (HTCC), the low threshold Cherenkov counter (LTCC) and the Time-of-flight scintillator arrays (TOF), (see Fig. 1). In the  $\sim 2.5 - 5 \text{ GeV}/c$  momentum region, the  $\pi/K$  separation relies only on the LTCC performance. Moreover, in the  $4.7 - 8 \text{ GeV}/c$  momentum region it is not possible to separate protons from kaons. In general, this PID system matches the requirements of the physics program at 12 GeV. However there are some physics reactions of high interest, such as the one covered by this proposal, that cannot be accessed without a better PID, especially for charged kaon detection. At 12 GeV for semi-inclusive processes, the  $K/\pi$  ratio is of the order of  $10 - 15\%$  thus the required rejection factor for pions is around  $1 : 1000$  (corresponding to  $4.7\sigma$  pion-kaon separation) while with the present configuration, assuming a pion detection inefficiency for the LTCC of  $10\%$ , the  $\pi/K$  contamination is  $1 : 1$ . A RICH detector, to be installed in place of the LTCC, will significantly improve the CLAS12 PID overcoming the above limitations. In the momentum range of interest an aerogel RICH represents the best

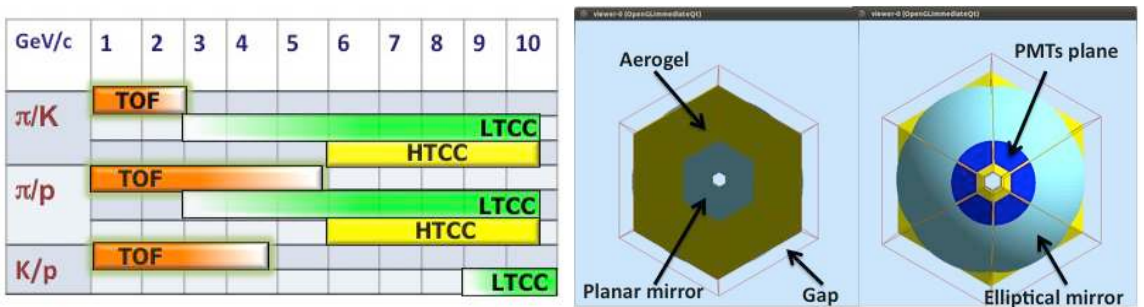


FIG. 1: Left panel: Hadron particle identification in CLAS12. Right panel: Drawing of the proposed proximity focusing RICH with focusing mirrors.

solution for the identification of  $\pi/K/p$ . This implies detecting Cherenkov light in the visible wavelength range and using photomultipliers (PMTs) as photon detectors. The use of aerogel as radiator and the detection of light in the visible wavelength range is however an expensive solution, in particular in the case of the CLAS12 RICH where, for each sector, the radiator area is of the order of  $4 \text{ m}^2$  and the photon detection surface is of the order of  $8 \text{ m}^2$ . To limit the area of the photon detector to about  $1 \text{ m}^2$  per sector the idea is to build a proximity focusing RICH with focusing mirrors. The approach is to instrument a limited area around the beam line to have direct detection of Cherenkov light for particles emitted in the forward region and at high momenta, while at large angles and lower momenta a system of focusing mirrors catches the light and reflect it toward the photon detector. A drawing of the proposed solution is illustrated in Fig. 1. Preliminary Monte-Carlo studies, based on GEANT4 with a realistic geometry of the CLAS12 detector and events generated with Pythia, have been performed with the aim to optimize all the components of the detector. The dimensions of the radiator thickness and the gap length as well as the pad/pixel size of the photon detector have been varied in order to find the optimal combination which gives the smaller reconstruction error in the Cherenkov angle and the highest number of photoelectrons. An average number of 10 and 5 photoelectrons has been obtained for the direct and reflected light collection, respectively.

In order to have a precise information about the RICH performances in terms of pion/kaon separation a pattern recognition algorithm based on the Direct Ray Tracing (DRT) which associates the various hits in the photon detector of the RICH with a ring assigned to a certain track, has been used. The selection of the most probable particle type is made by calculation of the likelihood that each particle type would generate the measured DRT

spectrum. The preliminary results of the ongoing Monte-Carlo analysis are encouraging about the performances of the proposed RICH; there are several margins of improvements which are under investigation. Also test in realistic conditions of the proposed solution with a small prototype is underway.

#### IV. UNCERTAINTIES AND PROJECTIONS

The expected number of counts and corresponding statistical errors in the following subsections are based on a full simulation of inclusive and semi-inclusive deep inelastic scattering with the CLAS12 acceptance folded in. Events were generated with the CLAS12-DIS generator [13]. This generator is basically an implementation of the LUND Monte-Carlo package called PEPSI (Polarized Electron-Proton Scattering Interactions) [14]. It is based on polarized and unpolarized parton distribution functions and the LUND string model for hadronization, and has been tested successfully against several low- $Q^2$  experiments in the 6 GeV era.

The usual DIS cuts were applied to the simulated data, namely  $Q^2 \geq 1 \text{ GeV}^2$ ,  $W \geq 2 \text{ GeV}$  and  $y = \nu/E \leq 0.85$ . The  $y$  cut is usually used to reduce the region where radiative corrections are large.

##### A. Multiplicities

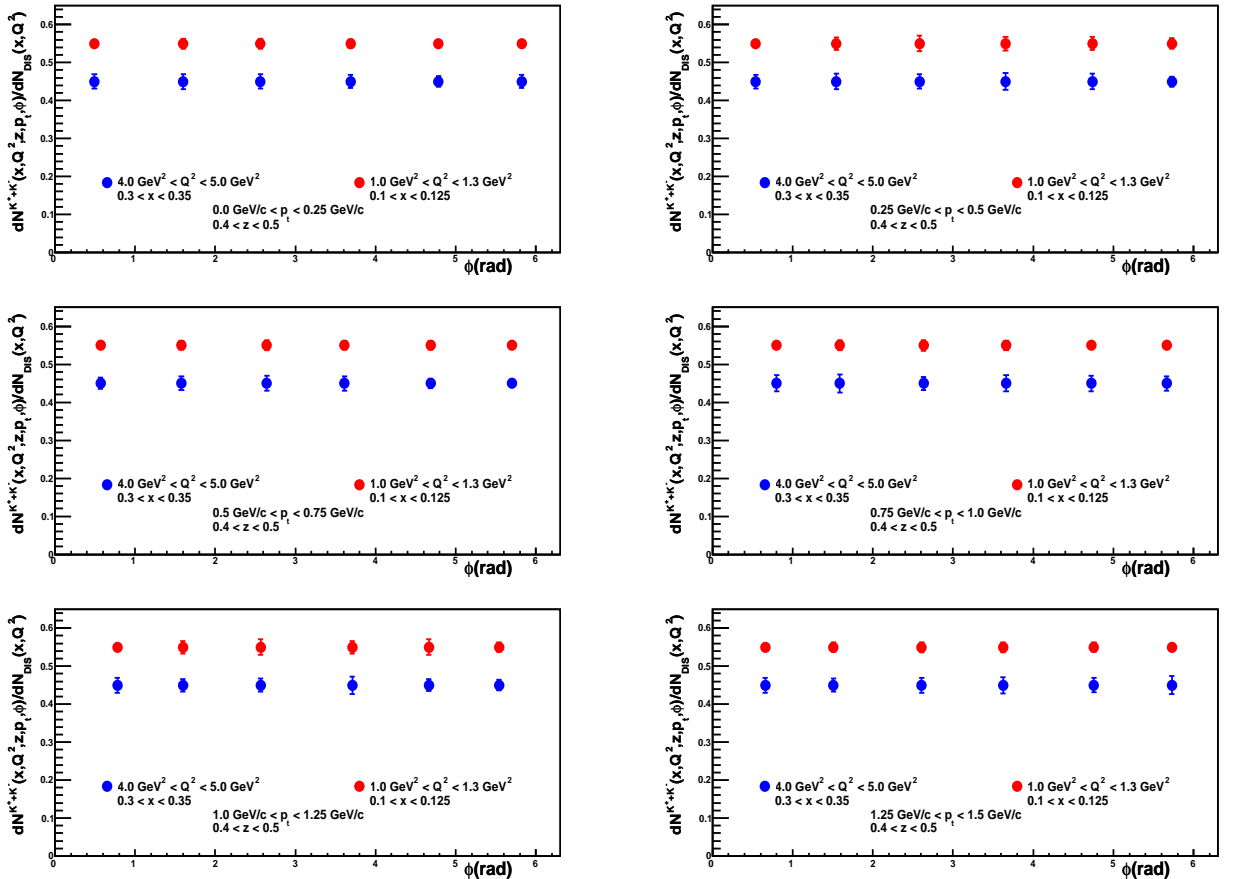


FIG. 2: The  $\phi$  dependence of multiplicities for  $K^+ + K^-$  from deuterium for four dimensional  $x, Q^2, P_t, z$  bins.

To obtain the final multiplicities, one has to apply several corrections. They include charge symmetric background correction, smearing, acceptance and radiative corrections. One should also correct for contributions from diffractive vector mesons such as  $\rho$ -meson for pions and  $\phi$ -meson for kaons. For systematic uncertainties, most of them will drop since the measurements are ratios from the same target but one should keep in mind those related to RICH inefficiencies. To estimate them, one can use vector meson decay data where the ID of the decay product is known then check the RICH response. At this stage, it is too early to put a number. However, one should keep it in mind when designing the RICH detector.

The statistical errors are calculated assuming 54 days of running with  $0.5 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$  and 80% RICH kaon detection efficiencies. Only a RICH coverage of two sectors was considered. Figure 2 shows statistical projections for the sum of charged kaons multiplicity for four dimensional  $x, Q^2, P_t, z$  bins.

## B. Asymmetries

TABLE I: Uncertainties for asymmetry measurements.

Item	Beam x targ pol	Depol and R	Dilution factor	Rad corrections	Transverse (to $\gamma^*$ ) spin effects
uncertainty on asymmetry	2%	4%	3%	3%	3%

The proposed spin asymmetry measurements are rather insensitive to uncertainties in acceptances and charge normalization. The main systematic error is due to possible contamination of the single pion sample with pions from decays of exclusive vector mesons. For kaons, RICH misidentification will also come to play. Other sources of systematic errors include the beam and target polarizations, dilution factor and the longitudinal to transverse photo-absorption cross section ratio,  $R(x, Q^2)$ . The main sources of systematic errors in measurements of double spin asymmetries are listed in the Table I. These errors are all scale errors, so are proportional to the size of the measured asymmetry. Studies of other sources of systematics, related to physics background, including target fragmentation, semi-exclusive processes, exclusive vector meson contributions and higher twist require the data of this measurement. We base our predicted statistical errors in the following sections on the assumption of running 30 days on  $\text{NH}_3$  and 50 days on  $\text{ND}_3$ , where half of the time we will be running with two opposite torus fields. The reason behind is that we will gain a factor of two in the number of  $K^-$  while the number of  $K^+$  will stay the same. This is due to the fact that in the electron-outbending configuration, the  $Q^2$  distribution shifts to lower values ( $Q^2 > 1\text{GeV}^2$ ) where the cross sections are larger. The number of days was chosen identical to the already approved proposals E12-06-109 and E12-07-107. For our estimate of the total systematic error, we have added the systematic errors listed in Table I in quadrature. Additional contributions to systematic error of measured asymmetries will come from uncertainties of unpolarized structure functions and also attenuation of hadrons in nuclear environment, which are a subject of a separate study (proposal E12-06-117 [15] on nuclei). The great wealth of data will allow us to extract individual flavor contributions to the nucleon spin. We start by extracting individual asymmetries for different hadrons ( $\pi^+$ ,  $\pi^-$ ,  $\pi^0$ ,  $K^+$ ,  $K^-$  and  $K_s^0$ ) from both proton and deuteron. The projected statistical precision is shown in Figs. 3 for  $K^-$ . Using these asymmetries and purities from Monte-Carlo, one can extract  $x\Delta q$  (see Fig. 4). The statistical projections for  $x(\Delta\bar{u} - \Delta\bar{d})$  are shown in Fig. 5. As one can see we can measure it with unprecedented precision. Answering the question whether or not the light sea is symmetrically polarized.

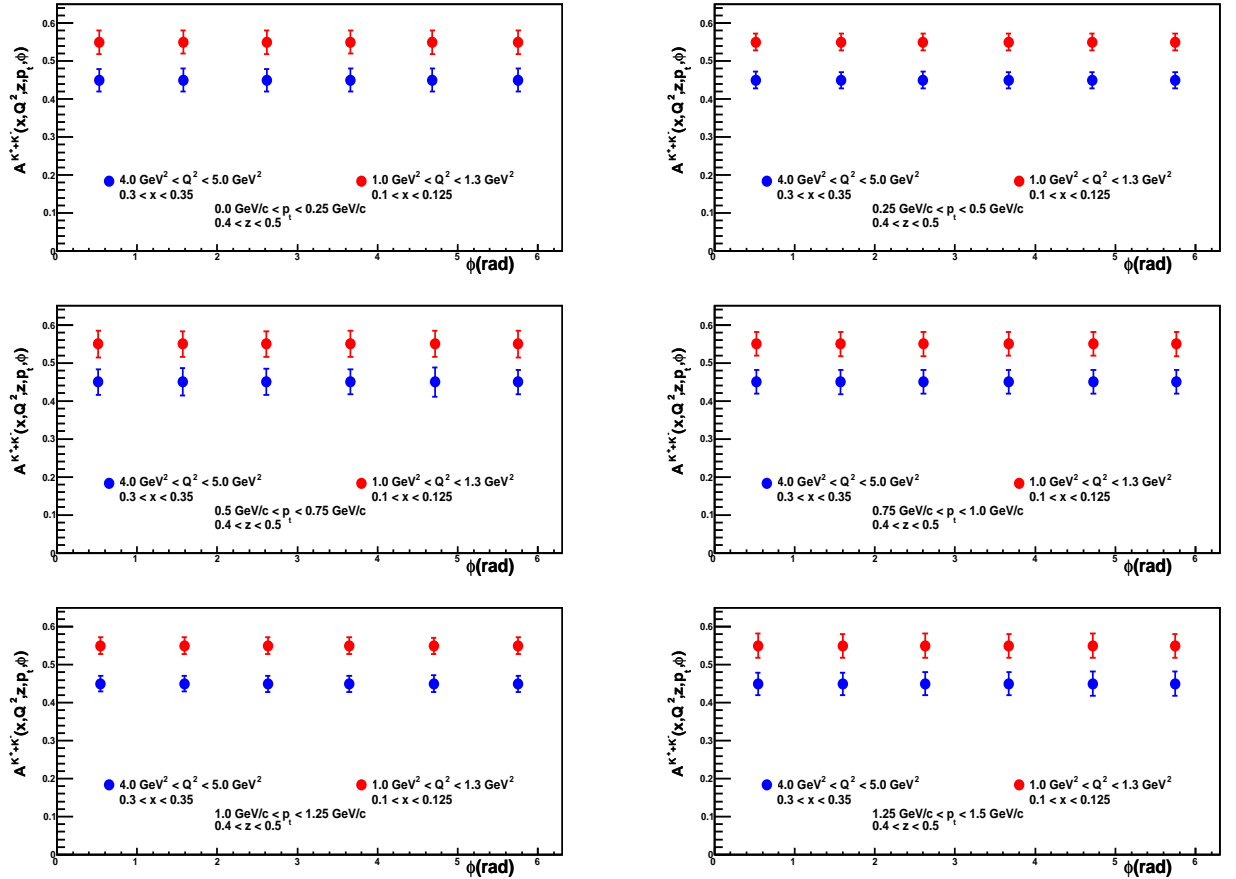


FIG. 3: The  $\phi$  dependence of multiplicities for  $K^+ + K^-$  from deuterium for four dimensional  $x, Q^2, P_t, z$  bins.

## V. BEAM TIME REQUEST

In this proposal, we are presenting a complete program for the study of individual quark contribution to the nucleon spin. It represents a giant step in this field since we are benefiting from the successful combination of the high luminosity and the large acceptance offered by CLAS12. These measurements will also benefit from the knowledge and experience accumulated during more than a decade by HERMES collaboration. Measuring multiplicities in the same kinematical range as the semi inclusive asymmetries is the best way to reduce the systematics in the quark flavor decomposition. In addition to the fact that these multiplicities will constitute a valuable database for constraining the fragmentation functions parameterizations. Identifying several hadron species ( $\pi^+, \pi^-, \pi^0, K^+, K^-$  and  $K_s^0$ ) in the final state is also an important element of success. In the  $x$  range between 0.05 and 0.7, we expect to measure with unprecedented precision the individual light flavor polarization using different methods that have different sensitivities and also systematics. We will make no assumption in the six flavor decomposition extraction. For the first time, all six flavors ( $\Delta u, \Delta d, \Delta s, \Delta \bar{u}, \Delta \bar{d}, \Delta \bar{s}$ ) can be extracted independently. We will also be able to precisely measure the most debatable quantity  $\Delta \bar{u} - \Delta \bar{d}$  and answer the question whether or not the light sea is symmetrically polarized. These data will test several models that were able to describe the flavor asymmetry in the unpolarized quark sector. Using unpolarized deuteron data, we will also be able to measure the shape of the strange parton distribution functions and check the ansatz that they are average of the two light sea quark distributions.

To achieve the goal of this proposal, we request a total of 54 days of an 11 GeV beam corresponding to  $10^{35}$



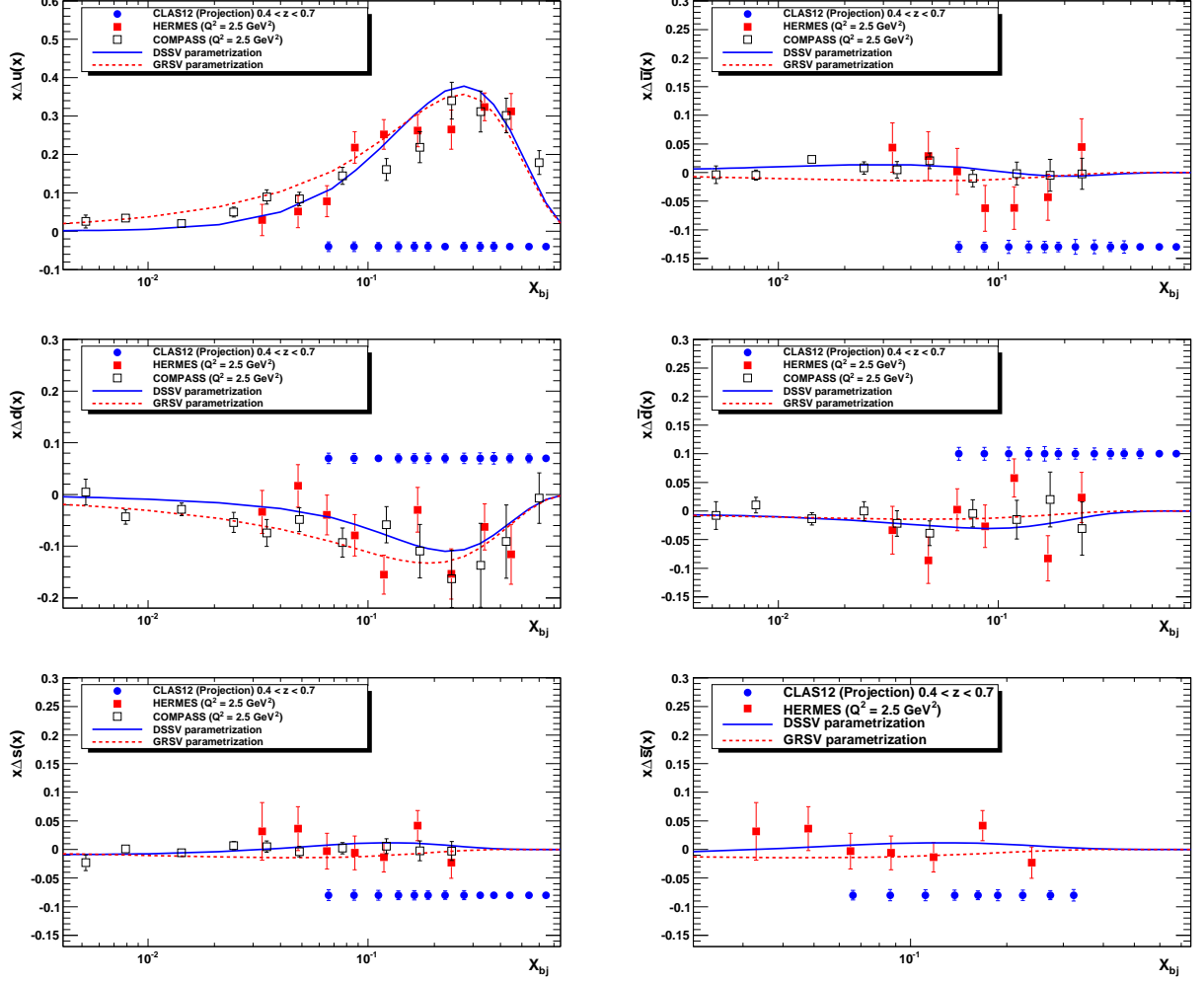


FIG. 4: Upper panel: Left (Right): Statistical projections for  $x\Delta u$  ( $x\Delta\bar{u}$ ). Middle panel: Left (Right): Statistical projections for  $x\Delta d$  ( $x\Delta\bar{d}$ ). Lower panel: Left (Right): Statistical projections for  $x\Delta s$  ( $x\Delta\bar{s}$ ).

$\text{cm}^{-2} \text{s}^{-1}$  luminosity on a dual target with both unpolarized hydrogen and deuterium cells. These measurements can run simultaneously with the approved proposal E12-07-104 [16]. Two additional days were requested for diagnostic tests like empty target runs and straight-track runs and for interchanging the hydrogen and deuterium targets. In the last procedure, we would switch the liquids in each cell to test for any measurable effects due to the different target positions.

For the polarized measurements, we request a total of 80 days of 11 GeV, 10 nA highly polarized electron beam. 50 days of which are with longitudinally polarized deuterium and the remaining 30 days are for the longitudinally polarized hydrogen. These measurements can run concurrently with the approved proposals E12-06-109 [17] and E12-07-107 [18]

An extra 23 days are needed for Commissioning (3 days), target anneals and/or change (3 days), Calibration run on  $^{12}\text{C}$  and empty target (10 days), production runs on  $^{15}\text{N}$  (5 days) and Möller polarimeter runs (2 days). These tasks are to be performed simultaneously with the approved proposals cited above.

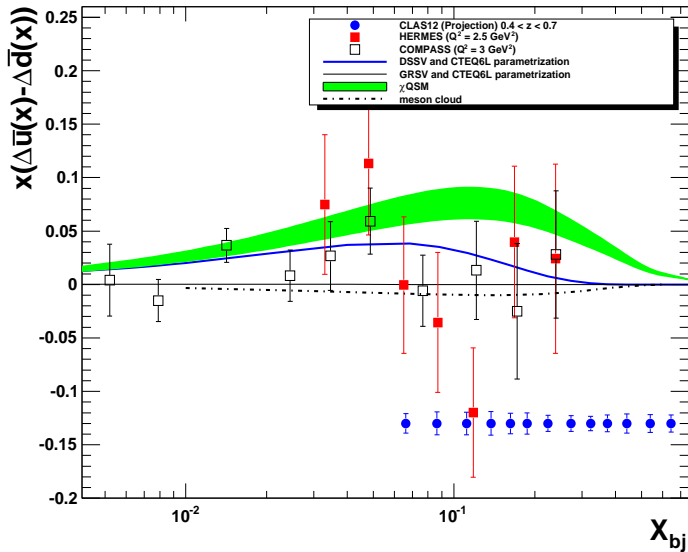


FIG. 5: Statistical projections for  $x(\Delta\bar{u} - \Delta\bar{d})$ .

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