**(A New Proposal to Jefferson Lab PAC-22)**

# Measurement of Charge Pion Production Ratios in Semi-Inclusive Deep-Inelastic Scattering at 6 GeV


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We propose to measure the semi-inclusive $(e, e'\pi^+)$ and $(e, e'\pi^-)$ yield ratios on hydrogen, deuterium and helium-3 targets in the deep inelastic scattering region of $0.15 < x < 0.35$ and $1.1 < Q^2 < 2.7$ (GeV/c)$^2$ (with $2.5 < W < 3.1$ GeV and $1.8 < W' < 2.6$ GeV) in Jefferson Lab Hall A with an incident electron beam of 6 GeV energy. The combined yield ratios of charged pions on a proton and a neutron would be independent of $z = E_\pi/\nu$ if factorization between the virtual photon-quark scattering and quark hadronization applies. We propose to determine the yield ratios to 2% statistical accuracy in order to test the level of violation of factorization at the Jefferson Lab energy scale. A total of 156 hours (6.5 days) of unpolarized beam is requested.

## 1 Introduction: Factorization in semi-inclusive reactions.

Semi-inclusive deep inelastic scattering (DIS) offers a great opportunity for determining the spin, flavor, and sea structure of the nucleon [1] , as well as extracting information on new distributions [2] (such as the transversity) which are not accessible in inclusive scattering, thereby significantly enriching our understanding of QCD and the nucleon structure.

At high energy the scattering and production mechanisms factorize: the cross section at leading order in QCD becomes a simple product of the structure function, which gives the probability of finding a quark in the nucleon, and a quark $\to$ meson fragmentation function, the probability that the quark hadronizes into the meson. The usefulness of semi-inclusive production lies in its ability to identify individual quark species in the nucleon by tagging specific mesons in the final state, so that both the flavor and spin of the quarks and antiquarks can be uniquely determined.

The extent to which factorization applies at lower energies is an open question. HERMES has demonstrated that, within their experimental precision, factorization works reasonably well at the HERMES kinematic conditions. Jefferson Lab is actively pursuing the opportunity of an energy upgrade to 12 GeV. Semi-inclusive processes could be a very rich program with the 12 GeV upgrade if factorization works to a reasonable level. The fact that Jefferson Lab has the highest luminosity, at the level of a few times $10^{38}$ particles/sec/cm$^2$, and 100% duty factor, would make it a unique facility to do precision semi-inclusive measurements to study the nucleon spin flavor and sea structure. The question of how well factorization will hold at the kinematics accessible with the 12 GeV upgrade is crucial for determining how clean and important the semi-inclusive program can become.

Recent Jefferson Lab Hall B results, with an incident electron energy of 4.3 GeV, of the single spin asymmetry for semi-inclusive $\pi$ production show a similar behavior (at the experimental accuracy of $< 50\%$) as the HERMES results with 27.5 GeV incident energy. It is an indication that the violation of factorization might be smaller than would be naively expect even at this rather low energy. One notable point is that the incident beam energy is only one of the kinematic variables. With the high luminosity of Jefferson Lab, it is often possible to perform precision measurements at large scattering angles, which makes $Q^2$ and W comparable to that of HERMES.