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The Fundamental $\gamma n \rightarrow \pi^- p$ Process in ^2H, ^4He, and ^{12}C in the 1.2 - 6.0 GeV Region

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High energy photoreactions are expected to be sensitive to the underlying quark structure of hadrons. For high energy exclusive photo pion reaction on the neutron, one might expect the quarks in the nucleon and pion exhibit short distance behavior. In particular, photoreactions might obey the constituent (quark) counting rules, the π^-/π^+ ratio would be dominated by the "down"/"up" quark charge squared, and the final state interactions could become weaker. The goal of the experiment is to determine whether these effects are observed in the $\gamma n \rightarrow \pi^- p$ reaction at high photon energies.

$\gamma n \rightarrow \pi^- p$ photo-pion production is not well studied in the past because of the lack of a neutron target. The proposed experiment will study this fundamental process using a deuteron target and bremsstrahlung photon beam. Coincidence measurements will be performed for quasifree kinematics. The experiment will cover a broad range of photon energies: from the nucleon resonance region to the expected constituent counting rule region. For the photo-pion production processes, previous data on $\gamma p \rightarrow \pi^+ n$ indicate counting rule behavior for photon energies above 2 GeV. However, it is not clear whether $\gamma p \rightarrow \pi^0 p$ reaction follows the same counting rule behavior because large discrepancies exist between different measurements. We plan to establish whether the constituent counting rule applies to the $\gamma n \rightarrow \pi^- p$ reaction.

Photo-pion production cross section ratio π^-/π^+ is another interesting quantity one would like to study. In the limit of small momentum transfer in which sea quark contribution dominates, the qaive quark model predicts that this ratio should be one. In the limit of high energy and large momentum transfer where valence quark contribution dominates, the quark model predict a quarter for this ratio. Data from Drell-Yan experiment on the muon pair production cross section ratio from a π^+ beam to that of π^- beam on an iso-scalar nuclear target ^{12}C, suggest the trend as predicted by the quark model. Nevertheless, the errors are too large to confirm the quark model predictions. Previous data on the photo-pion production ratio cover a very small momentum transfer region. We propose to extend the previous momentum transfer region by a factor of six to test the quark model predictions.

The photo-pion production process is one of the few fundamental reactions that can be used to study the final state interactions of hadrons with nucleons in nuclei. Nuclear transparency, a measure of final state interactions of hadrons with nucleons inside the nucleus, for the photo-pion production reaction has never been studied experimentally. ^4He is one of the few nuclei where exact calculations for the transparency can be performed. We propose to measure the nuclear transparency by performing quasifree exclusive $n(\gamma, \pi^-)p$ reaction in ^2H, ^4He, and ^{12}C. With good understanding of the energy dependence and the A-dependence of the nuclear transparency for the $\gamma n \rightarrow \pi^- p$ process in the 'low' energy region (1.2 - 6.0 GeV), ultimately, this reaction might be attractive for searching more exotic effects, such as color transparency.