

## E12-09-002

### Charge Symmetry Violating Quark Distributions via Precise Measurement of $\pi^+/\pi^-$ Ratios in Semi-inclusive Deep Inelastic Scattering.

Spokespersons: D. Dutta, D. Gaskell and K. Hafidi (contact person)

Principles of symmetry play a vital role in physics, they lead to conservation laws, help determine the allowable laws of nature and serve as guiding principles in search of unification of the laws of physics. The breaking of these symmetries are even more consequential and lead to the observed structure of the Universe. Charge symmetry is one such symmetry principle, under this symmetry, if one were to convert the up quarks in a proton into down quarks (the proton has two up quarks and a down quark) and the down quarks into up, thereby turning the proton into a neutrons (two down quarks and an up quark), the interaction between the quarks remains unchanged. At the quark level charge symmetry is broken because of the significant difference between the mass of up and down quarks. But, the symmetry breaking at the quark level is hidden in nuclei (the mass of the proton and neutron is almost equal). In fact charge symmetry has been routinely assumed to hold for distributions of quarks in protons and neutrons. Describing exactly how this comes about in terms of the accepted theory of the strong force (the force that holds atomic nuclei together), is an excellent test of the theory. But, before we can start to describe how the charge symmetry breaking at the quark level gets hidden in nuclei, we must know exactly how well charge symmetry is respected for quarks inside protons and neutrons. However, charge symmetry has never been rigorously tested, and it has been shown that the uncertainty in the existing experimental data allows for a significant violation of charge symmetry.

We have designed a new experiment that will scatter electrons from a deuterium target (the deuterium nucleus consists of a proton and a neutron bound together) and simultaneously detect the scattered electron and pions that are knocked out of the protons and neutrons. The existing HMS and new SHMS spectrometers in experimental Hall C will be used for this high precision experiment. Detecting pions simultaneously with the scattered electrons tags the type of quark which was struck inside the target nucleus. When a positive pion is detected it implies an up quark was struck while a negative pion indicates that a down quark was struck. The experiment will perform a series of precision measurements alternating between detecting positive and negative pions. These measurements will be used to form a particular ratio of positive to negative pions detected, the exact value of which is very sensitive to the amount of charge symmetry breaking. Thus, this experiment will be the first rigorous measurement of the amount of charge symmetry breaking in the quark distributions inside protons and neutrons. The experiment will allow detailed checks on the theory of the strong force and may also help resolve a long-standing anomalous measurement from neutrino scattering experiments.