Hall-B CLAS12 Run Group K - Summary

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CLAS12 Run Group K comprises three experiments, each addressing a complementary aspect of "Color Confinement and Strong QCD":

- Establishing the nucleon excitation spectrum with emphasis on the high mass region and gluonic excitations;
- Quantifying the role of the active degrees of freedom in the nucleon spectrum and their evolution with distance scale;
- Making inroads towards understanding the confinement of light quarks, gluons, and the meson cloud, their emergence from the confinement regime, and the role they have in providing dynamical stability of the nucleon.

A brief summary of each experiment is given below.

E12-16-010 – Search for Hybrid Baryons in Hall B with CLAS12

This experiment will search for new excited baryon states in the mass range from 1.8 GeV to 3 GeV, as well as to explore for the first time the behavior of resonance electrocouplings over the full spectrum of excited proton states at photon virtualities Q^2 approaching the photon point ($Q^2 < 0.2$ GeV^2). The experiment focuses on measuring K^+Y and $\pi^+\pi^-p$ exclusive final states in CLAS12 and detecting the scattered electrons in the angular range from 2.5° to 35°, using the electron detection capabilities of the Forward Tagger and the CLAS12 detector. The main aspect of this experiment is to search for new hybrid baryon states with the glue as an extra constituent beyond the three constituent quarks by focusing on measurements at $Q^2 < 1.0$ GeV^2 where the expected magnitudes of the hybrid electroexcitation amplitudes are maximal. Hybrid baryons may be identified as additional states in the N* spectrum beyond the regular three-quark states. Since spin-parities of hybrid baryons are expected to be the same as those for regular three-quark states, the hybrid-baryon signatures will emerge from the distinctively different low Q^2-evolution of their electrocouplings due to the additional gluonic component in their wave function. The study of the spectrum and structure of excited nucleon states at distance scales from low to high Q^2, encompassing the regime where low-energy meson-baryon degrees of freedom dominate to the regime where quark degrees of freedom dominate, creates new opportunities to better understand how the strong interaction of dressed quarks and gluons gives rise to the spectrum and structure of excited nucleon states and how these states emerge from QCD.

E12-16-010A - Nucleon Resonance Structure Studies Via Exclusive KY Electroproduction at 6.6 GeV and 8.8 GeV

The goal of this experiment is to study the spectrum and structure of high-lying nucleon excited states that couple to the $K^+\Lambda$ and $K^+\Sigma^0$ channels in the range of W from 1.6 GeV to 3.0 GeV over the full center-of-mass angular range of the K^+, spanning the intermediate range of Q^2 from 2 GeV^2 to 7 GeV^2. The data will be used to extract differential cross sections, separated structure functions, and recoil and beam-recoil polarization observables in bins of Q^2, W, and cos θ_K^*. These observables will be used to verify the findings of new N* states in the mass range below 2.1 GeV recently seen through $K^+\Lambda$ photoproduction data and then to search for new N* states in the mass range up to 3 GeV. These data will also be used to study the structure of the N* states that couple to KY by extracting the resonance transition form factors as a function of Q^2. These results are needed to provide an independent determination of these amplitudes compared to analysis of the $N\pi\pi$ channel. These form factors will allow for detailed studies of the emergence of the meson-baryon cloud from the core of confined quarks and gluons. In addition, these data will allow access to di-quark correlations to quantify their affect on the structure of different N* in a Q^2 domain where their contributions are expected to be maximal. Together with the data from the approved N* experiments that will take data at 11 GeV and which cover a range of Q^2 from 5 GeV^2 to 12 GeV^2, these data will allow for the exploration of the active degrees of freedom in excited nucleon states from meson-baryon dressing to dressed quark contributions, and to learn how the strong interaction creates di-quark correlations in various N* states starting from the QCD Lagrangian.

E12-16-010B - Deeply Virtual Compton Scattering with CLAS12 at 6.6 GeV and 8.8 GeV
Generalized Parton Distributions (GPDs) are physical observables that can provide deep insight into the internal structure of the nucleon. Deeply Virtual Compton Scattering (DVCS) is the cleanest process to access GPDs. This experiment will measure the DVCS process at 6.6 GeV and at 8.8 GeV, which together with the already approved DVCS experiment at 11 GeV, will allow comprehensive studies of this process. The high precision of the DVCS experiment over a large kinematical coverage accessible with low beam energies will have a significant impact on the GPD extraction, which is a much more demanding task than the extraction of PDFs or FFs due to their complex functional structure. Measurement at three beam energies 6.6 GeV, 8.8 GeV, and 11 GeV allow us to access the azimuthal, energy and helicity dependences of the cross sections in order to separate the interference and pure DVCS squared amplitude contributions to each of the Fourier moments of the cross section. For each term, its Q^2 dependence will be measured independently, which will allow the extraction of the D-term as a subtraction constant in the dispersion relation between the imaginary and real parts of the amplitude. The D-term is the least well-known part of those amplitudes, and it contains new physical insights that could shed light on the mechanism for confinement. At the same time, the exclusive π^0 electroproduction cross section will be also measured, separating the longitudinal and transverse contributions. The DVCS experiment will run with the standard configuration of CLAS12, requiring detection of all three particles in the final state, the electron in the forward detector, the photon in either the Forward Tagger calorimeter or the forward calorimeters (PCAL and EC) of CLAS12 and finally the proton in the central detector.