PR12-20-011: *Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule*

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This is a proposal to measure the polarized, total photoproduction cross sections on the nucleon (p and n) with the GlueX detector. In inclusive photon nucleon scattering there are two independent spin states, corresponding to the parallel and antiparallel orientation of the photon and nucleon spins. Using the optical theorem these can be related to the imaginary part of the (polarized) forward Compton amplitude. Furthermore the Cauchy dispersion relation for the Compton amplitude relates the integral over the energy of the difference in the two cross sections to the nucleon pole contribution, which is proportional to its anomalous magnetic moment. This is the GDH sum rule.

Measuring the cross-section difference at photon energies of up to 12GeV probes the high energy tail of the integrand in the GDH sum rule. This has important implications. The high energy behavior of the integrand is constrained by Regge theory but because of lack of data it has never been confronted with phenomenology, e.g. the expected dominance of the isovector, a and isoscalar, f Regge pole trajectories. The rate of convergence of the integrand determines validity of the sum rule. Microscopically it is related to the (non)existence of localized interactions of photons with quarks aka fixed Regge poles. Thus, since the vacuum pole does not contribute to the polarized cross section difference, its measurement becomes a sensitive probe of the nature of the short-range photon interactions with the nucleon.

The existing data is limited to photon energy $\sim$ 3GeV (MAMI, ELSA, GRAAL, CLAS6) which is not sufficient to determine the asymptotic behavior of the GDH integrand. There was an experiment planed at SLAC, but the program was closed before it had a chance to run. There is data from electroproduction at low-Q^2, including a measurement at Hall-A, which shows that i) there are potently large energy variations of the GDH integrand, especially for the neutron (see Fig. 3 in the proposal) ii) nontrivial Q^2 extrapolation from electro-production (Ref.[22]). This measurement therefore impacts the on the understanding of the quasi-real electro-production as well.

Hall D, is uniquely positioned to make this measurement. The GlueX collaboration has already published several analyses (e.g of single meson photoproduction beam asymmetries), which demonstrate the high performance of the detector and the quality of the photon beam. The GHD experiment requires a polarized target which will be a welcomed addition for the future GlueX physics program. Other elements of the experimental setup appear to be standard. The collaboration has also tools for measuring backgrounds from electromagnetic processes, e,g. the Bethe-Heitler production and to verify that the acceptance and efficiency are well understood.

The proposal has been endorsed by the GlueX collaboration.

The Hall D measurement is expected to extend by a factor of 4 and 7 for proton and neutron, respectively the range of the integrand in the GDH sum rule. This an important measurement with impact on nuclear and particle physics.