Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

INFN Istituto Nazionale di Fisica Nucleare

Dear Jan and Tom,

We are working on a proposal to investigate the existence of hybrid baryons from their electroexcitation off the nucleon at low Q^2 with Clas12 at Jlab. The idea follows from:

- the recent prediction of lattice QCD calculations of the existence of low energy hybrid states, in the positive parity baryon excitation spectrum see Figure 1 [1].

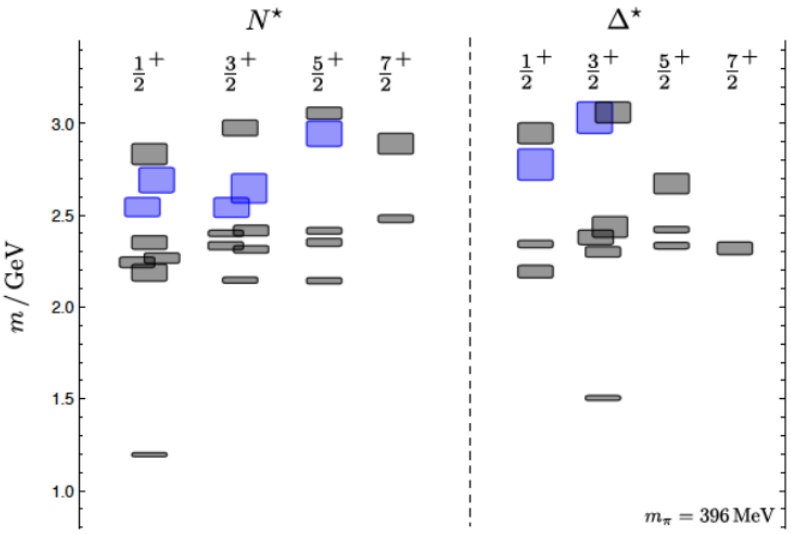

Figure 1: Mass and spin-parity projections of hybrid baryons (blue boxes) from Lattice QCD.

This idea initiates the development of proposal on hybrid baryon search with the CLAS12 [2].

- the observation that the study of the Q^2 evolution of the transition form factors has provided a clear indications on the nature of the Roper resonance. For example, the electrocoupling $S_{1/2}$ was predicted to be compatible with zero in the case of a hybrid baryon state (see Figure 2) [3,4]

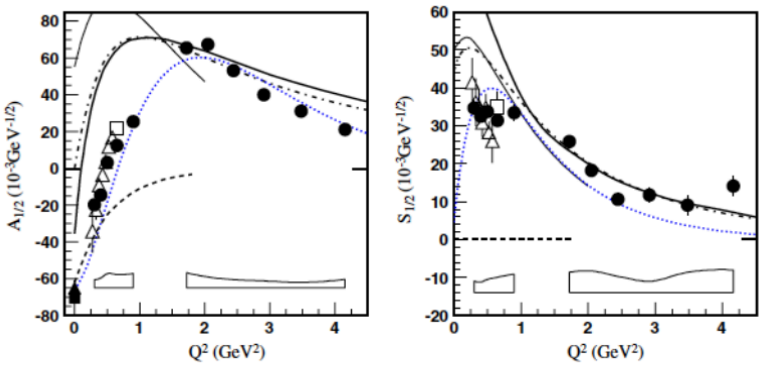

Figure 2: Transition amplitudes for the Roper resonance N(1440). The thick dashed lines are projections for the Roper as a hybrid baryon

The hybrid baryons are predicted to have the same quantum numbers of the N* resonances, contrary to what happens with hybrid mesons, where states that are not compatible with q-qbar quantum numbers may be identified. Hybrid baryon can be identified as extra state in the N* spectrum with distinctive behavior of its electrocouplings as function of Q^2 and characteristic pattern of hadronic decay. These particular features are still the subject of studies by Jlab LQCD group and within the framework of quark model under development by S.Capstick [5].

Based on available knowledge, the signature for hybrid baryons would consist of :

- extra resonances with masses from 1.8 GeV to 2.5 GeV, spin-parities shown in Fig. 1 and decays to $N\pi\pi$, KY final states;
- a drop of the transverse helicity amplitudes $A_{1/2}(Q^2)$ and $A_{3/2}(Q^2)$ faster than for three quark state because of extra glue-component in valence structure ;
- a suppressed longitudinal amplitude $S_{1/2}(Q^2)$ in comparison with transverse electroexcitation amplitude for the states withy $J^+=1/2^+$.

We are planning to start the search for hybrid baryons in exclusive $N\pi\pi$ and KY electroproduction off protons at photon virtualities Q^2 from 0.05 to 0.5 GeV^2 and at invariant masses of the final hadron system 1.8 GeV<W<2.5 GeV.

For the success of the proposal it is crucial to provide strong evidence that expected data quality from the CLAS12 detector will allow us to observe a signals from candidates for hybrid baryon states under realistic conditions of experimental measurements including luminosity, efficiency, resolution, as well as accounting for the non-resonant mechanisms and regular three-quark N* state contributions to the aforementioned exclusive channels.
We appreciate your help in achieving these objectives from analyses of KY exclusive electroproduction channels and looking for your contribution to our activity. As the starting point, we want to propose the following plan:

- Develop realistic event generator (EG) for $K^+\Lambda$ and $K^+\Sigma^0$ exclusive electroproduction channels at Q^2 from 0.05 to 0.5 GeV^2 and W from threshold up to 2.8 GeV based on the most advanced version of your model for KY electroproduction.
  For the development of this EG by hybrid-baryon collaboration we need from you the computer code or look-up table with differential cross sections and all polarization asymmetries estimated within the framework of your models in the aforementioned kinematics area. These observables should be evaluated
  a) with regular ingredients of your models on resonance and non-resonance contributions;
  b) with regular contributions of your models plus contribution from hybrid baryon state with parameters provided by our collaboration.

- Employing KY EG, the hybrid baryon collaboration will provide quasi-data in terms of KY event distributions measured with the CLAS12 detector accounting for all detector features as efficiency, acceptance, resolution, as well as for expected luminosity. These quasi-data will be used for development and checks of the experimental procedures for the extraction of differential cross section and polarisation asymmetries from KY event distributions measured in experiment. We may then provide your group with the

differential KY cross sections and polarization asymmetries determined from quasi-data simulated starting from the EG based on your models.

- We finally ask to your group to determine spin-parity, electrocouplings and hadronic decay parameters of the hybrid state, which was implemented into your model, from the KY differential cross section and polarization asymmetries reconstructed from quasi-data.

Consistent results between the hybrid state parameters derived from quasi-data and implemented to the model for EG will offer a sound evidence on capability of the CLAS12 detector to provide the data of quality which is sufficient for identification of candidate hybrid state(s).

We appreciate your opinion on the proposed plan and further suggestions on possible involvement of your group to the search for hybrid baryon state search with the CLAS12 detector after JLAB 12 GeV Upgrade.

References

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Sincerely
Viktor Mokeev and Annalisa D'Angelo for the Hybrid Baryon collaboration.