Date: June 1, 2020

For Proposal for JLab PAC48

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Cover Letter for KLF Proposal Submission to PAC48

This Proposal follows the Letter-of-Intent LoI12–15–001 and Proposals PR12–17–001, PR12–18–002, and C2–19–01 presented to PAC43, PAC45, PAC46, and PAC47, respectively. The Issues and Recommendations included in the PAC47 Final Report document read as follow:

Motivation: *The spectroscopy of strange baryons and mesons, including their fundamental strong interactions, is the focus of this proposal. New and unique data can be obtained with an intense K_L beam aimed at a hydrogen/deuterium target, using the GlueX apparatus to detect final state particles.*

Measurement and Feasibility: *The most significant technical aspect of this proposal is the addition of a Compact Photon Source (CPS) in the beamline leading into Hall D, which will have significant attendant cost and will impose an estimated six months changeover time for alternate running of GlueX. It is also important to be sure that GlueX can handle the background rates from neutrons and other beam-induced contaminants. It seems quite feasible that the GlueX detector can manage to detect the final state particles with enough particle discrimination to meet the spectroscopy needs.*

Issues: *Several points of discussion concerned the PAC.*
A) the missing mass technique to replace the direct proton detection at very low values of |t| was only presented in the open session and the details of the underlying simulations should be clarified;
B) a realistic simulation including beam backgrounds is to be presented with details to be spelled out and documented thoroughly;
C) A realistic project management plan needs to be developed to realize the experiment;
D) The analysis and extraction of key physics parameters requires theory guidance, which is now included within the group of proposing authors and makes use of JPAC. This facility will add a new physics reach to JLab, and the PAC is looking forward to see the idea being materialized, in conjunction with the plans for Hall D as spelled out in the white paper provided to us.

Summary: *The collaboration should return to the PAC with a well documented proposal. Simulations addressing backgrounds and the low |t| region are necessary. Also, a well-formed plan is needed to build the beamline and prepare for data taking with GlueX.*

The KLF Collaboration believes that the current proposal addresses all the concerns expressed by the PAC47, and have followed their recommendations as discussed below:

Q1: *The most significant technical aspect of this proposal is the addition of a Compact Photon Source (CPS) in the beamline leading into Hall D, which will have significant attendant cost.*

A1: Recently, a conceptual design study of a CPS for JLab was published in Nucl. Instrum. Meth. A **957**, 163429 (2020) by D. Day, P. Degtiarenko, S. Dobbs, R. Ent, D.J. Hamilton, T. Horn, D. Keller, C. Keppel, G. Niculescu, P. Reid, I. Strakovsky, B. Wojtsekhowski, and J. Zhang. This design is being optimized for the KLF project and initial studies indicate that no major obstacles to adapting this design exist. Similarly, a conceptual design of beryllium target for the KLF project was presented in arXiv:2002.04442 [physics.ins-det] by I. Strakovsky, M. Amaryan, M. Bashkanov, W. J. Briscoe, E. Chudakov, P. Degtyarenko, S. Dobbs, A. Laptev, I. Larin, A. Somov, and T. Whitlatch. In particular, the optimization of the KPT resulted in the weight of the device of 12 t and the estimated cost of $0.134M (note that the final total cost depends on the cost of tungsten).

Q2: *It is also important to be sure that GlueX can handle the background rates from neutrons and other beam-induced contaminants.*

A2: We have performed additional beam background studies to those described in our previous proposal, and find that the contribution to the reconstructed reactions under investigation is negligible, and that the contributions due to radiation damage are well within the expected tolerance of the detector components.

Q3: *It seems quite feasible that the GlueX detector can manage to detect the final state particles with enough particle discrimination to meet the spectroscopy needs.*

A3: In addition to the detailed simulation studies presented in our previous proposal, we have performed additional studies to prove that the GlueX detector can reconstruct the final state particles at a level sufficient to meet out hadron spectroscopy needs (see KLF Analysis Reports at https://wiki.jlab.org/klproject/index.php/PAC48).

Q4: *The missing mass technique to replace the direct proton detection at very low values of |t| was only presented in the open session and the details of the underlying simulations should be clarified.*

A4: Since the last PAC, in order to better cover the region of lowest |t| that is most important for the proposed Kpi measurements, we performed additional studies of two reactions in which the recoil particle is Δ^{++}, with have different Clebsch-Gordan linear combinations of S-wave isospin 1/2 and 3/2 amplitudes. Measuring both reactions allows us to disentangle the contribution from each isospin amplitude. In addition, the detectable |t| range at KLF for these reactions goes down to the t_{min} threshold.

Q5: *A realistic simulation including beam backgrounds is to be presented with details to be spelled out and documented thoroughly.*

A5: A large set of reactions was simulated and reconstructed using GlueX GEANT simulations and analysis software both on proton and neutron (deuteron quasi-free) targets (Sec. 4.3 and Ref. [25]). Some of the reactions were further analyzed theoretically utilizing partial wave analysis (Appendix A3). Possible backgrounds were studied thoroughly through similar simulations. An outcome of these studies is the

following: photon induced background is tiny (less than 4 photoproduction reaction per second); neutron induced background is small – 94% of neutron flux does not contribute to production reactions, only 1% of neutron flux can lead to strangeness production – and the exclusivity requirement suppresses neutron induced background below the per-mill level for all reactions of interest. Therefore, neutron background suppression at trigger level is unnecessary (Sec. 4.3 and references within).

The flux of secondary photons is not sufficient to provide any significant background in the case of γp or γd interactions in the cryogenic target (Sec. 5.2).

Q6: *A realistic project management plan needs to be developed to realize the experiment. / A well-formed plan is needed to build the beamline and prepare for data taking with GlueX.*

A6: We have added a section in the proposal to outline the subgroups working on this project and present a proposed timeline for how the beamline equipment can be designed, constructed, and installed. The KLF Collaboration represents a growing community from a wide variety of backgrounds, and we are committed to working with JLab management to realize this experiment.

Q7: *The analysis and extraction of key physics parameters requires theory guidance, which is now included within the group of proposing authors and makes use of JPAC. This facility will add a new physics reach to JLab, and the PAC is looking forward to see the idea being materialized, in conjunction with the plans for Hall D as spelled out in the white paper provided to us.*

A7: We are pleased that the PAC recognizes the exciting physics opportunities provided by the KLF project, and we will continue to work closely with our theoretical colleagues to further build the capability to interpret the unique data set that this experiment will collect.