

**Date:** June 1, 2018

## For Proposal for JLab PAC46

### *Strange Hadron Spectroscopy with Secondary $K_L$ Beam at GlueX*

## Cover Letter for KLF Proposal Submission to PAC46

This Proposal follows the Proposal PR12–17–001, *Strange Hadron Spectroscopy with a Secondary  $K_L$  beam at GlueX* presented to PAC45 in 2017. The Issues and Recommendations included in the PAC45 Final Report document read as follow:

**Issues:** *Mounting this experiment will transform the existing Hall D beamline, so it represents an almost irreversible change in direction for the GlueX apparatus. As such, the physics driver must be compelling, and the PAC doesn't feel that a sufficiently convincing physics case has been made. A broad program is suggested, so the PAC would welcome a larger presentation format along the lines of a run group proposal.*

*The CPS design is progressing but details on the KL target and shielding for the detector need to be fleshed out. The 64 ns beam structure will also require study to ensure that other halls are not adversely affected.*

*The beam time request is dominated by the hyperon polarimetry measurements. A simulated example of a PWA, and how it would feed into the proposed spectroscopy measurements, will be needed in a future proposal.*

*The LOI included doubly strange baryons but this topic was not much expanded upon in the proposal. This topic remains of considerable interest.*

**To summarize:** *This experiment would introduce a new and interesting area of physics at JLAB. The PAC recommends that the Collaboration work with the lattice and theoretical nuclear physics community to sharpen the physics case. In addition, more details on the KL production target and shielding will be needed before we can fully assess the feasibility of the experiment. Despite the progress made in delineating the expanded physics possibilities, the very substantial beam time request would be better motivated if more details could be provided on its impact on the proposed spectroscopic measurements.*

The KLF Collaboration for the GlueX Collaboration believes that the current proposal addresses all the concerns following the recommendations expressed by the PAC45:

1. **Q1:** *Mounting this experiment will transform the existing Hall D beamline, so it represents an almost irreversible change in direction for the GlueX apparatus.*

**A1:** Changeover from the photon to the KL beamline and from the KL to the photon beamline requires further evaluation. However, initial conservative estimates are that this changeover could be completed approximately in 6 months. Therefore, the majority of this changeover could be completed during a typical summer shutdown period in the CEBAF accelerator schedule.

2. **Q2:** *As such, the physics driver must be compelling, and the PAC doesn't feel that a sufficiently convincing physics case has been made. A broad program is suggested, so the PAC would welcome a larger presentation format along the lines of a run group proposal.*

**A2:** The KL facility addresses a broad range of outstanding problems related to strange hadron spectroscopy, and in the current proposal we focus on studies of double-strange  $\Xi$  baryons and  $K\pi$  scattering with regards to the  $\kappa$  meson. We agreed with the PAC45 and JLab management suggestion for a larger presentation format, and we plan to have three presentations at the PAC46 meeting:

- (a)  $K_L$  Beam Facility at GlueX;
- (b) Hyperon Spectroscopy with a  $K_L$  Beam;
- (c) Strange Mesons with a  $K_L$  Beam.

3. **Q3:** *The CPS design is progressing but details on the KL target and shielding for the detector need to be fleshed out.*

**A3:** Following the PAC45 suggestion, we improve the conceptual design for both the CPS (Sec. 10.1.2) and the Be-target ( $K_L$  production target) (Sec. 10.1.3):

- (a) The recent HIPS2017 Workshop [ <https://www.jlab.org/conferences/HIPS2017/> ] aimed at producing an optimized photon source concept with potential increase of scientific output at Jefferson Lab, and at refining the science for hadron physics experiments that will benefit from a high-intensity photon source. The JLab CPS Collaboration Working Group has considered the CPS case for Halls C/A in detail. The high intensity photon beam will be produced by this Working Group, very similar to the one designed by the JLab CPS group for Halls C/A.
  - i. The CPS will be located downstream of the tagger magnet. The tagger alcove has more space than that available in Halls C/A, so positioning and shielding placement are simplified.
  - ii. A 30 kW CPS has been designed for Halls C/A. The CPS Collaboration Working Group intends to provide the design for a 60 kW device for Hall D. For Hall D, the dose rates in the vault during full 60 kW beam operations are comparable to the nominal running conditions in the vault.
  - iii. The beam power can reach 60 kW (the beam current less than  $5 \mu\text{A}$  at 12 GeV). The ceiling shielding of the Tagger hall above the CPS position is the same as it is above the existing 60 kW dump. No radiation increase at the site boundary is expected with respect to 60 kW operations using the existing dump.
  - iv. The floor in the area can hold a 100 t CPS.
  - v. Different length/field magnet. Shielding may differ.

- vi. Hall D would require implementation of the rastering system in the beam line leading to the vault, that should be optimized.
- (b) The Be-target assembly will be located downstream at the beginning of the collimator cave. Our MC studies show that the Be-target assembly conceptual design satisfies the RadCon requirement establishing the radiation dose rate limit in the experimental hall. The full engineering design is pending the proposal approval. Modifications of the beamline from the beginning of the collimator cave to the cryogenic target, which includes the Be-target assembly, the shielding, etc. The Scenario is to use smaller pieces of shielding and keeping (but moving) the current sweep magnet and not removing Pair Spectrometer magnet. Everything else is removed from the collimator enclosure and the upstream platform.
4. **Q4:** *The 64 ns beam structure will also require study to ensure that other halls are not adversely affected.*  
**A4:** According to our discussions with accelerator experts (Geoff Krafft, Matt Poelker, Todd Satogata, Jay Benisch, Reza Kazimi, and Joe Grames) following the iTAC Report for PAC45, it has been explicitly stated that no problems are expected for a 64 ns beam structure from the beam delivery point of view. Todd is a member of our team and Section 10.1.1 of the proposal addresses this task. The beamline delivery system for the secondary  $K_L$  beam will require modest investment for a pulse picking system and a laser amplifier.
5. **Q5:** *A simulated example of a partial wave analysis, and how it would feed into the proposed spectroscopy measurements, will be needed in a future proposal.*  
**A5:** We generated quasi-data for a PWA model of non-strange baryon spectroscopy in the  $\pi^+p$  system to demonstrate the impact of the proposed KLF data on observed spectrum of  $\Lambda$  and  $\Sigma$  hyperons. These studies are discussed in Section 11.2.5 and will be presented during PAC46.
6. **Q6:** *The LOI included doubly strange baryons but this topic was not much expanded upon in the proposal. This topic remains of considerable interest.*  
**A6:** We agree that the double-strange baryons (excited  $\Xi$  baryons) remain a particularly interesting topic in light of recent observations in the heavy quark sector and the connections to states in the strange sector. Therefore, we included simulations of these states and expected precision obtained in KLF in Section 11.2.3 of the proposal.
7. **Q7:** *The PAC recommends that the Collaboration work with the lattice and theoretical nuclear physics community to sharpen the physics case.*  
**A7:** We are collaborating closely with members of the lattice and theory community. In addition, we hosted a workshop on the pion-kaon interactions PKI2018 at JLab recently, dedicated to the physics of strange mesons produced by the neutral kaon beam. Many lattice and theoretical nuclear physicists are co-authors of our proposal and contributed significantly to it.
8. **Q8:** *In addition, more details on the KL production target and shielding will be needed before we can fully assess the feasibility of the experiment.*  
**A8:** A conceptual design of the Be-target and shielding is described in Section 10.1.3, and

complete calculations of the resulting neutron and gamma radiation are presented in Appendix 4.

9. **Q9:** *Despite the progress made in delineating the expanded physics possibilities, the very substantial beam time request would be better motivated if more details could be provided on its impact on the proposed spectroscopic measurements.*

**A9:** We believe that the current proposal addresses all the concerns following the recommendations expressed by the PAC45. The new data will significantly constrain PWAs and reduce model-dependent uncertainties in the extraction of the properties and pole positions of the strange hyperon resonances, and establish the orbitally excited multiplets in the spectra of the  $\Xi$  and  $\Omega$  hyperons. The experiment will settle the still open issue of the existence or non-existence of the low lying strange scalar meson  $\kappa(800)$ . All details will be presented during PAC46.

### Statistics:

1. Proposal is signed by 203 researchers from 61 institutions representing 20 countries around the world.
2. The physics scope for the KL Facility has been explored in four international workshops:  
*KL2016* [60 people from 10 countries, 30 talks] OC: M. Amaryan, E. Chudakov, C. Meyer, M. Pennington, J. Ritman, and I. Strakovsky [ <https://www.jlab.org/conferences/kl2016/> ].  
*YSTAR2016* [71 people from 11 countries, 27 talks] OC: M. Amaryan, E. Chudakov, K. Rajagopal, C. Ratti, J. Ritman, and I. Strakovsky [ <https://www.jlab.org/conferences/YSTAR2016/> ].  
*HIPS2017* [43 people from 4 countries, 19 talks] OC: T. Horn, C. Keppel, C. Munoz-Camacho, and I. Strakovsky [ <https://www.jlab.org/conferences/HIPS2017/> ].  
*PKI2018* [48 people from 9 countries, 27 talks] OC: M. Amaryan, U.-G. Meißner, C. Meyer, J. Ritman, and I. Strakovsky [ <https://www.jlab.org/conferences/pki2018/> ].