Dear Stephan,

Thank you for careful reading of the proposal. Please find below the answers to your questions and comments sent to us.

Dear colleagues

Reading through your proposal and the analysis note there are numerous questions left open. I may just present a few of them here as I go through the material. I apologize if for some questions the answer may be found in one of the many documents accompanying the updated proposal and thus might have slipped my attention.

a) Kπ S-wave:

   a. A key aspect is the extraction of the Kπ S-wave phase shifts from KLF data. However, you do not demonstrate, how this is being done. There is an explicit claim that you assume OPE for the process you study but the material is missing a convincing strategy on how to prove this. Previous experiments have used Chew-Low extrapolations (see old bubble chamber experiments in the late 60's). You must somehow discriminate against other exchange graphs possible, as could be the rho. Similar to πγ(ρ) -> ππ made possible by the chiral anomaly you could imagine Kρ -> Kπ. Chew-Low gives you the amplitudes at $t=m_\pi^2$ as required. The old bubble chamber experiments didn't have the data set to do Chew-Low cosθ dependent.

      In the proposal we wrote:

      The pion exchange contribution is expected to dominate at low |t|, and the simulation studies demonstrate the acceptance in this critical regime. However, significant theoretical modeling of the |t| dependence of the production model will be required to extract the Kπ scattering amplitudes. Systematic uncertainties due to this theoretical modeling are very difficult to estimate and thus were not taken into account in previous measurements.

      We propose to follow the procedure of LASS and Estabrooks et. al. to model the |t| dependence of the amplitudes and determine the single pion exchange contribution. We agree that tuning of the model will be required for data obtained with KLF.

   b. You point to the lower invariant mass values for Kπ, which certainly will be helpful for theory analysis and the determination of the kappa poles (how much ??),

      According to our understanding and consequent analysis of Pelaez and Rodas, by adding 7 more points below lower limit of Kπ mass measured by the LASS experiment allows to improve precision of determination of the kappa mass and the width by factor of two. This is presented in the Table 2 in Sec. 4.2.3.

and you point to smaller values of t you can obtain by not reconstructing the recoil proton. However, for the latter issue you do not tell, how you reconstruct t when you do not know either the recoil momentum nor the beam particle momentum.

Correct, we state that the smaller values of t can be obtained if we do not detect the recoil proton. However, in order to be able to reconstruct missing proton, we need to know incoming beam momentum which is measured by time-of-flight as described in Sec. 5.7 of the main proposal document. In this case, the t can be measured from the difference between four momenta of incoming K_L beam and measured final state Kπ system: $t = (p_{beam} - p_{K\pi})^2$. In addition, we determine the missing mass, where we demonstrate that up to 4.5 GeV/c of the incoming beam momentum (see Fig. 11 of the analysis note) we can reconstruct recoil proton via the missing mass technique.

Also, your analysis note is confusing as you point to plots for the resolution in t with and without recoil momentum reconstruction and one figure is just referred to as "??" and missing in the document. Thus, your arguments are hard to follow.

Yes sorry, you are right, although we tried hard, some glitches remained in the analysis note. The updated the analysis note and uploaded it to the wiki page of our proposal. The direct link can be found below:

https://wiki.jlab.org/klproject/images/b/bd/KLF_AnalysisNote_Meson-current.pdf

c. It is unclear how clean your processes depicted in fig. 1 of Moskov's analysis paper can be singled out. FSI is not considered and the energies seem marginal to separate the two hemispheres of the recoiling system and the forward scattered system. To my mind you would need much higher energies.

   Theoretical analyses of kappa, presented in Fig. 13 of our proposal, used data on phase shifts obtained with incoming kaon momenta ranging from 3 to 14.3 GeV/c at different world facilities presented in Fig.12 of the proposal. The possibility of other than OPE mechanisms to contribute is not excluded, however realistic estimate of the level of such contributions and the impact on phase-shift analysis will require additional modeling.

d. You propose various reactions to separate the isospin components for the S-wave and a key ingredient is the Delta as a recoil particle.

   Yes, this is correct. The advantage of the Δ^{++} recoil that it utilizes the well-studied charged pion exchange mechanism. The isospin separation from the KLF data requires the measurement of the reaction with the final state K_L, as described in Section 6 of the Meson Analysis Report.

e. Figure 7 of Moskov's paper: Why should the mass resolution for $K\pi$ depend on whether you reconstruct the recoil proton?

This is some misunderstanding. Fig. 7 of the analysis note has two panels, the left one is the four-momentum resolution and the right is the invariant mass resolution. We do not say anything about $K\pi$ mass resolution being dependent on whether we reconstruct the recoil proton or not, however, the $K\pi$ mass resolution depends on the $K\pi$ mass.

f. How do you calculate the missing mass without exactly knowing the beam momentum?

Please see our answer to point b.

g. Your missing mass resolution quoted for the case of the proton recoil reactions worsens with increasing momentum of the beam particles. Isn't this a problem as highest momenta are crucial to avoid the resonance regions? Here you cannot easily discriminate against Δ production.

This is absolutely true and limits our studies with recoil proton up to 4.5 GeV/c of incoming kaon momenta for the case when the recoil particle is a missing proton.

h. What do you mean by "selection efficiency" in Moskov's analysis paper?

Sorry, the terminology we used here may be not so common. By "selection efficiency" we simply mean the acceptance function, the ratio of reconstructed over generated MC events.

i. Figure 12 in this report doesn't seem to be referenced. What is the mentioned for the different outgoing particles. What is p in this context?

The description of panels is presented in the caption of Figure 12. For each final state particle in the $K_Lp \rightarrow K^-\pi^0\Delta^{++}$ reaction a histogram of the polar angle vs momentum is shown for the generated (left) and reconstructed (right) particles. Unfortunately, we didn't repeat it in the main body of the note.

j. How flat is the angular ($\cos\theta$) acceptance and does this depend on mass?

In our note in Fig. 29, there is 2d plot, cosine of GJ angle versus the invariant mass. It is quite flat in the range below 1 GeV.

k. How well can you separate S and P waves?

The separated S and P waves are shown in the proposal in Fig. 48 (right panel) for P-wave I=1/2 and Fig. 49 (right panel) for S-wave I=1/2 and I=3/2, respectively. These are based on simulations of two independent reactions with Δ^{++} in final state with different CG coefficients.

l. Why is the reconstruction efficiency for t flat in case of the $K^-\pi^0$ final state (fig. 17) as compared to the $K^-\pi^+$ (figs. 8 and 9)?

This is due to the fact that in one case we have single recoil particle, the proton, in the other case, we have two-body Δ^{++}.

m. How comes you access low values of t for reconstructing the Delta as opposed to reconstructing the recoil proton only, which gives you zero acceptance for low t (reconstructed). I am puzzled and probably I am missing something important here.

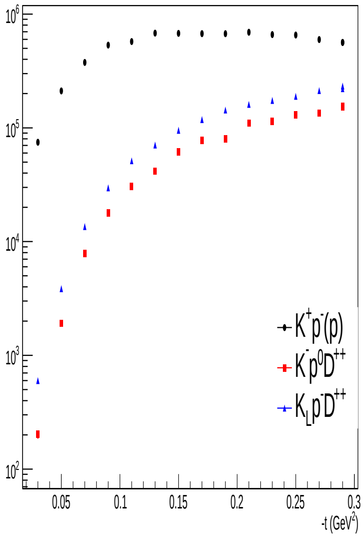
If we understood correctly the question is how it could be that with proton detected the minimal value of t is higher compared when the Delta is detected. The answer is that when the recoil particle is a proton its minimal momentum defines lowest t possible. However, when the recoil particle is Delta, the minimal value of t is defined by the momentum of Delta. Even if the Delta is produced at rest with zero momentum, the momentum of the decay proton is not zero.

n. For Fig 21: do you impose the K_L mass in the reconstruction of the invariant $K_L\pi$ mass (e.g. using a constrained fit ??)

That particular plot is done without the constrained fit. However, in the final analysis we used the constrained fit. The plot is updated in Fig. 21 of the note.

o. Do you have a plot, where you show the expected distribution of events as function of t for all three reactions?

Please find the plot you requested, statistics vs -t is s plotted for three reactions. In the channel with missing proton the upper cut on the momentum of the beam is placed to be P<4.5 GeV/c.



b) K* spectroscopy

   a. You mention the P-wave in Kπ and argue about the differences of Belle tau decays and LASS on the resonance parameters. I do not see this as an issue as the rho parameters are depending on the reaction mechanisms used for its production. Can you extract the (unique) pole positions?

      This is considered an issue by Veroniqe Bernard in her paper Ref. [75] of the proposal. In order to get consistent results from LASS and BELLE the author performed her own fit to the LASS data and obtained K* parameters that will not have a conflict with the measurement of the product of vector form factor and CKM matrix element, i.e., $f(0)_{+} V_{us}$ extracted from the tau decay. In KLF we will measure the position and the width of $K^*(K^0\pi^-)$ which is more relevant to τ^- decay, contrary to the charged Kπ final state measured by SLAC. Thus, providing independent experimental data.