Strange hadron spectroscopy with a secondary K_L beam in Hall D

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KLF proposal arXiv:2008.08215

Strange hyperon spectroscopy



* Baryon multiplets from 3 light quarks consist of many excited $N^*, \Delta^*, \Lambda^*, \Sigma^*, \Xi^*$ and Ω^* expected by the quark model

- Many "missing resonances" so far unobserved experimentally
- Lattice QCD calculations of the baryon spectrum also expect large numbers of additional states (some with gluonic DOF)

Production of hyperons

* Non-strange initial states: photoproduction, heavy flavor



* Kaon beams: direct or associated production



JLab PAC proposal K_I beam Facility: KLF arXiv:2008.08215 GlueX **Compact Pair Spectrometer** Spectrometer **Photon Source** North LINAC y beam e-beam **Be Target** Tagger Sweep Area Magnet Flux East ARC Monitor

 $5 \mu A e^-$ beam with 64 ns bunch spacing

- * New facility requires 3 major items of equipment:
 - * Compact Photon Source (CPS): high-intensity, untagged γ beam
 - * **Be target:** K_L production and significant new shielding
 - * K_L beam: angular spread requires 6 cm diameter LH₂/LD₂ target



- * Flux: ~ $10^4 K_L/s$ over broad momentum range, measured continuously through K_L decays in flight (with ~5% accuracy)
- * Beam momentum (or W) measured through TOF or exclusive final state reconstruction



Previous measurements KLF Projected



* Large acceptance of GlueX spectrometer allows for high-statistics exclusive reconstruction

KLF: PWA observables

- * Goal: coupled-channel PWA over wide W range to extract J^P and pole positions of contributing resonances
- * Requirements: large acceptance for $d\sigma/d\Omega$ and reconstruct hyperon decay for induced polarization: $I(\theta_{\pi}) \sim 1 \alpha Pcos(\theta_{\pi})$



KLF Σ^* projections

- * Generate pseudodata for $K_L p \to K^+ \Xi^0$, two Σ^* states: $\frac{5}{2}^-$ and $\frac{7}{2}^+$ with $M_{\Sigma^*} = 1.94$ GeV and $\Gamma_{\Sigma^*} = 0.35$ and 0.4
- * Projected uncertainties for $d\sigma/d\Omega$ and P, assuming 20 and 100 days of running time



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- Impact on resonance parameters obtained assuming 20 and 100 days of running time



KLF direct production summary

- * PWA of many 2-body final states to search for missing Σ^*, Λ^*
- * Proton target: pure Σ^* channels (already simulated for KLF)

*
$$K_L p \rightarrow K_s^0 p$$
,

*
$$K_L p \to \pi^+ \Lambda$$
,

- * $K_L p \rightarrow K^+ \Xi^0$, etc.
- * Neutron target: Σ^{0*}, Λ^*

*
$$K_L n \rightarrow K^+ \Xi^-$$
, etc.



Excited Ξ^* in associated production

- * Most information on Ξ^* from charged kaon beams in the 1960-80s, with little progress until very recently
- * Recent measurements from GlueX and Belle provide complementary production mechanisms



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* Expect significant cross sections based on K^-p data

★ KLF will search for Ξ* in many different exclusive final states

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Strange meson studies

- Study $K\pi$ scattering through π exchange
 - $\kappa/K^*(700)$ extracted from dispersive analysis of previous K^{\pm} beam data; predictions from Lattice QCD
- Opportunities and challenges for KLF:
 - High statistics datasets with K_L beam and modern experimental/analysis methods
 - Access to many $K\pi$ final states in both neutral and charged π exchange, however K_L detection required for isospin separation
 - Extracting of elastic $K\pi$ scattering: requires model of exchange dependence on *t* and p_{K_t}



 $\kappa/K^{*}(700)$:

20

10



KLF status and outlook

- * This proposal for a new K_L beam facility in Hall D was recently approved for 200 days by the JLab PAC
- Cross section and polarization measurements will search for new hyperons and study properties (J^P, pole positions and decay modes) of excited hyperons
- * Work on technical designs for KLF components and additional simulation studies ongoing
- * Approved Hall D photon beam program through ~2025, design allows for alternating running with $K_L \leftrightarrow \gamma$ beams

New collaborators welcome!

More information at https://wiki.jlab.org/klproject