The K_{Long} Facility in Hall D at Jefferson Lab

Future Directions in Spectroscopy Analysis 2025, Barcelona

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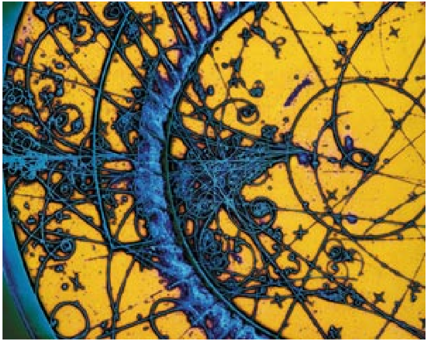
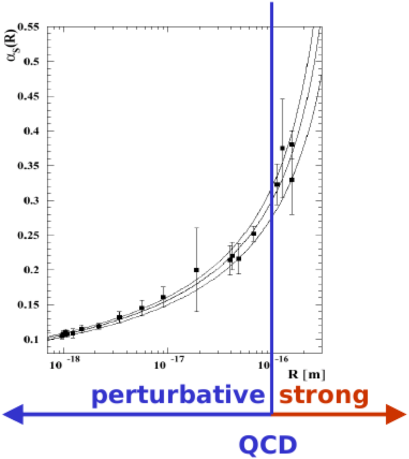
Introduction - QCD

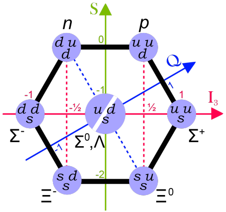
- Quantumchromodynamics - QCD - describes Strong force interactions in the Standard Model

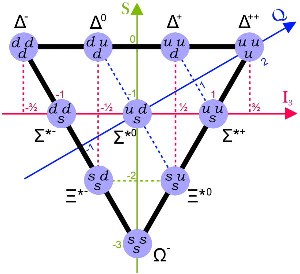


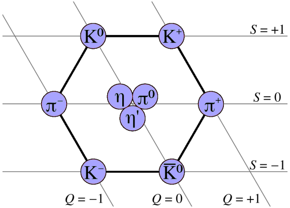


Quark Models

- Quark models play a vital role in the non-perturbative regime of QCD
- Numerous hadronic states predicted from the degrees of freedom associated with coloured quarks
- Experimental data has provided information on many of these states





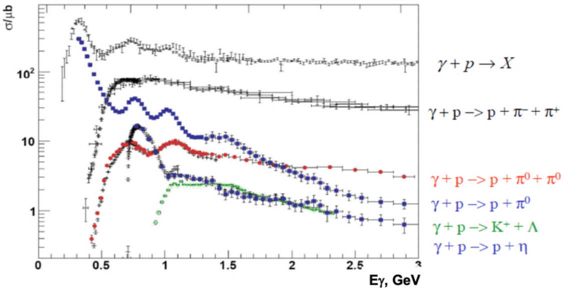


Finding Resonances

Hadron spectroscopy has two main goals:

- Precision measurements of the properties of observed states
- Searches for unseen, (un)predicted or unconventional states

Finding some states can be difficult in a simple "bump hunt"; many are wide and overlap

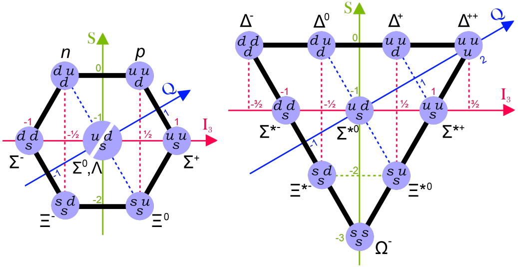


R. Beck and U. Thoma, EPJ Web Conf 134, 04003 (2017)

- Use alternative means; coupling strength to a reaction channel, manifestation in experimental observables, etc. to aid searches

Finding Resonances

Many more states predicted than observed



	Predicted	Observed
N^*	62	21
Δ^*	38	12
Λ^*	71	14
Σ^*	66	9
Ξ^*	73	6
Ω^*	36	2

R.G. Edwards et al. Phys Rev D87 (2013) 054506

This difference is even more pronounced in the Hyperons, where there is limited data

Experimental Facilities

Hadron beam facilities

Electromagnetic beam facilities

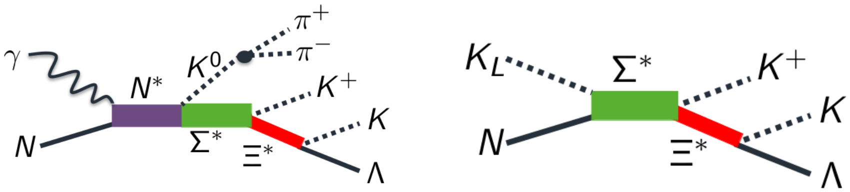
Bulk of hadron spectroscopy data from hadron beam facilities

- Dominance of πN scattering data limits sensitivity to resonances that weakly couple to this channel

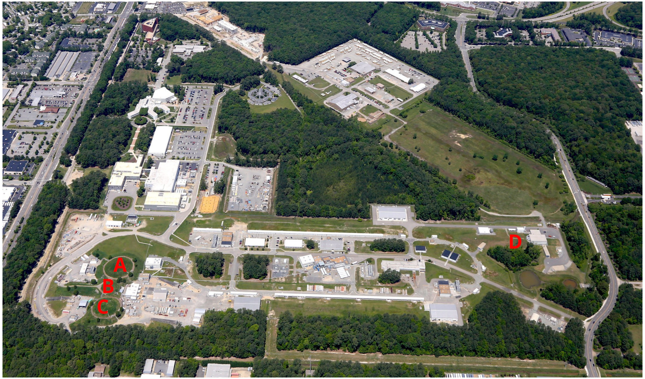
Electromagnetic beams can provide more information, but cross sections are smaller

Strange Beams

With a unit of Strangeness in the beam, producing hyperon resonances becomes much more straightforward



CEBAF

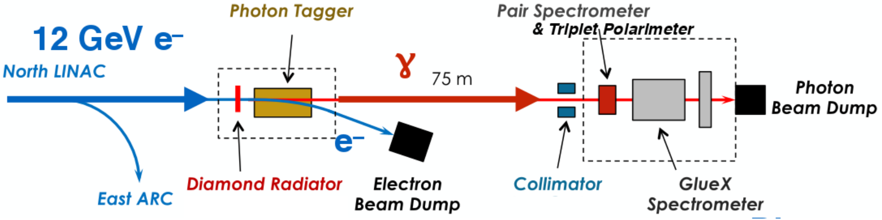


- **C**ontinuous **E**lectron **B**eam **A**ccelerator **F**acility
- Superconducting RF accelerator
- Electron beam energies up to 12 GeV
- Four experimental halls
- Secondary beams already available (real photons)

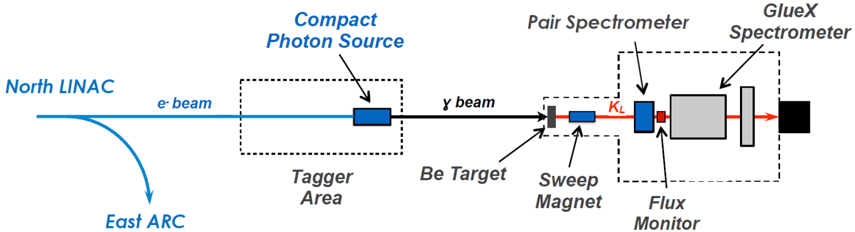
So, how do we make a strange beam?

K_{Long} Facility in Hall D

We take this:



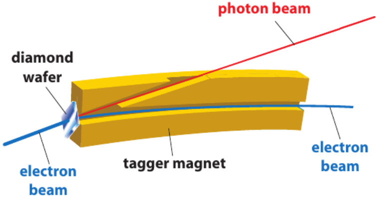
and turn it into this:



Compact Photon Source

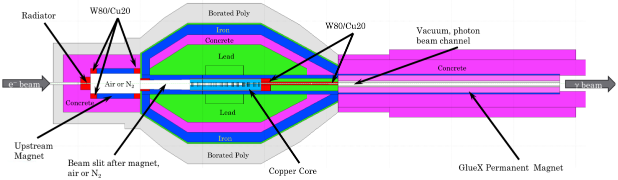
Secondary photon beam in GlueX:

- Thin radiators, minimise rescattering
- Limits photon beam intensity



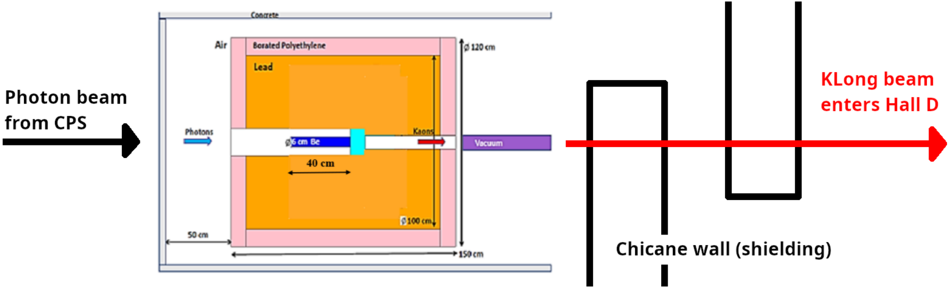
Tertiary K_{Long} beam, first produce photons from CEBAF electrons:

- Compact Photon Source - produces high intensity photon beam
- Thick radiator, heavily shielded to reduce background dose



K_{Long} Production

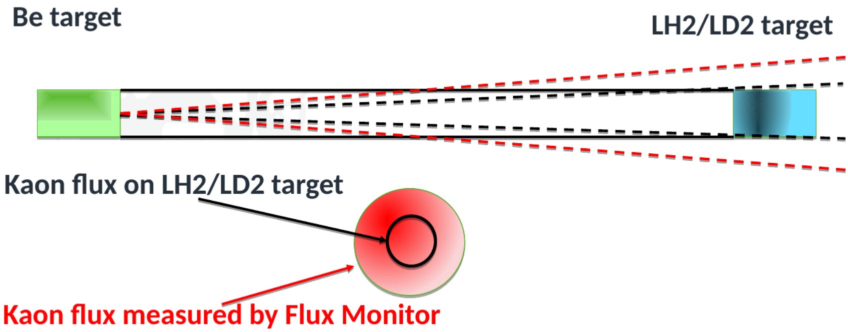
Beam from Compact Photon Source impinges on Beryllium target, producing K_{Long} beam



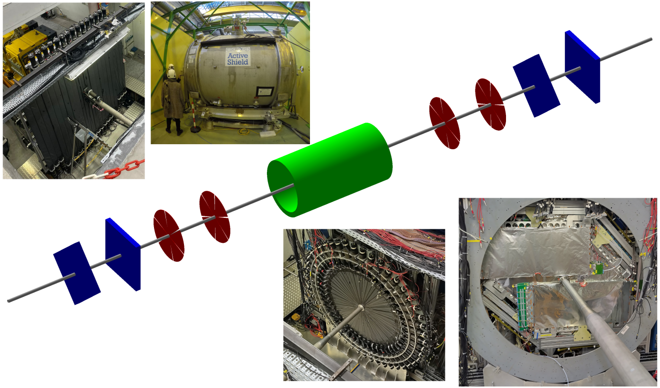
Measuring K_{Long} Flux

Flux at target can be inferred from measuring K_{Long} decays

- Install detectors to measure these in-flight K_{Long} decays - The Flux Monitor
- K_{Long} beam diverges, can be measured by careful choice of flux monitor location
- Assumes no information lost in beampipe

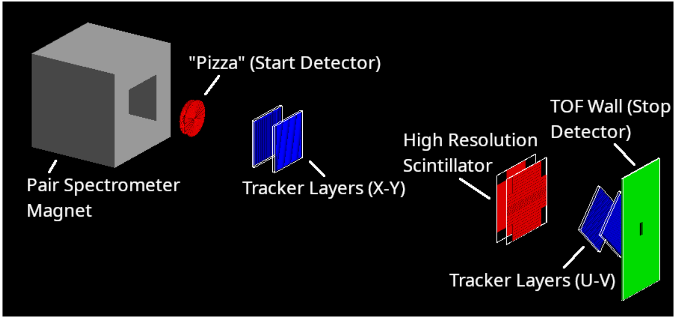


K_{Long} Flux Monitor



- Flux Monitor development led by York
- Reusing straw tube trackers and TOF components from the former WASA detector in Jeulich
- Concept allows for addition of a solenoid magnet to enhance capabilities

K_{Long} Flux Monitor



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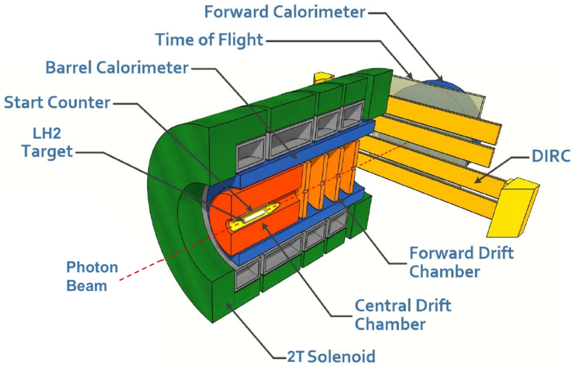
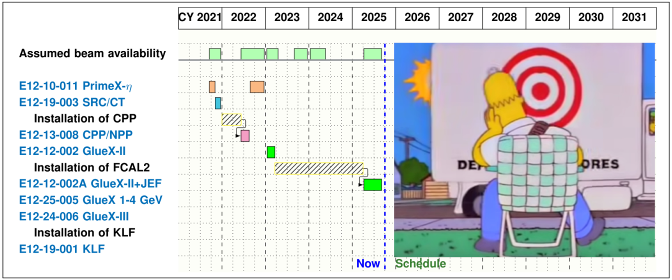
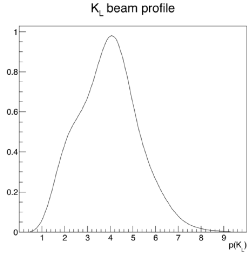
The GlueX Detector in Hall D

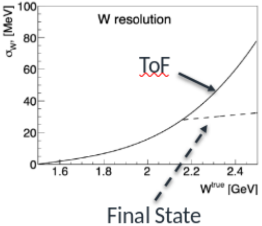


- Charged and neutral particle detection in a hermetic solenoid-based detector
- Uniform acceptance
- GlueX is a meson spectrosopy experiment, but hall and equipment used for other experiments, including KLF

Planning and Schedule



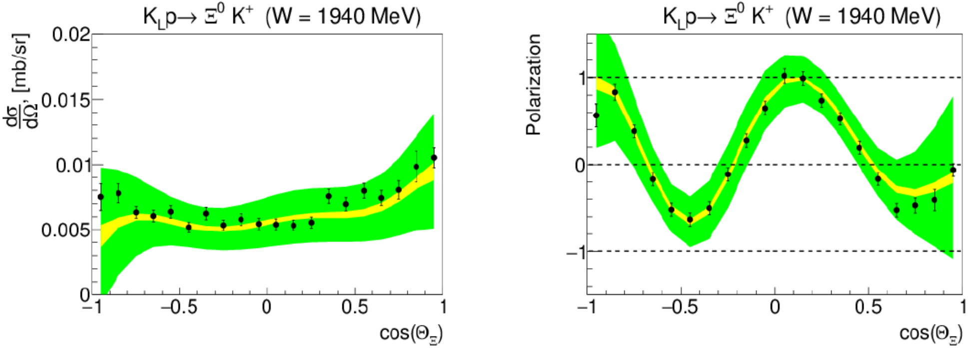




- Intense kaon beam on target
- Proton and neutron targets (100 days approved)
- Low background
- Exclusive and inclusive final states

Projected Results

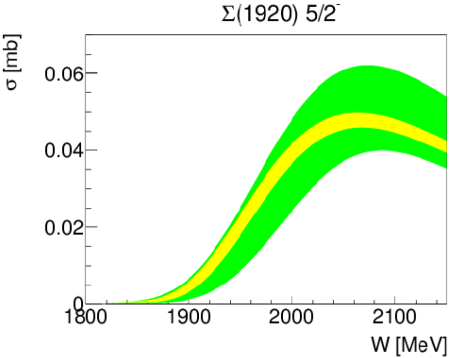
Cascade production on the proton, $K_L p \to K^+ \Xi^0$

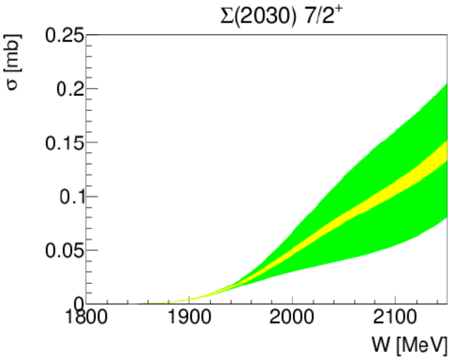


Green = 20 days running Yellow = 100 days running

Projected Results

Projected cross section error bars for Σ^* states





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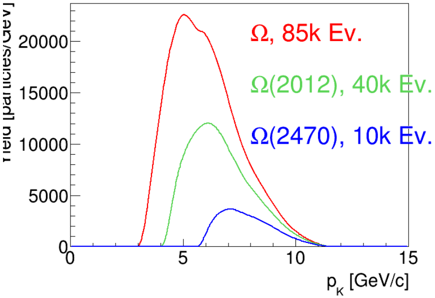
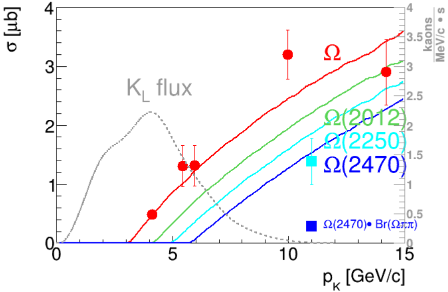
Projected Results

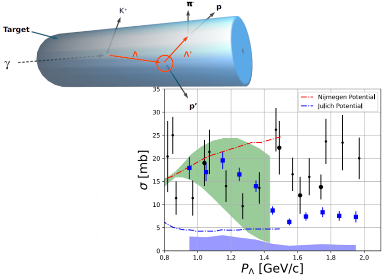
Expected Yields and Cross Sections for Ω^* states



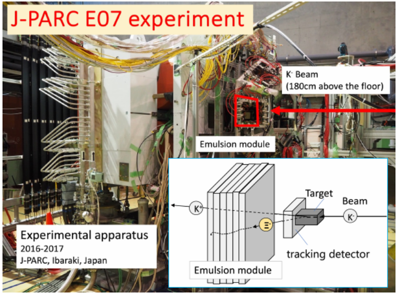


Additional Opportunities

- Hyperon-nucleon scattering
- Possible contribution to Neutron Star equation of state
- Very little existing data



J. Haidenbauer and U.-G. Meißner, Phys. Rev. C 72, 044005 (2005)
T. A. Rijken, V. G. J. Stoks, and Y. Yamamoto, Phys. Rev. C 59, 21 (1999).



- Hypernuclei detection in nuclear emulsions
- Similar set up behind GlueX in development for K_{Long}

Conclusions and Outlook

- Development of a K_{Long} beam facility is well underway at Jefferson Lab
- Makes heavy use of existing Hall D infrastructure and expertise to expand the JLab physics program
- Leveraging strangeness to greatly increase the world data on hyperon production
  - Physics observables will constrain Partial Wave Analyses and reduce model-dependent uncertainties in their interpretation
  - Enable detailed measurements of the properties of hyperon resonances
- University of York has a leading role;
  - Design and construction of the Kaon Flux Monitor
  - Simulation studies of several reactions
  - New ideas to expand the scope of the project