Λ Ratios at High ϵ From New Jefferson Lab data

Physics 499 Project
2019/2020 Session
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Protons are not fundamental particles, they are themselves formed of other particles known as quarks. Quarks within the proton interact with each other via the strong nuclear force, one of the four fundamental forces of nature. However, at the energy scales involved within the proton, these interactions are very poorly understood. Experimental measurements such as electroproduction reactions off the proton, in which an incoming high energy electron beam exchanges a virtual photon with a hydrogen target to produce various reaction products, are a vital tool for studying the internal structure of protons. A recent series of such electroproduction experiments at Jefferson Lab (JLab) have yielded a wealth of data that are yet to be analysed.

There are a wide range of physics channels that can be analysed in the data. One of the key categories of reactions involved are forward angle meson production reactions. A Feynman diagram of such a process can be seen in Figure 1. One of the possible reactions of this type is the $p(e, e'K^+)\Lambda$ reaction, in this instance the meson knocked out is the $K^+(u\bar{s})$ and the baryon produced is the $\Lambda(uds)$. However, the Λ produced does not necessarily need to be in its ground state, $\Lambda(1115)$, it is also possible to produce the Λ in different excited "resonance" states such as the $\Lambda(1405)$ and $\Lambda(1520)$. The goal of the project would be to examine the ratio of the production of these excited Λ states compared to the ground state for the data at high ϵ, the virtual photon polarisation.

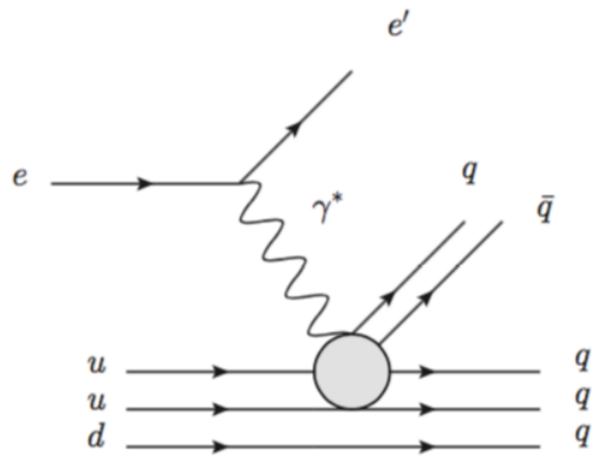

Figure 1: A generalised Feynman diagram of a forward angle meson production reaction. An incoming electron exchanges a virtual photon, γ^*, with a target proton which knocks out a meson, $q\bar{q}$, leaving behind a recoil baryon, qqq. [1]

It is expected that during the Fall semester, a student working on the project would familiarise themselves with the analysis framework and relevant software. This would likely involve the creation of short scripts or macros utilising the ROOT programming language to sort, filter and fit subsections of data from larger files. They would also be expected to read up on the relevant physics background and the experimental facility. This preparation should serve as excellent preparation to begin analysing the data in the Winter semester. Extracting the production ratio of the different Λ states would involve accurate fitting to the peaks in the missing mass spectra for numerous kinematic points. An example missing mass spectrum for detected kaon events at one particular kinematic point can be seen in Figure 2. The experimental analysis would include refining selection cuts to minimise the experimental background on these spectra and ascertaining the required fit to extract information from signal peaks. This would require a solid understanding of how the types of event we require are selected and how we can distinguish them from background events. This work would be carried out in close collaboration with other members of the research group working on a series of related projects.

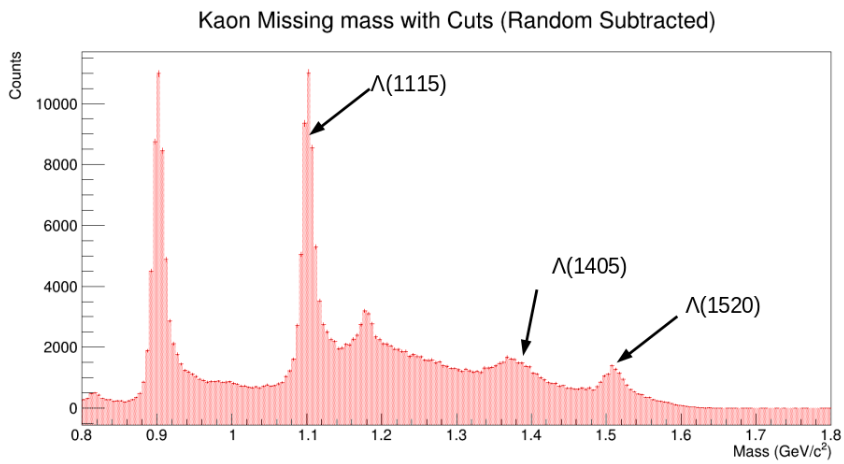

Figure 2: Missing mass spectrum for kaon events, the three Λ peaks are indicated.

[1] - M. Hladun *Simulations of Deep Exclusive* π^0, η, ρ, ω, η', ϕ *Meson Production at Jefferson Lab Hall C*, Honours thesis, University of Regina, 2018, available at https://hallcweb.jlab.org/doc-public/ShowDocument?docid=1035