Differential Cross Section Analysis in Kaon Photoproduction

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Motivation

Angular distributions of differential cross sections and other polarization observables from the latest CLAS data sets, for reaction $\gamma + p \rightarrow K^+ + \Lambda$ have been analysed using Legendre Polynomials.

In this work, we try to establish the most important baryon resonances which contribute to the $p(\gamma,K^+)\Lambda$ reaction. All observables can be represented by Legendre polynomial series (see Figure.1), where the Legendre coefficients may reflect qualitatively the baryon resonances structure. In addition, extracting Legendre coefficients may thus describe features of different resonances more directly than angular distributions alone.

One of the main questions to be addressed in this work is how many Legendre polynomials are required to describe the data. We construct data models with different number of Legendre polynomial components have been compared by calculating posterior probabilities in light of the data.

$$\mathcal{L}_0(I, \hat{E}, \hat{C}_{z'}, \hat{L}_{z'}) \rightarrow \sum_l ...P_{l0}(x),$$
$$\mathcal{L}_1 a(\hat{P}, \hat{H}, \hat{C}_{x'}, \hat{L}_{x'}) \rightarrow \sum_l ...P_{l1}(x),$$
$$\mathcal{L}_1 b(\hat{T}, \hat{F}, \hat{O}_{x'}, \hat{T}_{z'}) \rightarrow \sum_l ...P_{l1}(x),$$
$$\mathcal{L}_2(\hat{\Sigma}, \hat{G}, \hat{O}_{z'}, \hat{T}_{x'}) \rightarrow \sum_l ...P_{l2}(x).$$

Figure 1: All observables represented by Legendre Polynomials

KΛ Reaction Channel

How do we choose this reaction?

Constituent quark model (CQM) predict a much richer baryon resonances spectrum than has been observed in the experiments [S. Capstick & Roberts, PRD58(1998)074011]. These missing resonances may couple strongly to KΛ and KΣ channels. So this channel appears as best solution to search baryon resonances.

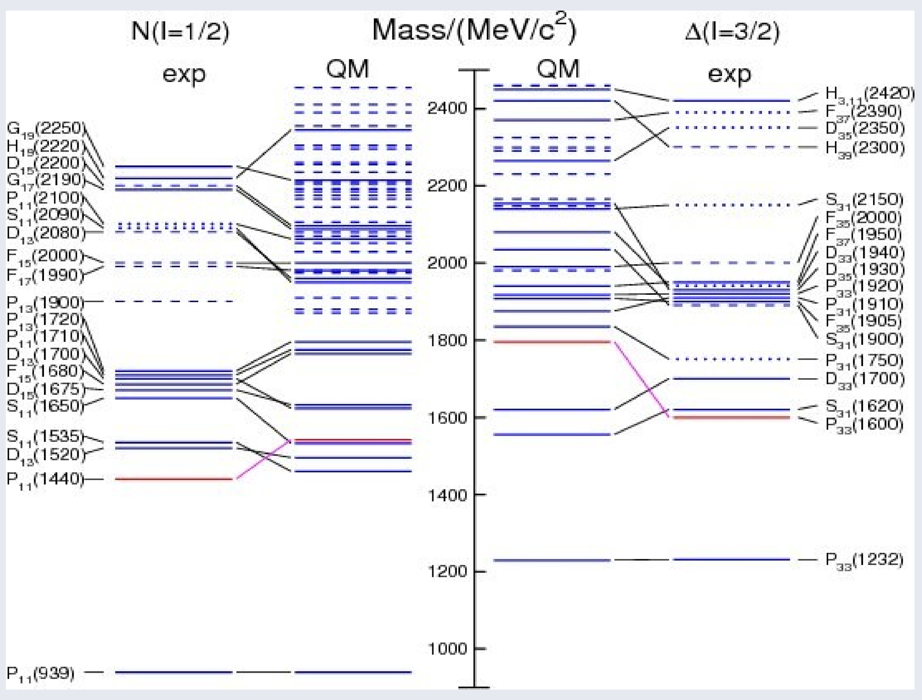

Figure 2: Baryon Resonances Spectrum

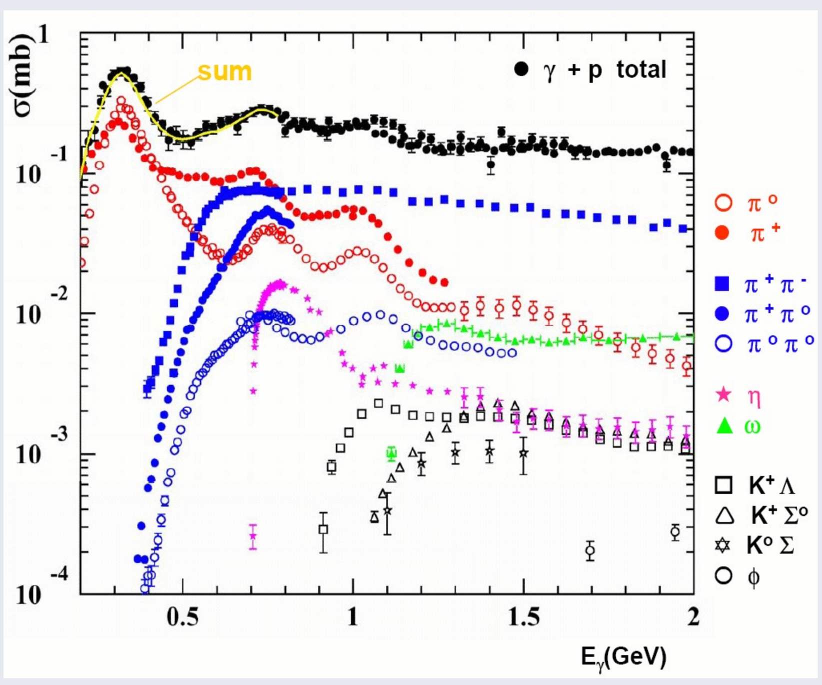

Figure 3: Kaon Photoproduction contribution on the proton

How do we study baryon resonances?

From the reaction channel in Figure. 4, we can calculate all observables using helicity representation.

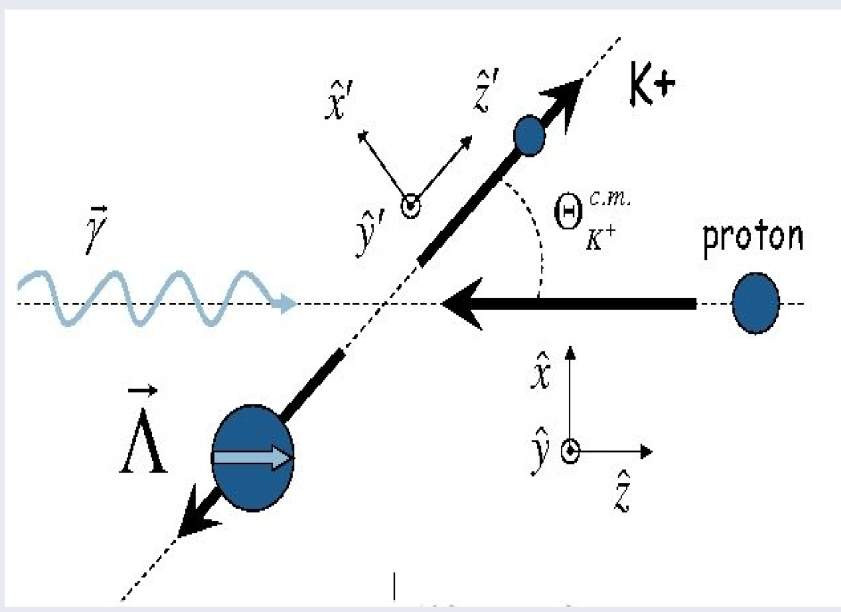

Figure 4: Reaction channel for $\gamma + p \rightarrow K^+ + \Lambda$

Double and single observables

- Differential cross section ($d\sigma/d\Omega$)
- Single polarization (P, Σ, T)
- Beam Target polarization (E, F, G, H)
- Beam-Recoil polarization (C_z, C_x, O_z,O_x)
- Target-Recoil polarization (T_x, T_z, L_x, L_z)

According to reaction channel in Figure. 4 we can calculate the sixteen observables in helicity representation and can classified them into four Legendre polynomials.

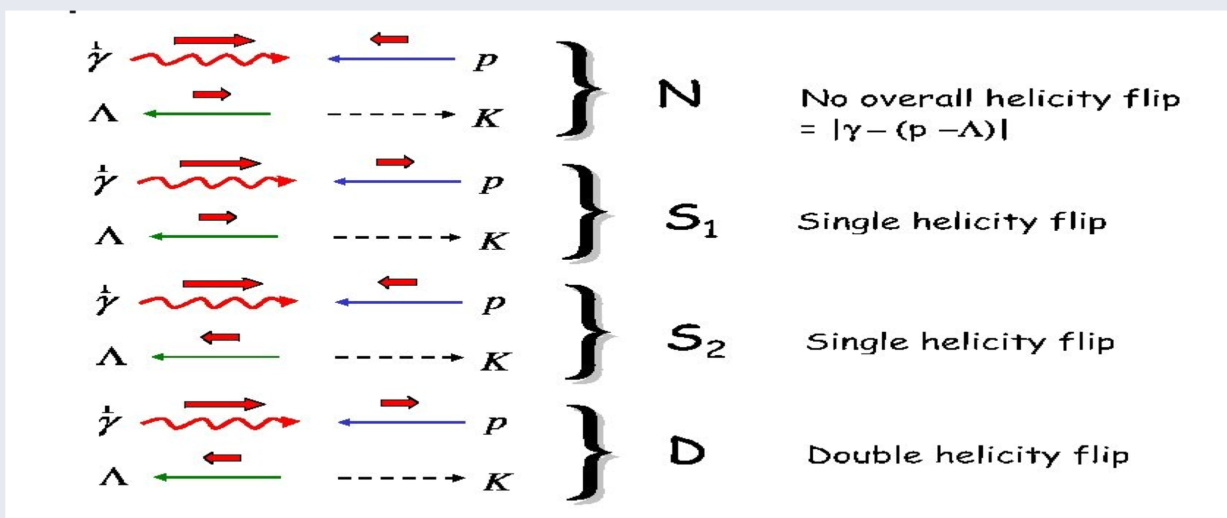

Figure 5: Helicity Representation

Analysis Procedure

We constructed data model :

<u>Data Model</u>

$$M_0 = A_0P_0\,(\cos\theta)$$
$$M_1 = M_0 + A_1P_1(\cos\theta).$$
$$M_l = M_0 + M_1 + ... + A_lP_l\,(\cos\theta)$$

<u>Model comparison</u>

$$R = \frac{P(M_i|D)}{P(M_0|D)} = \frac{P(D|M_i)P(M_i)}{P(D|M_0)P(M_0)}$$

<u>Marginalisation Likelihood</u>

$$P(D|M_i) = \int ... \int P(D, A_0, A_1, ..., A_i|M_i)\,dA_0\,dA_1 ... dA_i$$
$$P(D, A_0, A_1, ..., A_i|M_i) = P(D|A_0, A_1, ..., A_i, M_i) \times P(A_0, A_1, ..., A_i|M_i)$$
$$P(D|A_0, A_1, ..., A_L, M_L) \propto \exp\left(\frac{-\chi^2}{2}\right)$$

Preliminary Results

- **Differential Cross Section (photon energy =1.824 GeV)**

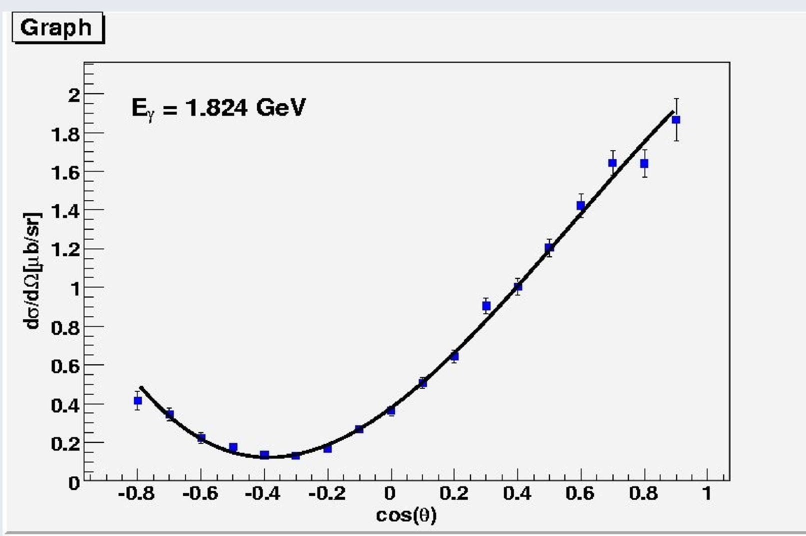

Figure 6: LP predicted results

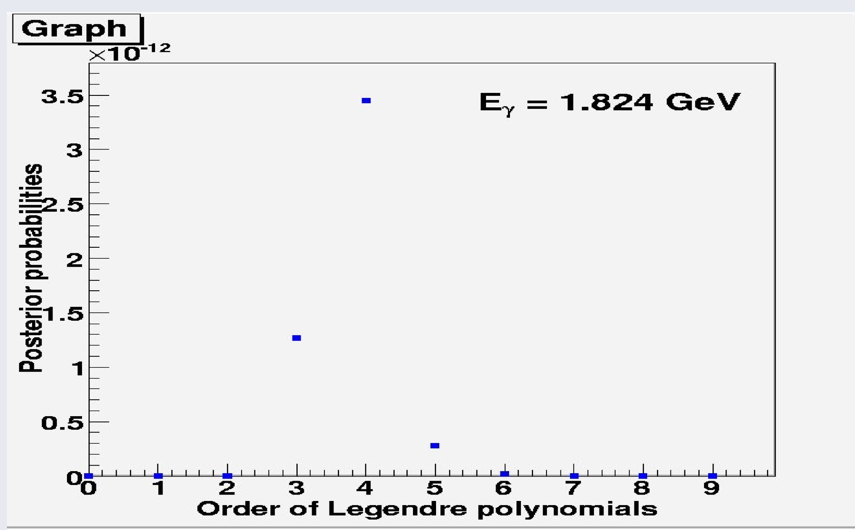

Figure 7: The maximum posterior

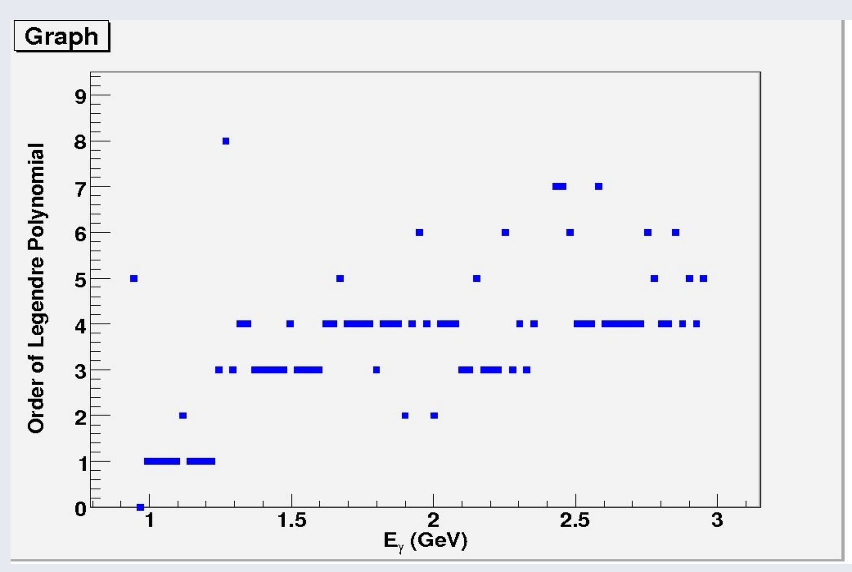

Figure 8: order of LP vs photon energy

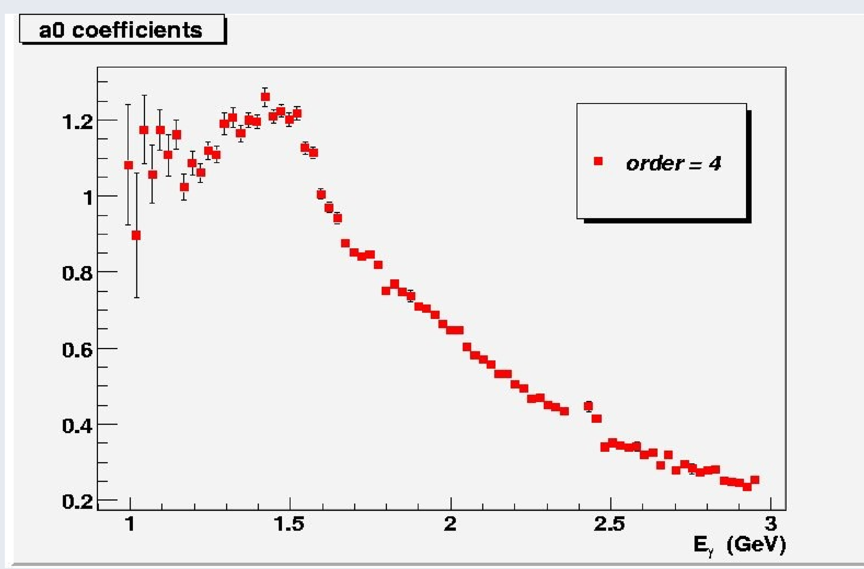

Figure 9: LP Coefficient extracted