A First Measurement of Spin Observables in the reactions $\gamma n \rightarrow K^0\Lambda$ and $\gamma n \rightarrow K^0\Sigma^0$

N. Hassall, Uni. Of Glasgow

Abstract

This poster presents the motivation for studying kaon photo-production from the deuteron using a linearly polarized photon beam. Preliminary results of the photon beam asymmetry Σ (single observable) are presented.

Introduction

In the 1950's, experiments revealed that hadrons are not fundamental particles and have some internal structure. This was the beginning of a new era of subatomic physics which describes the nature of hadrons in the context of quarks and gluons. The fundamental laws of quark and gluon interactions are explained by Quantum Chromodynamics (QCD). At low energies the hadrons look like structureless particles. At medium energies the substructure of hadrons can be explored. At very high energies (few hundred GeV) the complex nature of quarks and gluons inside the hadrons can be observed. At higher energies the strong coupling constant becomes much smaller than 1 and QCD can be treated perturbatively. At medium energies of about 1 GeV to 3 GeV where many of the resonant states of the nucleon exist, the coupling constant of the strong interaction is of order 1 and perturbation theory can no longer be used. Detailed experimental information on the structure of hadrons, in particular nucleons, can be obtained by understanding its excited states, i.e nucleon resonances. The internal structure of the nucleon is reflected in its excitation spectrum. Knowledge on nucleon resonances can be gained from experiments which involve the transfer of energy to the nucleon by a hadronic or electromagnetic probe. This energy transfer leaves the nucleonic system in one of its excited states which is then followed by a decay into the final state. The properties of these final states can be analysed and will yield information on the complex structure of the nucleon.

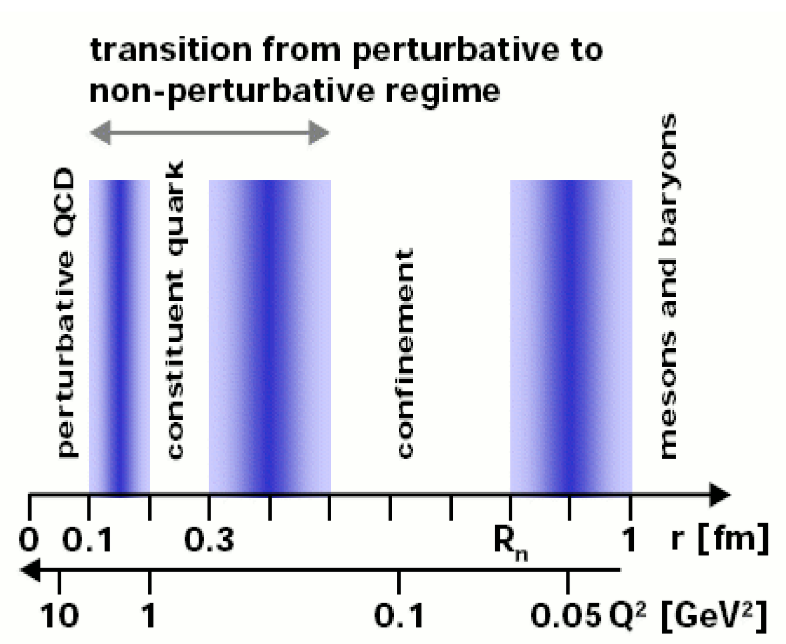

Fig 1: Scale showing the transition from perturbative to non-perturbative QCD.

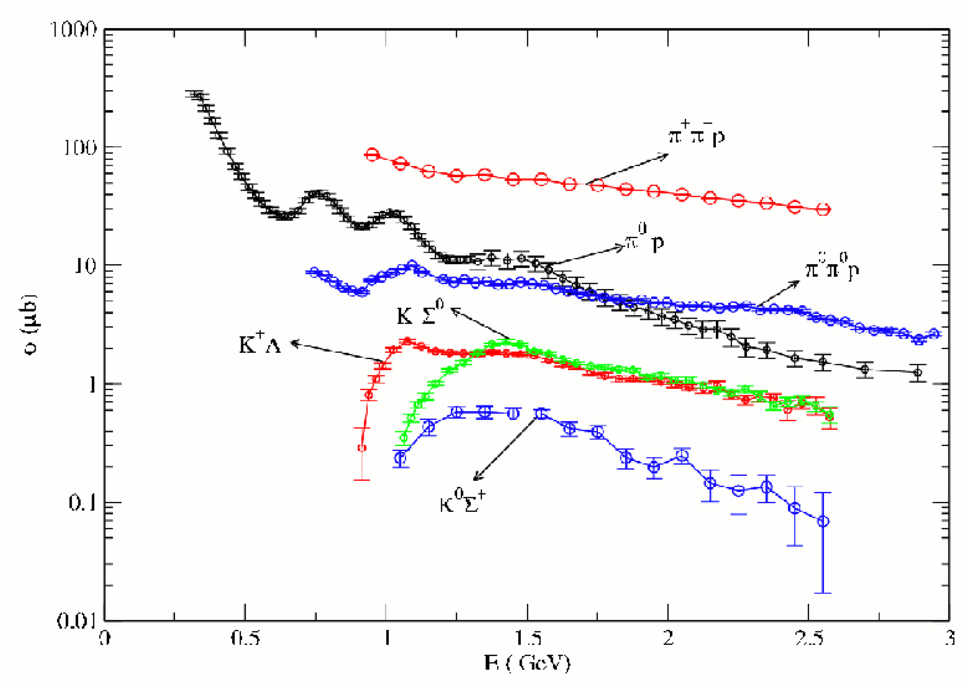

Fig 2: Resonance spectrum for meson photoproduction on the proton. There are currently no available data on the neutron.

G13b Experiment at CLAS

The experiment G13b, ran from March 2007 till June 2007 acquiring approximately 50 billion statistics from a liquid deuterium target. In order to detect multi particle final states the CEEBAF Large Acceptance Spectrometer in Hall B at Jefferson Lab was used. CLAS has an almost 4pi steradian coverage and has a momentum resolution of 300 MeV/c for charged particles.

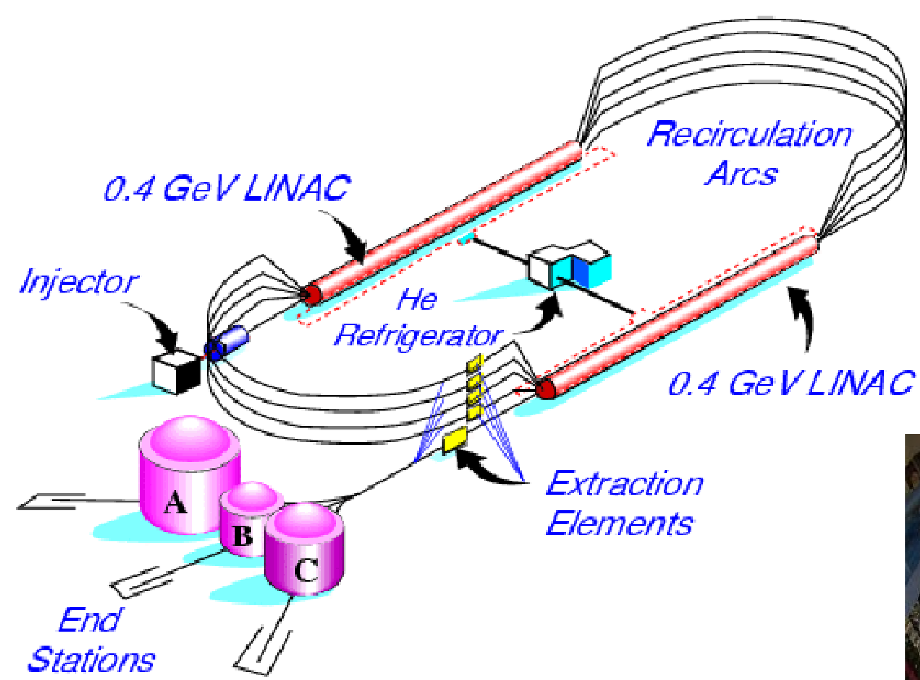

Fig 3: The racetrack configuration at the Thomas Jefferson National Accelerator Facility.

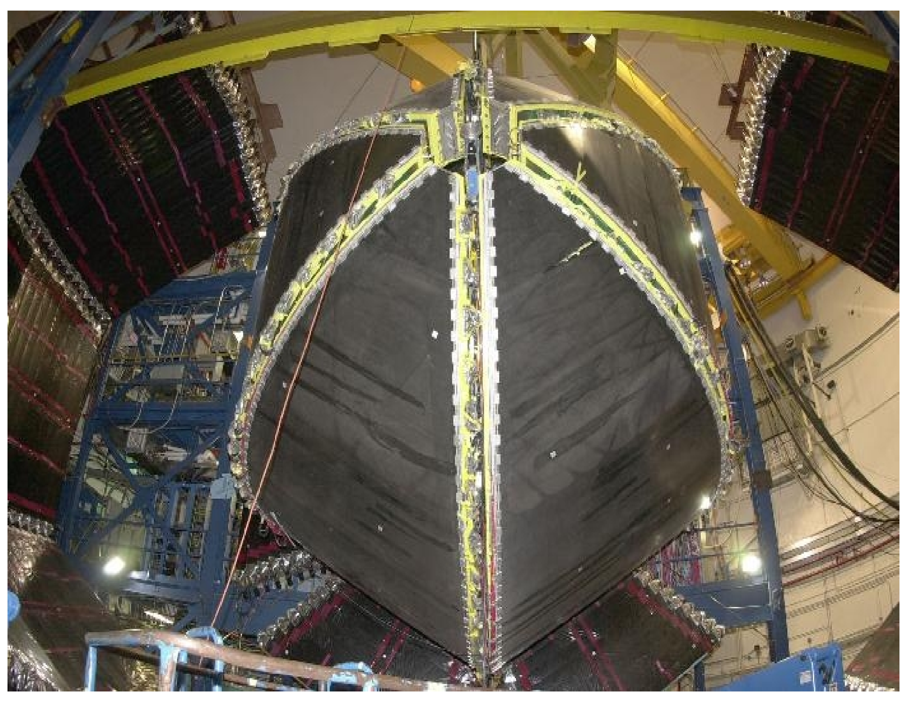

Fig 4: Picture of the CLAS in Hall B.

Strangeness Photo-production

Strangeness photo-production from the deuteron allows one to study quasi-free reactions from the neutron. The mechanism of strangeness production is poorly understood. The idea is that a strange meson is produced from a non-strange baryon so the fundamental question is where do the strange quarks come from? The investigation of strangeness production will focus on the analysis of the K-Lambda reaction channels:

The K-Sigma decay channel is somewhat more complicated to interpret theoretically as they couple to delta star states (I=3/2). The K-Lambda reaction however, is more straightforward as it decays via N* resonances (I=1/2). At low centre of mass energy only the S_{11}(1650), P_{11}(1710), P_{13}(1720) resonances contribute significantly. The missing D_{13}(1900) should play a role at higher centre of mass energy, so this experiment should be able to detect its existence or rule it out.

Spin Observables & Preliminary Analysis

In order to measure the polarisation observables we need to produce a polarized incident photon on our deuteron target.
The expression for the polarized cross section (note that this expression is reduced for the photon asymmetry only) for this reaction is given below and shows the relationship between the observables and the degree of linear polarisation.

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega_{un}} \{1 - P_\gamma^T \Sigma \cos 2\phi\}$$

The photon asymmetry observable should have a cosine 2 phi distribution, which can be seen in figure 6. From this plot one can measure the amplitude of the distribution and hence measure the photon asymmetry.

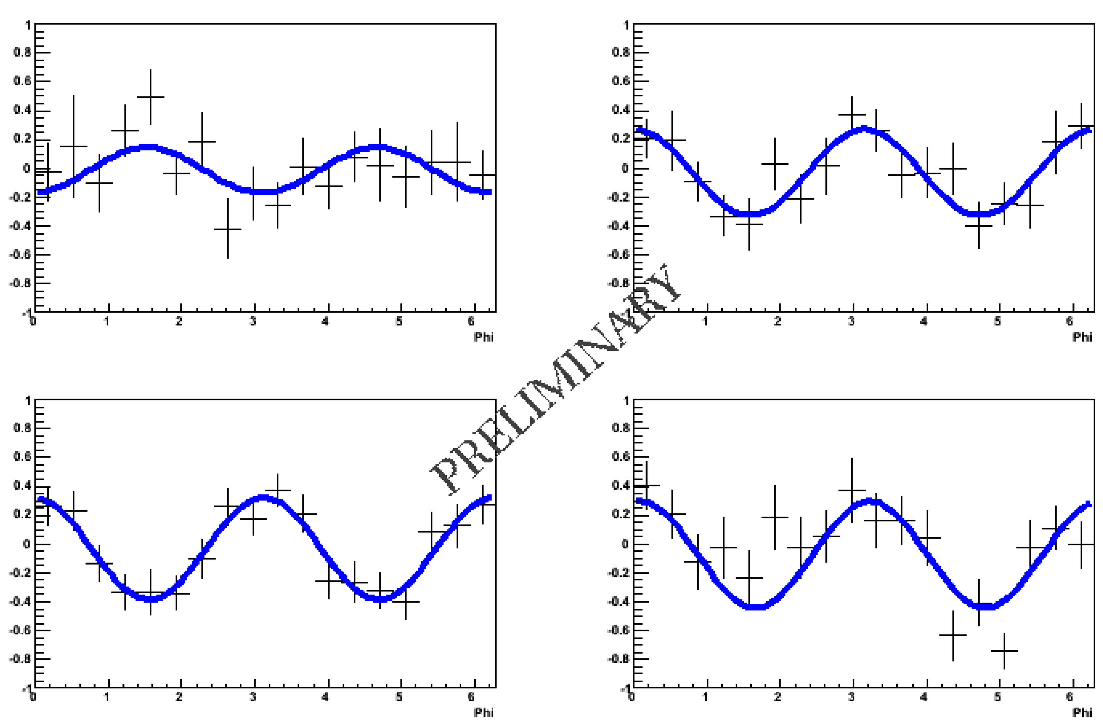

Fig 6: Raw photon asymmetry for $K^0\Lambda$ as a function of the kaon phi angle at a lab energy of 1.9 GeV. X-axis is in radians. Polarization values are taken to be 80% and 82% for para and perp respectively.

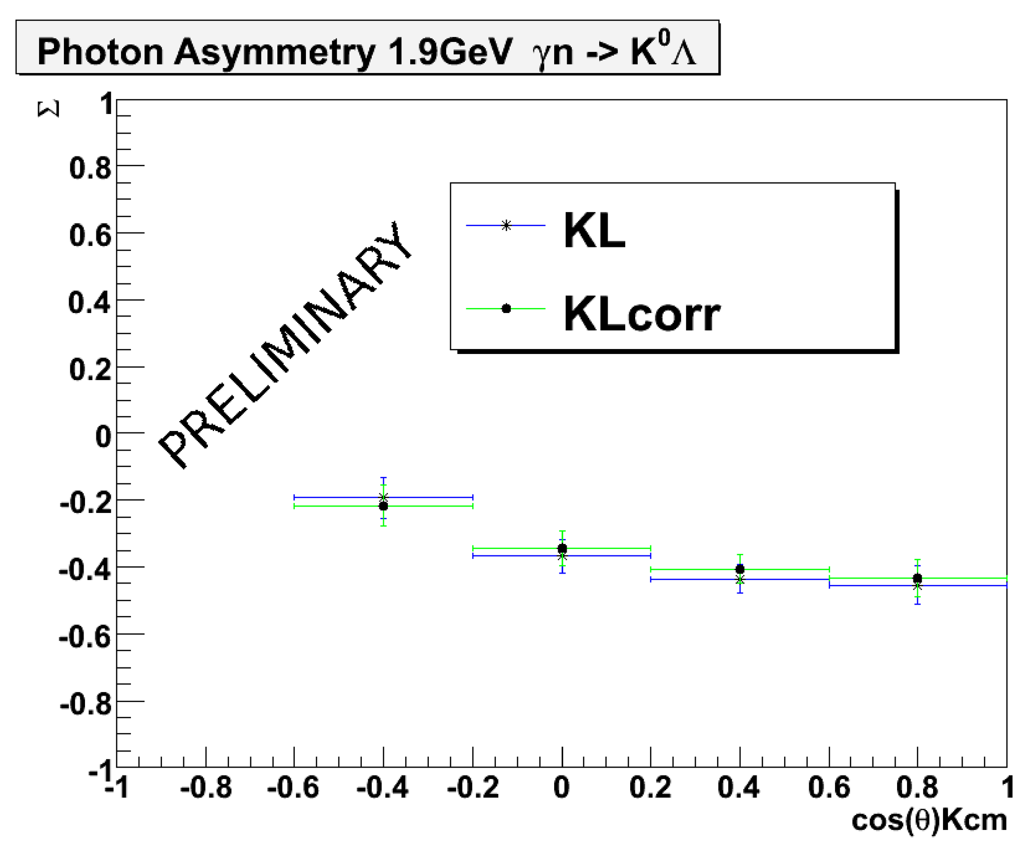

Fig 6: Photon asymmetry for $K^0\Lambda$ as a function of cos theta. Blue star points are asymmetries where there is no removal of $K^0\Sigma$ events. Green circular points show corrected asymmetry values.