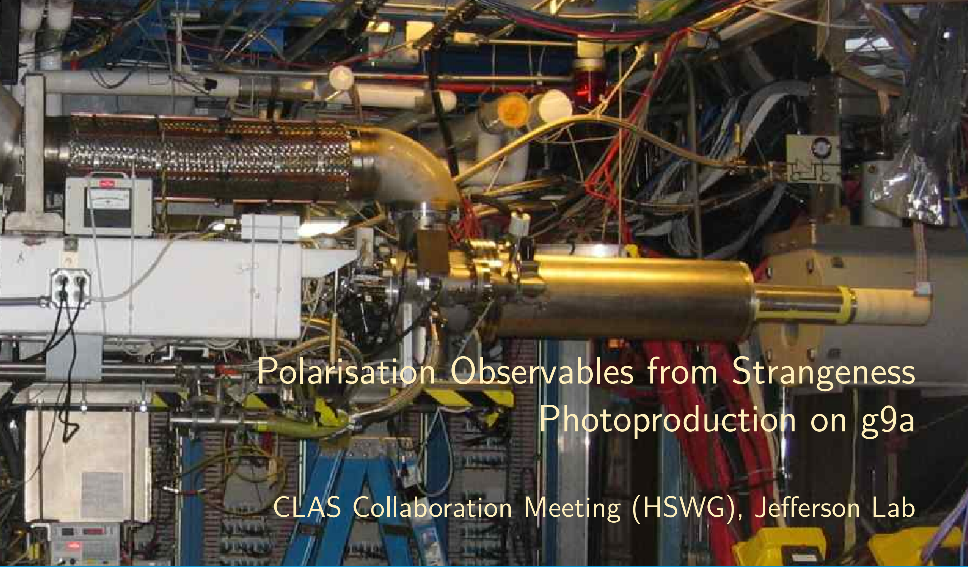


Polarisation Observables from Strangeness Photoproduction on g9a

CLAS Collaboration Meeting (HSWG), Jefferson Lab

THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

Stuart Fegan
George Washington University

March 8th, 2018

CEBAF Large Acceptance Spectrometer

Outline

A Long Time Ago...

- ...in a HSWG meeting not so far away...

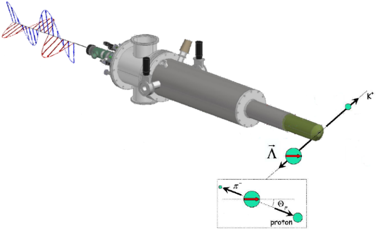
A World of Polarisation (Observables)

- Looking for polarisation observables on strangeness photoproduction

$$\gamma p \rightarrow K^+\Lambda \rightarrow K^+ p\pi^- \text{ (focus of this talk)}$$
$$\gamma p \rightarrow K^+\Sigma \rightarrow K^+\Lambda\gamma \rightarrow K^+ p\pi^-\gamma$$

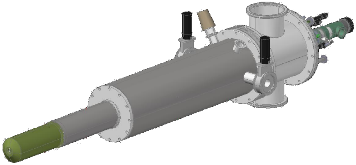
- 16 observables in all, arising from the scattering amplitudes of the interaction

- "Single": σ, Σ, P, T
- Beam-Target: E, F, G, H
- Beam-Recoil: O_X, O_Z, C_X, C_Z
- Target-Recoil: T_X, T_Z, L_X, L_Z



PARA/PERP, Target too

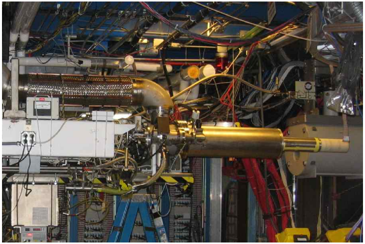
- With a polarised beam and target, can access the single and beam-target double observables
  - Single: σ, Σ, P, T
  - Beam-Target: E, F, G, H
- And more with recoil (i.e. with a self-analysing hyperon)



- This work seeks to measure the beam asymmetry, Σ, and one of the beam-target observables, G

g9a/FROST

- Data from g9a run period: November 2007 to February 2008
- Linearly and circularly polarised photon beams on a longitudinally polarised target

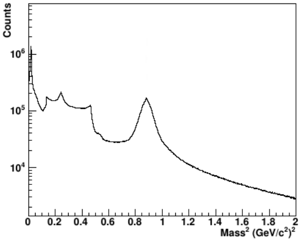


- Linpol data from g9a: 9 coherent peak settings spanning energy range 0.7 to 2.3 GeV
- In this case, the reduced cross section can be expressed as:

$$\frac{d\sigma}{d\Omega} = \sigma_0\{1 - P_{lin}\Sigma cos(2\phi) + P_z(P_{lin}Gsin(2\phi))\}$$

Analysis - Particle ID

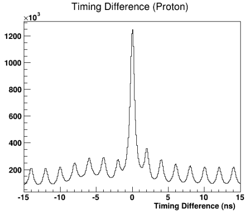
- Glasgow copies of the kaon skims were lost in a disk failure, analysis has taken place on a secondary skim used for my thesis, which performed some preliminary ID
- (Side note: May eventually re-run on original skims, archived on `/mss`, to verify this secondary skim)

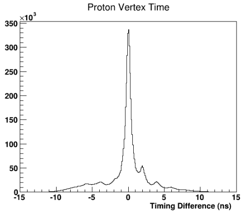


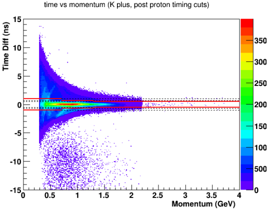
- Analysis cuts shadowed the $K^+\Lambda/K^+\Sigma$ analysis of g8b as it proceeded through review
- Minor tweaks to suit the unique conditions of the FROST run

Analysis - Particle ID (continued)

- Initial particle ID via combination of charge and time-of-flight mass
- Select potential events for the channel of interest from possible combinations of candidate particles; Proton, Kaon, optional Pion
- Misidentification of particles largely eliminated by photon-to-particle timing difference cuts (Proton and Kaon)





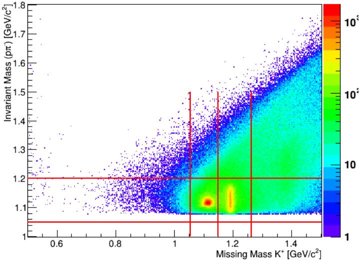


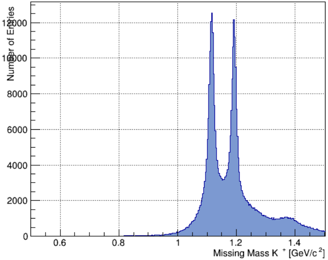
Channel Identification

- Looking for two channels:

$$\gamma p \to K^+\Lambda \to K^+ p\pi^-$$
$$\gamma p \to K^+\Sigma \to K^+\Lambda\gamma \to K^+ p\pi^-\gamma$$

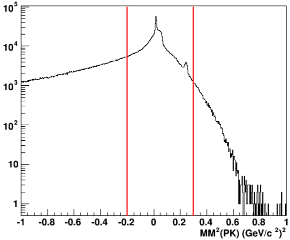
- Non exclusive selection, reconstructing pion from detected proton and kaon
- Lambda (and Sigma) hyperons identified via kaon missing mass and proton pion invariant mass

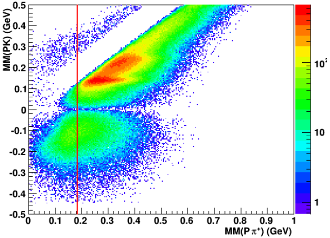




Channel Identification (continued)

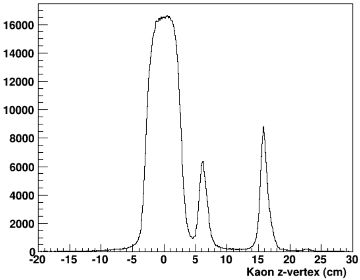
- Additional cuts to minimise particle misidentification
- Loose cut on Proton + Kaon missing mass, to verify Pion reconstruction (top)
- Assume detected Kaon is a Pion and plot pK^+ missing mass against $p\pi^+_{misID}$ (bottom)
- Reduce number of Kaons that are actually Pions through a cut on this "blob" feature

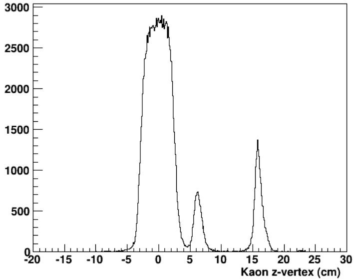




Target Selection

- FROST target contains three target materials; Butanol (left), Carbon (centre) and Polythene (right)
- Resolvable from Kaon z-vertex after particle and channel identification





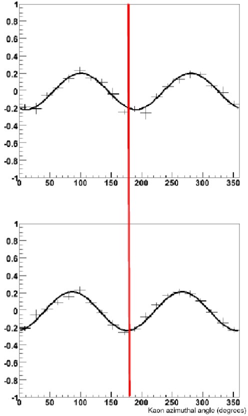
- Only Butanol is polarised, other targets used to account for nuclear backround and dilution effects of unpolarised nuclei in butanol

Extracting Observables

- All current results using binned fitting on asymmetries
- Good enough to verify Σ on a molecular target
- Recall that on a linpol beam and a longitudinally polarised target:

$$\frac{d\sigma}{d\Omega} = \sigma_0\{1 - P_{lin}\Sigma cos(2\phi) + P_z(P_{lin}Gsin(2\phi))\}$$

- A $\cos(2\phi) + \sin(2\phi)$ fit to a PARA/PERP asymmetry can be used to extract Σ and G for each state of target polarisation



Dilution of Observables

- Parameters extracted from $\cos(2\phi) + \sin(2\phi)$ fits are the free proton value, diluted with a carbon contribution (and beam and target polarisations)
- i.e. for the Σ observable, we actually measure $P_\gamma \Sigma_{Butanol}$, from which we can estimate the free proton value

$$P_\gamma \Sigma_{Proton} = \frac{1}{N_{Proton}} (N_{Butanol} P_\gamma \Sigma_{Butanol} - N_{Carbon} P_\gamma P_\sigma \Sigma_{Carbon})$$

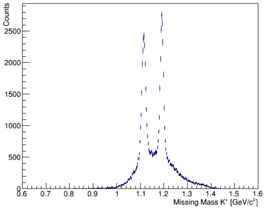
- For G, carbon in the target is unpolarised and we measure $P_\gamma P_{Target} G_{Butanol}$, estimating the free proton value via;

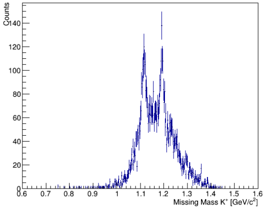
$$P_\gamma P_{Target} G_{Proton} = \frac{N_{Butanol}}{N_{Proton}} (N_{Butanol} P_\gamma P_{Target} G_{Butanol})$$

- The 'N' terms represent event yields per bin corresponding to the relevant material
- These must be estimated for Carbon and Proton...

Estimating Carbon

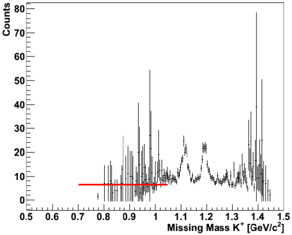
- Basic estimate of Carbon scaling factor obtained by dividing Kaon missing mass spectra for Butanol and Carbon
- This defines a *Carbon Scaling Factor*
- Rescales n_{Carbon}, the number of events measured in each bin on the Carbon target, to N_{Carbon}, the estimated amount of Carbon events in the corresponding bin on the Butanol target

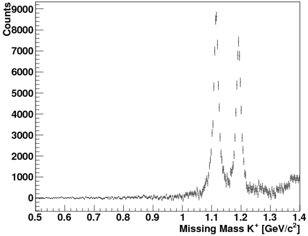




Estimating Carbon

- Use this ratio of events in the low Kaon missing mass region to define a Carbon Scaling Factor
- Technique has limits, and price is paid in larger uncertainties
- Good enough, however, for a first pass of results, and verification of previous measurements of Σ
- We can measure observables on this target! (which was basically the conclusion of my thesis)

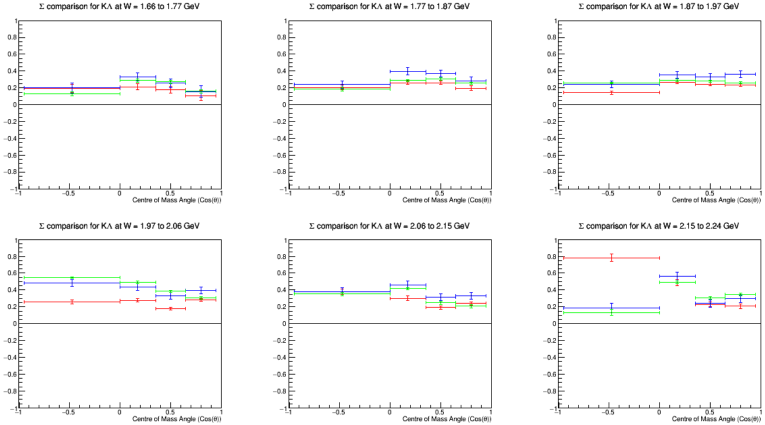




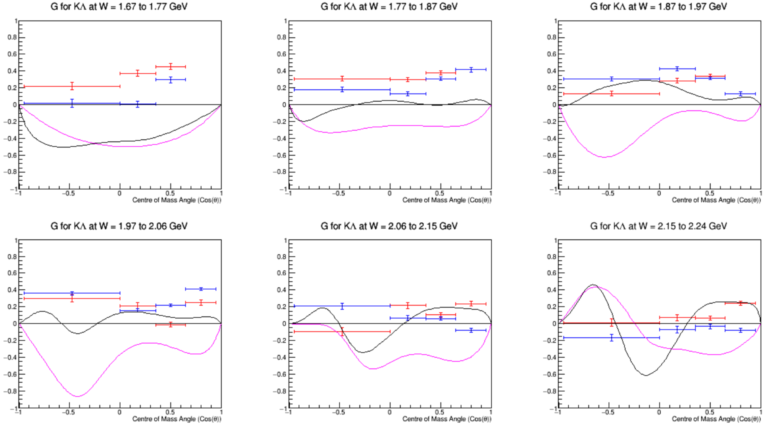
Initial Results

- Following slides show results for Σ and G observables, on $K^+\Lambda$
- Updated with new Carbon Scaling Factors, and g8b shadowed event selection scheme
- Red points positive target polarisation, blue points negative
- Σ results are compared to rebinned g8b results (green points), G is compared to Bonn-Gatchina (pink line) and Jülich Bonn (black line) model predictions
- Disclaimer: Full errors on G not propagated

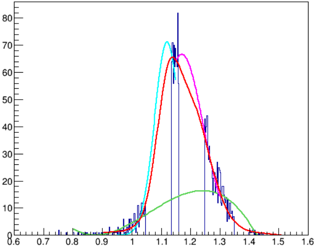
Initial Results, Σ

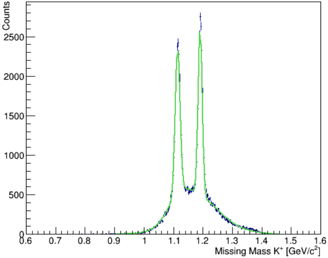


Initial Results, G



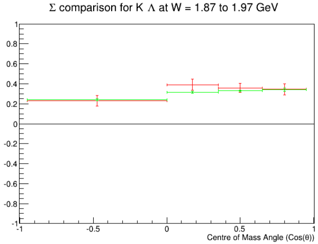
Next Steps

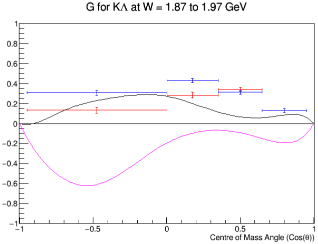




- Contolling systematic uncertainties, particularly on a measurement of G, needs a more robust method of accounting for Carbon
- Several possible methods to estimate the Carbon contribution,
- Outlined a few back in 2013, comparing their results is one immediate next step

Outlook and Plans





- First priority is to get the G measurement complete and into review
- $K^+\Sigma$ more or less comes for free here too
- Target-Recoil observables are possible, but were never a consideration for my thesis, or immediate follow up