Strangeness Photoproduction in g9a (linpol)

FROST Rungroup Meeting, Under Lockdown

Image: University of York/Alex Holland

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CEBAF Large Acceptance Spectrometer

Outline

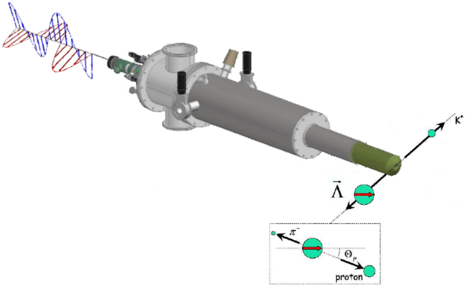
A World of Polarisation (Observables)

- Looking for Σ and G polarisation observables on strangeness photoproduction

$$\gamma p \to K^+\Lambda \to K^+ p\pi^- \text{ (Shown in this talk)}$$
$$\gamma p \to K^+\Sigma \to K^+\Lambda\gamma \to K^+ p\pi^-\gamma \text{ (Part of 2012 thesis analysis)}$$

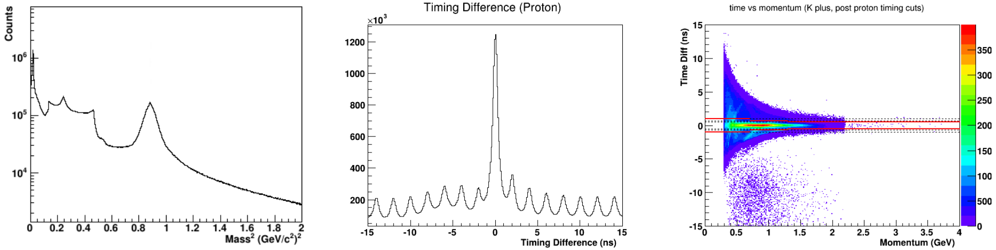
- In theory, all 16 observables should be measurable via strangeness channels

- "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



Analysis - Particle ID

- 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)



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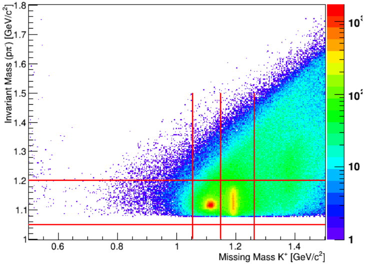
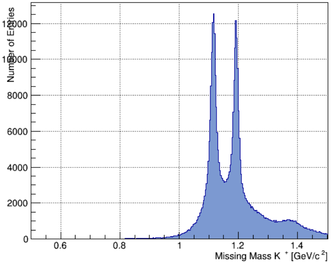
Channel Identification

- 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





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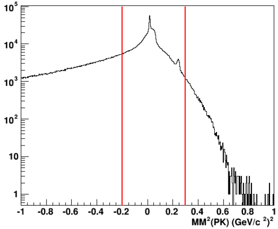
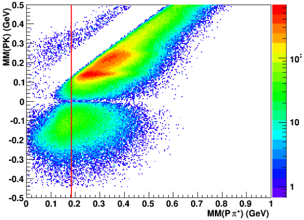
Channel Identification (continued)

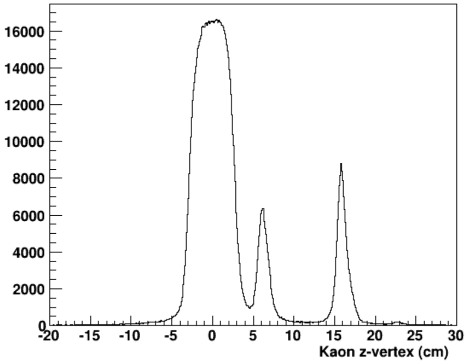
- Additional cuts to minimise particle misidentification
- Loose cut on Proton + Kaon missing mass, to verify Pion reconstruction (top)
- Assume detected Kaon is a Pion and plot pK^+ missing mass against $p\pi^+_{misID}$ (bottom)
- Reduce number of Kaons that are actually Pions through a cut on this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

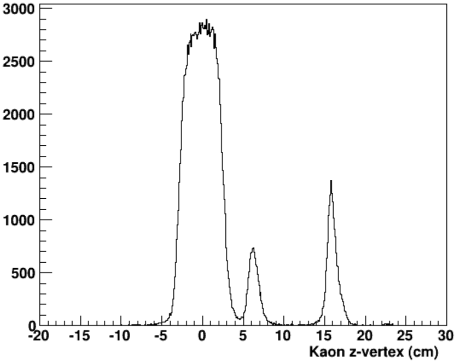




Target Selection

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





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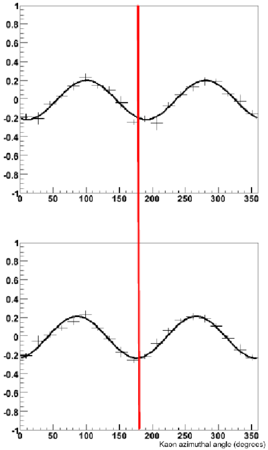
Extracting Observables

- 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



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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

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

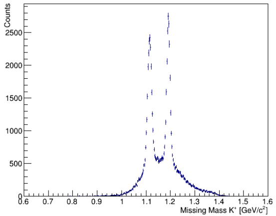
- For G, carbon in the target is unpolarised and we measure $P_{\gamma}P_{Target}G_{Butanol}$, estimating the free proton value via;

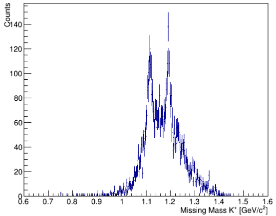
$$P_{\gamma}P_{Target}G_{Proton} = \frac{N_{Butanol}}{N_{Proton}}(N_{Butanol}P_{\gamma}P_{Target}G_{Butanol})$$

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

Estimating Carbon

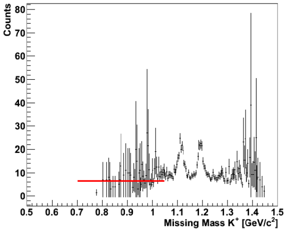
- Basic estimate of Carbon scaling factor obtained by dividing Kaon missing mass spectra for Butanol and Carbon
- This defines a *Carbon Scaling Factor*
- Rescales n_{Carbon}, the number of events measured in each bin on the Carbon target, to N_{Carbon}, the estimated amount of Carbon events in the corresponding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

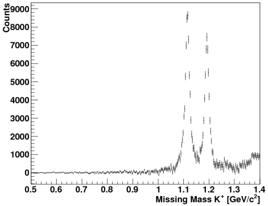




Estimating Carbon

- 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!

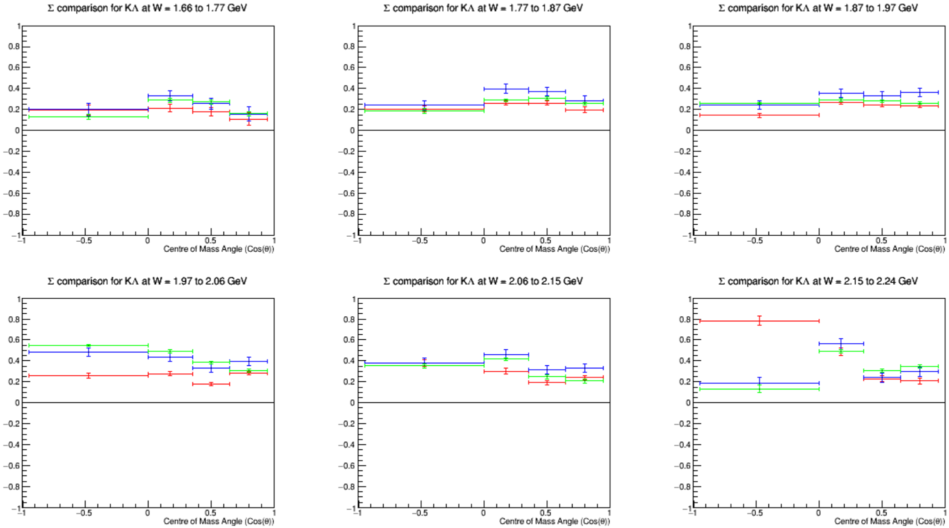




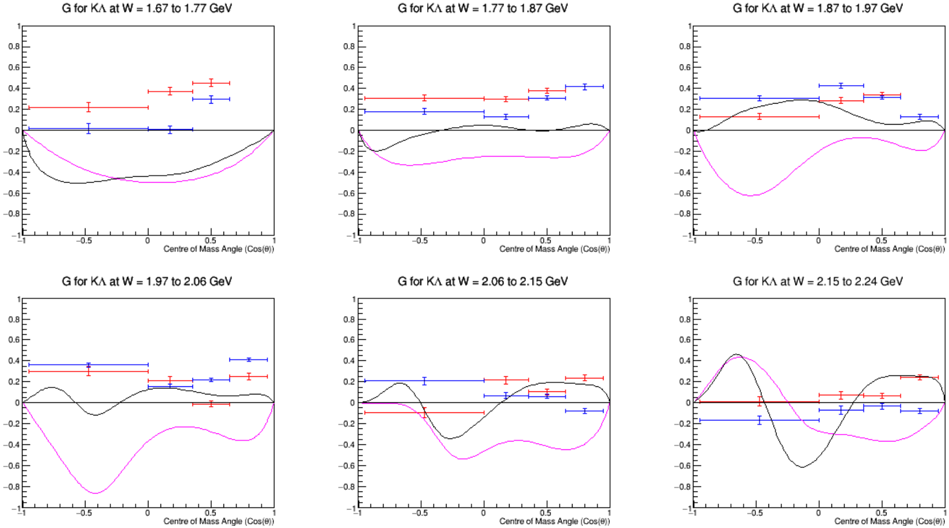
Initial Results

- Following slides show results for Σ and G observables, on $K^+\Lambda$
- Red points positive target polarisation, blue points negative
- Σ results are compared to rebinned CLAS g8b results (green points), G is compared to Bonn-Gatchina (pink line) and Jülich Bonn (black line) model predictions
- Disclaimer: VERY Preliminary results!!!!!!!!!

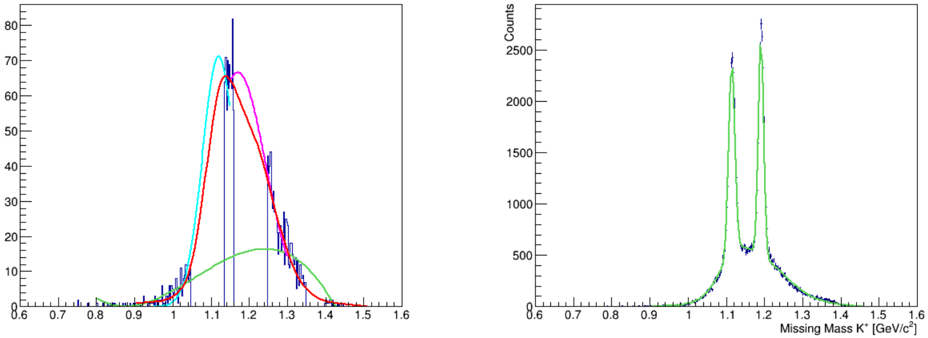
Initial Results, Σ



Initial Results, G



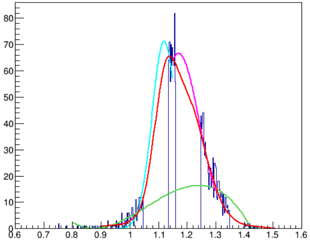
Next Steps



- Contolling systematic uncertainties, particularly on a measurement of G, needs a more robust method of accounting for Carbon

Estimating Carbon Yield - "Indirect Scaling"

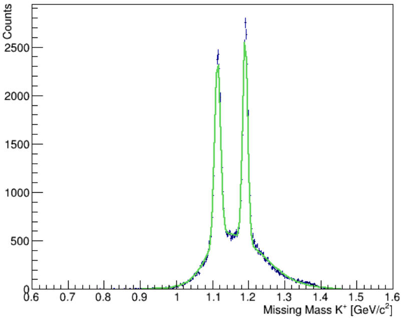
- Indirect scaling - derived from the techniques used in Edinburgh (J. McAndrew - g9a, P. Hall-Barrientos - CB@MAMI)
- Uses Carbon data to define a function shape to be fitted on Butanol
- This function is then integrated over the butanol mass range of interest to estimate carbon



- From the Kaon MM spectrum, the hyperon peaks are removed, and a two gaussian + poly(3) function is fit to the data
- The parameters obtained are used to initialise a fit on the Butanol spectrum

Estimating Carbon Yield - "Indirect Scaling"

- Two more gaussians are added, to represent Λ annd Σ hyperons on free protons in butanol
- Parameters from the Carbon fit used to initialise the carbon function



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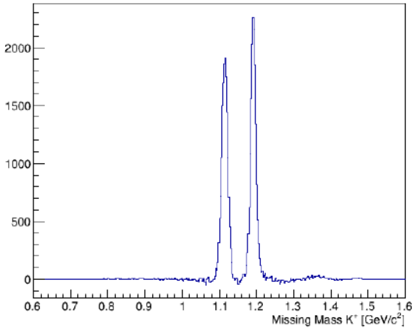
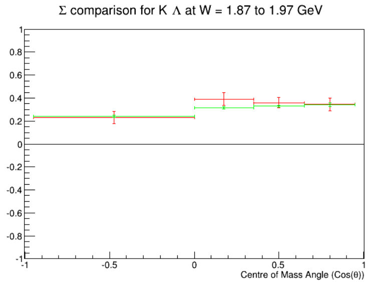
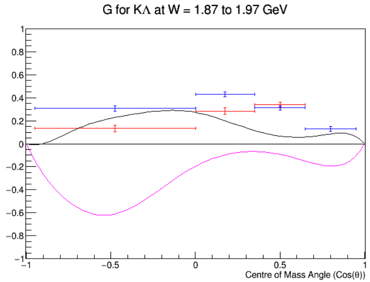
Estimating Carbon Yield - "Indirect Scaling"

- Integrate the Carbon function over Kaon MM, and subtract to estimate free proton
- Slight oversubtraction, but hyperons resolvable
- Further optimisation required before computing new results



Outlook and Plans





- Analysed ROOT trees exist, with mature event selection, and all relevant data corrections, polarisation tables, etc
- Use of indirect scaling for Carbon subtraction needs to be seen in results
- Observable extraction methods are key to finishing this work, contribution of recoil may complicate the standard binned asymmetry technique