Recent Activities in Hadron Spectroscopy at the University of York

November 2023 CLAS Collaboration Meeting, JLab

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University of York
November 9th, 2023

CEBAF Large Acceptance Spectrometer

Group Composition

Largest nuclear physics group in the UK, with an active and dynamic research program. Within this setup, the Hadron Physics subgroup consists of;

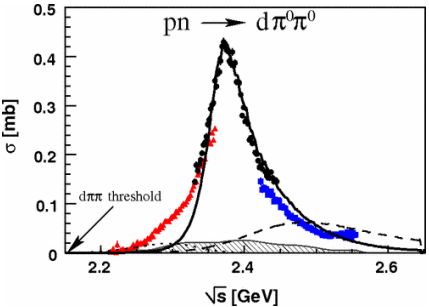
- Three Academics (D. Watts, N. Zachariou, M. Bashkanov)
- Two PDRAs (S. Fegan, S. Kay)
- 5 PhD students, 3 on CLAS projects (A. Acar, W. Booth, R. Williams)
- 2 masters by research, both CLAS-related (N. Hadjigavriel, C. Velasquez)
- Recent CLAS PhDs; M. Nicol, G. Clash

Everyone named here has some CLAS involvement in York, either directly or indirectly

Hexaquarks

- QCD allows many states beyond the familiar $q\bar{q}$ of mesons and qqq of baryons
- Hexaquarks are a category of objects consisting of either six valence quarks ($6q$) or three quarks and three antiquarks ($3q3\bar{q}$)

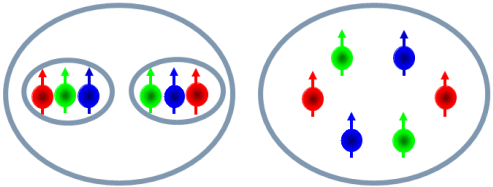
- Initial experimental evidence for the d*(2380) came from the WASA at COSY collaboration in 2011
- Prompted follow up work in the York hadron group at other facilities (A2@MAMI, JLab)

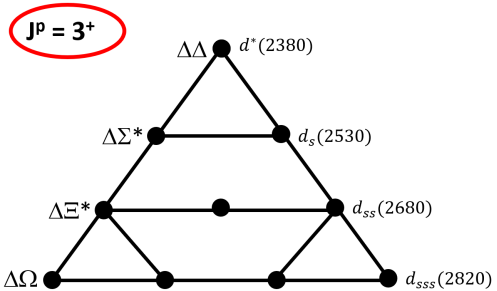


P.Adlarson et al., Phys Rev Lett 106 (2011) 242302

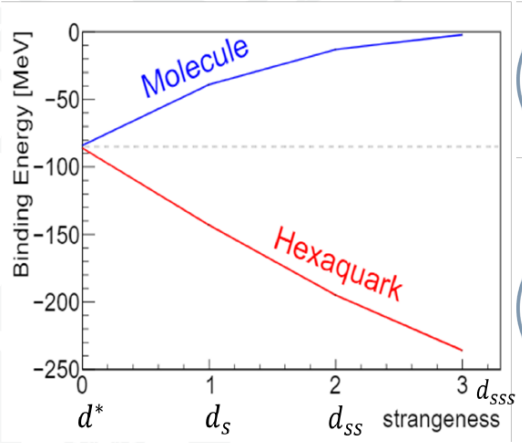
Hexaquarks at CLAS

- Looking to find and establish the nature of hexaquark states
- CAA submitted and approved last year (summer 2022 meeting)

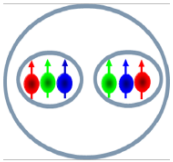


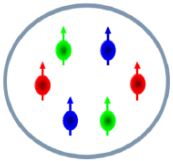


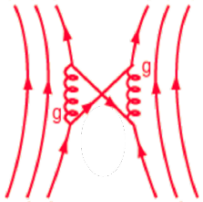
Hexaquarks at CLAS

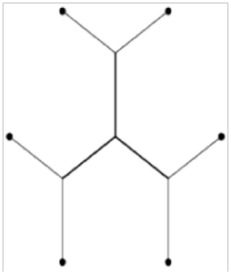


M. Bashkanov et al., arXiv:2012.11449v1



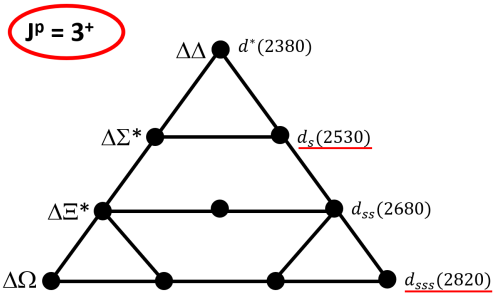






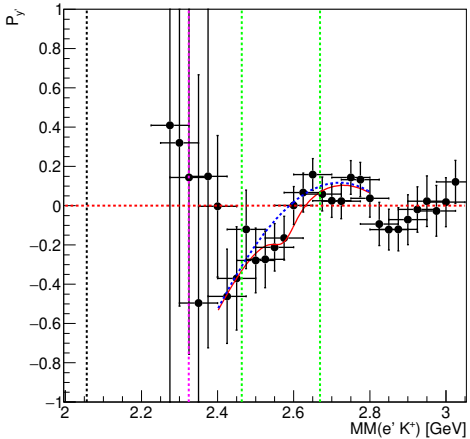
Hexaquarks at CLAS

- Two PhD analyses searching for d^* states so far in York:



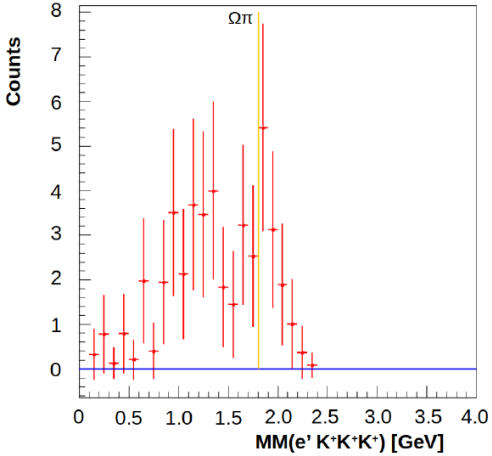
- G. Clash, defended last week, *Search for a Singly Strange Hexaquark Using Polarization Data From CLAS12*
- M. Nicol, defended last year, *Exploring The Strong Interaction Through Electroproduction of Exotic Particles*

Search for a Singly Strange Hexaquark (G. Clash)

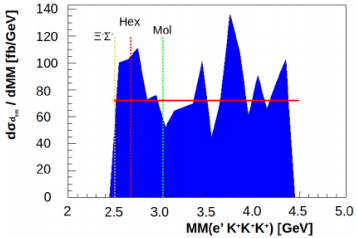


- Looking for signs of a hexaquark state in RGB data
- $ed \rightarrow e' K^+ d_s^0$
- The d_s^0 decays through Λn
- Final state of $e' K^+ p \pi^- n$
- Using polarisation as lens to perform this search
- $P_{y'}$ measurements of the Λ used to establish an upper limit on this state's peak strength

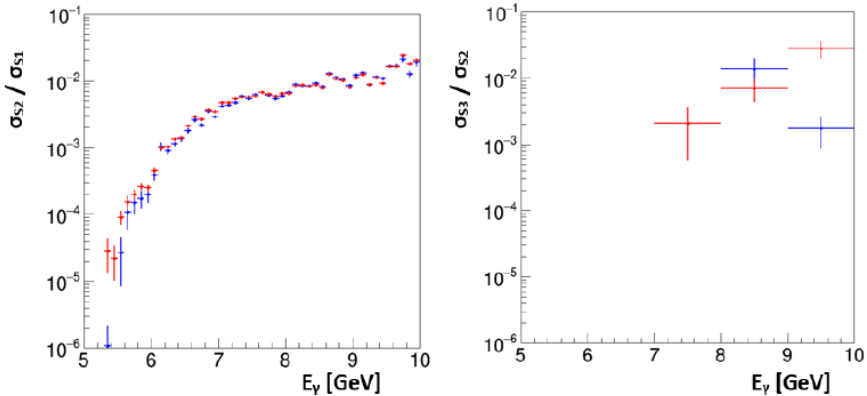
Search for d_{sss} (M. Nicol)



- Also RGB data
- $ed \rightarrow e' K^+ K^+ K^+ d_{sss}$
- "Bump hunt" shows no obvious d_{sss} signal
- Cross section upper limit established



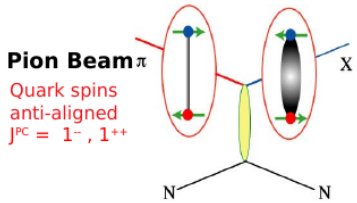
Very Strange

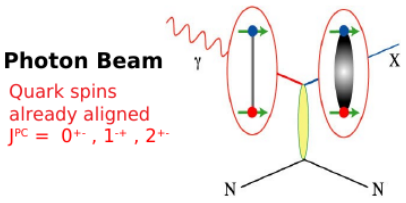


- New PhD student, Asli Acar, started last month
- Primarily involved with the Very Strange group, will pick up one of the Ξ channels

MesonEx

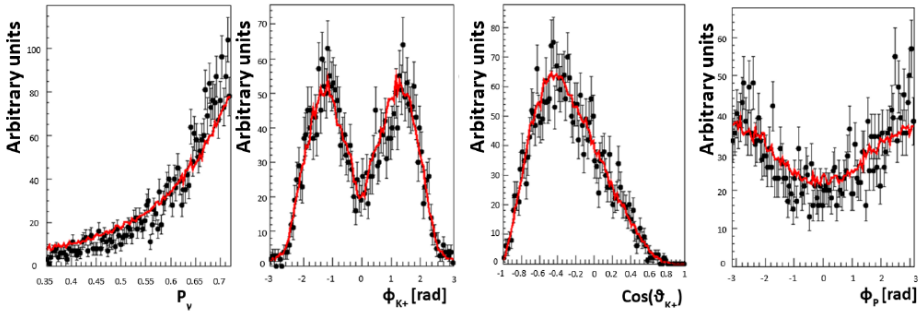
- Mesons, being composed of a quark and antiquark, are the simplest bound quark system, making them an obvious choice for studies of how quarks combine to form hadrons
- Strong theoretical and phenomenological evidence for the existence of a rich spectrum of unconventional states
- Hybrids and exotics may be more effectively produced by photon beams, i.e. low q^2 tagging with the FT





Exotic Meson search in K^+K^-

- Another aspect of M. Nicol's thesis analysis was a preliminary study of $\gamma^* p \to pK^+K^-$
- Determine decay angles of the intermediate resonance, and attempt to fit moments



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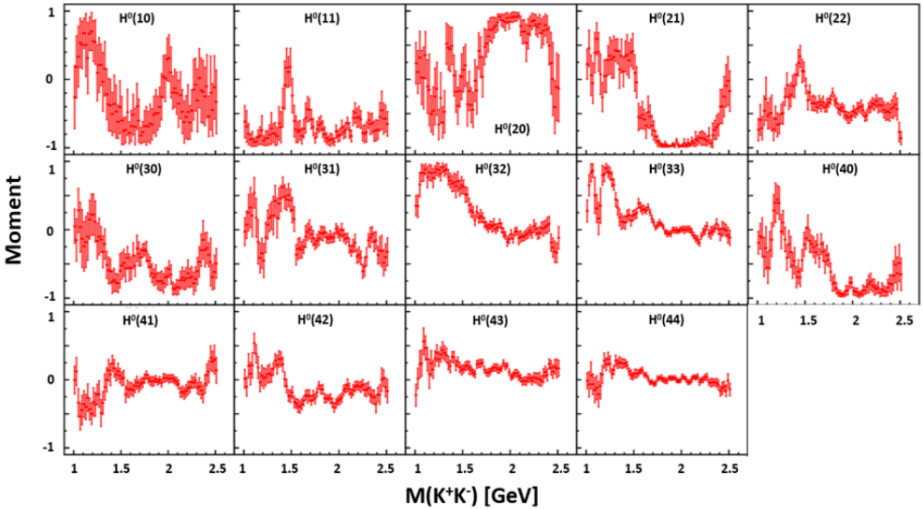

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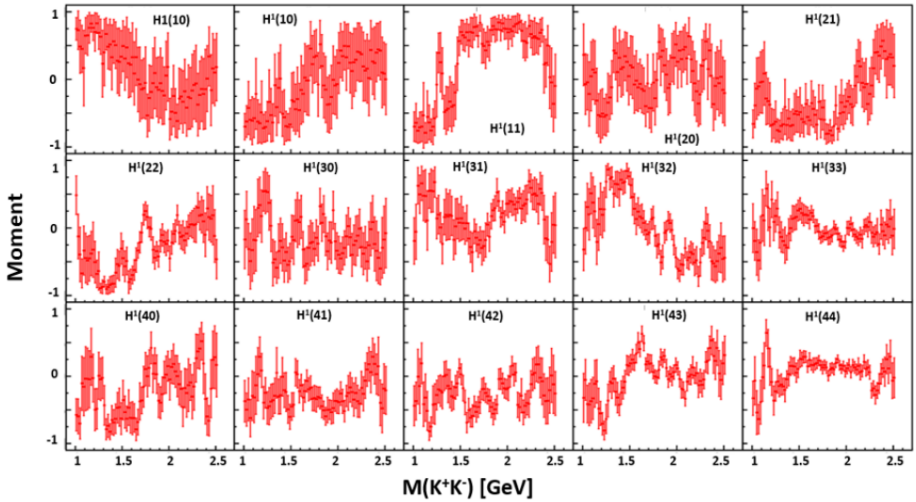
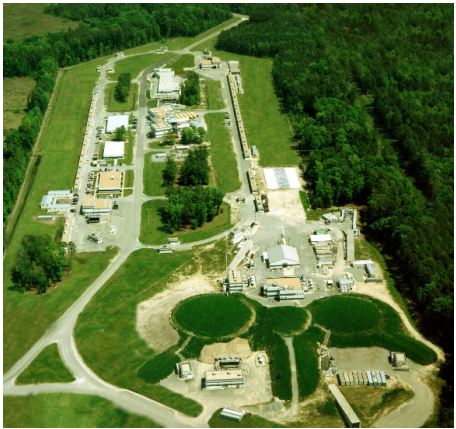
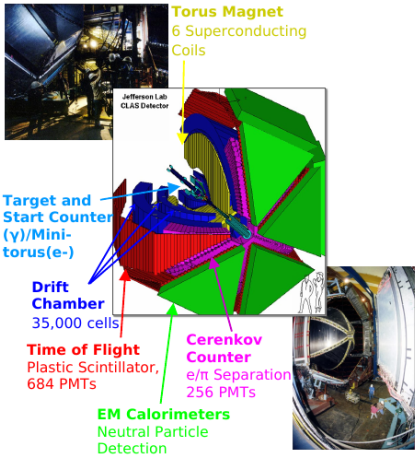


N* Experiments with CLAS



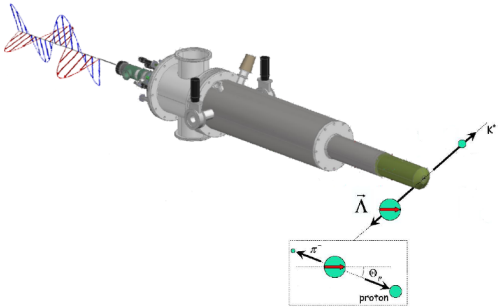


NIM A, 503(3), 2003

Polarisation Observables on Meson Photoproduction

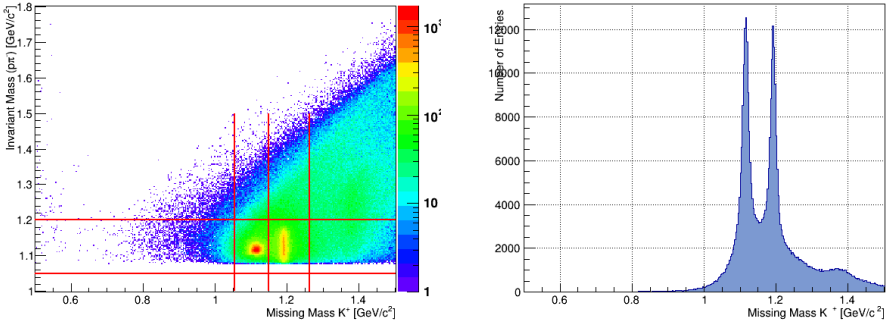
- Historical involvment in the measurement of polarisation observables on meson photoproduction reactions
- Several recent publications on pion and kaon channels
- 16 observables for single meson photoproduction, arising from the scattering amplitudes of the interaction and the particles which carry polarisation

- "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

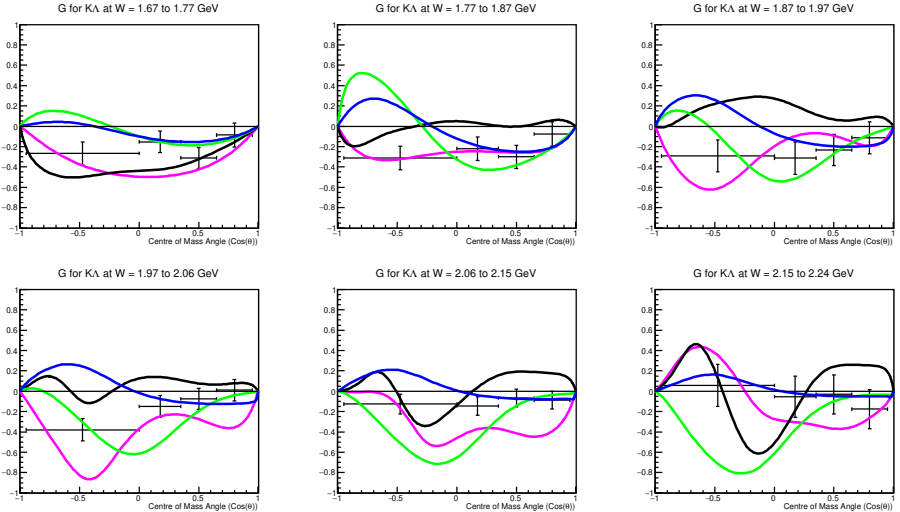


Strangeness Photoproduction on g9/FROST

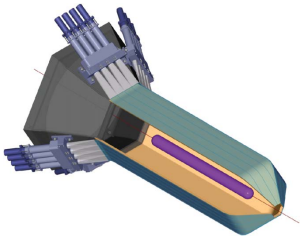
$$\gamma p \rightarrow K^+\Lambda \rightarrow K^+ p\pi^-$$

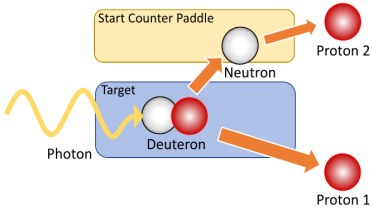


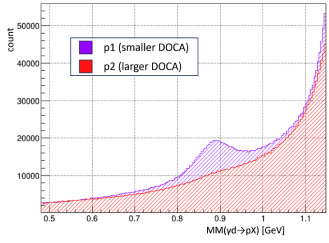
Results, G Observable for $K^+\Lambda$



Neutron Polarimetry (W. Booth)

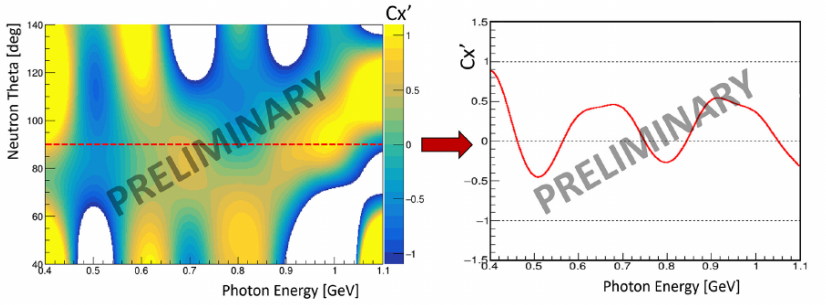






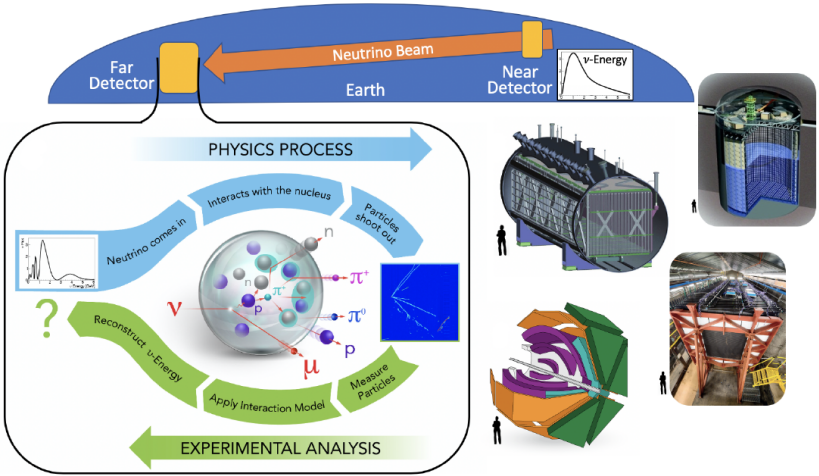
- Utilise the CLAS6 Start Counter as a Neutron Polarimeter with g13 data
- Provide insights into nucleon-nucleon phenomena, and provide another lens for our d^* studies

Neutron Polarimetry (W. Booth)



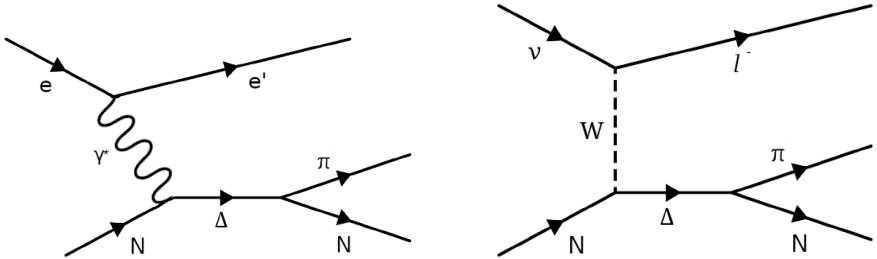
- Measuring neutron polarisation transfer, $C_{x'}$, greatly extending kinematic coverage of previous measurements
- Possibly repeat in CLAS12, using the SVT as the polarimeter

Electrons for Neutrinos - e4nu



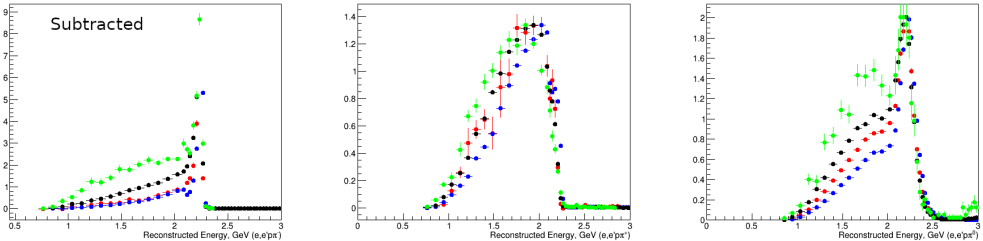
Resonance Production

- Resonance production from electrons similar to that from neutrinos



- Study the former to inform models of the latter

Electrons for Neutrinos



- Benchmark neutrino event generators against electron scattering data in the resonance region

Final Promotion

- Five years since the group moved from Edinburgh
- Four years since I joined
- Three active CLAS PhD students
- Two CLAS theses achieved
- One Longboi mug in the counting room!