

Search for Very Strange Dibaryon

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16th September 2021

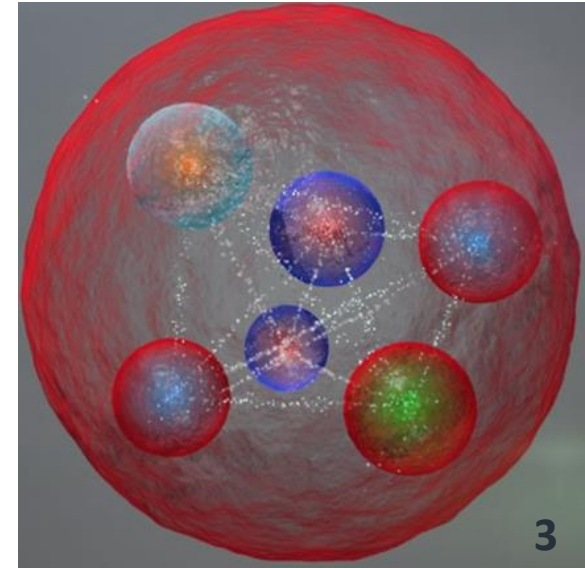
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- Introduction
- Motivation and theory
- Previous work
- Current work
- Next Steps

Introduction

- $d^*(2380)$ is the first hexaquark supported by experimental data
[PRL **106**, 242302, (2011)] [PRL **112**, 202301, (2014)] [PRL **124**, 123001, (2020)]
- Studies have been performed on this hexaquark
- Expand our studies of hexaquarks



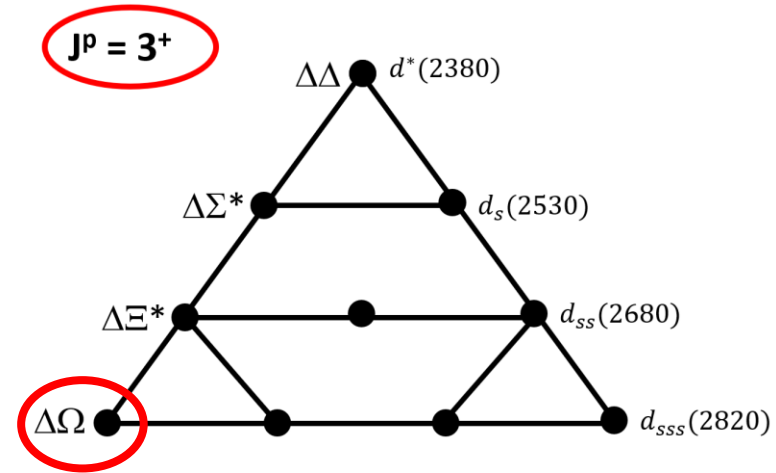
Motivation



- Hadrons are bound quark systems (QCD)
- Several new states have now been found including four-, five- and six-quark states
- Internal structure? (molecule, multiquark, ...)
- Internal structures \leftrightarrow many body effect in QCD
- Hexaquarks \rightarrow equation of state (EOS) of neutron stars

Antidecuplet

- d^* ($uuudd$), SU3 antidecuplet
 - Deuteron ($uudd$)
- Other members of the antidecuplet?
- d_{sss} is the very strange cousin of d^*
- d_{sss} ($dddsss$)

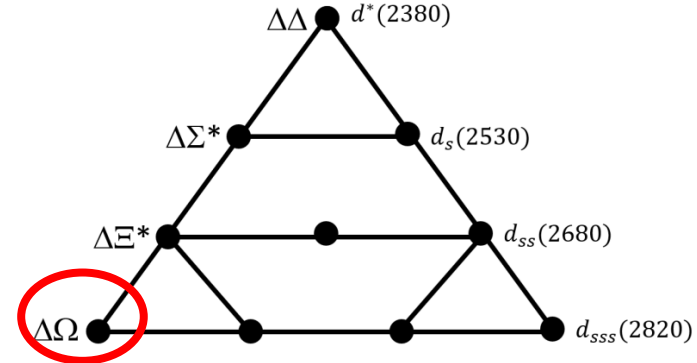
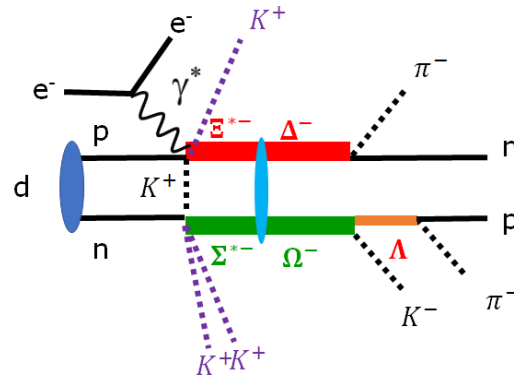
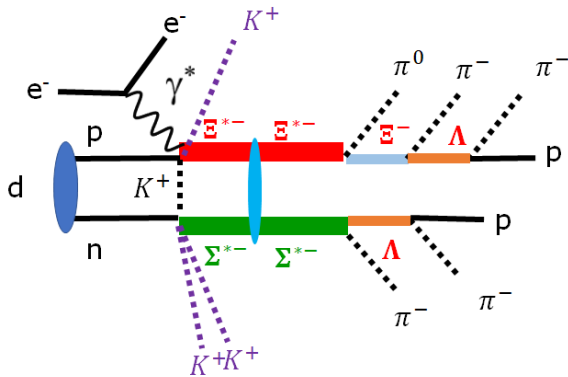
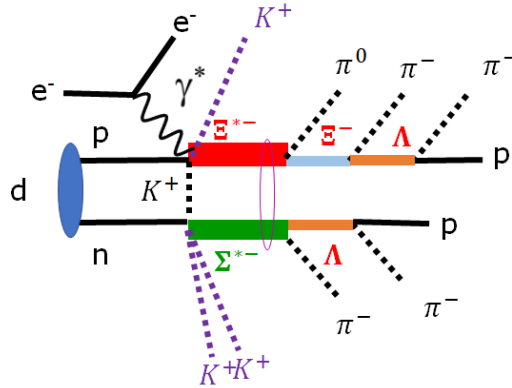


Goals

- Data analysis
 - Investigate d_{SSS} signal
 - Invariant mass distributions \leftrightarrow binding energy
- Monte Carlo simulations will be run with detector responses
 - Better idea of efficiencies
 - Study background contributions
- Observables
 - Mass and Widths
 - Cross sections
 - Angular distributions (spin/parity)

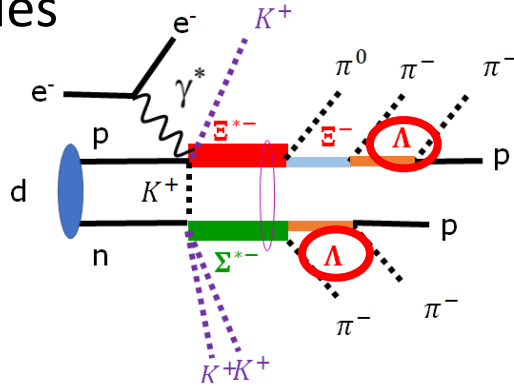
Candidate to study - d_{SSS}

- d_{SSS}^{--} is chosen here as there are no conventional resonant background channels

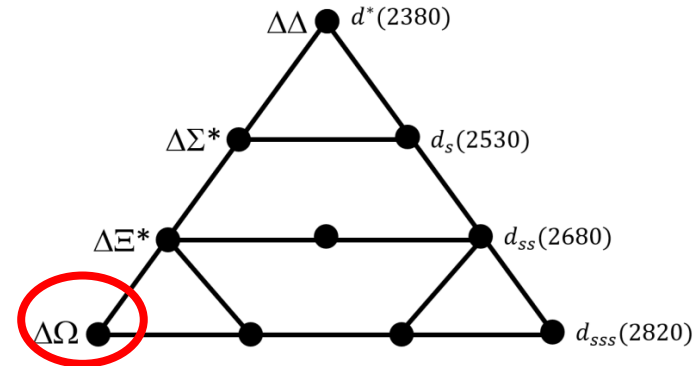
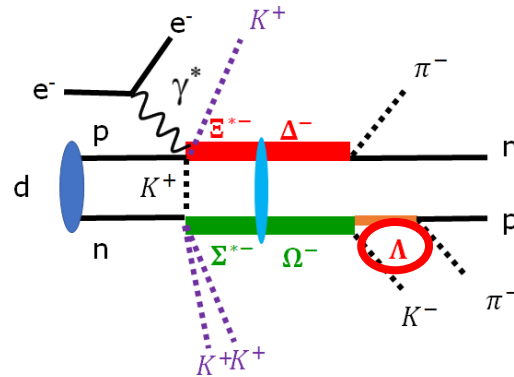
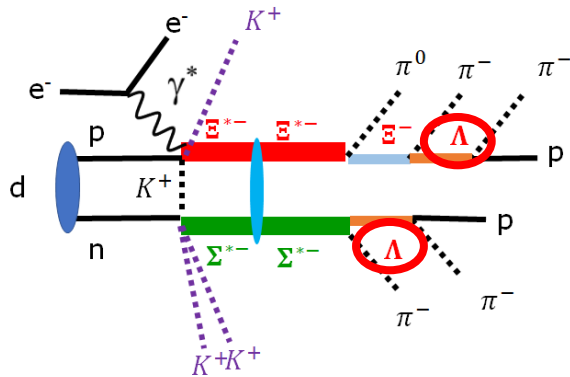


Candidate to study - d_{sss}

- Complex channels with large number of decays and final state particles

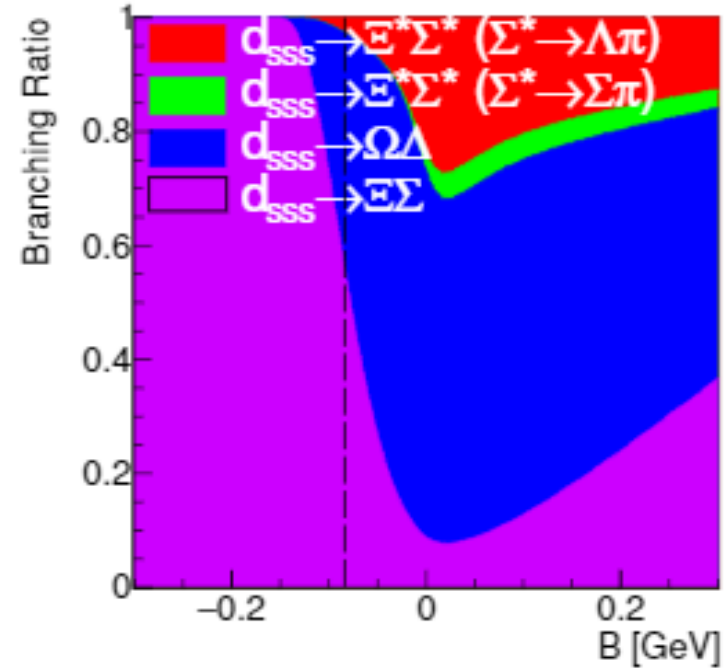
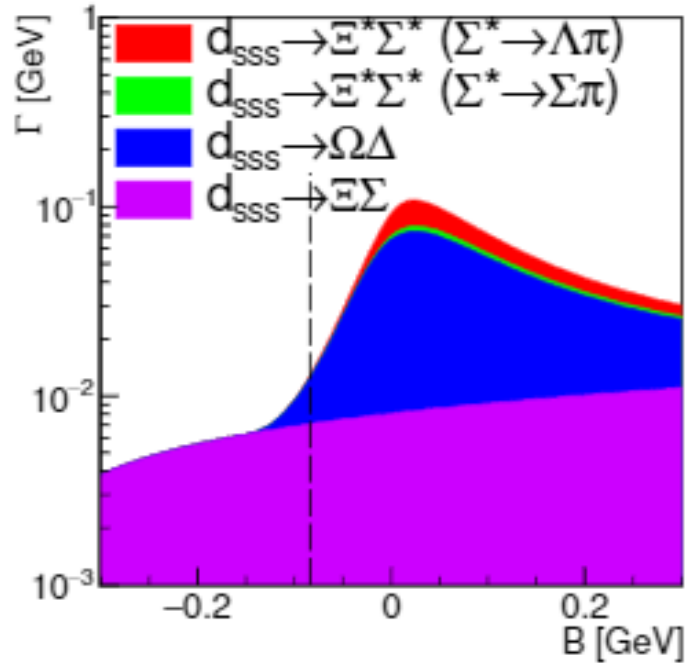


- Lambda identification is crucial!



Candidate to study - d_{SSS}

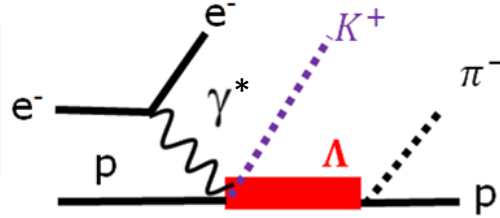
- Simulations performed to better understand decay channels



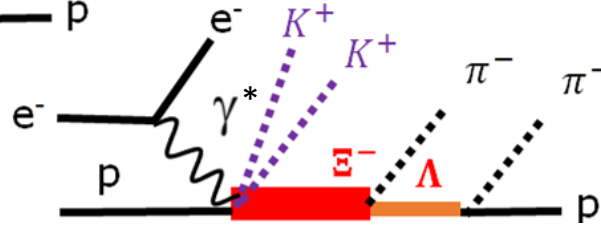
Benchmark Reaction

- Analysis on proton data (previous work)

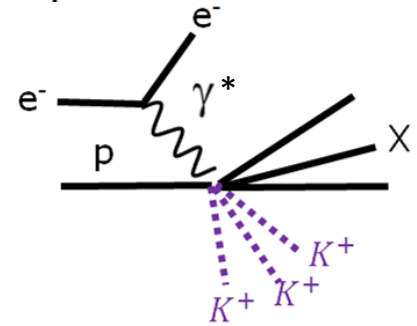
- Strangeness 1



- Strangeness 2

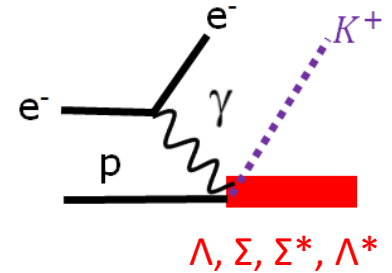
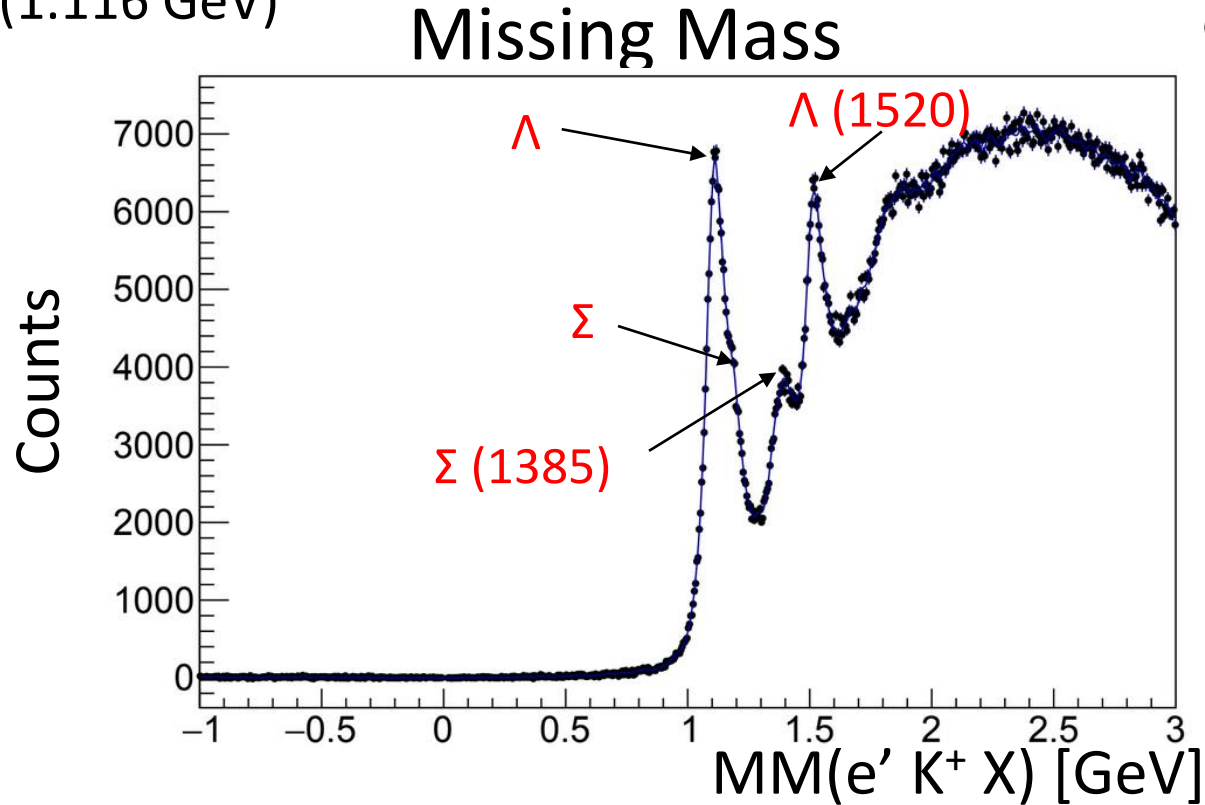


- Strangeness 3



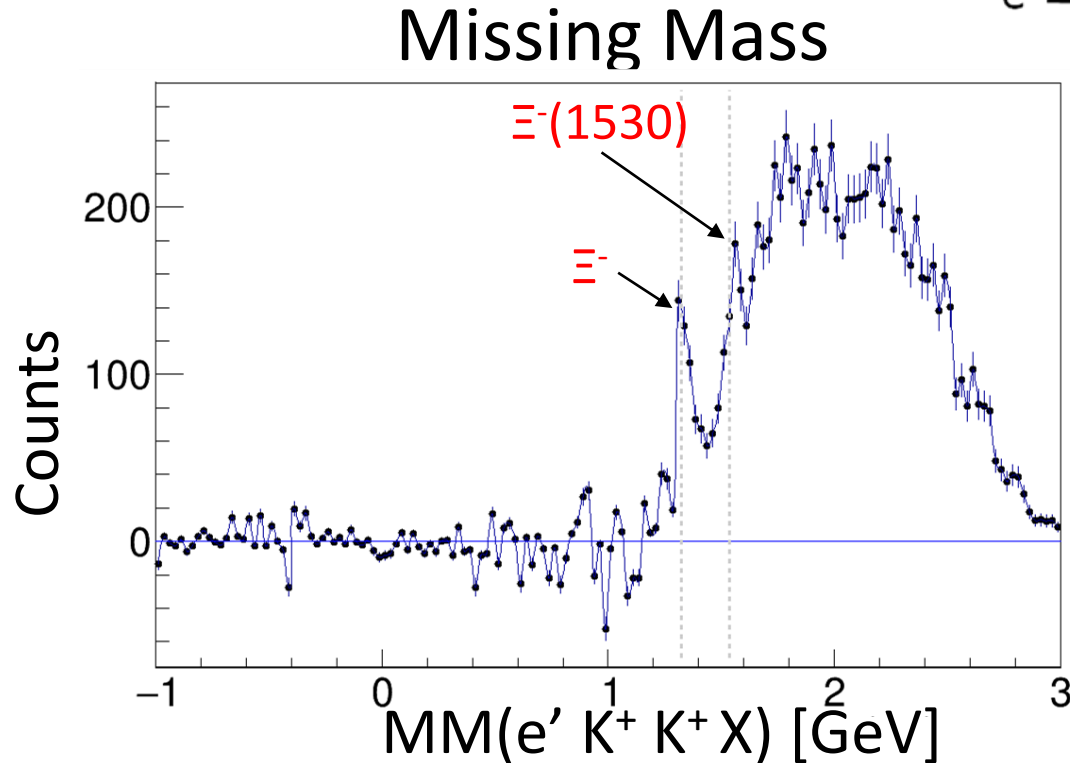
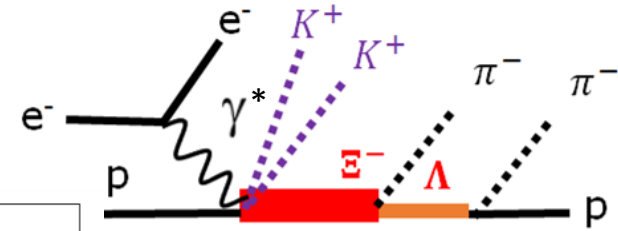
Strangeness 1 Analysis

- Lambda well identified with exclusivity cuts
 Λ (1.116 GeV)



Strangeness 2 Analysis

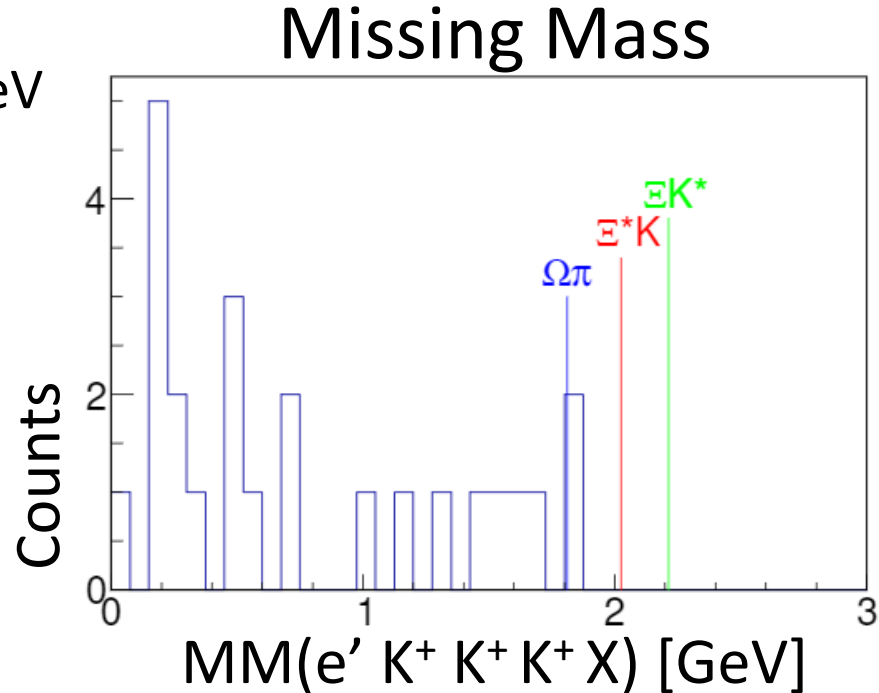
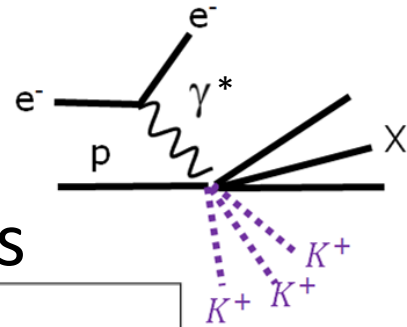
- Cascade well identified (First evidence from CLAS12 collaboration), Ξ^- (1.322 GeV)



Strangeness 3 Analysis



- Very low statistics
- Low Background for this channel
- d_{SSS} signal expected ~ 1.880 GeV
- Initial simulations estimate a width of the order of 15 MeV



	$\Omega\pi$	Ξ^*K	ΞK^*
Threshold, MeV	1811	2024	2213
Width, MeV	0	10	51



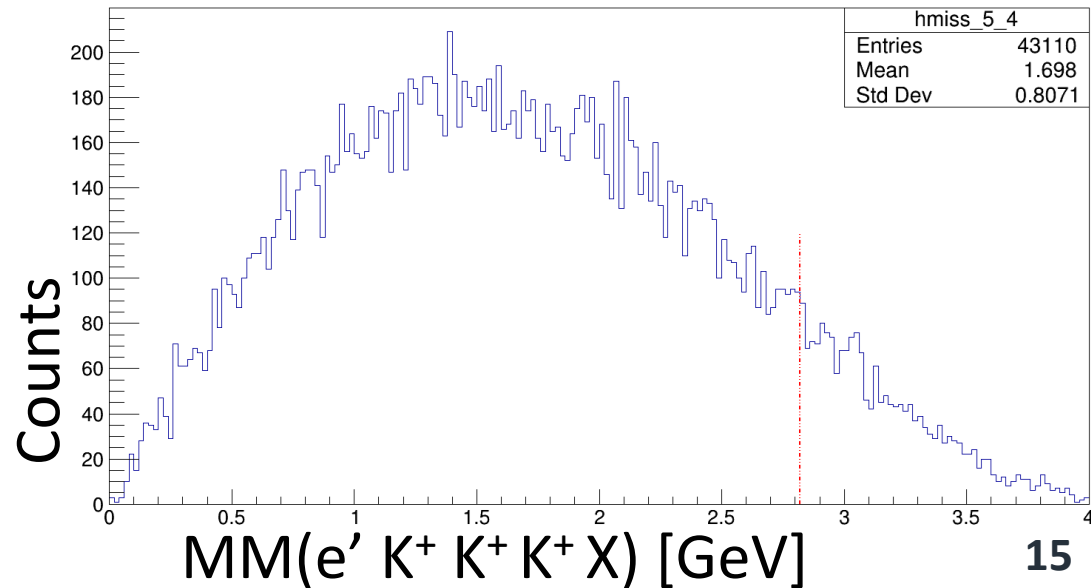
Current Work

Strangeness 3 Analysis



- Analysis performed on deuteron target
- Calibrations and corrections are expected to improve over next year
- Background removal using simulations
- Further methods to clean data are being explored
- Estimate of mass 2.82 GeV

Missing Mass



Conclusion



- Initial analysis of deuteron data shows events in region of possible dsss, further event cleaning needed
- Expected improvement in calibrations should improve resolutions and signal to background ratio

Next Steps

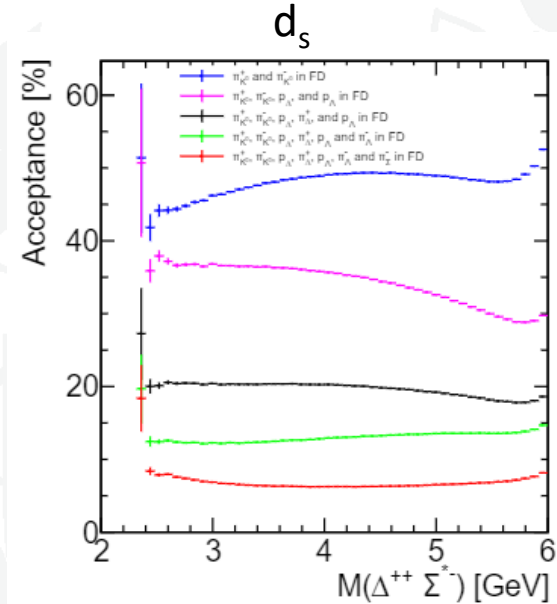
- Further clean 3 K^+ events
- Run simulations to better understand CLAS acceptance and background
- Determine first ever cross section of d_{SSS}



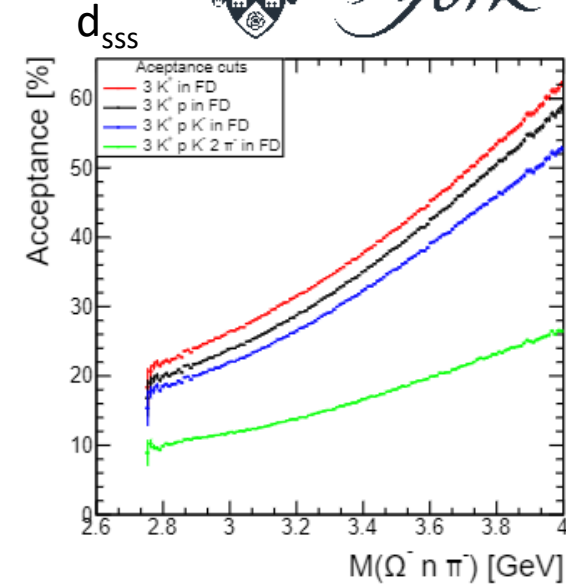
Thank you!

Any Questions?

Simulations performed



- Generated phase space
- Applied weights including:
 - q^2 dependence
 - Breit Wigner



Blue - K^0 in FD
 Pink - K^0 and 2 p in FD
 Black - K^0 , 2 p and π^+ in FD
 Green - K^0 and Δ in FD
 Red - K^0 , Δ and Σ in FD

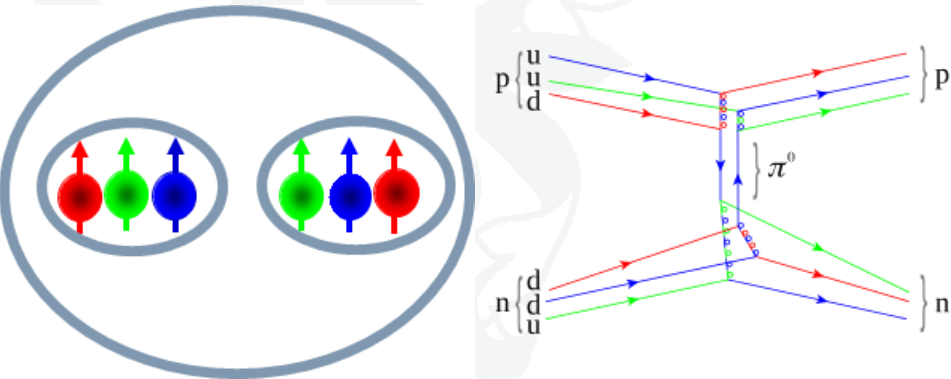
- Plotted acceptance

Red - 3 K^+ in FD
 Black - 3 K^+ and p in FD
 Blue - 3 K^+ , p and K^- in FD
 Green - 3 K^+ , p, K^- and 2 π^- in FD

Internal Structure

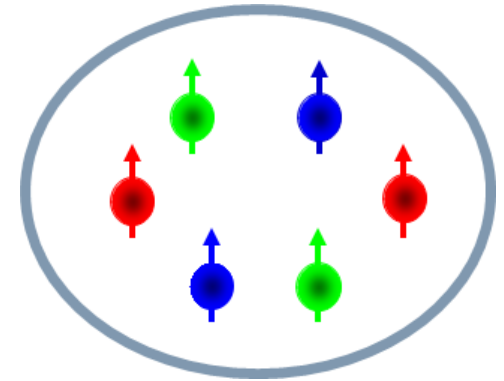
Molecule

- In molecular state pion exchange binds the two baryons together



- More strangeness \rightarrow less binding (pion doesn't couple to strange quarks)

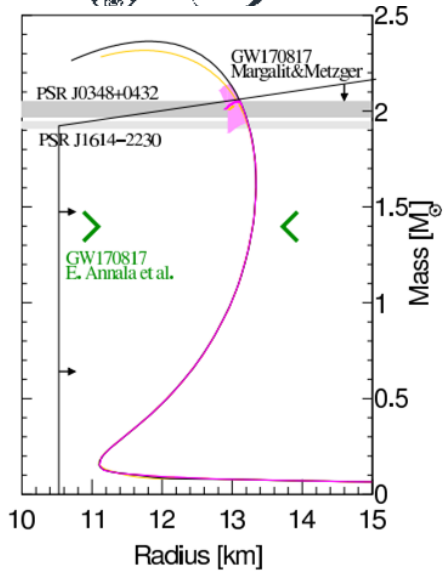
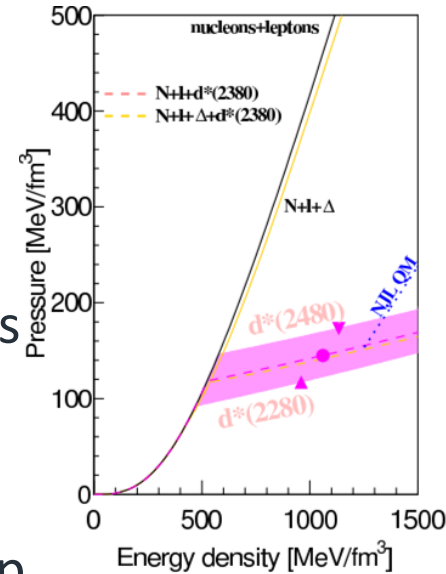
Multiquark



Heavier (more strangeness) \rightarrow stronger binding

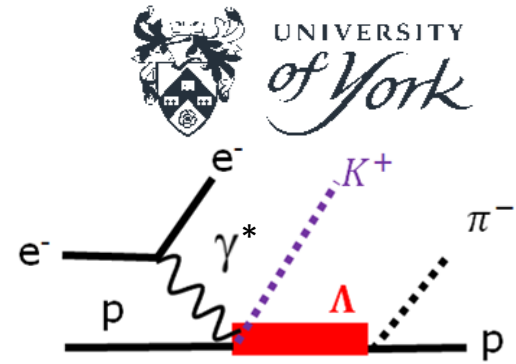
Motivation

- Hexaquarks \rightarrow equation of state (EOS) of neutron stars
- up to 20% in the centre of heavy stars [PLB781, 112, (2018)]
- d^*_{2380} correct mass-radius relationship
- Other members of the $d^*(2380)$ multiplet \rightarrow better understanding

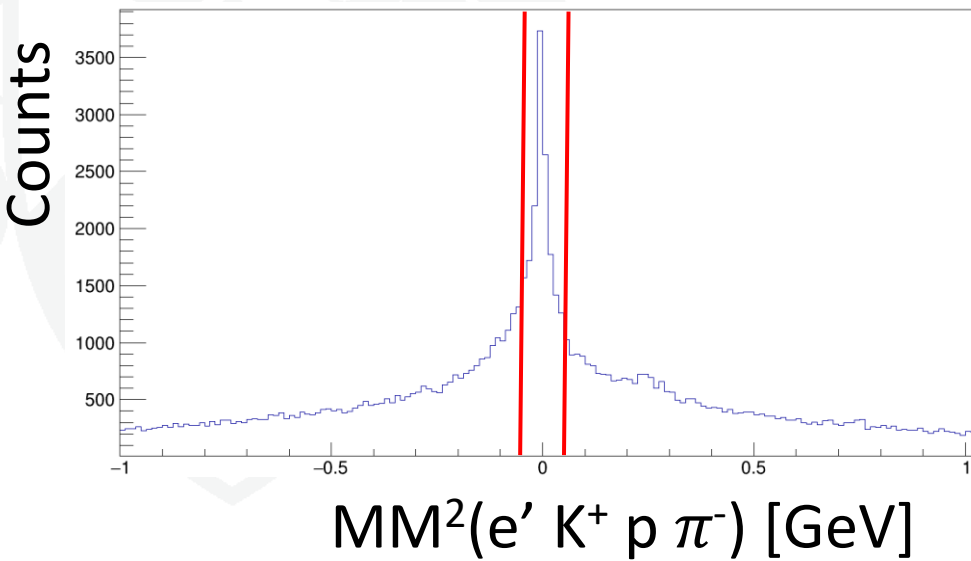


Analysis Process

- Exclusivity cuts



Missing Mass



Missing Momentum

