Search for Very Strange Dibaryon

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17th June 2021

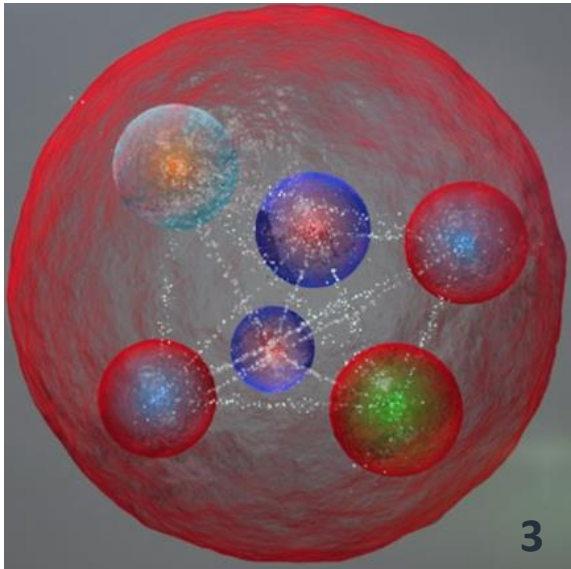
Contents

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

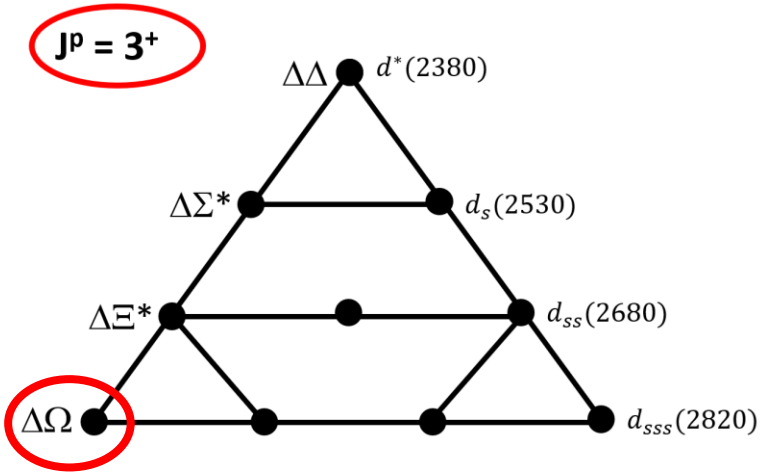


Motivation

- 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 <-> many body effect in QCD
- Hexaquarks -> equation of state (EOS) of neutron stars

Antidecuplet

- d* (uuuddd), SU3 antidecuplet
  - Deuteron (uududd)
- Other members of the antidecuplet?
- d_{sss} is the very strange cousin of d*
- d_{sss} (dddsss)



Goals

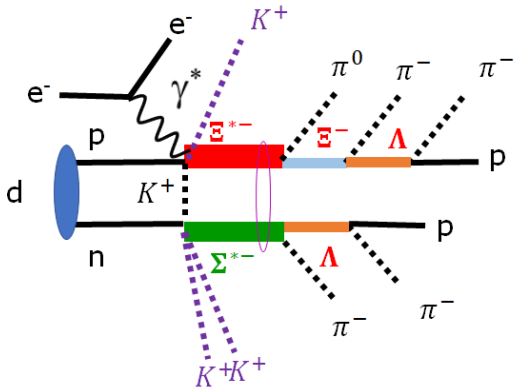
- Data analysis
  - Investigate d_{sss} signal
  - Invariant mass distributions <-> binding energy

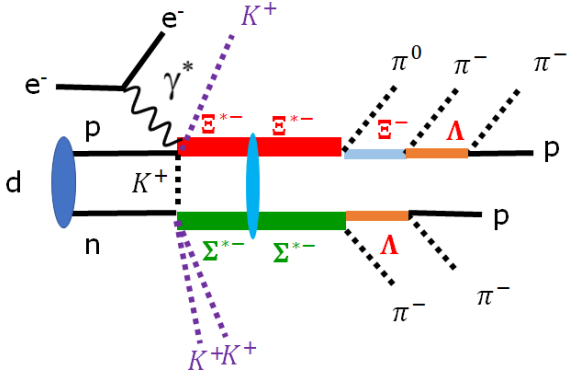
- Monte Carlo simulations will be run with detector responses
  - Better idea of efficiencies
  - Study background contributions

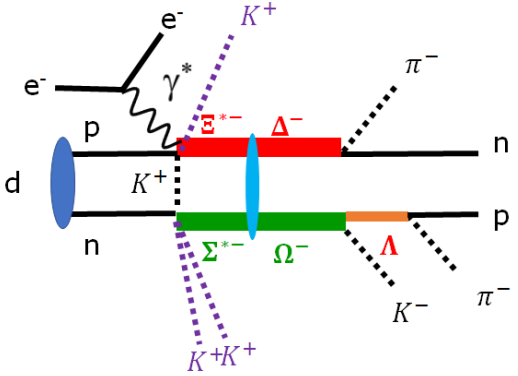
- Observables
  - Mass and Widths
  - Cross sections
  - Angular distributions (spin/parity)

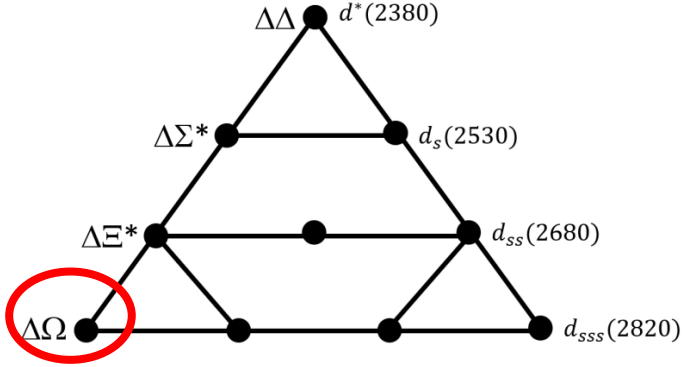
Candidate to study - d_{sss}

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



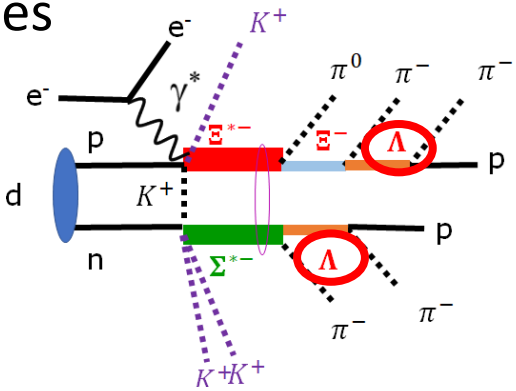




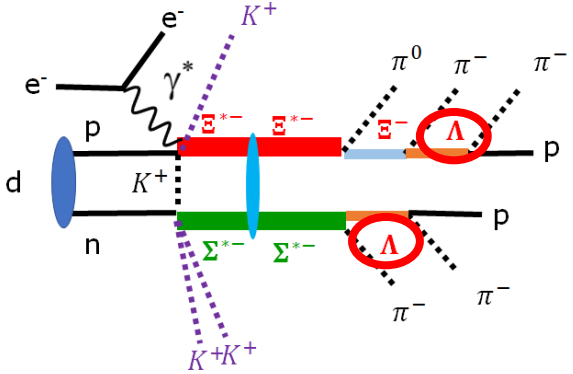


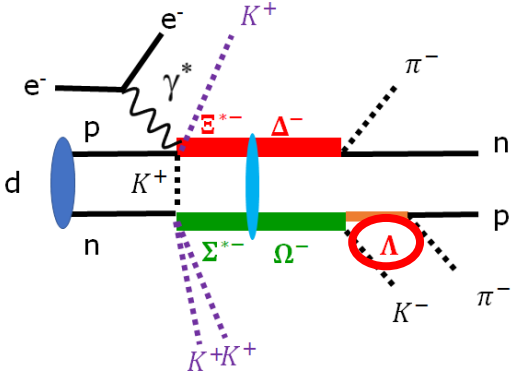
Candidate to study - d_{sss}

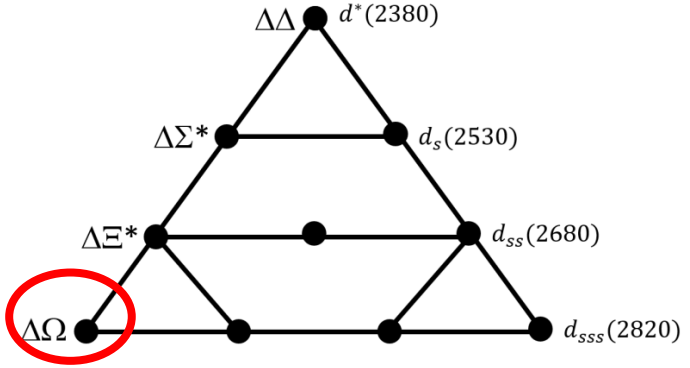
- Complex channels with large number of decays and final state particles



- Lambda identification is crucial!

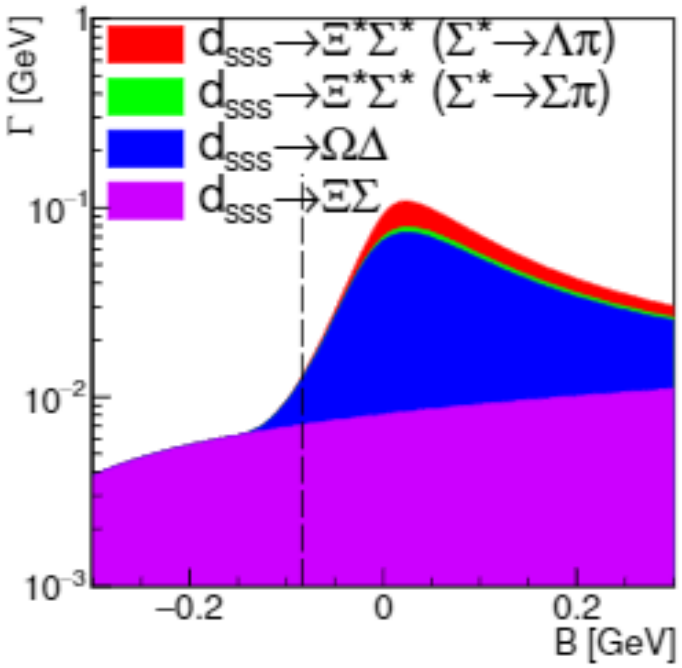


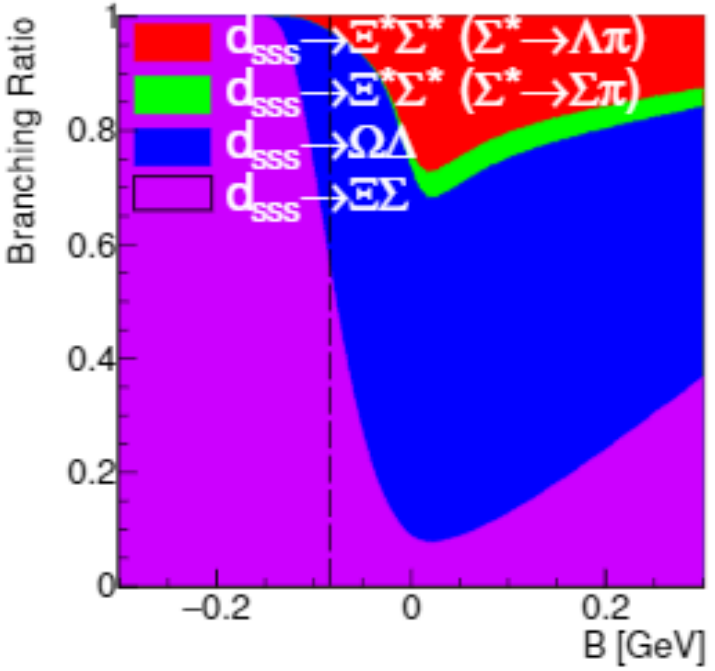




Candidate to study - d_{sss}

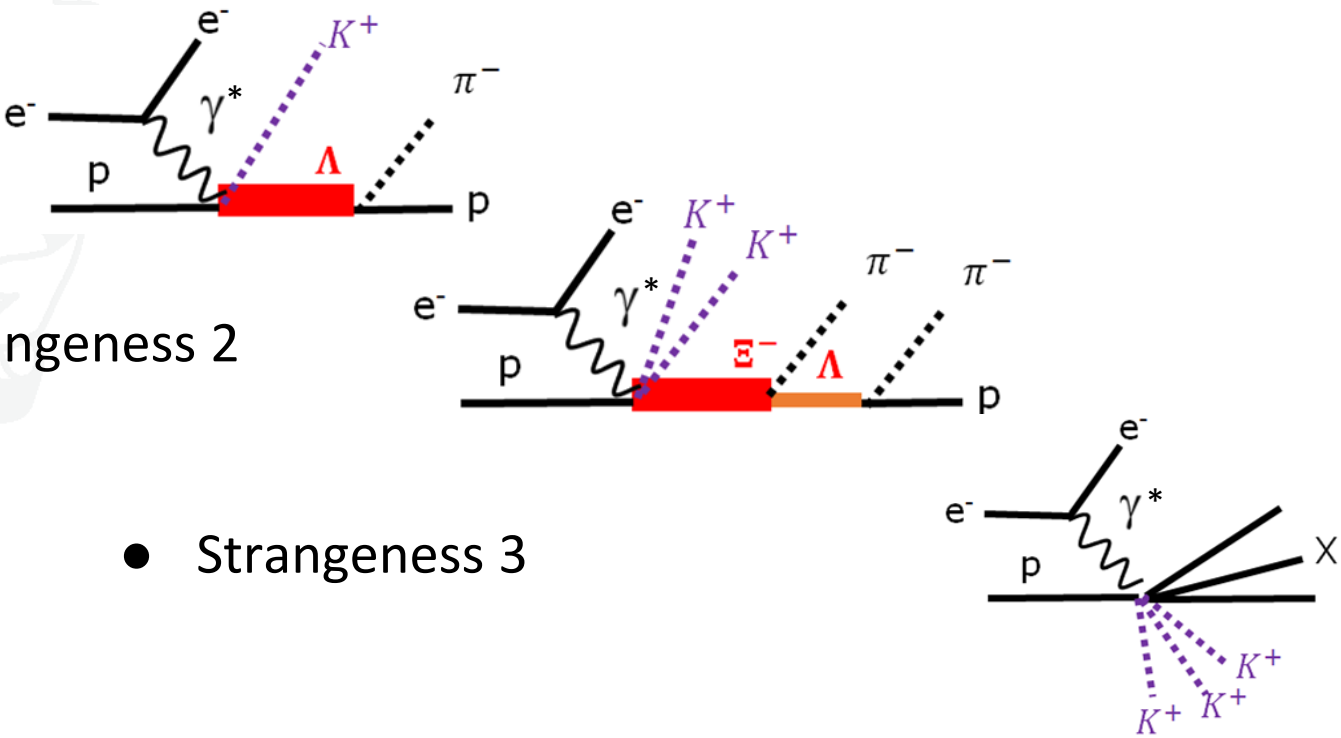
- Simulations performed to better understand decay channels





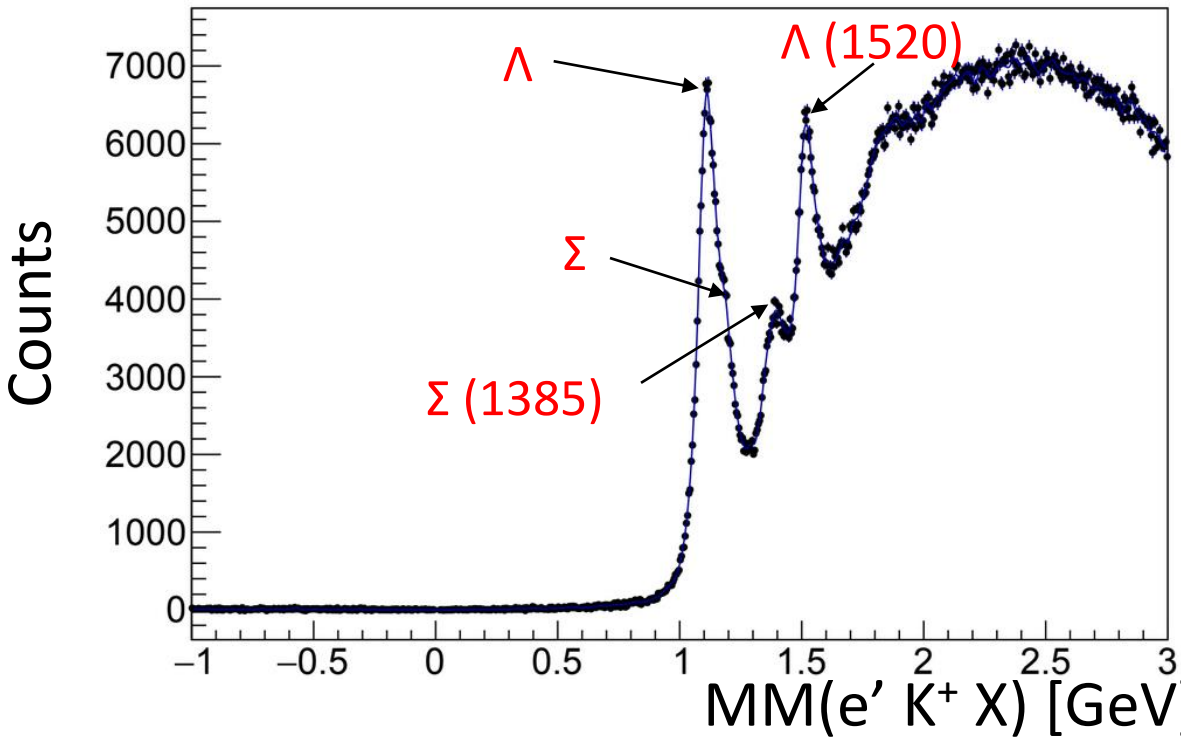
Benchmark Reaction

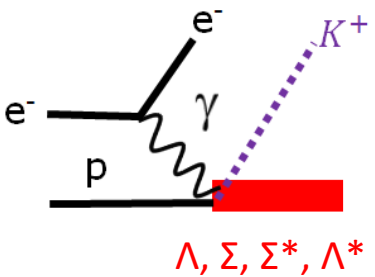
- Analysis on proton data (previous work)
- Strangeness 1
- Strangeness 2
- Strangeness 3



Strangeness 1 Analysis

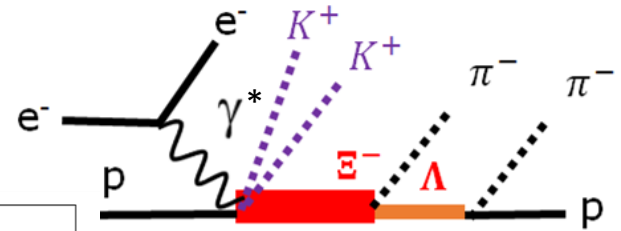
- Lambda well identified with exclusivity cuts
  Λ (1.116 GeV)

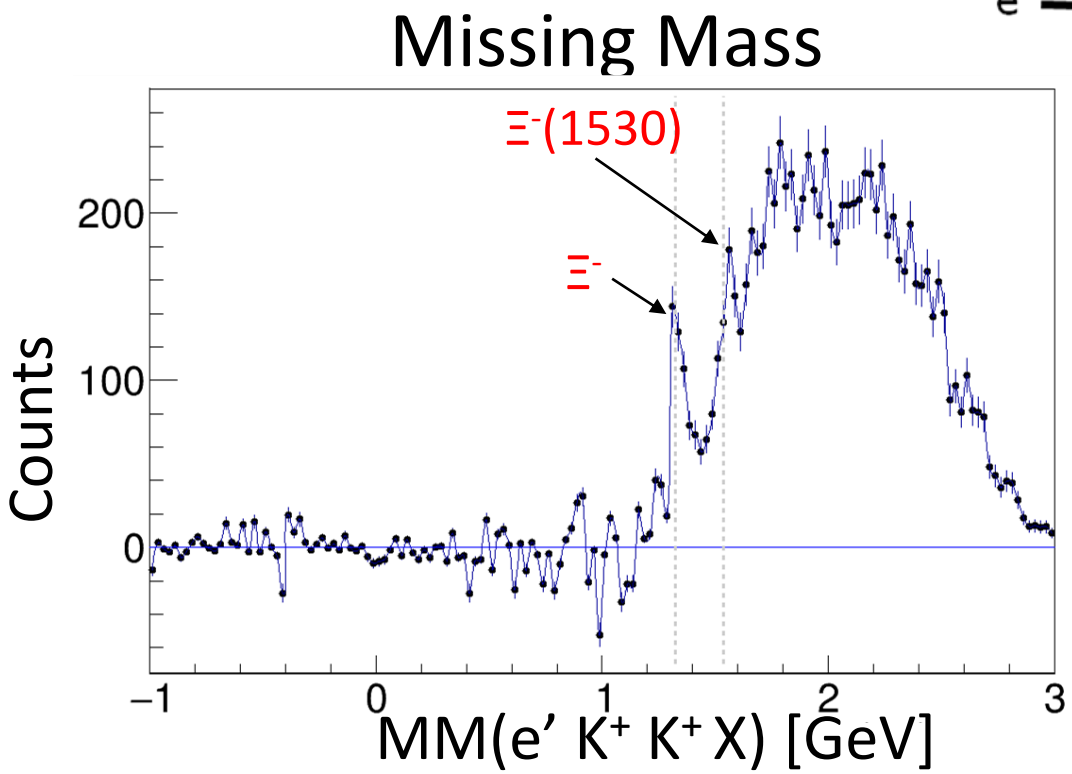




Strangeness 2 Analysis

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

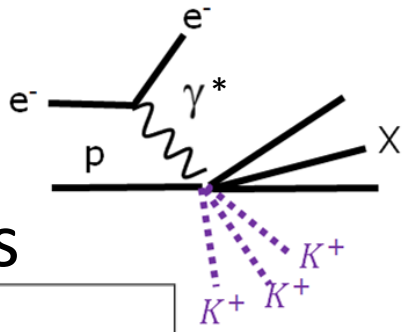




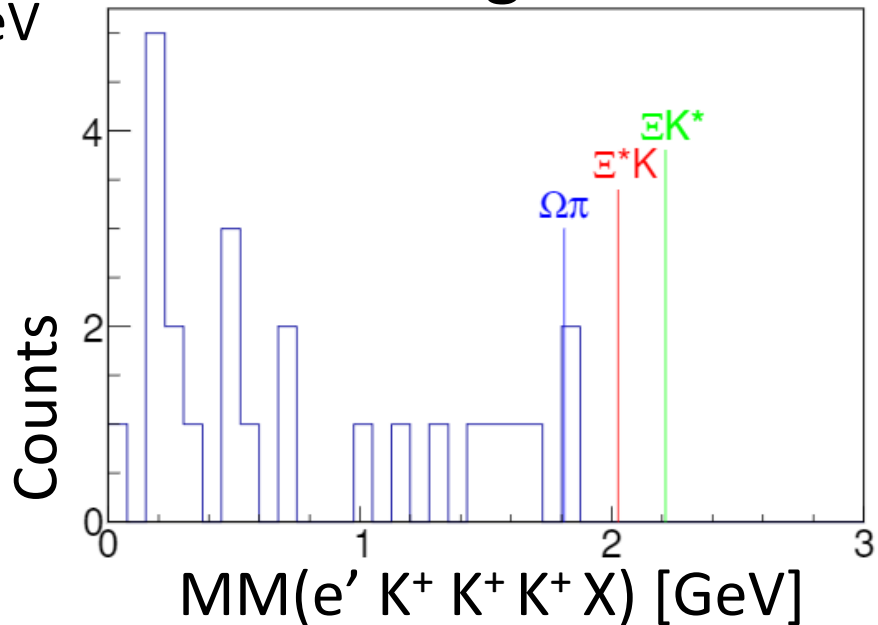
Strangeness 3 Analysis

- 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



Missing Mass

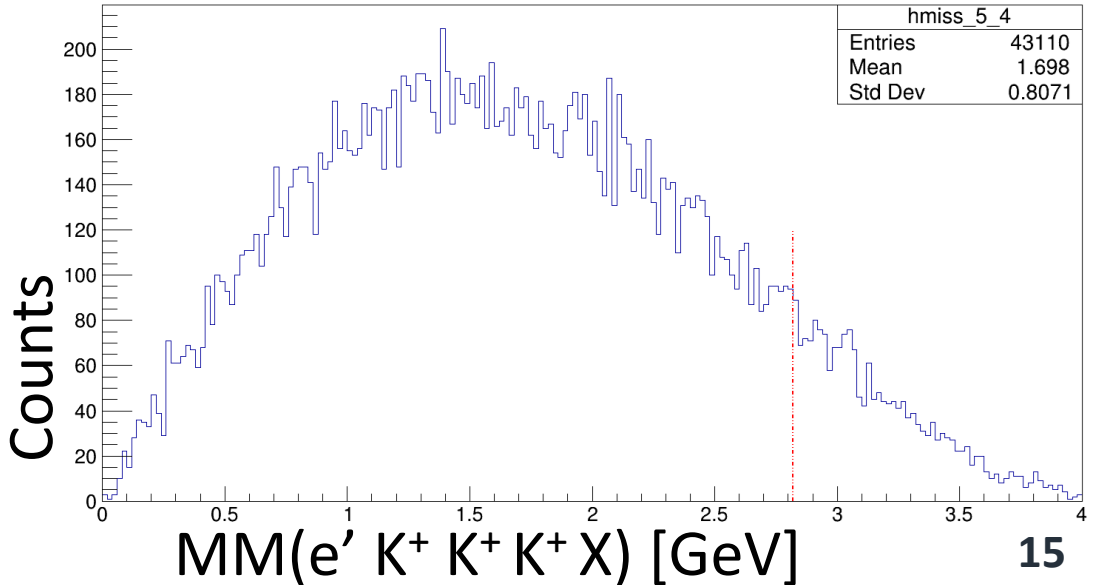


Current Work

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

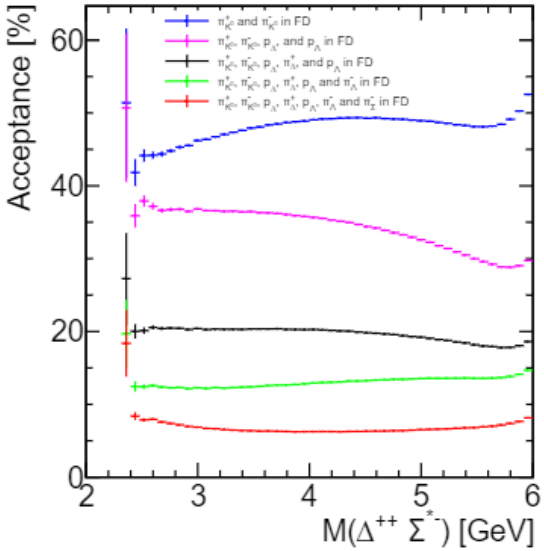
- Expected improvement in calibrations should improve resolutions and signal to background ratio

Next Steps

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

Simulations performed

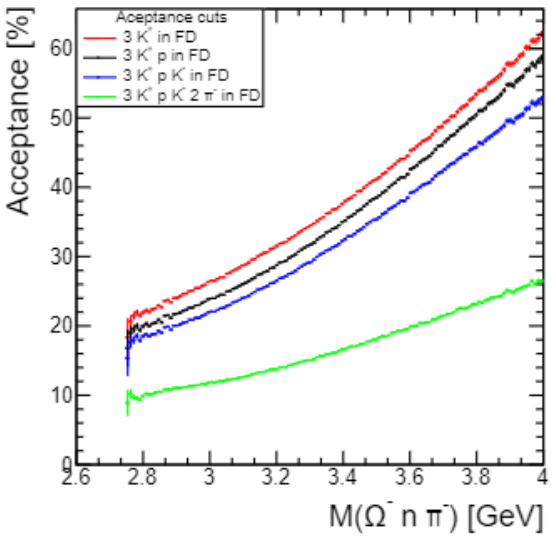
d_s



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

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

d_{sss}

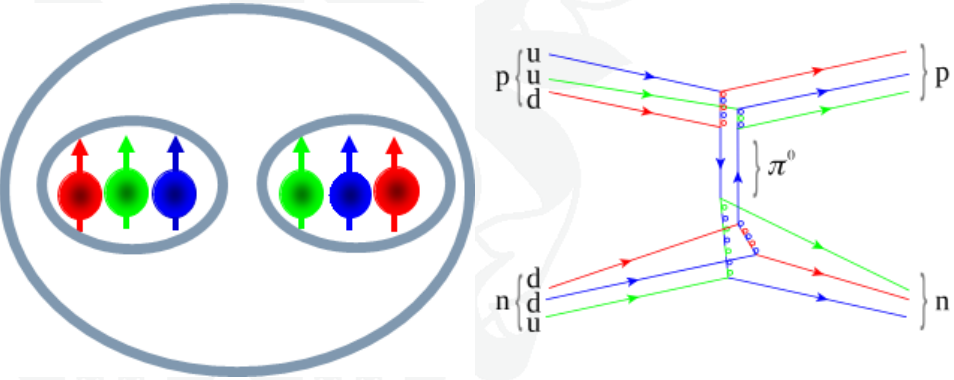


Red - 3 K^+ in FD
Black - 3 K^+ and p in FD
Blue - 3 K^+, p and K^- in FD
Green - 3 K^+, p, K^- and 2 π^- in FD

Internal Structure

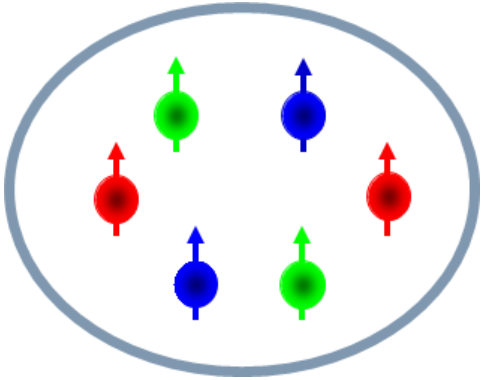
Molecule

- In molecular state pion exchange binds the two baryons together



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

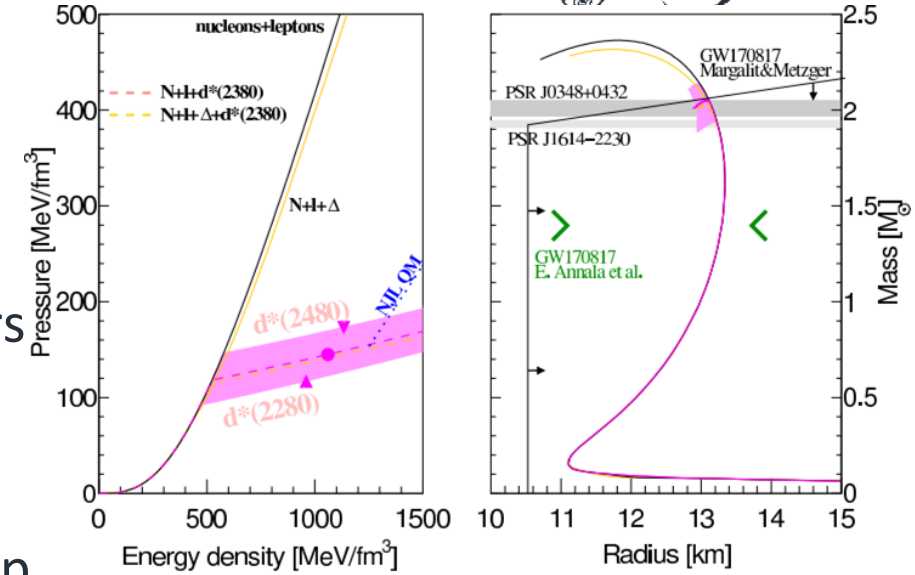
Multiquark



Heavier (more strangeness) -> stronger binding

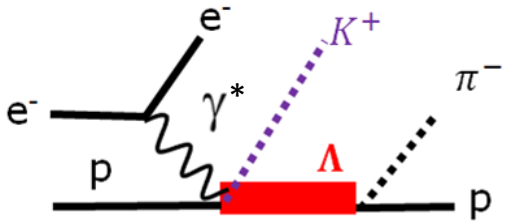
Motivation

- Hexaquarks -> 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 -> better understanding**

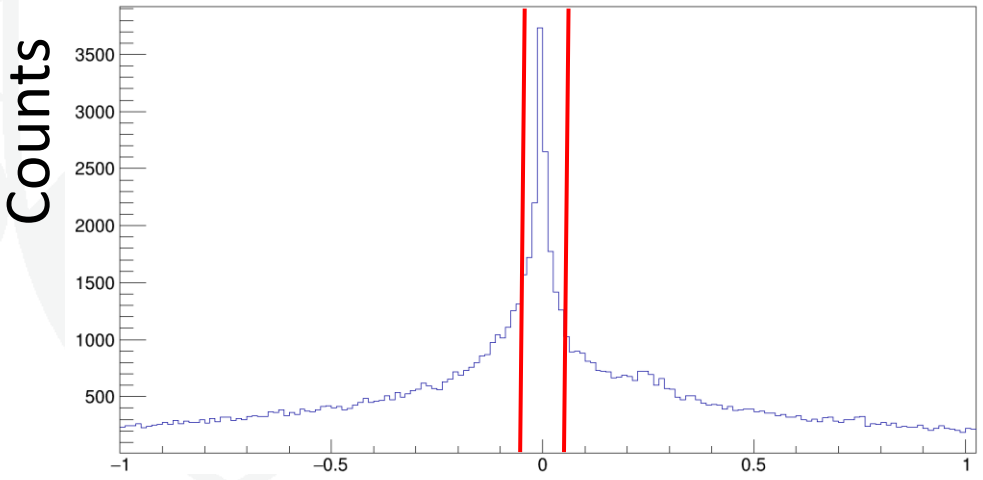


Analysis Process

- Exclusivity cuts

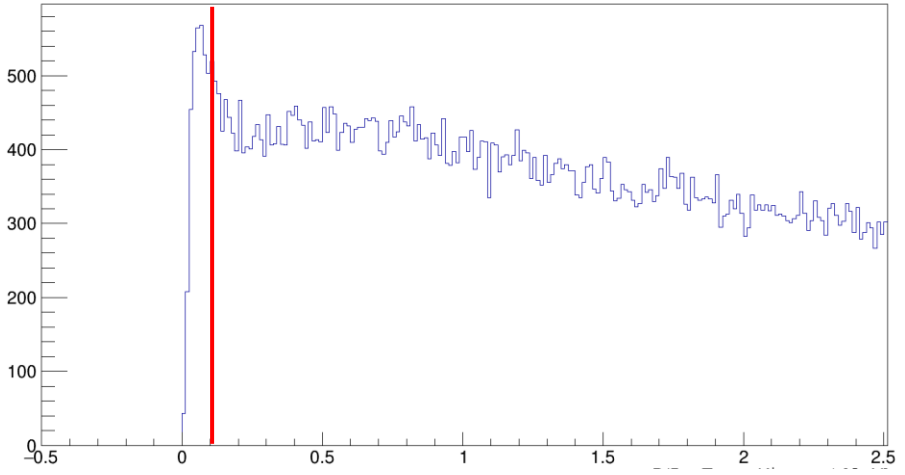


Missing Mass



$MM^2(e' K^+ p \pi^-)$ [GeV]

Missing Momentum



$P(B + T - e' - K^+ - p - \pi^-)$ [GeV]