The “Very strange” experiment at JLAB – preliminary analyses

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(CLAS collaboration)

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Outline

- Very strange programme @CLAS12
  - Brief motivation
  - CLAS12 apparatus
  - NEW Preliminary analyses

- Hyperon-nucleon interactions @CLAS6
  - Brief motivation
  - CLAS6 apparatus
  - Λp elastic scattering cross sections (published)
  - NEW Λd elastic scattering cross sections
  - NEW Σ^+/Σ^- p cross section ratios

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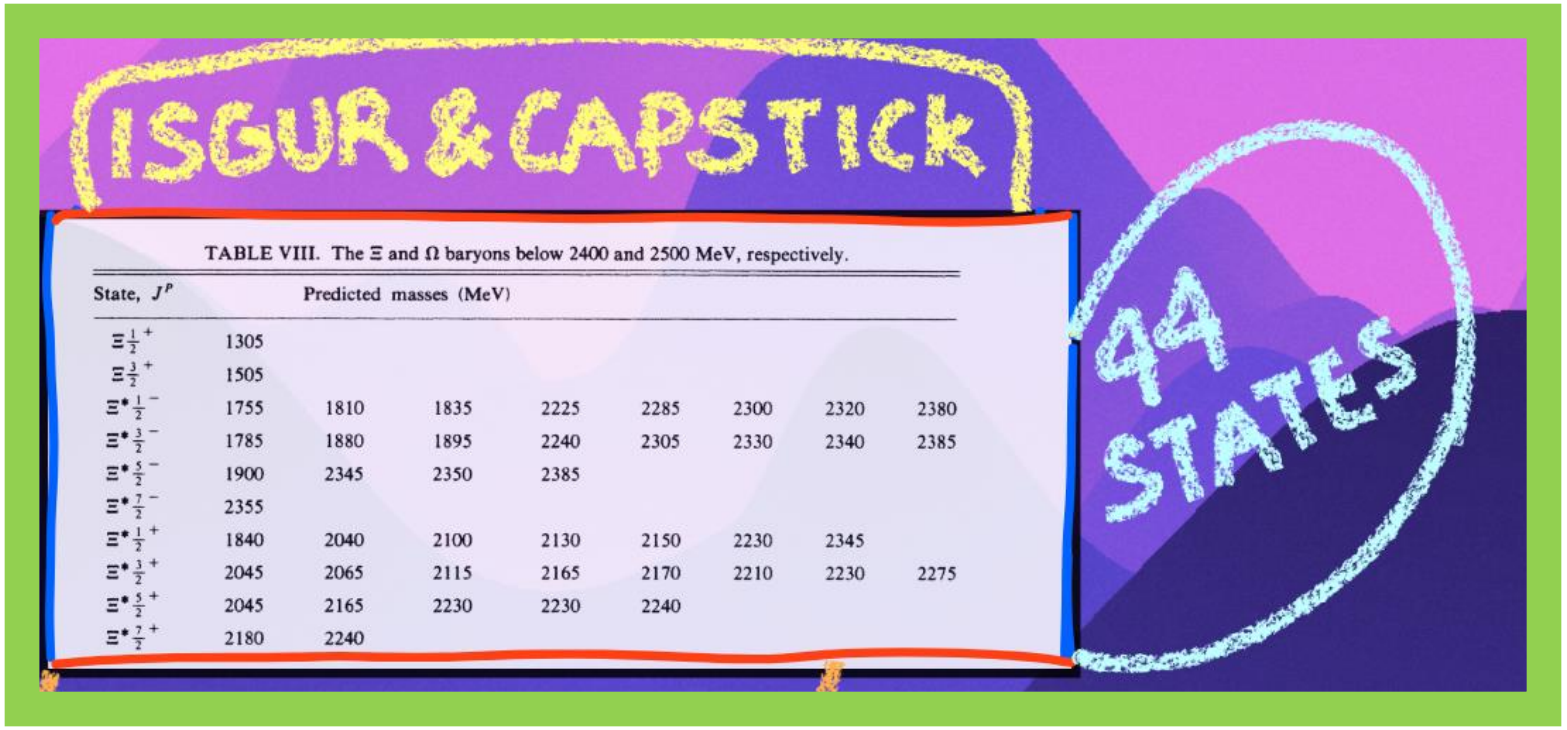
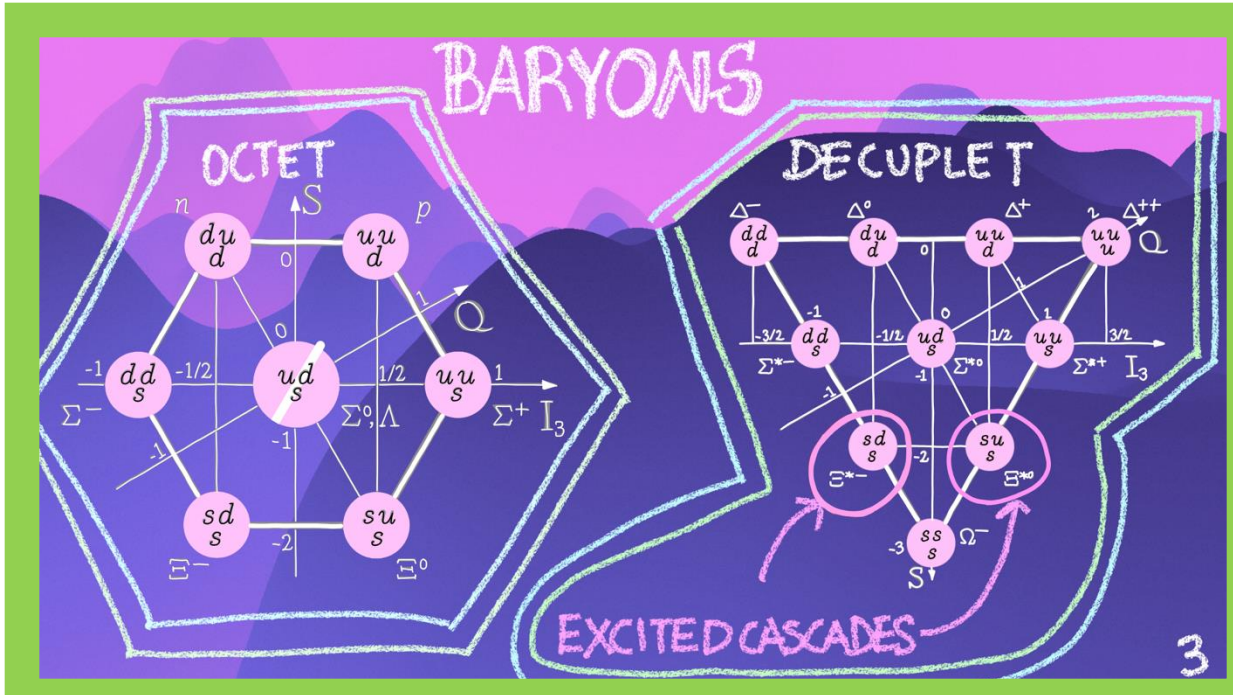
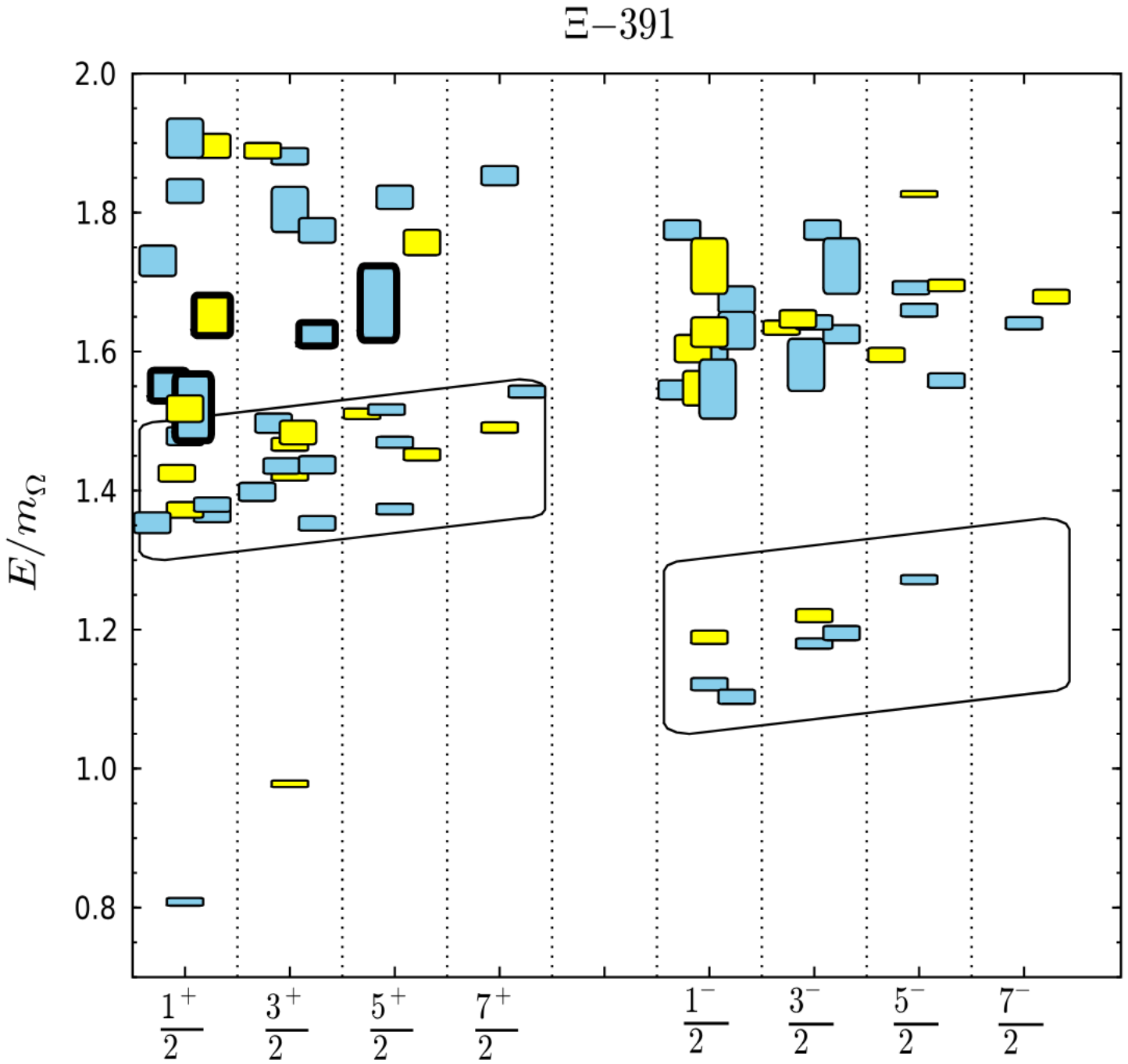
clas



Cascades
-> quark models





Cascades
-> Lattice QCD

PHYSICAL REVIEW D **87,** 054506 (2013)

Flavor structure of the excited baryon spectra from lattice QCD

Robert G. Edwards,[1,*] Nilmani Mathur,[2,†] David G. Richards,[1,‡] and Stephen J. Wallace[3,§]

(Hadron Spectrum Collaboration)

DECUPLET
OCTET

The missing cascade states …

Current Particle	Current Status	Previous Mass	Previous Status	Mass from MPS (MeV)
$\Xi(1318)$	****	1320	****	1320 ± 6
$\Xi(1530)$	****	1530	****	1541 ± 12
$\Xi(1620)$	*	1630	**	
$\Xi(1690)$	***	1680	**	
$\Xi(1820)$	***	1820	***	1822 ± 6
$\Xi(1950)$	***	1940	**	
$\Xi(2030)$	***	2030	***	2022 ± 7
$\Xi(2120)$	*	2120	*	
$\Xi(2250)$	**	2250	*	2214 ± 5
$\Xi(2370)$	**	2370	**	2356 ± 10
$\Xi(2500)$	*	2500	**	2505 ± 10

Now **1981**

6 excited states in PDG

Not much progress in past 4 decades

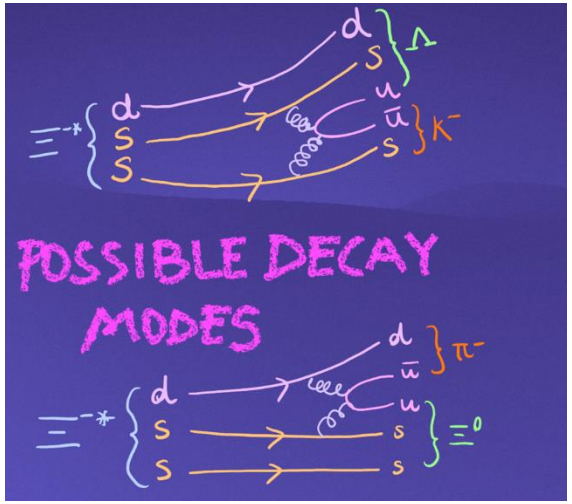
Paucity of BR determinations

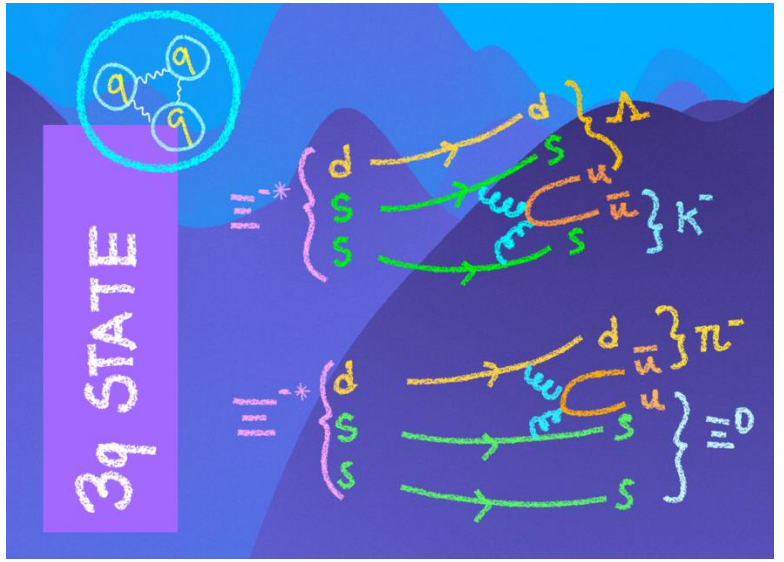
Ξ(1690)

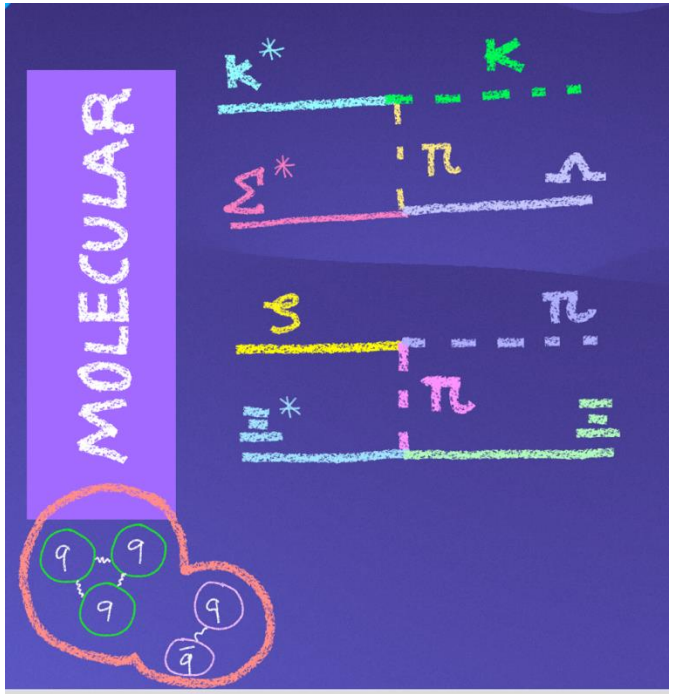
$I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1690 \pm 10$ MeV [c]
Full width $\Gamma < 30$ MeV

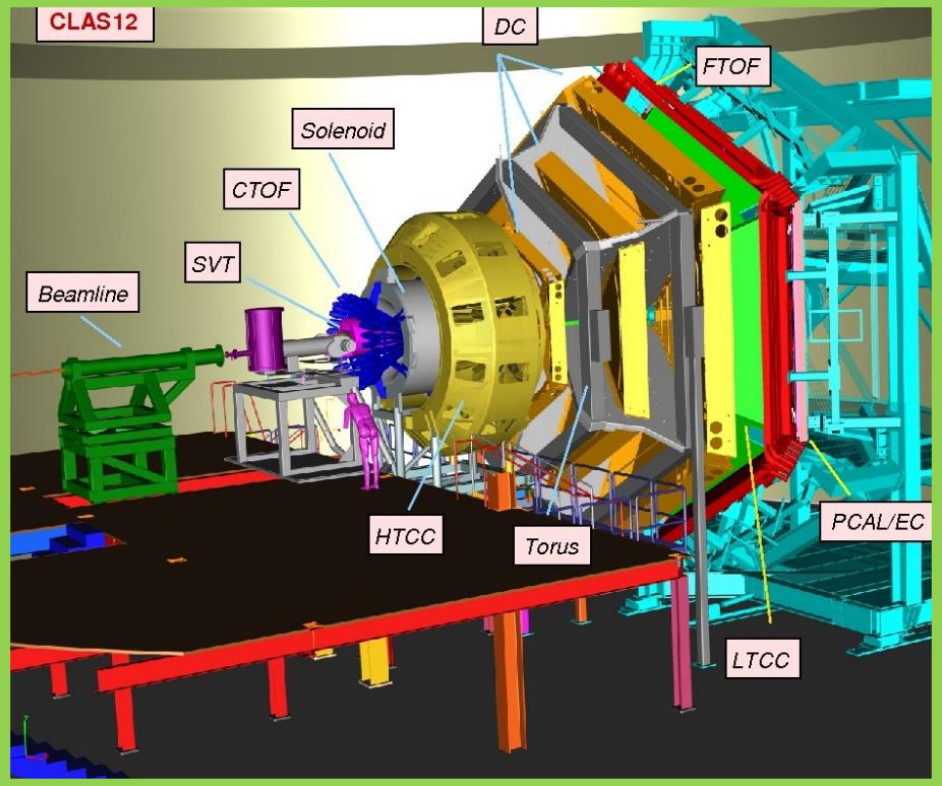
Ξ(1690) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	240
$\Sigma\overline{K}$	seen	70
$\Xi\pi$	seen	311
$\Xi^-\pi^+\pi^-$	possibly seen	213



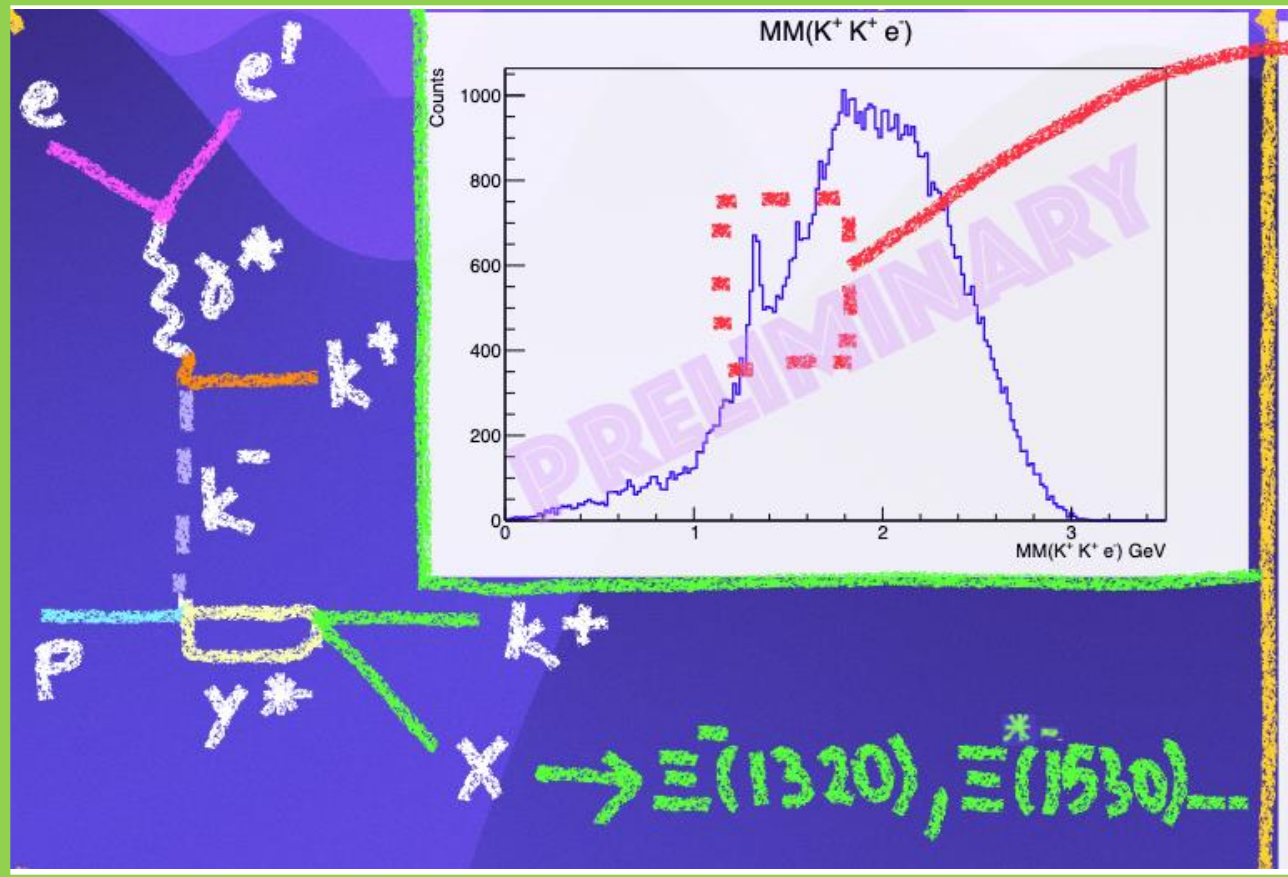


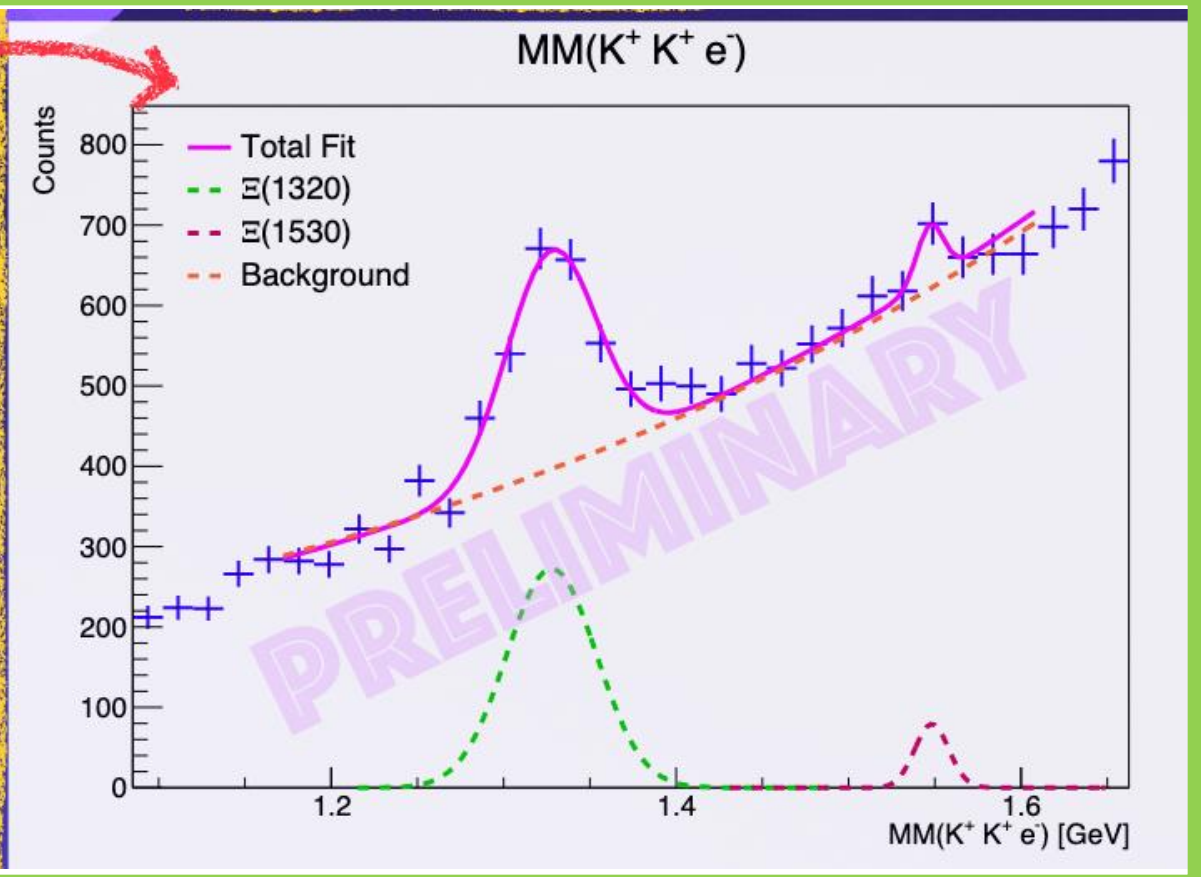


CLAS12@Jefferson Lab



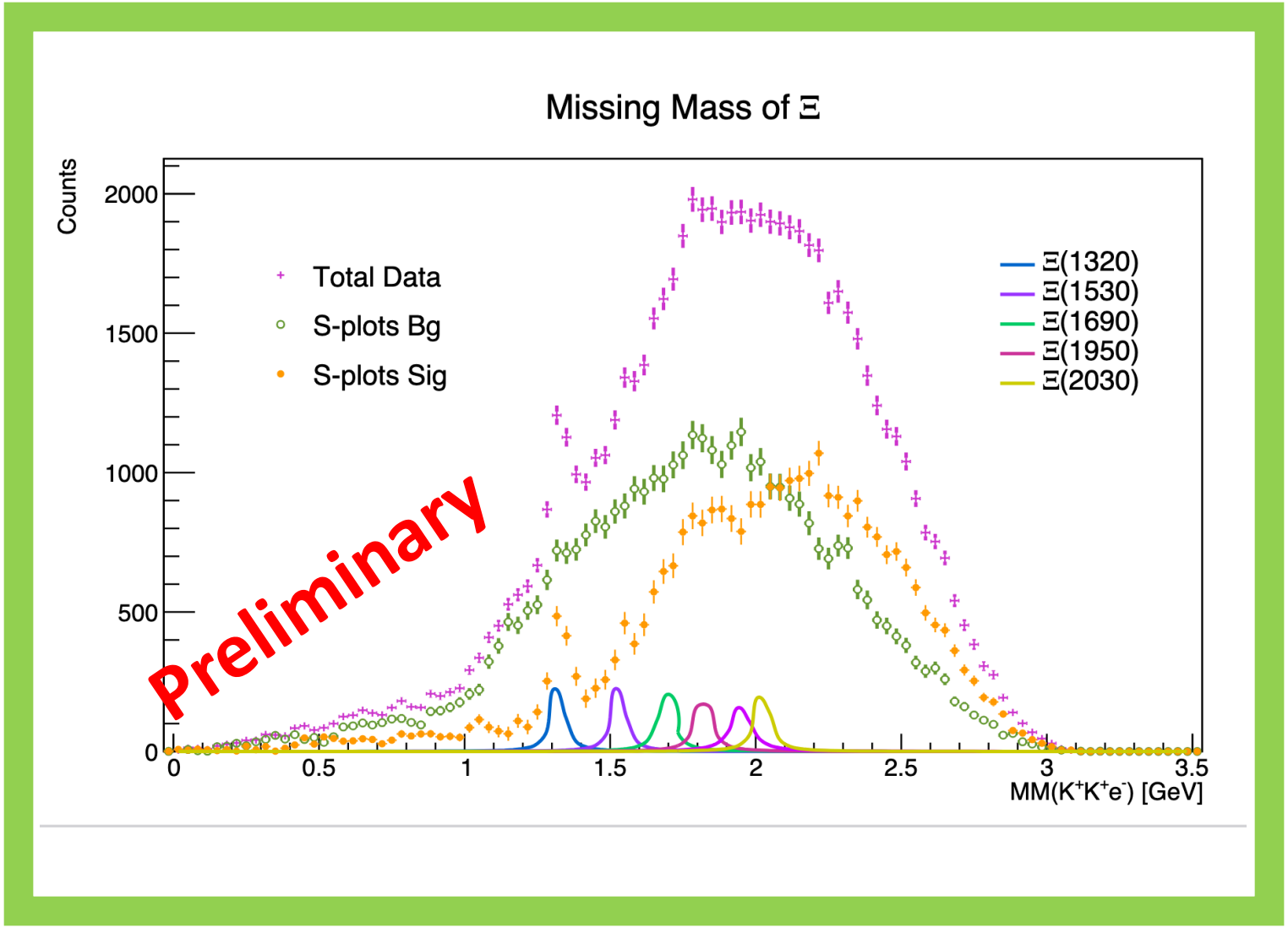
Forward detector (FD) data $K^+K^+(X)$





PhD analysis (Acar) – York (1/4 of available data)

FD data $K^+K^+(X)$ with background subtraction



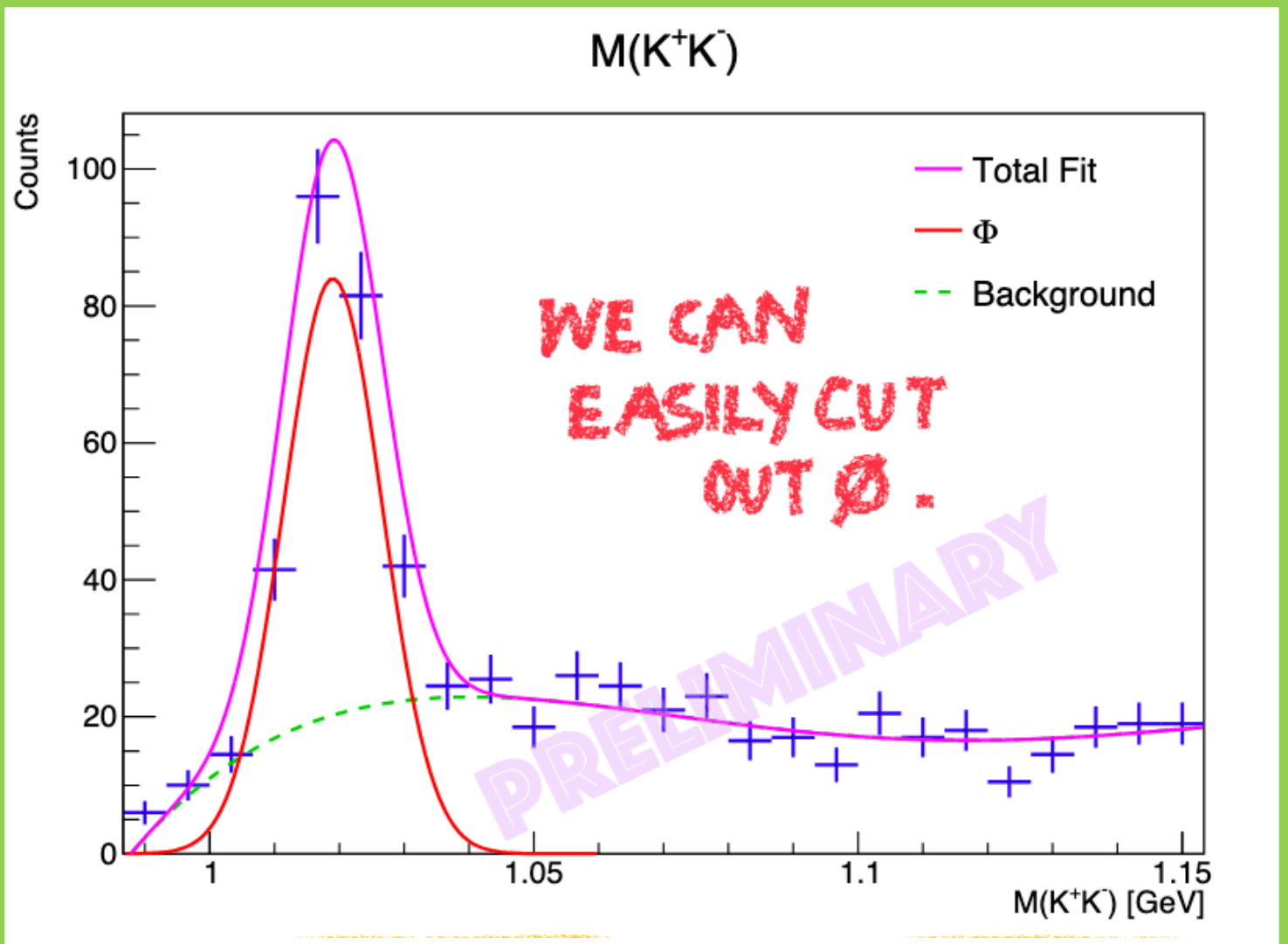
Unphysical Backgrounds

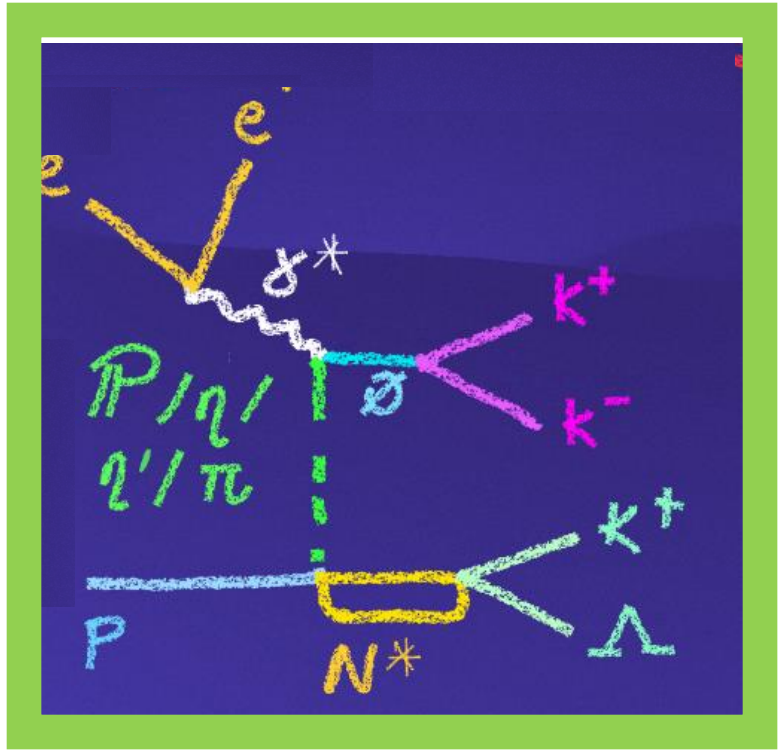
K/π separation
Out of time particles

Also **physical backgrounds** can be assessed and suppressed e.g. phi

PhD analysis (Acar) – York (1/4 of available data)

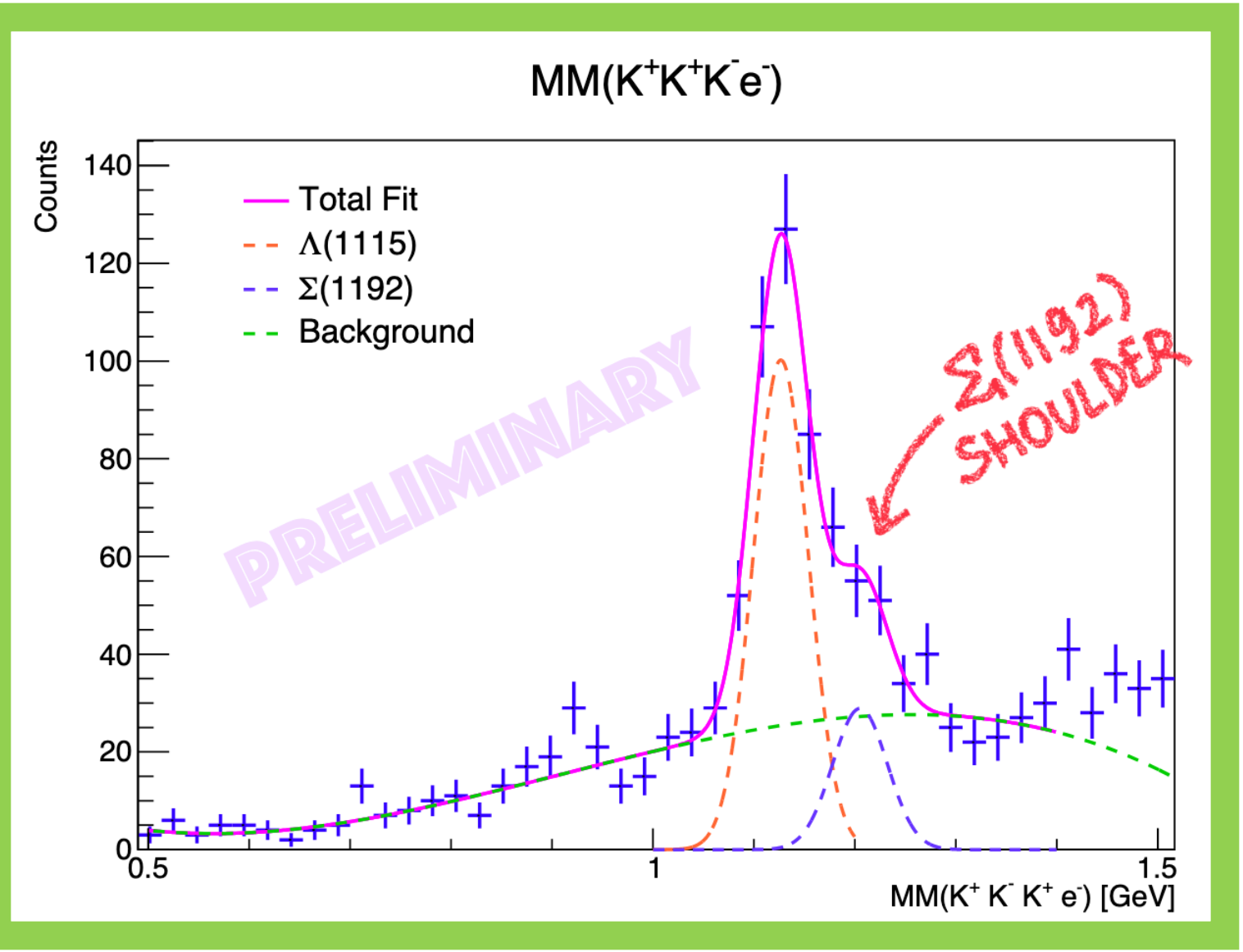
FD data $K^+K^+K^-(\mathbf{X})$ – ϕ background

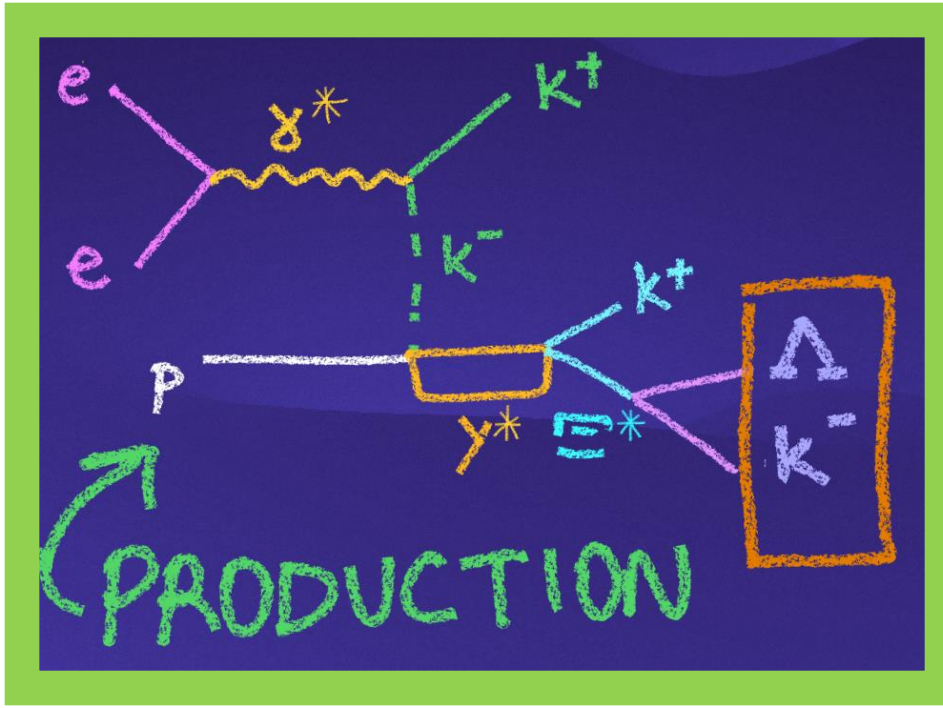




PhD analysis (Acar) – York (1/4 of available data)

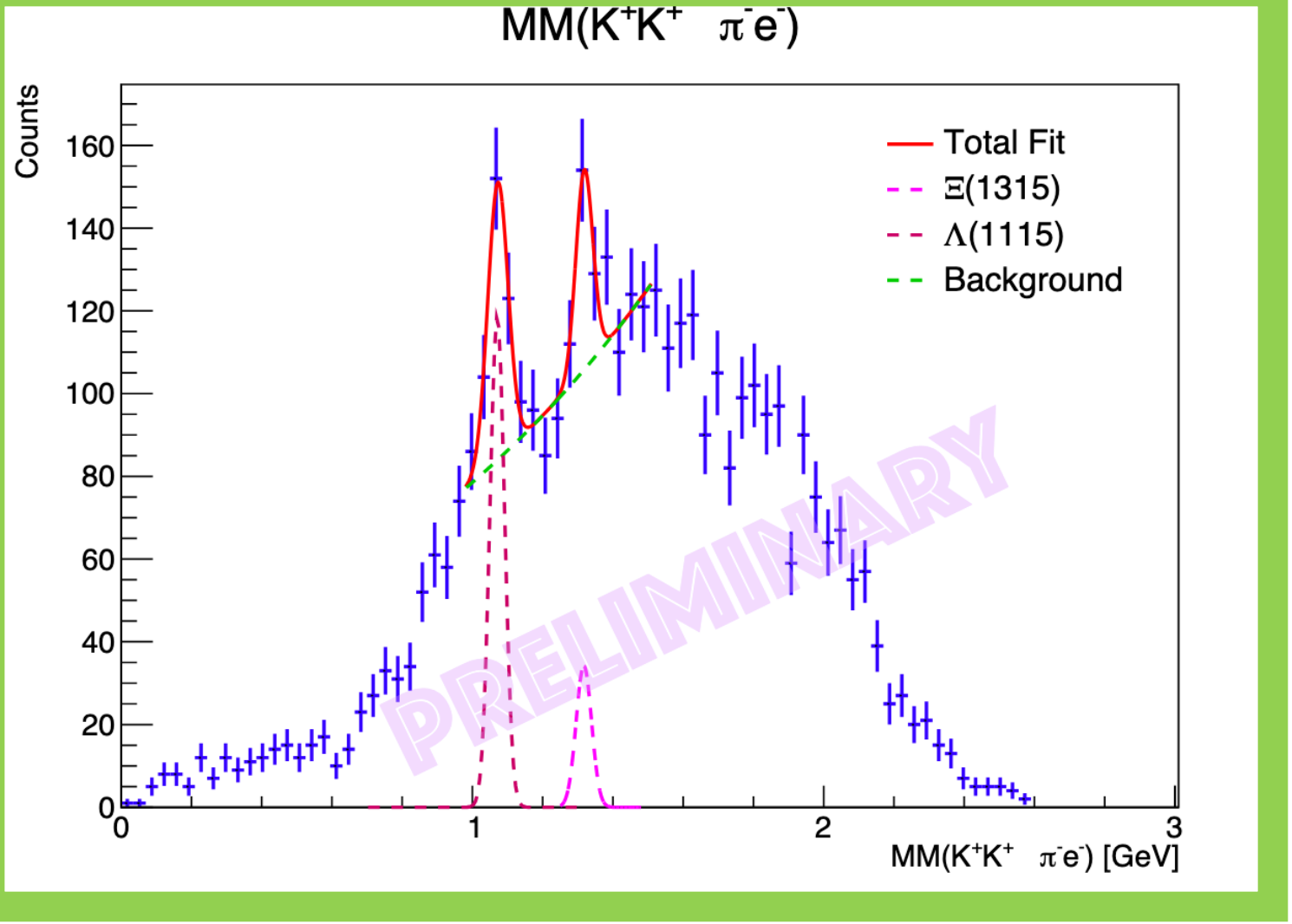
FD data $K^+K^+K^-(X)$ channel

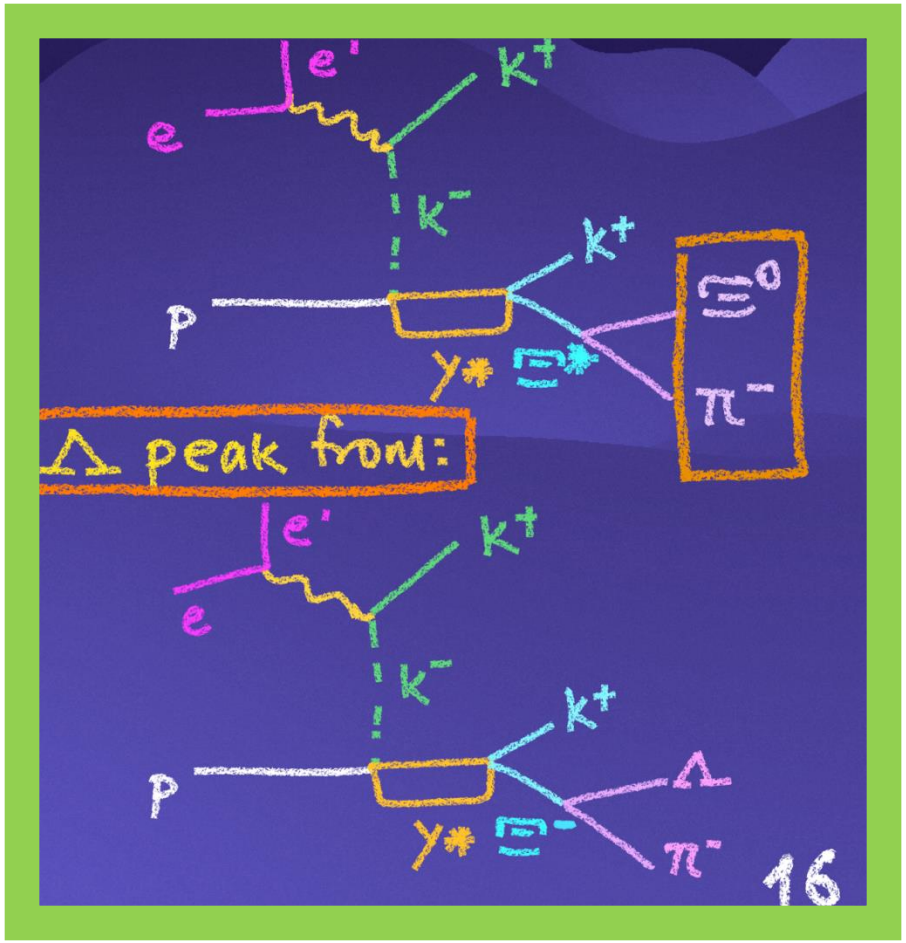




PhD analysis (Acar) – York (1/4 of available data)

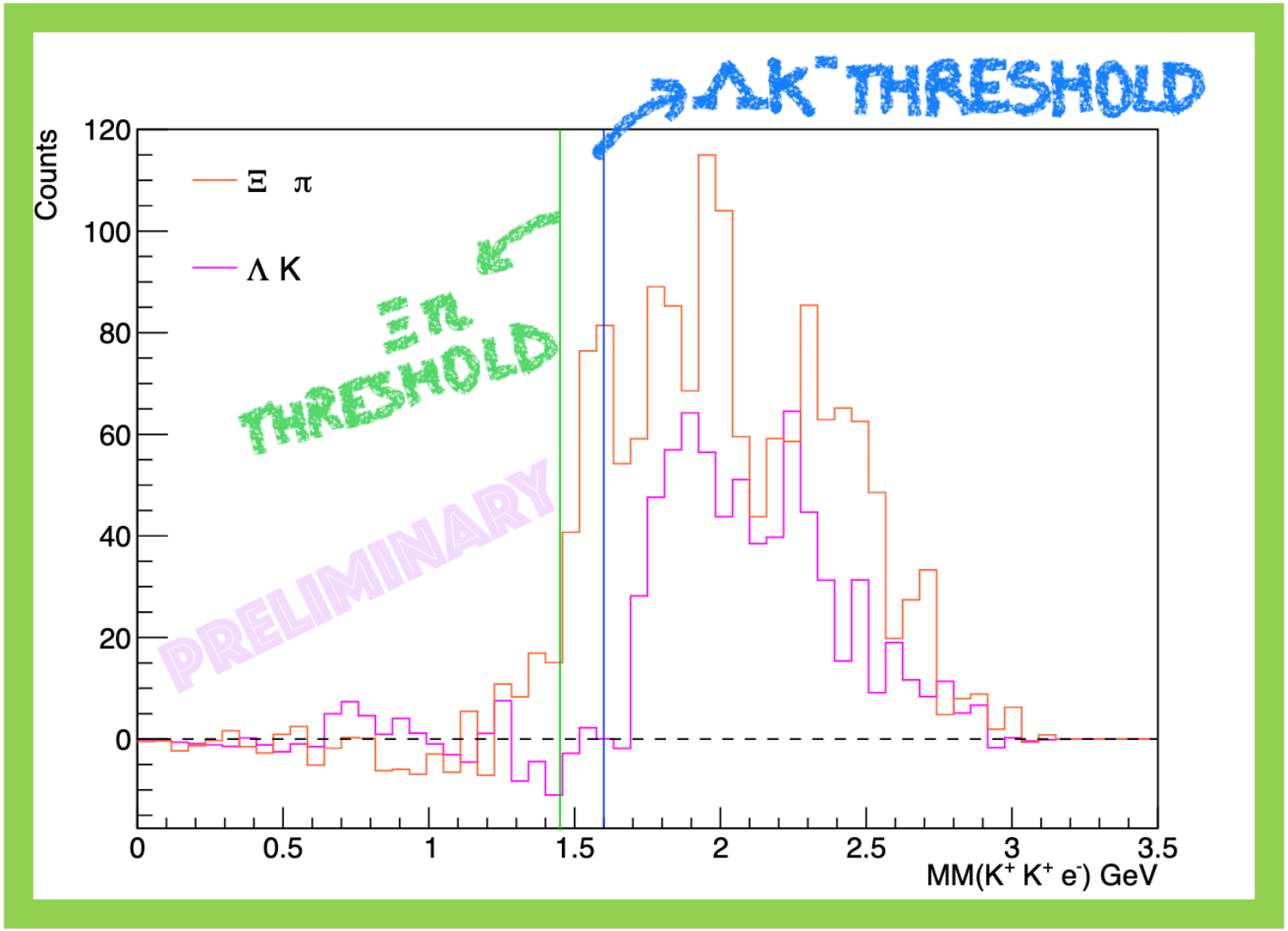
FD data: $K^+K^+\pi^-(X)$ channel





PhD analysis (Acar) – York (1/4 of available data)

FD data: Background subtracted $K^+K^+\pi^-(X)$ yields



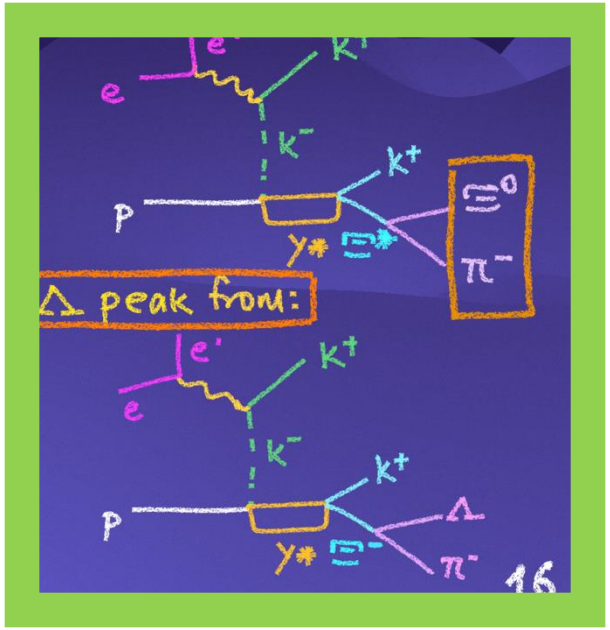
Unphysical Backgrounds

K/π separation

Out of time particles

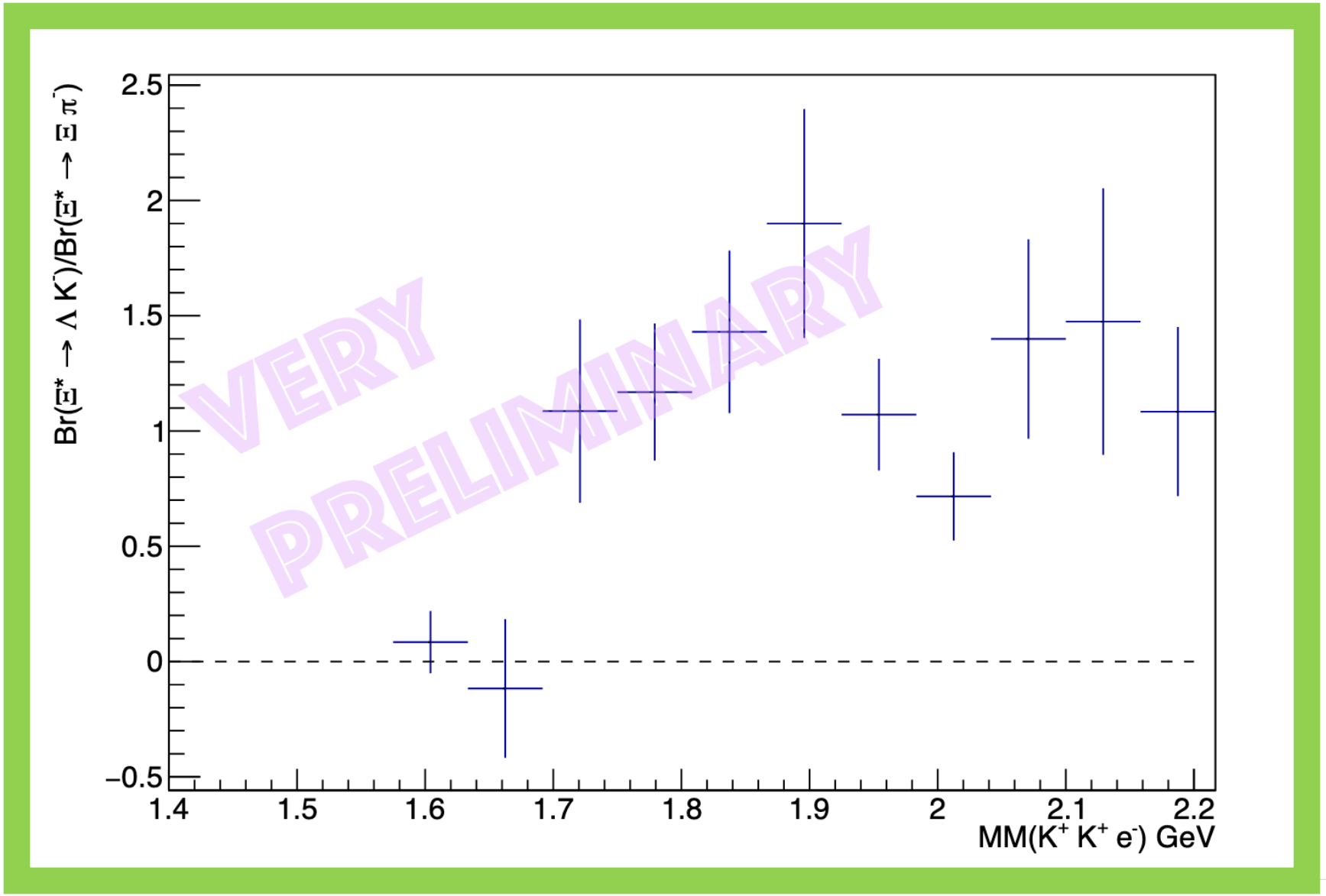
Physical backgrounds

e.g. phi



PhD analysis (Acar) – York (1/4 of available data)

Acceptance/efficiency corrected ratio of branchings

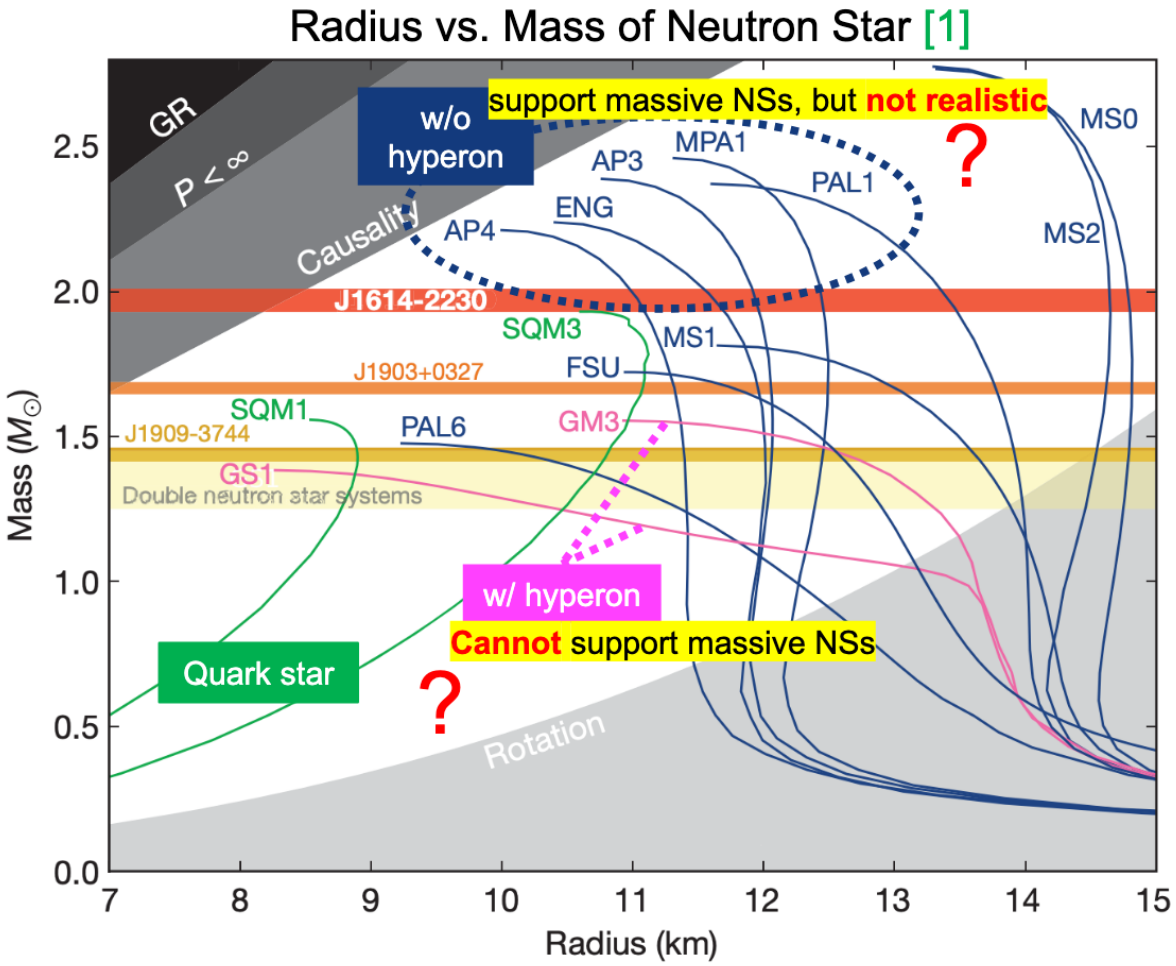


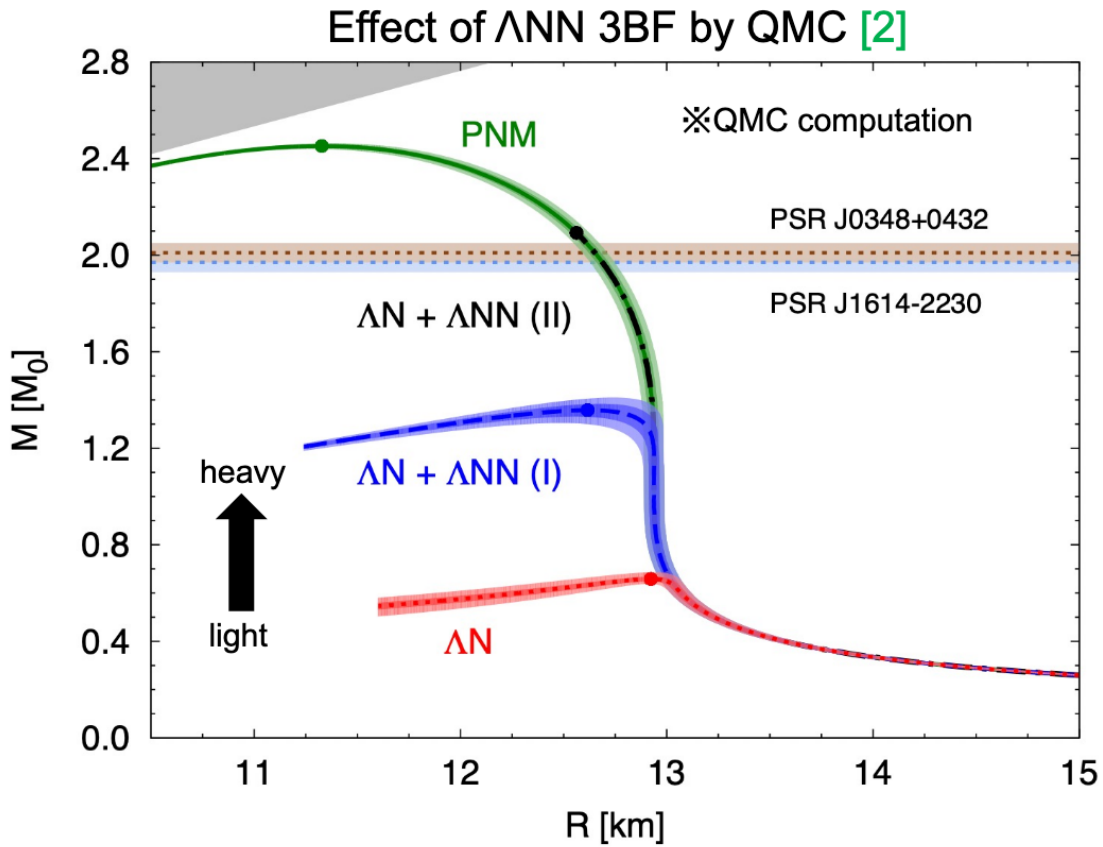
PhD analysis (Acar) – York (1/4 of available data)

Hyperon-nucleon interactions

Recent results from CLAS6 data

(Part of) the motivation – hyperon puzzle





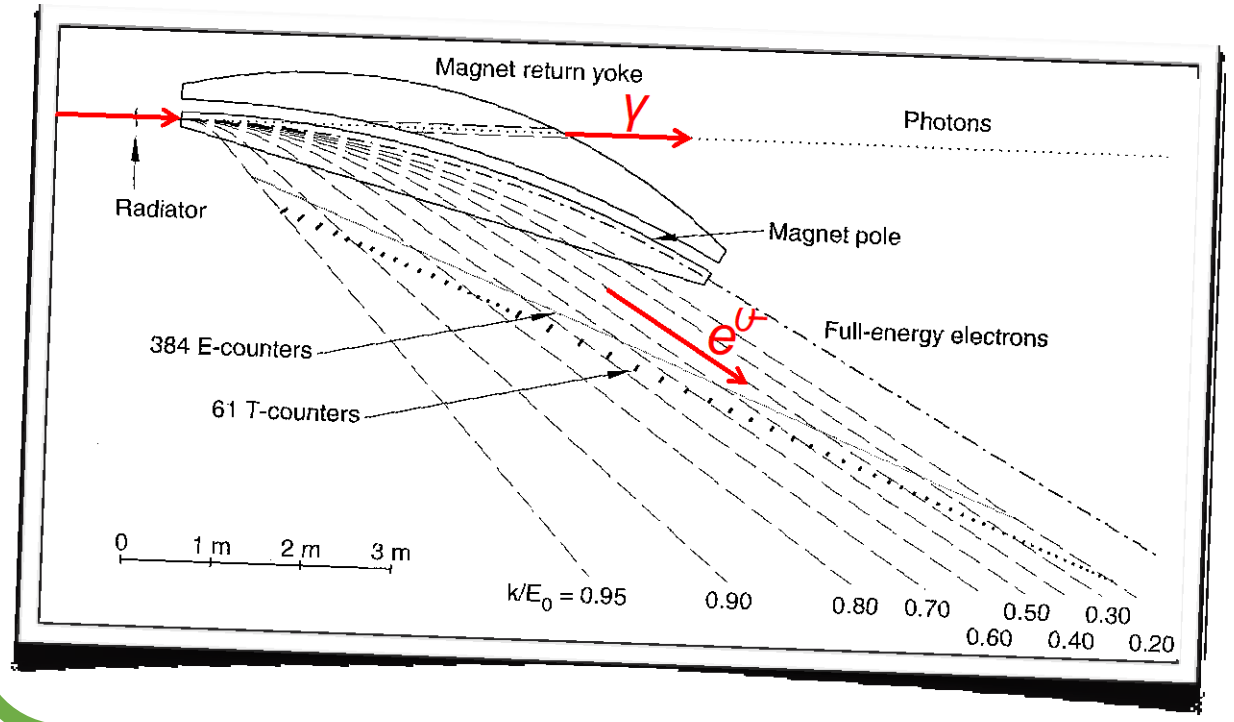
- Hyperon-nucleon (YN) interaction is repulsive in the short range (by the Quark Cluster Model).
- Λ is the first candidate of the hyperon appearance in Neutron Stars.

→ **ΛNN three-body forces (3BF)** could support massive NSs by making the EoS stiffer.

[1] P.B. Demorest *et al.*, Nature. 467., 2010
[2] Diego Lonardoni *et al.*, Phys. Rev. Lett. (2015)

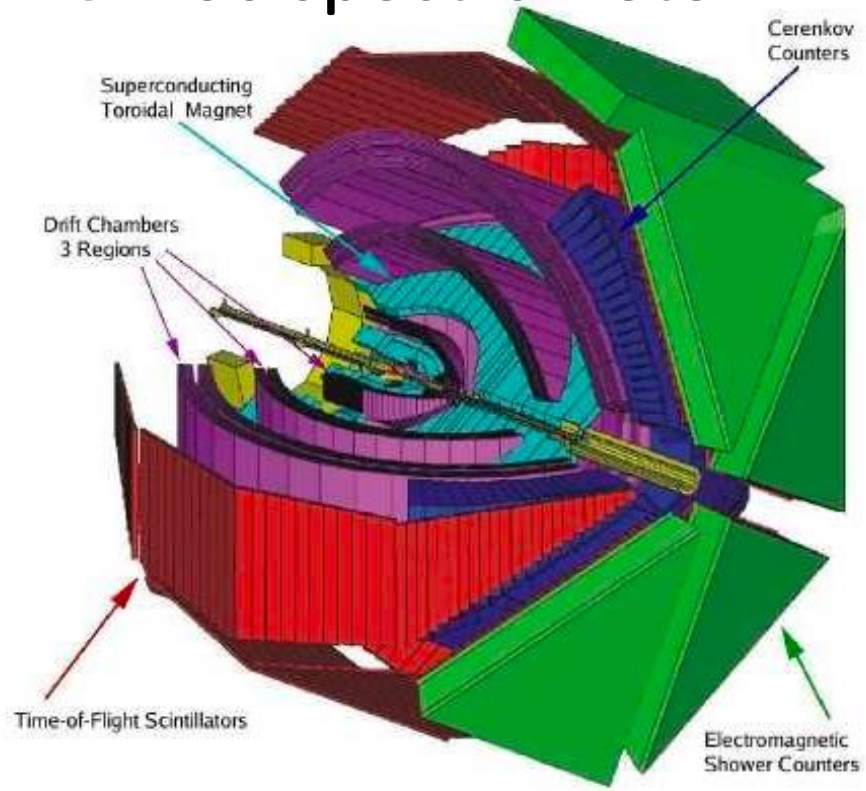
CLAS6@Jefferson Lab

Photon tagger



- Hyperon analysis uses “g12 and g13” data sets
- Photon energies 1.2 - 5.4 GeV
- Cryogenic liquid H/D targets - 40cm long 4cm diameter

CLAS6 spectrometer



$8^\circ < \theta < 140^\circ$ $\quad \sigma_\theta \sim 1$ mrad

$\phi \sim 1.7\pi$ $\quad \sigma_\phi \sim 4$ mrad

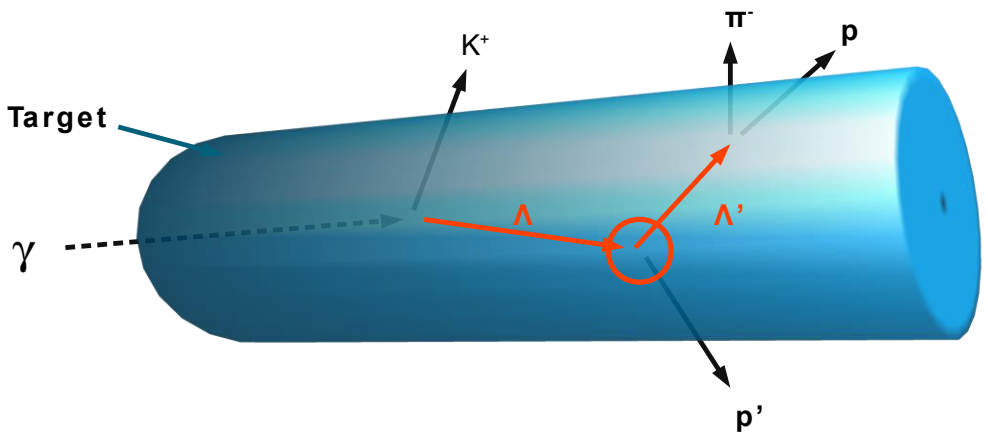
$\sigma_p/p \sim 1\%$

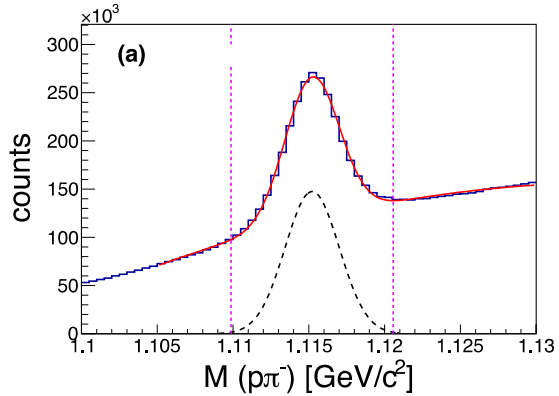
Λp Elastic Scattering

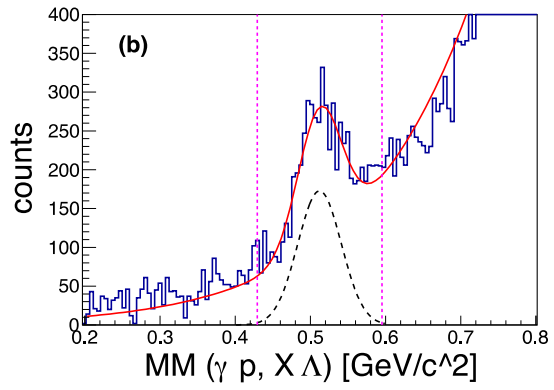
https://doi.org/10.1103/PhysRevLett.127.272303

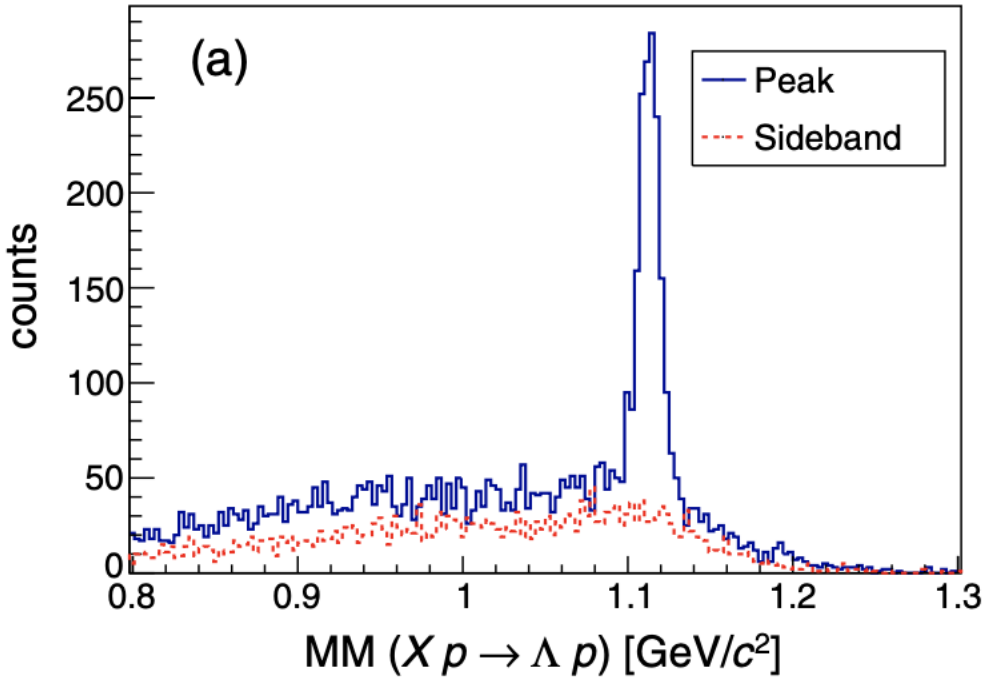
Improved Λ*p* Elastic Scattering Cross Sections between 0.9 and 2.0 GeV/*c* as a Main Ingredient of the Neutron Star Equation of State

J. Rowley,[35] N. Compton,[35] C. Djalali,[35] K. Hicks,[35] J. Price,[2] N. Zachariou,[47] K. P. Adhikari,[36] W. R. Armstrong,[1]

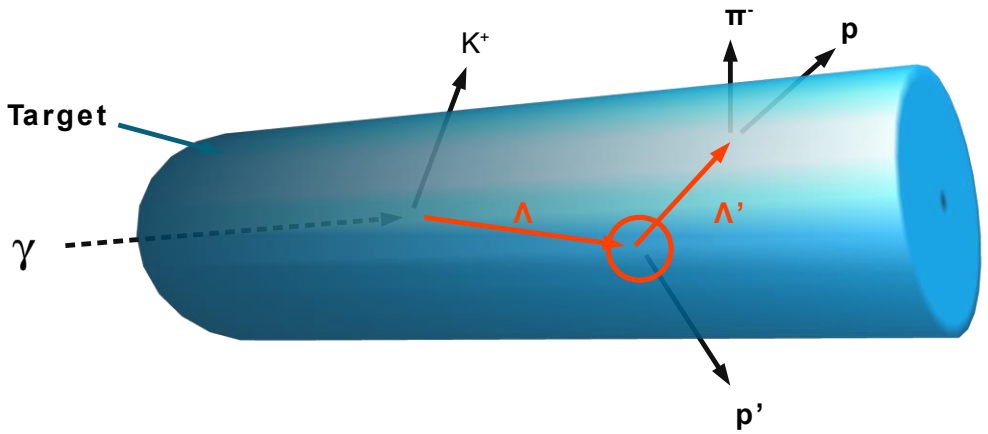






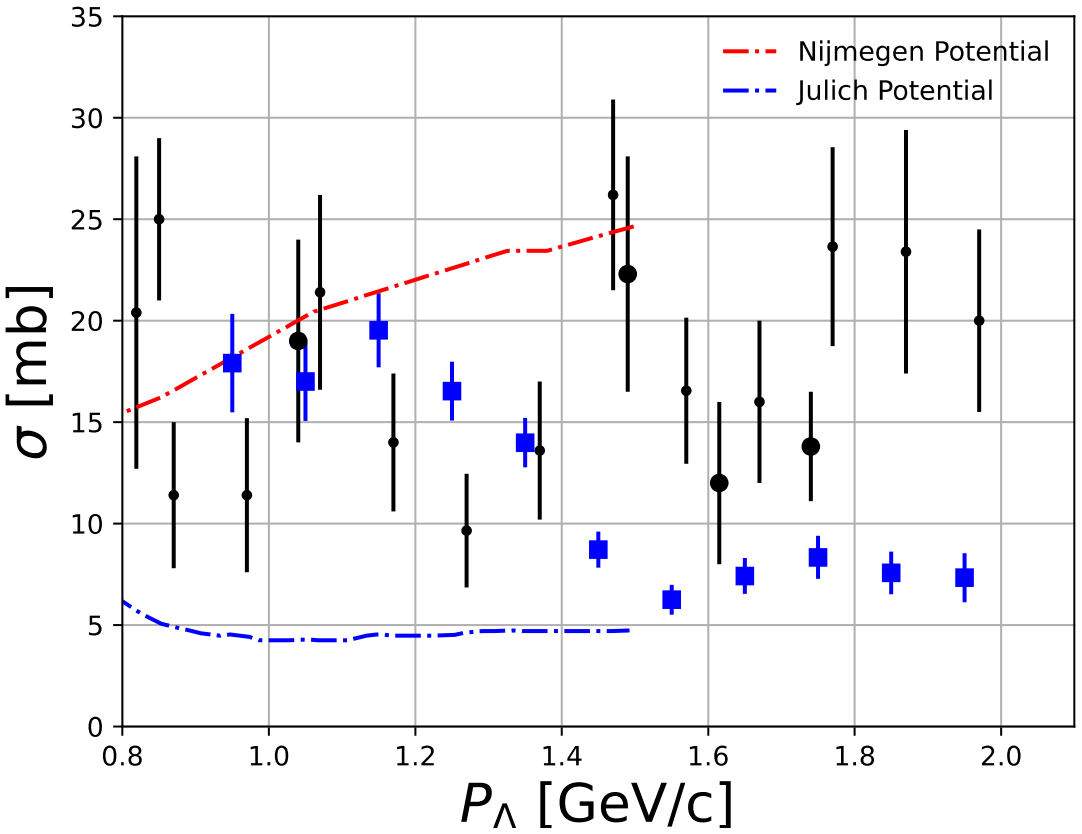


Λp Elastic Scattering



- Cross section determination challenging
- Need careful account of detector acceptance, efficiency

(see paper for details)

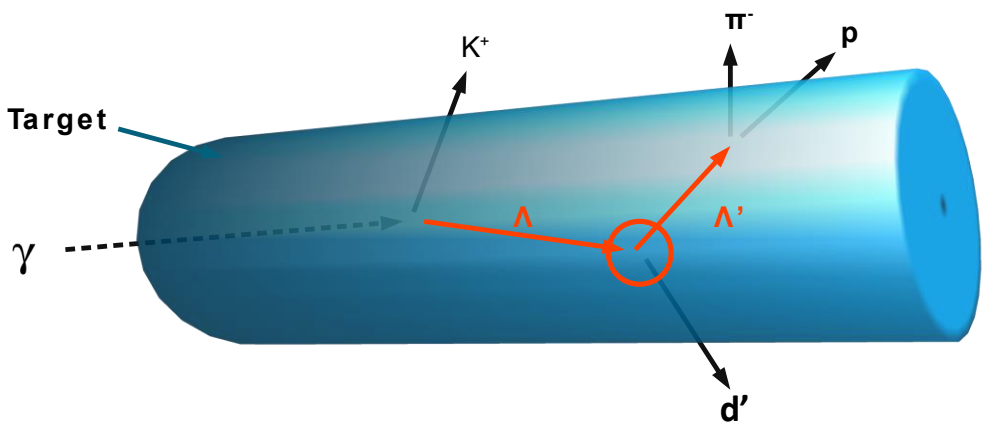


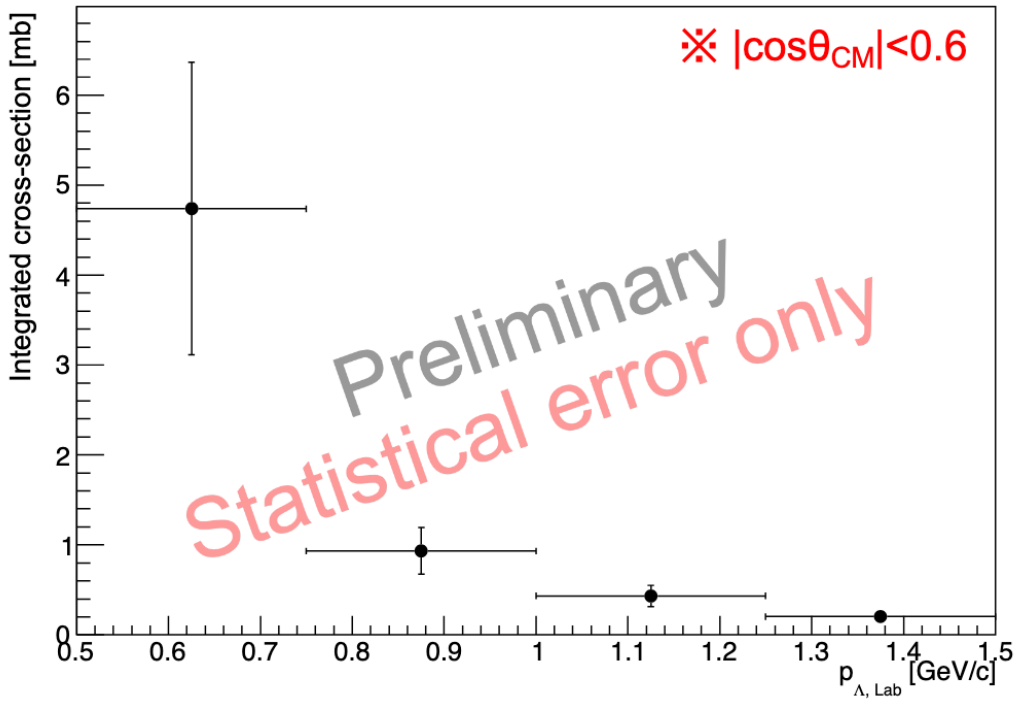
NLO chiral EFT(Haidenbauer *Eur. Phys. J. A* **56,** 91 (2020))

Haidenbauer, U.-G. Meißner, Phys. Rev. C 72, 044005 (2005)

Rijken, Stoks, Yamamoto, Phys. Rev. C 59, 21 (1999).

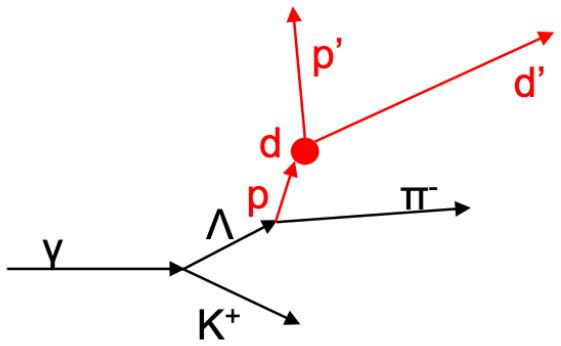
Λd Elastic Scattering

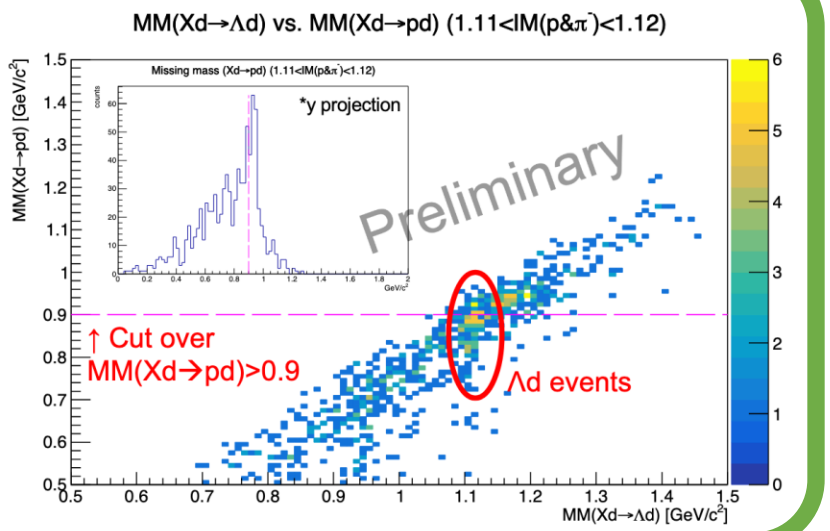




- Different backgrounds

Λ→π⁻p decay & pd scattering

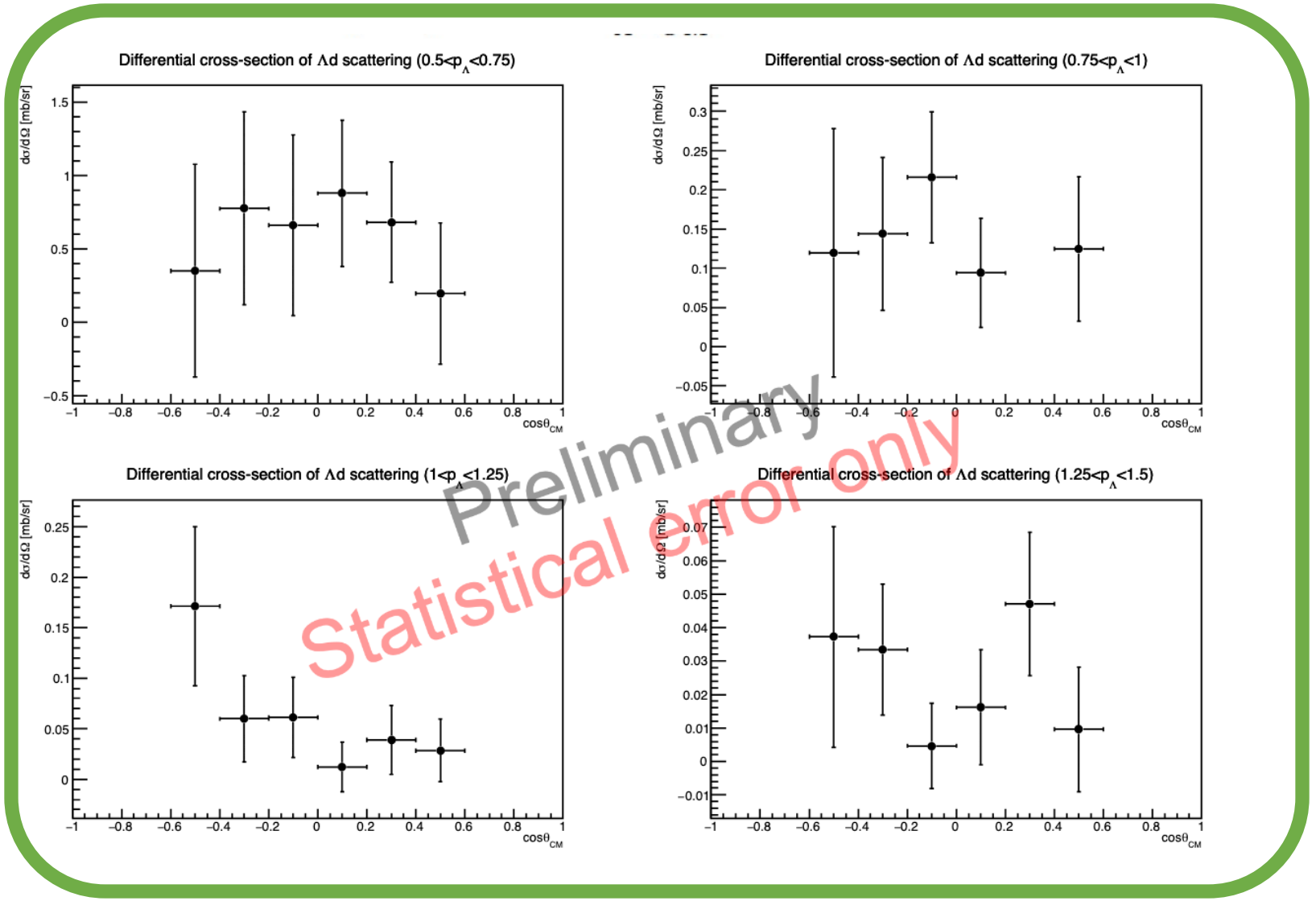




NEW

Analysis note under review
Hicks, Miwa, Mokeev, Sachao, Shresta, Zachariou

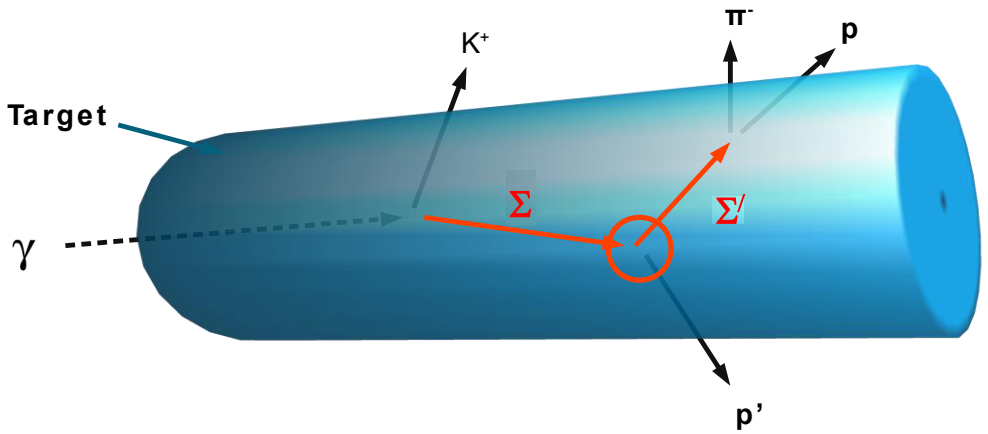
Λd scattering – angular distributions

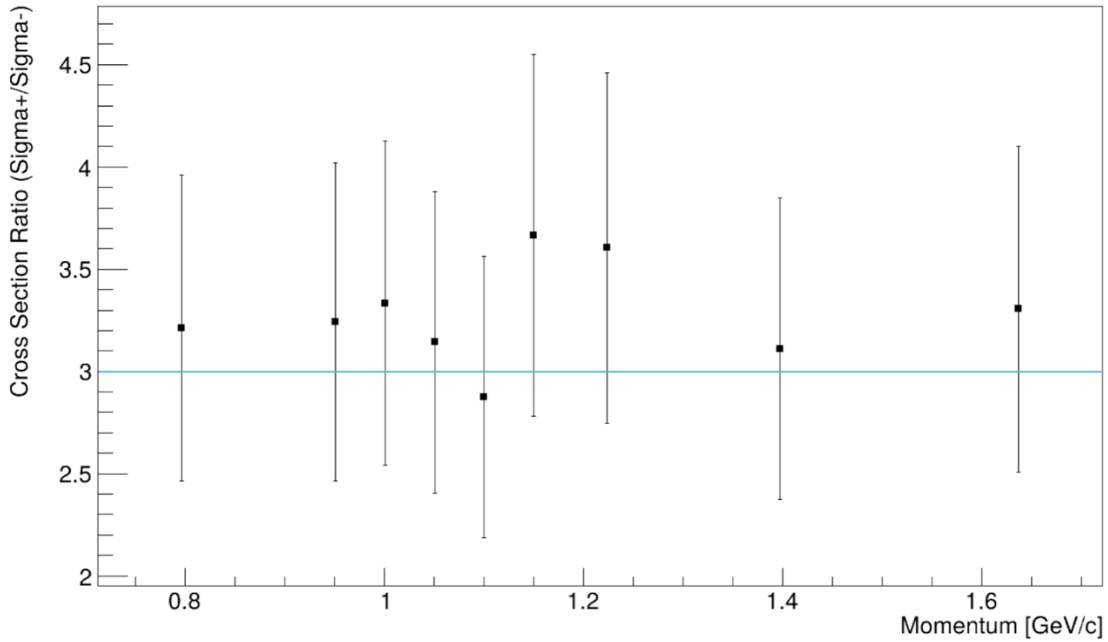


NEW

Analysis note under review
Hicks, Miwa, Mokeev, Sachao, Shresta, Zachariou

Σ^+/Σ^- elastic scattering





Ratio expected to be 3 from consideration of CG coefficients

$$\frac{\sigma_{\Sigma^+}}{\sigma_{\Sigma^-}} = \frac{\sigma_{\Sigma^+ p \to \Sigma^+ p}}{\sigma_{\Sigma^- p \to \Sigma^- p} + \sigma_{\Sigma^- p \to \Sigma^0 n}} = \frac{1}{3/9} = 3$$

Analysis note under review
Zachariou, Bryce

Summary

"Very strange" programme for CLAS12 will give quality new data on the (low Q^2) electroproduction of cascades

Photoproduced (short lived) hyperon states at JLAB – new insights into the hyperon Interaction in nuclear matter

Thanks for listening !