Search for Excited Ξ states and Preliminary Cross Section for $\Xi(1530)$

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Outline

- Motivation
- Preliminary $\Xi(1530)$ Cross Section
- Clebsch Gordan study of $\Xi^0\pi^-$ channel
- Simultaneous fitting between $\Xi^-\pi^0$ and $K^-\Lambda$ channels

Missing Resonance Problem

State, J^P	Predicted masses (MeV)							
$\Xi\frac{1}{2}^+$	1305							
$\Xi\frac{3}{2}^+$	1505							
$\Xi^*\frac{1}{2}^-$	1755	1810	1835	2225	2285	2300	2320	2380
$\Xi^*\frac{3}{2}^-$	1785	1880	1895	2240	2305	2330	2340	2385
$\Xi^*\frac{5}{2}^-$	1900	2345	2350	2385				
$\Xi^*\frac{7}{2}^-$	2355							
$\Xi^*\frac{1}{2}^+$	1840	2040	2100	2130	2150	2230	2345	
$\Xi^*\frac{3}{2}^+$	2045	2065	2115	2165	2170	2210	2230	2275
$\Xi^*\frac{5}{2}^+$	2045	2165	2230	2230	2240			
$\Xi^*\frac{7}{2}^+$	2180	2240						

- List of Cascade Baryons predicted by Capstick and Isgur with mass less than 2.4 GeV/c^2

Particle	J^P	Overall Status
$\Xi(1318)$	$1/2^+$	****
$\Xi(1530)$	$3/2^+$	****
$\Xi(1620)$		*
$\Xi(1690)$		***
$\Xi(1820)$	$3/2^-$	***
$\Xi(1950)$		***
$\Xi(2030)$	$5/2^?$	***
$\Xi(2120)$		*
$\Xi(2250)$		**
$\Xi(2370)$		**

- Current List of states in PDG with mass less than 2.4 GeV/c^2

Branching Fractions

State	ΛK	ΣK	$\Xi\pi$
$\Xi(1530)$			100 %
$\Xi(1690)$	seen	seen	seen
$\Xi(1820)$	large	small	small
$\Xi(1950)$	seen	seen?	seen
$\Xi(2030)$	20%	80%	small

- Per the PDG all the Cascade 1530s decay $\Xi\pi$, while for higher mass cascade states this channel is suppressed
- The Cascade 1530 is below threshold for the ΛK channel
- The $\Xi\pi$ channel can decay $\Xi^0\pi^-$ or $\Xi^-\pi^0$

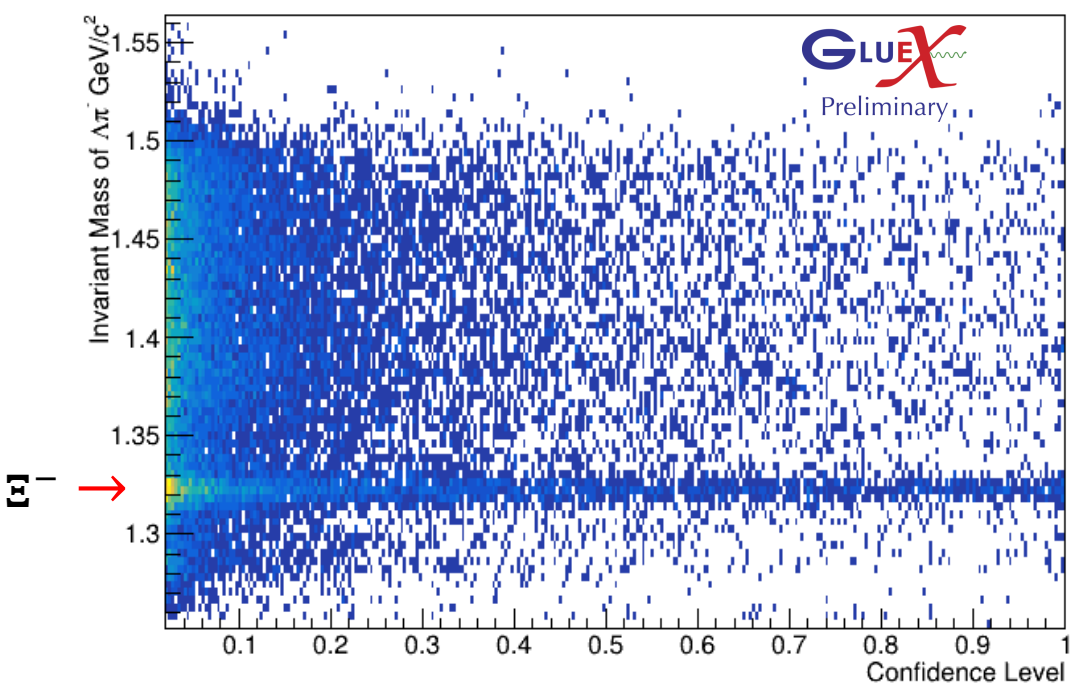
Decay Chain

$$\gamma p \rightarrow K^+ K^+ \Xi^{-*}$$
$$\Xi^{-*} \rightarrow \Xi^- \pi^0$$
$$\Xi^- \rightarrow \Lambda \pi^-$$

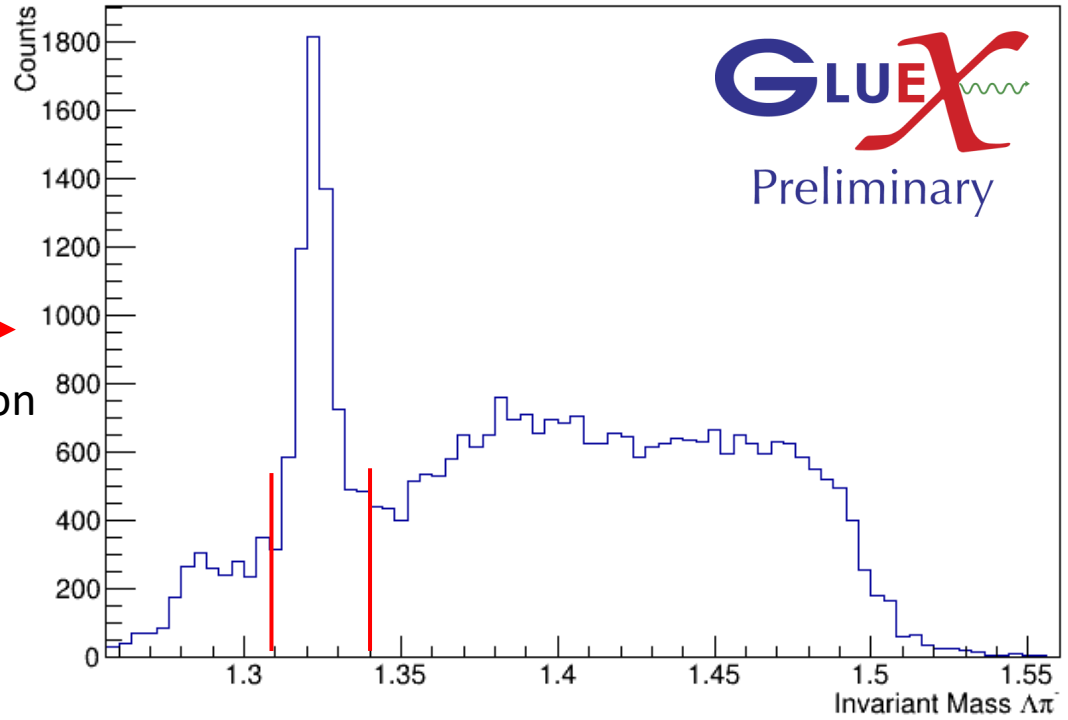
- Kinematically fit refers to using vertex and four momentum constraints to improve the resolution of measured data and help distinguish between different reactions

- The masses of Λ and π^0 are constrained to the known masses in the kinematic fit

Confidence Level Selection

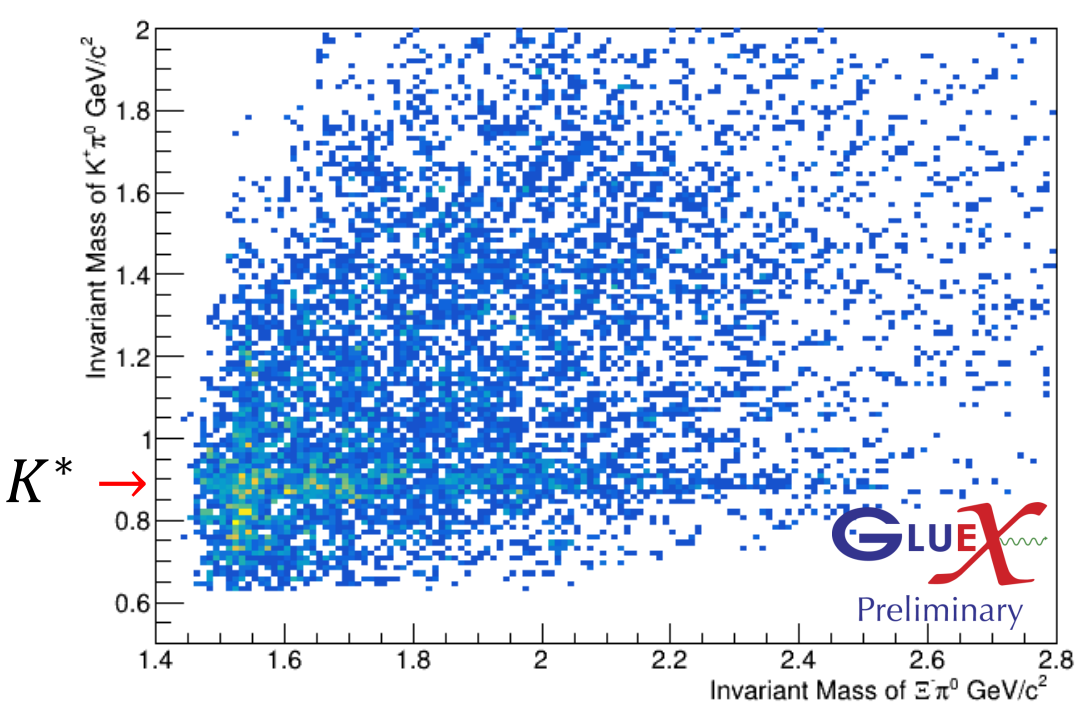


Y-Projection



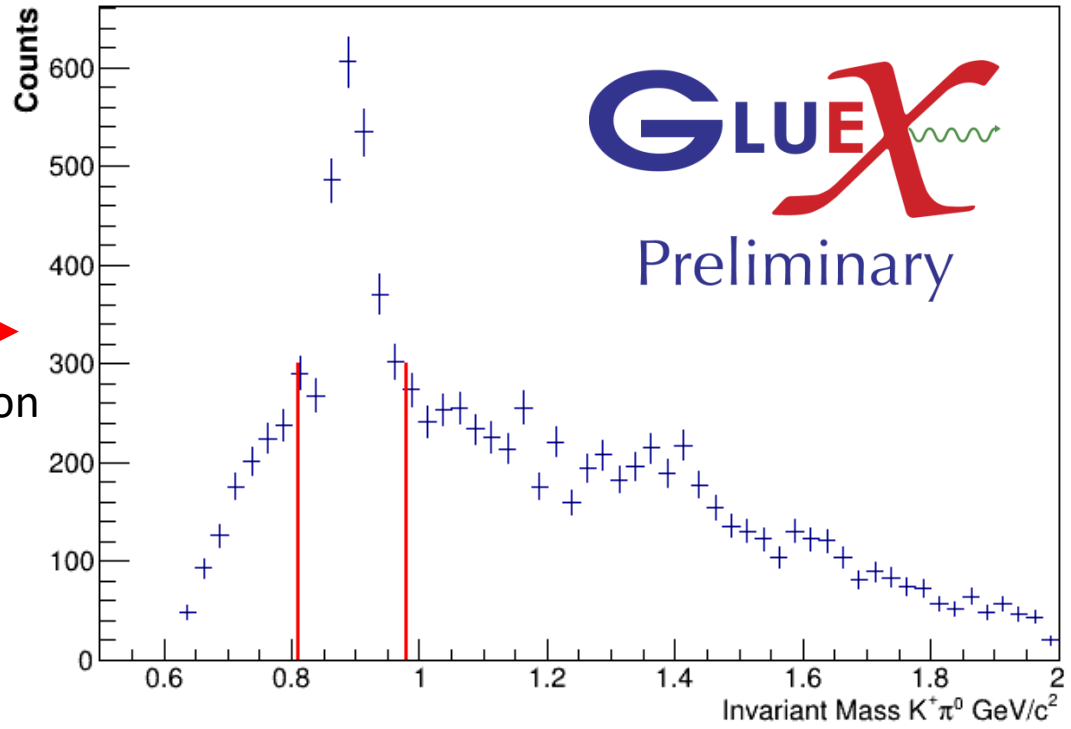
Cut around the signal of the ground state cascade

Background Contamination from K^*



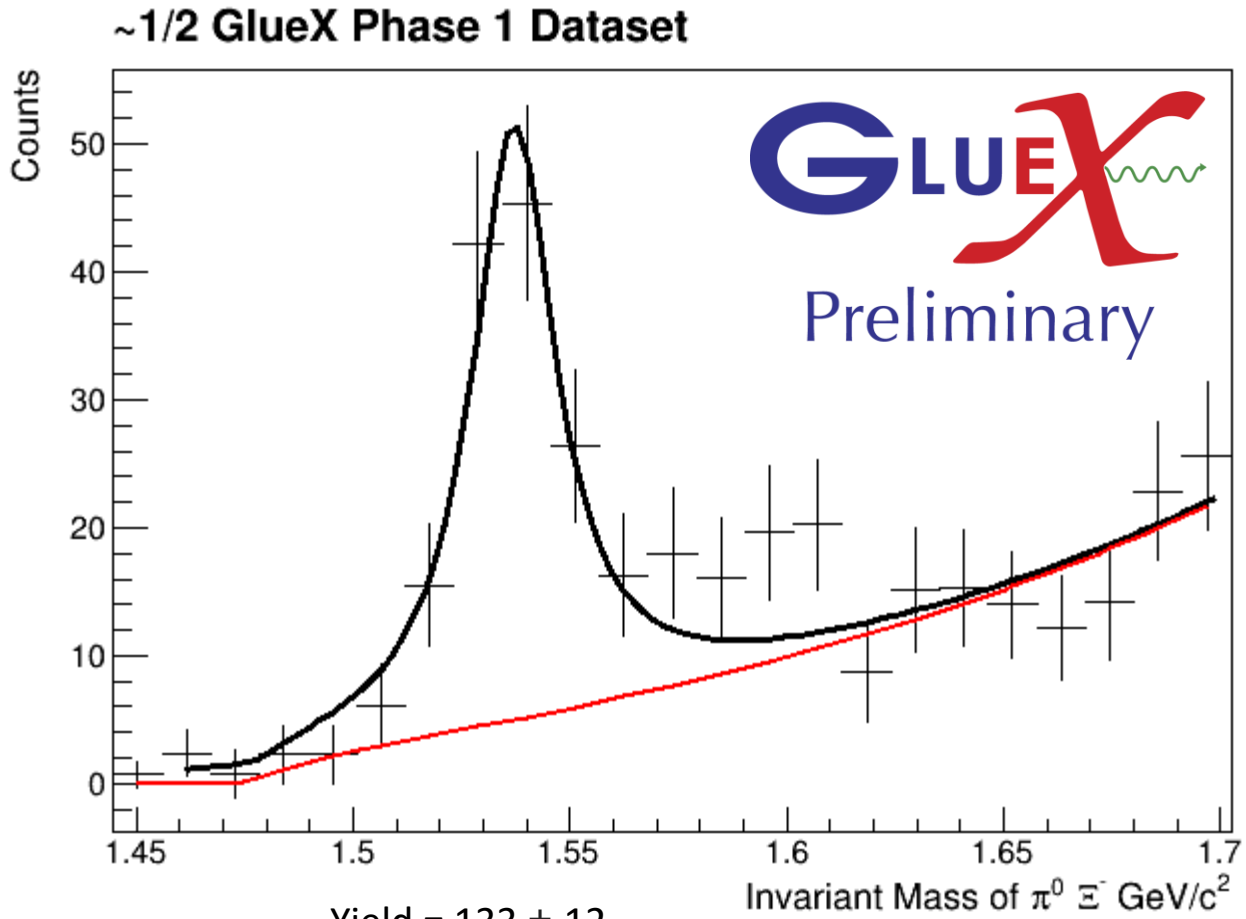
K^* →

Y-Projection



Reject events associated with $K^* \rightarrow K^+\pi^0$ contamination

Excited Cascade 1530



Yield = 133 ± 12
Center = 1.537(2) GeV/c^2
Width = 12(3) MeV/c^2

Ξ(1530) 3/2+

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

$\Xi(1530)^0$ mass $m = 1531.80 \pm 0.32$ MeV (S = 1.3)
$\Xi(1530)^-$ mass $m = 1535.0 \pm 0.6$ MeV
$\Xi(1530)^0$ full width $\Gamma = 9.1 \pm 0.5$ MeV
$\Xi(1530)^-$ full width $\Gamma = 9.9^{+1.7}_{-1.9}$ MeV

Ξ(1530) DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Xi\pi$	100 %		158
$\Xi\gamma$	<4 %	90%	202

Modeling the Cascade Production in Signal MC

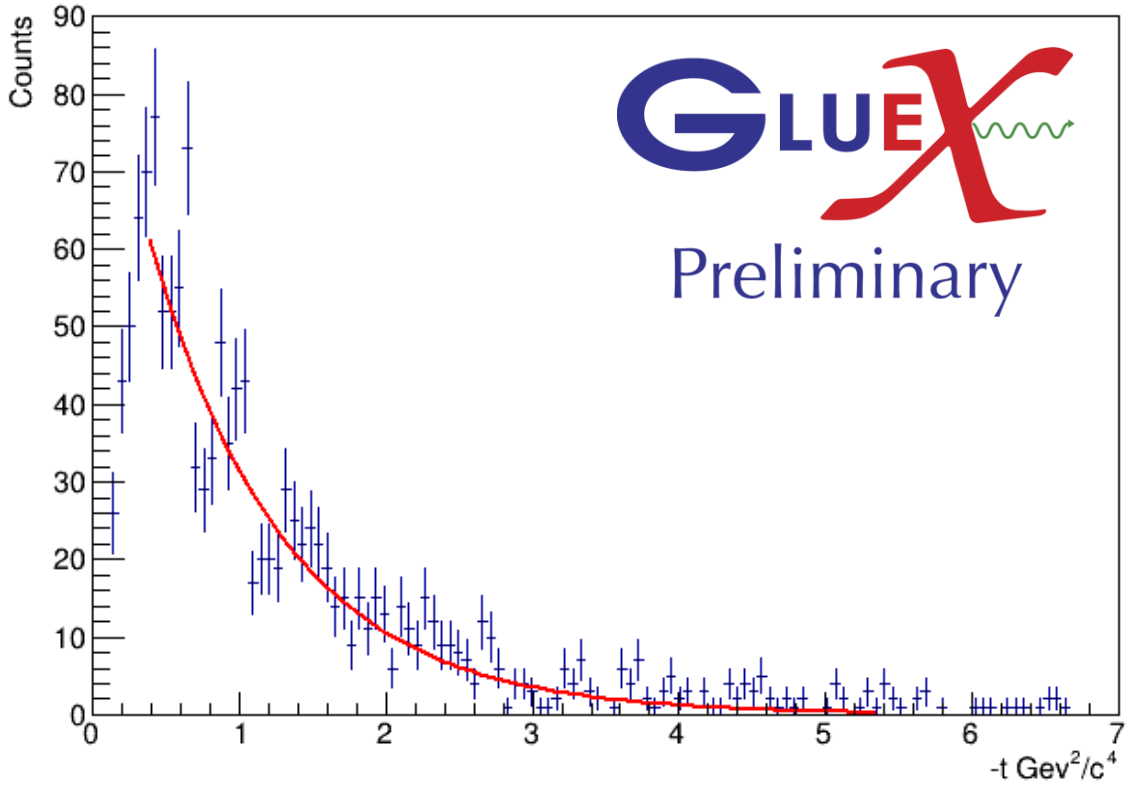
- Theoretical Calculations done by Nakayama, Oh and Haberzettl proposed the cascade/excited cascade are produced by a two-step process:

$$\gamma p \rightarrow K^{+} Y^{*}$$
$$Y^{*} \rightarrow K^{+} \Xi^{-*}$$

- Direct production of the Ξ^{-*} would be OZI suppressed with two strange- antistrange pairs at the production vertex. Therefore, I defined t as:

$$t = \left(P_{\gamma} - P_{K^{+}}\right)^{2}$$

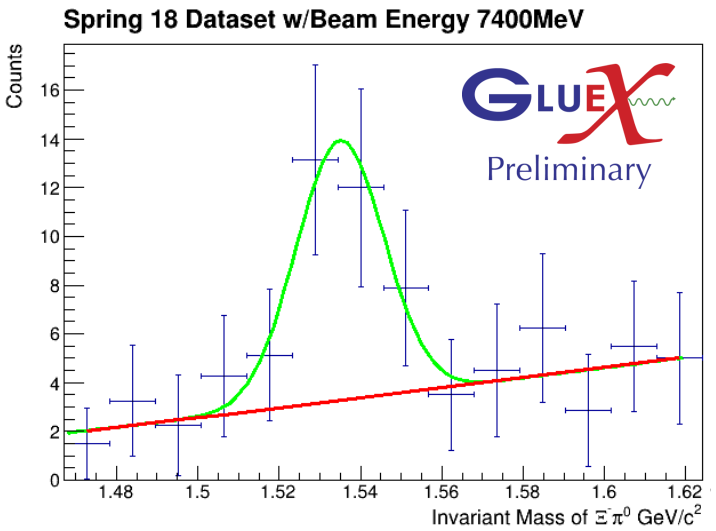
t-Slope extraction



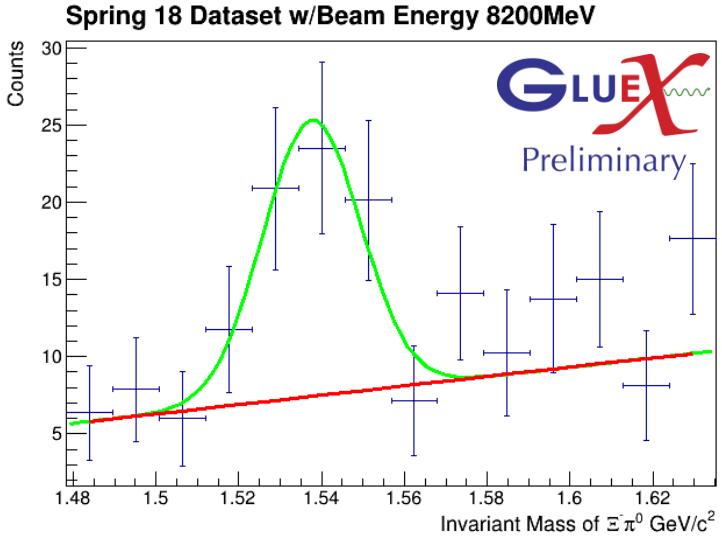
- Selecting events within the excited cascade 1530 peak
- Assuming : $\frac{d\sigma}{dt} \propto e^{-bt}$

$$b = 1.08(4)\ c^4/GeV^2$$

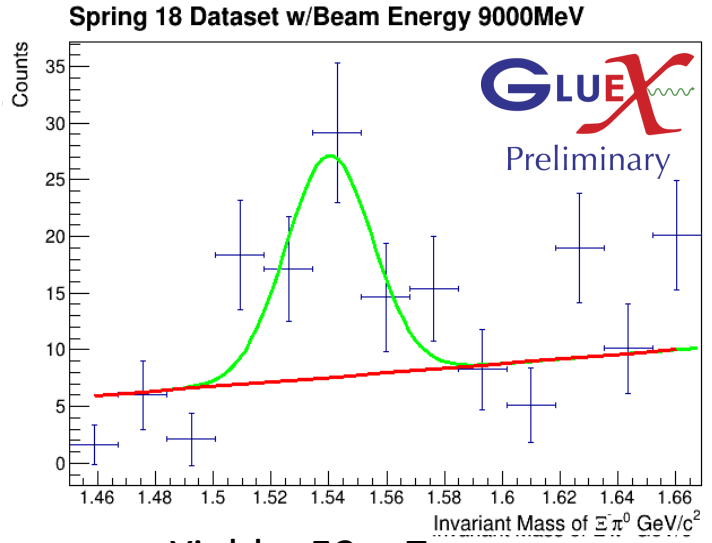
Energy-dependent $\Xi(1530)$ Yield Extraction



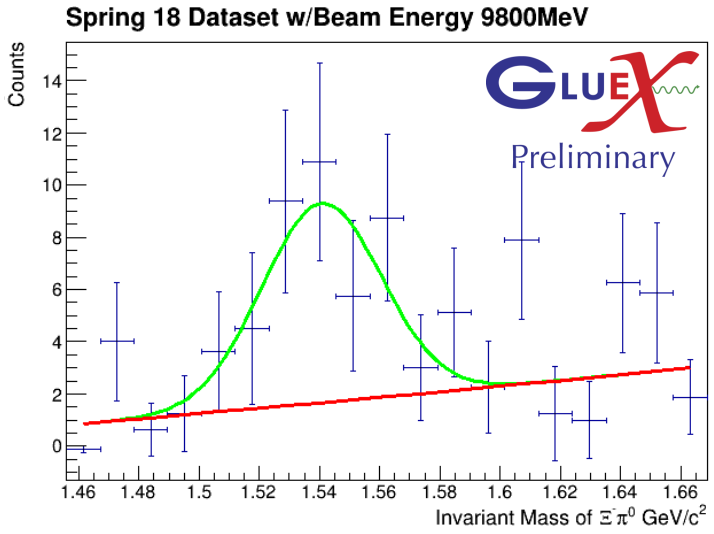
Yield = 25 ± 5



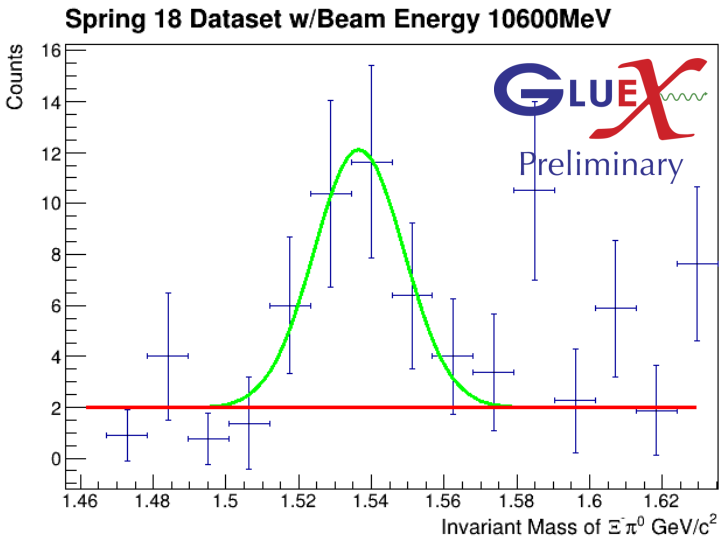
Yield = 51 ± 7



Yield = 52 ± 7

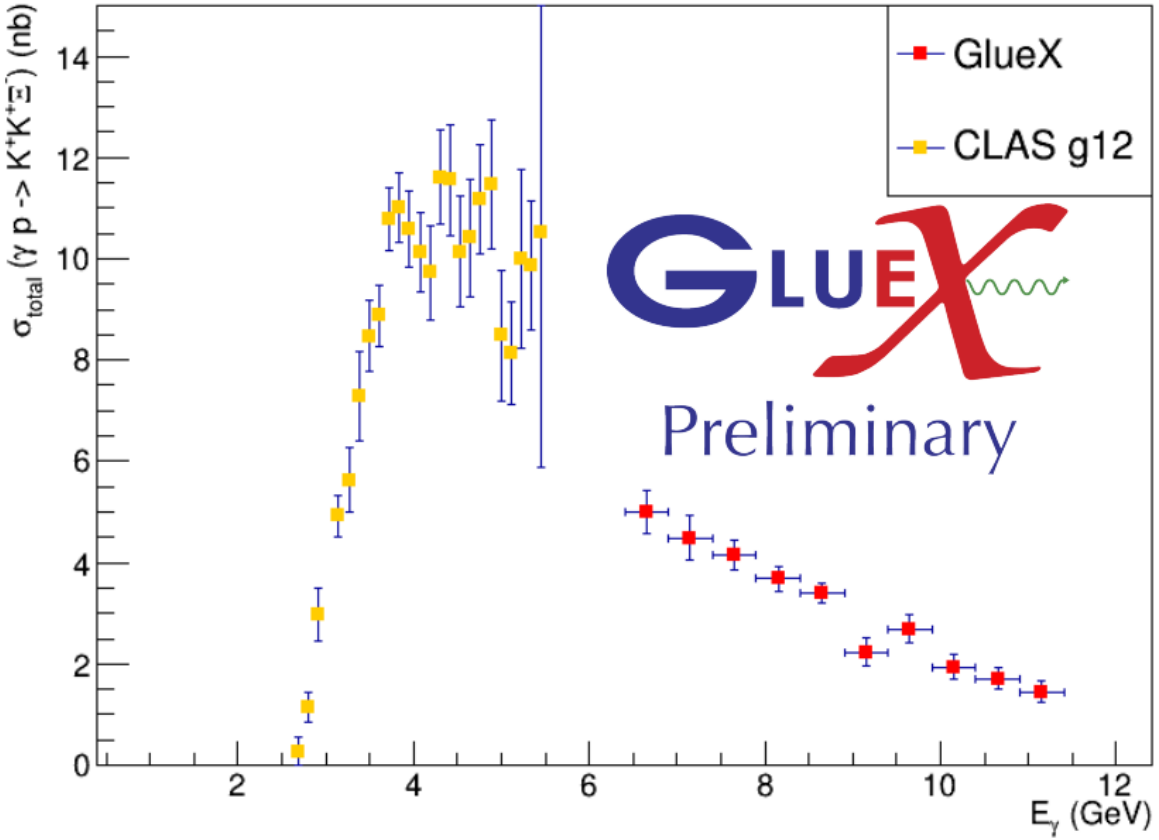


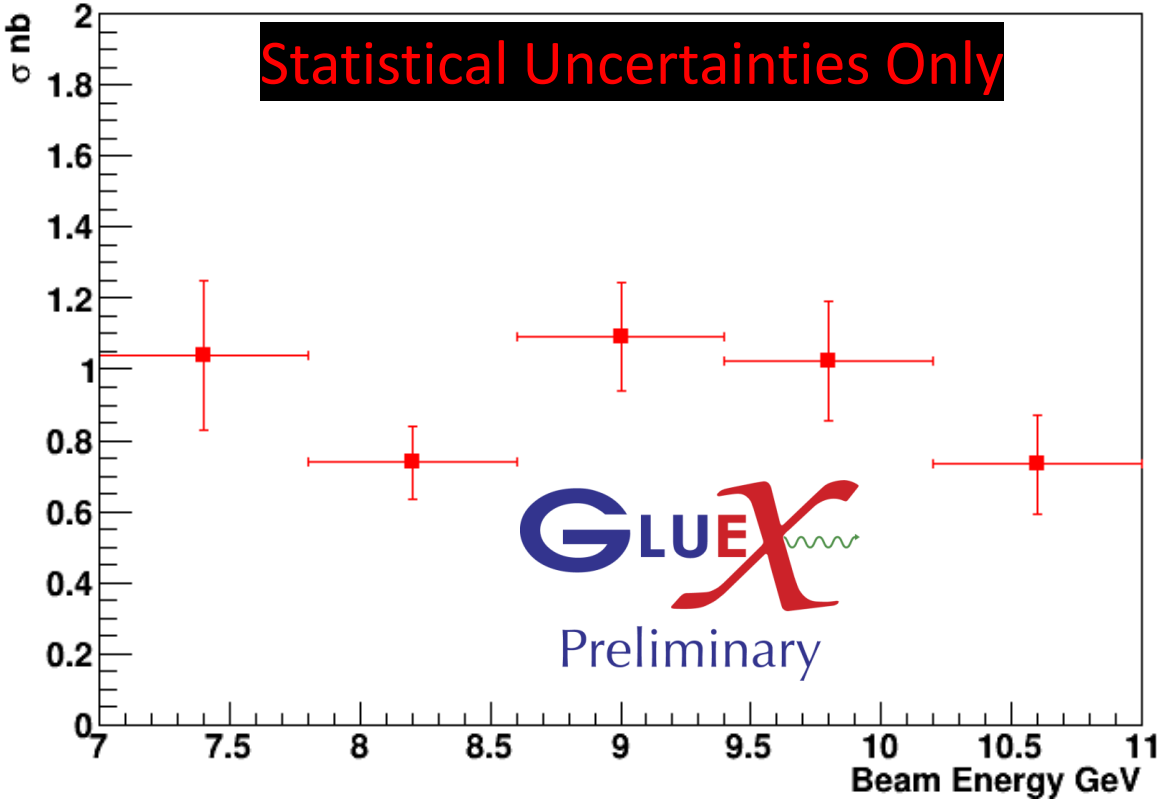
Yield = 37 ± 6



Yield = 28 ± 5

Cross Sections for Cascade Baryons





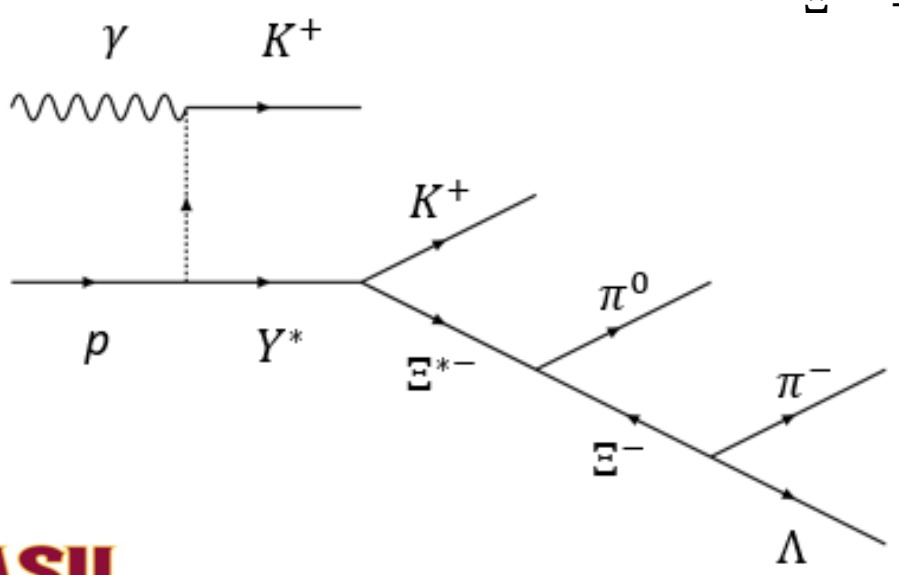
"Upper limits were calculated on the production total cross sections of the three best-known excited states: the $\Xi(1690)$, the $\Xi(1820)$ and the $\Xi(1950)$ [7] at 0.75 nb, 1.01 nb, and 1.58 nb, respectively"
-Study of Xi Photoproduction from Threshold to W = 3.3 GeV via CLAS collaboration

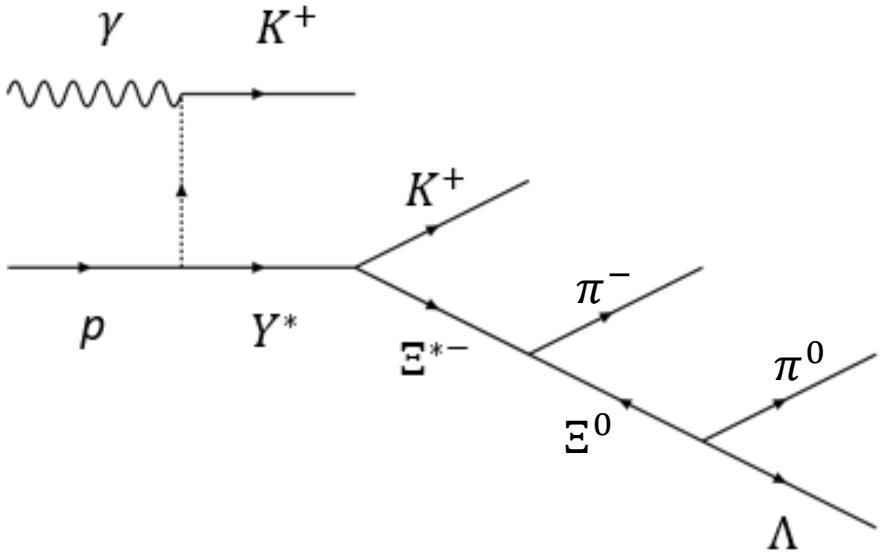
Charge Exchange Motivation

- This reaction should conserve isospin. Using Clebsch-Gordan coefficients we can that determine the neutral cascade channel should occur (roughly) twice as often.

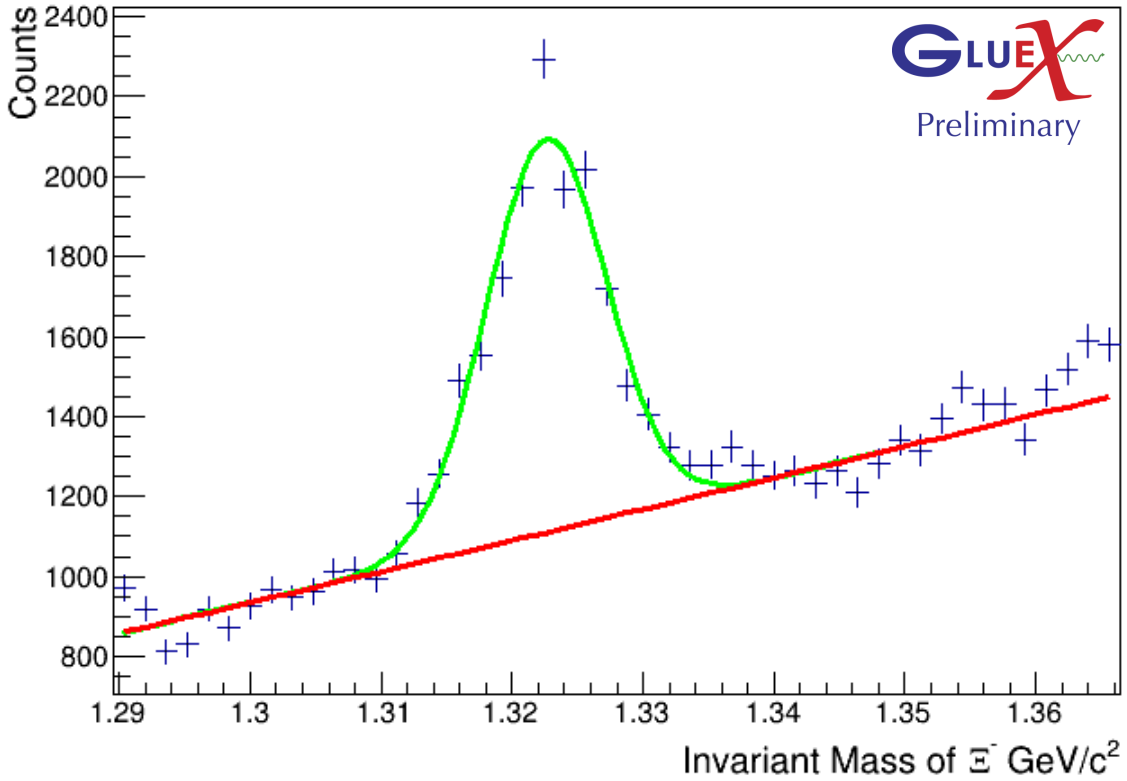
$$\left|\frac{1}{2},-\frac{1}{2}\right\rangle = \frac{1}{3}^{1/2}[|1,0\rangle\left|\frac{1}{2},-\frac{1}{2}\right\rangle] + \frac{2}{3}^{1/2}[|1,-1\rangle\left|\frac{1}{2},\frac{1}{2}\right\rangle]$$

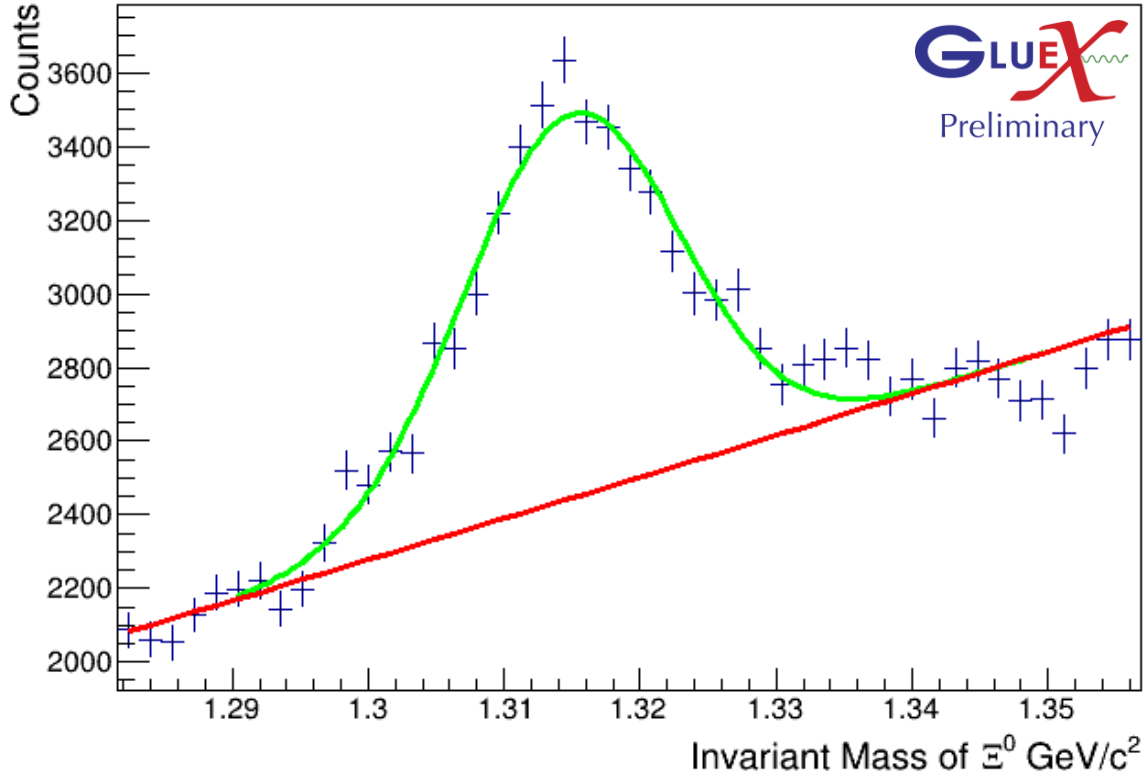
$$\Xi^{-*} = \frac{1}{3}^{1/2}|\pi^0\Xi^-\rangle + \frac{2}{3}^{1/2}|\pi^-\Xi^0\rangle$$





Yields From ground state cascade without vertex fitting





Yield(Ξ^-) = 7270 ± 85

Confidence level above 10^{-3}

Yield(Ξ^0) = 13351 ± 116

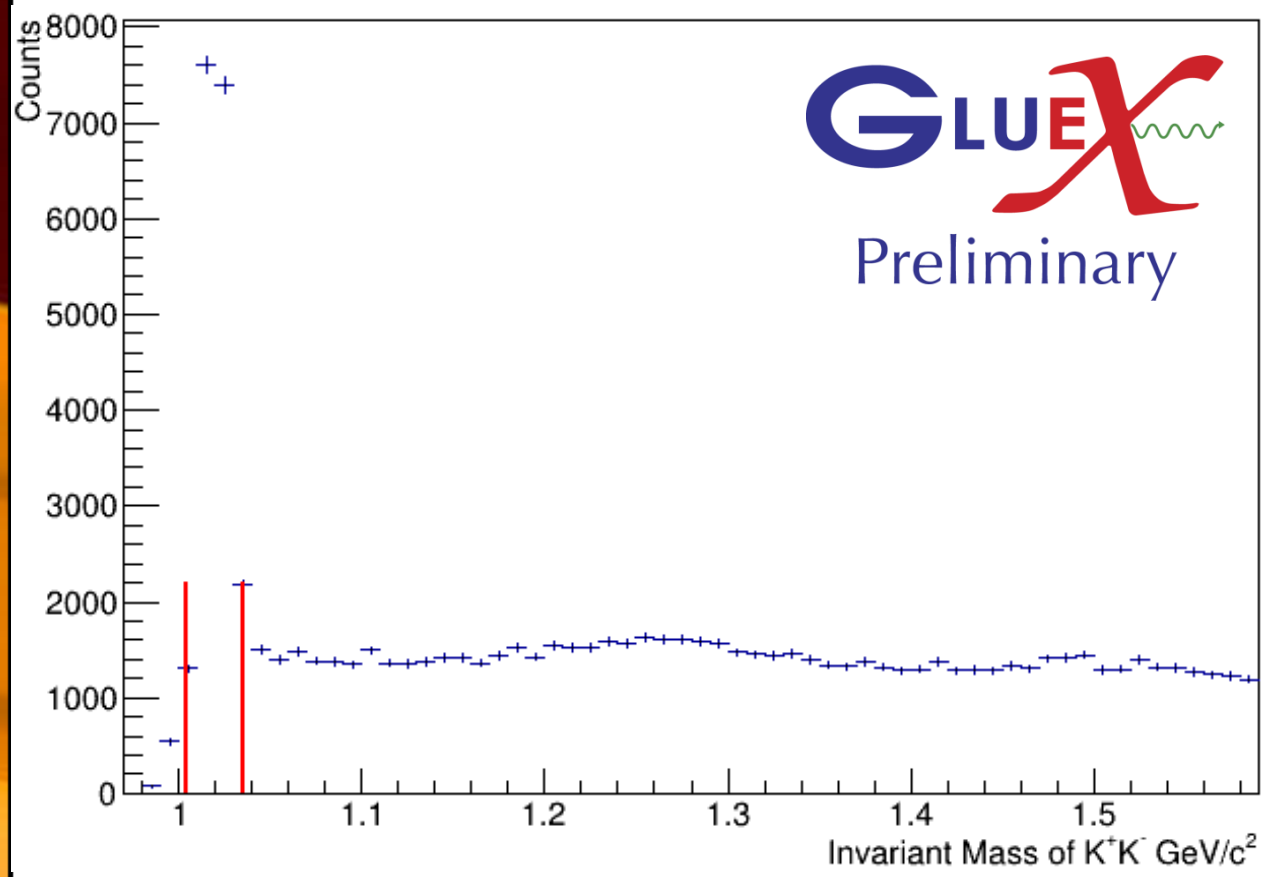
Ground state cascade yields for the neutral and charged states roughly follow their Clebsch-Gordan coefficients

$K^-\Lambda$ Decay Chain

$$\gamma p \rightarrow K^+ K^+ \Xi^{-*}$$
$$\Xi^{-*} \rightarrow K^- \Lambda$$

- The K^- is Kinematically constrained

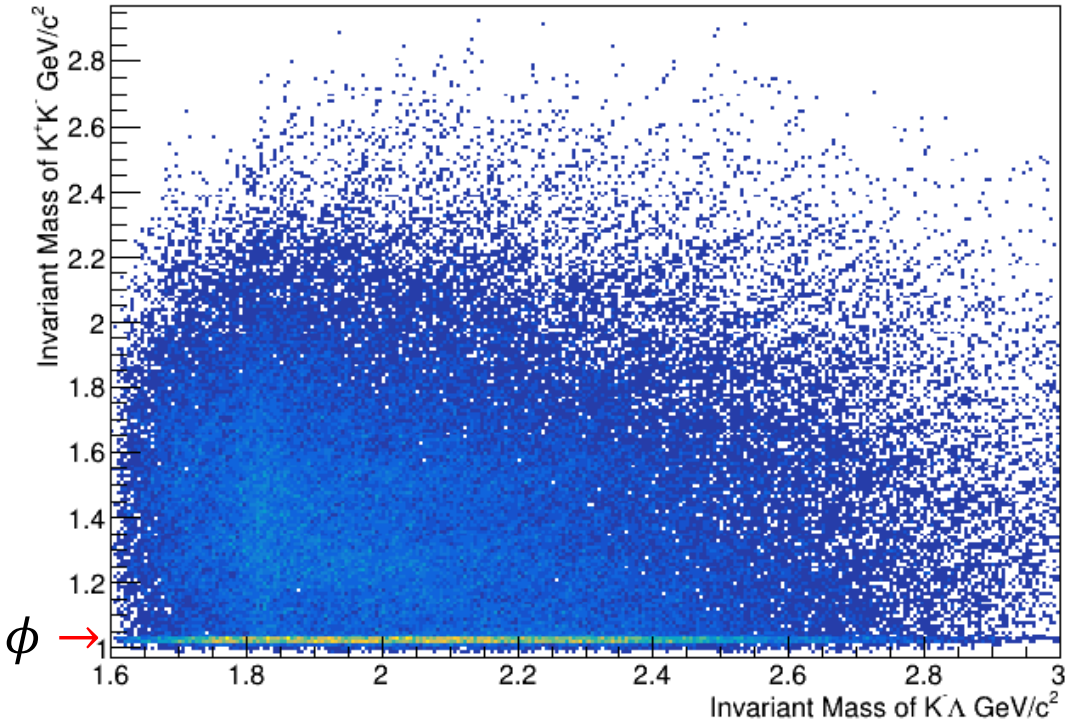
Event Selection



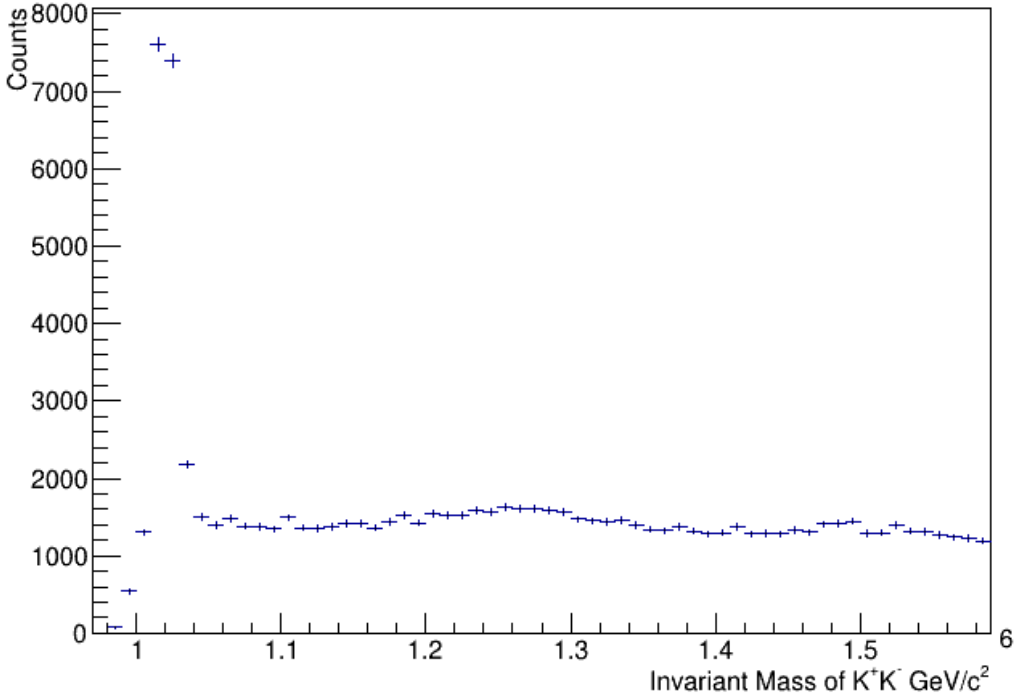
- Mass cut on Λ from 1.107 to 1.124 GeV/ c^2
- CL above 10^{-2}

ASU

Cut on K^+K^- Invariant Mass Spectrum

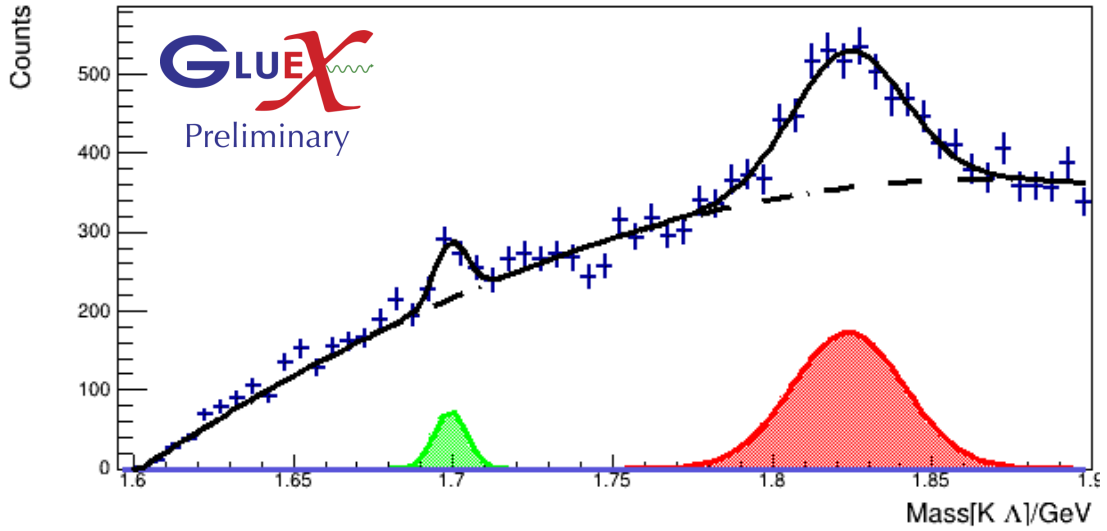


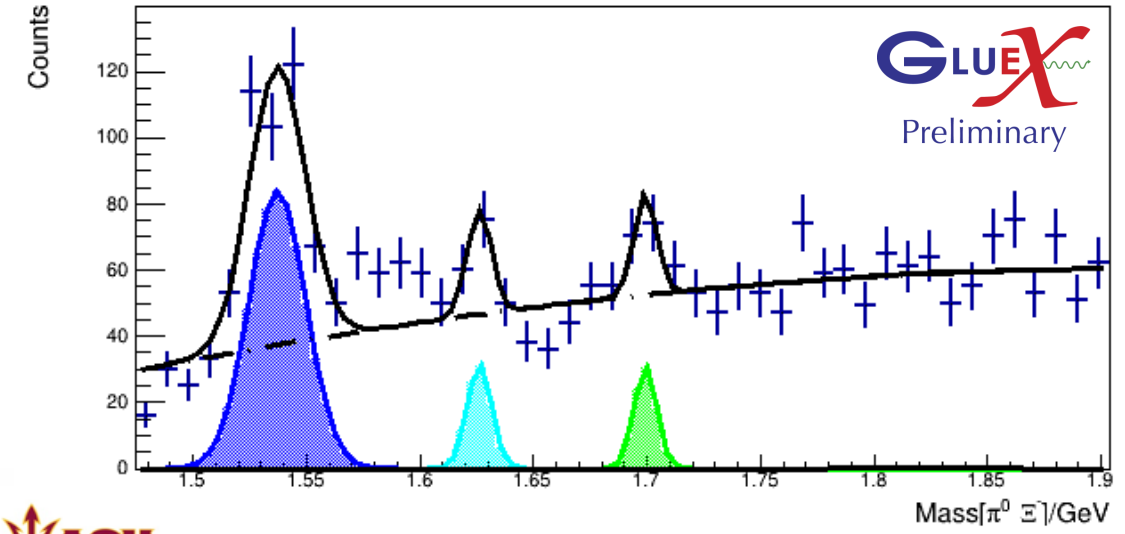
Y-Projection



Remove background associated with $\phi \rightarrow K^+K^-$ contamination

Simultaneous Fitting





- 3rd degree polynomial background with independent parameters
- The centers and widths are shared between the two channels

ASU

Conclusion

- The Cross Section for the reaction $\gamma p \rightarrow K^+ K^+ \Xi^- \pi^0$ has a preliminary value of 1 nb

- Iso-spin symmetry is shown to be approximately conserved in the charge exchange reaction

- GlueX can make a first-time measurement of branching ratio $\Gamma[\Xi(1690) \rightarrow K^- \Lambda] / \Gamma[\Xi(1690) \rightarrow \Xi^- \pi^0]$

Backup Slides

Charge Exchange Reaction

$$\gamma p \rightarrow K^+ K^+ \Xi^{-*}$$
$$\Xi^{-*} \rightarrow \Xi^0 \pi^-$$
$$\Xi^0 \rightarrow \Lambda \pi^0$$

- The Λ and π^0 are kinematically constrained