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

Brandon Sumner

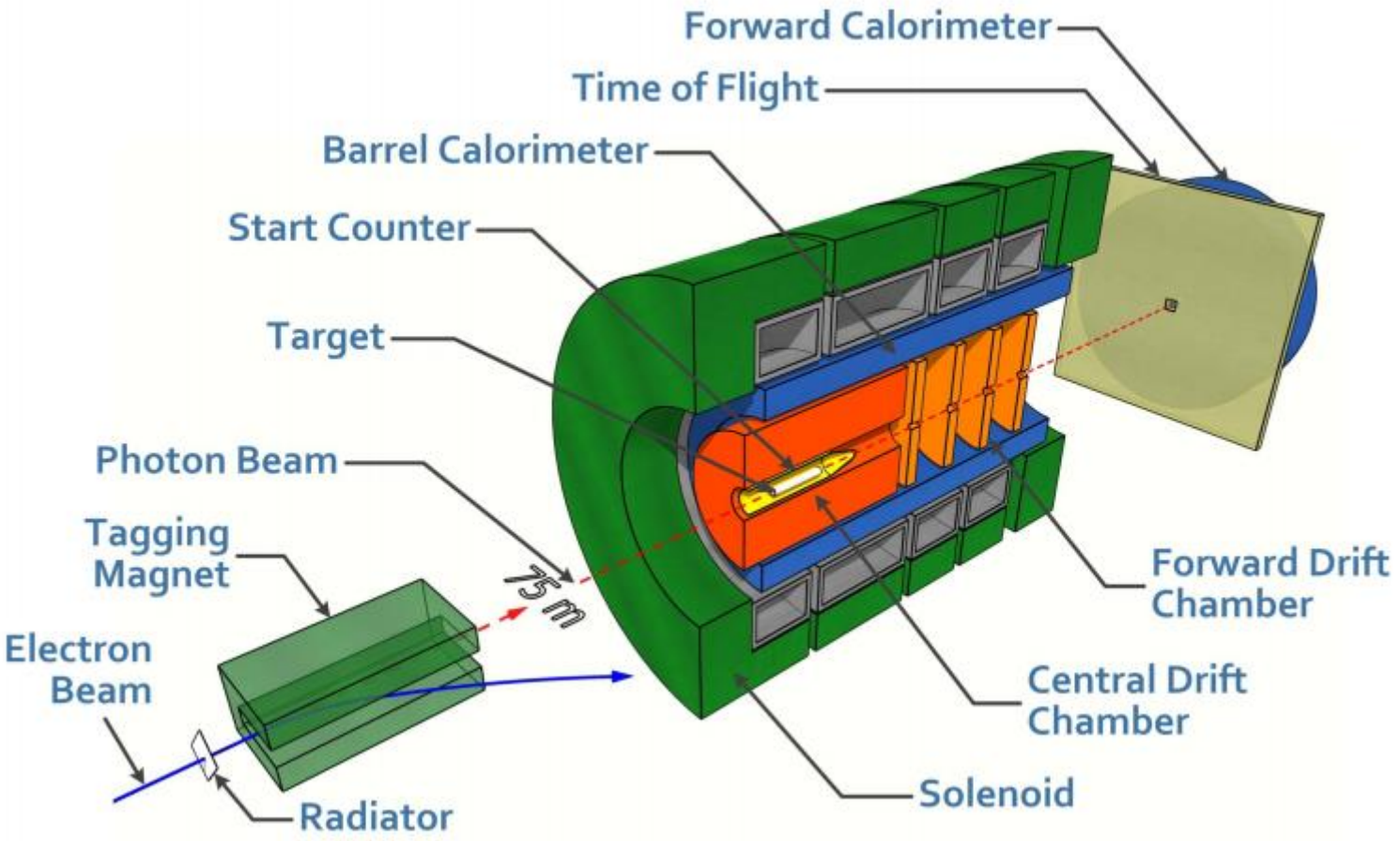
Missing Resonance Problem

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						

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

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

GlueX Phase I Detector

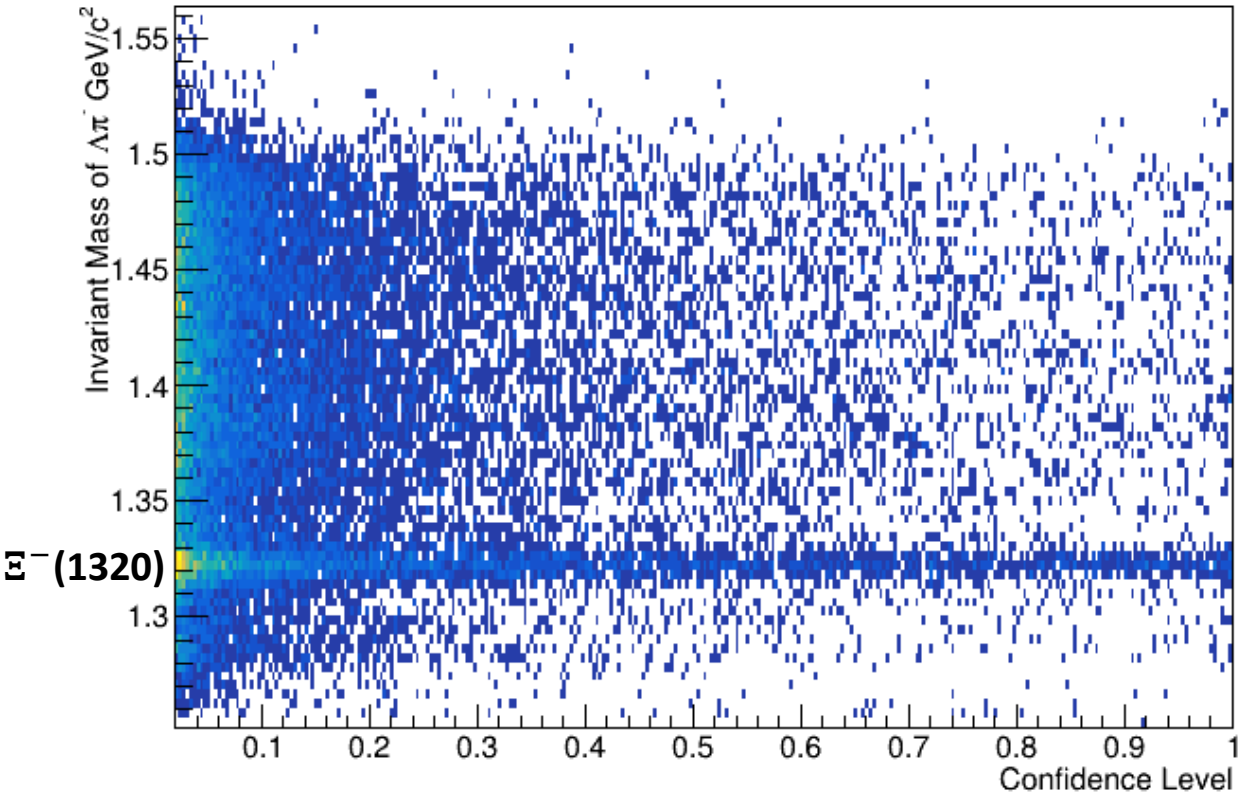


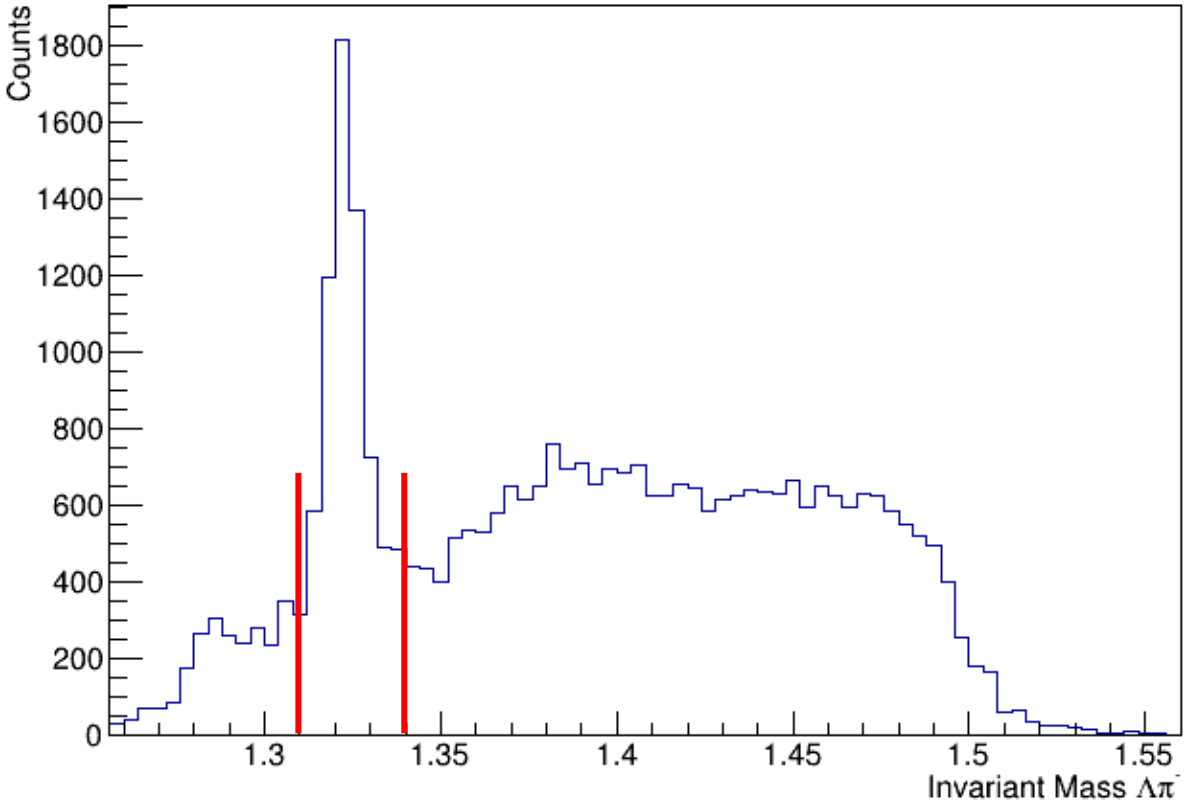
Decay Chain

$$\gamma p \rightarrow K^+ K^+ \Xi^{-*}(1530)$$
$$\Xi^{-*}(1530) \rightarrow \Xi^- \pi^0$$
$$\Xi^- \rightarrow \Lambda \pi^-$$

- 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 Cut





- There is a signal around the mass of the ground state cascade

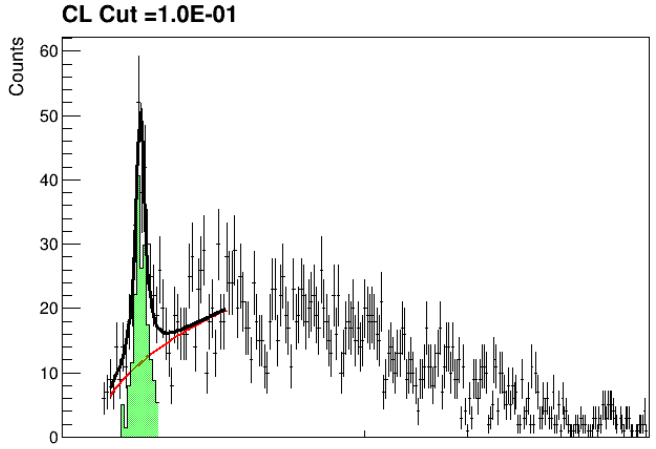
Optimizing the Kinematic Fit CL for the $\Xi(1530)$

- The CL cut needs to minimize the error in the yield improving the error in my final cross section measurement. Therefore, I defined a figure of merit (FOM) as the ratio of the signal yield over the error in the signal yield:

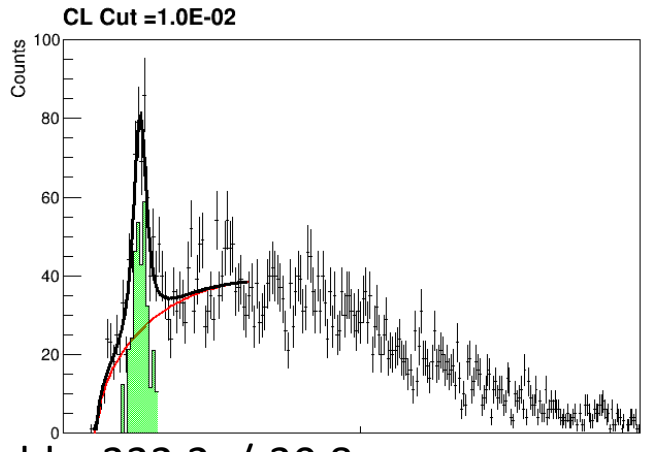
$$\text{FOM} = \frac{Y}{\sigma_Y} \qquad \sigma_Y = \sqrt{Y + 2B}$$

- The CL cut used in the analysis is determined by CL interval that maximizes the FOM

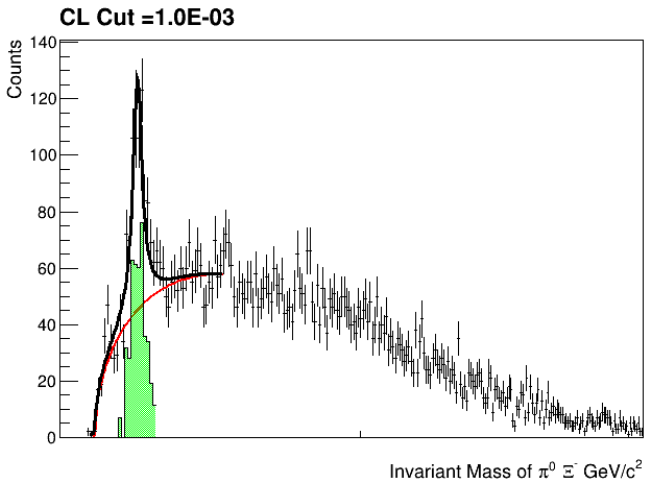
Excited Cascade Mass Spectrum



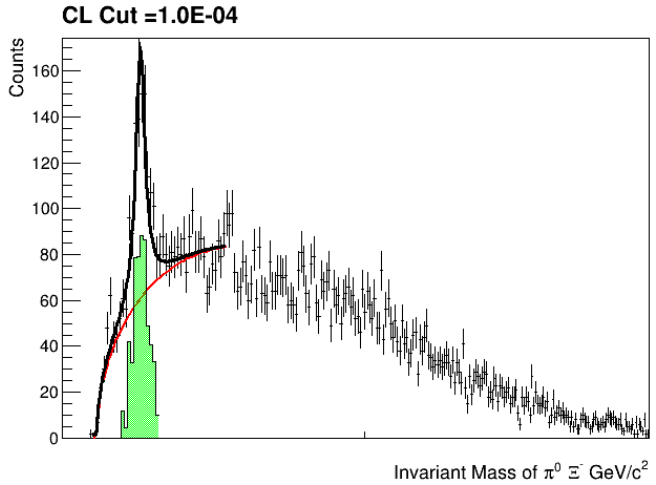
Yield = 188.9 +/-21.5



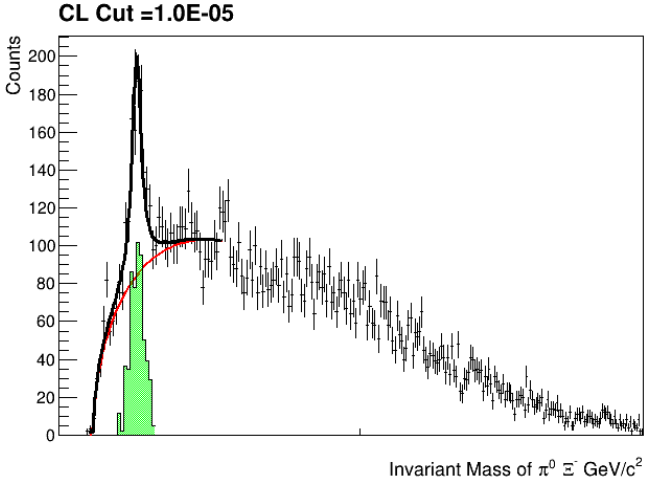
Yield = 332.2+/-30.8



Yield = 422.9 +/-38.7

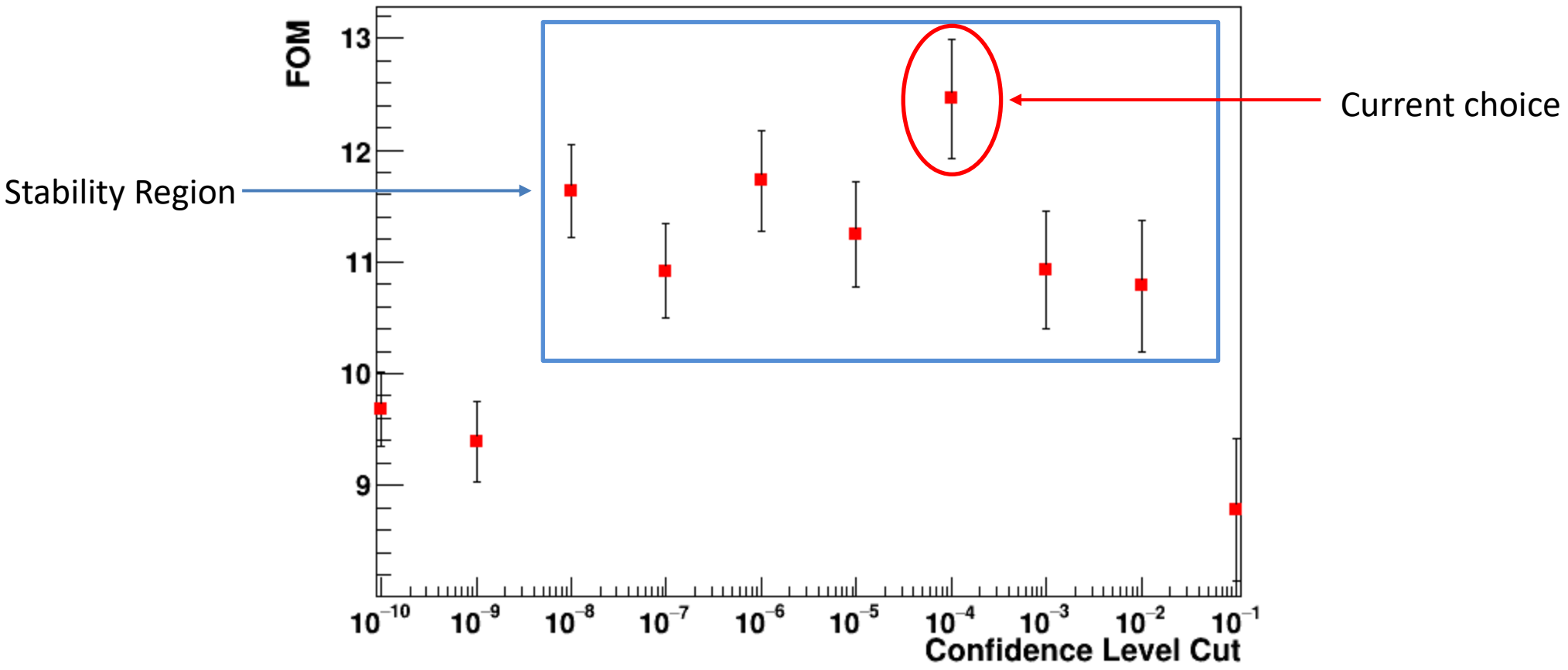


Yield = 556.9 +/-44.7

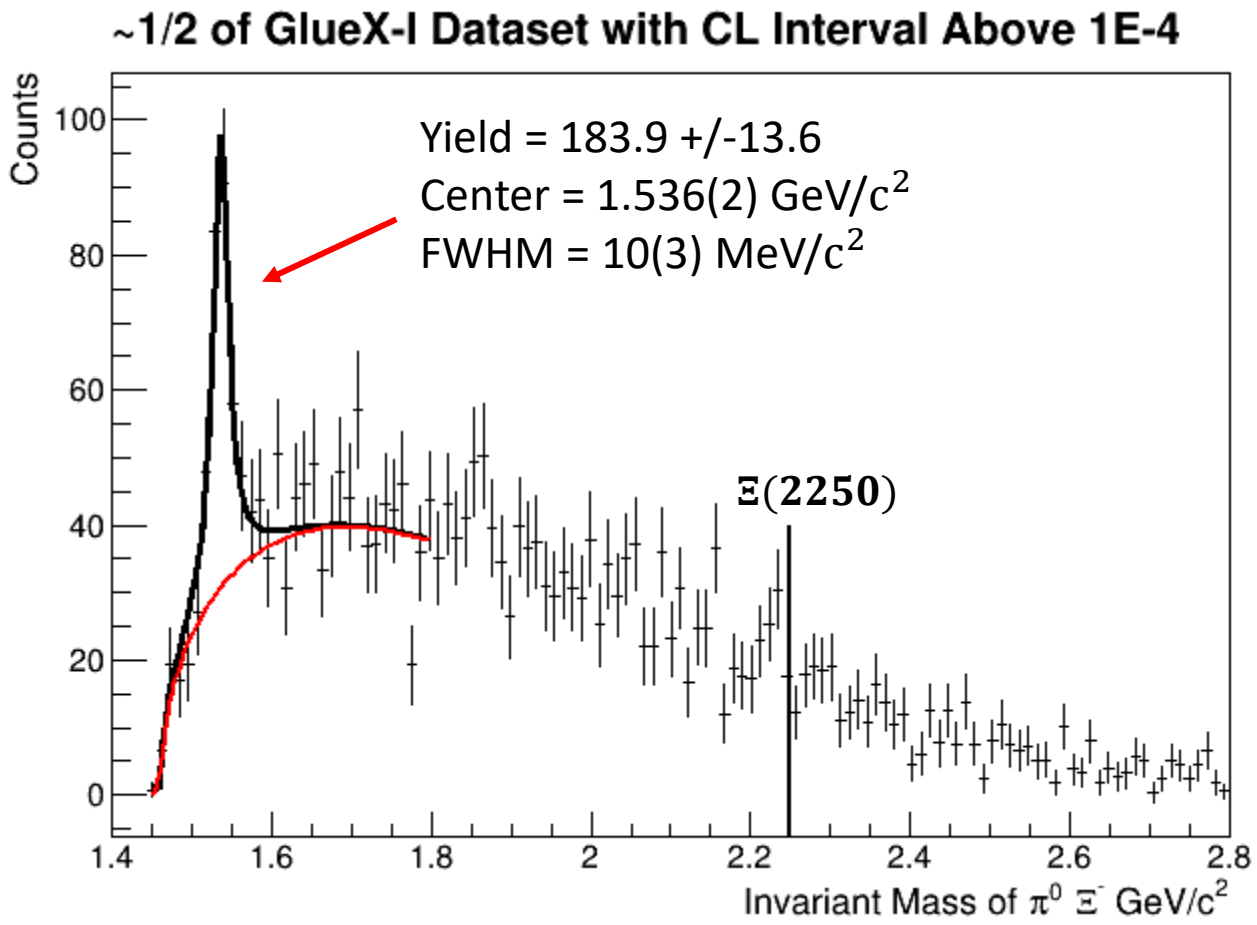


Yield = 569.2 +/-50.6

CL Study


Stability Region
Current choice
FOM
13
12
11
10
9
10^{-10}
10^{-9}
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
Confidence Level Cut

Searching for Excited Cascades



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

Ξ(2250) MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
≈ 2250 OUR ESTIMATE						
2189± 7	66	BIAGI	87	SPEC	–	Ξ^- Be → ($\Xi^-\pi^+\pi^-$) X
2214± 5		JENKINS	83	MPS	–	$K^-p \rightarrow K^+$ MM
2295±15	18	GOLDWASSER	70	HBC	–	K^-p 5.5 GeV/c
2244±52	35	BARTSCH	69	HBC		K^-p 10 GeV/c

Ξ(2250) WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
46±27	66	BIAGI	87	SPEC	–	Ξ^- Be → ($\Xi^-\pi^+\pi^-$) X
< 30		GOLDWASSER	70	HBC	–	K^-p 5.5 GeV/c
130±80		BARTSCH	69	HBC		

Modeling the Cascade Production in Signal MC

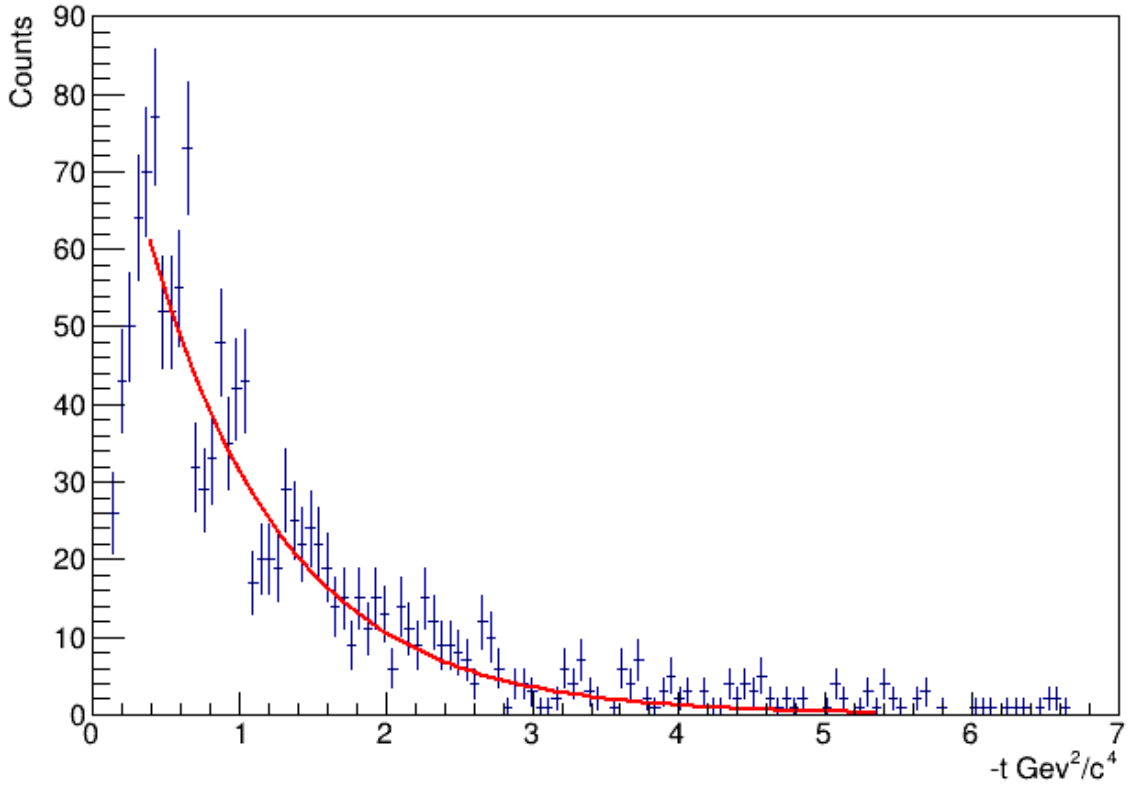
- Theoretical Calculations done by Nakayama, Oh and Haberzettl proposed the cascade/excited cascade are produced by a two-step process:

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

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

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

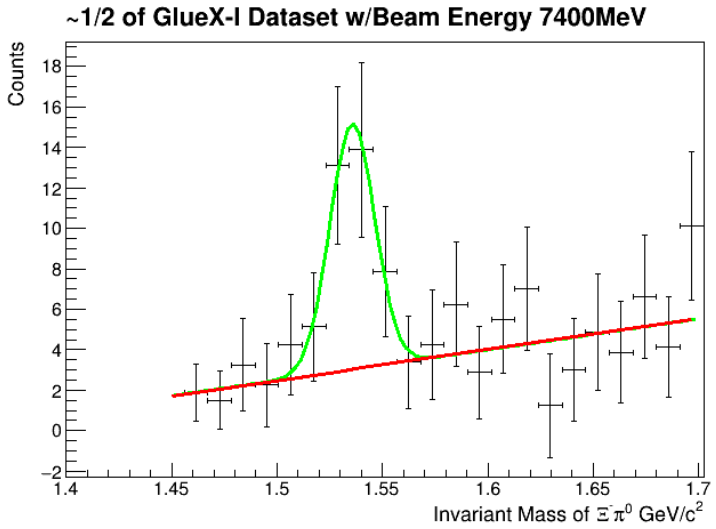
t-Slope extraction

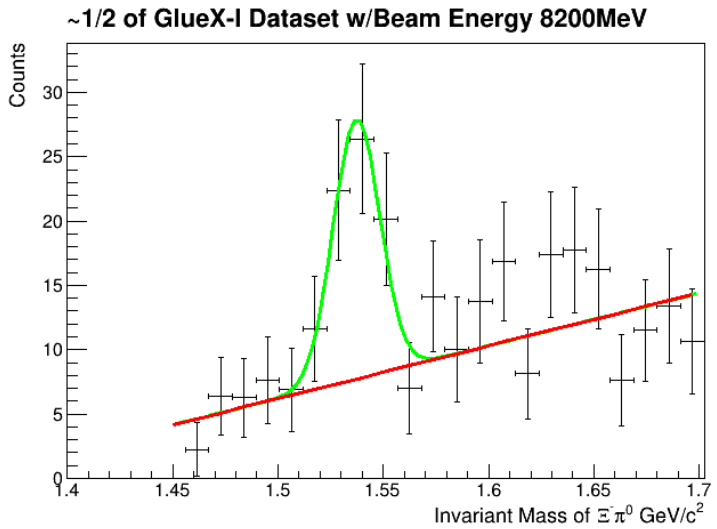


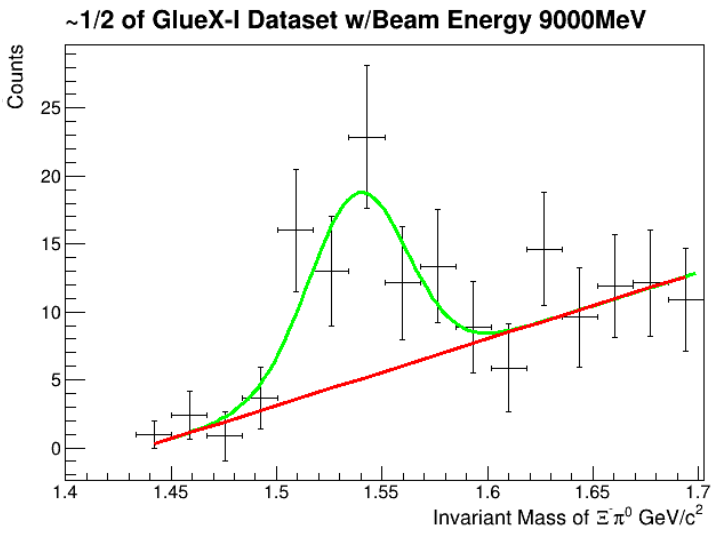
- Selecting events within the excited cascade 1530 peak
- Assuming : $\frac{d\sigma}{dt} \propto e^{-bt}$

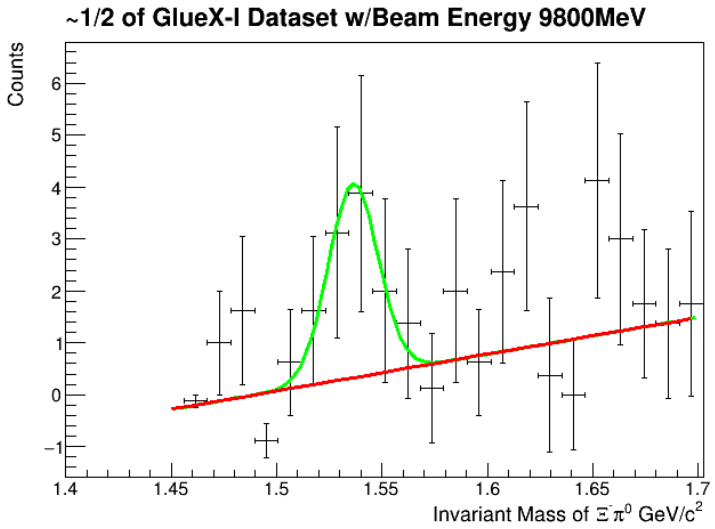
$$b = 1.08(4)\ c^4/GeV^2$$

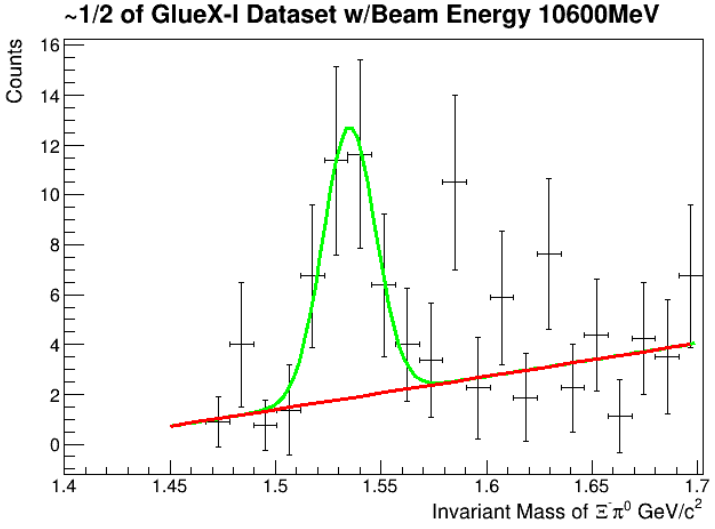
Energy-dependent $\Xi(1530)$ Yield Extraction











Conclusion

- $\Xi(1530) \rightarrow \Xi^{-}\pi^{0}$ observed in high energy photoproduction at GlueX

- Preliminary value of the cross section from $7.0 < E_{\gamma} < 11.0$ GeV is ~1nb with studies of systematic uncertainties ongoing

- Extending search for excited cascades with full GlueX-I data

GlueX Acknowledgements: gluex.org/thanks

End

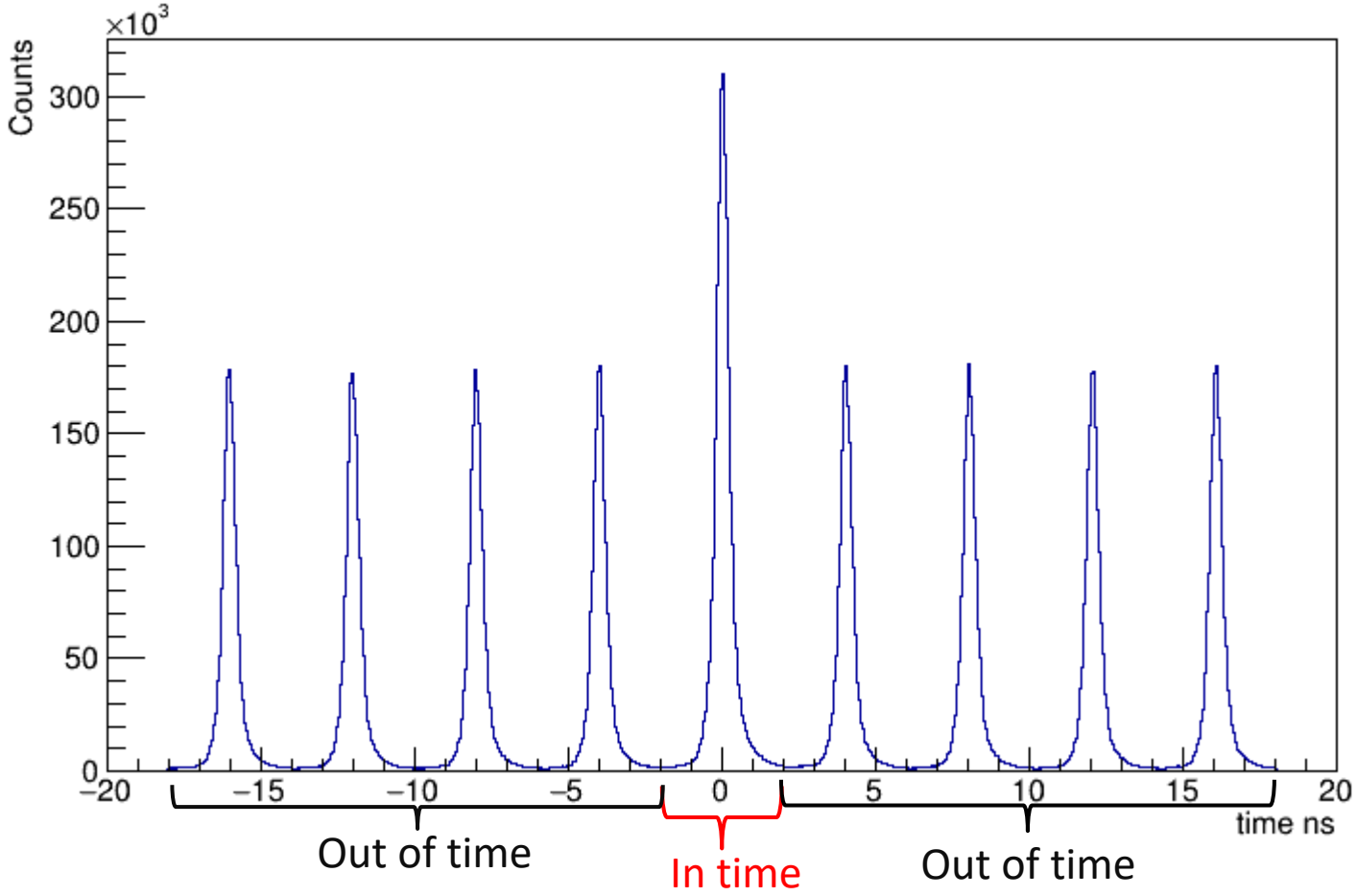
Cuts on Data

- Exclude events where either Kaon comes from start timer or NULL events
- Above a confidence level of .0001
- Invariant mass of $\Lambda\pi^-$ (note $\Xi^- \rightarrow \Lambda\pi^-$) between 1.31-1.34 GeV/c^2

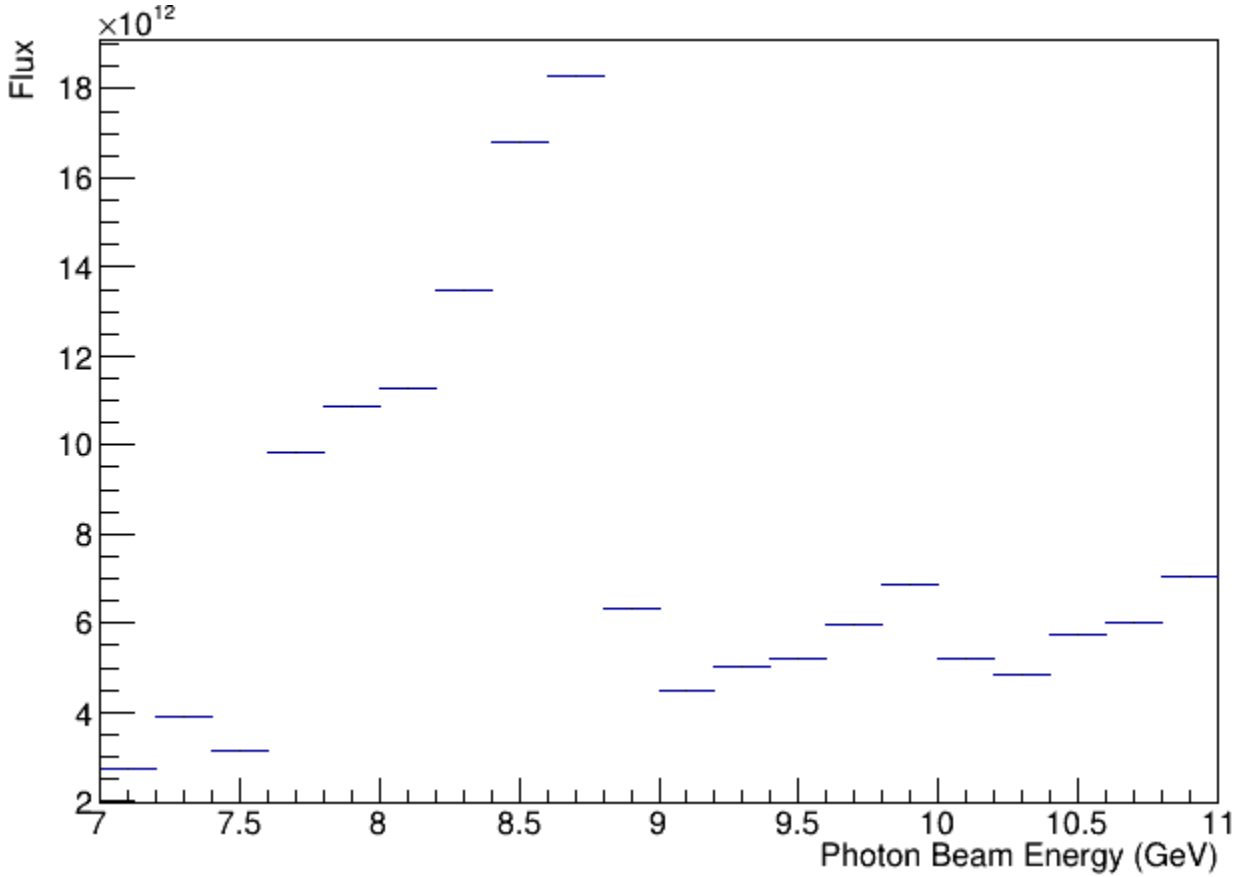
Accidental Subtraction

- Define in time events as events within 2ns of main beam bucket

- Appropriately weight the eight out of time accidentals



Photon Flux


Flux
×10^12
18
16
14
12
10
8
6
4
2
7
7.5
8
8.5
9
9.5
10
10.5
11
Photon Beam Energy (GeV)