Cascade Update $\Xi^-(1530)$ Collaboration Meeting

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Outline

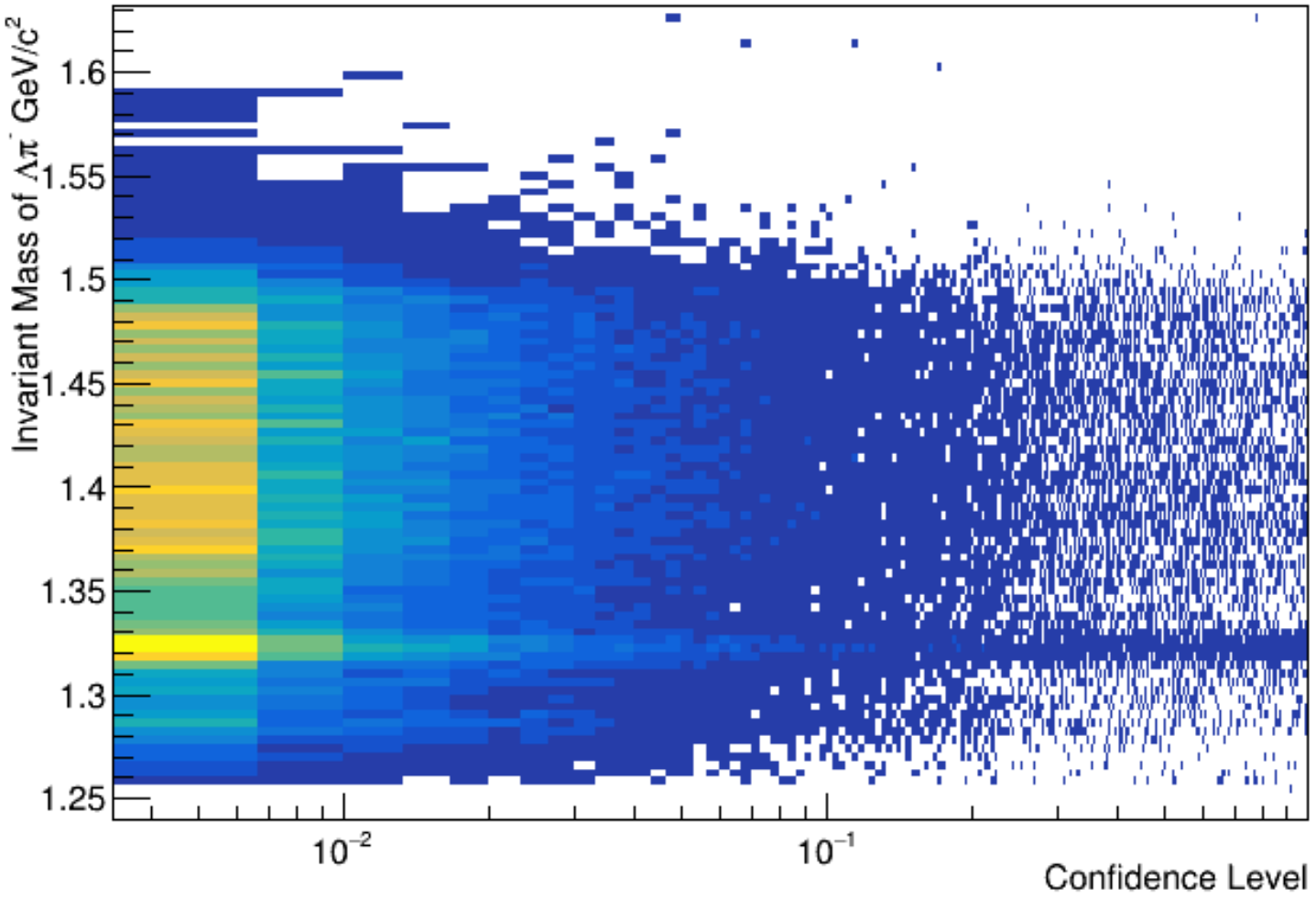
- Review of Cuts
- Excited Cascade mass spectrum
- Accidental Subtraction
- *t*-slope matching
- Cross Section

Decay Chain

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

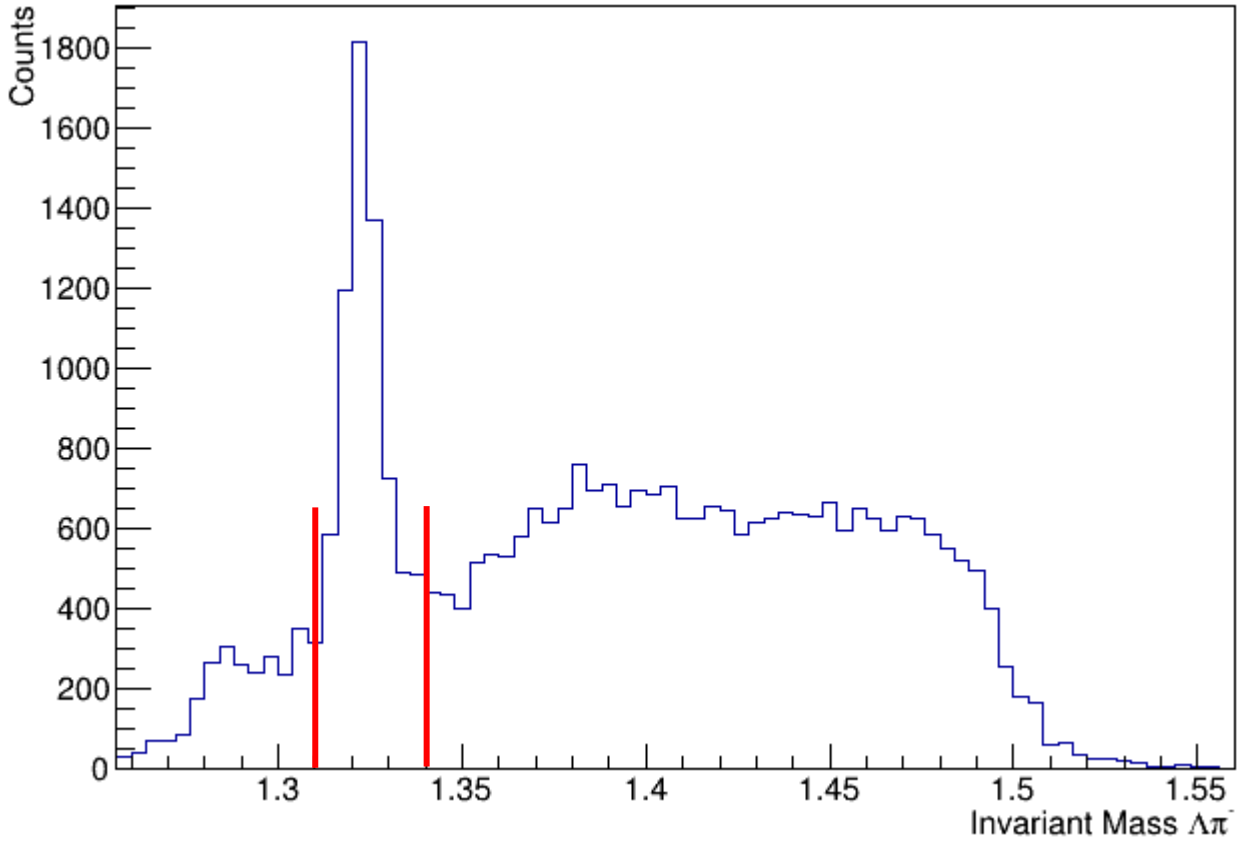
- The Λ and π^0 are Kinfit
- Data comes from Spring 18

Confidence Level Cut



- There is a signal around the mass of the ground state cascade
- Initially selected events with a CL cut above 10^{-4}

Cascade Mass Cut



- The cascade mass, with a detector cut and confidence level cut produced the following plot.
- I made a mass cut from 1.31-1.34 GeV/c^2

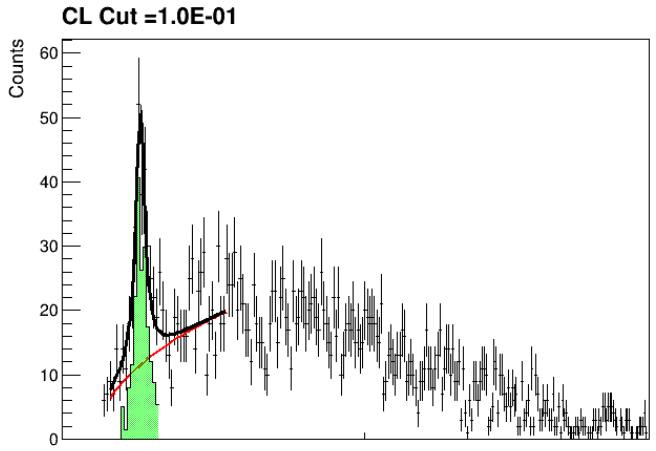
CL Study

- 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 inverse ratio of error in the signal yield over the signal yield:

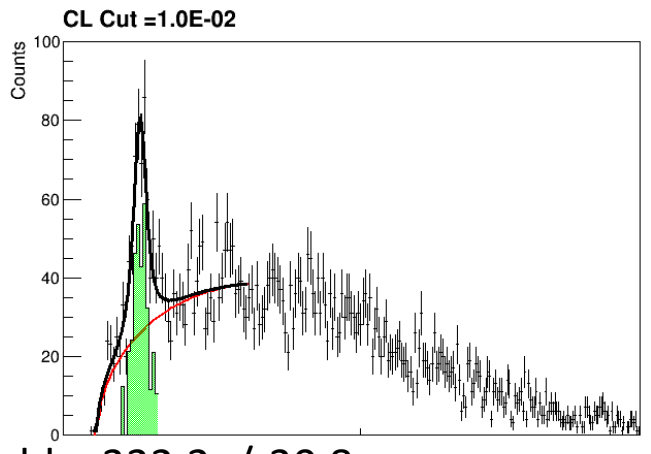
$$\text{FOM} = \left(\frac{\sigma_Y}{Y}\right)^{-1}$$

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

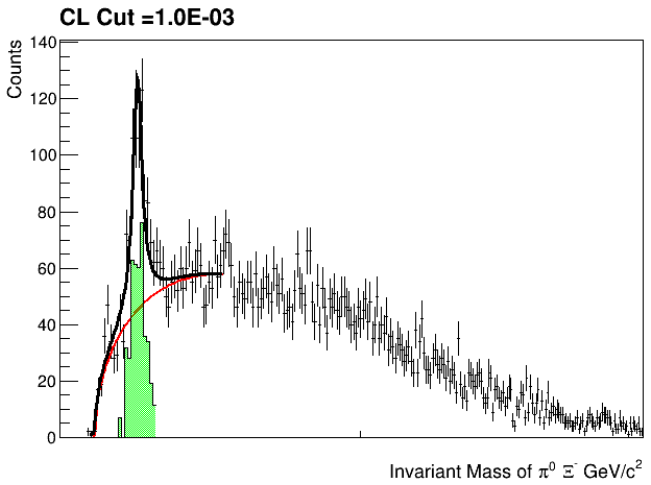
Excited Cascade Mass Spectrum (Slide 1 of 2)



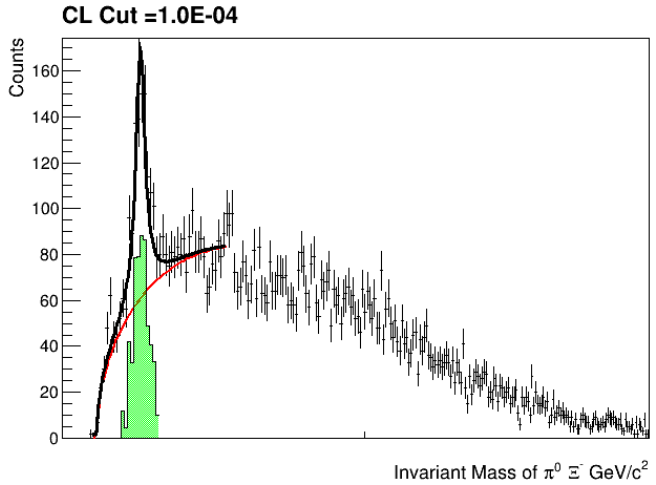
Yield = 188.9 +/-21.5



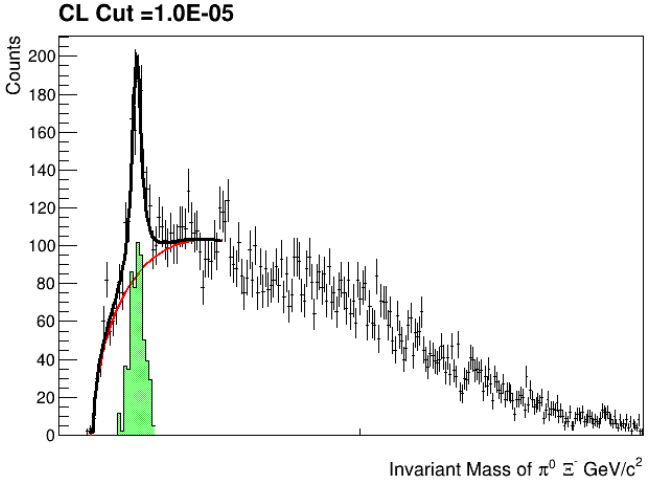
Yield = 332.2+/-30.8



Yield = 422.9 +/-38.7

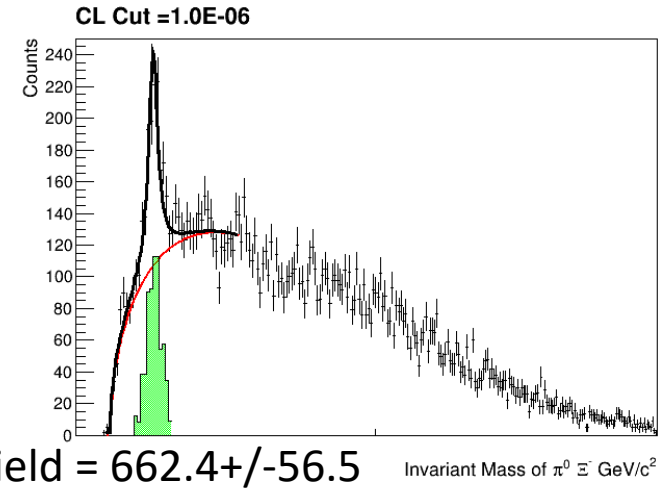


Yield = 556.9 +/-44.7

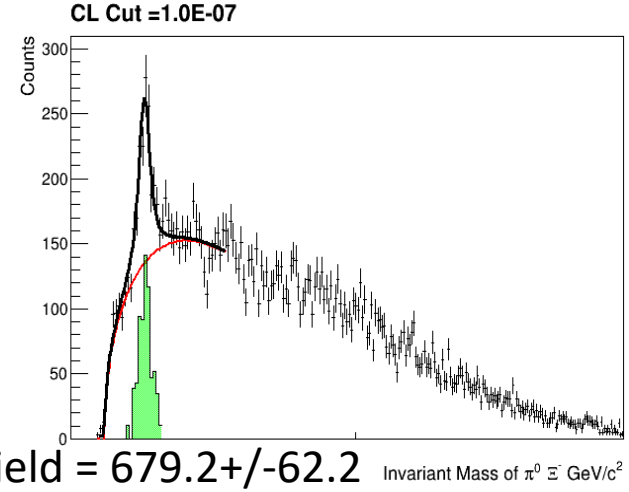


Yield = 569.2 +/-50.6

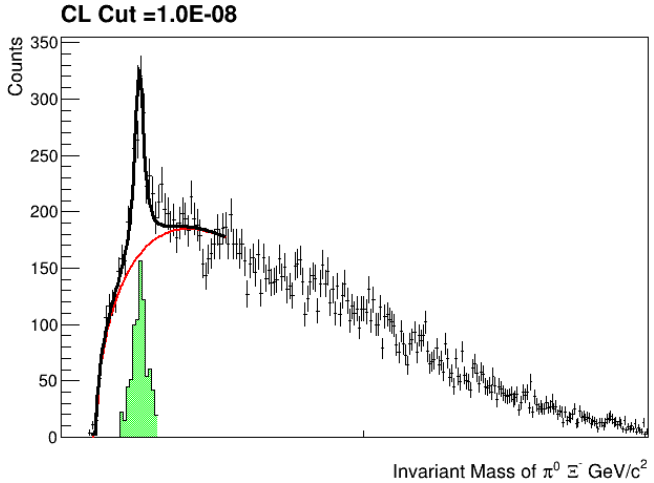
Excited Cascade Mass Spectrum (Slide 2 of 2)



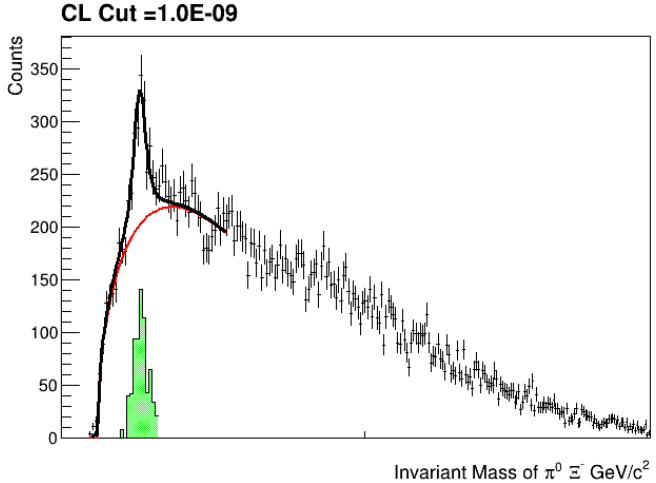
Yield = 662.4+/-56.5



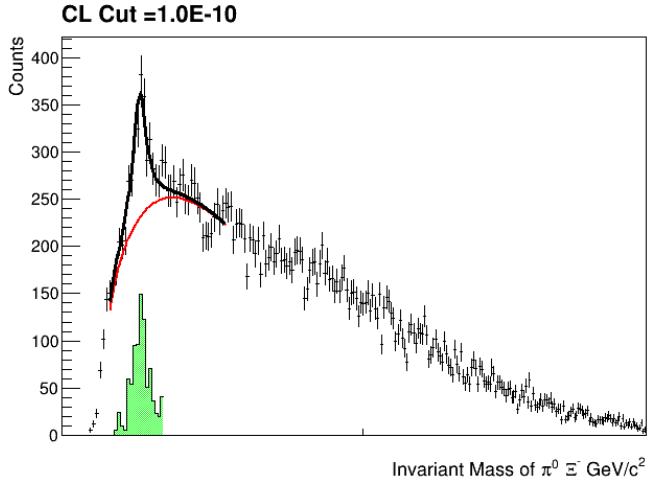
Yield = 679.2+/-62.2



Yield = 789.9+/-67.9

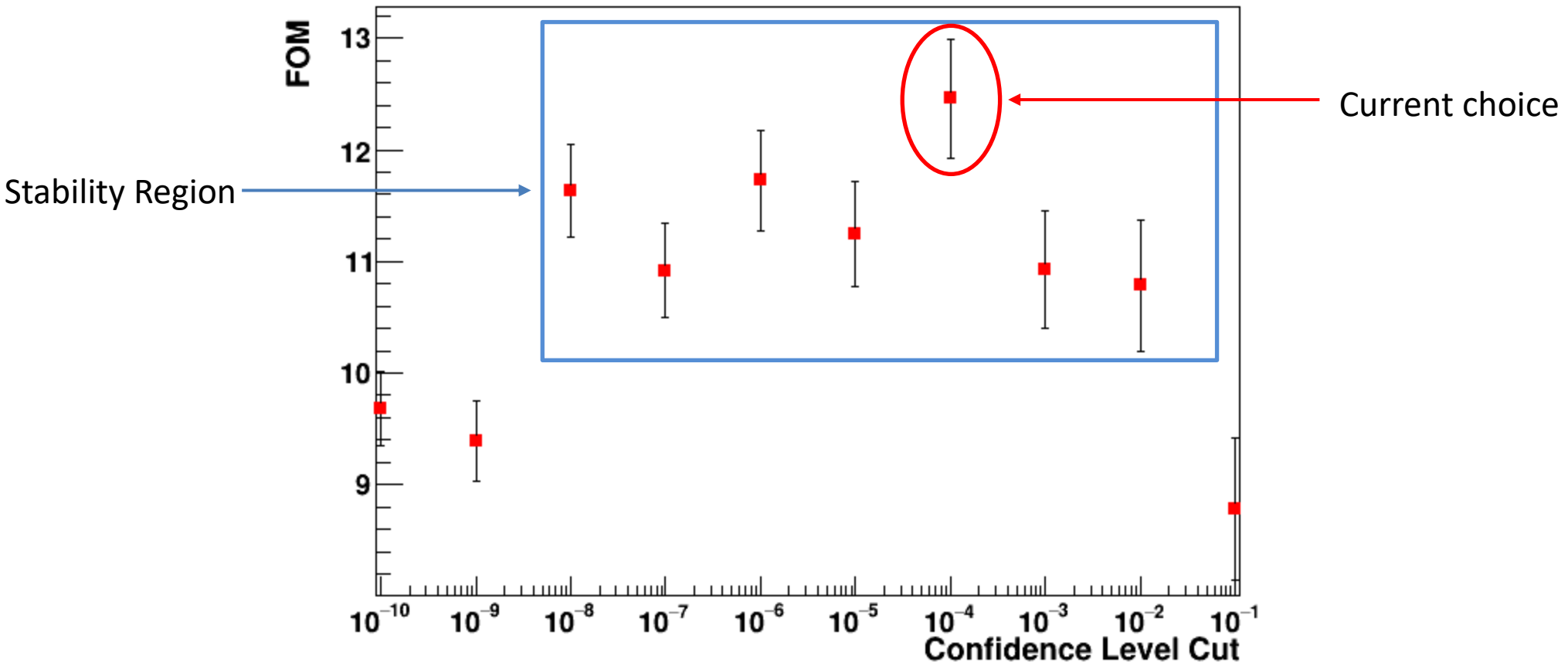


Yield = 692.1+/-73.8



Yield = 864.8+/-89.32

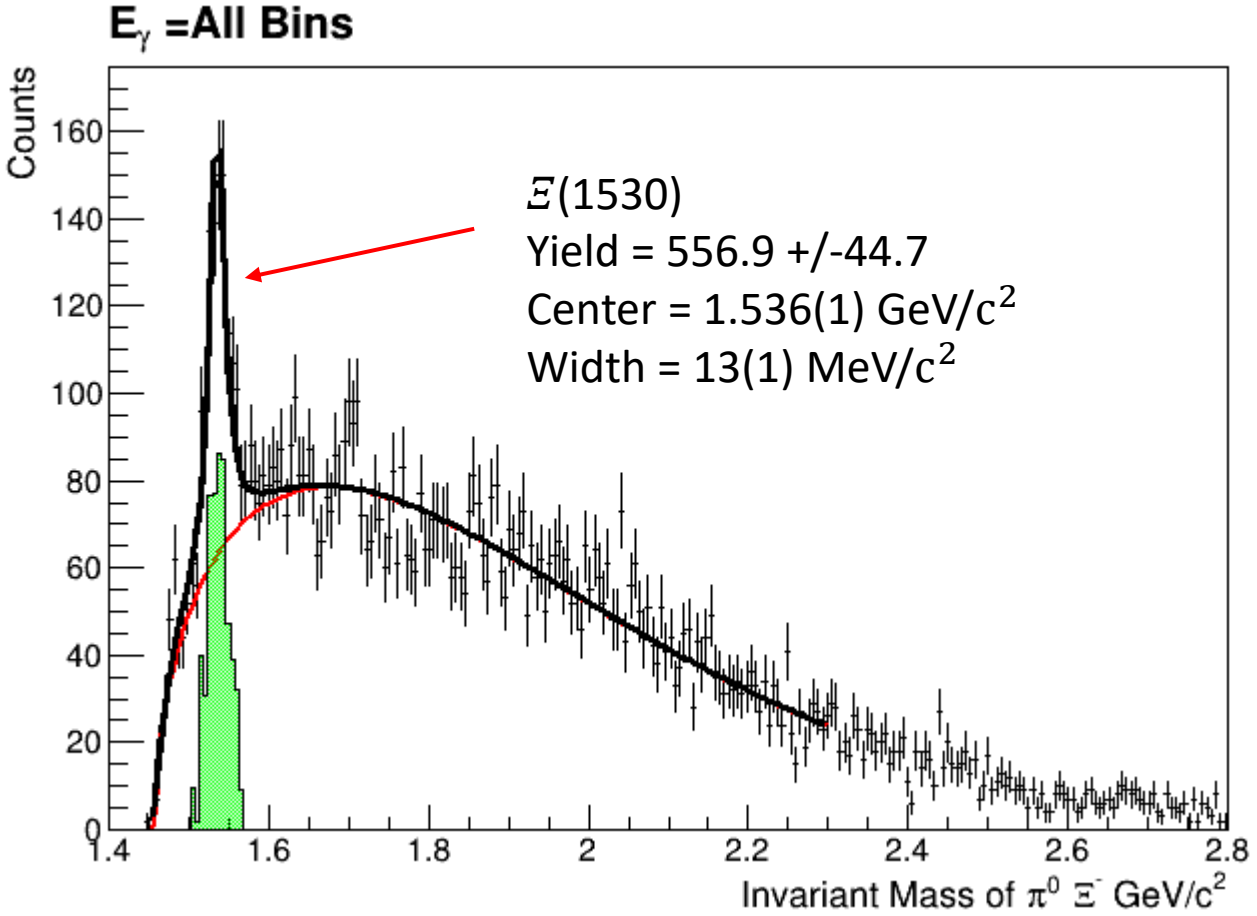
CL Study


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

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

Invariant Mass of Excited Cascade



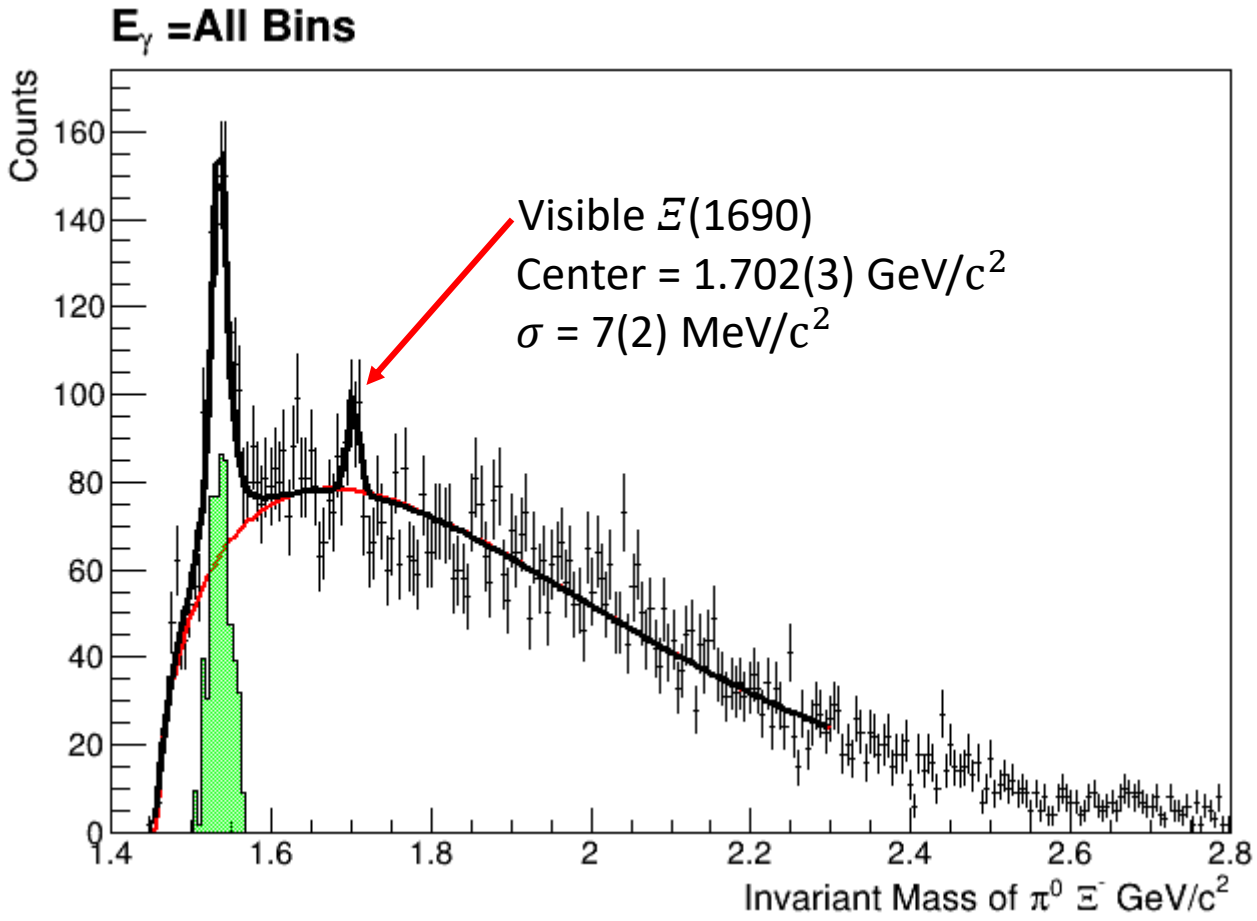
$\Xi(1530)$ $3/2^+$

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

$\Xi(1530)^0$ 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

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

Invariant Mass of Excited Cascade



$\Xi(1690)$ $I(J^P) = \frac{1}{2}(?^?)$

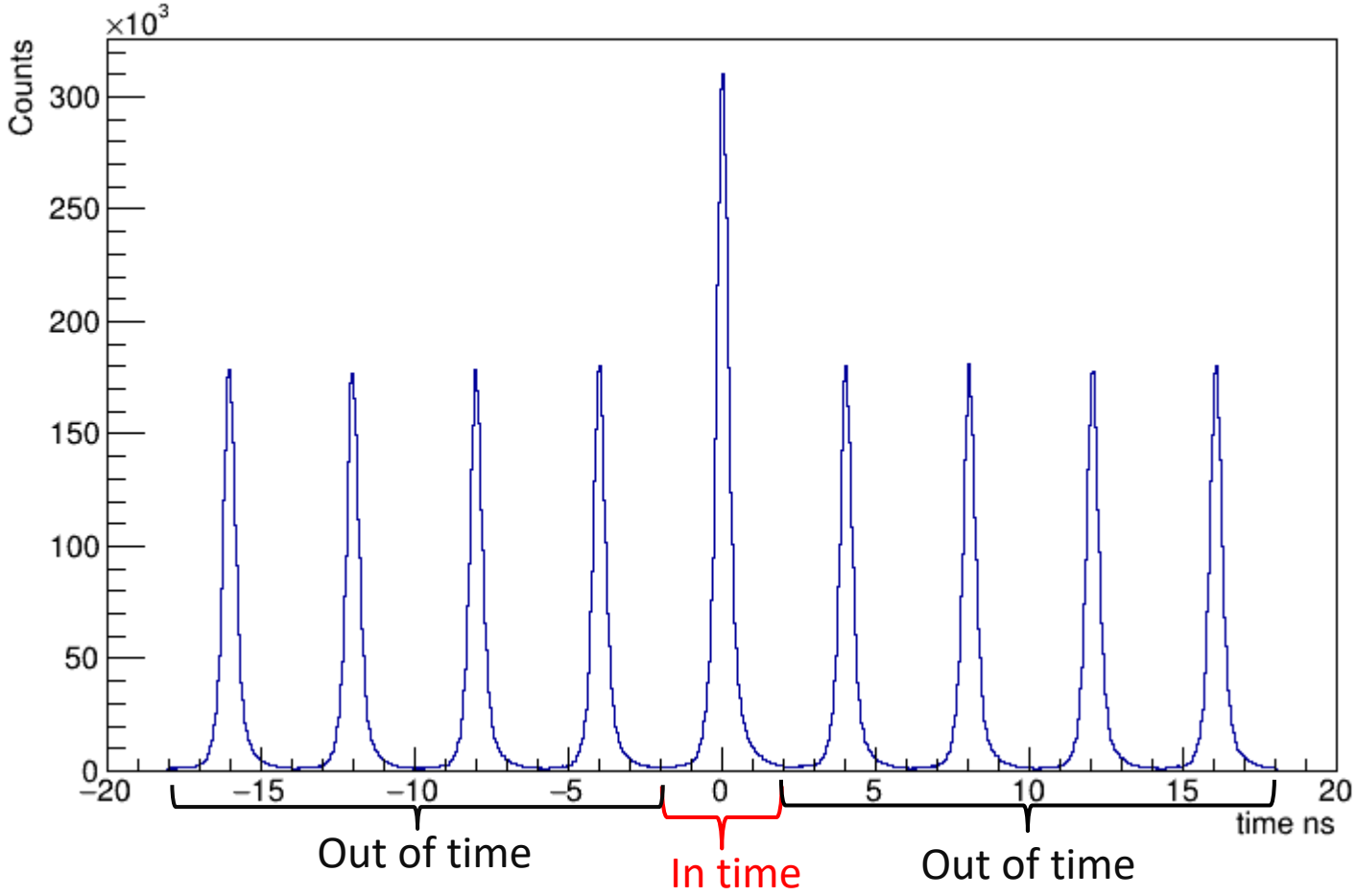
Mass $m = 1690 \pm 10$ MeV [c]
Full width $\Gamma < 30$ MeV

$\Xi(1690)$ 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

Accidental Subtraction

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

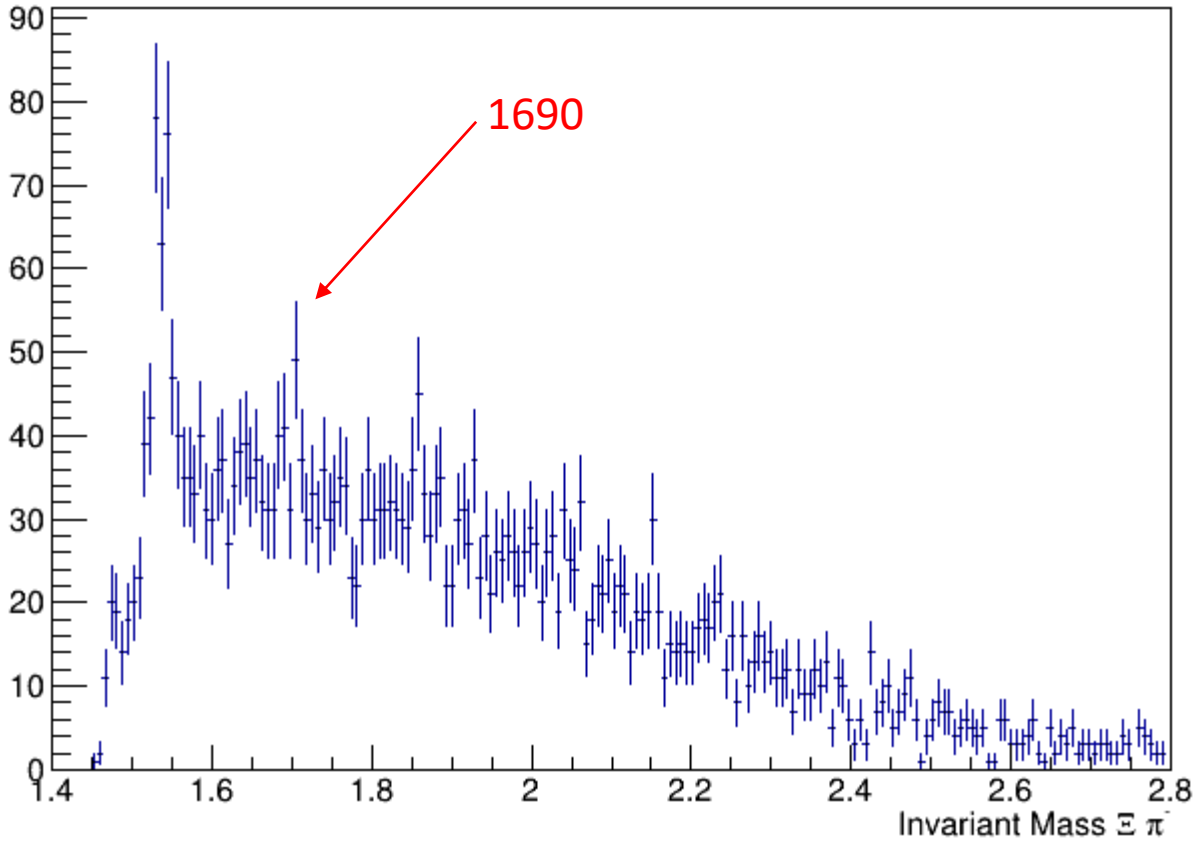
- Appropriately weight the eight out of time accidentals



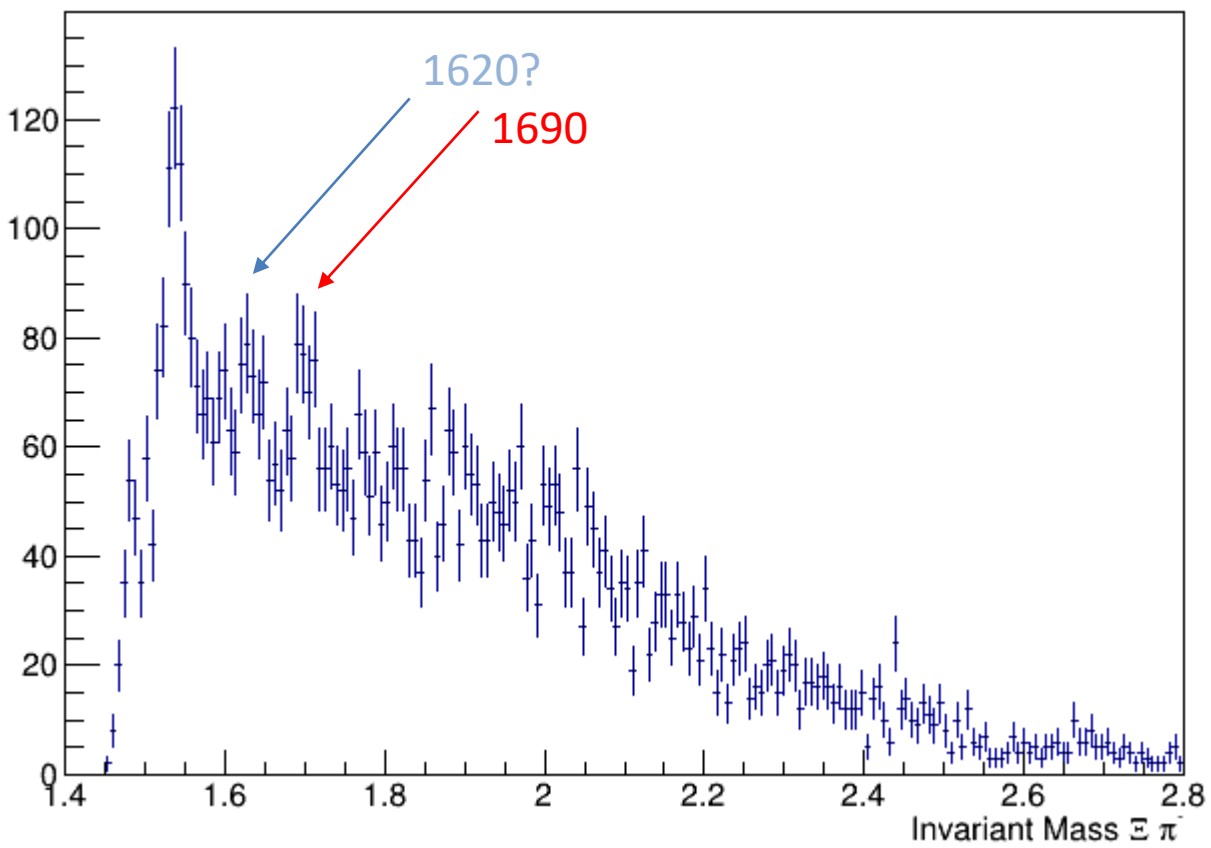
Will move away from this method in the future in exchange for choosing the best photon (i.e. with best CL) in the beam bucket

ASU

In/Out of time Invariant Mass distributions

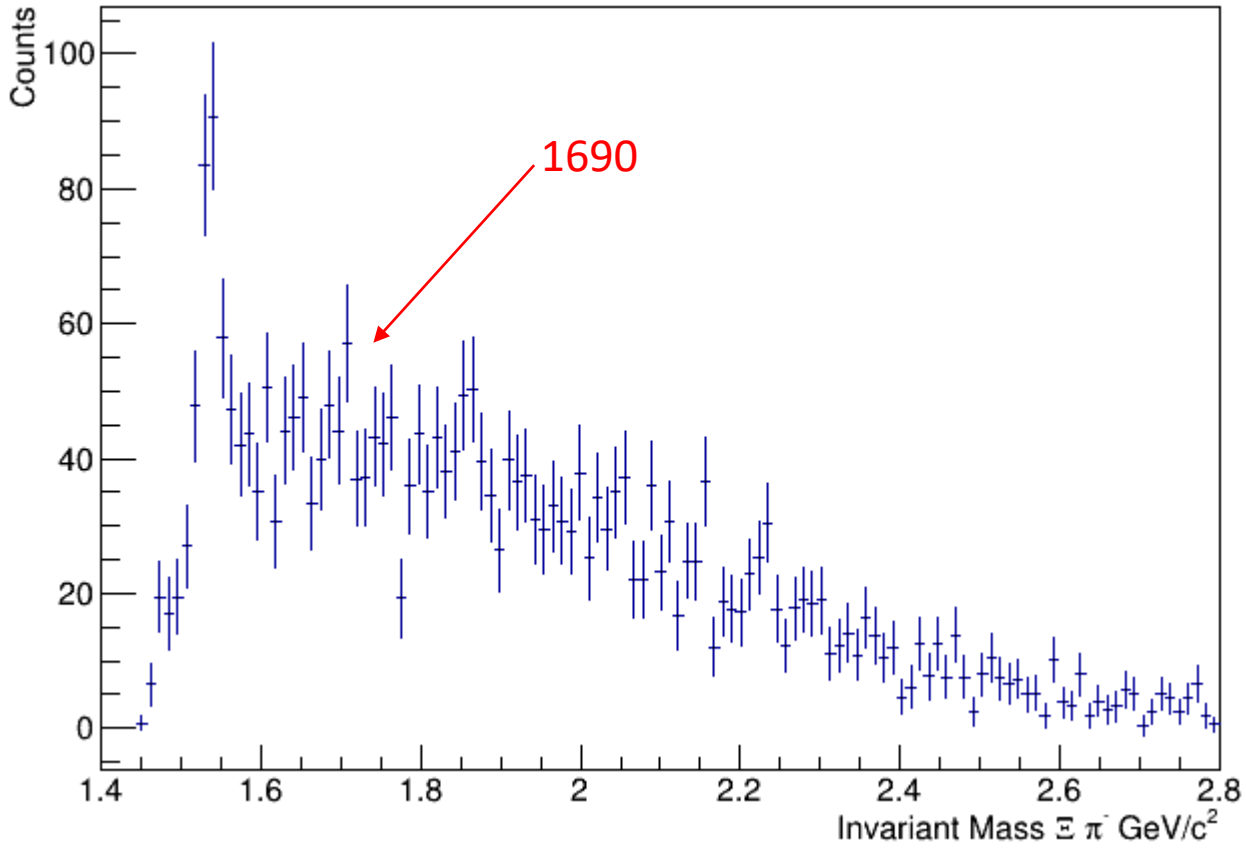


In time distribution



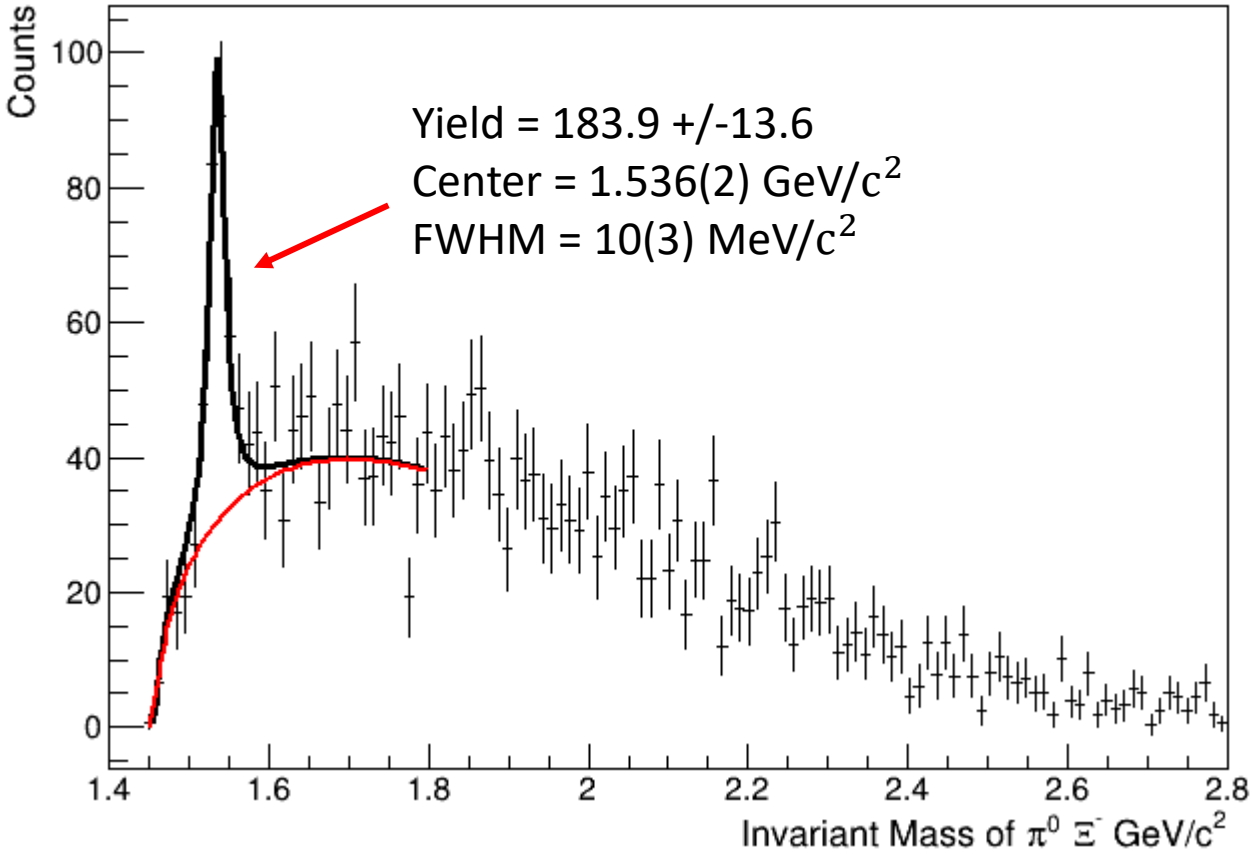
Out of time distribution

Accidentally Subtracted Cascade Mass Spectrum



- The 1690 peak far less prominent after accidental subtraction

Sp 18 Accidental subtracted, excited Cascade



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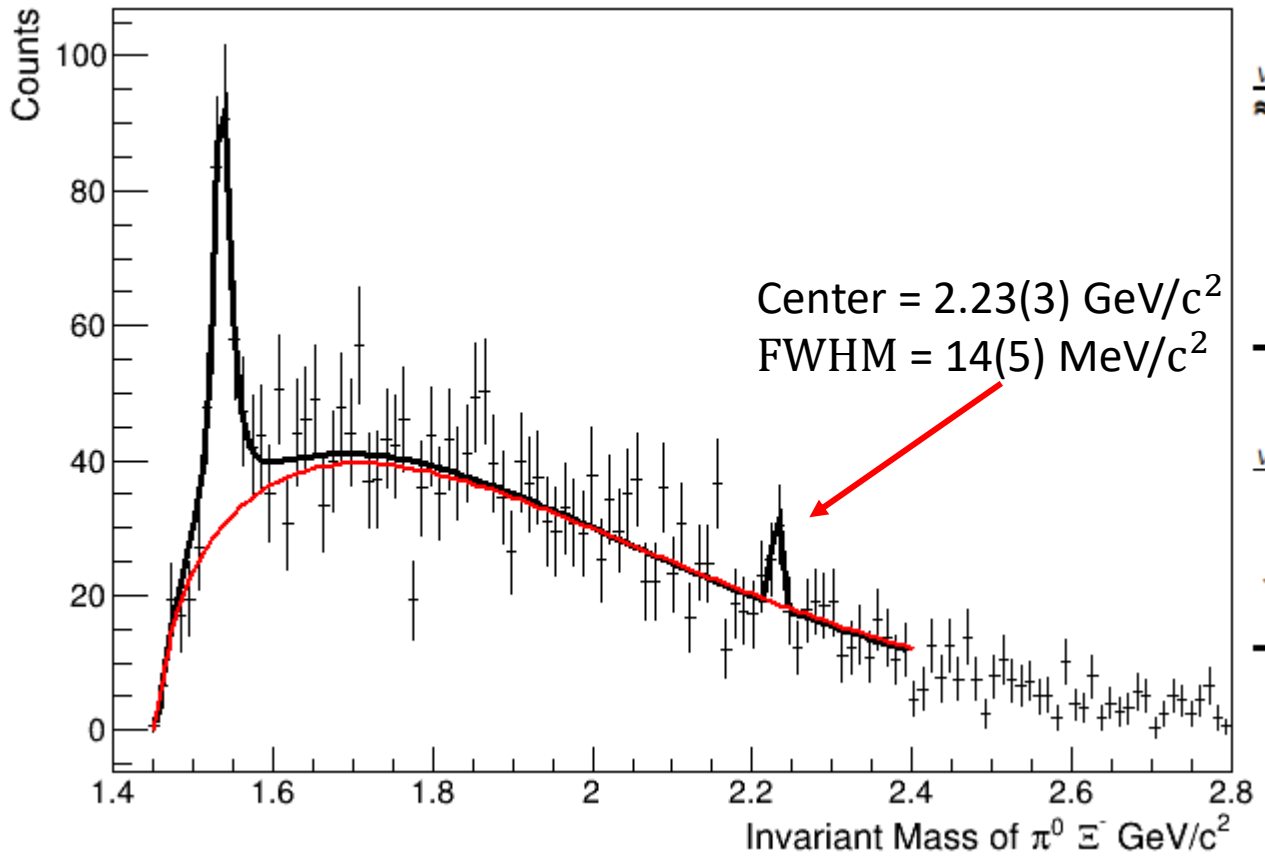
Further Excited states



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		

t-slope generation

- 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:

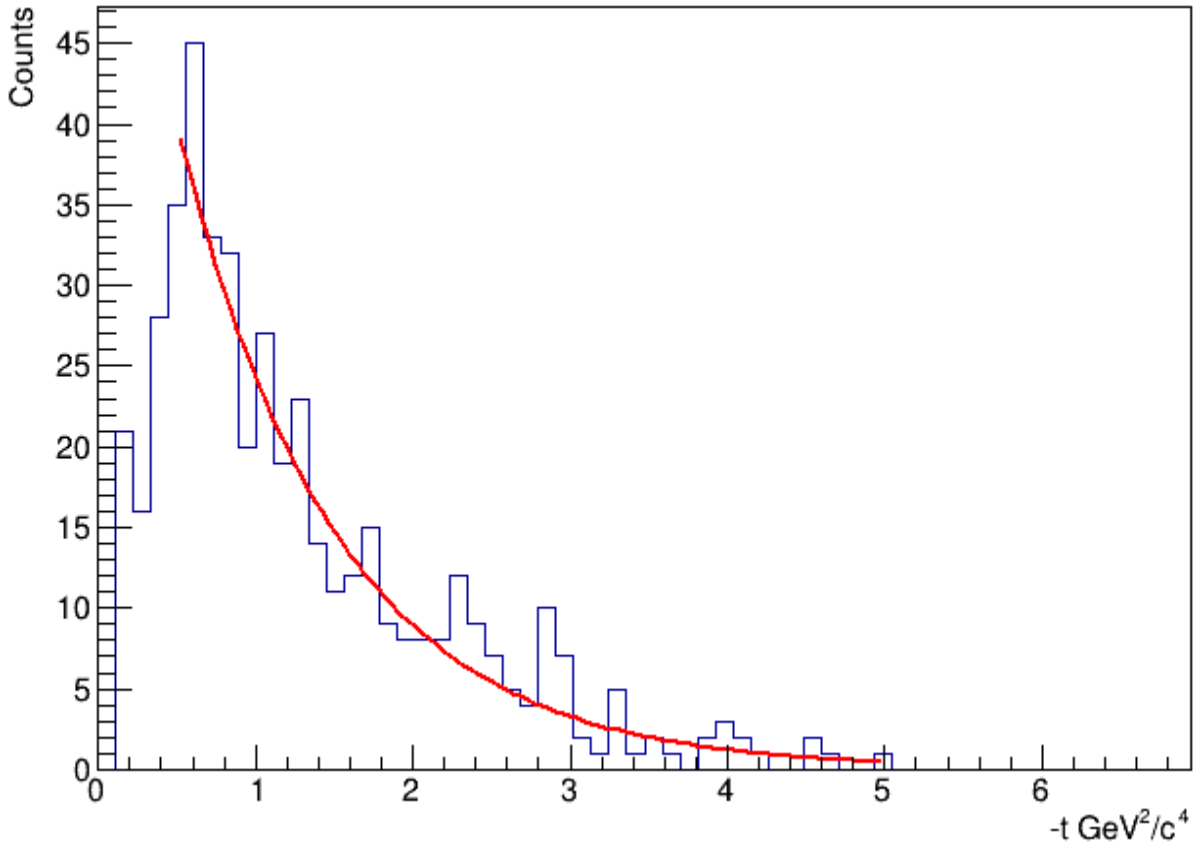
$$t = \left(P_{\gamma} - P_{K^{+}}\right)^{2}$$

MC Generation

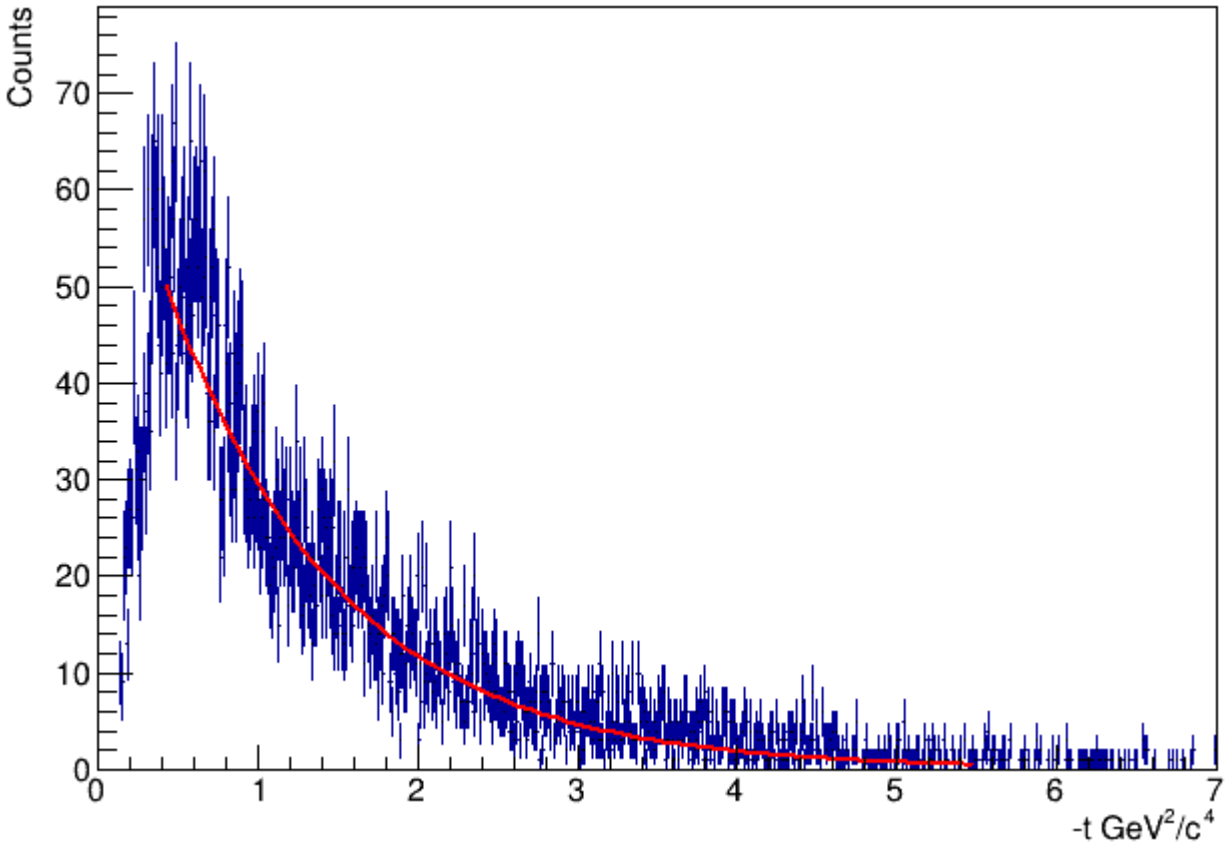
Assuming : $\frac{d\sigma}{dt} \propto e^{-bt}$

- 3.6 million events generated
- Using Genr8
- Initially setting the *t*-slope to be b = 1.1 $\mathrm{c}^4/\mathrm{GeV}^2$

t-slope: MC and real

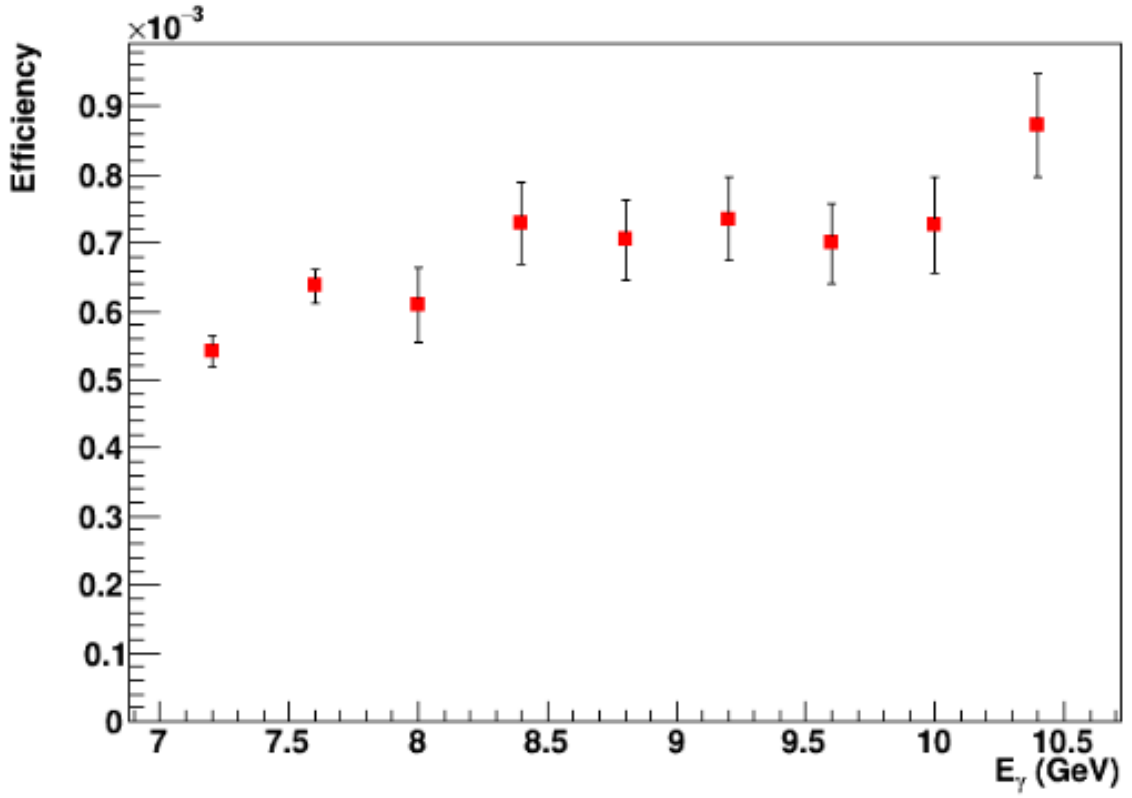


Seen MC *t*-slope = .99 $\mathrm{GeV}^2/\mathrm{c}^4$



Real *t*-slope = .92 $\mathrm{GeV}^2/\mathrm{c}^4$

Efficiency vs Beam energy



ASU Arizona State University

Cross Section Measurement

- Extract yields from the accidental subtracted excited cascade mass spectrum in 400 MeV wide beam energy bins from 7.0 – 11.0 GeV
- Use Gaussian for the signal and second order polynomial for the background
- Limits the gaussian fit range to be within 20% of MC simulation
- Using the Log likelihood method for fits instead of default Chi-squared method

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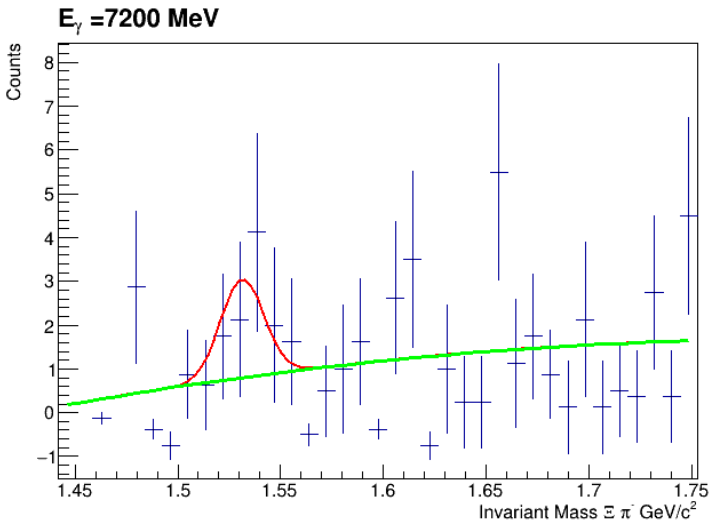
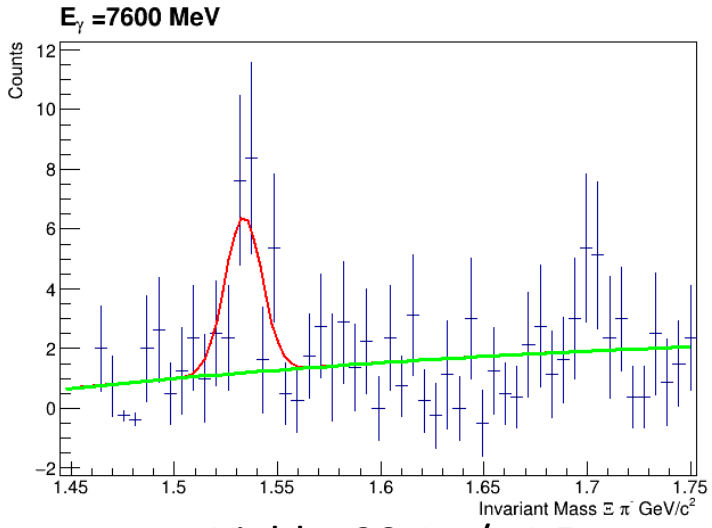
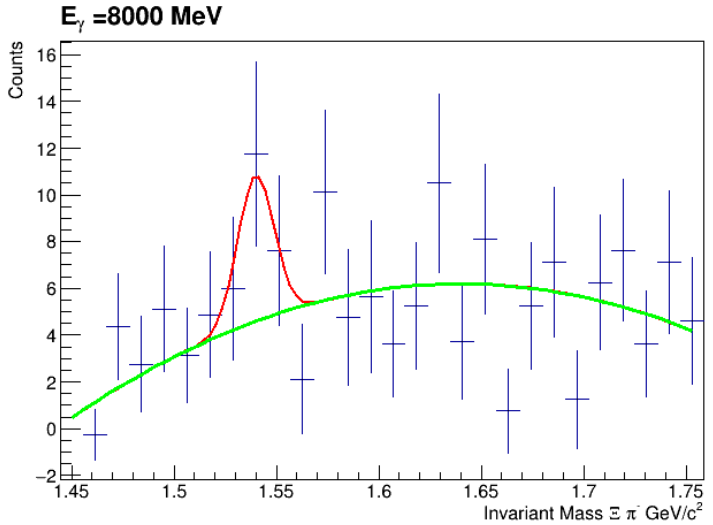
Yield Extraction



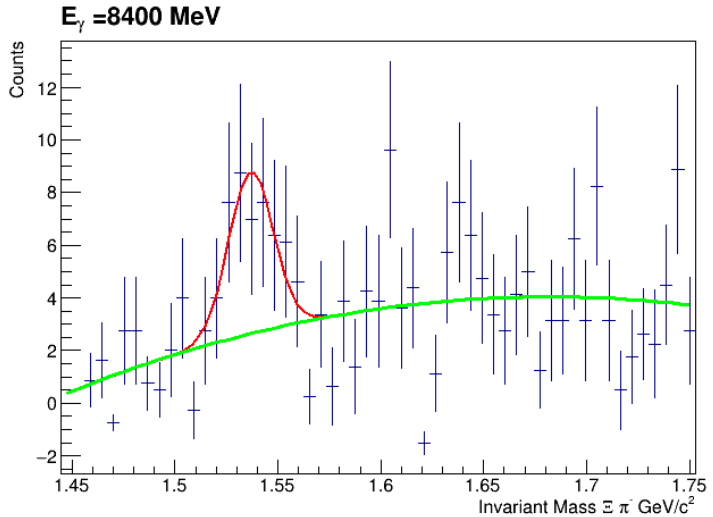
Yield = 4.8 +/- 2.2



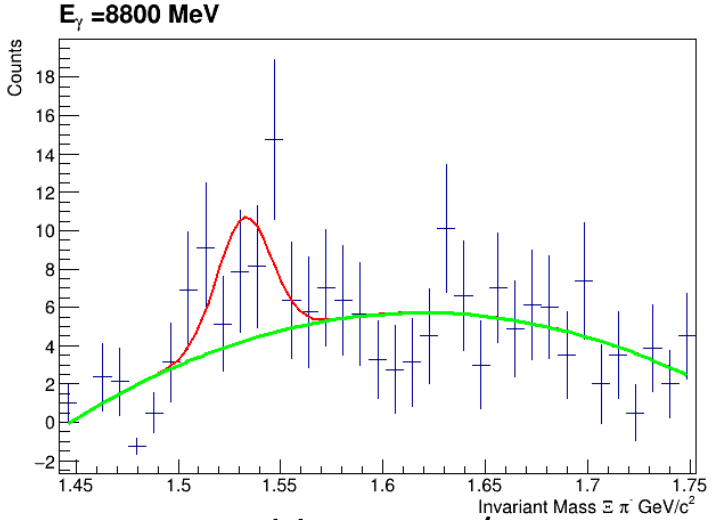
Yield = 20.1 +/- 4.5



Yield = 9.6 +/- 3.1

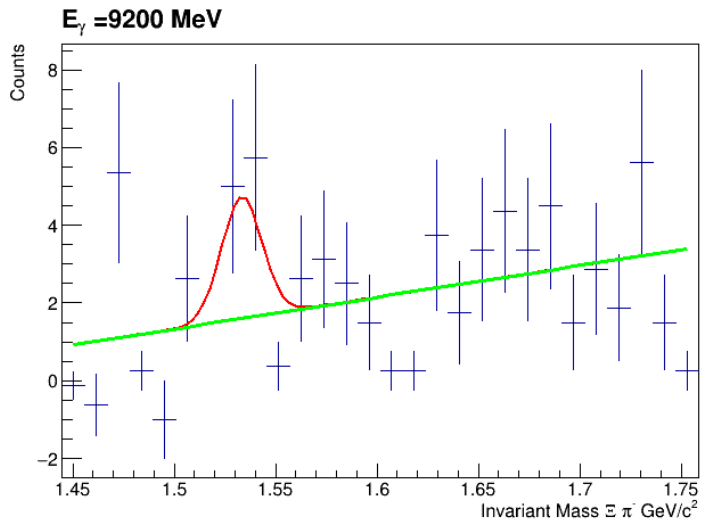


Yield = 28.2 +/- 5.3

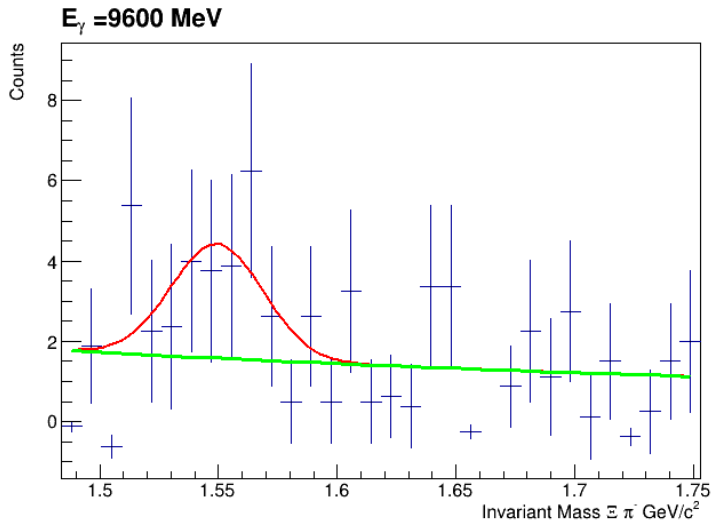


Yield = 32.0 +/- 5.7

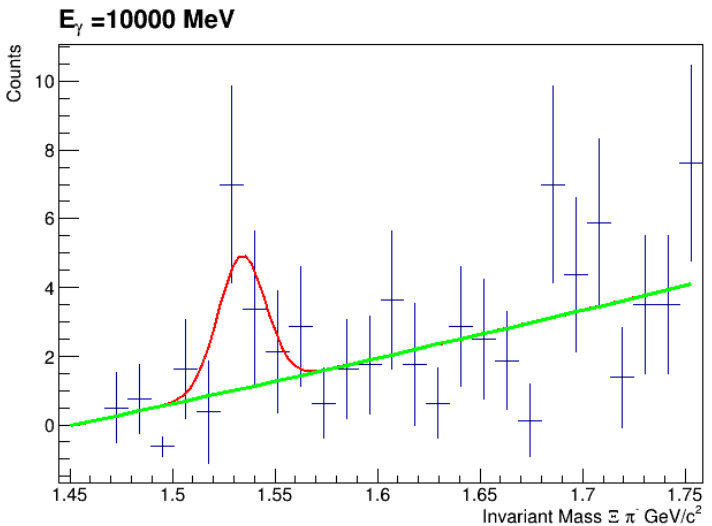
Yield Extraction



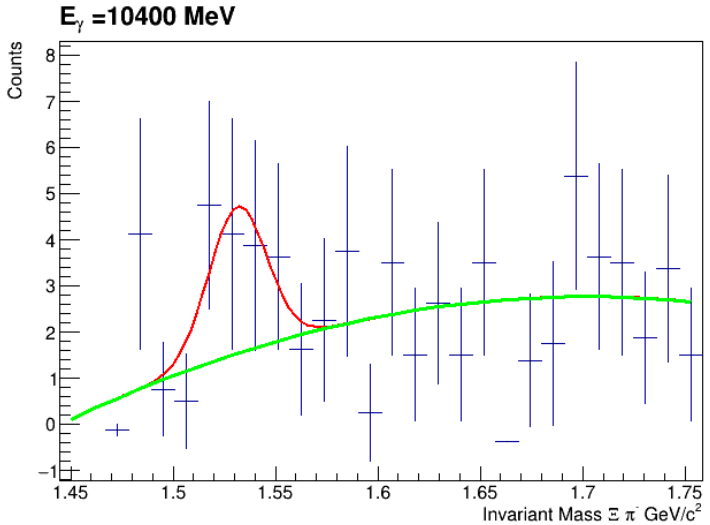
Yield = 6.7 +/- 2.6



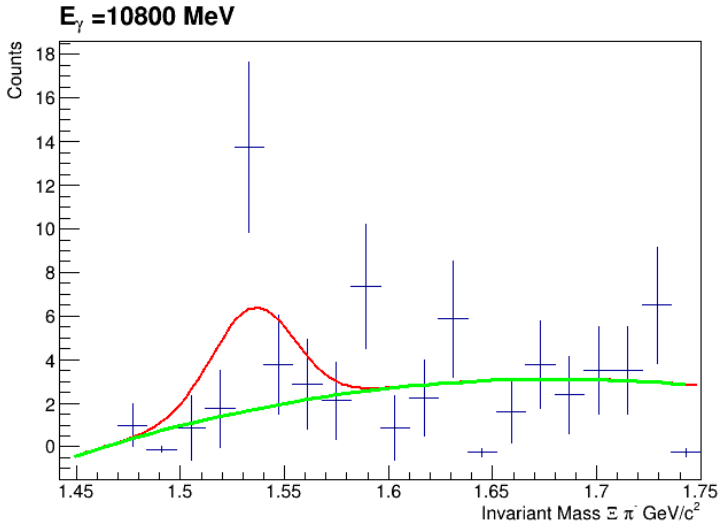
Yield = 14.7 +/- 3.8



Yield = 8.9 +/- 3.0

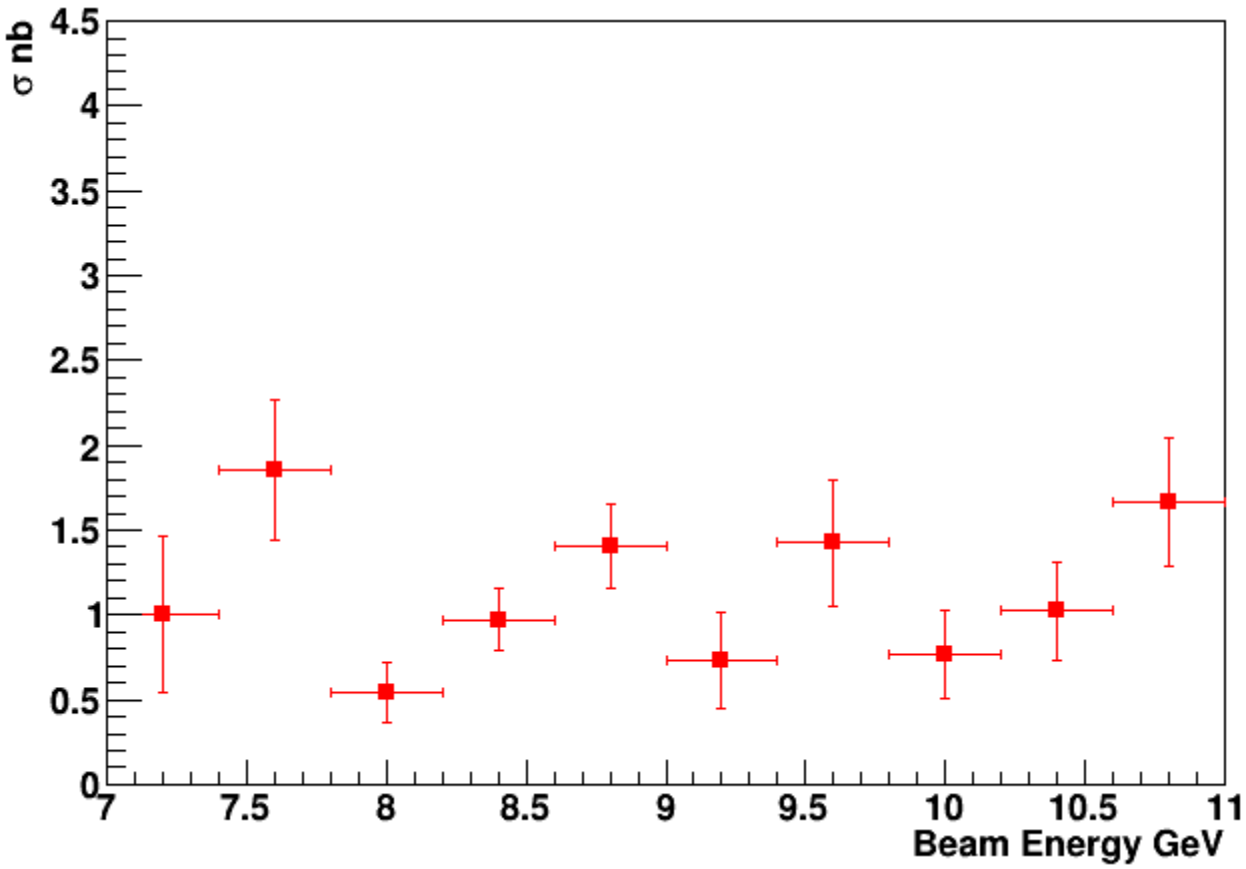


Yield = 12.5 +/- 3.5



Yield = 19.1 +/- 4.4

Cross Section



Future Analysis

- Will investigate charge exchange i.e., $\Xi^{*-} \rightarrow \Xi\pi^{-}$
- Look into another branch:

$$\gamma p \rightarrow K^{+}K^{+}\Xi$$

$$\Xi \rightarrow K^{-}\Lambda$$

End