Excited Ξ Photoproduction Utilizing 9 GeV Photons on a Proton Target: $\gamma\, p \rightarrow K^+\, K^+\, \Xi^{-*}$

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Presentation Overview

1. Motivation
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   - Hadrons
   - Ξ Resonances
   - PDG Status
2. Experiment
   - Thomas Jefferson National Accelerator Facility (TJNAF)
   - GlueX Detector
   - Our Reaction: $\gamma\, p \rightarrow K^{+}\, K^{+}\, \Xi^{-*}$
3. Data Analysis
   - Data Without Cuts
   - Applying Cuts to Data
   - Fractional Uncertainty Comparison
   - Without Cuts
   - Fitting Histogram Slices
4. Future Work

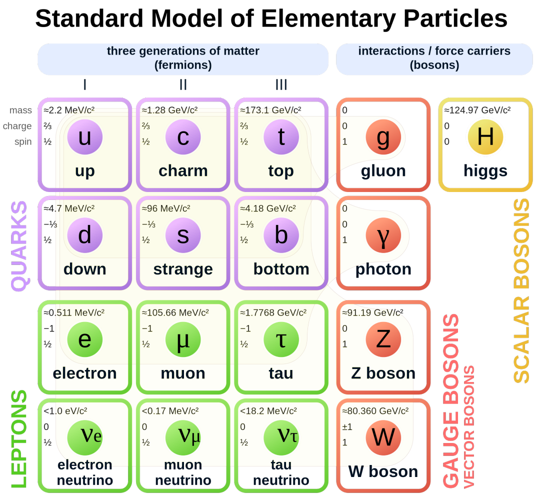

Figure: Standard Model

Hadrons: Baryons and Mesons

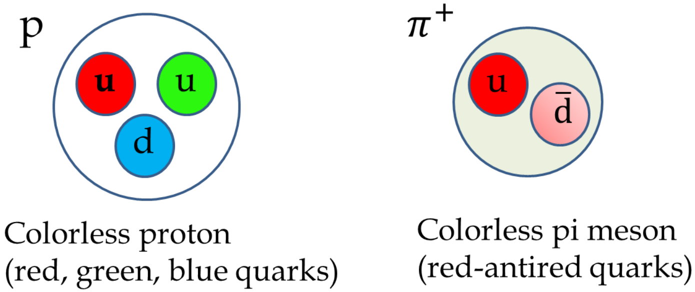

Figure: *https://www.quantumdiaries.org/2012/01/20/thats-right-count-them-4-quarks/*

Ξ Resonances

Missing Cascade States:

- Under explored compared to non-strange baryons:
  - smaller cross sections producing the Ξ states
  - inability to produce Ξ resonances through direct formulation
- Many resonances predicted have yet to be discovered
- This lack of data limits our understanding of these particles

PDG Status

Particle	J^P	Overall status	Status as seen in — $\Xi\pi$	ΛK	ΣK	$\Xi(1530)\pi$	Other channels
$\Xi(1318)$	1/2+	****					Decays weakly
$\Xi(1530)$	3/2+	****	****				
$\Xi(1620)$		*	*				
$\Xi(1690)$		***		***	**		
$\Xi(1820)$	3/2−	***	**	***	**	**	
$\Xi(1950)$		***	**	**		*	
$\Xi(2030)$		***		**	***		
$\Xi(2120)$		*		*			
$\Xi(2250)$		**					3-body decays
$\Xi(2370)$		**					3-body decays
$\Xi(2500)$		*		*	*		3-body decays

****	Existence is certain, and properties are at least fairly well explored.
***	Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, *etc.* are not well determined.
**	Evidence of existence is only fair.
*	Evidence of existence is poor.

Figure: 4 Star Status Cascade

Particle	J^P	Overall status	Status as seen in — $\Xi\pi$	ΛK	ΣK	$\Xi(1530)\pi$	Other channels
$\Xi(1318)$	1/2+	****					Decays weakly
$\Xi(1530)$	3/2+	****	****				
$\Xi(1620)$		*	*				
$\Xi(1690)$		***		***	**		
$\Xi(1820)$	3/2−	***	**	***	**	**	
$\Xi(1950)$		***	**	**		*	
$\Xi(2030)$		***		**	***		
$\Xi(2120)$		*		*			
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****	Existence is certain, and properties are at least fairly well explored.
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*	Evidence of existence is poor.

Figure: 1 Star Status Cascade

Thomas Jefferson National Accelerator Facility (TJNAF)

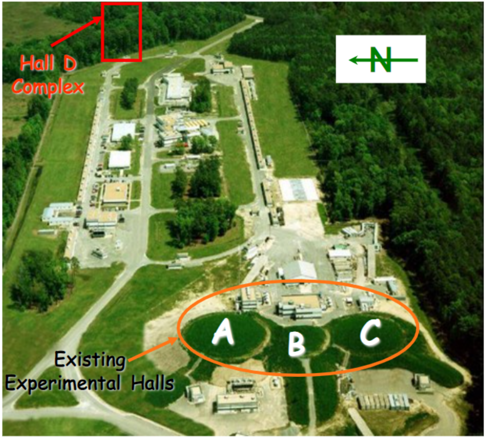


Figure: Jefferson Lab (JLab) Aerial View

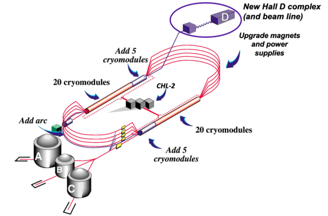


Figure: Continuous Electron Beam Accelerator Facility (CEBAF)

GlueX Detector

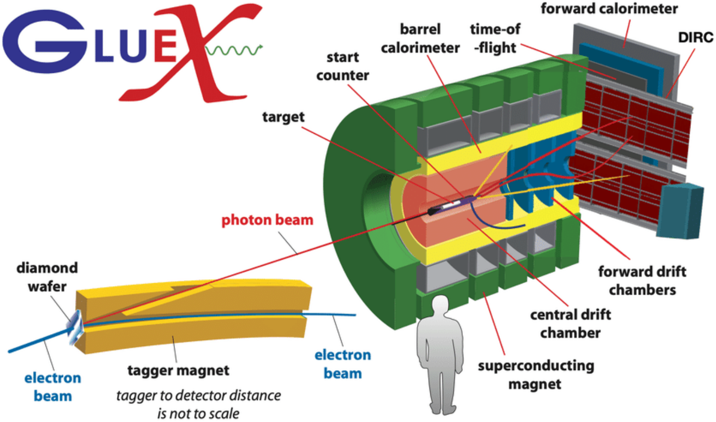


Figure: GlueX Detector

Our Reaction: $\gamma\, p \to K^+\, K^+\, \Xi^{-*}$

$$\gamma\, p \longrightarrow K^+\, K^+\, \Xi^{-*}$$

$$\hookrightarrow \Xi^-\, \pi^0$$

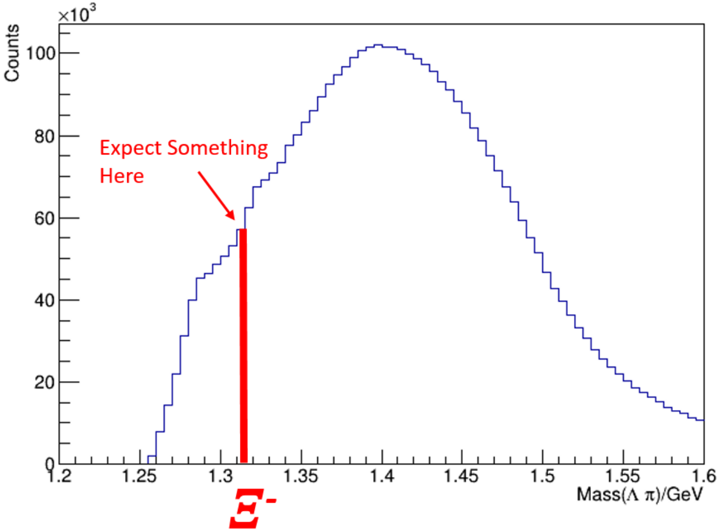
$$\pi^0 \hookrightarrow \gamma\gamma$$

$$\Xi^- \hookrightarrow \Lambda\, \pi^-$$

$$\Lambda \hookrightarrow p\, \pi^-$$

FINAL STATE PARTICLES: $K^+\, K^+\, \gamma\, \gamma\, p\, \pi^-\, \pi^-$

Data Without Cuts

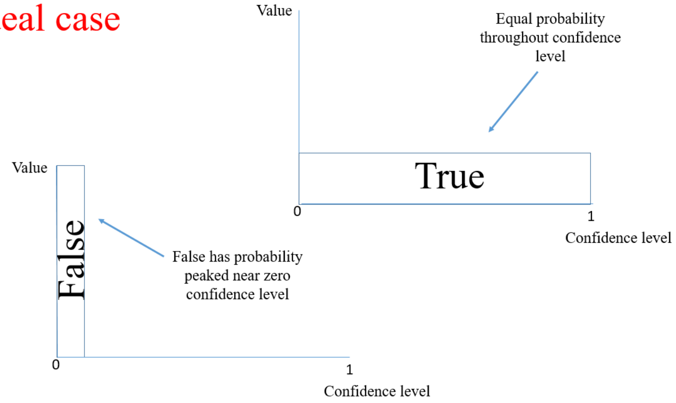


Applying Cuts to Data

- Cuts are criteria to select events from data
  - e.g. if reaction doesn't produce particles above certain threshold, we can 'cut' all events that have particles above that energy
- Isolate events representing physics of interest from the sea of background events
- One type of cut is a confidence level cut

Confidence Level Cuts

Ideal case



Confidence Level Plotted

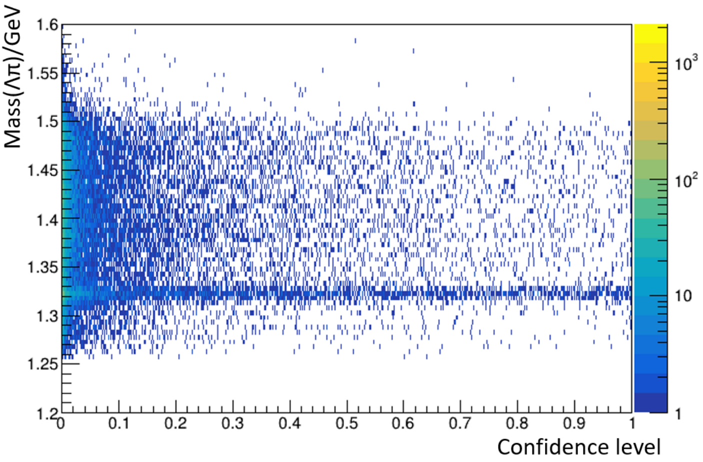


Figure: Confidence Level 2D Plot

Confidence Level Plotted in 1D

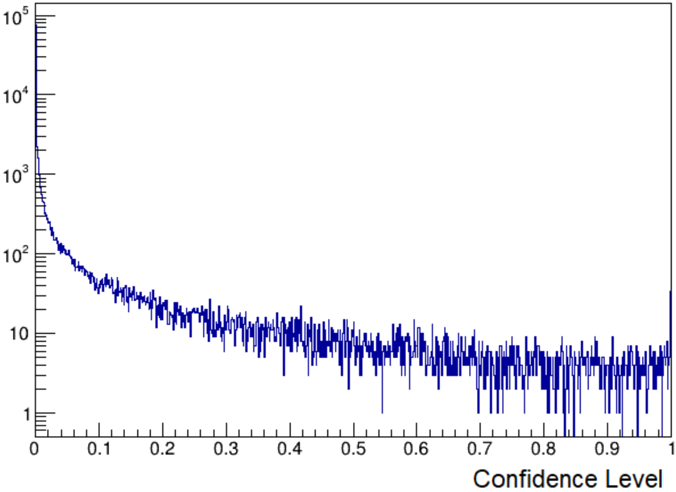
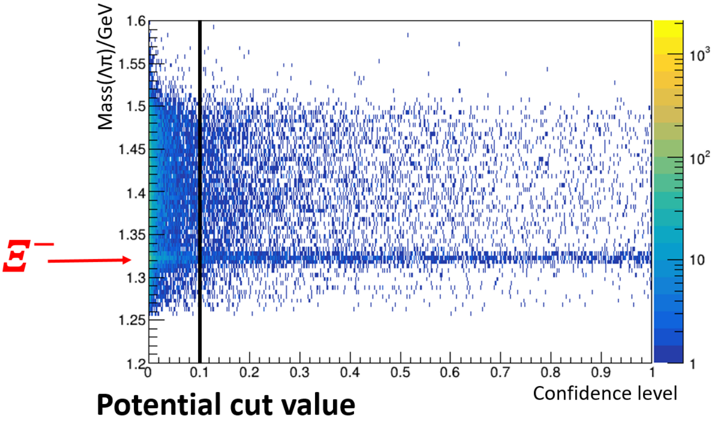
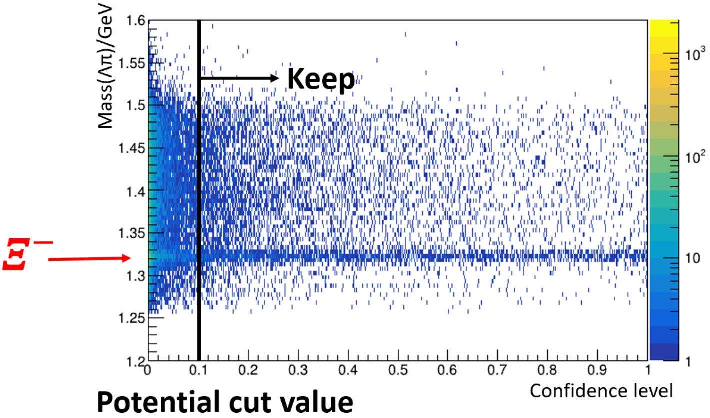


Figure: Confidence Level 1D Plot: Log Scale

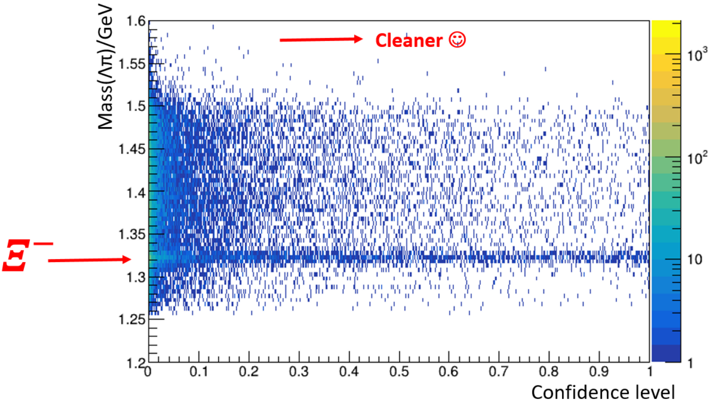
Confidence Level Plotted



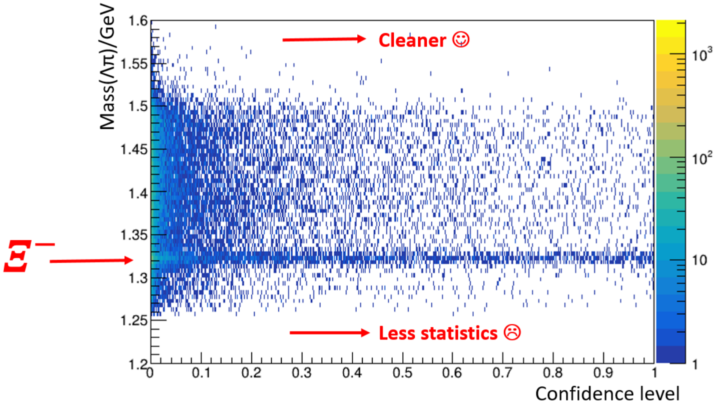
Confidence Level Plotted



Confidence Level Plotted



Confidence Level Plotted



Cuts from 0.1 to 0.00000001

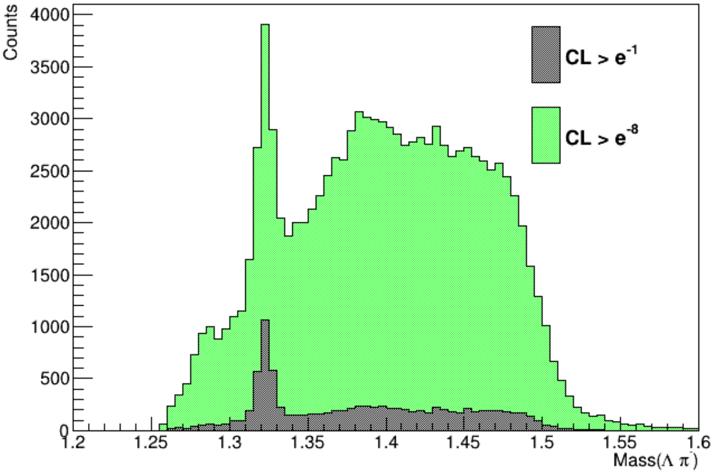
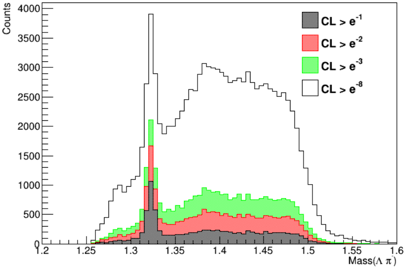
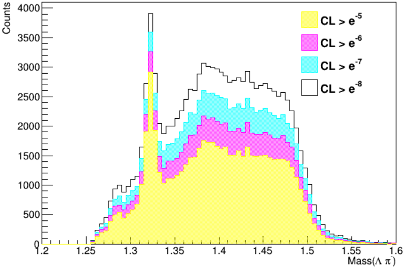


Figure: Grey: CL=0.1, Green: CL=0.00000001


Counts
Mass(Λ π⁻)
CL > e⁻¹
CL > e⁻²
CL > e⁻³
CL > e⁻⁸


Counts
Mass(Λ π⁻)
CL > e⁻⁵
CL > e⁻⁶
CL > e⁻⁷
CL > e⁻⁸

Fractional Uncertainty Comparison

- To determine what the best confidence level cut is we can compare their fractional uncertainties
- e.g. We can see here that the 0.01 cut has less statistics, but is cleaner than the 0.0001 cut

Fractional Uncertainty

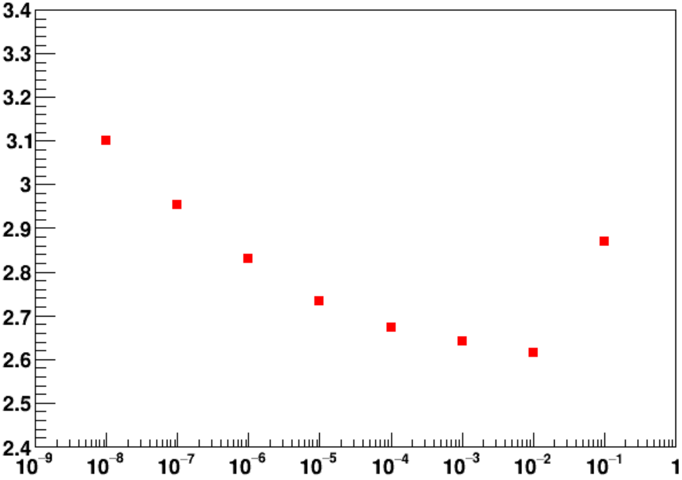
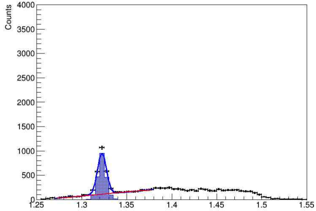
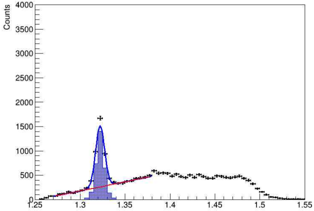


Figure: Fractional Uncertainty

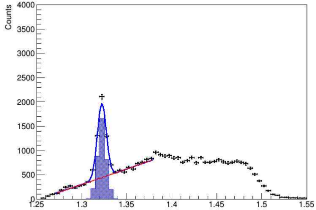
Determining Best Confidence Level Cuts



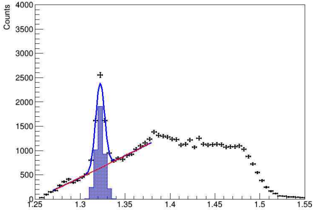
(a) 10^{-1}



(b) 10^{-2}

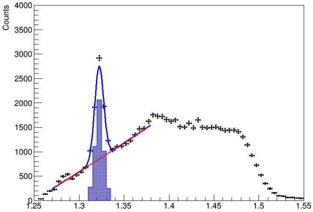


(c) 10^{-3}

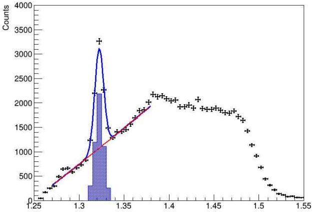


(d) 10^{-4}

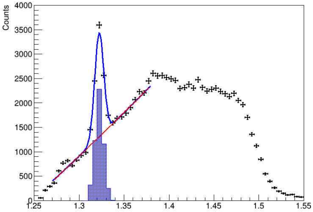
Best Confidence Level Cuts Cont'd...



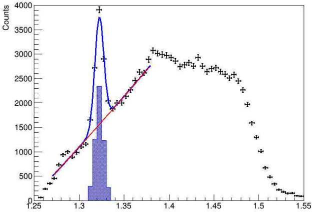
(a) 10^{-5}



(b) 10^{-6}

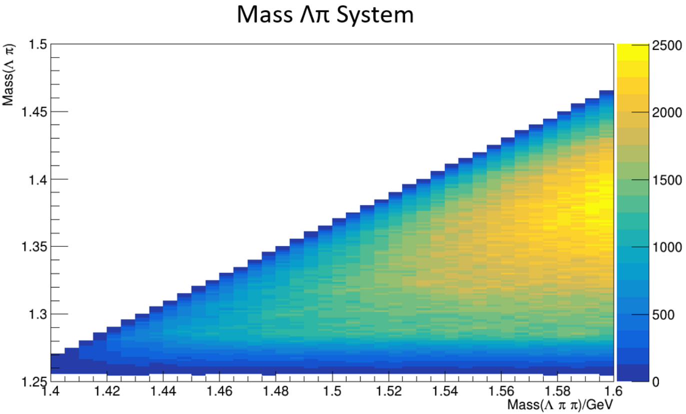


(c) 10^{-7}

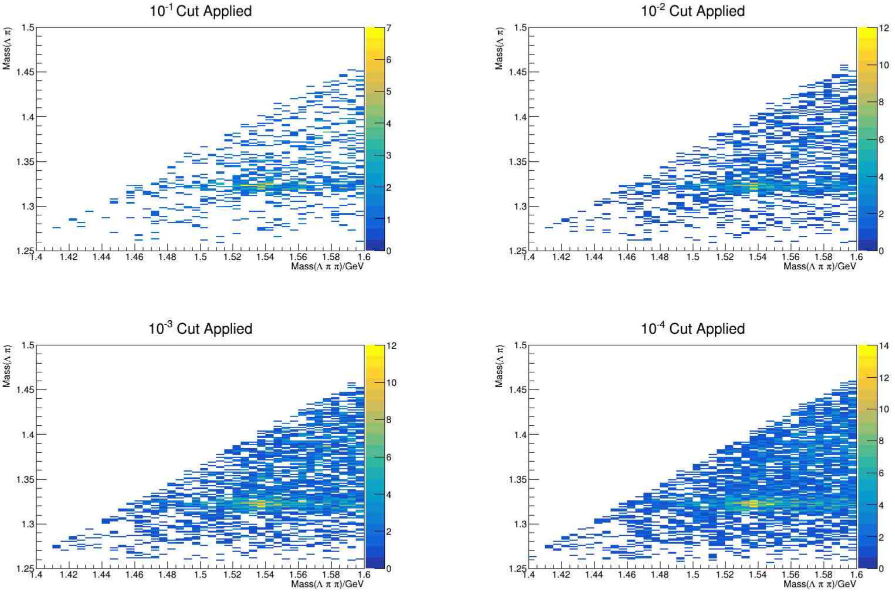


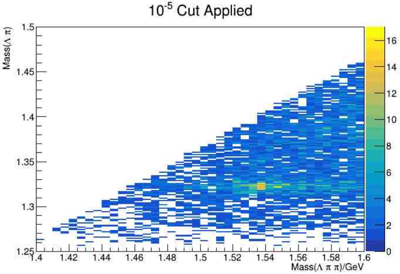
(d) 10^{-8}

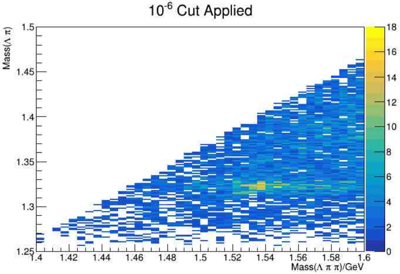
Mass $\Lambda\pi$ System

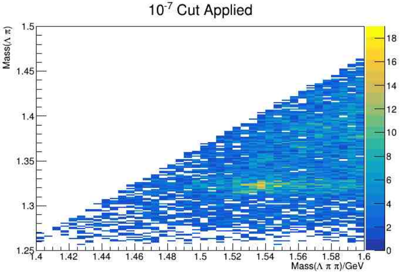


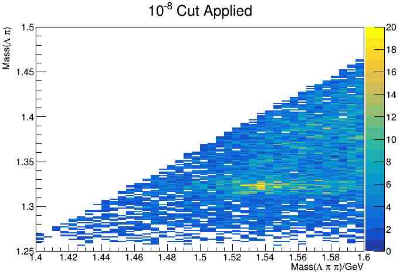
CL Cuts Applied to 2D Histograms




10^{-5} Cut Applied
Mass(Λ π)
Mass(Λ π π)/GeV
1.4 1.42 1.44 1.46 1.48 1.5 1.52 1.54 1.56 1.58 1.6
1.25 1.3 1.35 1.4 1.45 1.5
0 2 4 6 8 10 12 14 16


10^{-6} Cut Applied
Mass(Λ π)
Mass(Λ π π)/GeV
1.4 1.42 1.44 1.46 1.48 1.5 1.52 1.54 1.56 1.58 1.6
1.25 1.3 1.35 1.4 1.45 1.5
0 2 4 6 8 10 12 14 16 18


10^{-7} Cut Applied
Mass(Λ π)
Mass(Λ π π)/GeV
1.4 1.42 1.44 1.46 1.48 1.5 1.52 1.54 1.56 1.58 1.6
1.25 1.3 1.35 1.4 1.45 1.5
0 2 4 6 8 10 12 14 16 18


10^{-8} Cut Applied
Mass(Λ π)
Mass(Λ π π)/GeV
1.4 1.42 1.44 1.46 1.48 1.5 1.52 1.54 1.56 1.58 1.6
1.25 1.3 1.35 1.4 1.45 1.5
0 2 4 6 8 10 12 14 16 18 20

Ξ^- Can Be Seen

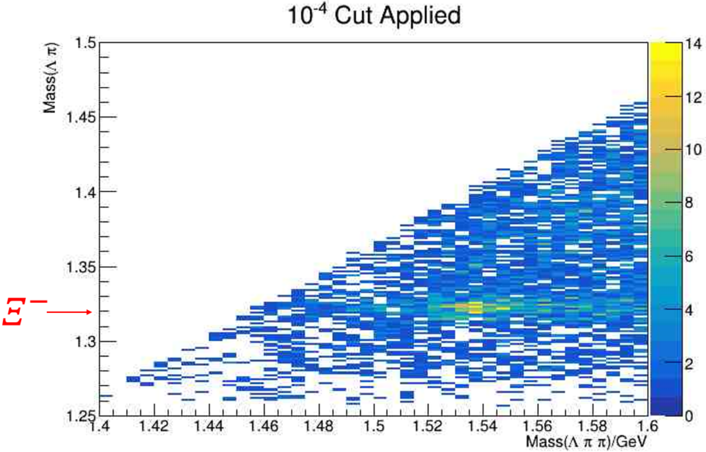


Figure: 10^{-4} CL Cut Showing Ξ^-

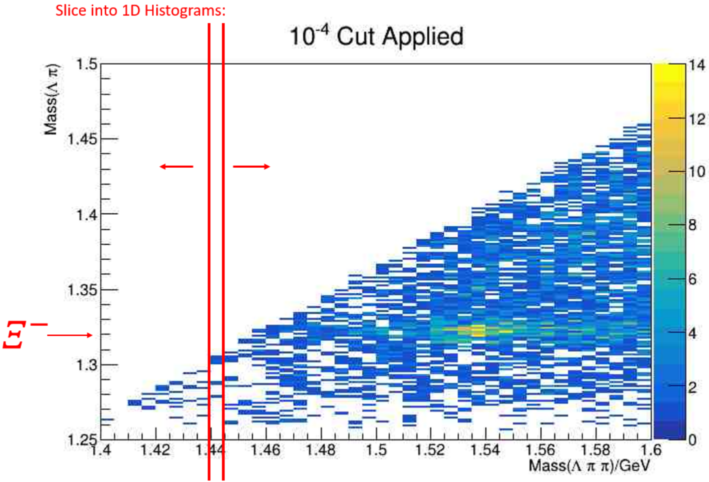


Figure: 2D Histogram Sliced by Bins into 1D Histograms

Fitting 1D Histogram Slices

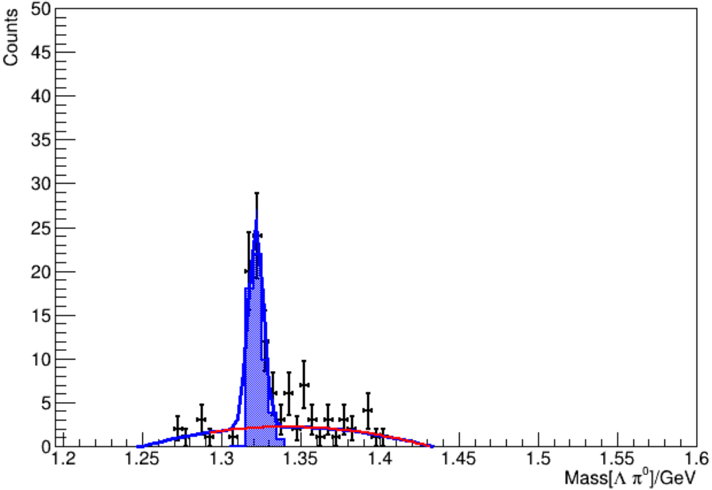


Figure: Fit of Bin 28 after 10^{-2} CL Cut Applied

Future Work

Now that I have completed this CL cut study on a well established resonance state, I can use this method onto other, lesser established resonances such as the $\Xi(1620)$ or other resonant states.

Acknowledgements

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- Dr. Brandon Sumner
- Alan Gardner

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- DOE
- ASU

The End

Questions? Comments?