Most recent Ξ^* bump hunt and $\Xi(1530)$ cross section

Reaction

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

where $$\Xi^{*-} \rightarrow \Xi^- \pi^0,$$

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

and $$\Lambda \rightarrow p \pi^-$$

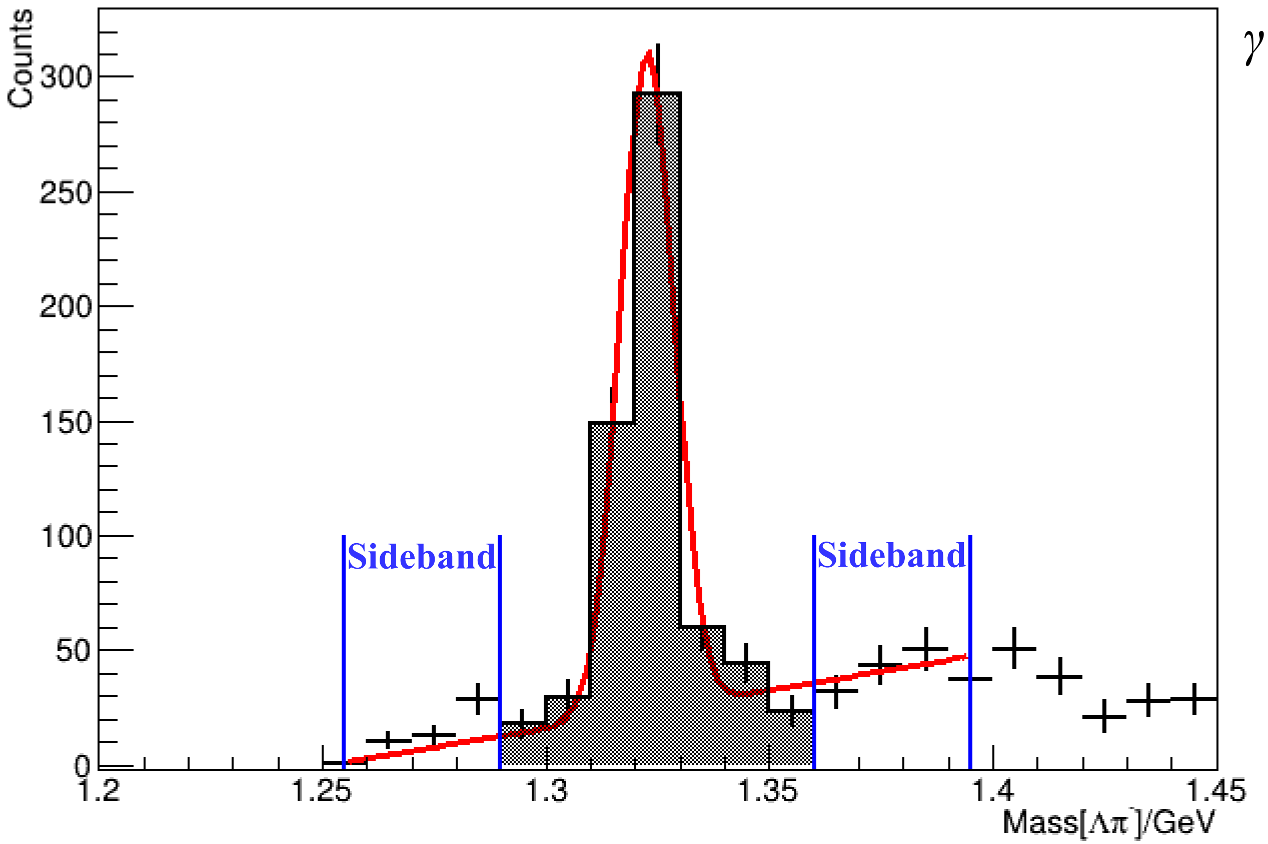
Determination of Ξ track-length significance and confidence level cut

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

Early study using best photon and no accidental subtraction found that the best value for fractional uncertainty in the yield (σ_Y/Y) of the ground state cascade was:

- CL > 10^{-6}
- Ξ track-length significance > 4

Invariant mass of $\Lambda\pi^-$



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

- Hybrid method for accidental subtraction
- CL cut at 10^{-6}
- Significance of Ξ^- pathlength > 4
- $|t_{\mathrm{fast}}| < 3$ GeV^2
- K^* cut (0.85 GeV < mass[$K^+\pi^0$] < 0.95 GeV removed)

Some details on data and analysis

<u>Included datasets:</u>

- 2017 (Just added)
- 2018-01
- 2018-08
- 2019-11
- 2023 (Just added)

<u>Cuts</u>

- CL cut at 10^{-6}
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<u>Accidental subtraction</u>

- Hybrid method

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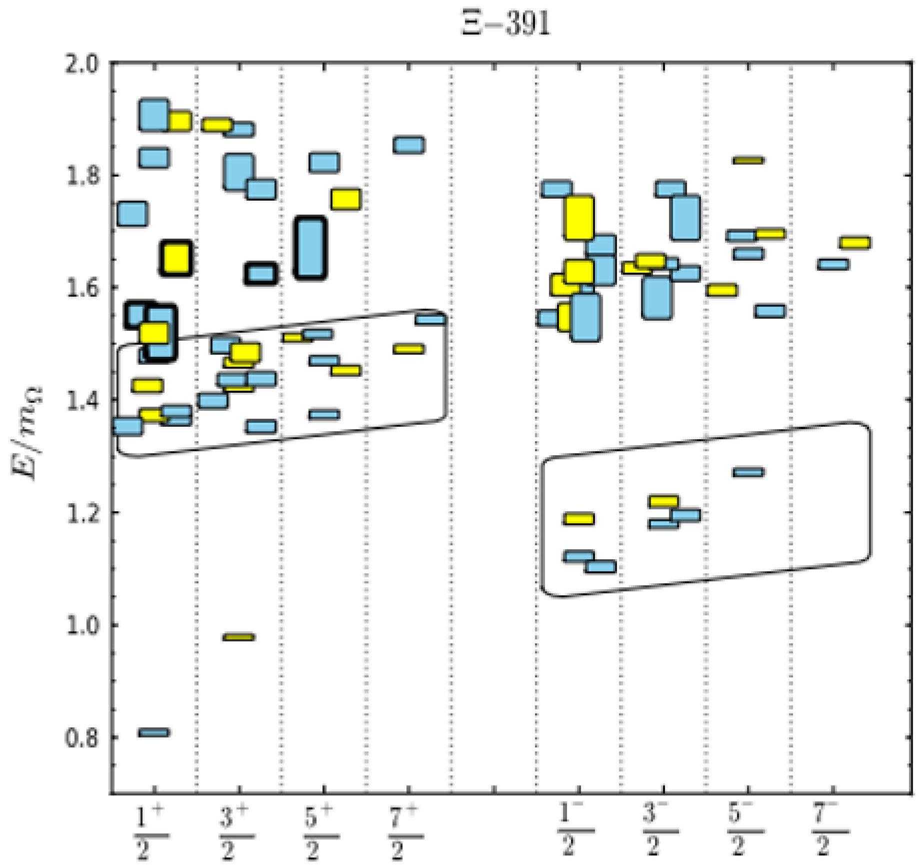
Accidental subtraction

- Hybrid method

Flow of the bump hunt slides will be very similar to shown in past

LQCD for Ξ states [1]

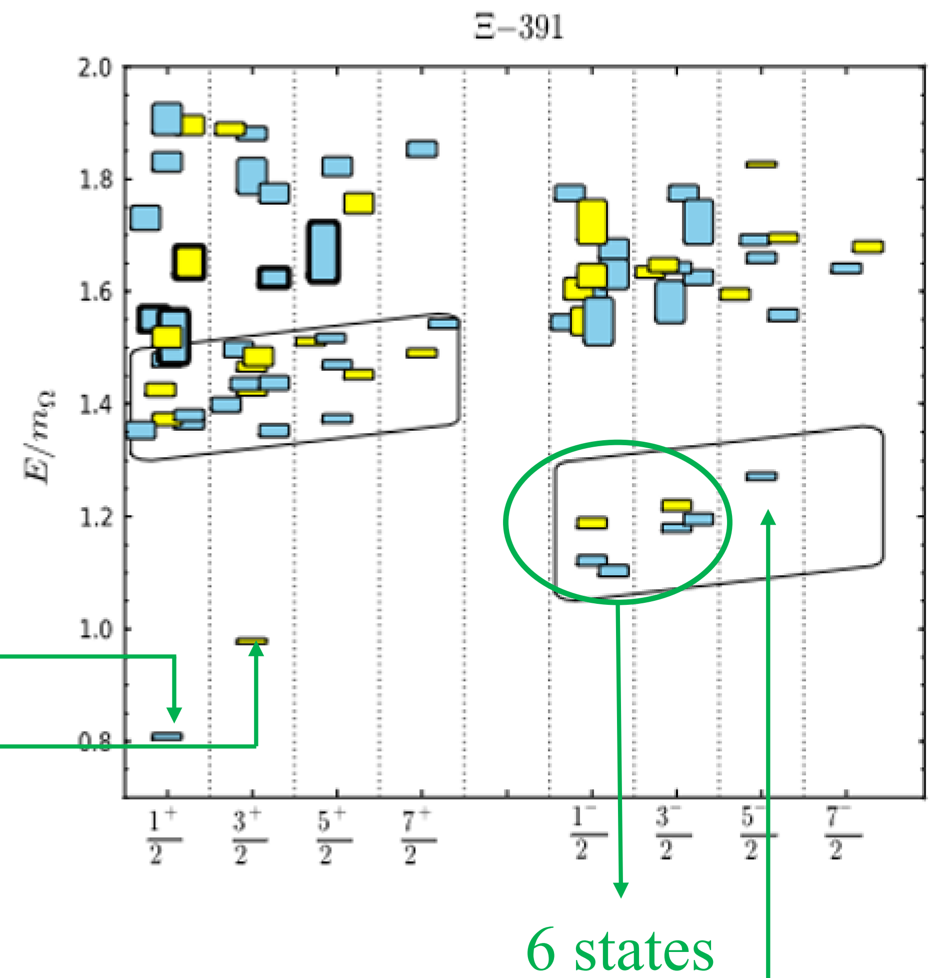
- Pion mass at 391MeV
- Yellow: flavor decuplet
- Blue: flavor octet
- Slanted boxes contain the low lying states that have quantum numbers consistent with quark model calculations



[1] R. G. Edwards, N. Mathur, D. G. Richards and S. J. Wallace, Flavor structure of the excited baryon spectra from lattice QCD, Phys. Rev. D 87 (2013), p. 054506, URL: https://link.aps.org/doi/10.1103/PhysRevD.87.054506

LQCD compared to PDG

- Assuming Ξ(2030) belongs in the boxed region of lowest mass, then $J = 5/2$
  - Implies there are a total of 8 states expected below the mass of the Ξ(2030)
  - Missing 2 PDG states w/mass below Ξ(2030) in order to be compatible with LQCD



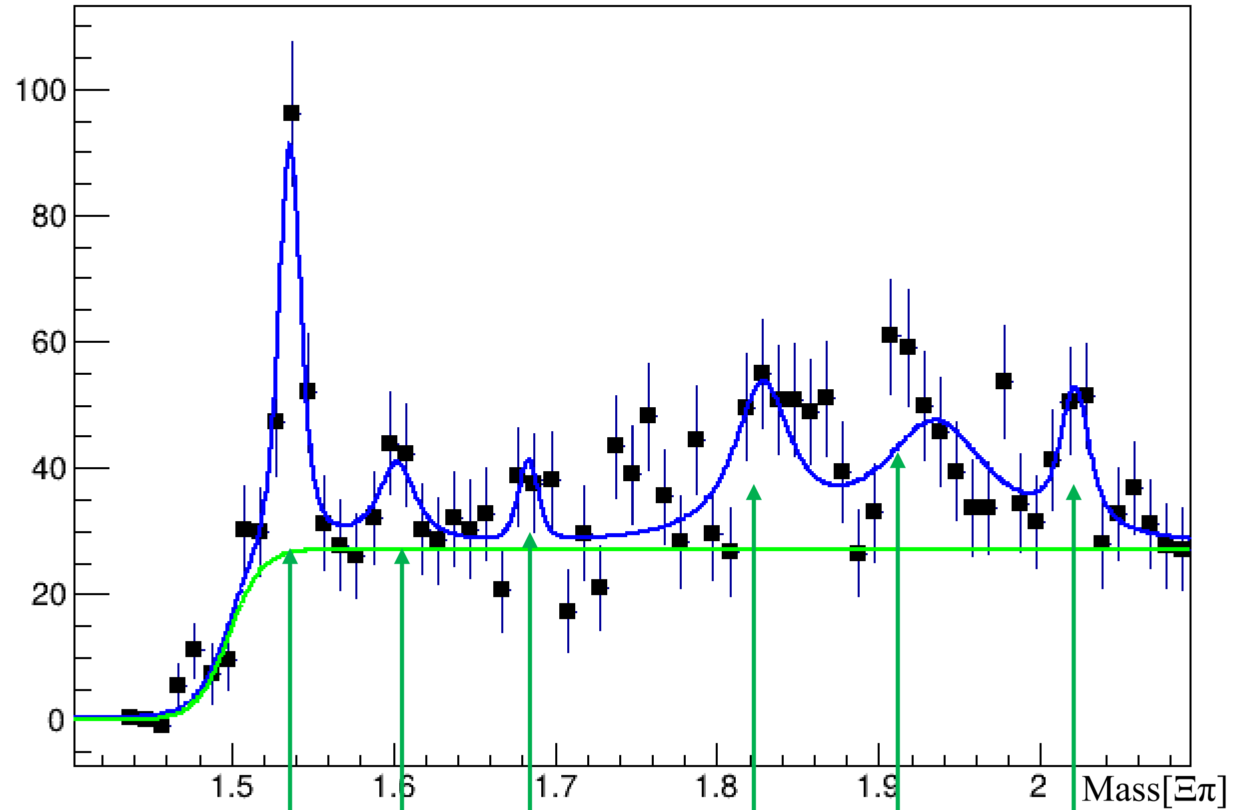
PDG	J, P
Ξ	1/2, +
Ξ(1530)	3/2, +
Ξ(1620)	?, ?
Ξ(1690)	?, ?
Ξ(1820)	3/2, -
Ξ(1950)	?, ?
Ξ(2030)	>= 5/2, ?

4 states

[1] R. G. Edwards, N. Mathur, D. G. Richards and S. J. Wallace, Flavor structure of the excited baryon spectra from lattice QCD, Phys. Rev. D 87 (2013), p. 054506, URL: https://link.aps.org/doi/10.1103/PhysRevD.87.054506

Bump Hunt 2026 V2

- Voigtians with background = sigmoid*constant
- σ smear range = 5-15 MeV (single par)
- Centers and widths of each Ξ allowed to vary within PDG limits
- No PDG guidance on range of center for two-star $\Xi(1620)$. We allowed +/- 20 MeV.



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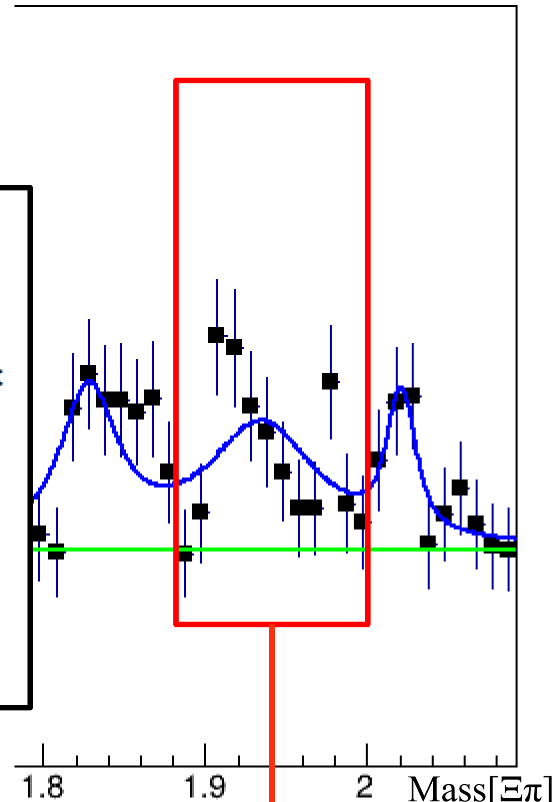
Bump Hunt 2026 V2

Citation: S. Navas *et al.* (Particle Data Group), Phys. Rev. D **110**, 030001 (2024) and 2025 update

$\boxed{\Xi(1950)}$ $I(J^P) = \frac{1}{2}(?^?)$ Status: ∗∗∗

We list here everything reported between 1875 and 2000 MeV. The accumulated evidence for a Ξ near 1950 MeV seems strong enough to include a $\Xi(1950)$ in the main Baryon Table, but not much can be said about its properties. In fact, there may be more than one Ξ near this mass.

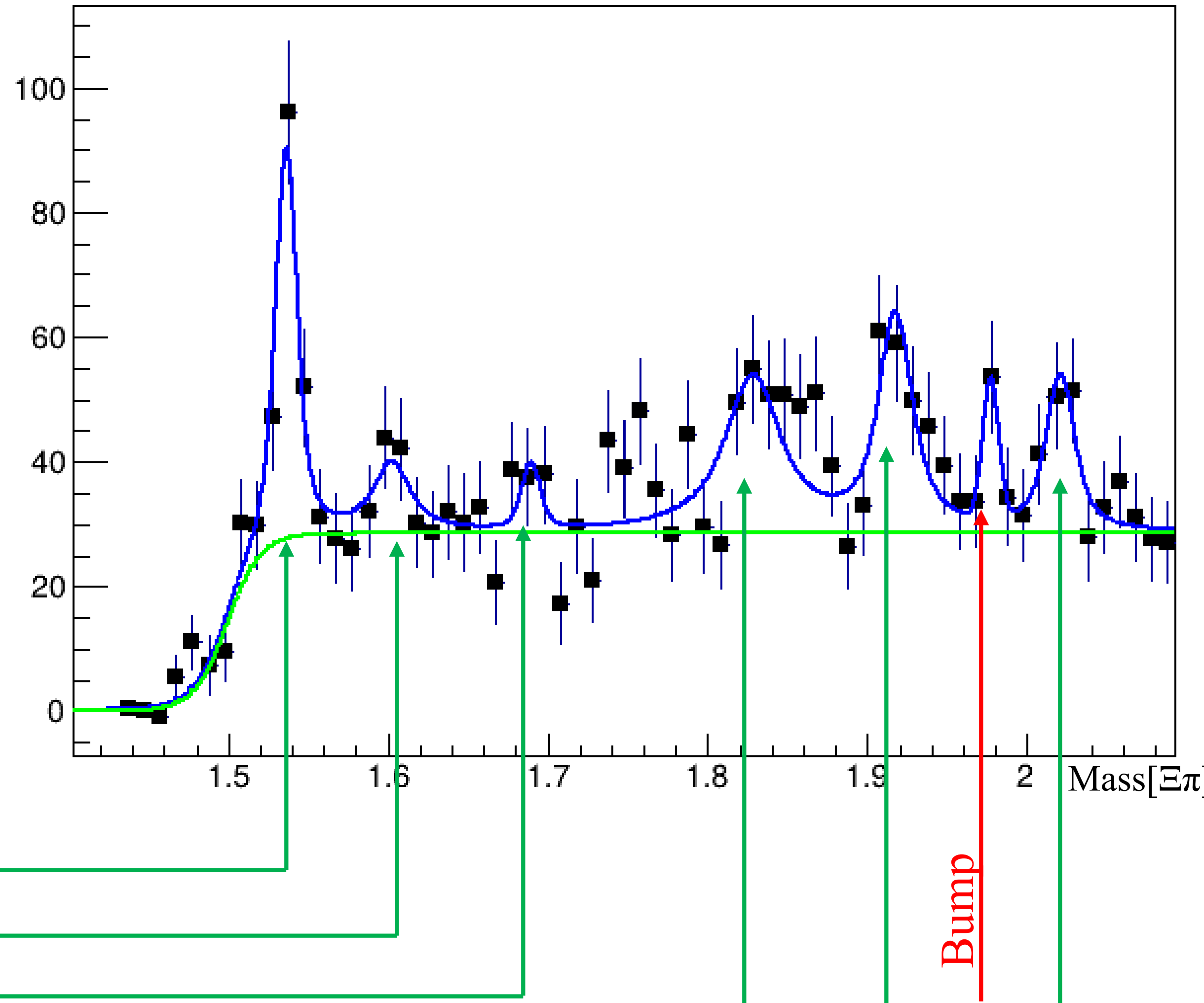


Lets try putting an extra bump in and letting fit parameters for original peak loose

Looks like a mess ☹

Bump Hunt 2026 V2

- Ξ(1950) split into two peaks. One of the peaks called “Bump”.



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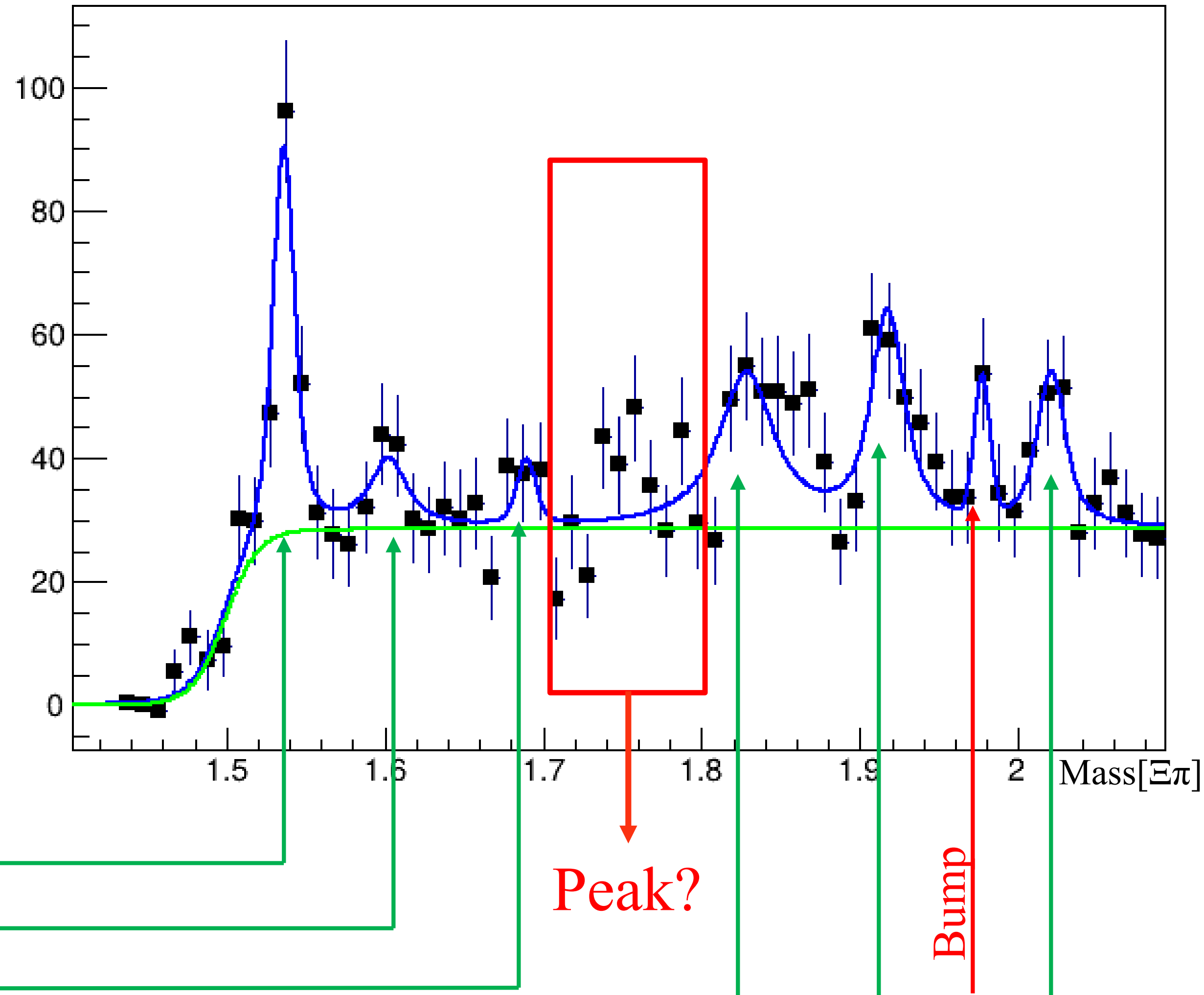
Bump Hunt 2026 V2

- Ξ(1950) split into two peaks. One of the peaks called "Bump".
- Additional bump near 1750?



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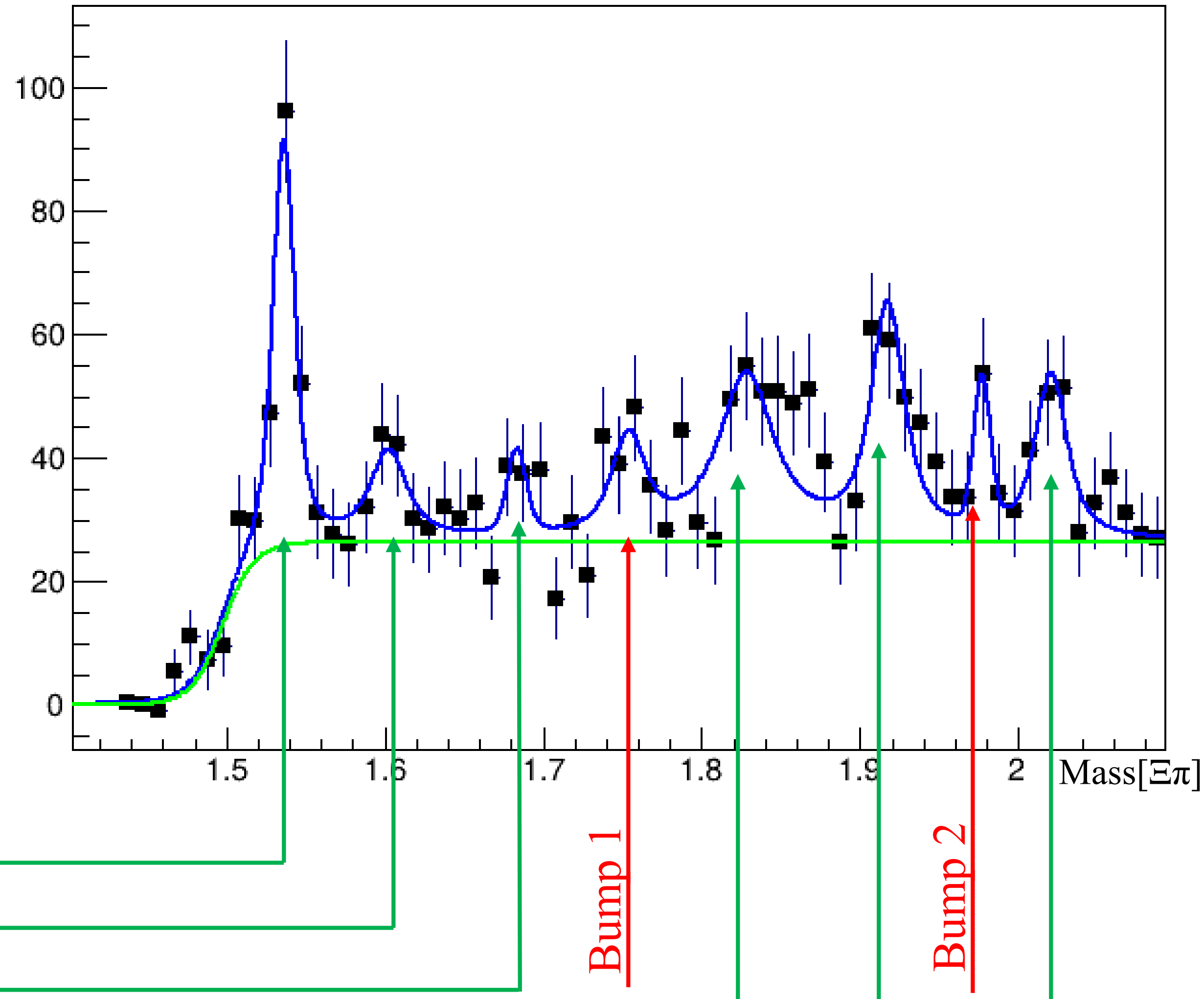
Bump Hunt 2026 V2

- Statistics are a major issue!
- What features are real and what features are statistical fluctuations?



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Number of standard deviations of bump

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- Convert probability to standard deviation you would obtain from a normal distribution

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Wilks' theorem:

- For nested model with Δndf = 1, we have $\chi^2 = \chi^2_{\text{(no bump)}} - \chi^2_{\text{(bump)}}$
  - The difference of the χ^2 distributions is another χ^2 distribution
- For ndf =1, the cumulative probability for the χ^2 distribution is very similar to that of the normal distribution.
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  - In such a case the *z*-value (number of standard deviations) is replaced by sqrt(χ^2)

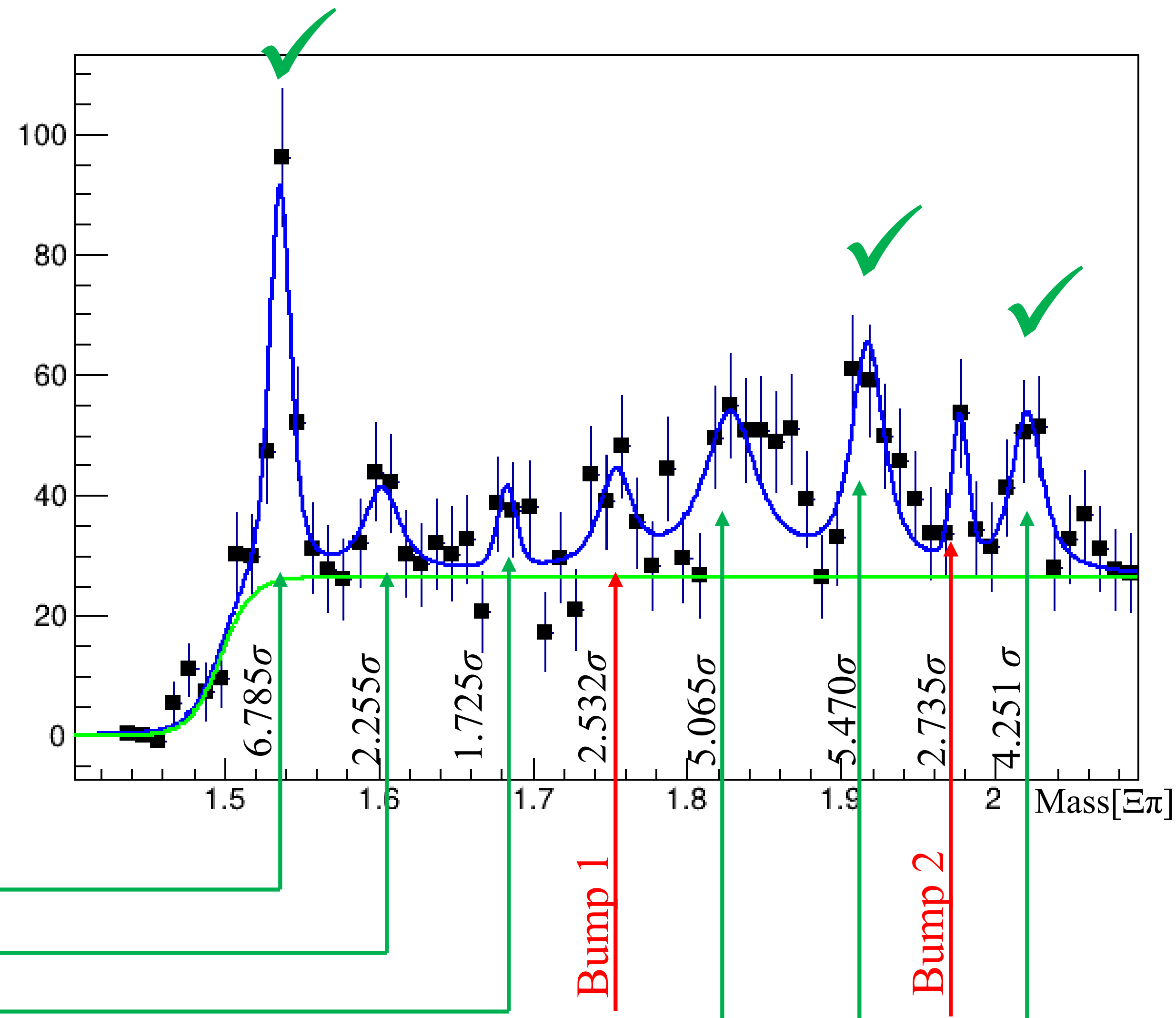
In practice:

- Make full fit with parameter of interest (amplitude of bump) locked to 0 to obtain $\chi^2_{\text{(no bump)}}$
- Make full fit with parameter of interest allowed to vary to obtain $\chi^2_{\text{(bump)}}$
- Create $\chi^2 = \chi^2_{\text{(no bump)}} - \chi^2_{\text{(bump)}}$ and
- Take sqrt(χ^2) as number of standard deviations for that bump

Bump Hunt 2026 V2

Assumed criteria:

- Bumps need to get to 5σ
- Know PDG states need to be at 3σ



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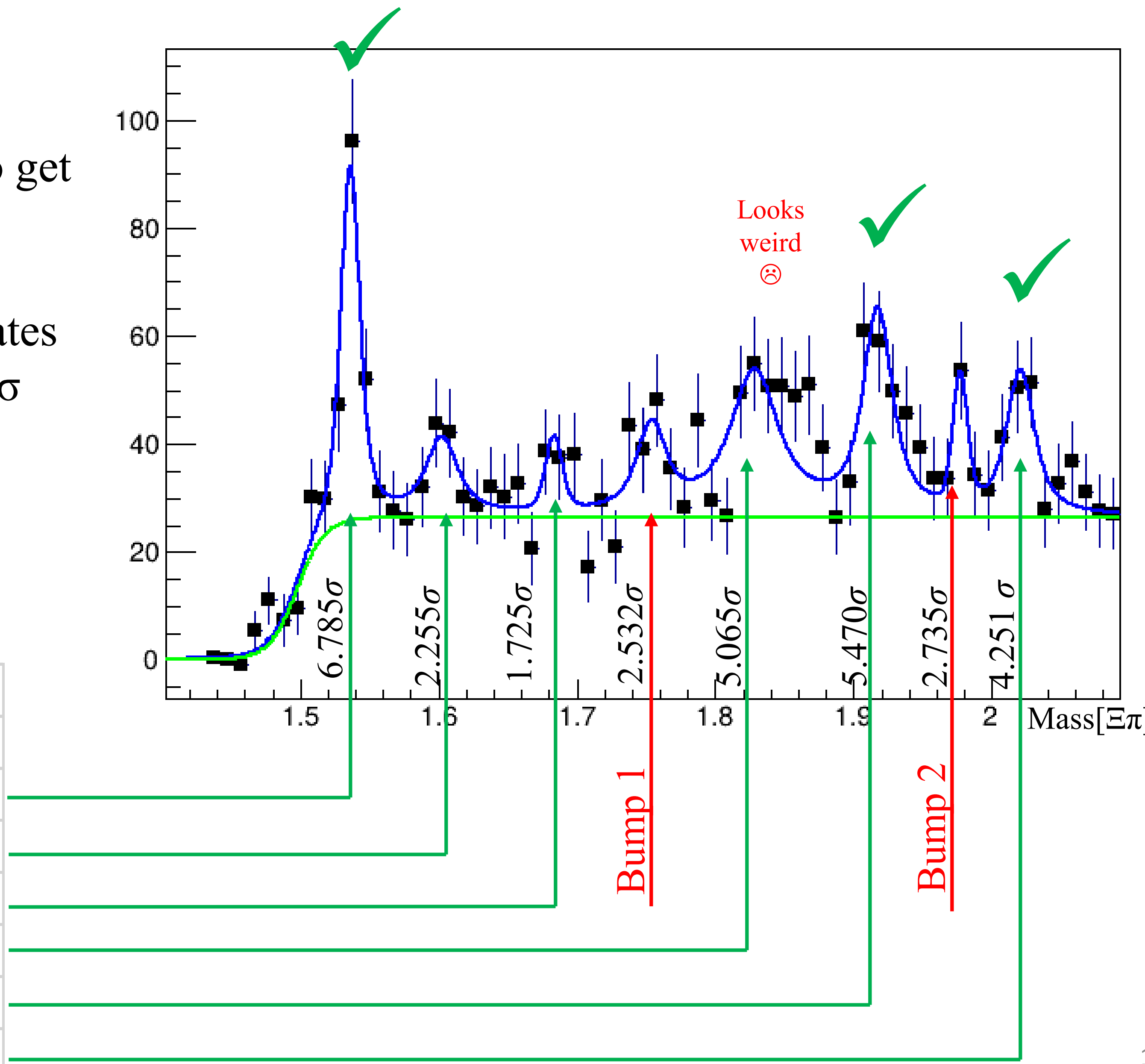

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How to determine how many additional events needed to achieve a particular z

- Simply assume that the standard deviation will scale as sqrt(N), where N = number of events
  - $N_{\text{target}}/N_{\text{current}} = (z_{\text{target}}/z_{\text{current}})^2$

For example, to get from $z_{\text{current}} = 2.352$ to $z_{\text{target}} = 5$ we would need $N_{\text{target}}/N_{\text{current}} = (5/2.352)^2 = 3.890$ (or $N_{\text{target}} = 3.890\text{x}\ N_{\text{current}}$)

Bump Hunt 2026 V2

Assumed criteria:

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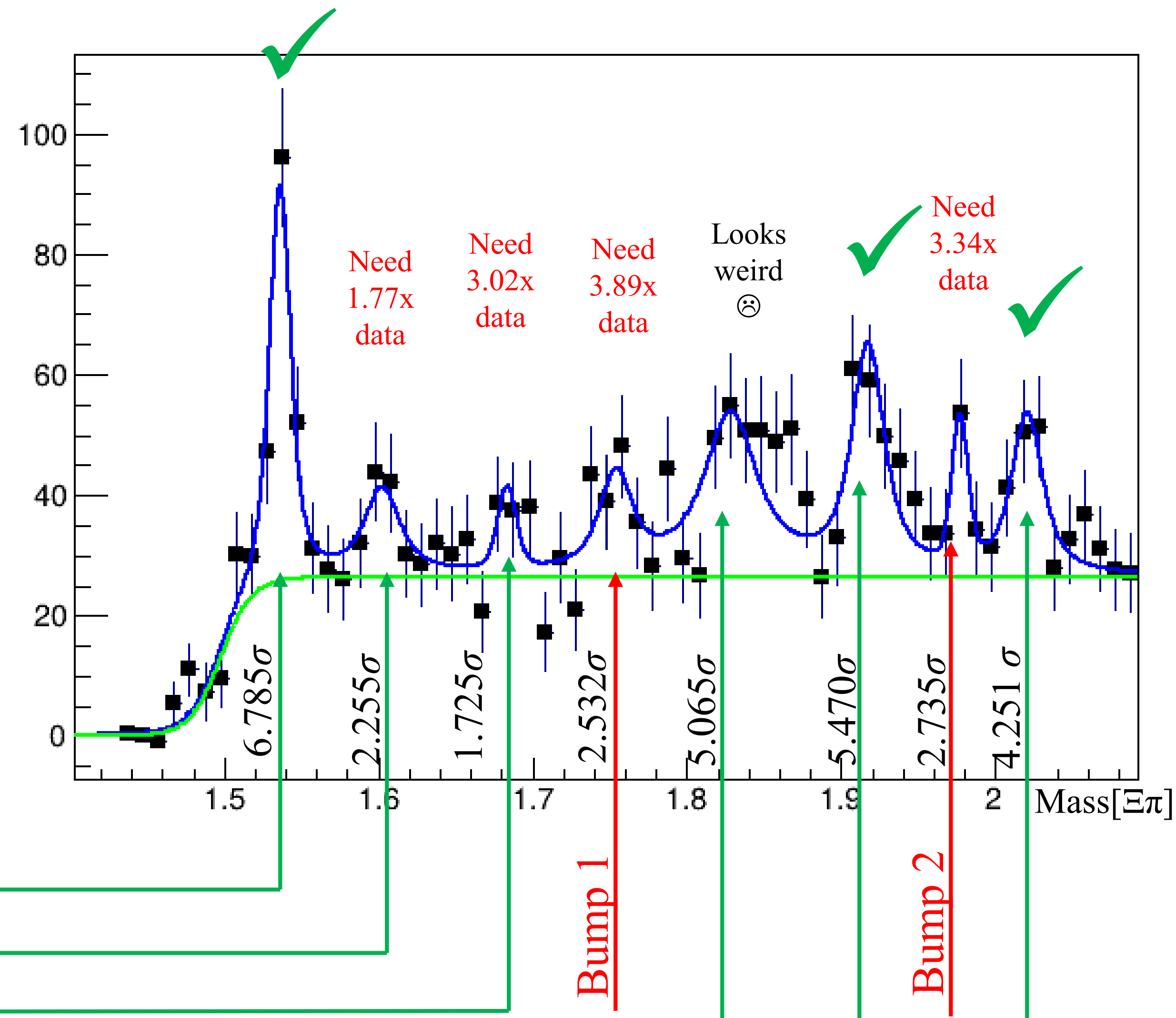

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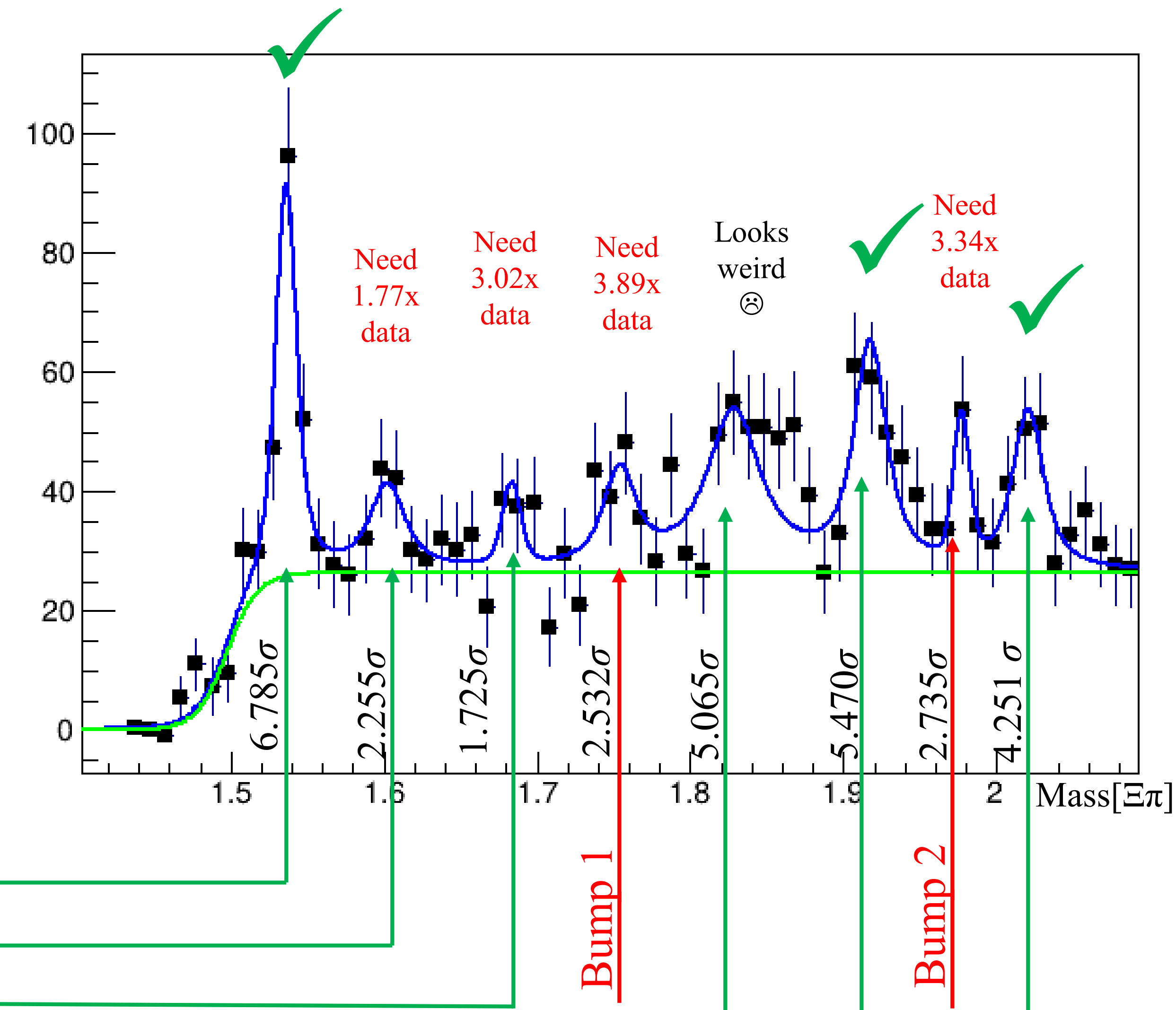
Bump Hunt 2026 V2

Assumed criteria:

- Bumps need to get to 5σ
- Know PDG states need to be at 3σ
- Estimate of data quantities on next slides



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GlueX Phase-I Dataset Summary

Below is a list of the GlueX Phase-I run periods with links to the individual dataset summaries. The tagged luminosity is determined from the flux tables in the CCDB in two energy ranges: the coherent peak and $E_\gamma > 8.1$ GeV.

Run Period	Run Numbers	RCDB Search / Approved Run List	Coherent Peak Range (GeV)	Coherent Peak Luminosity (pb^{-1})	$E_\gamma > 8.1$ GeV Luminosity (pb^{-1})	$E_\gamma > 6.0$ GeV Luminosity (pb^{-1}) (cross sections)	Fraction of GlueX Phase-I
Spring 2016 Dataset Summary	10391 - 11663	@is_production and @status_approved	8.4 - 9.0	2.0 ("Golden period" runs 11366-11555)	14.6 (All runs)		
Spring 2017 Dataset Summary	30274 - 31057	@is_production and @status_approved	8.2 - 8.8	21.8	53.1	74.7	17.4%
Spring 2018 Dataset Summary	40856 - 42559	@is_2018production and @status_approved	8.2 - 8.8	63.0	152.7	223.8	50.4%
Fall 2018 Dataset Summary	50685 - 51768	@is_2018production and @status_approved and beam_on_current>49	8.2 - 8.8	40.1	98.1	141.1	32.1%
GlueX phase 1 Summary	2017-2018		8.2 - 8.8	**125.0**		**439.6**	
Fall 2018 Dataset Summary "low energy"	51384 - 51457	@is_2018production and @status_approved and beam_on_current<49	6.2 - 7.0	-	1.1 (E_γ = 3-5.5 GeV)		

Last updated: September 21, 2020

2017+2018 → 439 pb^{-1}

GlueX Phase-II Dataset Summary

Below is a list of the GlueX Phase-II run periods with links to the individual dataset summaries. The tagged luminosity is determined from the flux tables in the CCDB in two energy ranges: the coherent peak and $E_\gamma > 8.1$ GeV.

Run Period	Run Numbers	RCDB Search / Approved Run List	Coherent Peak Range (GeV)	Coherent Peak Luminosity (pb^{-1})	$E_\gamma > 8.1$ GeV Luminosity (pb^{-1})	$E_\gamma > 6.0$ GeV Luminosity (pb^{-1}) (cross sections)
Spring 2020 Dataset Summary	71350-73266	@is_dirc_production and @status_approved	8.0 - 8.6	132.4	321.2	386.2
Spring 2023 Dataset Summary	120297-121207	@is_dirc_production and @status_approved	8.0 - 8.6	59.2	154.1	175.7
Spring 2025 Dataset Summary	131593-139999	@is_dirc_production and @status_approved	8.3 - 8.9			

Last updated: May 15, 2023

$$2020+2023 \rightarrow (386+175)pb^{-1} = 561\ pb^{-1}$$

- 2020+2023 : 102 PAC days, 561 pb^{-1}
- 2025 : 75 PAC days, $(75/102)*561\ pb^{-1} = 412\ pb^{-1}$
- 2026 : 40 PAC days, $(40/102)*561\ pb^{-1} = 220\ pb^{-1}$

Estimates in red box

Estimated int. luminosity for phaseIII

GlueX-III has 200 PAC days at double the rate of glueX-II (220 PAC days)

Estimated integrated luminosity for GlueX-III:
= (GlueX-II integrated luminosity)*(200/220)*2
= (561+412+220)pb^{-1}*(200/220)*2 = 2170 pb^{-1}

Ratio of [total expected] to [used so far]

- Run sets used so far: 2017, 2018, 2020, 2023
- Integrated luminosity of used so far: (439+561)pb^{-1} = 1000 pb^{-1}
- Expected integrated luminosity remaining: (412+220+2170) pb^{-1}= 2802 pb^{-1}
- [Total expected]/[used so far] ~ 3800 pb^{-1} OR 3.8x[used thus far]

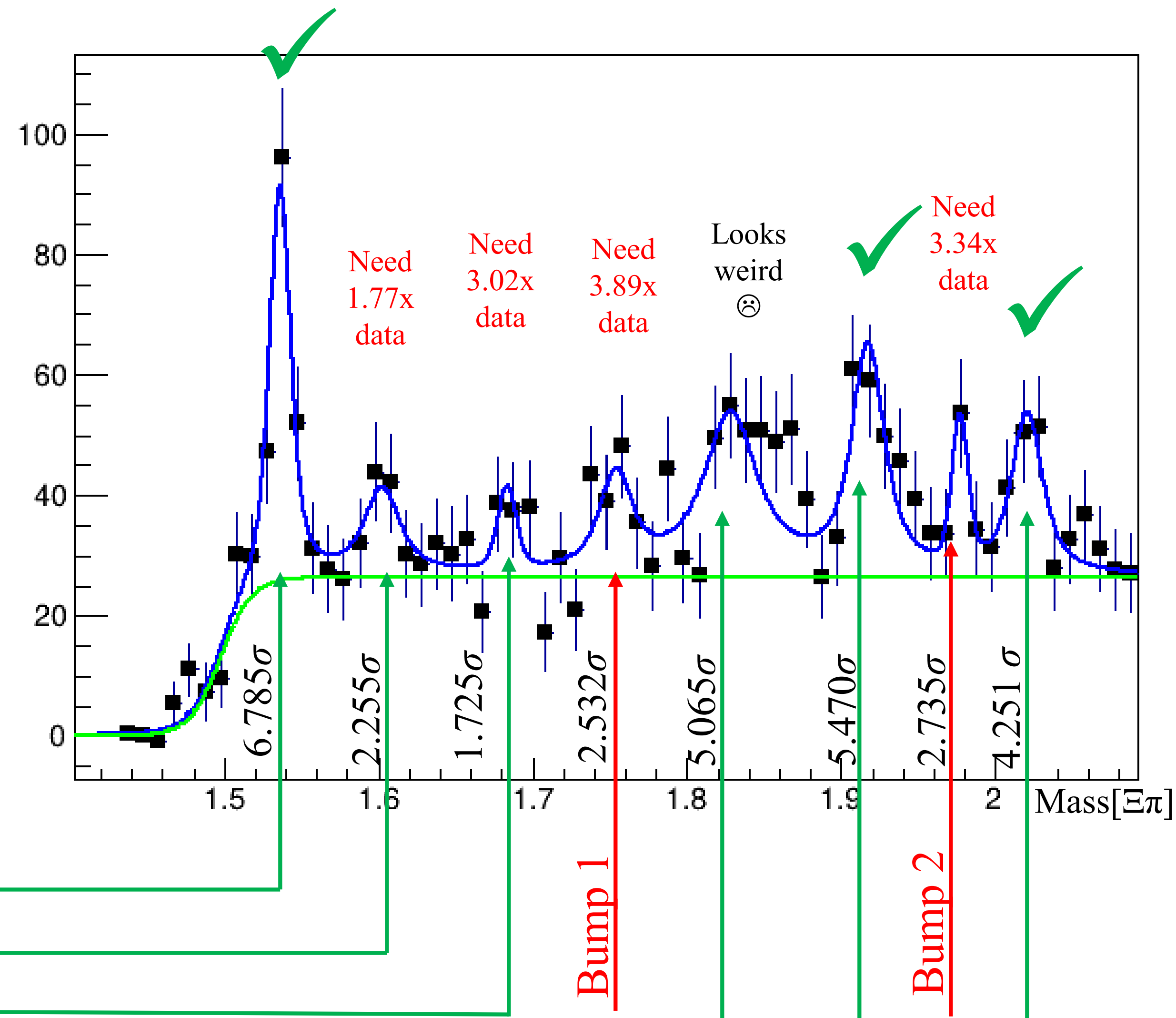
Roughly

- Include 2025 set → 1.4x[used so far]
- Include 2025, 2026 sets → 1.6x[used so far]
- Include 2025, 2026, 2027 sets → 2.7x[used so far]
- Include 2025, 2026, 2027, 2028 sets → 3.8x[used so far]

Bump Hunt 2026 V2

Assumed criteria:

- Bumps need to get to 5σ
- Know PDG states need to be at 3σ
- Expect about 3.8x current data shown here by end of GlueX-III



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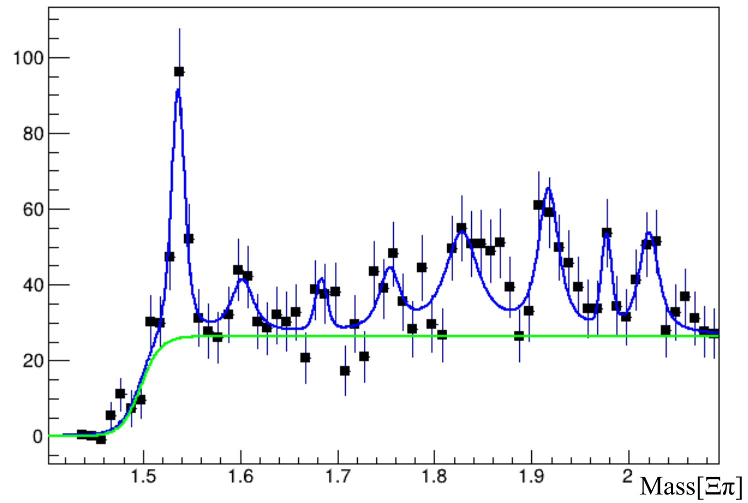
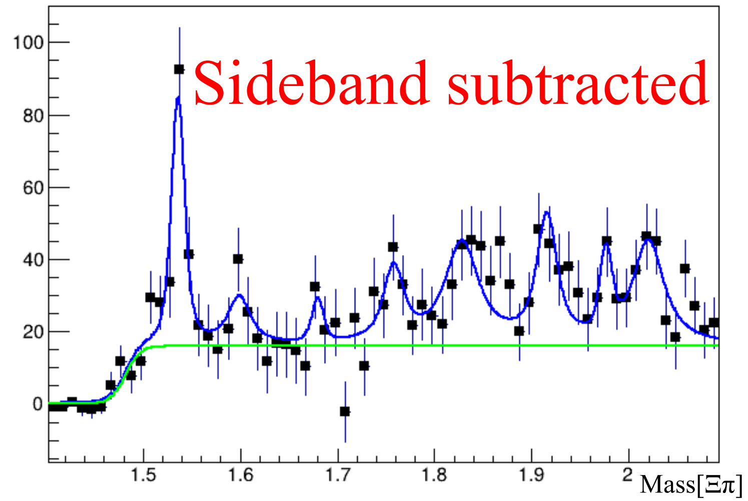
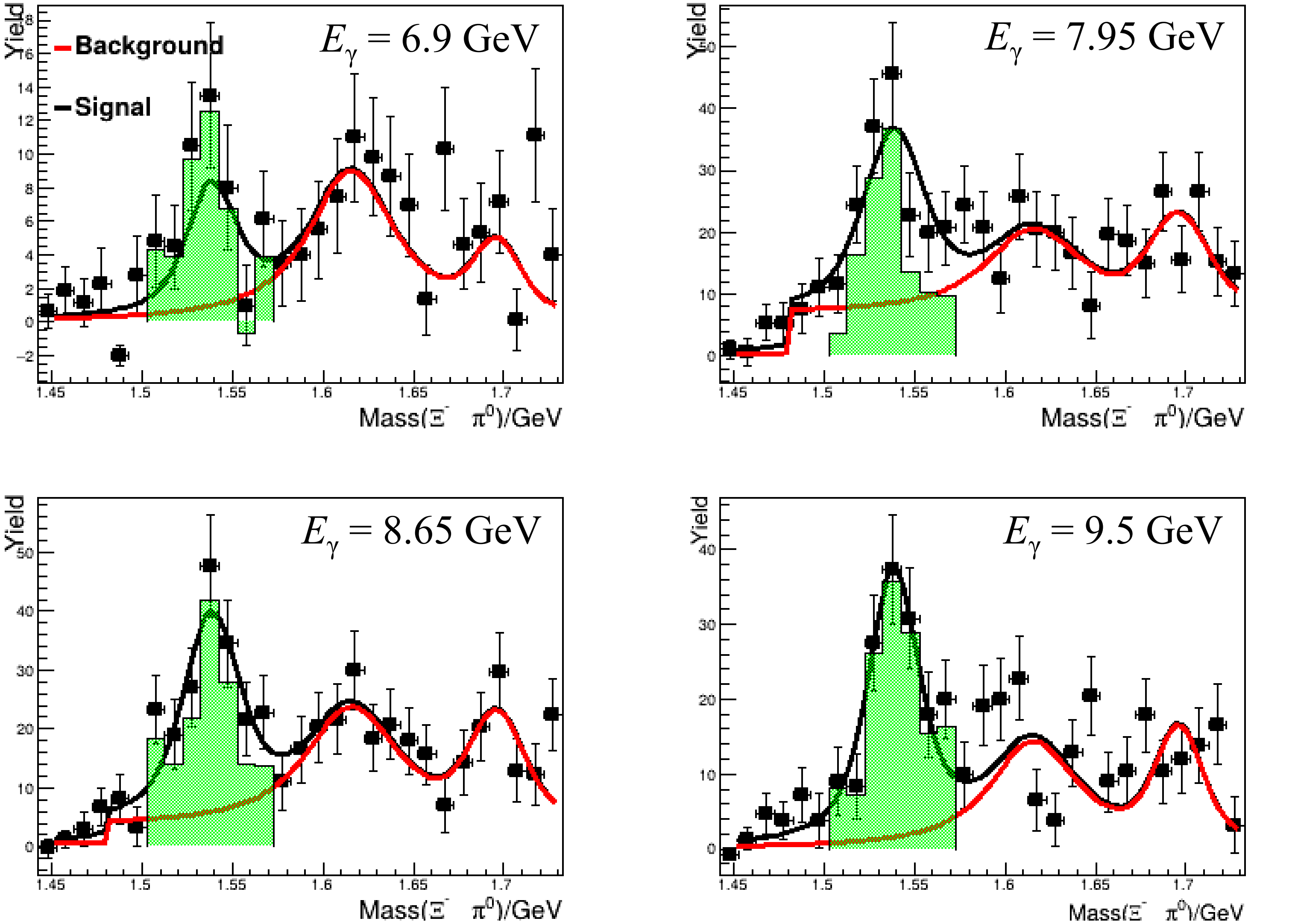
Comparison with/without sideband subtraction



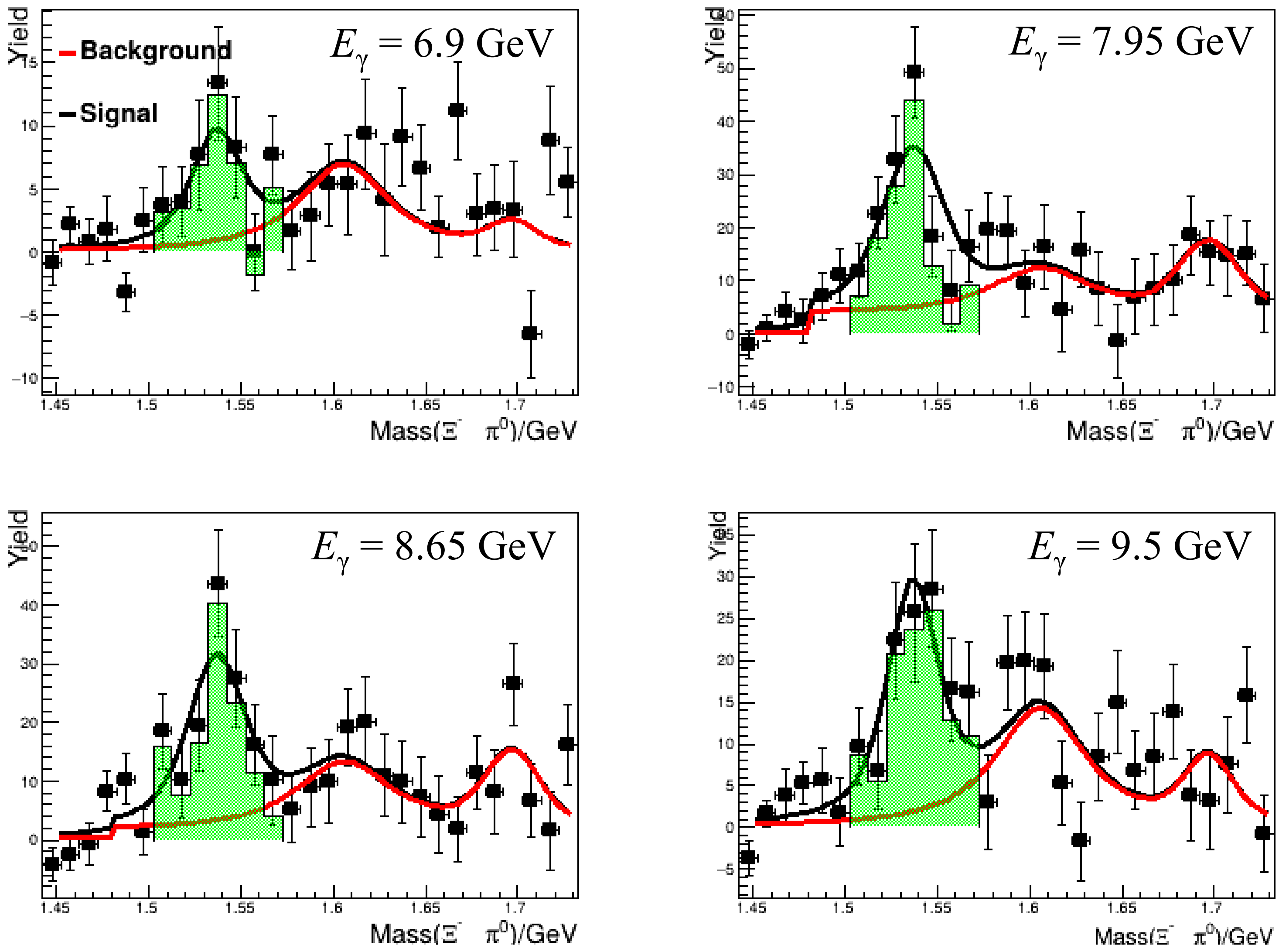


Preliminary cross section of $\gamma p \rightarrow KK\Xi(1530)$ done 4 ways

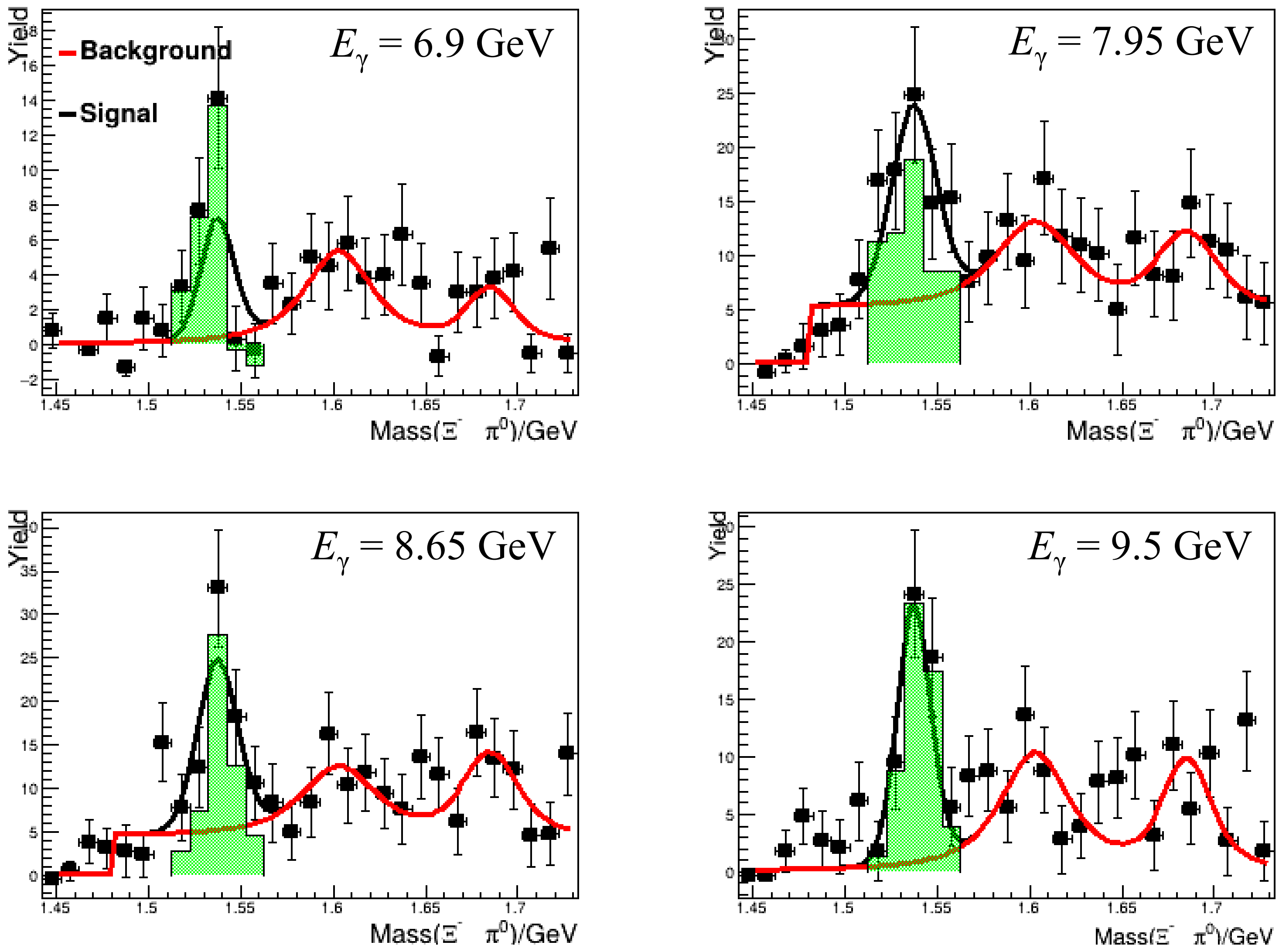
RF accidental subtraction



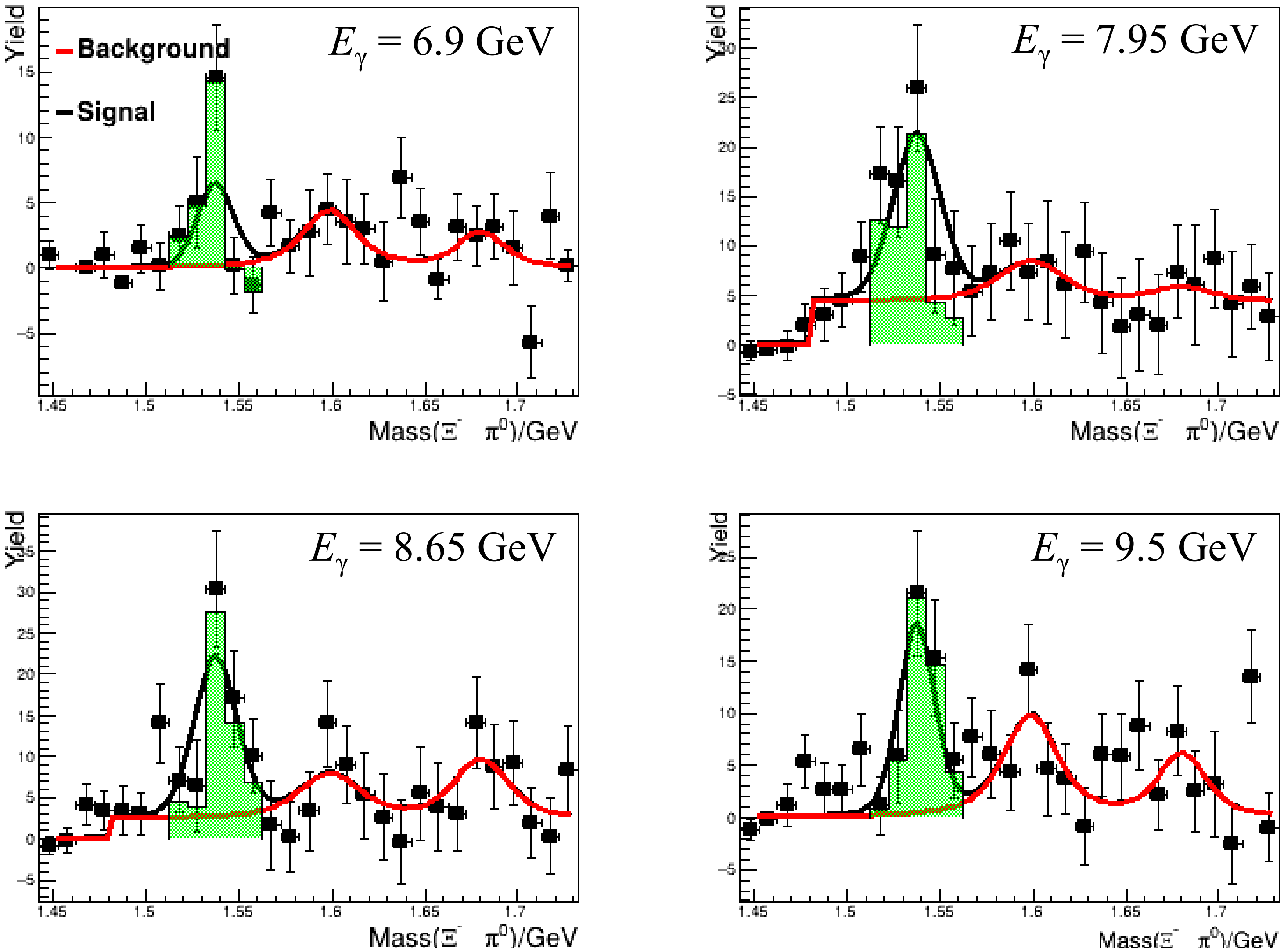
RF accidental subtraction + sideband subtraction



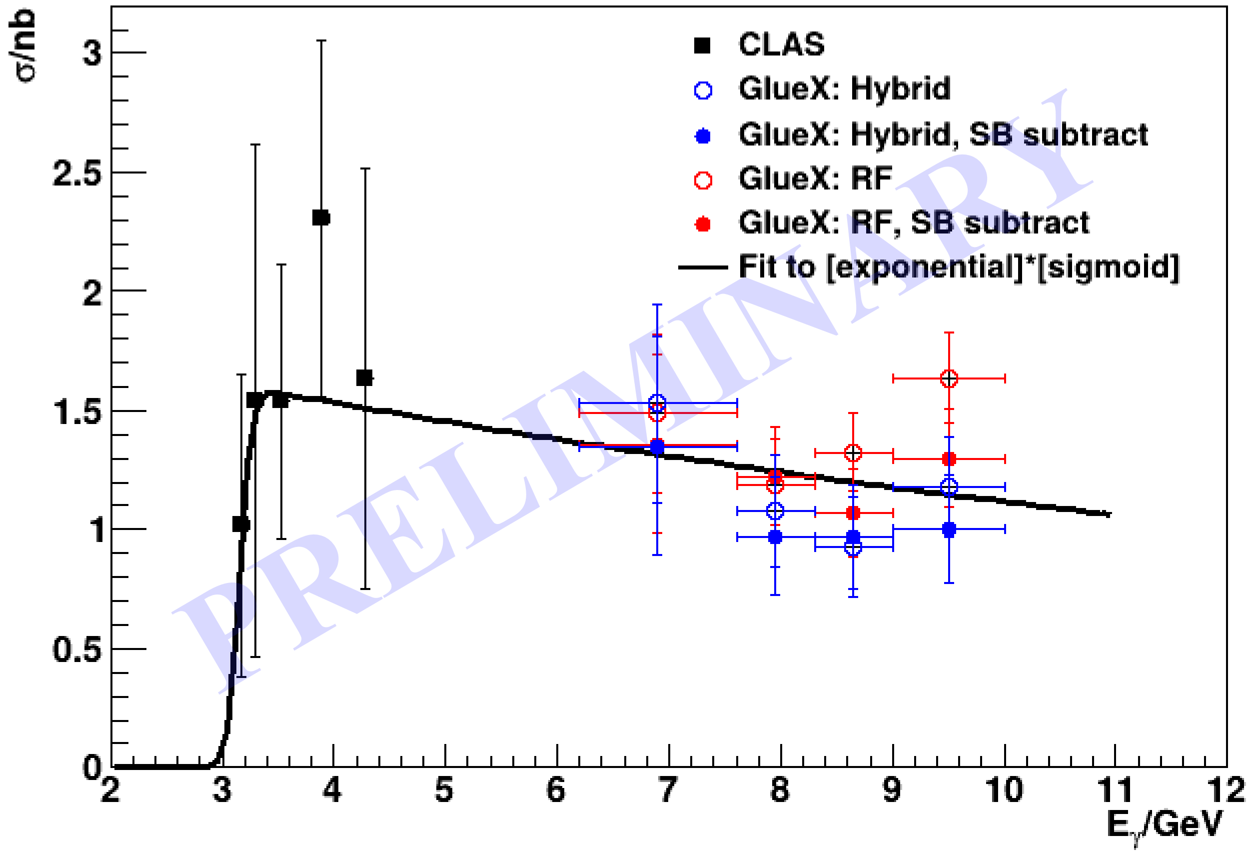
Hybrid accidental subtraction



Hybrid accidental subtraction + sideband subtraction



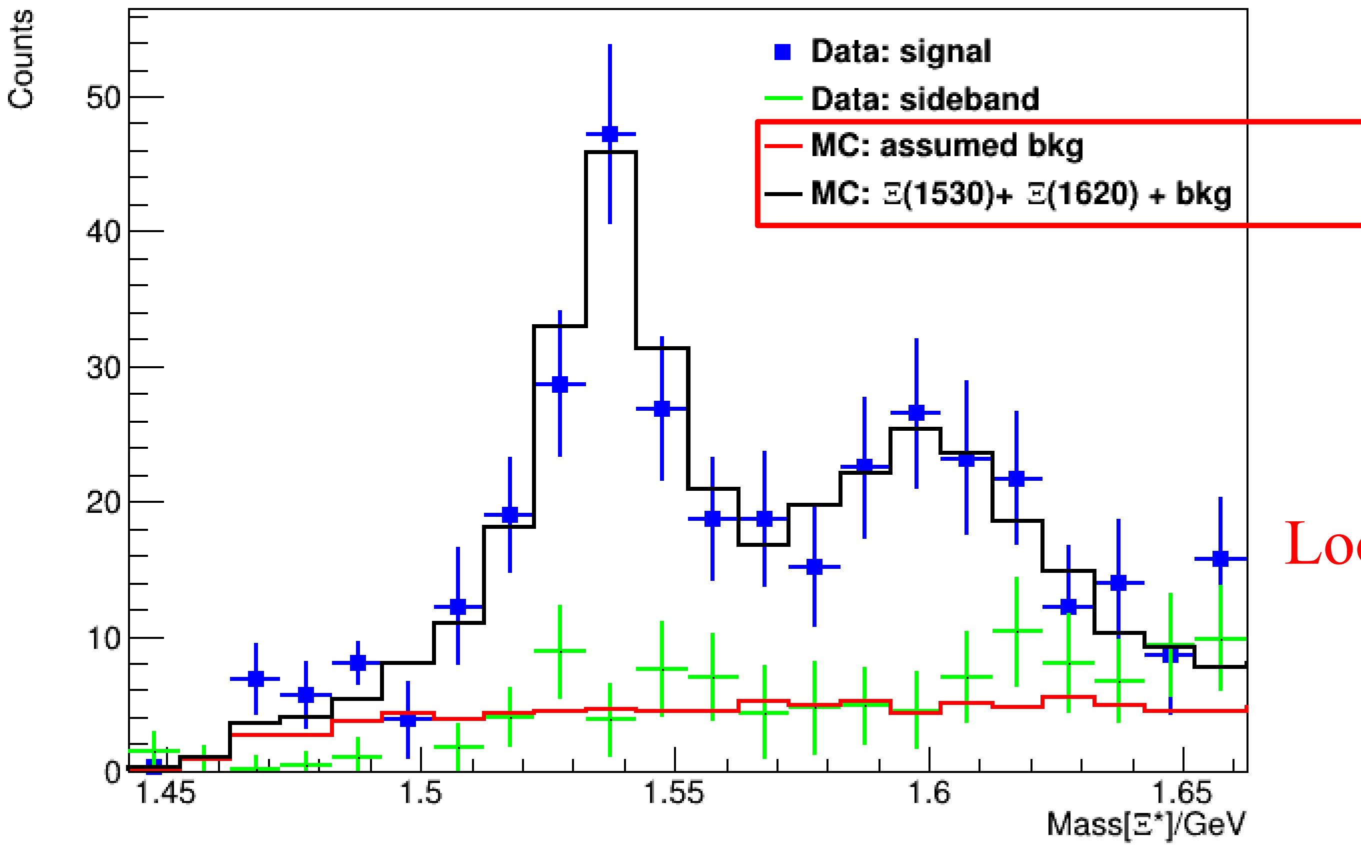
Ξ^-(1530) total cross section for binned E_γ with fit to [exponential]*[sigmoid]



Title

Title

Invariant mass of $\Xi^{-}\pi^{0}$ (presumably Ξ^{*})



Looks reasonable ☺

The Ξ(1620) generation set to:

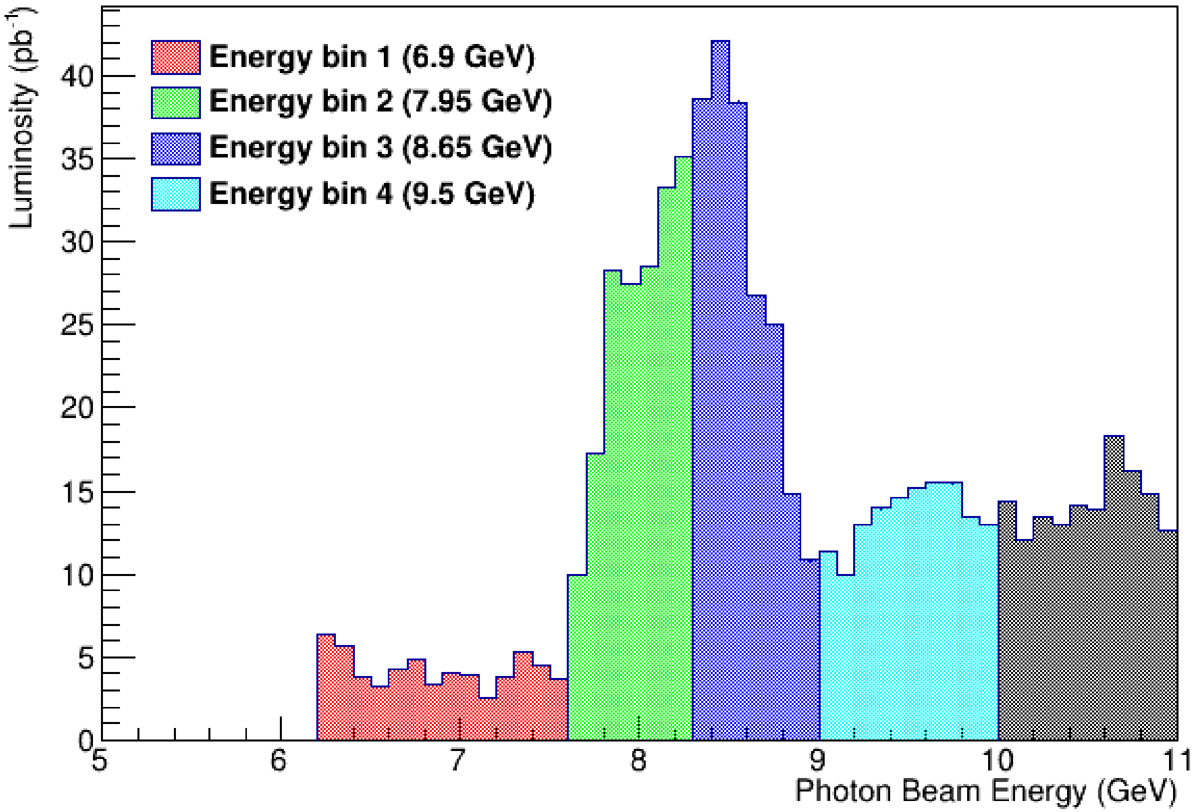
- Center = 1600 MeV
- Width = 30 MeV

Energy Binning

4

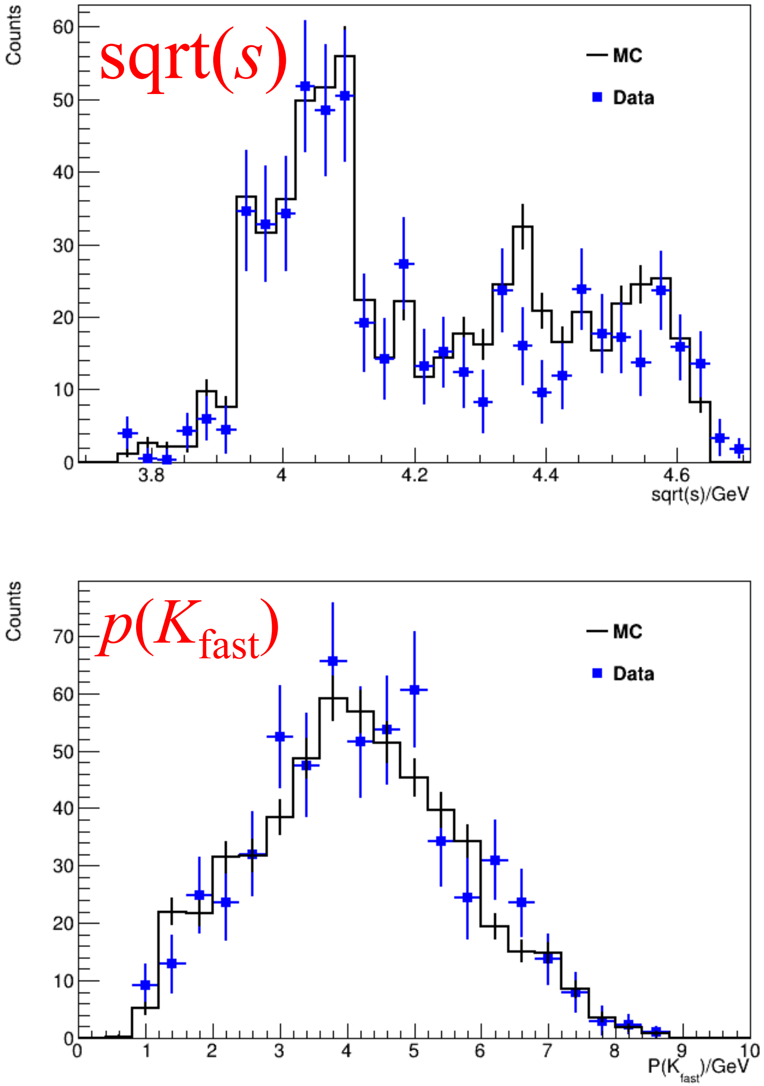
Energy bins:

- 6.2 GeV < E_γ < 7.6 GeV
- 7.6 GeV < E_γ < 8.3 GeV
- 8.3 GeV < E_γ < 9.0 GeV
- 9.0 GeV < E_γ < 10.0 GeV

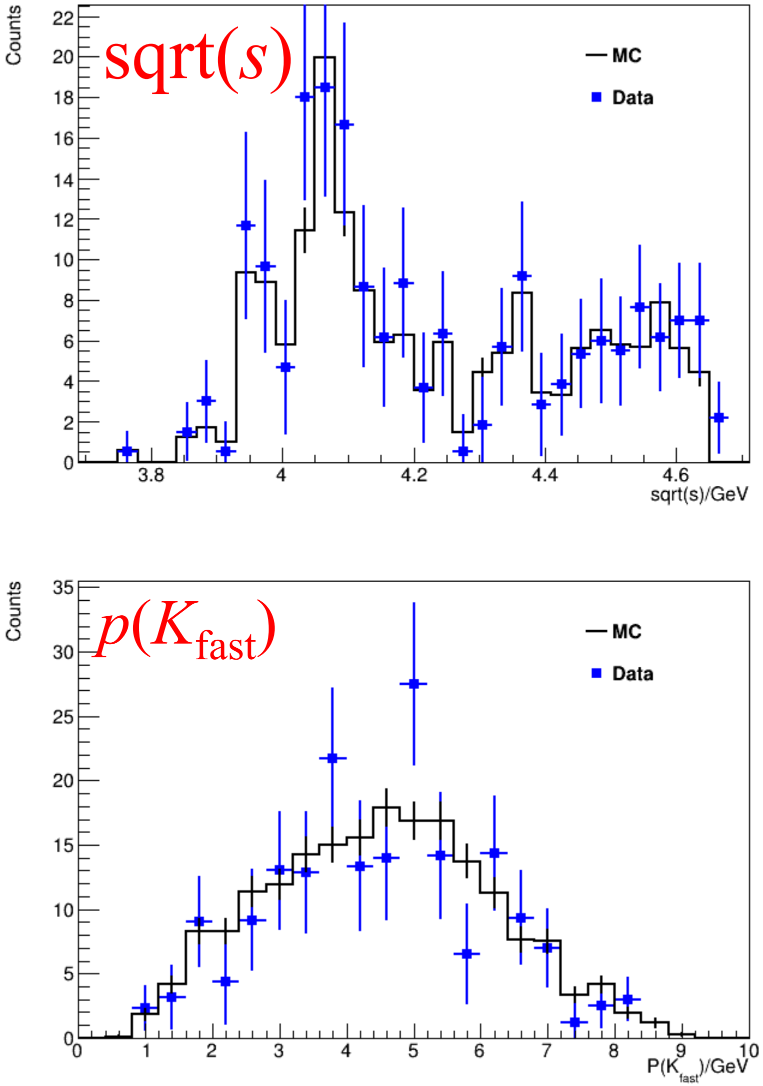


Ξ^* Comparison of Reconstructed MC to Actual Data

General reaction



$\gamma\, p \rightarrow K^+K^+\Xi^-(1530)$



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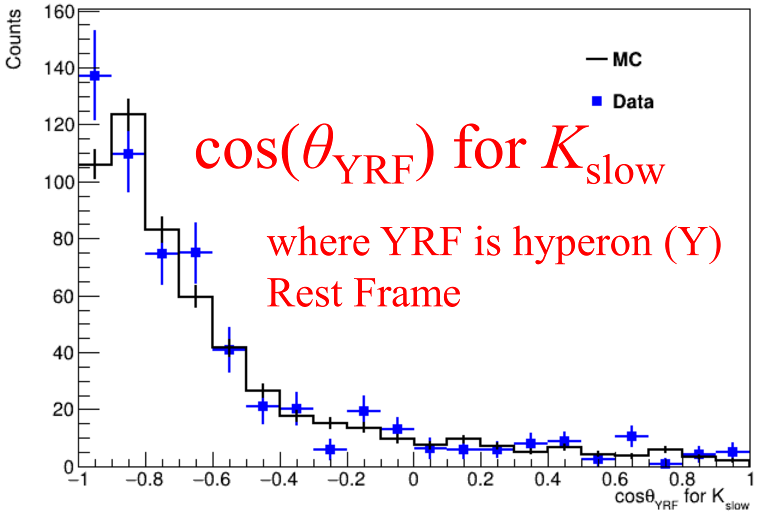

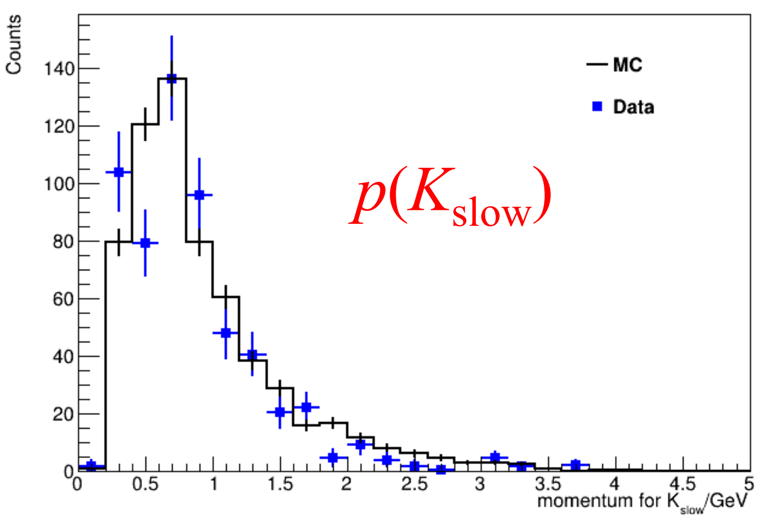

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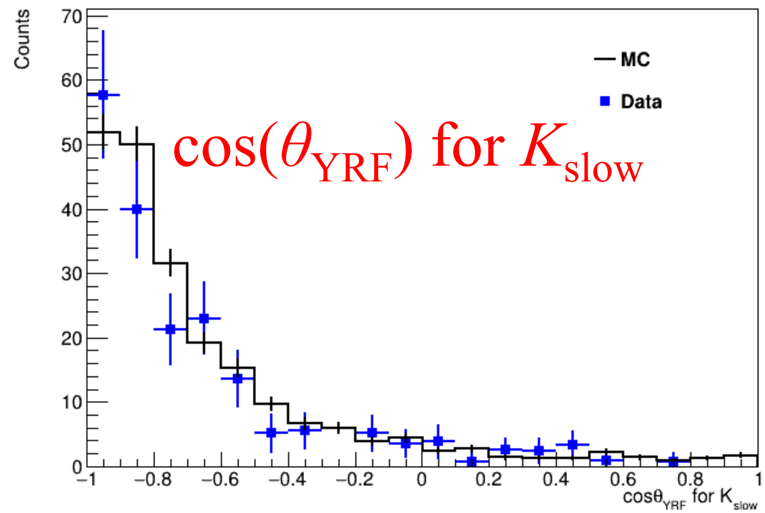

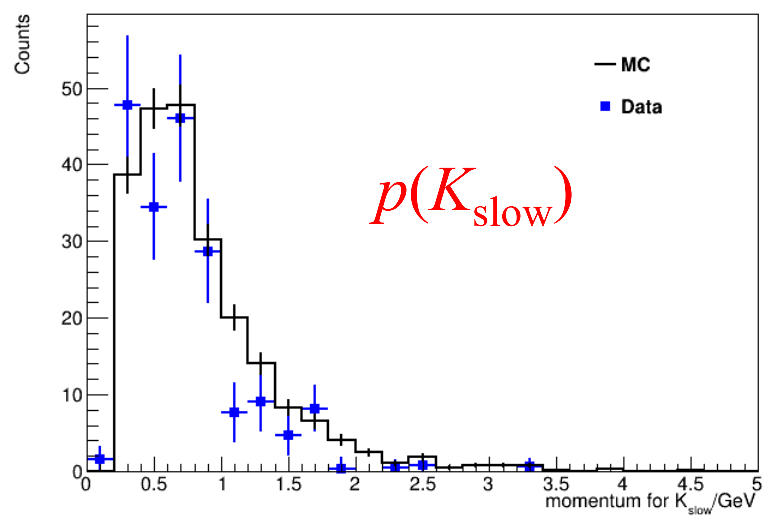

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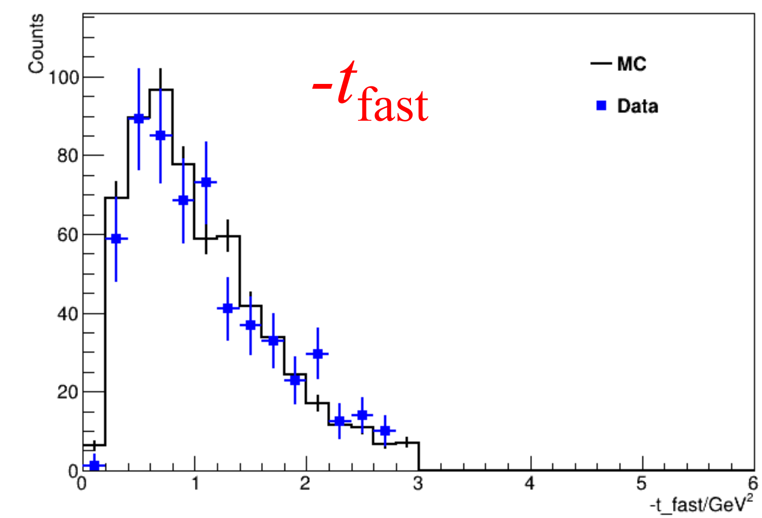

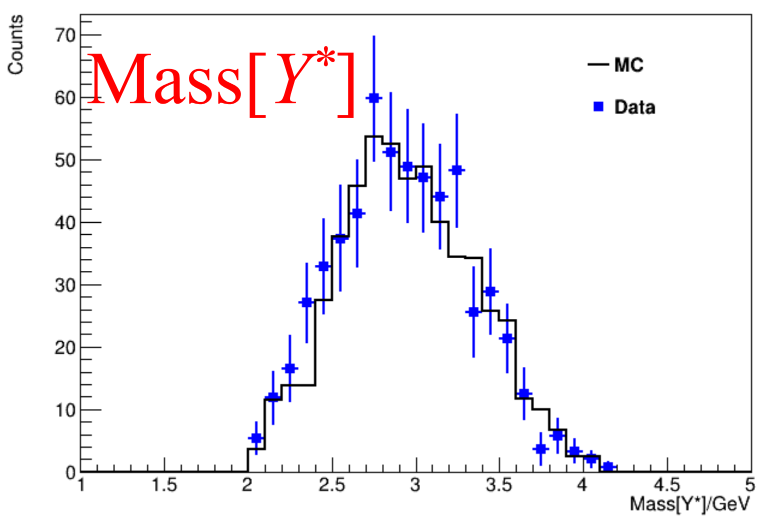

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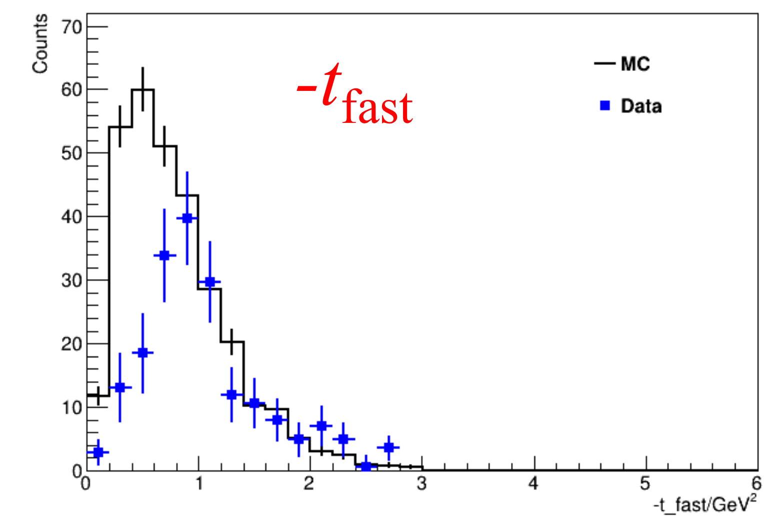

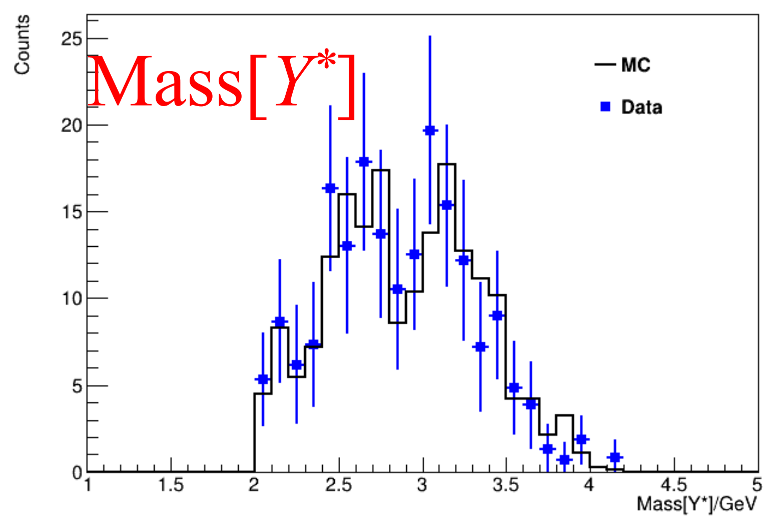

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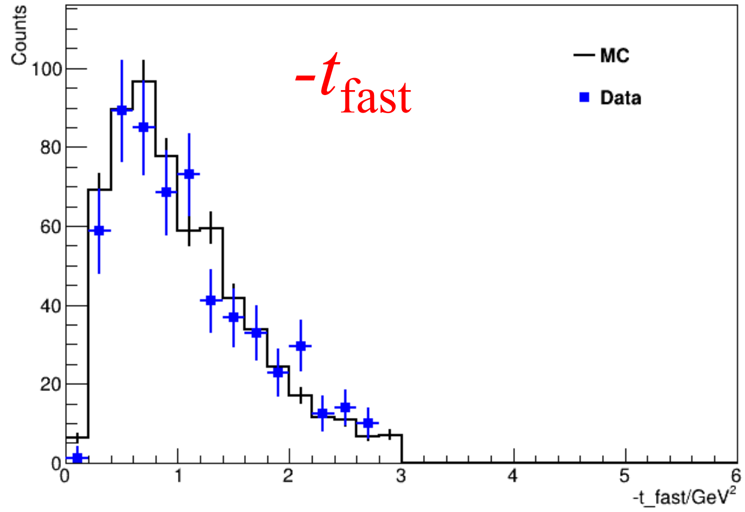
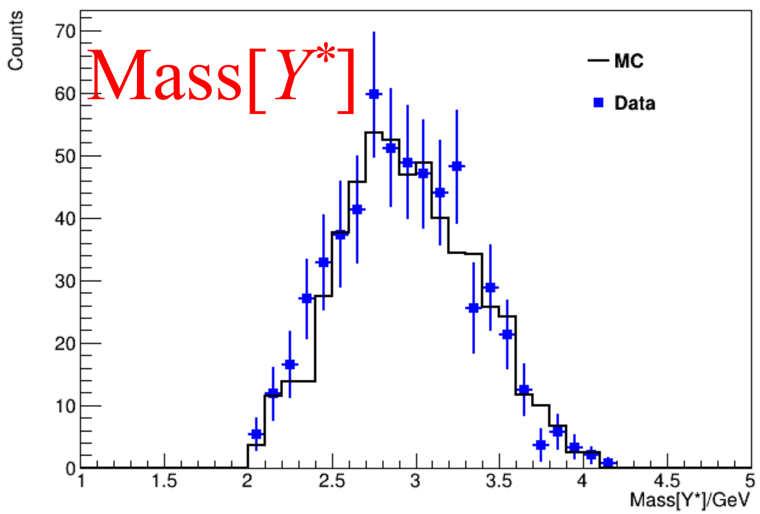
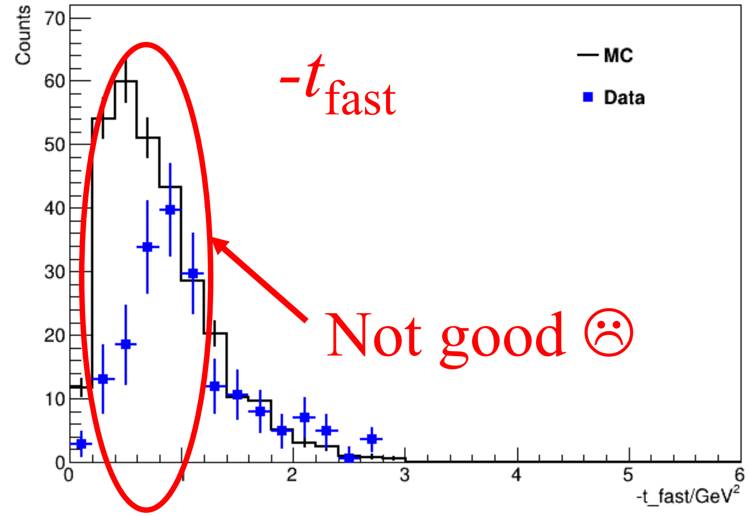
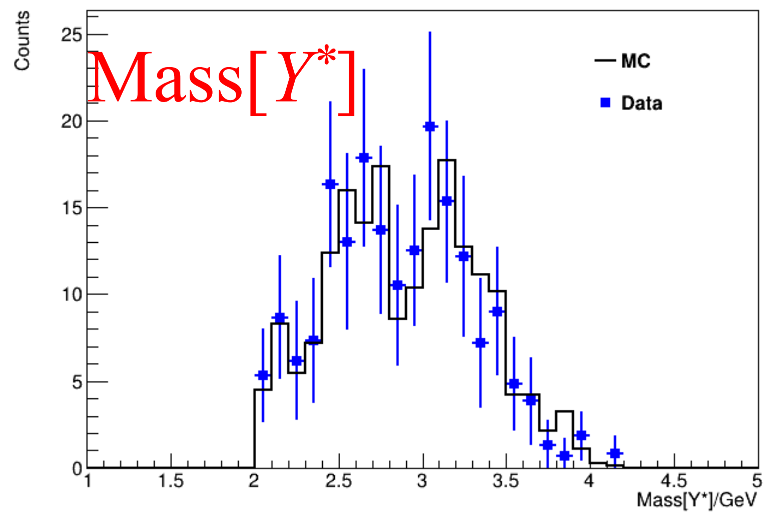




$\gamma\, p \rightarrow K^+ K^+ \Xi^-(1530)$

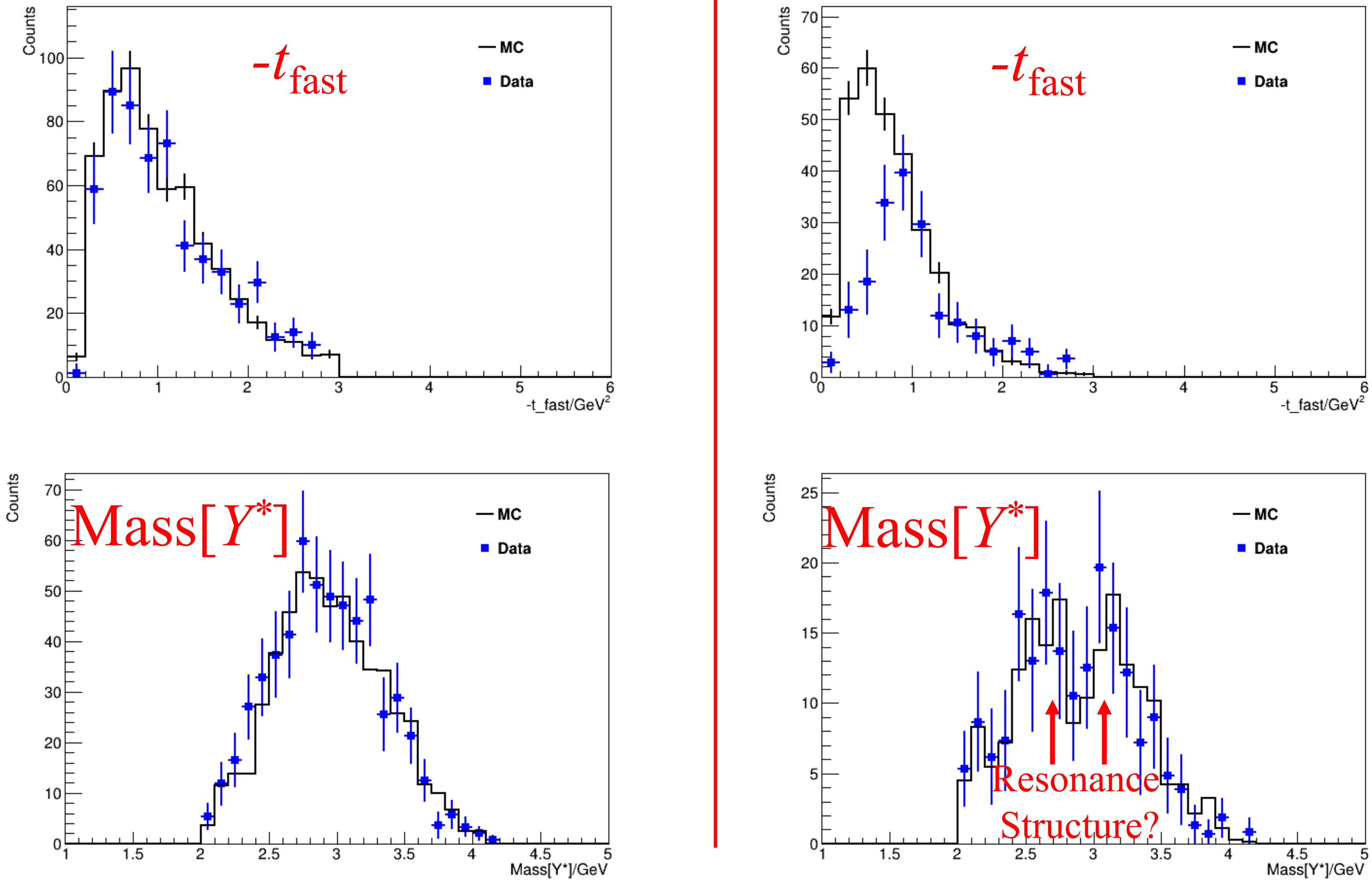




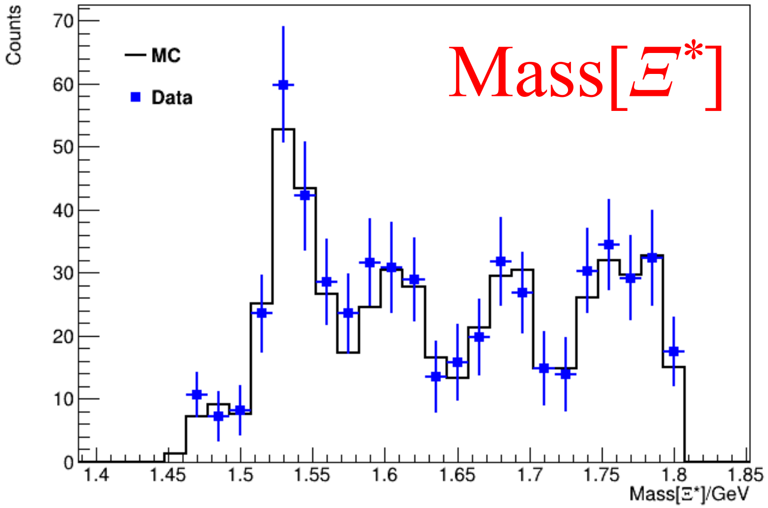
Ξ^* Comparison of Reconstructed MC to Actual Data

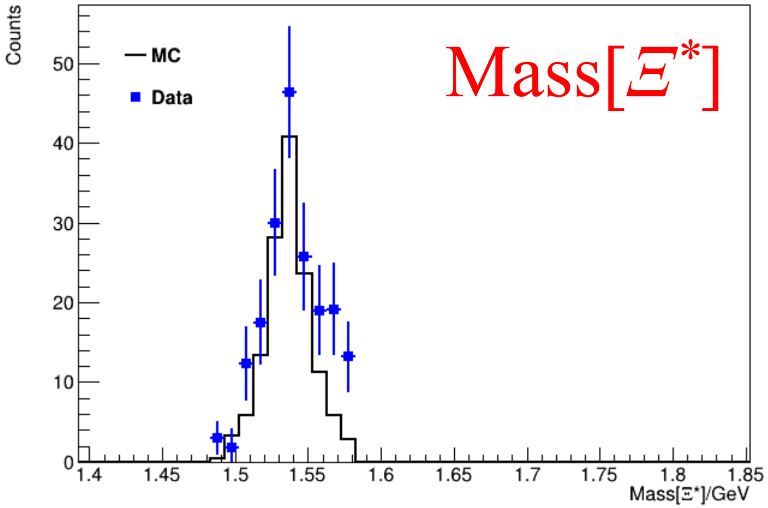
General reaction

$\gamma\, p \rightarrow K^+ K^+ \Xi^-(1530)$

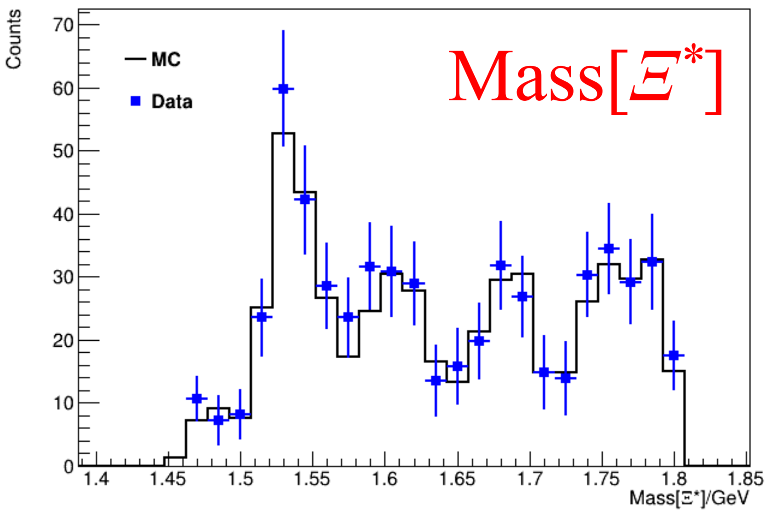


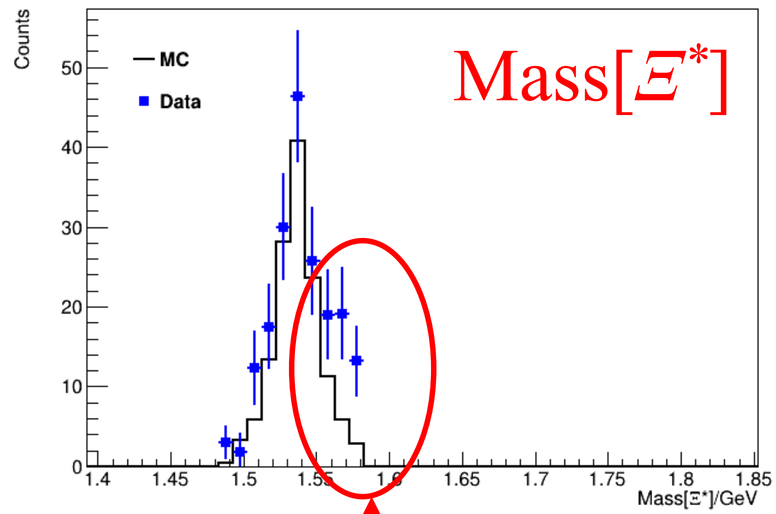
Ξ^* Comparison of Reconstructed MC to Actual Data





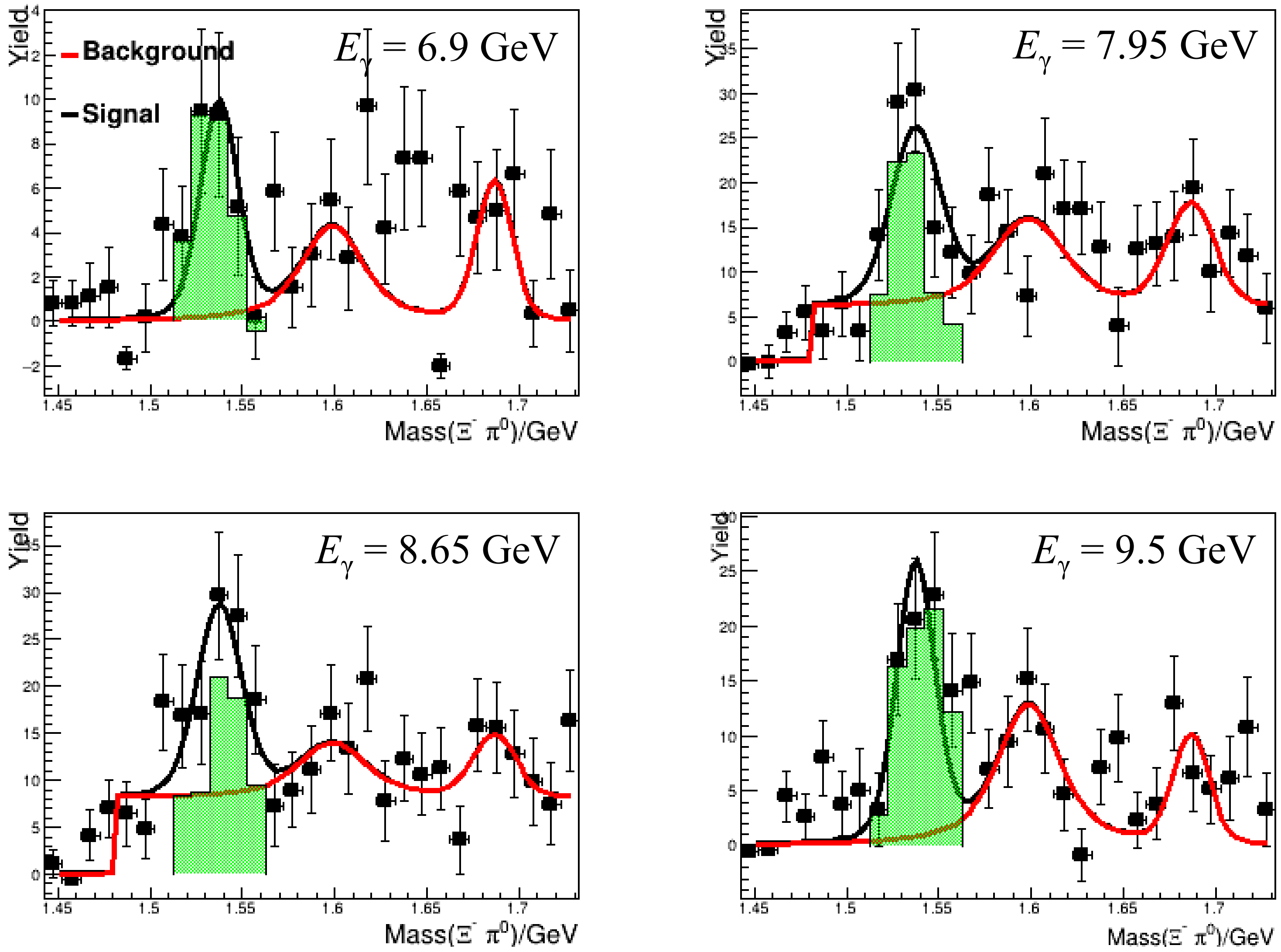
Ξ^* Comparison of Reconstructed MC to Actual Data





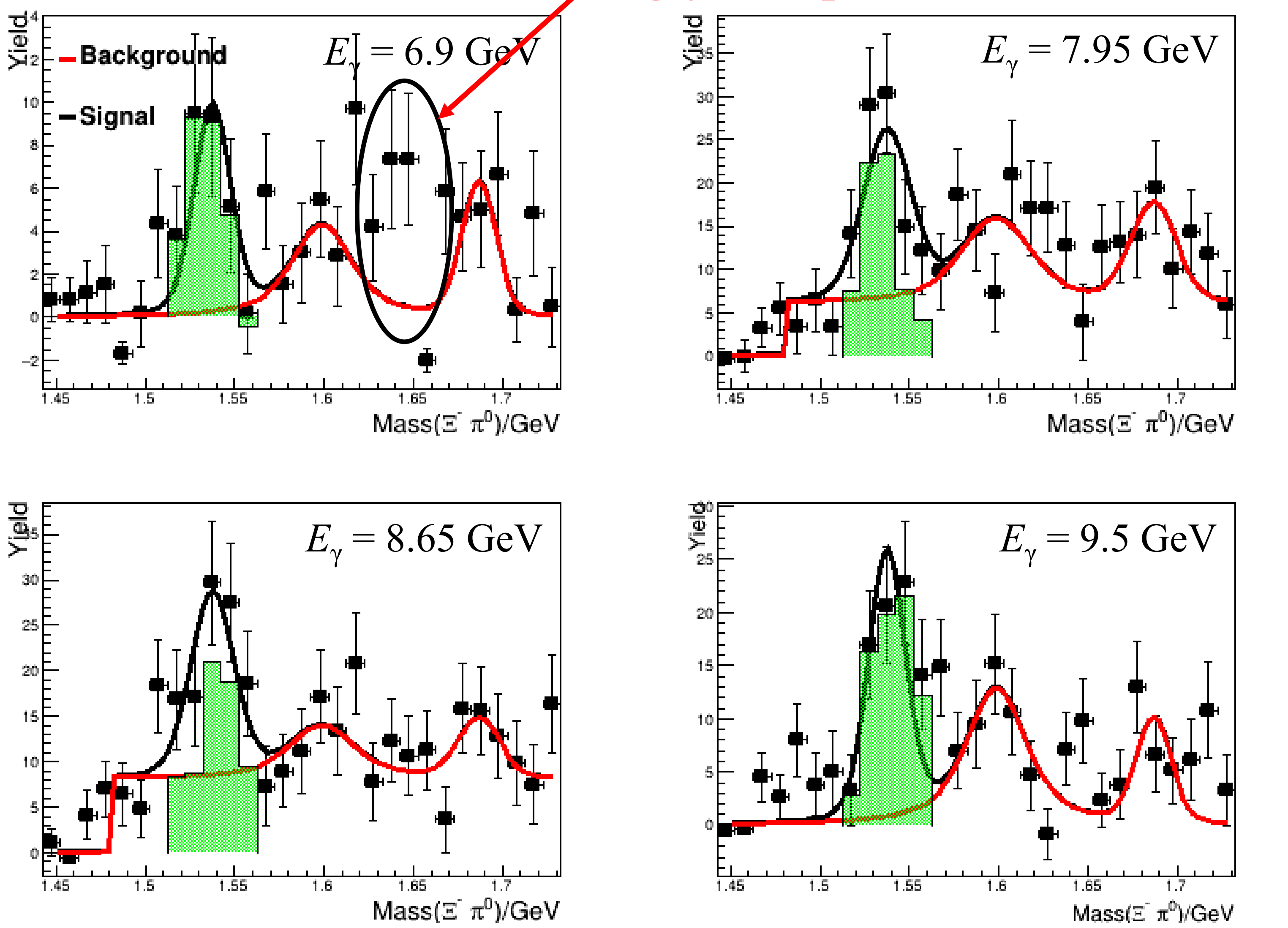
Need background estimate
to make better comparison

RF accidental subtraction

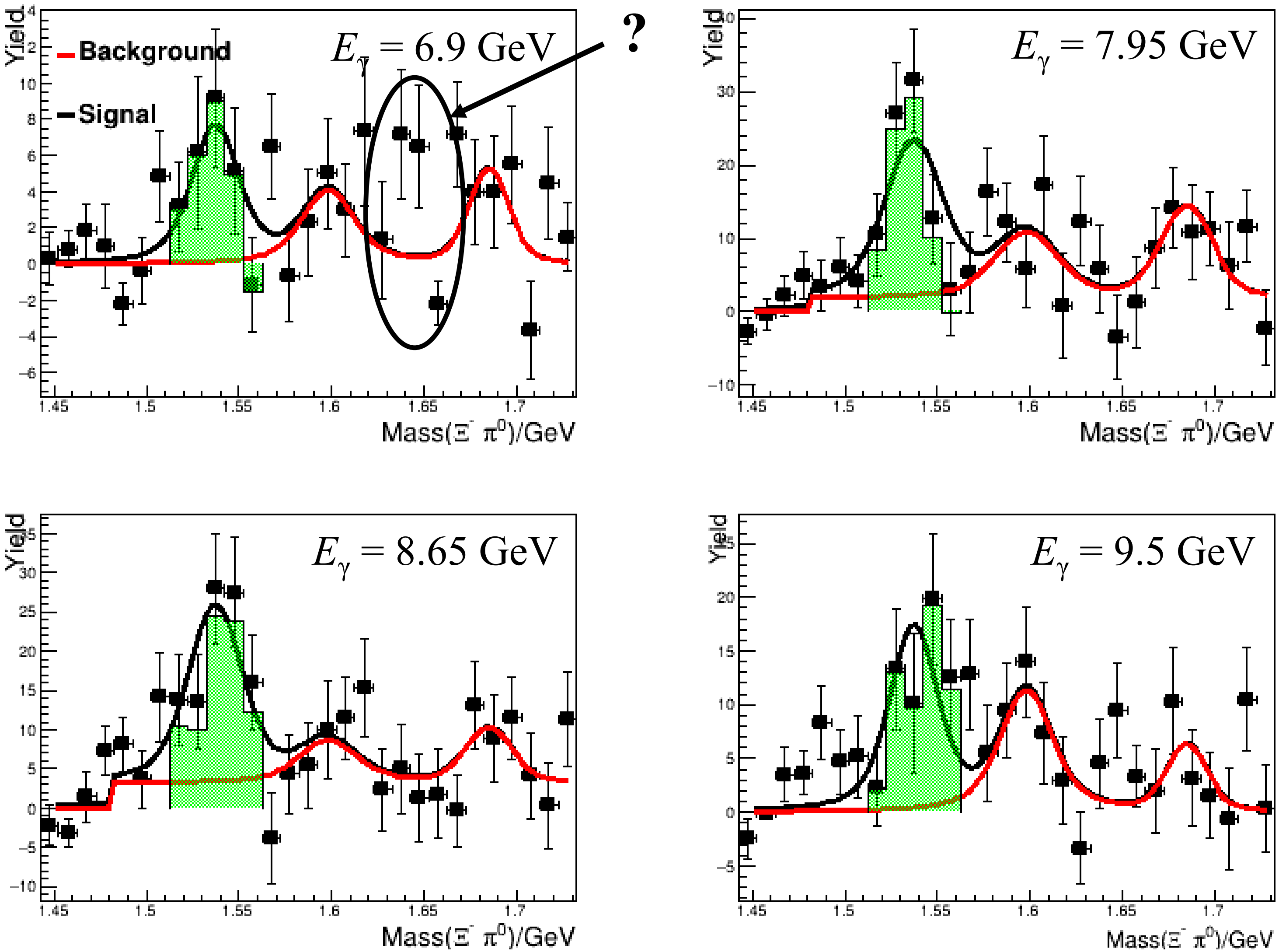


RF accidental subtraction

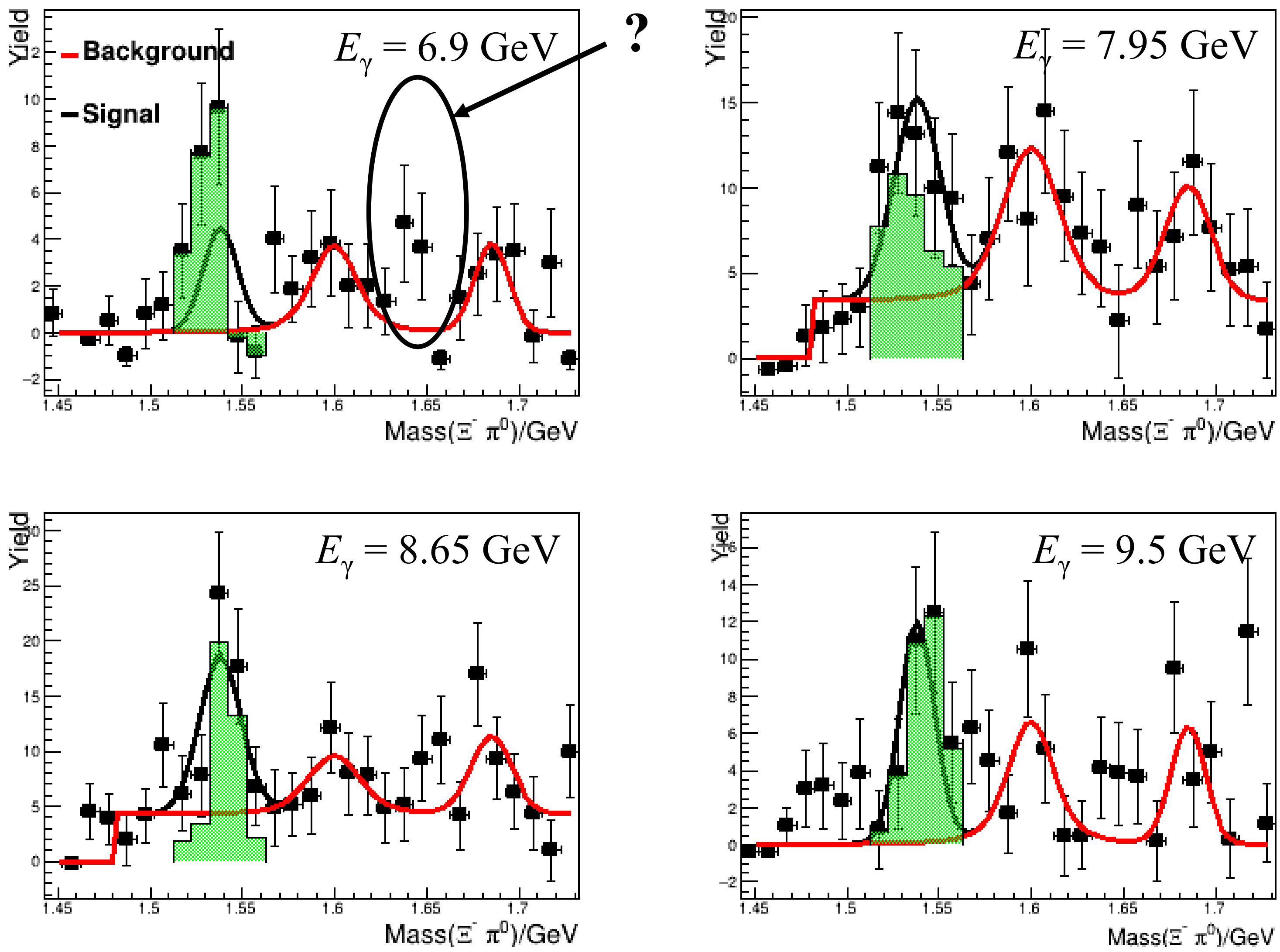
Ugly bump feature at ~1.64 GeV



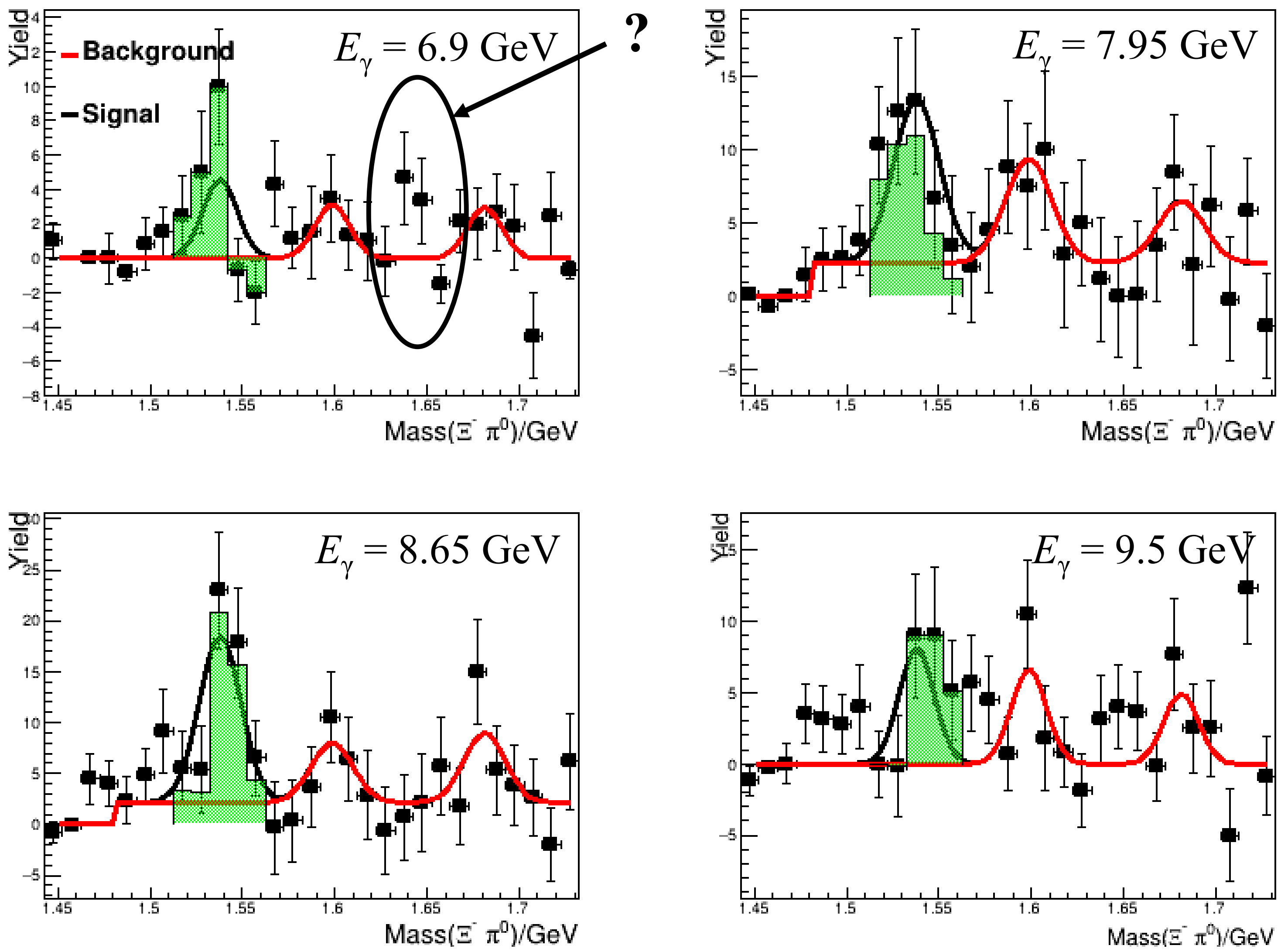
RF accidental subtraction + sideband subtraction



Hybrid accidental subtraction



Hybrid accidental subtraction + sideband subtraction



$\Xi^-(1530)$ total cross section for binned E_γ with fit to [exponential]*[sigmoid]