Photoproduction of $\Xi^-(1320)$ at GlueX

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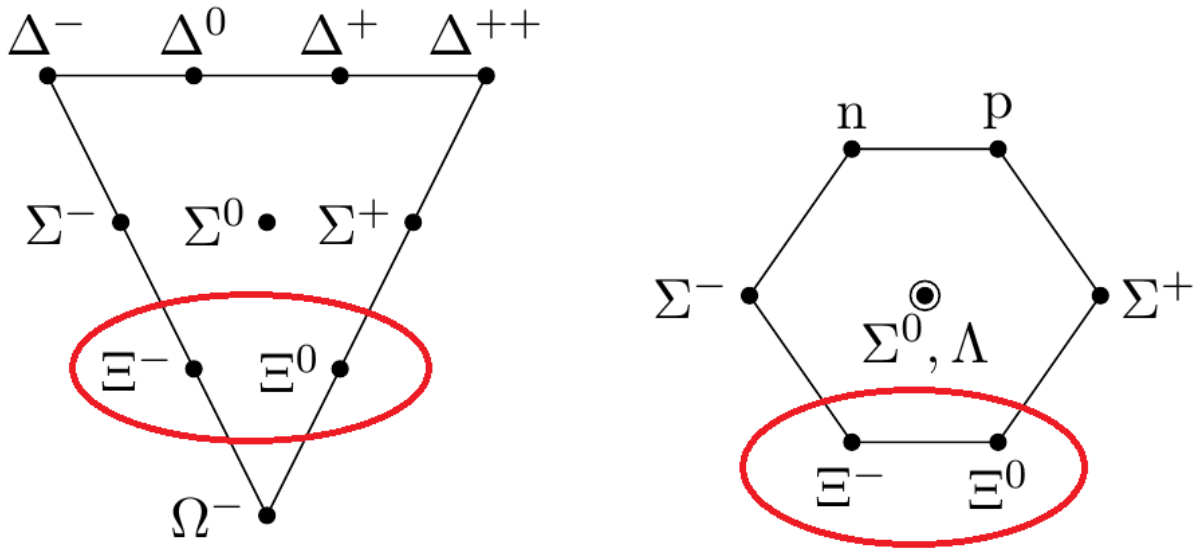
Cascade baryons Ξ

- The baryon spectrum provides a probe of QCD
- SU(3) flavor symmetry results in a decuplet and an octet where each member of the multiplet has similar properties.
- N* extensively studied



Cascade baryons Ξ

- Should be as many Ξ^*s as N^*s and Δ^*s combined
  - N: 20 *** and **** states
  - Δ: 12 *** and **** states
  - Ξ: 6 *** and **** states
- Experimentally difficult to produce
- Ξ's on the back burner still the 1980s

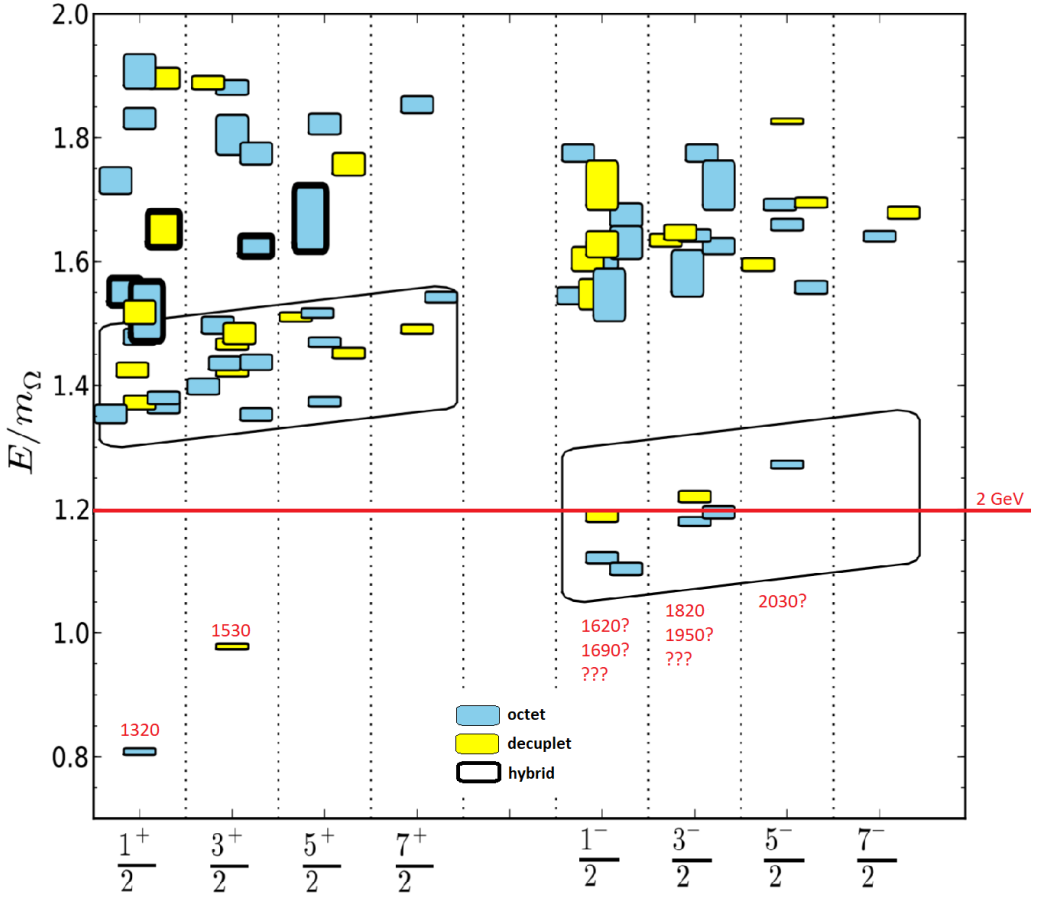
Particle	J^P	Overall Status
$\Xi(1318)$	$1/2^+$	****
$\Xi(1530)$	$3/2^+$	****
$\Xi(1620)$		*
$\Xi(1690)$		***
$\Xi(1820)$	$3/2^-$	***
$\Xi(1950)$		***
$\Xi(2030)$	$5/2^?$	***
$\Xi(2120)$		*
$\Xi(2250)$		**
$\Xi(2370)$		**
$\Xi(2500)$		*

Current status of the Ξ resonances from the 2019 PDG update.

assumption

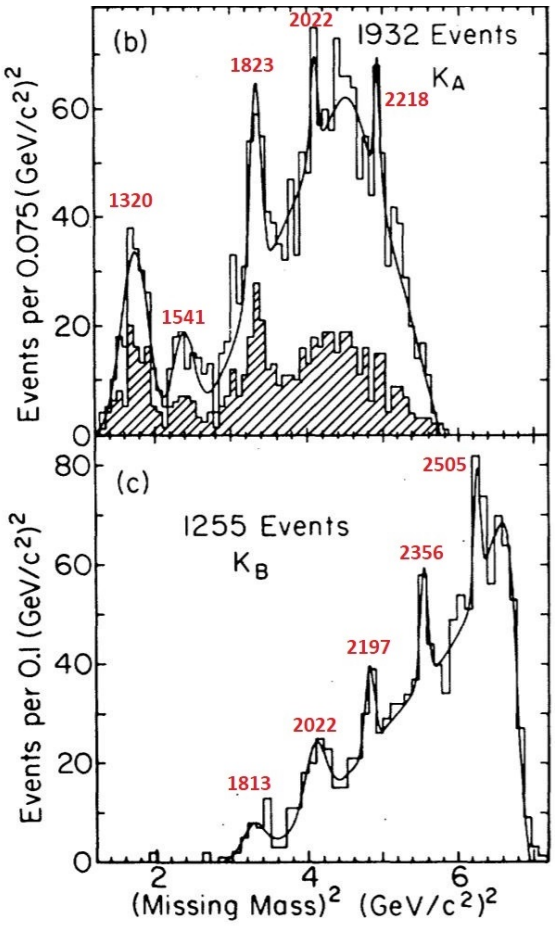
Cascade baryons, Ξ

- Lattice QCD predicts a large amount of states
- Two states in the first excitation band have never been seen
- Only the 1320 and 1530 have been seen in photoproduction



HadSpec: Robert G. Edwards et al. Phys. Rev. D87 (2013) 054506

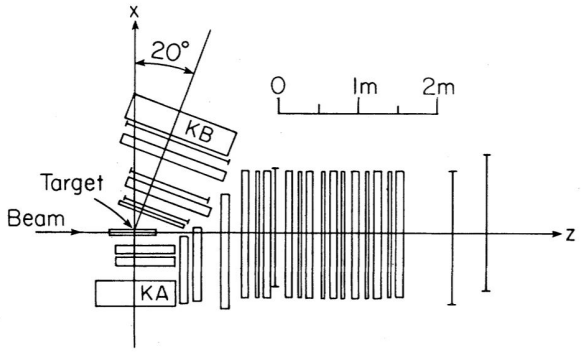
Experimental Landscape of Ξ



Jenkins, Charles M. et al. Phys.Rev.Lett. 51 (1983)

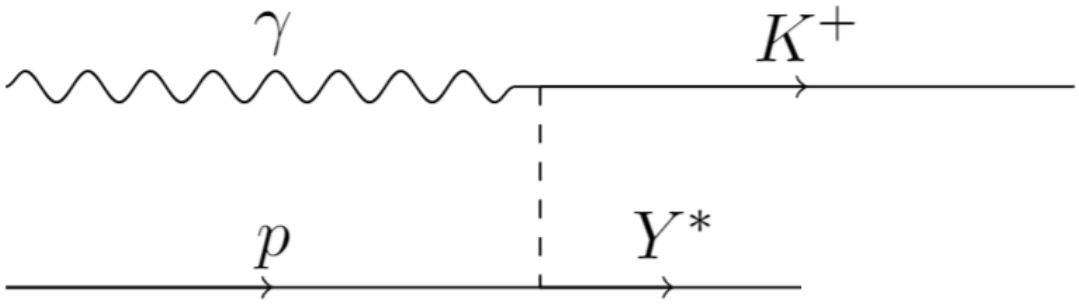
- Most knowledge is from Kaon production in the 1960-80s.
- Example: MultiParticle Spectrometer at BNL from the 1980s

$$K^- p \to K^+ (X)^-$$

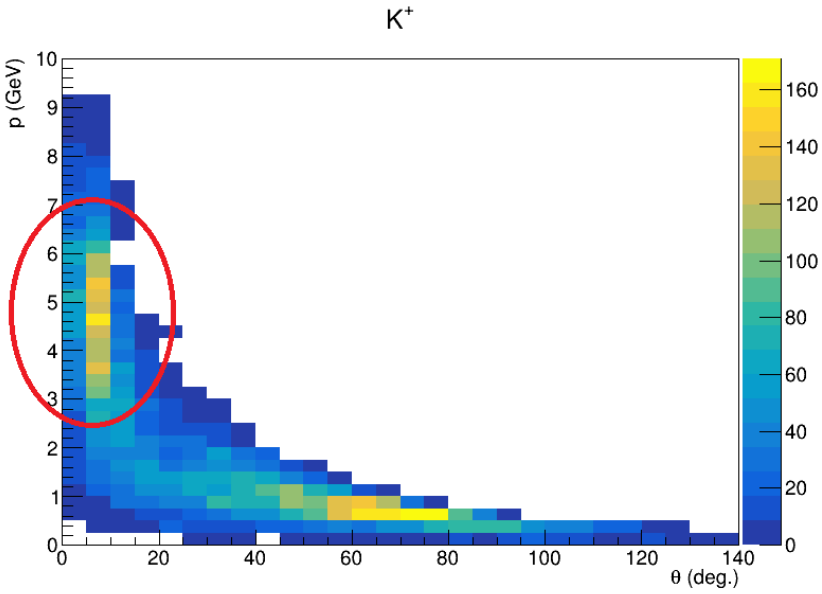


Modern Particle	MPS Particle	PDG(1982) Status	PDG(2019) Status
Ξ(1320)	Ξ(1320)	****	****
Ξ(1530)	Ξ(1541)	****	****
Ξ(1620)		**	*
Ξ(1690)		**	***
Ξ(1820)	Ξ(1822)	***	***
Ξ(1950)		**	***
Ξ(2030)	Ξ(2022)	***	***
Ξ(2120)		*	*
Ξ(2250)	Ξ(2214)	*	**
Ξ(2370)	Ξ(2356)	**	**
Ξ(2500)	Ξ(2505)	**	*

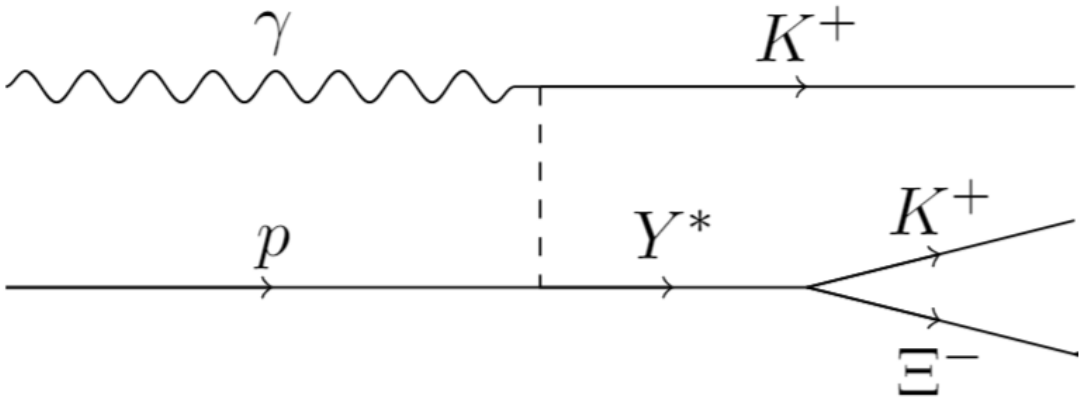
Photoproduction of Ξ



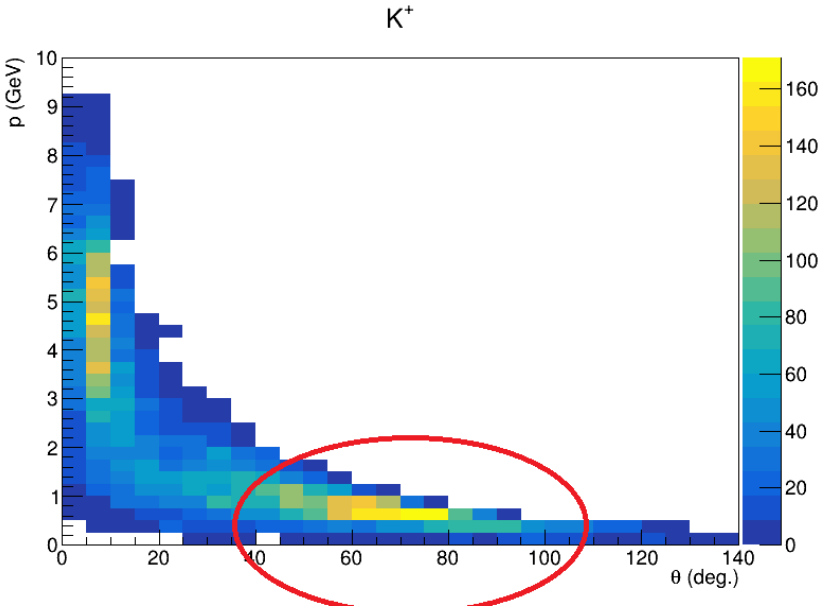
- No direct production due to OZI suppression
- High momentum K^+ near beamline through t-channel production mechanism
- Not much is known about the intermediate hyperon



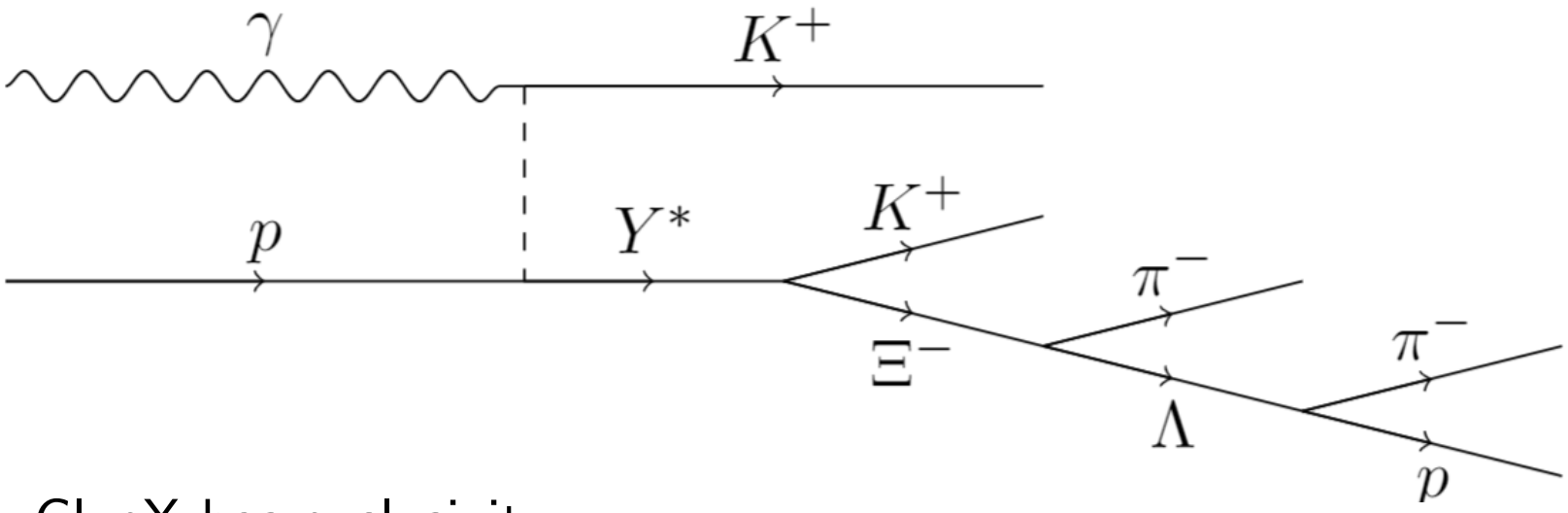
Photoproduction of Ξ



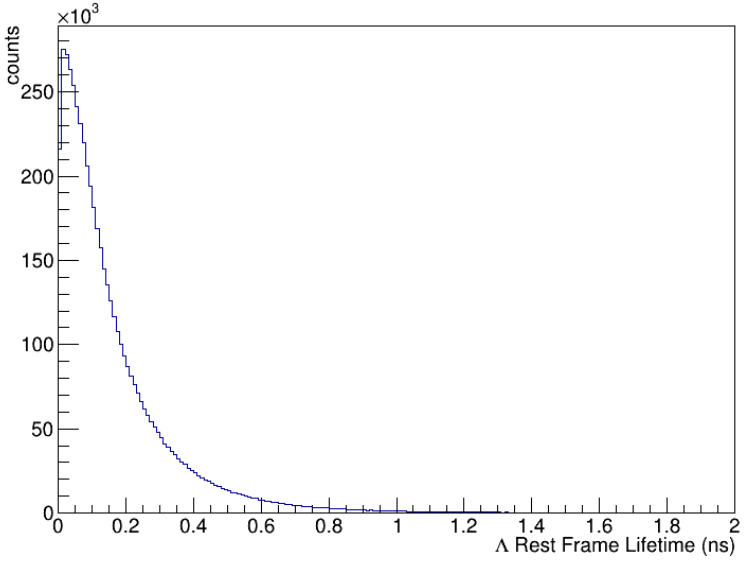
- Excited intermediate hyperon decays to Cascade baryon
- Decay K^+ is low momentum and wider polar angle
- Previous photoproduction experiments studied $MM(K^+K^+)$



Photoproduction of Ξ

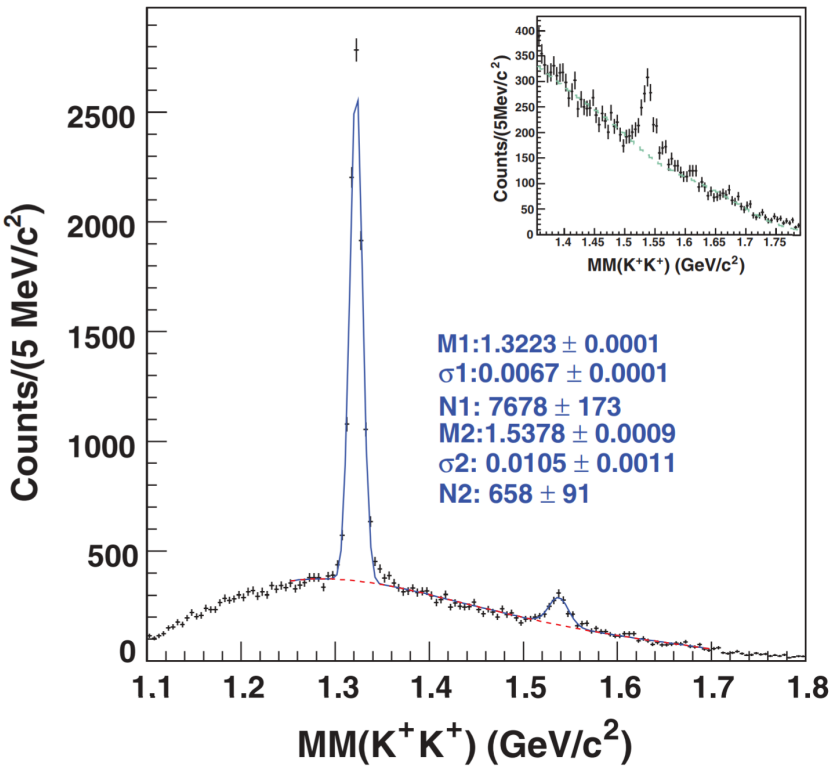


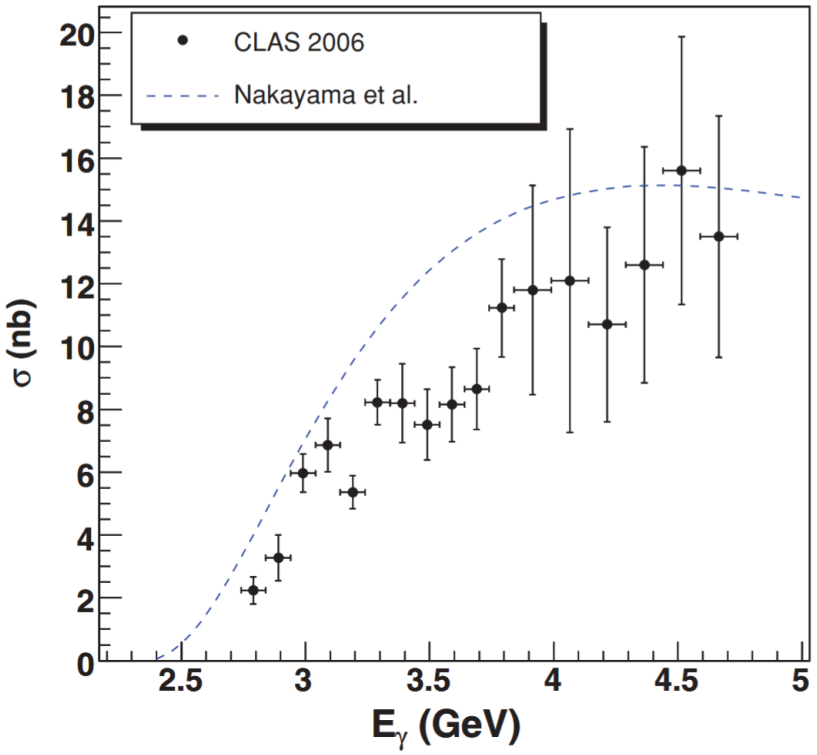
- GlueX has exclusivity resulting in unique access to decay angular distributions
- Detached vertex of Ξ and Λ can also be seen
- Detached vertices are useful in reducing background



Previous measurements of $\Xi^-(1320)$ cross section

- Total cross section at CLAS g11 for E_γ up to 4.75 GeV
- Statistical and systematic errors shown



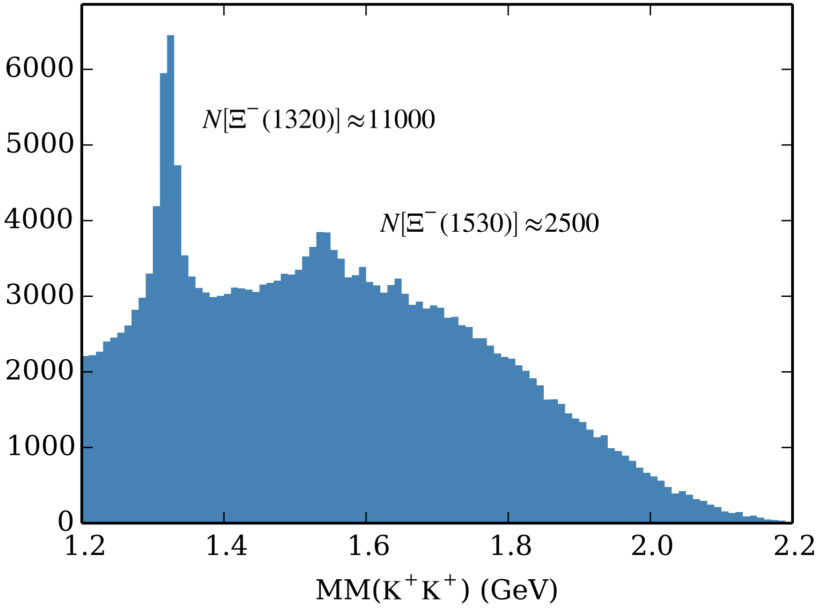


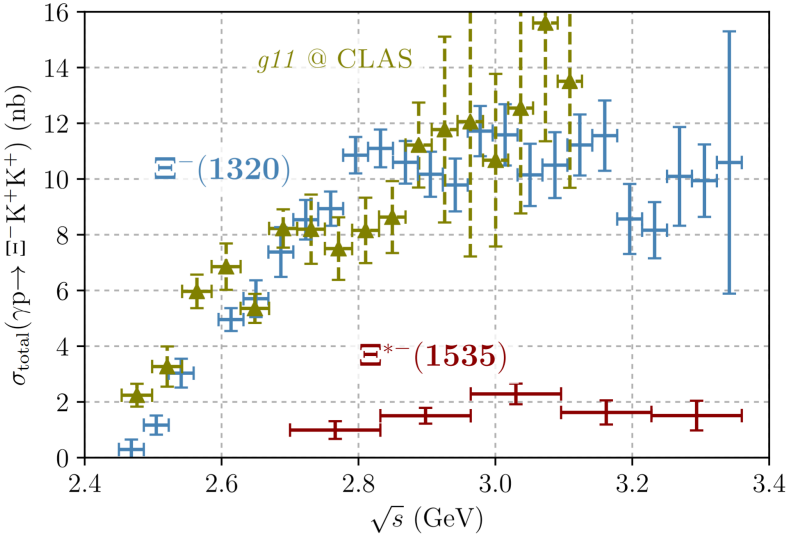
experiment: CLAS: Guo, L. et al. Phys. Rev. C 76, 025208 (2007)

theory model: K. Nakayama et al. Phys. Rev. C 74, 035205 (2006)

Previous measurements of $\Xi^-(1320)$ cross section

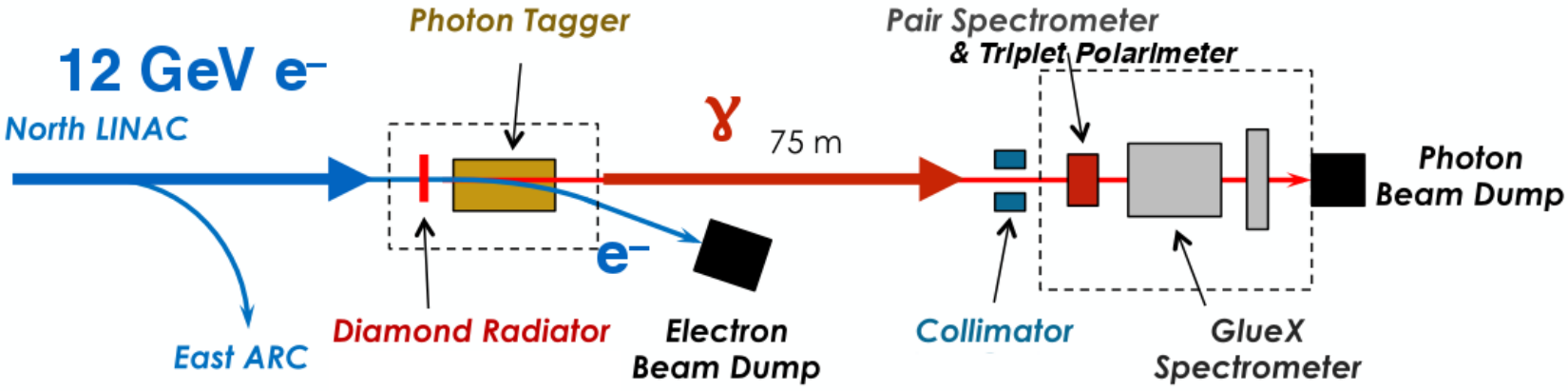
- Total cross section at CLAS g12 for E_γ up to 5.4 GeV
- Statistical errors shown with additional 8.8% systematic errors
- Expectation of cross section to plateau with increasing beam energy



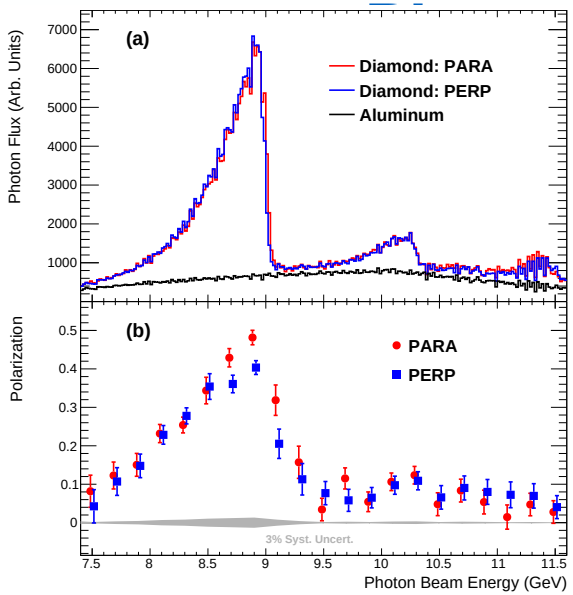


CLAS: J. T. Goetz et al. Phys. Rev. C 98, 062201 (2018)

GlueX Beamline



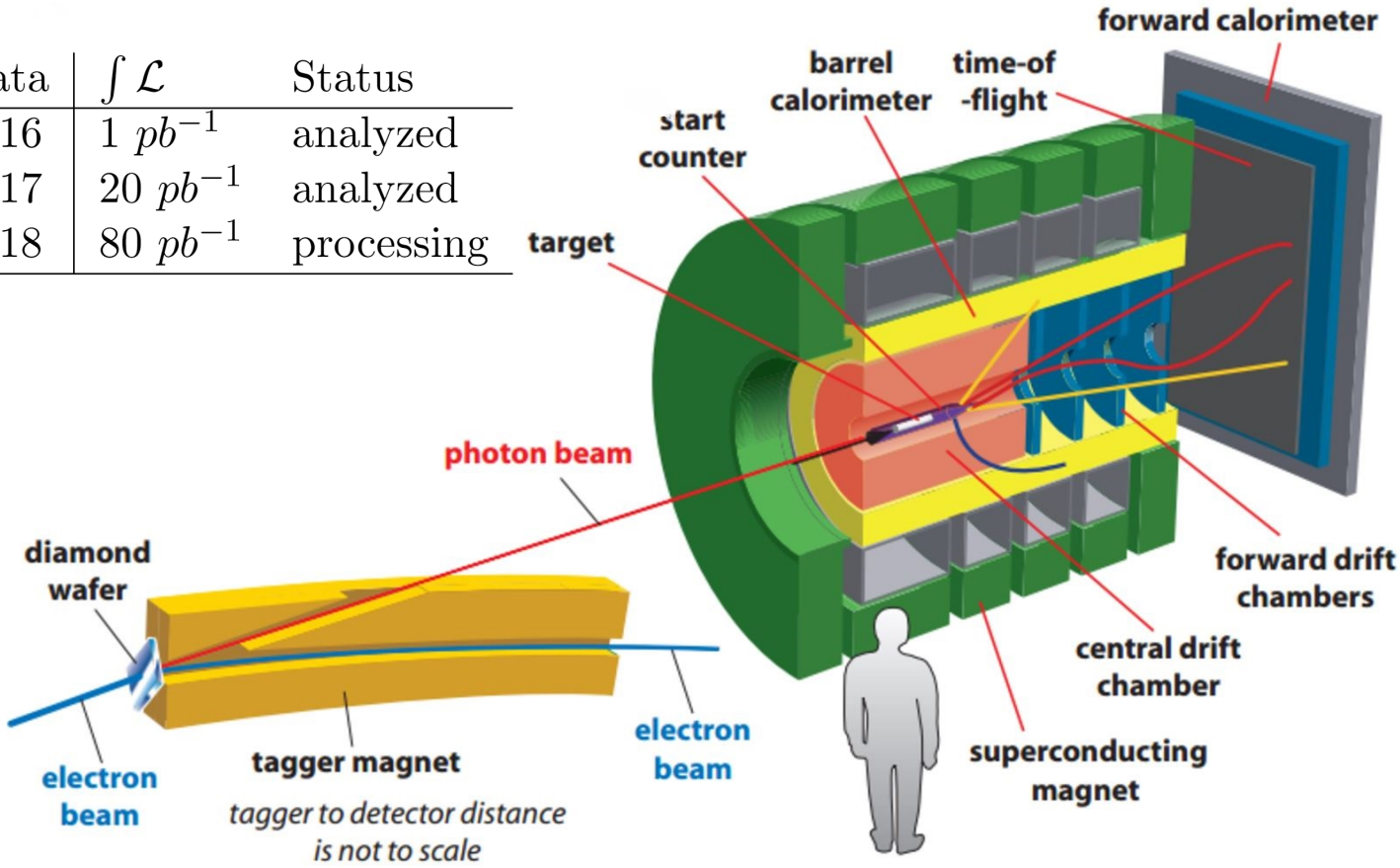
- Up to ∼12 GeV in e^- energy
- $\sim$ 9 GeV linearly polarized photon beam from coherent Bremsstrahlung
- $1 - 5 * 10^7 \gamma/s$ in the coherent peak



GlueX

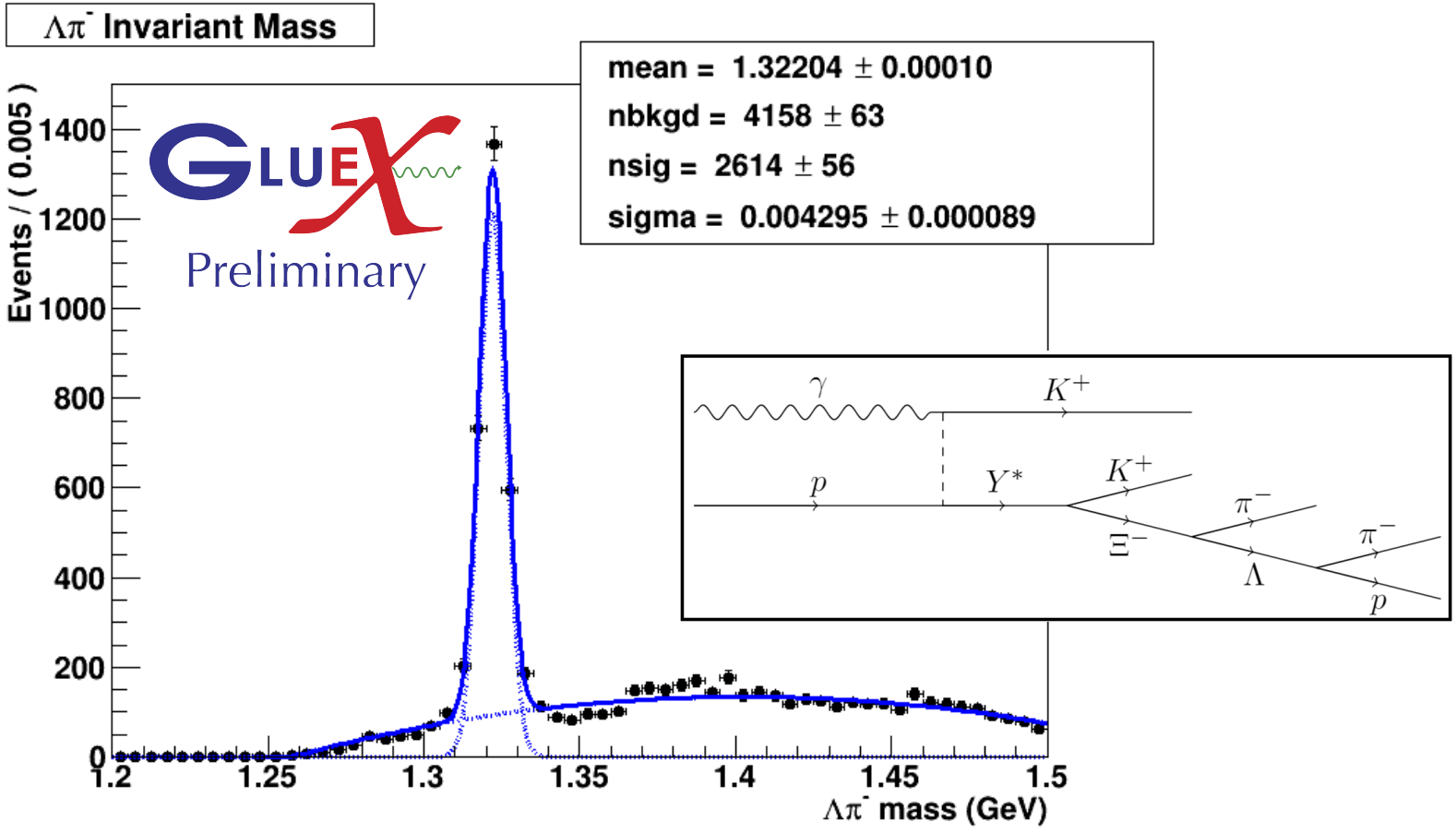
- Spectroscopy with nearly hermetic detector
- Exclusive final states

Data	$\int \mathcal{L}$	Status
2016	1 pb^{-1}	analyzed
2017	20 pb^{-1}	analyzed
2018	80 pb^{-1}	processing



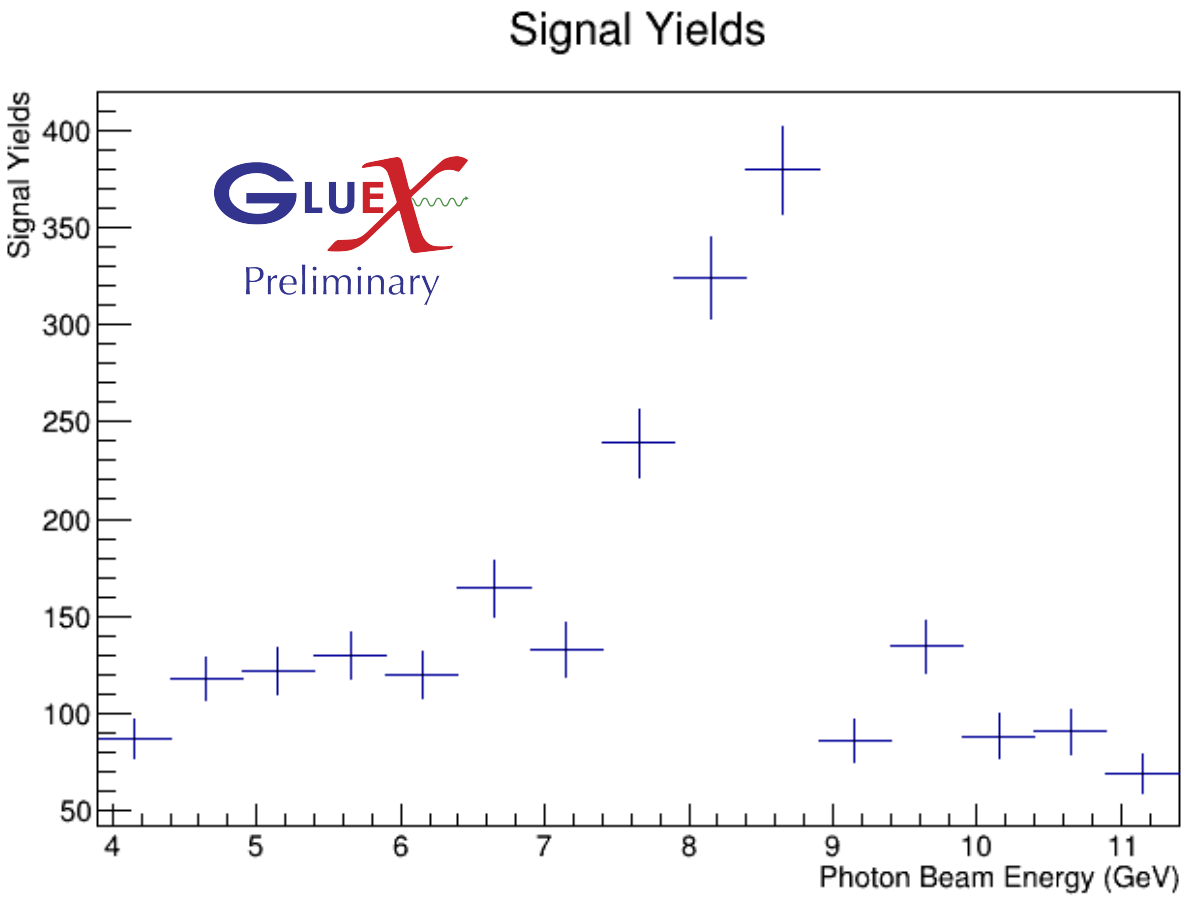
$\Xi^-(1320)$ at GlueX

- $\sim$ 20% of GlueX Phase-I
- Kinematic fitter constrains 4-momentum, vertices, and Λ mass



Ingredients for $\Xi^-(1320)$ Cross Section

$$\sigma = \frac{\mathbf{N}}{Target * Flux * BR * \epsilon}$$



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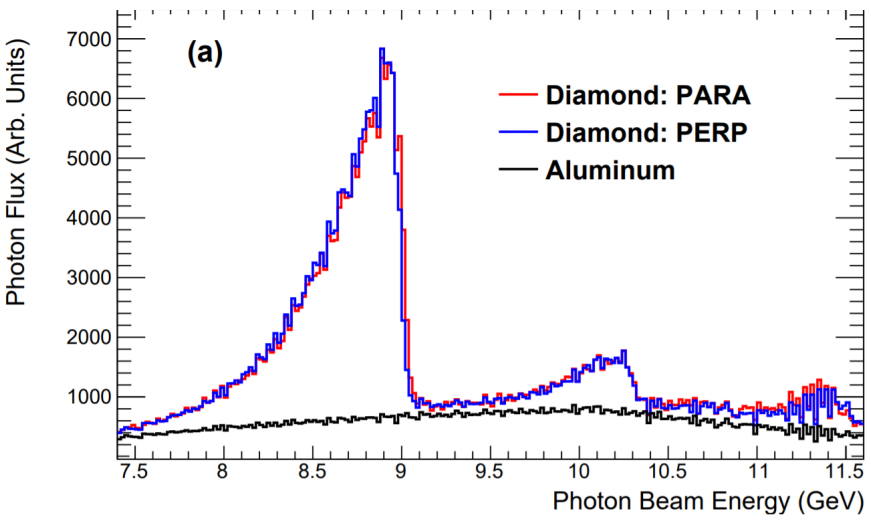

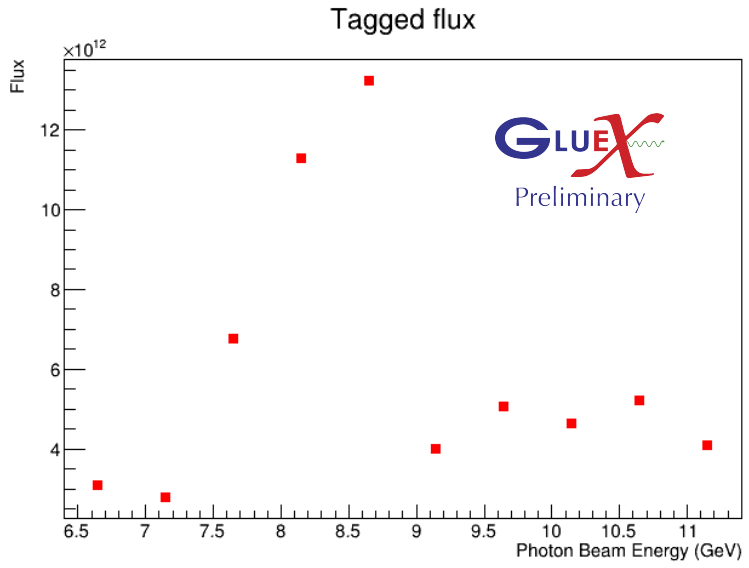

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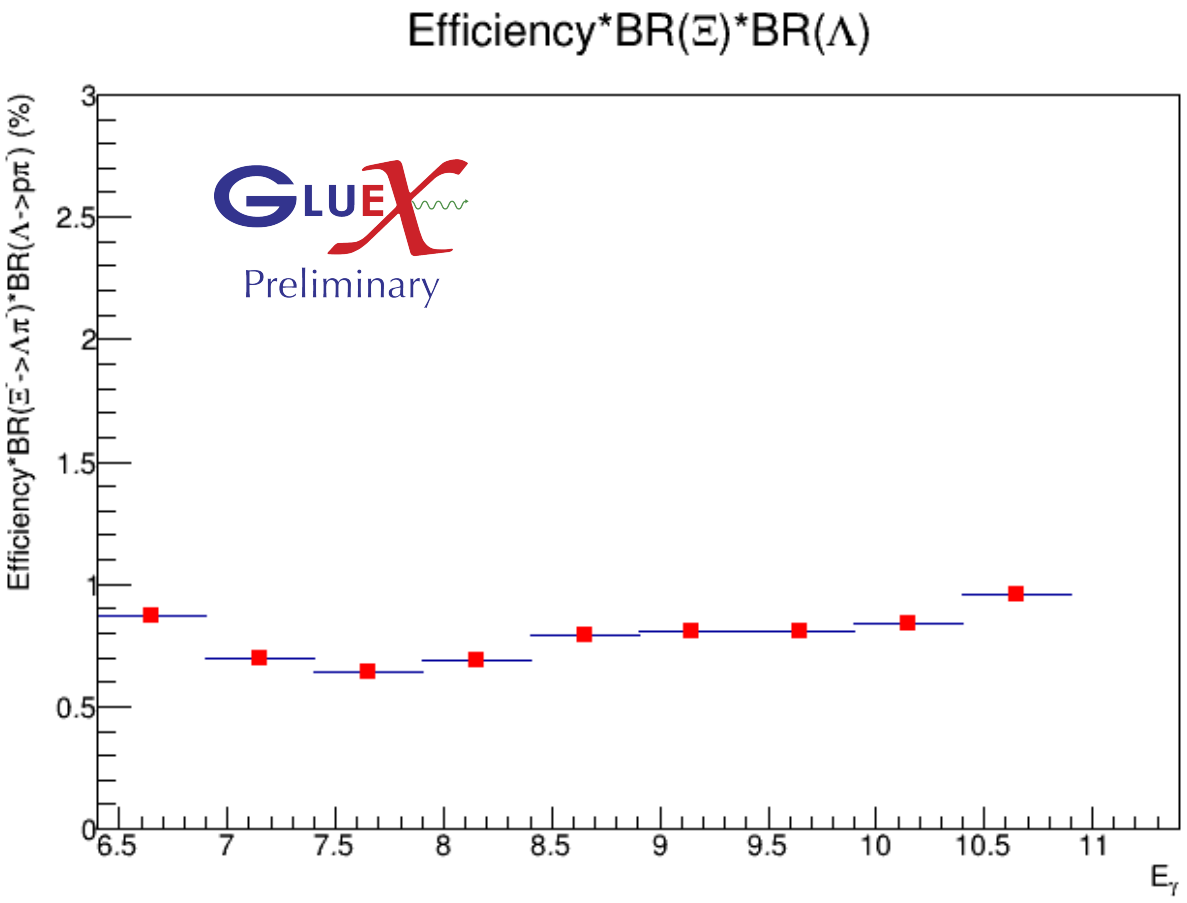
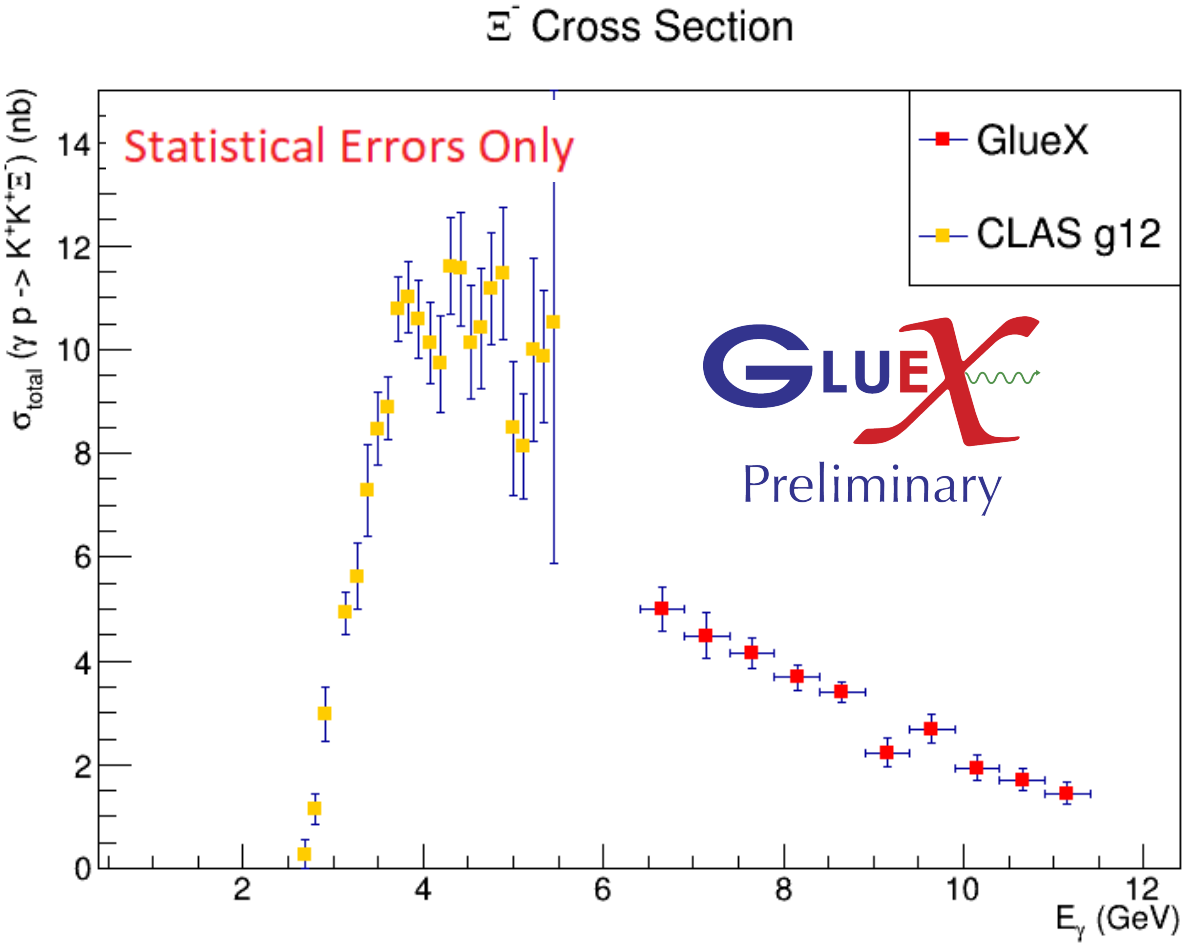
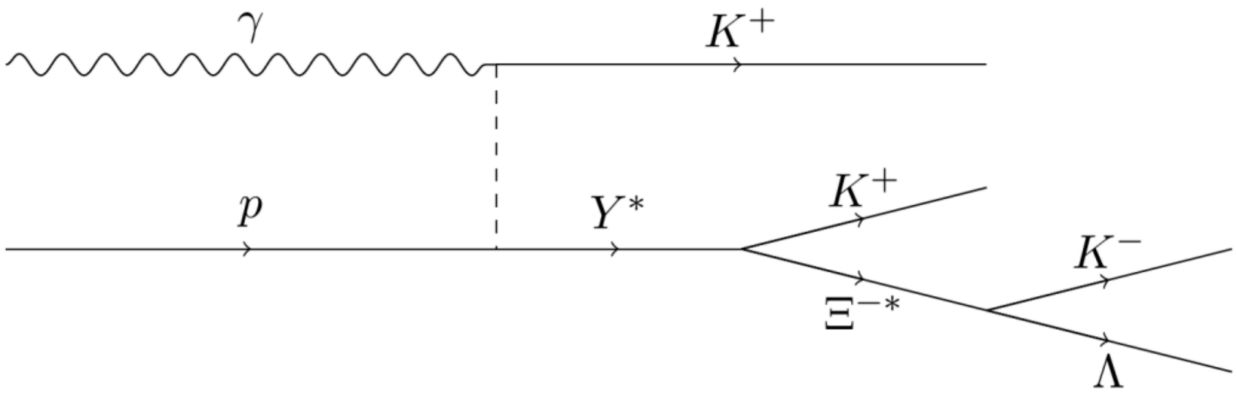


$\Xi^-(1320)$ Cross Section at GlueX



CLAS: J. T. Goetz et al. Phys. Rev. C 98, 062201 (2018)

Search for Excited Cascade Baryons, Ξ^*



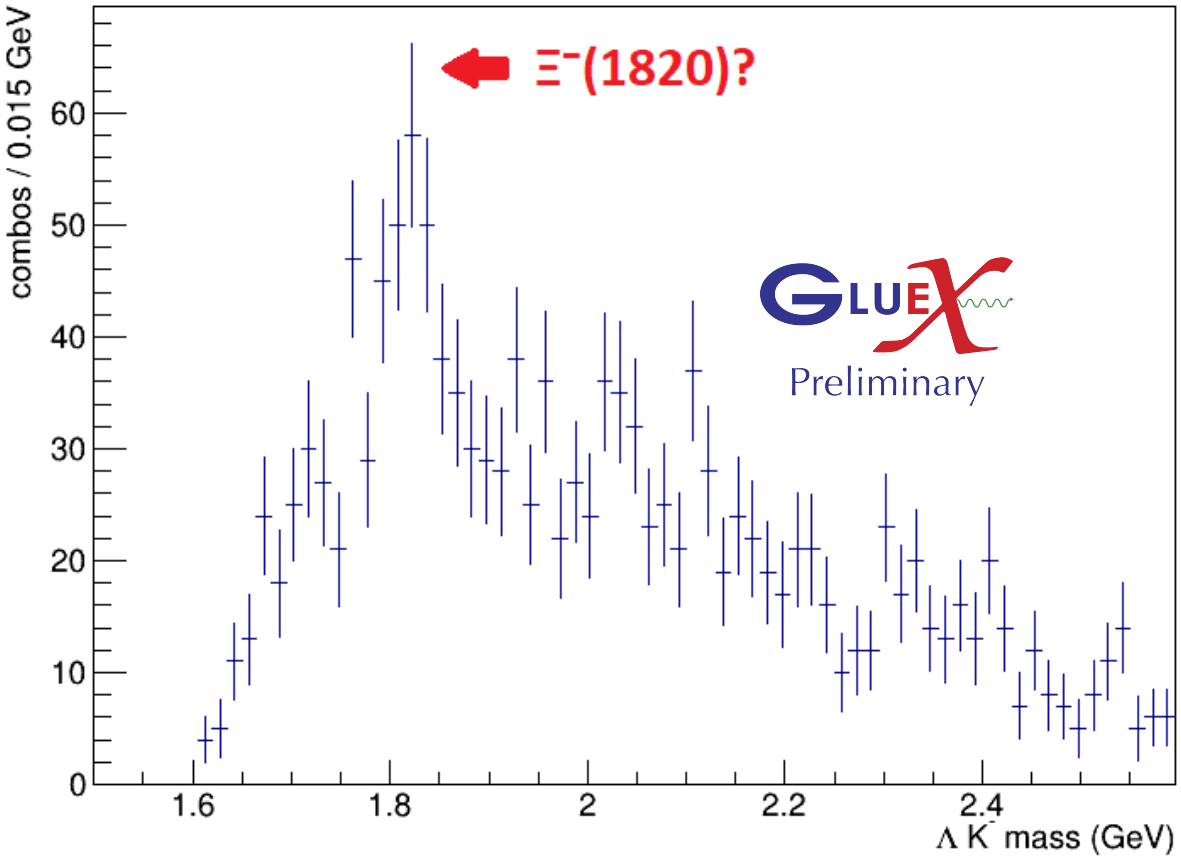
- $\gamma p \to K^+ K^+ K^- \Lambda$
- Kaon decays expected to be narrow

Decay	
Ξ^-	$\to \Lambda\pi^-$
Ξ^*	$\to \Lambda K$
	$\to \Sigma K$
	$\to \Xi\pi$
	$\to \Xi(1530)\pi$
	$\to \Xi\pi\pi$
	$\to \Lambda K\pi$
	$\to \Sigma K\pi$

Possible Resonances		BR
$\to \Lambda K$	$\Xi(1690)$	seen
	$\Xi(1820)$	large
	$\Xi(1950)$	seen
	$\Xi(2030)$	~ 0.2
	$\Xi(2120)$	seen

Search for Excited Cascade Baryons, Ξ^*

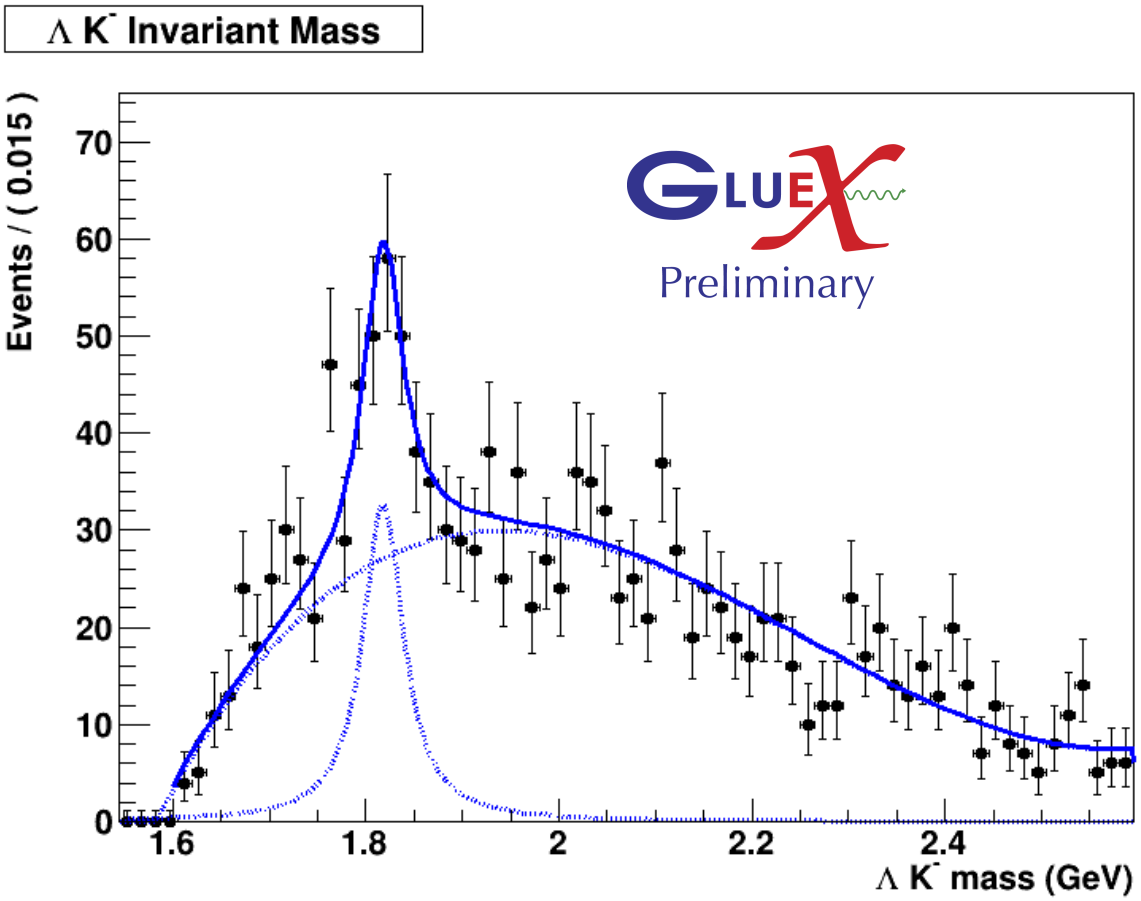
- Significant background from $\gamma p \to K^+ \phi \Lambda$
- $\Xi^-(1820)$ signal has a significance of $< 5\sigma$



Search for Excited Cascade Baryons, Ξ^*

- Significant background from $\gamma p \to K^+ \phi \Lambda$
- $\Xi^-(1820)$ signal has a significance of $< 5\sigma$

  $\Longrightarrow$ need more data

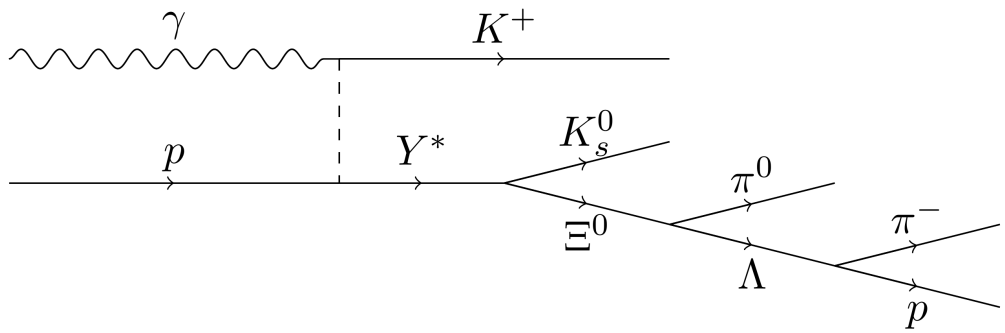


Outlook for Ξ Spectroscopy: GlueX-I

Future work:

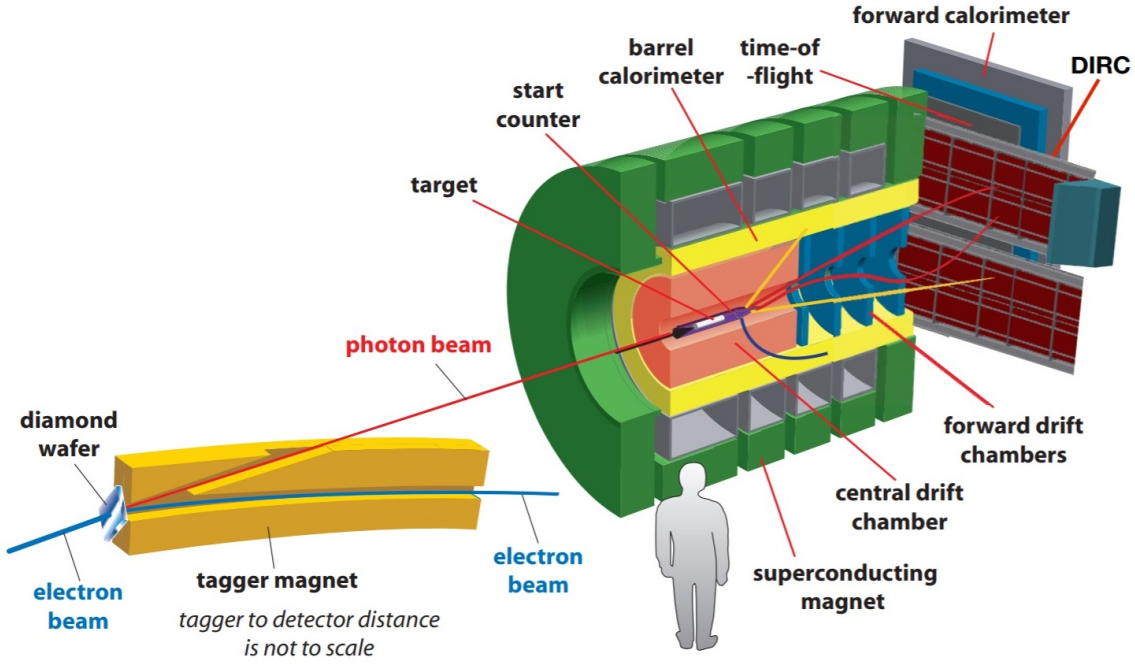
- J measurement and isospin mass splitting
- Beam asymmetry Σ for the intermediate hyperon $\gamma p \to K^+ Y^*_\Xi$
- Similar analysis for neutral ground state $\gamma p \to K^+ K^0_s \Xi^0(1320)$
- Search for excited states

	Decay
Ξ^-	$\to \Lambda\pi^-$
Ξ^*	$\to \Lambda K$
	$\to \Sigma K$
	$\to \Xi\pi$
	$\to \Xi(1530)\pi$
	$\to \Xi\pi\pi$
	$\to \Lambda K\pi$
	$\to \Sigma K\pi$



Outlook for Hyperon Spectroscopy: GlueX-II

- Higher beam intensities.
- DIRC will improve π/K separation.
- Many other strangeness channels are being analyzed.



Summary

- A clean signal for $\Xi^-(1320)$ is seen.
- Preliminary total cross section results are shown with only statistical errors.
- Exclusivity and linear beam polarization give access to new measurements.
- Search for excited Ξ's is ongoing.
- Establishes a firm basis for a Cascade baryon program.
- GlueX Phase-II will improve statistics and event selection.
- GlueX has potential for robust strangeness program.

Thank you!

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