

Peter Pauli Hurck, on behalf of the GlueX collaboration

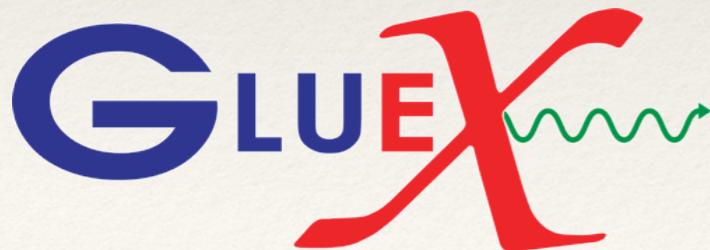
19th Oct, 2022

Overview of strangeness photoproduction studies at GlueX



University
of Glasgow

NSTAR 2022 - *The 13th International Workshop on the Physics of Excited Nucleons*
Parallel 3: Hyperon production with electromagnetic probes

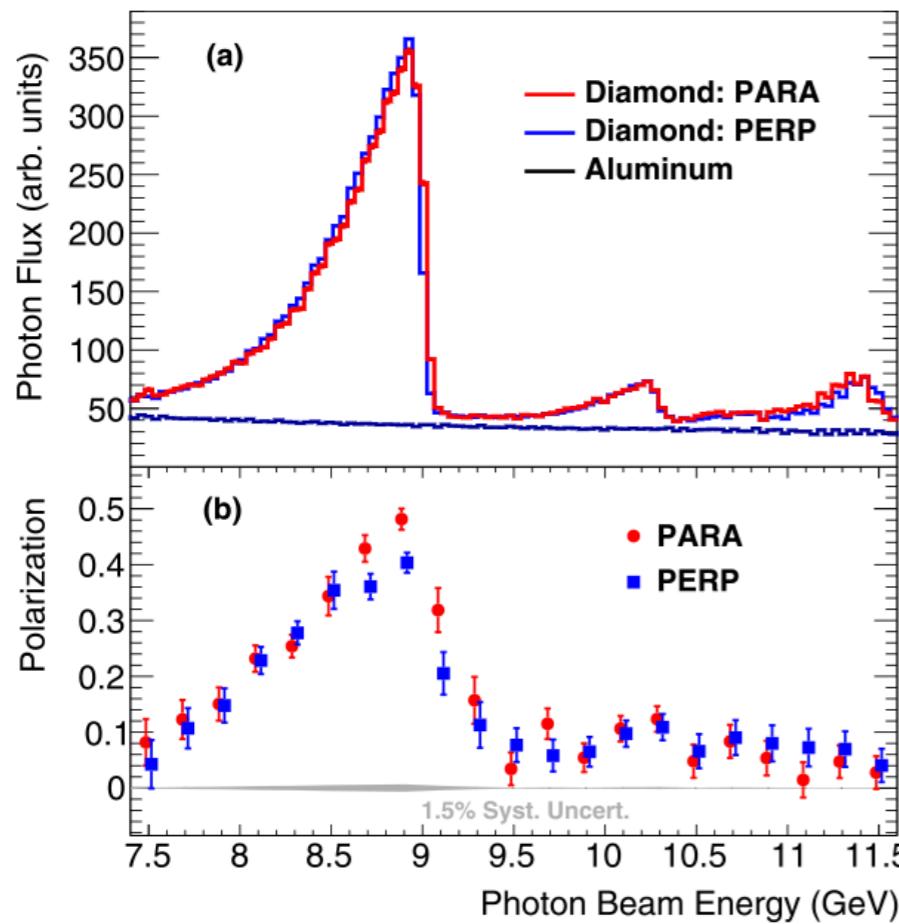


CEBAF at Jefferson Lab



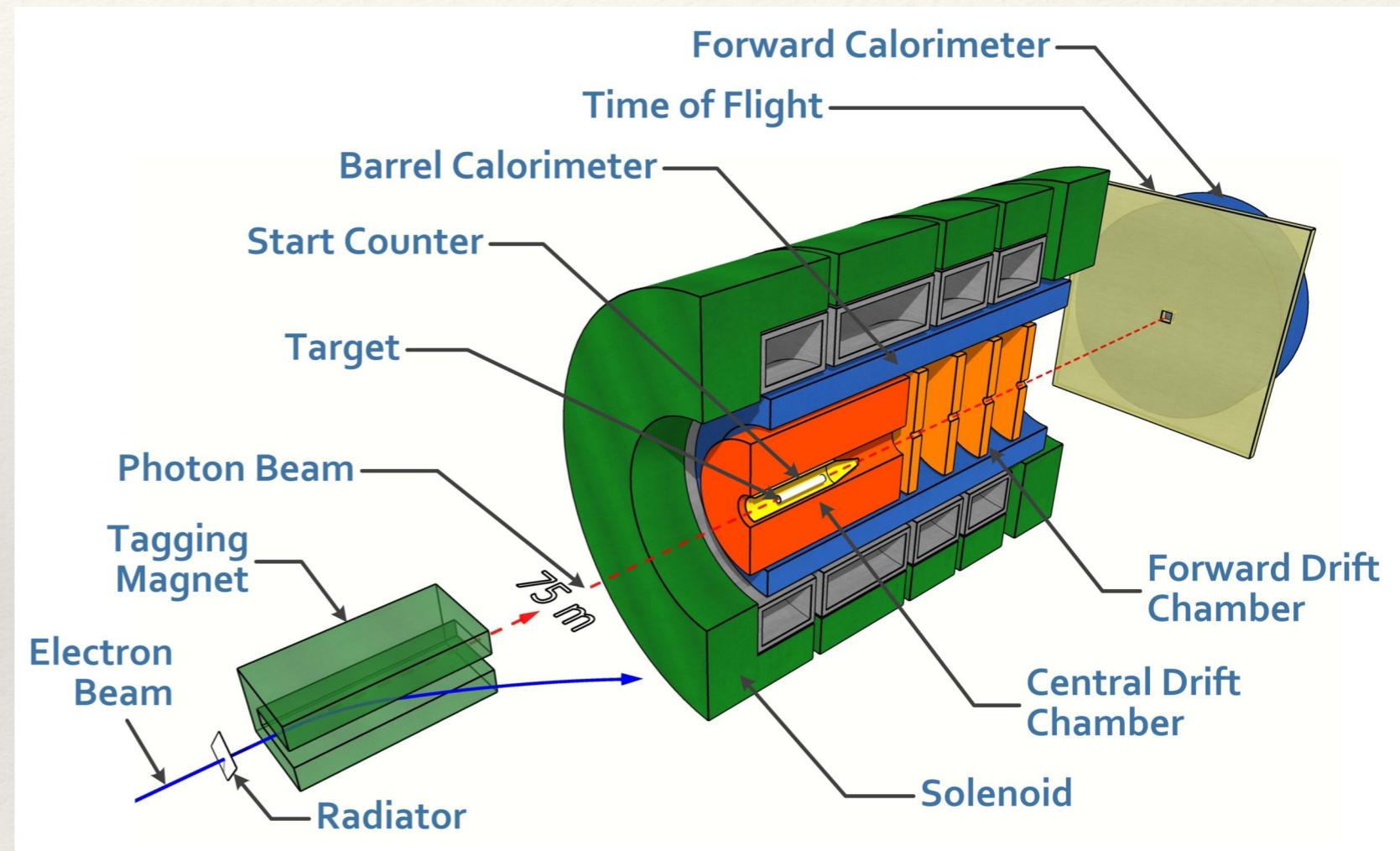
GlueX experiment in Hall D

Nucl. Instrum. & Meth. A987, 164807 (2021)



GlueX, Nucl. Instrum. Meth. A 987 (2021) 164807

- ❖ produce linearly polarized photon beam via coherent bremsstrahlung on thin diamond
- ❖ tag electrons to determine photon energy
- ❖ Acceptance: $\theta_{lab} \approx 1^\circ - 120^\circ$
- ❖ Charged particles: $\sigma_p/p \approx 1\% - 3\%$ ($8\% - 9\%$ very-forward high-momentum tracks)
- ❖ Photons: $\sigma_E/E = 6\%/\sqrt{E} \oplus 2\%$



Lambda - anti-Lambda

Hao Li (MENU 2019)

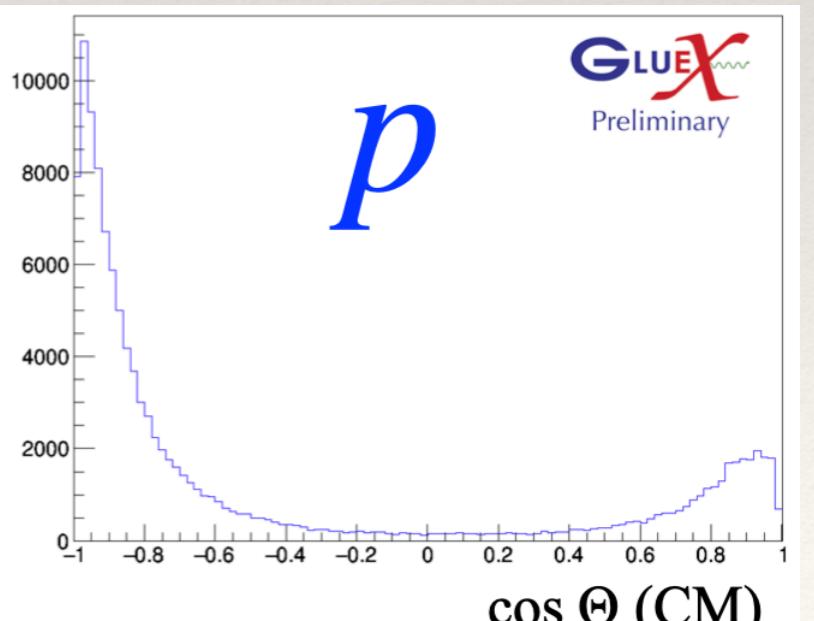
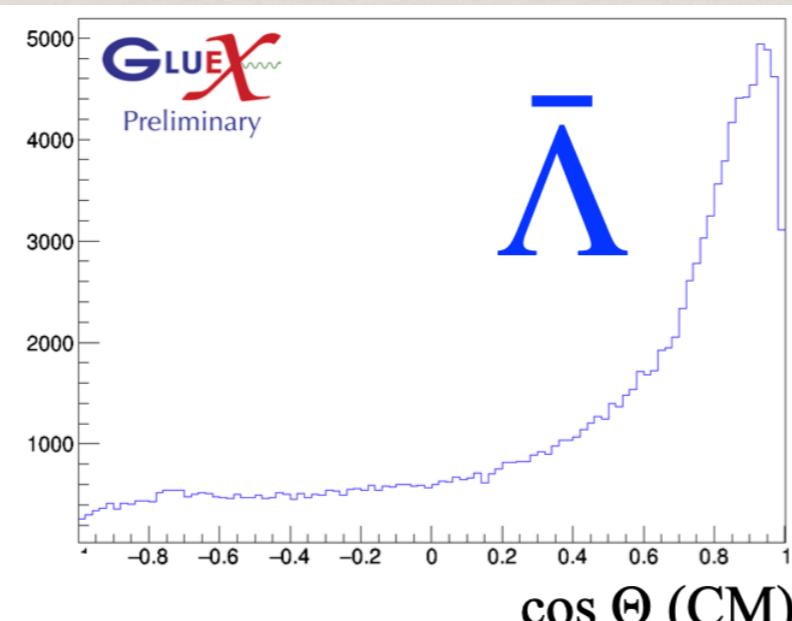
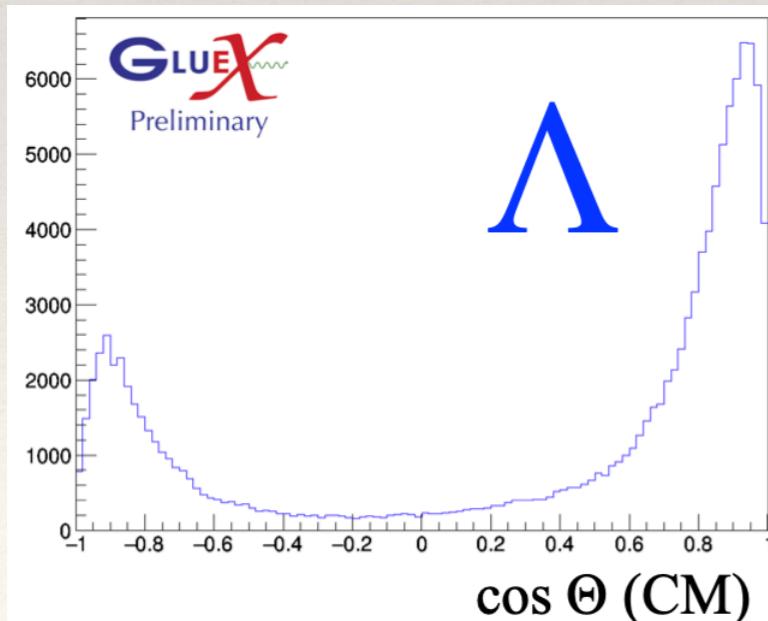
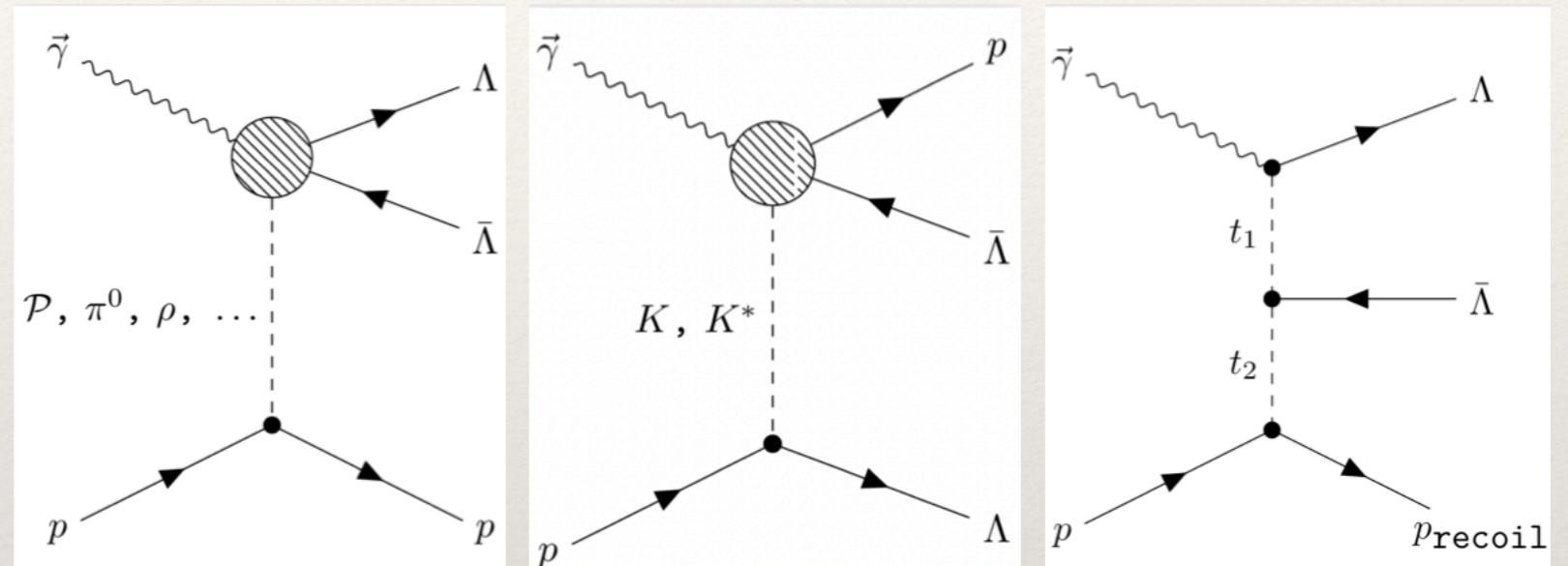
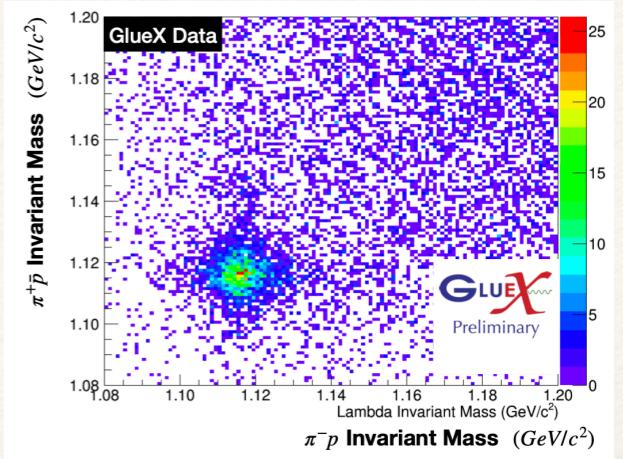
- ❖ BESIII saw interesting threshold enhancement

$$\gamma p \rightarrow p\Lambda\bar{\Lambda} \quad (\rightarrow p\{p\pi^-\}\{\bar{p}\pi^+\})$$

- ❖ GlueX-I:

~400k $\Lambda\bar{\Lambda}$
events

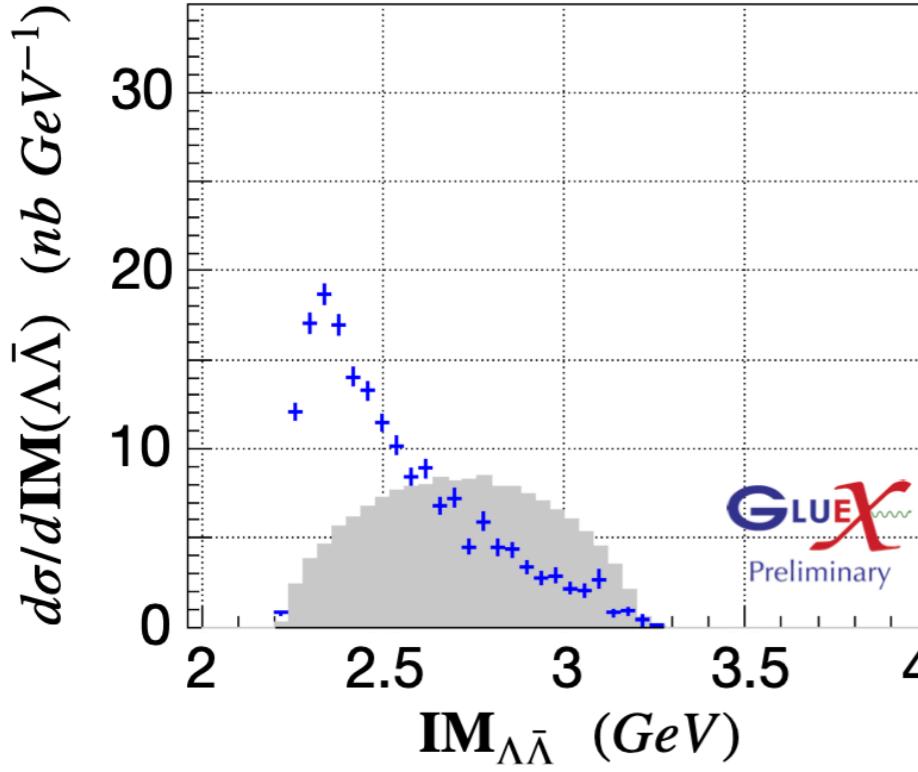
- ❖ Production mechanism
and cross-section
measurements



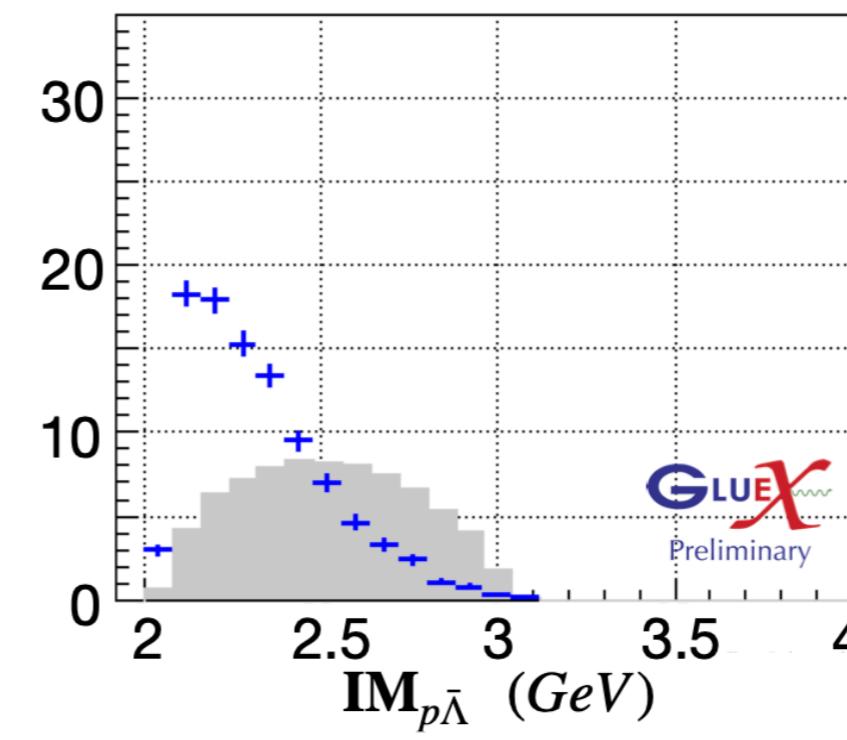
Lambda - anti-Lambda

Hao Li (APS DNP 2021)

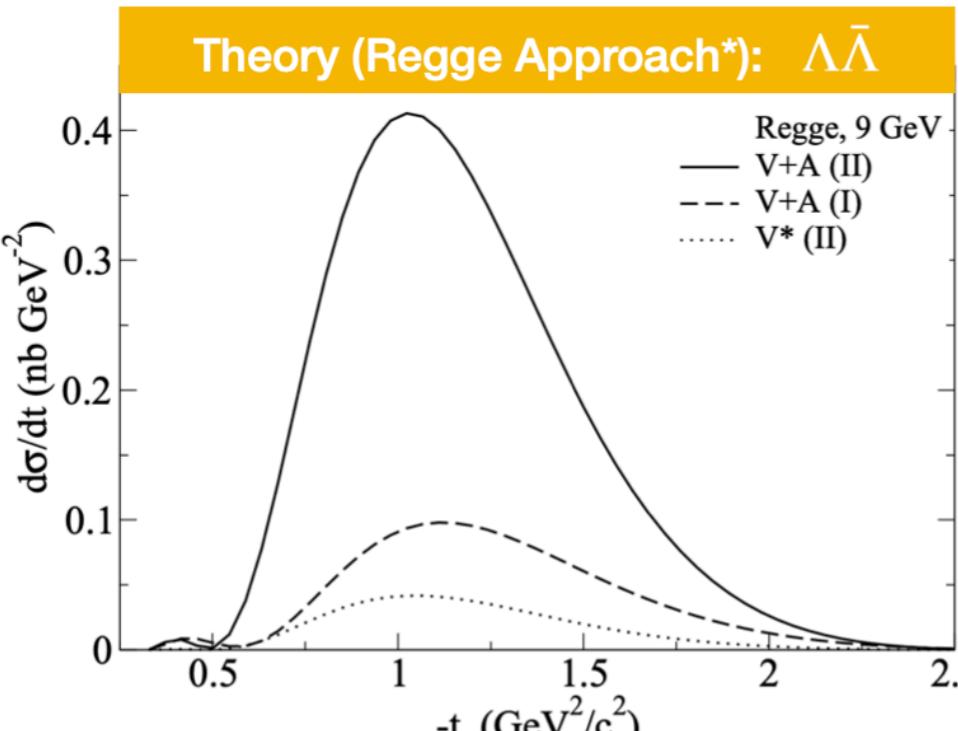
$\Lambda\bar{\Lambda}$ - system



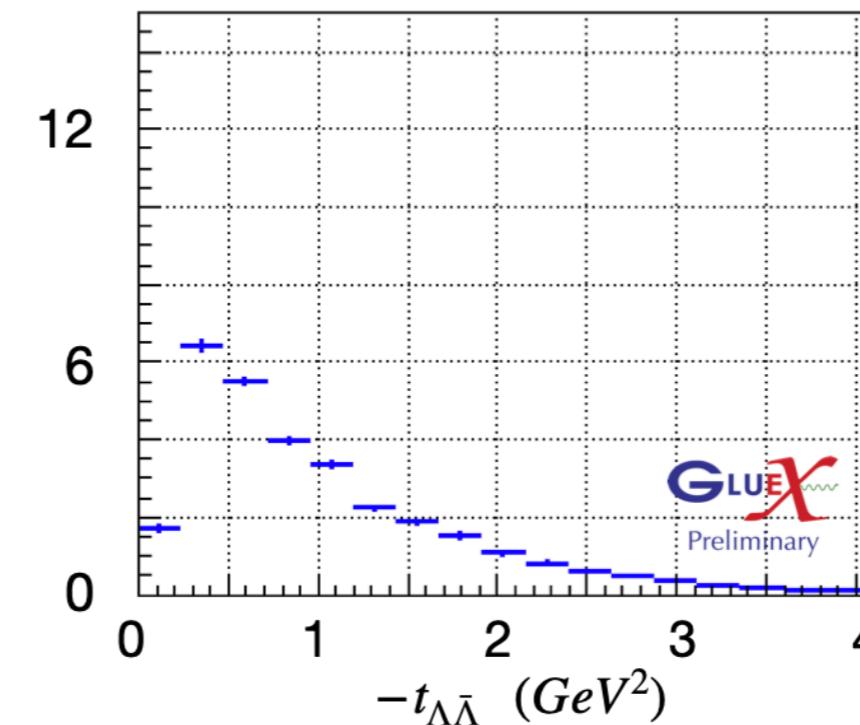
$p\bar{\Lambda}$ - system



Theory (Regge Approach*): $\Lambda\bar{\Lambda}$



GlueX Data: $\Lambda\bar{\Lambda}$

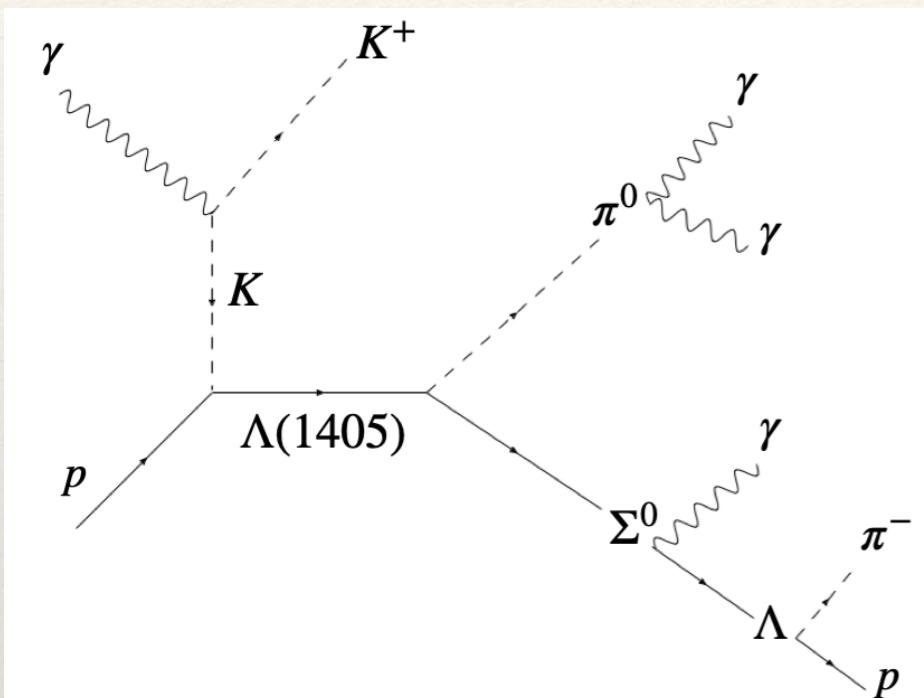


- ❖ measure beam asymmetry Σ
- ❖ Investigate threshold enhancement
- ❖ Study Λ polarization

*Gutsche, Thomas, et al. Physical Review D 96(5) (2017) 054024.

$\Lambda(1405)$ line shape measurement

N. Wickramaarachchi
(HYP2022)

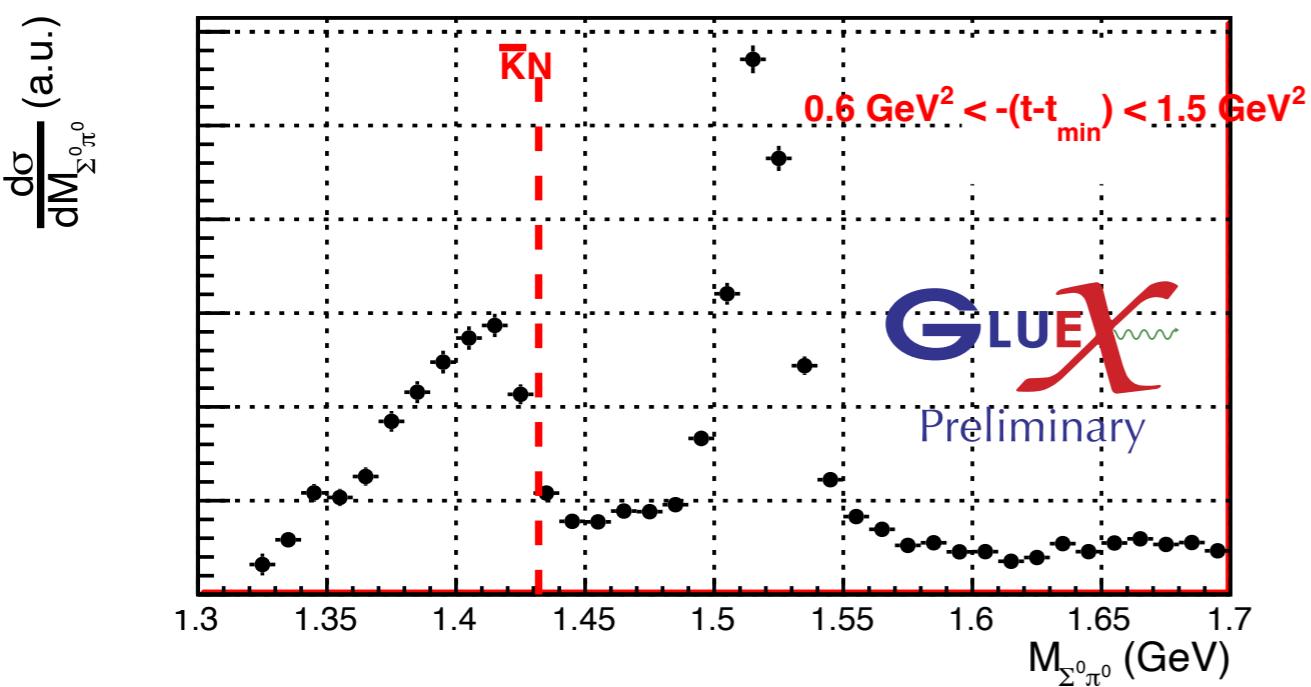
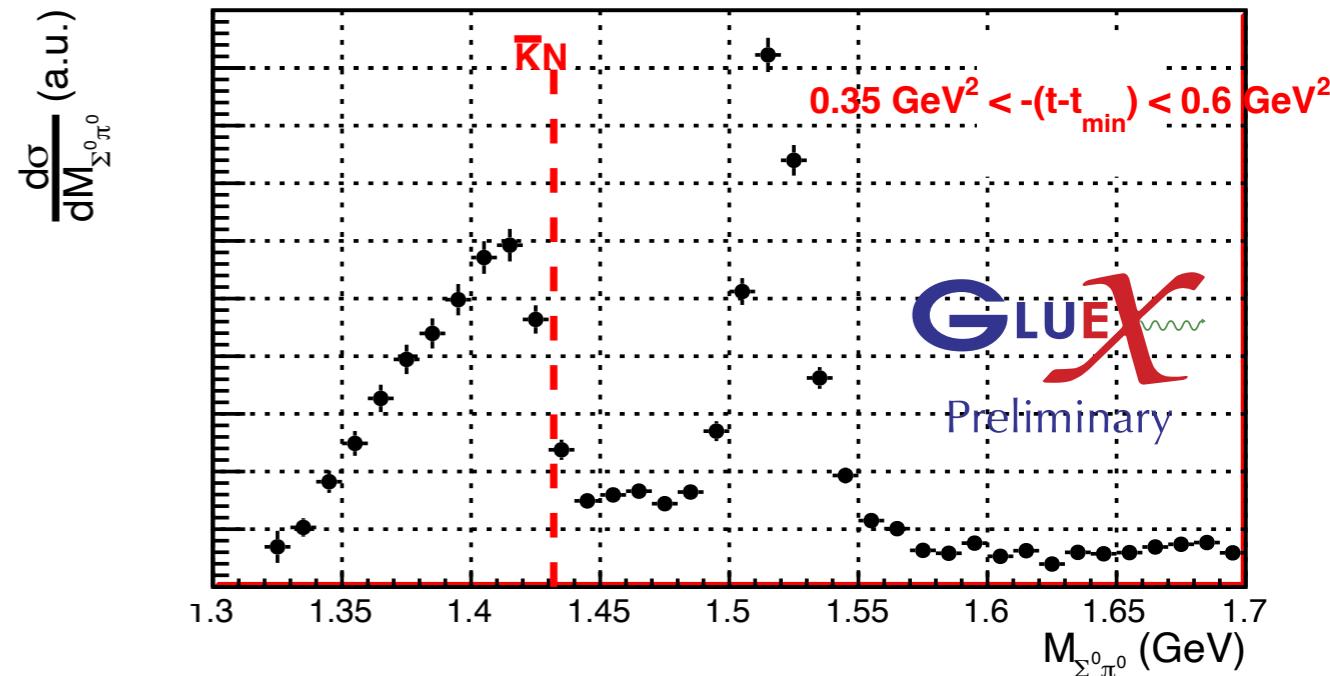
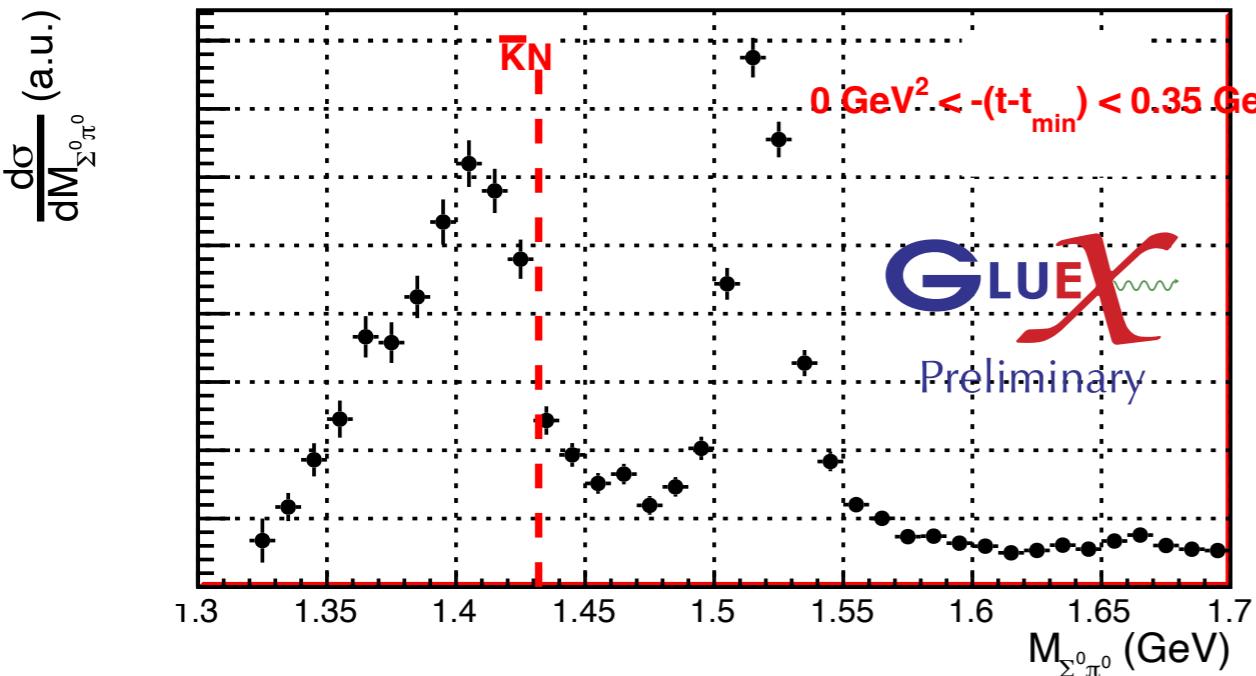


$\Lambda(1405) \rightarrow \Sigma^0\pi^0$ ($I = 0$) is free from $\Sigma(1385)$ background

- ❖ Excited Λ with $J^P = \frac{1}{2}^-$
- ❖ $\Lambda(1405) \rightarrow \Sigma\pi$
- ❖ Previous measurements (e.g. COSY-Jülich or CLAS) show very clear non-Breit-Wigner line shape
- ❖ Interpretation under active investigation
- ❖ Many theory models find two-pole structure:
not just one state
- ❖ Recent PDG addition: $^{**}\Lambda(1380)$

$\Lambda(1405)$ line shape measurement

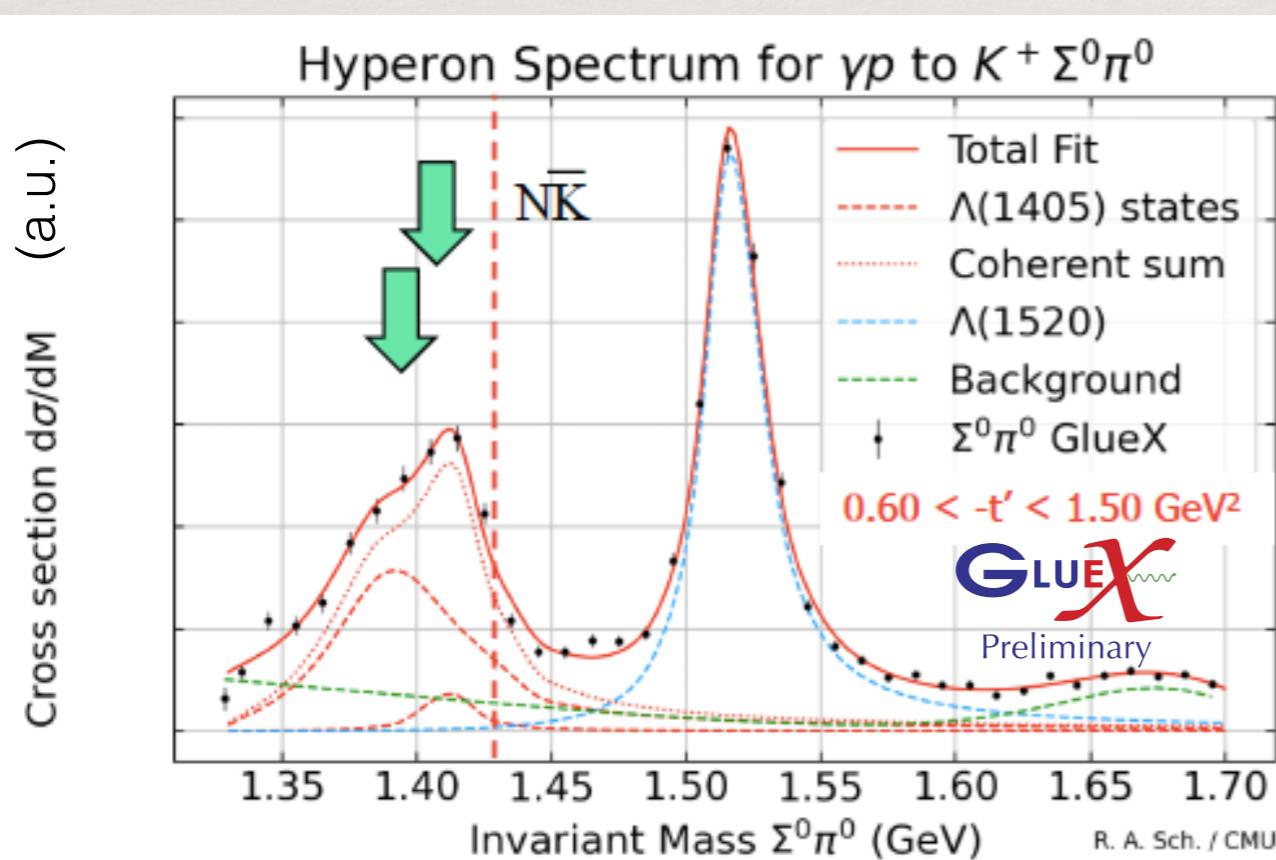
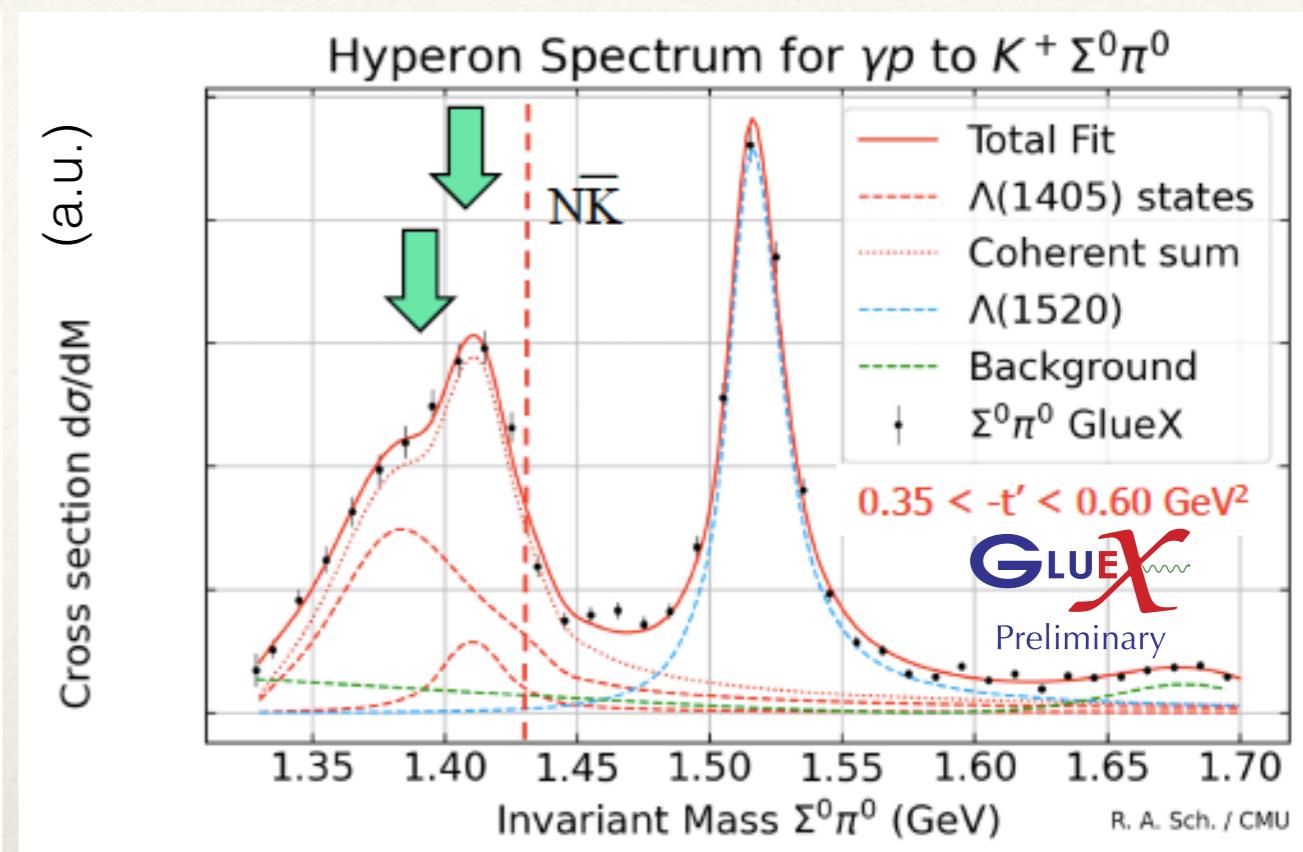
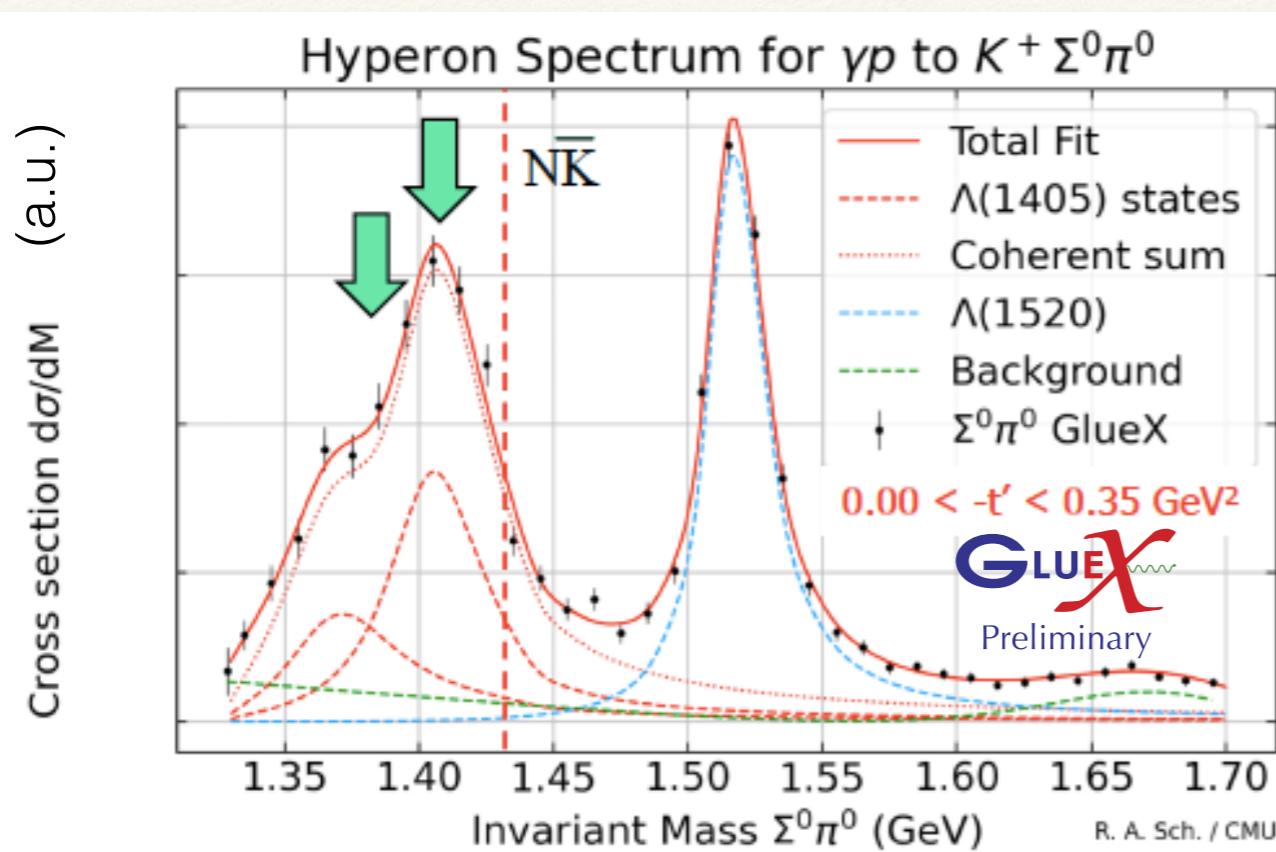
N. Wickramaarachchi
(HYP2022)



- ❖ $\Lambda(1405)$ t-dependent line shape?
- ❖ Could support two-pole structure

$\Lambda(1405)$ line shape measurement

N. Wickramaarachchi
(HYP2022)

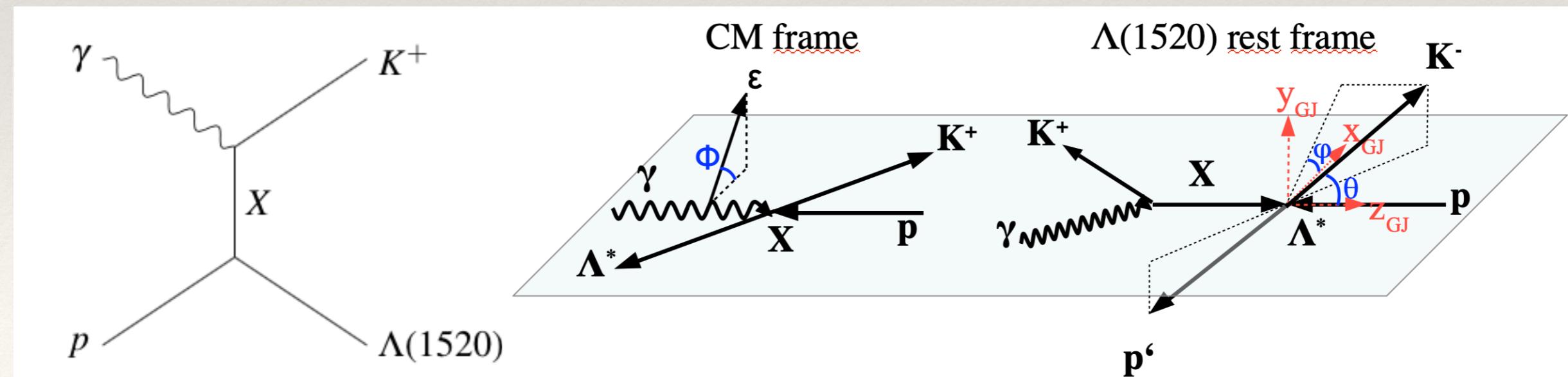
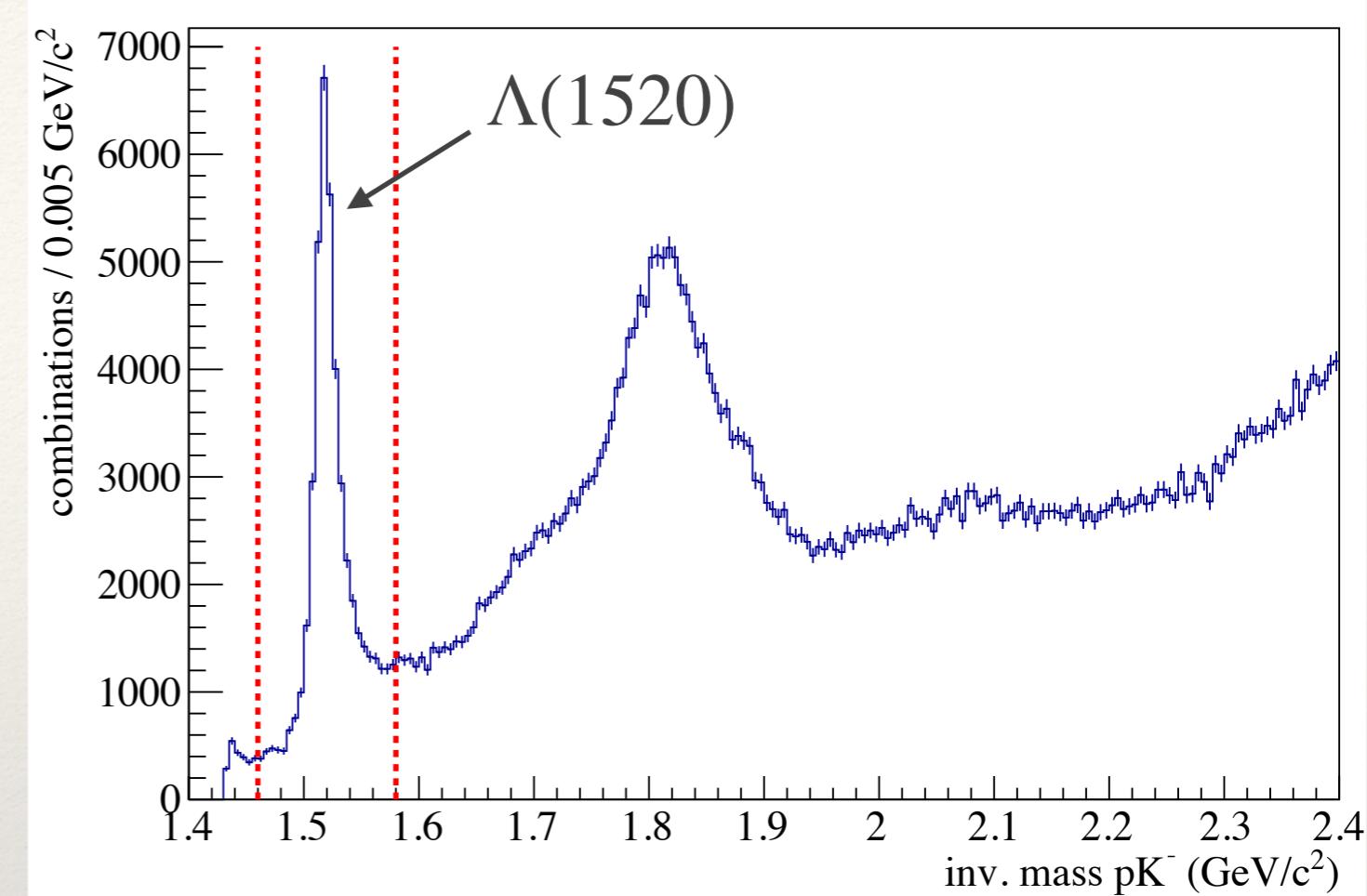


- ❖ Fit of two coherent Flatté amplitudes, incoherent $\Lambda(1520)$ and backgrounds
- ❖ Preliminary fit results support two-pole structure

$\Lambda(1520)$ SDMEs

PH (Phys. Rev. C 105, 035201)

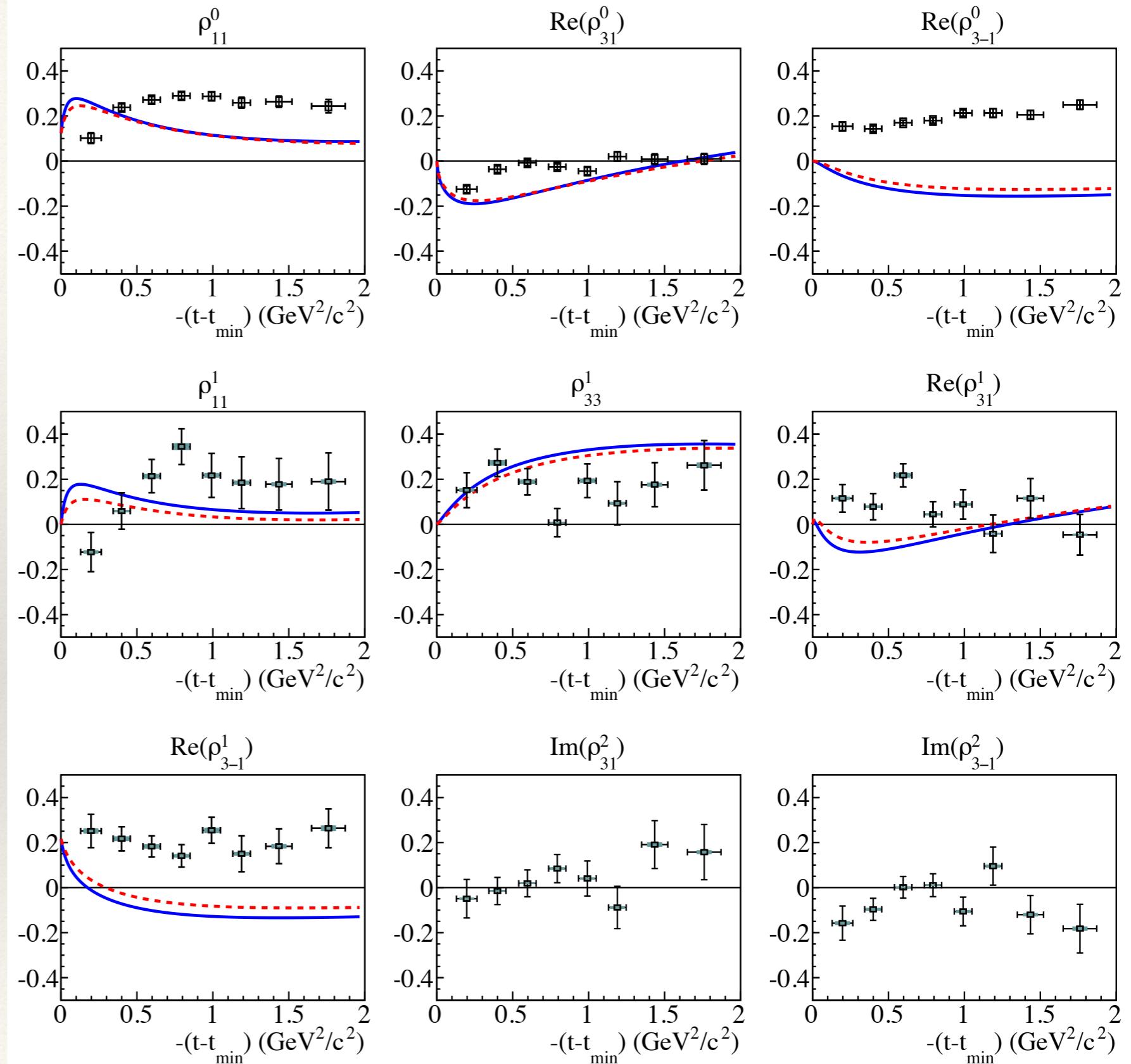
- ❖ Excited Λ hyperon with $J^P = \frac{3}{2}^-$
- ❖ $\Lambda(1520) \rightarrow K^- p$
- ❖ different mechanism compared to $\Lambda\bar{\Lambda}$
- ❖ Study in Gottfried-Jackson frame



$\Lambda(1520)$ SDMEs

PH (Phys. Rev. C **105**, 035201)

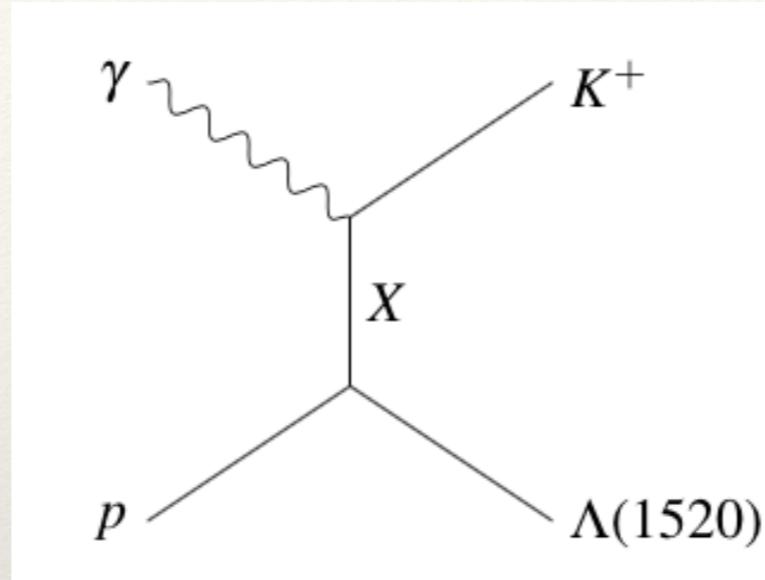
- ❖ So far, sparse data at high energies
- ❖ red and blue show model predictions in Reggeized framework (priv. comm. based on [1])
- ❖ these measurements constrain models in the future



$\Lambda(1520)$ SDME Interpretation

PH (Phys. Rev. C 105, 035201)

- ❖ to help with interpretation form combinations of SDMEs which correspond to purely natural (N) and purely unnatural (U) exchange amplitudes



X is exchange particle with spin-parity quantum number J^P and naturality $\eta = P(-1)^J$

Natural: e.g. $K^*(892)$, $K^*_2(1430)$

Unnatural: e.g. $K(492)$, $K_1(1270)$

$$\rho_{11}^0 + \rho_{11}^1 = \frac{2}{N}(|N_0|^2 + |N_1|^2)$$

$$\text{Re}(\rho_{31}^0 + \rho_{31}^1) = \frac{2}{N}(N_{-1}N_0^* - N_2N_1^*)$$

$$\rho_{11}^0 - \rho_{11}^1 = \frac{2}{N}(|U_0|^2 + |U_1|^2)$$

$$\text{Re}(\rho_{31}^0 - \rho_{31}^1) = \frac{2}{N}(U_{-1}U_0^* - U_2U_1^*)$$

$$\rho_{33}^0 + \rho_{33}^1 = \frac{2}{N}(|N_{-1}|^2 + |N_2|^2)$$

$$\text{Re}(\rho_{3-1}^0 + \rho_{3-1}^1) = \frac{2}{N}(N_{-1}N_1^* + N_2N_0^*)$$

$$\rho_{33}^0 - \rho_{33}^1 = \frac{2}{N}(|U_{-1}|^2 + |U_2|^2)$$

$$\text{Re}(\rho_{3-1}^0 - \rho_{3-1}^1) = \frac{2}{N}(U_{-1}U_1^* + U_2U_0^*)$$

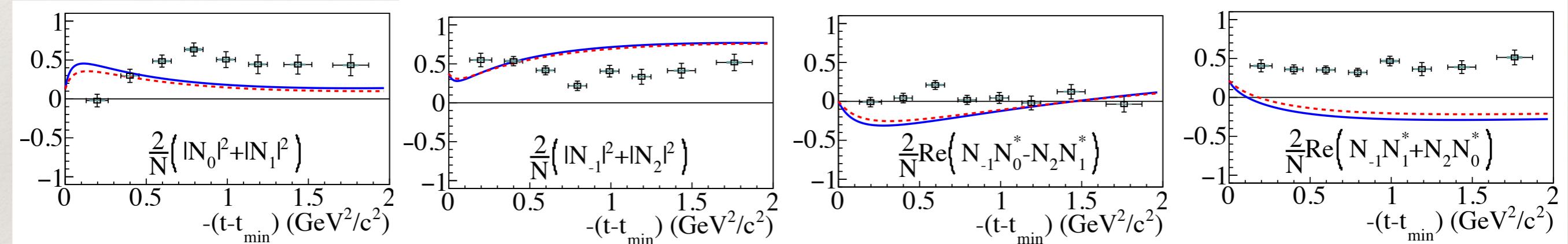
$$N = 2(|N_{-1}|^2 + |N_0|^2 + |N_1|^2 + |N_2|^2 + |U_{-1}|^2 + |U_0|^2 + |U_1|^2 + |U_2|^2)$$

$\Lambda(1520)$ SDME Interpretation

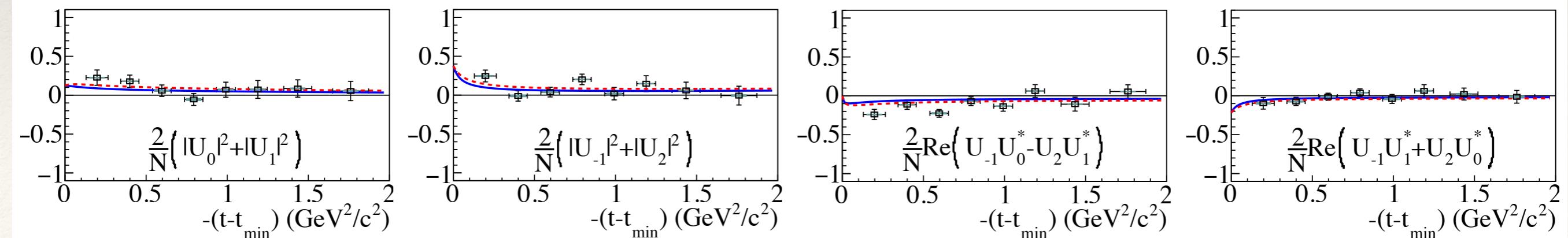
PH (Phys. Rev. C **105**, 035201)

- ❖ red and blue show combinations of previous model [1]
- ❖ natural amplitudes dominate
- ❖ More work needed to model the reaction accurately

Natural



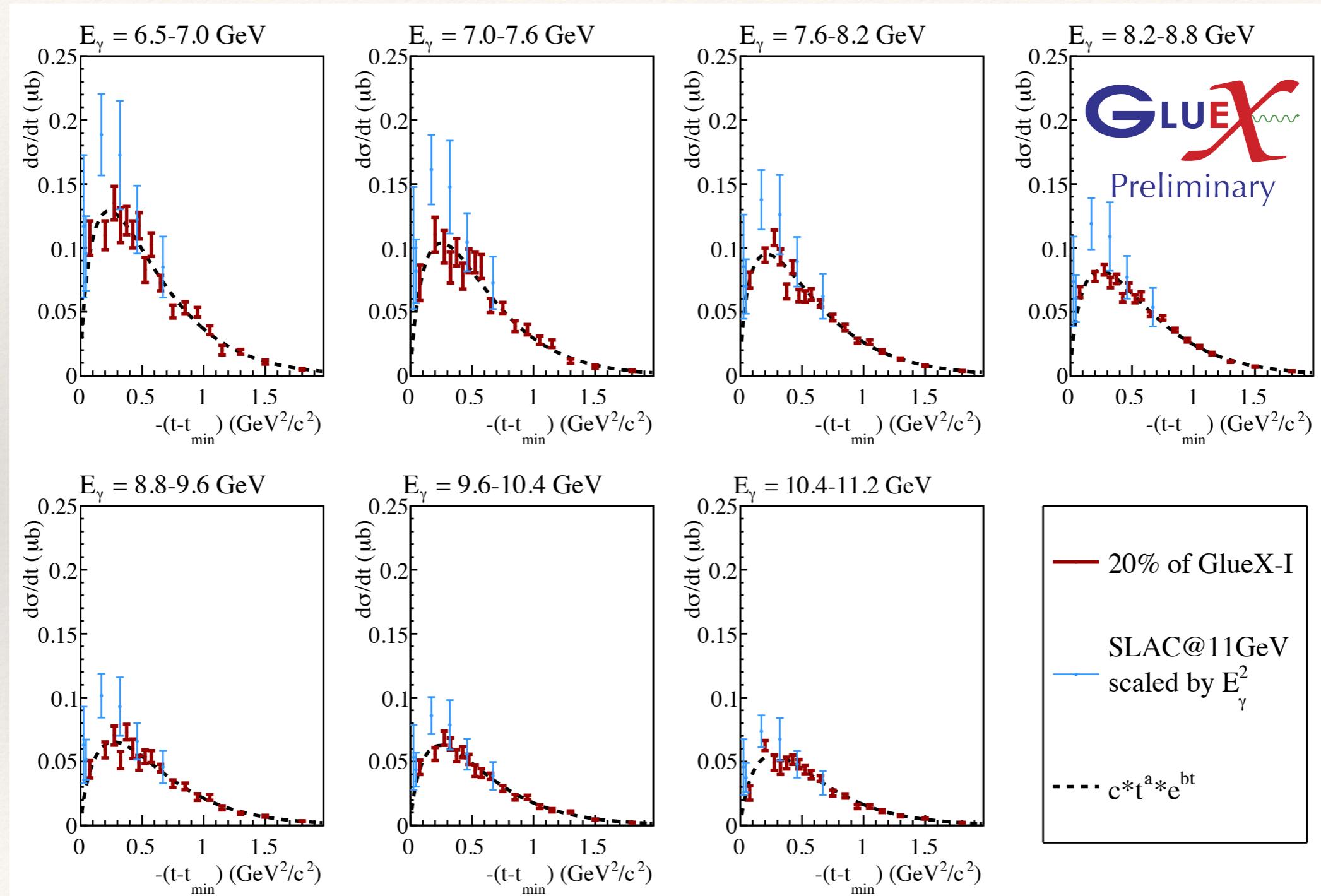
Unnatural



$\Lambda(1520)$ cross-sections

PH (HYP2022)

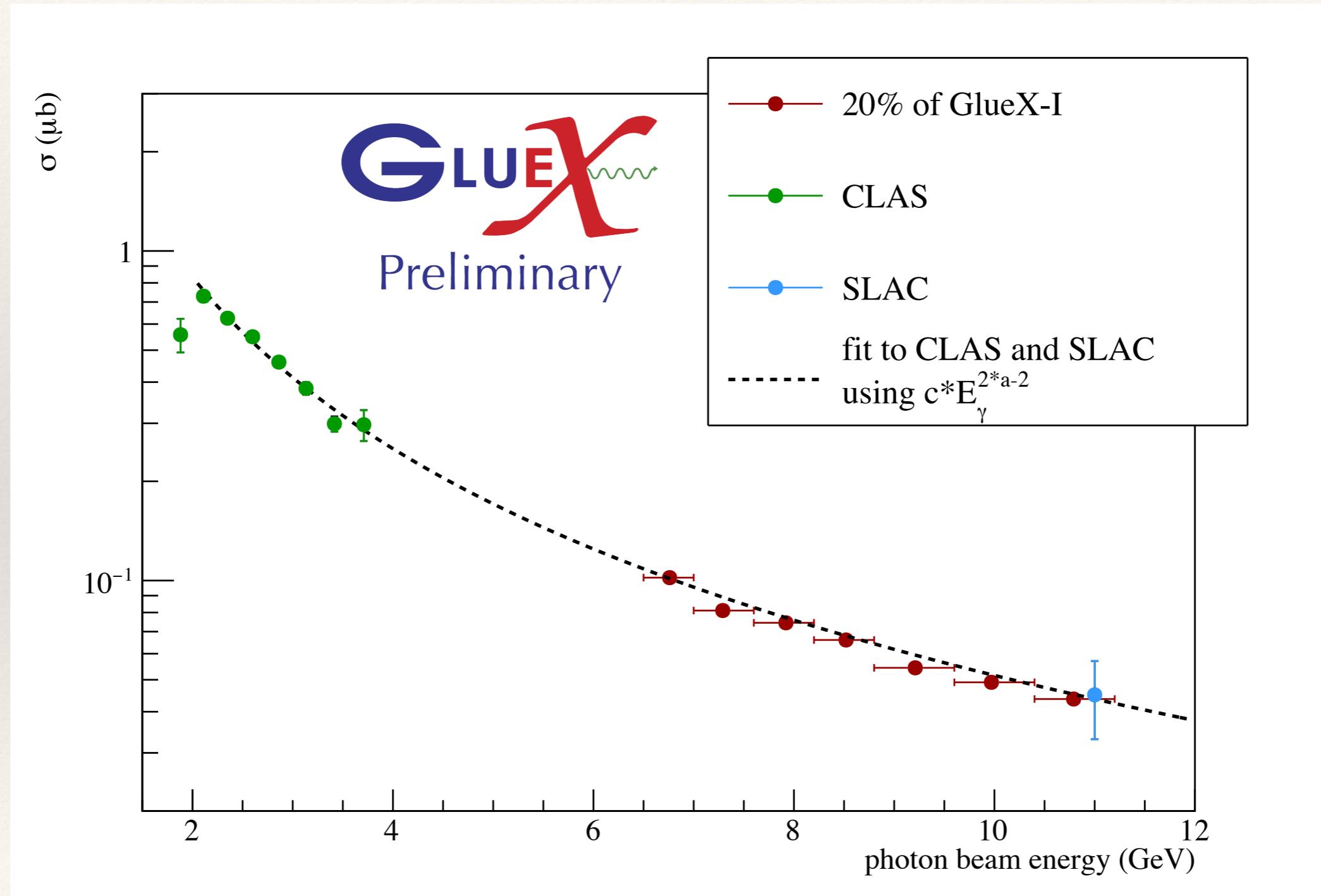
- ❖ To get full picture of production we need couplings: measure cross-sections
- ❖ Fit t-distribution and integrate to get “total cross-section”



$\Lambda(1520)$ cross-sections

PH (HYP2022)

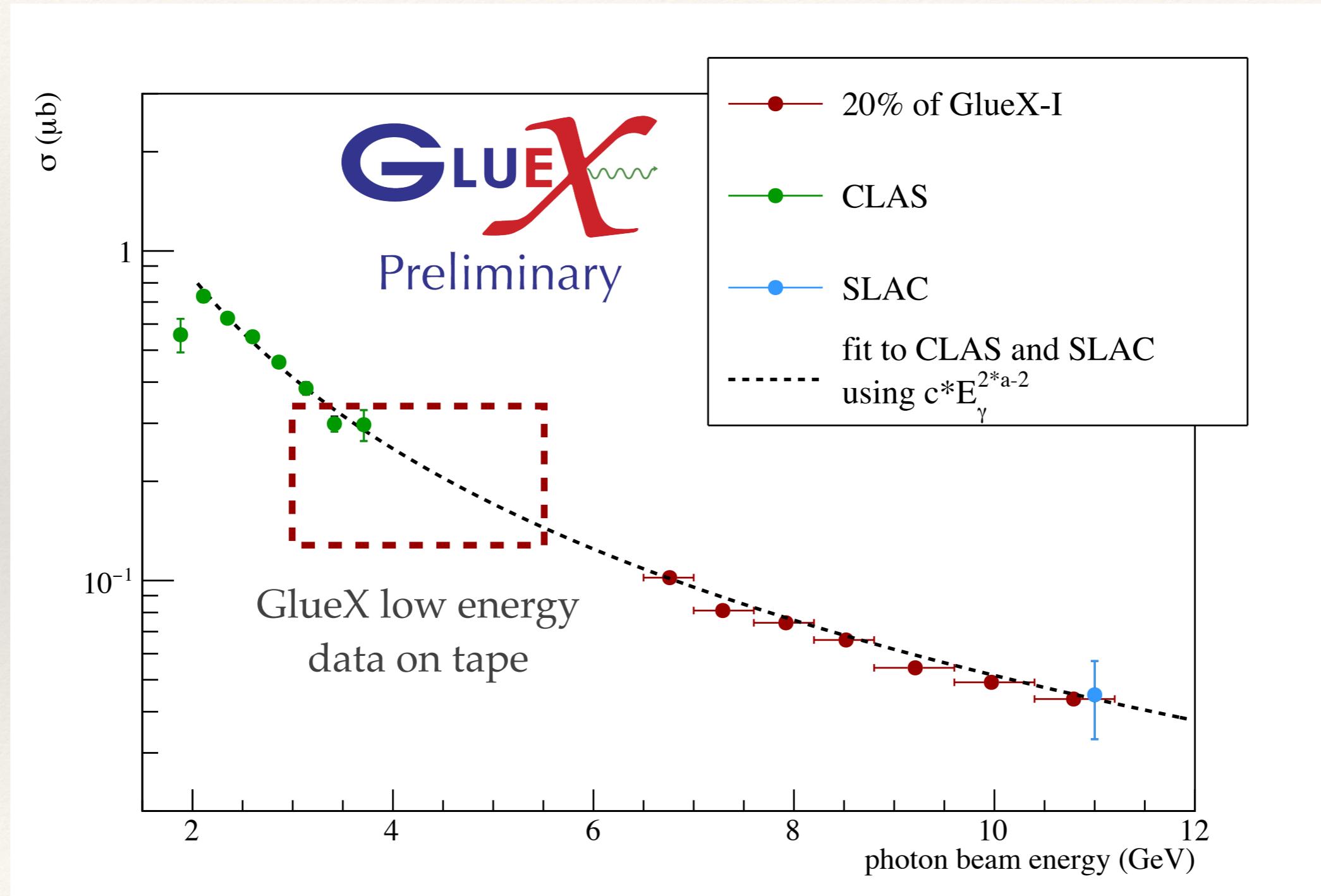
- ❖ Good agreement with previous data by SLAC
- ❖ More data on tape, including some with lower photon beam energy



$\Lambda(1520)$ cross-sections

PH (HYP2022)

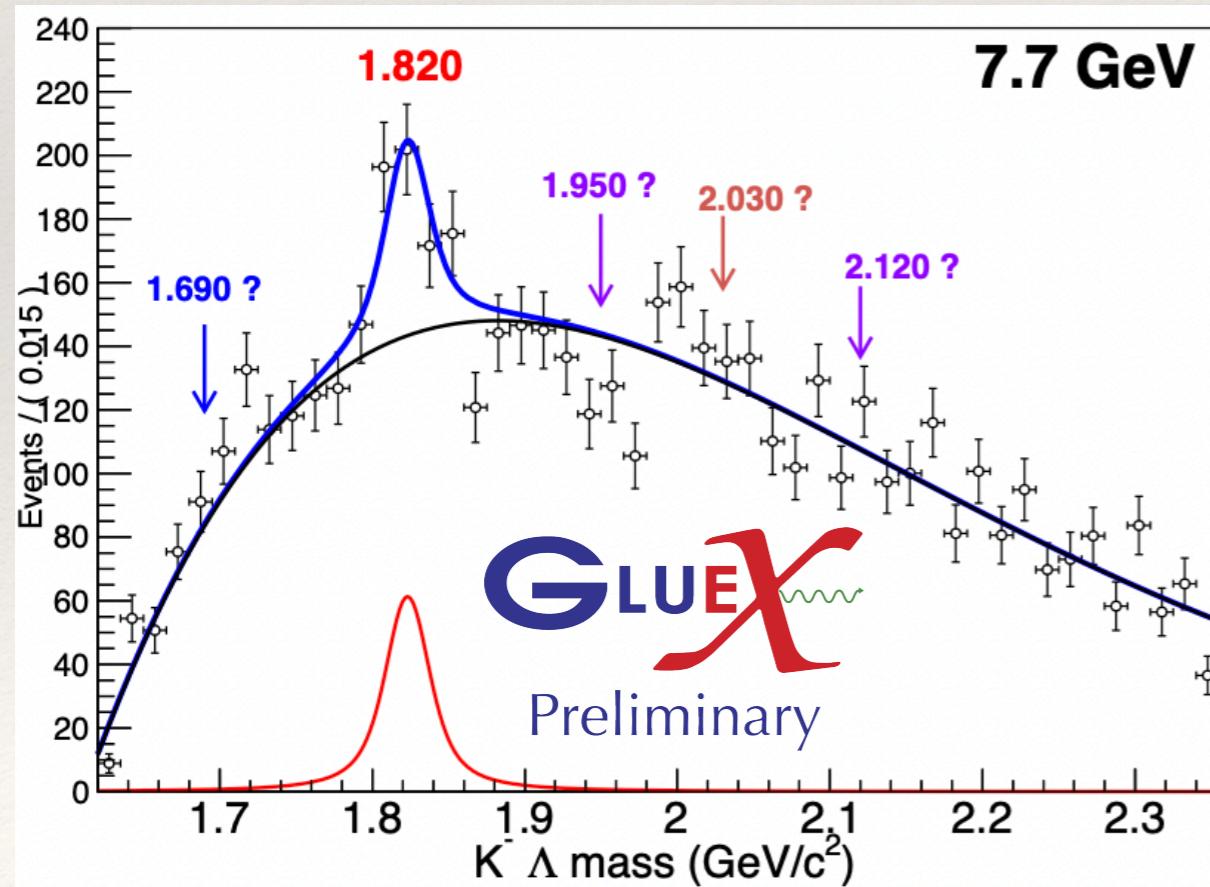
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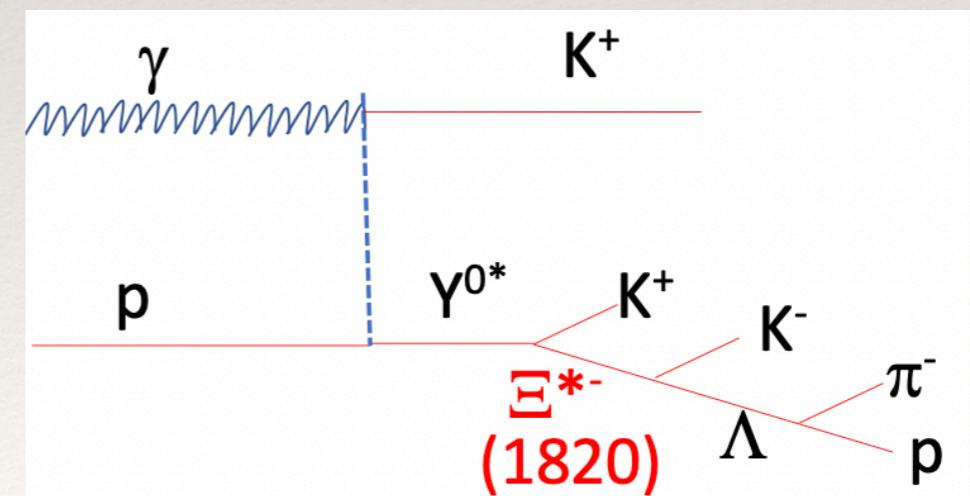
Cascades at GlueX

V. Crede (Wed 10:10)

Particle	J^P	Overall Status	– Status as seen in –			
			$\Xi\pi$	ΛK	ΣK	$\Xi(1530)\pi$
$\Xi(1318)$	$1/2^+$	****				
$\Xi(1530)$	$3/2^+$	****	****			
$\Xi(1620)$		*	*			
$\Xi(1690)$		***		***	**	
$\Xi(1820)$	$3/2^-$	***	**	***	**	**
$\Xi(1950)$		***	**	**		*
$\Xi(2030)$		***		**	***	
$\Xi(2120)$		*		*		
$\Xi(2250)$		**				
$\Xi(2370)$		**				
$\Xi(2500)$		*		*	*	

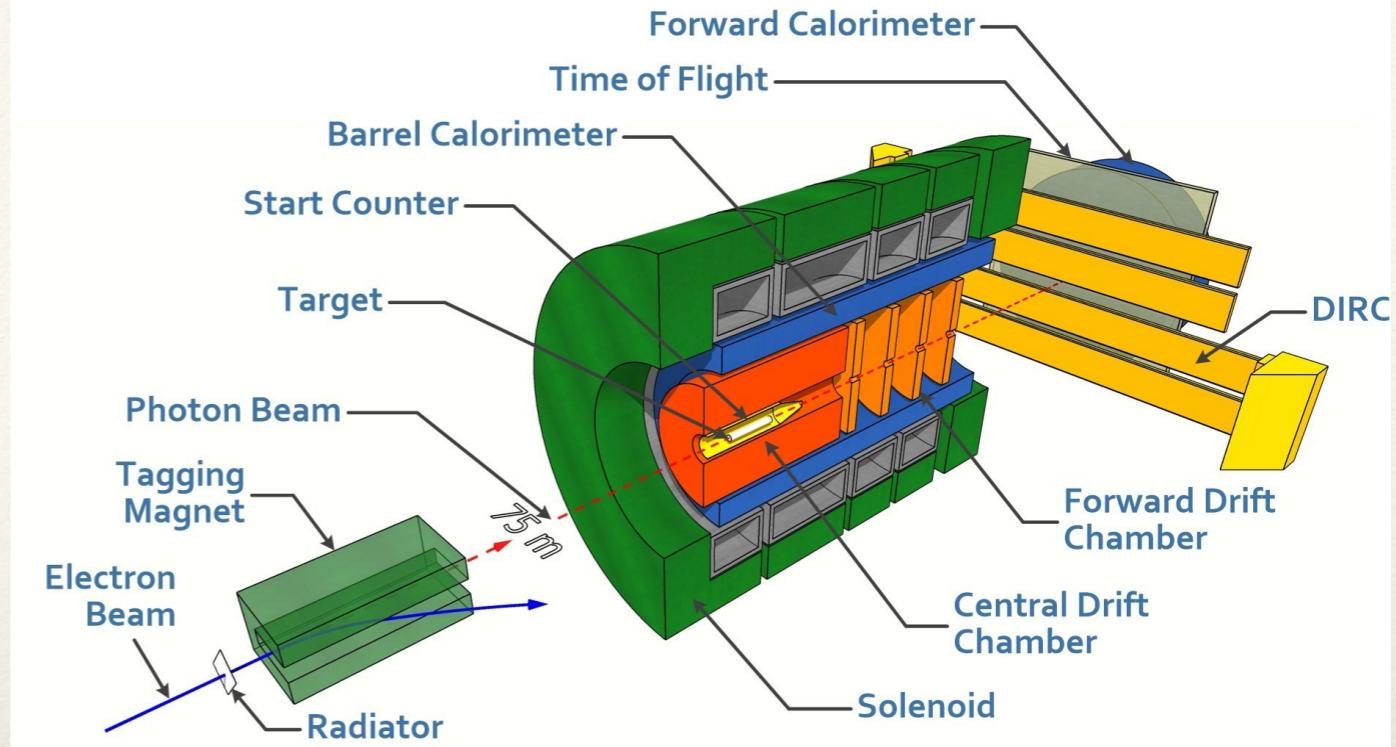


- ❖ Only six well known states ($>3^{***}$)
- ❖ Not many photoproduction experiments have been performed so far ($S = -2$)
- ❖ GlueX with its good charged and neutral final state particle coverage could help here
- ❖ Difficult analyses due to many final state particles



Summary

- ❖ GlueX has an exciting hyperon program and makes very good progress in many different analyses
- ❖ GlueX-II (including the DIRC) will improve our data for final states containing strangeness and will enable us to perform photoproduction measurements with unprecedented statistics
- ❖ We are open for ideas and suggestions for interesting measurements



GlueX acknowledges the support of several funding agencies and computing facilities: gluex.org/thanks

