UNIVERSITY OF SOUTH CAROLINA

Hyperon Physics at Jefferson Lab

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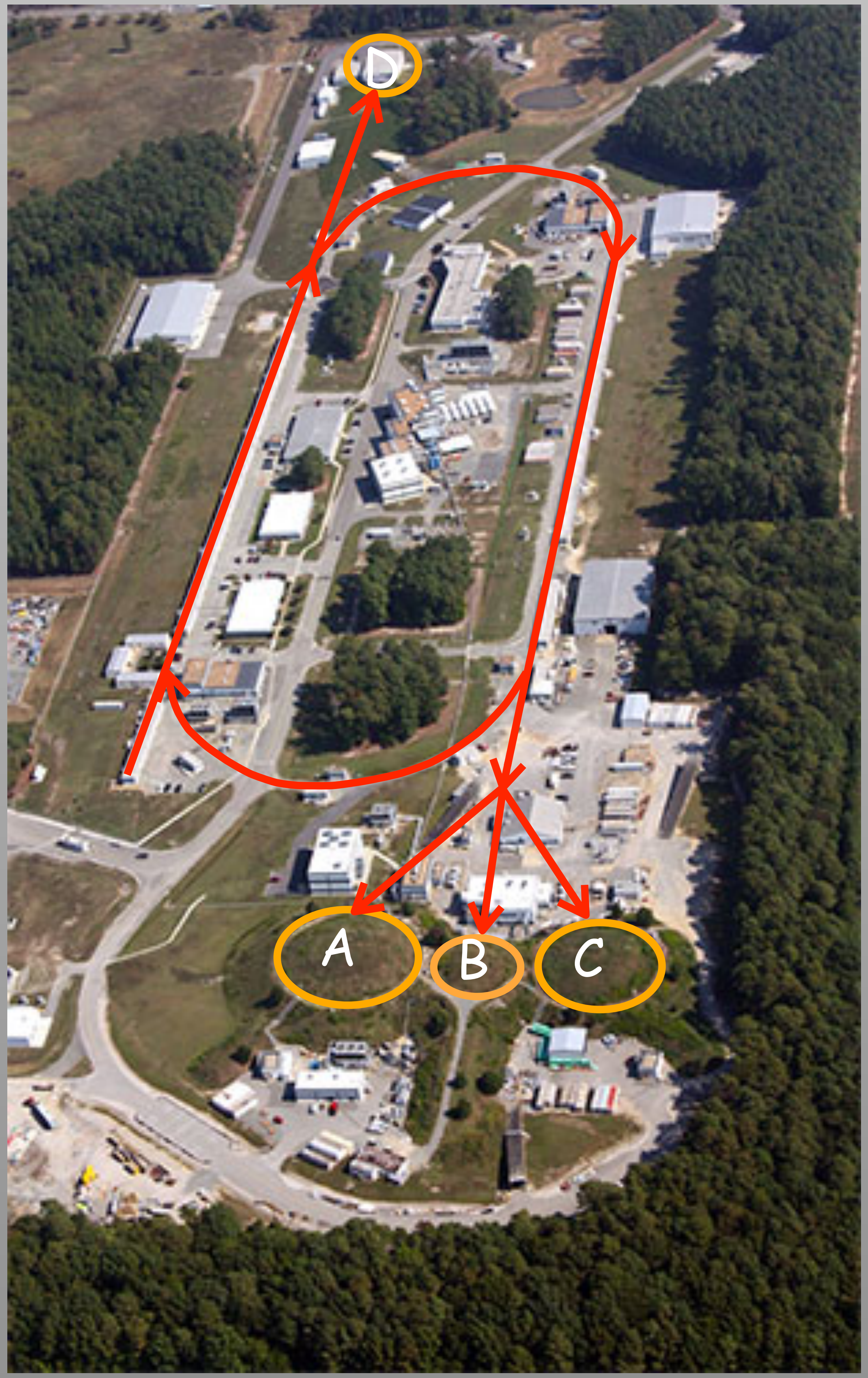
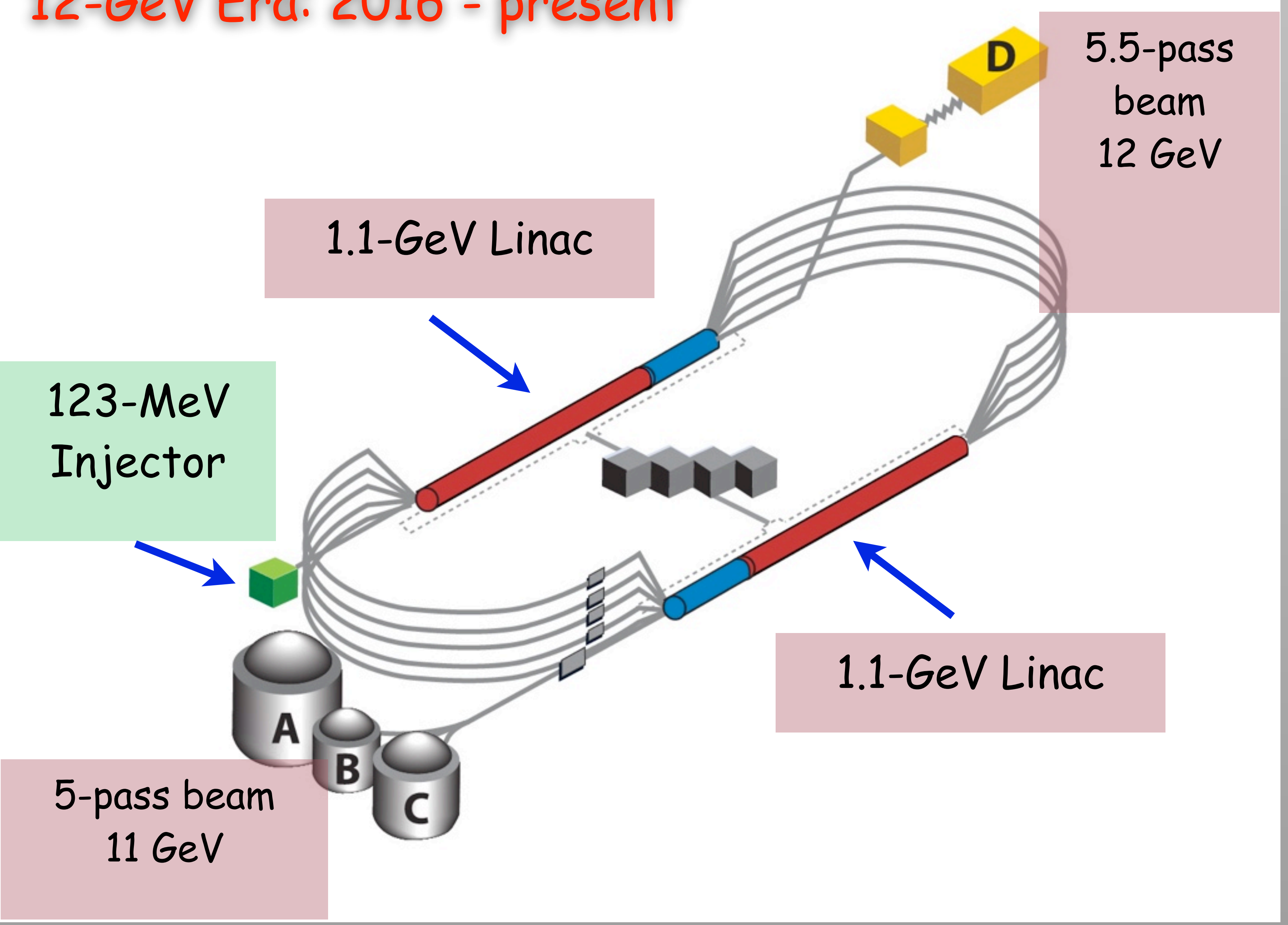
Research supported in part by the U.S. National Science Foundation

Thomas Jefferson National Accelerator Facility

Studies of the mechanism of confinement, partonic structure of nucleon, quark and gluon dynamics in the nuclear medium, nucleon spin decomposition, role of gluonic excitations in mesons, etc.



12-GeV Era: 2016 - present



2023 Community Statistics

- By 2024 ~800 PhDs completed (~22 U.S. PhDs/year, ~30% of the NP PhDs)
- 1904 users in 2023, 30% from foreign institutions

6-GeV Era: 1995 - 2012

- Polarized Beam: P_e ~ 86%
- Beam energies: E_0 = 0.4 — 6 GeV
- Beam Current up to 200 μA
- Simultaneous beam delivery to hree experimental halls: A, B, C

12-GeV Era

- Polarized Beam: P_e ~ 86%
- Beam energies: E_0 = 0.4 — 12 GeV
- Beam current up to 80 μA
- Simultaneous beam delivery to four experimental halls
  - Hall A: high luminosity, high resolution, and dedicated detectors
  - Hall B: CLAS12, electroproduction, quasi-real photoproduction
  - Hall C: high luminosity, high momentum spectrometers, and dedicated detectors
  - Hall D: polarized, tagged real-photon beam
- Planning for e^+ beam operations and 22-GeV upgrade

Studies of Non-Perturbative QCD with Hyperons

Low-energy YN interaction

- YN and YNN scattering experiments: Hall B
- Hypernuclear Spectroscopy: Halls A and C

Hyperon Spectroscopy

- Photoproduction of Hyperons: Hall D
- Quasireal photoproduction and electroproduction: Hall B (see talk by P. Achenbach)
- Future K_L Beamline: Hall D

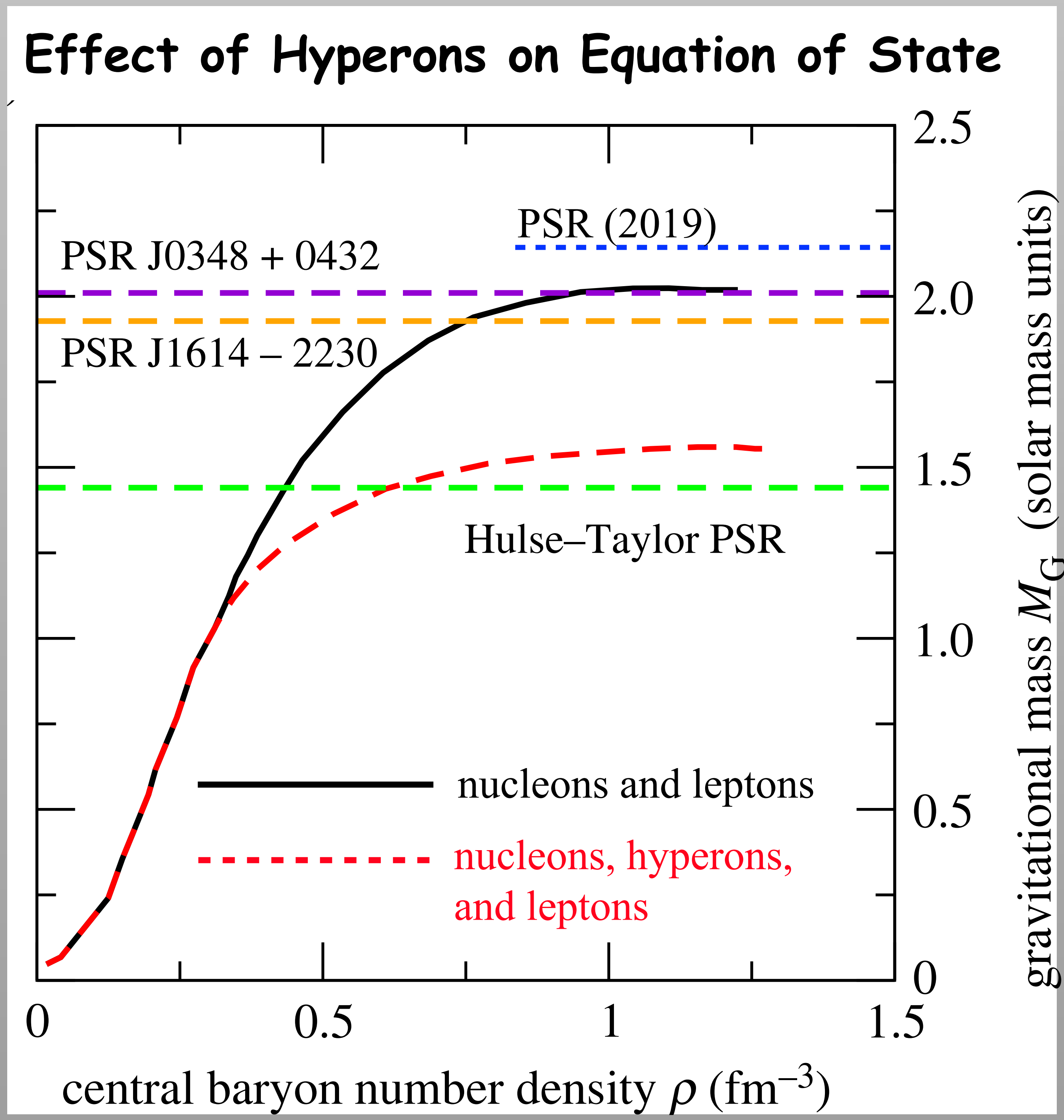
Studies of the YN Interaction

The Hyperon Puzzle of Neutron Stars

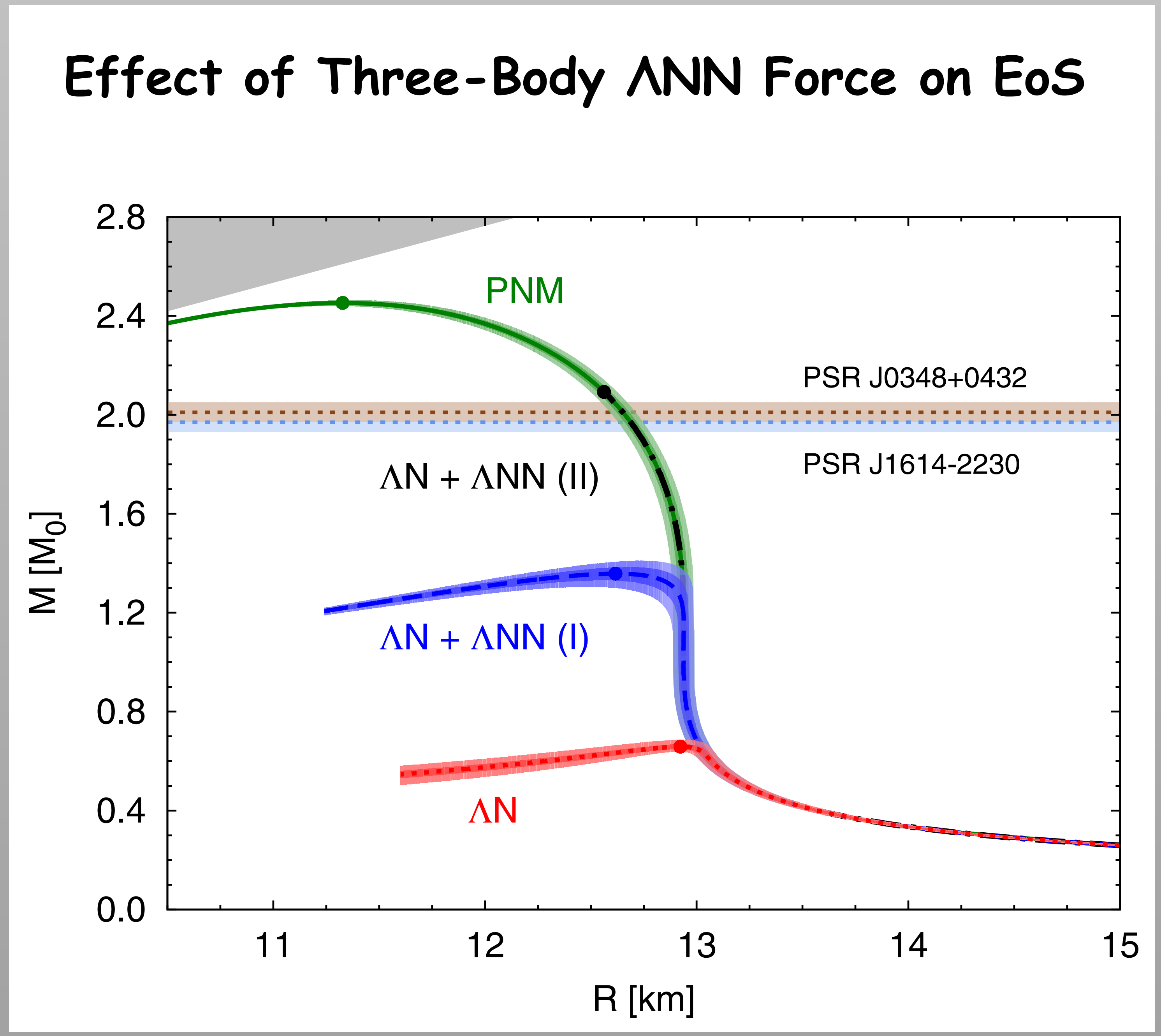
Impact on resolving the "hyperon puzzle" for neutron stars

- The appearance of hyperons in the core of neutron stars, softens the Equation of State (EoS) and leads to a reduction of the predicted mass. The observation of neutron stars with masses ≳2M⊙ is incompatible with such a soft EoS

- Repulsive ΛNN interaction could stiffen the EOS (W. Weise, EPJ Web of Conferences 271, 06003 (2022)) - relative strength of ΛNN to ΛN forces needs to be quantified



I. Vidana, Proc. R. Soc. A 474, 20180145 (2018) http://dx.doi.org/10.1098/rspa.2018.0145



D. Lonardoni et al., Phys. Rev. Lett 114, 092301 (2015)

R.A. Hulse and J.H. Taylor, Astrophysical Journal, 195, L51 (1975); P. Demorest et al., Nature, 467, 1081 (2010); J. Antoniadis et al., Science 340, 1233232 (2013); H.T. Cromartie et al., Nat. Astron. (2019) doi:10.1038/s41550-019-0880-2.

Low-Energy Hyperon Physics: Scattering

YN interaction as not as well known as the NN

- not all free parameters of the YN potential can be obtained from the NN potential via flavor SU(3) symmetry
- example: large uncertainties of ΛN scattering lengths:

  a($^1S_0$) = –0.7 – –2.6 fm,

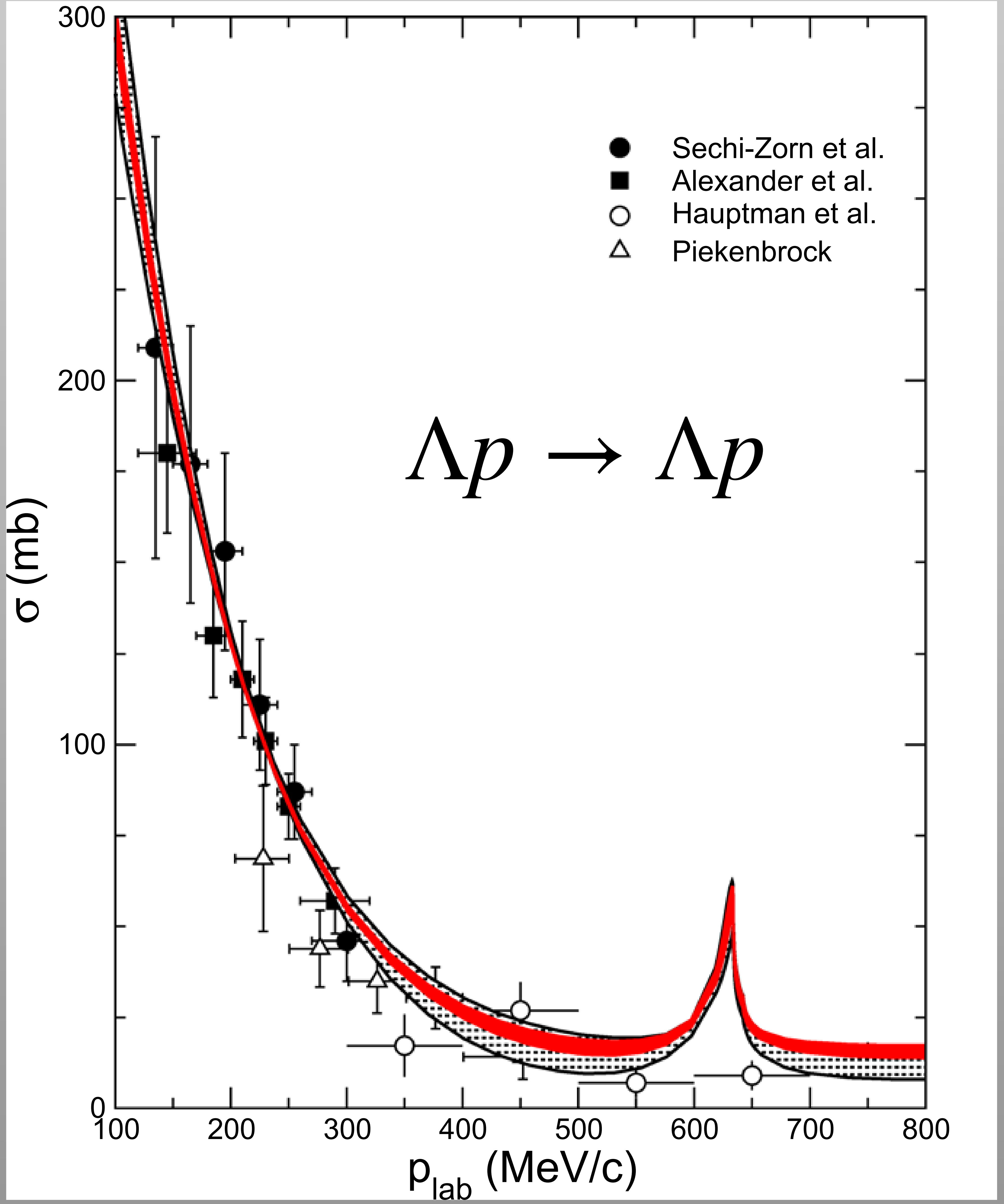
  a($^3S_1$) = –1.4 – 2.55 fm

- YN elastic scattering database poor

  Pre-2022: 36 data points, total cross sections only, all from the 1960s; 10 new data points, from KEK-PS E251 collaboration (2000)

  for comparison: 4000 NN data for Elab < 350 MeV

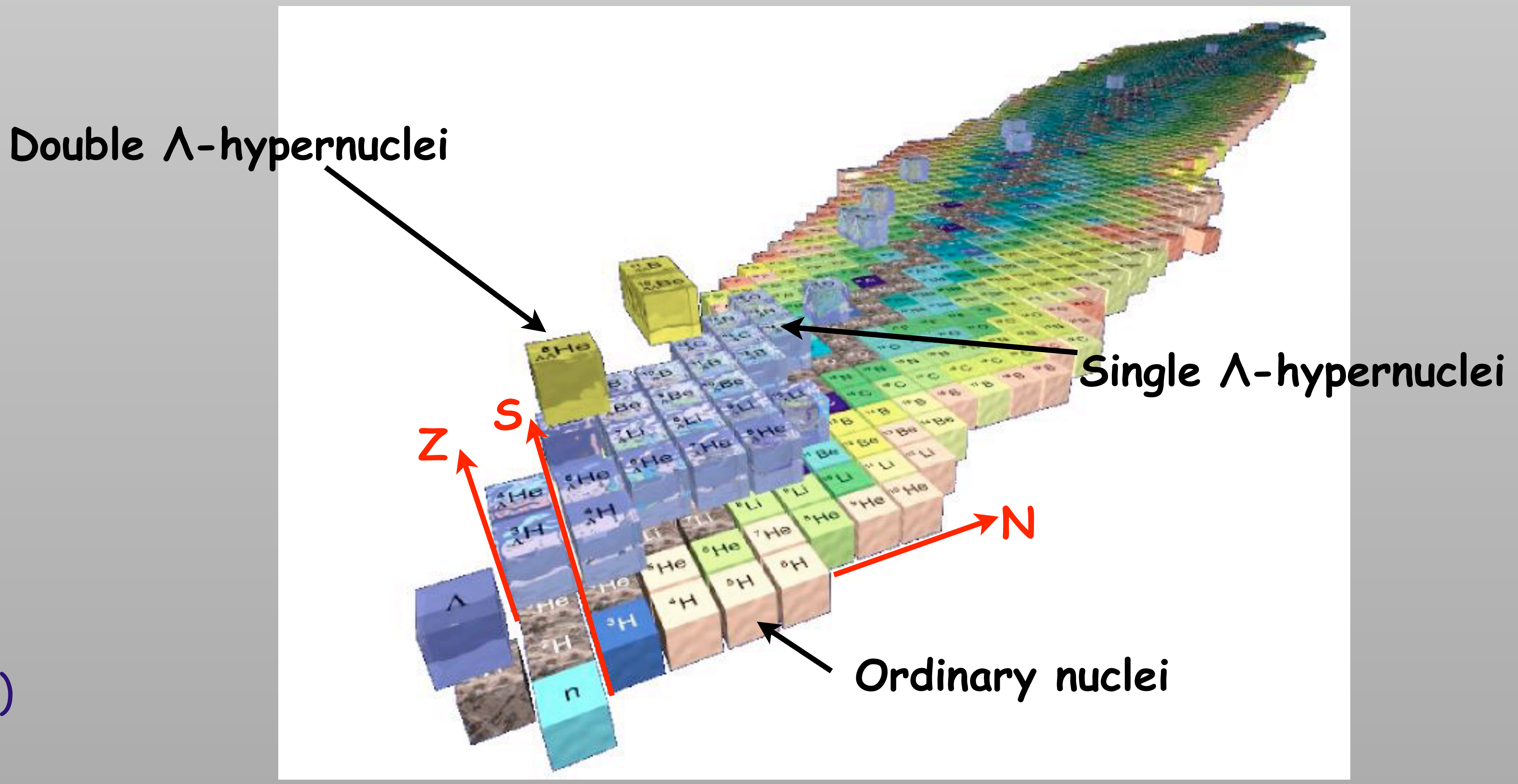
- No YY, YNN, YYN, or YYY scattering data



J. Haidenbauer et al., Eur. Phys. J. A 59, 63 (2023)

Low-Energy Hyperon Physics: Hypernuclei

- 41 single-Λ hypernuclei
- 3 double-Λ hypernuclei
- few Ξ hypernuclei
- ambiguous evidence of Σ-hypernuclei



I. Vidana, AIP Conf. Proc. 2130, 040011 (2019)

Charge-Symmetry Breaking in A=4 hypernuclei:

$$\Delta E(0^+) = E_\Lambda^{0^+}({}^4_\Lambda\text{He}) - E_\Lambda^{0^+}({}^4_\Lambda\text{H}) = 233 \pm 92 \text{ keV}$$
$$\Delta E(1^+) = E_\Lambda^{1^+}({}^4_\Lambda\text{He}) - E_\Lambda^{1^+}({}^4_\Lambda\text{H}) = -83 \pm 94 \text{ keV}$$

F. Schulz et al., Null. Phys. A 954, 149 (2016); A. Esser et al., Phys. Rev. Lett. 114, 232501 (2015)

T.O. Yamamoto et al., Phys. Rev. Lett. 115, 222501 (2015)

$$\Delta a^{CSB}({}^1S_0) = a_{\Lambda p} - a_{\Lambda n} = 0.62 \pm 0.08 \text{ fm}$$
$$\Delta a^{CSB}({}^3S_1) = a_{\Lambda p} - a_{\Lambda n} = -0.10 \pm 0.02 \text{ fm}$$

J. Haidenbauer et al., Few-Body Syst 62, 105 (2021)

Recent Developments in YN Scattering

New experimental techniques

- **Final-State YN interaction (FSI) in production experiments**

COSY TOF: $pp \to K^+ \Lambda p$ F. Hauenstein et al. (COSY-TOF Collaboration), Phys. Rev. C 95, 034001 (2017)

- **Direct YN Scattering Experiments**

J-PARC: $\Sigma^- p \to \Sigma^- p$, $\Sigma^+ p \to \Sigma^+ p$, $\Sigma^- p \to \Lambda n$ (J-PARC E40 Σp Scattering Experiment)

K. Miwa et al., Phys. Rev. C 104, 045204 (2021); K. Miwa et al., Phys. Rev. Lett. 128, 072501 (2022); T. Nanamura et al., Progr. Theoret. Exp. Phys 2022, 093D01 (2022)

CLAS JLab: $\Lambda p \to \Lambda p$

J. Rowley et. al., Phys. Rev. Lett. 127, 272303 (2021)

Clear need for more low-energy scattering YN data.

Clear need of YNN scattering data to constrain the three-body YNN force.

Experimental Facility: The CLAS at JLab

E04-005, E04-017, E08-003 (g12)

- LH_2 target, 40-cm long
- E_e = 5.715 GeV
- triggers: ~26×10^9 triggers

E06-103 (g13)

- LD_2 target, 40-cm long
- Circularly (g13a) and Linearly Polarized (g13b) Photons
- E_e = 2 GeV; 2.65 GeV (g13a)
- triggers: ~50×10^9 triggers

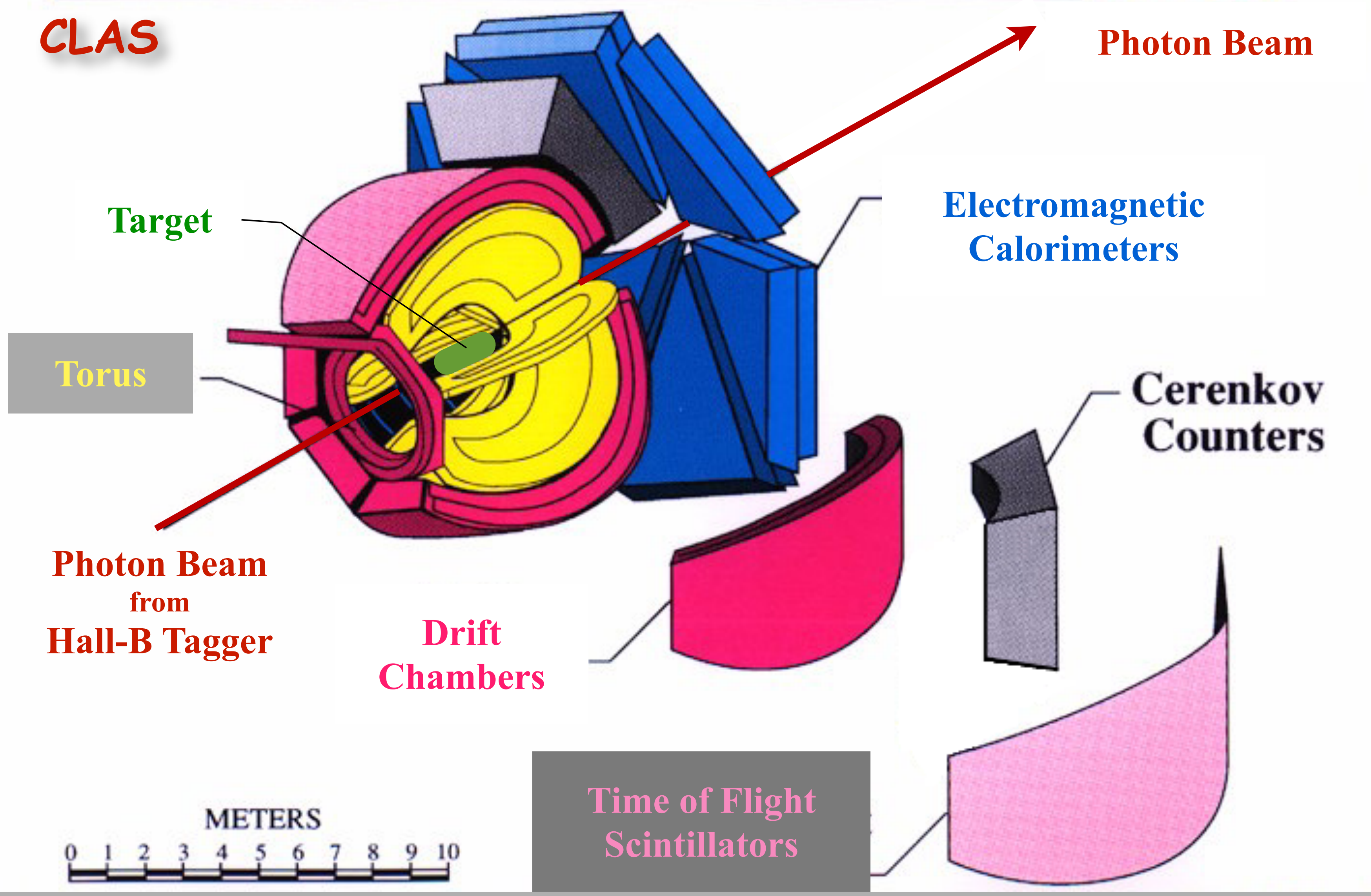
$8^\circ < \theta < 140^\circ$

$0^\circ < \phi < 360^\circ$

$\sigma_\theta \sim 1$ mrad

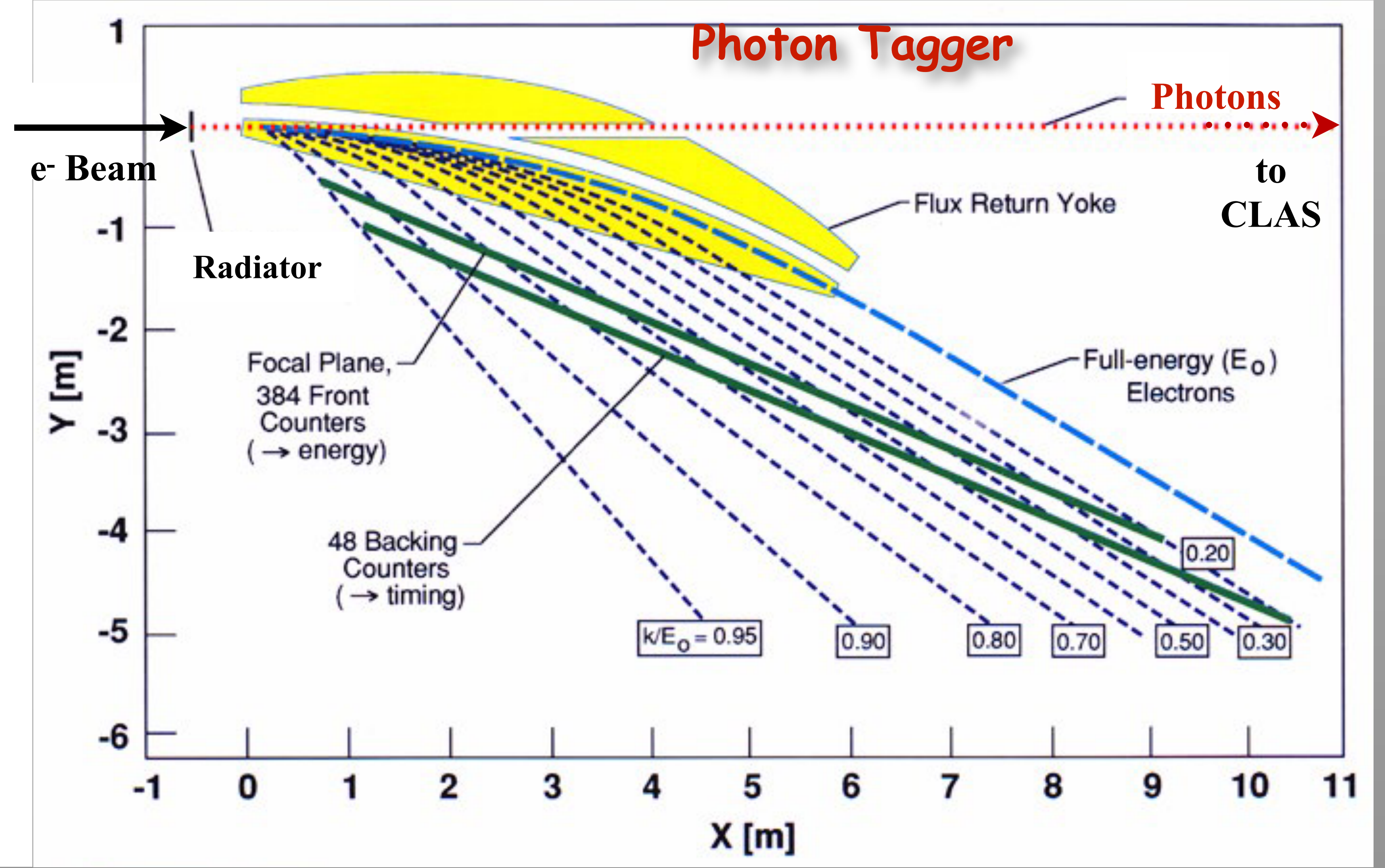
$\sigma_\phi \sim 4$ mrad

$\frac{\sigma_p}{p} \sim 1\,\%$



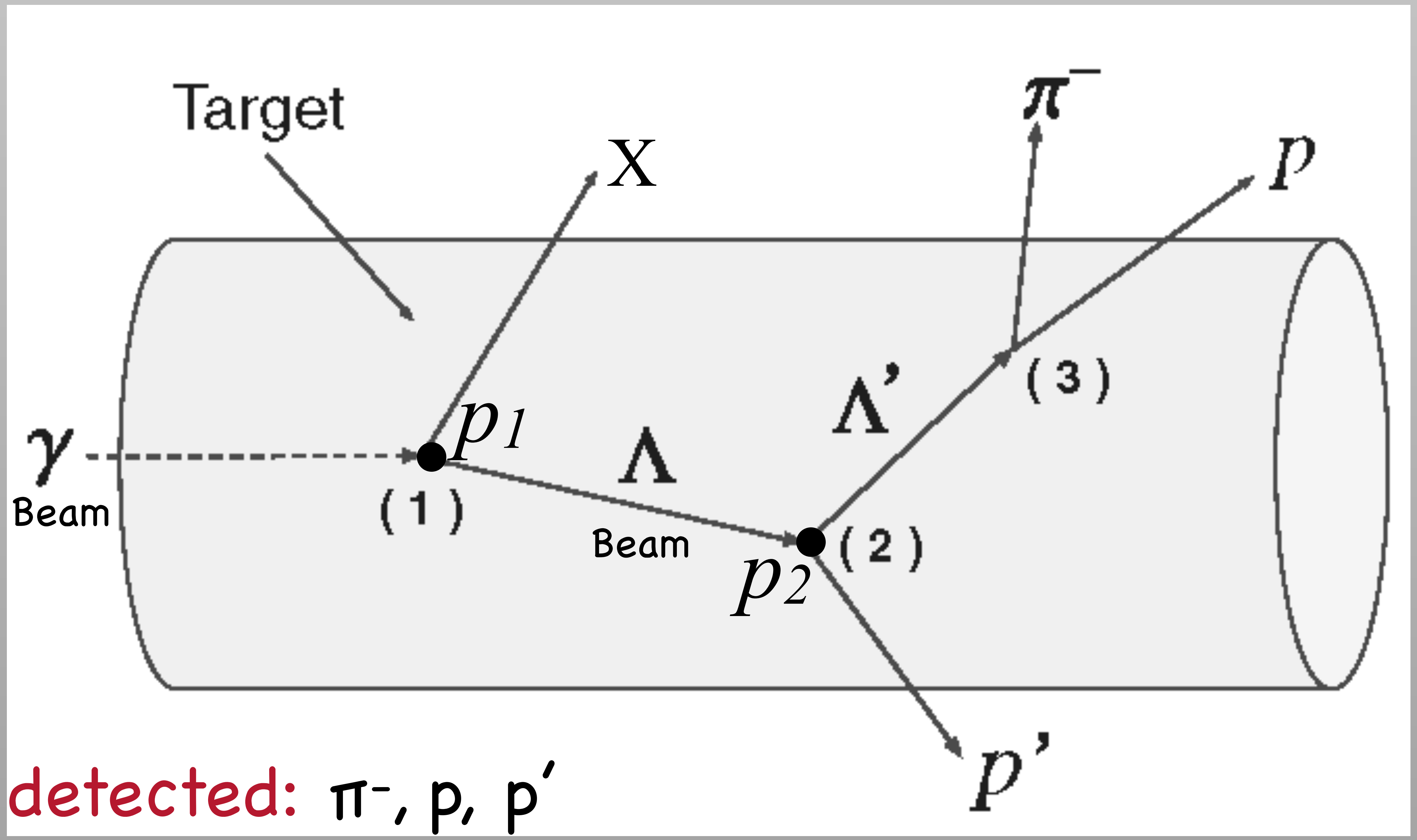
$E_\gamma : 0.2E_e,\ 0.95E_e$

$\frac{\sigma_{E_\gamma}}{E_\gamma} \sim 0.1\,\%$



Accessing YN scattering in Photoproduction

Technique: Rescattering off different nucleon/nucleus in same target cell



(1) Λ beam is produced in: $\gamma p_1 \rightarrow \Lambda X$

(2) Λ beam scatters off elastically: $\Lambda p_2 \rightarrow \Lambda' p'$

(3) Scattered Λ decays: $\Lambda' \rightarrow p\pi^-$

Advantages:

- Exclusive measurement of (2) - clean reaction selection
- Both target nucleons in (1) and (2) are at rest and on-shell — no Fermi smearing

Challenges:

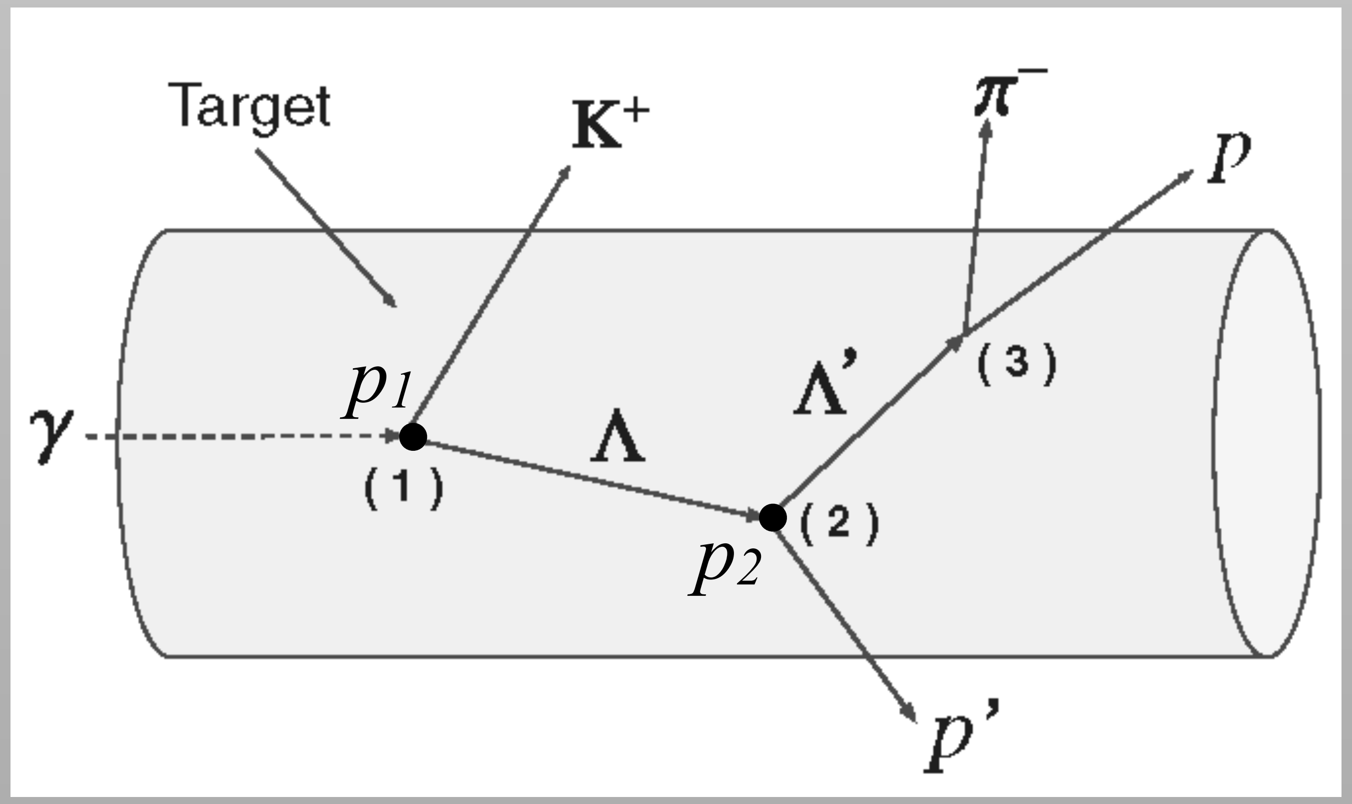
- Luminosity determination for (2)
- Statistics of (2)
- Λ beam momentum cannot be arbitrarily low

Measurement of $\Lambda p \to \Lambda p$ Cross Section

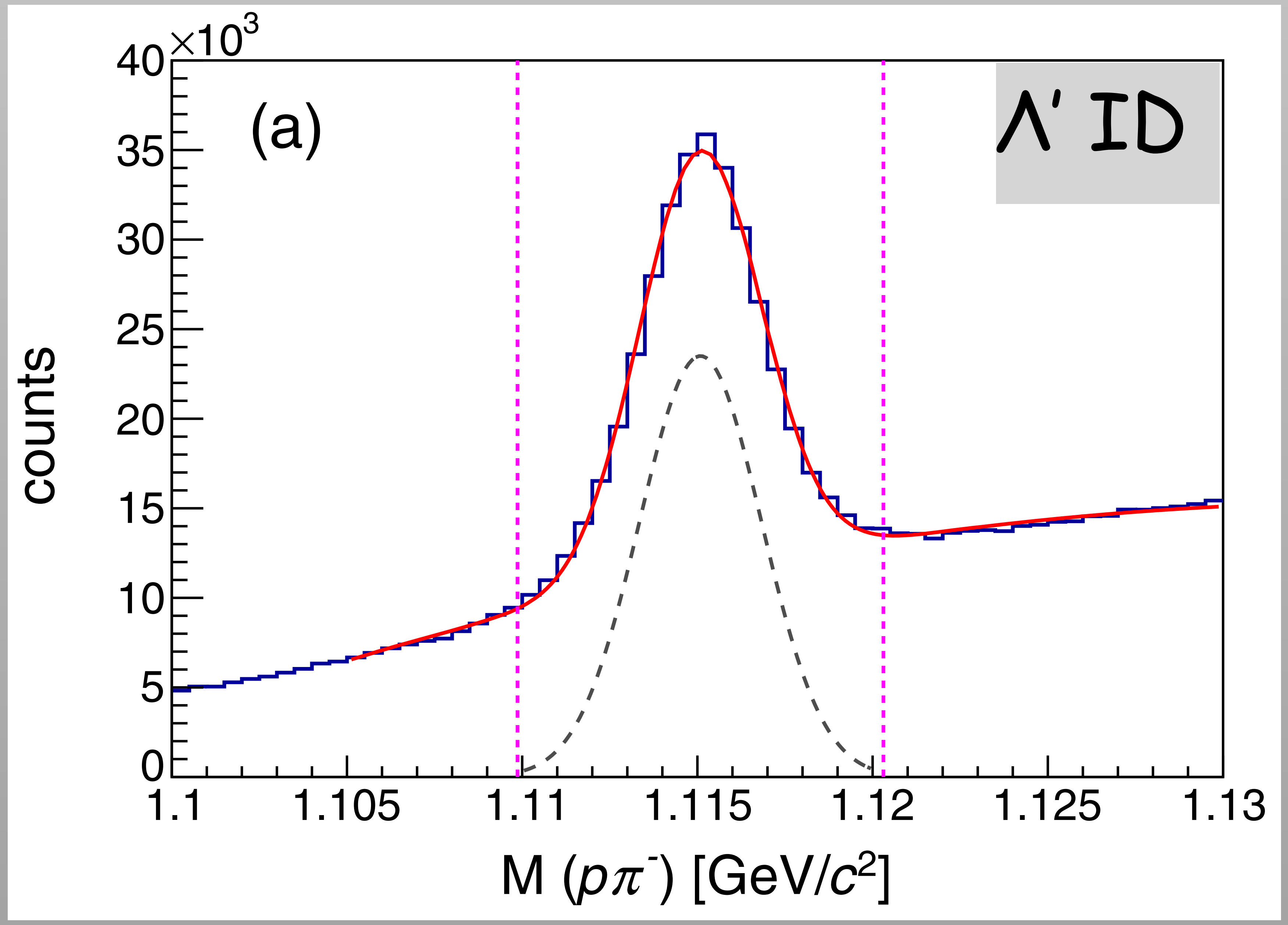
Technique applied to proton-target data

J. Rowley et. al., Phys. Rev. Lett. **127**, 272303 (2021)

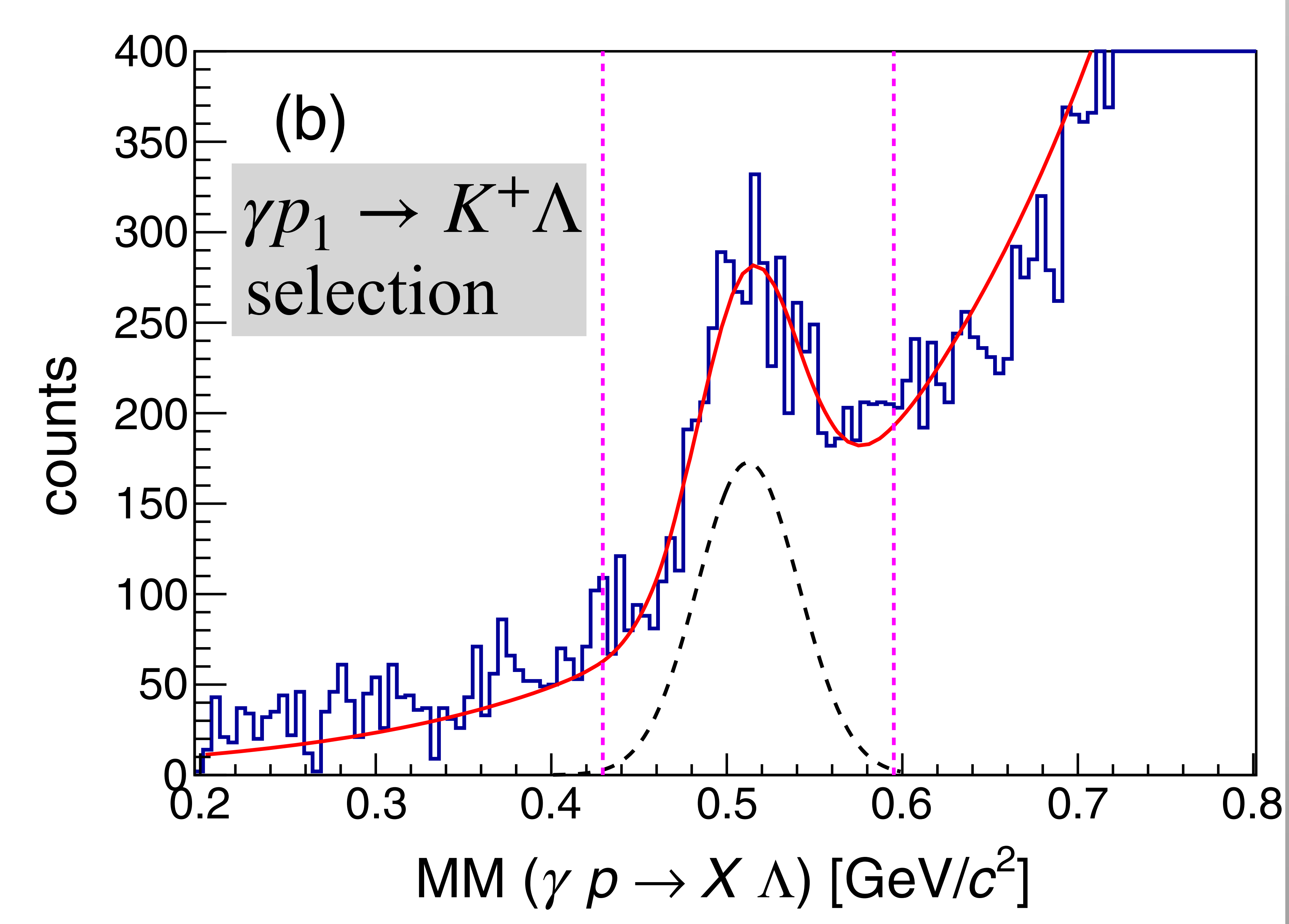
Event Selection



detected: π^-, p, p′



$$\tilde{p}_{\Lambda'} = \tilde{p}_{\pi^-} + \tilde{p}_p$$

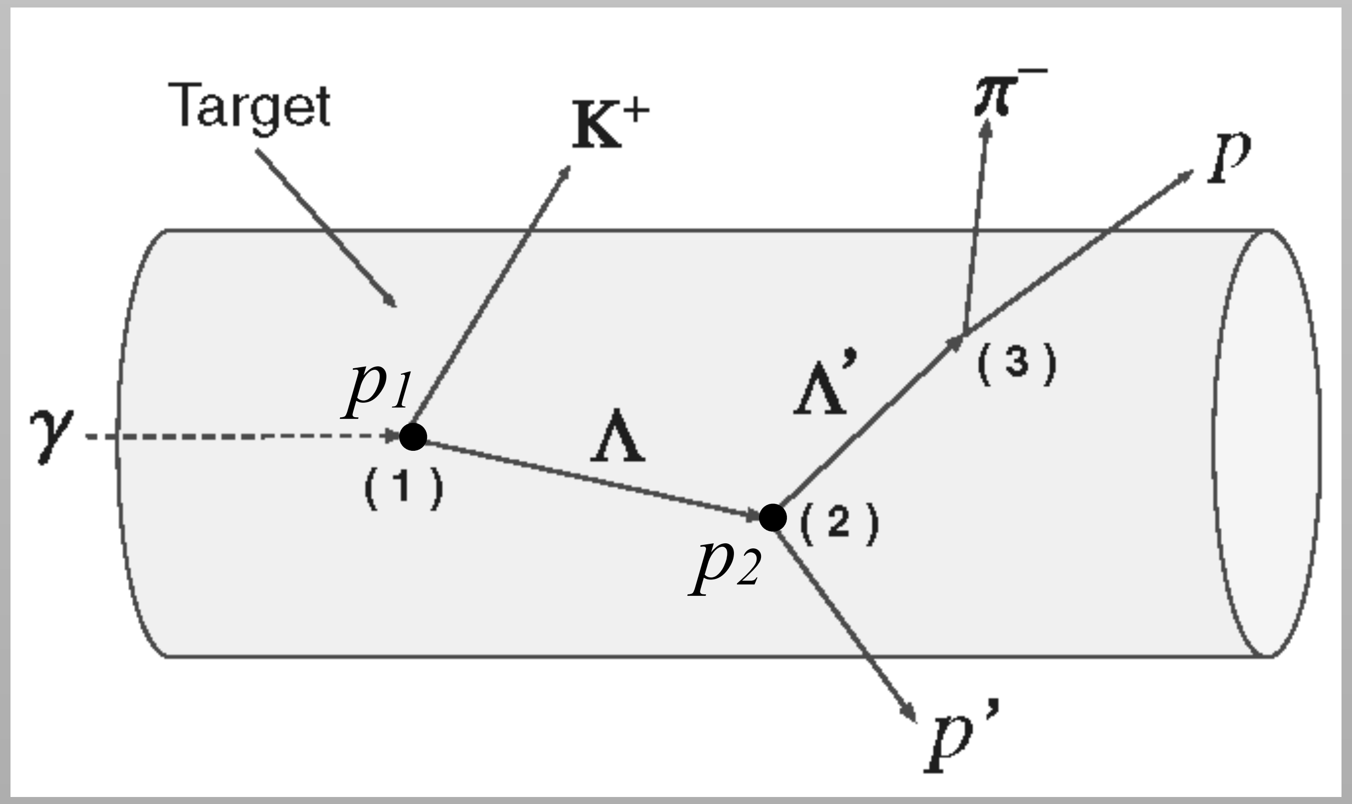


$$\tilde{p}_{K^+} = \tilde{p}_\gamma + \tilde{p}_{p_1} + \tilde{p}_{p_2} - \tilde{p}_{\Lambda'} - \tilde{p}_{p'}$$

Measurement of $\Lambda p \to \Lambda p$ Cross Section

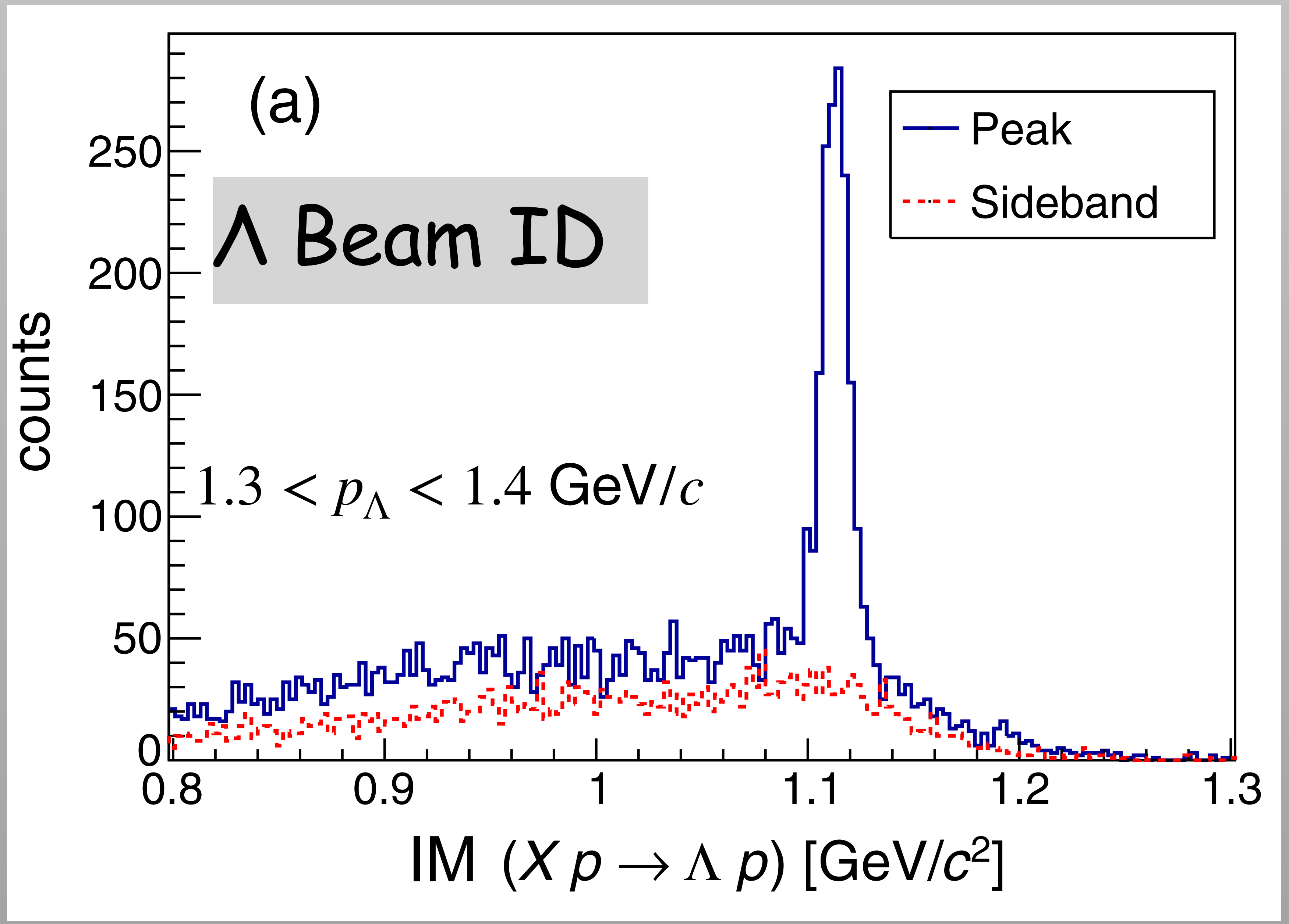
Technique applied to proton-target data

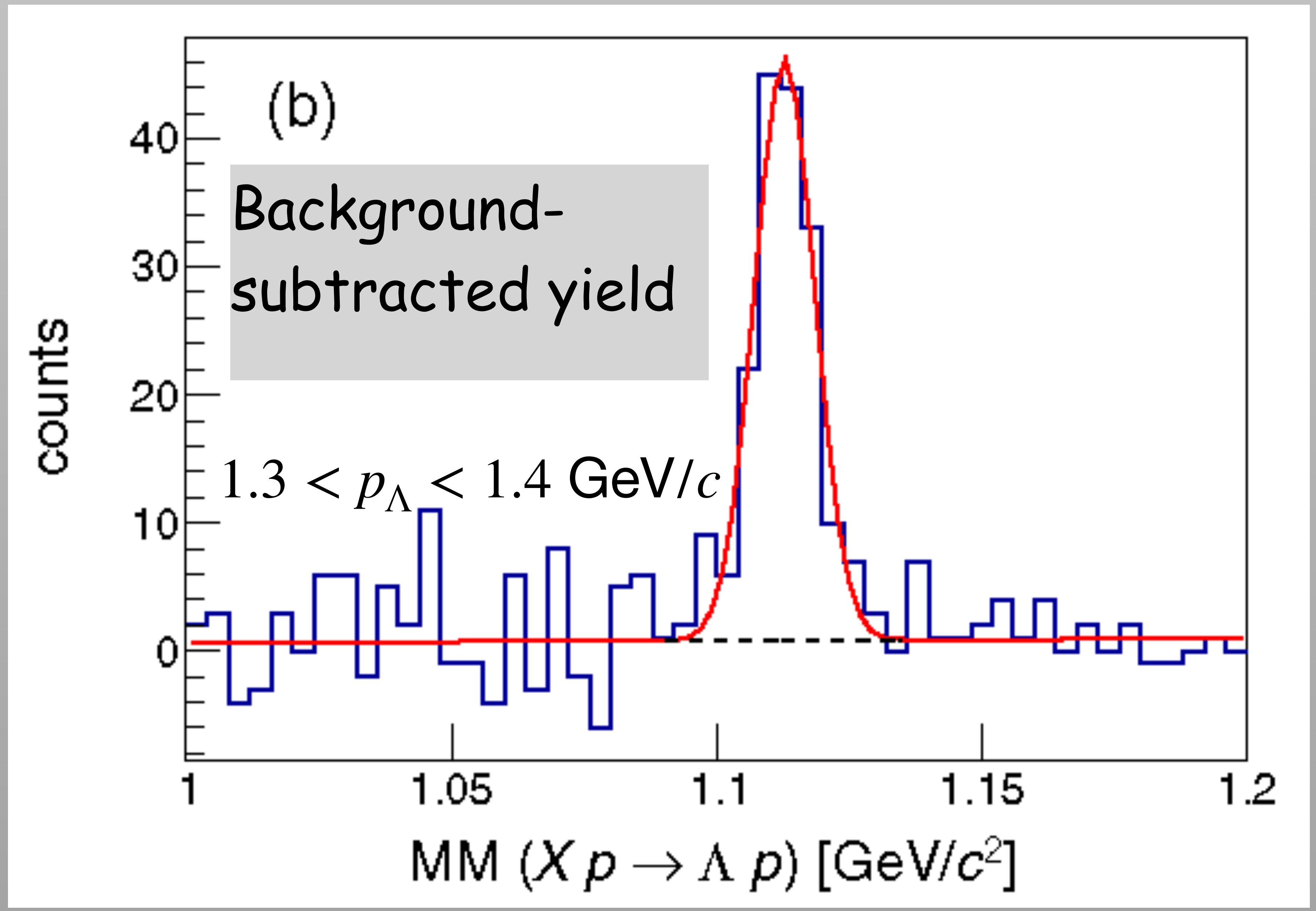
J. Rowley et. al., Phys. Rev. Lett. **127**, 272303 (2021)



detected: π^-, p, p′

Event Selection





$$\tilde{p}_\Lambda = \tilde{p}_{\Lambda'} + \tilde{p}_{p'} - \tilde{p}_{p_2}$$

Measurement of $\Lambda p \to \Lambda p$ Cross Section

Technique applied to proton-target data

J. Rowley et. al., Phys. Rev. Lett. **127**, 272303 (2021)

Total Cross Section Determination

$$\sigma(p_\Lambda) = \frac{Y(p_\Lambda)}{\mathscr{A}(p_\Lambda)\mathscr{L}(p_\Lambda)\Gamma_{\Lambda\to p\pi^-}}$$

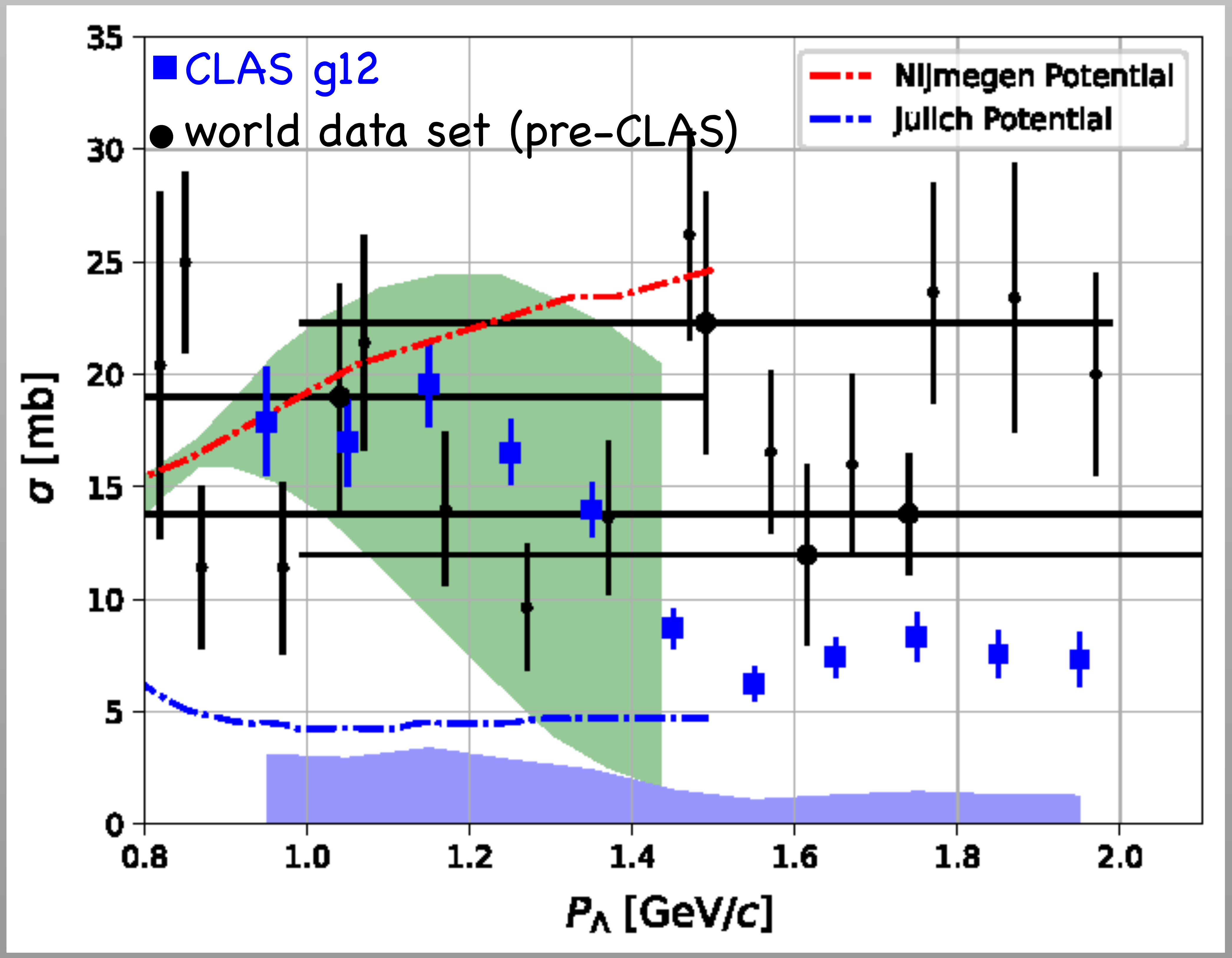
$$\mathscr{L}(p_\Lambda) = \frac{N_A \rho_T L}{M} N_\Lambda(p_\Lambda)$$

$$L: \ P(x) = \exp\left[-\frac{m_\Lambda}{p_\Lambda}\frac{x - x_0}{\tau}\right]$$

$$N_\Lambda(p_\Lambda) = \mathscr{L}_\gamma \frac{d\sigma}{d\Omega_{\gamma p\to K\Lambda}}(2\pi)(\Delta\cos\theta^*{}_K)$$

Simulations: $\mathscr{A}(p_\Lambda)$, L

Results



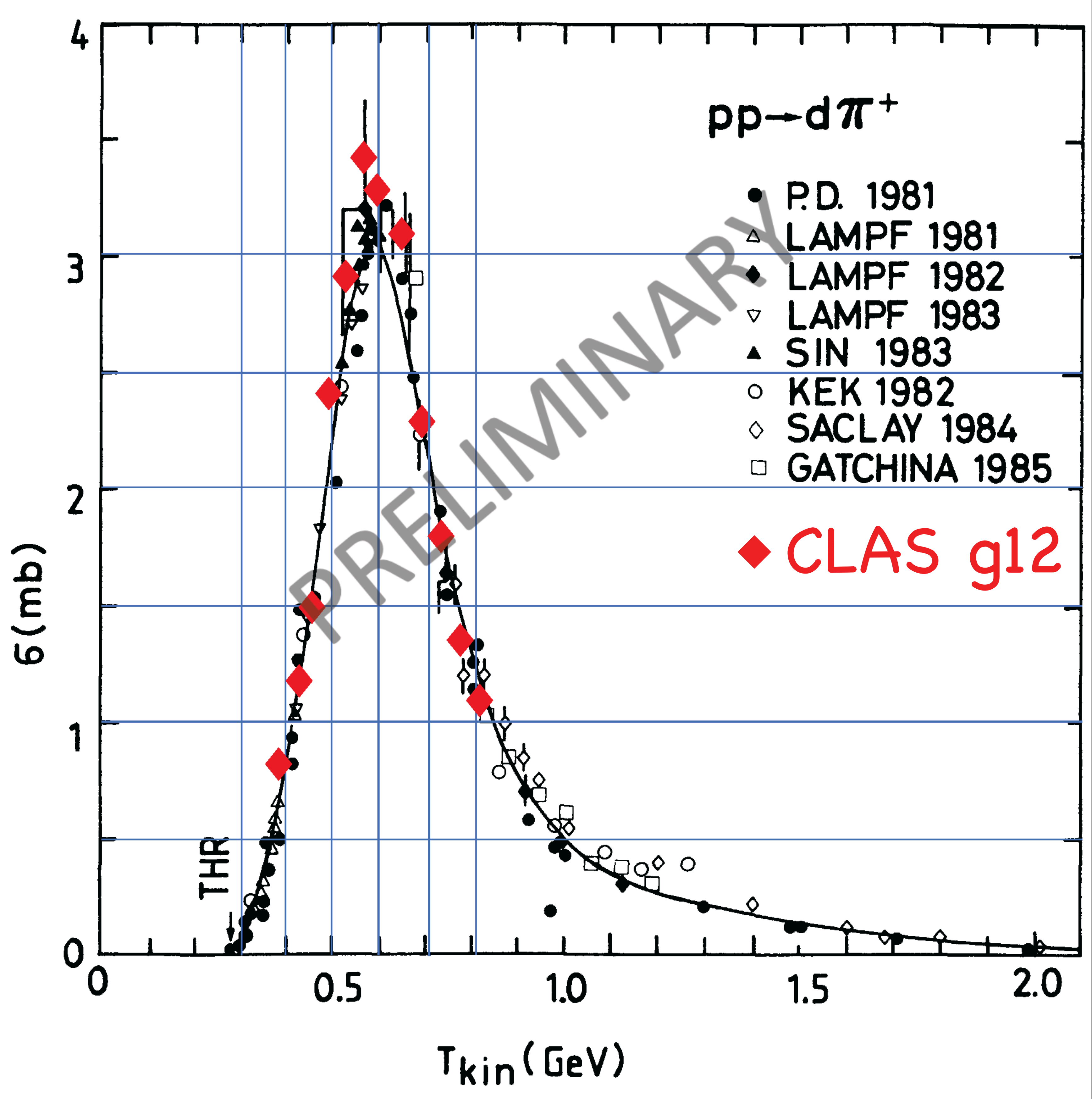
J. Haidenbauer and U.-G. Meißner, Phys. Rev. C 72, 044005 (2005)

T. A. Rijken, V. G. J. Stoks, and Y. Yamamoto, Phys. Rev. C 59, 21 (1999)

J. Haidenbauer, U.-G. Meißner, and A. Nogga, Eur. Phys. J. A 56, 91 (2020).

Measurement of $pp \to d\pi^+$ Cross Section

Technique: Validation



Work by Joe Rowley, Ken Hincks, Nick Zachariou

(1) $\gamma p \to p\pi^0$

(2) $pp \to d\pi^+$

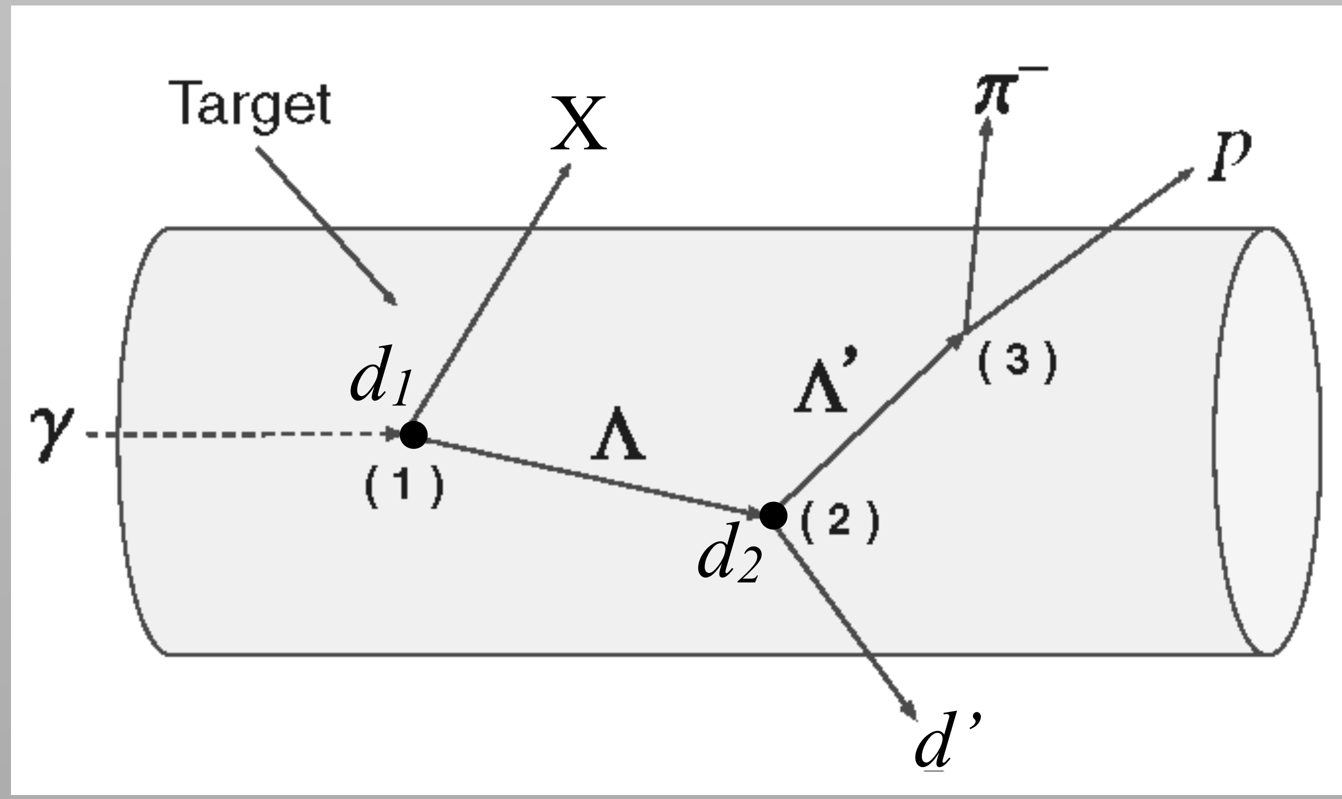
detected: d, π^+

- statistical uncertainties: size of marker
- Systematic uncertainties: about 10%

Good agreement with previous data

Measurement of $\Lambda d \to \Lambda d$ Cross Section

Technique applied to deuteron-target data



Theoretical Studies

- Elastic cross section can be used to extract $^2S_{1/2}$ and $^4S_{3/2}$ scattering lengths

  $a(^4S_{3/2}) = -7.6 \div -31.9$ fm - directly constrains $a(^3S_1)$ for ΛN

  (J. Haidenbauer, Phys. Rev. C 102, 034001 (2020))

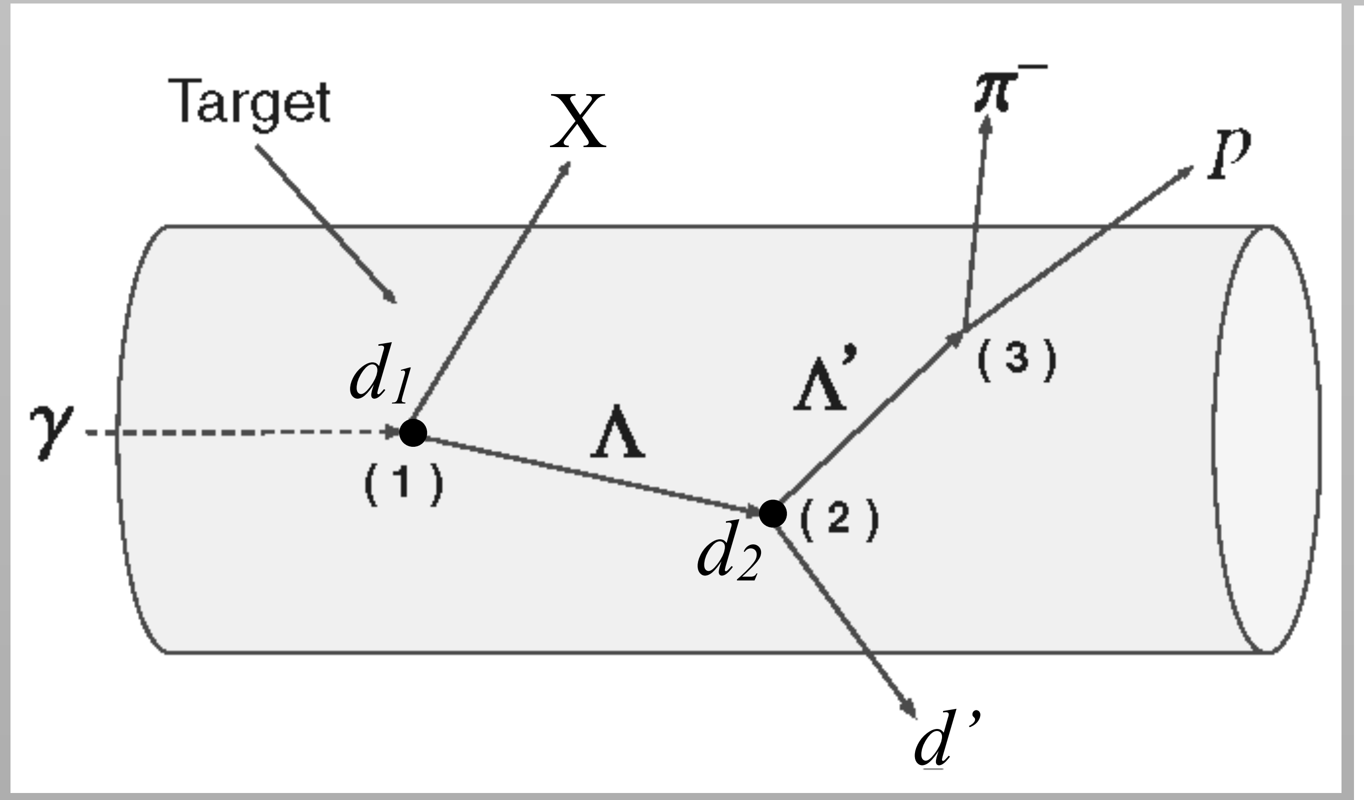
- Studies of Nd elastic cross sections at energies of our data show increased sensitivity to 3-body mechanisms→theoretical formalisms to extract the relative strength of these mechanisms will be applied to Λd cross sections to gain access to ΛNN

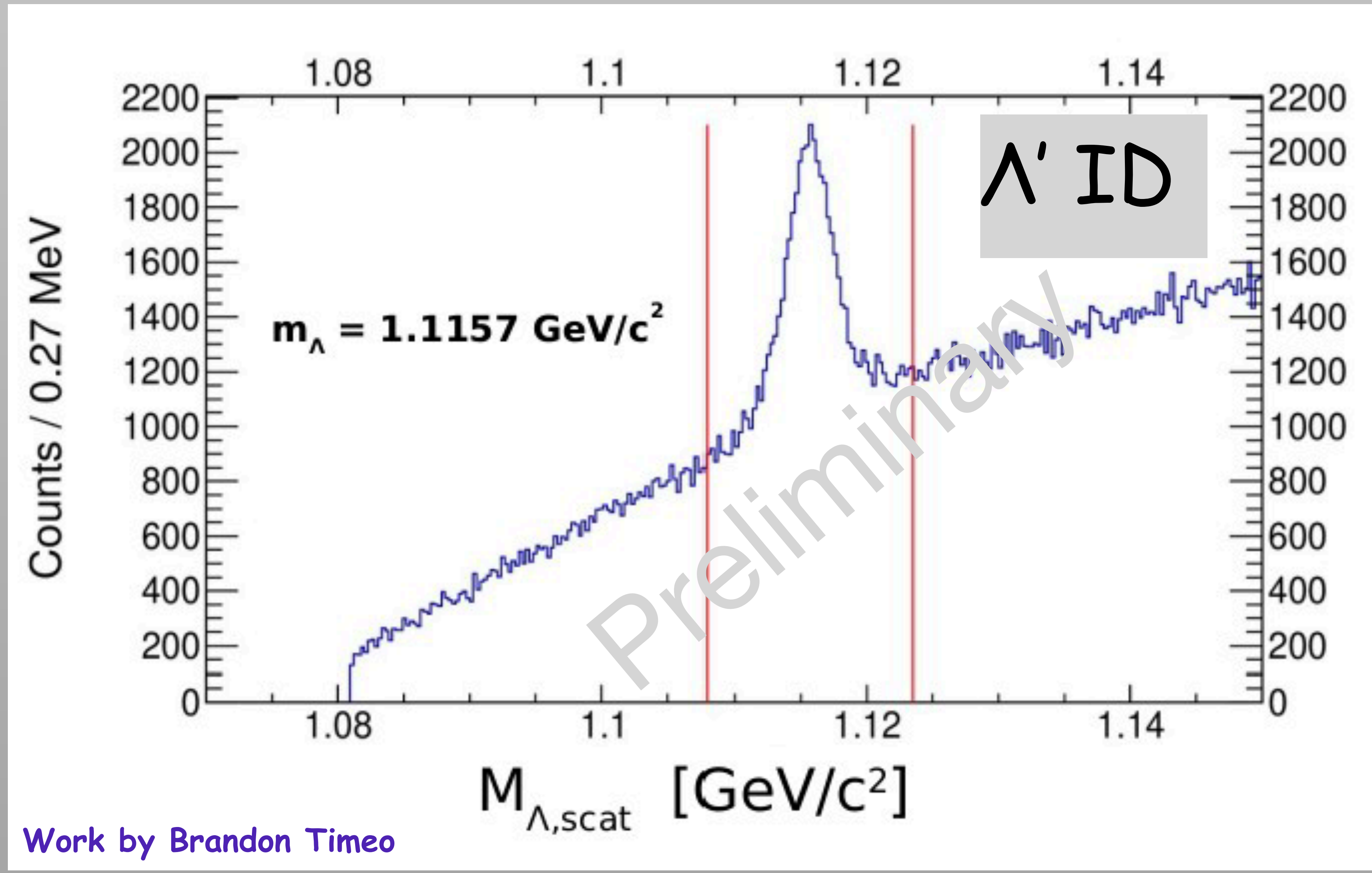
  (H. Garcilazo et al, Phys. Rev. C 75, 034002 (2007); B. Ghaffary Kashef, L. Schick, Phys. Rev. D 3, 2661 (1971), J. Hetherington, L. Schick, Phys. Rev. 139, B1164 (1965))

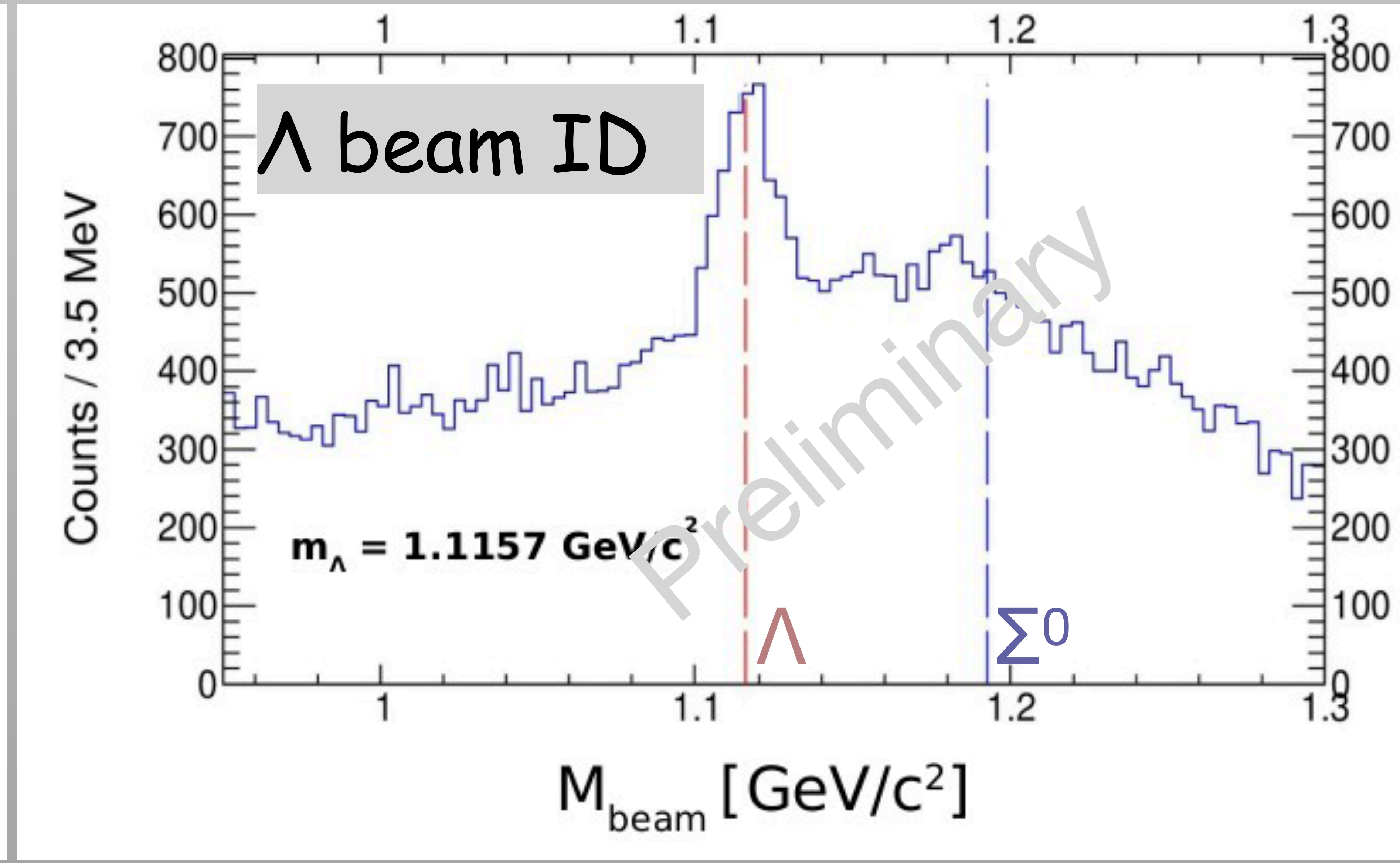
Measurement of $\Lambda d \to \Lambda d$ Cross Section

Technique applied to deuteron-target data

Event Selection







$$\tilde{p}_{\Lambda'} = \tilde{p}_{\pi^-} + \tilde{p}_p$$

$$\tilde{p}_{\Lambda} = \tilde{p}_{\Lambda'} + \tilde{p}_{d'} - \tilde{p}_{d_2}$$

detected: π^-, p, d'

At (1): inclusive Λ photo production to increase luminosity for (2)

Parallel analysis to extract $N_\Lambda(p_\Lambda)$ for $\gamma d \to \Lambda X$

Technique allows for adding circularly- and linearly-polarized data sets in a coherent way.

Measurement of $\Lambda d \to \Lambda d$ Cross Section

Technique applied to deuteron-target data

Expected Results

About 4000 elastic Λd events

Total Cross section

p_Λ(GeV/c)	$\delta_\sigma^{stat}/\sigma$(%)
0.6, 0.7	4
0.7, 0.8	4
0.8, 0.9	5
0.9, 1.0	5

For each momentum bin, differential cross section over $-0.6 < \cos\theta^*_{\Lambda'} < 0.8$

S-wave differential cross sections extracted by means of Legendre Polynomial Fits

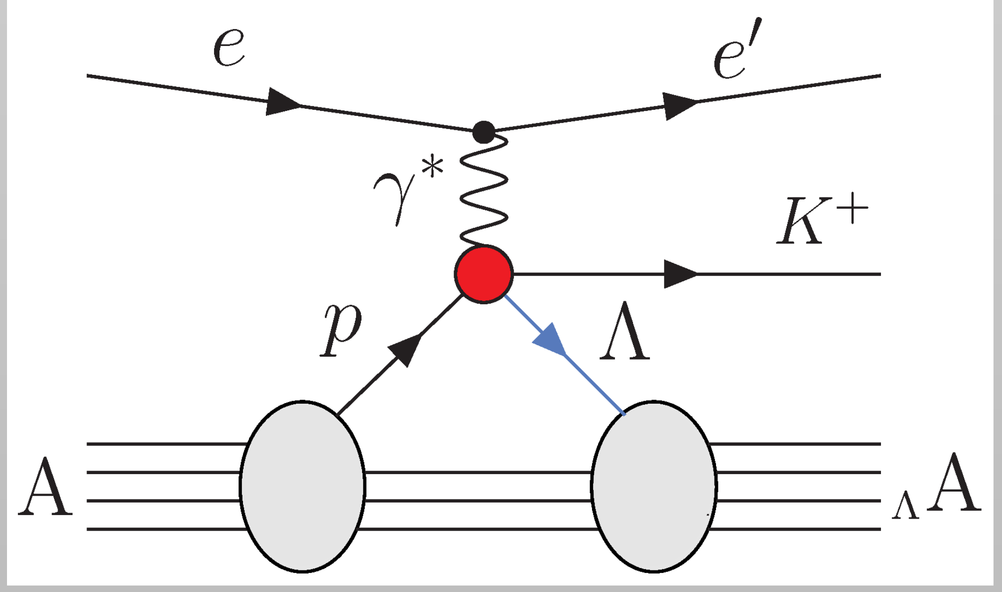
Λ′ induced polarization will be determined

Hypernuclear Spectroscopy: Halls A and C

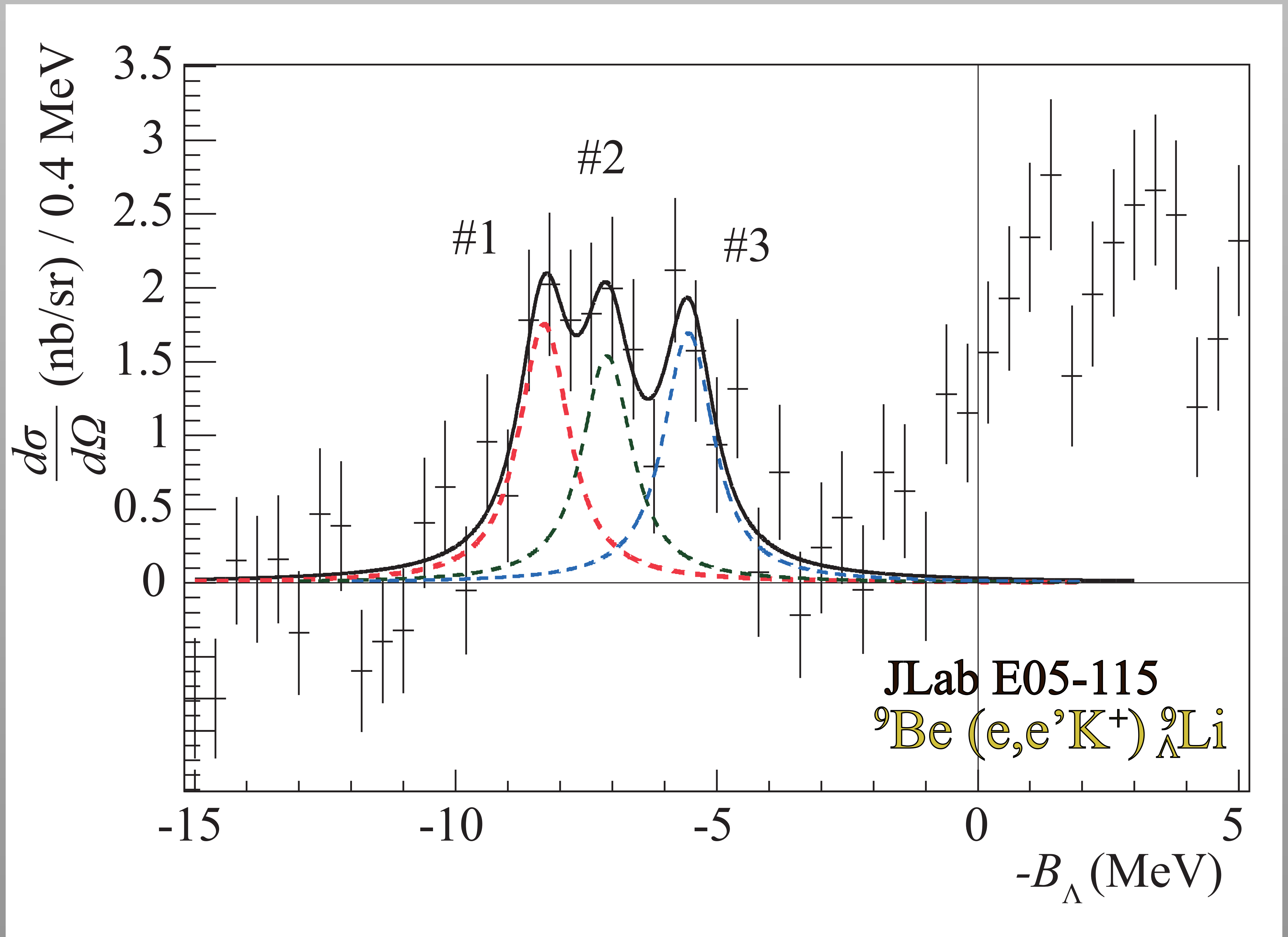
E89-009, E94-107, E01-011, E05-115, E12-17-003, E12-15-008

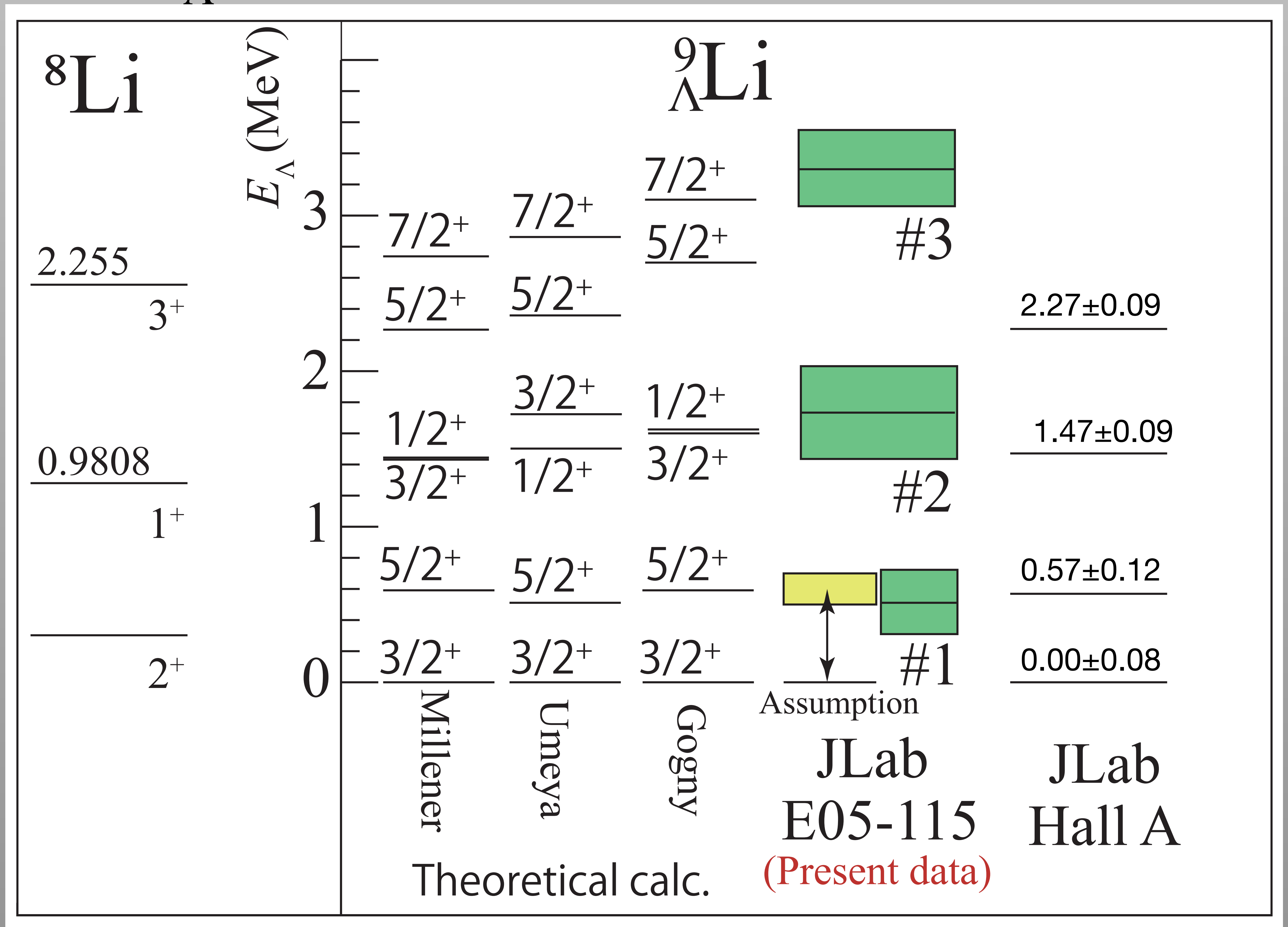
Measurements of binding and/or excitation energies of Λ hypernuclei in (e,e'K⁺)

$^{7}_{\Lambda}$He, $^{9}_{\Lambda}$Li, $^{10}_{\Lambda}$Be, $^{12}_{\Lambda}$B, $^{16}_{\Lambda}$N, $^{28}_{\Lambda}$Al, $^{52}_{\Lambda}$V, $^{40}_{\Lambda}$K, $^{48}_{\Lambda}$K



Sample Results: $^{9}_{\Lambda}$Li





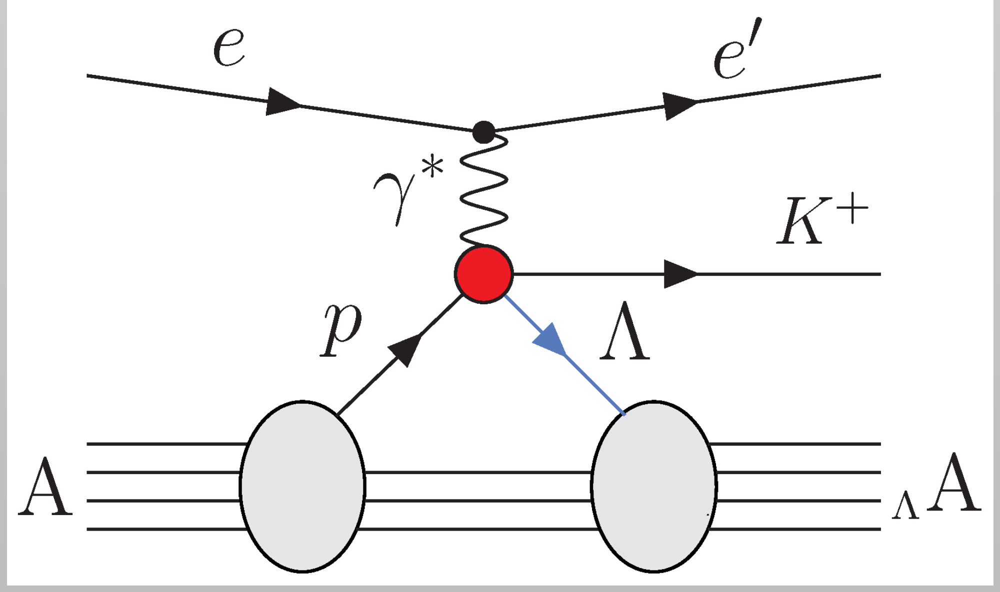
T.Gogami et al., Phys. Rev. C 103, L041301 (2021)

F. Garibaldi et al., Phys. Rev. C 99, 054309 (2019)

Hypernuclear Spectroscopy: Halls A and C

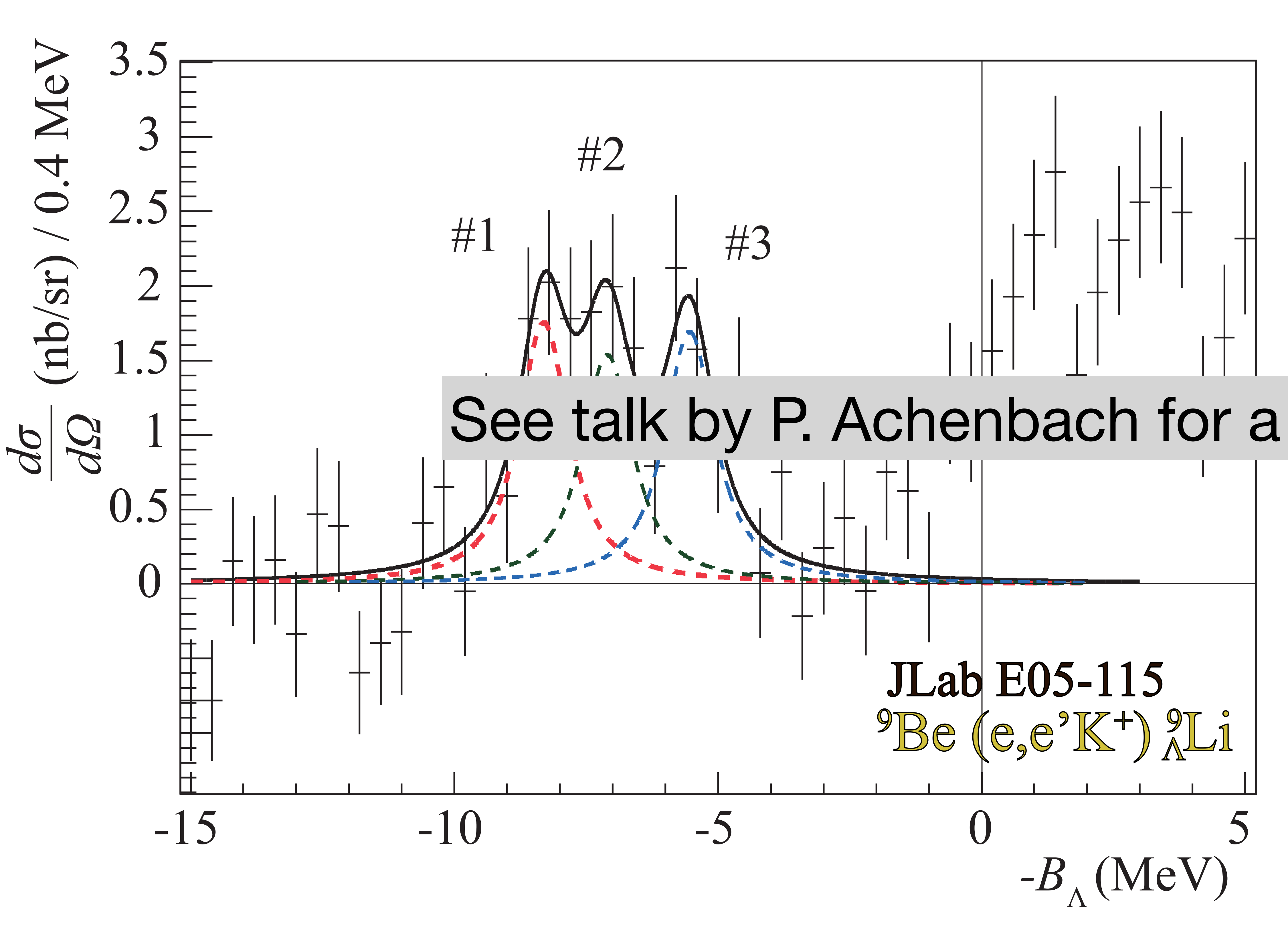
E89-009, E94-107, E01-011, E05-115, E12-17-003, E12-15-008

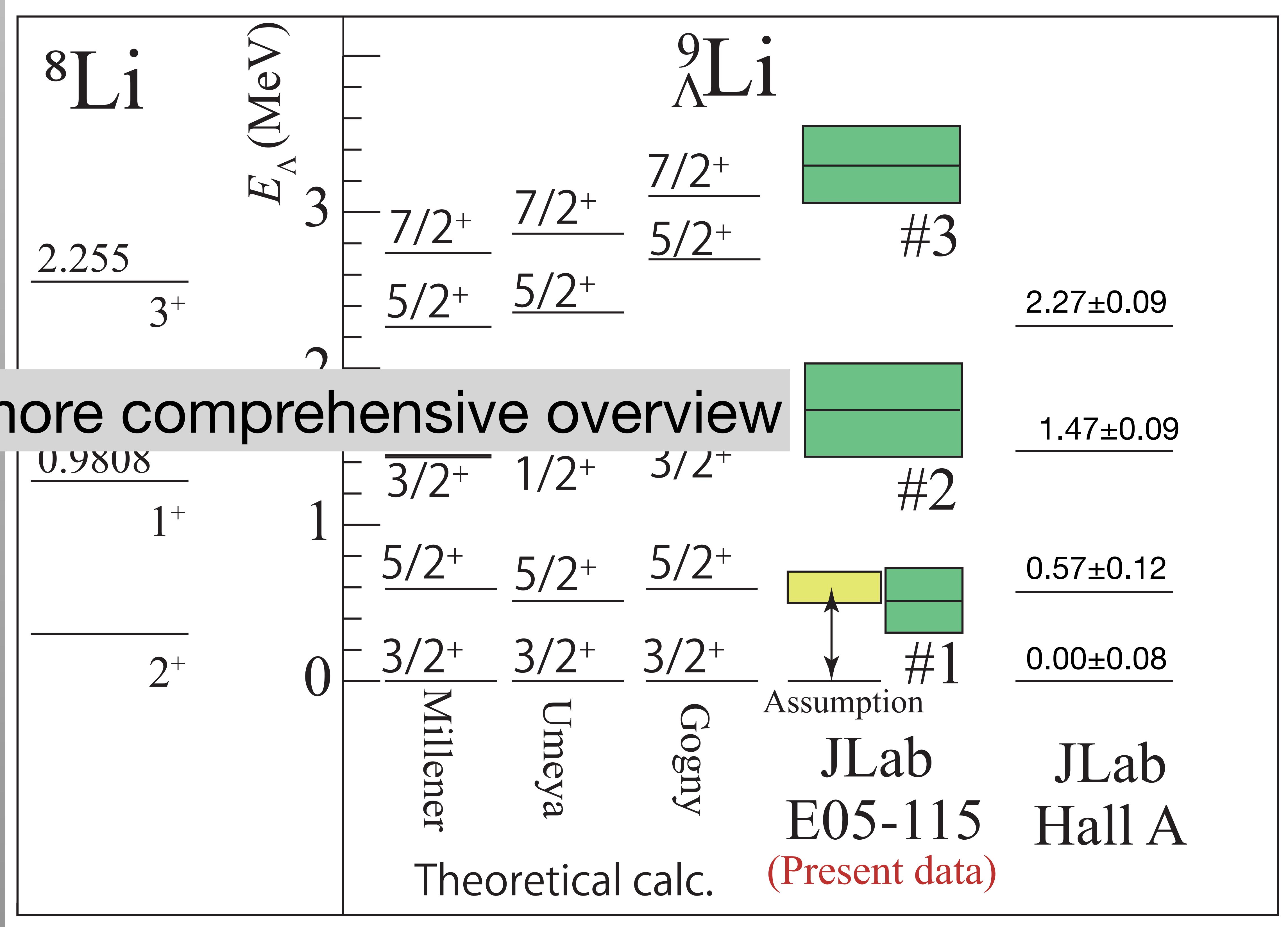
Measurements of binding and/or excitation energies of Λ hypernuclei in (e,e'K⁺)



${}^{7}_{\Lambda}$He, ${}^{9}_{\Lambda}$Li, ${}^{10}_{\Lambda}$Be, ${}^{12}_{\Lambda}$B, ${}^{16}_{\Lambda}$N, ${}^{28}_{\Lambda}$Al, ${}^{52}_{\Lambda}$V, ${}^{40}_{\Lambda}$K, ${}^{48}_{\Lambda}$K

Sample Results: ${}^{9}_{\Lambda}$Li





See talk by P. Achenbach for a more comprehensive overview

T.Gogami et al., Phys. Rev. C 103, L041301 (2021)

F. Garibaldi et al., Phys. Rev. C 99, 054309 (2019)

Hyperon Spectroscopy

What Do We Learn From Excited Baryons

Photoproduction

- the internal degrees of freedom of baryons
- the role of gluons
- the mechanisms leading to formation of excited baryon states

Electroproduction

- the Q^2 evolution of excited baryon electrocouplings provides insight into the transition from dressed to bare current quark and momentum evolution of dressed quark mass.

Strange Baryons in the PDG

Particle	J^P	Overall status	Status as seen in — $N\overline{K}$	$\Lambda\pi$	$\Sigma\pi$	Other channels
$\Sigma(1193)$	$1/2^+$	****				$N\pi$ (weak decay)
$\Sigma(1385)$	$3/2^+$	****		****	****	$\Lambda\gamma$
$\Sigma(1580)$	$3/2^-$	*	*	*	*	
$\Sigma(1620)$	$1/2^-$	*	*	*	*	
$\Sigma(1660)$	$1/2^+$	***	***	***	***	
$\Sigma(1670)$	$3/2^-$	****	****	****	****	
$\Sigma(1750)$	$1/2^-$	***	***	**	***	$\Sigma\eta$
$\Sigma(1775)$	$5/2^-$	****	****	****	**	
$\Sigma(1780)$	$3/2^+$	*	*	*	*	
$\Sigma(1880)$	$1/2^+$	**	**	*		
$\Sigma(1900)$	$1/2^-$	**	**	*	**	
$\Sigma(1910)$	$3/2^-$	***	*	*	**	
$\Sigma(1915)$	$5/2^+$	****	***	***	***	
$\Sigma(1940)$	$3/2^+$	*	*		*	
$\Sigma(2010)$	$3/2^-$	*	*	*		
$\Sigma(2030)$	$7/2^+$	****	****	****	**	$\Delta(1232)\overline{K}, N\overline{K}^*, \Sigma(1385)\pi$
$\Sigma(2070)$	$5/2^+$	*	*		*	
$\Sigma(2080)$	$3/2^+$	*		*		
$\Sigma(2100)$	$7/2^-$	*	*	*	*	
$\Sigma(2110)$	$1/2^-$	*	*	*	*	
$\Sigma(2230)$	$3/2^+$	*	*	*	*	
$\Sigma(2250)$		**	**	*	*	
$\Sigma(2455)$		*	*			
$\Sigma(2620)$		*	*			
$\Sigma(3000)$		*	*	*		
$\Sigma(3170)$		*				

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.

2023 PDG Listing

Λ^* and Σ^*: higher-mass states are poorly known.

Ξ^*: fewer states observed, mostly further information is desirable or poorly known

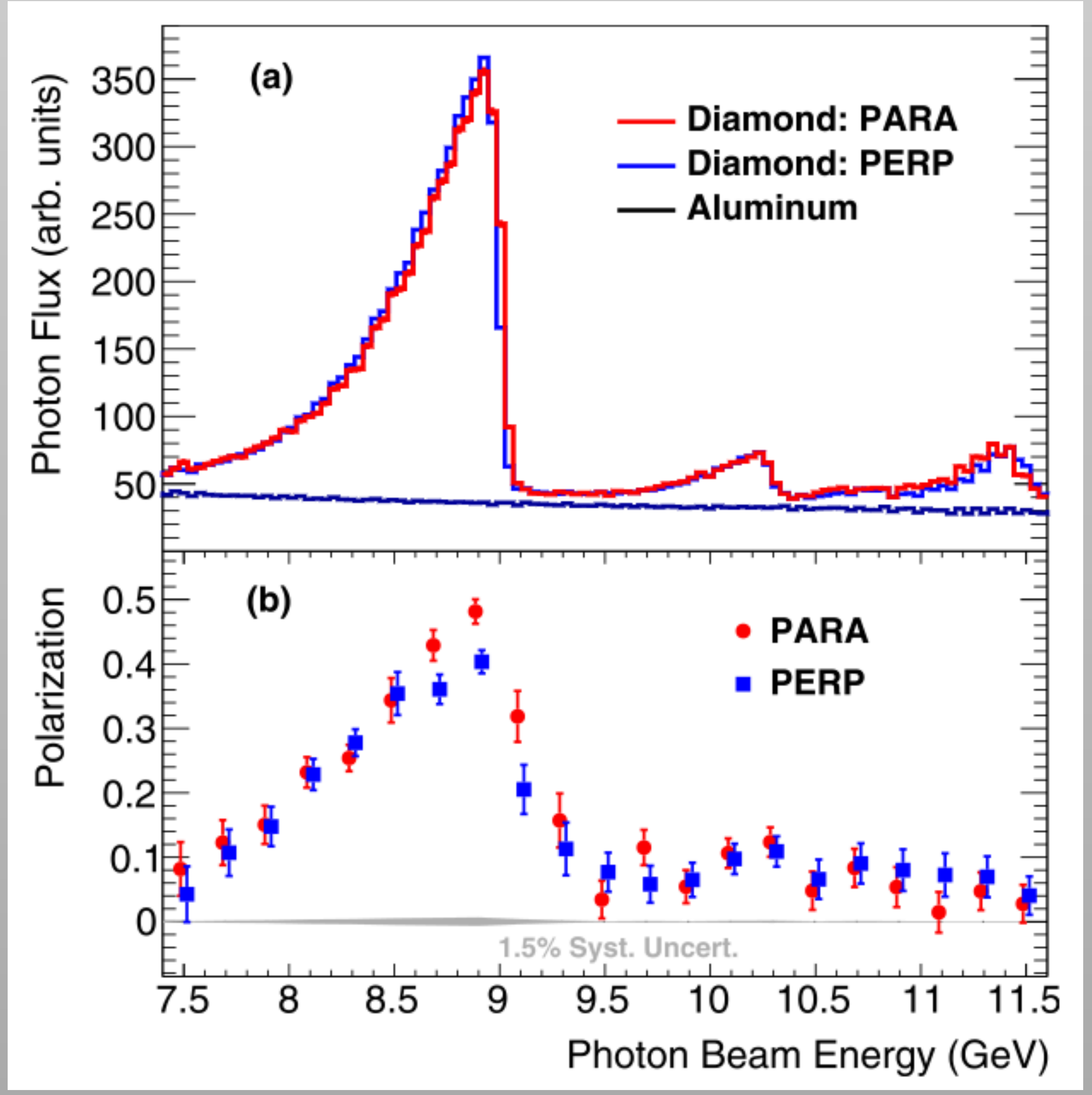
Strange Baryons from LQCD

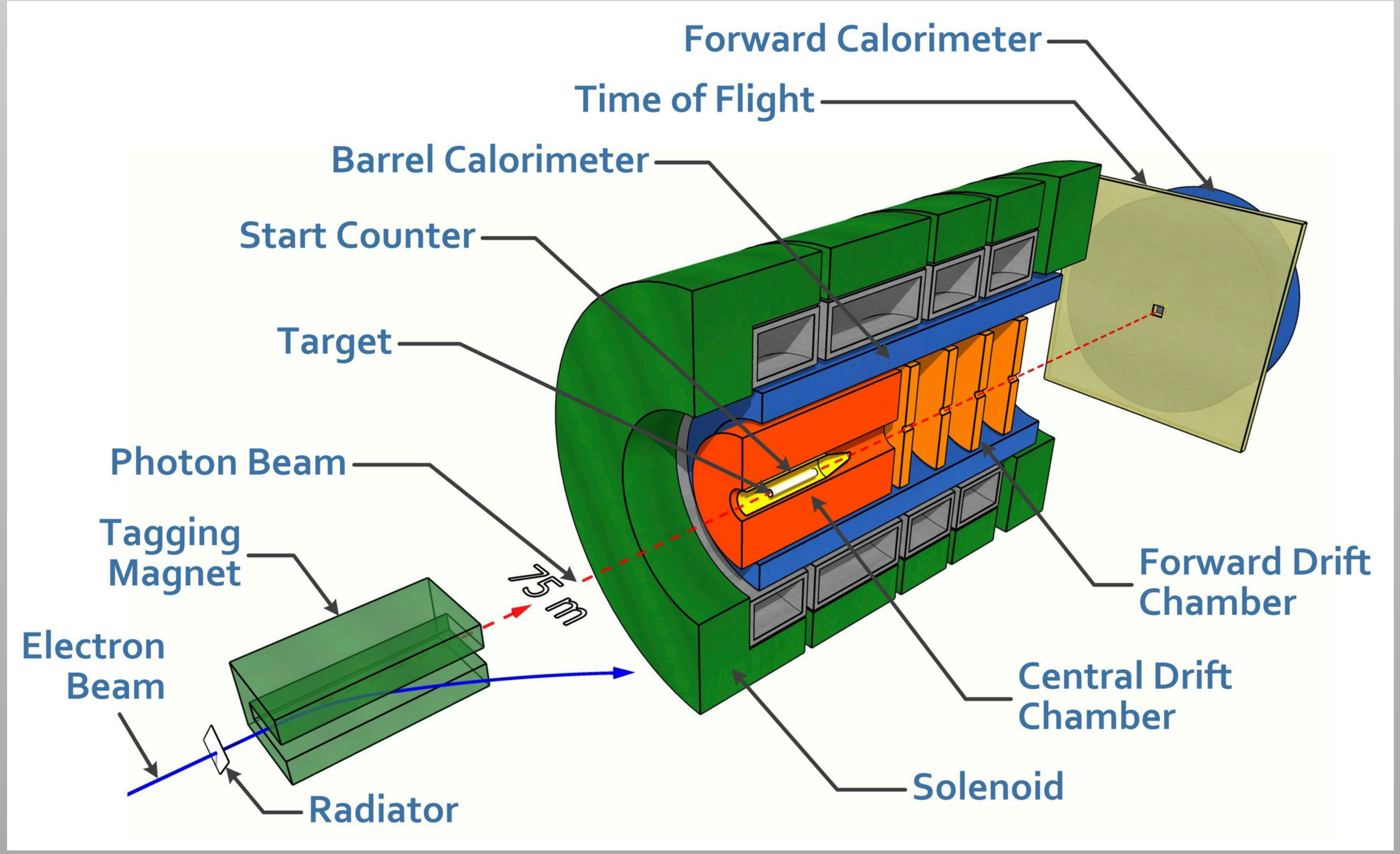
	LQCD* $(M < 2M_{\Omega})$	"Observed", PDG
N^*	62	21
Δ^*	38	12
Λ^*	71	14
Σ^*	66	9
Ξ^*	73	6
Ω^*	36	2

More states are predicted than observed

*R.G. Edwards et al, Phys.Rev.D 87 (2013) 5, 054506

The GlueX in Hall D





Since 2019: DIRC

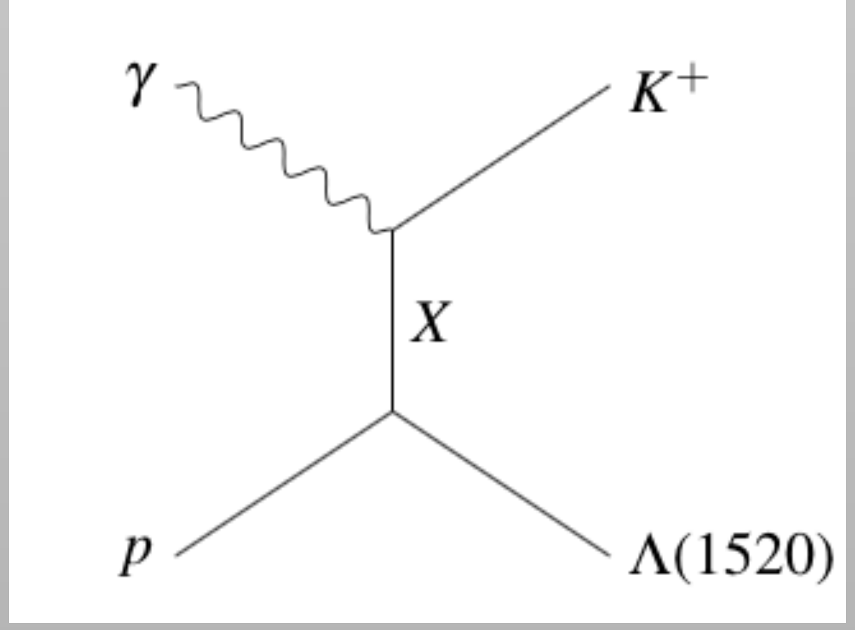
- Linearly-polarized, tagged real photon beam
- Acceptance: $\theta_{lab} = 1^\circ - 120^\circ$
- Charged particles: $\sigma_p/p \approx 1\% - 3\,\%$ (8% – 9% very-forward high-momentum tracks)
- Photons: $\sigma_E/E = 6\,\%/\sqrt{E} \oplus 2\,\%$

Slide from Peter Hurck (DPG 2024)

Selected Results: $\Lambda(1520)$

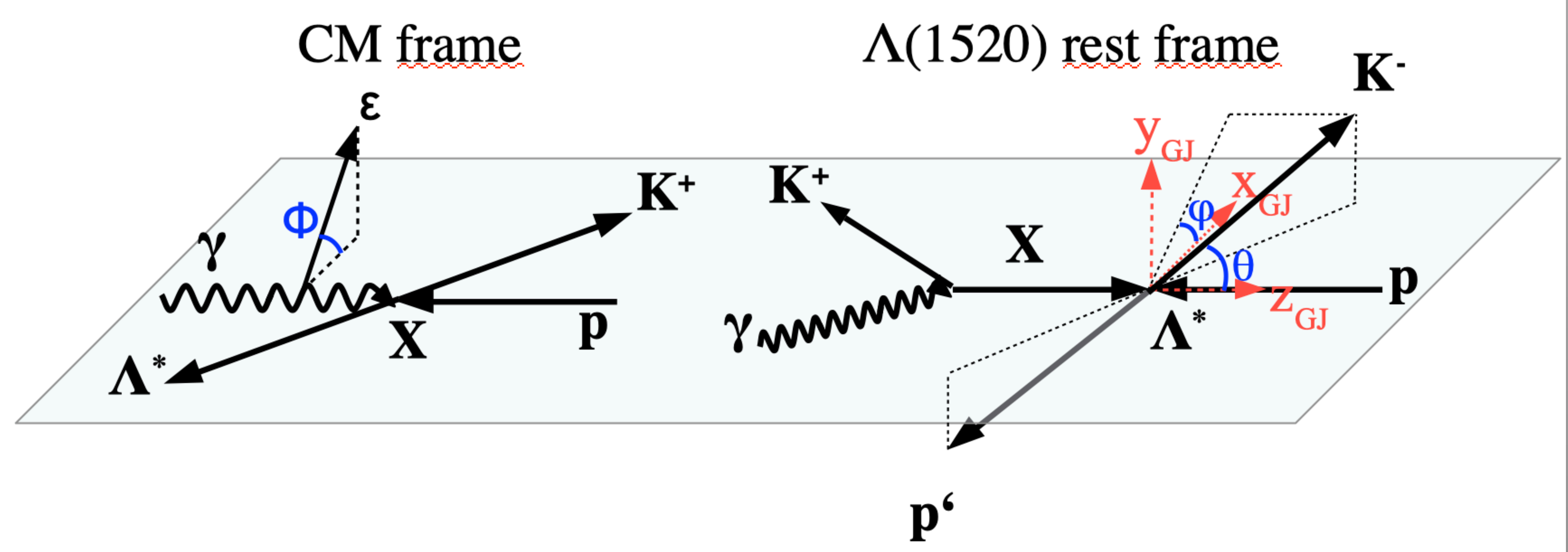
Production mechanism of $\Lambda(1520)$

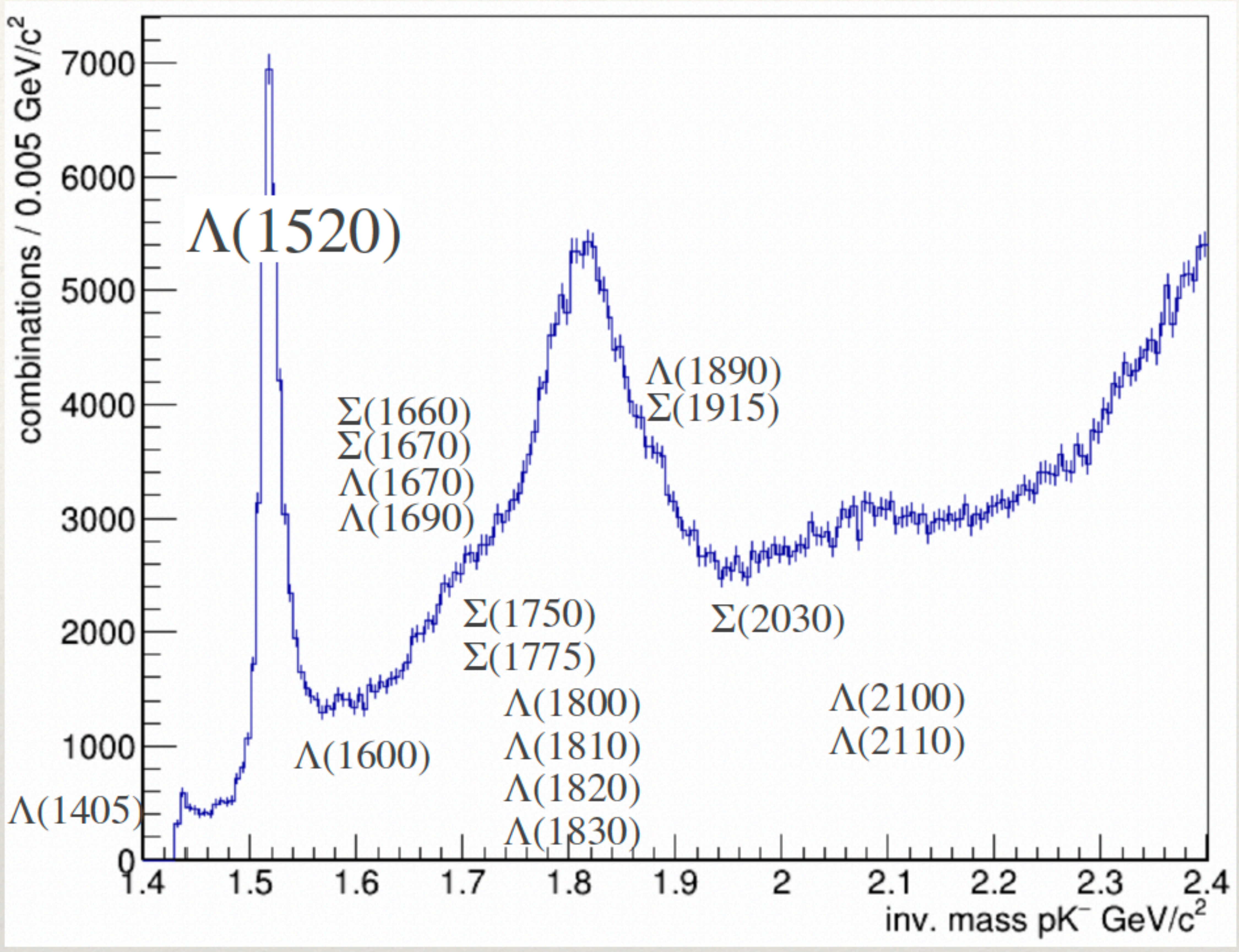
$$\vec{\gamma}p \rightarrow K^+\overrightarrow{\Lambda}^* \rightarrow K^+K^-p$$



- $E_\gamma = 8.2 - 8.8$ GeV
- K^+, K^-, p detected
- 10 spin-density matrix elements extracted by analyzing intensity distribution in GJ frame

At the GlueX energies, t—channel mechanisms expected to be dominant





Many excited Λ^* and Σ^* expected in the IM spectrum

Most prominent: $\Lambda(1520)$ with $J^P = \frac{3}{2}^-$

Slide from Peter Hurck (DPG 2024); Phys. Rev. C 105, 035201

Selected Results: $\Lambda(1520)$

Production mechanism of $\Lambda(1520)$

$$W(\theta,\phi,\Phi)=\frac{1}{2\pi}\frac{d\sigma}{dt}\frac{3}{4\pi}\Bigg\{\rho^0_{33}\sin^2\theta+\rho^0_{11}\left(\frac{1}{3}+\cos^2\theta\right)-\frac{2}{\sqrt{3}}\mathrm{Re}\rho^0_{31}\sin 2\theta\cos\phi-\frac{2}{\sqrt{3}}\mathrm{Re}\rho^0_{3-1}\sin^2\theta\cos 2\phi$$
$$-P_\gamma\cos 2\Phi\left[\rho^1_{33}\sin^2\theta+\rho^1_{11}\left(\frac{1}{3}+\cos^2\theta\right)-\frac{2}{\sqrt{3}}\mathrm{Re}\rho^1_{31}\sin 2\theta\cos\phi-\frac{2}{\sqrt{3}}\mathrm{Re}\rho^1_{3-1}\sin^2\theta\cos 2\phi\right]$$
$$-P_\gamma\sin 2\Phi\frac{2}{\sqrt{3}}\left[\mathrm{Im}\rho^2_{31}\sin 2\theta\sin\phi+\mathrm{Im}\rho^2_{3-1}\sin^2\theta\sin 2\phi\right]\Bigg\}.$$

$$\rho^0_{11}+\rho^1_{11}=\frac{2}{\mathcal{N}}(|N_0|^2+|N_1|^2),$$
$$\rho^0_{33}+\rho^1_{33}=\frac{2}{\mathcal{N}}(|N_{-1}|^2+|N_2|^2),$$
$$\mathrm{Re}(\rho^0_{31}+\rho^1_{31})=\frac{2}{\mathcal{N}}\mathrm{Re}(N_{-1}N_0^*-N_2N_1^*),$$

$$\mathrm{Re}(\rho^0_{3-1}+\rho^1_{3-1})=\frac{2}{\mathcal{N}}\mathrm{Re}(N_{-1}N_1^*+N_2N_0^*),$$
$$\rho^0_{11}-\rho^1_{11}=\frac{2}{\mathcal{N}}(|U_0|^2+|U_1|^2),$$
$$\rho^0_{33}-\rho^1_{33}=\frac{2}{\mathcal{N}}(|U_{-1}|^2+|U_2|^2),$$
$$\mathrm{Re}(\rho^0_{31}-\rho^1_{31})=\frac{2}{\mathcal{N}}\mathrm{Re}(U_{-1}U_0^*-U_2U_1^*),$$
$$\mathrm{Re}(\rho^0_{3-1}-\rho^1_{3-1})=\frac{2}{\mathcal{N}}\mathrm{Re}(U_{-1}U_1^*+U_2U_0^*).$$

t-channel exchange particle with J^P and naturality $\eta=P(-1)^J$

N: $\eta=1$, such as $K^*(892), K_2^*(1430)$

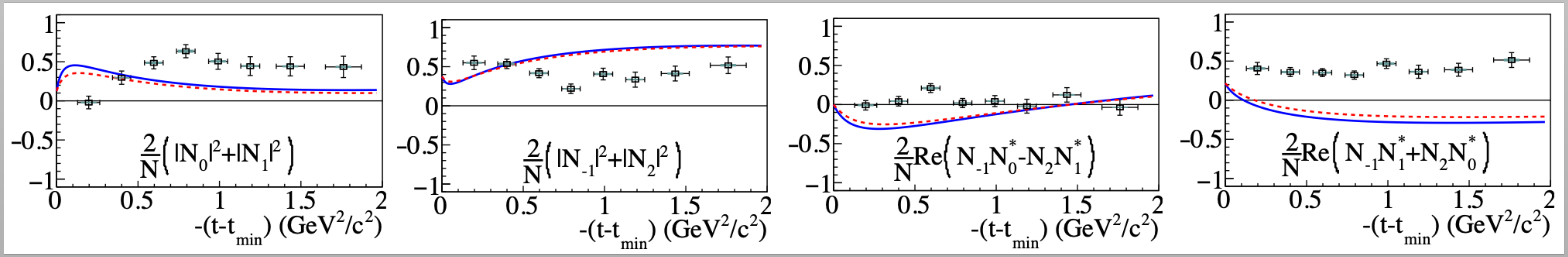
U: $\eta=-1$, such as $K(492), K_1(1270)$

S. Adhikari et al., Phys. Rev. C 105, 035201(2022)

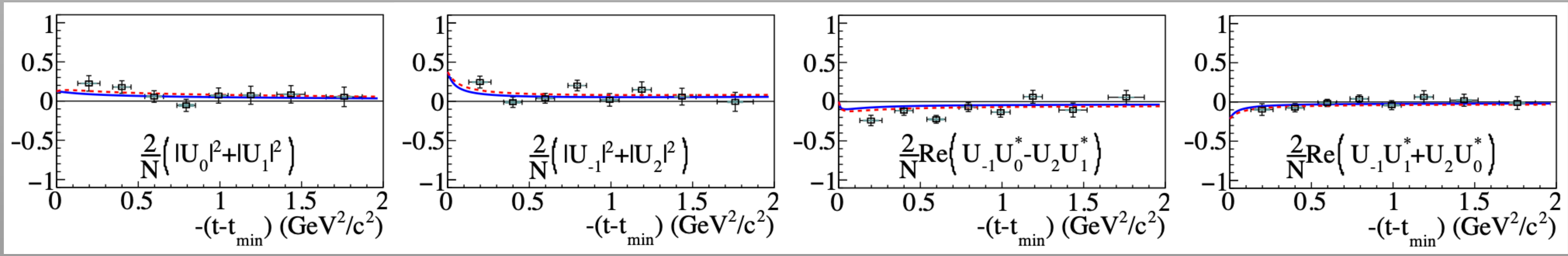
Selected Results: $\Lambda(1520)$

Production mechanism of $\Lambda(1520)$: dominated by natural-exchange amplitudes

Natural

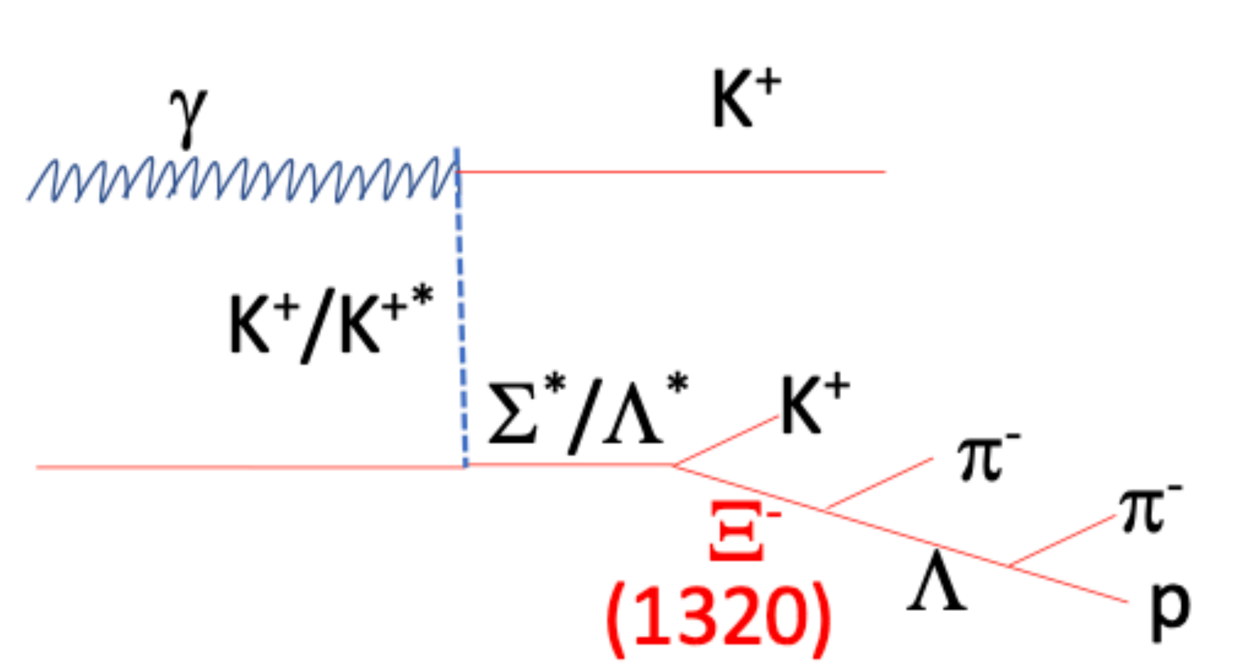


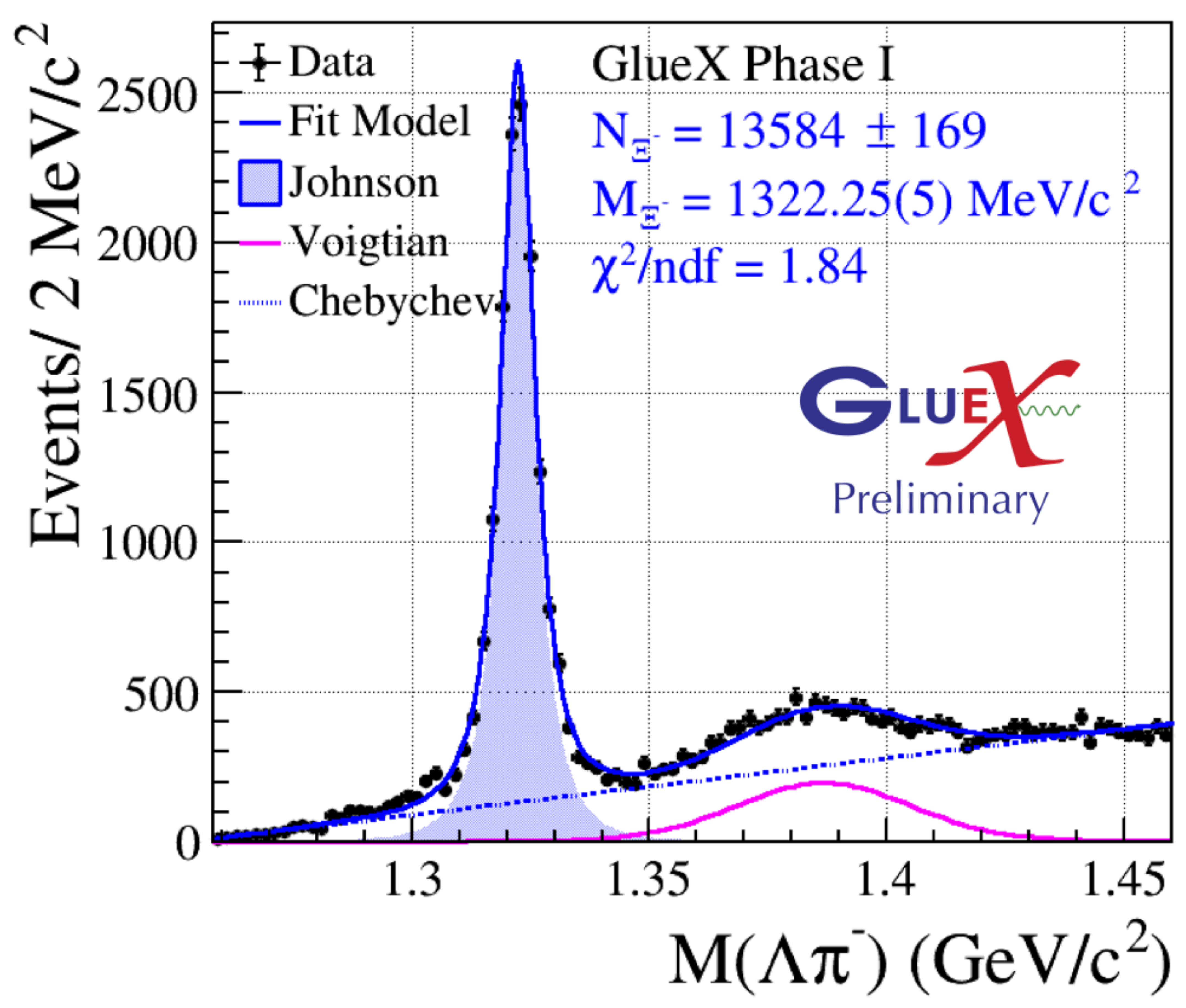
Unnatural



S. Adhikari et al. (GlueX Collaboration), Phys. Rev. C 105, 035201 (2022)   Byung-Geel Yu and Kook-Jin Kong, Phys. Rev. C 96, 025208 (2017)

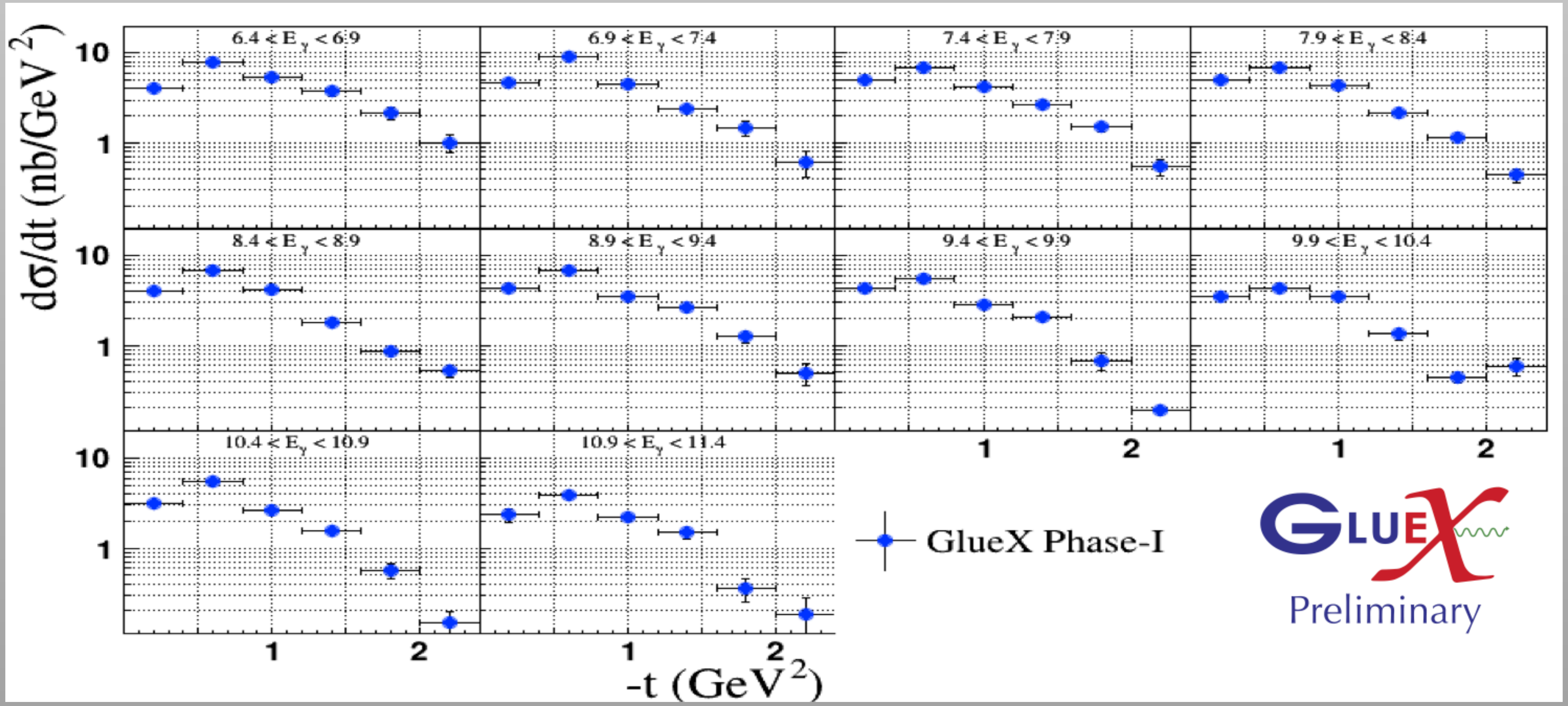
Selected Results: $\Xi^-(1320)$

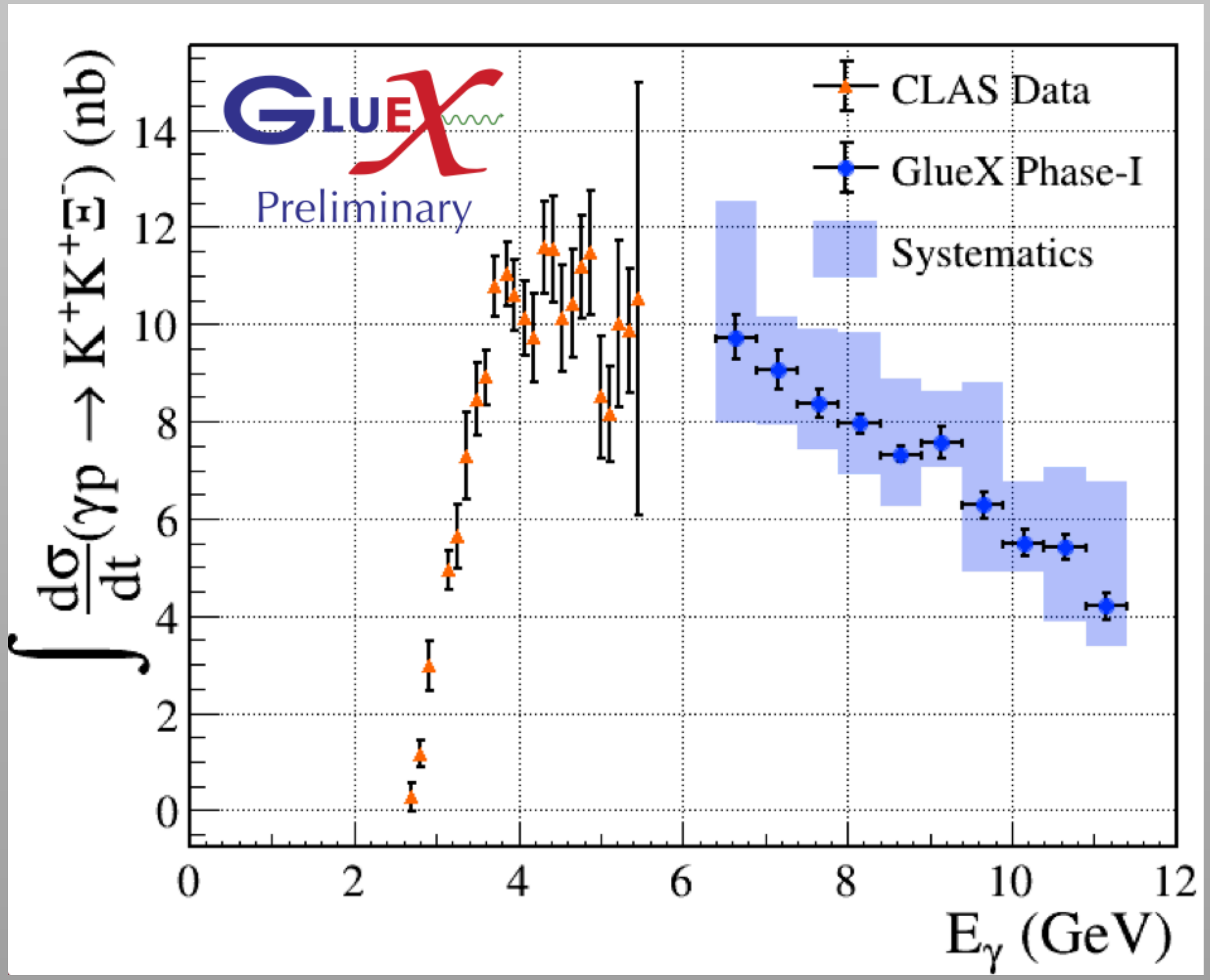




P.Hurck (DPG 2024), J. Hernandes (Baryon 2022)

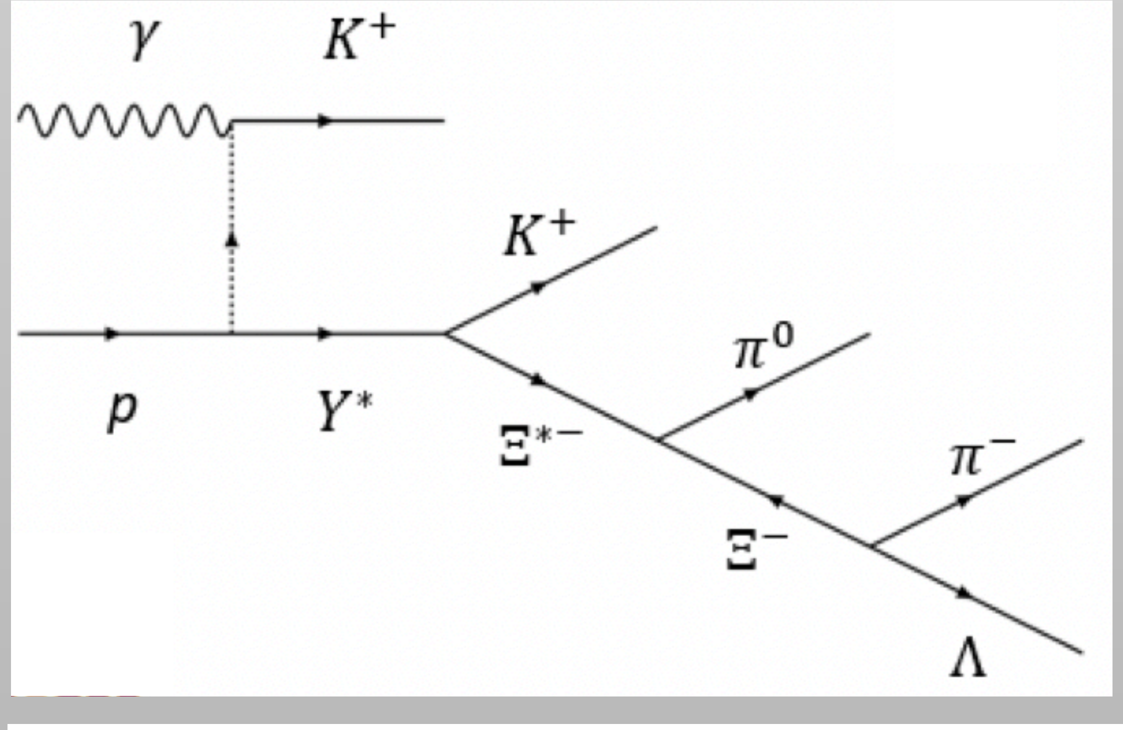
Selected Results: $\Xi^-(1320)$

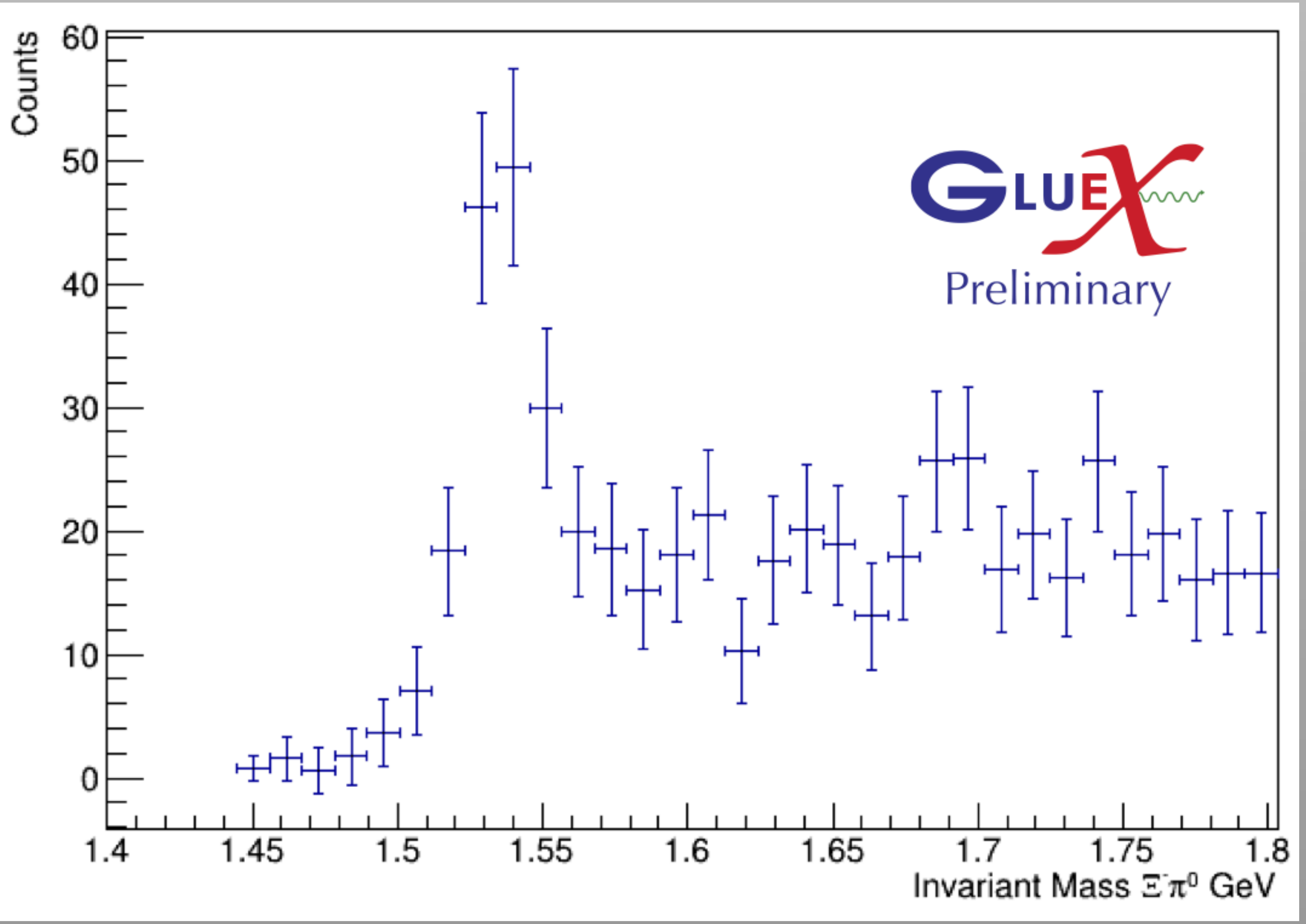


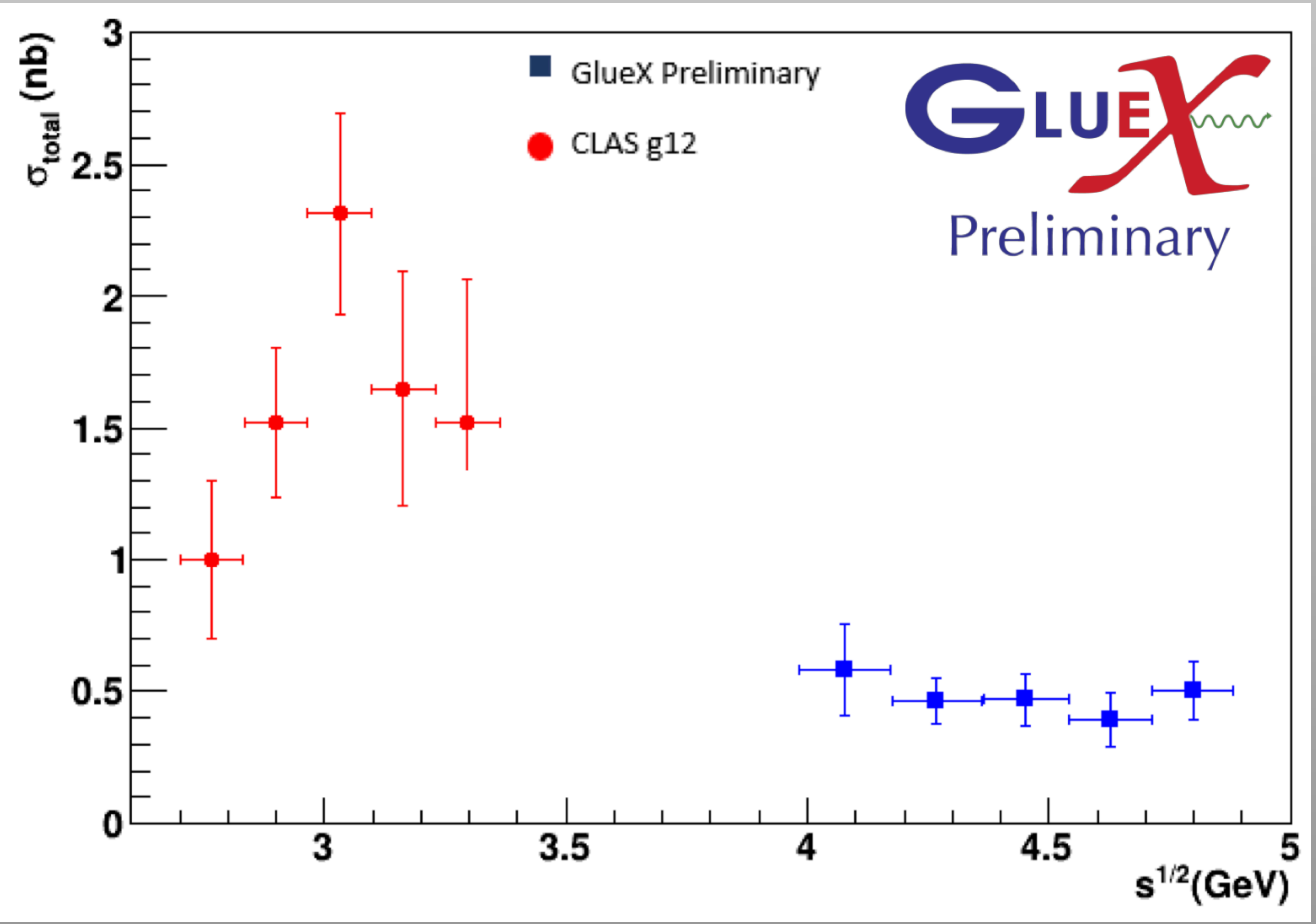


P.Hurck (DPG 2024), J. Hernandes (Baryon 2022)

Selected Results: $\Xi^* - (1530)$

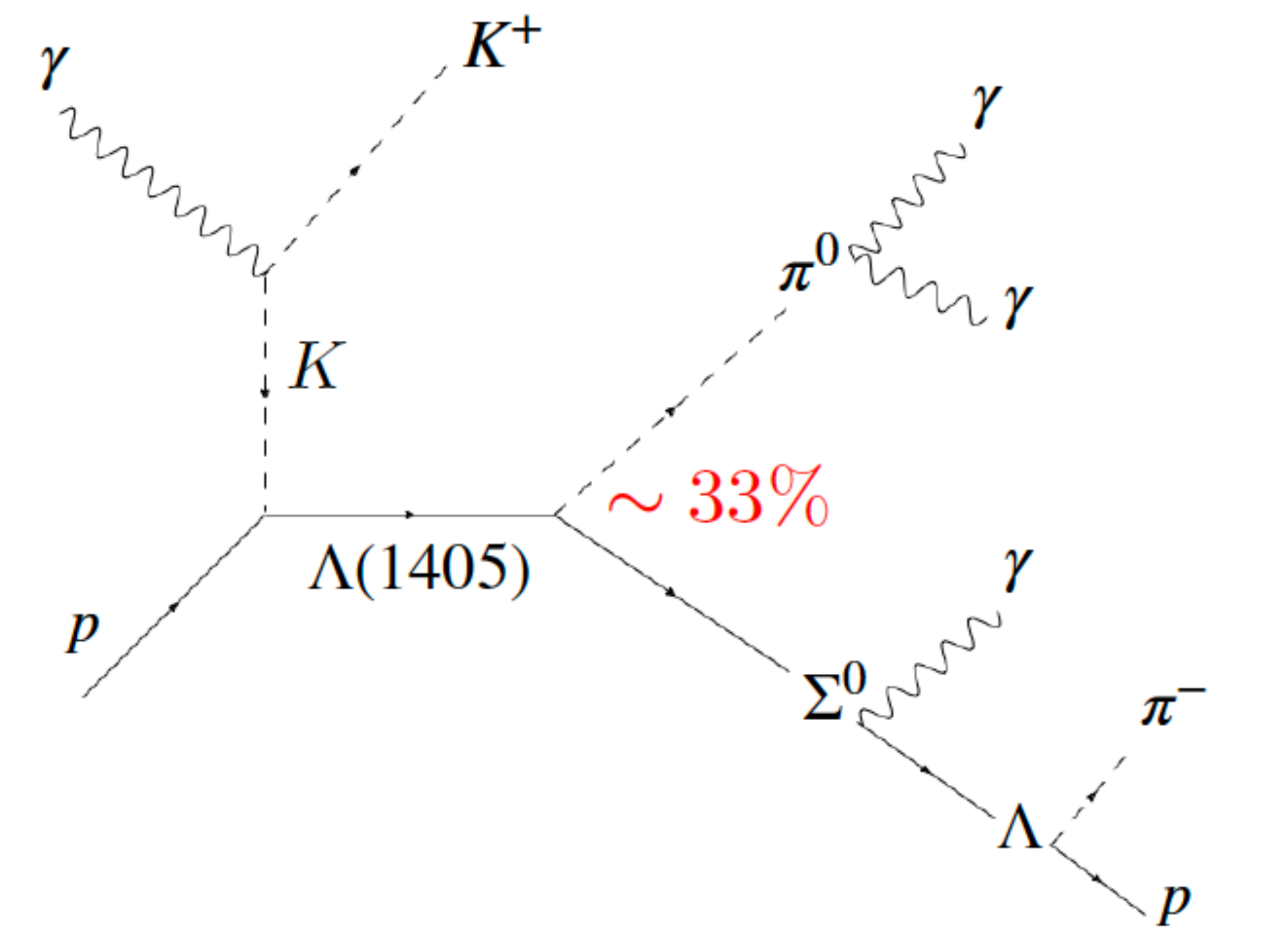


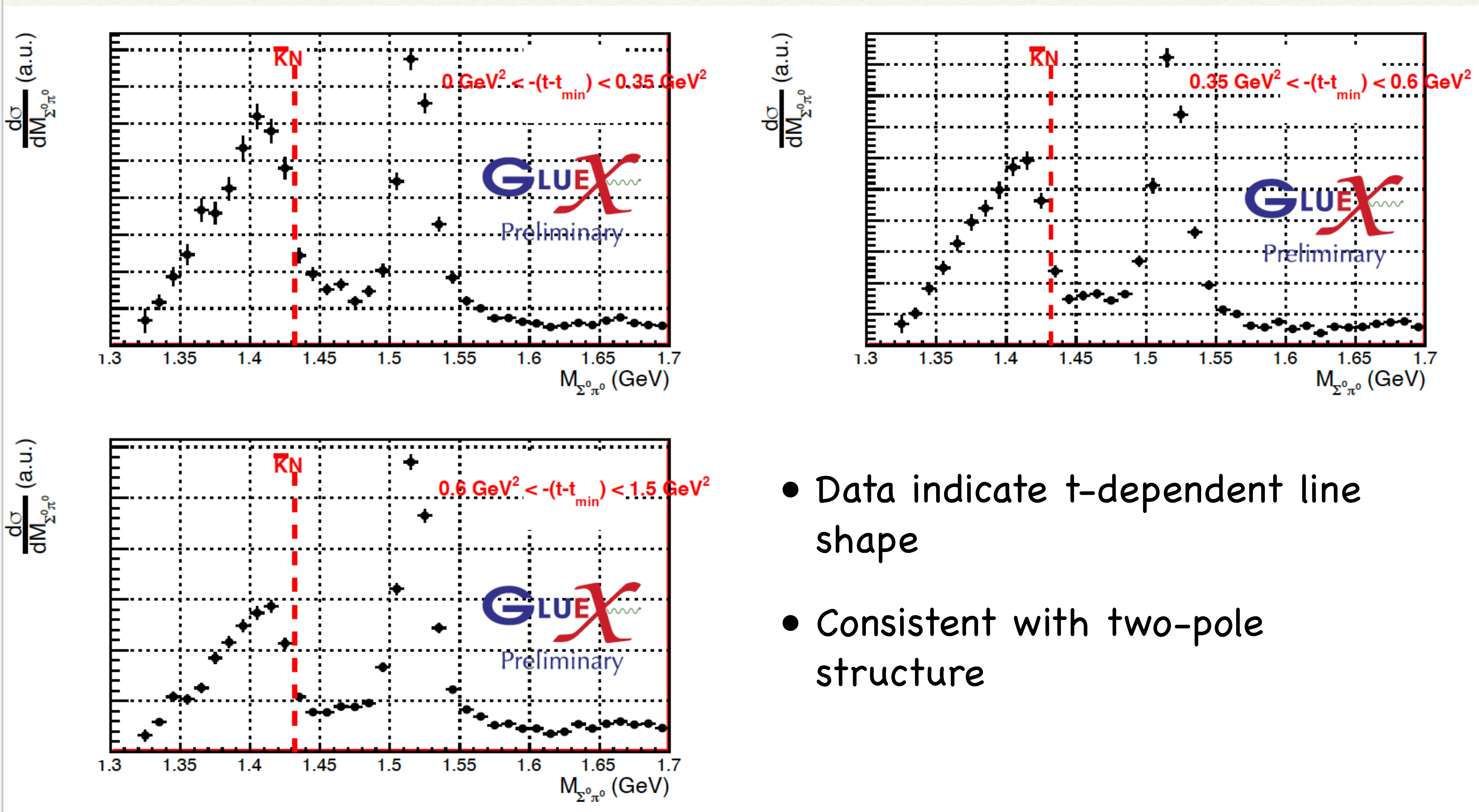




P.Hurck (DPG 2024), B. Sumner (GHP 2023).

Selected Results: $\Lambda(1405)$





- Previous measurements: non Breight-Wigner line shape
- Two-pole structure suggested by many theoretical models
- Recent PDG addition: $\Lambda(1380) **$

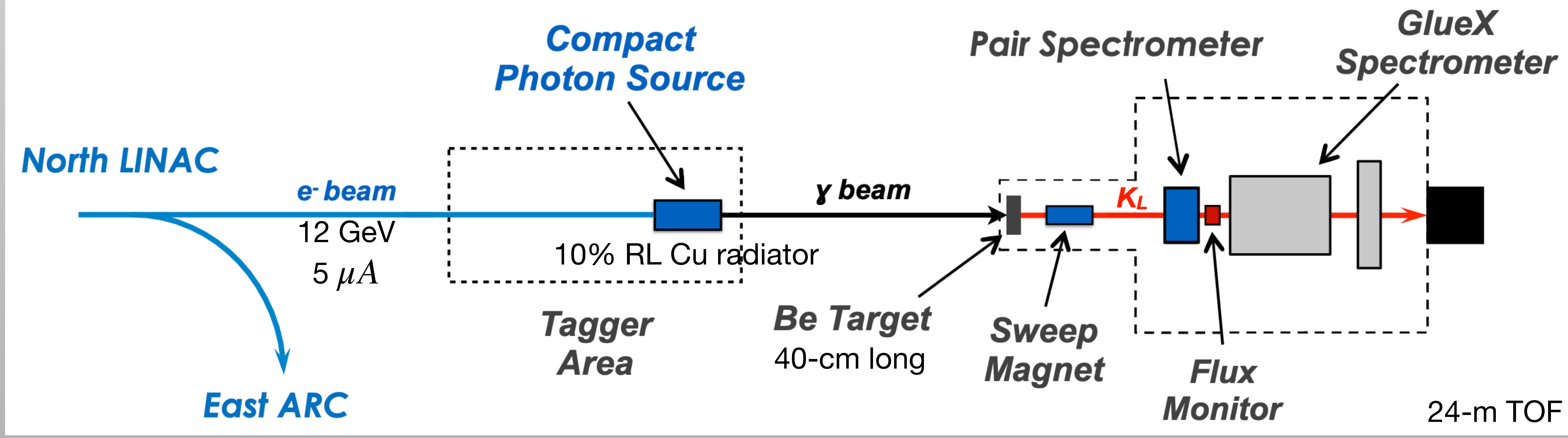
- Data indicate t-dependent line shape
- Consistent with two-pole structure

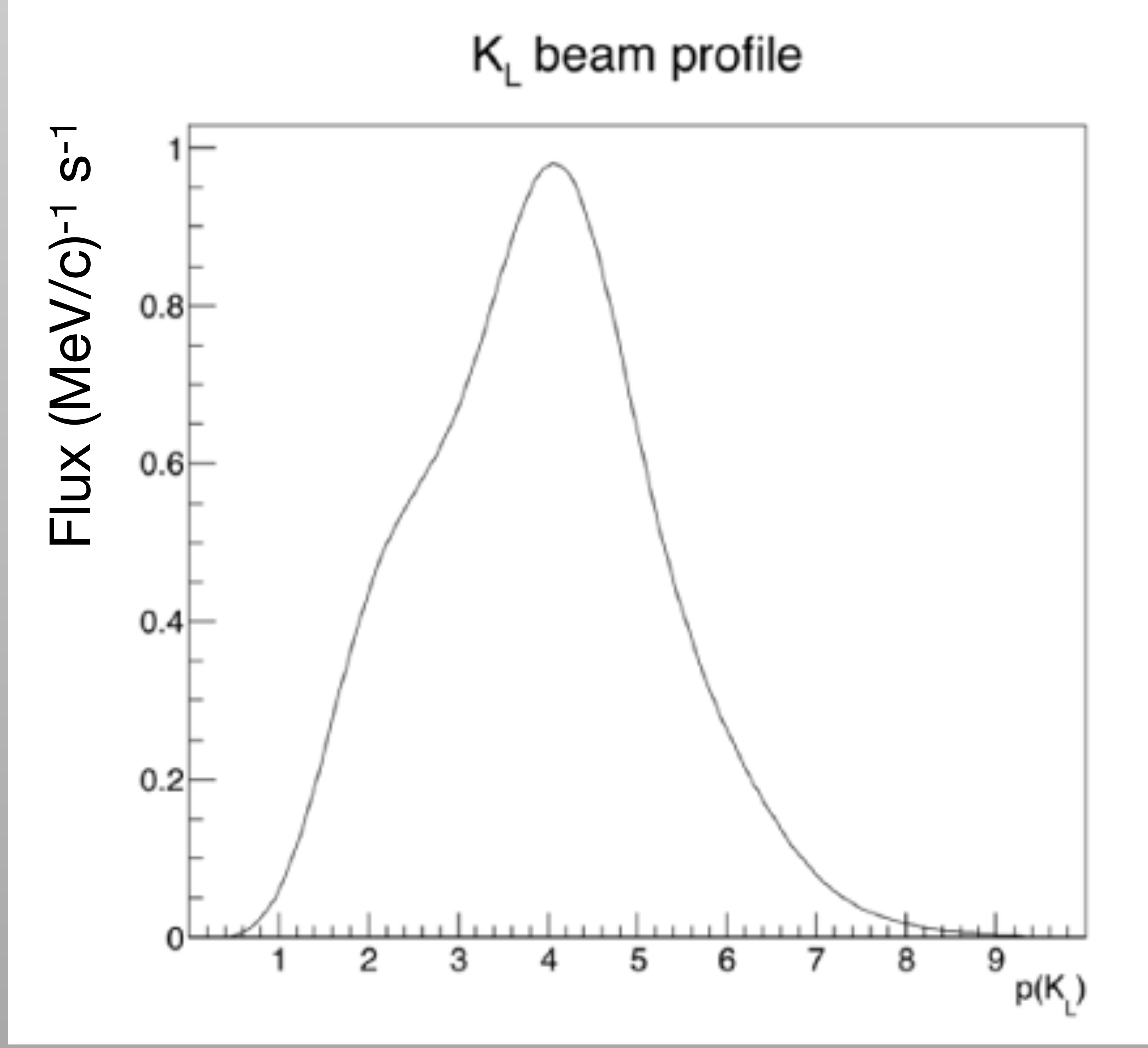
P.Hurck (DPG 2024), N. Wikramaarachchi (JLUO 2023).

Future: KLong Facility in Hall D

arXiv:2008.08215v3
KLF proposal 2020: Strange Hadron Spectroscopy with Secondary KL Beam in Hall D, C12-19-001

KLong Facility (KLF)





- New kaon beam facility approved to run 200 days in Hall D
  - LH2 target: approved 100 days
  - LD2 target: approved 100 days
- Intense KL beam: 10^4 kaons/s on target
- Low background levels
- Exclusive final states

Timelines

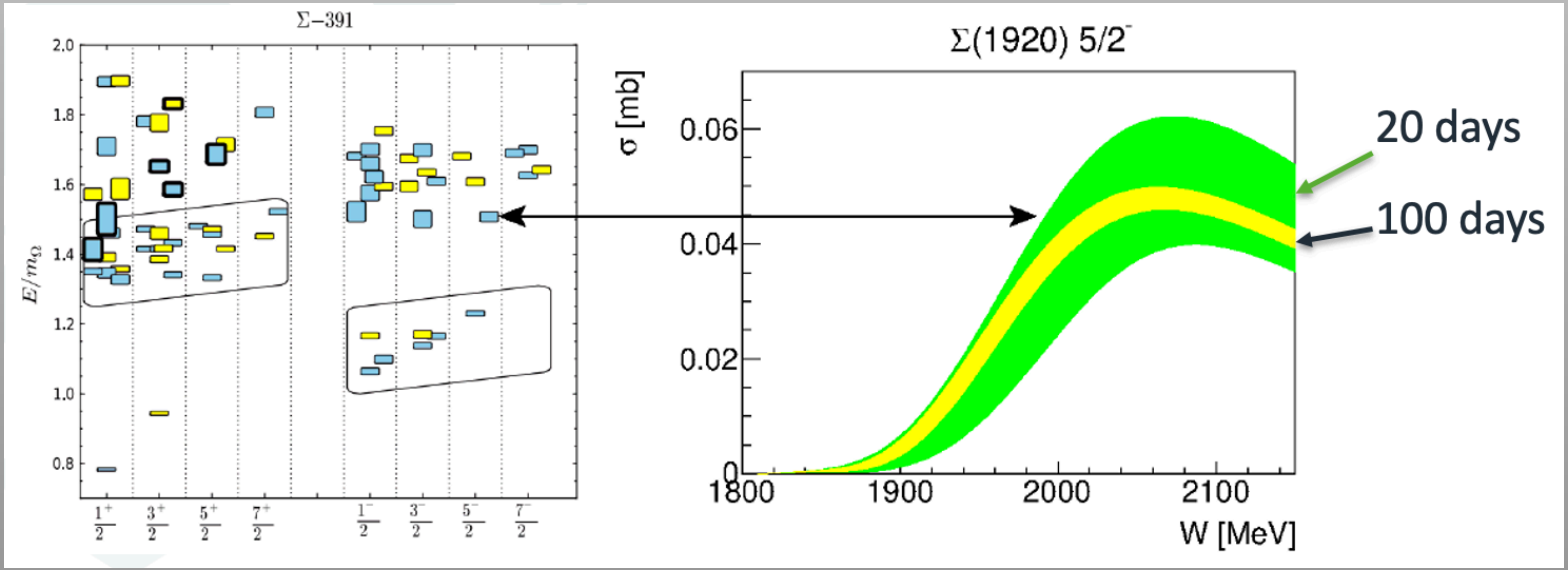
- Installation: March 2025 - June 2026
- Run: June 2026 - March 2027, June 2027 - March 2028

P.Hurck (DPG 2024), M. Bashkanov (MESON2023)

KLF Strange Hyperon Program: Example

Differential cross sections and induced polarizations of $\Lambda, \Sigma, \Xi,$ and Ω hyperons for $\cos\theta_{CM} = -0.95 - 0.95$ and $W = 1490 - 2500$ MeV (input to PWA to extract properties of strange hyperon resonances)

$K_L p \to \Sigma^* \to K^+ \Xi^0$



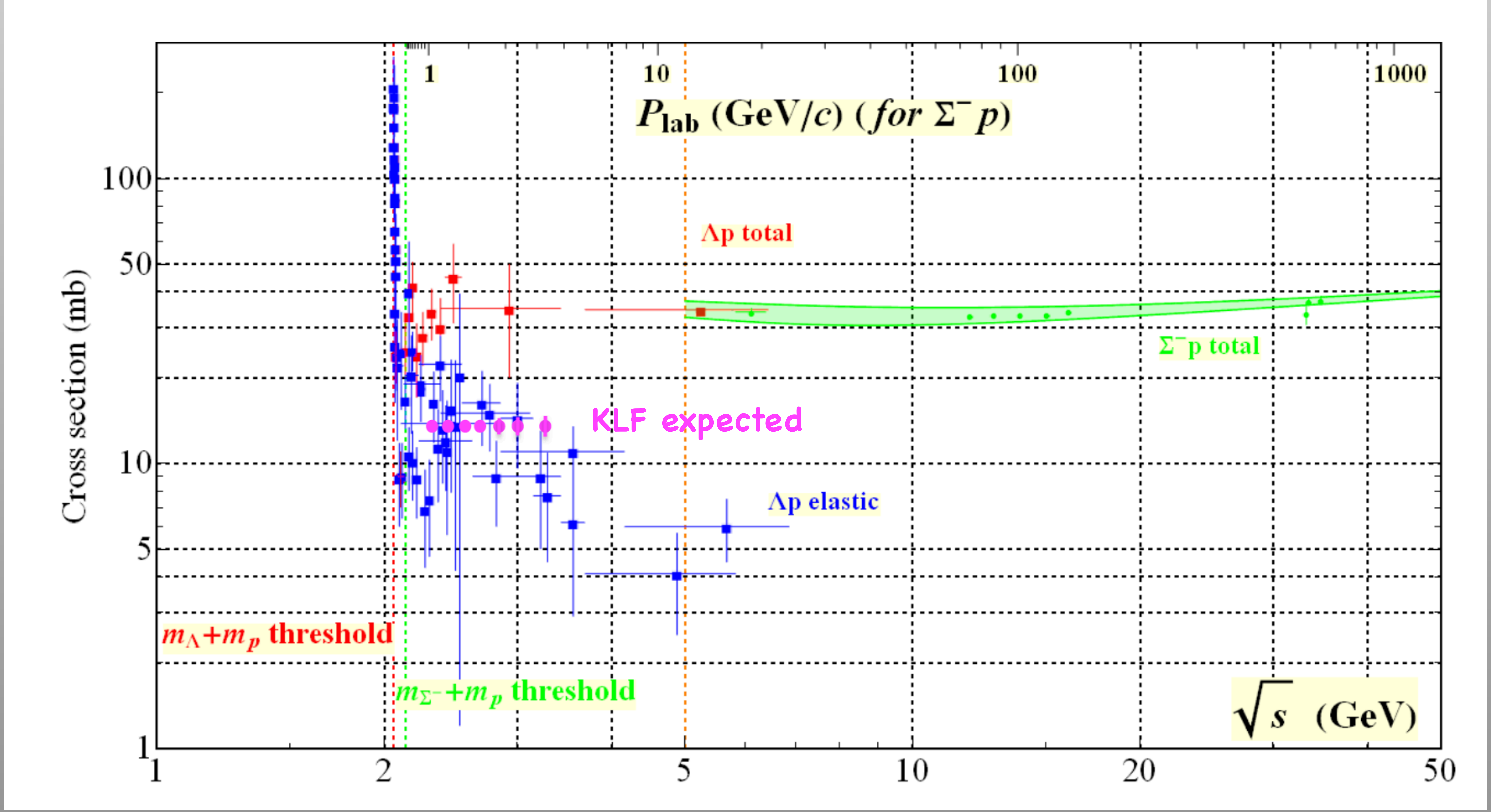
Σ Factory:

$K_L p \to \Sigma^* \to K_s p$
$K_L p \to \Sigma^* \to \pi^+ \Lambda$
$K_L p \to \Sigma^* \to K^+ \Xi^0$
$K_L p \to \Sigma^* \to \pi^0 \Sigma^+$
$K_L p \to \Sigma^* \to \eta \Sigma^+$
$K_L p \to \Sigma^* \to \omega \Sigma^+$
$K_L p \to \Sigma^* \to \eta' \Sigma^+$

R.G. Edwards et al, Phys.Rev.D 87 (2013), 054506

C12-19-001: Strange Hadron Spectroscopy with Secondary KL Beam in Hall D (2019)

KLF Strange Hyperon Program: YN



Tagged hyperon beams via:

$K_L p \to \pi^+ \Lambda/\Sigma$

$K_L p \to K^+ \Xi$

C12-19-001: Strange Hadron Spectroscopy with Secondary KL Beam in Hall D (2019)

Conclusion

Diverse physics programs with hyperons have been established at JLab in all experimental halls.

Data mining in Hall B has published Λp elastic total cross sections for $p_\Lambda = 0.9 \div 2.0$ GeV/c Direct-scattering technique established. Work on Λd elastic total and differential cross section is in progress.

Photoproduction in Hall D explores production mechanisms of Y*, line shape of $\Lambda(1405)$, and provides cross sections for cascades.

KLF in Hall D will provide K_L beam of 10^4 K/s for rich strangeness physics.

The End