MESON2026, Krakow, June 2026

Avraham Gal, HU, Jerusalem, Israel

Revisiting $\eta'(958)$ nuclear states

η'−^{11}C bound states in $^{12}\mathrm{C}(p,d)$ at GSI with high-momentum backward protons

R. Sekiya, et al., PRL 136 (2026) 142501

Friedman-Gal, PLB 870 (2025) 139916

Questioning MAMI's extraction of $B_\Lambda(^3_\Lambda\mathrm{H})$ in $^7\mathrm{Li}(e,e'K^+)$

R. Kino, et al., PRL 136 (2026) 152301

A. Gal, arXiv:2604.18259

$\mathbf{V}_{\rm opt}(\rho)$ phenomenology background:

$$\Lambda N \quad \Rightarrow \quad V_{\Lambda}^{(2)}(\rho) = -\frac{4\pi}{2\mu_{\Lambda}}\, b_0^{\rm lab}(\rho)\,\rho$$

$$b_0^{\rm lab}(\rho) = \frac{b_0^{\rm lab}}{1+\frac{3k_F}{2\pi}\,b_0^{\rm lab}}, \qquad b_0^{\rm lab} = (1+\frac{A-1}{A}\frac{\mu_{\Lambda}}{m_N})\,b_0,$$

for Pauli correlations, with $\mathbf{k}_F = (3\pi^2\rho/2)^{1/3}$.

Short-range correlations negligible at $\rho \le \rho_0$.

Pauli affects terms beyond $\rho^{4/3}$, e.g., ρ^2.

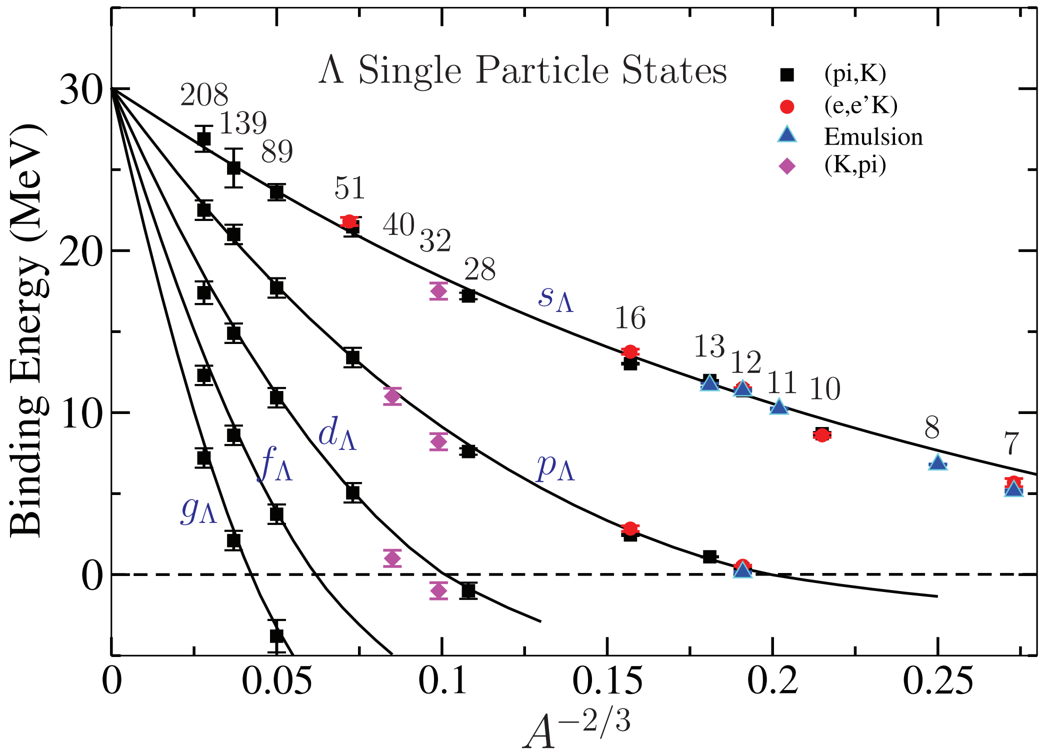
Low density limit: $\mathbf{b}_0 = \mathbf{a}_{\Lambda N}$ (scattering length).

Pauli is applied normally only to Re $\mathbf{b}_0$.

$$\Lambda N N \;\; \Rightarrow \;\; V_{\Lambda}^{(3)}(\rho) = +\frac{4\pi}{2\mu_{\Lambda}}\,(1+\frac{A-2}{A}\frac{\mu_{\Lambda}}{2m_N})\,B_0\,\frac{\rho^2}{\rho_0}.$$

Applying Pauli to $\mathbf{V}_{\Lambda}^{(3)}(\rho)$ has a minor effect.

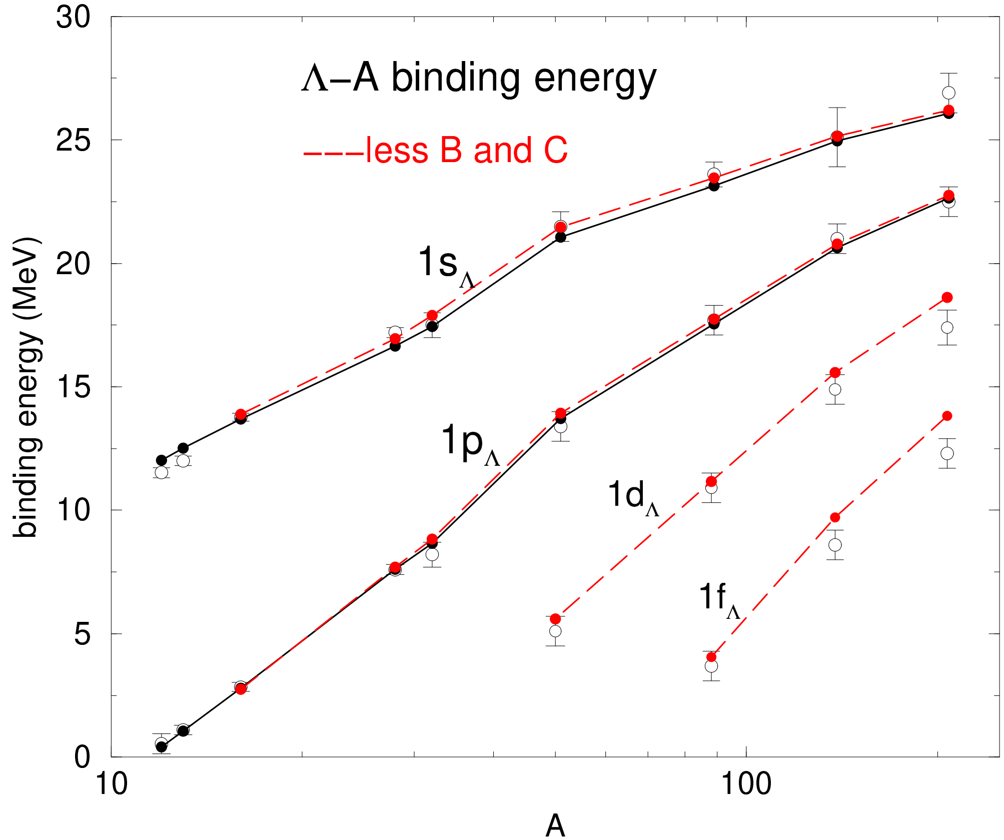
Update: Millener, Dover, Gal PRC 38, 2700 (1988)



Woods-Saxon $V = 30.05$ MeV, $r = 1.165$ fm, $a = 0.6$ fm

B_Λ values in ${}^{7}_{\Lambda}$Li to ${}^{208}_{\Lambda}$Pb from experiment and as calculated from a 3-parameter WS potential, suggesting a Λ-nucleus potential depth $D_\Lambda \approx -30$ MeV.

Data: Table IV Gal-Hungerford-Millener, RMP 88 (2016) 035004.



Fitting b_0 & B_0 to $B_\Lambda(A)$

$\vec{\tau}_1 \cdot \vec{\tau}_2$ in $\Lambda N_1 N_2$ OPE implies $\rho^2 \rightarrow (\rho^2_{\rm sym} + \rho^2_{\rm exc})$,

resulting in $\chi^2/19 = 0.95$ for 21 data points.

Friedman-Gal, Acta Phys. Pol. B 57 (2026) 2-A16

Λ hypernuclei summary

- $\mathbf{V}^{\Lambda}_{\rm opt}(\rho)$ applied to ($1s_\Lambda$, $1p_\Lambda$, $1d_\Lambda$, $1f_\Lambda$) s.p. states across the periodic table.
- Pauli corrected ΛN term, plus ΛNN term.
- Decoupling $\rho_{\rm exc}$ from $\rho_{\rm sym}$ in $\Lambda N_1 N_2$ ρ^2 term is motivated by $\vec{\tau}_1 \cdot \vec{\tau}_2$ isospin structure in $\Lambda \to (\Sigma, \Sigma^*) \to \Lambda$ isovector excitations.
- Depth values $D^{(2)}_\Lambda$ & $D^{(3)}_\Lambda$ fully correlated: $D^{(2)}_\Lambda$=$-$37.5$\mp$0.7 MeV with b_0=1.32$\pm$0.07 fm, $D^{(3)}_\Lambda$=9.8$\pm$1.2 MeV, D_Λ=$-$27.7$\pm$0.5 MeV.
- $D^{(3)}_\Lambda$ $\approx$10 MeV excludes in EFT Λ hyperons from dense neutron-star matter, $\mu_\Lambda > \mu_n$, see Gerstung-Kaiser-Weise, EPJA 56 (2020) 175.

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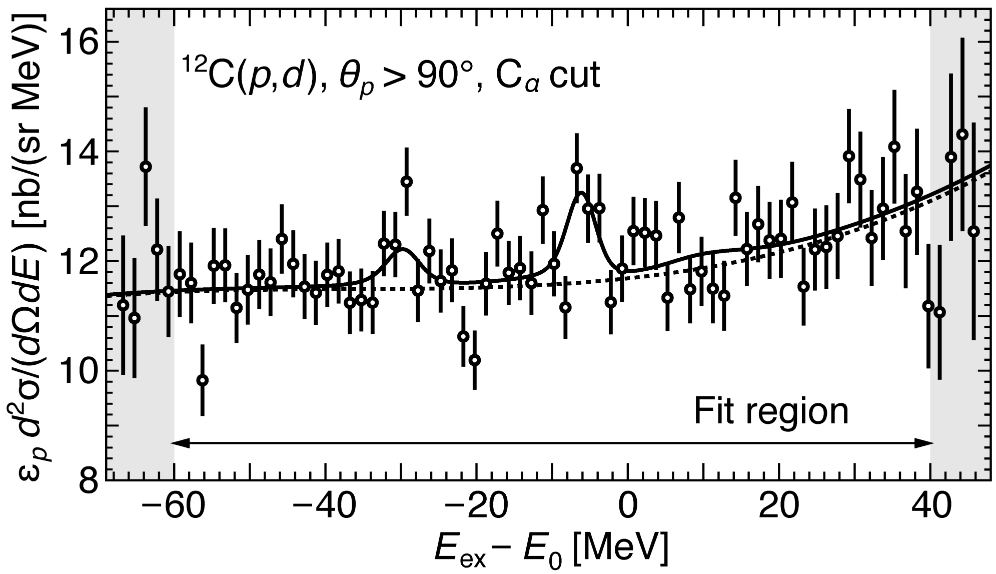


Excitation spectrum near η' emission threshold E_0

Bound state signals at -30 and -6 MeV ?

Implying $V_{\eta'}(\rho_0) \approx -60$ MeV $\sim V_N(\rho_0) \sim 2 \times V_\Lambda(\rho_0)$

Compatibility with $a_{\eta' N}$?

$\mathbf{a}_{\eta' N}$ experimental input

Near-threshold pp→ppη' production @COSY:

Re $\mathbf{a}_{\eta' p}$=(0.00±0.43) fm, Im $\mathbf{a}_{\eta' p}$=$0.37^{+0.02+0.28}_{-0.11-0.05}$ fm.

Near-threshold $\gamma p \to \eta' p$ photoproduction experiments:

$|a_{\eta' p}|$=(0.403±0.020±0.060) fm $\to$ (0.356±0.012) fm,

if no η'N s-wave resonance exists near threshold (1896 MeV).

Using $\mathrm{V}_{\eta'}(\rho)$ from Friedman-Gal, PLB 870 (2025) 139916,

these constraints suggest η' nuclear potential depths

in the range $\mathrm{D}_{\eta'} \approx$ (-17±6) - i(27±6) MeV,

with almost no chance for $\eta'-{}^{11}$C bound states.

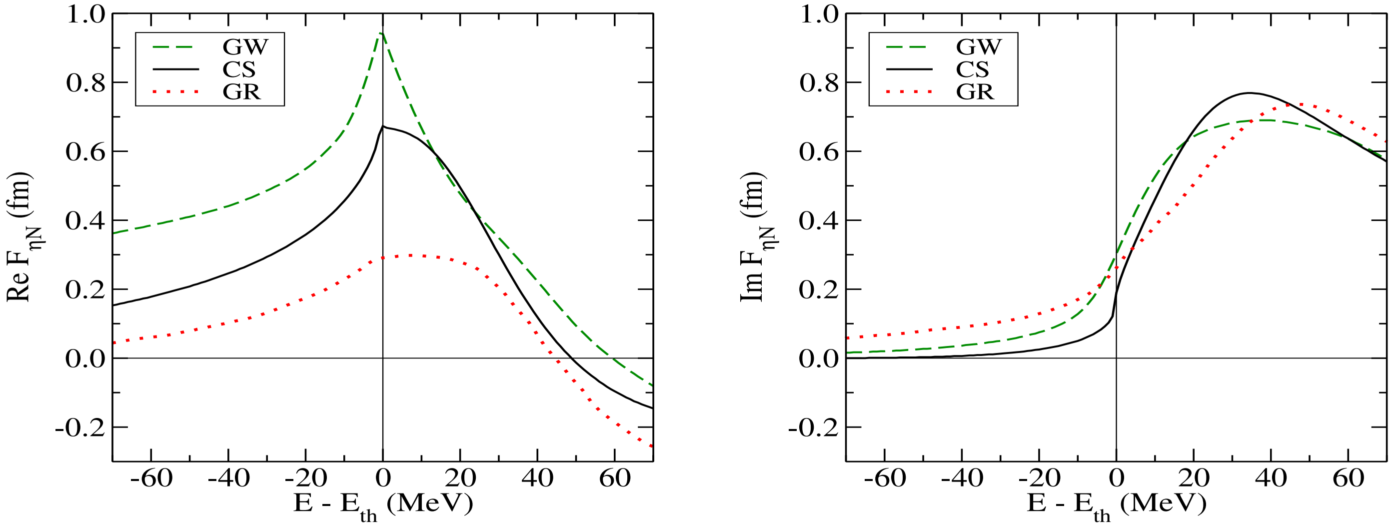
As for the nearby s-wave broad resonance N*(1895),

look up Bruns-Cieply & Sakai-Jido,

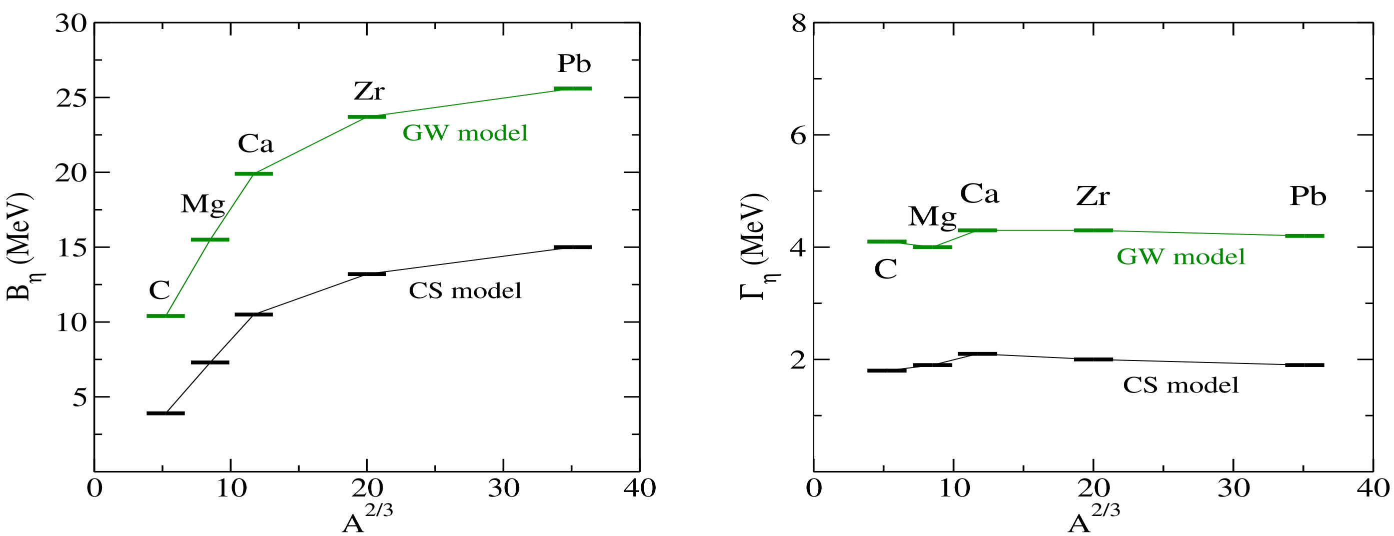
NPA 992 (2019) 121630, PRC 107 (2023) 025207.

Lessons from $a_{\eta N}$ vs. N*(1535) resonance?

s-wave $F_{\eta N}$ in two $N^*(1535)$ models



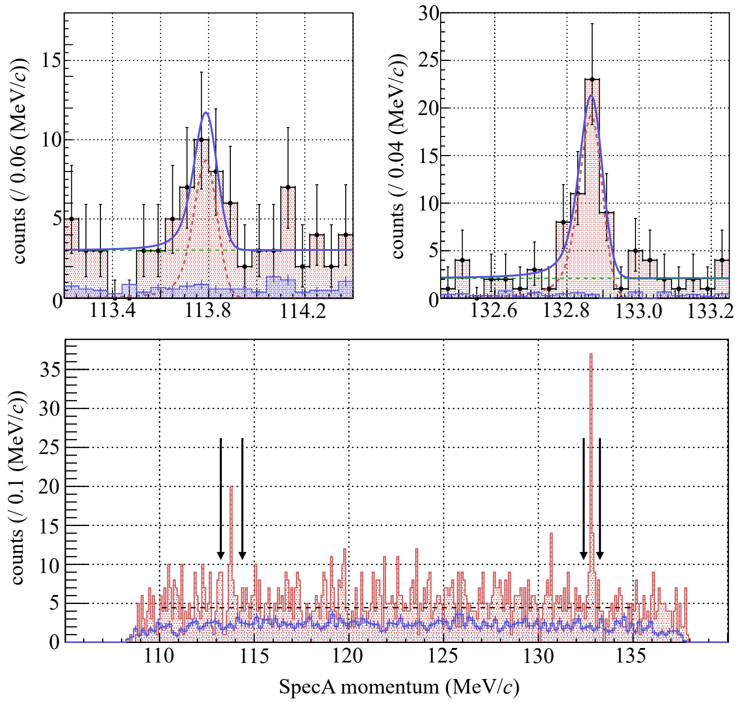
1s η-nuclear bound states in two models



Cieply-Friedman-Gal-Mareŝ, NPA 925 (2014) 126

Questioning MAMI's extraction of $B_\Lambda({}^3_\Lambda\mathrm{H})$ in ^{7}Li$(e,e'K^+)$

R. Kino, et al., PRL 136 (2026) 152301



Decay $p(\pi^-)$ spectrum in ^{7}Li$(e,e'K^+)$ from MAMI

$p(\pi^-)$ peaks attributed to ${}^3_\Lambda$H (left) and ${}^4_\Lambda$H (right).

Why not ${}^7_\Lambda$He ?

How large is $B_\Lambda({}^3_\Lambda\mathrm{H})$?

MAMI: B_Λ=0.523±0.013±0.075 MeV

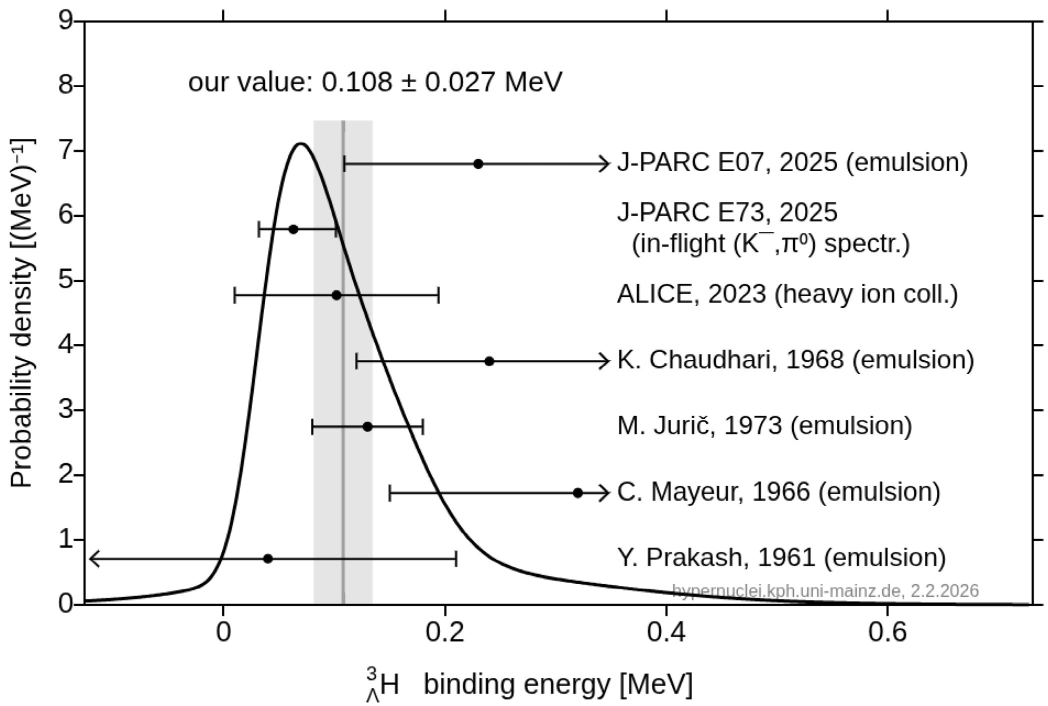
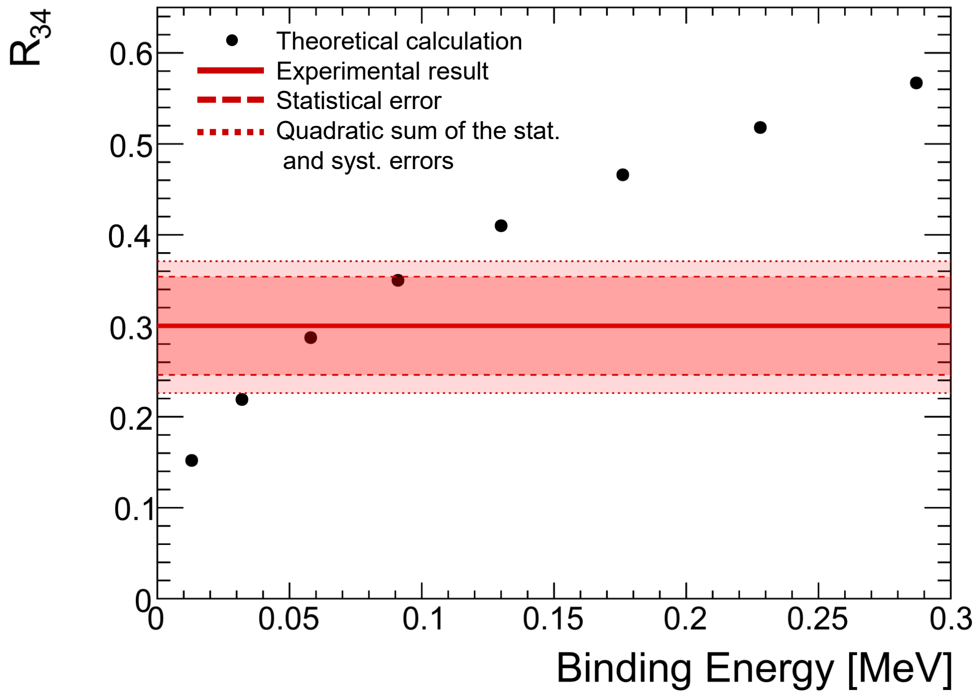


Chart of Hypernuclei before MAMI

At present, cites $0.181^{+0.102}_{-0.040}$ MeV

J-PARC E73 $^{3,4}\mathrm{He}(K^-,\pi^0)^{3,4}_{\Lambda}\mathrm{H}$



$^{3,4}_{\Lambda}$H production cross section ratio R_{34}

Exp. (red): T. Akaishi, et al., PLB 873 (2026) 140163

Calc. (black): T. Harada, Y. Hirabayashi, NPA 1072 (2026) 123417

$$\mathbf{B_\Lambda(^3_\Lambda H) = 0.063^{+0.029}_{-0.023}(stat.)^{+0.025}_{-0.021}(syst.)}$$

Questioning MAMI's extraction of $B_\Lambda(^{3}_{\Lambda}\mathrm{H}))$ in ^{7}Li$(e,e'K^{+})$

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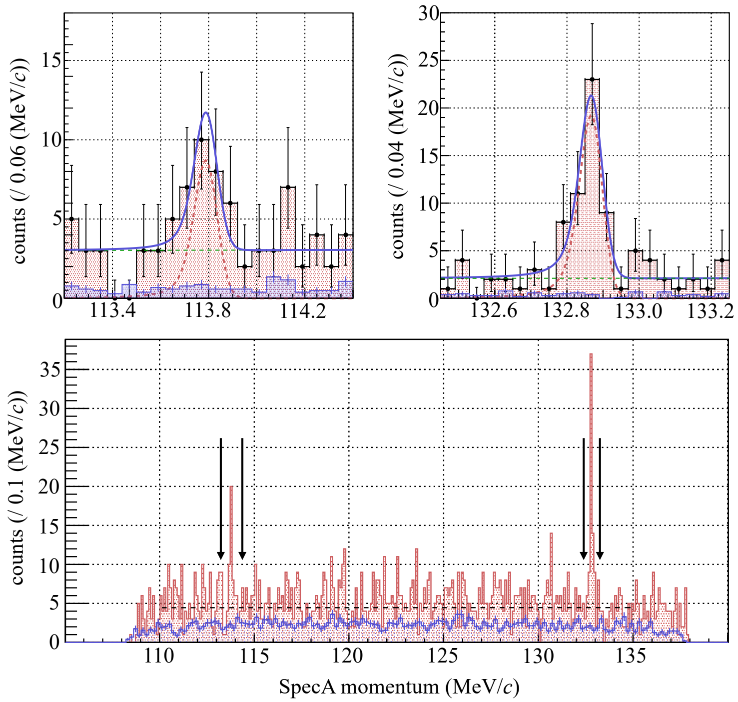

Decay $p(\pi^{-})$ spectrum in ^{7}Li$(e,e'K^{+})$ from MAMI

$p(\pi^{-})$ peaks attributed to $^{3}_{\Lambda}$H (left) and $^{4}_{\Lambda}$H (right).

Why not $^{7}_{\Lambda}$He ?

Trying out ${}^{7}_{\Lambda}$He

A. Gal, arXiv:2604.18259

p(π^-)=113.8 MeV/c line reassigned to **${}^{7}_{\Lambda}$He$\rightarrow \pi^- + {}^7$Li*(0.478 keV)**, requiring **B$_\Lambda$(${}^{7}_{\Lambda}$He)=5.84±0.07 MeV**, 2σ away from JLab's ^{7}Li$(e,e'K^+)$ value **5.55±0.15 MeV.**

But why decay to **^{7}Li(g.s.)** is not seen? Given the 10^{-10}s weak-decay time scale, **is ^{7}Li* a meaningful final state?** It emits γ much faster than π^- WD, so it is ^{7}Li(g.s.)

that is associated with the π^- WD time scale. Hence, there is only ONE final nuclear state with two amplitudes to reach it. Interference may leave only one of these transitions.

η' nuclei conclusion:

add vector mesons to N*(1895) models.

$B_\Lambda({}^3_\Lambda H)$: **large** (MAMI) **or small** (E73)?

Note: $\tau({}^3_\Lambda H) \approx \tau_\Lambda$ **suggests small** $B_\Lambda({}^3_\Lambda H)$.