EXOTIC BARYONS WITH HIDDEN STRANGENESS

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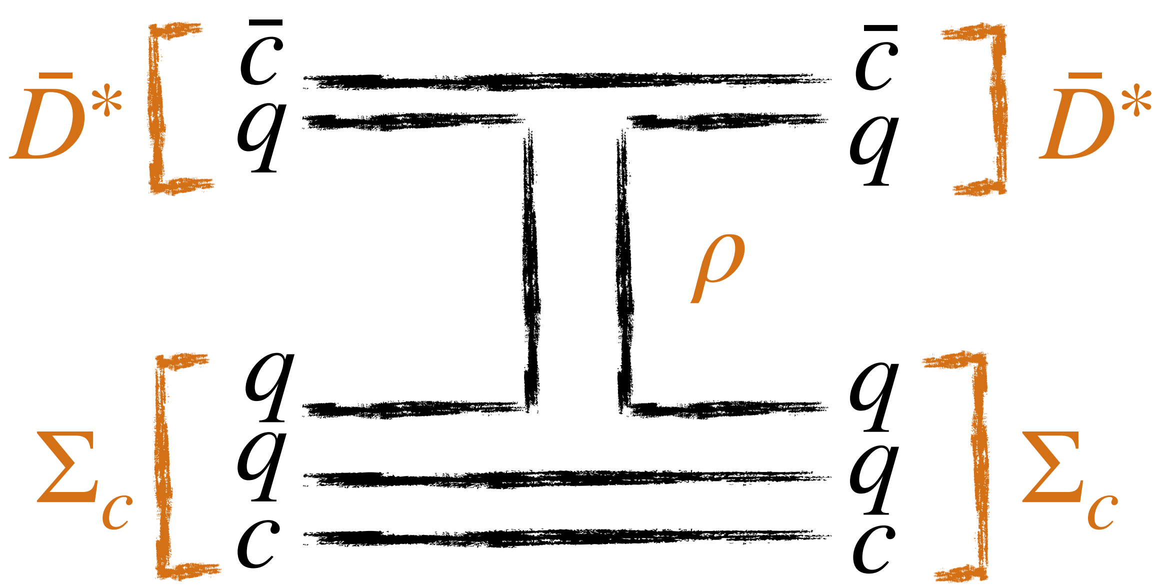
INTRODUCTION

- Experimental searches of exotic N^* resonances with $M \sim 2$ GeV (more than 30 years) : ϕp, $K\Sigma$, $K^*\Lambda$.

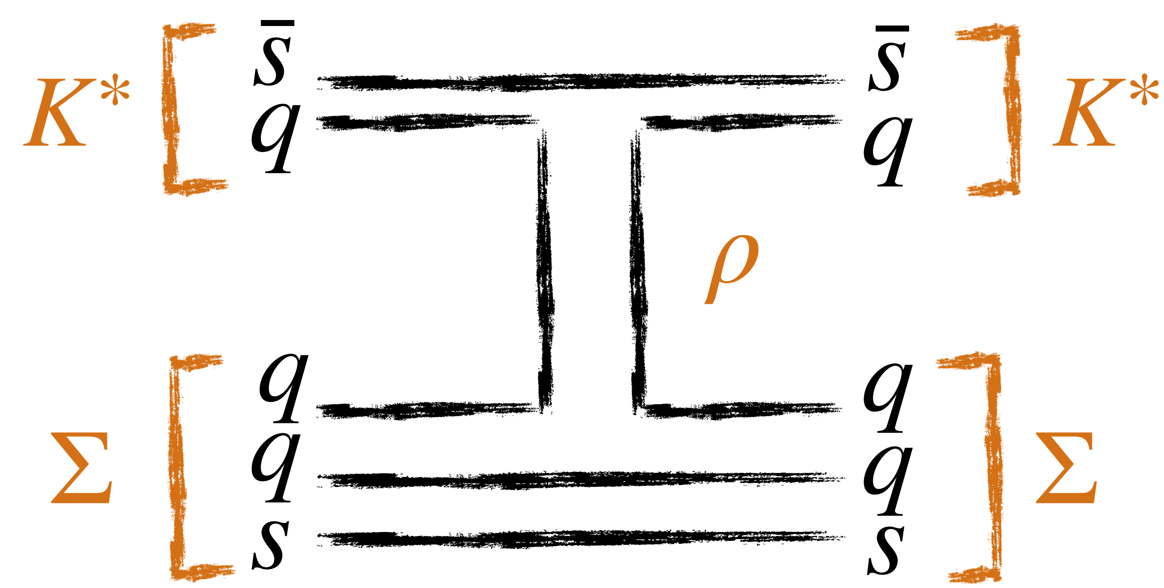
- More recently, the interest in this topic has grown: P_c states

$P_c(4457)$ $[J^P = 3/2^-]$



~ 8 MeV

$P_s(2080)$



Landsberg, Phys. Rept. 320, 223 (1999); Aaij et al., Phys. Rev. Lett. 115, 072001 (2015), Shu-Ming Wu, F. Wang, B. S. Zou, Phys. Rev. C108, 045201 (2023), Jun Shi, B. S. Zou, Phys. Rev. D 111, 114032 (2025).

INTRODUCTION

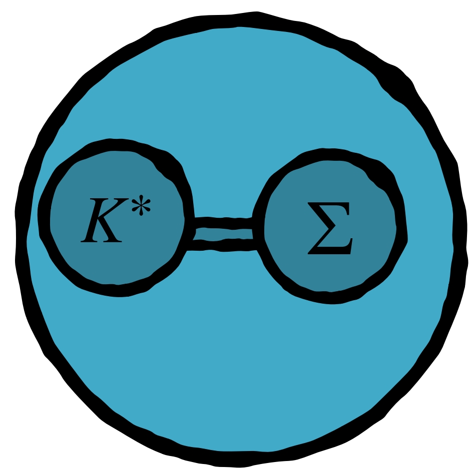
$$P_s(2080)$$

$[J^P = 3/2^-,$

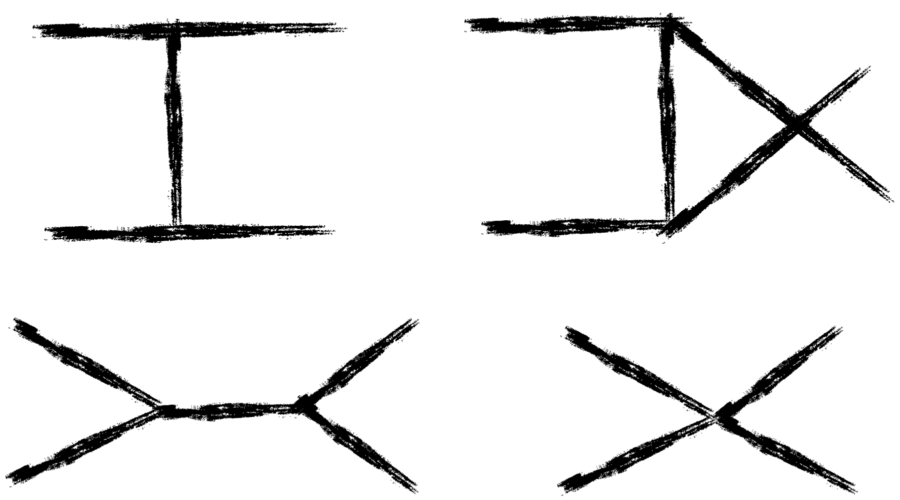
$M = 2079 - i30$ MeV]

Vector-Baryon coupled channels (hidden local symmetry):

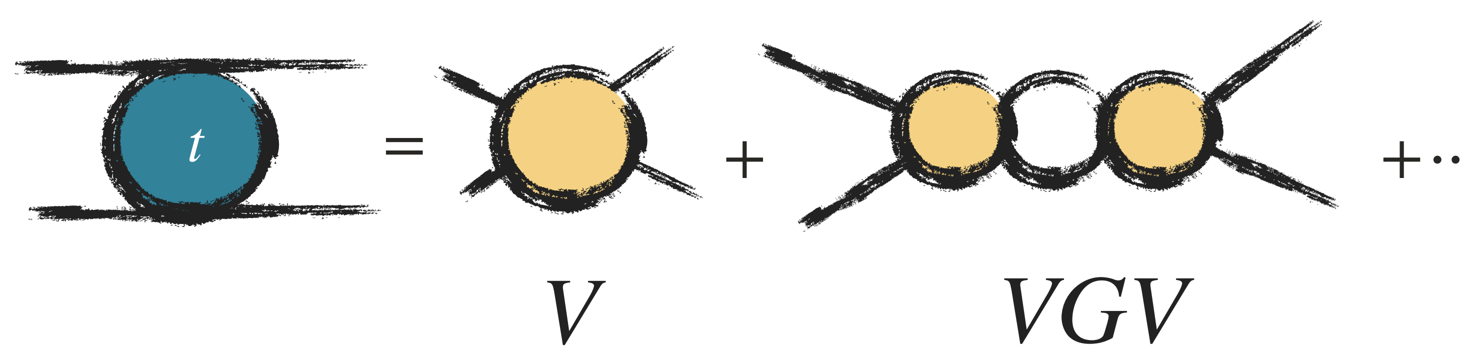
$K^*\Sigma, K^*\Lambda, \rho N, \omega N$



$$\mathcal{L}_{VB} = -g\Big\{\langle\bar{B}\gamma_\mu\big[\mathbb{V}_8^\mu, B\big]\rangle + \langle\bar{B}\gamma_\mu B\rangle\langle\mathbb{V}_8^\mu\rangle + \frac{1}{4M}\Big(F\langle\bar{B}\sigma_{\mu\nu}\big[\mathbb{V}_8^{\mu\nu}, B\big]\rangle + D\langle\bar{B}\sigma_{\mu\nu}\big\{\mathbb{V}_8^{\mu\nu}, B\big\}\rangle\Big) + \langle\bar{B}\gamma_\mu B\rangle\langle\mathbb{V}_0^\mu\rangle + \frac{C_0}{4M}\langle\bar{B}\sigma_{\mu\nu}\mathbb{V}_0^{\mu\nu}B\rangle\Big\}$$



$$V_{VB}^{I,S} = V_{t,\mathrm{VB}}^{I,S} + V_{s,\mathrm{VB}}^{I,S} + V_{u,\mathrm{VB}}^{I,S} + V_{\mathrm{CT,VB}}^{I,S}$$



K. P. Khemchandani, H. Kaneko, H. Nagahiro, A. Hosaka, Phys. Rev. D83, 114041 (2011). A. Ramos, E. Oset, Eur. Phys. J. A 44 (2010) 445-454 and Phys. Lett. B 727, 287 (2013), K. P. Khemchandani, A. Martínez Torres, H. Nagahiro, A. Hosaka, Phys. Rev. D88, 114016 (2013).

INTRODUCTION

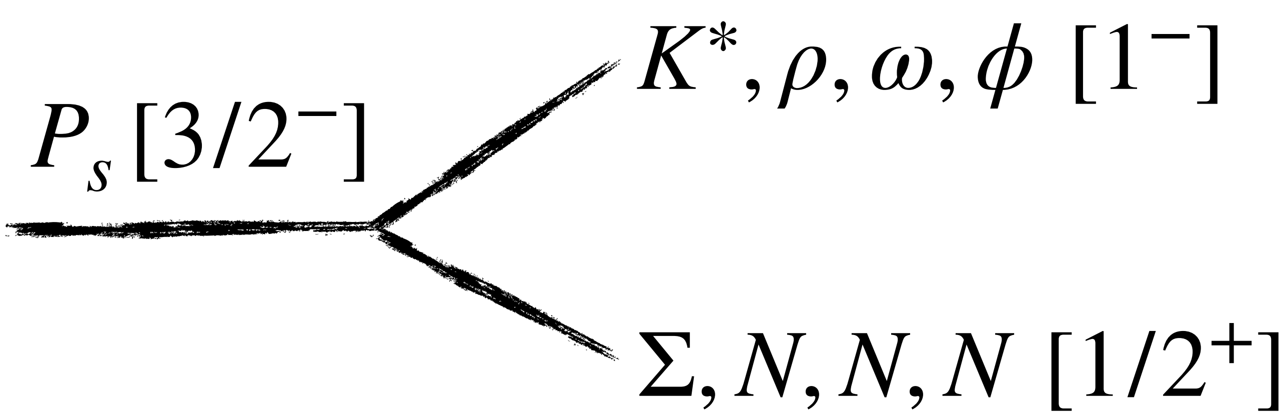
$N(1900)$	$3/2^+$	****
$N(1990)$	$7/2^+$	**
$N(2000)$ was $N(1900)$	$5/2^+$	**
$N(2040)$	$3/2^+$	*
$N(2060)$ was $N(2200)$	$5/2^-$	***
$N(2100)$	$1/2^+$	***
$N(2120)$	$3/2^-$	***
$N(2190)$	$7/2^-$	****

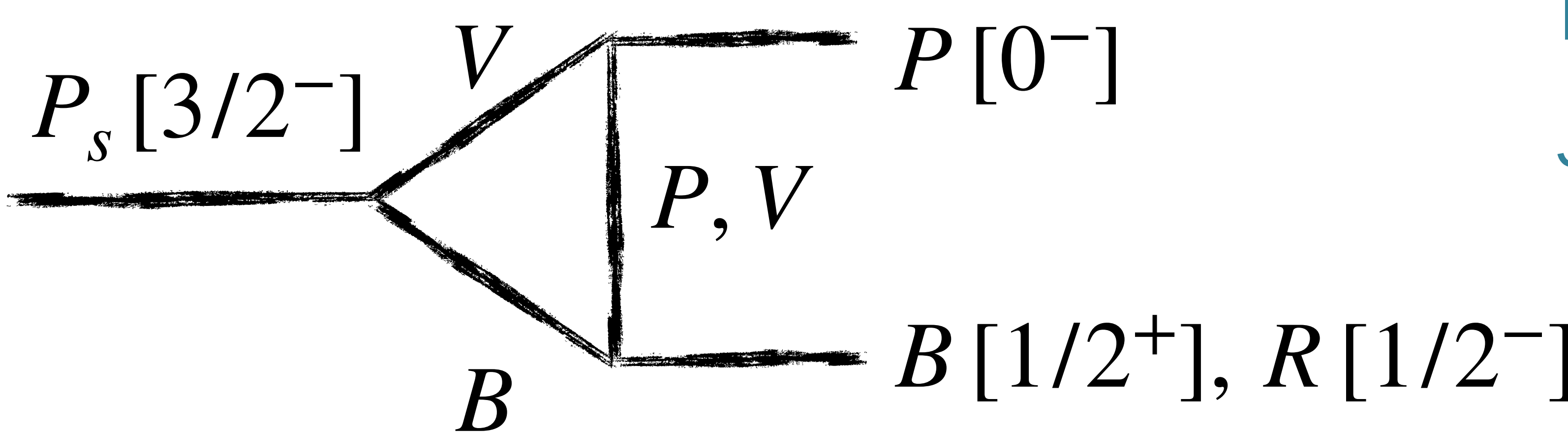
$N(2120)$ $I(J^P) = 1/2(3/2^-)$

$N(2120)$ **POLE POSITION**	
REAL PART	2050 to 2150 (≈ 2100) MeV
$-2\times$IMAGINARY PART	200 to 360 (≈ 280) MeV

- Partial Wave Analysis
- Large Uncertainty in the masses
- Broad states: 200-300 MeV
- πN, ηN final states

Where to observe $P_s(2080)$?





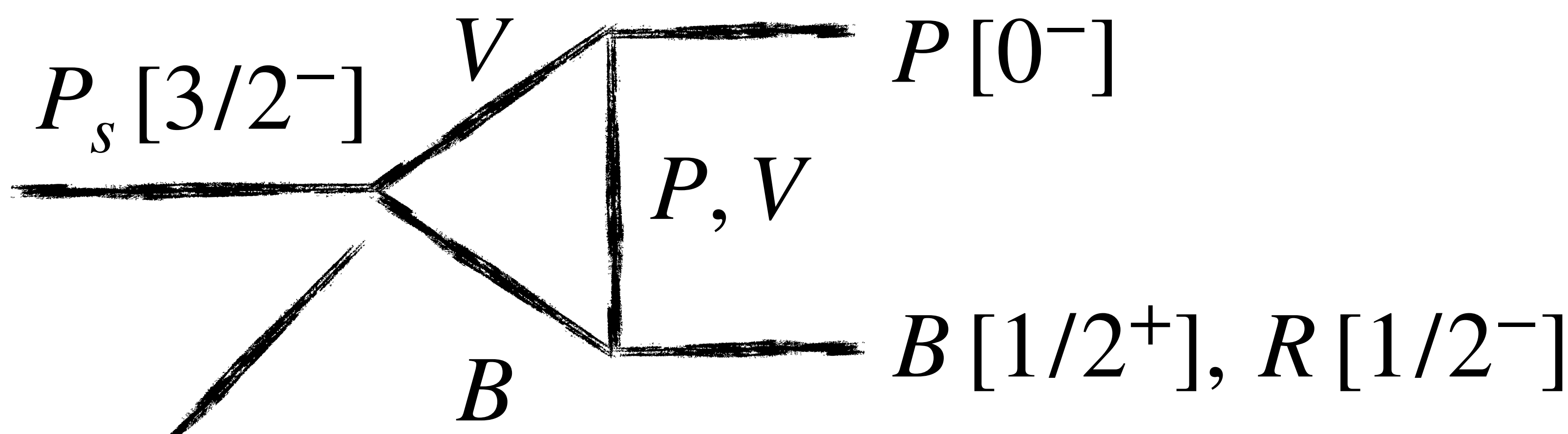
$$R \equiv \Lambda(1405), N^*(1535), N^*(1650)[1/2^-]$$

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

An ongoing proposal is being conducted at JPARC (Japan).

Yong-Hui Lin, Chao-Wei Shen, B. S. Zou, Nucl. Phys. A980, 21 (2018).

$$\mathcal{L}_{\rm VPP} = -ig\langle V^\mu [P, \partial_\mu P]\rangle,$$
$$\mathcal{L}_{\rm VVP} = \frac{G}{\sqrt{2}}\epsilon^{\mu\nu\alpha\beta}\langle \partial_\mu V_\nu \partial_\alpha V_\beta P\rangle,$$



$$R \equiv \Lambda(1405), N^*(1535), N^*(1650)[1/2^-]$$

$$-it_{P_s\to V_i B_i} = ig_{P_s\to V_i B_i}\bar{u}_{B_i}(P-k)\epsilon^\mu_{V_i}(k) u_{P_s \mu}(P)$$

Rarita-Schwinger spinor

$$\mathcal{L}_{\rm PBB} = -\frac{D+F}{\sqrt{2}f_\pi}\langle \bar{B}\gamma^\mu\gamma_5 \partial_\mu P B\rangle - \frac{D-F}{\sqrt{2}f_\pi}\langle \bar{B}\gamma^\mu\gamma_5 B \partial_\mu P\rangle$$
$$\mathcal{L}_{\rm VBB} = g[\langle \bar{B}\gamma_\mu [V^\mu, B]\rangle + \langle \bar{B}\gamma_\mu B\rangle\langle V^\mu\rangle],$$

$$-it_{PB\to R} = ig_{R\to PB}\bar{u}_R(p) u_B(P-k-q),$$
$$-it_{V'B\to R} = -\frac{g_{R\to V'B}}{\sqrt{3}}\epsilon^\mu_{V'}(q)\bar{u}_R(p)\gamma_\mu\gamma_5 u_B(P-k-q),$$

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

$$-it^{\mathrm{VBP}}_{P_s\to P'B'} = gC_{PB\to B'}C_{V\to P'P}g_{P_s\to VB}\bar{u}_{B'}(p)\gamma_5$$

$$\times\Big[(2p^\nu+(m_B+m_{B'})\gamma^\nu)(-I^{(1)}_{\nu\mu}+k_\mu I^{(2)}_\nu)$$

$$+I^{(3)}_\mu-k_\mu I^{(4)}\Big]u^\mu_{P_s}(P),$$

$$I^{(1)}_{\nu\mu} = \left(1+\frac{k^2}{m_V^2}\right)\mathbb{I}^{(1)}_{\nu\mu}-\frac{1}{m_V^2}\mathbb{I}^{(2)}_{\nu\mu},$$

$$I^{(2)}_{\nu} = \left(1-\frac{k^2}{m_V^2}\right)\mathbb{I}^{(3)}_{\nu}+\frac{1}{m_V^2}\mathbb{I}^{(4)}_{\nu},$$

$$I^{(3)}_{\mu} = \left(1+\frac{k^2}{m_V^2}\right)\mathbb{I}^{(4)}_{\mu}-\frac{1}{m_V^2}\mathbb{I}^{(5)}_{\mu},$$

$$I^{(4)} = \left(1-\frac{k^2}{m_V^2}\right)\mathbb{I}^{(6)}_{\nu}+\frac{1}{m_V^2}\mathbb{I}^{(7)},$$

$$\mathbb{I}^{(1)}_{\nu\mu} = \int\frac{d^4q}{(2\pi)^4}\frac{q_\nu q_\mu}{\mathbb{D}};\qquad \mathbb{I}^{(2)}_{\nu\mu} = \int\frac{d^4q}{(2\pi)^4}\frac{q^2 q_\nu q_\mu}{\mathbb{D}};$$

$$\mathbb{I}^{(3)}_{\nu} = \int\frac{d^4q}{(2\pi)^4}\frac{q_\nu}{\mathbb{D}};\qquad \mathbb{I}^{(4)}_{\nu} = \int\frac{d^4q}{(2\pi)^4}\frac{q^2 q_\nu}{\mathbb{D}},$$

$$\mathbb{I}^{(5)}_{\mu} = \int\frac{d^4q}{(2\pi)^4}\frac{q^4 q_\mu}{\mathbb{D}};\qquad \mathbb{I}^{(6)} = g^{\nu\mu}\mathbb{I}^{(1)}_{\nu\mu};$$

$$\mathbb{I}^{(7)} = g^{\nu\mu}\mathbb{I}^{(2)}_{\nu\mu};$$

$$\mathbb{D} = [(P-k-q)^2-m_B^2+i\epsilon][(k+q)^2-m_V^2+i\epsilon]$$

$$\times[q^2-m_P^2+i\epsilon].$$

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

$$\mathbb{I}^{(1)}_{\nu\mu} = a^{(1)}_1 g_{\nu\mu} + a^{(1)}_2 P_\nu P_\mu + a^{(1)}_3 k_\nu k_\mu + a^{(1)}_4 (P_\nu k_\mu + P_\mu k_\nu)$$

$$a^{(1)}_1 = -\frac{1}{2[(P\cdot k)^2 - P^2k^2]}\left[\mathbb{GI}^{(1)}\{-(P\cdot k)^2 + P^2k^2\} + 2\mathbb{PKI}^{(1)}(P\cdot k) - \mathbb{PPI}^{(1)}k^2 - \mathbb{KKI}^{(1)}P^2\right],$$

$$a^{(1)}_2 = -\frac{1}{2[(P\cdot k)^2 - P^2k^2]^2}\left[\mathbb{GI}^{(1)}k^2\{-(P\cdot k)^2 + P^2k^2\} - \mathbb{KKI}^{(1)}\{2(P\cdot k)^2 + P^2k^2\} + 6\mathbb{PKI}^{(1)}k^2(P\cdot k) - 3\mathbb{PPI}^{(1)}k^4\right],$$

$$+ \ldots$$

$$\mathbb{GI}^{(1)} \equiv g^{\nu\mu}\mathbb{I}^{(1)}_{\nu\mu} = \int_{-\infty}^{+\infty} \frac{d^4q}{(2\pi)^4}\frac{q^2}{\mathbb{D}},$$

$$\mathbb{PPI}^{(1)} \equiv P^\nu P^\mu \mathbb{I}^{(1)}_{\nu\mu} = \int_{-\infty}^{+\infty} \frac{d^4q}{(2\pi)^4}\frac{(P\cdot q)^2}{\mathbb{D}},$$

$$\mathbb{KKI}^{(1)} \equiv k^\nu k^\mu \mathbb{I}^{(1)} = \int_{-\infty}^{+\infty} \frac{d^4q}{(2\pi)^4}\frac{(k\cdot q)^2}{\mathbb{D}},$$

$$\mathbb{PKI}^{(1)} \equiv P^\nu k^\mu \mathbb{I}^{(1)}_{\nu\mu} = \int_{-\infty}^{+\infty} \frac{d^4q}{(2\pi)^4}\frac{(P\cdot q)(k\cdot q)}{\mathbb{D}},$$

$$I^{(1)}_{\nu\mu} = \left(1 + \frac{k^2}{m_V^2}\right)\mathbb{I}^{(1)}_{\nu\mu} - \frac{1}{m_V^2}\mathbb{I}^{(2)}_{\nu\mu},$$

$$I^{(2)}_{\nu} = \left(1 - \frac{k^2}{m_V^2}\right)\mathbb{I}^{(3)}_{\nu} + \frac{1}{m_V^2}\mathbb{I}^{(4)}_{\nu},$$

$$I^{(3)}_{\mu} = \left(1 + \frac{k^2}{m_V^2}\right)\mathbb{I}^{(4)}_{\mu} - \frac{1}{m_V^2}\mathbb{I}^{(5)}_{\mu},$$

$$I^{(4)} = \left(1 - \frac{k^2}{m_V^2}\right)\mathbb{I}^{(6)}_{\nu} + \frac{1}{m_V^2}\mathbb{I}^{(7)},$$

$$\mathbb{I}^{(1)}_{\nu\mu} = \int \frac{d^4q}{(2\pi)^4}\frac{q_\nu q_\mu}{\mathbb{D}}; \qquad \mathbb{I}^{(2)}_{\nu\mu} = \int \frac{d^4q}{(2\pi)^4}\frac{q^2 q_\nu q_\mu}{\mathbb{D}};$$

$$\mathbb{I}^{(3)}_{\nu} = \int \frac{d^4q}{(2\pi)^4}\frac{q_\nu}{\mathbb{D}}; \qquad \mathbb{I}^{(4)}_{\nu} = \int \frac{d^4q}{(2\pi)^4}\frac{q^2 q_\nu}{\mathbb{D}},$$

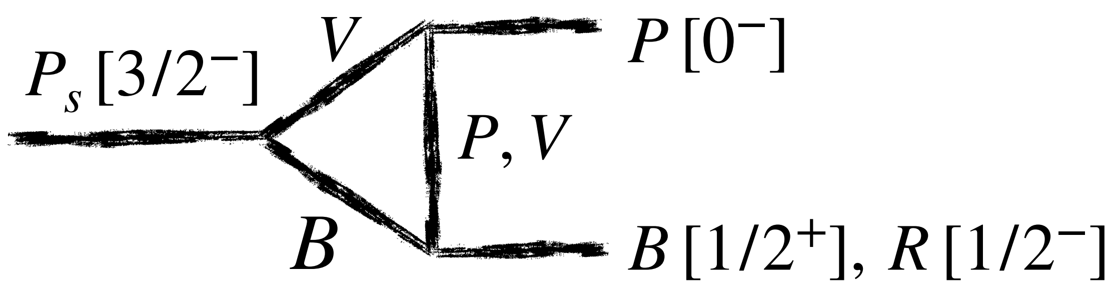
$$\mathbb{I}^{(5)}_{\mu} = \int \frac{d^4q}{(2\pi)^4}\frac{q^4 q_\mu}{\mathbb{D}}; \qquad \mathbb{I}^{(6)} = g^{\nu\mu}\mathbb{I}^{(1)}_{\nu\mu};$$

$$\mathbb{I}^{(7)} = g^{\nu\mu}\mathbb{I}^{(2)}_{\nu\mu};$$

$$\mathbb{D} = [(P-k-q)^2 - m_B^2 + i\epsilon][(k+q)^2 - m_V^2 + i\epsilon] \times [q^2 - m_P^2 + i\epsilon].$$

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

Coupled-channel dynamics:



VBP	$C_{V\to PP'}$ $K^+\Sigma^0/K^+\Lambda/K^+\Lambda(1405)$	$C_{BP\to B'}$ $K^+\Sigma^0$	$K^+\Lambda$
$K^{*0}\Sigma^+\pi^-$	1	F/f_π	$-D/(\sqrt{3}f_\pi)$
$K^{*+}\Sigma^0\pi^0$	$1/\sqrt{2}$	0	$-D/(\sqrt{3}f_\pi)$
$K^{*+}\Sigma^0\eta$	$\sqrt{3/2}C_\beta$	$(-DC_\beta+\sqrt{2}DS_\beta)/(\sqrt{3}f_\pi)$	0
$K^{*+}\Sigma^0\eta'$	$\sqrt{3/2}S_\beta$	$-D(\sqrt{2}C_\beta+S_\beta)/(\sqrt{3}f_\pi)$	0
$K^{*+}\Lambda\pi^0$	$1/\sqrt{2}$	$-D/(\sqrt{3}f_\pi)$	0
$K^{*+}\Lambda\eta$	$\sqrt{3/2}C_\beta$	0	$D(C_\beta+\sqrt{2}S_\beta)/(\sqrt{3}f_\pi)$
$K^{*+}\Lambda\eta'$	$\sqrt{3/2}S_\beta$	0	$D(-\sqrt{2}C_\beta+S_\beta)/(\sqrt{3}f_\pi)$
ρ^0pK^-	$-1/\sqrt{2}$	$(-D+F)/(2f_\pi)$	$(D+3F)/(2\sqrt{3}f_\pi)$
$\rho^+n\bar{K}^0$	-1	$(D-F)/(2f_\pi)$	$(D+3F)/(2\sqrt{3}f_\pi)$
ωpK^-	$-1/\sqrt{2}$	$(-D+F)/(2f_\pi)$	$(D+3F)/(2\sqrt{3}f_\pi)$
ϕpK^-	1	$(-D+F)/(2f_\pi)$	$(D+3F)/(2\sqrt{3}f_\pi)$

VBP	$C_{V\to PP'}$ π^0p/π^0N^{*+}	$C_{BP\to B'}$ π^0p
$K^{*0}\Sigma^+K^0$	$1/\sqrt{2}$	$(-D+F)/(\sqrt{2}f_\pi)$
$K^{*+}\Sigma^0K^+$	$-1/\sqrt{2}$	$(-D+F)/(2f_\pi)$
$K^{*+}\Lambda K^+$	$-1/\sqrt{2}$	$(D+3F)/(2\sqrt{3}f_\pi)$
$\rho^0p\pi^0$	0	$-(D+F)/(2f_\pi)$
$\rho^0p\eta$	0	$(C_\beta(D-3F)+2\sqrt{2}DS_\beta)/(2\sqrt{3}f_\pi)$
$\rho^0p\eta'$	0	$(-2\sqrt{2}DC_\beta+(D-3F)S_\beta)/(2\sqrt{3}f_\pi)$
$\rho^+n\pi^+$	$-\sqrt{2}$	$-(D+F)/(\sqrt{2}f_\pi)$
$\omega p\pi^0$	0	$-(D+F)/(2f_\pi)$
$\omega p\eta$	0	$(C_\beta(D-3F)+2\sqrt{2}DS_\beta)/(2\sqrt{3}f_\pi)$
$\omega p\eta'$	0	$(-2\sqrt{2}DC_\beta+(D-3F)S_\beta)/(2\sqrt{3}f_\pi)$
$\phi p\pi^0$	0	$-(D+F)/(2f_\pi)$
$\phi p\eta$	0	$(C_\beta(D-3F)+2\sqrt{2}DS_\beta)/(2\sqrt{3}f_\pi)$
$\phi p\eta'$	0	$(-2\sqrt{2}DC_\beta+(D-3F)S_\beta)/(2\sqrt{3}f_\pi)$

VBV'	$C_{V\to V'P'}$ $K^+\Sigma^0/K^+\Lambda/K^+\Lambda(1405)$	$C_{BV'\to B'}$ $K^+\Sigma^0$	$K^+\Lambda$
$K^{*0}\Sigma^+\rho^-$	1	$-\sqrt{2}$	0
$K^{*+}\Sigma^0\rho^0$	$1/\sqrt{2}$	0	0
$K^{*+}\Sigma^0\omega$	$1/\sqrt{2}$	$\sqrt{2}$	0
$K^{*+}\Sigma^0\phi$	1	1	0
$K^{*+}\Lambda\rho^0$	$1/\sqrt{2}$	0	0
$K^{*+}\Lambda\omega$	$1/\sqrt{2}$	0	$\sqrt{2}$
$K^{*+}\Lambda\phi$	1	0	1
ρ^0pK^{*-}	$1/\sqrt{2}$	$-1/\sqrt{2}$	$-\sqrt{3/2}$
$\rho^+n\bar{K}^{*0}$	1	$1/\sqrt{2}$	$-\sqrt{3/2}$
ωpK^{*-}	$1/\sqrt{2}$	$-1/\sqrt{2}$	$-\sqrt{3/2}$
ϕpK^{*-}	1	$-1/\sqrt{2}$	$-\sqrt{3/2}$

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

Partial decay widths:

Channel	Width P exchange	Width P + V exchange	Channel	Width P exchange	Width P + V exchange
$\pi^+ n$	0.77 ± 0.21	0.95 ± 0.27	$K^+\Lambda_2(1405)$	5.05 ± 0.76	5.10 ± 0.77
$\pi^0 p$	0.38 ± 0.11	0.47 ± 0.13	$\pi^+ N^{*0}(1535)$	1.18 ± 0.28	1.18 ± 0.28
ηp	0.87 ± 0.23	0.77 ± 0.21	$\pi^0 N^{*+}(1535)$	0.59 ± 0.14	0.59 ± 0.14
$K^+\Lambda$	3.83 ± 0.84	3.74 ± 0.82	$\eta N^{*0}(1535)$	0.33 ± 0.05	0.34 ± 0.06
$K^+\Sigma^0$	1.56 ± 0.31	1.45 ± 0.29	$\pi^+ N^{*0}(1650)$	0.34 ± 0.03	0.26 ± 0.02
$K^0\Sigma^+$	3.11 ± 0.62	2.90 ± 0.57	$\pi^0 N^{*+}(1650)$	0.17 ± 0.01	0.13 ± 0.01
$\eta' p$	0.014 ± 0.005	0.07 ± 0.02			
$K^+\Lambda_1(1405)$	16.97 ± 2.67	17.16 ± 2.71			

Channel	Width
ρN	5.66
ωN	1.33
ϕN	1.92
$K^*\Lambda$	6.64
$K^*\Sigma$	49.97

Without coupled channels:

$\Gamma_{\pi N} \sim 26$ times smaller;

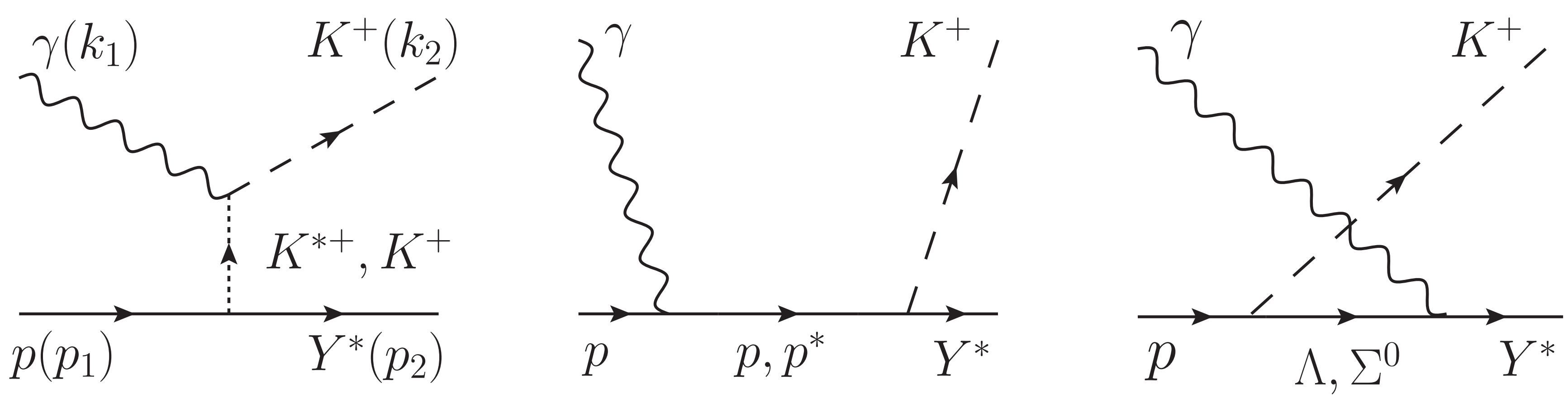
$\Gamma_{K\Sigma} \sim 2$ times smaller

Photoproduction of $K^0\Sigma^+, K^0\Sigma^0$ [A. Ramos, E. Oset, Phys. Lett. B727, 287 (2013)]

Photoproduction of $K^{*+}\Lambda$ [W. Tian, N. Wei, Y. F. Wang, F. Huang, B. S. Zou [Phys. Rev. C112, 055203 (2025)]

Breno Agatão et al., Phys. Rev. D111, 116013 (2025).

What about $N^*(1895)[J^P = 1/2^-]$?



$Y^* = \Lambda^*$ or Σ^*

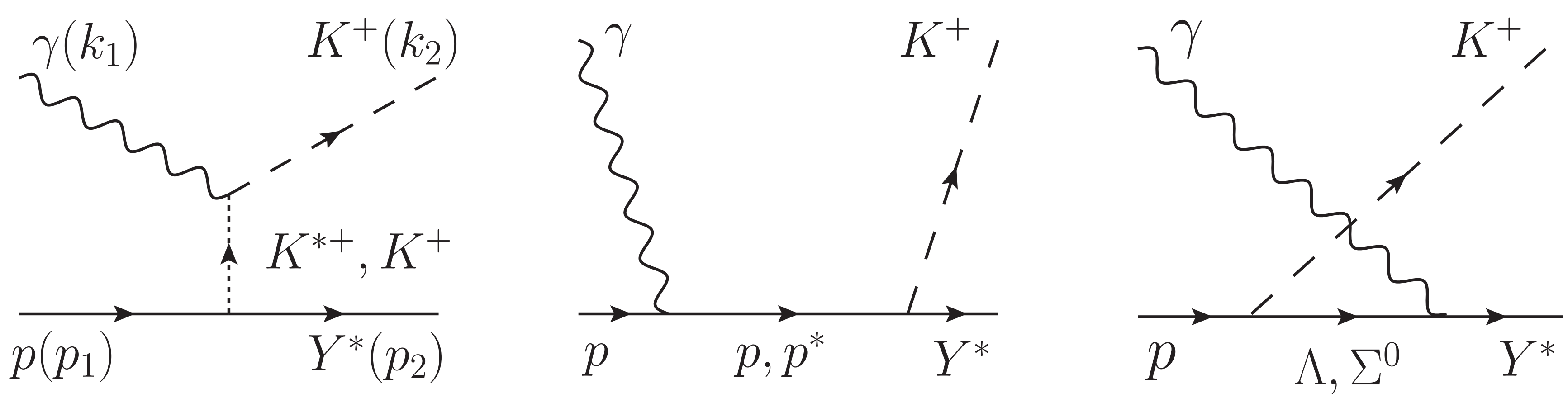
We determine radiative decays and magnetic moments of the resonances

Decay process	Partial width (KeV)	Decay process	Partial width (KeV)
$\Lambda_1(1405) \to \Lambda\gamma$	9.47 ± 2.17	$N_1^*(1895) \to p\gamma$	729.17 ± 78.20
$\Lambda_2(1405) \to \Lambda\gamma$	11.91 ± 3.39	$N_2^*(1895) \to p\gamma$	129.59 ± 13.89
$\Lambda(1405) \to \Lambda\gamma$	26.19 ± 6.93	$N^*(1895) \to p\gamma$	650.70 ± 65.10
$\Lambda_1(1405) \to \Sigma\gamma$	5.17 ± 1.75	$\Sigma(1400) \to \Lambda\gamma$	49.97 ± 8.57
$\Lambda_2(1405) \to \Sigma\gamma$	2.08 ± 1.72	$\Sigma(1400) \to \Sigma\gamma$	94.51 ± 9.33
$\Lambda(1405) \to \Sigma\gamma$	2.50 ± 1.37		

Decay process	Magnetic moment	Decay process	Magnetic moment
$\Lambda_1(1405) \to \Lambda\gamma$	0.28 ± 0.02	$N_1^*(1895) \to p\gamma$	0.56 ± 0.02
$\Lambda_2(1405) \to \Lambda\gamma$	0.26 ± 0.02	$N_2^*(1895) \to p\gamma$	0.20 ± 0.01
$\Lambda(1405) \to \Lambda\gamma$	0.42 ± 0.03	$N^*(1895) \to p\gamma$	0.45 ± 0.02
$\Lambda_1(1405) \to \Sigma\gamma$	0.33 ± 0.03	$\Sigma(1400) \to \Lambda\gamma$	0.60 ± 0.03
$\Lambda_2(1405) \to \Sigma\gamma$	0.15 ± 0.04	$\Sigma(1400) \to \Sigma\gamma$	1.28 ± 0.04
$\Lambda(1405) \to \Sigma\gamma$	0.20 ± 0.03		

S. H. Kim, K. P. Khemchandani, A. Martínez Torres, A. Hosaka, Phys. Rev. D103, 114017 (2021)

What about $N^*(1895)[J^P = 1/2^-]$?



$Y^* = \Lambda^*$ or Σ^*

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moments c

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$\Lambda(1405) \to \Lambda\gamma$	650.70 ± 65.10
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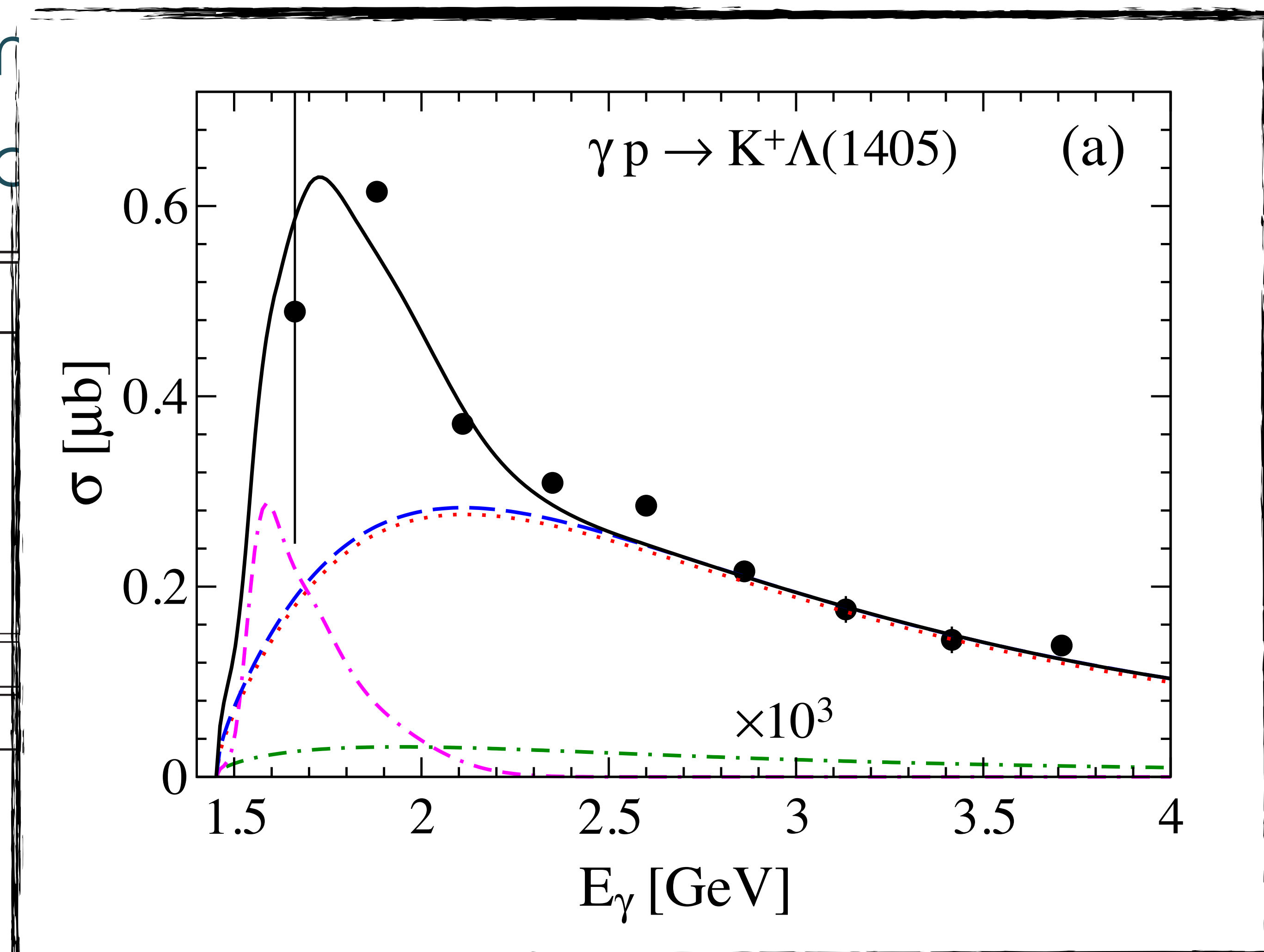
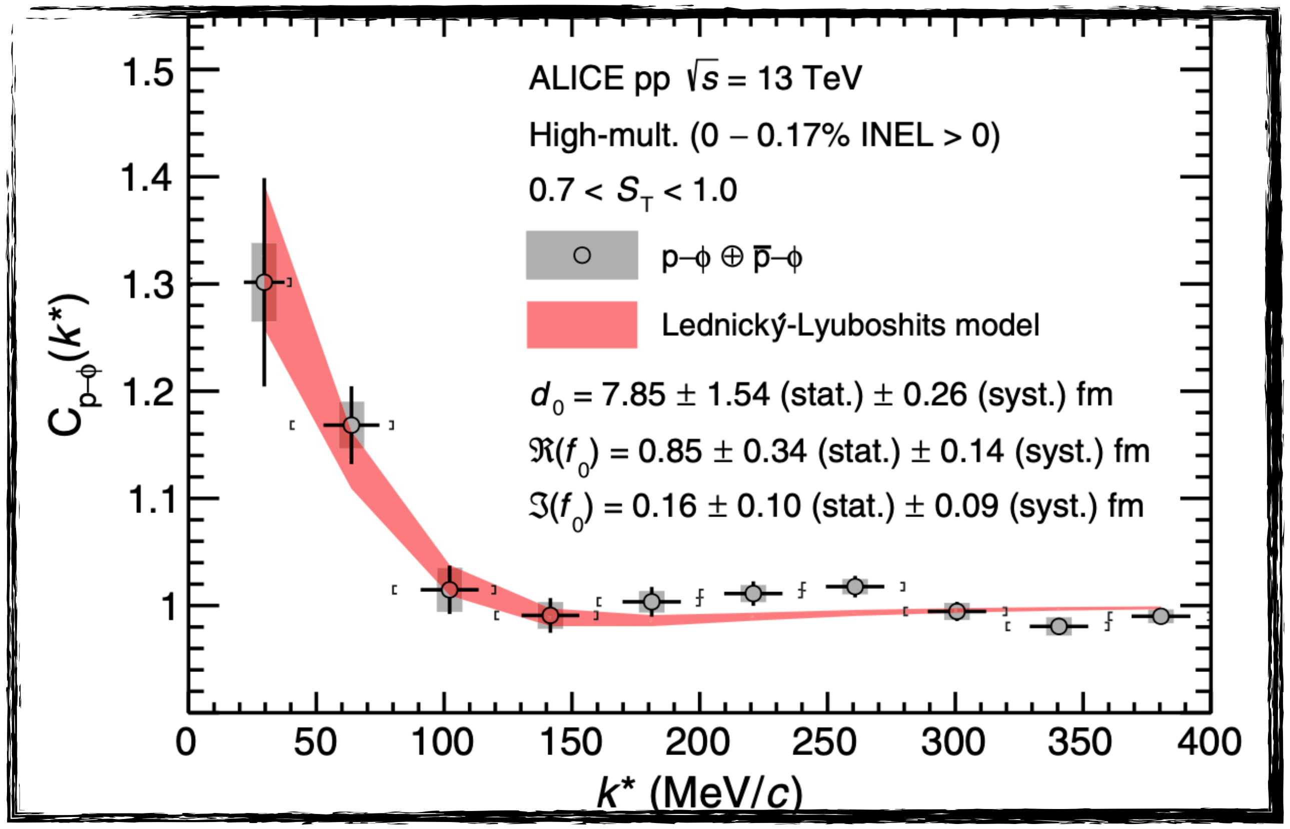
Decay process	ent
$\Lambda_1(1405) \to \Lambda\gamma$	
$\Lambda_2(1405) \to \Lambda\gamma$	
$\Lambda(1405) \to \Lambda\gamma$	
$\Lambda_1(1405) \to \Sigma\gamma$	
$\Lambda_2(1405) \to \Sigma\gamma$	
$\Lambda(1405) \to \Sigma\gamma$	



S. H. Kim, K. P. Khemchandani, A. Martínez Torres, A. Hosaka, Phys. Rev. D103, 114017 (2021)

- OZI rule: ϕN interaction biased (weak interaction: distinct quark content)



The real and imaginary parts of the scattering length obtained from the Lednický-Lyuboshits fit are $\Re(f_0) = 0.85 \pm 0.34(\text{stat}) \pm 0.14(\text{syst})$ fm and $\Im(f_0) = 0.16 \pm 0.10(\text{stat}) \pm 0.09(\text{syst})$ fm. The resulting effective range is $d_0 = 7.85 \pm 1.54(\text{stat}) \pm 0.26(\text{syst})$ fm. $\Re(f_0)$ deviates by 2.3σ from zero, indicating the attractiveness of the p-ϕ

- Lattice QCD simulations: ϕN interaction in spin $3/2$ is attractive [$a^{(3/2)} = -1.43(23)^{+36}_{-06}$ fm, $r^{(3/2)}_{\text{eff}} = 2.36(10)^{+02}_{-48}$fm.

ALICE Collaboration, Phys. Rev. Lett 127, 172301 (2021);
Liu, Doi, Hatsuda, et al., Phys. Rev. D106, 074507(2022)

N* resonances with hidden strangeness and OZI rule

- OZI rule: ϕN interaction biased (weak interaction: distinct quark content)

Indication of a p–ϕ bound state from a correlation function analysis

Emma Chizzali [a,b,*], Yuki Kamiya [c,d,*], Raffaele Del Grande [b], Takumi Doi [d], Laura Fabbietti [b], Tetsuo Hatsuda [d], Yan Lyu [e,d]

$$V_{N\phi}(r) = \beta \left(\sum_{i=1,2} a_i e^{-(r/b_i)^2} \right) + a_3 m_\pi^4 f(r; b_3) \frac{e^{-2m_\pi r}}{r^2} + i\gamma f(r; b_3) \frac{e^{-2m_K r}}{m_K r^2}, \quad (1)$$

where β and γ are free parameters to be constrained by the fit to experimental data; $a_{1,2,3}$ and $b_{1,2,3}$ are obtained by the fit to the lattice QCD data in the spin 3/2 channel at $t/a = 12$[1] provided in [28] and are common in both ${}^4S_{3/2}$ and ${}^2S_{1/2}$ channels, whose values are listed

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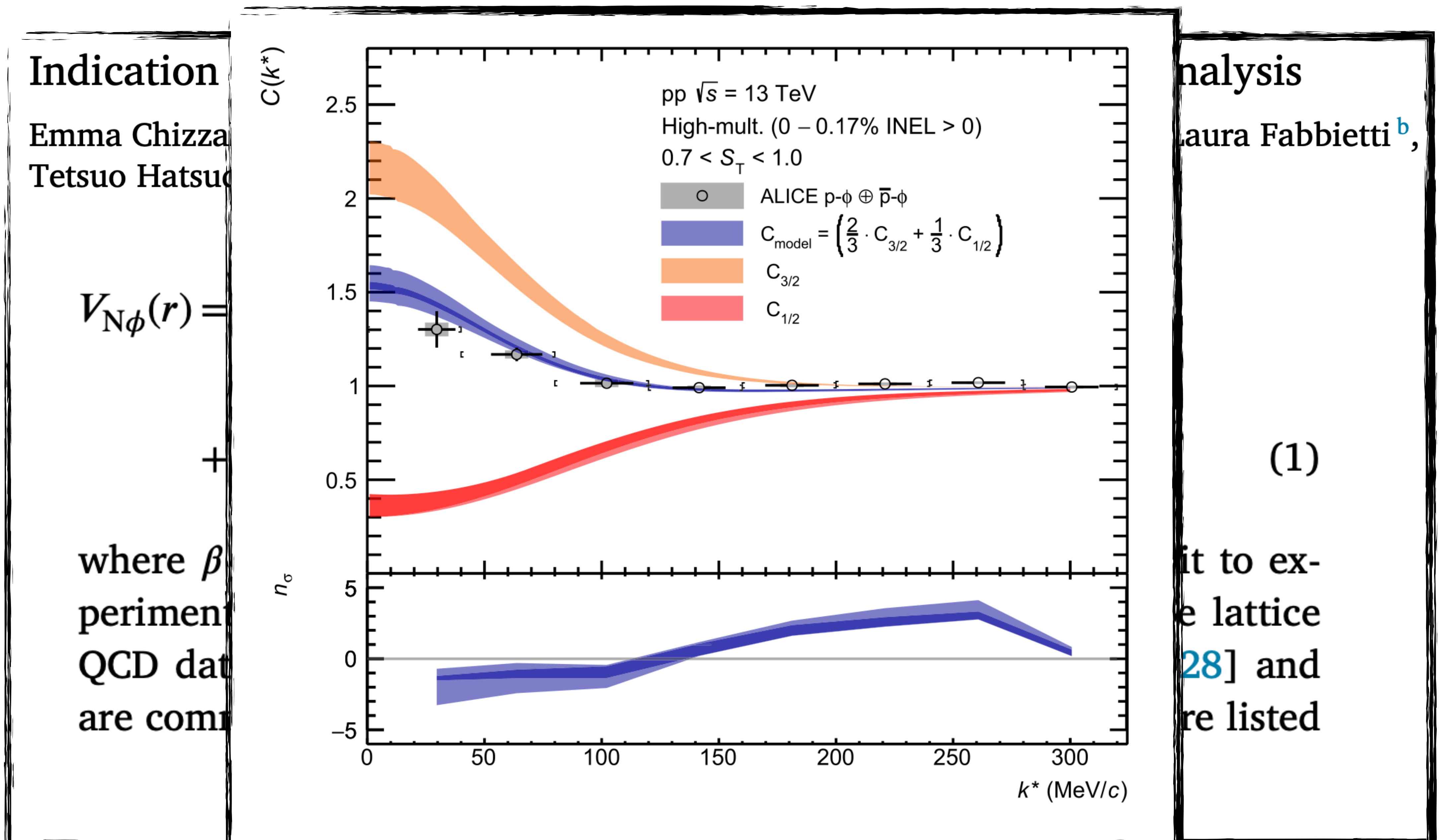

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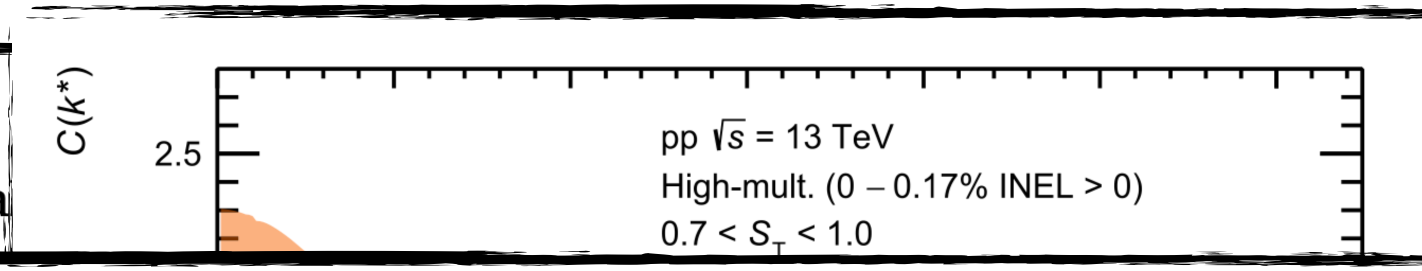
Indication

Emma Chizza



nalysis

aura Fabbietti [b],

Solving the Schrödinger equation with Eq. (1) leads to an eigenen-

The existence of a nucleon–ϕ (N–ϕ) bound state has been subject of theoretical and experimental investigations for decades. In this letter, indication of a p–ϕ bound state is found, using for the first time two-particle correlation functions as alternative to invariant mass spectra. Newly available lattice calculations for the spin 3/2 N–ϕ interaction by the HAL QCD collaboration are used to constrain the spin 1/2 counterpart from the fit of the experimental p–ϕ correlation function measured by ALICE. The corresponding $\boxed{\text{scattering length}}$ and effective range are $\boxed{f_0^{(1/2)} = \left(-1.54^{+0.53}_{-0.53}(\text{stat.})^{+0.16}_{-0.09}(\text{syst.}) + i \cdot 0.00^{+0.35}_{-0.00}(\text{stat.})^{+0.16}_{-0.00}(\text{syst.})\right)}$ fm and $d_0^{(1/2)} = \left(0.39^{+0.09}_{-0.09}(\text{stat.})^{+0.02}_{-0.03}(\text{syst.}) + i \cdot 0.00^{+0.00}_{-0.04}(\text{stat.})^{+0.00}_{-0.02}(\text{syst.})\right)$ fm, respectively. The results imply the appearance of a p–ϕ bound state with an estimated binding energy in the range of 12.8 – 56.1 MeV.

N* resonances with hidden strangeness and OZI rule

- OZI rule: ϕN interaction biased (weak interaction: distinct quark content) $\Longrightarrow$ Coupled channels dynamics extremely important.

- Spin averaged correlation function of ϕN measured by the ALICE collaboration: attractive interaction.

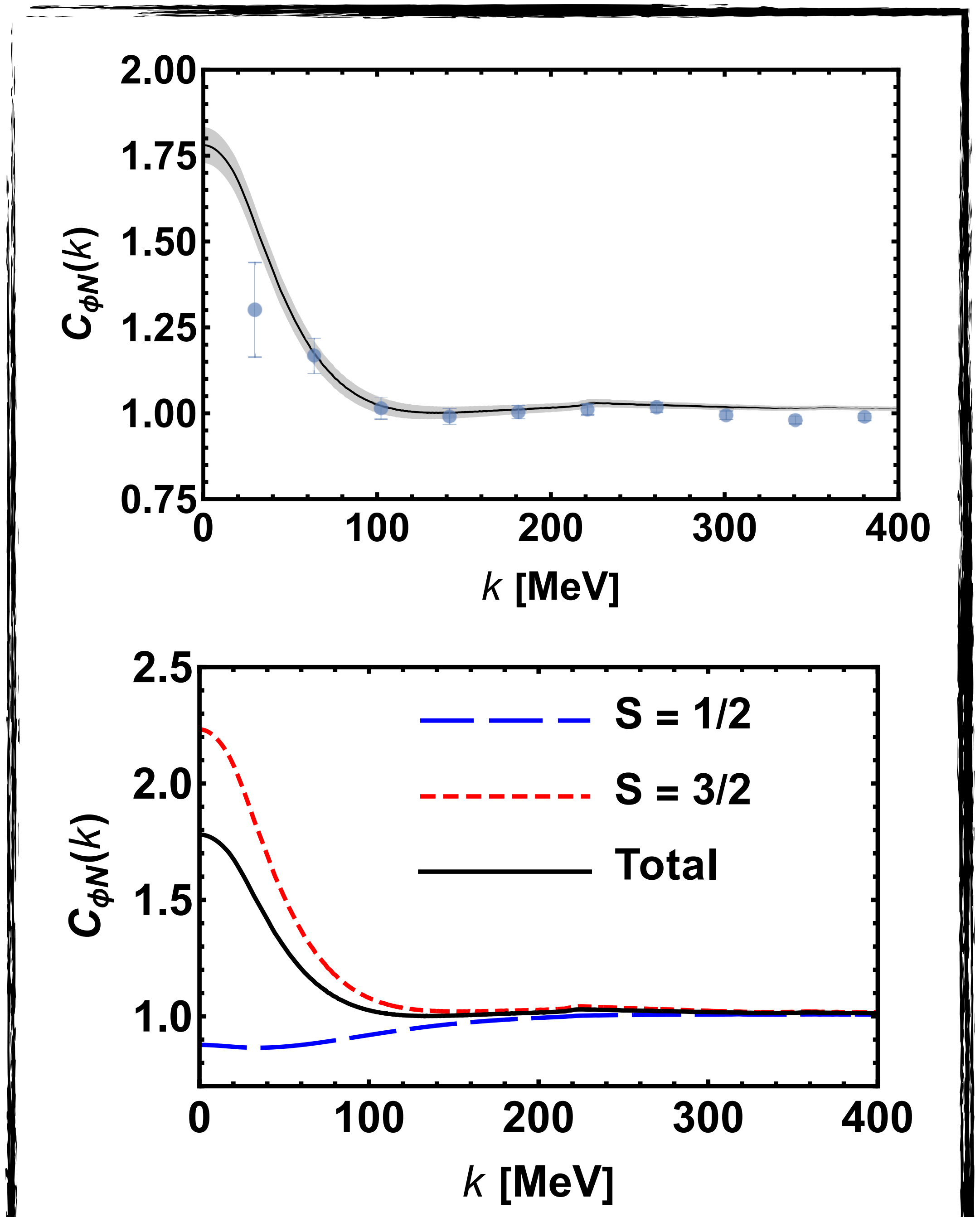
- Lattice QCD simulations: ϕN interaction in spin $3/2$ is attractive [$a^{(3/2)} = -1.43(23)^{+36}_{-06}$ fm, $r^{(3/2)}_{\text{eff}} = 2.36(10)^{+02}_{-48}$fm.

- Photo-production data: weak ϕN interaction [$a \ll 1$]

Strakovsky, Pentchev, Titov, Phys. Rev. C101, 045201 (2020)

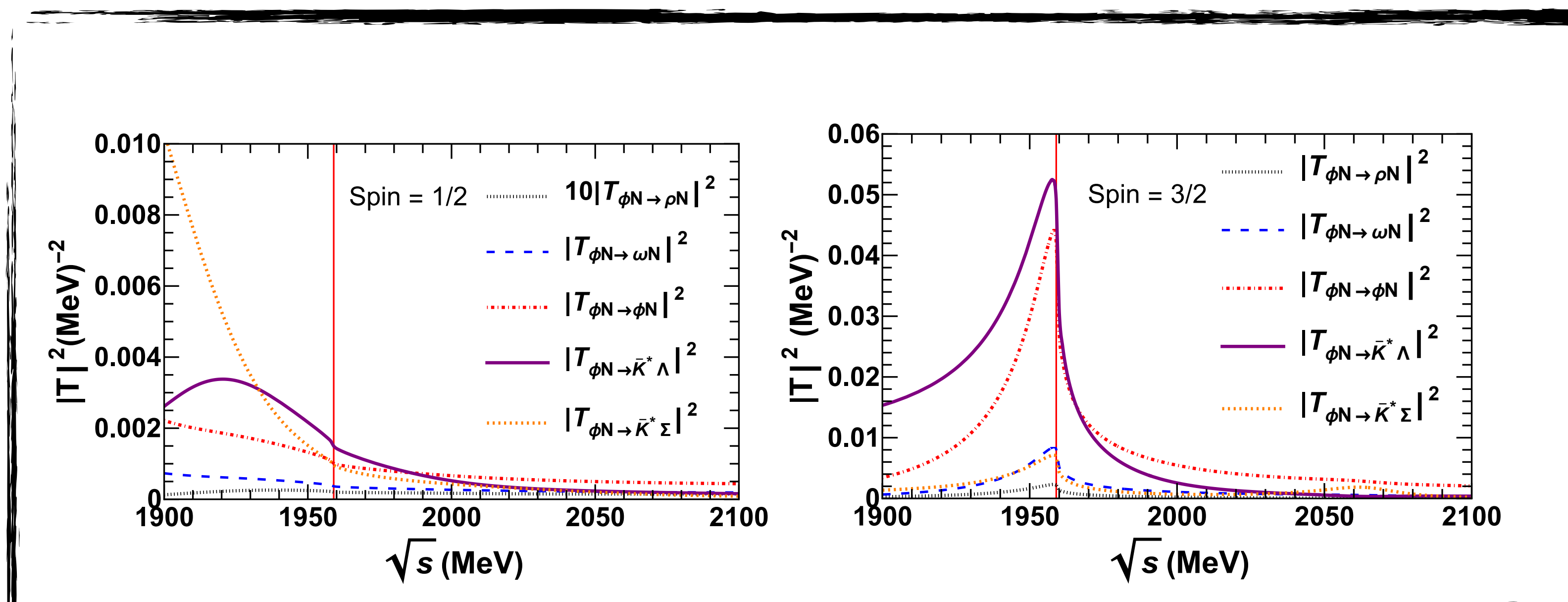
N* resonances with hidden strangeness and OZI rule

- Correlation functions of two hadrons: femtoscopy



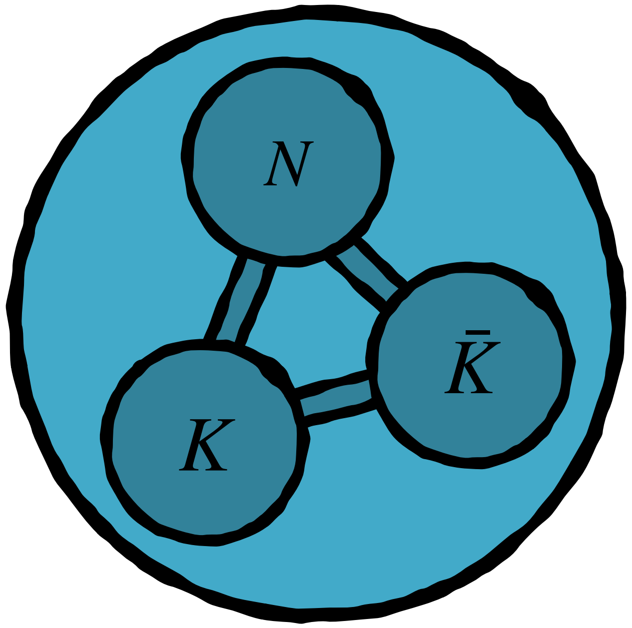
$$C(k) = \int d^3r S_{12}(\vec{r})|\Psi(\vec{k};\vec{r})|^2$$

It can be written in terms of the two-body t-matrix [I. Vidaña, A. Feijoo, Nieves, Oset, Phys. LettB 846, 138201 (2023)]



L. M. Abreu, P. Gubler, K. P. Khemchandani, A. Martínez Torres, A. Hosaka, Phys. Lett. B860, 139175 (2025).

- Three-body sector: $N^*(1920)$, S-wave interaction of $NK\bar{K}$



$$T^1 = t^1 + t^1 G[T^2 + T^3]$$
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D. Jido, Y. Kanada-En'yo, Phys. Rev. C78, 035203 (2008); A. Martínez Torres, K. P. Khemchandani, L. S. Geng, M. Napsuciale, E. Oset, Phys. Rev. D78,074031 (2008); A. Martínez Torres, K. P. Khemchandani, E. Oset, Phys. Rev. C, 065207 (2009); A. Martínez Torres, K. P. Khemchandani, Ulf-G. Meiβner, European. Phys. J. A41, 361 (2009); A. Martínez Torres, D. Jido, Phys. Rev. C82, 038202 (2010).

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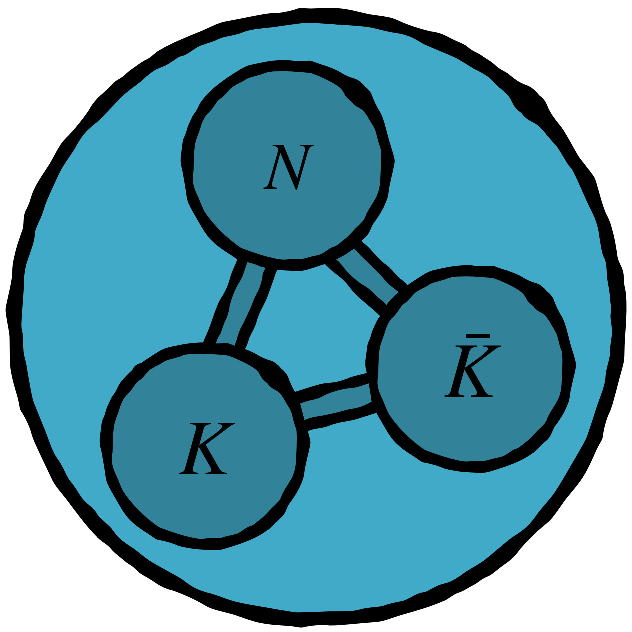

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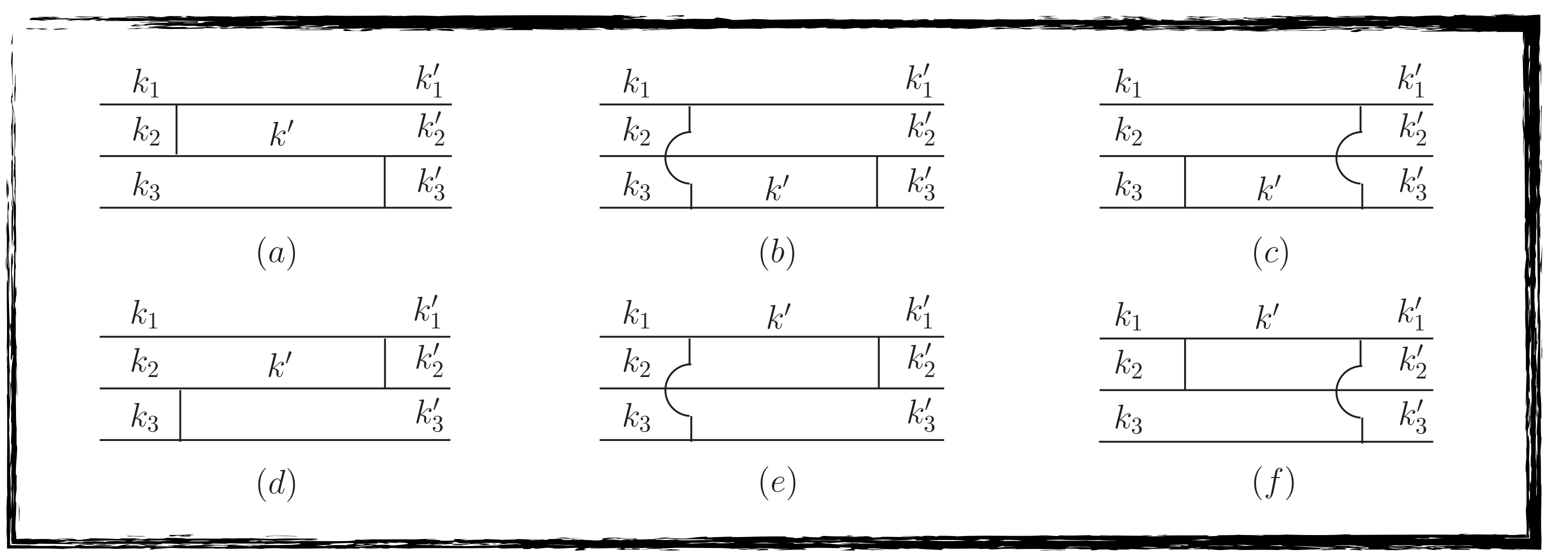

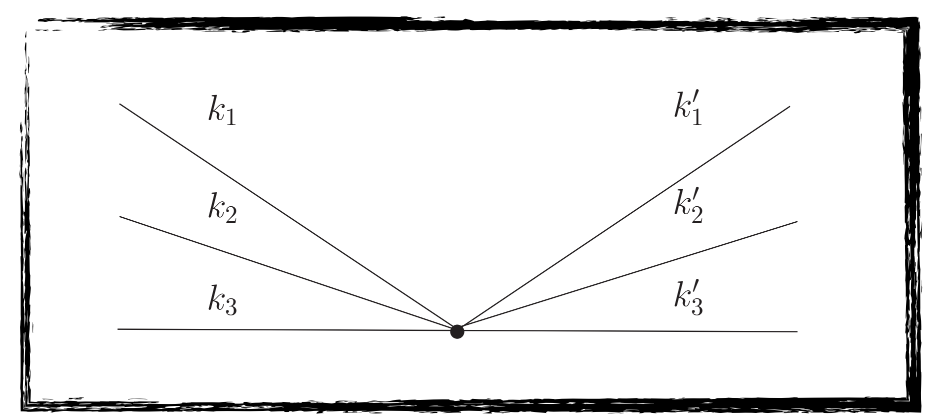

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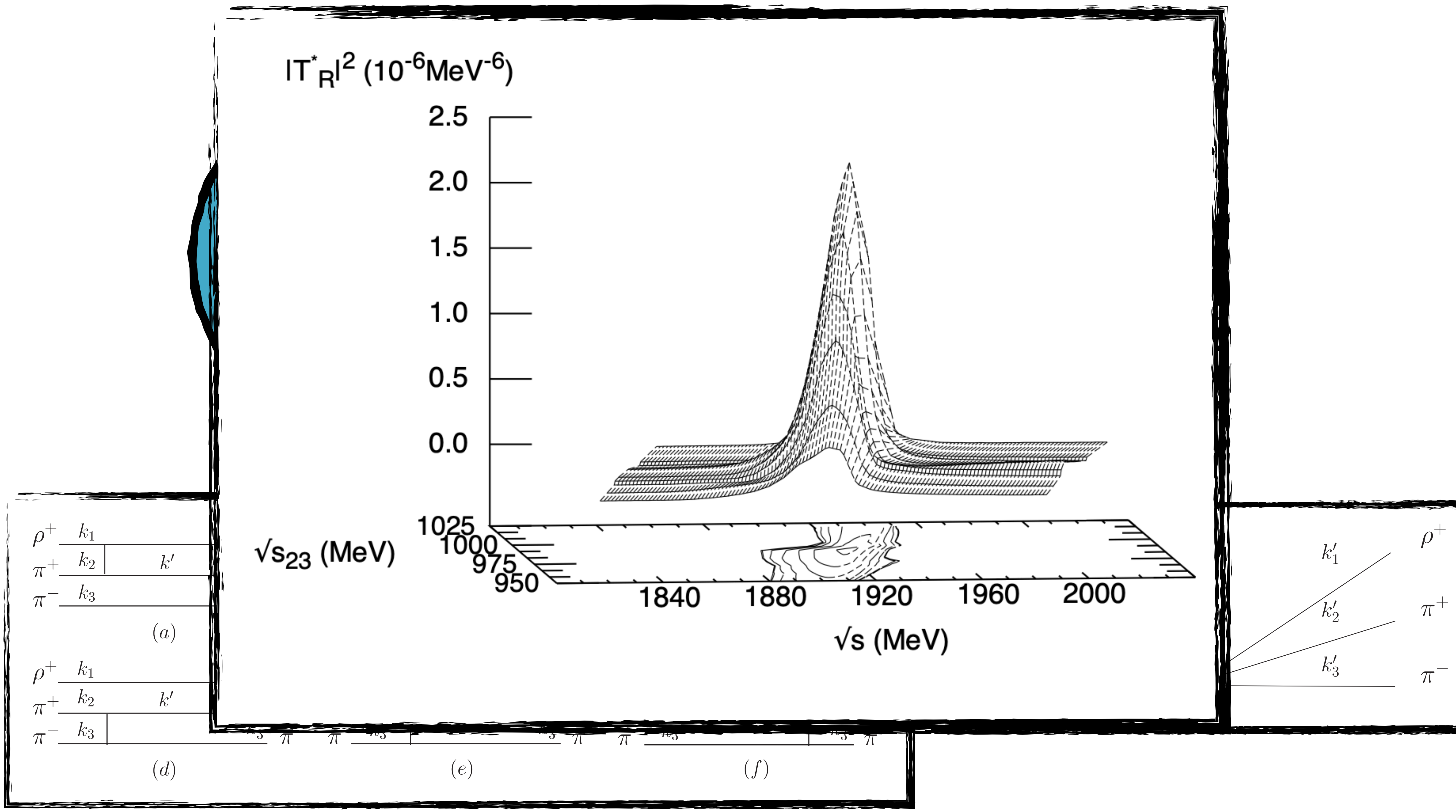

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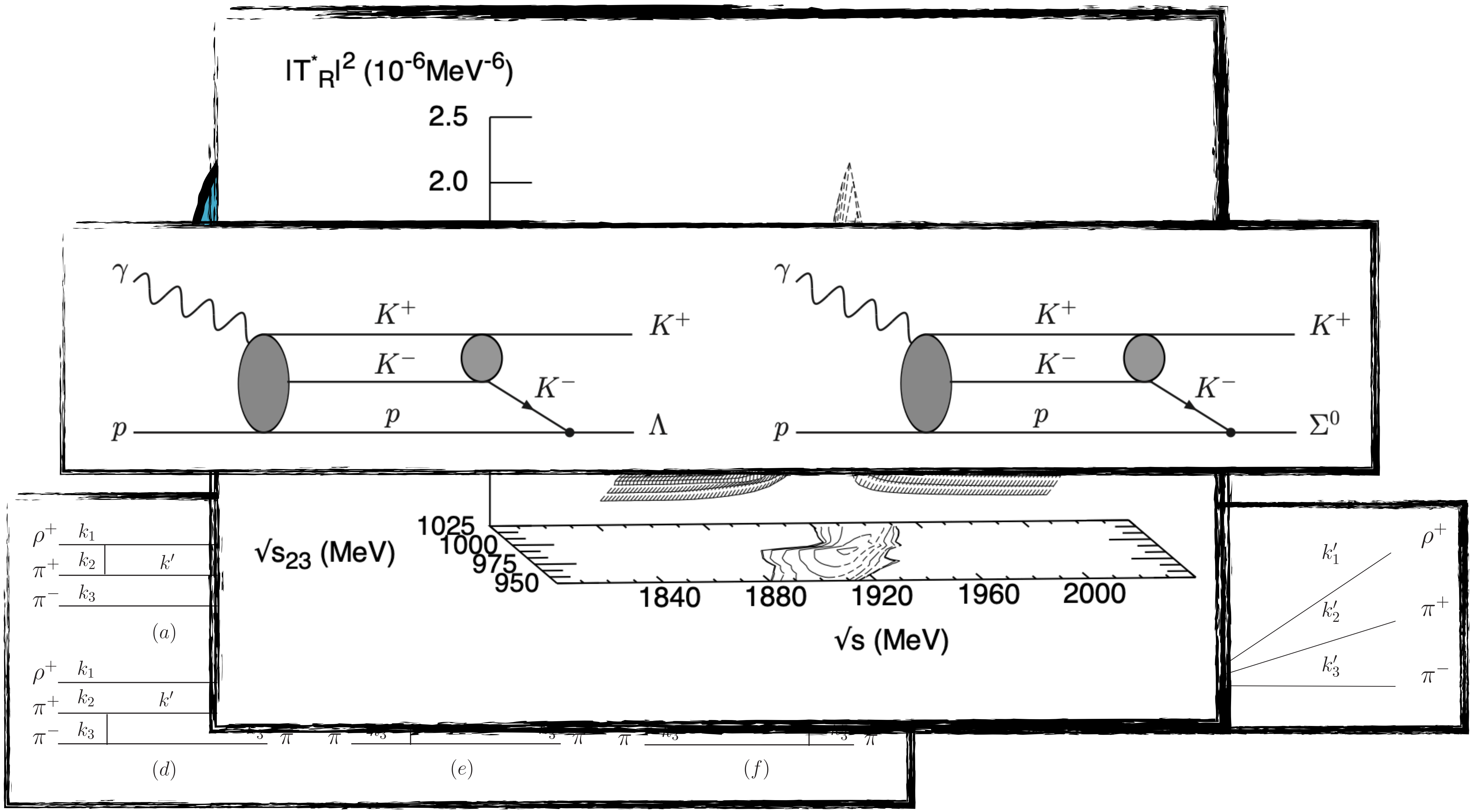

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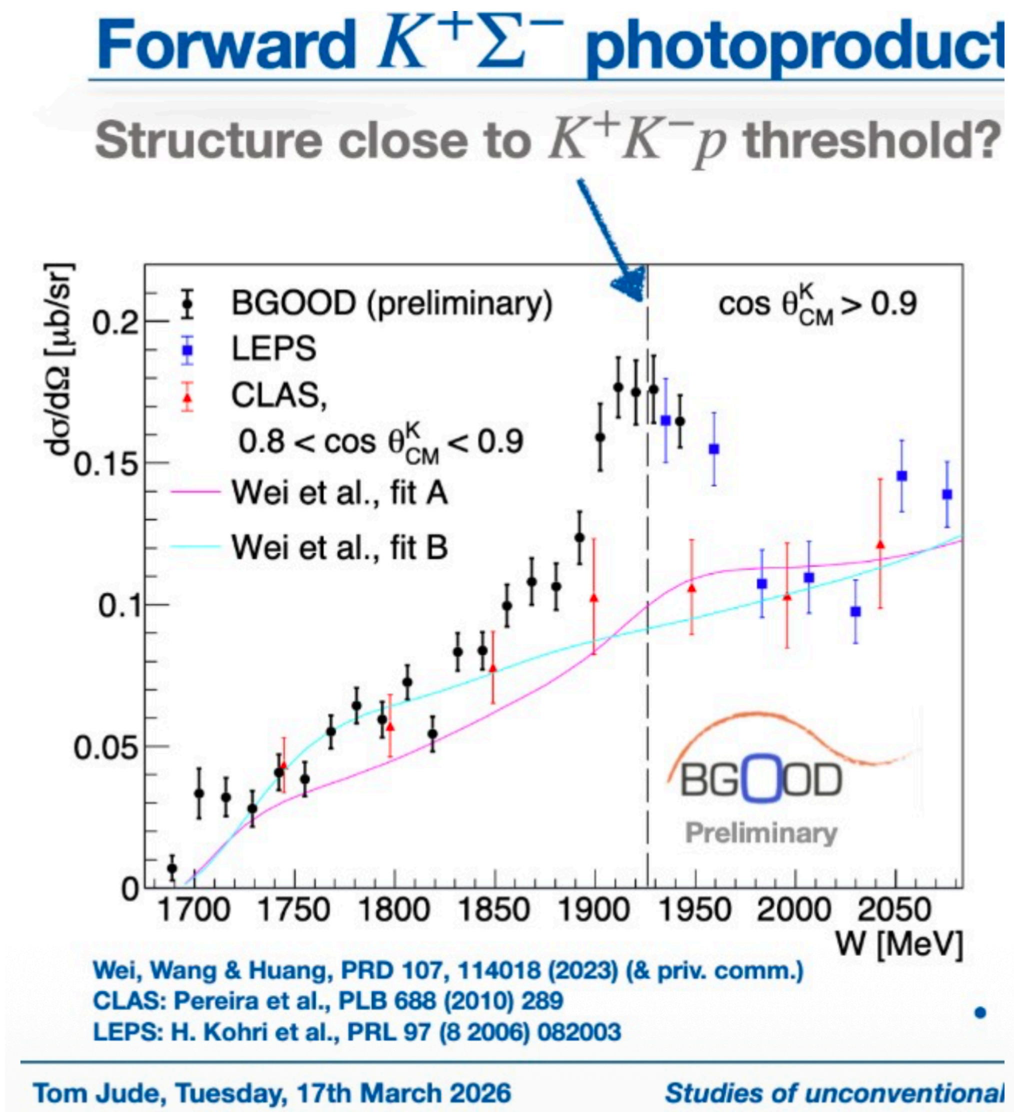
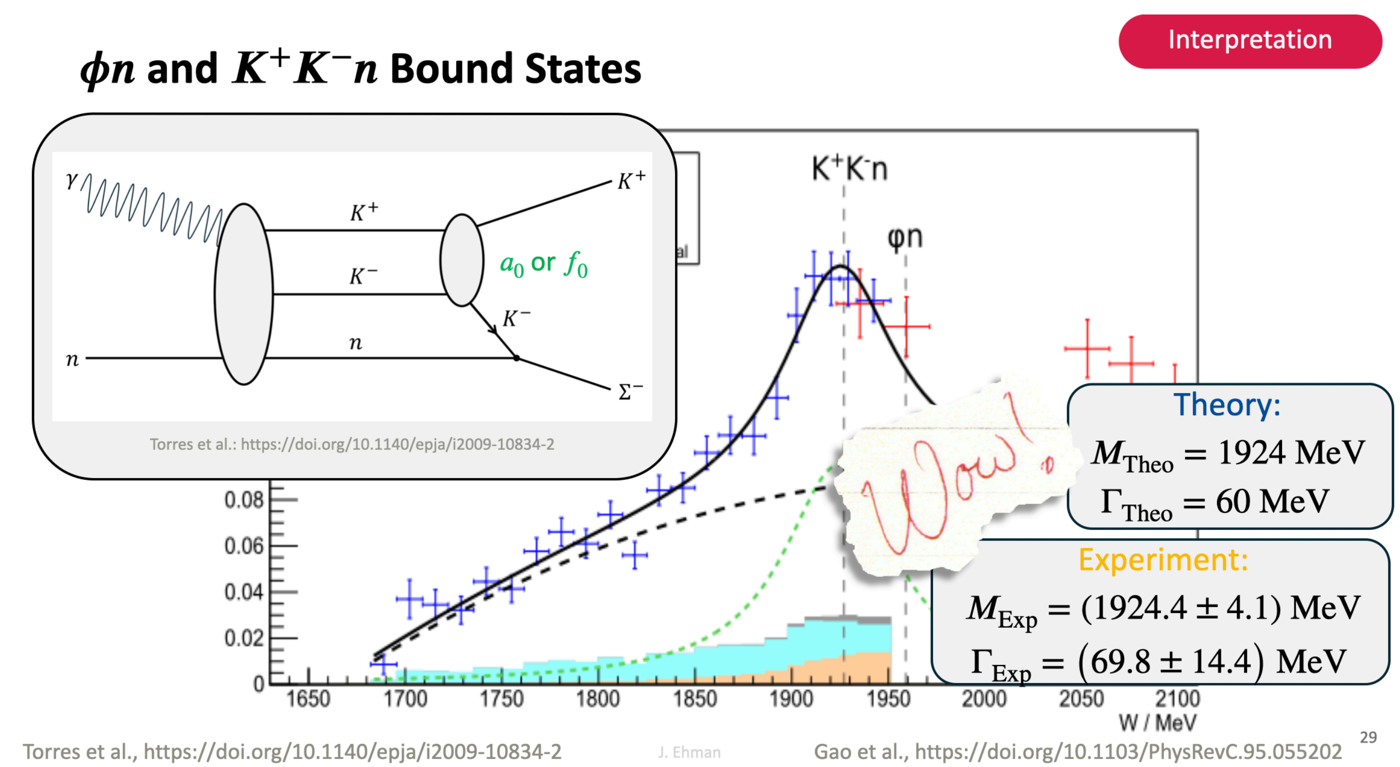


BGOOD collaboration



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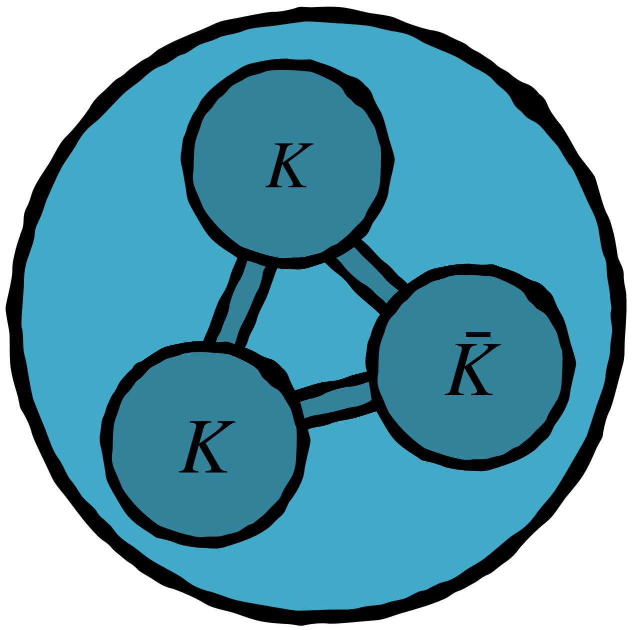
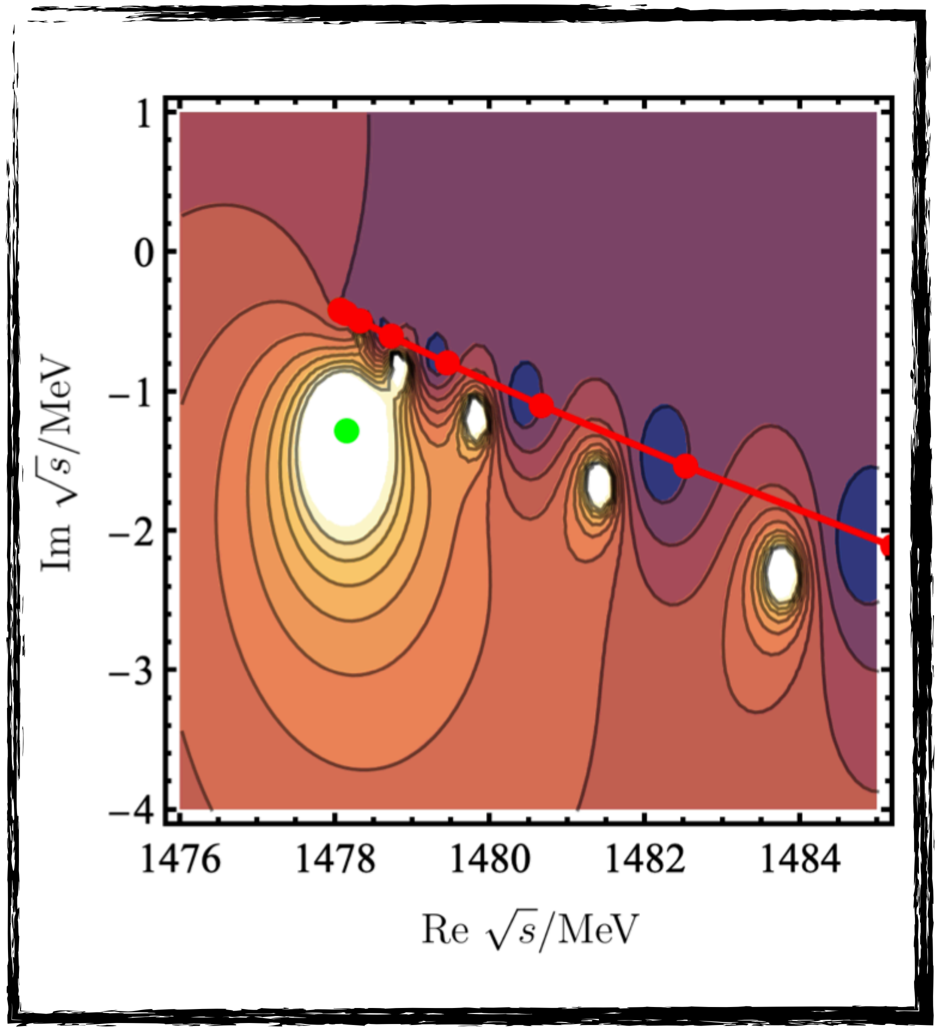
$K(1460)$

M. Döring, K. P. Khemchandani, A. Martínez Torres, Phys. Rev. D113, 034032 (2026)





SUMMARY

- There are several N^* resonances with hidden strangeness and $M \sim 2$ GeV.

- Vector-baryon dynamics in s-wave : $N^*(1895)\,[J^P = 1/2^-]$, $P_s(2080)\,[J^P = 3/2^-]$ [hidden strangeness partner of $P_c(4457)$]: $K^*\Sigma, K\Sigma, K\Lambda(1405), \pi N^*(1535)$

- Three-body dynamics: $N^*(1920)\,[J^P = 1/2^+]$

HADRONS 2027

SANTOS (SÃO PAULO STATE)