K* and D* Decays in pi-N Scattering

Strangeness production in pi-N and K-N scattering

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Ref. PRC 91, 065208 (2015), PRC 89, 025206 (2014), PRC 85, 042201 (2012)
PRC 95, 055206 (2017)

HYPERON SPECTRUM

- Missing hyperons and quantum numbers

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

Parity is not directly measured, but assigned by the quark model

— spin-parity known

20 N^* and 20 Δ^*

HYPERON SPECTRUM

- Model-dependence of hyperon spectrum

Ground state baryons are not enough.
We need more data!

Table 1. Low-lying Ξ and Ω baryon spectrum of spin 1/2 and 3/2 predicted by the non-relativistic quark model of Chao *et al.* (CIK), relativized quark model of Capstick and Isgur (CI), Glozman-Riska model (GR), large N_c analysis, algebraic model (BIL), and QCD sum rules (SR). The recent quark model prediction (QM) and the Skyrme model results (SK) are given as well. The mass is given in the unit of MeV.

State	CIK [4]	CI [5]	GR [6]	Large-N_c [7–11]	BIL [12]	SR [13,14]	QM [15]	SK [1]
$\Xi(\frac{1}{2}^+)$	1325	1305	1320		1334	1320 (1320)	1325	1318
	1695	1840	1798	1825	1727		1891	1932
	1950	2040	1947	1839	1932		2014	
$\Xi(\frac{3}{2}^+)$	1530	1505	1516		1524		1520	1539
	1930	2045	1886	1854	1878		1934	2120
	1965	2065	1947	1859	1979		2020	
$\Xi(\frac{1}{2}^-)$	1785	1755	1758	1780	1869	1550 (1630)	1725	1614
	1890	1810	1849	1922	1932		1811	1660
	1925	1835	1889	1927	2076			
$\Xi(\frac{3}{2}^-)$	1800	1785	1758	1815	1828	1840	1759	1820
	1910	1880	1849	1973	1869		1826	
	1970	1895	1889	1980	1932			
$\Omega(\frac{1}{2}^+)$	2190	2220	2068	2408	2085		2175	2140
	2210	2255	2166		2219		2191	
$\Omega(\frac{3}{2}^+)$	1675	1635	1651		1670		1656	1694
	2065	2165	2020	1922	1998		2170	2282
	2215	2280	2068	2120	2219		2182	
$\Omega(\frac{1}{2}^-)$	2020	1950	1991	2061	1989		1923	1837
$\Omega(\frac{3}{2}^-)$	2020	2000	1991	2100	1989		1953	1978

Exp.

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

The 3rd lowest state

$\bar{K}N \to K\Xi$

- Difficulties
  - Mostly, the decay distributions are used
  - Ground state: no strong decay
  - Remove model-dependence
- We need a model-independent method (based on symmetries only)
  - use the anti-kaon beam: larger cross sections
  - define
    $$\hat{\mathbf{n}}_1 \equiv (\mathbf{q} \times \mathbf{q}') \times \mathbf{q} / |(\mathbf{q} \times \mathbf{q}') \times \mathbf{q}|$$
    $$\hat{\mathbf{n}}_2 \equiv (\mathbf{q} \times \mathbf{q}') / |\mathbf{q} \times \mathbf{q}'|$$
    $$\bar{K}(q)N(p) \to K(q')\Xi(p')$$
  - choose $\hat{\mathbf{q}} = \hat{\mathbf{z}}, \quad \hat{\mathbf{n}}_1 = \hat{\mathbf{x}}, \quad \hat{\mathbf{n}}_2 = \hat{\mathbf{y}}$

$\hat{\mathbf{q}}$ and $\hat{\mathbf{n}}_1$ form the reaction plane

$\bar{K}N \to K\Xi$

- The general spin-structure of the reaction amplitude

$$\hat{M}^+ = M_0 + M_2 \boldsymbol{\sigma} \cdot \hat{\mathbf{n}}_2, \qquad \text{for positive parity } \Xi$$

$$\hat{M}^- = M_1 \boldsymbol{\sigma} \cdot \hat{\mathbf{n}}_1 + M_3 \boldsymbol{\sigma} \cdot \hat{\mathbf{n}}_3, \qquad \text{for negative parity } \Xi$$

$$\Rightarrow \hat{M} = \sum_{m=0}^{3} M_m \sigma_m$$

where $M_1 = M_3 = 0$ for positive parity Ξ
and $M_0 = M_2 = 0$ for negative parity Ξ

- The cross section

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\,\mathrm{Tr}\left(\hat{M}\hat{M}^\dagger\right) = \sum_{m=0}^{3} |M_m|^2$$

$\bar{K}N \to K\Xi$

- (Diagonal) spin-transfer coefficient

$$\frac{d\sigma}{d\Omega}K_{ii} = \frac{1}{2}\,\mathrm{Tr}\left(\hat{M}\sigma_i\hat{M}^\dagger\sigma_i\right) = |M_0|^2 + |M_i|^2 - \sum_{k\neq i}|M_k|^2$$

$$\Rightarrow \quad K_{ii} = \frac{d\sigma_i(++) - d\sigma_i(+-)}{d\sigma_i(++) + d\sigma_i(+-)}$$

- Therefore, when *i*=*y*, $K_{ii} = \pi_\Xi(= \pm 1)$
- Double polarization observable
  - The Ξ is self-analyzing, so we need polarized nucleon target only
  - should be possible to measure at J-PARC
- Generalization to Ξ^* resonances and to Ξ photoproduction is also possible

$$\pi_\Xi = \frac{K_{yy}}{\Sigma}$$

Nakayama, YO, Haberzettl, PRC **85** (2012) 042201(R)

$\bar{K}N \to K\Xi$

- Target Nucleon asymmetry

$$\frac{d\sigma}{d\Omega} T_i \equiv \frac{1}{2} \mathrm{Tr}\left(M \sigma_i M^\dagger\right) = 2\mathrm{Re}[M_0 M_i^*] + 2\mathrm{Im}[M_j M_k^*]$$

- Recoil Cascade asymmetry

$$\frac{d\sigma}{d\Omega} P_i \equiv \frac{1}{2} \mathrm{Tr}\left(M M^\dagger \sigma_i\right) = 2\mathrm{Re}[M_0 M_i^*] - 2\mathrm{Im}[M_j M_k^*]$$

Positive parity Cascade

$$\frac{d\sigma}{d\Omega}(T_y + P_y) = 4\mathrm{Re}[M_0 M_2^*]$$

$$\frac{d\sigma}{d\Omega}(T_y - P_y) = 0$$

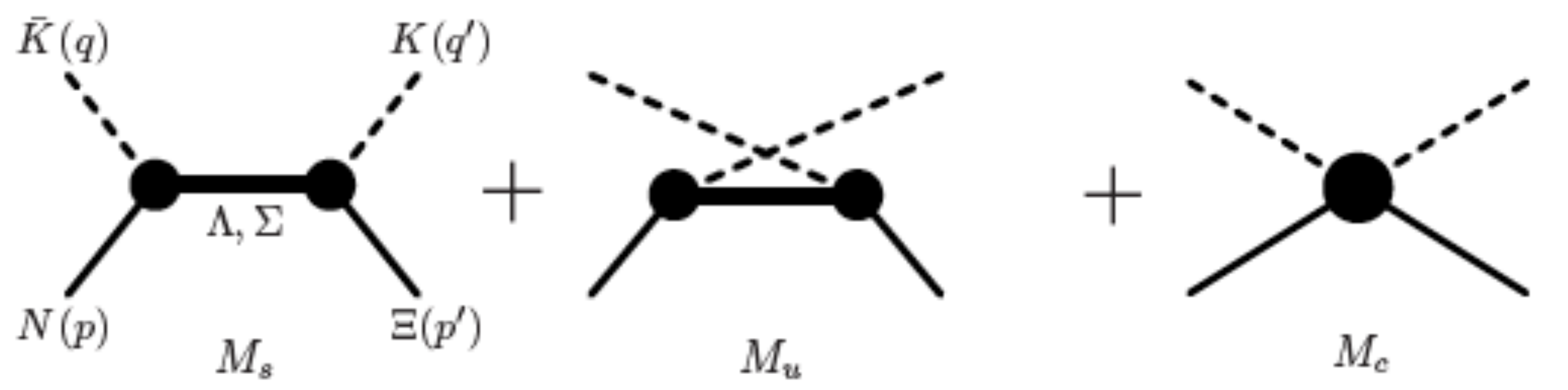
Negative parity Cascade

$$\frac{d\sigma}{d\Omega}(T_y + P_y) = 0$$

$$\frac{d\sigma}{d\Omega}(T_y - P_y) = 4\mathrm{Im}[M_3 M_1^*]$$

- More details for the kinematics of spin-1/2 and 3/2 Ξ baryon productions can be found in Jackson, YO, Haberzettl, Nakayama, PRC 89 (2014) 025206

$\bar{K}N \to K\Xi$ (MODEL CALCULATION)



Λ(1116) Σ(1193)
Λ(1405) Σ(1385)
Λ(1520)

the model parameters may be fixed from the relevant decay rates(PDG) and/or quark models and SU(3) symmetry considerations.

Λ states				Σ states			
State	J^P	Γ (MeV)		State	J^P	Γ (MeV)	
Λ(1600)	$1/2^+$	≈ 150	***	Σ(1660)	$1/2^+$	≈ 100	***
Λ(1670)	$1/2^-$	≈ 35	****	Σ(1670)	$3/2^-$	≈ 60	****
Λ(1690)	$3/2^-$	≈ 60	****	Σ(1750)	$1/2^-$	≈ 90	***
Λ(1800)	$1/2^-$	≈ 300	***	Σ(1775)	$5/2^-$	≈ 120	****
Λ(1810)	$1/2^+$	≈ 150	***	Σ(1915)	$5/2^+$	≈ 120	****
Λ(1820)	$5/2^+$	≈ 80	****	Σ(1940)	$3/2^-$	≈ 220	***
Λ(1830)	$5/2^-$	≈ 95	****	Σ(2030)	$7/2^+$	≈ 180	****
Λ(1890)	$3/2^+$	≈ 100	****	Σ(2250)	$?^?$	≈ 100	***
Λ(2100)	$7/2^-$	≈ 200	****				
Λ(2110)	$5/2^+$	≈ 200	***				
Λ(2350)	$9/2^+$	≈ 150	***				

no enough information to fix the parameters of the model.

TOOLS

$$\mathcal{L}^{3/2(\pm)}_{\Lambda N K} = \frac{g_{\Lambda N K}}{m_K}\,\bar{\Lambda}^{\nu}\big(D^{3/2(\pm)}_{\nu}\bar{K}\big)N + \text{H.c.}\,, \tag{A6a}$$

$$\mathcal{L}^{3/2(\pm)}_{\Sigma N K} = \frac{g_{\Sigma N K}}{m_K}\,\bar{\boldsymbol{\Sigma}}^{\nu}\cdot\big(D^{3/2(\pm)}_{\nu}\bar{K}\big)\boldsymbol{\tau}N + \text{H.c.}\,, \tag{A6b}$$

$$\mathcal{L}^{3/2(\pm)}_{\Xi\Lambda K_c} = \frac{g_{\Xi\Lambda K_c}}{m_K}\,\bar{\Xi}\big(D^{3/2(\pm)}_{\nu}K_c\big)\Lambda^{\nu} + \text{H.c.}\,, \tag{A6c}$$

$$\mathcal{L}^{3/2(\pm)}_{\Xi\Sigma K_c} = \frac{g_{\Xi\Sigma K_c}}{m_K}\,\bar{\Xi}\boldsymbol{\tau}\big(D^{3/2(\pm)}_{\nu}K_c\big)\cdot\boldsymbol{\Sigma}^{\nu} + \text{H.c.}\,, \tag{A6d}$$

$$\mathcal{L}^{5/2(\pm)}_{\Lambda N K} = \frac{g_{\Lambda N K}}{m_K^2}\,\bar{\Lambda}^{\mu\nu}\big(D^{5/2(\pm)}_{\mu\nu}\bar{K}\big)N + \text{H.c.}\,, \tag{A7a}$$

$$\mathcal{L}^{5/2(\pm)}_{\Sigma N K} = \frac{g_{\Sigma N K}}{m_K^2}\,\bar{\boldsymbol{\Sigma}}^{\mu\nu}\cdot\big(D^{5/2(\pm)}_{\mu\nu}\bar{K}\big)\boldsymbol{\tau}N + \text{H.c.}\,, \tag{A7b}$$

$$\mathcal{L}^{5/2(\pm)}_{\Xi\Lambda K_c} = \frac{g_{\Xi\Lambda K_c}}{m_K^2}\,\bar{\Xi}\big(D^{5/2(\pm)}_{\mu\nu}K_c\big)\Lambda^{\mu\nu} + \text{H.c.}\,, \tag{A7c}$$

$$\mathcal{L}^{5/2(\pm)}_{\Xi\Sigma K_c} = \frac{g_{\Xi\Sigma K_c}}{m_\kappa^2}\,\bar{\Xi}\boldsymbol{\tau}\big(D^{5/2(\pm)}_{\mu\nu}K_c\big)\cdot\boldsymbol{\Sigma}^{\mu\nu} + \text{H.c.} \tag{A7d}$$

$$\mathcal{L}^{7/2(\pm)}_{\Lambda N K} = \frac{g_{\Lambda N K}}{m_K^3}\,\bar{\Lambda}^{\mu\nu\rho}\big(D^{7/2(\pm)}_{\mu\nu\rho}\bar{K}\big)N + \text{H.c.}\,, \tag{A8a}$$

$$\mathcal{L}^{7/2(\pm)}_{\Sigma N K} = \frac{g_{\Sigma N K}}{m_K^3}\,\bar{\boldsymbol{\Sigma}}^{\mu\nu\rho}\cdot\big(D^{7/2(\pm)}_{\mu\nu\rho}\bar{K}\big)\boldsymbol{\tau}N + \text{H.c.}\,, \tag{A8b}$$

$$\mathcal{L}^{7/2(\pm)}_{\Xi\Lambda K_c} = \frac{g_{\Xi\Lambda K_c}}{m_K^3}\,\bar{\Xi}\big(D^{7/2(\pm)}_{\mu\nu\rho}K_c\big)\Lambda^{\mu\nu\rho} + \text{H.c.}\,, \tag{A8c}$$

$$\mathcal{L}^{7/2(\pm)}_{\Xi\Sigma K_c} = \frac{g_{\Xi\Sigma K_c}}{m_K^3}\,\bar{\Xi}\boldsymbol{\tau}\big(D^{7/2(\pm)}_{\mu\nu\rho}K_c\big)\cdot\boldsymbol{\Sigma}^{\mu\nu\rho} + \text{H.c.} \tag{A8d}$$

$$D^{1/2(\pm)}_{B'BM} \equiv -\Gamma^{(\pm)}\left(\pm i\lambda + \frac{1-\lambda}{m_{B'} \pm m_B}\,\partial\!\!\!/\right), \tag{A3a}$$

$$D^{3/2(\pm)}_{\nu} \equiv \Gamma^{(\mp)}\partial_\nu\,, \tag{A3b}$$

$$D^{5/2(\pm)}_{\mu\nu} \equiv -i\,\Gamma^{(\pm)}\partial_\mu\partial_\nu\,, \tag{A3c}$$

$$D^{7/2(\pm)}_{\mu\nu\rho} \equiv -\Gamma^{(\mp)}\partial_\mu\partial_\nu\partial_\rho\,, \tag{A3d}$$

$\Gamma^{(+)} \equiv \gamma_5$ and $\Gamma^{(-)} \equiv 1$

RESULTS

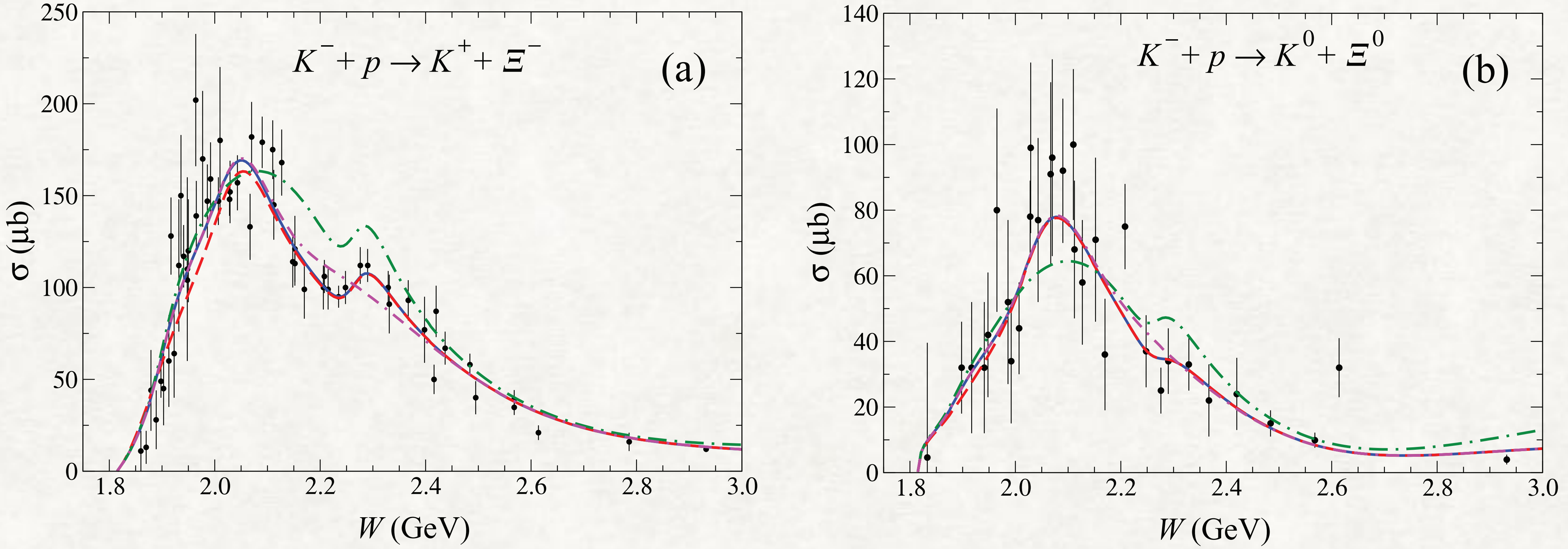


FIG. 4. (Color online) Total cross-section results with individual resonances switched off (a) for $K^- + p \to K^+ + \Xi^-$ and (b) for $K^- + p \to K^0 + \Xi^0$. The blue (gray) lines represent the full result shown in Figs. 2 and 3. The red (gray) dashed lines which almost coincide with the blue lines represent the result with $\Lambda(1890)$ switched off. The green (gray) dash-dotted lines represent the result with $\Sigma(2030)$ switched off and the magenta (dark gray) dash-dash-dotted lines represent the result with $\Sigma(2250)5/2^-$ switched off.

$\Lambda(1890), \quad \Sigma(2030), \quad \Sigma(2250)$

- Jackson, YO, Haberzettl, Nakayama, PRC 91 (2015) 065208

RESULTS

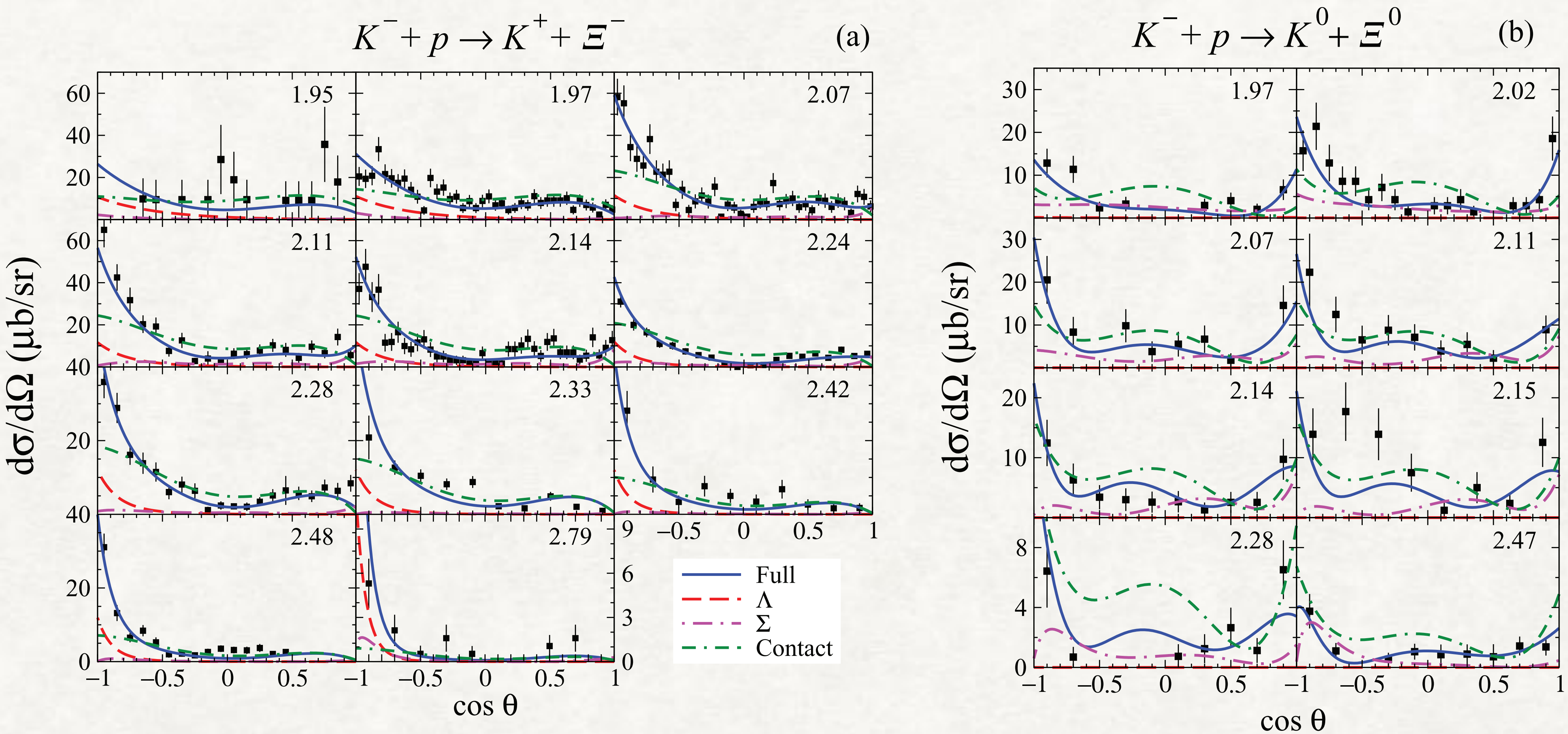


FIG. 5. (Color online) Kaon angular distributions in the center-of-mass frame (a) for $K^- + p \to K^+ + \Xi^-$ and (b) for $K^- + p \to K^0 + \Xi^0$. The blue (gray) lines represent the full model results. The red (gray) dashed lines show the combined Λ hyperon contributions. The magenta (dark gray) dash-dotted lines show the combined Σ hyperon contributions. The green (gray) dash-dash-dotted line corresponds to the contact term. The numbers in the upper right corners correspond to the centroid total energy of the system W. Note the different scales used. The experimental data (black circles) are the digitized version as quoted in Ref. [50] from the original work of Refs. [31–34,36,37] for the $K^- + p \to K^+ + \Xi^-$ reaction and of Ref. [30,36,37,40] for the $K^- + p \to K^0 + \Xi^0$ reaction.

RESULTS

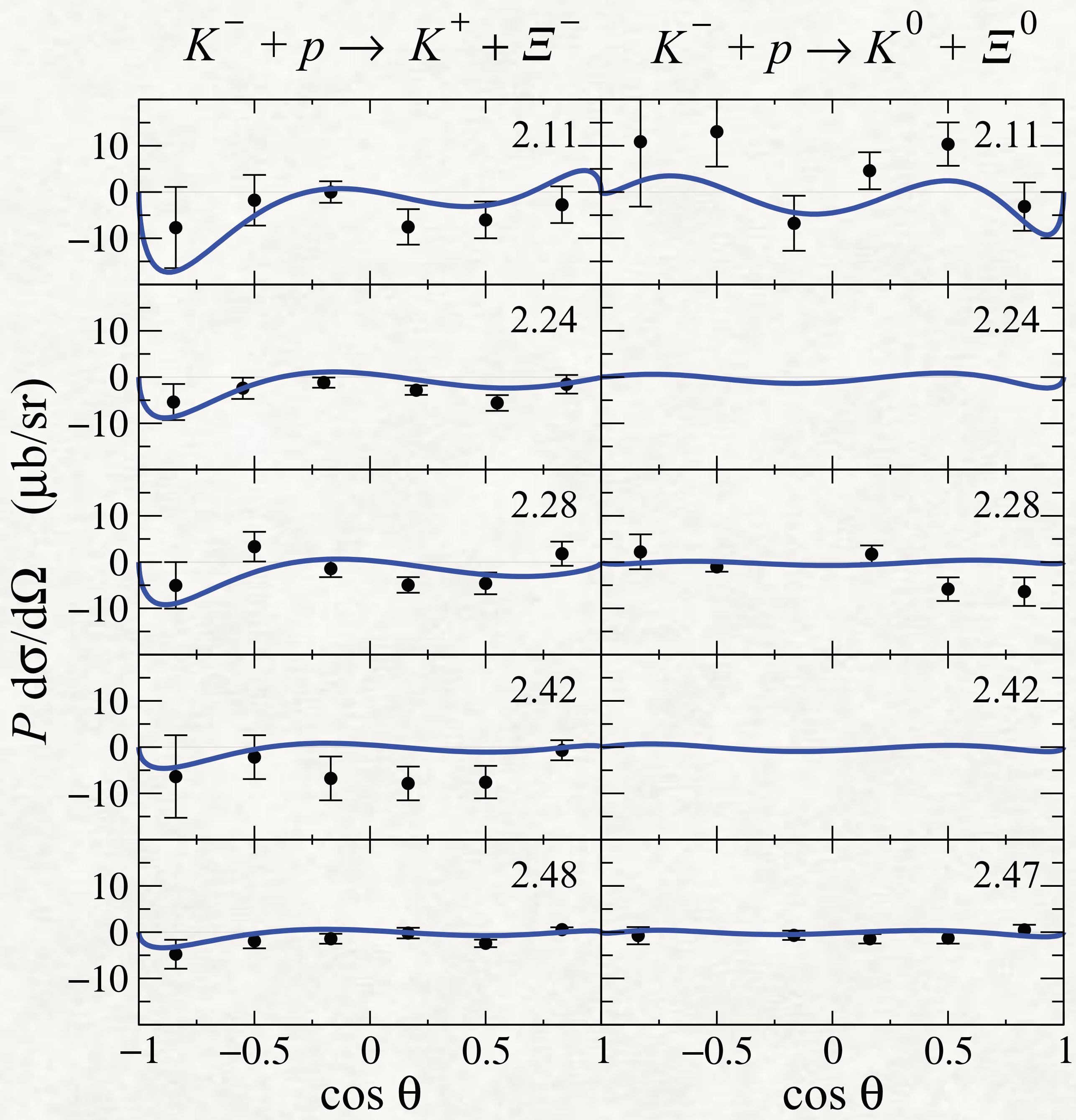
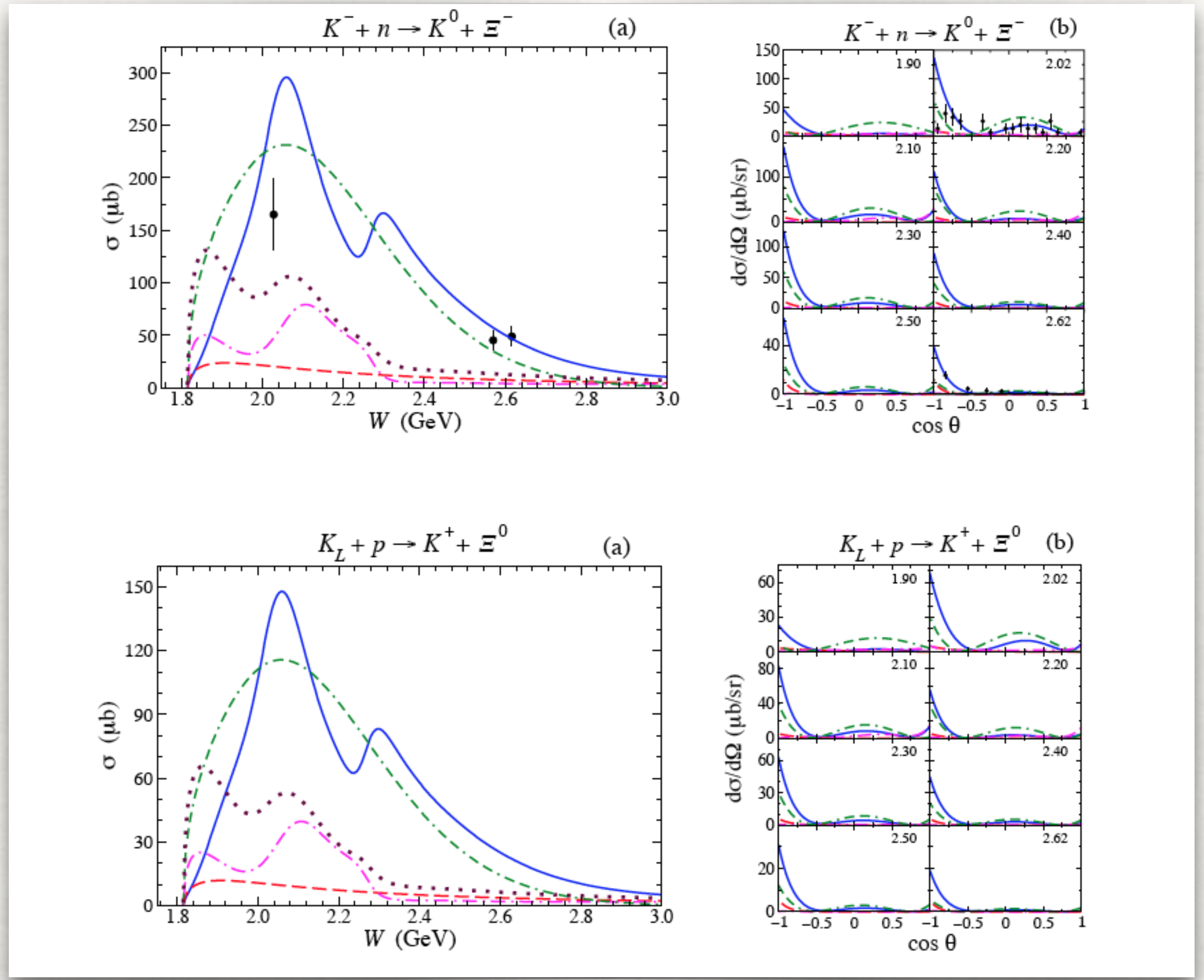


FIG. 9. (Color online) The recoil asymmetry multiplied by the cross section, $P\frac{d\sigma}{d\Omega}$, for both the $K^- + p \to K^+ + \Xi^-$ and $K^- + p \to K^0 + \Xi^0$ reactions. The blue (gray) solid lines represent the full results of the current model. Data are from Refs. [33,37].

RESULTS (PREDICTIONS)



$$\pi^- p \to K^{*0}\Lambda, \qquad \pi^- p \to D^{*-}\Lambda_c$$

* Motivation

- Reactions close to threshold: nonperturbative approaches
- Effective Regge exchanges
  - QGSM (Quark Gluon String Model): Kaidalov et al.
  - usually vector exchange only is assumed because of large intercept of the trajectory
  - but the coupling is not known
  - it is needed to check the dominance of vector exchanges.

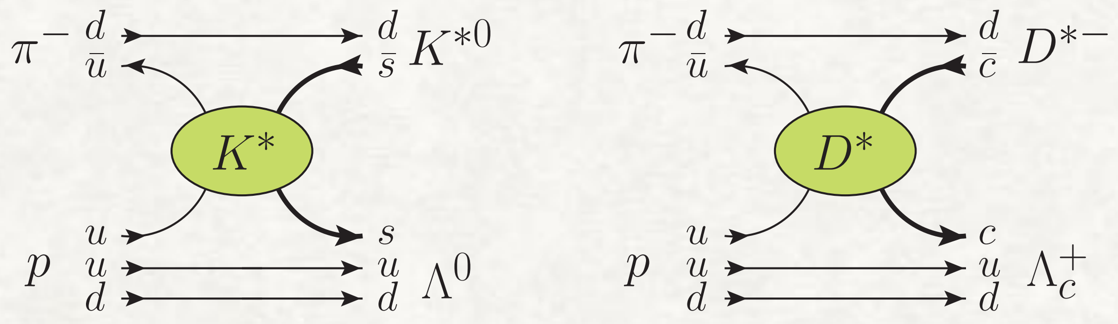


FIG. 2. Diagrammatic representation of the effective $\pi^- + p \to K^{*0} + \Lambda$ and $\pi^- + p \to D^{*-} + \Lambda_c^+$ reactions.

FORMALISM

Cross section for (two-body → three-body) through the decay of the produced particle

$$d\sigma = \left(\frac{1}{16\pi\lambda_i}|T_{fi}|^2 dt\right)\left(\frac{k_f d\Omega_f dM_V}{16\pi^3}\right)$$

$$\pi^- + p \to V + Y \to (P + \pi) + Y$$

$$T_{fi} = \mathcal{A}_{m_f,\lambda_V;m_i}\frac{1}{p_V^2 - M_0^2 + iM_0\Gamma_{\rm tot}}\mathcal{D}_{\lambda_V}(\Omega_f)$$

$$\mathcal{D}_\lambda = 2c\sqrt{\frac{4\pi}{3}}Y_{1\lambda}(\Omega_f)$$

* vector exchange

$$\mathcal{A}^V_{fi} = g_0^2\,\frac{s}{\bar{s}}\,\Gamma\big(1-\alpha^V_{\mathcal{R}}(t)\big)\left(\frac{s}{s^V_{0\mathcal{R}}}\right)^{\alpha^V_{\mathcal{R}}(t)-1}$$

$$S_{m_f,\lambda_V;m_i} = \epsilon^{\mu\nu\alpha\beta}q_\mu p_{V\alpha}\varepsilon^*_\beta(\lambda_V)\times\bar{u}_{m_f}(\Lambda) \times\left[(1+\kappa_{K^*p\Lambda})\gamma_\nu - \kappa_{K^*p\Lambda}\frac{(p_p+p_\Lambda)_\nu}{M_p+M_\Lambda}\right]u_{m_i}(p)$$

* pseudoscalar exchange

$$\mathcal{A}^{\rm PS}_{fi} \simeq g_0^2\,\Gamma\big(-\alpha^{\rm PS}_{\mathcal{R}}(t)\big)\left(\frac{s}{s^{\rm PS}_{0\mathcal{R}}}\right)^{\alpha^{\rm PS}_{\mathcal{R}}(t)}$$

$$S^{\rm PS}_{m_f,\lambda_V;m_i} = \varepsilon^*_\mu(\lambda_V)\,q^\mu\bar{u}_{m_f}(\Lambda)\gamma_5 u_{m_i}(p)$$

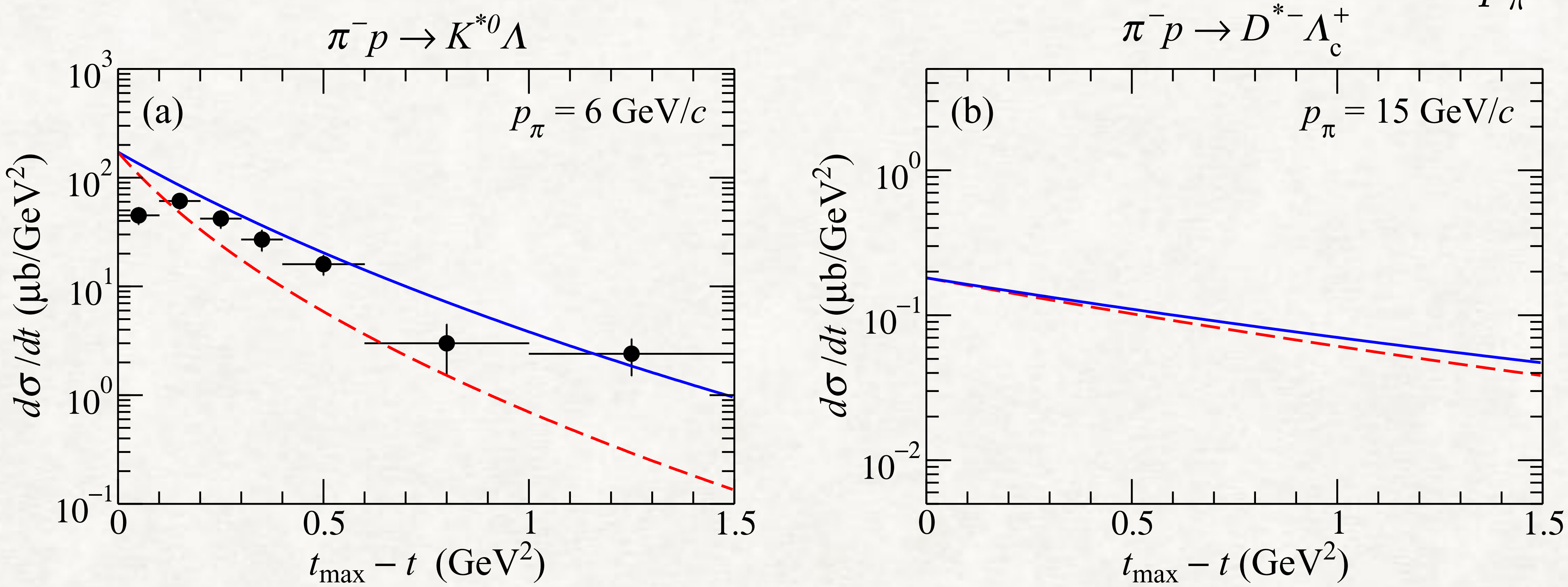
$$\alpha^V_{\rm strangeness} = -0.414 + 0.707\,t \qquad \alpha^V_{\rm charm} = -1.02 + 0.467\,t$$

$$\alpha^{PS}_{\rm strangeness} = -0.151 + 0.617\,t \qquad \alpha^{PS}_{\rm charm} = -1.611 + 0.439\,t$$

DIFFERENTIAL CROSS SECTIONS

$p_\pi = 6$ GeV

$p_\pi = 11$ GeV

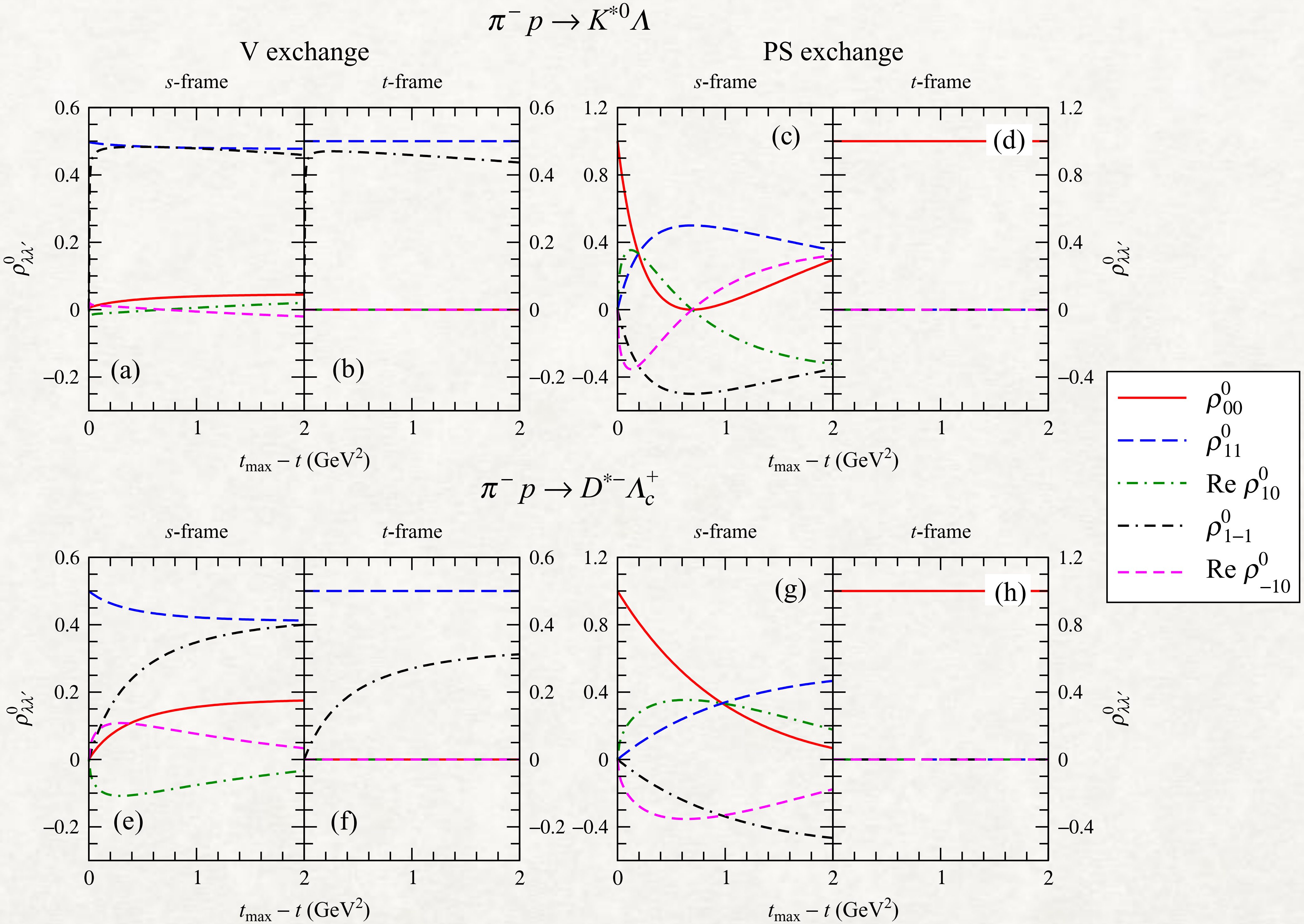


vector exchange

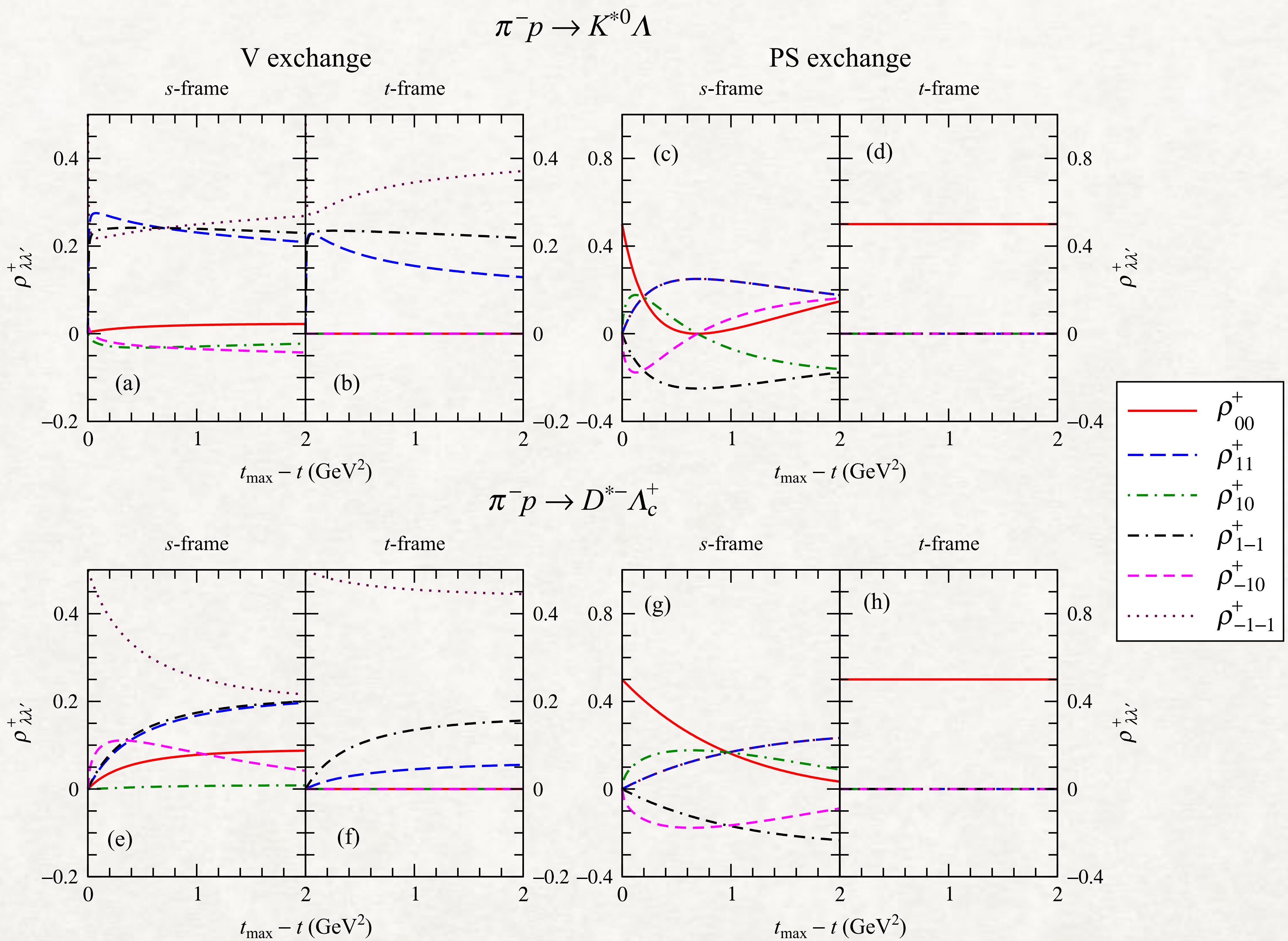
pseudoscalar exchange

Both exchanges are normalized to the differential cross sections at the forward angle.

SPIN-DENSITY MATRIX ELEMENTS

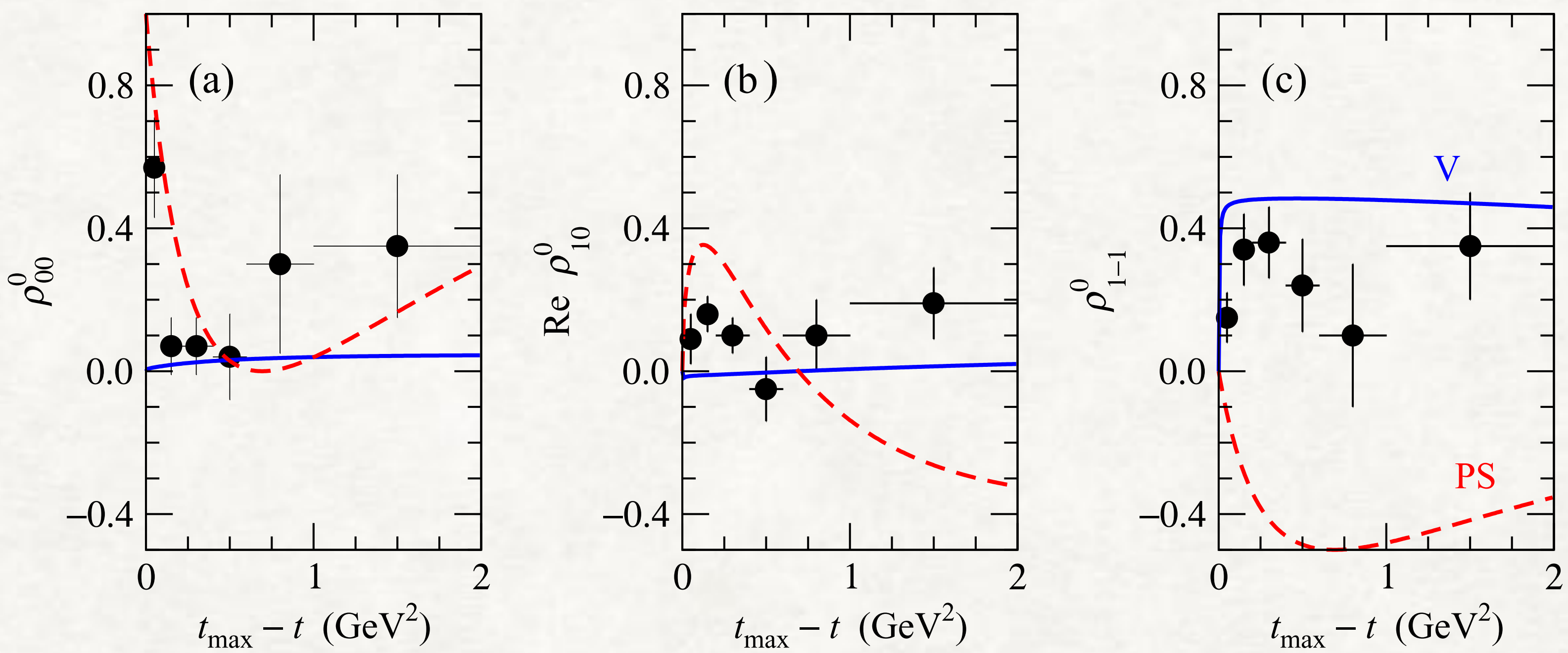


SPIN-DENSITY MATRIX ELEMENTS

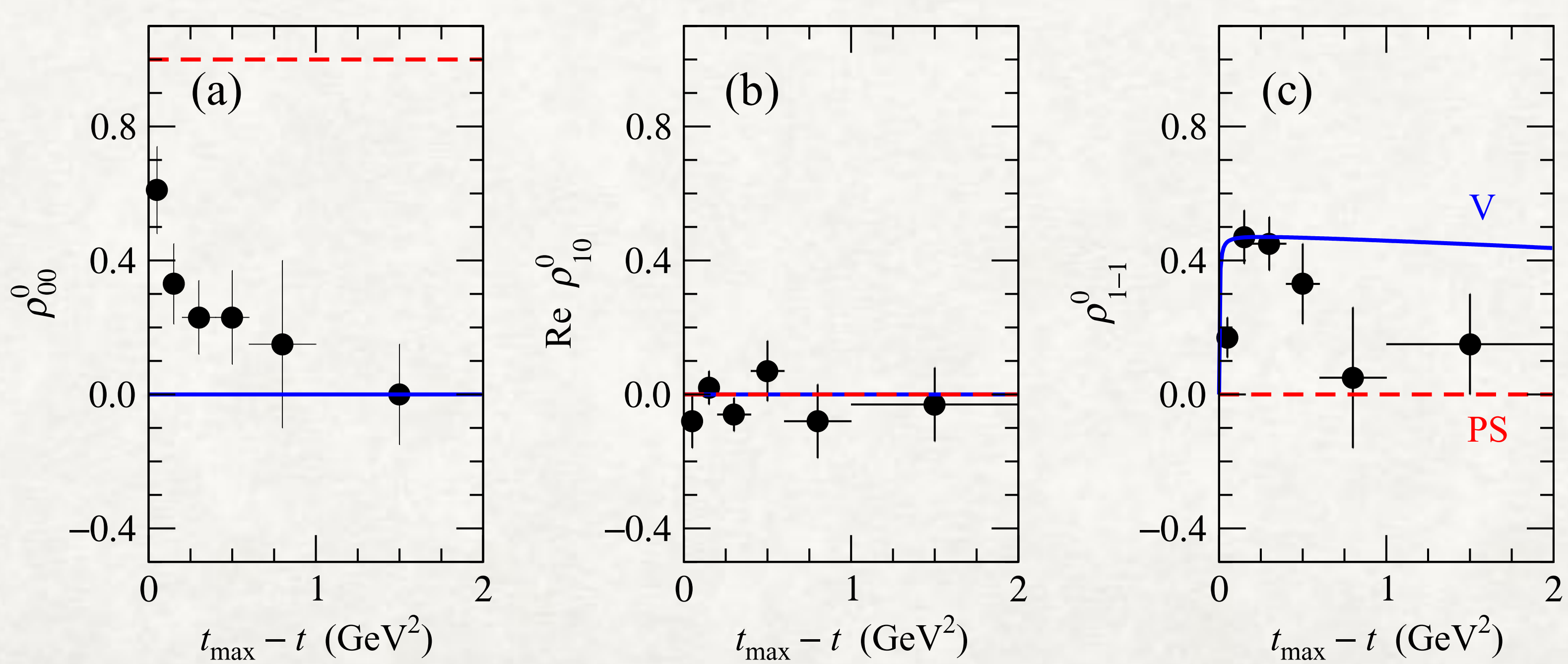


COMPARISON WITH DATA

$\pi^- p \to K^{*0}\Lambda$ (*s*-frame)



$\pi^- p \to K^{*0}\Lambda$ (*t*-frame)



DECAY ANGULAR DISTRIBUTION

$$\frac{d\sigma}{dt\, d\Omega_f} = \frac{d\sigma}{dt} W(\Omega_f) \quad \text{with } W(\Omega_f) = \sum_{m_i, m_f, \lambda_V, \lambda'_V} \mathcal{M}_{m_f,\lambda_V;m_i} \mathcal{M}^*_{m_f,\lambda'_V;m_i} Y_{1\lambda_V}(\Omega_f) Y^*_{1\lambda'_V}(\Omega_f)$$

* Define the density matrix elements

$$\rho^0_{\lambda\lambda'} = \sum_{m_i=\pm\frac{1}{2},\, m_f=\pm\frac{1}{2}} \mathcal{M}_{m_f,\lambda;m_i} \mathcal{M}^*_{m_f,\lambda';m_i}, \qquad \rho^{\pm}_{\lambda\lambda'} = \sum_{m_i=\pm\frac{1}{2}} \mathcal{M}_{m_f,\lambda;m_i} \mathcal{M}^*_{m_f,\lambda';m_i}$$

* Ambiguity in the choice of the quantization axis for VM decay

s-frame: antiparallel to the outgoing hyperon in the CM frame of the production process

t-frame: parallel to the incoming pion beam

Then

$$W^0(\Omega_f) = \frac{3}{4\pi}\Big[\rho^0_{00}\cos^2\Theta + \rho^0_{11}\sin^2\Theta - \rho^0_{1-1}\sin^2\Theta\cos 2\Phi - \sqrt{2}\,\mathrm{Re}(\rho^0_{10})\sin 2\Theta\cos\Phi\Big],$$

$$W^\pm(\Omega_f) = \frac{3}{4\pi}\Bigg[\rho^\pm_{00}\cos^2\Theta + \frac{1}{2}\left(\rho^\pm_{11} + \rho^\pm_{-1-1}\right)\sin^2\Theta - \rho^\pm_{1-1}\sin^2\Theta\cos 2\Phi - \frac{1}{\sqrt{2}}\mathrm{Re}\left(\rho^\pm_{10} - \rho^\pm_{-10}\right)\sin 2\Theta\cos\Phi\Bigg],$$

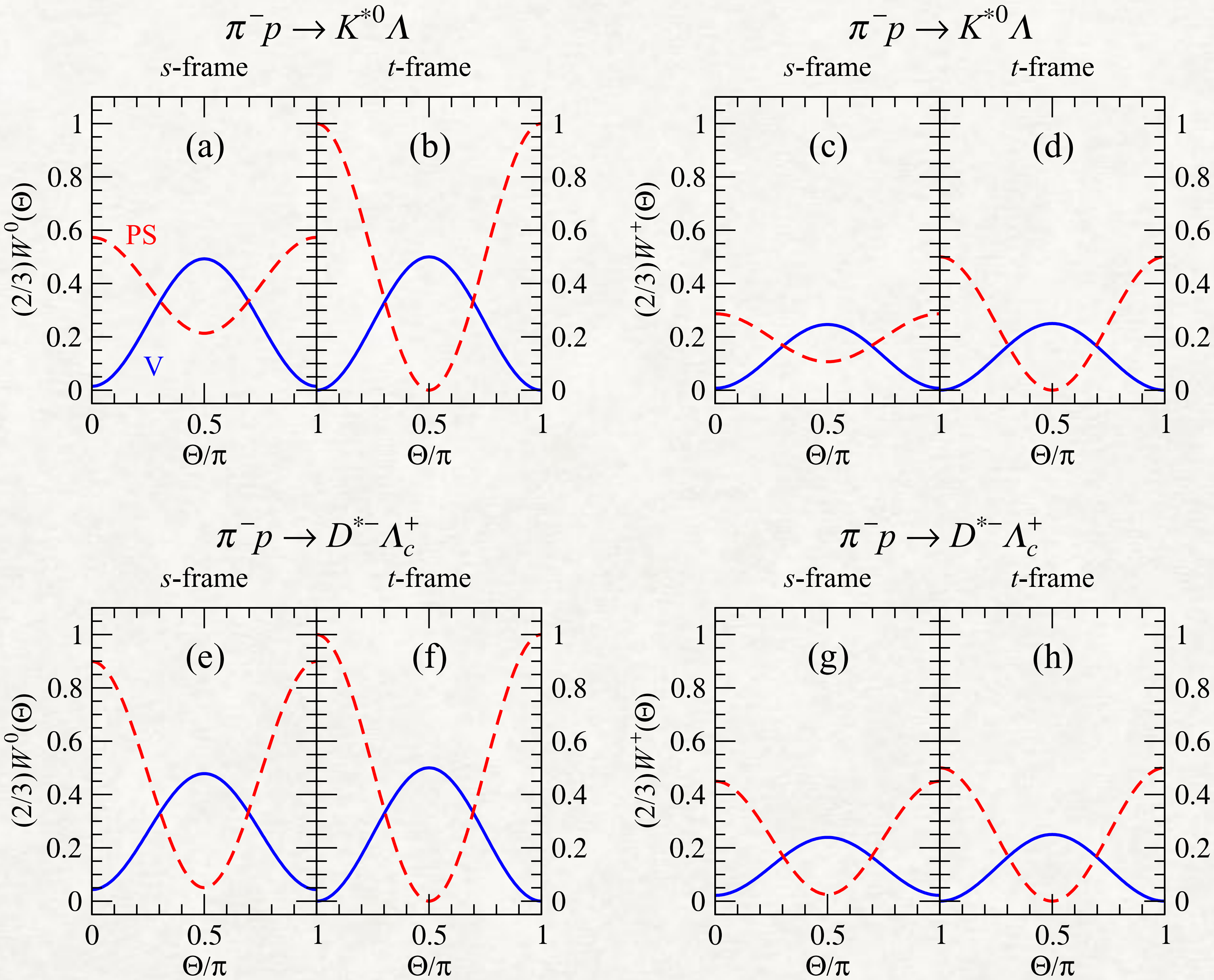
Integration over the azimuthal angle gives

$$\tfrac{2}{3}\,W^0(\Theta) = \rho^0_{00}\,\cos^2\Theta + \rho^0_{11}\,\sin^2\Theta,$$
$$\tfrac{2}{3}\,W^\pm(\Theta) = \rho^\pm_{00}\,\cos^2\Theta + \tfrac{1}{2}(\rho^\pm_{11} + \rho^\pm_{-1-1})\sin^2\Theta.$$

At fixed angles,

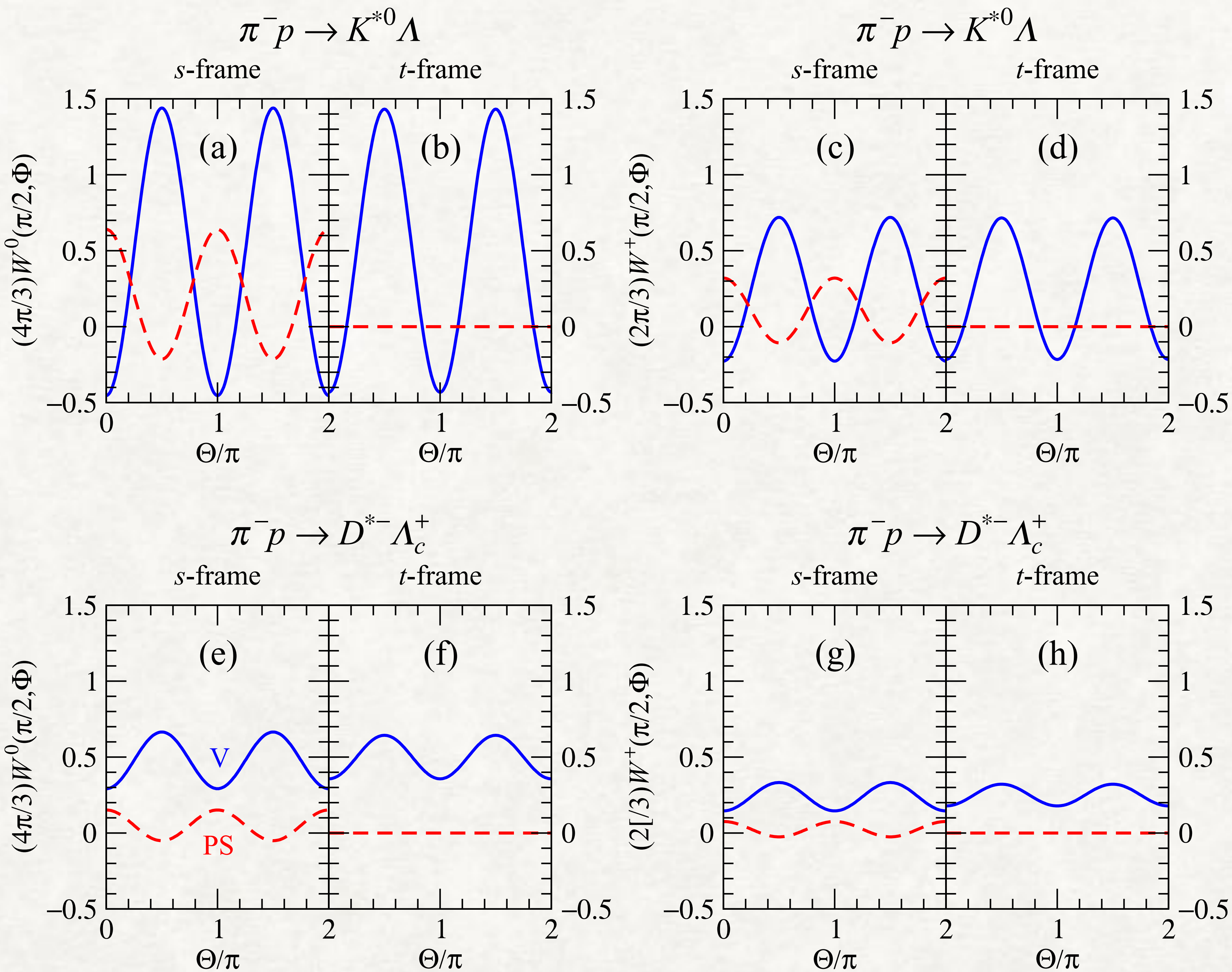
$$\frac{4\pi}{3}W^0\Big(\Theta = \frac{\pi}{2}, \Phi\Big) = \rho^0_{11} - \rho^0_{1-1}\cos 2\Phi,$$
$$\frac{4\pi}{3}W^\pm\Big(\Theta = \frac{\pi}{2}, \Phi\Big) = \frac{1}{2}(\rho^\pm_{11} + \rho^\pm_{-1-1}) - \rho^\pm_{1-1}\cos 2\Phi.$$

RESULTS (I)



$\pi^- p \to K^{*0}\Lambda$
s-frame
t-frame
(a)
(b)
(c)
(d)
PS
V
$(2/3)W^0(\Theta)$
$(2/3)W^+(\Theta)$
Θ/π
$\pi^- p \to D^{*-}\Lambda_c^+$
(e)
(f)
(g)
(h)

RESULTS (II)



$\pi^- p \to K^{*0}\Lambda$
$\pi^- p \to K^{*0}\Lambda$
s-frame
t-frame
s-frame
t-frame
(a)
(b)
(c)
(d)
$(4\pi/3)W^0(\pi/2,\Phi)$
$(2\pi/3)W^+(\pi/2,\Phi)$
1.5
1
0.5
0
−0.5
0
1
2
Θ/π
$\pi^- p \to D^{*-}\Lambda_c^+$
$\pi^- p \to D^{*-}\Lambda_c^+$
(e)
(f)
(g)
(h)
V
PS
$(4\pi/3)W^0(\pi/2,\Phi)$
$(2[/3)W^+(\pi/2,\Phi)$

SUMMARY

* Spectrum of excited hyperons
  * very model-dependent
  * a new window for studying hadron structure
* Ξ production in Kbar-N scattering
  * intermediate Λ and Σ hyperons
  * more precise and accurate data are needed
  * complimentary to photoproduction processes
* K*(D*) production and decay in pi-N scattering
  * vector exchange vs pseudoscalar exchange
  * decay angular distribution will be useful to pin down the spin structure of the production amplitudes
* All these studies may be tested at current facilities.

Thank You