8th KLF Collaboration Meeting

Combined Analysis of $K_L p \to \pi^+ \Sigma^0$ and $\pi^+ \Lambda$ Scattering

Dan Guo（郭丹）
Yanshan University

Dan Guo, Jun Shi (South-China Normal U.), Igor Strakovsky (Goerge-Washington U.) and Bing-Song Zou (Tsinghua U.), Analysis of Σ^* via isospin selective reaction $K_L p \to \pi^+ \Sigma^0$, Phys. Rev. D 112, 034006 (2025). And latest updates

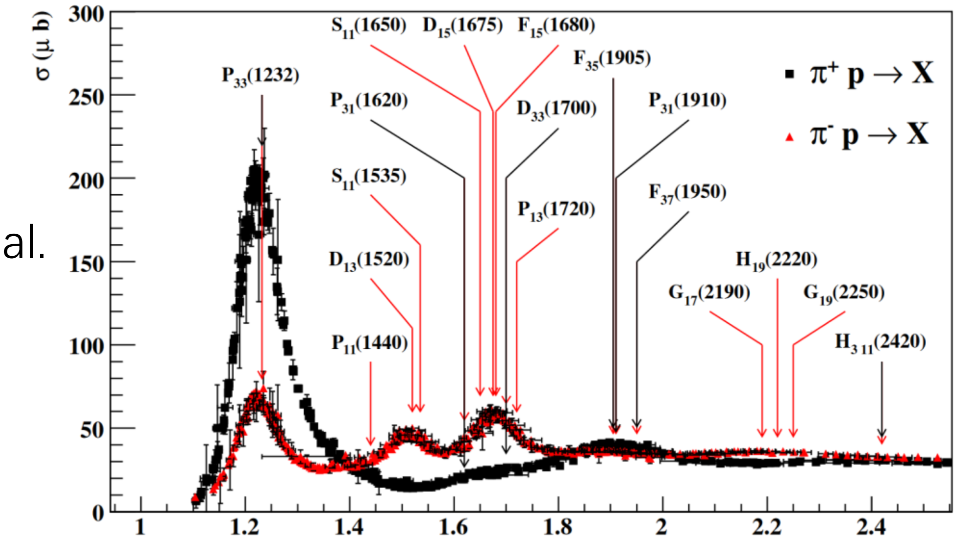
KLF Collaboration Meeting, JLab, Newport News, May 6, 2026

πN scattering: ~10^5 datasets

most clear in particle & nuclear physics.

All four-star N^*, Δ^*. Basic couplings $g_{\pi NN}$ et al.

PWA: SAID, MAID.



Thesis: Williams:2007zzg

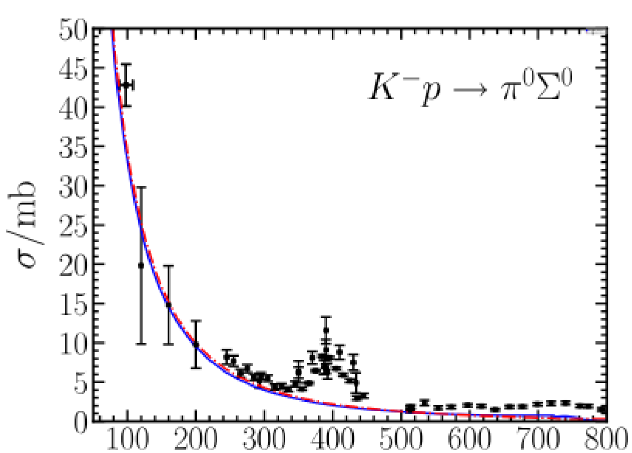
For **hyperon**: Λ^*, Σ^*, Ξ^*, Ω^*. $\bar{K}N$ scattering is most favored.

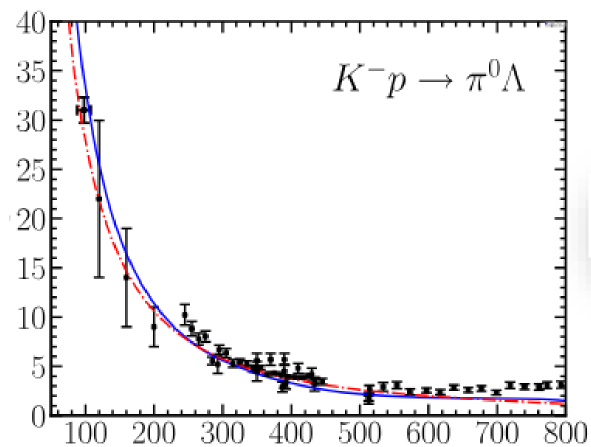
$Q > 0$ reaction,

kinematically allowed @ $P_{lab} = 0\ MeV$

$$Q = \sum_i m_i - \sum_f m_f$$

Near $\bar{K}N$ threshold with large phase space, strong coupling





~10 mb

$$\frac{d\sigma_{\pi^0\Lambda}}{d\Omega} = \frac{d\sigma_{\pi^0\Lambda}}{2\pi\, d\cos\theta} = \frac{1}{64\pi^2 s}\frac{|\mathbf{q}|}{|\mathbf{k}|}\overline{|\mathcal{M}|^2}$$

However, **hyperon** spectrum is very **ambiguous**

Mainly due to: old scattering data (1980s), scarcity of polarizations, **isospin-mixing**

$$
\begin{aligned}
T(K^- p \to \pi^- \Sigma^+) &= -\frac{1}{2} T^1(\overline{K}N \to \pi\Sigma) - \frac{1}{\sqrt{6}} T^0(\overline{K}N \to \pi\Sigma), \\
T(K^- p \to \pi^+ \Sigma^-) &= \frac{1}{2} T^1(\overline{K}N \to \pi\Sigma) - \frac{1}{\sqrt{6}} T^0(\overline{K}N \to \pi\Sigma), \\
T(K^- p \to \pi^0 \Sigma^0) &= \frac{1}{\sqrt{6}} T^0(\overline{K}N \to \pi\Sigma),
\end{aligned}
$$

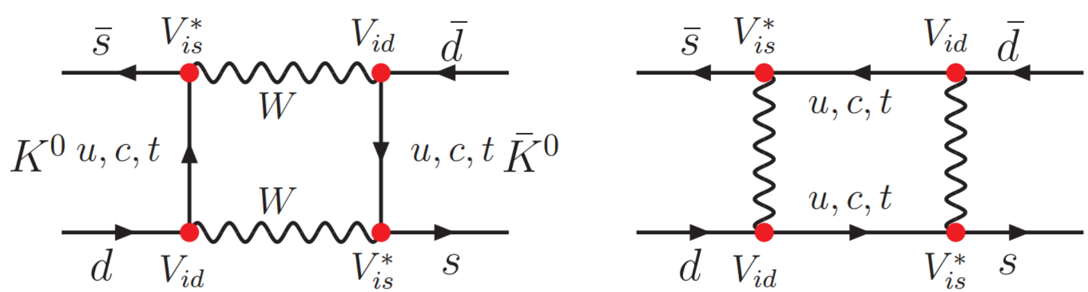
$K^- p$ include $I = 0, 1$ amplitudes

---

isospin selective $K_L p \to \pi^+ \Sigma^0$ and $\pi^+ \Lambda$ process

K^0 $\overline{K}^0$ as flavor eigenstates, could mix by box diagrams

$K^0 - \overline{K}^0$ mixing



Ignore *CP*-violation term ($< 10^{-3}$), define *CP* eigenstates:

$$K_S^0 = \frac{1}{\sqrt{2}}(K^0 + \overline{K}^0),\ K_L^0 = \frac{1}{\sqrt{2}}(K^0 - \overline{K}^0)$$

mean life K_L: $5.116 \times 10^{-8}\ s$ (cτ = 15.3 m)
K_S: $0.895 \times 10^{-10}\ s$ (cτ = 2.68 cm)

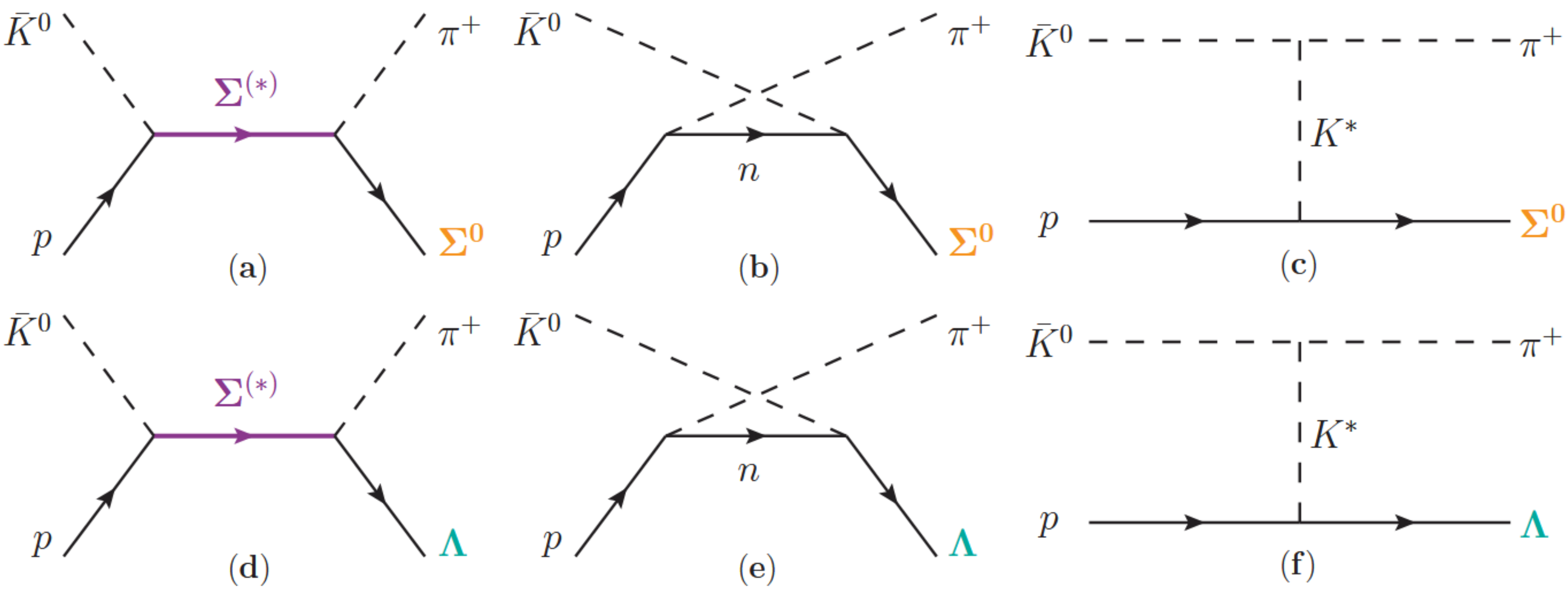
K_L suitable as a beam to collide on the proton target.
Most of $\bar{K}N$ scattering data from K^-p reaction, contain both isoscalar and isovector

$$T(K_L p \to \pi^+\Sigma^0) = -\frac{1}{2}T^1(\bar{K}N \to \pi\Sigma),$$
$$T(K_L p \to \pi^0\Sigma^+) = \frac{1}{2}T^1(\bar{K}N \to \pi\Sigma),$$

$$T(K_L p \to \pi^+\Lambda) = -\frac{1}{\sqrt{2}}T^1(\bar{K}N \to \pi\Lambda),$$
$$T(K^- p \to \pi^0\Lambda) = \frac{1}{\sqrt{2}}T^1(\bar{K}N \to \pi\Lambda).$$

$K_L p$ only $I = 1$ amplitudes

For $\boldsymbol{K_L p \to \pi^+\Sigma^0/\pi^+}\Lambda$, only $\bar{K}^0$ contributes, tree-level Feynman diagrams:



In the energy range up to 1.7 GeV, Σ^* resonances(up to D-wave): $J^P = 1/2^{\pm}, 3/2^{\pm}, 5/2^{-}$

effective Lagrangian:

$1/2^+$:

$$\mathcal{L}_{KN\Sigma} = \frac{g_{KN\Sigma}}{M_N + M_\Sigma}\partial_\mu \bar{K}\,\bar{\Sigma}\cdot\tau\gamma^\mu\gamma_5 N + \text{H.c.},$$
$$\mathcal{L}_{\pi\Sigma\Sigma} = i\frac{f_{\pi\Sigma\Sigma}}{m_\pi}\bar{\Sigma}\gamma^\mu\gamma_5\times\Sigma\cdot\partial_\mu\pi + \text{H.c.},$$
$$\mathcal{L}_{\pi\Lambda\Sigma} = \frac{g_{\pi\Lambda\Sigma}}{M_\Lambda + M_\Sigma}\bar{\Lambda}\gamma^\mu\gamma_5\partial_\mu\pi\cdot\Sigma + \text{H.c.},$$

$1/2^-$:

$$\mathcal{L}_{KN\Sigma(1/2^-)} = -ig_{KN\Sigma(1/2^-)}\bar{K}\,\bar{\Sigma}(1/2^-)\cdot\tau N + \text{H.c.},$$
$$\mathcal{L}_{\pi\Sigma\Sigma(1/2^-)} = g_{\pi\Sigma\Sigma(1/2^-)}\bar{\Sigma}(1/2^-)\times\Sigma\cdot\pi + \text{H.c.},$$
$$\mathcal{L}_{\pi\Lambda\Sigma(1/2^-)} = -ig_{\pi\Lambda\Sigma(1/2^-)}\bar{\Sigma}(1/2^-)\Lambda\pi + \text{H.c.}$$

$3/2^+$:

$$\mathcal{L}_{KN\Sigma^*} = \frac{f_{KN\Sigma^*}}{m_K}\partial_\mu\bar{K}\,\bar{\Sigma}^{*\mu}\cdot\tau N + \text{H.c.},$$
$$\mathcal{L}_{\pi\Sigma\Sigma^*} = i\frac{f_{\pi\Sigma\Sigma^*}}{m_\pi}\partial_\mu\pi\cdot\bar{\Sigma}^{*\mu}\times\Sigma + \text{H.c.},$$
$$\mathcal{L}_{\pi\Lambda\Sigma^*} = \frac{f_{\pi\Lambda\Sigma^*}}{m_\pi}\partial_\mu\pi\cdot\bar{\Sigma}^{*\mu}\Lambda + \text{H.c.}$$

$3/2^-$:

$$\mathcal{L}_{KN\Sigma(3/2^-)} = \frac{f_{KN\Sigma(3/2^-)}}{m_K}\partial_\mu\bar{K}\,\bar{\Sigma}^\mu(3/2^-)\cdot\tau\gamma_5 N + \text{H.c.},$$
$$\mathcal{L}_{\pi\Sigma\Sigma(3/2^-)} = i\frac{f_{\pi\Sigma\Sigma(3/2^-)}}{m_\pi}\partial_\mu\pi\cdot\bar{\Sigma}^\mu(3/2^-)\times\gamma_5\Sigma + \text{H.c.},$$
$$\mathcal{L}_{\pi\Lambda\Sigma(3/2^-)} = \frac{f_{\pi\Lambda\Sigma(3/2^-)}}{m_\pi}\partial_\mu\pi\bar{\Sigma}^\mu(3/2^-)\gamma_5\Lambda + \text{H.c.}$$

$5/2^-$:

$$\mathcal{L}_{KN\Sigma(5/2^-)} = g_{KN\Sigma(5/2^-)}\partial_\mu\partial_\nu\bar{K}\,\bar{\Sigma}^{\mu\nu}(5/2^-)\cdot\tau N + \text{H.c.},$$
$$\mathcal{L}_{\pi\Sigma\Sigma(5/2^-)} = ig_{\pi\Sigma\Sigma(5/2^-)}\partial_\mu\partial_\nu\pi\cdot\bar{\Sigma}^{\mu\nu}(5/2^-)\times\Sigma + \text{H.c.},$$
$$\mathcal{L}_{\pi\Lambda\Sigma(5/2^-)} = g_{\pi\Lambda\Sigma(5/2^-)}\partial_\mu\partial_\nu\pi\cdot\bar{\Sigma}^{\mu\nu}(5/2^-)\Lambda + \text{H.c.}$$

u-channel:

$$\mathcal{L}_{\pi NN} = \frac{g_{\pi NN}}{2M_N}\bar{N}\gamma^\mu\gamma_5\partial_\mu\pi\cdot\tau N,$$
$$\mathcal{L}_{KN\Lambda} = \frac{g_{KN\Lambda}}{M_N + M_\Lambda}\bar{N}\gamma^\mu\gamma_5\Lambda\partial_\mu K + \text{H.c.},$$

t-channel:

$$\mathcal{L}_{K^*K\pi} = ig_{K^*K\pi}\bar{K}^*_\mu(\pi\cdot\tau\partial^\mu K - \partial^\mu\pi\cdot\tau K),$$
$$\mathcal{L}_{K^*N\Sigma} = -g_{K^*N\Sigma}\bar{\Sigma}\cdot\tau\left(\gamma_\mu\bar{K}^{*\mu} - \frac{\kappa_{K^*N\Sigma}}{2M_N}\sigma_{\mu\nu}\partial^\nu\bar{K}^{*\mu}\right)N + \text{H.c.}$$
$$\mathcal{L}_{K^*N\Lambda} = -g_{K^*N\Lambda}\bar{\Lambda}\left(\gamma_\mu K^{*\mu} - \frac{\kappa_{K^*N\Lambda}}{2M_N}\sigma_{\mu\nu}\partial^\nu K^{*\mu}\right)N + \text{H.c.}$$

$$F_B(q_{ex}^2, M_{ex}) = \frac{\Lambda^4}{\Lambda^4 + (q_{ex}^2 - M_{ex}^2)^2}$$

Form factors account for off-shell effects

$$\mathcal{M}^{r_2,r_1}_{\bar{K}^0 p\to\pi^+\Sigma^0} = \bar{u}_{r_2}(p_2)\mathcal{A}u_{r_1}(p_1) = \bar{u}_{r_2}(p_2)\left(\sum_i \mathcal{A}_i\right)u_{r_1}(p_1)$$

Total amp.

$$\frac{d\sigma_{K_L p\to\pi^+\Sigma^0}}{d\Omega} = \frac{d\sigma_{K_L p\to\pi^+\Sigma^0}}{2\pi d\cos(\theta)} = \frac{1}{2}\frac{1}{64\pi^2 s}\frac{|\vec{k}_2|}{|\vec{k}_1|}\overline{|\mathcal{M}_{\bar{K}^0 p\to\pi^+\Sigma^0}|^2}$$

Differential cross section

Initial couplings estimated from SU(3) relations or partial decay widths.
A tunable scaling factor $\in [1/2, 2]$ is introduced account for SU(3) breaking.

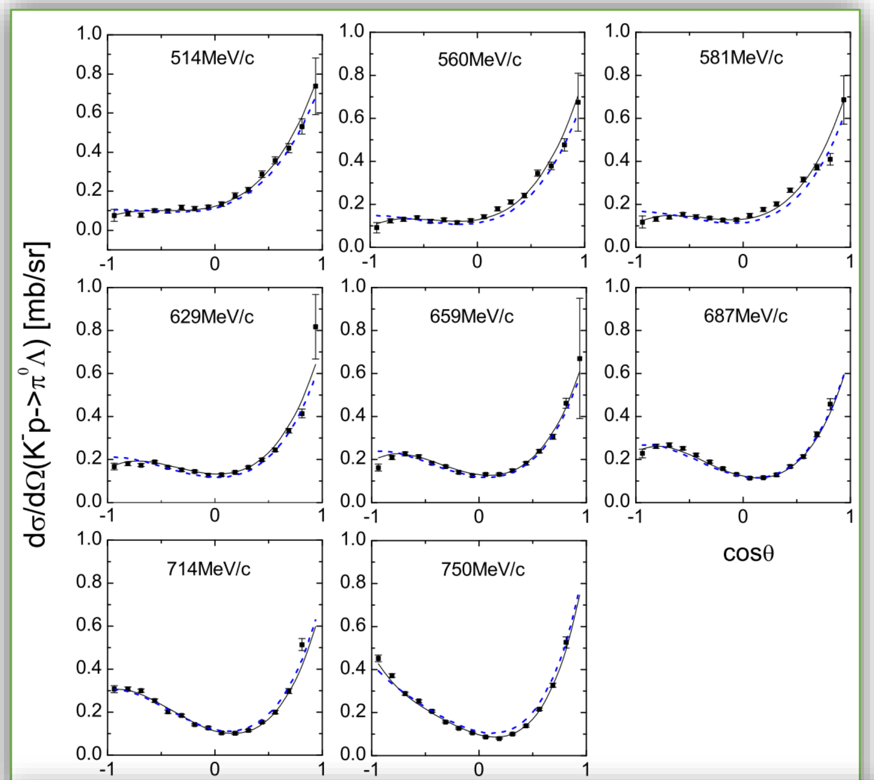
	Mass (MeV) (PDG estimate)	Γ_{tot} (MeV) (PDG estimate)	$(\Gamma_{\pi\Lambda}\Gamma_{KN})^{\frac{1}{2}}/\Gamma_{tot}$ (PDG range)
$\Sigma(1670)\frac{3}{2}^-$	$1673.1^{+1.4}_{-1.6}$ (1665, 1685)	$53^{+7}_{-5.5}$ (40, 80)	$+0.08^{+0.022}_{-0.018}$ (0.02, 0.17)
$\Sigma(1635)$ or $\Sigma(1660)\frac{1}{2}^+$	$1634.8^{+2.7}_{-4.5}$ (1630, 1690)	120 ± 12 (40, 200)	$-0.065^{+0.015}_{-0.017}$ (0,0.24)

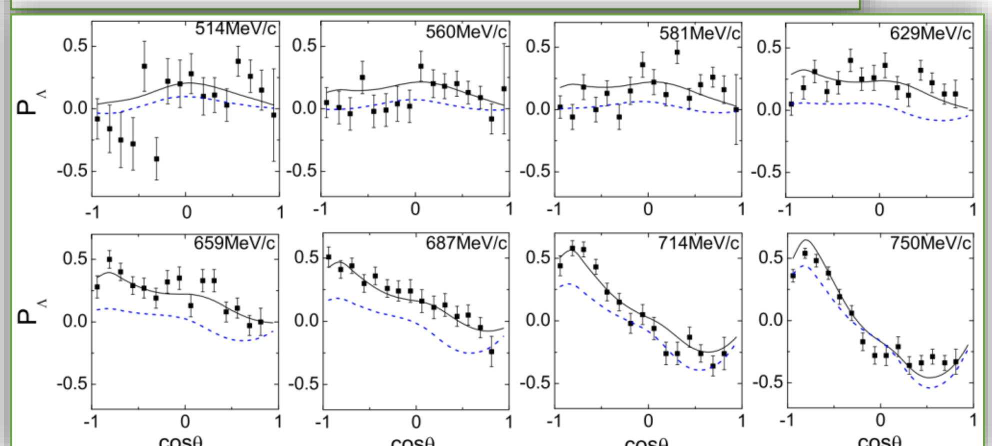
Our previous work:

P. Gao, B.S. Zou, A. Sibirtsev/ Nuclear Physics A 867 41 (2011)

$K^-p \to \pi^0\Lambda$: dcs and recoil polarization

Cited by PDG





Σ(1660) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1640 to 1680 (≈ 1660) OUR ESTIMATE				
1665 ±20	SARANTSEV	19	DPWA	$\overline{K}N$ multichannel
1633 ± 3	GAO	12	DPWA	$\overline{K}N \to \Lambda\pi$
1665.1±11.2	[1] KOISO	85	DPWA	$K^-p \to \Sigma\pi$
1670 ±10	GOPAL	80	DPWA	$\overline{K}N \to \overline{K}N$
1679 ±10	ALSTON-...	78	DPWA	$\overline{K}N \to \overline{K}N$
1668 ±25	VANHORN	75	DPWA	$K^-p \to \Lambda\pi^0$
1670 ±20	KANE	74	DPWA	$K^-p \to \Sigma\pi$

Σ(1660) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
100 to 300 (≈ 200) OUR ESTIMATE				
300^{+140}_{-40}	SARANTSEV	19	DPWA	$\overline{K}N$ multichannel
121^{+4}_{-7}	GAO	12	DPWA	$\overline{K}N \to \Lambda\pi$
81.5± 22.2	[1] KOISO	85	DPWA	$K^-p \to \Sigma\pi$
152 ± 20	GOPAL	80	DPWA	$\overline{K}N \to \overline{K}N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\overline{K} \to \Sigma(1660) \to \Lambda\pi$ $\quad (\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
$-0.064^{+0.005}_{-0.003}$	GAO	12	DPWA	$\overline{K}N \to \Lambda\pi$
< 0.04	GOPAL	77	DPWA	$\overline{K}N$ multichannel
$0.12^{+0.12}_{-0.04}$	VANHORN	75	DPWA	$K^-p \to \Lambda\pi^0$

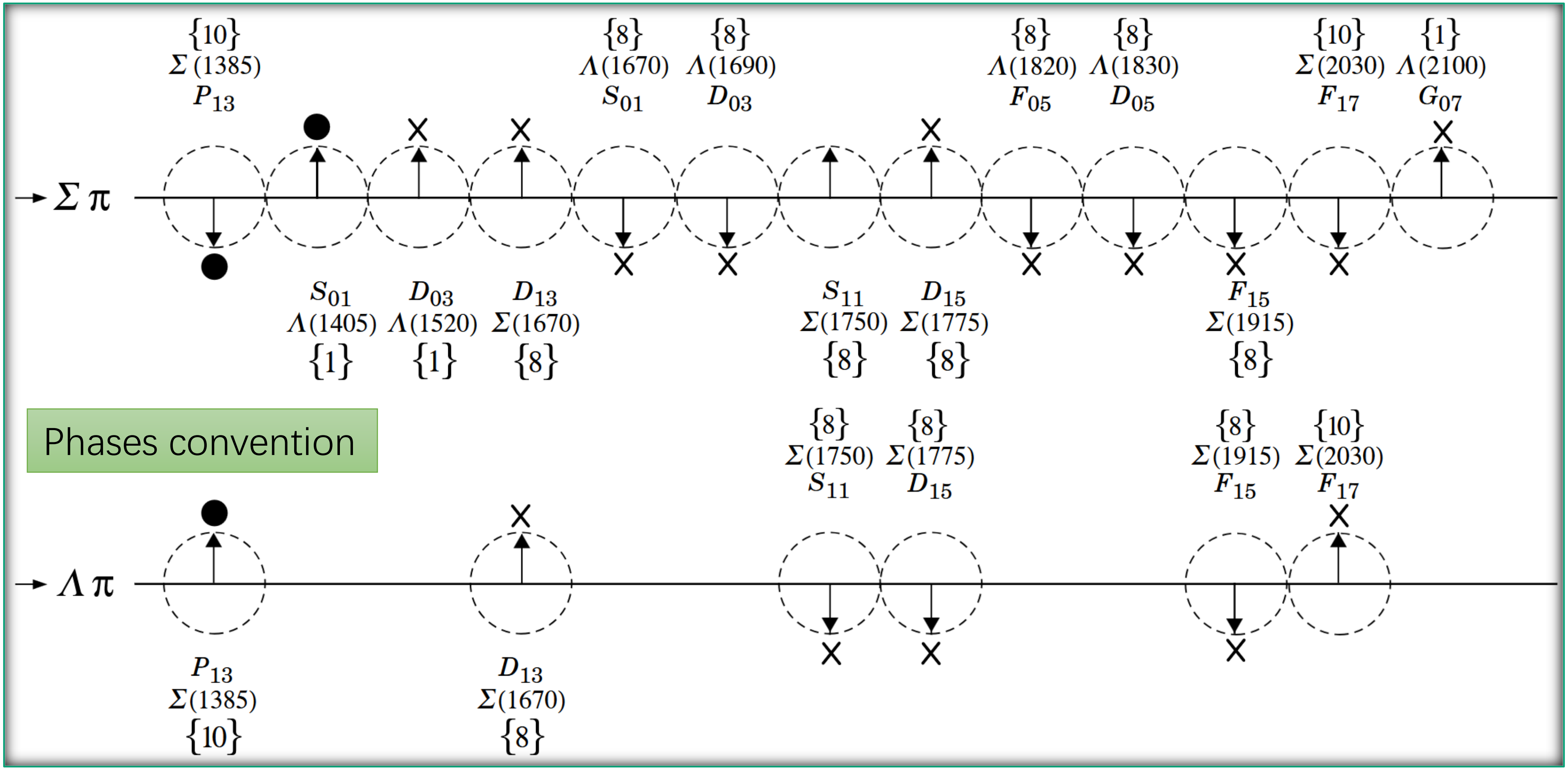
The sign denotes amp. phase

PDG review:

82. Λ and Σ Resonances

Revised August 2021 by V.D. Burkert (Jefferson Lab), V. Crede (Florida State U.), E. Klempt (Bonn U.), U. Thoma (Bonn U.), L. Tiator (KPH, JGU Mainz) and R.L. Workman (George Washington U.).

$\Sigma\pi$ final state: Σ^* Λ^* signs, $\Lambda\pi$: Σ^* signs.



● set by convention, ⇵ by SU(3) assignments, × experiment determined

Include four-star $\Sigma^{(*)}$: $\Sigma(1189)1/2^+$, $\Sigma(1385)3/2^+$, $\Sigma(1670)3/2^-$, $\Sigma(1775)5/2^-$
unestablished states: $\Sigma(1580)3/2^-$, $\Sigma(1620)1/2^-$, $\Sigma(1660)1/2^+$, $\Sigma(1750)1/2^-$

Fitted results

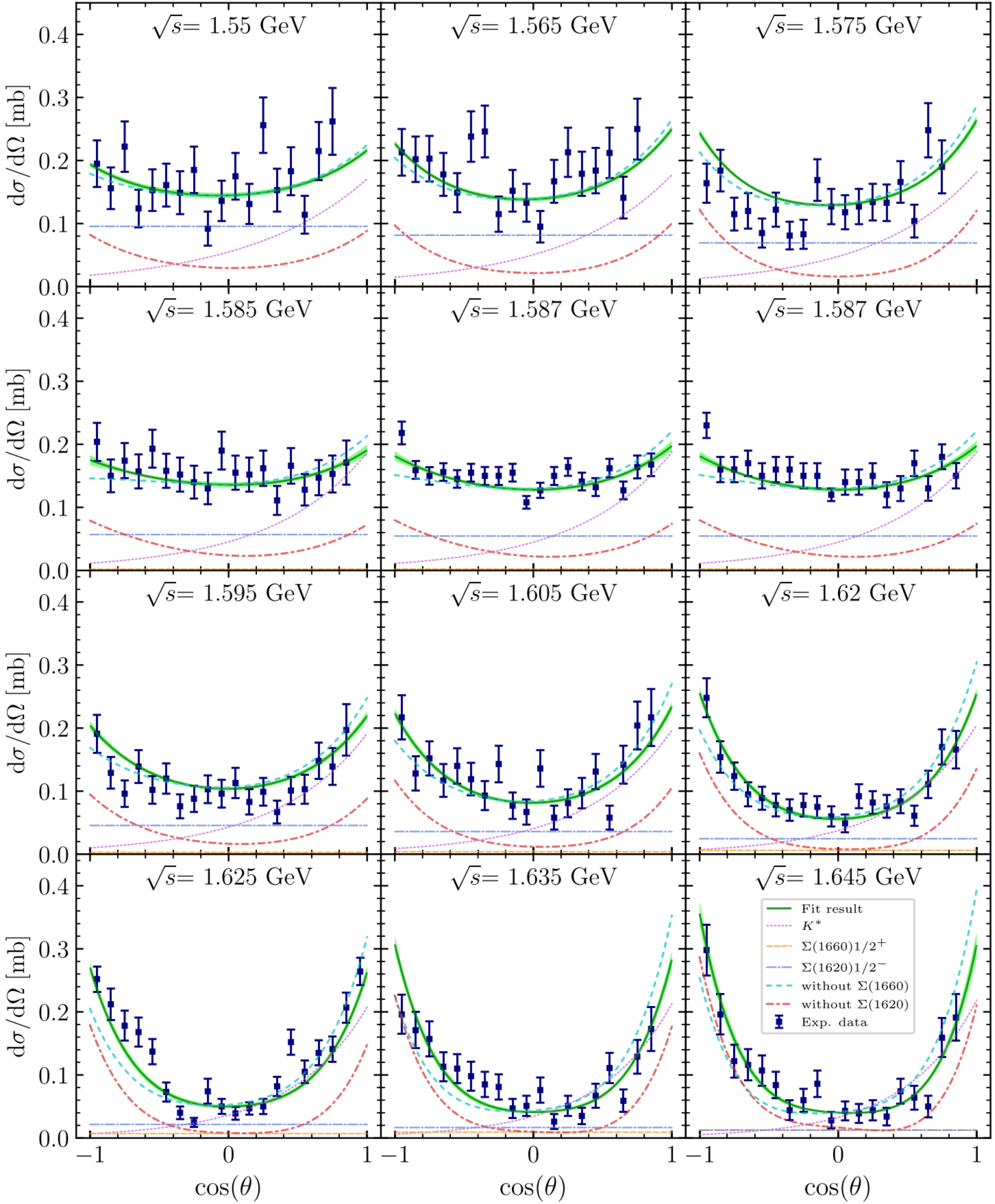
Origin: only **** states: $\chi^2/dof = 2.8$

keeping strict phase conventions

	m (MeV)	Γ (MeV)	Signs
$\Sigma(1189)1/2^+$	1192	0	...
$\Sigma(1385)3/2^+$	1384	36	↓
$\Sigma(1670)3/2^-$	1675	70	↑
$\Sigma(1775)5/2^-$	1775	120	↑

Resonances	Parameters	Optimal fit	Fit I	Fit II	Fit III	Estimates
K^*	$g_{K^*N\Sigma}$	-7.0 ± 0.5	-7.0	-2.7	-7.0 ± 1.2	$[-7.0, -1.2]$
	$\kappa_{K^*N\Sigma}$	-1.6 ± 0.2	-2.3	-2.3	-1.6 ± 0.8	$[-2.3, -0.2]$
	Λ	0.97 ± 0.01	1.01	2.0	0.97 ± 0.09	[0.5, 2.0]
N	Λ	1.42 ± 0.04	1.93	1.47	1.4 ± 0.4	[0.5, 2.0]
$\Sigma(1189)1/2^+$	$g_{KN\Sigma}f_{\pi\Sigma\Sigma}$	-1.50 ± 3.0	-3.39	-1.35	-1.50 ± 3.0	$[-5.4, -1.3]$
	Λ	0.5 ± 1.1	0.6	0.5	0.5 ± 1.3	[0.5, 2.0]
$\Sigma(1385)3/2^+$	$f_{KN\Sigma^*}f_{\pi\Sigma\Sigma^*}$	-1.34 ± 4.0	-4.49	-5.7	-1.34 ± 4.0	$[-5.7, -1.1]$
	Λ	0.50 ± 0.18	0.5	0.6	0.5 ± 1.3	[0.5, 2.0]
$\Sigma(1670)3/2^-$	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	$+0.26 \pm 0.04$	+0.27	+0.29	$+0.24 \pm 0.06$	[0.09, 0.38]
	Λ	0.72 ± 0.07	0.61	0.62	0.76 ± 0.17	[0.5, 2.0]
$\Sigma(1775)5/2^-$	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	$+0.24 \pm 0.04$	+0.24	+0.24	$+0.24 \pm 0.12$	[0.06, 0.24]
	Λ	2.0 ± 1.4	2.0	1.1	2.0 ± 1.5	[0.5, 2.0]
$\Sigma(1580)3/2^-$	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	$+0.032 \pm 0.005$	+0.034	...	$+0.031 \pm 0.005$	$[-0.4, 0.4]$
	Λ	0.50 ± 0.09	0.5	...	0.50 ± 0.11	[0.5, 2.0]
$\Sigma(1660)1/2^+$	M (GeV)	1.696 ± 0.010	1.75	...	1.673 ± 0.027	[1.40, 1.75]
	Γ (GeV)	0.108 ± 0.021	0.073	...	0.10 ± 0.04	[0.01, 0.40]
	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	-0.112 ± 0.006	-0.121	...	-0.086 ± 0.048	$[-0.48, 0.48]$
	Λ	2.0 ± 0.8	2.0	...	2.0 ± 1.2	[0.5, 2.0]
$\Sigma(1620)1/2^-$	M (GeV)	1.541 ± 0.003	1.4(Fixed)	1.545	1.542 ± 0.007	[1.35, 1.65]
	Γ (GeV)	0.129 ± 0.002	0.4	0.10	0.16 ± 0.05	[0.01, 0.40]
	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	-0.633 ± 0.009	-2.32	-0.45	-0.779 ± 0.259	$[-3.2, 3.2]$
	Λ	0.89 ± 0.04	1.07	0.59	0.72 ± 0.19	[0.5, 2.0]
$\Sigma(1750)1/2^-$	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	...	...	...	$+0.093 \pm 0.187$	$[-1.2, 1.2]$
	Λ	...	...	...	1.9 ± 0.8	[0.5, 2.0]
	d.o.f.	223	224	229	221	
	χ^2/d.o.f.	1.606	1.707	1.774	1.619	

Phys. Rev. D 112, 034006 (2025).



Narrow 1-σ errorband,
robust para constraint
χ^2/DoF=1.606

t-channel dominates the forward-angle.
s-channel no angle dependence.

$\Sigma(1660)1/2^+$	M (GeV)	1.696 ± 0.010
	Γ (GeV)	0.108 ± 0.021
	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	-0.112 ± 0.006
	Λ	2.0 ± 0.8
$\Sigma(1620)1/2^-$	M (GeV)	1.541 ± 0.003
	Γ (GeV)	0.129 ± 0.002
	$\sqrt{\Gamma_{\bar{K}N}\Gamma_{\pi\Sigma}}/\Gamma_{\rm tot}$	-0.633 ± 0.009
	Λ	0.89 ± 0.04

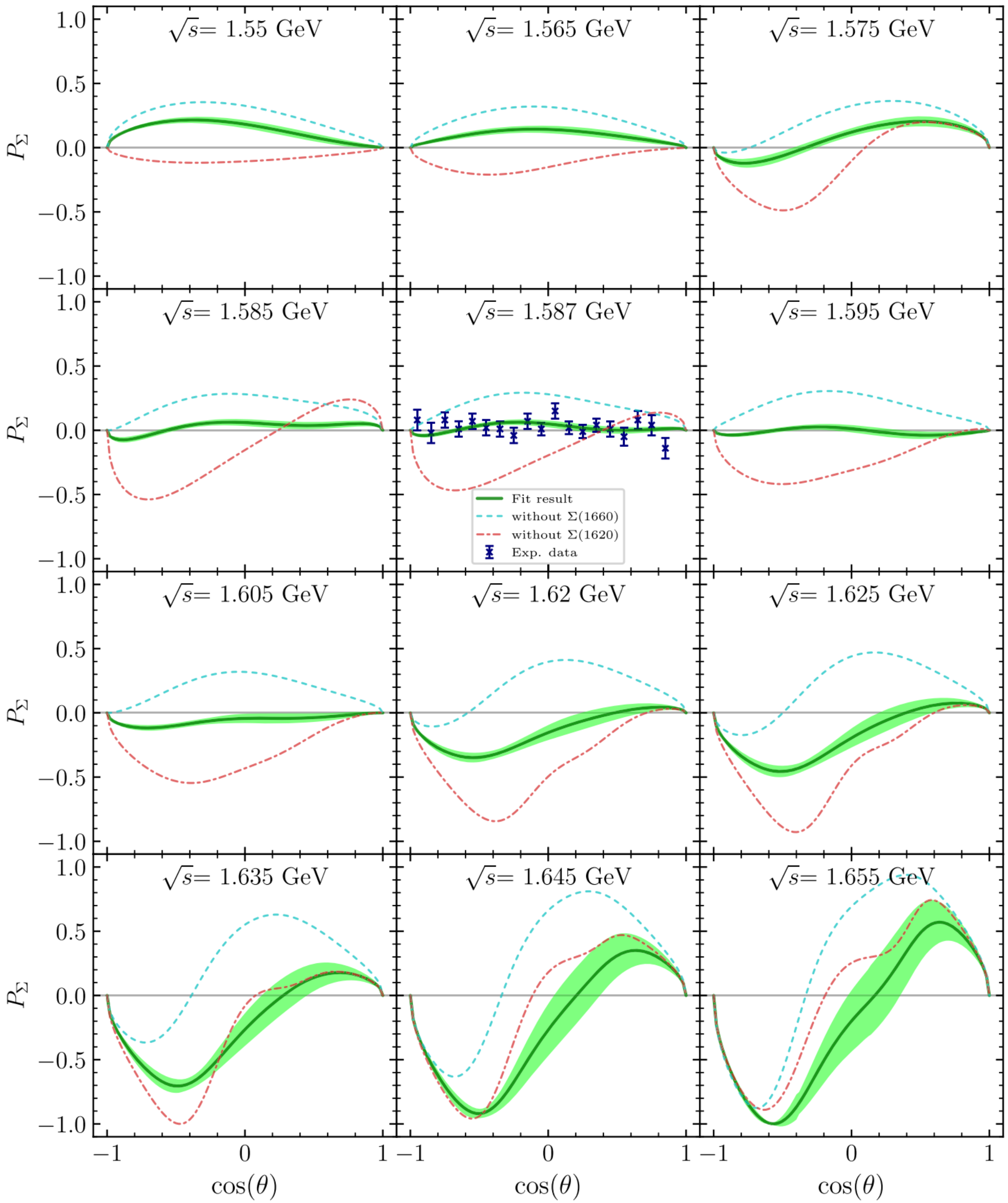
$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\overline{K} \to \Sigma(1660) \to \Sigma\pi$

VALUE	*DOCUMENT ID*	
-0.13 ± 0.04	[1] KOISO	85
-0.16 ± 0.03	GOPAL	77
-0.11 ± 0.01	KANE	74

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\overline{K} \to \Sigma(1620) \to \Sigma\pi$

VALUE	*DOCUMENT ID*	
$+0.32\pm0.03$	ZHANG	13A
not seen	HEPP	76B
$+0.40\pm0.06$	LANGBEIN	72
$+0.08$	KIM	71

Fitted M Γ of $\Sigma(1/2^-)$ compatible with
Phys. Rev. C 88, 035205 (2013).
Phys. Rev. C 92, 025205 (2015) .
Phys. Rev. D 112, 034006 (2025).



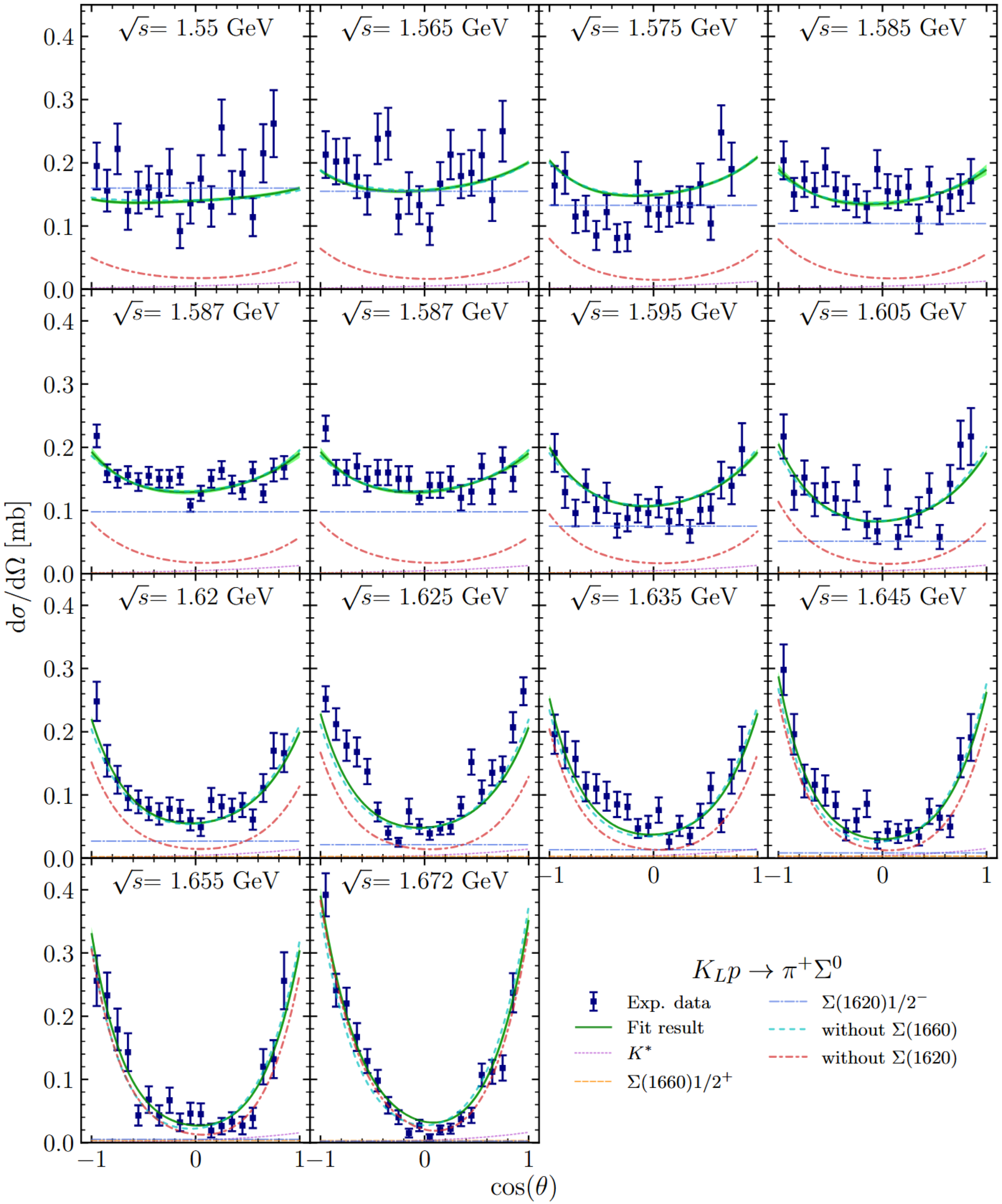
Recoil polarization

$$P_\Sigma = -\frac{2\,\mathrm{Im}\left(\mathcal{M}^{1/2,1/2}_{\bar{K}^0 p\to\pi^+\Sigma^0}\mathcal{M}^{*-1/2,1/2}_{\bar{K}^0 p\to\pi^+\Sigma^0}\right)}{\overline{\left|\mathcal{M}_{\bar{K}^0 p\to\pi^+\Sigma^0}\right|^2}}$$

Polarization arises from interference. Single diagram produce zero polarization.

Measuring the asymmetry in the spin distribution of the recoiling Σ^0 along the direction normal to the reaction plane.

Phys. Rev. D 112, 034006 (2025).



Further, $\pi^+\Sigma^0$ and $\pi^+\Lambda$, joint fitting

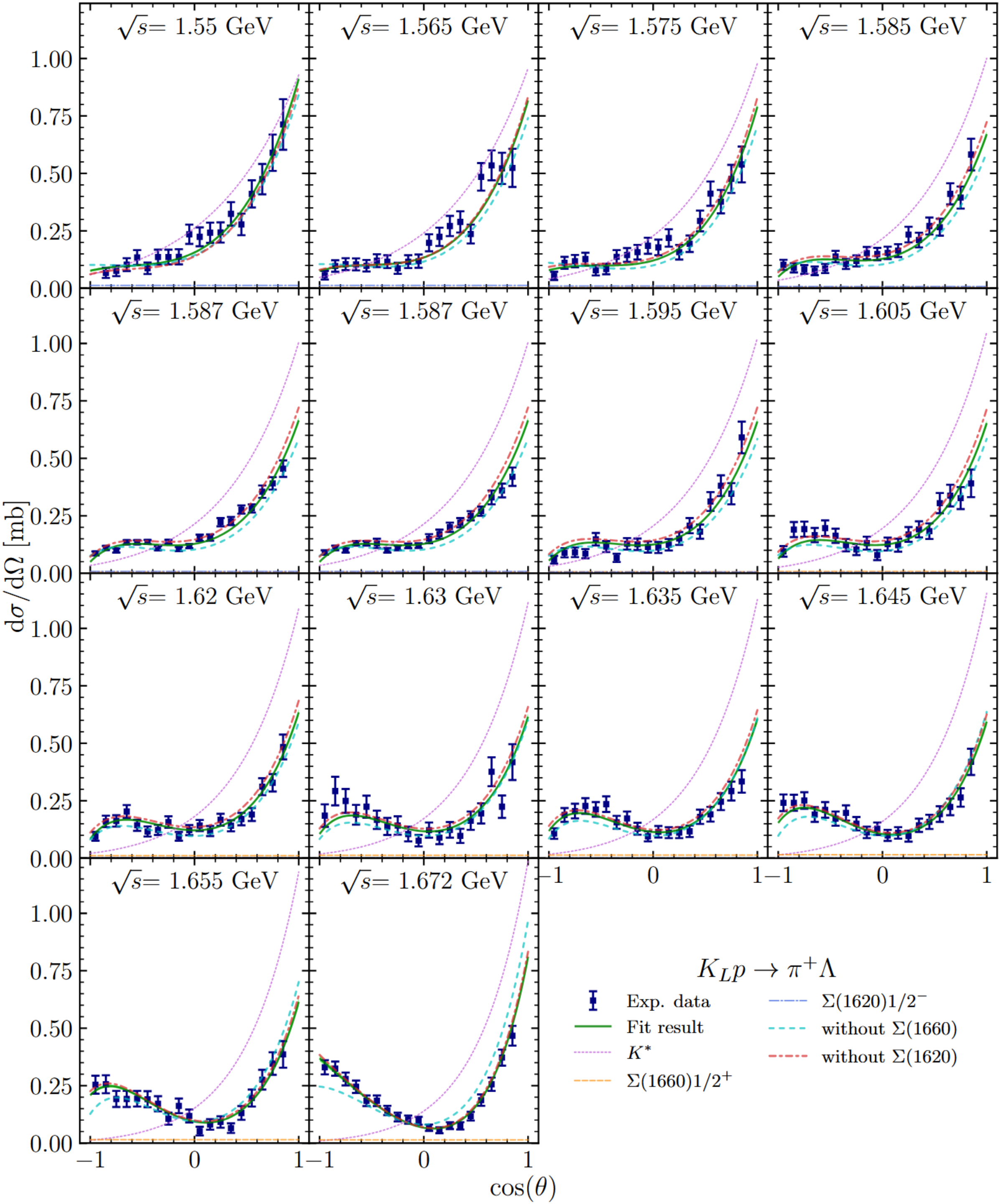
Common cutoffs and
Consistent phase for
two channels.
Almost invisible errorbands

χ^2= 855. 029,
χ^2/dof= 1. 6041
dof=283+284−34=533

$\Sigma(1660)1/2^+$:
$m = 1.637$ GeV,
$\Gamma = 0.129$ GeV

$\Sigma(1620)1/2^-$:
$m = 1.557$ GeV,
$\Gamma = 0.117$ GeV
Indispensable!

Latest updates!
Coming soon!



Further, $\pi^+\Sigma^0$ and $\pi^+\Lambda$, joint fitting

Common cutoffs and
Consistent phase for
two channels.
Almost invisible errorbands

χ^2= 855. 029,
χ^2/dof= 1. 6041
dof=283+284−34=533

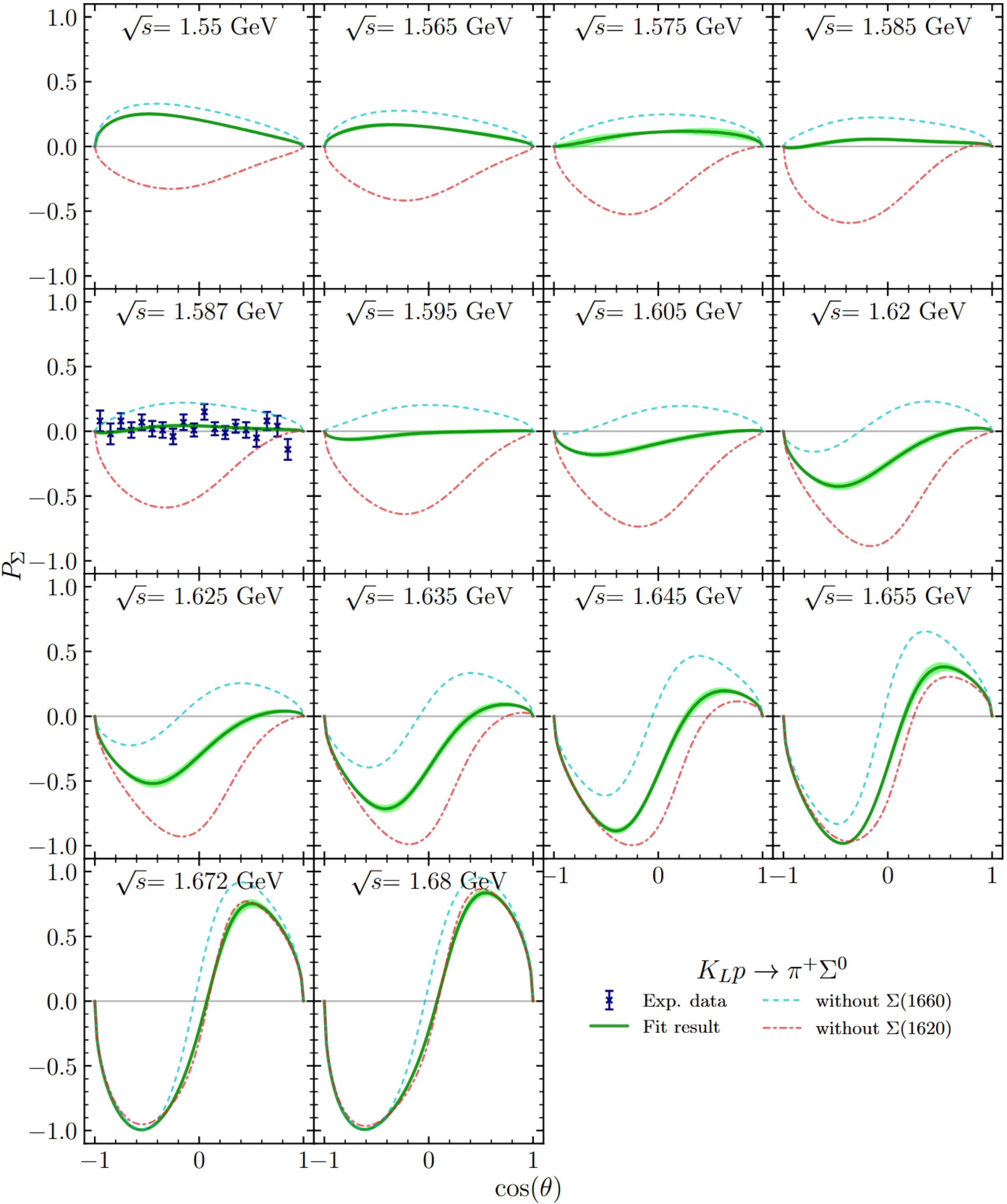
$\Sigma(1660)1/2^+$:
$m = 1.637$ GeV,
$\Gamma = 0.129$ GeV

$\Sigma(1620)1/2^-$:
$m = 1.557$ GeV,
$\Gamma = 0.117$ GeV
Negligible!

Latest updates!
Coming soon!

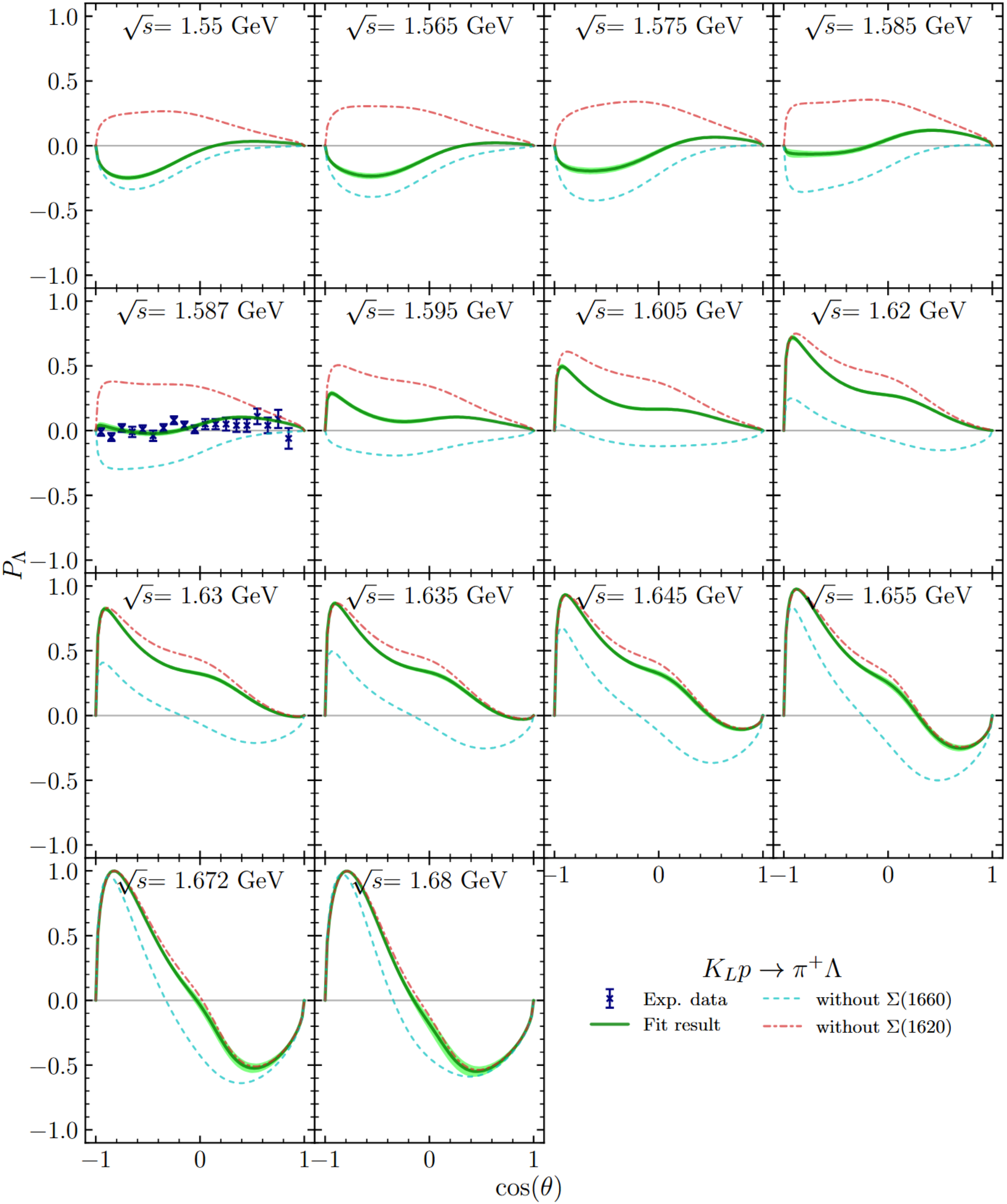
Further, $\pi^+\Sigma^0$ and $\pi^+\Lambda$, joint fitting

Common cutoffs and Consistent phase for two channels.
Almost invisible errorbands.



Polarizations @ other E_{cm} also constrained strictly

Latest updates! Coming soon!



Further, $\pi^+\Sigma^0$ and $\pi^+\Lambda$, joint fitting

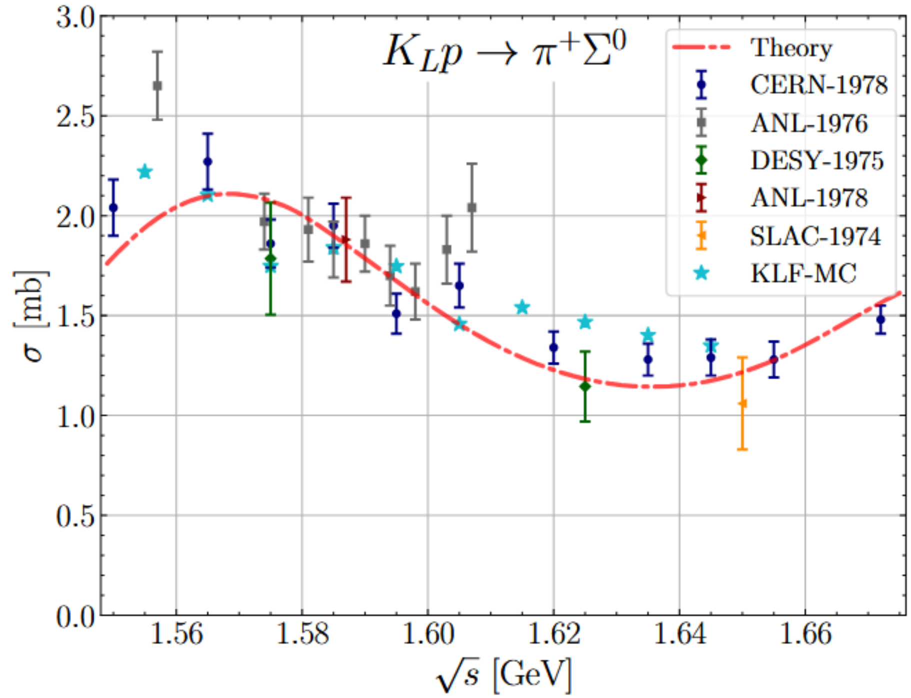
Common cutoffs and Consistent phase for two channels.
Almost invisible errorbands.

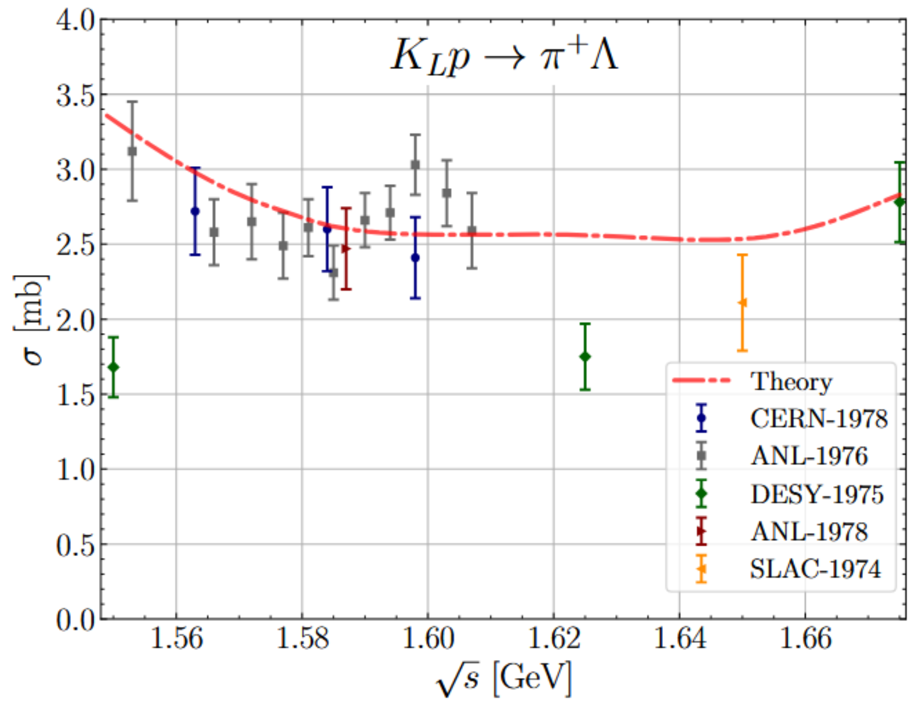
Polarizations @ other E_{cm} also constrained strictly

Latest updates! Coming soon!

In fit procedure, not include total c-s data.
Comparison of theoretical and experimental

Agree well with MC result(by Marshall Scott)





Conclusion

(1) The first theoretical analysis of $K_L p \to \pi^+\Sigma^0$ and $\pi^+\Lambda$ using effective Lagrangian method, with strict phase convention and isospin-selection.

(2) Further confirm the existence of $\Sigma(1660)1/2^+$.

(3) Due to the limited quality of historical data earlier than 1980, in present, the mass of $\Sigma(1620)1/2^-$ is fitted around 1.55 GeV.

(4) Multichannel fit imposes much stronger constraints on the common resonance parameters and relative phases, resulting almost invisible errorbands. $\Sigma(1620)1/2^-$ is indispensable in $\pi^+\Sigma^0$, but negligible in $\pi^+\Lambda$

Expecting more precise measurements of $K_L p$ scattering in wider energy range by **KLF**

Thank you for your attention!

燕山大學

YANSHAN UNIVERSITY

Back up

Error propagation

$\vec{x} = (x_1, \ldots, x_i)$ input data vector, $\vec{p} = (p_1, \ldots, p_n)$ parameter vector

Model output: $\vec{y} = f(\vec{x}; \vec{p}) = (y_1, \ldots, y_m)$

a fit by Minuit, given the covariance matrix C of para, $n \times n$

Numerically calculate the Jacobi matrix J of first derivatives, $m \times n$:

$$J_{ab} = \frac{\partial y_a}{\partial p_b}$$

then obtain the covariance matrix C' of output, $m \times m$

$$C' = JCJ^T$$

Square roots of diagonal elements giving the errors.