Prodution of high-spin ω_J/ρ_J(J=2,3,4,5) mesons in $\pi^- p$ reactions

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第五届强子与重味物理理论与实验联合研讨会

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outline

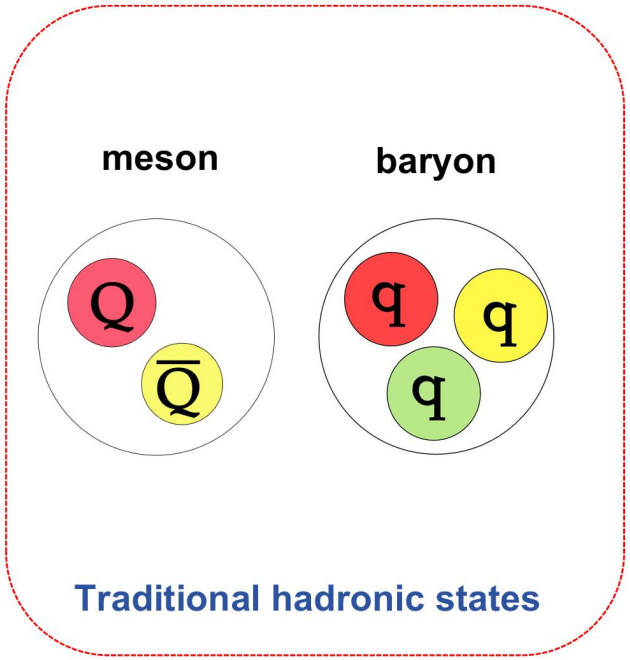
I. Backgroud and Motivation

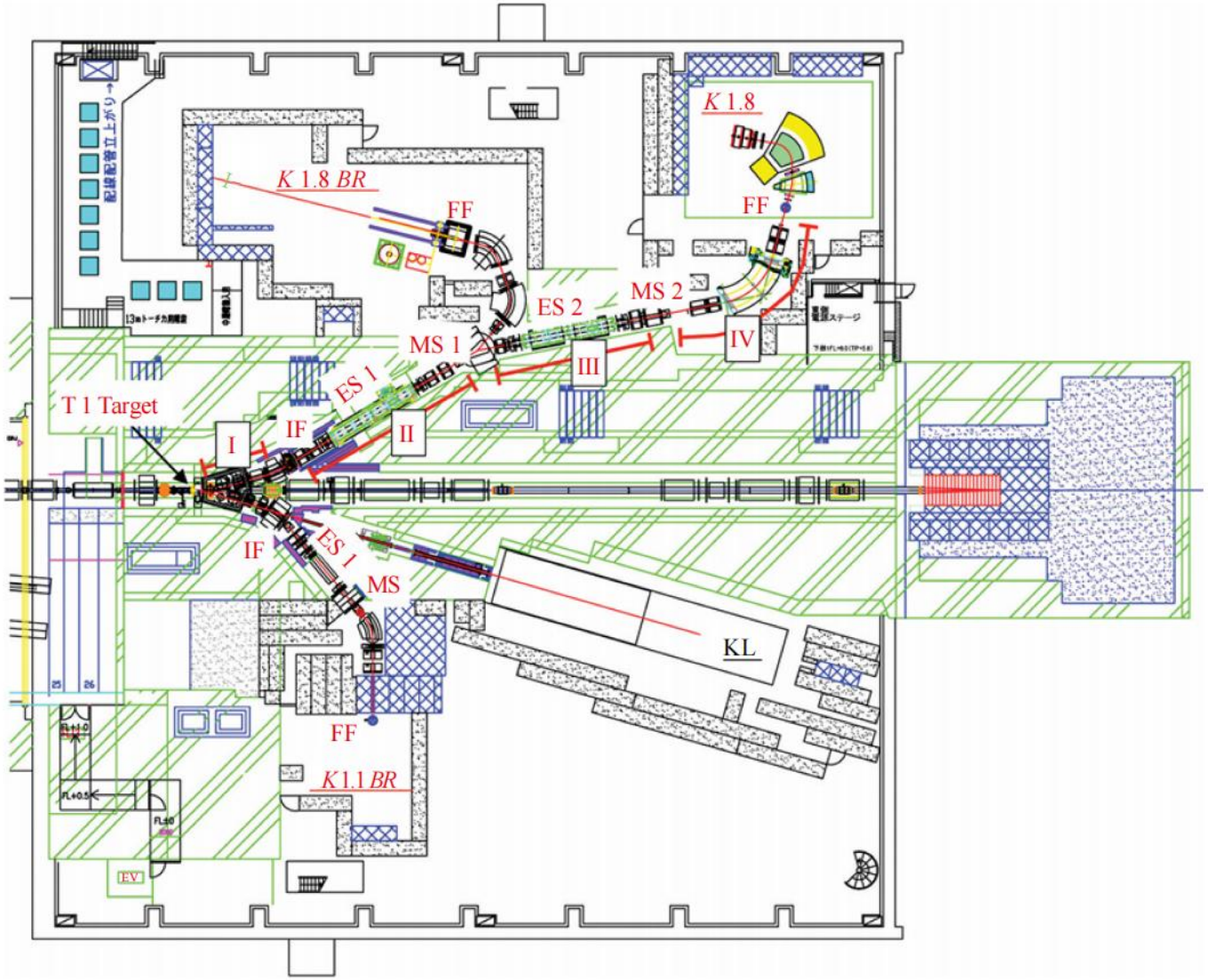
II. Theory framework

III. Numerical analysis

IV. Possible future prospect

Backgroud： meson beam experiments





Layout diagrams of the Hadron Experimental Hall, charged secondary beamlines, and various experimental areas at J-PARC

Backgroud： hadrons measured by meson beam experiments

➢ The energy region covers from a few tenths of a GeV to about 2 GeV.

η	0^-	√	$\rho(1450)$	1^-		$\eta_2(1870)$	2^-	√	$\rho_5(2350)$	5^-	√
$f_0(500)$	0^+		$\eta(1475)$	0^-	√	$\pi_2(1880)$	2^-	√	$f_6(2510)$	6^+	√
$\rho(770)$	1^-	√	$f_0(1500)$	0^+	√	$\rho(1900)$	1^-		$K_0^*(700)$	0^+	√
$\omega(782)$	1^-	√	$f_1(1510)$	1^+	√	$f_2(1910)$	2^+	√	$K^*(892)$	1^-	√
$\eta'(958)$	0^-	√	$f_2'(1525)$	2^+	√	$a_0(1950)$	0^+		$K_1(1270)$	1^+	√
$f_0(980)$	0^+	√	$f_2(1565)$	2^+	√	$f_2(1950)$	2^+	√	$K_1(1400)$	1^+	√
$a_0(980)$	0^+	√	$\rho(1570)$	1^-	√	$\rho_3(1990)$	3^-		$K^*(1410)$	1^-	√
$\phi(1020)$	1^-	√	$h_1(1595)$	1^+	√	$\eta_2(2030)$	2^-	√	$K_0^*(1430)$	0^+	√
$h_1(1170)$	1^+	√	$\pi_1(1600)$	1^-	√	$f_2(2010)$	2^+	√	$K_2^*(1430)$	2^+	√
$b_1(1235)$	1^+	√	$a_1(1640)$	1^+	√	$f_0(2020)$	0^+	√	$K(1460)$	0^-	√
$a_1(1260)$	1^+	√	$f_2(1640)$	2^+	√	$a_4(2040)$	4^+	√	$K_2(1580)$	2^-	√
$f_2(1270)$	2^+	√	$\eta_2(1645)$	2^-		$f_4(2050)$	4^+	√	$K(1630)$	?	√
$f_1(1285)$	1^+	√	$\omega(1650)$	1^-		$\pi_2(2100)$	2^-	√	$K_1(1650)$	1^+	√
$\eta(1295)$	0^-		$\omega_3(1670)$	3^-	√	$f_0(2100)$	0^+		$K^*(1680)$	1^-	√
$\pi(1300)$	0^-		$\pi_2(1670)$	2^-	√	$f_2(2150)$	2^+		$K_2(1770)$	2^-	√
$a_2(1320)$	2^+	√	$\phi(1680)$	1^-		$\rho(2150)$	1^-		$K_3^*(1780)$	3^-	√
$f_0(1370)$	0^+		$\rho_3(1690)$	3^-	√	$\phi(2170)$	1^-		$K_2(1820)$	2^-	√
$h_1(1380)$	1^+		$\rho(1700)$	1^-	√	$f_0(2200)$	0^+	√	$K(1830)$	0^-	√

Low-spin

So many particles!

High-spin

32260.14.NuclPhysRev.42.2024008

Backgroud： high spin states

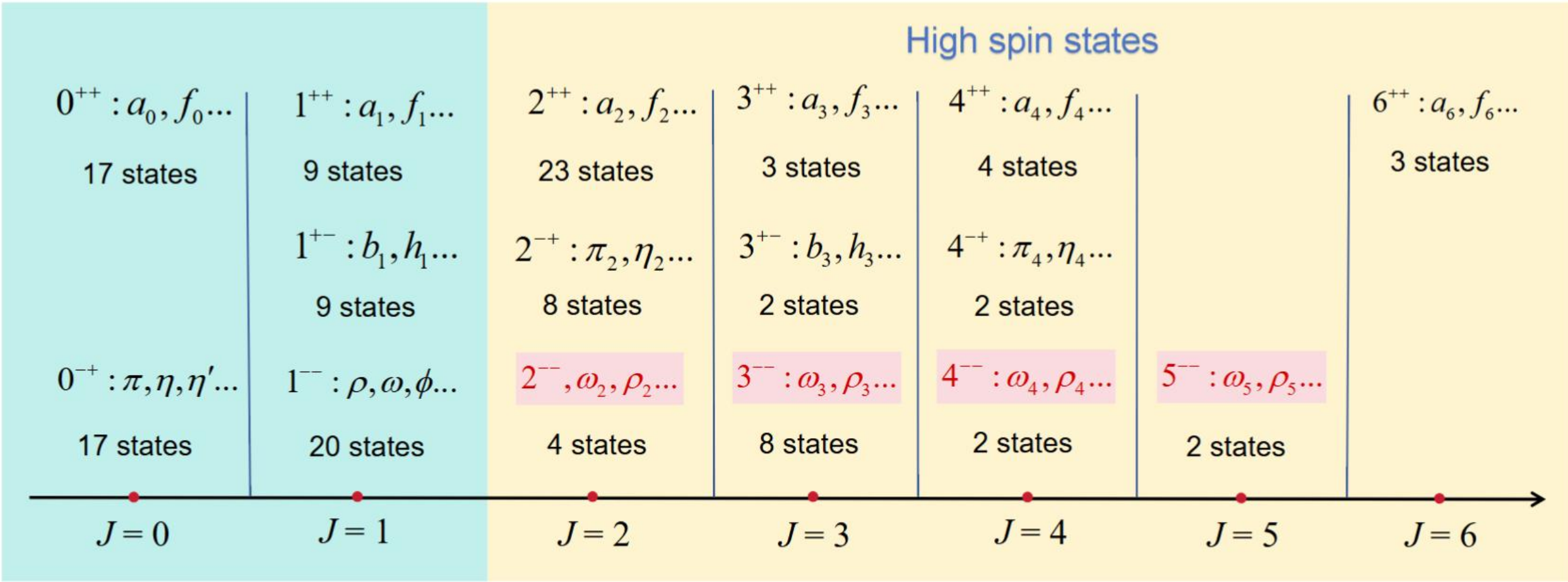


FIG. 1: A concise summary of light mesons [1].

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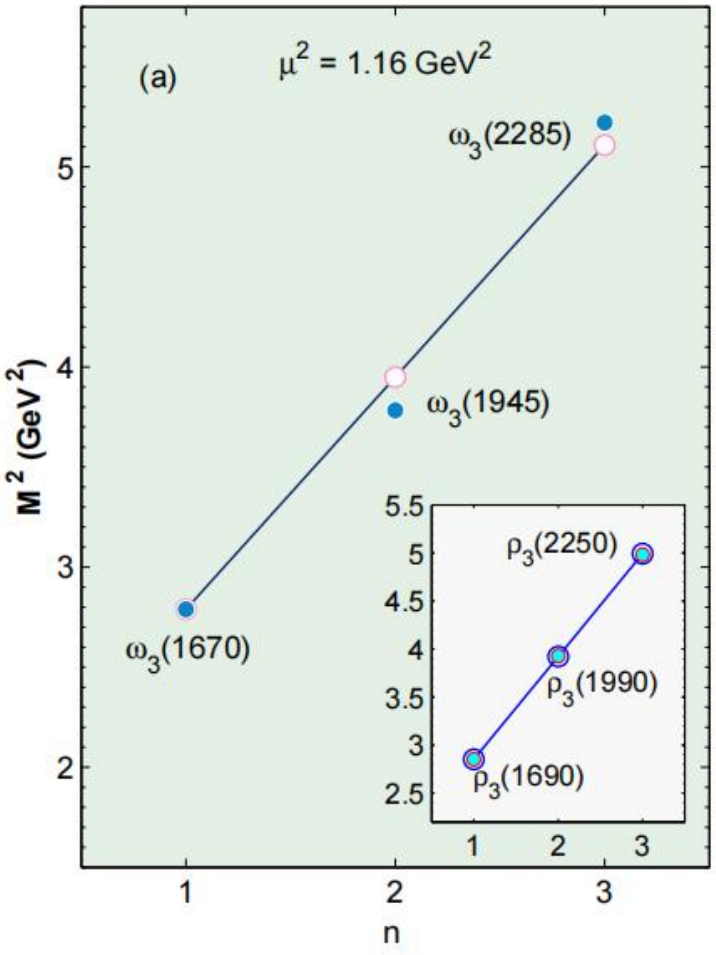
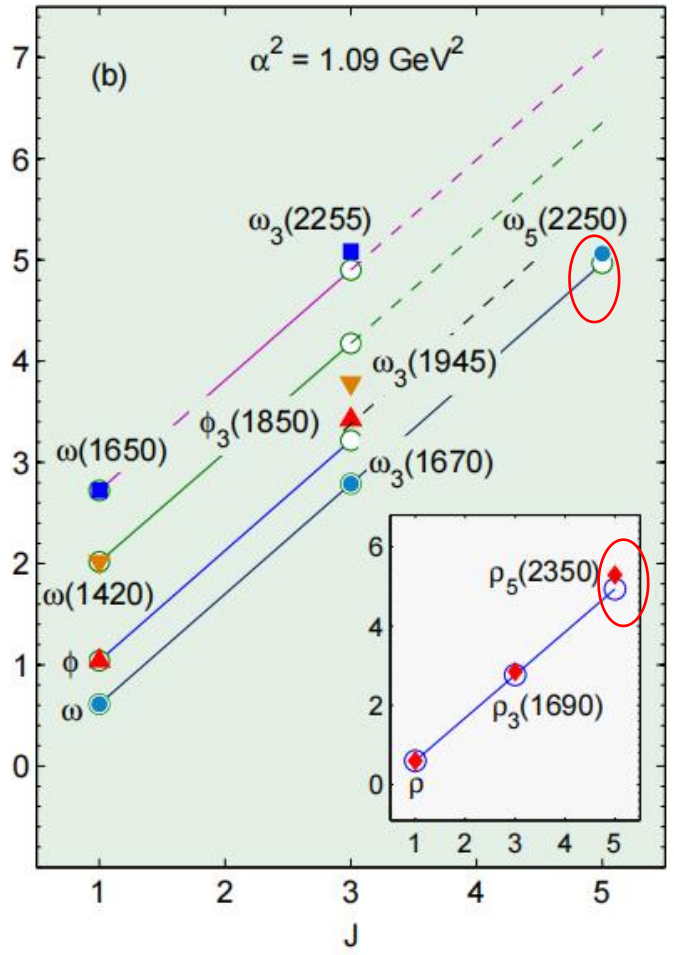
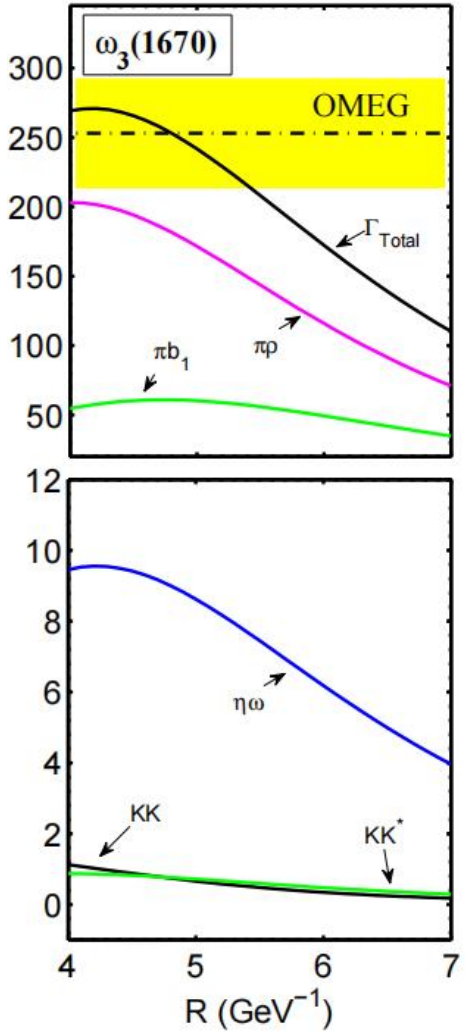
Backgroud： meson spectroscopy and strong decay for ω_J and ρ_J mesons







$\rho_3(1690)$, $\Gamma_{exp.}$ = 190 ± 40 [60]	
Channel	Value
Total	190
$\rho\rho$	105
$\pi\pi$	32.0
$\pi\omega$	23.1
πh_1	10.6
$a_2\pi$	8.07
$\eta\rho$	3.68
$a_1\pi$	3.26
KK	2.66

The establishment of the omega meson family remains to be improved

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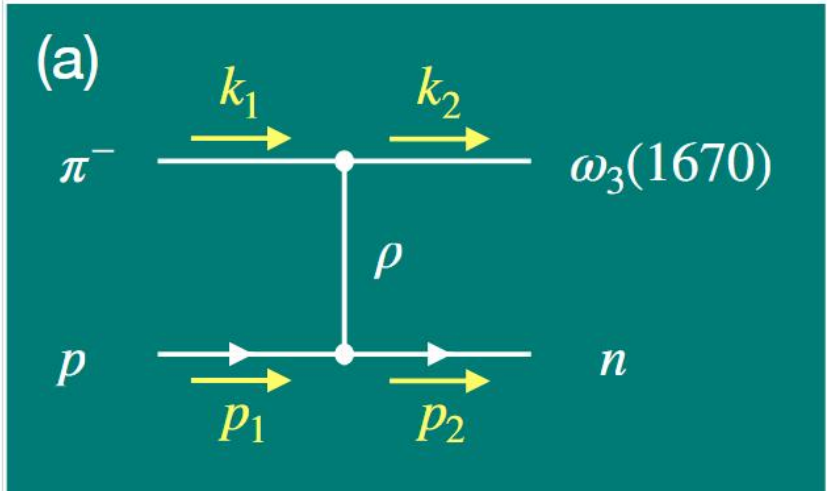
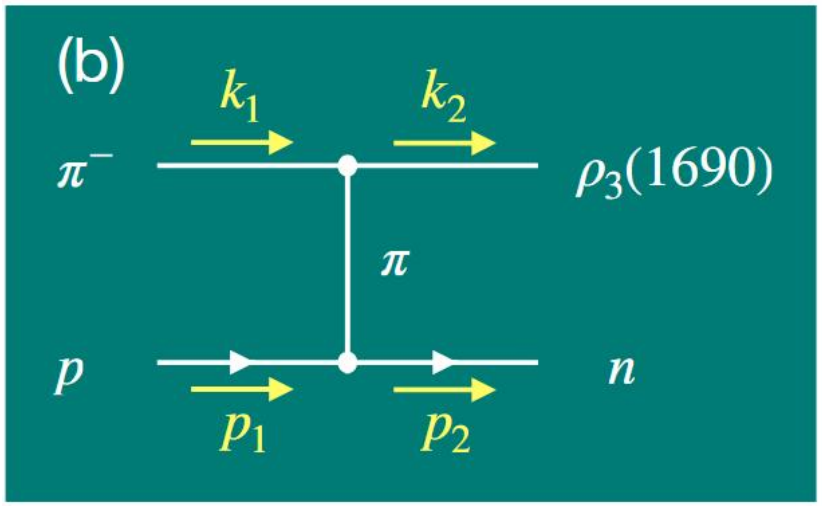
Phys.Rev.D 92 (2015) 1, 014012

Motivation： meson beam experiments

- The production challenges of high-spin ω_J and ρ_J mesons remain to be explored and addressed.
- Considering the tree-level Feynman diagrams, can this process be adequately described?





3^{--}	$\omega_3(1670)$ √	$\rho_3(1690)$ √
2^{--}	$\omega_2(1975)$	$\rho_4(2230)$
4^{--}	$\omega_4(2250)$	$\rho_4(2230)$
5^{--}	$\omega_5(2250)$	$\rho_5(2350)$

Nucl.Phys.B 138 (1978) 235-252

Phys.Rev.Lett. 32 (1974) 260-264

Phys.Rev.D 3 (1971) 2561-2572

Phys.Rev.Lett. 23 (1969) 146-149

Phys.Lett.B 26 (1968) 336-340

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Theory framework： the effective Lagrangian approach

- $3\times\bar{3}$ SU(3) flavor structure

$$P=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\eta+\pi^0}{\sqrt{2}} & \pi^+ & K^+\\ \pi^- & \frac{\eta_N-\pi^0}{\sqrt{2}} & K^0\\ K^- & \bar{K}^0 & \eta\end{pmatrix},$$

$$V_1^\mu=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\omega_1^\mu+\rho_1^{0\mu}}{\sqrt{2}} & \rho_1^{+\mu} & K_1^{*+\mu}\\ \rho_1^{-\mu} & \frac{\omega_1^\mu-\rho_1^{0\mu}}{\sqrt{2}} & K_1^{*0\mu}\\ K_1^{*-\mu} & \bar{K}_1^{*0\mu} & \omega_1^\mu\end{pmatrix},$$

$$A_1^\mu=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{f_1^\mu+a_1^{0\mu}}{\sqrt{2}} & a_1^{+\mu} & K_{1,A}^{+\mu}\\ a_1^{-\mu} & \frac{f_1^\mu-a_1^{0\mu}}{\sqrt{2}} & K_{1,A}^{0\mu}\\ K_{1,A}^{-\mu} & \bar{K}_{1,A}^{0\mu} & f_1^\mu\end{pmatrix}.$$

$$B_1^\mu=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{h_1^\mu+b_1^{0\mu}}{\sqrt{2}} & b_1^{+\mu} & K_{1,B}^{+\mu}\\ b_1^{-\mu} & \frac{h_1^\mu-b_1^{0\mu}}{\sqrt{2}} & K_{1,B}^{0\mu}\\ K_{1,B}^{-\mu} & \bar{K}_{1,B}^{0\mu} & h_1^\mu\end{pmatrix},$$

$$W_2^{\mu\nu}=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\omega_2^{\mu\nu}+\rho_2^{0\mu\nu}}{\sqrt{2}} & \rho_2^{+\mu\nu} & K_2^{+\mu\nu}\\ \rho_2^{-\mu\nu} & \frac{\omega_2^{\mu\nu}-\rho_2^{0\mu\nu}}{\sqrt{2}} & K_2^{0\mu\nu}\\ K_2^{-\mu\nu} & \bar{K}_2^{0\mu\nu} & \omega_2^{\mu\nu}\end{pmatrix}$$

$$W_3^{\mu\nu\rho}=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\omega_3^{\mu\nu\rho}+\rho_3^{0\mu\nu\rho}}{\sqrt{2}} & \rho_3^{+\mu\nu\rho} & K_3^{+\mu\nu\rho}\\ \rho_3^{-\mu\nu\rho} & \frac{\omega_3^{\mu\nu\rho}-\rho_3^{0\mu\nu\rho}}{\sqrt{2}} & K_3^{0\mu\nu\rho}\\ K_3^{-\mu\nu\rho} & \bar{K}_3^{0\mu\nu\rho} & \omega_3^{\mu\nu\rho}\end{pmatrix},$$

$$W_4^{\mu\nu\rho\sigma}=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\omega_4^{\mu\nu\rho\sigma}+\rho_4^{0\mu\nu\rho\sigma}}{\sqrt{2}} & \rho_4^{+\mu\nu\rho\sigma} & K_4^{+\mu\nu\rho\sigma}\\ \rho_4^{-\mu\nu\rho\sigma} & \frac{\omega_4^{\mu\nu\rho\sigma}-\rho_4^{0\mu\nu\rho\sigma}}{\sqrt{2}} & K_4^{0\mu\nu\rho\sigma}\\ K_4^{-\mu\nu\rho\sigma} & \bar{K}_4^{0\mu\nu\rho\sigma} & \omega_4^{\mu\nu\rho\sigma}\end{pmatrix},$$

$$W_5^{\mu\nu\rho\sigma\gamma}=\frac{1}{\sqrt{2}}\begin{pmatrix}\frac{\omega_{5N}^{\mu\nu\rho\sigma\gamma}+\rho_5^{0\mu\nu\rho\sigma\gamma}}{\sqrt{2}} & \rho_5^{+\mu\nu\rho\sigma\gamma} & K_5^{+\mu\nu\rho\sigma\gamma}\\ \rho_5^{-\mu\nu\rho\sigma\gamma} & \frac{\omega_5^{\mu\nu\rho\sigma\gamma}-\rho_5^{0\mu\nu\rho\sigma\gamma}}{\sqrt{2}} & K_5^{0\mu\nu\rho\sigma\gamma}\\ K_5^{-\mu\nu\rho\sigma\gamma} & \bar{K}_5^{0\mu\nu\rho\sigma\gamma} & \omega_5^{\mu\nu\rho\sigma\gamma}\end{pmatrix}.$$

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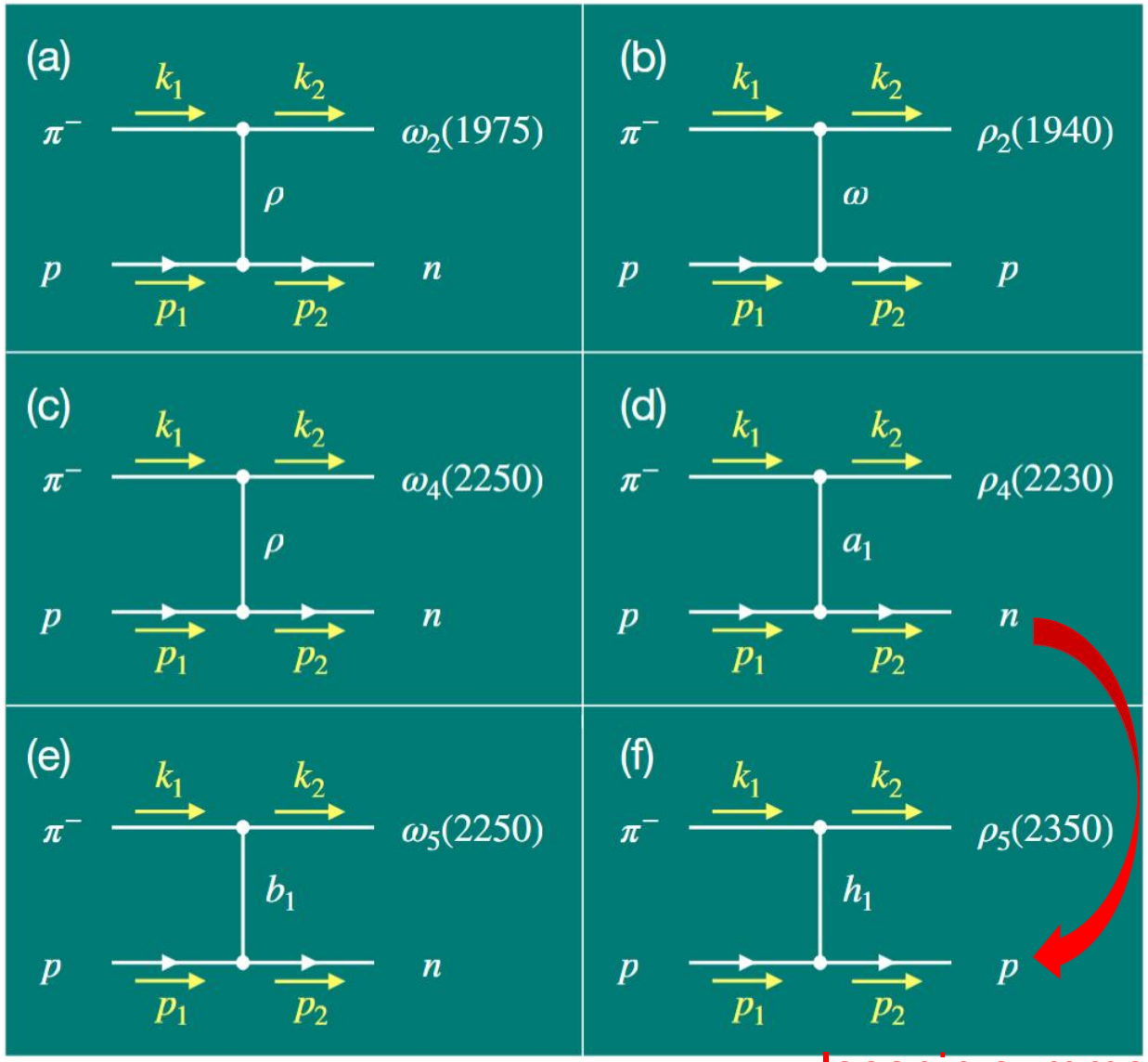
Theory framework： the effective Lagrangian approach



Isospin symmetry

FIG. 7: Feynman diagrams for the $\pi^- p \to \omega_J/\rho_J + N$ reactions.

$$\mathcal{L}_{\omega_2\rho\pi} = \frac{1}{2} g_{\omega_2\rho\pi} \omega_2^{\alpha\beta} \rho_\alpha^+ \partial_\beta \pi^-.$$

$$\mathcal{L}_{\rho NN} = g_{\rho NN} \overline{N} \gamma_\mu N \rho^\mu + \frac{f_{\rho NN}}{4M_p} \overline{N} \sigma_{\mu\nu} N (\partial^\mu \rho^\nu - \partial^\nu \rho^\mu),$$

$$\mathcal{L}_{\omega_4\rho\pi} = \frac{1}{2} g_{\omega_4\rho\pi} \omega_4^{\sigma\alpha\beta\gamma} \rho_\sigma^+ \partial_\alpha \partial_\beta \partial_\gamma \pi^-.$$

$$\mathcal{L}_{\rho_4 a_1 \pi} = \frac{1}{2} g_{\rho_4 a_1 \pi} \epsilon_{\mu\nu\rho\sigma} \rho_4^{\mu\alpha\beta\gamma} (\partial^\nu a_1^{\rho+}) \partial_\alpha \partial_\beta \partial_\gamma \partial^\sigma \pi^-,$$

$$\mathcal{L}_{a_1 NN} = g_{a_1 NN} [\bar{N} \gamma_\mu \gamma_5 N] a_1^\mu + \frac{i f_{a_1 NN}}{m_P} [\bar{N} \gamma_5 N] \partial_\mu a_1^\mu.$$

$$\mathcal{L}_{\omega_5 b_1 \pi} = \frac{1}{2} g_{\omega_5 b_1 \pi} \omega_5^{\sigma\alpha\beta\gamma\delta} b_{1,\sigma}^+ \partial_\alpha \partial_\beta \partial_\gamma \partial_\delta \pi^-.$$

$$\mathcal{L}_{b_1 NN} = \frac{i f_B}{m_{b_1}} \left[\bar{N} \sigma_{\mu\nu} \gamma_5 N \right] \partial^\nu b_1^\mu.$$

$$\mathcal{L}_{\rho_5 h_1 \pi} = \frac{1}{2} g_{\rho_5 h_1 \pi} \rho_5^{\mu\alpha\beta\gamma\delta} h_{1,\mu} \partial_\alpha \partial_\beta \partial_\gamma \partial_\delta \pi^-.$$

Theory framework： the effective Lagrangian approach

- Feynman amplitude

$\pi^- p \to \omega_2(1975) n$ *via t-channel* ρ *exchange:*

$$i\mathcal{M}_{\omega_2} = -\frac{i}{2} g_{\omega_2\rho\pi} \varepsilon^{\alpha\beta *}(k_2)(k_{1\beta}) \frac{-i(g^{\mu}_{\alpha} + q_\mu q_\alpha / m_\rho^2)}{t - m_\rho^2} \times \bar{u}(p_2)\left(g_{\rho NN}\gamma_\mu + \frac{f_{\rho NN}}{2m_p}\gamma_\mu \not{q}\right) u(p_1) F_t(q),$$

$\pi^- p \to \rho_2(1940) p$ *via t-channel* ω *exchange:*

$$i\mathcal{M}_{\rho_2} = -\frac{i}{2} g_{\rho_2\omega\pi} \varepsilon^{\alpha\beta *}(k_2)(k_{1\beta}) \frac{-i(g^{\mu}_{\alpha} + q_\mu q_\alpha / m_\omega^2)}{t - m_\omega^2} \times \bar{u}(p_2)\left(g_{\omega NN}\gamma_\mu + \frac{f_{\omega NN}}{2m_p}\gamma_\mu \not{q}\right) u(p_1) F_t(q),$$

$$i\mathcal{M}_{\omega_3} = \frac{1}{2} g_{\omega_3\rho\pi}\, \epsilon^{\mu\nu\rho\sigma}\, q_\nu\, k_1^\alpha\, k_1^\beta\, k_{1\sigma}\, \varepsilon^*_{\mu\alpha\beta}(k_2) \frac{-i\left(g^{\xi}_{\rho} + q^\xi q_\rho / m_\rho^2\right)}{t - m_\rho^2} \times \bar{u}(p_2)\left(g_{\rho NN}\gamma_\xi + \frac{f_{\rho NN}}{2m_p}\gamma_\xi \not{q}\right) u(p_1) F_t(q), \quad (7)$$

$$i\mathcal{M}_{\rho_3} = -\frac{1}{2} g_{\rho_3\pi\pi} \frac{f_{\pi NN}}{m_\pi} \bar{u}(p_2)\gamma_\sigma\gamma_5 u(p_1) q^\sigma \varepsilon^*_{\mu\nu\rho}(k_2) \times (k_{1\mu}k_{1\nu}k_{1\rho} + q_\mu q_\nu q_\rho) \frac{i}{t - m_\pi^2} F_t(q),$$

$$F_t(q) = \left(\frac{\Lambda_t^2 - m^2}{\Lambda_t^2 - q^2}\right)^2, \qquad \frac{1}{t - m_\pi^2} \to \left(\frac{s}{s_{scale}}\right)^{\alpha_\pi(t)} \frac{\pi\alpha'_\pi}{\Gamma[1 + \alpha_\pi(t)]\sin[\pi\alpha_\pi(t)]}, \qquad \alpha_\pi(t) = 0.7(t - m_\pi^2),$$

Theory framework： the effective Lagrangian approach

- Feynman amplitude

$\pi^- p \to \omega_4(2250) n$ *via t-channel* ρ *exchange:*

$$i\mathcal{M}_{\omega_4} = \frac{i}{2} g_{\omega_4\rho\pi} k_{1\alpha} k_{1\beta} k_{1\gamma} \varepsilon^{\sigma\alpha\beta\gamma *}(k_2) \frac{-i\left(g^{\mu}_{\sigma} + q^{\mu} q_{\sigma}/m_{\rho}^2\right)}{t - {m_{\rho}}^2} \times \bar{u}(p_2) \left[g_{\rho NN} \gamma_{\mu} + \frac{f_{\rho NN}}{2m_p} \gamma_{\mu} \not{q} \right] u(p_1) F_t(q),$$

$\pi^- p \to \rho_4(2230) n$ *via t-channel* a_1 *exchange:*

$$i\mathcal{M}_{\rho_4} = -\frac{1}{2} g_{\rho_4 a_1 \pi} \epsilon_{\mu\nu\rho\sigma} q^{\nu} k_{1\alpha} k_{1\beta} k_{1\gamma} k_1^{\sigma} \varepsilon^{\mu\alpha\beta\gamma *}(k_2) \frac{-i\left(g^{\xi}_{\rho} + q^{\xi} q_{\rho}/m_{a_1}^2\right)}{t - m_{a_1}^2} F_t(q) \times \bar{u}(p_2) \left(g_{a_1 NN} \gamma_{\xi} \gamma_5 - \frac{f_{a_1 NN}}{M_p} \gamma_5 \not{q} \right) u(p_1),$$

$\pi^- p \to \omega_5(2250) n$ *via t-channel* b_1 *exchange:*

$$i\mathcal{M}_{\omega_5} = \frac{1}{2} \frac{f_{b_1 NN}}{m_{b_1}} g_{\omega_5 b_1 \pi} k_{1\alpha} k_{1\beta} k_{1\gamma} k_{1\delta} \varepsilon^{\sigma\alpha\beta\gamma\delta *}(k_2) \times \frac{-i\left(g^{\mu}_{\sigma} + q^{\mu} q_{\sigma}/m_{b_1}^2\right)}{t - m_{b_1}^2} \bar{u}(p_2) \sigma_{\mu\nu} \gamma_5 u(p_1) \times q^{\nu} F_t(q),$$

$\pi^- p \to \rho_5(2350) n$ *via t-channel* h_1 *exchange:*

$$i\mathcal{M}_{\rho_5} = -\frac{1}{2} \frac{f_{h_1 NN}}{m_{b_1}} g_{\rho_5 h_1 \pi} k_{1\alpha} k_{1\beta} k_{1\gamma} k_{1\delta} \varepsilon^{\sigma\alpha\beta\gamma\delta *}(k_2) \times \frac{-i\left(g^{\mu}_{\sigma} + q^{\mu} q_{\sigma}/m_{h_1}^2\right)}{t - m_{h_1}^2} \bar{u}(p_2) \sigma_{\mu\nu} \gamma_5 u(p_1) \times q^{\nu} F_t(q).$$

$$\frac{1}{t - m_R^2} \to \left(\frac{s}{s_{scale}}\right)^{\alpha_R(t)-1} \frac{\pi \alpha'_R}{\Gamma[\alpha_R(t)] \sin[\pi \alpha_R(t)]}, \qquad \alpha_R(t) = 1 + \alpha'_R(t - m_R^2),$$

Theory framework： the effective Lagrangian approach

The differential cross section in the center-of-mass (c.m.) frame is given by

$$\frac{d\sigma}{d\cos\theta} = \frac{1}{32\pi s}\frac{\left|\vec{k}_2^{\,\text{c.m.}}\right|}{\left|\vec{k}_1^{\,\text{c.m.}}\right|}\left(\frac{1}{2}\sum_{\lambda}|\mathcal{M}|^2\right),$$

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The propagator of a field for a boson field can be written as

$$S(p) = \frac{1}{p^2 - M^2}(\not{p} + M)\Delta^{\beta_1\cdots\beta_{n-1}}_{\alpha_1\cdots\alpha_{n-1}}(j,p).$$

The explicit expressions for the projection operators of fields from spin-3 to spin-5 are given as follows

$$\Delta^{\beta}_{\alpha}(1,p) = -\bar{g}^{\beta}_{\alpha} = -\left(g^{\beta}_{\alpha} - \frac{1}{p^2}p_\alpha p^\beta\right). \qquad \Delta^{\beta_1\beta_2}_{\alpha_1\alpha_2}(2,p) = \frac{1}{2}\left(\bar{g}^{\beta_1}_{\alpha_1}\bar{g}^{\beta_2}_{\alpha_1} + \bar{g}^{\beta_1}_{\alpha_1}\bar{g}^{\beta_1}_{\alpha_2} - \frac{2}{3}\bar{g}_{\alpha_1\alpha_2}\bar{g}^{\beta_1\beta_2}\right).$$

$$\Delta^{\beta_1\beta_2\beta_3}_{\alpha_1\alpha_2\alpha_3}(3,p) = -\frac{1}{36}\sum_{P(\alpha),P(\beta)}\left(\bar{g}^{\beta_1}_{\alpha_1}\bar{g}^{\beta_2}_{\alpha_2}\bar{g}^{\beta_3}_{\alpha_3} - \frac{3}{5}\bar{g}_{\alpha_1\alpha_2}\bar{g}^{\beta_1\beta_2}\bar{g}^{\beta_3}_{\alpha_3}\right) \qquad \bar{g}_{\mu\nu} = g_{\mu\nu} - \frac{1}{p^2}p_\mu p_\nu.$$

$$\Delta^{\beta_1\beta_2\beta_3\beta_4}_{\alpha_1\alpha_2\alpha_3\alpha_4}(4,p) = \frac{1}{576}\sum_{P(\alpha),P(\beta)}\left(\bar{g}^{\beta_1}_{\alpha_1}\bar{g}^{\beta_2}_{\alpha_2}\bar{g}^{\beta_3}_{\alpha_3}\bar{g}^{\beta_4}_{\alpha_4} - \frac{6}{7}\bar{g}_{\alpha_1\alpha_2}\bar{g}^{\beta_1\beta_2}\bar{g}^{\beta_3}_{\alpha_3}\bar{g}^{\beta_4}_{\alpha_4} + \frac{3}{35}\bar{g}_{\alpha_1\alpha_2}\bar{g}_{\alpha_3\alpha_4}\bar{g}^{\beta_1\beta_2}\bar{g}^{\beta_3\beta_4}\right),$$

$$\Delta^{\beta_1\beta_2\beta_3\beta_4\beta_5}_{\alpha_1\alpha_2\alpha_3\alpha_4\alpha_5}(5,p) = -\left(\frac{1}{120}\right)^2\sum_{P(\alpha),P(\beta)}\left(\bar{g}^{\beta_1}_{\alpha_1}\bar{g}^{\beta_2}_{\alpha_2}\bar{g}^{\beta_3}_{\alpha_3}\bar{g}^{\beta_4}_{\alpha_4}\bar{g}^{\beta_5}_{\alpha_5} - \frac{10}{9}\bar{g}_{\alpha_1\alpha_2}\bar{g}^{\beta_1\beta_2}\bar{g}^{\beta_3}_{\alpha_3}\bar{g}^{\beta_4}_{\alpha_4}\theta^{\beta_5}_{\alpha_5} + \frac{5}{21}\bar{g}_{\alpha_1\alpha_2}\bar{g}_{\alpha_3\alpha_4}\bar{g}^{\beta_1\beta_2}\bar{g}^{\beta_3\beta_4}\bar{g}^{\beta_5}_{\alpha_5}\right),$$

Numerical analysis： the cross section of $\omega_3(1650)$ meson

- The fitted results
  Left: the total cross section
  Right: the different cross section

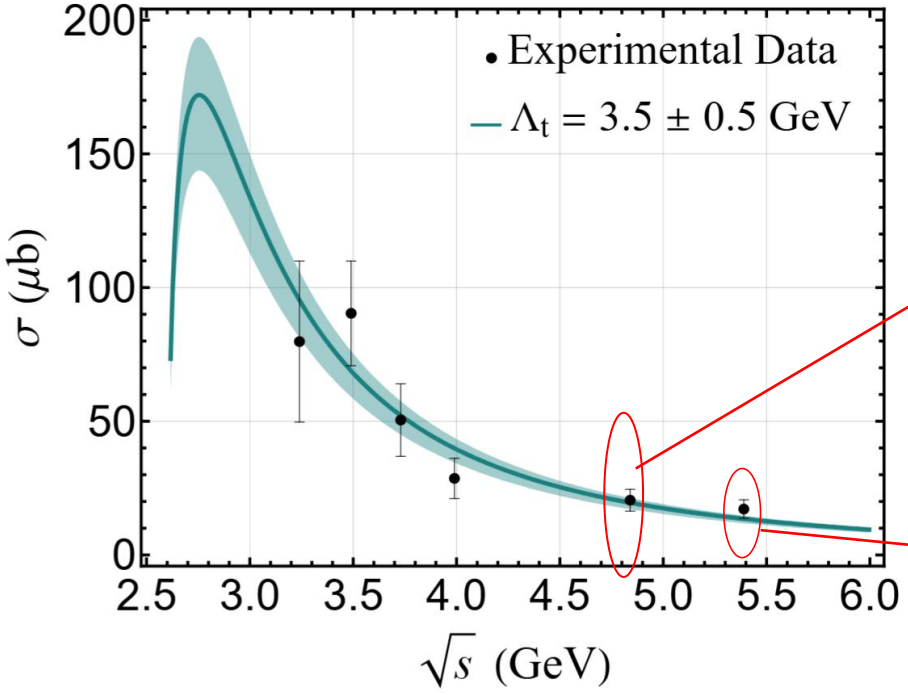


FIG. 3: The total cross section for the reaction $\pi^- p \to \omega_3(1670)n$. The black points with error bars correspond to the experimental data from Refs. [16, 17, 21–23].

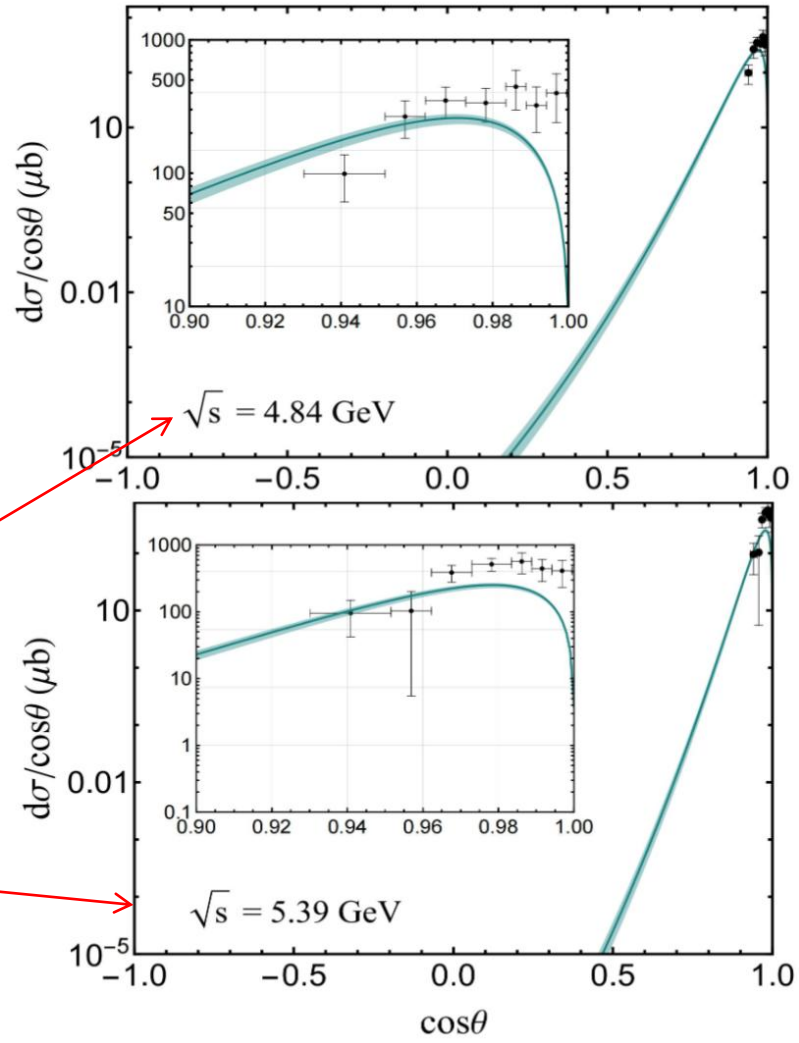


FIG. 4: The differential cross section $d\sigma/d\cos\theta$ of the $\omega_3(1670)$ production at different c.m. energy E_{cm}. The black points with error bars correspond to the experimental data from Ref. [17].

Numerical analysis： the cross section of the $\rho_3(1690)$ meson

- The fitted results
  Left: the total cross section
  Right: the different cross section

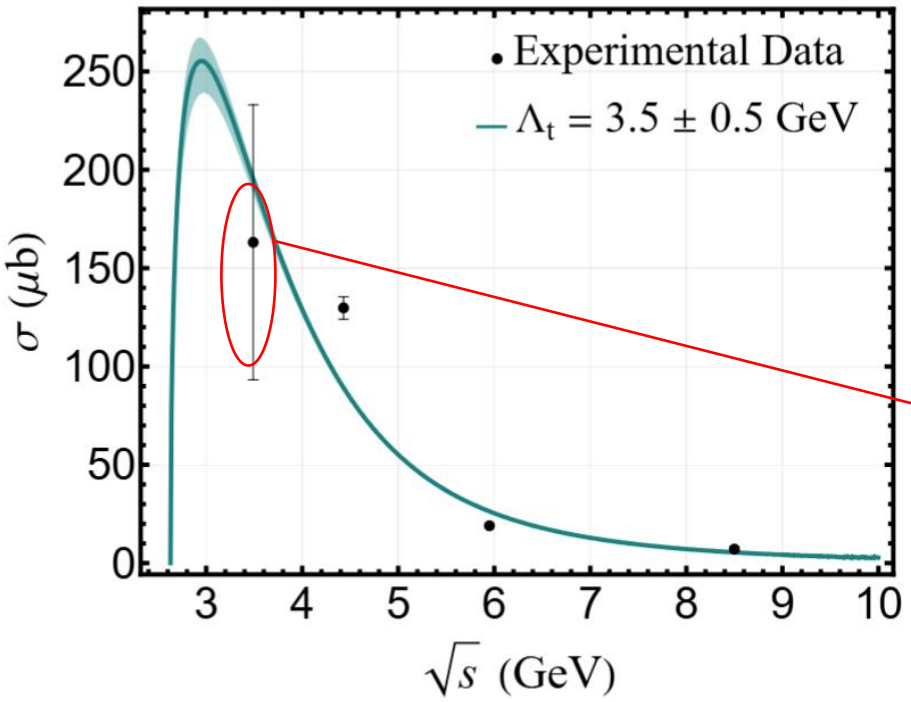


FIG. 5: The total cross section for the reaction $\pi^- p \to \rho_3(1690)n$. The black points with error bars correspond to the experimental data from Refs. [18, 24–26].

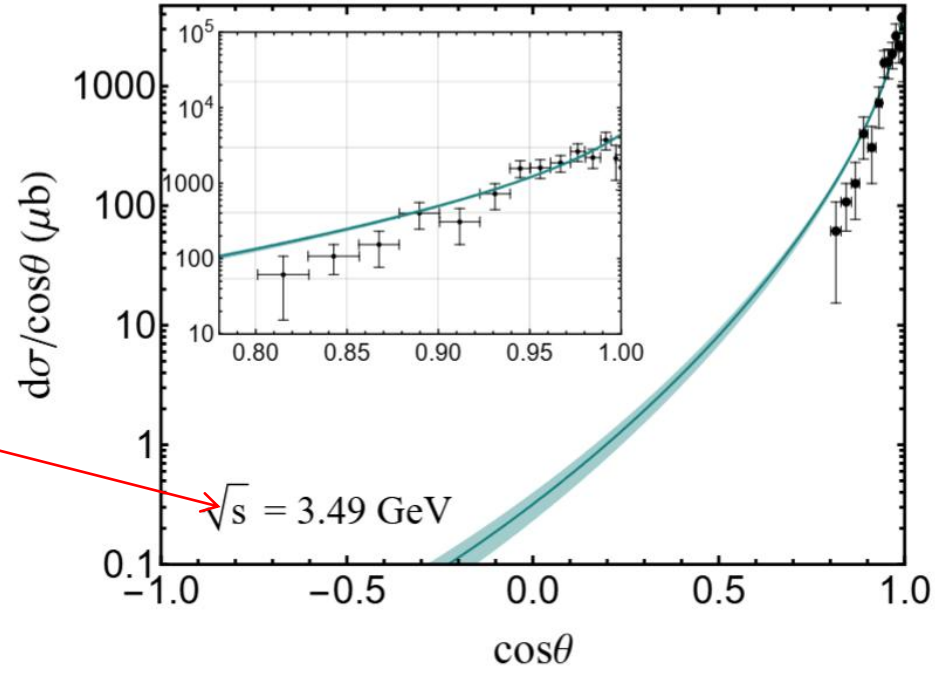


FIG. 6: The differential cross section $d\sigma/d\cos\theta$ of the $\rho_3(1690)$ production at c.m. energy E_{cm} = 3.49 GeV. The black points with error bars correspond to the experimental data from Ref. [18].

Numerical analysis： the total cross section of the $\omega_2(1975)$, $\rho_2(1940)$, $\omega_4(2250)$, $\rho_4(2230)$, $\omega_5(2250)$, $\rho_5(2350)$

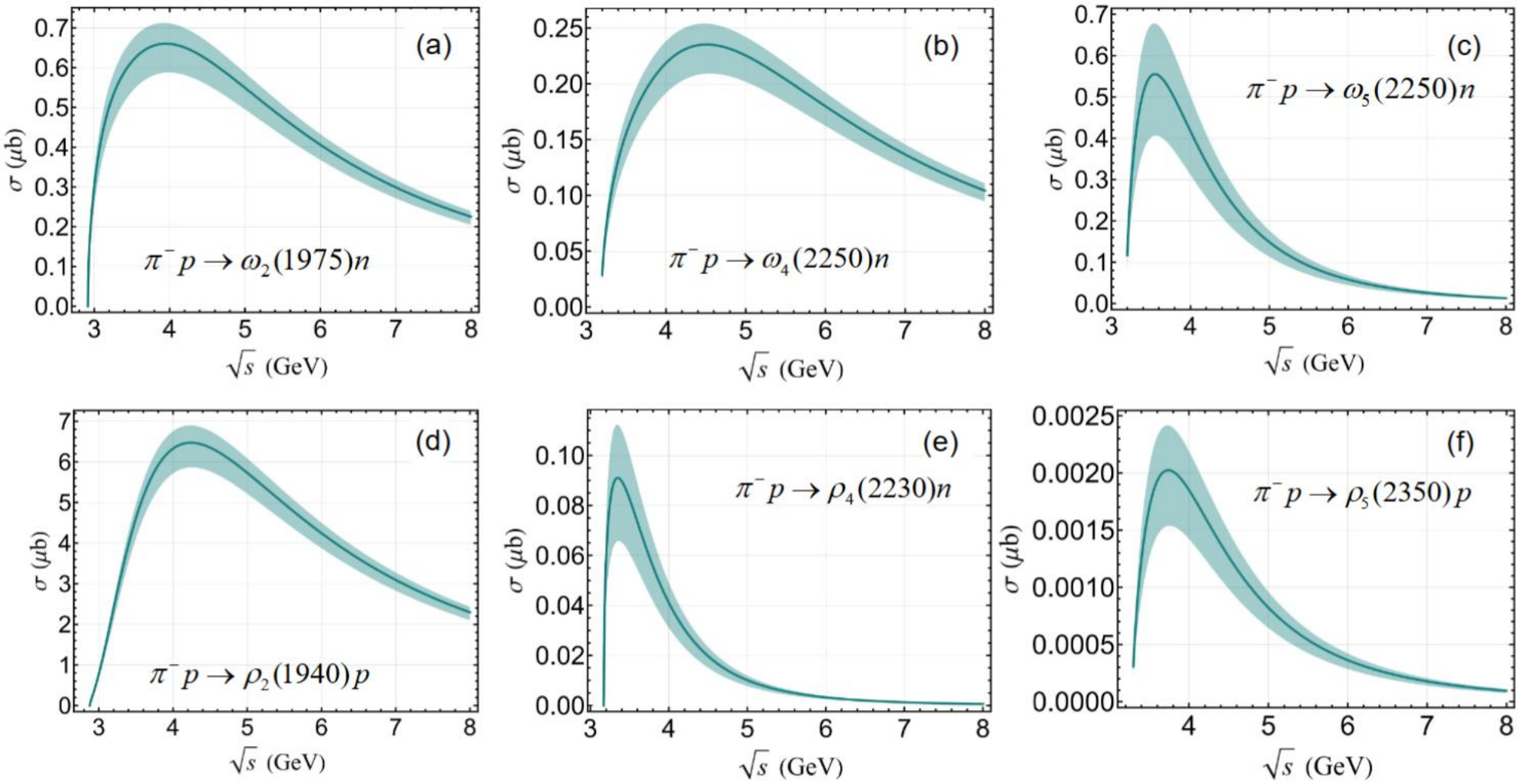


FIG. 8: The energy dependence of the total cross section for production of the $\omega_2(1975)$, $\rho_2(1940)$, $\omega_4(2250)$, $\rho_4(2230)$, $\omega_5(2250)$, $\rho_5(2350)$ through t-channel with cutoff $\Lambda_t = 3.5 \pm 0.5$ GeV.

Numerical analysis： the different cross section of the $\omega_2(1975)$, $\rho_2(1940)$, $\omega_4(2250)$, $\rho_4(2230)$, $\omega_5(2250)$, $\rho_5(2350)$

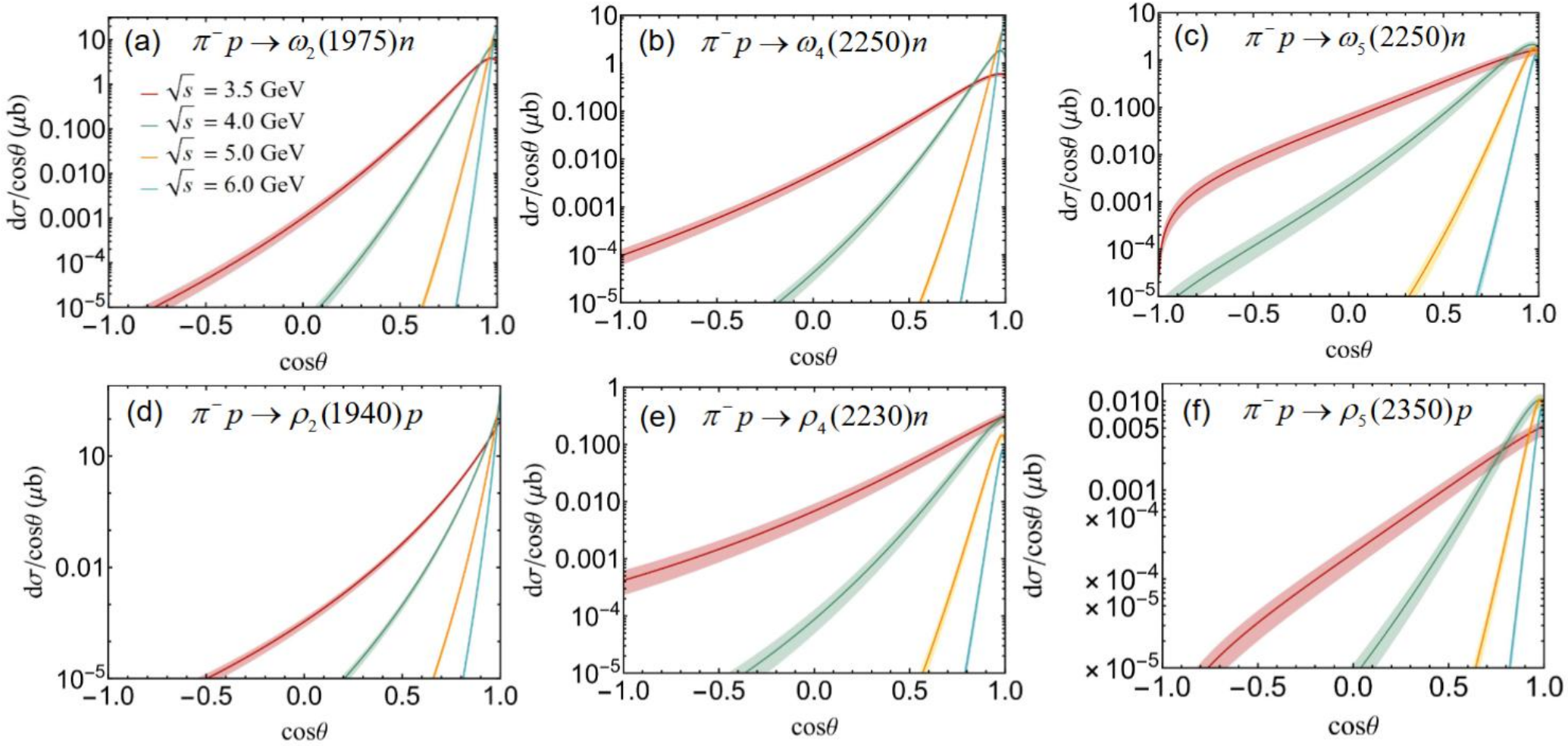
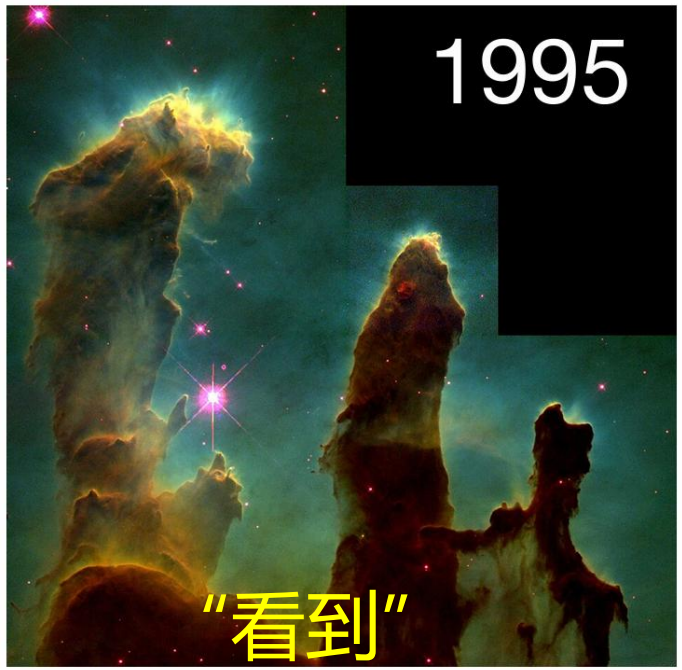


FIG. 9: The differential cross section $d\sigma/d\cos\theta$ of the $\omega_2(1975)$, $\rho_2(1940)$, $\omega_4(2250)$, $\rho_4(2230)$, $\omega_5(2250)$, $\rho_5(2350)$ production at different c.m. energies W = 3.5, 4, 5 and 6 GeV.

Possible future prospect

图片取自 刘翔教授 在“第八届强子谱和强子结构研讨会”的报告PPT

- The experimental data for two types of mesons were fitted using the same cutoff parameter.
- The production of six high-spin particles was predicted under the same production mechanism.
- Given the secondary decay channels. Experimentally, these high-spin particles can be reconstructed via their invariant mass spectra.



Thank you

从“已知”中提炼“未明”