Kaon Photoproduction on the Nucleon in Coupled-Channels

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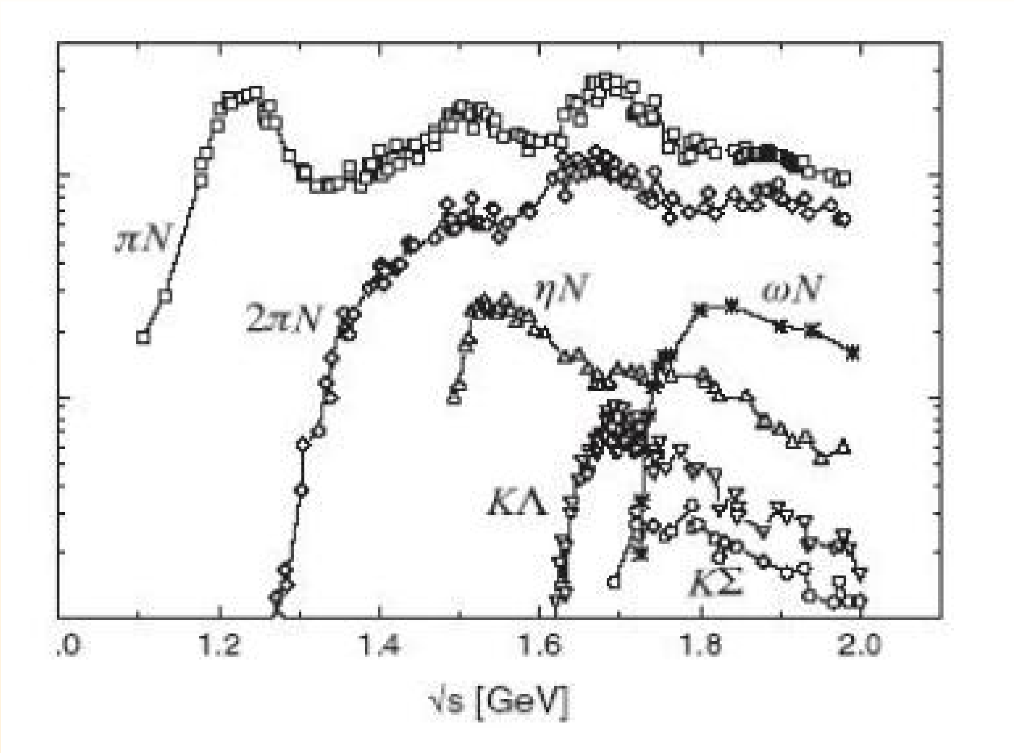
Motivation

Review of the Model

Discussion

MOTIVATION

Search for Missing Resonances



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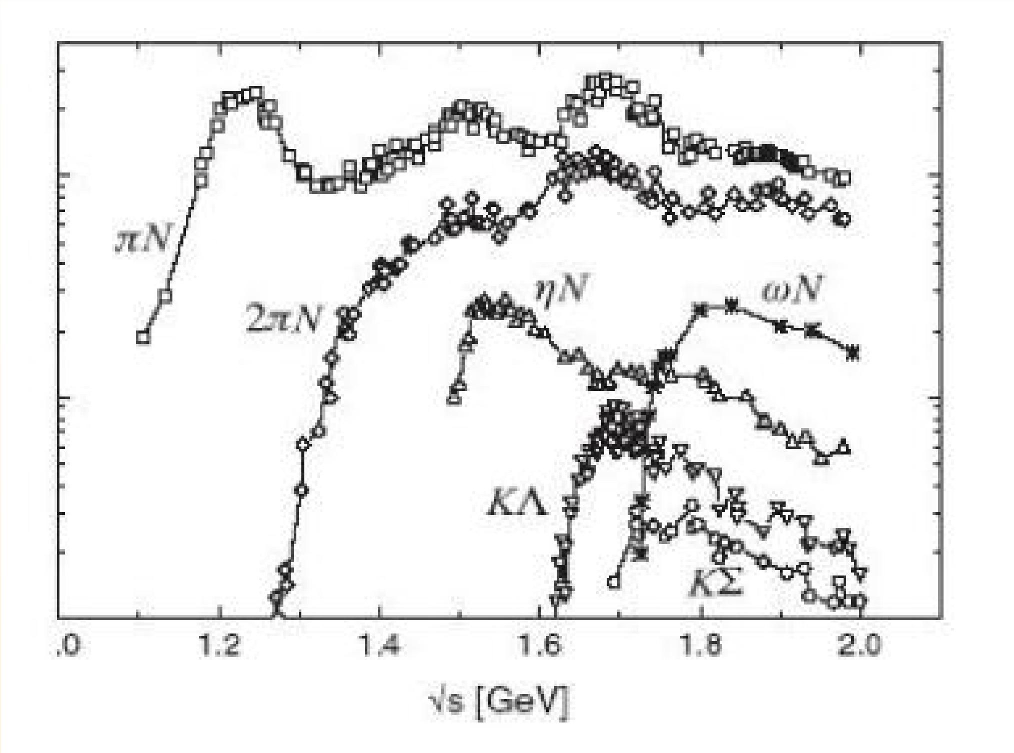

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  - ▷ Example: D_{13} nucleon resonances:

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$D_{13}(1700)$	$5 - 15$ %	$< 3\%$	-
$D_{13}(1900)$	?	?	?

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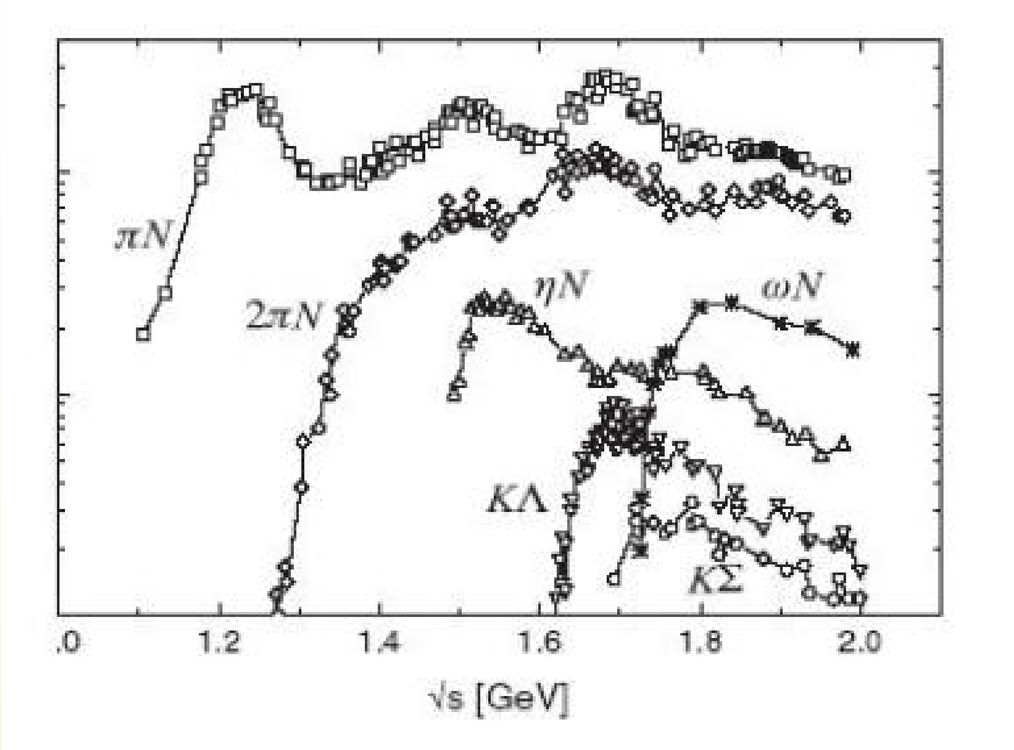

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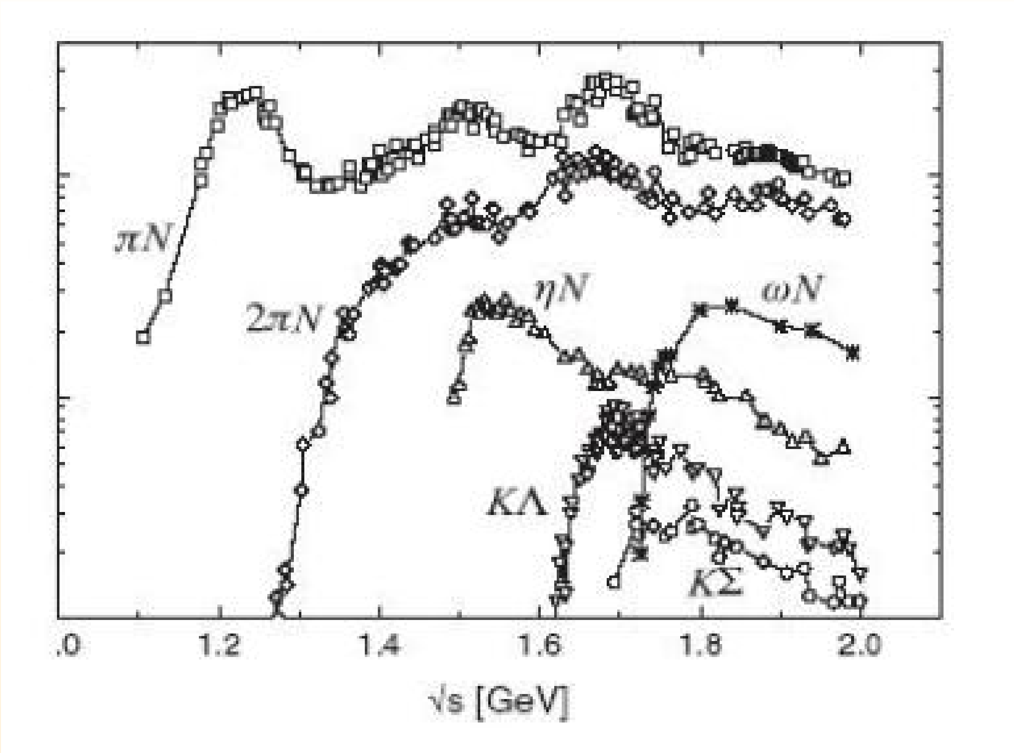

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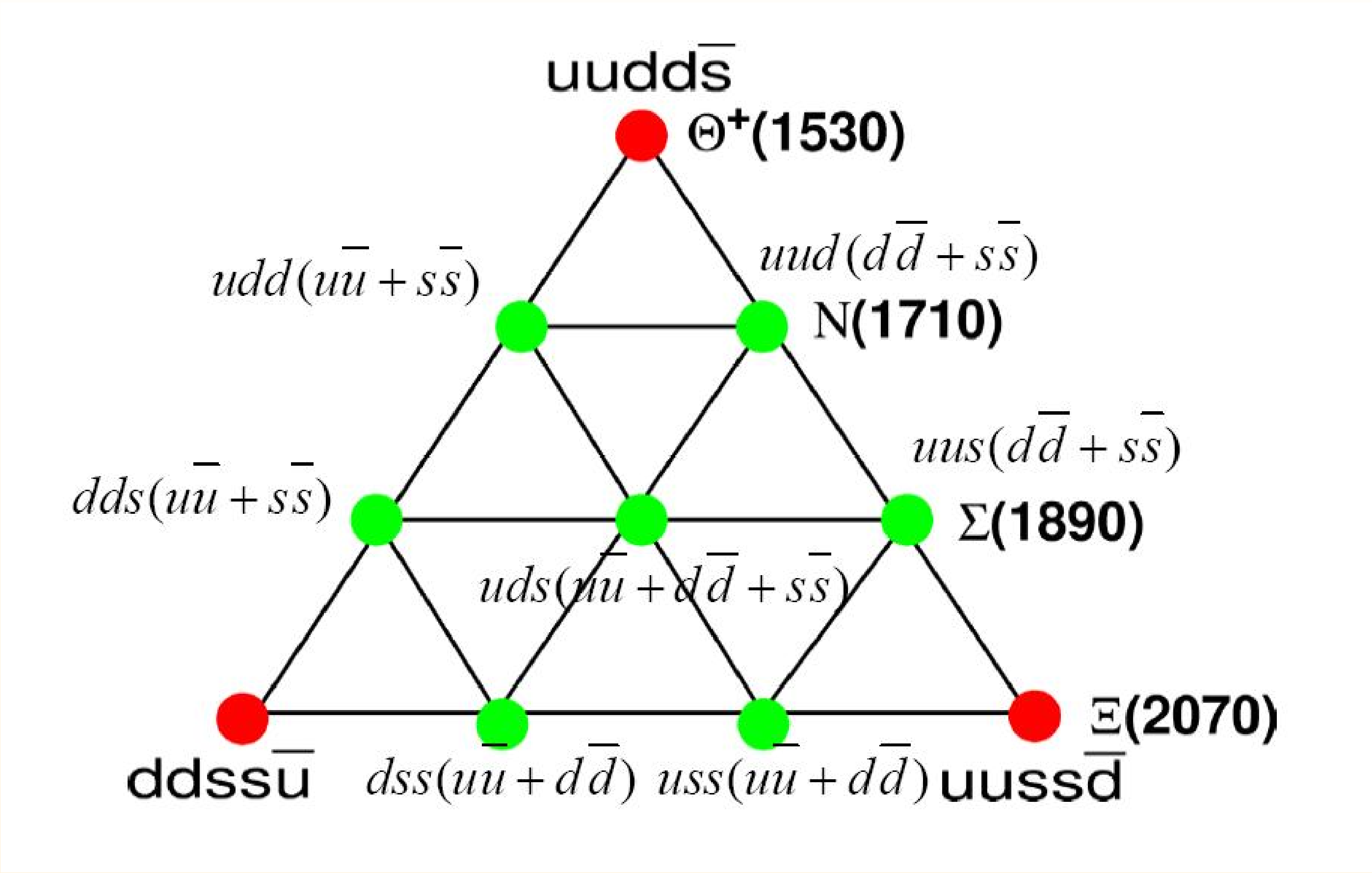
  - ▷ Why coupled-channels? Unitarity $\longrightarrow$ N* decay in several channels.

Recent discovery of pentaquark $\Theta^+(1540)$



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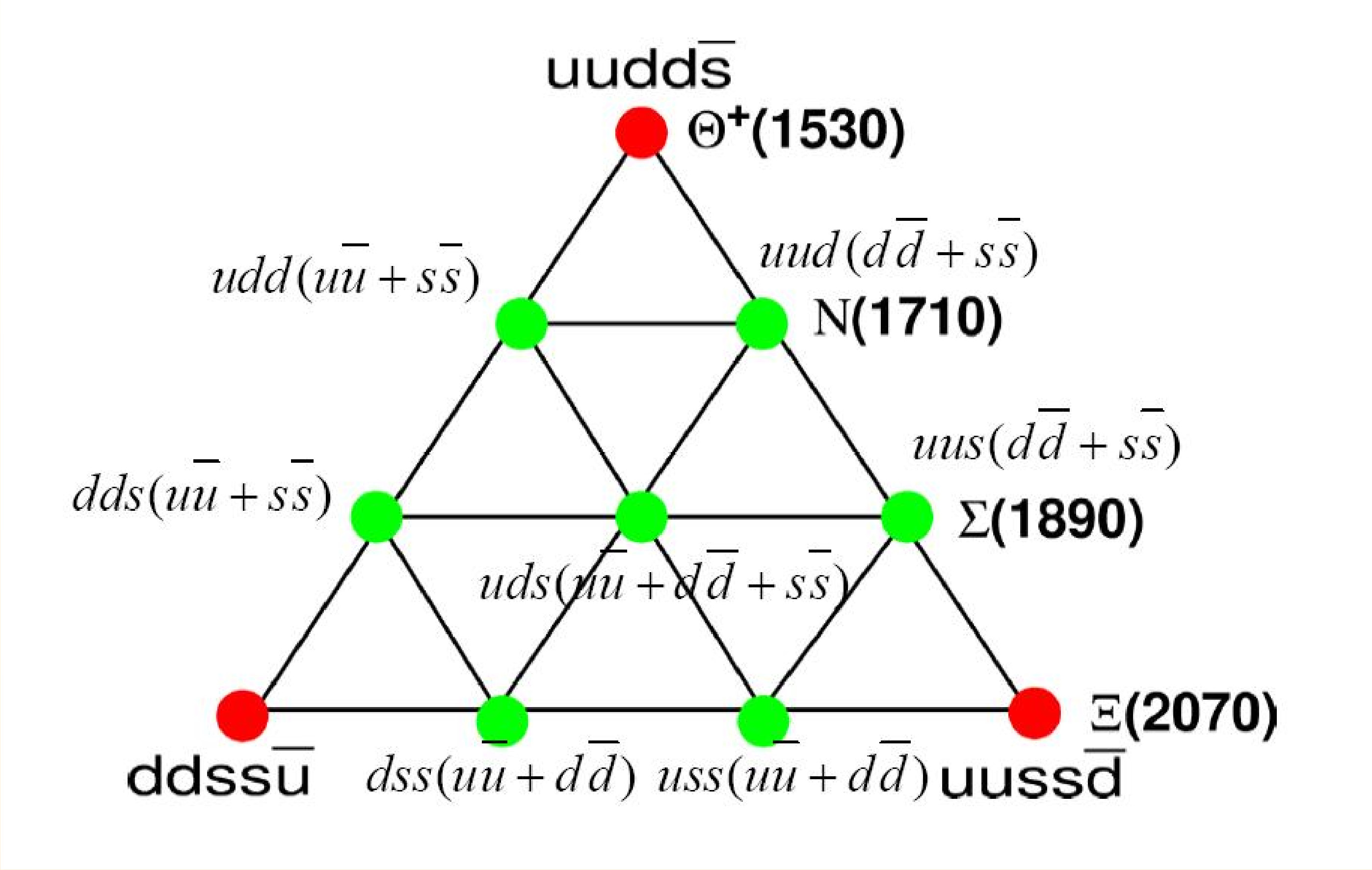

- D. Diakonov, V. Petrov, and M. Polyakov (Z. Physics A359 (1997)) predicted $P_{11}(1710)$ belongs to anti-decuplet 5-quark state with small width $\Gamma \sim 40$ MeV.

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- The 2π final state is parameterized through the coupling to a scalar isovector effective ζ-meson with mass $m_\zeta = 2m_\pi$.

Hadronic Background Contribution

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Follow chiral lagrangian:

- Meson-Baryon-Baryon

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$$\Gamma_{\pi\pi NN} = -\frac{(\not{k}' + \not{k})}{4F_\pi^2}, \tag{3}$$

where $F_\pi = 92.4$ MeV the (weak) decay constant of the pion, k and k' are incoming and outgoing pion respectively.

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$\longrightarrow$ very small contribution to the S and P partial waves of πN scattering.

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  - ▷ Scalar Meson: $\sigma(550)$

$$T^s = -2g_{sNN}\frac{\bar{c}_m 2m_\pi^2 + \bar{c}_d(t - 2m_\pi^2)}{F_\pi^2(t - m_s^2)} \tag{4}$$

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  - Vector Meson: $\rho(768)$, $k^*(894)$ and $a_0(983)$

$$\begin{aligned} T^v &= \frac{tG_{v\phi\phi}g_{vBB}}{m_v F_\pi^2(t - m_v^2)}\left((1+\kappa_v)\frac{\not{k} + \not{k}'}{2} + \frac{u-s}{4m_N}\kappa_v\right) \\ &- \frac{G_{v\phi\phi}g_{vBB}\kappa_v}{m_v F_\pi^2}\left(\frac{\not{k} + \not{k}'}{2} + \frac{u-s}{4m_N}\right) + \frac{t^2\sqrt{2}G_{v\phi\phi}}{4F_\pi^2(t - m_v^2)}T_+ \end{aligned} \tag{5}$$

  Meißner and Oller Nucl. Phys. A 673 (2000) 311-314

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- Contact Terms.

$$\begin{aligned} \mathcal{L}_{\phi\phi BB} &= \left(\alpha_1 g_{\mu\nu}+\frac{\alpha_2}{m_N}(P_\mu\gamma_\nu+\gamma_\mu P_\nu)+\frac{\alpha_3}{m_N^2}P_\mu P_\nu\right)(\partial^\mu\phi^\dagger)(\partial^\mu\phi) \\ &+ \left(\alpha_4\gamma_{\mu\nu}+\frac{\alpha_5}{m_N}\gamma_{\mu\nu\sigma}P^\sigma\right)(\partial^\mu\phi^\dagger)(\partial^\mu\phi). \end{aligned} \tag{6}$$

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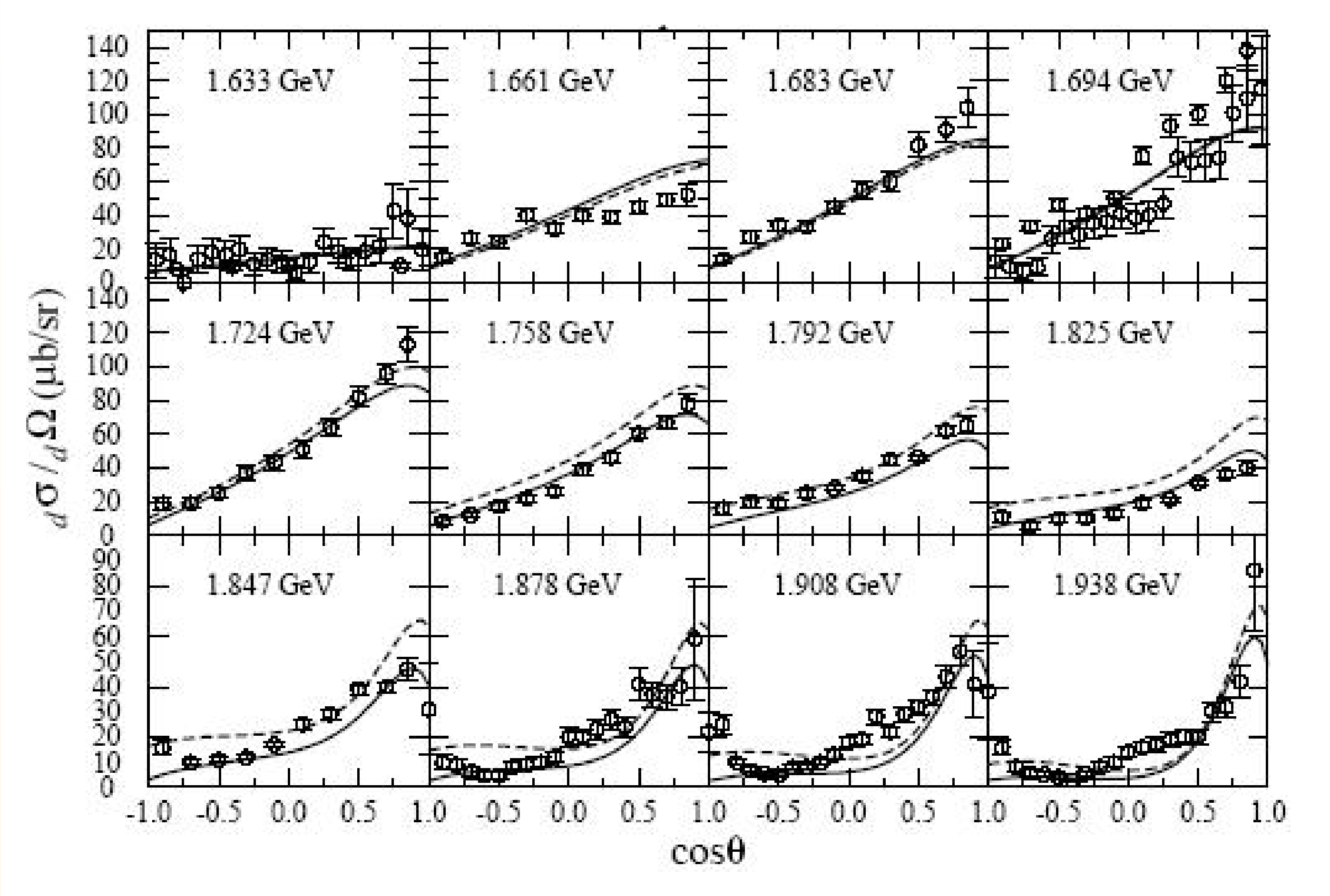
Similarly for $\gamma N \Delta$ coupling!

Discussion

Hadronic Reaction $\pi^- p \to K^0 \Lambda$



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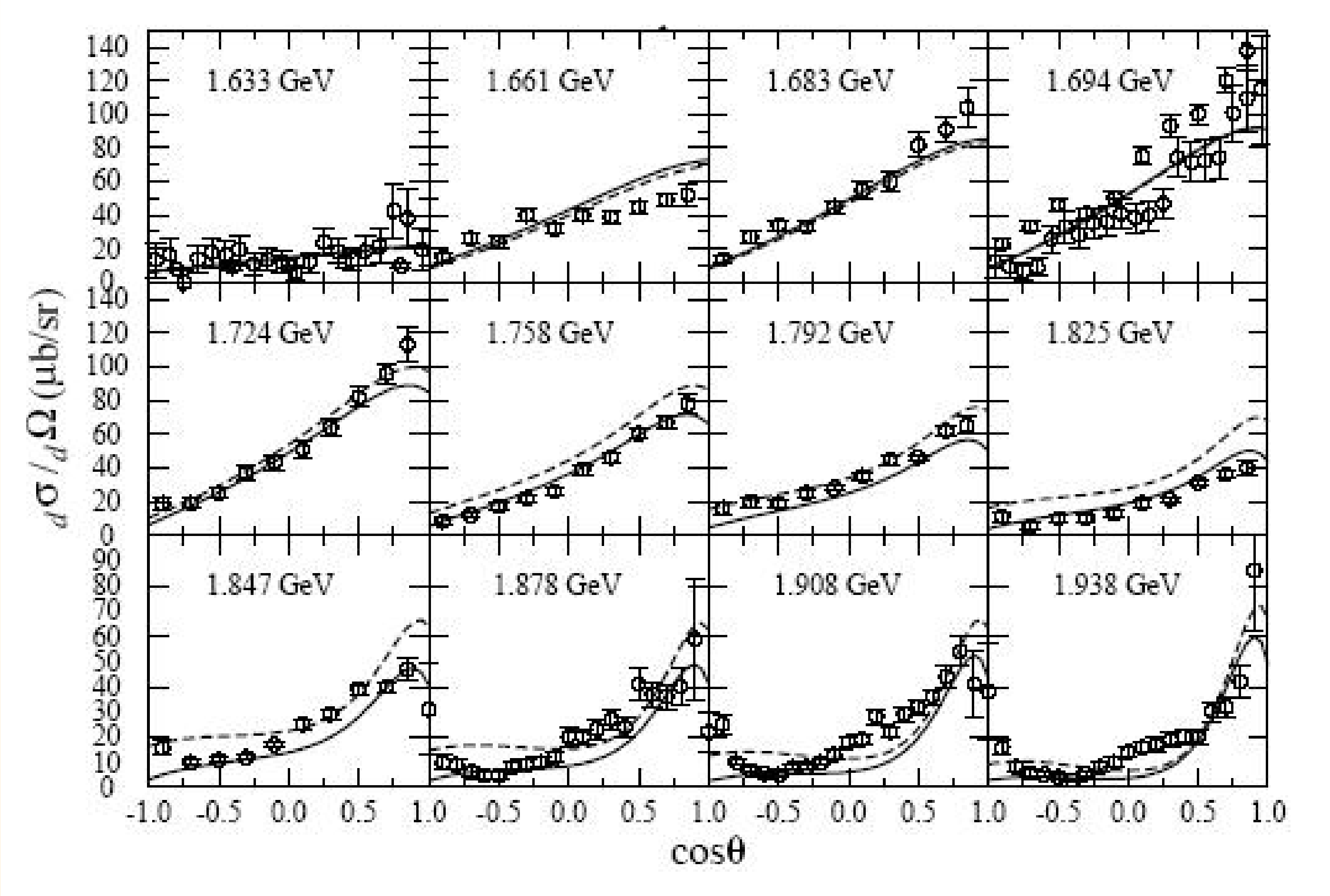

▷ Clear $S_{11}(1650) \to$ the threshold region,

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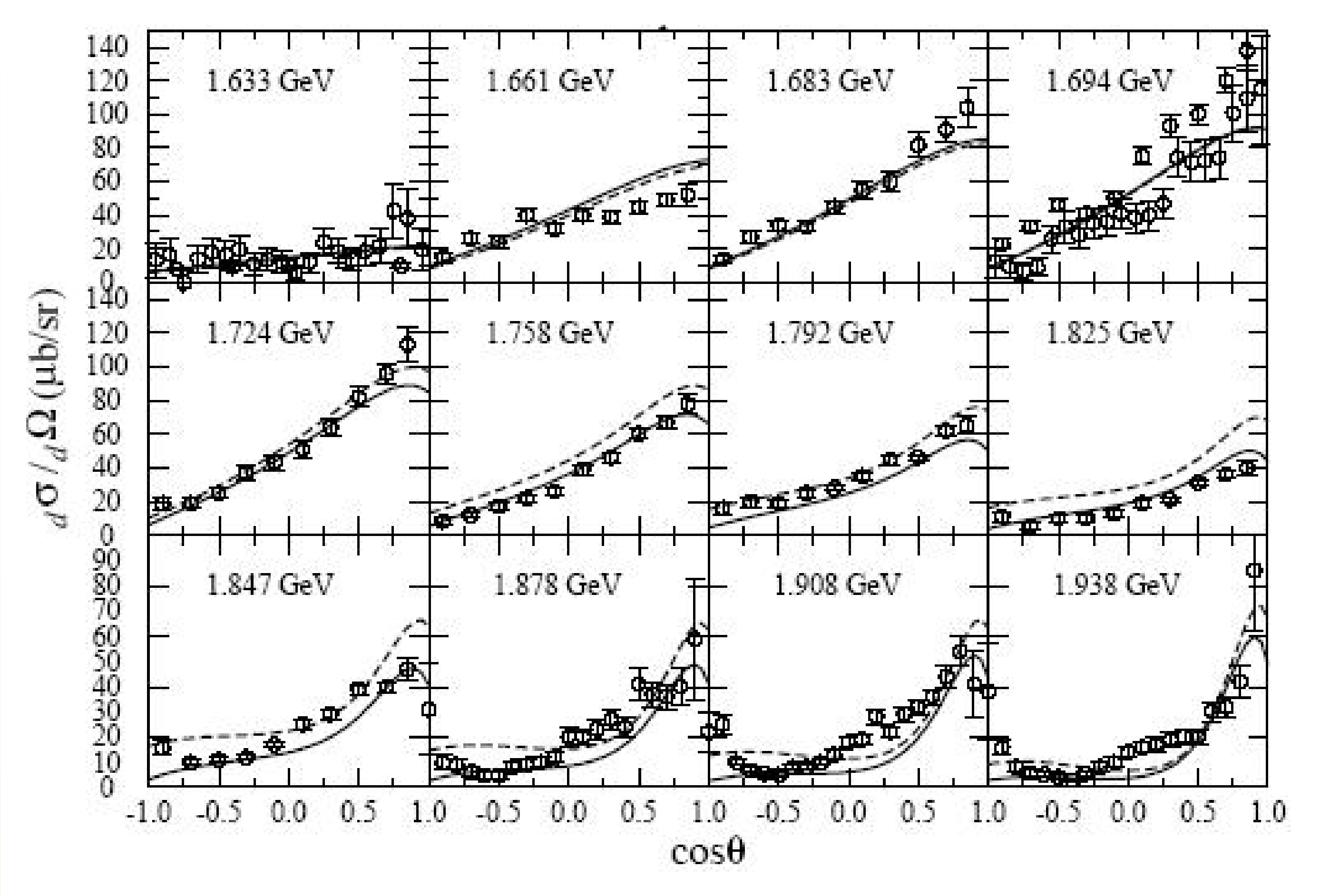

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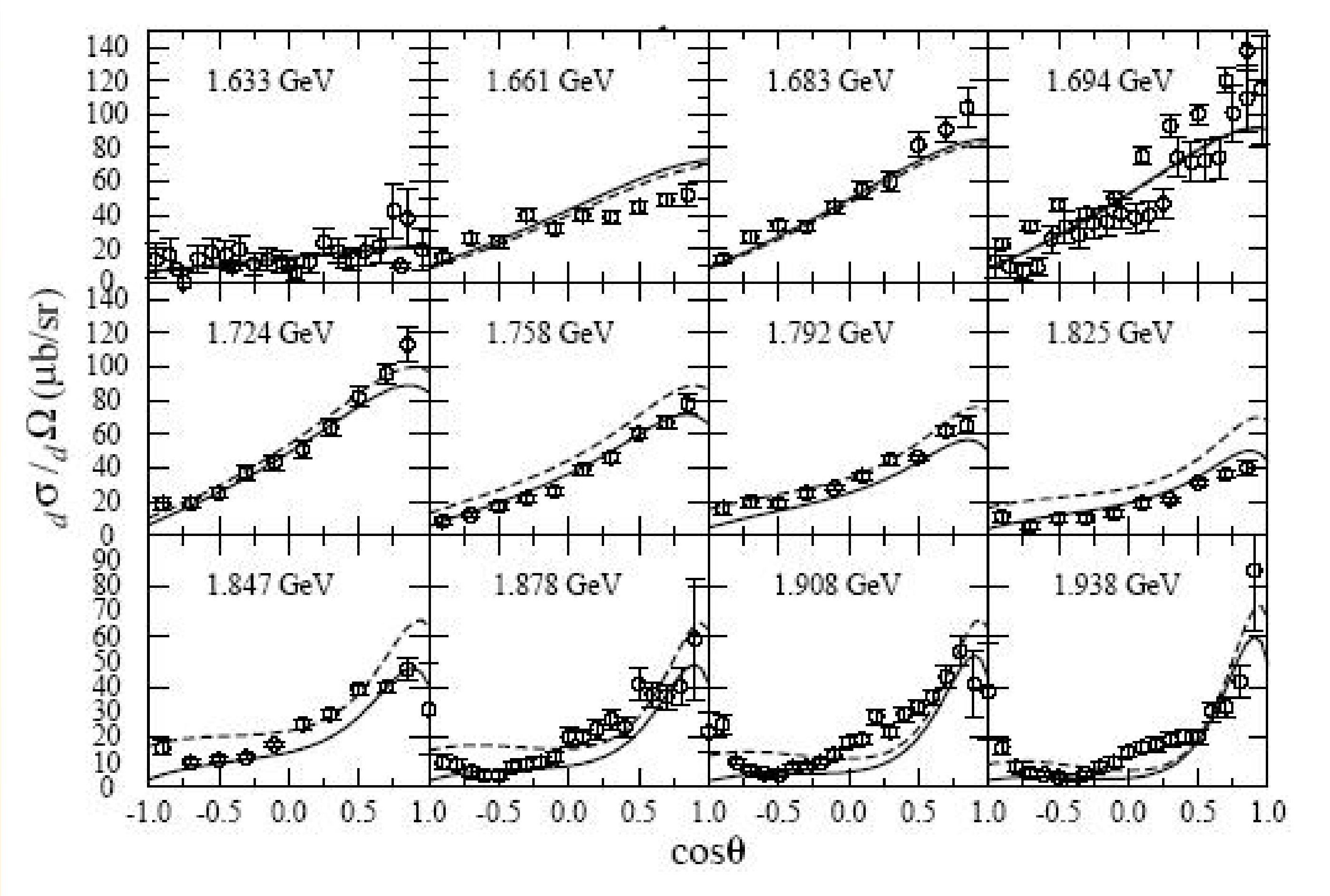
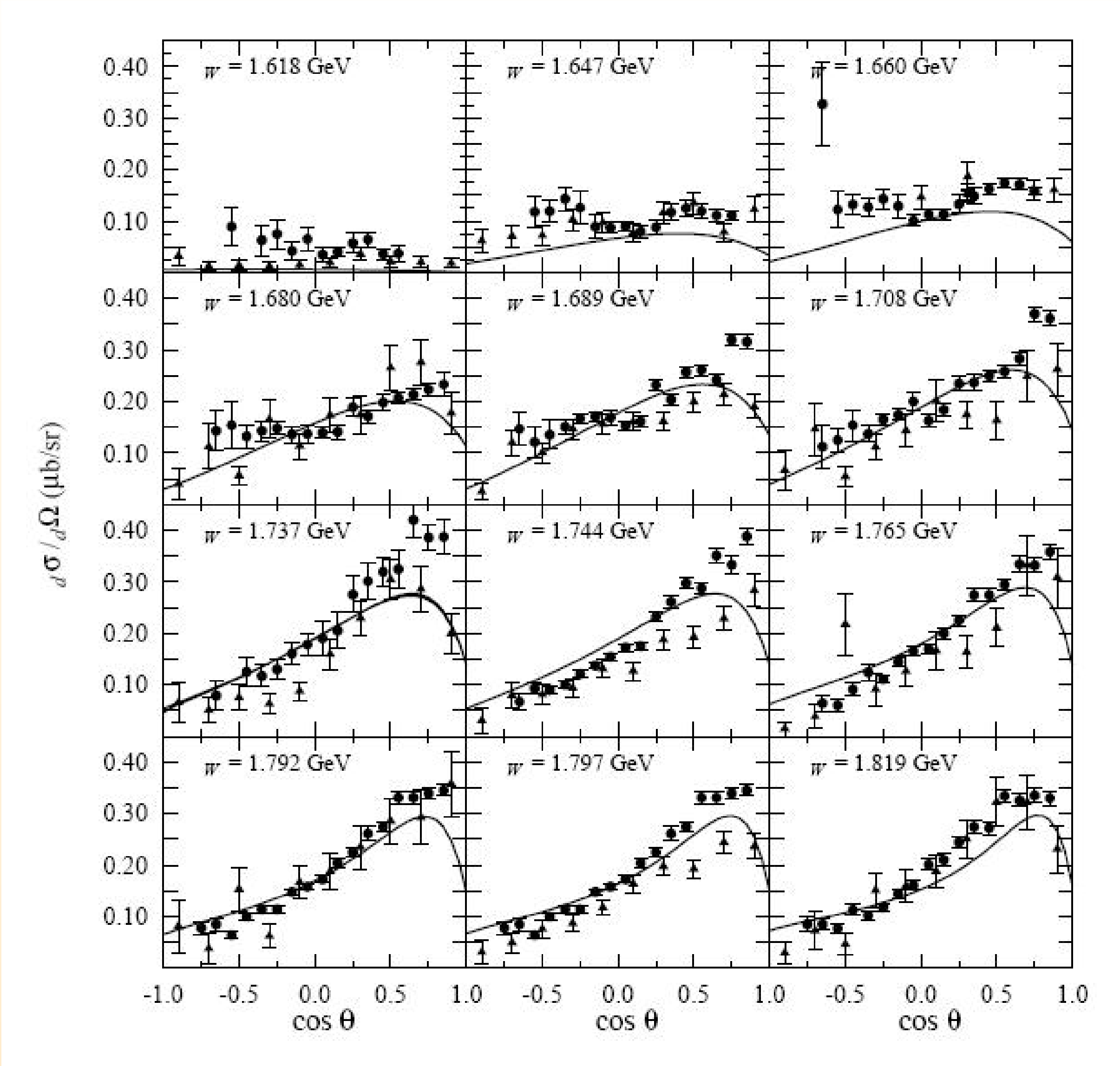


- ▷ Clear $S_{11}(1650) \to$ the threshold region,
- ▷ $P_{11}(1710)$ and $P_{13}(1720)$ around $W = 1700$ MeV
- ▷ k^* exchange in the t-channel $\to$ forward peaking in the high energy region.

Electromagnetic Reaction $\gamma p \to K^+\Lambda$



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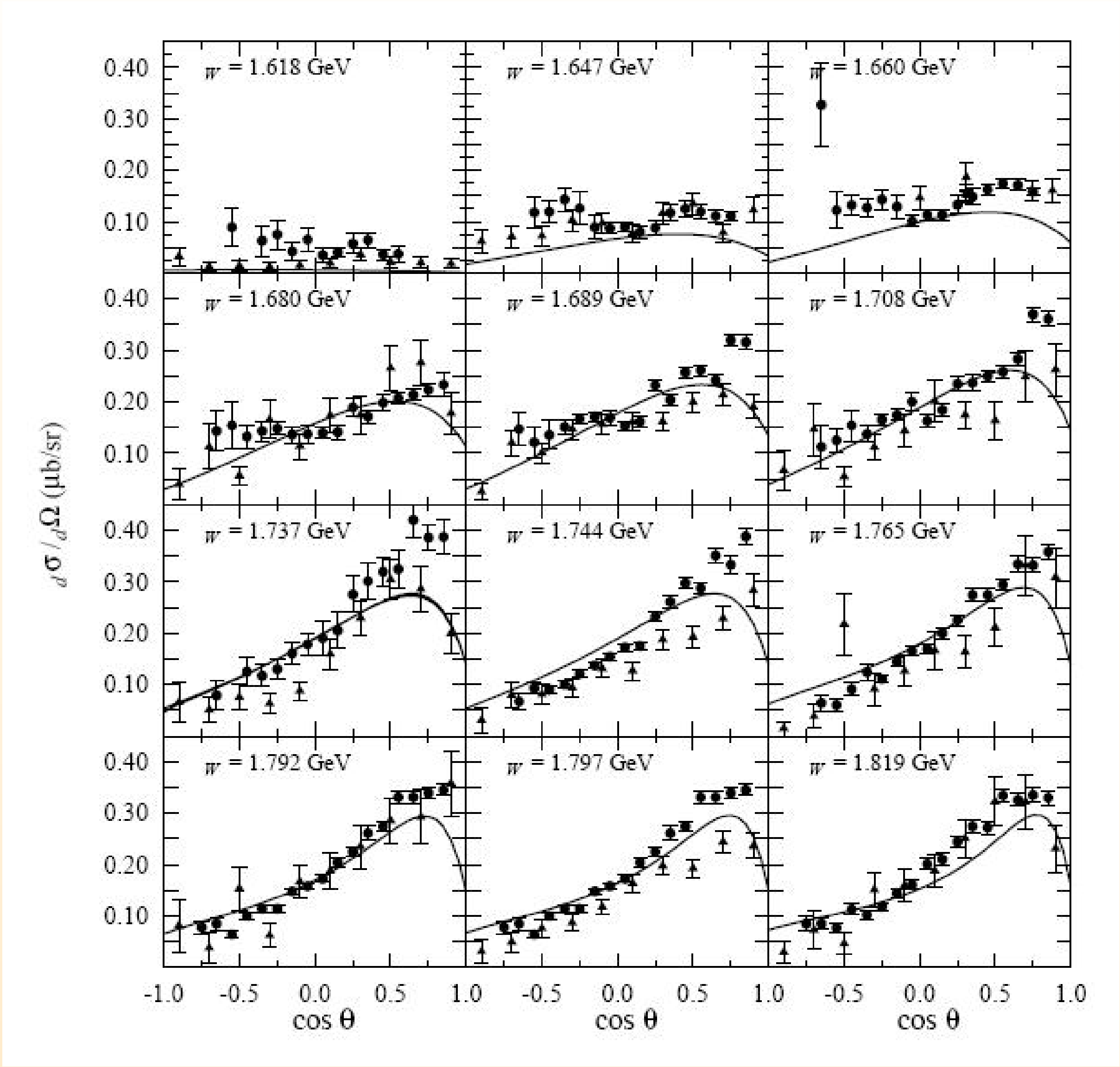

▷ Hadronic and electromagnetic productions are consistent!

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\begin{aligned}
M &= 1912 \text{ MeV} \\
\Gamma_{\text{total}} &= 598 \text{ MeV} \\
\Gamma_{\pi N} &= 51 \text{ MeV} \\
\Gamma_{\pi\pi N} &= 598 \text{ MeV} \\
\Gamma_{\eta N} &= 12 \text{ MeV} \\
\Gamma_{K\Lambda} &= 13 \text{ MeV} \\
\Gamma_{K\Sigma} &= 4 \text{ MeV}
\end{aligned}
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