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PHOTOPRODUCTION OF Θ^+ IN A REGGE MODEL

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IN COLL. WITH

→ M. GUIDAL, M. POLYAKOV

OUTLINE

⇒ REGGE ANALYSES OF HIGH-ENERGY PHOTOPRODUCTION REACTIONS

IN COLL. WITH M. GUIDAL & J.M. LAGET

- (γ, π) , $(e, e'\pi)$
- $\gamma p \to K^+\Lambda$, $K^+\Sigma^0$, $K^0\Sigma^+$ ←
  $ep \to eK^+\Lambda$, $eK^+\Sigma^0$
- (γ, η), (γ, η')
- (γ, ρ^0), (γ, ω), (γ, ϕ)

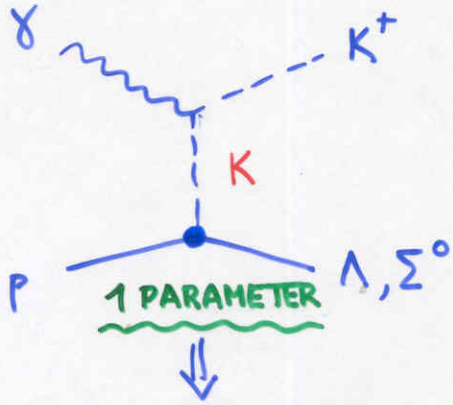
⇒ $\gamma n \to K^-\Theta^+$

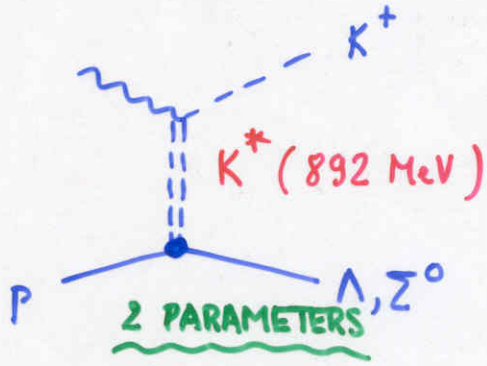
$\gamma p \to \bar{K}^0\Theta^+$

- MECHANISMS
- n/p RATIO
- OBSERVABLE SENSITIVE TO PARITY OF Θ^+

STRANGENESS PHOTOPRODUCTION

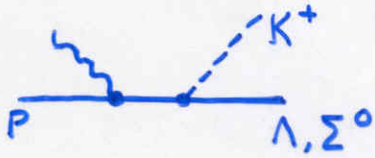
⇒





⇓

+ SAME IMPLEMENTATION OF GAUGE INV.



⇒ <u>COUPLING CONSTANTS</u>

- $g_{KN(\Lambda,\Sigma)}$ → cfr. SU(3) (20 % BROKEN)

$$9 \leq \frac{g^2_{KN\Lambda}}{4\pi} \leq 20.2 \quad (= 10.6)$$

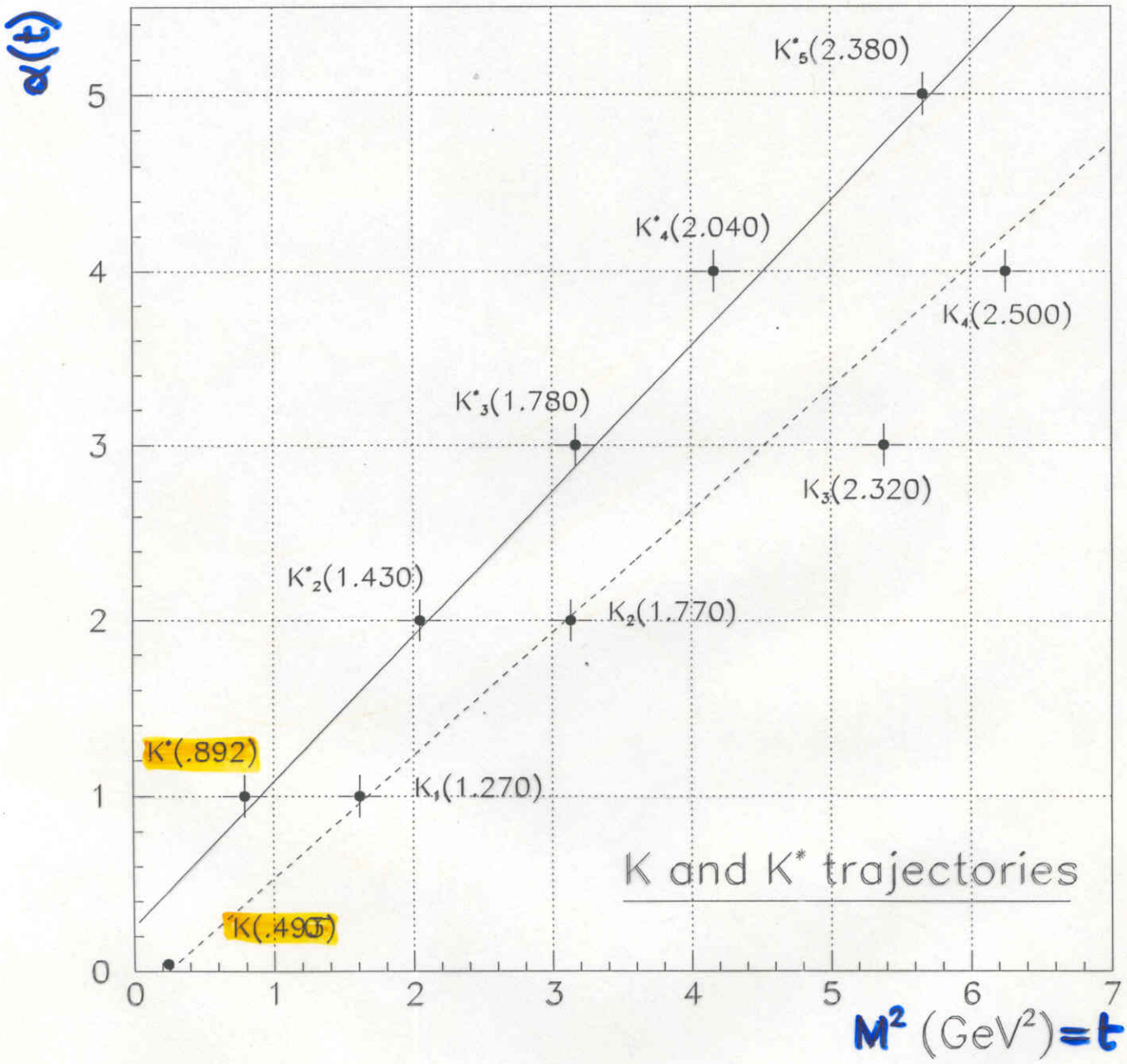
$$0.8 \leq \frac{g^2_{KN\Sigma}}{4\pi} \leq 1.7 \quad (= 1.6)$$

- K^* g_E, g_M

→ SIGN IN AGREEMENT WITH SU(6)

→ VALUE FITTED ↗ Λ
↘ Σ

K , K* REGGE TRAJECTORIES

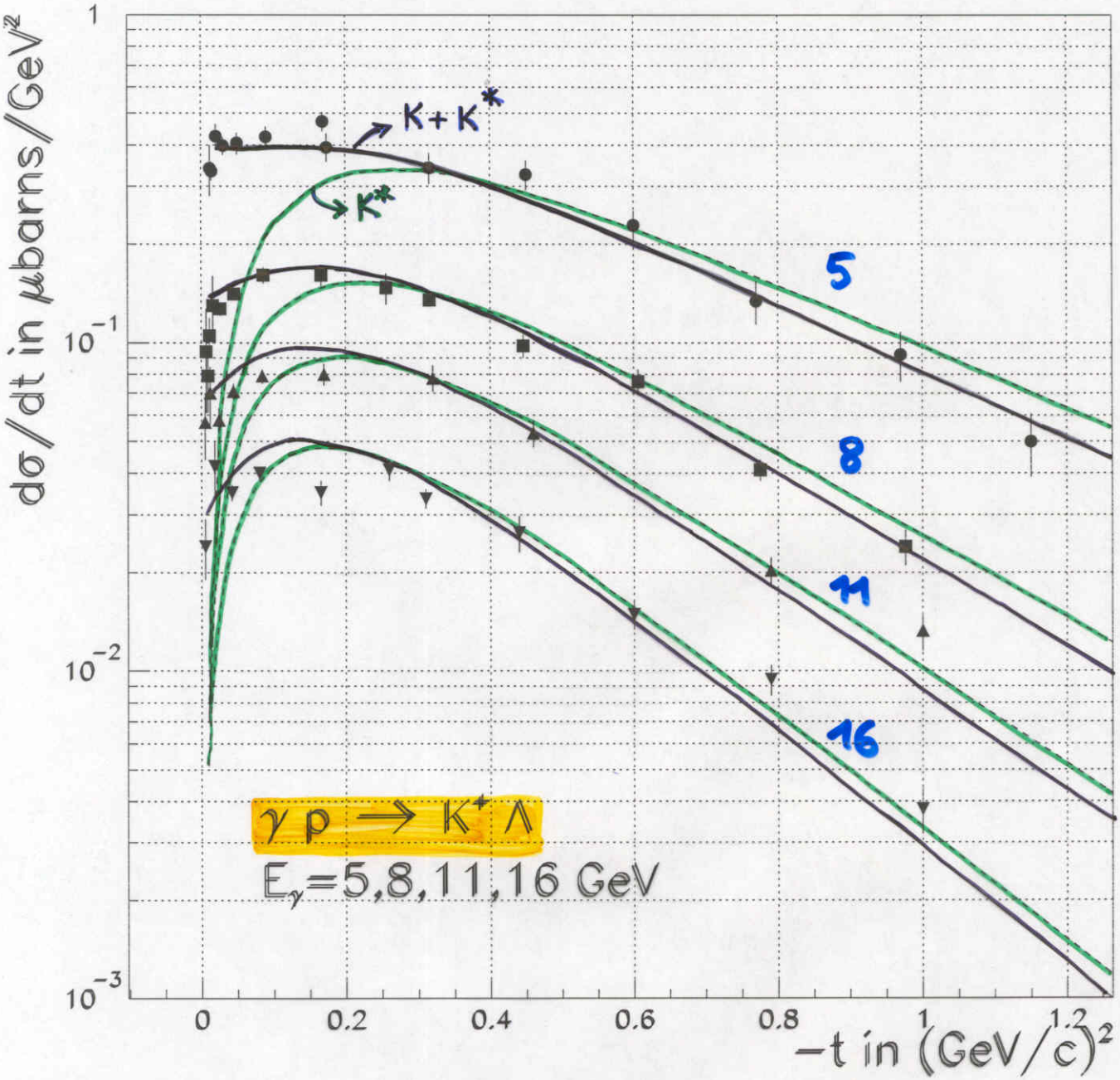


$$\mathcal{M} \sim s^{\alpha(t)}$$

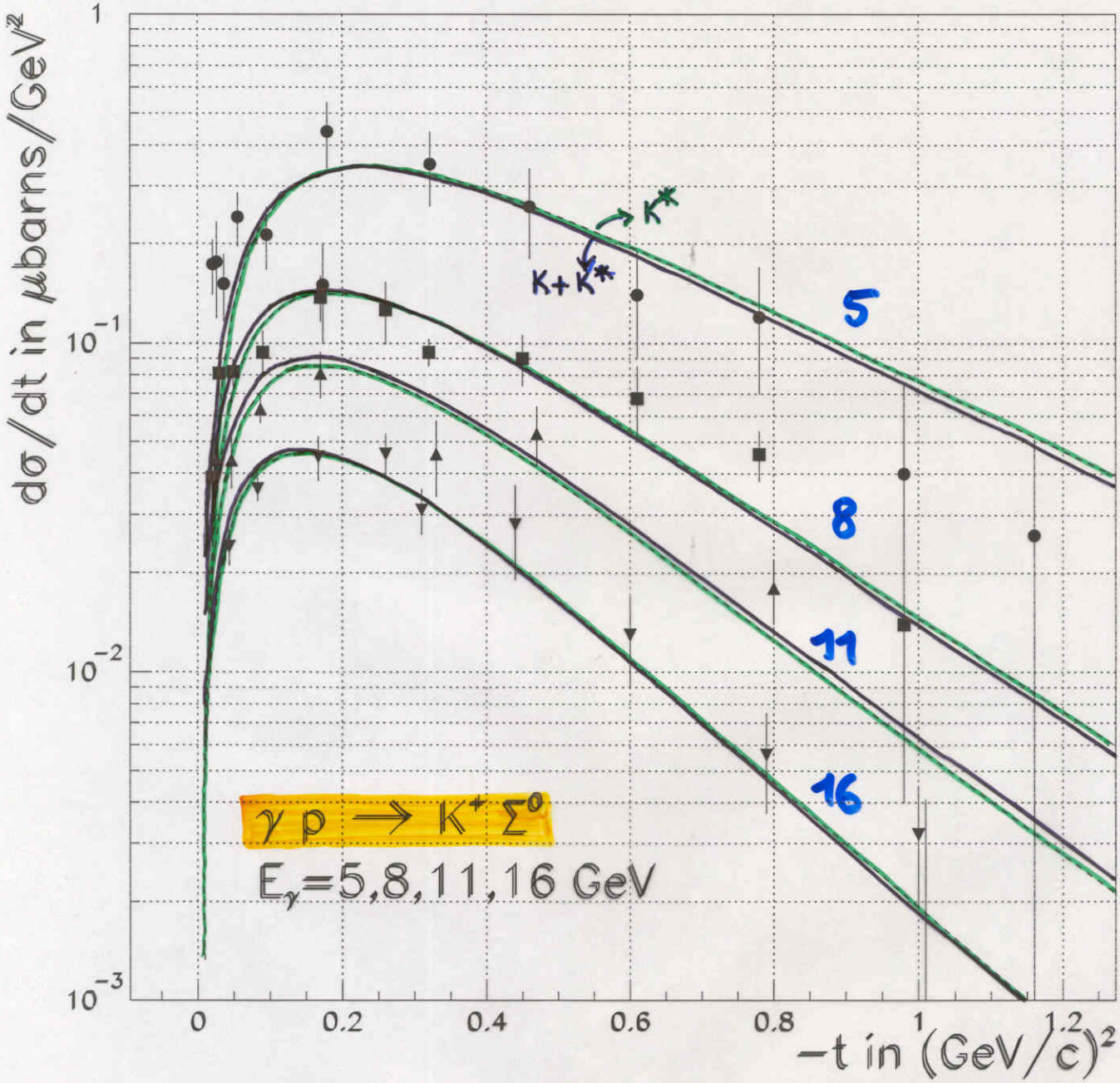
$$= s^{\alpha_0} \cdot e^{-\alpha'|t| \ln s}$$

$$\alpha(t) = \alpha_0 + \alpha' t$$

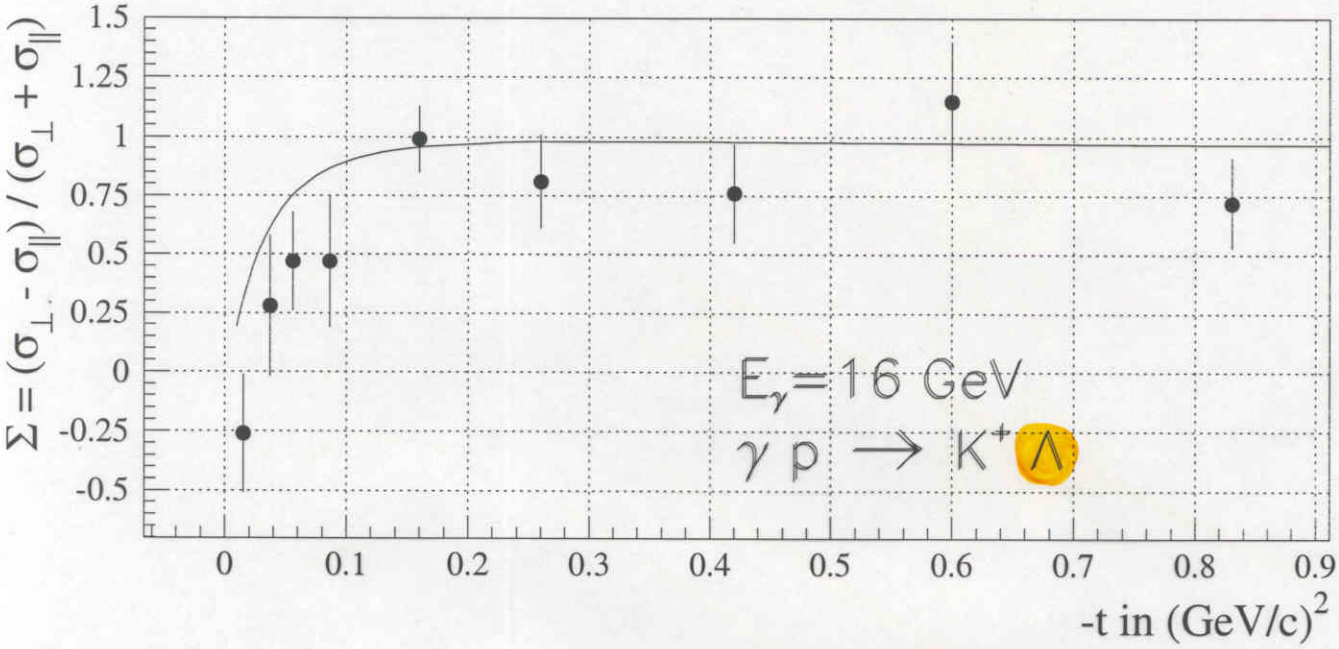
$$\alpha' \simeq 0.8 \ \mathrm{GeV}^{-2}$$

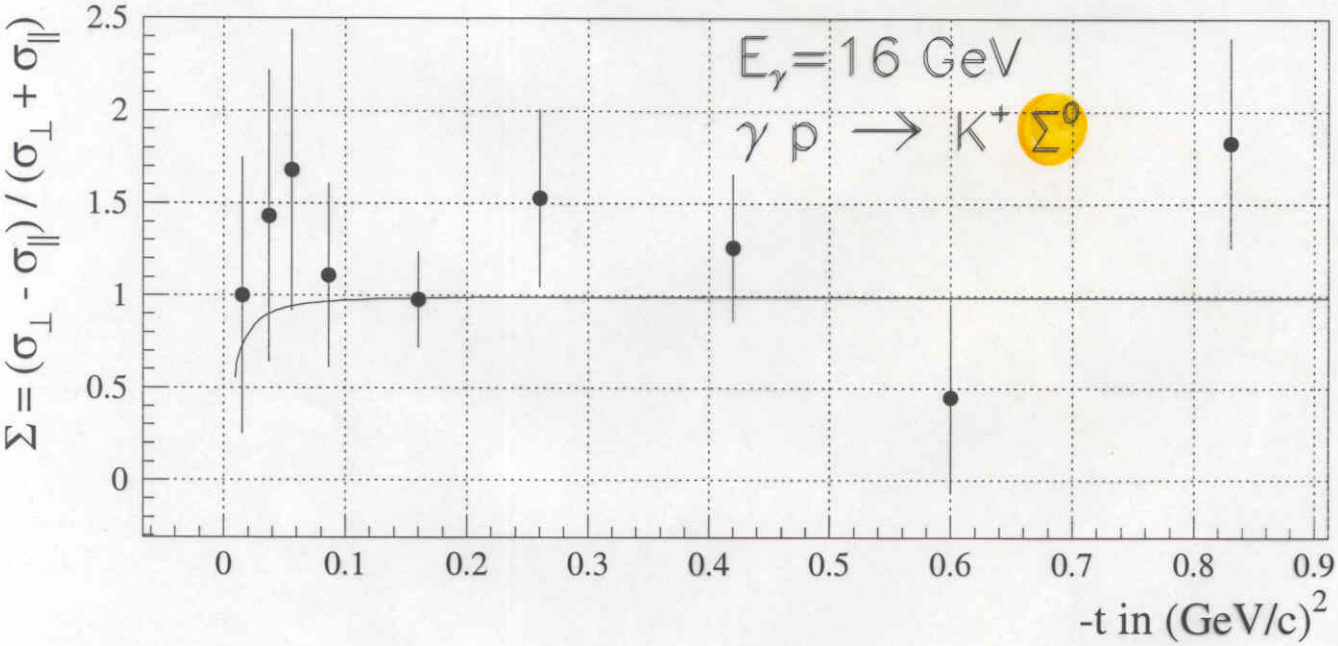


M. GUIDAL, J.M. LAGET, M. VDH, NPA 627 (1997) 645


dσ/dt in μbarns/GeV²
1
10⁻¹
10⁻²
10⁻³
0
0.2
0.4
0.6
0.8
1
1.2
−t in (GeV/c)²
K+K*
K*
5
8
11
16
γ p → K⁺ Σ⁰
E_γ=5,8,11,16 GeV

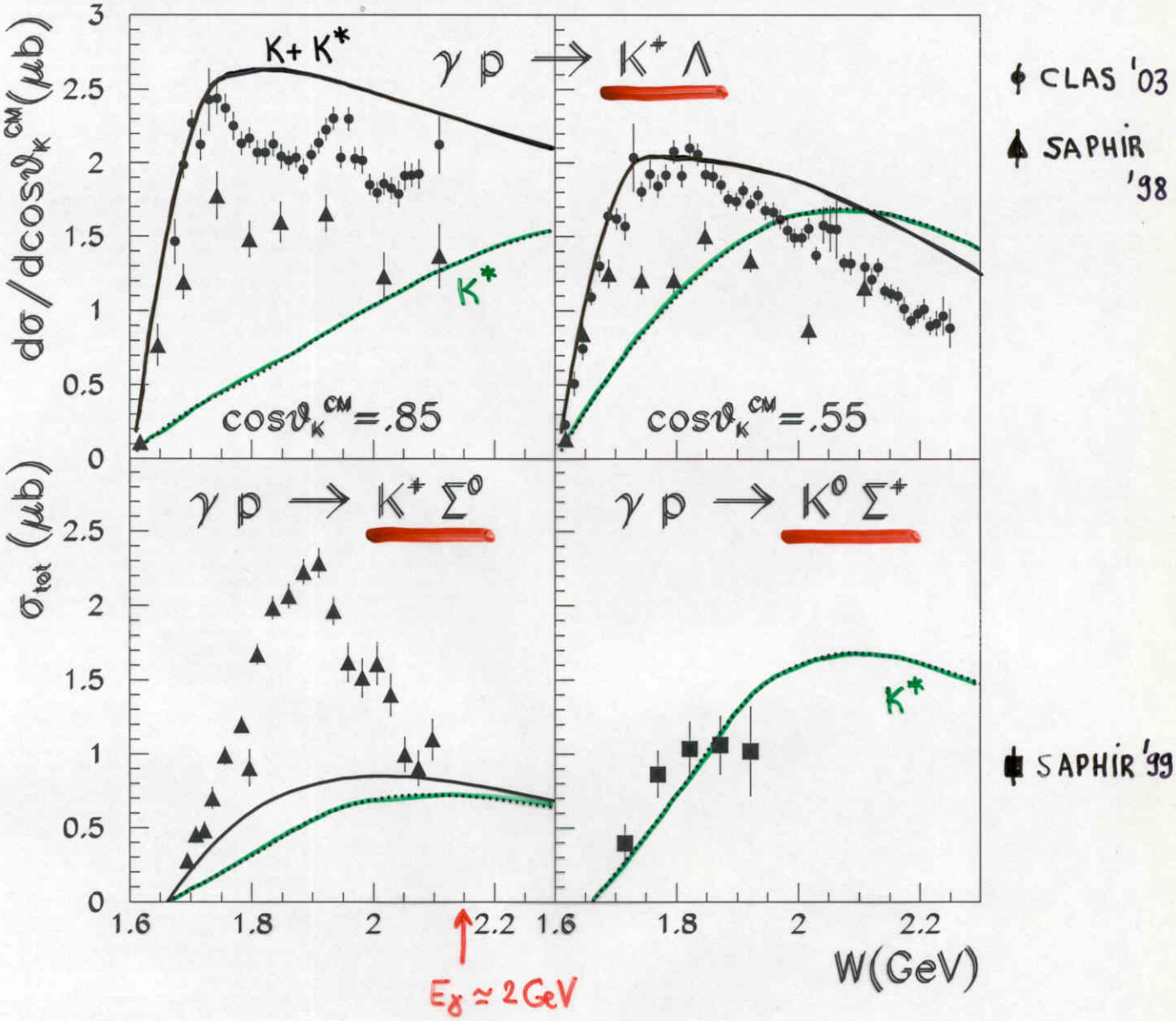
PHOTON ASYMMETRY





K DOMINANCE (UN-NATURAL PARITY EXCH) $\Rightarrow \Sigma \rightarrow -1$

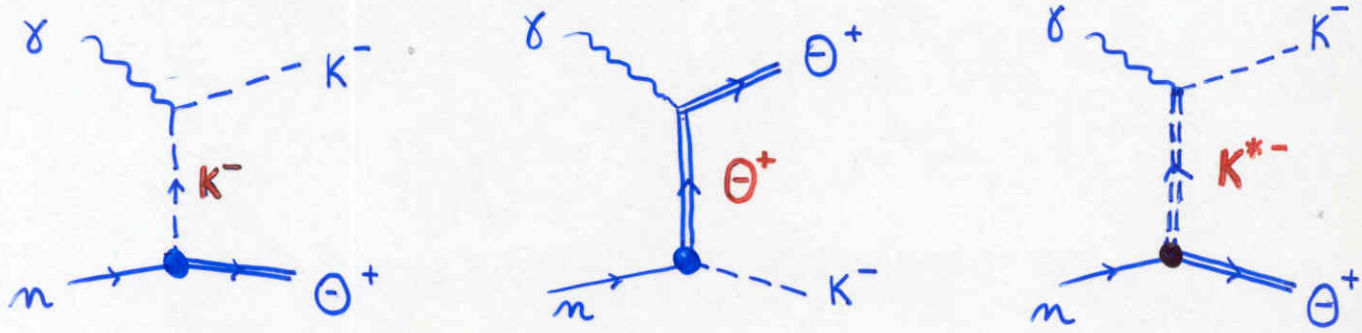
K^* DOMINANCE (NATURAL PARITY EXCH) $\Rightarrow \Sigma \rightarrow +1$



M. Guidal, J.M. Laget, M. Vdh, Phys. Rev. C (2003)
hep-ph/0308131

Θ^+ PHOTOPRODUCTION

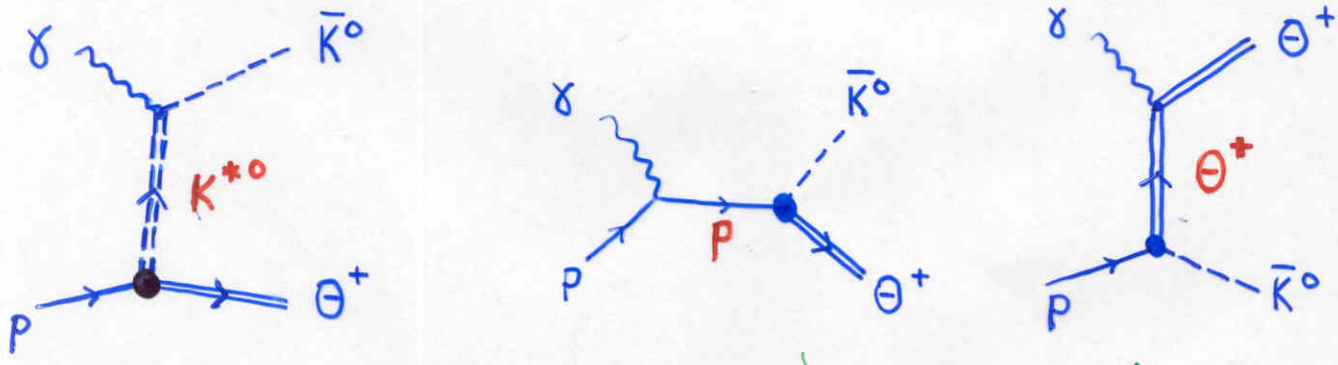
- **ON NEUTRON** : $\gamma n \to K^- \Theta^+$



SUM IS GAUGE INVARIANT

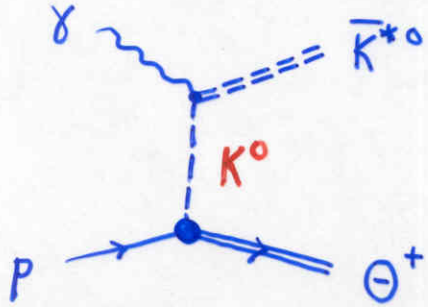
- **ON PROTON** : $\gamma p \to \bar{K}^0 \Theta^+$

NO K^0 EXCHANGE

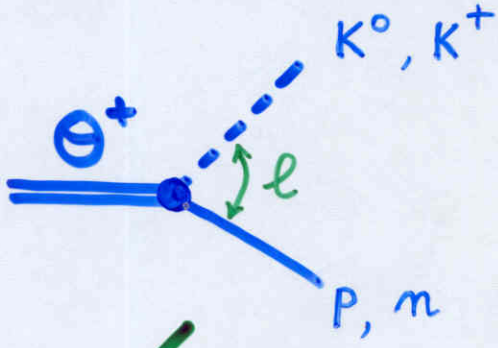


SUM IS GAUGE INVARIANT

- $\gamma p \to \bar{K}^{*0} \Theta^+$



SPIN - PARITY OF $\Theta^+(1540)$



$$\boxed{J^P = \frac{1}{2}^+}$$ $\ell = 1$ (p-WAVE)

$$\mathcal{L}_{KN\Theta} = i\, g_{KN\Theta} \left(\bar{\Theta} \gamma_5 N \bar{K} + \bar{N} \gamma_5 \Theta K \right)$$

$$\Gamma_{\Theta \to KN} = \frac{g^2_{KN\Theta}}{2\pi} \cdot \frac{|\bar{P}_K|}{M_\Theta} \left(E_N - M_N \right)$$

FOR $M_\Theta = 1.54$ GeV

$\hookrightarrow |\bar{P}_K| = 0.267$ GeV

FOR $\boxed{\Gamma_{\Theta \to KN} \simeq 0.015 \text{ GeV} \Downarrow g_{KN\Theta} \simeq 3.83}$

$$\boxed{J^P = \frac{1}{2}^-}$$ $\ell = 0$ (s WAVE)

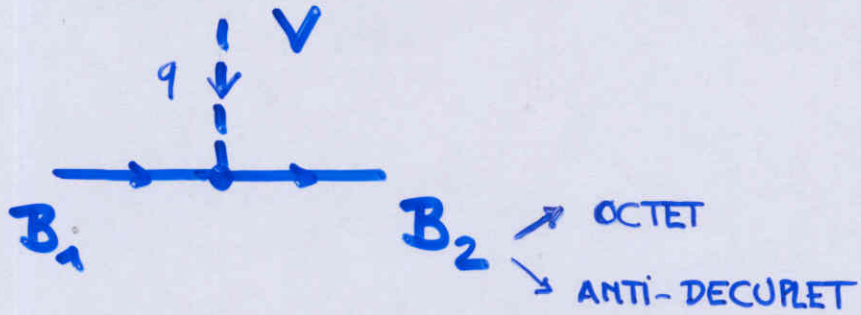
$$\mathcal{L}_{KN\Theta} = g_{KN\Theta} \left(\bar{\Theta} N \bar{K} + \bar{N} \Theta K \right)$$

$$\Gamma_{\Theta \to KN} = \frac{g^2_{KN\Theta}}{2\pi} \cdot \frac{|\bar{P}_K|}{M_\Theta} \left(E_N + M_N \right)$$

FOR $\boxed{\Gamma_{\Theta \to KN} \simeq 0.015 \text{ GeV} \Downarrow g_{KN\Theta} \simeq 0.533}$

FACTOR 7!

$K^* N \Theta^+$ COUPLING



$$\boxed{\begin{aligned}\mathcal{L}_{VB_1B_2} &= g_{VB_1B_2}\, \bar{B}_2\, \gamma_\mu\, B_1\, V^\mu \\ &+ f_{VB_1B_2}\, \bar{B}_2\, \frac{i\,\sigma_{\mu\nu}\, q^\nu}{M_1+M_2}\, B_1\, V^\mu\end{aligned}}$$

$\Downarrow$ SU(3) SYMMETRY

$$g_{\rho^0 pp} + f_{\rho^0 pp} = \frac{7}{10}\left(V_0 + \frac{1}{2}V_1\right) + \frac{1}{20}V_2$$

$$g_{\omega pp} + f_{\omega pp} = \frac{1}{10}\left(V_0 + \frac{1}{2}V_1\right) + \frac{23}{20}V_2$$

$$g_{\phi pp} + f_{\phi pp} = -\frac{1}{10}\left(V_0 + \frac{1}{2}V_1\right) + \frac{7}{20}V_2$$

$$g_{K^*\Theta^+ N} = 0$$

$$f_{K^{*0}\Theta^+ p} = \frac{3}{\sqrt{30}}\left(V_0 - V_1 - \frac{1}{2}V_2\right)$$

VALUE FROM χQSM

$$\boxed{f_{K^{*0}\Theta^+ p} = \underbrace{\left(g_{\rho^0 pp} + f_{\rho^0 pp}\right)}_{\simeq 18.7} \cdot \frac{3\sqrt{3}}{\sqrt{10}}\, \frac{\frac{4}{5} - R}{R+2}}$$

$R = \frac{V_1}{V_0} \simeq 0.35$

$f_{K^*\Theta^+ p} \simeq 5.9$

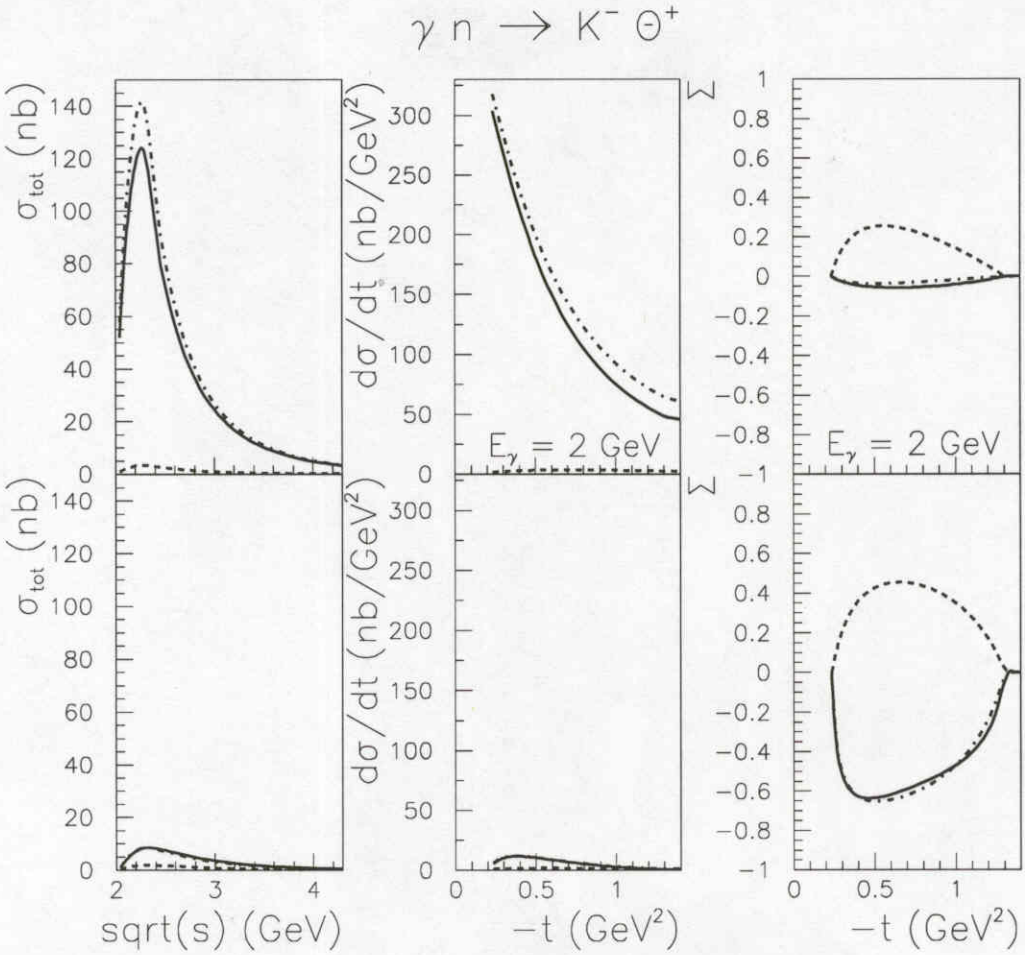


Figure 2: Regge model predictions for the $\gamma n \to K^- \Theta^+$ reaction for both possible parities of the Θ^+ resonance. Upper panels : positive parity case; lower panels : negative parity case. Left panels : total cross section; middle panels : differential cross section; right panels : photon asymmetry. Dashed-dotted curves : K Regge exchange; dashed curves : K^* Regge exchange, solid curves : $K + K^*$ exchanges.

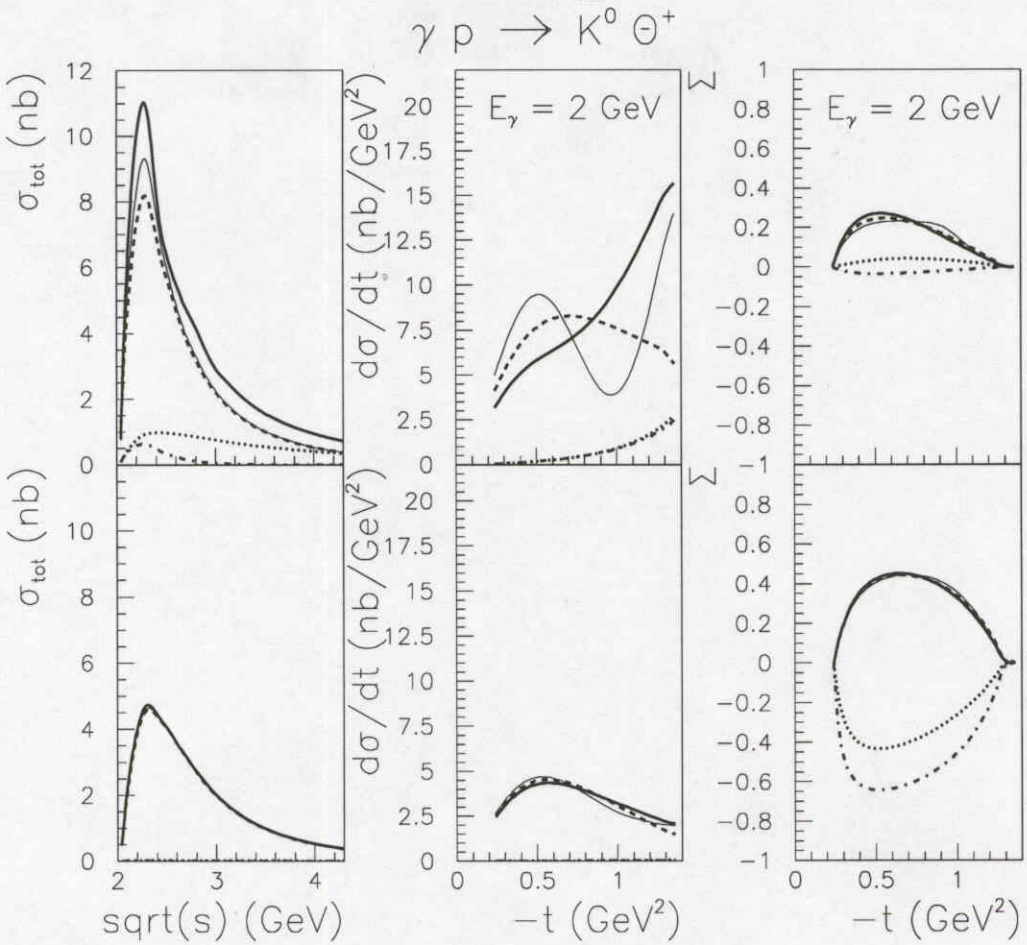


Figure 3: Regge model predictions for the $\gamma p \to \bar{K}^0\Theta^+$ reaction for both possible parities of the Θ^+ resonance. Upper panels : positive parity case; lower panels : negative parity case. Left panels : total cross section; middle panels : differential cross section; right panels : photon asymmetry. Dashed curves : K^* Regge exchange; dashed-dotted curves : gauge-invariant $s+u$ -channel exchange (with reggeized u-channel); thin solid curves : sum of $K^* + s + u$ reggeized exchanges. For comparison, the results are also shown when using pole exchanges for the $s+u$ -channel processes (with hadronic form factor $\Lambda = 0.7$ GeV and including a contact term to make them gauge invariant) : $s+u$ pole exchanges (dotted curves); sum of reggeized K^* exchange and s + u pole exchanges (thick solid curves).

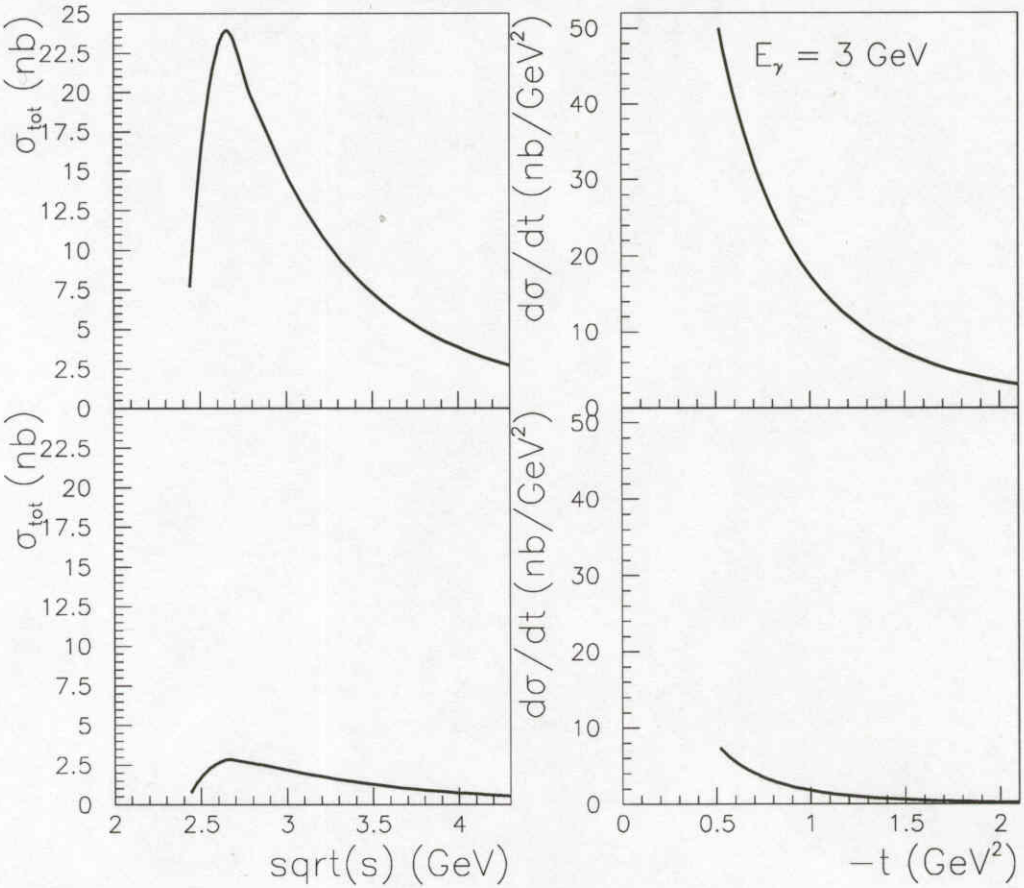


Figure 4: Regge model predictions for the $\gamma p \to \bar{K}^{*0}\Theta^+$ reaction for both possible parities of the Θ^+ resonance. Upper panels : positive parity case; lower panels : negative parity case. The solid curves correspond with K^0 Regge exchange.