

El Sabor de la Física

Taller en celebración del 60 aniversario Gabriel López Castro
7 Abril 2022

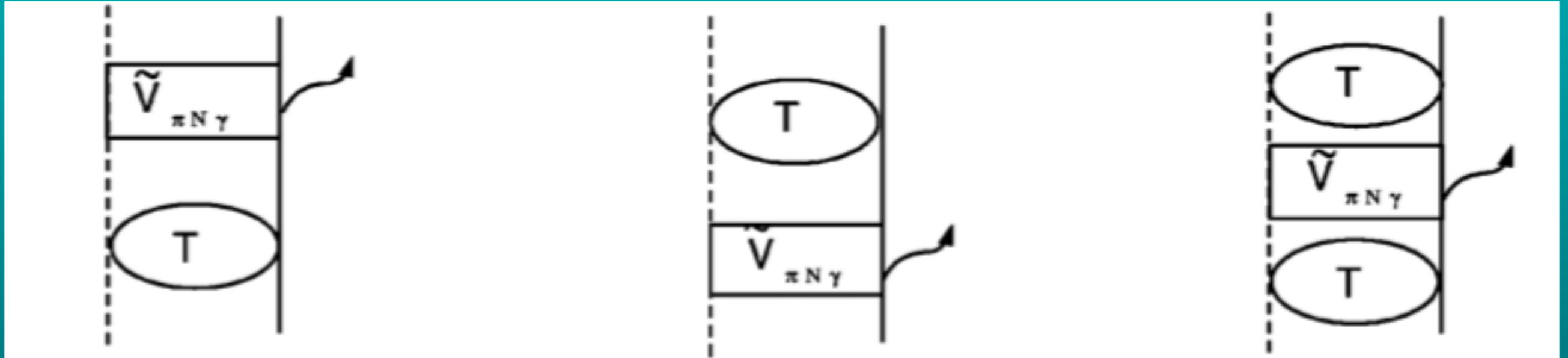
Alejandro E. Mariano
UNLP-IFLP
Argentina

Recapitulando nuestro trabajo



I MODELO DINÁMICO PARA BREMSSTRAHLUNG PIÓN-NUCLEÓN

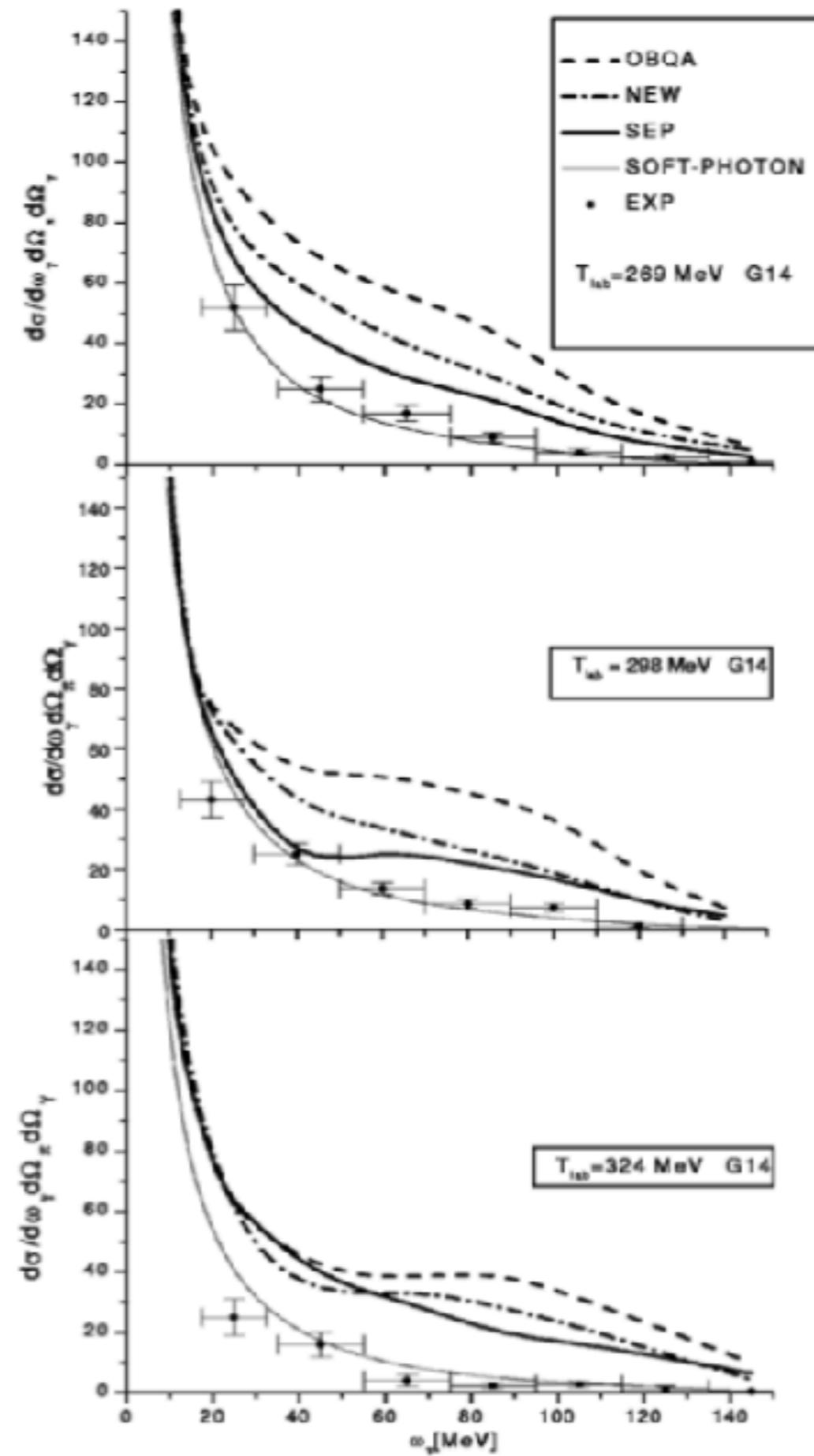
A. Mariano and G. López Cas- tro, Phys. Rev. **C62**, 014604(2000).



Cuando el potencial pión - nucleón es entre partículas sobre la capa de masas podemos ajustar las constantes indeterminadas comparando con los corrimientos de fase experimentales, por lo cual podemos plantear diferentes modelos de interacción que describir bien la dispersión sobre la capa de masas. Si embargo podemos tener diferentes comportamientos fuera de la capa de masas.

$$\hat{T}(\vec{q}', \vec{q}, z) = \hat{U}(\vec{q}', \vec{q}) + \int d^3 \vec{q}'' \hat{U}(\vec{q}', \vec{q}'') \hat{G}_{TH}(z, \vec{q}'') \hat{T}(\vec{q}'', \vec{q}, z)$$

Ecuación Bethe Salpeter

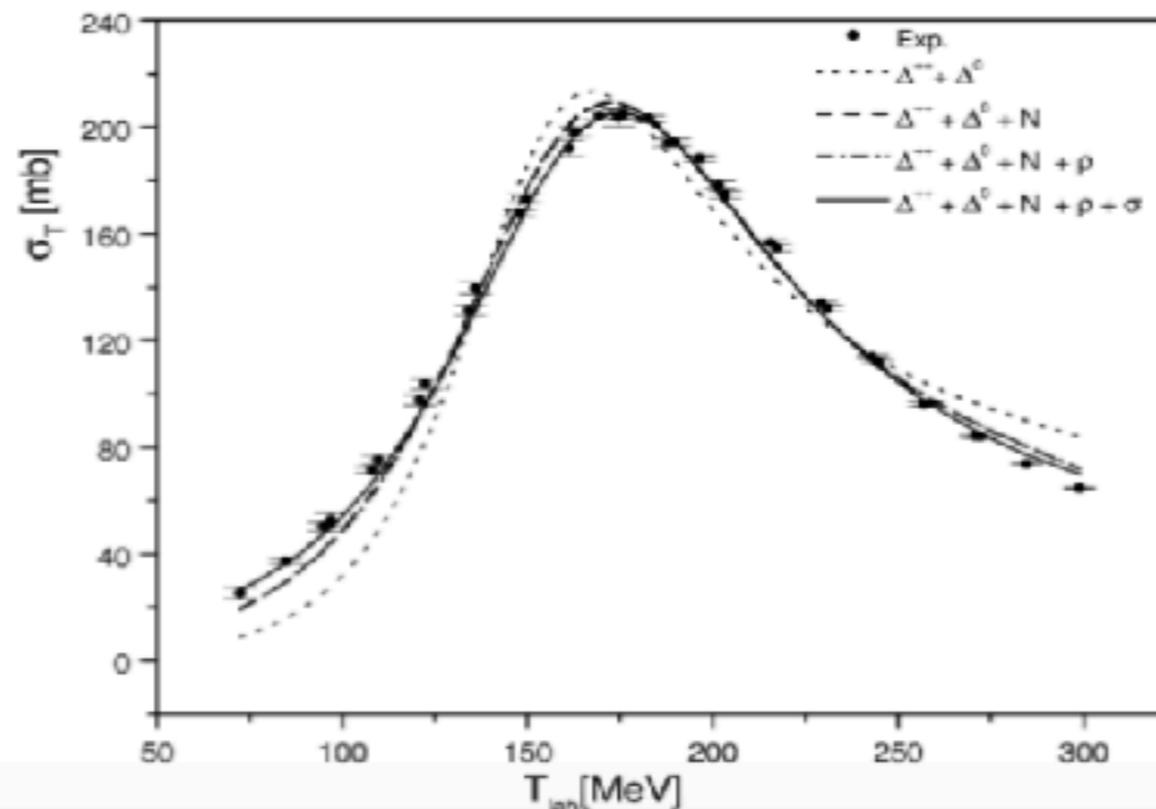


II Dispersión π^+p elástica y radiativa y las propiedades de la resonancia $\Delta(1232)$

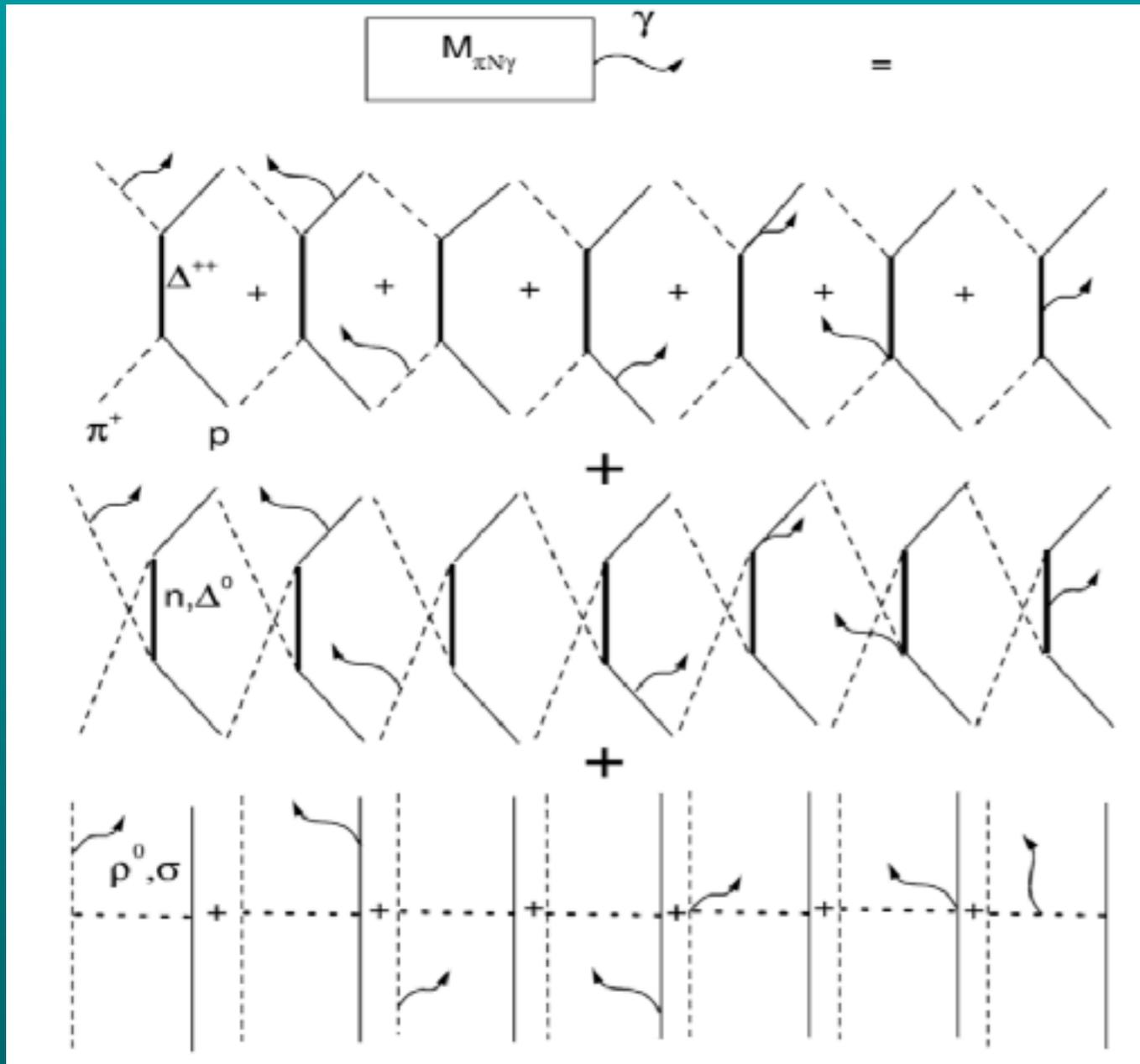
G. López Castro and A. Mariano, Phys. Lett. **B517**, 339 (2001). Nuc. Phys. **A697**, 440 (2001)

Primero ajustamos $m_\Delta, \Gamma_\Delta, \frac{f_{\pi N \Delta}}{m_\pi}$

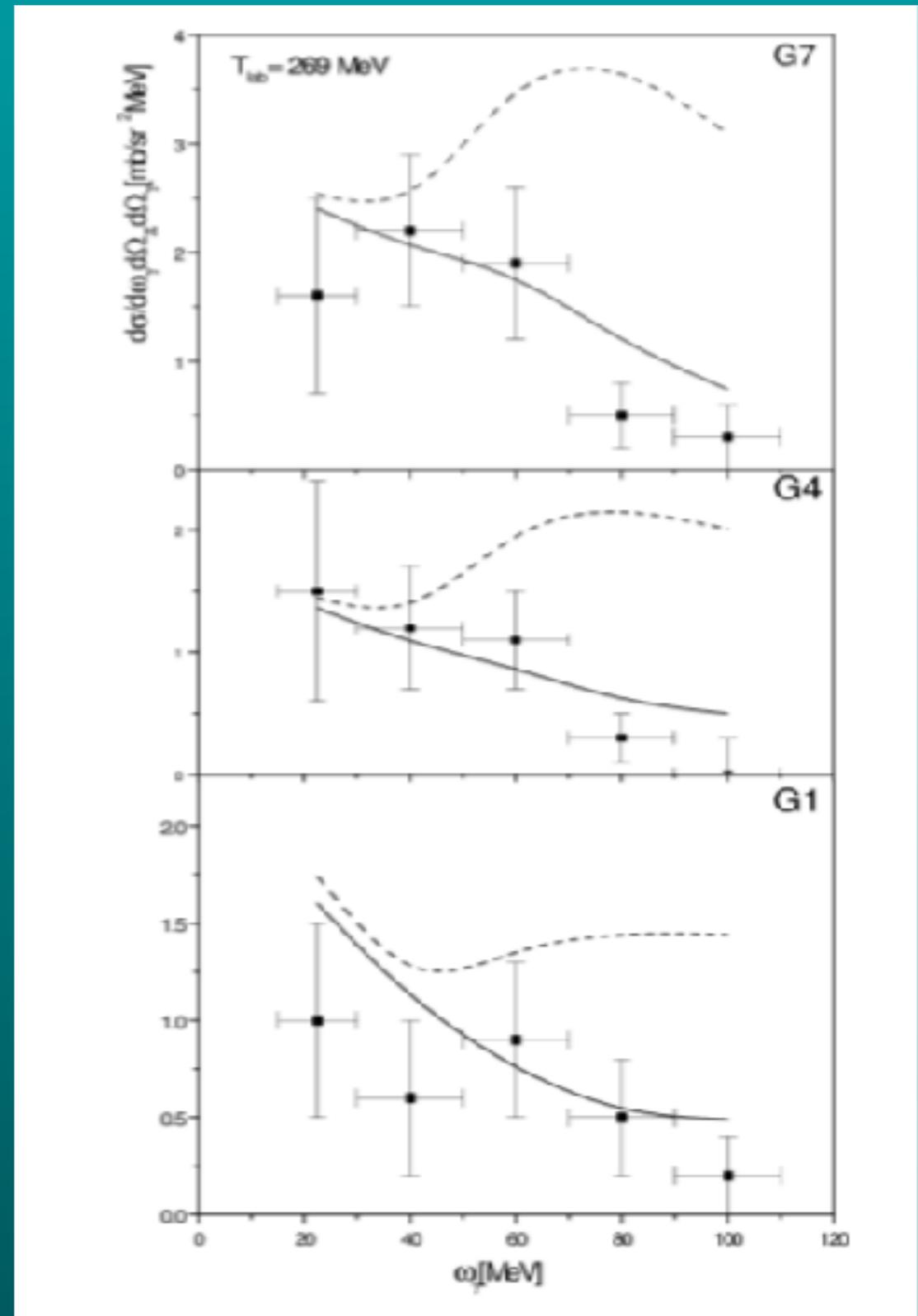
Interm. state	$f_{\Delta N \pi}^2/4\pi$	m_Δ (MeV)	Γ_Δ (MeV)	$g_\sigma/4\pi$	χ^2/dof
$\Delta^{++}, 0$	0.281 ± 0.001	1201.7 ± 0.2	69.8 ± 0.2	—	121.1
$\Delta^{++}, 0, N$	0.331 ± 0.003	1208.6 ± 0.2	87.5 ± 0.3	—	17.6
$\Delta^{++}, 0, N, \rho$	0.327 ± 0.001	1207.4 ± 0.2	85.6 ± 0.3	—	15.6
$\Delta^{++}, 0, N, \rho, \sigma$	0.317 ± 0.003	1211.2 ± 0.4	88.2 ± 0.4	1.50 ± 0.12	10.5



Luego ajustamos $\mu_{\Delta^{++}}$ para describir la radiativa



$$\mu_{\Delta} = (6.14 \pm 0.51) \frac{e}{2m_p}$$



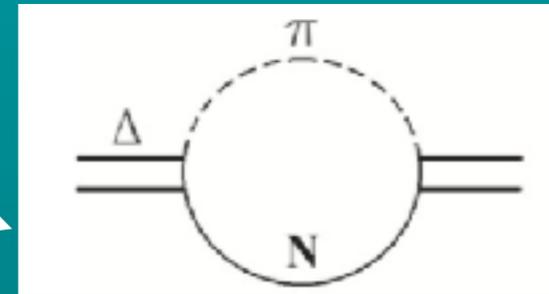
' $\Delta^{++}(1232)$ Magnetic Moment', G. López Castro and A. Mariano, P. Rev.D66, 010001(2002) (Particle Data Group).

III Propagador vestido resonancias spin 3/2

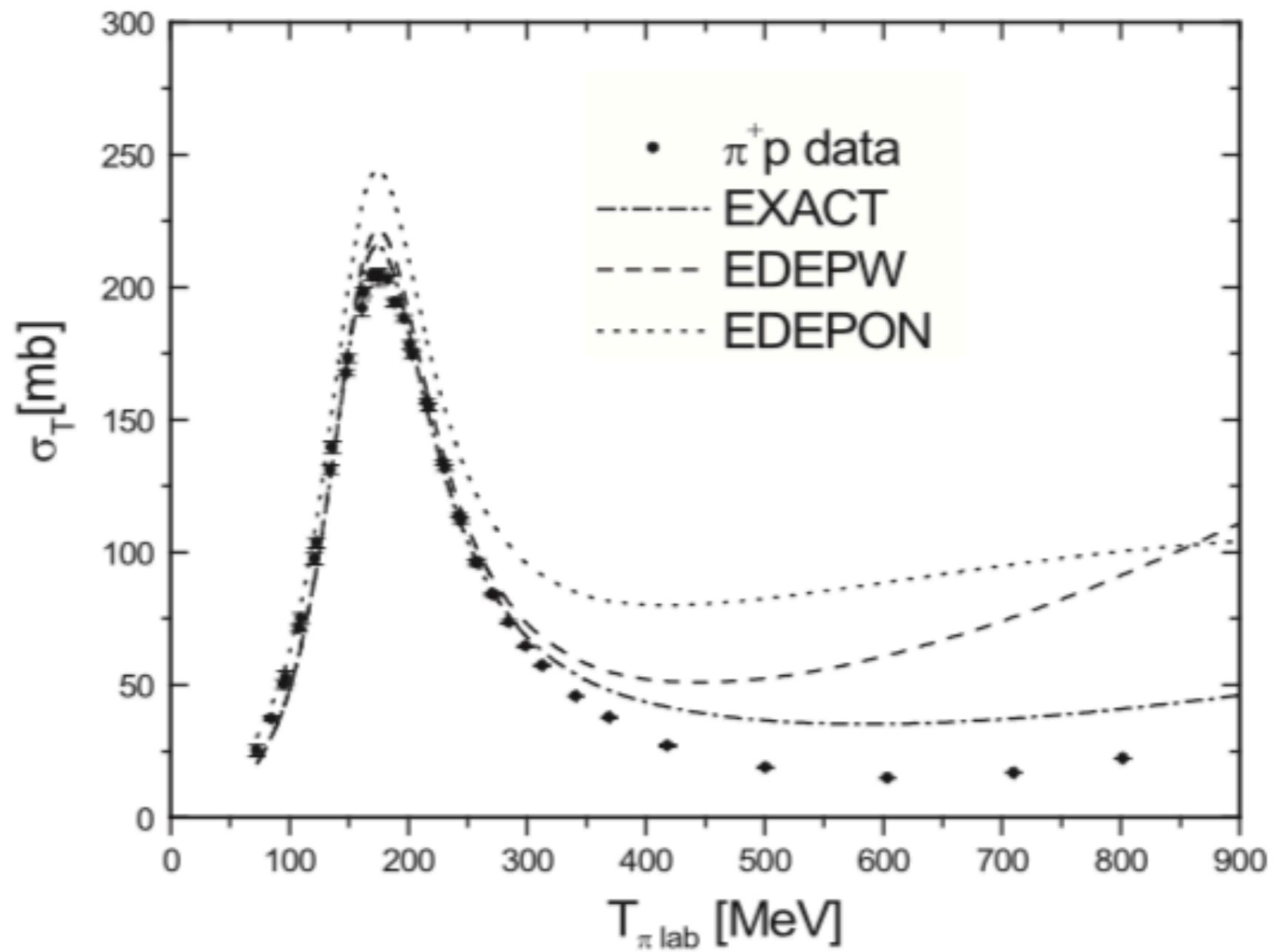
C Barbero, A Mariano and G López Castro, J. Phys. G: Nucl. Part. Phys. **39** (2012), 085011.

$$iG_0^{\mu\nu}(p) = \frac{m + \not{p}}{m^2 - p^2} (\mathcal{P}^{3/2})^{\mu\nu} - \frac{2}{m^2} (m + \not{p}) (\mathcal{P}_{11}^{1/2})^{\mu\nu} + \frac{\sqrt{3}}{m\sqrt{p^2}} \not{p} [(\mathcal{P}_{21}^{1/2})^{\mu\nu} - (\mathcal{P}_{12}^{1/2})^{\mu\nu}]$$

$$G^{\mu\nu}(p) = G_0^{\mu\nu}(p) - G_0^{\mu\nu'}(p) \Sigma_{\nu'\mu'}(p) G^{\mu'\nu}(p)$$



$$\begin{aligned}
 G^{\mu\nu}(p) = & \frac{\bar{m} + \not{p}}{\bar{m}^2 - p^2} (\mathcal{P}^{3/2})^{\mu\nu} \\
 & + \frac{1}{2} \left[\frac{2\bar{m} - 2\sqrt{p^2} + A_+}{-\bar{m}^2 + X_+} + \frac{2\bar{m} + 2\sqrt{p^2} + A_-}{-\bar{m}^2 + X_-} \right] (\mathcal{P}_{11}^{1/2})^{\mu\nu} \\
 & + \frac{1}{2\sqrt{p^2}} \left[-\frac{2\bar{m} - 2\sqrt{p^2} + A_+}{-\bar{m}^2 + X_+} + \frac{2\bar{m} + 2\sqrt{p^2} + A_-}{-\bar{m}^2 + X_-} \right] \not{p} (\mathcal{P}_{11}^{1/2})^{\mu\nu} \\
 & + \frac{1}{2} \left[\frac{3\frac{J_3 - \sqrt{p^2} J_4}{1 - J_2}}{-\bar{m}^2 + X_+} + \frac{3\frac{J_3 + \sqrt{p^2} J_4}{1 - J_2}}{-\bar{m}^2 + X_-} \right] (\mathcal{P}_{22}^{1/2})^{\mu\nu} \\
 & + \frac{1}{2\sqrt{p^2}} \left[\frac{3\frac{J_3 - \sqrt{p^2} J_4}{1 - J_2}}{-\bar{m}^2 + X_+} - \frac{3\frac{J_3 + \sqrt{p^2} J_4}{1 - J_2}}{-\bar{m}^2 + X_-} \right] \not{p} (\mathcal{P}_{22}^{1/2})^{\mu\nu} \\
 & + \frac{\sqrt{3}}{2} \left[\frac{\bar{m} - \left(\frac{J_1 + \sqrt{3} J_2}{1 - J_2} \right)}{-\bar{m}^2 + X_+} - \frac{\bar{m} - \left(\frac{J_1 - \sqrt{3} J_2}{1 - J_2} \right)}{-\bar{m}^2 + X_-} \right] [(\mathcal{P}_{21}^{1/2})^{\mu\nu} + (\mathcal{P}_{12}^{1/2})^{\mu\nu}] \\
 & - \frac{\sqrt{3}}{2\sqrt{p^2}} \left[\frac{\bar{m} - \left(\frac{J_1 + \sqrt{3} J_2}{1 - J_2} \right)}{-\bar{m}^2 + X_+} + \frac{\bar{m} - \left(\frac{J_1 - \sqrt{3} J_2}{1 - J_2} \right)}{-\bar{m}^2 + X_-} \right] \\
 & \times \not{p} [(\mathcal{P}_{21}^{1/2})^{\mu\nu} - (\mathcal{P}_{12}^{1/2})^{\mu\nu}],
 \end{aligned}$$

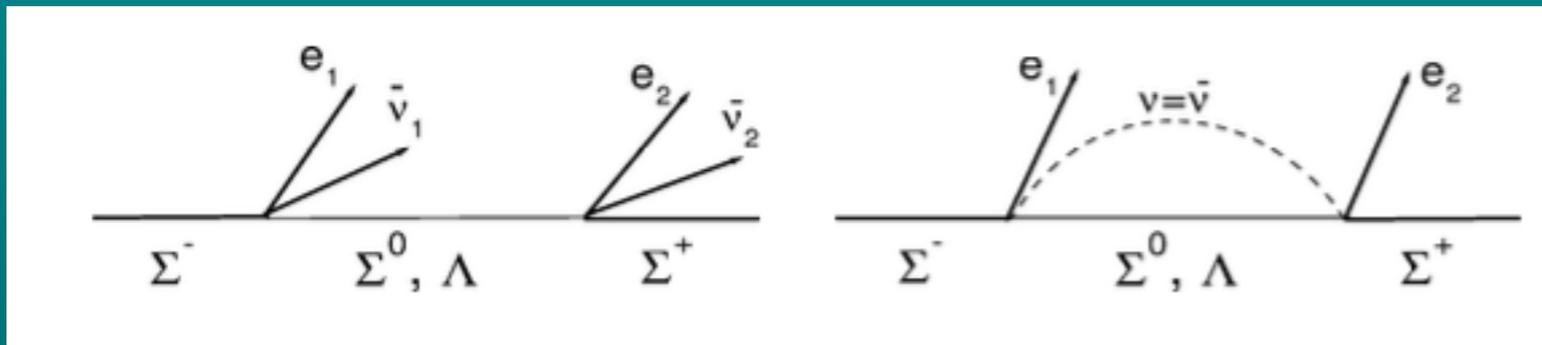


IV Decaimiento beta doble con hiperones Σ

C. Barbero, G. López Castro, A. Mariano, Physics, Letters **B566**, 98 (2003).

C. Barbero, Ling-Fong Li, G. López Castro, A. Mariano, Phys. Rev. **D76**, 116008 (2007).

C. Barbero, Ling-Fong Li, G. López Castro and A. Mariano, Phys. Rev. **D 87**, 036010 (2013).



$$B(\beta\beta_{\Sigma_{2\nu}}) = 1.38 \times 10^{-30}$$

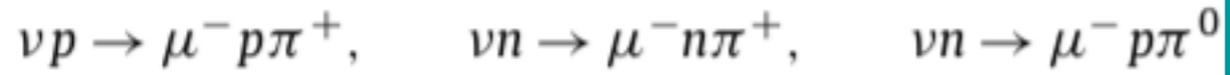
$$B(\beta\beta_{\Sigma_{0\nu}}) = 1.49 \times 10^{-35}$$

V Dispersión de neutrinos con producción de piones

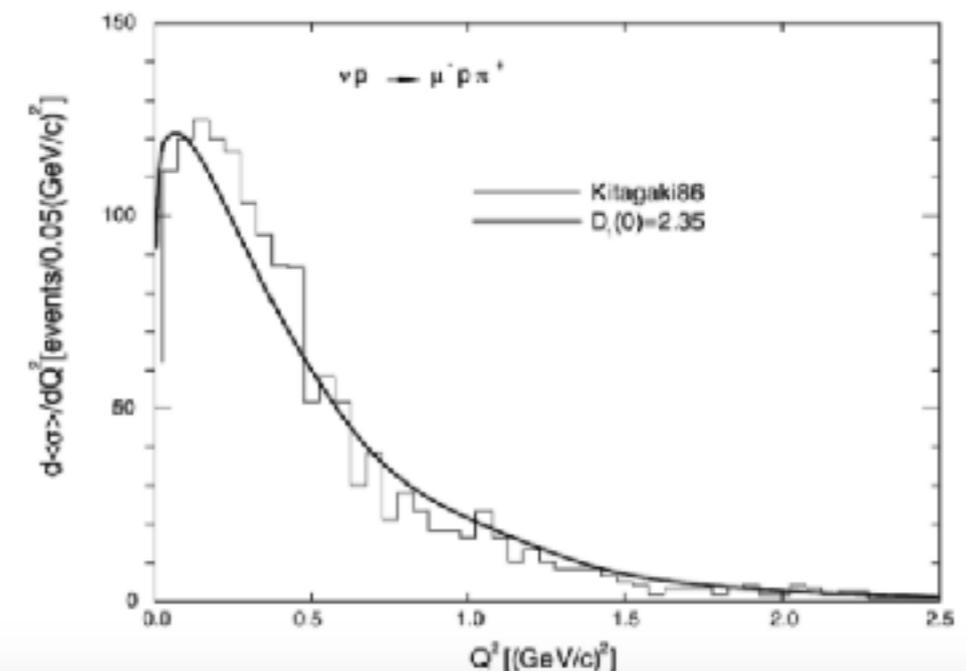
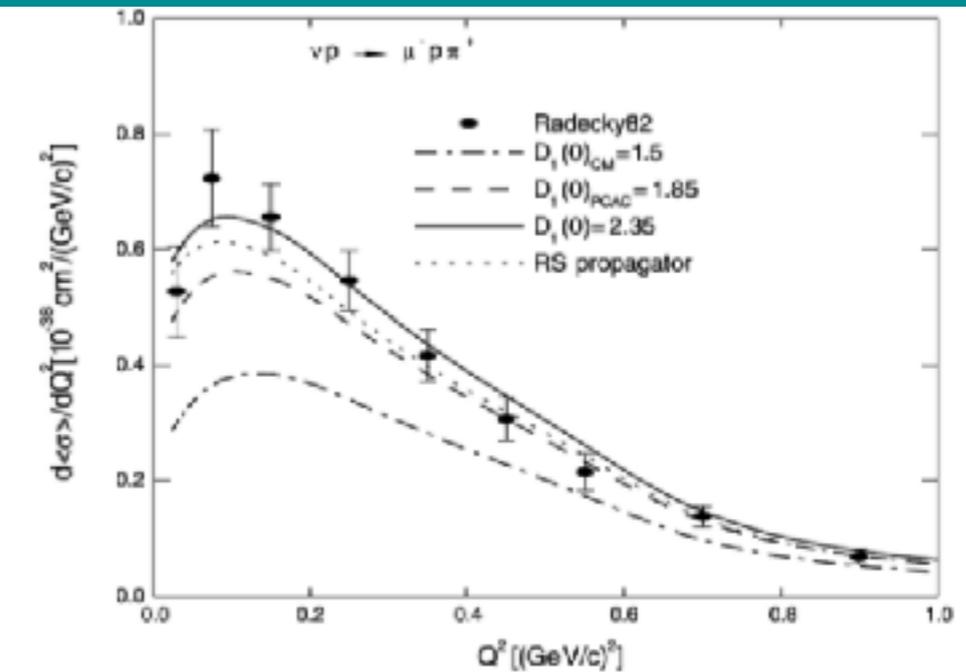
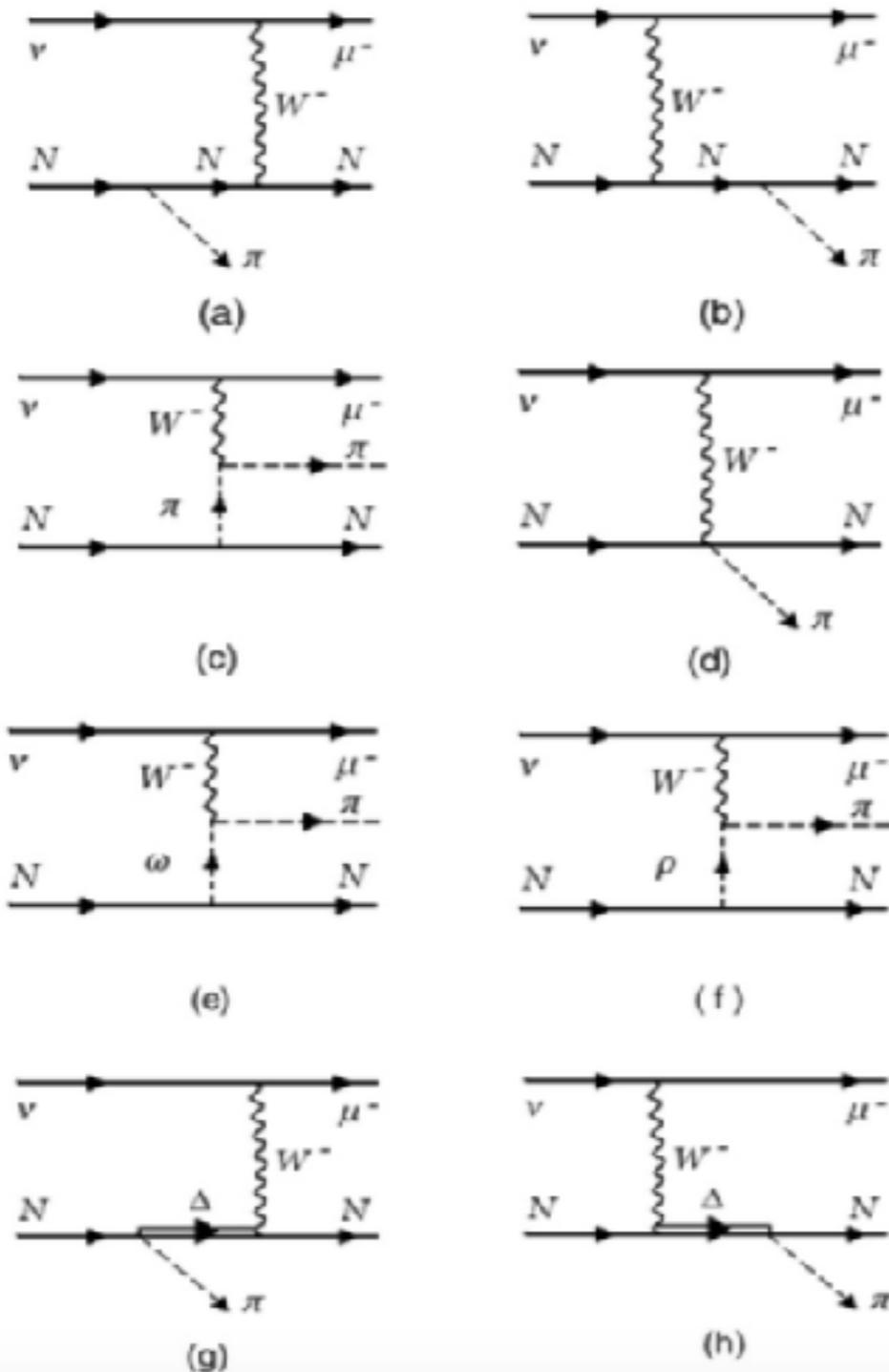
C. Barbero, G. López Castro, A. Mariano, Phys. Lett. **B664**, (2008)

A. Mariano, C. Barbero, G. López Castro, Nuc. Phys **A 849** (2011) 218–244.

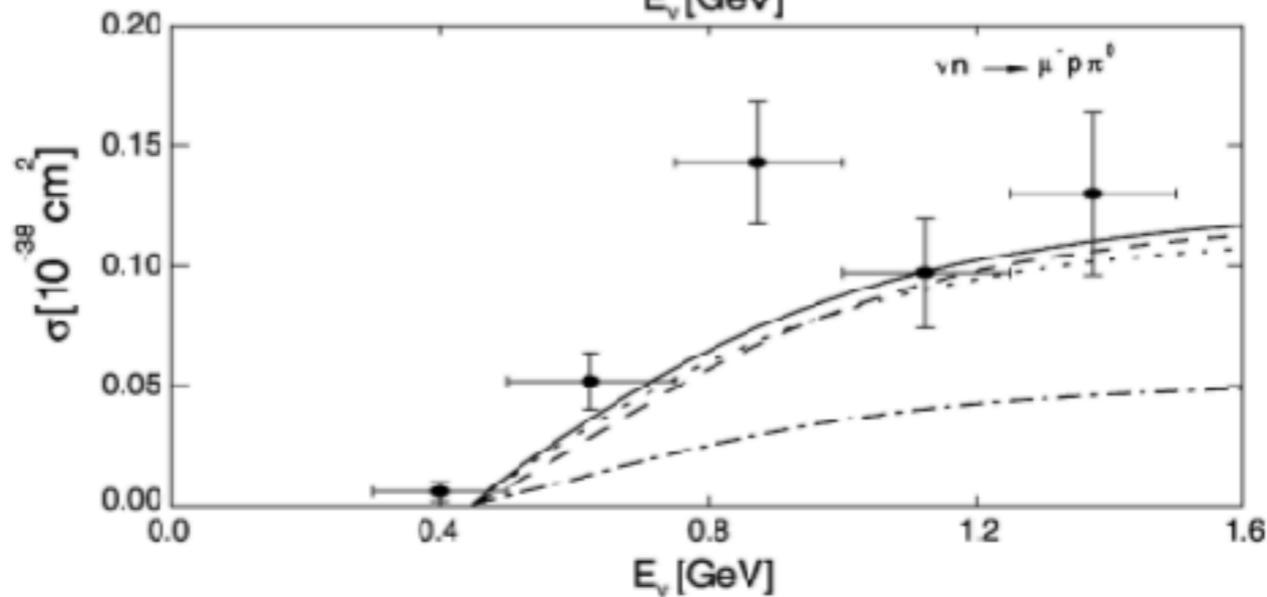
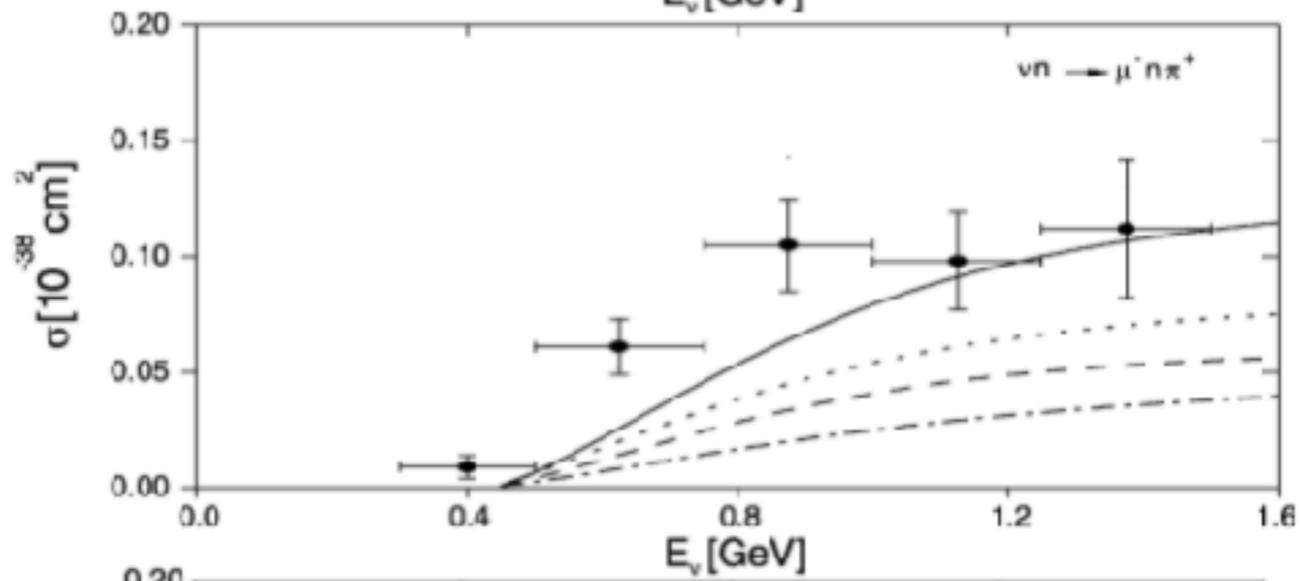
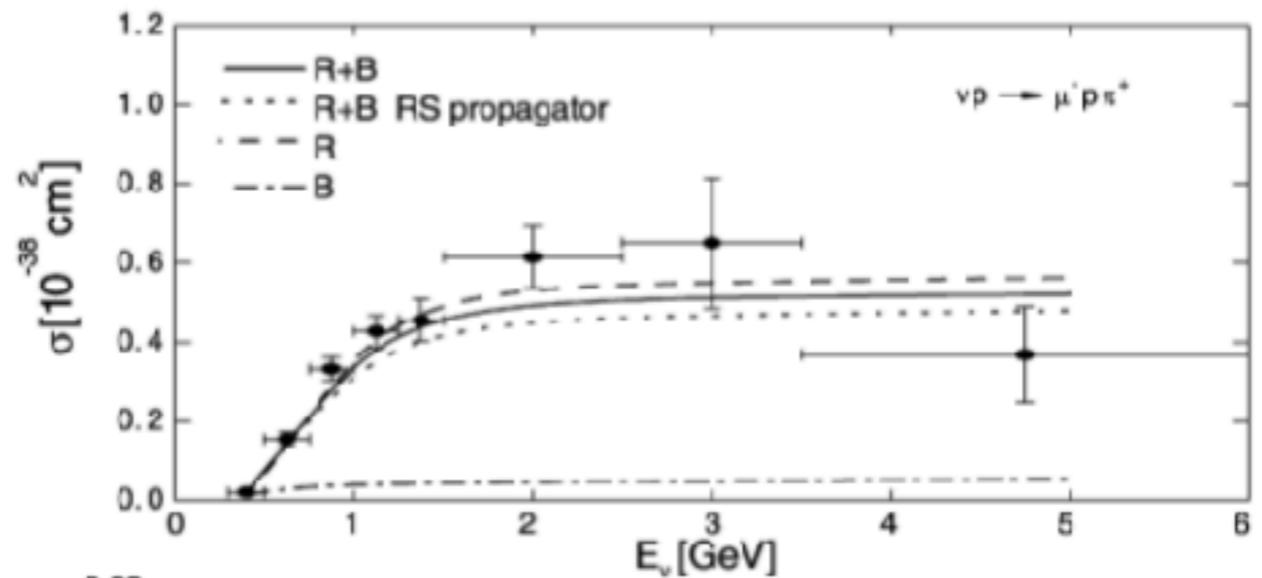
CC



Ajuste FF axiales

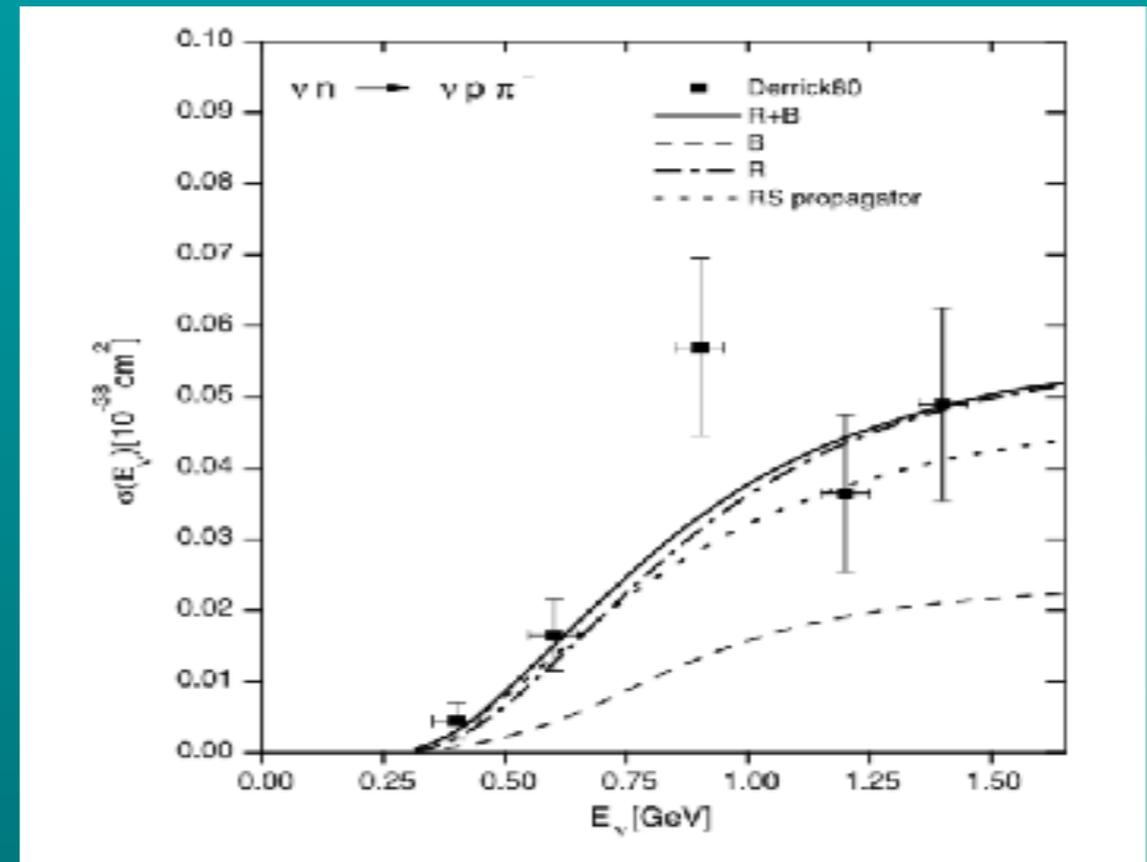
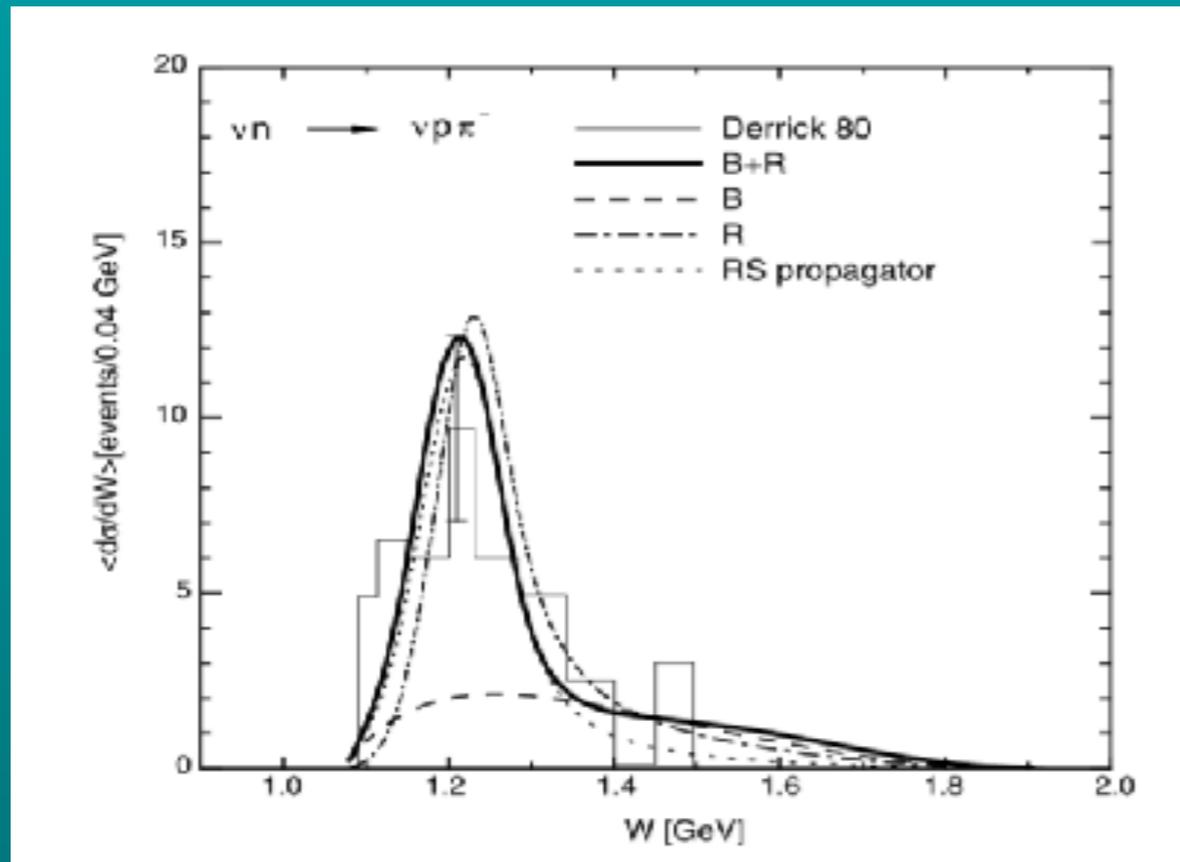


Reproducir secciones eficaces totales

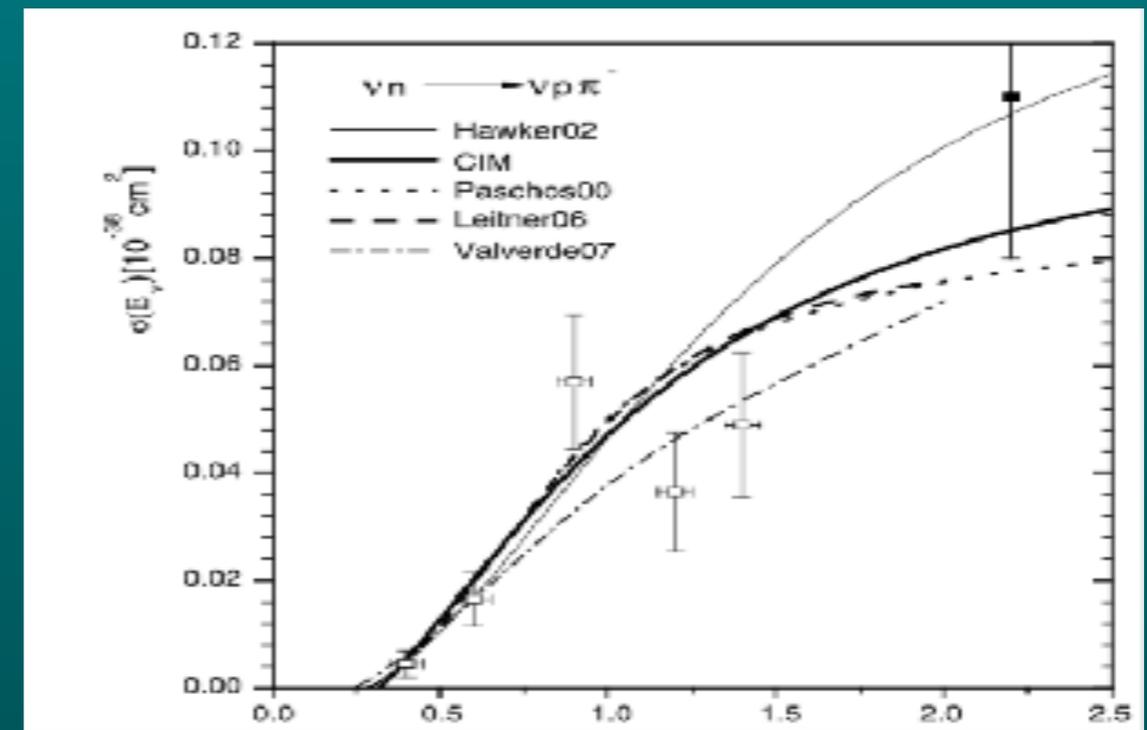
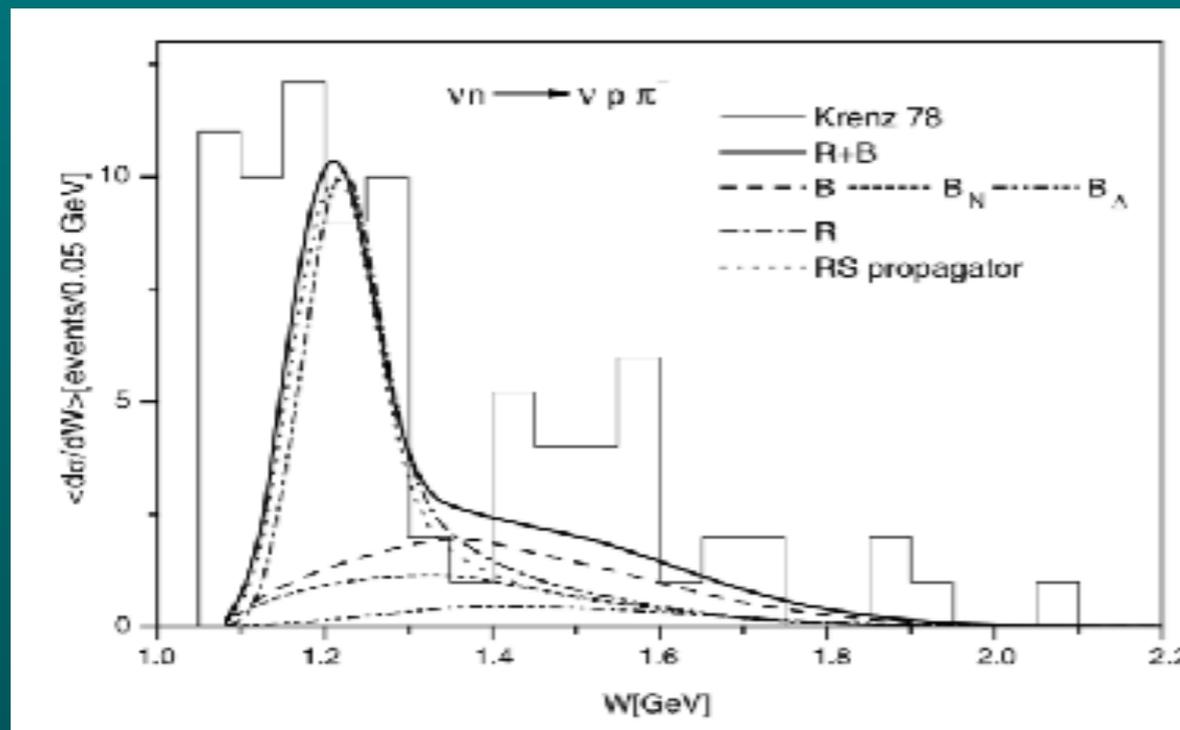


CN $W \rightarrow Z_0$

$W_{\pi N} < 1.5 \text{ GeV}$



Sin cortes



Trabajo actual (mucho inspirado en el trabajo con Gabriel)



VI Aspectos formales de la interacción $\pi NR(3/2)$

D. Badagnani, A. Mariano y C. Barbero Journal of Physics G Nucl. Part. Phys. **44** (2017) 025001 .

MARIANO, A, BADAGNANI, D., BARBERO C. , BERRUETA MARTINEZ, E..Physical Review C.: American Physical Society. 2019 vol.100 n°2. p1 - 7.

$$\mathcal{L}_{I_1} = g_1 \bar{\psi} \partial_\mu \phi^\dagger \cdot \mathbf{T}R(-1)^{\mu\nu} \Psi_\nu + \text{c.c.}$$

Se acopla a la parte 1/2 del propagador en dispersión πN

Inspirada en la "invariancia de Gauge 3/2" cuando se hace ($m_R = 0$)

$$\Psi_\mu \rightarrow \Psi_\mu + \partial_\mu \chi$$

$$\mathcal{L}_{I_2} = -g_2 \partial_\mu \phi^\dagger \cdot \mathbf{T}\epsilon^{\mu\nu\rho\beta} \gamma_\beta \gamma_5 \partial_\rho \Psi_\nu + \text{c.c.},$$

No se acopla a la parte 1/2 del propagador en dispersión πN

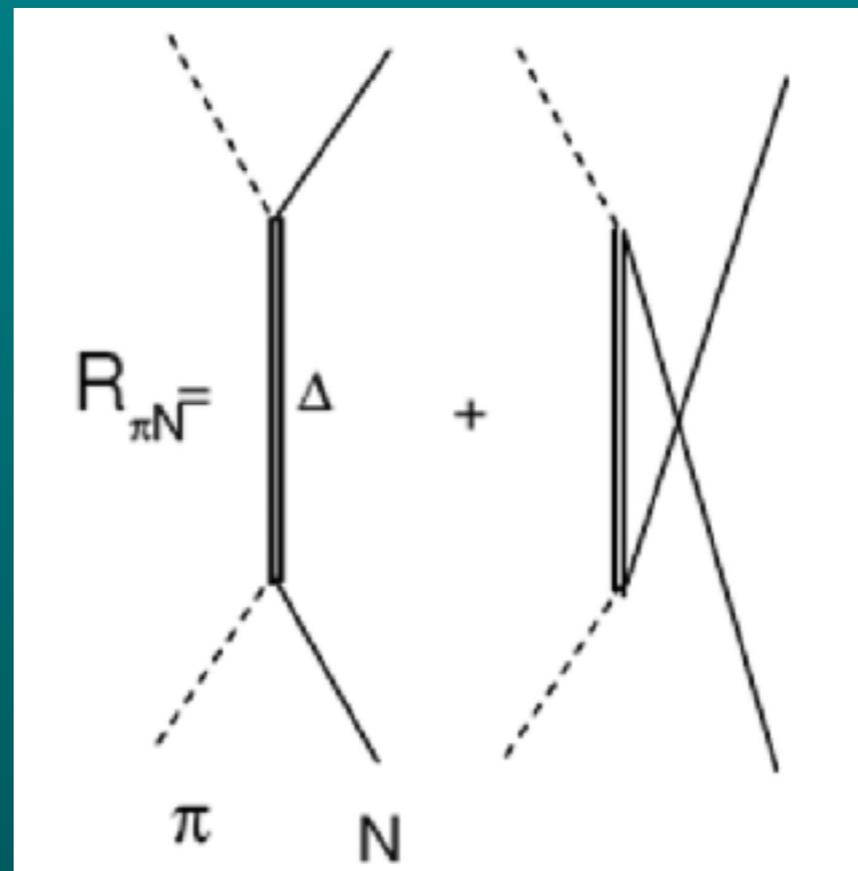
- 1) Usando el formalismo de los corchetes de Dirac hemos demostrado que cuando se cuantifican **ambas** pueden generar estados de norma negativa en presencia de los campos pseudoescalares

2) Algunos autores eligen usar I_2 en vez de I_1 por el desacople mencionado y porque haciendo la siguiente transformación

$$\Psi^\mu \rightarrow \Psi^\mu - \frac{f_{\pi N \Delta}}{m_\pi m} \Psi \partial_\mu \Phi \cdot \mathbf{T}^\dagger$$

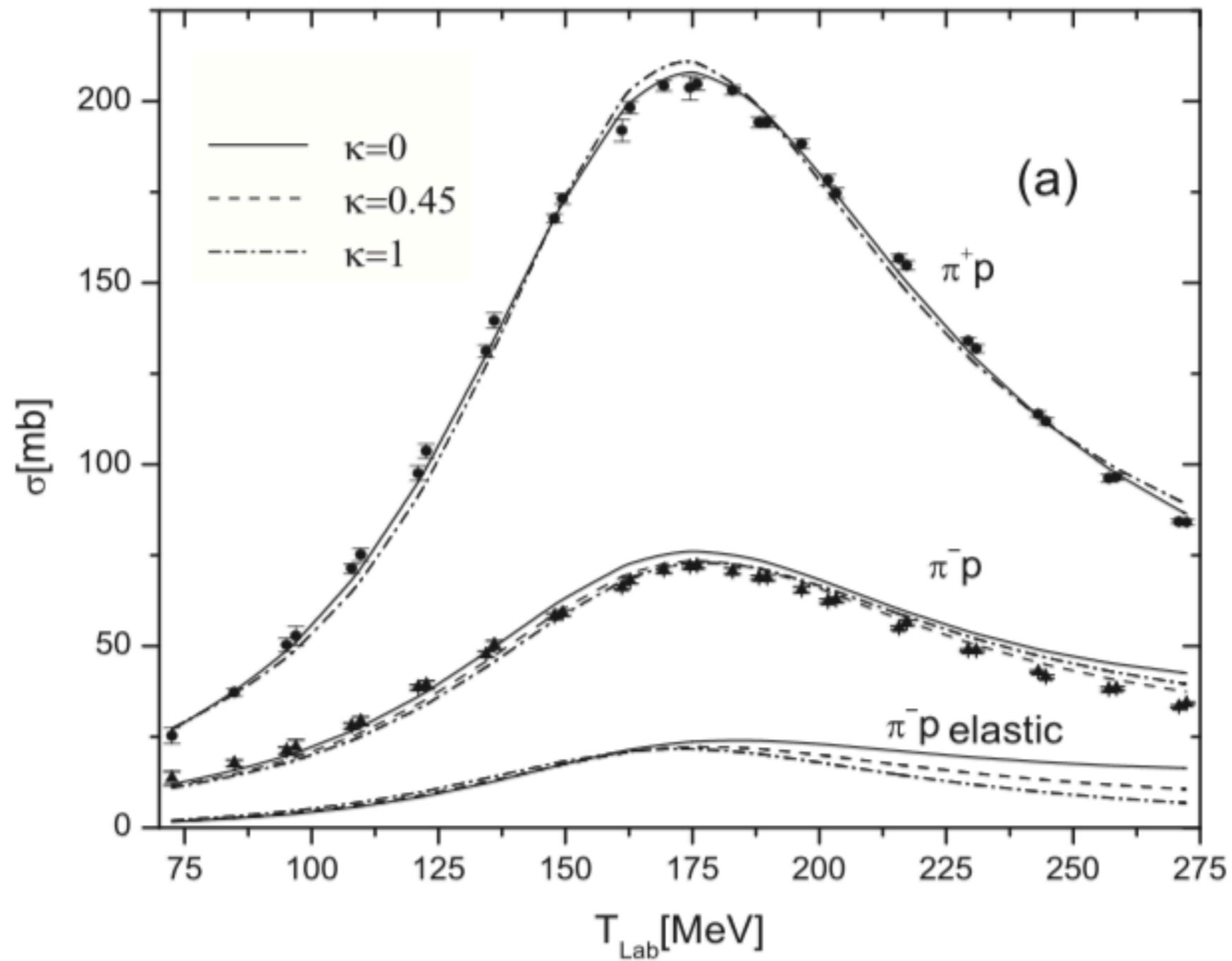
Se puede pasar de I_1 a I_2 más términos de contacto

3) Hemos visto que es más correcto usar $I_1 + I_2$ al evaluar



$$g_1 = (1 - \kappa)g,$$

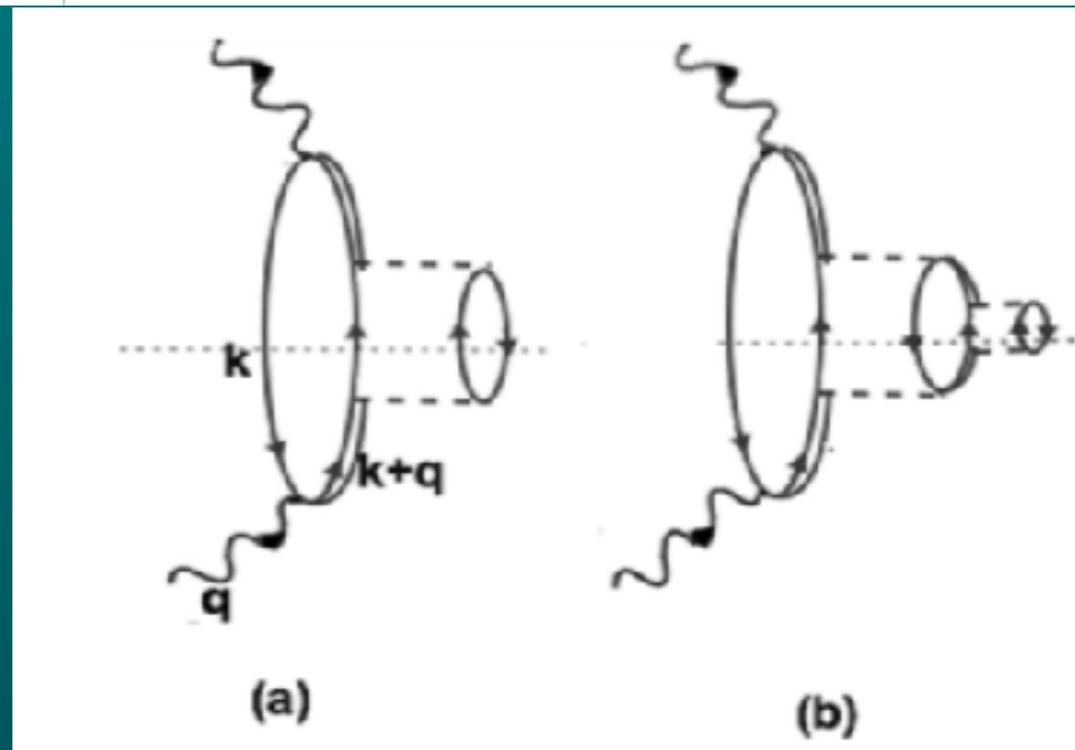
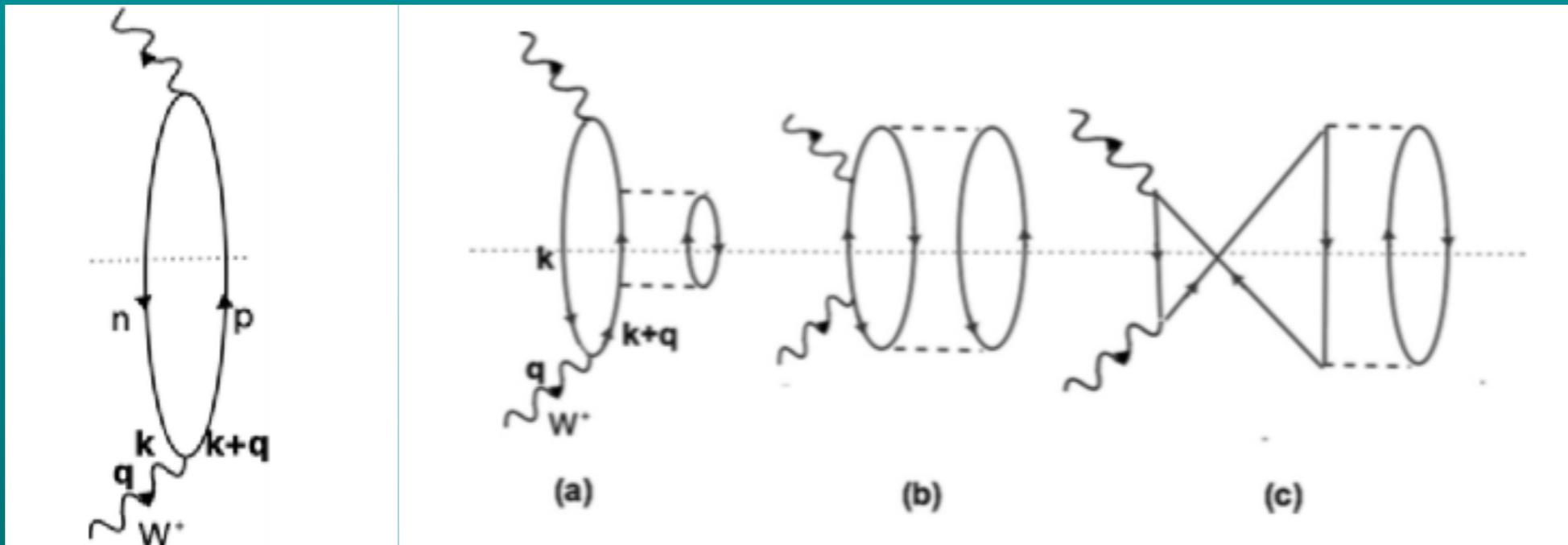
$$g_2 = \kappa \frac{g}{m},$$

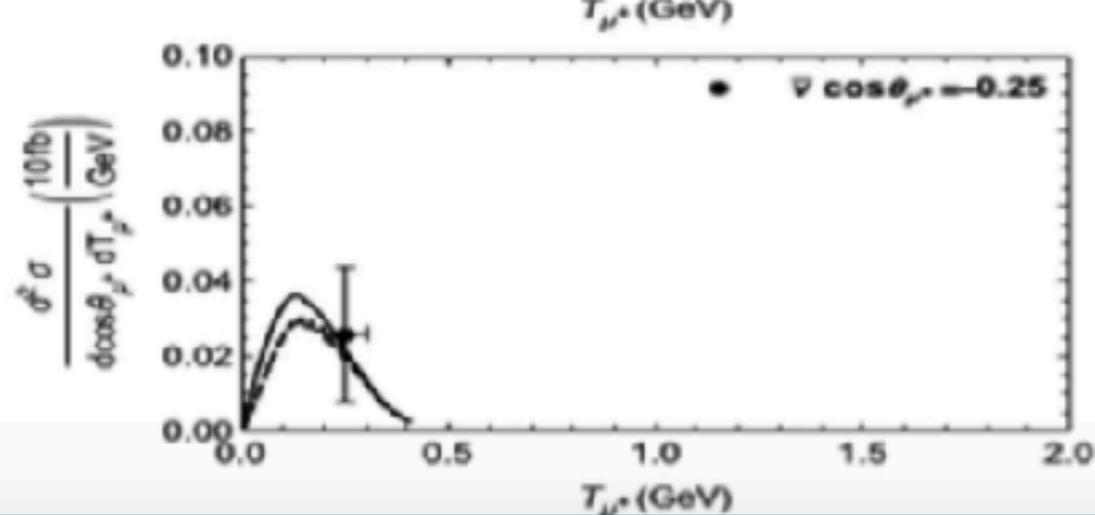
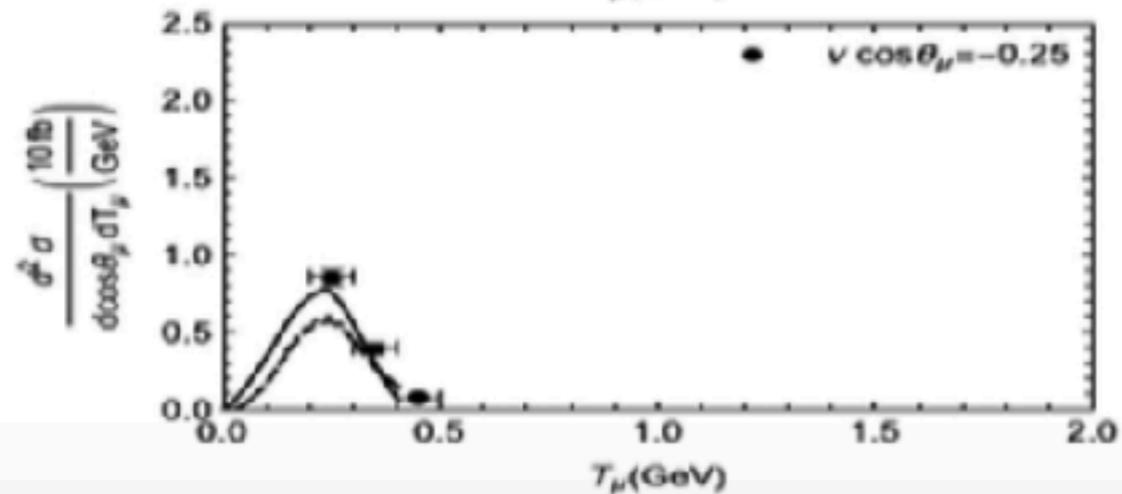
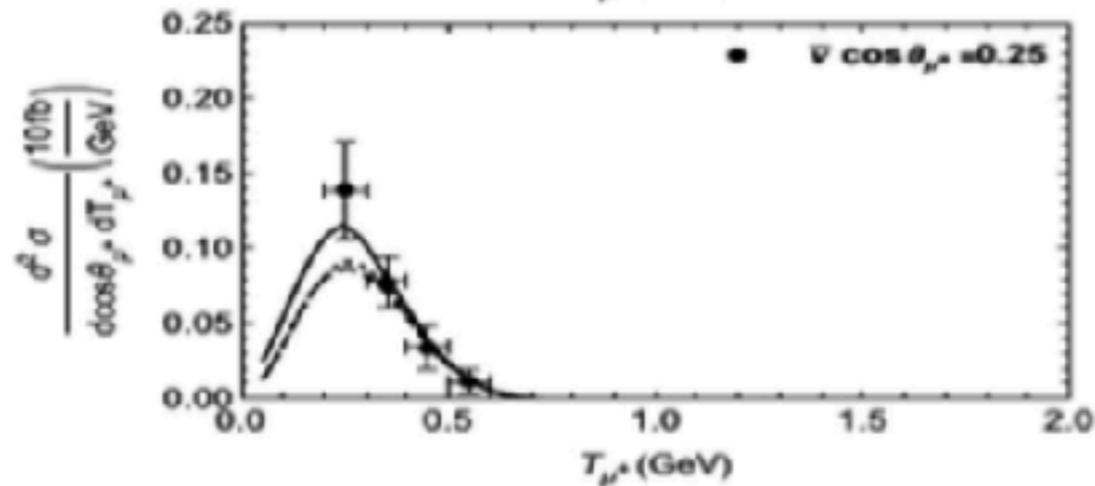
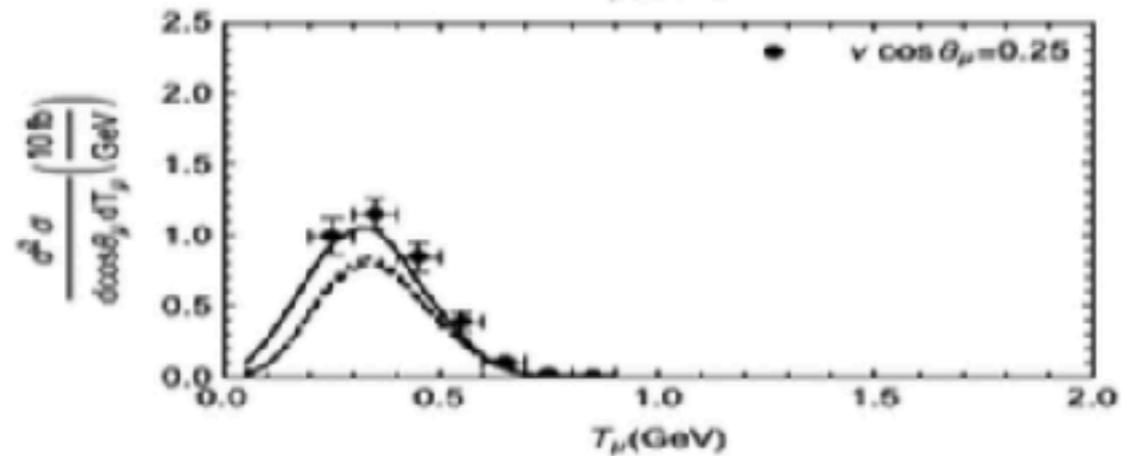
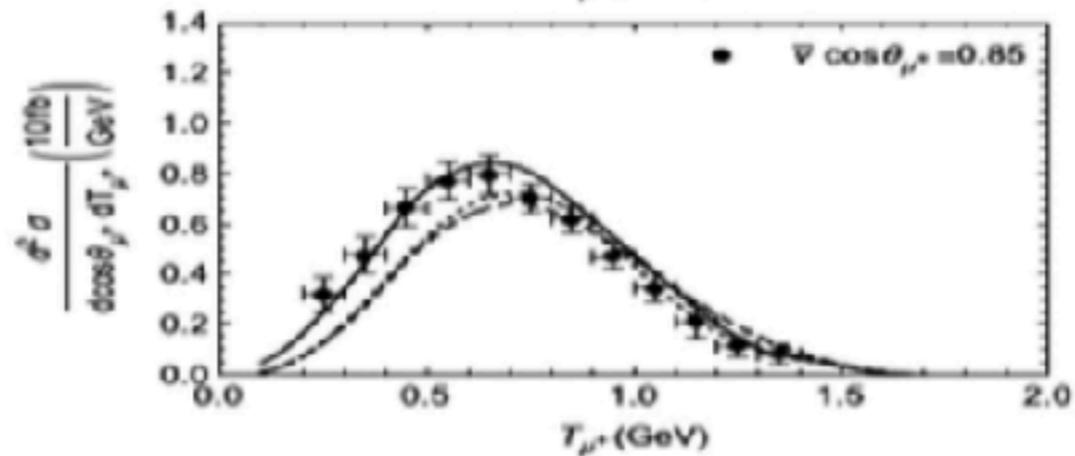
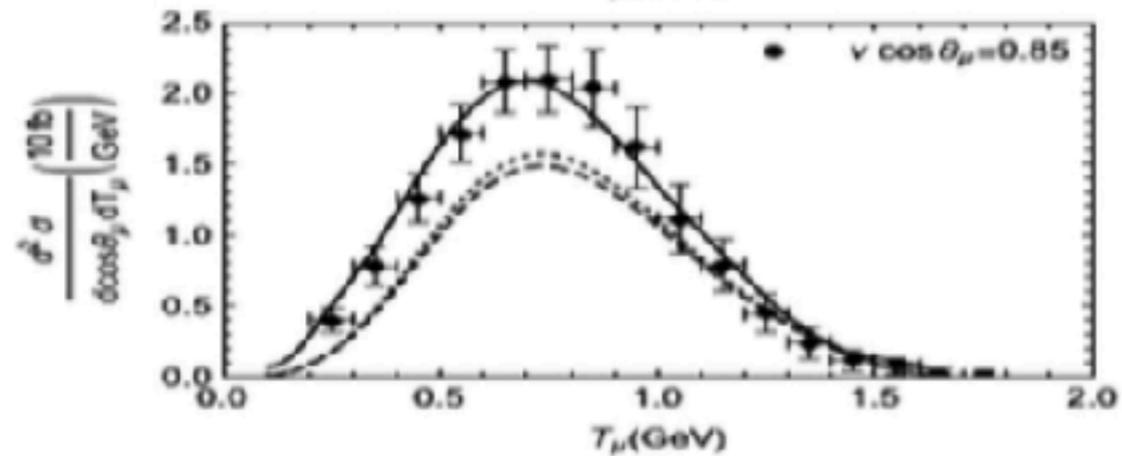
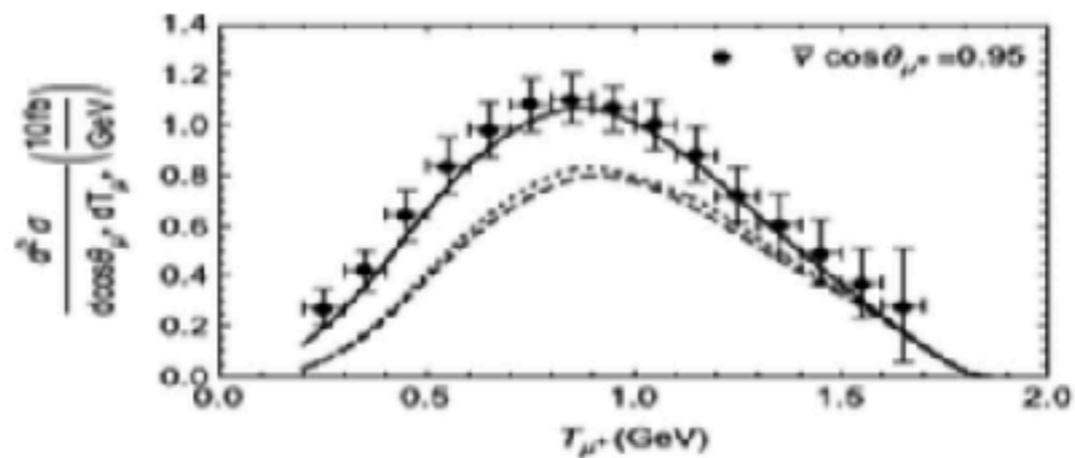
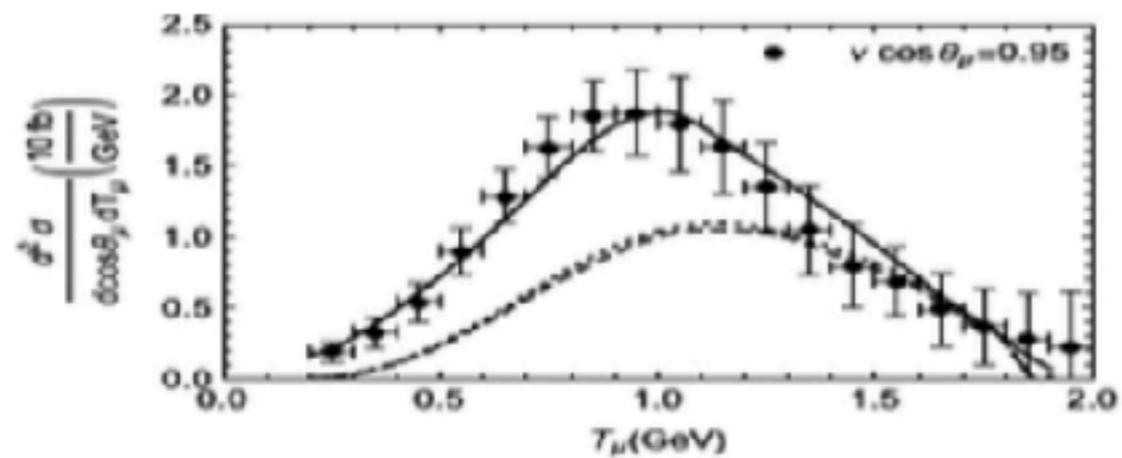


VII Dispersión cuasielástica νA

E. Berrueta Martinez ,A. Mariano ,and C. Barbero, PHYSICAL REVIEW C 103, 015503 (2021).

Cuando un ν llega a un detector A tenemos
 $\nu n \rightarrow \mu \cdot p$, $\nu n p' \rightarrow \mu \cdot p p''$, $\nu n n' \rightarrow \mu \cdot p n''$, etc





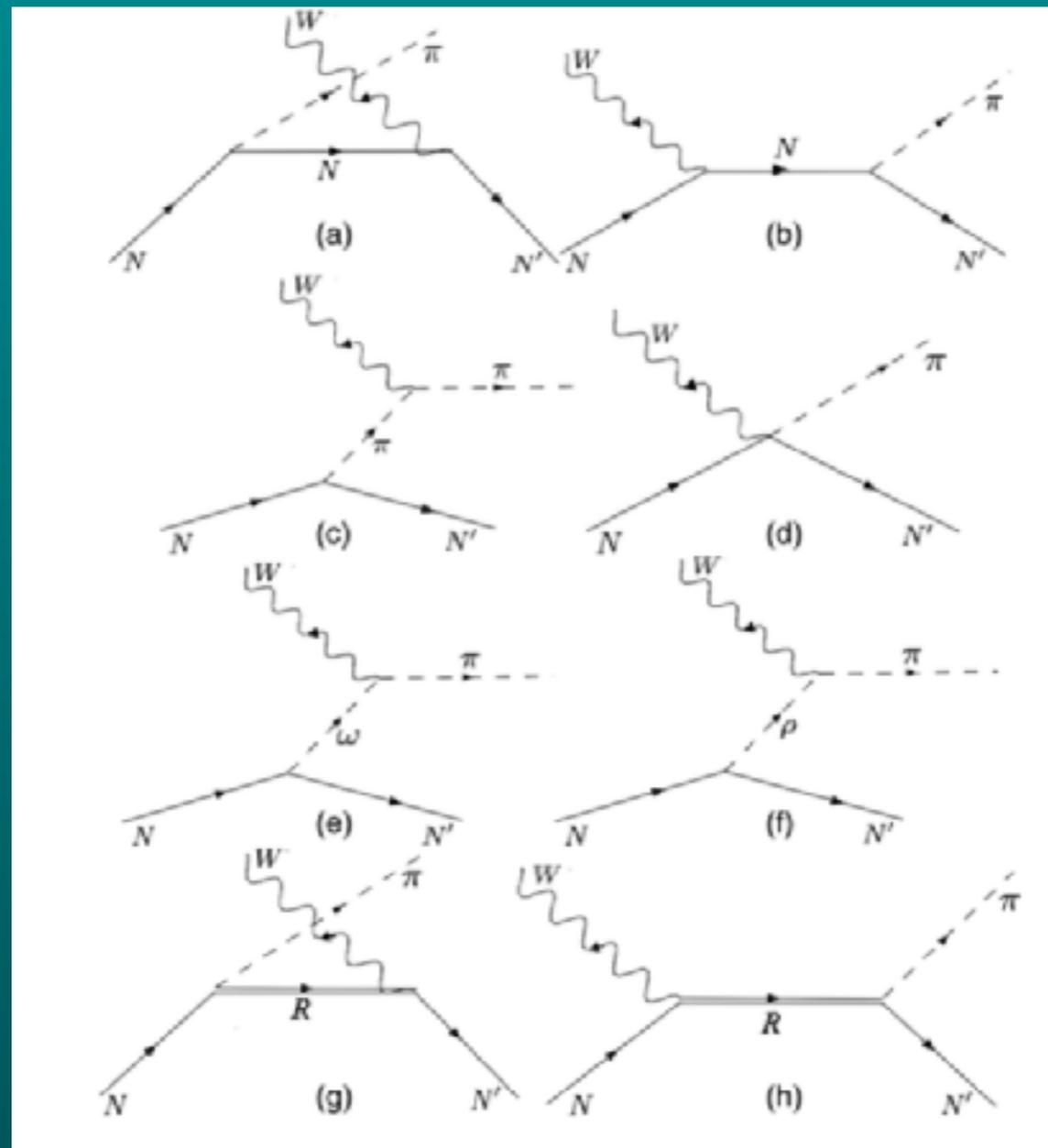
VIII Inclusión de la segunda región de resonancias en producción débil de piones

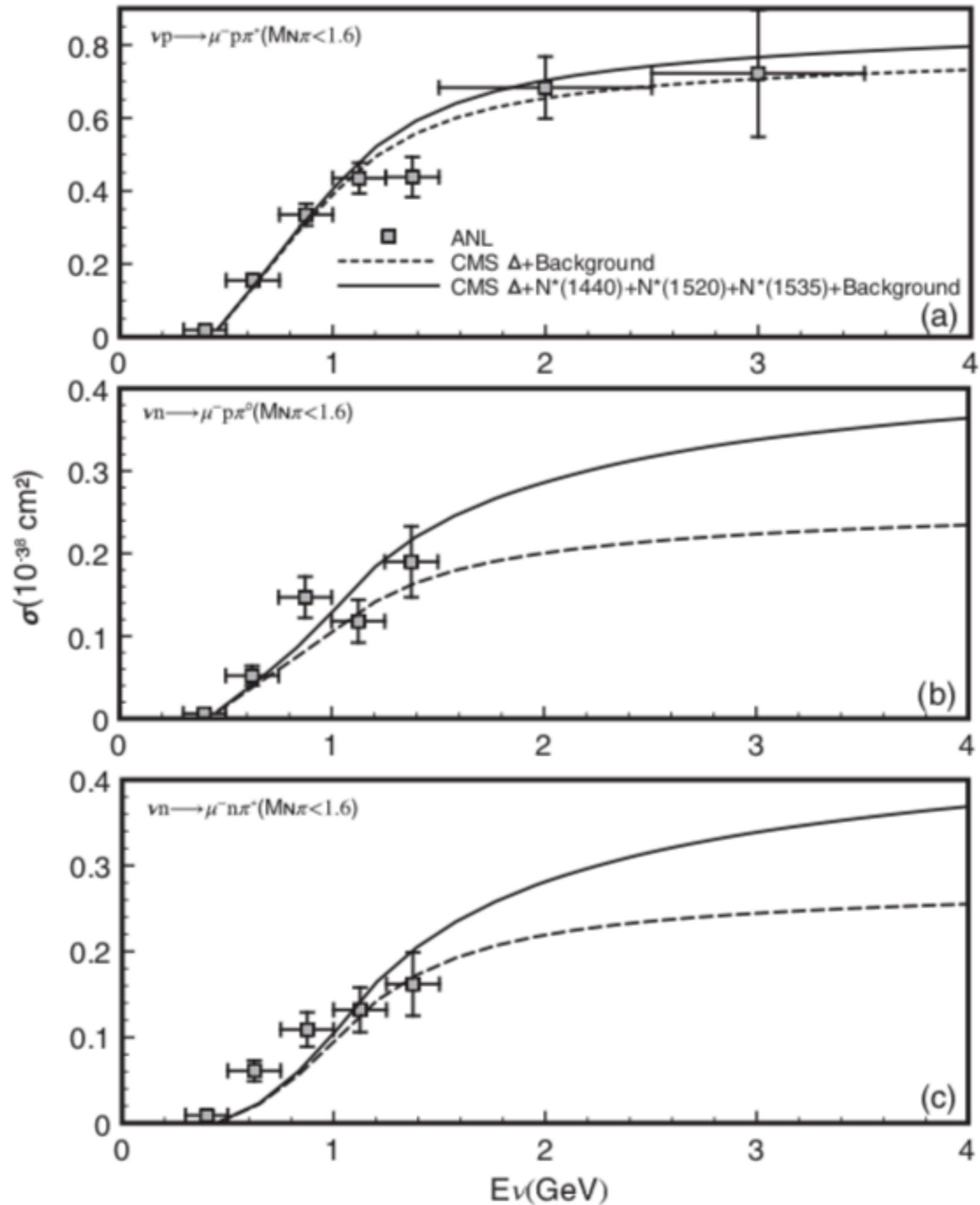
producción débil de piones

D. F. Tamayo Agudelo, A. Mariano, and D. E. Jaramillo Arango, PHYSICAL REVIEW D 105, 033008 (2022)

Quando queremos cortes más energéticos agregamos resonancias por encima de la Δ

$N^*(1440)$, $N^*(1535)$, $N^*(1520)$





Perspectivas



1) Estudiar $l_1 + l_2$ en fotoproducción y producción débil de piones.

2) Describir producción de piones sobre núcleos.

3) Estudiar violación de CP comparando

$$\nu N \rightarrow lN', \bar{\nu}N \rightarrow lN'$$

Muchas Gracias!!!