UNIVERSIDAD AUTÓNOMA DE NUEVO LEÓN

FACULTAD DE CIENCIAS FÍSICO MATEMÁTICAS

El sabor de la física

Taller en celebración del 60 aniversario del Dr. Gabriel López Castro

Dr. Francisco V Flores Baez

Outline

- Trabajo en el doctorado
- Trabajo con ideas de etapa anterior
- Estatus actual y perspectiva

Contribución Hadrónica dominante a g-2

- ¿Qué es g-2?

$$\frac{g-2}{2} = a_\mu$$

La ecuación de Dirac predice el valor de la razón giromagnética g=2. En el límite no relativista de la ecuación de Dirac,

$$\imath\hbar\frac{\partial H}{\partial t} = \ldots - \frac{e}{2mc}(\hat{\vec{L}} + g\,\hat{\vec{S}}) \cdot \vec{B} + \ldots$$ Ecuación de Pauli

Experimento

Medición en BNL (E821) usando $\mu^{\pm}$

$$a_\mu^{exp}(2004) = (11659208.0 \pm 5.8) \times 10^{-10}$$

Muon $(g-2)$ Collaboration (G.W. Bennett, *et al.*), 2004, Phys. Rev. Lett. **92**, 161802.

$$a_\mu^{th}(2004) = (11659182.8 \pm 6.3_{had,LO+NLO} \pm 3.5_{had,LBL} \pm 0.3_{QED+EW}) \times 10^{-10}$$

$$a_\mu^{exp} - a_\mu^{SM} = (25.2 \pm 9.2) \times 10^{-10}$$

Höcker, A., 2004, To appear in the proceedings of the 32nd International Conference on High-Energy Physics (ICHEP'04), Beijing, China, August 2004, [hep-ph/0410081].

FNAL muon g-2

$$a_\mu^{exp}(2021) = (116592061 \pm 41) \times 10^{-11}$$

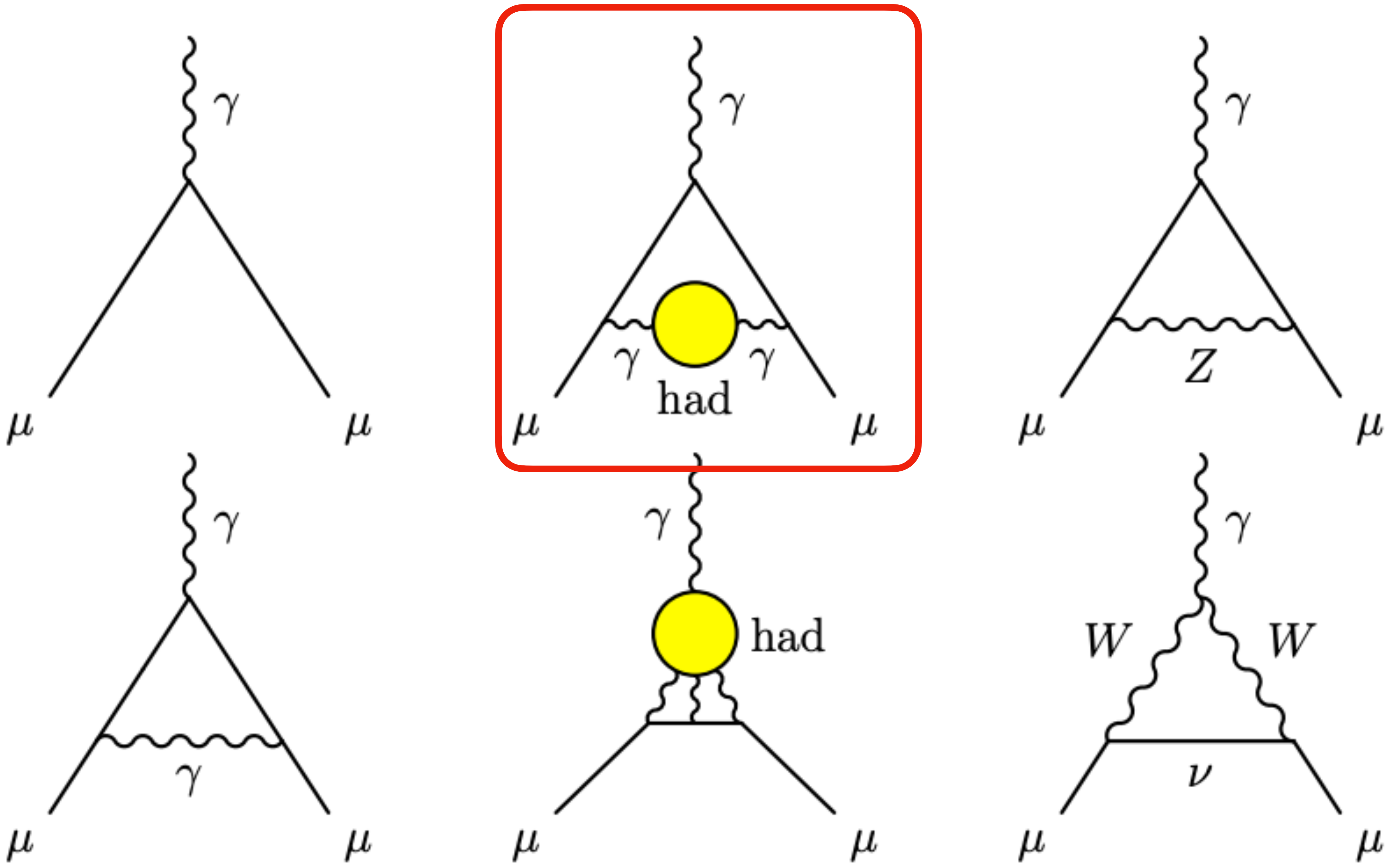
B. Abi et al. (Muon g-2), Phys. Rev. Lett. **126**, 141801 (2021), 2104.03281

$$a_\mu^{th}(2004) = (116591810.0 \pm 43) \times 10^{-11}$$

T. Aoyama et al., Phys. Rept. **887**, 1 (2020), 2006.04822

$$\Delta a_\mu = 4.2\sigma$$

¿Dónde contribuiremos?



See for example: M. Davier, A. Hocker and Z. Zhang, arXiv:hep-ph/0507078.

Rev.Mod.Phys.78:1043-1109,2006

$$a_\mu^{SM} = a_\mu^{QED} + a_\mu^{weak} + a_\mu^{hadronic}$$

$$a_\mu^{hadronic} = a_\mu^{had,LO} + a_\mu^{had,HO} + a_\mu^{had,LBL}$$

$$a_\mu^{\mathrm{had,LO}} = \frac{1}{3}\left(\frac{\alpha}{\pi}\right)^2 \int_{m_\pi^2}^{\infty} ds \, \frac{K(s)}{s} R^{(0)}(s) \; ,$$

Gourdin, M., and E. de Rafael, 1969, Nucl. Phys. **B10**, 667.
Brodsky, S.J., and E. de Rafael, 1968, Phys. Rev. **168**, 1620.

Bare Cross section

$$\frac{\sigma(e^+e^- \to \mathrm{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)} \equiv R^{(0)}$$

Calculo en QFT

Correcciones a CVC

$$\sigma(e^+e^- \to \pi^+\pi^-) = \frac{4\pi\alpha^2}{s} v_0(s)$$

$$v_0(s) = \frac{\beta_0^3(s)}{12} |F_\pi^0(s)|^2 ,$$

$$\mathcal{M}(\tau^- \to \text{hadrons}^- \nu_\tau) = \frac{G_F}{\sqrt{2}} |V_{CKM}| \ell_\mu h^\mu$$

$$\ell_\mu = \overline{\nu}_\tau \gamma_\mu (1 - \gamma_5) \tau$$

$$v_-(s) = \frac{\beta_-^3(s)}{12} |F_\pi^-(s)|^2 .$$

Isospin symmetry implies $v_-(s) = v_0(s)$.

Rompimiento de la simetría

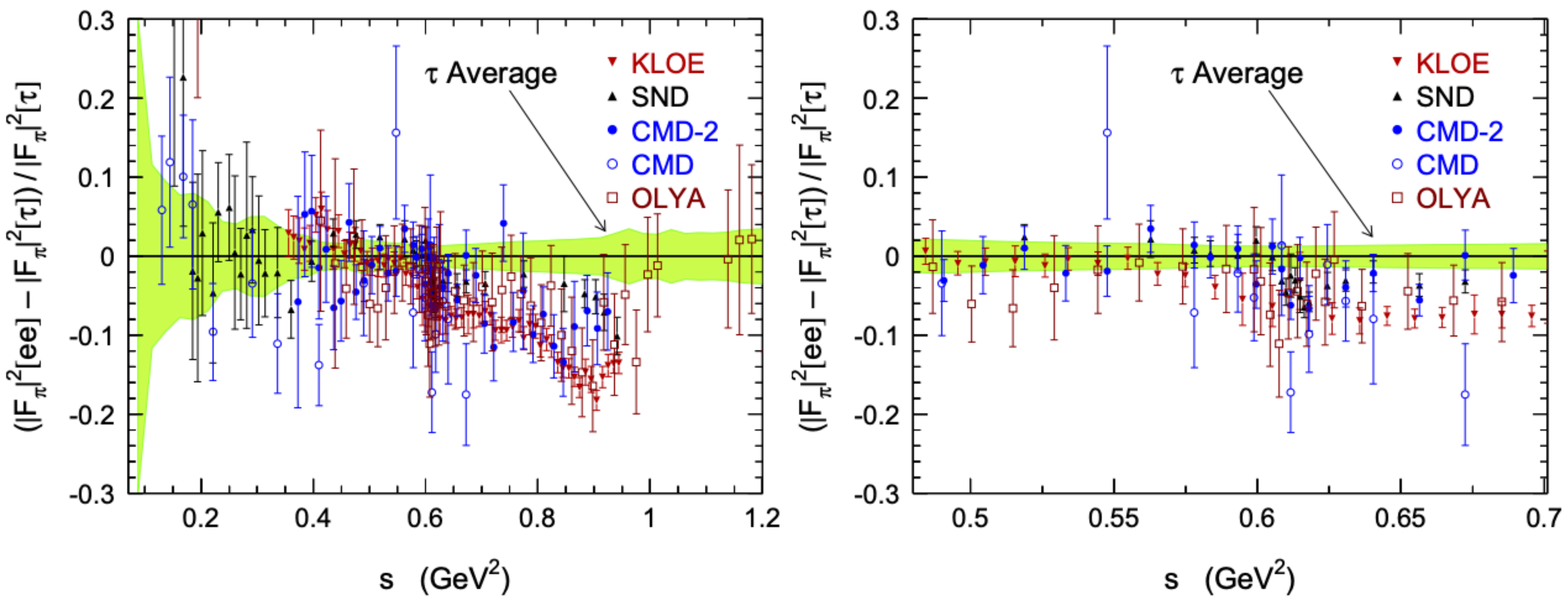
- Correcciones EW, diferencia de masa de $\pi\pm, \pi^0$, diferencia de masas en $\rho\pm, \rho^0$, EM width corrections de $\rho\pm, \rho^0$, $\rho - \omega$ mixing

Long distance Corrections (bajas energías)

Correcciones Short Distance (altas energías) —> S_{EW}

Correcciones Long distance (bajas energías)-> δ_{EM}

V. Cirigliano, G. Ecker and H. Neufeld, Phys. Lett. B **513**, 361 (2001) [arXiv:hep-ph/0104267].
V. Cirigliano, G. Ecker and H. Neufeld, JHEP **0208** (2002) 002 [arXiv:hep-ph/0207310].



•Correcciones radiativas: QED a **1 loop** y Bremsstrahlung

$$\Delta a_{\mu}^{LO,\pi\pi} = \frac{1}{4\pi^3}\int_{4m_\pi^2}^{m_\tau^2} dt K(t) \left[\frac{K_\sigma(t)}{K_\Gamma(t)}\frac{d\Gamma_{\pi\pi(\gamma)}}{dt}\right]\left(\frac{1}{G_{EM}(t)}-1\right)$$

Transferencia de momento sobrepasa el límite de aplicación de χPT. Se requiere un calculo en diferentes modelos: meson dominance modelo VMD

$$\frac{d\Gamma(\tau_{2\pi(\gamma)})}{dt} = \frac{G_F^2 m_\tau^3 S_{EW} |V_{ud}|^2}{384\pi^3} \beta_{\pi^+}^3 \left(1 - \frac{t}{m_\tau^2}\right)^2 \times \left(1 + \frac{2t}{m_\tau^2}\right) |f_+(t)|^2 G_{EM}(t) \ , \quad (2)$$

GEM contiene correcciones: fotones virtuales 1loop y fotones reales.

Model independent radiative corrections.

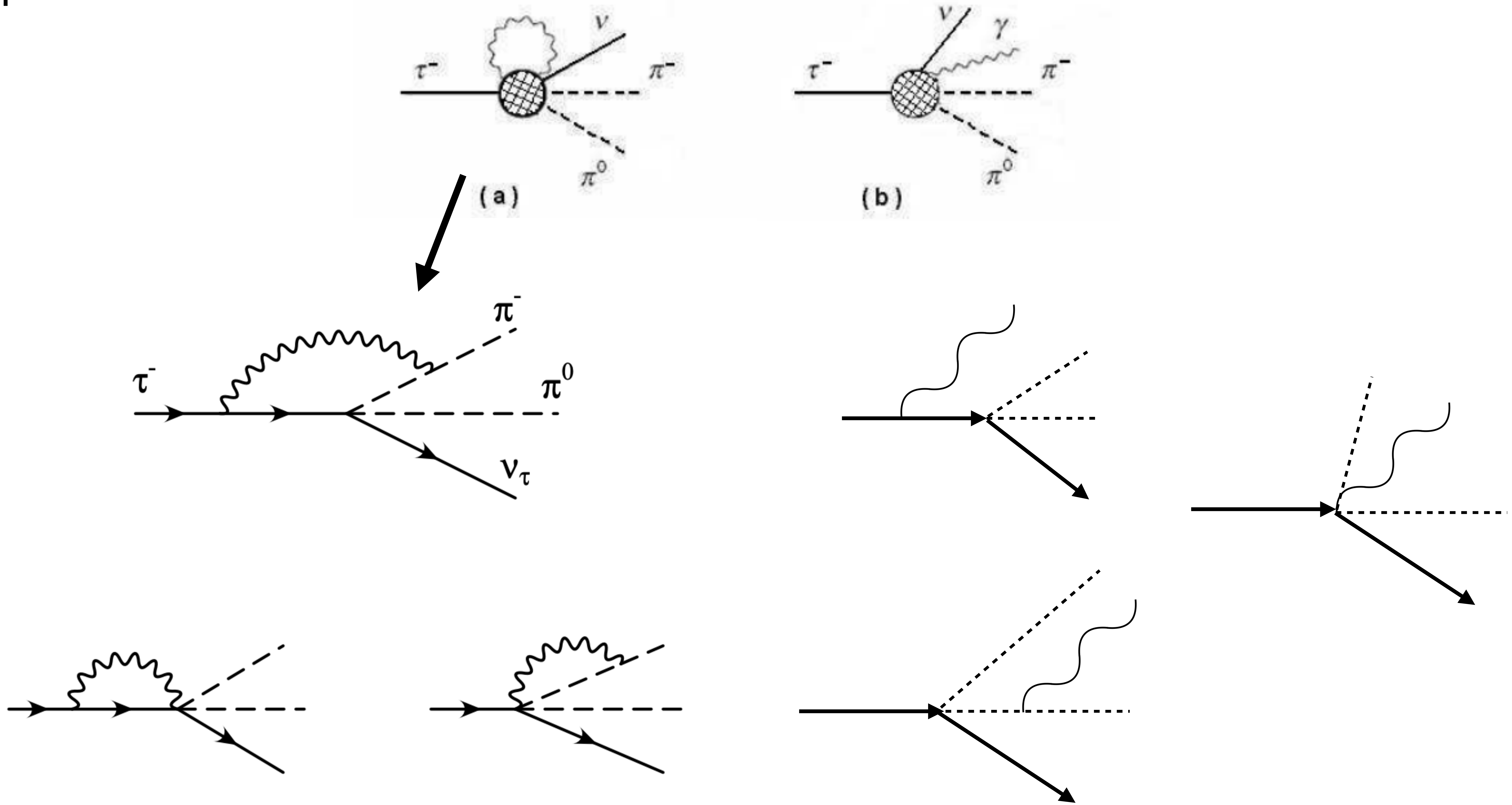
$$G_{EM}(t) = G^0_{EM}(t) + G^{m.d.}_{EM}(t) \ ,$$

T. H. Burnett and N. M. Kroll, Phys. Rev. Lett. **20**, 86 (1968); V. I. Zakharov, L. A. Kondratyuk and L. A. Ponomarev, Yad. Fiz. **8**, 783 (1968) [Sov. J. Nucl. Phys. **8**, 456 (1969)].

Correcciones de soft photons.

- Fotones virtuales
- Fotones reales que escapan del umbral de detección.

Soft photons



+ Self Energies

Correcciones electromagnéticas

- Libre de divergencias infrarrojas
- Fotones suaves: Teorema de Kroll.

T. H. Burnett and N. M. Kroll, Phys. Rev. Lett. **20**, 86 (1968); V. I. Zakharov, L. A. Kondratyuk and L. A. Ponomarev, Yad. Fiz. **8**, 783 (1968) [Sov. J. Nucl. Phys. **8**, 456 (1969)].

- Libre de divergencias ultravioleta.
- Regularización y renormalización (esquema regularización dimensional)
- Correcciones independientes del modelo

N. Meister and D. Yennie, Phys. Rev. **130**, 1210 (1963); A. Queijeiro and A. García, Phys. Rev. D**38**, 2218 (1988).

Correcciones dependientes e independientes del modelo

- Independientes del modelo

No existe una descripción del detalle de las interacciones pion-foton, vértice-foton.

- Dependientes del modelo

Es necesaria una descripción detallada de las interacciones foton-hadron.

- Adicionalmente: χpT - teoría efectiva, $E \sim 1\text{Gev}$

V. Cirigliano, G. Ecker and H. Neufeld, Phys. Lett. B **513**, 361 (2001) [arXiv:hep-ph/0104267].
V. Cirigliano, G. Ecker and H. Neufeld, JHEP **0208** (2002) 002 [arXiv:hep-ph/0207310].

Resultados del análisis

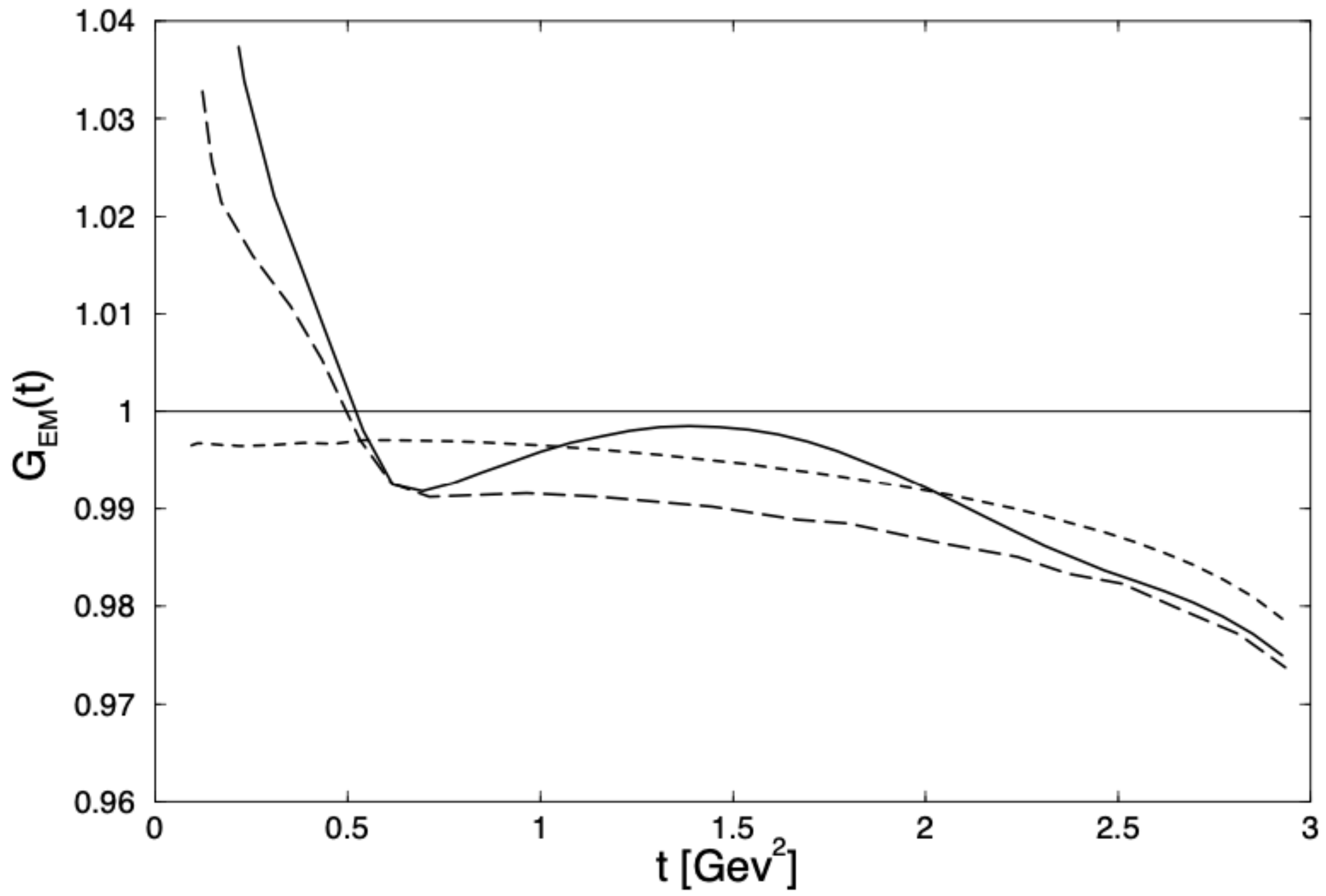


FIG. 1: Long-distance electromagnetic correction to the di-pion spectrum: this paper including all contributions (solid-line), model-independent (short-dashed-line) and full contributions of ref. [9] (long-dashed line).

$$G_{EM}(t) = 1 + \frac{\frac{d\Gamma_v^1}{dt} + \frac{d\Gamma_r^1}{dt}}{\frac{d\Gamma^0}{dt}} \; . \qquad G_{EM}(t) = G_{EM}^0(t) + G_{EM}^{m.d.}(t)$$

- Importante la contribución $\omega(782)$
- Mínima energía de un fotón ω_0

$$\Delta a_\mu^{LO,\pi\pi} = \frac{1}{4\pi^3}\int_{4m_\pi^2}^{m_\tau^2} dt K(t) \left[\frac{K_\sigma(t)}{K_\Gamma(t)} \frac{d\Gamma_{\pi\pi(\gamma)}}{dt}\right] \left(\frac{1}{G_{EM}(t)} - 1\right) = -3.7 \times 10^{-10} \; .$$

= 4X

V. Cirigliano, G. Ecker and H. Neufeld, JHEP **0208** (2002) 002 [arXiv:hep-ph/0207310].

Model-dependent radiative corrections to tau- ---> pi- pi0 nu revisited

#14

A. Flores-Tlalpa (CINVESTAV, IPN), F. Flores-Baez (CINVESTAV, IPN), G. Lopez Castro (CINVESTAV, IPN), G. Toledo Sanchez (Mexico U.) (Nov, 2006)

Published in: *Nucl.Phys.B Proc.Suppl.* 169 (2007) 250-254 • Contribution to: 9th International Workshop on Tau Lepton Physics (Tau06), 250-254 • e-Print: hep-ph/0611226 [hep-ph]

pdf DOI cite 29 citations

Long-distance radiative corrections to the di-pion tau lepton decay

#15

F. Flores-Baez (CINVESTAV, IPN), A. Flores-Tlalpa (CINVESTAV, IPN), G. Lopez Castro (CINVESTAV, IPN), G. Toledo Sanchez (Mexico U.) (Aug, 2006)

Published in: *Phys.Rev.D* 74 (2006) 071301 • e-Print: hep-ph/0608084 [hep-ph]

pdf DOI cite 56 citations

Correcciones QED independientes del modelo al ancho de decaimiento del meso rho

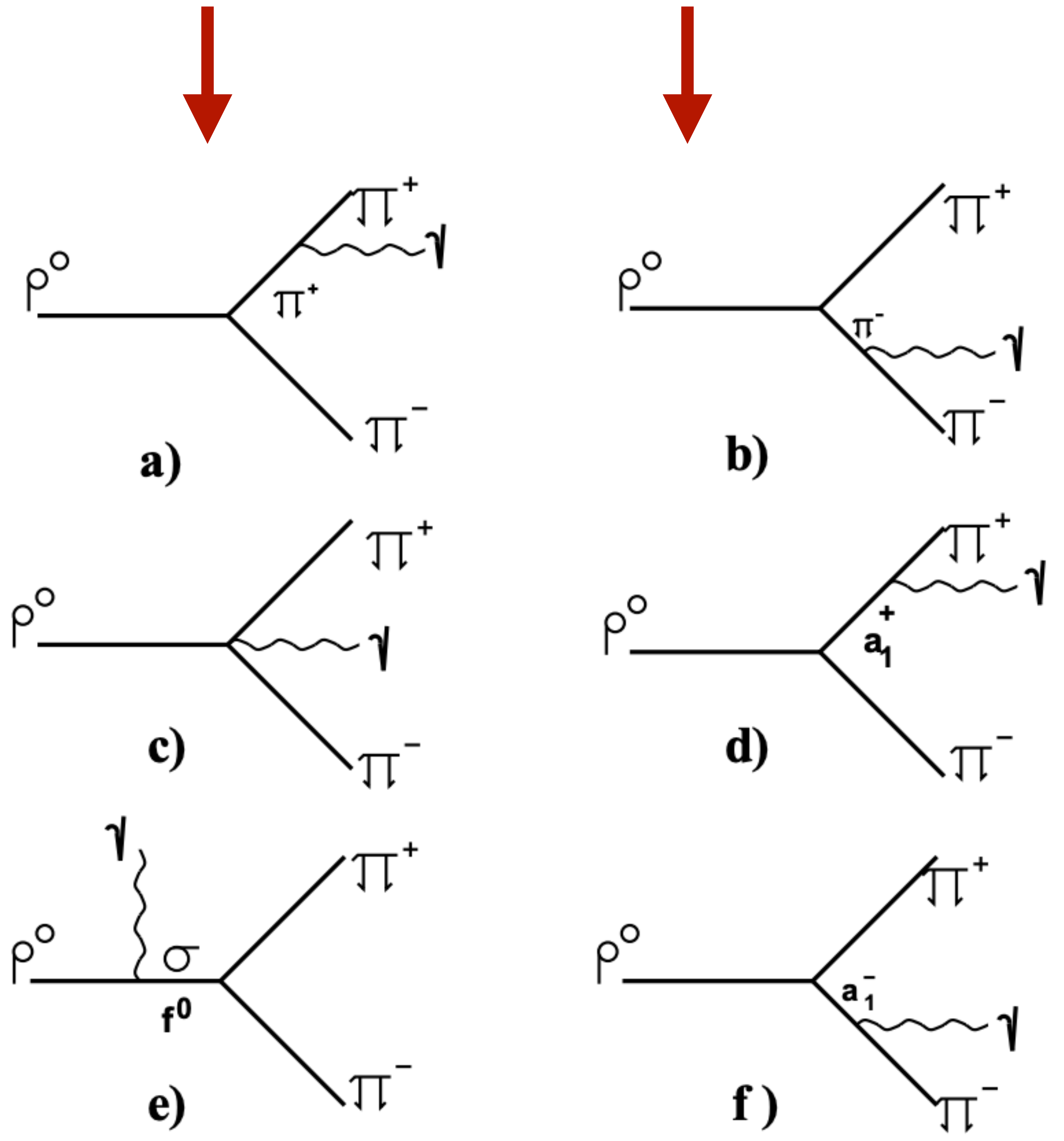
- Elementos de un mismo isomultiplete satisfacen la simetría de isospin al orden mas bajo

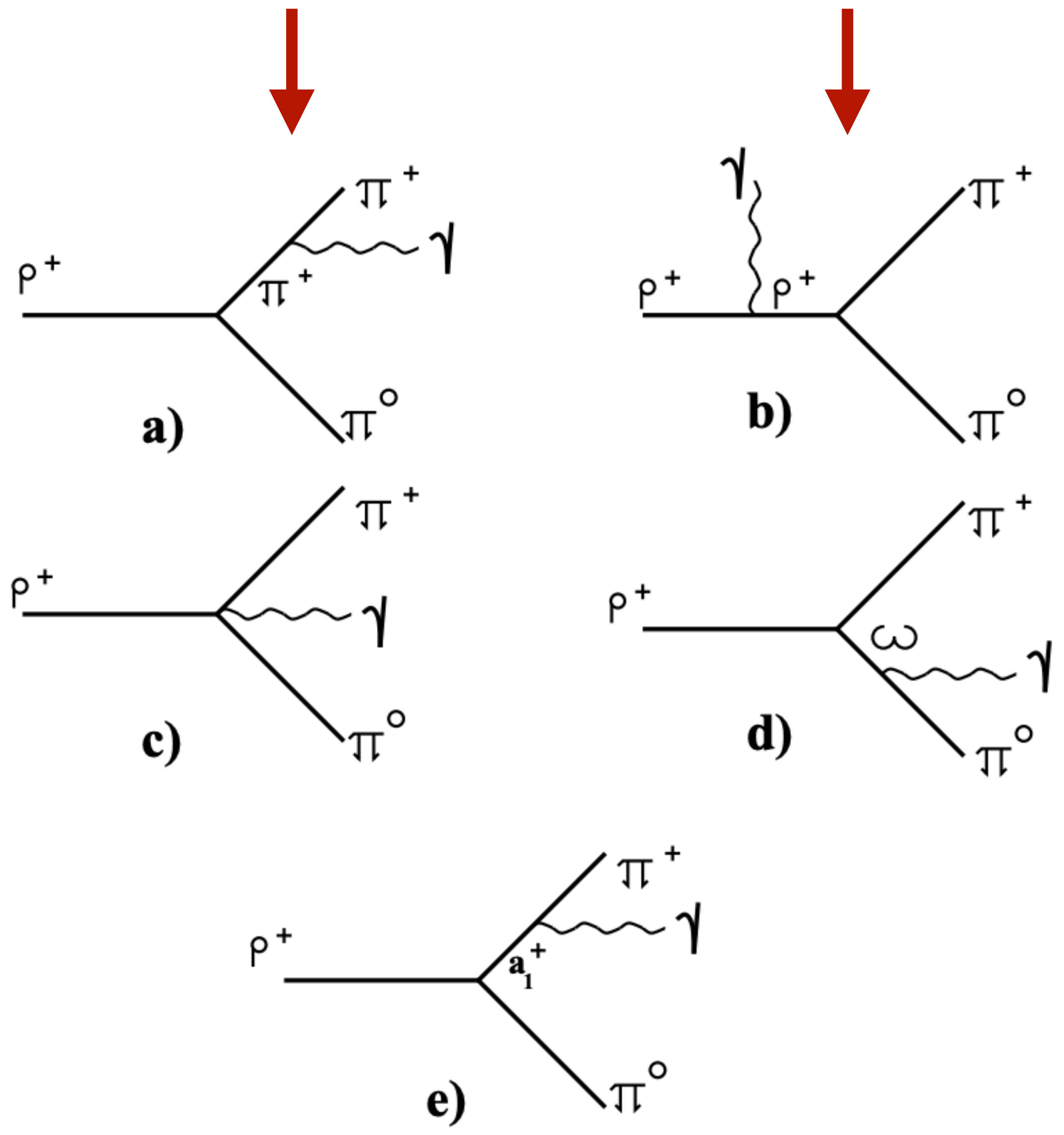
- Correcciones electromagnéticas rompen la simetría de isospin (también diferencias de masas)

- Modo de decaimiento dominante $\rho \to \pi\pi(\gamma)$

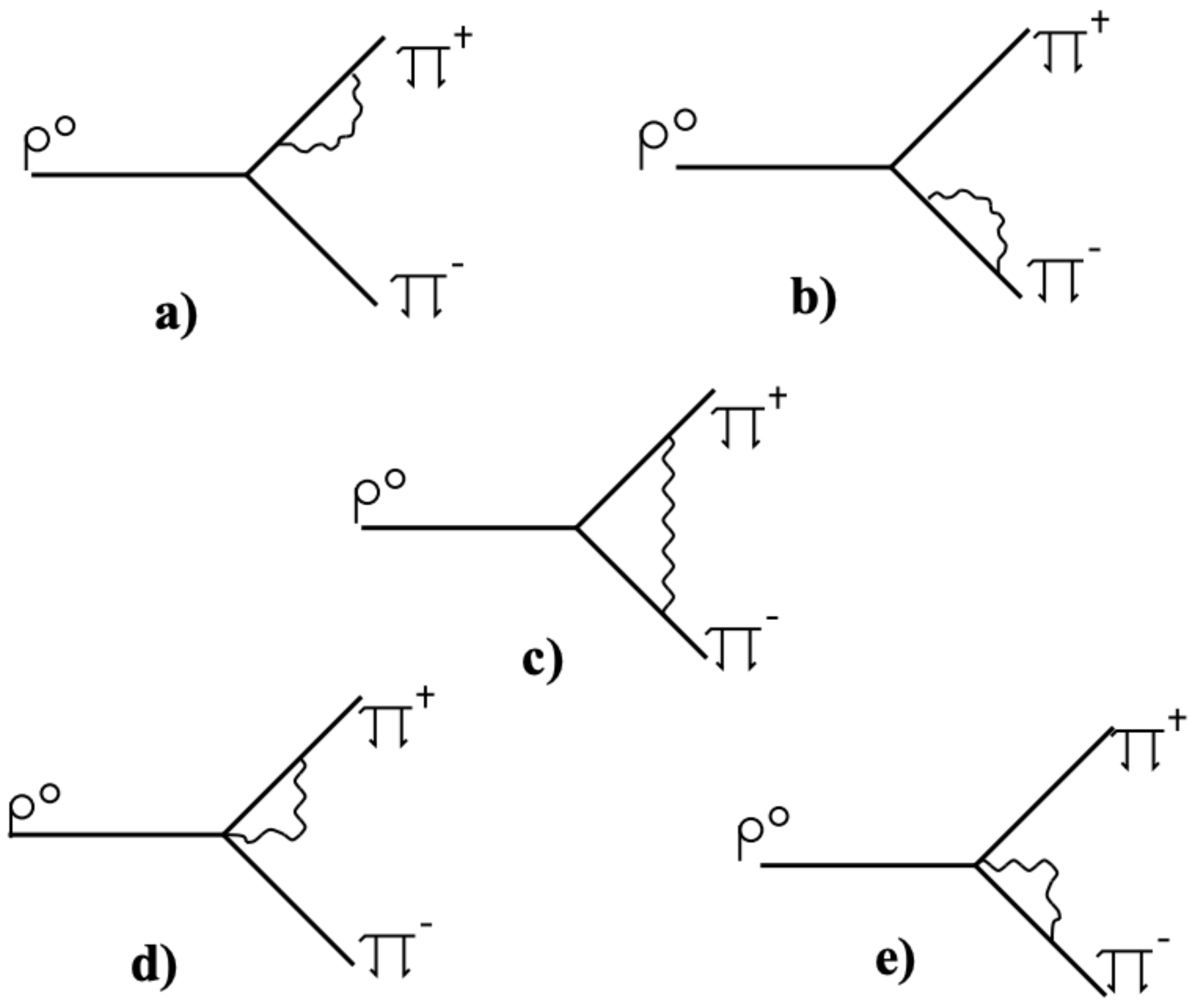
$$\begin{aligned}\Delta\Gamma_\rho \;=\; &\Gamma(\rho^0 \to \pi^+\pi^-(\gamma), \omega \leq \omega_0) - \Gamma(\rho^+ \to \pi^+\pi^0(\gamma), \omega \leq \omega_0) \\ &+ \Gamma(\rho^0 \to \pi^+\pi^-\gamma, \omega \geq \omega_0) - \Gamma(\rho^+ \to \pi^+\pi^0\gamma, \omega \geq \omega_0) + \Delta\Gamma_\rho^{\text{sub}}\end{aligned}$$

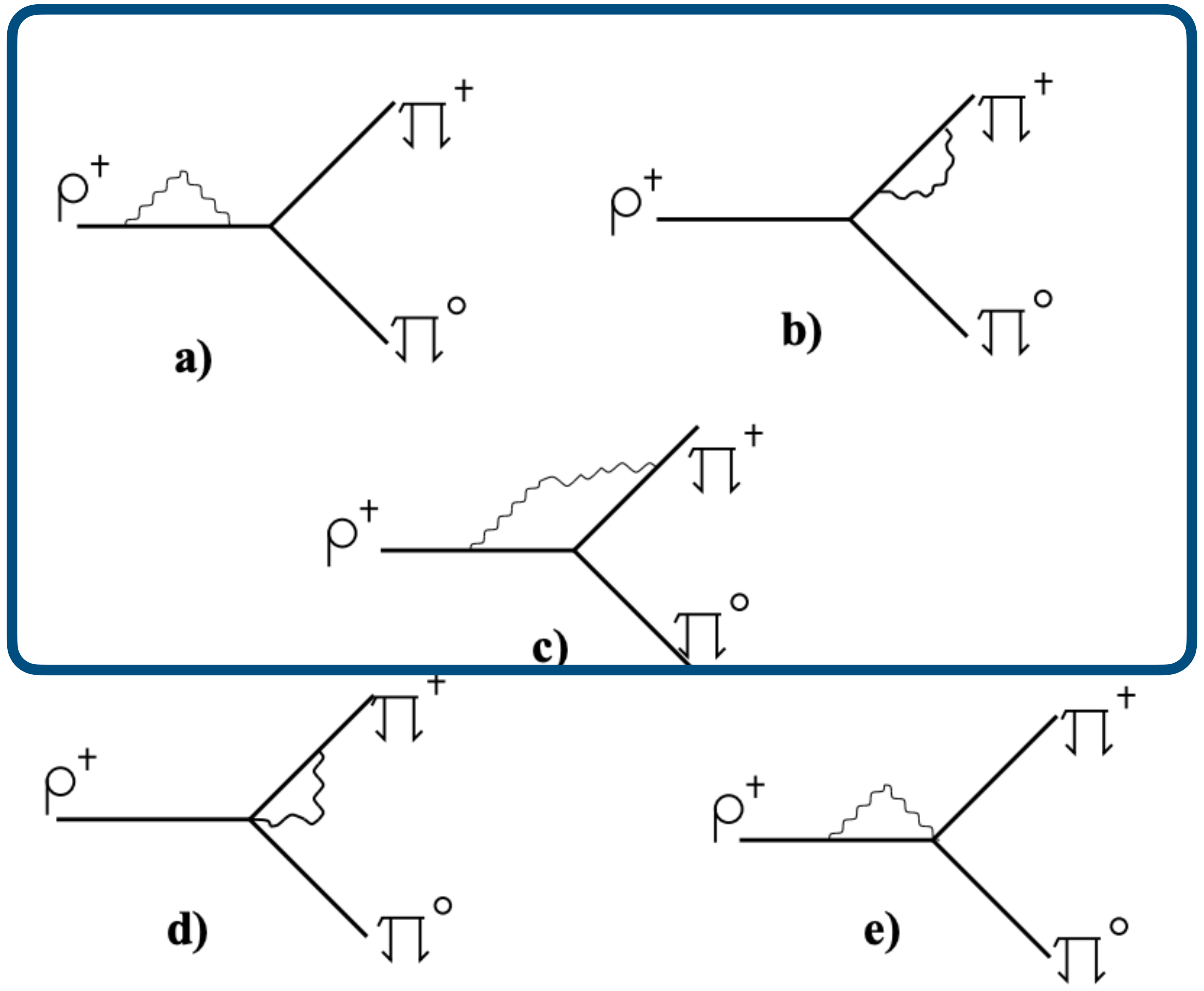
- $$\Delta\Gamma_\rho^{\text{sub}} < 0.5\,\%$$





$$
\begin{aligned}
\Gamma(\rho^i \to \pi\pi(\gamma), \omega \le \omega_0) &= \Gamma_i^0 + \Gamma_i^{1\mathrm{v}} + \Gamma_i^{\mathrm{soft}}(\omega_0) \\
&= \Gamma_i^0 \left[1 + \frac{\Gamma_i^{1\mathrm{v}}}{\Gamma_i^0} + \frac{\Gamma_i^{\mathrm{soft}}(\omega_0)}{\Gamma_i^0} \right] \\
&= \Gamma_i^0 \left[1 + \delta_{\rho^i} \right] \ .
\end{aligned}
$$





N. Meister and D. Yennie, Phys. Rev. **130**, 1210 (1963); A. Queijeiro and A. García, Phys. Rev. D**38**, 2218 (1988).

$$
\begin{aligned}
\frac{\Gamma_0^{\rm soft}(\omega_0)}{\Gamma_0^0} = \frac{\alpha}{\pi}\Bigg\{ & 2\ln\left(\frac{\lambda}{2\omega_0}\right)\left(1+\frac{1+v_0^2}{2v_0}\ln\left[\frac{1-v_0}{1+v_0}\right]\right)-\frac{1}{v_0}\ln\left(\frac{1-v_0}{1+v_0}\right)\\
&+\frac{1+v_0^2}{2v_0}\Bigg[\mathrm{Li}_2\left(\frac{1-v_0}{1+v_0}\right)-\mathrm{Li}_2\left(\frac{1+v_0}{1-v_0}\right)+\imath\pi\ln\left(\frac{1-v_0}{1+v_0}\right)\\
&+\ln\left(\frac{1-v_0}{1+v_0}\right)\ln\left(\frac{4v_0^2}{1-v_0^2}\right)\Bigg]\Bigg\}\ ,
\end{aligned}
$$

$$
\begin{aligned}
\frac{\Gamma_+^{\rm soft}(\omega_0)}{\Gamma_+^0} = \frac{\alpha}{\pi}\Bigg\{ & 1-2\ln 2+2\ln\left[\frac{\lambda}{\omega_0}\right]\left(1+\frac{1}{2v'_+}\ln\left[\frac{1-v'_+}{1+v'_+}\right]\right)\\
&+\frac{1}{2v'_+}\ln\left(\frac{1+v'_+}{1-v'_+}\right)-\frac{1}{2v'_+}\Bigg[\mathrm{Li}_2\left(\frac{1+v'_+}{1-v'_+}\right)-\mathrm{Li}_2\left(\frac{1-v'_+}{1+v'_+}\right)\\
&+\ln\left(\frac{v'^2_+}{1-v'^2_+}\right)\ln\left(\frac{1+v'_+}{1-v'_+}\right)+\imath\pi\ln\left(\frac{1+v'_+}{1-v'_+}\right)\Bigg]\Bigg\}\ ,
\end{aligned}
$$

$$
\begin{aligned}
\frac{\Gamma_0^{\rm 1v}}{\Gamma_0^0} = \frac{\alpha}{\pi}\Bigg[& \pi^2\left(\frac{1+v_0^2}{2v_0}\right)-2\left(1+\ln\left[\frac{\lambda}{m_{\pi^+}}\right]\right)\left(1+\frac{1+v_0^2}{2v_0}\ln\left[\frac{1-v_0}{1+v_0}\right]\right)\\
&-\left(\frac{1+v_0^2}{v_0}\right)\left[\mathrm{Li}_2(v_0)-\mathrm{Li}_2(-v_0)\right]-\frac{1+v_0^2}{2v_0}\left(\mathrm{Li}_2\left[\frac{2}{1+v_0}\right]-\mathrm{Li}_2\left[\frac{2}{1-v_0}\right]\right)\Bigg]
\end{aligned}
$$

$$
\begin{aligned}
\frac{\Gamma_+^{\rm 1v}}{\Gamma_+^0} = \frac{\alpha}{\pi}\Bigg\{ & -1-2\ln\left(\frac{\lambda}{m_{\rho^+}}\right)\left[1+\frac{1}{2v'_+}\ln\left(\frac{1-v'_+}{1+v'_+}\right)\right]+\frac{3}{4}\ln\left(\frac{m^2_{\pi^+}}{m^2_{\rho^+}}\right)\\
&+\frac{m^2_{\rho^+}}{4m^2_{\pi^0}}\Bigg[\ln\left(\frac{m^2_{\rho^+}}{m^2_{\pi^+}}\right)\left(1-\frac{\Delta_\pi^2}{m^2_{\rho^+}}\right)-v_+\Bigg[\ln\left(\frac{1-v_+-\frac{\Delta_\pi^2}{m^2_{\rho^+}}}{1+v_+-\frac{\Delta_\pi^2}{m^2_{\rho^+}}}\right)+\ln\left(\frac{1+v_+-\frac{\Sigma_\pi^2}{m^2_{\rho^+}}}{1-v_+-\frac{\Sigma_\pi^2}{m^2_{\rho^+}}}\right)\Bigg]\Bigg]\\
&+\frac{1}{2v'_+}\left[\ln\left(\frac{1-v'_+}{1+v'_+}\right)\left[-\frac{1}{4}\ln\left(\frac{1-v'_+}{1+v'_+}\right)+2\ln\left(\frac{2v'_+}{1+v'_+}\right)-\ln\left(\frac{m_{\rho^+}}{m_{\pi^+}}\right)\right]\right.\\
&\left.-\frac{\pi^2}{3}+2\mathrm{Li}_2\left(\frac{1-v'_+}{1+v'_+}\right)+\ln^2\left(\frac{m_{\pi^+}}{m_{\rho^+}}\right)\right.
\end{aligned}
$$

Fotones duros (Hard photons)

Fotones con energía mas grande que el corte ω_0

P. Singer, Phys. Rev. **130**, 2441 (1963); Erratum, *ibid* **161**, 1694 (1967).

G. Toledo Sanchez, J. L. Garcia Luna and V. Gonzalez Enciso, Phys. Rev. D **76**, 033001 (2007)

G. Lopez Castro and G. Toledo Sanchez, J. Phys. G **27**, 2203 (2001) [arXiv:hep-ph/0108248].

Fotones suaves (soft photons)

ω_0 (MeV)	$m_{\rho^0} = 772$ MeV δ_{ρ^0}	$m_{\rho^0} = 775$ MeV δ_{ρ^0}	$m_{\rho^0} = 778$ MeV δ_{ρ^0}
2	-0.03670	-0.03692	-0.03714
4	-0.02910	-0.02930	-0.02949
6	-0.02465	-0.02483	-0.02501
8	-0.02150	-0.02167	-0.02183
10	-0.01905	-0.01921	-0.01937
12	-0.01705	-0.01720	-0.01736
14	-0.01536	-0.01550	-0.01565
16	-0.01389	-0.01403	-0.01477
18	-0.01260	-0.01273	-0.01287
20	-0.01144	-0.01157	-0.01170
30	-0.00697	-0.00708	-0.00720
40	-0.00378	-0.00388	-0.00399
50	-0.00130	-0.00139	-0.00150
60	0.00074	-0.00065	0.00056
70	0.00249	0.00240	0.00232
80	0.00401	0.00393	0.00384
90	0.00536	0.00529	0.00521
100	0.00659	0.00651	0.00643

TABLE I: Radiative correction δ_{ρ^0} to the $\rho^0 \to \pi^+\pi^-(\gamma)$ decay rate (see definition in Eq. (5)) as a function of ω_0 and for three different values of m_{ρ^0}.

ω_0 (MeV)	$m_{\rho^+} = 772$ MeV δ_{ρ^+}	$m_{\rho^+} = 775$ MeV δ_{ρ^+}	$m_{\rho^+} = 778$ MeV δ_{ρ^+}
2	-0.01959	-0.01968	-0.01970
4	-0.01701	-0.01710	-0.01718
6	-0.01551	-0.01558	-0.01566
8	-0.01444	-0.01451	-0.01459
10	-0.01361	-0.01368	-0.01375
12	-0.01293	-0.01300	-0.01307
14	-0.01236	-0.01242	-0.01249
16	-0.01186	-0.01192	-0.01199
18	-0.01142	-0.01149	-0.01155
20	-0.01103	-0.01109	-0.01115
30	-0.00953	-0.00958	-0.00963
40	-0.00844	-0.00849	-0.00854
50	-0.00761	-0.00765	-0.00769
60	-0.00692	-0.00696	-0.00700
70	-0.00633	-0.00637	-0.00639
80	-0.00582	-0.00584	-0.00589
90	-0.00536	-0.00540	-0.00544
100	-0.00495	-0.00499	-0.00502

TABLE II: Radiative corrections δ_{ρ^+} to the $\rho^+ \to \pi^+\pi^0(\gamma)$ decay rate (see definition in Eq. (5)) as a function of ω_0 and for three different values of m_{ρ^i}.

Fotones duros (hard photons)

ω_0 (MeV)	$m_{\rho^{+,0}} = 772$ MeV Δ_{ρ^+}	Δ_{ρ^0}	$m_{\rho^{+,0}} = 775$ MeV Δ_{ρ^+}	Δ_{ρ^0}	$m_{\rho^{+,0}} = 778$ MeV Δ_{ρ^+}	Δ_{ρ^0}
2	0.01544	0.04475	0.01553	0.04497	0.01561	0.04518
4	0.01290	0.03724	0.01297	0.03742	0.01305	0.03761
6	0.01143	0.03288	0.01149	0.03305	0.011556	0.03322
8	0.01039	0.02981	0.01045	0.02997	0.01051	0.03013
10	0.00959	0.02745	0.00965	0.02760	0.00970	0.02775
12	0.00894	0.02553	0.00900	0.02568	0.00905	0.02582
14	0.00840	0.02393	0.00845	0.02406	0.00850	0.02420
16	0.00793	0.02255	0.00798	0.02268	0.00803	0.02281
18	0.00753	0.02134	0.00758	0.02147	0.00762	0.02159
20	0.00717	0.02027	0.00721	0.02039	0.00726	0.02051
30	0.00581	0.01624	0.00585	0.01635	0.00589	0.01645
40	0.00488	0.01350	0.00492	0.01359	0.00495	0.01369
50	0.00420	0.01146	0.00423	0.01155	0.00426	0.01163
60	0.00366	0.00987	0.00369	0.00994	0.00372	0.01002
70	0.00322	0.00857	0.00325	0.00864	0.00327	0.00871
80	0.00286	0.00750	0.00288	0.00757	0.00291	0.00763
90	0.00255	0.00659	0.00257	0.00665	0.00259	0.00672
100	0.00228	0.00582	0.00230	0.00588	0.00232	0.00593

TABLE III: Decay rates of $\rho^i \to \pi\pi\gamma$ (normalized to the tree-level rates Γ_i^0, see definition in Eq. (16)) as a function of the low photon energy cut ω_0 and for three different values of m_ρ.

$$\Gamma(\rho^0 \to \pi^+\pi^-\gamma,\ \omega_0 = 50\text{ MeV}) - \Gamma(\rho^+ \to \pi^+\pi^0\gamma,\ \omega_0 = 50\text{ MeV}) \approx 1.1\text{ MeV}$$

Fotones inclusivos

$$\frac{\Gamma(\rho^i \to \pi\pi(\gamma), \omega \le \omega_0) + \Gamma(\rho^i \to \pi\pi\gamma, \omega \ge \omega_0)}{\Gamma_i^0} = 1 + \delta_{\rho^i} + \Delta_{\rho^i} \equiv 1 + \sigma_{\rho^i} \; .$$

ω_0 (MeV)	σ_{ρ^0}	σ_{ρ^+}	$\sigma_{\rho^0} - \sigma_{\rho^+}$
2	8.05×10^{-3}	-4.15×10^{-3}	12.20×10^{-3}
4	8.12×10^{-3}	-4.13×10^{-3}	12.25×10^{-3}
6	8.22×10^{-3}	-4.09×10^{-3}	12.31×10^{-3}
8	8.30×10^{-3}	-4.06×10^{-3}	12.36×10^{-3}
10	8.39×10^{-3}	-4.03×10^{-3}	12.42×10^{-3}
12	8.48×10^{-3}	-4.00×10^{-3}	12.48×10^{-3}
14	8.56×10^{-3}	-3.97×10^{-3}	12.53×10^{-3}
16	8.65×10^{-3}	-3.94×10^{-3}	12.59×10^{-3}
18	8.74×10^{-3}	-3.91×10^{-3}	12.65×10^{-3}
20	8.82×10^{-3}	-3.88×10^{-3}	12.70×10^{-3}

TABLE IV: Photon inclusive corrections for $\rho^i \to \pi\pi\gamma$ (see definition in Eq. (19)) as a function of the photon energy ω_0. The masses of charged and neutral ρ mesons were fixed to 775 MeV's.

Differential decay width

$$\Delta\Gamma_\rho = \Gamma_0^0 \left[1 + \sigma_{\rho^0} - \left(\frac{m_{\rho^+} v_+^3}{m_{\rho^0} v_0^3}\right)[1 + \sigma_{\rho^+}]\right] + \Delta\Gamma^{\text{sub}}$$

$$\Gamma_0^0 = 150 \text{ MeV}$$

$$\omega_0 = 10 \text{ MeV}$$

$$\Delta\Gamma_\rho = \begin{cases} 0.86 \text{ MeV}, & \text{if } \Delta m_\rho = 0 \\ 0.02 \text{ MeV}, & \text{if } \Delta m_\rho = -3 \text{ MeV} \\ 1.70 \text{ MeV}, & \text{if } \Delta m_\rho = +3 \text{ MeV} \end{cases}$$

Impacto

The Width difference of rho vector mesons #13

F.V. Flores-Baez (CINVESTAV, IPN), G.Lopez Castro (CINVESTAV, IPN), G. Toledo Sanchez (Mexico U.)
(Aug, 2007)

Published in: *Phys.Rev.D* 76 (2007) 096010 • e-Print: 0708.3256 [hep-ph]

pdf DOI cite 26 citations

Aplicaciones

Correcciones electromagnéticas independientes del modelo

$$\tau \to K\pi\nu$$

$$\frac{d\Gamma_{K\pi}}{d\sqrt{s}} = \frac{G_F^2\left(|V_{us}|F_+^{K\pi}(0)\right)^2 m_\tau^3}{32\pi^3 s} S_{EW}\left(1-\frac{s}{m_\tau^2}\right)^2$$
$$\times\left[\left(1+\frac{2s}{m_\tau^2}\right)q_{K\pi}^3|\tilde{F}_+^{K\pi}(s)|^2+\frac{3\Delta_{K\pi}^2 q_{K\pi}|\tilde{F}_0^{K\pi}(s)|^2}{4s}\right]$$

$$\tilde{F}_+^{K\pi}(s) = \frac{F_+^{K\pi}(s)}{F_+^{K\pi}(0)}\,, \qquad \tilde{F}_0^{K\pi}(s) = \frac{F_0^{K\pi}(s)}{F_+^{K\pi}(0)}$$

$$q_{K\pi} = \frac{1}{2\sqrt{s}}\sqrt{(s-(m_K+m_\pi)^2)(s-(m_K-m_\pi)^2)} \times \theta(s-(m_K+m_\pi)^2)$$

$$\Delta_{K\pi} \equiv m_K^2 - m_\pi^2$$

Correcciones electromagnéticas

•Dependientes del cut off

See for example Edward S. Ginsberg. Physical Review Vol.142, No. 4,
(1966) 1035.

•Teoría chiral con resonancias (K_{l3})

V. Cirigliano, M. Knecht, H. Neufeld and P.Talavera. Eur. Phys. J. C 23
(2002) 121.

•Independientes del modelo

D.R. Yennie, S.C. Frautschi and H. Sura. Annals of Physics 13:379-452
(1961).
N.Meisteir and D.R. Yennie. Physical Review 130, No. 3, (1963) 1210
A. Sirlin. Physical Review 164, No. 5 (1967) 1767.

Invariancia de Gauge, finito IR, finito UV y términos dominantes logarítmicos.

Técnica ampliamente conocida

- Decamientos semileptónicos de hiperiones

D.M. Tun and S.R. Juárez W and A. García. Phys. Rev. D40, (1989) 2967-2979.

- Decaimientos leptonicos de mesones pseudoescalares

A. García and A. Queijeiro. Phys. Rev. D23, (1981) 1662-1566.

- Análisis de las correcciones al Dalitz Plot de Kl3

C. Juárez-León, A. Martínez, M. Neri, J.J. Torres and Rubén Flores Mendieta. Phys. Rev. D83, 054004 (2011).

Decaimiento hadrónico del tau

$$\frac{d\Gamma^{(0)}_{P^+P^0}}{d\sqrt{s}} = \frac{|G_F V_{CKM}|^2 m_\tau^3}{32\pi^3 s}[1-\frac{s}{m_\tau^2}]^2 \left[\frac{3\Delta_+^2 q_{+0}}{4s}|F_0(s)|^2 + |F_+(s)|^2(1+\frac{2s}{m_\tau^2})q_{+0}^3\right] A_{p^+p^{(0)}} \ ,$$

$$A_{p^+p^{(0)}} \ = \ \tfrac{4}{3}C_{CG}^2$$

$$q_{+0} = \frac{1}{2\sqrt{s}}\sqrt{(s-(m_+ + m_0)^2)(s-(m_+ - m_0)^2)} \times \theta(s-(m_+ + m_0)^2)$$

$$\tfrac{1}{3}(\tfrac{2}{3})$$

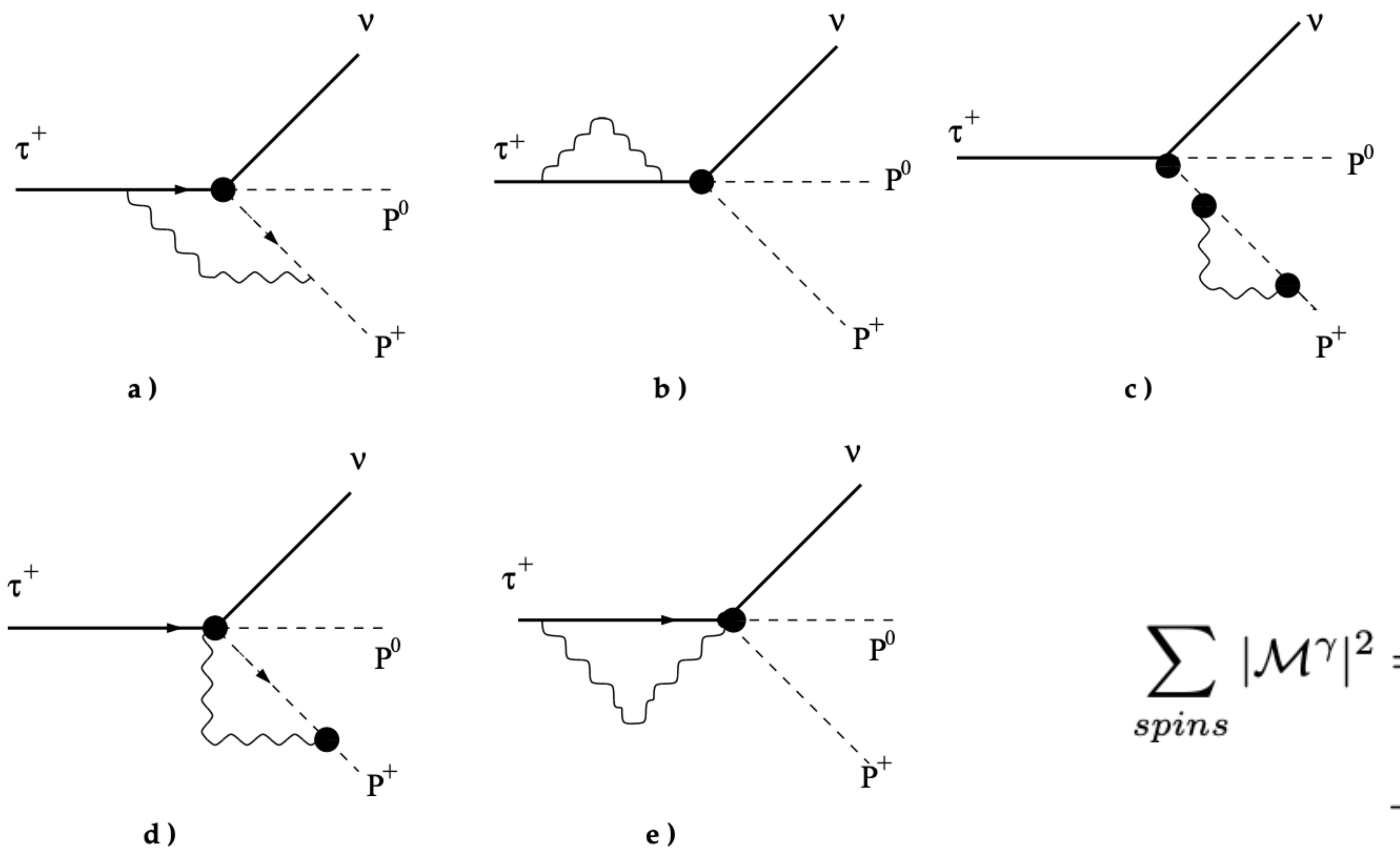
$K^+\pi^0, (K^0\pi^+)$

$$(m_+ + m_0)^2 \leq s \leq m_\tau^2 \ , \qquad u_-(s) \leq u \leq u_+(s)$$

$$u = (p_\tau - p^+)^2$$

Factores de forma

Belle Collaboration.
Physics Letters B 654, (2007) 65



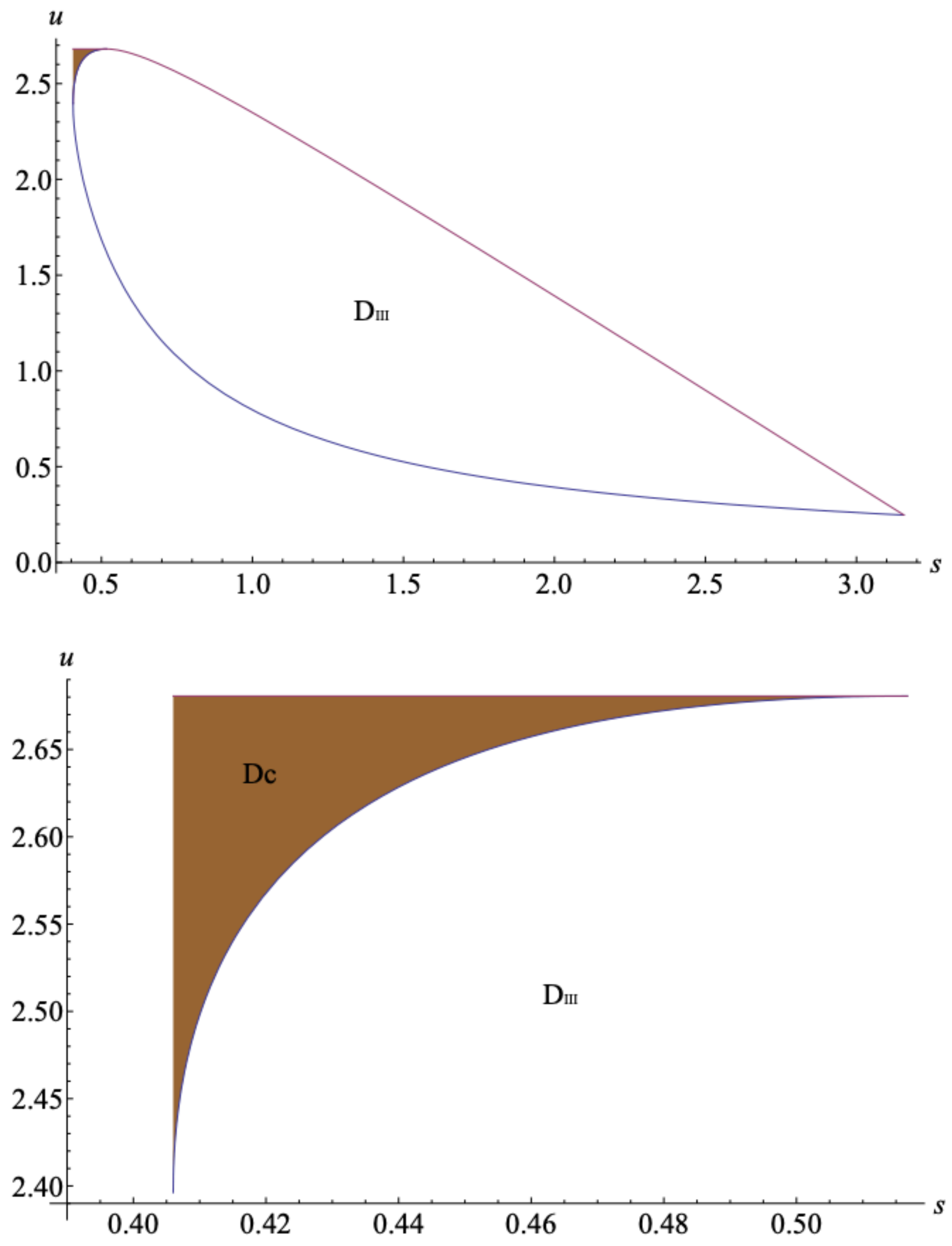
$$\sum_{spins} |\mathcal{M}^{\gamma}|^2 = \sum_{spins} |\mathcal{M}^{(0)}|^2 e^2 \left[\frac{p^+ \cdot \epsilon(k)}{p^+ \cdot k} - \frac{p_\tau \cdot \epsilon(k)}{p_\tau \cdot k} \right]^2 + \sum_{spins} |\mathcal{M}^{'}|^2 k^0 + \sum_{spins} |\mathcal{M}^{''}|^2 k^1 + \ldots ,$$

F. Bloch and A. Nordsieck, Phys. Rev. 52, (1937) 54.

F.E. Low, Phys. Rev. 110, (1958) 974

T.H. Burnett and N.M. Kroll, Phys.Rev.Lett.20, (1968) 86

F. Coester, Phys.Rev. 83, (1951) 798.
Jauch and Rohrlich. *The Theory of photons and electrons: the relativistic quantum field theory of charged particels with spin one-half.* Addison-Wesley, 1955.



The upper plot shows the projection of the 4-body radiative Dalitz Plot onto the u-s plane where can be seen that the 3-body Dalitz Plot is inside this region. The lower plot shows an amplification of the projected complementary region D_c (see text) accesible only to the radiative process.

Resultados

$$\Gamma_{K^0\pi^+} = \Gamma^{(0)}_{K^0\pi^+}[1 + \delta^{m.i.}_{EM}]$$

$$\delta^{m.i.}_{EM} = \frac{[\alpha/2\pi]}{m_\tau^8 I^{(0)}_{K\pi}} \frac{3}{4} \int \Big\{ |\tilde{F}_+(s)|^2 [\mathcal{D}(s,u) f_I^{m.i.} + \mathcal{G}(s,u) f_{II}^{m.i.}]$$
$$+ |\tilde{F}_-(s)|^2 [\mathcal{D}_2(s) f_I^{m.i.} + \mathcal{E}(s,u) f_{II}^{m.i.}]$$
$$+ 2\tilde{F}_-(s)\tilde{F}_+(s) [\mathcal{D}_3(s,u) f_I^{m.i.} + \mathcal{H}(s,u) f_{II}^{m.i.}] \Big\}\, ds du$$

$$\delta_{em}^{\bar{K}^0\pi^+} = -0.127\,\%$$

$$\delta_{em}^{\bar{K}^0\pi^+} = (-0.15 \pm 0.2)\%$$

Mario Antonelli, Vincenzo Cirigliano, Alberto Lusiani and Emilie Passemar. arXiv:1304.8134v1 [hep-ph] 30 Apr 2013

Published in: *JHEP* 10 (2013) 070 • e-Print: 1304.8134 [hep-ph]

Loops

- Contribuciones supersimétricas a LFV

Eur. Phys. J. C (2016) 76:561
DOI 10.1140/epjc/s10052-016-4402-4

THE EUROPEAN PHYSICAL JOURNAL C

CrossMark

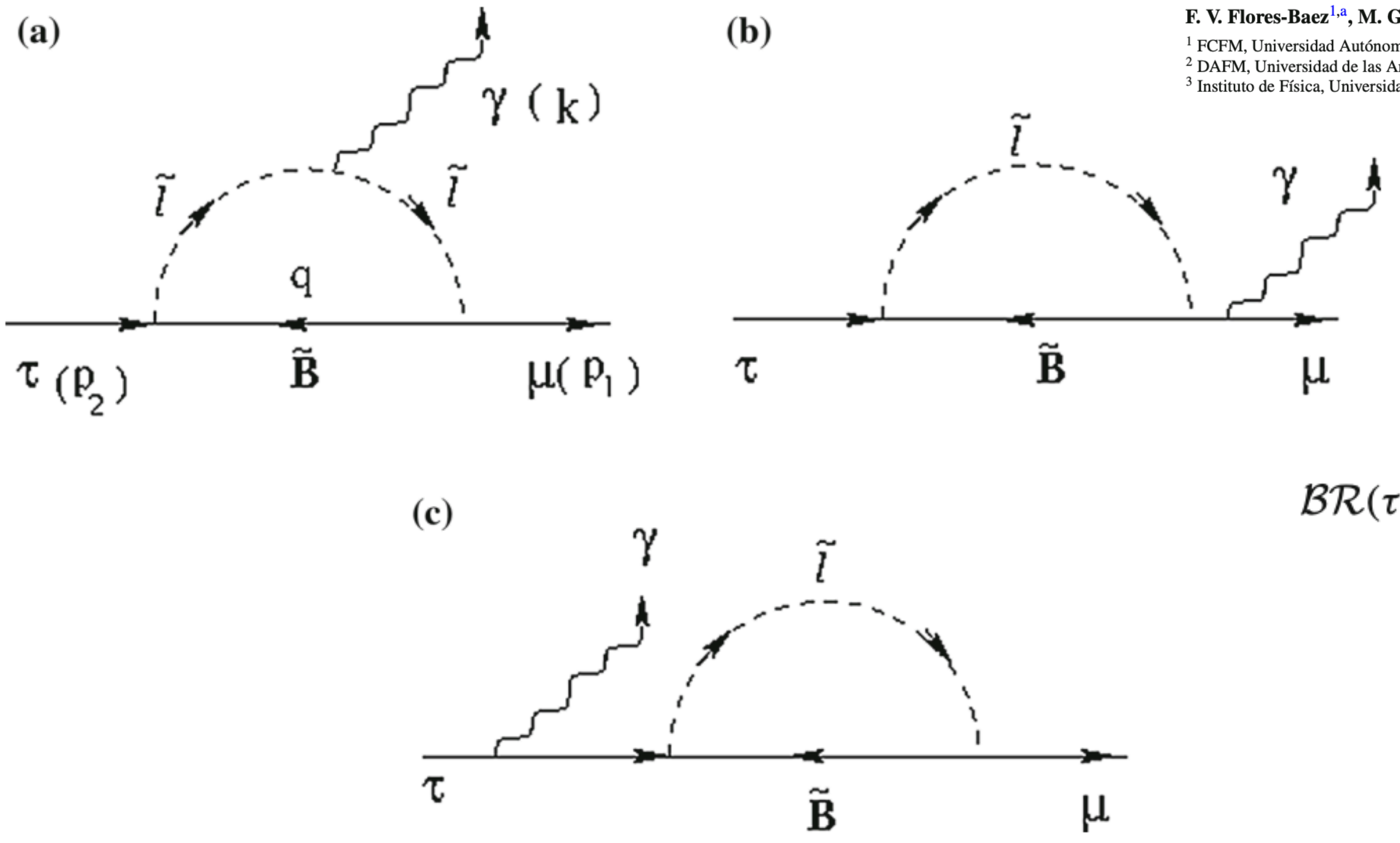
Regular Article - Theoretical Physics

Muon $g-2$ through a flavor structure on soft SUSY terms

F. V. Flores-Baez[1,a], **M. Gómez Bock**[2,b], **M. Mondragón**[3,c]

[1] FCFM, Universidad Autónoma de Nuevo León, UANL Ciudad Universitaria, 66450 San Nicolás de los Garza, Nuevo León, Mexico
[2] DAFM, Universidad de las Américas Puebla, UDLAP, Ex-Hacienda Sta. Catarina Mártir, Cholula, Puebla, Mexico
[3] Instituto de Física, Universidad Nacional Autónoma de México, Apdo. Postal 20-364, 01000 Mexico, D.F., Mexico

$$BR(\tau \to \mu + \gamma)$$



$$\mathcal{BR}(\tau \to \mu\gamma) = \frac{(1-x^2)^3 m_\tau^3}{4\pi\Gamma_\tau}[|E|^2 + |F|^2].$$

$$x = \frac{m_\mu}{m_\tau}$$

- Contribuciones a g-2

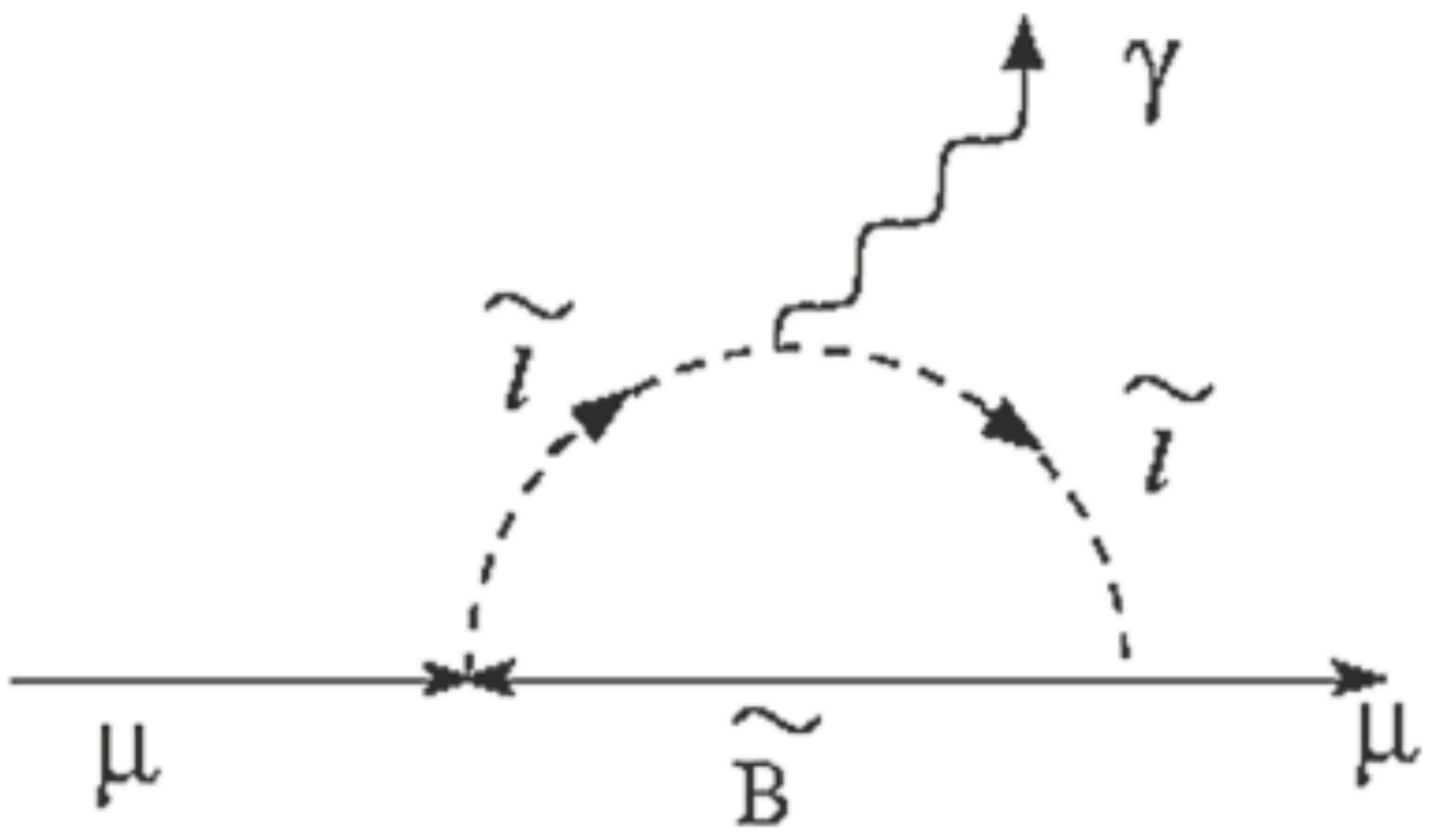


Fig. 2 Slepton contribution to a_μ

M.E. Peskin, D.V. Schroeder, *An Introduction to quantum field theory* (Addison-Wesley Publishing Company, 1995), p. 184

Estatus actual y el futuro próximo

- Formación académica en Licenciatura

- Clases: 5 cursos por semestre de licenciatura y 1 de posgrado en Ingeniería Física.

- Estudiantes de licenciatura: Tesinas, tutorías académicas, iniciación a la producción científica.

- Investigación

- Contribuciones completas de SUSY a LFV y g-2

- Correcciones radiactivas incluyendo los efectos dependientes del modelo*

- Explorar aplicación de teorías efectivas: χPT, R χPT