Pion Electromagnetic and Transition Form Factors with the Light-Front Approach

Venturing off the Light-Cone - Local Versus Global Features
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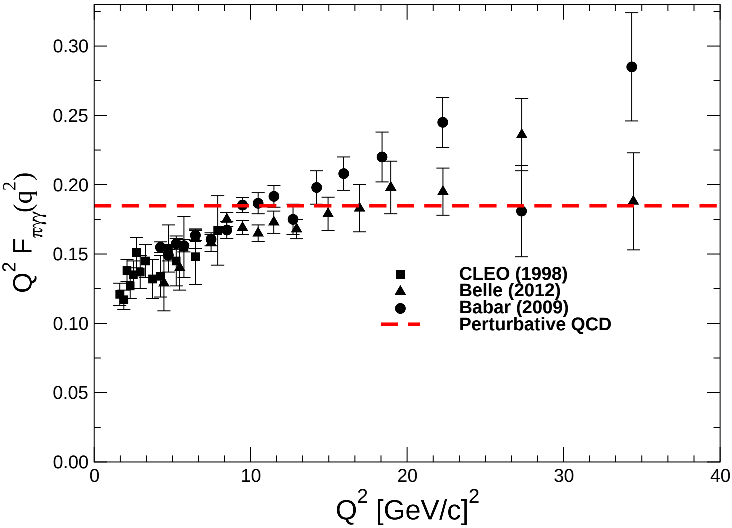
May 24, 2013

Motivations

- $\pi^0 \rightarrow \gamma\gamma$ **Most Important Example of the Triangle Anomaly**
- π^0 **Meson is the Lightest Meson cannot Decay to Another Hadronic State**
- $\pi^0 \rightarrow \gamma\gamma$ **Is Conected to the Adler-Bell-Jackiw Anomaly**
- **Babar Experiment (2009)**
- **Belle Experiment (2012)**



- **QCD**: $2f_\pi \implies$ **Brodsky & Lepage (1980)**

Light-Front Coordinates

Four-Vector $\implies x^\mu = (x^0, x^1, x^2, x^3) = (x^+, x^-, x_\perp)$

$x^+ = t + z \qquad x^+ = x^0 + x^3 \implies$ **Time**

$x^- = t - z \qquad x^- = x^0 - x^3 \implies$ **Position**

Metric Tensor and Scalar product

$$x \cdot y = x^\mu y_\mu = x^+ y_+ + x^- y_- + x^1 y_1 + x^2 y_2 = \frac{x^+ y^- + x^- y^+}{2} - \vec{x}_\perp \vec{y}_\perp$$

$$\begin{aligned} p^+ &= p^0 + p^3 \\ p^- &= p^0 - p^3 \\ p^\perp &= (p^1, p^2) \end{aligned}$$

Dirac Matrix and Electromagnetic Current

$\gamma^+ = \gamma^0 + \gamma^3 \implies$ **Electr. Current** $J^+ = J^0 + J^3$
$\gamma^- = \gamma^0 - \gamma^3 \implies$ **Electr. Current** $J^- = J^0 - J^3$
$\gamma^\perp = (\gamma^1, \gamma^2) \implies$ **Electr. Current** $J^\perp = (J^1, J^2)$

$p^\mu x_\mu = \frac{p^+ x^- + p^- x^+}{2} - \vec{p}_\perp \vec{x}_\perp$
$x^+, x^-, \vec{x_\perp} \implies p^+, p^-, \vec{p}_\perp$
$p^- \implies$ **Light-Front Energy**
$p^2 = p^+ p^- - (\vec{p}_\perp)^2 \implies p^- = \frac{(\vec{p}_\perp)^2 + m^2}{p^+}$ **On-shell**
Bosons $\implies S_F(p) = \frac{1}{p^2 - m^2 + \imath\epsilon}$
Fermions $\implies S_F(p) = \frac{\not{p} + m}{p^2 - m^2 + \imath\epsilon} + \frac{\gamma^+}{2p^+}$
Phys. Rept. 301, (1998) 299-486, Brodsky, Pauli and Pinsky

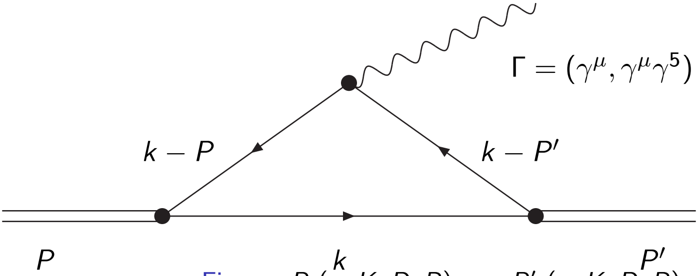


Figure: $P\ (\pi, K, D, B) \longrightarrow P'\ (\pi, K, D, B)$

- **Three-point Function** $\Rightarrow$ **The General Matrix Element**

$$\left\langle p' \left| J_q^{\mu}\left(q^2\right) \right| p \right\rangle = \frac{N_c}{(2\pi)^4} \int d^4k \; Tr\left[\Lambda_{M'}\left(k, p'\right) S_F\left(k - p'\right) J_q^{\mu} S(k-p) \Lambda_M\left(k, p\right) S_F\left(k\right)\right]$$

- $PS - q\bar{q}$ **Vertex:** γ^5
- **Fermi Propagator** $\Longrightarrow$ $S_F\left(p\right) = \frac{i}{\not{p} - m_i + i\varepsilon}$

Eletromagnetic Form Factor and Pseudoscalar Constant

$$\left\langle p' \left| J_q^{\mu}\left(q^2\right) \right| p \right\rangle = \left(p + p'\right)^{\mu} F_{PS}^{em}(q^2).$$

- **Weak Decay Constant of the Pseudoscalar Mesons**

$$\langle 0 \left| A^{\mu}(0) \right| p\rangle = \imath\sqrt{2} f_{ps} p^{\mu}$$

$$\Longrightarrow \qquad \mathbf{A}^{\mu} = \bar{\mathbf{q}}\gamma^{\mu}\gamma^{\mathbf{5}}\frac{\tau}{\mathbf{2}}\mathbf{q}(\mathbf{x})$$

$$\imath \mathbf{p}^{\mu}\mathbf{f}_{\pi} = \frac{\mathbf{m}}{\mathbf{f}_{\pi}}\mathbf{N_c}\int \frac{\mathbf{dk^4}}{(\mathbf{2}\pi)^{\mathbf{4}}}\mathbf{Tr}\left[\gamma^{\mu}\gamma^{\mathbf{5}}\mathbf{S}(\mathbf{k})\gamma^{\mathbf{5}}\mathbf{S}(\mathbf{k}-\mathbf{p})\right]\mathbf{\Lambda_M}(\mathbf{k},\mathbf{p})$$

- **Plus Component E.M. Current:** $\gamma^{+} = \gamma^{0} + \gamma^{3}$

Some QCD REMARKS

• $R = \frac{\sigma(e^+e^- \to q\bar{q})}{\sigma(e^+e^- \to \mu^-\mu^+)} = N_c \sum Q_q^2 = N_c \left[(\frac{2}{3})^2 + (\frac{-1}{3})^2 + (\frac{-1}{3})^2 \right] = \frac{2}{3} N_c = 2$

For $E_{cm} > 2\ GeV \gg 2m_u,\ 2m_d,\ 2m_s,$ **for** **(u,d,s)**

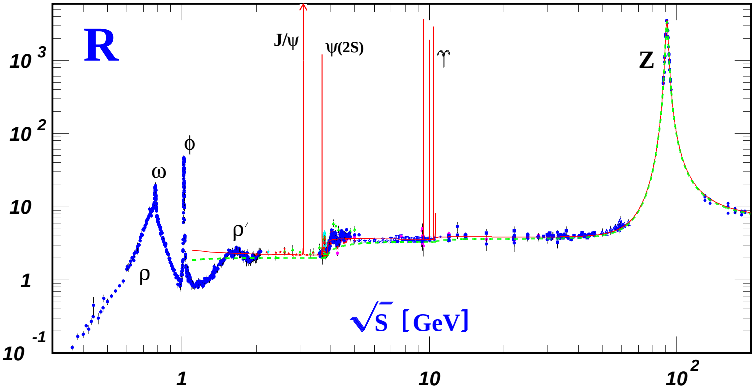
• $R = \frac{\sigma(e^+e^- \to q\bar{q})}{\sigma(e^+e^- \to \mu^-\mu^+)} = N_c \left[(\frac{2}{3})^2 + (\frac{-1}{3})^2 + (\frac{-1}{3})^2 + (\frac{2}{3})^2 \right] = \frac{10}{9} N_c$

For $E_{cm} > 3\ GeV \gg 2m_c,$ **for** **(u,d,s,c)**

• $R = \frac{\sigma(e^+e^- \to q\bar{q})}{\sigma(e^+e^- \to \mu^-\mu^+)} = N_c \left[(\frac{2}{3})^2 + (\frac{-1}{3})^2 + (\frac{-1}{3})^2 + (\frac{2}{3})^2 + (\frac{-1}{3})^2 \right] = \frac{11}{9} N_c$

For $E_{cm} > 10\ GeV \gg 2m_b,$ **for** **(u,d,s,c,b)**

⋆ **If** $N_C = 3$ **!!!**



Ref.: J. Beringer et al. (Particle Data Group), Phys. Rev. D86, 010001 (2012)

- $\pi^0 \rightarrow \gamma\gamma \quad \Longrightarrow \Gamma = \frac{g^2_{\pi^0\gamma\gamma}\alpha^2_{em} m^3_\pi}{16\pi^3 f^2_\pi}$

- **Exp.:** $\Gamma^{Exp} \simeq 7.80 \Longleftrightarrow \mathbf{N_c = 3}, \; \mathbf{g_{\pi\gamma\gamma} = 0.5}, \; \mathbf{f_\pi \simeq 92 \; MeV}$

- **Effective Theory:**

$$\Gamma = \frac{m^3_\pi}{64\pi}|A_{\gamma\gamma}|^2$$

Where: $|A_{\gamma\gamma}|^2 = \frac{\alpha N_c}{3\pi f_\pi}$

Again: $\Longrightarrow \; N_c = 3$ **and** $f_\pi \simeq 92 \; MeV$

Ref.Dynamics of the Standard Model by
J. F. Donoghue, E. Golowich and B. R. Holtein

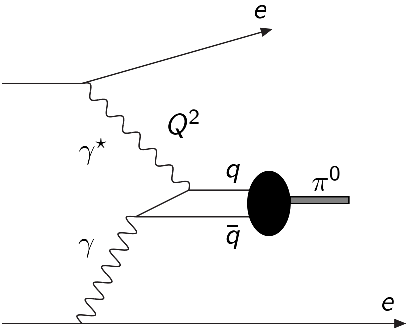


Figure: Feynman Diagram for $\gamma\gamma^{\star} \rightarrow q\bar{q} \rightarrow \pi^0$

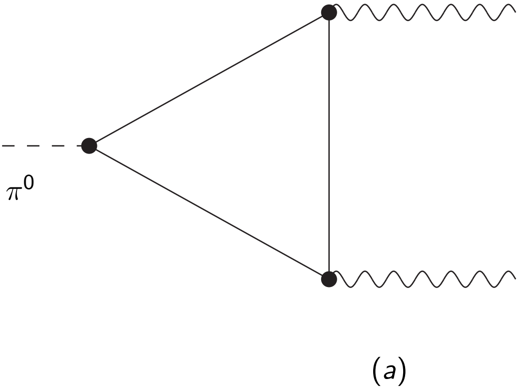


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Figure: Pion Decay Diagram (a).

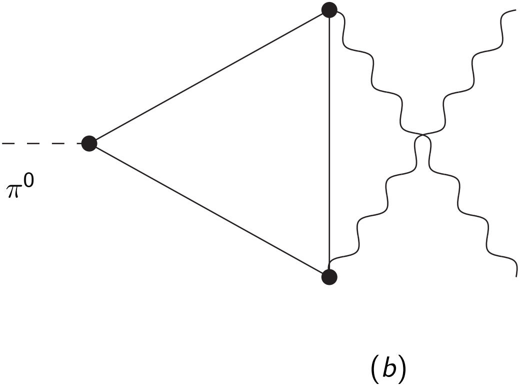

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Figure: Pion Decay Diagram (b).

Effective Interaction Lagrangian

$$\mathcal{L}^{int}_{\pi q} = -\imath \frac{M}{f_\pi} \vec{\pi} \cdot \vec{q} \gamma^5 \vec{\tau} q \ ;$$

Where:

$\rightarrow$ M: **Constituent Quark Mass**

$\rightarrow$ f_π: **Weak Decay Constant**

$\rightarrow$ π: **Pion Field**

$\rightarrow$ q: **Quark Field**

- $\hbar = c = 1$

$T^{\mu\nu}$ Tensor : Amplitude (a) and (b)

$$T^{\mu\nu} = t_{\mu\nu}(k_1, k_2) + t_{\mu\nu}(k_2, k_1)$$

- **After Calculation of Trace in Spinor and Flavour Basis:**

$$t_{\mu\nu} = \frac{4}{3}\frac{M^2}{f_\pi} e_0^2 N_c \epsilon_{\mu\nu\alpha\beta} k_1^\alpha k_2^\beta I(k_1^2) \ ;$$

$$I(k_1^2) = \int \frac{d^4k}{(2\pi)^4} \frac{1}{((k_2-k)^2 - M^2 + \imath\epsilon)} \frac{1}{(k^2 - M^2 + \imath\epsilon)} \frac{1}{((k_\pi - k)^2 - M^2 + \imath\epsilon)} \ .$$

- $k_\pi^\mu = k_1^\mu + k_2^\mu \quad \Longleftrightarrow$ **Pion Momentum**
- $k_1^\mu = q^\mu \quad \Longleftrightarrow$ **Momentum Transfer**

$$I(k_1^2) = \int \frac{d^4k}{(2\pi)^4} \frac{1}{((k_2-k)^2 - M^2 + \imath\epsilon)} \times \frac{1}{(k^2 - M^2 + \imath\epsilon)((k_\pi - k)^2 - M^2 + \imath\epsilon)} .$$

- **Ref. Frame:** $q^+ = q^- = 0$ **and** $q_\perp \neq 0$

k^- Integration:

$$I(k_1^2) = \frac{1}{2(2\pi)^4} \int dk^+ d^2k^+ dk^-$$
$$\frac{1}{(k^+(k_\pi^+ - k^+)(k_2^+ - k^+)(k^- - \frac{k_\perp^2 + M^2 - \imath\epsilon}{k^+})}$$
$$\times \frac{1}{(k_2^- - k^- - \frac{(\vec{k}_2 - \vec{k})_\perp^2 + M^2 - \imath\epsilon}{(k_2^+ - k^+)})(k_\pi^- - k^- - \frac{(\vec{k}_\pi - \vec{k})_\perp^2 + M^2 - \imath\epsilon}{(k_\pi^+ - k^+)})} ,$$

- $k_\pi^+ = k_2^+$ and $k_\pi^- = k_2^-$.

$$I(q^2) = -\frac{1}{2(2\pi)^3}\int \frac{dx d^2 k_\perp}{x(1-x)^2} \frac{1}{(k_2^- k_2^+ - \frac{k_\perp^2 + M^2}{x} - \frac{(\vec{k}_2 - \vec{k})_\perp^2 + M^2}{1-x})} \times \frac{1}{(k_\pi^- k_\pi^+ - \frac{k_\perp^2 + M^2}{x} - \frac{(\vec{k}_\pi - \vec{k})_\perp^2 + M^2}{1-x})}$$

Integral Contribuition

i) $k^+ < 0 \implies$ **Not Contribute**

ii) $k^+ > k_\pi^+ \implies$ **Not Contribute**

iii) $0 < k^+ < k_\pi \implies$ **Contribute** **(On-Shell Quark)**

- **Integral Results**

$$
\begin{aligned}
I(q^2) &= -\frac{1}{2(2\pi)^3}\int \frac{dx d^2k_\perp}{x(1-x)^2}\frac{1}{(k_2^- k_2^+ - \frac{k_\perp^2+M^2}{x} - \frac{(\vec{k}_2-\vec{k})_\perp^2+M^2}{1-x})} \\
&\times \frac{1}{(k_\pi^- k_\pi^+ - \frac{k_\perp^2+M^2}{x} - \frac{(\vec{k}_\pi-\vec{k})_\perp^2+M^2}{1-x})} \quad ,
\end{aligned}
$$

- $\Longrightarrow \quad \mathbf{0} < \mathbf{k}^+ < \mathbf{k}_\pi^+ \iff \mathbf{0} < \mathbf{x} < \mathbf{1}$

- **Relative momentum:** $\vec{K}_\perp = (1-x)\vec{k}_\perp - x(\vec{k}_\pi - \vec{k})_\perp$

$$I(q^2) = \frac{1}{2(2\pi)^3}\int \frac{dx d^2K_\perp}{(1-x)} \frac{1}{((\vec{K}+x\vec{q})_\perp^2 + M^2)(m_\pi^2 - M_0^2)}$$

- **Free Mass Operator**

$$M_0^2 = \frac{K_\perp^2 + M^2}{x(1-x)}$$

Pion Eletromagnetic Transition Form Factor

$$j_\mu = e_0^2 \epsilon_{\mu\nu\alpha\beta} \epsilon_\gamma^\nu q^\alpha k_\pi^\beta F_{\pi^0}(q^2)$$

$$F_{\pi^0}(-q^2) = \frac{N_c}{6\pi^3} \frac{M^2}{f_\pi} \int \frac{dx d^2 K_\perp}{(1-x)} \frac{1}{((\vec{K} + x\vec{q})_\perp^2 + M^2)(M_0^2 - m_\pi^2)}$$

- $\epsilon_\gamma^\nu \Rightarrow$ **Polarization // Real Photon**

Wave Function

- **The Wave Function // Replaced**

$$\frac{1}{-m_\pi^2 + M_0^2} \to \frac{\pi^{\frac{3}{2}} f_\pi}{M\sqrt{M_0 N_c}} \Phi_\pi(K^2)$$

- **Wave Function $\Phi(k^2)$ Normalization**

$$\int d^3K \Phi_\pi^2(k^2) = 1 \ ,$$

Ref.

- **T. Frederico and G. Miller, Phy. Rev. D45 (1992) 071901 ibid. Phy. Rev. D50 (1994) 210**
- **J.P.B.C. de Melo, T. Frederico and H.L. Naus Phy.Rev. C59 (1999) 2278**

- **Final Pion Transition Form Factor**

$$F_{\pi^0}(-q^2) = \frac{\sqrt{N_c} M}{6\pi^{\frac{3}{2}}} \int \frac{dx d^2 K_\perp}{(1-x)\sqrt{M_0}} \frac{\Phi_\pi(K^2)}{((\vec{K} - x\vec{q})^2_\perp + M^2)}$$

- **Soft Pion Limit** ***:**

$$F_{\gamma\pi^0}(0) = \frac{1}{4\pi^2 f_\pi}$$

$\star$ **J. S. Schwinger, Phy. Rev.82, (1951) 664.**
S. L. Adler, Phys. Rev. Phy. Rev. 177, (1969) 2426.
J. S. Bell, R. Jackiw, Nuovo Cimento, 60 , (1969) 47.

Wave Function

i) **Gaussian Wave Function**

$$\Phi_\pi = \left(\frac{8r_{NR}^2}{3\pi}\right)^{3/4} exp\left[-\left(\frac{4}{3}\right)(r_{NR}k)^2\right]$$

ii) **Hydrogen-Atom Wave Function**

$$\Phi_\pi = \frac{1}{2\pi}\left(\frac{\sqrt{3}}{r_{NR}}\right)^{5/2}\left[\frac{1}{(\frac{3}{4}r_{NR}^{-2}+k^2)^2}\right]$$

- **Two Independents Parameters**

i) Quark Mass: M

ii) Non-Relativistic Charge Radius: r_{NR}

$$r_{NR}^2 = -6 \frac{d}{dq^2} \int d^3K \Phi(|\vec{K} + \frac{\vec{q}}{2}) \Phi_\pi(K)$$

- **Neutral Pion Radius**

$$r^2_{\pi^0} = \frac{\sqrt{N_c}M}{F_{\pi^0}(0)\pi^{\frac{3}{2}}} \int \frac{dx d^2 K_\perp}{(1-x)\sqrt{M_0}} \frac{-\vec{K}^2_\perp + M^2}{(-\vec{K}^2_\perp + M^2)^3} \Phi_\pi(K^2) \ .$$

- **Limit:** $-q^2 \ \rightarrow \ \infty \ \Longrightarrow \sim \ q^2$

$$\Lambda_{\pi^0} = \lim_{-q^2 \to \infty} [-q^2 F_{\pi^0}(-q^2) = \frac{\sqrt{N_c}M}{6\pi^{\frac{3}{2}}} \int \frac{dx d^2 K_\perp}{(1-x)\sqrt{M_0}} \Phi_\pi(K^2)$$

Some Results

Table-I: f_π : 92.4 MeV **Fixed**

model	$m_{u,d}$ $[GeV]$	r_{nr} $[fm]$	$< r^2 >$ $[fm^2]$	$< r^2_{\pi^0} >$ $[fm^2]$
Gaussian	**0.220**	**0.345**	**0.637**	**0.683**
	0.330	**0.472**	**0.655**	**0.552**
Hydrogen	**0.220**	**0.593**	**0.795**	**0.782**
	0.330	**0.708**	**0.807**	**0.582**
Exp.[PDG]			**0.672±0.008**	

Table-II: Quark Mass fixed : $m_{u,d} = 0.220\ GeV$

model	f_π $[MeV]$	r_{nr} $[fm]$	$< r^2 >$ $[fm^2]$	$< r^2_{\pi^0} >$ $[fm^2]$
Gaussian	**92.4**	**0.345**	**0.637**	**0.683**
	97.0	**0.303**	**0.589**	**0.657**
	110.0	**0.172**	**0.406**	**0.664**
Hydrogen	**92.4**	**0.593**	**0.795**	**0.782**
	97.0	**0.543**	**0.750**	**0.767**
	110.0	**0.410**	**0.626**	**0.720**
Exp.[PDG]	**92.2 $\pm$ 0.021**		**0.672 $\pm$ 0.008**	

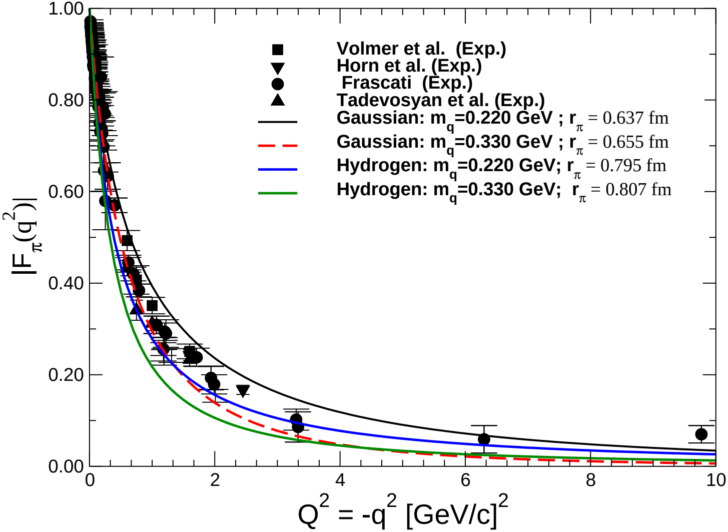
Exp. References:

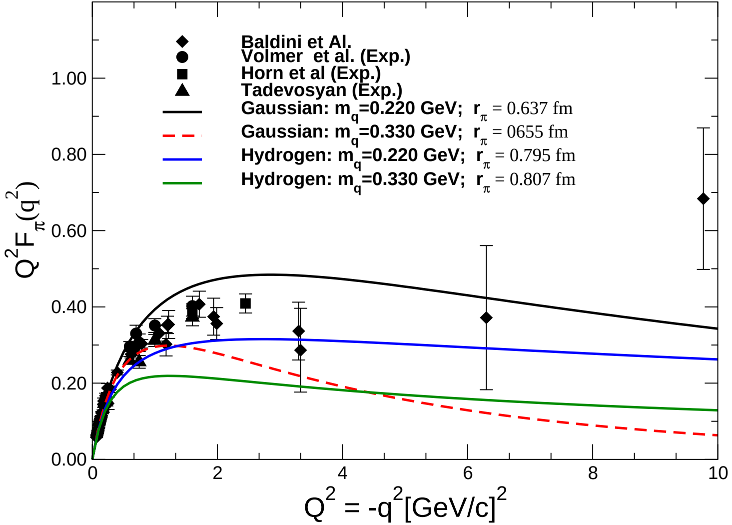
- **Pion Electromagnetic Form Factor**

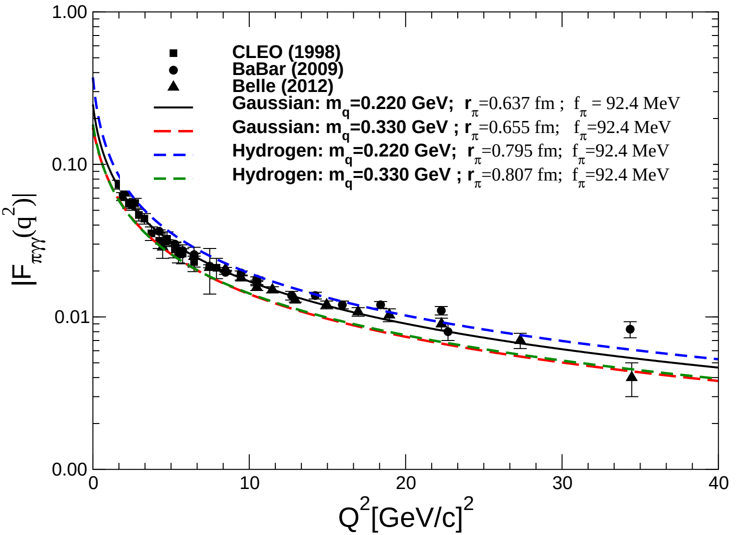
⋆ **R. Baldini, et al., Eur. Phys. J. C 11 (1999), 709**
Nucl. Phys. A666-667 (2000), 3
⋆ **J. Volmer et al., (The Jefferson Lab F_π Collaboration),**
Phy. Rev. Lett. 86 (2001), 1713
⋆ **T. Horn at al., Phys. Rev. Lett. 97, (2006), 192001**
⋆ **V. Tadevosyan et al., Phys. Rev. C 75, (2007), 055205**

- **Pion Transition Form Factor**

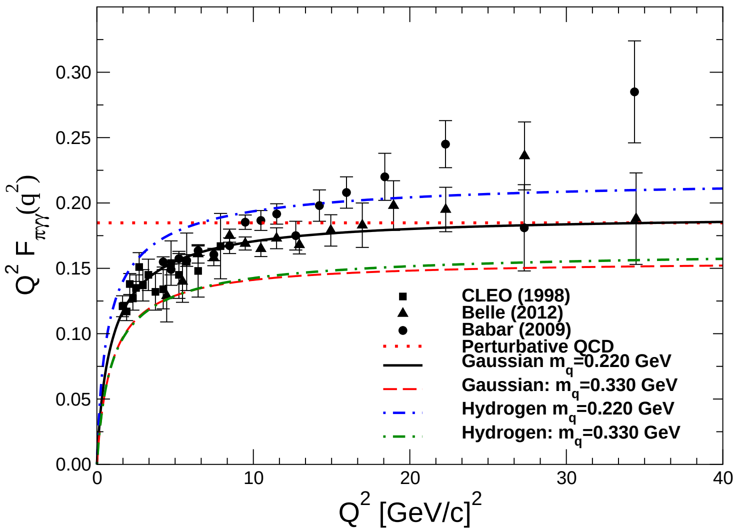
⋆ **(Belle-2012) S. Uehara et al., Phys. Rev. 86, (2012) 092007**
⋆ **(Babar-2009) B.Aubert et al., Phy. Rev. D 80, (2009) 052002**
⋆ **(CLEO-1998) J. Gronberg et al., Phy. Rev. D 57, (1998) 33**


1.00
0.80
0.60
0.40
0.20
0.00
0
2
4
6
8
10
|F_π(q²)|
Q² = -q² [GeV/c]²
Volmer et al. (Exp.)
Horn et al. (Exp.)
Frascati (Exp.)
Tadevosyan et al. (Exp.)
Gaussian: m_q=0.220 GeV ; r_π = 0.637 fm
Gaussian: m_q=0.330 GeV ; r_π = 0.655 fm
Hydrogen: m_q=0.220 GeV; r_π = 0.795 fm
Hydrogen: m_q=0.330 GeV; r_π = 0.807 fm

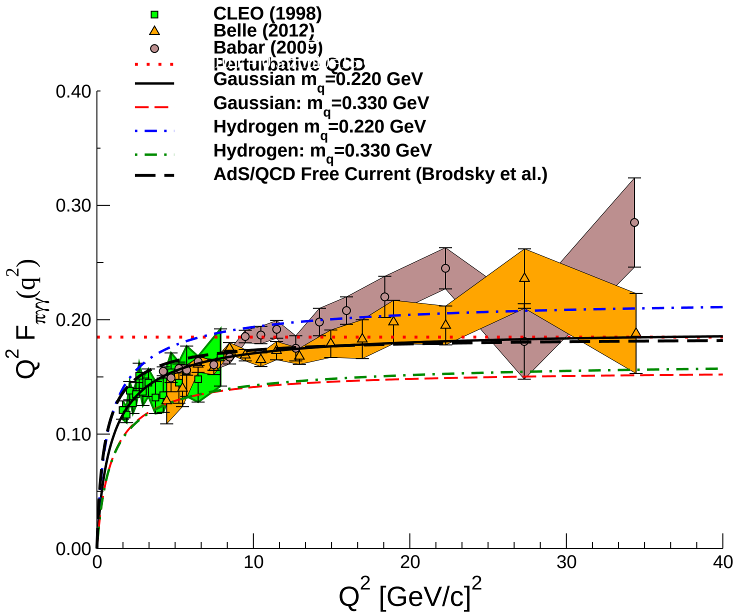

Baldini et Al.
Volmer et al. (Exp.)
Horn et al (Exp.)
Tadevosyan (Exp.)
Gaussian: m_q=0.220 GeV; r_π = 0.637 fm
Gaussian: m_q=0.330 GeV; r_π = 0655 fm
Hydrogen: m_q=0.220 GeV; r_π = 0.795 fm
Hydrogen: m_q=0.330 GeV; r_π = 0.807 fm
Q^2F_π(q^2)
Q^2 = -q^2[GeV/c]^2
0.00
0.20
0.40
0.60
0.80
1.00
0
2
4
6
8
10



1.00
0.10
0.01
0.00
0
10
20
30
40
$|F_{\pi\gamma\gamma}(q^2)|$
$Q^2[GeV/c]^2$
CLEO (1998)
BaBar (2009)
Belle (2012)
Gaussian: m_q=0.220 GeV; r_π=0.637 fm ; f_π = 92.4 MeV
Gaussian: m_q=0.330 GeV ; r_π=0.655 fm; f_π=92.4 MeV
Hydrogen: m_q=0.220 GeV; r_π=0.795 fm; f_π=92.4 MeV
Hydrogen: m_q=0.330 GeV ; r_π=0.807 fm; f_π=92.4 MeV

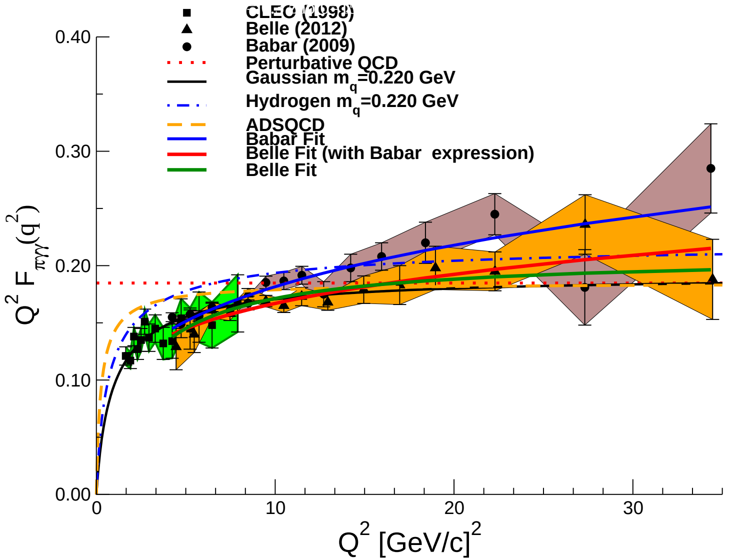


$Q^2 F_{\pi\gamma\gamma}(q^2)$
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
10
20
30
40
Q^2 [GeV/c]^2
CLEO (1998)
Belle (2012)
Babar (2009)
Perturbative QCD
Gaussian m_q=0.220 GeV
Gaussian: m_q=0.330 GeV
Hydrogen m_q=0.220 GeV
Hydrogen: m_q=0.330 GeV


CLEO (1998)
Belle (2012)
Babar (2009)
Perturbative QCD
Gaussian m_q=0.220 GeV
Gaussian: m_q=0.330 GeV
Hydrogen m_q=0.220 GeV
Hydrogen: m_q=0.330 GeV
AdS/QCD Free Current (Brodsky et al.)
0.00
0.10
0.20
0.30
0.40
0
10
20
30
40
Q^2 F_πγγ(q^2)
Q^2 [GeV/c]^2

Fit Curves:

- **Babar:** $Q^2|F(Q^2)| = A\,(\frac{Q^2}{10\ GeV^2})^{\beta} \Longrightarrow \begin{cases} A = 0.182\ GeV \\ \beta = 0.250 \end{cases}$
- **Belle:** $Q^2|F(Q^2)| = A_1\,(\frac{Q^2}{10\ GeV^2})^{\beta_1} \Longrightarrow \begin{cases} A_1 = 0.167\ GeV \\ \beta_1 = 0.204 \end{cases}$
- **Belle:** $Q^2|F(Q^2)| = \frac{B\ Q^2}{Q^2+C} \Longrightarrow \begin{cases} B = 0.209\ GeV \\ C = 2.2\ GeV^2 \end{cases}$



CLEO (1998)
Belle (2012)
Babar (2009)
Perturbative QCD
Gaussian m_q=0.220 GeV
Hydrogen m_q=0.220 GeV
ADSQCD
Babar Fit
Belle Fit (with Babar expression)
Belle Fit
0.40
0.30
0.20
0.10
0.00
0
10
20
30
Q^2 F_πγγ(q^2)
Q^2 [GeV/c]^2

Some Coments

- **Theoretical Analyses:** **Explain Babar Data** and **Not Explain**

Models try reproduce Babar:

- **Alteration of the asymptotic pion wave function or distribuition amplitude**
- **Dressing $\gamma - q\bar{q}$-vertex with Phenomelogical Interactions, ie., like VMD**

Some References:

- M. V. Polyakov, JETP, 90 (2009) 228
- S. Noguera and V. Vento, Eur. Phys. J. A48 (2012) 143
- S. S. Agaev, V. M. Braun, N. Offen and F. A. Porkert, Phys. Rev. D86 (2012) 077504
- I. Balakireva, W. Lucha, D. Melikhov, PoS (2012), arXiv:1212.5898v1, (Local-duality QCDSRL)
- A. P. Bakulev, V. V. Mikhailov and A. V. Pimikov and N. G. Stefanis, Phys. Rev. 86 (2012) 031501, (QCDSRL)
- S. J. Brodsky, Fu-Guang Cao and G. F. Teramond, Phys.Rev. D84 (2011) 075012 (ADS/QCD)
- H.L.L. Roberts, C. D. Roberts, A. Bashir, L.X.Gutiŕrez and P.C. Tandy, Phy. Rev. C82 (2010) 065202 (Dyson-Schwinger.)
- B. El-Bennich, de Melo, T. Frederico, Few-Body Syst. 52 (2013) 403. (Light-Front QCM)

Some Remarks

Ligth-Front Approach:

- $\Longrightarrow$ **Computation of Form-Factors and Decay Constants**
- $\Longrightarrow$ **Easy to Test Different Analytical Models**
- $\Longrightarrow$ **Correct Asymptotic Form-Factors**
- $\Longrightarrow$ **Agreement with Experiments (CLEO and Belle) and Others Models (but, also with Babar for small Q^2)**
- $\Longrightarrow$ **The Large Babar data is Not Consistent with QCD**

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