THE $\omega-\rho-\pi$ COUPLING AND THE INFLUENCE OF HEAVIER RESONANCES

Genaro Toledo

David García Gudiño

Instituto de Fisica, UNAM

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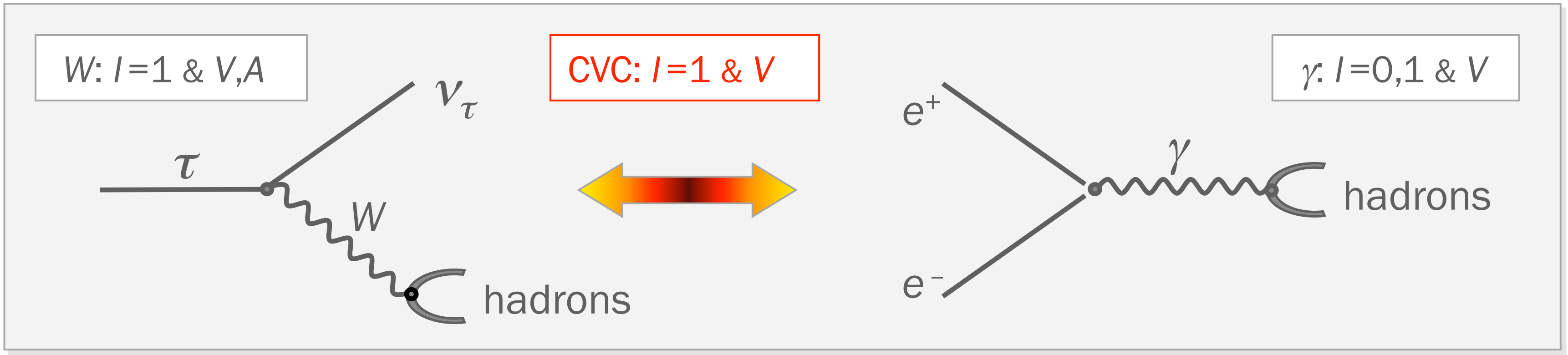
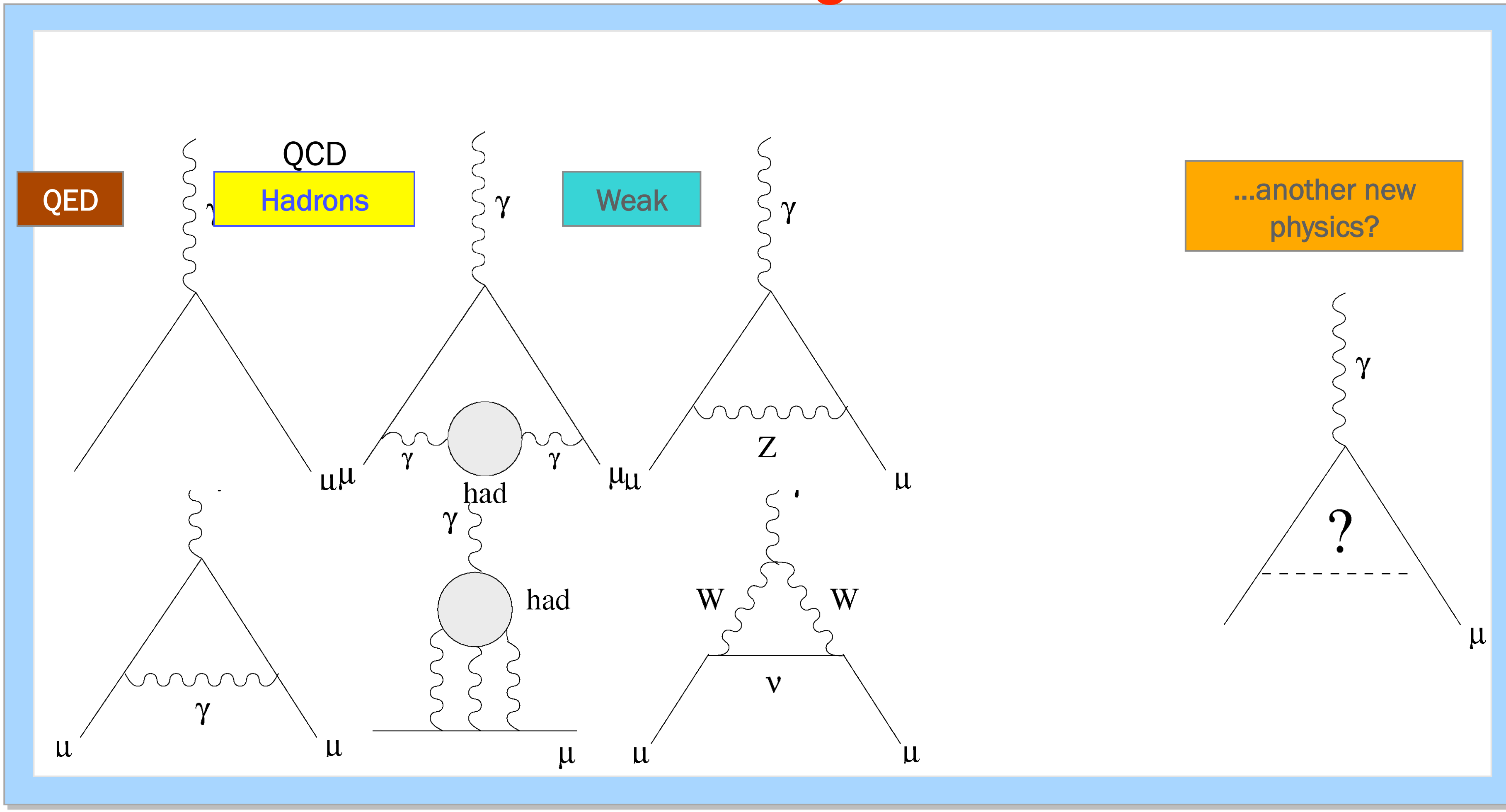
Motivation

- The $\omega-\rho-\pi$ mesons coupling ($g_{\omega\rho\pi}$) in precision measurements.

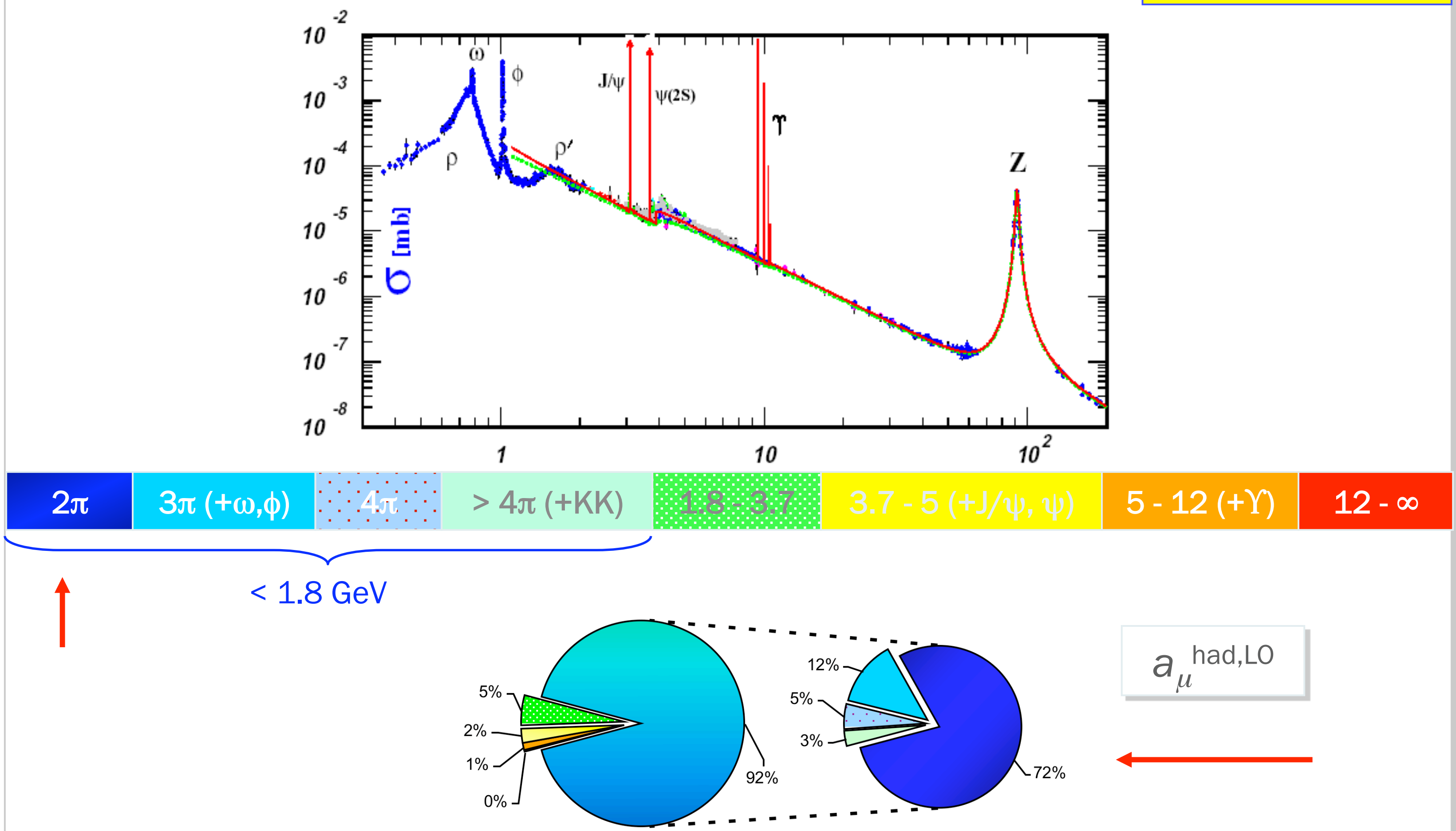


muon g-2



The importance of knowing hadrons

Hadronic HO



The most important channel is e+ e- ⟶ π π

The hadronic vertex in several processes

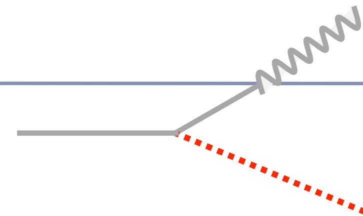
VMD

The VMD Lagrangian including the ρ, π and ω mesons can be set as:

$$\mathcal{L} = g_{\rho\pi\pi}\epsilon_{abc}\rho^a_\mu\pi^b\partial^\mu\pi^c + g_{\omega\rho\pi}\epsilon^{\mu\nu\lambda\sigma}\partial_\mu\omega_\nu\partial_\lambda\rho^a_\sigma\pi^b$$
$$+ g_{3\pi}\epsilon_{abc}\epsilon^{\mu\nu\lambda\sigma}\omega_\mu\partial_\nu\pi^a\partial_\lambda\pi^b\partial_\sigma\pi^c + \frac{em_V^2}{g_V}V_\mu A^\mu$$

Chiral Anomaly: Wess-Zumino-Witten

Radiative decays



The $g_{\omega\rho\pi}$ coupling can be obtained, within VMD, from radiative decays using the following relations:

The vertex

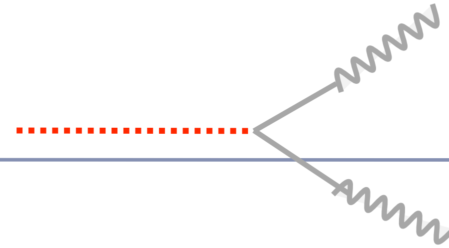
$$g_{\omega\rho\pi} = g_{\rho\pi\gamma}\, g_{\omega,\rho} / e$$

the coupling is obtained using

$$\Gamma(V \to \pi\gamma) = g^2_{V\pi\gamma} \frac{(m_V^2 - m_\pi^2)^3}{96\,\pi\, m_V^3}$$

Decay	$g_{\omega\rho\pi}$
$\rho \to \pi\,\gamma$	12.3 ± 0.9
$\rho \to \pi\,\gamma$	14.2 ± 1.0
$\omega \to \pi\,\gamma$	11.4 ± 0.2
$\pi \to \gamma\,\gamma$	11.6 ± 0.6
Weigthed average	11.6 ± 0.2

Low energy theorems and VMD



The $g_{\omega\rho\pi}$ coupling can be obtained, linking VMD and low energy theorems in the $\pi \to \gamma\gamma$ decay

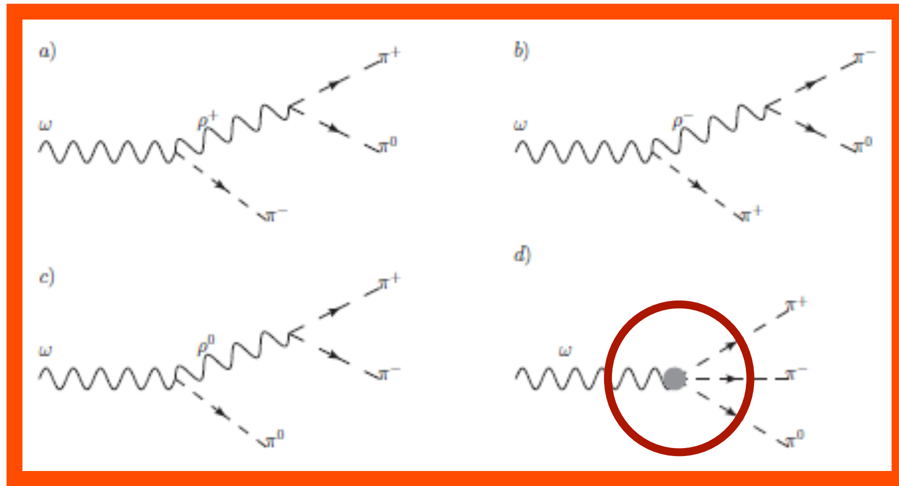
$$g_{\omega\rho\pi} = g_\rho \, g_\omega \, / 8\pi^2 f_\pi$$

using different approaches for the involved parameters, we get

Decay	$g_{\omega\rho\pi}$
$g_\rho = g_{\rho\pi\pi}$	11.5
$g_\rho = g_{\rho\pi\pi}$, $g_\rho = 3 g_\omega$ (SU3)	14.4
$g_{\rho\pi\pi} = m_\rho/(2 f_\pi)^{1/2}$ (KSFR)	14.2

$\omega \rightarrow 3\pi$ decay

Contribution from the ρ channel and the contact term.



M. Gell-Mann and F. Zachariasen, PR 124 953(1961).

The amplitude is given by $$\mathcal{M}_D = i\epsilon_{\mu\alpha\beta\gamma}\eta^{\mu}p_1^{\alpha}p_2^{\beta}p_3^{\gamma}\mathcal{A},$$

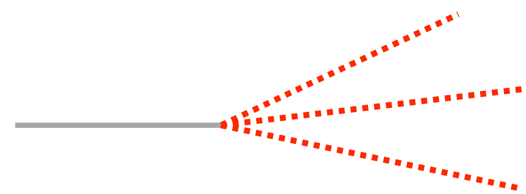
$$\mathcal{A} = 6g_{3\pi} + 2g_{\omega\rho\pi}g_{\rho\pi\pi}\left(D^{-1}[\rho^0, p1+p2] + D^{-1}[\rho^+, p1+p3] + D^{-1}[\rho^-, p2+p3]\right)$$

Using $\mathbf{g}_{\omega\rho\pi}$ the average from rad. decays and no contact term misses the experimental width by 45%

In order to reach the 100% of the experimental width, we can either increase $\mathbf{g}_{\omega\rho\pi}$ up to 15.7 or keep its value from radiative decays and add the contact term. A blind inclusion requires $\mathbf{g}_{3\pi}$= -65 pm 7 and 406 pm 10 GeV^{-3}

The contact term

The contact term can be seen as due to the presence of a heavier meson in the intermediate state and the chiral anomaly have a truly contact term. Therefore the information in an effective contact term have many contributions

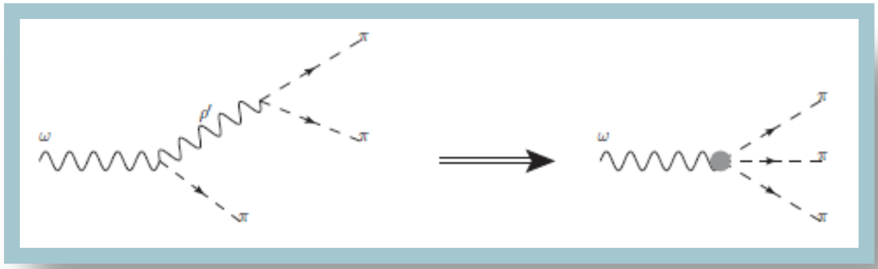


Linking VMD and thelow energy theorems requires

$$\begin{aligned} \alpha/(\pi f_\pi^3) &= e^2 6(g_{3\pi} + g_{\omega\rho\pi} g_{\rho\pi\pi}/m_\rho^2)/g_\omega \\ &\rightarrow g_{3\pi} = g_{\rho\pi\pi}/16\pi^2 f_\pi^3 = 47\ GeV^{-3}. \end{aligned}$$

Contact term as a ρ' channel

Using the VMD ideas, the contact term can be seen as a pinched diagram due to the presence of a heavier meson in the intermediate state. In this case the natural candidate is the $\rho'(1450)$, $m' = 1465$ MeV and $\Gamma' = 400$ MeV.



The heavy mass of the ρ' allows to make the following approximation:

$$|g_{3\pi}| \approx \frac{g_{\omega\rho'\pi}\, g_{\rho'\pi\pi}}{m^2_{\rho'}}$$

we assume that $g_{\omega\rho'\pi} / g_{\rho'\pi\pi} = g_{\omega\rho\pi} / g_{\rho\pi\pi} = 2.$ and $g_{\omega\rho'\pi}$ 10 – 18 GeV^{-1}

N. N. Achasov PRD 62 117503 (2000).

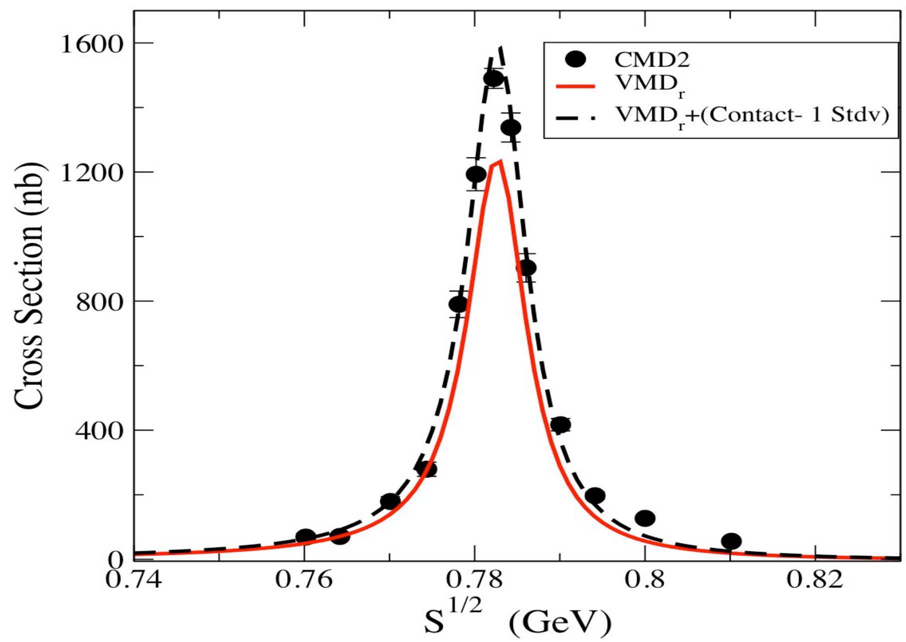
	$\vert g_{3\pi} \vert$
Rudaz	47
Dominguez	29 pm 3
Kuraev	123
Kaymakcalan	37
This work from $\Gamma(\omega\to 3\pi)$	65 pm 7
This work from ρ'	49 pm 24

S. Rudaz, PLB 145 281(1984).
E. A. Kuraev, Z. Silagadze, hep-ph 9502406 (1995).
Kaymakcalan, S. Rajeev, J. Schechter, PRD 30 594(1984).

$e^+e^- \rightarrow \omega \rightarrow 3\pi$ Cross Section

We can write the amplitude for the ω channel as follows:

$$\mathcal{M} = \frac{e^2 {m_\omega}^2}{g_\omega} \frac{\bar{v}\gamma^\mu u \epsilon_{\mu\alpha\beta\gamma} {p_1}^\alpha {p_2}^\beta {p_3}^\gamma}{q^2 \left(q^2 - m_\omega + i m_\omega \Gamma_\omega\right)} \mathcal{A}$$



R.R. Akhmetshin et al.. Phys. Lett. B 578 285(2004).

Global Results

Process	Without contact GeV^{-1}	With contact GeV^{-1}
Radiative processes	11.6 ± 0.2	11.6 ± 0.2
$\Gamma(\omega\to 3\pi)$	15.7 ± 0.1	12.6 pm 1.3
σ (e+ e- $\to 3\pi$)	13.1 ± 0.1	9.8 ± 1.4
Weighted average	13.8 ± 0.1	11.6 ± 0.2

Conclusions

We have determined the coupling for the omega-rho-pi mesons from several processes.

The value obtained for $g_{\omega\rho\pi}$ is sensible to the inclusion of the contact term.

We have taken the contact term as produced by a heavier resonance.

The combined values are useful to make more solid estimates of hadronic contributions in precision measurements