Hadronic Decays of the TAU Lepton within RESONANCE CHIRAL THEORY (RχT):

$$\tau^- \rightarrow (2K\,\pi)^- \,\nu_\tau$$

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FlaviA net

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SUMMARY:

- Hadronic decays of the τ lepton
- Tools : χPT, RχT, Large N_c (inspired)
- Previous work: $\tau^- \rightarrow (\pi\,\pi\,\pi)^- \nu_\tau$ (Gómez Dumm, Pich, Portolés '04)
- $\tau^- \rightarrow (2K\,\pi)^- \nu_\tau$ (Gómez Dumm, Pich, Portolés, R. '07 to appear)
- Outlook : $\tau^- \rightarrow (h_1 h_2 h_3)^- \nu_\tau$

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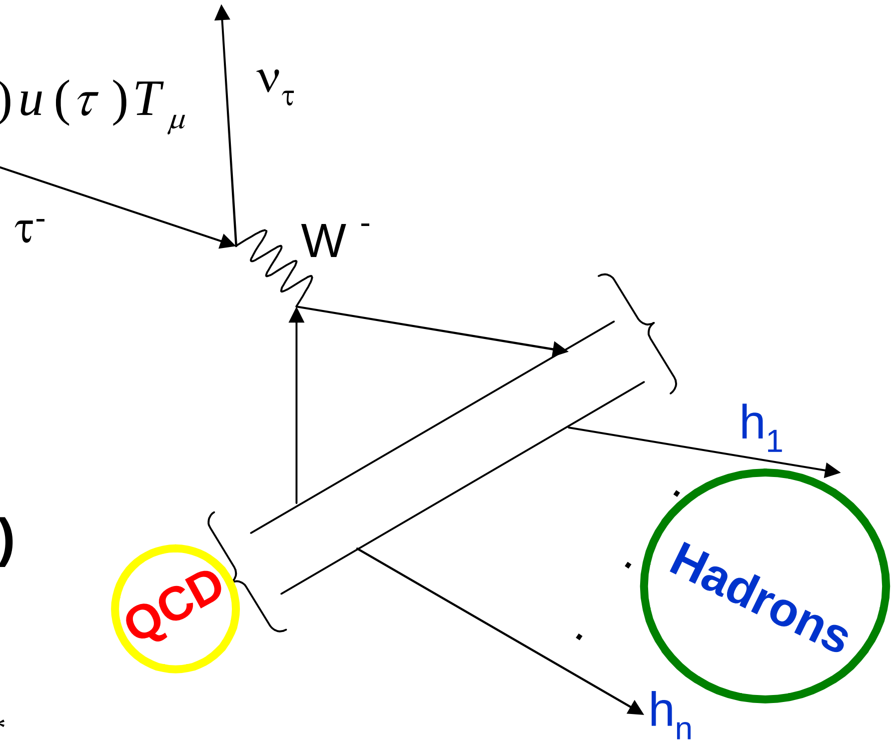
- Outlook : $\tau^- \to (h_1 h_2 h_3)^-\,\nu_\tau$ **$h_1h_2h_3$=3K, 2π K, 2π η, K$\pi\eta$**

HADRONIC DECAYS OF THE τ LEPTON

$$M = \frac{G_F}{\sqrt{2}} V_{CKM} \overline{u}(\nu_\tau)\gamma^\mu (1-\gamma_5) u(\tau) T_\mu$$



T_μ=<Hadrons|(V-A)$_\mu$ $e^{iS_{QCD}}$|0>=

=Σ_i(Lorentz Structure)^i $F_i(Q^2,s_j)$

$$d\Gamma = \frac{G_F^{\,2}}{4M_\tau^{\,2}} |V_{CKM}|^2 \, d\Phi^{(n+1)} \, L_{\mu\nu} T^\mu T^{\nu *}$$

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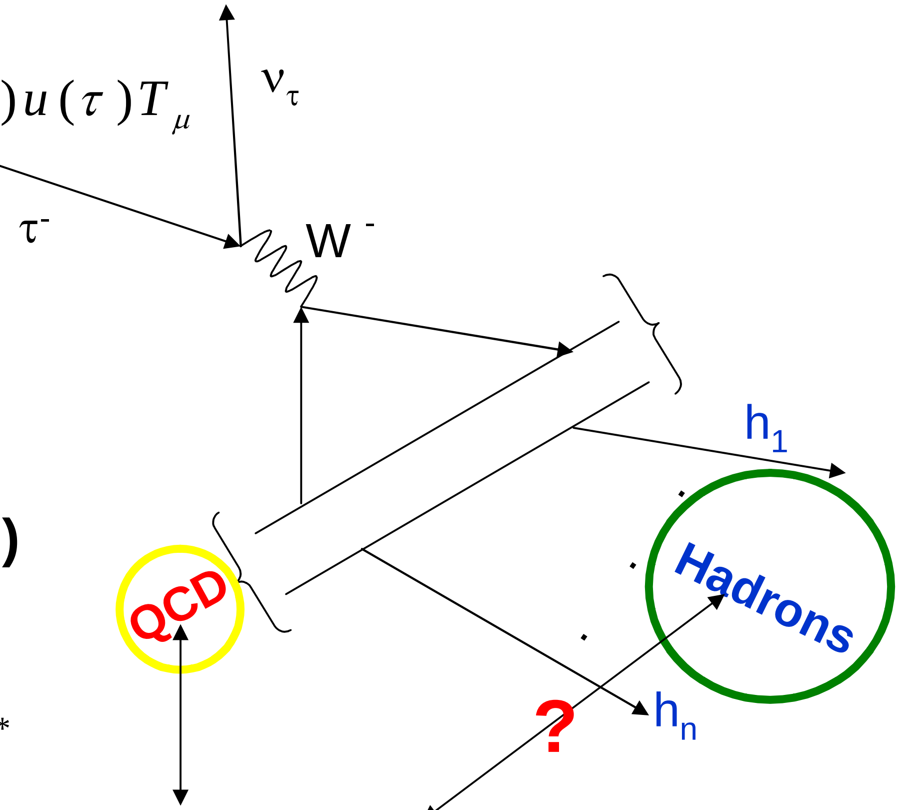

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$\Lambda_{QCD} = \Lambda_{QCD}\,(q_i, G_\mu^{\ a}; g_s, m_i)$

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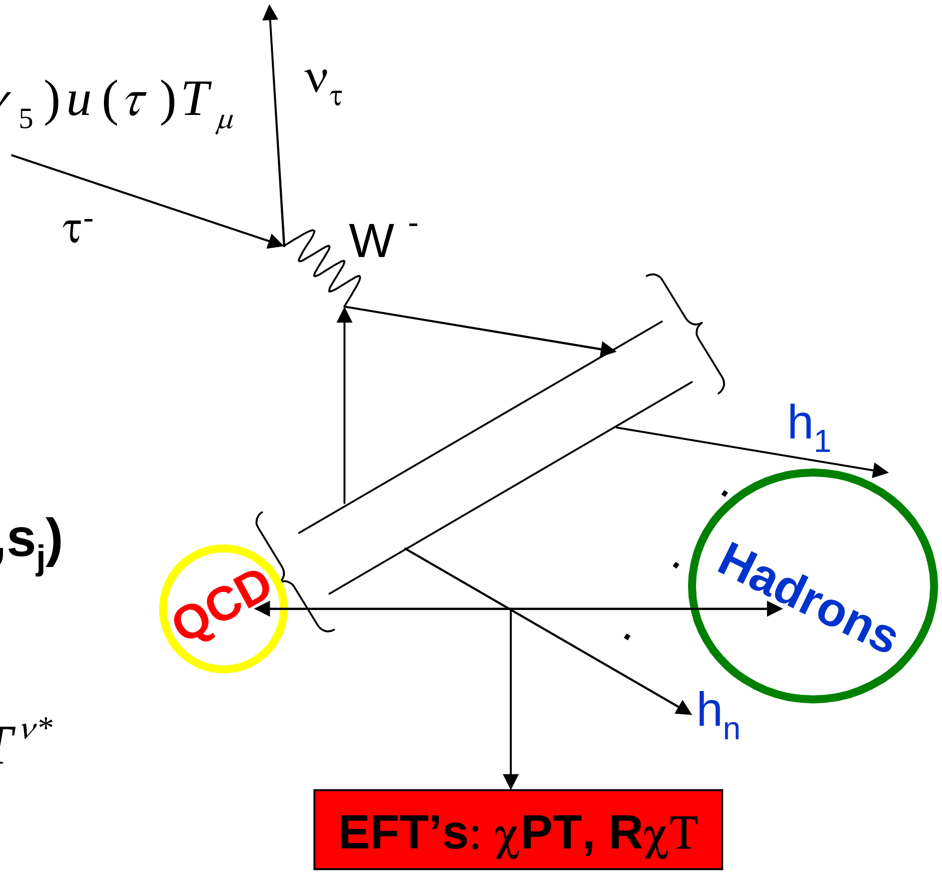

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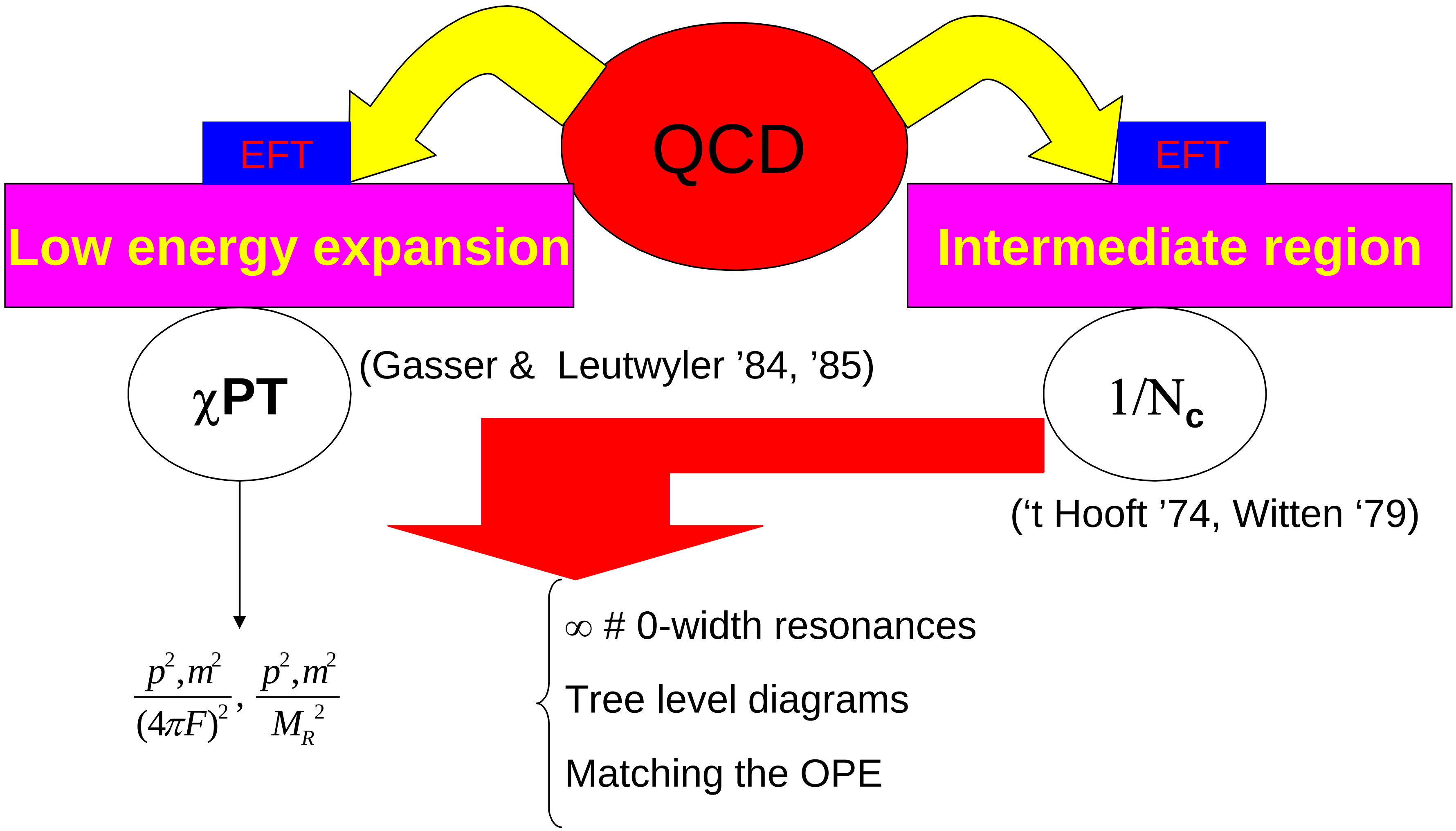
TOOLS: EFFECTIVE FIELD THEORIES



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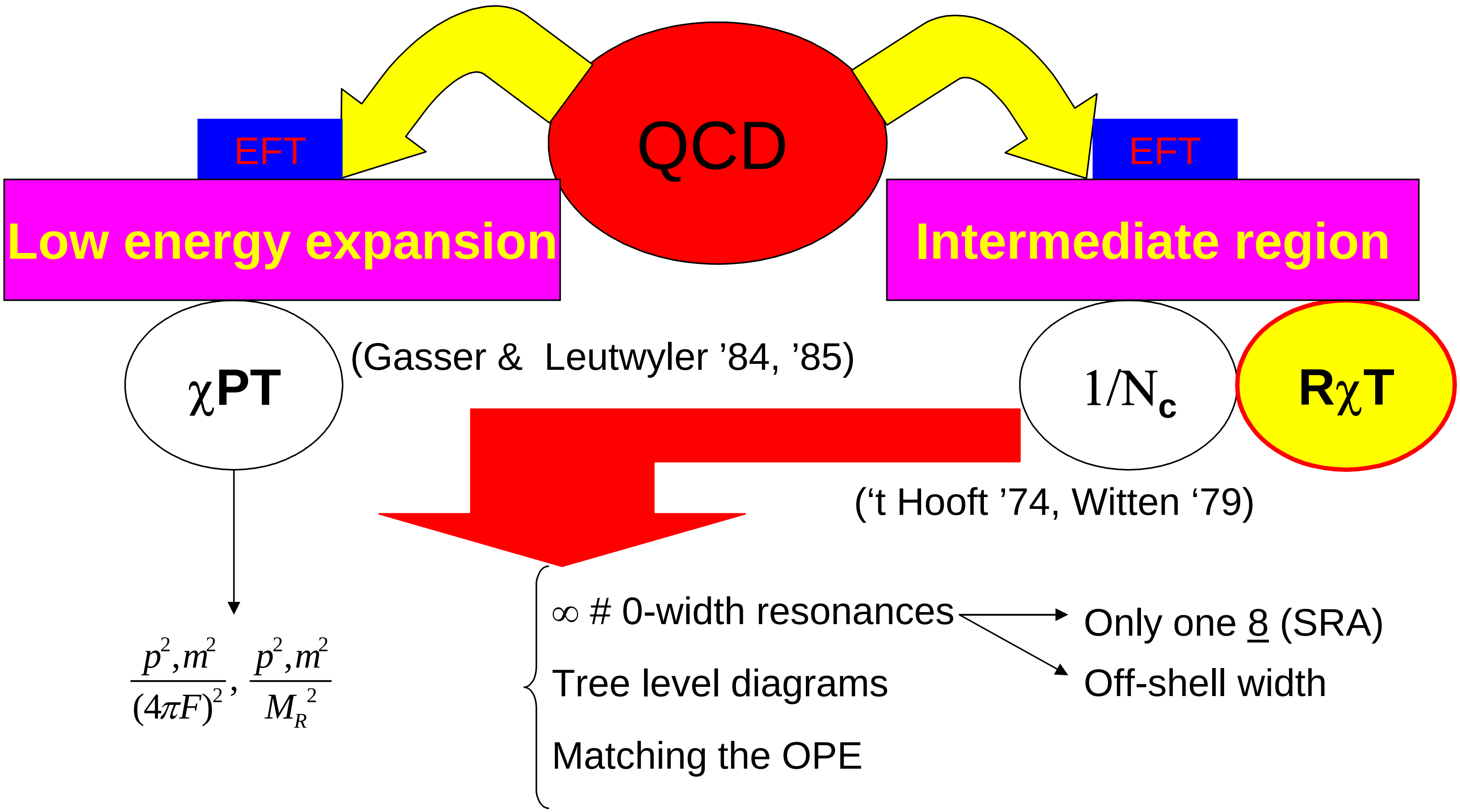


TOOLS : χPT

(Gasser & Leutwyler '84, '85)

χPT

$$\frac{p^2, m^2}{(4\pi F)^2}, \frac{p^2, m^2}{(M_R)^2}$$

(Gasser, Leutwyler '84, '85)

$$\varphi(x) = \begin{pmatrix} \frac{\pi^0}{\sqrt{2}} + \frac{\eta_8}{\sqrt{6}} & \pi^+ & K^+ \\ \pi^- & -\frac{\pi^0}{\sqrt{2}} + \frac{\eta_8}{\sqrt{6}} & K^0 \\ K^- & \bar{K}^0 & -\frac{2\eta_8}{\sqrt{6}} \end{pmatrix}$$

$$SU(3)_L \otimes SU(3)_R \to SU(3)_V$$

$$u(x) = \exp\left(\frac{i\varphi(x)}{\sqrt{2}F}\right), \quad u_\mu = i\left[u^\dagger(\partial_\mu - ir_\mu)u - u(\partial_\mu - il_\mu)u^\dagger\right]$$

$$\chi = 2B_0(s + ip), \quad \chi_\pm = u^\dagger \chi u^\dagger \pm u \chi u$$

$$f_\pm^{\mu\nu} = uF_L^{\mu\nu}u^\dagger \pm u^\dagger F_R^{\mu\nu} u$$

$$X \to h(g,\varphi)\, X\, h(g,\varphi)^\dagger$$

$$L^{(2)}_\chi = \frac{F^2}{4}\langle u_\mu u^\mu + \chi_+\rangle$$

$$L^{(4)}_\chi = L_1\langle u_\mu u^\mu\rangle^2 + \ldots + L_4\langle u_\mu u^\mu\rangle\langle\chi_+\rangle + \ldots + L_7\langle\chi_-\rangle^2 + \ldots - iL_9\langle f_+^{\mu\nu}u_\mu u_\nu\rangle + \ldots$$

$L^{(4)}_{\chi,\,WZW}$ in the odd-intrinsic parity sector

TOOLS : RχT

(Ecker, Gasser, Pich, De Rafael '89)

(Ecker, Gasser, Leutwyler, Pich, De Rafael '89)

$$L^{(P_l=+)}{}_{R\chi T} = L^{(2)}{}_{\chi} + L^{kin}{}_{V,A} + L_V + L_A + L_{VAP};$$

$$L_V = \frac{F_V}{2\sqrt{2}}\langle V_{\mu\nu} f_+^{\mu\nu}\rangle + \frac{iG_V}{\sqrt{2}}\langle V_{\mu\nu} u^\mu u^\nu\rangle$$

$$L_A = \frac{F_A}{2\sqrt{2}}\langle A_{\mu\nu} f_-^{\mu\nu}\rangle$$

Antisymmetric tensor formalism

$$V_{\mu\nu}(x) = \begin{pmatrix} \frac{\rho^0}{\sqrt{2}} + \frac{\omega_8}{\sqrt{6}} & \rho^+ & K^{*+} \\ \rho^- & -\frac{\rho^0}{\sqrt{2}} + \frac{\omega_8}{\sqrt{6}} & K^{*0} \\ K^{*-} & \bar{K}^{*0} & -\frac{2\omega_8}{\sqrt{6}} \end{pmatrix}_{\mu\nu}$$

$$L_{VAP} = \sum_{i=1}^{5} \lambda_i O^i(V_{\mu\nu}, A^{\mu\nu}, \varphi) = \lambda_1\langle [V_{\mu\nu}, A^{\mu\nu}]\chi_-\rangle + \ldots$$

(Gómez Dumm, Pich, Portolés '04)

VMD

$$L^{(P_l=-)}{}_{R\chi T} = L^{(4)}{}_{\chi(WZW)} + L_{VJP} + L_{VVP} + L_{VPPP};$$

$$L_{VJP} = \sum_{i=1}^{7} \frac{c_i}{M_V} O^i(V_{\mu\nu}, j^\nu, \partial^\mu\varphi) = \frac{c_5}{M_V}\varepsilon_{\mu\nu\rho\sigma}\langle\{\nabla_\alpha V^{\mu\nu}, f_+^{\rho\alpha}\} u^\sigma\rangle + \ldots$$

(Ruiz-Femenía, Pich, Portolés '03)

$$L_{VVP} = \sum_{i=1}^{5} d_i O^i(V_{\mu\nu}, V_{\rho\sigma}, \varphi) = d_1\varepsilon_{\mu\nu\rho\sigma}\langle\{V^{\mu\nu}, V^{\rho\alpha}\}\nabla_\alpha u^\sigma\rangle + \ldots$$

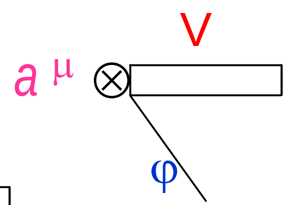
$$L_{VPPP} = \sum_{i=1}^{5} \frac{g_i}{M_V} O^i(V_{\mu\nu}, \varphi) = \frac{g_4}{M_V}\varepsilon_{\mu\nu\alpha\beta}\langle\{V^{\mu\nu}, u^\alpha u^\beta\}\chi_-\rangle + \ldots$$

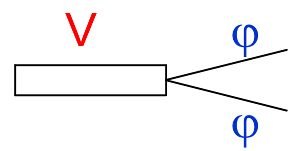
(Gómez Dumm, Pich, Portolés, R. '07 to appear)

TOOLS : RχT

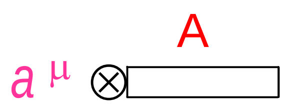
$$L^{(P_l=+)}{}_{R\chi T} = L^{(2)}{}_{\chi} + L^{kin}{}_{V,A} + L_V + L_A + L_{VAP};$$

$$L_V = \frac{F_V}{2\sqrt{2}}\langle V_{\mu\nu} f_+{}^{\mu\nu}\rangle + \frac{iG_V}{\sqrt{2}}\langle V_{\mu\nu} u^{\mu} u^{\nu}\rangle$$

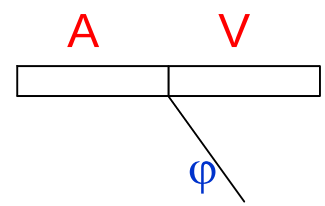




$$L_A = \frac{F_A}{2\sqrt{2}}\langle A_{\mu\nu} f_-{}^{\mu\nu}\rangle$$



$$L_{VAP} = \sum_{i=1}^{5} \lambda_i O^i (V_{\mu\nu}, A^{\mu\nu}, \varphi) = \lambda_1 \langle [V_{\mu\nu}, A^{\mu\nu}] \chi_- \rangle + \ldots$$



$$L^{(P_l=-)}{}_{R\chi T} = L^{(4)}{}_{\chi(WZW)} + L_{VJP} + L_{VVP} + L_{VPPP};$$

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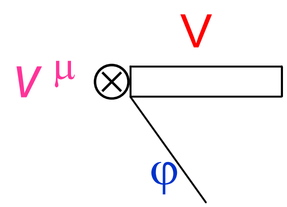
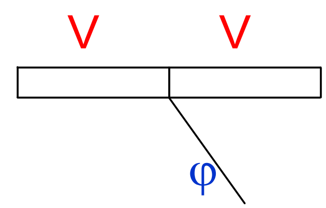


$$L_{VVP} = \sum_{i=1}^{5} d_i O^i (V_{\mu\nu}, V_{\rho\sigma}, \varphi) = d_1 \varepsilon_{\mu\nu\rho\sigma} \langle \left\{ V^{\mu\nu}, V^{\rho\alpha} \right\} \nabla_{\alpha} u^{\sigma} \rangle + \ldots$$



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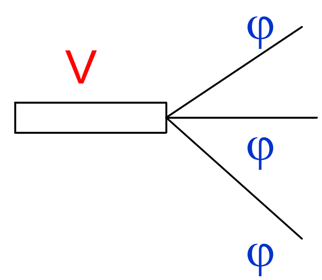

$\tau^- \to (2K\pi)^- \nu_\tau$ **in RχT**
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HADRONIC DECAYS OF THE τ LEPTON

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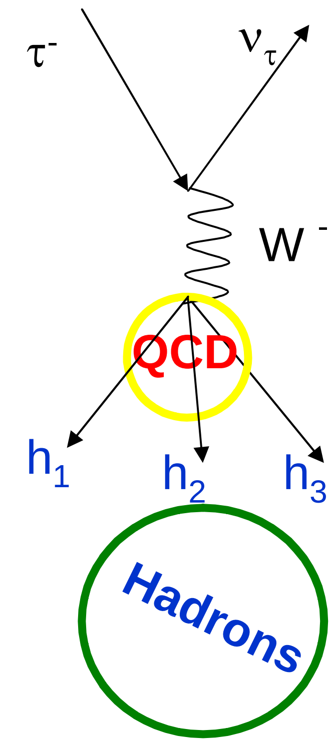
$$\tau^- \to h_1(p_1)h_2(p_2)h_3(p_3)\nu_\tau$$

$$(p_1+p_2+p_3)^\mu = Q^\mu,\; V_{1\mu} = \left(g_{\mu\nu} - \frac{Q_\mu Q_\nu}{Q^2}\right)(p_2-p_1)^\nu,\; V_{2\mu} = \left(g_{\mu\nu} - \frac{Q_\mu Q_\nu}{Q^2}\right)(p_3-p_1)^\nu$$

$$T_\mu = V_{1\mu}F_1 + V_{2\mu}F_2 + Q_\mu F_P + i\varepsilon_{\mu\nu\rho\sigma}p_1^{\ \nu}p_2^{\ \rho}p_3^{\ \sigma}F_V$$

$$\frac{d\Gamma}{dQ^2} = \frac{G_F^{\ 2}|V_{CKM}|^2}{128(2\pi)^5 M_\tau^{\ 3}}\int ds\,dt\; f\left(I_{0^-}, I_{1^+}, I_{1^-}\right)$$

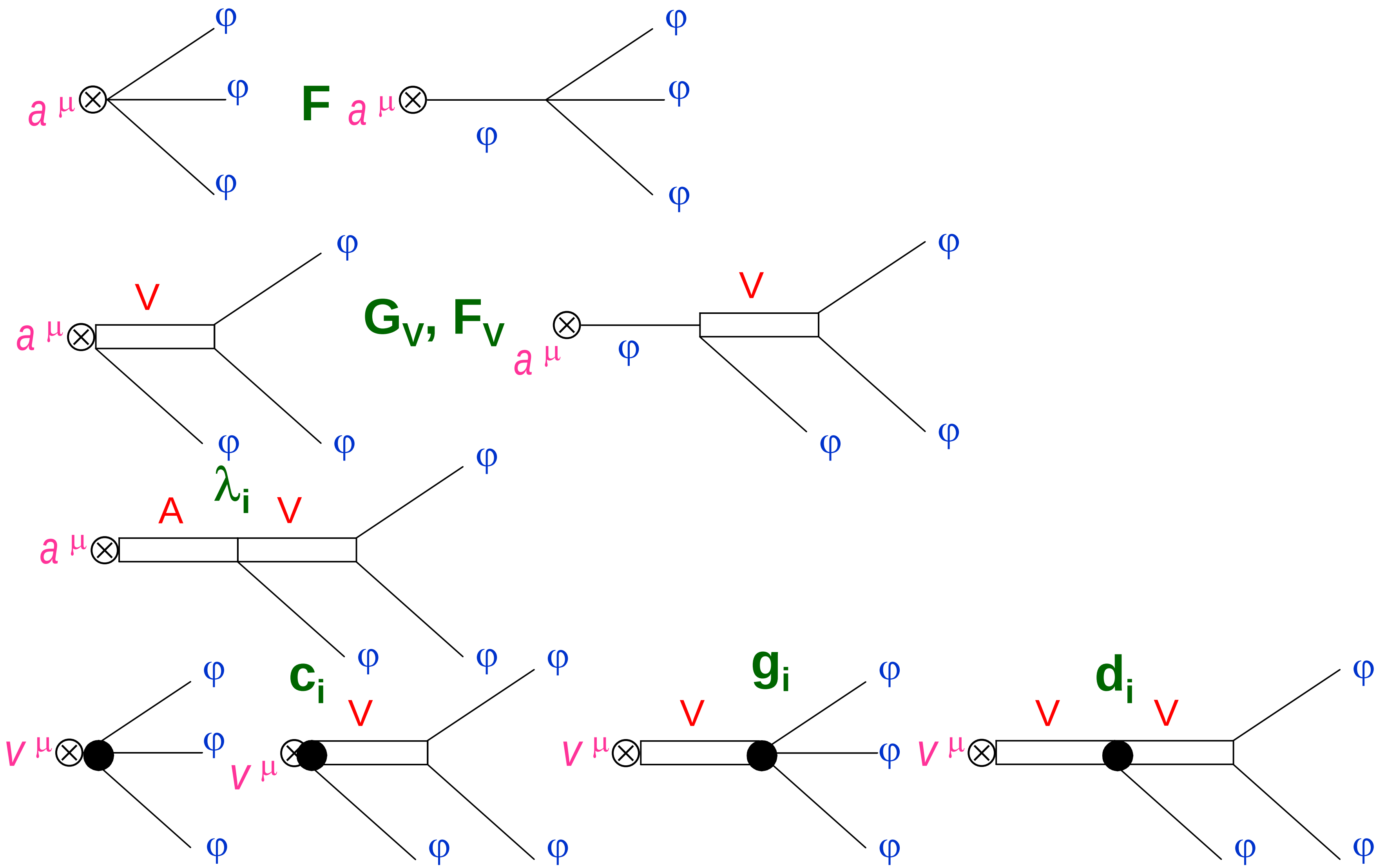


(**K**ühn, **S**antamaría ’90)(**KS**)

(**G**ómez-Cadenas, **G**onzález-García, **P**ich ’90) (**GGP**)

(**F**inkemeier, **M**irkes ‘96)(**FM**)

HADRONIC DECAYS OF THE τ LEPTON



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$\tau^- \rightarrow (2K\,\pi)^- \nu_\tau$ **in RχT**
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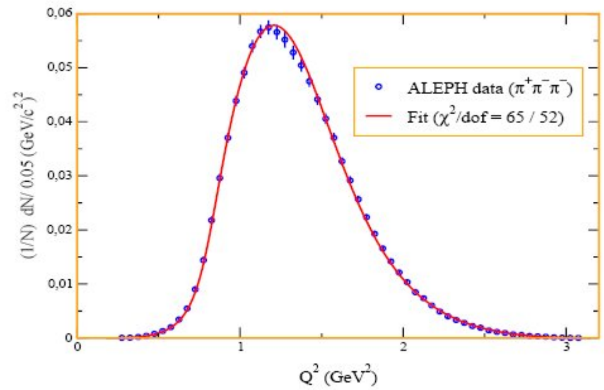
PREVIOUS WORK : $\tau^- \rightarrow (\pi\,\pi\,\pi)^- \nu_\tau$

Procedure and results [Gómez Dumm, Pich, Portolés, 2004]

Fit to the spectrum and BR

[ALEPH, 1998] $\tau^- \rightarrow \pi^-\pi^-\pi^+\nu_\tau$

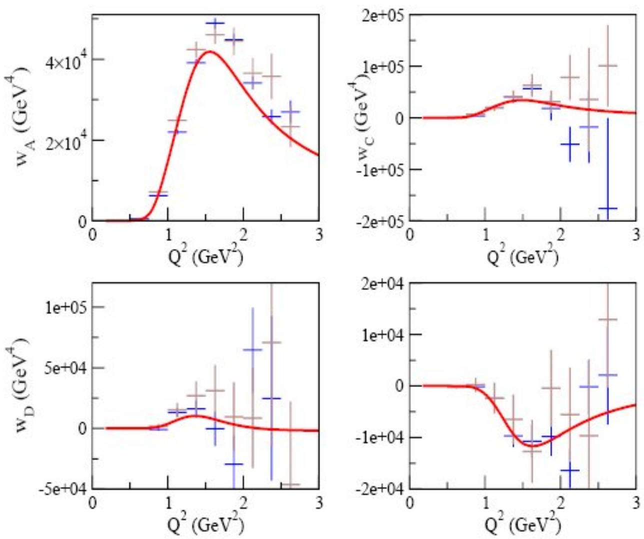
input



output

$\tau^- \rightarrow \pi^-\pi^0\pi^0\nu_\tau$

Structure Functions



[CLEO-II,2000,(blue)] [OPAL,1997,(grey)]

PDG06

M_{a1} = (1.204 ± 0.007) GeV

$\Gamma_{a1}(M_{a1})$ = (0.48 ± 0.02) GeV

Implemented in SHERPA ☑

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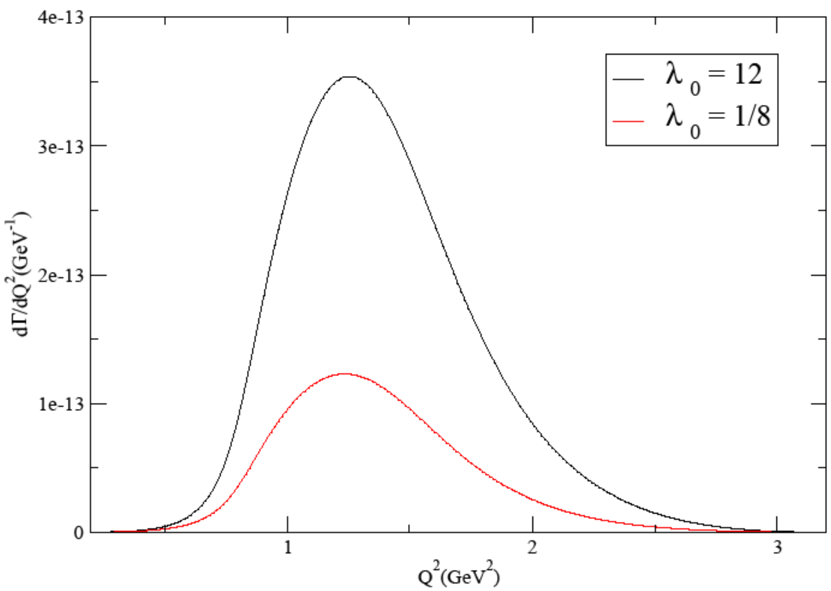
$\tau^- \to (\pi\,\pi\,\pi)^-\,\nu_\tau$

λ_0??

(Gómez-Dumm, Pich, Portolés '04) **12** ⟷ **1/8** (Cirigliano, Ecker, Eidemüller, Pich, Portolés '04)

<VAP>

$\tau^- \to (\pi\,\pi\,\pi)^-\,\nu_\tau$

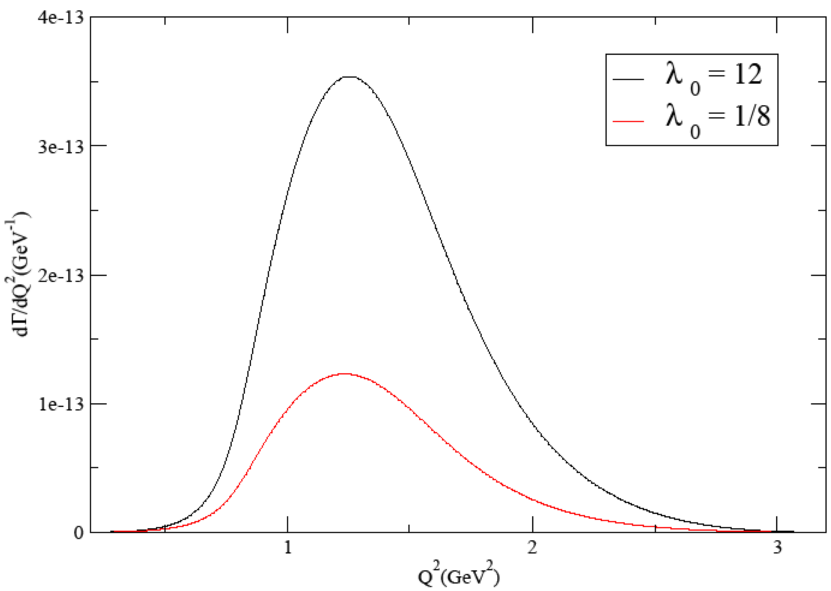


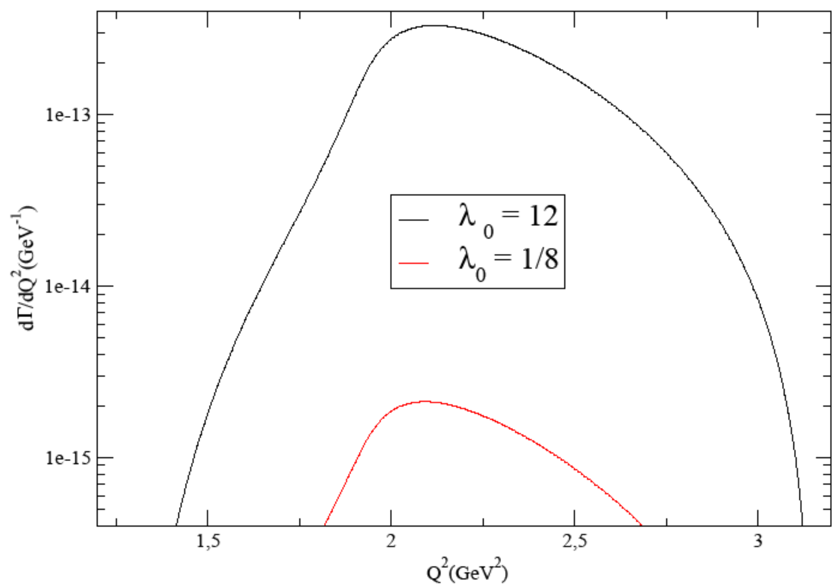
$$\tau^- \rightarrow (\pi\,\pi\,\pi)^-\,\nu_\tau$$

λ_0??

$$\lambda_0 \frac{m_\pi^2}{Q^2} \qquad \lambda_0 \frac{m_K^2}{Q^2}$$

$$\tau^- \rightarrow (\pi\,\pi\,\pi)^-\,\nu_\tau \qquad \tau^- \rightarrow (2K\,\pi)^-\,\nu_\tau$$





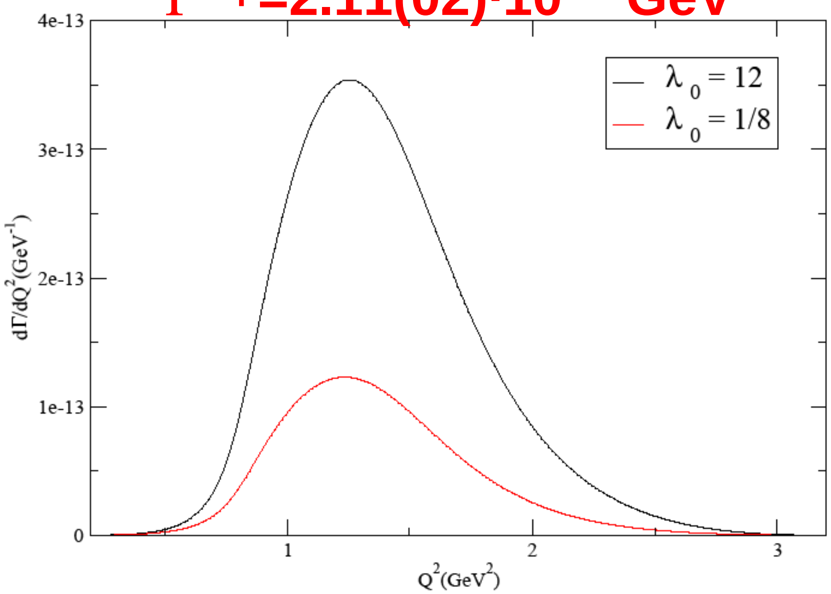
$\tau^- \to (\pi\,\pi\,\pi)^-\,\nu_\tau$

λ_0

$\lambda_0 \dfrac{m_\pi^2}{Q^2}$ $\qquad$ $\lambda_0 \dfrac{m_K^2}{Q^2}$

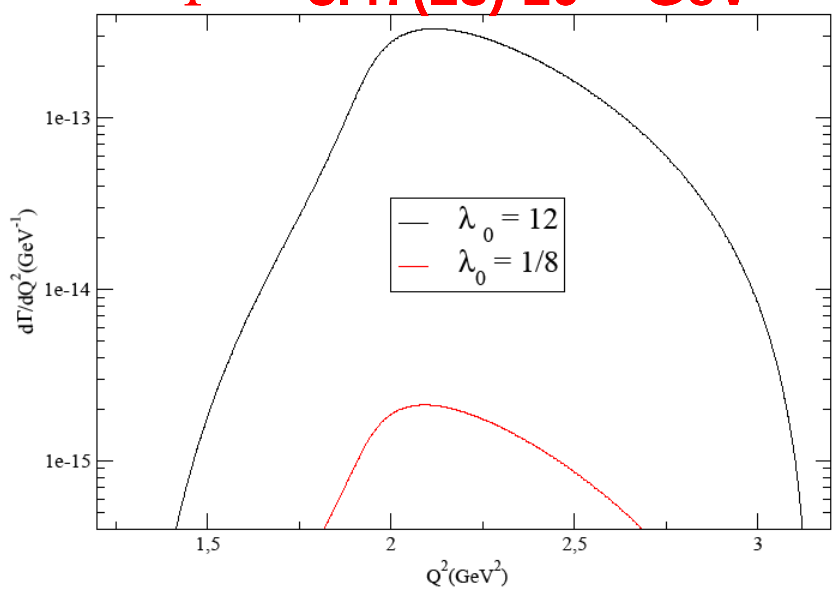
$\tau^- \to (\pi\,\pi\,\pi)^-\,\nu_\tau$

Γ^{exp}=2.11(02)·10^{-13} GeV



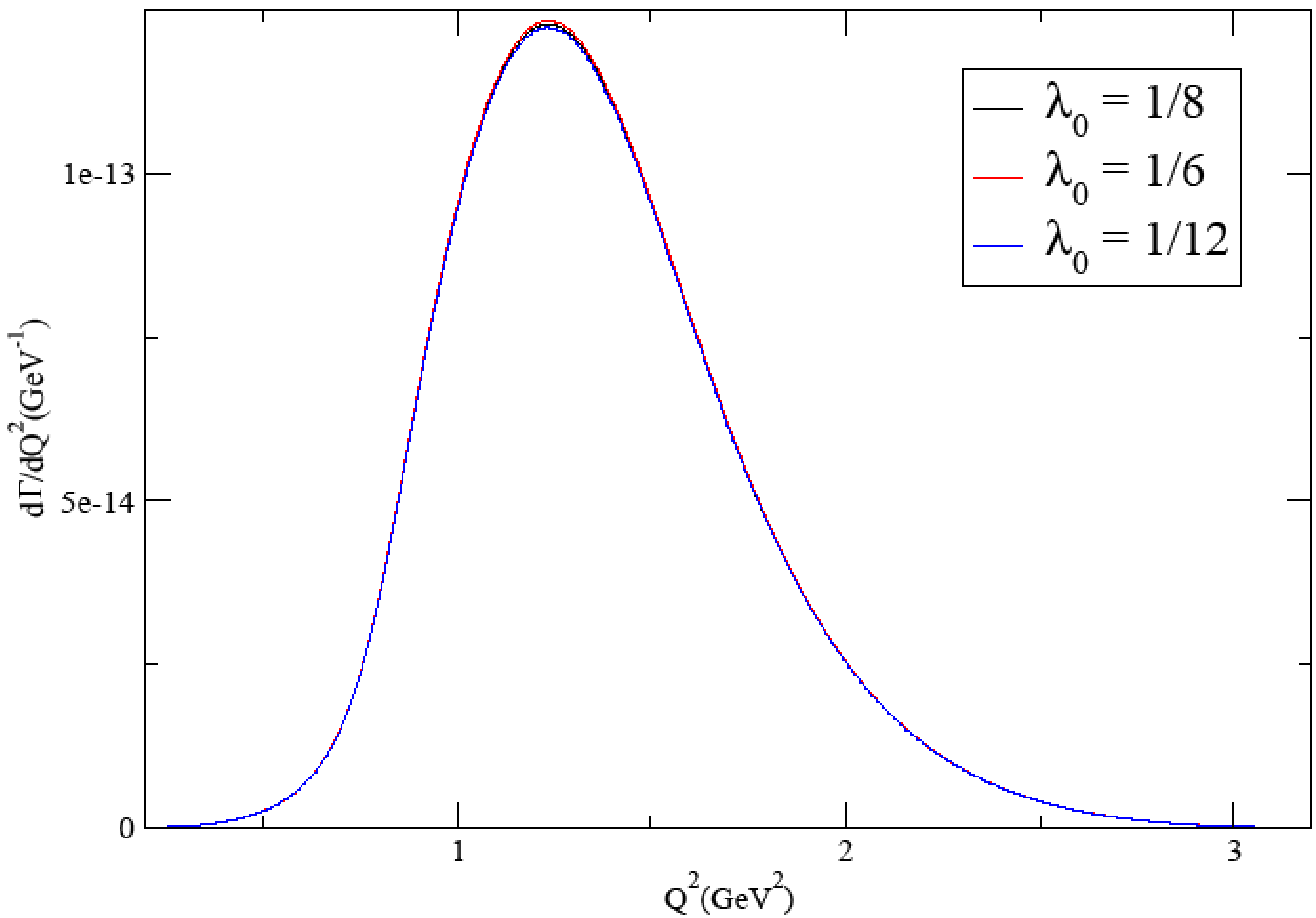
$\tau^- \to (2K\,\pi)^-\,\nu_\tau$

Γ^{exp}=3.47(23)·10^{-15} GeV



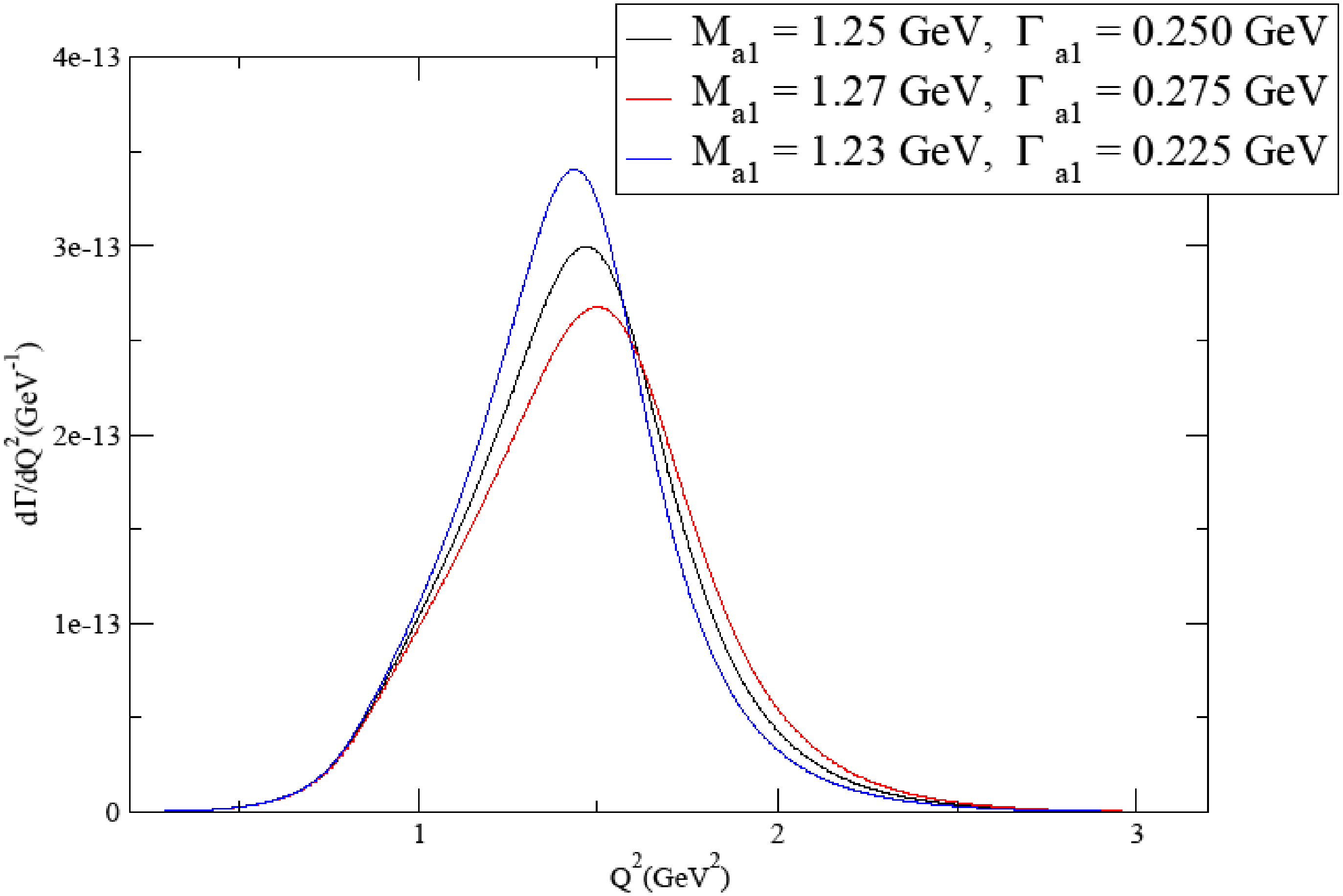
$\tau^- \rightarrow (\pi\,\pi\,\pi)^-\,\nu_\tau$

$\lambda_0 \sim$ **1/8**



$\tau^- \to (\pi\ \pi\ \pi)^- \nu_\tau$

λ_0 = 1/8 Varying M_{a1} and Γ_{a1}



$\tau^- \to (2K\,\pi)^- \nu_\tau$

$\tau^- \to (KK\pi)^- \nu_\tau$ **within Resonance Chiral Theory**

[Gómez Dumm, Pich, Portolés, Roig, **coming soon**]

- Analysis of both **axial-vector** and **vector** form factors
- Required Brodsky-Lepage behaviour : constraints on unknown couplings of the Lagrangian
- Implemented in **SHERPA** ☑

No experimental contrast

~~[CLEO-III,2004]~~

Normalization of form factors violating chiral symmetry at leading order

$$c_{1235} = c_1 + c_2 + 8c_3 - c_5$$
$$d_{123} = g_1 + 8d_2 - d_3$$
$$c_{125} = c_1 - c_2 + c_5$$
$$c_{1256} = c_1 - c_2 - c_5 + 2c_6$$
$$g_{123} = g_1 + 2g_2 - g_3$$

Free

c_{1235}, d_{123}, c_4, g_4, g_5

$\tau^- \rightarrow (2K\,\pi)^- \, \nu_\tau$

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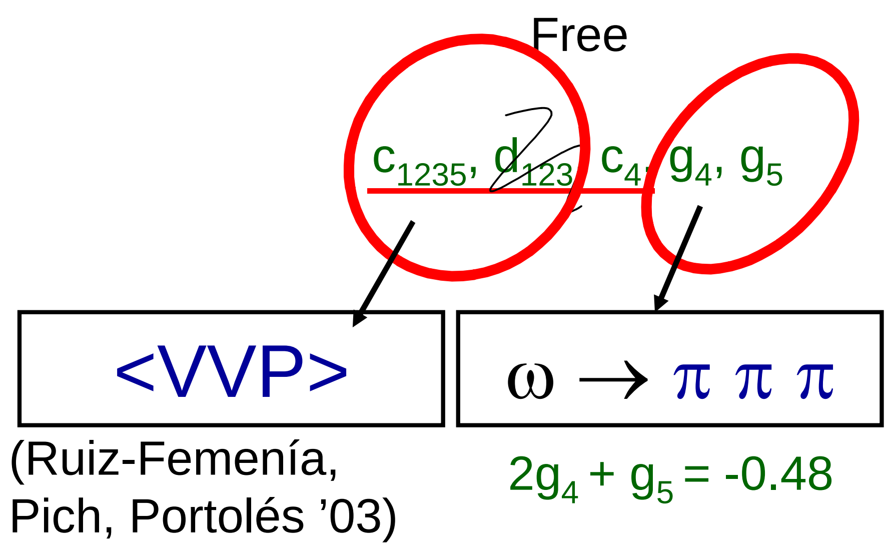

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~~[CLEO-III,2004]~~

Normalization of form factors violating chiral symmetry at leading order

Contributions to the decay width

	Axial-Vector	**Vector**
Our result	**~ 37 %**	**~ 63 %**
CLEO-III	**~ 50 %**	**~ 50 %**
[GGP,90]	**~ 10 %**	**~ 90 %**
[FM,96]	**~ 60 %**	**~ 40 %**

Free

c_{1235}, d_{123}, c_4, g_4, g_5

<VVP>

(Ruiz-Femenía, Pich, Portolés '03)

$\omega \rightarrow \pi\,\pi\,\pi$

$2g_4 + g_5 = -0.48$

$\tau^- \rightarrow (2K\,\pi)^- \nu_\tau$ in RχT
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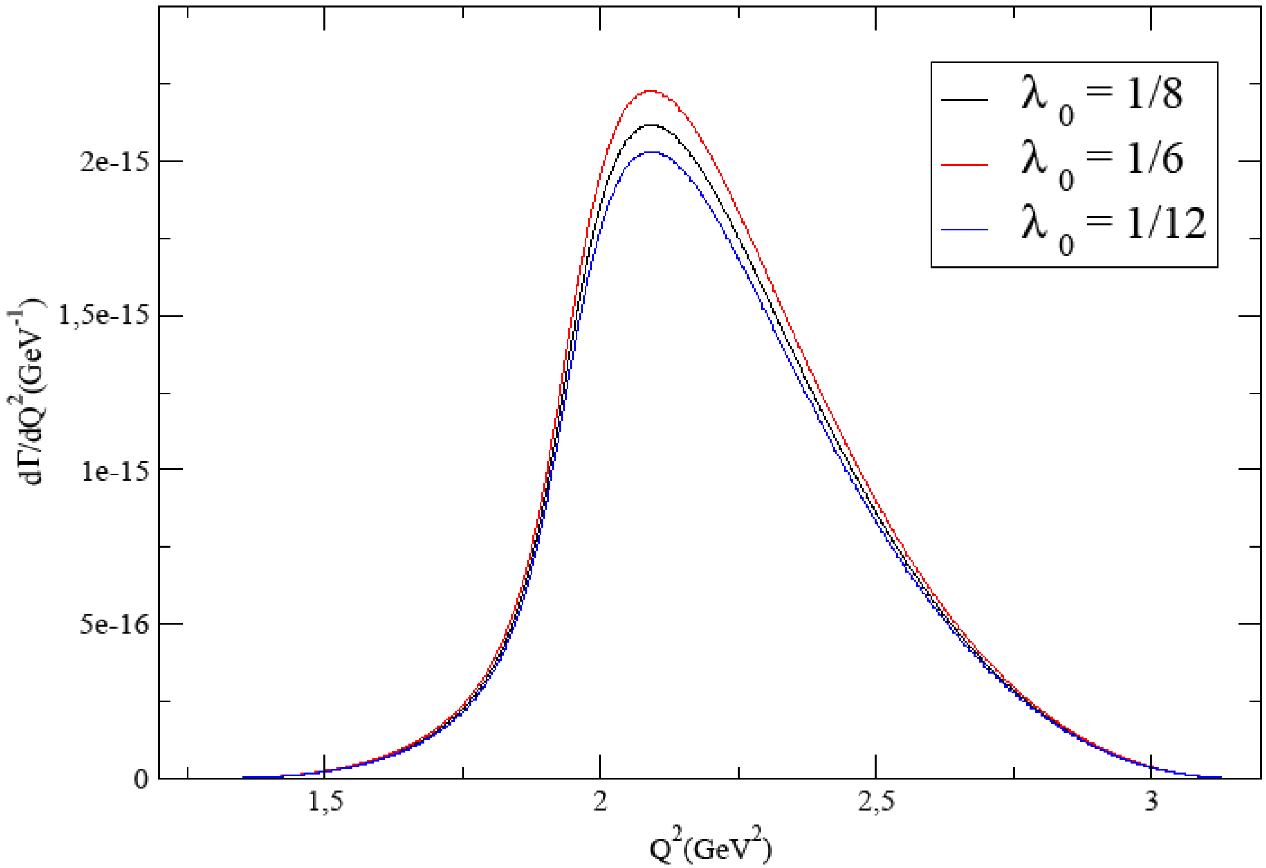
Different predictions for the $K \bar{K} \pi^-$ channels

		χPT at $O(p^2)$	χPT at $O(p^4)$			
	N_V/N_A	F^A	F^A	F_4^V	Γ_V	Γ_A
CLEO '04	**~ 1.5**	Yes	☹	☹	☹	☹
This work	**~ 3**	☺	☺	☺	☺	☹
(**G**ómez-Cadenas, **G**onzález-García, **P**ich **'90**)	**~ 9**	☺	☹	☺	-	-
(**F**inkemeier, **M**irkes **'96**)	**~ 0.4**	☺	☹	☺	☹	*ad-hoc*

$\tau^- \to (2K\pi)^- \nu_\tau$

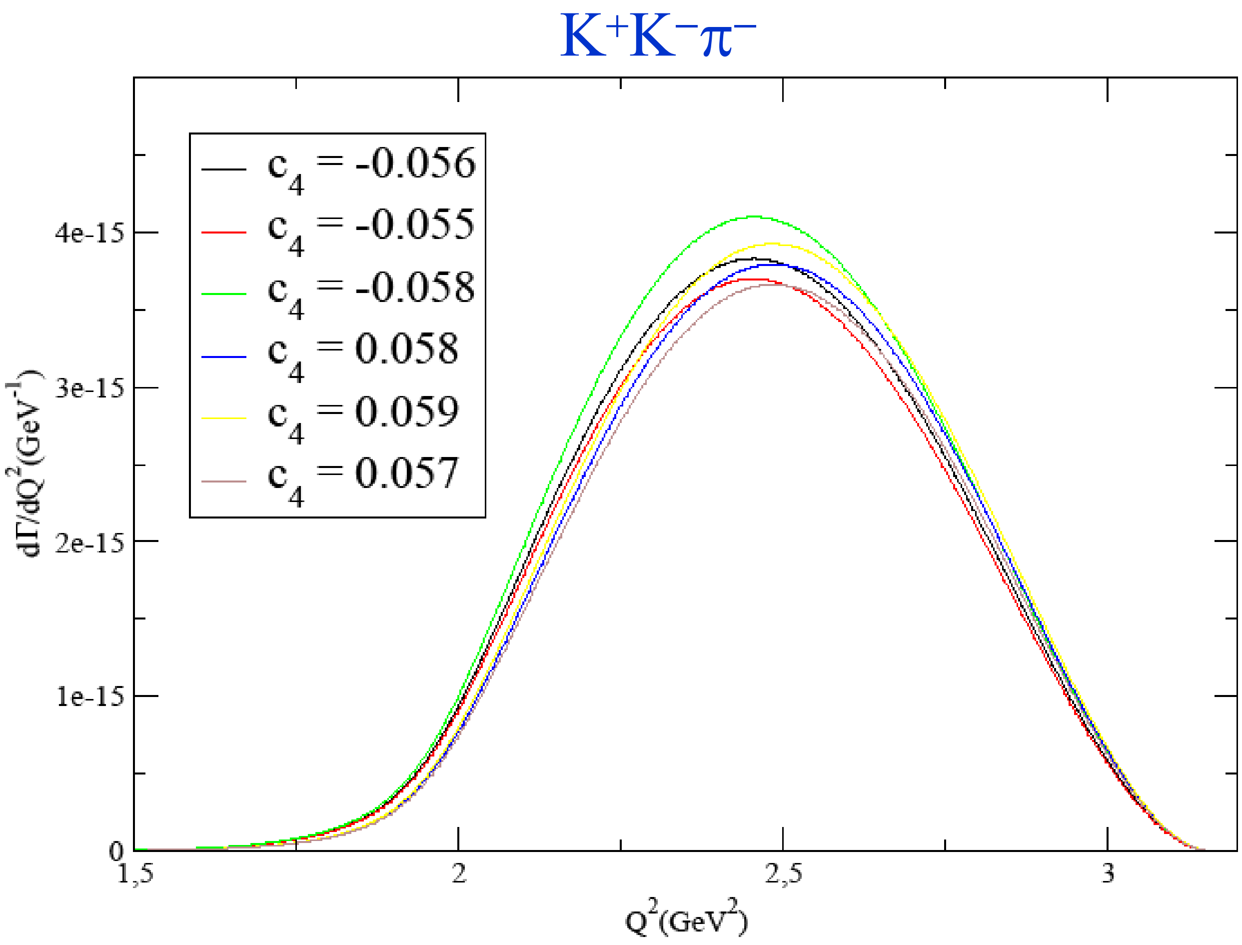
Axial vector current contribution: Dependence on λ_0

$K^+K^-\pi^-$



$\tau^- \to (2K\pi)^- \nu_\tau$

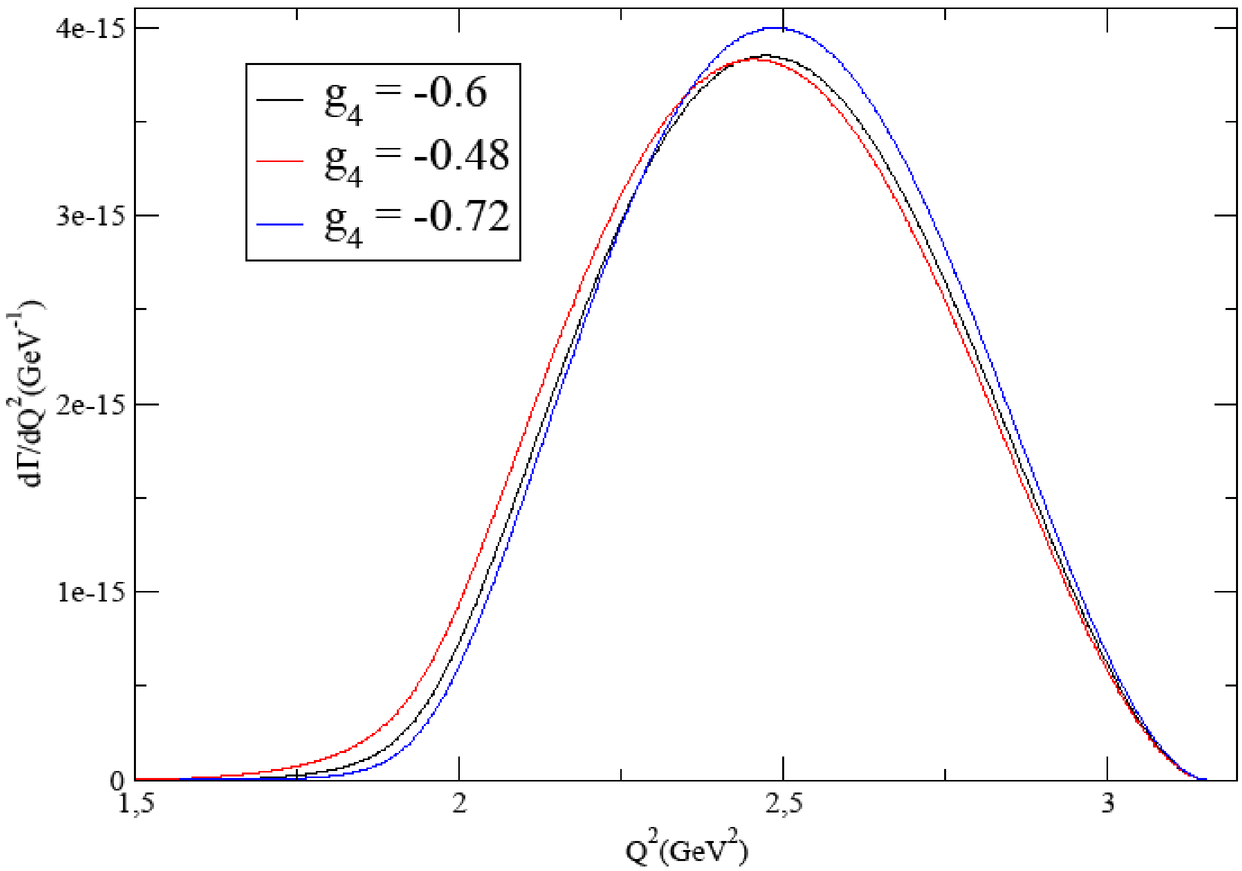
Vector current contribution: Dependence on c_4



$\tau^- \to (2K\,\pi)^- \nu_\tau$

Vector current contribution: Dependence on g_4

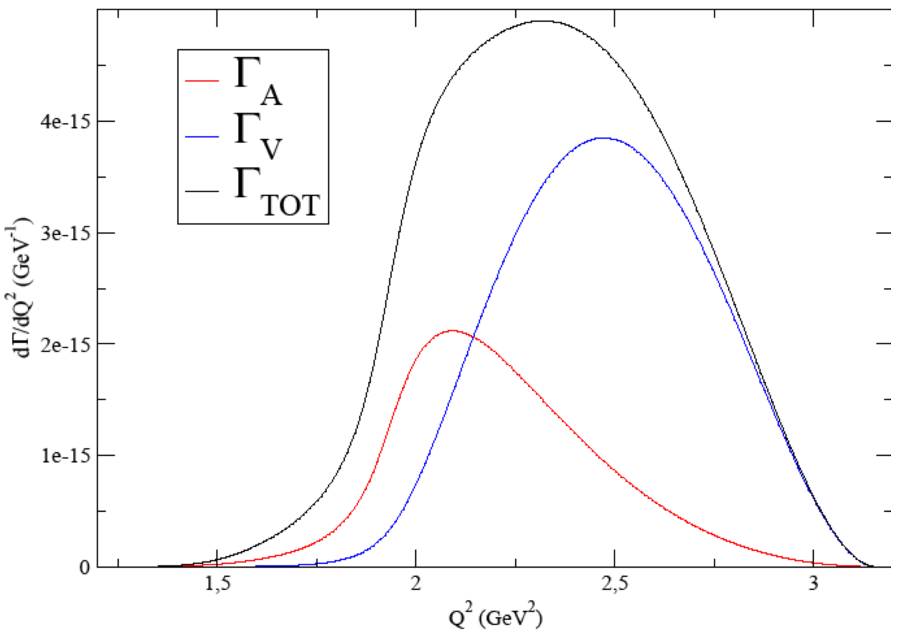
$K^+K^-\pi^-$

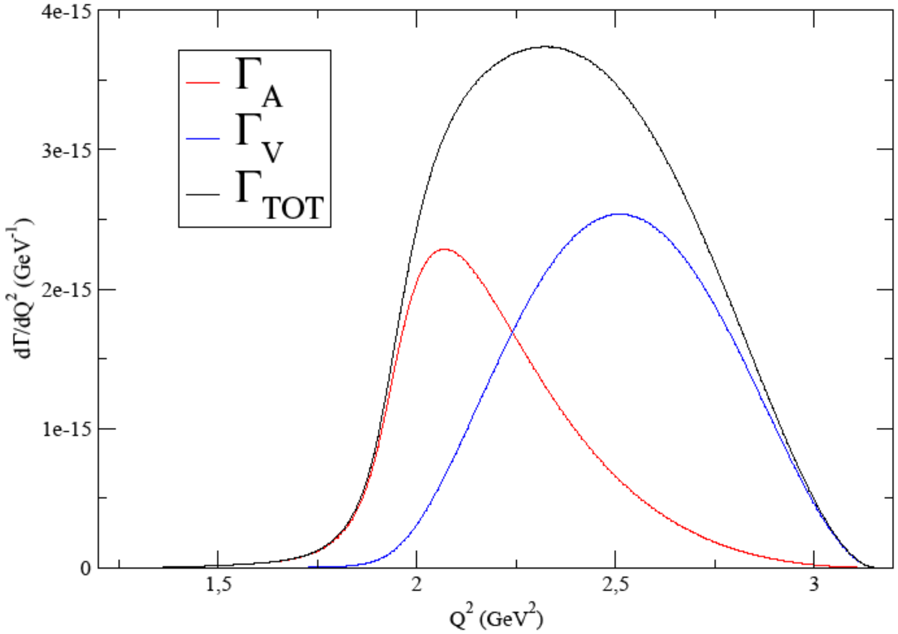


$\tau^- \to (2K\,\pi)^- \nu_\tau$

“BEST“ FITS

$K^+K^-\pi^-$ $\qquad$ $K^-K^0\pi^0$





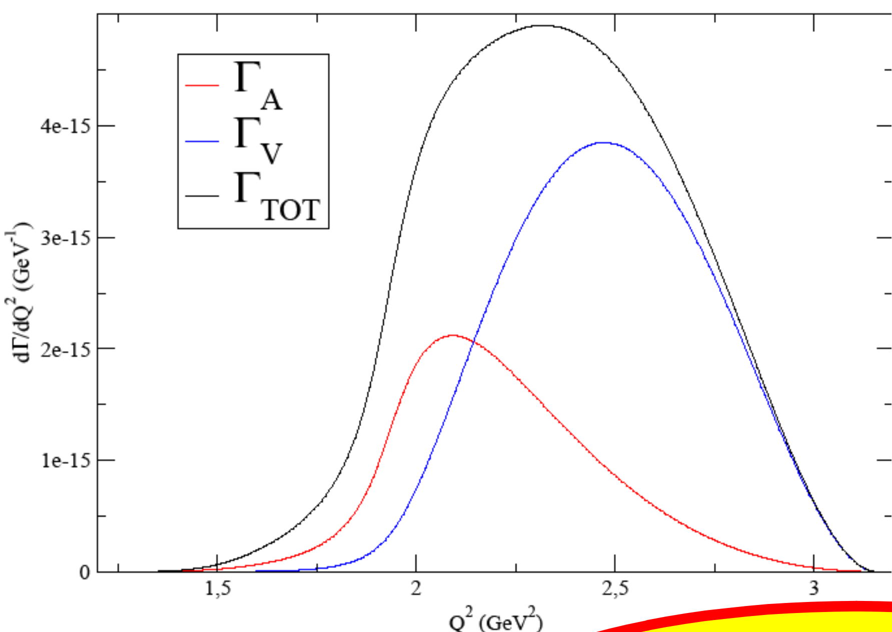
$\tau^- \rightarrow (2K\,\pi)^- \nu_\tau$

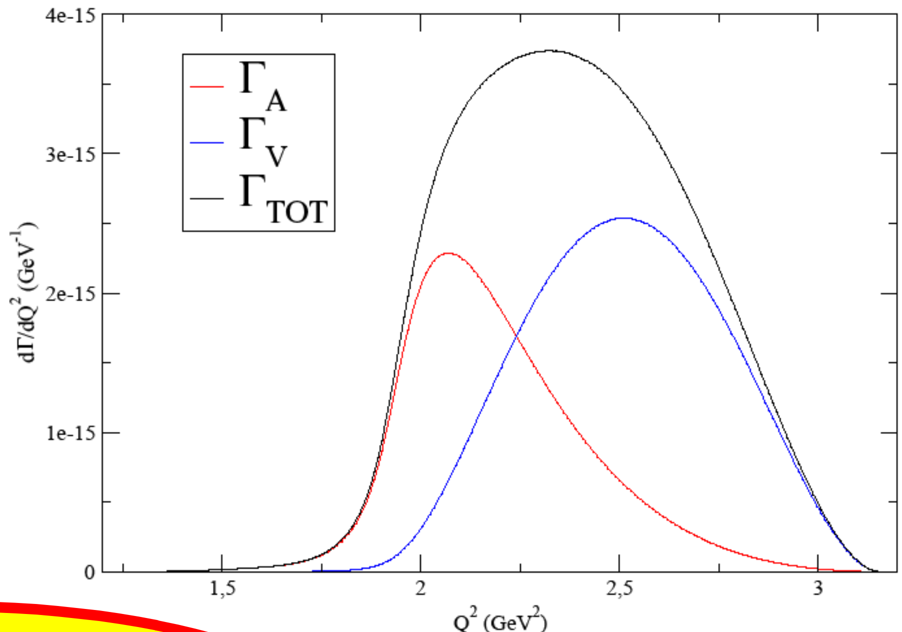
(I. Nugent TAU06)

"BEST" FITS

$K^+K^-\pi^-$

$K^-K^0\pi^0$





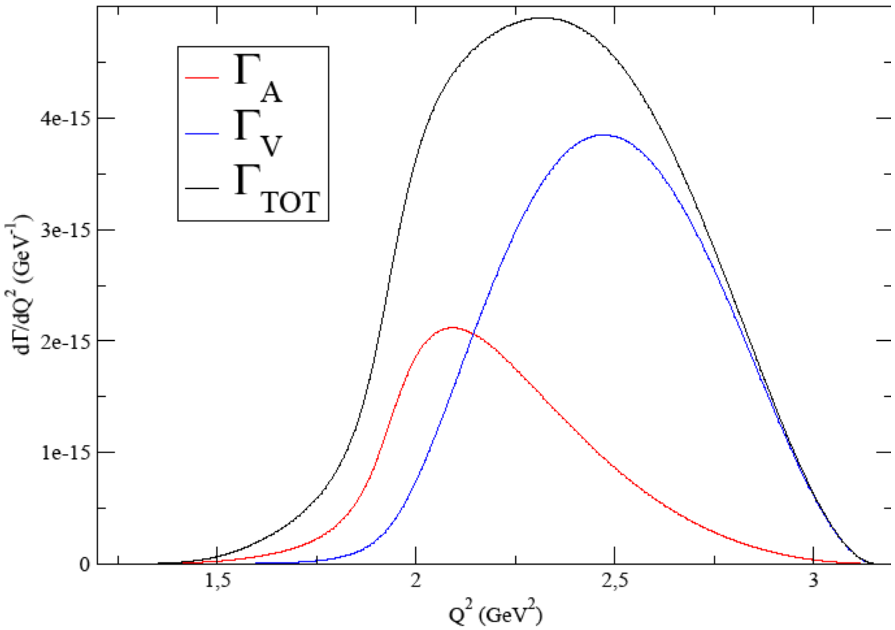
MC's BELLE **data**

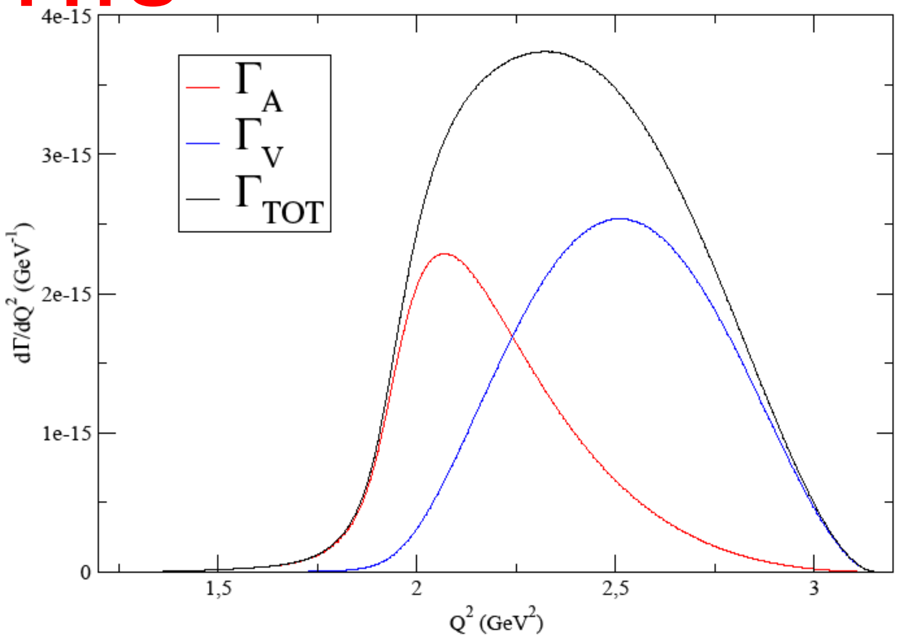
Our Hadronic matrix elements

$\tau^- \to (2K\,\pi)^- \nu_\tau$

$K^+K^-\pi^-$ $\qquad\qquad$ $K^-K^0\pi^0$

"BEST" FITS





$|c_4| = 0.057 \pm 0.005$

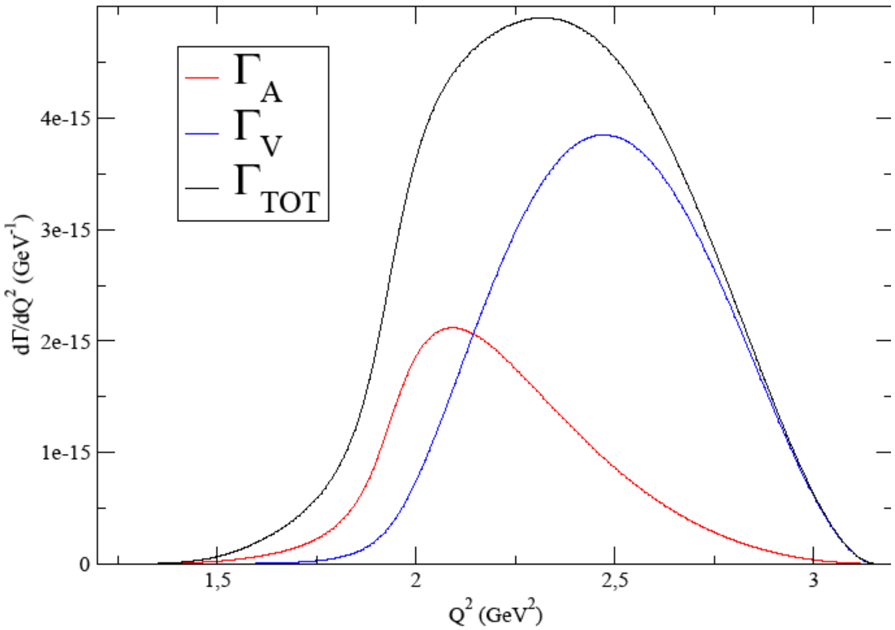
$g_4 = -0.48 \pm 0.24$

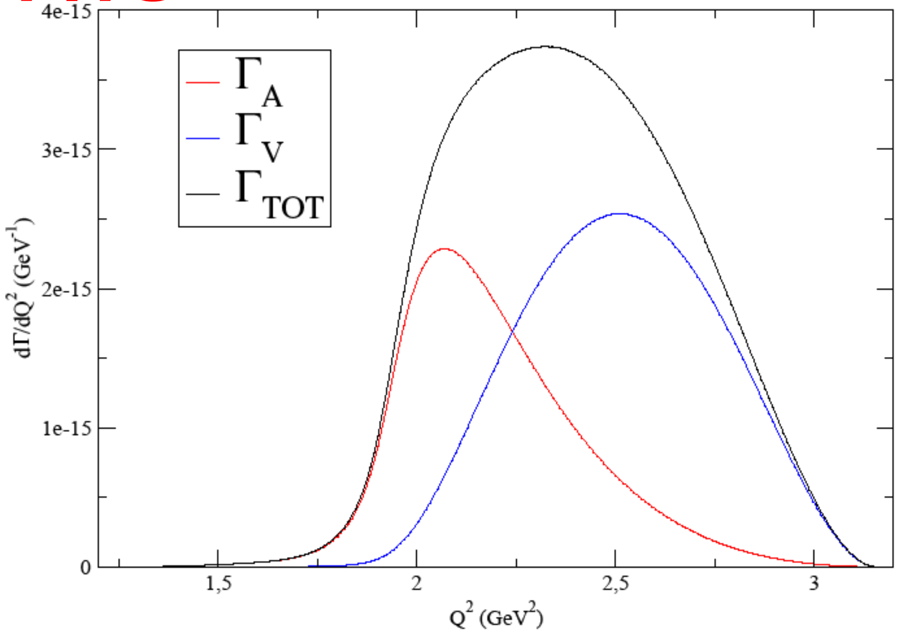
$M_{a1} = 1.25 \pm 0.03$ GeV

$\Gamma_{a1}(M_{a1}) = 0.25 \pm 0.03$ GeV

$\tau^- \to (2K\pi)^- \nu_\tau$

$K^+K^-\pi^-$ | "BEST" FITS | $K^-K^0\pi^0$





$$\frac{\Gamma(\tau^- \to K^+K^-\pi^-\nu_\tau)}{\Gamma(\tau^- \to K^-K^0\pi^0\nu_\tau)} = 1.7 \pm^{0.1}_{0.3}$$

$$\frac{\Gamma_V(\tau^- \to (2K\pi)^-\nu_\tau)}{\Gamma_A(\tau^- \to (2K\pi)^-\nu_\tau)} = 1.7 \pm^{1.0}_{0.6}$$

OUTLOOK: $\tau^- \to (h_1\, h_2\, h_3)^- \nu_\tau$

$h_1\, h_2\, h_3$	F_A	F_V	$V_{us},\, m_s$	m_{ν_τ}	
3π	√				
$2K\,\pi$	√	√			
$K\,2\pi$	√	√	√		
$2\pi\,\eta$		√			
$\pi\,K\,\eta$	√	√	√		
$3K$	√	√	√	√	$(\Phi \to \bar{K}K)$

$\tau^- \to (2K\,\pi)^- \nu_\tau$ in RχT
Pablo Roig Garcés
Instituto de Física Corpuscular

CONCLUSIONS

- Current analyses of $\tau^- \to (3\pi^-, K^+K^-\pi^-)\,\nu_\tau$ data using **TAUOLA** have shown noticeable inconsistencies. We would like to improve the hadronic matrix elements in **TAUOLA**.
- We have studied these decays within RχT with a **Large N_C**-inspired model guided by QCD.
- We have revisited $\tau^- \to 3\pi^-\,\nu_\tau$ obtaining a better parameterization
- Within the $2K\,\pi$ channels we have found more br to the channels containing π^-
- We have found Vector Current dominance on the $2K\,\pi$ channels
- Our results have been implemented in **SHERPA** (**LHC** and **TEVATRON**) and will be used by **BELLE**.
- **LHC**, **BABAR**, **BELLE**, **BES-III**…are promising facilities to test our predictions.
- The future looks even more promising and exciting: V_{us}, m_s, $\mathbf{m}_{\nu_\tau}$ and, of course, hadronization of QCD currents.

$\tau^- \to (2K\,\pi)^-\,\nu_\tau$ **in RχT**
Pablo Roig Garcés
Instituto de Física Corpuscular

SKIPPED SLIDES

$K\bar{K}\pi^-$ Channels within RχT

Experiment

$\Gamma = 3.47(23)\cdot 10^{-15}$ GeV

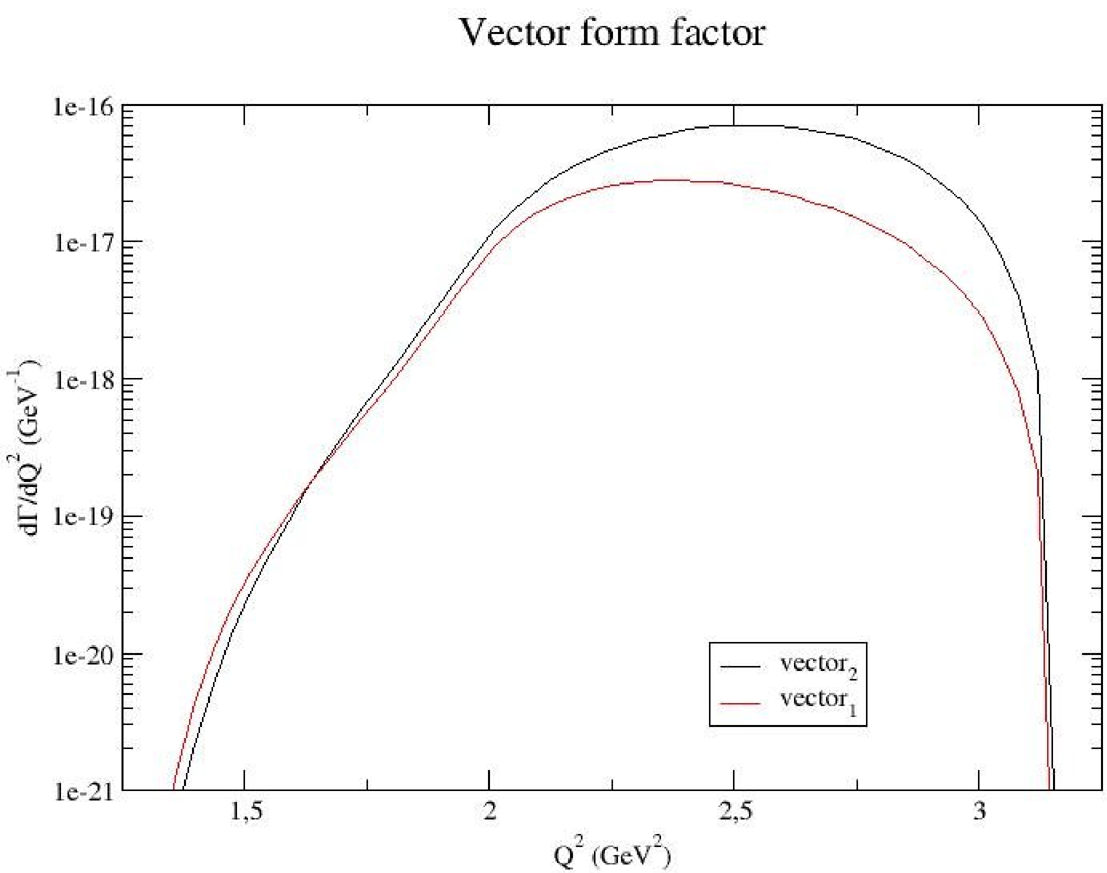
vector$_1$: (This work)

$\Gamma \sim 1.97\cdot 10^{-17}$ GeV

vector$_2$:

(Ruiz-Femenia, Pich, Portolés '03)

$\Gamma \sim 4.96\cdot 10^{-17}$ GeV



$\tau^- \to (2K\,\pi)^- \nu_\tau$

$\tau^- \to (KK\pi)^- \nu_\tau$ **within Resonance Chiral Theory**

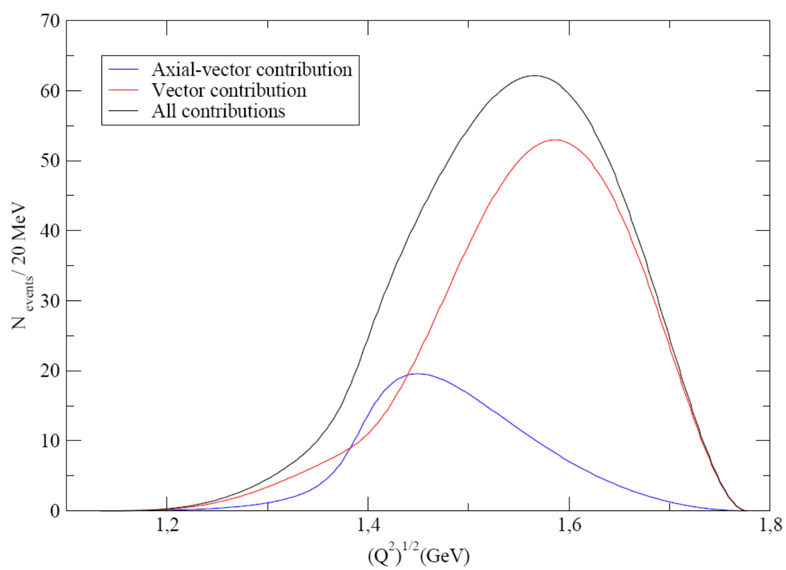
[Gómez Dumm, Pich, Portolés, Roig, coming soon]

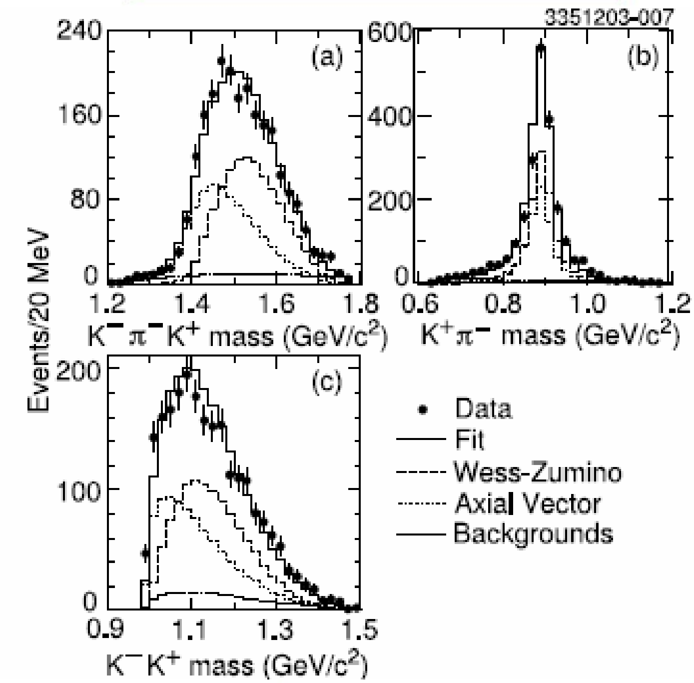
- Analysis of both **axial-vector** and **vector** form factors
- Required Brodsky-Lepage behaviour : constraints on unknown couplings of the Lagrangian
- Implemented in **SHERPA** ☑

No experimental contrast

~~[CLEO-III,2004]~~

Normalization of form factors violating chiral symmetry at leading order





$\tau^- \to (2K\,\pi)^- \nu_\tau$

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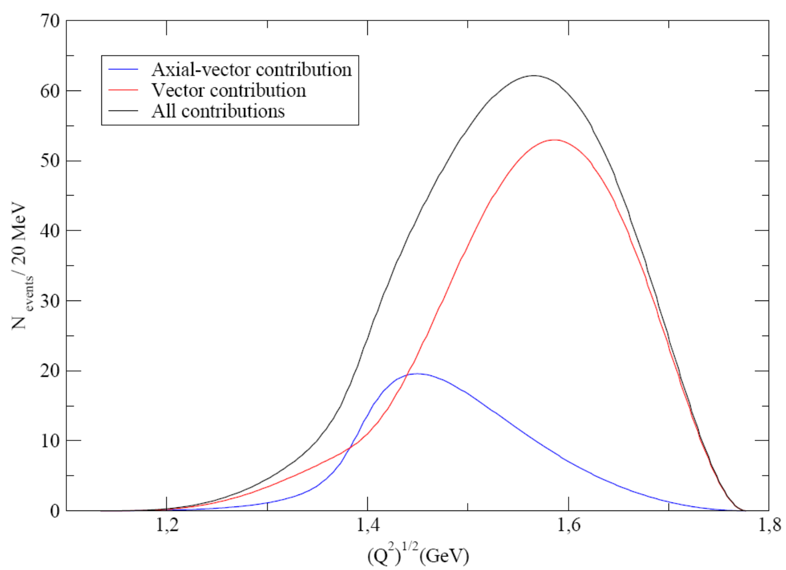

Experiment	# of τ pairs
LEP	$\sim 3\cdot 10^5$
CLEO	$\sim 1\cdot 10^7$
BABAR	$\sim 3\cdot 10^8$
BELLE	$\sim 5\cdot 10^8$
LHC	$\sim 1\cdot 10^{12}$

Chiral Resonance Theory + Large-N_C

Tensor formalism for spin=1 mesons

$$\mathcal{L}_{R\chi T} = \mathcal{L}_{\chi}^{(2)} + \mathcal{L}_{V} + \mathcal{L}_{A} + \mathcal{L}_{VAP}$$

$$\mathcal{L}_{\chi}^{(2)} = \frac{F^2}{4} \langle u_{\mu} u^{\mu} + \chi_{+} \rangle$$

$$\mathcal{L}_{V} = \frac{F_V}{2\sqrt{2}} \langle V_{\mu\nu} f_{+}^{\mu\nu} \rangle + \frac{iG_V}{\sqrt{2}} \langle V_{\mu\nu} u^{\mu} u^{\nu} \rangle$$

$$\mathcal{L}_{A} = \frac{F_A}{2\sqrt{2}} \langle A_{\mu\nu} f_{-}^{\mu\nu} \rangle$$

$$\mathcal{L}_{VAP} = \sum_{i}^{5} \lambda_i \, \mathcal{O}(V_{\mu}, A_{\mu}, \Pi) = \lambda_1 \langle [V_{\mu\nu}, A_{\mu\nu}] \chi_{-} \rangle + \ldots$$

5 unknown couplings

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Asymptotic behaviour of $\mathrm{Im}\Pi_{\mu\nu}{}^{A}$

[Floratos, Narison, de Rafael,1979]

$$\mathrm{Im}\,\Pi^{A}_{\mu\nu} = \frac{1}{2}\sum_{N}^{\infty}\int d\rho_{N}\delta^{(4)}(q-p_{N})\langle 0|A_{\mu}|N\rangle\langle N|A^{\dagger}_{\nu}|0\rangle \xrightarrow[(\mathrm{QCD},\ q^2\to\infty)]{} \mathrm{Constant}$$

☑ Asymptotic behaviour of Form Factors (QCD)

$$f_i\,(\lambda_k) = 0 \qquad , \qquad i = 1,2$$

3 unknown couplings

☑ Feynman diagrams : 1 only coupling, λ_0

4 parameters

$$\mathcal{L}_{VAP} \rightarrow \lambda_0$$

$$a_1(1260) \rightarrow M_{a_1}\ ,\ \Gamma_{a_1}\left(M^2_{a_1}\right)\ ,\ \alpha$$

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$\tau^- \to K^+K^-\pi^- \nu_\tau$ CLEO VERSION

(F. Liu '03, CLEO-III '04)

$$F_V = -\frac{1}{2\sqrt{2}\pi^2 F^3}\sqrt{R_B}\sum_i BW_i$$

$$BW_{V,A}(x = s_i, Q^2) = \frac{M_{V,A}{}^2}{M_{V,A}{}^2 - x - i\sqrt{x}\,\Gamma_{V,A}(x)}$$

$\tau^- \to K^+K^-\pi^- \nu_\tau$ CLEO VERSION

(F. Liu '03, CLEO-III '04)

$$F_V = -\frac{1}{2\sqrt{2}\pi^2 F^3}\sqrt{R_B}\sum_i BW_i$$

$$\underbrace{\frac{1}{2\sqrt{2}\pi^2 F^3}}_{L^{(4)}{}_{\chi,WZW}} \qquad \underbrace{\sqrt{R_B}\sum_i BW_i}_{\xrightarrow[Q^2\to 0]{} 1}$$

$\tau^- \to K^+K^-\pi^-\nu_\tau$ CLEO VERSION

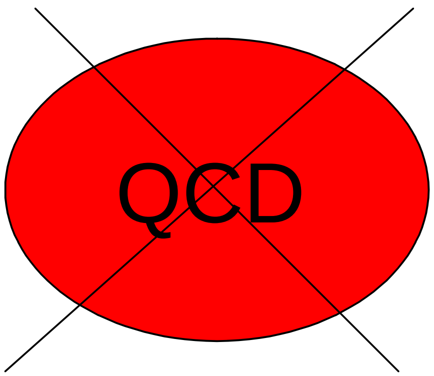
(F. Liu '03, CLEO-III '04)

$$F_V = -\frac{1}{2\sqrt{2}\pi^2F^3}\sqrt{R_B}\sum_i BW_i$$

$L^{(4)}_{\chi,WZW}$

$\xrightarrow[Q^2\to 0]{} 1$

R_B: 1.80±0.53



Kühn & Santamaría Model

[Kühn, Santamaría, 1990]

~~QCD~~

KS

- χPT $O(p^2)$ √
- χPT $O(p^4)$ ☒
- Vector meson dominance √
- Asymptotic behaviour ruled by QCD √
- $$BW_R = \frac{M_R^2}{M_R^2 - s - i\,\sqrt{s}\,\Gamma_R(s)}$$?

Example : Vector form factor of the pion

$$F_V(s) = \frac{BW_\rho\left(\frac{1+\alpha\,BW_\omega}{1+\alpha}\right) + \beta\,BW_{\rho'} + \gamma\,BW_{\rho''} + \ldots.}{1+\beta+\gamma+\ldots}$$

SHERPA

(**S**imulation of **H**igh **E**nergy **R**eactions of **PA**rticles)

•Institute for Theoretical Physics at TU Dresden (Germany) and I3P Durham (UK)

•Group Leader : Frank Krauss

•Tevatron + LHC

•http://www.physik.tu-dresden.de/~krauss/hep
•http://www.sherpa-mc.de/

Insertion of our matrix elements for hadronic tau decays