IFIC (CSIC-UV), València

RChT currents in TAUOLA: implementation, results and fit parameters

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together with

T. Przedzinski, P. Roig and Z. Was

Cracow, 14 May 2012

arXiv: 1203.3955 [hep-ph]

TAUOLA (Monte Carlo generator for tau decay modes)

Main references (manuals):

1. R. Decker, S.Jadach, M.Jezabek, J.H.Kuhn, Z. Was, Comput. Phys. Commun. 76 (1993) 361, ibid. 70 (1992) 69, ibid. 64 (1990) 275 ***CPC*** ***(reference) version***

2. P. Golonka, B. Kersevan ,T. Pierzchala, E. Richter-Was, Z. Was, M. Worek, Comput. Phys. Commun. 174 (2006) 818, hep-ph/0312240
3. J.H.Kuhn, Z. Was, Acta Phys. Polon. 39 (2008) 47 (5-pions), hep-ph/0602162
4. A. E. Bondar, S. I. Eidelman, A. I. Milstein, T. Pierzchala, N. I. Root, Z. Was and M. Worek (4 pions), Comput. Phys. Commun. 146 (2002) 139

The parametrization used by experimental collaboration (based on data 1997-1998):

1. Alain Weinstein : http://www.cithep.caltech.edu/~ajw/korb_doc.html#files *(cleo version)*
2. B. Bloch, private communications *(aleph version)*

Different intermediate states (because of different detector sensitivity), *e.g.*, $K\pi\pi$ *only* K^* *cleo* , K^*, ρ *aleph*

BaBar, Belle

Hadronic modes:

$\pi\nu_\tau$ $K\nu_\tau$ $2\pi\nu_\tau$ $2K\nu_\tau$ $K\pi\nu_\tau$ $3\pi\nu_\tau$ $KK\pi\nu_\tau$ $K\pi\pi\nu_\tau$ $2\pi\eta\nu_\tau$ $4\pi\nu_\tau$ $5\pi\nu_\tau$

88% hadronic width

CPC version

- **2 pseudoscalar modes written analogous to 2π τ**
  normalization not fixed (too small statics 1992),
  only vector FF , no scalar FF
- **3 pseudoscalar modes (CPC version)**
  3pion modes (BW(a1)*BW(ρ)) reproduces LO ChPT limit

KKpi modes:

- within CPC parametrization CLEO was not able to reproduce data
- CLEO parametrization: to adjust data added factors (hep-ex/0401005)

$$
\begin{aligned}
J^\mu &= \left(q_1^\mu - q_3^\mu - Q^\mu \frac{Q(q_1-q_3)}{Q^2}\right) F_1(s_1,s_2,Q^2) \\
&\quad + \left(q_2^\mu - q_3^\mu - Q^\mu \frac{Q(q_2-q_3)}{Q^2}\right) F_2(s_1,s_2,Q^2) \\
&\quad + i\epsilon^{\mu\alpha\beta\gamma} q_{1\alpha} q_{2\beta} q_{3\gamma} F_3(s_1,s_2,Q^2)
\end{aligned}
$$

$$
\begin{aligned}
F_1 &= -\frac{\sqrt{2}}{3f_\pi}\mathrm{BW}_{a_1}(Q^2)\frac{\mathrm{BW}_\rho(s_2)+\beta_\rho \mathrm{BW}_{\rho'}(s_2)}{1+\beta_\rho}, \\
F_2 &= -\frac{\sqrt{2}}{3f_\pi}\cdot R_F \cdot \mathrm{BW}_{a_1}(Q^2)\cdot \mathrm{BW}_{K^*}(s_1), \\
F_3 &= -\frac{1}{2\sqrt{2}\pi^2 f_\pi^3}\cdot\sqrt{R_B}\cdot\frac{\mathrm{BW}_\omega(s_2)+\alpha \mathrm{BW}_{K^*}(s_1)}{1+\alpha} \\
&\quad \cdot\frac{\mathrm{BW}_\rho(Q^2)+\lambda \mathrm{BW}_{\rho'}(Q^2)+\delta \mathrm{BW}_{\rho''}(Q^2)}{1+\lambda+\delta},
\end{aligned}
$$

$$R_B = 3.23 \pm 0.26$$

CONTENTS

TAUOLA 2011 (arXiv:1202.3955)

- Structure of the project, model etc.
- Results for currents

    2pions and 2 kaons

    K pion modes

    3 pions

    KKpi and KK0pi0

    width of resonances
- Tests
- Numerical results and parameters of fits

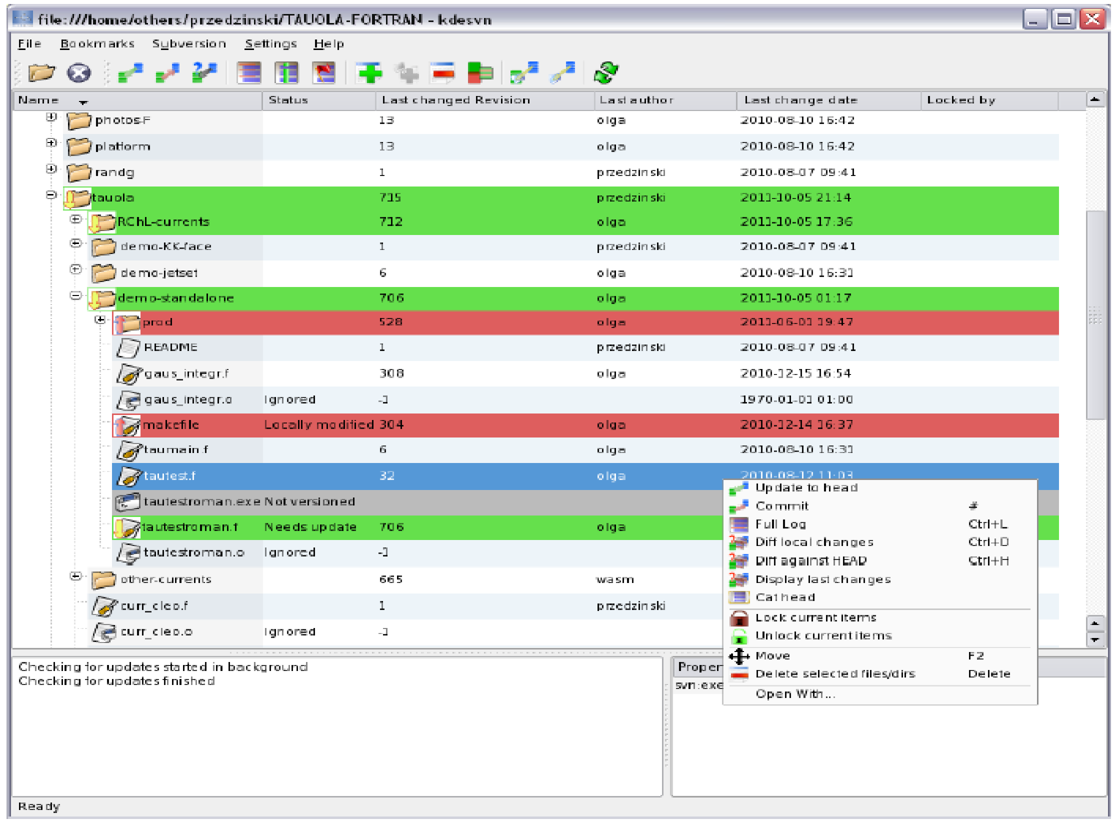
TAUOLA 2012

CONCLUSION

TAUOLA 2011 - 2012

Code management

- SVN revision control system
  - displaying recent changes
  - branching different approaches
  - tagging milestones and stable revisions
  - when bug is found – "blame" to check who and when
  - GUI: kdesvn



Z. Was, T. Przedzinski, O.Shekhovtsova ifj.edu.pl

Structure of *new-currents/RChL-currents*

Added to \tauola *cleo* version

- codes for currents
  - frho_pi.f pipi0 mode
  - fkk0.f kk0 mode
  - fkpipl.f kpi modes
  - f3pi_rcht.f 3 pion modes
  - fkkpi.f KKpi modes
  - fkk0pi0.f KK0pi0 mode
- library of functions used in the currents
  - funct_rpt.f Width of resonances etc
- code for a1 width as function of qq
  - /tabler/a1/da1wid_tot_rho1_gauss.f
  - wid_a1_fit.f linear interpolation
- numerical values of fit parameters, dipswitches
  - value_parameter.f
- tests of MC results (for separate modes)
  /cross-check/check_analyticity_and_numer_integr

Every directories with own README

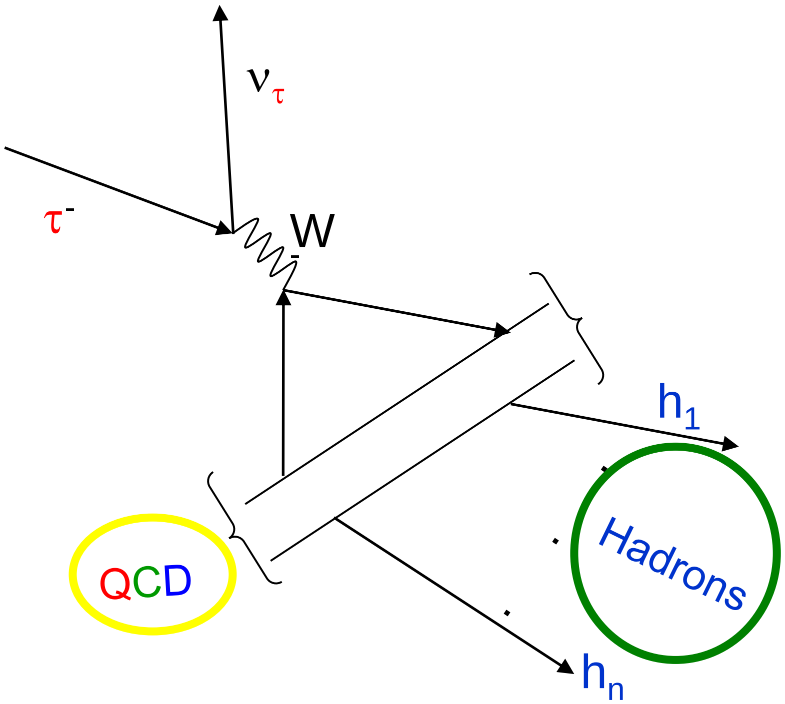
Hadronic decay mode of τ

$$\tau(P) \to X\nu_\tau(N)$$

$$\mathcal{M} = \frac{G_F}{\sqrt{2}}\bar{u}(N)\gamma^\mu(1-\gamma_5)u(P)J_\mu$$

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

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



3 pseudoscalars: 3 Lorentz independent structure
2 pseudoscalars: 2 Lorentz independent structure (vector; scalar)

TAUOLA: hadronic currents   tauola.f
Form factors new-currents/RChL-currents

Two meson modes: $\tau^- \to \pi^- \pi^0 \nu_\tau$; $\tau^- \to (K\pi)^- \nu_\tau$; $\tau^- \to K^- K^0 \nu_\tau$

$$J^\mu = N\left[(p_1 - p_2)^\mu F^V(s) + (p_1 + p_2)^\mu F^S(s)\right]$$

$$s = (p_1 + p_2)^2$$

$$N^{\pi^-\pi^0} = 1,\ N^{K^-K^0} = \frac{1}{\sqrt{2}},\ N^{\pi^-\bar{K}^0} = \frac{1}{\sqrt{2}},\ N^{\pi^0 K^-} = \frac{1}{2}$$

TAUOLA 2011: only vector FF

Three meson modes: $\tau^- \to (3\pi)^- \nu_\tau$; $\tau^- \to K^-\pi^-K^+ \nu_\tau$; $\tau^- \to K^0\pi^- K^0 \nu_\tau$; $\tau^- \to K^-\pi^0K^0 \nu_\tau$

$$J^\mu = N\left\{T_\nu^\mu\left[c_1(p_2 - p_3)^\nu F_1 + c_2(p_3 - p_1)^\nu F_2 + c_3(p_1 - p_2)^\nu F_3\right] + c_4 q^\nu F_4 - \frac{i}{4\pi^2 F^2} c_5 \varepsilon^{\mu\nu\rho\sigma} p_{1\nu} p_{2\rho} p_{3\sigma} F_5\right\}$$

Decay mode (p_1, p_2, p_3)	c_1	c_2	c_3	c_4	c_5
$\pi^-\pi^-\pi^+$	1	- 1	0	1	0
$\pi^0\pi^0\pi^-$	1	- 1	0	1	0
$K^-\pi^-K^+$	1	- 1	0	0	1
$K^0\pi^-\bar{K}^0$	1	- 1	0	0	1
$K^-\pi^0K^0$	0	1	- 1	0	- 1

$$N = \begin{cases} \cos\theta_{Cabibo}/F\ , & 2n\ kaons \\ \sin\theta_{Cabibo}/F\ , & 2n+1\ kaons \end{cases}$$

$$T_\mu^\nu = g^{\mu\nu} - \frac{q^\mu q^\nu}{q^2}, \quad q^\mu = p_1^\mu + p_2^\mu + p_3^\mu$$

FF: F_1, F_2, F_3 axial-vector, F_5 vector, F_4 pseudoscalar

→ RχT

Resonance Chiral Theory
(Chiral Theory with the explicit inclusion of *resonances*)

G.Ecker et al., Nucl. Phys B321(1989)311

1. **The resonance fields** ($V_{\mu\nu}$, $A_{\mu\nu}$ *antisymmetric tensor field*) is added by explicit way , based on ChPT
2. Reproduces NLO prediction of ChPT (at least)
3. Theoretical results for **2πτ, 2K τ, Kπτ, 3πτ, KKπτ** → **self consistent results for TAUOLA**
4. Correct high energy behaviour of form factors: $F_V G_V = f_\pi^2$, $F_V^2 - F_A^2 = f_\pi^2$, $F_V^2 M_V^2 = F_A^2 M_A^2$

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Finite numbers of parameters (one octet: f_π , F_V, G_V, F_A)

Talk Pablo Roig

2πτ, 2K τ, Kπτ, 3πτ, KKπτ **88% of tau hadronic width**

Currents in RChT in TAUOLA2011

Two pions and two kaons

SU(2) : $F^S_{KK}(s) = F^S_{\pi\pi}(s) = 0$ NLO SU(2) effect $(m_u - m_d)^2$

Vector Form Factors: $m_{\pi^\pm} \neq m_{\pi^0}$

$m_{K^\pm} \neq m_{K^0}$

$F^V_{KK}(s) = F^V_{\pi\pi}(s)$

ρ, ρ', ρ''

$$F^V_{\pi\pi}(s) = \frac{M_\rho^2 + s\left(\gamma e^{i\phi_1} + \delta e^{i\phi_2}\right)}{M_\rho^2 - s - iM_\rho\Gamma_\rho(s)} \exp\left\{\frac{-s}{96\pi^2F^2}\left[Re A_{\pi^-\pi^0}(s) + \frac{1}{2}Re A_{K^-K^0}(s)\right]\right\}$$
$$- \frac{s\gamma e^{i\phi_1}}{M_{\rho'}^2 - s - iM_{\rho'}\Gamma_{\rho'}(s)} \exp\left\{\frac{-s\Gamma_{\rho'}}{\pi M_{\rho'}^3\sigma_\pi^3(M_{\rho'}^2)}\left[Re A_\pi(s)\right]\right\}$$
$$- \frac{s\delta e^{i\phi_2}}{M_{\rho''}^2 - s - iM_{\rho''}\Gamma_{\rho''}(s)} \exp\left\{\frac{-s\Gamma_{\rho''}}{\pi M_{\rho''}^3\sigma_\pi^3(M_{\rho''}^2)}\left[Re A_\pi(s)\right]\right\},$$

- $\rho'(\rho'')$ phenomenologically
- SU(3) limit: δ , γ are the same for 2 pions and 2 kaons

  No SU(3) up to 30% difference $\Rightarrow$ **fit**
- $A_{PQ}(s)$ a loop function, presents FSI effects
- $F^V(0) = 1$, correct short distance behaviour $F^V(s \to \infty) = 0$
- unitarity, analyticity (NNLO)

P. Roig talk

K pion mode $\tau^- \to (K\pi)^- \nu_\tau$

$$m_{\pi^\pm} = m_{\pi^0}$$
$$m_{K^\pm} = m_{K^0}$$

$$J^\mu = N\left[(p_1 - p_2)^\mu F^V(s) + (p_1 + p_2)^\mu F^S(s)\right]$$

$F^S_{K\pi}(s) \neq 0$ $\qquad$ $F^V_{K\pi}(0) \neq 0$ (FSI effect)

TAUOLA 2012

Vector FF **(K*, K*′):**

1. Exponention of FSI

M.Jamin, A. Pich, J. Portoles, Phys. Lett B 664(2008) 78

$$F^V_{K\pi}(s) = \left(\frac{M^2_{K^*} + s\gamma_{K\pi}}{M^2_{K^*} - s - iM_{K^*}\Gamma_{K^*}(s)} - \frac{s\gamma_{K\pi}}{M^2_{K^{*\prime}} - s - iM_{K^{*\prime}}\Gamma_{K^{*\prime}}(s)}\right)$$
$$\exp\left\{\frac{-s}{128\pi^2 F^2}\left[ReA_{K\pi}(s) + ReA_{K\eta}(s)\right]\right\}.$$

different treatment of FSI

2. simplified version of *D.R. Boito, R.Escribano, M. Jamin, Eur. Phys. J C59(2009)821*

′Gounaris-Sakurai′

$$\widetilde{F}^{K\pi}_+(s) \equiv F^{K\pi}_+(s)/F^{K\pi}_+(0)$$
$$\widetilde{F}^{K\pi}_+(s) = \frac{m^2_{K^*} - \kappa_{K^*}\widetilde{H}_{K\pi}(0) + \gamma s}{D(m_{K^*}, \gamma_{K^*})} - \frac{\gamma s}{D(m_{K^{*\prime}}, \gamma_{K^{*\prime}})}$$
$$D(m_n, \gamma_n) \equiv m_n^2 - s - \kappa_n \mathrm{Re}\widetilde{H}_{K\pi}(s) - i\, m_n \gamma_n(s)$$

$$\Gamma_\rho(s),\quad \Gamma_{\rho'}(s),\quad \Gamma_{K^*}(s),\quad \Gamma_{K^{*\prime}}(s)$$
$$M_{K^*},\quad M_{K^{*\prime}},\quad M_\rho,\quad M_{\rho'},\quad F_V,\quad G_V,\quad \gamma_{K\pi},\quad \gamma,\quad \delta$$

Three pseudoscalar modes:

$m_{\pi^\pm} = m_{\pi^0}$
$m_{K^\pm} = m_{K^0}$

$\tau^- \to (3\pi)^- \nu_\tau$; $\tau^- \to K^-\pi^-K^+ \nu_\tau$; $\tau^- \to K^0\pi^-K^0 \nu_\tau$, $\tau^- \to K^-\pi^0K^0 \nu_\tau$

$$J^\mu = N\left\{T^\mu_\nu\left[c_1(p_2-p_3)^\nu F_1 + c_2(p_3-p_1)^\nu F_2 + c_3(p_1-p_2)^\nu F_3\right] + c_4 q^\nu F_4 - \frac{i}{4\pi^2F^2}c_5\varepsilon^{\mu\nu\rho\sigma}p_{1\nu}p_{2\rho}p_{3\sigma}F_5\right\}$$

$$T^\nu_\mu = g^{\mu\nu} - \frac{q^\mu q^\nu}{q^2}, \quad q^\mu = p_1^\mu + p_2^\mu + p_3^\mu$$

FF: F_1 F_2 F_3 axial-vector, F_5 vector, $F_5(3\pi) = 0$ **, F_4 pseudoscalar**

General structure

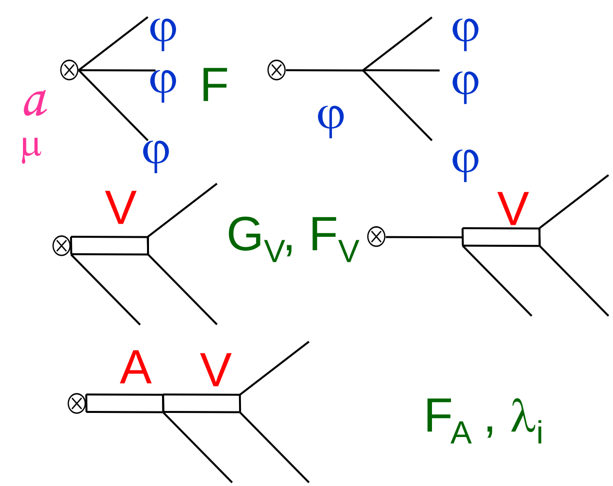
$$F_i = F_i^\chi + F_i^R + F_i^{RR}$$

$$F_4 \sim m_\pi^2 / q^2$$

χPT

RχT, 1R

RχT, 2R



No VV vertex for 3 pions

1 octet: F, F_V , G_V , λ_i (5, 3 for 3pi and Kkpi modes)

1 + 7 constants

$\tau^- \to \pi^0\pi^0\pi^-\nu_\tau$, $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$

arXiv:0911.4436

$$F_1^\chi(q^2,s_1,s_2) = -\frac{2\sqrt{2}}{3}$$

$$F_1^{\rm R}(q^2,s_1,s_2) = \frac{\sqrt{2}\,F_V\,G_V}{3\,F^2}\left[\frac{3\,s_1}{s_1-M_\rho^2-iM_\rho\Gamma_\rho(s_1)} - \left(\frac{2G_V}{F_V}-1\right)\left(\frac{2q^2-2s_1-s_3}{s_1-M_\rho^2-iM_\rho\Gamma_\rho(s_1)}+\frac{s_3-s_1}{s_2-M_\rho^2-iM_\rho\Gamma_\rho(s_2)}\right)\right],$$

$$F_1^{\rm RR}(q^2,s_1,s_2) = \frac{4\,F_A\,G_V}{3\,F^2}\,\frac{q^2}{q^2-M_A^2-iM_A\Gamma_A(q^2)}\left[-(\lambda'+\lambda'')\frac{3\,s_1}{s_1-M_\rho^2-iM_\rho\Gamma_\rho(s_1)} + H\left(\frac{s_1}{q^2},\frac{m_\pi^2}{q^2}\right)\frac{2q^2+s_1-s_3}{s_1-M_\rho^2-iM_\rho\Gamma_\rho(s_1)} + H\left(\frac{s_2}{q^2},\frac{m_\pi^2}{q^2}\right)\frac{s_3-s_1}{s_2-M_\rho^2-iM_\rho\Gamma_\rho(s_2)}\right],$$

$$F_2(q^2,s_2,s_1) = F_1(q^2,s_1,s_2)$$

Axial-vector

$$F_4^\chi(q^2,s_1,s_2) = \frac{2\sqrt{2}}{3}\,\frac{m_\pi^2[3(s_3-m_\pi^2)-q^2(1+2\kappa R^{3\pi})]}{2q^2(q^2-m_\pi^2)},$$

$$F_4^{\rm R}(q^2,s_1,s_2) = -\frac{\sqrt{2}\,F_V\,G_V}{3\,F^2}\left[\alpha_2(q^2,s_2,s_1)+\alpha_2(q^2,s_1,s_2)\right]$$

$$\alpha_2(q^2,s_1,s_2) = \frac{3G_V}{F_V}\,\frac{s_1}{q^2}\,\frac{m_\pi^2}{q^2-m_\pi^2}\,\frac{s_3-s_2}{s_1-M_\rho^2-iM_\rho\Gamma_\rho(s_1)}$$

Simplified version to include ρ'

$$\frac{1}{M_\rho^2-q^2-iM_\rho\Gamma_\rho(q^2)} \longrightarrow \frac{1}{1+\beta_{\rho'}}\left[\frac{1}{M_\rho^2-q^2-iM_\rho\Gamma_\rho(q^2)}+\frac{\beta_{\rho'}}{M_{\rho'}^2-q^2-iM_{\rho'}\Gamma_{\rho'}(q^2)}\right]$$

$$\beta_{\rho'} = -F_{V'}G_{V'}/F^2$$

$\Gamma_\rho(s)$, $\Gamma_{\rho'}(s)$, $\Gamma_A(s)$

M_A, M_ρ, $M_{\rho'}$, F_V, G_V, F_A, β_ρ

$$\tau^- \to K^-\pi^-K^+\,\nu_\tau \qquad \tau^- \to K^0\pi^-K^0\,\nu_\tau$$

$$F_i = F_i^{\chi} + F_i^{\rm R} + F_i^{\rm RR}\,, \qquad i = 1, 2, 5$$

$$F_1^{\chi}(q^2, s_2, s_1) = -\frac{\sqrt{2}}{3}$$

$$F_1^{\rm R}(q^2, s_2, s_1) = -\frac{\sqrt{2}}{6}\frac{F_V\,G_V}{F^2}\left[\frac{B^{\rm R}(s_1, s_3, m_K^2, m_K^2)}{M_\rho^2 - s_2 - iM_\rho\Gamma_\rho(s_2)} + \frac{A^{\rm R}(q^2, s_1, s_3, m_K^2, m_K^2, m_\pi^2)}{M_{K^*}^2 - s_1 - iM_{K^*}\Gamma_{K^*}(s_1)}\right]$$

$$F_1^{\rm RR}(q^2, s_2, s_1) = \frac{2}{3}\frac{F_A G_V}{F^2}\frac{q^2}{M_A^2 - q^2 - iM_A\Gamma_A(q^2)}\left[\frac{B^{\rm RR}(q^2, s_1, s_3, s_2, m_K^2, m_K^2, m_\pi^2)}{M_\rho^2 - s_2 - iM_\rho\Gamma_\rho(s_2)} + \frac{A^{\rm RR}(q^2, s_1, s_3, m_K^2, m_K^2, m_\pi^2)}{M_{K^*}^2 - s_1 - iM_{K^*}\Gamma_{K^*}(s_1)}\right].$$

$$F_2^{\chi}(q^2, s_2, s_1) = \;.....$$

Axial-vector

$$F_5^{\rm RR}(q^2, s_2, s_1) = -16\sqrt{2}\pi^2 F_V\,G_V\frac{1}{M_\rho^2 - q^2 - iM_\rho\Gamma_\rho(q^2)}\left[\frac{C^{\rm RR}(q^2, s_1, m_K^2)}{M_{K^*}^2 - s_1 - iM_{K^*}\Gamma_{K^*}(s_1)} + C^{\rm RR}(q^2, s_2, m_\pi^2)\left(\sin^2\theta_V\frac{1+\sqrt{2}\cot\theta_V}{M_\omega^2 - s_2 - iM_\omega\Gamma_\omega} + \cos^2\theta_V\frac{1-\sqrt{2}\tan\theta_V}{M_\phi^2 - s_2 - iM_\phi\Gamma_\phi}\right)\right],$$

Vector

$$\theta_V = \tan^{-1}(1/\sqrt{2})$$

$\Gamma_\rho(s),\quad \Gamma_{\rho'}(s),\quad \Gamma_A(s)$

$M_A,\quad M_\rho,\quad M_{\rho'},\quad F_V,\quad G_V,\quad F_A,\quad \theta_V$

$c_i,\quad d_i,\quad g_i$

Vector contribution

- within CPC parametrization CLEO was not able to reproduce data
- CLEO parametrization: to adjust data added factors (hep-ex/0401005)

$$J^\mu = \left(q_1^\mu - q_3^\mu - Q^\mu \frac{Q(q_1 - q_3)}{Q^2}\right) F_1(s_1, s_2, Q^2) + \left(q_2^\mu - q_3^\mu - Q^\mu \frac{Q(q_2 - q_3)}{Q^2}\right) F_2(s_1, s_2, Q^2) + i\epsilon^{\mu\alpha\beta\gamma} q_{1\alpha} q_{2\beta} q_{3\gamma} F_3(s_1, s_2, Q^2)$$

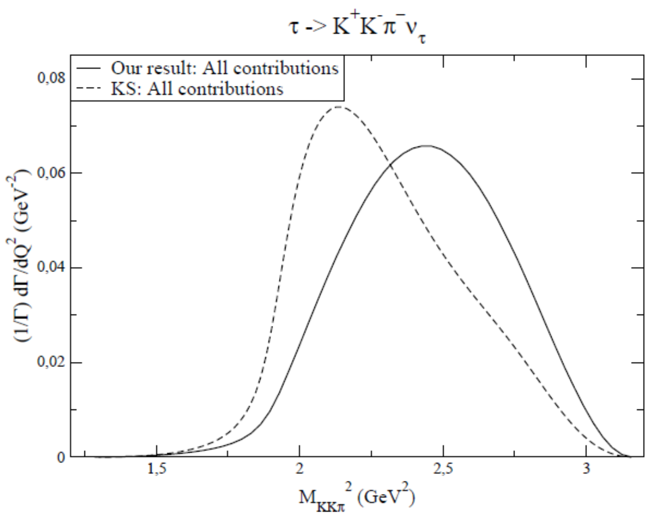
$$F_1 = -\frac{\sqrt{2}}{3f_\pi} \mathrm{BW}_{a_1}(Q^2) \frac{\mathrm{BW}_\rho(s_2) + \beta_\rho \mathrm{BW}_{\rho'}(s_2)}{1 + \beta_\rho},$$

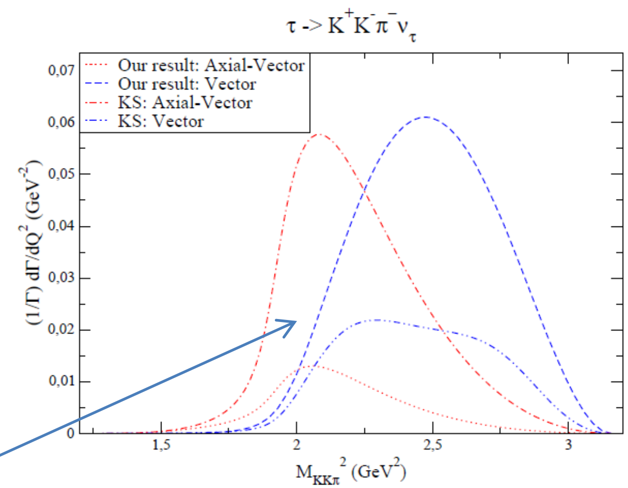
$$F_2 = -\frac{\sqrt{2}}{3f_\pi} \cdot R_F \cdot \mathrm{BW}_{a_1}(Q^2) \cdot \mathrm{BW}_{K^*}(s_1),$$

$$F_3 = -\frac{1}{2\sqrt{2}\pi^2 f_\pi^3} \cdot \sqrt{R_B} \cdot \frac{\mathrm{BW}_\omega(s_2) + \alpha \mathrm{BW}_{K^*}(s_1)}{1 + \alpha} \cdot \frac{\mathrm{BW}_\rho(Q^2) + \lambda \mathrm{BW}_{\rho'}(Q^2) + \delta \mathrm{BW}_{\rho''}(Q^2)}{1 + \lambda + \delta},$$

$$R_B = 3.23 \pm 0.26$$

CPC and TAUOLA 2011 (*arXiv:0911.2640*):





Sizable vector contribution in RChT

RChT prediction should be checked by data

WIDTH OF RESONANCES

RChL LO approximation $(N_c \to \infty)$ zero-width resonances

Width is from NLO as the imaginary part of the corresponding correlator and satisfies

- analyticity
- unitarity
- chiral symmetry of QCD

VV function $\to \rho\,(K^*)$ meson, VAP $\to a_1$

Vector resonances:

$$\Gamma_\rho(q^2) = \frac{M_\rho q^2}{96\pi F^2}\left[\theta(q^2 - thr_\pi)\lambda^{3/2}\left(1, \frac{m^2_{\pi^+}}{q^2}, \frac{m^2_{\pi^0}}{q^2}\right) + \frac{1}{2}\theta(q^2 - thr_K)\lambda^{3/2}\left(1, \frac{m^2_{K^+}}{q^2}, \frac{m^2_{K^0}}{q^2}\right)\right]$$

2 pions and 2 Kaons

$$\Gamma_{K^*}(q^2) = \Gamma_{K^*}\frac{q^2}{M^2_{K^*}}\frac{\lambda^{3/2}\left(1, \frac{m^2_K}{q^2}, \frac{m^2_\pi}{q^2}\right)\theta(q^2 - thr_{K\pi}) + \lambda^{3/2}\left(1, \frac{m^2_K}{q^2}, \frac{m^2_\eta}{q^2}\right)\theta(q^2 - thr_{K\eta})}{\lambda^{3/2}\left(1, \frac{m^2_K}{M^2_{K^*}}, \frac{m^2_\pi}{M^2_{K^*}}\right) + \lambda^{3/2}\left(1, \frac{m^2_K}{M^2_{K^*}}, \frac{m^2_\eta}{M^2_{K^*}}\right)}$$

Kpi modes

$$\lambda(x, y, z) = (x - y - z)^2 - 4yz \qquad thr_\pi = (m_{\pi^+} + m_{\pi^0})^2 \qquad thr_K = (m_{K^+} + m_{K^0})^2$$

$$thr_{PQ} = (m_P + m_Q)^2$$

Three meson modes: simplified versions of widths

$$\Gamma_\rho(q^2) = \frac{M_\rho q^2}{96\pi F^2}\left[\sigma_\pi^3(q^2)\theta(q^2-4m_\pi^2) + \frac{1}{2}\sigma_K^3(q^2)\theta(q^2-4m_K^2)\right]$$

$$\Gamma_{\rho'}(q^2) = \Gamma_{\rho'}\frac{q^2}{M_{\rho'}^2}\frac{\sigma_\pi^3(q^2)}{\sigma_\pi^3(M_{\rho'}^2)}\theta\left(q^2-4m_\pi^2\right) \qquad \sigma_P(q^2) \equiv \sqrt{1-4m_P^2/q^2}$$

$$\Gamma_{K^{*\prime}}(q^2) = \Gamma_{K^{*\prime}}\frac{q^2}{M_{K^{*\prime}}^2}\frac{\lambda^{3/2}\left(1,\frac{m_K^2}{q^2},\frac{m_\pi^2}{q^2}\right)}{\lambda^{3/2}\left(1,\frac{m_K^2}{M_{K^{*\prime}}^2},\frac{m_\pi^2}{M_{K^{*\prime}}^2}\right)}\theta(q^2-thr_{K\pi})$$

SU(2) limit

$m_{\pi^\pm} = m_{\pi^0}$

$m_{K^\pm} = m_{K^0}$

new-currents/RChL-currents/value_parameter.f

a_1 resonance:

$$\begin{aligned}\Gamma_{a_1}(q^2) &= 2\Gamma_{a_1}^{\pi}(q^2)\theta\left(q^2-9m_\pi^2\right)\\ &+ 2\Gamma_{a_1}^{K^\pm}(q^2)\theta\left(q^2-(m_\pi+2m_K)^2\right)+\Gamma_{a_1}^{K^0}(q^2)\theta\left(q^2-(m_\pi+2m_K)^2\right)\\ \Gamma_{a_1}^{\pi,K}(q^2) &= \frac{-S}{192(2\pi)^3F_A^2F^2M_{a_1}}\left(\frac{M_{a_1}^2}{q^2}-1\right)^2\\ &\int dsdt\,(V_1^\mu F_1+V_2^\mu F_2+V_3^\mu F_3)^{\pi,K}\left((V_{1\mu}F_1+V_{2\mu}F_2+V_{3\mu}F_3)^{\pi,K}\right)^*\end{aligned}$$

$$V_i^\mu = c_i T^{\mu\nu}(p_j-p_k)_\nu, \quad i\neq j\neq k=1,2,3$$

$$S = 1/n!$$

a1 width ($\Gamma_{a_1}(q^2)$) is tabulated to avoid problem with triple integration, linear interpolation

new-currents/RChL-currents/table/a1 ***new-currents/RChL-currents/wid_a1_fit.f***

DIPSWITCH PARAMETERS

new-currents/RChL-currents/value_parameter.f

DIPSWITCH	VALUE	MEANING	MODE
FFVEC	0, 1*	FSI OFF, ON*	PIPI0, KPI, KK0
FFKPIVEC	0, 1*	FSI GS, EXPON	KPI
FFKKVEC	0*,1	RHOPR OFF*,ON	KK0

* default value

Input: parameters from fit etc.

Parameters to fit

new-currents/RChL-currents/value_parameter.f

1. Non - model parameters
(non resonance + narrow resonance)

PDG values

Parameter	Var. name	Default
m_τ	MTAU	1.777
m_{ν_τ}	MNUTA	0.001
$\cos\theta_{\rm Cabibbo}$	set in TAUOLA init.	0.975
G_F	set in TAUOLA init.	$1.166375 \cdot 10^{-5}$
$m_{\pi^\pm}$	mpic	0.13957018
m_{π^0}	mpiz	0.1349766
m_η	meta	0.547
$m_{K^\pm}$	mkc	0.493677
m_{K^0}	mkz	0.497648
M_ω	mom	0.78194
Γ_ω	gom	0.00843
M_ϕ	mphi	1.019
Γ_ϕ	gphi	0.0042

2. Parameters from vector currents (with F_5) in KKpi modes

$$J^\mu = N\left\{ \ldots - \frac{i}{4\pi^2 F^2} c_5 \varepsilon^{\mu\nu\rho\sigma} p_{1\nu} p_{2\rho} p_{3\sigma} F_5 \right\}$$

$$\mathcal{L}_4^{\rm V} = \sum_{i=1}^{5} \frac{g_i}{M_V} \mathcal{O}^i_{\rm VPPP} + \sum_{i=1}^{7} \frac{c_i}{M_V} \mathcal{O}^i_{\rm VJP}$$

$$c_i, \quad d_i, \quad g_i$$

$$\mathcal{L}_2^{\rm RR} = \sum_{i=1}^{5} \lambda_i \mathcal{O}^i_{\rm VAP} + \sum_{i=1}^{4} d_i \mathcal{O}^i_{\rm VVP}$$

$$\begin{aligned} c_1 - c_2 + c_5 &= 0\,, \\ c_1 - c_2 - c_5 + 2c_6 &= -\frac{N_C}{96\,\pi^2}\frac{F_V\,M_V}{\sqrt{2}\,F^2} \\ d_3 &= -\frac{N_C}{192\,\pi^2}\frac{M_V^2}{F^2}\,, \\ g_1 + 2g_2 - g_3 &= 0\,, \\ g_2 &= \frac{N_C}{192\,\sqrt{2}\,\pi^2}\frac{M_V}{F_V} \end{aligned}$$

Correct high energy behaviour of vector form factor

$$H^3_{\mu\nu}(s,t,Q^2) \equiv T^3_\mu T^{3\,*}_\nu \qquad \int {\rm d}\Pi_3\, H^3_{\mu\nu}(s,t,Q^2) = (Q^2 g_{\mu\nu} - Q_\mu Q_\nu)\,\Pi_V(Q^2)$$

$$\Gamma(\omega \to \pi^+\pi^-\pi^0) \longrightarrow 2g_4 + g_5 = -0.60 \pm 0.02$$

P. Roig talk for errors/uncertainity

3. Model (resonance) parameters (two mesons and axial-vector current for three meson)

$$\Gamma_{\rho'},\quad M_A,\quad M_\rho,\quad M_{\rho'},\quad F_V,\quad G_V,\quad F_A,\quad \beta_\rho,\qquad \Gamma_{K^*},\quad \Gamma_{K^{*\prime}},\quad M_{K^*},\quad M_{K^{*\prime}},\quad \gamma_{K\pi},\quad \gamma,\quad \delta$$

depend on the mode and dipswicthes !!!

3.1 . Model constants

1. Fixed F and F_k (FIXED!!!)

2. Correct high energy behaviour of pion FF

$$G_V = F^2/F_V$$

3. F_A , F_V fit Aleph 3 pion spectrum

4. beta_rho, gamma_rcht fit to Belle spectrum (hep-ph/ ....)

4. ideal mixing angle for THETA $\theta_V = \tan^{-1}(1/\sqrt{2})$ (FIXED!!!)

Parameter	Var. name	Default	[suggested range]
F	fpi_rpt	0.0924	$[0.0920, 0.0924]$
F_K	fk_rpt	1.198F	$[0.94F, 1.2F]$
F_V	fv_rpt	0.18	$[0.12, 0.24]$
G_V	gv_rpt	F^2/F_V	$[0.xxF^2/F_V, 1.xxF^2/F_V]$
F_A	fa_rpt	0.149	$[0.10, 0.20]$
β_ρ	beta_rho	-0.25	$[-0.36, -0.18]$
$\gamma_{K\pi}$	gamma_rcht	-0.043	$[-0.033, -0.053]$
$\gamma_{K\pi}$	gamma_rcht	-0.039	$[-0.023, -0.055]$
θ_V	THETA	$35.26°$	$[15^o, 50^o]$
γ	coef_ga	0.14199	$[0.077, 0.099]$
δ	coef_de	-0.12623	$[-0.035, -0.012]$
ϕ_1	phi_1	-0.17377	$[0.5, 0.7]$
ϕ_2	phi_2	0.27632	$[0.5, 1.1]$

3.2. Masses, widths of resonances

Parameter	Var. name	Default	[suggested range]
M_ρ	mro	0.77554	[0.770, 0.777]
M_ρ	mro	0.775	[0.770, 0.777]
M_{a_1}	mma1	1.12	[1.00, 1.24]
$M_{\rho'}$	mrho1	1.453	[1.44, 1.48]
$M_{\rho'}$	mrho1	1.465	[1.44, 1.48]
$\Gamma_{\rho'}$	grho1	0.50155	[0.32, 0.39]
$\Gamma_{\rho'}$	grho1	0.4	[0.32, 0.39]
$M_{\rho''}$	mrho2	1.8105	[1.68, 1.78]
$\Gamma_{\rho''}$	grho2	0.4178	[0.08, 0.20]
γ	coef_ga	0.14199	[0.077, 0.099]
δ	coef_de	−0.12623	[−0.035, −0.012]
ϕ_1	phi_1	−0.17377	[0.5, 0.7]
ϕ_2	phi_2	0.27632	[0.5, 1.1]
$M_{K^{*\pm}}$	mksp	0.89166	[0.891, 0.892]
$M_{K^{*0}}$	mks0	0.8961	[0.895, 0.897]
M_{K^*}	mkst	0.8953	[0.8951, 0.8955]
M_{K^*}	mkst	$(M_{K^{*\pm}} + M_{K^{*0}})/2$	
m_{K^*}	mkst	0.94341	[0.9427, 0.9442]
Γ_{K^*}	gamma_kst	0.0475	[0.047, 0.048]
γ_{K^*}	gamma_kst	0.06672	[0.0655, 0.0677]
$\Gamma_{K^{*\prime}}$	gamma_kstpr	0.206	[0.155, 0.255]
$\gamma_{K^{*\prime}}$	gamma_kstpr	0.240	[0.120, 0.380]
$M_{K^{*\prime}}$	mkstpr	1.307	[1.270, 1.350]
$m_{K^{*\prime}}$	mkstpr	1.374	[1.330, 1.450]

3 pions, Aleph

PDG
3 mesons

2 pions, Aleph fit

PDG

KKpi

Kpi modes
fit to Belle

Difference between (exact) models ~4%, between GS and exponention ~15%

non-physical values for masses for GS in Kpi modes http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm

Numerical benchmarks of formfactor implementation:

1. a1 width is tabulated to avoid problem with triple integration:

   Cross check with linear interpolation

2. Check of every channel: **/cross-check/check_analyticity_and_numer_integr**

   semi-analytical result (Gauss integration): comparison with linear interpolated spectrum

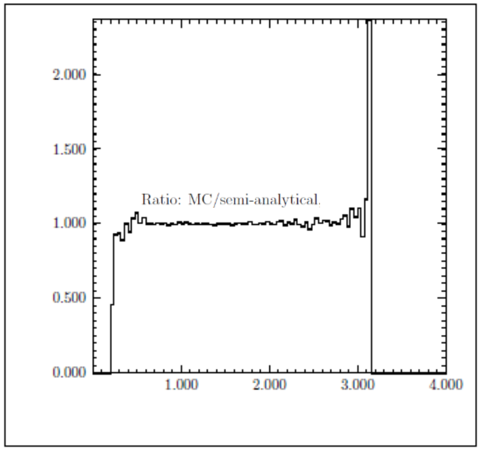
   ratio MC/semi-analytical of differential width (qq)

   comparison of analytical integration and MC for total width

   2 pion, 2 Kaon with physical mass of pions, Kaons

   others $m_\pi = (m_{\pi^0} + 2 \cdot m_{\pi^+})/3$ $m_K = (m_{K^0} + m_{K^+})/2$

An example: three pions ($\tau \to \pi^-\pi^-\pi^+\nu_\tau$):



- $F_1 = F$, $F_{others} = 0$ to check phase space
- F_1 = physical, $F_{others} = 0$
- F_{all} = physical

linear interpolation ~ 0.1% for whole spectrum except for ends

MC (6e6): (2.1013±0.016%)·10^{-13}GeV; semi-analyt(2.1007±0.02% %)·10^{-13}GeV

Comparison of semi-analytical integration and MC

3 pseudoscalars

$$\frac{d\Gamma}{dq^2} = \frac{G_F^2|V_{ud}|^2}{128(2\pi)^5 M_\tau F^2}\left(\frac{M_\tau^2}{q^2}-1\right)^2 \int dsdt\left[W_{SA}+\frac{1}{3}\left(1+2\frac{q^2}{M_\tau^2}\right)(W_A+W_B)\right]$$

$$W_B = \frac{1}{64\pi^4F^4}\left[stu+(m_{K,\pi}^2-m_\pi^2)(q^2-m_{K,\pi}^2)s+m_{K,\pi}^2(2m_\pi^2-q^2)q^2-m_{K,\pi}^2m_\pi^4\right]|F_5|^2,$$

$$W_{SA} = q^2|F_4|^2. \qquad W_A = -(V_1^\mu F_1+V_2^\mu F_2+V_3^\mu F_3)(V_{1\mu}F_1+V_{2\mu}F_2+V_{3\mu}F_3)^*,$$

$$\int dsdt = \int_{4m_{K,\pi}^2}^{\left(\sqrt{q^2}-m_\pi\right)^2} ds \int_{t_-(s)}^{t_+(s)} dt \qquad t_\pm(s)=\frac{1}{4s}\left\{(q^2-m_\pi^2)^2-\left[\lambda^{1/2}(q^2,s,m_\pi^2)\mp\lambda^{1/2}(m_{K,\pi}^2,m_{K,\pi}^2,s)\right]^2\right\}$$

Two pions

$$\frac{d\Gamma}{dq^2}=\frac{G_F^{''}|V_{ud}|^2 m_\tau^3}{384\pi^3}\left(1-\frac{q^2}{m_\tau^2}\right)^2\lambda\left(1,\frac{m_{\pi^+}^2}{q^2},\frac{m_{\pi^0}^2}{q^2}\right)|F_\pi|^2$$

Channel	Analytical , GeV^{-1}	Monte Carlo , GeV^{-1}
pipi0	$(5.2431\pm0.02\%)\cdot10^{-15}$	$(5.2441\pm0.005\%)\cdot10^{-15}$
KK0	$(2.0863\pm0.02\%)\cdot10^{-15}$	$(2.0864\pm0.005\%)\cdot10^{-15}$
Kpi0	$(2.5193\pm0.02\%)\cdot10^{-14}$	$(2.5197\pm0.008\%)\cdot10^{-14}$
pipipi	$(2.1007\pm0.02\%)\cdot10^{-13}$	$(2.1013\pm0.016\%)\cdot10^{-13}$
K-pi-K+	$(3.7379\pm0.024\%)\cdot10^{-15}$	$(3.7383\pm0.02\%)\cdot10^{-15}$
K0pi-K0	$(3.7385\pm0.024\%)\cdot10^{-15}$	$(3.7383\pm0.02\%)\cdot10^{-15}$
Kpi0K0	$(2.7370\pm0.02\%)\cdot10^{-15}$	$(2.7367\pm0.02\%)\cdot10^{-15}$

$m_{\pi^\pm}=m_{\pi^0}$

$m_{K^\pm}=m_{K^0}$

Numerical results

Channel	Width, [GeV]		
	PDG	Equal masses	Phase space with masses
$\pi^-\pi^0$	$(5.778 \pm 0.35\%) \cdot 10^{-13}$	$(5.2283 \pm 0.005\%) \cdot 10^{-13}$	$(5.2441 \pm 0.005\%) \cdot 10^{-13}$
$\pi^0 K^-$	$(9.72 \pm 3.5\%) \cdot 10^{-15}$	$(8.3981 \pm 0.005\%) \cdot 10^{-15}$	$(8.5810 \pm 0.005\%) \cdot 10^{-15}$
$\pi^-\bar{K}^0$	$(1.9 \pm 5\%) \cdot 10^{-14}$	$(1.6798 \pm 0.006\%) \cdot 10^{-14}$	$(1.6512 \pm 0.006\%) \cdot 10^{-14}$
K^-K^0	$(3.60 \pm 10\%) \cdot 10^{-15}$	$(2.0864 \pm 0.007\%) \cdot 10^{-15}$	$(2.0864 \pm 0.007\%) \cdot 10^{-15}$
$\pi^-\pi^-\pi^+$	$(2.11 \pm 0.8\%) \cdot 10^{-13}$	$(2.1013 \pm 0.016\%) \cdot 10^{-13}$	$(2.0800 \pm 0.017\%) \cdot 10^{-13}$
$\pi^0\pi^0\pi^-$	$(2.10 \pm 1.2\%) \cdot 10^{-13}$	$(2.1013 \pm 0.016\%) \cdot 10^{-13}$	$(2.1256 \pm 0.017\%) \cdot 10^{-13}$
$K^-\pi^-K^+$	$(3.17 \pm 4\%) \cdot 10^{-15}$	$(3.7379 \pm 0.024\%) \cdot 10^{-15}$	$(3.8460 \pm 0.024\%) \cdot 10^{-15}$
$K^0\pi^-\bar{K}^0$	$(3.9 \pm 24\%) \cdot 10^{-15}$	$(3.7385 \pm 0.024\%) \cdot 10^{-15}$	$(3.5917 \pm 0.024\%) \cdot 10^{-15}$
$K^-\pi^0K^0$	$(3.60 \pm 12.6\%) \cdot 10^{-15}$	$(2.7367 \pm 0.025\%) \cdot 10^{-15}$	$(2.7711 \pm 0.024\%) \cdot 10^{-15}$

only ρ with ρ' (parameters from pion mode) $(2.6502 \pm 0.008\%) \cdot 10^{-15}$ GeV

FSI effects

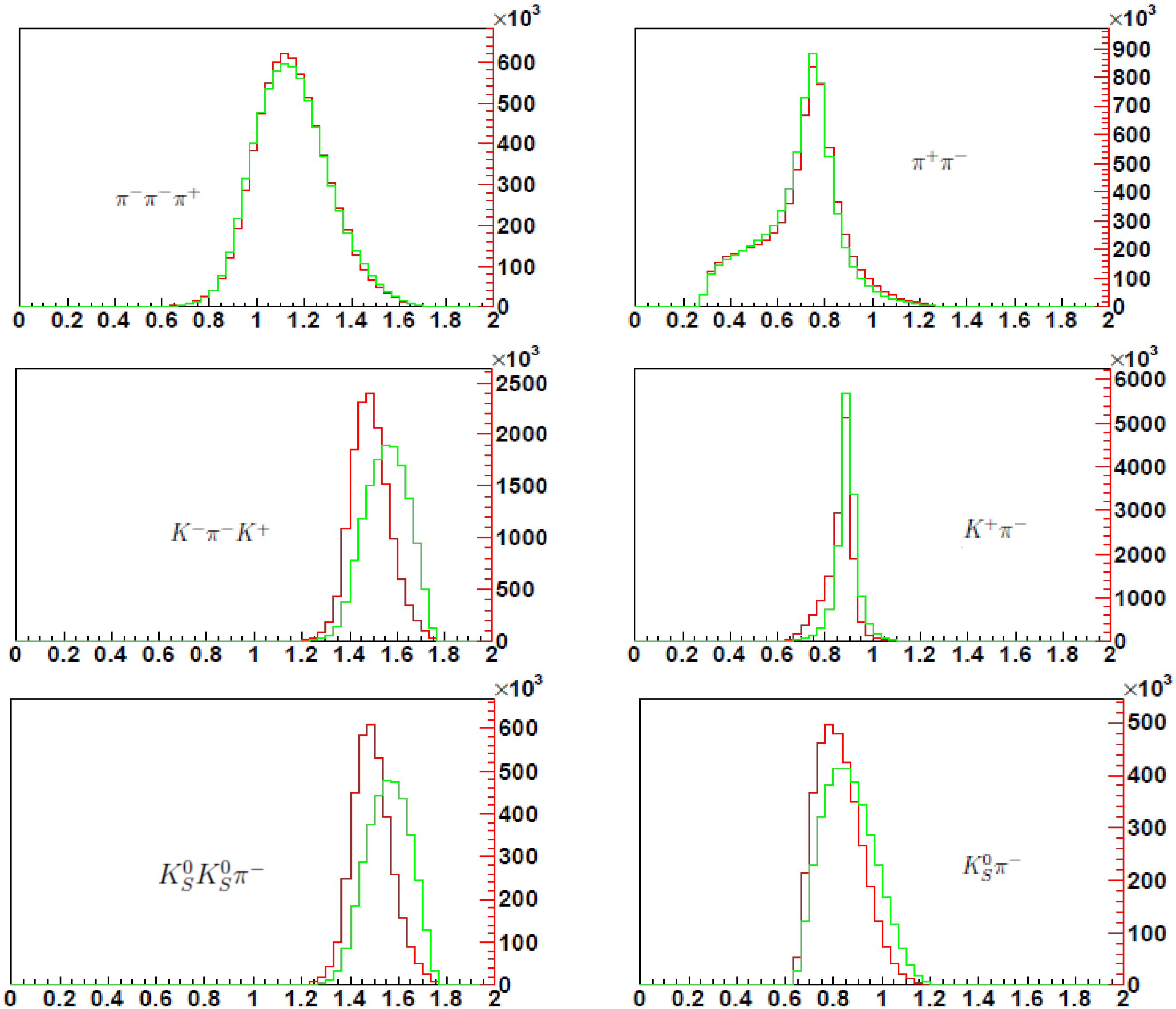
No.	Channel	Width [GeV]	Width [GeV]
1.	$\pi^-\pi^0$	$5.2441 \cdot 10^{-13} \pm 0.005\%$	$4.0642 \cdot 10^{-13} \pm 0.005\%$
2.	$\pi^0 K^-$	$8.5810 \cdot 10^{-15} \pm 0.005\%$	$7.4275 \cdot 10^{-15} \pm 0.005\%$
3.	$\pi^-\bar{K}^0$	$1.6512 \cdot 10^{-14} \pm 0.006\%$	$1.4276 \cdot 10^{-14} \pm 0.006\%$
4.	K^-K^0	$2.0864 \cdot 10^{-15} \pm 0.007\%$	$1.2201 \cdot 10^{-15} \pm 0.007\%$

FSI **No FSI**

$14\% - 32\%$

FFVEC = 1 (FSI), 0 (no FSI)

Comparison between CLEO and TAUOLA2011



TAUOLA2011

CLEO

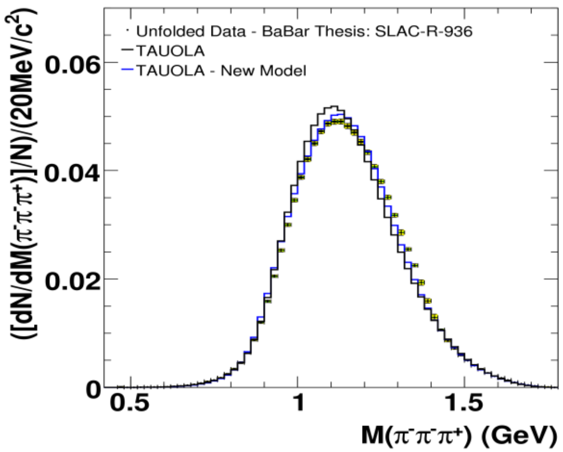
$\tau \to \pi^-\pi^-\pi^+\nu_\tau$

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

$\tau \to K^0\pi^-\bar{K}^0\nu_\tau$

http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm *http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm*

$$\tau \to \pi^- \pi^- \pi^+ \nu_\tau$$

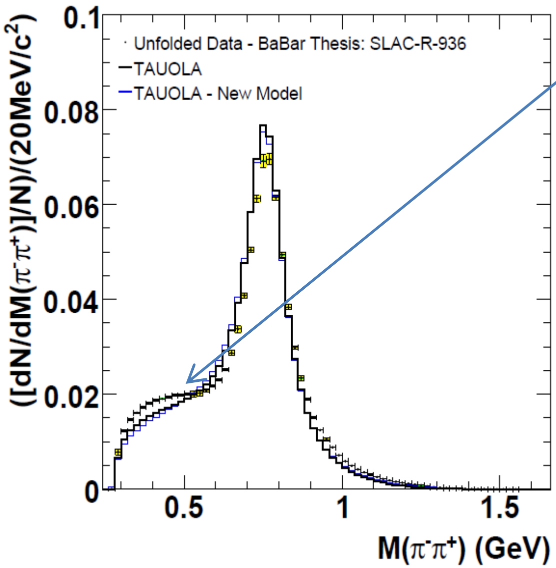


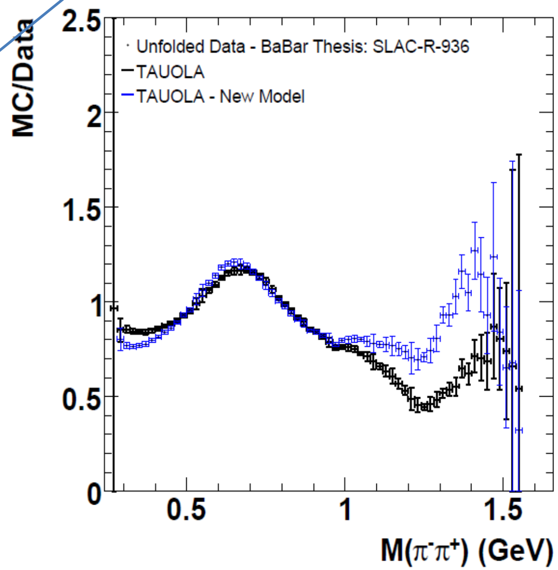
BABAR data: *Ian M. Nugent, (Victoria U.) . SLAC-R-936, Dec16, 2009. Ph.D. Thesis (Advisor: Dr. J. Michael Roney)*

Low energy region is not described well by both models CPC (LO ChT) RChT (NLO ChT)

?sigma meson?

TAUOLA 2012





Talk of Pablo Roig

TAUOLA 2011 lacks/limitation:

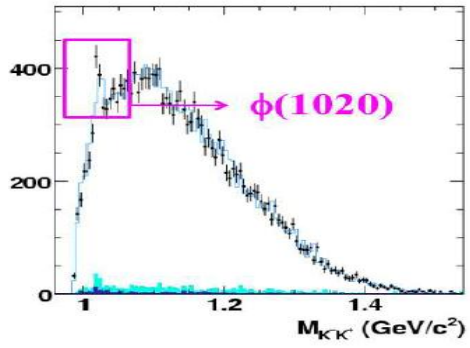
1. no scalar form factor for two pseudoscalar modes
2. low energy spectrum for three pion mode, two pion invariant mass

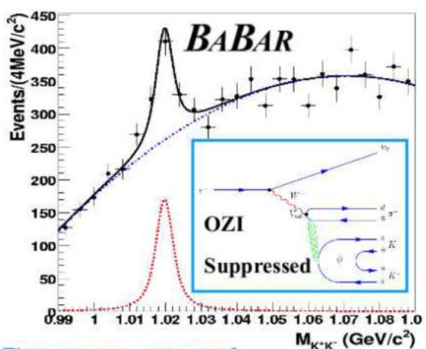
   distribution $\rightarrow$?? sigma meson, parametrization ??

3. excited resonances for Kkpi modes

4. fixed value of THETA: $\theta_V = \tan^{-1}(1/\sqrt{2})$

   ideal mixing angle $\Rightarrow$ no ϕ intermediate state





First measurement of:
$B(\tau^- \to \pi^- \phi \nu) = (3.42 \pm 0.55 \pm 0.25) \times 10^{-5}$
Significance: 5.7σ

Talk of Ian Nugent, Cracow, May 2011

TAUOLA 2012

1. K pion mode $\tau^- \to (K\pi)^- \nu_\tau$ $\quad J^\mu = N\left[(p_1 - p_2)^\mu F^V(s) + (p_1 + p_2)^\mu F^S(s)\right]$

1.1 $F^S_{K\pi}(s) \neq 0$ for $\sqrt{s} \leq 0.8\,\mathrm{GeV}$ compatible (large) than $F^V_{K\pi}(\sqrt{s})$

Two parametrization are applied for scalar FF :

- M. Jamin private code $\longrightarrow$ table for $F^S_{K\pi}(\sqrt{s})$ fitted to Belle spectrum
- E. Passemar private code $F^S_{K\pi}(s)$ arXiv:1103.4855

1.2. free parameters **THETA** and **fk_rpt**

2. Three pion modes

scalar contribution : sigma (2 pion interaction) + pion

ρ' included, exact results $\beta_{\rho'} = -F_{V'} G_{V'} / F^2 \longrightarrow F_{V'},\ G_{V'}$ $\quad F_V G_V + F_{V'} G_{V'} = F^2$

3. KKpi modes simplified version ρ', K*′

$$\frac{1}{M_\rho^2 - q^2 - iM_\rho \Gamma_\rho(q^2)} \longrightarrow \frac{1}{1+\beta_{\rho'}}\left[\frac{1}{M_\rho^2 - q^2 - iM_\rho \Gamma_\rho(q^2)} + \frac{\beta_{\rho'}}{M_{\rho'}^2 - q^2 - iM_{\rho'} \Gamma_{\rho'}(q^2)}\right]$$

4. Other channels: Keta, pi eta, 4 pions

DIPSWITCH PARAMETERS

new-currents/RChL-currents/value_parameter.f

DIPSWITCH	VALUE	MODE
FFVEC	0, 1	PIPI0, KPI, KK0
FFKPIVEC	0, 1	KPI
FFKKVEC	0, 1	KK0
FFKPISCAL	0, 1, 2	KPI
FF3PISCAL	0, 1	PIPIPI
FF3PIRHOPR	0, 1	PIPIPI
FFKKPIRHOPR	0, 1	KKPI,KK0PI0
FFKKPIKPR	0, 1	KKPI, KK0PI0

TAUOLA2012 *more flexibility for fit*

What can be improved ?

´theoretically better´ parametrization (a different way to include FSI effect)

$$F_V(s) = \frac{M_V^2}{M_V^2\left[1+\sum_{P,Q} N_{loop}^{PQ} \frac{s}{96\pi^2 F^2} A_{PQ}(s)\right] - s}$$

$$\delta^{PQ}(s) = Im\left[F_V^{PQ}(s)\right] / Re\left[F_V^{PQ}(s)\right]$$

$$F_V^{PQ}(s) = \exp\left\{\alpha_1 s + \alpha_2 s^2 + \frac{s^3}{\pi}\int_{s_{thr}}^{s_{cut}} ds' \frac{\delta^{PQ}(s')}{s'^3(s'-s-i\epsilon)}\right\}$$

Possible problems … it can be:

- time-consuming codes, numerical unstable
- non-physical value of the resonance masses
- numerical effect can be small

Conclusion: it should be implemented in TAUOLA 2012 and checked

http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm

Resonance chiral lagrangian currents and tau decay Monte Carlo
Progam is managed by: T. Przedzinski, O. Shekhovtsova, Z. Was

1. Paper (mar 18 2012) by: O. Shekhovtsova, T. Przedzinski, P. Roig, Z. Was
2. tar ball (nov 14, 2011) : for corresponding TAUOLA upgrade; svn tag inside.
3. -------------------------
4. **In future**, Next paper:
   (i) technical aspects simple, (ii) scalar form-factors, (iii) further updates on physics, possibly because of the first systematic results from comparisons with the data.
5. **In future,** new version of the tar ball
6. **In future,** Numerical results for the new version,
   hopefully with estimation of agreement with the data.

Results of numerical tests:

MC-TESTER: TAUOLA cleo vs. TAUOLA new currents	PS/PDF	rootfiles
Channels 4,5,7,22,14,15,16	PS PDF	first second
Tests in old style (90's): comparison with analytical calc.		
tau -> pi- pi0 nu	PS PDF	tgz (restr.)
tau -> K- pi0 nu	PS PDF	tgz (restr.)
tau -> pi- K0 nu	PS PDF	tgz (restr.)
tau -> K- K0 nu	PS PDF	tgz (restr.)
tau -> pi- pi- pi+ nu	PS PDF	TeX
tau -> pi0 pi0 pi- nu	PS PDF	TeX
tau -> K- pi- K+ nu	PS PDF	TeX
tau -> K0 pi- K0 nu	PS PDF	TeX
tau -> K- pi0 K0 nu	PS PDF	TeX
Technical tests, style of 90's too, MC analytical calc. Channel pi0 pi0 pi-		
F1=1, other formfactors zero, mpi=mpi0=aver	PS PDF	TeX
F1 physical, other formfactors zero, mpi=mpi0=aver	PS PDF	TeX
F1 F2 physical, other formfactors zero, mpi=mpi0=aver	PS PDF	TeX
All formfactors physical, mpi=mpi0=aver	PS PDF	TeX
ME reweighting, results of tests	PS/PDF	rootfiles
Cleo to RChL	PS PDF	first second
RChL to cleo	PS PDF	first second

We expect matrix element to evolve even after our paper is finished. This page is the place to check on the progress. Eventually new co-authors and contribution from data analysis will be added here or link to such works will be added.

Last update: 18 Mar 2012 by Z. Was

CONCLUSION

- released version, *http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm*
- done under SVN code manager
- **$2\pi\tau$, $2K\ \tau$, $K\pi\tau$, $3\pi\tau$, $KK\pi\tau$** **88% of tau hadronic width**
- first comparison with data

TAUOLA2012

- common work with experimentalists (I. Nugent, D. Epifanov) → fit of parameters
- higher energy resonances in 3 pseudoscalar modes
- scalar FF in Kpi mode, FSI for 2 pseudoscalar modes (*TALK OF P.ROIG*)
- sigma meson in 3 pseudoscalar modes
- 4 pion modes in RChT to get 97% hadronic width, G.Ecker, R. Unterdorfer, Eur.Phys. JC24 (2002) 535
- other channels: pi eta, k eta etc

Jorge Portoles: TAU04
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Hadronic tau decays have undergone, during the last years, a fruitful era of excellence from the point of view of collecting experimental data. Experimentalists have done and are doing a great job. Now time has come for theoreticians to do their task.

Common work: theory + experiment