Analysis of $\tau^- \rightarrow \nu_\tau K_S \pi^-$ Belle data in a chiral framework

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Summary

I. The form factors

II. Fits to the Belle $\tau^- \to \nu_\tau K_S \pi^-$ spectrum

III. Results and conclusions

[M. Jamin, A. Pich, J.P., Phys. Lett. B664 (2008) 78]

[M. Jamin, A. Pich, J.P., Phys. Lett. B640 (2006) 176]

I. The form factors

$$\langle \pi^-(p_2) K_S(p_1) | \, V_\mu \, e^{iL_{QCD}} | 0 \rangle = \frac{1}{\sqrt{2}} \left[\left(q_\mu - \frac{m_K^2 - m_\pi^2}{Q^2} Q_\mu \right) F_+^{K\pi}\left(q^2\right) + Q_\mu F_0^{K\pi}\left(q^2\right) \right]$$

$$\boldsymbol{q}_\mu = \left(\boldsymbol{p}_1 - \boldsymbol{p}_2\right)_\mu \quad , \quad \boldsymbol{Q}_\mu = \left(\boldsymbol{p}_1 + \boldsymbol{p}_2\right)_\mu$$

$J^P = 1^-$ (for $F_+^{K\pi}(q^2)$) $\qquad J^P = 0^+$ (for $F_0^{K\pi}(q^2)$)

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$J^P=1^-$ [M. Finkemeier, E. Mirkes, 1996] →

$$\boldsymbol{F}_+^{K\pi}(\boldsymbol{s}) = \frac{\boldsymbol{F}_+^{K\pi}(0)}{1+\beta} \left[\boldsymbol{BW}_{K^*(892)}(\boldsymbol{s}) + \beta \boldsymbol{BW}_{K^*(1410)}(\boldsymbol{s}) \right]$$

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[M. Finkemeier, E. Mirkes, 1996]

$J^P=0^+$ → $$\begin{cases} F_0^{K\pi}(s) = \lambda \dfrac{\sqrt{s}}{q_{K\pi}(s)} \left[\sin\delta_B e^{i\delta_B} + e^{i2\delta_B} BW_{K^*(1430)}(s) \right] \\ \cot\delta_B = \dfrac{1}{a\, q_{K\pi}(s)} + \dfrac{b\, q_{K\pi}(s)}{2} \end{cases}$$

[D. Aston et al, 1988]

LASS parameterization

Our form factors

1) **Vector form factor** [M. Jamin, A. Pich, J.P., 2006]

K*(892) ↓ K*(1410) ↓

$$F_+^{K\pi}(s) = \left[\frac{M_{K^*}^2 + \gamma s}{M_{K^*}^2 - s - iM_{K^*}\Gamma_{K^*}(s)} - \frac{\gamma s}{M_{K^{*\prime}}^2 - s - iM_{K^{*\prime}}\Gamma_{K^{*\prime}}(s)} \right] e^{\frac{3}{2}\mathrm{Re}\left[\overline{H}_{K\pi}(s) + \overline{H}_{K\eta}(s)\right]}$$

Resonance Chiral Theory (RχT)

chiral symmetry + Brodsky-Lepage asymptotic behaviour + Large-N_C + analyticity

1-loop χPT

Omnès resummed

2) **Scalar form factor** [M. Jamin, J.A. Oller, A. Pich, 2002, 2006]

Coupled channel determination (**$K\pi$**, $K\eta$ and **$K\eta'$**)

- Chiral constraints
- Resonance Chiral Theory matching
- Analyticity and unitarity strictures

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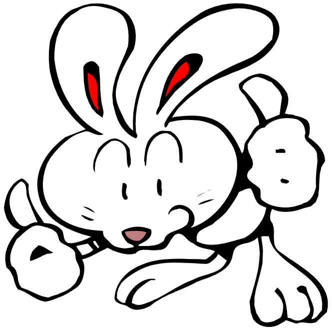
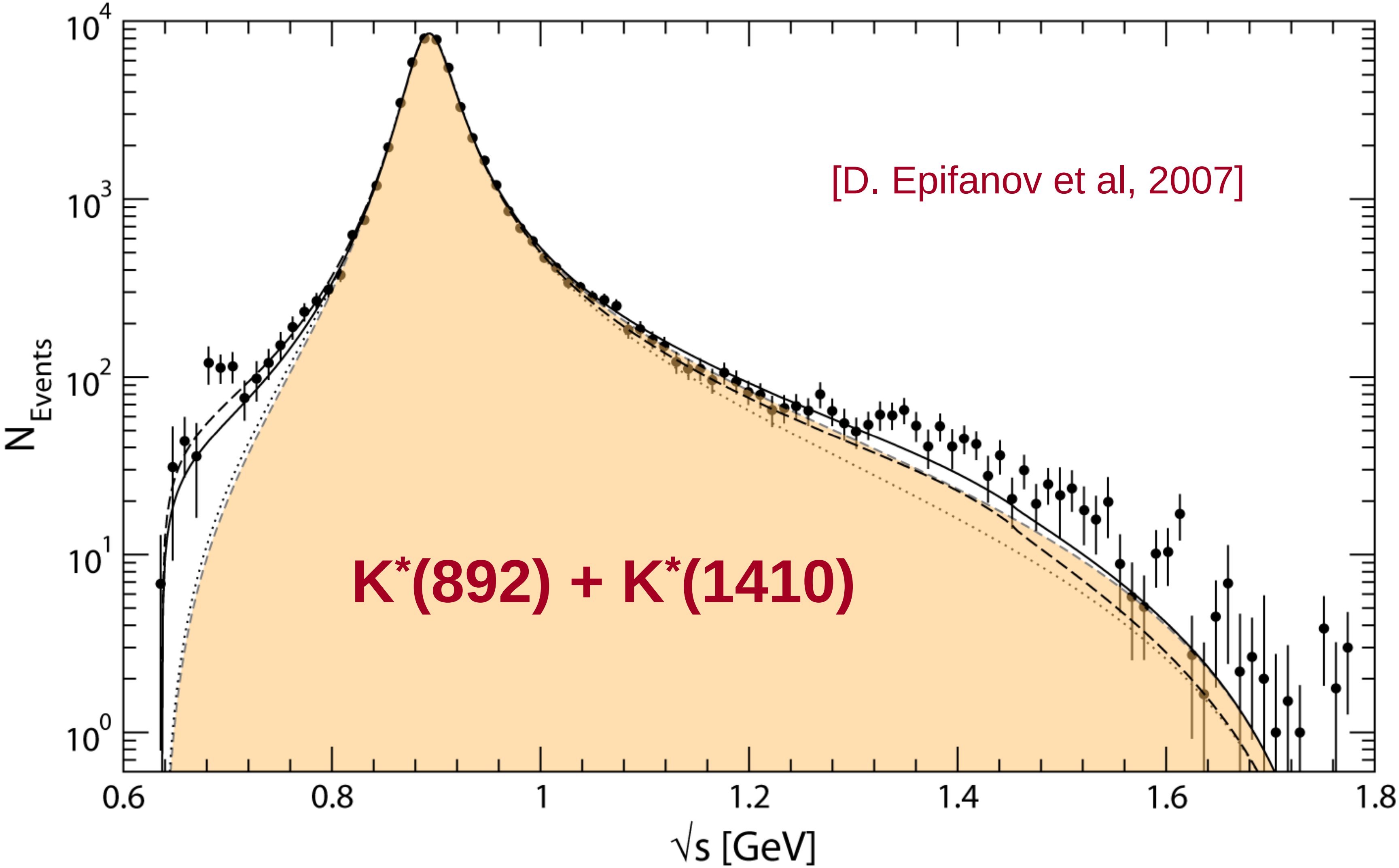
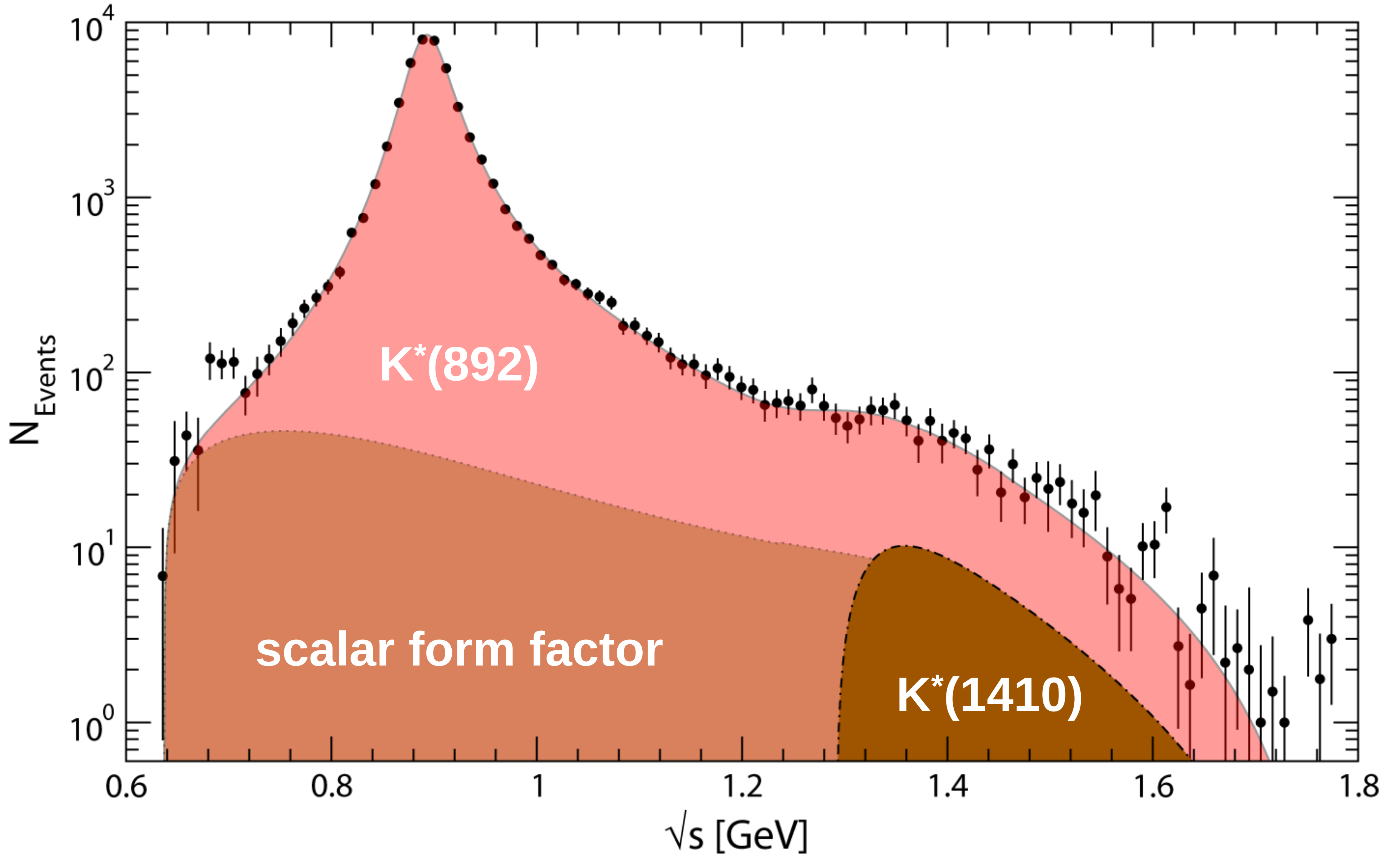
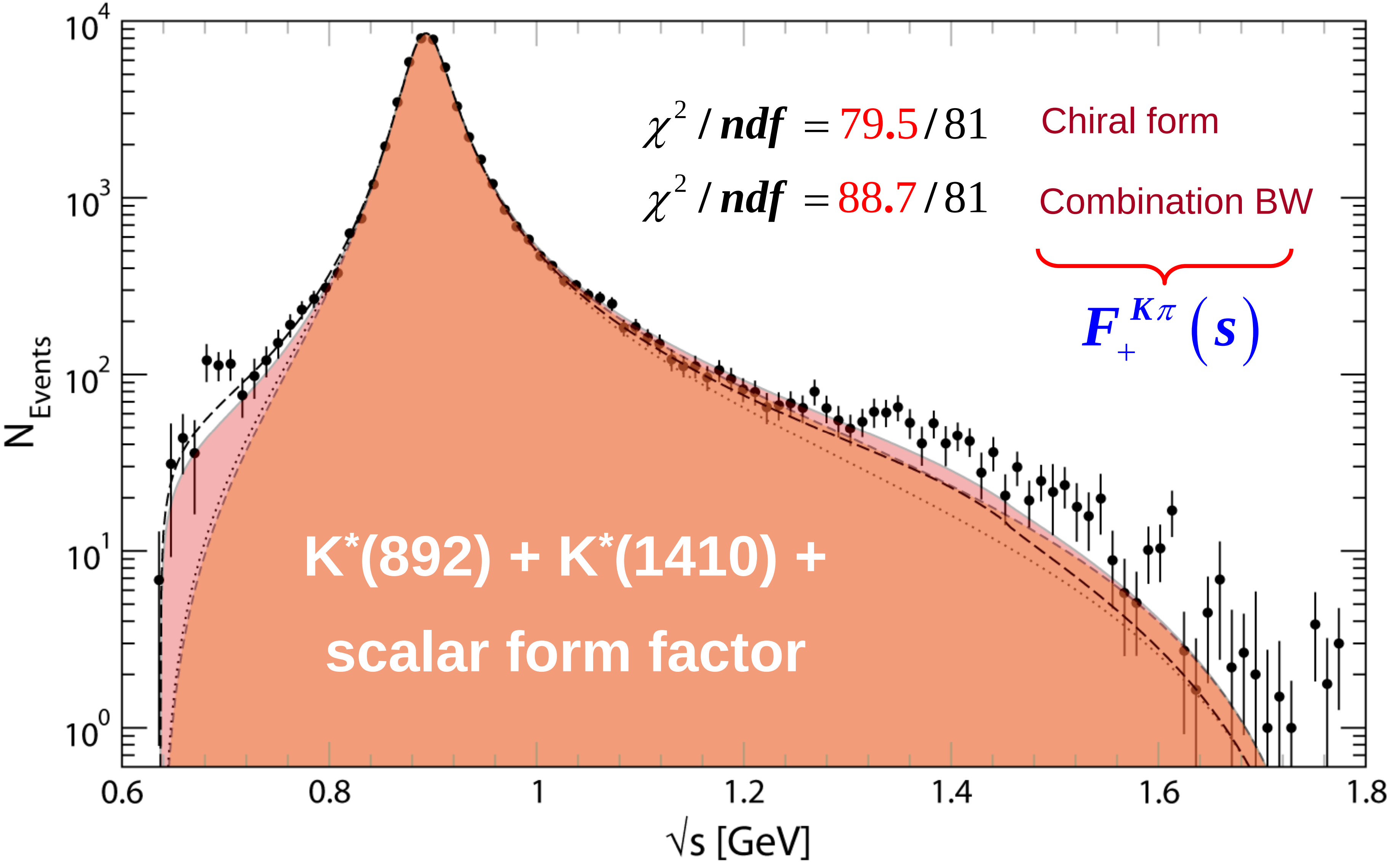


II. Fits to the Belle $\tau^- \to \nu_\tau K_S \pi^-$ spectrum





10^4
10^3
10^2
10^1
10^0
N_{Events}
0.6
0.8
1
1.2
1.4
1.6
1.8
√s [GeV]
K*(892)
scalar form factor
K*(1410)



$\chi^2/ndf = 79.5/81$
Chiral form
$\chi^2/ndf = 88.7/81$
Combination BW
$F_+^{K\pi}(s)$
K*(892) + K*(1410) +
scalar form factor
N_{Events}
√s [GeV]

III. Results and conclusions

(MeV)	Our results	Our results BW combination	PDG
$M_{K^*(892)}$	895.28(20)	895.12(19)	891.66(26)
$\Gamma_{K^*(892)}$	47.50(41)	46.79(41)	50.8(9)
$M_{K^*(1410)}$	1307(17)	1598(25)	1414(15)
$\Gamma_{K^*(1410)}$	206(49)	224(47)	232(21)

Slopes and curvatures of the vector form factor

$$\frac{F_+^{K\pi}(s)}{F_+^{K\pi}(0)} = 1 + \lambda_+^{'} \frac{s}{M_{\pi^-}^2} + \frac{1}{2}\lambda_+^{''} \frac{s^2}{M_{\pi^-}^4} + \frac{1}{6}\lambda_+^{'''} \frac{s^3}{M_{\pi^-}^6} + \ldots$$

$$\lambda_+^{'} = (25.20 \pm 0.33) \times 10^{-3}$$

$$\lambda_+^{''} = (12.85 \pm 0.31) \times 10^{-4}$$

$$\lambda_+^{'''} = (9.56 \pm 0.28) \times 10^{-5}$$

On the form factors …..

Chiral constrained vector form factor

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Chiral constrained <u>vector form factor</u>

<u>Scalar form factor</u> : LASS versus chiral

$$\cot \delta_B = \frac{1}{a\, q_{K\pi}(s)} + \frac{b\, q_{K\pi}(s)}{2}$$

[Belle Collaboration]

GeV^{-1}	a, b fixed	a, b free
a	2.13(10)	$10.9^{+7.4}_{-3.0}$
b	3.96(31)	$19.0^{+4.5}_{-3.6}$
χ^2/ndf	196.9/86	97.3/83

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Parsifal

[PARticleS and Interactions : Flavour And CoLour dynamics]

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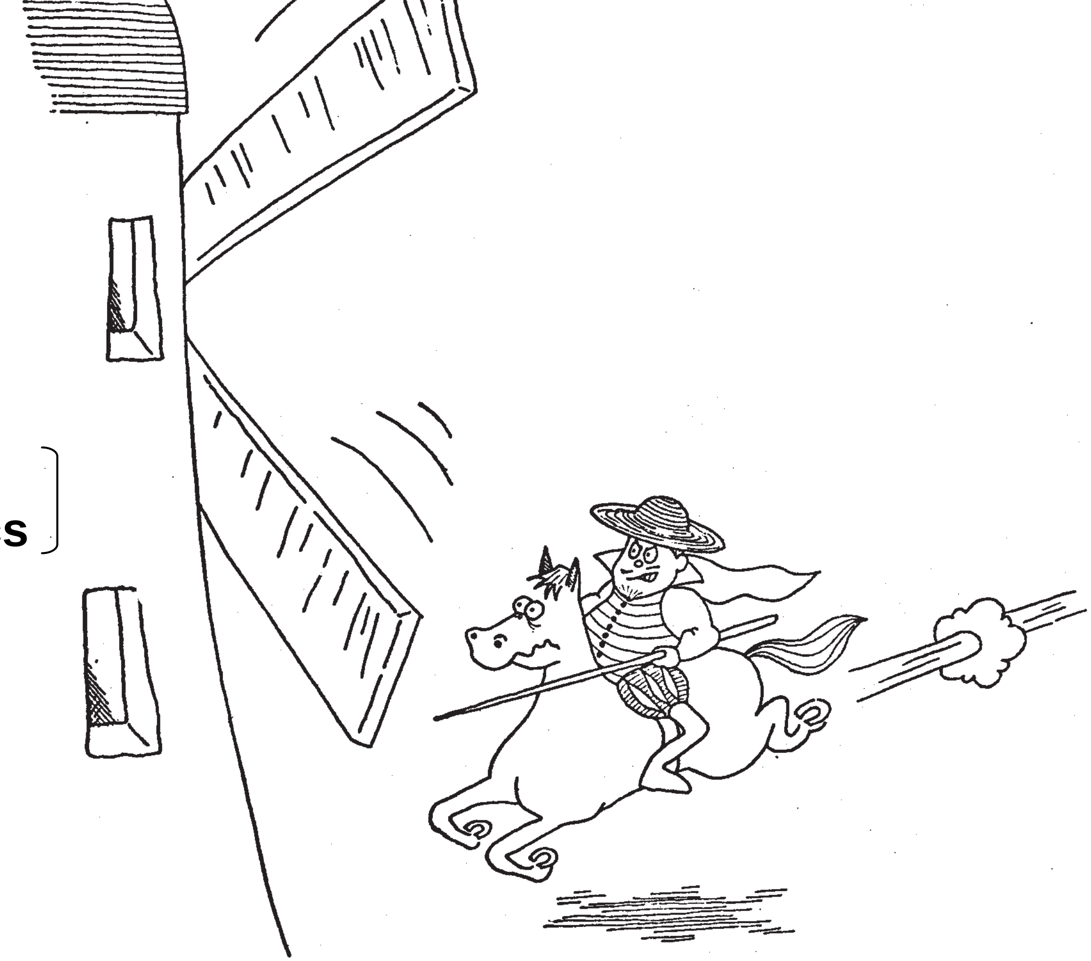
http://ific.uv.es/quiral



Stubbornly

Testing QCD