Has a coupling of right-handed quarks to W been observed?

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V. Bernard, M.O., E. Passemar, J.Stern, Phys. Lett. B 638 (2006) 480
V. Bernard, M.O., E. Passemar, J.Stern, in preparation

Structure of couplings of quarks to W

- Minimal (not quite decoupling) effective theory: first effects beyond the SM are non-standard couplings of fermions to W and Z (Hirn & Stern, ’04,’06)
- Effective quark charged current interaction (universal non-standard effects) at NLO ($\epsilon \neq 0$: coupling of right-handed quarks to W)

$$W_\mu^+ \Big((1+\delta)\, \bar{U}_L \, \gamma^\mu \, V^L \, D_L \; + \; \epsilon \, \bar{U}_R \, \gamma^\mu \, V^R \, D_R \Big) + h.c.$$

- V^L and V^R: two a priori independent unitary mixing matrices
- Effective couplings $(\mathcal{V}, \mathcal{A})$:

$$\bar{U} \underbrace{\left((1+\delta)V^L + \epsilon\, V^R\right)}_{\mathcal{V}_{eff}} \gamma_\mu D - \bar{U} \underbrace{\left((1+\delta)V^L - \epsilon\, V^R\right)}_{\mathcal{A}_{eff}} \gamma_\mu \gamma_5 D$$

- Right-handed charged currents in LR extensions of SM/SUSY, extra dimensions, too

Non-standard parameters in the light quark sector

- Focus on the light-quark sector (u, d, s):
  - RHCs in the (non)-strange sector: $\epsilon_{ns} = \epsilon \, \mathrm{Re}\left(\frac{V^R_{ud}}{V^L_{ud}}\right) \qquad \epsilon_s = \epsilon \, \mathrm{Re}\left(\frac{V^R_{us}}{V^L_{us}}\right)$
  - Unitarity (suppose V^L_{ub} negligible) $\longrightarrow$ $|V^L_{ud}|^2 + |V^L_{us}|^2 = 1$
  - Modification of the left-handed couplings: δ
- ϵ_s can be enhanced by inverted mixing hierarchy in right-handed sector
- Determination of EW couplings $\leftrightarrow$ knowledge of QCD parameters!
- Example: extraction of F_π from $\pi \to \mu\nu$ is modified if there are RHCs:

  this process does not probe directly $\quad i\sqrt{2}F_\pi q_\mu = \langle 0|\bar{u}\gamma_\mu\gamma_5 d|\pi(q)\rangle$
  but rather $F_\pi\,(1 - 2\epsilon_{ns}) \equiv \hat{F}_\pi$

Testing the SM using the scalar $K\pi$ form factor

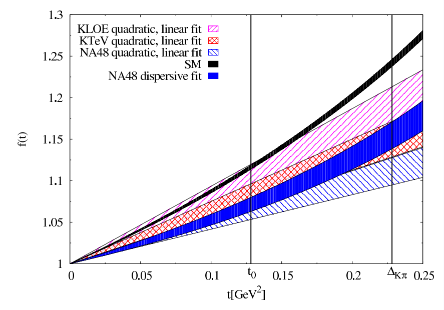
- Determining scalar $K\pi$ ff at the Callan-Treiman point ($\equiv C$) in two ways:
  1. Measuring scalar $K\pi$ ff (using dispersive representation)
  2. CT theorem + measured BRs for $K_{\ell 2}, \ldots$ + EW couplings of quarks
- Measuring scalar $K\pi$ ff at the CT point from $K_{\mu 3}$ decay distribution
  - First direct measurement of $\ln C$ using dispersive representation (NA48, PLB '07)

    $\ln C_{exp} = 0.1438(138)$
  - Assuming SM: $\ln C$ from measured BRs

    $\ln C_{\mathrm{SM}} = 0.2180(35) + \tilde{\Delta}_{\mathrm{CT}}$

    $\longrightarrow$ 5σ discrepancy?
  - Interpretation? RHCs?

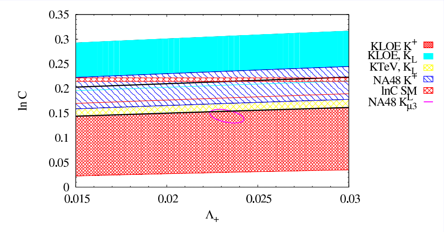
    $2\,(\epsilon_s - \epsilon_{ns}) + \tilde{\Delta}_{\mathrm{CT}} = -0.074(14)$



  - Experimental situation: slope parameter differs for NA48 ($\lambda_0 = 0.0095(14)$), KTeV ($\lambda_0 = 0.0128(18)$), and KLOE (preliminary $\lambda_0 = 0.0156(26)$)

Other possibilities to measure $\ln C$

- Measuring scalar $K\pi$ ff at the CT point from $K_{\ell 3}$ decay rates
  - $\frac{\Gamma(K_{\mu 3})}{\Gamma(K_{e3})} = f(\ln C)$
    very sensitive to $\ln C$
  - Isospin corrections small for the shape of the form factor
    $\longrightarrow$ compare with data from neutral and charged kaons

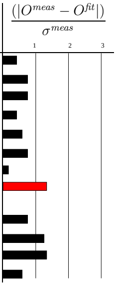


  - Values available from NA48 (hep-ex/0702015) and KLOE (KAON '07) for charged kaons and KTeV (PRD '04), KLOE (PLB '06) for neutral kaons
  - Experimental situation has to be clarified!
- Measuring scalar $K\pi$ ff at the CT point in $\tau \to K\pi\nu$ decays
  - Largely dominated by vector ff, difficult to access scalar ff
  - New data from Babar and Belle

Couplings to Z

- LEET predicts modification of couplings to Z, too.
- Analysis of data near the Z resonance at NLO: (LEP/SLD, Phys. Rep. '06)
  - Perform a fit to Z-pole data within LEET at NLO
  - Take EM/QCD radiative corrections into account
  - Good quality of the fit ($\chi^2/dof = 8.5/8$)
  - Simultaneous determination of α_s and non-standard couplings difficult
  - $\alpha_s(m_Z) = 0.1190$ for the presented result

	Measurement	Fit
Γ_Z [GeV]	2.4952(23)	2.4943
σ_{had} [nb]	41.540(37)	41.569
R_e	20.767(25)	20.785
A^l_{FB}	0.0171(10)	0.0165
$\mathcal{A}_l(P_\tau)$	0.1465(32)	0.1485
R_b	0.21629(66)	0.21685
R_c	0.1721(30)	0.1725
A^b_{FB}	0.0992(16)	0.1012
A^c_{FB}	0.0707(35)	0.0707
$\mathcal{A}_b$	0.923(20)	0.910
$\mathcal{A}_c$	0.670(27)	0.636
$\mathcal{A}_l$(SLD)	0.1513(21)	0.1485
$Br(W \to l\nu)$	0.1084(9)	0.1089



  - "A^b_{FB} puzzle" can be solved with universal modification of couplings important point: non-standard couplings of right-handed quarks
  - Values for the parameters coherent with the LEET expansion

Summary and outlook

- Summary:
  - Minimal (not quite decoupling) effective theory: first effects beyond the SM are non-standard couplings of fermions to W and Z
  - Determination of EW and QCD parameters correlated
  - $K^L_{\mu 3}$ decays: Two ways to determine $F_K/F_\pi f_+(0)$
    $\longrightarrow$ stringent test of couplings of quarks to W
  - NA48 result (dispersive representation) $\longrightarrow 5\sigma$ deviation with SM?
  - Other experiments (KLOE, KTeV) analysis using dispersive parametrisation underway
  - Couplings to Z: no inconsistencies with the systematics of the effective theory
- Outlook:
  - Heavy quark sector
  - Loop effects (CP violation, FCNC,....)