Semileptonic Asymmetries in the New Physics UTA

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- Introduction
- The Unitarity Triangle Analysis and NP
- Semileptonic asymmetries and penguins
- Conclusions

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INTRODUCTION

- All flavour mixing & weak CPV in the SM described by quark masses and CKM parameters (λ, A, $\bar{\rho}$, $\bar{\eta}$)
- No tree-level Flavour Changing Neutral Currents (FCNC) in the SM
  - FCNC fully calculable in the SM (up to hadronic dynamics)
- GIM suppression at the loop level
  - "mild GIM": $\log(m_q^2/m_W^2)$ for QCD and radiative penguins (including QCD corrections)
  - "hard GIM": m_q^2/m_W^2 for Z-penguins and $\Delta F=2$

INTRODUCTION II

- FCNC transitions CKM- and GIM-suppressed
  - highly sensitive to NP
  - more CKM&GIM suppression ⇔ more NP sensitivity
  - $\Delta F=2$ best case (double CKM suppression & hard GIM)
  - Very clean SM estimates for CPV in meson-antimeson mixing & $B_{(s)}$ oscillations

NEW PHYSICS IN $\Delta F=2$

- Generalize the UTA allowing for NP in loop-mediated processes:
  - V_{us}, V_{cb}, V_{ub}, γ from trees and α unaffected (provided no huge NP effect in EWP)
  - NP allowed in $\Delta F=2$ processes
- Extract both CKM parameters and NP contributions

NP ANALYSIS: RESULTS

$\bar{\rho}$ = 0.158 ± 0.037

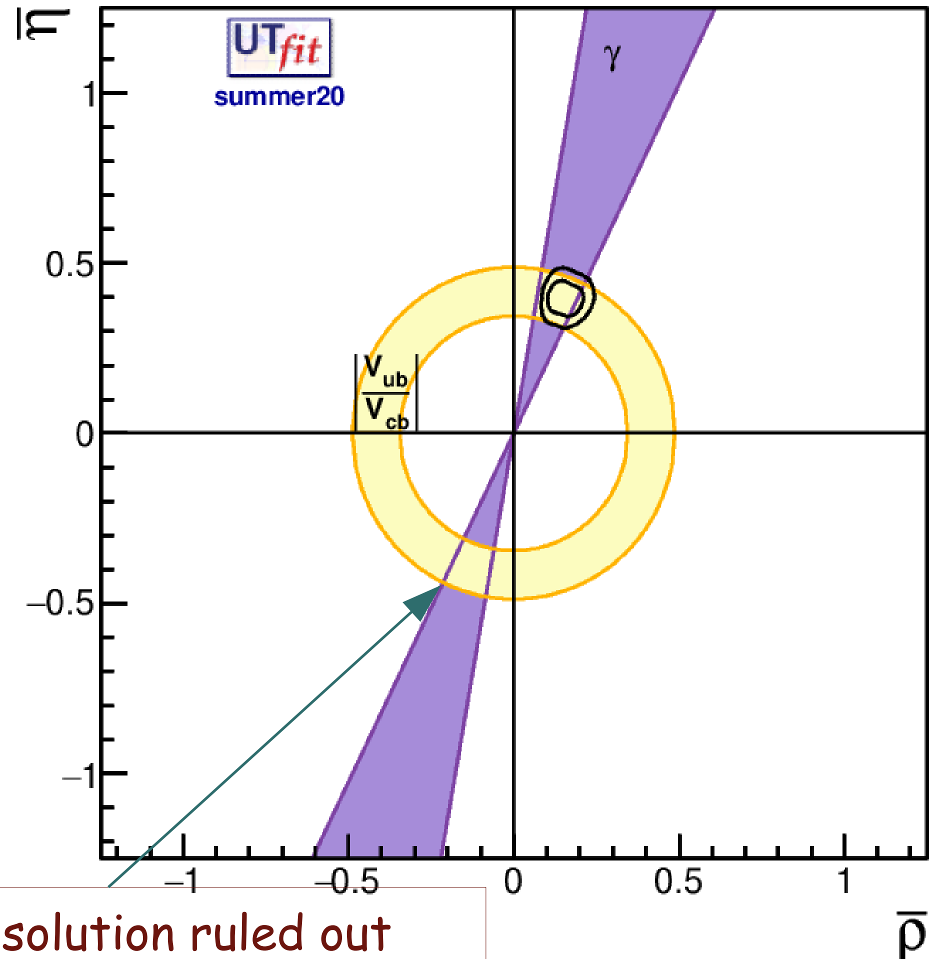
$\bar{\eta}$ = 0.397 ± 0.037

to be compared w.

$\bar{\rho}$ = 0.149 ± 0.013

$\bar{\eta}$ = 0.350 ± 0.013

in the SM



Second solution ruled out by semileptonic asymmetries

Laplace et al '02

NP CONTRIBUTIONS TO ΔF=2

- Phenomenological parameterization:

$$C_{B_q} e^{2i\phi_{B_q}} = \frac{\langle B_q | H_{\rm eff}^{\rm full} | \bar{B}_q \rangle}{\langle B_q | H_{\rm eff}^{\rm SM} | \bar{B}_q \rangle} = 1 + \frac{A_q^{\rm NP}}{A_q^{\rm SM}} e^{2i\phi_q^{\rm NP}}$$

$$\Delta m_{d,s}^{\rm exp} = C_{B_{d,s}} \Delta m_{d,s}^{\rm SM}$$

$$\sin 2\beta^{\rm exp} = \sin(2\beta + 2\phi_{B_d}) \qquad \phi_s^{\rm exp} = \beta_s - \phi_{B_s}$$

- Neglecting NP in penguins, one has:

$$A_{\rm SL} = -{\rm Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\sin 2\phi_{B_d}}{C_{B_d}} + {\rm Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\cos 2\phi_{B_d}}{C_{B_d}}$$

Laplace et al '02

A CLOSER LOOK AT A_{SL}

- In the SM, $M_{12} \propto (V_{tb}^* V_{tq})^2$
- Penguins come with the top CKM factor $V_{tb}^* V_{tq}$, on the other side take a current-current operator with up or charm quarks:

  $(V_{tb}^* V_{tq})(V_{ub}^* V_{uq}\, F(u,u) + V_{cb}^* V_{cq}\, F(c,c)) =$
- $-(V_{tb}^* V_{tq})^2\, F(u,u) - (V_{tb}^* V_{tq})(V_{cb}^* V_{cq})\, (F(u,u)-F(c,c))$
- Dominant contribution to Γ_{12} has the same CKM factor of M_{12}, so does not contribute to CP violation.

A CLOSER LOOK AT A_{SL}

- Therefore, in the SM the penguin contribution to $\mathrm{Im}(\Gamma_{12}/M_{12})$ is GIM-suppressed and tiny.
- NP penguins, however, might come with a different phase and therefore they may give a GIM-allowed, non-negligible contribution to A_{SL}.

A CLOSER LOOK AT A_{SL}

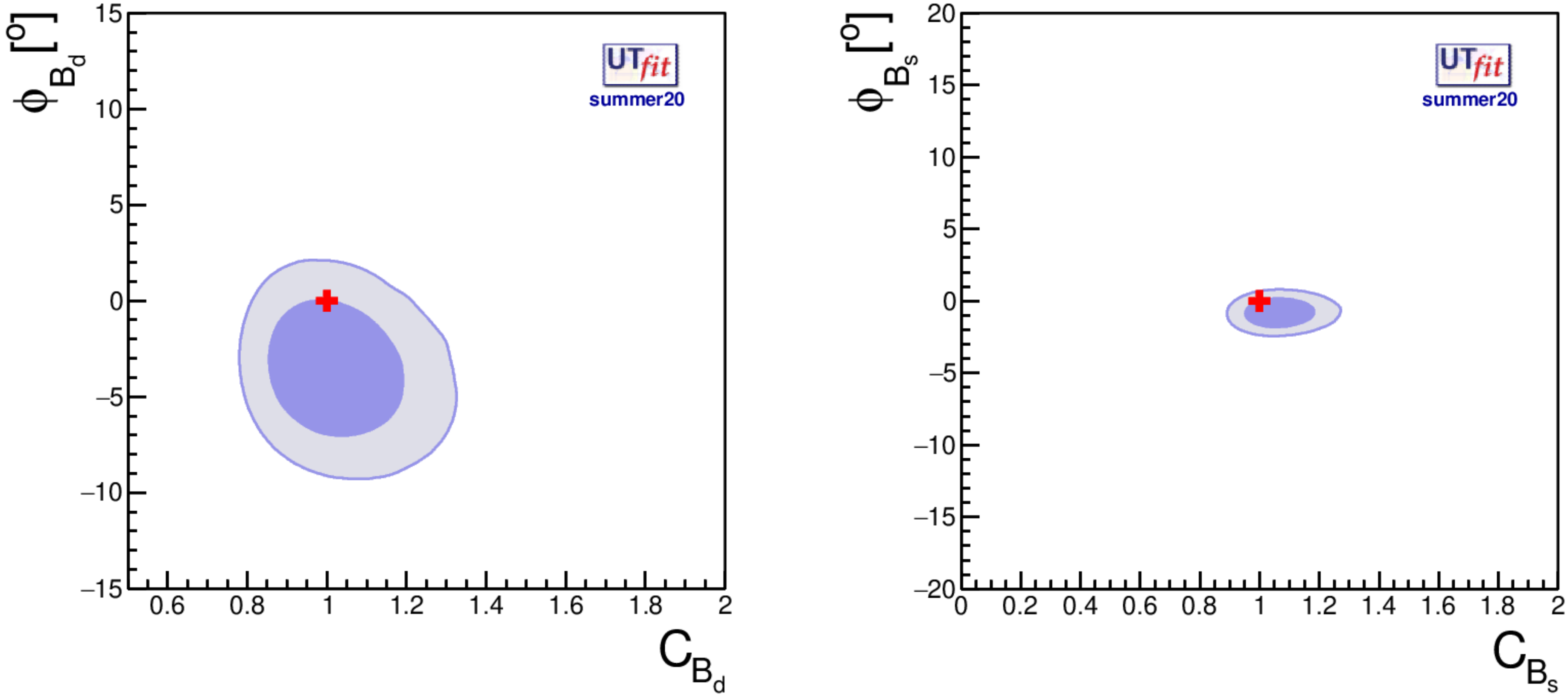
- In formulae (SM recovered for $C_{Pen}=1$, $\phi_{Pen}=0$),

$$A_{\rm SL} = -\frac{2\kappa}{C_{B_d}}\left\{\sin(2\phi_{B_d})\left(n_1+\frac{n_6 B_2+n_{11}}{B_1}\right)-\frac{\sin(\beta+2\phi_{B_d})}{R_t}\left(n_2+\frac{n_7 B_2+n_{12}}{B_1}\right)\right.$$
$$+\frac{\sin(2(\beta+\phi_{B_d}))}{R_t^2}\left(n_3+\frac{n_8 B_2+n_{13}}{B_1}\right)+\sin(\phi_{\rm Pen}+2\phi_{B_d})\,C_{\rm Pen}\left(n_4+n_9\frac{B_2}{B_1}\right)$$
$$\left.-\sin(\beta+\phi_{\rm Pen}+2\phi_{B_d})\frac{C_{\rm Pen}}{R_t}\left(n_5+n_{10}\frac{B_2}{B_1}\right)\right\} \qquad (10)$$

- To get a feeling for numbers:

$$A_{\rm SL} \sim \frac{2\kappa}{C_{B_d}}\left\{\sin(2\phi_{B_d})\left(0.18+\frac{1.01B_2-0.33}{B_1}\right)-\frac{\sin(\beta+2\phi_{B_d})}{R_t}\left(0.14+0.05\frac{B_2}{B_1}\right)\right.$$
$$\left.+\sin(\phi_{\rm Pen}+2\phi_{B_d})\,C_{\rm Pen}(-0.07)\frac{B_2}{B_1}\right\}. \qquad (11)$$

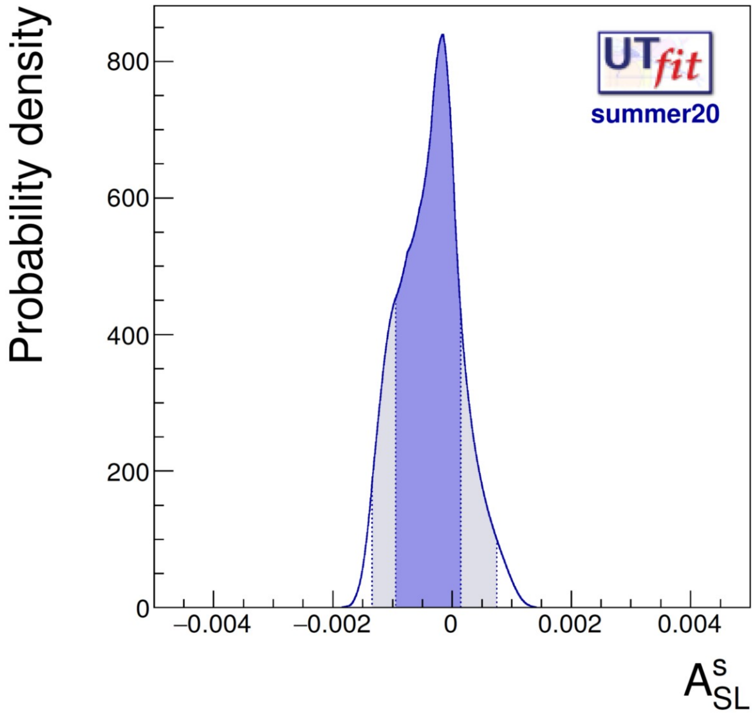
RESULTS ON NP PARAMETERS

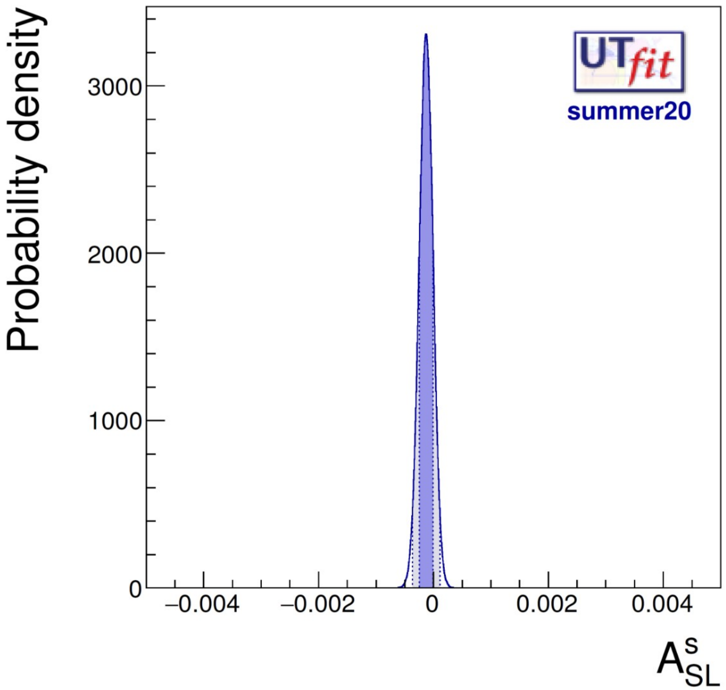


$C_{\varepsilon K} = 1.09 \pm 0.13$, $C_{Bd} = 1.04 \pm 0.12$, $\phi_{Bd} = (-3.6 \pm 2.4)^\circ$,

$C_{Bs} = 1.07 \pm 0.08$, $\phi_{Bs} = (0.8 \pm 0.6)^\circ$

ASLs





- Left: $C_{pen} \in [0,2]$, $\phi_{Pen} \in [0,2\pi]$, $A_{SL}{}^s$ = (-4.0±5.4) 10^{-4} (error dominated by prior on NP penguins)
- Right: no NP in penguins, $A_{SL}{}^s$ = (-1.3±1.2) 10^{-4}

CONCLUSIONS

- As the precision on ϕ_s increases, possible NP effects in Γ_{12} become relevant in the estimate of $A_{SL}{}^s$.
- Allowing for a conservative O(1) effect in penguins already gives dominant contribution in the current $A_{SL}{}^s$ uncertainty.
- We should investigate possible additional constraints to reduce this uncertainty.