BABAR Data in Tension with the Standard Model

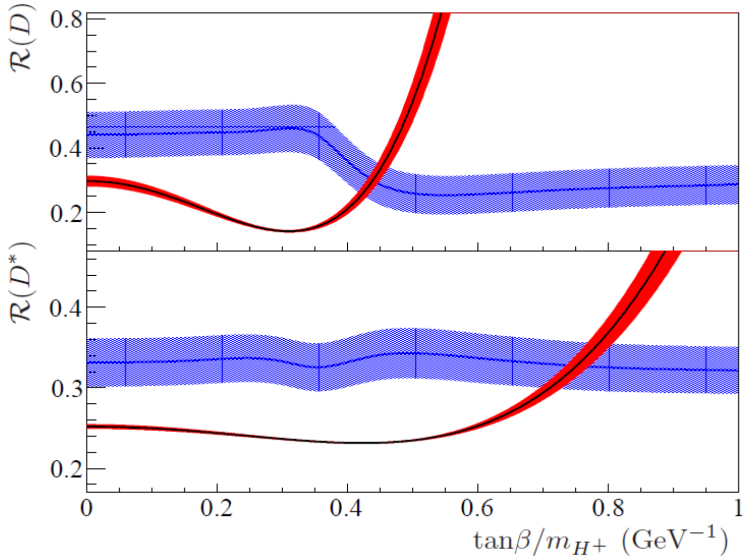
The *BABAR* Collaboration reported on improved measurements of the decays $\overline{B} \to D\tau\overline{\nu}_\tau$ and $\overline{B} \to D^*\tau\overline{\nu}_\tau$ at the Flavor Physics and CP Violation (FPCP) conference in Hefei, China on 24 May. *BABAR* finds the ranching fractions of these decays to be higher than predicted by the Standard Model with a 3.4 sigma level of significance. Preliminary results of these measurements were presented at the Europhysics Conference on High-Energy Physics (EPS) in July, 2011. Since then, *BABAR* has finalized the analysis and has updated the calculation of the branching fractions predicted by the Standard Model using more recent theoretical inputs and measurements of relevant parameters.

The decays $\overline{B} \to D\tau\overline{\nu}_\tau$ and $\overline{B} \to D^*\tau\overline{\nu}_\tau$ provide a particularly interesting probe of possible new physics at high mass scales. In the decay $\overline{B} \to D^{(*)}\tau\overline{\nu}_\tau$, the initial *B* meson and the final-state $D^{(*)}$ and tau all contain massive quarks or leptons, making it a very sensitive probe of possible non-Standard Model Higgs effects such as charged Higgs bosons.

BABAR determines the branching fraction ratios $R(D) = Br\left(\overline{B} \to D\tau\overline{\nu}_\tau\right)/Br\left(\overline{B} \to Dl\overline{\nu}_\tau\right)$ and $R(D^*) = Br\left(\overline{B} \to D^*\tau\overline{\nu}_\tau\right)/Br\left(\overline{B} \to D^*l\overline{\nu}_\tau\right)$, where l stands for an electron or a muon. Many systematic uncertainties cancel in these ratios, including much of the uncertainty associated with theoretical input, particularly non-perturbative QCD contributions that are difficult to calculate. Comparison of the measured and predicted values of these ratios constitutes a sensitive probe of new-physics contributions that impact the third-generation tau-lepton differently from the electron and muon. The *BABAR* measurements are $R(D) = 0.440 \pm 0.058 \pm 0.042$ and $R(D^*) = 0.332 \pm 0.024 \pm 0.018$, which exceed Standard-Model expectations by 2.0 and 2.7 standard deviations, respectively. Taken together, after accounting for correlations between the two ratios, the probability of obtaining the measured results or results farther from the Standard Model is 0.069%, if the Standard Model is assumed. This is equivalent to a significance of 3.4 standard deviations for a one-dimensional Gaussian-distributed observable.

In addition, the large values of $R(D)$ and $R(D^*)$ cannot be explained by a minimal extension of the Standard Model known as the Type-II Two-Higgs-Doublet Model, which introduces both charged and neutral Higgs bosons. The figure below shows in red the predicted values of $R(D)$ and $R(D^*)$ in this model, as a function of the ratio $\tan\beta$ between the vacuum expectation values of the two Higgs fields divided by the charged-Higgs mass m_{H^+}. The blue bands show the experimental results, which also depend on $\tan\beta/m_{H^+}$ since the presence of the charged Higgs changes the characteristics of the decay. The red and blue bands cross at different values of $\tan\beta/m_{H^+}$ for $R(D)$ and $R(D^*)$, so that this extension of the Standard Model is excluded with a 99.8% confidence level for all values of $\tan\beta/m_{H^+}$.

As a result, the *BABAR* measurement poses a challenge both the Standard Model and to minimal new physics extensions of the mass-generating Higgs sector.



The paper (http://arxiv.org/abs/1205.5442) describing these results has been submitted to *Physical Review Letters*.