The B $\to \pi\pi$, Kπ puzzle: how many pieces ?

CKM workshop (UCSD), March 2005

Jérôme Charles
CPT - Marseille

in collaboration with J. Malclès, J. Ocariz, A. Höcker

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I apologize: analysis not ready (yet)!

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why should we believe that annihilation/exchange terms are completely negligible ?

+ power suppression (Λ/m_b)
+ proportional to $f_B/m_B \simeq 5\%$
+ small in QCD factorization

- power suppression could be $10-30\%$ (of the same order than penguin contribution in $\pi^+\pi^-$, or naïve SU(3) breaking, or many other effects that people do take into account)
- f_B/m_B is actually $O(m_B^{-3/2})$: why no $1/m_B$ term ?
- QCD factorization estimate is perturbative $\propto \alpha_s$, and in any case divergent (global fit prefers large annihilation model parameters)
- annihilation topologies cannot be neglected in charm decays
- $(B \to D_s K)/(B \to D\pi)$ is power (exchange) and color suppressed, but still at the level of 10%
- $K^+K^-/\pi^+\pi^- \lesssim 30\%$ (exchange), $K^+\overline{K^0}/\pi^+\pi^- \simeq 60\%$ (annihilation + penguin)

A few remarks on puzzles

there IS a $B \to \pi\pi$ SU(2) puzzle: why color suppression (naïvely) seems to be so violated ?

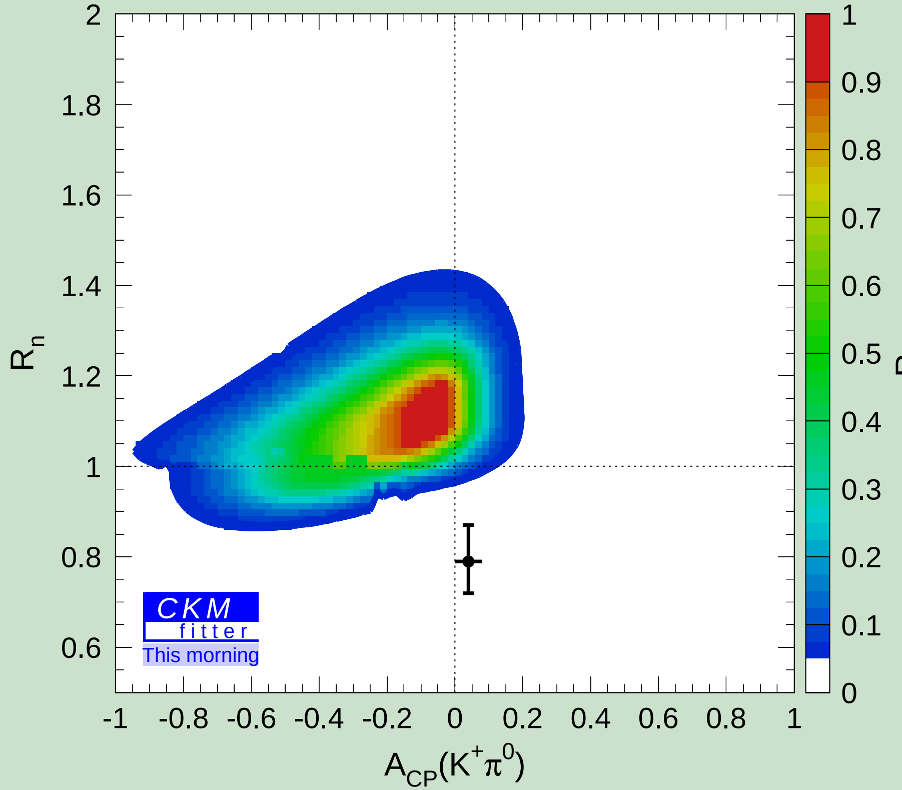
there is NO $B \to K\pi$ SU(2) puzzle, simply because from SU(2) there are nine hadronic parameters, two CKM's, and only nine observables (J.C. *etal* hep-ph/0406184, updated by J. Malclès last December); even neglecting annihilation, constraints from $K\pi$ SU(2) are quite weak and do not allow to fit for electroweak penguins

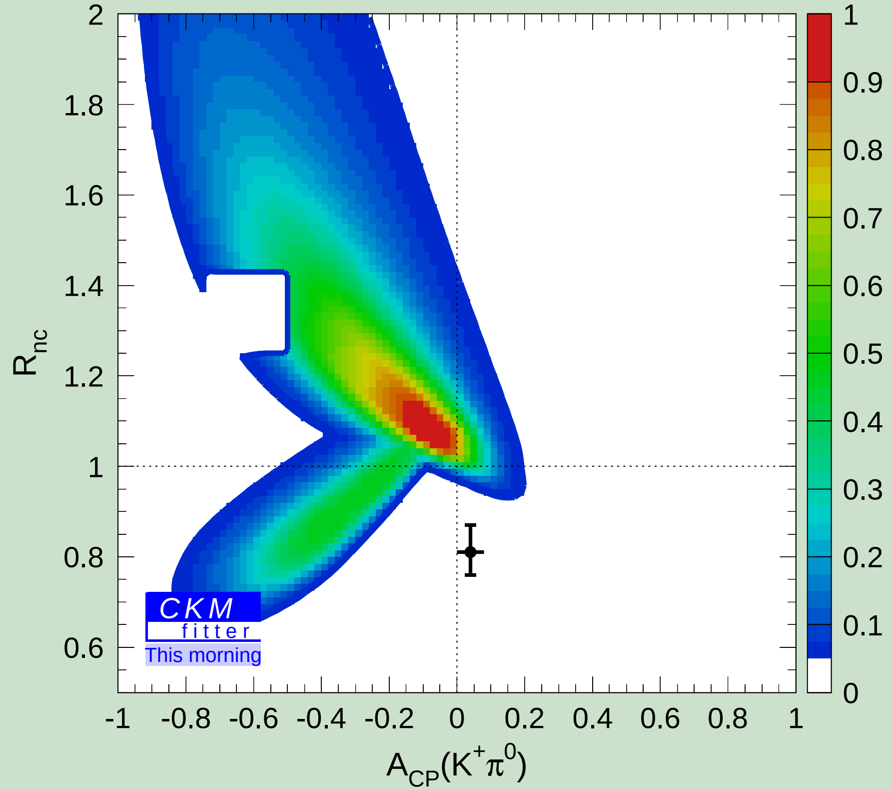
there seems to be a puzzle when one plugs in SU(3) and neglects all annihilation terms; however it is not clear whether the problem can be reduced to the single BFRS ratio R_n: R is not in a very good shape either

if one accepts that color suppression does not work (from $B \to \pi\pi$), then the amplitude P_C^{EW} should not be neglected; its inclusion does not introduce any new parameter in the Standard Model (good news) in contrast to New Physics (bad news)

BFRS-like analysis

JC *et al.* 2004





SU(3) in $B \to \pi^+\pi^-, K^+\pi^-, K^+K^-$

in the case of vanishing annihilation topologies, first introduced by Silva and Wolfenstein

later advocated by Gronau *et al.* and Fleischer to measure γ (with β as an input)

here another look:

$$A(\pi^+\pi^-) = e^{i\gamma} t_{\pi\pi} - p_{\pi\pi}$$
$$A(K^+\pi^-) = \lambda e^{i\gamma} t_{K\pi} + \frac{1}{\lambda} p_{K\pi}$$

solves to (if $t, p_{K\pi} = t, p_{\pi\pi}$)

$$\sqrt{1 - C^2_{\pi\pi}} |\mathcal{D}| \cos(2\alpha - 2\alpha_{\text{eff}} - \epsilon) = (1+\lambda^2)^2 - 2\lambda^2 \sin^2\gamma \left[1 + \frac{BR(K^+\pi^-)}{BR(\pi^-\pi^+)}\right]$$

and $BR(K^+\pi^-)C(K^+\pi^-) + BR(\pi^+\pi^-)C(\pi^+\pi^-) = 0$,

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this measures more α than γ !

taking into account annihilation contributions, one has $t, p_{K\pi} = t, p_{\pi\pi} - t, p_{KK}$ and obtains an analytical (but tricky) solution which can be viewed as a bound on $|\alpha - \alpha_{\text{eff}}|$, depending on the upper limit on $\mathrm{BR}(K^+K^-)$

β from SU(3) in $B \to K_S\pi^0,\ \pi^0\pi^0,\ K^+K^-$

same game !

obtains:

$$\sqrt{1 - C^2_{K_S\pi^0}}\,|\mathcal{D}|\cos(2\beta - 2\beta_{\rm eff} + \epsilon) = (1+\lambda^2)^2 - 2\lambda^2\sin^2\gamma\left[1 + \frac{BR(\pi^0\pi^0)}{BR(K_s\pi^0)}\right]$$

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again, this is not γ but β !

with $B \to K + K^-$, this formulation improves the Gronau-Grossman-Rosner bound which is not optimal

Sign of $K\pi$ CP-asymmetries

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18.16 \times (-)(-0.109 \pm 0.019) + 4.6 \times (-0.37 \pm 0.10) &= 0.28 \pm 0.58
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(-3.7 for the opposite sign)

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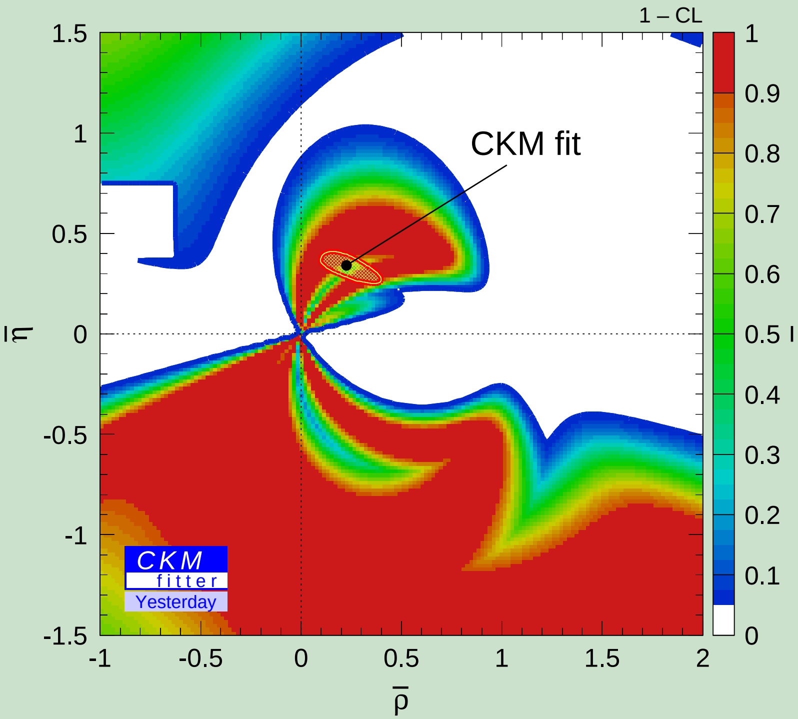
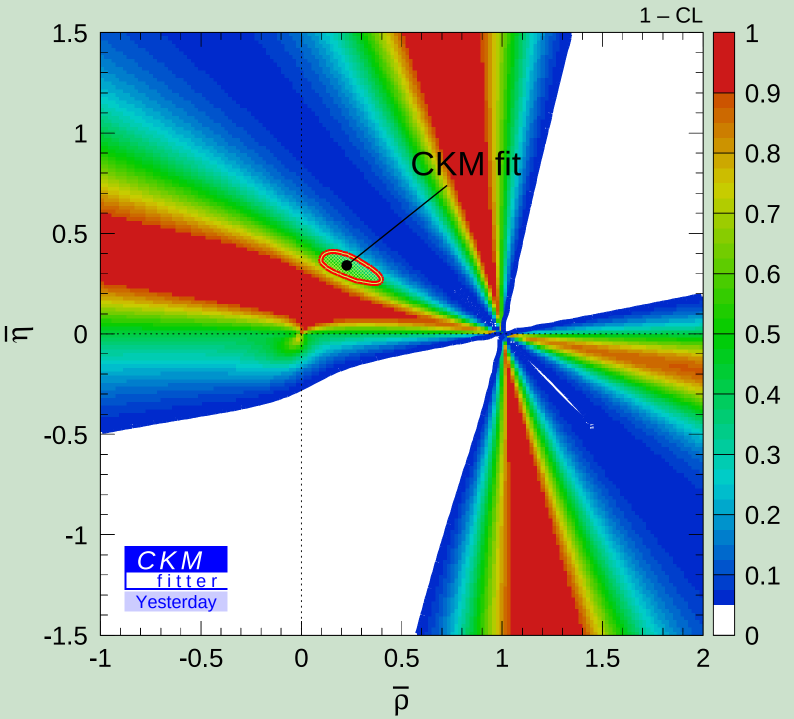
Fresh results in the strict SU(3) limit

our average: $\mathrm{BR}(B \to K^+K^-) = 0^{+2.7}_{-2.6} \times 10^{-6}$

α from $\pi^+\pi^-$, $K^+\pi^-$, K^+K^-

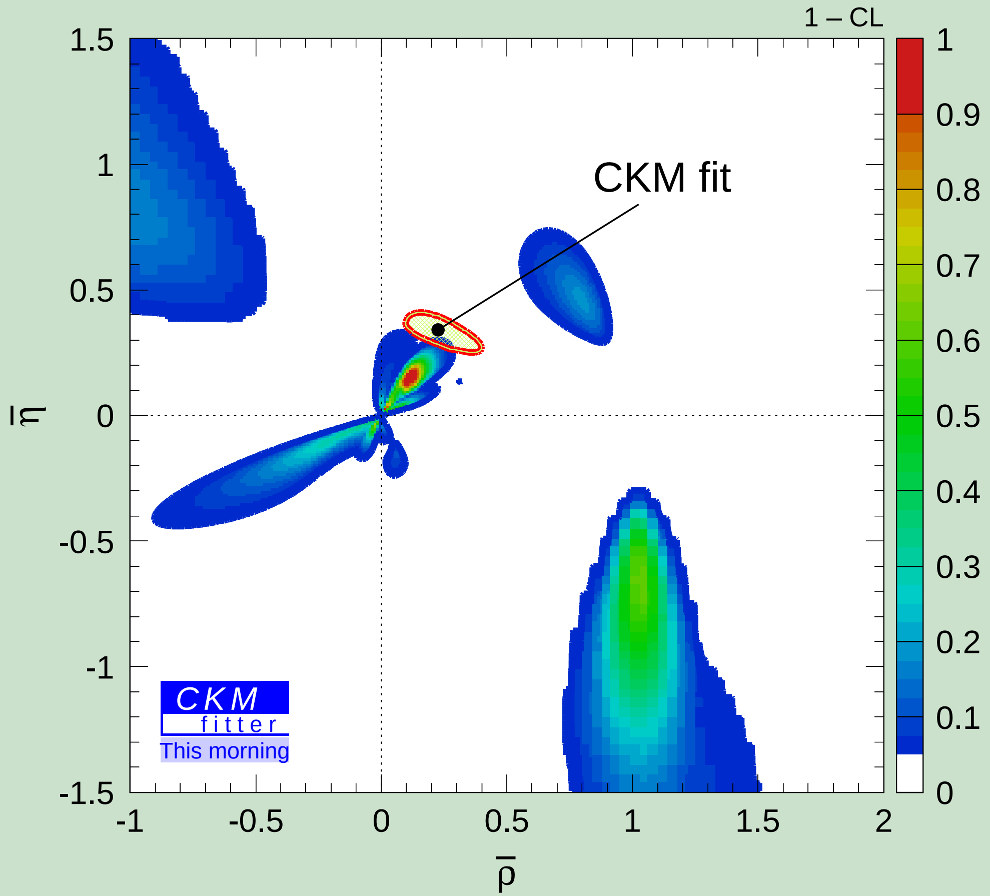


β from $K_S\pi^0$, $\pi^0\pi^0$, K^+K^-



Both α and β in the strict SU(3) limit

$\pi^+\pi^-, K_S\pi^0, K^+\pi^-, \pi^0\pi^0, K^+K^-$



!!!! PRELIMINARY !!!!

All modes

All observables in $B_{d,s} \to \pi(K)\pi(K)$ can be expressed in terms of CKM's and 13 phenomenological hadronic parameters: this is model-independent in the strict SU(3) limit, neglecting $O_{7,8}$ contributions from electroweak penguins

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imagine all $B_{d,s} \to \pi(K)\pi(K)$ observables are measured; this makes almost 50 constraints depending on "only" 15 hadronic parameters and CKM's