World average
and
experimental overview of γ

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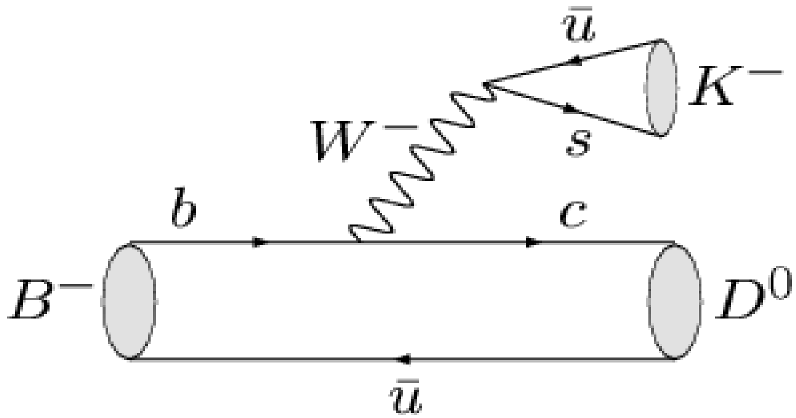
γ measurements from $B^{\pm} \to DK^{\pm}$

[see J.Brod's talk]

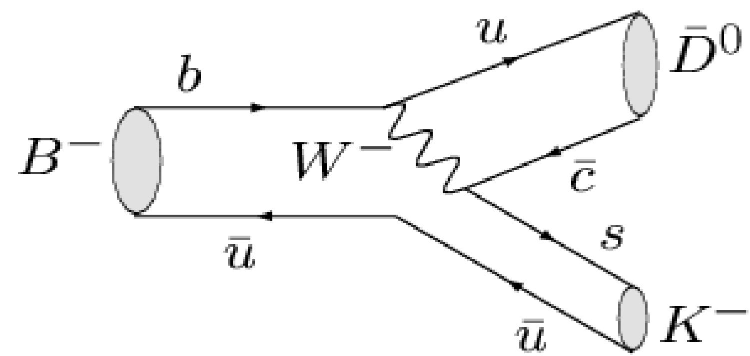
- Theoretically pristine $B \to DK$ approach
- Access γ via interference between $B^- \to D^0 K^-$ and $B^- \to \bar{D}^0 K^-$



color allowed

$B^- \to D^0 K^- \sim V_{cb} V_{us}^*$

$\sim \mathbf{A\lambda^3}$



color suppressed

$B^- \to \bar{D}^0 K^- \sim V_{ub} V_{cs}^*$

$\sim \mathbf{A\lambda^3(\rho + i\eta)}$

relative magnitude of suppressed amplitude is r_B

$$r_B = \frac{|A_{suppressed}|}{|A_{favoured}|} \sim \frac{|V_{ub} V_{cs}^*|}{|V_{cb} V_{us}^*|} \times [\text{color supp}] = 0.1 - 0.2$$

relative weak phase is γ, relative strong phase is δ_B

γ measurements from $B^{\pm} \to DK^{\pm}$

- Reconstruct D in final states accessible to both D^0 and $\overline{D}^0$
  - $D = D_{CP}$, CP eigenstates as K^+K^-, $\pi^+\pi^-$, $K_S\pi^0$

    GLW method (Gronau-London-Wyler)
  - $D = D_{sup}$, Doubly-Cabbibo suppressed decays as $K\pi$

    ADS method (Atwood-Dunietz-Soni)
  - Three-body decays as $D \to K_S\pi^+\pi^-$, $K_S K^+ K^-$

    GGSZ (Dalitz) method (Giri-Grossman-Soffer-Zupan)
- Largest effects due to
  - charm mixing
  - charm CP violation

  } small and can be taken into account

  Y.Grossman, A.Soffer, J.Zupan [PRD 72, 031501 (2005)]

  M.Rama [PRD 89, 014021 (2014)]
- ultimate theoretical error $< 10^{-7}$ [J.Brod and J.Zupan, arXiv:1308.5663]
- **Different B decays (DK, D^*K, DK^*)**
  - **different hadronic factors (r_B, δ_B) for each**

The small r_B issue

clearly in the $r_B \to 0$ limit the interference disappears and there is no sensitivity to the phase γ

when the true value of r_B is small, then the distribution of $\hat{r}_B$ best fit values for randomly generated data is biased towards larger values, until the experimental errors are sufficiently small to exclude the $r_B \sim 0$ region

on the other hand the error on γ is roughly proportional to $1/r_B$, hence for small r_B it is biased towards smaller values

in the language of frequentist statistics it means that the usual $\Delta \ln \mathcal{L} = 1/2$ rule does not work here, the 68%CL interval extracted from it does not cover the true value of γ at 68% frequency (undercoverage)

to correct for this effect one has to compute the actual distribution of the profile log-likelihood, and from that distribution deduce a p-value or a CL interval

problem: as soon as the log-likelihood is not distributed as a χ^2, its distribution *a priori* depends on the *nuisance parameters*, namely r_B, δ_B etc.

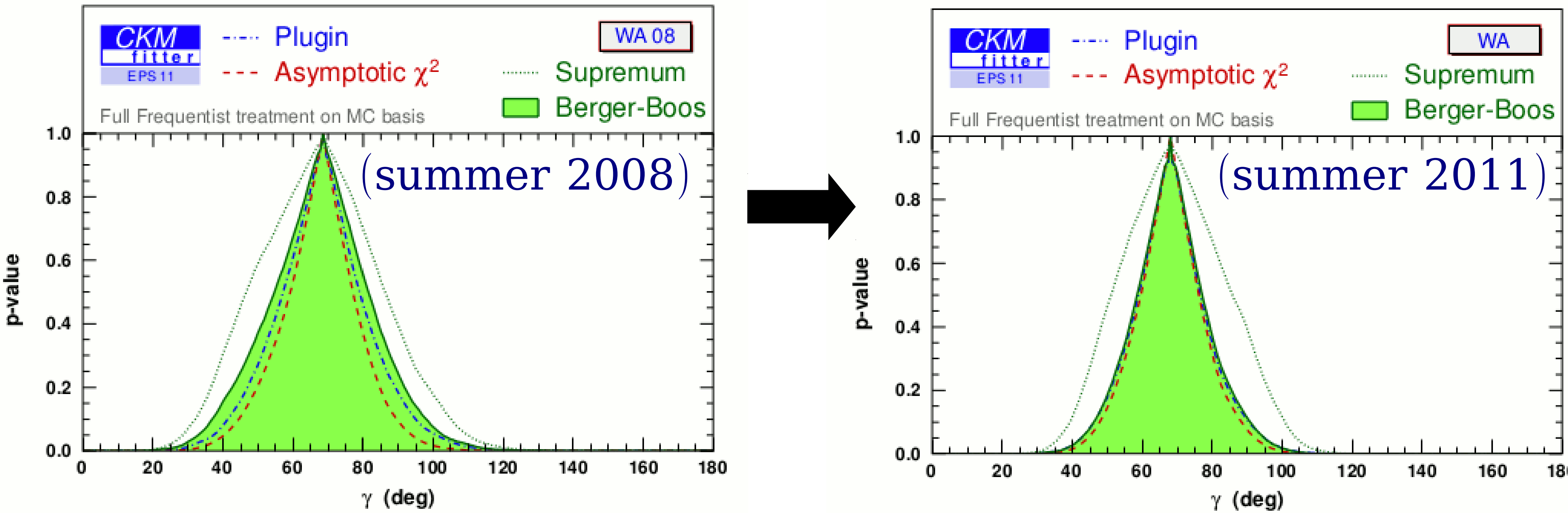
Different treatments of the nuisance parameters

to compute the distributions of the log-likelihood depending on the nuisance parameters ν:

1. use the best fit estimate, $\nu = \hat{\nu}$ (plugin method): coverage not not guaranteed if the true value of ν is different from $\hat{\nu}$

2. use the worst-case distribution: maximize the p-value over all possible values of ν (supremum method): coverage or overcoverage guaranteed by construction

3. maximize the p-value-a well-chosen subspace $\nu \in N$ (constrained supremum method, e.g. Berger-Boos)



r_B's away from zero, dependence wrt nuisance parameters is now weak

Outline:

(preliminary results)
(plugin method)

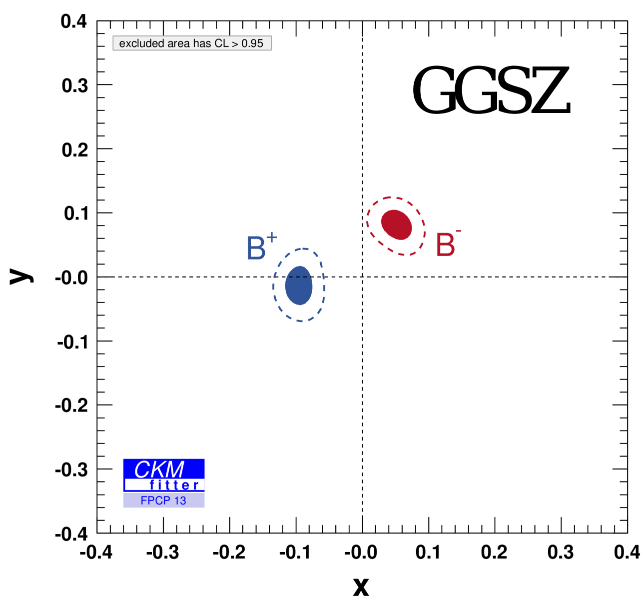
- start by inputs from γ observables only:
  - GGSZ observables of diff. exp., γ from GGSZ
  - prediction of GLW observables, γ from GGSZ+GLW
- ''charm' analysis: get the $K\pi$, $K\pi\pi^0$, $K3\pi$ strong phases and other hadronic parameters
  - comparison to CLEO-c results
  - pull of charm observables
- add ADS observables:
  - prediction of ADS observables, γ from GGSZ+GLW+ADS
  - δ_D discussion (from charm observables, from γ observables...)
- new observables from LHCb: DK^{*0} (GLW, ADS)...
- Summary

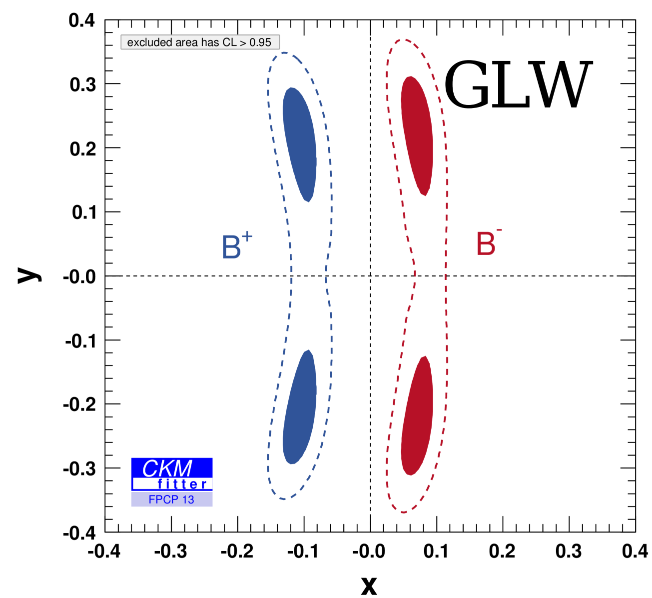
(r discussion: DK, $D\pi$, $D^*\rho$, D_sK)

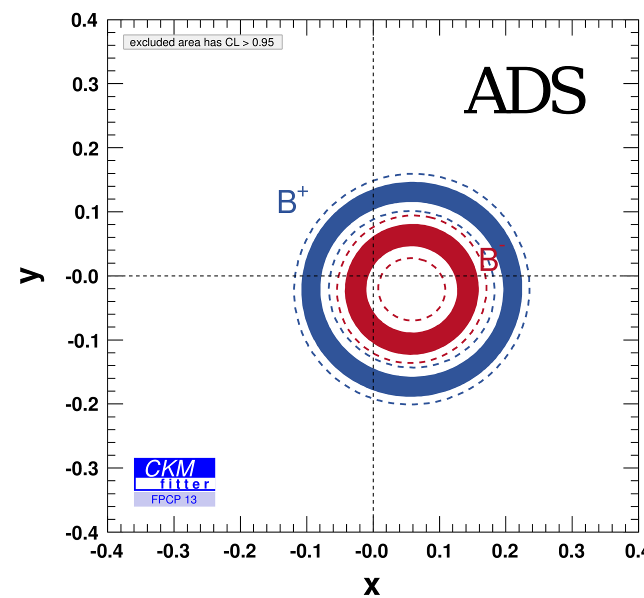
GGSZ, GLW, ADS in charged B decays

GGSZ	GLW	ADS
BaBar $DK+D^*K+DK^*$	BaBar $DK+D^*K+DK^*$	BaBar $DK+D^*K+DK^*$
Belle $DK+D^*K$	Belle $DK+D^*K$	Belle $DK+D^*K$, $K\pi/K\pi\pi^0$
LHCb DK	LHCb DK	LHCb DK, $K\pi$, $K3\pi$

$x_\pm = r_B \cos(\delta_B \pm \gamma)$ and $y_\pm = r_B \sin(\delta_B \pm \gamma)$ [just for illustration]



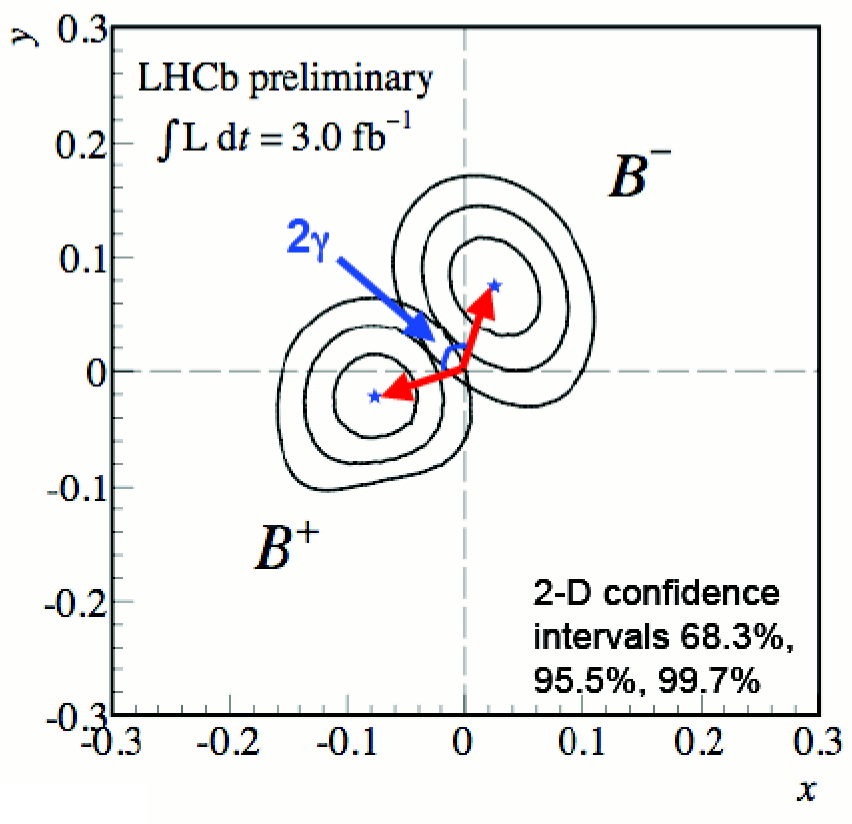




GGSZ update from LHCb

[see M.Karbach's talk]

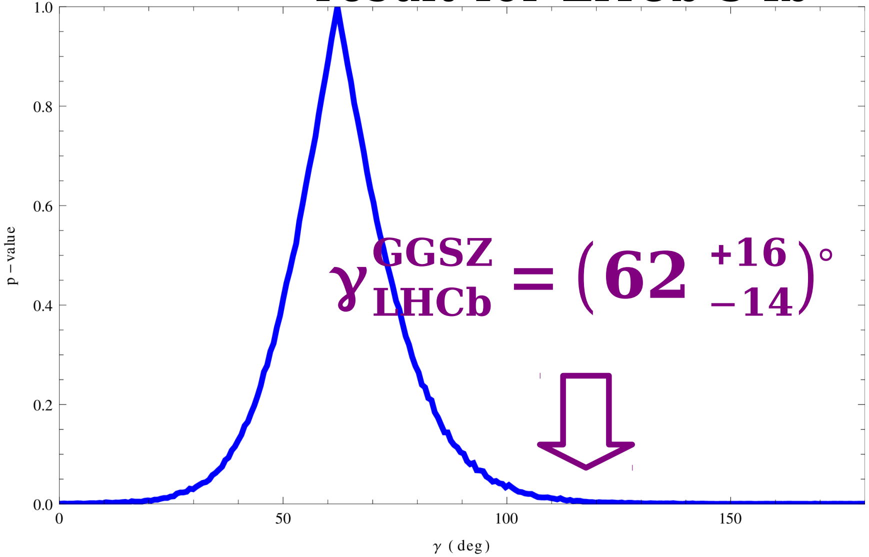
DK [arXiv:1408.2748]



lower and lower...

$$\gamma = (62^{+15}_{-14})^\circ$$
$$r_B = (8.0^{+1.9}_{-2.1}) \times 10^{-2}$$
$$\delta_B = (134^{+14}_{-15})^\circ$$

result for LHCb 3 fb^{-1}



$$\gamma^{GGSZ}_{LHCb} = (62\ ^{+16}_{-14})^\circ$$

result for LHCb 1+2 fb^{-1}, LHCb-CONF-2013-004

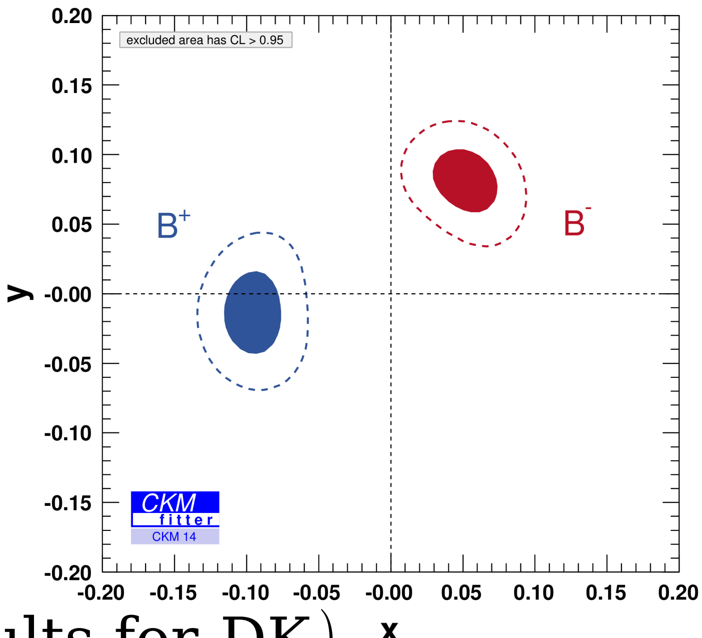
$$\gamma^{GGSZ}_{LHCb} = (57 \pm 16)^\circ$$

GGSZ

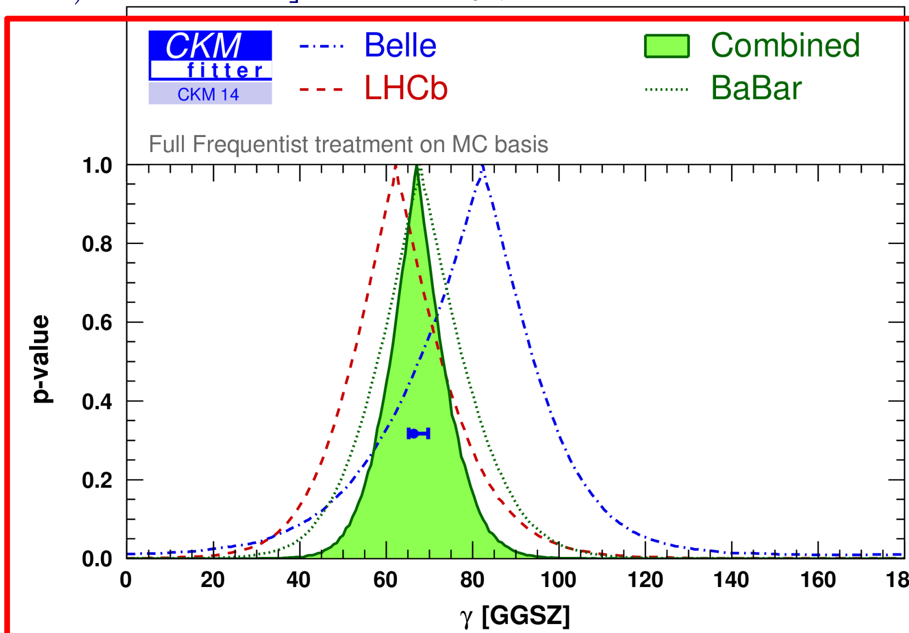
24 obs.

- DK, D^*K and DK^* [PRL 105 (2010) 121801]
- DK and D^*K [PRD 81 (2010) 112002]
- DK [arXiv:1408.2748]

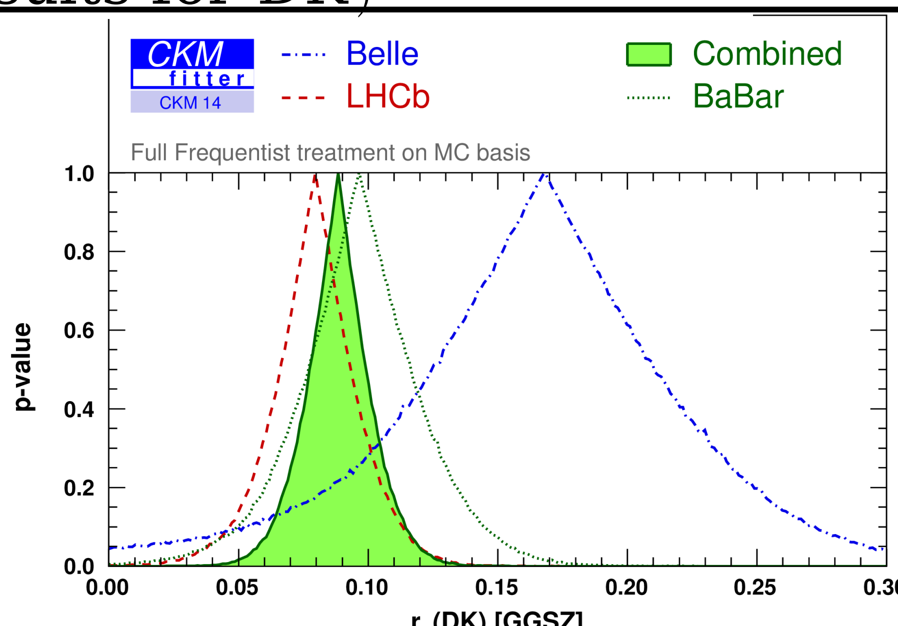
} model dep.



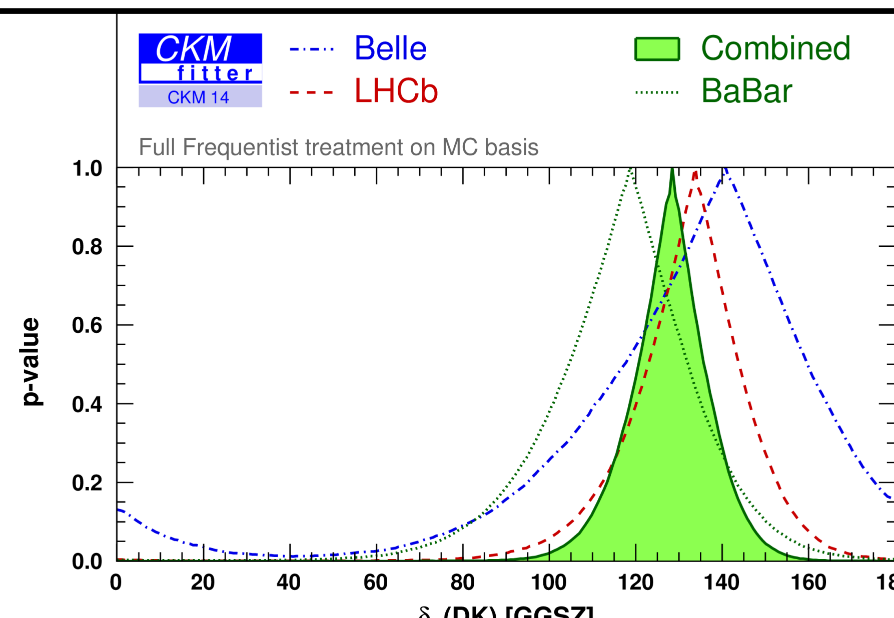
(results for DK)



$$\gamma^{GGSZ} = (67.0\ ^{+9.4}_{-9.3})^\circ$$



$$r_B^{GGSZ} = (0.088 \pm 0.016)$$

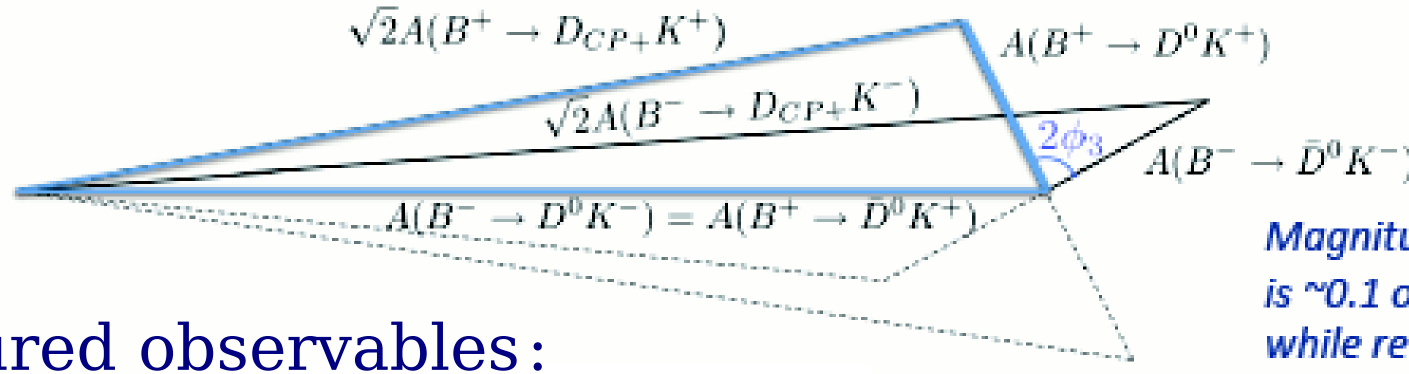


$$\delta_B^{GGSZ} = (128\ ^{+11}_{-12})^\circ$$

GLW with $D^{(*)}_{CP} K$

D decays to CP eigenstates

- Amplitude triangle:



Magnitude of one side is ~0.1 of the others while relative magnitude of the others help ϕ_3 constraint.

measured observables:

$$R_{CP\pm} \equiv \frac{Br(B^- \to D_{CP\pm} K^-) + Br(B^+ \to D_{CP\pm} K^+)}{Br(B^- \to D^0 K^-) + Br(B^+ \to \bar{D}^0 K^+)}$$

$$A_{CP\pm} \equiv \frac{Br(B^- \to D_{CP\pm} K^-) - Br(B^+ \to D_{CP\pm} K^+)}{Br(B^- \to D_{CP\pm} K^-) + Br(B^+ \to D_{CP\pm} K^+)}$$

Relation between $(R_{CP+}, R_{CP-}, A_{CP+}, A_{CP-})$ and (γ, r_B, δ_B)

$$R_{CP+} = 1 + r_B^2 + 2 r_B \cos\delta_B \cos\gamma \qquad R_{CP-} = 1 + r_B^2 - 2 r_B \cos\delta_B \cos\gamma$$

$$A_{CP+} = \frac{+2 r_B \sin\delta_B \sin\gamma}{1 + r_B^2 + 2 r_B \cos\delta_B \cos\gamma} \qquad A_{CP-} = \frac{-2 r_B \sin\delta_B \sin\gamma}{1 + r_B^2 - 2 r_B \cos\delta_B \cos\gamma}$$

$\Rightarrow$ look for $R_{CP\pm} \neq 1$ and $A_{CP\pm} \neq 0$

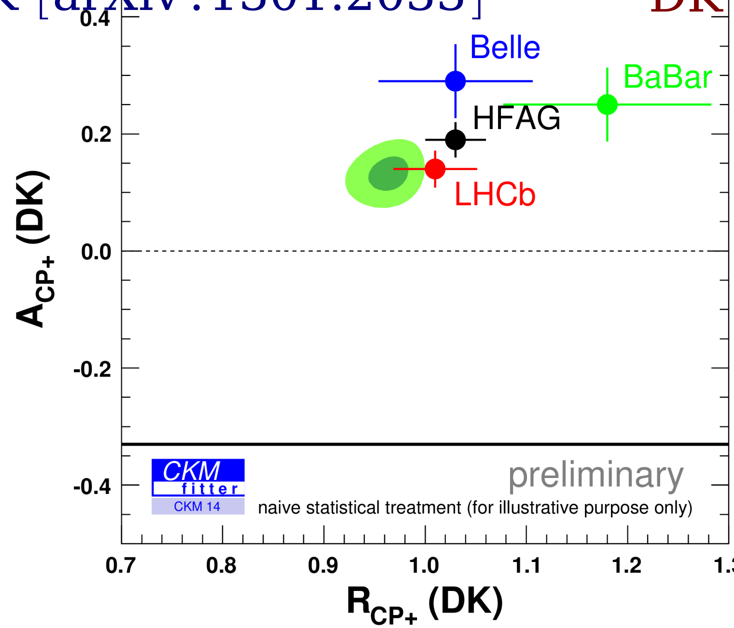
$\Rightarrow$ $\neq$ CP, $\neq$ sign of asymmetry

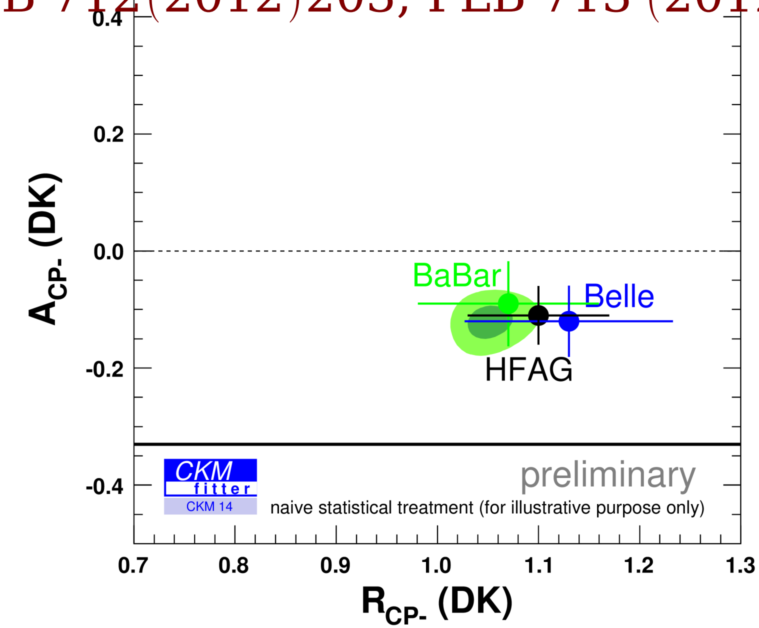
GLW observables (predictions vs measurements)

DK [PRD82(2010)072004], D^*K[PRD78(2008)092002], DK^* [PRDD80(2009)092001]

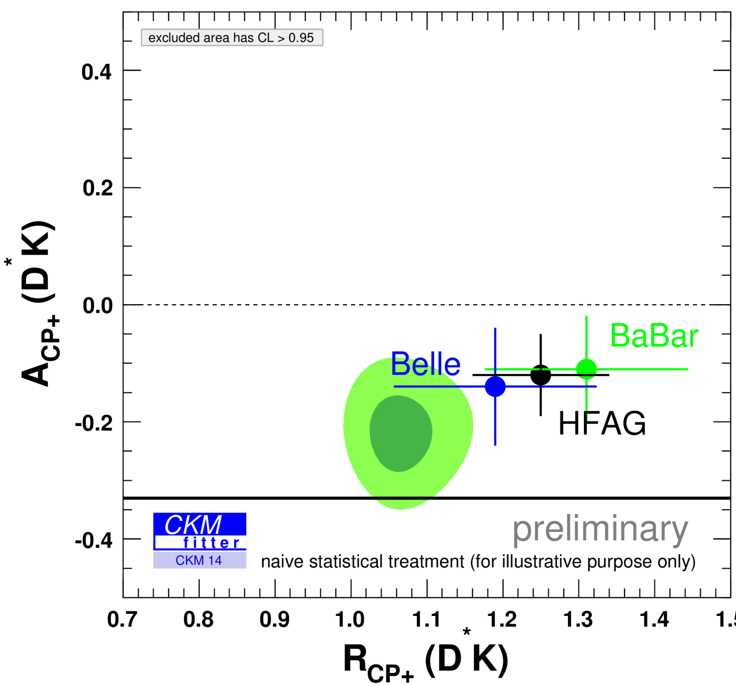
DK and D^*K [arXiv:1301.2033]

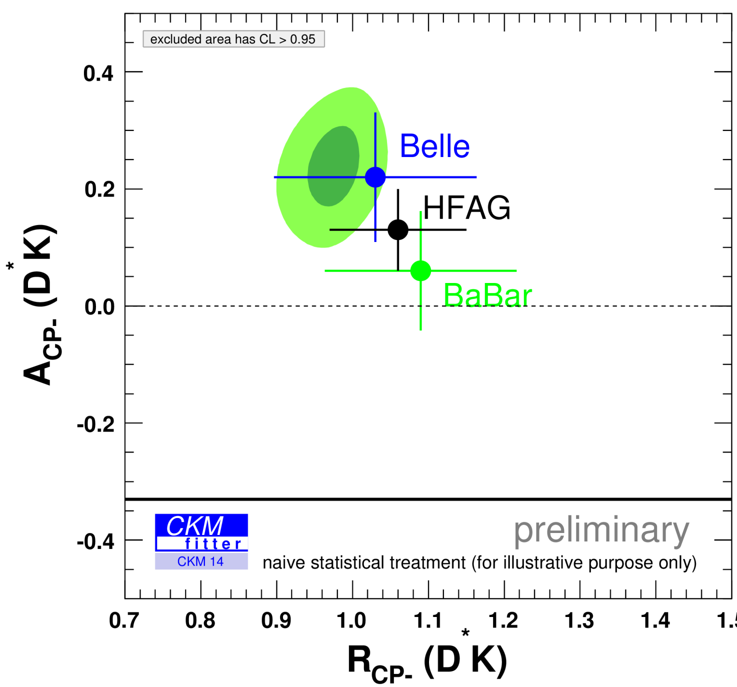
DK [PLB 712(2012)203, PLB 713 (2012) 351]





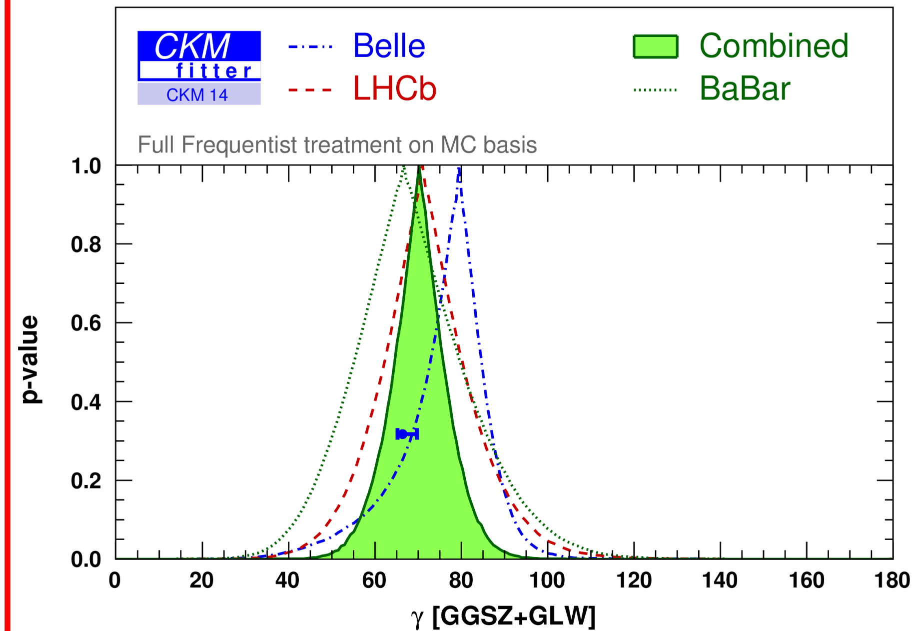
+ 22 obs.





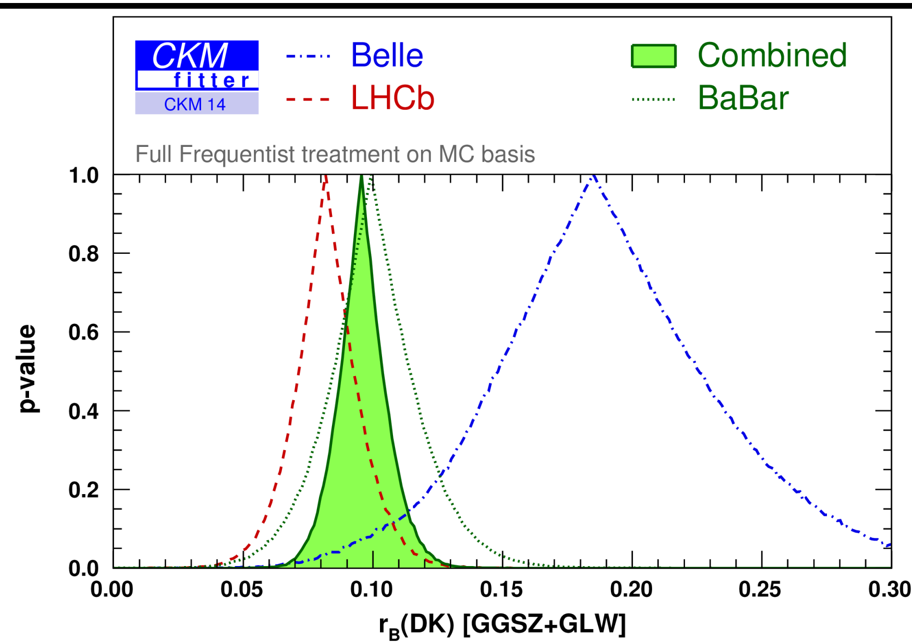
GGSZ+GLW

(assuming no DVCP in $D \to \pi\pi$, KK)

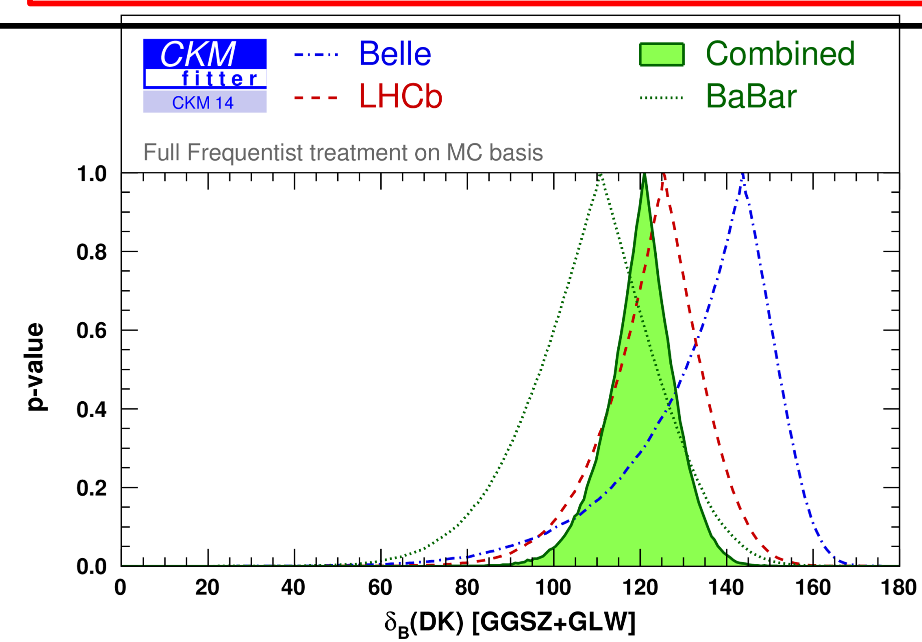


$$\gamma^{\mathrm{GGSZ+GLW}} = \left(70.2\,^{+8.2}_{-8.3}\right)^{\circ}$$

(results for DK)



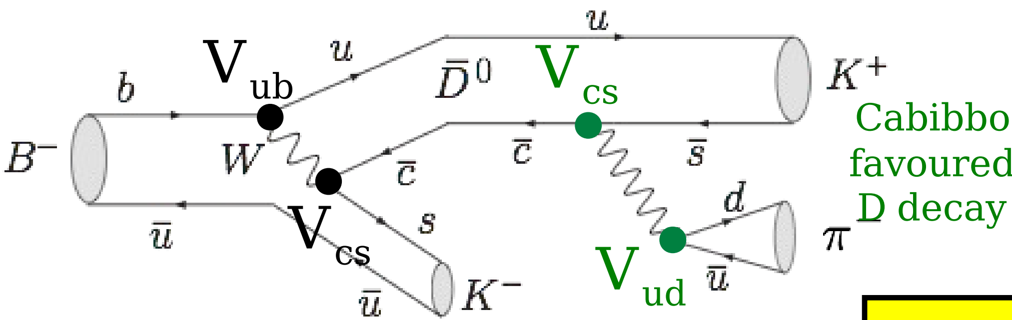
$$r_B^{\mathrm{GGSZ+GLW}} = (0.096 \pm 0.012)$$

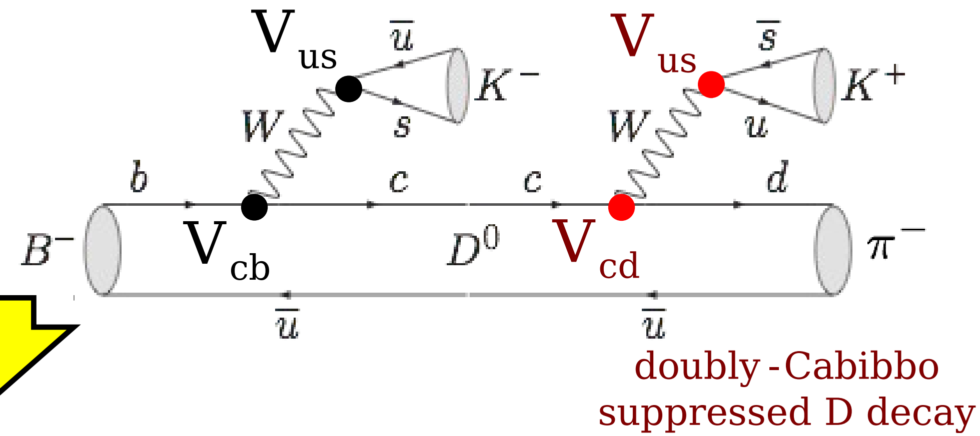


$$\delta_B^{\mathrm{GGSZ+GLW}} = \left(121.0\,^{+9.2}_{-10.3}\right)^{\circ}$$

ADS method: γ via the interference in rare $B^- \to [K^+\pi^-]_D K^-$ decays

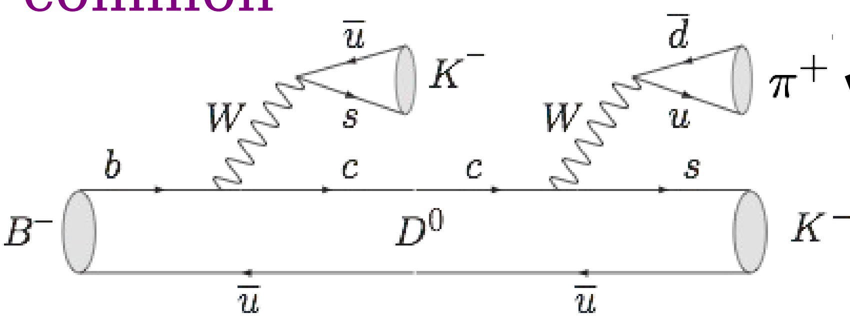
rate and asymmetry (relative to the common decay):





$$\mathcal{R}_{DK} = \frac{\Gamma([K^+\pi^-]\,K^-) + \Gamma([K^-\pi^+]\,K^+)}{\Gamma([K^-\pi^+]\,K^-) + \Gamma([K^+\pi^-]\,K^+)}$$

common



$$= r_B^{\,2} + r_D^{\,2} + 2 r_B r_D R \cos(\delta_B + \delta_D) \cos\gamma$$

$$\mathcal{A}_{DK} = \frac{\Gamma([K^+\pi^-]\,K^-) - \Gamma([K^-\pi^+]\,K^+)}{\Gamma([K^-\pi^+]\,K^-) + \Gamma([K^+\pi^-]\,K^+)}$$

$$= 2 r_B r_D R \sin(\delta_B + \delta_D) \sin\gamma \,/\, R_{DK}$$

where $r_D = \left| \frac{\mathcal{A}(D^0 \to K^+\pi^-)}{\mathcal{A}(\bar{D}^0 \to K^+\pi^-)} \right| = 0.0613 \pm 0.0010$

How to get δ_D and related (charm) hadronic parameters ?

- dedicated experiments (CLEO-c, BES III) using quantum correlations, running at $\psi(3770)$
  - CLEO-c: R_D, $\cos\delta$, $\sin\delta$ (but also BES III result...)
  - CLEO-c: $R_{K\pi\pi^0}$, $\delta_{K\pi\pi^0}$, $R_{K3\pi}$, $\delta_{K3\pi}$

R_f: coherence factor, can take any value from 0 to 1
indicates lack coherence between the intermediate states involved in the decay

- mixing/CPV results from BaBar, Belle, CDF, LHCb...
  - $D\to KK, \pi\pi$: y_{CP}, A_Γ (BaBar, Belle, LHCb)
  - $D\to K^0_S\pi\pi$: x, y, $|q/p|$, φ (BaBar, Belle)
  - $D\to Kl\nu$: R_M (BaBar, Belle...)
  - $D\to K\pi\pi^0$: x'', y'' (BaBar)
  - $D\to K\pi$: x', y' (BaBar, Belle, CDF, LHCb)
  - ...

- **CLEO-c/BES III, use external inputs to access the relevant physics parameters**
- **strong phases information in B-factories/LHCb**
- **x, y are also needed for D-mixing corrections in ADS observables**

$$R^{\mp} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B \mp \gamma + \delta_D)$$

$$\to R^{\mp} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B \mp \gamma + \delta_D) - y\, r_D \cos\delta_D - y\, r_B \cos(\delta_B \mp \gamma) + x\, r_D \sin\delta_D - x\, r_B \sin(\delta_B \mp \gamma)$$

⇒ combine charm observables to obtain γ and mixing/CPV charm parameters

Charm mixing in $D^0 \to K^+\pi^-$ [see M.Charles's talk]

The ratio $R(t)$ of WS $D^{*+} \to D^0\pi^+_s \to K^+\pi^-\pi^+_s$ to RS $D^{*+} \to D^0\pi^+_s \to K^-\pi^+\pi^+_s$ decay rates can be approximated (assuming $|x|, |y| << 1$ and no CPV) by:

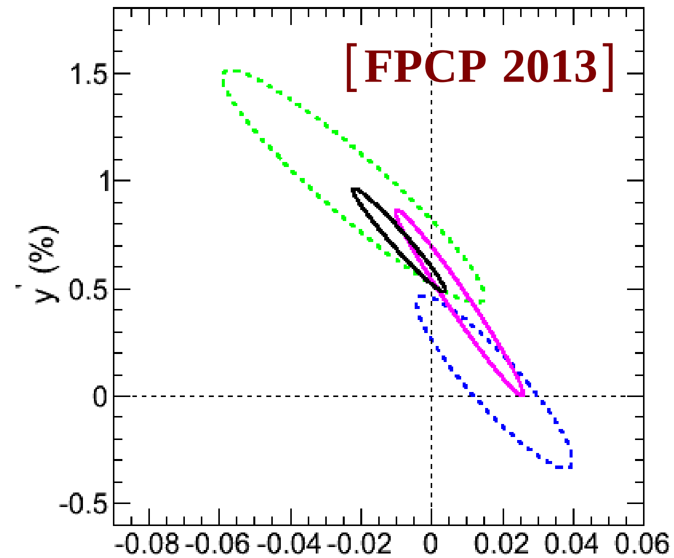
DCS to CF ratio — mixing rate

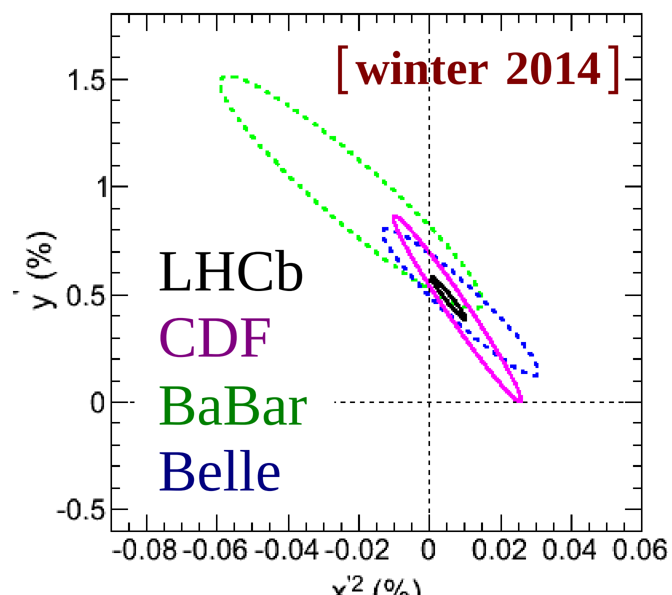
$$R(t) = R_D + \sqrt{R_D}\, y' t + \frac{x'^2 + y'^2}{4} t^2$$

$$x' = x\cos\delta_{K\pi} + y\sin\delta_{K\pi}$$
$$y' = y\cos\delta_{K\pi} - x\sin\delta_{K\pi}$$

$\delta_{K\pi}$: strong phase difference btw DCS and CF amplitudes

Exp	R_D (10^{-3})	y' (10^{-3})	x'^2 (10^{-3})	Σ
Belle PRL112 (2014) 111801	3.53 ± 0.13	4.6 ± 3.4	$+0.09 \pm 0.22$	5.1
BaBar PRL98 (2007) 211802	3.03 ± 0.19	9.7 ± 5.4	-0.22 ± 0.37	3.9
LHCb PRL111 (2013) 251801	3.57 ± 0.07	4.8 ± 1.0	$+0.055 \pm 0.049$	?
CDF preliminary (2013)	3.51 ± 0.35	4.3 ± 4.3	$+0.08 \pm 0.18$	6.1





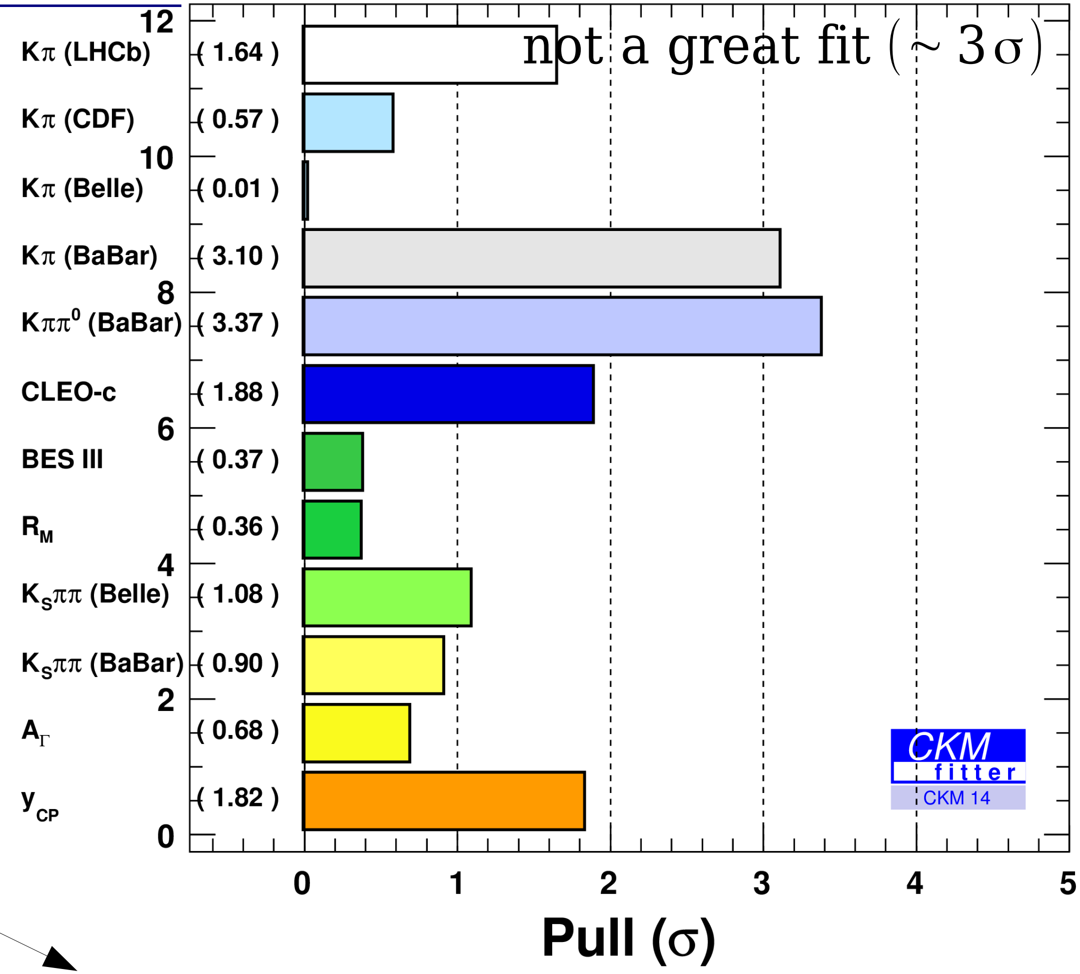
δ_D grand combination à la HFAG

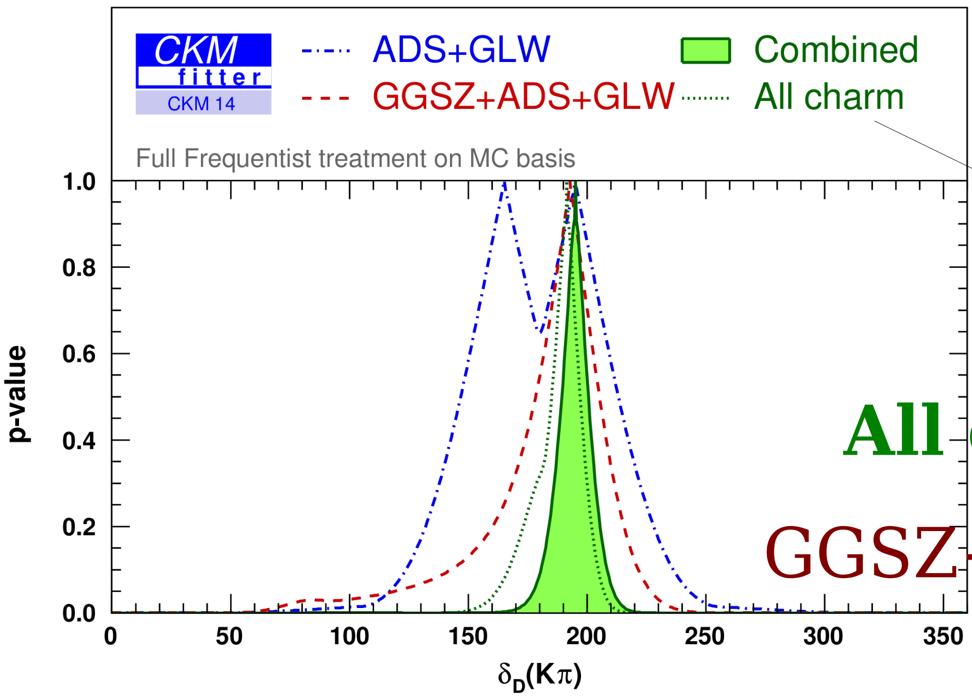
~ 35 observables

not a great fit ($\sim 3\sigma$)

8 parameters:

$x,\ y,\ \delta_D^{K\pi},\ r_D,\ A_D,\ |q|/|p|,\ \varphi,\ \delta_D(K\rho)$





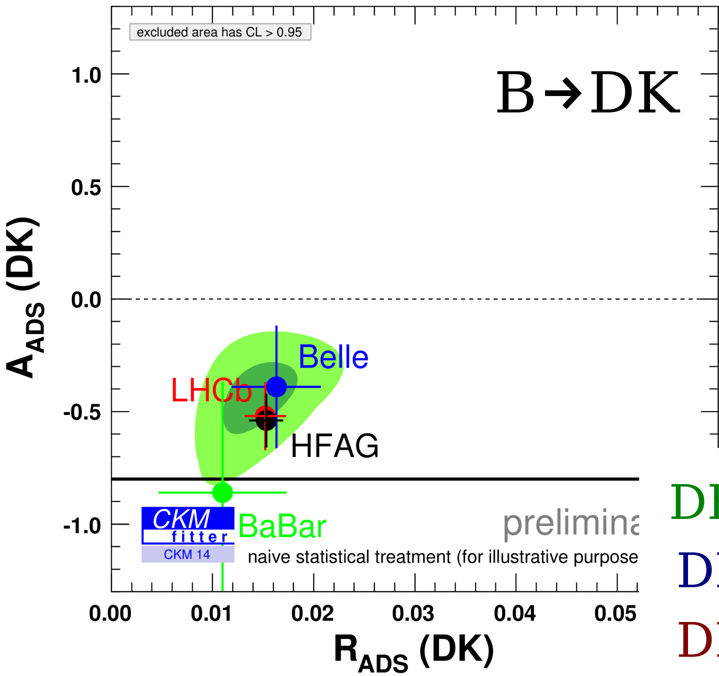
(include $K3\pi$, $K\pi\pi^0$ info, see next slides)

All charm: $\delta_D^{K\pi} = (191.4^{+8.2}_{-11.4})^\circ$ $\left(^{+16}_{-30}\right)$

GGSZ+GLW+ADS: $\delta_D^{K\pi} = (193^{+18}_{-23})^\circ$ $\left(^{+34}_{-77}\right)$

Comparison of the results obtained for $D^{(*)}K$ with expectations

where "expectations" are derived from the GGSZ observables, δ_D and r_D



$$R_{ADS}(DK) = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D) \cos\gamma$$
$$A_{ADS}(DK) = 2 r_B r_D \sin(\delta_B + \delta_D) \sin\gamma / R_{ADS}(DK)$$

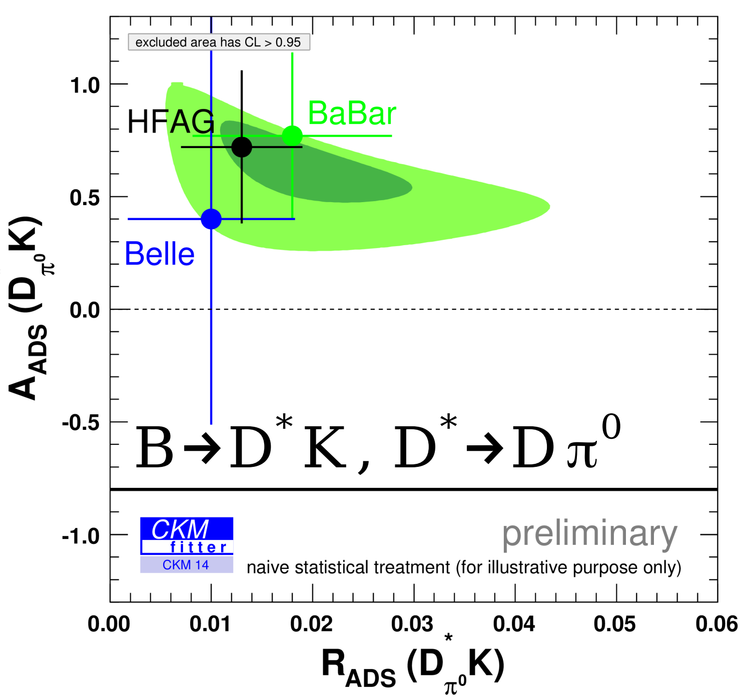
$$R_{ADS}(D^*_{\pi^0}K) = r_B^{*2} + r_D^2 + 2 r_B^* r_D \cos(\delta_B^* + \delta_D) \cos\gamma$$
$$A_{ADS}(D^*_{\pi^0}K) = 2 r_B^* r_D \sin(\delta_B^* + \delta_D) \sin\gamma / R_{ADS}(D^*_{\pi^0}K)$$

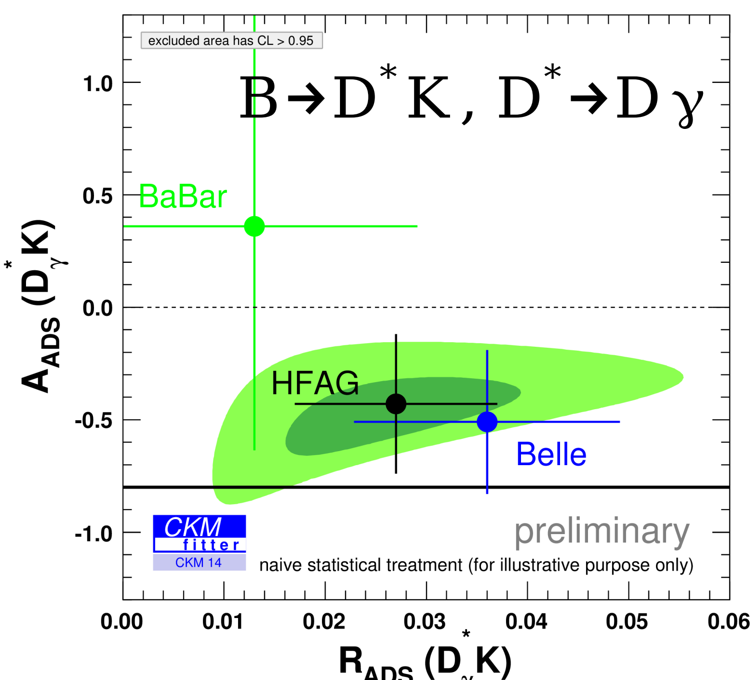
$$R_{ADS}(D^*_{\gamma}K) = r_B^{*2} + r_D^2 - 2 r_B^* r_D \cos(\delta_B^* + \delta_D) \cos\gamma$$
$$A_{ADS}(D^*_{\gamma}K) = -2 r_B^* r_D \sin(\delta_B^* + \delta_D) \sin\gamma / R_{ADS}(D^*_{\gamma}K)$$

DK, D^*K [PRD82 (2010) 072006], DK^*[PRD80 (2009) 0920

DK [PRL 106 (2011) 231803], D^*K [arXiv:1301.2033]

DK [PLB 712(2012)203, PLB 713 (2012) 351]





ADS observables

- (R_+, R_-) **instead of** (R_{ADS}, A_{ADS}) **whenever available**

Effect of D-$\bar{D}$ mixing on γ

- M.Rama, arXiv:1307.4384
- $R^{\mp} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B \mp \gamma + \delta_D)$

  → $R^{\mp} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B \mp \gamma + \delta_D) - y\, r_D \cos\delta_D - y\, r_B \cos(\delta_B \mp \gamma) + x\, r_D \sin\delta_D - x\, r_B \sin(\delta_B \mp \gamma)$
- tried on the current LHCb average (DK): ~ 1 degree difference

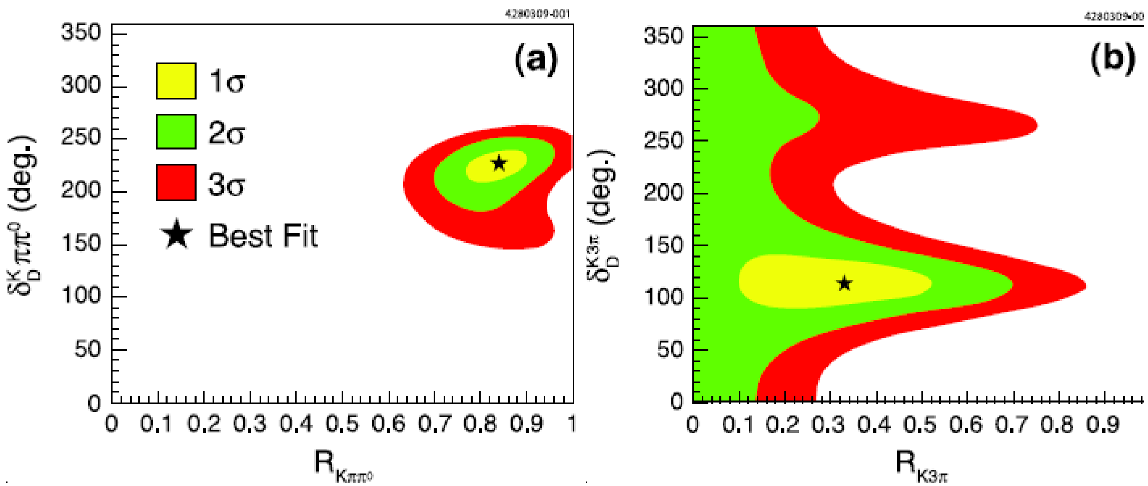
$K\pi\pi^0$, $K3\pi$ from CLEO-c

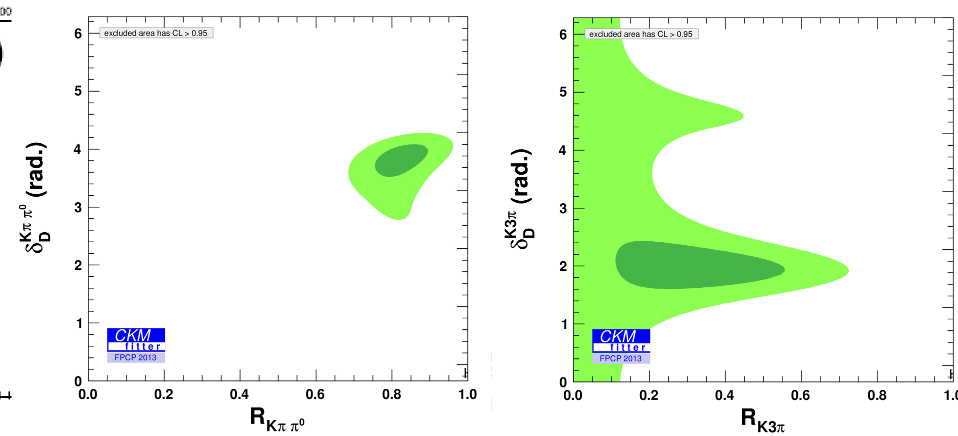
[see R.Briere's talk]

yields of double-tagged events where one meson decays into $K^-\pi^+\pi^0$ (or $K3\pi$), and the other meson decays into CP-odd, CP-even and $K\pi$

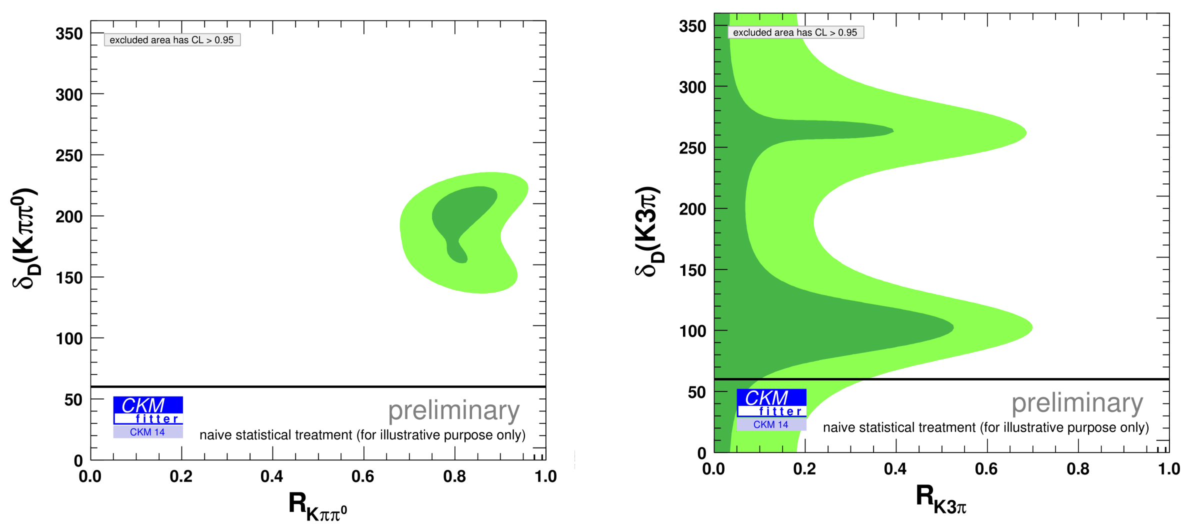
[arXiv:0903.4853, N.Lowrey et al]
(combined with external inputs: x, y, δ_D...)

that we could reproduce earlier extending the charm fitter (+ Br's)





2014 version (currently used in our γ combination):



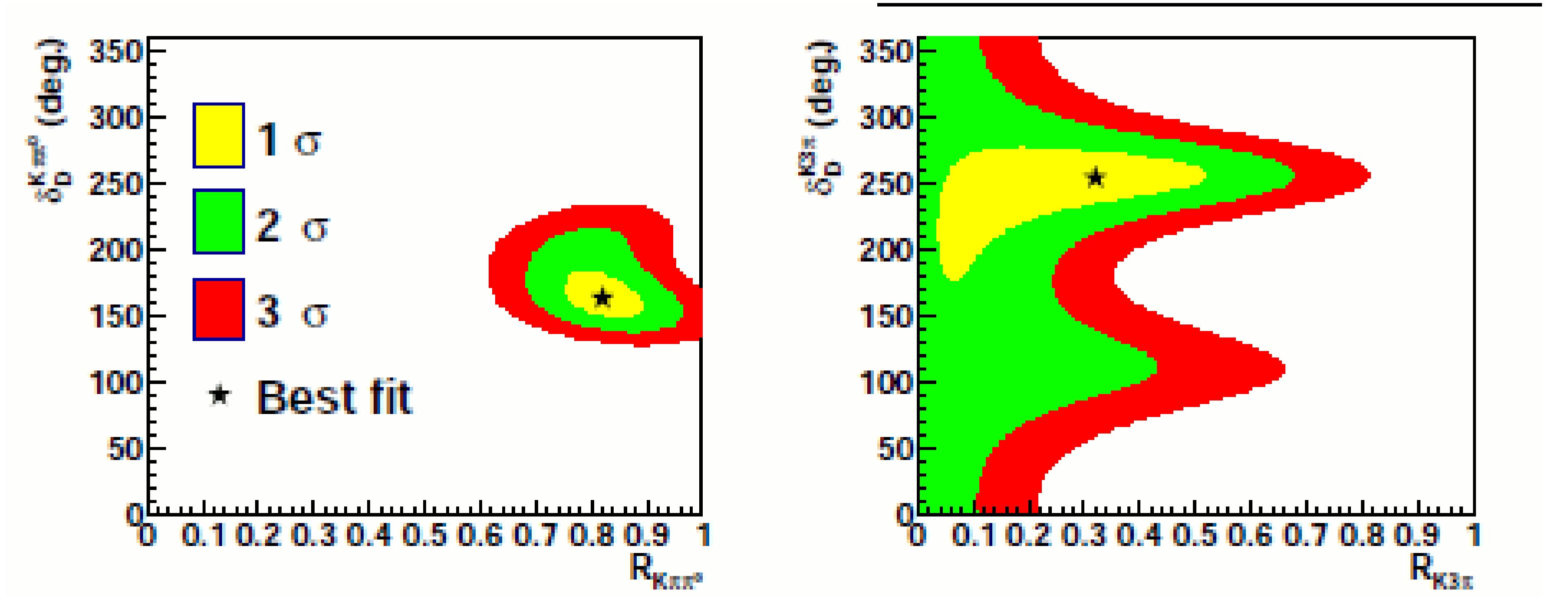
$K\pi\pi^0$, $K3\pi$ from CLEO-c [J.Libby et al, arXiv:1401.1904]

yields of double-tagged events where one meson decays into $K^-\pi^+\pi^0$ (or $K3\pi$), and the other meson decays into $K^0_S\pi^+\pi^-$

$$Y_i = H_{K\pi\pi^0}\Big(K_i + (r_D^{K\pi\pi^0})^2 K_{-i} - 2r_D^{K\pi\pi^0}\sqrt{K_i K_{-i}} R_{K\pi\pi^0}[c_i \cos\delta_D^{K\pi\pi^0} + s_i \sin\delta_D^{K\pi\pi^0}]\Big),$$

measure by CLEO-c

K_i : fractional yield of D^0 decays that fall into bin i



⇒ will soon include this information

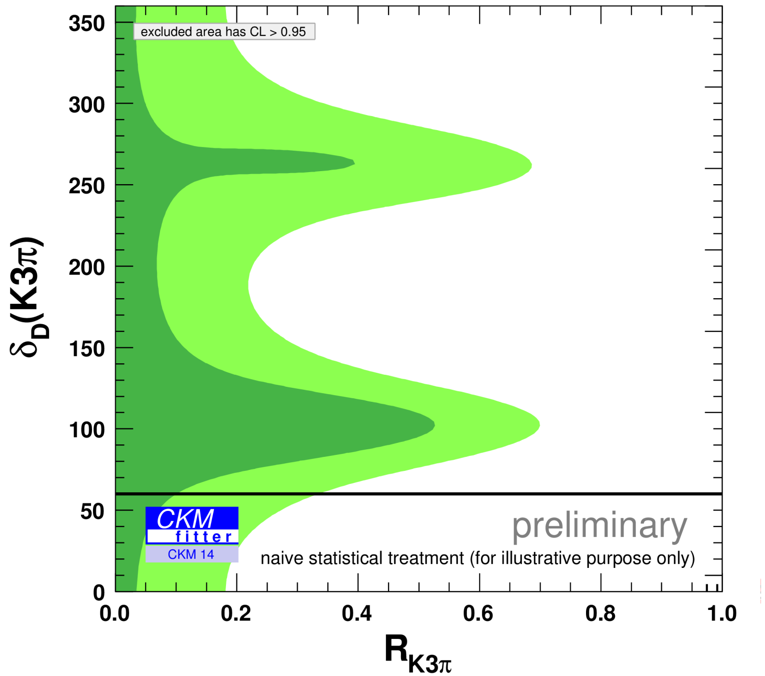
$K3\pi$ charm information is limited:

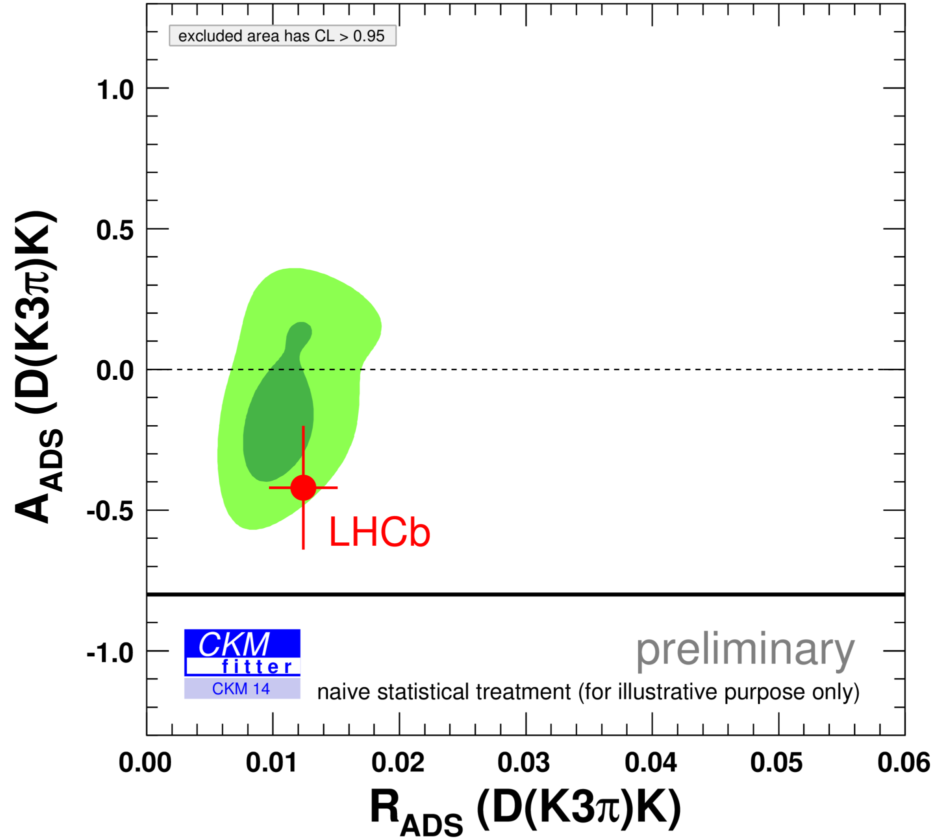
- possible additional inputs from BES III
- B factories/LHCb [S.Harnew and J.Rademacker, arXiv:1309.0134]

ADS $B \to D(K3\pi)K$

where "expectations" derived from the GGSZ observables, δ_D, r_D and R (for $K3\pi$)

D(K3π)K [PLB 723 (2013) 44]



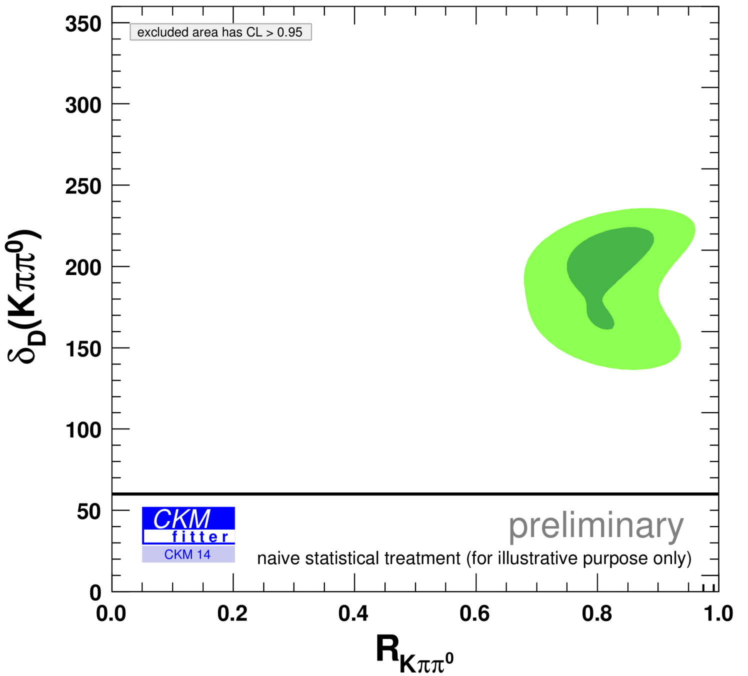


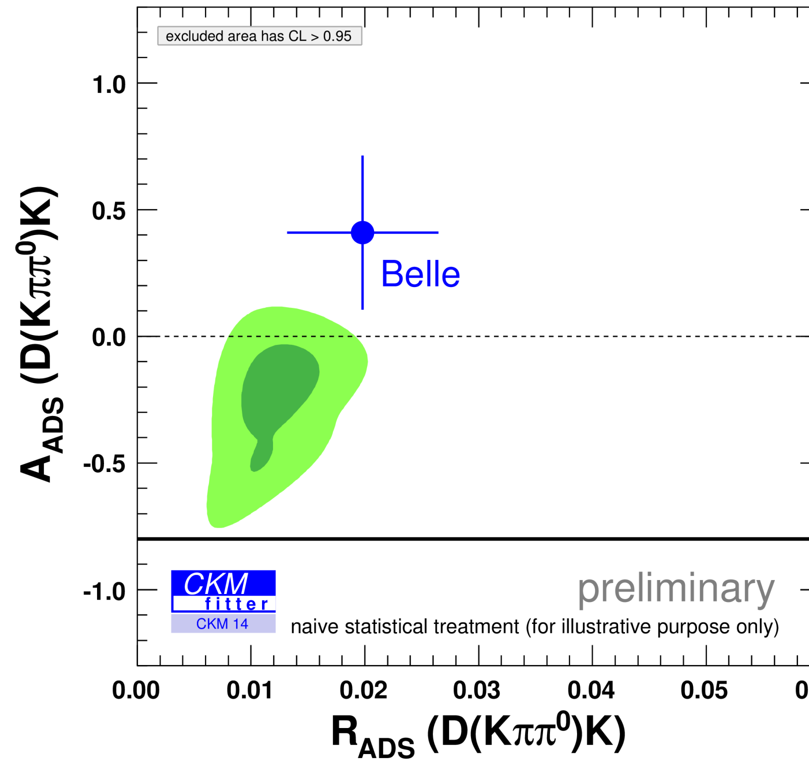
⇒ D(K3π)K LHCb result included in the γ combination

ADS $B \to D(K\pi\pi^0)K$

[see J.Libby's talk]

where "expectations" derived from the GGSZ observables, δ_D, r_D and R (for $K\pi\pi^0$)





Evidence for the suppressed decay $B^- \to DK^-, D \to K^+\pi^-\pi^0$

M. Nayak,[16] J. Libby,[16] K. Trabelsi,[12] I. Adachi,[12] H. Aihara,[55] D. M. Asner,[42] T. Aushev,[20] A. M. Bakich,[49]
A. Bala,[43] P. Behera,[16] K. Belous,[18] V. Bhardwaj,[34] G. Bonvicini,[60] A. Bozek,[38] M. Bračko,[27,21] T. E. Browder,[11]
D. Červenkov,[5] M.-C. Chang,[8] P. Chang,[37] V. Chekelian,[28] A. Chen,[35] B. G. Cheon,[10] R. Chistov,[20] I.-S. Cho,[62]
K. Cho,[24] V. Chobanova,[28] Y. Choi,[48] D. Cinabro,[60] J. Dalseno,[28,51] M. Danilov,[20,30] Z. Doležal,[5] Z. Drásal,[5]
G. Varner,[11] K. E. Varvell,[49] M. N. Wagner,[9] C. H. Wang,[36] M.-Z. Wang,[37] Y. Watanabe,[22] K. M. Williams,[59]
E. Won,[25] Y. Yamashita,[39] S. Yashchenko,[7] Y. Yusa,[40] V. Zhilich,[4] V. Zhulanov,[4] and A. Zupanc[23]
(The Belle Collaboration)

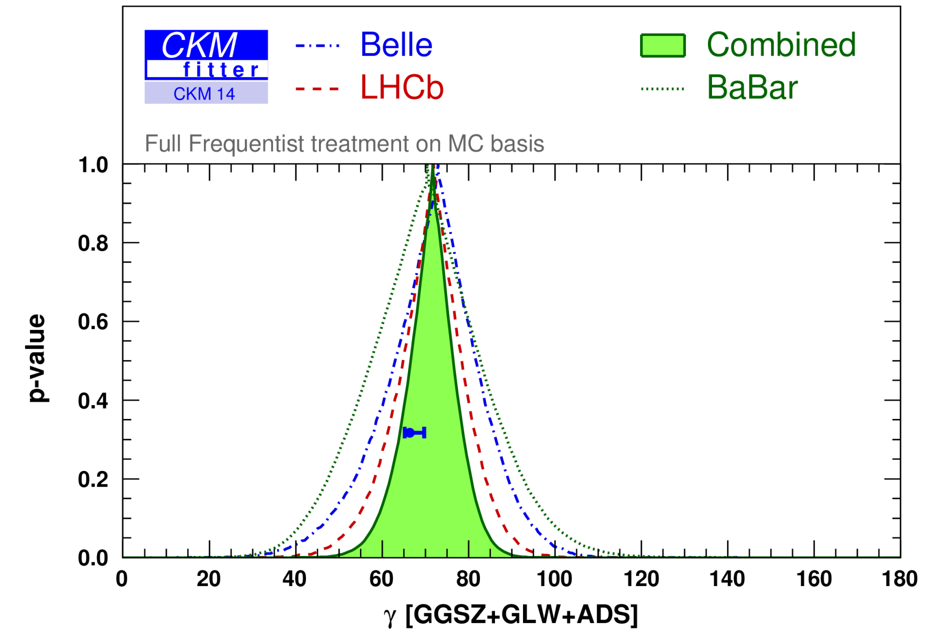
We report a study of the suppressed decay $B^- \to DK^-$, $D \to K^+\pi^-\pi^0$, where D denotes either a D^0 or a $\overline{D}^0$ meson. The decay is sensitive to the CP-violating parameter ϕ_3. Using a data sample of 772×10^6 $B\overline{B}$ pairs collected at the $\Upsilon(4S)$ resonance with the Belle detector, we measure the ratio of branching fractions of the above suppressed decay to the favored decay $B^- \to DK^-$, $D \to K^-\pi^+\pi^0$. Our result is $R_{DK} = [1.98 \pm 0.62(\text{stat.}) \pm 0.24(\text{syst.})] \times 10^{-2}$, which indicates the first evidence of the signal for this suppressed decay with a significance of 3.2 standard deviations. We measure the direct CP asymmetry between the suppressed B^- and B^+ decays to be $A_{DK} = 0.41 \pm 0.30(\text{stat.}) \pm 0.05(\text{syst.})$. We also report measurements for the analogous quantities $R_{D\pi}$ and $A_{D\pi}$ for the decay $B^- \to D\pi^-$, $D \to K^+\pi^-\pi^0$.

DK [PRD 88, 091104(R) (2013)]

⇒ Belle (and BaBar) $D(K\pi\pi^0)K$ results included in the γ combination

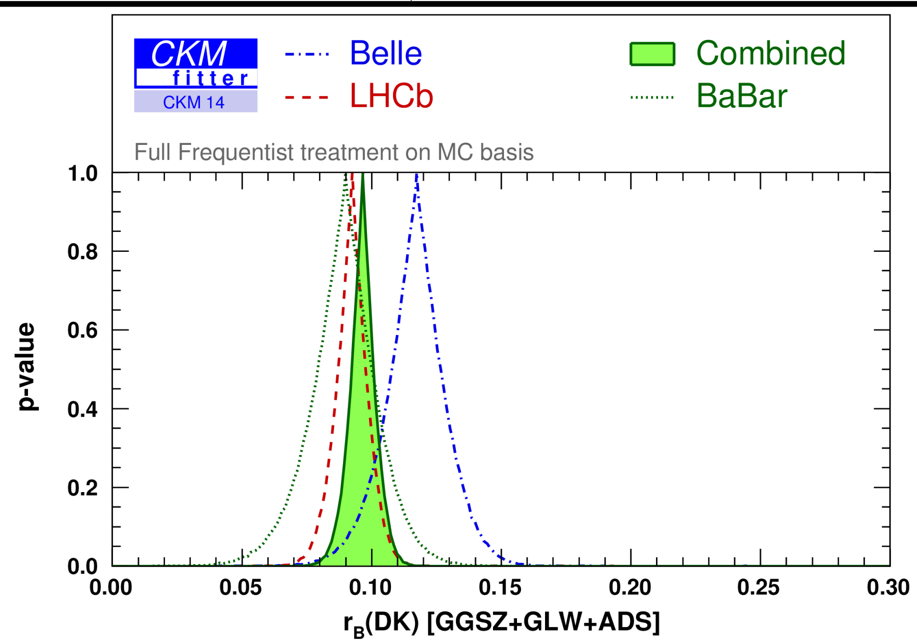
GGSZ+GLW+ADS

+20 obs.

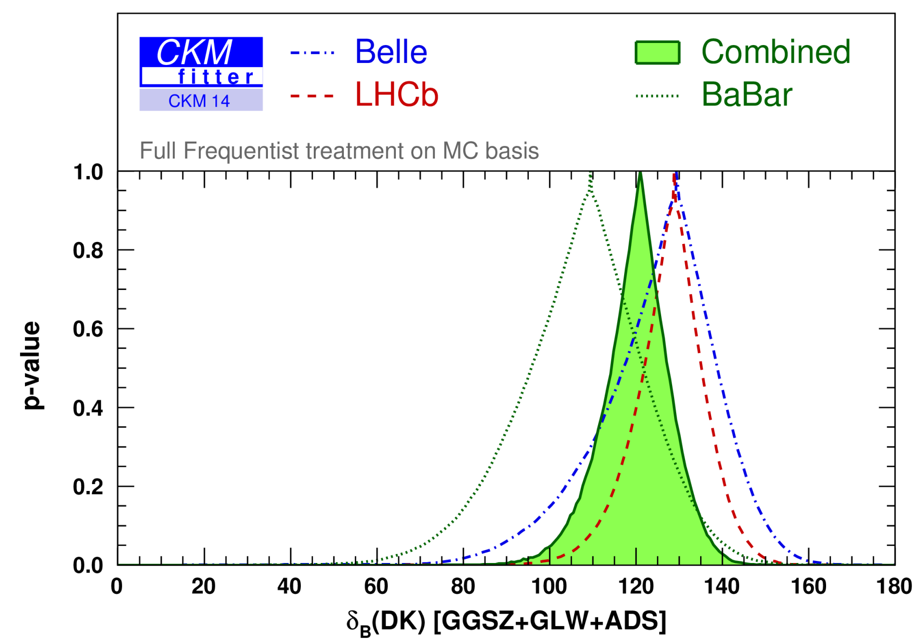


$$\gamma^{\text{GGSZ+GLW+ADS}} = \left(71.7\,^{+7.1}_{-7.4}\right)^\circ$$

(results for DK)



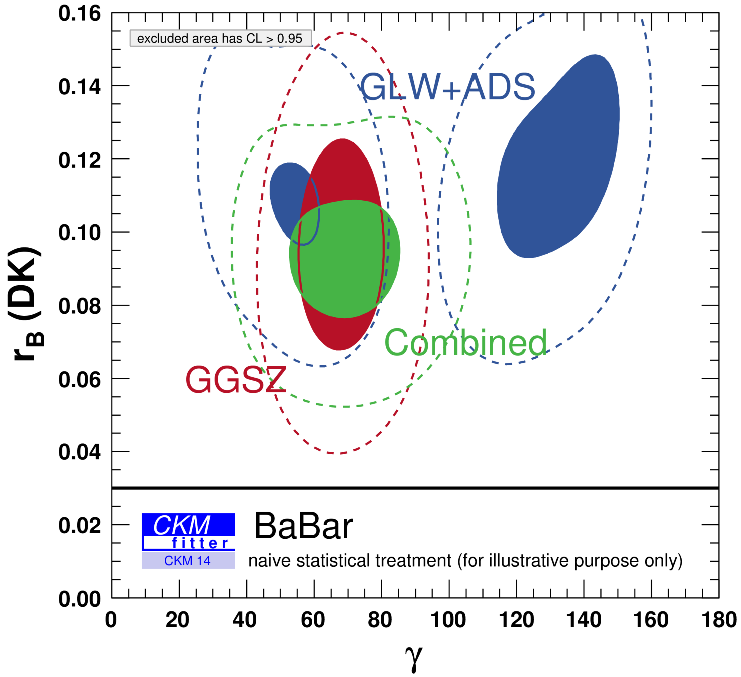
$$r_B^{\text{GGSZ+GLW+ADS}} = \left(0.0965\,^{+0.0062}_{-0.0063}\right)$$

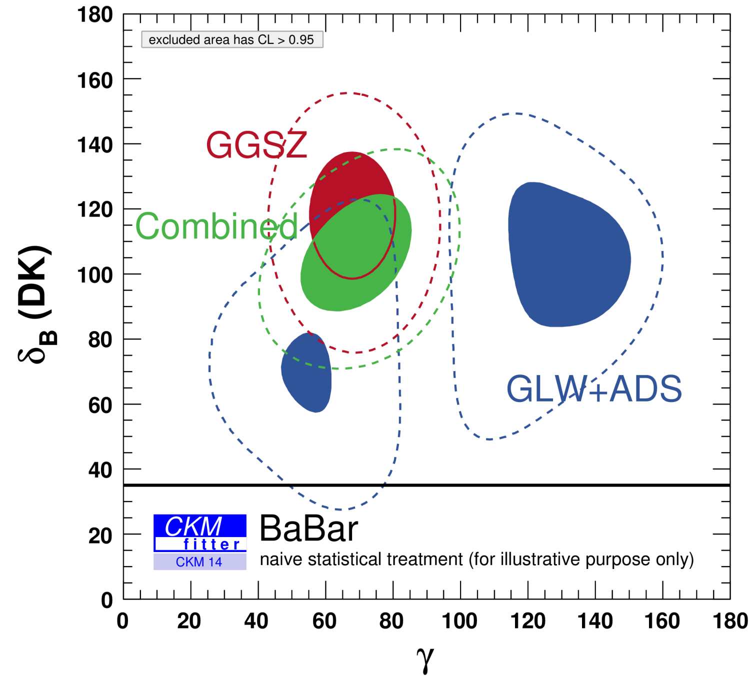


$$\delta_B^{\text{GGSZ+GLW+ADS}} = \left(124.6\,^{+7.2}_{-7.9}\right)^\circ$$

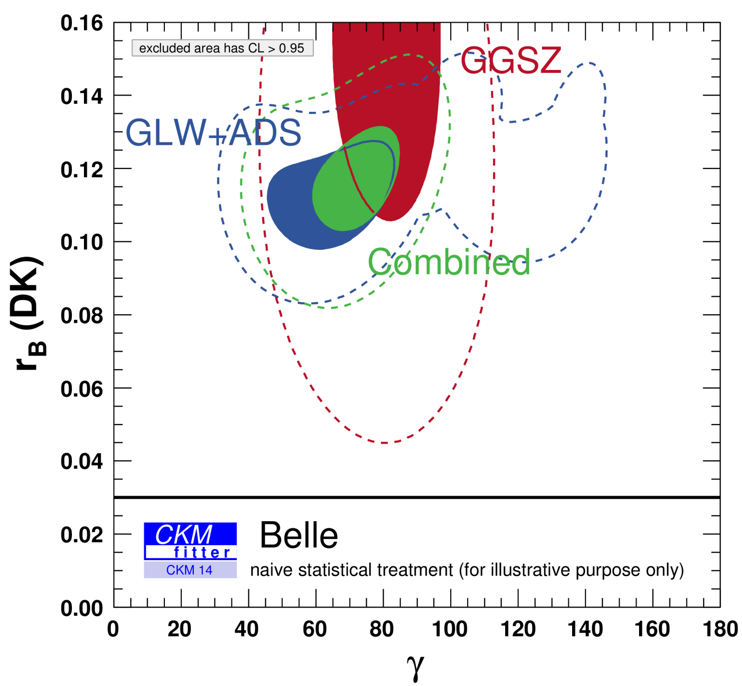
GGSZ versus GLW+ADS (r_B(DK) vs γ, δ_B(DK) vs γ)

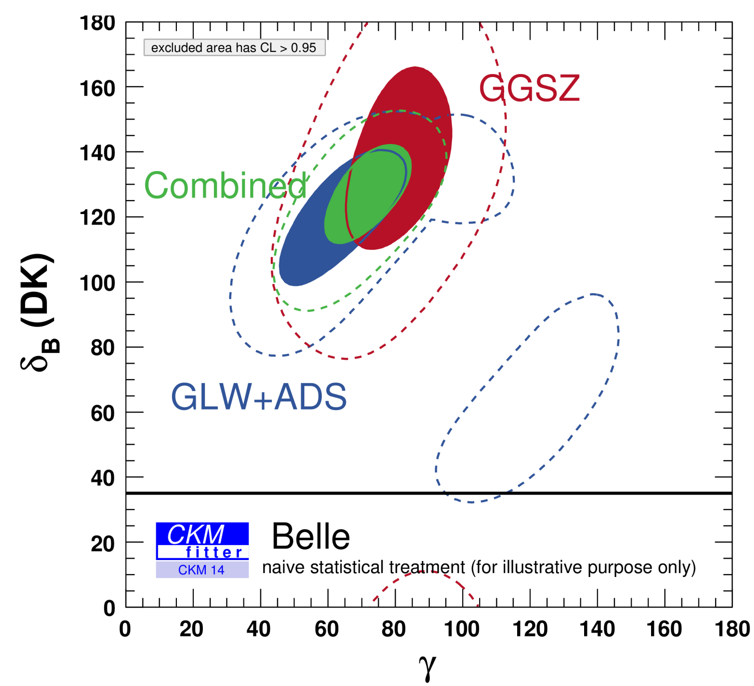
BaBar





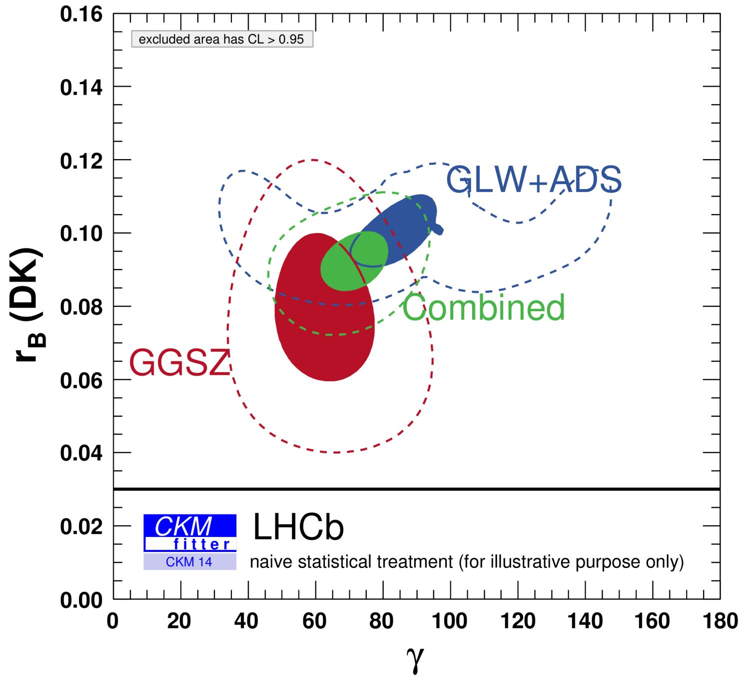
Belle

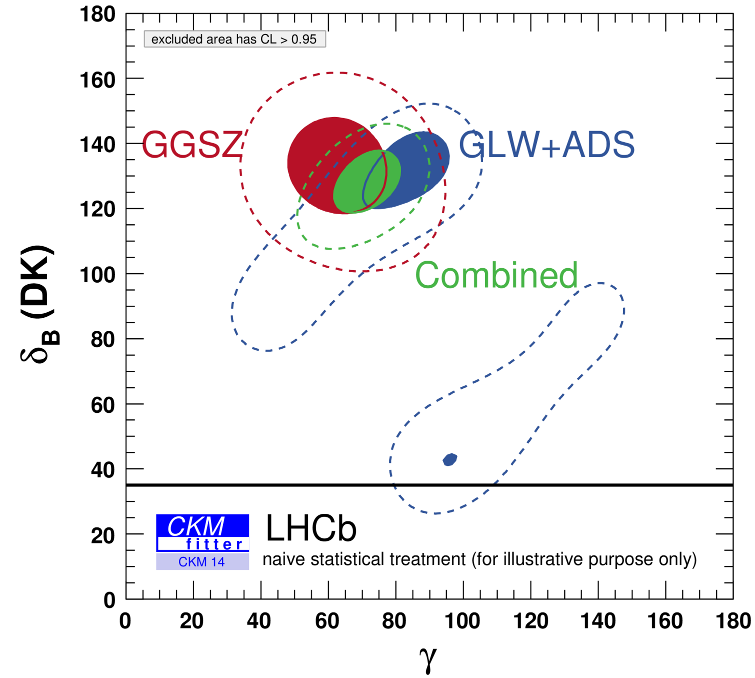




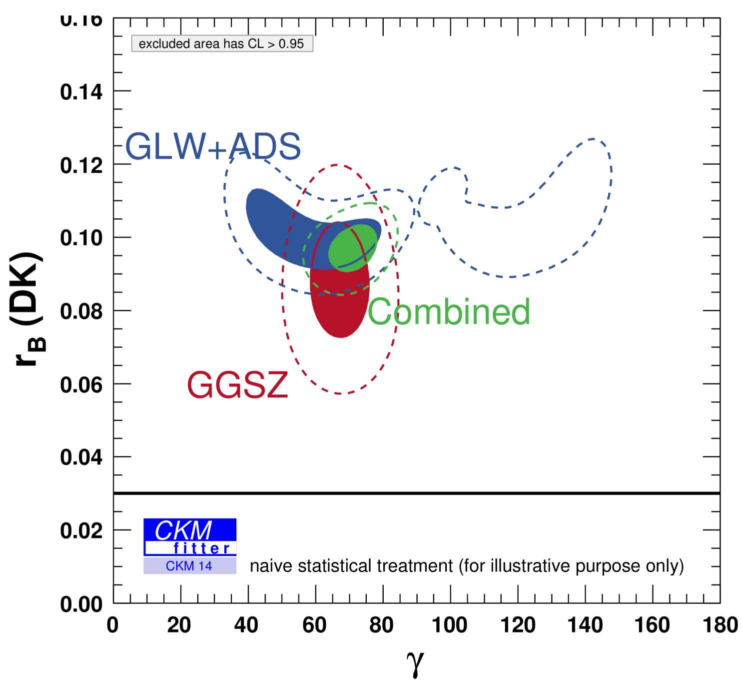
GGSZ versus GLW+ADS ($r_B(DK)$ vs γ , $\delta_B(DK)$ vs γ)

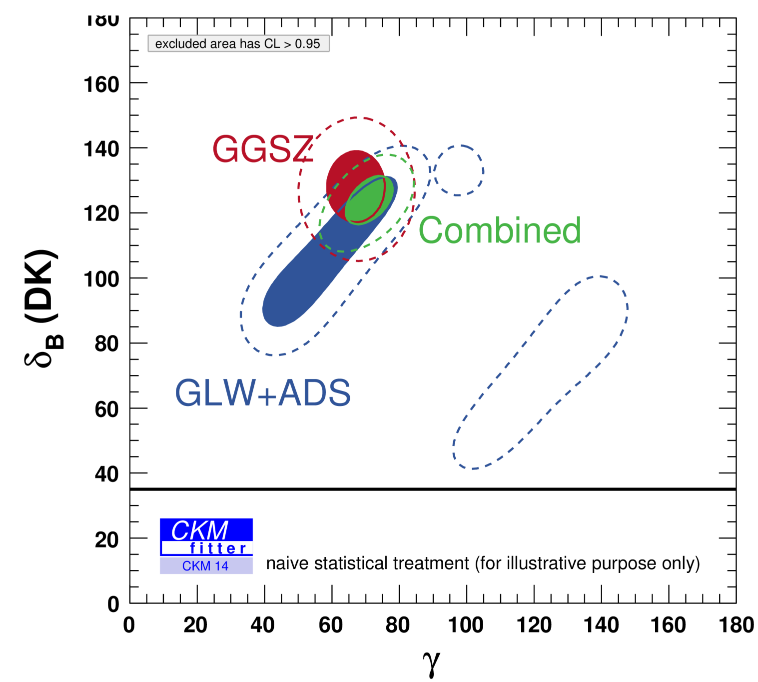
LHCb





All

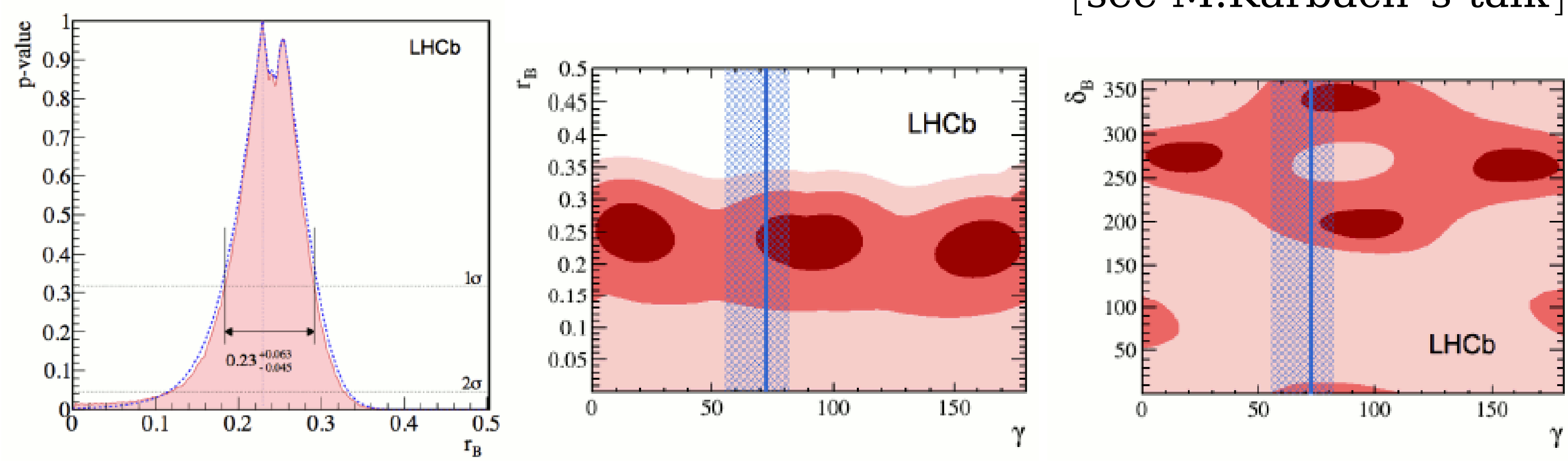




New LHCb results, DK^{*0}, $D\to hh$ (ADS, GLW)

$r_B(DK^{*0}) = (0.230\ ^{+0.063}_{-0.045})$

[arXiv:1407.8136]
[see M.Karbach's talk]

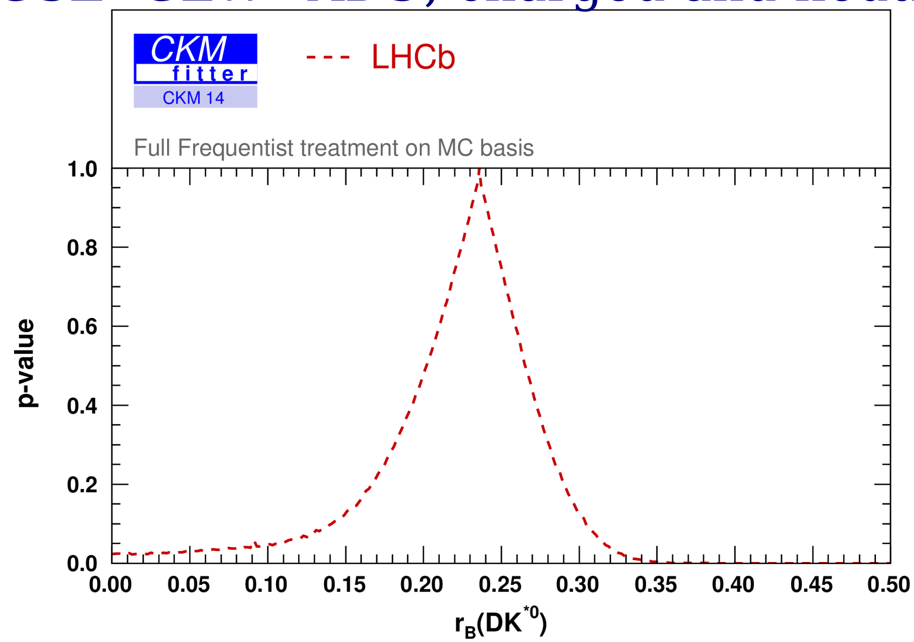


Combining all LHCb γ measurements (GGSZ+GLW+ADS, charged and neutral)

$r_B(DK^{*0}) = 0.236\ ^{+0.043}_{-0.052}$

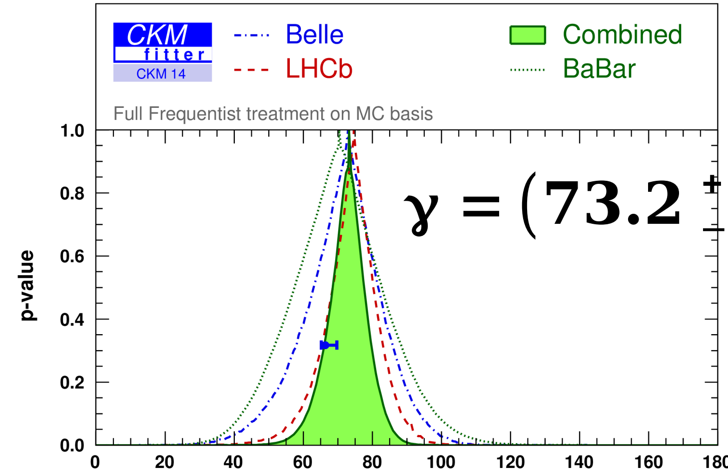
$^{+0.081}_{-0.137}$ (2σ)

$^{+0.12}_{-\infty}$ (3σ)



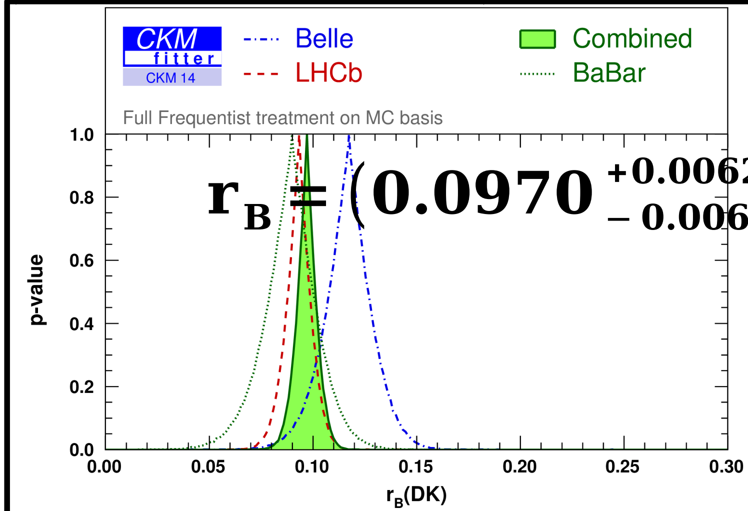
GGSZ+GLW+ADS

(charged and neutral B decays)

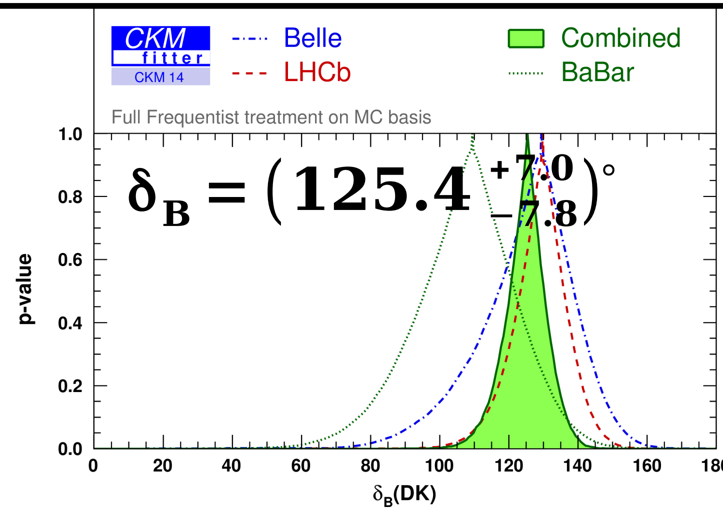


$$\gamma = (73.2\ ^{+6.3}_{-7.0})^{\circ}$$

(DK parameters)

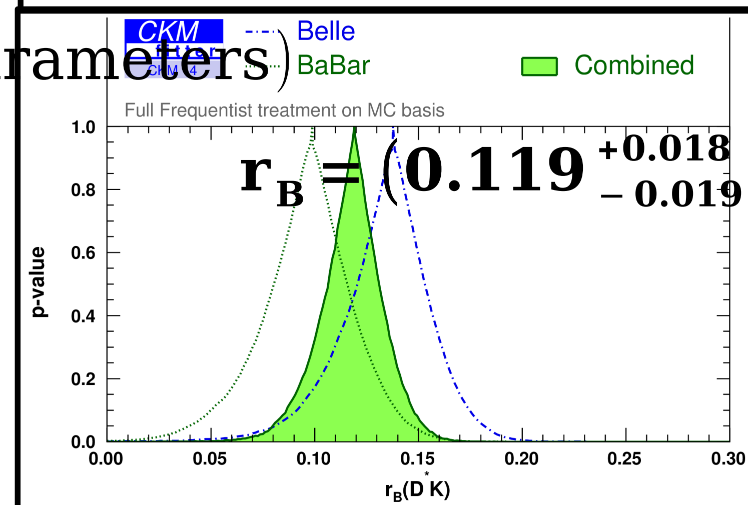


$$r_B = (0.0970\ ^{+0.0062}_{-0.0063})$$

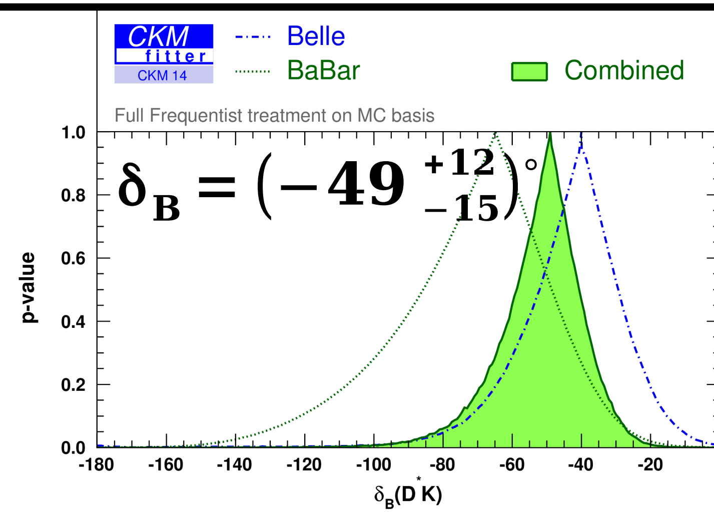


$$\delta_B = (125.4\ ^{+7.0}_{-7.8})^{\circ}$$

($D^* K$ parameters)



$$r_B = (0.119\ ^{+0.018}_{-0.019})$$



$$\delta_B = (-49\ ^{+12}_{-15})^{\circ}$$

Conclusion

- Combining GGSZ, GLW and ADS observables from charged and neutral B modes obtained by BaBar, Belle and LHCb experiments

$$\gamma = (73.2\ ^{+6.3}_{-7.0})^\circ$$ [CKM2014, preliminary]

γ [no direct γ measurements] $= (66.4\ ^{+1.3}_{-2.5})^\circ$ [CKMfitter, Moriond 2014]

- Next: include $D(K_S K\pi)K$ info (GLS method) from LHCb ?

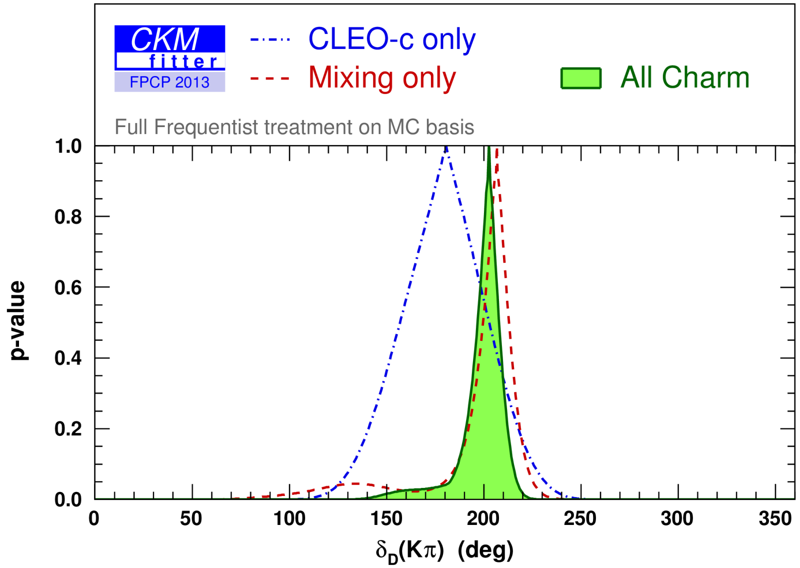
  $\Rightarrow$ include CLEO-c information on charm observables [arXiv:1203.3804]

- looking forward for additional/updated γ observables:

  - ADS/GLW observables with 3 fb^{-1} from LHCb
  - GGSZ observables from DK^{*0}
  - $(x^\pm, y^\pm)$ from $D(K_S\pi\pi)\pi$
  - ...

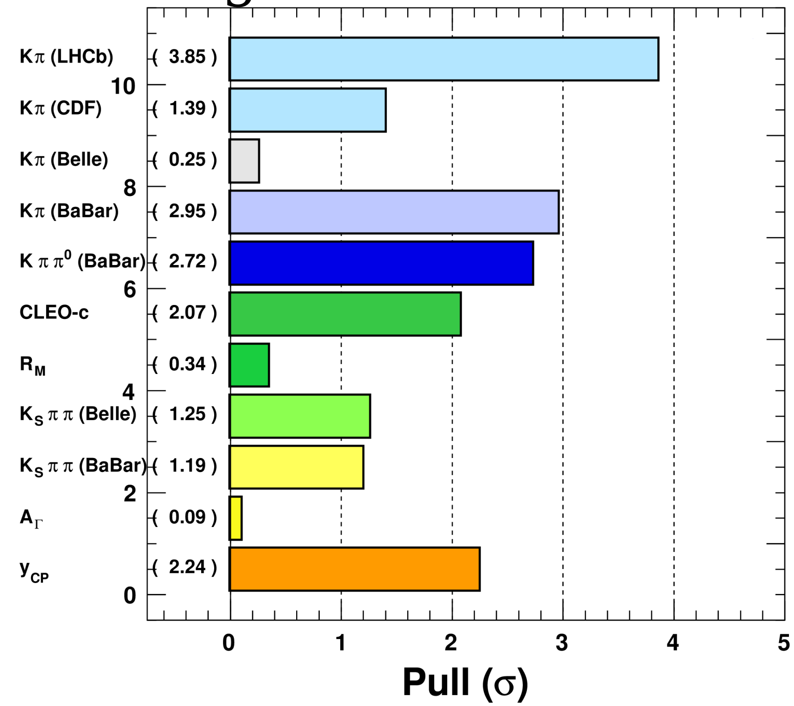
  and for charm observables:
  - from BES III
  - additional information on $K3\pi$ from LHCb and B-factories
  - ...

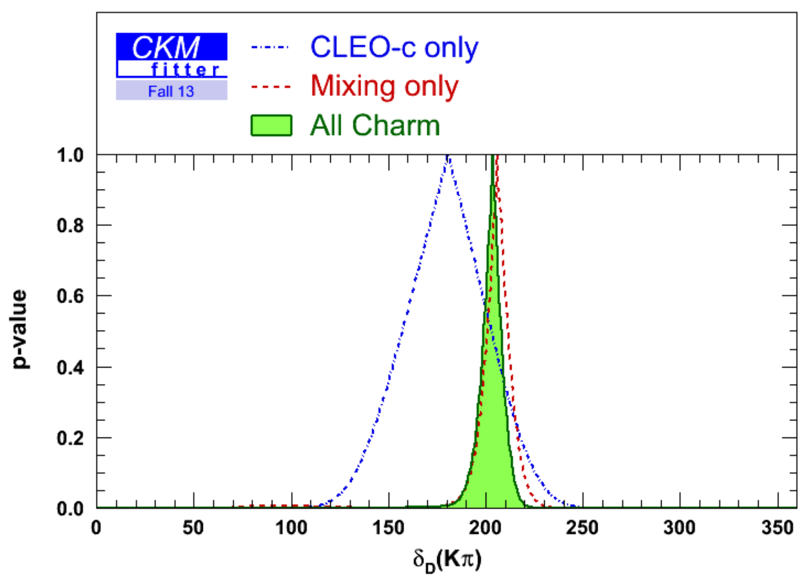
δ_D grand combination



$$\delta_D = \left(202.6^{+7.6}_{-8.9}\right)^\circ \quad \left({}^{+15}_{-20}\right) \quad \left({}^{+22}_{-64}\right)$$

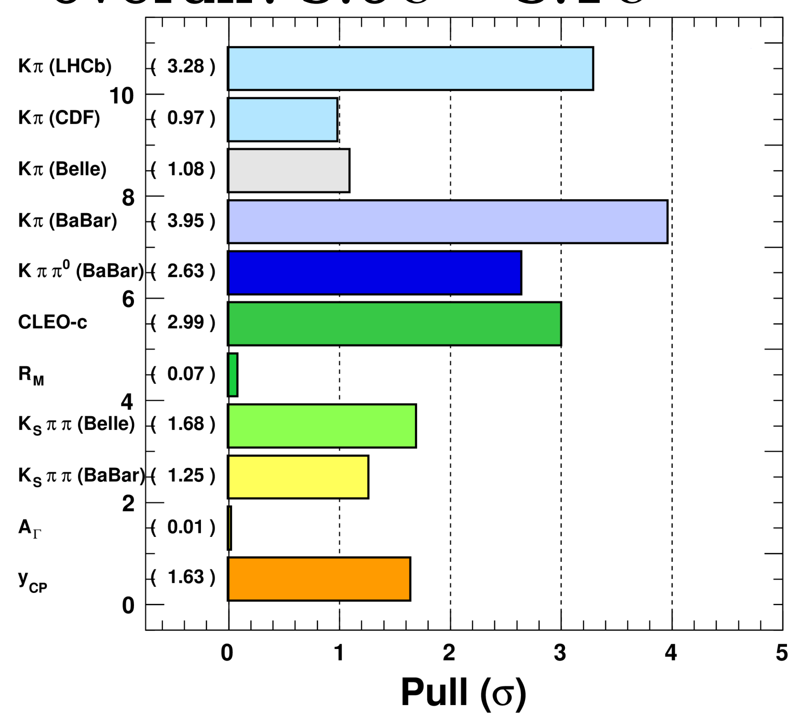
Not a great fit...





$$\delta_D = \left(203.4^{+6.4}_{-6.9}\right)^\circ \quad \left({}^{+13}_{-15}\right) \quad \left({}^{+20}_{-35}\right)$$

overall: $3.6\sigma \rightarrow 3.1\sigma$



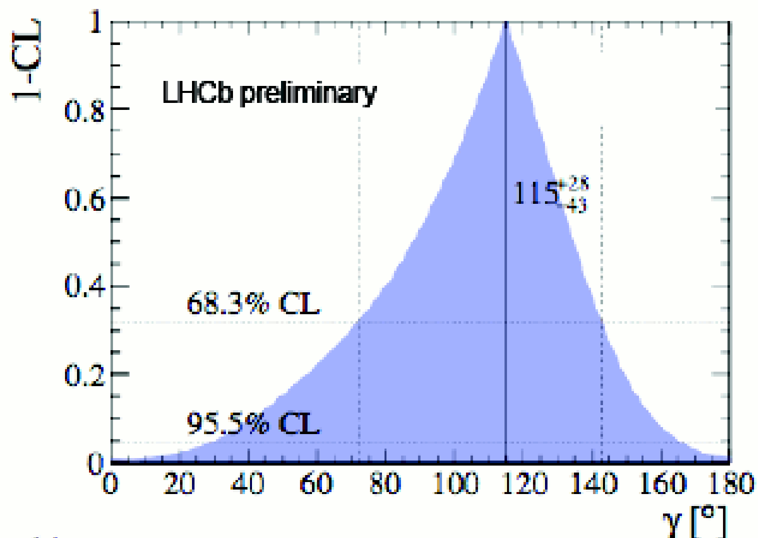
New LHCb results, $D_s K$ (only 1 fb^{-1})

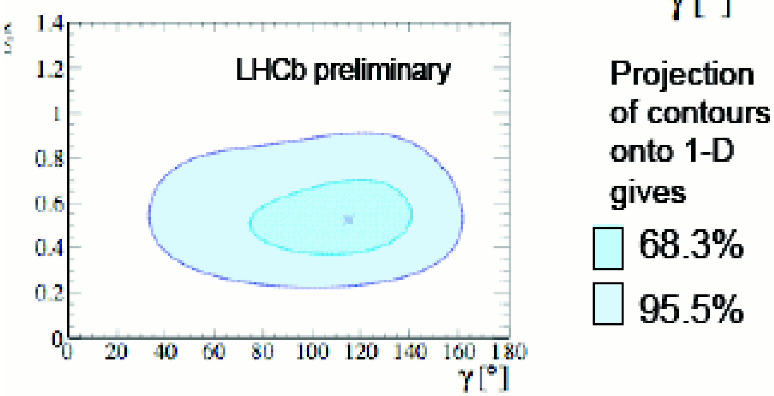
note: would expect a $r_B \approx 0.3$

$$\gamma = (115^{+28}_{-43})^\circ$$

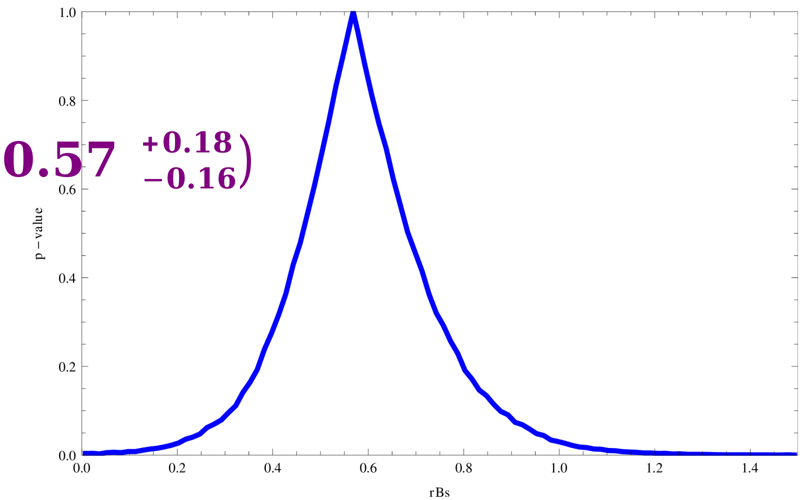
$$r_{D_sK} = (0.53^{+0.17}_{-0.16})$$

$$\delta_{D_sK} = (3^{+19}_{-20})^\circ$$

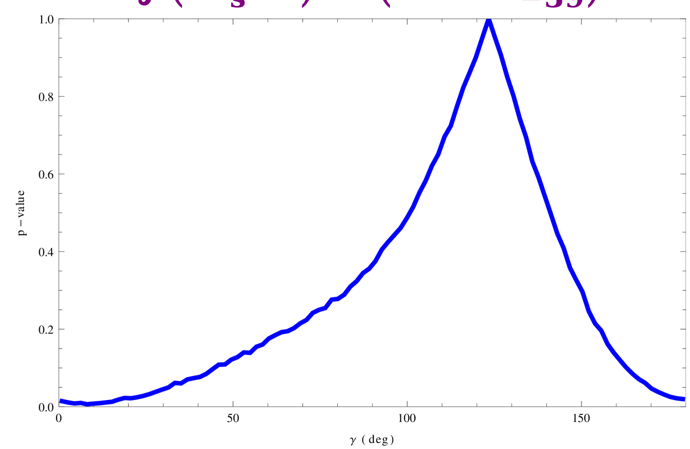




$r_B(D_s K) = (0.57 \; ^{+0.18}_{-0.16})$



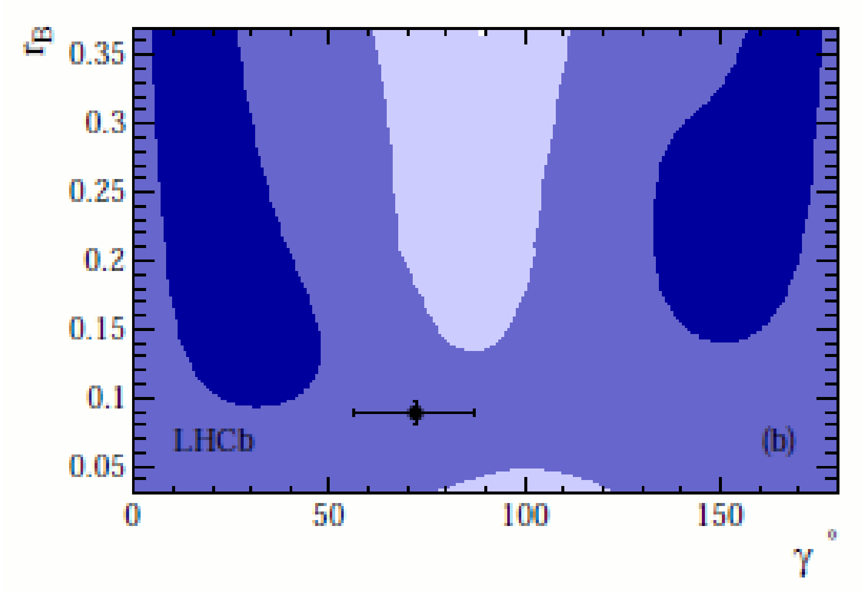
$\gamma(D_s K) = (123 \; ^{+26}_{-39})$

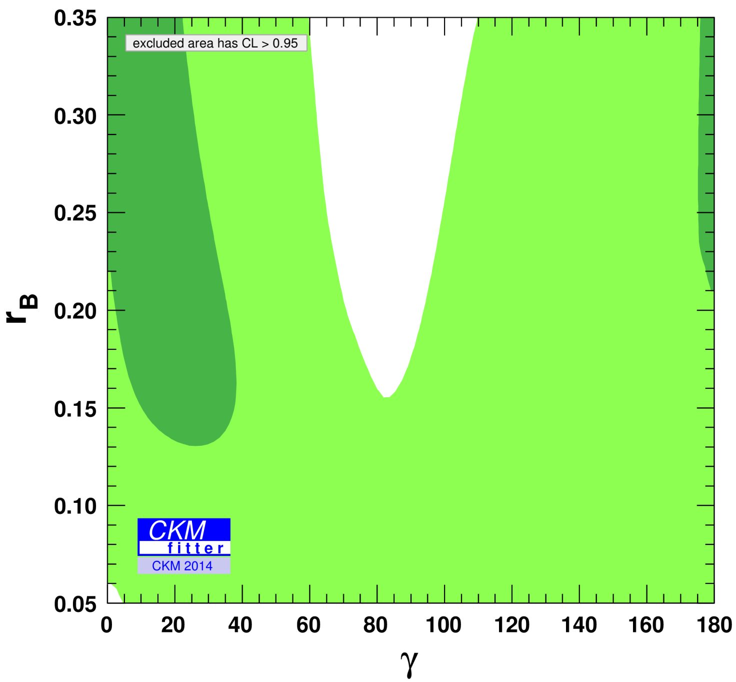


New LHCb results, DK, D→$K_S K\pi$

arXiv:1402.2982, 3 fb^{-1}

Observable	Whole Dalitz plot	$K^*(892)^{\pm}$ region
$\mathcal{R}_{SS/OS}$	$1.528 \pm 0.058 \pm 0.025$	$2.57 \pm 0.13 \pm 0.06$
$\mathcal{R}_{DK/D\pi,\,SS}$	$0.092 \pm 0.009 \pm 0.004$	$0.084 \pm 0.011 \pm 0.003$
$\mathcal{R}_{DK/D\pi,\,OS}$	$0.066 \pm 0.009 \pm 0.002$	$0.056 \pm 0.013 \pm 0.002$
$\mathcal{A}_{SS,\,DK}$	$0.040 \pm 0.091 \pm 0.018$	$0.026 \pm 0.109 \pm 0.029$
$\mathcal{A}_{OS,\,DK}$	$0.233 \pm 0.129 \pm 0.024$	$0.336 \pm 0.208 \pm 0.026$
$\mathcal{A}_{SS,\,D\pi}$	$-0.025 \pm 0.024 \pm 0.010$	$-0.012 \pm 0.028 \pm 0.010$
$\mathcal{A}_{OS,\,D\pi}$	$-0.052 \pm 0.029 \pm 0.017$	$-0.054 \pm 0.043 \pm 0.017$





not yet there...

(not using proper inputs for strong phases/coherence factor)

The r issue…

- was relevant for $B^{\pm} \to D^{(*)} K^{\pm}$, still is for $B^{\pm} \to D^{(*)} \pi^{\pm}$ (charged B)

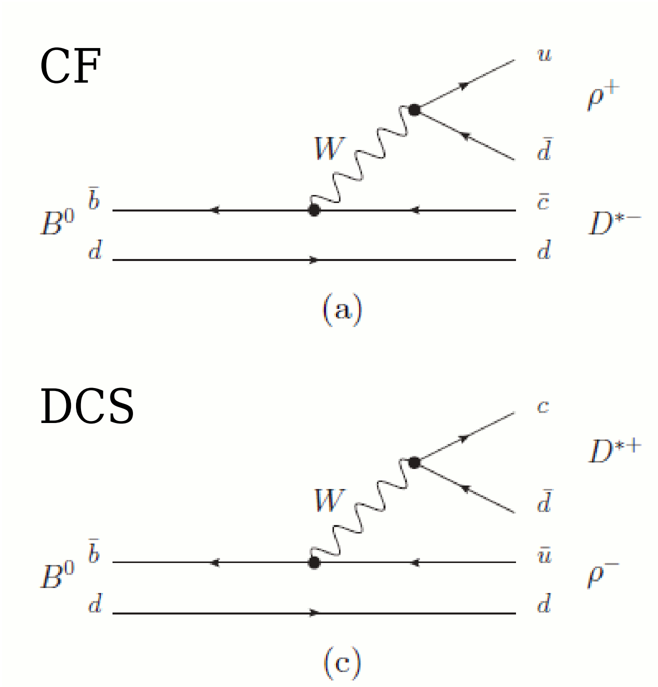
- remember $B \to D^{*\pm} \pi^{\mp}$, $D^{*\pm} \rho^{\mp}$?
  access $\sin 2\beta + \gamma$ with time-dep analysis

  done for $D^{*\pm} \pi^{\mp}$ by B-factories
  with external inputs ($BR(B \to D_s^{*} \pi)$) and SU(3)

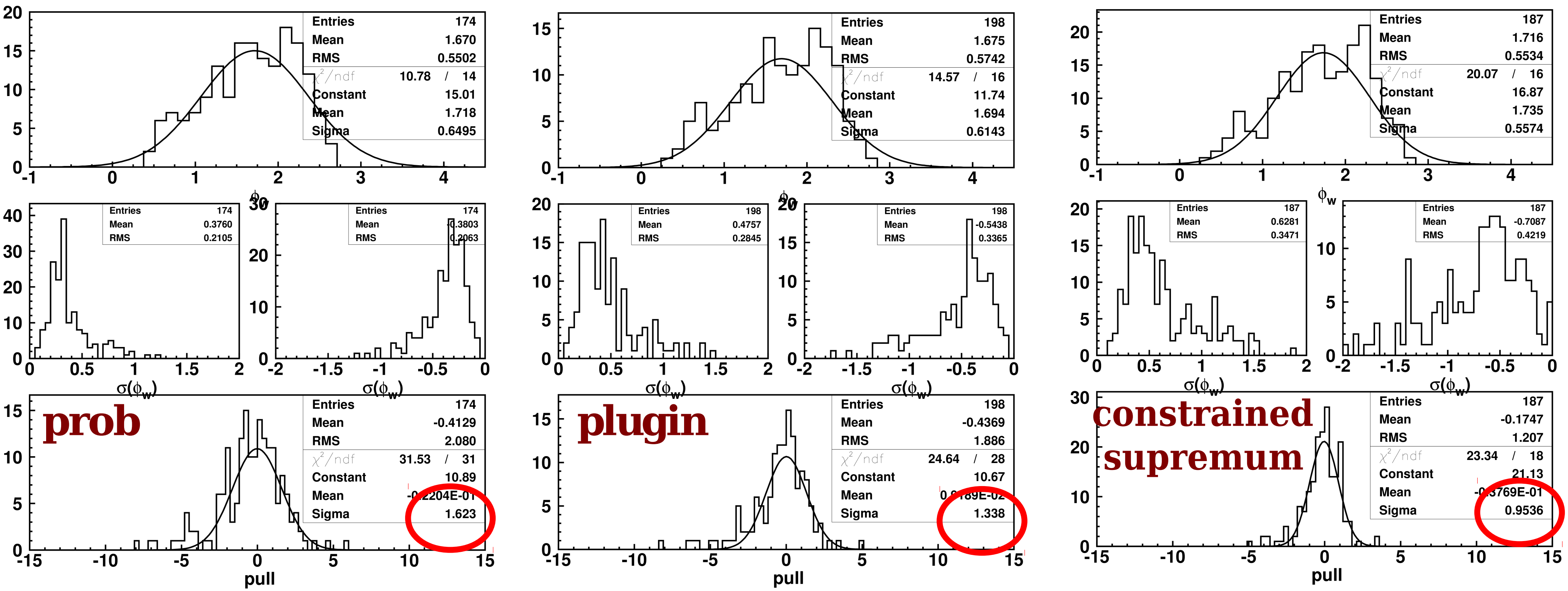
$$R_{D^{(*)}h} = \frac{|V_{cd}|}{|V_{cs}|} \frac{f_{D^{(*)}}}{f_{D_s^{(*)}}} \sqrt{\frac{\mathcal{B}(B^0 \to D_s^{(*)+} h^-)}{\mathcal{B}(B^0 \to D^{(*)-} h^+)}},$$

$$R_{D^*\pi} = (1.65 \pm 0.18 \pm 0.04)\%,$$

- could be done in $D^{*\pm} \rho^{\mp}$ and without external inputs ($B \to VV$)
  recently revisited the analysis, switched to cartesian coordinates:
  $\{\varphi_w, r_\lambda, \delta_\lambda\} \to \{x_\lambda, y_\lambda, \overline{x_\lambda}, \overline{y_\lambda}\}$
  on-going analysis at Belle (→ realistic toys)
  how to extract φ_w ?
  r is small… ~ 0.01 (DCS/CF)



$B \to D^{*\pm}\rho^{\mp}$



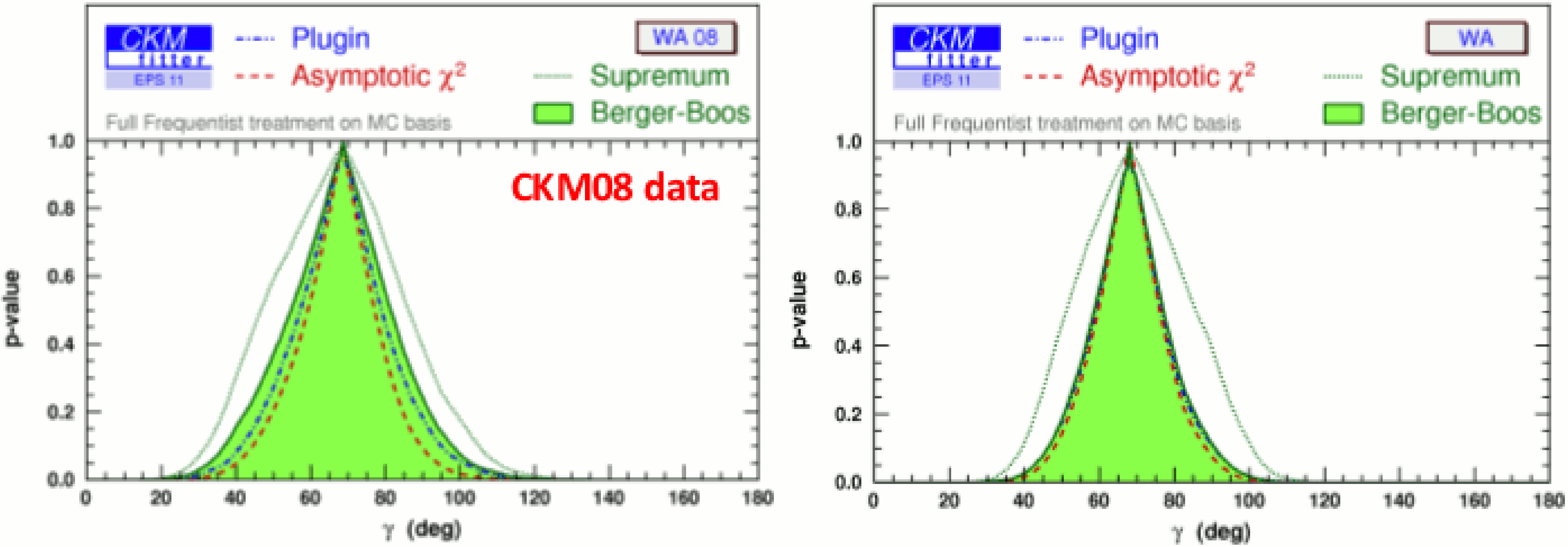
seems to work... will pursue the study (r's plots)

Gamma and the Berger-Boos *p* value

■ **The Berger-Boos, p_β, p-Value** [JASA 89, 427 (1994)] makes a more powerful use of the data than the supremum *p* value, p_{sup}, by providing **control over the nuisance parameters, θ**. It is a valid / conservative *p* value defined as: $p_\beta = \sup_{\theta \in C_\beta} p(\theta) + \beta$, where C_β is a level 1-β confidence set for the nuisance θ.

⇒ we use the **Likelihood** under the null hypothesis to infer the **confidence region C_β**.

■ The **very increased accuracy on γ not only** comes **from the new statistical treatment**, **but also from more accurate measurements**, which help constraining the nuisance, r_B. This is illustrated below by re-playing various stat. treatment with CKM08 data.



Experiment by experiment