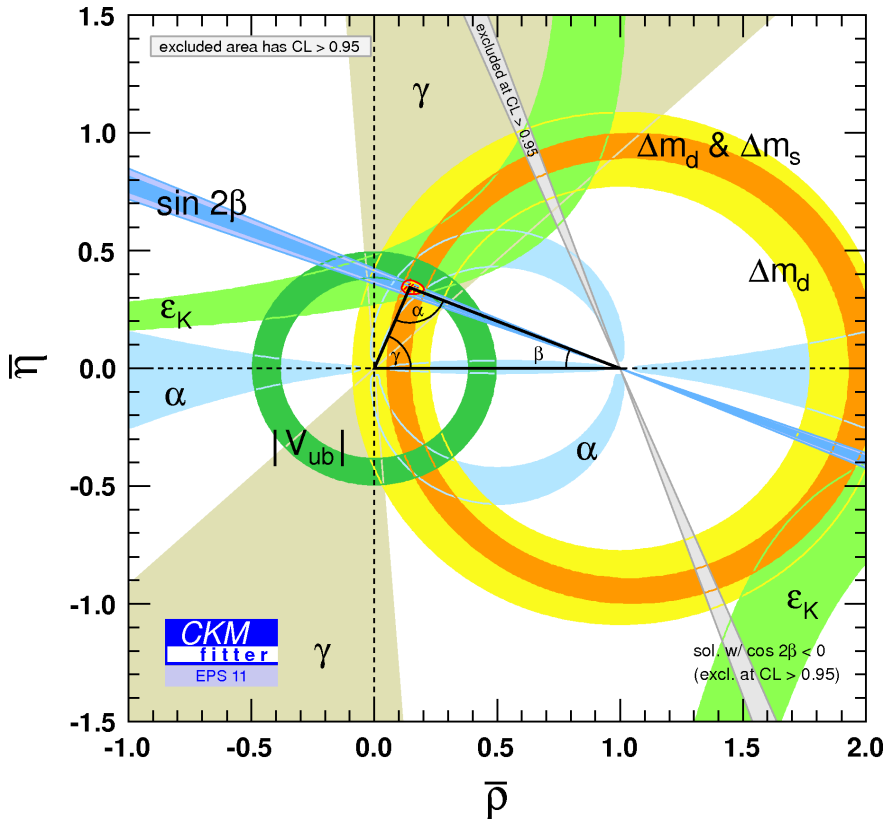
SM benchmarks

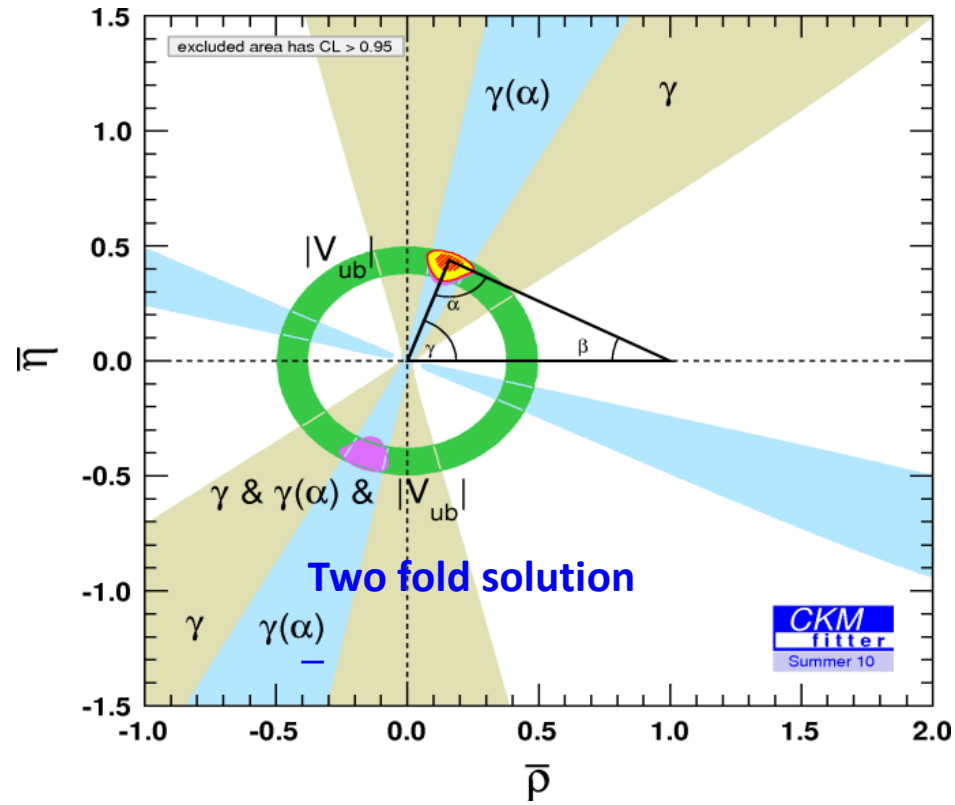
Jonas Rademacker (Univ of Bristol, LHCb)

ordnance survey standard benchmark

Scope of this talk

tree-level decays





contraints on the UT that are unaffected (or nearly so) by loop processes.

$|V_{ub}|$ and β now

β: Loop

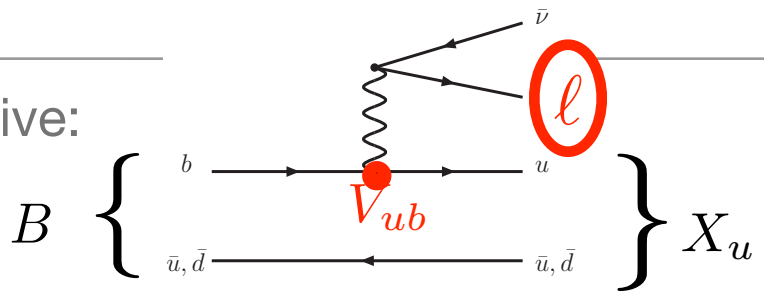
V_{ub}: Tree (+QCD)

β

$|V_{ub}|$

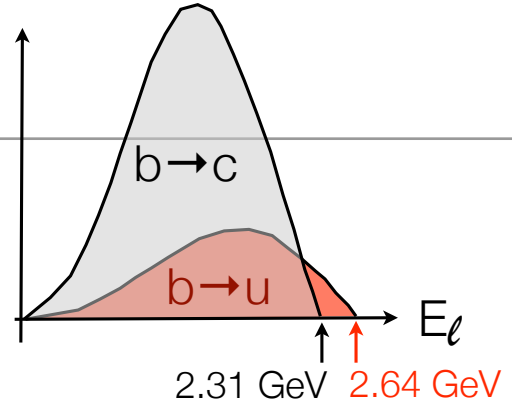
values from PDG 2010

- Inclusive:



$$|V_{ub}| = (4.27 \pm 0.15_{\rm exp} \pm 0.19_{\rm th} \pm 0.30_{\rm NNLO}) \times 10^{-3}$$

Theory required to predict signal shape

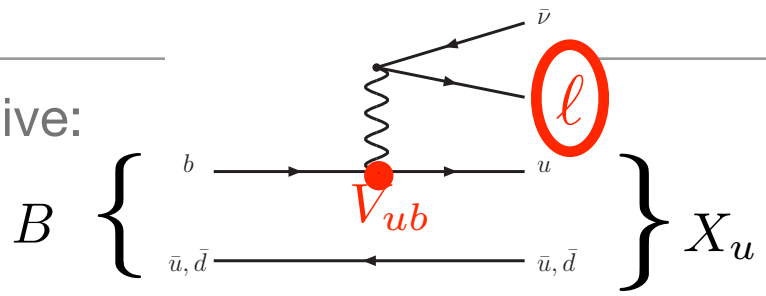


large (irreducible?) theory uncertainty

|Vub|

values from PDG 2010

- Inclusive:



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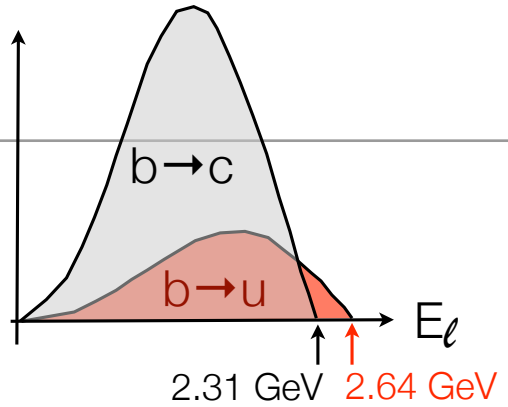

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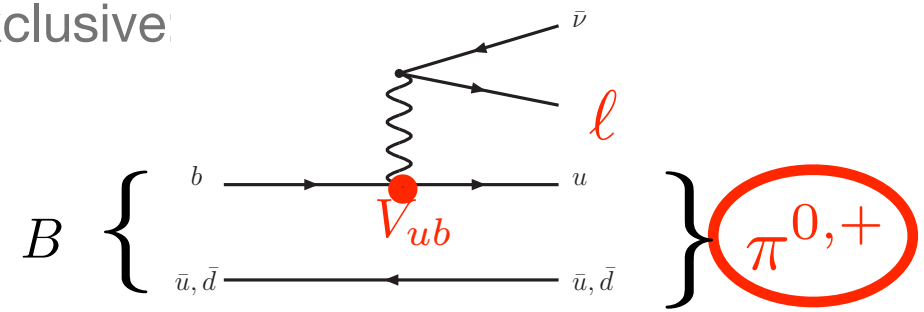


Theory to predict form factor.
Lattice QCD can do this, keeps improving.
Error LQCD-dominated.

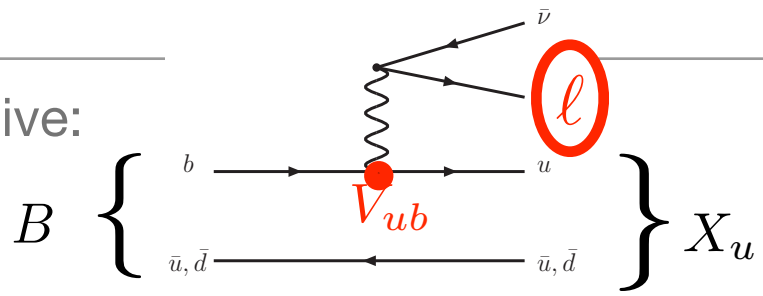
$$|V_{ub}| = (3.38 \pm 0.036) \cdot 10^{-3}$$

MILC: PhysRevD.79.054507 error equally divided between exp, lattice-stat, lattice syst

|Vub|

values from PDG 2010

- Inclusive:



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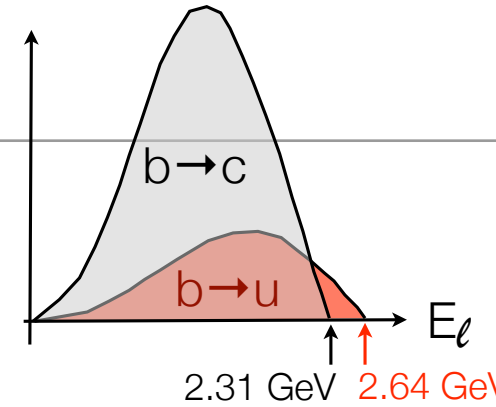

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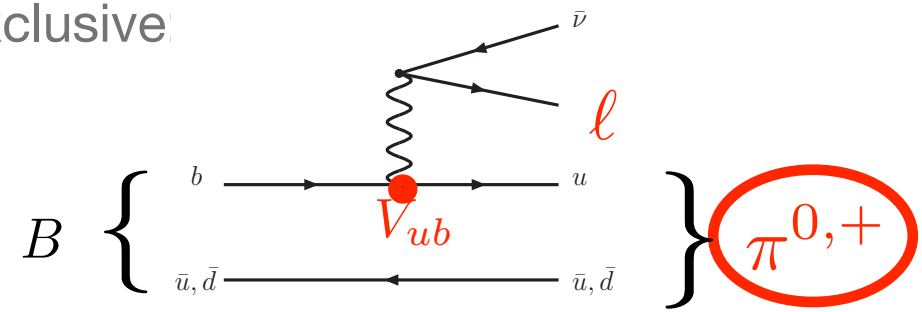

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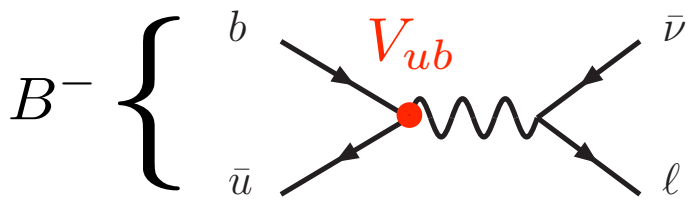
- Leptonic:



Theoretically cleanest: Decay constant (~probability that u,b meet inside B meson) from LQCD

$$|V_{ub}| = (5.2 \pm 0.5(\text{exp}) \pm 0.05(\text{theo})) \times 10^{-3}$$

$|V_{ub}|$

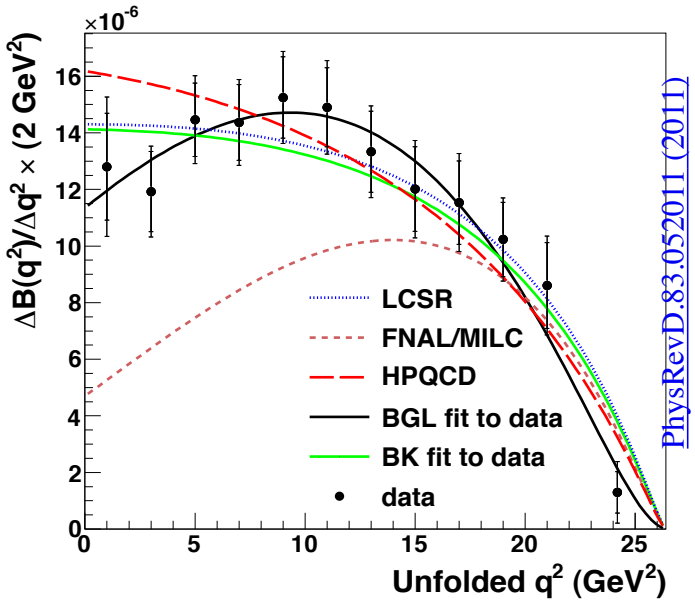
- In 2011, BaBar and BELLE published new |Vub|-exclusive measurements:

$$\text{BaBar:}\quad |V_{ub}| = \left(3.09 \pm 0.08 \pm 0.12^{+0.35}_{-0.29}\right) \cdot 10^{-3}$$

PhysRevD.83.052011 (2011) PhysRevD.83.032007 (2011)

$$\text{BELLE:}\quad |V_{ub}| = (3.43 \pm 0.33) \cdot 10^{-3}$$

PhysRevD.83.071101 (2011)



- Compare incl/exclusive determination:

$$\text{My average:}\quad |V_{ub}|\,(\text{excl}) = (3.26 \pm 0.33) \cdot 10^{-3}$$

$$\text{PDG 2010:}\quad |V_{ub}|\,(\text{incl}) = (4.27 \pm 0.38) \cdot 10^{-3}$$

(a similar tension in the incl/ excl determination of $|V_{cb}|$)

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A disturbed benchmark.

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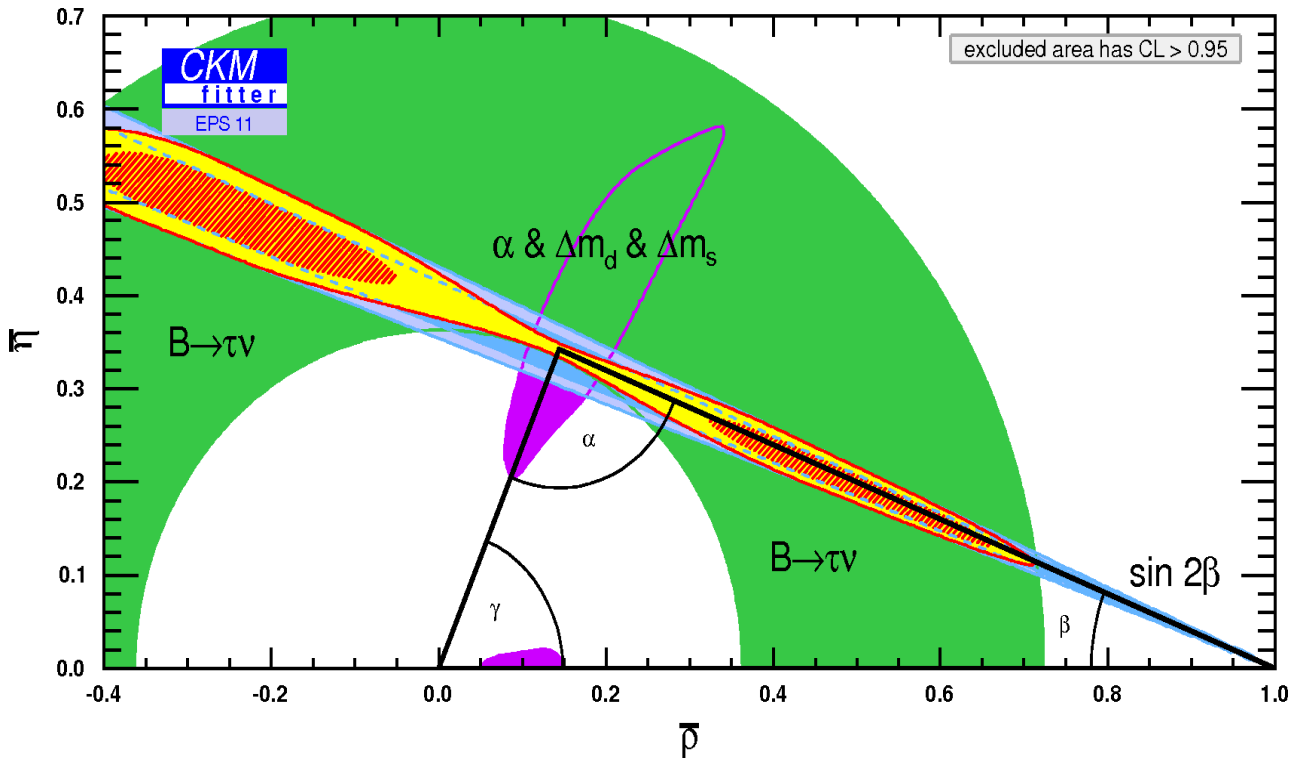
A disturbed benchmark.

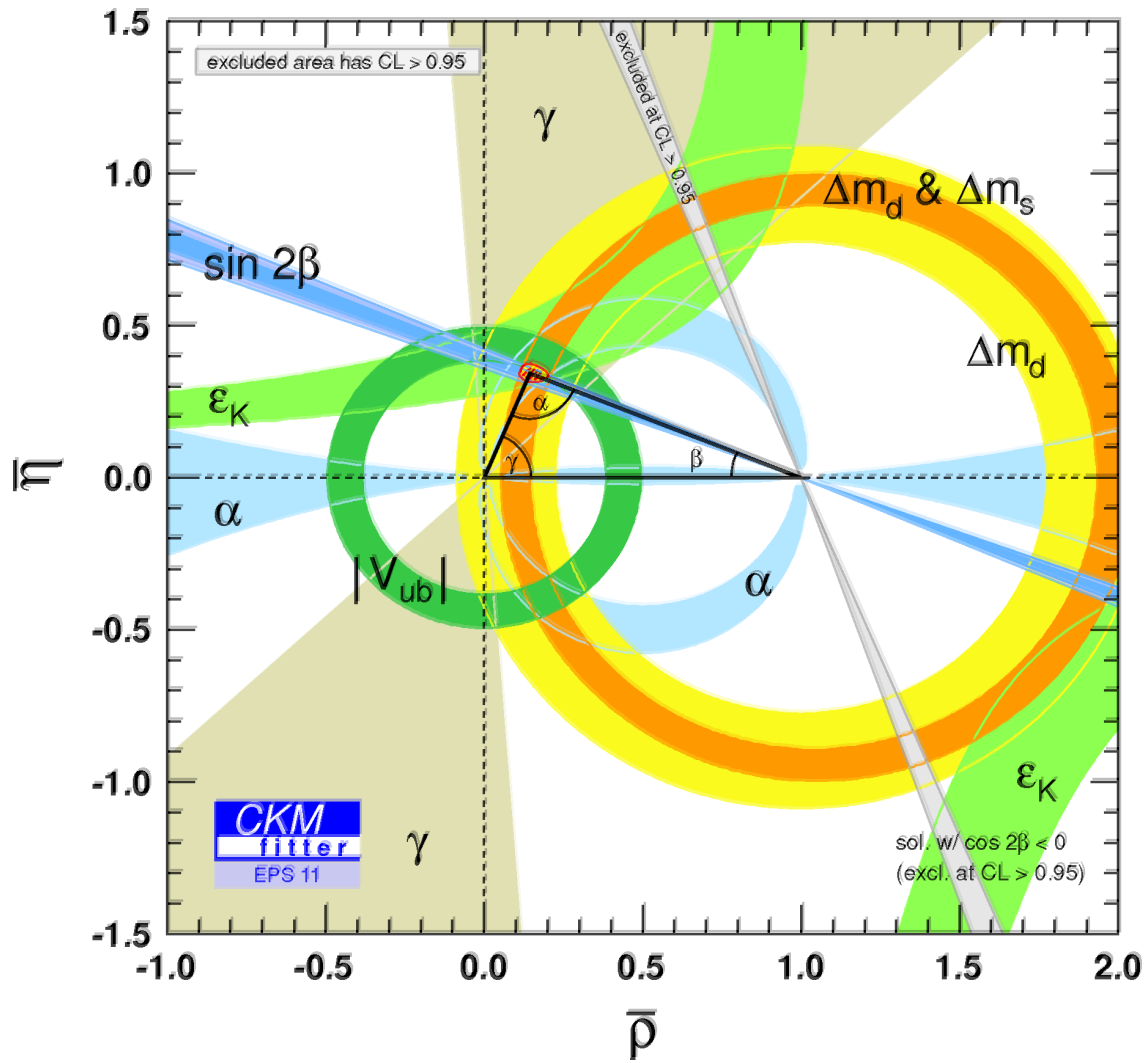
Should we arrest the theorists?

Tension between B→τν and sin 2β

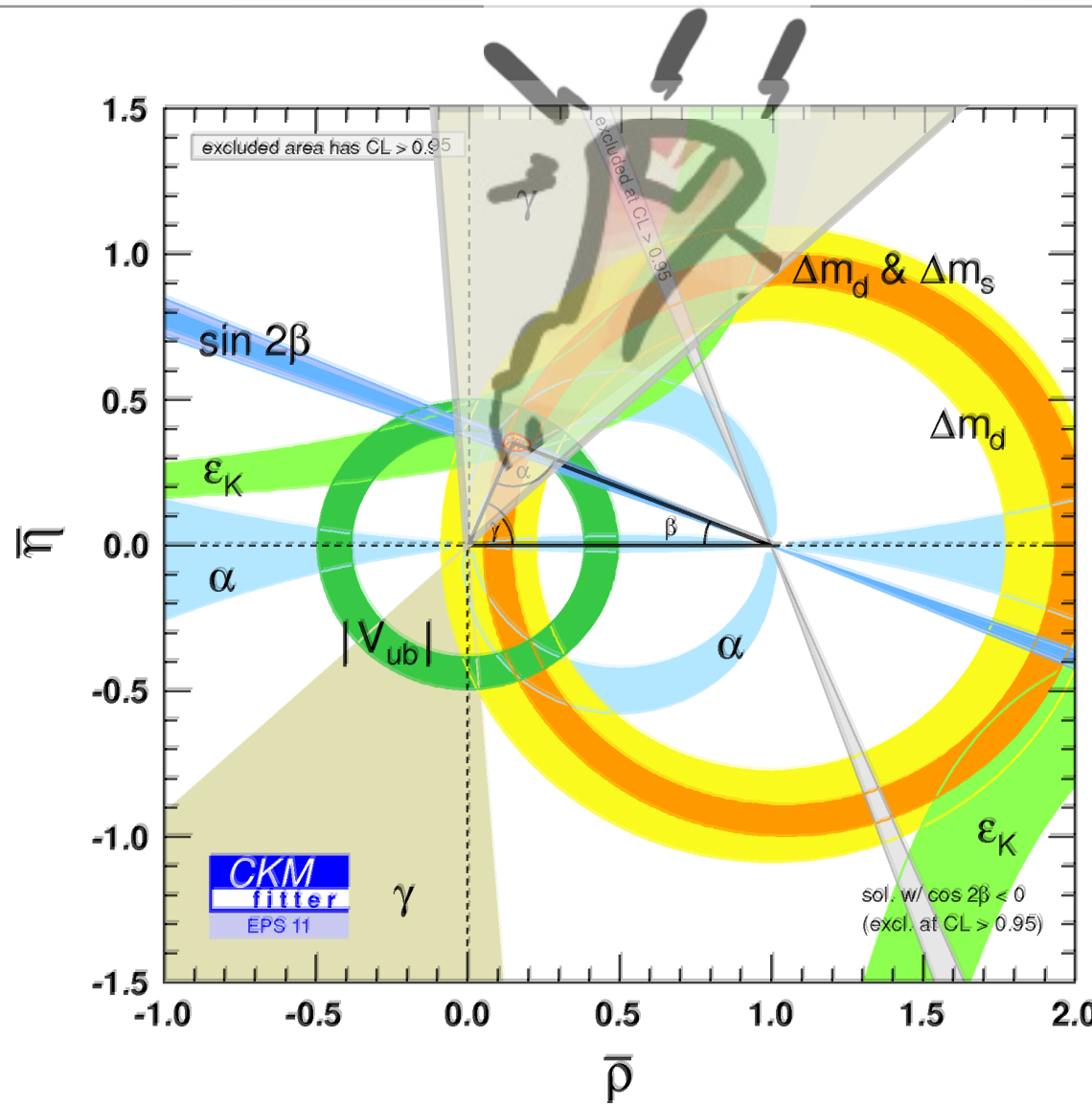


Yellow area: 95% CL for combined fit with $\sin(2\beta_{cc})$ and BR[B → τν]. The orange dashed area indicates the 1 σ confidence level.

γ


excluded area has CL > 0.95
excluded at CL > 0.95
γ
Δm_d & Δm_s
sin 2β
Δm_d
ε_K
α
β
γ
α
|V_ub|
α
ε_K
CKM fitter
EPS 11
γ
sol. w/ cos 2β < 0
(excl. at CL > 0.95)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
η̄
ρ̄

γ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γ
Δm_d & Δm_s
sin 2β
Δm_d
ε_K
α
β
γ
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EPS 11
γ
sol. w/ cos 2β < 0
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1.5
1.0
0.5
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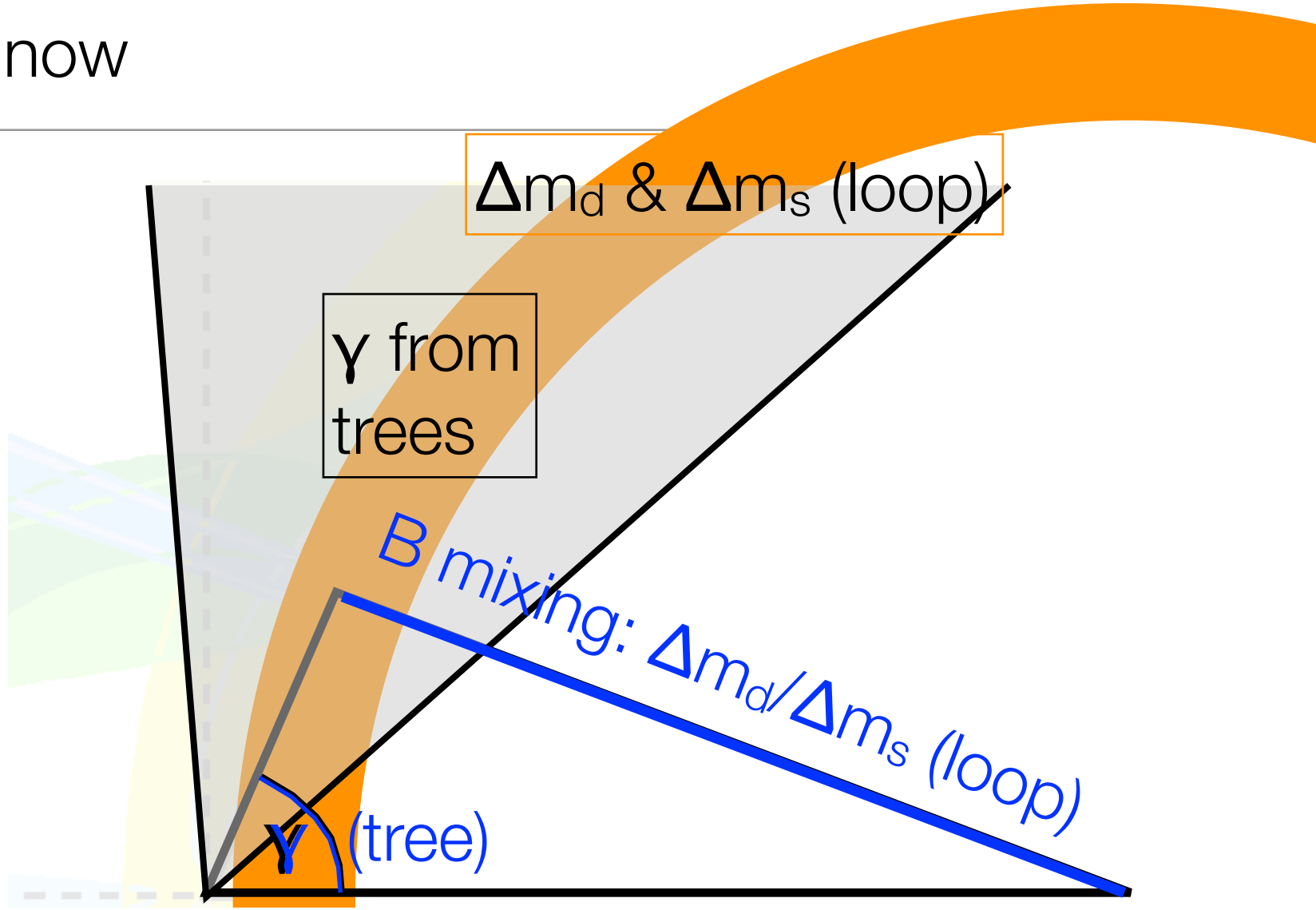
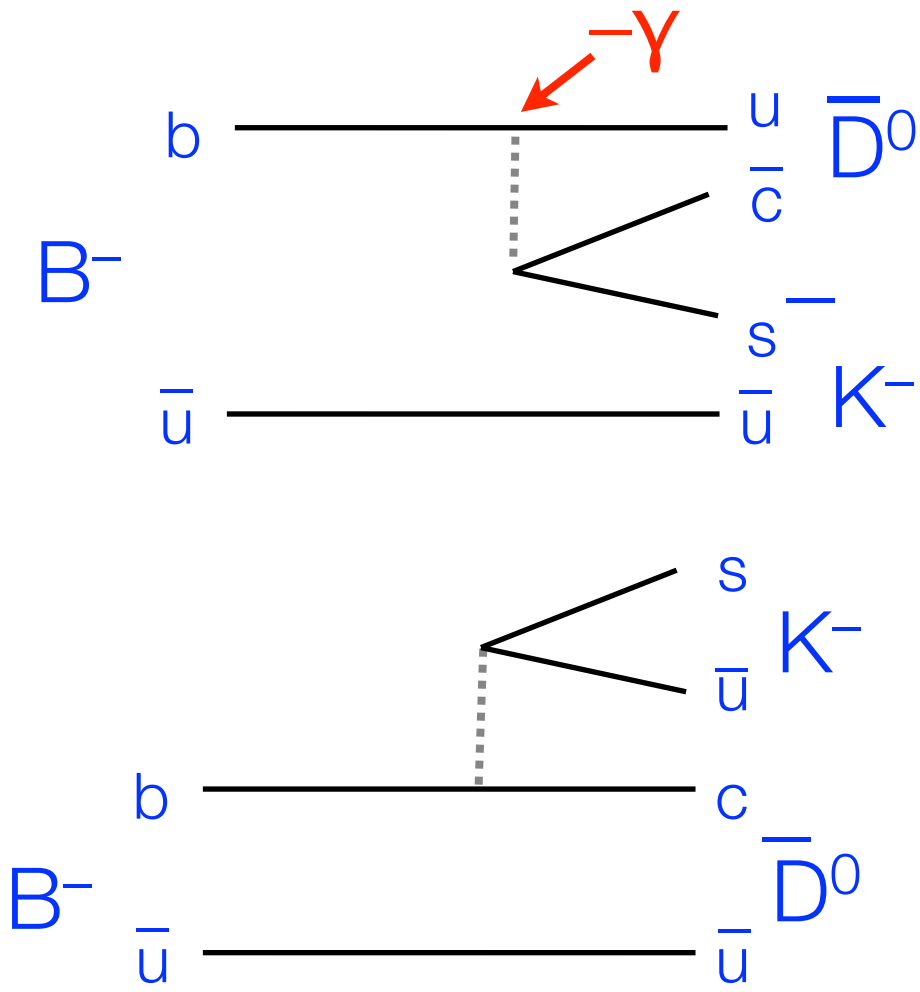
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
η̄
ρ̄

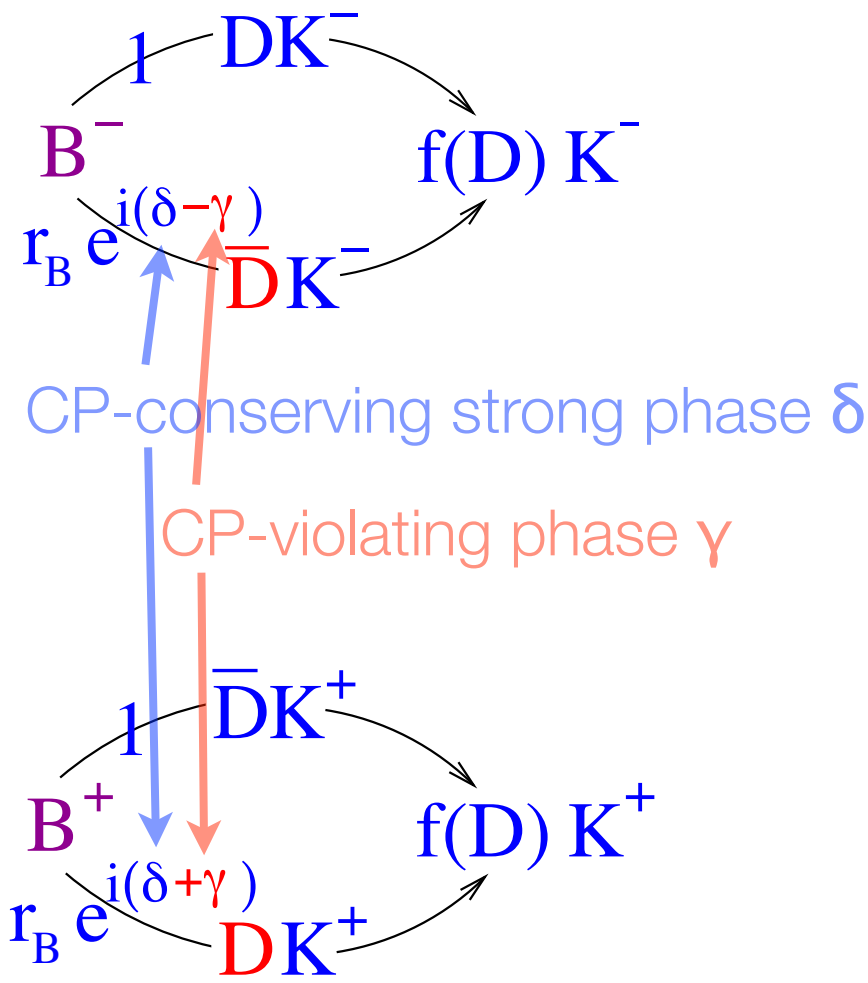
γ and Δm now



Currently: γ(direct) =68° ± 13°, dominant error: statistics
γ(from side) = 68° ± 4°, dominant error: Lattice QCD

$B^{\pm} \to DK^{\pm}$





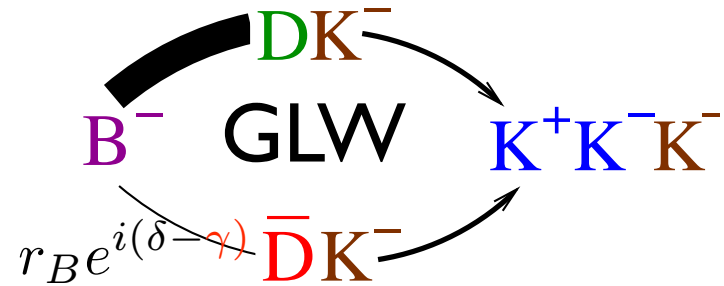
Gronau, Wyler Phys.Lett.B265:172-176,1991, (GLW), Gronau, London Phys.Lett.B253:483-488,1991 (GLW) Atwood, Dunietz and Soni Phys.Rev.Lett. 78 (1997) 3257-3260 (ADS) Giri, Grossman, Soffer and Zupan Phys.Rev. D68 (2003) 054018 Belle Collaboration Phys.Rev. D70 (2004) 072003

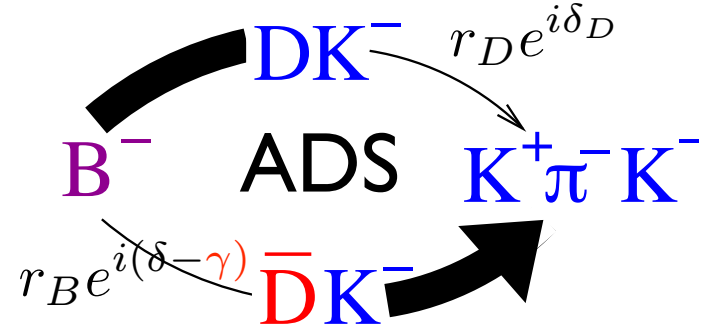
$B^{\pm} \to D(\text{2-body})K^{\pm}$

- CP-violating rate asymmetry

$$
\begin{aligned}
A &= \frac{\Gamma(B^- \to f_D K^-) - \Gamma\left(B^+ \to \overline{f}_D K^+\right)}{\Gamma(B^- \to f_D K^-) + \Gamma\left(B^+ \to \overline{f}_D K^+\right)} \\
&= 2 r_D r_B \, \sin(\gamma) \, \cos(\delta_B + \delta_D) \, / \, R
\end{aligned}
$$

where, for GLW, $R \equiv 1$, $r_D \equiv 1$ and $\delta_D \equiv 0$. $R < 1$ for ADS.





- Counting experiment. All parameters can be extracted by simultaneously analysing several decay channels (although external CLEO-c input on δ_D helps).

Gronau, Wyler Phys.Lett.B265:172-176,1991, (GLW),
Gronau, London Phys.Lett.B253:483-488,1991 (GLW)
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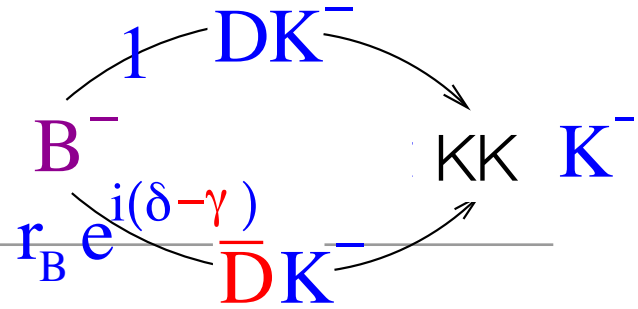
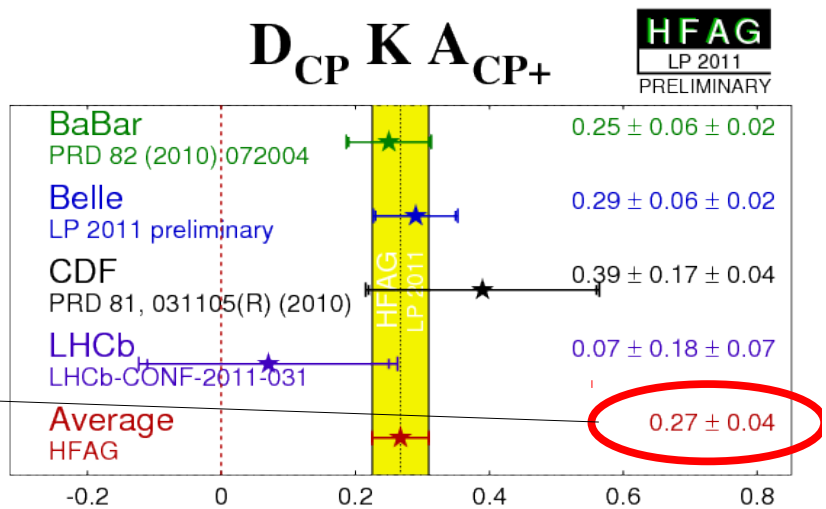
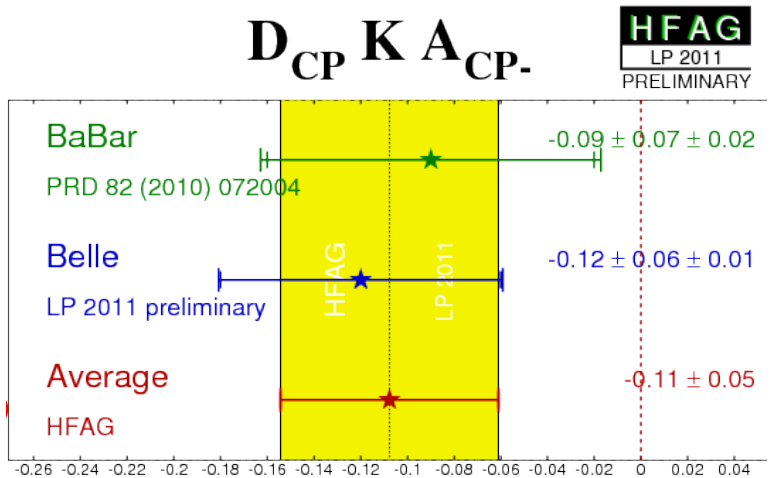
“GLW” - D decays to CP eigenstate

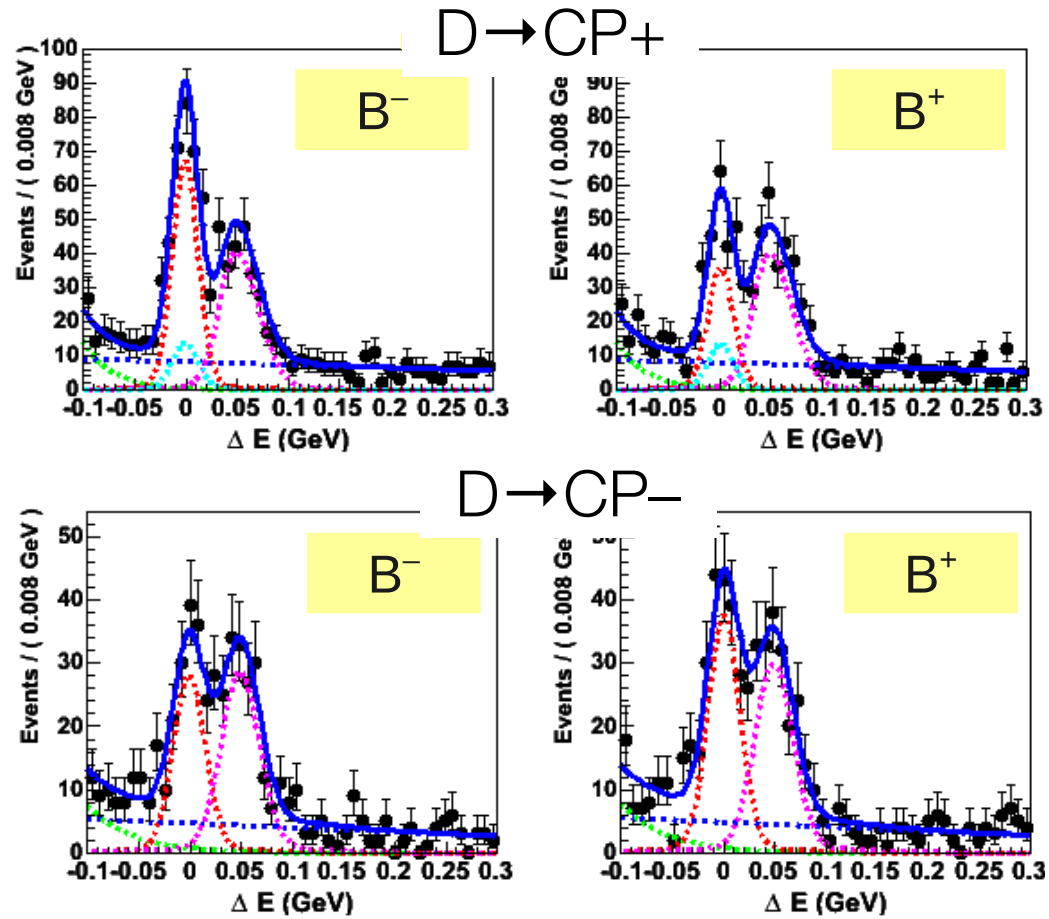


clear evidence for CPV in CP+





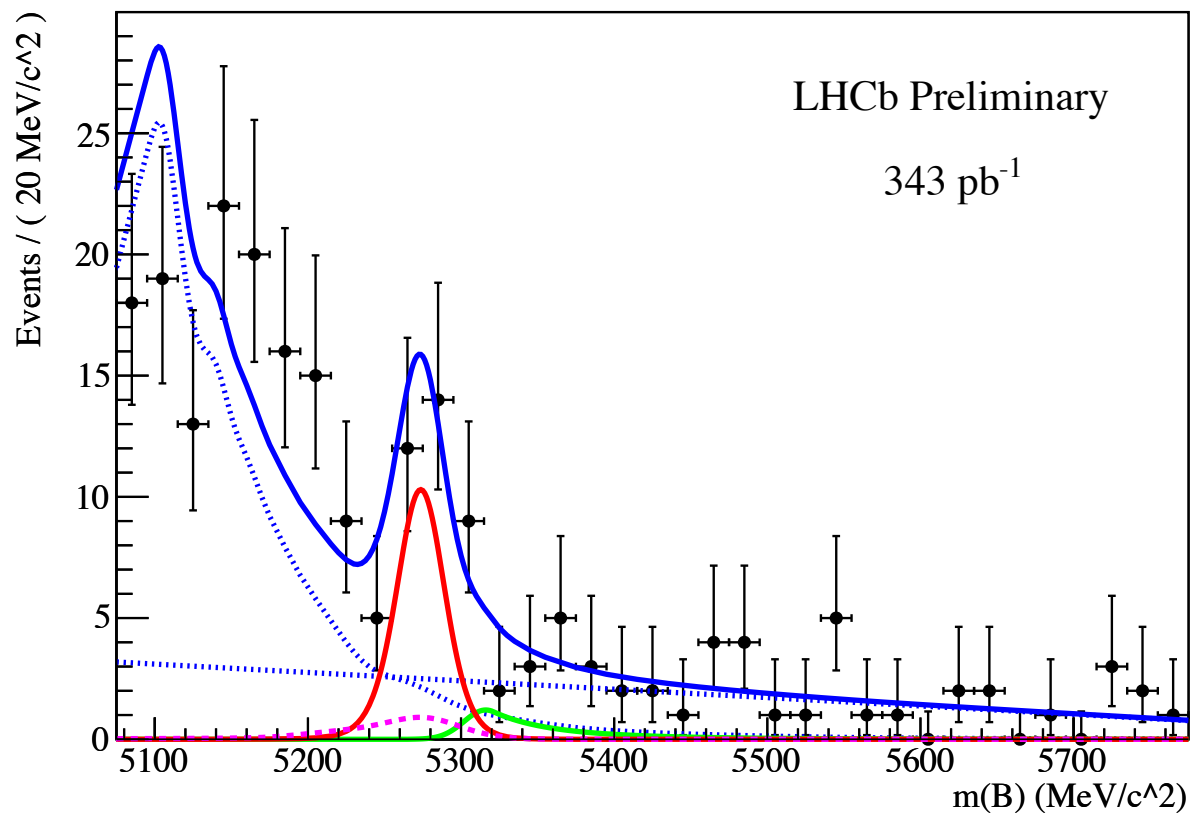
New BELLE result presented at Lepton-Photon 2011 (BELLE-CONF-1112)



ADS with $B^{\pm} \to D(K\pi)K^{\pm}$ at LHCb

- Significant signal (4σ) for suppressed mode in 343/pb.
- Data-driven methods reduce systematics:
  - production and detection asymmetries from data
  - PID efficiencies from data
  - Use $B^{\pm} \to D(K\pi)\pi^{\pm}$ as normalisation mode.

$$B^- \to (K^+\pi^-)_D K^- + cc$$



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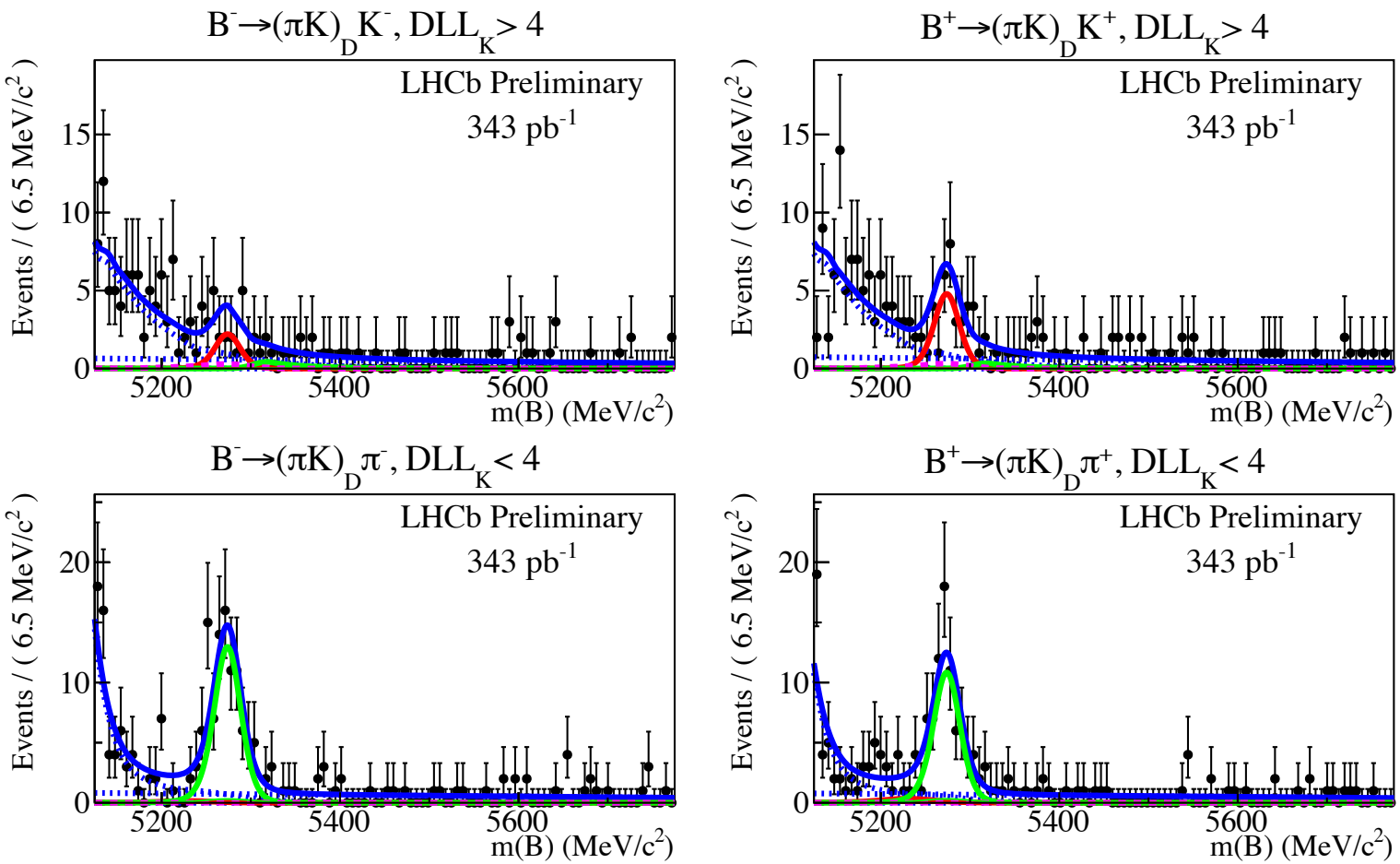
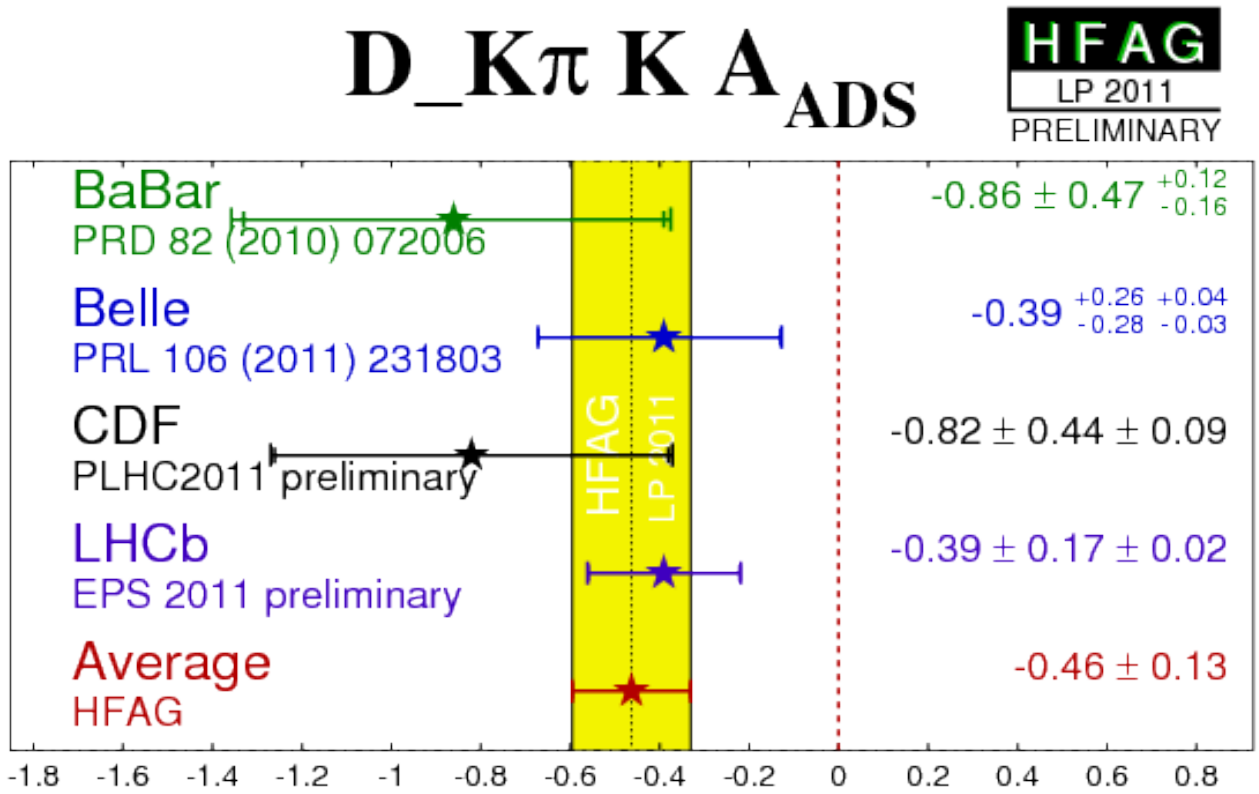
$B^{\pm} \to D(K\pi)K^{\pm}$ signal.

$B^{\pm} \to D(K\pi)\pi^{\pm}$ reference mode



$B^{\pm} \to D(K\pi)K^{\pm}$ summary

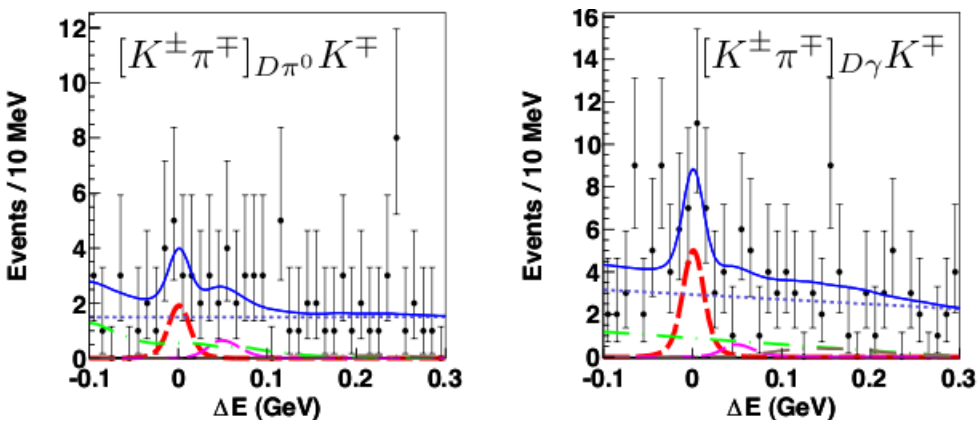


huge CP-violation asymmetry of ~50%

ADS from B→D*K

New results at Lepton Photon. BELLE-CONF-1112

- D* goes to either Dπ° or Dγ. The two modes are related by a 180° phase shift, thus providing additional phase information.

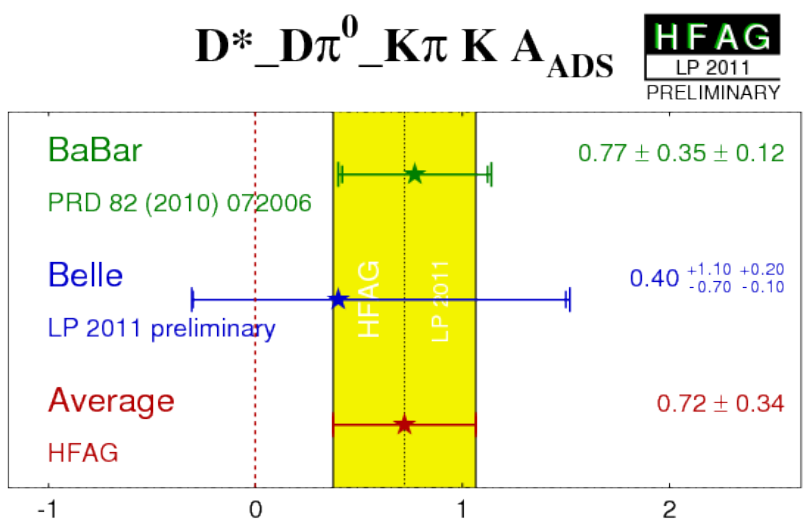


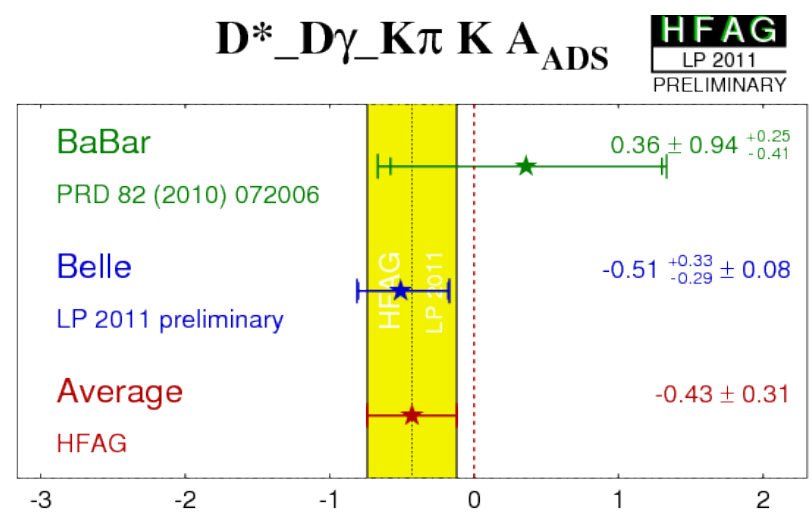
Phase-relation helps resolve ambiguities. Current results indicate negative

$\cos(\delta_B^* + \delta_D)\cos\gamma$

and positive

$\sin(\delta_B^* + \delta_D)\cos\gamma$





Dalitz analyses to extract γ

Most precise gamma measurements to date come from 3-body decays.

$\mathrm{D}^0 \longrightarrow$

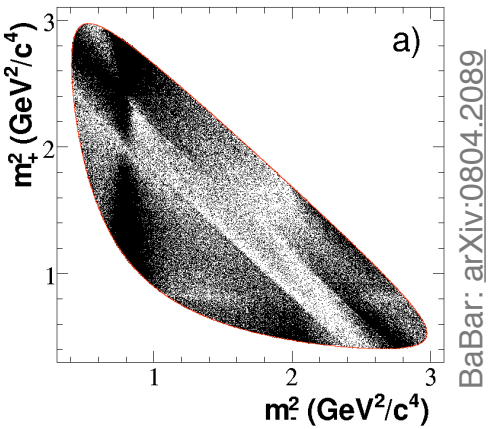
Intermediate state	Amplitude $\lvert c_j \rvert$	Phase δ_j (°)
$K^*(892)^+\pi^-$	1.656 ± 0.012	137.6 ± 0.6
$K^*(892)^-\pi^+$	$(14.9 \pm 0.7) \times 10^{-2}$	325.2 ± 2.2
$K_0^*(1430)^+\pi^-$	1.96 ± 0.04	357.3 ± 1.5
$K_0^*(1430)^-\pi^+$	0.30 ± 0.05	128 ± 8
$K_2^*(1430)^+\pi^-$	1.32 ± 0.03	313.5 ± 1.8
$K_2^*(1430)^-\pi^+$	0.21 ± 0.03	281 ± 9
$K^*(1680)^+\pi^-$	2.56 ± 0.22	70 ± 6
$K^*(1680)^-\pi^+$	1.02 ± 0.2	103 ± 11
$K_S\rho^0$	1.0 (fixed)	0 (fixed)
$K_S\omega$	$(33.0 \pm 1.3) \times 10^{-3}$	114.3 ± 2.3
$K_S f_0(980)$	0.405 ± 0.008	212.9 ± 2.3
$K_S f_0(1370)$	0.82 ± 0.10	308 ± 8
$K_S f_2(1270)$	1.35 ± 0.06	352 ± 3
$K_S\sigma_1$	1.66 ± 0.11	218 ± 4
$K_S\sigma_2$	0.31 ± 0.05	236 ± 11
non-resonant	6.1 ± 0.3	146 ± 3

$\longrightarrow \mathrm{K_s}\pi\pi$

Similarly, $D \rightarrow K_S KK$

Dalitz Plots for γ at Belle&BaBar

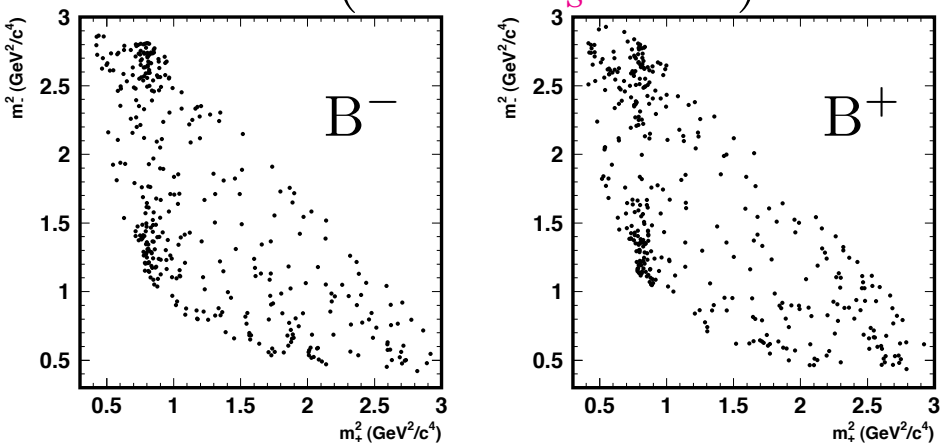
$D^0 \to K_s\pi^+\pi^-$



BaBar: arXiv:0804.2089

+ $D_{flavour}$ amplitude model +

$B^\pm \to (D^0 \to K_s\pi^+\pi^-)K^\pm$



BELLE: arXiv:0803.3375v1 [hep-ex]

Combined result (CKM-fitter, EPS 2011*): $\gamma = 68^\circ \pm 13^\circ$

*includes pre-LHCb ADS/GLW constraints, but result is completely dominated by $K_S\pi\pi$ and K_SKK Dalitz plot results)

Model required to interpret measured D-Dalitz plot in terms of complex amplitudes (magnitudes and phases)

Model dependence introduces uncertainty between 3°–9°. Would eventually limit LHCb's precision.

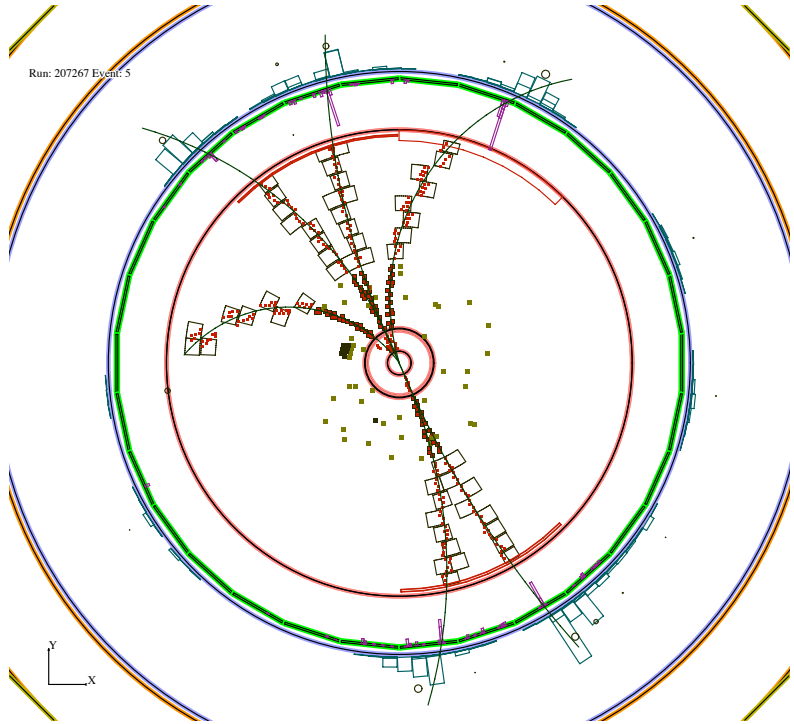
BaBar: Phys.Rev.D78:034023,2008, BELLE: arXiv:0803.3375v1 [hep-ex]
CKMfitter: Eur. Phys. J. C41, 1-131 (2005) [hep-ph/0406184], http://ckmfitter.in2p3.fr

CLEO-c and BES III

$e^+e^- \rightarrow \psi(3770) \rightarrow D\overline{D}$

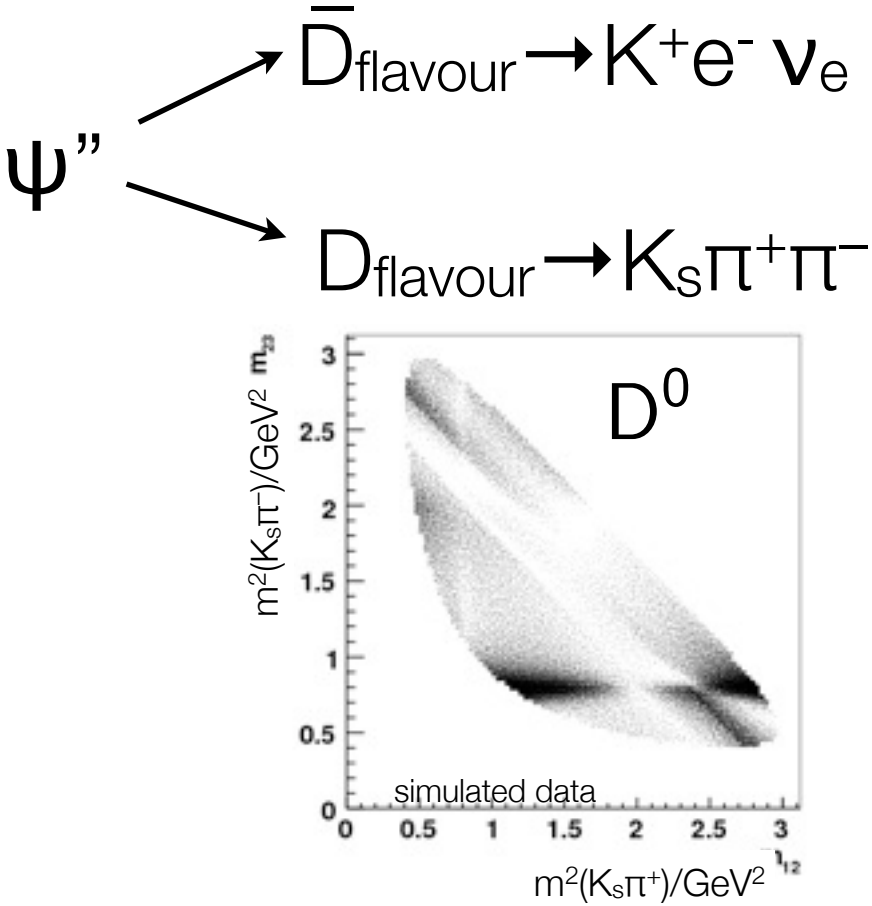
- Threshold production of correlated DD.
- Final state must be CP-even with L=1: D mesons must have opposite CP.
- Final state is also flavour-neutral.
- That gives us access to both amplitude and phase across the Dalitz plot.

CLEAN-c

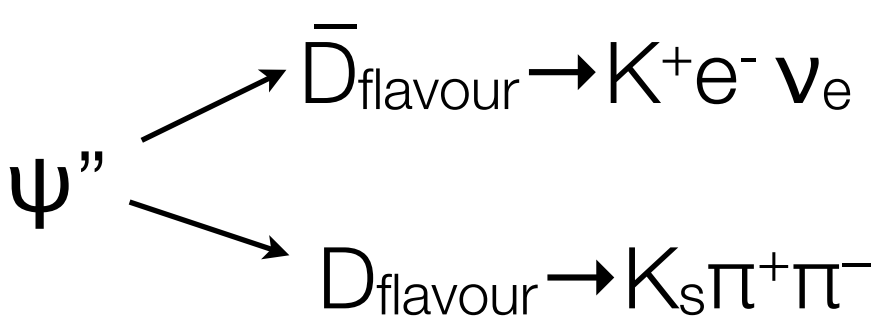


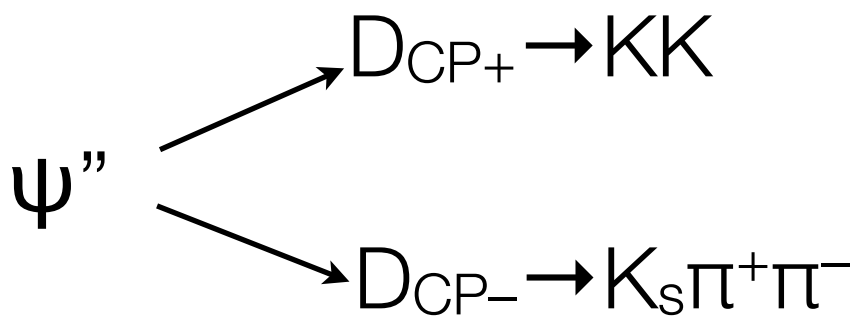
$$\psi(3770) \rightarrow D^0(K_S\pi^+\pi^-)\bar{D}^0(K^+\pi^-)$$

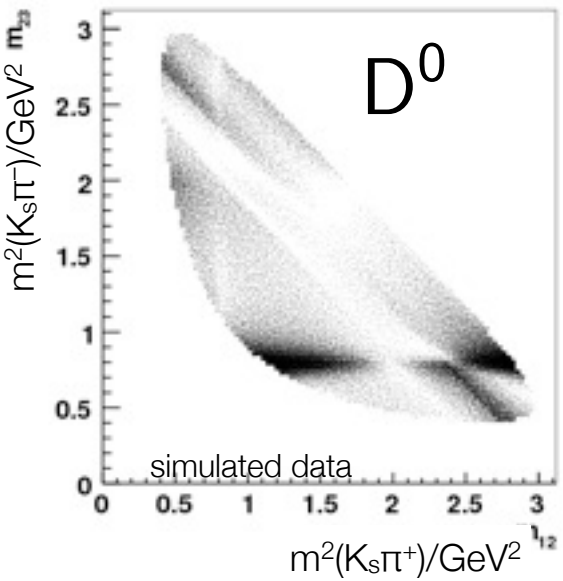
CP and flavour tagged D°

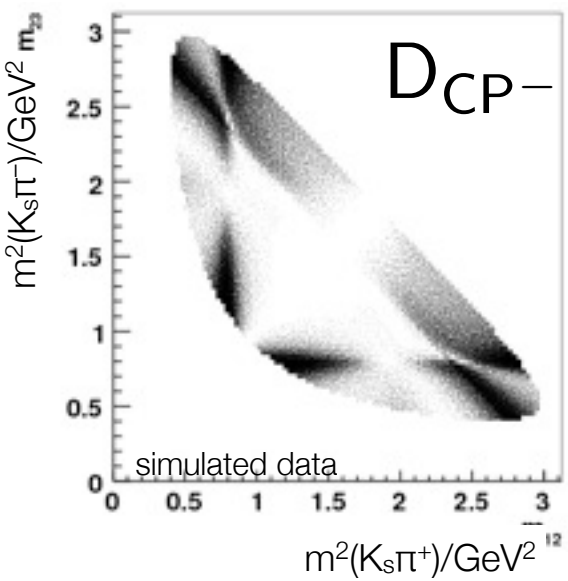


CP and flavour tagged D°

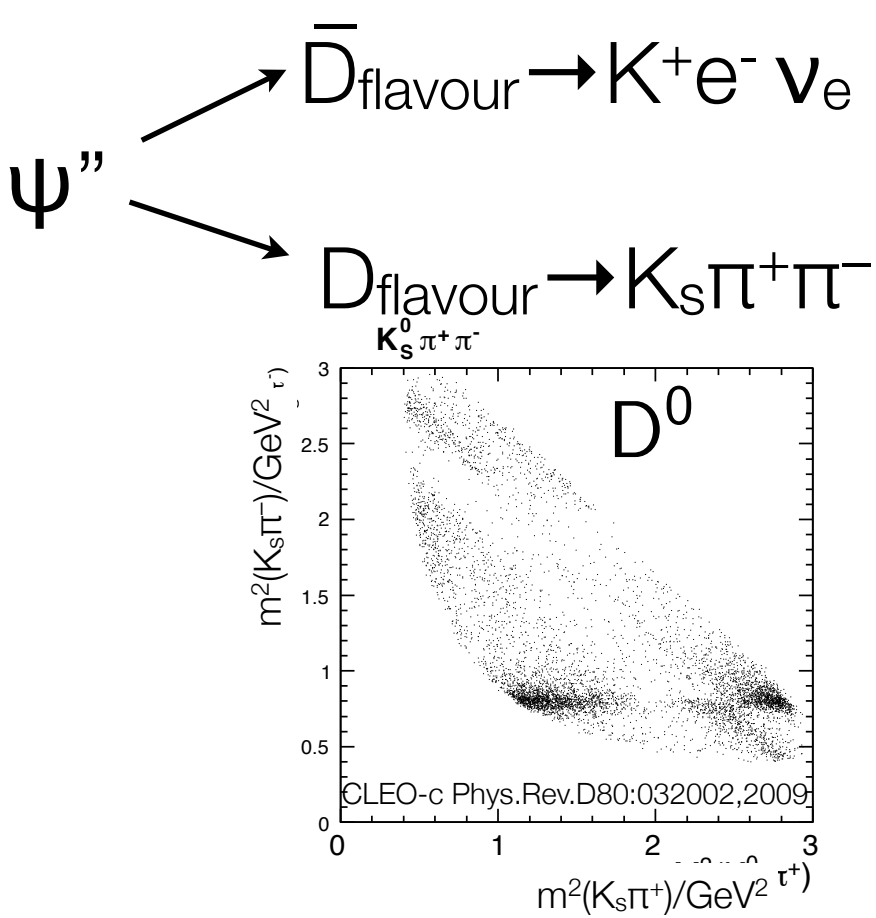


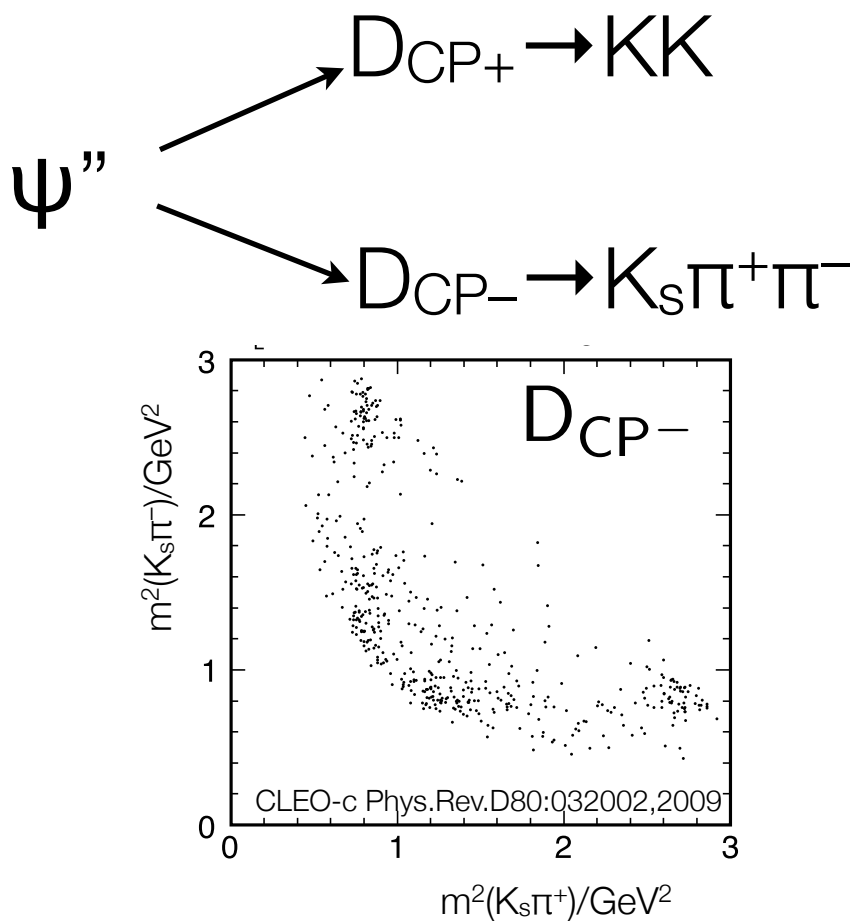




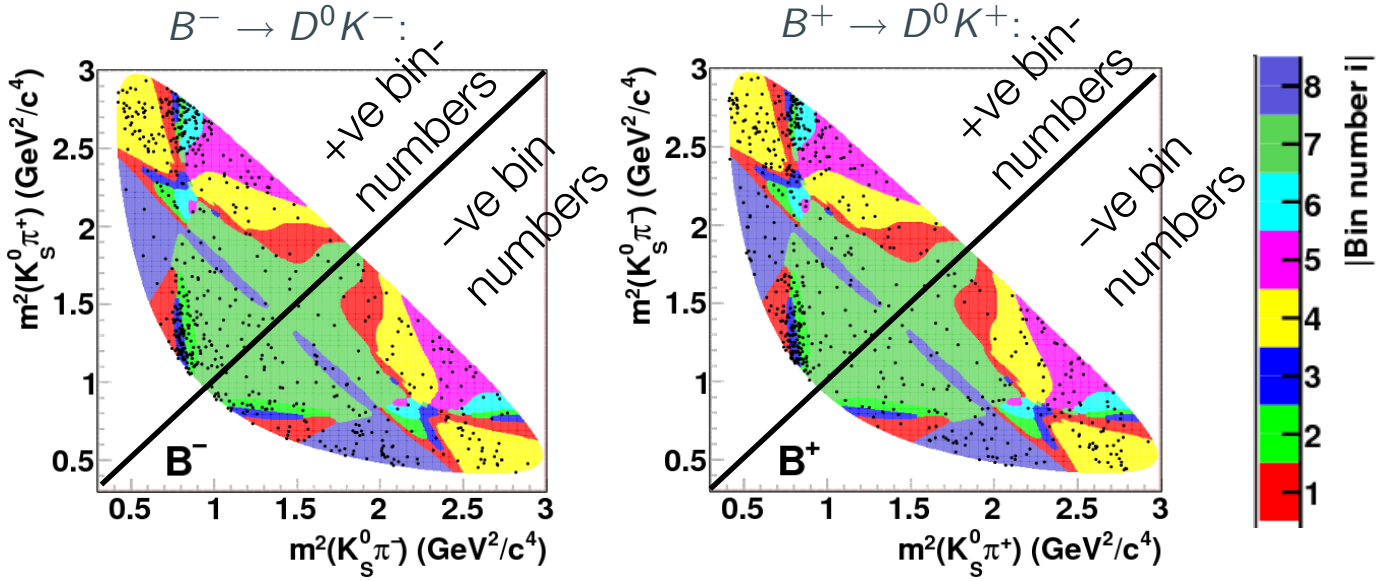


CP and flavour tagged Dº at CLEO-c



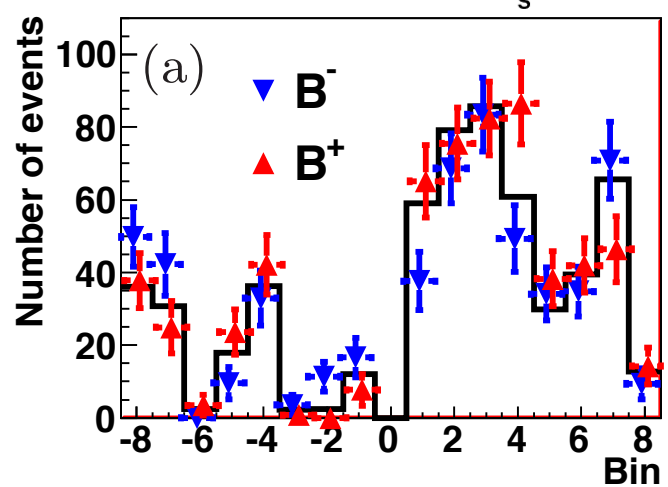


First model-independent γ measurement (BELLE)



$$\gamma = (77.3^{+15.1}_{-14.9} \pm 4.2 \pm 4.3)^\circ$$
$$r_B = 0.145 \pm 0.030 \pm 0.011 \pm 0.011$$
$$\delta_B = (129.9 \pm 15.0 \pm 3.9 \pm 4.7)^\circ,$$

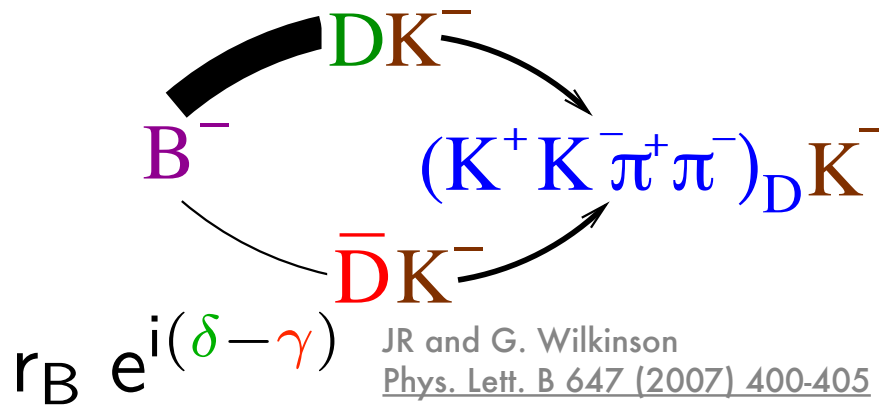
where the last uncertainty on γ of 4.3° the former model uncertainty of 8.9°



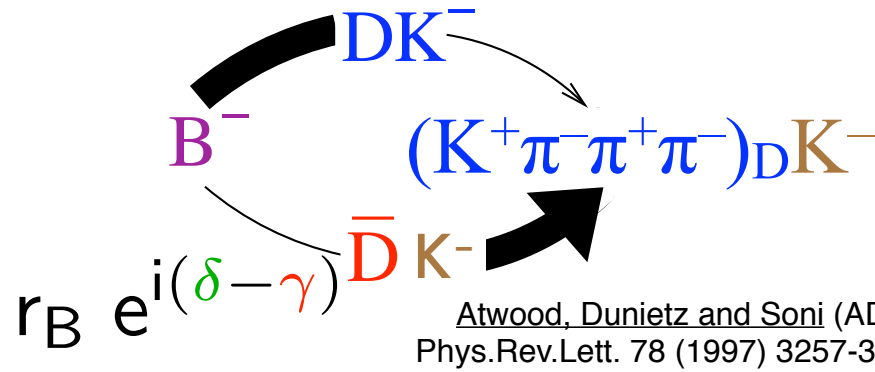
BELLE: **arXiv:1106.4046**. See also Anton Poluektov's talk at Moriond EW 2011 (from which I lifted several of the plots shown here): http://belle.kek.jp/belle/talks/moriondEW11/poluektov.pdf
CLEO-c input:Phys.Rev.D82:112006,2010.

Why stop here

- Why stop at 3-body decays?
- 4-body amplitude analyses very promising for γ measurement at LHCb.
- First step: “quasi two body” (coherence factor) analysis. See next slide.



JR and G. Wilkinson
Phys. Lett. B 647 (2007) 400-405

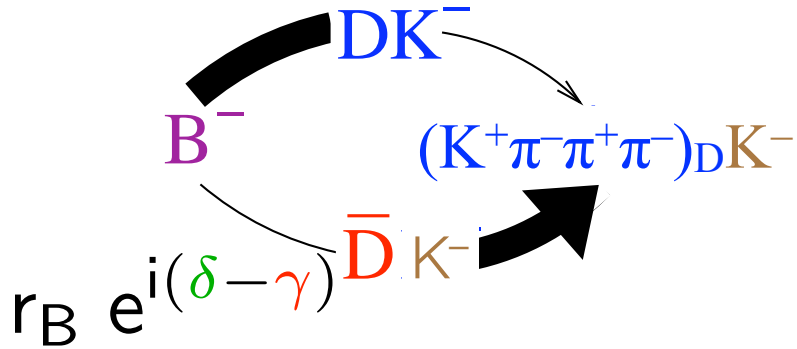


Atwood, Dunietz and Soni (ADS),
Phys.Rev.Lett. 78 (1997) 3257-3260

Atwood, Soni: Phys.Rev. D68 (2003) 033003

Coherence Factor Analysis of:

Atwood, Soni: Phys.Rev. D68 (2003) 033003



- Treat K3π like two-body decay with single effective strong phase δ_D.
- New parameter: Coherence factor R < 1.

$$\Gamma\left(B^- \to \left(K^+ 3\pi\right)_D K^-\right) \propto r_B^2 + \left(r_D^{K3\pi}\right)^2 + 2R_{K3\pi} r_B r_D^{K3\pi} \cdot \cos\left(\delta_B + \delta_D^{K3\pi} - \gamma\right)$$

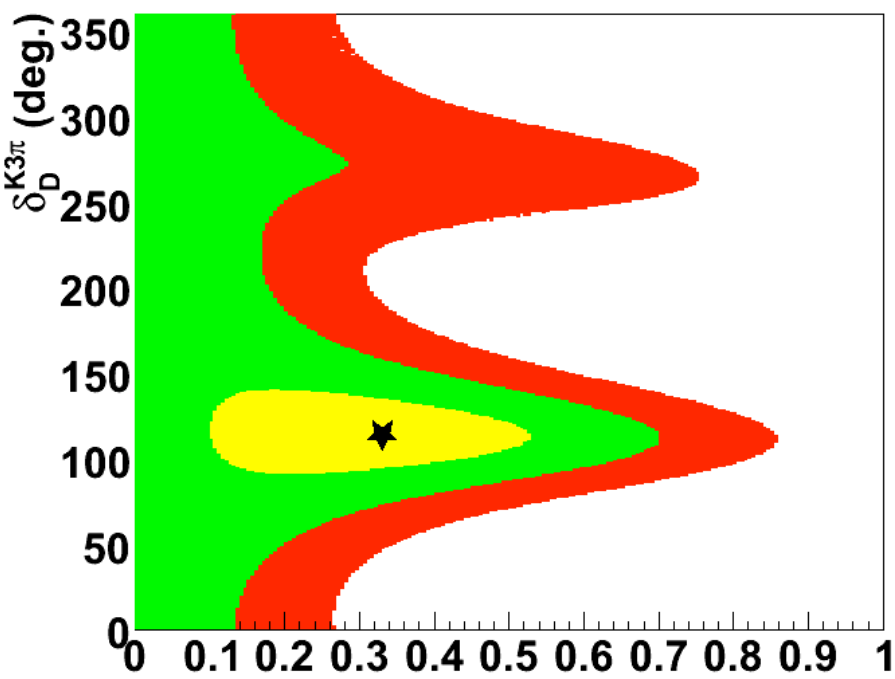
- CLEO-c's coherent ψ(3770)→DD events allow measurement of R, δ_D.

Phys.Rev.D80:031105,2009

Kππ and Kππ° Coherence Factor

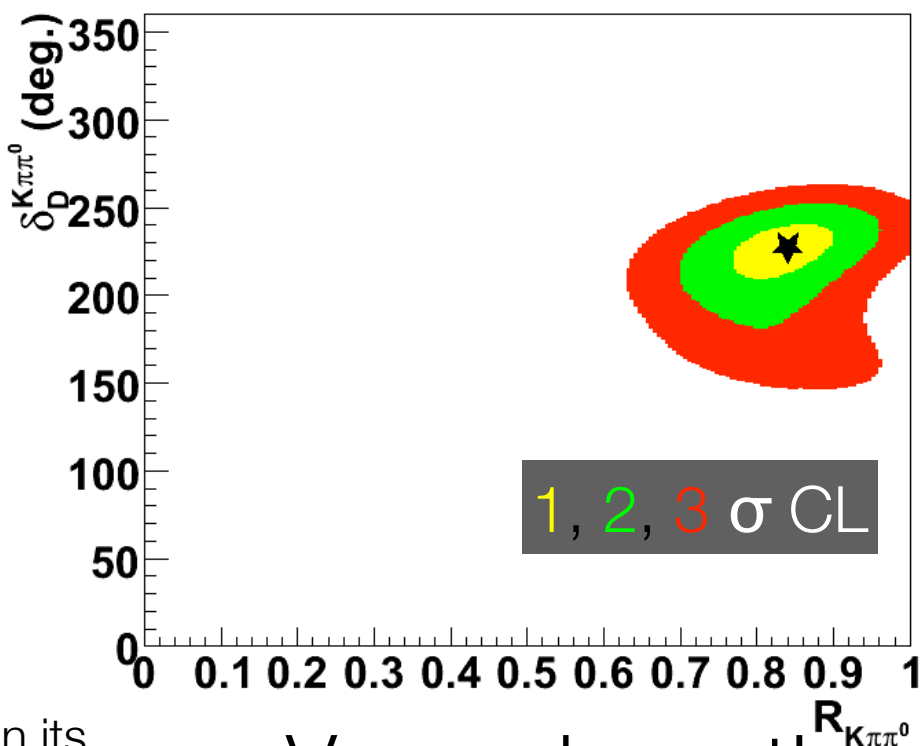
$R_{K3\pi} = 0.33^{+0.20}_{-0.23}$

$\delta_D^{K3\pi} = (114^{+26}_{-23})^{o}$



$R_{K\pi\pi^0} = 0.84 \pm 0.07$

$\delta^{K\pi\pi^0} = (227^{+14}_{-17})^{o}$



Low coherence in K3π implies low sensitivity to γ on its own, but as a low R helps measure r_B, it still has significant impact when combined with other modes.

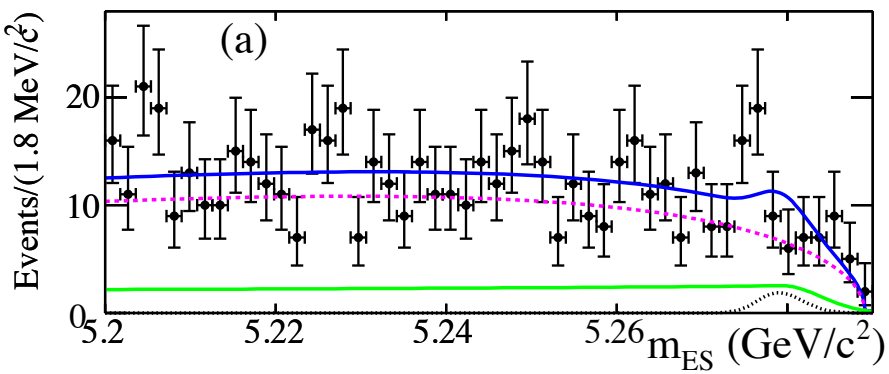
Very coherent!

Phys.Rev.D80:031105,2009

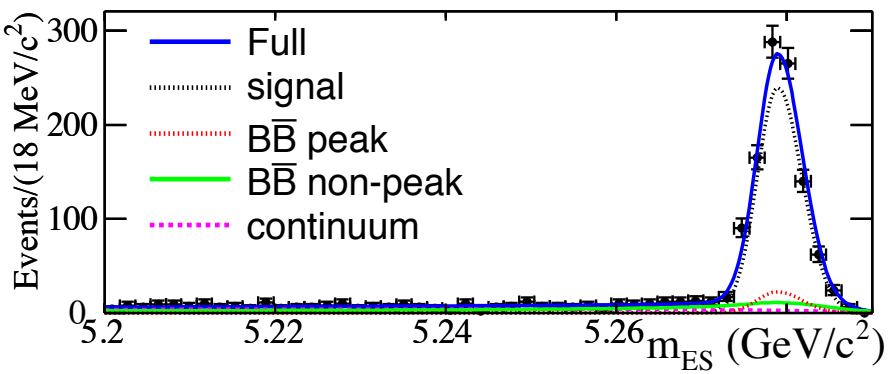
BaBar's $B^- \to (K^-\pi^+\pi^0)_D K^- + cc$

Phys.Rev.D84:012002,2011.

$B^- \to (K^+\pi^-\pi^0)_D K^-$ $+cc$ ~20 events



$B^- \to (K^-\pi^+\pi^0)_D K^-$ $+cc$ ~2000 events

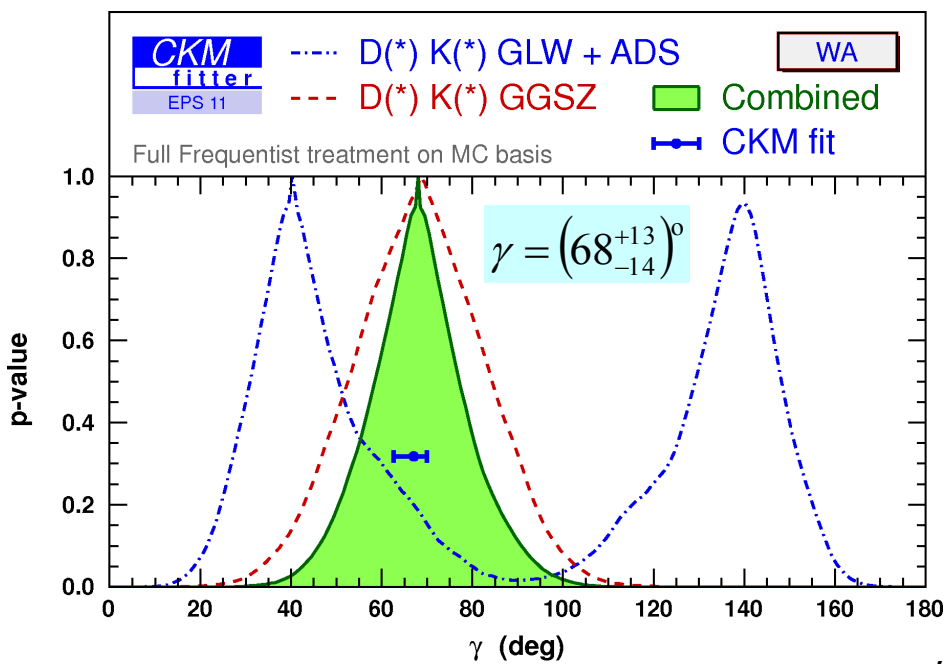


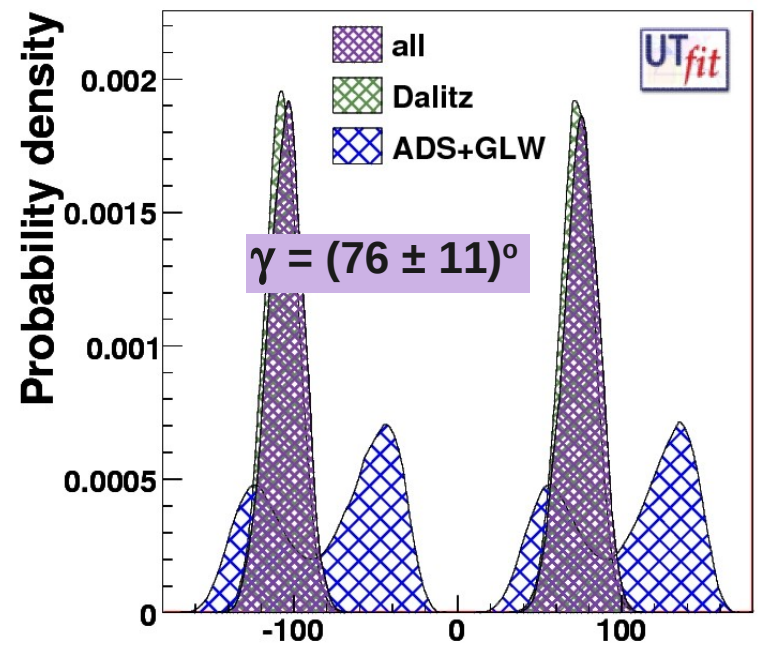
$$R_{\rm ADS} = \left(9.1^{+8.2}_{-7.6}({\rm stat})^{+1.4}_{-3.7}({\rm syst})\right) \times 10^{-3} \qquad r_B < 0.13 \text{ at } 90\%$$

$R_{\rm ADS} < 21 \times 10^{-3}$ at 90% CL

First to use CLEO-c's coherence factor measurement.

CKM-fitter & UTFit results

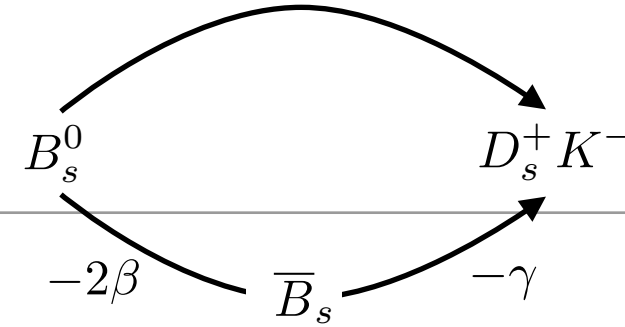




EPS 2011, does not yet include new LHCb constraints

Now (roughly) agree on uncertainty, but - given they use the same input - the central values are surprisingly different.

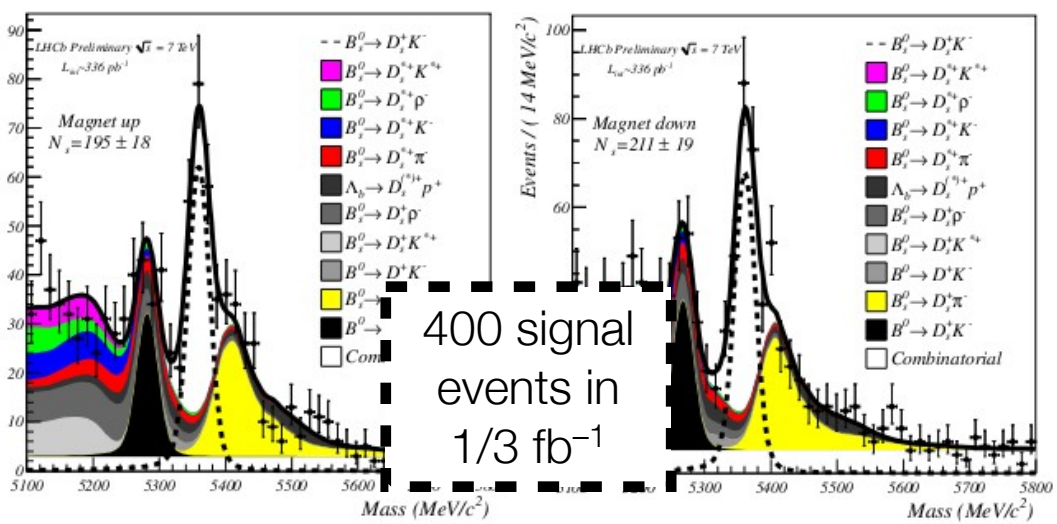
Time-dependent $B_s \to D_s K$ at LHCb



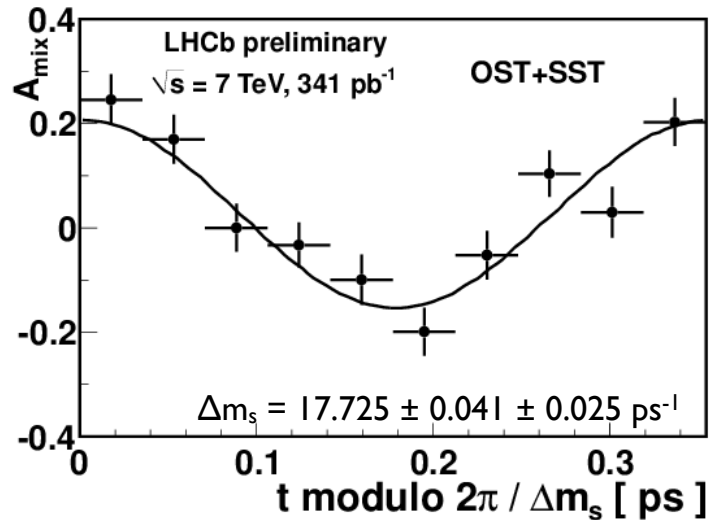
- Clean, tree-only γ: $B_s \to D_s K$, $B \to D^{(*)}\pi$, but much larger interference with former.
- Ingredient 1: Identify $B_s \to D_s K$ signal (RICH particle ID crucial)
- Ingredient 2: Time-dependent asymmetries - demonstrated in flavour specific $B_s \to D_s \pi$.

magnet up

magnet down



[LHCb-CONF-2011-057]

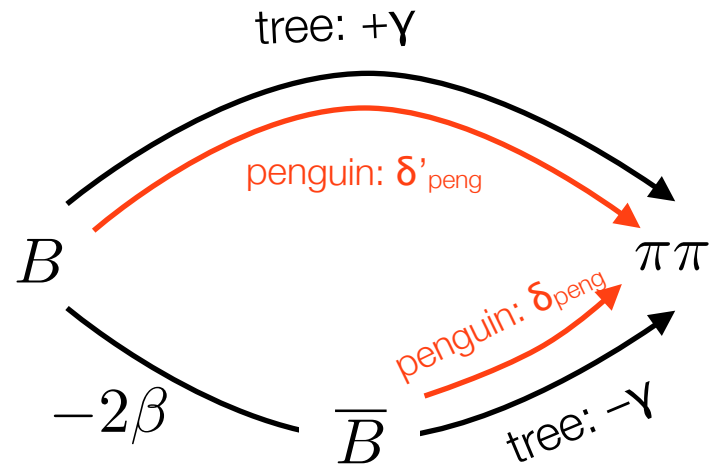


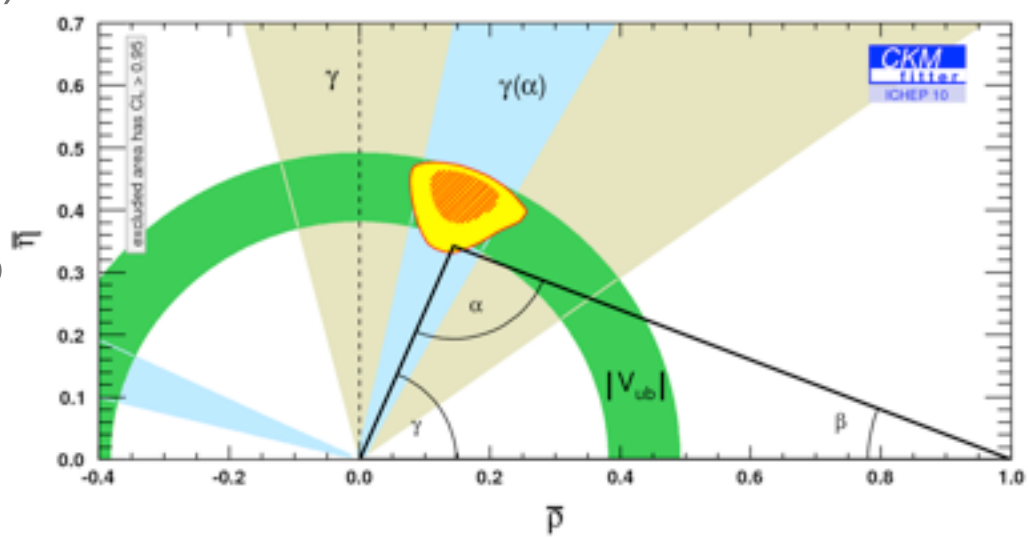
(most precise Δms measurement today, result compatible with CDF)

$$B\left(B_s \to D_s^{\mp} K^{\pm}\right) = \left(1.97 \pm 0.18\,(stat)\,^{+0.19}_{-0.20}\,(syst)\,^{+0.11}_{-0.10}\,(f_s/f_d)\right) \times 10^{-4}$$

B→hh' α/γ

- B→ππ, B→ρρ, B_s→KK proceed (at tree level) via b→u transitions and are thus sensitive to γ.
- Penguin contributions complicate things. Can by disentangled using U-spin (B→ππ, B_s→KK at LHCb in future) or isospin (B-factories) to extract tree-level γ.
- Without subtracting 2β, B→ππ, B→ρρ measure α.





α dominated by B-factories' B→ρρ

$B_s \to KK$ lifetime

- Measures (approximately) the CP-even B_s lifetime and is thus sensitive to $\Delta\Gamma$. 1st step to time-dependent $B \to hh\ \gamma$ measurement.

- LHCb use MC-independent correction for trigger bias (hadronic trigger is based on selecting long-lived decays).

Nucl.Instrum.Meth.A570:525-528,2007; Phys.Rev.D83:032008,2011; LHCb-PUB-2009-022

- Results:

$$\tau^{LHCb}_{B_S \to KK} = (1.44 \pm 0.10 \pm 0.01)\ \text{ps}$$

LHCb-CONF-2011-018

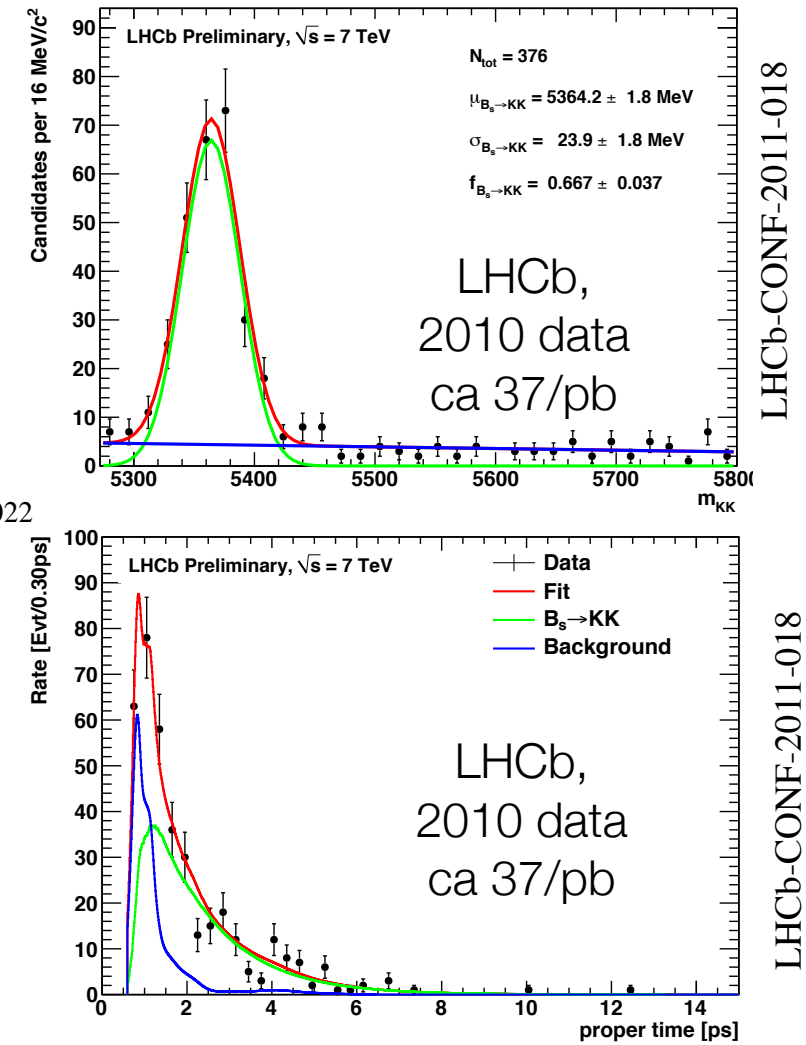
$$\tau^{CDF}_{B_S \to KK} = (1.53 \pm 0.18 \pm 0.02)\ \text{ps}$$

CDF Note 06-01-26

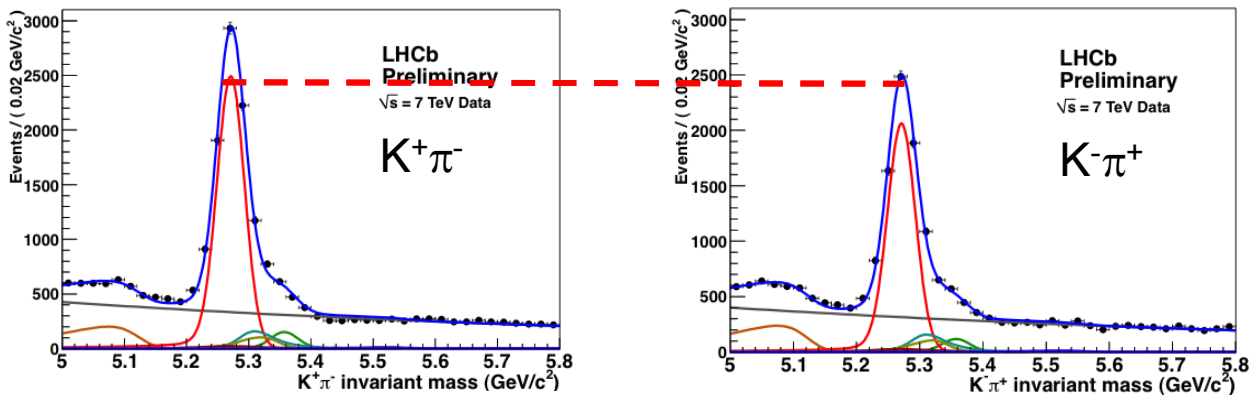
$$\tau^{SM}_{B_S \to KK} = (1.390 \pm 0.032)\ \text{ps}$$

Robert Fleischer, Robert Knegjens Eur.Phys.J.C71:1532,2011

$$\tau^{HFAG}_{B_S - \text{flavour}} = (1.48 \pm 0.02)\ \text{ps}$$



Direct CPV in $B_{(s)} \to K\pi$ at LHCb

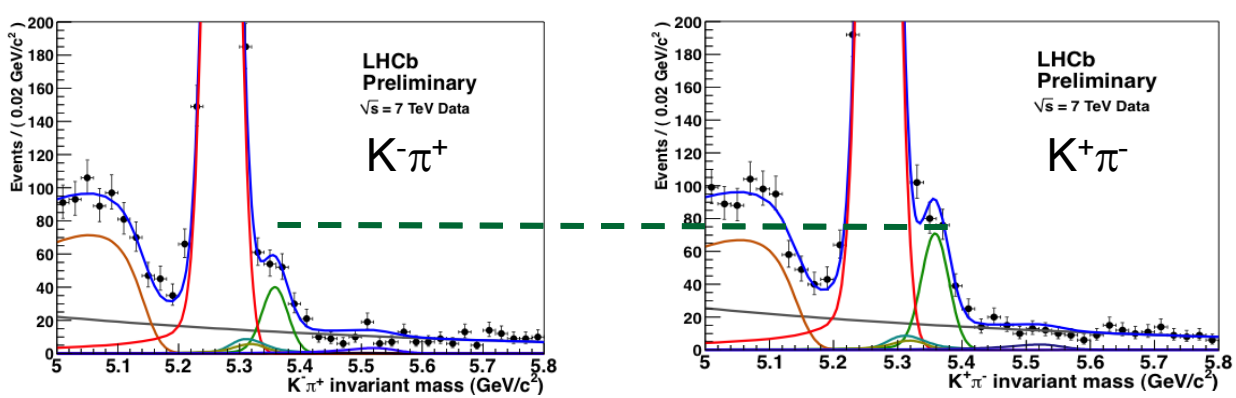


$$A_{CP}\left(\mathrm{B}^0 \to \mathrm{K}^+\pi^-\right) = -0.088 \pm 0.011 \pm 0.008$$

Compare to prev. world-average:

$$A_{CP}(B^0 \to K^+\pi^-) = -0.098^{+0.012}_{-0.011}$$

Best single measurement, first 5σ observation.



$$A_{CP}\left(\mathrm{B}_\mathrm{s}^0 \to \pi^+\mathrm{K}^-\right) = 0.27 \pm 0.08 \pm 0.02$$

First evidence of CP violation in B_s decays.

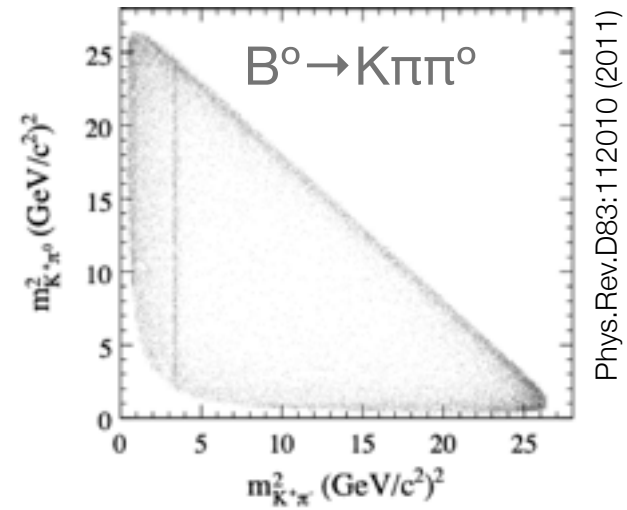
Prev result by CDF:

$$A_{CP}(B_s^0 \to \pi^+K^-) = 0.39 \pm 0.17$$

Dalitz Analyses of B decays for CPV in trees

- $B^0 \to K\pi\pi^0$ to extract a tree-only constraints on γ using isospin. Measured at BaBar. Limited sensitivity due to smallness of the tree amplitude. Authors suggest a similar analysis in B_s decays could lead to better constraints.

  Theory: M. Ciuchini, M. Pierini, and L. Silvestrini, Phys. Rev. D 74, 051301(R) (2006)
  Exp: BaBar: PhysRevD.83.112010

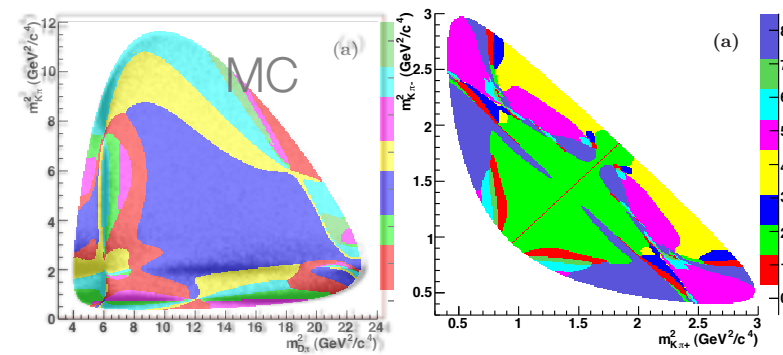


Phys.Rev.D83:112010 (2011)

- "Double-Dalitz analysis" of $B_d \to DK\pi$, $D \to K_S\pi\pi$ allows a clean extraction of γ w/o external input.

  Poluektov & Gershon, Phys.Rev. D81 (2010) 014025

$B_d \to DK\pi$ $D \to K_S\pi\pi$



- Measuring β w/o a penguin contribution is possible with time-dependent analyses of $B^0 \to D\pi^0$ or $B^0 \to D\pi^+\pi^-$ decays

  J. Charles, A. Le Yaouanc, L. Oliver, O. Pene, and J. C. Raynal, Phys. Lett. B425, 375 (1998)
  Latham & Gershon, J.Phys.G G36 (2009) 025006

Summary & Outlook

- B-factories / Tevatron continue to publish plenty of beautiful flavour physics results with final / close-to-final data sets.

- The coming flavour-physics years will be LHCb's. With ca 1/3 of the 2011 dataset, LHCb is already competitive and in many channels provides the most precise results.

- With 2011 data LHCb will be in a position to measure tree-level γ from $B \to DK$ decays to about 5° to 10° - that's of course just the beginning. CLEO-c and BES-III input will play an important role in high-precision γ measurements - principle proven by BaBar (coherence factor) and BELLE (Dalitz analysis).

- Improvements on $|V_{ub}|$ rely mainly on improvements in theory/LQCD - except $B \to \tau\nu$, where a future flavour factory could have significant impact.

Evidence against 4th generation

CAN NOT BE JUST SM4

- **Simple SM4 light higgs seems strongly disfavored by data**

(Amarjit Soni)

$\sigma_{SM4}/\sigma_{SM3}$ ~ 9 (the reason why a wider range for SM4 has been excluded compared with SM3)

(Xiao-Gang He)

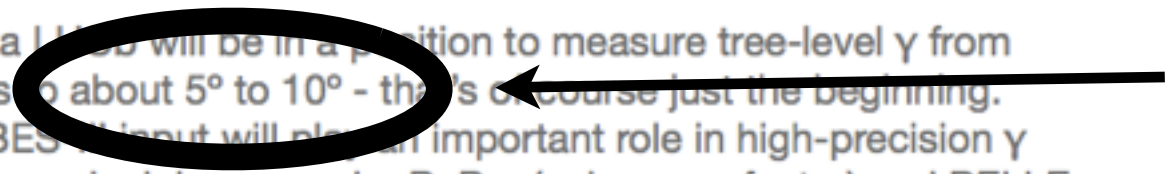
If with SM3 like cross section, 4th generation is ruled out?

...l not find the Higgs in the whole expected mass range up to ...t exist? Also SM4 is not favored.

There seems to be a lot of evidence against a "straightforward" 4th generation - are the solutions contrived workarounds?

SM benchmarks

- With 2011 data LHCb will be in a position to measure tree-level γ from B→DK decays to about 5° to 10° - that's of course just the beginning. CLEO-c and BES III input will play an important role in high-precision γ measurements - principle proven by BaBar (coherence factor) and BELLE (Dalitz analysis).



implies a precision of a few degrees after 5/fb at 14TeV

→How precisely do you need to know γ?

Determination of V_{ub} (Ulrik Egede)

Use BFs of B→K*μμ, B→ρμν, D→K*μν, D→ρμν

Pirjol, Grinstein PRD**70** (2004) 114005

→Any ideas for other cans of worms to be thrown at V_{ub} by LHCb?

⇒How is any of this relevant to 4th generation physics?


U.S. COAST & GEODETIC SURVEY
U.S.E.A. $250 FINE OR IMPRISONMENT
EL 34
1947
FOR DISTURBING THIS MARK
ABOVE MEAN SEA LEVEL
BENCH MARK

Backup Slides

CLEO-c's input to γ

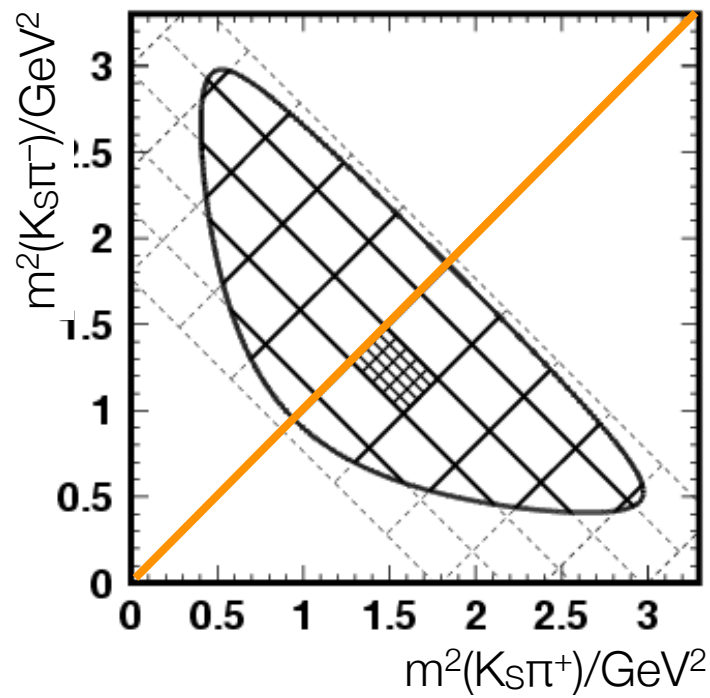
- CLEO-c's input is concerned with δ_D, the phase difference between

  $A(D^0 \to K_S\pi^+\pi^-)$ and $A(\bar{D}^0 \to K_S\pi^+\pi^-)$

  at each point on the Dalitz plot.

- Measure the cosine and sine of this phase difference, averaged over bins:

  $c_i = \langle \cos(\delta_D) \rangle_i$, $s_i = \langle \sin(\delta_D) \rangle_i$



Giri, Grossmann, Soffer, Zupan, Phys Rev D 68, 054018 (2003).

- This input allows model-independent γ measurement.

*bin width uniform in δ_D based on BaBar model PRL 95 (2005) 121802

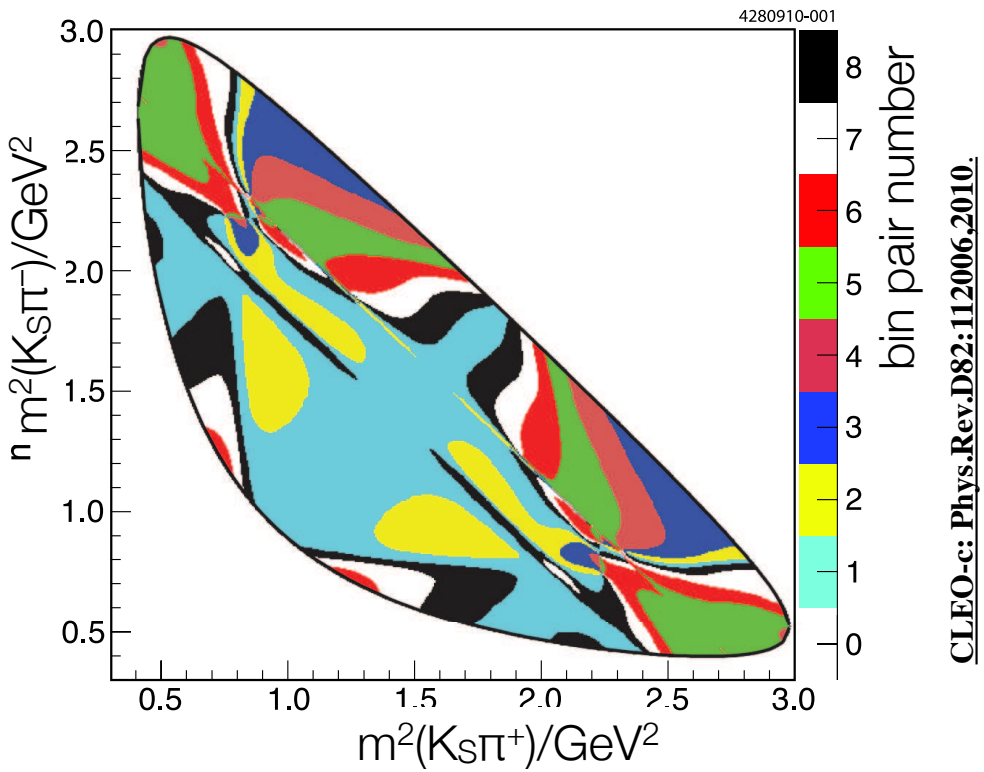
Optimal binning

- γ sensitivity improves if δ_D is as constant as possible over each bin[1]. Other considerations for optimal binning include event numbers per bin, robustness against migration etc.

- Results for several options based on BaBar and BELLE amplitude models were obtained.

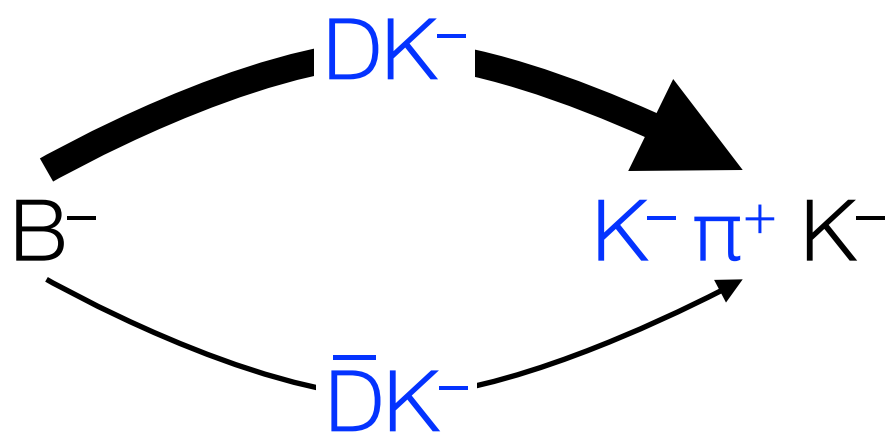
- Choice of model will not bias result - instead a bad model reduces the statistical precision of the result, so you might get blind, but not biased.

Equal-δ binning based on BaBar model*



Phys. Rev. D 78, 034023 (2008).

[1] Bondar, Poluektov hep-ph/0703267v1 (2007)


DK^-
B^-
$K^-\,\pi^+\,K^-$
$\bar{D}K^-$

$|V_{ub}|$

- In 2011, BaBar and BELLE published new |Vub|-exclusive measurements:

$$\text{BaBar:}\quad |V_{ub}| = \left(3.09 \pm 0.08 \pm 0.12^{+0.35}_{-0.29}\right) \cdot 10^{-3}$$

PhysRevD.83.052011 (2011) PhysRevD.83.032007 (2011)

$$\text{BELLE:}\quad |V_{ub}| = (3.43 \pm 0.33) \cdot 10^{-3}$$

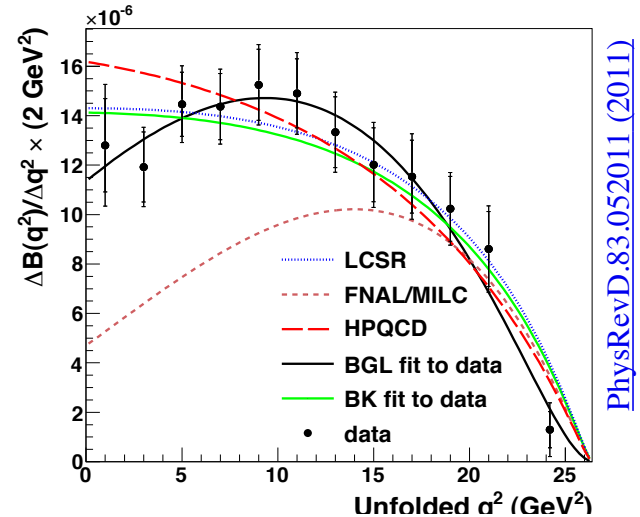
PhysRevD.83.071101 (2011)

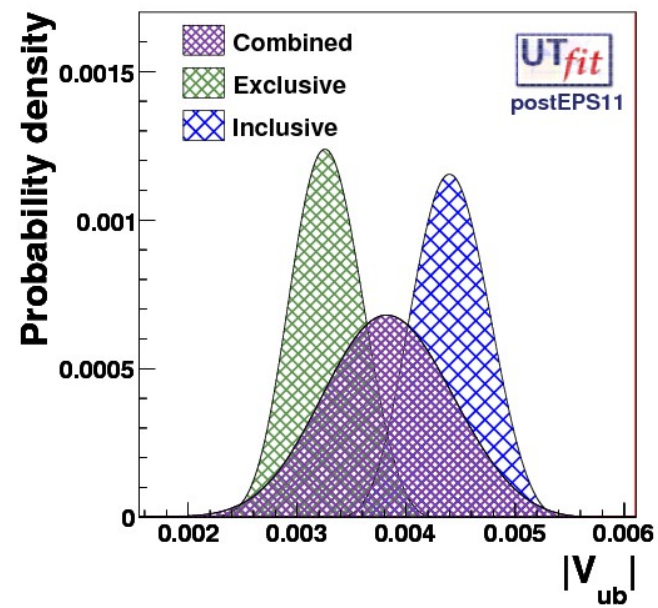
- Compare incl/exclusive determination:

$$\text{My average:}\quad |V_{ub}|\,(\text{excl}) = (3.26 \pm 0.33) \cdot 10^{-3}$$

$$\text{PDG 2010:}\quad |V_{ub}|\,(\text{incl}) = (4.27 \pm 0.38) \cdot 10^{-3}$$

- A similar tension exists in the incl vs excl determination of $|V_{cb}|$





$B^{\pm} \to D(\text{2-body})K^{\pm}$

- Measure:

ratio suppressed/favoured (only ADS):

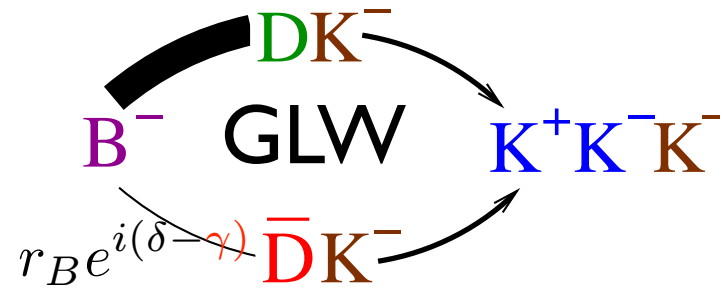
$$R = \frac{\Gamma(B^- \to f_D K^-) + \Gamma(B^+ \to \overline{f}_D K^+)}{\Gamma(B^- \to \overline{f}_D K^-) + \Gamma(B^+ \to f_D K^+)} = r_B^2 + r_D^2 + 2 r_D r_B \cos(\gamma) \cos(\delta_B + \delta_D)$$

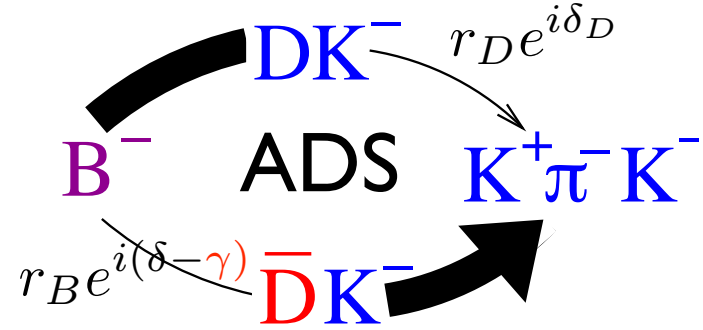
CP-violating rate asymmetry

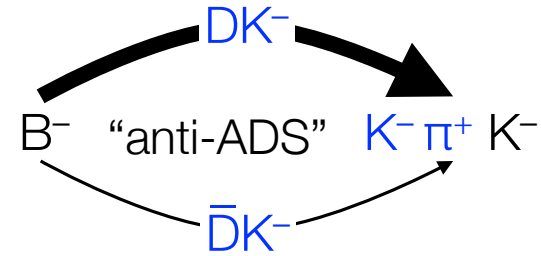
$$A = \frac{\Gamma(B^- \to f_D K^-) - \Gamma(B^+ \to \overline{f}_D K^+)}{\Gamma(B^- \to f_D K^-) + \Gamma(B^+ \to \overline{f}_D K^+)} = 2 r_D r_B \sin(\gamma) \cos(\delta_B + \delta_D) \,/\, R$$

where, for GLW, $R \equiv 1$, $r_D \equiv 1$ and $\delta_D \equiv 0$.

- Counting experiment. All parameters can be extracted by simultaneously analysing several decay channels (although external CLEO-c input on δ_D helps).

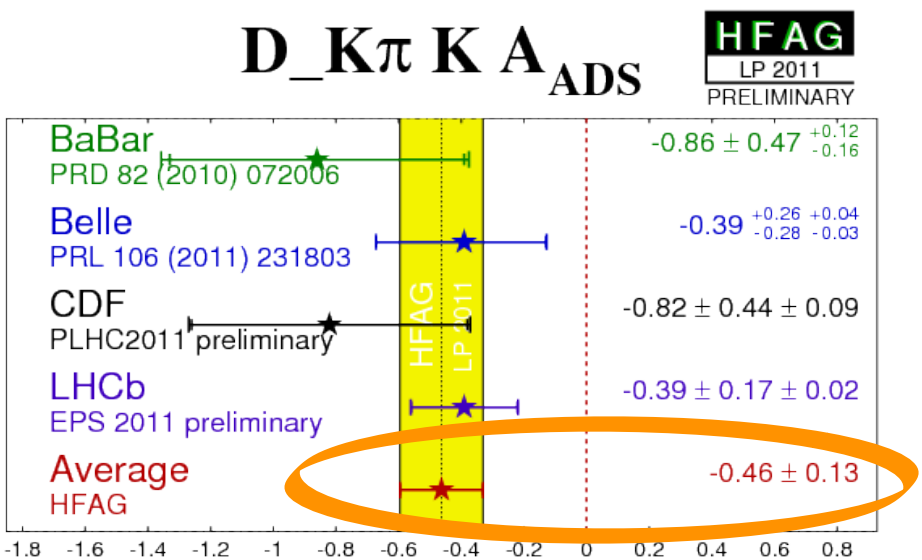


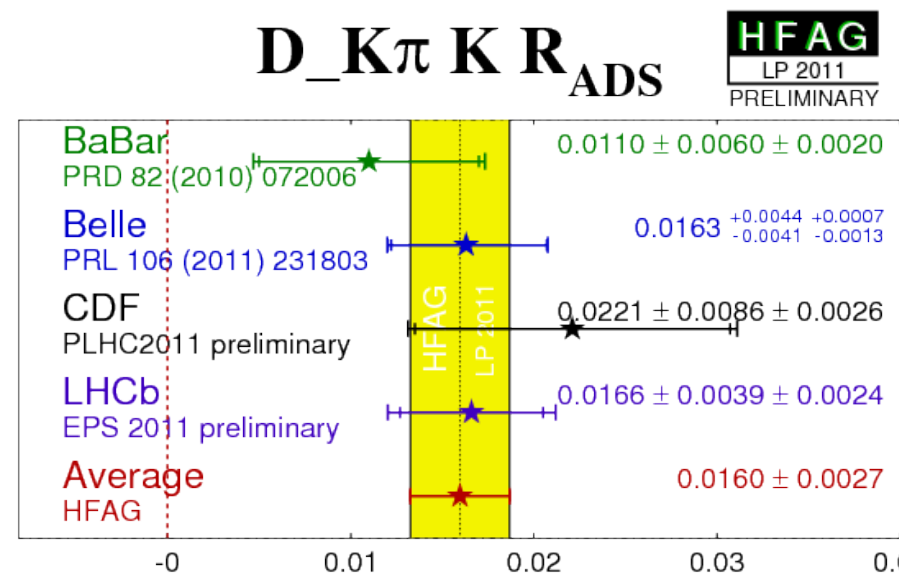




Gronau, Wyler Phys.Lett.B265:172-176,1991, (GLW),
Gronau, London Phys.Lett.B253:483-488,1991 (GLW)
Atwood, Dunietz and Soni Phys.Rev.Lett. 78 (1997) 3257-3260 (ADS)

$B^{\pm} \to D(K\pi)K^{\pm}$ summary

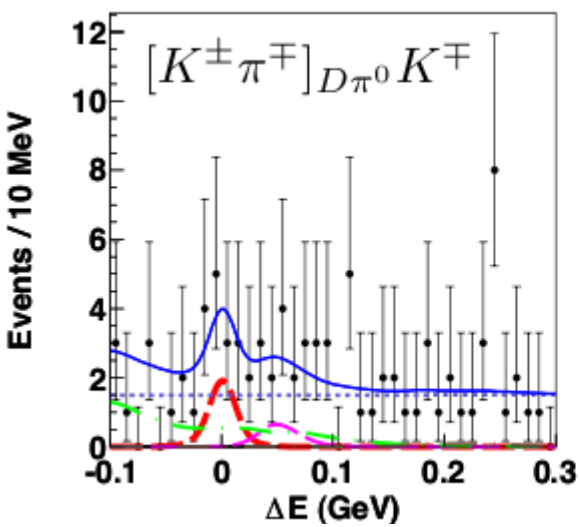


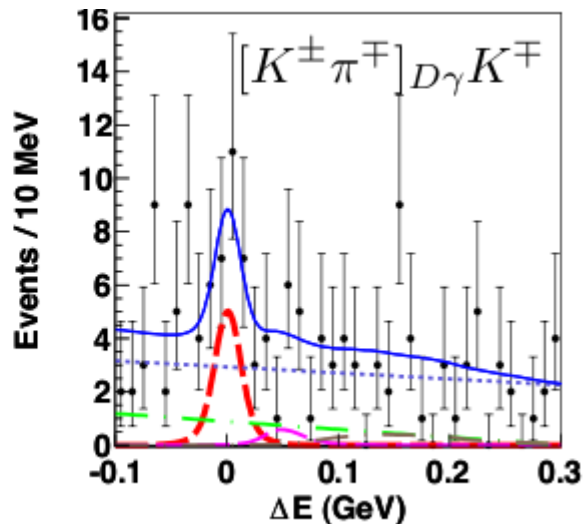


huge CP-violation asymmetry of ~50%

ADS from B→D*K

- D* goes to either Dπ° or Dγ. The two modes are related by a 180° phase shift, thus providing additional phase information.





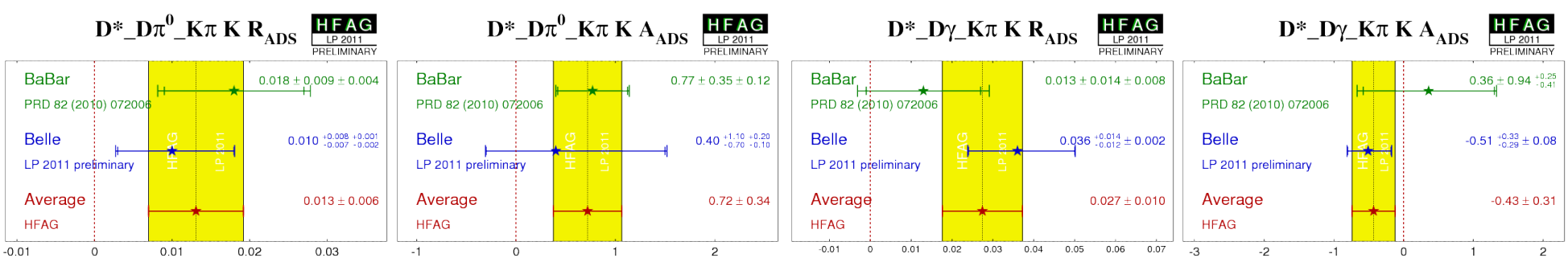
Phase-relation helps resolve ambiguities. Current results indicate negative

$\cos(\delta_B^* + \delta_D)\cos\gamma$

and positive

$\sin(\delta_B^* + \delta_D)\cos\gamma$

New results at Lepton Photon. BELLE-CONF-1112



Loops vs Trees

- The co-incidence (?) that α≈90° gives two pairs of nearly de-coupled tree vs loop measurements. (Of course tree-level benchmarks are also important for many other New-Physics sensitive channels.)