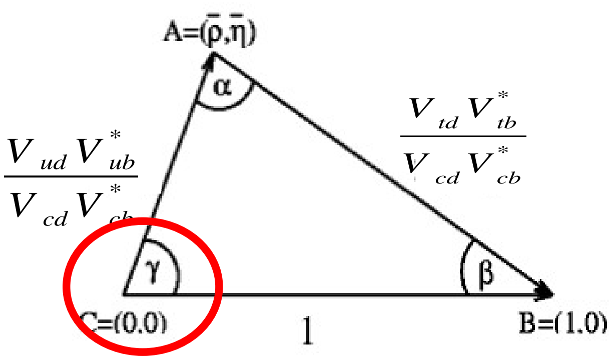
The CKM angle γ/φ_3

(B-factories results review)



Viola Sordini, Moriond EW 2008

Outline

- CP violation and CKM matrix
- B factories datasets
- Measurements of γ/φ_3: experimental techniques
- **G**ronau **L**ondon **W**yler method results
- **A**twood **D**unietz **S**oni method results
- **G**iri **G**rossman **S**offer **Z**upan (Dalitz) method results
- combining all the results

The CKM matrix and the Unitarity Triangle

In the SM, CP violation arises from an irreducible phase in the **CKM matrix**

weak interaction eigenstates

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

mass eigenstates

V_{CKM} Unitary matrix

Cabibbo
Kobayashi
Maskawa

UNITARITY CONDITION:

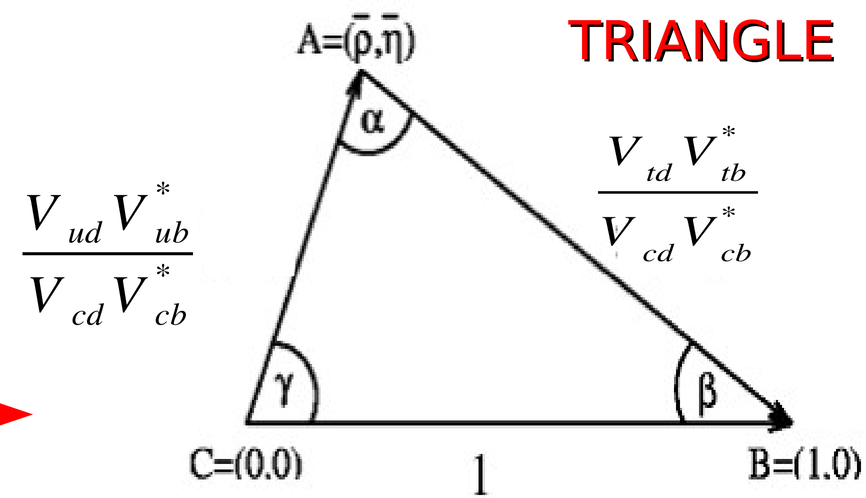
$$V_{CKM} V^{+}_{CKM} = V^{+}_{CKM} V_{CKM} = 1$$

three independent relations,
within them we choose:

$$V^{*}_{ub} V_{ud} + V^{*}_{cb} V_{cd} + V^{*}_{tb} V_{td} = 0$$

B physics

UNITARITY TRIANGLE



In a complex plane $(\bar{\rho}, \bar{\eta})$

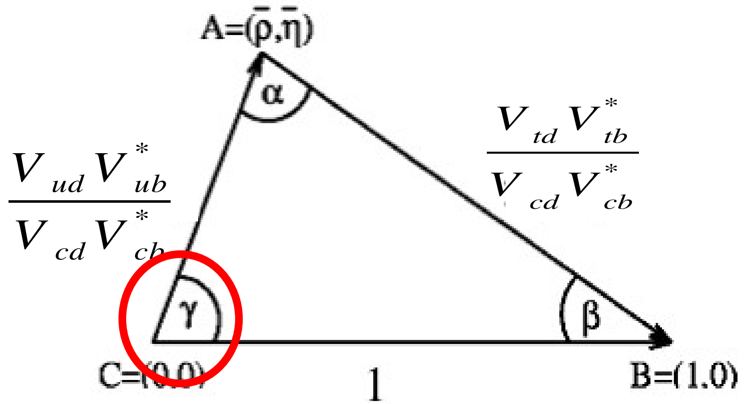
the CKM angle γ/φ_3

Wolfenstein parametrization:

$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\bar{\rho}-i\bar{\eta}) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\bar{\rho}-i\bar{\eta}) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^5)$$

$$\lambda \sim 0.22,\ A \sim 0.8$$

$$\gamma/\phi_3 = arg\{-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\}$$



In Wolfenstein parametrization, $V_{ub} = \sqrt{\bar{\rho}^2+\bar{\eta}^2}\, e^{-i\gamma}$ $\rightarrow$ γ/φ_3 is the phase of V_{ub}^*

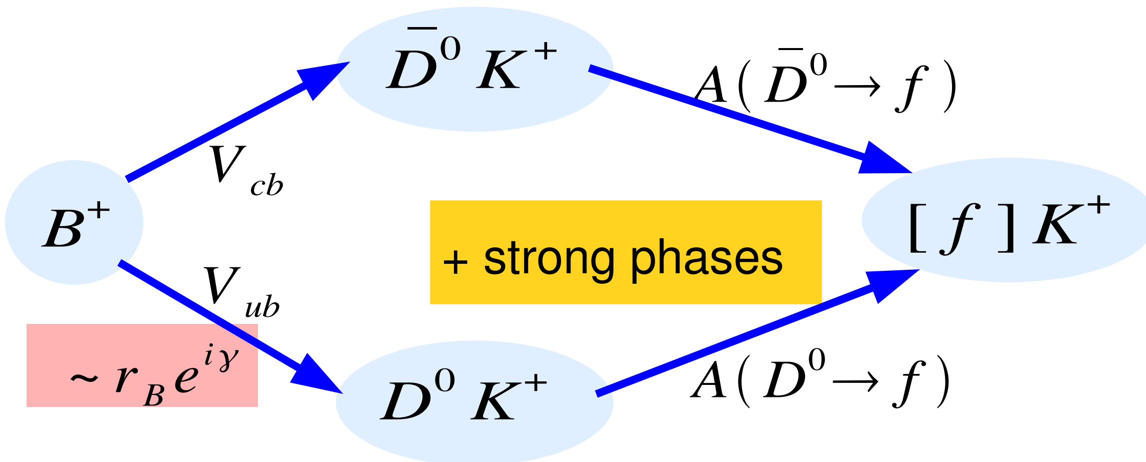
γ/φ_3 measured in the $B\rightarrow DK$ system, in the interference between $b\rightarrow c$ and $b\rightarrow u$ transitions

measuring a phase

CP violation detectable when there are two paths to reach the same final state.

Interference in the B→DK system allows the determination of γ/φ_3

$$|A_1 + A_2 e^{i\phi}|^2 = A_1^2 + A_2^2 + 2A_1 A_2 \cos(\phi)$$



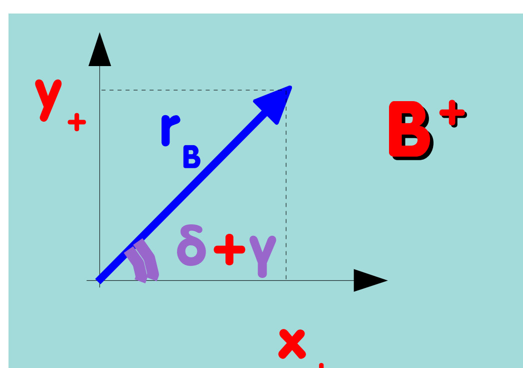
interference $\propto \cos(\delta+\gamma)$

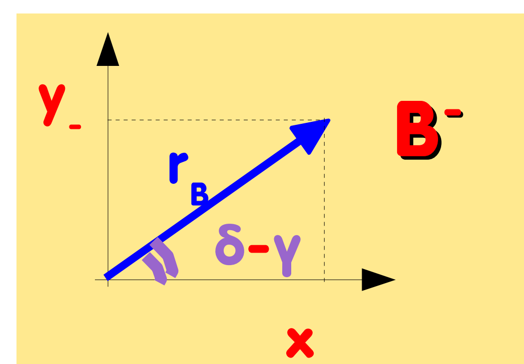
($\propto \cos(\delta-\gamma)$ for B^-)

Sensitivity to γ/φ_3 is driven by the ratio $\mathbf{r_B} = \mathbf{|A(b\to u)|/|A(b\to c)|}$ (channel-dependent)

cartesian coordinates

$$x_\pm = r_B \cos(\delta \pm \gamma)$$
$$y_\pm = r_B \sin(\delta \pm \gamma)$$



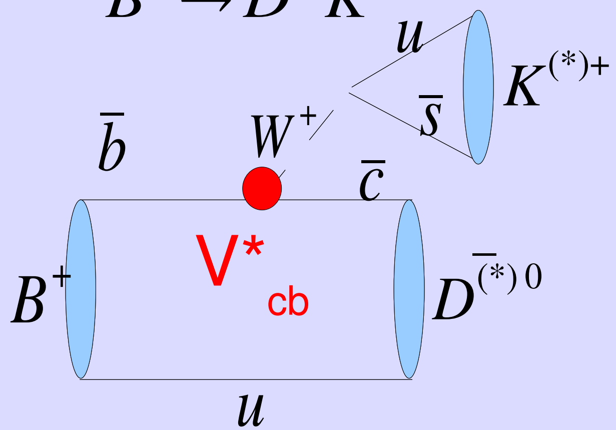


where to look

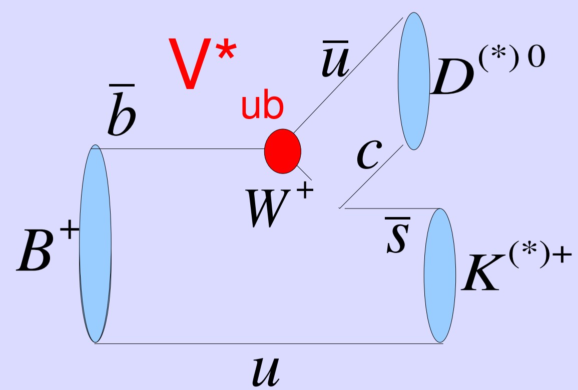
γ/φ_3 weak phase between b→c and b→u transition. In the **B→DK system**

CHARGED B

$B^+ \to \overline{D}^0 K^+$



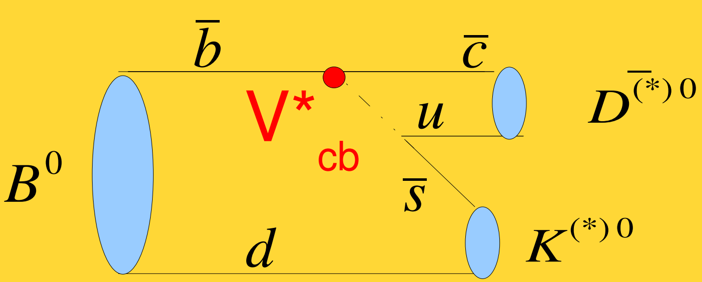
$B^+ \to D^0 K^+$



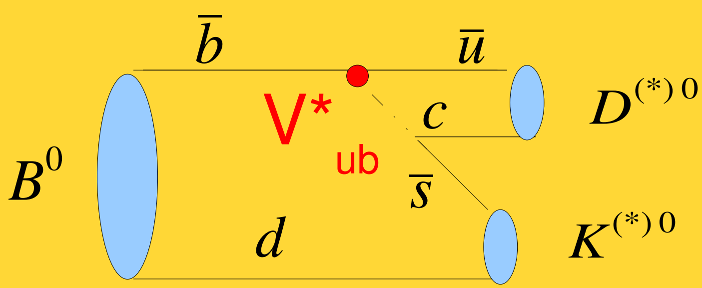
those are not the only two diagrams contributing, see backup

NEUTRAL B

$B^0 \to \overline{D}^{(*)0} K^{*0}$



$B^0 \to D^{(*)0} K^{(*)0}$



the r_B ratios

Sensitivity to γ/φ_3 in each channel driven by the ratio $\mathbf{r_B = |A(b\to u)|/|A(b\to c)|}$

$$r_B(D^0K^+) = \frac{|A(B^+\to D^0K^+)|}{|A(B^+\to \bar{D}^0K^+)|} = \frac{|V_{cs}V^*_{ub}|}{|V_{us}V^*_{cb}|}\frac{|\bar{C}+A|}{|T+C|}$$

$$r_B(D^0K^0) = \frac{|A(B^0\to D^0K^0)|}{|A(B^0\to \bar{D}^0K^0)|} = \frac{|V_{cs}V^*_{ub}|}{|V_{us}V^*_{cb}|}\frac{|\bar{C}|}{|C|}$$

Hadronic elements, complex quantities. Channel-dependent!

$R_b \sim 0.37$

$$R_b \equiv \frac{|V_{ud}V^*_{ub}|}{|V_{cd}V^*_{cb}|} = \sqrt{\bar{\varrho}^2+\bar{\eta}^2} = (1-\frac{\lambda^2}{2})\frac{1}{\lambda}\left|\frac{V_{ub}}{V_{cb}}\right|$$

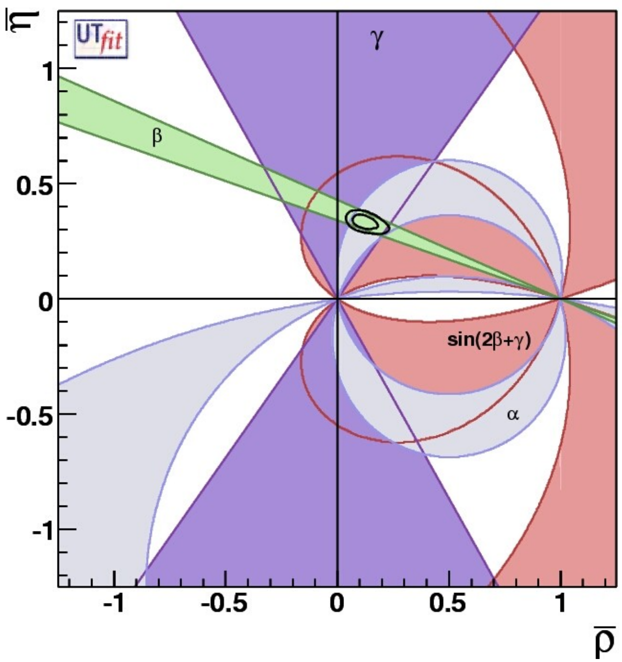
For the $B^+ \to D^{(*)0}K^+$, the r_B ratio is of the order ~0.1 (in amplitude!)

For the $B^0 \to D^{(*)0}K^{(*)0}$, the r_B ratio is expected to be of the order ~0.4

Need to be measured!

Notice: In the case of B→DK* decays, the r_S ratio is used instead, that takes into account that the K* is a naturally broad resonance

status of the measurements



constraints from angles measurements (LP2007)

γ/φ_3 is much less precisely determined, with respect to α and β (same remark for 2β+γ). Measurements of γ/φ_3 are difficult, because we look for small effects.

Actual knowledge comes from the combination of several methods (GLW, ADS, GGSZ) and several channels.

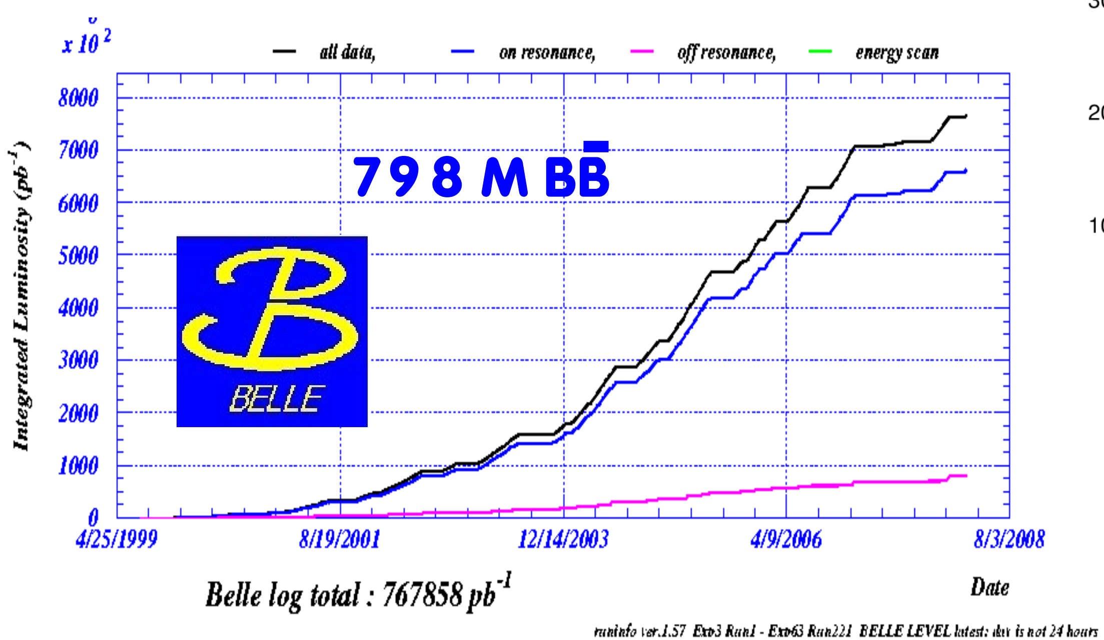
The b→u transitions are strongly suppressed (r_B=|A(b→u)|/|A(b→c)|).

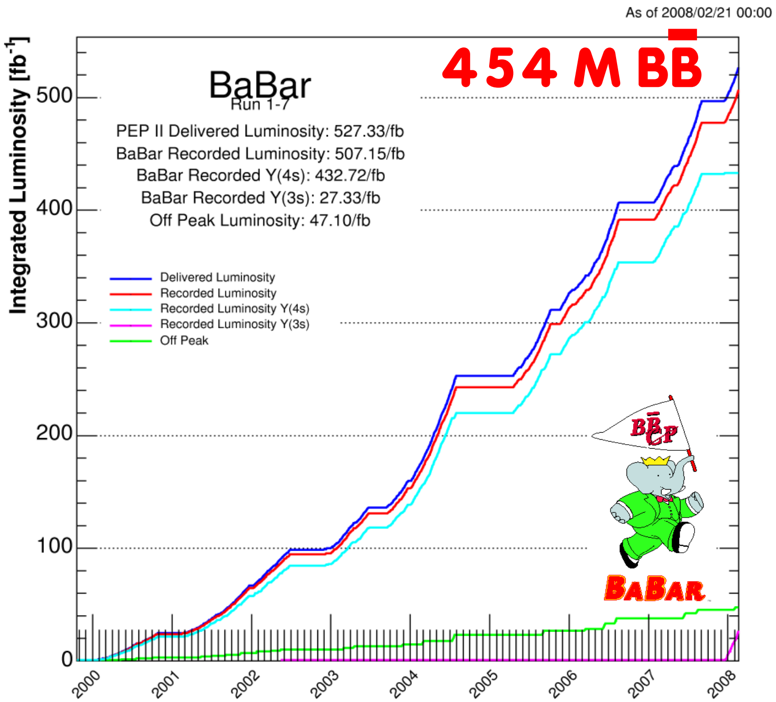
B-factories

e^+e^- colliders with asymmetric beam energies @Y(4s) for B meson pairs production: PEP II at SLAC (U.S.A.) and KEK in Tsukuba (Japan).

General purpose detectors: Belle and Babar

1.2 ab^{-1} OVERALL!!





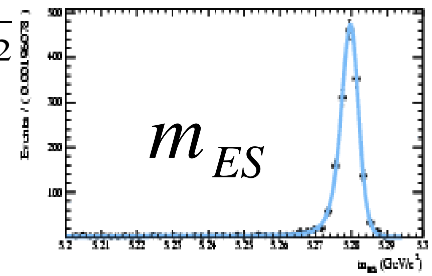
Experimental measurement techniques

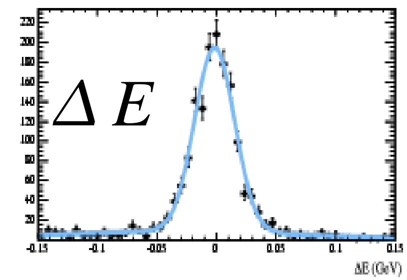
Exclusive reconstruction of B decays. Two sources of background: from $B\bar{B}$ events and from **continuum events** ($e^+e^-\rightarrow q\bar{q}$, with q=u,d,s,c).

Two almost-independent kinematic variables to characterize the B mesons:

$$m_{ES}(M_{bc})=\sqrt{(s/2+\vec{p}_B\vec{p}_{ee})^2/E_{ee}^2-\vec{p}_B^{\,2}}$$

$$\Delta E=E_B^*-\sqrt{s}/2$$

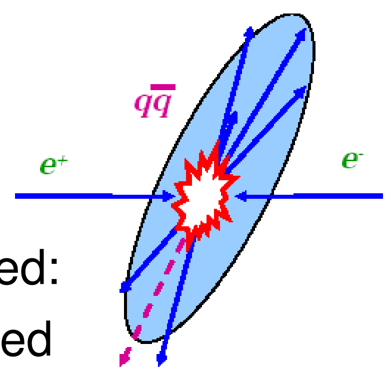




$(E_{B(ee)},p_{B(ee)})$ = 4-momentum of the reconstructed B or of the e^+e^- initial state in the laboratory frame. The * denotes the e^+e^- center of mass (CM) frame

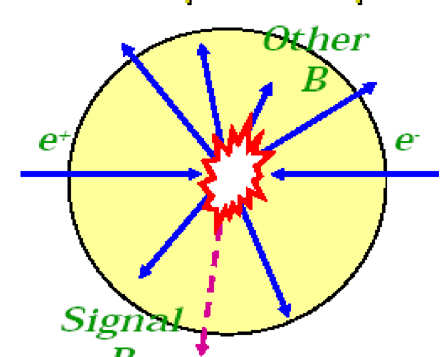
Typically, in all these analyses, dominant source of background: **continuum events** ($e^+e^-\rightarrow q\bar{q}$, with q=u,d,s,c).
Different spatial distribution is exploited: several topological variables (combined in a Fisher discriminant)

jet-like shape



$e^+e^-\rightarrow q\bar{q}$

isotropic shape



$e^+e^-\rightarrow b\bar{b}$

different methods

Different methods proposed to study the $B \to D^0 K$ decays,

- **GLW method**:
  D^0 mesons reconstructed in two-body CP-eigenstate final states: K^+K^-, $\pi^+\pi^-$ (CP even) $K_s\pi^0$, $K_s\omega$ (CP odd)

- **ADS method**:
  D^0 mesons reconstructed in non CP-eigenstate final states: $K^-\pi^+$, $K^-\pi^+\pi^0$

more sensitive to r_B

- **GGSZ (Dalitz) method**:
  D^0 mesons reconstructed in three-body CP-eigenstate final states: $K_s\pi^+\pi^-$, $K_sK^+K^-$, $\pi^+\pi^-\pi^0$

the one that gives the best error on γ/φ_3

In the following I will concentrate on new/updated results

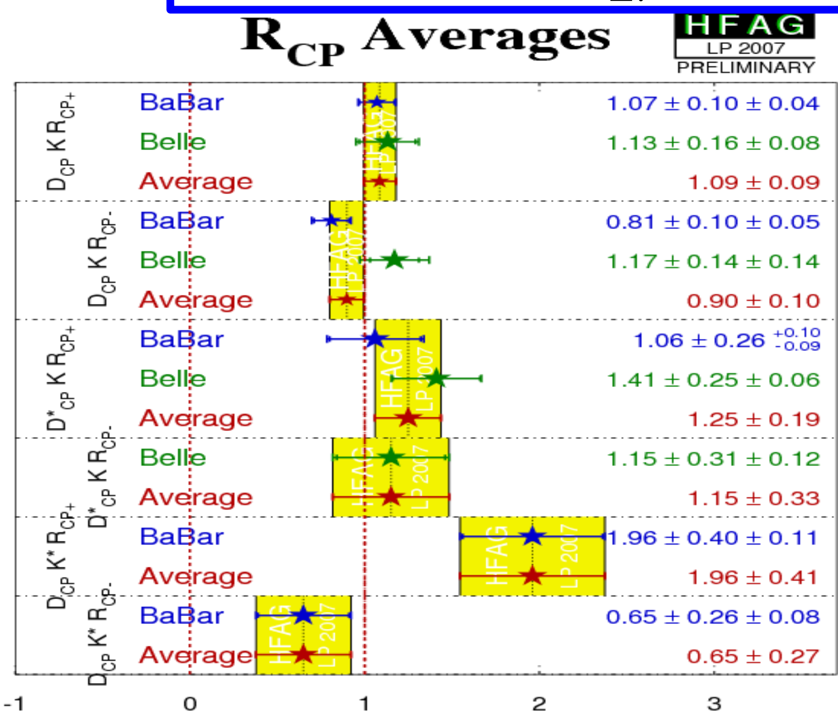
charged B: GLW results

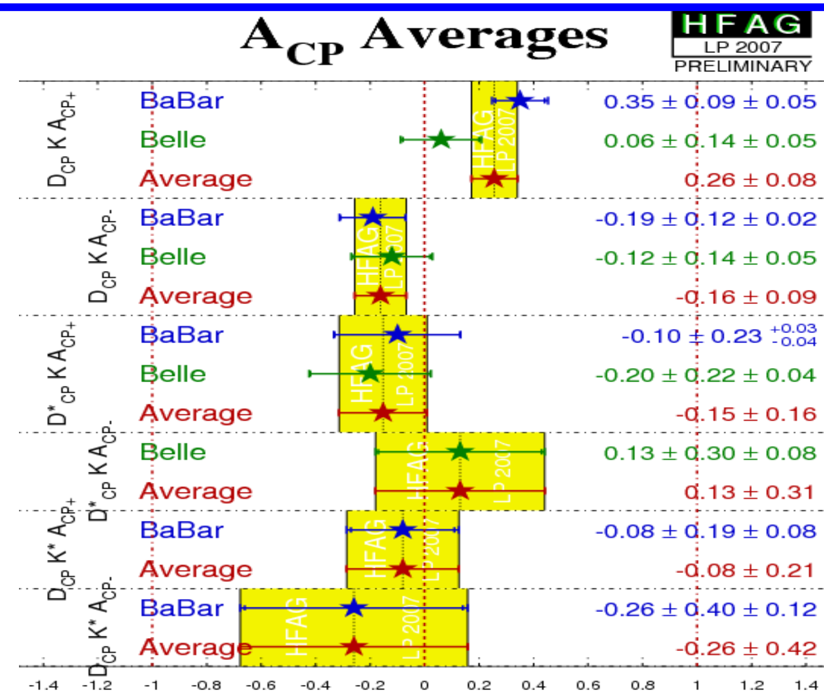
Gronau, London, Wyler - Phys.Rev.Lett. B265(1991) 172

Neutral D mesons reconstructed in CP-eigenstate final states (CP even: K^+K^-, $\pi^+\pi^-$ and CP odd $K_s\pi^0$, $K_S\omega$)

$$R_{CP^{\pm}}=\frac{\Gamma(B^+\rightarrow D^0_{\pm}K^+)+\Gamma(B^-\rightarrow D^0_{\pm}K^-)}{\Gamma(B^+\rightarrow D^0K^+)+\Gamma(B^-\rightarrow \bar{D}^0K^-)}=1+r_B^2\pm 2r_B\cos\gamma\cos\delta$$

$$A_{CP^{\pm}}=\frac{\Gamma(B^+\rightarrow D^0_{\pm}K^+)-\Gamma(B^-\rightarrow D^0_{\pm}K^-)}{\Gamma(B^+\rightarrow D^0_{\pm}K^+)+\Gamma(B^-\rightarrow D^0_{\pm}K^-)}=\frac{\pm 2r_B\sin\gamma\sin\delta}{R_{CP^{\pm}}}$$





$$D^0_{\pm}=\frac{1}{\sqrt{2}}(D^0\pm\bar{D}^0)$$

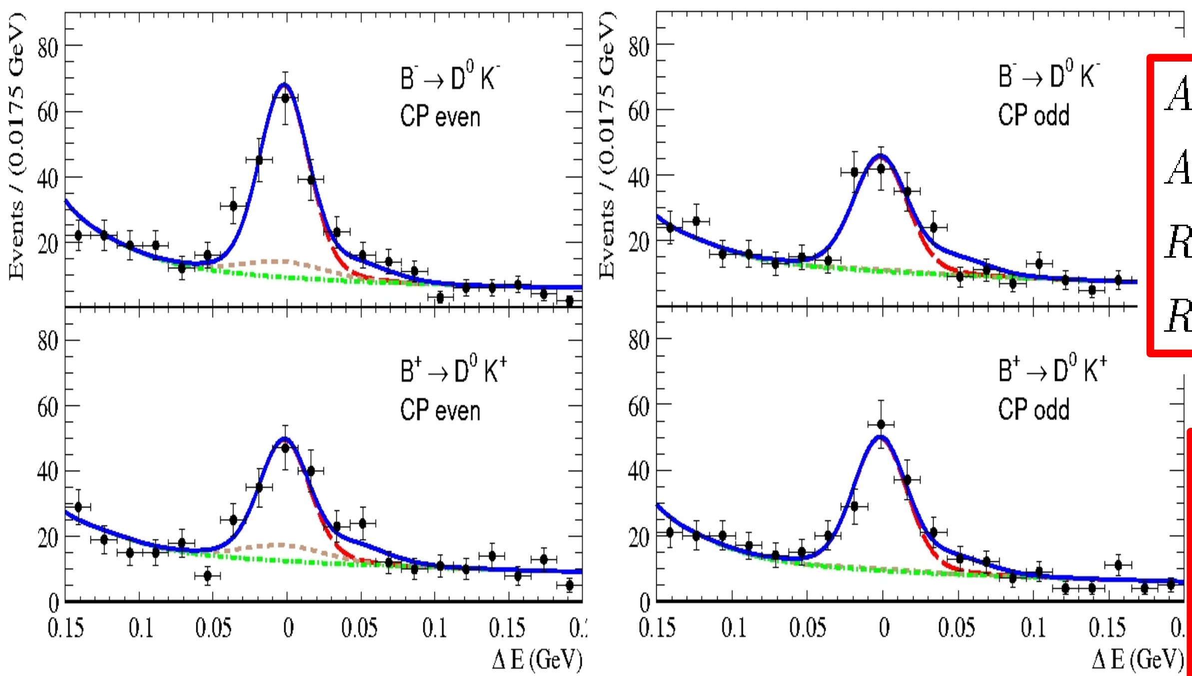
charged B: GLW results

UPDATED

arXiv:0802.4052

Update of the GLW analysis $B^- \to D^0 K^-$, with $D^0 \to K^+K^-$, $\pi^+\pi^-$, $K_s\pi^0$, $K_s\omega$ and $K^-\pi^+$ (for normalization) on **382M** of BB pairs

- cut on m_{ES} and event shape variables
- extended maximum likelihood fit to the ΔE and Cerenkov distribution



$$A_{CP+} = 0.27 \pm 0.09(\text{stat}) \pm 0.04(\text{syst})$$
$$A_{CP-} = -0.09 \pm 0.09(\text{stat}) \pm 0.02(\text{syst})$$
$$R_{CP+} = 1.06 \pm 0.10(\text{stat}) \pm 0.05(\text{syst})$$
$$R_{CP-} = 1.03 \pm 0.10(\text{stat}) \pm 0.05(\text{syst})$$

also expressed in terms of:

$$x_+ = -0.09 \pm 0.05(\text{stat}) \pm 0.02(\text{syst}),$$
$$x_- = +0.10 \pm 0.05(\text{stat}) \pm 0.03(\text{syst}),$$
$$r^2 = +0.05 \pm 0.07(\text{stat}) \pm 0.03(\text{syst}).$$

$$x_\pm = \frac{R_{CP+}(1 \mp A_{CP+}) - R_{CP-}(1 \mp A_{CP-})}{4}, \qquad r^2 = x_\pm^2 + y_\pm^2 = \frac{R_{CP+} + R_{CP-} - 2}{2},$$

charged B: ADS results

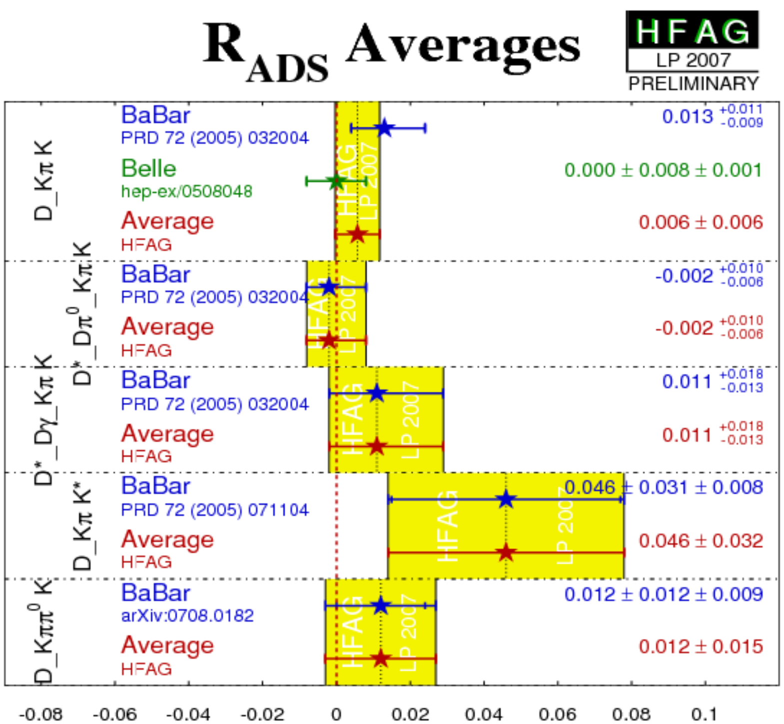
Atwood, Dunietz, Soni - Phys.Rev.Lett. 78, 3257 (1997) (hep-ph/9612433)

Neutral D mesons reconstructed in non CP-eigenstate final states f=$K^-\pi^+$, $K^-\pi^+\pi^0$

V_{ub} suppressed $B^+ \to D^{(*)0} K^+$ — favoured $D^0 \to f$

V_{cb} favoured $B^+ \to \bar{D}^{(*)0} K^+$ — suppressed $\bar{D}^0 \to f$

Same final state, sensitivity to the weak phase γ/φ_3



$$R_{ADS} = \frac{\Gamma(B^+ \to f K^+) + \Gamma(B^- \to \bar{f} K^-)}{\Gamma(B^+ \to \bar{f} K^+) + \Gamma(B^- \to f K^-)}$$

$$= r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D) \cos\gamma$$

$$A_{ADS} = \frac{\Gamma(B^+ \to \bar{f} K^+) - \Gamma(B^- \to f K^-)}{\Gamma(B^+ \to \bar{f} K^+) + \Gamma(B^- \to f K^-)}$$

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

typically not enough statistics to determine A_{ADS}

$$r_D = \left| \frac{A(\bar{D}^0 \to f)}{A(D^0 \to f)} \right|$$

ADS method useful to measure r_B, almost no sensitivity to γ/φ_3

charged B: ADS results

PRELIMINARY

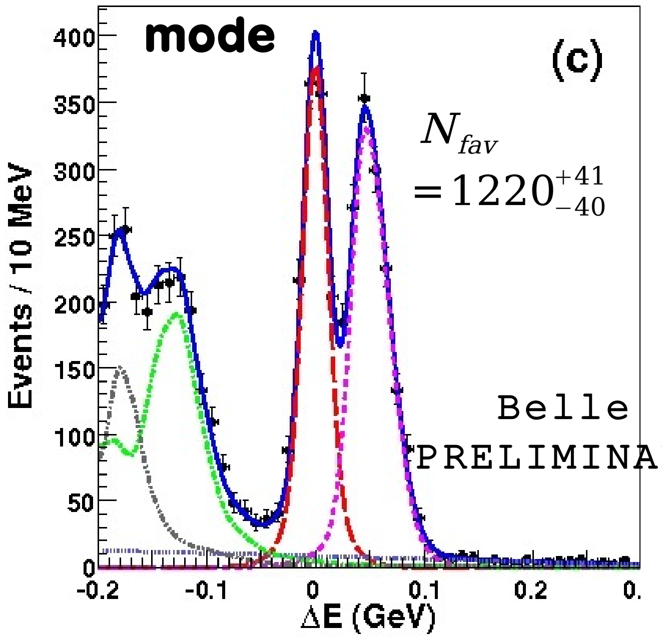
UPDATED

Update of the ADS analysis $B^- \to D^0 K^-$, with $D^0 \to K^- \pi^+$ on **657M** of BB pairs

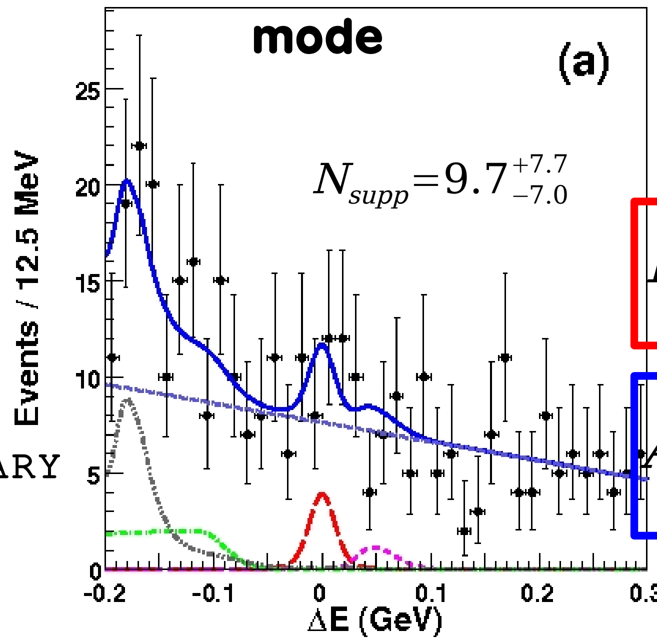
PRELIMINARY

- cut on M_{bc} and event shape variables
- extended maximum likelihood fit to the ΔE distribution

denominator mode



numerator mode



no significant ADS signal found

$$R_{ADS} = (8.0^{+6.3+2.0}_{-5.7-2.8})10^{-3}$$

$$A_{ADS} = -0.13^{+0.97}_{-0.88} \pm 0.26$$

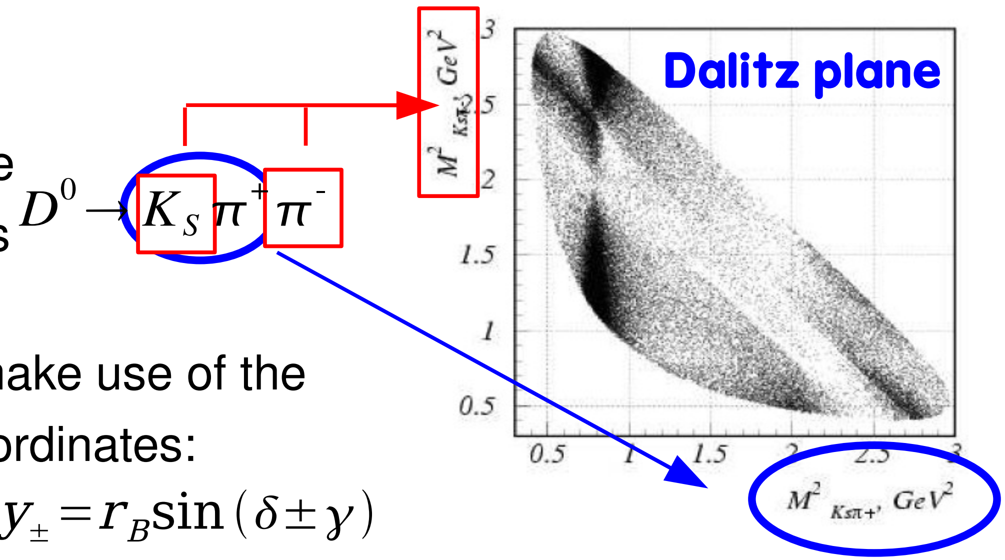
$$r_B < 0.19 \ @90\% \ C.L.$$

charged B: GGSZ results

Giri, Grossman, Soffer, Zupan – Phys.Rev. D68 (2003) 054018 (hep-ph/0303187)

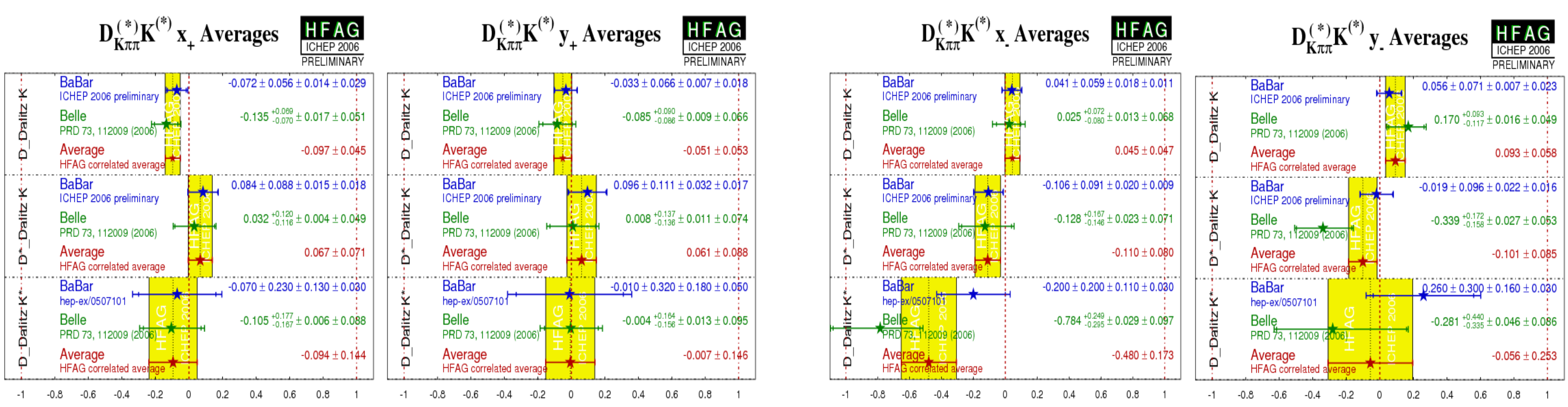
Neutral D mesons reconstructed in three-body CP-eigenstate final states (typically $D^0 \to K_S \pi^+ \pi^-$)

The complete structure (amplitudes and strong phases) of the D^0 decay in the phase space is obtained on independent data sets and used as input in the analysis.



These analyses make use of the cartesian coordinates:

$$x_\pm = r_B \cos(\delta \pm \gamma),\ y_\pm = r_B \sin(\delta \pm \gamma)$$



GGSZ Dalitz method best error on γ / φ_3

charged B: GGSZ results

PRELIMINARY

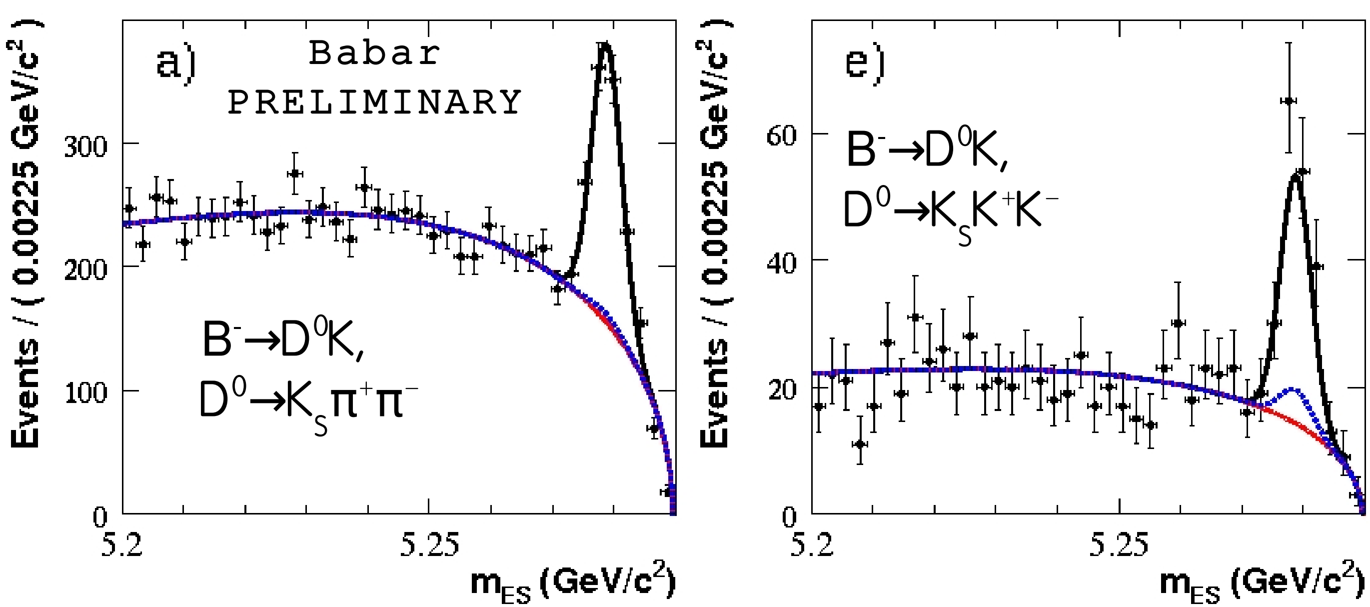
NEW

Update of the Dalitz analysis of $B^- \to D^0K^-$, $D^{*0}K$ and D^0K^{*-} with $D^0 \to K_S\pi^+\pi^-$

and, **for the first time, $D^0 \to K_SK^+K^-$** (no D^0K^{*-}). Also reconstructed control samples: $B^- \to D^0\pi^-$, $D^{*0}\pi^-$ and $D^0a_1^-$

Analysis performed on **383M** of BB pairs

- m_{ES}, ΔE and shape variables are used in a maximum likelihood fit to discriminate between signal and background
- D^0 Dalitz distributions determined on independent data samples and used as an input in the fit
- CP fit for extraction of cartesian coordinates for DK, D*K and DK*



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charged B: GGSZ results

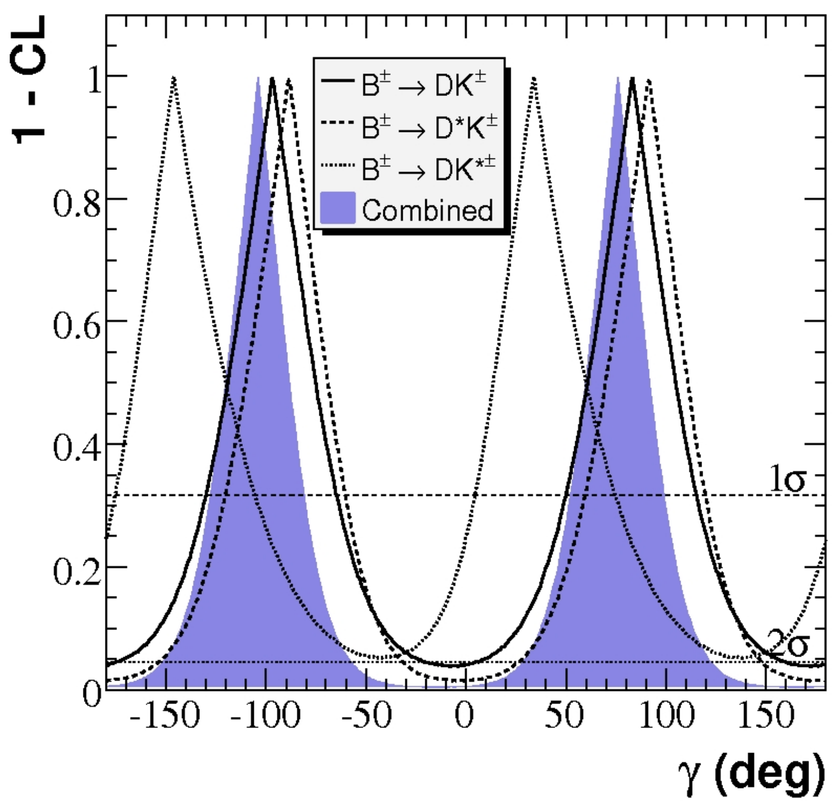
NEW

PRELIMINARY

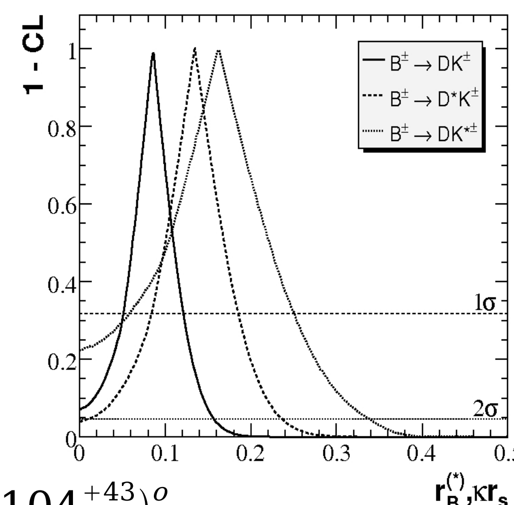
Results for the cartesian coordinates

(statistical, systematic and model errors included)

Parameters	$B^- \to \tilde{D}^0 K^-$	$B^- \to \tilde{D}^{*0} K^-$	$B^- \to \tilde{D}^0 K^{*-}$
x_- , x_-^* , x_{s-}	$0.090 \pm 0.043 \pm 0.015 \pm 0.011$	$-0.111 \pm 0.069 \pm 0.014 \pm 0.004$	$0.115 \pm 0.138 \pm 0.039 \pm 0.014$
y_- , y_-^* , y_{s-}	$0.053 \pm 0.056 \pm 0.007 \pm 0.015$	$-0.051 \pm 0.080 \pm 0.009 \pm 0.010$	$0.226 \pm 0.142 \pm 0.058 \pm 0.011$
x_+ , x_+^* , x_{s+}	$-0.067 \pm 0.043 \pm 0.014 \pm 0.011$	$0.137 \pm 0.068 \pm 0.014 \pm 0.005$	$-0.113 \pm 0.107 \pm 0.028 \pm 0.018$
y_+ , y_+^* , y_{s+}	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$	$0.080 \pm 0.102 \pm 0.010 \pm 0.012$	$0.125 \pm 0.139 \pm 0.051 \pm 0.010$



$$\gamma/\phi_3 = (76^{+23}_{-24})^o (mod.\,180^o)$$
$$r_B(DK) = 0.086 \pm 0.035$$
$$r_B(D*K) = 0.135 \pm 0.051$$
$$r_S(DK*) = 0.181^{+0.100}_{-0.118}$$



$\delta(DK) = (109^{+28}_{-31})^o$, $\delta(D^* K) = (-63^{+28}_{-30})^o$, $\delta(DK^*) = (104^{+43}_{-41})^o$

charged B: GGSZ results

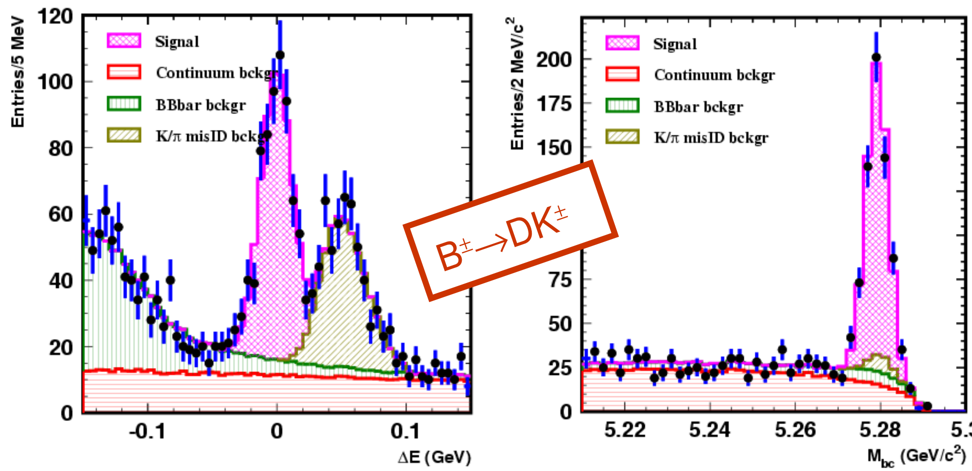
PRELIMINARY

UPDATED

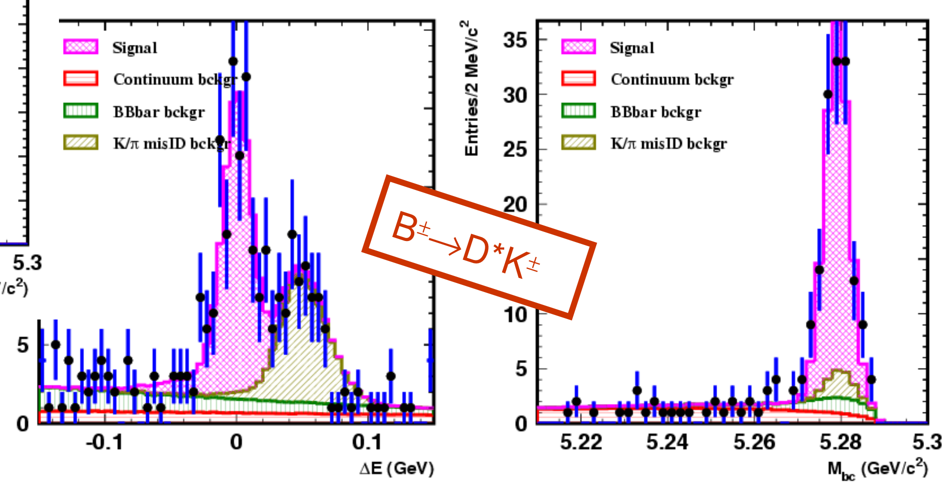
Update of the Dalitz analysis of $B^- \to D^0 K^-$ and $D^{*0}K$, with $D^0 \to K_S \pi^+ \pi^-$ and $D^{*0} \to D^0 \pi^0$.

Analysis performed on **635M** of BB pairs

- M_{bc}, ΔE and shape variables are used in a maximum likelihood fit to discriminate between signal and background
- D^0 Dalitz structure used as an external input
- CP fit for extraction of cartesian coordinates for DK and D*K

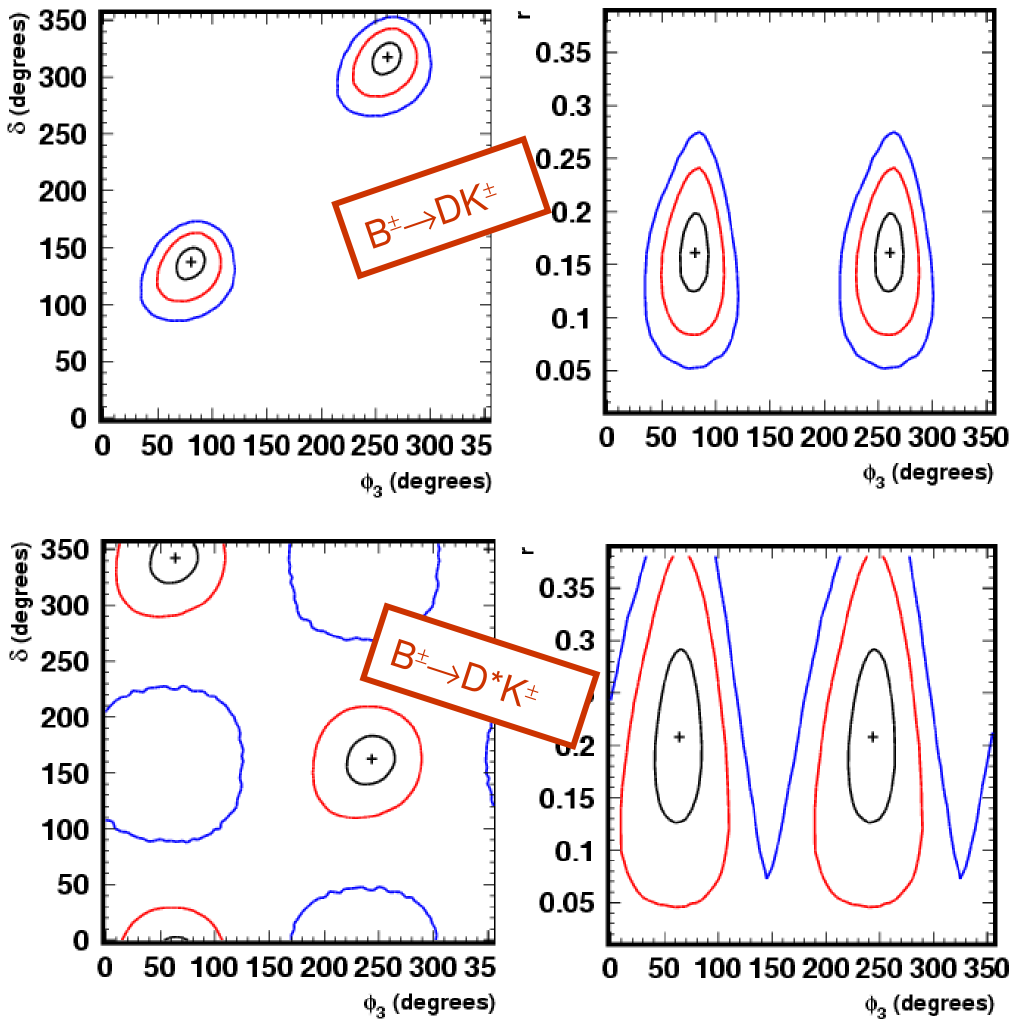


Belle PRELIMINARY



charged B: GGSZ results

PRELIMINARY



Results for the cartesian coordinates (errors are statistical and experimental systematics, model error not included):

Parameter	$B^+ \to DK^+$	$B^+ \to D^* K^+$
x_-	$+0.105 \pm 0.047 \pm 0.011$	$+0.024 \pm 0.140 \pm 0.018$
y_-	$+0.177 \pm 0.060 \pm 0.018$	$-0.243 \pm 0.137 \pm 0.022$
x_+	$-0.107 \pm 0.043 \pm 0.011$	$+0.133 \pm 0.083 \pm 0.018$
y_+	$-0.067 \pm 0.059 \pm 0.018$	$+0.130 \pm 0.120 \pm 0.022$

model error estimate is the same as in previous analysis

$$\gamma/\phi_3 = (76^{+12}_{-13} \pm 4 \pm 9)^o (mod. 180^o)$$
$$r_B(DK) = 0.16 \pm 0.04 \pm 0.01 \pm 0.05$$
$$r_B(D*K) = 0.21 \pm 0.08 \pm 0.02 \pm 0.05$$

$$\delta(DK) = (136^{+14}_{-16} \pm 4 \pm 23)^o$$
$$\delta(D^* K) = (343^{+20}_{-22} \pm 4 \pm 23)^o$$
$$(mod. 180^o)$$

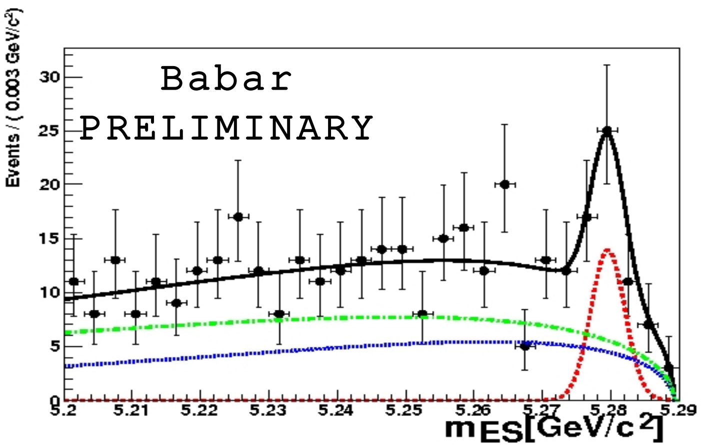
neutral B: new results on γ

PRELIMINARY

NEW

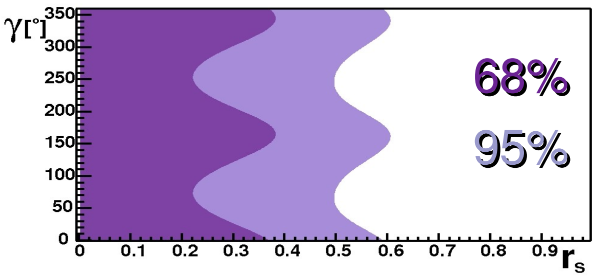
Analysis of $B^0 \to D^0 K^{*0}$, with $D^0 \to K_S \pi^+ \pi^-$ and $K^{*0} \to K^- \pi^+$. The charge of the K from the K* tags the flavor of the B^0, no time-dependent analysis is needed.
First analysis extracting γ from neutral $B^0 \to D^0 K^{*0}$ decays.
Analysis performed on **371M** of BB pairs

- m_{ES} and shape variables are used in a maximum likelihood fit to discriminate between signal and background
- D^0 Dalitz distribution used as an input in the fit
- CP fit for extraction of a 3D likelihood for γ, r_S, δ.



$$\gamma/\phi_3 = (162 \pm 56)^o (mod.\ 180^o)$$
$$r_S(D^0 K^{*0}) < 0.55\ @95\%\ prob.$$

BABAR



Combined with the likelihood for r_s from B.Aubert et al (Babar coll.) Phys.Rev. D74, 031101 (2006)

neutral B: new results on 2β+γ

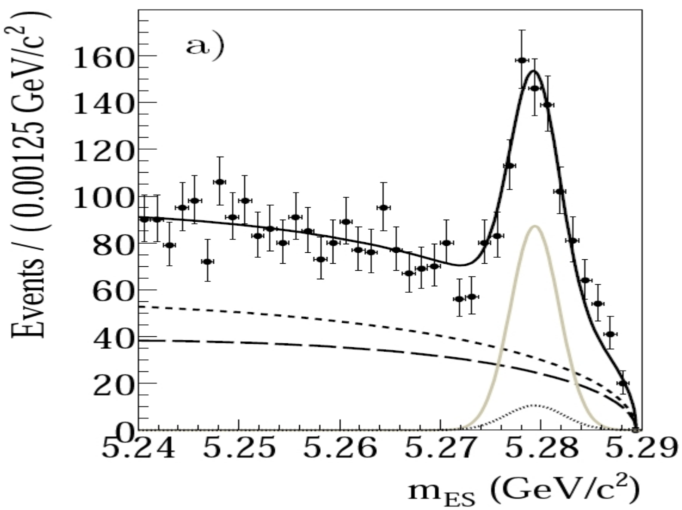
arXiv:0712.3469, accepted by PRD

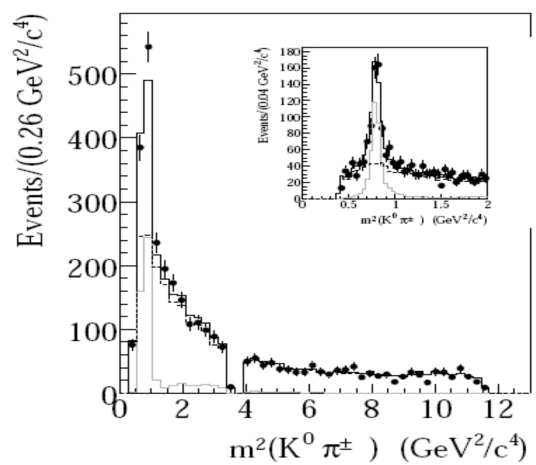
NEW

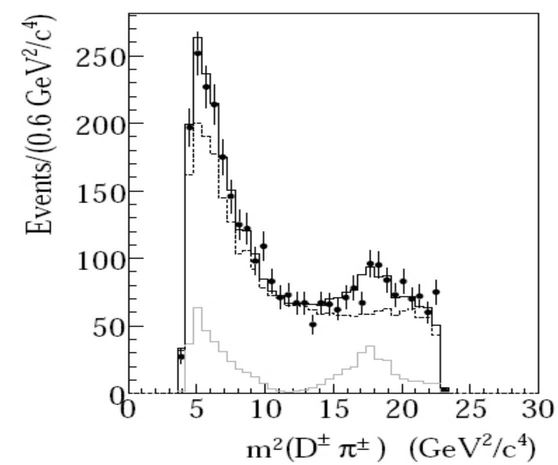
Time dependent Dalitz plot analysis of $B^0 \to D^- K^0 \pi^+$.

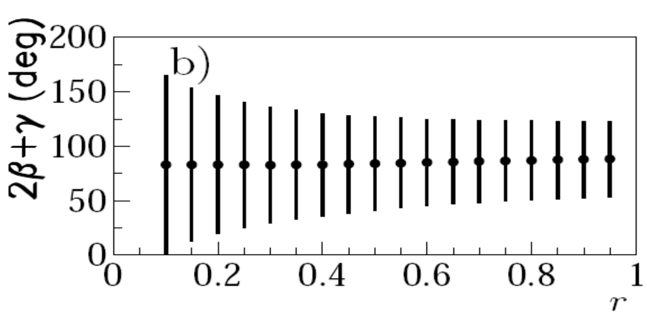
Three-body B decay. Interference between b→u and b→c transitions through the mixing: sensitivity to 2β+γ. Analysis performed on **347M** of BB pairs

- m_{ES}, ΔE and shape variables are used in a maximum likelihood fit to discriminate between signal and background
- time dependent fit to the B^0 Dalitz distribution assuming r_B=0.3





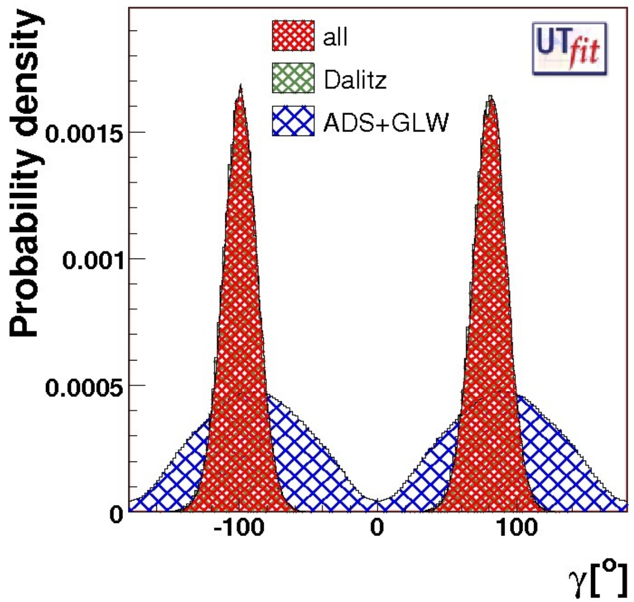




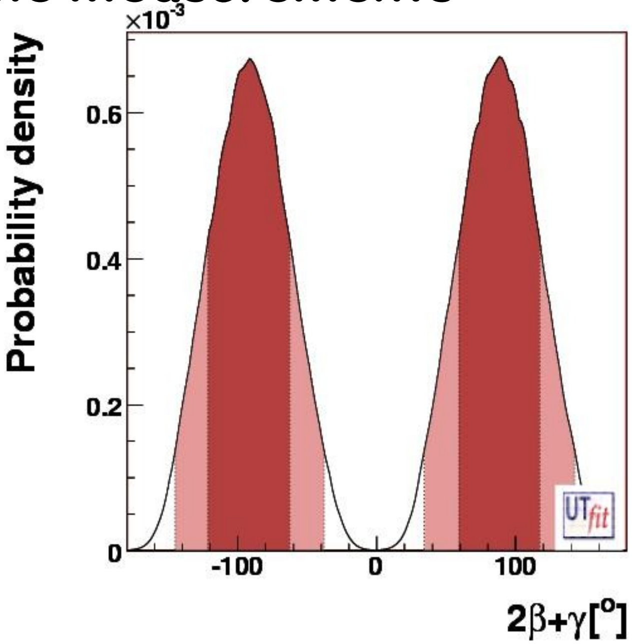
$$2\beta+\gamma/(2\phi_1+\phi_3)=(83\pm53\pm20)^o(mod. 180^o)$$

combining them all

Babar + Belle, from the combination of all the measurements

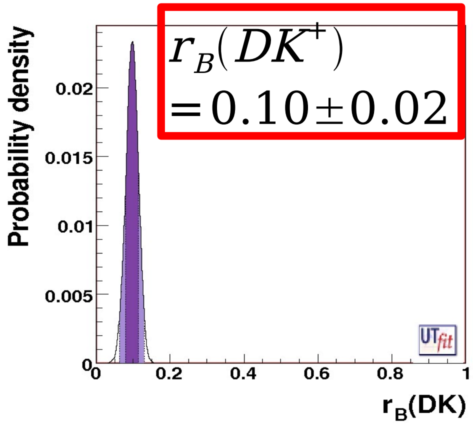


WOLRD AVERAGE (all new measurements here presented are included)

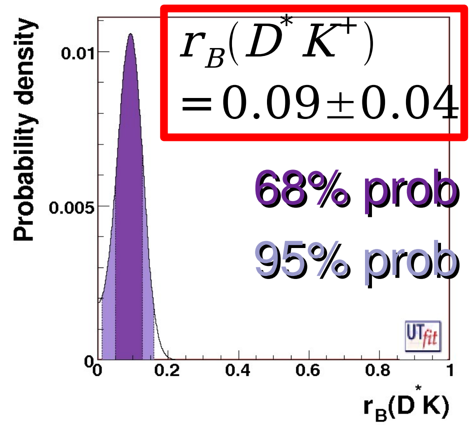


$$\gamma/\phi_3 = (80 \pm 13)^o (mod. 180^o)$$

$$2\beta + \gamma = (88 \pm 29)^o (mod. 180^o)$$



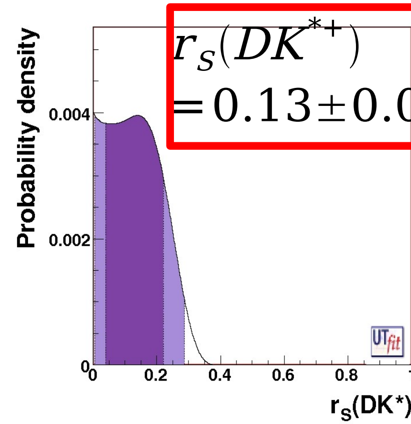
$r_B(DK^+) = 0.10 \pm 0.02$



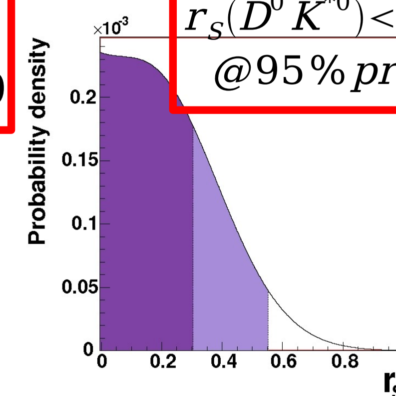
$r_B(D^* K^+) = 0.09 \pm 0.04$

68% prob

95% prob



$r_S(DK^{*+}) = 0.13 \pm 0.09$



$r_S(D^0 K^{*0}) < 0.55$ @95% prob.

conclusions

- both in Belle and Babar efforts to constrain γ/φ_3 in many ways
- r_B ratios confirmed to be small (~ 0.1)
- despite the small values of the r_B ratios, γ/φ_3 is now known with a precision (13°) that was not expected to be accessible at the B-factories
- the actual error comes from the combination of many methods in several channels

Backup slides

CPV in the SM

Field theory that describes strong, weak and electromagnetic interactions in terms of gauge group theories, starting from the elementary particles.

gauge group

strong interactions

$$SU(3) \times SU(2) \times U(1)$$

electroweak interactions

color symmetry (strong interactions)

isospin symmetry (weak)

hypercharge svmmetrv

6 leptons (antipleptons), in three families $\begin{pmatrix} \nu_e \\ e \end{pmatrix}, \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}, \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}$

6 quarks (antiquarks), in three families $\begin{pmatrix} u \\ d \end{pmatrix}, \begin{pmatrix} c \\ s \end{pmatrix}, \begin{pmatrix} t \\ b \end{pmatrix}$

Parity :

$$P(t, \vec{x}) = (t, -\vec{x})$$

Charge conjugation: particle → antiparticle

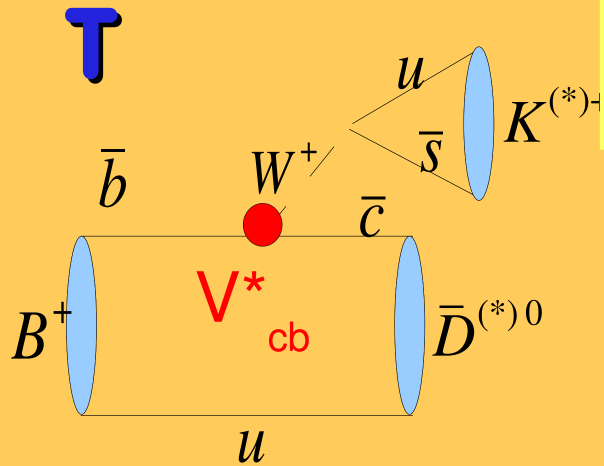
CP violation discovered in 1964 in the K rare decays and then confirmed by the B-factories results

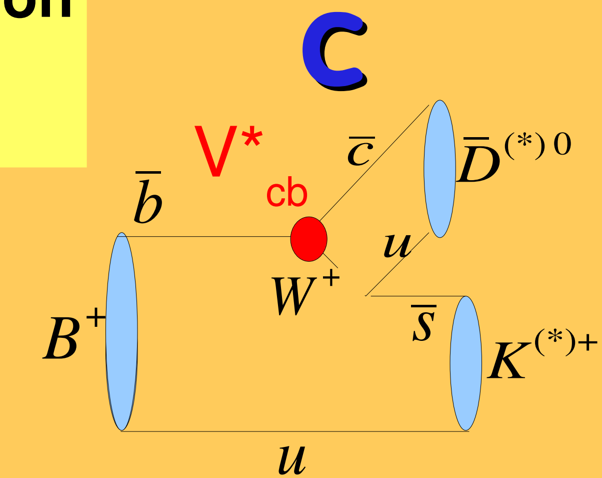
all the diagrams

CHARGED B

b→c transistion

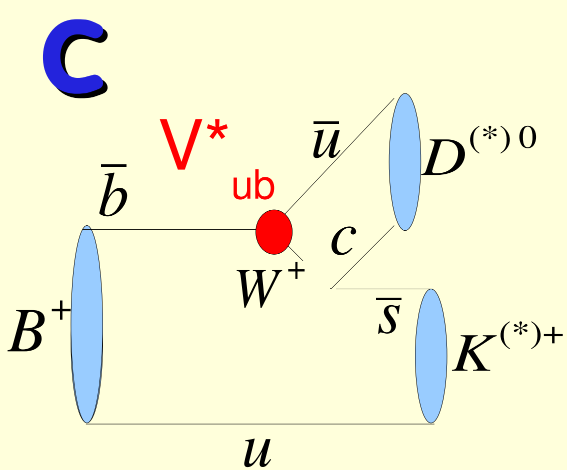
$$B^+ \to \bar{D}^0 K^+$$

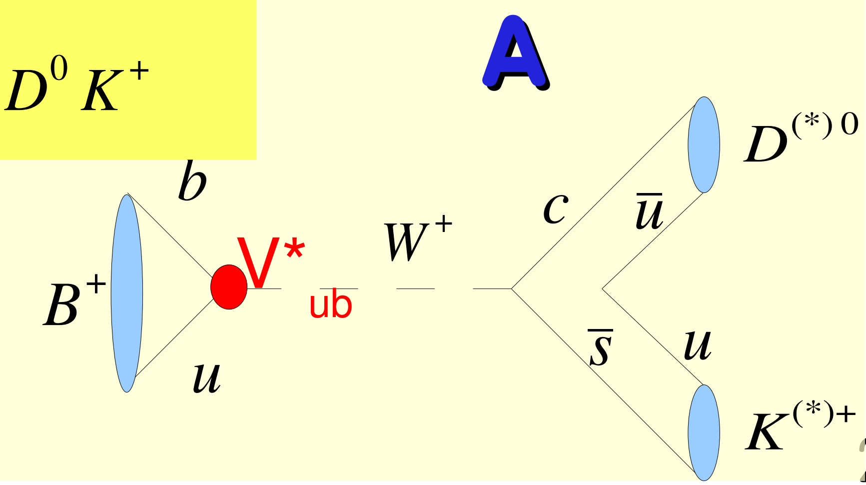




b→u transistion

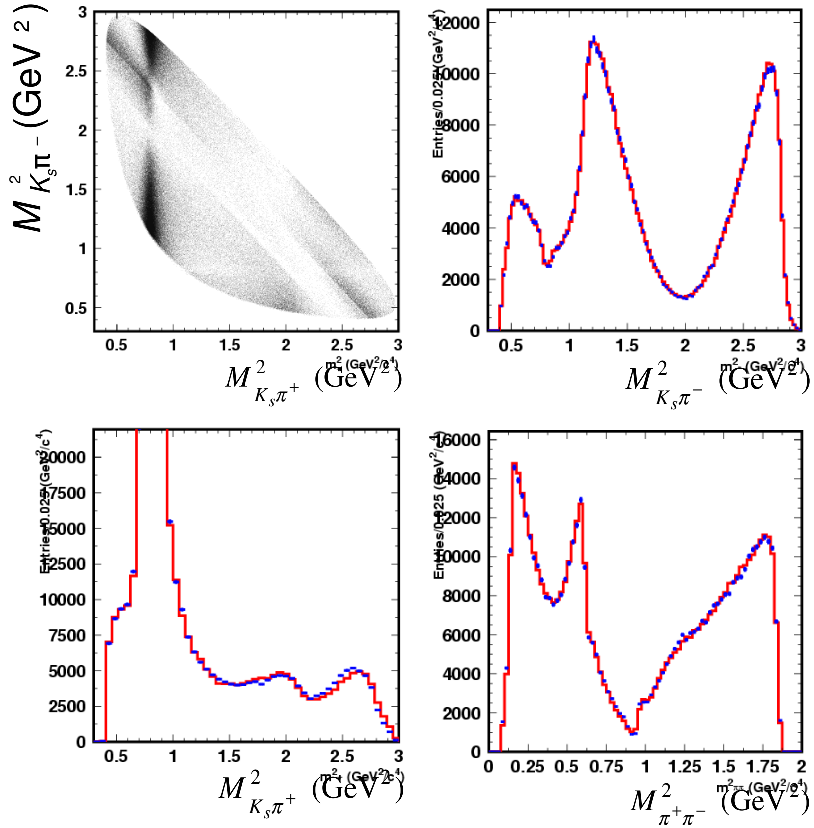
$$B^+ \to D^0 K^+$$





$D^0 \to K_s \pi^+ \pi^-$ amplitude fit (Belle)

Quasi two-body model is used as a baseline. K-matrix for systematics test.



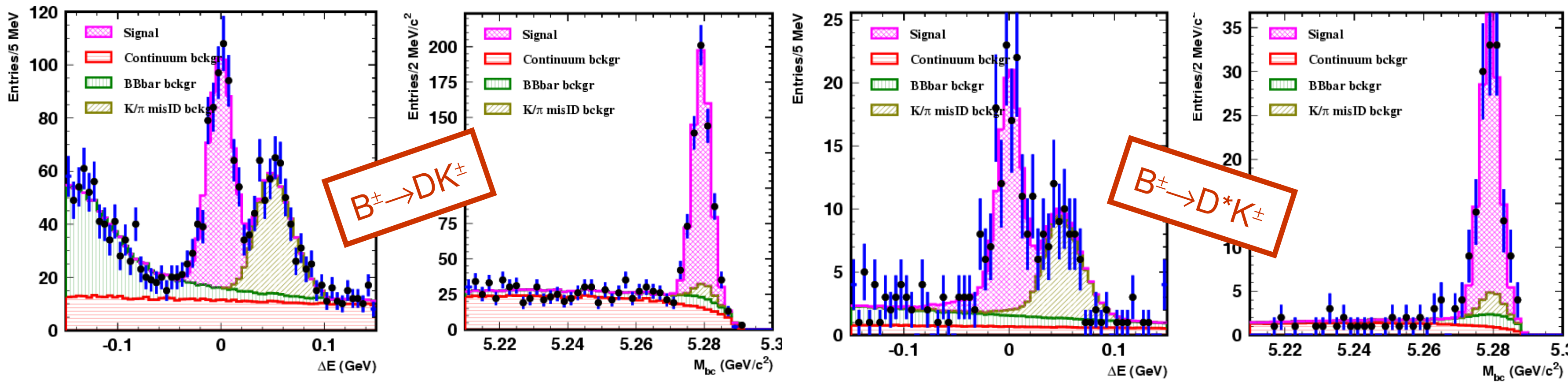
σ_1(M=522±6 MeV, Γ=453±10 MeV)

σ_2(M=1033±7 MeV, Γ=88±7 MeV)

Intermediate state	Amplitude	Phase, °
$K_s\,\sigma_1$	1.56±0.06	214±3
$K_s\,\rho(770)$	1 (fixed)	0 (fixed)
$K_s\,\omega$	0.0343±0.0008	112.0±1.3
$K_s\,f_0(980)$	0.385±0.006	207.3±2.3
$K_s\,\sigma_2$	0.20±0.02	212±12
$K_s\,f_2(1270)$	1.44±0.04	342.9±1.7
$K_s\,f_0(1370)$	1.56±0.12	110±4
$K_s\,\rho(1450)$	0.49±0.08	64±11
$K^*(892)^+\pi^-$	1.638±0.010	133.2±0.4
$K^*(892)^-\pi^+$	0.149±0.004	325.4±1.3
$K^*(1410)^+\pi^-$	0.65±0.05	120±4
$K^*(1410)^-\pi^+$	0.42±0.04	253±5
$K^*_0(1430)^+\pi^-$	2.21±0.04	358.9±1.1
$K^*_0(1430)^-\pi^+$	0.36±0.03	87±4
$K^*_2(1430)^+\pi^-$	0.89±0.03	314.8±1.1
$K^*_2(1430)^-\pi^+$	0.23±0.02	275±6
$K^*(1680)^+\pi^-$	0.88±0.27	82±17
$K^*(1680)^-\pi^+$	2.1±0.2	130±6
Nonresonant	2.7±0.3	160±5

$B^- \to D^{(*)}K^-$ signal (Belle)

605 fb^{-1} data sample [preliminary]



- $|\Delta E|<30$ MeV
- $M_{bc}>5.27$ GeV/c^2
- $|M_{K_S\pi\pi}-M_D|<11$ MeV/c^2
- $144.9 < \Delta M < 145.9$ MeV/c^2 ($B\to D^*K$ only)
- Continuum rejection variables $\cos\theta_{thr}$, "virtual calorimeter" Fisher discriminant:

  $|\cos\theta_{thr}|<0.8$, $F>-0.7$ in M_{bc}, ΔE fit to determine background composition.

  Whole range is used in Dalitz fit, included into likelihood.

756 events, 29% background ($B\to DK$). In "clean" signal region

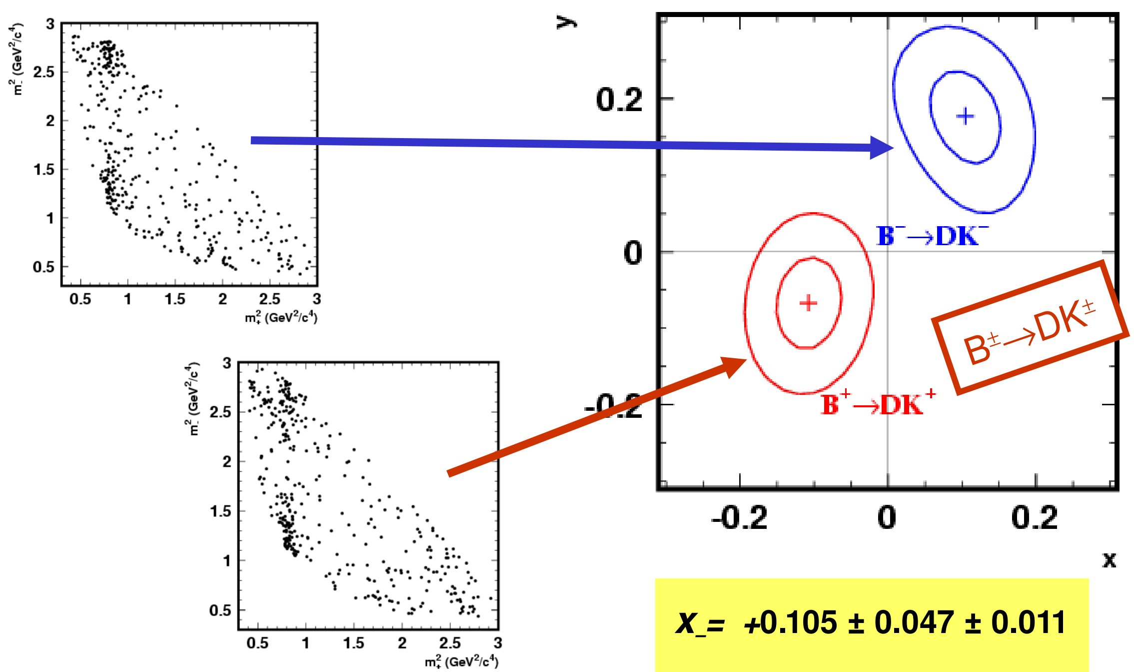
149 events, 20% background ($B\to D^*K$). ($|\cos\theta_{thr}|<0.8$, $F>-0.7$)

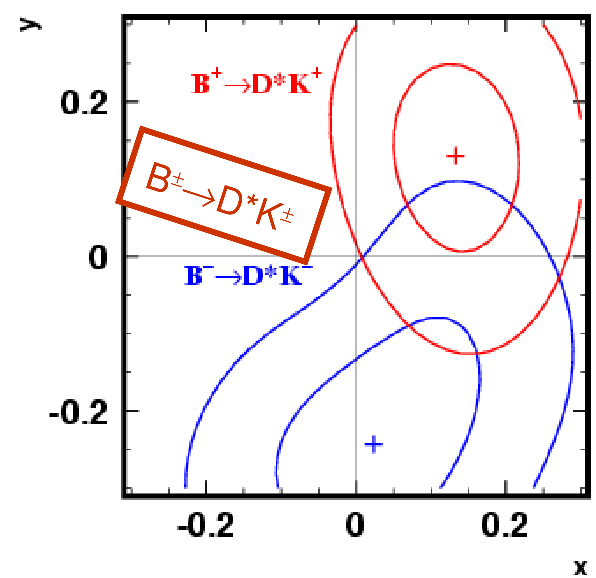
$(x_\pm, y_\pm)$ fit results (Belle)

Fit parameters are $x_\pm = r_B \cos(\pm\varphi_3+\delta)$ and $y_\pm = r_B \sin(\pm\varphi_3+\delta)$ [preliminary]

Unbinned maximum likelihood fit with event-by-event background treatment

(ΔE, M_{bc}, $|\cos\theta_{thr}|$, F included into likelihood)





Errors are statistical and experimental systematic. Model error not included.

$x_- = +0.105 \pm 0.047 \pm 0.011$

$y_- = +0.177 \pm 0.060 \pm 0.018$

$x_+ = -0.107 \pm 0.043 \pm 0.011$

$y_+ = -0.067 \pm 0.059 \pm 0.018$

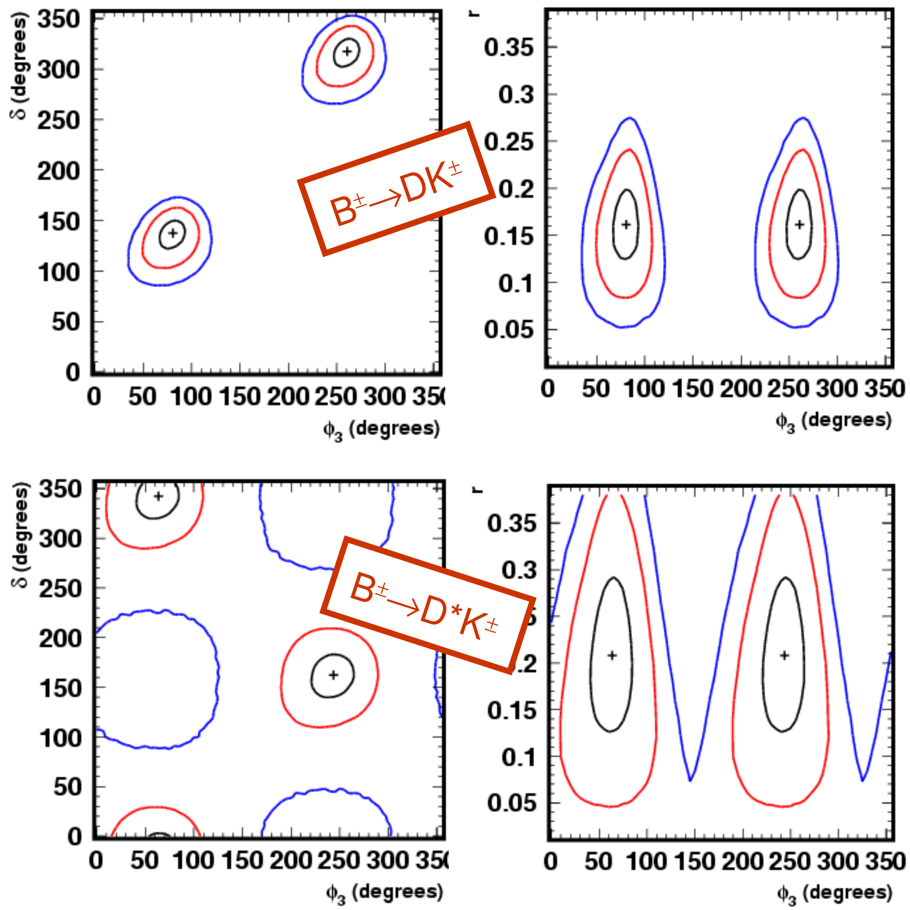
$x_- = +0.024 \pm 0.140 \pm 0.018$

$y_- = -0.243 \pm 0.137 \pm 0.022$

$x_+ = +0.133 \pm 0.083 \pm 0.018$

$y_+ = +0.130 \pm 0.120 \pm 0.022$

φ_3 constraints



[preliminary]

B±→DK± only:

$\varphi_3 = 81^{+13}_{-15}$ °±5°(syst)±9°(model)

B±→D*K± only:

$\varphi_3 = 64^{+21}_{-23}$ °±4°(syst)±9°(model)

B±→DK± , B±→D*K± combined:

$\varphi_3 = 76^{+12}_{-13}$ °±4°(syst)±9°(model)

r_{DK}=0.16±0.04±0.01(syst)±0.05(model)

r_{D^*K}=0.21±0.08±0.01(syst)±0.05(model)

$\delta_{DK} = 136^{+14}_{-16}$ °±4°(syst)±23°(model)

$\delta_{D^*K} = 343^{+20}_{-22}$ °±4°(syst)±23°(model)

Model error estimate is the same as in previous analysis.

Stat. confidence level of CPV is $(1-5.5\cdot10^{-4})$ or 3.5σ !