CP Violation in the B system

Outline:

- Mixing induced CPV and B_s mixing phase ϕ_s 

- Search for CPV in B_s mixing
- Direct CPV in $B \to DK$ and CKM phase γ
- Direct CPV in charmless B decays

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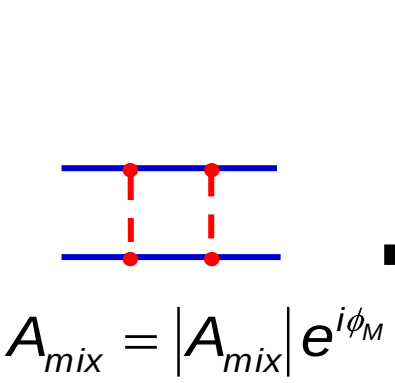
Heidelberg University

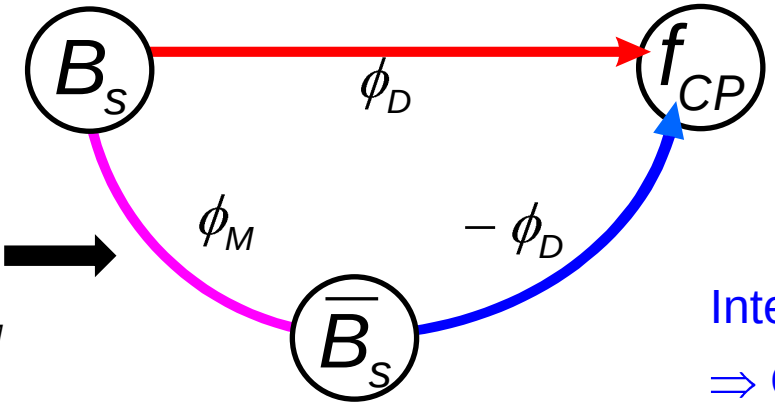
On behalf of the LHCb Collaboration

La Thuile 2013

Mixing induced CP Violation and ϕ_s



$$A_{mix} = |A_{mix}| e^{i\phi_M}$$

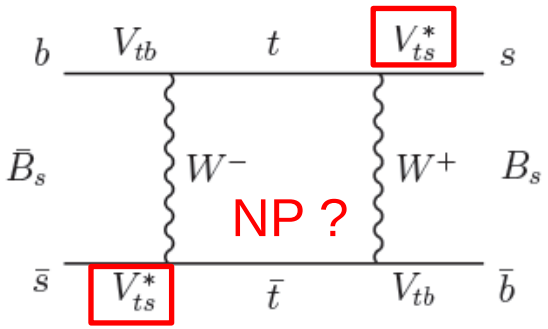


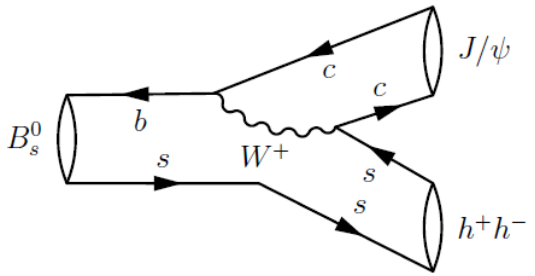
$B_s \to J/\psi\ \phi(KK)$
$B_s \to J/\psi\ \pi\pi$

Interference of mixing & decay:

$\Rightarrow$ CPV phase $\phi_s = \phi_M + 2\phi_D$

Standard Model:





+ small penguin pollution

$$\phi_D^{SM} = -2\arg\left(V_{cs}V_{cb}^*\right) \approx 0$$

Precise prediction: $\phi_s^{SM} = -0.0364 \pm 0.0016$ rad *(CKMFitter)*

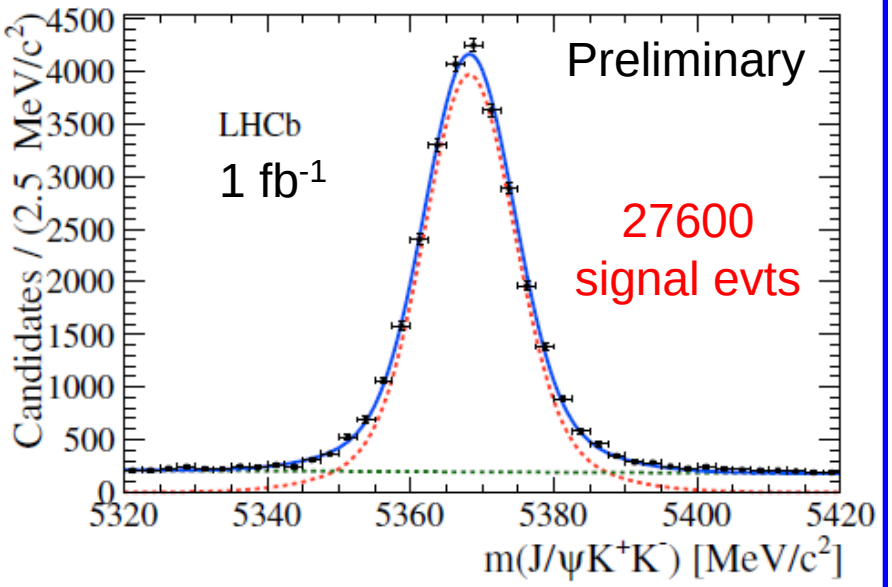
Possible New Physics contribution: $\phi_s = \phi_s^{SM} + \Delta\phi_s^{NP}$

$B_s \rightarrow J/\psi\,(\mu\mu)\,\phi(KK)$

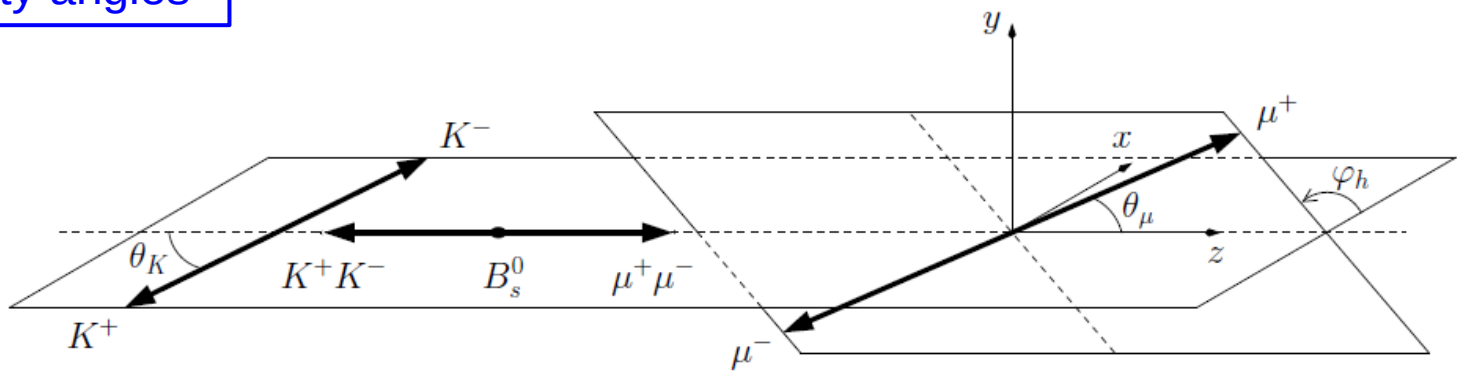
new

LHCb-Paper-2013-002
to be submitted to PRD

- experimentally clean
- VV final state: angular analysis to separate CP even/odd components
- Use helicity frame to describe decay angles ($\cos\theta_K$, $\cos\theta_{\mu,}$ ϕ_h)
- Non-resonant KK (s-wave) comp.: CP odd



Helicity angles



Analysis procedure

Unbinned maximum likelihood fit to proper time and angular distributions:

$$S(\lambda, t, \Omega) = \epsilon(t, \Omega) \cdot \left[\left(\frac{1+qD}{2} \cdot P_B(\lambda, t, \Omega) + \frac{1-qD}{2} \cdot \overline{P_B}\,(\lambda, t, \Omega) \right) \otimes R_t \right]$$

Ingredients:

Proper time and angular acceptance — tagging — Proper time resolution

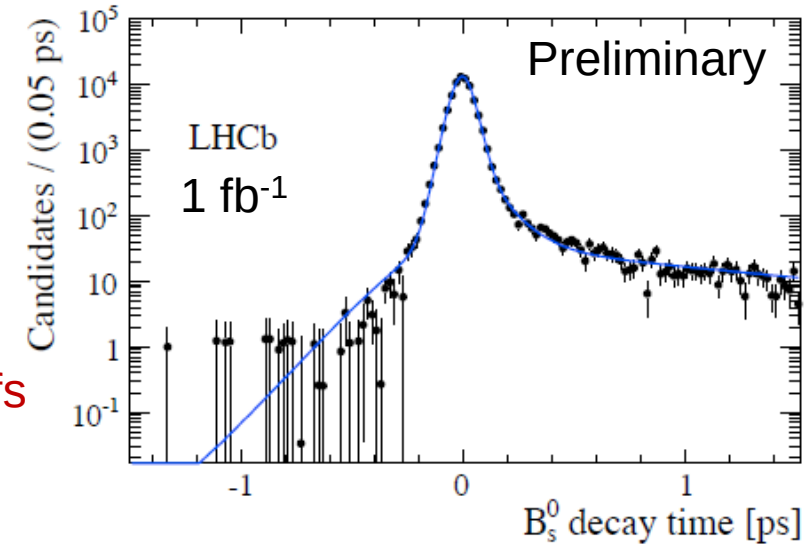
Acceptance correction:

- Proper time acceptance from data
- Angular acceptance from simulation

Proper time resolution:

- Calibration of per-event error w/ prompt J/ψ's + random tracks

$\sigma_t \approx 45$ fs



Flavor Tagging

LHCb-Paper-2013-002

Preliminary

new

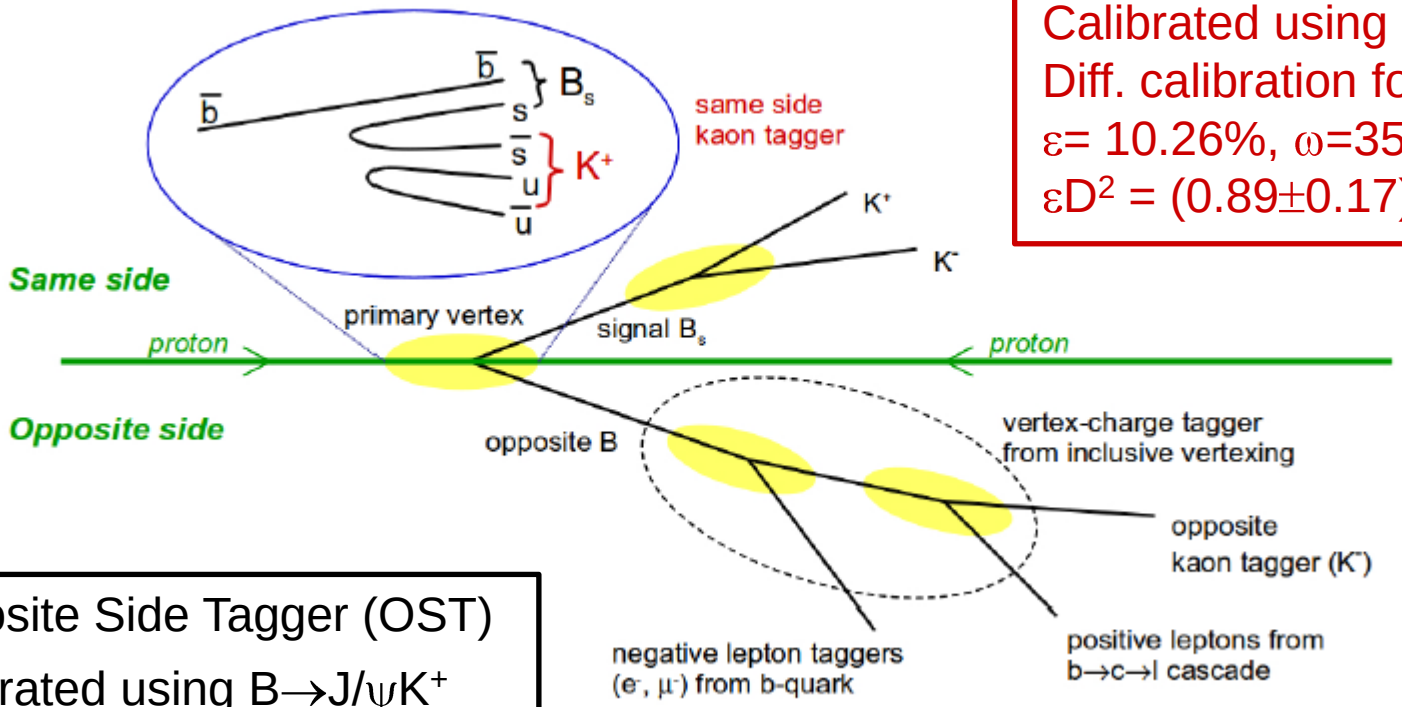
Same Side Kaon Tagger

Calibrated using $B_s \to D_s \pi$

Diff. calibration for B_s / $\overline{B}_s$

ε= 10.26%, ω=35.27%

εD^2 = (0.89±0.17)%



Opposite Side Tagger (OST)

Calibrated using $B \to J/\psi K^+$

Different calibration for $B/\overline{B}$

ε = 33.00%, ω=36.83%

εD^2 = (2.29 ± 0.06)%

Combined tagging performance

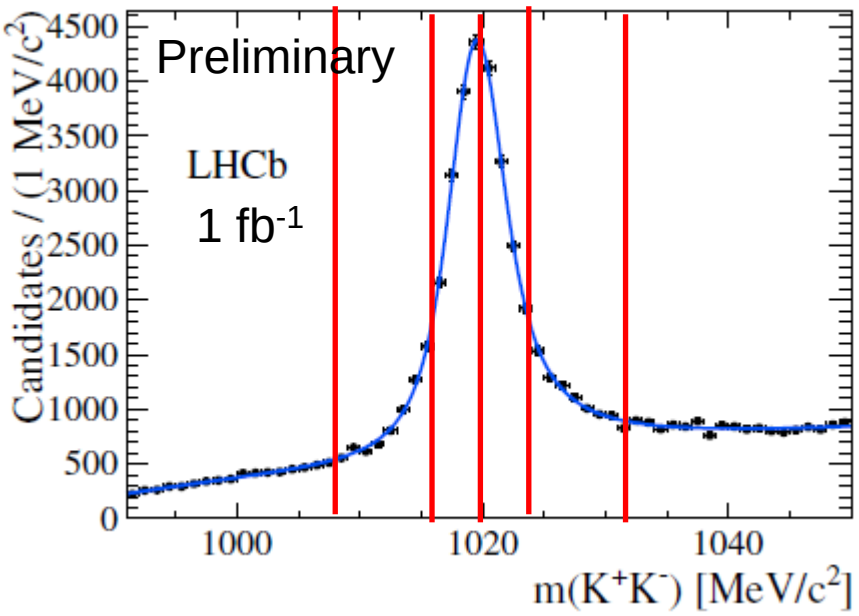
ε = 39.36%, ω=35.9%

εD^2 = (3.13±0.23)%

Fitting procedure

- sFit approach to fit only signal events
- Fit in 6 bin of KK-mass:
  different s-wave component and
  p and s wave phase difference
- Account for KK-mass dependence of the p+s wave interference terms:
  KK-mass dependent corrections C_{SP}
- Allow for CPV in decay by fitting for:
  $|\lambda| \neq 1 \Leftrightarrow$ CPV in decay

$$\lambda = \eta_{CP} \frac{q}{p} \frac{\overline{A}_f}{A_f}$$



Sign of $\Delta\Gamma$

new

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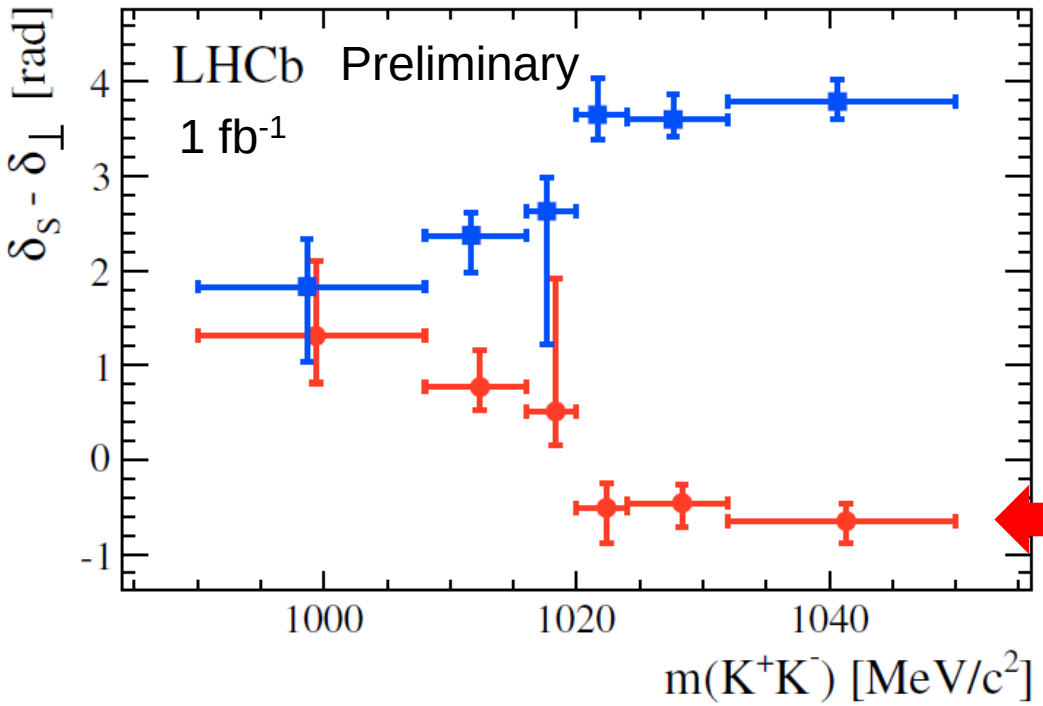
Invariance: $(\phi_s, \Delta\Gamma_s, \delta_0, \delta_{//}, \delta_\perp, \delta_s) \Leftrightarrow (\pi-\phi_s, -\Delta\Gamma_s, -\delta_0, -\delta_{//}, \pi-\delta_\perp, -\delta_s)$

→ Resolved via m_{KK} dependent phase difference between p and s-wave (resonant p-wave contribution changes phase from $-\pi/2 \rightarrow +\pi/2$)



Physical solution

$\Delta\Gamma_s > 0$

Results

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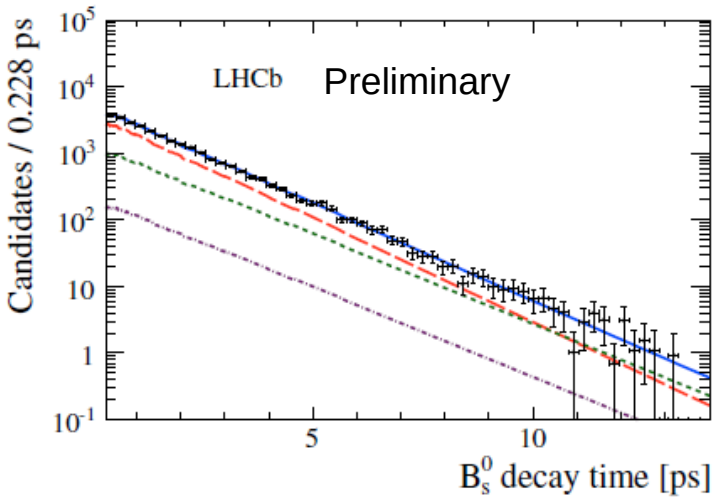
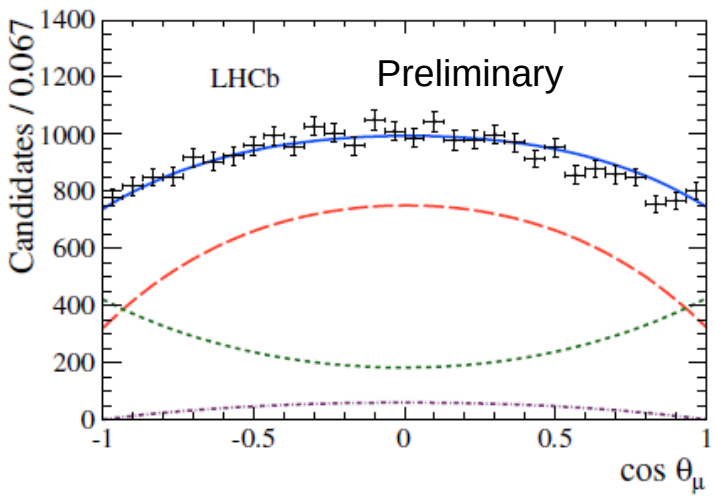
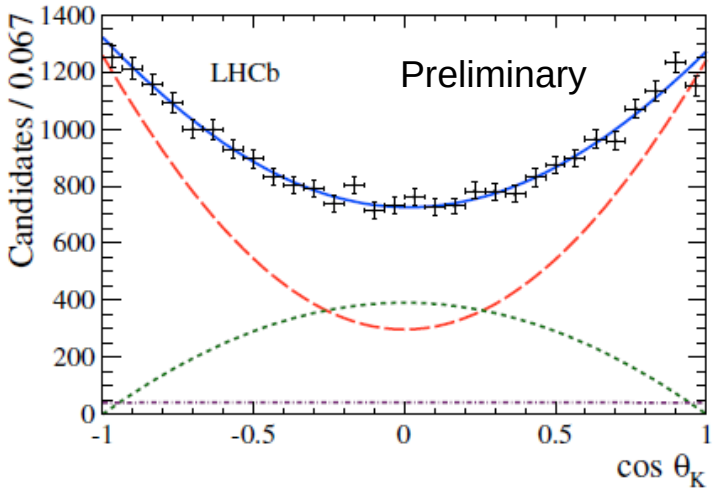
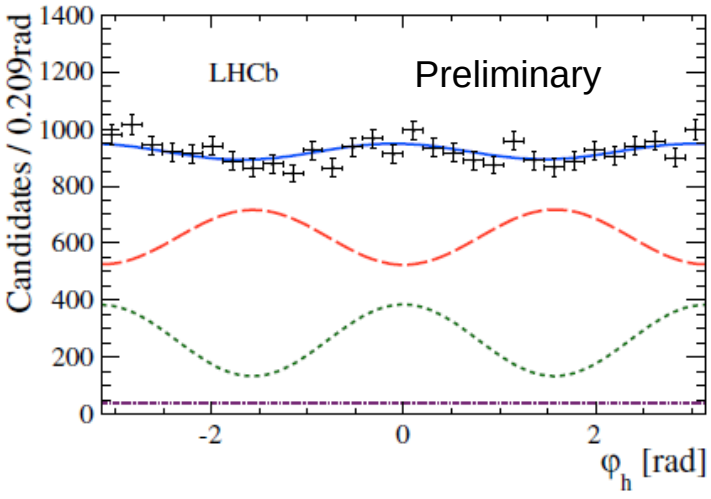




CP-even CP-odd S-wave

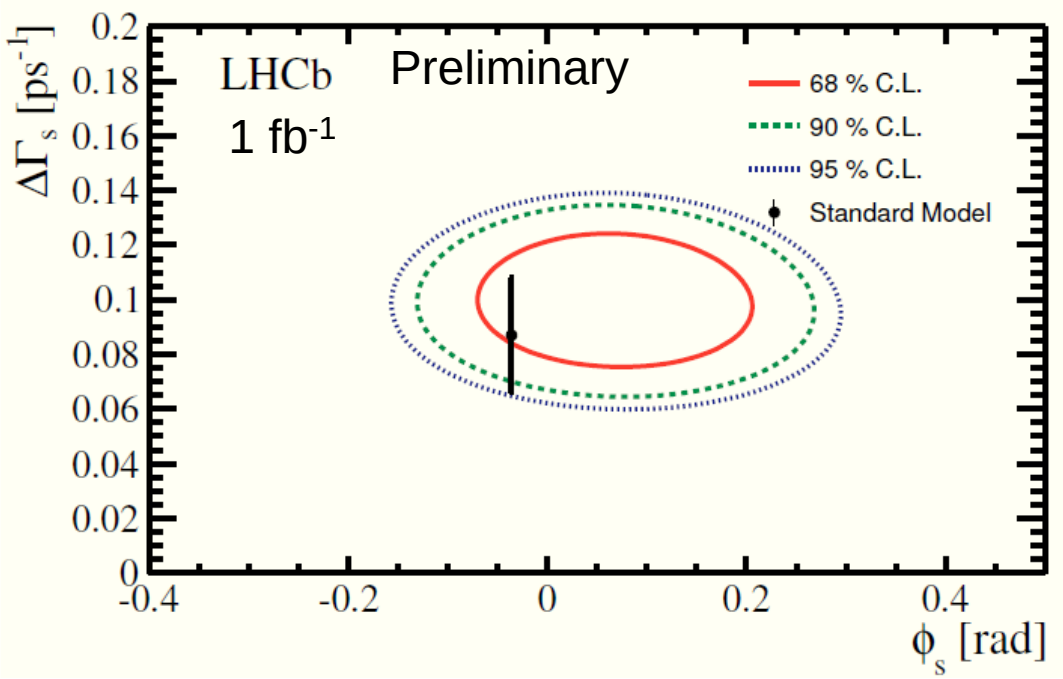




Mixing Phase ϕ_s

new

LHCb-Paper-2013-002



(stat. error only)

$$\phi_s = 0.07 \pm 0.09 \text{ (stat)} \pm 0.01 \text{ (syst) rad},$$
$$\Gamma_s = 0.663 \pm 0.005 \text{ (stat)} \pm 0.006 \text{ (syst) ps}^{-1}$$
$$\Delta\Gamma_s = 0.100 \pm 0.016 \text{ (stat)} \pm 0.003 \text{ (syst) ps}^{-1}$$

$|\lambda| = 0.94 \pm 0.03 \pm 0.02$ (compatible w/ no CPV in decay)

Preliminary

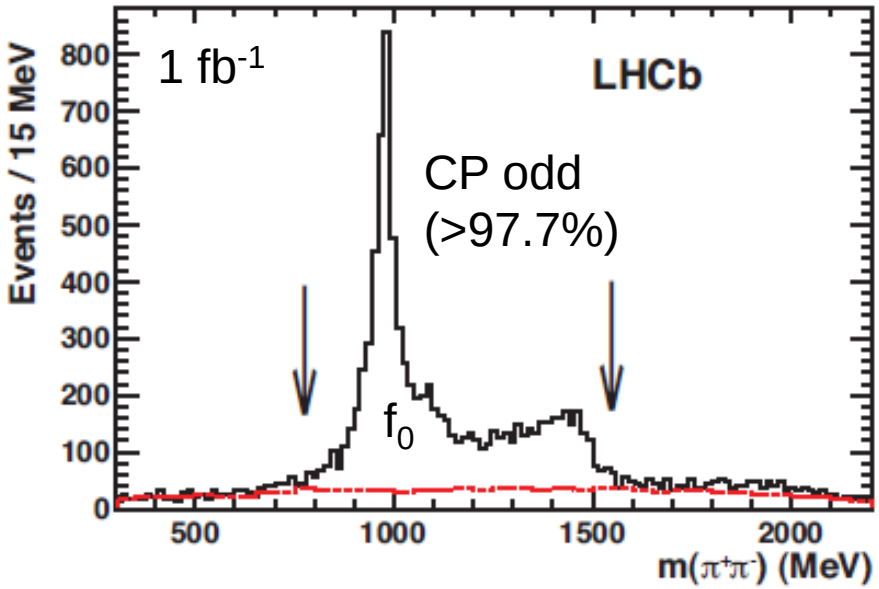
Systematics - ϕ_s : Angular accept. ; $\Delta\Gamma$: Bckg + t accept.

$B_s \to J/\psi\,\pi\pi$

$B_s \to J/\psi\,\pi\pi$ is (pure) CP odd state
$\to$ no angular analysis

Repeat analysis of *PL B713* but using OST and SSKT information.
(~7420 signal events)

Phys.Lett. B713 (2012) 378-386



Constrain Γ and $\Delta\Gamma$ to the $J/\psi\phi$ result:

$$\phi_s = -0.14^{+0.17}_{-0.16} \pm 0.01\,\text{rad}$$

new

Preliminary

LHCb-Paper-2013-002

Simultaneous fit of $B_s \to J/\psi\,\pi\pi$ and $B_s \to J/\psi\phi$

$$\begin{aligned}
\phi_s &= 0.01 \pm 0.07\ (\text{stat}) \pm 0.01\ (\text{syst})\ \text{rad}, \\
\Gamma_s &= 0.661 \pm 0.004\ (\text{stat}) \pm 0.006\ (\text{syst})\ \text{ps}^{-1} \\
\Delta\Gamma_s &= 0.106 \pm 0.011\ (\text{stat}) \pm 0.007\ (\text{syst})\ \text{ps}^{-1}
\end{aligned}$$

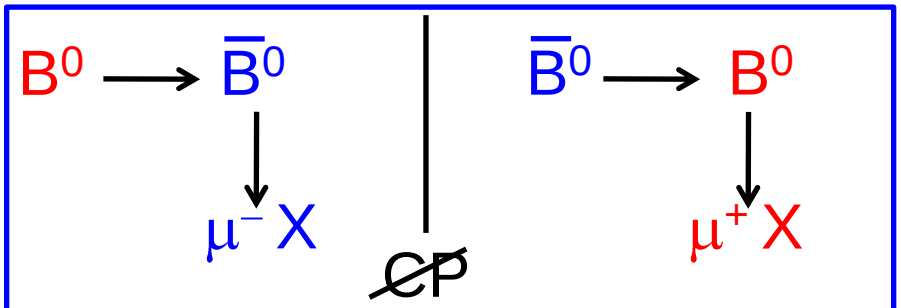
new

Preliminary

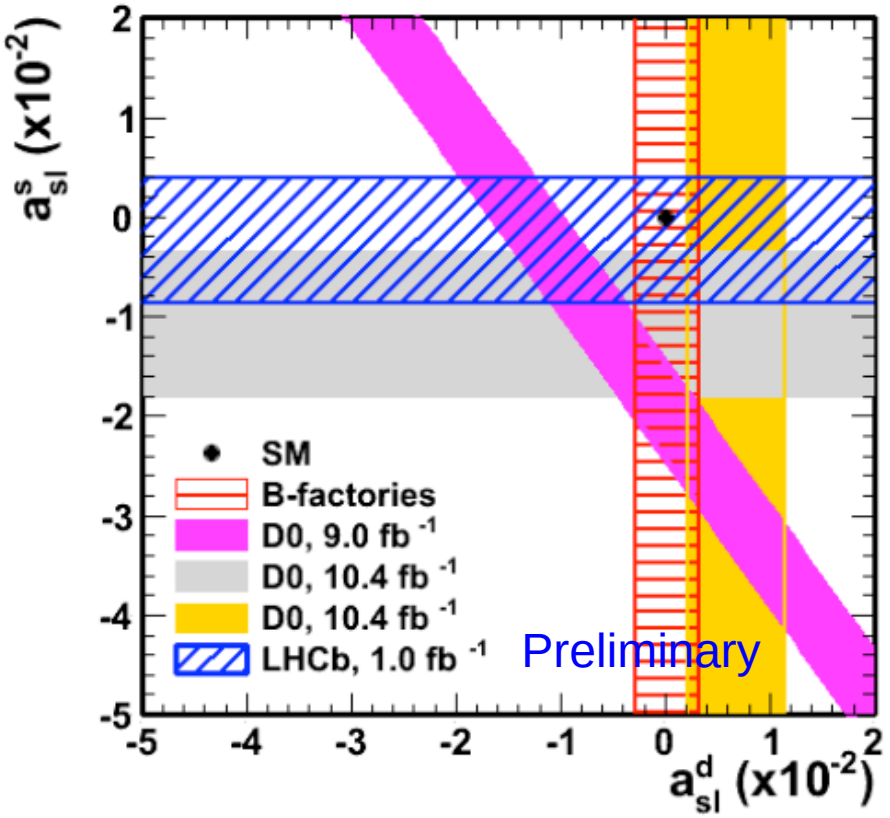
LHCb-Paper-2013-002

CP Violation in B_s Mixing

LHCb-CONF-2012-022

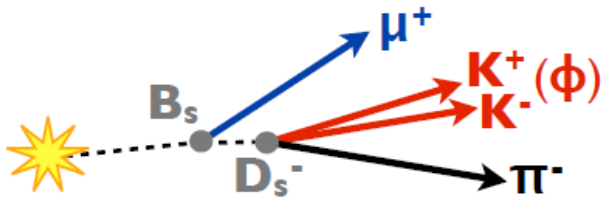


$$a_{sl}^{q} \equiv \frac{\Gamma(\bar{B}_q^0 \to \mu^+ X) - \Gamma(B_q^0 \to \mu^- X)}{\Gamma(\bar{B}_q^0 \to \mu^+ X) + \Gamma(B_q^0 \to \mu^- X)}$$



Problem: Production asymmetry at LHC

$\Rightarrow$ Use quickly oscillating B_s mesons only



$$\frac{a_{\rm sl}^s}{2} = \frac{N(D_s^- \mu^+) - N(D_s^+ \mu^-)}{N(D_s^- \mu^+) + N(D_s^+ \mu^-)}$$

$$a_{\rm sl}^s = (-0.24 \pm 0.54 \pm 0.33)\%$$

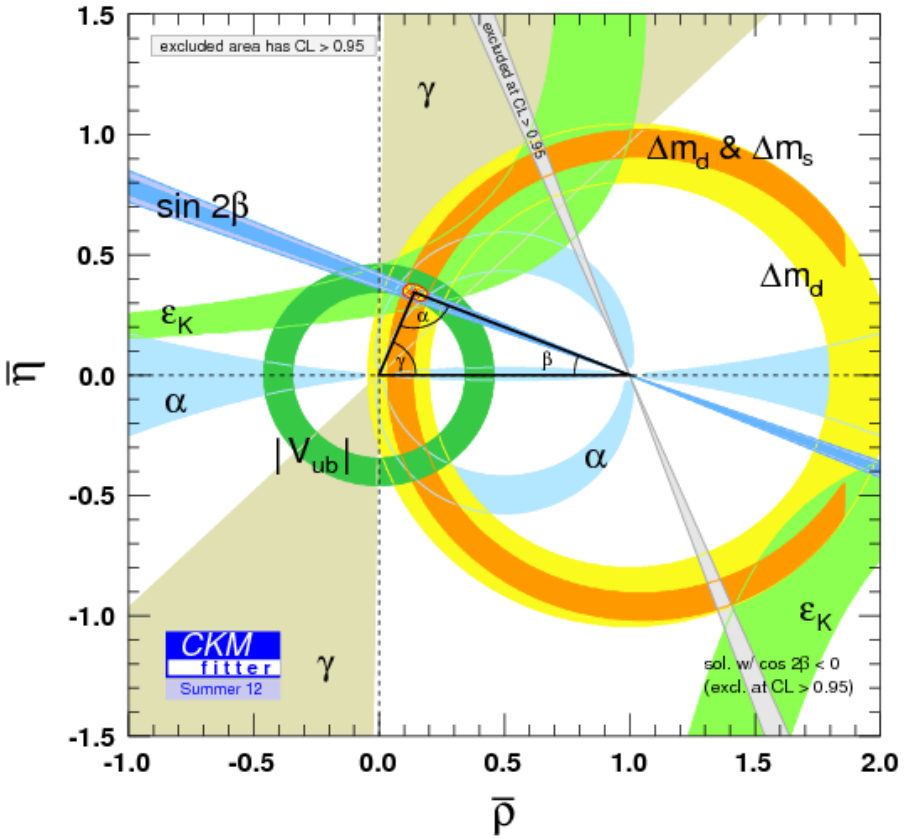
Main syst.: L0 μ-trigger efficiency

Consistent with Standard Model

$a_{\rm sl}^s = (1.9 \pm 0.3) \times 10^{-5}$ *(A.Lenz)*

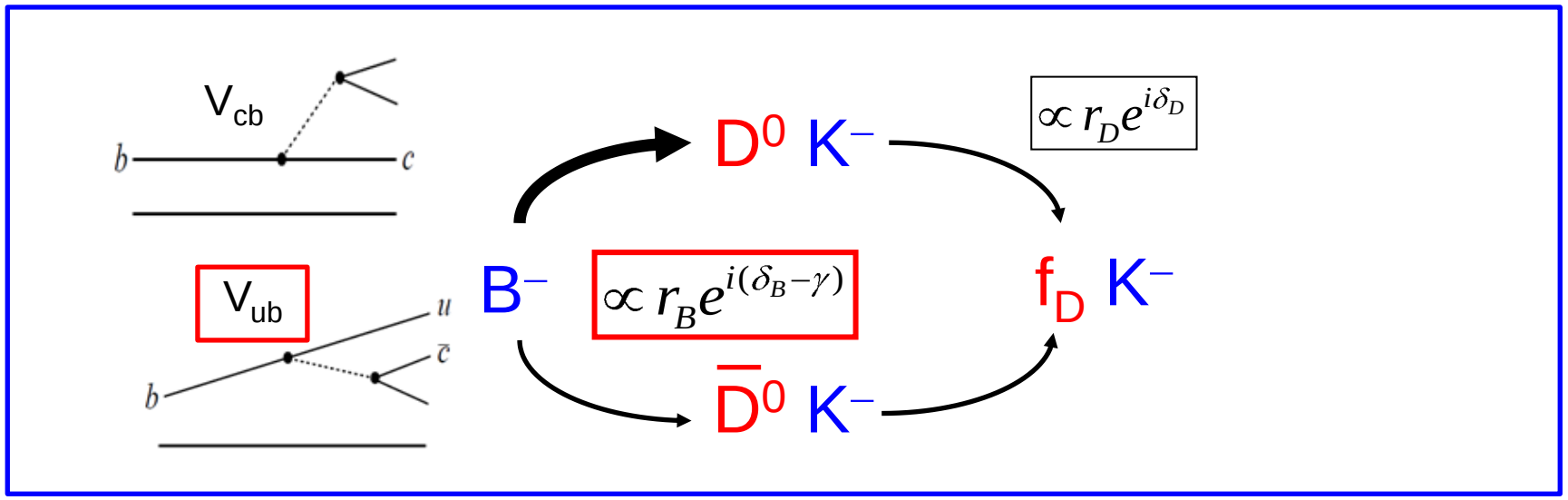
CKM Angle γ

http:://ckmfitter.in2p3.fr/



$$\gamma = \arg\left(-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$$

Determination of γ from B→DK decays



Gronau, London, Wyler (GLW)

f_D = KK, ππ (CP state)

LHCb
- $B^\pm \to D(KK)\ K^\pm$
- $B^\pm \to D(\pi\pi)\ K^\pm$
- $B^\pm \to D(KK)\ \pi^\pm$
- $B^\pm \to D(\pi\pi)\ \pi^\pm$

Phys. Lett. B 712 (2012) 203.

Atwood, Dunietz, Soni (ADS)

f_D = Kπ and πK

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

Phys. Lett. B 712 (2012) 203.

Giri, Grossman, Soffer, Zupan

(GGSZ)

Self conjugated Dalitz modes

ADS with $B^{\pm} \to D(K3\pi)K^{\pm}$

LHCB-CONF-2012-030

ADS with "K3π " mode *)

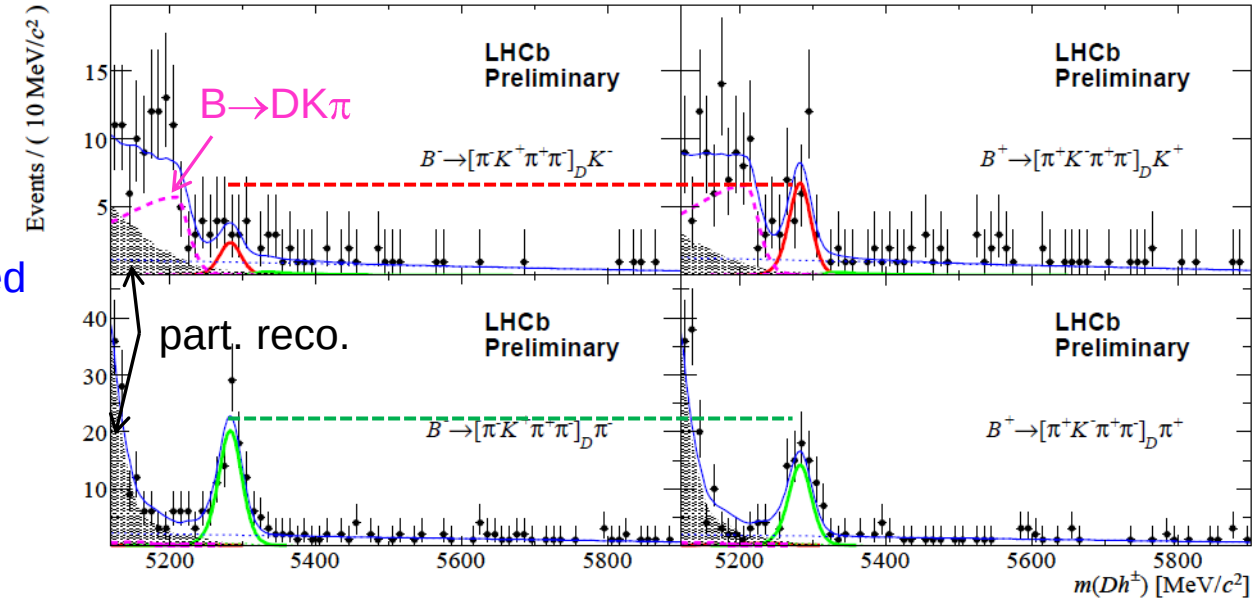
$B^{\pm} \to D\,(\pi^+K^-\pi^+\pi^-)\,K^{\pm}$

$B^{\pm} \to D\,(\pi^+K^-\pi^+\pi^-)\,\pi^{\pm}$

$B^{\pm} \to D(K^+\pi^-\pi^+\pi^-)\,K^{\pm}$] favored

$B^{\pm} \to D(K^+\pi^-\pi^+\pi^-)\,\pi^{\pm}$]

First observation [5.7σ, >10σ] of both modes



Observables:
e.g. D→Kπ

$$R_{ADS}^{DK} \equiv \frac{\Gamma([K^+\pi^-]_D K^-) + \Gamma([K^-\pi^+]_D K^+)}{\Gamma([K^-\pi^+]_D K^-) + \Gamma([K^+\pi^-]_D K^+)} = r_B^2 + r_D^2 + 2r_B r_D \cos\gamma \cos(\delta_B + \delta_D)$$

$$A_{ADS}^{DK} \equiv \frac{\Gamma([K^+\pi^-]_D K^-) - \Gamma([K^-\pi^+]_D K^+)}{\Gamma([K^+\pi^-]_D K^-) + \Gamma([K^-\pi^+]_D K^+)} = 2r_B r_D \sin\gamma \sin(\delta_B + \delta_D) / R_{ADS}^{DK}$$

*) *A. Powell, CERN-THESIS-2010-010*

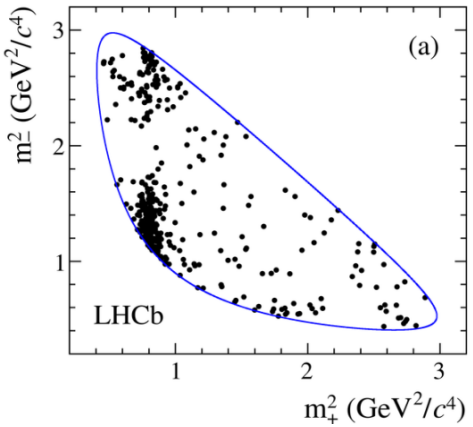
GGSZ analysis: B→ D($K_s h^+ h^-$)K *PLB 718(2012) 43*

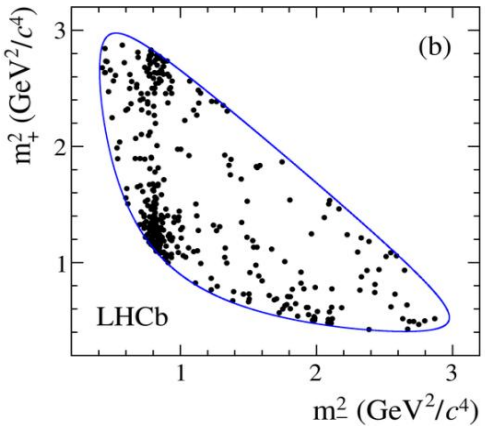
Giri, Grossman, Soffer, Zupan

$m_\pm = m(K_S h^\pm)$

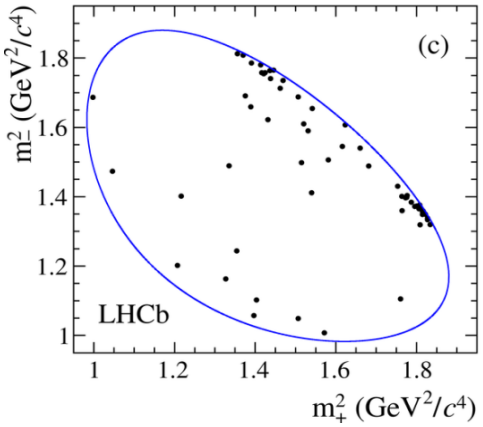
B^+ B^-

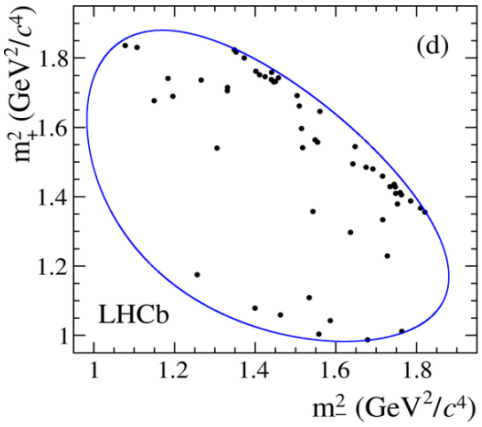
D $K_S\pi^+\pi^-$ 690 signal events



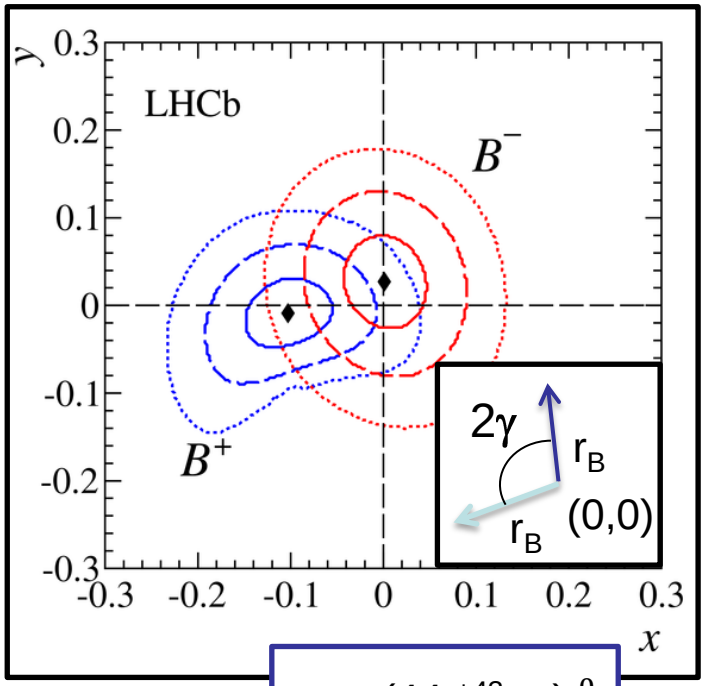


D $K_S K^+K^-$ 110 signal events





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



$\gamma = (44\ ^{+43}_{-38})^0$

$r_B = 0.07 \pm 0.04$

$$N(B^\pm)_{+i} = K_{\mp i} + (x_\pm^2 + y_\pm^2)K_{\pm i} + 2\sqrt{K_i K_{-i}}\{x_\pm c_i \mp y_\pm s_i\}$$

GGSZ analysis: B→ D(K$_s$hh)K

PLB 718(2012) 43

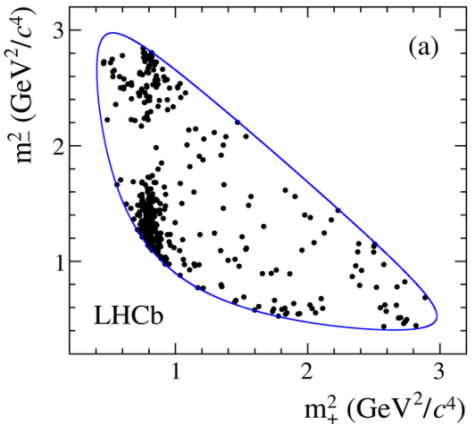
Giri, Grossman, Soffer, Zupan

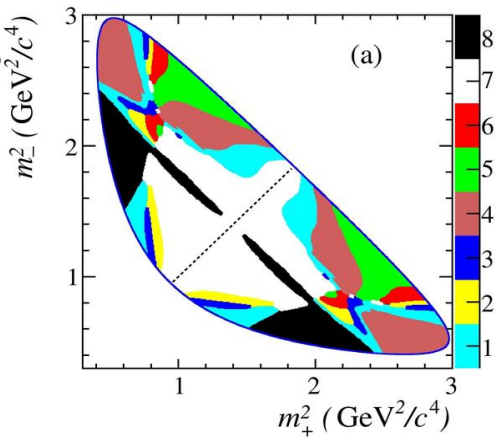
$m_\pm = m(K_S h^\pm)$

B$^+$ B$^-$ CLEO binning

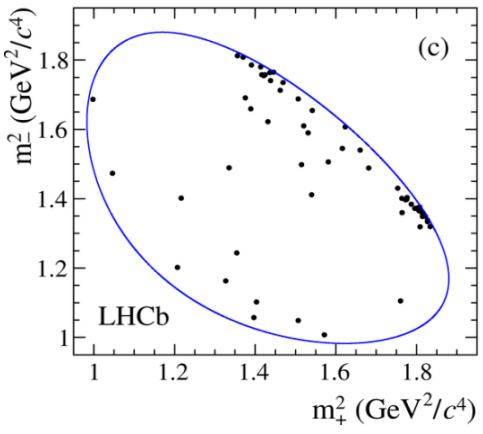
$$x_\pm = r_B \cos(\delta_B \pm \gamma)$$
$$y_\pm = r_B \sin(\delta_B \pm \gamma)$$

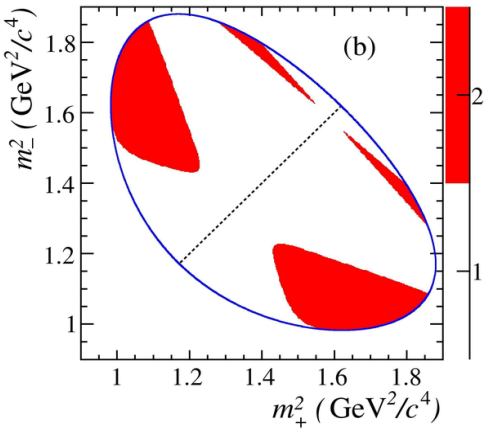
D → $K_S\pi^+\pi^-$
690 signal events

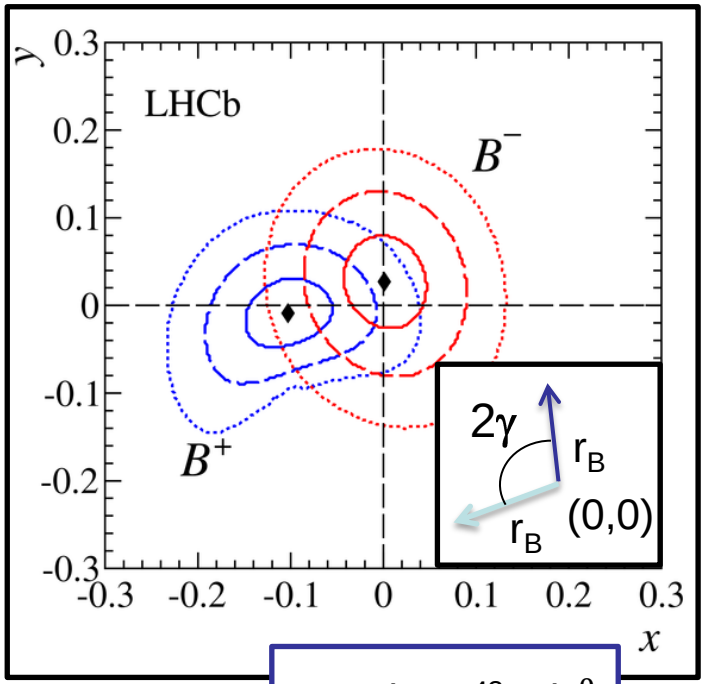




D → $K_S K^+K^-$
115 signal events







$\gamma = (44\ ^{+43}_{-38})^0$

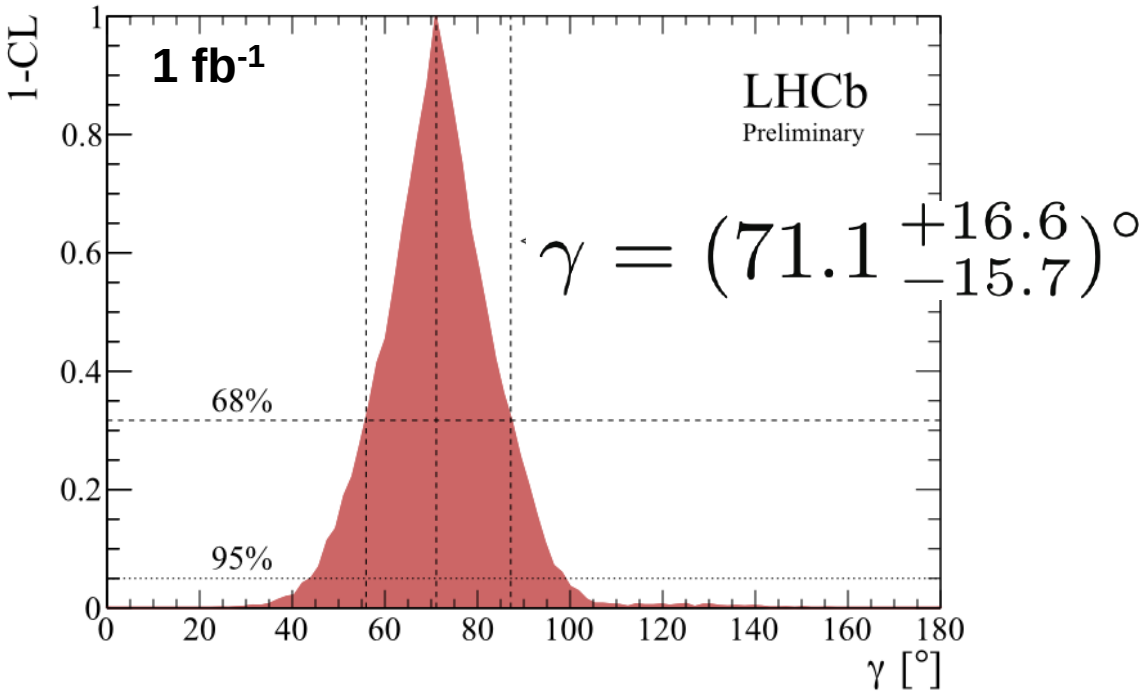
$r_B = 0.07 \pm 0.04$

$$N(B^\pm)_{+i} = K_{\mp i} + (x_\pm^2 + y_\pm^2)K_{\pm i} + 2\sqrt{K_i K_{-i}}\{x_\pm c_i \mp y_\pm s_i\}$$

c_i, s_i from CLEO

Combination of B→DK results

LHCB-CONF-2012-032

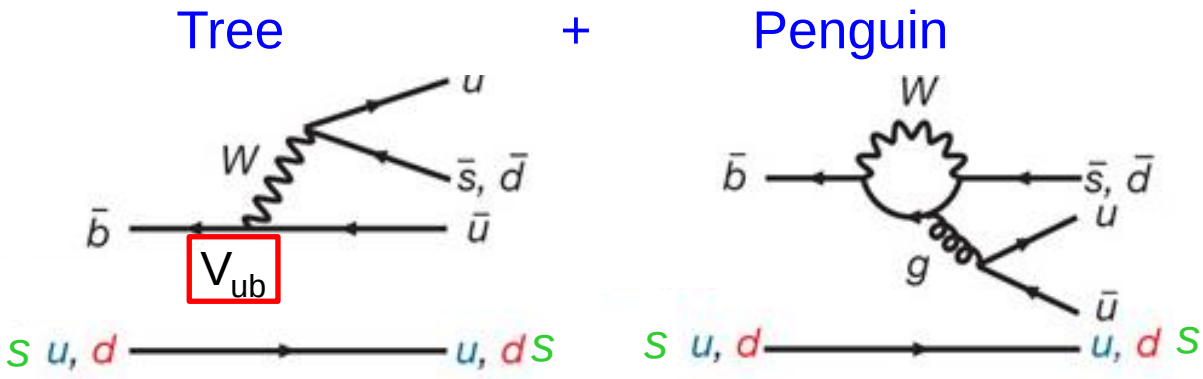


For comparision:

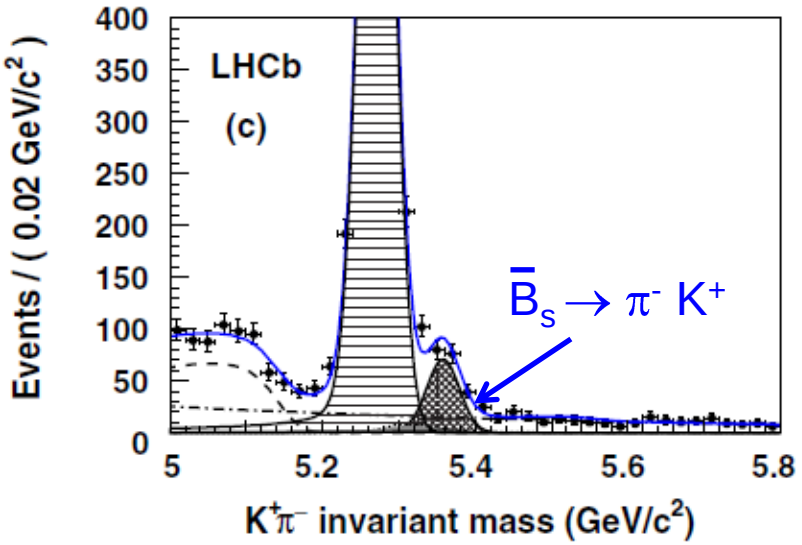
BaBar : $\langle\gamma\rangle = 69\ ^{+17}_{-16}\ (^\circ)$

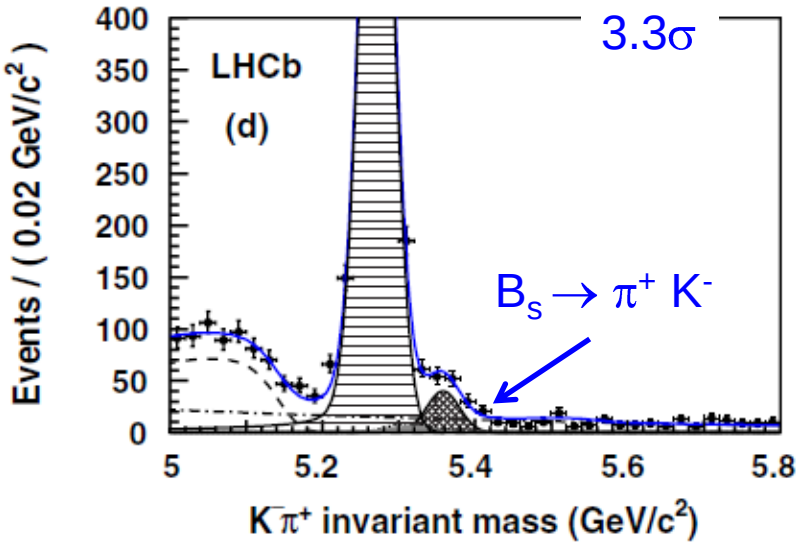
Belle : $\langle\gamma\rangle = 68\ ^{+15}_{-14}\ (^\circ)$

Direct CPV in charmless decays



First evidence for CPV in B_s: $A_{CP}(B_s^0 \to K\pi) = 0.27 \pm 0.08(\text{stat}) \pm 0.02(\text{syst})$ *)



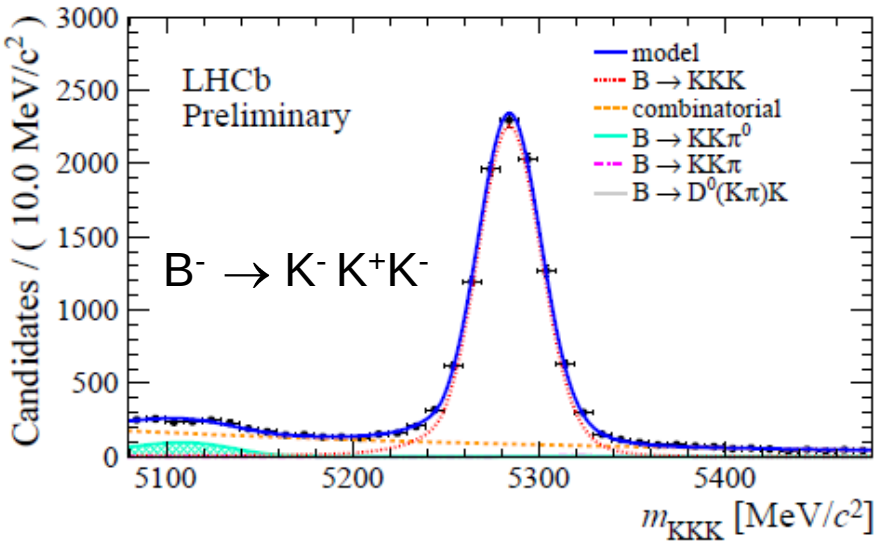


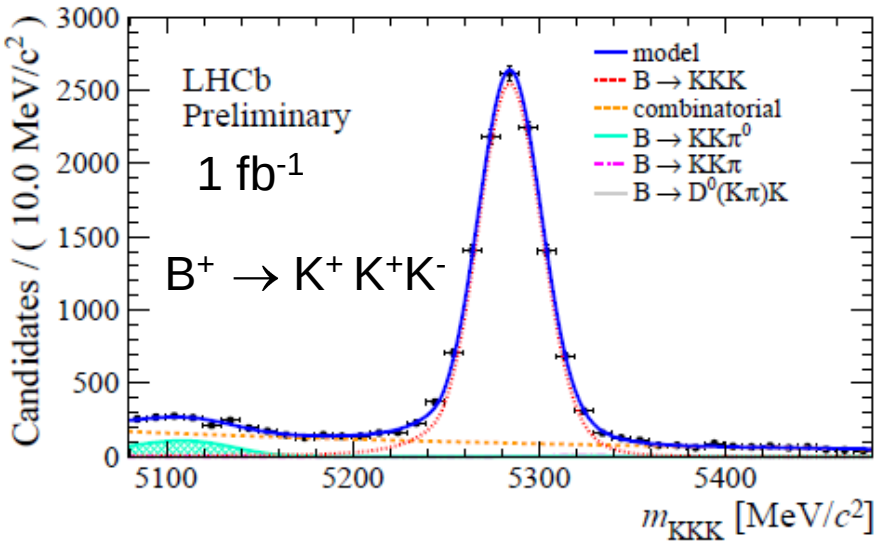
*) Corrected for production and detection asym.

PRL 108, 201601 (2012)

Evidence for CPV in $B^{\pm} \to h^{\pm}h^{+}h^{-}$ (h=K,π)

LHCB-CONF-2012-018





LHCB-CONF-2012-018

$$A_{CP}(B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}) = +0.034 \pm 0.009(\text{stat}) \pm 0.004(\text{syst}) \pm 0.007(J/\psi K^{\pm}) \quad 2.8\sigma$$

$$A_{CP}(B^{\pm} \to K^{\pm}K^{+}K^{-}) = -0.046 \pm 0.009(\text{stat}) \pm 0.005(\text{syst}) \pm 0.007(J/\psi K^{\pm}) \quad 3.7\sigma$$

LHCB-CONF-2012-028

$$A_{CP}(B^{\pm} \to \pi^{\pm}\pi^{+}\pi^{-}) = +0.120 \pm 0.020(\text{stat}) \pm 0.019(\text{syst}) \pm 0.007(J/\psi K^{\pm}) \quad 4.2\sigma$$

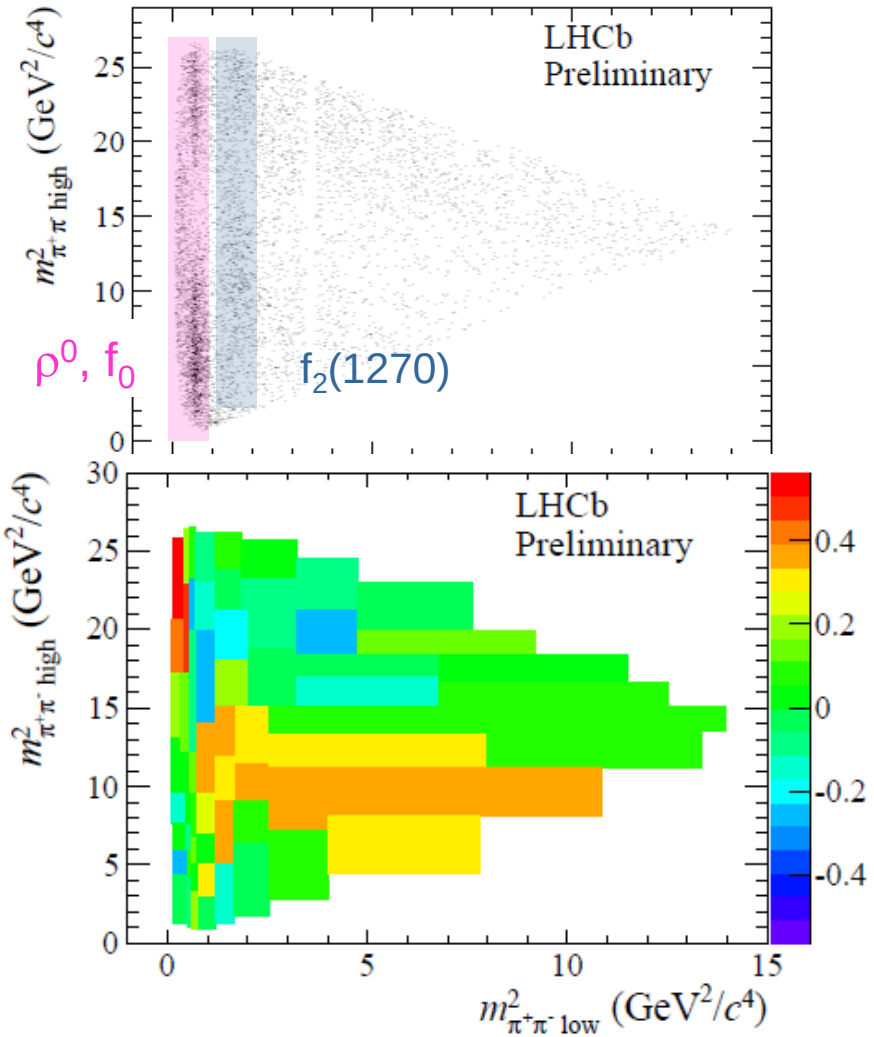
$$A_{CP}(B^{\pm} \to K^{+}K^{-}\pi^{\pm}) = -0.153 \pm 0.046(\text{stat}) \pm 0.019(\text{syst}) \pm 0.007(J/\psi K^{\pm}) \quad 3.0\sigma$$

Use A_{CP} ($B^{\pm} \to J/\psi K^{\pm}$) to estimate production and detection asymmetry.

Phase space dependence

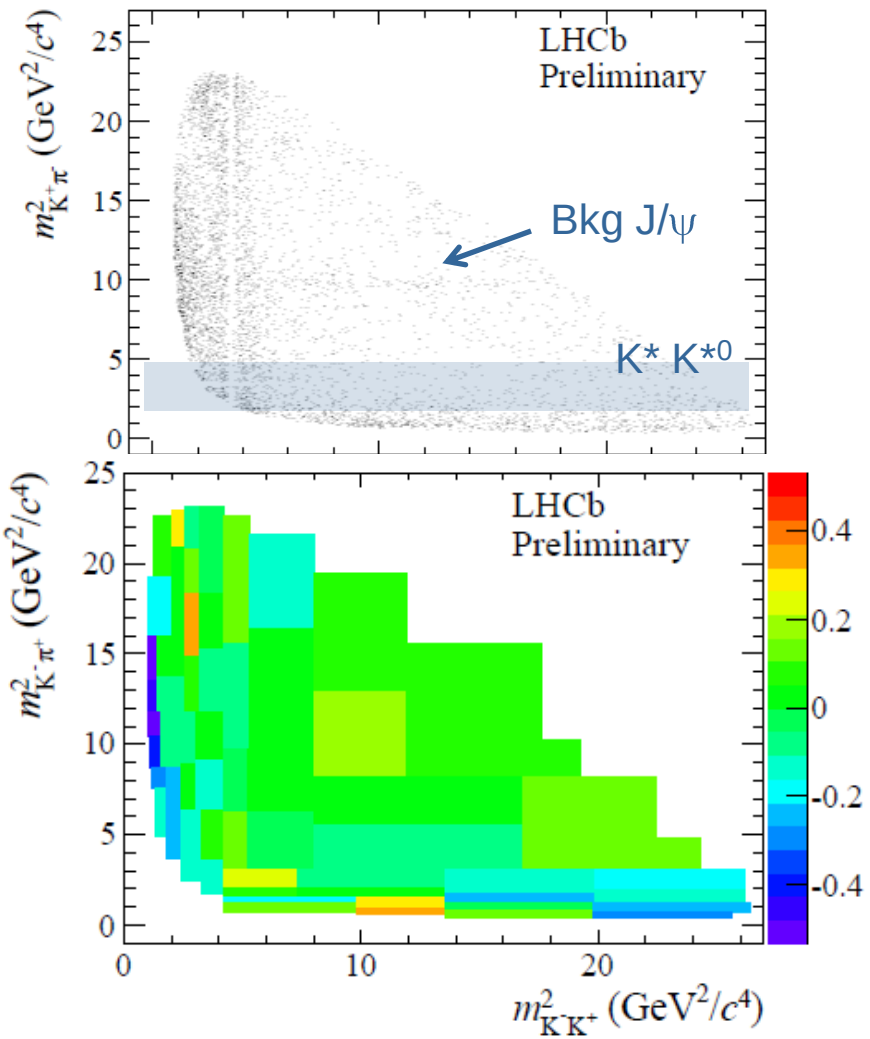
LHCB-CONF-2012-028

$B^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$



large pos. CPV outside resonances (>9σ)

$B^{\pm} \rightarrow \pi^{\pm}K^{+}K^{-}$



large negative CPV (>7σ)

Conclusion

- New LHCb measurement of B_s mixing phase ϕ_s and $\Delta\Gamma_s$

  $\phi_s = 0.01 \pm 0.07 \pm 0.01$ rad

  $\Delta\Gamma_s = 0.106 \pm 0.011 \pm 0.007$ ps^{-1}

- Test of CPV in B_s mixing agrees with Standard Model
- First combined LHCb determination of angle γ
- Evidence of CPV in charmless 3-body B-decays
- All measurements use only 1 fb^{-1} of data (2011), Additional 2 fb^{-1} from 2012 is being analyzed now.

Backup

$B_s \rightarrow J/\psi\,(\mu\mu)\,\phi(KK)$ Results

Parameter	Value	σ_{stat}	σ_{sys}
Γ_s [ps^{-1}]	0.663	0.005	0.006
$\Delta\Gamma_s$ [ps^{-1}]	0.100	0.016	0.003
$\lvert A_\perp \rvert^2$	0.249	0.009	0.006
$\lvert A_0 \rvert^2$	0.521	0.006	0.010
$\delta_\parallel$ [rad]	3.30	$^{+0.13}_{-0.21}$	0.08
$\delta_\perp$ [rad]	3.07	0.22	0.07
ϕ_s [rad]	0.07	0.09	0.01
$\lvert\lambda\rvert$	0.94	0.03	0.02
Δm_s [ps^{-1}] unconstrained	17.70	0.10	0.01

Correlations

	Γ_s [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	$\lvert A_\perp\rvert^2$	$\lvert A_0\rvert^2$	$\delta_\parallel$ [rad]	$\delta_\perp$ [rad]	ϕ_s [rad]	$\lvert\lambda\rvert$
Γ_s [ps^{-1}]	1.00	**-0.39**	**0.37**	**-0.27**	-0.09	-0.03	0.06	0.03
$\Delta\Gamma_s$ [ps^{-1}]		1.00	**-0.68**	**0.63**	0.03	0.04	-0.04	0.00
$\lvert A_\perp\rvert^2$			1.00	**-0.58**	**-0.28**	-0.09	0.08	-0.04
$\lvert A_0\rvert^2$				1.00	-0.02	-0.00	-0.05	0.02
$\delta_\parallel$ [rad]					1.00	**0.32**	-0.03	0.05
$\delta_\perp$ [rad]						1.00	**0.28**	0.00
ϕ_s [rad]							1.00	0.04
$\lvert\lambda\rvert$								1.00

$B_s \to J/\psi\phi$ Systematic Uncertainties

Source	Γ_s [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	$\lvert A_\perp\rvert^2$	$\lvert A_0\rvert^2$	$\delta_\parallel$ [rad]	$\delta_\perp$ [rad]	ϕ_s [rad]	$\lvert\lambda\rvert$
Stat. uncertainty	0.0048	0.016	0.0086	0.0061	$^{+0.13}_{-0.21}$	0.22	0.091	0.031
Background subtraction	0.0041	0.002	-	0.0031	0.03	0.02	0.003	0.003
$B^0 \to J/\psi K^{*0}$ background	-	0.001	0.0030	0.0001	0.01	0.02	0.004	0.005
Ang. acc. reweighting	0.0007	-	0.0052	0.0091	0.07	0.05	0.003	0.020
Ang. acc. statistical	0.0002	-	0.0020	0.0010	0.03	0.04	0.007	0.006
Lower decay time acc. model	0.0023	0.002	-	-	-	-	-	-
Upper decay time acc. model	0.0040	-	-	-	-	-	-	-
z + p scale	0.0009	-	-	-	-	-	-	-
Fit bias	-	-	0.0010	-	-	-	-	-
Quadratic sum of syst.	0.0063	0.003	0.0064	0.0097	0.08	0.07	0.009	0.022
Total uncertainties	0.0079	0.016	0.0107	0.0114	$^{+0.15}_{-0.23}$	0.23	0.091	0.038

Combined $B_s \to J/\psi\phi$ and $J/\psi\pi\pi$

Parameter	Value	σ_{stat}	σ_{sys}
Γ_s [ps^{-1}]	0.661	0.004	0.006
$\Delta\Gamma_s$ [ps^{-1}]	0.106	0.011	0.007
$\lvert A_\perp \rvert^2$	0.246	0.007	0.006
$\lvert A_0 \rvert^2$	0.523	0.005	0.010
$\delta_\parallel$ [rad]	3.32	$^{+0.13}_{-0.21}$	0.08
$\delta_\perp$ [rad]	3.04	0.20	0.07
ϕ_s [rad]	0.01	0.07	0.01
$\lvert\lambda\rvert$	0.93	0.03	0.02

Only $B_s \to J/\psi\pi\pi$

$$\phi_s = -0.14^{+0.17}_{-0.16} \pm 0.01\,\text{rad}$$

$$\tau^{J/\psi\pi\pi}_{\text{single}} = 1.652 \pm 0.024(\text{stat}) \pm 0.024(\text{syst})\,\text{ps}.$$

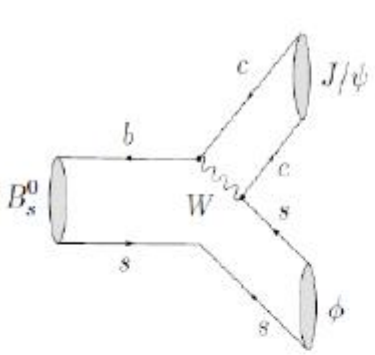
$$\Gamma^{J/\psi\pi\pi}_{\text{single}} = 0.605 \pm 0.009(\text{stat}) \pm 0.009(\text{syst})\,\text{ps}^{-1}$$

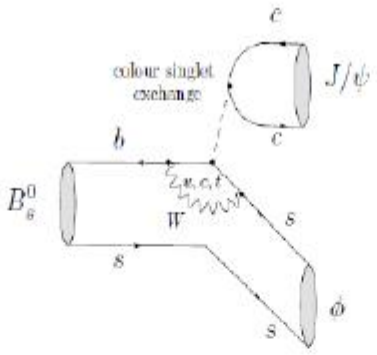
(corresponds to Γ_H in the limit of $\phi_s = 0$)

Penguin pollutions in $B_s \to J/\psi\phi$

[S. Faller et al. arXiv:0810.4248v1]

O. Leroy, La Thuile 2011

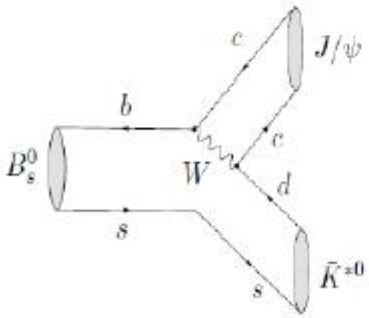


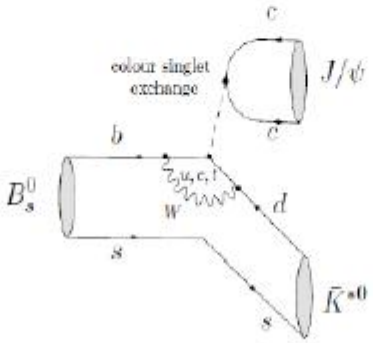


$$\bar{b} \to \bar{s}c\bar{c}$$

Penguins suppressed by λ^2

$$A(B_s^0 \to (J/\psi\phi)_f) = \left(1 - \frac{\lambda^2}{2}\right) \mathcal{A}_f \left[1 + \epsilon a_f e^{i\theta_f} e^{i\gamma}\right] \qquad \epsilon \equiv \lambda^2/(1-\lambda^2)$$





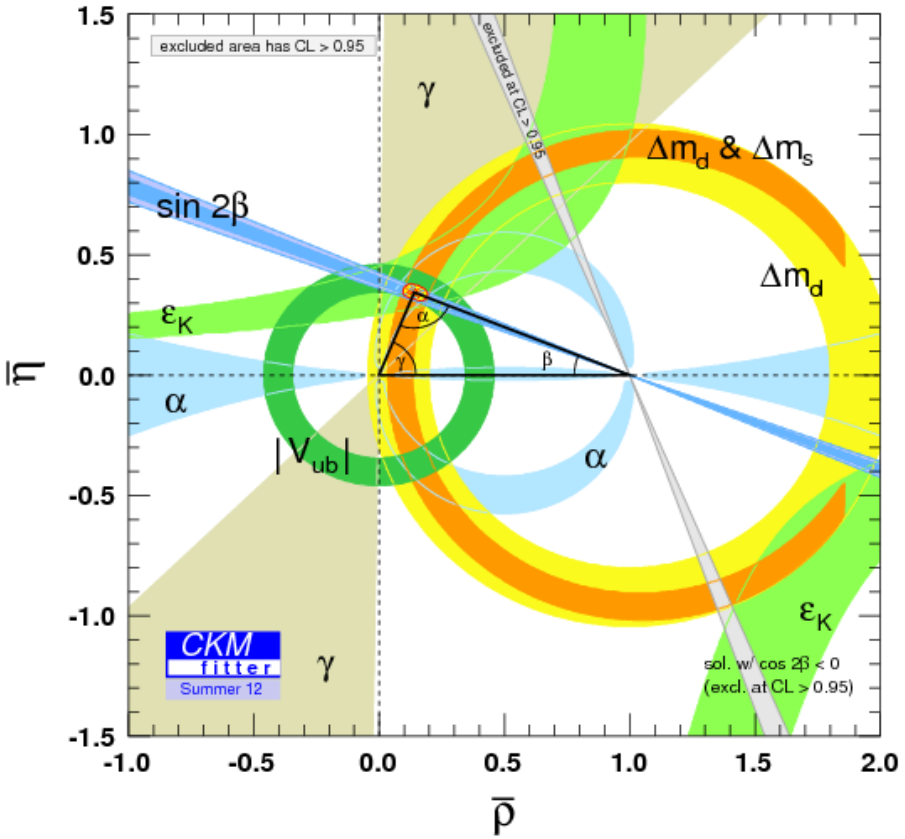
$$\bar{b} \to \bar{d}c\bar{c}$$

Penguins NOT suppressed wrt tree

$$A(B_s^0 \to (J/\psi\bar{K}^{*0})_f) = \lambda\mathcal{A}'_f \left[1 - a'_f e^{i\theta'_f} e^{i\gamma}\right]$$

CKM Angle γ

http:://ckmfitter.in2p3.fr/



$$\gamma = \arg\left(-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$$

GLW and ADS measurements

Phys. Lett. B712 (2012) 203.

GLW

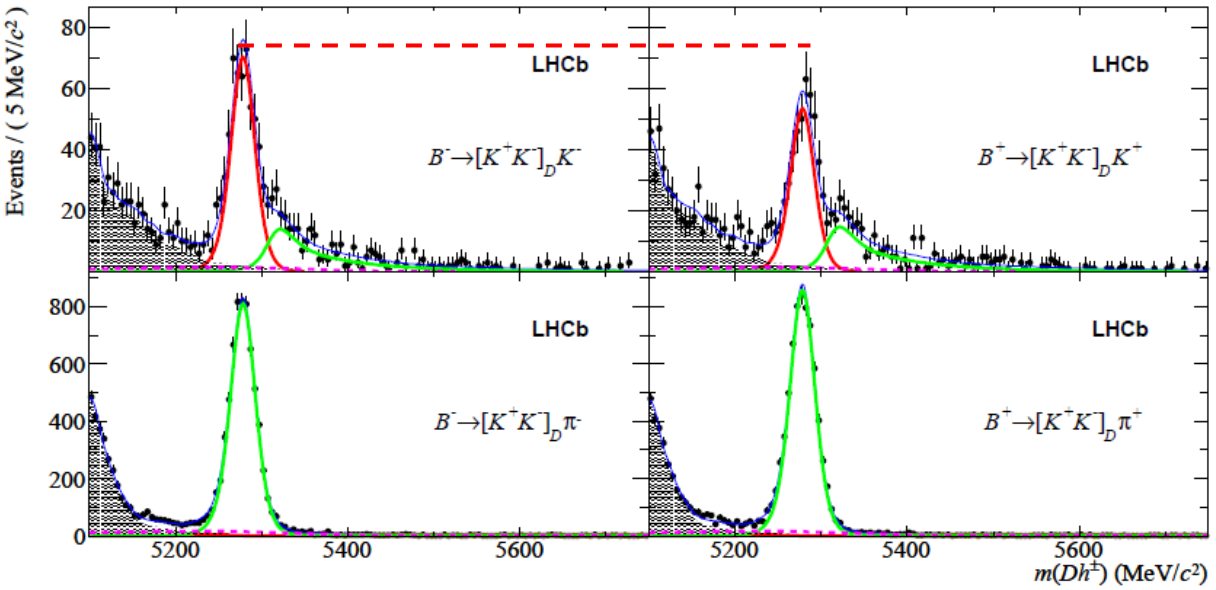
D^0 decays to CP state:

$B^\pm \to D(KK)\ K^\pm$

$B^\pm \to D(KK)\ \pi^\pm$

$B^\pm \to D(\pi\pi)\ K^\pm$

$B^\pm \to D(\pi\pi)\ \pi^\pm$



ADS

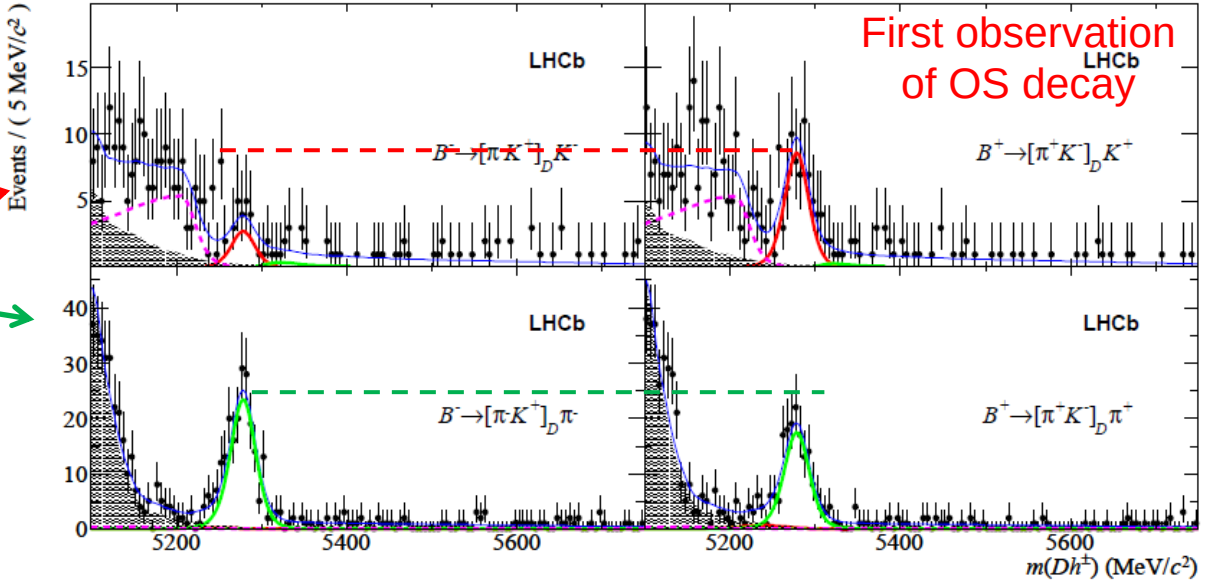
D^0 decays suppressed:

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

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

$B^\pm \to D(K^+\pi^-)\ K^\pm$] favored

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

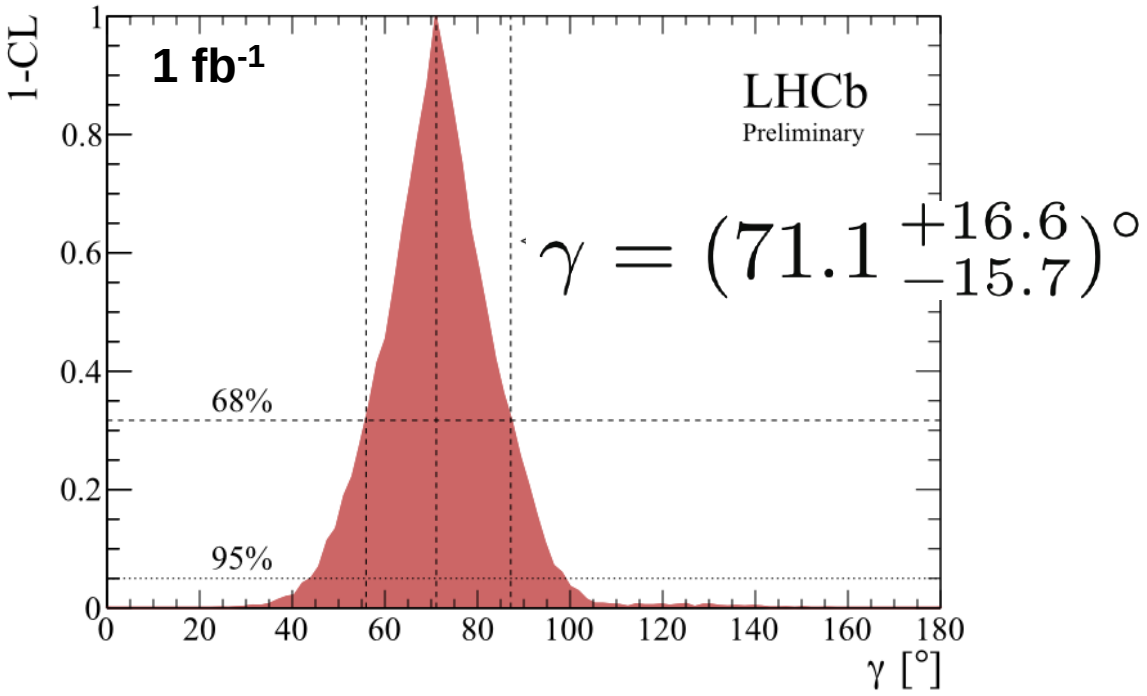


ADS with $B^{\pm} \to D(K3\pi)K^{\pm}$

Mode	B^-	B^+
$[K^{\mp}\pi^{\pm}\pi\pi]_D\pi^{\mp}$	$20,791 \pm 232$	$21,054 \pm 235$
$[K^{\mp}\pi^{\pm}\pi\pi]_D K^{\mp}$	$1,567 \pm 57$	$1,660 \pm 60$
$[\pi^{\mp}K^{\pm}\pi\pi]_D\pi^{\mp}$	87 ± 11	68 ± 10
$[\pi^{\mp}K^{\pm}\pi\pi]_D K^{\mp}$	11 ± 5	29 ± 7

Combination of B→DK results

LHCB-CONF-2012-032



For comparision:

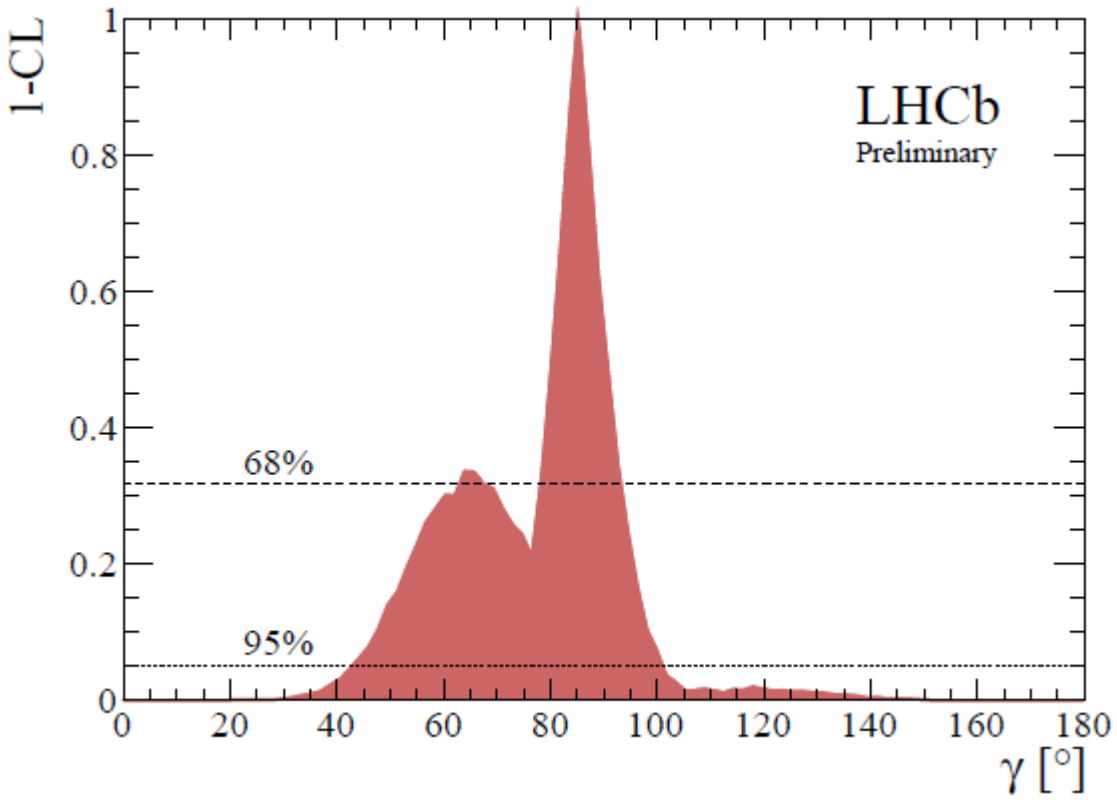
BaBar : $\langle\gamma\rangle = 69\,^{+17}_{-16}\,(^\circ)$

Belle : $\langle\gamma\rangle = 68\,^{+15}_{-14}\,(^\circ)$

Combination of $B^+ \to DK^+$ and $D\pi^+$ results

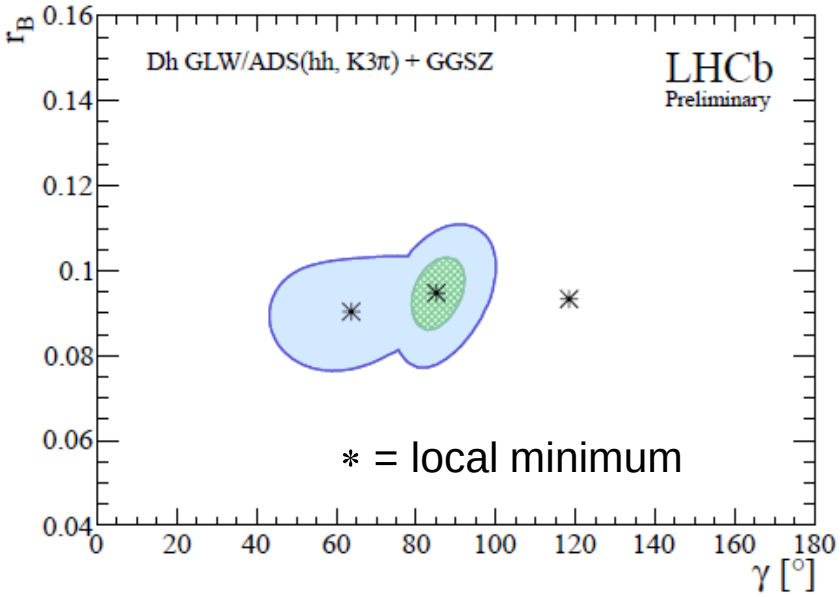
LHCB-CONF-2012-032

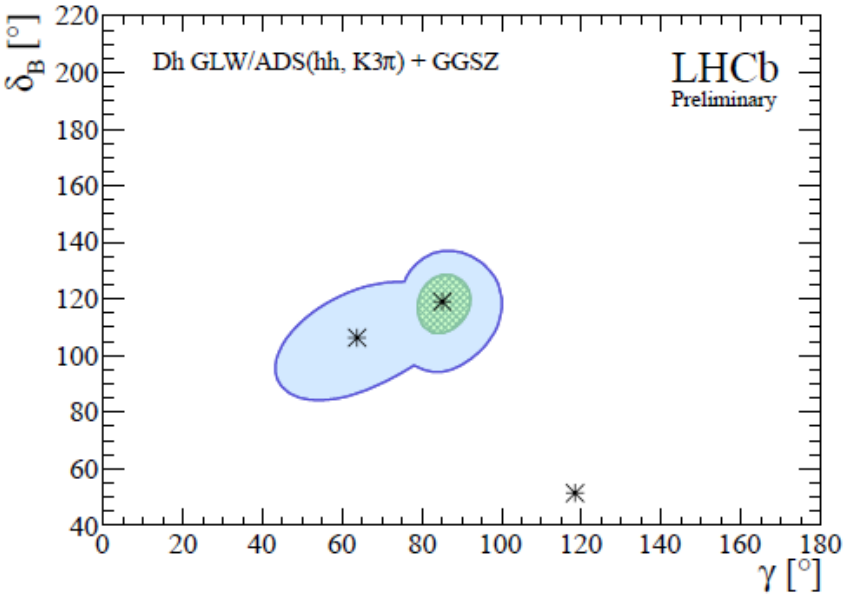
If for first time also $D\pi^+$ results are included:

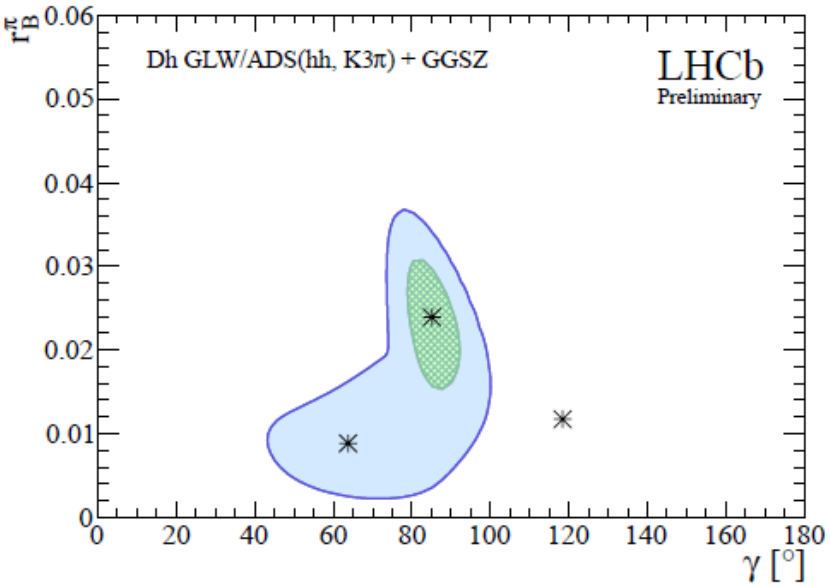


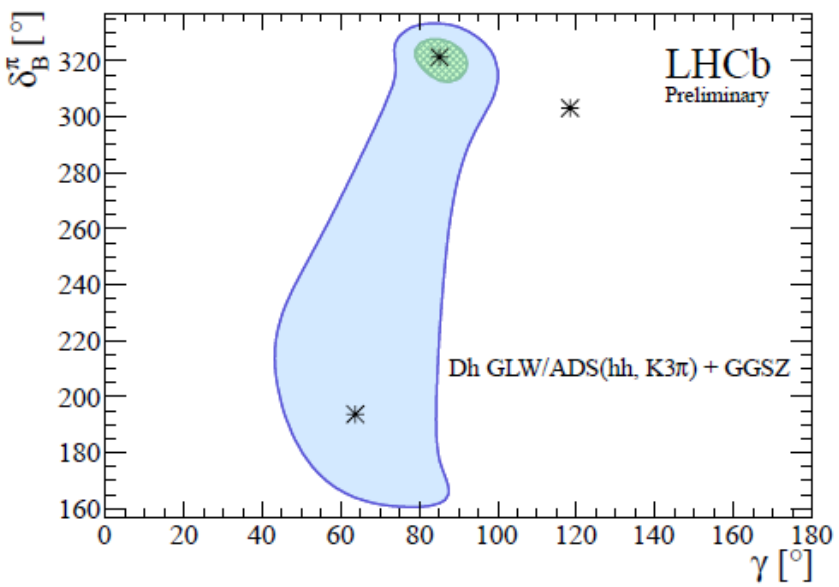
$$\gamma \in [61.8, 67.8]^\circ \quad \text{or} \quad [77.9, 92.4]^\circ \quad @\,68\%\ \text{CL}$$
$$\gamma \in [43.8, 101.5]^\circ \quad @\,95\%\ \text{CL}$$

$B \to D\pi$ events: Preferred solution around 85° consistent w/ unexpected positive asymmetry in $B^\pm \to [\pi^\pm K\, \pi\pi]_D\, \pi^\pm$


Dh GLW/ADS(hh, K3π) + GGSZ
LHCb
Preliminary
r_B
γ [°]
∗ = local minimum


Dh GLW/ADS(hh, K3π) + GGSZ
LHCb
Preliminary
δ_B [°]
γ [°]

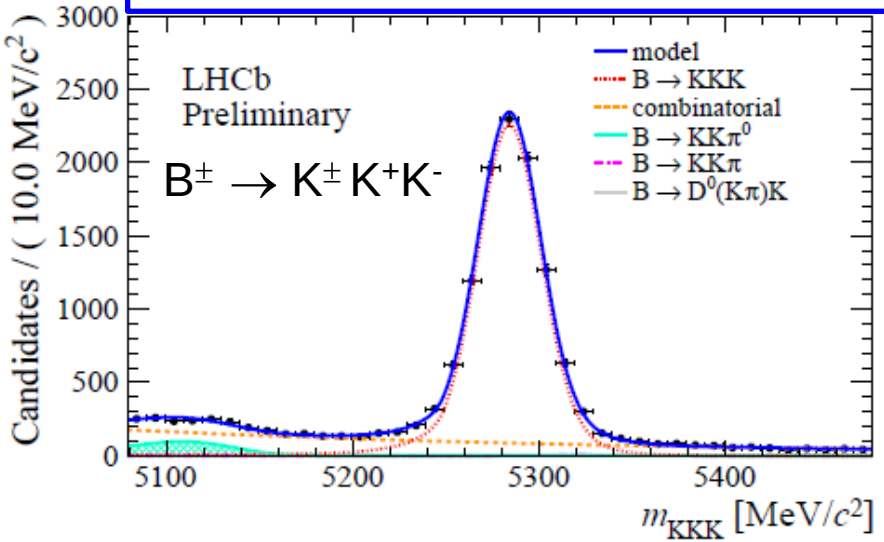

Dh GLW/ADS(hh, K3π) + GGSZ
LHCb
Preliminary
r_B^π
γ [°]

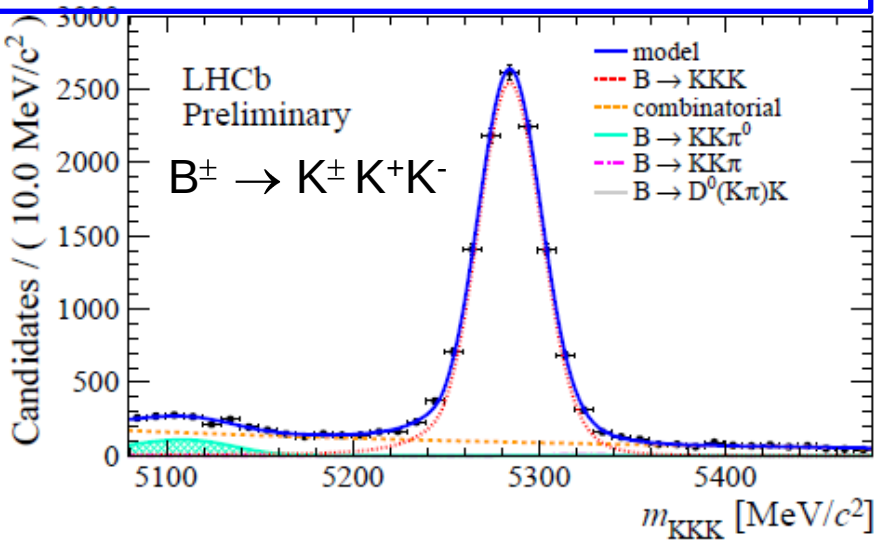

LHCb
Preliminary
δ_B^π [°]
Dh GLW/ADS(hh, K3π) + GGSZ
γ [°]

$B^{\pm} \to K^{\pm} K^{+} K^{-}$, $K^{\pm} \pi^{+} \pi^{-}$

LHCB-CONF-2012-018

$$A_{CP}(B^{\pm} \to K^{\pm} K^{+} K^{-}) = -0.046 \pm 0.009(\text{stat}) \pm 0.005(\text{syst}) \pm 0.007(J/\psi K^{\pm})$$





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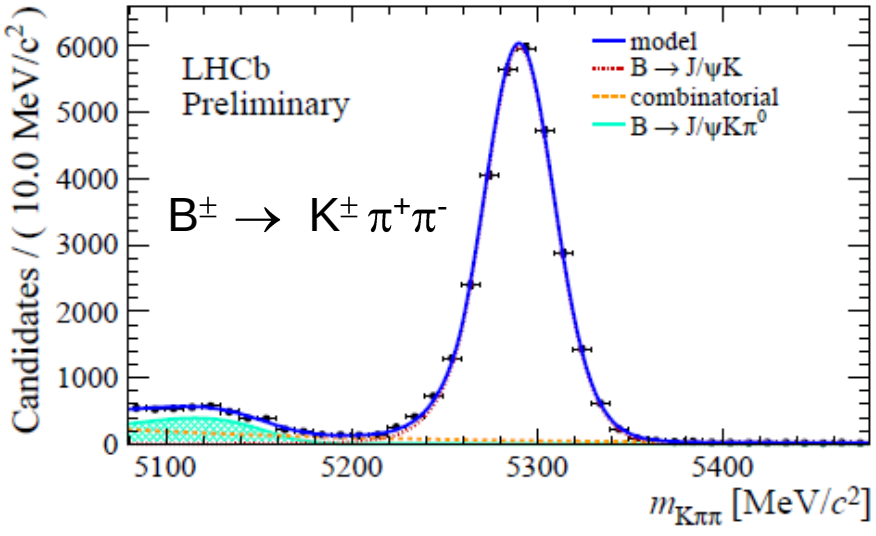
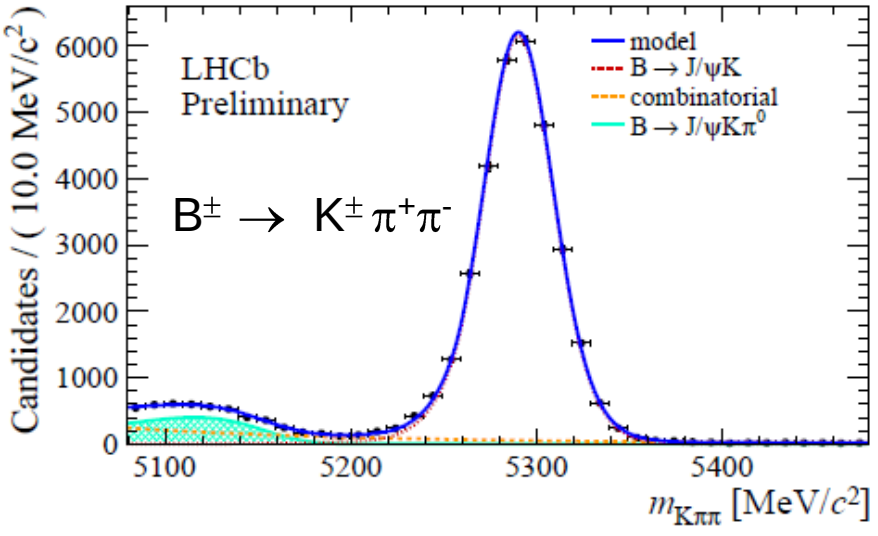
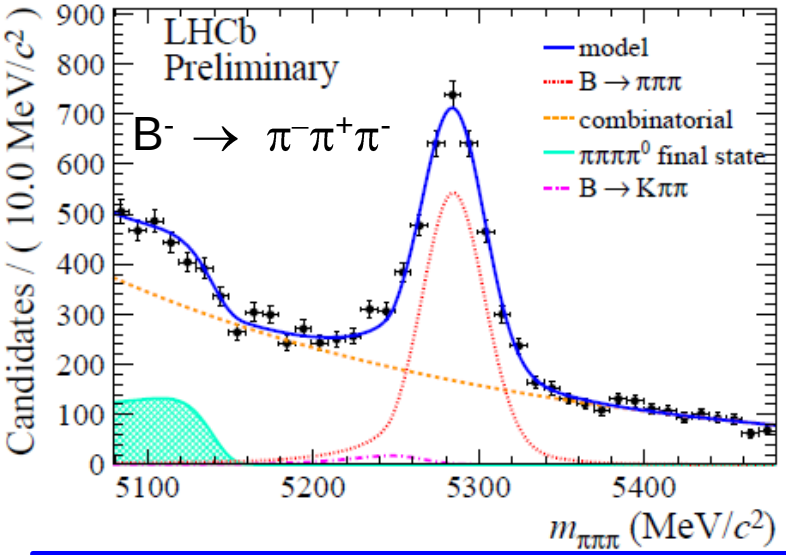


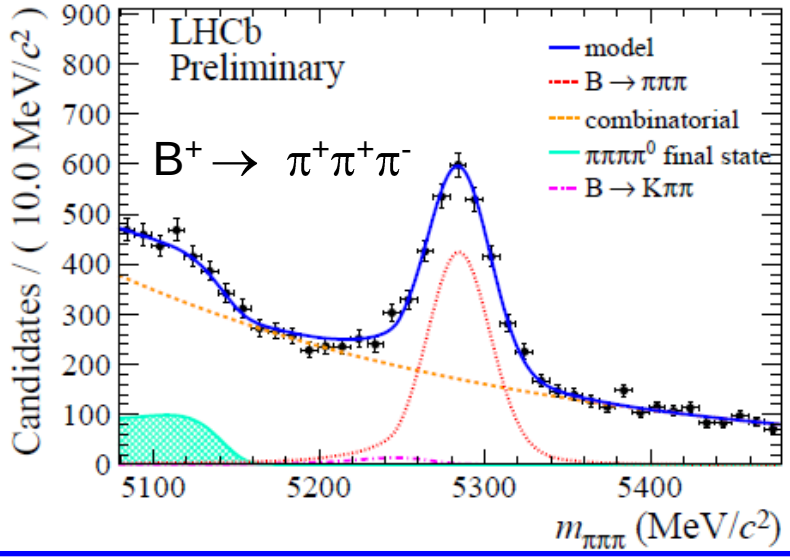


$B^{\pm} \to \pi^{\pm}\pi^{+}\pi^{-}$, $\pi^{\pm}K^{+}K^{-}$

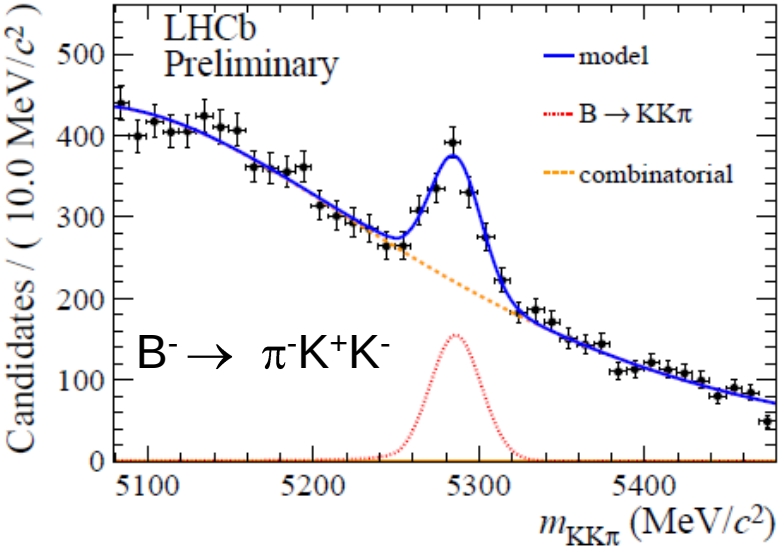
LHCB-CONF-2012-028

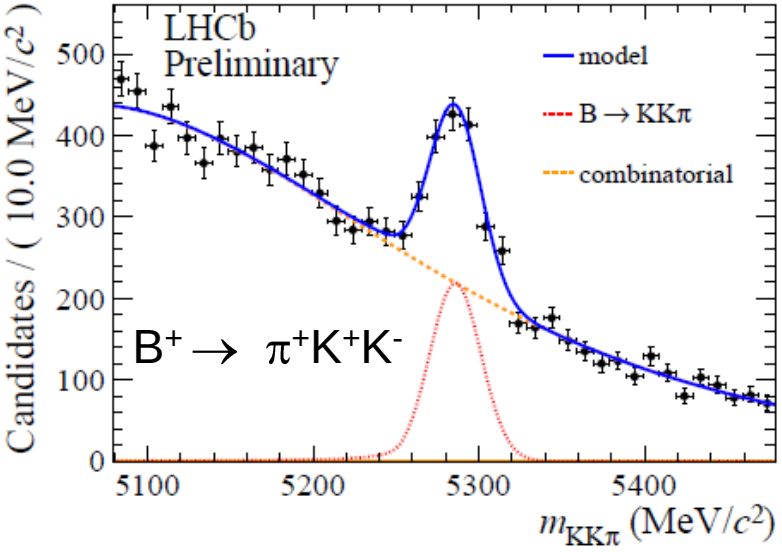
$$A_{CP}(B^{\pm} \to \pi^{\pm}\pi^{+}\pi^{-}) = +0.120 \pm 0.020(\text{stat}) \pm 0.019(\text{syst}) \pm 0.007(J/\psi K^{\pm})$$





$$A_{CP}(B^{\pm} \to K^{+}K^{-}\pi^{\pm}) = -0.153 \pm 0.046(\text{stat}) \pm 0.019(\text{syst}) \pm 0.007(J/\psi K^{\pm})$$





Systematics

LHCB-CONF-2012-018

Contribution	$K^{\pm}\pi^{+}\pi^{-}$	$K^{\pm}K^{+}K^{-}$
Signal fixed parameters	0.002	0.002
Signal model	0.0001	0.0001
Signal shape	0.0012	0.0001
Background model	0.0003	0.00002
Background asymmetry	0.0002	0.0001
Acceptance	0.001	0.0015
Trigger correction	0.0011	0.001
Subtraction method	0.003	0.004
Total	0.004	0.005

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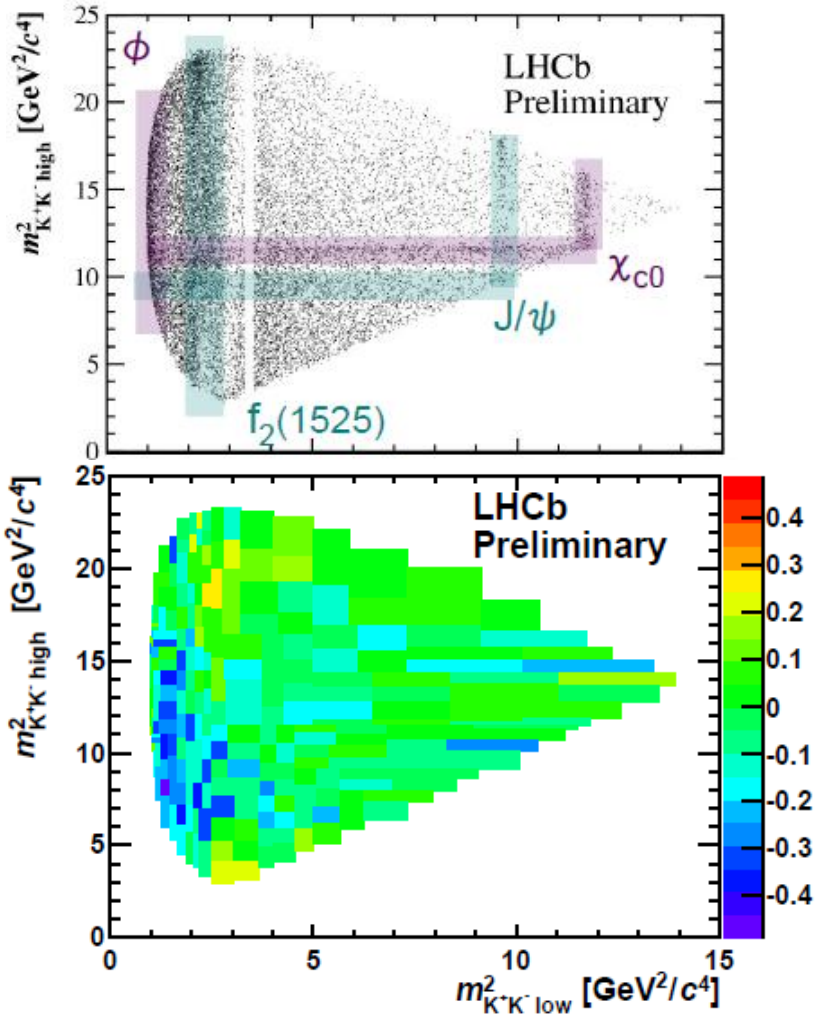
Contribution	$\pi\pi\pi$	$KK\pi$
Fit function model	0.008	0.009
Acceptance	0.015	0.014
A_{D}^{K} kaon kinematics	0.008	0.008
A_{D}^{K} stat. uncertainty	0.002	0.002
A_{D}^{π} stat. uncertainty	0.003	0.003
Total	0.019	0.019

Phase space dependence …

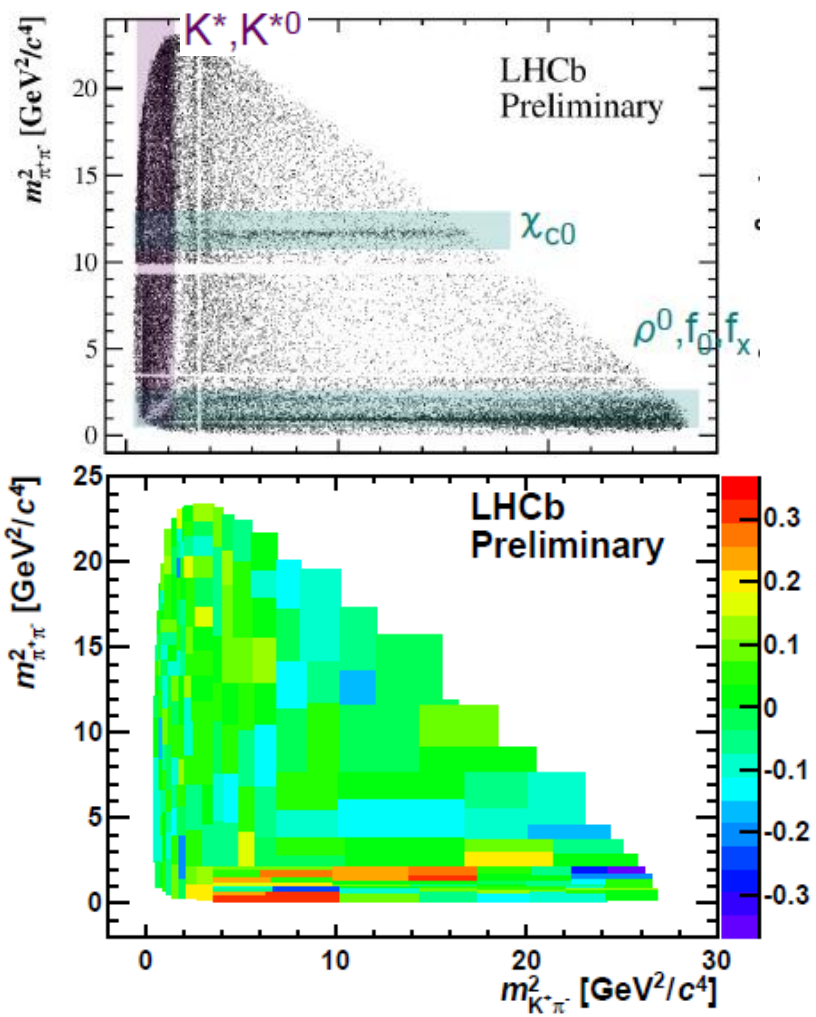
LHCB-CONF-2012-018

$B^{\pm} \to K^{\pm} K^{+}K^{-}$



large negative CPV at low m_{KK}
(region of resonances)

$B^{\pm} \to K^{\pm} \pi^{+}\pi^{-}$



large positive CPV at low $m_{\pi\pi}$