Study of CKM angle γ sensitivity using flavor untagged $B_s \to D^{(*)}\phi$ decays

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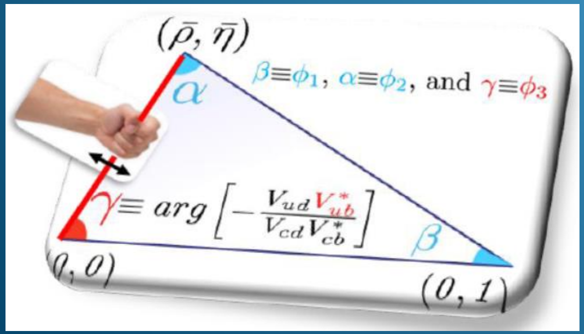

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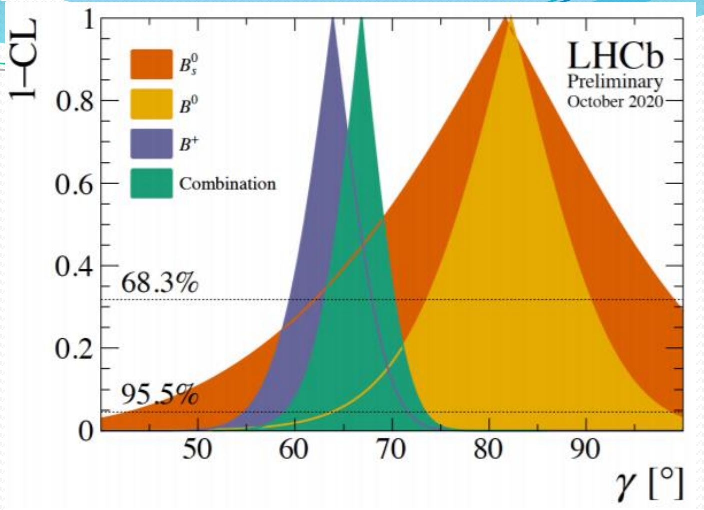
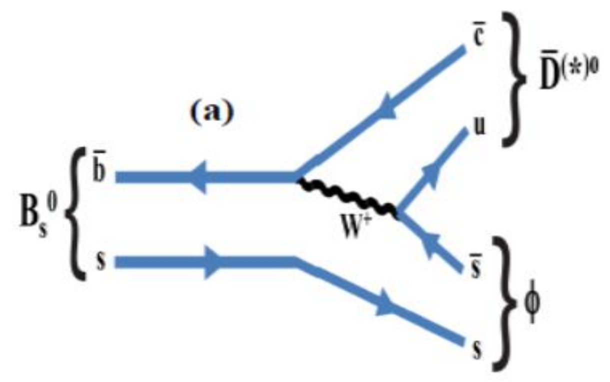
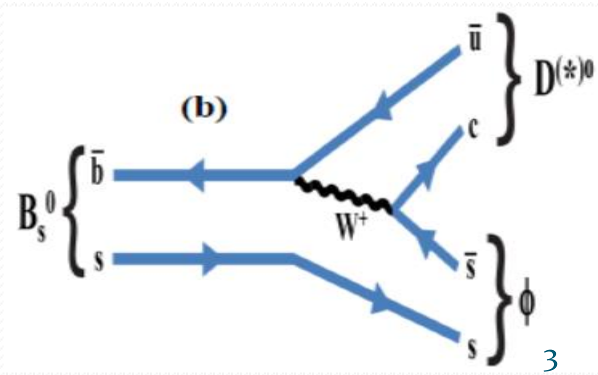
Introduction



- LHCb-CONF-2020-003 give:
  - $\gamma = (67 \pm 4)^o$
- LHCb latest measurement $\gamma = (69 \pm 5)^o$ from GGSZ method (single best world measurement, LHCb-CONF-2020-001)
- B_S result based on $B_S \rightarrow D_S K$ and $D_S K2pi$ with large uncertainty
- Additional B_S will help improve the measurement precision





Formalism

$$\tau = \Gamma_s t, \quad \Gamma_s = \frac{\Gamma_L + \Gamma_H}{2}, \quad \Delta\Gamma_s = \Gamma_L - \Gamma_H,$$
$$y = \frac{\Delta\Gamma_s}{2\Gamma_s}, \quad \lambda_f = \frac{q}{p}\cdot\frac{\bar{A}_{Bf}}{A_{Bf}},$$

- We define the amplitudes (neglecting CPV in D decays):

$$A\left(B_S \to \bar{D}^{(*)0}\phi\right) = A_B^{(*)},\ A\left(B_S \to D^{(*)0}\phi\right) = A_B^{(*)} r_B^{(*)} e^{i(\delta_B^{(*)}+\gamma)},$$

$$A(\bar{D}^0 \to f) = A\left(D^0 \to \bar{f}\right) = A_f, A(D^0 \to f) = A\left(\bar{D}^0 \to \bar{f}\right) = A_f r_D^f e^{i\delta_D^f},$$

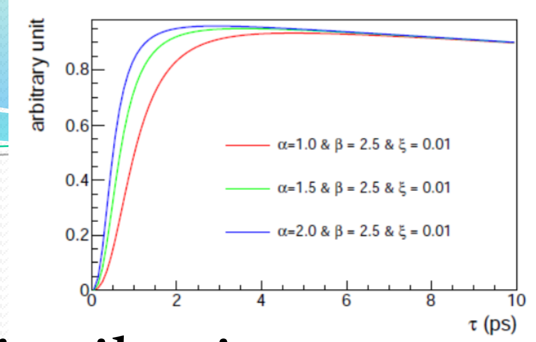
- According to the tree-level Amplitudes of $\bar{b} \to \bar{u}c\bar{s}$ and $\bar{b} \to \bar{c}u\bar{s}$,

$$A_{Bf} = A\left(B_S \to [f]_{D^{(*)}}\phi\right) = A_B^{(*)} A_{\mathrm{f}}^{(*)}[1 + r_B^{(*)} r_D^f e^{i(\delta_B^{(*)}+\delta_D^f+\gamma)}],$$

$$A_{B\bar{f}} = A\left(B_S \to [\bar{f}]_{D^{(*)}}\phi\right) = A_B^{(*)} A_{\mathrm{f}}^{(*)}\left[r_B^{(*)} e^{i\left(\delta_B^{(*)}+\gamma\right)} + r_D^f e^{i\delta_D^f}\right],$$

$$\frac{d\Gamma(B_S(\tau) \to [f]_{D^{(*)}}\phi)}{d\tau} + \frac{d\Gamma(\bar{B}_S(\tau) \to [f]_{D^{(*)}}\phi)}{d\tau} \propto$$
$$e^{-\tau}|\mathrm{A}_{Bf}|^2\left[\left(1 + |\lambda_f|^2\right)\cosh(y\tau) - 2Re\left(\lambda_f\right)\sinh(y\tau)\right]$$

Time acceptance



- Time acceptance effect on decay time distribution (Trigger & selection requirement to inefficiencies)

$$\varepsilon_{ta}(\tau) = \frac{(\alpha\tau)^{\beta}}{1+(\alpha\tau)^{\beta}}(1-\xi\tau),$$

Trigger & selection cut effect
Efficiency decreasing when vertex of track far away from beam

- Use MC we modeled α=1.5, β=2.5 and ξ=0.01

$$\Gamma\left(\bar{B}_S \to [f]_{D^{(*)}}\phi\right) = \int_0^{\infty}\left[\frac{d\Gamma\left(B_S(\tau) \to [f]_{D^{(*)}}\phi\right)}{d\tau} + \frac{d\Gamma\left(\bar{B}_S(\tau) \to [f]_{D^{(*)}}\phi\right)}{d\tau}\right]\varepsilon_{ta}(\tau)d\tau$$

$$\Rightarrow \quad \Gamma(B_s^0 \to [f]_D\phi) \propto |A_{Bf}|^2 \left[(1+|\lambda_f|^2)\mathcal{A} - 2y\mathrm{Re}(\lambda_f)\mathcal{B}\right],$$

$\mathcal{A}$ and $\mathcal{B}$ are parameters and defined in backup.

Observables for D^0 decay

- Using flavor modes: D→Kπ, K3π and Kππ°, and CP modes D→KK, ππ

$$N\left(B_s^0 \to \left[K^-\pi^+\right]_D \left[K^+K^-\right]_\phi\right) = C_{K\pi}\Big[-2\mathcal{B}yr_B\cos\left(\delta_B + 2\beta_s - \gamma\right) + \mathcal{A}\left(1 + {r_B}^2 + 4r_B r_D^{K\pi}\cos\delta_B\cos\left(\delta_D^{K\pi} + \gamma\right)\right)\Big],$$

  - Make approximation $(r_D^{K\pi})^2 \ll 1$ and $yr_D^{K\pi} \ll 1$
  - Normalization factor $C_{K\pi}$(Estimated from LHCb Run1 data):

$$C_{K\pi} = N(B_s^0) \times \epsilon(B_s^0 \to D(K^-\pi^+)\phi(K^+K^-)) \times \frac{C}{\Gamma(B_s^0 \to all)}$$

$$\boxed{C = \frac{(2\pi)^4}{2M_{B_s}}\int |A_B|^2|A_f|^2|A_\phi|^2 d\Phi_4(P, p1, p2, p3, p4)}$$

$$= N(B_s^0) \times \epsilon(B_s^0 \to D(K^-\pi^+)\phi(K^+K^-)) \times Br(B_s^0 \to D(K^-\pi^+)\phi(K^+K^-))$$

- For f= K3π / Kππ° (more observables in backup)

$$N\left(B_s^0 \to \left[f^-\right]_D \left[K^+K^-\right]_\phi\right) = C_{K\pi}F_f\Big[-2\mathcal{B}y\left[x_-\cos\left(2\beta_s\right) - y_-\sin\left(2\beta_s\right)\right] + \mathcal{A}\left(1 + x_-^2 + y_-^2 + 2r_D^f R_D^f\left[\left(x_+ + x_-\right)\cos\delta_D^f - \left(y_+ - y_-\right)\sin\delta_D^f\right]\right)\Big],$$

  - F_f is scale factor of f decay relative to Kπ decay

$$F_f = \frac{C_f}{C_{K\pi}} = \frac{\varepsilon(D \to f)}{\varepsilon(D \to K\pi)} \times \frac{[Br(D^0 \to f) + Br(\overline{D}^0 \to f)]}{[Br(D^0 \to K^-\pi^+) + Br(\overline{D}^0 \to K^-\pi^+)]}.$$

Observables for D^{*0} decay

- According to *Phys. Rev.* **D 70** (2004) 091503, consider CP eigenstate $D^* \to D\pi^0$ and $D\gamma$:
  - $D^*_{\pm} \to D_{\pm}\pi^0$, observables similar as $D\phi$
  - $D^*_{\pm} \to D_{\mp}\gamma$, observables with an effective strong phase shift of π
- D^* CP eigenstate: Longitudinal polarization fraction $f_L = (73 \pm 15 \pm 4)\%$ *Phys. Rev.* **D 98** (2018) 071103
- Examples (more in backup)

$$N\left(B_s^0 \to [[K^-\pi^+]_D \pi^0]_{D^*} [K^+K^-]_\phi\right) = C_{K\pi\pi^0}\Big[-2\mathcal{B}yr_B^* \cos(\delta_B^* + 2\beta_s - \gamma) + \mathcal{A}\left(1 + {r_B^*}^2 + 4r_B^* r_D^{K\pi} \cos\delta_B^* \cos(\delta_D^{K\pi} + \gamma)\right)\Big],$$

$$N\left(B_s^0 \to [[K^-\pi^+]_D \gamma]_{D^*} [K^+K^-]_\phi\right) = C_{K\pi\gamma}\Big[2\mathcal{B}yr_B^* \cos(\delta_B^* + 2\beta_s - \gamma) + \mathcal{A}\left(1 + {r_B^*}^2 - 4r_B^* r_D^{K\pi} \cos\delta_B^* \cos(\delta_D^{K\pi} + \gamma)\right)\Big],$$

Expected yields

- According to Run1 result (*Phys. Rev.* **D 98** (2018) 071103)

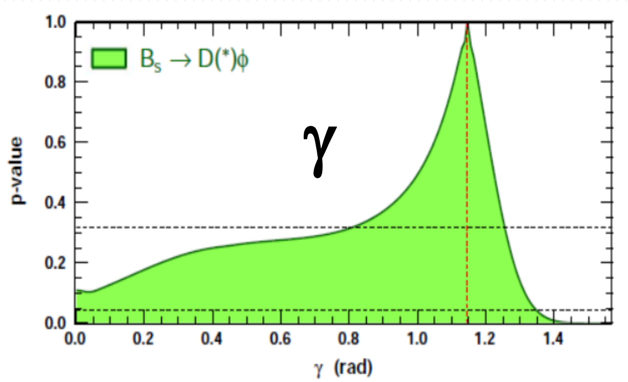
Years/Run	$\sqrt{s}$ (TeV)	int. lum.(fb^{-1})	cross section	equiv. 7 TeV data
2011	7	1.1	$\sigma_{2011} = 38.9\ \mu\mathrm{b}$	1.1
2012	8	2.1	$1.17 \times \sigma_{2011}$	2.4
Run 1	–	3.2	–	3.5
2015-2018 (Run 2)	13	5.9	$2.00 \times \sigma_{2011}$	11.8
Total	–	9.1	–	15.3

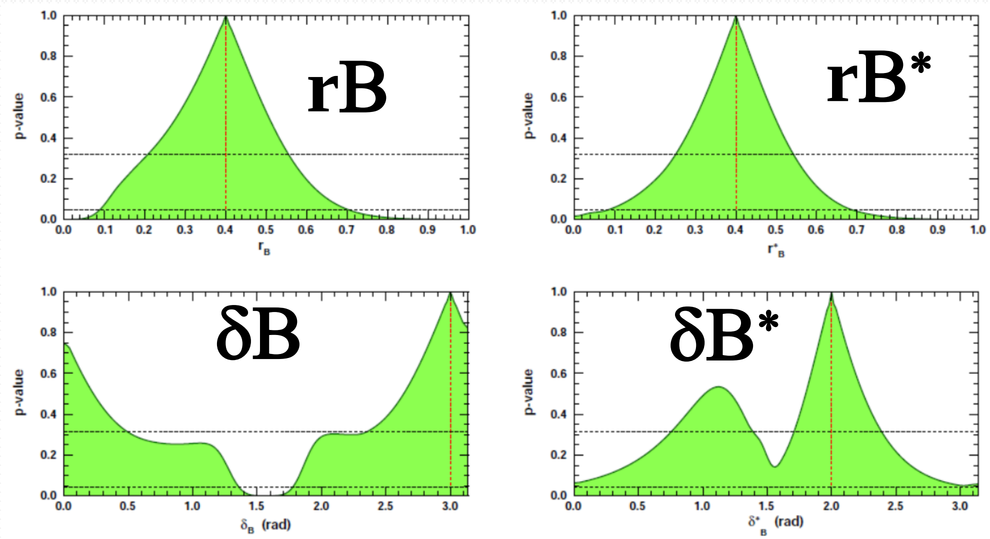
	Expect. yield (Run 1 only)	
$B_s^0 \to \tilde{D}^0(K\pi)\phi$	577 (132 ± 13 [18])	
$B_s^0 \to \tilde{D}^0(K3\pi)\phi$	218	
$B_s^0 \to \tilde{D}^0(K\pi\pi^0)\phi$	58	
$B_s^0 \to \tilde{D}^0(KK)\phi$	82	
$B_s^0 \to \tilde{D}^0(\pi\pi)\phi$	24	
$B_s^0 \to \tilde{D}^0(K_S^0\pi\pi)\phi$	54	
$B_s^0 \to \tilde{D}^0(K_S^0KK)\phi$	8	
$B_s^0 \to \tilde{D}^{*0}\phi$ mode	$D^0\pi^0$	$D^0\gamma$
$B_s^0 \to \tilde{D}^{*0}(K\pi)\phi$	337	184
	(119 [18])	
$B_s^0 \to \tilde{D}^{*0}(K3\pi)\phi$	127	69
$B_s^0 \to \tilde{D}^{*0}(K\pi\pi^0)\phi$	34	18
$B_s^0 \to \tilde{D}^{*0}(KK)\phi$	48	26
$B_s^0 \to \tilde{D}^{*0}(\pi\pi)\phi$	14	8

- Normalization factor:
  - $C_{K\pi}$=608 ± 67
  - $C_{K\pi\ \pi0}$=347 ± 56
  - $C_{K\pi\ \gamma}$=189 ± 31

Sensitivity study for Run 1&2 dataset

- A procedure involving global χ^2 fit based on CKMfitter package
- Establish formulism between γ and observables
- Set initial variables: γ, $rB^{(*)}$, $\delta B^{(*)}$ → Obtain observables mean value
- Use observables errors from data set (e.g. Run 1&2) → generate toys → refit to obtain γ sensitivity
- γ set to be $(65.64^{+0.97}_{-3.42})^{o}$ (1.146 rad), $rB^{(*)}$=0.4, δB=3.0 rad, δB^{*}=2.0 rad





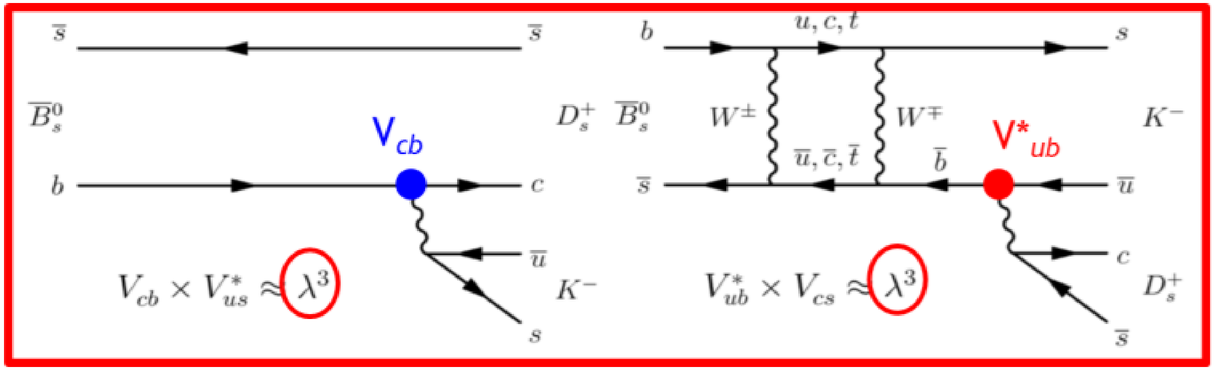
Relationship between γ and other variables

- $\delta B^{(*)}$ is a nuisance parameter, 6 different values are assigned: (0,1,2,3,4,5 rad)
- $rB^{(*)}$ is expected to be $|V_{ub}V_{cs}|/|V_{cb}V_{us}|$~0.4, also 0.22 from $B^0 \rightarrow DK^{*0}$ is tested.
- → 72 tested configuration ($2 \times 6 \times 6$)
- 4000 pseudoexperiments are generated for each configuration
- An extended unbinned maximum likelihood fit is performed based on the 4000 toys
- The sensitivity is deduced and any bias or correlation is eventually hightlighted and studied

Different rB$^{(*)}$

Color favour

$B_s \to D_s^{\mp} K^{\pm}$

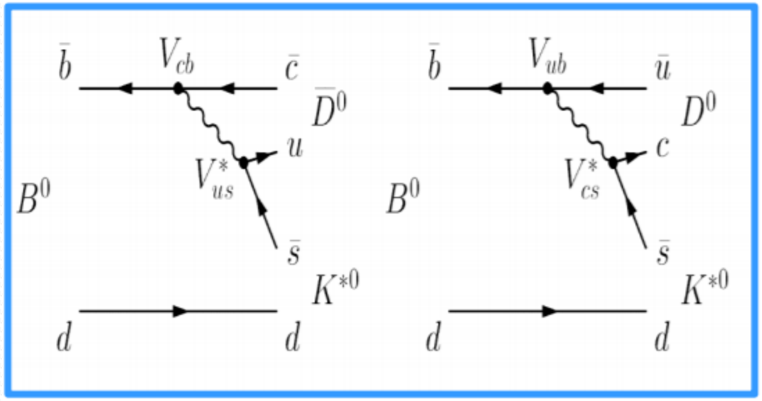


- $r_B = 0.37^{+0.10}_{-0.09}$

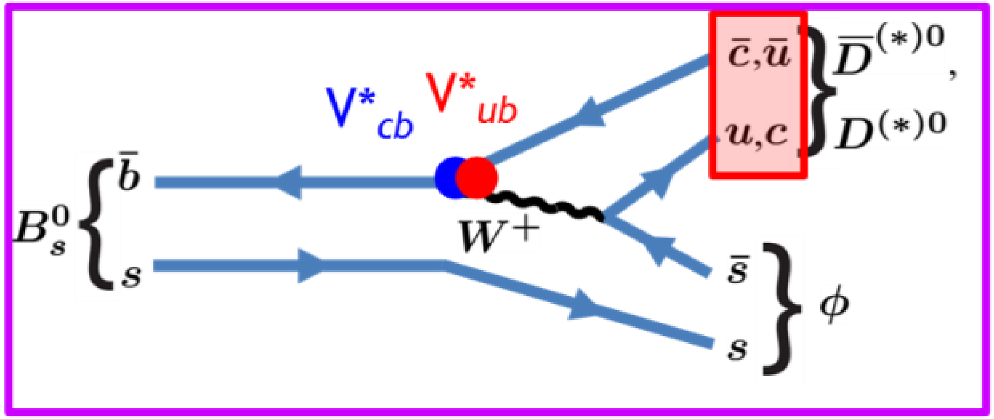
  JHEP 1803 (2018) 059)

Color suppress

$B^0_d \to DK^{*0}$



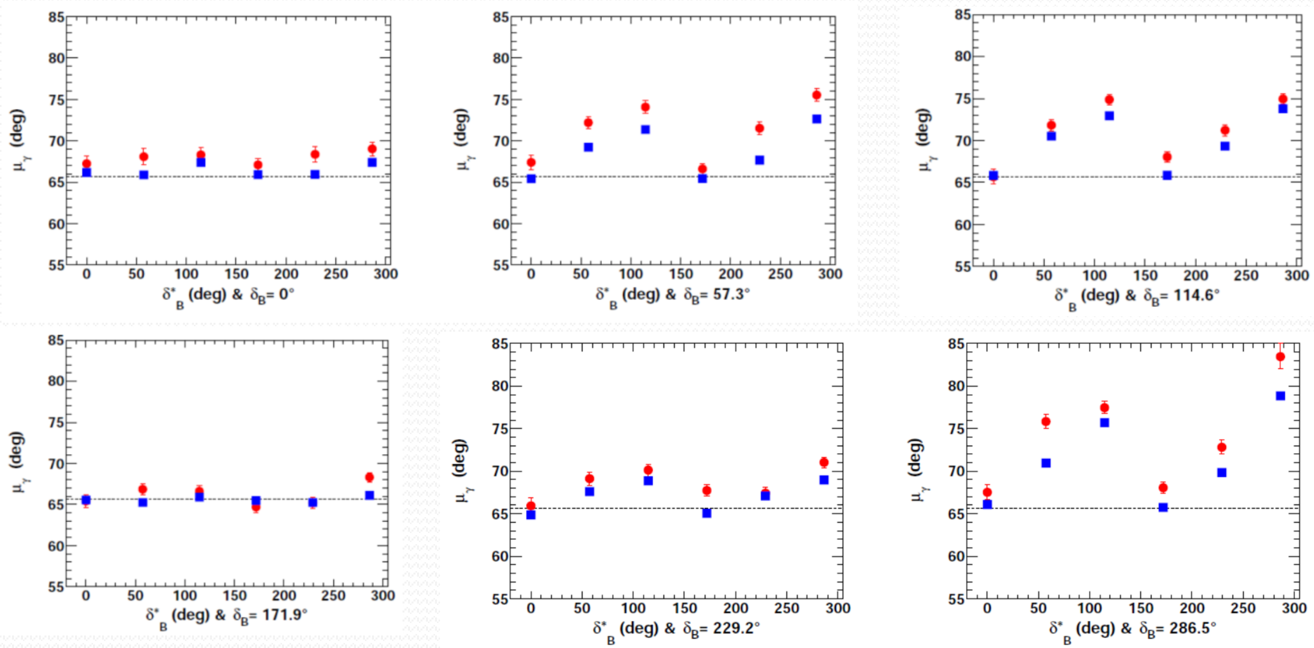
$B^0_s \to D^{(*)0}\phi$



- $r_B = 0.221^{+0.044}_{-0.047}$ LHCb-CONF-2018-002

Varying $\delta B^{(*)}$ and $rB^{(*)}$

Fitted mean value of γ, uncertainties are statistical only



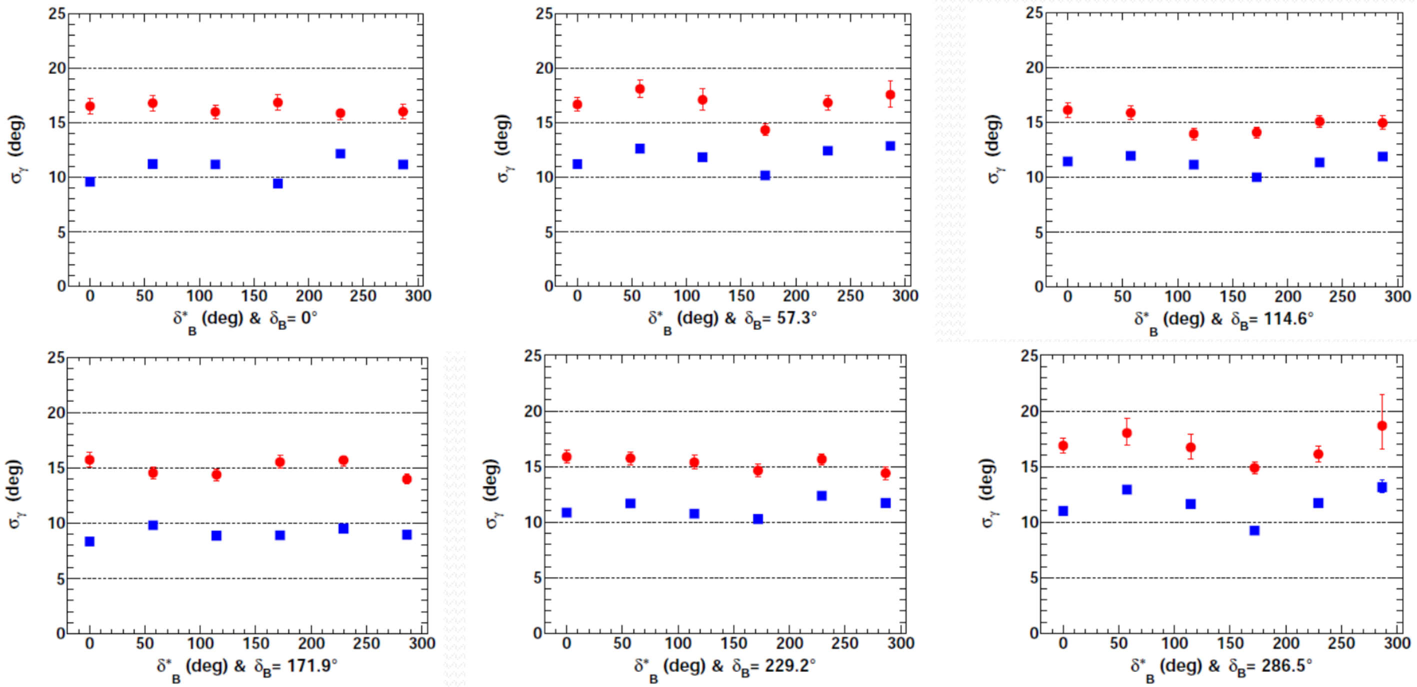
$rB^{(*)}=0.4$

$rB^{(*)}=0.22$

- γ mean value float with different $\delta B^{(*)}$, the best agreement when $\delta B^{(*)} \sim 0/180$ degree (reasonable from formulism, largest CP violation effects there)
- Worst sensitivity when $\delta B^{(*)} = 90/270$ degree

Varying $\delta B^{(*)}$ and $rB^{(*)}$ (II)

Fitted resolution of γ , uncertainties are statistical only

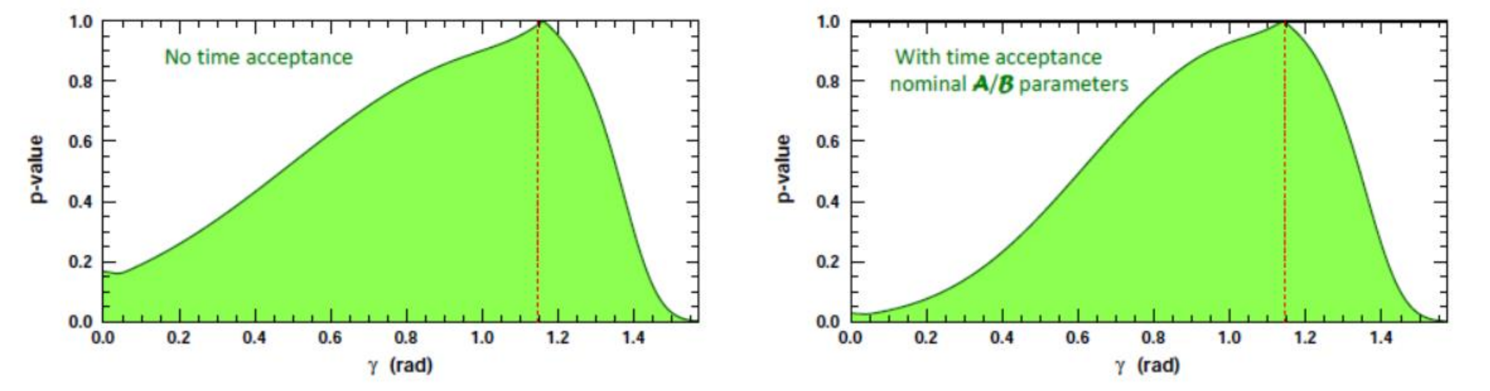


$rB^{(*)}$=0.4
$rB^{(*)}$=0.22

- $rB^{(*)}$ is strongly impact the precision on γ as $1/rB^{(*)}$
- Best resolutions when $rB^{(*)} \sim$ 0/180 degree
- For $rB^{(*)}$ =0.4(0.22), $\sigma_\gamma \sim 10^o$ (15^o)

Effect of the time acceptance parameters

- Test the time acceptance is taken into account or not (With γ =1.146 rad, rB$^{(*)}$=0.4, δB$^{(*)}$=1.0 rad)



- For B/A≈1.6, as opposed to B/A≈1.6, the impact of the first term in equation of P5, which is directly proportional to cos(δB+2βs-γ), is amplified with respect to the second term, for which the sensitivity to γ is more diluted.

Effect of the time acceptance parameters (II)

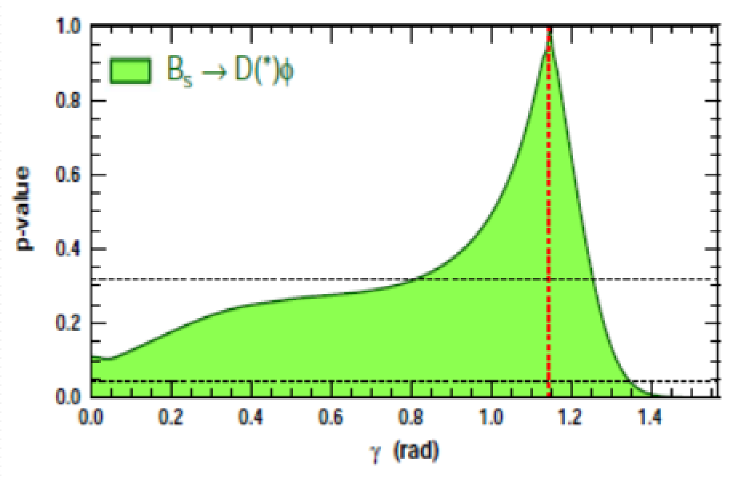
- Overall efficiency is constant, the shape of the acceptance varied, so α, β and ξ changes

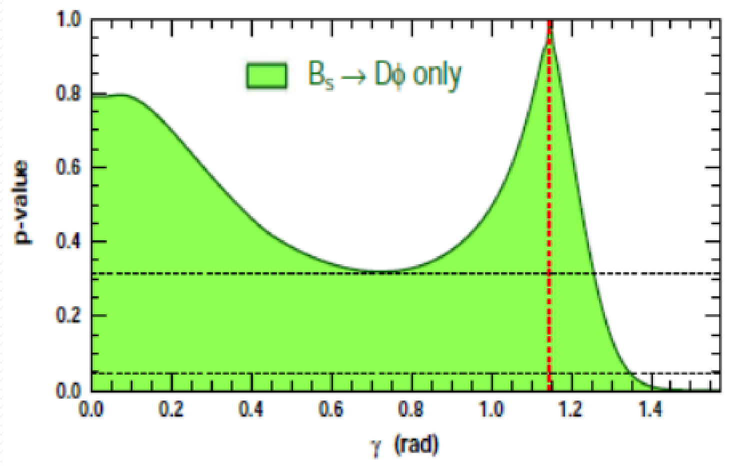
α	β	ξ	$\mathcal{A}$	$\mathcal{B}$	$\mathcal{B}/\mathcal{A}$	fitted γ (°)
1.0	2.5	0.01	0.367	0.671	1.828	$66.5^{+13.8}_{-40.1}$
1.5	**2.5**	**0.01**	**0.488**	**0.773**	**1.584**	$\mathbf{65.3^{+14.3}_{-38.4}}$
2.0	2.5	0.01	0.570	0.851	1.493	$65.3^{+13.2}_{-37.8}$
1.5	2.0	0.01	0.484	0.751	1.552	$65.9^{+13.2}_{-39.0}$
1.5	3.0	0.01	0.491	0.789	1.607	$66.5^{+13.2}_{-38.4}$
1.5	2.5	0.02	0.480	0.755	1.573	$66.5^{+13.8}_{-39.5}$
1.5	2.5	0.005	0.492	0.783	1.591	$65.3^{+13.8}_{-36.7}$

- α increases, A and B turn larger, but B/A decreases
- β or ξ decreases, A, B and B/A increase.
- Effect of changing β or ξ alone is small
- All have weak impact on precision of γ

Effect of using or not the Bs→D*ϕ decays

- there is a relative loss on precision to the unfolded value of γ of about 10 (25)%, when the Bs→D*ϕ decay are not used. For future datasets the improvement obtained by including Bs→D*ϕ modes is less significant, but not negligible and helps to improve the measurement of γ.

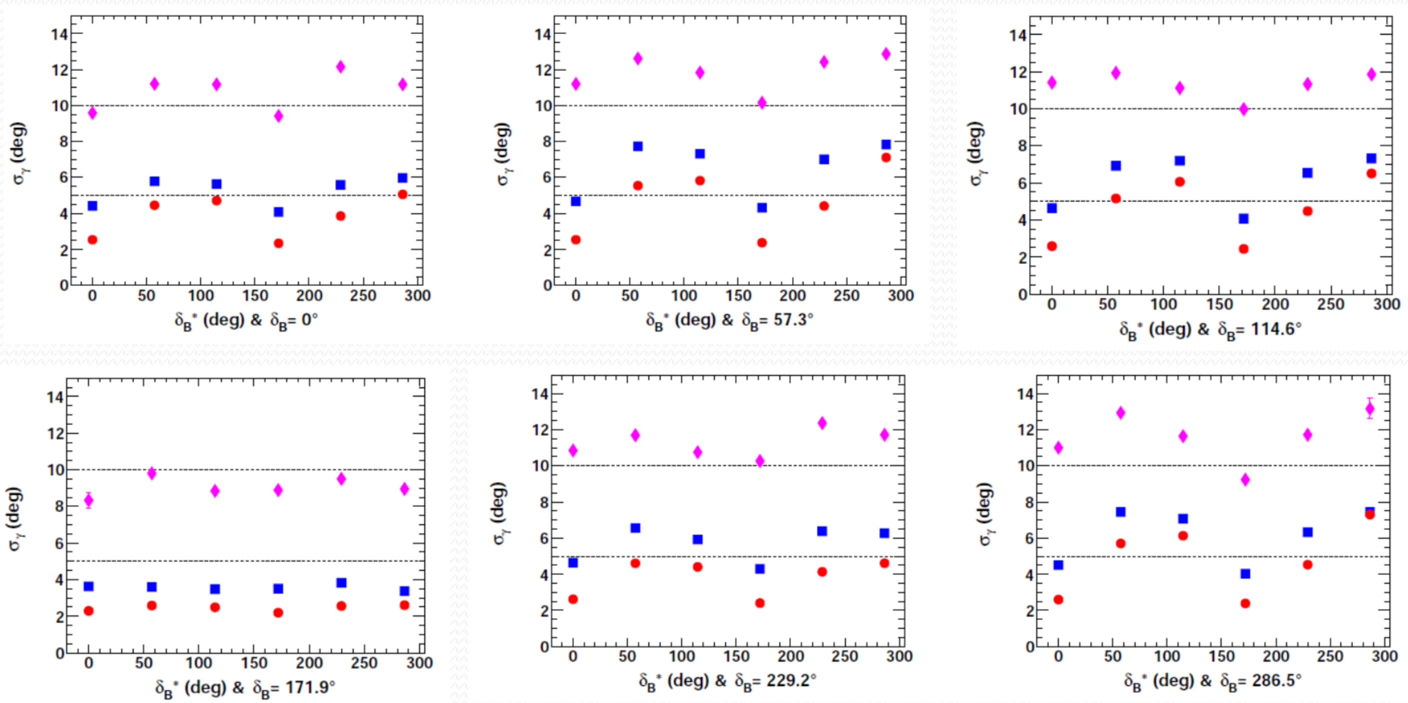




Prospective for Run 1-3 and HL-LHC

- According to LHCb-PUB-2018-009, ~23fb^{-1} by 2025 (run1~3), ~300fb^{-1} by 2035 (HL-LHC)

Fitted resolution of γ, uncertainties are statistical only, with rB$^{(*)}$=0.4



Run1&2
Run1~3
HL-LHC

More details in backup

Conclusion

More details in https://arxiv.org/abs/2008.00668

- Untagged $Bs \rightarrow D^{(*)}\phi$ provide another theoretically clean path to measure γ.
- By using expected event yields for 5 D sub-modes(3 flavor and 2 CP), we have shown that a precision on γ of about 8~19^{o} with LHCb Run1&2 data
- With more data 3-8^{o} with Run 1-3(~23fb^{-1}) and 2-7^{o} with HL-LHC(~300fb^{-1})
- The asymptotic sensitivity is anyway dominated by the possibly large correlations of γ with respect to the nuisances parameters $\delta B^{(*)}$ and $rB^{(*)}$
- This method will improve our knowledge of γ from Bs decays & help understand the discrepancy of γ between measurements with B^{+} and Bs modes.

Thank you!

backup

About Time acceptance

$\frac{q}{p} \approx 1$, $y^2 << 1$ and $x >> 1$,

$$\begin{aligned}
\int_0^\infty \Gamma_{B_s^0\to f}(\tau)\cdot\epsilon(\tau)d\tau &= |A_f|^2\int_0^\infty e^{-\tau}\left[(1+|\lambda|^2)\cosh y\tau - 2Re(\lambda)\sinh y\tau\right]\cdot\frac{\alpha\tau^\beta}{1+(\alpha\tau)^\beta}\cdot(1-\xi\tau)d\tau \\
&= |A_f|^2(1+|\lambda|^2) - 2y|A_f|^2Re(\lambda) \\
&\quad -|A_f|^2\int_0^\infty e^{-\tau}\left[(1+|\lambda|^2)\cosh y\tau - 2Re(\lambda)\sinh y\tau\right]\cdot\frac{1+\xi\tau(\alpha\tau)^\beta}{1+(\alpha\tau)^\beta}d\tau. \\
&= (|A_f|^2(1+|\lambda|^2))\left[1-\frac{f(1-y)+f(1+y)}{2}\right] - 2y|A_f|^2Re(\lambda)\left[1-\frac{f(1-y)-f(1+y)}{2y}\right].
\end{aligned}$$

$$f(x) = \int_0^\infty \frac{e^{-x\tau}(1+\xi\tau(\alpha\tau)^\beta)}{1+(\alpha\tau)^\beta}d\tau,$$

$$\Gamma(B_s^0\to[f]_D\phi)\propto|A_{Bf}|^2\left[(1+|\lambda_f|^2)\mathcal{A} - 2y\mathrm{Re}(\lambda_f)\mathcal{B}\right],$$

With y=(0.128$\pm$0.009)/2 for B_S meson, one gets A=0.488$\pm$0.005 and B=0.773$\pm$0.008

Normalization factor

- Consider Bs→Dphi, D→Kpi,

$$|A_{B\to D\phi}^{K^-\pi^+}|^2 = |A_B|^2|A_f|^2|A_\phi|^2\left[1+r_B^2+4r_Br_D^{K\pi}\cos\delta_B\cos(\delta_D^{K\pi}+\gamma)-2yr_B\cos(\delta_B+2\beta_s-\gamma)\right]$$

- Then

$$\mathrm{d}\Gamma(B_s^0\to D(K^-\pi^+)\phi(K^+K^-)) = \frac{(2\pi)^4}{2M_{B_s}}|A_{B\to D\phi}^{K^-\pi^+}|^2\mathrm{d}\Phi_4(P,p1,p2,p3,p4),$$

- Integrating,

$$\Gamma(B_s^0\to D(K^-\pi^+)\phi(K^+K^-)) = C\left[1+r_B^2+4r_Br_D^{K\pi}\cos\delta_B\cos(\delta_D^{K\pi}+\gamma)-2yr_B\cos(\delta_B+2\beta_s-\gamma)\right]$$

where $C = \frac{(2\pi)^4}{2M_{B_s}}\int|A_B|^2|A_f|^2|A_\phi|^2\mathrm{d}\Phi_4(P,p1,p2,p3,p4)$

$$Br(B_s^0\to D(K^-\pi^+)\phi(K^+K^-)) = \frac{C}{\Gamma(B_s^0\to all)}\left[1+r_B^2+4r_Br_D^{K\pi}\cos\delta_B\cos(\delta_D^{K\pi}+\gamma)-2yr_B\cos(\delta_B+2\beta_s-\gamma)\right],$$

- The bracket ~1 and have

$$\frac{C}{\Gamma(B_s^0\to all)} \simeq Br(B_s^0\to D(K^-\pi^+)\phi(K^+K^-))$$

Observables for D^0 decay

$$N\left(B_s^0 \to [f^-]_D [K^+K^-]_\phi\right) = C_{K\pi}F_f\Big[-2\mathcal{B}yr_B\cos\left(\delta_B + 2\beta_s - \gamma\right) + \mathcal{A}\left(1 + {r_B}^2 + 4r_B r_D^f R_D^f \cos\delta_B \cos\left(\delta_D^f + \gamma\right)\right)\Big],$$

$$N\left(B_s^0 \to [f^+]_D [K^+K^-]_\phi\right) = C_{K\pi}F_f\Big[-2\mathcal{B}yr_B\cos\left(\delta_B - 2\beta_s + \gamma\right) + \mathcal{A}\left(1 + {r_B}^2 + 4r_B r_D^f R_D^f \cos\delta_B \cos\left(\delta_D^f - \gamma\right)\right)\Big],$$

$$F_f = \frac{C_f}{C_{K\pi}} = \frac{\varepsilon(D \to f)}{\varepsilon(D \to K\pi)} \times \frac{[Br(D^0 \to f) + Br(\overline{D}^0 \to f)]}{[Br(D^0 \to K^-\pi^+) + Br(\overline{D}^0 \to K^-\pi^+]}.$$

$$N\left(B_s^0 \to [h^+h^-]_D [K^+K^-]_\phi\right) = 4C_{K\pi}F_{hh}\Big[\mathcal{A}\left(1 + {r_B}^2 + 2r_B\cos\delta_B\cos\gamma\right) - \mathcal{B}y \times \left(\cos 2\beta_s + {r_B}^2\cos 2\left(\beta_s - \gamma\right) + 2r_B\cos\left(2\beta_s - \gamma\right)\cos\delta_B\right)\Big].$$

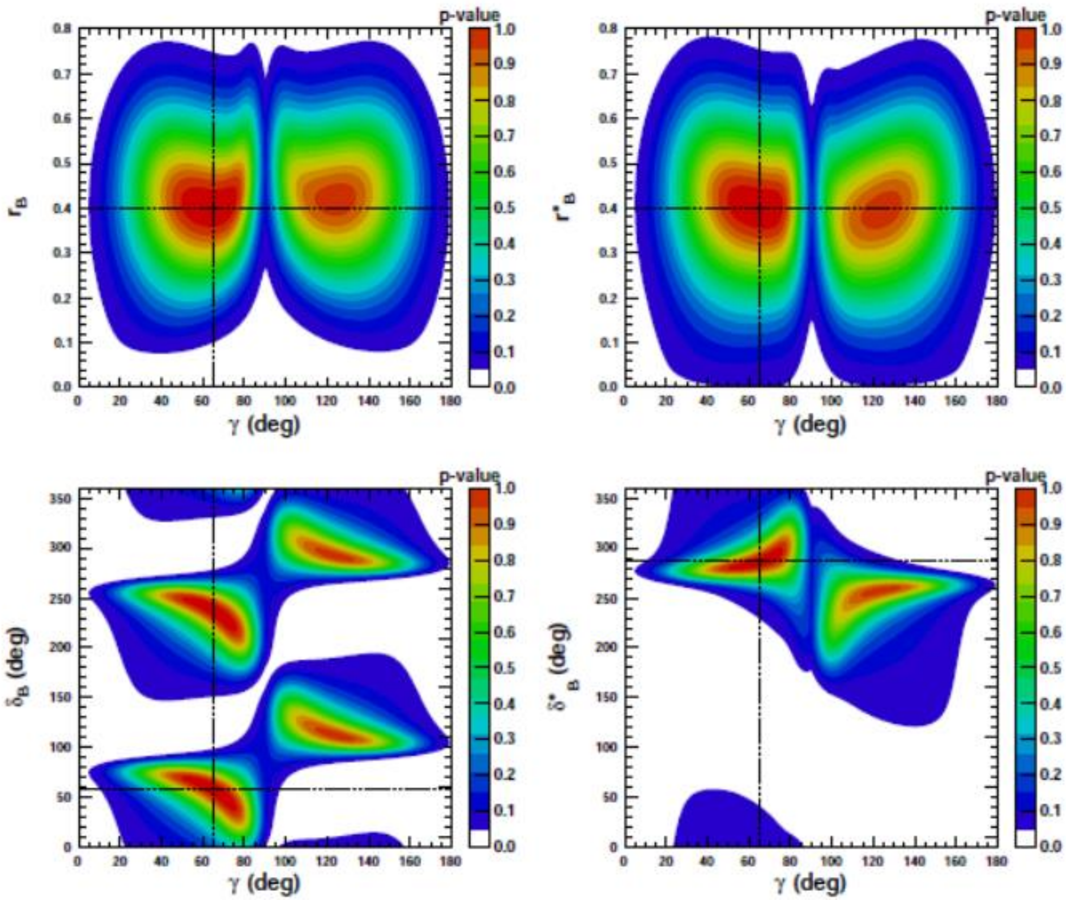
$$F_{hh} = \frac{C_{hh}}{C_{K\pi}} = \frac{\varepsilon(D \to hh)}{\varepsilon(D \to K\pi)} \times \frac{Br(D^0 \to hh)}{[Br(D^0 \to K^-\pi^+) + Br(\overline{D}^0 \to K^-\pi^+]}$$

Other external parameters

Parameter	Value
$-2\beta_S$ [mrad]	-36.86 ± 0.82 [35]
$y = \Delta\Gamma_s/2\Gamma_s$ (%)	6.40 ± 0.45 [21]
$r_D^{K\pi}$ (%)	$5.90^{+0.34}_{-0.25}$ [21]
$\delta_D^{K\pi}$ [deg]	$188.9^{+8.2}_{-8.9}$ [21]
$r_D^{K3\pi}$ (%)	5.49 ± 0.06 [36]
$R_D^{K3\pi}$ (%)	43^{+17}_{-13} [36]
$\delta_D^{K3\pi}$ [deg]	128^{+28}_{-17} [36]
$r_D^{K\pi\pi^0}$ (%)	4.47 ± 0.12 [36]
$R_D^{K\pi\pi^0}$ (%)	81 ± 6 [36]
$\delta_D^{K\pi\pi^0}$ [deg]	198^{+14}_{-15} [36]
Scale factor (wrt $K\pi$)	(stat. uncertainty only)
$F_{K3\pi}$ (%)	37.8 ± 0.1 [22]
$F_{K\pi\pi^0}$ (%)	10.0 ± 0.1 [23]
F_{KK} (%)	14.2 ± 0.1 [22]
$F_{\pi\pi}$ (%)	4.2 ± 0.1 [22]

- Scale factor are calculated according to *Phys. Lett.* **B 760**(2016) 117 and *Phys. Rev.* **D 91**(2015) 112014

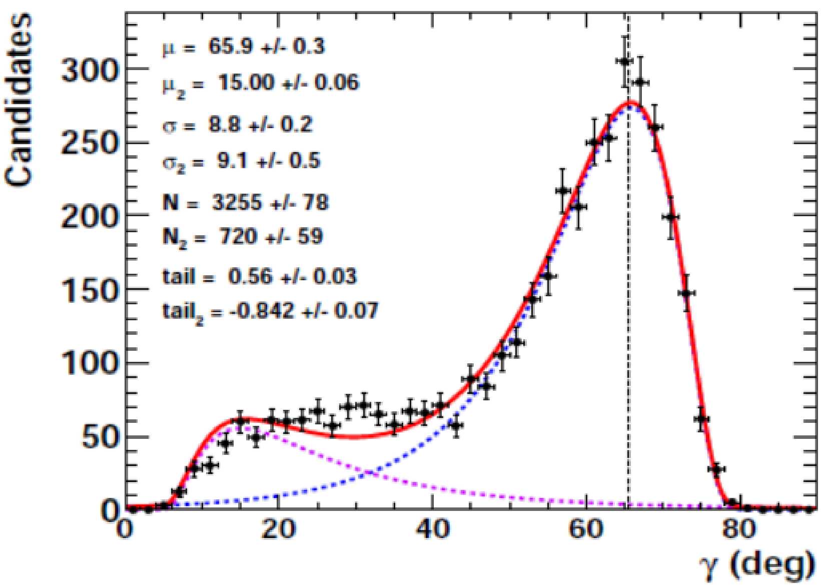
2-D p-value profile distribution

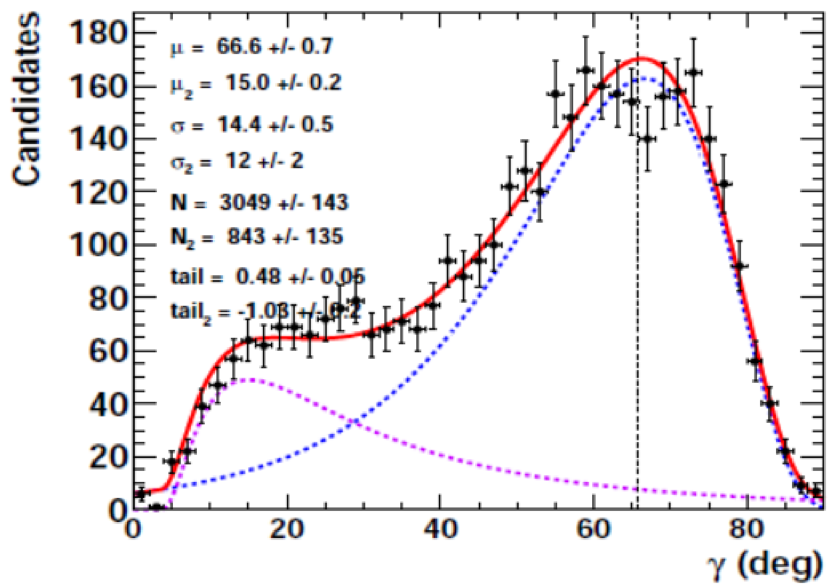


- With γ =1.146 rad, $rB^{(*)}$=0.4, δB=1.0 rad, δB^{*}=5.0 rad

Fitting distributions

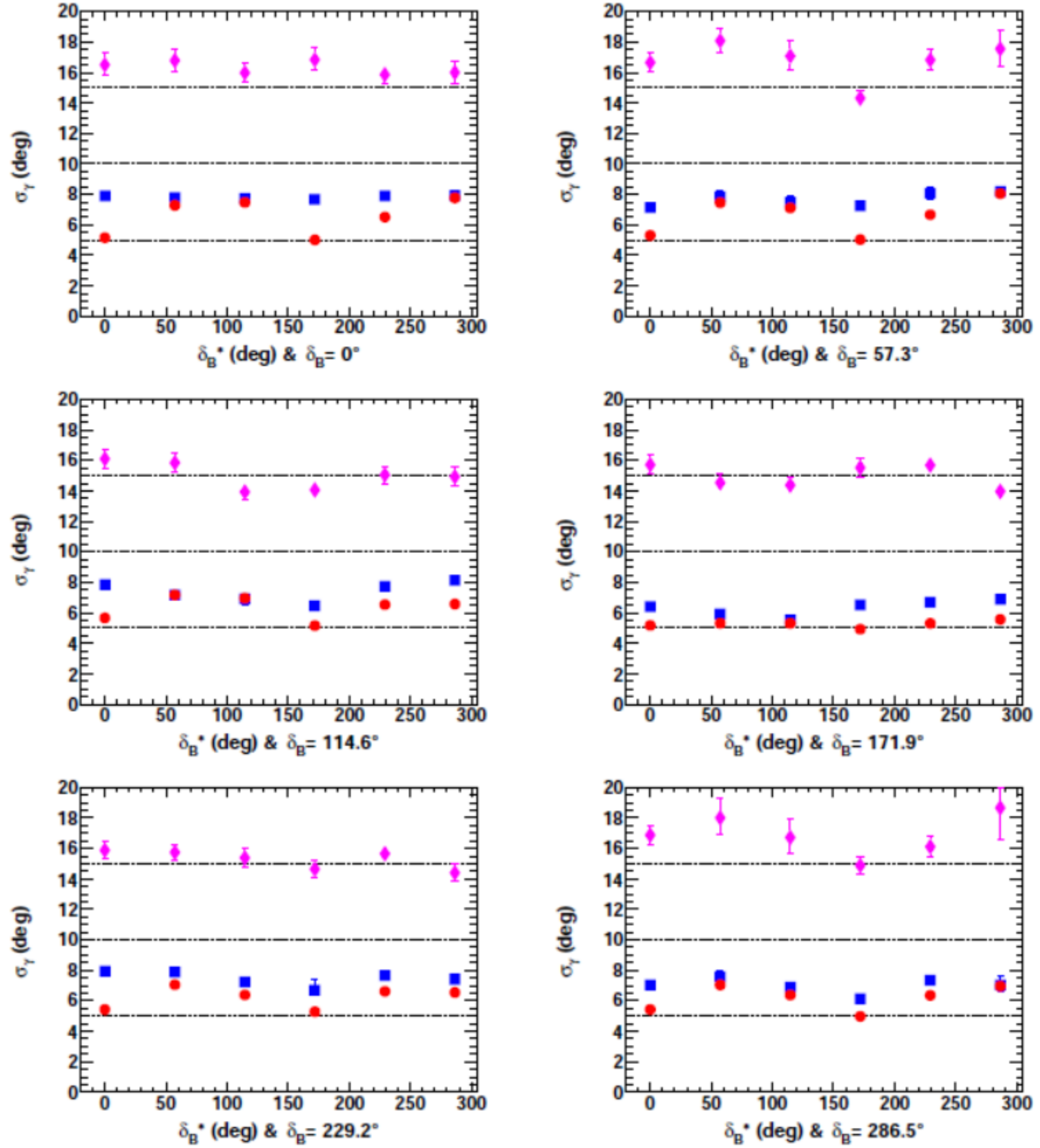
- Fit to the distributions of the nuisance parameters obtained from 4000 pseudo-experiments
- With γ =1.146 rad, $rB^{(*)}$=0.4(left) and 0.22(right), δB=3.0 rad, δB^{*}=2.0 rad





Prospective

Fitted resolution of γ, uncertainties are statistical only, with rB(*)=0.22



Run1&2
Run1~3
HL-LHC

Discussion about D→Kspipi/KsKK

- Only ~50(8) events expected for Kspipi(KsKK) mode in Run1&2
- 16 bins in Dalitz plot for the analysis
- Not consider now, but leave it to Run3 (~340 signals)

Effect of D→pipi or D→Kpipi0

- Low statistics from scaling the B^{+}→DK/Dpi modes
- The expected yields may be underestimated
- D→pipi is a CP mode
- R(Kpipi0)=(81+-6)% large coherence factor
- 3~15% precision loss if not use D→pipi mode
- 3~22% precision loss if not use D→Kpipi0 mode

Effect of a new binning scheme for D→K3π decay

- According to *Phys. Lett.* **B 802** (2020) 135188, averaged values of the K3π input parameters over phase space defined as

$$R_D^{K3\pi} e^{-i\delta_D^{K3\pi}} = \frac{\int A^*_{\overline{D}^0\to K3\pi}(x) A_{D^0\to K3\pi}(x) dx}{A_{\overline{D}^0\to K3\pi} A_{D^0\to K3\pi}},$$

- A more attractive approach could be to perform the analysis in disjoint bins of the phase space.→ The parameters are re-defined within each bin.
- No noticeable change on γ and $rB^{(*)}$ were seen, but it is possible that some fold-effects on $\delta B^{(*)}$ become less probable
- Also D→ K3π is not the dominant decay & new measurements in each bin still have large uncertainties

Effect of the strong parameters from D meson and of y

- Improvement of these parameters from BESIII or future super τ-charm factory

uncertainties on D-meson params.	Now	$\times 1/2$	$\times 1/5$	$\times 1/10$
Run 1 & 2 ($r_B^{(*)}=0.4$)	8.8 ± 0.2	8.1 ± 0.3	8.0 ± 0.3	7.8 ± 0.2
Run 1 & 2 ($r_B^{(*)}=0.22$)	12.9 ± 0.3	13.2 ± 0.5	13.1 ± 0.5	12.8 ± 0.9
full HL-LHC ($r_B^{(*)}=0.4$)	2.6 ± 0.1	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
full HL-LHC ($r_B^{(*)}=0.22$)	5.4 ± 0.1	5.3 ± 0.1	5.2 ± 0.1	5.1 ± 0.1

uncertainty on $y=\Delta\Gamma_s/2\Gamma_s$	Now	$\times 1/2$	$\times 1/5$	$\times 1/10$
Run 1 & 2 ($r_B^{(*)}=0.4$)	8.8 ± 0.2	8.3 ± 0.2	8.2 ± 0.2	8.1 ± 0.3
Run 1 & 2 ($r_B^{(*)}=0.22$)	12.9 ± 0.3	12.6 ± 0.4	12.5 ± 0.5	12.5 ± 0.5
full HL-LHC ($r_B^{(*)}=0.4$)	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
full HL-LHC ($r_B^{(*)}=0.22$)	5.3 ± 0.1	5.3 ± 0.1	5.2 ± 0.1	5.2 ± 0.1

- With much more data, future improvements on the parameters from D meson don't seem to impact much the sensitivity to γ in this mode