Synergy of BESIII/HIEPA and LHCb Physics Programs

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On behalf of the LHCb collaboration

HIEPA, 18-21 March 2018, Huairou China

- ➢ **Very successful and productive workshop; further synergy between BESIII/LHCb planned**
- ➢ **A lot of material in this talk from the workshop**

CKM constraints

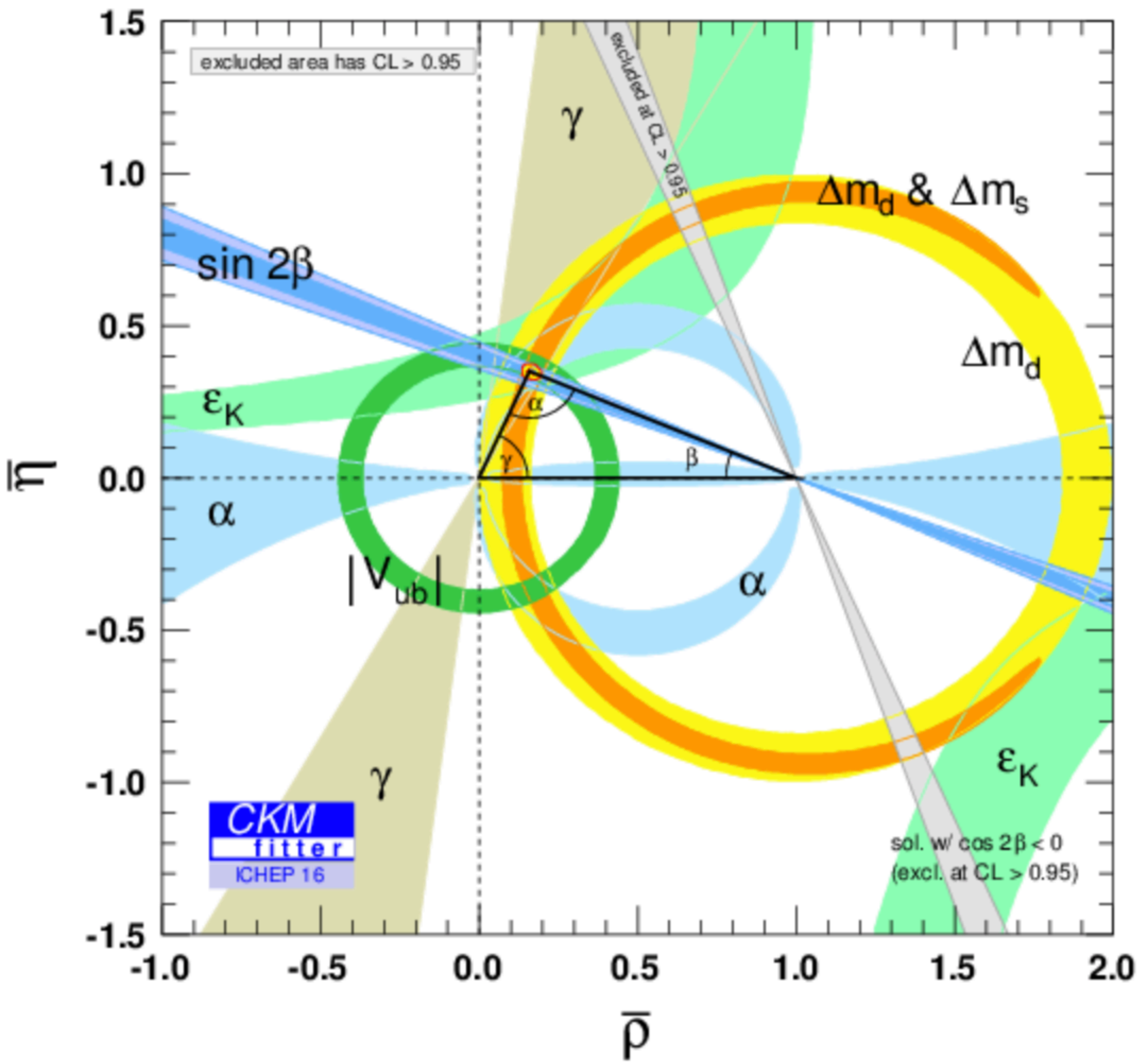
LHCb

Δm_d, Δm_s

α, β, γ

$|V_{ub}|$, $|V_{cb}|$

……



BESIII/HIEPA

$|V_{cs}|$, $|V_{cd}|$

$|V_{ts}|$, $|V_{td}|$

$|V_{ub}|$, $|V_{cb}|$

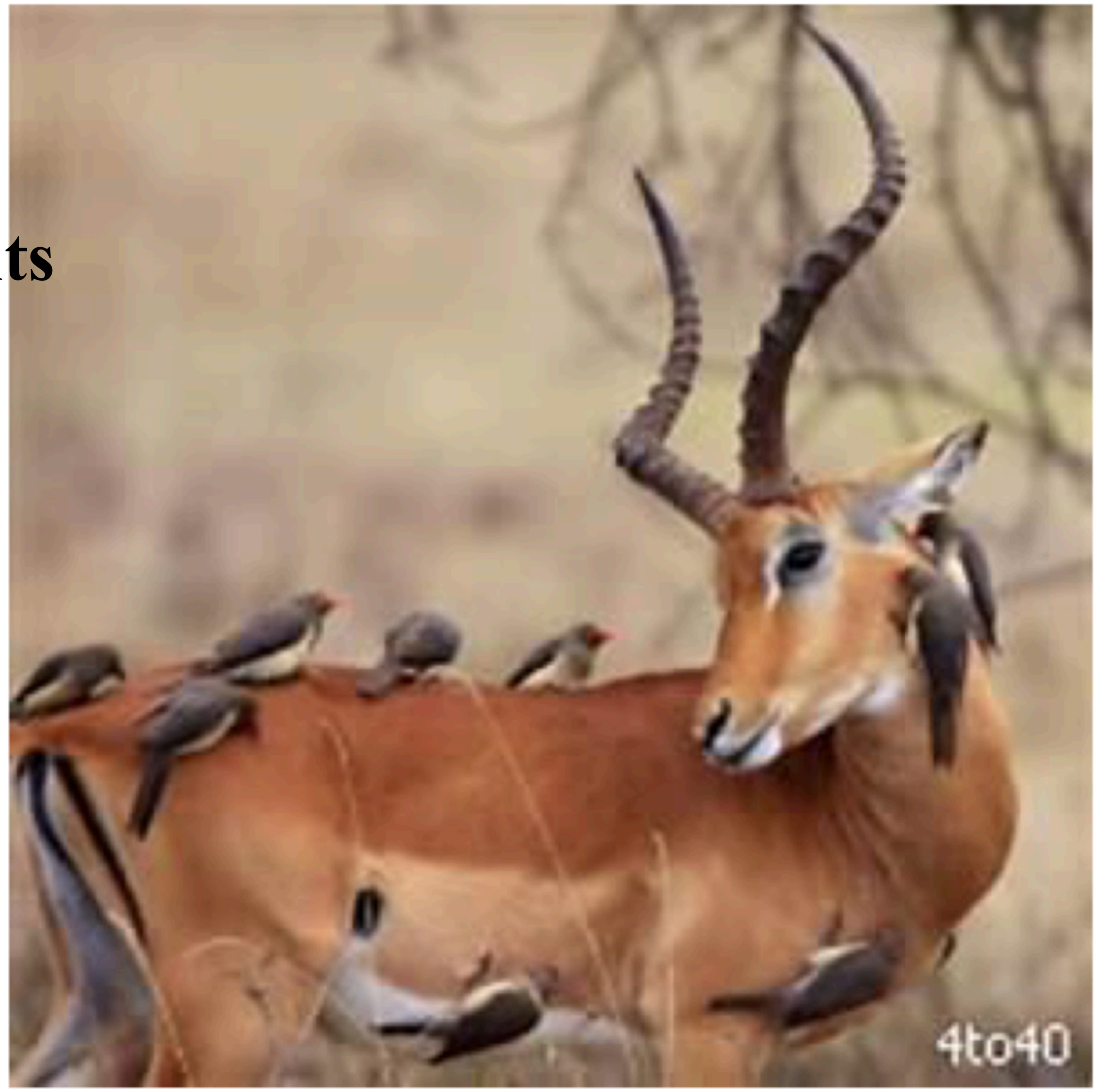
……

➢ **Inputs from different experiments already required to over-constrain CKM matrix and search for extra CPV sources**

Areas of common interests

Synergy and complementarity

- ➢ CKM angle γ measurements
- ➢ Absolute branching fraction measurements in D, Λ_c decays
- ➢ Spectroscopy and exotics (LHCb status by S. Barsuk)
- ➢ Charm CPV (LHCb status by M. Saur)
- ➢ Rare charm decays (LHCb status by S. Barsuk)



Disclaimer: A LHCb-member point of view

LHCb detector

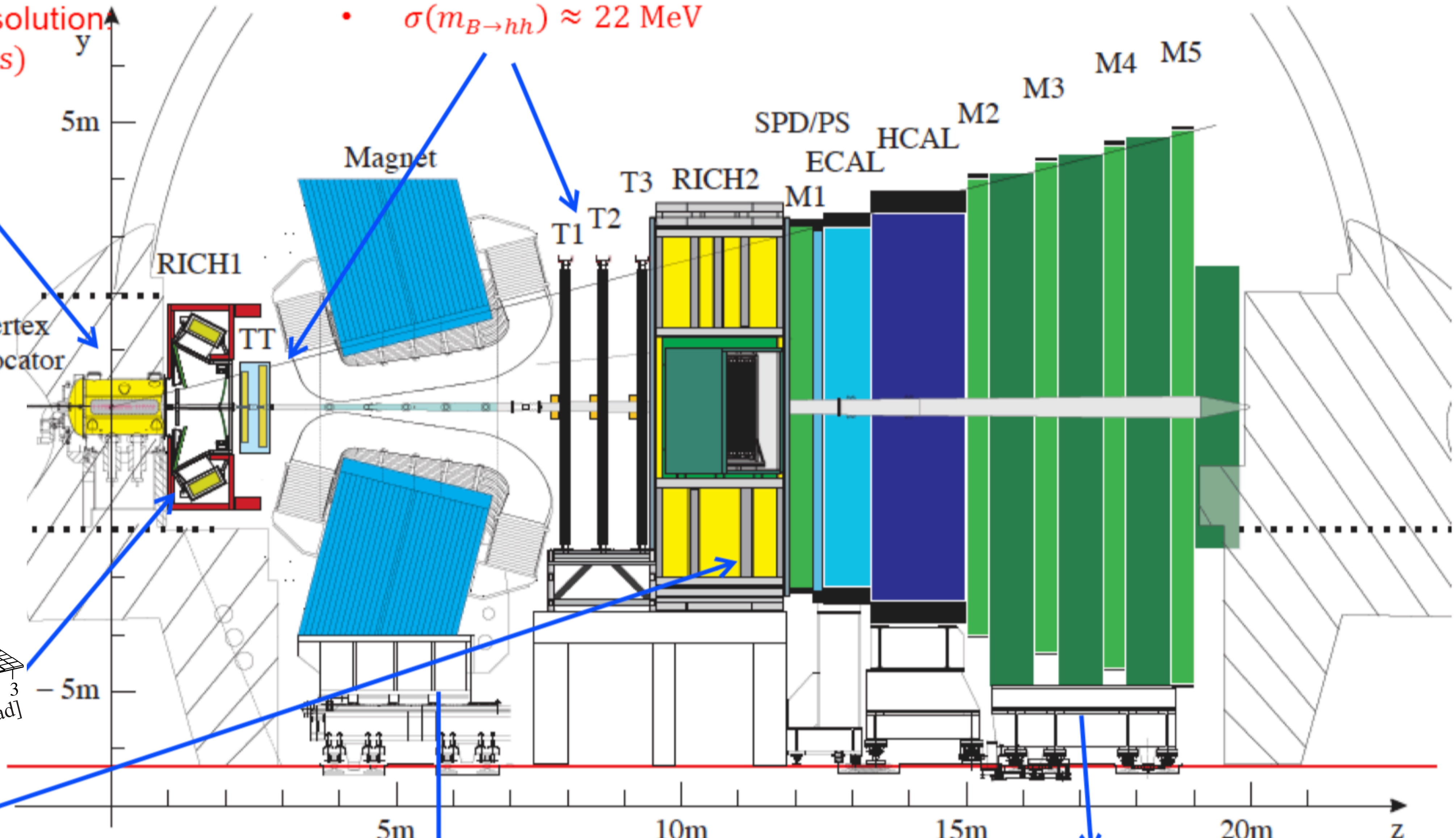
➢ **Forward spectrometer @ collider, acceptance: 1.9<η<4.9**

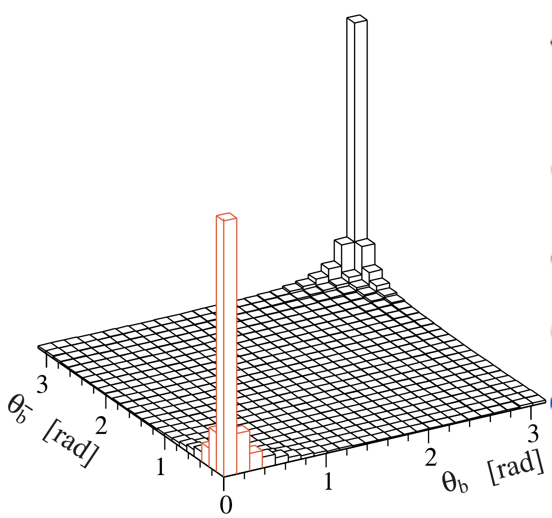
$$\eta = \frac{1}{2}\ln\frac{p+p_z}{p-p_z}$$

JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

Vertex Locator(vertex reconstruction)
- Impact parameter resolution: 20 μm
- Decay time resolution 45 fs (τ_B~1.5 ps)

Tracking system(particle reconstruction)
- ϵ(Tracking) ~96%
- $\delta p/p$ ~0.5%-1%(5-200 GeV)
- $\sigma(m_{B\to hh}) \approx$ 22 MeV





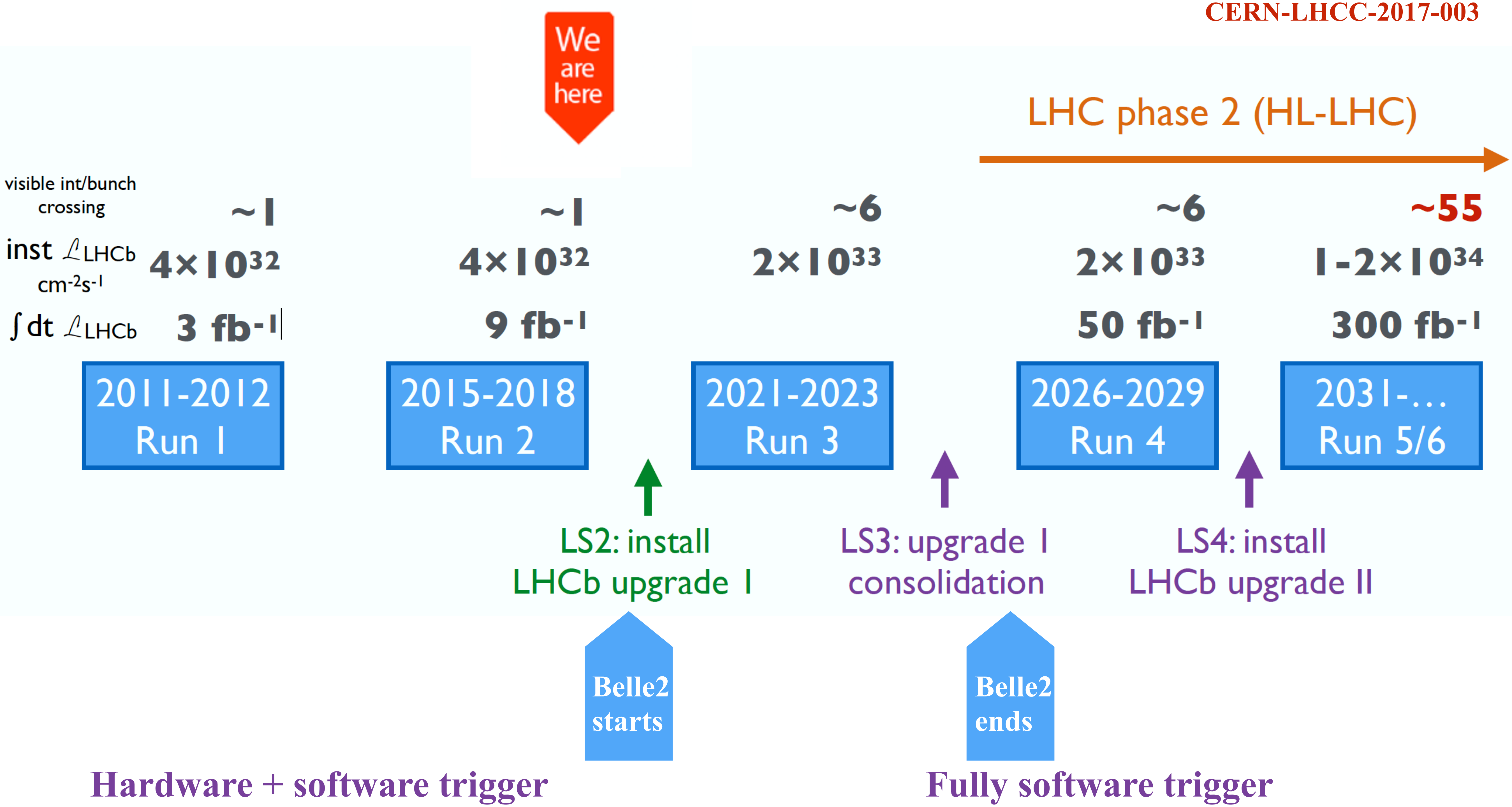
RICH: particle ID
- $\varepsilon(K\to K)$ ~95%
- Mis-ID: $\varepsilon(\pi\to K)$ ~5%

Magnet
- Bending power: 4 Tm

Muon system
- μ ID: $\varepsilon(\mu\to\mu)$ ~97%
- Mis-ID: $\varepsilon(\pi\to\mu)$ ~1-3%

LHCb upgrade plans

CERN-LHCC-2017-003



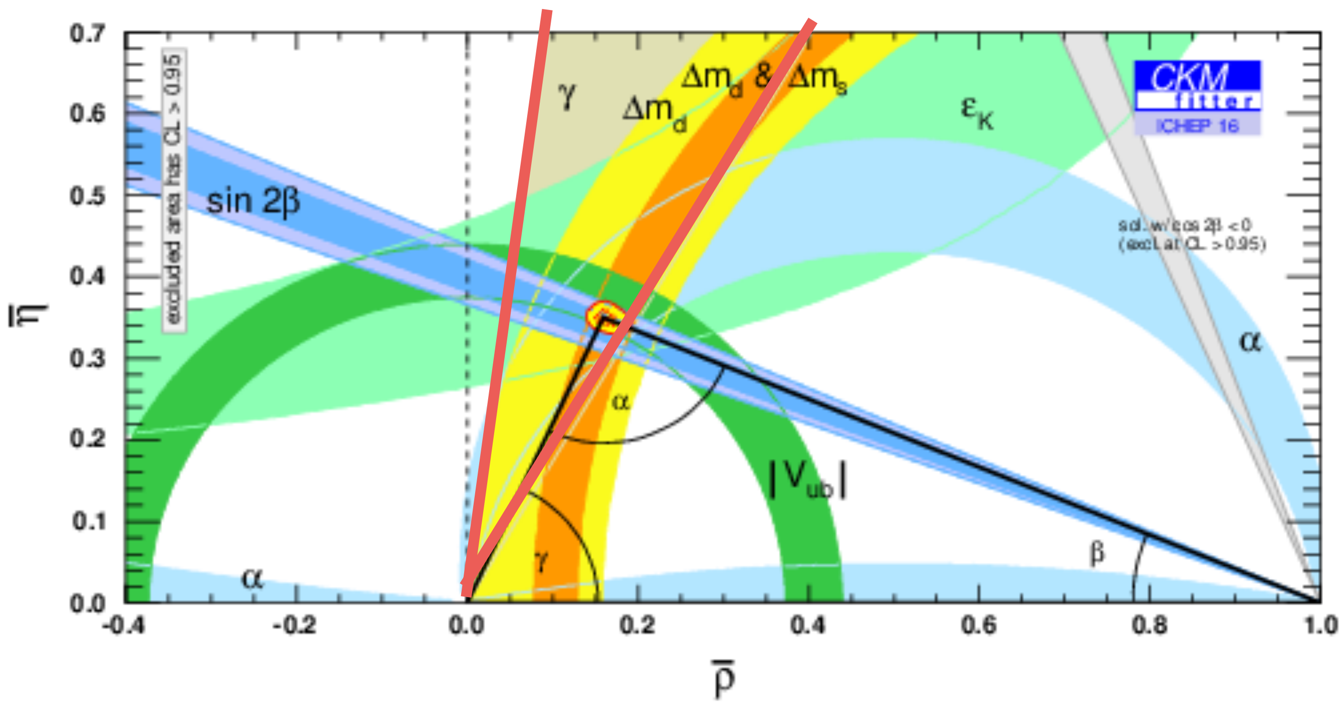
- ➢ **Upgrade I: several detector replaced; 40 MHz readout with fully software trigger**
- ➢ **Upgrade II: new ideas under study on tracking, calorimeter, adding timing info etc**

CKM angle γ

CKM angle γ

➢ **Least well known CKM parameters**

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



Direct: $\gamma = (73.5^{+4.3}_{-5.0})^{\circ}$

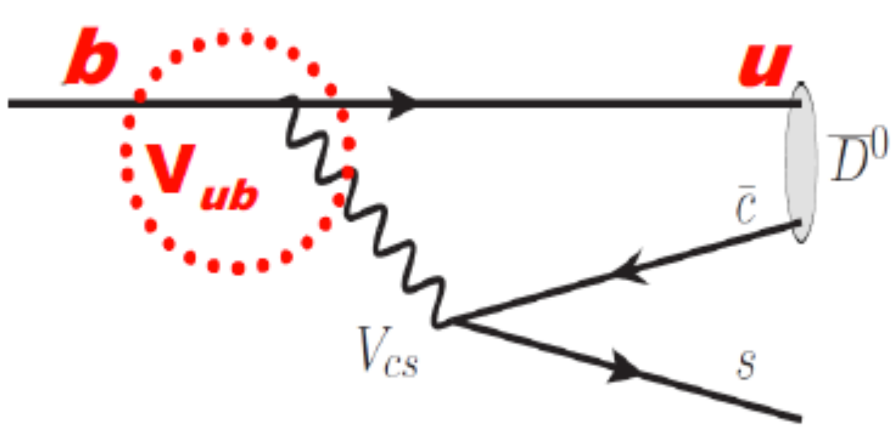
VS

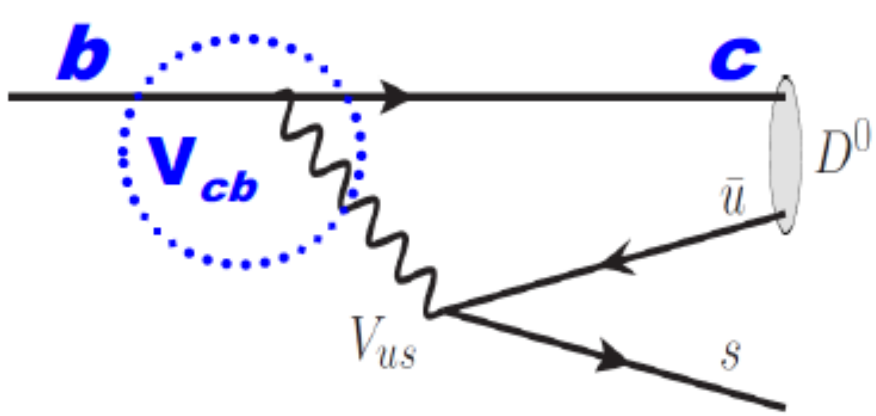
Indirect: $\gamma = (65.3^{+1.0}_{-2.5})^{\circ}$

New Physics?

➢ **γ at tree level: clean theory prediction δγ/γ ~ 10^{-7}**

JHEP 1401 (2014) 051





Methodology for γ measurement

- **Sensitive channels with small BFs: need to combine many channels**

  GLW: D = CP eigenstates, e.g. KK, $\pi\pi$ Phys. Lett. B 253 (1991) 483 Phys. Lett. B 265 (1991) 172

  ADS: D = quasi-flavour-specific states e.g. $K\pi$ Phys. Rev. Lett. 78 (1997) 3257

  GGSZ: D = self-conjugate multi(3)-body states e.g. $K_s\pi\pi$ Phys. Rev. D68 (2003) 054018

  GLS: ADS variant with singly Cabbibo-suppressed decay $D\to K_sK\pi$ Phys. Rev. D67 (2003) 071301

  time-dependent $B_s\to D_sK$, $B^0\to D\pi$ etc (not discussed here)

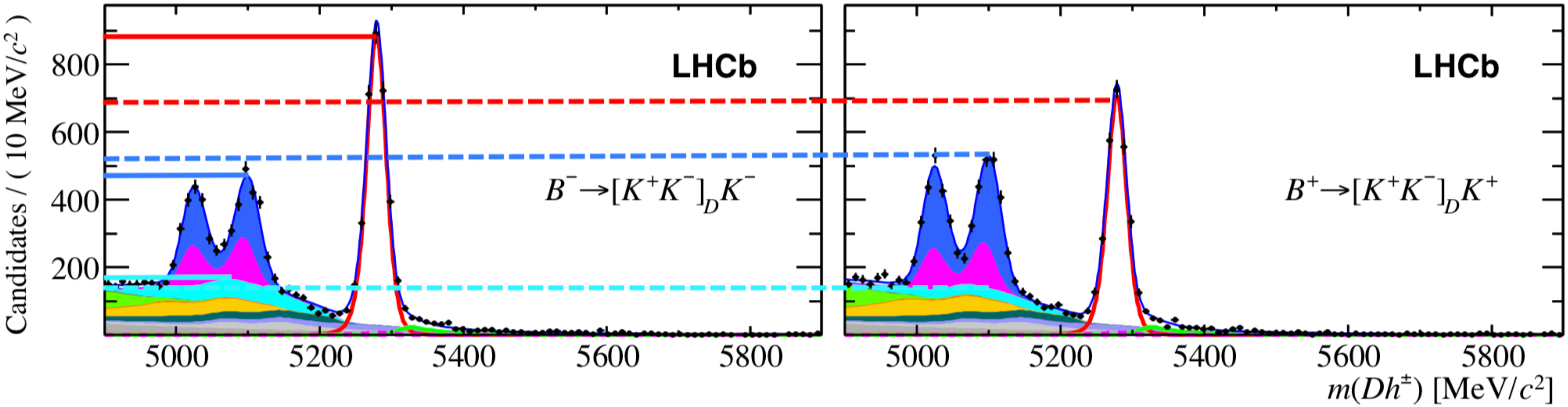
  Dalitz (GW) method: $B^0\to DK\pi$

- **Global fit needed to extract γ (also other nuisance parameters)**

- **Charm inputs crucial (BESIII/HIEPA)**

GLW measurements

Phys. Lett. B777 (2018) 16



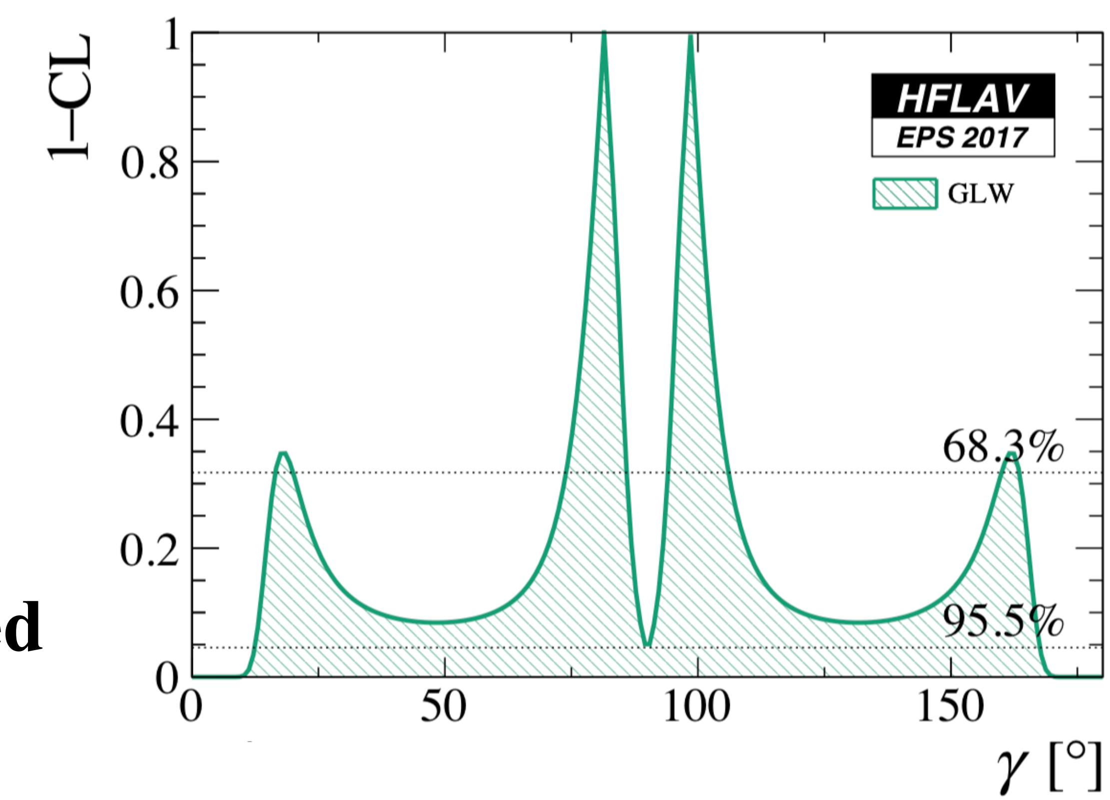
- ➢ 2 fb^{-1} (7 TeV) + 1 fb^{-1} (8 TeV) + 2 fb^{-1} (13 TeV)
- ➢ Using both fully reco. B→DK and partially reco. B→D*(Dγ/Dπ^0)K

$$R_{CP\pm} = \frac{2[\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)]}{\Gamma(B^- \to D^0K^-) + \Gamma(B^+ \to \overline{D}^0K^+)},$$

$$A_{CP\pm} = \frac{\Gamma(B^- \to D_{CP\pm}K^-) - \Gamma(B^+ \to D_{CP\pm}K^+)}{\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)}.$$

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

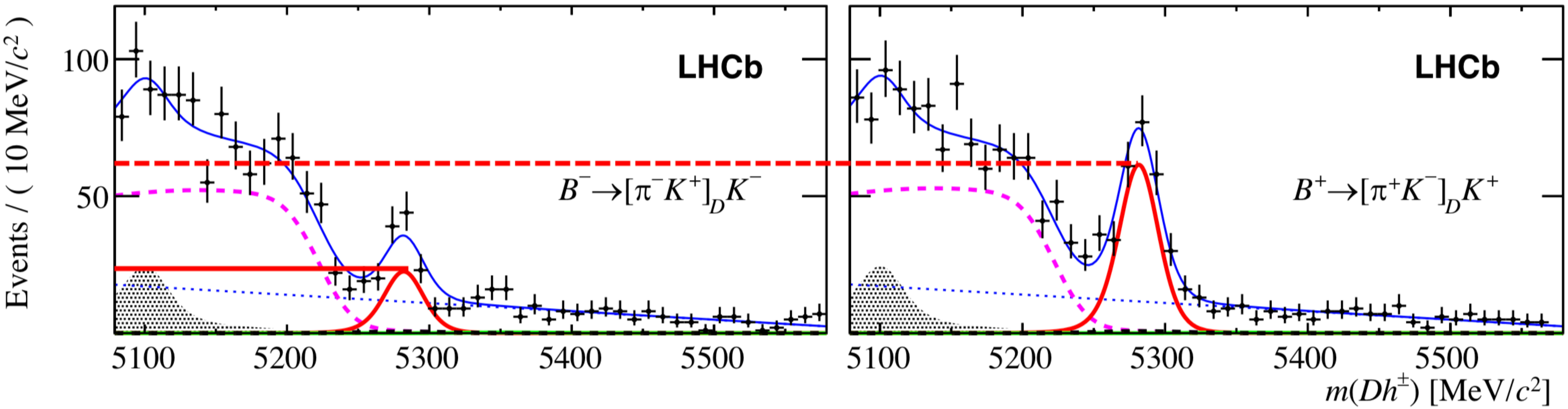
$$A_{CP\pm} = \pm 2r_B \sin\delta_B \sin\gamma / R_{CP\pm}.$$



- ➢ Extension like D→$\pi\pi\pi^0$ can be used => need inputs from charm friends

ADS measurements

Phys. Lett. B760 (2016) 117



➢ **2 fb^{-1} (7 TeV) + 1 fb^{-1} (8 TeV)**

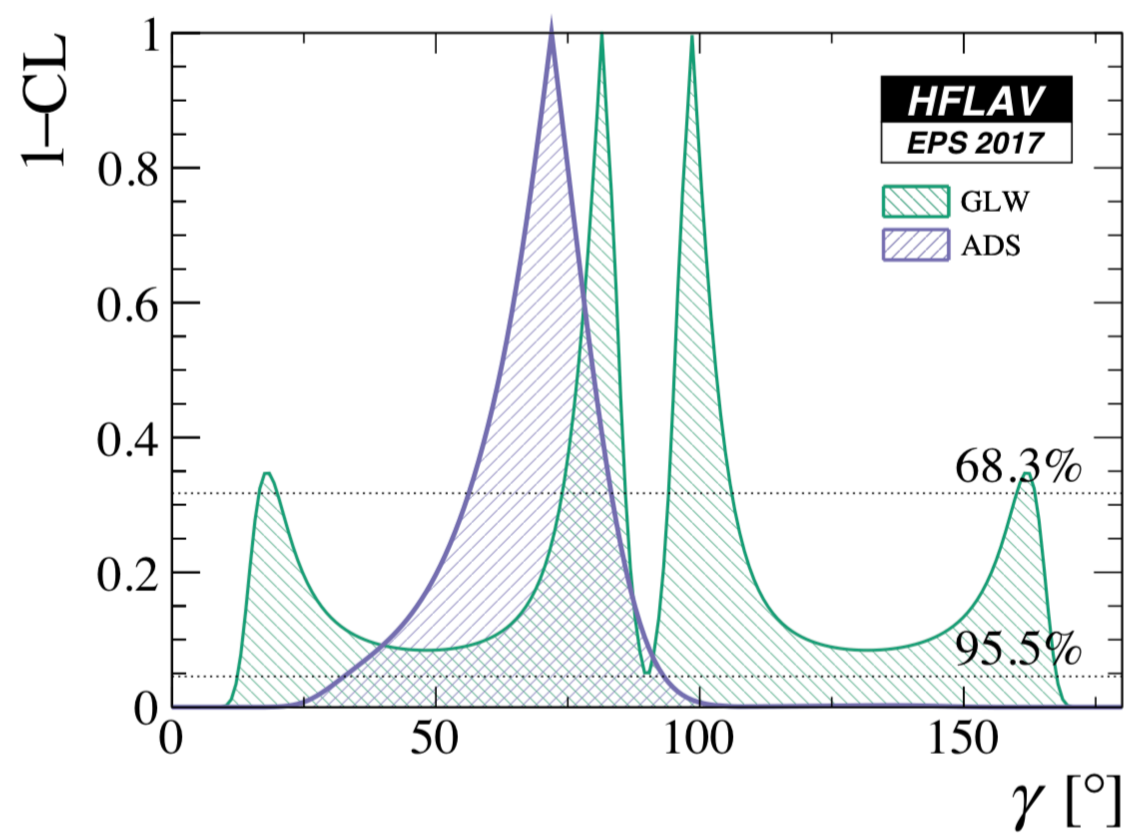
$$R_{\mathrm{ADS}} = \frac{\Gamma(B^- \to D[\to \pi^- K^+]K^-) + \Gamma(B^+ \to D[\to \pi^+ K^-]K^+)}{\Gamma(B^- \to D[\to K^- \pi^+]K^-) + \Gamma(B^+ \to D[\to K^+ \pi^-]K^+)}$$

$$A_{\mathrm{ADS}} = \frac{\Gamma(B^- \to D[\to \pi^- K^+]K^-) - \Gamma(B^+ \to D[\to \pi^+ K^-]K^+)}{\Gamma(B^- \to D[\to \pi^- K^+]K^-) + \Gamma(B^+ \to D[\to \pi^+ K^-]K^+)}$$

$$R_{\mathrm{ADS}} = (r_B^K)^2 + \boxed{r_{K\pi}^2} + 2 r_B^K \boxed{r_{K\pi}} \cos\gamma \cos(\delta_B^K + \boxed{\delta_{K\pi}})$$

$$A_{\mathrm{ADS}} = 2 r_B^K\, r_{K\pi} \sin\gamma \sin(\delta_B^K + \delta_{K\pi}) / R_{\mathrm{ADS}}$$

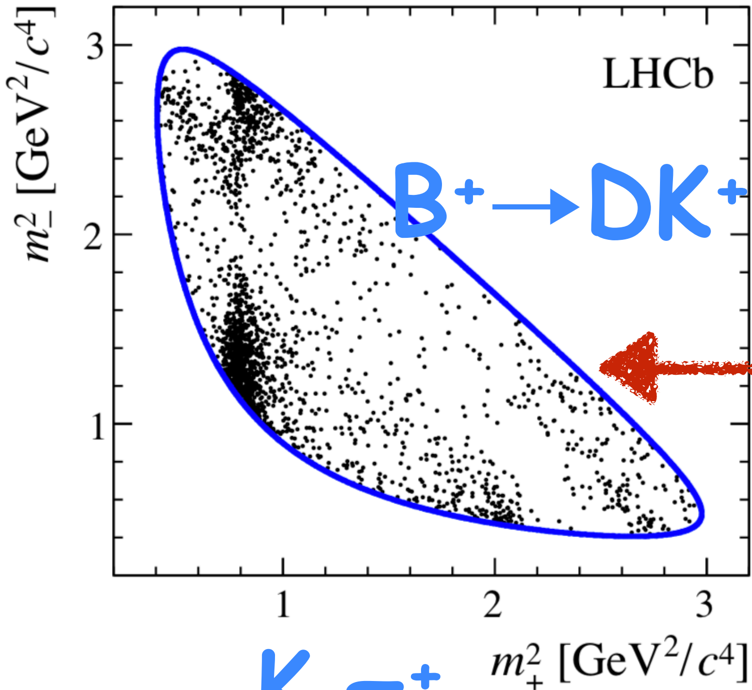
➢ **Inputs from charm basic for the analysis**



GGSZ measurements

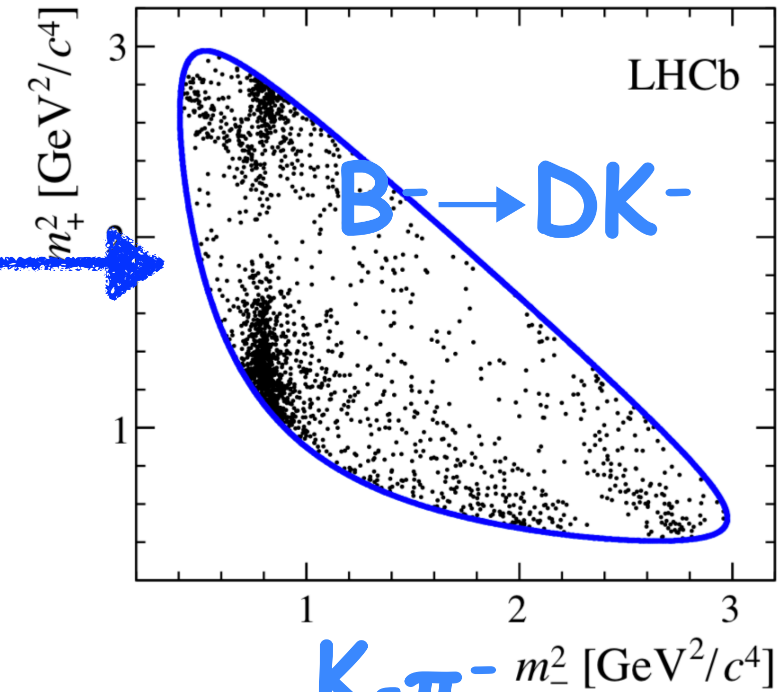
➢ **Similar to many ADS analyses over Dalitz plane**

JHEP 10 (2014) 097



$$\mathcal{A}_{B^-} \sim A_f + r_B e^{i(\delta_B - \gamma)} \bar{A}_f,$$
$$\mathcal{A}_{B^+} \sim \bar{A}_f + r_B e^{i(\delta_B + \gamma)} A_f$$

$$A_f = \langle f | \mathcal{H} | D^0 \rangle$$
$$\bar{A}_f = \langle f | \mathcal{H} | \bar{D}^0 \rangle$$

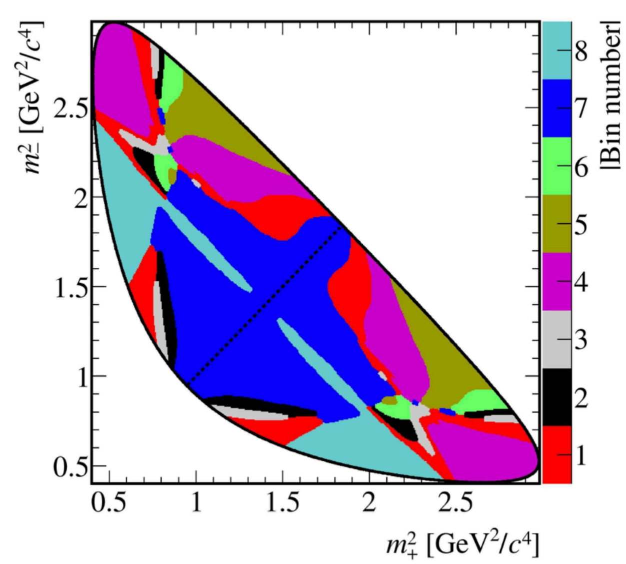


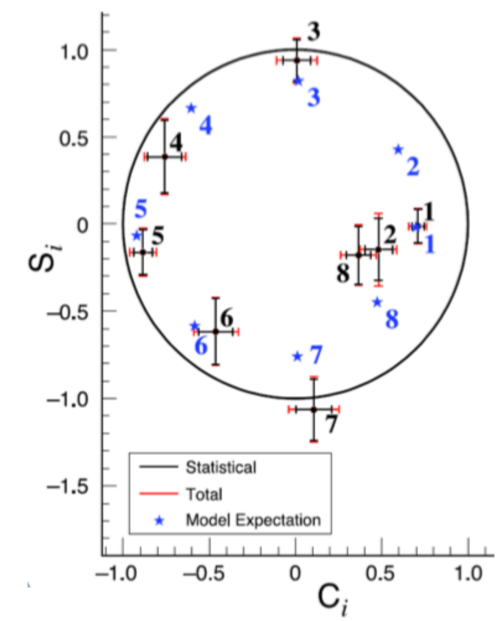
➢ **2 fb-1 (7 TeV) + 1 fb-1 (8 TeV)**

$$x_\pm \equiv r_B \cos(\delta_B \pm \gamma) \quad \text{and} \quad y_\pm \equiv r_B \sin(\delta_B \pm \gamma).$$

$$N_{\pm i}^{+} = h_{B^+}\left[F_{\mp i} + (x_+^2 + y_+^2)F_{\pm i} + 2\sqrt{F_i F_{-i}}(x_+ c_{\pm i} - y_+ s_{\pm i})\right],$$
$$N_{\pm i}^{-} = h_{B^-}\left[F_{\pm i} + (x_-^2 + y_-^2)F_{\mp i} + 2\sqrt{F_i F_{-i}}(x_- c_{\pm i} + y_- s_{\pm i})\right],$$

➢ **Charm inputs of c_i, s_i crucial for the measurements**





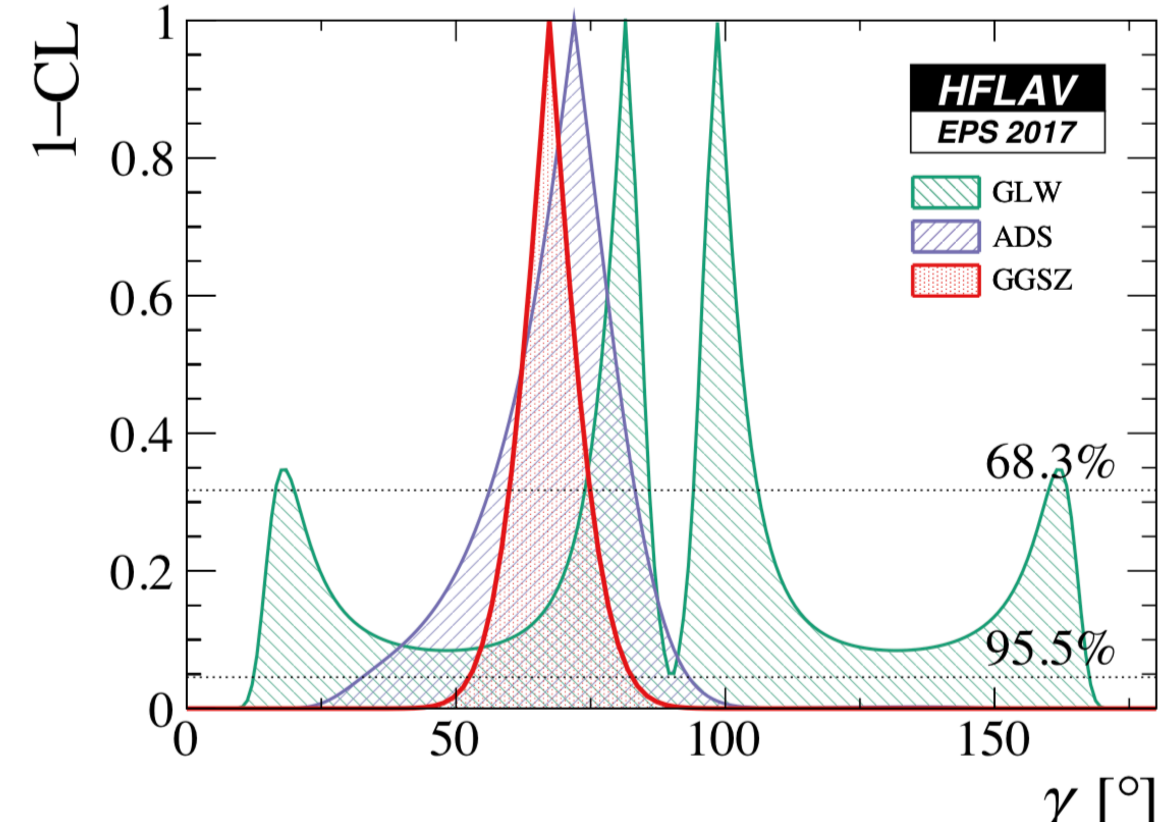
CLEO-c

GGSZ measurements results

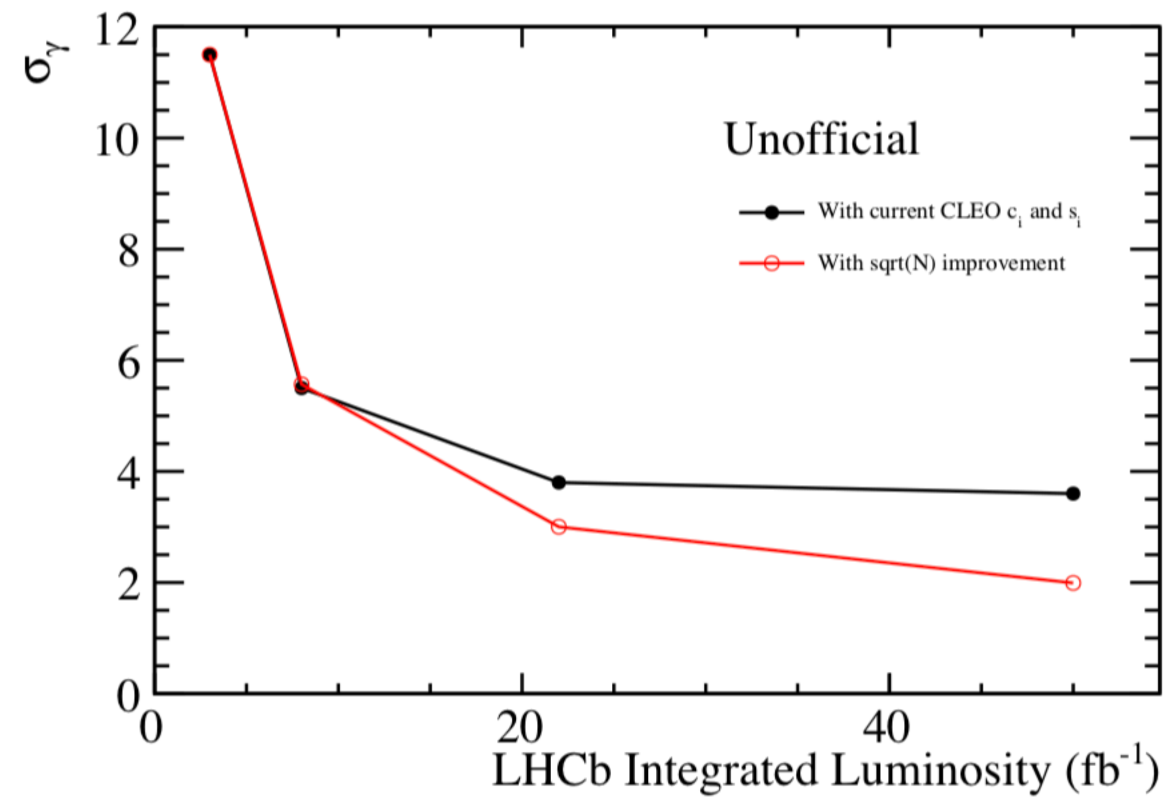
JHEP 10 (2014) 097

$$x_+ = (-7.7 \pm 2.4 \pm 1.0 \pm 0.4) \times 10^{-2},$$
$$y_+ = (-2.2 \pm 2.5 \pm 0.4 \pm 1.0) \times 10^{-2},$$

$$x_- = (2.5 \pm 2.5 \pm 1.0 \pm 0.5) \times 10^{-2},$$
$$y_- = (7.5 \pm 2.9 \pm 0.5 \pm 1.4) \times 10^{-2},$$



- ➢ Effects from uncertainties on c_i, s_i becomes important with more LHCb data (Run 3 and later)
- ➢ With large enough data, LHCb has sensitivity to c_i, s_i
- ➢ Dalitz model obtained from Dalitz analyses on charm decays ($K_s hh$ or similar channels) important for optimizing binning scheme for c_i, s_i;



GW measurements

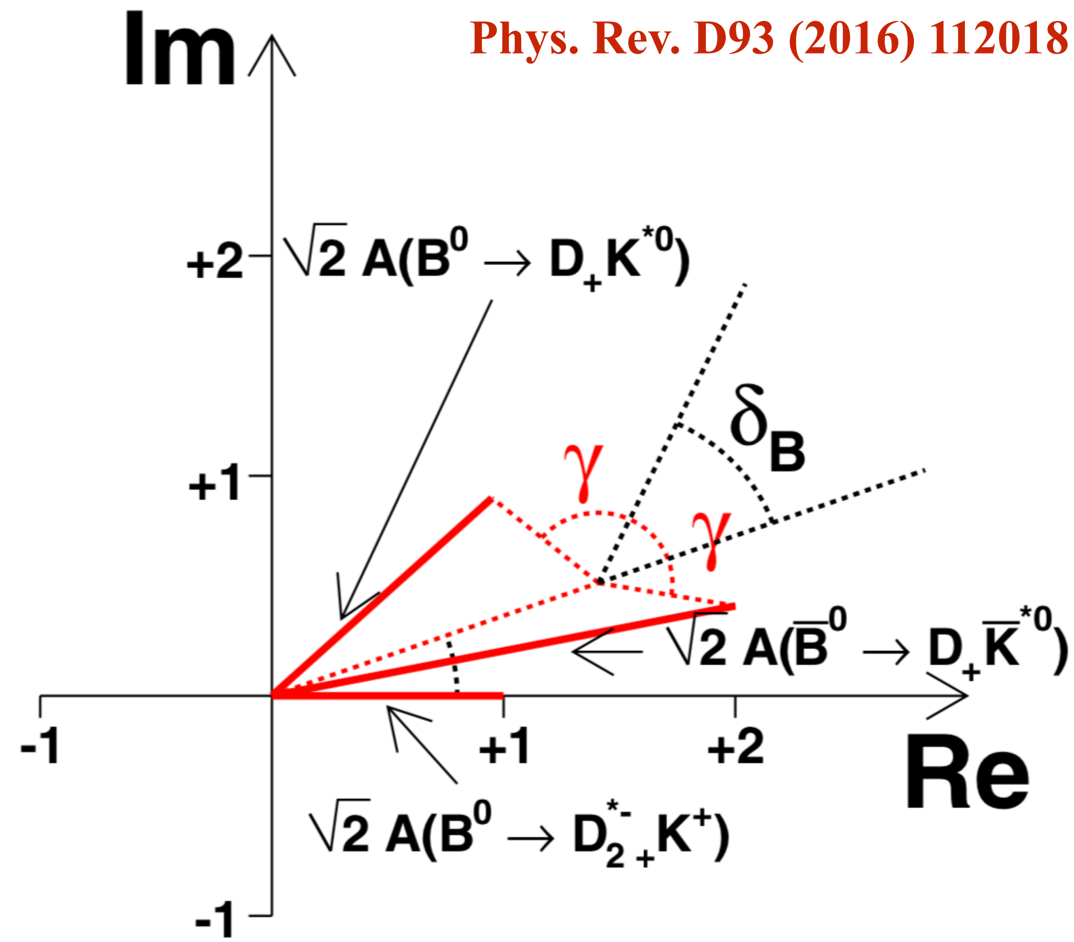
Phys. Rev. D93 (2016) 112018

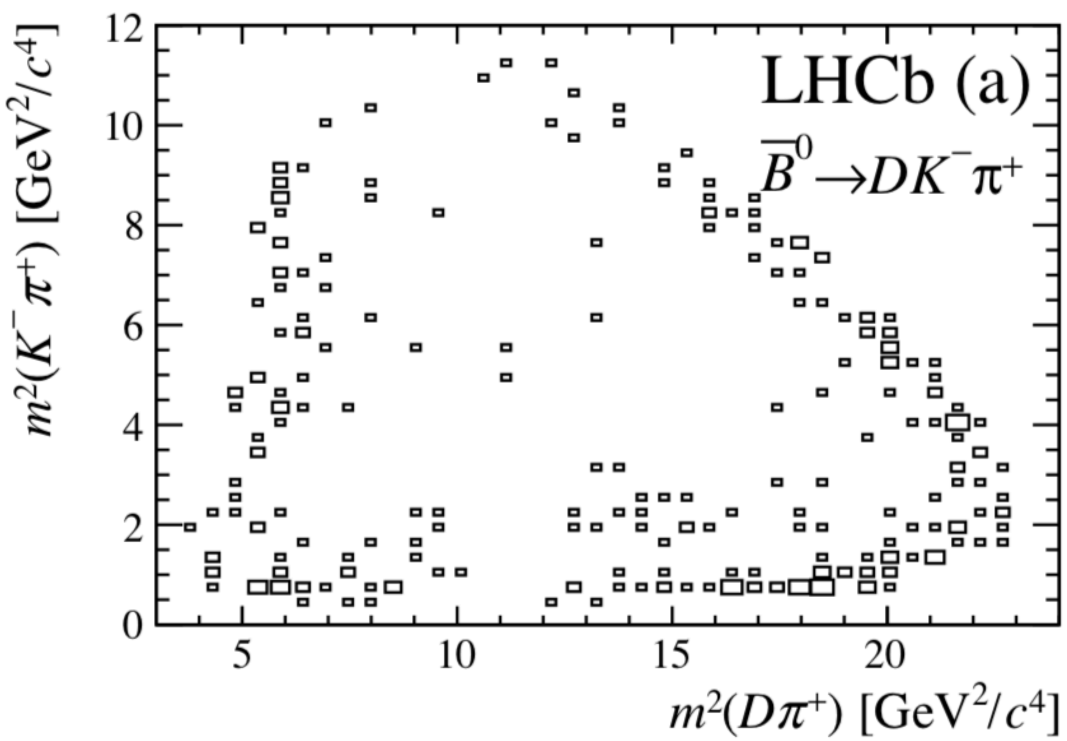
➢ $B^0 \to DK\pi$ are the decay channel of interest

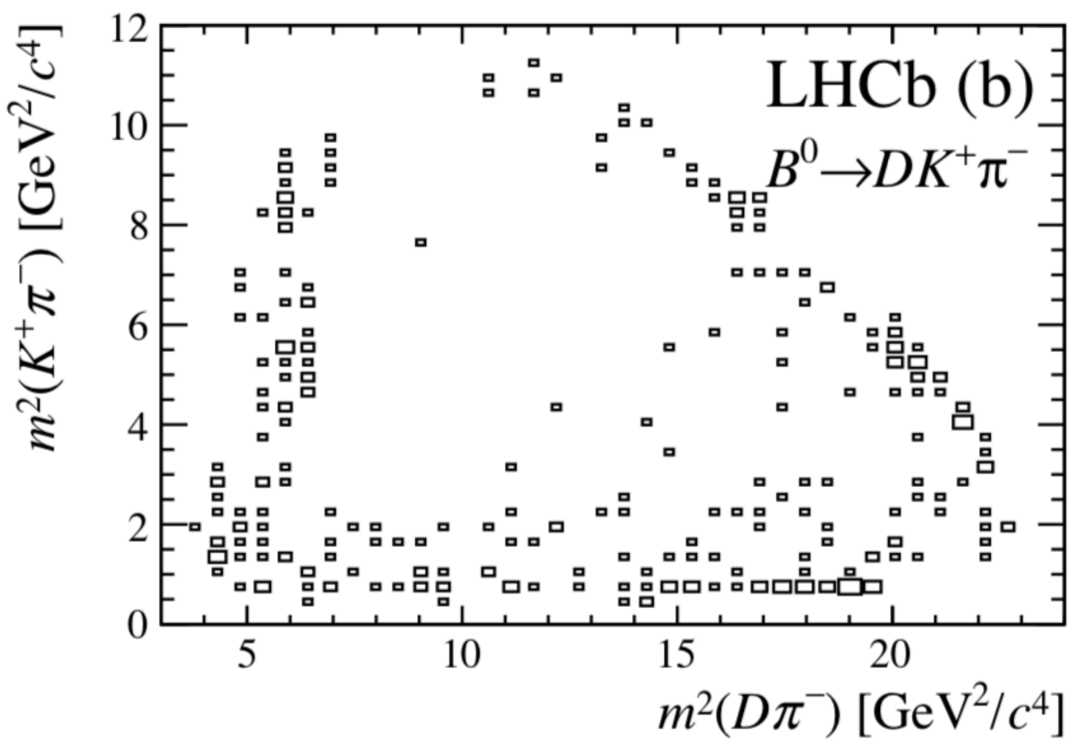
➢ Sensitivity to γ from K^* resonances while D^* as reference point

➢ Currently GLW type analysis has been performed by LHCb

➢ Starts to offer constraints to γ and related parameters







GW-GGSZ measurements

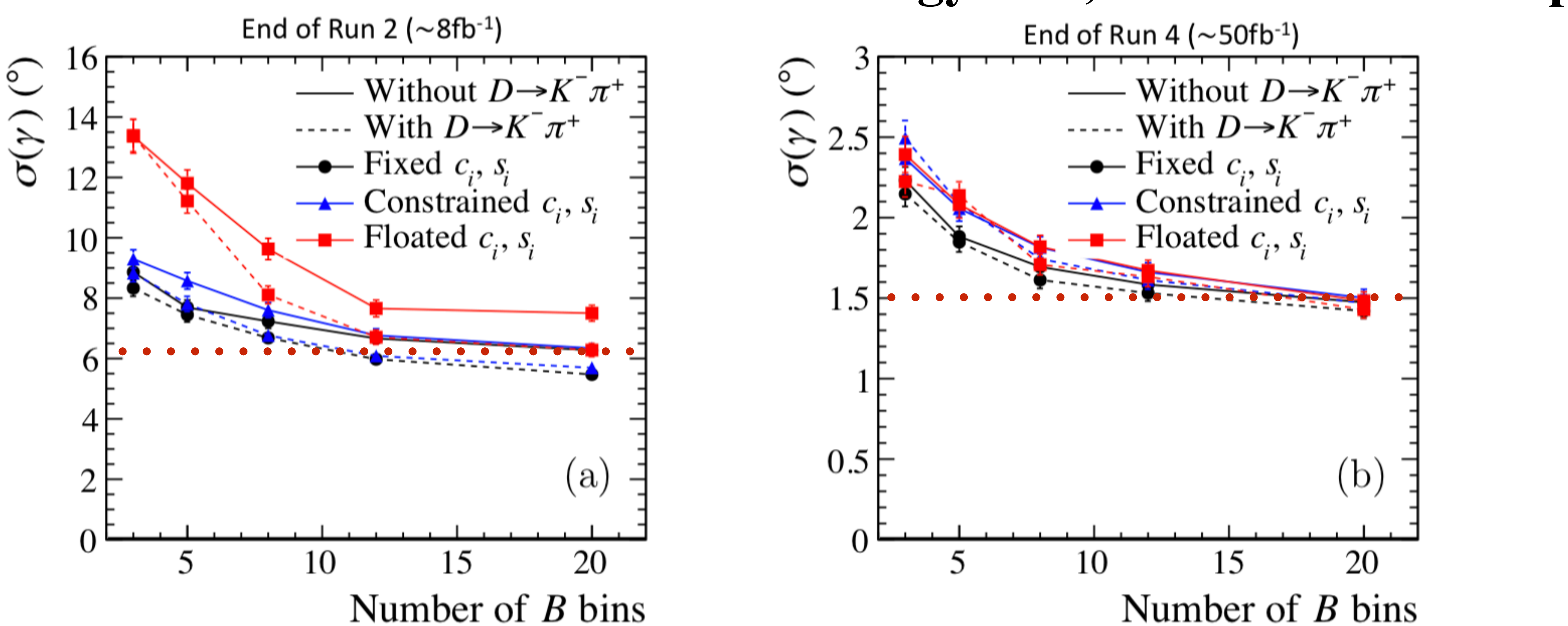
arXiv:1712.07853

- $B^0 \to DK\pi$ are the decay channel of interest

- **Studies also performed on GGSZ-type of analysis: two Dalitz plots!**

$$|A_{\rm dbl\,Dlz}|^2 = |\overline{A}_B|^2 |\overline{A}_D|^2 + |A_B|^2 |A_D|^2 + 2 |\overline{A}_B| |\overline{A}_D| |A_B| |A_D| [(\varkappa c - \sigma s)\cos\gamma - (\varkappa s + \sigma c)\sin\gamma] \,,$$

Analogy to c_i, s_i but for B Dalitz plot



- **Charm inputs of c_i, s_i will be important for Run 1+2 data; LHCb will have self-constraints on c_i, s_i with more data but external inputs are still important**

LHCb status on γ measurements

Slides stolen from Matt. Kenzie
in BESIII/LHCb workshop

Status of γ at LHCb

LHCb UNIVERSITY OF CAMBRIDGE

			Highest Statistics	Poorer sensitivity at LHCb			High potential (Dalitz structure of B)		Low stats (multibody B)
Method		B Decay / D Decay	$B^- \to D^0K^-$	$B^- \to D^0K^{*-}$ $[K^{*-}\to K^0_S\pi^-]$	$B^- \to D^{*0}K^-$ $[D^{*0}\to D^0\pi^0],[D^{*0}\to D^0\gamma]$ part-rec	full-rec	$B^0 \to D^0K^+\pi^-$ K^{*0} res	Dalitz	$B^- \to D^0K^-\pi^+\pi^-$
GLW	(+)	$D^0 \to K^+K^-$	$5\,\mathrm{fb}^{-1}$	$5\,\mathrm{fb}^{-1}$	$5\,\mathrm{fb}^{-1}$	•	$3\,\mathrm{fb}^{-1}$(•)	$3\,\mathrm{fb}^{-1}$	$3\,\mathrm{fb}^{-1}$
		$D^0 \to \pi^+\pi^-$	$5\,\mathrm{fb}^{-1}$	$5\,\mathrm{fb}^{-1}$	$5\,\mathrm{fb}^{-1}$	•	$3\,\mathrm{fb}^{-1}$(•)	$3\,\mathrm{fb}^{-1}$	$3\,\mathrm{fb}^{-1}$
		$D^0 \to K^+K^-\pi^0$	$3\,\mathrm{fb}^{-1}$(•)	-	-	-	-	-	-
		$D^0 \to \pi^+\pi^-\pi^0$	$3\,\mathrm{fb}^{-1}$	-	-	-	-	-	-
		$D^0 \to K^+K^-\pi^+\pi^-$	-	-	-	-	-	-	-
		$D^0 \to \pi^+\pi^-\pi^+\pi^-$	$3\,\mathrm{fb}^{-1}$(•)	$5\,\mathrm{fb}^{-1}$	•	•	•	-	-
	(−)	$D^0 \to K^0_S\pi^0$	•	-	-	-	-	-	-
ADS		$D^0 \to K^+\pi^-$	$3\,\mathrm{fb}^{-1}$(•)	$5\,\mathrm{fb}^{-1}$	•	•	$3\,\mathrm{fb}^{-1}$(•)	•	$3\,\mathrm{fb}^{-1}$
		$D^0 \to K^+\pi^-\pi^0$	$3\,\mathrm{fb}^{-1}$	-	-	-	-	-	-
		$D^0 \to K^+\pi^-\pi^+\pi^-$	$3\,\mathrm{fb}^{-1}$(•)	$5\,\mathrm{fb}^{-1}$	•	•	•	-	-
GGSZ		$D^0 \to K^0_S\pi^+\pi^-$	$3\,\mathrm{fb}^{-1}$(•)	•	-	•	$3\,\mathrm{fb}^{-1}$(•)	•	-
		$D^0 \to K^0_SK^+K^-$	$3\,\mathrm{fb}^{-1}$(•)	•	-	•	$3\,\mathrm{fb}^{-1}$(•)	•	-
		$D^0 \to K^0_S\pi^+\pi^-\pi^0$	•	-	-	-	-	-	-
		$D^0 \to K^0_SK^+K^-\pi^0$	•	-	-	-	-	-	-

KEY: •: (update) in progress

•: requires input from Charm sector (r_D,δ_D, κ_D)

NOTE: LHCb has a $3\,\mathrm{fb}^{-1}$(•) TD result with $B^0_s \to D^-_sK^+$

LHCb has a $3\,\mathrm{fb}^{-1}$(•) GLS result from $B^- \to D^0K^-$ with $D^0 \to K^0_SK^\pm\pi^\mp$

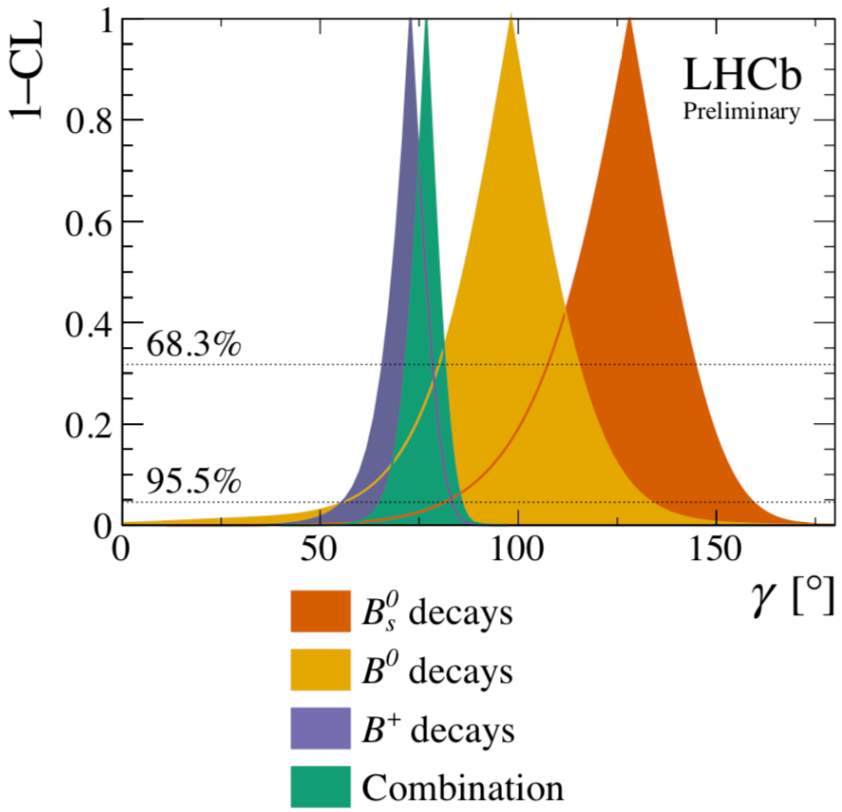
γ average

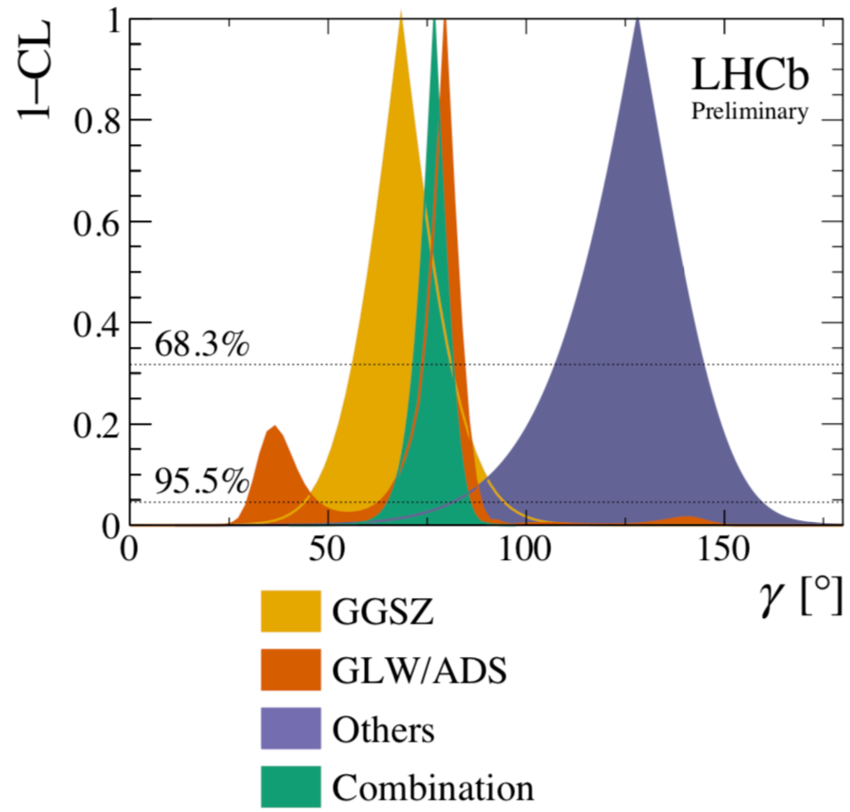
LHCb-CONF-2017-004

➢ **Combining all LHCb measurements, we have**

$$\gamma \in [71.1, 81.9]^\circ \quad \text{at } 68.3\% \text{ CL}, \qquad \gamma \in [64.3, 86.6]^\circ \quad \text{at } 95.5\% \text{ CL}.$$

or $\gamma = (76.8\,^{+5.1}_{-5.7})^\circ$,





➢ **Some tension exists and may be interesting to follow-up**

➢ **Future sensitivities (scaled according to statistical uncertainties)**

Run 1	Run 2	Upgrade 1	Upgrade 2
5.5°	2.8°	0.71°	0.28°

New GGSZ analysis

arXiv:1712.08326

➢ **Use Fourier transformation over strong phase obtained from a model to extract information**

$$\Phi(m_+^2, m_-^2) = \arg A_D^{(\mathrm{model})}(m_+^2, m_-^2) - \arg A_D^{(\mathrm{model})}(m_-^2, m_+^2)$$

➢ **Fourier transformation applied to both quantum-correlated data and to LHCb B data**

$$\bar{p}_B(\phi) \propto p_D(\phi) + r_B^2 \bar{p}_D(\phi) + 2[x_+ C(\phi) - y_+ S(\phi)],$$

➢ **All orders of Fourier transformations give constraints on $x_\pm$ and $y_\pm$**

➢ **Binning of Dalitz plot according to amplitude ratio can help**

Ultimate precision:

$\sigma(\gamma) = 2.91 \pm 0.07^\circ$

Sample size	γ resolution, $^\circ$		
LHCb Run 1: ~2000 CLEO: 470	Binned optimal	Fourier non-split	Fourier split
$2 \times 10^4\ B^\pm \to DK^\pm$, $10^3\ D^0\bar{D}^0$	4.33 ± 0.10	4.54 ± 0.10	3.73 ± 0.08
$2 \times 10^4\ B^\pm \to DK^\pm$, $10^4\ D^0\bar{D}^0$	3.60 ± 0.08	4.51 ± 0.10	3.43 ± 0.08
$2 \times 10^4\ B^\pm \to DK^\pm$, $10^5\ D^0\bar{D}^0$	3.49 ± 0.10	4.47 ± 0.10	3.32 ± 0.08

➢ **New approaches requiring efforts from LHCb and BESIII/HIEPA to make it possible**

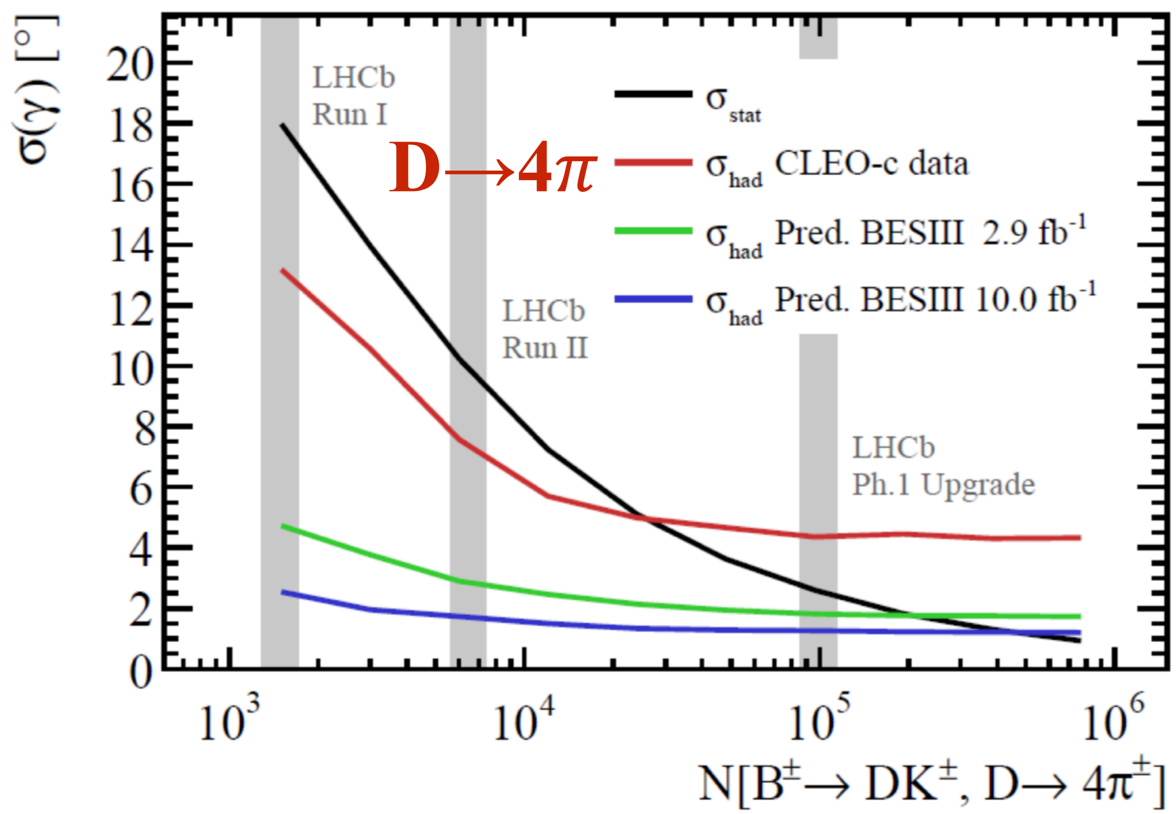
Other interesting channels

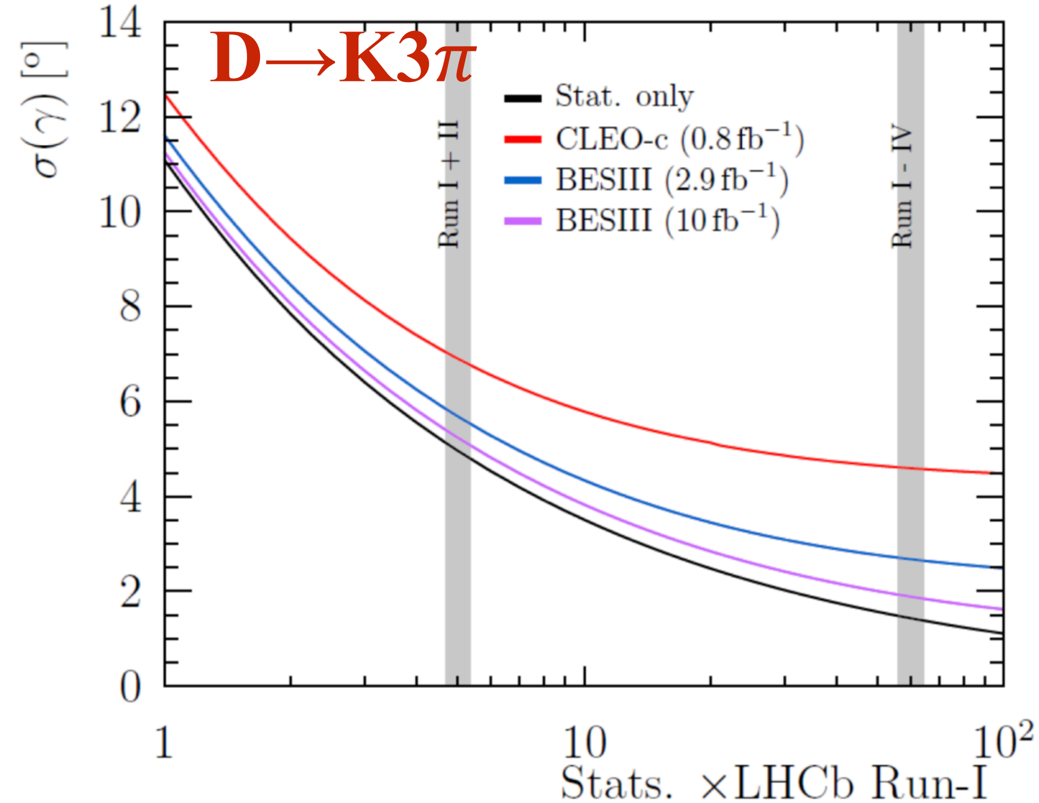
arXiv:1712.08326

- Other D decay channels have been used for γ measurements:

  $K_S K\pi$, 4π global, $K3\pi$ global, $K\pi\pi^0$, $\pi\pi\pi^0$, $KK\pi^0$ etc.

- Inputs from BESIII/HIEPA can definitely help a lot





Run 2: 10° stat.
7° sys. from CLEO-c

Run 2: 5° stat.
8° sys. from CLEO-c

$K_S\pi\pi$ in Run 2: 7° uncertainty (stat. dominate)

- Other channels like $K_S\pi\pi\pi^0$ may also be interesting
- Common PWA would be very interesting for these D decays

Other similar measurements

arXiv:1802.00200

➢ $B^0 \to D\pi\pi$ with $D \to hh$ was proposed to measure CKM angle β, where not only sin2β but also cos2β can be accessed;

Phys. Lett. B 425 (1998) 375
J. Phys. G36 (2009) 025006

➢ Same decay channel but with $D \to K_S hh$ is proposed and with similar ideas as GGSZ $B \to DK$ analysis;

➢ Charm inputs from c_i, s_i required as for GGSZ analysis

$$g_{ij}(\Delta t) \propto \mathcal{U}_{ij} + q_B\left[\mathcal{D}_{ij}\cos(\Delta m \Delta t) - \mathcal{F}_{ij}\sin(\Delta m \Delta t)\right]$$

$$\mathcal{U}_{ij} = K_i k_j + K_{-i} k_{-j}, \qquad \mathcal{D}_{ij} = K_i k_j - K_{-i} k_{-j},$$

$$\mathcal{F}_{ij} = 2\sqrt{K_i K_{-i} k_j k_{-j}}\,\left[(\underline{C_i} s_j - \underline{S_i} c_j)\cos 2\beta - (\underline{C_i} c_j + \underline{S_i} s_j)\sin 2\beta\right]$$

Decay	Belle II (50 ab^{-1})	LHCb (50 fb^{-1})
$B^0 \to D\pi^+\pi^-$	1.5°	1.5°
$B^0 \to Dh^0$	0.7°	–

Analogy to those from $B^0 \to DK\pi$ Dalitz

➢ c_i, s_i inputs from quantum-correlated charm mesons will be important when statistic is low; The system can also offer self-constraints on c_i, s_i with large enough dataset (i.e. LHCb 50 fb^{-1})

➢ c_i, s_i inputs are also used in charm mixing parameter measurements (model independent approach)

Absolute Branching fractions

Charm branching fraction measurements

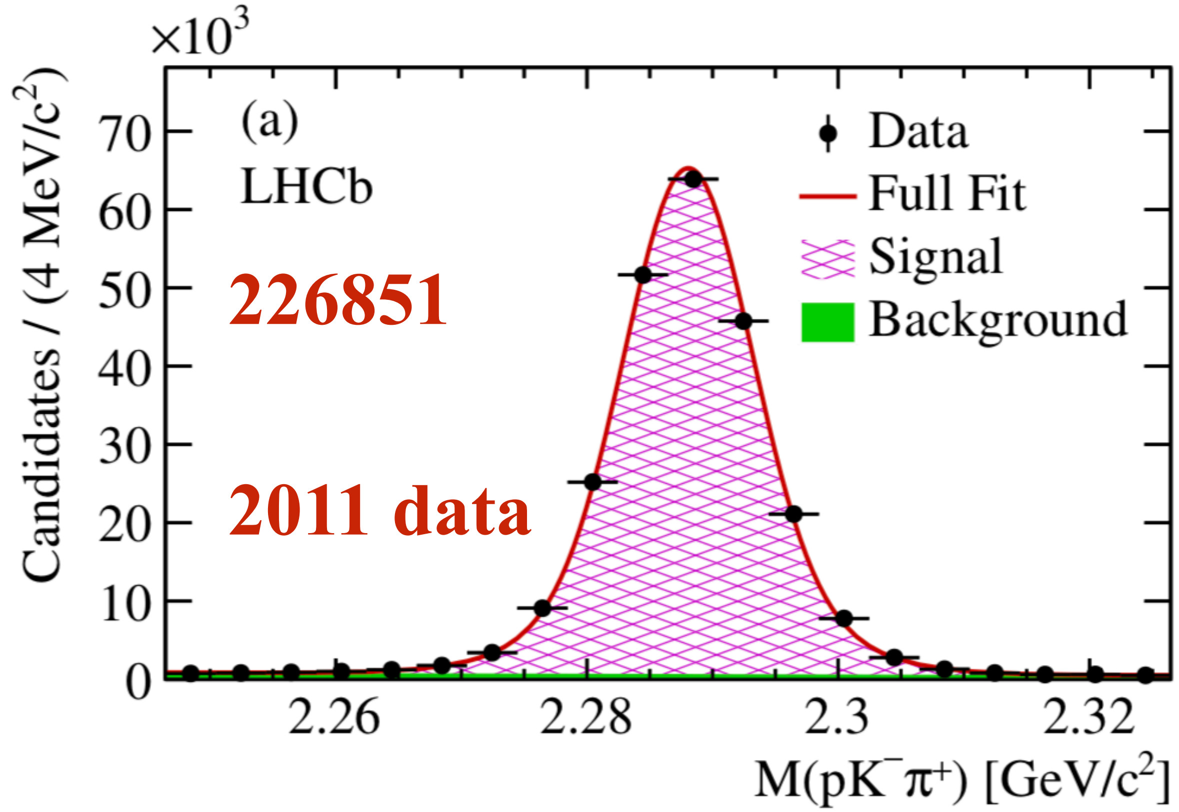
arXiv:1711.01157

➢ **In LHCb, we measure relative branching fractions;**

$$\frac{\mathcal{B}(\Lambda_c^+ \to p\pi^-\pi^+)}{\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)} = (7.44 \pm 0.08 \pm 0.18)\%,$$

$$\frac{\mathcal{B}(\Lambda_c^+ \to pK^-K^+)}{\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)} = (1.70 \pm 0.03 \pm 0.03)\%,$$

$$\frac{\mathcal{B}(\Lambda_c^+ \to p\pi^-K^+)}{\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)} = (0.165 \pm 0.015 \pm 0.005)\%.$$



$$\left.\begin{aligned}
\mathcal{B}(\Lambda_c^+ \to p\pi^-\pi^+) \times 10^3 &= 4.72 \pm 0.05 \pm 0.11 \pm 0.25 \\
\mathcal{B}(\Lambda_c^+ \to pK^-K^+) \times 10^3 &= 1.08 \pm 0.02 \pm 0.02 \pm 0.06 \\
\mathcal{B}(\Lambda_c^+ \to p\pi^-K^+) \times 10^4 &= 1.04 \pm 0.09 \pm 0.03 \pm 0.05
\end{aligned}\right\}$$

external $\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$

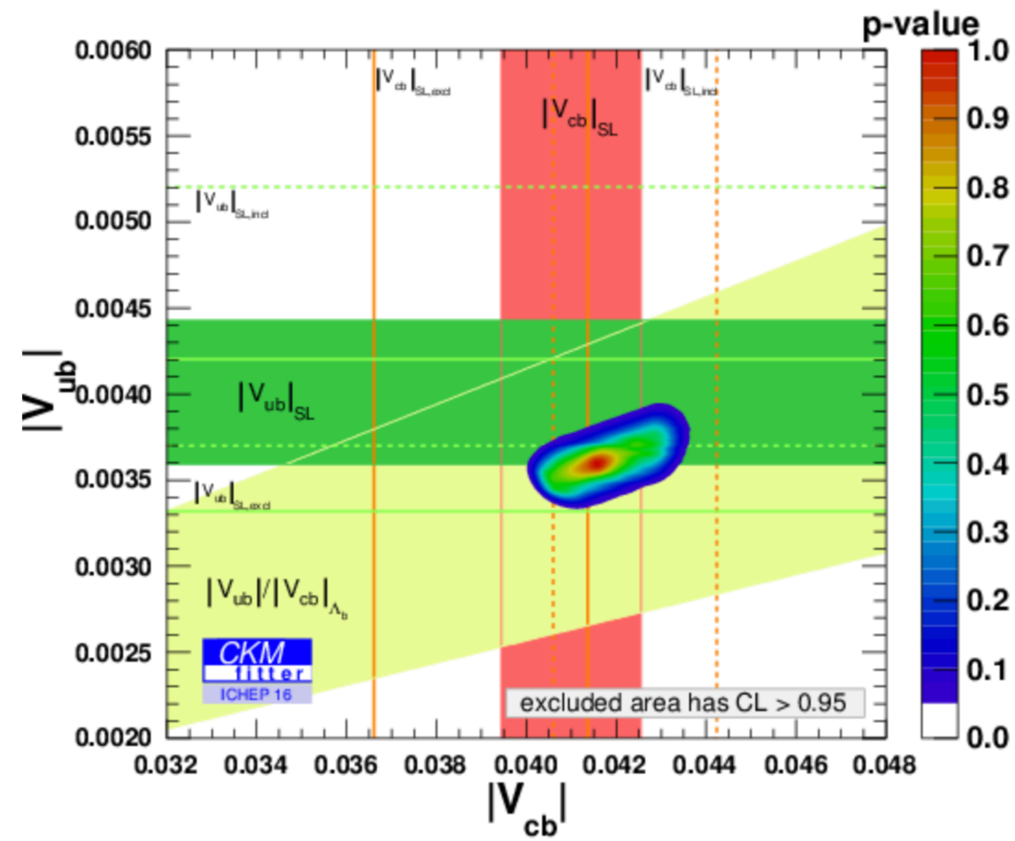
(6.35 ± 0.33)%

➢ **Clearly, uncertainties due to external inputs are dominant/important**

|Vub| measurement

Nature Phys. 11 (2015) 743-747

- |V_{ub}| is one of the key CKM matrix elements
- Some tension between inclusive and exclusive measurements
- Ratio between |V_{ub}| and |V_{cb}| has been measured by LHCb using baryon decays



$$\frac{\mathcal{B}(\Lambda_b^0 \to p\mu^-\overline{\nu}_\mu)_{q^2>15\,\mathrm{GeV}^2}}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+\mu^-\overline{\nu}_\mu)_{q^2>7\,\mathrm{GeV}^2}} = (1.471 \pm 0.095 \pm 0.109)\left|\frac{V_{ub}}{V_{cb}}\right|^2$$

Dominant uncertainty

Shift in central value

$$\frac{\mathcal{B}(\Lambda_b^0 \to p\mu^-\overline{\nu}_\mu)_{q^2>15\,\mathrm{GeV}^2}}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+\mu^-\overline{\nu}_\mu)_{q^2>7\,\mathrm{GeV}^2}} = \frac{N(\Lambda_b^0 \to p\mu^-\overline{\nu}_\mu)}{N(\Lambda_b^0 \to \Lambda_c^+(pK^-\pi^+)\mu^-\overline{\nu}_\mu)} \cdot r_\epsilon \cdot \mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$$

(6.35 ± 0.33)%

- Charm inputs on the branching fractions are crucial (for similar analyses)

Hadronization factor measurements

JHEP 1304 (2013) 001
Phys. Rev. D 85 (2012) 032008

➢ **Hadronization factors for b hadrons uses charm branching fraction measurements unavoidably**

$$\frac{f_s}{f_d} = \frac{\mathcal{B}(B^0 \to D^-(K^+\pi^-\pi^-)K^+)}{\mathcal{B}(B_s^0 \to D_s^-(K^+K^-\pi^-)\pi^+)} \frac{\epsilon_{D^-K^+}}{\epsilon_{D_s^-\pi^+}} \frac{N_{D_s^-\pi^+}}{N_{D^-K^+}}$$

$$= \Phi_{\rm PS} \left|\frac{V_{us}}{V_{ud}}\right|^2 \left(\frac{f_K}{f_\pi}\right)^2 \frac{\tau_{B^0}}{\tau_{B_s^0}} \frac{1}{\mathcal{N}_a\mathcal{N}_F} \frac{\mathcal{B}(D^- \to K^+\pi^-\pi^-)}{\mathcal{B}(D_s^- \to K^+K^-\pi^-)} \frac{\epsilon_{D^-K^+}}{\epsilon_{D_s^-\pi^+}} \frac{N_{D_s^-\pi^+}}{N_{D^-K^+}}$$

$\Phi_{\rm PS}$ is a phase space factor, $\mathcal{N}_a$ parameterizes nonfactorizable SU(3)-breaking, $\mathcal{N}_F$ is the ratio of form factors.

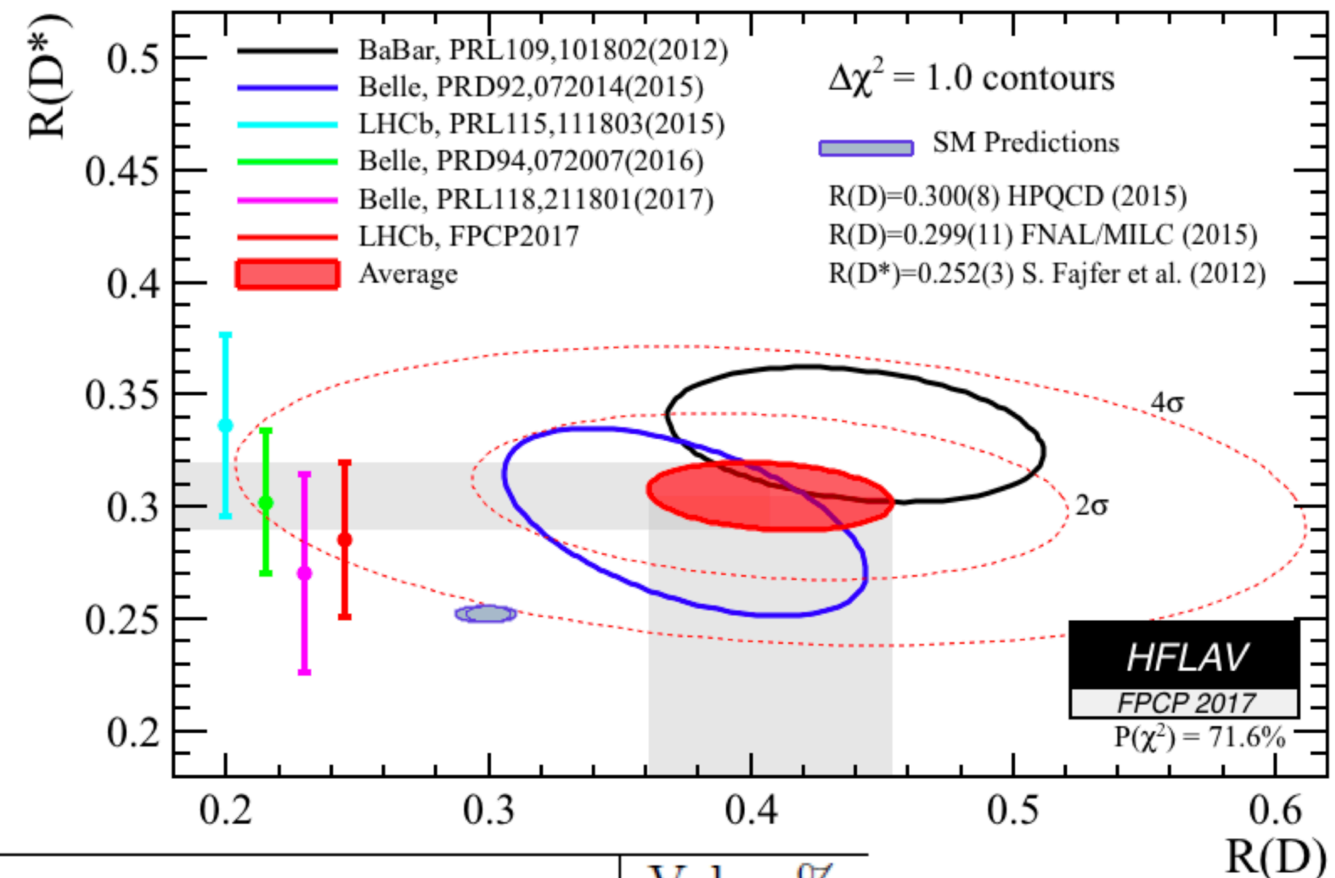
➢ **Systematic uncertainties from charm branching fractions normally dominate (similar situation also for $f_{\Lambda b}/(f_d + f_u)$ etc)**

Lepton flavor universality measurements

arXiv:1708.08856

➢ **Lepton flavor universality test becomes a hot topic after many deviations seen from B-factories and LHCb measurements**

➢ **Charm inputs are very important for understanding backgrounds of R(D) and R(D*) measurements with $\tau \to 3\pi\nu$**

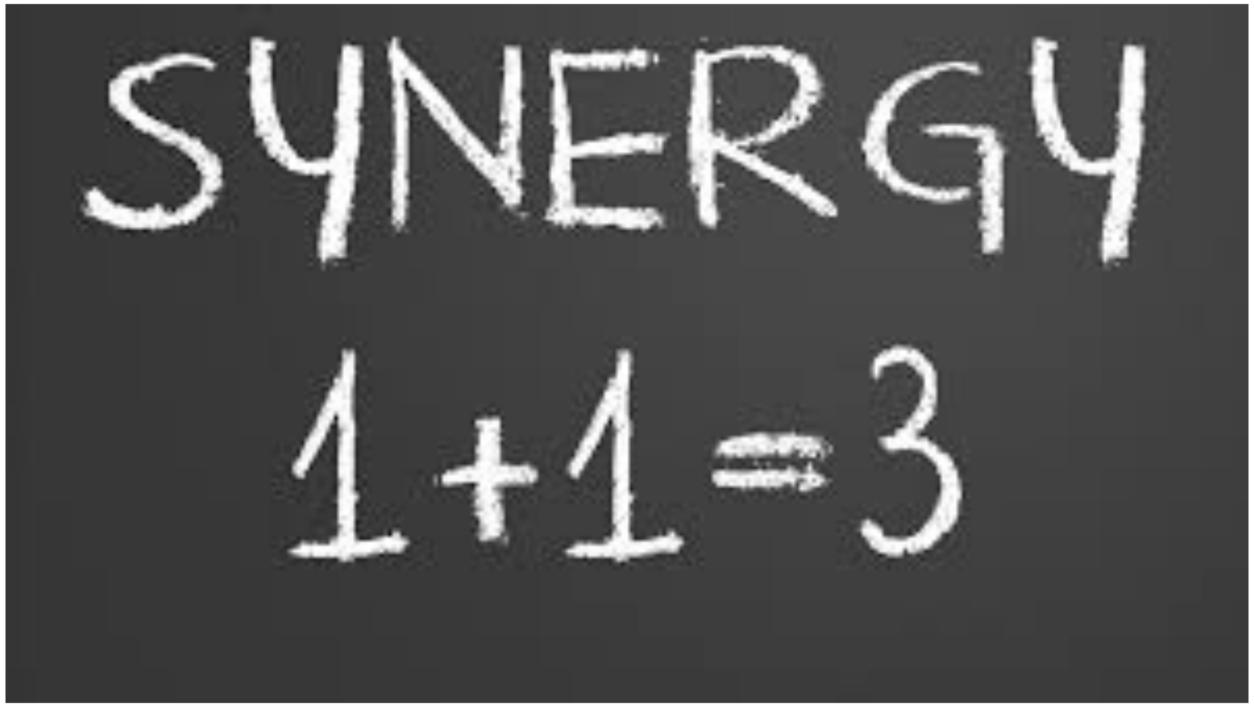


Contribution	Value %
Simulated sample size	4.7
Signal modeling	1.8
$D^{**}\tau\nu$ and $D_s^{**}\tau\nu$ feed-downs	2.7
$D_s^+ \to 3\pi X$ decay model	2.5
$B \to D^{*-}D_s^+X$, $B \to D^{*-}D^+X$, $B \to D^{*-}D^0X$ backgrounds	3.9
Combinatorial background	0.7
$B \to D^*3\pi X$ background	2.8
Empty bins in templates	1.3
Efficiency ratio	3.9
Total internal uncertainty	8.9
$\mathcal{B}(B^0 \to D^*3\pi)$ and $\mathcal{B}(B^0 \to D^*\mu\nu_\mu)$	4.5

Conclusion

➢ **Many important physics results need synergy between BESIII/HIEPA and LHCb**

➢ **Combined efforts from both experiments may lead to long-waited new physics**



3 == New Physics !!!