ϕ_3 Experimental Overview

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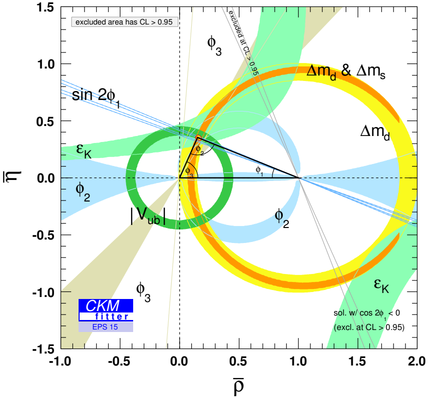
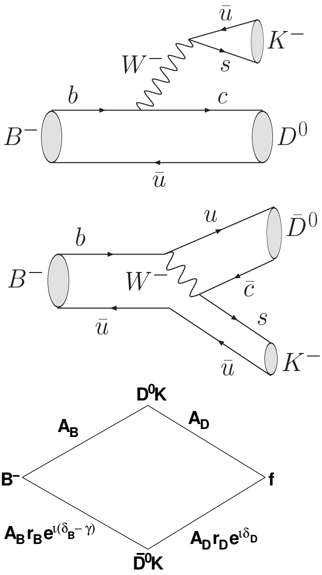
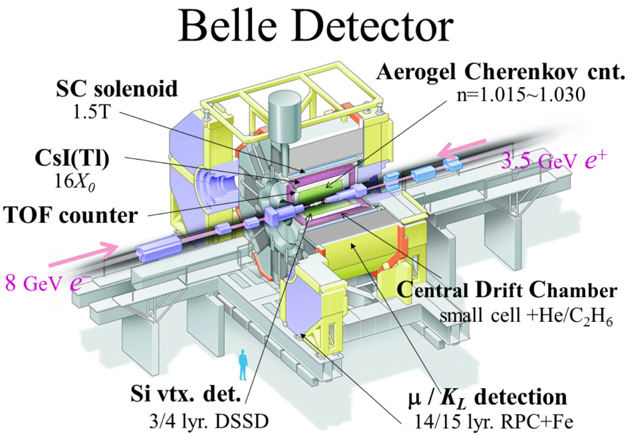
ϕ_3 Overview



- $\phi_3 = \arg\left(-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$
  - Currently, least constrained CKM angle
- Measurable with tree level $b \to u$ and $b \to c$ interference
  - Negligible loop contribution, theory uncertainties $O(10^{-7})$
- With large datasets, potential to measure at or below 1°



- Measurable with tree level $b \to u$ and $b \to c$ interference in $B \to D^{(*)}K^{(*)}$
- Interferes with D decay common to D^0 & $\bar{D}^0$
- $A_{B^\pm} = A_D + r_B e^{i(\delta_B \pm \phi_3)} \bar{A}_D$
  - $r_B \approx \frac{|V_{cs}V_{ub}^*|}{|V_{us}V_{cb}^*|} f_{col} \approx 0.1$ for $B^\pm \to DK^\pm$
- Several methods proposed, based on the way the D decays:
  - Analyse D decays to CP eigenstates "GLW"
  - DCS decays, e.g. $D \to K^+\pi^-$ "ADS"
  - Dalitz analysis of 3-body decays "GGSZ"
- Today, a selection of recent and not-so-recent results from LHCb and Belle (with apologies to BaBar)

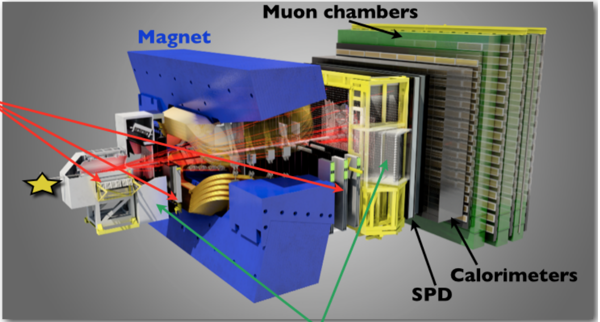


- Belle is a hermetic detector on KEKB asymmetric e^+e^- collider
- Started in 1999 with data taking until 2010
- Total of 772M $\Upsilon(4S) \to B\bar{B}$ sample

Experiments: LHCb

Vertex Locator and tracking system:
B and D vertex positions and track momenta

IP resolution: 20μm
Δp/p: 0.4-0.6 %

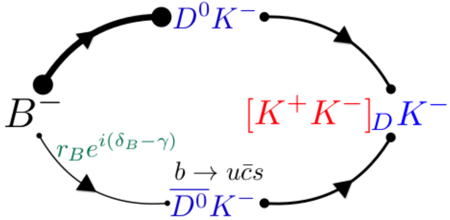


RICH detectors:
K/π separation

Trigger: Hardware (calo, muon) 20 MHz $\rightarrow$ 1MHz, Software (high p_T track followed by multi-variate topological trigger) $\rightarrow$ O(kHz)

- Topology: long B and D flight distances, large decay product impact parameter
- Kinematic: B momentum; high p_T solo-particle from B decay
- Data taking 2011 @ 7 TeV (1 fb^{-1}) and 2012 @ 8 TeV (2 fb^{-1})

GLW Method



- Use D decaying to CP eigenstates ($D_\pm$)
- CP even $D \to K^+K^-$, $D \to \pi^+\pi^-$; CP odd $D \to K_S\pi^0$, $D \to K_S\omega$

Observables:

$$R_{CP\pm} = \frac{\Gamma(B^+ \to D^0_\pm K^+) + \Gamma(B^- \to D^0_\pm K^-)}{\Gamma(B^+ \to D^0 K^+) + \Gamma(B^- \to \bar{D}^0 K^+)} = 1 + r_B^2 \pm 2 r_B \cos\phi_3 \cos\delta_B$$

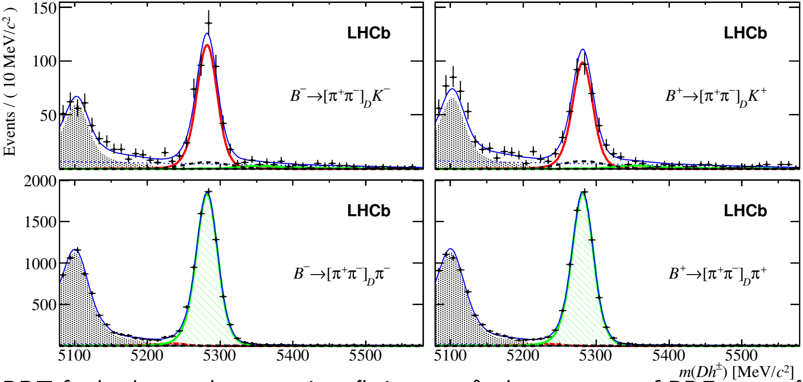
$$A_{CP\pm} = \frac{\Gamma(B^+ \to D^0_\pm K^+) - \Gamma(B^- \to D^0_\pm K^-)}{\Gamma(B^+ \to D^0_\pm K^+) + \Gamma(B^- \to D^0_\pm K^-)} = \frac{\pm 2 r_B \sin\phi_3 \sin\delta_B}{R_{CP\pm}}$$

- Eight-fold degeneracy in extraction of ϕ_3

M. Gronau, D. Wyler, PLB 265 (1991) 172-176

M. Gronau, D. London, PLB 253 (1991) 483-488

LHCb GLW Example $B^\pm \to [\pi\pi]_D K^\pm$

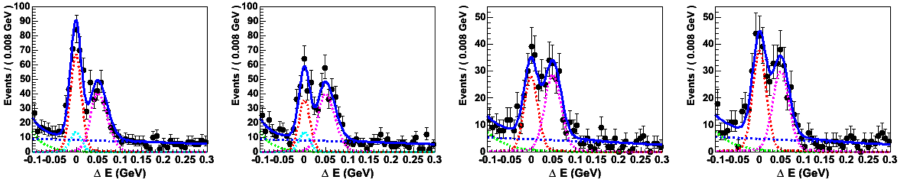


- BDT for background suppression, fit in mass & share aspects of PDF across fits:
  - Constain cross-feed ($D\pi$ in DK) using known PID eff.
  - Charmless cross-feed fixed relative to favored $B \to D\pi$, partially reconstructed bkg'ds modelled
- $A_{CP}^{\pi\pi} = 0.128 \pm 0.037 \pm 0.012$
- $R_{CP}^{\pi\pi} = 1.002 \pm 0.040 \pm 0.026 \pm 0.010$ [Final uncertainty from assumption $r_B^{D\pi} = 0$]

LHCb (arXiv:1603.08993)

Belle GLW

$D_{CP+} \to KK,\ \pi\pi$ $D_{CP-} \to K_S\pi^0,\ K_S\eta$

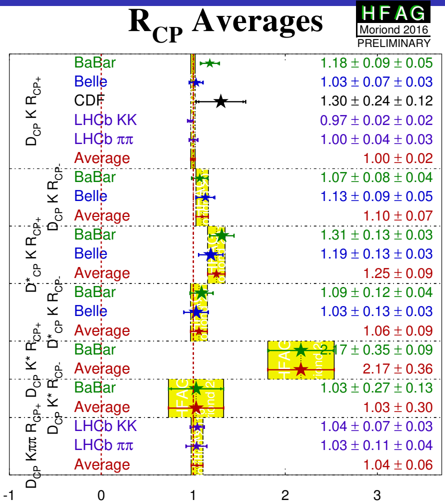


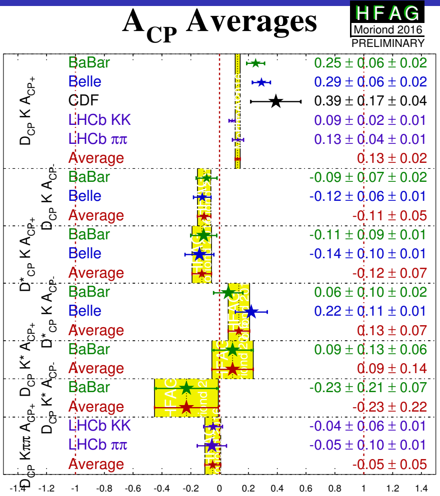
B^- B^+ B^- B^+

- B factories still have the advantage in CP- states where neutral π^0/η reconstruction becomes necessary
- Signal $B \to DK$, Cross-feed $B \to D\pi$
- $R_{CP-} = 1.13 \pm 0.09 \pm 0.05$, $A_{CP-} = -0.12 \pm 0.06 \pm 0.01$
- $R_{CP+} = 1.03 \pm 0.07 \pm 0.02$, $A_{CP+} = +0.29 \pm 0.06 \pm 0.02$
  - $A_{CP\pm}$ shows expected sign change

Belle preliminary LP2011, 772M $B\bar{B}$

GLW Combination (HFAG Moriond 2016 Preliminary)



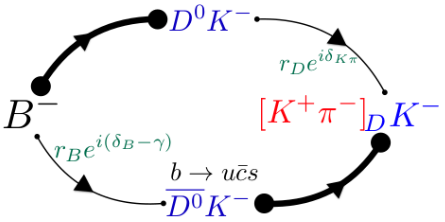


- HFAG Combination against inputs from Belle, Babar, LHCb, CDF

$$R_{CP\pm} = \frac{\Gamma(B^+ \to D^0_\pm K^+) + \Gamma(B^- \to D^0_\pm K^-)}{\Gamma(B^+ \to D^0 K^+) + \Gamma(B^- \to \bar{D}^0 K^+)} = 1 + r_B^2 \pm 2 r_B \cos\phi_3 \cos\delta_B$$

$$A_{CP\pm} = \frac{\Gamma(B^+ \to D^0_\pm K^+) - \Gamma(B^- \to D^0_\pm K^-)}{\Gamma(B^+ \to D^0_\pm K^+) + \Gamma(B^- \to D^0_\pm K^-)} = \frac{\pm 2 r_B \sin\phi_3 \sin\delta_B}{R_{CP\pm}}$$

ADS Method



- Interference through the favored and doubly-Cabibbo-suppressed decays of the D
  - Favored D decay follows suppressed B decay
  - Suppressed D decay follows favored B decay
  - Leads to relatively similar amplitudes, enhancing possible CP asymmetry

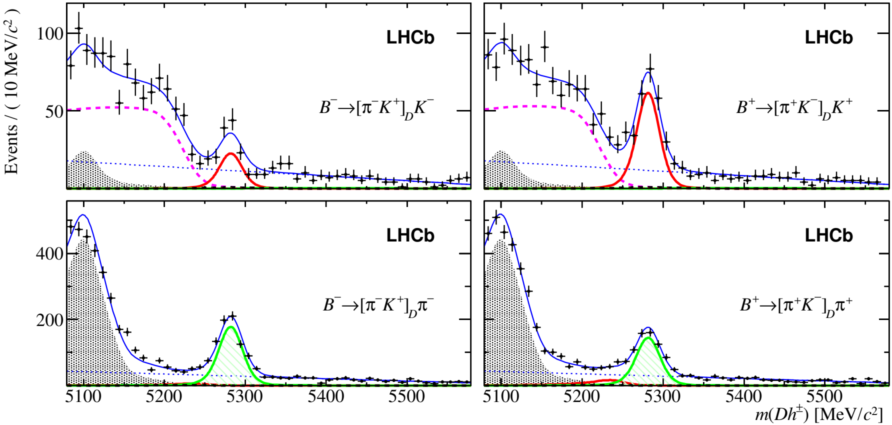
Observables (using $D \to K\pi$ as an example):

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

$$r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D) \cos\phi_3$$

$$A_{ADS} = \frac{\Gamma(B^+ \to [K^-\pi^+]_D K^+) - \Gamma(B^- \to [K^+\pi^-]_D K^-)}{\Gamma(B^+ \to [K^-\pi^+]_D K^+) + \Gamma(B^- \to [K^+\pi^-]_D K^-)} = \frac{2 r_B r_D R \sin(\delta_B + \delta_D) \sin\phi_3}{R_{ADS}}$$

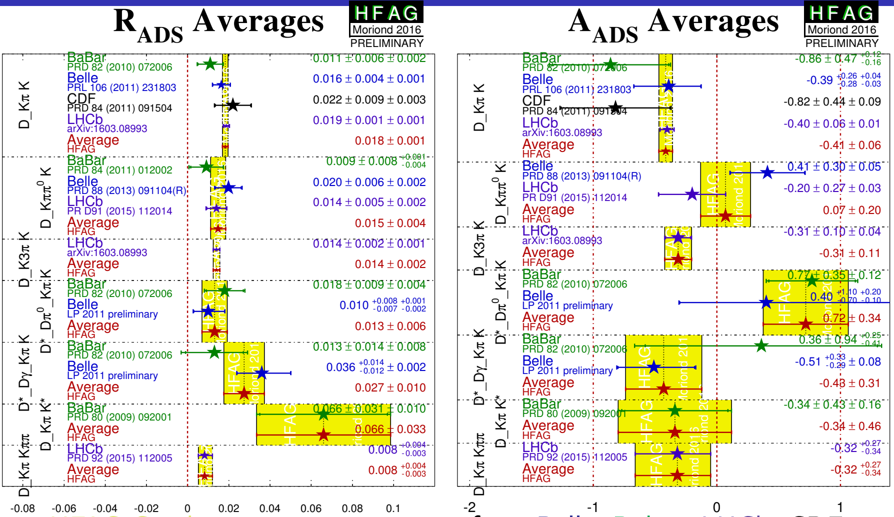
LHCb ADS Example $B^\pm \to []_D K^\pm$



- As for GLW, BDT background suppression and shared PDF parameters
- $A_{ADS}^{\pi K} = -0.403 \pm 0.056 \pm 0.011$
- $R_{ADS}^{\pi K} = 0.0188 \pm 0.0011 \pm 0.0010$
- 8σ evidence for CPV in $B^\pm \to [\pi^\pm K^\mp]K^\pm$

LHCb (arXiv:1603.08993)

ADS Combination (HFAG Moriond 2016 Preliminary)

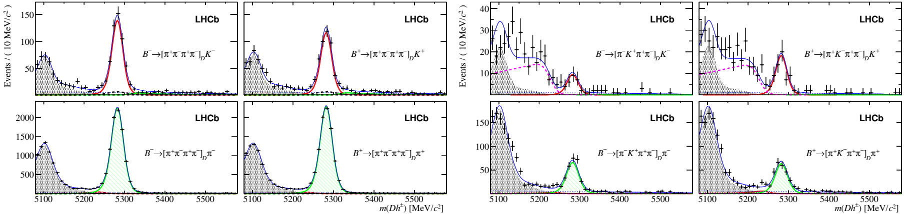


- HFAG Combination against inputs from Belle, Babar, LHCb, CDF

$$R_{ADS} = \frac{\Gamma(B^+ \to [\bar{f}]_D K^+) + \Gamma(B^- \to [f]_D K^-)}{\Gamma(B^+ \to [f]_D K^+) + \Gamma(B^- \to [\bar{f}]_D K^-)} = r_B^2 + r_D^2 + 2 r_B r_D k_D k_B \cos(\delta_B + \delta_D) \cos\phi_3$$

$$A_{ADS} = \frac{\Gamma(B^+ \to D^0_\pm K^+) - \Gamma(B^- \to D^0_\pm K^-)}{\Gamma(B^+ \to D^0_\pm K^+) + \Gamma(B^- \to D^0_\pm K^-)} = \frac{2 r_B r_D R \sin(\delta_B + \delta_D) \sin\phi_3}{R_{ADS}}$$

LHCb "quasi"-GLW and -ADS

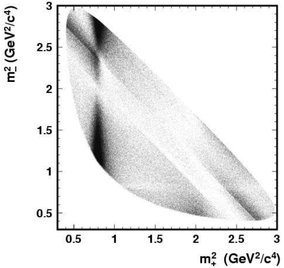


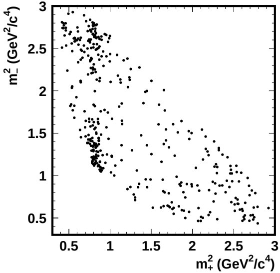
- LHCb extends the GLW to "quasi"-GLW/ADS using 4-body decay modes $D \to \pi^+\pi^-\pi^+\pi^-$ (left) and $D \to K^-\pi^+\pi^+\pi^-$ (right)
- For GLW-like $D \to \pi^+\pi^-\pi^+\pi^-$, interference reduced by measured CP-even fraction of states $F_+^{4\pi} = 0.737 \pm 0.028$ measured in CLEO data
  - Enters as factor $2F_+^{4\pi} - 1$ multiplied into the usual GLW A_{CP+}, R_{CP+}
- $A^{4\pi} = 0.10 \pm 0.03 \pm 0.02$, $R^{4\pi} = 0.97 \pm 0.04 \pm 0.02$, 2.7$\sigma$ CP violation effect.
- In $D \to K^-\pi^+\pi^+\pi^-$, sensitivity reduced by coherence factor $\kappa^{K3\pi} = 0.32 \pm 0.10$ and averaged strong-phase difference $\delta^{K3\pi}$ from CLEO/LHCb combination (2016)
  - $R_{ADS} = r_B^2 + r_D^2 + 2 r_B r_D \kappa_D^{K3\pi} \cos(\delta_B + \delta_D^{K3\pi} - \gamma)$
- $A^{\pi K \pi\pi} = -0.313 \pm 0.102 \pm 0.038$, $R^{\pi K \pi\pi} = 0.0140 \pm 0.0015 \pm 0.0006$

LHCb (arXiv:1603.08993)

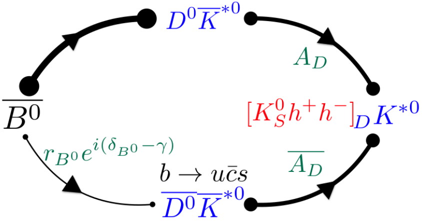
GGSZ Dalitz Analysis Overview

Belle hep-ex/0604054





Belle hep-ex:1003.3360

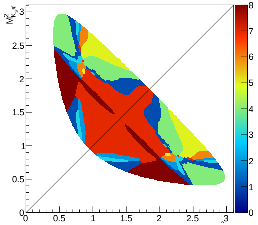


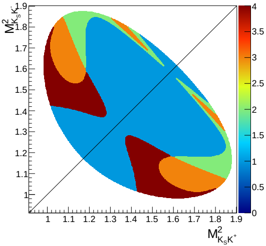
- $\Gamma_{B^\pm}(m_+^2, m_-^2) \propto |\bar{A}_D|^2 + r_B^2|A_D|^2 + 2\left(x_\pm \Re(A_D\bar{A}_D^*) + y_\pm \Im(\bar{A}_D A_D^*)\right)$
- Measure ϕ_3 by analysing D Dalitz plots in $B^\pm \to DK^\pm$ for $D - \bar{D}$ mixture
  - Use flavour decays $D^{*\pm} \to \pi^\pm D$ for A_D
  - Use as input to $B^\pm \to DK^\pm$ to measure $(x_\pm, y_\pm) = r_B(\cos(\pm\phi_3 + \delta_B), \sin(\pm\phi_3 + \delta_B))$
  - Use Cartesian coords. due to fit edge $r_B = 0$ introducing bias to r_B
- Fitting the Dalitz amplitude leads to a model-dependent uncertainty, here $\sigma_{\phi_3} = 8.9^\circ$ (Belle)

Original GGSZ paper Bondar/Poluektov feasibility study

Model-Independent Dalitz Analysis

Optimal $K_S\pi^+\pi^-$ binning



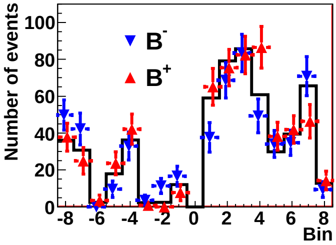


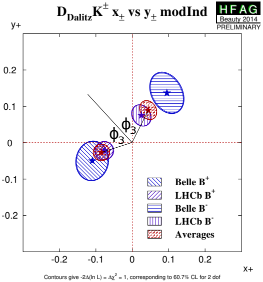
3 bins equal $\Delta\delta_D$

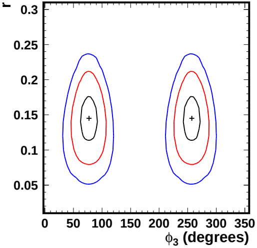
$K_S K^+ K^-$

- For degree-level precision, instead, bin the Dalitz plot, symmetric ($i \leftrightarrow -i$) about m_+^2 & m_-^2
- Number of events in a particular bin in $B^\pm \to DK^\pm$
  $N_i^\pm \propto K_i + r_\pm^2 K_{-i} + 2\sqrt{K_i K_{-i}}\,(x_\pm c_i + y_\pm s_i)$
- $|A_D^{+-}|_i^2$ from number of flavor tagged events in the i^{th} bin [of $D^{*\pm} \to \pi^\pm D$], K_i
- Averaged phase variation over Dalitz bin $\mathcal{D}_i$
  $(s_i, c_i) = (-s_{-i}, c_{-i}) \equiv$
  $$\frac{\int_{\mathcal{D}_i} |A_D^{+-}||A_D^{-+}| \sin \Delta\delta_D^{+-}\, d\mathcal{D}}{\sqrt{\int_{\mathcal{D}_i} |A_D^{+-}| d\mathcal{D} \int_{\mathcal{D}_i} |A_D^{-+}| d\mathcal{D}}}, \frac{\int_{\mathcal{D}_i} |A_D^{+-}||A_D^{-+}| \cos \Delta\delta_D^{+-}\, d\mathcal{D}}{\sqrt{\int_{\mathcal{D}_i} |A_D^{+-}| d\mathcal{D} \int_{\mathcal{D}_i} |A_D^{-+}| d\mathcal{D}}}$$
  - Set binning to minimize phase variation or optimize sensitivity to ϕ_3
  - Measured by CLEO-c from quantum correlated $D\bar{D}$ decays of $\psi(3770)$
- Fit in $B^\pm \to DK^\pm$
  - $(x_\pm, y_\pm) = r_B(\cos(\pm\phi_3 + \delta_B), \sin(\pm\phi_3 + \delta_B))$

$B^\pm \to D^0 K^\pm$, $D^0 \to K_S\pi^+\pi^-$ Model-Independent Results





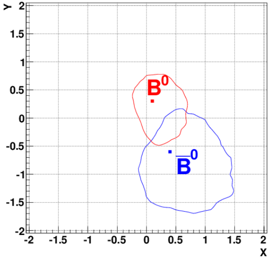


- Belle results for $[K_S\pi^+\pi^-]_D$ for N signal in bins compared with flavor, then fit in $(x_\pm, y_\pm)$ plane (+LHCb/HFAG), and converted to (r_B, ϕ_3)
- Belle Dalitz Analysis: $\phi_3 = (80.8^{+13.1}_{-14.8} \pm 5.0 \pm 8.9)^\circ$ [stat, syst, model]
  Model Indp't $\phi_3 = (77.3^{+15.1}_{-14.9} \pm 4.1 \pm 4.3)^\circ$ [stat, syst, CLEO (c_i, s_i)]
  - Model Indp't analysis uses 710 fb^{-1} vs 605 fb^{-1} for Dalitz analysis
  - Model Indp't measures $r_B = 0.145 \pm 0.03 \pm 0.01 \pm 0.01$
  - Dalitz Analysis: $r_B = 0.16 \pm 0.04 \pm 0.01^{+0.05}_{-0.01}$
- LHCb $\phi_3 = (62^{+15}_{-14})^\circ$, $r_B = 0.080^{+0.019}_{-0.021}$, including $D \to K_S K^+ K^-$

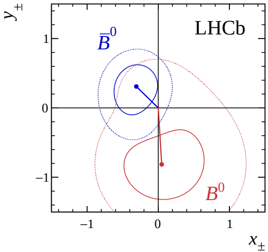
Belle Mod. Indep't $K_S\pi^+\pi^-$ (arxiv:1204.6561), LHCb

$B^0 \to D^0 K^{*0}$ Model Independent Results

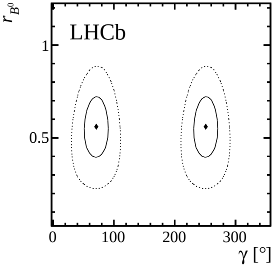
Belle



LHCb



LHCb Constraints

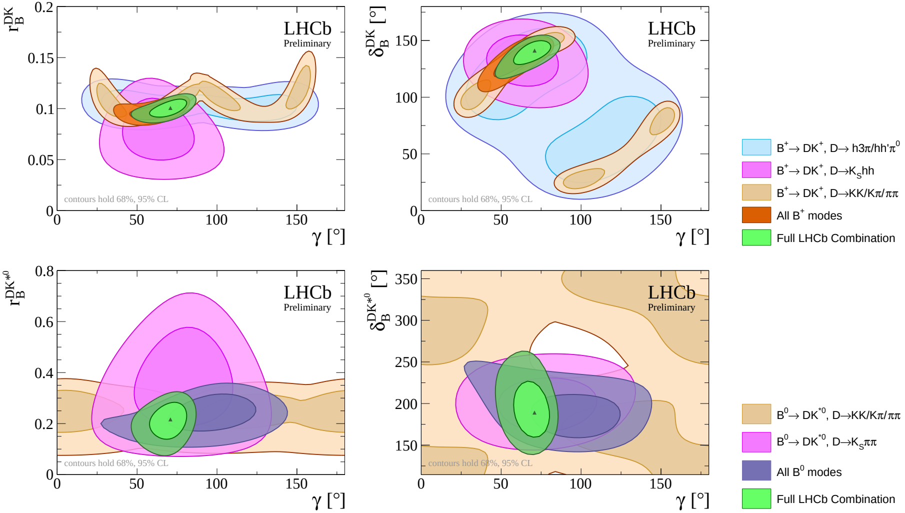


- The model independent method has also been used for $B^0 \to D^0 K^{*0}$, $K^{*0} \to K^+ \pi^-$, where B^0 flavor tagged by kaon charge
- $N_i^\pm \propto K_i + r_{S,\pm}^2 K_{-i} + 2\kappa\sqrt{K_i K_{-i}}\,(x_\pm c_i + y_\pm s_i)$
  - $\kappa \approx 0.958$ a coherence factor for the chosen $K^+\pi^-$ region
- Belle sets an upper limit of $r_S < 0.87$ (68% CL)
- LHCb finds $r_S = 0.56 \pm 0.17$, $\phi_3 = (71 \pm 20)^\circ$
- LHCb also has model-dependent Dalitz with consistent fit results

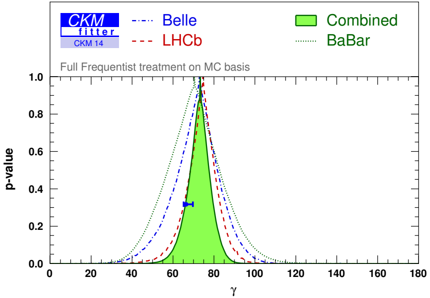
Belle (arxiv:1509.01098) LHCb (arxiv:1604.01525)

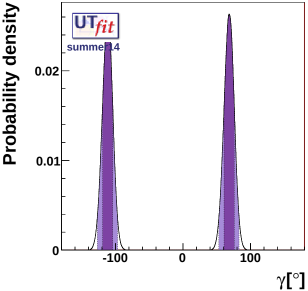
LHCb Combination of Modes

Using the plugin method, LHCb has produced an LHCb combination including new 2016 results (LHCb-CONF-2016-001)

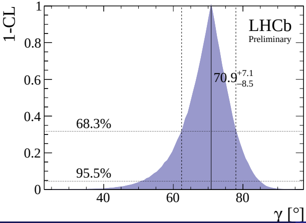


ϕ_3 Experimental Combination



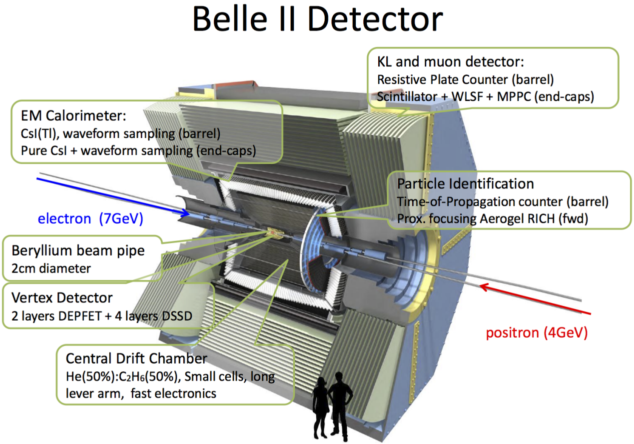


- CKMFitter/UTFit have combinations from all experimental results as of 2014 (above)
- Using the plugin method, LHCb has produced an LHCb combination for 2016 (below)
- Also have CKMFitter prediction, based on CKM measurements excluding direct ϕ_3



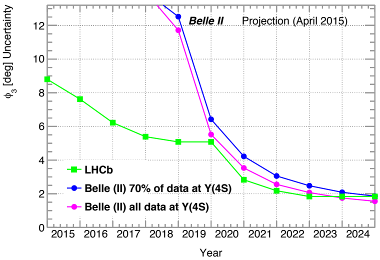
Combination	ϕ_3 [°]
LHCb (2016)	$70.9^{+7.1}_{-8.5}$
CKMFitter (2014)	$73.2^{+6.3}_{-7.0}$
CKMFitter (Belle)	73^{+13}_{-15}
CKMFitter (BaBar)	73 ± 18
CKMFitter (LHCb)	$74.6^{+8.4}_{-9.2}$
CKMFitter (Prediction)	$66.9^{+1.0}_{-3.7}$

The Future: Belle II Detector



- Improved tracking should increase K_S efficiency
- Improved PID, better $K\pi$ separation
- Waveform sampling in Ecal: improved γ/π^0
  - Better D^{*0} recon.
- High luminosity, aim for 50 ab^{-1} by 2024

ϕ_3 Expected Evolution Over Time



Included modes

Belle II	LHCb
$D \to KK$	$D \to KK$
$D \to \pi\pi$	$D \to \pi\pi$
$D \to K\pi$	$D \to K\pi$
$D \to K\pi\pi\pi$	$D \to K\pi\pi\pi$
$D \to K_S\pi\pi$	$D \to K_S\pi\pi$
	$D \to K_S K\pi$
	$D \to K_S KK$

$B^{\pm} \to D^{(*)}K$
Combined σ

Belle II	
Belle 14°	50 ab^{-1} 1.9°
	50 ab^{-1} 1.5°

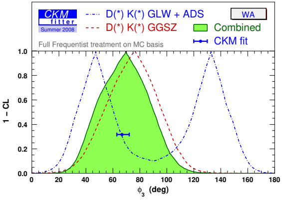
LHCb	
Run-1 8.8°	25 fb^{-1} 1.9°

- Projection based on
  - LHCb-PUB-2014-040 upgrade schedule and parameters
  - March 2015 Belle II EB schedule
- Projection of the uncertainty on the combined ϕ_3 result
- Belle II will become comparable with LHCb a year or 2 after running starts
- Ultimately, systematics limit Belle II and LHCb to around 1-2° uncertainty for GGSZ

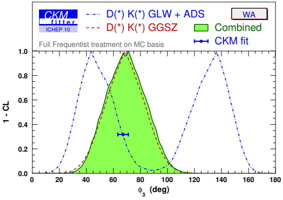
For more, see B2TiP workshop talks GGSZ at Belle II and Belle II Sensitivity Study

Summary

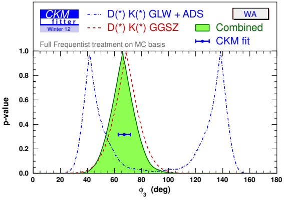
2008



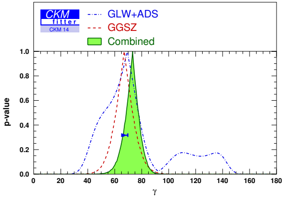
2010



2012



2014



- Exciting times for ϕ_3, lots of activity to reduce uncertainty in recent years
- LHCb taking more data and exploring new modes
- Belle II will start to be competitive within the next few years
- Lots of activity in the years to come, degree-level precision on the horizon

BACKUP

References

GLW

- M. Gronau, D. Wyler, PLB 265 (1991) 172-176
- M. Gronau, D. London, PLB 253 (1991) 483-488
- Babar $B^{\pm} \to D_{CP} K^{\pm}$ PRD82 (2010) 072004

ADS

- D. Atwood, I. Dunietz, A. Soni, PRL 78 (1997) 3257-3260
- Evidence for the Suppressed Decay $B- \to DK-$, $D \to K + pi-$ (Belle) PRL 106 (2011) 231803
- Search for $b \to u$ transitions in $B \to DK$ and D^K Decays (Babar) PRD 82 (2010) 072006

References (cont'd)

GGSZ Theory

- GGSZ paper (arxiv)
- Model Independent Feasibility Study (Bondar, Poluektov) (arxiv)
- Use of Quantum Correlated D Decays (Bondar, Poluektov) (arxiv)
- On D^*K decays (Bondar, Gershon) (arxiv)

D mixing

- Charm mixing in model-indpt (Bondar, Poluektov, Vorobiev) (arxiv)
- Effect of DD mixing (Grossman, Soffer, Zupan) (arxiv)

GSGZ Model Dependent Analyses

- Babar $D^{(*)}K^{(*)}$, $K_S h^+ h^-$ (arxiv)
- Belle $D^{(*)}K$, $K_S\pi^+\pi^-$ (2010) (arxiv)
- Belle $D^{(*)}K^{(*)}$, $K_S\pi^+\pi^-$ (2006) (arxiv)

GGSZ Inputs

- CLEO (arxiv)
- BES III: Presented by D. Ambrose at APS Meeting, 2014

References (cont'd)

LHCb, recent updates

- Measurement of CP observables in $B^{\pm} \to DK^{p}m$ and $B \to D\pi^{\pm}$ with two- and four-body D decays (arXiv:1603.08993) LHCb w/3fb^{-1}
- Constraints on the unitarity triangle angle γ from Dalitz plot analysis of $B^0 \to DK^{+}\pi$ decays (arxiv:1602.03455v1)
- Measurement of the CKM angle γ from a combination of $B \to DK$ analyses (LHCb-CONF-2016-001)

GGSZ Model Independent Analyses

- Belle Mod. Indep't $K_S\pi^+\pi^-$ (arxiv)
- LHCb Mod. Indep't $K_S h^+ h^-$ 1 fb^{-1} @ 7 TeV (2012, PLB) (arxiv)
- LHCb Mod. Indep't $K_S h^+ h^-$ 1+2 fb^{-1} @ 7+8 TeV (arxiv)
- Belle $B \to DK^*$ (1509.01098)
- LHCb $B \to DK^*$ (1604.01525)

LHCb Upgrade

- LHCb upgrade future prospects (arxiv) Section 3.4 on ϕ_3

References (cont'd)

CLEO CP-even fraction

- First determination of the CP content of $D \to \pi^+\pi^{\pi^+ pi}$ and updated determination of the CP contents of $D \to \pi^+\pi^{\pi^0}$ and $D \to K^+K^{\pi^0}$ arXiv:1504.05878

CLEO coherence factor $K3\pi$

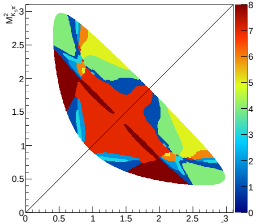
- CLEO (2009)
- CLEO/LHCb combination (2016)

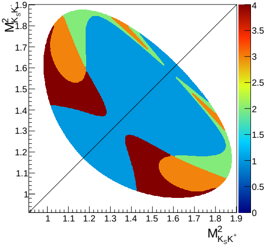
Combinations

- HFAG Moriond 2016 Preliminary Results
- UTFit ϕ_3 Results (2014)
- CKMfitter ϕ_3 Results (2014)

Model-Independent Dalitz Analysis

Optimal $K_S\pi^+\pi^-$ binning



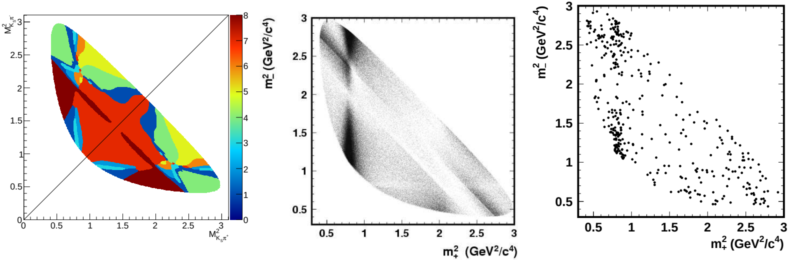


3 bins equal $\Delta\delta_D$

$K_S K^+ K^-$

- For degree-level precision, instead, bin the Dalitz plot, symmetric ($i \leftrightarrow -i$) about m^2_+ & m^2_-
- Number of events in a particular bin in $B^\pm \to DK^\pm$
  $N_i^\pm \propto K_i + r_\pm^2 K_{-i} + 2\sqrt{K_i K_{-i}}\,(x_\pm c_i + y_\pm s_i)$
- $|A_D^{+-}|_i^2$ from number of flavor tagged events in the i^{th} bin [of $D^{*\pm} \to \pi^\pm D$], K_i
- Averaged phase variation over Dalitz bin $\mathcal{D}_i$
  $(s_i, c_i) = (-s_{-i}, c_{-i}) \equiv$
  $$\frac{\int_{\mathcal{D}_i} |A_D^{+-}||A_D^{-+}| \sin \Delta\delta_D^{+-}\, d\mathcal{D}}{\sqrt{\int_{\mathcal{D}_i} |A_D^{+-}| d\mathcal{D} \int_{\mathcal{D}_i} |A_D^{-+}| d\mathcal{D}}}, \frac{\int_{\mathcal{D}_i} |A_D^{+-}||A_D^{-+}| \cos \Delta\delta_D^{+-}\, d\mathcal{D}}{\sqrt{\int_{\mathcal{D}_i} |A_D^{+-}| d\mathcal{D} \int_{\mathcal{D}_i} |A_D^{-+}| d\mathcal{D}}}$$
  - Set binning to minimize phase variation or optimize sensitivity to ϕ_3
- Measured by CLEO-c from quantum correlated $D\bar{D}$ decays of $\psi(3770)$
- E.g. number of events in double-$K_S h^+ h^-$:
  $M_{ij} \propto K_i K_{-j} + K_{-i} K_j - 2\sqrt{K_i K_{-j} K_{-i} K_j}(c_i c_j + s_i s_j)$

GGSZ Model-Independent Method



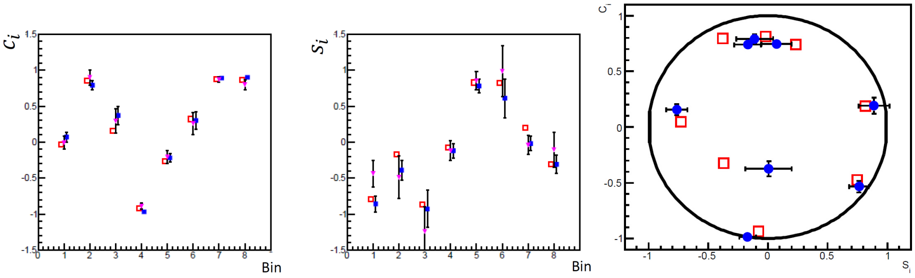
- One can measure CKM ϕ_3 without Dalitz model dependency by binning D Dalitz in $B \to DK$, symmetric $M(K_S\pi^+) = M(K_S\pi^-)$
- Number of events $N_i^{\pm}$ in a particular bin in $B^{\pm} \to DK^{\pm}$

$$N_i^{\pm} \propto K_i + r_{\pm}^2 K_{-i} + 2\sqrt{K_i K_{-i}}\,(x_{\pm} c_i + y_{\pm} s_i)$$

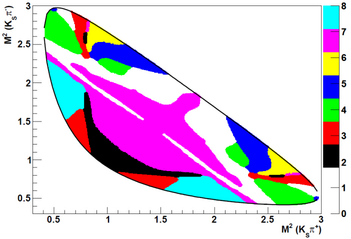
- Averaged phase differences measured at CLEO or BES-III
- K_i Flavor dalitz content, number of signal events measured in $D^{*\pm} \to D\pi^{\pm}$
- Fit in $B^{\pm} \to DK^{\pm}$
  - $(x_{\pm}, y_{\pm}) = r_B(\cos(\pm\phi_3 + \delta_B), \sin(\pm\phi_3 + \delta_B))$

Belle hep-ex/0604054

$D \to K_S\pi^+\pi^-$ Strong Phases from BES III

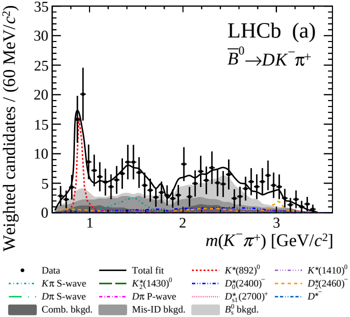


- For Belle 2, we will need more tightly constrained strong phases
- BES III APS 2014 results, 2.9 fb^{-1} \
  CLEO used .8 fb^{-1} in their analysis \
  Comparison with Babar Model
- Should allow for sub-degree systematic for the model-independent analysis
- Further work needed assess the impact of finer binning in future measurements



Plots from Roy Briere's CKM 2014 Talk
Errors stat. only

LHCb GLW/ADS Dalitz Method $B^0 \to DK^+\pi^-$



- For $B \to DK^*$ both b amplitudes are color suppressed, expect large CPV
- Reconstruct $D \to K\pi$, KK, $\pi\pi$
- Fit isobar model to $B^0 \to DK^+\pi^-$ simultaneously, modelling eff./bkg'd
- From Dalitz analysis, also find hadronic parameters used in $B^0 \to D^0K^{*0}(892)$ quasi-two-body analysis, $\kappa = 0.958^{+0.005}_{-0.010}{}^{+0.002}_{-0.045}$