Hadronic B Decays to Open Charm @ LHCb

LHCb_Collaboration::Mike_Williams

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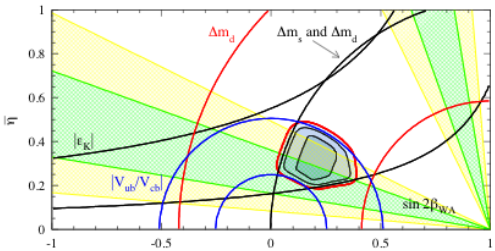
Introduction/Motivation

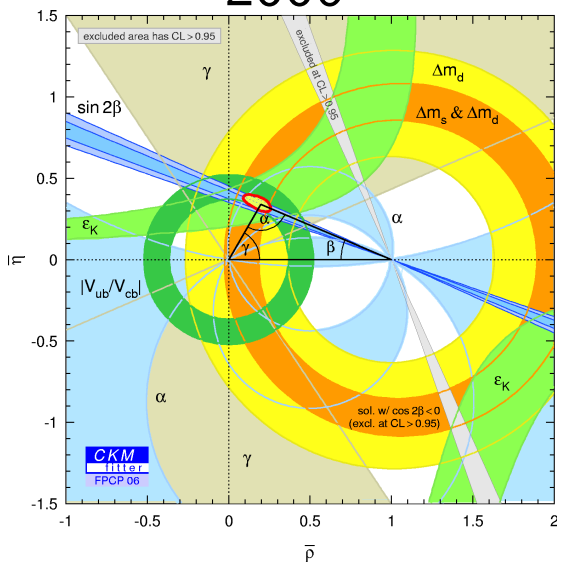
The CKM matrix describes all quark flavor-changing processes in the SM.

Amazing progress in the past 10+ years . . . but still more to learn.

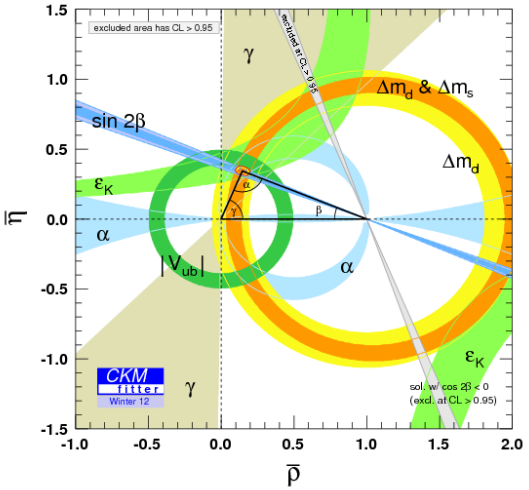
2001



2006



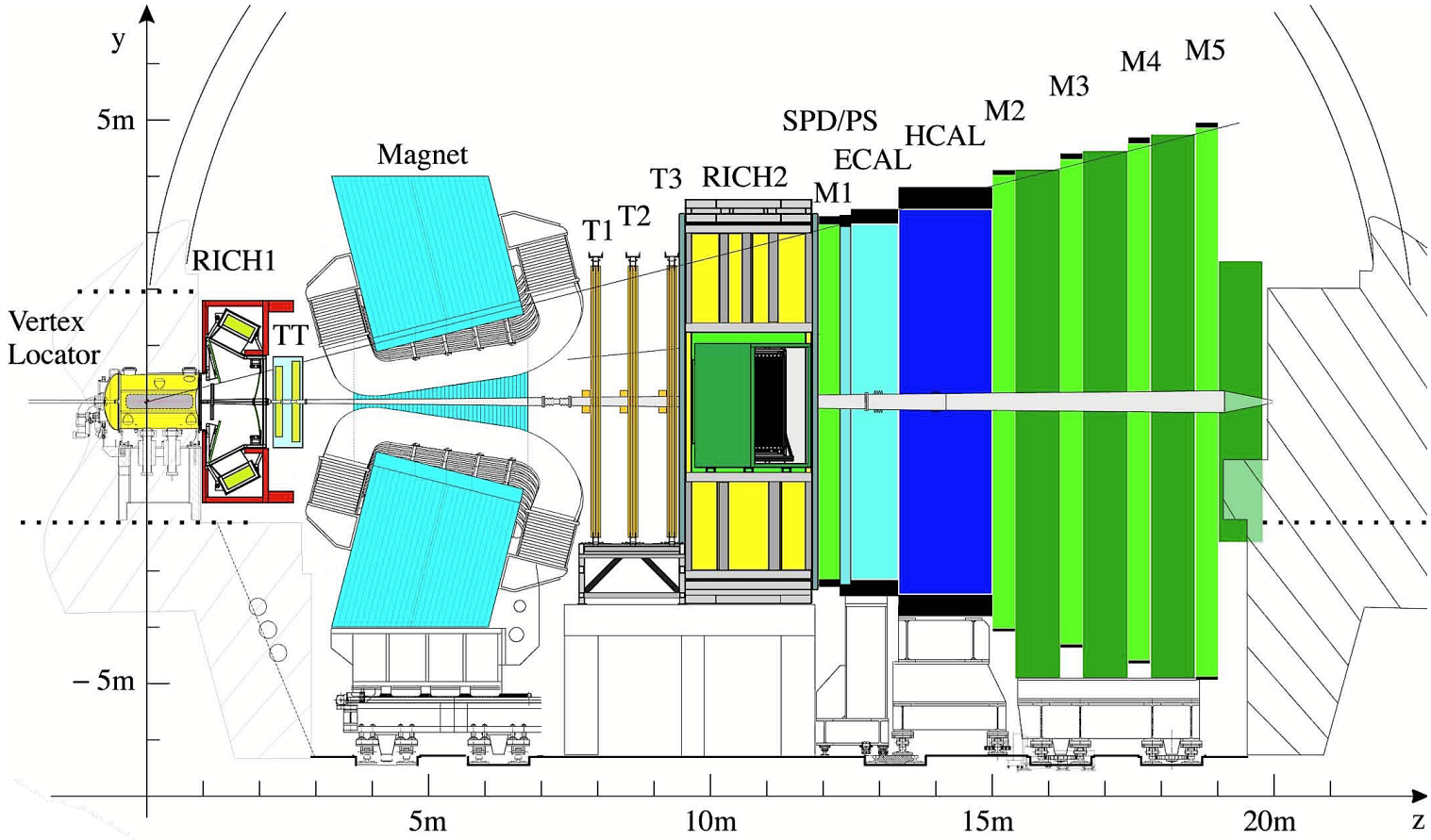
2012



This talk focuses on tree-level determination of γ and alternative ways of measuring other CKM parameters using $B \to DD'$ decays.

The LHC*b* Detector

LHC*b*: FWD spectrometer ($2 < \eta < 5$) built to study heavy-quark physics.



LHC*b* has excellent vertex and momentum resolution, PID, μ-ID, *etc.*

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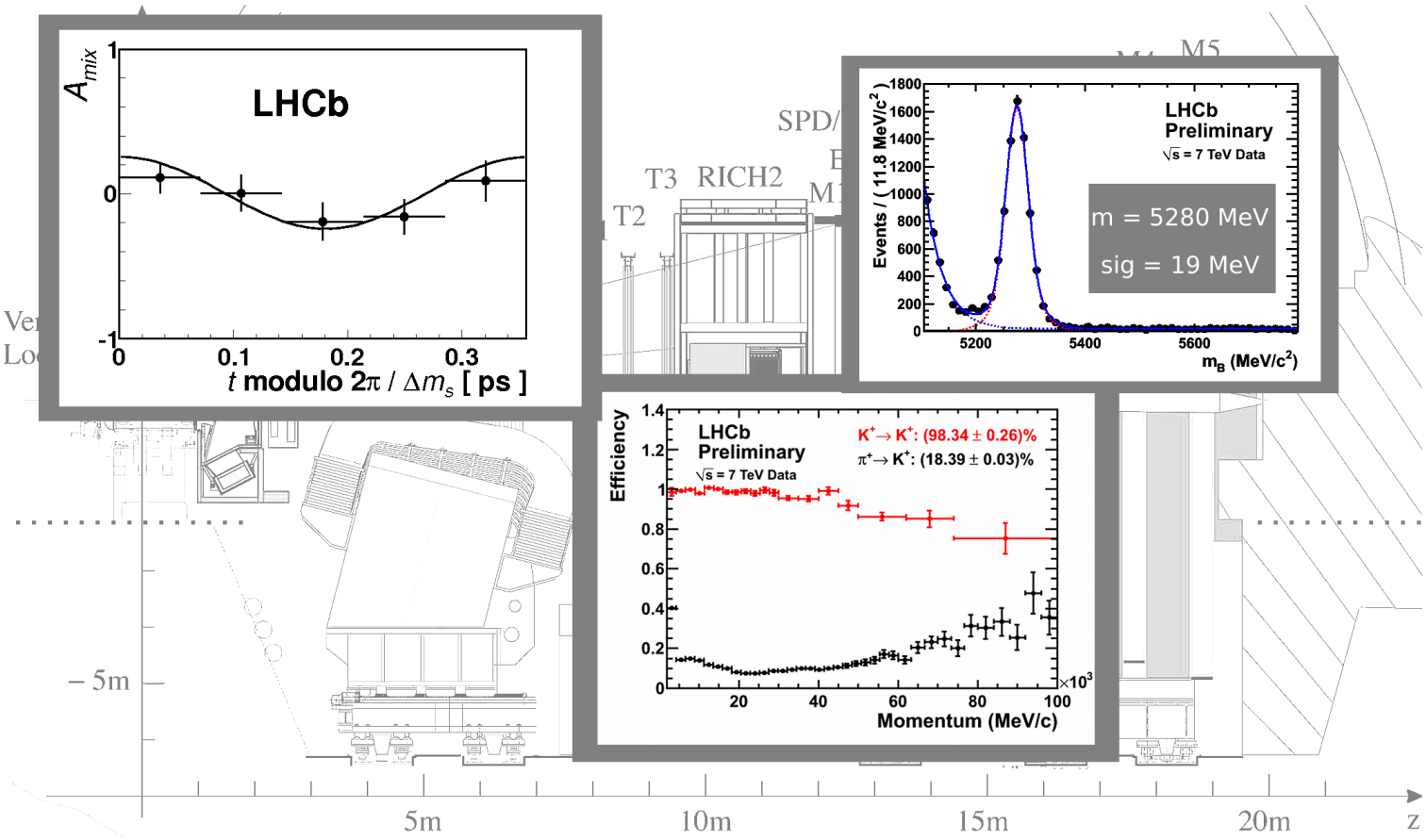

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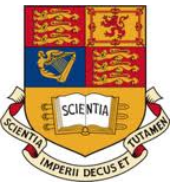
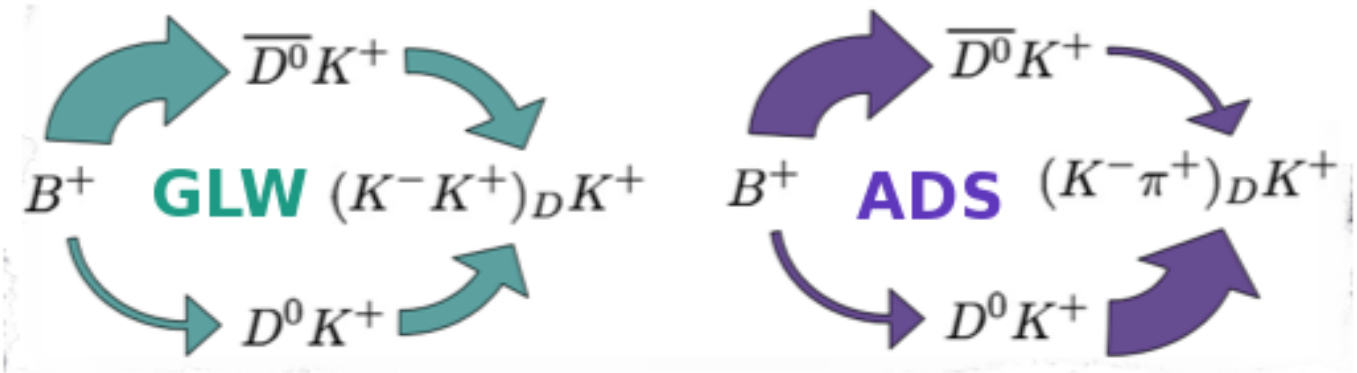


CKM γ via GLW/ADS

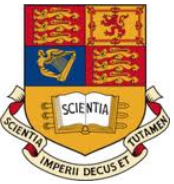
Use interference b/t $\mathcal{A}^{\bar{b}\to\bar{u}}_{b\to u} = \mathcal{A}_{bu}e^{\pm i\gamma}$ and $\mathcal{A}^{\bar{b}\to\bar{c}}_{b\to c} = \mathcal{A}_{bc}$ to extract γ.



[nb, this equation is slightly oversimplified as it ignores the D-decay amplitudes]

$$\begin{aligned}\mathcal{N}_\pm &= |\mathcal{A}_{B^\pm\to D^0K^\pm} + \mathcal{A}_{B^\pm\to\bar{D}^0K^\pm}|^2 \\ &= |\mathcal{A}_{D^0}|^2 + |\mathcal{A}_{\bar{D}^0}|^2 + 2|\mathcal{A}_{D^0}||\mathcal{A}_{\bar{D}^0}|\cos\left(\Delta\theta_{\text{strong}} \pm \gamma\right)\end{aligned}$$

These are tree-level ampltidues; thus, no *pollution* from penguins *etc.* So, what we measure here is really the SM γ.

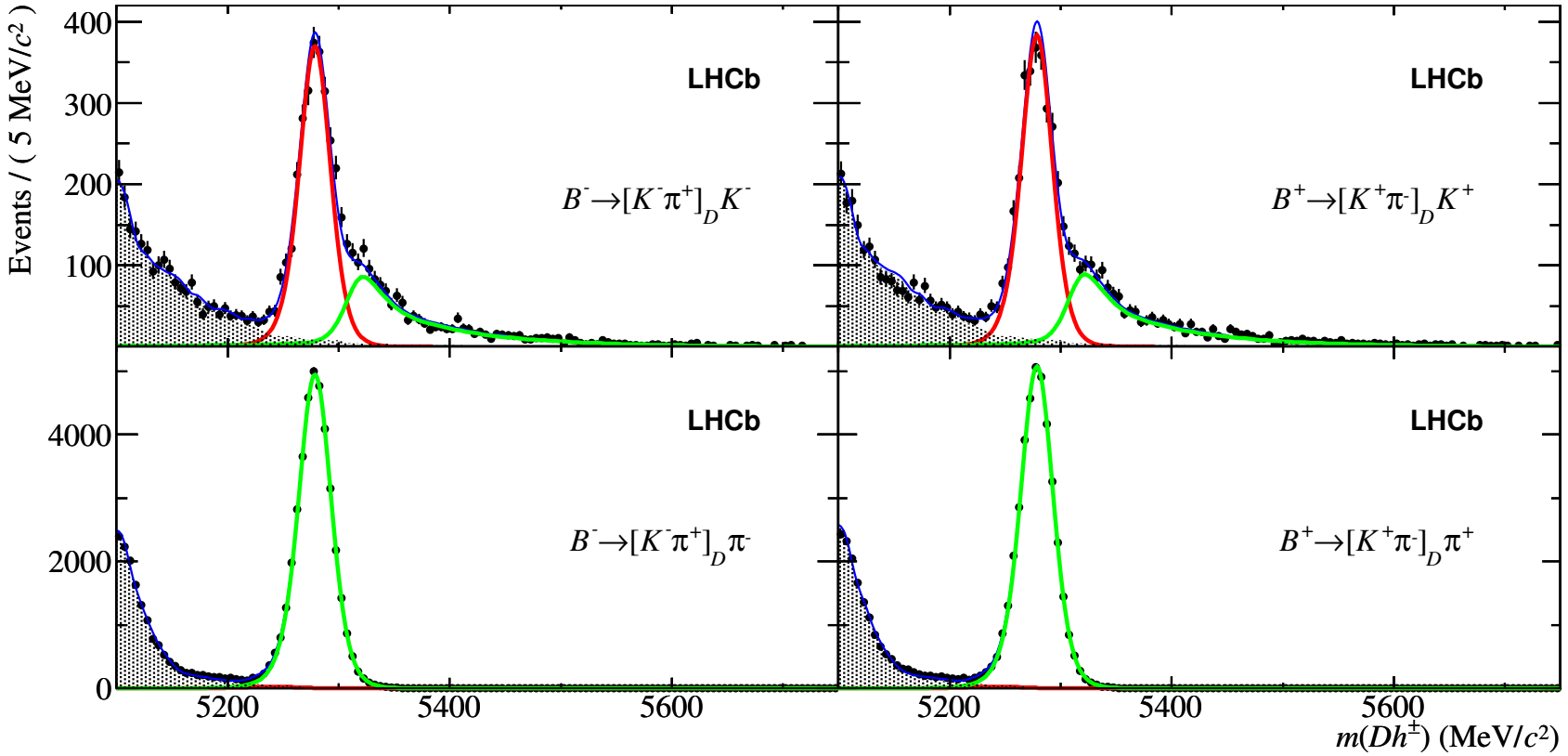


GLW/ADS [LHCB-PAPER-2012-001]

- Reconstruct all $B \to D(hh)h$ mass combinations ($h = \pi, K$).
- Multivariate selection designed to suppress combinatoric background.
- Simultaneous fit with 13 free parameters:
  - 3 partial width ratios: $R^f_{K/\pi} = \frac{\Gamma(B^+ \to D(f)K) + \Gamma(B^- \to D(f)K)}{\Gamma(B^+ \to D(f)\pi) + \Gamma(B^- \to D(f)\pi)}$
  - 6 CP asymmetries: $A^f_h = \frac{\Gamma(B^- \to D(f)h) - \Gamma(B^+ \to D(f)h)}{\Gamma(B^- \to D(f)h) + \Gamma(B^+ \to D(f)h)}$
  - 4 charge-separated ADS partial-width ratios: $R^\pm_h = \frac{\Gamma(B^\pm \to D(K^\mp\pi^\pm)h^\pm)}{\Gamma(B^\pm \to D(K^\pm\pi^\mp)h^\pm)}$

GLW/ADS [LHCB-PAPER-2012-001]

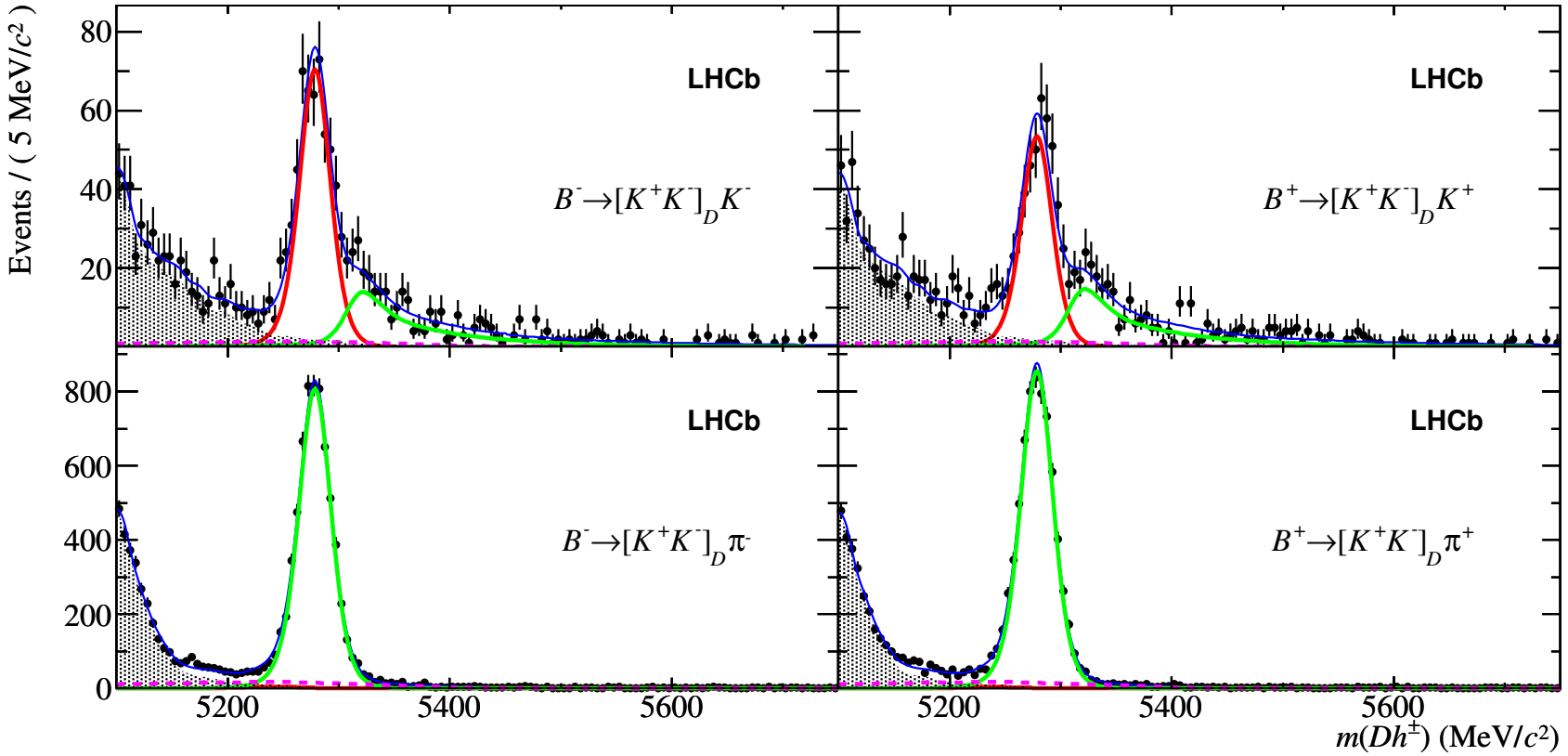
$D \to K\pi$(favored): $B \to D\pi$, $B \to DK$ $(\epsilon_{\rm PID}(K) = 87.6\%,\ \text{misID}(\pi) = 3.8\%)$



As expected, very little *CP* asymmetry in the favored modes.

GLW/ADS [LHCB-PAPER-2012-001]

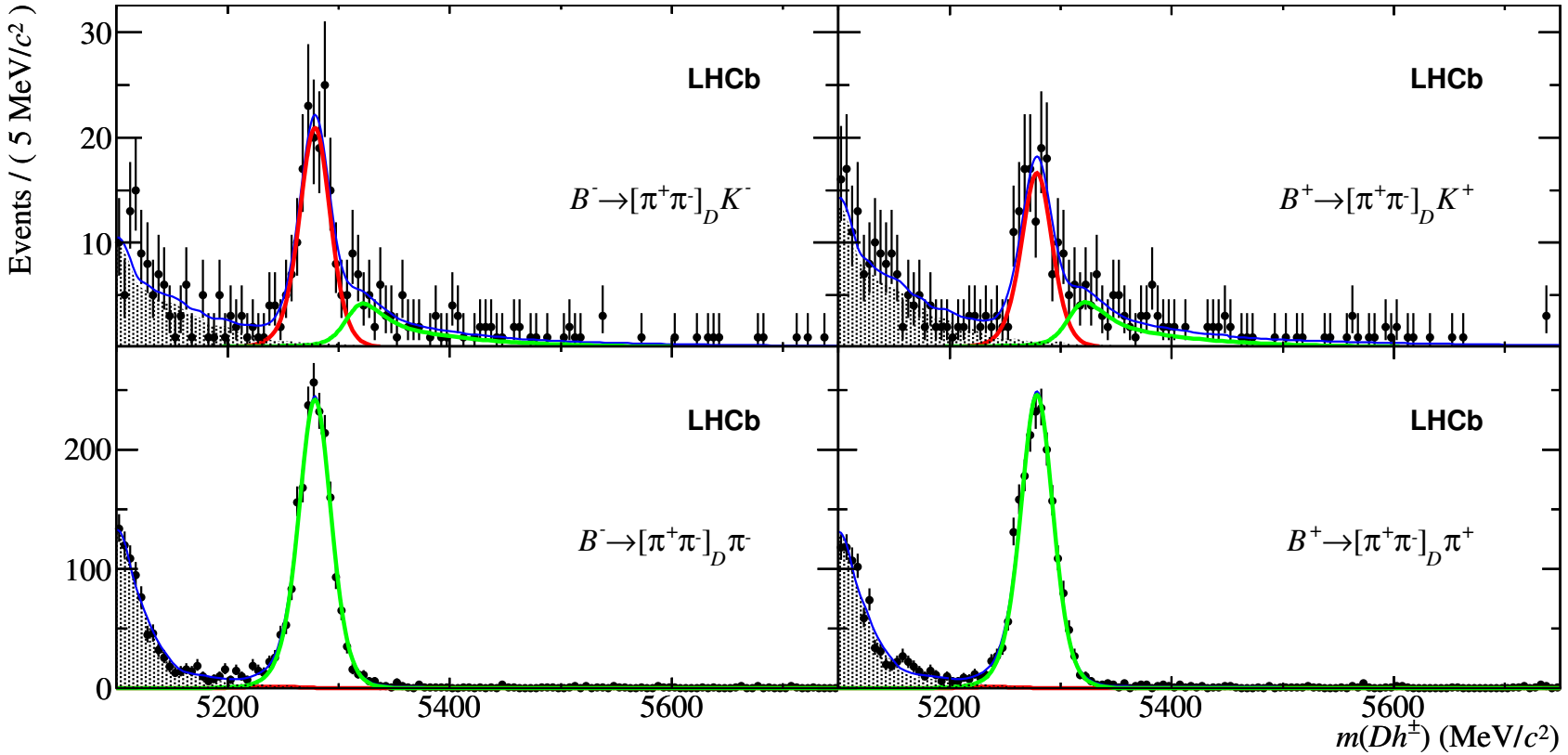
$D \to KK(CP+)$: $B \to D\pi$, $B \to DK$ $\left(\epsilon_{\rm PID}(K) = 87.6\%,\ \text{misID}(\pi) = 3.8\%\right)$



As expected, clear CP asymmetry in $B \to DK$ but not $B \to D\pi$.

GLW/ADS [LHCB-PAPER-2012-001]

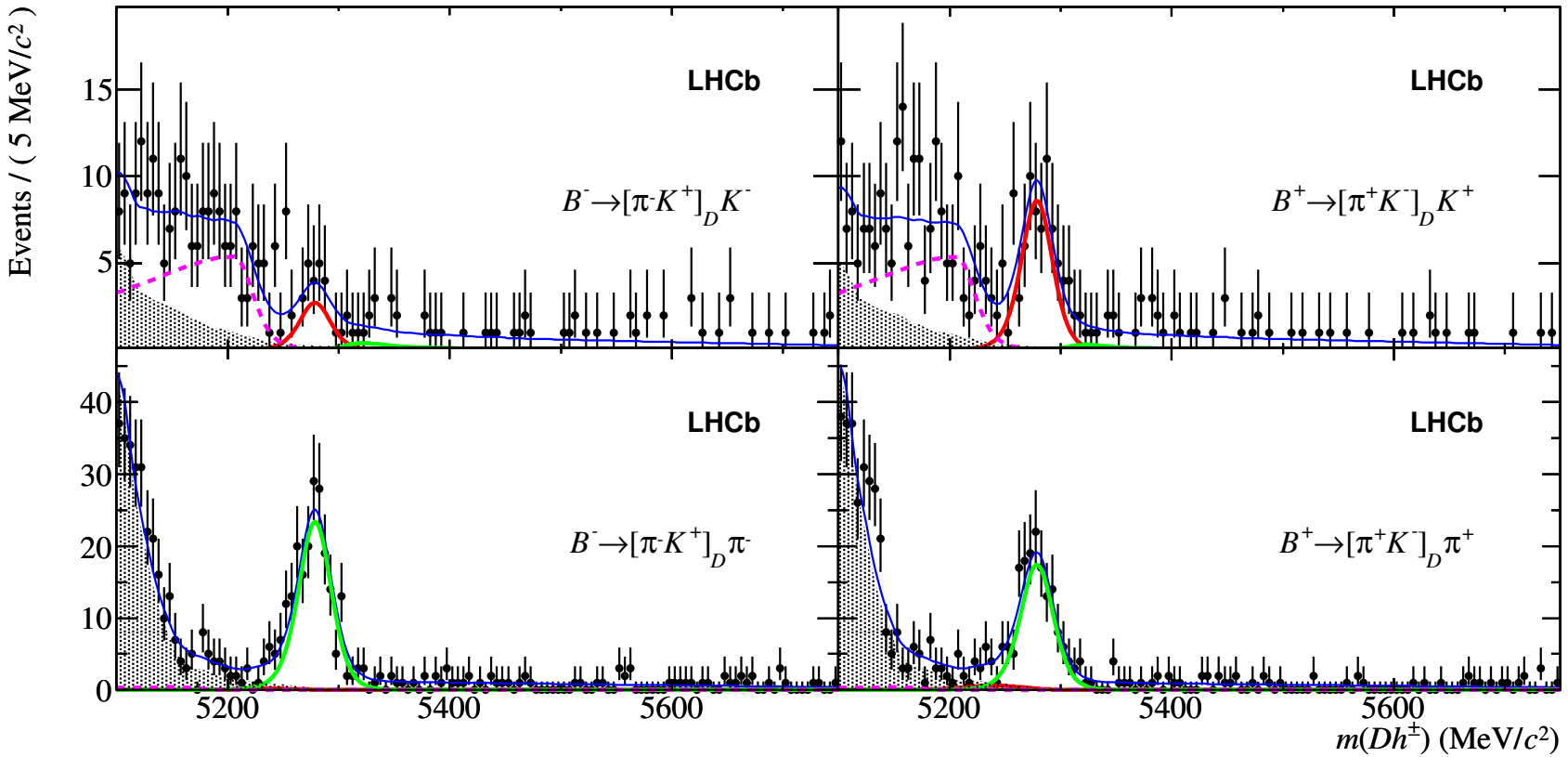
$D \to \pi\pi(CP+)$: $B \to D\pi$, $B \to DK$ $\left(\epsilon_{\rm PID}(K) = 87.6\%,\ \text{misID}(\pi) = 3.8\%\right)$



As expected, clear CP asymmetry in $B \to DK$ but not $B \to D\pi$.

GLW/ADS [LHCB-PAPER-2012-001]

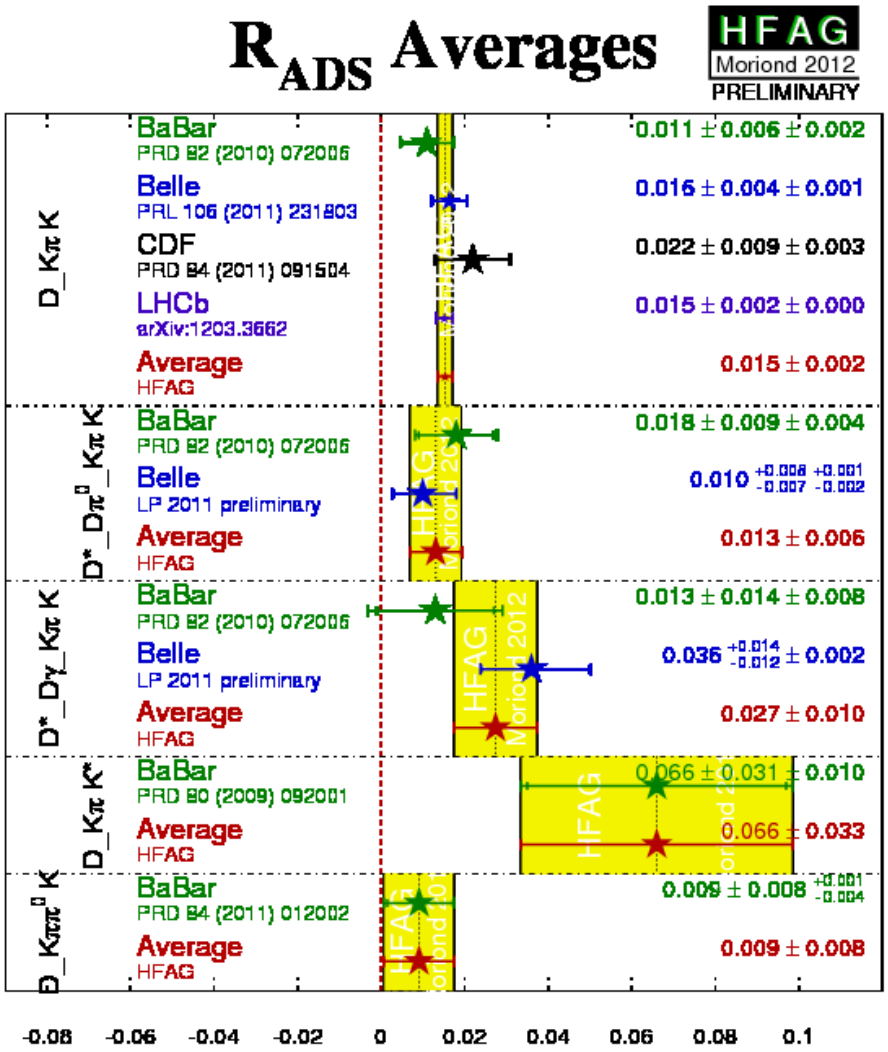
$D \to K\pi$(suppressed): $B \to D\pi$, $B \to DK$ $\left(\epsilon_{\rm PID}(K) = 87.6\%,\ \text{misID}(\pi) = 3.8\%\right)$

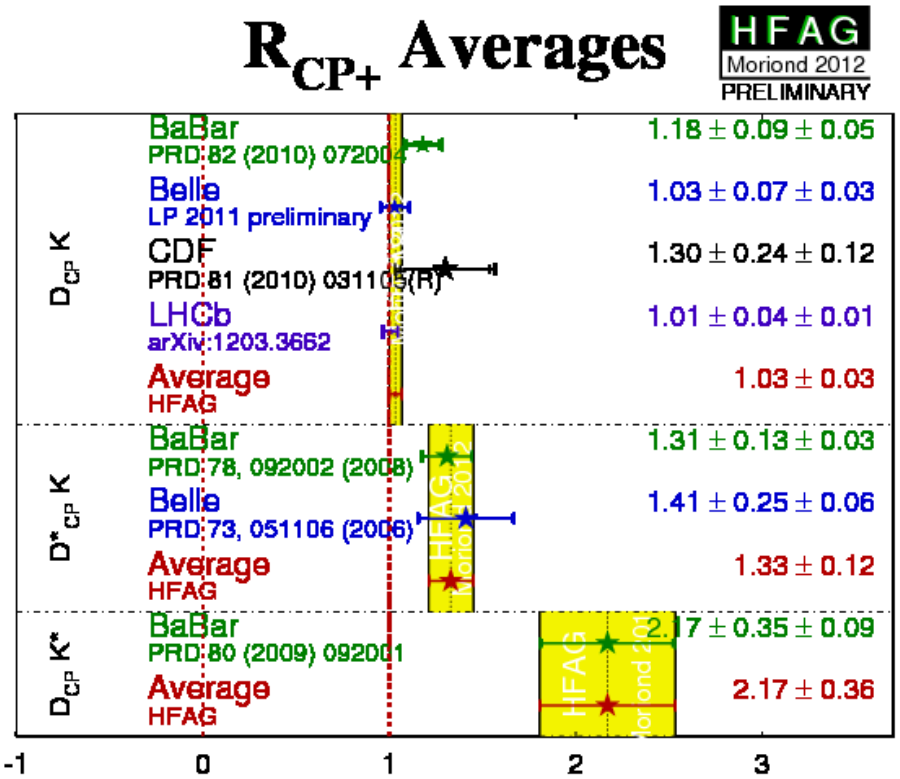


First observation of $B \to D(\text{sup})K$; hint of CPV in $B \to D(\text{sup})\pi$.

GLW/ADS

LHCb's results are by far the World's best.





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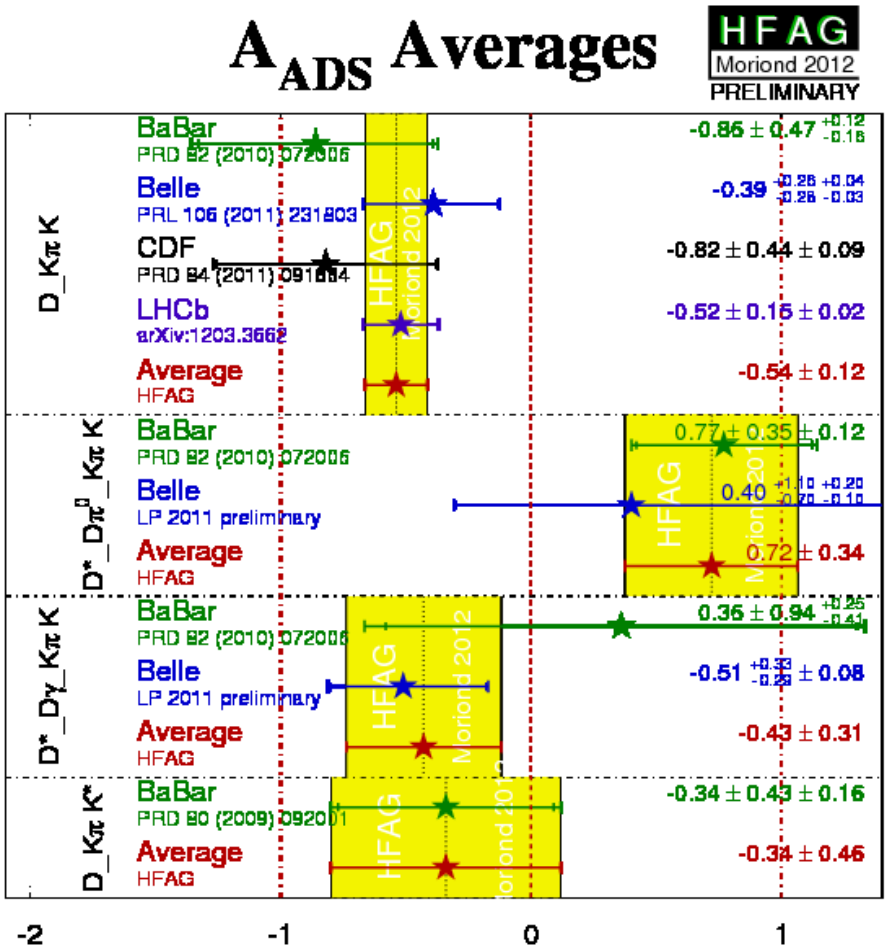
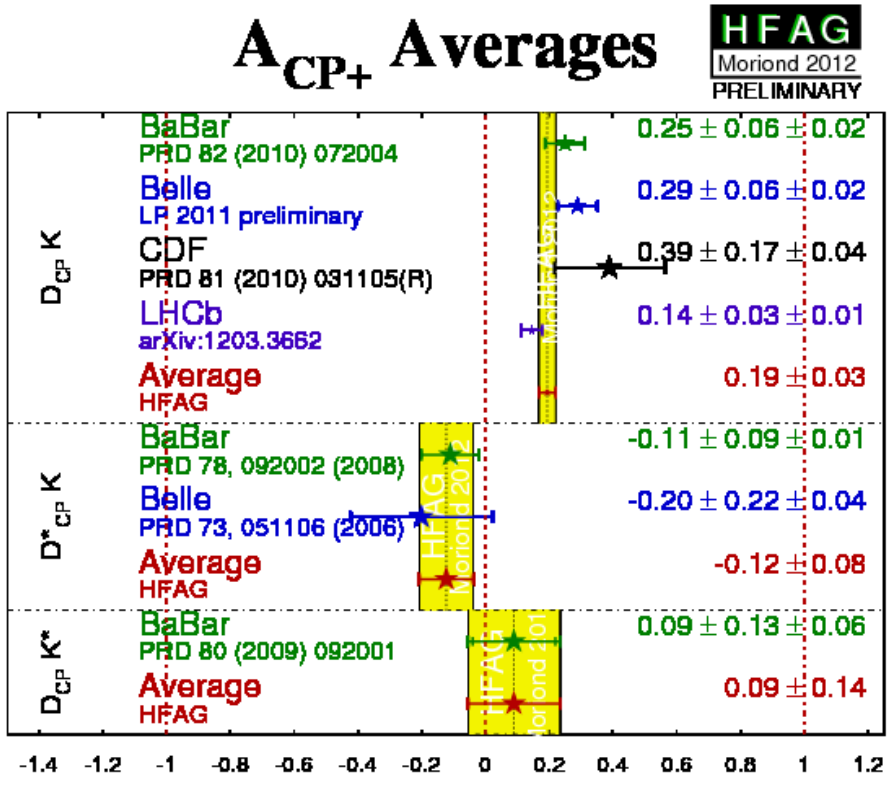
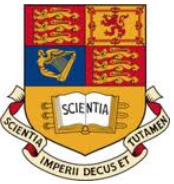




LHCb is on track to measure γ to better than 10° by the end of 2012.



$B \to DD'$ Decays

These decays are interesting for looking for physics beyond the SM:

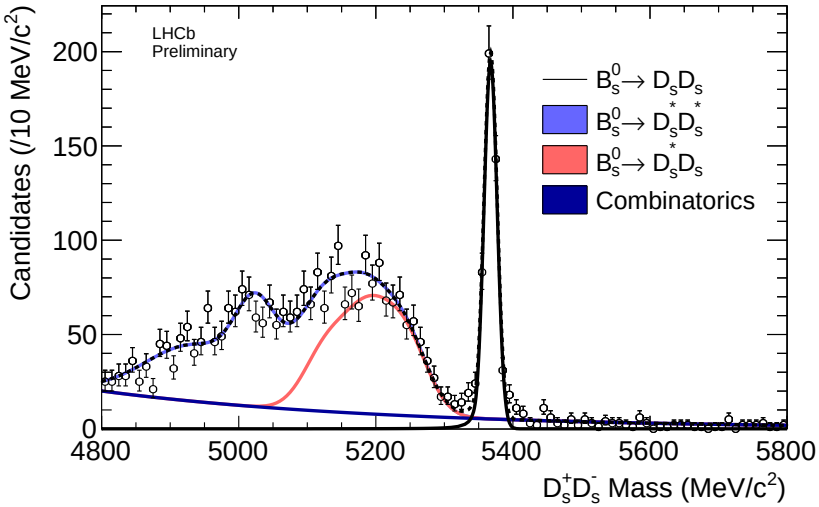
- ϕ_s from $B_s \to D_s D_s$
- $\sin 2\beta$ from $B_d \to DD$
- γ (assuming U-spin symmetry)

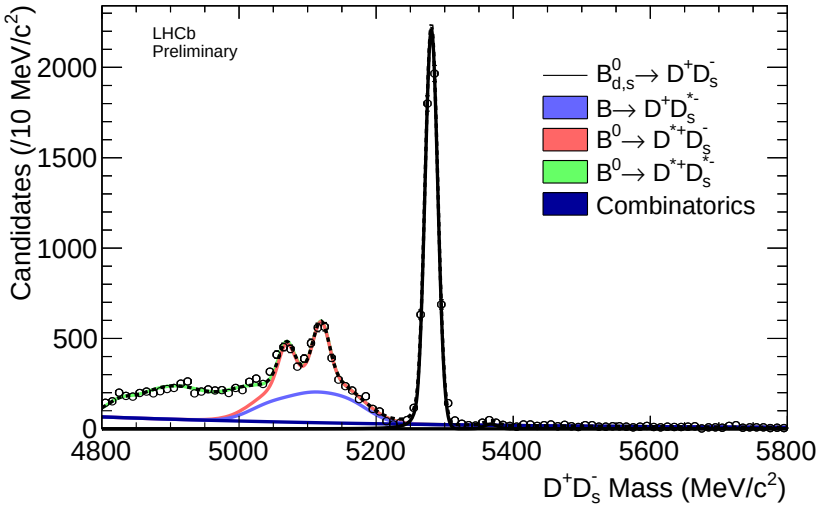
LHCb Analysis:

- Multi-variate BDT selections for D decays trained on $B_{u,d,s} \to D_{u,d,s}\pi$ data.
- Cross feeds suppressed using PID info and kinematics.
- Systematics largely cancel for modes normalized using the same final state. For different final states systematics still small.

$B_s \to D_s D_s / B_d \to D_s D$ [LHCb-CONF-2012-009]

$$\mathcal{B}(B_s \to D_s D_s)/\mathcal{B}(B_d \to D_s D) = 0.508 \pm 0.026(\text{stat}) \pm 0.043(\text{syst})$$

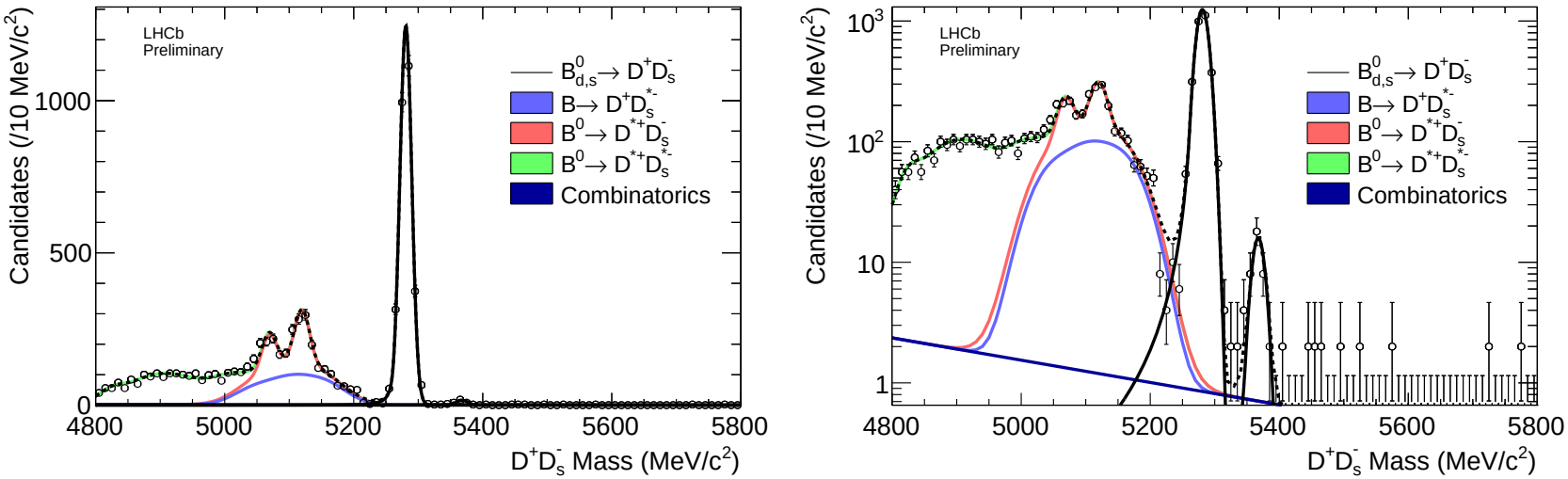




- PDG: $\mathcal{B}(B_s \to D_s D_s)/\mathcal{B}(B_d \to D_s D) = 1.44 \pm 0.44$.
- CDF (new at Lake Louise):
  $\mathcal{B}(B_s \to D_s D_s)/\mathcal{B}(B_d \to D_s D) = (0.183 \pm 0.021 \pm 0.017) \cdot (f_s/f_d)$
  $= 0.685 \pm 0.079 \pm 0.074$

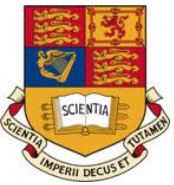
$B_s \to D_s D / B_d \to D_s D$ [LHCb-CONF-2012-009]

First observation of $B_s \to D_s D$ @ 10.1σ



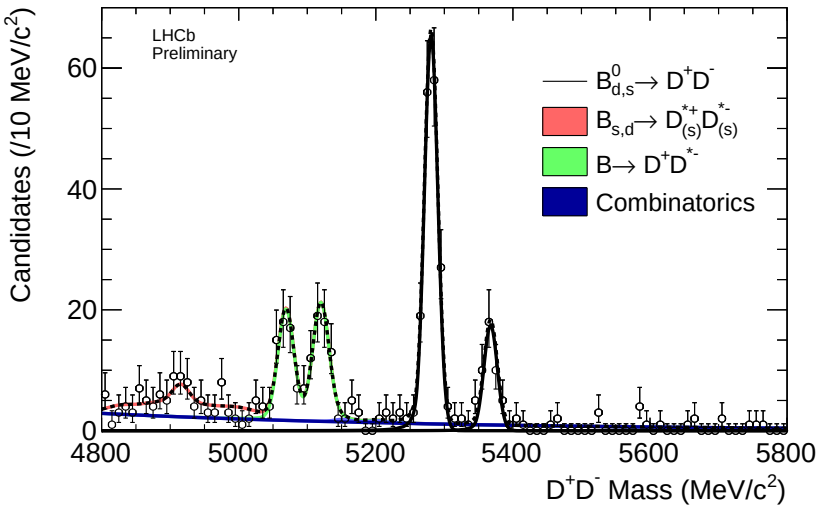
$$\mathcal{B}(B_s \to D_s D)/\mathcal{B}(B_d \to D_s D) = 0.048 \pm 0.008(\text{stat}) \pm 0.004(\text{syst})$$

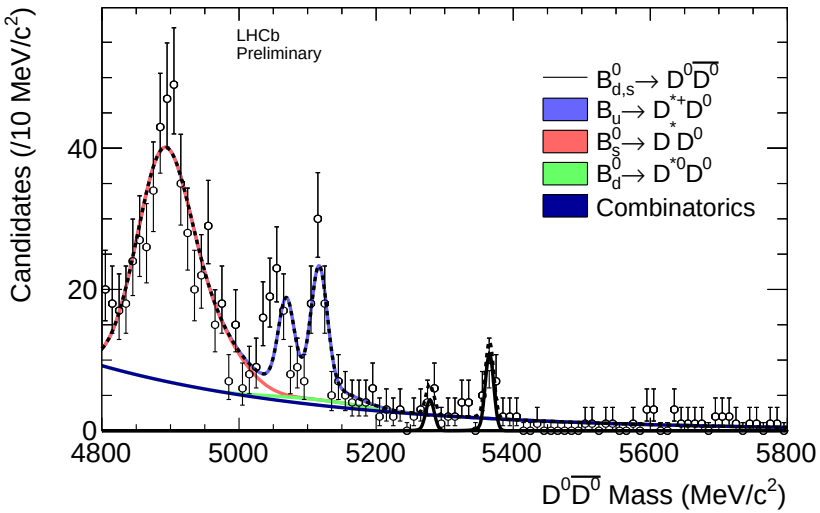
Expect: $\mathcal{B}(B_s \to D_s D)/\mathcal{B}(B_d \to D_s D) \approx \frac{|V_{cd}|^2}{|V_{cs}|^2} \sim 0.051$



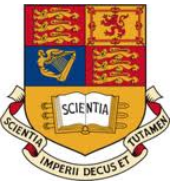
$B_s \to DD, B_s \to D^0\bar{D}^0$ [LHCb-CONF-2012-009]

First Observations of $B_s \to DD$ and $B_s \to D^0\bar{D}^0$





- $\mathcal{B}(B_s \to DD)/\mathcal{B}(B_d \to DD) = 1.00 \pm 0.18 \pm 0.09$ @ 10.7σ
- $\mathcal{B}(B_s \to D^0\bar{D}^0)/\mathcal{B}(B \to D^0 D_s) = 0.015 \pm 0.004 \pm 0.001$ @ 5.4σ
- $B_d \to D^0\bar{D}^0$ is 2.1σ



Summary

- LHCb performed great in 2011 and collected just over 1 fb^{-1} of data.
- Many more interesting B to open charm results using 2011 data will be ready for this summer.
- We expect to collect about 1.5 fb^{-1} in 2012. Thus, results produced using the full 2011+2012 data will have about 2.5$\times$ the stats of the results shown today.
- Stay tuned!