Bundesministerium
für Bildung
und Forschung

Results on direct CP Violation on B decays in LHCb

Till Moritz Karbach

Technische Universität Dortmund

on behalf of the LHCb collaboration

Moriond EW 2012

till.moritz.karbach@cern.ch

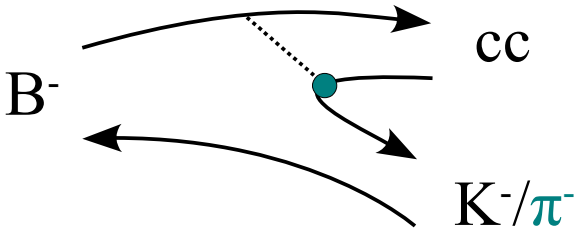
New measurements

CP asymmetry in $\mathbf{B \to \psi\pi}$	350 pb^{-1} **preliminary** LHCB-PAPER-2011-024 *to be submitted to Phys.Rev.X*
CP violation in $\mathbf{B \to K\pi}$	350 pb^{-1} arXiv:1202.6251 *submitted to Phys.Rev.Lett*
CP violation in $\mathbf{B \to DK}$	1.0 fb^{-1} (full 2011 data) **preliminary** LHCB-PAPER-2012-001 *to be submitted to Phys.Lett.B*

Till Moritz Karbach
technische universität dortmund

$B^- \to \psi h^-$

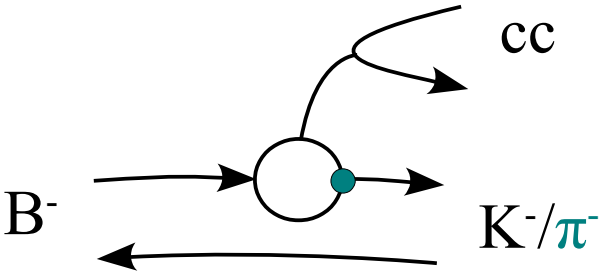
- **$B^- \to J/\psi\ K^-$**
  - abundant
  - Tree and Penguin have **same** weak phase → no CP violation expected, none found [PDG]



$V_{cb} V_{cs} \sim A\,\lambda^2$

$V_{cb} V_{cd} \sim A\,\lambda^3$

- **$B^- \to J/\psi\ \pi^-$**
  - Tree and Penguin have **different** weak phases, contribution may be $A_{CP} \sim 10^{-3}$
  - Decay is Cabibbo suppressed.



$V_{tb} V_{ts} \sim A\,\lambda^2$

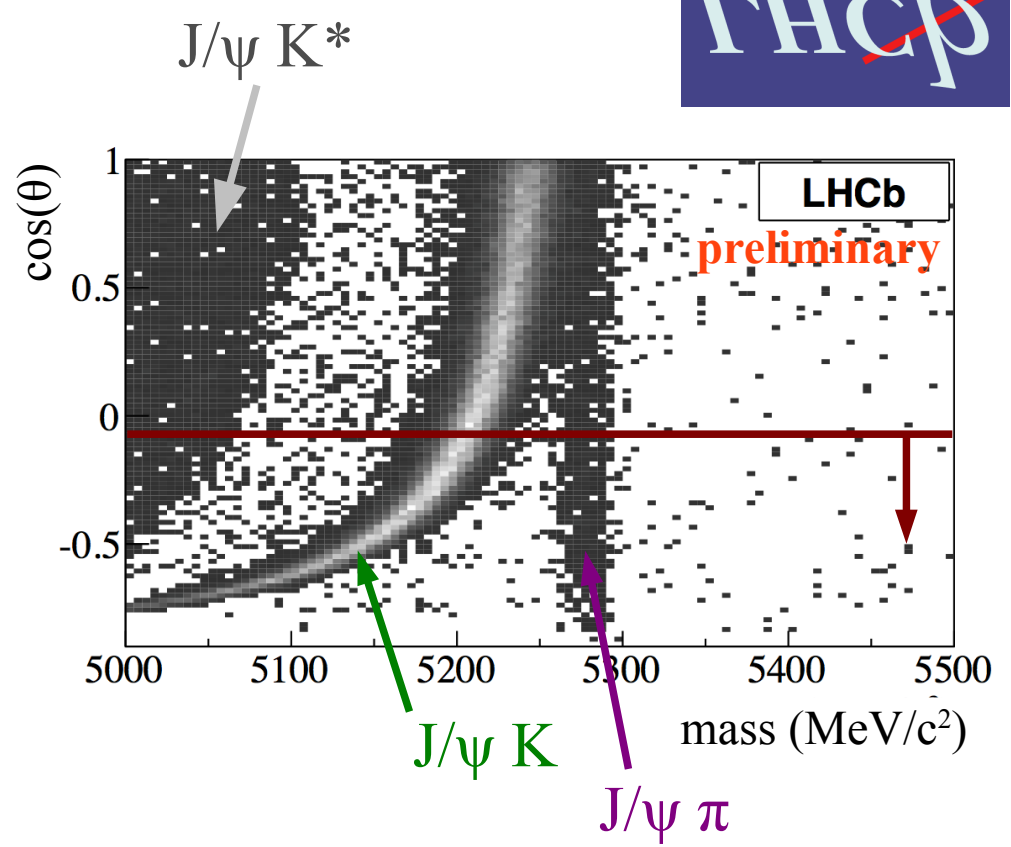
$V_{tb} V_{td} \sim A\,\lambda^3(1-\rho-i\eta)$

- **$B \to \psi(2S)\ K/\pi$**
  - less well explored

Till Moritz Karbach
technische universität dortmund

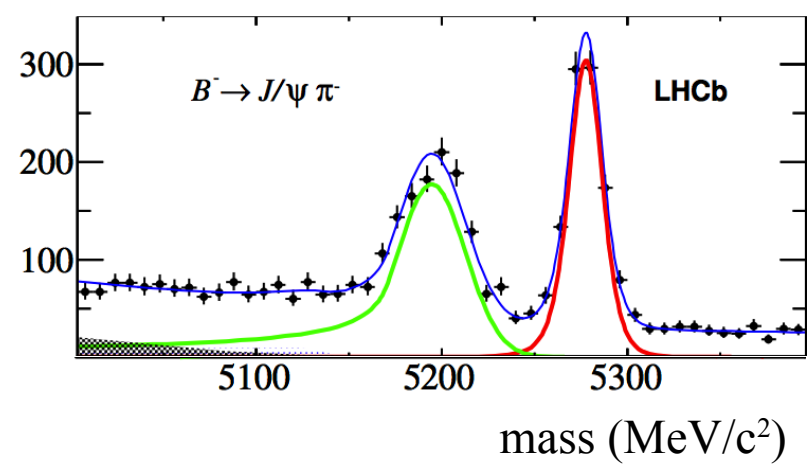
$B^- \to \psi h^-$

- Select ($\mu^+\mu^-h^-$) candidates
- Separate h = K, π by
  - helicity angle cos(θ)
  - RICH particle ID, split samples
- Simultaneous fit of 8 subsamples, extracting yields

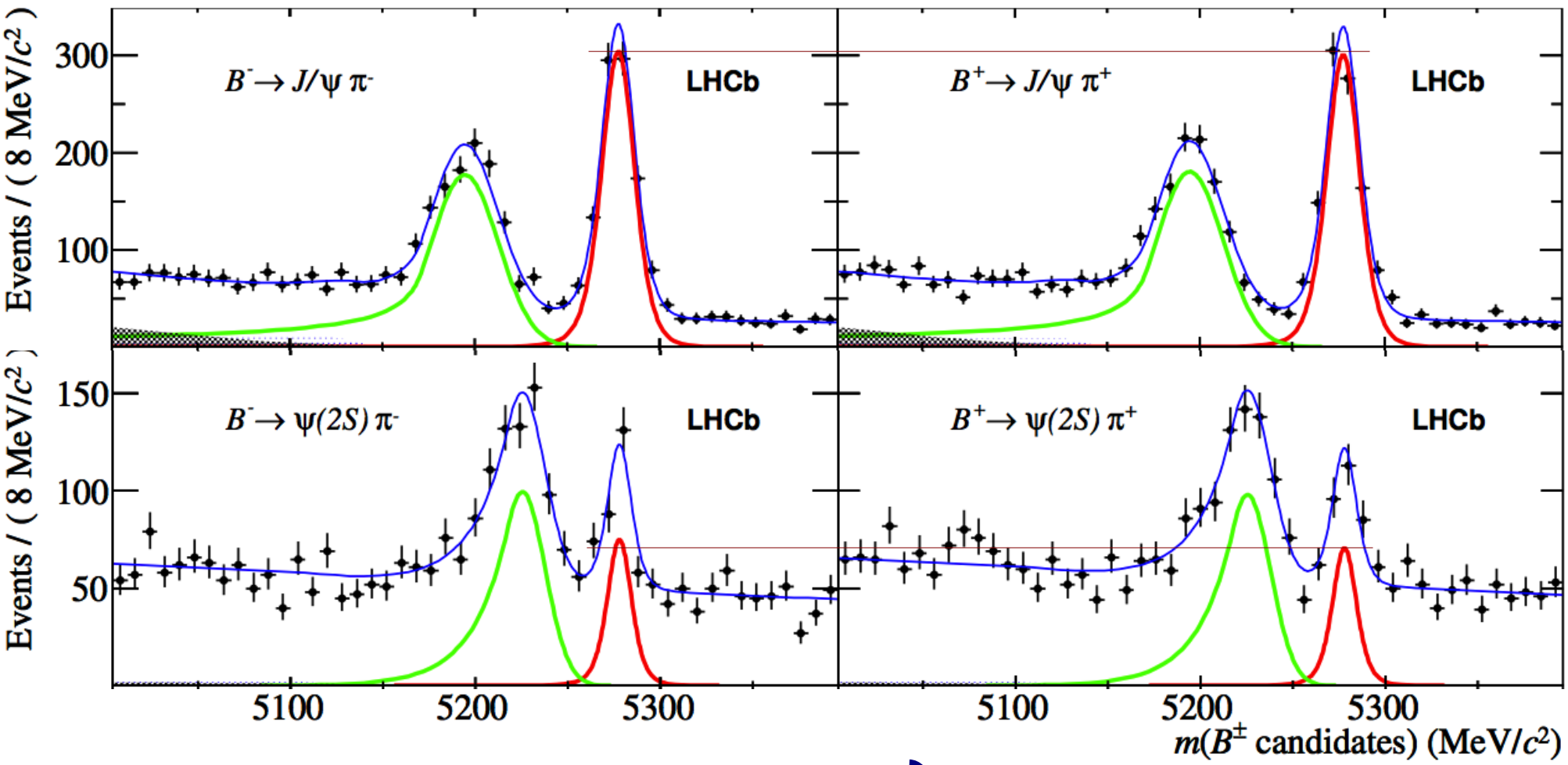


$$R_\psi = \frac{\mathcal{B}(B^\pm \to \psi\pi^\pm)}{\mathcal{B}(B^\pm \to \psi K^\pm)}$$

$$A_{CP}^{\psi\pi} = \frac{\mathcal{B}(B^- \to \psi\pi^-) - \mathcal{B}(B^+ \to \psi\pi^+)}{\mathcal{B}(B^- \to \psi\pi^-) + \mathcal{B}(B^+ \to \psi\pi^+)}$$



$B^- \to \psi h^-$



$$A_{CP}^{J/\psi\,\pi} = 0.005 \pm 0.027 \pm 0.011$$
$$A_{CP}^{\psi(2S)\pi} = 0.048 \pm 0.090 \pm 0.011$$
$$A_{CP}^{\psi(2S)K} = 0.024 \pm 0.014 \pm 0.008$$

No evidence of CP violation.

$B_{(d,s)} \rightarrow K^{-}\pi^{+}$

350 pb^{-1} @ 7 TeV

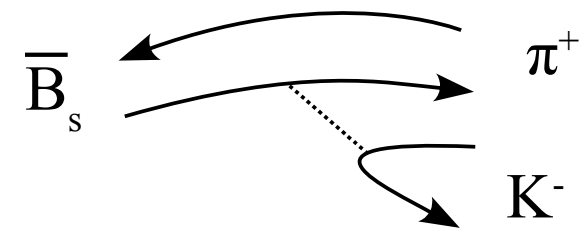
paper submitted to Phys.Rev.Lett.

arXiv:1202.6251

$B_{(d,s)} \to K^-\pi^+$

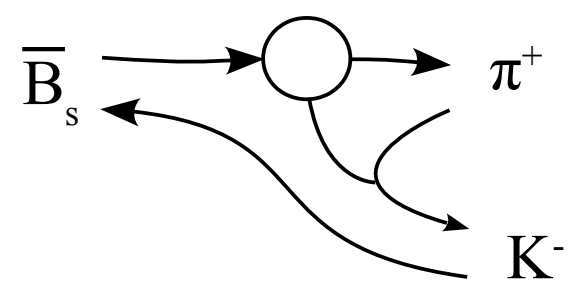
arXiv:1202.6251

- Interference of tree and loop diagrams.
- Potentially sensitive to new physics.
- CP asymmetry in $B_d \to K\pi$ is established.



$V_{ub} V_{cs} \sim A\lambda^3(\rho - i\eta)$

- Consider B_s system!
  - 14 times lower decay rate, 4 times lower production rate



$V_{tb} V_{td} \sim A\lambda^3(1 - \rho - i\eta)$

$$A_{CP} = \frac{N(K^+\pi^-) - N(K^-\pi^+)}{N(K^+\pi^-) + N(K^-\pi^+)}$$

$B_{(d,s)} \to K^-\pi^+$

arXiv:1202.6251

- Use RICH **particle ID** to define the charge subsamples.
  - carefully control the PID efficiencies and mis-ID rate from data: large calibration samples of $D^* \to D\pi \to (K\pi)\pi$ and $\Lambda \to p\pi$ decays
- Use MC to predict **crossfeed** from $B \to \pi\pi$ and $B \to KK$
- Fits to the mass spectra to extract raw asymmetries:

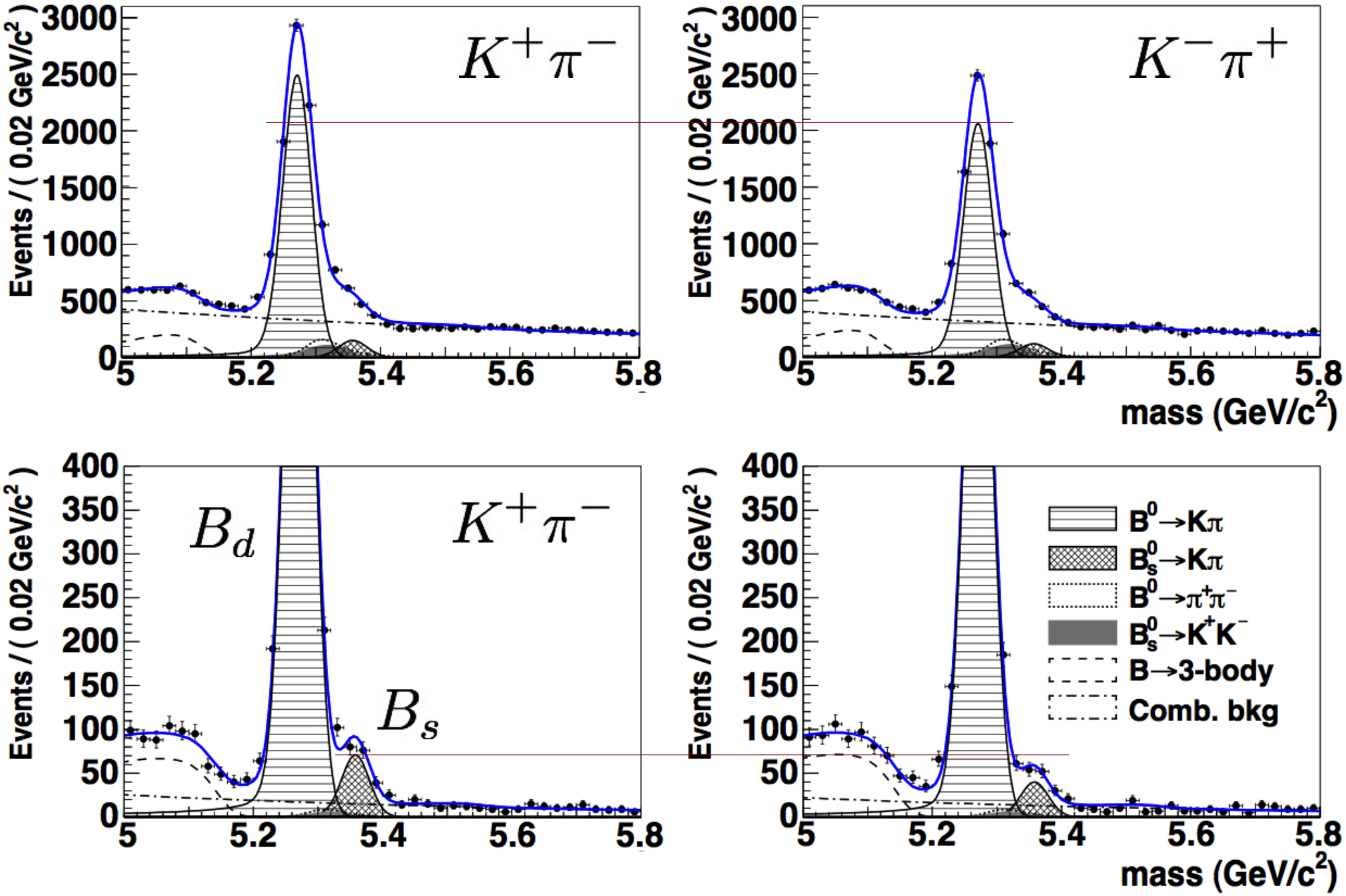
$$A_{\rm raw}(B^0 \to K\pi) = -0.095 \pm 0.011$$

$$A_{\rm raw}(B_s^0 \to K\pi) = \underline{0.28 \pm 0.08}$$

Till Moritz Karbach
technische universität dortmund

$B_{(d,s)} \rightarrow K^-\pi^+$

arXiv:1202.6251



$B_{(d,s)} \to K^-\pi^+$

arXiv:1202.6251

- Corrections:

$$A_{CP} = A_{\text{raw}} \pm A_D(K\pi) - \underbrace{\kappa_{d(s)}}_{\text{mixing}} A_P(B^0_{(s)})$$

- detector asymmetry (from D* samples): $A_D = -0.010 \pm 0.002$
- dilution due to B mixing: $\kappa_d = 0.303 \pm 0.005$, $\kappa_s = -0.033 \pm 0.003$
- production asymmetry: $A_P(B^0) = 0.010 \pm 0013$
  from $A_{\text{raw}}(B^0 \to J/\psi K^{*0})$
- **total corrections:** $\Delta A_{CP}(B^0) = -0.007 \pm 0.006$
  $\Delta A_{CP}(B_s) = 0.010 \pm 0.002$ (= - A_D)

$B_{(d,s)} \to K^-\pi^+$

arXiv:1202.6251

Systematic uncertainty	$A_{CP}(B^0 \to K\pi)$	$A_{CP}(B_s^0 \to K\pi)$
[a] PID calibration	0.0012	0.001
[b] Final state radiation	0.0026	0.010
[b] Signal model	0.0004	0.005
[b] Combinatorial background	0.0001	0.009
[b] 3-body background	0.0009	0.007
[b] Cross-feed background	0.0011	0.008
[c] Instr. and prod. asym. (A_Δ)	0.0078	0.005
Total	0.0084	0.019

Result

$$A_{CP}(B^0 \to K\pi) = -0.088 \pm 0.011\,(\text{stat}) \pm 0.008\,(\text{syst})$$

Good agreement with WA.

Most precise!

$$A_{CP}(B_s^0 \to K\pi) = 0.27 \pm 0.08\,(\text{stat}) \pm 0.02\,(\text{syst})$$

First evidence of CPV in last neutral meson system!

3σ

$B \rightarrow DK$

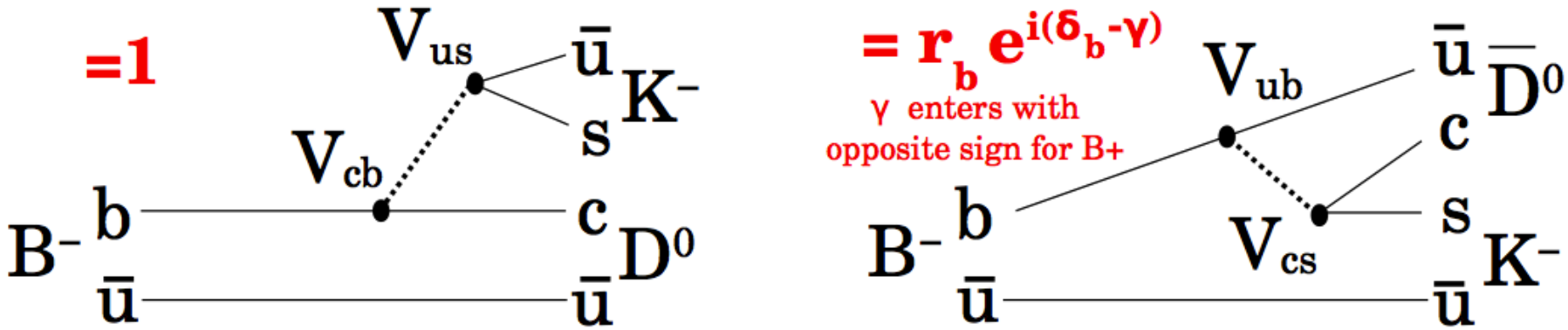
1.0 fb^{-1} @ 7 TeV

paper to be submitted to PLB

LHCB-PAPER-2012-001

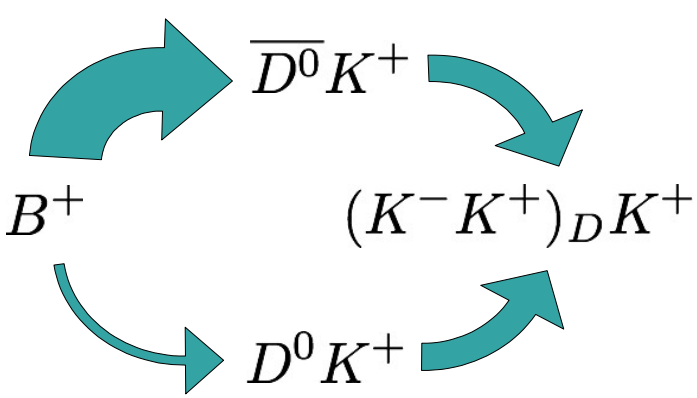
B → DK

- Standard mode to measure weak phase γ.



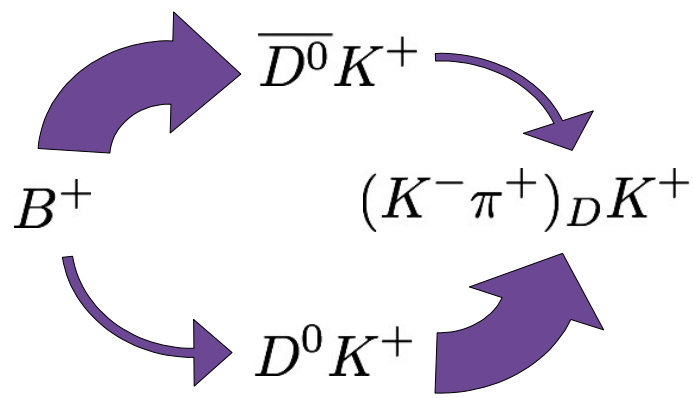
- Tree decays, theoretically clean.

"GLW"



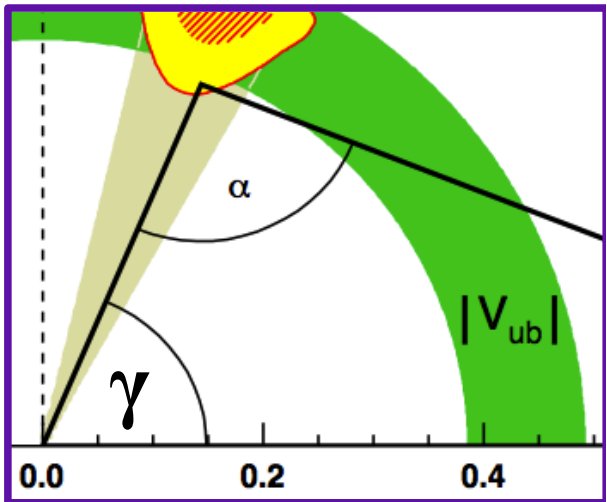
Phys.Lett. B253 (1991) 483
Phys.Lett. B265 (1991) 172

"ADS", "suppressed"



Phys.Rev.Lett 78 (1997) 3257
Phys.Rev. D63 (2001) 036005

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



$B \to DK$: Observables

- Define observables as yield ratios (some systematics cancel).
- Charge **asymmetries**:

$$A_h^f = \frac{\Gamma(B^- \to [f]_D h^-) - \Gamma(B^+ \to [f]_D h^+)}{\Gamma(B^- \to [f]_D h^-) + \Gamma(B^+ \to [f]_D h^+)}$$

final states $[f]_D$:
KK, ππ
Kπ, πK

- Charge averaged **Kaon/pion** ratio:

$$R_{K/\pi}^f = \frac{\Gamma(B^\pm \to [f]_D K^\pm)}{\Gamma(B^\pm \to [f]_D \pi^\pm)}$$

- **Suppressed/favored** decay ratio:

13 observables

$$R_h^\pm = \frac{\Gamma(B^\pm \to [\pi^\pm K^\mp]_D h^\pm)}{\Gamma(B^\pm \to [K^\pm \pi^\mp]_D h^\pm)}$$
$$= r_B^2 + r_D^2 + 2 r_B r_D \cos(\pm\gamma + \underbrace{\delta_B + \delta_D}_{\text{strong phase diff.}})$$

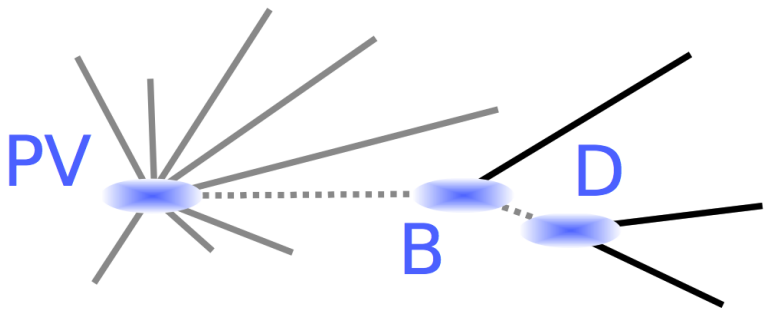
B → DK: Analysis method

- Most backgrounds are combinatorial

  multivariate analysis (BDT) with 20 variables

- Charmless backgrounds

  exploit large forward boost of the D



cut on D flight distance

- Simultaneous fit on 16 slices

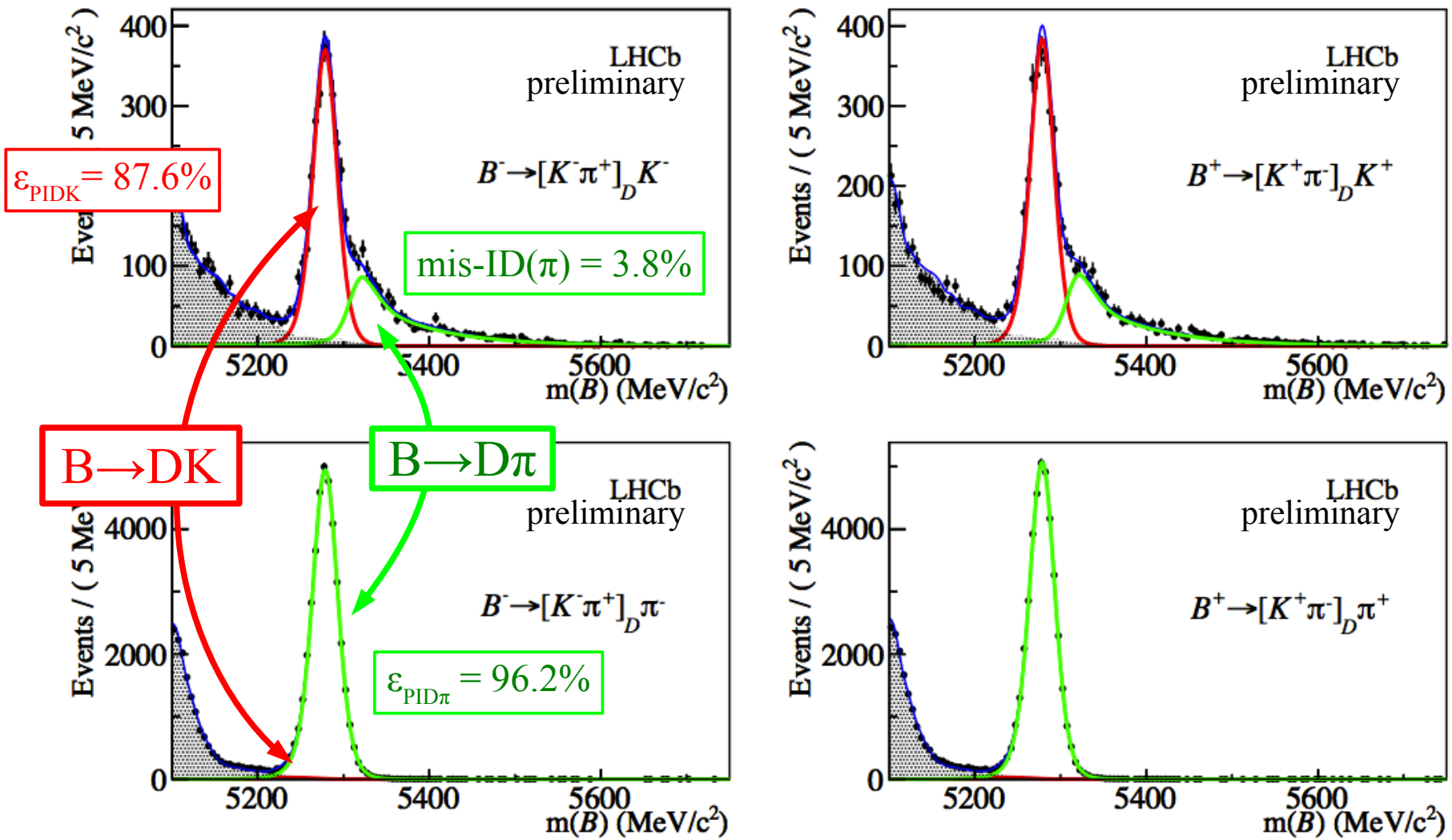
  2 (charges) x 4 (D modes) x 2 (K/π)

- Dominant systematics

  intrinsic charge asymmetries (A_{CP})

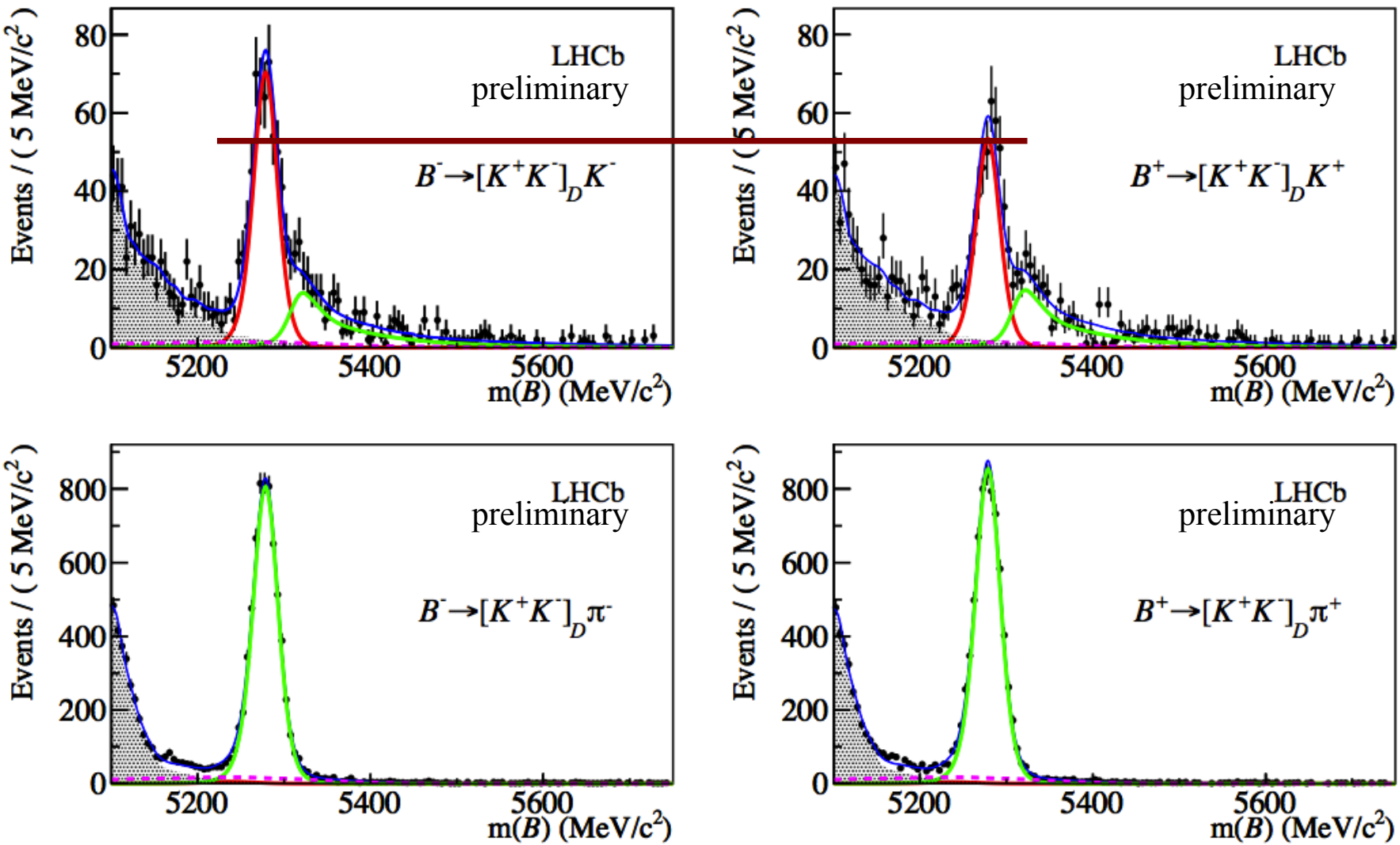
  particle ID ($R_{K\pi}$)

B → DK: favored ADS mode



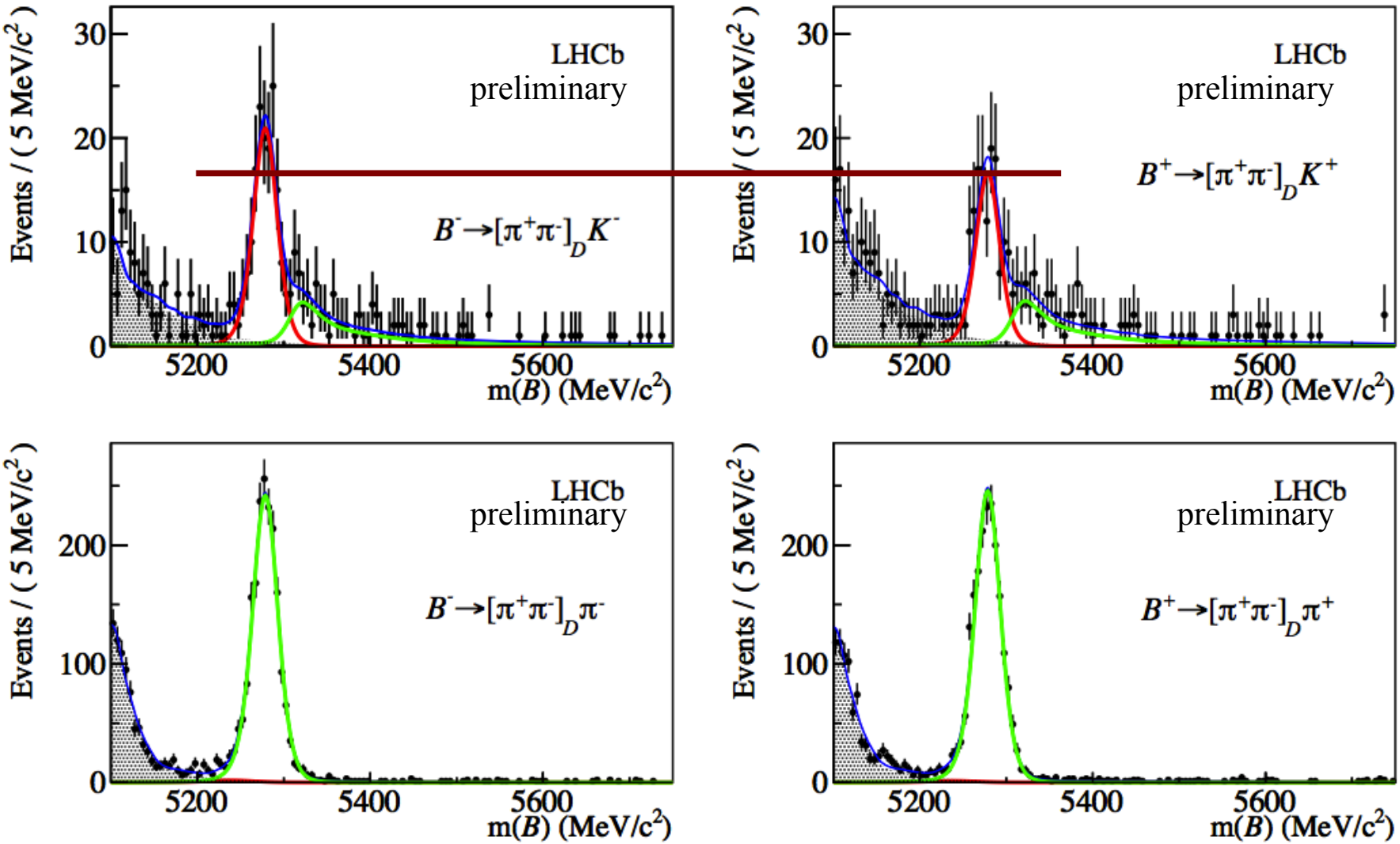
LHCB-PAPER-2012-001

B → DK: GLW CP+ mode



LHCB-PAPER-2012-001

B → DK: GLW CP+ mode (II)

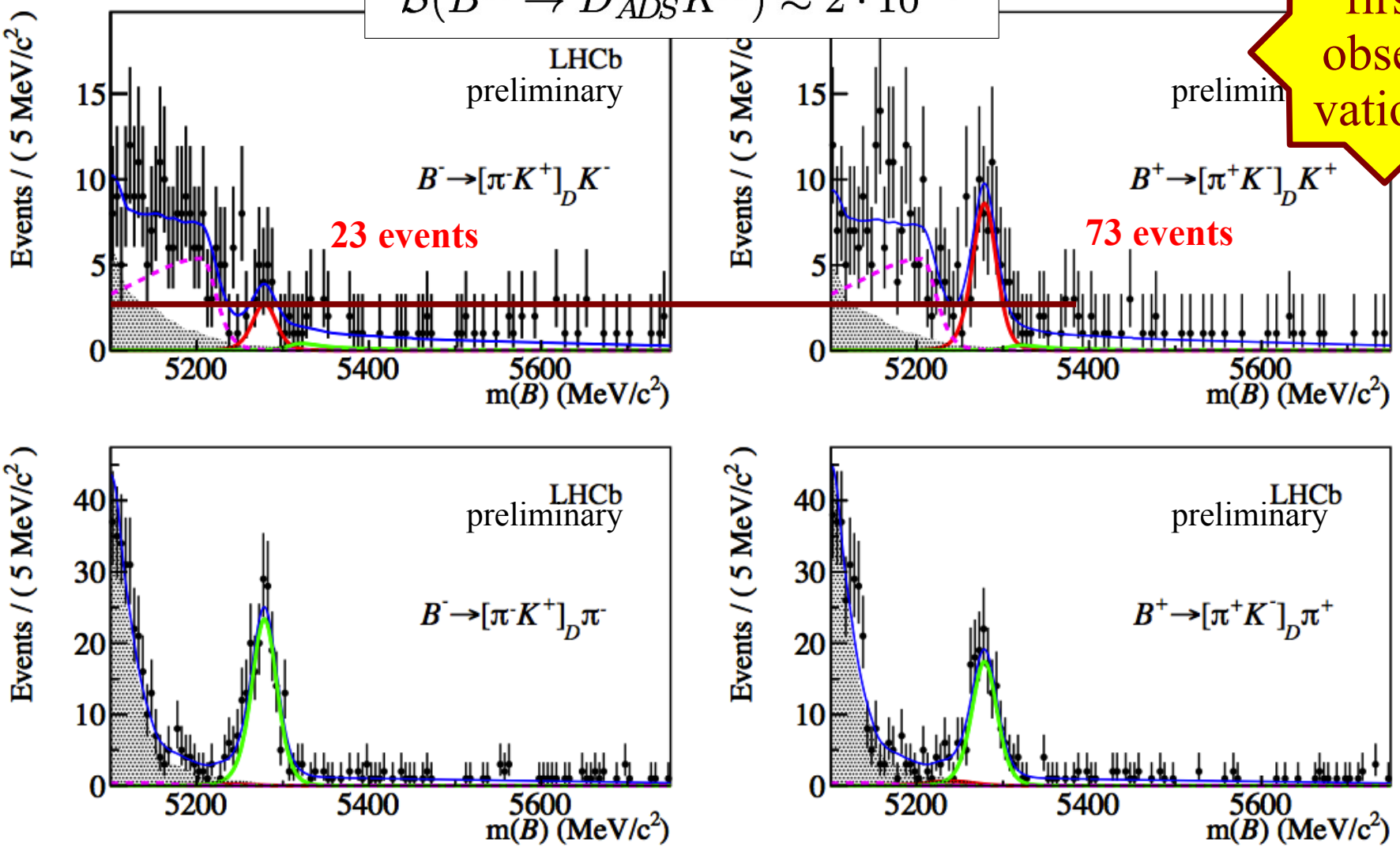


LHCB-PAPER-2012-001

B → DK: suppressed ADS mode

$$\mathcal{B}(B^{\pm} \to D_{ADS} K^{\pm}) \approx 2 \cdot 10^{-7}$$

first obser-vation!



LHCB-PAPER-2012-001

$B \to DK$: Results

LHCB-PAPER-2012-001
preliminary

$$
\begin{aligned}
R^{K\pi}_{K/\pi} &= 0.0774 \pm 0.0012 \pm 0.0018 \\
R^{KK}_{K/\pi} &= 0.0773 \pm 0.0030 \pm 0.0018 \\
R^{\pi\pi}_{K/\pi} &= 0.0803 \pm 0.0056 \pm 0.0017 \\
A^{K\pi}_{\pi} &= -0.0001 \pm 0.0036 \pm 0.0095 \\
A^{K\pi}_{K} &= 0.0044 \pm 0.0144 \pm 0.0174 \\
A^{KK}_{K} &= 0.1480 \pm 0.0369 \pm 0.0097 \\
A^{\pi\pi}_{K} &= 0.1351 \pm 0.0661 \pm 0.0095 \\
A^{KK}_{\pi} &= -0.0199 \pm 0.0091 \pm 0.0116 \\
A^{\pi\pi}_{\pi} &= -0.0009 \pm 0.0165 \pm 0.0099 \\
R^{-}_{K} &= 0.0073 \pm 0.0023 \pm 0.0004 \\
R^{+}_{K} &= 0.0232 \pm 0.0034 \pm 0.0007 \\
R^{-}_{\pi} &= 0.00469 \pm 0.00038 \pm 0.00008 \\
R^{+}_{\pi} &= 0.00352 \pm 0.00033 \pm 0.00007
\end{aligned}
$$

Till Moritz Karbach
technische universität
dortmund

B → DK: Results

LHCB-PAPER-2012-001
preliminary

$$R^{K\pi}_{K/\pi} = 0.0774 \pm 0.0012 \pm 0.0018$$
$$R^{KK}_{K/\pi} = 0.0773 \pm 0.0030 \pm 0.0018$$
$$R^{\pi\pi}_{K/\pi} = 0.0803 \pm 0.0056 \pm 0.0017$$

$$A^{K\pi}_{\pi} = -0.0001 \pm 0.0036 \pm 0.0095$$
$$A^{K\pi}_{K} = 0.0044 \pm 0.0144 \pm$$
$$A^{KK}_{K} = 0.1480 \pm 0.0369 \pm 0.0097$$
$$A^{\pi\pi}_{K} = 0.1351 \pm 0.0661 \pm 0.0095$$
$$A^{KK}_{\pi} = -0.0199 \pm 0.0091 \pm 0.0116$$
$$A^{\pi\pi}_{\pi} = -0.0009 \pm 0.0165 \pm 0.0099$$
$$R^{-}_{K} = 0.0073 \pm 0.0023 \pm 0.0004$$
$$R^{+}_{K} = 0.0232 \pm 0.0034 \pm 0.0007$$
$$R^{-}_{\pi} = 0.00469 \pm 0.00038 \pm 0.00008$$
$$R^{+}_{\pi} = 0.00352 \pm 0.00033 \pm 0.00007$$

$$R_{CP+} \approx < R^{\pi\pi}_{K/\pi}, R^{KK}_{K/\pi} > / R^{K\pi}_{K/\pi}$$
$$= 1.007 \pm 0.038 \pm 0.012$$

The GLW charge-averaged ratio, D(CP) over D(flavor).

Till Moritz Karbach
technische universität dortmund

B → DK: Results

LHCB-PAPER-2012-001
preliminary

$$R^{K\pi}_{K/\pi} = 0.0774 \pm 0.0012 \pm 0.0018$$
$$R^{KK}_{K/\pi} = 0.0773 \pm 0.0030 \pm 0.0018$$
$$R^{\pi\pi}_{K/\pi} = 0.0803 \pm 0.0056 \pm 0.0017$$
$$A^{K\pi}_{\pi} = -0.0001 \pm 0.0036 \pm 0.0095$$
$$A^{K\pi}_{K} = 0.0044 \pm 0.0144 \pm 0.0174$$
$$A^{KK}_{K} = 0.1480 \pm 0.0369 \pm 0.0097$$
$$A^{\pi\pi}_{K} = 0.1351 \pm 0.0661 \pm 0.0095$$
$$A^{KK}_{\pi} = -0.0199 \pm 0.0091 \pm 0.0116$$
$$A^{\pi\pi}_{\pi} = -0.0009 \pm 0.0165 \pm 0.$$
$$R^{-}_{K} = 0.0073 \pm 0.0023 \pm 0.$$
$$R^{+}_{K} = 0.0232 \pm 0.0034 \pm 0.0007$$
$$R^{-}_{\pi} = 0.00469 \pm 0.00038 \pm 0.00008$$
$$R^{+}_{\pi} = 0.00352 \pm 0.00033 \pm 0.00007$$

The GLW
charge asymmetry

$$A_{CP+} \approx < A^{\pi\pi}_{K/\pi}, A^{KK}_{K/\pi} >$$
$$= 0.145 \pm 0.032 \pm 0.010$$

4.5σ

Till Moritz Karbach
technische universität
dortmund

B → DK: Results

LHCB-PAPER-2012-001
preliminary

$$R^{K\pi}_{K/\pi} = 0.0774 \pm 0.0012 \pm 0.0018$$
$$R^{KK}_{K/\pi} = 0.0773 \pm 0.0020 \pm 0.0018$$
$$R^{\pi\pi}_{K/\pi} = 0.0803 \pm 0.$$
$$A^{K\pi}_{\pi} = -0.0001 \pm 0.$$
$$A^{K\pi}_{K} = 0.0044 \pm 0.$$
$$A^{KK}_{K} = 0.1480 \pm 0.$$
$$A^{\pi\pi}_{K} = 0.1351 \pm 0.0661 \pm 0.0095$$
$$A^{KK}_{\pi} = -0.0199 \pm 0.0091 \pm 0.0116$$
$$A^{\pi\pi}_{\pi} = -0.0009 \pm 0.0165 \pm 0.0099$$

$$R_{ADS(K)} = 0.0152 \pm 0.0020 \pm 0.0004$$ 10σ

$$A_{ADS(K)} = -0.520 \pm 0.150 \pm 0.021$$ 4σ

$$R_{ADS(\pi)} = 0.00410 \pm 0.00025 \pm 0.00005$$

$$A_{ADS(\pi)} = 0.143 \pm 0.062 \pm 0.011$$ 2.4σ

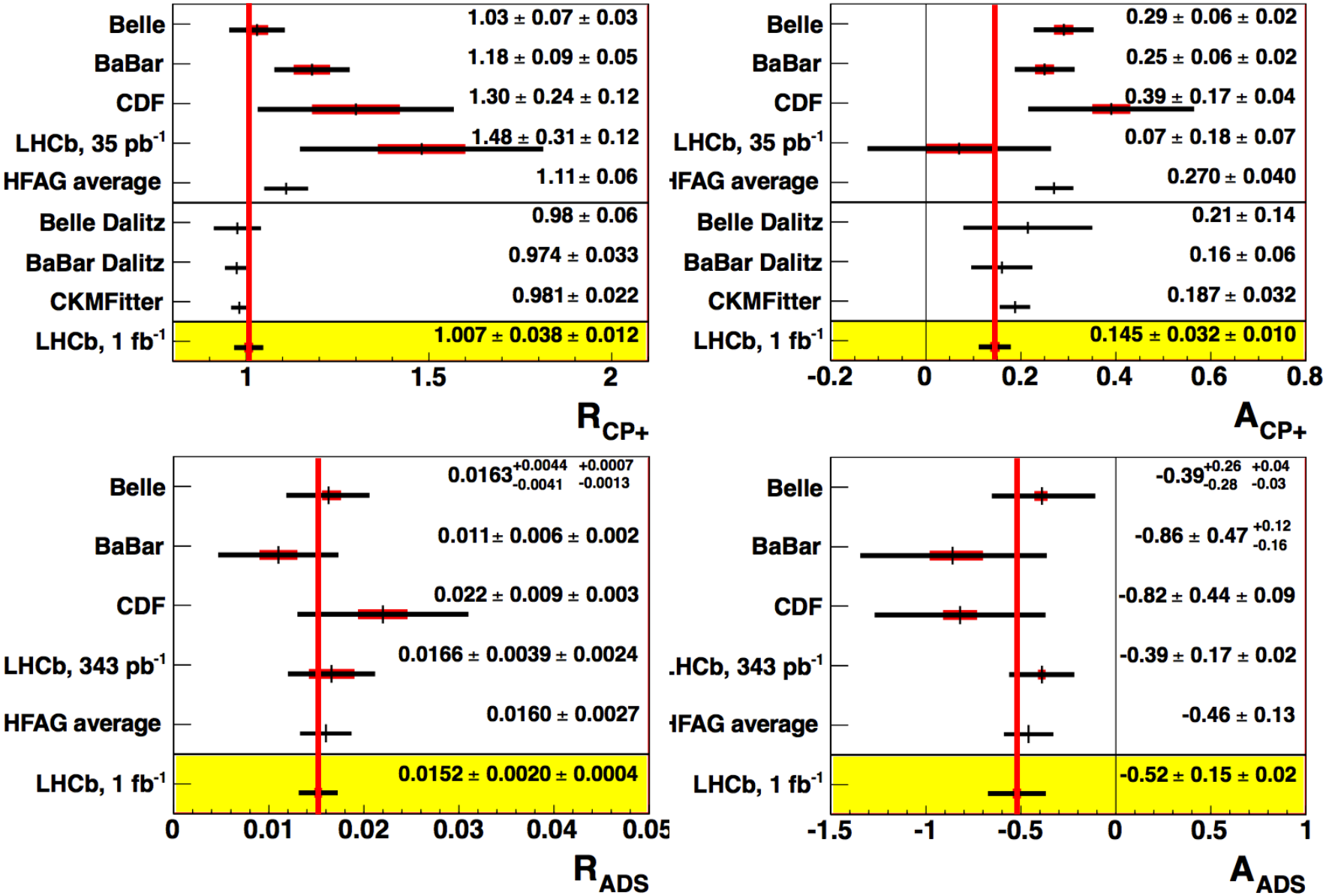
$$R^{-}_{K} = 0.0073 \pm 0.0023 \pm 0.0004$$
$$R^{+}_{K} = 0.0232 \pm 0.0034 \pm 0.0007$$
$$R^{-}_{\pi} = 0.00469 \pm 0.00038 \pm 0.00008$$
$$R^{+}_{\pi} = 0.00352 \pm 0.00033 \pm 0.00007$$

The ADS observables

Till Moritz Karbach
technische universität
dortmund

$B \to DK$

LHCB-PAPER-2012-001
preliminary



Conclusion

- **CP asymmetry in B → ψπ**

  No evidence for CP violation.

  350 pb^{-1} @ 7 TeV

  to be submitted to Phys.Rev.X
  LHCB-PAPER-2011-024
  preliminary

- **CP violation in B → Kπ**

  First evidence of CPV in B_s! 3σ

  $$A_{CP}(B_s^0 \to K\pi) = 0.27 \pm 0.08\,(\text{stat}) \pm 0.02\,(\text{syst})$$

  350 pb^{-1} @ 7 TeV

  submitted to Phys.Rev.Lett.
  arXiv:1202.6251

- **CP violation in B → DK**

  4σ

  $$A_{ADS(K)} = \quad -0.520 \pm 0.150 \pm 0.021$$

  1.0 fb^{-1} @ 7 TeV

  to be submitted to Phys.Lett.B
  LHCB-PAPER-2012-001
  preliminary

  10σ

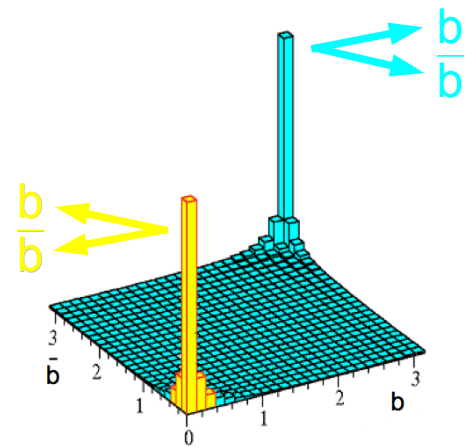
  First observation of ADS mode!

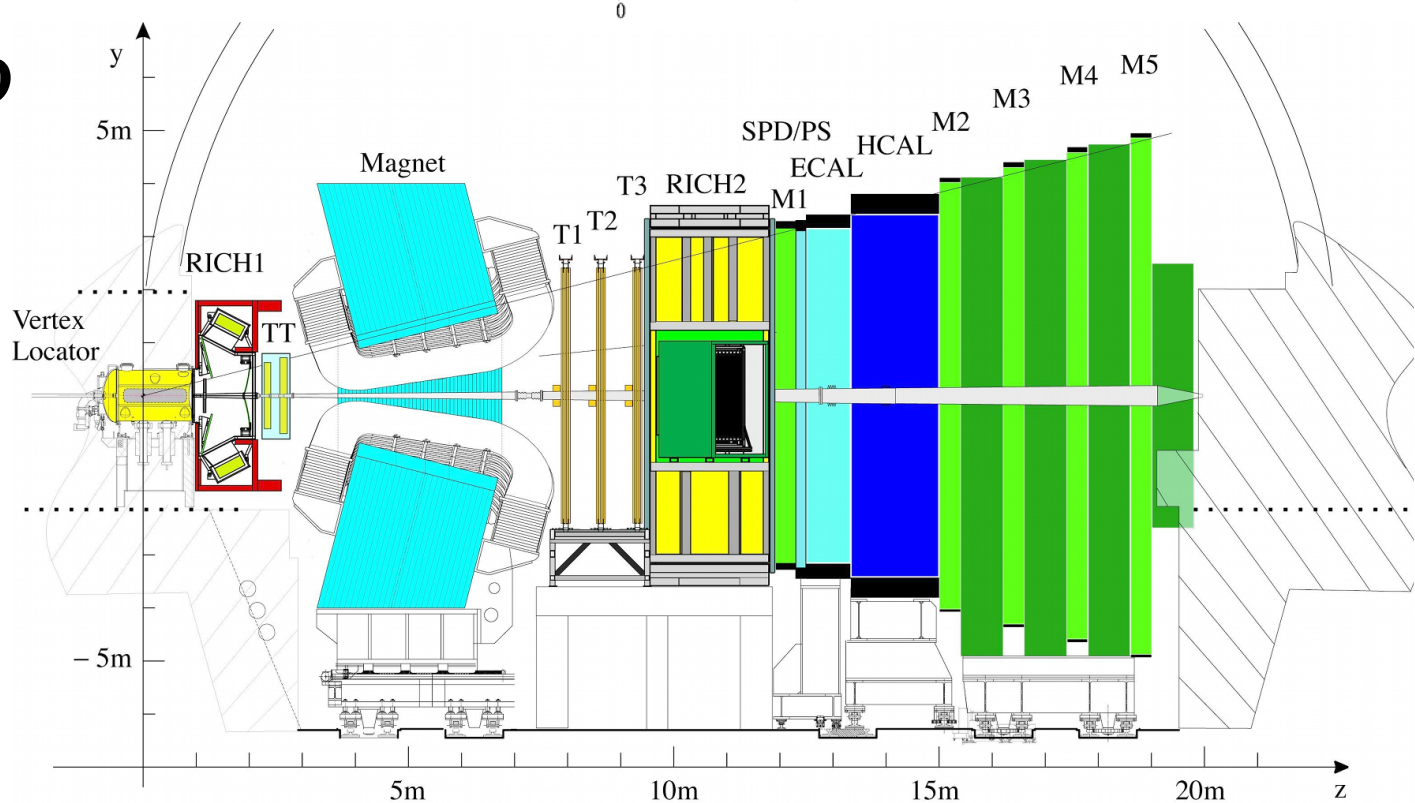
Till Moritz Karbach
technische universität
dortmund

Backup.

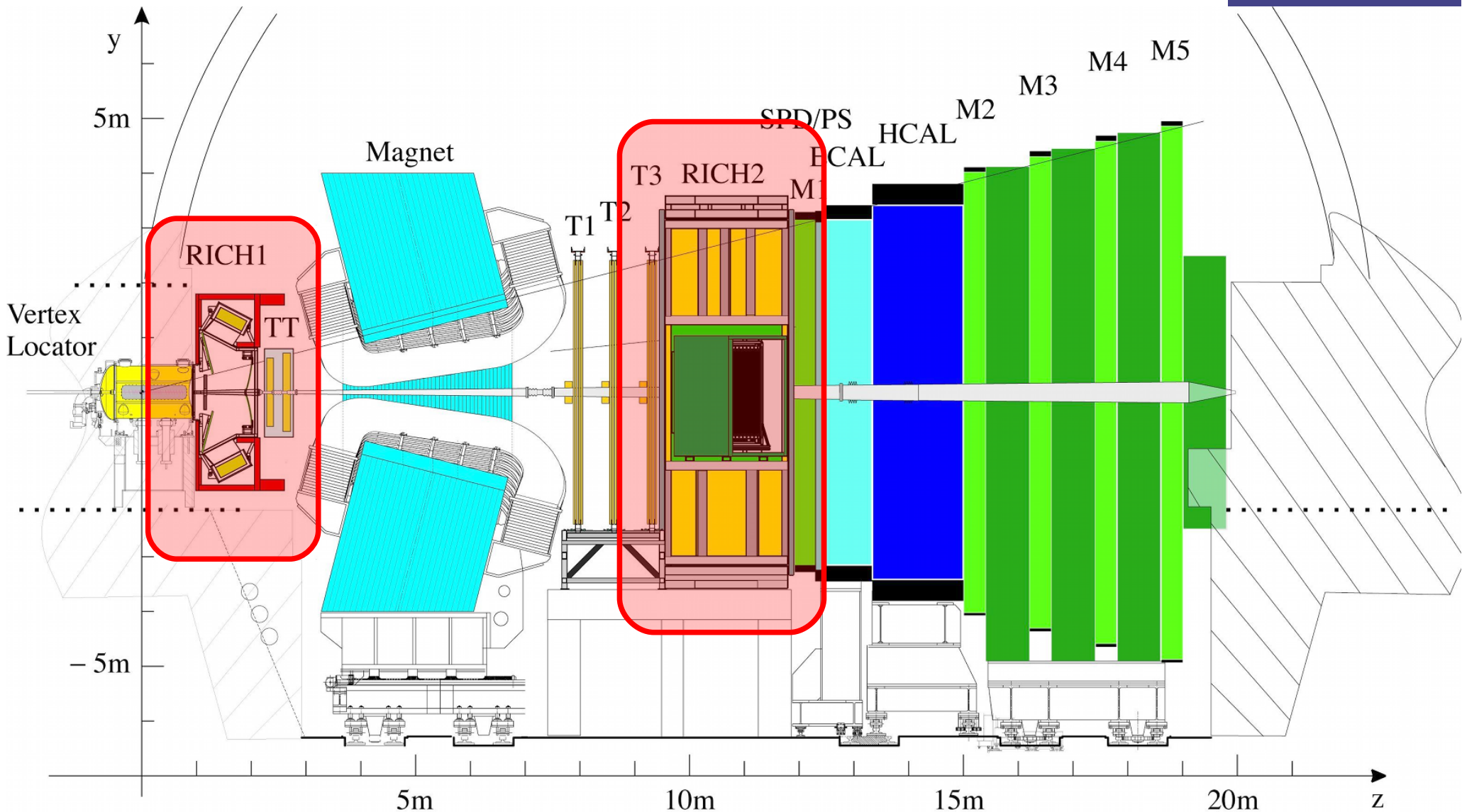
LHCb

- one arm forward spectrometer
- b pair production correlated
- covers **1.9 < η < 4.9**
- tracking stations before and after magnet
- particle identification by two RICH detectors





LHCb

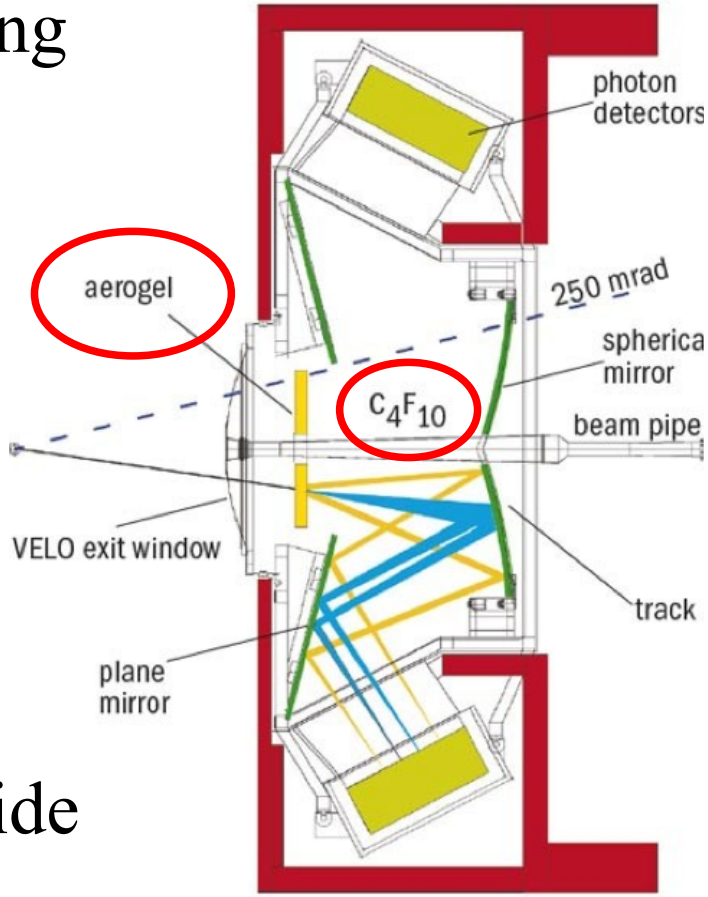

y
5m
– 5m
Vertex
Locator
RICH1
TT
Magnet
T1
T2
T3
RICH2
SPD/PS
ECAL
HCAL
M1
M2
M3
M4
M5
5m
10m
15m
20m
z

PID system

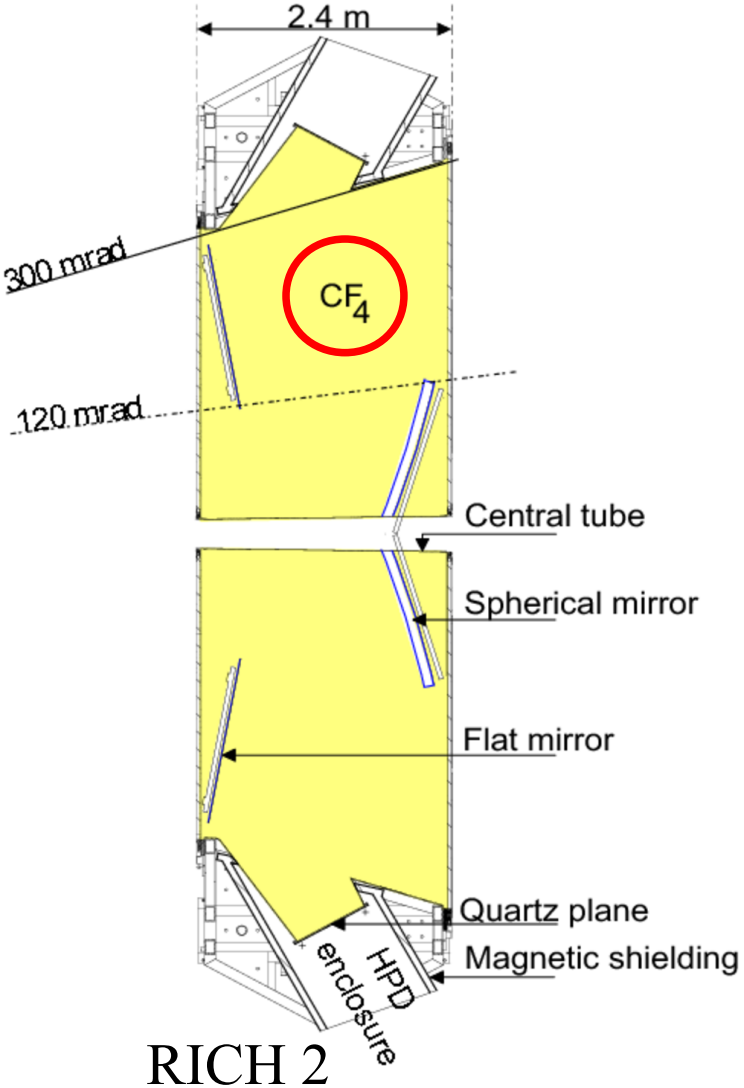
- Ring Imaging Cherenkov Detectors

$$\cos\theta = \frac{1}{\beta n}$$

- 3 radiators covering wide momentum range

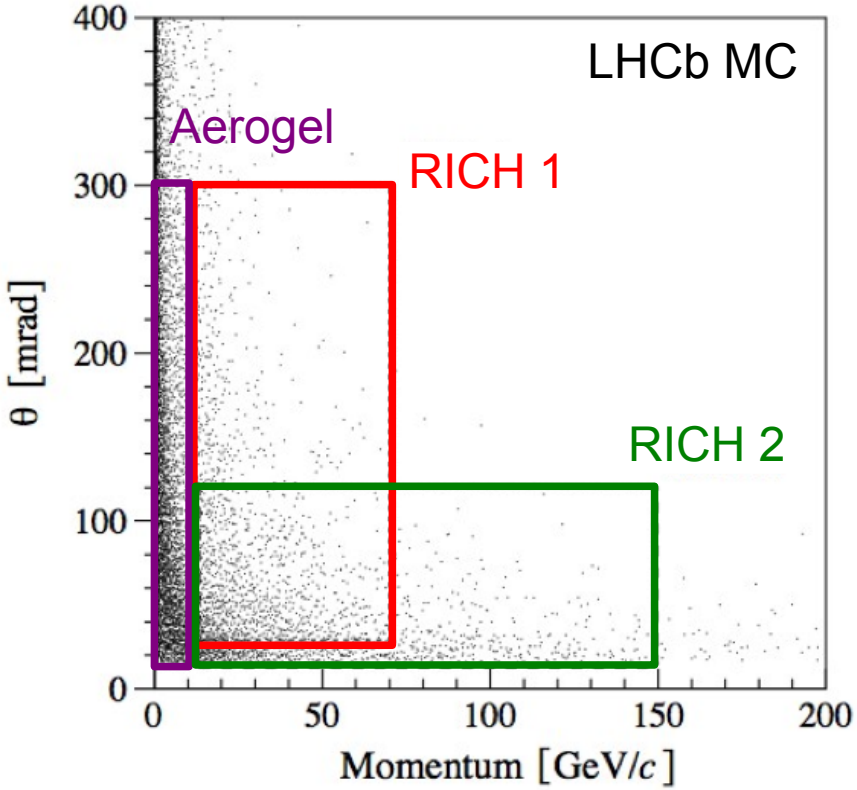


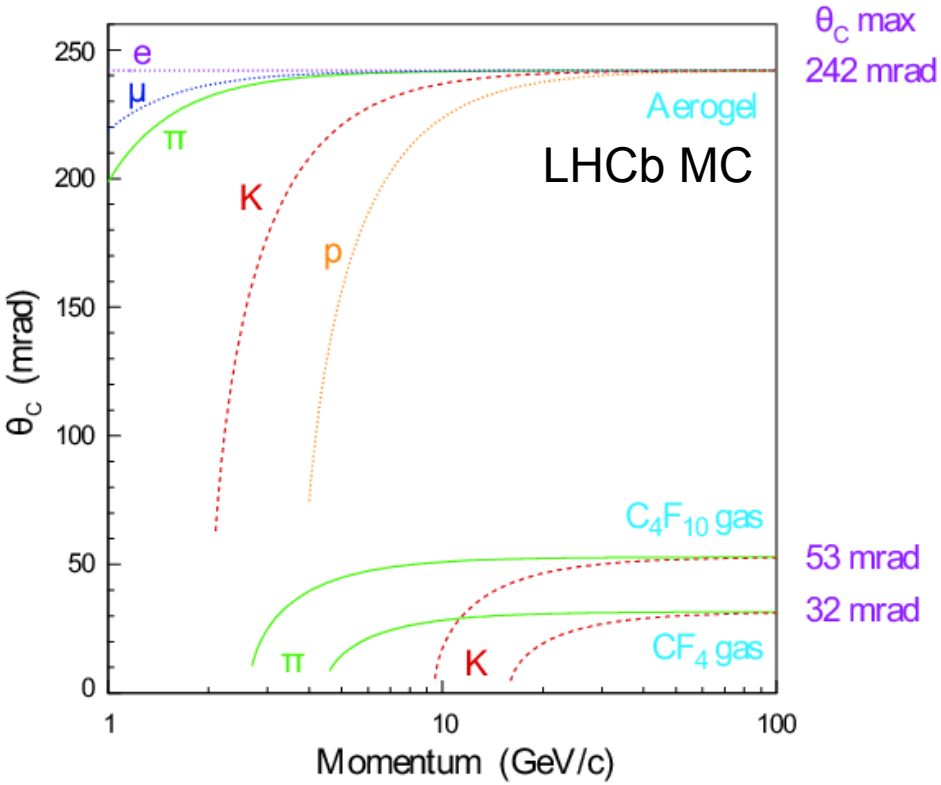
RICH 1
(side view)



RICH 2
(top view)

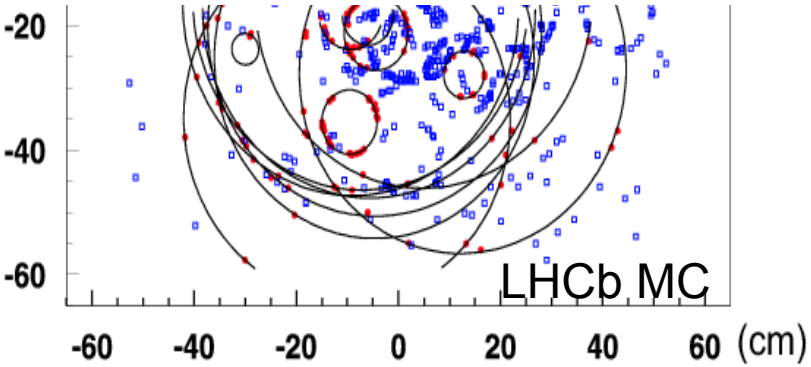
PID system



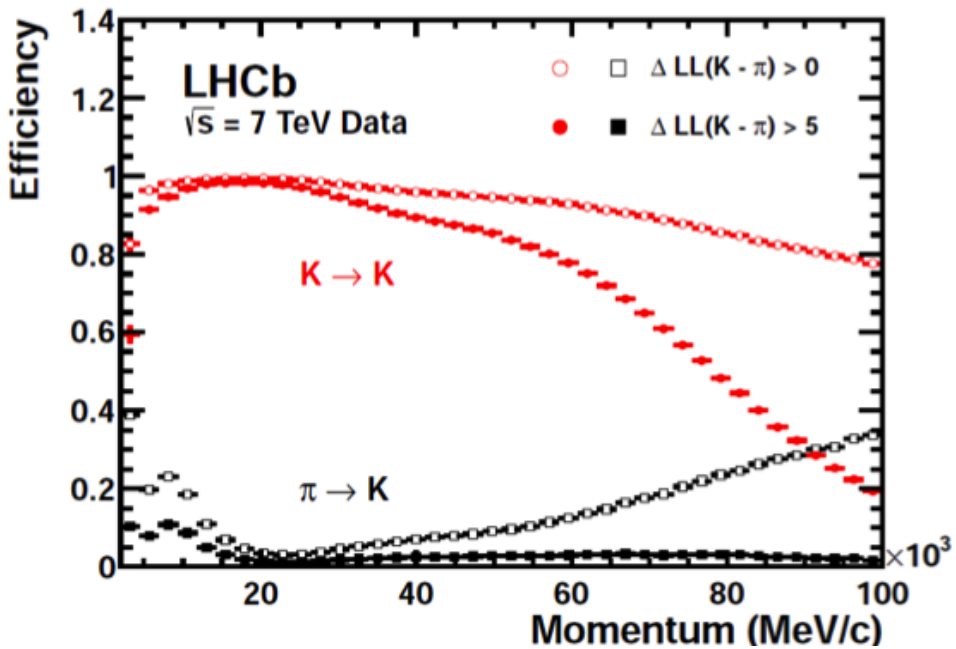


- Aerogel, n = 1.03, p < 10 GeV/c
- C4F10, n = 1.0014, p intermediate
- CF4, n = 1.0005, p > 20 GeV/c

[comparison: Air, n = 1.0003]



PID system


LHCb
√s = 7 TeV Data
Δ LL(K - π) > 0
Δ LL(K - π) > 5
K → K
π → K
Efficiency
Momentum (MeV/c)
×10³
0
0.2
0.4
0.6
0.8
1
1.2
1.4
20
40
60
80
100

$B^- \to \psi h^-$

$$R^{J/\psi} = (3.83 \pm 0.11 \pm 0.07) \times 10^{-2}$$ → 3σ lower than WA

$(5.2 \pm 0.4) \times 10^{-2}$ [PDG]

$$R^{\psi(2S)} = (3.95 \pm 0.40 \pm 0.12) \times 10^{-2}$$ → compatible w/ Belle

$(3.99 \pm 0.36 \pm 0.17) \times 10^{-2}$ [6]

[6] Belle collaboration, V. Bhardwaj *et al.*, *Observation of $B^\pm \to \psi(2S)\pi^\pm$ and search for direct CP-violation*, Phys.Rev. **D78** (2008) 051104, arXiv:0807.2170.

$$\mathcal{B}(B^\pm \to J/\psi\,\pi^\pm) = (3.88 \pm 0.11 \pm 0.15) \times 10^{-5}$$
$$\mathcal{B}(B^\pm \to \psi(2S)\pi^\pm) = (2.52 \pm 0.26 \pm 0.15) \times 10^{-5}$$

$B^- \to \psi h^-$

Systematics

Table 3: A summary of systematic uncertainties. The fit errors are included for comparison.

	$R^{J/\psi}$ ($\times 10^{-2}$)	$A^{J/\psi\,\pi}$	$R^{\psi(2S)}$ ($\times 10^{-2}$)	$A^{\psi(2S)\pi}$	$A^{\psi(2S)K}$
Simulation uncertainty	0.045	-	0.088	-	-
PID efficiencies	0.043	-	0.052	-	-
$A^{J/\psi\,K}$ (PDG [3])	-	0.0070	-	0.0070	0.0070
$A^{J/\psi\,K}_{\mathrm{Raw}}$ statistical error	-	0.0046	-	0.0046	0.0046
Detection asymmetries	-	0.0056	-	0.0056	-
Relative trigger efficiency	0.020	0.0031	0.050	0.0036	0.0003
Fixed fit parameters	0.005	0.0006	0.017	0.0013	0.0001
Sum in quadrature (syst.)	0.065	0.0106	0.115	0.0108	0.0084
Fit error (stat.)	0.110	0.0268	0.404	0.0901	0.0136

Till Moritz Karbach
technische universität
dortmund

$B_{(d,s)} \to K^-\pi^+$

B mixing dilution factor:

$$A_{CP}^{\text{int}} = \frac{\int \Gamma(B)\mathrm{d}t - \int \Gamma(\overline{B})\mathrm{d}t}{\int \Gamma(B)\mathrm{d}t + \int \Gamma(\overline{B})\mathrm{d}t}$$

$$\kappa_{d(s)} = \frac{\int_0^\infty e^{-\Gamma_{d(s)}t}\cos\left(\Delta m_{d(s)}t\right)\varepsilon(B^0_{(s)} \to K\pi;\, t)\mathrm{d}t}{\int_0^\infty e^{-\Gamma_{d(s)}t}\cosh\left(\frac{\Delta\Gamma_{d(s)}}{2}t\right)\varepsilon(B^0_{(s)} \to K\pi;\, t)\mathrm{d}t}$$

Till Moritz Karbach
technische universität
dortmund

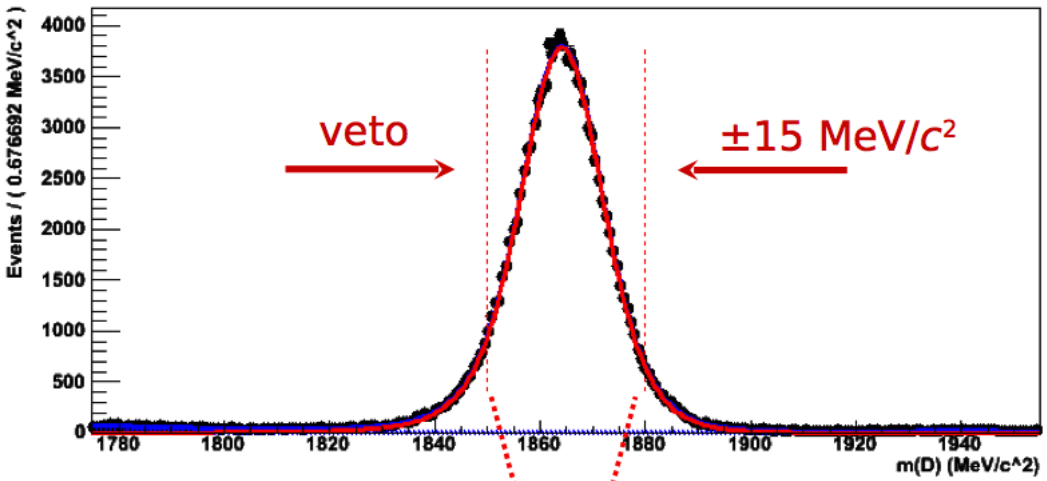
$B_{(d,s)} \rightarrow K^-\pi^+$: Crossfeeds

Double mis-ID veto

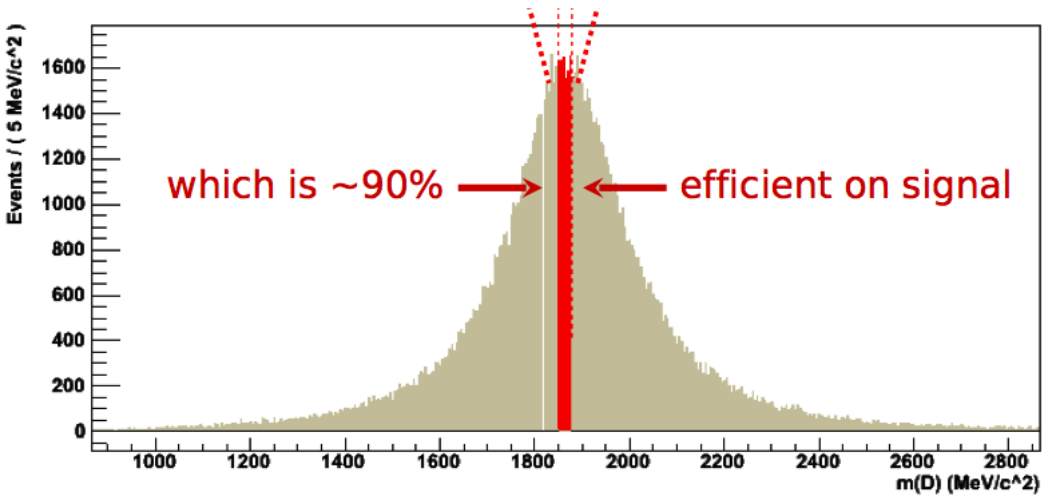
$B^{\pm} \rightarrow [K\pi]h^{\pm}$

$B^{\pm} \rightarrow [\pi K]h^{\pm}$

correct mass assignment



swapped mass assignment



B → DK: Results

LHCB-PAPER-2012-001
preliminary

$$R^{K\pi}_{K/\pi} = 0.0774 \pm 0.0012 \pm 0.0018$$
$$R^{KK}_{K/\pi} = 0.0773 \pm 0.0030 \pm 0.0018$$
$$R^{\pi\pi}_{K/\pi} = 0.0803 \pm 0.0056 \pm 0.0017$$
$$A^{K\pi}_{\pi} = -0.0001 \pm 0.0036 \pm 0.0095$$
$$A^{K\pi}_{K} = 0.0044 \pm 0.0144 \pm 0.0174$$
$$A^{KK}_{K} = 0.1480 \pm 0.0369 \pm 0.0097$$
$$A^{\pi\pi}_{K} = 0.1351 \pm 0.0661 \pm 0.0095$$
$$A^{KK}_{\pi} = -0.0199 \pm 0.0091 \pm 0.0116$$
$$A^{\pi\pi}_{\pi} = -0.0009 \pm 0.0165 \pm 0.0099$$
$$R^{-}_{K} = 0.0073 \pm 0.0023 \pm 0.0004$$
$$R^{+}_{K} = 0.0232 \pm 0.0034 \pm 0.0007$$
$$R^{-}_{\pi} = 0.00469 \pm 0.00038 \pm 0.00008$$
$$R^{+}_{\pi} = 0.00352 \pm 0.00033 \pm 0.00007$$

CP asymmetries in favored modes **consistent with 0** (as expected).

Till Moritz Karbach
technische universität dortmund

B → DK: Results

LHCB-PAPER-2012-001
preliminary

$$
\begin{aligned}
R_{ADS(K)} &= (R_K^- + R_K^+)/2 \\
&= 0.0152 \pm 0.0020 \pm 0.0004 \\
A_{ADS(K)} &= (R_K^- - R_K^+)/(R_K^- + R_K^+) \\
&= -0.520 \pm 0.150 \pm 0.021 \\
R_{ADS(\pi)} &= (R_\pi^- + R_\pi^+)/2 \\
&= 0.00410 \pm 0.00025 \pm 0.00005 \\
A_{ADS(\pi)} &= (R_\pi^- - R_\pi^+)/(R_\pi^- + R_\pi^+) \\
&= 0.1426 \pm 0.0621 \pm 0.0110
\end{aligned}
$$

Till Moritz Karbach
technische universität
dortmund

B → DK: ADS relations

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

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

$$R_{\mathrm{ADS}} = r_B^2 + r_D^2 + 2 r_B r_D \cos\gamma \cos(\delta_B + \delta_D)$$

$$A_{\mathrm{ADS}} = 2 r_B r_D \sin\gamma \sin(\delta_B + \delta_D)/R_{\mathrm{ADS}}$$

$$R_\pm \equiv \frac{\Gamma(B^\pm \to [K^\mp\pi^\pm]_D K^\mp)}{\Gamma(B^\pm \to [K^\pm\pi^\mp]_D K^\pm)} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\pm\gamma + \delta_B + \delta_D)$$

Till Moritz Karbach
technische universität dortmund

B → DK: GLW relations

$$R_{CP\pm} = \frac{2[\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)]}{\Gamma(B^- \to D^0K^-) + \Gamma(B^+ \to \overline{D}^0K^+)} = 1 + r_B^2 \pm 2r_B \cos\delta_B \cos\gamma$$

$$A_{CP\pm} = \frac{\Gamma(B^- \to D_{CP\pm}K^-) - \Gamma(B^+ \to D_{CP\pm}K^+)}{\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)} = \frac{\pm 2r_B \sin\delta_B \sin\gamma}{1 + r_B^2 \pm 2r_B \cos\delta_B \cos\gamma}$$

$B \to DK$: Systematics

	PID	PDFs	MC	$A_{instr.}$	$\sqrt{\sum \sigma_i^2}$
$R_{K/\pi}^{K\pi}$	0.0014	0.0009	0.0008	0.0	0.0018
$R_{K/\pi}^{KK}$	0.0013	0.0008	0.0009	0.0	0.0018
$R_{K/\pi}^{\pi\pi}$	0.0013	0.0006	0.0008	0.0	0.0017
$A_{\pi}^{K\pi}$	0.0	0.0010	0.0	0.0094	0.0095
$A_{K}^{K\pi}$	0.0002	0.0041	0.0	0.0169	0.0174
A_{K}^{KK}	0.0016	0.0013	0.0005	0.0095	0.0097
$A_{K}^{\pi\pi}$	0.0019	0.0023	0.0	0.0090	0.0095
A_{π}^{KK}	0.0001	0.0066	0.0	0.0095	0.0116
$A_{\pi}^{\pi\pi}$	0.0001	0.0004	0.0	0.0099	0.0099
R_{K}^{-}	0.0002	0.0004	0.0	0.0001	0.0004
R_{K}^{+}	0.0004	0.0005	0.0	0.0001	0.0007
R_{π}^{-}	1e-05	3e-05	0.0	7e-05	8e-05
R_{π}^{+}	1e-05	3e-05	0.0	7e-05	7e-05

Till Moritz Karbach
technische universität
dortmund