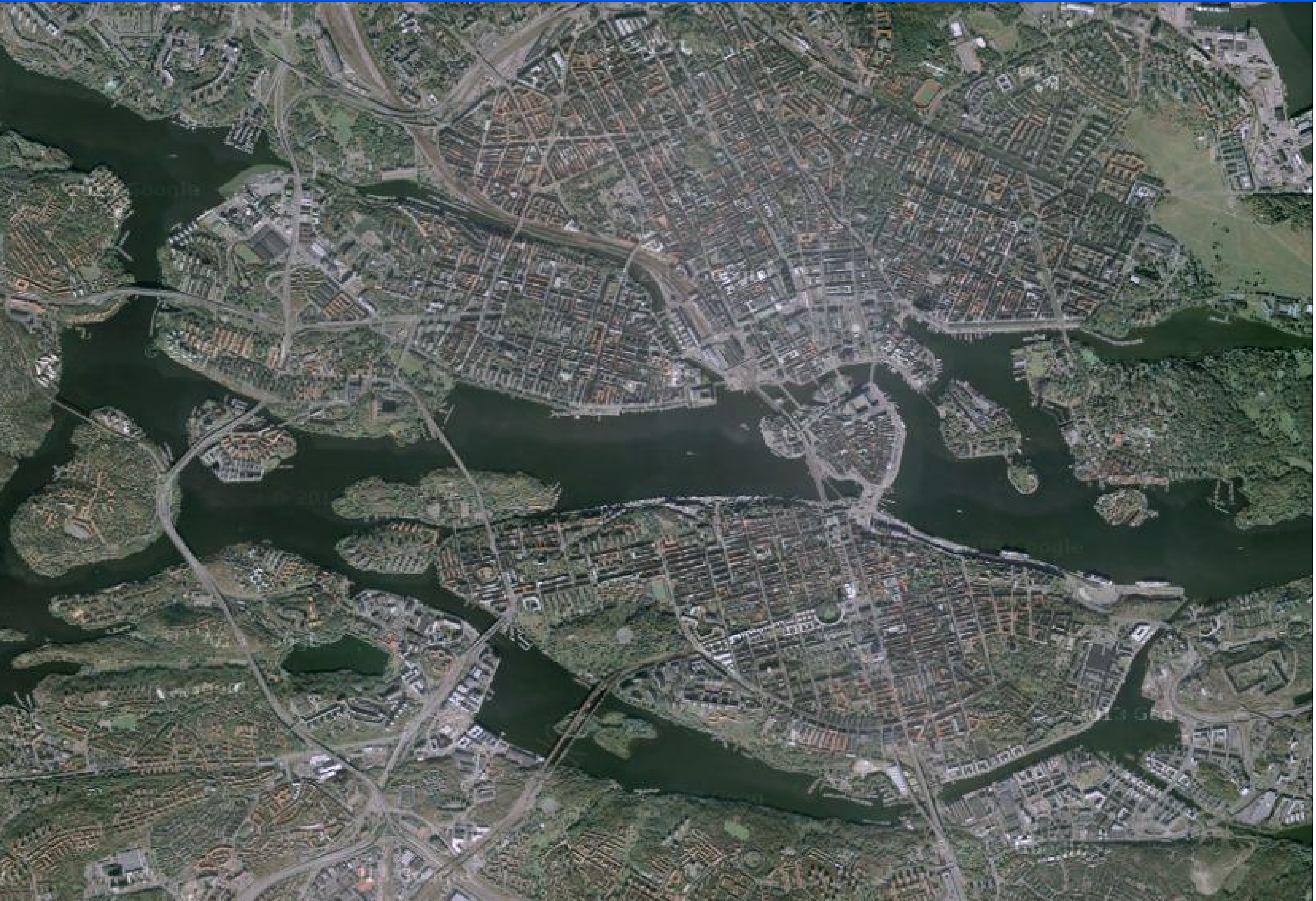
Beauty to open charm decays at LHCb



EPS-HEP
July 2013
Stockholm

Mark Whitehead on behalf of the LHCb Collaboration

Image: Google maps

Introduction

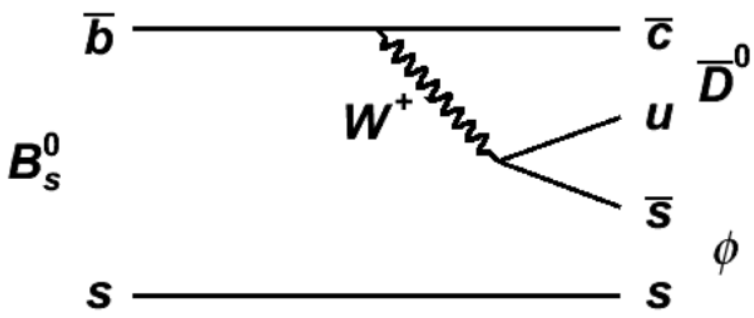
- Latest results from LHCb beauty to open charm programme
  - This is not a talk about γ – see Paolo's talk from Thursday

- General comments
  - Results shown are from the 1.0 fb^{-1} dataset from 2011
  - We have an additional 2 fb^{-1} available from 2012
  - Analyses in reverse chronological order, brand new to Spring 2013
  - All channels presented reconstructed using the decay $D^0 \rightarrow K\pi$
  - Value of f_s/f_d used 0.256 ± 0.020 [1]

[1] JHEP 1304 (2013) 001

First observation of $B_s \to D^0\varphi$ decays

- Sensitivity to γ and φ_s in future analyses
  - Both time dependent and time independent analyses possible [2-5]
  - Time independent the focus for now
  - No penguins – theoretically clean
- Search relative to $B_s \to D^0K^*$
  - Minimise systematic uncertainties
  - Also get $B^0 \to D^0K^*$
  - Update the measurement of $\mathcal{B}(B_s \to D^0K^*)$ [1]
- This analysis is still preliminary
  - LHCb-PAPER-2013-035 in preparation



[1] Phys.Lett. B706 (2011) 32-39

[2] Phys.Rev. D85 (2012) 114015

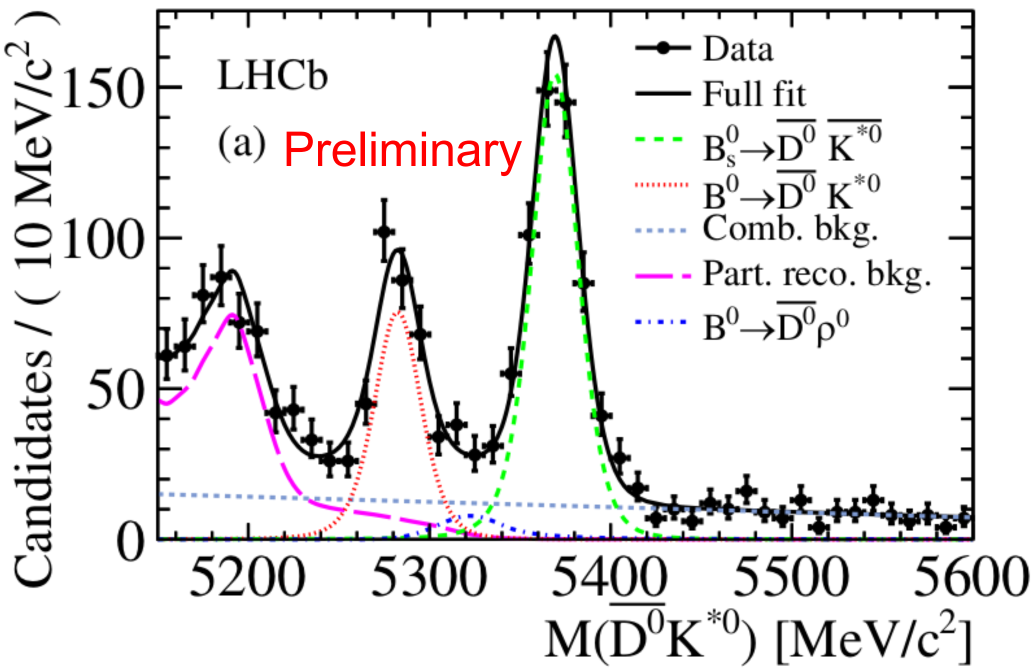
[3] Phys.Lett. B253 (1991) 483-488

[4] Phys.Rev. D69 (2004) 113003

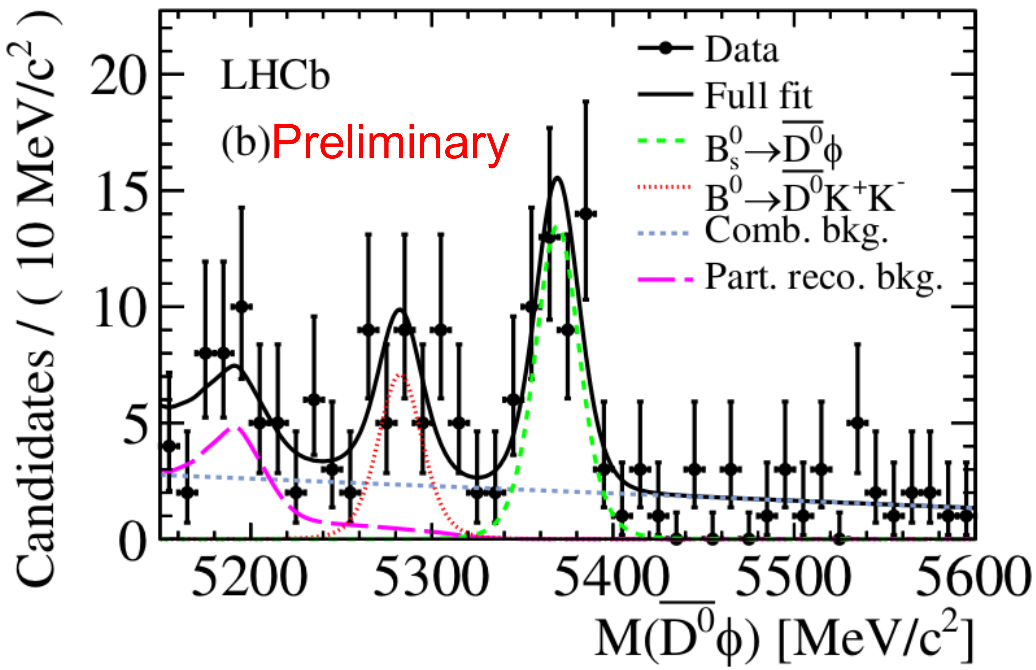
[5] Phys.Lett. B649 (2007) 61-66

First observation of $B_s \rightarrow D^0\phi$ decays

Normalisation channel



Signal channel



LHCb-PAPER-2013-035

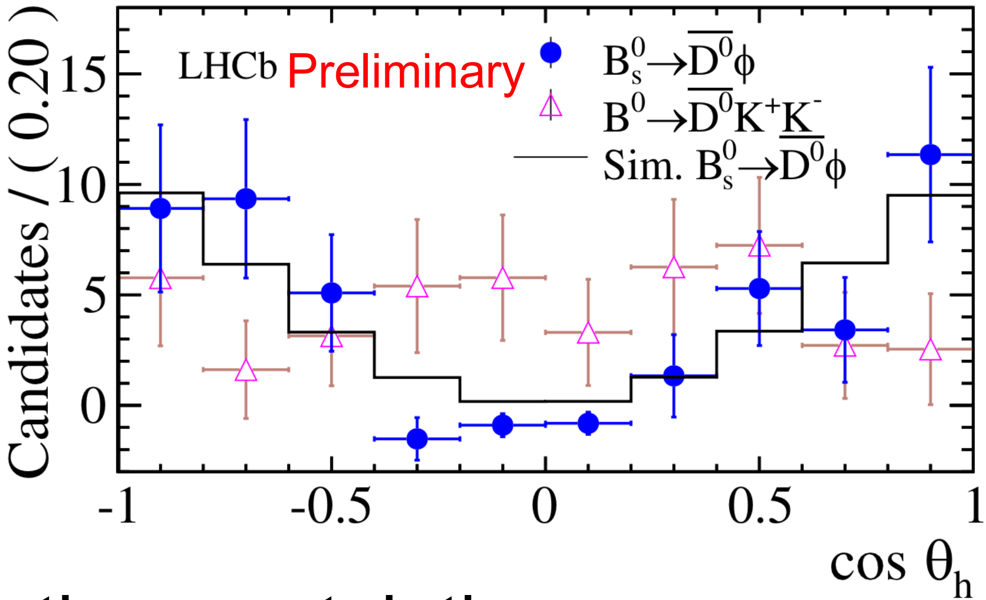
- MVA used
  - Uses 9 kinematic variables
  - Trained on data sidebands and signal MC
  - Reduces combinatoric background

- Yields
  - $B^0 \rightarrow D^0K^{*0}$: 260 ± 24
  - $B_s \rightarrow D^0K^{*0}$: 535 ± 30
  - $B_s \rightarrow D^0\phi$: 43 ± 8

First observation of $B_s \to D^0\varphi$ decays

LHCb-PAPER-2013-035

- How do we know these are $B_s \to D^0\varphi$ decays?
  - Could be S-wave $B_s \to D^0KK$
  - Check the cosine of helicity angle of the φ candidates
  - $1009.5 < m(\varphi) < 1029.5$ MeV/c^2



Source	$\mathcal{R}_{K^{*0}}$	$\mathcal{R}_{\phi}$
PID	-	0.002
Trigger	-	0.003
Flight distance	-	0.002
Selection	-	0.002
Simulation statistics	0.10	0.001
Fit bias	0.03	0.001
Signal model	0.04	0.001
Background model	0.01	0.001
Charmless correction	0.10	0.003
Non-resonant correction	0.22	0.004
ϕ branching fraction	-	0.001
Total	0.26	0.007

- Systematic uncertainties
  - Non-resonant correction dominant
  - Accounts for $B_s \to D^0KK$, $B^0 \to D^0K\pi$ and $B_s \to D^0K\pi$

First observation of $B_s \to D^0\varphi$ decays

•Results

LHCb-PAPER-2013-035

Preliminary

- The ratio of $B(B_s \to D^0K^{*0})$ to $B(B^0 \to D^0K^{*0})$ is found to be

$$\mathcal{R}_{K^{*0}} = 7.81 \pm 0.71 \text{ (stat)} \pm 0.26 \text{ (syst)} \pm 0.61 \text{ (f}_\text{s}/\text{f}_\text{d})$$

- Using the known branching fraction for the B^0 mode

$$\mathcal{B}(B_s^0 \to \overline{D}^0\overline{K}^{*0}) = [3.3 \pm 0.3 \text{ (stat)} \pm 0.1 \text{ (syst)} \pm 0.3 \text{ (f}_\text{s}/\text{f}_\text{d}) \pm 0.5 \text{ } (\mathcal{B}(\text{B}^0 \to \overline{\text{D}}^0\text{K}^{*0}))] \times 10^{-4}$$

- The ratio of $B(B_s \to D^0\varphi)$ to $B(B_s \to D^0K^{*0})$ is

6.2σ significance

$$\mathcal{R}_\phi = 0.069 \pm 0.013 \text{ (stat)} \pm 0.007 \text{ (syst)}$$

- Using the new branching fraction for $B_s \to D^0K^{*0}$

$$\mathcal{B}(B_s^0 \to \overline{D}^0\phi) = [2.3 \pm 0.4 \text{ (stat)} \pm 0.2 \text{ (syst)} \pm 0.5 \text{ } (\mathcal{B}(\text{B}_\text{s}^0 \to \overline{\text{D}}^0\overline{\text{K}}^{*0}))] \times 10^{-5}$$

$B_{(s)} \rightarrow D^0K\pi$ branching fractions

Phys. Rev. D 87, 112009 (2013)

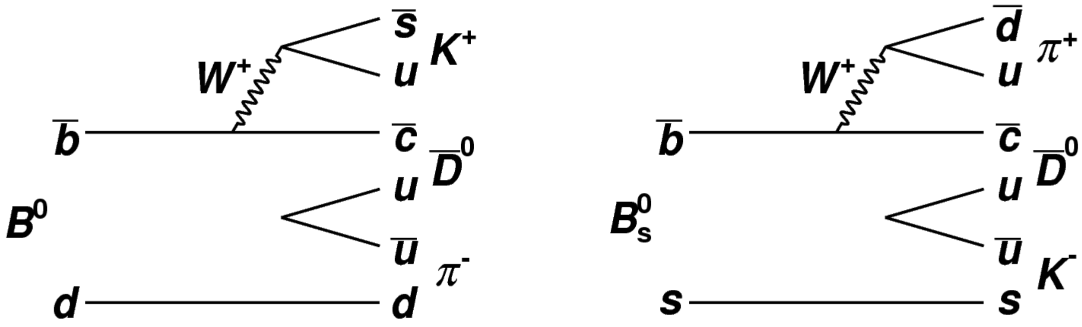
- $B_s \rightarrow D^0K\pi$ not previously measured
  - LHCb has seen $B_s \rightarrow D^0K^{*0}$ [1]
  - $\mathcal{B}(B^0 \rightarrow D^0K\pi)$ has ~20% uncertainty [2]
  - $B^0 \rightarrow D^0\pi\pi$ used as the control channel
- $B^0 \rightarrow D^0K\pi$ interesting to measure γ
  - Interference of $b \rightarrow c$ and $b \rightarrow u$ amplitudes of similar magnitude
  - Extra sensitivity[2,3] from amplitude analysis w.r.t. to $B^0 \rightarrow D^0K^{*0}$
- First steps towards γ
  - Observe both modes
  - $B_s \rightarrow D^{(*)0}K\pi$ a background

[1] Phys.Lett. B706 (2011) 32-39

[2] Phys.Rev. D86 (2012) 010001

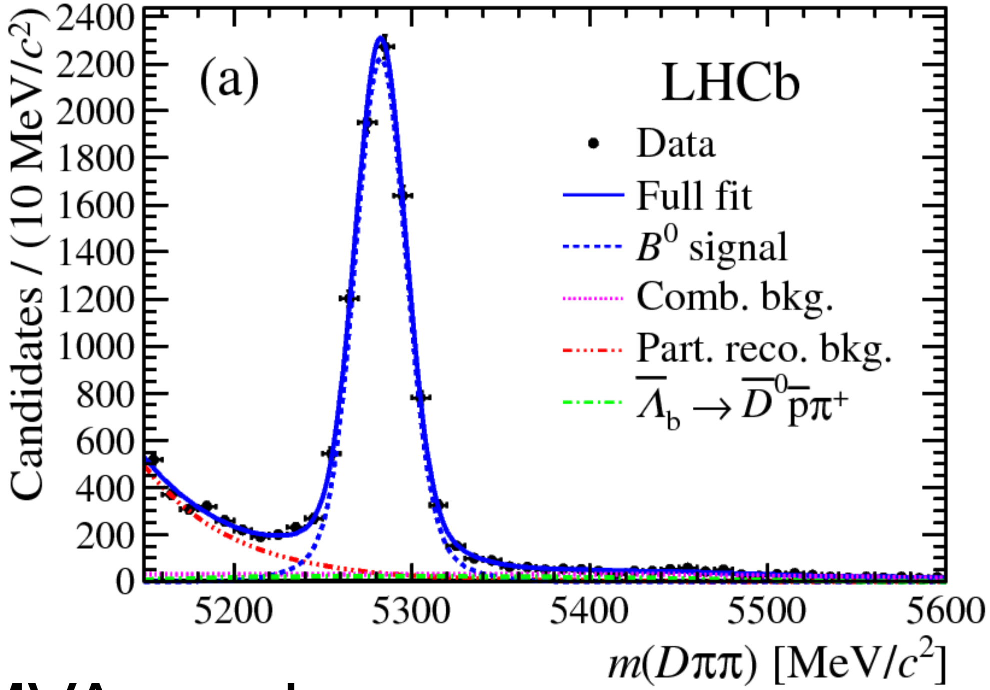
[3] Phys.Rev. D79 (2009) 051301

[4] Phys.Rev. D80 (2009) 092002

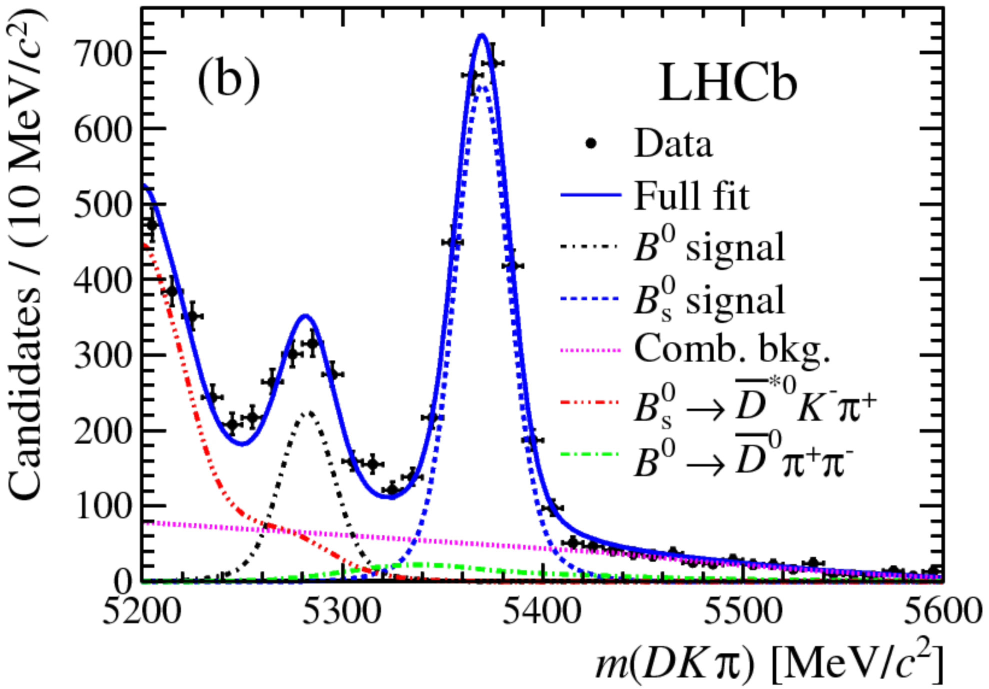


$B_{(s)} \to D^0 K\pi$ branching fractions

Normalisation channel



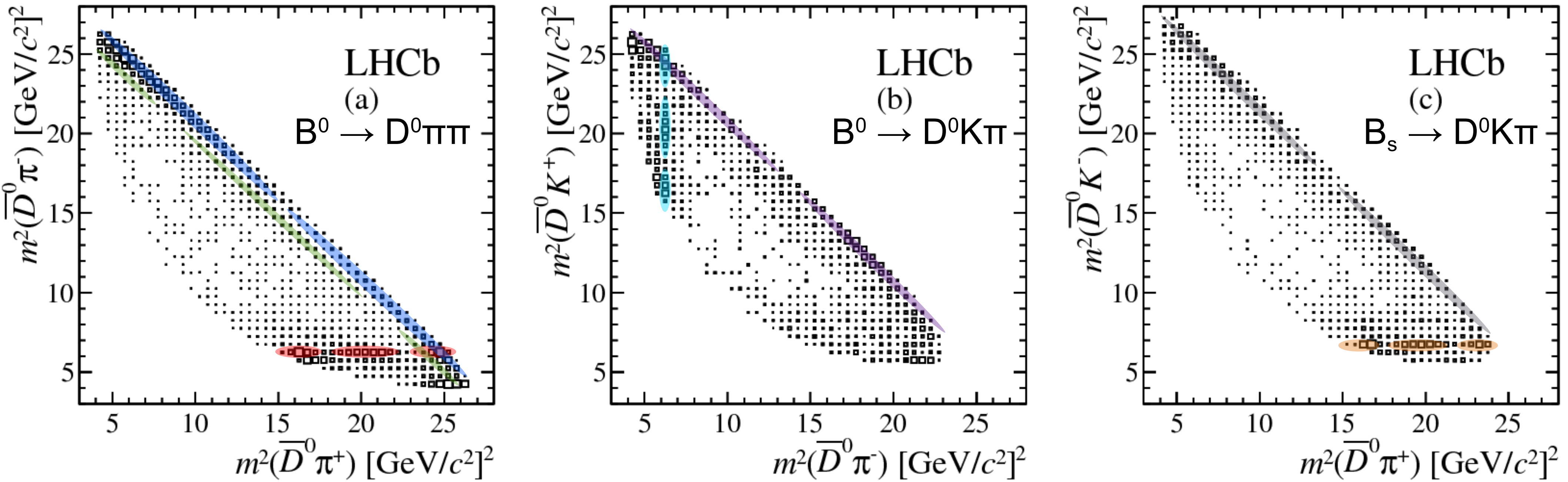
Signal channel



Phys. Rev. D 87, 112009 (2013)

- MVA used
  - Based on 10 kinematic variables
  - Trained on $B^0 \to D^0\pi\pi$ data
  - Optimised for $B_s \to D^0 K\pi$
- Yields
  - $B^0 \to D^0\pi\pi$: 8558 ± 134
  - $B_s \to D^0 K\pi$: 2391 ± 81
  - $B^0 \to D^0 K\pi$: 815 ± 55

$B_{(s)} \to D^0K\pi$ branching fractions



$\rho^0(770)$ $f_2(1270)$ $D_2^*(2460)^-$ $K^{*0}(892)$ $D_2^*(2460)$- $K^{*0}(892)$ $D_{s2}^*(2573)^-$

- This is not a Dalitz plot (DP) analysis

Phys. Rev. D 87, 112009 (2013)

  - These sWeighted, efficiency corrected DPs shown for interest only
  - No amplitude analysis performed – look out for future papers

$B_{(s)} \to D^0K\pi$ branching fractions

Phys. Rev. D 87, 112009 (2013)

- Systematic uncertainties
  - Dominated by the fit model
  - Some statistical in nature
  - Limited knowledge of f_s/f_d

Source	Uncertainty (%) B^0	B_s^0
Modelling of efficiency	3.4	3.1
Fit model	6.3	4.3
$D^{*\pm}$ veto	< 0.1	1.0
$D^{\pm}$ veto	2.0	0.2
$D_s^{\pm}$ veto	0.2	0.5
Trigger	1.0	1.0
Particle identification	1.0	1.0
Simulation statistics	2.0	2.0
f_s/f_d	–	7.8
Total	7.8	9.8

- Results
  - Branching fraction of $B_s \to D^0K\pi$ (first observation)

$$\mathcal{B}\left(B_s^0 \to \overline{D}^0 K^- \pi^+\right) = (1.00 \pm 0.04\,(\text{stat.}) \pm 0.10\,(\text{syst.}) \pm 0.10\,(\mathcal{B})) \times 10^{-3}$$

  - Branching fraction of $B^0 \to D^0K\pi$ (world best measurement)

$$\mathcal{B}\left(B^0 \to \overline{D}^0 K^+ \pi^-\right) = (9.0 \pm 0.6\,(\text{stat.}) \pm 0.7\,(\text{syst.}) \pm 0.9\,(\mathcal{B})) \times 10^{-5}$$

Search for $B_s \to D^{*-}\pi^+$ decays

- LHCb recent observations - $B_s \to D^+D^-$, D^0D^0 and $\pi^+\pi^-$ [1,2]
  - All have weak exchange and penguin annihilation contributions
  - $B_s \to D^{*-}\pi^+$ is pure weak exchange – learn about the interplay
- Perform a simultaneous fit
  - Bin in the angle between the D^* and π in the lab frame $\to \theta_\pi$
  - Aim to reduce the B^0 width to reveal the potential B_s peak
  - Normalise to the huge B^0 peak
- No significant signal observed

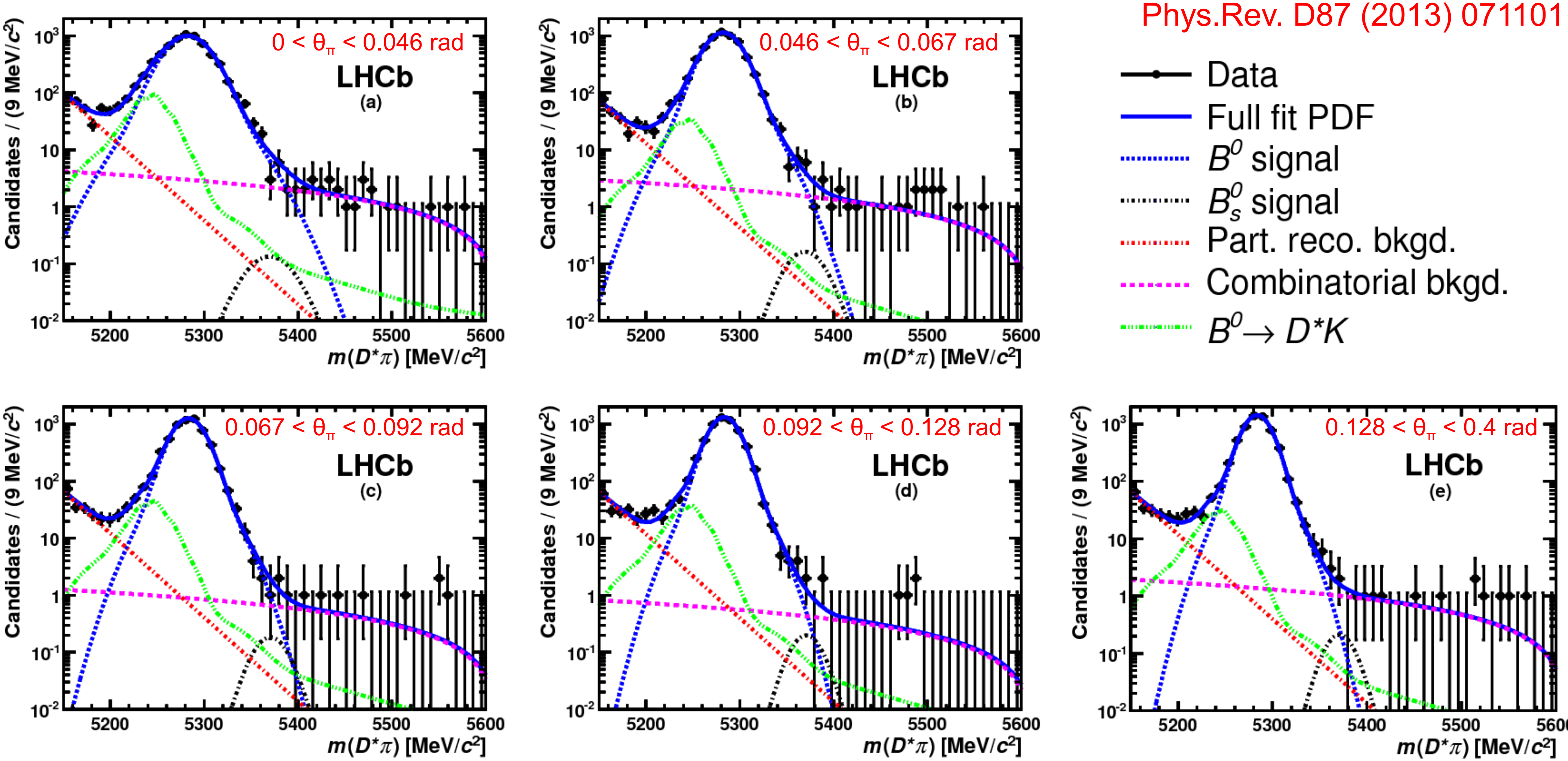
$$\mathcal{B}(B_s^0 \to D^{*\mp}\pi^{\pm}) < 6.1\ (7.8) \times 10^{-6} \text{ at } 90\,\%\ (95\,\%)\ \mathrm{CL}$$

[1] Phys.Rev. D87 (2013) 092007   [2] JHEP 1210 (2012) 037

Phys.Rev. D87 (2013) 071101

Search for $B_s \to D^{*-}\pi^+$ decays

Phys.Rev. D87 (2013) 071101



- Larger angle gives better mass resolution – compare (a) and (e)

Conclusion

- Latest results from the beauty to open charm programme
  - Rich and diverse part of the LHCb physics output
  - Look forward to more exciting results on the 3 fb^{-1} data sample
  - First observation of $B_s \rightarrow D^0\phi$ at 6.2σ
  - World's best measurement of $\mathcal{B}(B_s \rightarrow D^0K^{*0})$
  - First observation of $B_s \rightarrow D^0K\pi$ at $> 10\sigma$
  - World's best measurement of $\mathcal{B}(B^0 \rightarrow D^0K\pi)$
- Thank you...
  - … for the invitation to speak at this excellent conference
  - … to the LHC machine group for their brilliant performance

Back up

LHCb detector