Production asymmetries of neutral B mesons in pp collisions at LHCb

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Introduction

- In pp collisions b and $\bar{b}$ quarks are produced in pairs
  - b and $\bar{b}$ hadrons production rates are not expected to be exactly equal
    - Produced $\bar{b}$ quark can combine with an u or d valence quark from the colliding protons
      - Slight excess of B^+ and B^0 over B^- and $\bar{B}^0$
    - Other b meson/baryon species must compensate
- It is important to measure these effects
  - An asymmetry in the initial state can **easily mimic CP violation** $\rightarrow$ one must correct for this effect
- Production asymmetry defined as

$$A_P\left(B^0_{(s)}\right) = \frac{\sigma\left(\bar{B}^0_{(s)}\right) - \sigma\left(B^0_{(s)}\right)}{\sigma\left(\bar{B}^0_{(s)}\right) + \sigma\left(B^0_{(s)}\right)}$$

- Measurement also performed in bins of $B^0_{(s)}$ p_T and η
  - Production asymmetries could depend on kinematics

Production asymmetry

- The following decays have been used:
  - $B^0 \rightarrow J/\psi(\mu^+\mu^-)K^{*0}(K^+\pi^-)$
  - $B^0 \rightarrow D^-(K^+\pi^-\pi^-)\pi^+$
  - $B^0_s \rightarrow D^-_s(K^+K^-\pi^-)\pi^+$
- The time-dependent decay rate asymmetry is:

Asymmetries $\lesssim 1\%$ so we retain only first order terms

$$A(t) = \frac{\mathcal{R}(B(t) \rightarrow \bar{f}) - \mathcal{R}(B(t) \rightarrow f)}{\mathcal{R}(B(t) \rightarrow \bar{f}) + \mathcal{R}(B(t) \rightarrow f)} \simeq A_{CP} + A_D + A_P \frac{\cos(\Delta m_{d(s)} t)}{\cosh\left(\frac{\Delta\Gamma_{d(s)} t}{2}\right)}$$

Direct CP asymmetry

Final state detection asymmetry

Oscillatory term whose amplitude is the production asymmetry

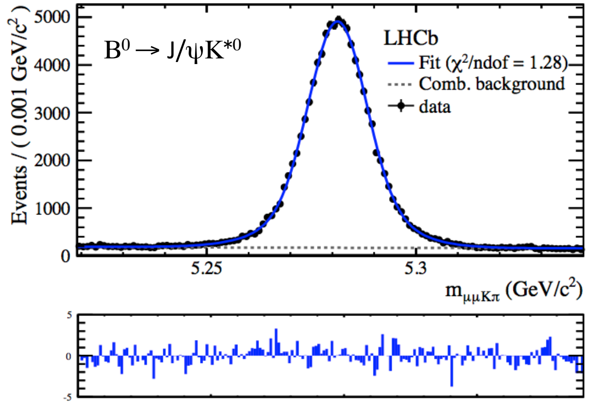
where B(t) stands for $B^0_{(s)}$ or $\overline{B}^0_{(s)}$

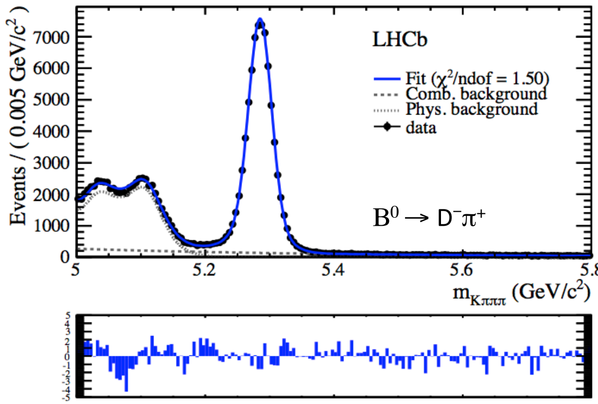
  - The flavour of the meson oscillates between $B^0_{(s)}$ or $\overline{B}^0_{(s)}$ states
- Measuring A(t) one can extract A_P as the **amplitude of the oscillatory term**
- Untagged time-dependent analysis

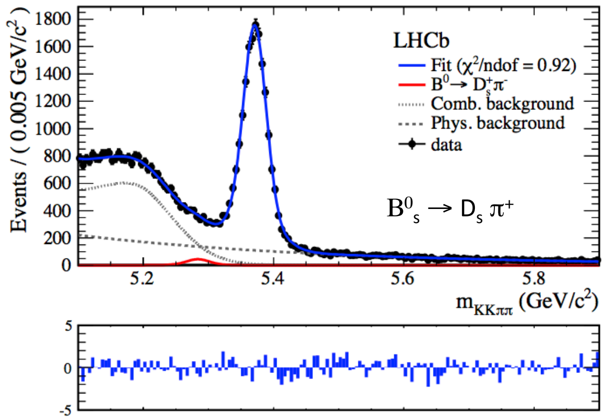
Data sample and event selection

- We used the full 2011 data sample collected by the LHCb detector
  - Integrated luminosity: $\mathscr{L}$ = 1.0 fb^{-1} at $\sqrt{s}$ = 7 TeV
- PID requirements to suppress background due to mis-ID of final state particles
- Multivariate analysis (BDT) to suppress combinatorial background
- From maximum likelihood fits we obtain

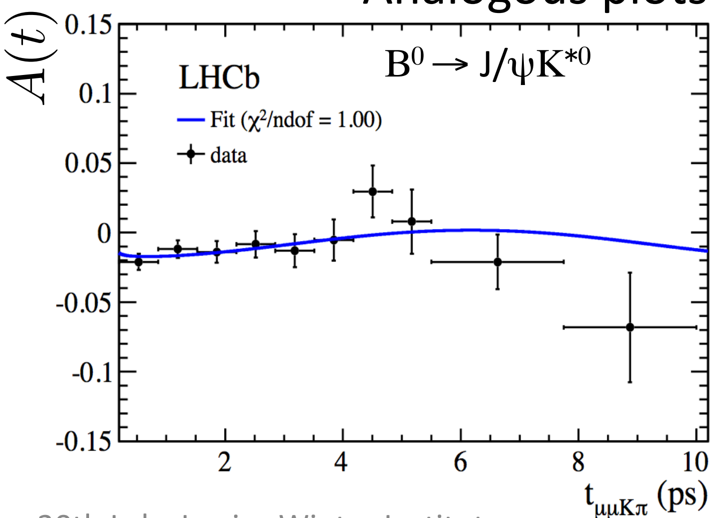
$$N^{sig}_{B^0\to J/\psi K^{*0}} = 93627 \pm 360$$
$$N^{sig}_{B^0\to D^-\pi^+} = 76682 \pm 308$$
$$N^{sig}_{B^0_s\to D_s^-\pi^+} = 16887 \pm 174$$

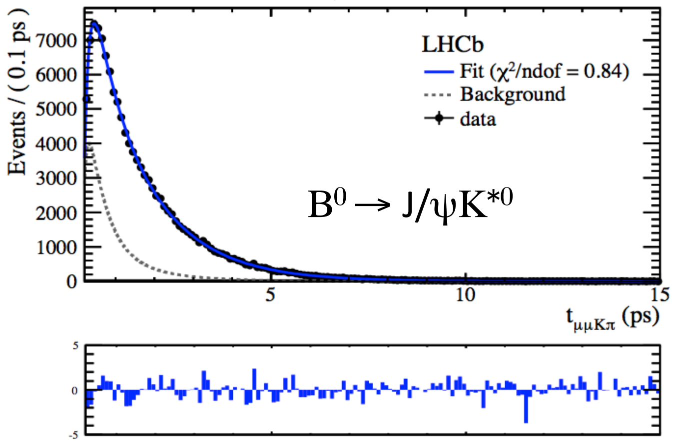






Analogous plots for others decays

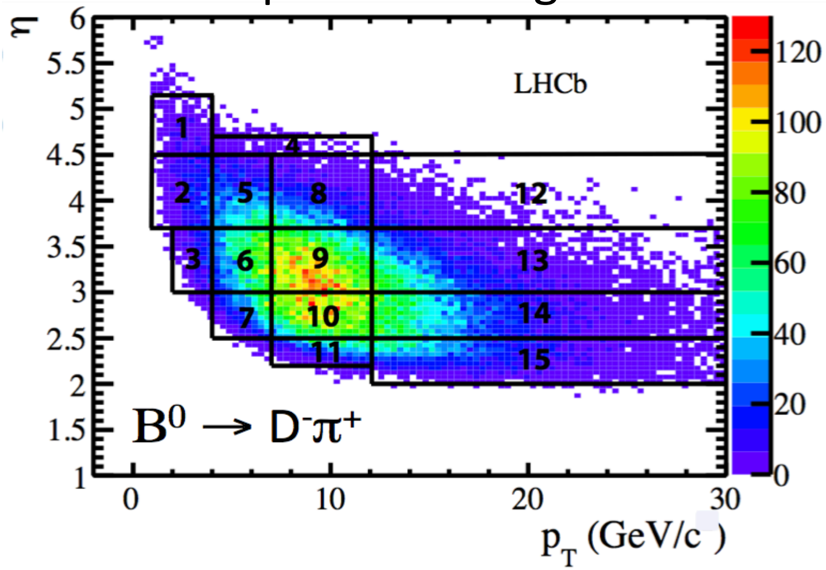




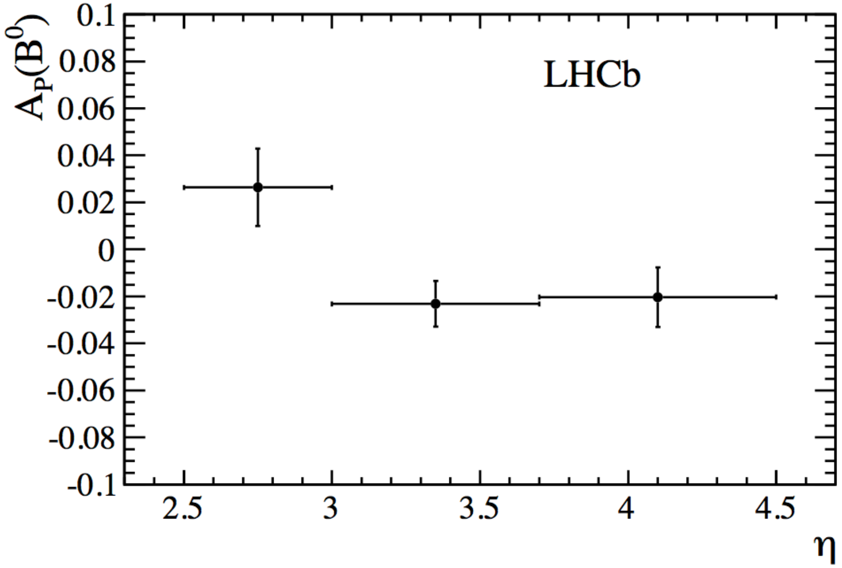
Analysis strategy

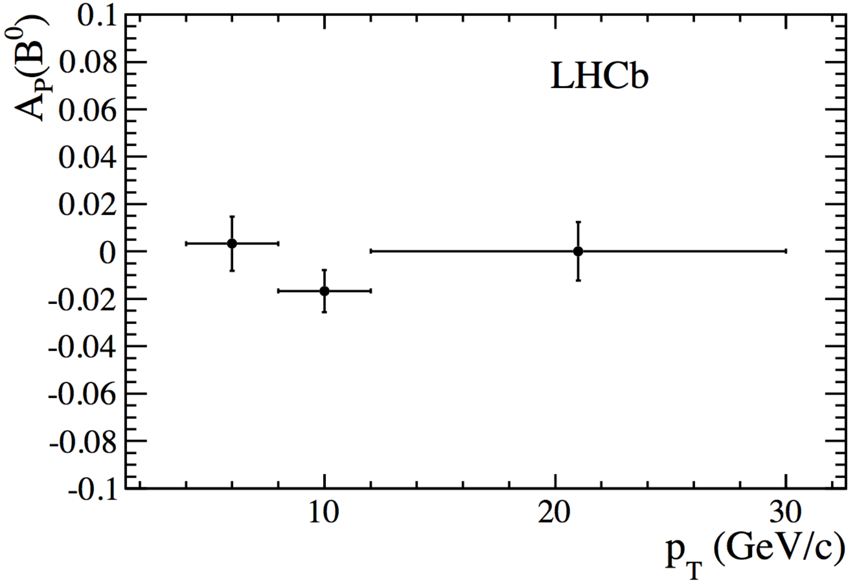
- Divide the data sample in bins of p_T and η
  - Different binning schemes for the 3 decays, since distributions are slightly different

Example of binning scheme



- Perform 2-D simultaneous invariant mass and decay time fits for each bin
  - Integrate A_P over a rectangular region to obtain the final integrated result
  - Integrate A_P over p_T or η to obtain the dependence w.r.t. the other variable





Analogous plots for B^0_s

No evidence of dependence of production asymmetry on p_T and η

Conclusions

- We measured A_P in the range $0 < p_T < 30$ GeV/c and $2.5 < \eta < 4.5$

$$A_P(B^0) = -0.0035 \pm 0.0076(\text{stat.}) \pm 0.0028(\text{syst.})$$

$$A_P(B^0_s) = 0.0109 \pm 0.0261(\text{stat.}) \pm 0.0061(\text{syst.})$$

- No evidence of a dependence on p_T and η of the production asymmetries
- This analysis has been published by LHCb Collaboration
  - LHCb Collaboration, Phys. Lett. **B739** (2014) 218
- Analyses ongoing to update the measurement with the full statistics and to measure B^+ and Λ^0_b production asymmetries