b-hadron production asymmetries at LHCb

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Introduction

- The production of b and $\bar{b}$ hadrons in *pp* collisions **is not expected** to be identical
  - The initial state contains **only quarks** → naively speaking, the production of B^0 and B^+ mesons containing $\bar{b}$ **should be favoured** with respect to the production of mesons containing b quarks
  - This effect should be compensated by an asymmetry in b particles
- The production asymmetry is a necessary ingredient to **measure CP violation**
  - An initial state asymmetry would produce an effect that **could mimic CP violation** → one must disentangle these quantities
- Production asymmetries are defined as:

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

- We measure B^0 and B^0_s production asymmetry using the following decays:
  - $B^0 \rightarrow D^-(K^+\pi^-\pi^-)\pi^+$
  - $B^0 \rightarrow J/\psi(\mu^+\mu^-)K^{*0}(K^+\pi^-)$
  - $B^0_s \rightarrow D^-_s(K^+K^-\pi^-)\pi^+$

Analysis strategy

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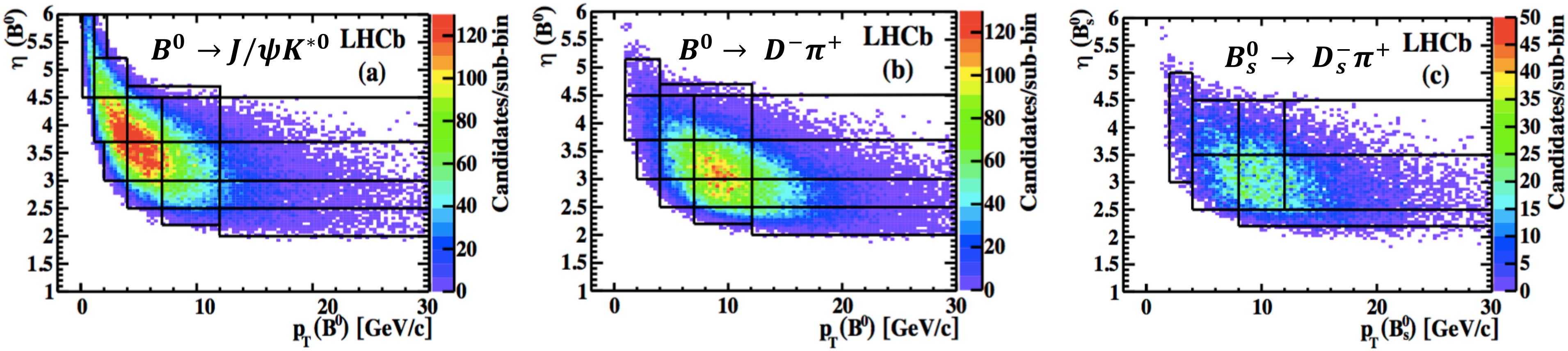
- We used data collected by LHCb during 2011, at a centre of mass energy of 7 TeV, corresponding to an integrated luminosity of 1.0 fb^{-1}
- **Offline selection** to reduce backgrounds
  - Apply **particle identification (PID) requirements** on final state particles to suppress **mis-identified backgrounds**
  - Use a **multivariate algorithm** (Boosted Decision Tree) to suppress **combinatorial background**
- Divide the data sample in bins of $\mathbf{p_T}$ and $\boldsymbol{\eta}$ of the $B^0_{(s)}$ meson to investigate **whether the production asymmetries depend on these quantities**



Global fits to the data

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- Perform **simultaneous maximum likelihood invariant mass and decay time fits** in each (p_T,η) bin to extract the production asymmetry
  - The **time-dependent decay rate asymmetry** is:

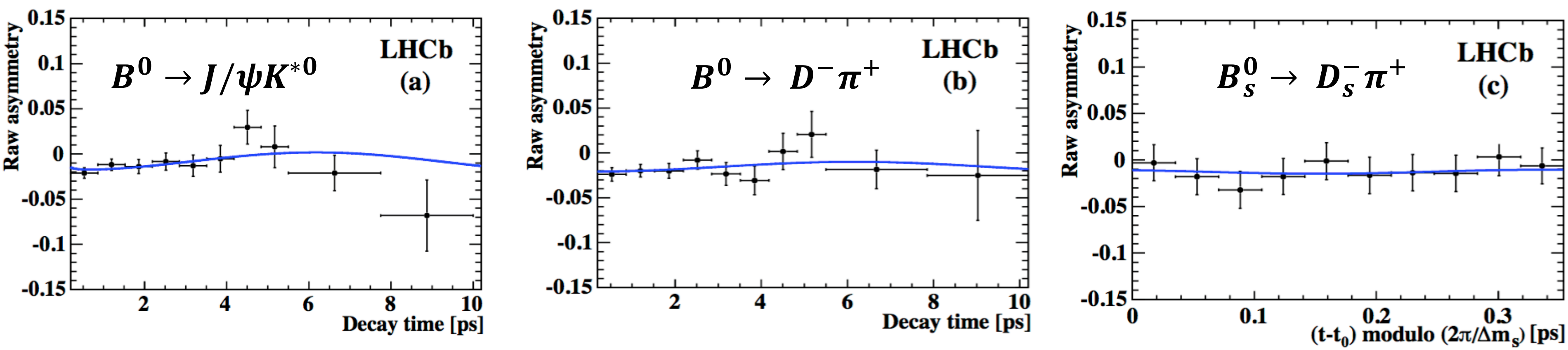
$$A(t) = \frac{\mathcal{R}(B(t)\to f)-\mathcal{R}(B(t)\to \bar{f})}{\mathcal{R}(B(t)\to f)+\mathcal{R}(B(t)\to \bar{f})} = A_{CP} + A_{D} + A_{P}\frac{\cos(\Delta m_{d(s)}t)}{\cosh(\Delta\Gamma_{d(s)}t/2)}$$

Final state CP asymmetry

Final state detection asymmetry

Production asymmetry multiplied by an osciallatory term

where $B(t)$ stands for $B^0_{(s)}$ and $\bar{B}^0_{(s)}$.



A_P as a function of p_T and η

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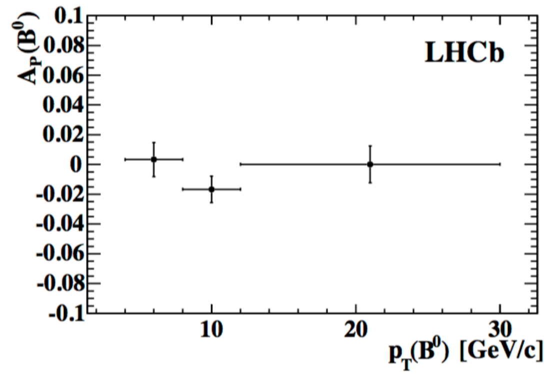
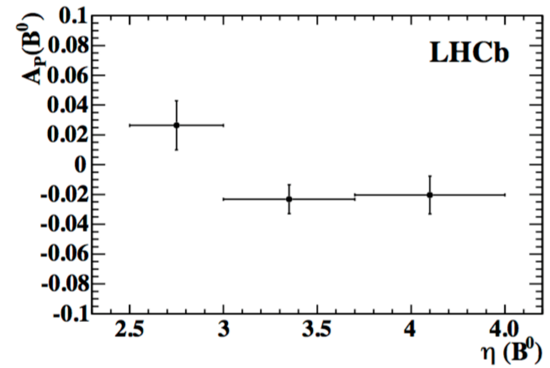
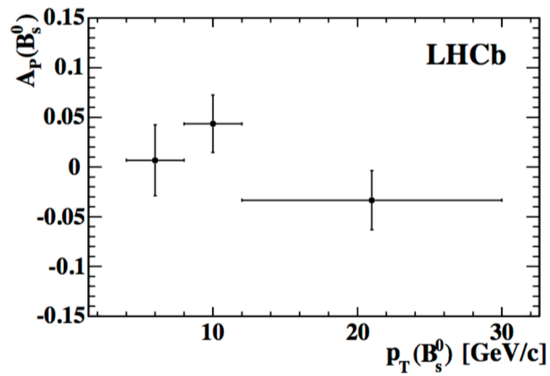
- Production asymmetry measured as a function of p_T and η
  - No visible trend within current precision

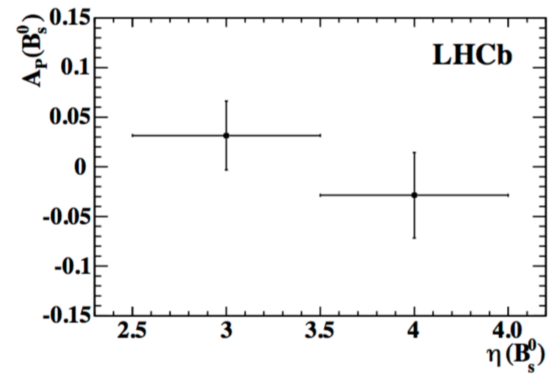
Variable	Bin	$A_P(B^0)$
p_T (GeV/c)	(4, 7)	$0.0033 \pm 0.0111 \pm 0.0028$
	(7, 12)	$-0.0167 \pm 0.0084 \pm 0.0028$
	(12, 30)	$0.0001 \pm 0.0130 \pm 0.0029$
η	(2.5, 3.0)	$0.0264 \pm 0.0161 \pm 0.0030$
	(3.0, 3.7)	$-0.0232 \pm 0.0093 \pm 0.0028$
	(3.7, 4.5)	$-0.0203 \pm 0.0125 \pm 0.0021$





Variable	Bin	$A_P(B^0_s)$
p_T (GeV/c)	(4, 8)	$0.0069 \pm 0.0351 \pm 0.0067$
	(8, 12)	$0.0435 \pm 0.0283 \pm 0.0039$
	(12, 30)	$-0.0334 \pm 0.0296 \pm 0.0038$
η	(2.5, 3.5)	$0.0315 \pm 0.0342 \pm 0.0060$
	(3.5, 4.5)	$-0.0286 \pm 0.0412 \pm 0.0088$





Results

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- LHCb has measured the $B^0_{(s)}$ meson production asymmetry integrated in the range $0 < p_T < 30$ GeV/c and $2.5 < \eta < 4.5$:

$$A_P(B^0) = -0.0035 \pm 0.0076\,(\text{stat}) \pm 0.0028\,(\text{syst})$$
$$A_P(B^0_s) = \quad 0.0109 \pm 0.0261\,(\text{stat}) \pm 0.0061\,(\text{syst})$$

- **No evidence of a dependence** of production asymmetries on p_T and η within current precision
- Update of this analysis **is ongoing**
  - Change binning from (p_T,η) to (p_T,y)
  - Increase statistics by adding 2012 data ($\mathcal{L}$ = 2.0fb^{-1} collected at $\sqrt{s}$ = 8 TeV)
- Measure also the B^+ production asymmetry using $B^+ \to J/\psi(\mu^+\mu^-)K^+$ events
- Together with $A_P(B^0)$ and $A_P(B^0_s)$ this measurement will allow **to calculate $A_P(\Lambda^0_b)$ by means of a unitarity relation**