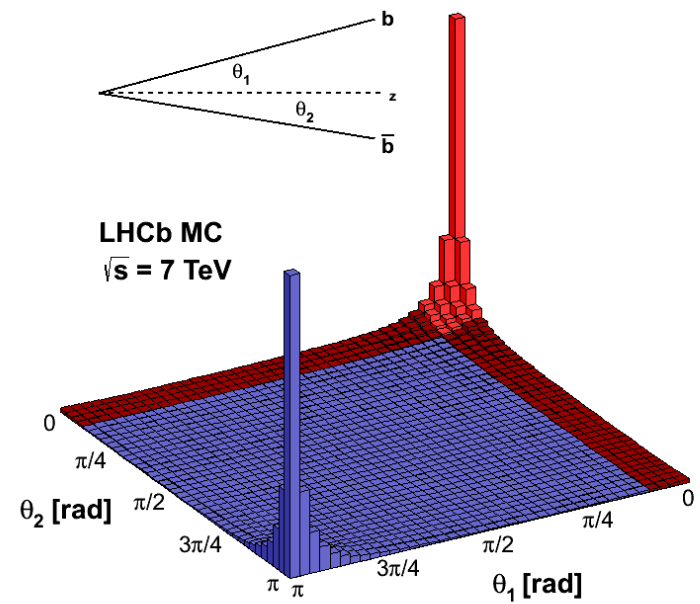
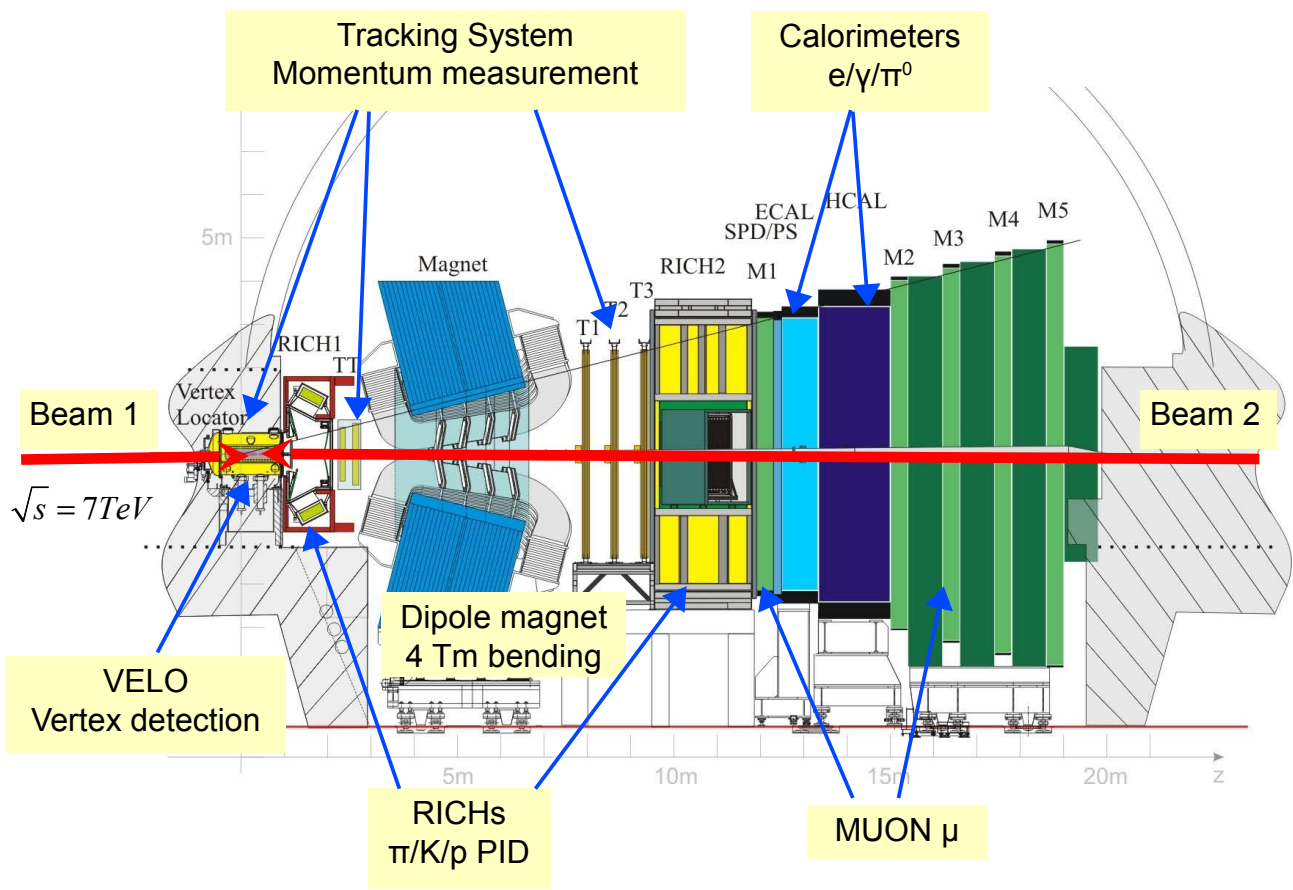


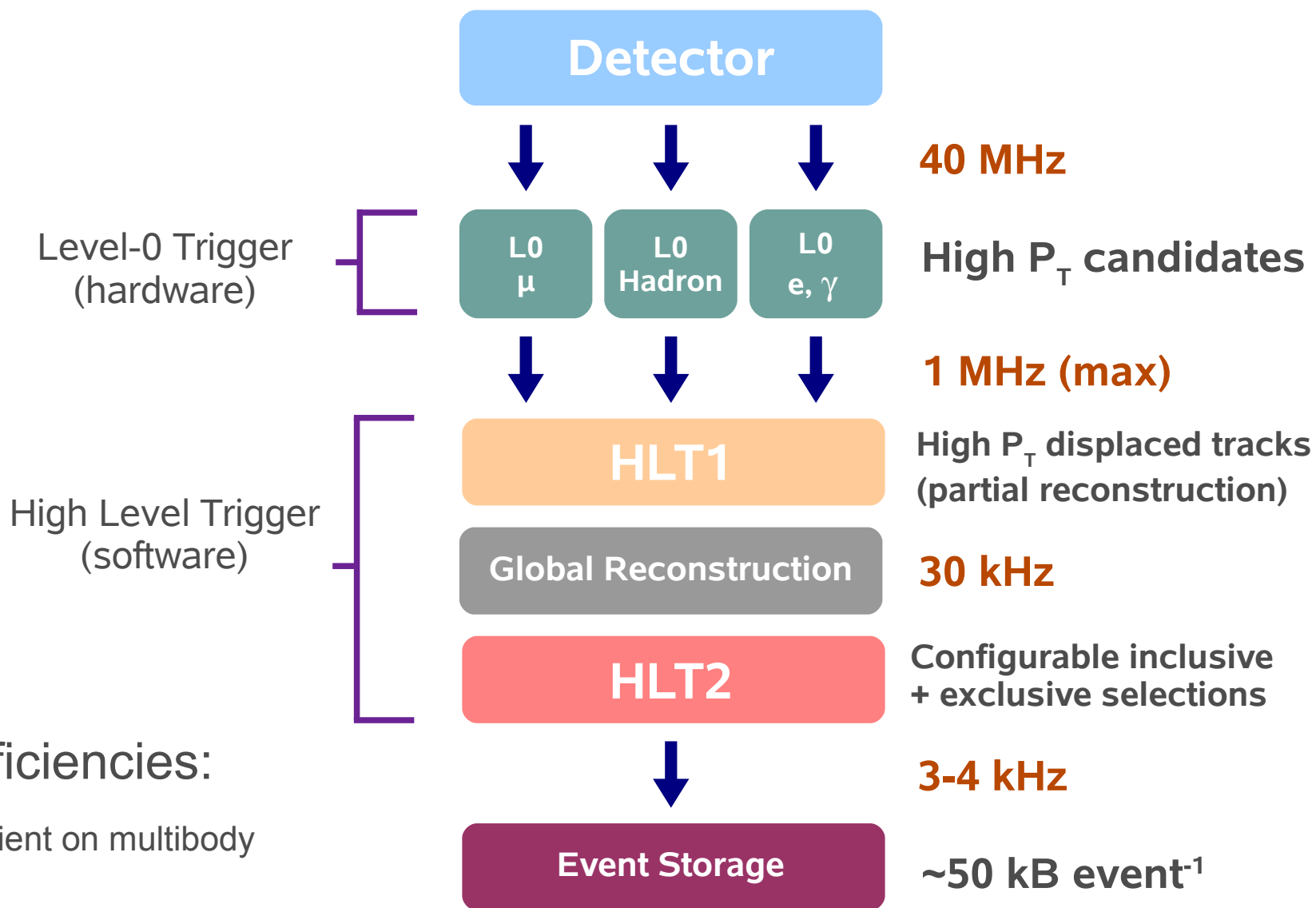
Hadronic Charmless B Decays

David Dossett – University of Warwick

On behalf of the LHCb Collaboration

- B hadron (and charm) production occurs in the very forward or backward regions.
- Single arm spectrometer in the forward (positive z) region.





Trigger Efficiencies:

- $\sim 30\%$ efficient on multibody hadronic
- $\sim 90\%$ efficient for dimuons

Recorded $\sim 1\text{fb}^{-1}$ in 2011

Charmless Charged 2-Body Decays $B_{d,s} \rightarrow h^+ h^-$

- Several different diagrams contribute to each decay amplitude, including...

- Tree (T)
- Strong and Electroweak Penguin (P, P_{EW}^C)
- Penguin Annihilation (PA)
- Exchange (E)

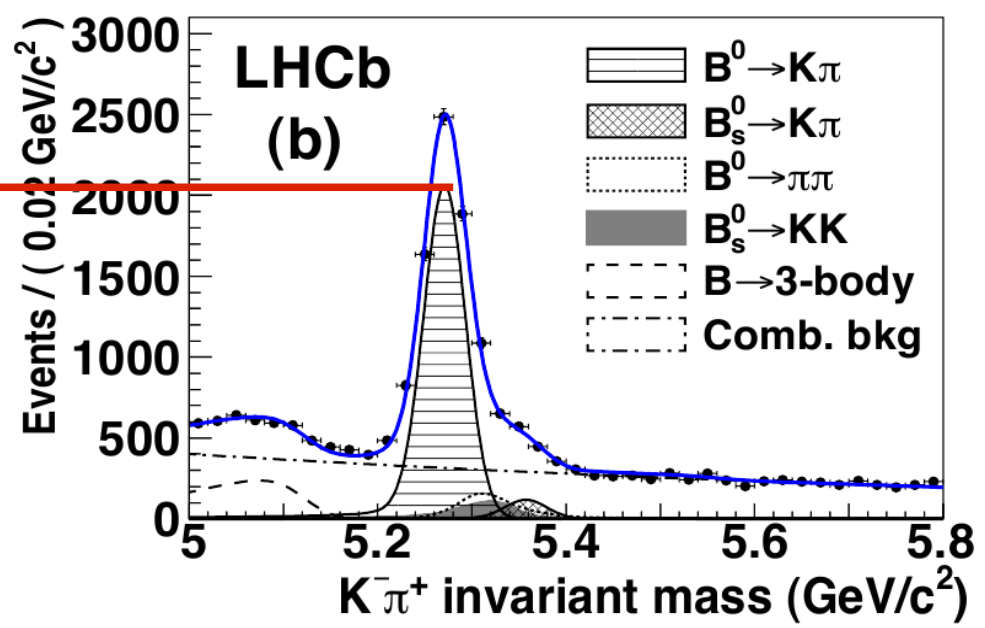
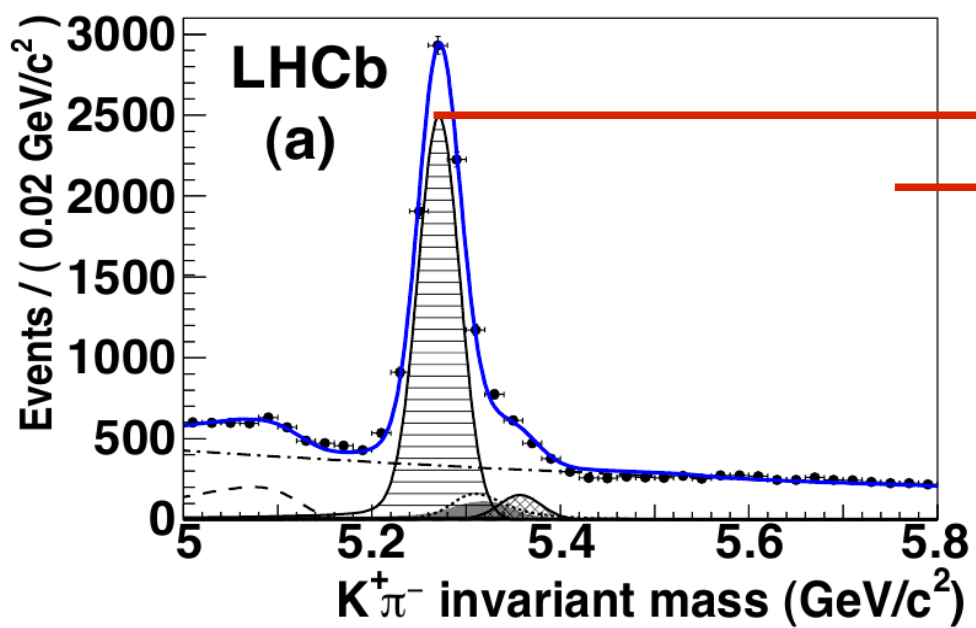
Decay mode	Contributing diagrams
$B^0 \rightarrow \pi^+ \pi^-$	T, P, PA, P_{EW}^C, E
$B^0 \rightarrow K^+ \pi^-$	T, P, P_{EW}^C
$B_s^0 \rightarrow \pi^+ K^-$	T, P, P_{EW}^C
$B_s^0 \rightarrow K^+ K^-$	T, P, PA, P_{EW}^C, E
$B^0 \rightarrow K^+ K^-$	PA, E
$B_s^0 \rightarrow \pi^+ \pi^-$	PA, E

- Gives test of U-spin symmetry ($d \leftrightarrow s$) since in the case of negligible annihilation contributions for $K\pi$ modes

$$A_{\pi\pi}^{dir} \approx A_{CP}(B_s \rightarrow \pi K) \qquad A_{KK}^{dir} \approx A_{CP}(B^0 \rightarrow K\pi)$$

Direct CP Asymmetry in $B^0 \rightarrow K\pi$

$\int Ldt = 0.35 \text{ fb}^{-1}$ \longrightarrow ~ 13000 candidates



arXiv:1202.6251 (accepted by PRL)

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

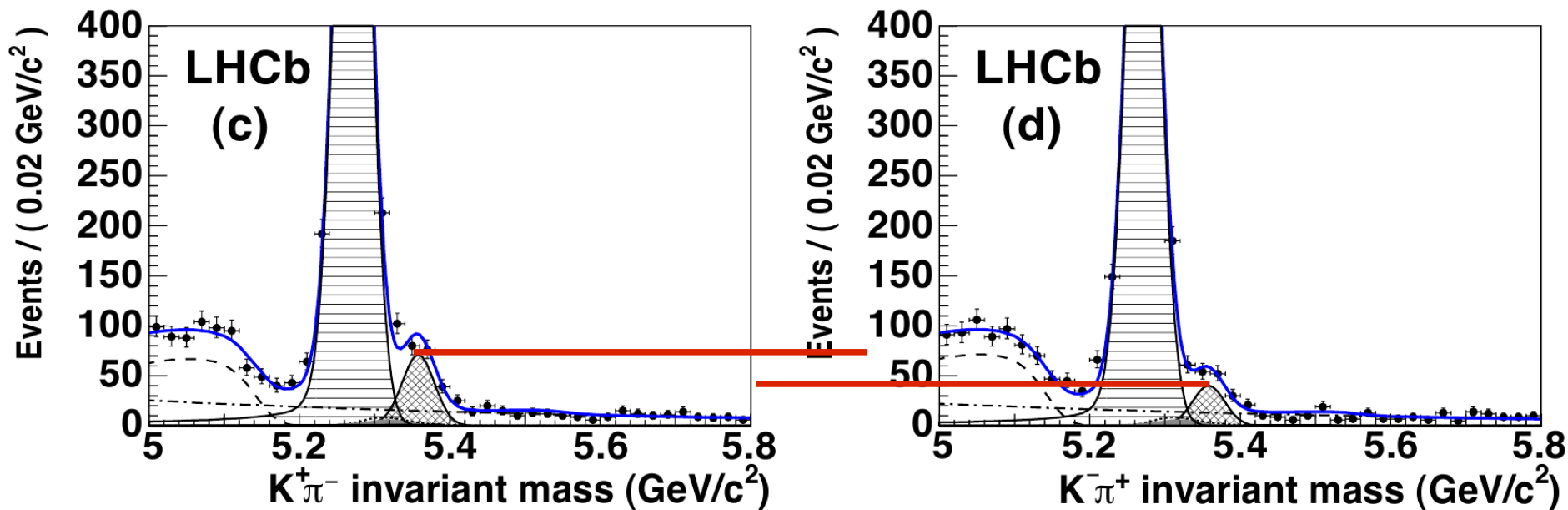
World's most precise measurement ($>6\sigma$)

In agreement with HFAG world average:

$$A_{CP}^{HFAG}(B^0 \rightarrow K\pi) = -0.098^{+0.012}_{-0.011}$$

Direct CP Asymmetry in $B_s \rightarrow K\pi$

$\int Ldt = 0.35 \text{ fb}^{-1}$ \longrightarrow ~ 300 candidates



arXiv:1202.6251 (accepted by PRL)

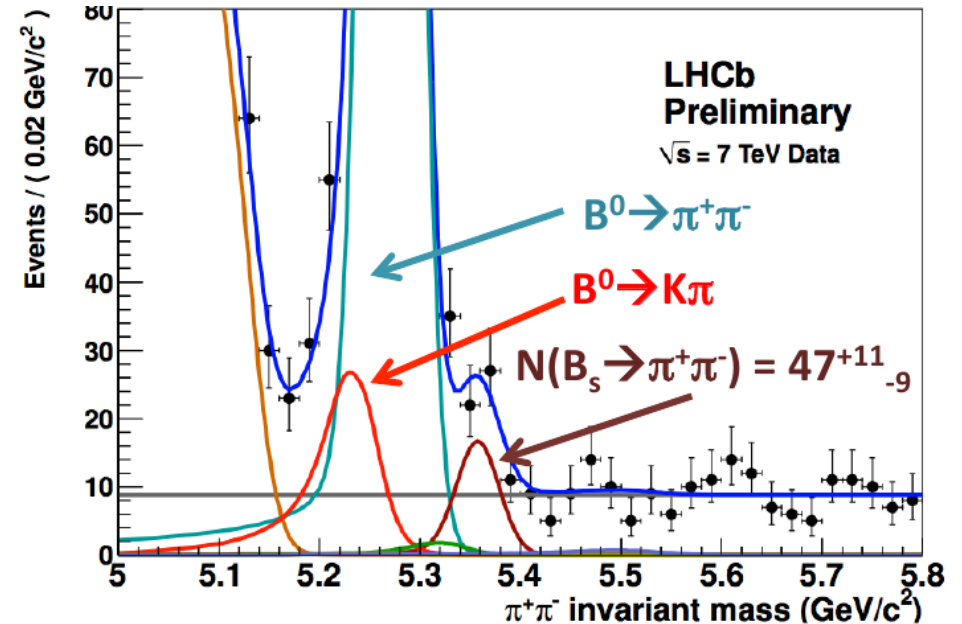
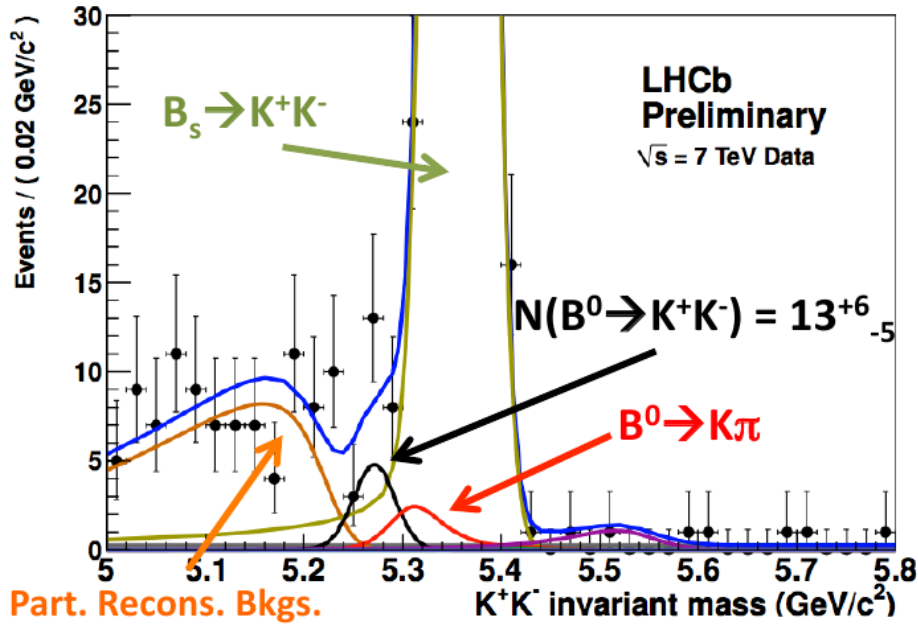
LHCb: $A_{CP}(B_s^0 \rightarrow K\pi) = 0.27 \pm 0.08 \text{ (stat)} \pm 0.02 \text{ (syst)}$

CDF: $A_{CP}(B_s^0 \rightarrow K^- \pi^+) = +0.39 \pm 0.15 \text{ (stat)} \pm 0.08 \text{ (syst)}$

[Phys. Rev. Lett. 106 (2011) 181802]

**First evidence of direct CP violation in B_s system
(3.3σ)**

LHCb-CONF-2011-042 $\int Ldt = 0.32 \text{ fb}^{-1}$

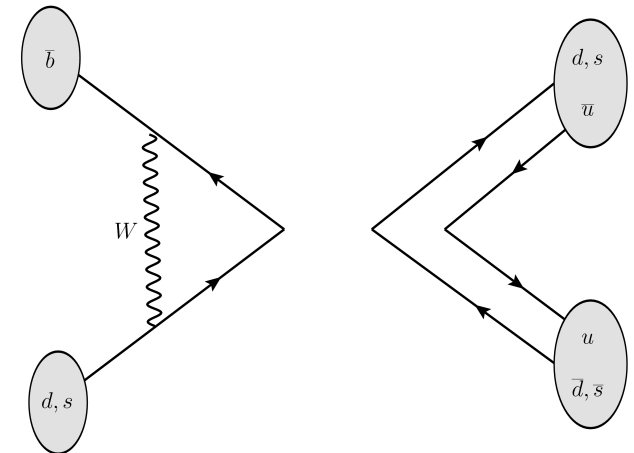


LHCb Preliminary

$$BR(B^0 \rightarrow K^+ K^-) = (0.13_{-0.05}^{+0.06} \pm 0.07) \times 10^{-6}$$

$$BR(B_s^0 \rightarrow \pi^+ \pi^-) = (0.98_{-0.19}^{+0.23} \pm 0.11) \times 10^{-6}$$

First observation of $B_s \rightarrow \pi^+ \pi^-$ (5.3σ)

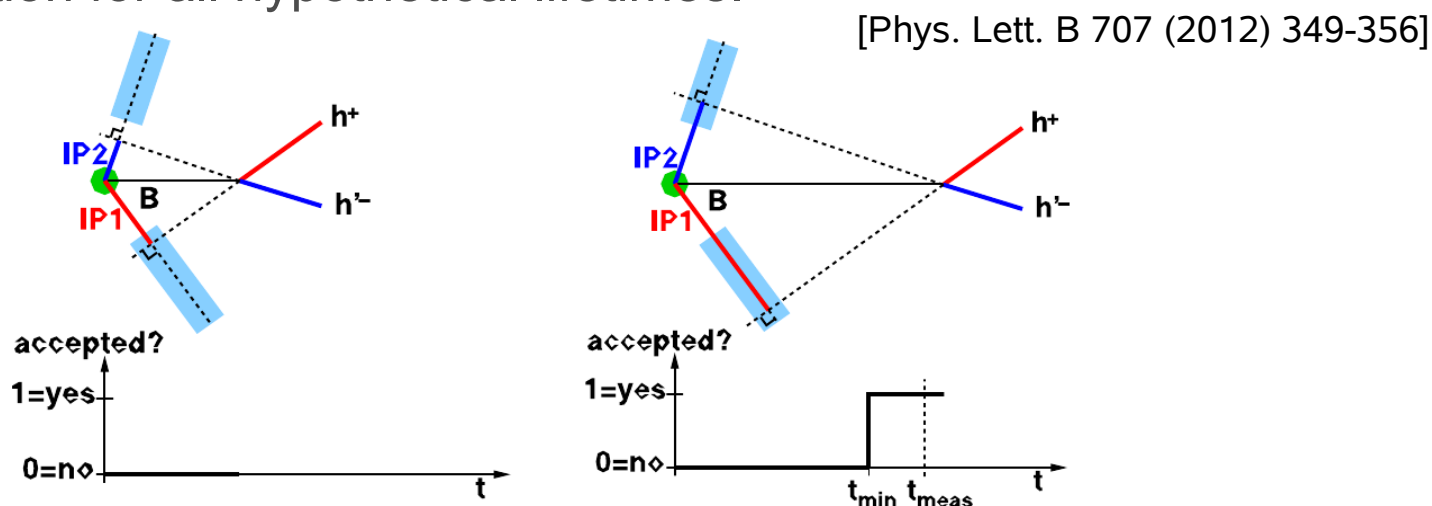


- Untagged decay time distribution given by

$$\Gamma(t) \propto (1 - \mathcal{A}_{\Delta\Gamma_s})e^{-\Gamma_L t} + (1 + \mathcal{A}_{\Delta\Gamma_s})e^{-\Gamma_H t} \quad \mathcal{A}_{\Delta\Gamma_s} = 0.97^{+0.014}_{-0.009}$$

- Selecting the events causes a lifetime bias. Two methods used to correct for it.

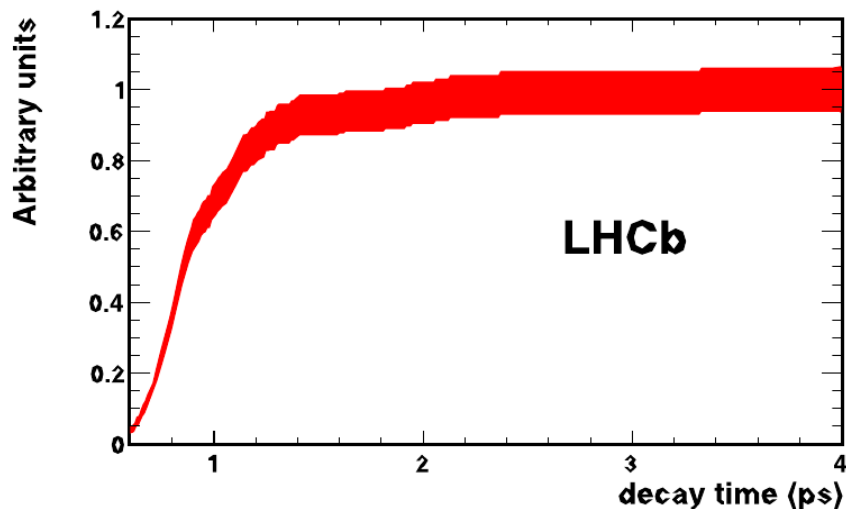
- 1) Correct event by event using an acceptance function from rerunning software trigger+selection for all hypothetical lifetimes.



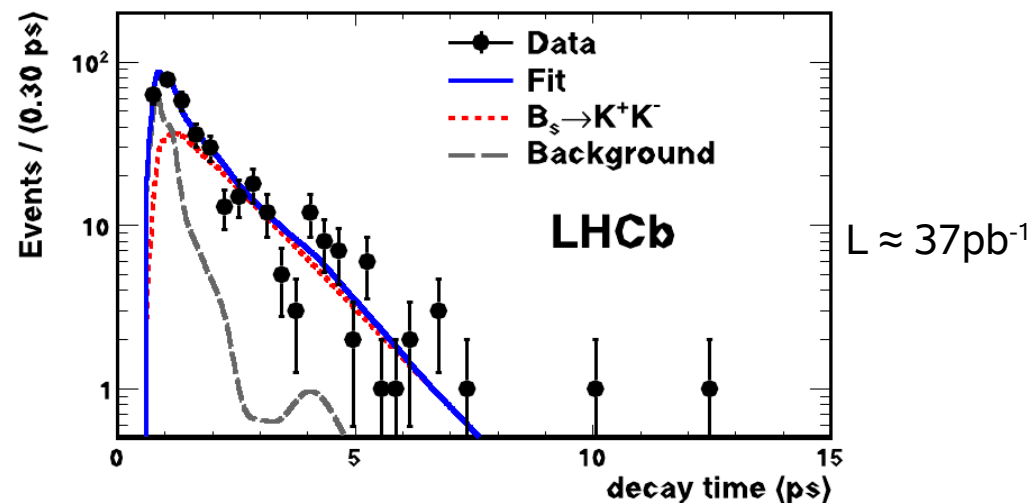
- 2) Measure the lifetime relative to the kinematically similar decay $B^0 \rightarrow K\pi$ to cancel the acceptance bias.

- Results quoted from the absolute lifetime measurement.

[Phys. Lett. B 707 (2012) 349-356]



Average decay time acceptance function with statistical uncertainty.



Fitted decay time distribution for $B_s \rightarrow K^+K^-$.

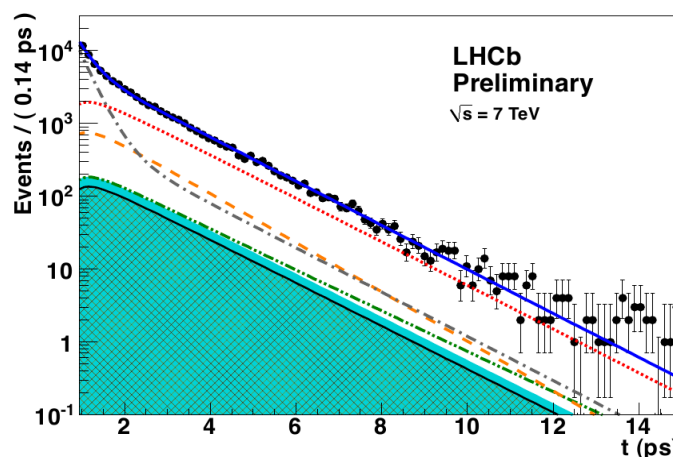
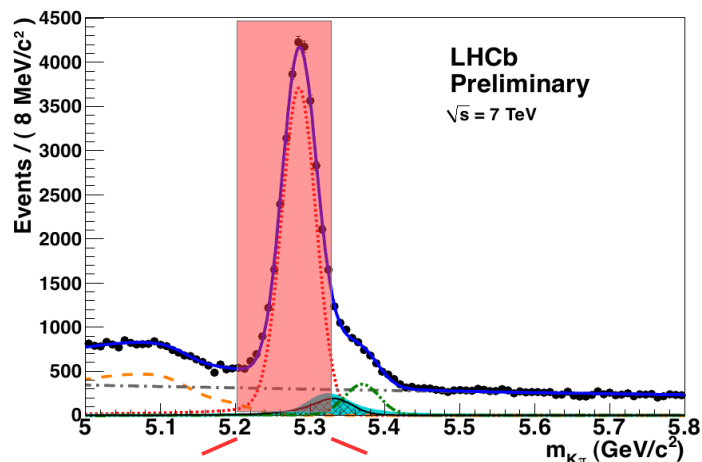
LHCb $\tau_{KK} = 1.440 \pm 0.096$ (stat) ± 0.008 (syst) ± 0.003 (model) ps

CDF preliminary $\tau_{KK} = 1.53 \pm 0.18$ (stat) ± 0.02 (syst) ps CDF note 06-01-26

SM prediction $\tau_{KK} = 1.390 \pm 0.032$ ps

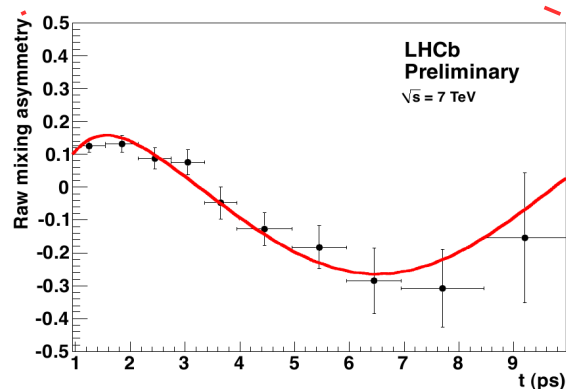
- Results are consistent with SM prediction.

- Need to determine the production flavour of the b quark before oscillation \rightarrow Tagged analysis
- $K\pi$ mode used to determine tagging performance for the KK and $\pi\pi$ modes.



$$\int L dt = 0.69 \text{ fb}^{-1}$$

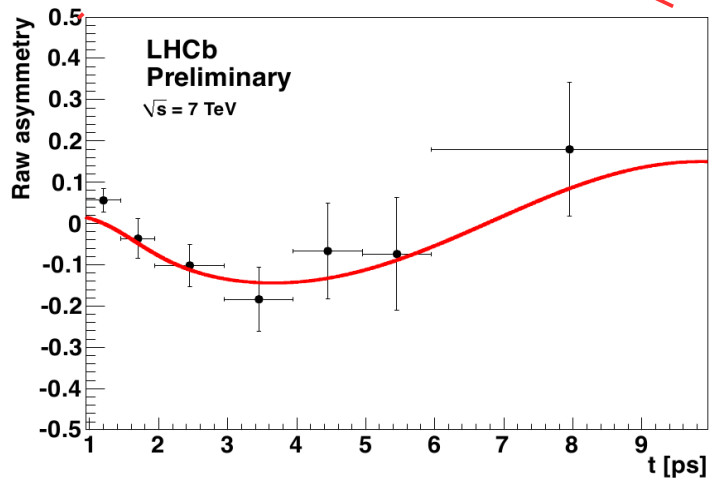
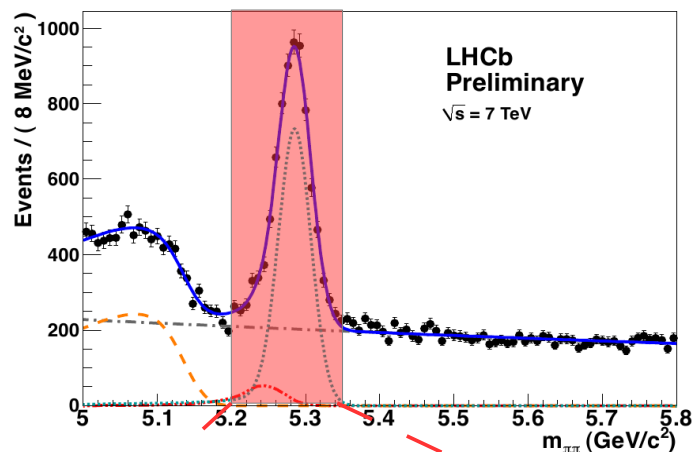
LHCb-CONF-2012-007



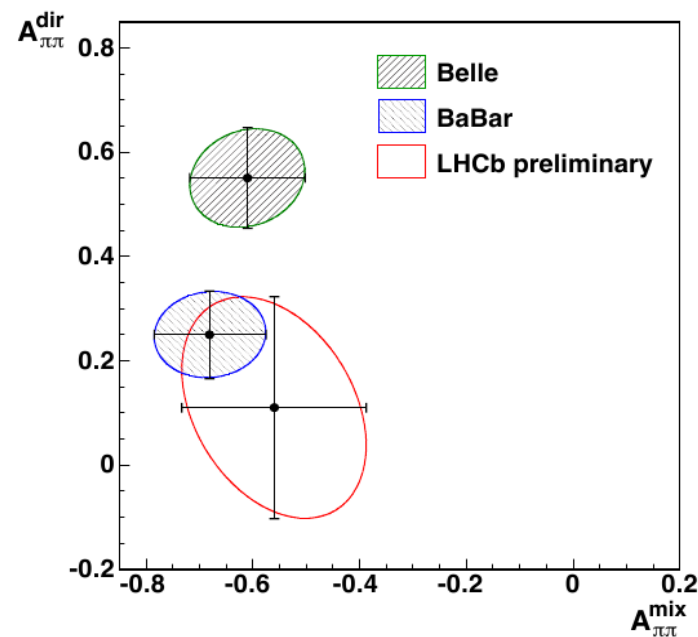
- Asymmetric mass window used to exclude the fast oscillating B_s .

Time Dependent CP Violation in $B^0 \rightarrow \pi^+\pi^-$

$$\int L dt = 0.69 \text{ fb}^{-1}$$



LHCb-CONF-2012-007



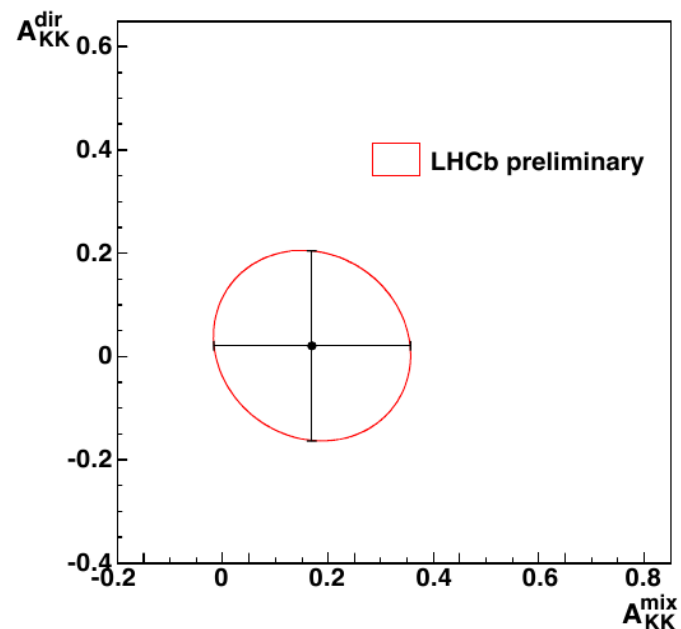
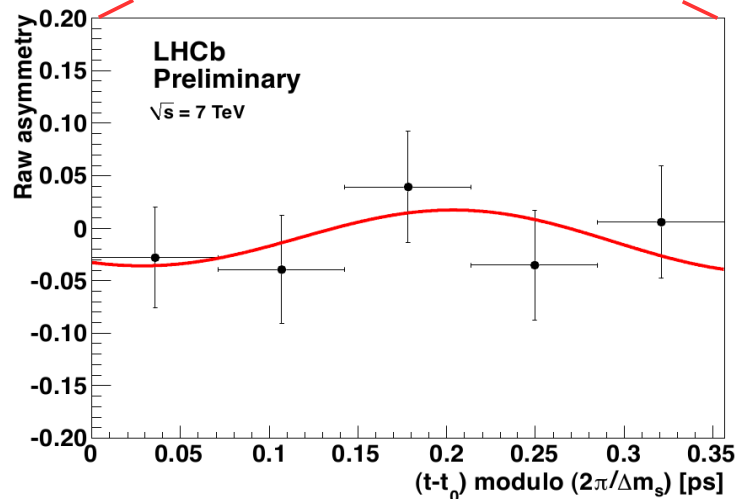
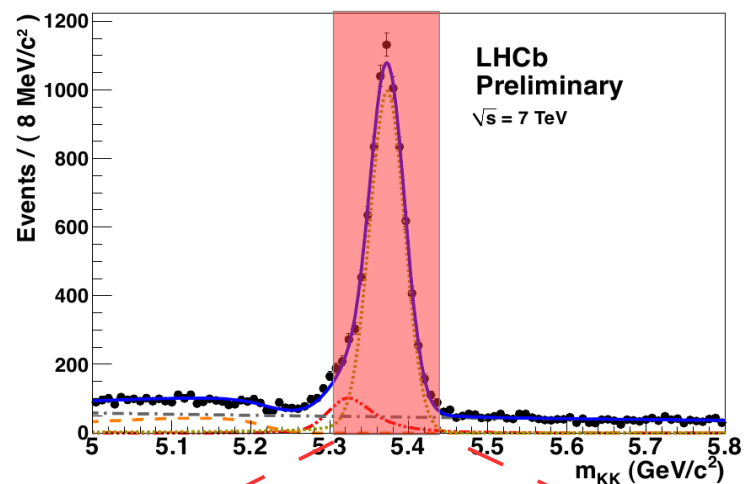
$$A_{\pi\pi}^{\text{dir}} = 0.11 \pm 0.21 \pm 0.03$$

$$A_{\pi\pi}^{\text{mix}} = -0.56 \pm 0.17 \pm 0.03$$

LHCb
Preliminary

- Results compatible with previous measurements.
- First evidence of mixing induced CP violation at a hadron collider (3.2σ)

$$\int L dt = 0.69 \text{ fb}^{-1}$$



$$A_{KK}^{\text{dir}} = 0.02 \pm 0.18 \pm 0.04$$

$$A_{KK}^{\text{mix}} = 0.17 \pm 0.18 \pm 0.05$$

LHCb
Preliminary

**First measurement of $B_s \rightarrow K^+K^-$
time dependent CP asymmetries.**

LHCb-CONF-2012-007

- World's most precise measurement of direct CP asymmetry in $B^0 \rightarrow K^+\pi^-$ and first evidence of direct CP asymmetry in the B_s sector.
- First observation of $B_s \rightarrow \pi^+\pi^-$ (5.3σ).
- Measurement of the $B_s \rightarrow K^+K^-$ effective lifetime.
- Measurement of time dependent CP asymmetry in $B^0 \rightarrow \pi^+\pi^-$ and first measurement of time dependent CP asymmetry in $B_s \rightarrow K^+K^-$.
- Vector analyses $B_s \rightarrow K^{0*}K^{0*}$ [Phys. Lett. B 709 (2012) 50-58] and $B_s \rightarrow \varphi\varphi$ [arXiv:1204.2813] not discussed here but are important results.
- Updating measurements with the full 2011 dataset.
- 3-body mode analyses are also coming soon/available.
- Expecting $\sim 1.5\text{fb}^{-1}$ of 8TeV data in 2012.