



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Search for $B_{(s)}^0 \rightarrow \pi\pi\mu\mu$ decays at LHCb.

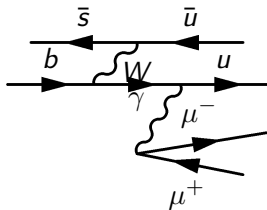
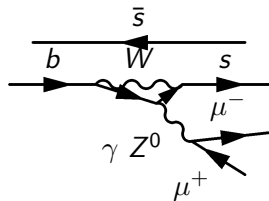
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Motivations

$B \rightarrow \pi\pi\mu\mu$ with $M_{\pi\pi} \in [0.5 - 1.3]$ GeV:

- $B_s^0 \rightarrow f_0\mu^+\mu^-$, $f_0(980)$: 40-100 MeV width
- $B^0 \rightarrow \rho\mu^+\mu^-$, $\rho(770)$: 150 MeV width
- Both not observed yet
- Sensitive to new physics
- Large uncertainties on predictions



$\text{Br}(B_s^0 \rightarrow f_0\mu^+\mu^-)$	Ref.
$(5.21^{+3.23}_{-2.06}) \times 10^{-7}$	[ARXIV:0811.2648]
$(9.5^{+3.1}_{-2.6}) \times 10^{-8}$	[ARXIV:1002.2880]
$(1.67 \pm 0.61) \times 10^{-7}$	[ARXIV:1002.2880]
$(0.81 - 2.02) \times 10^{-8}$	[PhysRevD81,016012]
$(0.63 - 3.37) \times 10^{-9}$	[PhysRevD81,016012]

Brief overview

Observable to measure

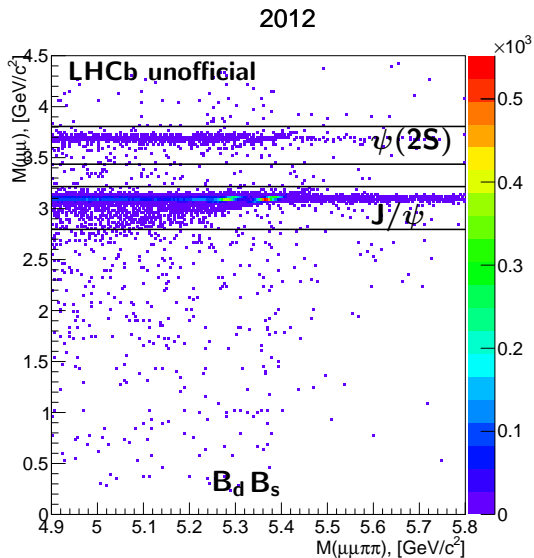
$$R = \frac{Br(B_{(s)}^0 \rightarrow \pi\pi\mu\mu)}{Br(B^0 \rightarrow J/\psi K^*)} = \frac{N_{B_{(s)}^0 \rightarrow \pi\pi\mu\mu}}{N_{B^0 \rightarrow J/\psi K^*}} \times \frac{\epsilon_{B^0 \rightarrow J/\psi K^*}}{\epsilon_{B_{(s)}^0 \rightarrow \pi\pi\mu\mu}} \left(\times \frac{f_s}{f_d} \right)$$

Extracted from the fit to data

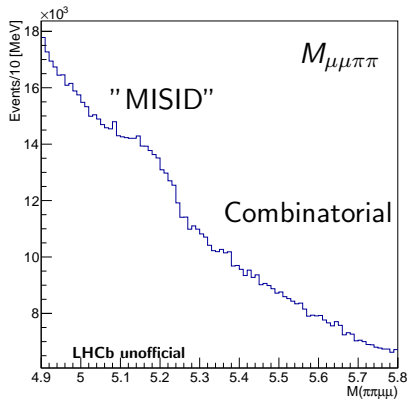
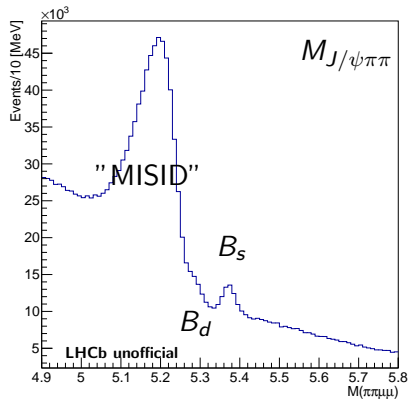
Obtained from MC studies

External input [HFAG]

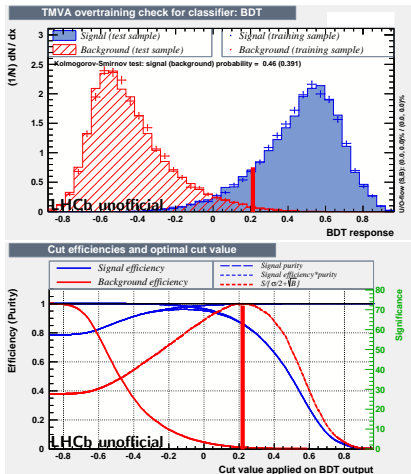
Dimuon spectrum



After pre-selection

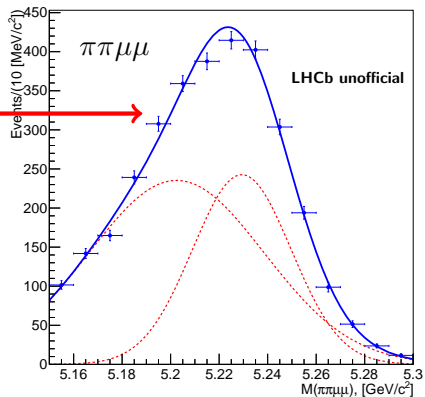
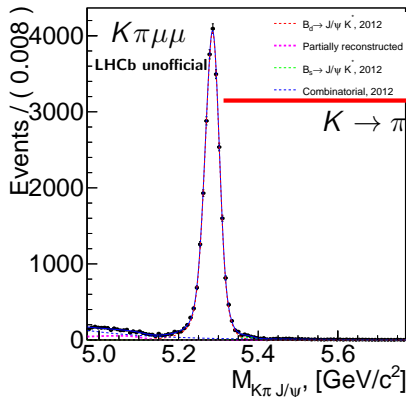


BDT optimisation

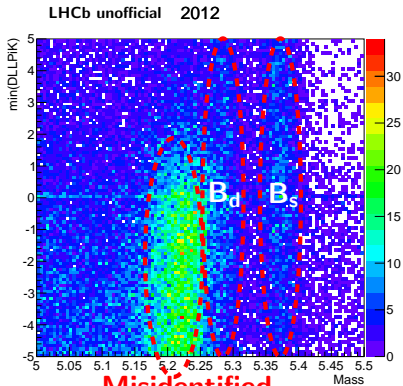
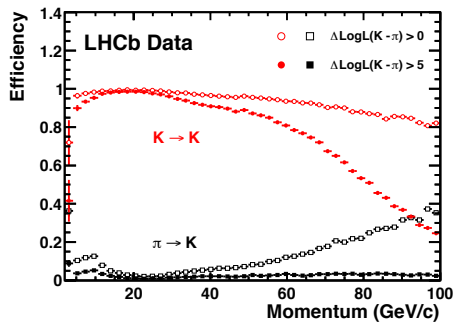


- Kinematic variables to distinguish signal and combinatorial
- Optimize figure of merit toward observation:
$$\frac{\epsilon}{(\sigma/2 + \sqrt{B})}$$
- Two independent BDTs for 2011 and 2012.

Misidentified background



Misidentified background suppression



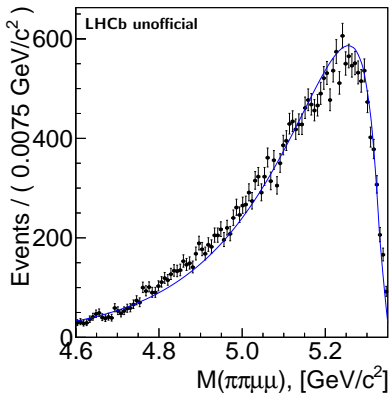
Other backgrounds

Small (≤ 10 ev. expected):

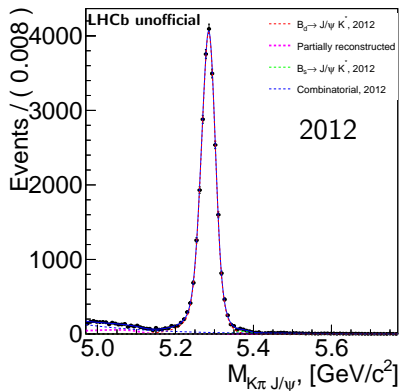
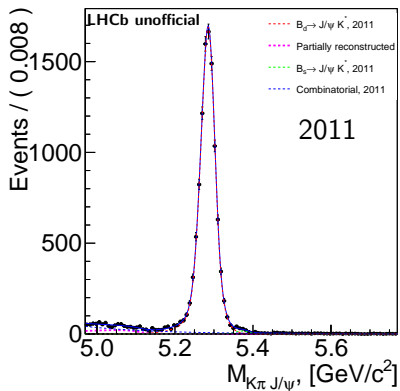
- $B_s \rightarrow \eta^{(\prime)}(\rightarrow \pi\pi\gamma)\mu\mu$
- $B_s \rightarrow \phi(\rightarrow \pi\pi\pi)\mu\mu$
- $B^+ \rightarrow K(+\pi)\mu\mu$

Negligible:

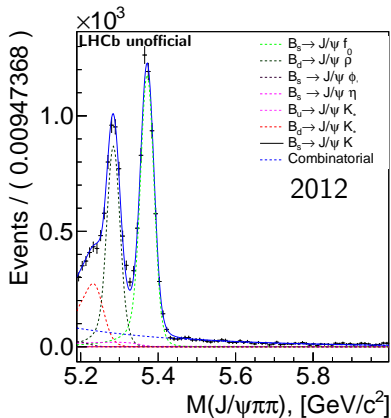
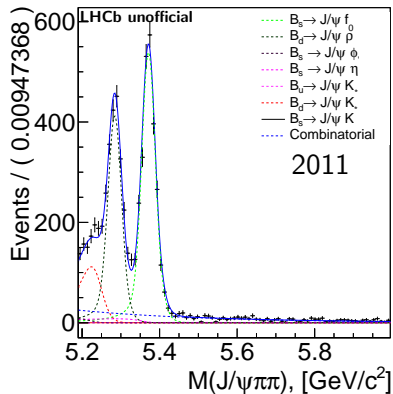
- $B^0 \rightarrow D^-(\rightarrow \rho\mu^- X)\mu + X.$
- $B^0 \rightarrow D^-(\rightarrow \phi(\rightarrow \mu\mu)\pi)\pi$
- $B^0 \rightarrow J/\psi\omega(\rightarrow \pi\pi\pi)$
- Double mis-ID $B_s^0 \rightarrow J/\psi f_0$ events
- $\Lambda_b^0 \rightarrow hh\mu\mu$
- $B_s \rightarrow J/\psi(\rightarrow \gamma\mu\mu)f_0$



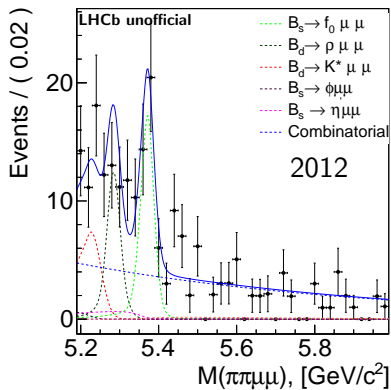
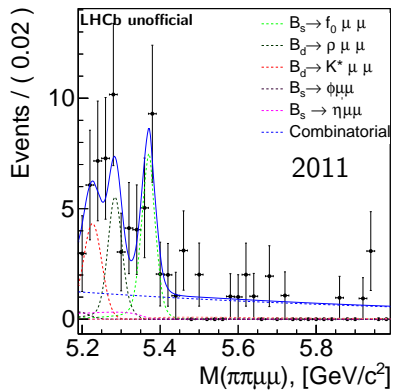
Normalisation: Fit of $B^0 \rightarrow J/\psi K^*$



Resonant sample.

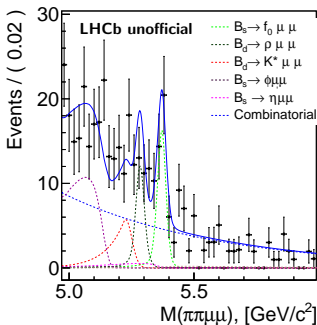
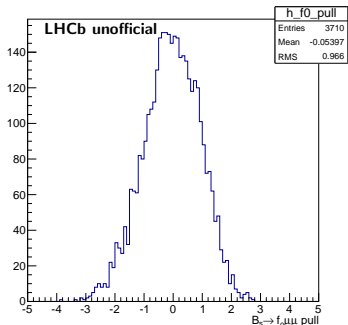


Signal sample.



Finger polish

- Toy studies - to ensure unbiased results and proper coverage
- Sanity checks (fit with different models, sample splitting, etc.)
- Even more tests to check stability of results...
- Study of systematics



Conclusions

- Both decays are observed, *but analysis is still preliminary*.
- Branching ratios are measured. Uncertainties are statistically dominated, $\sigma(R)/R \sim 30\%$.
- Systematic uncertainties are $\sigma^{\text{sys}}(R)/R \sim 15\%$.
- Publication in preparation.

Backup

2011+2012 mass distribution

