First observation of $B^+ \to \pi^+ \mu^+ \mu^-$ with LHCb

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INTRODUCTION

- Many $b \to s \mu \mu$ processes have been observed, but no $b \to d \mu \mu$
- $B^+ \to \pi^+ \mu^+ \mu^-$ would be the first $b \to d \mu \mu$
  process observed
- BR can be enhanced by new physics, even with $b \to s \mu \mu$ constraints
- CKM-suppressed cousin to $B^+ \to K^+ \mu^+ \mu^-$
- Background from misidentified $B^+ \to K^+ \mu^+ \mu^-$ events
- SM prediction: $\text{BR}(B^+ \to \pi^+ \mu^+ \mu^-) = (1.96 \pm 0.21) \times 10^{-8}$
- Best limit: $\text{BR}(B^+ \to \pi^+ \mu^+ \mu^-) < 6.9 \times 10^{-8}$ (90 % confidence), from BELLE
- Analysis documented in LHCb-CONF-2012-006

FIT VALIDATION

- Validate fit on $B^+ \to J/\psi \pi^+$

RESULTS

- $B^+ \to \pi^+ \mu^+ \mu^-$ yield of $25.3^{+6.7}_{-6.4}$ extracted from the fit
- $5.2 \sigma$ significance
- $\text{BR}(B^+ \to \pi^+ \mu^+ \mu^-) = (2.4 \pm 0.6 \text{ (stat)} \pm 0.2 \text{ (syst)}) \times 10^{-8}$
  (all results preliminary)
- Rarest B decay observed

SELECTION

- Entire 2011 dataset used, 1.0 $fb^{-1}$
- Use BDT to reject combinatorial background
- Selection trained on $B^+ \to \pi^+ \mu^+ \mu^-$ MC signal, portion of data sideband
- Sideband events used for training removed from final analysis

FIT

- Fit used to isolate $B^+ \to \pi^+ \mu^+ \mu^-$ from $B^+ \to K^+ \mu^+ \mu^-$, combinatorial background
- Invariant mass distribution for $B^+ \to \pi^+ \mu^+ \mu^-$ ($B^+ \to K^+ \mu^+ \mu^-$) taken from the $B^+ \to J/\psi K^+$ control sample, under the kaon (pion) mass hypothesis, left and right plots respectively
- The invariant mass distribution is corrected for the differences in phase space between $B^+ \to J/\psi K^+$ and $B^+ \to K^+ \mu^+ \mu^-$, as it has a strong momentum dependence under the wrong mass hypothesis
- Simultaneous fit, with relevant systematics included as constraints

NORMALISATION

- Measure BR relative to $B^+ \to J/\psi K^+$
- Relative efficiencies from simulation, validated on data control sample
- Except for particle identification (PID) efficiencies, from data