Search for New Physics with exclusive electroweak FCNC decays of B(s) mesons

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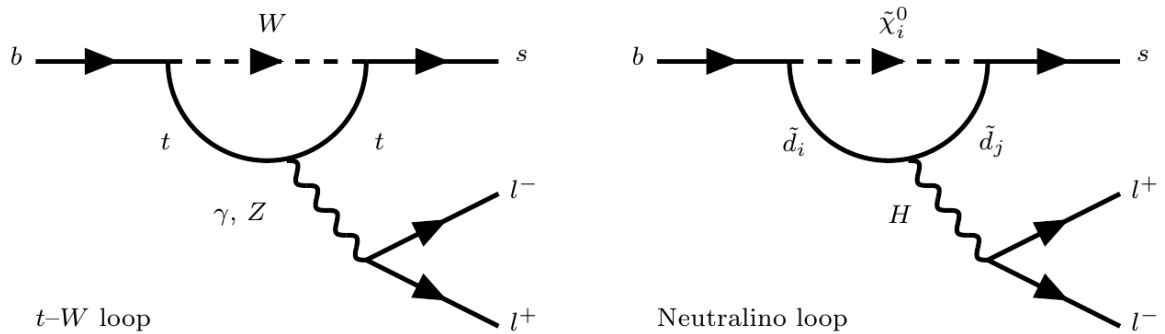
Introduction



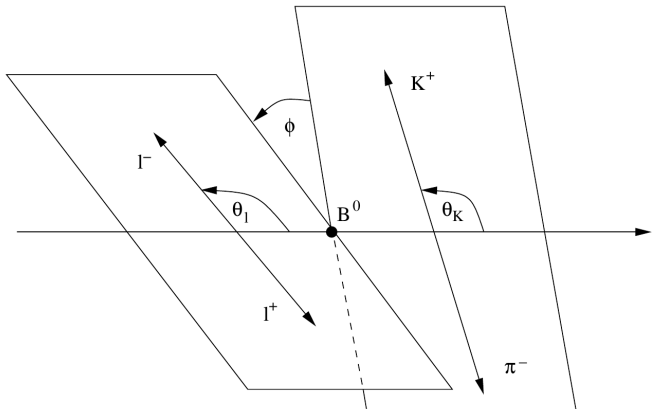
- New particles enter into loop diagrams, if they exist
- Their influence may measurably change observables:
  - Branching fraction (total or differential)
  - Angular distribution
  - CP asymmetry
- Look in processes which only occur at loop level in SM - FCNCs
- Will cover broad range of rare FCNC processes

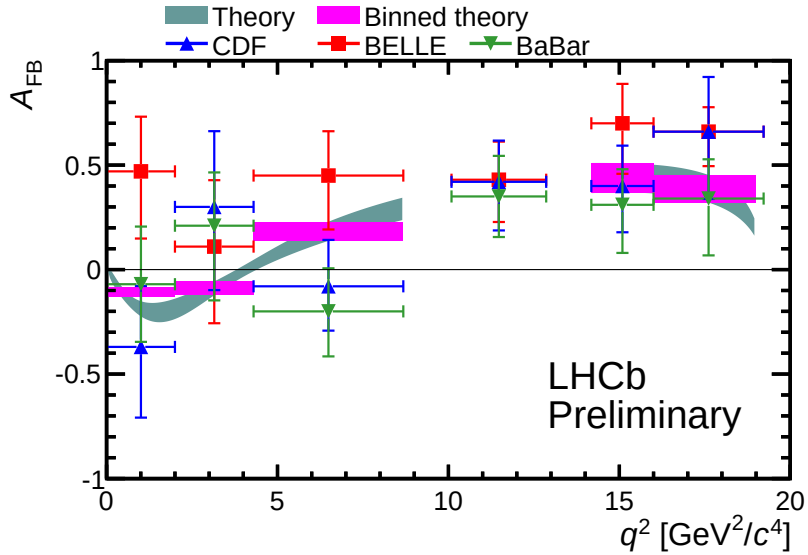
General method

- General selection criteria:
  - B vertex displacement, quality, pointing to primary vertex...
  - Daugther, B impact parameters, P_T..
  - Track quality, PID..
- Events used for selection development not used in final analysis
- Measure $\mathcal{B}$ relative to normalization mode
  - Sensitive only to ratio of efficiencies, reduced systematic uncertainties
  - Use $J/\psi \to \mu^+\mu^-$ modes
- Also use as control channel to estimate systematic uncertainties
- All analyses presented use full 2011 dataset - 1 fb^{-1}

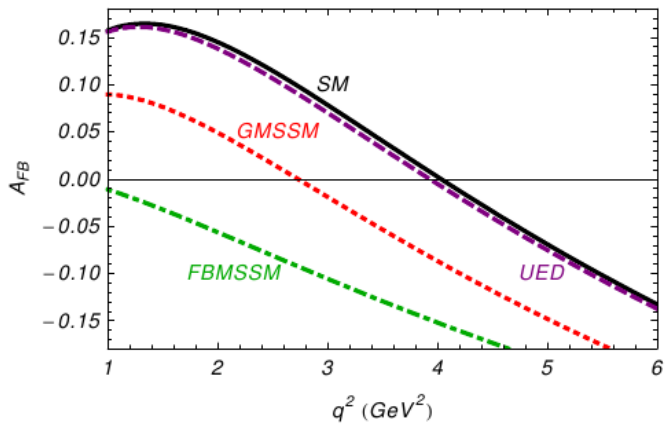
$B^0 \to K^{*0}\mu^+\mu^-$

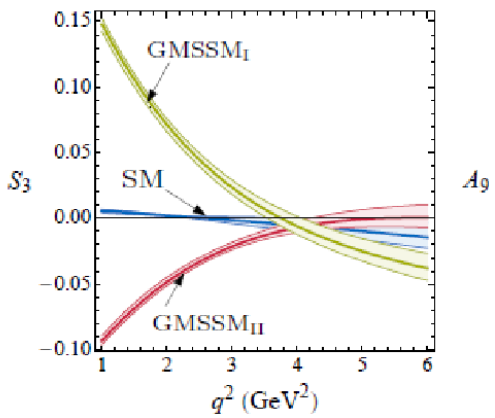
- Angular distribution of $B^0 \to K^{*0}\mu^+\mu^-$ a sensitive test of new physics
- Described by three angles $(\theta_L, \theta_K, \phi)$, with the angular distribution varying with dimuon mass (q^2)
- Can be parameterised in terms of theoretically clean observables, with differing new physics sensitivities
  - A_{FB}, the forward-backward asymmetry
  - F_L, the fraction of K^{*0} longitudinal polarisation
  - $S_3 \propto A_T^2(1 - F_L)$, the asymmetry in K^{*0} transverse polarisation [1]
  - A_{IM}, a T-odd CP asymmetry [2]

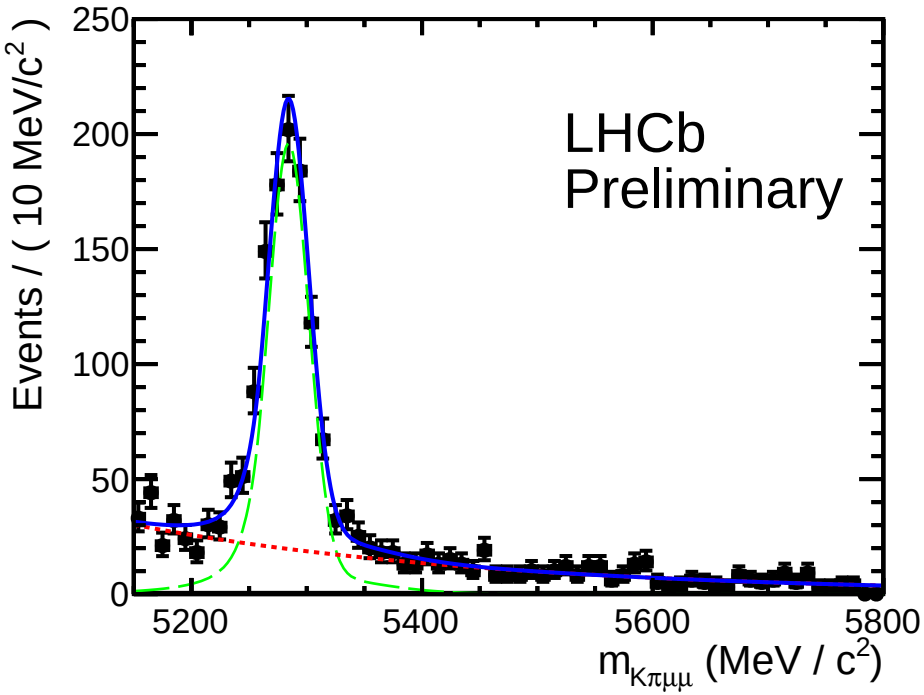




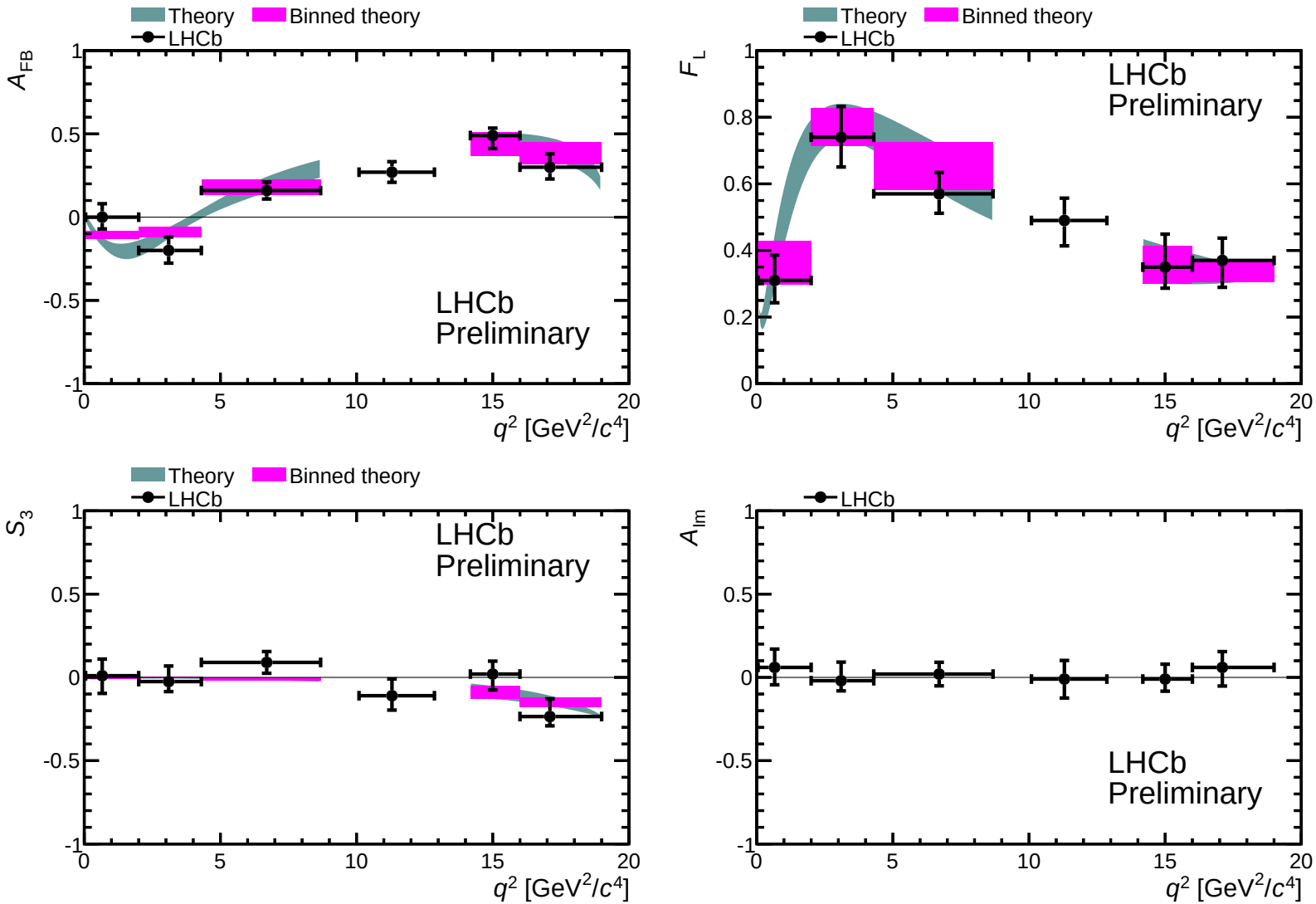
- Previous results from BaBar, Belle, CDF hinted at large deviation in A_{FB} [3, 4, 5]
- Theory predictions shown below for Generic MSSM (GMSSM), Flavour Blind MSSSM (FBMSSM) [6]



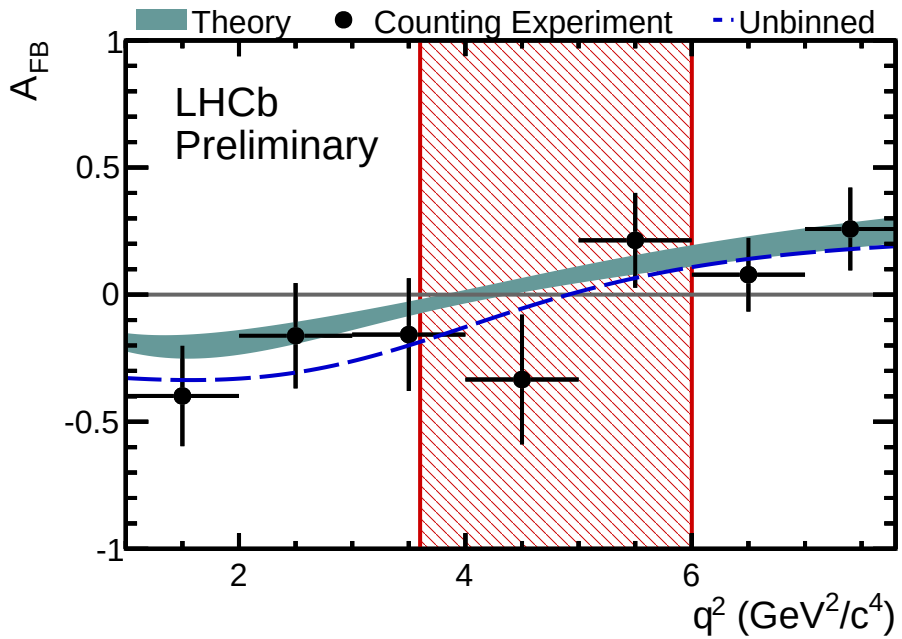




- Combinatorial background suppressed using a BDT selection
- Peaking backgrounds rejected with PID requirements
- 900 ± 34 $B^0 \to K^{*0}\mu^+\mu^-$ candidates
- Correction applied for angular bias arising from detector acceptance, taken from simulation
- Bin in q^2, 4D angular fit (3 angles + B mass)

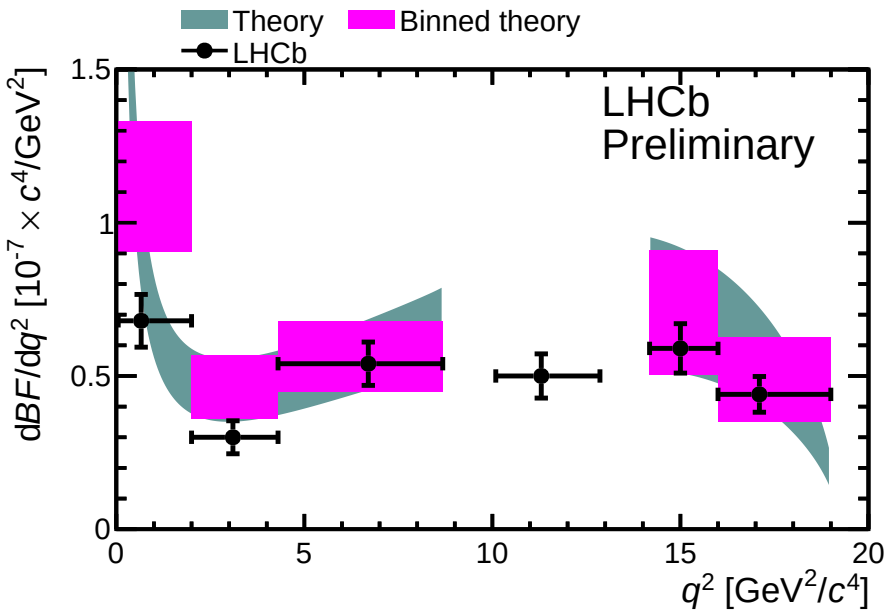


- Most precise measurements to date
- All consistent with SM [7, and references therein]



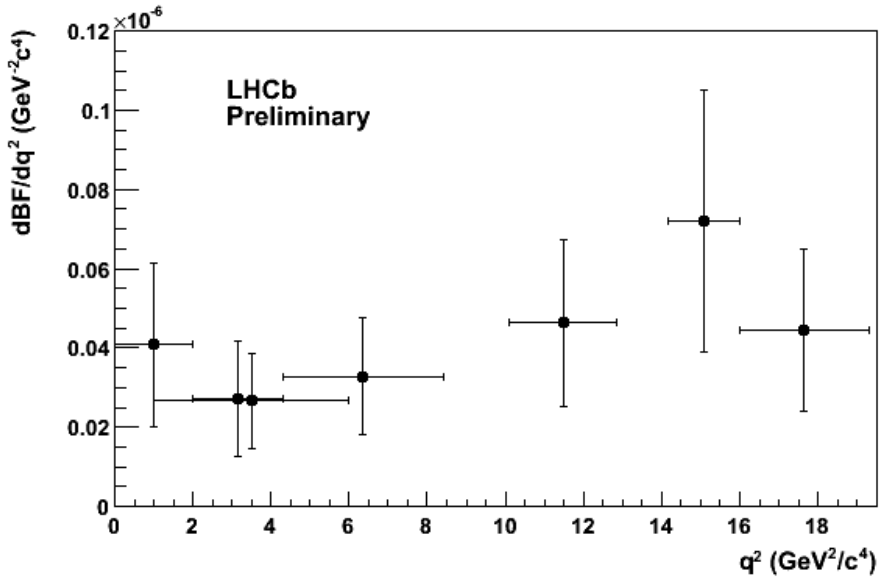
- Zero-crossing point in q^2 of A_{FB} (q_0^2) an especially sensitive observable
- SM predictions range from 4-4.3 GeV^2/c^4 [7, 8, 9]
- World's first measurement made: $q_0^2 = 4.9^{+1.1}_{-1.3}$
- Consistent with SM

- Measurement made of $B^0 \to K^{*0}\mu^+\mu^-$ differential branching fraction



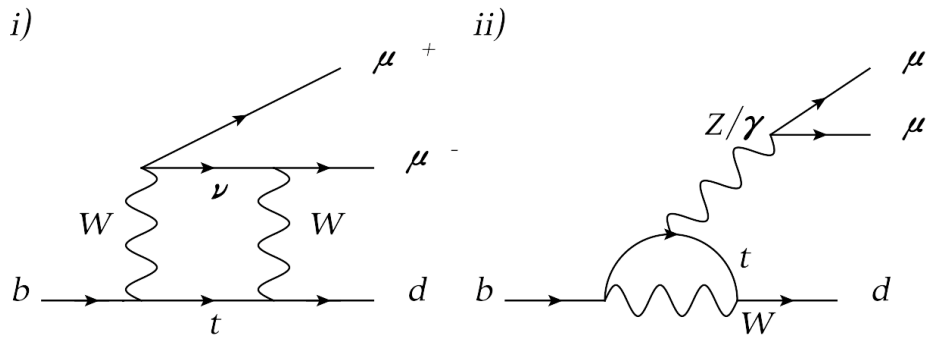
- Consistent with SM predictions [7, and references therein]

$B_s^0 \to \phi\mu^+\mu^-$

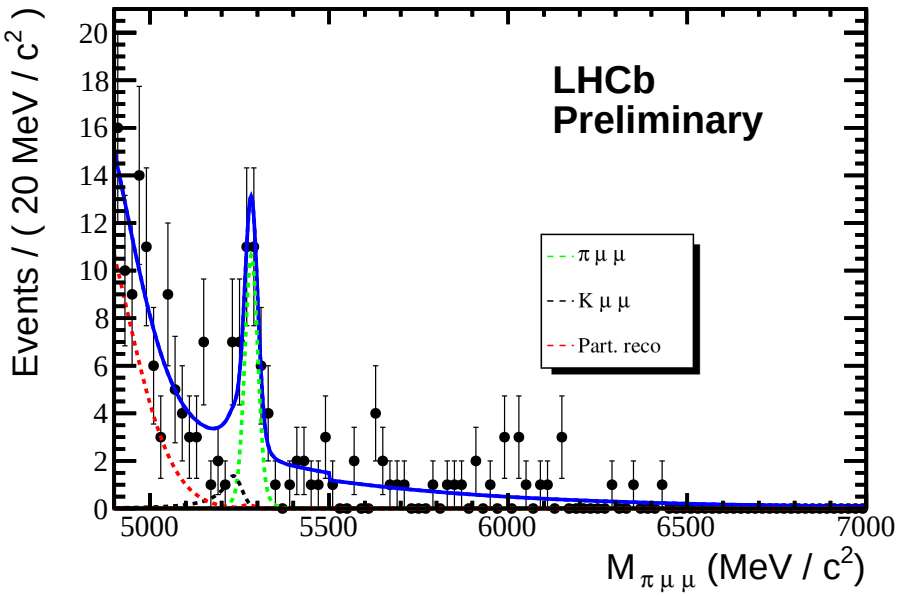


- $B_s^0 \to \phi\mu^+\mu^-$ total and differential branching fractions measured
- $\frac{\mathcal{B}(B_s^0 \to \phi\mu^+\mu^-)}{\mathcal{B}(B_s^0 \to J/\psi\phi)} = 0.558 \pm 0.070(stat.) \pm 0.043(syst.)$
- $\mathcal{B}(B_s^0 \to \phi\mu^+\mu^-) =$
  $(0.78 \pm 0.10(stat.) \pm 0.06(syst.) \pm 0.28(\mathcal{B})) \times 10^{-6}$
- Consistent with SM predictions [10]

$B^+ \to \pi^+\mu^+\mu^-$



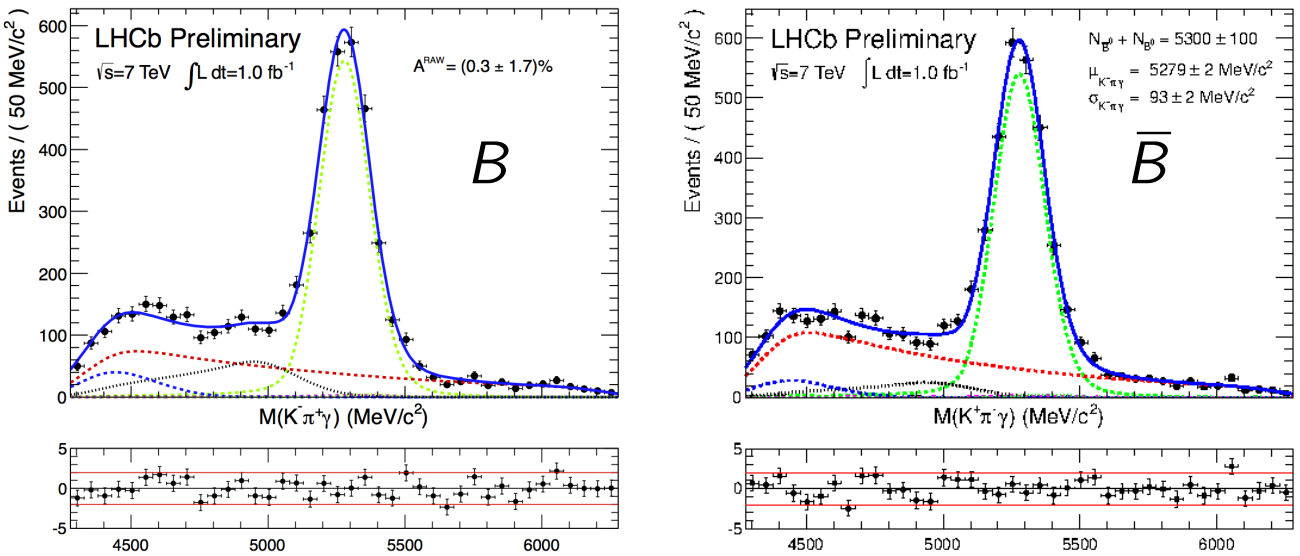
- $B^+ \to \pi^+\mu^+\mu^-$ is a $b \to d\mu^+\mu^-$ transition
  - None previously observed
- CKM suppressed cousin to $B^+ \to K^+\mu^+\mu^-$
- Previous best limit is $< 6.9 \times 10^{-8}$, from BELLE [11]
- SM prediction $(1.96 \pm 0.21) \times 10^{-8}$ [12]
- May be enhanced by new physics, even with $b \to s\mu^+\mu^-$ constraints
- Sensitive to MFV-violating physics



- $25.3\ ^{+6.7}_{-6.4}$ $B^+ \to \pi^+\mu^+\mu^-$ candidates, corresponding to a significance of 5.2 σ
- $(B^+ \to \pi^+\mu^+\mu^-) = (2.4 \pm 0.6\ (\text{stat}) \pm 0.2\ (\text{syst})) \times 10^{-8}$
- Consistent with SM prediction of $(1.96 \pm 0.21) \times 10^{-8}$
- Rarest B decay observed, first $b \to d\mu^+\mu^-$ transition
- Possible future interest:
  - Extract $|\frac{V_{td}}{V_{ts}}|$ (measure $\mathcal{B}$ relative to $B^+ \to K^+\mu^+\mu^-$)
  - CPV potential larger in $b \to d\mu^+\mu^-$ than $b \to s\mu^+\mu^-$ [13]
  - Large A_{FB} or F_H?

$\mathcal{A}^{\mathrm{CP}}\ (B^0 \to K^{*0}\gamma)$

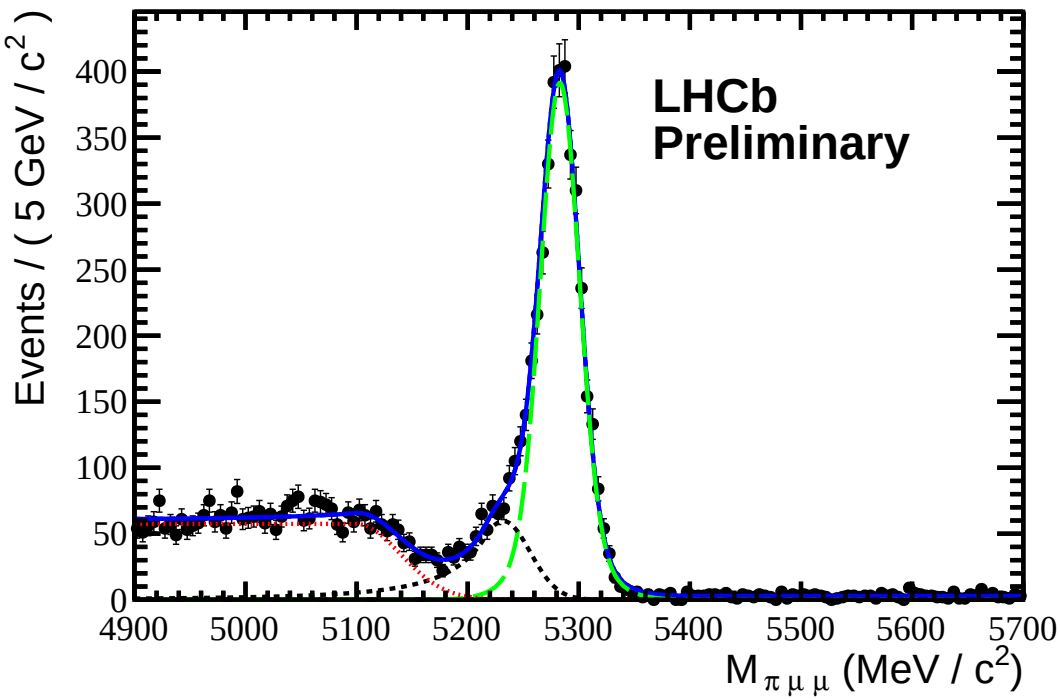
- Probe CP violation in $b \to s\gamma$ via the exclusive mode $B^0 \to K^{*0}\gamma$
  - SM prediction: $\mathcal{A}^{\mathrm{CP}} =$ -0.006 $\pm$ 0.004 [14]
  - Previous best measurement: $\mathcal{A}^{\mathrm{CP}} =$ -0.016 $\pm$ 0.022 $\pm$ 0.007, from BaBar [15]
- Fit for raw asymmetry (below)
  - Subtract B^0 production asymmetry, $K\pi$ detection asymmetry
- $\mathcal{A}^{\mathrm{CP}}\ (B^0 \to K^{*0}\gamma) =$ -0.008 $\pm$ 0.017 (stat) $\pm$ 0.009 (syst) (preliminary)

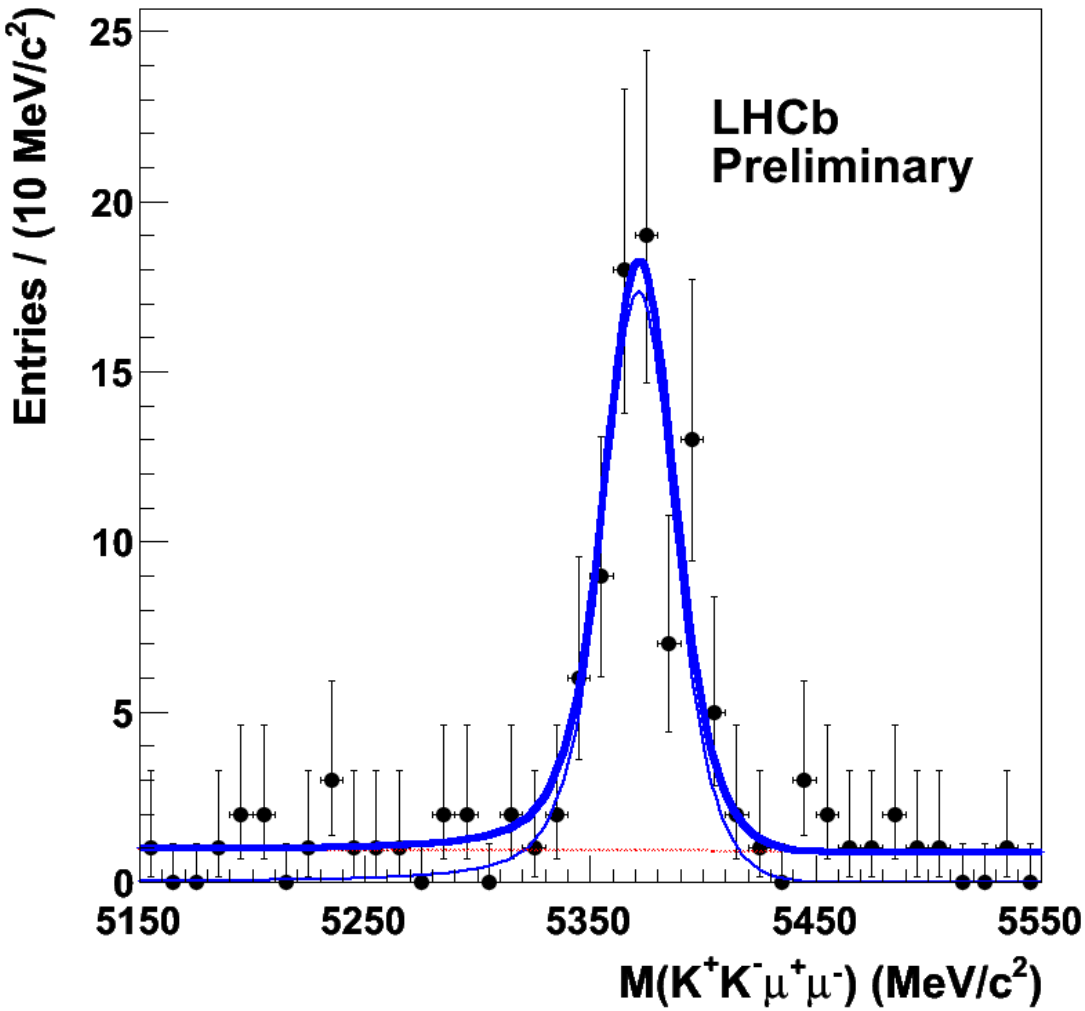


Conclusion

- $B^0 \to K^{*0}\mu^+\mu^-$- Worlds most precise measurements
- $B_s^0 \to \phi\mu^+\mu^-$- Worlds most precise measurements
- $B^+ \to \pi^+\mu^+\mu^-$- Worlds first observation (of any $b \to d\mu^+\mu^-$ mode), rarest B decay
- $\mathcal{A}^{\mathrm{CP}}$ $(B^0 \to K^{*0}\gamma)$ - Worlds most precise measurement
- Many more measurements to come this year

Backup Slides


LHCb
Preliminary
Events / (5 GeV / c^2)
400
350
300
250
200
150
100
50
0
4900
5000
5100
5200
5300
5400
5500
5600
5700
M$_{\pi\mu\mu}$ (MeV / c^2)


LHCb
Preliminary
Entries / (10 MeV/c²)
M(K⁺K⁻μ⁺μ⁻) (MeV/c²)
0
5
10
15
20
25
5150
5250
5350
5450
5550

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