ATLAS measurements of CP violation and rare decay processes with beauty mesons

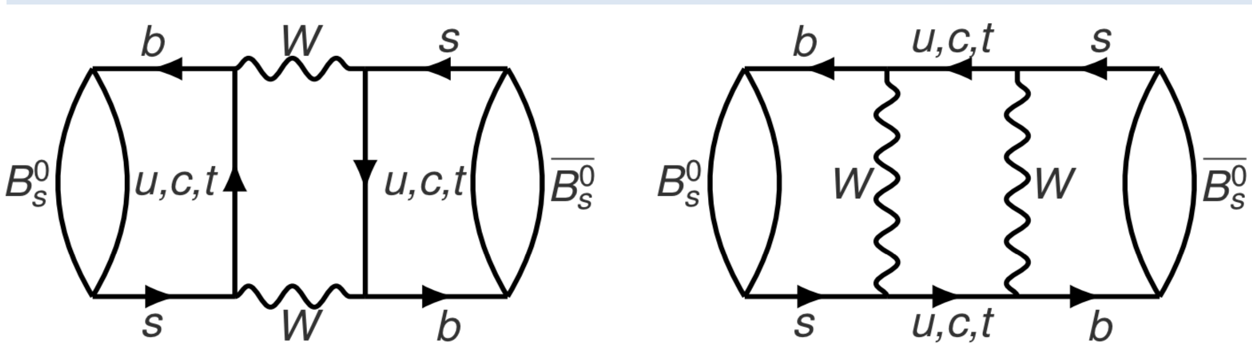
WIN2021, 7th-12th June

This poster will focus on the latest results from the ATLAS collaboration, in particular for rare processes $B^0_{(s)} \to \mu^+\mu^-$, and CP violation in the $B^0_s \to J/\psi\phi$ decays. In the latter, the Standard Model predicts the CP violating mixing phase, ϕ_s, to be very small and its SM value is very well constrained, while in many new physics models large ϕ_s values are expected. Latest measurements of ϕ_s and several other parameters describing the $B^0_s \to J/\psi\phi$ decays will be reported.

Measurement of the CP violation phase ϕ_s

Introduction

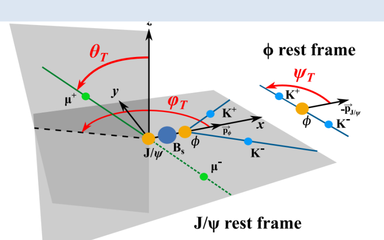
- $B^0_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$ is used to measure the CP-violating phase ϕ_s which is potentially sensitive to new physics.
- ϕ_s is defined as the weak phase difference between the $B^0_s - \bar{B}^0_s$ mixing amplitude and the $b \to c\bar{c}s$ decay amplitude.
- In standard model (SM), $\phi_s \simeq 2\arg\left[-\frac{V_{ts}V^*_{tb}}{V_{cs}V^*_{cb}}\right] = -0.03696^{+0.00072}_{-0.00082}\ rad$



Strategy

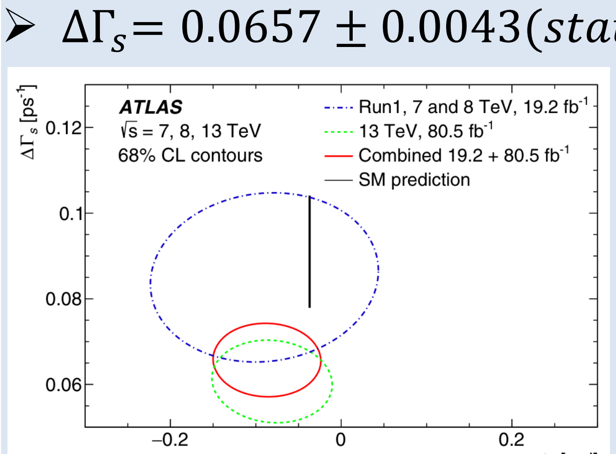
- Time-dependent angular analysis with flavour tagging technique
  - Efficiency (ε), dilution (D), tagger power (T)
- An unbinned maximum likelihood fit

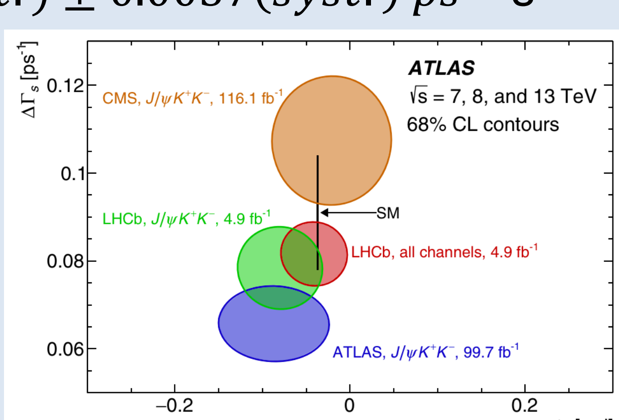
Tag method	ϵ_x [%]	D_x [%]	T_x [%]
Tight muon	4.50 ± 0.01	43.8 ± 0.2	0.862 ± 0.009
Electron	1.57 ± 0.01	41.8 ± 0.2	0.274 ± 0.004
Low-p_T muon	3.12 ± 0.01	29.9 ± 0.2	0.278 ± 0.006
Jet	12.04 ± 0.02	16.6 ± 0.1	0.334 ± 0.006
Total	21.23 ± 0.03	28.7 ± 0.1	1.75 ± 0.01



Results

- $\phi_s = -87 \pm 36(stat.) \pm 21(syst.)\ mrad$
- $\Delta\Gamma_s = 0.0657 \pm 0.0043(stat.) \pm 0.0037(syst.)\ ps^{-1}$s





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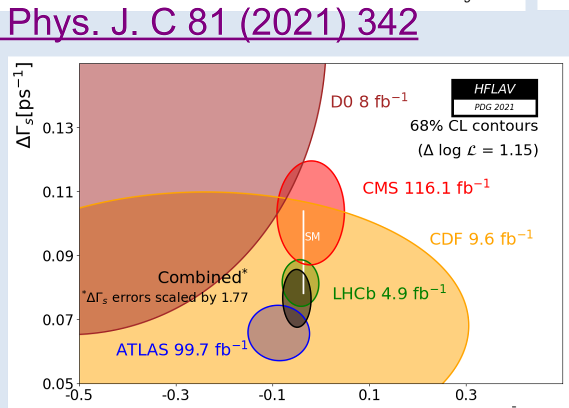
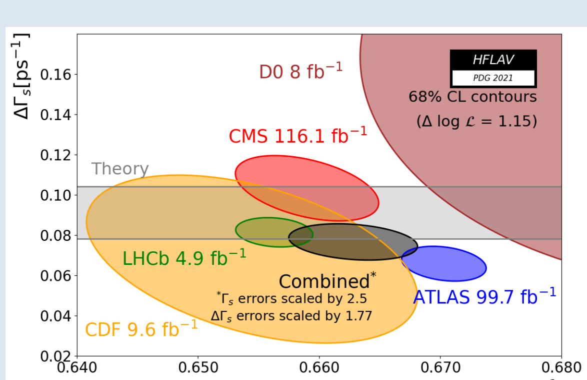




$B^0_{(s)} \to \mu^+\mu^-$

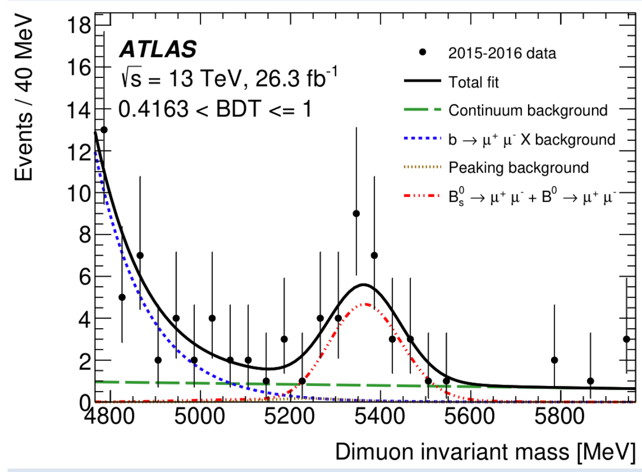
High precision SM predictions of branching fractions for muonic $B^0_{(s)}$ decays:

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.66 \pm 0.14) \times 10^{-9}$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (1.03 \pm 0.05) \times 10^{-10}$$

ATLAS results

Branching fractions are measured relative to the reference decay mode $B^+ \to J/\psi(\mu^+\mu^-)K^+$ which is abundant and well-measured:

$$\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) = \frac{N_{d(s)}}{\varepsilon_{\mu^+\mu^-}} \times [\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu^+\mu^-)] \frac{\varepsilon_{J/\psi K^+}}{N_{J/\psi K^+}} \times \frac{f_u}{f_{d(s)}}$$



Source	B^0_s [%]	B^0 [%]
f_s/f_d	5.1	—
B^+ yield	4.8	4.8
R_ε	4.1	4.1
$\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu^+\mu^-)$	2.9	2.9
Fit systematic uncertainties	8.7	65
Stat. uncertainty (from likelihood est.)	27	150

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (2.8 \pm 0.7) \times 10^{-9}$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (-1.9 \pm 1.6) \times 10^{-10}$$

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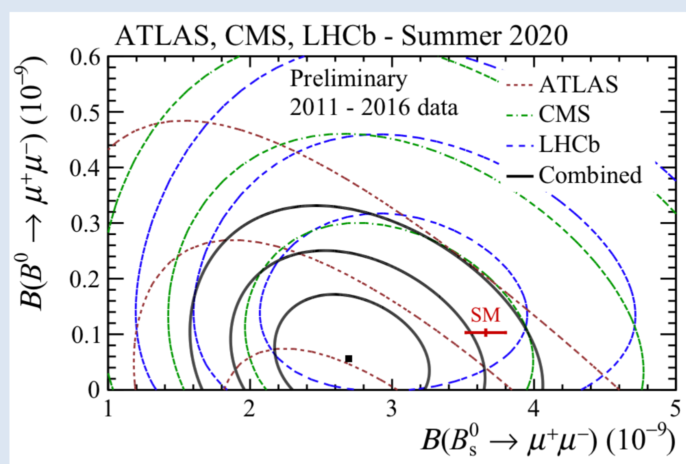
Combination

- Three binned lo—likelihoods fitted using a two-dimensional variable-width Gaussian
- The maximum is used the evaluate the central values and the uncertainties:

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \left(2.69^{+0.37}_{-0.35}\right) \times 10^{-9}$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (0.6 \pm 0.7) \times 10^{-10}$$

- The upper limit on $\mathcal{B}(B^0 \to \mu^+\mu^-)$ is 1.9×10^{-10}
- Effective lifetimes: $\tau_{B^0_s \to \mu^+\mu^-} = 1.91^{+0.37}_{-0.35}$ ps.



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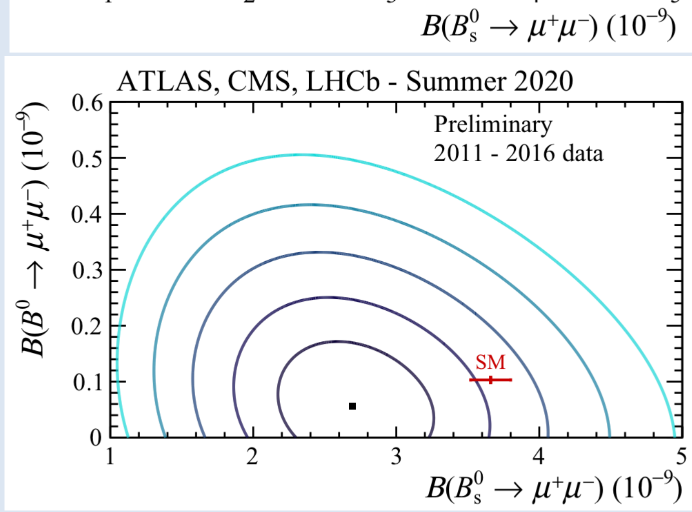

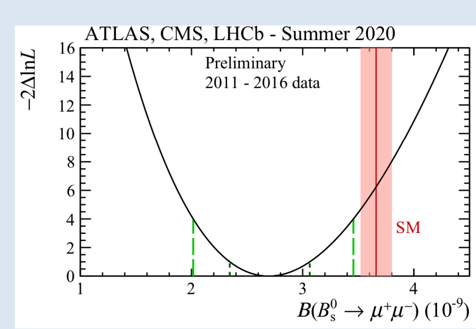

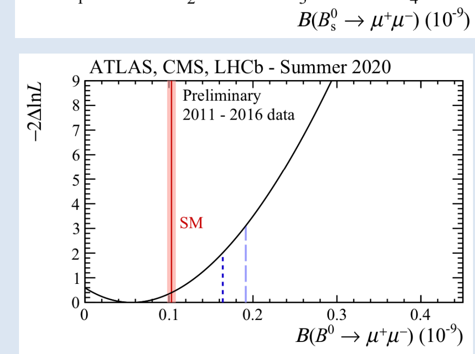

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ATLAS EXPERIMENT