PROCEEDINGS OF SCIENCE

Measurement of CP violation and mixing in $B_s \to J/\psi\phi$ in ATLAS

Tomas Jakoubek[*†]
Institute of Physics of the Academy of Sciences of the Czech Republic
E-mail: tomas.jakoubek@cern.ch

Flavour tagged time dependent angular analysis of the $B_s \to J/\psi\phi$ decay is reported, using 14.3 fb^{-1} of integrated luminosity collected by the ATLAS detector from 8 TeV LHC proton-proton collisions recorded in 2012. CP-violation in this channel is described by a weak phase ϕ_s, which is sensitive to new physics contributions. Measured parameters are statistically combined with those from 4.9 fb^{-1} of 7 TeV data, leading to the final results from ATLAS in Run1: $\phi_s = -0.098 \pm 0.084$ (stat.) ± 0.040 (syst.) rad, which is in good agreement with Standard Model expectations. Also other measured parameters are consistent with the world average.

16th International Conference on B-Physics at Frontier Machines
2-6 May 2016
Marseille, France

[*]Speaker.
[†]On behalf of the ATLAS collaboration.

PoS(BEAUTY2016)067

1. Introduction

The $B_s^0 \to J/\psi\phi$ decay channel is expected to be sensitive to new physics contributions. In this channel, *CP* violation occurs due to interference between direct decays and decays occurring through $B_s^0 - \overline{B_s^0}$ mixing. The frequency of this mixing is characterized by the mass difference ΔM_s between light (B_L) and heavy (B_H) mass eigenstates. Difference between decay widths can be described using a *CP*-violating phase ϕ_s. In the Standard Model (SM) this phase can be related to the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix elements via the relation

$$\phi_s \simeq -2 \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right). \tag{1.1}$$

Assuming no physics beyond the SM contributions to the B_s^0 mixing and decays, a value of $\phi_s = -0.0363^{+0.0016}_{-0.0015}$ rad is predicted by combining beauty and kaon physics observables [1]. Other physical quantity involved in $B_s^0 - \overline{B_s^0}$ mixing are the decay width $\Gamma_s = \frac{\Gamma_L^s+\Gamma_H^s}{2}$ and the the decay width difference $\Delta\Gamma_s = \Gamma_L^s - \Gamma_H^s$, where Γ_L^s and Γ_H^s are the decay widths of the different eigenstates. Many new physics models predict larger ϕ_s values whilst satisfying all existing constraints, including the precisely measured value of ΔM_s.

Our analysis is based on 4.9 fb^{-1} of $\sqrt{s} = 7$ TeV data from proton-proton collisions collected with the ATLAS detector [2] in the year 2011 [3], combined with 14.3 fb^{-1} of $\sqrt{s} = 8$ TeV data from the year 2012 into the complete Run1 results presented here [4].

2. Methodology

To be selected, events must contain at least one reconstructed primary vertex, formed from at least four Inner Detector (ID) tracks, and at least one pair of oppositely charged muons reconstructed using information from the Muon Spectrometer (MS) and the ID. Pairs of oppositely charged muon tracks are refitted to a common vertex and the pair is accepted if $\chi^2/\text{ndf} < 10$. To account for varying mass resolution in different parts of the detector, the $|\eta(\mu)|$ dependent J/ψ mass cuts are applied. Decays $\phi \to K^+K^-$ are reconstructed from all pairs of oppositely charged particles with $p_T > 1$ GeV and $|\eta| < 2.5$ that are not identified as muons. Candidates for B_s are selected by fitting the four tracks to a common vertex with J/ψ mass constrain [5]. Candidate is accepted if the vertex fit has $\chi^2/\text{ndf} < 3$ and $|m(K^+K^-) - m_\phi| < 11$ MeV, where the ϕ mass value, m_ϕ, is taken from [5]. If there is more than one accepted B_s candidate in the event, the one with the lowest χ^2/ndf is selected.

For each B_s candidate the proper decay time t is calculated:

$$t = \frac{L_{xy}\, m(B_s)}{p_T(B_s)}, \tag{2.1}$$

where $p_T(B_s)$ is the transverse momentum of the B_s meson and $m(B_s)$ is the mass of the B_s meson, taken from [5]. The transverse decay length L_{xy} is the displacement in the transverse plane of the B_s meson decay vertex with respect to the primary vertex, projected onto the direction of the B_s transverse momentum.

Flavour tagging has been used to improve this *CP* violation measurement. Initial flavour of (neutral) B_s can be inferred using the other *B*-meson, produced in the event (so-called "Opposite-Side Tagging"). Muon, electron, and jet-charge tagging methods have been used. Calibration of these methods have been done using decays of "self-calibrated" channel $B^{\pm} \to J/\psi K^{\pm}$ (flavour of the *B*-meson at production is provided by the kaon charge).

Detector effects have been studied using Monte Carlo (MC) - "acceptance maps" (relying on three angles and p_{T}) have been created and applied to the data. Also an observed time dependence of the muon trigger has been corrected by weighting function (derived using real data and MC).

3. Results

Time-angular unbinned maximum likelihood fit has then been performed on B_s^0 candidates within a mass range of 5.15 GeV $< m(B_s^0) <$ 5.65 GeV to extract the parameters characterising the decay. Below the important physical parameters are summarized: mean B_s^0 lifetime, the decay width difference $\Delta\Gamma_s$, and the *CP*-violating week phase ϕ_s. All results (2011, 2012, and the full Run1 statistical combination) are consistent with the world average values. Mass and lifetime fit projections are shown in Figure 1. Comparison with other experiments is shown in Figure 2.

	8 TeV data			7 TeV data			Run1 combined		
Par	Value	Stat	Syst	Value	Stat	Syst	Value	Stat	Syst
ϕ_s [rad]	-0.123	0.089	0.041	0.12	0.25	0.05	-0.098	0.084	0.040
$\Delta\Gamma_s$ [ps^{-1}]	0.096	0.013	0.007	0.053	0.021	0.010	0.083	0.011	0.007
Γ_s [ps^{-1}]	0.678	0.004	0.004	0.677	0.007	0.004	0.677	0.003	0.003

Table 1: Current results using data from 8 TeV *pp* collisions, the previous measurement using 7 TeV data, and the values for the parameters of the two measurements, statistically combined [4].

4. Acknowledgments

I would like to thank for support from grants of the Ministry of Education, Youth and Sports of the Czech Republic under the project LG15052.

References

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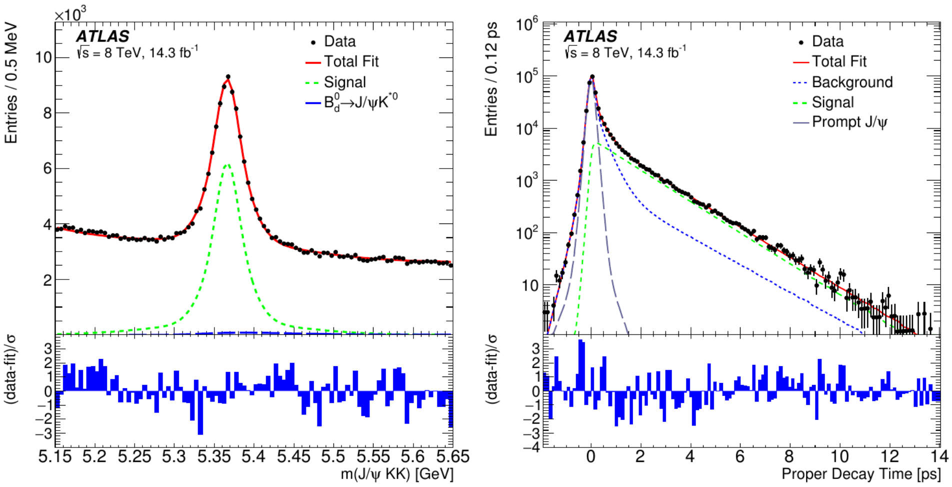

Figure 1: (Left) Mass fit projection of the 2012 data. The red line shows the total fit, the dashed green line shows the signal component while the long-dashed blue line shows the contribution from $B_d^0 \to J/\psi K^{0*}$ events. (Right) Proper decay time fit projection of 2012 data. The red line shows the total fit while the green dashed line shows the total signal. The total background is shown as the blue dashed line with the long-dashed grey line showing the prompt J/ψ background [4].

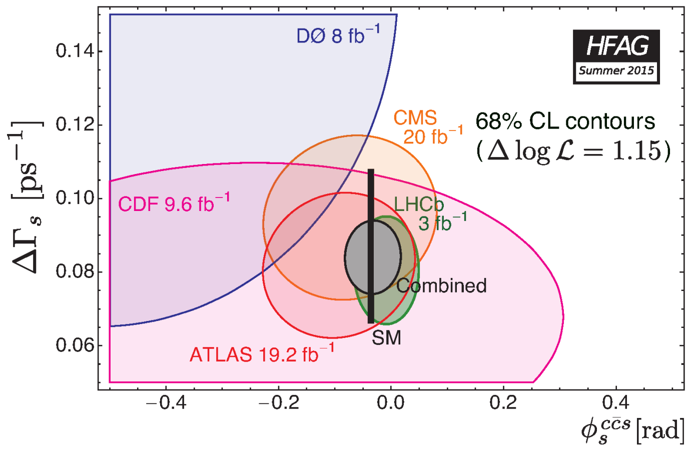

Figure 2: Plot of the 68% confidence-level contours in the $\phi_s - \Delta\Gamma_s$ plane with the individual contours of ATLAS, CMS, CDF, DØ, and LHCb experiments, their combined contour (solid line and shaded area), as well as the Standard Model predictions (thin black rectangle) [6].

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