Erratum: Study of the Dalitz decay $J/\psi \to e^+e^-\eta$ [Phys. Rev. D 99, 012006 (2019)]

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(Received 23 September 2021; published 23 November 2021)

DOI: 10.1103/PhysRevD.104.099901

We report here corrected results on a study of the electromagnetic Dalitz decay $J/\psi \to e^+e^-\eta$ and search for dielectron decays of a light dark gauge boson (γ') in $J/\psi \to \gamma'\eta$ with the two η decay modes $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$, using $(1310.6 \pm 7.0) \times 10^6$ J/ψ events collected with the BESIII detector. In particular we update the measurement of the pole mass of the transition form factor of $J/\psi \to e^+e^-\eta$ to be $\Lambda = 2.56 \pm 0.04(\text{stat}) \pm 0.03(\text{syst})$ GeV$/c^2$. The branching fraction of $J/\psi \to e^+e^-\eta$ and the kinetic-mixing strength between the Standard Model photon and γ' are also updated after taking the corrected Λ value into account. The measured branching fraction of $J/\psi \to e^+e^-\eta$ is updated to be $(1.42 \pm 0.04(\text{stat}) \pm 0.07(\text{syst})) \times 10^{-5}$, where the first and second uncertainties are statistical and systematic, respectively.

Previously, we reported the study of the electromagnetic (EM) Dalitz decay $J/\psi \to e^+e^-\eta$ and search for di-electron decays of a light dark gauge boson (γ') in $J/\psi \to \gamma'\eta$ with the two η decay modes $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$ using $(1310.6 \pm 7.0) \times 10^6$ J/ψ events collected with the BESIII detector. The dielectron invariant mass-dependent transition form factor (TFF) in this decay describes the deviation from the standard pointlike prediction of quantum electrodynamics (QED) and thus serves as a sensitive probe of the inner structure of the mesons involved in the process [1].

In scrutinizing the published analysis, we realized that our QED prediction computed using Eq. (1) in the paper was wrongly implemented. Thus the measured $m_{e^+e^-}$-dependent TFF is also wrong. We thank Dr. Sergi Gonzalez-Solis [2] for bringing this error to our attention. The measured TFF value also affects the measured branching fraction of $J/\psi \to e^+e^-\eta$ and the 90% confidence level (C.L.) upper limits on the coupling strength ϵ between the dark sector and the SM as a function of dark photon mass. This erratum presents the updated values of these measurements.

We compute the QED-predicted branching fraction of $J/\psi \to e^+e^-\eta$ once again using the formula of Eq. (1) in the paper. Figure 1 shows the distribution of $\mathcal{B}(J/\psi \to e^+e^-\eta)^i$ normalized to the $m_{e^+e^-}$ bin size superimposed with the QED-predicted branching fraction. Table I summarizes the background-subtracted signal events N^i_{sig}, the measured and QED-predicted $\mathcal{B}(J/\psi \to e^+e^-\eta)^i$ branching fractions, and the updated TFF values for all 20 bins.

Figure 2 shows a plot of the resultant TFF versus $m_{e^+e^-}$ together with a fit curve based on a modified multipole function,

$$|F_{J/\psi\eta}(q^2)|^2 = |A_\rho|^2\left(\frac{m_\rho^4}{(m_\rho^2 - q^2)^2 + \Gamma_\rho^2 m_\rho^2}\right) + |A_\Lambda|^2\left(\frac{1}{1 - q^2/\Lambda^2}\right)^2, \tag{1}$$

where $q^2 = m^2_{e^+e^-}$ is the squared four-momentum transfer, Λ is the pole mass, A_Λ is the coupling constant of the nonresonant contribution, and m_ρ, Γ_ρ, and A_ρ are the mass, width, and coupling constant of the ρ meson, respectively. The mass and width of the ρ resonance are fixed to the values in the PDG [3]. The statistical significance of the ρ signal is determined to be 4.3σ. The pole mass is determined to be $\Lambda = 2.56 \pm 0.04(\text{stat}) \pm 0.03(\text{syst})$ GeV$/c^2$, where the first and second uncertainties are statistical and systematic, respectively.

We update the branching fraction of $J/\psi \to e^+e^-\eta$ in both decay modes of $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$ after evaluating the efficiency with the simulated signal MC sample generated with the measured $\Lambda = 2.56$ GeV$/c^2$. The corresponding efficiencies are determined to be 26.2% and 13.8%, respectively. Two alternative MC samples with values of the pole mass Λ differing by $\pm 1\sigma$ are generated, and the resulting largest relative difference in efficiencies, 1.5% for the decay mode $\eta \to \pi^+\pi^-\pi^0$ and 1.0% for the decay mode $\eta \to \gamma\gamma$, are assigned as the systematic uncertainty. The branching fraction of $J/\psi \to e^+e^-\eta$ is determined to be $(1.39 \pm 0.06(\text{stat}) \pm 0.07(\text{syst})) \times 10^{-5}$ in the decay modes of $\eta \to \gamma\gamma$ and

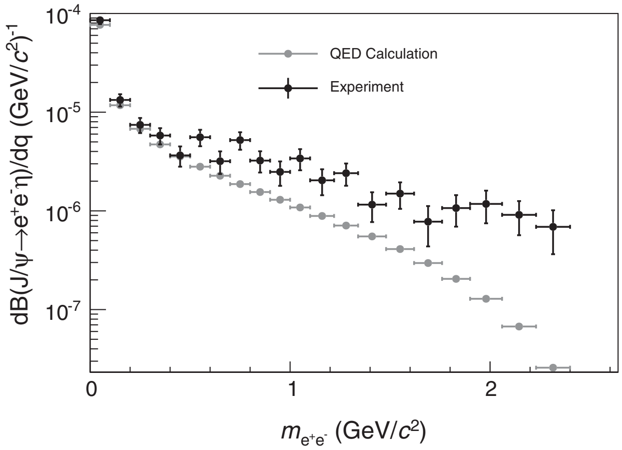

FIG. 1. Differential branching fraction $J/\psi \to e^+e^-\eta$ as a function of $m_{e^+e^-}$. The black dots with error bars are experimental data, where the error bars include both statistical and systematic uncertainties, and the gray dots with error bars are the standard pointlike predictions of QED.

$(1.45 \pm 0.06(\mathrm{stat}) \pm 0.08(\mathrm{syst})) \times 10^{-5}$ in the decay mode $\eta \to \pi^+\pi^-\pi^0$. The combined $\mathcal{B}(J/\psi \to e^+e^-\eta)$ for both the decay modes is calculated to be $(1.42 \pm 0.04(\mathrm{stat}) \pm 0.07(\mathrm{syst})) \times 10^{-5}$ using a weighted-average method while taking the correlated and uncorrelated systematic uncertainties into account as described in the previous BESIII measurement. The updated branching fraction of $J/\psi \to e^+e^-\eta$ remains almost unchanged.

We also update the upper limits of the coupling strength ϵ between the dark sector and the SM at the 90% C.L. as a function of $m_{\gamma'}$, where the TFF is given by Eq. (3) in the paper with $\Lambda = 2.56\ \mathrm{GeV}/c^2$. As shown in Fig. 3, the upper limits on ϵ at the 90% C.L. vary in the range $10^{-2} - 10^{-3}$ for $0.01 \le m'_\gamma \le 2.4\ \mathrm{GeV}/c^2$ depending on the value of $m_{\gamma'}$.

We thank Zhi-Hui Guo for cross-checking the QED prediction independently.

TABLE I. Fitted values of N^i_{sig}, the measured and QED predicted $\mathcal{B}(J/\psi \to e^+e^-\eta)^i$ differential branching fraction, and the TFF $|F(q^2)|^2$, for all 20 bins. The first uncertainty is statistical and the second is systematic.

$m_{e^+e^-}$ (GeV/c^2)	N^i_{sig}	$\mathcal{B}(J/\psi \to e^+e^-\eta)^i$ (10^{-7})	$\mathcal{B}(J/\psi \to e^+e^-\eta)^i$ (10^{-7} QED)	$\vert F(q^2)\vert^2$
[$2m_e$, 0.1]	$302.7 \pm 18.1 \pm 19.2$	$84.6 \pm 5.1 \pm 5.4$	75.93	$1.11 \pm 0.07 \pm 0.07$
[0.1, 0.2]	$60.9 \pm 7.8 \pm 3.9$	$13.3 \pm 1.7 \pm 0.8$	11.76	$1.13 \pm 0.15 \pm 0.07$
[0.2, 0.3]	$40.4 \pm 6.6 \pm 2.6$	$7.4 \pm 1.2 \pm 0.5$	6.79	$1.10 \pm 0.18 \pm 0.07$
[0.3, 0.4]	$32.0 \pm 5.7 \pm 2.0$	$5.8 \pm 1.0 \pm 0.4$	4.72	$1.23 \pm 0.22 \pm 0.08$
[0.4, 0.5]	$20.6 \pm 4.6 \pm 1.3$	$3.7 \pm 0.8 \pm 0.2$	3.56	$1.03 \pm 0.23 \pm 0.06$
[0.5, 0.6]	$31.6 \pm 5.7 \pm 2.0$	$5.6 \pm 1.0 \pm 0.4$	2.80	$1.99 \pm 0.36 \pm 0.12$
[0.6, 0.7]	$18.2 \pm 4.5 \pm 1.3$	$3.2 \pm 0.8 \pm 0.2$	2.27	$1.40 \pm 0.35 \pm 0.10$
[0.7, 0.8]	$29.8 \pm 5.7 \pm 1.9$	$5.2 \pm 1.0 \pm 0.3$	1.87	$2.79 \pm 0.53 \pm 0.18$
[0.8, 0.9]	$19.1 \pm 4.5 \pm 1.2$	$3.2 \pm 0.8 \pm 0.2$	1.55	$2.08 \pm 0.49 \pm 0.13$
[0.9, 1.0]	$14.4 \pm 3.9 \pm 0.9$	$2.5 \pm 0.7 \pm 0.2$	1.30	$1.92 \pm 0.52 \pm 0.12$
[1.0, 1.1]	$19.8 \pm 4.6 \pm 1.2$	$3.4 \pm 0.8 \pm 0.2$	1.08	$3.14 \pm 0.73 \pm 0.20$
[1.1, 1.22]	$14.6 \pm 4.2 \pm 1.0$	$2.5 \pm 0.7 \pm 0.2$	1.07	$2.30 \pm 0.66 \pm 0.15$
[1.22, 1.34]	$16.8 \pm 4.1 \pm 1.1$	$2.9 \pm 0.7 \pm 0.2$	0.85	$3.39 \pm 0.84 \pm 0.21$
[1.34, 1.48]	$9.7 \pm 3.2 \pm 0.6$	$1.6 \pm 0.5 \pm 0.1$	0.77	$2.10 \pm 0.69 \pm 0.13$
[1.48, 1.62]	$12.4 \pm 3.6 \pm 0.8$	$2.1 \pm 0.6 \pm 0.1$	0.57	$3.65 \pm 1.07 \pm 0.23$
[1.62, 1.76]	$6.3 \pm 2.7 \pm 0.6$	$1.1 \pm 0.5 \pm 0.1$	0.42	$2.63 \pm 1.13 \pm 0.24$
[1.76, 1.90]	$9.1 \pm 3.1 \pm 0.6$	$1.5 \pm 0.5 \pm 0.1$	0.29	$5.22 \pm 1.81 \pm 0.34$
[1.90, 2.06]	$10.2 \pm 3.7 \pm 0.6$	$1.9 \pm 0.7 \pm 0.1$	0.21	$9.15 \pm 3.28 \pm 0.57$
[2.06, 2.23]	$7.6 \pm 2.8 \pm 0.5$	$1.6 \pm 0.6 \pm 0.1$	0.12	$13.54 \pm 5.05 \pm 0.87$
[2.23, 2.40]	$5.7 \pm 2.7 \pm 0.4$	$1.2 \pm 0.6 \pm 0.1$	0.04	$26.74 \pm 12.47 \pm 1.95$

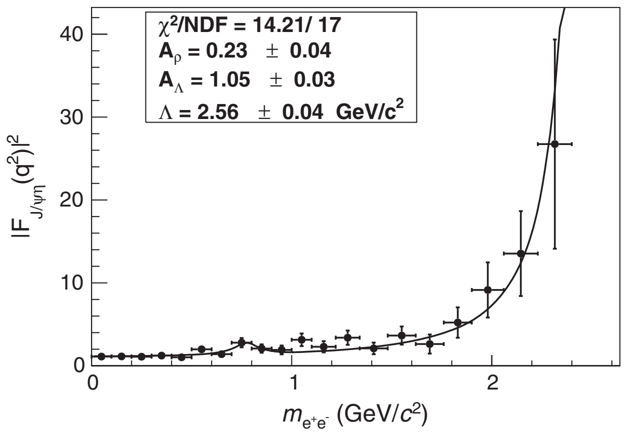

FIG. 2. Fit to the TFF versus $m_{e^+e^-}$ for data. The black dots with error bars are data, which include both statistical and systematic uncertainties, and the solid black curve shows the fit results.

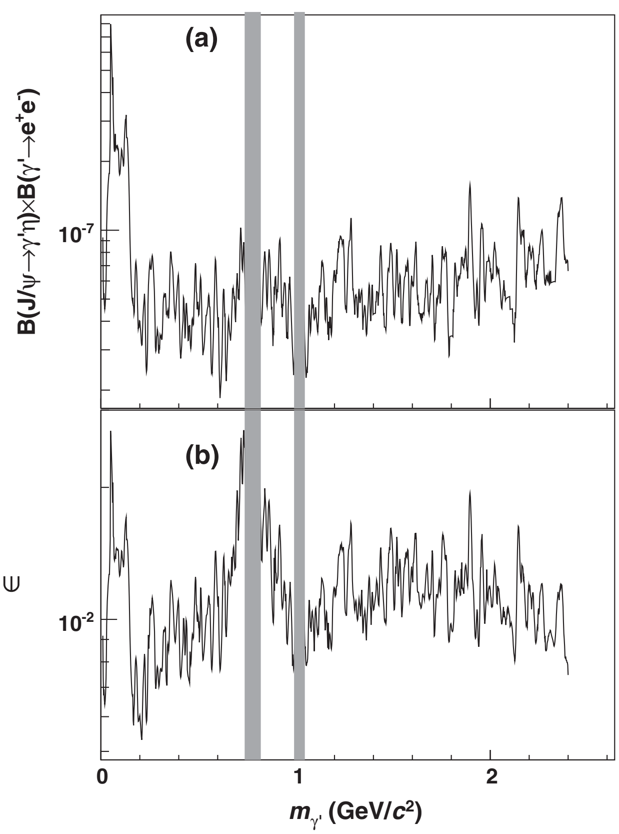

FIG. 3. The combined upper limits at the 90% C.L. on (a) product branching fraction $\mathcal{B}(J/\psi \to \gamma'\eta) \times \mathcal{B}(\gamma' \to e^+e^-)$ and (b) coupling strength (ϵ) between the SM and dark sector as a function of $m_{\gamma'}$ for both η decay modes. The regions of ω and ϕ resonances shaded by gray lines are excluded from the γ' search.

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[2] S. Gonzalez-Solis (private communication).
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