Erratum: Viability of $\Delta m^2 \sim 1$ eV^2 sterile neutrino mixing models in light of MiniBooNE electron neutrino and antineutrino data from the Booster and NuMI beamlines [Phys. Rev. D 80, 073001 (2009)]

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The sign in front of the CP-violating phase, ϕ_{45}, in Eq. (4) is incorrect. The equation should read

$$P(\nu_\mu \to \nu_e) = 4|U_{\mu4}|^2|U_{e4}|^2\sin^2 x_{41} + 4|U_{\mu5}|^2|U_{e5}|^2\sin^2 x_{51} + 8|U_{\mu5}||U_{e5}||U_{\mu4}||U_{e4}|\sin x_{41}\sin x_{51}\cos(x_{54} - \phi_{45}), \quad (1)$$

as opposed to

$$P(\nu_\mu \to \nu_e) = 4|U_{\mu4}|^2|U_{e4}|^2\sin^2 x_{41} + 4|U_{\mu5}|^2|U_{e5}|^2\sin^2 x_{51} + 8|U_{\mu5}||U_{e5}||U_{\mu4}||U_{e4}|\sin x_{41}\sin x_{51}\cos(x_{54} + \phi_{45}). \quad (2)$$

The above mistake has no impact on the results or the conclusions of the paper, since in our computations we use a formula that is derived directly from Eq. (1), as follows. In the case of disappearance:

$$P(\nu_\alpha \to \nu_\alpha) = 1 - 4|U_{\alpha4}|^2|U_{\alpha5}|^2\sin^2 x_{54} + 4(1 - |U_{\alpha4}|^2 - |U_{\alpha5}|^2)(|U_{\alpha4}|^2\sin^2 x_{41} + |U_{\alpha5}|^2\sin^2 x_{51}), \quad (3)$$

where $\alpha = e$ or μ, and in the case of appearance:

$$\begin{aligned} P(\nu_\mu \to \nu_e) = {} & -4|U_{e5}||U_{\mu5}||U_{e4}||U_{\mu4}|\cos\phi_{45}\sin^2 x_{54} + 4(|U_{\mu4}||U_{e4}| + |U_{\mu5}||U_{e5}|\cos\phi_{45})|U_{\mu4}||U_{e4}|\sin^2 x_{41} \\ & + 4(|U_{\mu4}||U_{e4}|\cos\phi_{45} + |U_{\mu5}||U_{e5}|)|U_{\mu5}||U_{e5}|\sin^2 x_{51} \\ & + 2|U_{e5}||U_{\mu5}||U_{e4}||U_{\mu4}|\sin\phi_{45}\sin(2x_{54}) \quad (4) \\ & + 2|U_{\mu5}||U_{e5}||U_{\mu4}||U_{e4}|\sin\phi_{45}\sin(2x_{41}) \quad (5) \\ & - 2|U_{\mu4}||U_{e4}||U_{\mu5}||U_{e5}|\sin\phi_{45}\sin(2x_{51}). \quad (6) \end{aligned}$$

However, in the case of the new MiniBooNE booster neutrino beam (BNB-MB) data sets and NuMI beam (NUMI-MB) data sets [BNB-MB(ν), BNB-MB($\bar{\nu}$), and NUMI-MB], the CP-violating terms (4)–(6) from the above formulas were incorrectly included in the fit as functions of $\sin^2(x_{ij})$ rather than as functions of $\sin(2x_{ij})$. This error affects any (3 + 2) CP-violating fit results where the MiniBooNE data sets were included. Because of this, some of the results in Secs. V.B and VI are incorrect.

It should be noted that this error does not affect (3 + 1) fits or (3 + 2) CP-conserving fits, since all $\sin(2x_{ij})$ terms are multiplied by $\sin\phi_{45}$, which is zero by definition in both of those scenarios.

An updated analysis of these results with the correction in place for the MiniBooNE data sets shows that, in comparison to the original article, higher χ^2 probabilities are achieved for (3 + 2) CP-violating fits where the MiniBooNE data sets are included. The following summarizes the main changes, from less to more significant.

(i) In the case of fits to all short-baseline (SBL) data sets (appearance and disappearance), the changes are negligible, due to the overwhelming constraints from disappearance data sets. The χ^2 probability and best fit parameters are still approximately valid.

(ii) In the case of fits to antineutrino-only data sets [KARMEN, LSND, Bugey, CHOOZ, and BNB-MB($\bar{\nu}$)] and antineutrino appearance-only data sets the changes are also small. In both of those cases, the χ^2's have been found smaller than in the original article by ~1–2 units.

(iii) A small but noticeable improvement in the fit quality was found for the neutrino-only fit and appearance neutrino-only fit. In both of those cases, the χ^2's have been found smaller relative to the original article by ~5 units.

(iv) The largest effect was found in the case of appearance-only and signal-only [BNB-MB(ν) + BNB-MB($\bar{\nu}$) + LSND] fits. In both of those cases we have found a significant improvement in the fit, as illustrated in Table I.

Because of the above changes, the conclusion regarding (3 + 2) CP-violating fits should be revised, in that

(i) In the case of appearance-only fits, and, in particular, fits to the BNB-MB(ν) + BNB-MB($\bar{\nu}$) + LSND appearance data sets, there is a significant improvement over (3 + 2) CP-conserving fits when CP-violation is allowed. This is in agreement with results obtained in the past by the authors of Ref. [1].

(ii) The compatibility between appearance and disappearance data sets, when data from the CDHS experiment, atmospheric constraints, and the BNB-MB(ν) data set are excluded from the fit, is 24% (not 36%).

(iii) The compatibility between neutrino appearance and antineutrino appearance data sets is 6.8% (not 2.2%).

Finally, the parameter goodness-of-fit test has been incorrectly applied in the case where three or more sets of experiments are compared. In those cases, the number of degrees of freedom, ndf_{PG}, used to calculate compatibility is

TABLE I. Comparison of old χ^2 and χ^2-probability (gof) from Table V, and updated values and best fit parameters with the corrected $\sin(2x_{ij})$ term for (3 + 2) *CP*-violating fits. The correction results in significantly higher χ^2-probabilities for fits where only appearance (APP) data sets are considered.

Fit	Old: χ^2(gof)	New: χ^2(gof)	Δm^2_{41}	Δm^2_{51}	$\lvert U_{e4}\rvert$	$\lvert U_{\mu 4}\rvert$	$\lvert U_{e5}\rvert$	$\lvert U_{\mu 5}\rvert$	ϕ_{45}
Signal APP	42.5 (21%)	34.7 (53%)	0.59	1.21	0.19	0.33	0.20	0.16	1.1π
APP	92.6 (27%)	82.5 (56%)	0.39	1.10	0.40	0.20	0.21	0.14	1.1π
All SBL	190.2 (52%)	189.3 (54%)	0.92	26.5	0.13	0.13	0.078	0.15	1.7π

TABLE II. Comparison of old parameter goodness-of-fit (PG) values from Tables VI and IV, and updated values obtained with corrected $ndf_{\rm PG}$.

Fit		PG	Old (%)	New (%)
(3 + 1)	APP	PG [BNB-MB (ν), BNB-MB ($\bar{\nu}$) , LSND, NUMI-MB, KARMEN, NOMAD]	1.7×10^{-2}	6.8
	Signal APP	PG [BNB-MB (ν), BNB-MB ($\bar{\nu}$), LSND]	0.26	1.8
	$\bar{\nu}$ APP	PG [BNB-MB ($\bar{\nu}$), LSND, KARMEN]	3.4	15
	ν APP	PG [BNB-MB (ν), NUMI-MB, NOMAD]	8.8	30
	All SBL	PG [BNB-MB (ν), BNB-MB ($\bar{\nu}$), LSND, NUMI-MB, KARMEN, NOMAD, Bugey, CHOOZ, CCFR84, CDHS, ATM]	7.6×10^{-8}	0.11
		PG (ν,$\bar{\nu}$)	8.1×10^{-3}	2.9×10^{-2}
	ν	PG [BNB-MB (ν), NUMI-MB, NOMAD, CCFR84, CDHS, ATM]	6.3×10^{-2}	6.5
	$\bar{\nu}$	PG [BNB-MB ($\bar{\nu}$), LSND, KARMEN, Bugey, CHOOZ]	1.5	30
(3 + 2)	All SBL	PG [BNB-MB (ν), BNB-MB (ν), LSND, NUMI-MB, KARMEN, NOMAD, Bugey, CHOOZ, CCFR84, CDHS, ATM]	2.2×10^{-7}	7
		PG (ν,$\bar{\nu}$)	8.2×10^{-2}	6.4×10^{-2}
	APP	PG [BNB-MB (ν), BNB-MB ($\bar{\nu}$), LSND, NUMI-MB, KARMEN, NOMAD]	1.7×10^{-2}	74
	DIS	PG (Bugey, CHOOZ, CCFR84, CDHS, ATM)	8.6	70
	ν	PG [BNB-MB (ν), NUMI-MB, NOMAD, CCFR84, CDHS, ATM]	0.37	43
	$\bar{\nu}$	PG [BNB-MB ($\bar{\nu}$), LSND, KARMEN, Bugey, CHOOZ]	5.8	80
	ν APP	PG [BNB-MB (ν), NUMI-MB, NOMAD]	56	98
	$\bar{\nu}$ APP	PG [BNB-MB ($\bar{\nu}$), LSND, KARMEN]	18	74
	All ATM	PG (All SBL-ATM, ATM)	5.6	2.1

incorrect. According to [2], in cases where three or more sets of experiments are considered, $ndf_{\rm PG}$ is given by the number of fit parameters relevant to each set of experiments considered, minus the total number of useful parameters in the fit, which generally leads to larger $ndf_{\rm PG}$ than what was used in the original article. As a result, the true compatibilities in those cases are larger than those quoted. This error affects some of the results in Tables IV and VI of the original article. The updated values, where applicable, are given in Table II.

The above error does not affect the main conclusions of the paper beyond what has already been outlined in this erratum. Specifically, the incompatibility between appearance and disappearance experiments still holds, in both (3 + 1) and (3 + 2) models; neutrino data alone and antineutrino data alone are compatible both in (3 + 1) and (3 + 2) fits, whereas appearance data alone are only compatible in (3 + 2) fits when *CP* violation is allowed.

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[1] M. Maltoni and T. Schwetz, Phys. Rev. D **76**, 093005 (2007).
[2] M. Maltoni and T. Schwetz, Phys. Rev. D **68**, 033020 (2003).