Erratum: New physics and tau $g-2$ using LHC heavy ion collisions [Phys. Rev. D 102, 113008 (2020)]

Lydia Beresford and Jesse Liu

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This Erratum reports and corrects a bug found in the code that converts the Wilson coefficient $C_{\tau B}$ to δa_τ and δd_τ. The conversion is correctly printed in Eq. (4) of our paper; however, a bug in the code erroneously set the electron charge to unity rather than the correct $1/\sqrt{4\pi}$ in Heaviside-Lorentz units. This led to $\sqrt{4\pi} \simeq 3.5$ times faster cross-section variations as a function of δa_τ and δd_τ. In Figs. 1 (left and center), 2–5, and Table I, we correct the δa_τ and δd_τ values by this flat factor of $\sqrt{4\pi}$ to fix the error. These replace Figs. 2 (left and center), 3, 5, 6, 7, and Table I in the paper, respectively.

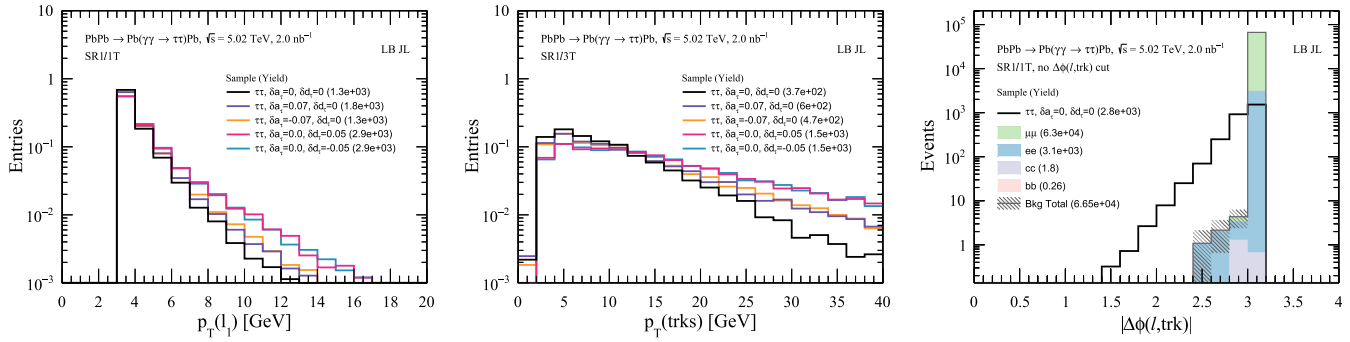

FIG. 1. Distributions of lepton p_T in SR1ℓ1T (left) and the 3-track system p_T in SR1ℓ3T (center) for benchmark signals with various δa_τ, δd_τ couplings. These are normalized to unit integral to illustrate shape changes with varying $\delta a_\tau, \delta d_\tau$. The lepton-track azimuthal angle $|\Delta\phi(\ell, \mathrm{trk})|$ in SR1ℓ1T (right) is shown for backgrounds (filled) and signal $\delta a_\tau = \delta d_\tau = 0$ (line), illustrating powerful discrimination against dilepton processes.

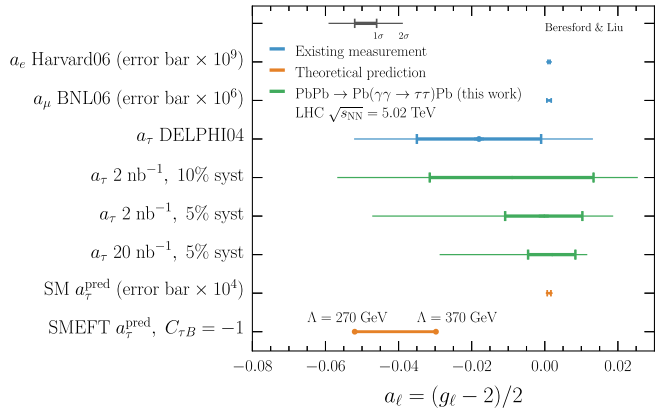

FIG. 2. Summary of lepton anomalous magnetic moments $a_\ell = (g_\ell - 2)/2$. Existing single-experiment measurements of a_e [1], a_μ [2], and a_τ [3] are in blue. Our benchmark projections (green) assume 2 nb^{-1} and 20 nb^{-1} for 5% and 10% systematic uncertainties. For visual clarity, we inflate 1σ error bars on a_e (a_μ) measurements by 10^9 (10^6), and 10^4 for the SM prediction a_τ^{pred} (orange) [4]. Collider constraints have thick (thin) lines denoting 68% C.L., 1σ (95% C.L., $\sim 2\sigma$). The SMEFT predictions [5,6] from Eq. (4) of the paper with $C_{\tau B} = -1$ displays BSM scales $270 < \Lambda < 370$ GeV (thick orange).

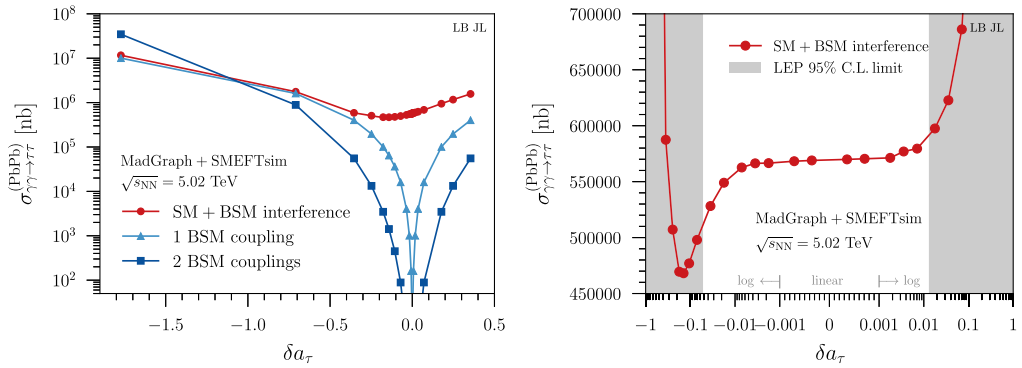

FIG. 3. Generator level cross sections for $\gamma\gamma \to \tau\tau$ sourced by our implementation of the Pb photon flux in MadGraph. This is interfaced with SMEFTsim for BSM coupling variations in δa_τ defined in Eq. (4) of the paper, fixing $\delta d_\tau = 0$ at $\sqrt{s_{NN}} = 5.02$ TeV. Left: contribution from only 1 BSM coupling (light blue triangles), 2 BSM couplings (dark blue squares), and their combined interference with the SM (red circles). The markers indicate the sampled points from δa_τ. Right: closeup of the δa_τ values near zero with gray regions denoting the 95% C.L. exclusion by DELPHI, where the horizontal axis is linear scale for $\delta a_\tau \in [-0.001, 0.001]$ and logarithmic elsewhere.

Figure 1 (right) is unaffected by the conversion error; however, we clarify the y-axis label to be "Events" rather than "Events/0.20"; this figure replaces Fig. 2 (right) in the paper. We note a further clarification: when requiring exactly one lepton plus track(s) in the definition of the signal regions, muons and electrons with transverse momentum down to 0.5 GeV are utilized and tracks with transverse momentum down to 0.1 GeV are utilized; this was not stated in the paper.

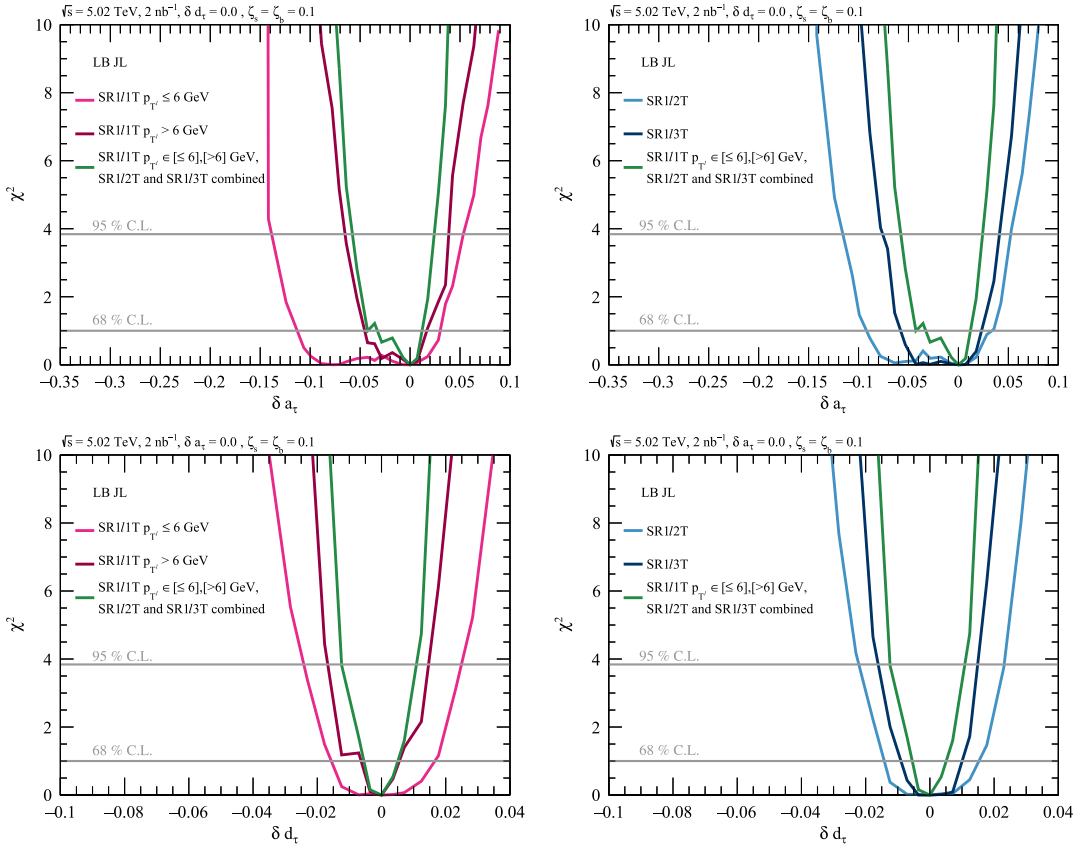

FIG. 4. The χ^2 distributions as a function of δa_τ assuming $\delta d_\tau = 0$ (upper), and δd_τ assuming $\delta a_\tau = 0$ (lower) are displayed for 10% systematics at $\mathcal{L} = 2$ nb^{-1}. Left: results from the SR1ℓ1T regions and the impact of binning in p_T^ℓ. Right: results from the SR1ℓ2/3T regions. The four signal region combined χ^2 is shown by the green line for reference. The gray horizontal lines correspond to 68% C.L. ($\chi^2 = 1$) and 95% C.L. ($\chi^2 = 3.84$). The unphysical spikes are due to limited MC statistics.

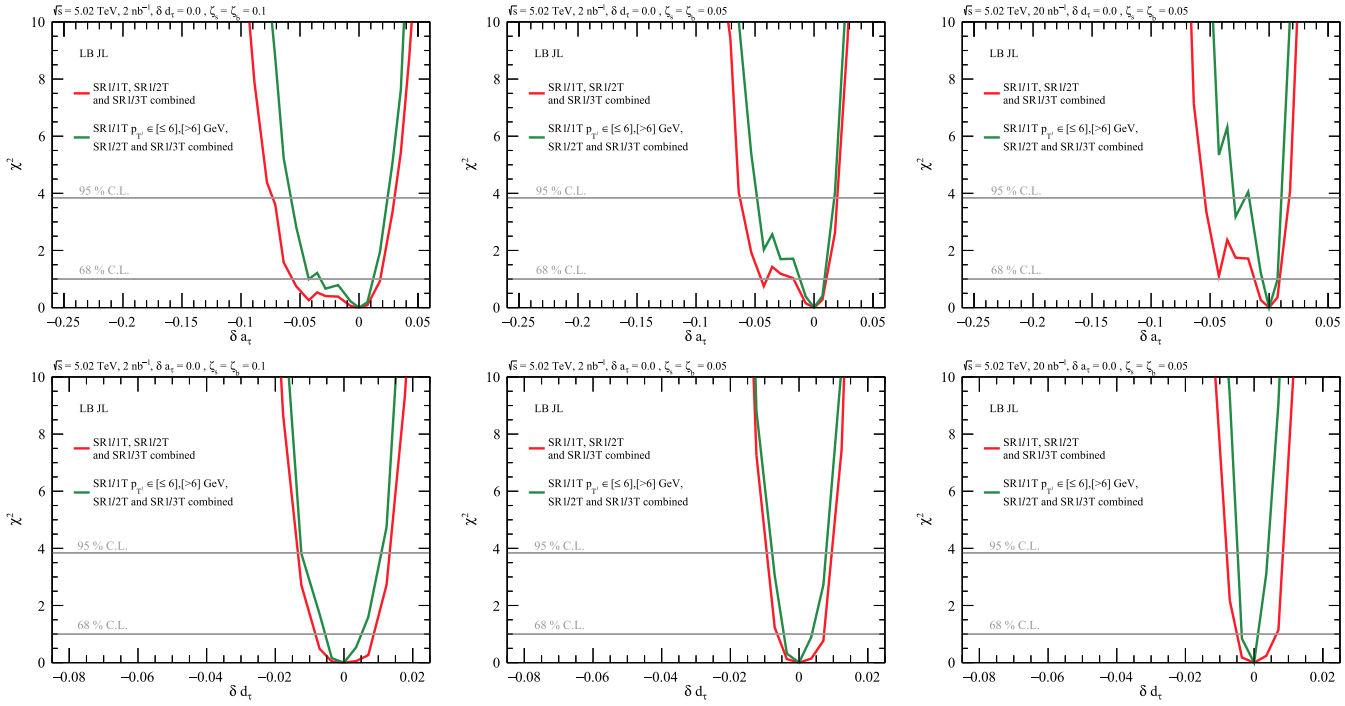

FIG. 5. The χ^2 distributions as a function of δa_τ assuming $\delta d_\tau = 0$ (upper), and δd_τ assuming $\delta a_\tau = 0$ (lower). These are displayed for 10% (left), 5% (center) systematics at $\mathcal{L} = 2$ nb^{-1}, and 5% systematics result extrapolated to $\mathcal{L} = 20$ nb^{-1} (right). The combined χ^2 for all three track SRs is shown by the red line, while the impact of dividing SR1ℓ1T into two orthogonal p_{T}^{ℓ} bins is shown by the green line. The gray horizontal lines correspond to 68% C.L. ($\chi^2 = 1$) and 95% C.L. ($\chi^2 = 3.84$). The unphysical spikes are due to limited MC statistics.

TABLE I. Cutflow of event yields after each requirement applied sequentially, normalized to $\mathcal{L} = 2$ nb^{-1} for the different analyses. For the $\gamma\gamma \to \tau\tau$ signal processes, we show these for benchmark points with parameter values labeled by $(\delta a_\tau, \delta d_\tau)$ displayed in the column header. Backgrounds are shown for various dilepton $\mu\mu$, ee, and diquark where the letters denote the flavor. The initial value in each cutflow is the cross-section σ times luminosity $\mathcal{L}$, followed by the efficiency $\varepsilon_{\mathrm{filter}}$ of the filter applied at generator level to the $\gamma\gamma \to \tau\tau$ samples.

Requirement	$\tau\tau$ (0, 0)	$\tau\tau$ (0.018, 0)	$\tau\tau(-0.035, 0)$	$\mu\mu$	ee	bb	cc	ss	uu	dd
1 lepton + 1 track analysis (SR1ℓ1T)										
$\sigma \times \mathcal{L}$	1139800	1195060	1056400	844080	844080	2999	604080	37754	604080	37754
$\sigma \times \mathcal{L} \times \varepsilon_{\mathrm{filter}}$	241140	253920	226300	844080	844080	2999	604080	37754	604080	37754
1ℓ plus 1 track	20492.2	21619.3	19348.4	263443	3299.3	5.4	2905.0	0.3	5.4	0.2
$p_{\mathrm{T}}^{e/\mu} > 4.5/3$ GeV, $\lvert\eta^{e/\mu}\rvert < 2.5/2.4$	3659.9	3882.7	3582.8	79043	3118.9	1.1	4.8	0.0	0.0	0.0
$p_{\mathrm{T}}^{\mathrm{trk}} > 0.5$ GeV, $\lvert\eta^{\mathrm{trk}}\rvert < 2.5$	3324.5	3535.9	3256.9	78973	3117.8	1.0	3.0	0.0	0.0	0.0
$\lvert\Delta\phi(\ell, \mathrm{trk})\rvert < 3$	1519.7	1605.7	1468.3	0.9	5.3	0.7	1.8	0.0	0.0	0.0
$m_{\ell,\mathrm{trk}} \notin \{[3, 3.2], [9, 11]\}$ GeV	1275.1	1353.6	1242.3	0.9	5.3	0.2	1.2	0.0	0.0	0.0
$p_{\mathrm{T}}^{\ell} \leq 6.0$ GeV	1197.7	1262.3	1154.7	0.9	0.0	0.2	1.2	0.0	0.0	0.0
$p_{\mathrm{T}}^{\ell} > 6.0$ GeV	77.3	91.3	87.6	0.0	5.3	0.0	0.0	0.0	0.0	0.0
1 lepton + multitrack analysis (SR1ℓ2/3T)										
$\sigma \times \mathcal{L}$	1139800	1195060	1056400	844080	844080	2999	604080	37754	604080	37754
$\sigma \times \mathcal{L} \times \varepsilon_{\mathrm{filter}}$	241140	253920	226300	844080	844080	2999	604080	37754	604080	37754
1ℓ plus 2 or 3 tracks	5945.1	6260.1	5572.2	33.8	23.2	43.8	8056.6	5.4	132.9	6.8
$p_{\mathrm{T}}^{e/\mu} > 4.5/3$ GeV, $\lvert\eta^{e/\mu}\rvert < 2.5/2.4$	1010.0	1073.3	978.6	12.2	4.2	1.8	13.3	0.0	0.0	0.0
$\ell + 2$ tracks, $p_{\mathrm{T}}^{\mathrm{trk}} > 0.5$ GeV, $\lvert\eta\rvert^{\mathrm{trk}} < 2.5$	519.9	548.1	485.8	5.6	4.2	0.8	4.8	0.0	0.0	0.0
$\ell + 3$ tracks, $p_{\mathrm{T}}^{\mathrm{trk}} > 0.5$ GeV, $\lvert\eta\rvert^{\mathrm{trk}} < 2.5$	370.5	398.3	381.1	0.0	0.0	0.4	3.6	0.0	0.0	0.0

As shown in Fig. 2, after the bug fix and assuming the current dataset $\mathcal{L} = 2$ nb^{-1} with 10% systematics, we find $-0.031 < a_\tau < 0.013$ at 68% C.L. Prospects assuming halved systematics give $-0.011 < a_\tau < 0.010$ (68% C.L.). A tenfold dataset increase assumed for the High-Luminosity LHC (HL-LHC) reduces this to $-0.0046 < a_\tau < 0.0083$ (68% C.L.). The orange line in Fig. 2 shows $270 < \Lambda < 370$ GeV, where our 20 nb^{-1}, 5% systematics proposal has 95% C.L. sensitivity, surpassing DELPHI by 100 GeV. Our projected 95% C.L. sensitivity on $d_\tau = (e/m_\tau)\delta d_\tau$ is $|d_\tau| < 1.2 \times 10^{-16}$ e cm, assuming $\delta a_\tau = 0$ with 2 nb^{-1}, 10% systematics. Note that the bug only affects BSM variations and does not impact the SM cross section. Although fixing this bug quantitatively changes our results, qualitatively the physics message is unchanged: the analyses proposed in the paper utilizing LHC heavy-ion collisions remains an innovative and promising way to surpass existing lepton collider precision on a_τ, opening novel avenues to new physics, and should therefore be pursued experimentally by the LHC collaborations.

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