Erratum: Detection of a gamma-ray source in the Galactic Center consistent with extended emission from dark matter annihilation and concentrated astrophysical emission [Phys. Rev. D 86, 083511 (2012)]

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CORRECTION.—We correct two separate errors in calculating the relation between the observed flux and the gamma-ray spectrum in the published version of this manuscript. The results and conclusions regarding the nature of the source, its statistical significance, and its spectrum do not change from that stated in the published manuscript. However, the inferred annihilation rate that fits the signal best is reduced by a factor of 5.

The differential flux for a dark matter candidate with cross section $\langle\sigma_{\rm A} v\rangle$ in a pixel "i" is

$$\frac{dN_{\rm i}}{dA\,dt\,dE} = \frac{dN_\gamma}{dE}\frac{\langle\sigma_{\rm A} v\rangle}{2}\frac{J_{\rm i}}{4\pi m_\chi^2}, \tag{1}$$

where dN_γ/dE is the photon spectrum from a single annihilation event, $\langle\sigma v\rangle$ is the annihilation rate, and m_χ is the dark matter particle mass. Here

$$J_{\rm i} \equiv \int_{\Delta\Omega_{\rm i}} \rho^2(r_{\rm gal}(b, \ell, z))dz d\Omega \tag{2}$$

is the integral of the dark matter density squared along the line of sight (z) over the ith pixel, and $\Delta\Omega_{\rm i}$ is the pixel's solid angle.

The gamma-ray spectrum per annihilation was calculated from PYTHIA as $dN_\gamma/dE = E^{-1}dN_\gamma/d\ln E$. The term $d\ln E$ was inadvertently omitted in the numerical code calculating the spectrum. This factor is the equally spaced logarithmic energy bin, and in our calculation it varies from approximately 0.07 to 0.12 depending on the particle masses. This increased the inferred annihilation rate by the inverse of these factors.

The spectrum required by the Fermi science tools relates the dark matter extended source's spatial distribution to the flux in a given pixel. We find that the relation between the spectrum and its normalization required by the tools for a specific dark matter extended source template should be

$$\frac{dN_{\rm tools}}{dE} = \frac{dN_\gamma}{dE}\frac{\langle\sigma v\rangle}{2}\frac{1}{4\pi m_\chi^2}\frac{J_{\rm map}}{\Delta\Omega_{\rm i}}, \tag{3}$$

where it has been implicitly assumed that the sum of the spatial template's pixel values has been normalized to unity and all pixels subtend the same solid angle $\Delta\Omega_{\rm i}$. If the sum of the template's pixel values is normalized to $1/\Delta\Omega_{\rm i}$, as suggested in the Fermi tools extended source analysis thread [1], then the $\Delta\Omega_{\rm i}$ term in the denominator of Eq. (3) should be omitted. In the above equation, $J_{\rm map}$ is the integral of the dark matter density squared along the line of sight over the entire template map's solid angle of $\Delta\Omega_{\rm map}$, which is typically larger than the region of interest. There was an error in the numerical calculation of this $J_{\rm map}$ integral in the published version of this manuscript of approximately a factor of 2 large, decreasing the inferred annihilation rate by this amount.

As stated above, the results and conclusions regarding the nature of the source, its statistical significance, and its spectrum do not change from that given in the published manuscript. However, the dark matter annihilation rate required to produce the observed flux is decreased by approximately a factor of 5 with the above corrections. This shifts the parameter region in $\langle\sigma_{\rm A} v\rangle$ vs m_χ consistent with the dark matter interpretation down by the same factor of about 5. See the corrected parameter space in Figs. 1 and 2. There are related minor unit corrections in the text: the normalizations in Sec. IV should be $N_0 = (9.66 \pm 1.01) \times 10^{-9}$ ph cm^{-2} s^{-1} sr^{-1} for the log-parabola spectrum and $N_0 = (7.10 \pm 1.19) \times 10^{-9}$ ph cm^{-2} s^{-1} sr^{-1} for the power law with an exponential cutoff spectrum.

DISCUSSION.—The parameter region consistent with the Galactic Center source is now below that in Ref. [2], with the same assumptions of local dark matter density $\rho_\odot = 0.4$ GeV cm^{-3} and dark matter halo profile $\gamma = 1.3$. Reference [2] preferred a region at $\sim 10^{-26}$ cm^3 s^{-1} at $m_\chi \approx 30$ GeV for a pure $b/\bar{b}$ annihilation case. These assumptions correspond to the lower edge of the lighter pink band in Fig. 1, which we find to be at $\sim 3 \times 10^{-27}$ cm^3 s^{-1}—a factor of a few lower than that inferred in Ref. [2]. This is likely due to the use of a toy dark matter profile of $\rho \propto r^{-\gamma}$ in that work. Using a generalized Navarro-Frenk-White (NFW) form such as in this work shifts the region down by a factor of approximately 3,

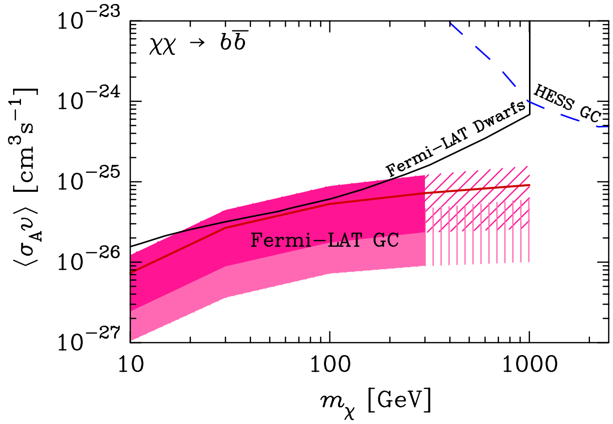

FIG. 1 (color online). Shown are the corrected parameters of particle dark matter mass m_χ and cross section $\langle\sigma_A v\rangle$ for annihilation to $b\bar{b}$ quarks consistent with the extended gamma-ray source at the Galactic Center (GC) at 68% C.L. (dark pink) for a dark matter density profile with central slope $\gamma = 1.2$ (best-fit spatial model). The red line is for $\rho_\odot = 0.3$ GeV cm^{-3}. The diagonally hatched region is approximately where the $2\Delta \ln \mathcal{L}$ significance drops below $\approx 5\sigma$. The light pink region shows the extension of the consistency region for $\gamma = 1.3$, with the vertically hatched region corresponding to approximately where the $2\Delta \ln \mathcal{L}$ significance drops below $\approx 5\sigma$. The region above the solid line indicates the parameters excluded at 95% C.L. by stacked dwarf analyses [8]. The region above the dashed line indicates the parameters excluded at 95% C.L. by HESS observations of the GC [9]. We have assumed here that all of the extended emission is due to dark matter annihilation. If only part of it is due to dark matter, then the required cross section should be lower.

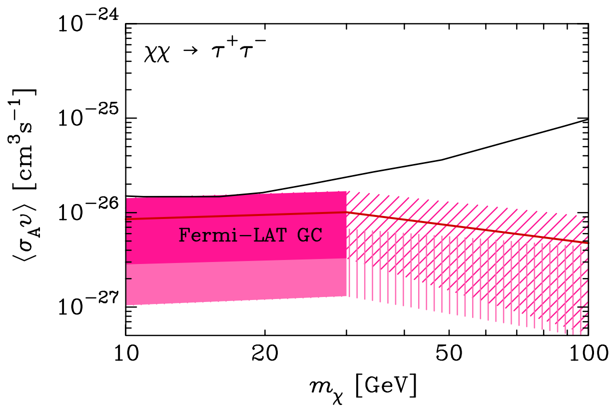

FIG. 2 (color online). Shown are the corrected parameters of particle dark matter mass m_χ and cross section $\langle\sigma_A v\rangle$ for annihilation to $\tau^+\tau^-$ leptons consistent with the extended gamma-ray source at the GC at 68% C.L. for a central density profile of $\gamma = 1.2$ (the best-fit model, in dark pink) and $\gamma = 1.3$ (light pink). The red line is for the case of $\rho_\odot = 0.3$ GeV cm^{-3}. The diagonally and vertically hatched regions are approximately where the $2\Delta \ln \mathcal{L}$ significance drops below $\approx 5\sigma$ for the $\gamma = 1.2$ and $\gamma = 1.3$ cases, respectively. The region above the solid line indicates the parameters excluded at 95% C.L. by stacked dwarf analyses [8].

in good agreement with the results here [3], and in agreement with the dark matter interpretation of the signal in the Fermi bubbles [4]. With the small shift to lower annihilation rates, the overall region is more consistent with that expected from phenomenological supersymmetric models of thermal neutralino dark matter, e.g. in Refs. [5–7].

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