



Erratum to: Search for annihilating dark matter in the Sun with 3 years of IceCube data

IceCube Collaboration

M. G. Aartsen², M. Ackermann⁵², J. Adams¹⁶, J. A. Aguilar¹², M. Ahlers³⁰, M. Ahrens⁴², D. Altmann²⁴, K. Andeen³², T. Anderson⁴⁸, I. Ansseau¹², G. Anton²⁴, M. Archinger³¹, C. Argüelles¹⁴, J. Auffenberg¹, S. Axani¹⁴, X. Bai⁴⁰, S. W. Barwick²⁷, V. Baum³¹, R. Bay⁷, J. J. Beatty^{18,19}, J. Becker Tjus¹⁰, K.-H. Becker⁵¹, S. BenZvi⁴⁹, D. Berley¹⁷, E. Bernardini⁵², A. Bernhard³⁴, D. Z. Besson²⁸, G. Binder^{7,8}, D. Bindig⁵¹, M. Bissok¹, E. Blaufuss¹⁷, S. Blot⁵², C. Boehm⁴², M. Börner²¹, F. Bos¹⁰, D. Bose⁴⁴, S. Böser³¹, O. Botner⁵⁰, J. Braun³⁰, L. Brayeur¹³, H.-P. Bretz⁵², S. Bron²⁵, A. Burgman⁵⁰, T. Carver²⁵, M. Casier¹³, E. Cheung¹⁷, D. Chirkin³⁰, A. Christov²⁵, K. Clark⁴⁵, L. Classen³⁵, S. Coenders³⁴, G. H. Collin¹⁴, J. M. Conrad¹⁴, D. F. Cowen^{47,48}, R. Cross⁴⁹, M. Day³⁰, J. P. A. M. de André²², C. De Clercq¹³, E. del Pino Rosendo³¹, H. Dembinski³⁶, S. De Ridder²⁶, P. Desiati³⁰, K. D. de Vries¹³, G. de Wasseige¹³, M. de With⁹, T. DeYoung²², J. C. Díaz-Vélez³⁰, V. di Lorenzo³¹, H. Dujmovic⁴⁴, J. P. Dumm⁴², M. Dunkman⁴⁸, B. Eberhardt³¹, T. Ehrhardt³¹, B. Eichmann¹⁰, P. Eller⁴⁸, S. Euler⁵⁰, P. A. Evenson³⁶, S. Fahey³⁰, A. R. Fazely⁶, J. Feintzeig³⁰, J. Felde¹⁷, K. Filimonov⁷, C. Finley⁴², S. Flis⁴², C.-C. Fösig³¹, A. Franckowiak⁵², E. Friedman¹⁷, T. Fuchs²¹, T. K. Gaisser³⁶, J. Gallagher²⁹, L. Gerhardt^{7,8}, K. Ghorbani³⁰, W. Giang²³, L. Gladstone³⁰, T. Glauch¹, T. Glüsenkamp²⁴, A. Goldschmidt⁸, J. G. Gonzalez³⁶, D. Grant²³, Z. Griffith³⁰, C. Haack¹, A. Hallgren⁵⁰, F. Halzen³⁰, E. Hansen²⁰, T. Hansmann¹, K. Hanson³⁰, D. Hebecker⁹, D. Heereman¹², K. Helbing⁵¹, R. Hellauer¹⁷, S. Hickford⁵¹, J. Hignight²², G. C. Hill², K. D. Hoffman¹⁷, R. Hoffmann⁵¹, K. Hoshina^{30,53}, F. Huang⁴⁸, M. Huber³⁴, K. Hultqvist⁴², S. In⁴⁴, A. Ishihara¹⁵, E. Jacobi⁵², G. S. Japaridze⁴, M. Jeong⁴⁴, K. Jero³⁰, B. J. P. Jones¹⁴, W. Kang⁴⁴, A. Kappes³⁵, T. Karg⁵², A. Karle³⁰, U. Katz²⁴, M. Kauer³⁰, A. Keivani⁴⁸, J. L. Kelley³⁰, A. Kheirandish³⁰, J. Kim⁴⁴, M. Kim⁴⁴, T. Kintscher⁵², J. Kiryluk⁴³, T. Kittler²⁴, S. R. Klein^{7,8}, G. Kohnen³³, R. Koirala³⁶, H. Kolanoski⁹, R. Konietz¹, L. Köpke³¹, C. Kopper²³, S. Kopper⁵¹, D. J. Koskinen²⁰, M. Kowalski^{9,52}, K. Krings³⁴, M. Kroll¹⁰, G. Krückl³¹, C. Krüger³⁰, J. Kunnen¹³, S. Kunwar⁵², N. Kurahashi³⁹, T. Kuwabara¹⁵, M. Labare²⁶, J. L. Lanfranchi⁴⁸, M. J. Larson²⁰, F. Lauber⁵¹, D. Lennarz²², M. Lesiak-Bzdak⁴³, M. Leuermann¹, L. Lu¹⁵, J. Lünemann¹³, J. Madsen⁴¹, G. Maggi¹³, K. B. M. Mahn²², S. Mancina³⁰, M. Mandelartz¹⁰, R. Maruyama³⁷, K. Mase¹⁵, R. Maunu¹⁷, F. McNally³⁰, K. Meagher¹², M. Medici²⁰, M. Meier²¹, A. Meli²⁶, T. Menne²¹, G. Merino³⁰, T. Meures¹², S. Miarecki^{7,8}, T. Montaruli²⁵, M. Moulai¹⁴, R. Nahnhauser⁵², U. Naumann⁵¹, G. Neer²², H. Niederhausen⁴³, S. C. Nowicki²³, D. R. Nygren⁸, A. Obertacke Pollmann⁵¹, A. Olivas¹⁷, A. O’Murchadha¹², T. Palczewski^{7,8}, H. Pandya³⁶, D. V. Pankova⁴⁸, P. Peiffer³¹, Ö. Penek¹, J. A. Pepper⁴⁶, C. Pérez de los Heros⁵⁰, D. Pieloth²¹, E. Pinat¹², P. B. Price⁷, G. T. Przybylski⁸, M. Quinlan⁴⁸, C. Raab¹², L. Rädcl¹, M. Rameez^{20,25,a} , K. Rawlins³, R. Reimann¹, B. Relethford³⁹, M. Relich¹⁵, E. Resconi³⁴, W. Rhode²¹, M. Richman³⁹, B. Riedel²³, S. Robertson², M. Rongen¹, C. Rott⁴⁴, T. Ruhe²¹, D. Ryckbosch²⁶, D. Rysewyk²², L. Sabbatini³⁰, S. E. Sanchez Herrera²³, A. Sandrock²¹, J. Sandroos³¹, S. Sarkar^{20,38}, K. Satalecka⁵², P. Schlunder²¹, T. Schmidt¹⁷, S. Schoenen¹, S. Schöneberg¹⁰, L. Schumacher¹, D. Seckel³⁶, S. Seunarine⁴¹, D. Soldin⁵¹, M. Song¹⁷, G. M. Spiczak⁴¹, C. Spiering⁵², T. Stanev³⁶, A. Stasik⁵², J. Stettner¹, A. Steuer³¹, T. Stezelberger⁸, R. G. Stokstad⁸, A. Stöbl¹⁵, R. Ström⁵⁰, N. L. Strotjohann⁵², G. W. Sullivan¹⁷, M. Sutherland¹⁸, H. Taavola⁵⁰, I. Taboada⁵, J. Tatar^{7,8}, F. Tenholt¹⁰, S. Ter-Antonyan⁶, A. Terliuk⁵², G. Tešić⁴⁸, S. Tilav³⁶, P. A. Toale⁴⁶, M. N. Tobin³⁰, S. Toscano¹³, D. Tosi³⁰, M. Tselengidou²⁴, A. Turcati³⁴, E. Unger⁵⁰, M. Usner⁵², J. Vandenbroucke³⁰, N. van Eijndhoven¹³, S. Vanheule²⁶, M. van Rossem³⁰, J. van Santen⁵², M. Vehring¹, M. Voge¹¹, E. Vogel¹, M. Vraeghe²⁶, C. Walck⁴², A. Wallace², M. Wallraff¹, N. Wandkowsky³⁰, Ch. Weaver²³, M. J. Weiss⁴⁸, C. Wendt³⁰, S. Westerhoff³⁰, B. J. Whelan², S. Wickmann¹, K. Wiebe³¹, C. H. Wiebusch¹, L. Wille³⁰, D. R. Williams⁴⁶, L. Wills³⁹, M. Wolf⁴², T. R. Wood²³, E. Woolsey²³, K. Woschnagg⁷, D. L. Xu³⁰, X. W. Xu⁶, Y. Xu⁴³, J. P. Yanez²³, G. Yodh²⁷, S. Yoshida¹⁵, M. Zoll^{42,b}

¹ III. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany

² Department of Physics, University of Adelaide, Adelaide 5005, Australia

- ³ Department of Physics and Astronomy, University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK 99508, USA
- ⁴ CTSPS, Clark-Atlanta University, Atlanta, GA 30314, USA
- ⁵ School of Physics and Center for Relativistic Astrophysics, Georgia Institute of Technology, Atlanta, GA 30332, USA
- ⁶ Department of Physics, Southern University, Baton Rouge, LA 70813, USA
- ⁷ Department of Physics, University of California, Berkeley, CA 94720, USA
- ⁸ Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
- ⁹ Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany
- ¹⁰ Fakultät für Physik & Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany
- ¹¹ Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany
- ¹² Science Faculty CP230, Université Libre de Bruxelles, 1050 Brussels, Belgium
- ¹³ Dienst ELEM, Vrije Universiteit Brussel (VUB), 1050 Brussels, Belgium
- ¹⁴ Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
- ¹⁵ Department of Physics and Institute for Global Prominent Research, Chiba University, Chiba 263-8522, Japan
- ¹⁶ Department of Physics and Astronomy, University of Canterbury, Private Bag 4800, Christchurch, New Zealand
- ¹⁷ Department of Physics, University of Maryland, College Park, MD 20742, USA
- ¹⁸ Department of Physics and Center for Cosmology and Astro-Particle Physics, Ohio State University, Columbus, OH 43210, USA
- ¹⁹ Department of Astronomy, Ohio State University, Columbus, OH 43210, USA
- ²⁰ Present Address: Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark
- ²¹ Department of Physics, TU Dortmund University, 44221 Dortmund, Germany
- ²² Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA
- ²³ Department of Physics, University of Alberta, Edmonton, AB T6G 2E1, Canada
- ²⁴ Erlangen Centre for Astroparticle Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany
- ²⁵ Département de physique nucléaire et corpusculaire, Université de Genève, 1211 Geneva, Switzerland
- ²⁶ Department of Physics and Astronomy, University of Gent, 9000 Ghent, Belgium
- ²⁷ Department of Physics and Astronomy, University of California, Irvine, CA 92697, USA
- ²⁸ Department of Physics and Astronomy, University of Kansas, Lawrence, KS 66045, USA
- ²⁹ Department of Astronomy, University of Wisconsin, Madison, WI 53706, USA
- ³⁰ Department of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin, Madison, WI 53706, USA
- ³¹ Institute of Physics, University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany
- ³² Department of Physics, Marquette University, Milwaukee, WI 53201, USA
- ³³ Université de Mons, 7000 Mons, Belgium
- ³⁴ Physik-department, Technische Universität München, 85748 Garching, Germany
- ³⁵ Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany
- ³⁶ Department of Physics and Astronomy, Bartol Research Institute, University of Delaware, Newark, DE 19716, USA
- ³⁷ Department of Physics, Yale University, New Haven, CT 06520, USA
- ³⁸ Department of Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, UK
- ³⁹ Department of Physics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, USA
- ⁴⁰ Physics Department, South Dakota School of Mines and Technology, Rapid City, SD 57701, USA
- ⁴¹ Department of Physics, University of Wisconsin, River Falls, WI 54022, USA
- ⁴² Department of Physics, Oskar Klein Centre, Stockholm University, 10691 Stockholm, Sweden
- ⁴³ Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA
- ⁴⁴ Department of Physics, Sungkyunkwan University, Suwon 440-746, Korea
- ⁴⁵ Department of Physics, University of Toronto, Toronto, ON M5S 1A7, Canada
- ⁴⁶ Department of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA
- ⁴⁷ Department of Astronomy and Astrophysics, Pennsylvania State University, University Park, PA 16802, USA
- ⁴⁸ Department of Physics, Pennsylvania State University, University Park, PA 16802, USA
- ⁴⁹ Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA
- ⁵⁰ Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden
- ⁵¹ Department of Physics, University of Wuppertal, 42119 Wuppertal, Germany
- ⁵² DESY, 15735 Zeuthen, Germany
- ⁵³ Earthquake Research Institute, University of Tokyo, Bunkyo, Tokyo 113-0032, Japan

Received: 29 January 2019 / Accepted: 19 February 2019 / Published online: 8 March 2019

© The Author(s) 2019

Erratum to: Eur. Phys. J. C (2017) 77:146

<https://doi.org/10.1140/epjc/s10052-017-4689-9>

The original article can be found online at <https://doi.org/10.1140/epjc/s10052-017-4689-9>.

^a e-mail: mohamed.rameez@nbi.ku.dk

^b e-mail: marcel.zoll.physics@gmail.com

In the analysis published in Ref. [1], constraints on the number of signal events n_s can be interpreted as constraints on the volumetric neutrino to muon conversion rate $\Lambda_{\nu\bar{\nu}\rightarrow\mu^+\mu^-}$,

Table 1 p values and 90% C.L. upper limits on the number of signal events within the two samples in ~532 days of livetime, corresponding to three years of operation of IceCube-DeepCore in its final configuration. The average effective volumes over the three years are also provided, as well as upper limits on the muon flux, annihilation rate, and the spin-dependent and spin-independent WIMP-proton scattering cross sections

m_χ (GeV)	Annih. channel	Dataset	p value %	$n_s^{90\%C.L.}$	V_{eff} (km ³)	$\bar{\Phi}_{\mu^+\mu^-}$ (km ⁻² year ⁻¹)	$\Phi_{\mu^+\mu^-}^{90\%C.L.}$ (km ⁻² year ⁻¹)	$\Gamma_{\chi\chi \rightarrow SM}^{90\%C.L.}$ (s ⁻¹)	$\sigma_{SD}^{90\%C.L.}$ (pb)	$\sigma_{SI}^{90\%C.L.}$ (pb)
20	$\tau^+\tau^-$	DC	>50	97.2	4.40e-04	3.49e+03	3.36e+03	9.19e+23	4.85e-04	4.06e-06
35	$b\bar{b}$	DC	>50	96.8	2.79e-04	4.01e+03	3.91e+03	7.39e+24	9.25e-03	4.77e-05
35	$\tau^+\tau^-$	DC	>50	59.1	1.26e-03	1.30e+03	1.25e+03	1.08e+23	1.35e-04	6.95e-07
50	$b\bar{b}$	DC	>50	87.3	4.71e-04	2.83e+03	2.79e+03	2.79e+24	6.39e-03	2.44e-05
50	$\tau^+\tau^-$	DC	48.4	48.9	2.31e-03	7.70e+02	8.03e+02	3.46e+22	7.90e-05	3.02e-07
100	$b\bar{b}$	DC	46.1	65.2	1.39e-03	1.19e+03	1.26e+03	4.09e+23	3.29e-03	7.38e-06
100	W^+W^-	DC	34.7	36.1	6.64e-03	3.06e+02	4.07e+02	1.18e+22	9.52e-05	2.13e-07
100	$\tau^+\tau^-$	DC	31.3	37.6	9.40e-03	2.30e+02	2.97e+02	3.60e+21	2.91e-05	6.48e-08
250	$b\bar{b}$	DC+IC	28.2	55.1	4.42e-03	5.22e+02	6.59e+02	5.96e+22	2.80e-03	3.50e-06
250	W^+W^-	DC+IC	39.8	64.7	7.38e-02	1.35e+02	1.62e+02	1.13e+21	5.30e-05	6.62e-08
250	$\tau^+\tau^-$	DC+IC	42.1	90.6	7.20e-02	1.83e+02	2.04e+02	5.99e+20	2.82e-05	3.52e-08
500	$b\bar{b}$	DC+IC	46.1	75.6	1.54e-02	3.68e+02	4.09e+02	1.66e+22	3.06e-03	2.82e-06
500	W^+W^-	IC	39.3	36.0	1.87e-01	4.04e+01	5.53e+01	2.04e+20	3.76e-05	3.49e-08
500	$\tau^+\tau^-$	IC	38.7	45.1	1.95e-01	4.71e+01	5.93e+01	7.96e+19	1.46e-05	1.35e-08
1000	$b\bar{b}$	IC	37.2	43.1	3.24e-02	1.30e+02	1.55e+02	3.56e+21	2.59e-03	2.00e-06
1000	W^+W^-	IC	48.9	24.6	2.67e-01	3.06e+01	3.31e+01	9.34e+19	6.80e-05	5.28e-08
1000	$\tau^+\tau^-$	IC	46.5	28.6	2.86e-01	3.30e+01	3.46e+01	2.84e+19	2.07e-05	1.60e-08
3000	$b\bar{b}$	IC	48.2	32.1	6.62e-02	7.29e+01	7.56e+01	1.04e+21	6.76e-03	4.65e-06
3000	W^+W^-	IC	49.6	23.1	2.86e-01	3.07e+01	3.13e+01	8.33e+19	5.42e-04	3.70e-07
3000	$\tau^+\tau^-$	IC	49.4	21.1	2.92e-01	2.85e+01	2.90e+01	1.85e+19	1.21e-04	8.25e-08
5000	$b\bar{b}$	IC	49.1	33.7	7.72e-02	7.11e+01	7.24e+01	8.74e+20	1.58e-02	1.06e-05
5000	W^+W^-	IC	49.8	22.4	3.09e-01	2.78e+01	2.84e+01	7.59e+19	1.37e-03	9.14e-07
5000	$\tau^+\tau^-$	IC	49.8	22.3	3.10e-01	2.86e+01	2.93e+01	1.82e+19	3.28e-04	2.19e-07
10000	$b\bar{b}$	IC	49.8	32.5	8.26e-02	6.74e+01	6.87e+01	7.31e+20	5.27e-02	3.46e-05
10000	W^+W^-	IC	>50	25.2	3.18e-01	3.08e+01	3.11e+01	8.26e+19	5.96e-03	3.88e-06
10000	$\tau^+\tau^-$	IC	>50	25.0	3.19e-01	3.18e+01	3.21e+01	1.94e+19	1.40e-03	9.11e-07

$$\Lambda_{\nu\bar{\nu}\rightarrow\mu^+\mu^-}^{90\% \text{C.L.}} = \frac{n_s^{90\% \text{C.L.}}}{\sum_j T_{\text{live}}^j V_{\text{eff}}^j}, \quad (1)$$

where T_{live} and V_{eff} are the livetime and effective volume of the data sample of index j . These can then be interpreted as constraints on the muon flux $\Phi_{\mu^+\mu^-}$, dark matter (DM) annihilation rate in the Sun $\Gamma_{\chi\chi\rightarrow\text{SM}}$, as well as the spin-dependent (SD) and spin-independent (SI) scattering cross sections σ_{SD} and σ_{SI} using `WimpSim` [2].

In Table 4 of Ref. [1], the labels and units of columns 7 and 8 suggest that the muon flux $\Phi_{\mu^+\mu^-}$ (in units $\text{km}^{-2} \text{year}^{-1}$) is being presented. However for the first 12 rows, corresponding to points in which the DeepCore (DC) dataset was included, the volumetric neutrino to muon conversion rate $\Lambda_{\nu\bar{\nu}\rightarrow\mu^+\mu^-}$ (in units $\text{km}^{-3} \text{year}^{-1}$) were erroneously reported instead. The corrected table (Table 1) is presented hereby. All other columns remain unchanged. All quantities that go into the right hand side of Eq. 1 are presented in the table, as well as median sensitivities and 90% C.L. upper limits on the muon flux $\Phi_{\mu^+\mu^-}$ derived using `WimpSim` [2].

The final results and conclusions presented in Ref. [1] in terms of constraints on the SD and SI scattering cross sections σ_{SD} and σ_{SI} as well as the DM annihilation rate in the Sun $\Gamma_{\chi\chi\rightarrow\text{SM}}$, remain unchanged.

In Section 4.2 of Ref. [1], the maximum zenith angle of the Sun is erroneously mentioned as 104° . The correct maximum zenith angle of the Sun is 114° at the South Pole.

Acknowledgements We thank Joakim Edsjö and Tom Gaisser for the careful scrutiny through which these errors were brought to light. The authors gratefully acknowledge support from the following agencies and institutions: USA – U.S. National Science Foundation-Office of Polar Programs, U.S. National Science Foundation-Physics Division, Wisconsin Alumni Research Foundation, Center for High Throughput Computing (CHTC) at the University of Wisconsin-Madison,

Open Science Grid (OSG), Extreme Science and Engineering Discovery Environment (XSEDE), U.S. Department of Energy-National Energy Research Scientific Computing Center, Particle astrophysics research computing center at the University of Maryland, Institute for Cyber-Enabled Research at Michigan State University, and Astroparticle physics computational facility at Marquette University; Belgium – Funds for Scientific Research (FRS-FNRS and FWO), FWO Odysseus and Big Science programmes, and Belgian Federal Science Policy Office (Belspo); Germany – Bundesministerium für Bildung und Forschung (BMBF), Deutsche Forschungsgemeinschaft (DFG), Helmholtz Alliance for Astroparticle Physics (HAP), Initiative and Networking Fund of the Helmholtz Association, Deutsches Elektronen Synchrotron (DESY), and High Performance Computing cluster of the RWTH Aachen; Sweden – Swedish Research Council, Swedish Polar Research Secretariat, Swedish National Infrastructure for Computing (SNIC), and Knut and Alice Wallenberg Foundation; Australia – Australian Research Council; Canada – Natural Sciences and Engineering Research Council of Canada, Calcul Québec, Compute Ontario, Canada Foundation for Innovation, WestGrid, and Compute Canada; Denmark – Villum Fonden, Danish National Research Foundation (DNRF), Carlsberg Foundation; New Zealand – Marsden Fund; Japan – Japan Society for Promotion of Science (JSPS) and Institute for Global Prominent Research (IGPR) of Chiba University; Korea – National Research Foundation of Korea (NRF); Switzerland – Swiss National Science Foundation (SNSF).

Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. Funded by SCOAP³.

References

1. M.G. Aartsen et al. (IceCube Collaboration), *Eur. Phys. J. C* **77**, 146 (2017)
2. M. Blennow, J. Edsjö, T. Ohlsson, *JCAP* **01**, 021 (2008)