

## REFERENCES

- [1] A. Vieregg, K. Bechtol, and A. Romero-Wolf, "A technique for detection of PeV neutrinos using a phased radio array," *Journal of Cosmology and Astroparticle Physics*, vol. 2016, no. 02, p. 005, 2016.
- [2] J. Avva, K. Bechtol, T. Chesebro, L. Cremonesi, C. Deaconu, A. Gupta, A. Ludwig, W. Messino, C. Miki, R. Nichol, E. Oberla, M. Ransom, A. Romero-Wolf, D. Saltzberg, C. Schlupf, N. Shipp, G. Varner, A. Vieregg, and S. Wissel, "Development toward a ground-based interferometric phased array for radio detection of high energy neutrinos," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 869, pp. 46–55, 2017.
- [3] J. C. Hanson, "Broadband RF Phased Array Design with MEEP: Comparisons to Array Theory in Two and Three Dimensions," *Electronics*, vol. 10, no. 4, 2021.
- [4] J. A. Aguilar, P. Allison, J. J. Beatty, H. Bernhoff, D. Besson, N. Binglefors, O. Botner, S. Buitink, K. Carter, B. A. Clark, A. Connolly, P. Dasgupta, S. d. Kockere, K. D. d. Vries, C. Deaconu, M. A. DuVernois, N. Feigl, D. García-Fernández, C. Glaser, A. Hallgren, S. Hallmann, J. C. Hanson, B. Hendricks, B. Hokanson-Fasig, C. Hornhuber, K. Hughes, A. Karle, J. L. Kelley, S. R. Klein, R. Krebs, R. Lahmann, M. Magnuson, T. Meures, Z. S. Meyers, A. Nelles, A. Novikov, E. Oberla, B. Oeyen, H. Pandya, I. Plaisier, L. Pyras, D. Ryckbosch, O. Scholten, D. Seckel, D. Smith, D. Southall, J. Torres, S. Toscano, D. J. V. D. Broeck, N. v. Eijndhoven, A. G. Vieregg, C. Welling, S. Wissel, R. Young, and A. Zink, "Design and sensitivity of the Radio Neutrino Observatory in Greenland (RNO-G)," *Journal of Instrumentation*, vol. 16, no. 03, p. P03025, 2021.
- [5] E. Arnold, C. Leuschen, F. Rodriguez-Morales, J. Li, J. Paden, R. Hale, and S. Keshmiri, "CRE-SIS airborne radars and platforms for ice and snow sounding," *Annals of Glaciology*, vol. 61, no. 81, p. 58–67, 2020.
- [6] L. Li, J.-B. Yan, C. O'Neill, C. D. Simpson, and S. P. Gogineni, "Coplanar Side-Fed Tightly Coupled Ultra-Wideband Array for Polar Ice Sounding," *IEEE Transactions on Antennas and Propagation*, vol. 70, no. 6, pp. 4331–4341, 2022.
- [7] S. Hussain, S.-W. Qu, A. Sharif, H. Abubakar, X.-H. Wang, M. Imran, and Q. Abbasi, "Current Sheet Antenna Array and 5G: Challenges, Recent Trends, Developments, and Future Directions," *Sensors*, vol. 22, no. 9, 2022.
- [8] A. Fedeli, C. Montecucco, and G. L. Gragnani, "Open-Source Software for Electromagnetic Scattering Simulation: The Case of Antenna Design," *Electronics*, vol. 8, no. 12, p. 1506, 2019.
- [9] O. Yurduseven, S. Ye, T. Fromenteze, B. Wiley, and D. Smith, "3D Conductive Polymer Printed Metasurface Antenna for Fresnel Focusing," *Designs*, vol. 3, no. 46, 2019.
- [10] F. Pizarro, R. Salazar, E. Rajo-Iglesias, M. Rodríguez, S. Fingerhuth, and G. Hermosilla, "Parametric Study of 3D Additive Printing Parameters Using Conductive Filaments on Microwave Topologies," *IEEE Access*, vol. 7, pp. 106814–106823, 2019.
- [11] Allison, P., et al, "Low-threshold ultrahigh-energy neutrino search with the Askaryan Radio Array," *Phys. Rev. D*, vol. 105, p. 122006, Jun 2022.
- [12] M. E. Thompson, "Grade Expectations: The Role of First-Year Grades in Predicting the Pursuit of STEM Majors for First- and Continuing-Generation Students," *The Journal of Higher Education*, vol. 92, no. 6, pp. 961–985, 2021.
- [13] M. Estrada, "Creating Pathways of Kindness and Inclusion in STEM Education." Inclusivity in Introductory STEM Courses (Cottrell Scholars Network), 2022.
- [14] C. Singh, "Promoting Equity in Science Learning." Inclusivity in Introductory STEM Courses (Cottrell Scholars Network), 2022.
- [15] C. Freeman, A. Kittredge, H. Wilson, and B. Pajak, "The Duolingo Method for App-based Teaching and Learning," tech. rep., Duolingo Research Report, 2023.

- [16] D. Shin and J. Shim, "A Systematic Review on Data Mining for Mathematics and Science Education," *International Journal of Science and Mathematics Education*, pp. 1–21, 2020.
- [17] C. Cooper and P. Pearson, "A Genetically Optimized Predictive System for Success in General Chemistry Using a Diagnostic Algebra Test," *Journal of Science Education and Technology*, vol. 21, no. 1, 2011.
- [18] J. Grossman, Z. Lin, H. Sheng, J. Wei, J. Williams, and S. Goel, "MathBot: Transforming On-line Resources for Learning Math into Conversational Interactions," *Association for the Advancement of Artificial Intelligence*, 2019.
- [19] Lee, H.S. et al, "Automated text scoring and real-time adjustable feedback: Supporting revision of scientific arguments involving uncertainty," *Science Education Journal*, vol. 103, no. 3, 2019.
- [20] J. Ghimire, F. D. Diba, J.-H. Kim, and D.-Y. Choi, "Vivaldi Antenna Arrays Feed by Frequency-Independent Phase Shifter for High Directivity and Gain Used in Microwave Sensing and Communication Applications.," *Sensors*, vol. 21, no. 18, p. 6091, 2021.
- [21] F. Cui, G. Dong, Y. Chen, C. Wang, D. Teng, and R. Wang, "Numerical modeling and data signal analysis of GPR array based on dual-field domain-decomposition time-domain finite element method," *Journal of Applied Geophysics*, vol. 208, p. 104876, 2023.
- [22] R. Mailloux, *The Phased Array Handbook*, 3rd ed. Boston: Artech House, 2017.
- [23] A. F. Oskooi, D. Roundy, M. Ibanescu, P. Bermel, J. Joannopoulos, and S. G. Johnson, "Meep: A flexible free-software package for electromagnetic simulations by the FDTD method," *Computer Physics Communications*, vol. 181, no. 3, pp. 687–702, 2010.
- [24] J. C. Hanson, "Broadband RF Phased Array Design with Meep." MeepCon 2022, 2022.
- [25] O. Yurduseven, P. Flowers, S. Ye, D. L. Marks, J. N. Gollub, T. Fromenteze, B. J. Wiley, and D. R. Smith, "Computational microwave imaging using 3D printed conductive polymer frequency-diverse metasurface antennas," *IET Microwaves, Antennas & Propagation*, vol. 11, no. 14, pp. 1962–1969, 2017.
- [26] K. Yee, "Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media," *IEEE Transactions on Antennas and Propagation*, vol. 14, no. 3, pp. 302–307, 1966.
- [27] A. Hammond, "High-Performance Topology Optimization for Photonics Inverse Design." MeepCon 2022, 2022.
- [28] The IceCube Collaboration, "Evidence for High-Energy Extraterrestrial Neutrinos at the IceCube Detector," *Science*, vol. 342, no. 6161, pp. 1242856–1242856, 2013.
- [29] The IceCube Collaboration, "Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert," *Science*, vol. 361, no. 6398, pp. 147–151, 2018.
- [30] The IceCube Collaboration, "Evidence for neutrino emission from the nearby active galaxy NGC 1068," *Science*, vol. 378, no. 6619, pp. 538–543, 2022.
- [31] The IceCube Collaboration, "Observation of high-energy neutrinos from the Galactic plane," *Science*, vol. 380, no. 6652, pp. 1338–1343, 2023.
- [32] M. Ackermann et al, "Astrophysics Uniquely Enabled by Observations of High-Energy Cosmic Neutrinos," 2019.
- [33] M. Ackermann et al, "Fundamental Physics with High-Energy Cosmic Neutrinos," 2019.
- [34] The ANITA Collaboration, "Constraints on the ultrahigh-energy cosmic neutrino flux from the fourth flight of ANITA," *Physical Review D*, vol. 99, no. 12, p. 122001, 2019.
- [35] The ARIANNA Collaboration, "A search for cosmogenic neutrinos with the ARIANNA test bed using 4.5 years of data," *Journal of Cosmology and Astroparticle Physics*, vol. 2020, no. 03, pp. 053–053, 2020.
- [36] The IceCube Collaboration, "Differential limit on the extremely-high-energy cosmic neutrino flux in the presence of astrophysical background from nine years of IceCube data," *Physical Review D*, vol. 98, no. 6, p. 062003, 2018.

- [37] G. Askaryan, "Cherenkov Radiation and Transition Radiation from Electromagnetic Waves," *Soviet Physics JETP*, vol. 15, no. 5, 1962.
- [38] E. Zas, F. Halzen, and T. Stanev, "Electromagnetic pulses from high-energy showers: Implications for neutrino detection," *Physical Review D*, vol. 45, no. 1, p. 362, 1992.
- [39] J. C. Hanson, S. W. Barwick, E. C. Berg, D. Z. Besson, T. J. Duffin, S. R. Klein, S. A. Kleinfelder, C. Reed, M. Roumi, T. Stezelberger, J. Tatar, J. A. Walker, and L. Zou, "Radar absorption, basal reflection, thickness and polarization measurements from the Ross Ice Shelf, Antarctica," *Journal of Glaciology*, vol. 61, no. 227, pp. 438–446, 2015.
- [40] J. Avva, J. Kovac, C. Miki, D. Saltzberg, and A. Viereg, "An in situ measurement of the radio-frequency attenuation in ice at Summit Station, Greenland," *Journal of Glaciology*, 2014.
- [41] P. Allison, J. Auffenberg, R. Bard, J. Beatty, D. Besson, S. Böser, C. Chen, P. Chen, A. Connolly, and J. Davies, "Design and initial performance of the Askaryan Radio Array prototype EeV neutrino detector at the South Pole," *Astroparticle Physics*, vol. 35, no. 7, pp. 457–477, 2012.
- [42] I. Kravchenko et al, "Updated results from the RICE experiment and future prospects for ultra-high energy neutrino detection at the south pole," *Physical Review D*, vol. 85, no. 6, p. 062004, 2012.
- [43] P. Allison, S. Archambault, J. J. Beatty, M. Beheler-Amass, D. Z. Besson, M. Beydler, C. C. Chen, C. H. Chen, P. Chen, B. A. Clark, W. Clay, A. Connolly, L. Cremonesi, J. Davies, S. d. Kockere, K. D. d. Vries, C. Deaconu, M. A. DuVernois, E. Friedman, R. Gaior, J. Hanson, K. Hanson, K. D. Hoffman, B. Hokanson-Fasig, E. Hong, S. Y. Hsu, L. Hu, J. J. Huang, M. H. Huang, K. Hughes, A. Ishihara, A. Karle, J. L. Kelley, R. Khandelwal, K. C. Kim, M. C. Kim, I. Kravchenko, K. Kurusu, H. Landsman, U. A. Latif, A. Laundrie, C. J. Li, T. C. Liu, M. Y. Lu, B. Madison, K. Mase, T. Meures, J. Nam, R. J. Nichol, G. Nir, A. Novikov, A. Nozdrina, E. Oberla, A. O'Murchadha, J. Osborn, Y. Pan, C. Pfendner, J. Roth, P. Sandstrom, D. Seckel, Y. S. Shiao, A. Shultz, D. Smith, J. Torres, J. Touart, N. v. Eijndhoven, G. S. Varner, A. G. Viereg, M. Z. Wang, S. H. Wang, S. A. Wissel, S. Yoshida, R. Young, and A. Collaboration, "Constraints on the diffuse flux of ultrahigh energy neutrinos from four years of Askaryan Radio Array data in two stations," *Physical Review D*, vol. 102, no. 4, p. 043021, 2020.
- [44] D. Saltzberg, P. Gorham, D. Walz, C. Field, R. Iverson, A. Odian, G. Resch, P. Schoessow, and D. Williams, "Observation of the Askaryan effect: coherent microwave Cherenkov emission from charge asymmetry in high-energy particle cascades.," *Physical review letters*, vol. 86, no. 13, pp. 2802–5, 2001.
- [45] P. Miocinovic, R. Field, P. Gorham, E. Guillian, R. Milincic, D. Saltzberg, D. Walz, and D. Williams, "Time-domain measurement of broadband coherent Cherenkov radiation," *Physical Review D*, vol. 74, no. 4, p. 043002, 2006.
- [46] P. W. Gorham, S. W. Barwick, J. J. Beatty, D. Z. Besson, W. R. Binns, C. Chen, P. Chen, J. M. Clem, A. Connolly, P. F. Dowkontt, M. A. DuVernois, R. C. Field, D. Goldstein, A. Goodhue, C. Hast, C. L. Hebert, S. Hoover, M. H. Israel, J. Kowalski, J. G. Learned, K. M. Liewer, J. T. Link, E. Lusczek, S. Matsuno, B. Mercurio, C. Miki, P. Miočinović, J. Nam, C. J. Naudet, J. Ng, R. Nichol, K. Palladino, K. Reil, A. Romero-Wolf, M. Rosen, L. Ruckman, D. Saltzberg, D. Seckel, G. S. Varner, D. Walz, and F. Wu, "Observations of the askaryan effect in ice," *Phys. Rev. Lett.*, vol. 99, p. 171101, Oct 2007.
- [47] J. C. Hanson and R. Hartig, "Complex analysis of Askaryan radiation: A fully analytic model in the time domain," *Phys. Rev. D*, vol. 105, p. 123019, Jun 2022.
- [48] K. Dookayka, *Characterizing the Search for Ultra-High Energy Neutrinos with the ARIANNA Detector*. PhD thesis, University of California, Irvine, 2011.
- [49] The ARA Collaboration, "First constraints on the ultra-high energy neutrino flux from a prototype station of the Askaryan Radio Array," *Astroparticle Physics*, vol. 70, pp. 62–80, 2015.

- [50] C. Glaser, D. García-Fernández, A. Nelles, J. Alvarez-Muñiz, S. W. Barwick, D. Z. Besson, B. A. Clark, A. Connolly, C. Deaconu, K. D. d. Vries, J. C. Hanson, B. Hokanson-Fasig, R. Lahmann, U. Latif, S. A. Kleinfelder, C. Persichilli, Y. Pan, C. Pfendner, I. Plaisier, D. Seckel, J. Torres, S. Toscano, N. v. Eijndhoven, A. Viereg, C. Welling, T. Winchen, and S. A. Wissel, “NuRadioMC: simulating the radio emission of neutrinos from interaction to detector,” *The European Physical Journal C*, vol. 80, no. 2, p. 77, 2020.
- [51] C. Glaser, A. Nelles, I. Plaisier, C. Welling, S. W. Barwick, D. García-Fernández, G. Gaswint, R. Lahmann, and C. Persichilli, “NuRadioReco: a reconstruction framework for radio neutrino detectors,” *The European Physical Journal C*, vol. 79, no. 6, p. 464, 2019.
- [52] Anker, A, et al, “Probing the angular and polarization reconstruction of the ARIANNA detector at the South Pole,” *Journal of Instrumentation*, vol. 15, no. 09, pp. P09039–P09039, 2020.
- [53] C. Welling, P. Frank, T. Enßlin, and A. Nelles, “Reconstructing non-repeating radio pulses with Information Field Theory,” *Journal of Cosmology and Astroparticle Physics*, vol. 2021, no. 04, p. 071, 2021.
- [54] S. Barwick, E. Berg, D. Besson, T. Duffin, J. Hanson, S. Klein, S. Kleinfelder, M. Piasecki, K. Ratzlaff, C. Reed, M. Roumi, T. Stezelberger, J. Tatar, J. Walker, R. Young, and L. Zou, “Time-domain response of the ARIANNA detector,” *Astroparticle Physics*, vol. 62, pp. 139–151, 2015.
- [55] S. Barwick, E. Berg, D. Besson, G. Binder, W. Binns, D. Boersma, R. Bose, D. Braun, J. Buckley, V. Bugaev, S. Buitink, K. Dookayka, P. Dowkontt, T. Duffin, S. Euler, L. Gerhardt, L. Gustafsson, A. Hallgren, J. Hanson, M. Israel, J. Kiryluk, S. Klein, S. Kleinfelder, H. Niederhausen, M. Olevitch, C. Persichilli, K. Ratzlaff, B. Rauch, C. Reed, M. Roumi, A. Samanta, G. Simburger, T. Stezelberger, J. Tatar, U. Uggerhoj, J. Walker, G. Yodh, and R. Young, “A first search for cosmogenic neutrinos with the ARIANNA Hexagonal Radio Array,” *Astroparticle Physics*, vol. 70, pp. 12–26, 2015.
- [56] S. Barwick, D. Besson, A. Burgman, E. Chiem, A. Hallgren, J. Hanson, S. Klein, S. Kleinfelder, A. Nelles, C. Persichilli, S. Phillips, T. Prakash, C. Reed, S. Shively, J. Tatar, E. Unger, J. Walker, and G. Yodh, “Radio detection of air showers with the ARIANNA experiment on the Ross Ice Shelf,” *Astroparticle Physics*, 2016.
- [57] S. Barwick, E. Berg, D. Besson, G. Gaswint, C. Glaser, A. Hallgren, J. Hanson, S. Klein, S. Kleinfelder, L. Köpke, I. Kravchenko, R. Lahmann, U. Latif, J. Nam, A. Nelles, C. Persichilli, P. Sandstrom, J. Tatar, and E. Unger, “Observation of classically ‘forbidden’ electromagnetic wave propagation and implications for neutrino detection,” *Journal of Cosmology and Astroparticle Physics*, vol. 2018, no. 07, p. 055, 2018.
- [58] C. Deaconu, A. G. Viereg, S. A. Wissel, J. Bowen, S. Chipman, A. Gupta, C. Miki, R. J. Nichol, and D. Saltzberg, “Measurements and modeling of near-surface radio propagation in glacial ice and implications for neutrino experiments,” *Phys. Rev. D*, vol. 98, p. 043010, Aug 2018.
- [59] S. Barwick, E. Berg, D. Besson, T. Duffin, J. Hanson, S. Klein, S. Kleinfelder, K. Ratzlaff, C. Reed, M. Roumi, T. Stezelberger, J. Tatar, J. Walker, R. Young, and L. Zou, “Design and Performance of the ARIANNA HRA-3 Neutrino Detector Systems,” *IEEE Transactions on Nuclear Science*, vol. 62, no. 5, pp. 2202–2215, 2015.
- [60] J. A. Aguilar, P. Allison, J. J. Beatty, D. Besson, A. Bishop, O. Botner, S. Bouma, S. Buitink, M. Cataldo, B. A. Clark, and et al., “In situ, broadband measurement of the radio frequency attenuation length at summit station, greenland,” *Journal of Glaciology*, p. 1–9, 2022.
- [61] S. Barwick, D. Besson, P. Gorham, and D. Saltzberg, “South Polar in situ radio-frequency ice attenuation,” *Journal of Glaciology*, vol. 51, no. 173, p. 231–238, 2005.
- [62] M. Stockham, J. Macy, and D. Besson, “Radio frequency ice dielectric permittivity measurements using CReSIS data,” *Radio Science*, vol. 51, no. 3, pp. 194–212, 2016.

- [63] X. Shi, F. Park, L. Wang, J. Xin, and Y. Qi, "Parallelization of a color-entropy preprocessed Chan–Vese model for face contour detection on multi-core CPU and GPU," *Parallel Computing*, vol. 49, pp. 28–49, 2015.
- [64] K. Bui, F. Park, Y. Lou, and J. Xin, "A Weighted Difference of Anisotropic and Isotropic Total Variation for Relaxed Mumford–Shah Color and Multiphase Image Segmentation," *SIAM Journal on Imaging Sciences*, vol. 14, no. 3, pp. 1078–1113, 2021.
- [65] A. Majumder, "Ultracompact Nanophotonic Devices and Diffractive Structures for Imaging." MeepCon 2022, 2022.
- [66] A. Oskooi, "Tutorial #2: Diffraction Efficiency of Binary Gratings." MeepCon 2022, 2022.
- [67] A. Hammond, "Tutorial #3: Inverse Design of a Power Splitter for Silicon Photonics." MeepCon 2022, 2022.
- [68] K. Staats, "Genetic programming applied to RFI mitigation in radio astronomy," Master's thesis, University of Cape Town, South Africa, Dec. 2016.
- [69] S. Ventura, *Genetic Programming - New Approaches and Successful Applications*. InTech, 2012.