Stephanie Wissel

Astroparticle Physicist and Professor

Education

2004 – 2010 | **University of Chicago, Chicago IL USA** *SM and PhD in Physics*

2000 – 2004 | **University of Dallas, Irving TX USA**

Appointments

2023 - present | **Pennsylvania State University**
Interim Director for the Center for Multimessenger Astrophysics, Institute for Gravitation and the Cosmos

2022 - present | *Downsbrough Early Career Assistant Professor, Physics and Astronomy & Astrophysics*

2020 - present | *Assistant Professor, Physics and Astronomy & Astrophysics*

2015 - 2020 | **California Polytechnic State University, San Luis Obispo** *Assistant Professor of Physics*

2012 - 2015 | **University of California, Los Angeles** *Postdoctoral Scholar*

2010 - 2012 | **The Princeton Plasma Physics Laboratory** *Postdoctoral Scholar*

Grants

2023 - 2025 | **NSF Particle Astrophysics, PI, $390k, $1.9M total** *Collaborative Research: WoU-MMA: Ultrahigh Energy Neutrinos with the Radio Neutrino Observatory in Greenland*

2022 - 2025 | **NASA APRA, Co-I, $205k** *Continued Development of nuSpaceSim: Modeling of Extensive Air Shower Signals from Cosmic Neutrinos for Space-based Experiments*

2021 - 2024 | **NSF Particle Astrophysics, Co-I, $500k** *WoU-MMA: New Advancements to Enable Multi-Messenger Astrophysics with the Radio Neutrino Observatory in Greenland*

2021 - 2026 | **NASA Pioneers, Co-I, $1.4M, $17M total** *The Payload for Ultrahigh Energy Observations (PUEO): A Long-duration Balloonborne Instrument to Detect the Highest Energy Astrophysical Particles*

2018 - 2023 | **NSF CAREER, PI, $670k** *CAREER Advancing the Search for UltraHighEnergy Tau Neutrinos with High Elevation Radio Detectors*

2016 - 2022 | **NASA APRA, Co-I $310k** *Four bridge grants for PUEO and ANITA*

Awards

2023 | **Dean's Climate & Diversity Group Award in the Eberly College of Science**, *Penn State*

2022 | **Eberly College of Science Teaching Innovation Award**, *Penn State*

2021-2024 | **Downsbrough Early Career Professorship in Physics** *Penn State*

2018-2022 | **NSF CAREER Award**

2007, 2009 | **Graduate Merit Fellowship** *Illinois Space Grant Consortium*

2000-2004 | **Cardinal Spellman, Clare Boothe Luce, & Montosorri Awards** *University of Dallas*

Service

- Interim Director of the Center for Multimessenger Astrophysics within the Institute of Gravitation and the Cosmos at Penn State
- Management of the Detector Development Lab, an electronics shop shared between the Physics and Astronomy & Astrophysics Depts. at Penn State
- Four polar deployments to McMurdo Station, WAIS Divid, Siple Dome, and Summit Station in Greenland, earning an Antarctic Service Medal in 2017
- Snowmass Summer Study in Particle Physics Convener for two whitepapers
- Referee for *PRL*, *PRD*, *JINST*, *AJP*, *Cambridge University Press Books*
- Reviewer for NSF, Netherlands Organisation for Scientific Research (NWO), Research Foundation Flanders (FWO), European Research Council ERC Advance Grants, Deutsche Forschungsgemeinshaft (German Research Foundation) Grants, French National Research Agency, Natural Sciences and Engineering Research Council of Canada (NSERC), NASA ROSES
- Colloquia and Seminar Series Oranization: Colloquium Commitees at Penn State and Cal Poly, Gravity, Astroparticle, and Particle Physics Seminar Series Co-Chair
- Graduate Admissions Committee in Astronomy & Astrophysics at Penn State and in Physics at Chicago

Mentees

2023-2023 | **Kaeli Hughes** Presidential Postdoctoral Fellowship, *Now faculty at the Ohio State University*

2021-2022 | **Valentin Decoene** *Now faculty at Subatech and Nantes Université*

2021- | **Marco Muzio** NSF MPS-ASCEND Postdoctoral Fellow

2021- | **Austin Cummings**

2019- | **Ryan Krebs** Institute for Gravitation and the Cosmos Frymoyer Award

2019- | **Bryan Hendricks** APS April Meeting Travel Grant

2020- | **Andrew Zeolla** University Graduate Fellowship, Institute for Gravitation and the Cosmos Frymoyer Award, APS April Meeting Travel Grant

2020- | **Yuchieh Ku** Institute for Gravitation and the Cosmos Mebus Award, APS April Meeting Travel Grant

2015- | **Undergraduates** Average of 4-5 per year undergraduate research students including several co-authors on peer reviewed articles, yearly posters and presentations at regional and national conferences

Recent Invited Colloquia and Seminars

2023 | **University of Maryland** *Tuning into Cosmic Neutrinos at High Elevation*

2023 | **University of Wisconsin-Madison** *Cosmic Neutrinos at the Highest Energies*

2023 | **Ohio State University** *Tuning into Cosmic Neutrinos*

2023 | **University of Utah** *Multimessenger Astrophysics with the Highest Energy Neutrinos*

2022 | **University of Nevada Las Vegas** *Tuning into Cosmic Neutrinos*

2022 | **University of Delaware** *Tuning into Cosmic Neutrinos with Current and Future Experiments*

2022 | **University of Utah** *Multi-messenger neutrino astrophysics with current and future experiments*

2022 | **Idaho State University** *Tuning into the Highest Energy Cosmic Neutrinos*

2022 | **USCB** *Tuning into the Highest Energy Cosmic Neutrinos*

2022 | **KICP** *Tuning into the Highest Energy Cosmic Neutrinos*

2022 | **Cornell** *Tuning into the Highest Energy Cosmic Neutrinos*

2021 | **Bucknell University** *Tuning into the Highest Energy Cosmic Neutrinos*

2021 | **Radbound University, Nijmegen** *Tuning into the Highest Energy Cosmic Neutrinos*

2021 | **Max-Planck Institüt für Kernphysik Heidelberg** *Cosmic Neutrino Experiments at the Highest Energies : Present and Future*

2021 | **UC Davis** *Cosmic Neutrino Experiments at the Highest Energies*

2021 | **University of Iowa** *Cosmic Neutrino Searches at High Elevations*

2021 | **MSU** *Cosmic Neutrino Searches at High Elevations*

2020 | **IGC PSU** *Expanding the Reach of Cosmic Neutrino Experiments*

2020 | **University of Delaware** *Prospects and Progress in Radio Searches for Ultra-High-Energy Neutrinos*

2020 | **McGill SSI** *Progress in Radio Searches for Ultra-High Energy Neutrinos*

2020 | **CSU LA** *The Quest for Cosmic Neutrinos at the Highest Energies*

2019 | **OSU** *Radio Searches for Neutrinos at the Cosmic Energy Frontiers*

2019 | **Penn State** *Radio Searches for Neutrinos at the Cosmic Energy Frontier*

2019 | **MIT** *Radio Searches for Neutrinos at the Cosmic Energy Frontier*

2018 | **Columbia** *Radio Searches for Tau Neutrinos at High Altitudes*

2018 | **Caltech** *Radio Detection of Cosmic Neutrinos*

2016 | **UCSB** *High-energy Particle Astrophysics using the Radio Technique*

2015 | **University of Dallas** *Chasing Astroparticles to the Ends of the Earth*

Recent Invited Conference Talks

2023 | **JEM-EUSO Collaboration Meeting** Plenary Talk *Radio Experiments at High Altitude*

2023 | **APS Mid-Atlantic Section** Talk *Tuning into Cosmic Neutrinos with the Radio Neutrino Observatory in Greenland*

2022 | **TAMBO Touch Base** Talk *Experience with BEACON*

2022 | **NuFact** Plenary Talk *Astrophysical Neutrinos: Status and Future*

2022 | **Neutrino Dark Matter** Plenary Talk *Astrophysical Neutrinos: Status and Future*

2022 | **Neutrino Frontier Snowmass Workshop** Panel Session *>10 GeV Neutrinos in the Neutrino Frontier*

2021 | **Snowmass CF7 Day** Talk *High Energy and Ultra-High Energy Neutrinos*

2021 | **ICRC 2021** Plenary Talk *The Radio Neutrino Observatory Greenland (RNO-G)*

2020 | **Yukawa Institute for Theoretical Physics Workshop: Connecting high-energy astroparticle physics for origins of cosmic rays and future perspectives** Talk *Radio detection of Ultra-High Energy Neutrinos: Present and Future*

2020 | **American Physical Society Mid-Atlantic Section** Plenary Talk *Cosmic Neutrino Searches at High Elevations*

2020 | **Snowmass Community Planning Meeting** Panel *High and Ultrahigh Energy Neutrino Experiments*

2020 | **Neutrino2020** Talk *Prospects in Ultra-High Energy Neutrinos*

2018 | **APS April Meeting 2018.** Talk *Cosmic Neutrino Searches at the Highest Energies*

2016 | **ARENA** Talk *Phased arrays: A strategy to lower the energy threshold for neutrinos*

2016 | **UHEAP Workshop, Univ. of Chicago** Talk *Implications for the Radio Detection of Cosmic Rays from Accelerator Measurements of Particle Showers in a Magnetic Field.*

Teaching Experience

2020-present | **Pennsylvania State University**

- SC-220: Principles and Strategies for Effective STEM Learning I
- PHYS-211: Introduction to Mechanics
- PHYS-237: Modern Physics
- PHYS-402: Electronics for Scientists
- ASTRO-589: Seminar in Neutrino Astrophysics

2015-2020 | **California Polytechnic State University, San Luis Obispo**

- PHYS-123/133: General Physics III (Algebra- and Calculus-based electromagnetism, lecture, lab, studio)
- PHYS-132: General Physics II (Calculus-based waves, optics, thermal physics, studio)
- PHYS-206: Experimental Physics (lab)
- PHYS-341: Quantum Lab II
- PHYS-403: Particle & Nuclear Physics

Curriculum Development

- 2022 | Course redesign for 402: Electronics for Physicists
- 2021 | Astro Seminar course design in Neutrino Astrophysics
- 2017-2019 | 133 and 132 Studio Curriculum Development
- 2018 | Capstone project in LabView and practical exam for Experimental Physics Course (206)
- 2017-2019 | Learning Assistant Program

Professional Development

- 2023 | Eberly College Teaching Innovation Showcase invited poster presentation
- 2020 | APS-IDEA
- 2020 | EBTA: Evidence-Based Teaching Academy
- 2018 | Working Group on Equity in Undergraduate Research in Physics
- 20217 | International Learning Assistant Conference
- 2017 | APS/AAPT/AAS New Physics and Astronomy Faculty Workshop
- 2016 | Undocumented Student Training
- 2016 | LSAMP-CTLT Undergraduate Research Mentorship Workshop

Conference Organization

- 2024 | **GRAND-BEACON** Workshop *Penn State*
- 2023 | **RNO-G** Collaboration meeting *Penn State*
- 2023 | **Gen2-Radio** Workshop *Penn State*
- 2022 | **PUEO** Collaboration meeting and Preliminary Design Review host *Penn State*
- 2021 | **NuTau2021** Workshop on Tau Neutrinos from GeV to EeV 2021 *online*
- 2021 | **TIPP** International Committee for the Space and Astro-Particle Experiment session *online*
- 2021 | **ICRC** International Scientific Program Committee for Neutrino (ISPC-NU) sessions *online*
- 2019 | **ARENA** International Organizing Committee for Acoustic &Radio EeV Neutrino Detection *international*
- 2107 | **TeVPA** Mini-workshop on the Radio Detection of Cosmic Rays and Neutrinos *Ohio*
- 2017 | **ANITA** Collaboration Meeting host *California*
- 2008 | **IMPACT** KICP IMPACT Workshops *Illinois*

Outreach

2022- **Pulsar Search Collaboratory** Faculty advisor for student organization designed to self-teach independent research with radio data*Penn State*

2023 **AstroFest** Astronomy outreach reaching hundreds of local community members*Penn State*

2023 **Experimental Particle Physics, CUWiP** Invited talk at national conference aimed towards empowering undergraduate women physicists *Penn State*

2023 **Making Transitions in a Physics Career: From Undergraduate and Beyond** Organized panel session on transitions in physics careers from 2-yar to 4-year colleges, to bridge programs, to career transitions *Penn State*

2022 **Tuning into Cosmic Neutrinos** Invited public astronomy lecture *Penn State, Astronomy on Tap*

2017-2019 **Blast Off with Computing for Research** Series of workshops aimed to introduce early career undergraduates to research and computing for research. *Cal Poly College of Science and Mathematics*

2015-2019 **Resumes, grad school application workshops** *Cal Poly Physics*

2010-2012 **Young Women's Conference** Director of Young Women's Conference in which 200-400 young women in grades 7-10 meet professional female scientists, placing special emphasis on underrepresented minorities and diverse career paths. Doubled student and scientist participation at YWC. Several lectures and invited talks on women in physics *PPPL*

2012-2015 **Women in Physics and Astronomy** *UCLA*

2010-2012 **CLOμDs** Led 4 teams of K-12 teachers, museum educators, and high-school students from diverse backgrounds on zero-gravity flights to build experiments and investigate science topics; Curriculum development with teachers and project-based learning *PPPL*

2009-2010 **AstoConversations** Public lectures with astronomical visualizations in the Adler SVL *Adler Plantarium*

2008-2010 **Women in Physics Chat & Chow** Organized events for graduate students and undergraduates to increase visibility among female physics graduate students *Chicago*

2008-2010 **S.T.O.M.P.** Weekly after-school program for elementary-school students which required designing activities that emphasized experimentation and scientific inquiry. *Chicago*

Equity, Diversity and Inclusion

2022- **Physics for Inclusivity** Faculty Advisor for inclusion group under development *Penn State*

2021- **Cal-Brige Program** Partnership Cal-Bridge Scholars program and Penn State Physics encouraging diverse applicants to the Penn State Physics program *Penn State*

2020- **Bridge Program Chair** Development of Master's degree program meant to diversify Physics PhDs nationally *Penn State*

2020- **WISER/MURE/FURP Mentor** Academic-year research experience for 1^{st}-year undergraduates *Penn State*

2020-2022 **APS-IDEA** Cultural change at Penn State to build a more inclusive department *Penn State*

2020- **Cal-Bridge Summer Liaison** Provide a path for a diverse group of scholars from Cal State schools to conduct summer research at Penn State *Penn State*

2017-2020 **Cal-Bridge/CAMPARE Liaison** Support for Cal Poly students applying for research experiences with Cal-Bridge Summer/CAMPARE *Cal Poly*

Press

2021 **Orbital Index Newsletter** S. Wissel *You have to go big to get small*

2020 **Discover** S. Ornes *Are Strange Space Signals in Antarctica Evidence of a Parallel Universe?*

2018 **Gizmodo** R. Mandelbaum *Astronomers Propose Huge New Telescope System to Understand the Most Energetic Particles Ever Detected*

2018 **ScienceNews** E. Conover *Hints of weird particles from space may defy physicists' standard model*

2018 **NewScientist** C. Whyte *Weird signals in Antarctica could be hints of a new realm of physics*

2018 **KCBX** G. Mart *Issues & Ideas*

2018 **Physics World** E. Cartlidge *Mysterious radio signals could be from new type of neutrino*

2017 **NASA PCOS Newsletter** S. Wissel *Above the Earth, a Neutrino View of the High-Energy Universe*

2015 **Symmetry** A. Anderson *High adventure physics*

2014 **Symmetry** L. A. White *Cosmic rays on demand*

Research Statement

Neutrinos play a key role in multi-messenger astrophysics, a growing field that combines observations from neutrinos, photons, cosmic rays, and gravitational waves to build a complete picture of the particle accelerators and the extreme physics that drives them. My primary goal is to discover the first neutrinos in a new uncharted energy regime: *ultra-high energies* (UHE, $\geq 10\,\mathrm{PeV}$). UHE neutrinos can deliver key evidence in the decades-long search for the cosmic ray accelerators and their cosmological evolution: cosmogenic neutrinos made when the highest-energy cosmic rays interact with photon backgrounds. Astrophysical UHE neutrinos can pinpoint the most powerful particle accelerators, which may include compact object mergers, gamma ray bursts, and blazars, among others. With their Gigaparsec baselines, rich flavor physics, and energies inaccessible in terrestrial accelerators, UHE cosmic neutrinos uniquely probe particle physics within and beyond the standard model. Recently, we described the state of the field in recent community-led Snowmass whitepapers, including two co-led by me [1, 2].

The challenge facing all UHE neutrino detectors is one of scale, requiring enormous detector volumes to observe a low expected flux. Making a discovery first, soon, and with maximal significance calls for scalable designs that increase the detector volume a hundredfold over the current state of the art. Particle showers from neutrino interactions emit coherent broadband (MHz–GHz) radio pulses known as Askaryan radiation. A similar radio pulse is emitted due to the Earth's magnetic field separating charges in air showers initiated by cosmic rays. Because radio waves can propagate long distances, a small radio array can monitor a large volume. My work has made significant advances in recent years by defining and building the next generation of radio experiments [3, 4, 5] as well as modeling neutrino signatures – both in an accelerator [6, 7] and from cosmic sources [8] – and interpreting experimental data [9, 10].

Over the last decade, I have led or co-led several advances needed to make radio neutrino detectors viable for this novel energy band and enable discoveries [6, 7, 9, 11]. We are capitalizing on these advances through the path-breaking ANITA and ARA experiments, new testbeds like BEACON [3] and RNO-G [5] and the next-generation PUEO balloon mission [4]. Ultimately this work prepares the way for the next generation neutrino instrument, IceCube-Gen2 experiment which will include a large radio array and I plan to play a large role in building this experiment [12].

Balloon-Borne Neutrino Telescopes

The ANtarctic Impulsive Transient Antenna (ANITA) experiment holds world-leading limits on the flux of UHE neutrinos with energies $> 10^{19.5}$ eV, constraining proton-dominated scenarios of the cosmogenic neutrino flux [13]. We also observed six anomalous events that are consistent with air showers, but with a radio polarity that indicates they are not the usual downgoing cosmic rays [14, 15, 10]. Explaining the origin of these anomalies is challenging, particularly in the case of the two steep events [14, 15], and several scenarios outside of the standard model have been proposed. One of the more straightforward ones is that the neutrino-nucleon cross section is suppressed and Earth-skimming tau neutrinos generate tau leptons that decay in air. Together with my colleagues, I have shown that attributing these events to tau neutrinos would be in strong tension with existing limits from other experiments under both diffuse [9] and transient hypotheses [16]. Follow-up with current and future experiments [17, 18] is well-warranted, including with new instrumentation and modeling tools for PUEO and BEACON that my group and I are building [3, 4, 19].

The Payload for Ultrahigh Energy Observations (PUEO) improves on ANITA's sensitivity by using phased array triggering and twice as many antennas. A phased array trigger exploits the radio signature by coherently summing the impulsive signal. This has the effect of increasing the signal-to-noise ratio for weak events, thereby lowering the trigger threshold. Multiple beams can be formed in firmware so that the full neutrino volume is continuously monitored. The PUEO flight is scheduled for 2025 and payload is starting to take shape in our labs. With PUEO, we anticipate world-leading sensitivity the flux of neutrinos at the highest energies ($> 10^{18}$ eV).

I play a leading role in the PUEO experiment by working towards understanding and characterizing the air-shower channel. In my group, we are building an independent instrument, the Low Frequency instrument, that will enhance the sensitivity of PUEO to air showers (cosmic rays, tau neutrinos, and ANITA anomalies) by a factor of 2. Using an array of large scale (2-m diameter) deployable antennas, the LF instrument will extend the observation of air shower events down to 50 MHz and have an independent measure of the polarity, polarization, and spectrum of air shower events – vital for both searching for tau neutrinos and understanding neutrino backgrounds. This array may form the basis for a future radio instrument searching for tau neutrinos near the Earth's limb that combines radio and optical techniques.

Mountaintop Neutrino Telescopes

I am the PI on the the Beamforming Elevated Array for Cosmic Neutrinos (BEACON) experiment. The BEACON concept uses a mountaintop radio interferometer to detect upgoing tau neutrinos. Because the array is on a high mountain (3-4 km) and pointed towards the horizon, each 10-antenna station achieves a large detector area. We further enhance the sensitivity with using beams formed from phased arrays of antennas. Multiple beams allow us tune the sensitivity into an annulus near the horizon with a high gain, reject backgrounds at the trigger level, and reconstruct the neutrino arrival direction.
I have shown that the concept is highly efficient for searching for tau neutrinos, requiring $\mathcal{O}(\infty///)$ stations to reach the flux sensitivity expected for some of the most pessimistic models of cosmogenic neutrinos [3]. BEACON could also be sensitive to the ANITA anomalous events with different systematics. The large detector area combined, phased array trigger, and a high duty cycle ($\sim$100%) make BEACON an attractive UHE tau neutrino observatory concept. Stations are designed to be independent, so several stations deployed at multiple sites can cover the full sky.

I have built a prototype and demonstrated its capability to trigger on fast radio pulses consistent with air showers [20, 21]. Our goal is to study highly inclined air showers from cosmic rays and testing out triggering strategies and study the possible radio backgrounds from this geometry. The cosmic ray search is underway which contribute to the experimental validation of the expected neutrino sensitivity of a full-scale instrument. This season we enhanced the prototype by installing a purpose-built data acquisition system and a scintillator array that will allow us to validate the performance of the instrument using cosmic ray observations.

Once we demonstrate of its feasibility as a tau neutrino detector, we can expand to include multiple stations either along the same mountain ridge or at multiple sites around the world, thereby scaling up to achieve full sky coverage using a technique complementary to all flavor experiments. Our work on BEACON will inform other tau neutrino radio detectors such as GRAND which plans to use many inexpensive radio stations to search for UHE tau neutrinos. Similarly, I am exploring the possibility of co-locating BEACON-like stations with other Earth-skimming concepts like Trinity and TAMBO. In the coming years, I plan to compare radio backgrounds at multiple high-elevation sites using modular survey equipment to assess the scalability and sensitivity of the BEACON concept.

In-Ice Radio Neutrino Telescopes

In-ice radio detectors like the Radio Neutrino Observatory in Greenland (RNO-G) and the Askaryan Radio Array (ARA) search for all flavors of neutrinos at the EeV energy scale. They do this by looking for Askaryan radiation from neutrino showers using antennas embedded deep in polar ice. ARA is located at the South Pole and has now accumulated a deep exposure with 5 prototypical stations [22]; RNO-G is in Greenland and will be the largest UHE neutrino detector in the world and the only one with a view of the Northern sky [5]. Since the antennas are near the showers, these experiments achieve a lower energy threshold (10^{17} eV) than PUEO and therefore may better suited to the observing the astrophysical neutrino flux.

ARA and RNO-G both benefit from a deep trigger installed below the surface of the ice where the neutrino volume is large. In ARA, most stations use a coincidence-based trigger formed by requiring several antennas to trigger simultaneously within a causal time window, but the fifth station of ARA also includes a phased array trigger that lowers the trigger and therefore energy threshold. Our work in Greenland using analog beamforming laid the groundwork for the current phased array used in ARA [11]. The technique is so promising that in RNO-G all stations have a phased array trigger as does the design for the radio array in IceCube-Gen2. In RNO-G, we are also studying a hybrid station design that adds antennas to the surface to serve as a cosmic ray veto and can modestly improve the neutrino sensitivity.

With ARA we are conducting sensitive searches for UHE neutrinos building on over ten years of science operations. We first developed the phased array technique with ARA [23, 24, 25]. My group is leading a comprehensive study of the phased array data and the full ten-year data set [26, 27]. We are also studying how lepton propagation can impact in-ice detectors' sensitivity to different flavor topologies [28, 29].

Now under construction in Greenland, RNO-G is the largest UHE neutrino detector in the world and the only one with a view of the Northern sky [5]. We conducted the first studies of the suitability of ice and radio environment in Greenland in 2015 [30, 11]. We are well underway to building the large array (40 km^2). My group has played an integral role in developing the site, defining this experiment, building hardware, and deploying and commissioning stations [11, 31, 32] and as the U.S. NSF PI I direct the program more broadly here in the U.S. My group has developed novel firmware necessary for triggering on neutrino showers and cosmic ray air showers and we have developed novel, scalable antennas. We are further studying cosmic rays to understand and enhance background rejection in neutrino searches.

In-ice radio experiments can be true multi-messenger observatories that can respond to multi-messenger alerts and identify interesting, neutrino-like signals. With RNO-G we have a plan to first develop rapid follow-up analyses of interesting multimessenger alerts and work towards sending alerts in the future [33]. My group is developing the software needed to run on the on-station single board computers to identify neutrino-like signals. I am also working to connect RNO-G to the first network capable of sending alerts based on coincidences in multiple observatories, AMON [34].

Our work on ARA and RNO-G provide important R&D for the next generation of detector. IceCube-Gen2 will define a new era of neutrino science, measuring the all-flavor neutrino flux with a transformative 10- to 100-fold improved sensitivity in a broad energy range [12]. I am a leader in designing the radio array that will drive this observatory's sensitivity at the highest energies and our work now on RNO-G will be especially important for IceCube-Gen2 soon.

Summary

Because of recent advances in the radio technique, the current generation of experiments may discover UHE neutrinos. I occupy a unique position at the forefront of this field, via leading roles in experiments that use innovative and complementary techniques. PUEO searches for the highest-energy end of the cosmic neutrino spectrum. BEACON is gearing up to explore flavor physics through the tau neutrino channel at energies bridging astrophysical and cosmogenic neutrinos. RNO-G and ARA – and soon IceCube-Gen2 – search for all flavors of both cosmogenic and astrophysical neutrinos with deep exposures and multi-messenger capabilities. With the discovery of UHE neutrinos, we will continue to explore the rich physics in cosmic accelerators and how neutrinos interact at the highest energies.

References

[1] M. Ackermann et al., "High-energy and ultra-high-energy neutrinos: A Snowmass white paper", *JHEAp* **36** 55 [2203.08096].

[2] R. Mammen Abraham et al., "Tau neutrinos in the next decade: from GeV to EeV", *J. Phys. G* **49** 110501 [2203.05591].

[3] S. Wissel et al., "Prospects for high-elevation radio detection of >100 PeV tau neutrinos", *JCAP* **11** (2020) 065 [2004.12718].

[4] PUEO Collaboration, "The Payload for Ultrahigh Energy Observations (PUEO): a white paper", *JINST* **16** (2021) P08035 [2010.02892].

[5] RNO-G Collaboration, "Design and Sensitivity of the Radio Neutrino Observatory in Greenland (RNO-G)", *JINST* **16** (2021) P03025 [2010.12279].

[6] T-510 Collaboration, "Accelerator measurements of magnetically-induced radio emission from particle cascades with applications to cosmic-ray air showers", *Phys. Rev. Lett.* **116** 141103 [1507.07296].

[7] K. Bechtol et al., "SLAC T-510 experiment for radio emission from particle showers: Detailed simulation study and interpretation", *Phys. Rev. D* **105** (2022) 063025 [2111.04334].

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[9] A. Romero-Wolf et al., "Comprehensive analysis of anomalous ANITA events disfavors a diffuse tau-neutrino flux origin", *Phys. Rev. D* **99** (2019) 063011 [1811.07261].

[10] ANITA Collaboration, "Unusual Near-Horizon Cosmic-Ray-like Events Observed by ANITA-IV", *Phys. Rev. Lett.* **126** 071103 [2008.05690].

[11] J. Avva et al., "Development Toward a Ground-Based Interferometric Phased Array for Radio Detection of High Energy Neutrinos", *Nucl. Instrum. Meth. A* **869** 46 [1605.03525].

[12] IceCube-Gen2 Collaboration, "IceCube-Gen2: the window to the extreme Universe", *J. Phys. G* **48** (2021) 060501 [2008.04323].

[13] ANITA Collaboration, "Constraints on the ultrahigh-energy cosmic neutrino flux from the fourth flight of ANITA", *Phys. Rev. D* **99** (2019) 122001 [1902.04005].

[14] ANITA Collaboration, "Characteristics of Four Upward-pointing Cosmic-ray-like Events Observed with ANITA", *Phys. Rev. Lett.* **117** (2016) 071101 [1603.05218].

[15] ANITA Collaboration, "Observation of an Unusual Upward-going Cosmic-ray-like Event in the Third Flight of ANITA", *Phys. Rev. Lett.* **121** (2018) 161102 [1803.05088].

[16] ANITA Collaboration, "Analysis of a tau neutrino origin for the near-horizon air shower events observed by the fourth flight of the Antarctic Impulsive Transient Antenna", *Phys. Rev. D* **105** (2022) 042001 [2112.07069].

[17] Pierre Auger Observatory Collaboration, "Search for upward-going showers with the Fluorescence Detector of the Pierre Auger Observatory", *PoS* **ICRC2021** (2021) 1140.

[18] IceCube Collaboration, "A search for IceCube events in the direction of ANITA neutrino candidates", 2001.01737.

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[20] BEACON Collaboration, "Searching for RF-Only Triggered Cosmic Ray Events with the High-Elevation BEACON Prototype", *PoS* **ICRC2021** (2021) 1084.

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Teaching and Service Statement

I am committed to enhancing the community of physics and astronomy. This can be done by educating and mentoring future scientists, expanding access to physics for a broader range of people, and serving the international scientific community.

University Education

In my first postdoc, in science education at the Princeton Plasma Physics Lab, my mission was to expand science interest among people underrepresented in the sciences. As a faculty member, I have been working to expand equitable access to research experiences for undergraduates and graduate students. I also have extensive experience teaching and designing curricula for a variety of levels (introductory and senior level) and a variety of formats (upper and lower division labs, studios, lectures). I have experience teaching at both a primarily undergraduate institution (Cal Poly) and a large research-focused institution (Penn State) and the two experiences inform my educational philosophy and approach.
Students learn best when they are actively engaging with the material and routinely confronted with common deeply held misconceptions about the physical world. For this reason, I try to build the course structure and my classroom time around activities that help the students grapple with the material. My preferred method of teaching is to give a short lecture, followed by a brief question that requires both individual reasoning and peer discussion, and then a longer-form, more rigorous problem that the students can work on together. I have used a variety of methods in my teaching practice for group work: lecture tutorials, whiteboards, worksheets, and computational exercises, but each time the goal is to challenge the students enough that they work together and learn from each other. I follow research-based practices learned at the AAPT/APS/AAS New Faculty Workshop and the Penn State Evidence-Based Teaching Academy and have incorporated these practices in undergraduate courses both introductory and advanced.

As an example, learning assistants (LAs) are near-peer mentors who facilitate discussions among groups of students in a class, thereby reorienting the class dynamics from a focus on the instructor to a focus on the students. The primary role of LAs in the classroom is to elicit student thinking and to engage each student working on challenging problems, but the programs are also known to additionally enhance retention and understanding of topics for the LAs themselves. I collaborated with Physics Education researchers at Cal Poly to build a Learning Assistant program where near-peer physics students facilitate student learning via group discussions, which supports equity in introductory physics. Since then, I have found in my own teaching practice that LAs are most beneficial when the students are working on activities like the Lecture Tutorials in Physics that are challenging enough that they must discuss them with their group and would otherwise not be able to complete the task on their own. LA programs have been shown to have a positive impact on retention among women and People Excluded from science because of their Ethnicity or Race (PEERs), both among students in the classroom and the LAs themselves. I continue this work at Penn State, teaching a course training Learning Assistants in pedagogical practice and working with them in my courses.

The techniques students learn in labs are vital both to the modern physicist and to the technical occupations that most undergraduate physics majors pursue after graduation. Laboratory experiments force students to think carefully about sources of noise, about how systematic error can affect their measurements, and about what tools they have available for debugging. Long-term laboratory projects are vital to building good experimental skills in our students. I recently revamped the *PHYS-402:Electronics for Physicists* course at Penn State, building on the contributions to the curriculum I made at Cal Poly in two similar laboratory courses. I emphasize a combined understanding of *how to use* circuits, *how to build* experiments, and *how to validate* your instrument. The capstone projects in the course invite students to build their own circuit and I secured funding for this through a Teaching Innovation Award at Penn State and was invited to showcase these results at the Eberly College Teaching Showcase. Since good experiments are expensive and take careful design to help students understand an experimental topic over the course of a few hours, we must disseminate innovations in teaching and teaching apparatus in either journal articles (see e.g., my article in *AJP*) or scientific conferences.

My research interests and teaching experience makes me especially suited to teaching introductory physics, E&M, modern physics, quantum, particle & nuclear physics, and upper level laboratory courses. Special topics courses could include particle astrophysics, neutrino astrophysics, high-energy astrophysics, or instrumentation.

Mentorship

Effective mentoring is a critical component of a student's education, particularly when it comes to research. My goal as a research mentor is to build independence and a deep knowledge of the research topic while building camaraderie and a support network. I meet with students regularly, work in the lab with them, and collaborate with them and others around the world to keep students actively engaged in their research projects. With graduate students, I focus on building their knowledge and critical thinking early in their career. I encourage them to become autonomous and work with our collaborators at other institutions, while also identifying opportunities for them for professional growth. We regularly re-evaluate their interests and goals as we work towards ground-breaking research projects and papers. With postdocs, I work with them to develop a portfolio that expands their capabilities and builds on their strengths. I work to build undergraduate cohorts within my group by working in the lab together and having weekly meetings focused specifically on undergraduate research. This is possible because I typically support several (3-8) undergraduates working in my group over the course of a year and seek out opportunities to support undergraduate research I pair senior researchers with my undergraduates to introduce undergrads to the process of my research group and give the graduate students and postdocs the opportunity to provide mentorship. I also serve as a professional mentor for graduate students, postdocs, and honors students.

I am invested in engaging early career undergraduates in research. At Cal Poly, I developed workshops that introduced early career undergraduates to research, computing, and basic laboratory skills, and along the way encouraged them establish relationships with faculty mentors. At Penn State, I regularly work with first-year students interested in research through the WISER/MURE/FURP program. Indeed, sustained and early engagement in undergraduate research with faculty positively impacts retention rates and graduation rates, particularly for PEERs. I am working towards helping young students develop a physics identity, as evidenced by my participation in Cal Poly's First Year Experience committee and my role on the Mentoring Committee at Penn State. Students who feel that they belong to the physics community are more resilient to challenges like stereotype threat and imposter syndrome, which is particularly important for PEERs. My work expanding access to science builds on my experience as a postdoc in science education at PPPL where I directed a conference for 400+ middle-school girls meant to encourage them to pursue a career in STEM.

Service

At WIPAC, I plan to serve and enhance the scientifically both locally within the center and in the national and international scientific community. I will draw on my experience as the interim Director of the Center for Multimessenger Astrophysics in the Institute for Gravitation and Cosmology at Penn State where my goal is to reinvigorate our community after the pandemic and connect the strengths of the center across particle astrophysics, neutrino astroparticle physics, and gravitational wave physics. More broadly I have served to enhance the scientific discourse through peer review and organizing seminars, colloquia, conferences, and national and international scientific planning exercises.

As a leader in my collaborations and in the broader astroparticle physics community I aim to support the entire community, especially early career researchers. If we developing the right initial conditions, then major scientific advances can be made. Within my scientific community, I have taken on several significant roles. I serve in several leadership positions on BEACON (PI), RNO-G (US PI), PUEO (L2 manager), and IceCube-Gen2 (L3 manager). I have led several deployment campaigns both at RNO-G and at BEACON. I have served as a convener for the Snowmass process which is a decadal survey guiding particle physics investments in the US. I have served on the organizing committee and board for two international conferences: the ICRC and ARENA. Moreover I direct the Detector Development Lab at Penn State which houses engineering staff that support several research groups in Physics and Astronomy and Astrophysics.

Perhaps my most notable accomplishment to promote equity, diversity, and inclusion is my work on the partnering with bridge programs. Through this work I brought the Cal-Bridge program to Penn State and Cal Poly. Nationally, the Cal-Bridge program trains and mentors talented students in physics and astronomy from a diverse applicant pool. Five Cal-Bridge scholars have matriculated to our graduate program in the three years it has been established, earning fellowships and earned an NSF Graduate Research Fellowship. Cal-Bridge also supports summer research for their undergrad scholars, and we have hosted 10 Cal-Bridge Summer students within our REU program. Together with my colleagues, I am also developing a bridge program that will create a path to doctoral study for more students from marginalized backgrounds, consistent with the American Physical Society's Bridge Program. Our work together was recognized with the Eberly College Group Award for Diversity and Inclusion. My postdoc, Marco Muzio, is also active in making the department a more inclusive and equitable environment, particularly through the APS-IDEA and postdoc community group, work that is supported by a grant we were awarded together (NSF MPS-ASCEND).

Conclusions

I believe that our greatest impact as educators and scientists comes through the people and communities we work with, serve, and teach. Getting young and diverse students to pursue STEM majors was a major component of my postdoc in science education at PPPL. My role as a physics professor is to build in all students a deep understanding of the foundations of modern physics and a command of the analytical, computational, and experimental tools that we all share as physicists. I believe that we are all charged to expand access to scientific research and understanding to a broader range of people than in decades past for the simple reason that the intellectual exploration should be available to all people, not just the privileged few. Finally, one of my most important roles as a scientist is to inspire, educate, and support the next generation.

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h-index: 39, from InSpire
For a up-to-date list of publications, see ORCID
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