Blake Wilson

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# Summary

Mr. Wilson is a Ph.D. student developing software and theory for quantum and classical machine learning algorithms applied to inverse design, optimization, and characterization of photonic systems. Specifically, Wilson focuses on machine learning assisted global optimization of metastructures, cryptographic plasmonic systems, and variational quantum algorithms for inverse design. With a strong background in algorithm design and analysis, Wilson’s ideas are often at the intersection between computer science and physics, developing techniques in combinatorics, machine learning theory, and quantum information to design condensed matter systems.

# Education

## Ph.D. Electrical and computer engineering 2019-present

*Purdue University*

* **GPA: 3.7** | Focus: Quantum Machine Learning for Nanophotonic Applications
* Advisors: [Alexandra Boltasseva](https://engineering.purdue.edu/~aeb/), [Sabre Kais](https://www.chem.purdue.edu/kais/), [Vladimir Shalaev](https://engineering.purdue.edu/~shalaev/), and [Alexander Kildishev](https://nanohub.org/members/6059?_ga=2.215915991.1930921897.1640103943-1678915802.1579782013)

## BS computer engineering 2015-2019

*Purdue University*

* **GPA: 3.4** | Focus: Algorithms for Multi-Agent Systems and VLSI | Minor: Philosophy

# Professional Career

**Research Intern – QuEra Computing** 05/2022

**Graduate Research Assistant, Purdue University and Oak Ridge Natl. Lab.** 2021-present

**Graduate Teaching Assistant, ECE 368, Purdue University** Summer 2021

**Graduate Research Assistant, Air Force Research Lab, Purdue University** 2021

**Graduate Teaching Assistant, ECE 264, Purdue University** Fall 2020

**Graduate Assistant, SURF, Purdue University** Summer 2020

**Graduate Teaching Assistant, ECE Shop, Purdue University** 2019-2020

**Verification Software Engineering Intern, ARM** Summer 2019

**SURF Fellow, Purdue University** Summer 2017

**Residential Assistant** 2016-2018

# Leadership Positions

**Team Lead - Quantum Science Center Postdoc and Graduate Student Association** 2021-present

**Team Lead - Nanophotonics Machine Learning Lab** 2021-present

**Software Team Lead – System on Chip Team** 2018-2019

# Teaching and Mentoring Experience

## team lead – postdoctoral and graduate student association 2021-present

*Quantum Science Center, Purdue University, West Lafayette, IN | Oak Ridge National Laboratory, Oak Ridge, TN*

* Organize and host the biweekly seminars and fireside chats for 60+ postdoctoral researchers and graduate students.
* Regularly attract world leading PI’s and scientists in quantum information science from Harvard, Caltech, Microsoft, IBM, Google, etc. to have open discussions with graduate students.

## team lead – Nanophotonics machine learning team 2021-present

*Elmore Emerging Frontiers Center, Purdue University, West Lafayette, IN*

* Organize biweekly meetings to discuss machine learning ideas and guide multidisciplinary projects in nanophotonics.
* Teach undergraduate, graduate, and postdoctoral researchers about machine learning and discuss ways to apply machine learning algorithms to physics.

## Graduate Assistant – Summer Undergraduate Research Fellowship (SURF) Summer 2020

*Engineering Undergraduate Research Office, Purdue University, West Lafayette, IN*

* Organize and host career development seminars for over 100 undergraduate researchers to learn about opportunities in industry, national labs, and academia.
* Personally mentored 16 SURF Fellows from across the world in a 10-week virtual fellowship program.
* Several of my students went on to win research awards and become Ph.D. students at prestigious universities and companies.

## Graduate Teaching Assistant 2019-2021

*School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN*

* Hosted several office hours throughout the week for undergraduate students in ECE 264 and ECE 368, the Advanced C programming and Algorithm and Data Structures courses, respectively, in Purdue ECE. Regularly used office hours as a way to mentor students careers and give advice on success in ECE.
* Wrote Python grading programs to automatically grade hundreds of students programming assignments automatically.
* Mentored senior design teams and created an open-door community in the ECE shop.
* Reorganized the ECE Shop layout and created the famous “RGB ECE Shop” sign to create a more welcoming community for students to work on circuit design, PCB fabrication, and electrical engineering projects.

# Engineering and Research Experience

## Research Assistant 2016-present

*Purdue University, West Lafayette, IN | Oak Ridge National Laboratory, Oak Ridge, TN*

* Generalized the use cases for a drone routing algorithm to utilize multiple drones to capture an adversary in road networks. Can be apply to rescue kidnapped children using drones.
* By studying the drone routing problem, I discovered a new connection between combinatorics and drone routing problems through graph partitioning.
* Developed a quantum algorithm for designing the topology of nanophotonic devices by sampling the latent space of a variational autoencoder via a factorization machine surrogate model.
* The ML algorithm can generate 500 thermal emitter designs in 30 minutes, of which the top 50 designs are high-efficiency designs (> 95% spectrum overlap for highly constrained problems). State of the art, non-ML based algorithms take several hours to days for similar efficiencies. [1]
* Built and integrated scientific packages (S4, D-Wave Leap, Quantum Monte-Carlo) with Cloud API’s, Python, MATLAB, and C/C++ for implementing my team’s research projects.

## Graduate Software Engineering Intern Summer 2019

*ARM, Austin, TX*

* Improved ARMv8 verification self-test reproducibility and the Chi-Square distribution of ARM’s software verification suite RNG from 0.2 to 0.5 by restructuring the RNG seeding.
* Wrote Python scripts to compare the coverage of ARMv8 self-tests generated by various C++ RNG’s.
* Rebuilt 2 ARMv8 self-test directives to reduce the complexity of debug self-tests.

## System-on-Chip Software Team Lead  2018-2019

*System-on-Chip Team, Purdue University, West Lafayette, IN*

* Tasked to lead a team to generate bootup code and a ROM module in 3 months for running startup tests in a custom 90nm RISCV System-on-Chip (SOC) fabricated at MIT Lincoln Labs, [the AFTx04](https://engineering.purdue.edu/SoC-Team/about/system-on-chips).
* Developed a Python tool to compile C code into thousands of lines of RISCV machine code that generated an onboard Verilog based ROM module and integrated it with my teammates designs.
* After finishing the ROM module early, I fixed critical bugs in the entire system-on-chip from source code to netlist level. This work directly led to the team’s first completely functional SOC and led to future research projects and more funding for the next version of the chip.
* Developed test vectors for verifying the SOC with NSWC Crane and MIT-Lincoln Lab engineers.

# Publications

## peer-reviewed

1. Wilson, B.A., Kudyshev, Z.A., Kildishev, A., Kais, S., Shalaev, V., and Boltasseva, A., **“Machine Learning Framework for Quantum Sampling of Highly Constrained Optimization Algorithms,”** Applied Physics Reviews, 8, 041418 (2021) <https://doi.org/10.1063/5.0060481>
2. Wilson, B.A., Hudack, J., and Sundaram, S., **“Planning for Package Deliveries in Risky Environments Over Multiple Epochs,”** Accepted to ACC 2022
3. Wilson, B.A., Kudyshev, Z.A., Kildishev, A., Kais, S., Shalaev, V., and Boltasseva, A., **“Metasurface design optimization via D-Wave based sampling,”** 2021 Conference on Lasers and Electro-Optics (CLEO), 2021, pp. 1-2

## Poster presentations

1. Wilson, B.A., Mkhitaryan, V., Shalaev, V., Kais, S., Kildishev, A. and Boltasseva, A., **“Source Shaping for Electromagnetic Optimization via Higher-Order Variational Quantum Algorithms,”** Elmore Center Student Poster Session, Feb. 24, 2022
2. Iyer, V., Wilson, B.A., Shalaev, V., Kais, S., Kildishev, A. and Boltasseva, A., **“Measuring bVAE Reconstruction Loss Against Binary Latent Space Size,”** Elmore Center Student Poster Session, Feb. 24, 2022
3. Wilson, B.A., Kudyshev, Z., Kildishev, A., Kais, S., Shalaev, V. and Boltasseva, A., **“QUBO Sampling of Highly-Constrained Optimization Problems: Inverse Design of Metasurfaces,”** 1st Quantum Science Center Poster Session, Mar. 14, 2021, <https://qscience.org/wp-content/uploads/2021/03/14-Blake-Wilson.pdf>
4. Singhal, M., Stevens, J.R., Wilson, B.A., Swabey, M., Johnson, M., **“AFTx04 Design and Tapeout,”** NSWC Crane Microelectronics Integrity Meeting, 2018
5. Wilson, B.A., Prasad, A., and Sundaram, S., **“Pursuit Evasion with Multiple Pursuers: Capturing a Ground Vehicle on a Road Network with Multiple Drones,”** The Summer Undergraduate Research Fellowship (SURF) Symposium, Aug. 3, 2017. Paper 54. https://docs.lib.purdue.edu/surf/2017/presentations/54

# Honors and Awards

**Universities Space Research Association Quantum Grant** 2020

**Oak Ridge Leadership Computing Facility D-Wave Grant** 2020

**National Rube Goldberg Competition – 2nd Place** Spring 2016

# Organizations and Memberships

**Optica** 2021-Present

**IEEE Computer Society** 2020

**Purdue Society of Professional Engineers** 2015-2016

# Technical Skills and Programming Languages

**Proficient:** Python, C/C++, MATLAB, Quantum Information, Machine Learning, Optimization Algorithms

**Familiar:** Git, Linux, Shell Scripting, Software Engineering

# References

**Alexandra Boltasseva**, Ron And Dotty Garvin Tonjes Professor Of Electrical and Computer Engineering

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# Mentor Statement – “How to Effectively Mentor Scientists”

Your goal as a mentor to future scientists is to prepare them for fulfilling and successful careers while providing a scientific family for them to express their ideas freely. They should become autonomous contributors to the scientific community that can mentor their own labs, classrooms, and students. My history with mentoring students extends back only 10 years, but I’ve observed some key steps for mentors to help students become great researchers while building a scientific family.

The most important first step to mentoring students in this global generation is understanding their goals and social, economic, and cultural pressures. From here, we can provide a space to discuss the appropriate professional, life, and research goals that will help students grow and accomplish their goals while accounting for their life circumstances. Understanding every student on that kind of level takes enormous time and effort, and every mentor should consider whether they have the resources to do so properly. For example, I’ve mentored several international students and oftentimes the first barriers to their goals are language deficiencies, presentation style differences, and cultural pressures, all of which can cause considerable mental health issues. The most effective way to alleviate these stressors is to be open to the cultural differences, e.g., family expectations, extended time off for travel, etc., and to setup micro-goals that introduce the appropriate style of research within the community, give the student a sense of accomplishment early on, and actively bolsters any weak skills.

As the student builds confidence by accomplishing these micro-goals, you should begin to challenge them by setting up goals that require autonomy, the most important skill for a researcher. Slowly stop providing intermediate steps toward their goals so that they must create them. Show them why, how, and where to develop the desired skills and understanding on their own. This is where positive encouragement is most important because the first time a student takes a leap of faith to pioneer their own ideas or prove an idea’s legitimacy to themselves without an authority, they will fear failure and ignorance. Reinforce their confidence by normalizing their fears and show them how to find and prove their ideas through open discussions. No idea is too outlandish to consider but test the student’s ideas with them by considering the bigger picture, application domain, and legitimacy based on establish literature. Your goal is delicate here. Encourage them to try bold ideas but show them how to avoid illogical or impractical avenues of research. Eventually, they will develop enough skill in trying new ideas and testing them that they can begin considering the bigger picture of their research.

This is the part where your connections to industry and other universities become vital to their career. Your next goal should be to network with your student to prepare a trajectory in the scientific community that will further their career beyond what you can provide them. For example, I regularly host fireside chats and open discussions through the Quantum Science Center with world leaders in industry and academia. These chats provide an open discussion for postdocs and graduate students to meet their scientific heroes and create future job opportunities by connecting students to future labs and learning about careers in industry, national labs, and academia.

Additionally, I am actively bringing research opportunities to hundreds of undergraduate and graduate researchers through seminars, fireside chats, poster sessions, and conferences through my leadership positions at Purdue University and Oak Ridge National Lab. I’ve played an integral part in bringing research collaborations with professors from Harvard, QuEra Computing, MIT, and UT Knoxville to my students. My SURF 2020 cohort have gone on to become Ph.D. students, research assistants, and engineers at prestigious universities and companies like Johns Hopkins, UC Irvine, Amazon, and the University of Michigan.

My goal as a mentor is to prepare my students for fulfilling and successful careers by training them to be autonomous leaders in open, collaborative research environments. The best mentors give their students all their time and energy, teach their students how to surpass them and raise their students to continue mentoring others. I will share my mentoring philosophy and lessons learned by teaching you how I've been successful at mentoring future engineers and scientists over the course of the past ten years.

The first step to mentoring students is understanding their goals and social, economic, and cultural stressors. It's critical to provide early, achievable goals, i.e., micro-goals, that develop minor research skills, especially for international students that are adjusting to a new culture. The goals should always train the students to understand the scientific community's expectations, give them an early accomplishment, and actively bolsters any weak skills, e.g., program a simple Python script and present it at a group meeting.

As the student builds confidence by accomplishing these micro-goals, you should begin to challenge them by creating research goals that require more autonomy, the most important skill for a researcher. Slowly stop providing intermediate steps toward their goals so that they must create them. Show them how your community develops the desired skills and understanding to tackle its problems, e.g., famous textbooks or lecture series. This is where positive encouragement is most important because the first time a student takes a leap of faith to pioneer their ideas, they will fear failure and ignorance. Reinforce their confidence by normalizing their fears and showing them how to find and test their ideas by considering the bigger picture, application domain, and legitimacy using established literature. Your goal is delicate here. Encourage them to try bold ideas but show them how to avoid illogical or impractical avenues of research. Eventually, they will develop enough skill in trying new ideas and testing them that they can start considering the bigger picture of their research career.

This is the part where your connections to industry and other universities become vital to their career. Your next goal should be to network with your student to prepare a trajectory in the scientific community that will further their career beyond what you can provide them. For example, I am actively bringing research opportunities to hundreds of undergraduate and graduate researchers through seminars, fireside chats, poster sessions, and conferences using my leadership positions at Purdue University and Oak Ridge National Lab. I’ve played an integral part in bringing research collaborations with professors from Harvard, QuEra Computing, MIT, and UT Knoxville to my students. Use your leadership positions to give back to the students that want to follow your lead. My goal is to continue giving back to my students by earning a professorship. I firmly believe in not waiting until you receive a job title to start fulfilling the job's role. So, I've been pouring my time and energy into the next generation of scientific leaders as if I were already a professor and teaching them how to do good research in open, collaborative environments.