Rafael Arturo Coca Salazar

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Education

Washington University in St. Louis — **St. Louis, MO**
Ph.D. student in Physics — *Aug. 2026 – Present*

Princeton University — **Princeton, NJ**
Bachelor of Arts in Physics, Minor in Mathematics — *Sep. 2021 – May 2025*

Honors and Fellowships

2026: **Arthur L. Hughes Fellowship**, Washington University in St. Louis

2018, 2019: **Bolivian National Computer Science Olympiad** Bronze medals at the intermediate and advanced levels, respectively. Helped train and lead high-school team

Research Experience

Trait Interactions in Microbial Consumer–Resource Models *Nov. 2026 – Present*
Washington University in St. Louis, St. Louis, MO | Supervised by Mikhail Tikhonov
Planning a cavity-method analysis of how interactions between microbial traits shape species abundances and resource availability in the Moran–Tikhonov consumer–resource model.

Genomic Analysis of Conditional Auxotrophy *Sep. 2026 – Present*
Washington University in St. Louis, St. Louis, MO | Supervised by Mikhail Tikhonov
In collaboration with the Seppe Kuehn group at the University of Chicago.
- Applied a GapMind-based genome-analysis approach to predict which amino acids bacteria require from their environment and compared these predictions with experimental results.
- Found that genome-based predictions missed many experimentally observed amino acid requirements, identifying a limitation of the approach.

Local Optimization in Three-Spin Glasses *Sep. 2026 – Present*
Washington University in St. Louis, St. Louis, MO | Supervised by Zohar Nussinov
- Implemented a local solver for the Baxter–Wu spin glass to study how well its lowest-energy configuration can be predicted from local information. Benchmarked predictions against exact solutions for 2,000 random coupling realizations using integer programming and tensor-network methods.
- Found that enlarging the locally solved region improves prediction accuracy more slowly for three-spin interactions than for pairwise interactions over the sizes studied. Manuscript in preparation.

Machine-Learned Emulators for Nuclear Response Densities *May 2026 – Present*
Washington University in St. Louis, St. Louis, MO | Supervised by Saori Pastore and Alex Gnech
- Led the design and implementation of a neural-network emulator for nuclear responses in lepton scattering, using quantum Monte Carlo calculations in the short-time approximation.
- Reduced prediction error for longitudinal and transverse helium responses by 71–78% relative to the interpolation baseline, using only three simulated momentum transfers for training and evaluating on held-out momentum transfers.
- Implemented a principal component analysis and Gaussian process approach to identify where an additional simulation would be most informative. The planned workflow will request simulations until a user-defined uncertainty threshold is reached.

Generative Modeling of Beam-Induced Backgrounds *Sep. 2025 – Sep. 2026*

Lawrence Berkeley National Laboratory, Berkeley, CA (remote) | Supervised by Angira Rastogi and Simone Pagan Griso

U.S. Muon Collider Collaboration.

- Built a generative adversarial network trained on FLUKA simulations to test a lower-cost source of muon-collider beam-induced backgrounds for downstream Geant4 detector simulations.
- Benchmarked generated samples against FLUKA using single-particle kinematics and correlations within particle families. The model reproduced several kinematic distributions and the relative fractions of electrons, neutrons, and photons, with discrepancies in particle positions and rare species.
- Evaluated an alternative oversampling method that preserved particle correlations and found no appreciable difference relative to the existing approach.

Hamiltonian Lattice QED in $2+1$ Dimensions *Sep. 2024 – Apr. 2025*

Princeton University, Princeton, NJ | Supervised by Silviu Pufu

Senior thesis.

- Derived a lattice Hamiltonian from prior work, characterized its representations, and implemented the model in Mathematica.
- Reproduced perturbative results for ground-state energy, the fermion bilinear, and mass gaps on a 2×2 lattice. Estimated how Hilbert-space size scales with lattice size under an electric-field cutoff.

Calorimeter Biases in the CMS Level-1 Trigger *Jun. 2024 – Jul. 2024*

CERN, CMS Experiment, Geneva, Switzerland | Supervised by Isobel Ojalvo and Andrew Loeliger

Research internship.

- Generated calorimeter energy-deposit patterns to probe the CICADA algorithm and identified small systematic biases consistent with calorimeter tower miscalibration.
- Explored how to adapt the analysis for machine-learning triggers in other experiments.

Large-Order Behavior of Quantum-Mechanical Correlation Functions *Jan. 2024 – Apr. 2024*

Princeton University, Princeton, NJ | Supervised by Simone Giombi

Junior paper.

- Used instanton calculus in $0+1$ dimensions to study the large-order behavior of correlation functions in a toy model.
- Derived arbitrary-order results for the one-point function and simplified the second-order calculation for the two-point function.

Review of Axion Detection Experiments *Sep. 2023 – Jan. 2024*

Princeton University, Princeton, NJ | Supervised by James Olsen

Junior paper. Reviewed axion detection methods for an undergraduate audience, emphasizing sensitivity and signal amplification.

Heading-Error Corrections in SERF Magnetometers *May 2023 – Jul. 2023*

Princeton University, Princeton, NJ | Supervised by Michael Romalis

Summer internship.

- Isolated heading errors proportional to the generated magnetic field in spin-exchange relaxation-free magnetometers.
- Designed and built proof-of-concept Helmholtz coils to test corrections for these errors.

Remote Follow-Focus System *May 2022 – Aug. 2022*

Helmholtz-Zentrum Berlin, Berlin, Germany | Supervised by William Smith

Summer internship through the Princeton Department of German.

- Iterated on the camera chassis design and programmed an interface for remote focus control.
- Gained hands-on experience with soldering, circuit-board operation, and EPICS interfacing.

Conference and Workshop Presentations

Accelerating Physics with AI: A Scientific Discovery Workshop
Poster presentation *Oct. 2026*
Machine-Learned Emulators and Uncertainty Estimation for Quantum Monte Carlo Nuclear Responses
Presented by Rafael Arturo Coca Salazar, with Saori Pastore and Alex Gnech.
Washington University in St. Louis, St. Louis, MO

Teaching Experience

Teaching Assistant, PHYSICS 1760 (Focused Physics I)
Washington University in St. Louis, St. Louis, MO *Fall 2026*
Hold weekly office hours for a class of 40 students. Grade initial submissions of challenge problems, provide individualized feedback, and assess students' revised solutions.

Peer Tutor, Department of Physics
Princeton University, Princeton, NJ *Sep. 2023 – Dec. 2024*
Tutored students in classical Mechanics and Quantum Mechanics I and II, with an emphasis on conceptual reasoning and problem-solving.

Undergraduate Course Assistant
Princeton University, Princeton, NJ *Feb. 2023 – May 2024*
Held office hours, led problem sessions, and prepared solutions for PHY 103 (Introductory Mechanics) and PHY 104 (Introductory Electromagnetism).

Technical Skills

Computing: Python, C++, Java, ROOT, Mathematica, Linux/Unix, computing clusters, Git/GitHub, LaTeX

Machine learning: TensorFlow, Keras, generative adversarial networks, Gaussian process regression, principal component analysis

Other tools: Creo Parametric, Siemens NX, EPICS

Languages: Spanish (native), English (C2)

Leadership and Service

President, Princeton Society of Physics Students
Princeton University, Princeton, NJ *Feb. 2024 – Jan. 2025*
Organized research talks and community events, managed the mentoring program, curated academic and career resources, and contributed problems to the 2024 Physics Unlimited Premier Competition.

Treasurer, Towards an Inclusive Community of Undergraduate Physicists
Princeton University, Princeton, NJ *Feb. 2023 – Jan. 2024*
Helped secure funding for undergraduate events and promoted mental-health awareness through events and newsletters.

Professional Memberships

2022 – Present: American Physical Society

Referees

Prof. Mikhail Tikhonov, tikhonov@wustl.edu

Prof. Silviu Pufu, spufu@princeton.edu