

Gabriel Rabanal Bolaños

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EDUCATION

Harvard University

Ph.D. in Physics

M.A. in Physics

Advisor: Melissa Franklin

Cambridge, MA

2023

2020

National University of Engineering

Bachelor of Science in Physics

Advisor: Orlando Pereyra

Lima, Peru

2016

RESEARCH EXPERIENCE

Harvard University ATLAS Experiment Group

Graduate researcher

Cambridge, MA / Geneva, Switzerland

Measurement of triboson production

2021 — 2023

Based at Harvard University and at CERN

- Thesis: served as the main analyzer for the four-lepton decay channel in the measurement of the production of **three massive vector bosons** (VVZ , where $V = W, Z$) in proton-proton collisions
- Optimized Deep Neural Networks and Boosted Decision Trees models on the kinematic properties of leptons from particle collision simulations. These optimizations were critical for accurately targeting signal processes, significantly boosting the measurement's sensitivity and precision
- Developed a comprehensive system to evaluate the performance of machine learning models on Monte Carlo events. This included pruning redundant variables and resolving issues with Neural Network training, ensuring robust and reliable model performance
- Optimized signal region selections to improve the rejection of non-prompt leptons by leveraging new lepton quality and isolation working points
- Created control regions to validate the Monte Carlo background predictions against real data to ensure the accuracy of background estimations and the overall reliability of the analysis
- Conducted detailed statistical analyses using the TRexFitter framework, incorporating the treatment of systematic uncertainties into the data fitting process
- Trained and mentored undergraduate and high school researchers, integrating them into the Harvard ATLAS research group. Provided guidance on research methodologies, data analysis techniques, and the use of advanced machine learning models in high-energy physics

New Small Wheel Upgrade

2019 — 2021

Based at CERN

- Authorship task: Commissioning of the first Micromegas chambers (gaseous particle detectors) for the New Small Wheel, an upgrade to the ATLAS forward end-cap muon spectrometers
- Worked at the cosmic ray test stand based in building BB5 at CERN
- Collaborated in C++ software development for Micromegas detectors by implementing the full detector geometry of each Micromegas chamber

- Collected data from cosmic muon hits in order to measure the response of the detector (hits) which were used to fit tracks
- Measured the spatial resolution (directly related to momentum resolution) and tracking efficiency of the first-ever complete Micromegas chambers
- Analyzed the performance of different spatial sectors of each detector under different high voltage conditions after the voltages needed to be lowered in order to stop high spark rates
- Characterized the electronic noise (which produced spurious readings reconstructed as hits) as a function of the electronic baseline with noise runs
- Debugged readout timing issues where the recorded data was not associated to the proper triggers
- Mentored other graduate students in the use of the analysis software

Measurement of $WWW \rightarrow \ell\nu\ell\nu\ell\nu$

2018

Based at CERN

- Implemented detailed cutflow analyses to systematically reduce background noise
- Evaluated the efficiency of various lepton selection criteria and trigger algorithms in signal regions
- Enhanced expertise in data analysis tools and techniques specific to high-energy physics, including ROOT and Python

Yale University

New Haven, CT

Undergraduate researcher

2016

- Participated in research and development for the PROSPECT reactor antineutrino experiment
- Conducted comprehensive data analysis on prototypes of liquid scintillator cells using Python
- Developed and executed simulations of a Compton scattering test setup using C++ and GEANT4

Peruvian Institute of Nuclear Energy

Lima, Peru

Undergraduate researcher

2015

- Conducted calibration of high-purity germanium detectors using a variety of radioactive sources
- Measured neutron flux density in the RP-10 reactor core using neutron activation analysis, including sample preparation, irradiation, identification of activation products, and gamma spectrum analysis to calculate neutron flux
- Gained hands-on experience with nuclear instrumentation and radiation detection techniques

PUBLICATIONS

- ATLAS Collaboration. *Measurement of VVV production in pp collisions at $\sqrt{s} = 13$ TeV* (forthcoming)
- Rabanal Bolaños, G. on behalf of the ATLAS Collaboration. *Cosmic results with the final Micromegas sectors for the ATLAS Muon upgrade*. In *Proceedings of 40th International Conference on High Energy Physics — PoS(ICHEP2020)*, volume 390 (pp. 773-778)
- ATLAS Collaboration. *Evidence for the production of three massive vector bosons with the ATLAS detector*. *Phys. Lett. B* 798 (2019) 134913. [arXiv:1903.10415 \[hep-ex\]](https://arxiv.org/abs/1903.10415)

PUBLIC TALKS

- **Records from Ancient Iraq: Deciphering Sumerian Cuneiform Tablets at Kenyon College**
Kenyon College, April 2, 2024
- **Search for production of Standard Model VVZ in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector**
[Elementary Particle Experiment \(EPE\) Seminar](#), University of Washington (virtual), May 4, 2023
- **Search for the production of three massive vector bosons in proton-proton collisions using data at $\sqrt{s} = 13$ TeV recorded with the ATLAS detector at the Large Hadron Collider**
Laboratory for Particle Physics and Cosmology Student Seminar, Harvard University, August 25, 2022
- **Cosmic results with the final Micromegas sectors for the ATLAS Muon upgrade**
[40th International Conference on High Energy Physics \(ICHEP\)](#), virtual meeting, July 28, 2020

ADDITIONAL TRAINING

- **US ATLAS Machine Learning Training Event** Remote
Lawrence Berkeley National Laboratory (LBNL) 2022
- **Signals in Particle Detectors** Geneva, Switzerland
CERN Academic Training Lectures 2019
- **US ATLAS CAMPFIRE** Lemont, IL, USA
Argonne National Laboratory 2019
- **First Peruvian School on High-Energy Physics and Cosmology** Lima, Peru
National University of Engineering 2015
- **Nuclear Energy and Radiological Protection** Lima, Peru
Peruvian Institute of Nuclear Energy 2015

TEACHING EXPERIENCE

Harvard University Cambridge, MA
Teaching assistant in the Department of Physics

- **Introductory Mechanics and Relativity** 2023
 - Undergraduate-level course aimed at students in physics and engineering
 - Conducted two theory sections, worked through examples, reviewed lecture topics
 - Held office hours to provide one-on-one support to students
- **Electromagnetism, Circuits, Waves, Optics, and Imaging** 2019
 - Undergraduate-level course aimed at students in life sciences and medicine
 - Led two laboratory sections, taught students to code in Python and to use Arduino kits
 - Assisted students in troubleshooting and debugging their code
- **Electromagnetism** 2018
 - Undergraduate-level course aimed at students in science and engineering
 - Led two laboratory sections, taught students to code in Python for basic data analysis
 - Provided detailed feedback on lab reports to help students improve their scientific writing skills

- **Mathematical Methods for Physicists** 2015
 - Undergraduate-level course for advanced physics students
 - Assisted in reviewing quizzes and answering students' questions
 - Helped students develop problem-solving strategies and analytical thinking skills

AWARDS

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|---|------------|
| National University of Engineering | Lima, Peru |
| • Class of 2015 valedictorian (physics) and salutatorian (all majors) | 2015 |
| • Undergraduate award for academic excellence, Manuel Pardo y Lavalle Award | 2013 |
| • First place in the national entrance exam for the physics major | 2010 |

OUTREACH EXPERIENCE

- **Panelist on EducationUSA's webinar on higher education in the USA** 2020
Invited to offer expert advice in a webinar organized in conjunction with the US Embassy in Lima to assist Peruvians seeking to study in the USA
- **Host for underprivileged Peruvian students researching at Harvard** 2017 — 2018
Provided lodging free of charge to Peruvian students in need

SKILLS

Programming

- Languages: Python, C++/ROOT (Proficient), Julia (Prior experience)
- Tools: Tensorflow, Keras, XGBoost, Pandas, NumPy, SciPy, Seaborn, Scikit-learn, Jupyter
- Techniques: Machine learning algorithms (DNN, BDT, etc.), data visualization, statistical modeling

Natural Languages

- Fluent: English, Spanish (native)
- Advanced: French, Akkadian, Sumerian
- Basic: Quechua, Mandarin, German