Jose Miguel **Muñoz Arias**

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EDUCATION

Sept. 2023 -	PhD student, **Massachusetts Institute of Technology**	
2019 - 2023	Physics Bachelor, **EIA University**	GPA: 4.8/5.0
2016 - 2018	Astrophyics Diploma, **Universidad de Antioquia**	GPA: 4.9/5.0
2021	Data Science Programme, **CorrelationOne**	GPA: 98/100

AWARDS & HONORS

Scholarships-based awards:

- **Summer Student Internship**, CERN, Switzerland.   Aug. 2022
- **Mitacs Research Scholarship**, British Columbia University, Canada.   May. 2022
- **Erasmus+ Scholarship**, Sivas Cumhuriyet University, Türkiye   Jan. 2022

Dean's Lists:

- **Honorable Rolls**, EIA University, Colombia   July and Dec. 2021
  Awarded to the best student in the Physics department.   July and Dec. 2020
      July 2019
- **Best academic semester**, Universidad de Antioquia, Colombia.   Dec. 2019
  Awarded based on GPA.

Others:

- **EIA Datathon**, EIA University   Sept 2023
- **Regional Research Winner**, RedColsi (Colombian Research Network)   Sept 2020
  First place for the project "Study of the conditions necessary to constrain the vacuum in extensions of the Standard Model within extensions of the Standard Model with scalar Dark Matter particles, using the co-positivity criterion".
- **Gold medal**, Colombian Astronomy Olympiads   2018
- **Silver medal**, **Latin American Olympiads on Astronomy and Astronautics**, Paraguay   2018
- **Honourable mention**, International Olympiadss of Astronomy and Astrophysics, China   2018
- **First place**, Colombian Physics Olympiads   2018
- **Bronze medal**, Latin American Olympiads on Astronomy and Astronautics, Chile   2017
- **Silver medal**, Colombian Astronomy Olympiads   2017

PUBLICATIONS

Batatia, Ilyes et al. (2023). "A General Framework for Equivariant Neural Networks on Reductive Lie Groups". In: *NeurIPs*. arXiv: 2306.00091 [stat.ML].

Munoz, Jose M. et al. (Mar. 2023). "Predicting β-decay energy with machine learning". In: *Phys. Rev. C* 107 (3), p. 034308. DOI: 10.1103/PhysRevC.107.034308. URL: https://link.aps.org/doi/10.1103/PhysRevC.107.034308.

Munoz, Jose M et al. (Dec. 2022). "Boost invariant polynomials for efficient jet tagging". In: *Machine Learning: Science and Technology* 3.4, 04LT05. DOI: 10.1088/2632-2153/aca9ca.

Munoz, Jose M, Ilyes Batatia, Christoph Ortner, and Francesco Romeo (2023). "Retrieval of Boost Invariant Symbolic Observables via Feature Importance". In: arXiv: 2306.13496 [physics.comp-ph].

Benavides, Richard H. et al. (July 2022). "Five texture zeros in the lepton sector and neutrino oscillations at DUNE". In: Phys Rev D): 2207.04072 (hep-ph). URL: https://arxiv.org/abs/2207.04072.

Munoz, Jose M (Sept. 2022). *Unsupervised Anomaly Detection for the PLT Detector with the CMS Collaboration at the LHC*. Tech. rep. Geneva: CERN. URL: https://cds.cern.ch/record/2826805.

Munoz Jose M, Esteban Vásquez (2022). *El universo algebraico, una introducción (The Algebraic Universe)*. Escuela de Ingeniería de Antioquia. ISBN: 978-628-95287-3-2. URL: https://isbn.camlibro.com.co/catalogo.php?mode=detalle&nt=413957.

WORKS IN PROGRESS

- **ML Guided Theory of nuclear-decays**, Jose M Munoz, Ronald F. Gracía, Sulviu Andrescu
  Using a regression approach, we focus on obtaining a functional model for the Nuclear Mass and β-decay energy. We show that the model matches the experimental data and allows for low prediction error, high robustness, and extrapolation capabilities. Furthermore, the extrapolation

- **Pool GNN for Sensitivity Estimation in Poisson Counting Experiments**, Amalia Betancur, Andres Gómez, Jose M Munoz, Guillermo Palacio, Esteban Vásquez.
  We compare approaches to excluding phenomenological parameter space regions within a toy Poisson counting experiment. Moreover, we introduce the Pool parametric Graph Neural Network model, which we show is superior in parameter rejection and extrapolation.

- **A Many Body Atomic view of the nuclear Hamiltonian**, Jose M Munoz, Christoph Ortner.
  We propose a systematic construction of the many-body Schrödinger equation in the context of nuclear physics by using the ACE framework.

- **Improved Dark Matter Doublet Inert model Sensitivity in DUNE Experiment via ML**, Amalia Betancur, Andres Gómez, Jose M Munoz, Guillermo Palacio, Esteban Vásquez.
  We propose a double scalar Dark Matter model constrained by phenomenological constants. We look for sensibility in the DUNE experiment and we demonstrate a higher rejection power via ML methods.

RESEARCH EXPERIENCE

CERN CMS Researcher, Vanderbilt University   Oct. 2022 - June. 2023

Supervisor: <u>Francesco Romeo</u>.

– Investigate improvements on Transformer and Graph Neural Networks for improved sensibility to $b-$tagging at high momentum, integrated into the CMS ML framework.

– Study beyond Standard Model Dark Matter proposals and the feasibility of measuring it at the LHC.

– Work on data processing pipelines for multivariate anomaly detection with Machine Learning at the BRIL-CMS Luminosity detector.

Research Assistant, EIA University   Jan. 2022 - Oct. 2022

Supervisor: <u>Amalia Betancur</u>.

– Studied quasi-elastic scattering processes at the future Deep Underground Neutrino Experiment (DUNE) near detector within a scalar Dark Matter doublet model.

– Researched methods to estimate and improve sensitivity via Machine Learning methods for a phenomenological parameter space.

Summer Intern, CERN July 2022 - Sept. 2022

Supervisor: <u>Andres Delannoy</u>.

– Developed an ML algorithm for detecting anomalies in experimental data of instant luminosity using bayesian computation and unsupervised learning.

– Improved the computational postprocessing pipeline of the data recording for the CMS experiment.

Research Intern, UBC University May 2022 - July 2022

Supervisor: <u>Christoph Ortner</u>.

– Researched applications of the Atomic Cluster Expansion method of material sciences to high energy physics.

– Investigated the application of different parametric group-symmetry conserving computational models.

– Explored Clebsch–Gordan coefficients representation to non-compact group representations.

Research Intern, Sivas Cumhuriyet University Feb 2022 - May 2022

Supervisor: <u>Serkan Akkoyun</u>; <u>Murat Koksal</u>.

– Researched the feasibility of measuring anomalous magnetic and electric magnetic moments of τ-lepton on future hadronic and electronic colliders.

– Calculated numerically the expected cross-sections of different proton pdf for virtual-photon models.

– Investigated Machine Learning methods for understanding unstable atomic decay energy.

Theoretical and Applied Physics Member, EIA University Jan 2020 - Dec 2021

Supervisor: <u>Amalia Betancur</u>, <u>Juan G. Suárez</u>.

– Explored bounding phenomenological constraints using matrix co-positivity via symbolic restrictions to the quartic couplings of the Standard Model Lagrangian.

– Surveyed relic density restrictions to different Dark Matter masses via general and dedicated Montecarlo simulations.

– Developed geometric DL algorithms for particle reconstruction at neutrino experiments.

– Investigated the time-dependent Schrodinger solutions for different systems via Informed Neural Networks.

Science Research Group Member, University of Medellin Mar 2020 - Jan 2021

Supervisor: <u>David V. Forero</u>.

– Explored the feasibility of measuring violations to the CP symmetry at the DUNE far detector given neutrino oscillations and the Jarlskog for different lepton mixing.

– Surveyed state-of-the-art precision proofs of Lepton non-universality.

Econo-physics Research, EIA University July 2020 - Dec 2020

Supervisor: <u>Nathaly Rendón</u>.

– Solved Stochastic Equilibrium Partial Differential equations for modeling macro-econometric evolution.

– Investigated regression models for GDP via Short-Long Term Neural Networks from network search factors.

WORK EXPERIENCE

Data Scientist, guane Enterprises   Sept 2021 - Dec. 2022

Leader of a Data Science Team and role as full-time Data Scientist and Machine Learning Engineer.

- Implement state-of-the-art ML models such as transformer networks for NLP and Computer Vision tasks.
- Performing statistical analyzes on big data from an industrial context.
- Coordinate the effort of the team of developers and data artisans working on projects with agile methodologies.

ACADEMIC CONFERENCES

- **Interpretability in Jet Tagging using BIPs, recovering symbolic forms.**
  Oral talk. ML4Jets2022 (New Jersey, USA), Rutgers University, 1–4 Nov 2022.

- **BIPs Efficient Invariant representation of Jets.**
  Oral talk. 21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research (Bari, Italy), 23–28 Oct 2022.

- **Boost-Invariant Polynomials: an efficient and interpretable approach to jet tagging.**
  Poster. 14th International Workshop on Boosted Object Phenomenology, Reconstruction, Measurements, and Searches in HEP, University of Hamburg (Hamburg, Germany), 15–19 Aug 2022.

- **Enhancing Parameter Exclusion and Extrapolation in Physics Applications with Advanced Machine Learning Techniques: A Phenomenological Perspective**
  Oral talk. Moca 2023. 11-12 May 2023.

OUTREACH

- **Astrophysics Colloquium**. Medellin's Parque Explora.   (2021-Present)
  Public talks about astronomy and physics, including topics such as explanations of Nuclear phenomena, cosmic rays, dark matter, and cosmology. In addition to the virtual attendance, they are streamed via youtube with more than 3000 views.

- **Preparation for Science Olympiad**, Planetarium of Medellin.   (2019-2021)
  Formed a team of volunteer teachers who gave free lectures (on math, physics, and astronomy) to last year's high school students who are preparing to attend the regional and national Olympiads.

- **Physics Colloquium**, EIA University. Given several public lectures to the Physics department about modern computational Methods in physics (i.e, Physics Informed NN for solving differential Equations) and Compurer Methods and Gitflow for scientists.

- **Putting the Geometry back in Deep Learning**, . Given Public lectures within the Web3ForU about geometric deep learning. Given public lectures at the Universidad de Antioquia.

TEACHING EXPERIENCE

- **Teaching Assistant, EIA University**   June 2019 - Dec 2021
  Was TA for several physics courses (physics I and II on mechanics, and electromagnetism & gravitation). TA at university for the courses of all the Calculus courses (differential, integral and multivariate) and Linear Algebra.

- **Chair teacher, CCB School**   June 2019 - Aug 2021
  Taught statistics (with programming) and physics (with basics of astronomy) courses at the CCB

middle school.

Languages

- **English**, C1
- **Spanish**, Native
- **French**, B1
- **Portuguese**, A2

Skills

Programming Languages

- Python
- Julia
- C & C++
- Mathematica
- Fortran
- BASH
- CUDA
- HTML/CSS
- React
- Go
- LaTeX

Frameworks

- ROOT
- PyTorch
- Jax
- Optuna
- Qiskit
- Docker
- Kubernetes
- Pythia
- GEANT4
- MadGraph
- Deep Graph Library