

# Dr Héctor de la Torre Pérez

ASSISTANT PROFESSOR · NORTHERN ILLINOIS UNIVERSITY · DEPARTMENT OF PHYSICS

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## Education

### PhD in Physics

UNIVERSIDAD AUTÓNOMA DE MADRID

Madrid, Spain

January 2016

### BSc in Physics (Sep 2008) & MSc in Theoretical Physics (Jan 2011)

UNIVERSIDAD AUTÓNOMA DE MADRID

Madrid, Spain

January 2011

## Fellowships and contracts

### Assistant Professor

NORTHERN ILLINOIS UNIVERSITY

DeKalb, USA

Since April 2023

### Research associate

MICHIGAN STATE UNIVERSITY

East Lansing, USA

May 2016 - February 2023

### Research fellow (4 years) and Research assistant

UNIVERSIDAD AUTÓNOMA DE MADRID

Madrid, Spain

August 2009 - April 2016

## Funding and awards

### NSF solicitation: Investigator-Initiated Research Projects (Principal Investigator)

HEAVY QUARKS: A WINDOWS BEYOND THE STANDARD MODEL AT THE LHC, USD 450K AWARDED (3 YEARS)

National Science Foundation

August 2024

### Research and artistry opportunity grant (Principal Investigator)

IMPROVING BSM SEARCHES WITH HEAVY QUARKS AT THE LHC, USD 16K AWARDED

Northern Illinois University

April 2024

### DOE Solicitation: Traineeship in Computational High Energy Physics (Senior Personnel)

CHICAGOLAND COMPUTATIONAL TRAINEESHIP IN HIGH ENERGY PARTICLE PHYSICS, USD 665K AWARDED (3 YEARS)

US Department of energy

October 2022

## Teaching and Mentoring

### Courses taught at Northern Illinois University

PHYS 253 (2 semesters)

PHYS 684

FUNDAMENTALS OF PHYSICS I

INTRODUCTION TO HIGH ENERGY PHYSICS

Since fall 2024

Spring 2024

### Mentoring and supervision

Graduate student supervision at NIU

Graduate student supervision at MSU

FOUR CURRENT STUDENTS (THREE PHD, ONE MSC)

THREE PHD STUDENTS GRADUATED BETWEEN 2020 AND 2023

Since 2023

2016 - 2023

### Certificates and awards

Certificate in Effective Teaching Practice Framework  
Faculty Academy on Cultural Competence and Equity

ASSOCIATION OF COLLEGE AND UNIVERSITY EDUCATORS  
NORTHERN ILLINOIS UNIVERSITY

May 2024

June 2023

## Positions and appointments

### Leadership positions

Deputy L1 Manager (Physics Support)

Convener

Convener

Run coordinator

US-ATLAS

UPPH AND GPER GROUPS, ATLAS COLLABORATION

HQT SUBGROUP, ATLAS COLLABORATION

LAR CALORIMETER GROUP, ATLAS COLLABORATION

Since Nov. 2024

Since Oct. 2023

2019 - 2021

2011 - 2013

### Editor and reviewer roles

Reviewer (competitive funding proposals)

Spokesperson delegate reviewer (multiple papers)

Editorial board on ATLAS physics analyses (multiple)

PhD Thesis committee (multiple)

Referee

Paper editor of ATLAS physics results (multiple)

SWISS NATIONAL SCIENCE FOUNDATION

ATLAS COLLABORATION

EXOTICS GROUP, ATLAS COLLABORATION

MADRID AND VALENCIA UNIVERSITIES

JOURNAL OF HIGH ENERGY PHYSICS

EXOTICS AND SM GROUPS, ATLAS COLLABORATION

Since 2024

Since 2023

Since 2021

Since 2021

2021-2021

Since 2013

## Selected international conferences and seminars

### 42th International Conference on High Energy Physics (ICHEP 2024)

ATLAS EXOTIC HEAVY RESONANCE SEARCHES

Prague, Czechia

August 2024

### The Mitchell conference on collider, dark matter and neutrino physics (MITCHELL 2024)

RECENT BSM HIGHLIGHTS FROM ATLAS AND CMS

College Station, Texas

May 2024

### US LHC Users Association annual meeting (Hosted at Fermi National Laboratory)

ATLAS STATUS REPORT

Batavia, USA

December 2023

### Argonne National Laboratory, High Energy Physics division seminar

CHALLENGES AND OPPORTUNITIES FOR ATLAS AT THE HIGH-LUMINOSITY LHC

Lemont, USA

November 2023

### US ATLAS Summer Workshop 2023 (Hosted at Yale University)

UPGRADE PHYSICS PROJECTIONS

New Haven, USA

July 2023

### 11th Large Hadron Collider Physics Conference (LHCP 2023)

CONVENER OF THE BSM-1 (TeV-SCALE) SESSION

Belgrade, Serbia

May 2023

### 14th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2022)

CONVENER OF THE PHYSICS AT HIGH ENERGIES SESSIONS & PLENARY TALK (PHYSICS AT HIGH ENERGIES)

Lake Buena Vista, USA

August 2022

### 40th International Conference on High Energy Physics (ICHEP 2020)

SEARCH FOR NEW PHYSICS IN FINAL STATES WITH HEAVY-FLAVOUR QUARKS USING THE ATLAS DETECTOR

Virtual conference

August 2020

### US ATLAS Physics Workshop 2019

OVERVIEW OF THE EXOTICS SEARCH PROGRAM: PRESENT AND FUTURE

Amherst, USA

August 2019

### 39th International Conference on High Energy Physics (ICHEP 2018)

EXPECTED PERFORMANCE OF THE UPGRADED ATLAS EXPERIMENT FOR HL-LHC

Seoul, South Korea

July 2018

## Selected publications

ON A TOTAL OF 1344 RESEARCH PAPERS. FULL LIST CAN BE ACCESSED THROUGH THE ORCID LINK INCLUDED IN THE HEADER OF THIS DOCUMENT

1. ATLAS Collaboration, *Exploration at the high-energy frontier: ATLAS Run 2 searches investigating the exotic jungle beyond the Standard Model*, Phys. Rep. (2024), arXiv: 2403.09292 [hep-ex]
2. ATLAS Collaboration, *Combination of searches for heavy spin-1 resonances using 139 fb<sup>-1</sup> of proton-proton collision data at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, JHEP **04** (2024) 118, arXiv: 2402.10607 [hep-ex]
3. ATLAS Collaboration, *Search for vector-boson resonances decaying into a top quark and a bottom quark using pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, JHEP **12** (2023) 073, arXiv: 2308.08521 [hep-ex]
4. ATLAS Collaboration, *Search for single vector-like B quark production and decay via  $B \rightarrow bH(b\bar{b})$  in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, JHEP **23** (2023) 168, arXiv: 2308.02595 [hep-ex]
5. Hector de la Torre and Trisha Farooque, *Looking beyond the Standard Model with Third Generation Quarks at the LHC*, Symmetry **14.3** (2022), ISSN: 2073-8994, URL: <https://www.mdpi.com/2073-8994/14/3/444>
6. ATLAS Collaboration, *Search for heavy particles in the b-tagged dijet mass distribution with additional b-tagged jets in proton-proton collisions at  $\sqrt{s} = 13$  TeV with the ATLAS experiment*, Phys. Rev. D **105.1** (2022) 012001, arXiv: 2108.09059 [hep-ex]
7. ATLAS Collaboration, *Search for  $t\bar{t}$  resonances in fully hadronic final states in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, JHEP **10** (2020) 061, arXiv: 2005.05138 [hep-ex]
8. ATLAS Collaboration, *Search for vector-boson resonances decaying to a top quark and bottom quark in the lepton plus jets final state in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, Phys. Lett. B **788** (2019) 347, arXiv: 1807.10473 [hep-ex]
9. Xabier Cid Vidal et al., *Report from Working Group 3: Beyond the Standard Model physics at the HL-LHC and HE-LHC*, CERN Yellow Rep. Monogr. **7** (2019) 585, ed. by Andrea Dainese et al., arXiv: 1812.07831 [hep-ph]
10. ATLAS Collaboration, *Search for  $W' \rightarrow tb$  decays in the hadronic final state using pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, Phys. Lett. B **781** (2018) 327, arXiv: 1801.07893 [hep-ex]

## Outreach

### Quarknet Masterclass

ORGANIZATION, SUPERVISION OF STUDENTS

Mar. 2024

### Interview for the program 'En fase experimental' on particle physics (Spanish)

YOUTUBE AND OTHER PODCAST PLATFORMS

Oct. 2023

## The HL-LHC upgrade programme for the ATLAS detector

- **Convener of Global Performance group (Since 2024):** In 2024 the ATLAS Collaboration took the decision to phase-out the upgrade group to start integrating the upgrade efforts into the other performance and physics groups. As part of the reorganization, a new group dedicated to the study and implementation of existing and new strategies for global and advance particle flow. The success and nature of these strategies will inform the object reconstruction scheme that ATLAS will use for the HL-LHC era. As one of the initial conveners of this new group I manage and coordinate all studies related to particle flow in ATLAS. The group also serves as a discussion forum for a variety of reconstruction topics that involve more than one single performance group, aiming at increasing the collaboration between them and streamlining the reconstruction of physics objects.
- **Continuation of studies on the Global trigger (Since 2023):** My research group conducts performance studies related to jet reconstruction at the trigger level with HL-LHC conditions as part of the effort to design the Global trigger. This new planned trigger system consists of a layer of incoming multiplexing nodes that feed into a layer of global event processors. This structure makes the whole event available on a single processor (one FPGA), decoupled from the LHC bunch-crossing rate. It will be able to run complex algorithms to maintain or improve the performance of the ATLAS trigger in the challenging environment of the HL-LHC. We also develop and maintain the software framework that the global-trigger team utilises to do performance studies on a variety of trigger algorithms and object reconstruction at the trigger level.
- **Convener of Upgrade Physics group (2023 - 2024):** I managed and coordinated all performance, physics, and simulation studies related to the upgrade program of the ATLAS detector done during my tenure. In addition to purely upgrade efforts, I advised Physics, detector, and computing groups to ensure that short-term decisions keep the upgrade objectives in mind. The studies taking place in the group shape and define the planning and execution of the detector upgrades to be installed in ATLAS in preparation for the HL-LHC.
- **Coordinator of the TDAQ Phase II Physics Performance and Event selection group (2023-2023):** I managed a dedicated group within the ATLAS trigger community dedicated to coordinating and supporting performance studies for the upgrade of the trigger system for HL-LHC.

## Searches for new physics beyond the Standard Model with the ATLAS Detector

- **New VLQ searches (Since 2024):** My research group is participating on the next generation of Vector-like Quark searches, to be done during run 3, with the ATLAS experiment. Our interest lies primarily in the study of new production modes that may be beyond the sensitivity of the analyses performed in the last few years.
- **Run 2 exotics physics report (2023-2024):** During 2023 and 2024 I was one of the two leading editors of a report summarizing the whole program of BSM searches performed within the Exotics group of the ATLAS Collaboration during run 2. We compiled all relevant results, summarized their content and obtained relevant conclusions on the extent and reach of the program in each category of BSM physics explored. The report was published in arXiv in March of 2024 and has been submitted for final publication to Physics Reports.
- **Heavy resonance combination (2023-2024):** I participated in the statistical combination of 18 searches dedicated to heavy vector resonances. Liaison for the searches with top quarks in the final state,  $W' \rightarrow tb$  and  $Z' \rightarrow t\bar{t}$ . Provided the relevant inputs from the  $W' \rightarrow tb$  analysis. The combination was published in February of 2024.
- **$W' \rightarrow tb$  searches with entire run 2 data (2023-2023):** I led the last iteration of the search, looking for new heavy vector resonances decaying into a top quark and a bottom quark, using the complete run-2 dataset. The search, published in August of 2023, has a better sensitivity than any previous analysis by either ATLAS or CMS and combines both the leptonic and hadronic channels into a single result. It takes advantage of the latest improvements in machine learning methods applied to jet tagging to boost the reach of the analysis and set limits on the production of heavy vector resonances with masses up to 6 TeV.
- **Monotop search (2023-2024):** As a member of the editorial board, I take part in this search for new physics in final states composed of one top quark accompanied by missing transverse energy with interpretations in dark matter and Vector-like quarks (VLQ) models. Results were published in February of 2024.
- **Right-handed neutrino search (2023-2023):** As a member of the editorial board, I participated in a search for exotic resonances in final states with multiple leptons and jets, focusing on the hunt for heavy neutrinos. The analysis was published in April of 2023.

## Computation in HEP

- **Computational HEP traineeship (Since 2023)** I take part as a faculty mentor in the Chicagoland Computational Traineeship in High Energy Particle Physics (C<sup>2</sup>-THE-P<sup>2</sup>, an effort between NIU and UIC to train new graduate students in computational skills aimed at improving research in high energy physics. I supervise two students: one working on the implementation and usability in physics analysis of RNTuple, the next generation of ROOT I/O subsystem, and the other working on the implementation of new and more efficient geometries and models in the fast simulation environment for HEP detectors.

# Previous research experience in the ATLAS Collaboration

AS A RESEARCH ASSOCIATE AT MICHIGAN STATE UNIVERSITY AND GRADUATE STUDENT AT UNIVERSIDAD AUTÓNOMA DE MADRID, 2009-2023

## Simulation and processing of simulated samples for physics groups

- **Derivation production for the exotics group (2021-2023):** I was responsible for the group's derivation framework. This framework is used to process the common Monte Carlo simulation ATLAS format into simplified formats, with less content and/or events, that are easier to work with for specific analyses. I also process and submit to the grid production system the derivation requests from the different teams in the group.
- **Monte Carlo sample production for the exotics group (2018-2019) :** I was in charge of collecting, validating, and processing the Monte Carlo requests of the different analysis teams of the group.

## ATLAS Upgrade programme

- **Studies on the Global trigger (2017-2023):** I participated in performance studies on cluster and jet reconstruction for the Global trigger in the context of the HL-LHC ATLAS upgrade program. Coordinated the design of a dedicated software framework for global trigger performance studies.
- **Monte Carlo sample production for HL(HE)-LHC studies (2017-2019):** I designed and executed a sample simulation strategy for physics and performance studies used for the six Technical Design Reports (TDR) published by ATLAS in 2017. These TDRs compiled the plans for the HL-LHC upgrade of the ATLAS detector. The same set of samples was used to perform studies included in the Yellow report on the physics potential of the HL(HE)-LHC, a fundamental input for the update of the European strategy for particle physics finalized in 2020. Coordinated with relevant experts and analyzers to ensure the samples were created according to specifications and took care of producing the samples with the ATLAS grid production system.
- **Performance studies for Trigger and Data Acquisition TDR (2016-2017):** I led calorimeter performance studies for the global trigger and provided inputs for other team members using a custom-built analysis framework.

## Searches for new physics beyond the Standard Model

- **$b\bar{b}Z' \rightarrow b\bar{b}b\bar{b}$  search (2019-2022):** I was responsible for the definition and study of new signal samples using Madgraph and performed the truth-level analyses needed to determine the analysis strategy. This novel analysis published in 2022 was focused on vector-like resonances that couple exclusively to third-generation quarks. This is especially relevant in models incorporating lepton flavor universality violation.
- **$W' \rightarrow tb$  searches (2016-2021):** I led the publication of preliminary results with the entire run 2 dataset on the  $W' \rightarrow tb \rightarrow qqbb$  channel published in 2021 as a first step of the full publication that would be completed in 2023. I supervised two students, who graduated in 2021 and 2022, respectively. I was the main analyzer of the first 13 TeV iteration of  $W' \rightarrow tb \rightarrow qqbb$  search, published in 2018. I led on statistical analysis, framework development, and strategy design. I was responsible for sample generation, truth-level studies for the exact search, and another on the complementary channel,  $W' \rightarrow tb \rightarrow l\nu b\bar{b}$ . A combination of both searches was published in 2019.
- **Convener of Heavy Quarks, Top and composite Higgs (HQT) subgroup (2019-2021):** I managed the search subgroup, part of the exotics group, focused on physics beyond the SM with final states of third generation quarks. I coordinated 20 analyses with approximately 200 analyzers under my care, dealing with many resonance searches and the complete ATLAS program of VLQ analyses. I reviewed relevant talks, internal notes, and papers.
- **$VLB \rightarrow bh(bb)$  search (2019-2021):** I participated as HQT convener in the full run-2 version of the analysis, with preliminary results published in 2021. I supervised the main analyzer, a student who graduated the same year and I was integral in the design of the background estimation method. The analysis took advantage of an innovative background estimation method to improve the sensitivity with respect to previous VLB searches in a challenging all-hadronic final state. After a delay necessary to understand signal modelling, the full version of the analysis was published in 2023.
- **$Z' \rightarrow t\bar{t}$  search (2019-2020):** I participated as HQT convener in the all-hadronic, full run-2 version of the analysis, published in 2020. Worked closely with the team to validate the background estimation process based on a functional form. It was the first analysis to introduce deep neural network top-tagger in ATLAS.

## Physics measurements of standard model processes

- **Photon + jet differential cross section measurement (2013-2017)** I led a new physics analysis effort in the Standard Model group for the photon + jets analysis at 8 TeV, published in 2017. The analysis contained differential cross-section measurements as a function of 15 different observables in events with one photon and up to three additional jets. It constituted the first test of color coherence effects in photon + jets events in ATLAS.

## Liquid argon (LAr) calorimeter operations

- **LAr run coordinator (2011-2013):** I led the LAr operations team, managing a team of around 15 experts and shifters. The team ensured the smooth operation of LAr within the ATLAS detector during the 8 TeV data-taking period. I was the point of contact between the LAr operations team and ATLAS management.
- **LAr software on-call (2011-2013):** I was available 24 hours a day to investigate and repair issues related to the LAr online software and back-end electronics
- **LAr online software developer (2011-2013):** I developed two tools running on the ATLAS online framework during data taking. One tool to investigate single event upsets in LAr front-end boards and a monitoring tool to check the LAr configuration at the beginning of each run.