University of Puerto Rico
Mayagüez Campus
Physics Department

Annual Report 2022–2023

Submitted by:

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(Associate Director) / (Director)

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STATUS REPORT ON ACTIVITIES AND ACHIEVEMENTS

A. Executive Summary

At the Physics Department, our mission is to explore the fundamental principles that govern the universe and advance our understanding of the physical world. We are committed to fostering a vibrant intellectual community and a collaborative academic environment that promotes curiosity, critical thinking, and scientific inquiry. Our dedicated faculty members provide a comprehensive and rigorous education in physics by involving students in hands-on experiences and opportunities to engage them in groundbreaking research. *The Department also values interdisciplinary collaborations, encouraging our faculty and students to engage with other fields to address pressing global issues. Ultimately, our goal is to inspire the next generation of physicists, nurturing their passion for discovery and empowering them to make meaningful contributions to society through the pursuit of scientific knowledge.*

The mission of the UPRM's Physics Department fits within the triple mission of the University of Puerto Rico:

- ***Teach:*** Educate our students to help them understand and explore physical phenomena, apply critical thinking when presenting, analyzing, and solving problems, maintain a high degree of professional integrity in the practice of their careers.
- ***Research:*** Support and advance knowledge of physics and related fields, and the investigation of physical phenomena.
- ***Service:*** Promote the knowledge of physics and related fields in universities, schools and the community in general.

Accompanying the mission of the Department of Physics, we have the ***Goals and Objectives of the Department:***

1) Provide an effective comprehensive and rigorous education in physics and related disciplines to help students acquire a deep understanding of fundamental physics principles and problem-solving skills.
2) Conduct cutting-edge research in various areas of physics, pushing the boundaries of knowledge and contributing to the scientific community.
3) Develop innovative experimental techniques and computational methods to explore new frontiers in physics research.
4) Stimulate the development of interdisciplinary activities between physics or related fields and other branches of knowledge.
5) Stimulate and facilitate the professional development of the members of the department.
6) Promote interactions of the Department's faculty and students with industry, government agencies, national laboratories, and other academic or research institutions.
7) Prepare our students to compete in the job market.
8) Engage in outreach activities by disseminating and promoting effective science communications, both to the wider public and within the whole department (students, faculties, etc.) to enhance understanding and appreciation for physics education and its

applications.

During the academic year 2022-2023, the Physics Department kept faithful to its Strategic Plan, aligned in turn with the Strategic Plan of the Campus's Faculty of Arts and Sciences 2012-2022.

In the following part of this report, we described the dedicated efforts of the department in teaching, outreach and research of physics once we have returned in the face-to-face mode from the on-line activities due to the COVID19 pandemic.

During this time, the department's faculties have work on teaching, outreach and have published a considerable number of scientific articles in conference proceeding and in refereed journals.

In addition, students through their association continued to carry out various activities to promote their organization and cooperate in outreach activities to schools and other organizations for the general public.

B. Mission

The Department of Physics, in line with the mission of the Mayagüez Campus, is dedicated to educating students to better understand and explore physics phenomena, to apply critical thinking in the formulation, analysis and solution of physics problems, and to maintain high professional standards in their careers. It is also dedicated to the promotion of research in physics, and other related disciplines as well as to the promotion of physics in the university, local schools, and the community in general.

This year (2023), the Graduation Day for the Faculty of Arts and Sciences was held on Saturday 10th June and our department awarded sixteen (16) degrees to the students who completed their studies. Six (6) students received the Bachelor of Science in Theoretical Physics, three (3) students received the Bachelor of Science in Physical Sciences and seven (7) students a Master of Science in Physics. During the first semester of the 2022-2023 academic year, twenty-eight (28) students enrolled in the Physics Department, eighteen of them in the Theoretical Physics program, seven (7) in the Physical Sciences program and three (3) students in the Master of Physics graduate program. In order to better educate these students, our department has several initiatives to add new programs and revise existing ones. A review of the baccalaureate in Physical Sciences, Theoretical Physics, and the master's program is currently underway.

The possibility of creating an interdisciplinary program with the Department of Marine Sciences in Marine Atmospheric Sciences is also being considered, as well as the possibility of promoting the Ph.D. program in Physics.

In the research area, the work of the Physics Department has been very diverse, including grant proposals submitted to federal agencies, oral and poster presentations at local and

national conferences and scientific publications in peer-reviewed journals in several specialized areas such as high energy physics, meteorology, astronomy and condensed matter. In the area of community service or outreach, the department runs several programs as (i) QuarkNet, a program designed to train high school physics/chemistry teachers on current experimental particle physics experiments, (ii) faculty visits to schools to promote our programs and certification, (iii) NANOGrav, a program design to stimulate the student participation in astronomy, (iv) the Optics outreach program and (v) Software training workshop for high school teachers.

In the Astronomy UPRM's group, a new professor, Dr. Allison Smith, joins the faculty to strengthen the group and area by teaching astronomy courses and doing research at Arecibo Observatory. Dr. Smith's appointment is combined with the College's CARSE NSF grant proposal, and she will start on July 1, 2023.

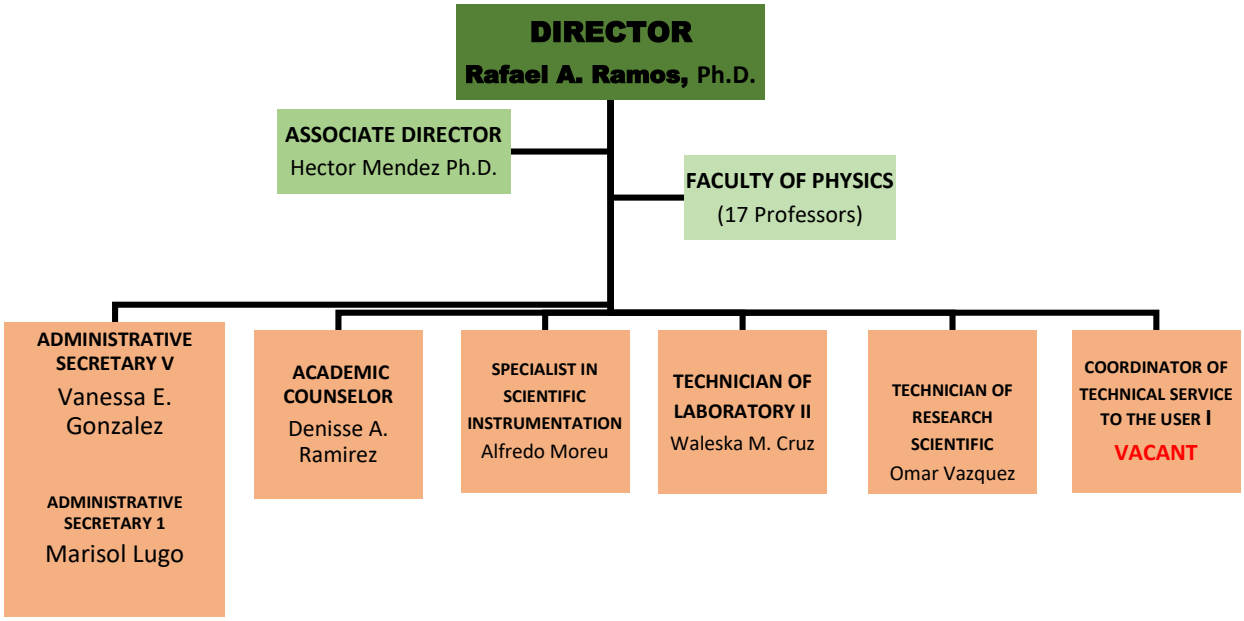
Finally, our student societies also contribute to the promotion of Physics, Atmospheric Sciences, Meteorology and Astronomy as alternatives for professional careers among university and high school students. This document describes the activities carried out by the Physics Department in order to fulfil the mission of the Mayagüez Campus.

The Department of Physics is composed of non-academic staff (6), tenured faculties (17) and in recent years we have employed six (6) adjunct professors per semester to meet the demand for courses mainly for engineering and biology students.

Organization chart of the Department of Physics

Physics department
University of Puerto Rico
Mayaguez University Campus

ORGANIGRAM
DEPARTMENT OF PHYSICS, UPRM



C. To institutionalize a culture of strategic planning and assessment

The Strategic Plan of the Physics Department can be found on the website of the Mayagüez University Campus at the address **https://www.uprm.edu/arci/planificacion-estrategica/**. During the academic year 2022-23, the Department of Physics continued to review the Strategic Plan, which was last revised during the academic year 2021-22. The Department of Physics has begun to implement part of the new administrative Assessment Plan. The review of the Physics Department Strategic Plan has not yet been completed and we expect to be able to continue its review early next academic year.

The current Strategic Plan of the Department of Physics is aligned with the Strategic Plan of the Faculty of Arts and Sciences 2012-2022 and with the goals of Ten for the Decade: Diary for the Planning in the University of Puerto Rico (2005-2015). We hope that as the

strategic plan changes at the level of the University of Puerto Rico changes, our plan will show the necessary alignment with it.

The Department of Physics continues to send the Exit Survey by e-mail to its graduates from all the programs offered by the Department. The results of the survey are currently being analyzed and we hope that they will help us to update all our strategic plans so that we can adapt our academics offer accordingly.

D. To lead higher education throughout Puerto Rico while guaranteeing the best education for our students

The Department of Physics has made a concerted effort to strengthen and expand its academic programs, in order to provide an academic offering that meets the needs of the student community.

Curricular reviews

The curricular review of the Physics program is being carried out by the Curriculum Committee composed by Dr. Carlos U. Pabon, Dr. Samuel Santana, Dr. Héctor Jiménez, Dr. Raúl Portuondo and Dr. Henri Radovan. The aim of the revision is to reduce the number of credits in the whole program and to increase the possible options within Physics courses. The options currently under consideration are the Bachelor of Physics with a specialization in Physics, Atmospheric Sciences and Meteorology, Computational Physics, and Traditional Physics. Considering the review of the general education courses carried out by the committee appointed by the UPRM Academic Senate, the total number of credits in the three options must be 127 credits, 14 credits less than the total in the current Physics baccalaureate.

New Academic programs (In Progress)

An ad hoc committee is being formed by the Department to work on the establishment of a Ph.D. program in Physics which, if approved, will offer numerous benefits, including the opportunity to delve deeply into cutting-edge research and make significant contributions to scientific knowledge. Among other things, it provides a platform for intellectual growth and will open doors to a wide range of career options, including academia, research institutions, industry, and entrepreneurship, where advanced expertise is highly valued. The committee is currently working on a draft which will be submitted to the Faculty for further consideration and then to the Faculty of Art and Sciences and beyond. The committee is composed of Dr. S. Lysenko, Dr. F. Bezares, Dr. S. Santana, Dr. H. Méndez, Dr. S. Malik and Dr. D. Sánchez.

An interdisciplinary program in Marine Atmospheric Sciences in collaboration with the Department of Marine Sciences is also being considered as a new emerging program in the Department.

Initiatives to strengthen teaching

The Center of Tutorials of Physics has been operating in the room F-449 during the last

academic year. Each of the laboratory tutors offered one hour of tutorials/consultation during the week.

Student participation in academic competitions and activities

During this academic year, several undergraduate students have participated in the **NANOGrav** program under the supervision of **Dr. Henri Radovan**, through academic activities carried out at the University of Wisconsin, Oregon State University and the Arecibo Observatory in the following dates:

- Three (3) Physics undergrads went to the NANOGrav Fall Science Meeting at University of Wisconsin Milwaukee on October 17-19, 2022

- Two (2) Physics undergrads went to the NANOGrav Spring Science Meeting at Oregon State University on March 27-29, 2023

- Eight (8) Physics undergrads and one Physics grad went to the NANOGrav Arecibo Observatory Workshop on December 19-21, 2022

A student working with Dr Rafael Ramos on Computational Physics to study scientific problems using computational methods, which combines computer science, physics and applied mathematics to develop scientific solutions to complex problems such as earthquake modelling, presented at the following conferences:

- Ortega, J.G., Ramos, R.A., & Vanacore, E. (17-20 abril, 2023). Computational Study of Foreshocks in the Burridge-Knopoff Earthquake Model Using Machine Learning. Poster presented at the Seismological Society of America Annual Meeting, San Juan, PR.

- Ortega, J.G., Ramos, R.A., & Vanacore, E. (17 mayo, 2023). Computational Study of Foreshocks in the Burridge-Knopoff Earthquake Model Using Machine Learning. Poster presented at the Simposio de Investigación para Facultad y Estudiantes Graduados del UPRM, Mayaguez, PR.

Students from the University of Puerto Rico campus Humacao (UPRH) and Mayaguez (UPRM) working on **Condensed Matter** with **Dr. Francisco Bezares** were involved in the following activities:

- Presentation - Magnetron Sputtering Physical Vapor Deposition for Large-area, Ultra-high Sensitivity and Selectivity Sensors, NSF UPRH-UPENN PREM Annual Meeting, Humacao PR, students: Camila Negrón & Gabriel Garcia (UPRH), 12/12/23, Palmas del Mar, Humacao

- Poster - Optical Studies of Magnetron Sputtering Physical Vapor Deposition of Ag for Ultra-sensitive, Large-area Plasmonic Sensors, ACS SERMACS 2022

Conference, San Juan PR, 10/19-22/22, students: Camila Negrón & Lorena Reyes (UPRH), 10/21/22, San Juan Convention Center, PR

- Poster - TEM and SEM of Ag via Magnetron Sputtering Physical Vapor Deposition for Photonic Sensing Devices, ACS SERMACS 2022 Conference, San Juan PR, 10/19-22/22, students: Edgard Díaz & Gabriel García (UPRH), 10/21/22, San Juan Convention Center, PR

- Poster - Topographic and SERS Study of Magnetron Sputtering PVD of Ag Nanoparticles for Ultra-sensitive, Large-area Plasmonic Sensors, MRS Spring Meeting, April 10-14 2023, San Francisco CA, student: Joshua Chaparro (UPRM)

- Presentation - The Effects of Magnetron Sputtering Physical Vapor Deposition Paramenters in Ag Nanoparticles for Surface-enhanced Raman Scattering, 10mo Encuentro Estudiantil de Investigación, Creación y Servicio Comunitario, UPR-Cayey, 05/12/23, students: Edgard Díaz & Wanda Rivera (UPRH)

- Poster - Pillar[5]arene as Host Macro-molecules for Surface-enhanced Raman Scattering (SERS) Sensors, Simposio de Investigación UPRM 2023, UPR-Mayagüez, 05/17/23, students: Germán Váquez (UPRM)

Students working on **High Energy Physics** with **Dr. Sudir Malik** were involved in the following activities:

(1) Guillermo Fidalgo facilitated and participated “DANCE/CoDaS@Snowmass 2022 computational and data science software training” co-located with “Seattle Snowmass Summer Meeting 2022”, University of Washington, Seattle, WA 19-23 July 2022 https://indico.cern.ch/event/1151329/page/26089-participants

(2) Guillermo Fidalgo participated in “Fourth Computational and Data Science school for HEP (CoDaS-HEP 2022)” at Princeton University, NJ 1-5 August 2022 https://codas-hep.org/pages/participants-2022.html and https://indico.cern.ch/event/1151367/timetable/

(3) Yarelis Acevedo presented poster "Searching for pair production of new heavy quark that decays into a W boson and light quark", at APS CUWiP conference at University of Central Florida, January 20 - 22, 2023

(4) Arianna Cesani-Colon presented poster " EMJ Top Signal Implementation and Analysis Using Pythia 8", at APS CUWiP conference at University of Central Florida, January 20 - 22, 2023

(5) Tiahra Aviles presented poster " Dee plaquettes thermal studies to improve manufacture", at APS CUWiP conference at University of Central Florida, January 20 - 22, 2023

(6) Yarelis Acevedo presented "Searching for pair production of new heavy quark that decays into a W boson and light quark" at US ATLAS SUPER Symposium (12 August 2022), Aug 12, 2022.

(7) Three students from CMS group – Cristhian Barbosa, Roy Cruz Candelaria and Guillermo traveled to Fermilab for CMS Data Analysis School, 9-13 January 2023 https://lpc.fnal.gov/programs/schools-workshops/cmsdas.shtml

(8) Tiahra Gonzalez (Physics undergrad): Undergrad spent summer of second time 2022 (her second time) at Cornell and extended her past work on thermal analysis of the modules located on the Dee.

(9) Reynaldo Falcon (Physics undergrad): Falcon spent summer of 2022 at Cornell working on the design of a mechanical arrangement that can hold the Dee in pace while TIM gets deposited.

(10) Yarelis Acevedo (Physics undergrad):

- Yarelis traveled in summer 2022 to Oklahoma State University, Stillwater to do summer internship on ATLAS SUPER Program and worked on “Searching for pair production of new heavy quark that decays into a W boson and light quark”
- Yarelis got a 2023 summer undergrad fellowship at IRIS-HEP project to work on "Creating a lesson on unit tests for the HSF Analysis Preservation Training"

Strengthening of facilities for academic use

The Physics Department completed the installation of projectors in all the Physics Department rooms several years ago. At present, the lecturers have the option of teaching their classes with a projector only, with a blackboard only or with a combination of both resources.

The physics department also received approval for technology fee money to replace some of the computers in the general physics labs. The refurbishment of several classrooms began. One of them is the electronics lab in F-313 lounge. The Physics Department's computer center was moved to room F-437 a few years ago and is still awaiting improvements to its facilities during the academic year.

Currently, the Department has the goal of changing all the chalk boards, as well as repositioning the projector screens to improve classes that combine projector and blackboard simultaneously, as well as the installation of equipment to teach classes in mixed mode in the near future.

Academic offerings

In the academic year 2022-23, the academic offer was similar to that of recent years. The distribution of sections by course for graduate and undergraduate physics, physical sciences, astronomy and meteorology is shown below:

Course:	***Sections offered:***		
	summer 2022	***1st sem.***	***2nd sem.***
FISI 3091	**1**	**3**	**2**
FISI 3092	**1**	**4**	**4**
FISI 3151	**2**	**10**	**5**
FISI 3152	**1**	**6**	**9**
FISI 3153	**1**	**14**	**8**
FISI 3154	**1**	**9**	**14**
FISI 3161		**1**	**1**
FISI 3163		**1**	**1**
FISI 3162		**1**	**1**
FISI 3164			**1**
FISI 3171	**2**	**17**	**12**
FISI 3172	**1**	**11**	**16**
FISI 3173	**1**	**26**	**15**
FISI 3174	**1**	**16**	**23**
FISI 4001		**1**	
FISI 4002			**1**
FISI 4017		**1**	
FISI 4020			**1**
FISI 4051		**1**	
FISI 4052			**1**
FISI 4057		**1**	
FISI 4063		**1**	

FISI 4071			**1**
FISI4076		**2**	
FISI 4077			**2**
FISI 4078		**1**	
FISI 4105		**1**	**1**
FISI 4106		**1**	
FISI 4107			**1**
FISI 4125			**1**
FISI 4126		**1**	
FISI 4127		**1**	**1**
FISI 4871			**1**
FISI 4996		**1**	**1**
FISI 4997			**2**
FISI 4999		**5**	**1**
FISI 5037		**1**	
FISI 6090		**1**	
FISI 6190			**1**
FISI 6280		**1**	**1**
FISI 6380		**1**	**1**
FISI 6431		**1**	
FISI 6451			**1**
FISI 6477			**1**
FISI 6510		**1**	**1**
FISI 6991	1	**7**	**7**
ASTR 4005		**1**	
ASTR 4006			**1**
ASTR 4007		**1**	
ASTR 4015		**1**	
ASTR 4999			**1**
CIFI 3011		**1**	
CIFI 3012			**1**
METE 4006		**1**	
METE 4007		**1**	
METE 4008			**1**
METE 4057			**1**
METE 4061		**1**	
METE 4075		**1**	
METE 4085			**1**
METE 5065			**1**

E. To increase and diversify the Institution's sources of revenue

Initiatives to obtain funds:

- Proposals by **Dr. Armando Rúa** to support his research on **Materials:**

  1) MRI: Track #1 Acquisition of a physical properties measurement system to support research and training in Quantum Materials and Transformative Devices, NSF, $867,00 (pending), PI

  2) Unraveling the switching mechanism in phase-change materials for brain-inspired computing applications, Gordon and Moore Foundation, $1,250,000 (pending), PI

- Proposals by **Dr. Sergiy Lysenko** to support his research on **Materials**:

  1) PreProposal: EPiQS Flexible Funding Ideas 2023, Agency Moore, $800,000, 2024-2027, Status: Pending

  2) Equipment: MRI Track 1: Acquisition of a physical properties measurement system to support research and training in Quantum Materials and Transformative Devices, NSF $865,003, Period: 03/16/2023 - 02/21/2023, Status: Pending

  3) Dual Use Exoplanet Telescope, NIAC, $500,000, Period: 2022-2024, Status: Rejected

- Proposals by **Dr. Francisco Bezares** to support his research on **Materials**:

  1) Ultra-thin Molecular Lasers for Quantum and Photonic Technology Applications, NSF Early Career Program, $250K/2yr, Submitted 01/21/2023 (pending)

  2) Acquisition of AFM-Raman Confocal Microscope to Enhance Materials Research and Training of STEM, NSF MURI Program, $350K Raman Confocal Microscope, Submitted 02/21/23 (pending)

External funds received

- Proposals by **Dr. Henri Radovan** for continuation of his work in the **NANOGrav** collaboration:
  NSF award #2216793
  PI: Henri Radovan
  Title: NANOGrav@UPRM: Growing and characterizing the NANOGrav gravitational-wave detector
  funds: $520,646
  duration: August 1, 2022 to July 31, 2025

- Proposals by **Dr. Sudhir Malik** for continuation of his work and **CMS:**

  (1) Project Name (approved, continuing award - 1 September 2021 to 31 August 2024) - “Physics
  Beyond Standard Model with the CMS Pixel Detector”
  Principal Investigator: Malik, Sudhir
  Funding Sponsor – NSF (Award number NSF PHY – 2111134)
  Period of funding - 1 August 2021 to 31 September 2024
  Amount - $375,000.00

  (2) Project Name (approved, continuing award - 1 September 2018 to 31 August 2023) – “Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP)”
  Principal Investigator: Malik, Sudhir
  Funding Sponsor – NSF (Subaward via Princeton University Award Number NSF OAC-1836650)
  Period of funding – 1 September 2021 to 31 August 2022
  Funding - $75,291.00

  (3) Project Name (approved, continuing award - 1 September 2018 to 31 August 2023) - “High
  Luminosity (HL) LHC CMS Detector Upgrade Project FPIX: Mechanics & Assembly”
  Principal Investigator: Malik, Sudhir
  Funding Sponsor – NSF (Subaward via Cornell University Award Number NSF PHY-1946735)
  Period of funding - 1 October 2021 to 31 March 2023
  Funded amount - $18,998.00

  (4) Project Name (approved, period - 1 January 2022 to 31 December 2025) - “RENEW-HEP: U.S.
  CMS SPRINT - A Scholar Program for Research INTernship”
  Principal Investigator: Malik, Sudhir
  Funding Sponsor – DOE (Award Number - DE-SC0023680)
  Period of funding - 1 August 2021 to 31 September 2024
  Amount - $57,990.00

  (5) Project Name (submitted, period - 1 September 2023 to 31 August 2028) - “S2I2: Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP)”
  Principal Investigator: Malik, Sudhir
  Funding Sponsor – NSF (Proposal Number: 2323298)
  Period of funding - 1 September 2023 to 31 August 2028
  Amount requested - $385,769.00

F. To implement efficient and expedient administrative procedures

The Department of Physics did not implement new administrative procedures during the academic year 2023-2024.

G. To strengthen research and competitive creative endeavors

a) Quantity of external funds received, by source, for research and creative work.

NATIONAL SCIENCE FOUNDATION (NSF)	
Research Project	***2022-2023:***
Student-Driven Internship Opportunities in the Atmospheric Sciences: Breaking Barriers to Diversity, Inclusion, and Equal Access - **(Dr. Héctor J. Jiménez)** Funded amount: $299,927.00 [01/01/2022 – 12/31/2023]	*$144,169.00*
NANOGrav at UPRM: Growing and characterizing the NANOGrav gravitational-wave detector – **(Dr. Henri Radovan)** Funded amount: $520,565.00 [09/01/2022 – 08/31/2025]	*$152,457.00*
Physics Beyond Standard Model with the CMS Pixel Detector **(Dr. Sudhir Malik)** Funded amount: $375,000. [1/Sep/2021-31/Aug/2024]	$154,601.00
Ultrafast dynamics of iron-based superconductors **(Dr. Sergiy Lysenko)** Funded amount: $ 498,612.80 [08/01/19 - 07/31/22]	$163,703.36

NATIONAL SCIENCE FOUNDATION (NSF) **(Collaborative Agreements with Princeton University)**	
Institute for Research and Innovation in Software for HighEnergy Physics (IRIS-HEP) - **(Dr. Sudhir Malik**) Funded amount: **$103,475** 09/01/2018 – 08/31/2023 Period of funding – September 1, 2022 through August 31, 2023 (NCE)	$23,571.00
NATIONAL SCIENCE FOUNDATION (NSF) **(Collaborative Agreements with Cornell University)**	

High Luminosity (HL) LHC CMS Detector Upgrade Project FPIX:Mechanics & Assembly"- **(Dr. Sudhir Malik)** Period of funding - 1 April 2020 to 31 March 2023 Amount funded: $47,988.	$9,231.00
Department of Defense (DoD)	
Imaging and electrical characterization of brain-inspired devices **(Dr. Armando Rúa)** 7/01/2022 – 6/30/2023	$363,961.00

b) Total number of proposals submitted and approved by department.

Proposals submitted	10
Proposals approved	2

c) Number of new research and creative work projects.

Two (2)

d) Number of ongoing research and creative work projects.

Seven (7)

e) Brief description of new and ongoing projects with significant impact.

<u>NANOGrav at UPRM: Growing and characterizing the NANOGrav gravitational-wave detector</u>

(Dr. Henri Radovan)

This proposal partners the Physics Department at the Mayagüez campus of the University of Puerto Rico (UPRM) with the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Physics Frontiers Center to advance several key NANOGrav science goals and to increase the participation and retention of minorities in the field of physics. NANOGrav's mission is to detect and characterize low frequency gravitational waves from the merger of supermassive black hole binaries using a pulsar timing array as galactic-scale detector. NANOGrav has been engaged in forefront research for the past 15 years in areas including radio astronomy, astrophysics, and cosmology and comprises currently over 200 members at more than 50 mainland universities. Undergraduate students from UPRM will be involved in research projects of relevance to NANOGrav's mission, mentored at UPRM as well as remotely and onsite at several NANOGrav institutions. The research will involve searching for new pulsars, data quality checks, pulsar simulation development, and characterizing pulsar emission properties. The students will also have the opportunity to participate in workshops at UPRM, the Arecibo Observatory, and other NANOGrav sites, as well as to attend general NANOGrav and training meetings on the mainland. Furthermore, they will have a chance to deliver

standard NANOGrav talks at local high schools, thereby gaining presentation skills and motivating high schoolers to enroll in physics programs.

Infrastructure development for research in oxide electronics and quantum materials

Armando Rúa, PhD

This is a proposal to acquire a Bruker Dimension Icon XR atomic force microscope (AFM) with capabilities for in-situ studies and mapping of electric and mechanical properties of wide range of materials at the micro and nanoscale, and in a temperature range from room temperature to 250oC. An AFM is an extremely important tool in studies of thin film materials. Information on the microstructure and defects/inhomogeneities can be gained through it. Besides the high-resolution direct view of sample morphology, which a standard AFM can provide, the electrical modes will be extremely useful since they allow correlation between morphology and electrical properties such as surface potential, via Kelvin probe force microscopy, and local conductivity via conductive atomic force microscopy, and current-voltage measurements directly on microstructures and nanostructures. Nanoscale-level studies will provide direct access to the intrinsic electrical properties as a function of temperature. This is a particular relevant as phase transitions are traversed in some of the most promising transition metal oxides and quantum materials. The AFM requested is a versatile instrument that can be applied as a nano-indenter and as a molecular force apparatus to probe the mechanical properties of the sample. The instrument is also capable of performing nanolithography and nanomanipulation, which will be very useful for prototype device fabrication. The acquisition of these this instrument is the first step toward establishing a Laboratory for Quantum Matter under Extreme Conditions at the University of Puerto Rico at Mayagüez. Clearly, the new AFM capabilities will promote the development of significant new research in the Department of Physics at University of Puerto Rico-Mayaguez, the higher learning institution serving the largest number of Hispanic STEM students in the United States.

Student-Driven Internship Opportunities in the Atmospheric Sciences: Breaking Barriers to Diversity, Inclusion, and Equal Access

Héctor J. Jiménez, PhD

This proposal addresses the need for increasing the levels of representation and retention of racial and ethnic minorities in the Atmospheric Sciences. In particular, it focuses on underrepresented minority students at Hispanic Serving Institutions. We are proposing a novel approach to increasing the appeal of Atmospheric Science and Meteorology programs, the retention of students, and the probability of success after graduation, through the implementation of an internship program driven by student needs and input. The outcome of the activities that comprise this model would be a much better understanding and fine tuning of an approach that has the potential to complement and perhaps replace some of the existing ways of providing students with enriching and motivating internship opportunities. We expect that the internships themselves will constitute an important recruitment tool to attract and retain larger numbers of underrepresented minorities into the Geosciences.

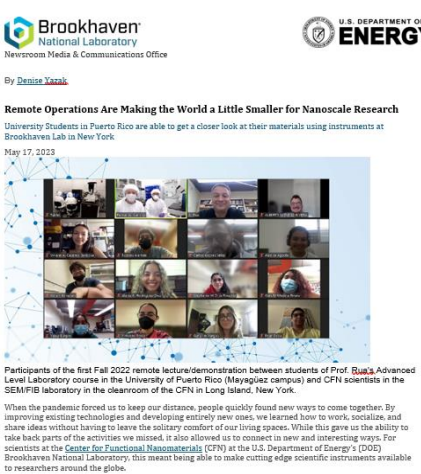
Ultrafast dynamics of iron-based superconductors
Sergiy Lysenko, PhD

This research program focuses on understanding of fundamental processes of superconductivity (SC) and nonequilibrium dynamics of iron-based quantum materials (i.e. pnictides, oxypnictide and iron chalcogenides) at the fundamental timescales, and intends to elucidate the evolution of nonequilibrium phases upon photoexcitation. A variety of powerful femtosecond laser spectroscopy techniques, including state-of-the-art pump-probe ultrafast angle-resolved light scattering with light polarization control, will be applied to study matter far from equilibrium with superior sensitivity and resolution in both space and time to create and characterize novel quantum phases, quasiparticle relaxation and the electron–boson interactions. Methods of ultrafast optics will help to visualize multidimensional dynamics of quantum materials on the timescale of lattice vibrations and yield new insights on the role of electronic correlations in nonequilibrium dynamics of highly entangled states of iron-based materials in their SC state versus material morphology, size and statistical distribution of domains on the mesoscale. Reliable protocols will be developed for the fabrication of novel ironbased SC epitaxial films with relatively high critical temperatures, above ~20 K. The film morphology and size effects in unconventional SC of iron-based materials are of particular interest. Close collaboration between experienced material growth scientists and laser spectroscopists will facilitate rapid progress.

Physics Beyond Standard Model with the CMS Pixel Detector
Sudhir Malik, PhD

This proposal requests continuation of support for the 3-year period from 9/1/2021 to 8/31/2024 for the ongoing research program in experimental High Energy Physics (HEP) at the University of Puerto Rico Mayaguez (UPRM). The program is centered on the CMS experiment currently running at the proton Large Hadron Collider (LHC), at CERN in Geneva, Switzerland, and it draws on the expertise of the PI gained from the strong and continuous contribution to the CMS experiment. The PI joined University of Puerto Rico Mayaguez (UPRM) as a tenure-track Associate Professor of Physics in July 2014 to establish and secure funding for a High Energy Physics research program. NSF awarded funding for this program in the past from 6/1/2015 to 5/31/2018 and 9/1/2018 to 8/31/2021. UPRM is the only institute pursuing research in High Energy Physics in Puerto Rico and the Caribbean.

f) Impact outcomes of research and creative work projects (e.g., patents, discoveries).



Brookhaven National Laboratory
Newsroom Media & Communications Office

U.S. DEPARTMENT OF ENERGY

By Denise Yazak

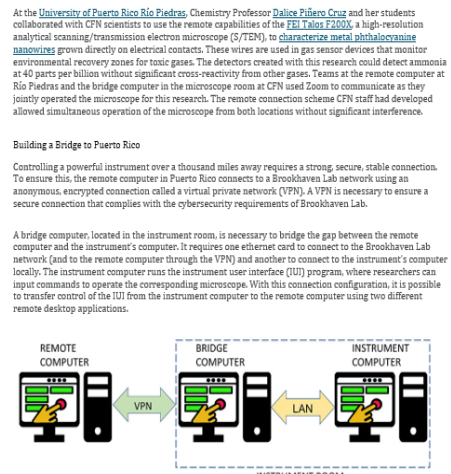
Remote Operations Are Making the World a Little Smaller for Nanoscale Research

University Students in Puerto Rico are able to get a closer look at their materials using instruments at Brookhaven Lab in New York

May 17, 2023

Participants of the first Fall 2022 remote lecture/demonstration between students of Prof. Ruiz's Advanced Level Laboratory course in the University of Puerto Rico (Mayagüez campus) and CFN scientists in the SEM/FIB laboratory in the cleanroom of the CFN in Long Island, New York.

When the pandemic forced us to keep our distance, people quickly found new ways to come together. By improving existing technologies and developing entirely new ones, we learned how to work, socialize, and share ideas without having to leave the solitary comfort of our living spaces. While this gave us the ability to take back parts of the activities we missed, it also allowed us to connect in new and interesting ways. For scientists at the Center for Functional Nanomaterials (CFN) at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory, this meant being able to make cutting edge scientific instruments available to researchers around the globe.



At the University of Puerto Rico Río Piedras, Chemistry Professor Dalice Piñero Cruz and her students collaborated with CFN scientists to use the remote capabilities of the FEI Talos F200X, a high-resolution analytical scanning/transmission electron microscope (S/TEM), to characterize metal phthalocyanine nanowires grown directly on electrical contacts. These wires are used in gas sensor devices that monitor environmental recovery zones for toxic gases. The detectors created with this research could detect ammonia at 40 parts per billion without significant cross-reactivity from other gases. Teams at the remote computer at Río Piedras and the bridge computer in the microscope room at CFN used Zoom to communicate as they jointly operated the microscope for this research. The remote connection scheme CFN staff had developed allowed simultaneous operation of the microscope from both locations without significant interference.

Building a Bridge to Puerto Rico

Controlling a powerful instrument over a thousand miles away requires a strong, secure, stable connection. To ensure this, the remote computer in Puerto Rico connects to a Brookhaven Lab network using an anonymous, encrypted connection called a virtual private network (VPN). A VPN is necessary to ensure a secure connection that complies with the cybersecurity requirements of Brookhaven Lab.

A bridge computer, located in the instrument room, is necessary to bridge the gap between the remote computer and the instrument's computer. It requires one ethernet card to connect to the Brookhaven Lab network (and to the remote computer through the VPN) and another to connect to the instrument's computer locally. The instrument computer runs the instrument user interface (IUI) program, where researchers can input commands to operate the corresponding microscope. With this connection configuration, it is possible to transfer control of the IUI from the instrument computer to the remote computer using two different remote desktop applications.

A LOUD BACKGROUND CHORUS —

NANOGrav hears "hum" of gravitational wave background, louder than expected

Exotic stars called millisecond pulsars serve as celestial metronomes.

JENNIFER OUELLETTE - 6/28/2023, 8:00 PM

Enlarge / In this artist's interpretation, a pair of supermassive black holes (top left) emits gravitational waves that ripple through the fabric of space-time. Those gravitational waves compress and stretch the paths of radio waves emitted by pulsars (white).

Aurore Simonnet for the NANOGrav Collaboration

WITH

Gravitational waves are ripples in the fabric of spacetime predicted by Albert Einstein's general theory of relativity, first detected in 2015. But an expected corresponding low-frequency gravitational wave background—a kind of "hum" comprised of a chorus of gravitational waves, most likely emanating from binary pairs of supermassive black holes—has proven more elusive. Now the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) has announced the first evidence of this gravitational wave background. The results and related analyses are described in several new papers published in the The Astrophysical Journal Letters.

Dr. Henri Radovan, UPRM Physics professor and member of North American Nanohertz Observatory for Gravitational Waves (NANOGrave) has announced the first evidence of gravitational wave background.

https://arstechnica.com/science/2023/06/nanograv-picks-up-signal-of-cosmic-choir-of-supermassive-black-holes/

g) Initiatives to involve students in research and creative work projects. <u>Two</u>

1. Student-Driven Internship Opportunities in the Atmospheric Sciences: Breaking Barriers to Diversity, Inclusion, and Equal Access – **Dr. Héctor Jiménez**

2. NANOGrav at UPRM: Growing and characterizing the NANOGrav gravitational-wave detector – **Henri Radovan, PhD**

h) Number of research collaboration agreements and brief description (purpose, validity period, and agency name). **FOUR (4)**

- **"Laboratorio de Comunicación Científica" between NotiCentro -WAPA TV and Meteorology Program" Since August 2021.**

  This collaboration allows that our Meteorology and Atmospheric Sciences students can have the experience of being TV communicators and can help to strengthen the UPRM Meteorology program.

- "High Luminosity (HL) LHC CMS Detector Upgrade Project FPIX: Mechanics & Assembly" (approved, continuing award - 1 September 2018 to 31 August 2023) - Principal Investigator: **Sudhir Malik**
  Funding Sponsor – NSF (Subaward via Cornell University Award Number: NSF PHY-1946735)
  Period of funding - 1 October 2021 to 31 March 2023
  Funded amount - $18,998.00

- **NANOGrav** collaboration between Physics Department with the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Physics Frontiers Center.

  This partnership looks to advance several key NANOGrav science goals and to increase the participation and retention of minorities in the field of physics. Undergraduate students from UPRM will be involved in research projects of relevance to NANOGrav's mission, mentored at UPRM as well as remotely and onsite at several NANOGrav institutions.

- Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP) - **(Dr. Sudhir Malik**)
  Collaborative Agreements with Princeton University
  09/01/2018 – 08/31/2023

i) Most relevant publications and presentations.

SCIENTIFIC PUBLICATIONS:

As an active member of the **NANOGrav** collaboration, **Dr. Henri Radovan** has published the following articles in the field of astronomy:

- The NANOGrav 15-year Data Set: Observations and Timing of 68 Millisecond Pulsars
  G. Agazie et al., submitted to Astrophysical Journal Letters (May 2023)

- The NANOGrav 15-Year Data Set: Detector Characterization and Noise Budget
  G. Agazie et al., submitted to Astrophysical Journal Letters (May 2023)

- The NANOGrav 15-year Data Set: The Stochastic Gravitational-Wave Background
  G. Agazie et al., submitted to Astrophysical Journal Letters (May 2023)

- The NANOGrav 15-year Data Set: Search for Signals from New Physics
  A. Afzal et al., submitted to Astrophysical Journal Letters (May 2023)

- **Dr. Mark Jury** has published and has under review the following scientific articles in the field of **Meteorology**:

  - Caribbean mid-summer climate, driven from the southern edge, Earth Int. (in review)

  - A statistical analysis of tropical salinity and its relationship to SST, highlighting two contrasting areas, Dynam. Atmos. Oceans, (in review)

  - Meteorology of 'ridging high' rainfall over the KwaZulu-Natal coastal plains, Intl J. Climatol. (in review)

  - Winter climate of the Dominican Republic and implications for cacao & coffee production, Climate MDPI, (in review)

  - Modulation of the marine environment in the Natal Bight, MDPI Remote Sensing, 15, 1434, doi.org/10.3390/rs15051434

  - Atmosphere-ocean processes governing inflow to the northern Caribbean Sea, J. Marine Science Eng., 11, 718, doi.org/10.3390/jmse11040718.

  - Spring-time SW cloud bands in the central Caribbean, J. Appl. Meteo. Climatol., 62, 251-262, doi.org/10.1175/JAMC-D-22-0126.1

  - with Minda, T.T., Turkana low-level jet influence on southwest Ethiopia climate, J. Hydro-Meteo., 24, 585-599, doi.org/10.1175/JHM-D-22-0134.1

  - Historical and projected climatic trends in KwaZulu-Natal: 1950-2100, WaterSA, 48: doi.org/10.17159/wsa/2022.v48.i4.3991

  - Inter-comparison of past and projected climate change in Puerto Rico: 1950-2100, J. Water & Climate Change, 13: 2713–2724, doi.org/10.2166/wcc.2022.071

  - with Buthelezi, Air pollution dispersion over Durban South Africa, Atmosphere MDPI, doi.org/10.3390/atmos13050811.

- with Kerr, J. Seasonal climate effects on influenza-pneumonia mortality and public health, Climate Weather & Society, 14, doi.org/10.1175/WCAS-D-21-0073.1

- with Matyas, C., Tropical cyclones in the northern Mozambique Channel: Composite intra-seasonal forcing and 2019 event, Meteo. Atmos. Physics, 134, doi.org/10.1007/s00703-022-00911-8

- Representing the Indian Ocean Dipole, Physical Oceanography, 29, 417-432. doi.org/10.22449/1573-160X-2022-4-417-432.

- The climate of Madagascar, Chapter 3, in The new natural history of Madagascar, Princeton Univ Press, ISBN: 9780691222622,

- **Dr. Armando Rúa** has published on **Advanced Materials** Journal:

    - Sujan Kumar Das, Sanjoy Kumar Nandi, Camilo Verbel Marquez, **Armando Rúa**, Mutsunori Uenuma, Etienne Puyoo, Shimul Kanti Nath, David Albertini, Nicolas Baboux, Teng Lu, Yun Liu, Tobias Haeger, Ralf Heiderhoff, Thomas Riedl, Thomas Ratcliff, Robert Glen Elliman, Physical Origin of Negative Differential Resistance in V3O5 and Its Application as a Solid-State Oscillator, Advanced Materials, 35, 2208477 (2023).

- The following scientific paper on **Material Science** has been co-authored by **Dr. Sergiy Lysenko**, **Dr. Armando Rúa** and their respective groups:

    - Bartenev, R Kolodka, C Verbel, M Lozano, F Fernandez, A Rua, Sergiy Lysenko **"Nonequilibrium carrier dynamics in FeSe0.8Te0.2**," MRS Advances (2023) doi:10.1557/s43580-023-00514-4

    - R Kolodka, A. Bartenev, Ki-Tae Eom, Jong-Hoon Kang, Eric E. Hellstrom, Chang-Beom Eom, Armando Rua, Sergiy Lysenko, **"Photoinduced excited-state dynamics in Co-doped BaFe2As2 superconducting films"**, MRS Advances (2023) doi:10.1557/s43580-023-00513-5

In addition, the following talks were given at the following conferences by the Materials Science Group:

- Talks given by **Dr. Armando Rúa's** group:

    - Sujan Kumar Das, David Albertini, Nicolas Baboux, Robert G Elliman, Yun Liu, Teng Lu, Camilo Verbel, Sanjoy Kumar Nandi, Shimul Kanti Nath, Etienne Puyoo, Thomas Ratcliff, Armando Rúa, Mutsunori Uenuma, Joint Congress of 24th Australian Institute of Physics Congress, Australian and New Zealand Conferences on Optics and Photonics, 7th International

Workshop on Speciality Optical Fibers and Conference on Optoelectronic and Microelectronic Materials and Devices, V3O5: a promising material for solid-state neurons, 11-16 December 2022, Adelaide (Australia)

- Amanda Román Ashby, Camilo Verbel, Manuel Lozano, and Armando Rúa de la Asunción. 2023 Emerging Researchers National (ERN) Conference in STEM. Electrical switching and Radio-frequency characterization of a novel phase change material, February 9-11 (2023). Washington, D.C.

- Talks and Posters Presentations by **Dr. Sergiy Lysenko** and **Dr. Armando Rúa** groups:

  - Roman Kolodka, Alexander Bartenev, Camilo Verbel, Manuel Lozano, Felix Fernández, Armando Rua, Sergiy Lysenko, 23rd International Young Scientist Conference and High Technology Material Science SPO 2022 ONLINE "STAND WITH UKRAINE", Transient nematicity of FeSe0.8Te0.2 superconductor, 24-26 November 2022, Kyiv (Ukraine).

  - Adrián A. Rúa Meléndez, Alexander Bartenev, Roman Kolodka, Camilo Verbel, Armando Rúa de la Asunción, Sergiy Lysenko. 2023 Emerging Researchers National (ERN) Conference in STEM. Pulsed laser deposition and ultrafast dynamics of FeSe0.8Te0.2 thin films, February 9-11 (2023). Washington, D.C.

  - Adrián A. Rúa Meléndez, Alexander Bartenev, Roman Kolodka, Camilo Verbel, Armando Rúa de la Asunción, Sergiy Lysenko. Pulsed laser deposition and ultrafast dynamics of FeSe0.8Te0.2 thin films, 41st Puerto Rico Interdisciplinary Scientific Meeting (PRISM) & 56th ACS Junior Technical Meeting (JTM), UPR Bayamón, Puerto Rico, April 29 (2023).

  - ”Roman Kolodka, Alexander Bartenev, Ki-Tae Eom, Jong-Hoon Kang, Eric E. Hellstrom, Chang-Beom Eom, Armando Rua and Sergiy Lysenko,“Photoinduced Excited-State Dynamics in Co-Doped BaFe2As2 Superconducting Films,” EQ02.09.01, SESSION EQ02.08: Emergent Materials and Alternative Designs, November 29, 2022, “2022 MRS Fall Meeting & Exhibit” November 27 - December 2, Boston, Massachusetts, Hynes Convention Center.

  - Roman Kolodka, Alexander Bartenev, Camilo Verbel, Manuel Lozano, Felix Fernandez, Armando Rua and Sergiy Lysenko; “Nonequilibrium Carrier Dynamics in FeSe0.8Te0.2” EQ02.11.03, SESSION EQ02.11: Microstructure, Composition and Nonequilibrium Carrier Dynamics,

November 30, 2022, “2022 MRS Fall Meeting & Exhibit” November 27 - December 2, Boston, Massachusetts, Hynes Convention Center.

- On the subject of **Consensed Matter**, **Dr. Francisco Bezares** has given the following talks and Poster presentations:

  • Plasmonics: Harnessing the Power of Light for Large-area, Ultra-high Sensitivity and Selectivity Sensors, 10/29/22, UPR-Rio Piedras

  • Magnetron Sputtering Physical Vapor Deposition Photonic Sensors for Trace Analyte Detection, 11/11/22, UPR-Cayey

  • Plasmonic Renaissance: Beyond Sensing Applications, 02/24/23, UPR-Cayey

  • Nanophotonics Research Program Pitch, 03/24/23, US Army Corps of Engineers Visit to UPR-Mayagüez

  • Nanophotonics Research Pitch, 03/26/23, US Department of Energy Visit to UPR-Mayagüez

  • Physical Vapor Deposition of Metal Alloys Nanoparticles for Renewable Energy Applications, 05/17/23, Simposio de Investigación UPRM 2023, UPR-Mayagüez

- **Prof. Silvana Urcia** gave a presentation at the Universidad de Nacional Jorge Basadle Grodhmann in Tacna, Perú on 16 November 2022 entitled "Metal Organic Frameworks for CO2 removal in Confined Spaces".

- On the subject of Experimental Neutrino Physics, **Dr. Héctor Méndez** and **professors Daniel Gutiérrez and Cesar Pollack** as members of the international **DUNE** (Deep Underground Neutrino Experiment) collaborations has published in 2023:

  - “Impact of cross-section uncertainties on supernova neutrino spectral parameter fitting in the Deep Underground Neutrino Experiment”
    Adam Abed Abud et al. (DUNE Collaboration, Mar 29, 2023)
    e-Print: 2303.17007 [hep-ex]

- **Dr. Héctor Méndez** as **DUNE** collaborator has published in 2022:

  - “Highly-parallelized simulation of a pixelated LArTPC on a GPU”
    Adam Abed Abud et al. (DUNE Collaboration, Dec 19, 2022)
    Published in: JINST 18 (2023) 04, P04034 - e-Print: 2212.09807

  - “Identification and reconstruction of low-energy electrons in the ProtoDUNE-SP detector”

A. Abed Abud et al. (DUNE Collaboration, Nov 2, 2022)
e-Print: 2211.01166 [hep-ex]

- "DUNE Offline Computing Conceptual Design Report"
  Adam Abed Abud et al. (DUNE Collaboration, Oct 28, 2022)
  e-Print: 2210.15665

- "Reconstruction of interactions in the ProtoDUNE-SP detector with Pandora"
  Adam Abed Abud et al. (DUNE Collaboration, Jun 29, 2022)
  e-Print: 2206.14521 [hep-ex]

- "Separation of track- and shower-like energy deposits in ProtoDUNE-SP using a convolutional neural network"
  Adam Abed Abud et al. (DUNE Collaboration)
  Published in: Eur.Phys.J.C 82 (2022) 10, 903 - e-Print: 2203.17053

- "Scintillation light detection in the 6-m drift-length ProtoDUNE Dual Phase liquid argon TPC"
  Adam Abed Abud et al. (DUNE Collaboration)
  Published in: Eur.Phys.J.C 82 (2022) 7, 618 - e-Print: 2203.16134

- "Snowmass Neutrino Frontier: DUNE Physics Summary"
  A. Abed Abud et al. (DUNE Collaboration)
  Contribution to: Snowmass 2021 - e-Print: 2203.06100 [hep-ex]

- "A Gaseous Argon-Based Near Detector to Enhance the Physics Capabilities of DUNE"
  A. Abed Abud et al. (DUNE Collaboration)
  Contribution to: Snowmass 2021 - e-Print: 2203.06281 [hep-ex]

- "Low exposure long-baseline neutrino oscillation sensitivity of the DUNE experiment"
  A. Abud Abed et al. (DUNE Collaboration)
  Published in: Phys.Rev.D 105 (2022) 7, 072006 - e-Print: 2109.01304 [hep-ex]

- "Design, construction and operation of the ProtoDUNE-SP Liquid Argon TPC"
  A. Abed Abud et al. (DUNE Collaboration)
  Published in: JINST 17 (2022) 01, P01005 • e-Print: 2108.01902

- **Dr. Sudhir Malik** as a member of the **CMS** (Compact Muon Solenoid) at the **LHC** at **CERN** has published the following articles:

- Search for resonances in events with photon and jet final states in proton-proton collisions at $sqrt{s}$= 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2305.07998 [hep-ex]

- Search for top squark pair production in a final state with at least one hadronically decaying tau lepton in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2304.07174 [hep-ex]

- First measurement of the top quark pair production cross section in proton-proton collisions at $\sqrt{s}$ = 13.6 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2303.10680 [hep-ex]

- Community Engagement Frontier
  Kétévi A. Assamagan (Brookhaven), Breese Quinn (Mississippi U.), Kenneth Bloom (Nebraska U.), Véronique Boisvert (Royal Holloway, U. of London), Carla Bonifazi (Rio de Janeiro Federal U.) et al.
  e-Print: 2211.13210 [physics.soc-ph]
  Published in:

- Summary Report of the Topical Group on Career Pipeline and Development (CommF2) Community Engagement Frontier Snowmass 2021
  Julie Hogan, Aneliya Karadzhinova-Ferrer, Sudhir Malik
  e-Print: 2209.10114 [physics.ed-ph]
  Published in:

- Summary Report of the Topical Group on Physics Education, Community Engagement Frontier (CEF4/CommF4) Snowmass 2021
  Sibrand J. de Jong, Sudhir Malik, Randal Ruchti
  e-Print: 2209.08225 [physics.ed-ph]

- U.S. CMS - PURSUE (Program for Undergraduate Research SUmmer Experience)
  Tulika Bose, Sudhir Malik, Meenakshi Narain
  e-Print: 2209.10109 [physics.ed-ph]

- Search for new physics in the lepton plus missing transverse momentum final state in proton-proton collisions at $\sqrt{s} =$ 13 TeV

CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
e-Print: 2202.06075 [hep-ex]
DOI: 10.1007/JHEP07(2022)067 (publication)
Published in: JHEP 07 (2022), 067

- A portrait of the Higgs boson by the CMS experiment ten years after the discovery
  CMS Collaboration • Armen Tumasyan (Tbilisi, Inst. Phys.) et al.
  e-Print: 2207.00043 [hep-ex]
  DOI: 10.1038/s41586-022-04892-x
  Published in: Nature 607 (2022) 7917, 60-68

- Beam test performance of a prototype module with Short Strip ASICs for the CMS HL-LHC tracker upgrade
  Tracker Group of the CMS Collaboration • W. Adam (Vienna, OAW) et al.
  DOI: 10.1088/1748-0221/17/06/P06039
  Published in: JINST 17 (2022) 06, P06039

- Test beam performance of a CBC3-based mini-module for the Phase-2 CMS Outer Tracker before and after neutron irradiation
  Tracker Group of the CMS Collaboration • W. Adam (Vienna, OAW) et al.
  e-Print: 2205.00961 [physics.ins-det]
  DOI: 10.1088/1748-0221/18/04/P04001
  Published in: JINST 18 (2023) 04, P04001

- Strange hadron collectivity in pPb and PbPb collisions
  CMS Collaboration • A. Tumasyan (Yerevan State U. and Yerevan Phys. Inst.) et al.
  e-Print: 2205.00080 [nucl-ex]
  DOI: 10.1007/JHEP05(2023)007
  Published in: JHEP 05 (2023), 007

- Software Training in High Energy Physics
  Michel H. Villanueva (DESY), Sudhir Malik (Puerto Rico U., Mayaguez), Meirin Oan Evans (Sussex U.)
  e-Print: 2203.04775 [physics.ed-ph]
  DOI: 10.1088/1742-6596/2438/1/012063
  Published in: J.Phys.Conf.Ser. 2438 (2023) 1, 012063,

- Search for new particles in an extended Higgs sector with four b quarks in the final state at s=13TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2203.00480 [hep-ex]
  DOI: 10.1016/j.physletb.2022.137566 (publication)
  Published in: Phys.Lett.B 835 (2022), 137566

- Search for a W′ boson decaying to a vector-like quark and a top or bottom quark in the all-jets final state at $ \sqrt{\mathrm{s}} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.12988 [hep-ex]

DOI: 10.1007/JHEP09(2022)088
Published in: JHEP 09 (2022), 088

- Measurement of the Drell-Yan forward-backward asymmetry at high dilepton masses in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.12327 [hep-ex]
  DOI: 10.1007/JHEP08(2022)063
  Published in: JHEP 2022 (2022) 08, 063

- Nuclear modification of Υ states in pPb collisions at $\sqrt{s_\mathrm{NN}}$ = 5.02 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.11807 [hep-ex]
  DOI: 10.1016/j.physletb.2022.137397 (publication)
  Published in: Phys.Lett.B 835 (2022), 137397

- Search for Higgs Boson Pair Production in the Four b Quark Final State in Proton-Proton Collisions at s=13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.09617 [hep-ex]
  DOI: 10.1103/PhysRevLett.129.081802 (publication)
  Published in: Phys.Rev.Lett. 129 (2022) 8, 081802

- Inclusive nonresonant multilepton probes of new phenomena at $\sqrt s$=13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.08676 [hep-ex]
  DOI: 10.1103/PhysRevD.105.112007 (publication)
  Published in: Phys.Rev.D 105 (2022) 11, 112007

- Measurement of the Higgs boson width and evidence of its off-shell contributions to ZZ production
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2202.06923 [hep-ex]
  DOI: 10.1038/s41567-022-01682-0
  Published in: Nature Phys. 18 (2022) 11, 1329-1334

- Search for invisible decays of the Higgs boson produced via vector boson fusion in proton-proton collisions at s=13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.11585 [hep-ex]
  DOI: 10.1103/PhysRevD.105.092007 (publication)
  Published in: Phys.Rev.D 105 (2022) 9, 092007

- Observation of B^0$\to$$\psi$(2S)K$^0_\mathrm{S}\pi^+\pi^-$ and B$^0_\mathrm{S}$$\to$$\psi$(2S)K$^0_\mathrm{S}$ decays
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.09131 [hep-ex]
  DOI: 10.1140/epjc/s10052-022-10315-y (publication)
  Published in: Eur.Phys.J.C 82 (2022), 499

- Search for resonances decaying to three W bosons in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.08476 [hep-ex]
  DOI: 10.1103/PhysRevLett.129.021802 (publication)
  Published in: Phys.Rev.Lett. 129 (2022) 2, 021802

- Identification of hadronic tau lepton decays using a deep neural network
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.08458 [hep-ex]
  DOI: 10.1088/1748-0221/17/07/P07023 (publication)
  Published in: JINST 17 (2022), P07023

- Search for charged-lepton flavor violation in top quark production and decay in pp collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.07859 [hep-ex]
  DOI: 10.1007/JHEP06(2022)082
  Published in: JHEP 06 (2022), 082

- Precision measurement of the W boson decay branching fractions in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.07861 [hep-ex]
  DOI: 10.1103/PhysRevD.105.072008 (publication)
  Published in: Phys.Rev.D 105 (2022) 7, 072008

- Measurement of the inclusive and differential $\mathrm{t\bar{t}}\gamma$ cross sections in the dilepton channel and effective field theory interpretation in proton-proton collisions at $\sqrt{s}$ =13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.07301 [hep-ex]
  DOI: 10.1007/JHEP05(2022)091
  Published in: JHEP 05 (2022), 091, JHEP 05 (2022), 091

- Search for long-lived heavy neutral leptons with displaced vertices in proton-proton collisions at $ \sqrt{\mathrm{s}} $ =13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.

e-Print: 2201.05578 [hep-ex]
DOI: 10.1007/JHEP07(2022)081
Published in: JHEP 07 (2022), 081

- Search for higgsinos decaying to two Higgs bosons and missing transverse momentum in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.04206 [hep-ex]
  DOI: 10.1007/JHEP05(2022)014
  Published in: JHEP 05 (2022), 014

- Observation of the B_c^+ Meson in Pb-Pb and pp Collisions at $\sqrt{s_{NN}}$=5.02 TeV and Measurement of its Nuclear Modification Factor
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.02659 [hep-ex]
  DOI: 10.1103/PhysRevLett.128.252301 (publication)
  Published in: Phys.Rev.Lett. 128 (2022) 25, 252301

- Search for high-mass resonances decaying to a jet and a Lorentz-boosted resonance in proton-proton collisions at s=13TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.02140 [hep-ex]
  DOI: 10.1016/j.physletb.2022.137263 (publication)
  Published in: Phys.Lett.B 832 (2022), 137263, Phys.Lett.B 832 (2022), 137263

- Search for single production of a vector-like T quark decaying to a top quark and a Z boson in the final state with jets and missing transverse momentum at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2201.02227 [hep-ex]
  DOI: 10.1007/JHEP05(2022)093
  Published in: JHEP 05 (2022), 093

- CMS Phase-2 Inner Tracker Upgrade
  CMS Tracker Collaboration • Sudhir Malik (Puerto Rico U., Mayaguez) for the collaboration.
  DOI: 10.1088/1742-6596/2374/1/012053
  Published in: J.Phys.Conf.Ser. 2374 (2022) 1, 012053

- Search for long-lived particles decaying into muon pairs in proton-proton collisions at $ \sqrt{s} $ = 13 TeV collected with a dedicated high-rate data stream
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.13769 [hep-ex]

DOI: 10.1007/JHEP04(2022)062
Published in: JHEP 04 (2022), 062

- Search for resonances decaying to three W bosons in the hadronic final state in proton-proton collisions at $\sqrt s$ =13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.13090 [hep-ex]
  DOI: 10.1103/PhysRevD.106.012002 (publication)
  Published in: Phys.Rev.D 106 (2022) 1, 012002

- Probing Charm Quark Dynamics via Multiparticle Correlations in Pb-Pb Collisions at $\sqrt{s_\mathrm{NN}}$ =5.02 TeV
  CMS and (CMS Collaboration)* Collaborations • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.12236 [hep-ex]
  DOI: 10.1103/PhysRevLett.129.022001 (publication)
  Published in: Phys.Rev.Lett. 129 (2022) 2, 022001

- Search for resonant production of strongly coupled dark matter in proton-proton collisions at 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.11125 [hep-ex]
  DOI: 10.1007/JHEP06(2022)156
  Published in: JHEP 06 (2022), 156

- Measurement of the production cross section for Z+b jets in proton-proton collisions at $\sqrt s$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.09659 [hep-ex]
  DOI: 10.1103/PhysRevD.105.092014 (publication)
  Published in: Phys.Rev.D 105 (2022) 9, 092014

- Search for flavor-changing neutral current interactions of the top quark and the Higgs boson decaying to a bottom quark-antiquark pair at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.09734 [hep-ex]
  DOI: 10.1007/JHEP02(2022)169
  Published in: JHEP 02 (2022), 169

- Measurement of the inclusive $ \mathrm{t}\overline{\mathrm{t}} $ production cross section in proton-proton collisions at $ \sqrt{s} $ = 5.02 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.09114 [hep-ex]
  DOI: 10.1007/JHEP04(2022)144

Published in: JHEP 04 (2022), 144

- Evidence for WW/WZ vector boson scattering in the decay channel ℓνqq produced in association with two jets in proton-proton collisions at s=13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.05259 [hep-ex]
  DOI: 10.1016/j.physletb.2022.137438 (publication)
  Published in: Phys.Lett.B 834 (2022), 137438

- Search for a right-handed W boson and a heavy neutrino in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.03949 [hep-ex]
  DOI: 10.1007/JHEP04(2022)047
  Published in: JHEP 04 (2022), 047

- Search for heavy resonances decaying to a pair of Lorentz-boosted Higgs bosons in final states with leptons and a bottom quark pair at $ \sqrt{s} $= 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.03161 [hep-ex]
  DOI: 10.1007/JHEP05(2022)005
  Published in: JHEP 05 (2022), 005

- Measurements of the associated production of a W boson and a charm quark in proton–proton collisions at $\sqrt{s}=8\,\text {TeV} $
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2112.00895 [hep-ex]
  DOI: 10.1140/epjc/s10052-022-10897-7
  Published in: Eur.Phys.J.C 82 (2022) 12, 1094

- Measurement of W$^\pm\gamma$ differential cross sections in proton-proton collisions at $\sqrt{s}$ = 13 TeV and effective field theory constraints
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.13948 [hep-ex]
  DOI: 10.1103/PhysRevD.105.052003 (publication)
  Published in: Phys.Rev.D 105 (2022) 5, 052003

- Search for heavy resonances decaying to ZZ or ZW and axion-like particles mediating nonresonant ZZ or ZH production at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.13669 [hep-ex]
  DOI: 10.1007/JHEP04(2022)087

Published in: JHEP 04 (2022), 087

- Search for a heavy resonance decaying into a top quark and a W boson in the lepton+jets final state at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • A. Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.10216 [hep-ex]
  DOI: 10.1007/JHEP04(2022)048
  Published in: JHEP 04 (2022), 048

- Measurement and QCD analysis of double-differential inclusive jet cross sections in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.10431 [hep-ex]
  DOI:10.1007/JHEP02(2022)142,10.1007/JHEP12(2022)035 (publication)
  Published in: JHEP 02 (2022), 142, JHEP 12 (2022), 035 (addendum)

- Strategies and performance of the CMS silicon tracker alignment during LHC Run 2
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.08757 [physics.ins-det]
  DOI: 10.1016/j.nima.2022.166795 (publication)
  Published in: Nucl.Instrum.Meth.A 1037 (2022), 166795

- Search for supersymmetry in final states with two or three soft leptons and missing transverse momentum in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.06296 [hep-ex]
  DOI: 10.1007/JHEP04(2022)091
  Published in: JHEP 04 (2022), 091

- Observation of triple J/ψ meson production in proton-proton collisions
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.05370 [hep-ex]
  DOI: 10.1038/s41567-022-01838-y , 10.1038/s41567-023-01992-x (erratum)
  Published in: Nature Phys. 19 (2023) 3, 338-350, Nature Phys. 19 (2023) 3, 461 (erratum)

- Study of dijet events with large rapidity separation in proton-proton collisions at $ \sqrt{s} $ = 2.76 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.04605 [hep-ex]
  DOI: 10.1007/JHEP03(2022)189
  Published in: JHEP 03 (2022), 189

- Inclusive and differential cross section measurements of single top quark production in association with a Z boson in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.02860 [hep-ex]
  DOI: 10.1007/JHEP02(2022)107
  Published in: JHEP 02 (2022), 107

- A new calibration method for charm jet identification validated with proton-proton collision events at $\sqrt{s}$ =13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.03027 [hep-ex]
  DOI: 10.1088/1748-0221/17/03/P03014
  Published in: JINST 17 (2022) 03, P03014

- Search for Flavor-Changing Neutral Current Interactions of the Top Quark and Higgs Boson in Final States with Two Photons in Proton-Proton Collisions at $\sqrt{s}=13\text{ }\text{ }\mathrm{TeV}$
  CMS Collaboration • A. Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.02219 [hep-ex]
  DOI: 10.1103/PhysRevLett.129.032001 (publication)
  Published in: Phys.Rev.Lett. 129 (2022) 3, 032001

- Search for low-mass dilepton resonances in Higgs boson decays to four-lepton final states in proton–proton collisions at $\sqrt{s}=13\,\text {TeV} $
  CMS Collaboration • A. Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2111.01299 [hep-ex]
  DOI: 10.1140/epjc/s10052-022-10127-0
  Published in: Eur.Phys.J.C 82 (2022) 4, 290

- Search for long-lived particles produced in association with a Z boson in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2110.13218 [hep-ex]
  DOI: 10.1007/JHEP03(2022)160
  Published in: JHEP 03 (2022), 160, JHEP 03 (2022), 160

- Measurement of the inclusive and differential WZ production cross sections, polarization angles, and triple gauge couplings in pp collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2110.11231 [hep-ex]
  DOI: 10.1007/JHEP07(2022)032
  Published in: JHEP 07 (2022), 032

- First Search for Exclusive Diphoton Production at High Mass with Tagged Protons in Proton-Proton Collisions at $\sqrt s$ = 13 TeV
  (TOTEM Collaboration)‡ and (CMS Collaboration)† and TOTEM and CMS Collaborations • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2110.05916 [hep-ex]
  DOI: 10.1103/PhysRevLett.129.011801 (publication)
  Published in: Phys.Rev.Lett. 129 (2022) 1, 011801

- Analysis of the CP structure of the Yukawa coupling between the Higgs boson and τ leptons in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2110.04836 [hep-ex]
  DOI: 10.1007/JHEP06(2022)012
  Published in: JHEP 06 (2022), 012

- Search for long-lived particles decaying to leptons with large impact parameter in proton–proton collisions at $\sqrt{s} = 13\,\text {Te}\text {V} $
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2110.04809 [hep-ex]
  DOI: 10.1140/epjc/s10052-022-10027-3
  Published in: Eur.Phys.J.C 82 (2022) 2, 153

- Measurement of double-parton scattering in inclusive production of four jets with low transverse momentum in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2109.13822 [hep-ex]
  DOI: 10.1007/JHEP01(2022)177
  Published in: JHEP 01 (2022), 177

- Search for heavy resonances decaying to Z($\nu\bar{\nu}$)V(q$\bar{q}$') in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2109.08268 [hep-ex]
  DOI: 10.1103/PhysRevD.106.012004 (publication)
  Published in: Phys.Rev.D 106 (2022) 1, 012004

- Search for heavy resonances decaying to WW, WZ, or WH boson pairs in the lepton plus merged jet final state in proton-proton collisions at $\sqrt{s}$ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2109.06055 [hep-ex]
  DOI: 10.1103/PhysRevD.105.032008 (publication)
  Published in: Phys.Rev.D 105 (2022) 3, 032008

- Study of quark and gluon jet substructure in Z+jet and dijet events from pp collisions
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2109.03340 [hep-ex]
  DOI: 10.1007/JHEP01(2022)188
  Published in: JHEP 01 (2022), 188

- Observation of Bs0 mesons and measurement of the Bs0/B+ yield ratio in PbPb collisions at Image 1 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2109.01908 [hep-ex]
  DOI: 10.1016/j.physletb.2022.137062 (publication)
  Published in: Phys.Lett.B 829 (2022), 137062

- Measurement of the inclusive and differential Higgs boson production cross sections in the decay mode to a pair of τ leptons in pp collisions at $\sqrt{s} = $ 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2107.11486 [hep-ex]
  DOI: 10.1103/PhysRevLett.128.081805 (publication)
  Published in: Phys.Rev.Lett. 128 (2022) 8, 081805

- Search for electroweak production of charginos and neutralinos in proton-proton collisions at $ \sqrt{s} $ = 13 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2106.14246 [hep-ex]
  DOI: 10.1007/JHEP04(2022)147
  Published in: JHEP 04 (2022), 147

- Fragmentation of jets containing a prompt J$/\psi$ meson in PbPb and pp collisions at $\sqrt{s_\mathrm{NN}} =$ 5.02 TeV
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2106.13235 [hep-ex]
  DOI: 10.1016/j.physletb.2021.136842 (publication)
  Published in: Phys.Lett.B 825 (2022), 136842

- Search for Wγ resonances in proton-proton collisions at $\sqrt{s} =$ 13 TeV using hadronic decays of Lorentz-boosted W bosons
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.
  e-Print: 2106.10509 [hep-ex]
  DOI: 10.1016/j.physletb.2022.136888 (publication)
  Published in: Phys.Lett.B 826 (2022), 136888

- Search for strongly interacting massive particles generating trackless jets in proton–proton collisions at $\sqrt{s} = 13\,\text {TeV} $
  CMS Collaboration • Armen Tumasyan (Yerevan Phys. Inst.) et al.

e-Print: 2105.09178 [hep-ex]
DOI: 10.1140/epjc/s10052-022-10095-5
Published in: Eur.Phys.J.C 82 (2022) 3, 213

- Using Z Boson Events to Study Parton-Medium Interactions in Pb-Pb Collisions
  CMS Collaboration • Albert M Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 2103.04377 [hep-ex]
  DOI: 10.1103/PhysRevLett.128.122301 (publication)
  Published in: Phys.Rev.Lett. 128 (2022) 12, 122301

- Evidence for X(3872) in Pb-Pb Collisions and Studies of its Prompt Production at $\sqrt {s_{NN}}$=5.02 TeV
  CMS Collaboration • Albert M. Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 2102.13048 [hep-ex]
  DOI: 10.1103/PhysRevLett.128.032001 (publication)
  Published in: Phys.Rev.Lett. 128 (2022) 3, 032001

- Search for heavy Higgs bosons decaying to a top quark pair in proton-proton collisions at $\sqrt{s} =$ 13 TeV
  CMS Collaboration • Albert M Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 1908.01115 [hep-ex]
  DOI: 10.1007/JHEP04(2020)171 (publication), 10.1007/JHEP03(2022)187 (erratum)
  Published in: JHEP 04 (2020), 171, JHEP 03 (2022), 187 (erratum)

- Measurement of exclusive Υ photoproduction from protons in pPb collisions at $\sqrt{s_\mathrm{NN}} =$ 5.02 TeV
  CMS Collaboration • Albert M. Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 1809.11080 [hep-ex]
  DOI: 10.1140/epjc/s10052-019-6774-8 , 10.1140/epjc/s10052-022-10276-2 (erratum)
  Published in: Eur.Phys.J.C 79 (2019) 3, 277, Eur.Phys.J.C 82 (2022) 4, 343 (erratum)

- Measurement of the top quark mass with lepton+jets final states using $\mathrm {p}$ $\mathrm {p}$ collisions at $\sqrt{s}=13\,\text {TeV} $
  CMS Collaboration • Albert M Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 1805.01428 [hep-ex]
  DOI: 10.1140/epjc/s10052-018-6332-9 , 10.1140/epjc/s10052-022-10277-1 (erratum)
  Published in: Eur.Phys.J.C 78 (2018) 11, 891, Eur.Phys.J.C 82 (2022) 4, 323 (erratum)

- Search for new physics in dijet angular distributions using proton–proton collisions at $\sqrt{s}=$ 13 TeV and constraints on dark matter and other models
  CMS Collaboration • Albert M Sirunyan (Yerevan Phys. Inst.) et al.
  e-Print: 1803.08030 [hep-ex]
  DOI: 10.1140/epjc/s10052-018-6242-x , 10.1140/epjc/s10052-022-10278-0 (erratum)
  Published in: Eur.Phys.J.C 78 (2018) 9, 789, Eur.Phys.J.C 82 (2022) 4, 379 (erratum)

- Searches for Long-Lived Charged Particles in pp Collisions at $\sqrt{s}$=7 and 8 TeV
  CMS Collaboration • Serguei Chatrchyan (Yerevan Phys. Inst.) et al.
  e-Print: 1305.0491 [hep-ex], 1305.0491
  DOI: 10.1007/JHEP07(2013)122 , 10.1007/JHEP11(2022)149 (erratum)
  Published in: JHEP 07 (2013), 122, JHEP 11 (2022), 149 (erratum)

- Search for Fractionally Charged Particles in pp Collisions at $\sqrt{s}=7$ TeV
  CMS and CMS Collaborations • S. Chatrchyan et al.
  e-Print: 1210.2311 [hep-ex]
  DOI: 10.1103/PhysRevD.87.092008 , 10.1103/PhysRevD.106.099903 (erratum)
  Published in: Phys.Rev.D 87 (2013) 9, 092008, Phys.Rev.D 106 (2022) 9, 099903 (erratum)

- Presentations given by **Dr. Sudhir Malik**

(1) Sudhir Malik gave a talk on “Train to Sustain” at CHEP2023, Norfolk, Virginia, 8-12 May 2023

(2) Sudhir Malik was primary author talk on “Building a Global HEP Software Training Community” at CHEP2023, Norfolk, Virginia, 8-12 May 2023

(3) Sudhir Malik was primary author talk on “Software Training Outreach In HEP ” at CHEP2023, Norfolk, Virginia, 8-12 May 2023

(4) Sudhir Malik was primary author talk on “Training and on-boarding initiatives in HEP” at CHEP2023, Norfolk, Virginia, 8-12 May 2023

(5) Sudhir Malik gave a Plenary talk on “Obstacles and Solutions to Careers in HEP” at “Seattle Snowmass Summer Meeting 2022”, University of Washington, Seattle, WA 16-26 July 2022
https://indico.fnal.gov/event/22303/timetable/?view=standard#537-obstacles-and-solutions-to

(6) Sudhir Malik co-organized session on “Community Engagement Frontier: Early Career panel (session is Q&A on non-HEP/industry jobs)” at “Seattle Snowmass Summer Meeting 2022”, University of Washington, Seattle, WA 16-26 July 2022 https://indico.fnal.gov/event/22303/timetable/?view=standard#b-24789-community-engagement-f

(7) Sudhir Malik gave a Plenary talk on “Selected Key CEF Recommendations-Empowering marginalized communities through education” at “Seattle Snowmass Summer Meeting 2022”, University of Washington, Seattle, WA 16-26 July 2022 https://indico.fnal.gov/event/22303/timetable/?view=standard#174-selected-key-cef-recommend

(8) Sudhir Malik co-organised “DANCE/CoDaS@Snowmass 2022 computational and data science software training” co-located with “Seattle Snowmass Summer Meeting 2022”, University of Washington, Seattle, WA 19-23 July 2022 http://seattlesnowmass2021.net/2022/05/10/dance/

(9) Sudhir Malik co-organized “Fourth Computational and Data Science school for HEP (CoDaS-HEP 2022)” at Princeton University, NJ 1-5 August 2022 https://codas-hep.org/pages/participants-2022.html and https://indico.cern.ch/event/1151367/timetable/

j) Graduate assistantships for research and teaching (quantity and amount awarded).

Graduate teaching assistantships total $86,100.21 during the first semester of the academic year 2022-2023, and $75,166.85 during the second semester of the academic year 2022-2023. While the graduate research assistantships total was $53,825.00 for the entire academic year.

k) Origin of graduate students (OPIMI).

During academic year 2022-2023, the Department of Physics had 27 graduate students on 1st semester and 25 on 2nd semester:

Physics	Year of study								
	Total			1			2		
	Total	Femenine	Masculine	Total	Femenine	Masculine	Total	Femenine	Masculine
1st semester	27	3	24	3	0	3	24	3	21
2nd semester	25	3	22	4	0	4	21	3	18

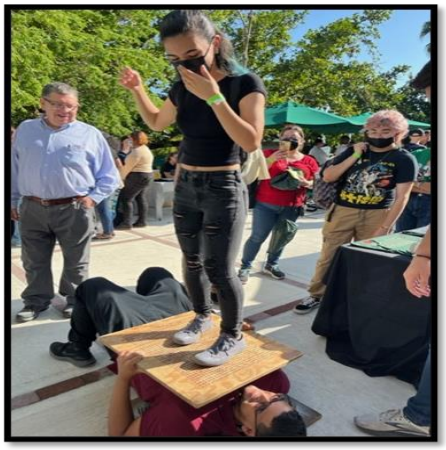
On average, the program of master's in physics had 9 students from Puerto Rico, 11 students from Colombia, 2 students from Ukraine, and 4 students from Perú.

H. To impact our Puerto Rican society

a. Participation in community initiatives (students, non-teaching staff, teaching staff)

On November 10, 2022, the Department of Physics participated in the 2002 UPRM Open House.

2022 UPRM Open House



On March 17, 2023, the Department of Physics participated in "Graduate Studies Open House" in UPRM Student Center.

Graduate students, Javier Ruidiaz and Edgar Albelo in Physics' table.

e) Activities aimed at students and young people of school age

1. Society of Physics Students (SPS) and Sociedad Meteorológica de PR (SMPR) offered demonstrations and brief talks to 35 students from Manuel Ramos Hernández School in Quebradillas (9th and 12th grade) on March 7, 2023 in room F-329. Teacher: Liduvina Cruz.

Arts & Sciences Summer Camp
June 15, 2023

For second consecutive year, the Department of Physics participated in Arts & Sciences Summer Camp: "Explora tu Vocación en la Artes y las Ciencias" that was held during June 13-17, 2023 in our Campus. Eighty-one (81) students from 34 towns participated in it. Prof. Samuel Santana offered the Physics Dept. presentation and Prof. Daniel Gutiérrez offered some Physics demonstrations.

I. To strengthen school spirit, pride, and identity

a. Improvement in services offered to students

The Department of Physics made available two classrooms (F-449 and F-317B) for study rooms for undergraduate and graduate students from any program in UPRM. The rooms were available for group study from Monday to Friday from 8:00 am until 9:00 pm.

b. Activities of student organizations

Society of Physics Students UPRM Chapter

The UPRM SPS chapter had most of its activities on campus. We held general assemblies, game nights, study nights, special topics meetings, fundraising activities, and more. During this academic year our chapter was also working alongside the UPRM Women in Physics (WiP) student association. We united due to lack of people for board positions in both organizations. This allowed for members of SPS and WiP to attend all meetings organized by both groups. Most of the activities did not require the use of funds, however, for the Induction ceremony and the Physics Awards, we organized multiple fundraising events throughout the year.

The UPRM SPS chapter always tries to encourage their members to participate in all activities, especially those that are organized as social activities to help members fraternize among themselves. We also have an office space where members can go to study, individually or in groups, and also, lay back and socialize with other members. Our office space has 5 to 6 desks and chairs, 1 whiteboard, a varied selection of textbooks of physics, math, and other subjects, as well as a comfy couch and a snack bar.

Game nights are always a fun activity to do at the start of each semester as an icebreaker and catch up with members; "*trivias*" has become quite popular amongst our members this year! Members were also very interested in activities where they learnt how to prepare for REUs, grad school, and that sort of process; we held different activities on

that topic. To know what our members were interested in this year, it helped using a *Google form* at the end of our first General Assembly where we asked them to suggest or request activities they would love to be involved in during the academic year.

This academic year we communicated with our members via a *WhatsApp* group and through email. All activities and announcements were sent through both media, however we maintained a better and closer communication via the *WhatsApp* groups. We also maintained ourselves active in social media, such as *Instagram* and *Twitter*.

During this academic year, our SPS chapter attended the 2022 Physics Congress "PhysCon" held in Washington D.C. Members of our chapter presented their research posters during the poster session. It was a very successful academic trip where members could meet some of their inspirations. One of our members, Caryelis Bayona, was very grateful for the opportunity to present, during the poster session, her research to Jocelyn Bell, the woman who inspires her to study astrophysics.

We also had another member, Viviana Cáceres, attend the 2023 APS April Meeting with the SPS Reporter Award, for which she submitted a report to be published in the SPS Observer magazine, detailing her personal experience at the conference.

Social Activities:

- **Game nights:** members were invited to participate and bring games, sing, dance, eat pizza and socialize with us
- **Study nights:** during exam weeks we did various nights of study sessions using the Pomodoro technique, during the breaks we would socialize or play games with each other's
- **Movie nights**: members were invited to bring friends, their own blankets and join us with some fresh popcorn to watch movies ('Hidden Figures', 'Shrek', movie version of the musical 'Rent')
- **Presentations night:** this activity was organized by our leader of the Inclusivity and Diversity committee, we created a safe space where members could talk or give brief 5-minutes presentations of their topic of interest
- **Beach day:** on a Saturday morning we visited a beach in Aguadilla, PR called Crashed Boat and enjoyed the day with our members at the beach playing volleyball, swimming, socializing, etc.
- **Escape room:** on a Thursday night we visited an escape room in Aguadilla, PR called *Salsipuedes* after we went out to eat pizza
- **Planksgiving:** a Thanksgiving dinner organized by our board members to celebrate along with the faculty members of the Physics department as well as other physics department student organizations
- **Induction Ceremony & "*Parranda Navideña*" :** we had our Induction Ceremony for new members on a Saturday night in December, along with a dinner; once the dinner was over we visited faculty member's houses with a *Parranda Navideña* (*Puertorrican* tradition to surprise visit people's houses during the Christmas time and sing Christmas songs together)

- **Physics Awards:** social activity at the end of the academic year to celebrate the end of a school year and our members achievements; it consisted of a ceremony, dinner, trivia, dancing, and singing

Professional Activities:

- **Personal Statement Workshop** by English Department professor Edward Contreras, Ph.D
- **How to study Physics** by Physics Department professor Raúl Portuondo, Ph.D
- **Public Speaking Workshop** by our member Vanelie Olivieri
- **REU Info-session** with participating programs from Cornell University, U. of Chicago, Virginia Tech, University of Illinois Urbana Champaign
- **LaTeX Workshop** by our member Mario Escabí
- **Summer Research Physics Symposium** along with UPRM Physics Department
- **Women in Physics Research & Discussion Panel** with participation of Caryelis Bayona, Viviana Cáceres, Stephanie Ortiz, Amanda Román
- **Special topic meeting: astronomy** by General Studies Faculty professor Mayra Lebrón, Ph.D. presenting her research project "Estudio en infrarrojo de regiones de formación de estrellas en las nubes moleculares de Perseo y Orión"
- **How to prepare a research presentation** by our member Tiahra Avilés

Charitable Activities:

- First aid supplies and canned food collection for affected people by hurricane Fiona
- **Siembra Colegial**: activity for the restoration of the Biology Department forest along with students organizations of the Biology Department

Outreach Activities:

- UPRM Open House: physics demonstrations, info-session table about our SPS chapter
- School visits: performed physics demonstrations as requested by science teachers for high school students of various schools in the Mayagüez area
- WeatherFest: provided physics demonstrations with application to meteorology for an activity organized by the Physics Department AMS chapter where students from schools all over the country and general community visited to learn about careers, topics and more related to meteorology

Fundraising Activities:

- Pizza sales every two weeks at the Physics Department Lobby
- Brownies sales in collaboration with "The Brownie Alchemist" small local brownie and baked goods business
- Valentine's Day flowers and love letter sale
- Nacho sale
- T-shirt and stickers sale

Our SPS UPRM chapter participated in the following conferences/meetings:

- 2022 Physics Congress 'Physcon 2022'

- 241st Meeting of The American Astronomical Society
- APS Conference for Undergraduate Women in Physics at the University of Central Florida
- APS April Meeting 2023

Sociedad Meteorológica de Puerto Rico
Capítulo Estudiantil afiliado a la American Meteorological Society (AMS)
UPR- Recinto Universitario de Mayagüez

Annual report
Academic Year 2022-2023

During this year, “Sociedad Meteorológica de Puerto Rico” (SMPR) focused on expanding professional and personal growth opportunities for our members. With the participation of professors of Atmospheric Sciences from the University of Colorado at Boulder, Columbia University and the University of Wisconsin at Madison, as well as experiences such as voluntary practices or "shadowings" at the National Weather Service in San Juan, we prioritize a diversity of options with the purpose that our members get involved in this branch and the motivation to explore more topics in it grows. In addition, with great enthusiasm and pride, we participated in the Annual Meteorology Conference in Denver, Colorado in January 2023, in which, thanks to the sponsorship of the NASA Space Grant program in collaboration with meteorologist Ada Monzón and fundraising activities, we achieved the participation of 8 members. In this national activity, several of our members presented the investigations carried out in their past internships. Likewise, we received an honorable mention as part of the student chapters of the year.

At the community level, we direct our efforts by offering hurricane talks and demonstrations, both hosting students in the Physics Department and visiting public schools on the island. In May, we held our traditional Weather, where about 150 high school students received information about meteorology and other branches of science and engineering. Apart from educational initiatives, we donated supplies to the “Come Colegial” organization after Hurricane Fiona passed through the island in September 2022.

The dedication of our members to meteorology was key to their being selected to participate in internship opportunities at research centers such as NCAR (SOARS and NESSI), Woods Hole Oceanographic Institution, University of Wisconsin at Madison, University of Albany, Princeton University and the Arecibo Observatory. In fact, two of our members (the University of Wisconsin at Madison and the University of Albany) are part of the NSF Student Driven Opportunities led by Prof. Héctor Jiménez, who was in charge of guiding our members on the requirements to apply for a beginning of the academic year. It is important to note that two of our members graduated from the Department of Geology and they are: Coralis D. Friedman and Idamis E. Rodríguez, who will continue their graduate studies at Cornell University and the University of Wisconsin-Madison

respectively. Finally, we managed to carry out our 16th initiation in person, where we initiated 15 new members.

We want to extend our gratitude to Prof. Hector Jiménez, meteorologist Ada Monzón in collaboration with the NASA Space Grant program and the Department of Physics for their collaboration with the Puerto Rico Meteorological Society to make this academic year one full of opportunities and achievements for our organization.

Cordially,

SMPR Directive 2022-2023

• President: Juan L. Colón-Pérez
• Vice President: Andrea N. Belvis Aquino
• Secretary: Stephanie M. Ortiz Rosario
• Treasurer: Arianna B. Ginés Ocasio
• Historian: Xamyr Guerrero Cortés
• Magazine Editor: Coralis D. Friedman Álvarez
• Leader of the Demonstration Committee: Bianca V. Méndez Cruz
• Outreach Committee Leader: Astrid K. Vera Torres

c. Activities to promote links with alumni – N/A

d. Donations received from alumni – N/A

e. Collaboration agreements with government agencies, the private sector, and various entities (purpose, validity, and name of the agency)

- "Laboratorio de Comunicación Científica" between NotiCentro -WAPA TV and Meteorology Program" Since August 2021.

  This collaboration allows that our Meteorology and Atmospheric Sciences students can have the experience of being TV communicators and can help to strengthen the UPRM Meteorology program.

f. Activities aimed at the community in general

The department runs several community service programs, including those aimed at: Physics/Chemistry teachers (QuarkNet), visiting middle and high schools, outreach on optics, software for teachers and other related activities.

a) QuarkNet.

The mentors of the QuarkNet program at UPRM are **Dr. Héctor Méndez** and **Prof. Daniel Gutiérrez M.S.**

QuarkNet is a national education program involving various national and international physics laboratories, and more than 60 universities across the United States, including the University of Puerto Rico in Mayaguez. The QuarkNet Center for PR was established in 2003 to provide training and academic support to high school physics/chemistry teachers, who in turn bring their educational experience into the classroom. During these 20 years of uninterrupted operation working with teachers and their students, we have found indescribable talent in the schools of Puerto Rico, many of whom have gone on to higher studies in physics, including masters and doctoral degrees.
The primary goal of the program is to provide teachers with a basic knowledge of particle physics and its interactions, with the main aim of integrating the study of high-energy physics into the high school curriculum and motivating their students to pursue careers in STEM subjects.

Laboratories participating in the program include the particle accelerators at Fermilab in Batavia, Ill. CERN in Geneva, Switzerland, BNL (Brookhaven National Lab) in uptown, New York, among others. Several of the teachers participating in the program have attended national workshops in Puerto Rico, as well as workshops and international schools in Switzerland, Greece, USA, etc. These experiences are not only extremely motivating, but also improve the quality of teaching in the classroom.

During the past 2022-2023 school year, QuarkNet engaged with teachers and students in the following activities:

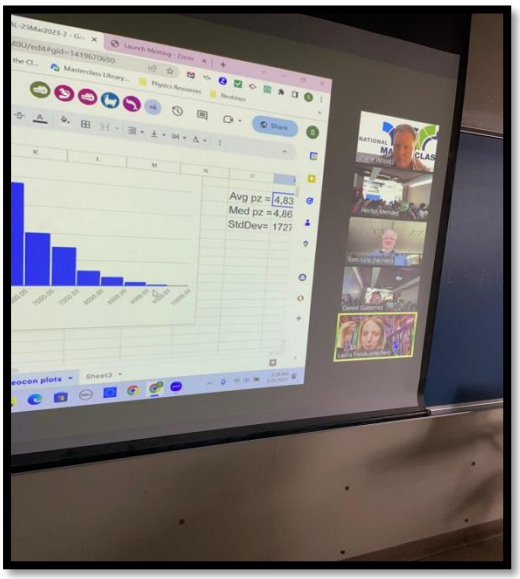
- **Taller para Maestros de Física/Química** (D. Gutiérrez M.S.- H. Méndez Ph.D.)
  November 11, 2023 at Dept. of Physics (UPRM)
  https://quarknet.org/content/taller-de-f%C3%ADsica-de-neutrinos
  Presentaciones:
  1. "Physics Overture" (Héctor Méndez)
  2. "QuarkNet Program" (Héctor Méndez)
  3. "Modelo Estandar de las Partículas Elementales" (Daniel Gutiérrez)

- **Taller de Preparación para MasterClass** (D. Gutiérrez M.S.-H. Méndez Ph.D.)
  March 4, 2023, Dept. of Physics (UPRM)
  http://tiny.cc/uprm-o-23/
  Presentaciones:
  1. "Standard Model & Neutrino Physics. A brief Summary" (Héctor Méndez)
  2. "Introducción al Taller de QuakNet" (Héctor Méndez)

3. "Minerva Experiment for the MasterClass" (Daniel Gutiérrez)

- **MasterClass Internacional para Estudiantes de Escuela Superior**
  (D. Gutiérrez M.S., S. Santana Ph.D. & H. Méndez Ph.D.)
  More than **70 students** from all around PR attended to the MasterClass.
  Marzo 25, 2023. Depto de Física (UPRM)
  http://tiny.cc/uprm-mc23/
  Presentaciones:
  1. **"The Standard Model of Particle Physics and Neutrino Physics"** (Samuel Santana)
  2. **"MasterClass activities & VideoConference"** (Daniel Gutiérrez)

Videoconference with scientists from Fermi National Laboratory Accelerator (Fermilab) and students from the University of Minnesota Duluth and UPRM were held to analyze and discuss the results of the MasterClass.



b) Visiting middle and high schools.

Prof. Daniel Gutierrez M.S. has been on a tour of schools, promoting our **physics** programs to students:

o On Tuesday 24 January 2023, he visited the school El Faro Christian Academy school in Adjuntas, PR, and on Thursday 23 February 2023 Colegio Santísima Trinidad in Ponce, PR. In both places, he gave physics experiment demonstrations to students in grades four to twelve and seven to twelve respectively.

- The TRIO Talent Search Program of ASPIRA of Puerto Rico with 30 students visited the campus on the 24th of March to get more information about some university programs like Physics. Dr. Héctor Méndez gave the presentation "El Departamento de Física de UPRM" where he explained the different possibilities to pursue a career in Physics at UPRM.

c) Outreach on Optics.

Activities in the field of optics aimed at the community in general by **Dr. Sergiy Lysenko:**

- Dr. Sergiy Lysenko is serving as Editorial Board Member of “Scientific Reports”, Nature Publishing Group since 2012: https://www.nature.com/srep/about/editors#physics_section; Currently, in 2023, he is a Guest Editor for the ‘Ultrafast optics’

Collection https://www.nature.com/collections/hhaebhgbba/guest-editors

Sergiy Lysenko has extensive experience in ultrafast science and condensed matter physics.

- Sergiy Lysenko is advisor of the first OPTICA (OSA) Student Chapter in Puerto Rico, organizer of numerous outreach activities:
  https://twitter.com/OpticaUPRM
  https://fisica.uprm.edu/light/OSA.html
  Lysenko and OSA student members have organized OPTICA (OSA) Workshop “Woman in Optics 2023”: Zoom webinar on Feb 7, 2023, 10:30 AM
  https://www.youtube.com/watch?v=gVrWr5bYb-Y

- X-Rays: We explained what x-rays consist of, how they are produced in nature and the laboratory, and how their interaction with atoms in periodic arrangements, through the phenomenon of diffraction, allows us to elucidate crystalline structures. We devoted special attention to the use of X-ray diffraction as a non-destructive technique to identify materials present in solid samples.
  1. Difracción de Rayos X - parte 1: Fundamentos y desarrollo histórico
  2. Difracción de Rayos X - parte 2: Aplicaciones a estudio de estructuras de sólidos.
  3. Difracción de Rayos X - parte 3

At the high school level, Dr Lysenko has developed the following types of workshops:

- (July 2022) Summer Camp: "Defining your vocation in the Arts and Sciences" at the University of Puerto Rico. As an Optica chapter, we are engaged with the new generation of students. We present our chapter and demonstration in the summer.

- Open House at the University of Puerto Rico, more than 2.500 high school students were registered. We talked about optics, and many students fell in love with science! It was a very successful Open House; Many students got interested in joining the Physics program at UPRM.

Virtual engagement:

- We have received an exceptional package from the BPHOTChapter that has taken our outreach activities to another level; OpticaUPRM is now bringing photonics to the public with the Photonic Explorer Kit. Thanks to BPHOTChapter.

- We participated in the Tercer Simposio “El Poder de la Mujer en la Ciencia.” As an OPTICA chapter, we show how we are committed to equal access and participation. We presented a demonstration of how to align a laser in the lab for all students. (High School).

- We present a webinar called Exploring Photonics, a talk for all students from primary to secondary, they connected with us and we explored photonics together. We used the exceptional Photonic Explorer Kit from BPHOTChapter.

d) Software Training Workshops

(1) Guillermo Fidalgo tutored “Python 101 for STEM teachers (at CROEM)” - 17 August 2022 - https://indico.cern.ch/event/1188757/ (Yarleis Acevedo, Roy Candelaria, Cristhian Barbosa and Brian Cruz mentored at the same workshop) attended by 10 STEM teachers.
(2) CROEM workshop, August 2022

(3) Guillermo Fidalgo tutored “Python 101 for STEM teachers from PR schools at UPRM Physics Dept)” - 20 August 2022 - https://indico.cern.ch/event/1180502/timetable/ (Yarelis Acevedo, Roy Cruz, Erick Vargas, Cristhian Suarez mentored at the same workshop) attended by 10 STEM teachers. Teachers were funded by FIRST-HEP grant, PI - Malik

(4) Software Carpentry (virtual) - 13–15 Jul 2022 https://indico.cern.ch/event/1159157/
(Co-mentored by Guillermo Fidalgo, Scarlet Norberg)

(5) Software Carpentry (virtual) - 28–30 Sept 2022 – https://indico.cern.ch/event/1190572/
(Co-mentored by Guillermo Fidalgo)
(6) Training on Analysis Preservation in HEP (virtual) - 16-21 December 2023
(Co-mentored by Guillermo Fidalgo) https://indico.cern.ch/event/1219810/
(7) Software Carpentry (virtual) – 18-20 May 2022 – https://indico.cern.ch/event/1190572/
(Led by by Richa Sharma and co-mentored Guillermo Fidalgo)

(e) Other Outreach activities

(1) **Dr. Francisco Bezares** took part in the **summer camp**:
"Experimenta con PREM", Two-week STEM summer camp for high school students in PR, June 6-16 2023, UPR Cayey/Humacao

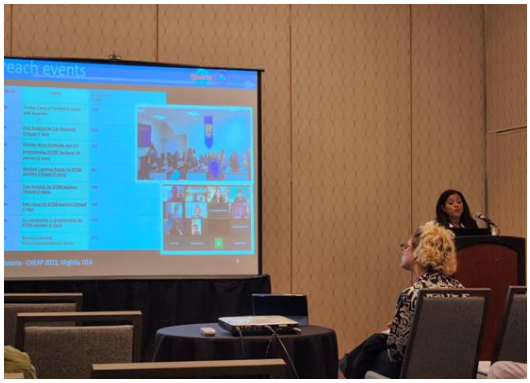
(2) **Malik** moderated Quarknet Fermilab Masterclasses
1. 11 March 2023 - Schools were Boston, Hermosillo, Medellin, Williamsburg
https://quarknet.org/content/fermilab-masterclass-moderators

(3) **Malik** moderated W2D2 (10 Nov 2022) – Schools were Mbour, Ziguinchor II, Henrico, (https://quarknet.org/content/w2d2-videoconferences - sched)

(4) **Malik** gave on 27 July 2023 remote LECTURE at the very first Quarknet/IRIS-HEP coding camp at Fermilab (July 24 - Friday, July 29)

(5) **Norberg** met with K-12 teachers as a motivator on 27 July 2023 at the very first Quarknet/IRIS-HEP coding camp at Fermilab (July 24 - Friday, July 29)

(6) **Danelix Cordero**, in figure Physics Teacher from CROEM, Mayaguez) was supported by Malik's IRIS-HEP project to give a talk on "Software Training Outreach In HEP " at CHEP2023, Norfolk, Virginia, 8-12 May 2023



Following activities (1-4) were targeted at the HEP community for a vision of next 20 years

(1) Malik is co-convener of Snowmass2021 Community Engagement Frontier: Career Pipeline & Development (https://snowmass21.org/community/career)

(2) Malik is co-convener of Snowmass2021 Community Engagement Frontier: Physics Education (https://snowmass21.org/community/education)

(3) Malik is organizing weekly Snowmass2021 Community Engagement Frontier: Career Pipeline & Development (https://indico.fnal.gov/category/1156/)

(4) Malik is organizing weekly Snowmass2021 Community Engagement Frontier: Physics Education (https://indico.fnal.gov/category/1158/)

(5) Malik is the co-convener of Training, Education and Outreach Coordinator for IRIS-HEP Project

(6) Malik is co-convener of Training working group of HEP Software Foundation (https://hepsoftwarefoundation.org/workinggroups/training.html)

(7) USCMS Undergraduate Summer Internship 2022 (6 June -22 August 2022) Malik co-organized this 10-week program for 16 students from underrepresented populations, including those at minority serving institutions have traditionally faced many barriers that have resulted in their being under-represented in high energy physics.

g. Activities aimed at the university community

"Cuadro de Honor (2021-2022) and 2023 Physics' Graduates Activity" May 10, 2023

2023 Candidates to graduation with GPA 3.50 or higher: Viviana Cáceres, Adriel Jiménez, Tiahra Avilés, Arianna Colón and Rebeca Reyes.

Viviana Cáceres (2023 Enrico Fermi Medal recipient) with Dr. Gilbes, Dean of Arts & Sciences and Physics' professors: Héctor Méndez, Rafael A. Ramos, Samuel Santana and Henri Radovan.

On March 30th, Prof. Mayra Lebrón (UPR RP) offered the talk "Estudio en infrarrojo de regiones de formación de estrellas en la nube molecular de Perseo" to Physics and Astronomy students in F-329.

Summer Research Symposium
March 16 and March 20, 2023

Nine Physics' students offered a brief presentation about their research projects during Summer 2022. Also, Physics Post-Doc, Richa Sharma, PhD, offered a presentation about her plans and research project.

AGENDA

Simposio de Investigaciones en Física

Práctica COOP y Verano 2022

JUEVES, 16 DE MARZO DE 2023

10:30 A.M. – Bienvenida y saludos
Dr. Rafael Ramos - Director
Dr. Héctor Méndez – Director Asociado

PRESENTACIONES:

10:40 A.M. – *"Search of pair productions of a new heavy quark that decays into a W boson and a light quark in pp collisions at √s = 8 TeV with the ATLAS detector"*
Estudiante: *Yarelis D. Acevedo Rios*
Internado de verano realizado en: Oklahoma State University
Campo estudiado: Altas Energías

11:00 A.M. – *"Dee Plaquettes Thermal Studies to Improve Manufacture"*
Estudiante: *Tiahra Avilés González*
Internado en: Cornell University
Campo estudiado: Altas Energías

11:20 A.M. – *"Chemical Vapor Deposition Synthesis of WS2 Monolayers and their Optical Characterization"*
Estudiante: *Joshua Emanuel Chaparro Mata*
Internado de verano realizado en: Binghamton University - Smart Energy Building
Campo estudiado: Materiales

11:40 A.M. – *"Exploring Diverse Horizons"*
UPRM Post Doc: Richa Sharma, PhD

Simposio de Investigaciones en Física

Práctica COOP y Verano 2022

AGENDA

MARTES, 21 DE MARZO DE 2023

10:30 A.M. – ***Bienvenida***

10:40 A.M. – ***"Comparing Chemistry of Small Molecules in Planet Forming Disks"***

Estudiante: ***Carlos Ortiz Quintana***
Internado de verano realizado en: Space Telescope Science Institute (STScI)
Campo estudiado: Astronomía / Astrofísica

11:00 A.M. – ***"Mitigating the effect of glitches on gravitational-wave parameter estimation using an inpainting filter"***
Estudiante: ***Viviana A. Cáceres Barbosa***
Internado de verano realizado en: California Institute of Technology
Campo estudiado: Astronomía / Astrofísica

11:20 A.M. – ***"Laboratorio de Comunicación de Meteorología de Noticentro por WAPA-TV"***
Estudiante: ***Cherilyn Toro Acosta***
Práctica COOP en: WAPA-TV
Campo estudiado: Ciencias Atmosféricas y Meteorología

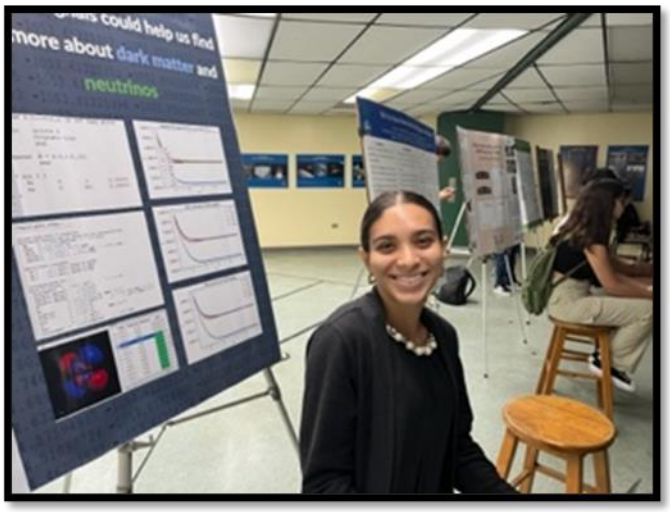
11:40 A.M. – ***"Stimulated Raman Scattering for Scanning Technology"***
Estudiante: ***Rebeca Reyes Carrión***
Práctica COOP: MIT Lincoln Laboratory
Campo estudiado: Óptica

"Poster": ***"Insights on the star formation efficiency in the high-redshift Universe"***

Estudiante: ***Rebeca Reyes Carrión***
Internado realizado en: Cosmic Dawn Center, Denmark Technical University

12:00 PM – ***"Investigating the flux asymmetry of double-lobed radio sources"***
Estudiante: ***Caryelis Bayona Figueroa***
Internado de verano realizado en: University of Wisconsin-Madison
Campo estudiado: Astronomía / Astrofísica

12:20 PM – ***"Refinement of the Thermal Interface Material Deposition Routine for CMS's Inner Tracker"***
Estudiante: Reynaldo J. Falcón Torres
Internado realizado en: Cornell University
Campo estudiado: Altas Energías


could help us find
more about dark matter and
neutrinos

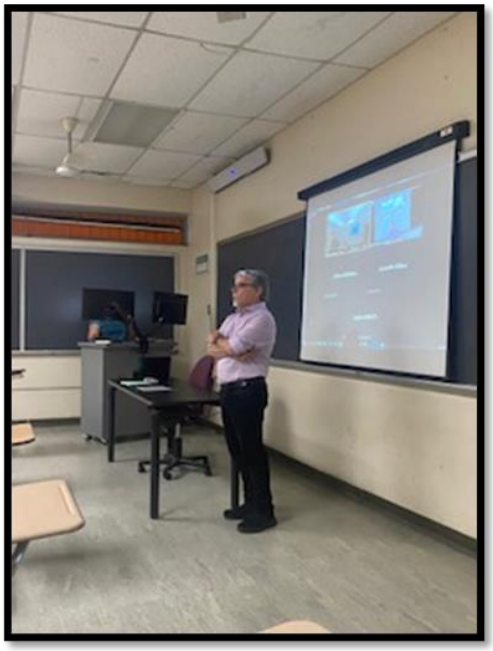

NASA


SA

Cherilyn Toro, who participated in COOP Practice in WAPA-TV, offered a talk about her experience.

2022 Meteorology Summer Internship Symposium
August 27, 2022

Nine UPRM students and four students from University of the Incarnate Word (UIW) offered a presentation about their summer internship research project.



Student-Driven Internship Opportunities in the Atmospheric Sciences: Breaking Barriers to Diversity, Inclusion, and Equal Access

UNIVERSITY OF THE INCARNATE WORD

2022 Summer Internship Symposium
Saturday, August 27, 2022
Agenda (Atlantic Time, Texas time is 1 hour earlier)

9:15am – 9:30am Welcome Messages

Students Presentations:

9:30 am – 9:50 am ***Janluis Rivera-Ramos - UPRM***

"Assessing the skill of the CariCOF rainfall outlook for Puerto Rico and the US Virgin Islands"
Place of Internship: *National Weather Service – San Juan Office*
Mentor: *Ernesto Rodriguez*

9:50 am – 10:10 am ***Dia Jackson – UIW***

"Shadowing NWS"
Place of Internship: *National Weather Service – El Paso*

10:10 am – 10:30 am ***Harry Rivera-Quintana – UPRM***

"Mapping Hazard Vulnerabilities and Risks in Puerto Rico"
Place of Internship: *National Weather Service – San Juan Office*
Mentor: *Ernesto Rodriguez and Carlos Anselmi*

10:30 am – 10:50 am ***Raisa Rodriguez – UPRM***

"Analysis of Climatological Records Across the NWS Corpus Christi County Warning Area"
Place of Internship: *National Weather Service – Corpus Christi Office*
Mentor: *Alina Nieves / Tim Humphrey*

10:50 am – 11:10 am ***Katelyn Simonsen – UIW***

"Civilian Internship with the United States Air Force JBSA"
Place of Internship: *US Air Force*

11:10 am – 11:30 am ***Deborah Damiani-Dávila – UPRM***

"Microplastics in Puerto Rico and New York City beaches"
Place of Internship: *Columbia University, Lamont-Doherty Earth Observatory*
Mentors: *Beizhan Yan, Bob Newton, and Madgaly Sevilla*

11:30 am - 11:50 am ***Juliana Symons – UIW***

"Unpacking Historical Redlining Through the Analysis of Lead Contamination and Air Pollution Across New York"
Place of Internship: *Columbia University, Lamont-Doherty Earth Observatory*

11:50 am – 12:10 md *Idamis E. Rodríguez-Nazario – UPRM*

"Impacts of the Different Types of El Niño on the Caribbean Precipitation"
Place of Internship: *University of Wisconsin-Madison*
Mentors: *Victor C. Mayta, Angel Adames*

Lunch Break

1:00 pm – 1:20 pm *Enrique Flores – UIW*

"My San Antonio River Authority Lab Internship"
Place of Internship: *San Antonio River Authority*

1:20 pm – 1:40 pm *Allan Cruz – UPRM*

"Changes in atmospheric blocking statistics in response to idealized global warming"
Place of Internship: *Princeton University*
Mentors: *Dr. Ming Zhao, Dr. Steve Garner, Dr. Ping Liu*

1:40 pm – 2:00 pm *Christian Schnell – UIW*

"Preparing for the Future: Hyperspectral Sounder"
Place of Internship: *NOAA's Educational Partnership Program with Minority Serving Institutions (EPP/MSI)*

2:00 pm – 2:20 pm *Niwdé M. Rivera-Maldonado – UPRM*

"Isotopic records of cryptic sedimentary carbon cycling"
Place of Internship: *The Pennsylvania State University*
Mentors: *Dr. Matthew Fantle, Dr. Max Lloyd, and Dr. Christopher Gorski*

2:20 pm – 2:40 pm *Andrea Belvis-Aquino – UPRM*

"Effects of the 2021 Supply Chain Crisis on Local Air Quality near the Ports of Los Angeles/Long Beach"
Place of Internship: *NASA Student Airborne Research Program*
Mentors: *Dr. Andreas Beyersdorf, Dr. Roya Bahreini, Eva-Lou Edwards*

2:40 pm – 3:00 pm *Juan L. Colón-Pérez - UPRM*

"Effects of Large-Scale Dynamics on African Easterly Waves and its relationship to Tropical Cyclogenesis"
Place of Internship: *University of Wisconsin-Madison*
Mentor: *Angel F. Adames-Corraliza*

h. Improvements to infrastructure and buildings – N/A

J. Internacional activity

The Department has a large international component among its graduates, students and faculties. It also has three active and very productive international collaborations:

1) NANOGrav (North American Nanohertz Observatory for Gravitational Waves) is an international collaboration of astronomers and physicists dedicated to detecting and studying low-frequency gravitational waves using pulsar timing arrays,

2) DUNE (Deep Underground Neutrino Experiment) is a major international collaboration to study neutrinos (subatomic particles with very little mass and no

electric charge). The experiment involves building a massive neutrino detector deep underground to reduce interference from other particles. DUNE will use a beam of neutrinos produced at Fermilab in Illinois, USA, and detect them 800 miles away at the Sanford Underground Research Facility in South Dakota, USA. The primary goals of the experiment are to study the properties of neutrinos, such as their oscillation behavior, and to potentially uncover new physics beyond the current understanding of particle physics.

3) CMS (Compact Muon Solenoid Detector) is a high energy proton-proton collisions experiment located at the LHC (Large Hadron Collider) at CERN (European Organization for Nuclear Research) in Switzerland. The primary goal of the CMS experiment is to explore the fundamental building blocks of matter and the forces that govern them, to study the properties of particles, to search for new particles, and to test theories such as the Standard Model of particle physics and beyond.

a) Number of international students in the department/faculty

b) Number of international faculty in department/faculty

Faculty:	International
Tenure Track	8
Adjunct	3
Total	**11**

c) Publications with international co-authors

All the Department's publications from the international collaborations NANOgrav, DUNE and CMS have been included in point G (To strengthen research and competitive creative endeavors) above.

d) Projects and initiatives with international collaboration

CMS collaboration.

e) Collaborations resulting in internships or exchanges in other countries

CMS collaboration.

f) Participation in international conferences, symposiums, forums, or seminars

(2) Prof. Silvana Urcia co-chaired a session at the annual meeting of the American Crystallographic Association (ACA), "What I learn from My first Structures", 31 July 2022 in Portland (USA).

(3) **Dr. Armando Rúa's** group:

a. Sujan Kumar Das, David Albertini, Nicolas Baboux, Robert G Elliman, Yun Liu, Teng Lu, Camilo Verbel, Sanjoy Kumar Nandi, Shimul Kanti Nath, Etienne Puyoo, Thomas Ratcliff, Armando Rúa, Mutsunori Uenuma, Joint Congress of 24th Australian Institute of Physics Congress, Australian and New Zealand Conferences on Optics and Photonics, **7th International Workshop on Speciality Optical Fibers and Conference on Optoelectronic and Microelectronic Materials and Devices, V3O5: a promising material for solid-state neurons, 11-16 December 2022, Adelaide (Australia)**

- Talks and Posters Presentations by **Dr. Sergiy Lysenko** and **Dr. Armando Rúa** groups:

(4) Roman Kolodka, Alexander Bartenev, Camilo Verbel, Manuel Lozano, Felix Fernández, Armando Rua, Sergiy Lysenko, **23rd International Young Scientist Conference and High Technology Material Science SPO 2022 ONLINE "STAND WITH UKRAINE"**, Transient nematicity of FeSe0.8Te0.2 superconductor, **24-26 November 2022**, **Kyiv (Ukraine**).

g) **Study trips to other countries organized by the department/faculty** - N/A

h) **Courses with international collaborators** – N/A