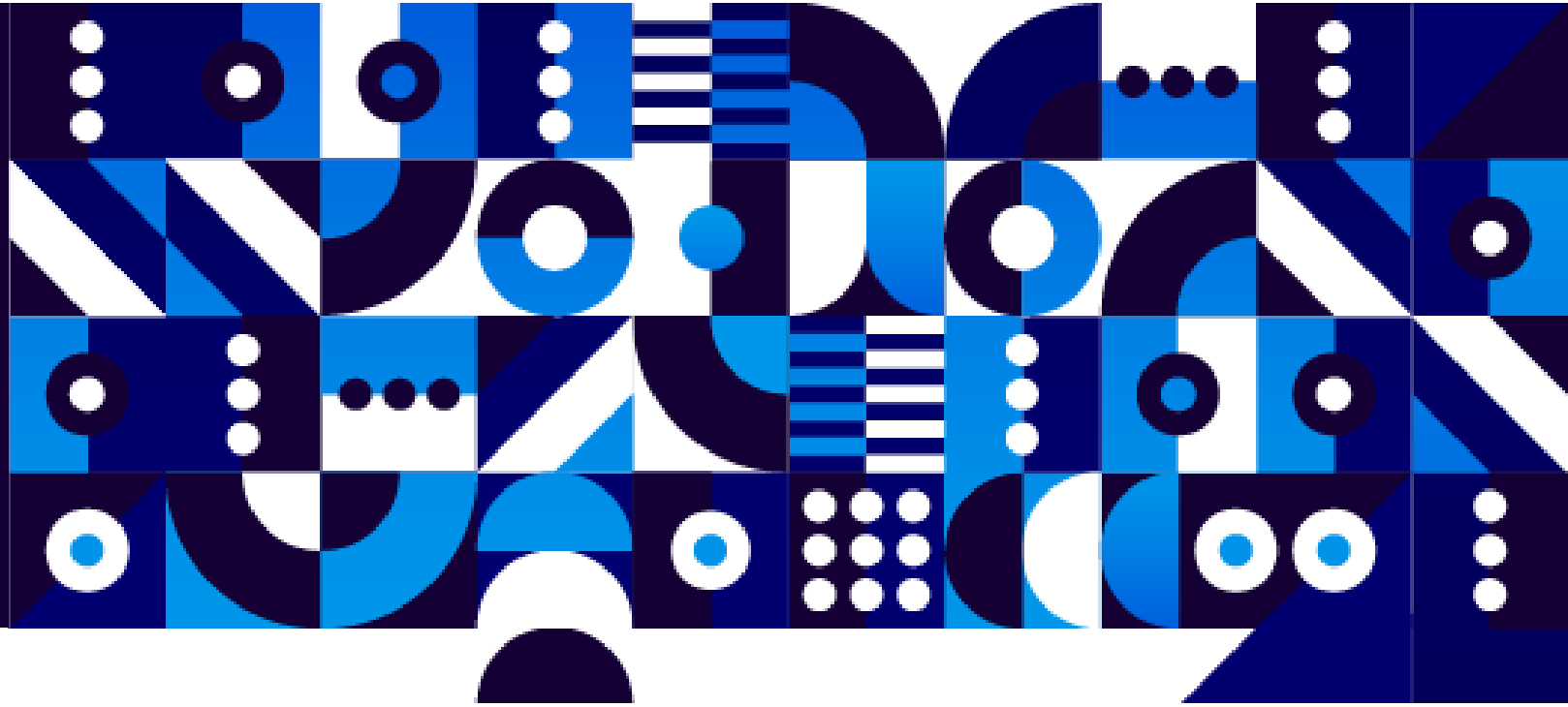
ANNUAL
REPORT
2022

INSTITUTO DE FÍSICA CORPUSCULAR

IFIC
INSTITUT DE FÍSICA CORPUSCULAR

VNIVERSITAT DE VALÈNCIA

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



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WELCOME

1 LETTER FROM THE DIRECTOR

Español

En 2022 hemos podido recuperar por fin la normalidad después de la pandemia, y volver a la plena actividad presencial, de la que mencionaré sólo algunos ejemplos, ya que la podéis encontrar reflejada en esta memoria. En particular, hemos continuado realizando Jornadas científicas dedicadas a las distintas líneas de investigación del IFIC, concretamente las líneas L5 “Gravity and the Dark Universe. Gravitational Waves and Black Holes”, L2 “Neutrinos and leptón flavour” y L7 “Advanced instrumentation and computing in fundamental physics”. Gracias a todos los organizadores y participantes por las interesantes charlas y discusiones.

También me gustaría destacar la organización del workshop FlipPhysics, especialmente dedicado a dar una visión general de la física de partículas, nuclear y aplicaciones a jóvenes postdocs y doctorandas/os, y cuyo objetivo es también dar visibilidad a las investigadoras, promoviendo la participación de mujeres para intentar reducir la desigualdad de género en nuestro campo científico.

En mayo recibimos la visita de Diana Morant, Ministra de Ciencia e Innovación, para conocer de cerca los tres proyectos de I+D+i en hadronterapia del IFIC: HYMNS-ERC, liderado por el investigador César Domingo, VALID liderado por la investigadora Gabriela Llosá y INITIAL-LINAC6+, liderado por el investigador Juan Fuster en colaboración con el CIEMAT.

Con motivo del X aniversario del descubrimiento del bosón de Higgs en el colisionador LHC del CERN, la comisión de divulgación de IFIC organizó una sesión conmemorativa para el público general con gran éxito de participación.

En octubre tuvo lugar una reunión híbrida del Comité Científico Asesor del IFIC, al que agradecemos su tiempo y sus aportaciones para ayudarnos a mejorar. Despedimos al profesor Peter Jenni, de la Universidad de Freiburg, Alemania, y CERN, con nuestra gratitud por sus consejos durante estos años, y damos la bienvenida en el comité a la profesora Manuella Vincter, de la Universidad de Carleton, Canadá, y CERN.

Este año 2022, los investigadores del IFIC han conseguido un récord de financiación competitiva, como se puede ver en la memoria, en buena parte debido al Plan Complementario de I+D+i en Astrofísica y Física de Altas Energías, apoyado por la Generalitat Valenciana y el Ministerio de Ciencia e Innovación, del que es coordinador en la Comunidad Valenciana nuestro compañero el Profesor de Investigación Carlos Lacasta.

Por supuesto, quiero resaltar que este año el IFIC ha sido galardonado con el “Distintivo de acreditación en igualdad de género” del CSIC 2022. Enhorabuena a todos y todas, y gracias a la Comisión de Igualdad y Diversidad del IFIC por su esfuerzo y por las numerosas iniciativas que nos han hecho merecedores de este distintivo.

Dos investigadores del IFIC han asumido en 2022 una vez más importantes responsabilidades internacionales: Carlos Mariñas ha sido nombrado nuevo coordinador técnico del experimento Belle II en Japón y María José Costa presidenta del Consejo de la Colaboración del experimento ATLAS, uno de los dos grandes detectores del Gran Colisionador de Hadrones (LHC).

Destacar también la relevancia de las tesis doctorales realizadas en el IFIC: Ricardo Cepedello y Rafael Pavao obtuvieron el premio extraordinario de Doctorado 2021 de la Universitat de València, y Clara Murgui el premio a la mejor tesis de España de la División de Física Teórica y de Partículas (DFTP) de la Real Sociedad Española de Física (RSEF).

Gracias a la iniciativa de varios miembros del IFIC, hemos creado la Comisión de Sostenibilidad del instituto, integrada por personal del CSIC y de la Universitat de València, que ha empezado a trabajar para ayudarnos a disminuir el impacto de nuestra actividad en el planeta.

Lamentablemente este año hemos sufrido la triste pérdida de dos de nuestros compañeros,

Esteban Fullana y Vicent Giménez, que nos han dejado demasiado pronto. No les olvidamos en nuestro día a día, y también les queremos recordar en esta memoria.

Es conveniente aclarar que la reducción de publicaciones respecto a años anteriores se debe a la suspensión de las publicaciones de los cuatro mayores experimentos del LHC (incluidos ATLAS y LHCb) en marzo de 2022, debido a la falta de acuerdo sobre cómo incluir a los científicos e institutos rusos y bielorrusos tras la invasión rusa de Ucrania.

Como siempre, quiero terminar reconociendo el trabajo y dedicación de los miembros del IFIC, tanto el personal docente e investigador como el personal técnico, de administración y comunicación. Gracias a todos por haber hecho posibles las numerosas actividades descritas en esta memoria y por mantener nuestro liderazgo internacional.

Nuria Rius

Directora del IFIC

1 LETTER FROM THE DIRECTOR

En Valencià

En 2022 hem pogut recuperar per fi la normalitat després de la pandèmia, i tornar a la plena activitat presencial, de la qual esmentaré només alguns exemples, ja que la podeu trobar reflectida en aquesta memòria. En particular, hem continuat realitzant Jornades científiques dedicades a les diferents línies d'investigació de l'IFIC, concretament les línies L5 “Gravity and the Dark Universe. Gravitational Waves and Black Holes”, L2 “Neutrinos and lepton flavour” i L7 “Advanced instrumentation and computing in fundamental physics”. Gràcies a tots els organitzadors i participants per les interessants xarrades i discussions.

També m'agradaria destacar l'organització del workshop FlipPhysics, especialment dedicat a donar una visió general de la física de partícules, nuclear i aplicacions a joves postdocs i doctorands/es, i també donar visibilitat a les investigadores, promovent la participació de dones per a intentar reduir la desigualtat de gènere en el nostre camp científic.

Al maig vàrem rebre la visita de Diana Morant, Ministra de Ciència i Innovació, per a conèixer de prop els tres projectes d'I+D+i en hadronterapia de l'IFIC: HYMNS-ERC, liderat per l'investigador César Domingo, VALID liderat per la investigadora Gabriela Llosá i INITIAL-LINAC6+, liderat per l'investigador Juan Fuster en col·laboració amb el CIEMAT.

Amb motiu del X aniversari del descobriment del bosó d'Higgs en el colisionador LHC del CERN, la comissió de divulgació d'IFIC va organitzar una sessió commemorativa per al públic general amb gran èxit de participació.

A l'octubre va tindre lloc una reunió híbrida del Comitè Científic Assessor de l'IFIC, al qual agraïm el seu temps i les seues aportacions per a ajudar-nos a millorar. Acomiadem al professor Peter Jenni, de la Universitat de Freiburg, Alemanya i CERN, amb la nostra gratitud pels seus consells durant aquests anys, i donem la benvinguda en el comitè a la professora Manuella Vincter, de la Universitat de Carleton, Canadà, i CERN.

Aquest any 2022, els investigadors de l'IFIC han aconseguit un rècord de finançament competitiu, com es pot veure en la memòria, en bona part a causa del Pla Complementari d'I+D+i en Astrofísica i Física d'Altes Energies, secundat per la Generalitat Valenciana i el Ministeri de Ciència i Innovació, del qual és coordinador a la Comunitat Valenciana el nostre company el Professor d'Investigació Carlos Lacasta.

Per descomptat, vull ressaltar que enguany l'IFIC ha sigut guardonat amb el “Distintiu d'acreditació en igualtat de gènere” del CSIC 2022. Enhorabona a tots i totes, I gràcies a la Comissió d'Igualtat i Diversitat de l'IFIC pel seu esforç i per les nombroses iniciatives que ens han fet mereixedors d'aquest distintiu.

Dos investigadors de l'IFIC han assumit en 2022 importants responsabilitats internacionals: Carlos Mariñas ha sigut nomenat nou coordinador tècnic de l'experiment Belle II al Japó i María José Costa, presidenta del Consell de la Col·laboració de l'experiment ATLAS, un dels dos grans detectors del Gran Colisionador d'Hadrons (LHC).

Destacar també la rellevància de les tesis doctorals realitzades en l'IFIC: Ricardo Cepedello i Rafael Pavao van obtenir el premi extraordinari de Doctorat 2021 de la Universitat de València, i Clara Murgui el premi a la millor tesi d'Espanya de la Divisió de Física Teòrica i de Partícules (DFTP) de la Reial Societat Espanyola de Física (RSEF).

Gràcies a la iniciativa de diversos membres de l'IFIC, hem creat la Comissió de Sostenibilitat de l'institut, integrada per personal del CSIC i de la Universitat de València, que ha començat a treballar per a ajudar-nos a disminuir l'impacte de la nostra activitat en el planeta.

Lamentablement, enguany hem patit la trista pèrdua de dues dels nostres companys, Esteban Fullana i Vicent Giménez, que ens han deixat massa prompte. No els oblidem en el nostre dia a dia, i també els volem recordar en aquesta memòria.

És convenient aclarir que la reducció de publicacions respecte a anys anteriors es deu

a la suspensió de les publicacions dels quatre majors experiments del LHC (inclosos ATLAS i LHCb) al març de 2022, a causa de la falta d'acord sobre com incloure als científics i instituts russos i bielorusos després de la invasió russa d'Ucraïna.

Com sempre, vull acabar reconeixent el treball i dedicació dels membres de l'IFIC, tant el personal docent i investigador com el personal tècnic, d'administració i comunicació. Gràcies a tots per haver fet possibles les nombroses activitats descrites en aquesta memòria i per mantenir el nostre lideratge internacional.

Nuria Rius

Directora de l'IFIC

1 LETTER FROM THE DIRECTOR

English

In 2022 we have finally been able to recover normality after the pandemic, and to return to full in-person activity, of which I will mention only a few examples, since you can find it reflected in this report. In particular, we have continued to hold scientific conferences dedicated to the different lines of research at IFIC, specifically the lines L5 “Gravity and the Dark Universe. Gravitational Waves and Black Holes”, L2 “Neutrinos and lepton flavour” and L7 “Advanced instrumentation and computing in fundamental physics”. Thanks to all the organizers and participants for the interesting talks and discussions.

I would also like to highlight the organization of the FlipPhysics workshop, especially dedicated to giving an overview of particle and nuclear physics and applications to young postdocs and doctoral students, and whose objective is also to give visibility to female researchers, promoting the participation of women to try to reduce gender inequality in our scientific field.

In May we received a visit from Diana Morant, Minister of Science and Innovation, to get to know first-hand about the three R&D&i projects in hadron therapy at IFIC: HYMNS-ERC, led by researcher César Domingo; VALID, led by researcher Gabriela Llosá; and INITIAL-LINAC6+, led by researcher Juan Fuster in collaboration with CIEMAT.

On the occasion of the 10th anniversary of the discovery of the Higgs boson at the CERN LHC collider, IFIC’s outreach commission organized a commemorative event for the general public, with great participation.

A hybrid meeting of IFIC’s Scientific Advisory Committee took place in October, and we thank the committee members for their time and contributions to help us improve. We say goodbye to Professor Peter Jenni, from the University of Freiburg (Germany) and CERN, with our gratitude for his advice over the years. We welcome Professor Manuella Vincter, from Carleton University (Canada) and CERN, to the committee.

This year, 2022, IFIC researchers have obtained the largest-ever amount of competitive funding, as can be seen in the report. This is partly due to the Complementary R&D&I Plan in Astrophysics and High Energy Physics, supported by the Generalitat Valenciana and the Ministry of Science and Innovation, of which our colleague Research Professor Carlos Lacasta is coordinator in the Valencian Community.

Of course, I want to highlight that this year IFIC has been awarded the “Gender Equality Accreditation Distinction” from CSIC. Congratulations to everyone, and thanks to IFIC’s Equality and Diversity Commission for their efforts and for the numerous initiatives that have earned us this distinction.

Two IFIC researchers have once again assumed important international responsibilities this year: Carlos Mariñas has been appointed new technical coordinator of the Belle II experiment in Japan, and María José Costa president of the Collaboration Council of the ATLAS experiment, one of the two large detectors of the Large Hadron Collider (LHC).

I would also like to highlight the relevance of the doctoral theses carried out at IFIC: Ricardo Cepedello and Rafael Pavao obtained the extraordinary 2021 Doctorate award from the University of Valencia, and Clara Murgui the award for the best thesis in Spain from the Division of Theoretical Physics and Particles (DFTP) of the Royal Spanish Society of Physics (RSEF).

Thanks to the initiative of several IFIC members, we have created the Institute's Sustainability Commission, composed of staff from CSIC and from the University of Valencia, which has begun to work to help us reduce the impact of our activity on the planet.

Unfortunately, this year we have suffered the sad loss of two of our colleagues, Esteban Fullana and Vicent Giménez, who have left us too soon. We do not forget them in our daily lives, and we also want to remember them in this report.

It is worth clarifying that the reduction in publications compared to previous years is

due to the suspension of publications of the four largest LHC experiments (including ATLAS and LHCb) in March 2022, due to the lack of agreement on how to include Russian and Belarusian scientists and institutes after the Russian invasion of Ukraine.

As always, I want to finish by recognizing the work and dedication of IFIC members, both the teaching and research staff as well as the technical, administrative and communication staff. Thank you all for having made the numerous activities described in this report possible, and for maintaining our international leadership.

Nuria Rius

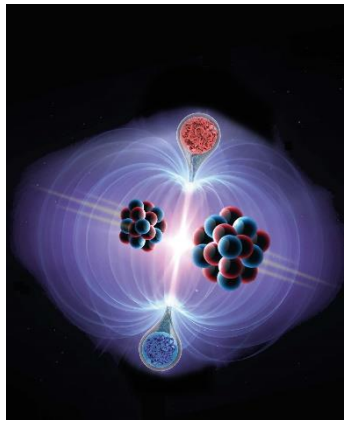
IFIC Director

2

HIGHLIGHTS OF THE YEAR

2 HIGHLIGHTS OF THE YEAR

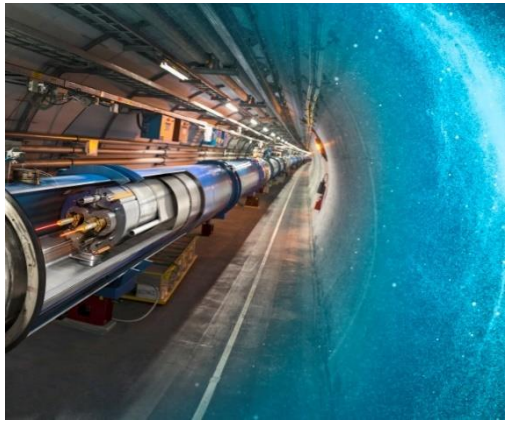
THE MOEDAL EXPERIMENT PUBLISHES NEW RESULTS IN THE SEARCH FOR THE HYPOTHETICAL MAGNETIC MONOPOLES



Taking advantage of the intense magnetic fields produced in the collisions of heavy ions at the LHC, an international team with IFIC participation has shown a way to discover the long-sought magnetic monopoles. The results of this work, published in the journal 'Nature', rule out the existence of light magnetic monopoles. More information here.

FIRST MEASUREMENT OF THE MASS OF ONE OF THE BASIC CONSTITUENTS OF MATTER VIA ITS INTERACTION WITH THE HIGGS BOSON

IFIC researchers, in collaboration with researchers from the Universities of Vienna and Tohoku and the Paul Scherrer Institute, measure for the first time the mass of the bottom quark from its interactions with the Higgs boson and confirm, as predicted by theory, that this quantity changes with energy. More information here.



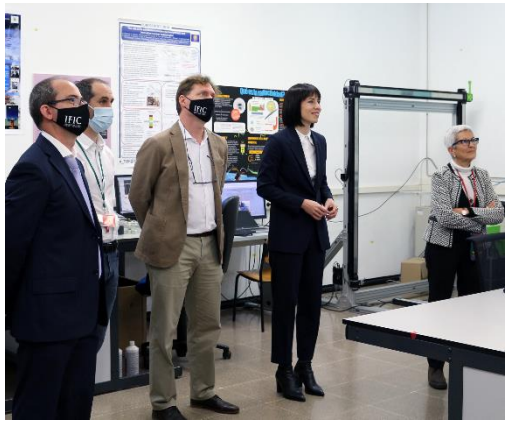
2 HIGHLIGHTS OF THE YEAR

@FLIPPHYSICS WORKSHOP REVERSES GENDER PARTICIPATION STATISTICS FOR NUCLEAR AND PARTICLE PHYSICS CONFERENCES

The @FlipPhysics Workshop has been organized at IFIC. It had a participation of around 200 people and has achieved its goal of completely reverting the typical statistics in conferences related to nuclear, particle and astroparticle physics. The participation was 75% women, and 25% men, with the majority of the presentations given by women, 87%. More information here.

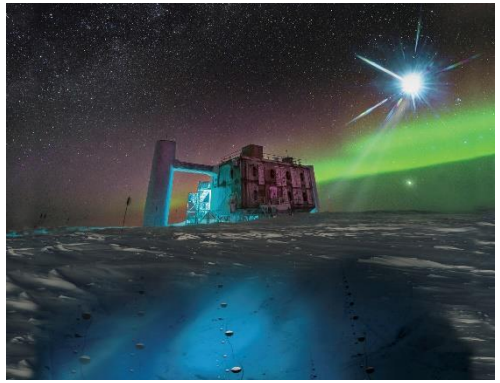
THE MINISTER OF SCIENCE AND INNOVATION VISITS IFIC'S HADRONTHERAPY R&D&I PROJECTS

The Minister for Science and Innovation, Diana Morant, visited IFIC's facilities. Among them, the ERC Consolidator HYMNS project, the technological development INITIAL-LINAC6+ Project and the VALID project. They all contribute towards improving hadronic therapy technology against cancer, one of the greatest challenges facing society today. More information here.



2 HIGHLIGHTS OF THE YEAR

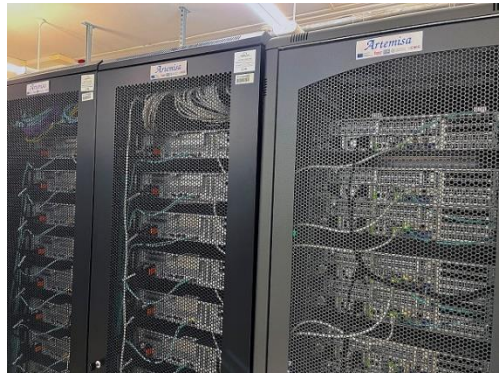
A STUDY SHOWS FOR THE FIRST TIME THE PRODUCTION OF A TYPE OF NEUTRINO FROM EXTREME PHENOMENA



IFIC and Harvard researchers have shown for the first time that other types of neutrinos can produce tau neutrinos when they cross the Earth. This component is significant and had not been taken into account until now. This work is cover on the prestigious Physical Review Letters journal. More information here.

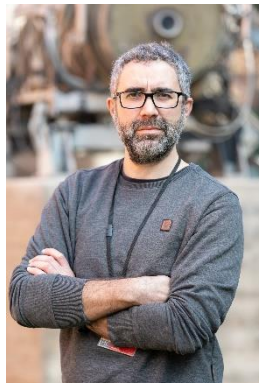
IFIC'S ARTEMISA ARTIFICIAL INTELLIGENCE INFRASTRUCTURE OBTAINS THE PRESTIGIOUS ISO 27001 SECURITY CERTIFICATION

IFIC becomes one of the first CSIC centers to have this certification. The certification grants greater guarantees in terms of information security to Artemisa users against possible cyberattacks. More information here.



2 HIGHLIGHTS OF THE YEAR

CARLOS MARIÑAS, NEW TECHNICAL COORDINATOR OF THE BELLE II EXPERIMENT IN JAPAN



IFIC researcher Carlos Mariñas has been appointed as the new chair of the Belle II technical committee, and coordinator of future vertex and tracking detector improvements. Belle II is a particle physics experiment designed to study the properties of the so-called B meson. More information here.

MARÍA JOSÉ COSTA, NEW COLLABORATION BOARD CHAIR OF THE ATLAS EXPERIMENT

IFIC researcher María José Costa Mezquita has been elected chair of the Collaboration Board for the ATLAS experiment. She will be responsible for the governance of the experiment. Her term begins in 2023 as deputy chair, to go on to chair the Board for two years, in 2024 and 2025. More information here.

2 HIGHLIGHTS OF THE YEAR

IFIC OBTAINS CSIC'S EQUALITY DISTINCTION

CSIC has granted the fifth edition of its Distinction of accreditation in gender equality to IFIC. The objective is to promote the gender perspective in all aspects of CSIC's operation and to eliminate the barriers that women encounter in the exercise of their profession. More information here.

FERNANDO HUESO GONZÁLEZ RECEIVES THE BRUCE H HASEGAWA YOUNG INVESTIGATOR MEDICAL IMAGING SCIENCE AWARD 2022

Each year the IEEE hands over several highly regarded awards in the field of medical physics, including the Bruce H Hasegawa Young Investigator Medical Imaging Science Award. Fernando Hueso's work focuses primarily on improving the precision with which proton therapy cancer treatments are administered. More information here.

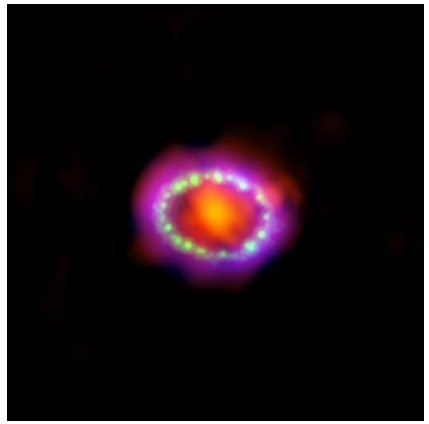
2 HIGHLIGHTS OF THE YEAR

DISMANTLING OF THE ANTARES NEUTRINO TELESCOPE

After more tan a decade of operation, the ANTARES neutrino telescope was dismantled. During all these years, ANTARES has provided a rich harvest of scientific results on many topics related to neutrino astronomy (including multi-messenger studies) and particle physics (dark matter searches and neutrino properties). More information here.

NOVEL TECHNIQUE TO MEASURE THE ABSOLUTE MASS OF NEUTRINOS

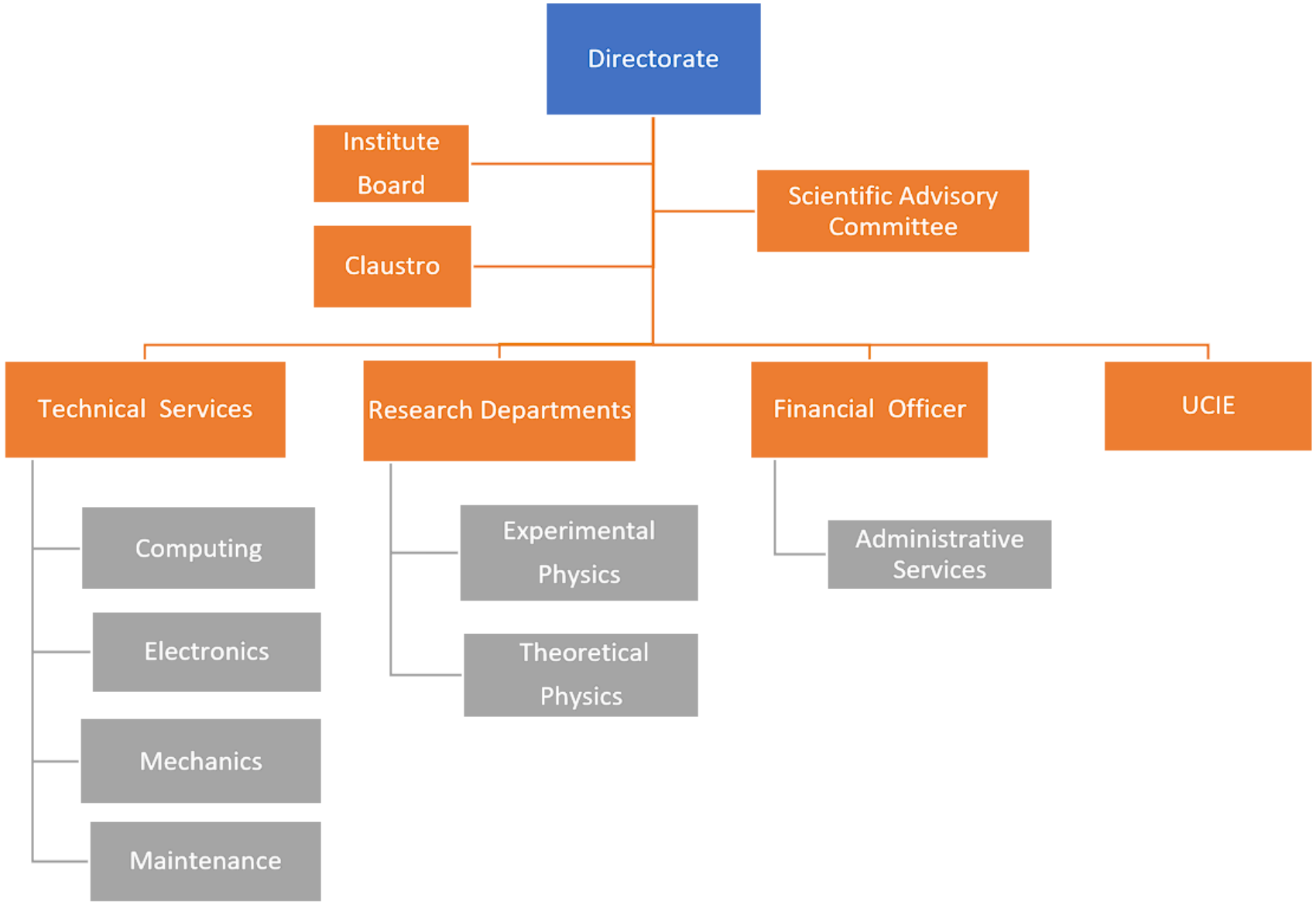
An IFIC team proposes that supernovae may be a source for determining the mass of neutrinos. This is explained in a study published in the journal Physical Review Letters. Experimental confirmation of the proposal could be carried out within the framework of the international collaboration DUNE (Deep Underground Neutrino Experiment). More information here.



3

STRUCTURE AND ORGANIZATION

3 IFIC STRUCTURE



3 STRUCTURE


Deputy Director
José E. García
Deputy Director
Berta Rubio
Manager
Ana Fandos
Deputy Director
Michel Sorel
Director
Nuria Rius

3 STRUCTURE

Heads of the research departments

- Experimental Physics — Luca Fiorini
- Theoretical Physics — Luis Álvarez

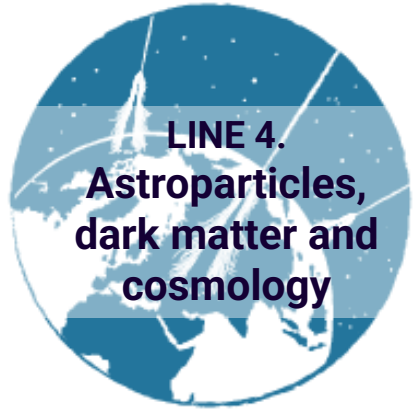
Personnel representatives

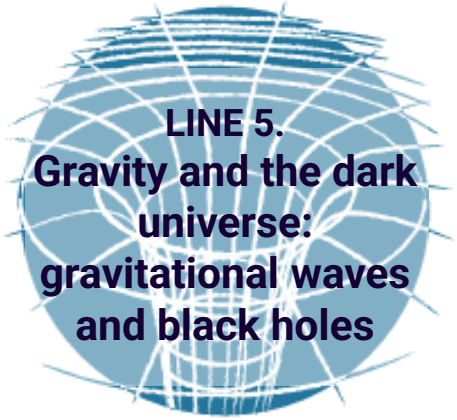
- Non-PhD members — Teresa Cámara
- PhD members — Martín González

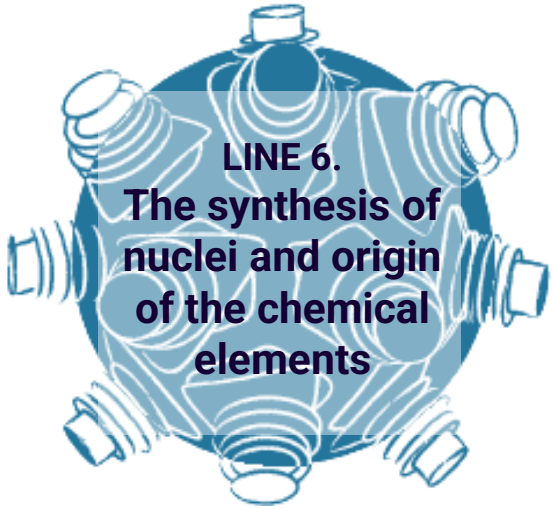
International Scientific Advisory Committee

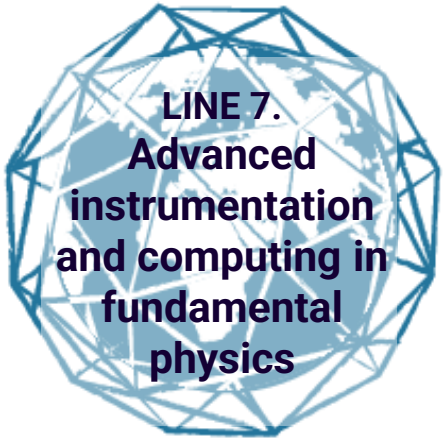
> Gustavo C Branco (CFTP/IST, Univ. Lisbon, Portugal)
> William Gelletly (Univ. Surrey, UK)
> Francis Halzen (Univ. Wisconsin, USA)
> Cecilia Jarlskog (Univ. Lund, Sweden)
> Manuella Vincter (Univ. Carleton, Canada, and CERN)
> Antonio Masiero (INFN and Univ. Padua, Italy)
> Tatsuya Nakada (EPFL Lausanne, Switzerland)
> Bing-Song Zou (ITP, Chinese Academy of Sciences, China)

RESEARCH LINES



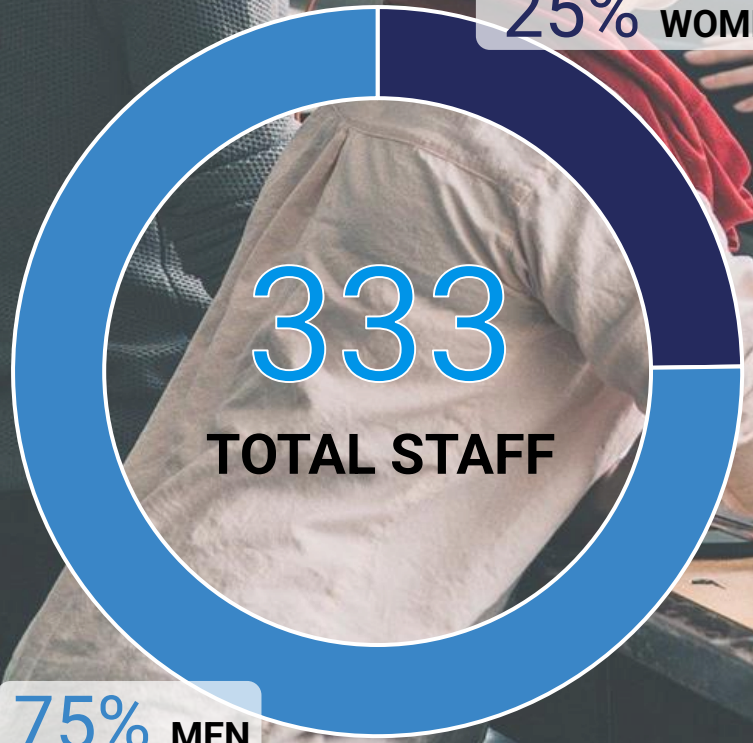






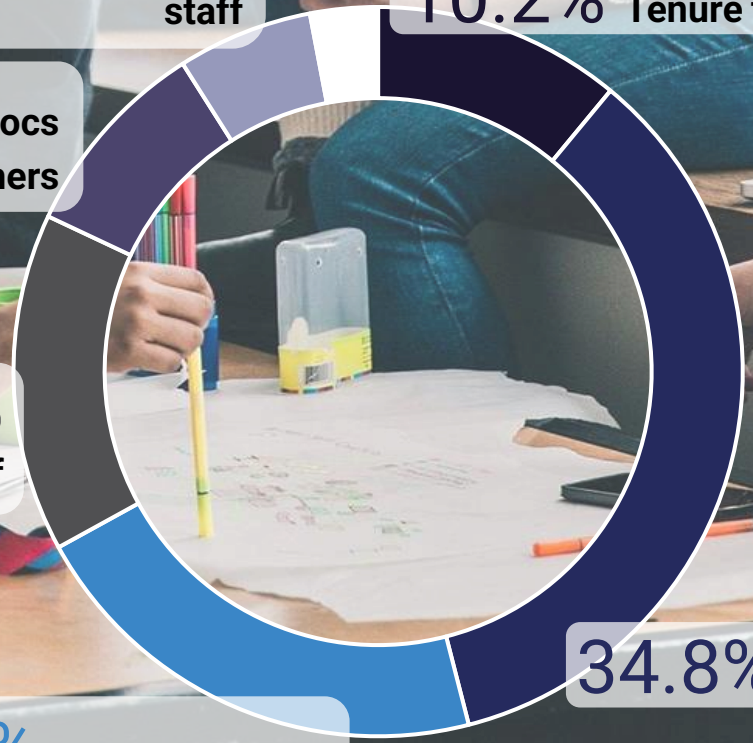
3 PERSONNEL

DECEMBER 2022



25% **WOMEN**

75% **MEN**



6.3% **Administrative staff**

2.4% **Professors emeriti and visiting researchers**

10.2% **Tenure track researchers**

9.6% **Post-docs researchers**

15.3% **Technical staff**

34.8% **PhD Students**

21.3% **Permanent staff researchers**

Personnel list

4

SCIENTIFIC PRODUCTION

4 SCIENTIFIC OUTCOME

ARTICLES IN INDEXED JOURNALS 370*

(ONLY DOCUMENT TYPE ARTICLE OR REVIEW). SEE ANNEX FOR FULL LIST OF PUBLICATIONS

86% **IN FIRST QUARTILE JOURNALS**

(JCR-WoS OR CITESCORE-SCOPUS, 2022)

TOP 5 JOURNALS
(BY IMPACT FACTOR, JCR-WoS) WITH IFIC AUTHORS

Nature (IF 64.8)	2
Nature Physics (IF 19.6)	3
Science Bulletin (IF 18.9)	1
Reports on Progress in Physics (IF 18.1)	2
Nature Communications (IF 16.6)	1

TOP 5 JOURNALS
(BY NUMBER OF PAPERS) WITH IFIC AUTHORS

76	Physical Review D (IF 5.0)
56	Journal of High Energy Physics (IF 5.4)
51	European Physical Journal C (IF 4.4)
20	Physical Review Letters (IF 8.6)
17	J. Cosmology & Astroparticle Physics (IF 6.4)

*The reduction in articles compared to previous years is due to the suspension of publications from the four largest LHC experiments (including ATLAS and LHCb) in March 2022, due to lack of agreement on how to list Russian and Belarusian scientists and institutes after the Russian invasion of Ukraine.

Full list of publications

4 CONFERENCES, WORKSHOPS, SEMINARS AND COLLOQUIA

CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS	CONFERENCES AND WORKSHOPS ORGANIZED	COLLOQUIA ORGANIZED	SEMINARS ORGANIZED
454	14	7	79

Full list of events

4.1 CONFERENCES AND WORKSHOPS

CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS

NATIONAL AND INTERNATIONAL CONFERENCES

IFIC researchers present their results in the main international conferences and workshops. A total of 454 contributions were presented in 2022: 416 talks (42 invited, 153 plenary) and 38 posters.

454

CONFERENCES AND WORKSHOPS ORGANIZED

IFIC members have organized 14 conferences and workshops during 2022. The full listing can be found in Annex 3.

14

Full list of events

4.2 COLLOQUIA

'SEVERO OCHOA' COLLOQUIA ORGANIZED

The colloquium series "Severo Ochoa" invites world leading experts in their area of science. Lectures are primarily devoted to particle, astroparticle and nuclear physics, but also explore other areas. Colloquia are open to scientists, personnel and students of other research institutes and science faculties. The outreach department shares recordings of the lectures on the institute's YouTube channel. In 2022, IFIC celebrated 7 Severo Ochoa Colloquia. The listing can be found in Annex 4. Organisers: Alejandro Algora, Sergio Palomares Ruiz and Marcel Vos.

7

Full list of events

4.3 SEMINARS

SEMINARS ORGANIZED

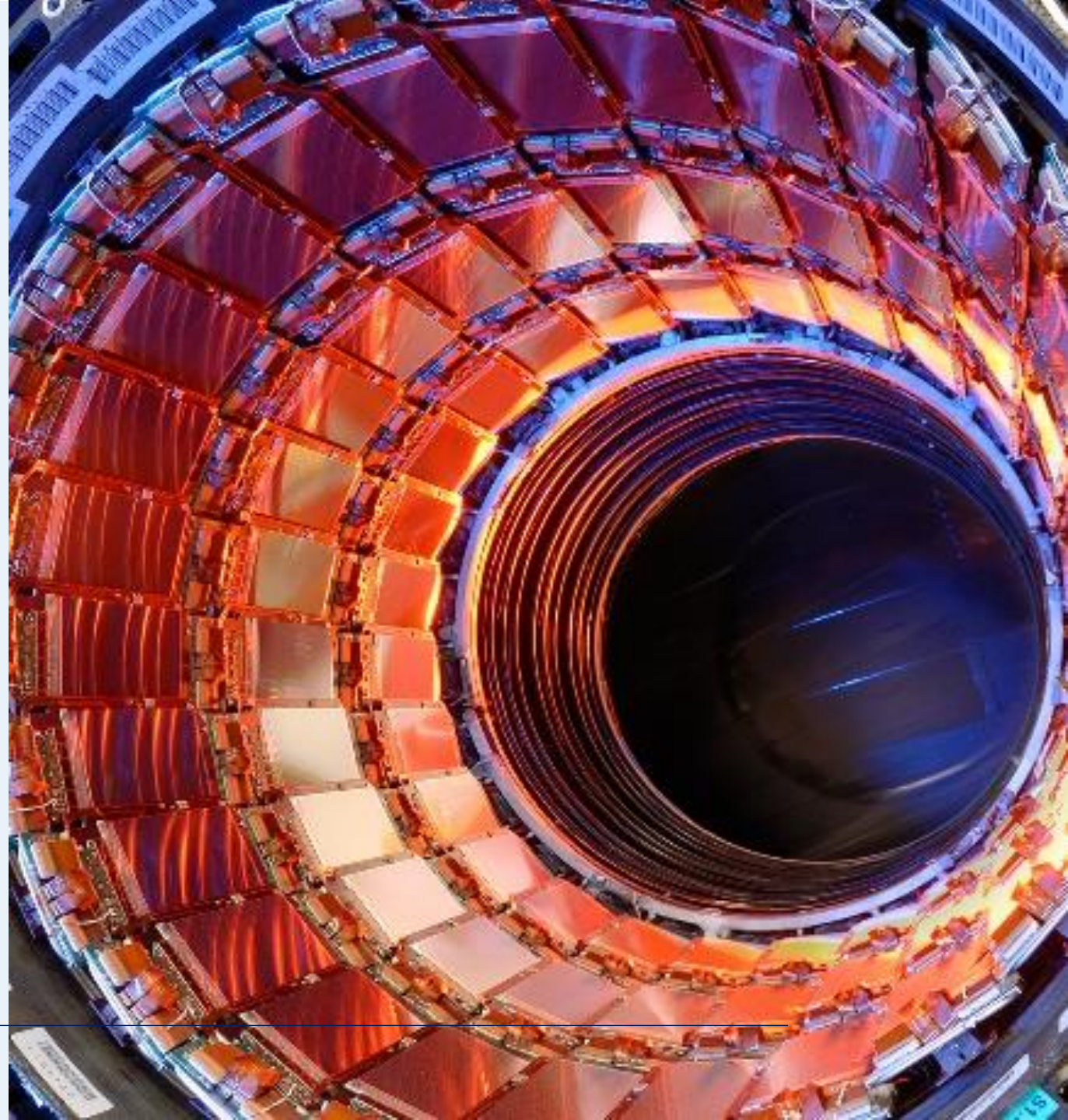
Seminars are more specific research talks given by an invited speaker, usually connected to one of the IFIC research groups. Some of them are more informal talks followed by a discussion session, such as those within the Student Seminars series. In 2022 we hosted a total of 79 seminars, including 16 student seminars. The complete list can be found in Annex 5. Organisers: Josu Cantero, Leandro Cieri, Andrea Donini, Carlos Escobar, Daniel G. Figueroa, Adrián Irles, Jacobo López, Neus López, Laura Molina, Raquel Molina, Miguel Nebot, Sergio Palomares, Avelino Vicente.

79

Full list of events

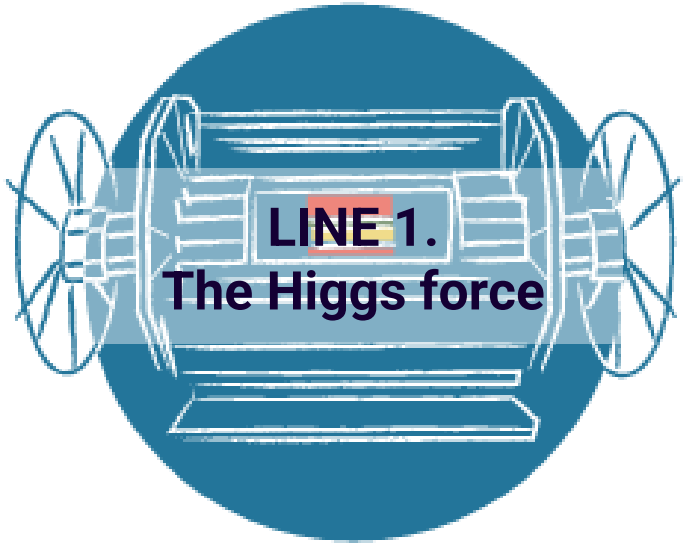
5

RESEARCH REPORT




THE ORIGIN OF MASS

SCIENTIFIC RESEARCH LINES



The goal is to reach a deeper understanding of the Higgs force from LHC Run 3 at CERN with the ATLAS experiment and future colliders. The focus is on the interactions of the Higgs boson and the top quark, novel methodologies and formal developments for beyond state-of-the-art theoretical predictions and phenomenological analysis at higher orders in perturbative quantum field theory, as well as in the theoretical interpretation of the experimental data in terms of effective field theories (SMEFT, HEFT), which contain a large number of parameters and call for innovative methods in parameter fitting, e.g. using Machine Learning techniques. At the same time, this line aims to continue the direct search for new particles at the energy frontier.

5 L1: THE HIGGS FORCE

During 2022, the Large Hadron Collider (LHC) at CERN restarted operations with protons, after a four-years-long shutdown. Operations restarted with collisions at 900 GeV, before quickly ramping-up to collisions at the world record energy in the center of mass of 13.6 TeV. In total, an integrated luminosity of 38.5 fb^{-1} has been delivered to ATLAS (35.7 fb^{-1} recorded). Our activity areas in the ATLAS experiment of the LHC dealt with the restart of the LHC detector operation, trigger, software and computing, while preparing at the same time the phase-II upgrade of the detector for the HL-LHC. We engaged in intense activities related to the physics exploitation of the ATLAS experiment via the data analysis.

ATLAS Operations

The trigger is a key part of the ATLAS experiment, selecting the events that are kept for permanent storage and subsequent physics analysis. During 2022, the IFIC team was in charge of the ATLAS trigger system. The system faced great challenges to quickly adapt to varying beam conditions and a quick luminosity ramp-up, characterized by a high number of concurrent interactions per bunch crossing.

The IFIC team was in charge of the operations of the ATLAS Tile Calorimeter during 2022 with Run Coordination responsibilities. The fraction of active cells of the calorimeter has been better or around 99% during the whole year. One of the calorimeter modules was equipped with the so-called “demonstrator”, a prototype which operates with Phase-II electronics, but it also provides signals compatible with the present read-out and trigger system. The demonstrator worked correctly during the 2022 data-taking and proved the reliability of the future Phase-II electronics.

We participated as well in the operations of the inner tracker of the ATLAS detector. The semiconductor tracker (SCT) operated smoothly with high hit efficiency, ending 2022 with 98.3% of all strips active. The depletion voltage and leakage current of the SCT followed the expected model.

Our group plays a leading role in the electron, photon and tau lepton performance studies in ATLAS. During the first half of 2022, IFIC members coordinated the ATLAS e/gamma group. Among other areas, we contribute to the deployment of the algorithms for the alignment of the inner detector, as well as the reconstruction and identification of leptons (muons, electrons and tau-leptons) within the ATLAS experiment software.

Precision measurements Higgs/Top

IFIC has greatly contributed to the analysis of the LHC proton-proton collisions data. The year 2022 marked the 10th anniversary of the discovery of the Higgs boson by the ATLAS and CMS experiments. ATLAS published “a detailed map of Higgs boson interactions ten years after the discovery” [P3], which provides the state of the art in the knowledge of the properties of the Higgs boson and limits on signatures of beyond the Standard Model (BSM) physics.

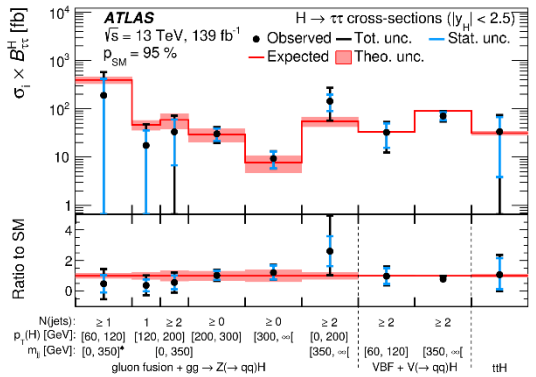
IFIC participated in the precise measurement of the couplings of the Higgs boson to tau fermions (Yukawa coupling), one of the priorities of the LHC physics program and also for our group.

We have been particularly active as well in the measurement of the Higgs boson coupling to top-quarks with the complete dataset accumulated during the Run 2 of the LHC.

Our studies focused on the measurement of the cross-section of the Higgs boson according to the simplified template cross-section (STXS) scheme.

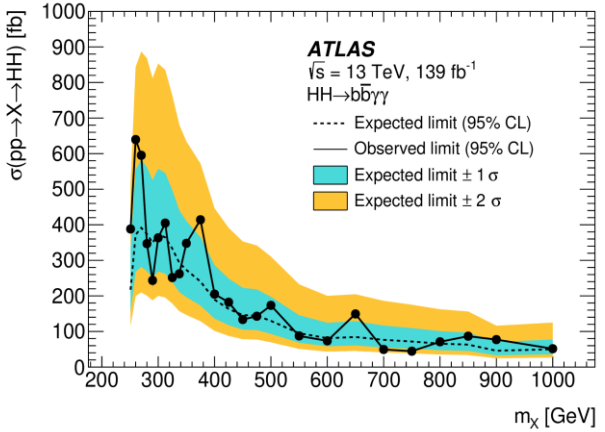
Our contribution focused on the fiducial cross-section measurement of the vector-boson fusion (VBF), where the Higgs boson decay into taus has an excellent sensitivity, and the measurement of the top-quark associated production. The VBF cross-section is measured with a precision better than 15%.

5 L1: THE HIGGS FORCE



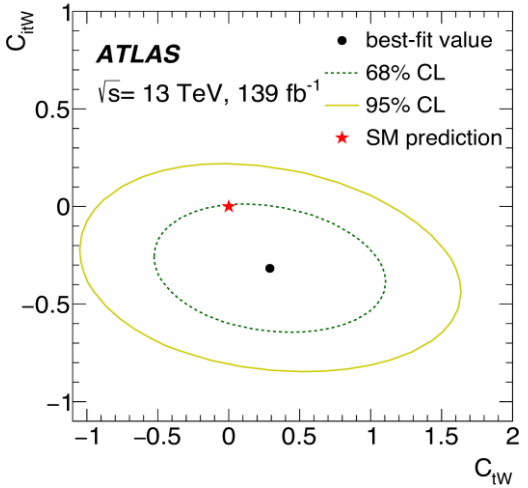
The measured values for σH× B(H→ττ) relative to the SM expectations in the nine fiducial volumes defined in the STXS measurement. Also shown is the result from the combined fit.

IFIC is also involved in the ATLAS searches of the Higgs boson self-coupling. This is one of the most important properties of the Higgs boson, related to the stability of the electro-weak vacuum. This parameter is very hard to measure, because the processes where it contributes have very small probabilities. One of these processes is the production of Higgs boson pairs. IFIC members have been among the main analyzers of the measurement of the Higgs boson pair production into the final states with two bottom quarks and two photons, using the complete Run 2 dataset of the LHC, which is one of the most sensitive channels for di-Higgs production searches. Results include 95% confidence-level upper limits of 4.2 times the cross section predicted by the Standard Model. Limits on resonant production of two Higgs bosons are also produced in the mass range between 251 and 1000 GeV.



Observed and expected limits at 95% CL on the production cross section of a narrow-width scalar resonance X as a function of the mass mX of the hypothetical scalar particle.

Our group also produced the ATLAS measurement of the top quark polarization in single top production at the LHC. This analysis presented a simultaneous measurement of the three components of the top-quark and top-antiquark polarisation vectors in the t-channel single-top-quark production. The analysis used the leptonic decay of the top quarks (either to electrons or muons) and requested large missing transverse momentum and exactly two jets (with one being b-tagged). The top-quark and top-antiquark polarisation vectors were measured from the distributions of the direction cosines of the charged - lepton momentum in the top - quark rest frame. Then, normalised differential cross-sections corrected to a fiducial region at the stable-particle level were presented as a function of the charged-lepton angles for top-quark and top-antiquark events inclusively and separately. These measurements were in agreement with Standard Model predictions but also allowed to perform constraints to the complex Wilson coefficient of the dimension-six tW operator in the framework of an effective field theory (EFT).



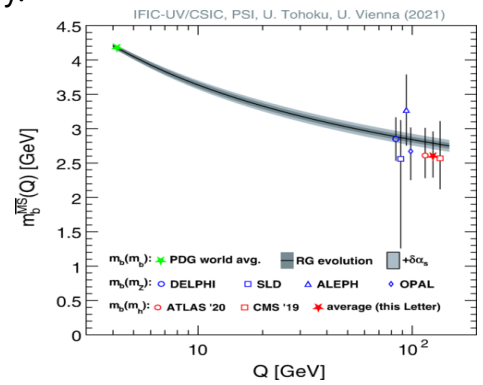
The observed best-fit value (dot) for the Wilson coefficients CtW and CitW with the uncertainty contours at 68% CL (dashed) and 95% CL (solid). The red star indicates the SM prediction.

IFIC researchers produced phenomenological results for ttbar j+X production at the LHC, of interest for designing forthcoming

5 L1: THE HIGGS FORCE

experimental analyses of this process. Reference predictions are produced in the on-shell, MS and MSR top-quark mass renormalization schemes, applying the latter scheme to this process for the first time. These results are particularly important for those analyses aiming at extracting the top-quark mass from cross-section measurements.

IFIC researchers also published the determination of the b quark running mass [P2]. The measurement is performed in the MS scheme at the renormalization scale of the Higgs boson mass from measurements of Higgs boson decay rates at the LHC. The obtained value is $m_b(m_H)$=2.60+0.36−0.31 GeV, which comes with a negligible theory uncertainty and excellent prospects to improve at the HL-LHC and a future Higgs factory.



The scale evolution of the bottom quark MS mass.

Searches Higgs/Top

The discovery of a Higgs boson opens the possibility that new physics (beyond the SM) appears in the Higgs sector. Our researchers are involved in the study of the Higgs sector and greatly contributed to the analysis of the Run 2 data of the LHC.

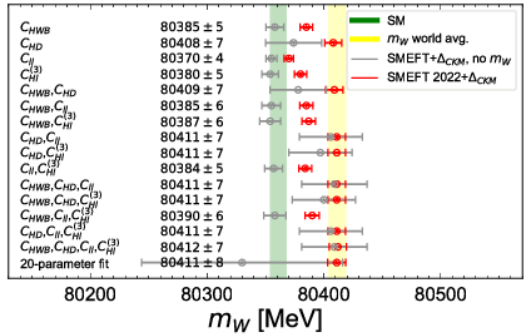
The international community is involved in the study of the prospects of the Higgs boson and Top quark with the High Luminosity LHC (HL-LHC) and with new colliders which will be operating afterwards. Among the prospects for the HL-LHC, the IFIC researchers contributed to the extrapolation of the sensitivities in the H->ττ channel, as well as the search of lepton-flavor violating (LFV) decays of the Higgs boson. The prospects for future colliders have been summarized in the so-called Snowmass documents. IFIC researchers contributed to several reports in 2022 on the ILC, top-quark, electroweak and heavy flavor prospects, as well as searches for LFV phenomena of the tau lepton and for Long Lived Particles.

IFIC was also involved in the improvement of experimental techniques to improve the simulation of additional proton–proton interactions in the ATLAS simulation, by presampling sets of inelastic Monte Carlo (MC) events and reducing the CPU needs for the MC production by around 20%, while reproducing the properties of the reconstructed quantities relevant for physics analyses with good accuracy.

Interpretation of the W-mass anomaly in terms of the SM Effective Field Theory (SMEFT) global fits

We used [P4] our global fit framework, Fitmaker, to incorporate the recent CDF measurement of m_W in a global fit to electroweak, Higgs, and diboson data in the Standard Model Effective Field Theory (SMEFT) including dimension-6 operators at linear order. We found that there are 4 operators which could explain the anomaly and provide a better fit to the data than the SM. We analysed which tree-level single-field extensions of the Standard Model could generate such operator coefficients with the appropriate sign, and discussed the masses and couplings of these fields that best fit the CDF measurement and other data. In particular, the global fit favours either a singlet Z' vector boson, a scalar electroweak triplet with zero hypercharge, or a vector electroweak triplet with unit hypercharge, followed by a singlet heavy neutral lepton, all with masses in the multi-TeV range for unit coupling.

5 L1: THE HIGGS FORCE



Values of m_W in fits including all combinations of operators entering linearly in mW, including from 1 to 4 operator coefficients, as well as a fit to 20 operator coefficients. The vertical green band is the SM prediction for m_W based on other data, and the yellow band is the current world average of m_W measurements.

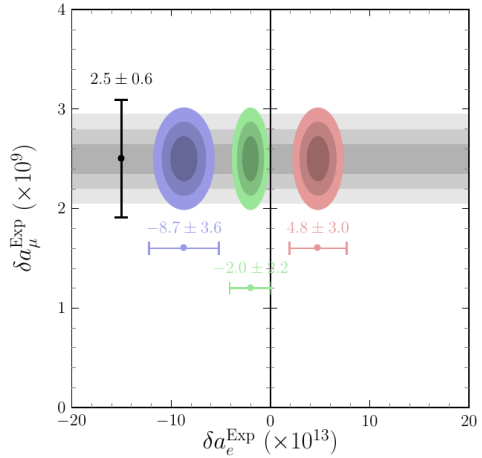
Mapping UV models to the SMEFT

The matching of the SMEFT to UV scenarios is a difficult task and requires the development of new methods to perform a systematic exploration of models. We have developed a diagrammatic technique to construct in an automated way a complete set of possible UV models that can produce specific groups of SMEFT operators. We have illustrated the use of this method by generating models with no tree-level contributions to four-fermion (4F) operators and Dark Matter scenarios. Those scenarios can contain relatively light particles that could be discovered at the LHC in direct searches. For this class of models, we find an interesting interplay between indirect SMEFT and direct searches.

Muon and electron g-2 anomalies in a flavor conserving 2HDM with an oblique view on the CDF Mw value

We considered [P5] a type I or type X two Higgs doublets model with a modified lepton sector. The generalized lepton sector is also flavor conserving, but with the new Yukawa couplings completely decoupled from lepton mass proportionality. The model is one loop stable under renormalization group evolution and it allows to reproduce the g-2 muon anomaly together with the different scenarios one can consider for the electron g-2 anomaly, related to the Cesium and/or to the Rubidium recoil measurements of the fine structure constant. Thorough parameter space analyses are performed to constrain all the model parameters in the different scenarios, either including or not including the recent CDF measurement of the W boson mass. For light new scalars with masses in the 0.2–1.0 TeV range, the muon anomaly receives dominant one loop contributions; it is for heavy new scalars with masses above 1.2 TeV that two loop Barr-Zee diagrams are needed. The electron g-2 anomaly, if any, must always be obtained with the two loop contributions. The final allowed regions are quite sensitive to the assumptions about perturbativity of Yukawa couplings, which influence unexpected observables like the allowed scalar mass ranges.

On that respect, intermediate scalar masses, highly constrained by direct LHC searches, are allowed provided that the new lepton Yukawa couplings are fully scrutinized, including values up to 250 GeV. In the framework of a complete model, fully numerically analysed, we showed the implications of the recent M_W measurement.



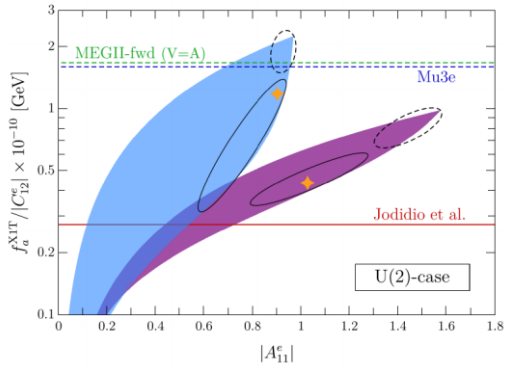
Allowed δa_μ^{Exp} vs. δa_e^{Exp} regions in the different analyses.

Anomaly-free ALP from non-Abelian flavor symmetry

Motivated by the XENON1T excess in electron-recoil measurements, we investigated the prospects of probing axion-like particles (ALP) in lepton flavor violation experiments. In particular, we identify such ALP as a pseudo-Goldstone from the spontaneous breaking of the flavor symmetries that explain the mixing structure of the Standard Model leptons. We present the case of the flavor symmetries

5 L1: THE HIGGS FORCE

being a non-Abelian U(2) and the ALP originating from its U(1) subgroup, which is anomaly – free with the Standard Model group. We build two explicit realistic examples that reproduce leptonic masses and mixings and show that the ALP which is consistent with XENON1T anomaly could be probed by the proposed LFV experiments.



Values of the ALP decay constant compatible with the XENON1T result assuming a U(2)f flavor symmetry in the 12-doublet-case (blue region) and 23-doublet-case (violet region) and Q = −q = 1.

Selected Publications

[P1] V. Miralles, M.M. López, M.M. Llácer, A. Peñuelas, M. Perelló and M. Vos, *The top quark electro-weak couplings after LHC Run 2*,' Journal of High Energy Physics 02 (2022) 032 DOI [arXiv]

[P2] J. Aparisi, J. Fuster, A. Hoang, A. Irles, C. Lepenik, G. Rodrigo, M. Spira, S. Tairafune, M. Vos and H. Yamamoto, et al., *mb at mH: The Running Bottom Quark Mass and the Higgs Boson*, Physical Review Letters 128 (2022) 122001 DOI [arXiv]

[P3] ATLAS Collaboration, *A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery*, Nature 607 (2022) 52-59 [erratum: Nature 612 (2022) E24] DOI [arXiv]

[P4] E. Bagnaschi, J. Ellis, M. Madigan, K. Mimasu, V. Sanz and T. You, *SMEFT analysis of m_W*, Journal of High Energy Physics 08 (2022) 308 DOI [arXiv]

[P5] F.J. Botella, F. Cornet-Gómez, C. Miró and M. Nebot, *Muon and electron g-2 anomalies in a flavor conserving 2HDM with an oblique view on the CDF M_W value*, European Physical Journal C 82 (2022) 915 DOI [arXiv]

Selected Conference Talks

Adrián Irles, *Search for non-Standard Model interactions of the top quark at ILC*, ICHEP 2022. Bologna (Italy)

Verónica Sanz, *New Physics: where do we stand?*, ICHEP 2022. Bologna (Italy)

Paolo Sabatini, ATLAS Inner Detector alignment towards Run 3, Connecting The Dots 2022. Princeton (USA)

Vasiliki Mitsou, *Searches for Supersymmetry with the ATLAS and CMS detectors*, Workshop on Standard Model and Beyond. Corfu (Greece)

Josep Navarro, *Search for invisible particles produced in association with single-top-quarks with the ATLAS detector using Run-2 data*, ICHEP 2022. Bologna (Italy)

Josu Cantero, *Measurements of photons and multijet events with ATLAS*, XI Int. Conference on New Frontiers in Physics. Kolymbari (Greece)

Miguel Villaplana, *Monte Carlo generators for top quark production at the LHC*, 15th Int. Workshop on Top-Quark Physics. Durham (UK)

Fabio Cardillo, *Top quark mass and couplings*, 41st Int. Symposium on Physics in Collision. Tiblisi (Georgia)

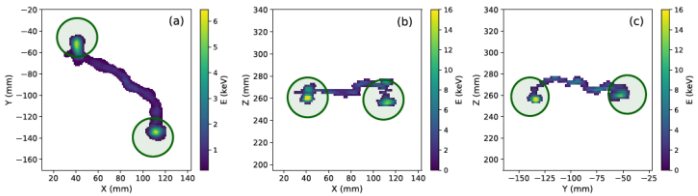
SCIENTIFIC RESEARCH LINES

The aim is to reconstruct the origin of neutrino mass from neutrino properties. The strategic objectives include: A) analyzing upcoming data from current neutrino experiments with IFIC participation (NEXT-100, KM3NeT-ORCA); B) constructing a new detector to measure beta decay spectra shapes to improve the determination of the primary fluxes of reactor neutrinos; C) playing a leading role in the three science pillars of the next-generation neutrino experiment DUNE: long-baseline oscillation physics, detection of astrophysical neutrinos, and new physics searches; D) continuing state-of-the-art global analyses of neutrino and cosmological measurements to pin down neutrino properties and E) continuing to reduce the uncertainties in neutrino-nucleus cross-sections, that are the dominant systematic error in present and future neutrino oscillation experiments.

5 L2: NEUTRINOS AND LEPTON FLAVOUR

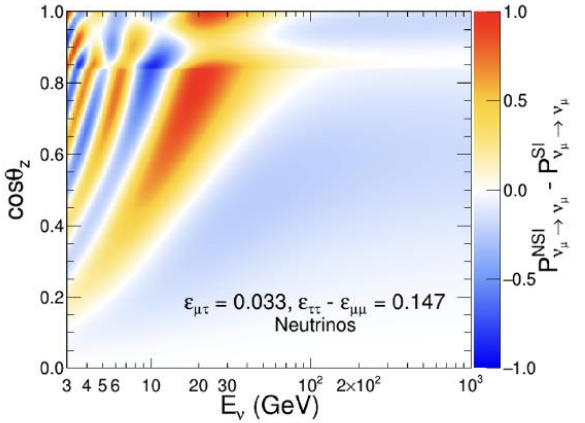
The confirmation that neutrinos are massive has led to spectacular experimental progress in particle physics. This discovery was awarded the Nobel Prize in Physics in 2015 and constitutes a clear deviation from the Standard Model. The research lines of IFIC, a leading institute in both experimental and theoretical neutrino physics, explore the properties of these elusive particles, such as their mass and mixing pattern or the neutrino nature.

IFIC is involved in two long-baseline accelerator neutrino experiments: Tokai to Kamioka (T2K) in Japan and the future Deep Underground Neutrino Experiment (DUNE) in the United States. T2K is a world-leading experiment studying the neutrino mixing pattern and their CP properties, while DUNE is the next generation project. IFIC contributed strongly to the T2K measurements of the neutrino flux and cross sections, as well as the oscillation parameters. Our institute is also involved in the design and construction of the DUNE far detectors and their prototypes at CERN, having important responsibilities at the technical level. IFIC members are also leading some of the physics groups and are developing important analyses as the identification of secondary kaons in the CERN prototypes and its impact on future proton decays searches in the far detectors.



XY, XZ and YZ projections of 3D double-electron tracks measured with the NEXT-White detector.

The discovery of an extremely rare radioactive process, neutrinoless double beta decay ($\beta\beta0\nu$), would prove that neutrinos are Majorana particles, making neutrinos very special particles, "double agents" of the matter and antimatter realm. IFIC is the proponent and a major leader of the Neutrino Experiment with a Xenon TPC (NEXT), that has developed a new technology to search for $\beta\beta0\nu$ using a high pressure ^{136}Xe time projection chamber (TPC), and is the flagship experiment of the national Canfranc Underground Laboratory. Recently, the 5 kg NEXT-White detector successfully completed its physics programme, while the NEXT-100 (100 kg) detector construction will start taking data in 2023. The NEXT collaboration reported in 2022 a measurement of the half-life of the ^{136}Xe two-neutrino double beta decay [1], an analysis that relies on the data collected with the NEXT-White detector (with a fiducial mass of only 3.5 kg of Xe), as well as on the topology of double-electron tracks. The presented technique demonstrates the feasibility of unique background-model-independent neutrinoless double beta decay searches.

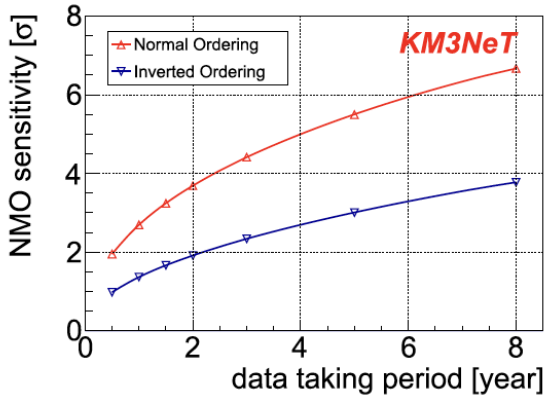


Example of the modifications induced by non-standard neutrino interactions on the disappearance probabilities of muon neutrinos, as a function of the true neutrino energy and cosine of the zenith angle, that can be studied with data from ANTARES.

Neutrinos produced in cosmic-ray showers in the atmosphere have been essential to measure neutrino properties. Data from neutrino telescopes on the highest energy tail of these atmospheric fluxes can be used to study neutrino oscillations or to perform a tomography of the Earth, as proven by IFIC researchers. The Valencia Experimental Group of Astroparticles (VEGA) group, member of the ANTARES and KM3NeT collaborations, has the study of neutrino properties as one of its main research lines. In 2022, after 16 years taking data, the ANTARES telescope definitely stopped and the detector lines were

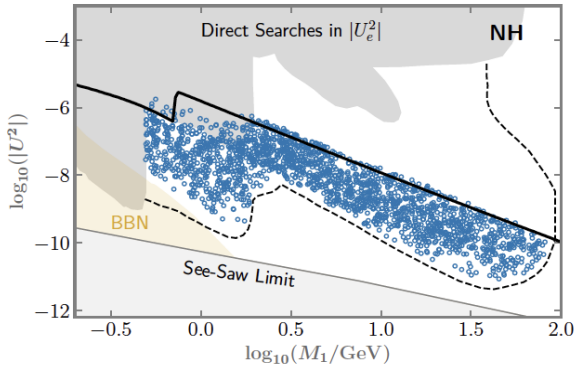
5 L2: NEUTRINOS AND LEPTON FLAVOUR

dismantled, but the analysis of available data have provided many interesting results on neutrino properties, such as the search for non-standard neutrino interactions ([2] and Jerzy Mańczak's PhD thesis). The group also contributes to technical matters in this topic producing the Monte Carlo simulations for neutrino and atmospheric muon background and developing the machine learning algorithm that it is used to identify particles in KM3NeT/ORCA, whose sensitivity to determine the neutrino mass ordering and oscillation parameters was evaluated in [3].



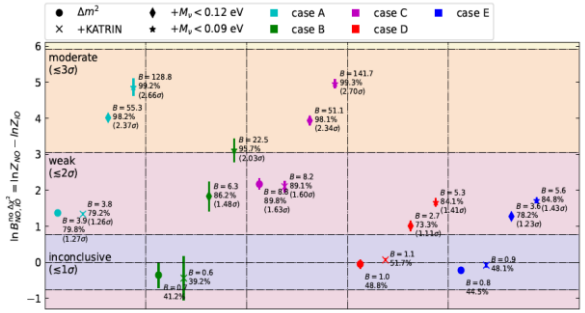
KM3NeT/ORCA sensitivity to the neutrino mass ordering as a function of data taking time for both normal and inverted ordering.

IFIC neutrino theorists are world leaders in exploring the new physics associated with the origin of neutrino mass or in the determination of neutrino properties from all current and upcoming oscillation experiments, as well as complementary observations such as neutrinoless double beta decay results or cosmological data. For instance, the authors of [4] revisit the generation of the cosmological matter-antimatter asymmetry in the minimal extension of the Standard Model with two singlet heavy neutral leptons, that can explain the smallness of neutrino masses.



Region of the parameter space leading to the correct baryon asymmetry of the Universe in a minimal extension of the Standard Model with two singlet heavy neutral leptons.

Neutrinos are the second most abundant of all known particles in the cosmos and, surprisingly, their tiny masses can influence the evolution of our Universe, leaving measurable features in the cosmic microwave background and the distribution of galaxies. In 2022, an analysis claimed that current oscillation, beta decay and cosmological limits on different observables provided a robust decisive Bayesian evidence in favour of the normal ordering of the neutrino mass spectrum. An international team, including IFIC theorists Olga Mena and Mariam Tórtola, quantified in [5] the preference in favour of the normal ordering, while accounting for data from oscillation and beta-decay experiments, as well as from cosmological probes. They found no decisive evidence for the normal mass ordering and described how this kind of analyses must rely on priors and parameterizations that are ordering-agnostic: robust results should be regarded as those in which the preference for the normal neutrino mass ordering is driven exclusively by the data.

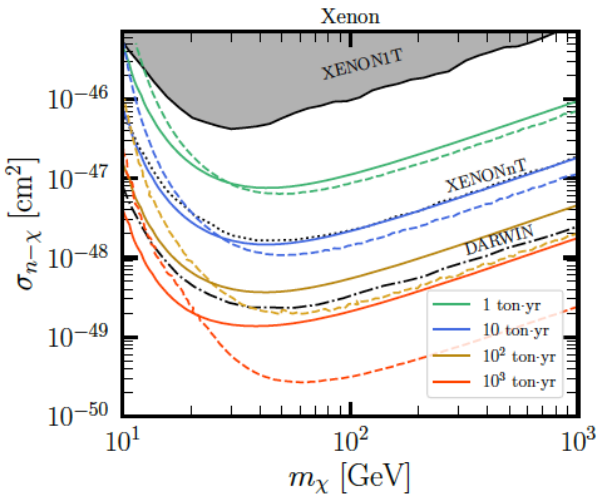


Statistical significance of the preference of one way of ordering neutrino masses (normal) over the other (inverted), using oscillation data alone and in combination with other data sets sensitive to the absolute scale of neutrino masses.

IFIC theorists have also considered the implications for particle physics and astrophysics of coherent elastic neutrino-nucleus scattering (CEvNS), a process first measured in 2017 by the COHERENT

5 L2: NEUTRINOS AND LEPTON FLAVOUR

collaboration. In particular, the interaction of solar and atmospheric neutrinos with the nuclei of a dark matter detector produces an irreducible background, known as neutrino floor. The authors of [6] have analysed the impact of current COHERENT data on the discovery sensitivities of dark matter (of the WIMP kind), of particular interest for future multi-ton detectors such as XENONnT or DARWIN.



WIMP dark matter discovery limits obtained using the CEvNS cross section measurements at COHERENT with the CsI detector.

Selected Publications

[1] NEXT Collaboration, *Measurement of the ^{136}Xe two-neutrino double-beta-decay half-life via direct background subtraction in NEXT*, Physical Review C 105 (2022) 055501 DOI [arXiv]

[2] ANTARES Collaboration, *Search for non-standard neutrino interactions with 10 years of ANTARES data,* Journal of High Energy Physics 07 (2022) 048 DOI [arXiv]

[3] KM3NeT Collaboration, *Determining the neutrino mass ordering and oscillation parameters with KM3NeT/ORCA*, European Physical Journal C 82 (2022) 26 DOI [arXiv]

[4] P. Hernández, J. López-Pavón, N. Rius, S. Sandner, *Bounds on right-handed neutrino parameters from observable leptogenesis*, Journal of High Energy Physics 12 (2022) 012 DOI [arXiv]

[5] S. Gariazzo, O. Mena, M. Tórtola, et al, *Neutrino mass and mass ordering: no conclusive evidence for normal ordering*, Journal of Cosmology and Astroparticle Physics 10 (2022) 010 DOI [arXiv]

[6] D. Aristizábal Sierra, V. De Romeri, L.J. Flores, D.K. Papoulias, *Impact of COHERENT measurements, cross section uncertainties and new interactions on the neutrino floor*, Journal of Cosmology and Astroparticle Physics 01 (2022) 055 DOI [arXiv]

Selected Conference Talks

J.W.F. Valle, *Neutrino theory outlook*, 30th Int. Symposium on Lepton Photon Interactions at High Energies. Online conference

O. Mena, *Non-standard neutrino scenarios and the cosmos*, XXX Int. Conference on Neutrino Physics and Astrophysics (NEUTRINO 2022). Online conference

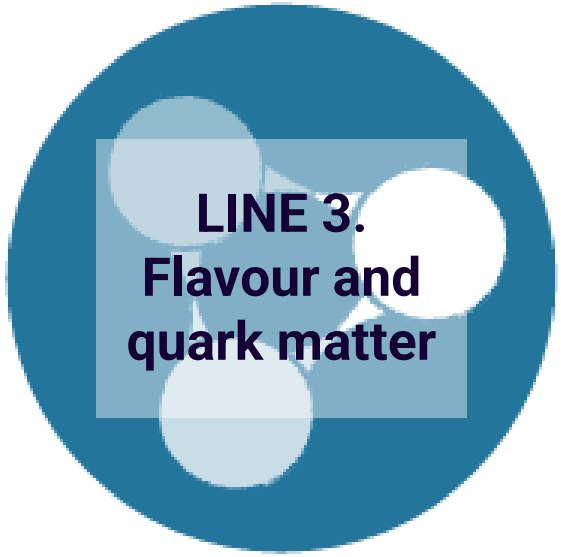
M. Sorel, *Gaseous detectors for neutrinoless double beta decay searches: NEXT and PandaX-III*, XXX Int. Conference on Neutrino Physics and Astrophysics (NEUTRINO 2022). Online conference

L. Álvarez-Ruso, *Neutrino cross sections for future oscillation experiments*, Neutrino Oscillation Workshop (NOW 2022). Ostuni (Italy)

S. Pastor, *Relic neutrino decoupling in some non-standard scenarios*, Current Topics in Astroparticle Physics. Munich (Germany)

G. Barenboim, *Neutrinos at 66*, XIV Latin American Symposium on High Energy Physics (SILAFAE 2022). Quito (Ecuador)

SCIENTIFIC RESEARCH LINES



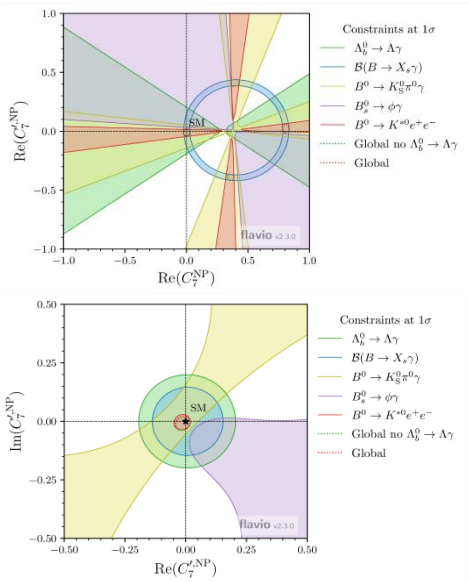
The LHCb and ATLAS teams pursue the exploration of the flavour sector, leading several analyses of LHC Run 3 data at CERN. The IFIC theory team applies non-perturbative approaches to QCD (effective field theories and lattice methods) and exploits the complementarity of flavour and collider physics to constrain beyond the Standard Model scenarios. The LHCb experimental groups in collaboration with the theory team have pioneered a feasibility study to measure electric dipole moments of strange and charmed baryons. The interpretation of the newly discovered exotic resonances as tetra or pentaquark states is an area of very active research. The IFIC team leads a novel approach to use heavy hadron decays as laboratories to do spectroscopic studies of new exotic resonances and search for signatures of possible explanations of the anomalies in the flavour sector, such as Leptoquarks and lepton-flavour-violating decays of heavy particles.

5 L3: FLAVOUR AND QUARK MATTER

Experiment

Experimental efforts on flavour and quark matter are pursued through the involvement of IFIC researchers in two dedicated experiments, LHCb at CERN and Belle II at KEK, and ALTAS, which is also contributing to this research line with key measurements. During 2021 and 2022, the groups have been deeply involved in the detector and data acquisition upgrades and operations, but also in the data analysis exploitation.

The LHCb team has completed and presented new results on radiative b-hadron decays, that occur in the Standard Model via flavour changing neutral currents and are thus sensitive probes for new physics. Exploiting all Run 1 and Run 2 collected data, amounting to 6 /fb, the photon polarization in $b \to s\gamma$ transitions has been measured for the first time in radiative b-baryon decays exploiting the unique spin structure of $\Lambda_b \to \Lambda\gamma$ decays. This new measurement has been used to place constraints on the electromagnetic dipole Wilson coefficients of the effective Hamiltonian of the $b \to s\ \gamma$ transitions, namely $C_7^{(eff)}$ and $C'_7{}^{(eff)}$. This has enabled the experimental exclusion of two solutions with large real values of the two coefficients, which, although phenomenologically unfavoured, were experimentally allowed by all previous measurements. Moreover, its SU(3) partner, the $\Xi_b \to \Xi\gamma$ decay, has been searched for the first time using the same data sample. While no signal is found, stringent limits have been set, which are in slight tension with predictions from light-cone sum rules but are consistent with flavor-symmetry driven predictions. A new measurement of the photon polarization from mixing-induced CP asymmetry of the radiative b-meson decay $B_s \to \phi\gamma$, exploiting the full data set and improved analysis techniques, is also under progress.



Constraints at 68% confidence level on new physics contributions to the (top) left- and right-handed Wilson coefficients, $C_7^{(eff)}$ and $C_7'^{(eff)}$, and on the (bottom) real and imaginary parts of $C_7'^{(eff)}$. The measurements of the inclusive branching fraction, $B(B \to X_s\gamma)$, and the $B^0 \to K^0_S\pi^0\gamma$ mixing-induced CP asymmetry by the Belle and BaBar experiments, are shown in blue and yellow, respectively, the $B^0_s \to \phi\gamma$ and $B^0 \to K^{*0}e+e-$ measurements by the LHCb experiment previously measured are in purple and red, respectively, and the $L_b \to L\gamma$ measurement in green. The global fit is shown in dashed red (green) lines including (excluding) this measurement.

The team has also been investing and mastering in experimental studies of production polarization and decay properties of charm baryons in multihadronic decays with either a proton or a hyperon in the final state, sensitive to nonperturbative QCD and new physics effects. These uncharted measurements offer also a tool for new physics studies with b-hadron and other decays. Several data analyses are on going, some of which have been completed and released during 2022 (published in 2023). A main result has been the measurement, through an amplitude analysis, of the complex dynamical structure of the dominant hadronic mode of the most abundant charm baryon, the L_c^+, and the first measurement of its polarization in semileptonic b-hadron decays.

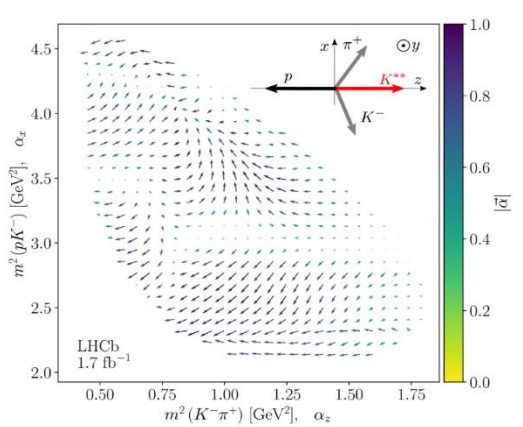


Figure: Aligned polarimeter vector field encapsulating the effective, parity-violating decay parameters of the $L_c^+ \to pK^-p^+$ decay, the dominant hadronic mode of the most abundant charm baryon, as a function of the Dalitz-plot coordinates. The z and x components of the α vector are shown by the horizontal and vertical projections of the arrow, respectively, and the colour indicates its length. The sketch in the top right corner shows the decay-plane orientation.

5 L3: FLAVOUR AND QUARK MATTER

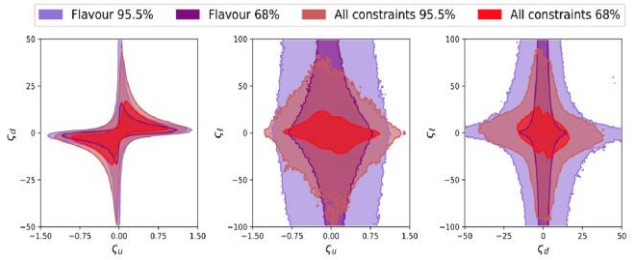
IFIC researchers have been strongly involved in the LHCb RTA project, aiming at a pioneering implementation of a two-stage, fully software-based trigger and real-time processing of LHCb's data for Run 3 and beyond. Together with the upgraded electronics and replaced subsystems, this provides a factor of five higher luminosity compared to Run 2. The team has been playing a leading role in signatures of long-lived particles (LLPs), as well as the physics opportunities within and beyond the Standard Model that these could bring in the next few years.

The ATLAS team improved the searches for lepton flavour violating Higgs decays including new techniques and the full Run 2 dataset. The analysis achieved the best sensitivity for the search of $H \to e\tau$ and $H \to \mu\tau$ decays, which would imply the existence of non-zero off-diagonal terms in the Yukawa coupling matrix. A small excess was observed, which evolution with Run 3 data will be carefully analysed. The group has started the search for new particles predicted by models that could explain the observed B-anomalies, in particular leptoquarks in final states with tau - leptons and b-jets, with preliminary results shown at conferences. The team pursues the exploration of new sources of CP violation in the Higgs interactions, following the work pioneered in 2020, and in top interactions, where a new result has been provided probing the Wtb vertex. It corresponds to the first measurement of the three top quark polarization components in the single top t-channel electroweak production, leading to the strongest direct constraints in the complex phase of the tWb dipole operator. In addition, the CP nature of the top-Higgs Yukawa coupling has been probed in ttH and tH events using the $H \to bb$ channel for the first time. This result further expands the ways to study the Yukawa coupling of the Higgs boson to the top-quark.

Theory and phenomenology

IFIC theorists have made leading contributions to different aspects of flavour and hadronic physics. We have written the review on “Tests of Conservation Laws”, included in the 2022 “Review of Particle Physics” (Particle Data Group). The so-called flavour, g-2 and M_W anomalies have been thoroughly analysed within several new-physics scenarios, such as leptoquarks, two-Higgs doublet models or vector-like fermions; additional observables able to disentangle the different possibilities have been studied.

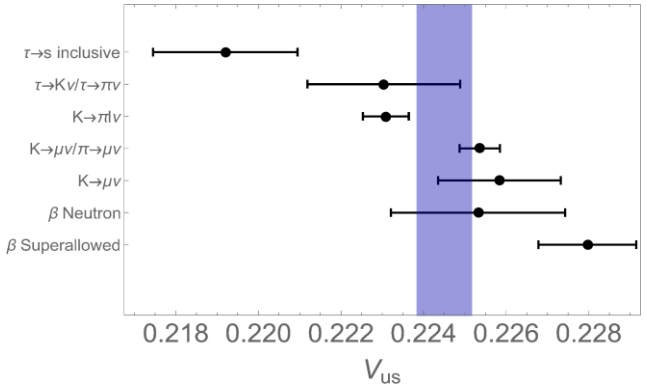
Strategies to unveil hidden beyond-Standard-Model (BSM) signatures in the LHC data have been investigated in detail. The impact of flavour and collider data on scalar extensions (both with and without colour) of the Standard Model has been also investigated through global fits, using the HEPfit package.



Constraints on the alignment parameters that characterize the Yukawa couplings of the Aligned Two-Higgs-Doublet model from a global fit with/without flavour observables.

Using effective field theory techniques, an extensive analysis of semileptonic tau decay data has been performed in order to extract phenomenological constraints on generic models of new physics. Together with previous analyses of other low-energy observables (nuclear beta, baryon, pion and kaon decay data), it provides a comprehensive and model-independent description of new physics hints in the combined dataset. Special attention has been devoted to the so-called Cabibbo anomaly in the V_{ud} and V_{us} determinations, and its possible new-physics interpretations.

5 L3: FLAVOUR AND QUARK MATTER

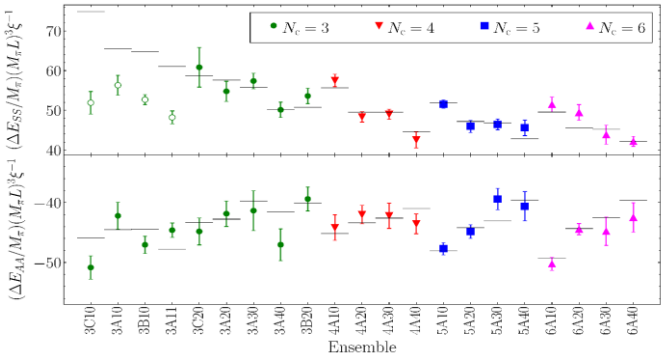


Determinations of V_{us} within the Standard Model.

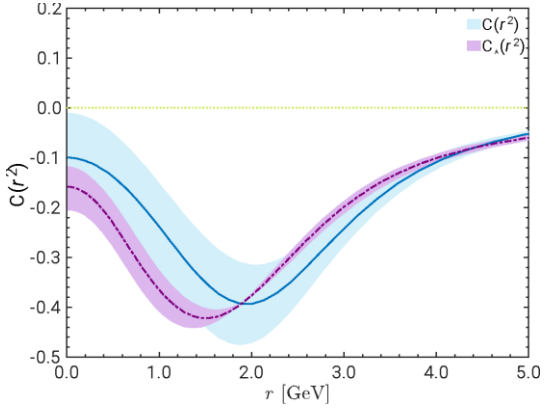
The use of extra space-time dimensions provides a promising approach to the flavour problem. A model introduced by IFIC researchers makes use of a 6-dimensional orbifold construction to make interesting predictions for quark and lepton masses and mixings, for neutrino oscillations and neutrinoless double beta decay, providing also a very good global description of all flavour observables.

On the QCD side, we have been actively studying several different aspects of numerical strong interactions. Thus, we have significantly collaborated on the results presented in the FLAG 2021 Review that collect relevant Lattice Field Theory updates useful for phenomenology of strong and electro-weak interactions. In particular, we have contributed to the derivation of the present lattice world average for α_s and the B_K parameter. Another significant result is the development of a modification of the HMC algorithm that may sample satisfactorily the different topological sectors of the QCD action. We have also studied two-pions scattering at large N_c in lattice QCD with $N_f = 4$, focusing on two particular channels: the fully symmetric SS channel (isospin-2) and the antisymmetric one in both quark and antiquarks, denoted as AA. The latter channel is attractive and it could display a resonance which might be interpreted as a tetraquark candidate. Both the SS and the AA channel results have been compared with Chiral Perturbation Theory (ChPT), finding nice agreement with leading N_c expectations.

The synergy between lattice simulations and continuum methods, Schwinger-Dyson equations in particular, has been exploited to explore nonperturbative properties of the fundamental form factors of the three-gluon vertex and to exhibit the emergence of a mass gap in the gauge sector of QCD. The old controversy on the role of duality violations inlow-energy determinations of the strong coupling has been also clarified with an exhaustive analysis of tau decay data.



Results for the simultaneous chiral and N_c fit of the energy shifts for both SS (top) and AA (bottom) channels. Lattice results for different N_c values are depicted as points.

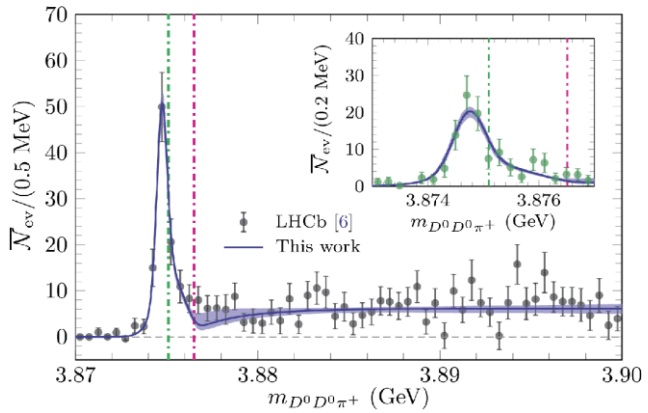


Displacement function $C(r^2)$ that signals the action of the Schwinger mechanism in QCD and its subsequent dynamical gluon mass generation obtained from (i) the Slavnov-Taylor identity using the lattice results as inputs (solid blue) and (ii) the Bethe-Salpeter equation describing the formation of massless poles (purple dot-dashed).

5 L3: FLAVOUR AND QUARK MATTER

The activity related to exotic states dynamically generated from the interaction of pairs of charmed heavy-light mesons $(D_{(s)}, D^*_{(s)}, \underline{D}_{(s)}, \underline{D}^*_{(s)})$ has been intense, triggered by the discovery of new states by the BES and LHCb collaborations. We highlight the evidence reported by BES in 2020 of a peak, which could be interpreted as strange hidden-charm tetraquark state $Z_{cs}(3985)$. We presented in 2021 a successful combined analysis of the BES data for both the $Z_c(3900)$ and $Z_{cs}(3985)$, assuming that the latter is an SU(3) flavor partner of the former one. This latter work, together with the experimental evidences of the $X(3960)$ in the Summer of 2022, triggered a new study, where we established the heavy quark spin and light flavor molecular multiplets of the $X(3872)$, $Z_c(3900)$ and $X(3960)$ exotic states. Of also special relevance for the field was the discovery in Summer 2021 of a charged tetraquark state (T_{cc}^+) by the LHCb Collaboration. We have significantly contributed to the discussion on the interpretation of both the T_{cc}^+ and of the mass distribution reported by LHCb, and predicted spin and flavor (light and heavy) symmetry partners of this exotic state. In the context of the possible molecular picture for the T_{cc}^+, we have also reanalyzed the relation of scattering length and effective range parameters with the compositeness of a S-wave weakly bound state.

We have also made progress in the understanding of electroweak properties of hadrons and electroweak interactions on strong interacting systems using effective field theories and phenomenology. These studies are relevant to unravel the structure of QCD in the non-perturbative regime and as an input for the neutrino physics experimental program. We have investigated the light-quarkmass dependence of the nucleon axial isovector charge, showing the relevance of the Δ(1232) to describe the trend exhibited by recent state-of-the-art lattice QCD (LQCD) results and extracting relevant low-energy constants in a model independent way.



$D^0D^0\pi^0$ spectrum showing the prominent T_{cc}^+ signal. The data come from the LHCb collaboration and the theoretical curve is calculated in M. Albaladejo, Phys. Lett. B B 829 (2022) 137052.

Selected Publications

[1] LHCb Collaboration, Measurement of the photon polarization in $\Lambda^0_b \to \Lambda\gamma$ decays, Physical Review D 105 (2022) L051104 DOI [arXiv]

[2] LHCb Collaboration, *Amplitude analysis of the $\Lambda^+_c \to pK^-\pi^+$ decay and Λ^+_c baryon pola-rization measurement in semileptonic beauty hadron decays*, Physical Review D 108 (2023) 012023 DOI [arXiv] and Journal of High Energy Physics 07 (2023) 228 DOI [arXiv]

[3] M. Borsato et al., *Unleashing the full power of LHCb to probe stealth new physics*, Reports on Progress in Physics 85 (2022) 024201 DOI [arXiv]

[4] ATLAS Collaboration, *Measurement of the polarisation of single top quarks and antiquarks produced in the t-channel at √s=13 TeV and bounds on the tWb dipole operator from the ATLAS experiment*, Journal of High Energy Physics 11 (2022) 040 DOI [arXiv]

[5] V. Cirigliano, D. Díaz-Calderón, A. Falkowski, M. González-Alonso, A. Rodríguez-Sánchez, *Semileptonic tau decays beyond the Standard Model*, Journal of High Energy Physics 04 (2022) 152 DOI [arXiv]

[6] A. Pich, M. Ramsey-Musolf, *Tests of Conservation Laws*, in Review of Particle Physics (Particle Data Group), PTEP 2022 (2022) 083C01 DOI [PDG]

5 L3: FLAVOUR AND QUARK MATTER

[7] O. Eberhardt, A. Peñuelas Martínez, A. Pich, *Global fits in the Aligned Two-Higgs-Doublet model*, Journal of High Energy Physics 05 (2021) 005 DOI [arXiv]

[8] F.J. de Anda, O. Medina, J.W.F. Valle, C.A. Vaquera-Araujo, *Scotogenic Majorana neutrino masses in a predictive orbifold theory of flavor*, Physical Review D 105 (2022) 055030 DOI [arXiv]

[9] D. Albandea, P. Hernández, A. Ramos, F. Romero-López, *Topological sampling through windings*, European Physical Journal C 81 (2021) 873 DOI [arXiv]

[10] M. Albaladejo, *T^{+}_{cc} coupled channel analysis and predictions*, Physics Letters B 829 (2022) 137052 DOI [arXiv]

[11] J. Papavassiliou, *Emergence of mass in the gauge sector of QCD*, Chinese Physics C 46 (2022) 112001 DOI [arXiv]

Selected Conference Talks

A. Oyanguren, *Overview of LHCb recent results*, 2021 School on the Physics of Baryons. Online event

M. Nebot Gómez, *Lepton g−2 anomalies in general flavour conserving two Higgs doublets models*, 7th Symposium on Prospects in the Physics of Discrete Symmetries (DISCRETE 2020-21). Bergen (Norway)

J. Ruiz-Vidal, *CP violation and mixing in charm at LHCb*, 30th Int. Symposium on Lepton Photon Interactions at High Energies. Online conference

I. Sanderswood, *Expanding physics reach with unused tracks in LHCb*, Connecting The Dots 2022. Princeton (USA)

M. Miralles López, *Search for the leptonic charge asymmetry of top-quark–antiquark pair production in association with a W boson with ATLAS*, 15th Int. Workshop on Top-Quark Physics. Durham (UK)

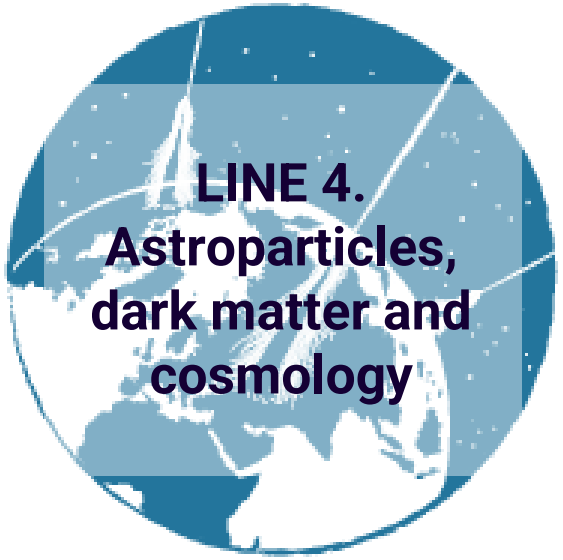
K. Amos, *Search for Lepton-Flavour-Violating Decays of the Higgs Boson*, Higgs 2022. Pisa (Italy)

L. Vale Silva, *Direct CP Violation in hadronic two-body charm-meson decays*, ICHEP 2022. Bologna (Italy)

J. Baeza-Ballesteros, *$\pi\pi$ scattering at large N_c*, 38th International Symposium of Lattice Field Theory (LATTICE 2021), Online conference


THE ORIGIN OF
MATTER

SCIENTIFIC RESEARCH LINES



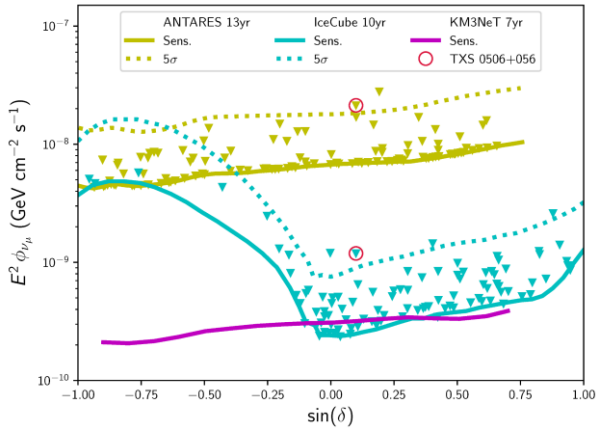
The origin of the matter-antimatter asymmetry in the universe remains an open question. New sources of CP violation are searched for at the LHC by the ATLAS team, with a focus in the top-higgs sector. On the other hand, the baryon imbalance may be induced by a lepton asymmetry (leptogenesis). Inputs from collider searches, from neutrino oscillation experiments, as well as from neutrinoless double-beta decay searches are used to test these scenarios. In the coming years, important new results are expected in the search for dark matter (DM). IFIC experimental astroparticle group plays a leading role in indirect DM searches within the KM3NeT-ARCA project. On the other hand, the ATLAS team leads the search for DM that couples preferentially to the top quark. The IFIC theory team develops global fits to test DM models exploiting the complementarity of DM, colliders and cosmological measurements. We are involved in the search for axions with BayIAXO and RADES. The recently inaugurated multi-messenger astronomy offers new opportunities to explore transient sources in the Universe, such as the collisions of neutron stars or black holes. IFIC plays a leading role in these searches within the ARCA project.

5 L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY

The research topics of this line include cosmic messengers, especially cosmic neutrinos, dark matter searches and cosmology. IFIC participates in various international collaborations, such as ANTARES/KM3NeT, ATLAS, LHCb, MAPP-MoEDAL, NA64, RAD.ES, babyIAXO and CADEx, it is involved in the future project MATHUSLA, and has an active theory group.

ANTARES/KM3NeT

During 2022, the ANTARES neutrino telescope was dismantled after more than a decade of fruitful data taking, which yielded a rich harvest of scientific results on many topics related to neutrino astronomy and particle physics [P1]. In the meantime, new lines of the KM3NeT detector have been installed and are providing data. The year 2022 marked significant advancements in the global context of neutrino astronomy. Towards the end of the year, the IceCube Collaboration published in Science the second evidence (more than 4σ) of a source of cosmic neutrinos, the galaxy M77. The search for cosmic neutrino sources is one of the main topics of the VEGA group at IFIC [C1]. During 2022 members of the group have been preparing the analysis of the final ANTARES dataset, which includes data up to February 2022, when ANTARES ceased operations. Additionally, the study of the prospects for KM3NeT are on-going. Multi-messenger searches have been one of the main topics of the group, which included the follow-up of interesting alerts using ANTARES data and the first analyses with KM3NeT data.



Differential energy flux sensitivity curves as a function of the declination from current neutrino telescopes with flux upper limits for individual source candidates.

Dark matter is also one of the main research topics for ANTARES and KM3NeT. The first searches for neutrinos from dark matter annihilation have been performed with both KM3NeT telescopes ARCA and ORCA, whose coverage has topped the effective area of ANTARES. ANTARES has published its new results on searches for secluded dark matter in the Galactic Centre (JCAP 06 (2022) 028). This analysis was led by R. Gozzini, new CIDEGENT researcher.

ATLAS and MATHUSLA

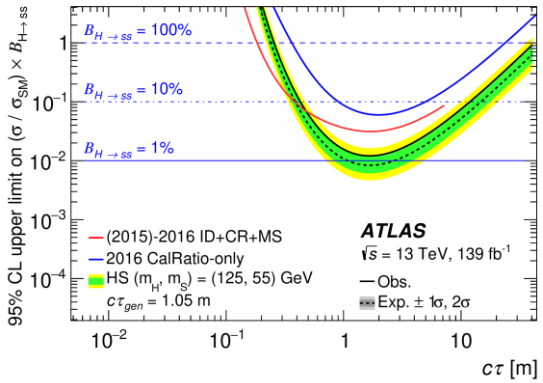
During 2022, the ANTARES neutrino telescope was dismantled after more than a decade of fruitful data taking, which yielded a rich harvest of scientific results on many topics related to neutrino astronomy and particle physics [P1]. In the meantime, new lines of the KM3NeT detector have

The IFIC ATLAS team has led searches for CP violation in top and Higgs interactions and constraints on the Higgs self-coupling that encodes properties of the electroweak phase transition, inputs which could be important in the context of understanding the matter-antimatter asymmetry in the Universe.

They are also focused on the search for dark matter produced in association with a top quark and are also leading dedicated searches for long-lived particles. IFIC is also strongly involved in searches for supersymmetric particles, looking for features in the two opposite-sign lepton invariant mass spectrum, an idea initiated by IFIC with the 8 TeV data. Some of the 2022 highlights are: searches using events with a single top quark and an energetic W-boson; searches for events with one top quark and missing transverse momentum in the final state; searches for displaced jets in the ATLAS calorimeter, which could arise in any BSM scenario where a neutral long-lived particle decays hadronically after passing the ATLAS inner detector.

5 L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY

In parallel, the exploration of these same benchmark models is the goal of the MATHUSLA experiment [C2], a new proposed detector to be built on the surface above CMS for the search of ultra-long-lived particles in the HL-LHC phase. IFIC has participated in this project since 2020, mainly in the study of the potential backgrounds that MATHUSLA will have to deal with. The latest update can be found in arXiv:2203.08126 [hep-ex].



Latest results in the search for displaced jets in the ATLAS Calorimeter. Regions in the Higgs branching fraction to a pair of long-lived neutral scalars versus cτ plane excluded at 95% CL

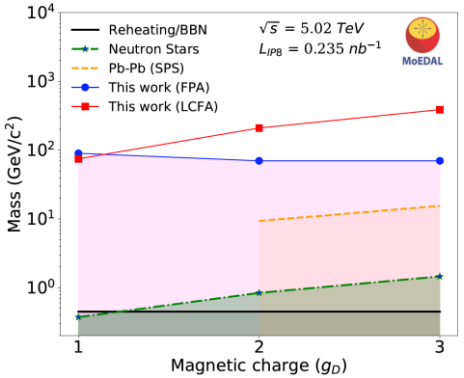
LHCb

LHCb also has a program to search for long-lived particles of a dark sector, with the focus on improving the trigger capabilities of the detector by adapting algorithms to increase their capabilities to select the data of interest (Front. Big Data 5 (2022) 1008737).

MAPP-MoEDAL

IFIC has a strong participation in MoEDAL, an experiment designed to search for new physics through highly ionizing particles produced at the LHC. MoEDAL is the sole contender in searches for highly charged magnetic monopoles [P2], has carried out the sole dyon search in accelerator experiment and the first search for monopoles produced via Schwinger mechanism. It has recently entered the arena of electrically charged particles constraining high electric charges.

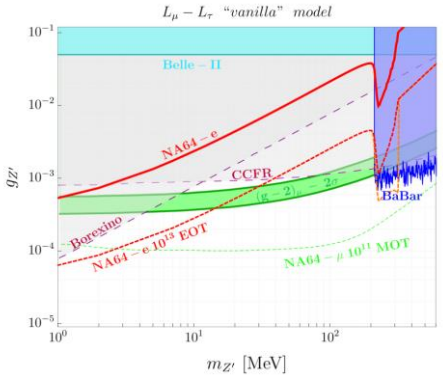
The IFIC team is coordinating the physics analyses and other aspects of the experiment and is strongly involved in the development and testing of key theoretical scenarios, such as monopole production processes, supersymmetric models and electrically charged particles. In addition, the MoEDAL Apparatus for Penetrating Particles (MAPP), approved by the CERN Research Board in December 2021, will extend the MoEDAL physics program to feebly interacting, long-lived messengers of dark matter scenarios and neutrino portal models.



The 95% C.L. exclusion regions for the magnetic monopole production via the Schwinger mechanism for Pb-Pb collisions. Other limits are also shown.

NA64

NA64 is a fixed target experiment testing New Physics using e-/e+, muon and hadron beams at CERN SPS. During 2022, NA64 has tripled its previous statistics using electrons. The first positron run and the first pilot run with pions to study its potential to search for dark sector particles coupled to hadrons were also carried out. The muon program NA64μ, whose feasibility studies and pilot run are led by IFIC, had a second pilot run. The projected sensitivities for invisible Z' Lμ−Lτ decays were published, demonstrating the experiment capabilities to probe the full region of the parameter space suggested by the muon g-2 anomaly (Phys. Rev. D105, 052006, 2022). This Z' can also be produced using the electron beam, and previous NA64 limits exclude the region up to mZ' ~ 1 MeV. Thus, in case of a signal, both programs will be complementary to unequivocally probe these scenarios. Finally, L. Molina was responsible for writing the 2022 annual NA64 SPSC report summarizing the status of the experiment and gave the annual presentation [C3].



The NA64e exclusion limit for the Lμ − Lτ model (red line) with the 2016-2018 statistics, for the minimal model with Z' decaying to neutrinos. Different sensitivity projections are also shown.

5 L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY

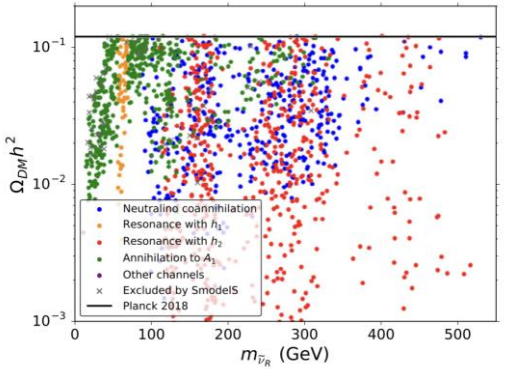
RAD.ES, babyIAXO and CADEx

The AITANA group also works on the electromagnetic analysis and design of haloscopes for the search of dark matter axions. Following the inverse Primakoff effect, haloscopes are microwave resonators immersed in a high magnetostatic field region. Different microwave frequency regions are being explored, associated with three different international collaborations: RAD.ES (X-band, around 35 μeV), babyIAXO (L and C bands, around 1 μeV) and CADEx (W-band, around 400 μeV) which might allow detecting axions with different masses [P3]. Numerical techniques based on full-wave modal analysis and commercial software have been implemented for very efficient and accurate simulations, including information of both module and phase of the recorded signals. The formulation for gravitational waves detection in the microwave frequency region is being used.

THEORY

The main efforts in the theory side have been devoted to the study of different dark matter candidates from different perspectives and to explore leptogenesis scenarios for the generation of the matter-antimatter asymmetry of the Universe.

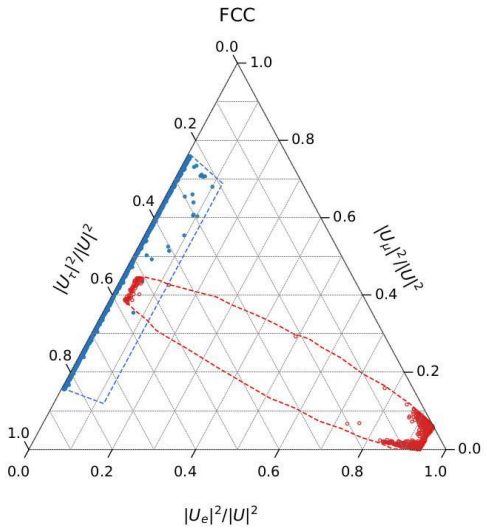
By way of illustration of the theoretical work performed at IFIC on this topic, we comment on several lines of investigation. In [P4] non-minimal dark sectors and their production mechanisms were considered. In particular, the amount of relic particles in a generic dark sector and the final abundance of both symmetric and asymmetric components were studied. Links between the dark matter problem and the origin of neutrino masses have been also explored in a variant of the so-called scotogenic model, which can reproduce the measured abundance of dark matter as well as neutrino oscillation data [P5]. An analysis of the (g−2)μ discrepancy in the context of the R-parity conserving next-to-minimal supersymmetric Standard Model plus right-handed neutrinos was also performed (Nucl. Phys. B 974 (2022), 115637). The model was able to reproduce neutrino physics data and includes a right-handed sneutrino as the lightest supersymmetric particle and a viable dark matter candidate. On another work, robust and self-consistent limits on the amount of the axion as a hot dark matter component were computed (JCAP 09 (2022) 022), avoiding approximate methods often exploited in the literature. Furthermore, the potential of axion haloscopes to discover not only the QCD axion, but also other dark matter candidates is also being explored [C4]. Applications of machine learning techniques for dark matter studies is also a topic of research at IFIC [C5]. Finally, in this incomplete enumeration, the problem of accretion of dark matter particles in stellar bodies and its phenomenological consequences is also being actively studied at IFIC [C6].



Relic density for the parameter points with a RH neutrino as dark matter candidate that fulfills all the constraints considered. The black solid line corresponds to the observed dark matter density.

Concerning leptogenesis scenarios, in [P6] the generation of the baryon asymmetry of the Universe was considered via low-scale leptogenesis in a type-I seesaw framework endowed with a flavor and a CP symmetry and (nearly) mass-degenerate right-handed neutrinos. On another work, a minimal low scale seesaw model was shown to simultaneously explain the origin of neutrino masses and the baryon asymmetry of the Universe and interesting correlations with different observable parameters were found (JHEP 12 (2022) 012).

5 L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY



Points of a numerical scan with successful baryogenesis within the sensitivity region of FCC for regions for fixed ΔM/M = 10-2 and NH (blue) and IH (red).

Selected Publications

[P1] J.J. Hernández-Rey et al., *Science with neutrino telescopes in Spain*, Universe 8 (2022) 89 DOI

[P2] B. Acharya, V. Mitsou, J. Papavassiliou, R. Ruiz de Austri, V. Vento, O. Vives et al. (MoEDAL Collaboration), *Search for magnetic monopoles produced via the Schwinger mechanis*, Nature 602 (2022) 63-67 DOI [arXiv]

[P3] B. Aja, B. Gimeno et al, *The Canfranc Axion Detection Experiment (CADEx): search for axions at 90 GHz with Kinetic Inductance Detectors*, Journal of Cosmology and Astro-particle Physics 11 (2022) 044 DOI [arXiv]

[P4] A. Bas i Beneito, J. Herrero-García, D. Vatsyayan, *Multi-component dark sectors: symmetries, asymmetries and conversions* Journal of High Energy Physics 10 (2022) 075 DOI [arXiv]

[P5] V. De Romeri, M. Puerta, A. Vicente, *Dark matter in a charged variant of the scotogenic model*, European Physical Journal C 82 (2022) 623 DOI [arXiv]

[P6] M. Drewes, Y. Georis, C. Hagedorn, J. Klaric, *Low-scale leptogenesis with flavour and CP symmetries*, Journal of High Energy Physics 12 (2022) 044 DOI [arXiv]

Selected Conference Talks

[C1] F. Salesa„ *High energy multi-messenger astronomy*, XIII CPAN Days. Huelva (Spain). Invited plenary talk

[C2] E. Torró, *Transverse dedicated LLP detectors*, Searching for long-lived particles at the LHC and beyond: 11th workshop of the LLP Community. Online conference. Invited plenary talk

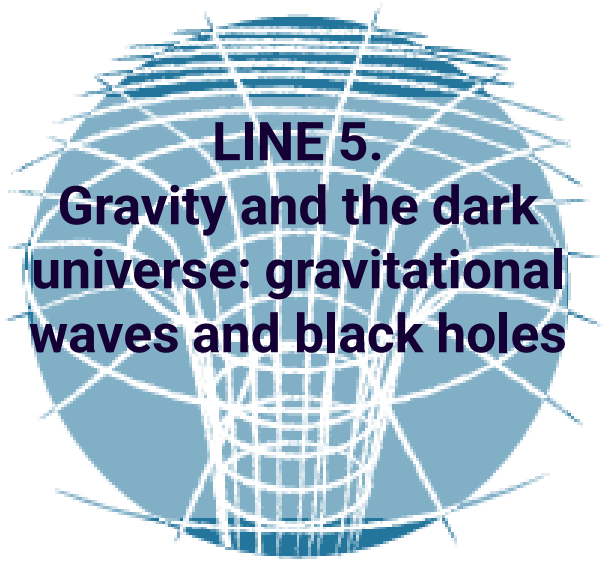
[C3] L. Molina Bueno, *Status and plans of the NA64 experiment*, 146th Meeting of the SPSC. Geneva (Switzerland). Invited plenary talk.

[C4] C. García-Cely, *New ideas inspired by axion electrodynamics*, 14th International Conference on Identification of Dark Matter, Vienna (Austria). Invited plenary talk.

[C5] B. Zaldívar, *On machines learning about some dark matters,* Dark Matters 2022. Brussels (Belgium). Invited plenary talk.

[C6] S. Palomares-Ruiz, *Dark matter evaporation from celestial bodies*, 3rd GNN Workshop on Indirect Dark Matter searches with Neutrino Telescopes. Granada (Spain). Invited plenary talk.

SCIENTIFIC RESEARCH LINES



IFIC team explores fundamental physics with gravitational waves (GWs) and new cosmological measurements. IFIC researchers are members of the ESFRI project SKA, the largest radio telescope that aims to map the 21cm line, and play a leading role in defining its fundamental physics case. The discovery of primordial GWs created by quantum effects at the very earliest instants of the universe or of a stochastic GW background that might have originated from post-inflationary preheating, first order phase transitions, or cosmic string networks, would be a spectacular discovery of physics beyond the Standard Model of particle physics. IFIC groups study the detailed gravitational-wave ringdown of colliding black holes, expected to be tested in future GW detectors, as probes of physics beyond general relativity and of quantum effects in gravity.

5 L5. GRAVITY AND THE DARK UNIVERSE: GRAVITATIONAL WAVES AND BLACK HOLES

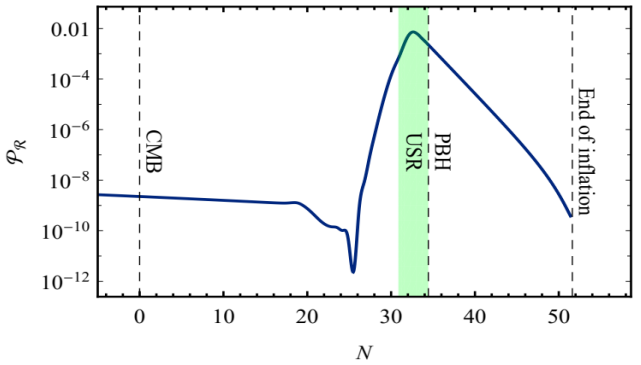
The research topics of this line include the theory and detection of gravitational waves (GWs), black holes solutions and primordial black holes, modified gravity, and quantum aspects of gravity. Members participating in this line of research are involved in international collaborations, like the Laser Interferometer Space Antenna (LISA) and the Einstein Telescope (ET), which represent the will-be first space-base and next generation of ground-based GW detectors, respectively, that will start taking data in the middle of 2030's. Members of L5 also aim to study the interface between gravity and quantum field theory in cosmological and black hole scenarios, analog models of gravity, and supersymmetry among others.

Stochastic gravitational wave backgrounds (SGWBs)

One of the main topics of the L5 research line is the study of SGWBs as a probe of high-energy physics and early universe cosmology. In [GW1]* we explored the possibility to measure particle couplings with SGWBs. Under certain circumstances a sequence of peaks of different amplitude and frequency - a stairway -, emerges in a SGWB spectrum, with each peak probing a different coupling. The detection of such signature opens up the possibility to reconstruct couplings (spectroscopy) of particle species involved in high energy phenomena generating SGWBs. Stairway-like signatures may arise in causally produced backgrounds in the early Universe, e.g. from preheating or first order phase transitions. As a proof of principle we studied a preheating scenario with an inflaton coupled to multiple daughter fields with different coupling strengths. As a clear stairway signature was imprinted in the SGWB spectrum, we reconstructed the relevant couplings with various detectors, including LISA and BBO.

Implications of stochastic effects for primordial black hole production in ultra-slow-roll inflation

Another major main topic of the L5 research line is the study of primordial black holes (PBHs). In [PBH1&2] we studied the impact of stochastic noise on the generation of primordial PBH seeds in ultra-slow-roll (USR) inflation. We consider the non-linearity of the system by consistently taking into account the noise dependence on the inflaton perturbations, while evolving the perturbations on the coarse-grained background affected by the noise. We captured in this way the non-Markovian nature of the dynamics, and demonstrate that non-Markovian effects are subleading. Using the Delta-N formalism, we find the probability distribution of the comoving curvature perturbation. We considered inflationary potentials that fit the CMB and lead to PBH dark matter with i) asteroid, ii) solar, or iii) Planck mass, as well as iv) PBHs that form the seeds of supermassive black holes. We find that stochastic effects enhance the PBH abundance by a factor of O(10)-O(10^8), depending on the PBH mass. We also showed that the usual approximation, where stochastic kicks depend only on the Hubble rate, either underestimates or overestimates the abundance by orders of magnitude, depending on the potential. This research articles accumulate already over 100 citations.



The power spectrum P(k) for the PBH asteroid mass case over different scales, evaluated at the end of inflation when all the super-Hubble scales have frozen. Taken from JCAP 05 (2022) 05, 027, e-Print: 2111.07437 [astro-ph.CO].

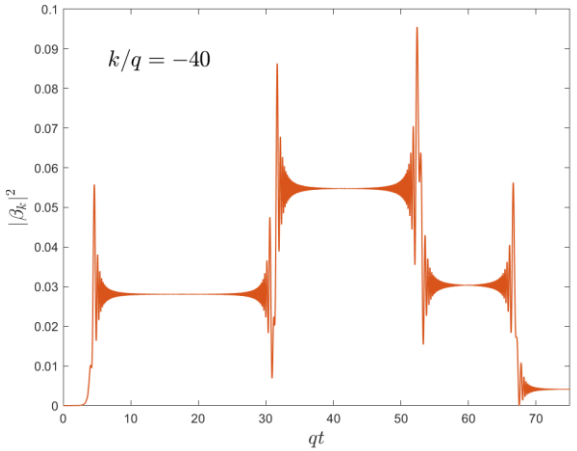
Particle creation and the Schwinger effect

We have also investigated the process of particle production in the presence of electric fields with quantum field theory techniques, known as the Schwinger effect. In [P1], solutions to the backreaction equation in 1 + 1 - dimensional semiclassical electrodynamics

*This article has been awarded the 2022 Buchalter Cosmology – Third Prize.

5 L5. GRAVITY AND THE DARK UNIVERSE: GRAVITATIONAL WAVES AND BLACK HOLES

were obtained and analyzed when a time-varying homogeneous electric field (initially generated by a classical electric current) is coupled to either a quantized scalar field or a quantized spin-1/2 field. They investigated the validity of the semiclassical approximation in this framework.



Time-dependent particle number for a scalar field in the presence of an electric field (source: P1).

Quantum field theory in curved spacetime

We have also continued our research on renormalization and particle creation in curved spacetimes. We have investigated the choice of non-adiabatic vacua in a radiation-dominated cosmological spacetime, and in particular, on how to impose CPT-invariant, ultraviolet regular initial conditions at the big bang (see arXiv:2204.05414). Furthermore, we have investigated the correlations across the horizon of a black hole in order to highlight the particle-partner pair creation mechanism at the origin of Hawking radiation (PRD 105 (2022) 045010). The analysis was carried out for both acoustic and gravitational black holes. By considering equal-time correlation functions we found a striking disagreement between the two cases: the expected characteristic peak centered along the trajectories of the Hawking particles and their partners seems to appear only for the acoustic black hole, but not for the gravitational Schwarzschild one.

Modified gravity and black holes

In [P2] we studied the existence of additional light rings in some spherically symmetric black hole and wormhole geometries characterized by the presence of a second critical curve, via a uniparametric family of extensions of the Schwarzschild metric. By assuming three toy models of geometrically thin accretion disks, they showed the presence of additional light rings in the intermediate region between the two critical curves. The observation of such rings could represent compelling evidence for the existence of black hole mimickers having multiple critical curves (see also PLB 829 (2022) 137045). Moreover, in the context of Chern-Simons gravity, we have proposed a new metric-affine generalization, able to preserve projective invariance, and they have applied the formalism to the study of quasinormal mode emission for Schwarzschild black holes (JCAP 05 (2022) 032). Preliminary results have been presented at the conference Rencontres de Moriond 2022 [C1].

Primordial black holes

Had Primordial Black Holes (PBHs), with mass between 10^{12} g and 10^{16} g, formed in the early Universe, they would be sources of neutrinos emitted via Hawking radiation, which could be detected at Earth. In this work, constraints on the abundance of these PBHs were derived from the null observation of this neutrino flux. Improved constraints using Super-Kamiokande neutrino data were obtained, as well as forecasts for next-generation neutrino (Hyper-Kamiokande, JUNO, DUNE) and dark matter (DARWIN, ARGO) detectors (JCAP 10 (2022) 068).

5 L5. GRAVITY AND THE DARK UNIVERSE: GRAVITATIONAL WAVES AND BLACK HOLES

Selected Publications

[GW1]. D.G. Figueroa, A. Florio, N. Loayza and M. Pieroni, *Spectroscopy of particle couplings with gravitational waves,* Physical Review D 106 (2022) 063522 DOI [arXiv]. Winner of the **2022 Buchalter Cosmology** – Third Prize

[PBH1, PBH2] D.G. Figueroa, S. Raatikainen, S. Rasanen and E. Tomberg, *Non-Gaussian Tail of the Curvature Perturbation in Stochastic Ultraslow-Roll Inflation: Implications for Primordial Black Hole Production,* Physical Review Letters 127 (2021) 101302 DOI [arXiv] and Journal of Cosmology and Astro-particle Physics 05 (2022) 027 DOI [arXiv]

[P1] S. Pla, I.M. Newsome, R.S. Link, P.R. Anderson, J. Navarro-Salas, *Pair production due to an electric field in 1+1 dimensions and the validity of the semiclassical approximation,* Physical Review D 103 (2021) 105003 DOI [arXiv]

[P2] M. Guerrero, G.J. Olmo, D. Rubiera-Garcia, D. Gómez Sáez-Chillón, *Light ring images of double photon spheres in black hole and wormhole spacetimes,* Physical Review D 105 (2022) 084057 DOI [arXiv]

Selected Conference Talks

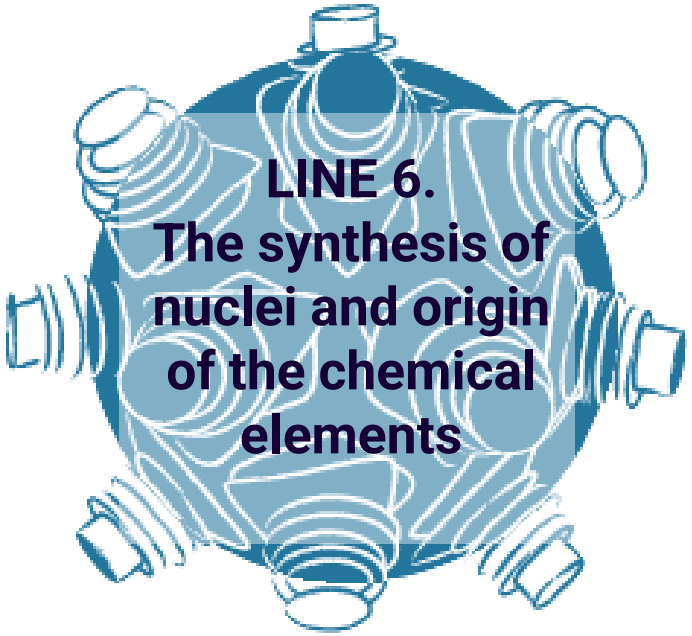
[C1] Flavio Bombacigno, *Quasinormal modes of Schwarzschild black holes in metric affine Chern-Simons theory,* 56th Rencontres de Moriond: Gravitation. La Thuile (Italy)

[C2] Daniel G. Figueroa, *The early universe… numerically speaking.* Beyond the Standard Models Particle Physics meets Cosmology. IFT Madrid (Spain). Invited Plenary talk

[C3] Camilo García Cely, *Adopting axion dark matter ideas to detect high-frequency gravitational waves.* 33rd Rencontres de Blois on Exploring the Dark Universe. Blois (France). Invited Plenary talk

[C4] Valentina De Romeri, *Signatures of primordial black hole dark matter at DUNE and THEIA.* TeV Particle Astrophysics (TeVPA 2022). Kingston (Canada)

SCIENTIFIC RESEARCH LINES



The recent observation of gravitational waves from a merger and the associated electromagnetic emission has led for the first time to the "in vivo" observation of the synthesis of heavy elements. Nuclear physics input from very neutron-rich exotic nuclei is required to pin down the complex processes taking place in those events. The experimental nuclear physics group at IFIC leads measurements of the decay properties of key nuclei at RIKEN (Japan), FAIR phase 0 and CERN/ISOLDE. On the other hand, it is known that about 50% of the heavy elements in the Universe originate instead in neutron-induced reactions in red-giant stars on a much longer timescale. The HYMNS project has built an innovative instrument, i-TED, to carry out measurements of key stellar nucleosynthesis reactions at n_TOF at CERN during the next years. IFIC is also a key player in the new MANY collaboration to exploit Spanish infrastructures (CNA, CMAM) for the measurement of astrophysically relevant reactions.

5 L6: THE SYNTHESIS OF NUCLEI AND ORIGIN OF THE CHEMICAL ELEMENTS

EXPERIMENTAL NUCLEAR PHYSICS

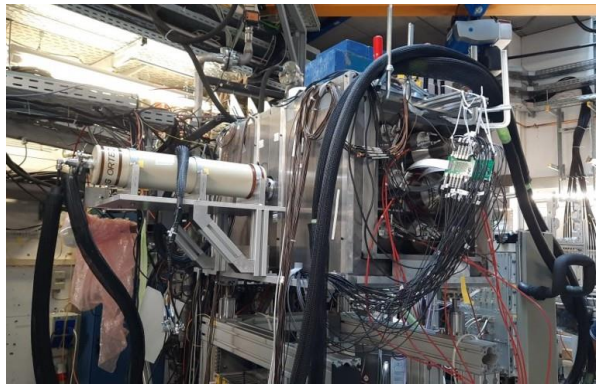
Experimental Nuclear Physics activity at IFIC is carried out by two groups, the AGATA group (in-beam research) and the Gamma and Neutron Spectroscopy group. The research of both groups covers aspects of nuclear structure, astrophysics, applications and the development of instrumentation.

One important result of the Gamma and Neutron Spectroscopy group this year is the study of the beta decay of ^{70}Kr into ^{70}Br published in Physics Letters B [1]. ^{70}Kr is the most exotic Z=N+2 nucleus accessible that decays into a N=Z nucleus. The study of this type of decay is important since it can provide information about proton-neutron pairing in the isospin T=0 channel. An enhancement of the Gamow-Teller strength to the first excited 1+ state in ^{70}Br was found with respect to the decay of ^{62}Ge, a similar case studied earlier. If pn pairing in the T=0 channel exists, we would expect strong beta decay transitions of this type comparable in intensity with the Fermi transition. Our work shows a change in the trend with increased correlations with respect to ^{62}Ge decay, but unfortunately the information obtained is not conclusive.

It is also of interest, that the decay data can be very well described using a pseudo-SU(4) model, which shows a recovery of the pseudo-SU(4) symmetry for this decay. The study was based on an experiment led by our group at the Radioactive Ion Beam Factory (RIBF) of the RIKEN Nishina Center (Japan).

Another relevant result of the group in 2022 [2] is the study of the time evolution of the ambient neutron rate in Hall-A of the Canfranc Underground Laboratory in correlation with environmental variables, investigated for a period of 412 live days. The measurement was carried out with the new High Efficiency Neutron Spectrometry Array (HENSA). This is the first long-term measurement with sensitivity to a broad range of neutron energies carried out in any underground laboratory so far. It is of importance for a vast spectrum of experiments, ranging from nuclear astrophysics to astroparticle physics.

Another important achievement is that during June 2022 the first experiment with DTAS at FAIR Phase-0 was successfully performed in Darmstadt (Germany). The Decay Total Absorption Spectrometer DTAS build by the Gamma Spectroscopy and Neutron Group, is a key instrument of the DESPEC Experiment within the NUSTAR Collaboration and one of the major Spanish contributions to FAIR. The experiment lead by the group and approved by the PAC in tight competition, aims to shed light on the synthesis of the heaviest chemical elements during the astrophysical rapid neutron capture process.



The DTAS detector at FAIR Phase-0.

Another development of instrumentation is related to the MANY project. MANY (Measurement of Alpha Neutron Yields) aims to obtain better nuclear data on (α,n) reactions relevant for underground physics, nuclear astrophysics, and nuclear technologies. The project capitalizes on existing infrastructures in Spain, particularly the alpha beams generated by the ICTS at CMAM (Madrid) and CNA (Sevilla). Within the MANY collaboration IFIC has led the development of the miniBELEN detector, a modular neutron counter for the study of (α,n) reactions (N. Mont-Geli et al., EPJ Web of Conferences 284, 06004). This detector has been commissioned successfully at CMAM in 2022. Ongoing activities primarily focus on using this new instrument to measure (α,n) reactions in different materials.

5 L6: THE SYNTHESIS OF NUCLEI AND ORIGIN OF THE CHEMICAL ELEMENTS

During 2022 also a major upgrade of Lucrecia, the total absorption spectrometer (TAS) at ISOLDE has also been carried out. In particular, a new tape transport system that allows the implantation of radioactive sources directly from the isotope separator in the centre of the gamma spectrometer has been installed and commissioned. This allows for the study of more exotic species with shorter half-lives and, consequently, new proposals and experiments have started to happen. Already in 2022, we had a campaign of 3 experiments, two of which were led by members of IFIC.

The AGATA collaboration has started in 2022 the new experimental campaign at INFN-Laboratori Nazionali di Legnaro. AGATA is presently used in combination with the magnetic spectrometer PRISMA, aiming mainly to perform nuclear structure studies using multi-nucleon transfer reactions and fission reactions to populate the nucleus of interest.

The AGATA group at IFIC has participated actively in the experimental activity as well as providing support to the operation of the array.

Additionally, the group has completed the

The AGATA detector together with the magnetic spectrometer PRISMA

analysis of the E730 experiment, aiming at studying the quadrupole and octupole collectivity of the nucleus ^{112}Xe. The experiment was performed at GANIL with the setup consisting on AGATA, NEDA+Neutron Wall and DIAMANT. Of particular relevance was the use of NEDA, a neutron trigger detector, with a sizeable contribution from IFIC and ETSE-University of Valencia. This is useful in the investigation of extreme neutron-deficient nuclei populated in fusion-evaporation reactions. The results are part of the PhD thesis of Maria de la Luz Jurado Gómez, defended successfully in May 2022. Among our results for ^{112}Xe, the measurement of the anomalous B(E2; 4^+_1 -> 2^+_1)/B(E2; 2^+_1 -> 0^+_1) ratio is of particular relevance since it indicates an early change in the collectivity of the ^{112}Xe Yrast band.

Finally, in the context of the L6 line it is worth highlight one contribution related to theory. In the INT workshop on BSM Physics with Nucleons and Nuclei a plenary talk was presented discussing the implications of precision measurements in beta decay.

Selected Publications

[1] A.Vitéz-Sveiczer et al., *The β-decay of ^{70}Kr into ^{70}Br: Restoration of the pseudo-SU(4) symmetry*, Physics Letters B 830 (2022) 137123 DOI

[2] S.E.A. Orrigo et al., *Long-term evolution of the neutron rate at the Canfranc Underground Laboratory,* European Physical Journal C 82 (2022) 814 DOI [arXiv]

[3] R.M. Pérez-Vidal et al., *Evidence of Partial Seniority Conservation in the πg$_{9/2}$ Shell for the N=50 Isotones,* Physical Review Letters 129 (2022) 112501DOI

Selected Conference Talks

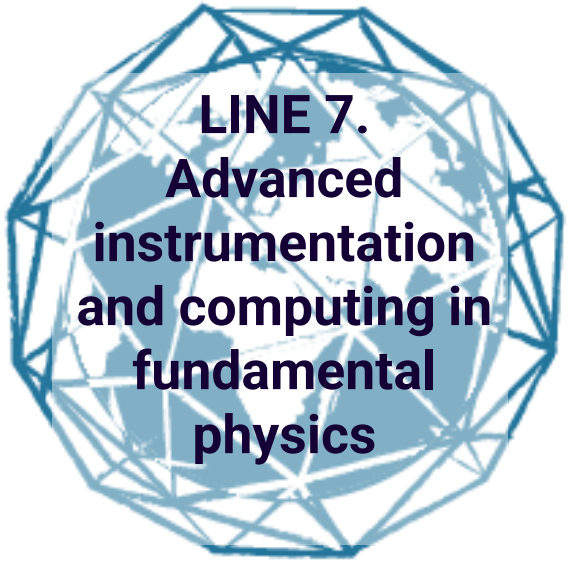
G. Alcalá et al., *Beta spectrum shape studies for the predictions of the antineutrino spectrum from reactors*. Invited talk, 15th International Conference on Nuclear Data for Science and Technology,. Online conference. EPJ Web of Conferences 284 (2023) 08001 DOI

A. Algora, *Total absorption spectroscopy applications*. Plenary talk, 3rd International Conference on Radiation and Applications (ICRAA'3). Algiers (Algeria)

M. González-Alonso, *Precision measurements in beta decay*. Plenary talk, INT workshop on BSM Physics with Nucleons and Nuclei. Seattle (USA)

ADVANCED INSTRUMENTATION AND COMPUTING

SCIENTIFIC RESEARCH LINES



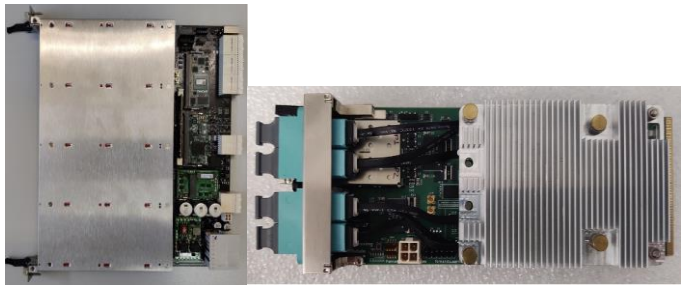
IFIC has set a number of ambitious goals that include the construction and commissioning of cutting-edge instruments, where we have taken a major in-house responsibility. Several construction projects are particularly strategic for the institute in the coming years: the upgrades of the LHC experiments (ATLAS and LHCb), the construction of NEXT-100, the development of new instruments for nuclear physics (i-TED and AGATA), for super B-factories (Belle II) and for Higgs factories (ILC, CLIC). The leadership of IFIC researchers in these projects is widely and internationally recognized. The KM3NeT neutrino telescope has deployed already 18 lines, and a huge increase in the deployment is expected during the coming years. The neutrino team is also involved in the proto-DUNE projects at the CERN neutrino platform. From a scientific-technological point of view, the Spanish ATLAS Tier-2 focuses on the needs for Run3 and the preparations for the HL-LHC within the WLCG (Worldwide LHC Computing GRID) program, including the usage of HPC resources, the ATLAS Event Index, Core Computing tasks and Physics Analysis applying ML.

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

ATLAS and LHCb detectors at the LHC

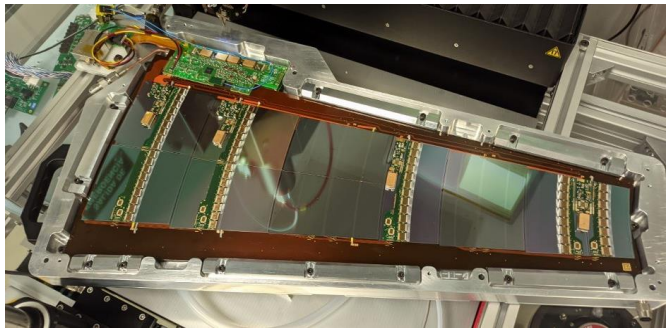
IFIC is one of the main actors in the upgrade of the ATLAS detector for the LHC high luminosity phase in two of the subsystems: the central hadronic calorimeter (TileCal) and the microstrip silicon detector system in the Inner Tracker (ITk). Both projects have been preparing for the fabrication of the detector components during 2022 and have passed many technical reviews to give green light to production.

The HL-LHC TileCal demonstrator, including the PreProcessor prototype module designed by the IFIC team, is being operated smoothly during Run 3. The final PreProcessor design has been produced and certified at IFIC and it is ready for the Final Design Review.



Picture of the ATLAS TileCal Tile PreProcessor module (left) which can host up to four Compact Processing Modules (right).

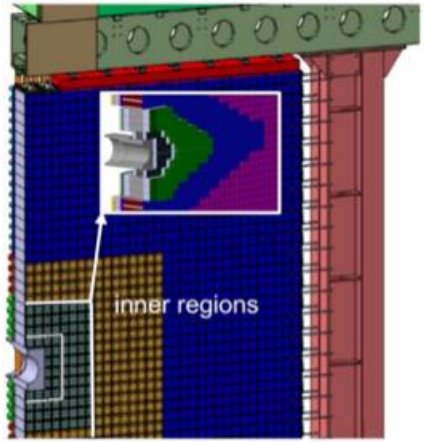
On the other hand, all the setups for the ITK-Strips detector are ready for production of modules, loading support structures (petals) with modules and the service module. First pre-series modules and petals have been fabricated and tested in the clean room of the institute.



ATLAS ITk petal loaded with modules and their electronics. It is a double-sided object and on each of them there are 9 silicon detectors.

The tracker downstream of the LHCb dipole magnet, called SciFi, has been installed and commissioned during 2021 and 2022. IFIC has been one of the main contributors to the readout chip, called PACIFIC, now in steady operation. For the first time, the LHCb detector will be capable of triggering particle trajectories originating far from the collision point (long-lived), an area where IFIC has been playing a leading role, opening new physics opportunities. Looking beyond, R&D with FPGAs accelerators has started.

The innermost region of the current electromagnetic calorimeter (ECAL) needs To be upgraded for Run 4 during the LS3. The new detector channels and electronics are being designed to cope with high levels of occupancy and reduce the effects of pile-up by increasing the channel granularity and adding a time measurement with resolution of 10 ns. Main responsibilities have been undertaken in the definition of specifications and design of the new front-end chip, which will rely on 65nm CMOS technology.



LHCb ECAL upgrade during LS3 will introduce single-section radiation tolerant 2x2 and 3x3 cm^2 cells in inner regions and rebuilt in rhombic shape to comply with Upgrade II conditions. The plan is to include timing information.

The design and proof-of-principle of a two-crystal setup to be installed at interaction region 3 of the LHC, called TWOCRYST, foreseen during Run 3, has been steadily progressing. This setup will enable uncharted measurements: g-2 and electric dipole moments of short-lived particles, and of zero-angle production and polarization of heavy hadrons in dense targets.

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Detector R&D for future colliders

The group continues to contribute to the detector R&D for a future electron-positron collider "Higgs factory" in the CALICE collaboration and in the European project AIDAinnova. Group members occupy coordination roles in the ILC international development team, in the European Committee for Future Accelerators and in the expert panel that prepared the Euroepean road map for detector R&D.

AGATA

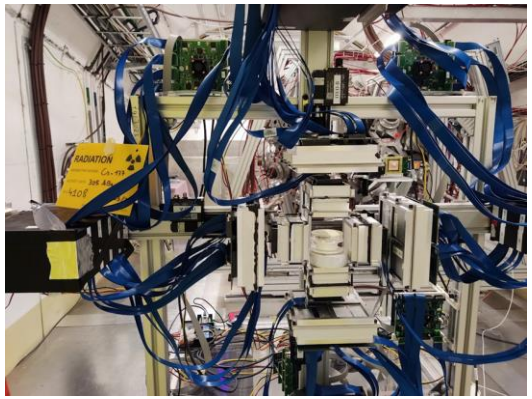
In 2022 AGATA has started the construction phase 2, with IFIC as one of the participating institutes. Any tracking HP-Ge array as AGATA relies for the position sensitivity of the HP-Ge detectors on the sampling digital electronics with spectroscopic quality (i.e., s/n ratio >72 dBFS). Our group is responsible, together with the AGATA group at ETSE University of Valencia, for the development of the pre-processing electronics PACE-CAP board. This board includes the IDM "time multiplexing" device, developed in previous years by our group and it has the pre-processing FPGA integrated in a commercial SoM. PACE-CAP works coupled with the STARE Ethernet readout board, which provides large data transfer rates and monitoring capabilities. A sophisticated cooling mechanics has been designed by our groups and the mechanics workshop service of IFIC.

Left: Pre-processing motherboard PACE-CAP developed for AGATA at IFIC and ETSE. Right: Cooling mechanics with heat-exchanger and cooling blocks, built at the IFIC mechanical workshop.

During 2022 we have completed the prototyping and pre-production phases, with tests in experimental conditions with AGATA detectors at INFN-LNL. We expect to go to mass production in the second half of 2023. Our group has also contributed to the installation and completion of the present AGATA subarray coupled to PRISMA at INFN-LNL and to the on-going experimental campaign.

n_TOF experiment

In 2022 the first measurement of the 79Se(n,g) reaction, a key branching nucleus in the s-process path of stellar nucleosynthesis, was carried out at CERN n_TOF. The experiment was performed with the i-TED array of four Compton cameras developed in the framework of the HYMNS ERC-Consolidator Grant. Regarding technology transfer and applications, a patent has been granted for an upgrade of i-TED, which enables simultaneous neutron-gamma imaging. Further, the i-TED system was successfully utilized at the 18MeV cyclotron of CNA-Seville in order to perform the first proof-of-concept measurements for hybrid Compton-PET imaging in ion-range monitoring for hadron therapy treatments.



Full i-TED array of 4 Compton cameras developed at IFIC and installed at CERN n_TOF for the first measurement of the 79Se(n,g) cross section.

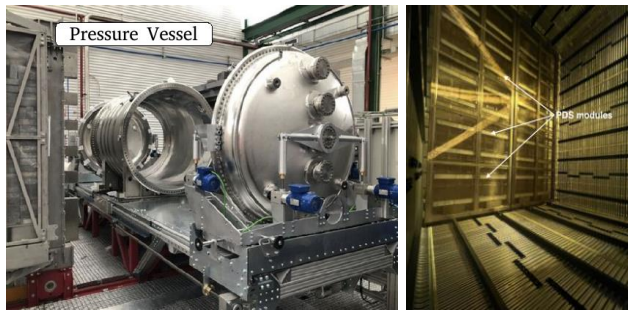
Instrumentation for neutrino physics

IFIC has a strong commitment to the instrumentation of the NEXT and DUNE experiments. IFIC has started in 2022 the installation of the NEXT-100 detector at the Laboratorio Subterráneo de Canfranc (LSC), leading the mechanics and the gas system of the experiment. This detector aims at the first competitive search for the neutrinoless double beta decay with the NEXT technology (electroluminescent gas-pressure TPCs), as well as at setting the grounds for a future

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

ton-scale detector. The R&D lines towards the implementation of this massive device have continued during 2022, covering the design of a barrel fiber detector and different TPC operation conditions taking advantage of the DEMO++ detector operated at IFIC.

In addition, IFIC leads the cryogenics instrumentation of the DUNE detectors, which will use the largest liquid argon cryostats ever built, and has a strong participation in the photon detection system of both the near and the far detector. In 2022 IFIC was committed to the R&D on both systems and led their installation in the two CERN large scale prototypes, which will be operated in 2024.



Left: the NEXT-100 pressure vessel at the LSC. Right: the ProtoDUNE-HD 4x6x6 m^3 Time Projection Chamber at CERN, with indication of the integrated photon detection system (PDS).

Computing

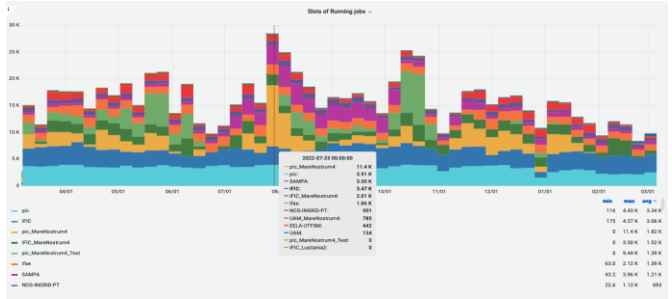
The research topics of the IFIC ATLAS-GRID Team include mainly the Spanish ATLAS Tier-2 goals. The exploitation of LHC data in Run3 will push to the limit the computing resources available. This includes several generic activities devoted to the application of Distributed Computing and to improve the performance of the physics analysis work:

a) Delivery of the committed resources for 2022 (in April). The Tier-2 IFIC site has provided 52000 HS06 and 4600 TB of disk. The efficiency of the whole Tier-2 has been about 100%.

b) During 2022 our group has continued the exploitation of MareNostrum 4 HPC (BSC) running conventional ATLAS simulated data production. The computing yield has been more than 30 million CPU hours and more than 400 millions of events of a complete simulation of the detector. The 50% of the simulation production assigned to Spain is executed in MN4 resources. It should be noted that in 2022 30% of the IFIC's contribution to ATLAS computing has been through MareNostrum 4 HPC.

c) The group has continued their duties with the ATLAS Event Index project (ATLAS event catalogue). We are in charge of the Data Collection and Data Production. The upgrade of the Event Index Supervisor, the Producer and testing of the new Event Index database based on HBase and Phoenix to satisfy the demanding requirements of data generation during LHC Run3 have been the most important contributions at the beginning of 2022. The new system is in operation since Spring 2022 and performing excellently.

d) In 2022, IFIC triggered a transversal effort to promote the application of Machine Learning (ML) techniques for data challenges. These methods are being used by IFIC researchers in data fitting and event-reconstruction. IFIC has ARTEMISA, a computing infrastructure including a server with GPUs NVIDIA Tesla Volta V100, available to IFIC researchers. IFIC ATLAS-GRID team has performed some studies of resonance decays into ttbar pairs using publicly available simulated data. A contribution to improve the resolution of the ttbar invariant mass by applying Machine Learning/Deep Learning techniques was carried out. Moreover, ML has been used by several Generative Models to produce simulated data at low computational cost. Most of this work was performed on the ARTEMISA infrastructure at IFIC.



More than 5k slots of running jobs during 2022, shown here by resource type, were responsibility of IFIC.

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Selected Publications

[1] A. Cervelló, F. Carrió, R. García, J. Martos, J. Soret, J. Torres, A. Valero, ATLAS Collaboration, *The TileCal PreProcessor interface with the ATLAS global data acquisition system at the HL-LHC*, Nuclear Instruments & Methods in Physics Research A 1043 (2022) 167492 DOI

[2] LHCb Collaboration, *A Comparison of CPU and GPU Implementations for the LHCb Experiment Run 3 Trigger*, Computing and Software for Big Science 6 (2022) 1 DOI [arXiv]

[3] CALICE Collaboration, *Energy reconstruction of hadronic showers at the CERN PS and SPS using the Semi-Digital Hadronic Calorimeter*, Journal of Instrumentation 17 (2022) P07017 DOI [arXiv]

[4] DUNE Collaboration, *Design, construction and operation of the ProtoDUNE-SP Liquid Argon TPC*, Journal of Instrumentation 17 (2022) P01005 DOI [arXiv]

[5] C. Massimi, S. Cristallo, C. Domingo-Pardo and C. Lederer-Woods, *n_TOF: Measurements of Key Reactions of Interest to AGB Stars,* Universe 8 (2022) 100 DOI

[6] ATLAS Collaboration, *AtlFast3: The Next Generation of Fast Simulation in ATLAS*, Computing and Software for Big Science 6 (2022) 7 DOI [arXiv]

Selected Conference Talks

Fernando Carrió, *Integration and Commissioning of the ATLAS Tile Demonstrator Module for Run 3*, 23rd IEEE Real Time Conference. Online confence

Luca Fiorini, *Upgrade of the ATLAS Hadronic Tile Calorimeter for the High Luminosity LHC*, ICHEP 2022. Bologna (Italy)

Adrián Irles, *CALICE Imaging Calorimeters: A Review and New Results,* ICHEP 2022. Bologna (Italy)

Andrés Gadea, *Prospects for nuclear astro-physics measurements with AGATA at LNL*, ChETEC-INFRA 2nd General Assembly. Padova, (Italy)

César Domingo-Pardo, *The neutron time-of-flight facility n_TOF at CERN: recent facility upgrades and detector developments*, 28th International Nuclear Physics Conference (INPC 2022). Cape Town (South Africa)

Alvaro Fernández Casani, *Big Data analytics for the ATLAS Event Index project with Apache Spark*, Computational and Mathematical Methods in Science and Engineering 2022 and International Conference in HPC 2022 (CMMSE & HPC), Cádiz (Spain)

SCIENTIFIC RESEARCH LINES

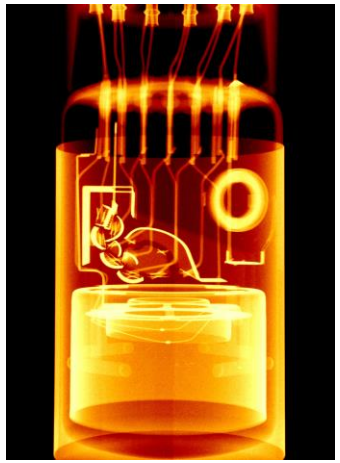
In recent years, the multidisciplinarity and societal impact of IFIC research projects has increased significantly. IFIC is developing various applications in medical therapy, imaging, dosimetry and diagnosis. Several gamma and neutron detectors are being developed with imaging capabilities. Neutron detectors to monitor neutron doses in therapy are being implemented. There is also a research line in diagnosis with a xenon-based PET-technology development, as well as a gamma-ray with ultrasound imaging device to guide breast biopsies in real time. Artificial Intelligence (AI) solutions are applied to medical diagnosis, including COVID-19, catastrophic event prevention, environmental studies, and space weather. Neutron detectors are developed for space weather and single event failures investigation. Detectors are developed for safety protocols in nuclear industry. IFIC researchers are involved in the development of a compact accelerator for hadron therapy.

5 L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

The activities of L8 focus on medical and societal applications of the advances on instrumentation and computing.

In the area of medical applications, the IRIS group dedicated to medical physics continues the developments on Positron Emission Tomography (PET) and systems for hadron therapy treatment monitoring. From the analysis of the data taken in the Krakow protontherapy centre with the two Compton cameras developed, the group has been able to detect variations of 2 mm in the Bragg peak position with the two systems. The system is also being assessed for verification and dosimetry of treatments with radiopharmaceuticals, in collaboration with La Fe hospital. Images have been acquired with different radioactive compounds in a Derenzo-like phantom, improving the spatial resolution with respect to the gamma camera employed in the hospital. Tests with volunteer patients have also been carried out.

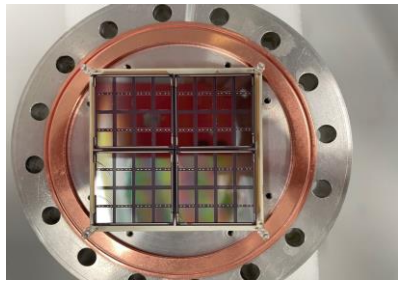
Concerning the development of a coaxial prompt gamma-ray detector also for treatment monitoring, characterization tests of an ultra-fast photomultiplier tube have been carried out with LEDs, scintillation crystals as well as background. In addition, Monte Carlo simulations of electron transport and amplification inside a photomultiplier tube were performed, as well as modelling its dependence on the operating voltage and magnetic field. The goal is to predict the behaviour of the photomultiplier gain in the clinical environment, where it sustains high overall loads, changing magnetic fields, as well as quick load variations.



X-ray image of the PMT employed in the coaxial prompt gamma monitoring prototype

Within the IMAS project for the development of a total body PET scanner, the group has implemented a method for image improvement by reducing inter-crystal scattering.

The PETALO group continues the development of a prototype of a PET scanner based on liquid xenon, read out by silicon photomultipliers, with the aim of assessing the energy and time resolution attainable with this technology. In 2022 the first data runs were taken and a measurement of the energy resolution of 511-keV gammas in liquid xenon was carried out, using scintillation light only, obtaining promising results.



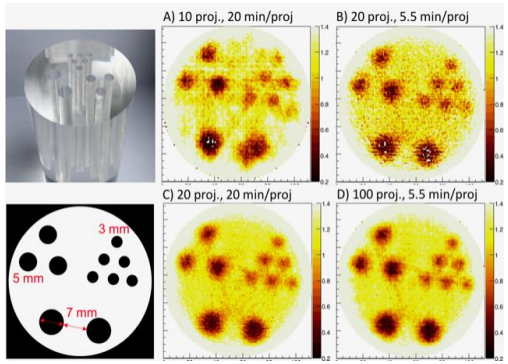
Array of VUV-sensitive SiPMs used in the PETALO prototype

The Gamma and Neutron Spectroscopy group is involved in different medical applications. The MAGAS project, which develops a gamma and ultrasound hybrid imaging system for guiding the cancer biopsy on real-time, has performed initiatives for increasing the TRL level of the development and for promoting the transfer of the technology to the market.

In the framework of the PRONTO project, the work on proton radiography was finished and published in 2022. The second part of the work on proton tomography (pCT) has been developed at CCB (Krakow), where tomographic images have been obtained. The scanner can produce medium-high quality images, spatial resolution better than 2 mm in radiography, below 3 mm in tomography and resolving power in the Relative Stopping Power comparable to other state of the art

5 L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

pCT cameras.



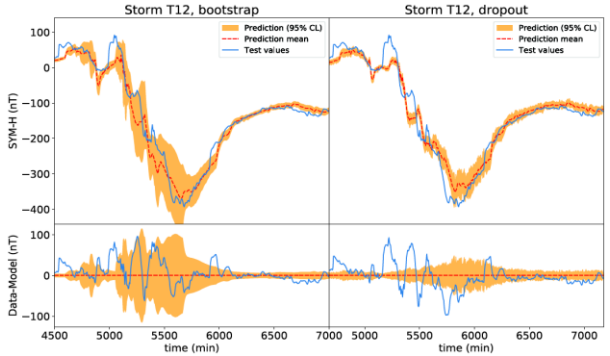
Cuts from a proton CT image of a Derenzo-like phantom, taken with the proton scanner developed within the PRONTO project

As a spinout application from the HYMNS-ERC project, an array of four Compton cameras was optimized and its applicability for ion-range monitoring in hadrontherapy treatments was investigated. After a detailed MC study and development of Artificial Inteligence (AI)-based data processing and image reconstruction algorithms first proof-of-concept experiments were carried out at the radiobiology beamline of the cyclotron at CNA-Sevilla. The most outstanding result of this research concerns the possibility to simultaneously perform PET -and Prompt-Gamma-Imaging with the Compton - cameras array operated in a front-to-front and synchronous configuration. This development allows one to exploit the complementarity of both imaging techniques.

During 2022 the accelerator physics group continued working on the testing of a 3 GHz high-gradient accelerating cavity for proton-therapy. First measurements were performed of the energy spectrum of the background photons generated due to non-linear EM phenomena intensified in high-gradient conditions in collaboration with other groups. In addition, the team worked on design optimization studies of Dielectric Assist Accelerating structures based on ultralow-loss ceramic as an alternative to conventional disk-loaded copper cavities for proton-therapy linear accelerators. They also worked within a multi-disciplinary team on the research of using gold nanoparticles as radiosensitizer for proton therapy. The results from a first radiobiological experiment performed with protons are promising.

The Laboratory of environmental radioactivity (LARAM – Laboratorio de Radioactividad Ambiental) is developing a monitor of tritium in water for the surveillance of water discharges from nuclear power plants into the rivers located in their vicinity. It is composed of modular units based on scintillating fibres read out by photosensors, a water purification system, and a system of mitigation of cosmic and environmental radiation. The laboratory measurements performed with the latest TRITIUM prototype at IFIC in 2022 have shown that the monitor sensitivity surpasses the state of the art for tritium-in-water detection by two orders of magnitude.

The project carried out by the Space Weather group develops an early warning system to evaluate, in real-time, the impact of hazardous geomagnetically induced currents produced by violent solar storms on Spanish critical infrastructures. A predictive model based on an long short-term memory (LSTM) network is developed to forecast the behaviour and severity of geomagnetic storms through the 1-hour ahead through the SYM-H activity index by using interplanetary magnetic field data measured by the NASA's ACE spacecraft at the L1 Lagrangian point and past SYM-H values. Furthermore, the uncertainty of this prediction is also estimated using the block-bootstrapping technique and it turns out to be sizeable at the critical stages of the geomagnetic storms.



Results of the first solar storms predictive model based on LSTM including two techniques: block-bootstrap and concrete dropout.

5 L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

Selected Publications

[1] J. Roser, L. Barrientos, J. Bernabéu, M. Borja-Lloret, E. Muñoz, A. Ros, R. Viegas and G. Llosá, *Joint image reconstruction algorithm in Compton cameras*, Physics in Medicine and Biology 67 (2022) 155009 DOI

[2] J. Pérez-Calatayud, F. Ballester, Å. Carlsson Tedgren, L.A. DeWerd, P. Papagiannis, M.J. Rivard, F.A. Siebert, J. Vijande, *GEC-ESTRO ACROP recommendations on calibration and traceability of HE HDR-PDR photon-emitting brachytherapy sources at the hospital level*, Radiotherapy and Oncology 176 (2022) 108–117 DOI

[3] J. Lerendegui-Marco, J. Balibrea-Correa, V. Babiano-Suárez et al., *Towards machine learning aided real-time range imaging in proton therapy,* Scientific Reports 12 (2022) 2735 DOI [arXiv]

Selected Conference Talks

R. Viegas, L. Barrientos, M. Borja-Lloret, J. V. Casaña, F. Hueso-González, J. Pérez-Curbelo, A. Ros, J. Roser, C. Senra, G. Llosá, *MACACOp Compton camera performance at proton therapy centres*. 2022 IEEE Nuclear Science Symposium and Medical Imaging Conference. Milan (Italy)

P. Ferrario, *The PETALO project*, LIDINE 2022: LIght Detection In Noble Elements. Warsaw (Poland)

P. Martínez-Reviriego, D. Esperante, C. Blanch, N. Fuster-Martínez, B. Gimeno, D. Gonzalez-Iglesias, P. Martín-Luna, J. Fuster, *Non-linear phenomena studies in high-gradient RF technology for hadrontherapy*, International Particle Accele-rator Conference (IPAC 2022). Proceedings

L. Caballero et al., *Breast cancer biopsy guided by a hybrid gamma-ray and ultrasound imaging device*, 28th Int. Nuclear Physics Conference (INPC 2022). Cape Town (South Africa)

M. Martínez Roig, *TRITIUM: Design, Construction and Commissioning of an In-Water Tritium Detector,* 3rd International Conference on Radiation and Applications (ICRAA'3). Algiers (Algeria)

6

TECHNOLOGY TRANSFER

6 TECHNOLOGY TRANSFER

IFIC has a serious commitment to promote the societal impact of our research. The Innovation and Technology Transfer Office (UCIE) at IFIC (Unidad Científica de Innovación Empresarial - UCIE) serves as a connection between the researchers and the needs of technology institutes and industry. UCIE has established its role inside the institute as go to office for researchers seeking guidance to port their developments to outside academia.

UCIE is funded by the Valencian Agency for Innovation (AVI). This year AVI changed its funding strategy implementing a competitive call for proposals. IFIC-UCIE's proposal was considered among the best ones.

Innovation Agents

César Blanch
Rosa Rodríguez
Ana I. Delgado
César Senra

Contact: ucie@ific.uv.es

6 TECHNOLOGY TRANSFER

This has been a fruitful year in terms of Innovation and Technology Transfer, some of the highlights related to intellectual property and/or evolution of innovation projects:

- Obtaining an international exploitation patent license.
- 3 protected software.
- 6 patent extensions to the international level.
- In addition, two “Proof of Concept Projects” and a CSIC COMTE-Innovation mentoring program have been obtained.

A very good approval ratio is obtained for projects submitted in search of financing as well as approved patents.

Actions aimed at reinforcing internally and externally the impact of the IFIC UCIE

Successful actions have been continued and more have been added to strengthen innovation and technology transfer ecosystem at IFIC and its relations with outside partners.

Among those some relevant or new during 2022:

- Communication actions:
  - Maintaining UCIE IFIC website, with continuous renewal of news, inclusion of new capabilities.
  - Creation of several videos on IFIC technologies and their capabilities.
  - Launching a monthly newsletter including news during that month published at IFICs web and information about Innovation and Technology Transfer.
- Contacts are maintained with a significant number of companies and with technological and health institutes.

Through the UCIE, IFIC has been present at local, national and international technological forums and meetings:

- Transfiere: Transfer Forum 2022 in Malaga.
- Participation in the international conference on particle accelerators, IPAC 2022, together with INEUSTAR. From June 12 to 17, 2022, the 13th edition of IPAC was held in Bangkok, attended by IFIC researchers.
- Big Science Business Forum (BSBF 2022) with the objective of representing and publicizing activities and capabilities of the IFIC among the different players of the Science Industry.
- Overall UCIE has participated and represented IFIC in no less than 50 events (courses, conferences, seminars, webinars...).

IFICs UCIE has continued working in close collaborations with national and regional alliances as:

- Inndromeda, an Innovative Technologies Alliance of the Valencian Community. Consolidation of Inndromeda into InnDIH will allow concrete activities to be carried out to promote this alliance.
- INEUSTAR and INDUCIENCIA, Spanish association to promote the Science Industry sector, and in the search for transversality towards other sectors.

Additionally UCIE has kept supporting IFIC facilities like Artemisa and PET/CT.

Organization of training related to Innovation and technology transfer.

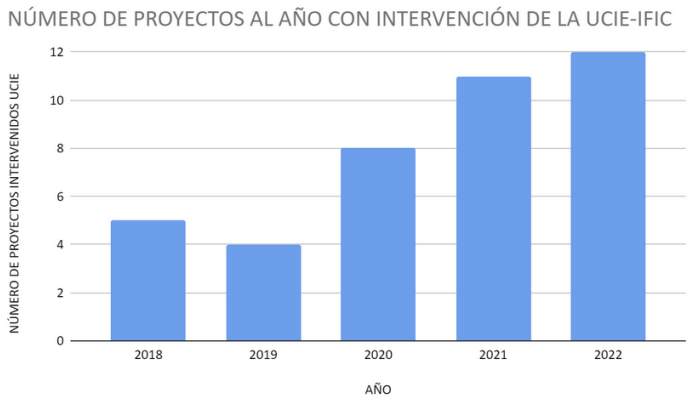
The training program aimed at the institute's researchers continues, to point to a couple of activities promoted by UCIE: one directed to illustrate on the ethical aspects of science and other to provide information on the technology transfer path.

Specific actions to support groups with technological potential and impact

During 2022, UCIE has consolidated the number of projects which are being closely

6 TECHNOLOGY TRANSFER

watched and possess potential for a transfer to industry. The list of projects that have been checked and/or helped by UCIE:



HGRF: study and characterization of radiofrequency cavities. Conducts research on high gradient phenomena and develops RF technology, paying special attention to systems for medical and industrial applications.

Radon: environmental radioactivity measurement and radiological monitoring. Promotes measurement of radon in air for the prevention of lung cancer.

Brainvector: Develops and validates nanovectors for targeted transport of antitumor agents throughphysiological barriers. Promotes new lines of diagnosis and therapy in diseases.

ASICOLD: Guided biopsy in breast cancer using a hybrid gamma imaging and ultrasound system

Betiop: Manufactures a prototype intraoperative beta probe for radiation- guided oncology surgery.

RX3D: It looks for applications in areas of health for RX3D and improve the experience in its use.

UCNAOH: Maximizes the benefits of cancer therapies based on the use of protons and ions, i.e., hadrontherapy.

GNVISION: Implements dual neutron and gamma radiation imaging device, capable of displaying both gamma radiation and neutron emitters.

Radioimagen: Development of a system to improve imaging capabilities in treatments and diagnosis with radiopharmaceuticals.

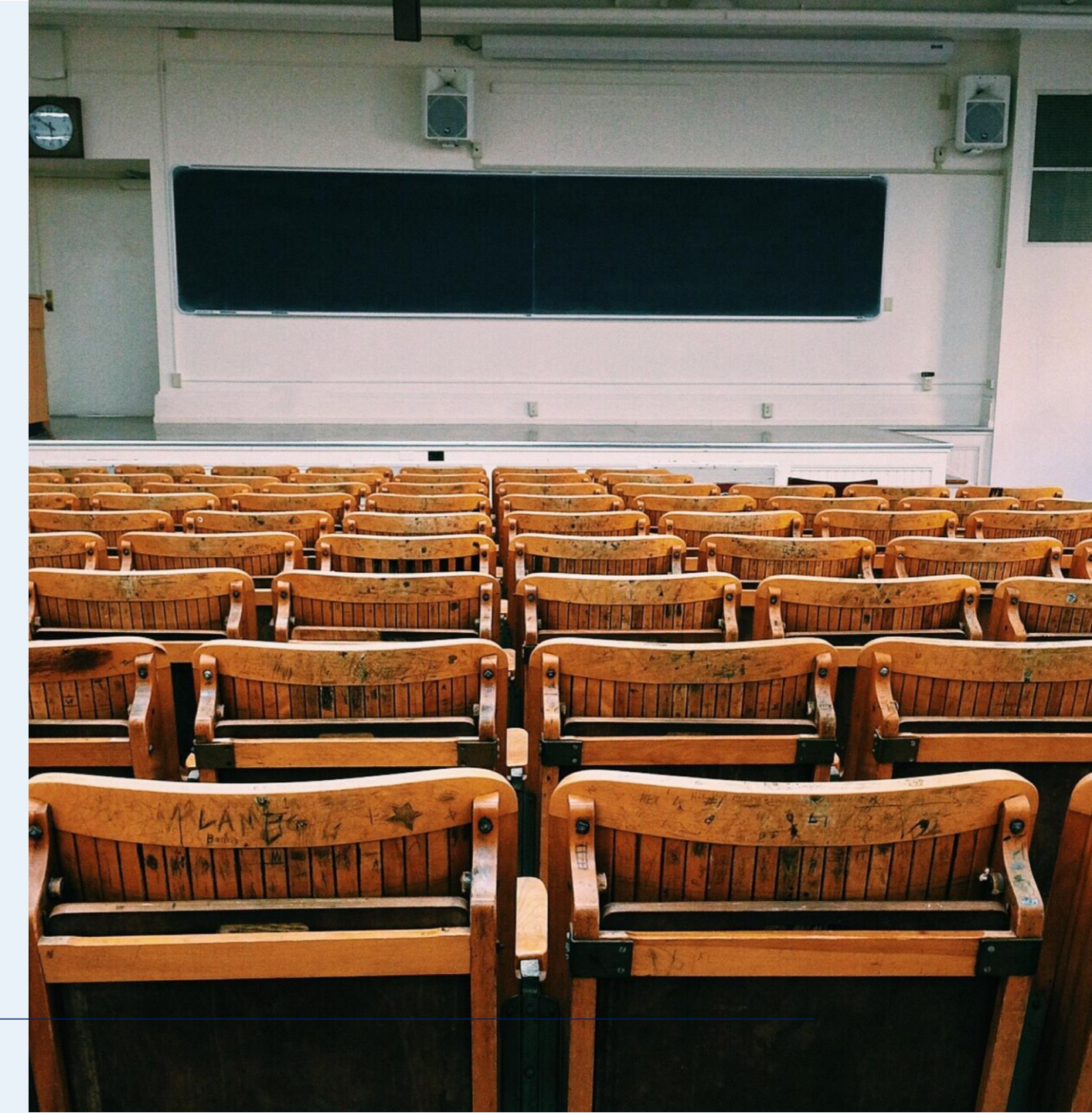
Kairos: Wireless sub-nanosecond data reading and synchronization system for multisensor detectors.

TRITIUM: Real-time monitoring of tritium activity in water.

SENSTRAF: Applications of AI to traffic sensing and prediction of pollution levels.

7

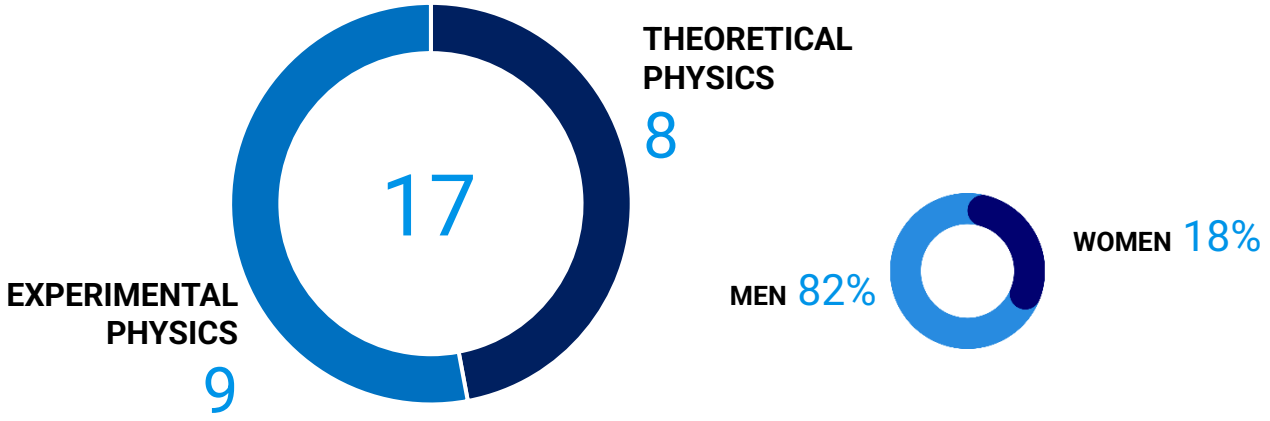
TRAINING



7 TRAINING

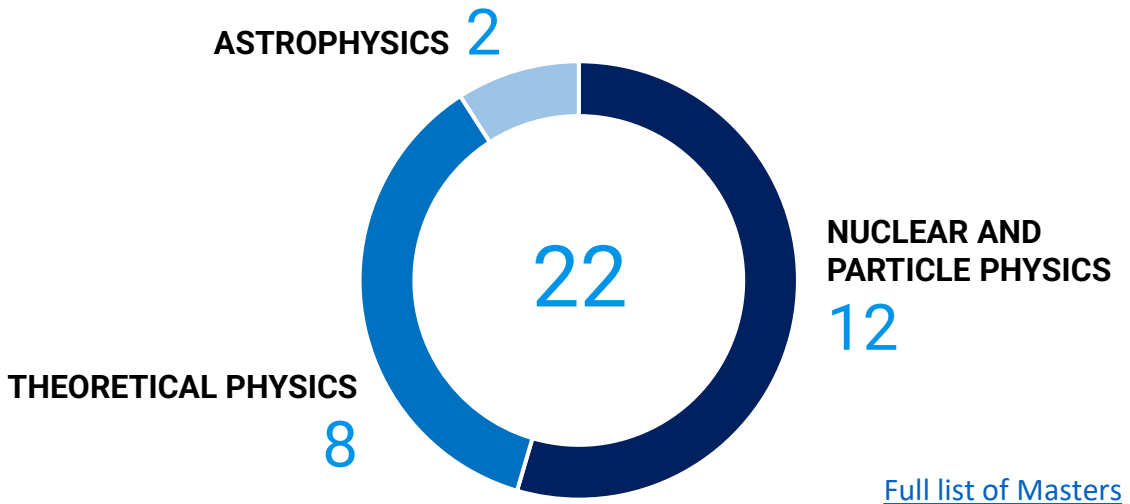
The members of IFIC with positions at the University of Valencia are mainly involved in its Degree in Physics, although they also teach in Chemistry and Engineering. At the postgraduate level, IFIC participates in two of the Master's Degrees offered by the UVEG: Master in Advanced Physics and Master in Medical Physics. In the former, we are responsible for two of the four specialities: Theoretical Physics and Nuclear & Particle Physics. IFIC also coordinates the PhD program in Physics at the UVEG.

PHD THESES WITH IFIC SUPERVISORS



Full list of PhD theses

MASTER PROJECTS



Full list of Masters

COMMITTEES

8

ARTIFICIAL INTELLIGENCE

8 ARTIFICIAL INTELLIGENCE

Artemisa is a Big Data & Artificial Intelligence (AI) infrastructure for research and experimentation. Artemisa is a GPU-intensive computing infrastructure located at IFIC's data center. The facility is very well endowed with last generation GPUs plus ancillary CPU and disk space. It provides a trusted, secure, reliable framework and excellent performance that makes possible the accelerated development of projects involving artificial intelligence areas.

Members

ARTEMISA: Francisco Albiol, Vicente Giménez, Jose Enrique García, Juan José Hernández, Arantza Oyanguren, José Salt, Javier Sánchez, Verónica Sanz, Nuria Rius

8 ARTIFICIAL INTELLIGENCE

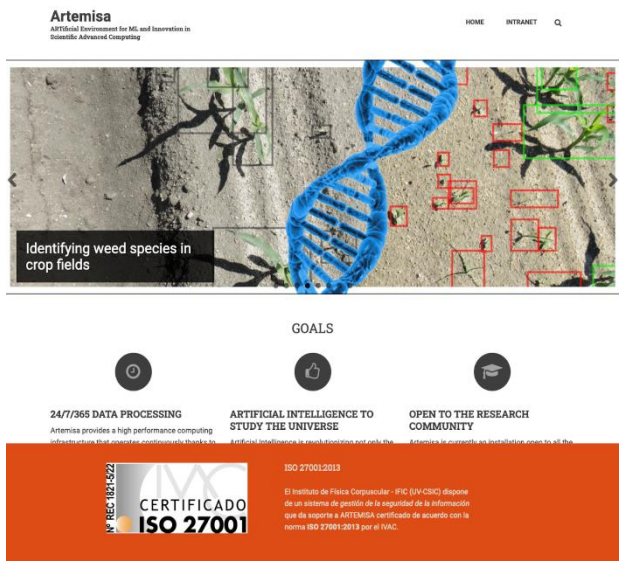
ARTEMISA

ARTificial Environment for ML and Innovation in Scientific Advanced Computing

During this year, IFIC's facility Artemisa has consolidated its position as a reference infrastructure for development of projects in AI and big data in science in Spain.

Artemisa is currently composed of a total of 35 servers. 22 servers host one NVIDIA GPU Volta V100 each and 11 servers with one NVIDIA GPU Ampere A100. Additionally, two multi-GPU servers, one with a 4-V100 NVIDIA GPU and one 8-A100 NVIDIA GPU. The servers are especially suitable for computing in artificial intelligence. In addition to these servers, which must be used in "batch" mode, there are two interfaces where the users can previously test their software.

During 2022, the work done the previous year toward the infrastructure certification has crystallized in the successful attainment of the ISO 27001 certification. This is the international standard on the management of information security, and currently only two institutes at CSIC have obtained this certificate. The certificate includes a compromise to maintain and improve the information security management system so it needs to be renewed annually to prove that high standards continue to be met.



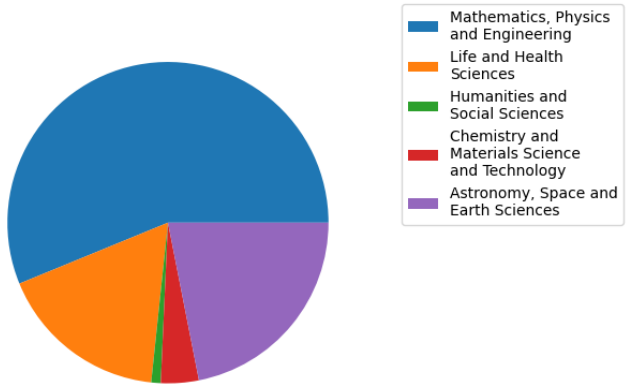
In 2022, a project centered in Artemisa was granted with funding within the "Programa de I+D+i de Astrofísica y Física de Altas Energías". This project aims to enhance the computational infrastructure offered by Artemisa and improve the services provided, which will be reflected in an even greater increase in projects that use it, both internal and external to IFIC. The project will act in two ways: improvement of the software, documentation and support, and small upgrade of the hardware of the infrastructure.

Artemisa is also part of the project InnDIH (**European Digital Innovation Hub**) of the Valencia Community. The project was granted by the European Commission this year, and it will start in January 2023. InnDIH is funded by the EU, national and regional governments represents the great centralized bet of public-private collaboration where the business ecosystem, universities, technological and

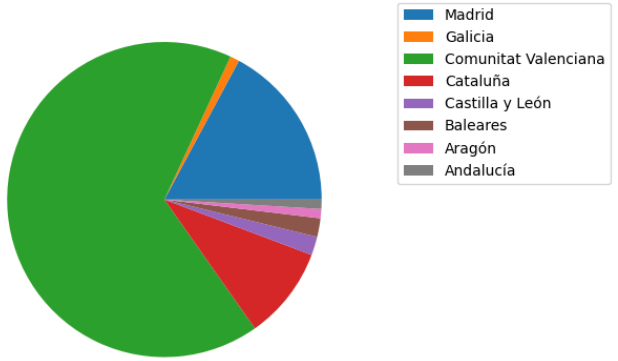
8 ARTIFICIAL INTELLIGENCE

research centers join efforts to contribute to the digitization of SMEs and the Public Administration and promote the economic development of the Valencian Community. This will allow SME from the Comunitat Valenciana to profit from the services of Artemisa.

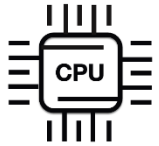
The Artemisa infrastructure has continued to give service in several regions and areas, encouraging groups of different lines and origins (CV institutes and other communities) to participate in the calls and use the services it offers. Although a large part of the projects originate from IFIC, the majority comes from external institutions.



The pie charts in the figure show the distribution of the projects by region of origin and area of the projects. The distribution has remained almost stable since last year. Communities such as Madrid and Catalonia continue to dominate the projects from outside Comunitat Valenciana.

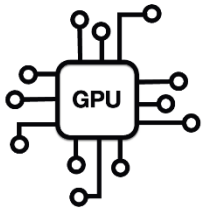


Although the total number of projects is smaller than the previous year, the GPU hours usage has not experienced a decrease, pointing to fewer but more active projects applying to Artemisa calls. The system has been able to deliver during 2022 around 80 thousand hours of GPU to the projects.



3400 CPUs

64.000 Hours Delivered in 2022



44 GPUs

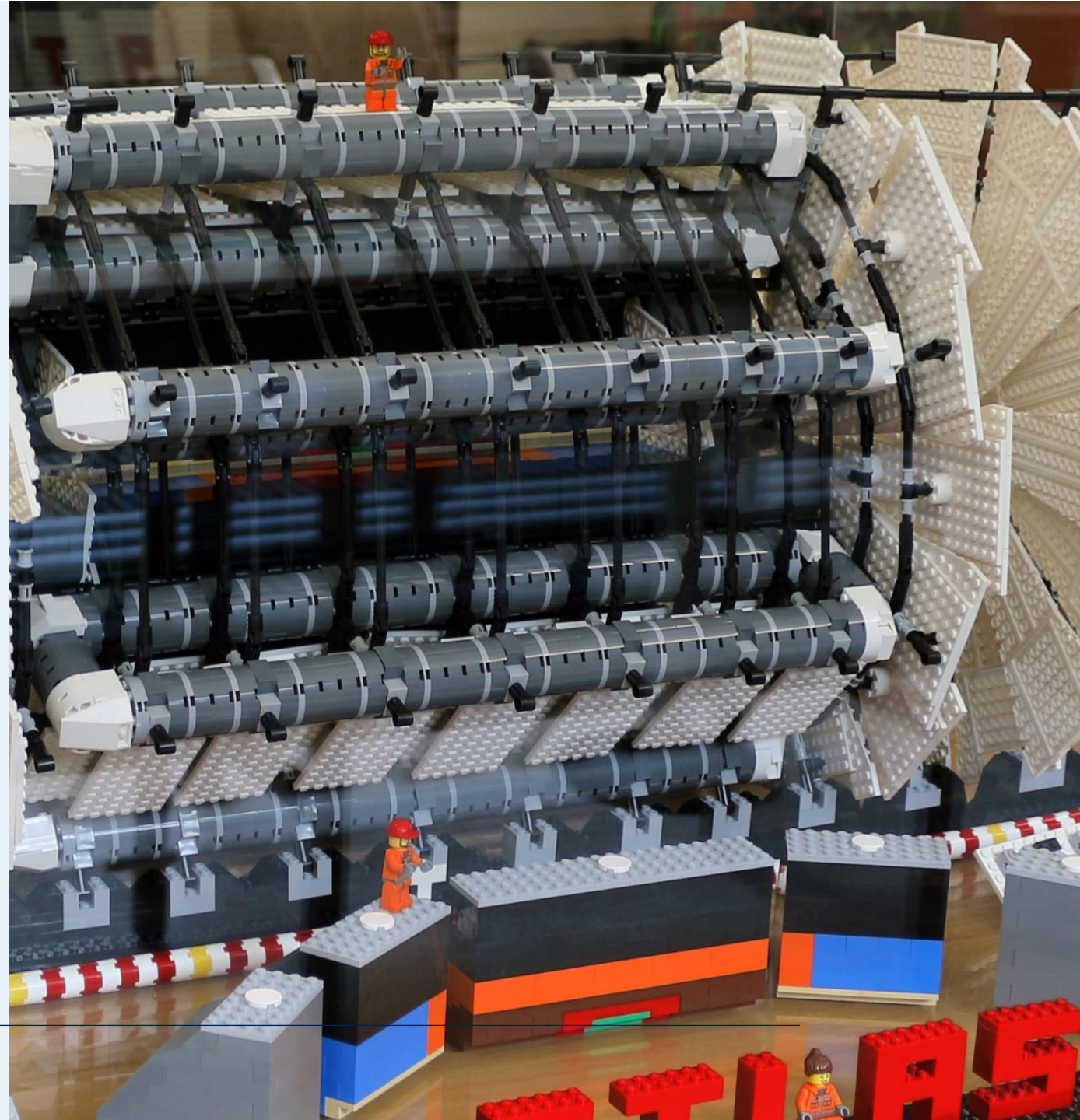
80.000 Hours Delivered in 2022

The computing resources have been used by a great thematic diversity of projects, which have in common the use of Artificial Intelligence as a fundamental analysis tool. Most of the projects are related to activities and studies in fundamental physics, but there is a sizable percentage of projects oriented to other areas like Health, Earth and Social sciences.

Several activities related with Artemisa and AI have taken place during 2022 in the framework of the AIHUB and COMCHA network. Among those is the petition of a COFUND including members of the AIHUB, and AIHUB meetings to promote synergies between different institutes.

9

OUTREACH



9 OUTREACH COMMITTEE

IFIC actively sponsors and participates in a good number of outreach activities, made possible through the active engagement of our Institute's members. These activities encompass a wide range, from public talks held outside our facilities to opening our laboratories' doors, targeting both the general public and the educational community.

In 2022, eight individuals from IFIC led the Outreach Committee, overseeing these activities. Ángela Molina managed our website, social media presence, and liaised with journalists and press offices from other institutions. Alberto Aparici coordinated activities and materials aimed at students and the general public. Núria Falcó managed the scientific communication and outreach of the strategic network CPAN, which is managed from IFIC, and provided support to IFIC's communication and outreach. Additionally, five IFIC staff scientists played crucial roles in coordinating and developing these activities: Enrique Nácher, Olga Mena, Avelino Vicente, and, as of the end of 2022, Emma Torró and Carlos Escobar.

The committee's efforts are complemented by the active involvement of numerous IFIC researchers and technical staff engaged in outreach activities and logistics.

It's worth noting the significant impact achieved through the Meitner Project, which was funded by FECyT, among other institutions.

Outreach Committee

Ángela Molina
Alberto Aparici
Núria Falcó
Olga Mena
Enrique Nácher
Avelino Vicente
Carlos Escobar
Emma Torró

9 OUTREACH CONTRIBUTIONS

17 Guided tours for students

After the interruption caused by COVID-19, we were able to resume the guided tours in 2022. IFIC received 17 groups, primarily of high school and undergraduate students, with a total of around 300 visitors.

55 High school talks

Many members of IFIC offer outreach talks to local high schools as part of our outreach programme. In 2022 IFIC offered 55 such talks, with five different topics: in addition to the three usual ones (LHC physics, astroparticles, and nuclear physics), the new topics of cosmology and quantum physics were added. Around 2,300 students attended these talks.

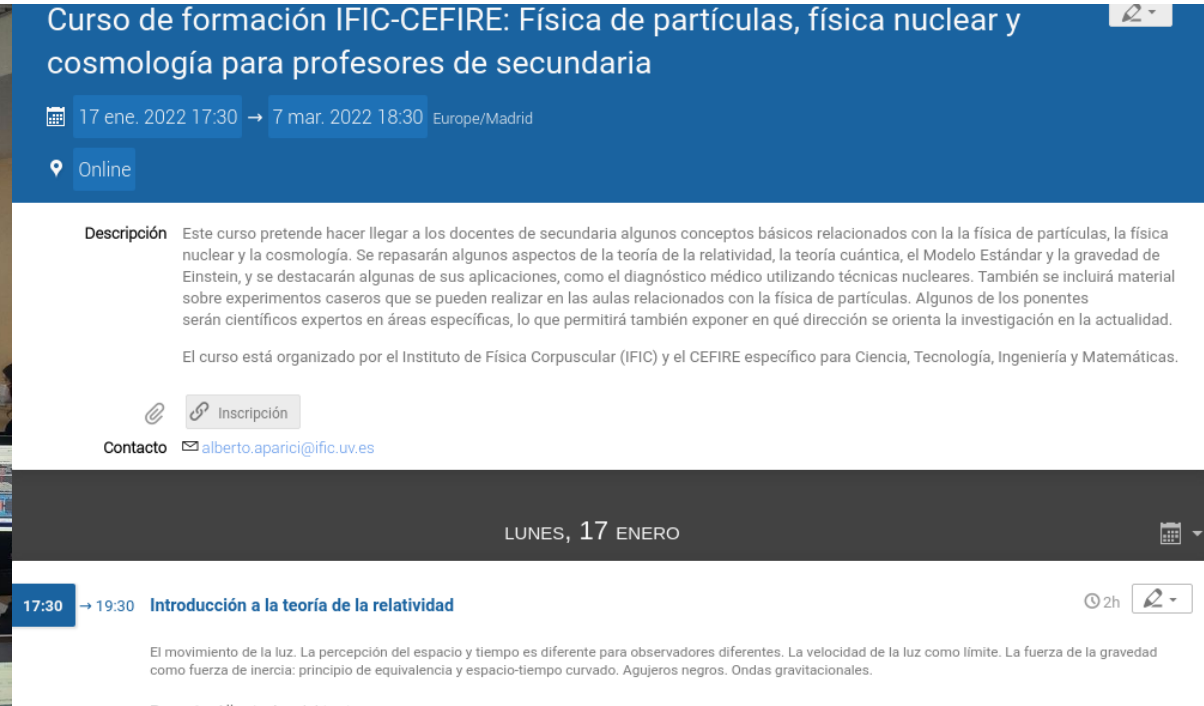
9 OUTREACH CONTRIBUTIONS

4 Masterclasses for high school students

The masterclasses were another activity that was interrupted by the pandemic. In 2022, we resumed their organisation and had the participation of 86 schools from all over Comunitat Valenciana, with a total of 271 students. The participants analysed data from the ATLAS, LHCb, and MINERvA experiments.
More than 40 members of IFIC were involved in these activities.

Training course for secondary school teachers

This course aims to provide secondary school teachers with some basic concepts related to particle physics, nuclear physics and cosmology. As the previous year, the activity was carried out entirely in an online format. More than 100 teachers participated, and the educational videos produced the previous year collected more than 5,000 views.



9 OUTREACH EVENTS

Armonía Cuántica 2022

Armonía Cuántica is a project that bridges physics and musical creation. Researchers from IFIC and members of Conservatorio Superior de Música de Valencia collaborate throughout the academic year to produce a series of musical works inspired by scientific concepts. The theme for this edition was gravitational waves. The works are premiered in the spring at the Museum of Sciences, performed by an instrumental ensemble composed of conservatory students.

Anniversary of the Higgs Boson

In July 2022, we celebrated the tenth anniversary of the discovery of the Higgs boson by the ATLAS and CMS experiments. At IFIC, we wanted to commemorate this milestone by organising an entire afternoon of outreach activities centred around the Higgs boson. The event featured the participation of science communicators Alberto Aparici, Javier Santaolalla, and Rocío Vidal, as well as visual artist Patossa. Over 700 people attended the event.

9 OUTREACH EVENTS

Expociencia 2022

After a two-year hiatus due to the pandemic, the Open Day of the Science Park also returned. During this event, various research institutes organise recreational and educational activities aimed at the general public, especially the youngest of the families. IFIC contributed with twelve activities, and the event had an attendance of over 3,500 people.

Experimenta XVII

Experimenta is a festival organised by the Faculty of Physics in Valencia and aimed at high school students, who submit their science projects for a contest with several categories in physics and technology. IFIC collaborates regularly with the festival.

9 OUTREACH CONTRIBUTIONS

La Cerveciencia

This activity, organised as part of the CSIC Science Week, aims to encourage the general public to casually discuss science while enjoying a beer. The activity consisted of two short talks held in a pub, followed by a round of questions and discussion. The talks centered on the origins of quantum theory and the production of atomic nuclei in the cosmos.

Dark Matter Day

The Dark Matter Day is an annual event around which outreach activities are organised, focusing on the 'dark' part of our universe, and particularly on dark matter. The celebration coincides with the Halloween night on October 31st. In 2022, IFIC participated with two conferences, one at the Museum of Sciences in Valencia, and another at the Planetarium of Castellón, where the documentary Phantom of the Universe, co-produced by members of IFIC, was also displayed.

9 OUTREACH IFIC IN MEDIA

23 IFIC in the news

Several initiatives and research results involving IFIC reached the news in 2022, and in all cases statements from members of the institute were provided for the journalists.

100 Radio and podcast pieces

Several members of IFIC collaborate regularly with radio shows and podcasts that have science as their primary theme. In 2022 these collaborations amounted to around one hundred different pieces.

9 OUTREACH - GENDER PROJECT

Proyecto Meitner

It is a project promoted by the Institute of Corpuscular Physics (IFIC) with the collaboration of the Spanish Foundation for Science and Technology (FECYT) - Ministry of Science and Innovation. With it, the IFIC recovers and revalues the contribution of the great pioneers of Nuclear and Particle Physics through the figure of Lise Meitner.
A play, a conference on science and gender, a science and art contest, videos on social networks and a lot of educational material to give visibility to women in science, bringing scientists of the past and present in Nuclear and Particle Physics to all audiences. And all with the aim of promoting social equality and scientific culture, encouraging scientific vocations and highlighting the legal, cultural, historical and social barriers that women scientists have faced throughout history.
In this project, the participation of both the dissemination and the equality and diversity committees has been fundamental.

9 OUTREACH-GENDER PROJECT: PROYECTO MEITNER

Art Contest: Express-Arte ConCiencia

The contest was aimed at secondary school and vocational training students. A total of 53 assignments were accepted in the competition. Winning and selected works.

Express-Arte ConCiencia Awards Ceremony

The awards ceremony of the second edition of the Express-Art ConCiencia contest took place on May 28, 2022, during the celebration of Expociència. More than 40 people attended the event and almost 25 followed the ceremony remotely.

10

EQUALITY AND DIVERSITY COMMISSION

10 EQUALITY AND DIVERSITY COMMISSION - CID

CID commission

Coordinators:
Emma Torró Pastor
Neus López March

Members:
Sergio Alves Garre
María Teresa Andreu García
Andrea Donini
Pilar Hernández Gamazo
Marta Lanzac Berrocal
Raquel Molina Peralta
Ángela Molina Ruiz
Víctor Montesinos Llácer
Emanuela Musumeci
Enrique Nácher González
Sonja Orrigo
Neus Penalva Martínez
Ana Ros García
Berta Rubio Barroso
María Amparo Tórtola Baixauli

The Equality and Diversity Commission (CID) arises from the Office of Young Researchers, Gender and Diversity, created in October 2017, and whose original functions were divided between the CID and the Office of Young Researchers (OJI). The objective of the CID is to try to eliminate discrimination or harassment that may take place in the Institute, ensuring equal opportunities for all its members and promoting good relations between the components of all its sections.

10 CID ACTIVITIES AND EVENTS

DISTINTIVO DE IGUALDAD DEL CSIC

In 2022 IFIC was awarded with the "Distintivo de Igualdad del CSIC" in recognition to the work done by the institute to reach a real equality between men and women.

This distinction, awarded to IFIC among the 121 centers at CSIC, is funded with a 5,000 € prize.

The jury highlighted IFIC's actions towards fulfulling CSIC's "Plan de Igualdad", the implication of IFIC's directorate and all the personel and the equality policies taken by IFIC against all kinds of discrimination. It also recognized the large number of initiatives for the education and to increase awarness in matters related to equality and specially to stimulate female vocations in science.

DISTINTIVO DE IGUALDAD CSIC

10 CID ACTIVITIES AND EVENTS

8 M: Maternitat i carrera científica

As every year, IFIC organized an event in collaboration with the Institute of Agrochemistry and Food Technology (IATA - CSIC), to celebrate International Women's day. This year we had a presentation by Alicia Villar, a sociologist at UV, talking about maternity and the research career followed by a round table including research personnel from IFIC, IATA and the Institute of Molecular Science (ICMol – UV)

VI JORNADA DE LA MUJER INVESTIGADORA ICMOL - IFIC

The activity, focusing on ethics for equal science, was organized by ICMol in collaboration with IFIC. It started with a talk by a renowned female researcher presenting the key problems that women face during the research career. The second part of the event was dedicated to discuss how to create a Committee for equality and diversity and the experience from several centers.

10 CID ACTIVITIES AND EVENTS

11 F: INTERNATIONAL DAY OF WOMEN AND GIRLS IN SCIENCE

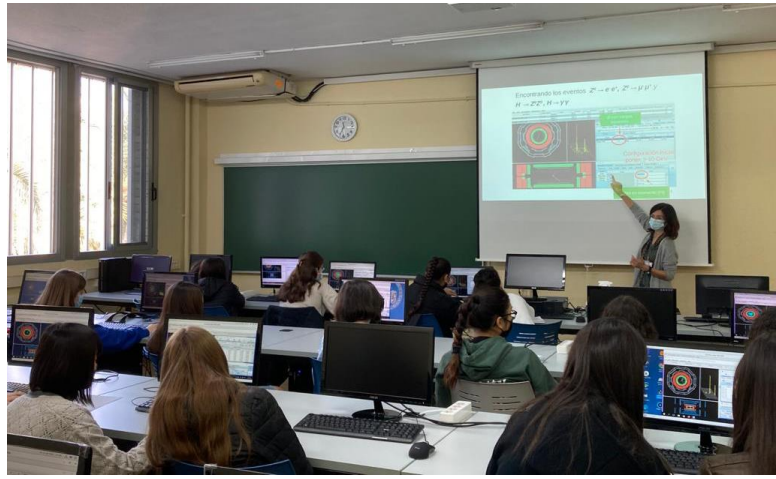
11 F: Conferences In High Schools

7 IFIC researchers gave a series of talks, 11 in total, in different secondary schools in the Valencian Community.

11 F: MASTERCLASS ON PARTICLE PHYSICS

Close to 70 female students from 25 High School institutes around the Valencian Community participated in this one-day hands—on activity. Starting with introductory lectures to theory and experiments in High Energy Physics and continuing with a 2-hour practical session where they analyse real data from the ATLAS experiment, students experience what being a scientist is. All lectures are given by IFIC female researchers, including an open discussion on Women in Science.

This activity is organized by the International Particle Physics Outreach Group (IPPOG) and done simultaneously in several research centres along the Globe.



11

YOUNG RESEARCHERS OFFICE

11 YOUNG RESEARCHERS OFFICE

The mission of the Office of Young Researchers (YRO) is to carry out actions that favour the professional development of doctoral and postdoctoral researchers at IFIC.

Objectives
The actions carried out by the OJI to fulfil its mission are framed in the development of several activities throughout the academic year aimed at helping new recruits, and to disseminate the skills and abilities acquired by IFIC PhDs in the business world.

1. Programme to help the integration of doctoral and postdoctoral researchers at the institute: Presentation day for new postdocs, in collaboration with the heads of unit, welcome day for master's and doctoral students, etc.

2. Programme to support the integration of PhDs in the workplace: Round table with IFIC PhDs currently working in the world of work, conference with companies, colloquium by an IFIC PhD with a relevant position in a company, ...

YRO committee
María Moreno
Alberto Ramos

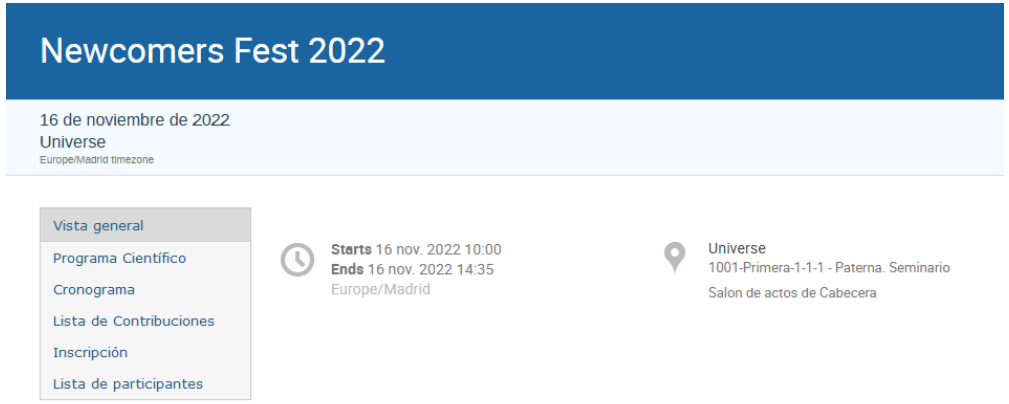
11 YOUNG RESEARCHERS OFFICE

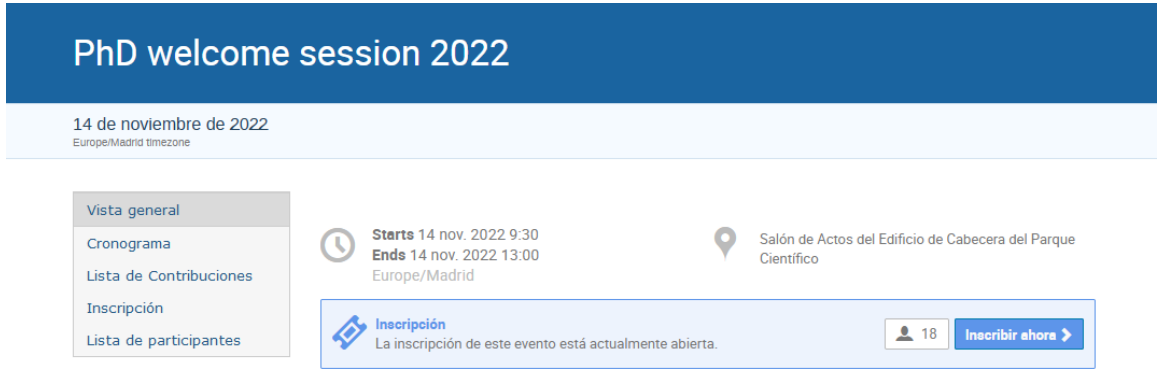
Along the academic course 2021/2022 the OJI has continued in his mission to help young researchers arriving to the institute.

For this purpose, we have organized a welcome event for postdoctoral researchers: Newcomers Fest 2022. In this even researchers that join the IFIC have the opportunity to present his/her line of research to the members of the institute as well as to their fellow newcomers. The event also includes some key talks by the Director of the institute to help newcomers to get a picture of the different research activities carried in the institute.

In a similar fashion the OJI has organized a welcome event for the new PhD students. In this event new students know each other, present their background, interests and hobbies. Special lectures by the Director of the Institute and by the coordinator of the PhD program help the students understand what is expected from a PhD student at IFIC, and what are the steps that they need to follow in order to get a Doctor degree.

Moreover the OJI in collaboration with the professional development office of the University and the UCIE (technology transfer office), have been preparing an event with companies to show on one hand, the kind of work that the private sector can offer to a researcher from IFIC, and on the other hand to show the companies the abilities that a typical IFIC researcher has.





12

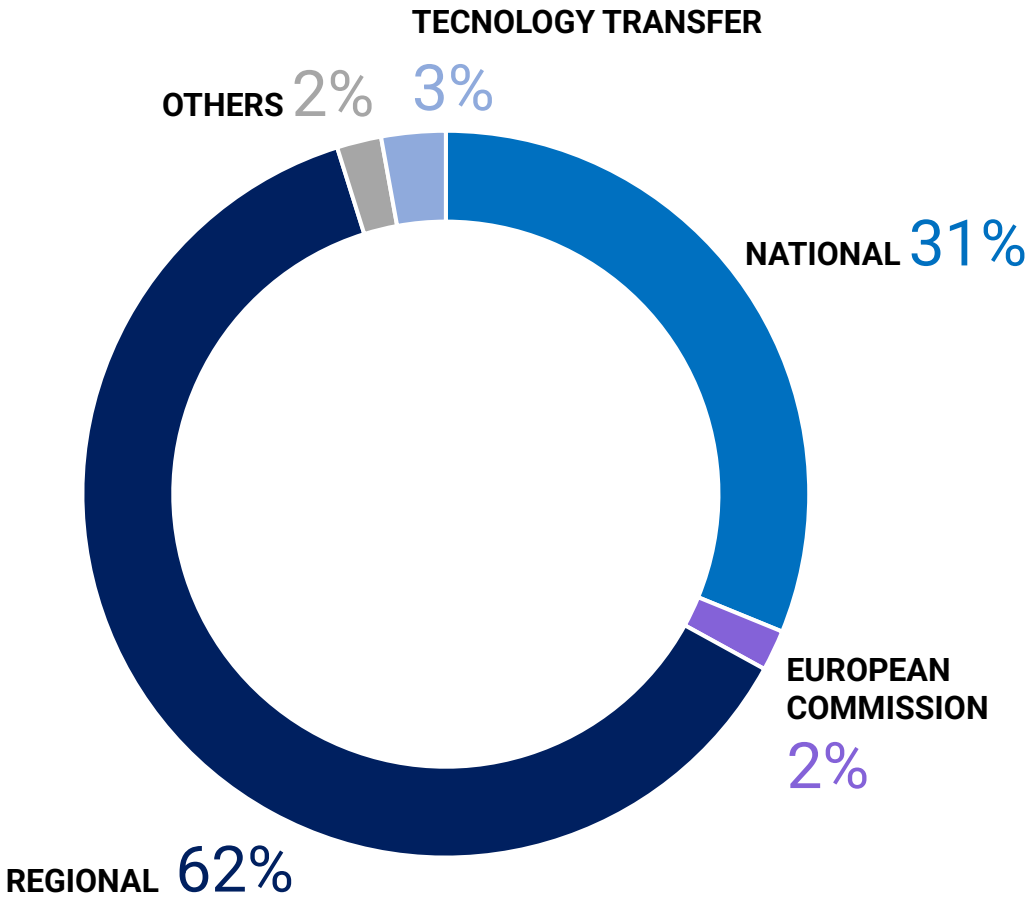
FUNDING

12 PROJECTS

* Map of experimental collaborations in fundamental physics with IFIC's participation

12 TOTAL INCOME BY SOURCE

NATIONAL	6,144,324.83 €
EUROPEAN COMMISSION	358,000.00 €
REGIONAL	12,253,770.83 €
OTHERS	389,790.62 €
TECHNOLOGY TRANSFER	563,333.00 €
TOTAL	**19,709,219.28 €**



Full list of grants

ANNEXES

1 Personnel List

Permanent staff researchers: 70

Albiol Colomer, Francisco Javier
Algora, Alejandro
Alvarez Ruso, Luis
Barenboim, Gabriela
Bordes Villagrasa, José Manuel
Botella Olcina, Francisco J.
Cabrera Urbán, Susana
Cases Ruiz, Ramón
Castillo Giménez, M. Victoria
Cervera Villanueva, Anselmo
Costa Mezquita, María José
Díaz Medina, José
Domingo Pardo, César
Donini, Andrea
Fabbri, Alessandro
Fiorini, Luca
Furtado Valle, José Wagner
Fuster Verdú, Juan A.
Gadea Raga, Andrés
García García, Carmen
Garcia Navarro, José Enrique
Gimeno Martinez, Benito
González de la Hoz, Santiago
González Marhuenda, Pedro
Hernández Gamazo, Pilar
Hernández Rey, Juan Jose
Hirsch, Martin
Lacasta Llacer, Carlos
Lledó Barrena, Mª Antonia
Llosá Llácer, Gabriela
Marti García, Salvador
Martínez Vidal, Fernando
Mena Requejo, Olga
Mitsou, Vasiliki
Molina Peralta, Raquel
Navarro Salas, José
Nácher González, Enrique
Nieves Pamplona, Juan Miguel
Noguera Puchol, Santiago
Novella Garijo, Pau
Olmo Alba, Gonzalo
Oyanguren Campos, Arantza
Palomares Ruiz, Sergio
Papavassiliou, Ioannis
Pastor Carpi, Sergio
Peñarrocha Gantes, José Antonio
Pérez Cañellas, Armando
Pich Zardoya, Antonio
Portolés Ibáñez, Jorge
Rius Dionis, Nuria
Rodrigo García, Germán
Rubio Barroso, Berta
Ruiz de Austri Bazan, Roberto
Salt Cairols, José
Sanchis Lozano, Miguel Angel
Santamaría Luna, Arcadi
Sorel, Michel
Taín Enríquez, José Luis
Tarifeño Saldivia, Ariel
Tortola Baixauli, Mª Amparo
Valls Ferrer, Juan Antonio
Velasco González, Jorge
Vicente Vacas, Manuel
Vidal Perona, Jorge
Vijande Asenjo, Javier
Vives García, Oscar
Vos, Marcel
Yahlali Haddou, Nadia
Zornoza Gómez, Juan de Dios
Zuñiga Román, Juan

Tenure-track researchers: 32

Albaladejo Serrano, Miguel
Campanario Pallás, Francisco
Cieri, Leandro Javier
De Romeri, Valentina
Escobar Ibáñez, Carlos
Figueroa, Daniel G.
García Cely, Camilo Alfredo
Gessner, Manuel
González Alonso, Martín
Gozzini, Sara Rebecca
Gross, Christian
Hagedorn, Claudia
Herrero García, Juan Andres
Irles Quiles, Adrian
Lopez Pavon, Jacobo
Mariñas Pardo, Carlos Manuel
Martín-Albo Simón, Justo
Molina Bueno, Laura
Moreno Llácer, María
Nebot Gómez, Miguel
Passemar, Emilie
Poveda Torres, Joaquin
Ramos Martínez, Alberto
Ruiz Martínez, Arantxa
Salesa Greus, Francisco
Sanchez Losa, Agustin
Sanz González, Veronica
Torró Pastor, Emma
Villaplana Pérez, Miguel
Vicente Montesinos, Avelino
Zaldívar Montero, Bryan
Zurita, José Francisco

Professors emeriti and visiting researchers: 8

Azcárraga Feliu, José Adolfo de
Bernabéu Alberola, José
Fassi Imlahi, Farida
Ferrario, Paola
Ferrer Soria, Antonio
Higón Rodriguez, Emilio
Oset Báguena, Eulogio
Vento Torres, Vicente

1

Post-doctoral researchers: 35

Babiano Suarez, Victor
Balibrea Correa, Javier
Caballero Ontanaya, Luis
Cantero García, Josu
Carrió Argos, Fernando
Coutinho, Antonio Manuel
Da Silva Leite, Julio Rafael
Del Rio Vega, Adrian
Dhani, Prasanna Kumar
Esperante Pereira, Daniel
Feijoo Aliau, Eduardo Alberto
Fuster Martinez, Nuria
Garcia Folgado, Miguel
García Soto, Alfonso Andrés
Gargalionis, Johnathon
Gupta, Aritra
Hueso Gonzalez, Fernando
Karan, Anirban
Landini, Giacomo
Lang, Nicolas
Lerendegui Marco, Jorge
Lopez March, Neus
Martín Lozano, Víctor
Martins Cosme, Catarina
Morales Lopez, Ana Isabel
Orrigo, Sonja Elena Agata
Perez Vidal, Rosa Maria
Rahaman, Ushak
Ros Garcia, Ana
Saibel, Andrej
Sánchez García, Gonzalo
Simakachorn, Peera
Soto Oton, Jose Alfonso
Torrentí Salom, Francisco
Vale Silva, Luiz Henrique

PhD students: 116

Agius, Dominic Alfred Klaus
Aikot, Arya
Albandea Jordan, David
Alcala Escalona, Gustavo Adolfo
Alvarado Alvarez, Fernando
Alves Garre, Sergio
Amar Es-Sghir, Hamza
Amedo Martínez, Pablo
Amerio, Aurelio
Amos, Kieran
Anglés Castillo, Andreu
Antonova, Maria
Autieri, Andrea
Baeza Ballesteros, Jorge Juan
Bariego Quintana, Adriana
Barrientos Mauriz, Luis Alfredo
Bas Beneito, Arnau
Beltrán Lloría, Rebeca
Borja Lloret, Marina
Bouchhar, Naseem
Breso Pla, Victor Ernesto
Carrasco Mejía, Juliana Mara
Carretero Cuenca, Victor
Carrión Martínez, Clara
Chitishvili, Mariam
Conde Villatoro, Daniel Eduardo
Coro, Federico
Di Meglio, Francesco Paolo
Díaz Calderón, David
Didenko, Mariia
Dimitriou, Androniki
Escalante Castro, José Manuel
Escribano Valiente, Pablo
Esser, Fabian
Ferrando Solera, Sergio
Ferreiro de Aguiar, Antonio Eduardo
Fonseca Vargas, Angie Carolina
Fontelles López, Oscar
García Lorenzo, Amador
Garcia Peris, Miguel Angel
Gil Dominguez, Fernando
Gomez Delegido, Antonio Jesus
Gómez Lurbe, Rafael
Hajjar Muñoz, Rasmi Enrique
Hallam, James
Herrero Brocal, Antonio
Jaimes Elles, Sergio Javier
Kellerer, Fabian
Lanzac Berrocal, Marta
Lazo Pedrajas, Alfonso
Lessing, Nadja
Loayza Romero, Nicolas
Lozano Durán, Paula
Márquez Hernández, Jesús Pedro
Martín Luna, Pablo
Martinez Agulló, Pablo
Martínez de Lejarza Samper, Jorge Juan
Martínez López, Eduardo
Martinez Mirave, Pablo
Martinez Reviriego, Pablo
Martinez Roig, Marcos
Masó Ferrando, Andreu Sales
Medina Rosales, Omar
Mehrabankar, Somayeh
Miralles Lopez, Marcos
Miró Arenas, Carlos
Monsalvez Pozo, Kevin
Monsonis Romero, Luis
Montesinos Llácer, Víctor
Muñoz Albornoz, Victor Manuel
Muñoz Candela, Pablo
Muñoz Ovalle, Alejandro
Muñoz Perez, David
Musumeci, Emanuela
Nadal Gisbert, Sergi
Navarro Gonzalez, Josep
Ortega Mediavilla, Samuel
Palacios Gonzalez, Juan
Parra Aedo, Selene Bárbara
Pastor Gómez, Emilio Jesús
Pattnaik, Baibhab
Penalva Martinez, Neus

Pérez Curbelo, Javier
Pérez Soler, Javier
Pompa, Federica
Prades Ibañez, Alberto
Ramirez Uribe, Norma Selomit
Renteria Olivo, Andres Ernesto
Rodrigues Sandner, Stefan Marinus
Rodríguez García, David
Romo Luque, Carmen
Roser Martinez, Jorge
Rubio Jiménez, Adrián
Saina, Adrian
Sánchez Blázquez, Lucia
Sánchez Muñoz, Julián Andrés
Sanchez Sebastian, Victoria
Sanderswood, Izaac Gregory
Senthilkumar, Varsha
Simeó Vinaixa, Mireia
Soares Narciso Ferreira, Antonio Mauricio
Solomonidi, Eleftheria
Svintozelskyi, Volodymyr
Telo Rodrigues Catumba, Guilherme
Tuzi, Mirald
Ureña González, Julio
Urrea González, Salvador
Usón Andrés, Alberto
Valenciano Ruano, Fernando
Valiente Moreno, Enrique
Varriale, Lorenzo
Vatsyayan, Drona
Vegas Luque, Victor
Victoria Fernandez, Jose Antonio
Viegas Botelho Correia Rego, Rita
Zhuo, Jiahui

Technical staff: 51

Agramunt Ros, Jorge
Álvarez Puerta, Jesús
Benítez Montiel, Carlos Gaspar
Bernabeu Verdú, José
Blanch Gutierrez, Cesar
Blasco Miquel, José
Brzezinski, Karol Wiktor
Calvo Diaz-Aldagalán, David
Cámara García, María Teresa
Capilla Fernández, Elvira
Capó Torres, Jordi
Carrasco de Fez, Rosa
Carcel Garcia, Sara
Casaña Copado, Jose Vicente
Cervelló Duato, Antonio
Civera Navarrete, José Vicente
Delgado Belmar, Ana Isabel
Elesgaray Susierra, Oihan
Fernández Casaní, Álvaro
Fuentes Castilla, Angel
Gallego Baviera, Francisco Javier
González González, Francisco
Gonzalez Iglesias, Daniel
Goyanes, Adrian
Hernández Navalón, David
Ladarescu Palivan, Ion
López López, Hanlez
Lopez Redondo, Manuel
Marco Hernández, Ricardo
Martín Valladolid, Francisco
Martínez Ferrer, Miguel
Martínez Saez, Carlos
Mazorra de Cos, José
Menéndez Márquez, Abraham
Mestre Antoni, Josep Vicent
Nácher Arándiga, Jorge
Nadal Durà, Joaquin
Platero Garcia, Adrian
Platero Montagut, Vicente
Querol Segura, Marc
Real Máñez, Diego
Rivera Nebot, Antonio Daniel
Rodriguez Cespedosa, Nicolas
Sánchez Martínez, Fco. Javier
Senra Moledo, Cesar
Solaz Contell, Carles
Soldevila Serrano, Urmila
Tchogna Davis, Daniel
Teruel Pardo, Simón
Tortajada Velert, Salvador
Valero Biot, José Alberto

Administrative staff: 21

Aguilar Argilés, Teresa
Andreu Garcia, Mª Teresa
Claramunt Pedrón, Luis Miguel
Cordero Ruiz, Victoria
Falcó Moreno, Nuria
Fandos Lario, Ana María
Ferrer Lazaro, Jose Manuel
Fillol Ricart, Amparo
Garcia Gonzalez, Soledad
Gonzalez Romeu, Maria Teresa
Gracia Vidal, Maria Jose
Hernando Recuero, Maria Luisa
Molina Ruiz, Ángela
Monserrate Fandos, María
Montesinos Reig, Leonor
Monzón Herrero, Benjamín
Novo Picouto, José Carlos
Pérez García, José
Rubiera Prats, Chabely
Salgado Lopez, Óscar
Sanjuan Martín, Neus

2 Publications

The full list of scientific publications in 2022 is available at the IFIC Literature Database

3 Conferences and workshops organized

- Innocharlas: "Del Concepto al Mercado" y "Experiencia en la creación de spin-off", Dec 19
- Belle II Physics Week, Nov 28 – Dec 2
- NanoAc 2022, Nov 22-23
- WORKSHOP on ion beam therapy, Nov 22
- 2nd workshop of AI Initiative for Science, Nov 18
- DUNE Module of Opportunity Workshop, Nov 2-4
- The Universe in a Box - a one day miniworkshop, Sep 9
- 7ª Reunión "Presencial" (PRESENCIAL) del Proyecto VMGRID (ATLAS TIER2 ESPAÑA), Jun 28-29
- Symposium: The dark matter multi-messenger challenge, Jun 27-28
- AIHUB - Low power, high speed sustenaible hardware, Jun 7
- ATLAS Top Workshop 2022, May 4-6
- CALICE Collaboration Meeting at Valencia, Apr 20-22
- Si-ECAL Pre-CALICE Collaboration Meeting, Apr 19-20
- @FlipPhysics, Mar 21-25

4 Colloquia organized

- Héctor Socas-Navarro, "From podcast to paper: when outreach feeds back on research", Dec 1
- Migle Laukyte, "Ethics of Machine Learning", Oct 20
- Barry Barish, "The Birth of Multimessenger Astronomy", May 30
- Maurice Haguenauer, "From neutral currents to the Higgs boson", May 26
- Alberto Loarte, "Objectives and status of the ITER project, the first fusion reactor under construction", Apr 7
- Lior Arazi, "Alpha-DaRT: breakthrough technology in radiation therapy", Mar 3
- Sonia I. Seneviratne, "Limiting global warming to 1.5°C: our physical insights on the climate emergency", Jan 13

5 Seminars organized

- 15 Dec Luigi Del Debbio, "Topical Seminar: Dilaton & Scale Invariance"
- 13 Dec Giovanna Cottin, "IFIC Seminar: The need for long-lived particle searches at the LHC and beyond"
- 29 Nov David Marzocca, "HiDDeN webinar: What did the flavour anomalies teach us?"
- 29 Nov Francisco Torrenti, "IFIC Seminar: Illuminating the primordial dark age after inflation"
- 24 Nov Piotr Korcyl, "IFIC Topical Seminar: Hierarchical autoregressive approach to two-dimensional statistical systems"
- 21 Nov Jorge Roser Martínez, "se-fis-med: Last Compton imaging developments and advances in the IRIS group"
- 18 Nov Daniel Camarero Munoz, "Topical seminar: Measurements of the inclusive isolated-photon and photon-plus-jet production in pp collisions at sqrt(s) = 13 TeV with the ATLAS detector"
- 14 Nov Aritra Biswas, "IFIC Topical Seminar: SM and beyond via b → dll decays"
- 09 Nov Maria Antonova, "#StudentSeminar: Ageing of the scintillator detectors of the T2K off-axis and on-axis near detectors, ND280 and INGRID"
- 08 Nov Jaehoon Yu, "IFIC Seminar: Exploring Physics Beyond the Standard Model with DUNE"
- 07 Nov Carlos García Montoro, "IFIC experimental seminar: "The ATLAS EventIndex: Cataloging Hundreds of Billions of Records.""
- 03 Nov Shakeel Ur Rahaman, "Topical seminar: Tracing new physics using EFT"
- 02 Nov Arunima Bhattacharya, "IFIC Topical Seminar: "Radiative corrections and threshold resummed predictions to pseudoscalar Higgs boson production""
- 25 Oct Clara Murgui, "HiDDeN webinar: Atom Interferometer Tests of Dark Matter"
- 19 Oct Héctor García Cabrera, "IFIC Topical Seminar: Exploring the structure of hadronic showers with CALICE's Semi-Digital hadronic calorimeter prototype"
- 17 Oct Montserrat Carles Farina, "se-fis-med: Multimodality imaging in oncology: improving its clinical implementation by medical physics research."
- 13 Oct Prasanna Dhani, "IFIC Topical Seminar: Collinear functions for QCD resummations"

5 Seminars organized

- 11 Oct Patricia Camargo Magalhaes, "IFIC Seminar: CP violation in heavy mesons decays"
- 06 Oct Jerzy Mańczak #StudentSeminar: Neutrino non-standard interactions measurement with the KM3NeT/ORCA Phase1 detector
- 04 Oct Manuel Gessner, "IFIC Seminar: Quantum metrology - from fundamentals to applications"
- 03 Oct Carlos Marinas, "IFIC Experimental Seminar: Monolithic pixel sensors for future collider experiments"
- 27 Sep Jesus Guerrero Rojas, "#Student Seminar, Jesús Guerrero Rojas: Search for associated production of a Higgs boson and a single top quark in 3l and 2lSS final states at 13 TeV in ATLAS."
- 27 Sep Christopher Thomas, "IFIC Seminar: Hadron scattering, resonances and exotics from lattice QCD"
- 20 Sep Carlos García Canal, "IFIC Seminar: Relation between the quantum Berry phase and the classical Hannay phase"
- 19 Sep Dario Barberis, "IFIC Experimental Seminar: Evolution of Computing for the ATLAS Experiment in LHC Run 3 and beyond"
- 14 Sep Diego Aristizábal Sierra, "IFIC Topical Seminar: Data-driven neutrino floor and the importance of CEvNS data"
- 12 Sep Kevin Monsálvez, "#StudentSeminar: Model-independent analysis of flavour physics and the role of leptoquarks."
- 25 Jul Jonathan Link, "IFIC experimental seminar: "CHANDLER: A New Technology for Surface-level Reactor Neutrino Detection""
- 18 Jul Dolores Corella, Óscar Coltell Simón, "se-fis-med: Oportunidades de las ómicas para la investigación en Medicina de Precisión"
- 14 Jul Nicolò Incardona #StudentSeminar: Lightfield imaging: an emerging technique for 3D capture and display
- 12 Jul Oleg Lebedev, "IFIC Seminar -- Neglected effects in dark matter studies: relativistic corrections and collective phenomena"
- 07 Jul Raymond Volkas, "IFIC Topical Seminar: Prospects for physics beyond the standard model: facts and opinions"
- 01 Jul Selomit Ramírez Uribe, "#StudentSeminar: From Causal Representation of Feynman loop integrals to Quantum Computing"

5 Seminars organized

- 30 Jun Victor Muños, "#StudentSeminar: Searching beyond the Standard Model particles in Atmospheric Showers"
- 29 Jun Mauro Valli, "IFIC Topical Seminar: "Hints from Flavor: Where Are We Going?""
- 28 Jun Antonio Coutinho, "IFIC Seminar: High precision in muon decays confronts lepton-flavor-violating ALP searches"
- 27 Jun Luis Alberto Sánchez Domínguez #StudentSeminar: Transverse acoustic resonances in optical fibers: detection techniques and applications
- 23 Jun Alejandro Gimeno Gómez #StudentSeminar: Tunnable 3D structured illumination microscopy
- 21 Jun Raghuveer Garani, "IFIC Seminar: Neutron stars probes of particle dark matter"
- 07 Jun Pedro De La Torre Luque, "IFIC Seminar: Status of indirect dark matter searches with anti-nuclei"
- 01 Jun Patrick Bolton, "IFIC Seminar: Probing New Physics Hidden in the Lepton Sector"
- 31 May Ennio Salvioni , "HiDDeN webinar: Gegenbauer Goldstones"
- 25 May [#StudentSeminar] Javier Aparisi Pozo: The top quark mass and its interpretation in ATLAS
- 24 May Dimitrios Papoulias, "IFIC Seminar: Coherent elastic neutrino nucleus scattering: current status and new directions"
- 23 May Alejandro Mus, "#StudentSeminar: A* behind the scenes"
- 23 May Carlos Faubel, "Carlos Faubel, "#StudentSeminar: Dark Matter from a complex scalar singlet: from symmetries to phenomenology""
- 19 May Joan Ruiz Vidal, "#StudentSeminar Electric dipole moments: phenomenology and experiment"
- 17 May Camilo García Cely, "IFIC Seminar: Synergy between axion and gravitational-wave searches"
- 16 May Carmen Romo Luque, "se-fis-med: Overview and Current Status of the PETALO Project"
- 13 May Mikael Chala, "Positivity bounds in the Standard Model effective field theory"
- 13 May Christoph Andreas Ternes, "IFIC Topical Seminar: Neutrino oscillations in presence of new states"
- 10 May Kevin James Kelly, "IFIC Seminar: The Future of Heavy Neutral Lepton Searches"
- 03 May Martin Bauer, "HiDDeN webinar: ALP searches with Flavour and Collider observables"
- 03 May John Gargalionis, "IFIC Seminar: Exploding operators for Majorana neutrino masses"

5 Seminars organized

- 02 May Hitoshi Yamamoto, "IFIC Experimental Seminar: International Linear Collider - a Higgs Factory"
- 26 Apr Giacomo Landini, "IFIC Seminar: "Dark Matter through the gravity portal: gravitational freeze-in and macroscopic relics""
- 12 Apr Mikhail Gorchtein, "IFIC Seminar: Precision Standard Model calculations for BSM searches with the CKM unitarity tests"
- 11 Apr Nadya Shusharina, "se-fis-med: Feasibility study of clinical target volume definition for soft-tissue sarcoma using diffusion tensor imaging"
- 06 Apr Przemysław Kopycki #StudentSeminar: Reconstruction of integral images and examining integral imaging monitors
- 05 Apr Laura Lopez-Honorez, "HiDDeN webinar: Freeze-in, SuperWIMPs and Primordial Black holes as possible sources of Non-cold dark matter"
- 05 Apr Jeff Lazar, "IFIC Seminar: Beyond Standard Model Searches at Neutrino Telescopes: Now and in the Future"
- 04 Apr Ariel Tarifeno Saldivia, "IFIC experimental seminar: "Neutron spectrometry with HENSA: from underground physics to space weather applications""
- 30 Mar Norberto Scoccola, "Strong interaction matter under extreme conditions within effective chiral quark models"
- 29 Mar Manibrata Sen, "IFIC Seminar: Supernovae as probes of soft lepton number violation"
- 08 Mar Daniele Gaggero, "IFIC Seminar: Black Holes & Dark Matter"
- 07 Mar David Renteria-Estrada, "Reaching momentum fractions in high energy collisions by machine learning techniques"
- 01 Mar Anirban Karan, "IFIC Seminar: Angular distribution and distinction of leptoquarks at different colliders"
- 23 Feb Ivan Sayago Galvan, "[#StudentSeminar] Ivan Sayago Galvan: Search for Higgs boson pair production in the bbγγ final state with the full Run 2 dataset by ATLAS."
- 22 Feb Francesco Capozzi, "IFIC Seminar: Frontiers in Neutrino Physics"
- 21 Feb Lana Beck, "se-fis-med: Real-time beam monitoring of X-ray radiotherapy treatments."

5 Seminars organized

- 16 Feb Norberto Scoccola, "Aspects of Excited Baryon Phenomenology in the 1/Nc expansion of QCD"
- 15 Feb Tracy Slatyer , "HiDDeN webinar: Thermal Squeezeout for Strongly Interacting Dark Matter"
- 11 Feb Sven Heinemeyer, "IFIC Topical Seminar: New Physics around the corner?!"
- 07 Feb Javier Balibrea Correa, "IFIC Experimental Seminar: Compton Imaging and Machine Learning within the HYMNS-ERC project"
- 27 Jan #Student Seminar Victor Babiano Suarez: High resolution 80Se(n,γ) cross section measurement and i-TED detector development.
- 21 Jan Juan Antonio Aguilar Saavedra, "Red LHC webinar: Anomaly detection with SOFIE - Digging the tiniest signals at the LHC"
- 17 Jan Pablo Martinez Reviriego, "se-fis-med: Particle accelerators in medical physics: High-Gradient studies"
- 11 Jan Zahra Tabrizi , "HiDDeN webinar: ``EFT at FASERv: An experiment to probe them all""

6 PhD Theses 2022

THEORETICAL PHYSICS

- *Hunting for new physics signals in the LHC era*
  Víctor Miralles Aznar Advisor: Antonio Pich Zardoya January 14, University of Valencia
  TESEO: 2108745

- *Precise Phenomenology in the LHC Era*
  Iván Rosario Bonastre Advisor: Francisco Campanario Pallas March 22, University of Valencia
  TESEO: 2140122

- *Asymptotic expansions and causal representations through the loop-tree duality*
  Judith Plenter Advisor: Germán Rodrigo García June 7, University of Valencia
  TESEO: 2188125

- *Quantum field theory under external conditions: gravitation and electrodynamics*
  Silvia Pla García Advisor: José Navarro Salas June 22, University of Valencia
  TESEO: 2188668

- *New scalars at the origin of dark matter and anomalies in magnetic moments*
  Carlos Faubel Alamá Advisors: Jordi Vidal Perona, Arcadi Santamaria Luna and Juan Herrero García July 28, University of Valencia
  TESEO: 2212179

- *Composite scalars and dark matter from four fermion interactions*
  Leonardo Coito Advisors: Arcadi Santamaria, Juan Herrero García and Joannis Papavassiliou September 16, University of Valencia
  TESEO: 2243157

- *Unified Study of Spectrum and Properties of Heavy Mesons at Energies below and above Meson-Meson Thresholds*
  Roberto Bruschini Advisor: Pedro González Marhuenda September 19, University of Valencia
  TESEO: 2209572

- *Effective field theory flavored paths to beyond the Standard Model dynamics*
  Kevin Monsálvez Pozo Advisor: Jorge Portolés Ibáñez November 22, University of Valencia
  TESEO: 2286279

EXPERIMENTAL PHYSICS

- *Measurement of top-quark polarisation observables and a search for dark matter in single-top-quark production with the ATLAS detector at the LHC*
  Galo Rafael Gonzalvo Rodríguez Advisors: María José Costa Mezquita and José Enrique García Navarro January 28, University of Valencia
  TESEO: 2102082

- *High resolution 80Se(n,gamma) cross section measurement at CERN n_TOF and evelopment of the novel i-TED detection system*
  Víctor Babiano Suárez Advisors: César Domingo Pardo, Javier Balibrea Correa and Jorge Lerendegui Marco April 27, University of Valencia
  TESEO: 2131422

- *Low energy calibration, continuous monitoring, and background studies for the NEXT-White detector at the LSC*
  Brais Palmeiro Pazos Advisors: Michel Sorel and José Ángel Hernando Morata May 18, University of Valencia
  TESEO: 2149527

- *Nuclear structure studies on quadrupole and octupole correlations in the vecinity of heavy N=Z nuclei with AGATA and NEDA*
  María de la Luz Jurado Gómez Advisors: Andrés Gadea Raga, José Javier Valiente Dobón and Emmanuel Clément May 26, University of Valencia
  TESEO: 2163585

- *Search for Higgs boson pair production in the two bottom quarks plus two photons final state in pp collisions at sqrt(s) = 13 TeV with the ATLAS detector*
  Iván Sayago Galván Advisors: Luca Fiorini and Arantxa Ruiz Martínez July 1, University of Valencia
  TESEO: 2196702

- *Development of low-diffusion techniques for a high pressure xenon electroluminescent TPC*
  Ryan Felkai Advisors: Francesc Monrabal Capilla and Neus López March July 22, University of Valencia
  TESEO: 2207079

- *Precision measurements in boosted top quarks in the ATLAS detector*
  Javier Aparisi Pozo Advisors: Santiago González de la Hoz and Marcel Vos September 30, University of Valencia
  TESEO: 2232519

- *Experiments and phenomenology of electric dipole moments*
  Joan Ruiz Vidal Advisor: Fernando Martínez Vidal October 11, University of Valencia
  TESEO: 2267859

- *TRITIUM: Design, Construction and ommissioning of an In-Water Tritium Detector*
  Marcos Martínez Roig Advisors: José Díaz Medina and Nadia Yahlali Haddou November 11, University of Valencia
  TESEO: 2255088

7 Masters 2022

THEORETICAL PHYSICS

• *Modelling of Dark Matter Candidate Axions*
Anar Akberov
Advisor: Oscar Vives

• *Accidental symmetries of the Standard Model: An Effective Field Theory approach*
Elena Bermejo Martínez
Advisors: John Gargalionis, Juan Herrero-García

• *Colapso acústico y agujeros negros acústicos en la sonoluminiscencia*
Raúl Fernández Clement
Advisors: Jaime Ramis Soriano, Alessandro Fabbri

• *Static quantum corrections to the Schwarzschild spacetime from the trace anomaly*
Irene Garcia Martínez
Advisors: José Navarro-Salas, Pau Beltrán Palau, Sergi Nadal Gisbert

• *Electro-weak scale right-handed neutrinos and LHC*
Meritxell Garcia Suñer
Advisor: Martin Hirsch

• *Gravedad Teleparalela y formulaciones alternativas en gravedad con torsión*
Marcos Gil Gómez
Advisors: Maria Antonia Lledó Barrena y Alessandro Fabbri

• *Inverse seesaw mechanism with spontaneous lepton number violation*
Antonio Herrero Brocal
Advisor: Avelino Vicente Montesinos

• *Coherent elastic neutrino-nucleus scattering: a COHERENT CsI analysis within the Standard Model*
Pablo Muñoz Candela
Advisor: Valentina De Romeri

• *Efectos cuánticos en agujeros negros acústicos*
Juan Rodríguez Pérez
Advisor: Alessandro Fabbri

• *Boundary conditions at the Big Bang, quantum fields, and particle creation*
Clara Roldán Domínguez
Advisors: José Navarro-Salas Silvia Pla García

• *Black hole evaporation: a solvable model*
David Sanz Ruiz
Advisors: Alessandro Fabbri, Jose Navarro Salas

• *Neutrino masses and thermal effects in the Zee-Babu model*
Pablo Torrón Pérez
Advisor: Claudia Hagedorn

NUCLEAR AND PARTICLES PHYSICS

• *Modelado del rendimiento de una cámara Compton mediante simulaciones de Monte Carlo y experimentos de validación*
Angie Carolina Fonseca Vargas
Advisors: Gabriela Llosá Llácer, Fernando Hueso Gonzalez

• *Effective QQLL interactions to probe lepton flavour universality at the LHC and future colliders*
Abel Carlos Gutiérrez Camacho
Advisors: María Moreno Llácer, Marcel André Vos

• *Study of long lived particles beyond the Standard Model at LHCb*
Miguel Jiménez Ortega
Advisor: Arantza Oyanguren Campos

• *Optimization of the photodetection system of the DUNE experiment*
Marta Lanzac Berrocal
Advisors: Laura Molina Bueno, Justo Martín-Albo Simón

• *Estudio y caracterización de módulos detectores basados en bromuro de lantano para hadroterapia*
Fernando López Berenguer
Advisor: Gabriela Llosá Llácer

• *Separation of HH and ttbarH processes*
Sara Martín Luengo
Advisors: María Moreno Llácer, Luca Fiorini

• *Estudi de l'acoblament del bosó de Higgs als muons a través del canal de producción Higgs-Strahlung i desintegració quatreleptònica a partir de les dades del Run 2 d'ATLAS*
Pol Molina Grífols
Advisor: Salvador Martí García

• *Search for new physics in the Deep Underground Neutrino Experiment (DUNE)*
Alberto Sánchez Bravo
Advisor: Justo Martín-Albo Simón

ASTROPHYSICS

• *Clasificación de fuentes no asociadas mediante técnicas de Machine Learning*
María Iranzo Muñoz
Advisor: Bryan Zaldívar Montero

• *Gravitational wave detection with Deep Learning*
Juan Diego Salamanca Cerón
Advisors: Roberto Ruiz de Austri, Alejandro Torres

8 Grants

NATIONAL GRANTS

• Stochastic Gravitational wave backgrounds: From first principles calculation to detection and implications for fundamental physics
Ref. EUR2022-134028
PI: Daniel Garcia Figueroa
89,646 € (Dec 2022 – Nov 2023)

• ATLAS participation in the LHC IFIC
Ref. PCI2022-135002-2
PI: Salvador Marti García
102,000 € (Jan 2022 – Dec 2024)

• The ITK Upgrade of ATLAS IFIC
Ref. PCI2022-135087-2
PI: Carlos Lacasta Llácer
765,000 € (Jan 2022 – Dec 2024)

• Proton Range and Imaging Device for protontherapy
Ref. PDC2022-133382-100
PI: Enrique Nacher González
149,500 € (Dec 2022 – Nov 2024)

• Telescopio para CT de protones ha Hadron Terapia
Ref. PDC2022-133605-100
PI: Carlos Lacasta Llácer
115,000 € (Dec 2022 – Nov 2024)

• LHC y la fábrica de Higgs - física y aspectos tecnológicos
Ref. PID2021-122134NB-C21
PI: Vasiliki Mitsou
446,490 € (Sep 2022 – Aug 2025)

• Búsquedas de sectores oscuros con el experimento NA64 en el CERN
Ref. PID2021-123955NA-100
PI: Laura Molina Bueno
102,850 € (Sep 2022 – Aug 2025)

• Telescopios de neutrinos para física fundamental y astronomía multimensajero
Ref. PID2021-124591NB-C41
PI: Juan de Dios Zornoza Gómez
919,600 € (Sep 2022 – Aug 2025)

• Contribución a la operación del experimento ATLAS y su programa de física durante el Run3 del LHC
Ref. PID2021-124912NB-100
PI: Salvador Marti Garcia
592,900 € (Sep 2022 – Aug 2025)

• Upgrade del detector ATLAS: Electrónica del Tile Calorimeter, Trigger y Explotación del Programa de Física
Ref. PID2021-125069OB-100
PI: Arantxa Ruiz Martínez
699,380 € (Sep 2022 – Aug 2025)

• Explotación científica del detector NEXT-100 y R&D para el detector NEXT-HD
Ref. PID2021-125475NB-C52
PI: Pau Novella Garijo
505,780 € (Sep 2022 – Aug 2025)

• Outlining sensors for future experiments in large radiation environments and the Itk strip upgrade of ATLAS
Ref. PID2021-1263270B-C21
PI: Carlos Lacasta Llácer
605,000 € (Sep 2022 – Aug 2025)

• Restoration Ecology and Artificial Intelligence (RESECARIN)
Ref. TED2021-130852B-100
PI: Luca Fiorini, Veronica Sanz
575,000 € (Sep 2022 – Aug 2025)

• Física Nuclear y Hadrónica a Energías Intermedias
Ref. PID2020-112777GB-100
PI: Juan Miguel Nieves Pamplona
193,600 € (Sep 2021 – Aug 2024)

• Predicción de amenazas asociadas a corrientes inducidas goemagnéticamente en las infraestructuras críticas españolas
Ref. PID2020-113135RB-C33
PI: Carlos Escobar Ibáñez
54,450 € (Sep 2021 – Aug 2024)

• Astropartículas y Física de Altas Energías
Ref. PID2020-113775GB-100
PI: Martin Hirsch
176,660 € (Sep 2021 – Aug 2024)

• Estudios de Estructura Nuclear y Desarrollos Instrumentales para AGATA un multidetector de trazado para las instalaciones de haces estables y radioactivos en Europa
Ref. PID2020-118265GB-C42
PI: Andrés Gadea
359,249 € (Sep 2021 – Aug 2024)

• Cámara Compton para verificación de rango en hadronterapia
Ref. PDC2021-121536-C21
PI: Cesar Domingo Pardo
74,7450 € (Dec 2021 – Nov 2023)

• Partículas elementales: el Modelo Estándar y sus extensiones
Ref. PID2020-113334GB-I00
PI: Oscar Manuel Vives García
279,631 € (Sep 2021 – Aug 2024)

• Física de sabor, del bosón de Higgs y de las interacciones fuertes en el LHC y la frontera de intensidad
Ref. PID2020-114473GB-I00
PI: Antonio Pich Zardoya
279,510 € (Sep 2021 – Aug 2024)

• Sabor y Origen de la Materia
Ref. PID2020-113644GB-I00
PI: Pilar Hernández Gamazo
290,400 € (Sep 2021 – Aug 2024)

• Campos y Gravedad
Ref. PID2020-116567GB-C21
PI: Gonzalo Olmo Alba
96,800 € (Sep 2021 – Aug 2024)

• Valorización de nuevos detectores para imagen médica
Ref. PDC2021-121839-100
PI: Gabriela Llosá Llácer
115,000 € (Dec 2021 – Nov 2023)

• The Future Upgrade of the ATLAS Strip Tracker for the High-Luminosity LHC
Ref. PID2019-110189RB-C21
PI: Carlos Lacasta Llacer
949,245 € (Jun 2020 – May 2022)

• Nuclear Structure Astrophysics and Applications (NUSTASAP-IFIC)
Ref. PID2019-104714GB-C21
PIs: Enrique Nacher Arándiga, Alejandro Algora
506,990 € (Jun 2020 – May 2023)

8 Grants

• Hacia un genuino TIER-2 (centro IFIC) federado español de ATLAS para afrontar el reto de la gestión y procesado del Big Data del LHC (FASEII)
Ref. PID2019-104301RB-C21
PI: Santiago González de la Hoz
603,790 € (Jun 2020 – May 2023)

• Monitorización y dosimetria en terapia hadronica
Ref. PID2019-110657RB-I00
PI: Gabriela Llosá Llácer
98,010 € (Jun 2020 – May 2023)

• Contribución del IFIC al programa científico del experimento de neutrinos DUNE
Ref. PID2019-104676GB-C33
PI: Anselmo Cervera Villanueva
356,950 € (Jun 2020 – May 2023)

• Modelos de hadrones, interacciones fundamentales y física nuclear
Ref. PID2019-105439GB-C21
PI: Pedro González Marhuenda
60,500 € (Jun 2020 – May 2023)

• Retos de Física y Tecnológicos en el IFIC con el Experimento LHCb del CERN
Ref. PID2019-106448GB-C33
PI: Arantza Oyanguren Campos
360,580 € (Jun 2020 – May 2023)

EUROPEAN COMMISSION GRANTS

• Asymmetry
HORIZON-MSCA-2021-SE-01-01/101086085
PI: Pilar Hernández
358,000 € (Dec 2022 - Dec 2026)

• A charming decade: using colliders to probe the charm sector of the Standard Model and Beyond
H2020-MSCA-IF-2020/101031558-charming-DecaDe
Fellow: Luiz Vale
PI: Antonio Pich Zardoya
160,932 € (Nov 2021 – Oct 2023)

• UNOS: Unifying Neutrino Observatories Searches
H2020-MSCA-IF-2020/101025085-UNOS
Fellow: Alfonso Andrés García Soto
PI: Juan de Dios Zornoza Gómez
204,415 € (May 2021 – Apr 2024)

• HIDDeN. Hunting invisibles: Dark sectors, Dark Matter and Neutrinos
H2020-MSCA-ITN-2019/860881-HIDDeN
PI: Pilar Hernández Gamazo
382,175 € (Jan 2020 – Sep 2024)

• SANDA. Supplying Accurate Nuclear Data for energy and non-energy Application
NFRP-2018 Ref. 847552
PI: Alejandro Algora
48,999 € (Sep 2019 – Aug 2023)

• STRONG-H2020. The strong interaction at the frontier of knowledge:- fundamental research and applications
H2020-INFRAIA-2018-1 Ref. 824093
PI: Santiago Noguera Puchol
81,500 € (Jun 2019 – Jul 2024)

• A positron emission tomography apparatus based on liquid xenon with time of flight applications - PETALO
ERC-2017-STG Ref. 757829
PI: Anselmo Cervera Villanueva
224,856 € (July 2018 – June 2024)

• A positron emission tomography apparatus based on liquid xenon with time of flight applications – PETALO
ERC-2017-STG Ref.757829
PI: Pilar Hernández Gamazo
306,250 € (July 2018 – June 2024)

REGIONAL GRANTS

• Computación avanzada para el procesado intensivo de Big Data en ATLAS
Ref. ASFAE/2022/006
PI: Miguel Villaplana Pérez
299,863 € (Apr 2022 – Jun 2025)

• Detector de trazas de ATLAS para el HL-LHC
Ref. ASFAE/2022/007
PI: Carlos Escobar Ibáñez
299,920 € (Apr 2022 – Jun 2025)

• Upgrade del detector ATLAS: Electrónica del Tile Calorimeter y Explotación del Programa de Física
Ref. ASFAE/2022/008
PI: Luca Fiorini
299,693 € (Apr 2022 – Jun 2025)

• Algoritmos cuánticos en fenomenología de partículas elementales
Ref. ASFAE/2022/009
PI: Germán Vicente Rodrigo García
123,219 € (Apr 2022 – Jun 2025)

• Operación del experimento ATLAS durante el RUN 3 del LHC y explotación de sus datos para el estudio del bosón de Higgs y el quark top
Ref. ASFAE/2022/010
PI: Joaquín Poveda Torres
212,469 € (Apr 2022 – Jun 2025)

• Tecnologías de RF para monitores de haz en aceleradores y para detectores de axiones de materia oscura
Ref. ASFAE/2022/013
PI: Daniel Esperante Pereira
284,050 € (Apr 2022 – Jun 2025)

• Desarrollo y construcción de un demostrador de un detector de alta granularidad basado en tecnologías de silicio para futuras fábricas de Higgs y Top
Ref. ASFAE/2022/015
PI: Adrián Irles Quiles
284,979 € (Apr 2022 – Jun 2025)

• Sensores Monolíticos para búsqueda de Nueva Física
Ref. ASFAE/2022/016
PI: Carlos Mariñas Pardo
203,719 € (Apr 2022 – Jun 2025)

• Imagen Compton para terapia con radionúclidos (ICOR)
Ref. ASFAE/2022/019
PI: Gabriela Llosá Llácer
299,920 € (Apr 2022 – Jun 2025)

• Ondas Gravitacionales, Axiones y Materia Oscura, Lattice e Inteligencia Artificial
Ref. ASFAE/2022/020

8 Grants

PI: Alberto Ramos Martínez
299,843 € (Apr 2022 – Jun 2025)

• Modeling neutrino interactions with matter for current and futures experiments
Ref. ASFAE/2022/022
PI: Luis Alvárez Ruso
106,877 € (Apr 2022 – Jun 2025)

• Adquisición y sincronización avanzada para Astrofísica
Ref. ASFAE/2022/023
PI: Juan de Dios Zornoza Gómez
300,000 € (Apr 2022 – Jun 2025)

• Artificial Environment for ML and Innovation in Scientific Advanced Computing
Ref. ASFAE/2022/024
PI: José Enrique García Navarro
299,000 € (Apr 2022 – Jun 2025)

• Detectores complementarios modulares de nueva generación
Ref. ASFAE/2022/027
PI: Alejandro Algora
299,587 € (Apr 2022 – Jun 2025)

• Creation of a multipurpose laboratory at IFIC for the development of cryogenically-cooled gas and liquid noble element detectors
Ref. ASFAE/2022/028
PI: Anselmo Cervera Villanueva
299,000 € (Apr 2022 – Jun 2025)

• Development of state-of-the-art light detection systems for the DUNE and NEXT experiments
Ref. ASFAE/2022/029
PI: Nadia Yahladi Haddou
299,000 € (Apr 2022 – Jun 2025)

• Retos tecnológicos para el descubrimiento con el detector LHCb mejorado del CERN
Ref. ASFAE/2022/030
PI: Fernando Martínez Vidal
273,102 € (Apr 2022 – Jun 2025)

• Instrumentación avanzada para la experimentación con GRIT y AGATA
Ref. ASFAE/2022/031
PI: Andrés Fco. Gadea Raga
284,596 € (Apr 2022 – Jun 2025)

• Coordinación Proyectos ASFAE
Ref. ASFAE/COORD
PI: Carlos Lacasta Llácer
300,000 € (Apr 2022 – Jun 2025)

• Desarrollo de aceleradores lineales de alto gradiente y nuevas técnicas para su aplicación en radioterapia
Ref. CDEIGENT/2021/012
PI: Nuria Fuster Martínez
285,000 € (Apr 2022 – Dec 2025)

• Información cuántica y metrología
Ref. CDEIGENT/2021/014
PI: Manuel Gessner
285,000 € (Jul 2022 – Jul 2026)

• Estudio del autocoplamiento del bosón de Higgs en el experimento ATLAS del LHC
Ref. CIAICO/2021/154
PI: Arantxa Ruiz Martínez
90,000 € (Jan 2022 – Dec 2024)

• Dark and Shiny Dresses around Black Holes
Ref. CIDEGENT/2021/017
PI: Daniele Gaggero
539,765 € (Jan 2022 – Dec 2025)

• Search for new physics signatures and measurement of fundamental neutrino properties with the KM3NeT telescope
Ref. CIDEGENT/2021/023
PI: Sara Rebecca Gozzini
556,000 € (Jan 2022 – Dec 2025)

• Dark Bosons and Dark Matter
Ref. CIDEGENT/2021/025
PI: Christian Gross
481,706 € (Jul 2022 – Jul 2026)

• Searching for new physics in the flavour sector with precision hadronic physics
Ref. CIDEGENT/2021/037
PI: Emilie Passemar
610,000 € (Jul 2022 – Jul 2026)

• Dark Matter capture in Celestial bodies
Ref. CIDEIG/2022/22
PI: Aritra Gupta
284,902 € (Dec 2022 – Nov 2026)

• Astroparticle and neutrino physics: from Cosmology to the LHC (AstroParNu)
Ref. CIPROM/2021/054
PI: Maria Amparo Tórtola Baixauli
600,000 € (Jan 2022 – Dec 2025)

• Innovación y desarrollo en la mejora y personalización de los tratamientos de radioterapia convencional y protonterapia.
Ref. CIPROM/2021/064
PI: Javier Vijande Asenjo
412,522 € (Jan 2022 – Dec 2025)

• The Quest for New Physics (QNe2Phys). High precision, direct searches and technology development
Ref. CIPROM/2021/073
PI: Juan Antonio Fuster Verdu
600,000 € (Jan 2022 – Dec 2025)

• Total Absorption spectroscopy Technique Applied to Key Isotopes in r-Process nucleosynthesis of trans-bismuth elements (TATAKI-Pro)
Ref. CISEJI/2022/25
PI: Ana Isabel Morales López
320,000 € (Jan 2022 – Dec 2025)

• Radiotrazadores para el estudio de ecosistemas marinos y oceánicos (REMO)
Ref. THINKINAZUL/2021/036
PI: Enrique Nacher González
205,324 € (Jan 2022 – Sep 2025)

• Cámara dual de visualización neutrón-gamma para protonterapia (gnvision4health)
Ref. VALORITZA I TRANSFEREIX
PI: Jorge Lerendegui Marco
58,696 € (Sep 2022 – Sep 2023)

• Instrumentación avanzada en detección de neutrones para la vida y el clima espacial: HENSA++
Ref. IDIFEDER/2021/002
PI: Berta Rubio Barroso
260,199 € (Jan 2021 – Dec 2022)

8 Grants

• Understanding non-perturbative phenomena in fundamental physics
Ref. PROMETEO/2021/083
PI: Verónica Sanz González
469,106 € (Jan 2021 – Dec 2024)

• Valorización de un Sistema de Monitorización para terapia Hadrónica (Valmont)
Ref. INNVA1/2021/37
PI: Gabriela Llosá Llácer
337,926 € (Jan 2021 – Dec 2023)

• Open questions on the fundamental interactions of matter at the LHC and Intensity Frontiers
Ref. PROMETEO/2021/071
PI: Antonio Pich Zardoya
475,000 € (Jan 2021 – Dec 2024)

• Física experimental de neutrinos en el IFIC
Ref. PROMETEO/2021/087
PI: Michel Sorel
524,893 € (Jan 2021 – Dec 2024)

• Effective field theories in hadron and nuclear physics
Ref. PROMETEO/2020/023
PI: Juan M. Nieves Pamplona
216,634 € (Jan 2020 – Dec 2023)

• Telescopios de neutrinos en el Mediterráneo
Ref. Telescopios de neutrinos en el Mediterráneo
PI: Juan José Hernández Rey
250,353 € (Jan 2020 – Dec 2023)

• Aspectos clásicos y cuánticos en gravitación: agujeros negros, cosmología, ondas gravitacionales y más allá
Ref. PROMETEO/2020/079
PI: Gonzalo Olmo Alba
192,160 € (Jan 2020 – Dec 2023)

• Desrrollos tecnológicos e instrumentales para AGATA
Ref. PROMETEO/2019/005
PI: Andrés Gadea Raga
276,677 € (Jan 2019 – Dec 2022)

• Search for new physics at LHC with the ATLAS detector
Ref. PROMETEO/2019/006
PI: M. Carmen García García
262,885 € (Jan 2019 – Dec 2022)

• Núcleos exóticos y Astrofísica Nuclear
Ref. PROMETEO/2019/007
PI: Berta Rubio Barroso
309,782 € (Jan 2019 – Dec 2022)

• Sabor y origen de la materia
Ref. PROMETEO/2019/083
PI: Nuria Rius Dionis
254,928 € (Jan 2019 – Dec 2022)

• Estudios perturbativos y no perturbativos del modelo estándar y sus extensiones
Ref. PROMETEO/2019/087
PI: Arcadi Santamaría Luna
241,434 € (Jan 2019 – Dec 2022)

• Reto en física de sabor: el EXPErimento Desafía la Teoría (EXPEDITE)
Ref. PROMETEO/2019/113
PI: Francisco J. Botella Olcina
213,065 € (Jan 2019 – Dec 2022)

• Frontiers in neutrino oscillations: precision and new phenomena
Ref. CDEIGENT/2020/003
PI: Francesco Capozzi
244,667 € (Nov 2021 – Jun 2025)

• Unitary effective theories in hadron physics: new particles and new physics
Ref. CIDEGENT/2020/002
PI: Miguel Albaladejo Serrano
402,015 € (Jul 2021 – Jun 2025)

• N3LO as the New Standard for Precision Physics at the LHC
Ref. CIDEGENT/2020/011
PI: Leandro Javier Cieri
409,702 € (Jul 2021 – Jun 2025)

• Estudios de Física e I+D en detectores para futuros colisionadores de leptones
Ref. CIDEGENT/2020/021
PI: Adrián Irles Quiles
410,000 € (Jan 2021 – Dec 2024)

• Multimessenger astronomy in the KM3NeT observatory: gravitational waves, gamma rays and cosmic neutrinos
Ref. CIDEGENT/2020/049
PI: Agustín Sánchez Losa
408,735 € (Apr 2021 – Mar 2025)

• Novel methods in Dark Matter searches with Artificial Intelligence
Ref. CIDEGENT/2020/055
PI: Bryan Zaldívar Montero
403,140 € (Jul 2021 – Jun 2025)

• Contribución al experimento ATLAS y análisis de datos I+D para futuros aceleradores y estudios de la física del quart
Ref. CDEIGENT/2019/003
PI: Adrián Irles Quiles
252,250 € (Jul 2020 – Jun 2024)

• Novel cost-effective proton range verification based on coaxial prompt gamma-ray monitoring
Ref. CDEIGENT/2019/011
PI: Fernando Hueso González
252,250 € (Jun 2020 – May 2024)

• Neutrino physics in the NEXT, T2K and DUNE experiments
Ref. CDEIGENT/2019/016
PI: Laura Molina Bueno
229,333 € (Jun 2020 – Jun 2024)

• The strong coupling for precision physics
Ref. CIDEGENT/2019/040
PI: Alberto Ramos Martínez
381,500 € (Jul 2020 – Jun 2024)

• Física en el experimento ATLAS del LHC
Ref. CIDEGENT/2019/029
PI: Carlos Escobar Ibáñez
381,475 € (Jan 2020 – Jun 2024)

• Search for new physics in the neutrino sector with the DUNE and NEXT experiments
Ref. CIDEGENT/2019/049
PI: Justo Martín-Albo Simón
381,500 € (Jul 2020 – Jun 2024)

8 Grants

• Search for long-lived particles with LHC data
Ref. CIDEGENT/2019/023
PI: Emma Torro Pastor
381,475 € (Apr 2020 – Mar 2024)

• Long-lived particles (LLPs) at present and future experiments
Ref. CIDEGENT/2019/068
PI: José Francisco Zurita
338,456 € (Dec 2020 – Nov 2024)

• Effective field theories for hadron exotic states with applications in lattice QCD
Ref. CIDEGENT/2019/015
PI: Raquel Molina Peralta
376,167 € (Jul 2020 – Jun 2024)

• What New Physics Lies Beyond The Standard Model
Ref. CIDEGENT/2019/024
PI: Miguel Rubén Nebot Gómez
370,410 € (Jul 2020 – Jun 2024)

• Precision jet substructure in the LHC
Ref. CIDEGENT/2019/027
PI: Miguel Villaplana Pérez
381,500 € (Jul 2020 – Jun 2024)

• Neutrino Masses and Dark Matter: Towards the New Standard Model
Ref. CIDEGENT/2020/020
PI: Juan Andrés Herrero García
409,999 € (Jan 2020 – Nov 2024)

• Les Fosques. Fenomenología de lo invisible un camino hacia la nueva física
Ref. SEJI/2020/016
PI: Valentina De Romeri
181,348 € (Jul 2020 – Dec 2022)

• Can the Higgs particle explain the matter-antimatter
Ref. SEJI/2020/034
PI: María Moreno Llácer
191,959 € (Jul 2020 – Dec 2022)

• The present and future of precision physics
Ref. CIDEGENT/2018/014
PI: Martín González Alonso
327,525 € (Jul 2019 – Dec 2022)

• Advanced Pixel Detector for Future Colliders
Ref. CIDEGENT/2018/020
PI: Carlos Mariñas Pardo
333,242 € (Jul 2019 – Dec 2022)

• Search for the sources of high-energy cosmic rays with the KM3NeT neutrino telescope in the era of Multi-messenger astronomy
Ref. CIDEGENT/2018/034
PI: Francisco Salesa Greus
320,183 € (Aug 2019 – Dec 2022)

• Neutrinos: Hunting a new Physics Scale
Ref. CIDEIGENT/2018/019
PI: Jacobo López Pavón
366,820 € (Jan 2019 – Dec 2022)

OTHER PROJECTS

• Potenciación de la UCIE del IFIC
Ref. INNVA2/2022/15
PI: J. Enrique García Navarro, Nuria Rius Dionis
244,000 € (Jan 2022 – Dec 2022)

• Podcast de Física del IFIC
Ref. 16756
PI: Enrique Nacher González
18,000 € (Jan 2022 – Dec 2023)

• Proyecto Meitner. Recordando a Lise Meitner
Ref. 16806
PI: Angela Molina Ruiz
25,000 € (Jul 2022 – Jun 2023)

• gAMma IMAging Systems
Ref. Ayudas emprendimiento e innovación jovenes investigadores
PI: Luis Caballero Ontanaya
11,000 € (Jan 2022 – Dec 2022)

• Ayuda extra CSIC PGC2018-094856-B-100
Ref. 2021AEP063
PI: Juan Antonio Fuster
37,500 € (Jan 2022 – Aug 2022)

• Ayuda Extraordinaria Severo ochoa
Ref. 20215CEX004
PI: Pilar Hernandez Gamazo
54,750 € (Mar 2021 – Mar 2022)

• The third-generation quarks and new physics: from the LHC to a Higgs Factory
Ref. I-LINKB20065
PI: Juan Antonio Fuster
24,000 € (Jan 2021 – Dec 2022)

• Programa VLC-BIOMED (2020). New-TIM-Nuevas tecnologías en imagen médica
Ref. PI2020-16
PI: Gabriela Llosá Llácer
11,166 € (Apr 2021 – Mar 2022)

• Upgrade del detector de trazas de ATLAS para el HL-LHC
Ref. PIE 202050E027
PI: Carlos Lacasta Llacer
315,000 € (Jan 2020 – Apr 2022)

• Medidas de alta precisión de las propiedades quark top en el “Large Hadron Collider” (LHC-ATLAS) y su evaluación prospectiva en futuros colisionadores
Ref. PIE:202050E040
PI: Juan A. Fuster Verdú
108,500 € (Jan 2020 – Dec 2022)

• Impulso a la estrategia de comunicación, divulgación y networking del IFIC
Ref. 201950E066
PI: Juan José Hernández Rey
300,000 € (May 2019 – May 2022)

CONTRACTS AND AGREEMENTS

• Convenio CSIC-CIEMAT DUNE
Ref. 20220237
PI: Anselmo Cervera Villanueva
533,333 € (Jan 2022 – Dec 2022)

• Convenio EPPCN
Ref. 20204555
PI: Antonio Pich Zardoya
4,700 € (Jan 2022 – Dec 2022)

8 Grants

• MoEDAL: Monopole and Exotics detector at the LHC
Ref. Colab IFIC- MoEDAL
PI: Vasiliki Mitsou
30,000 € (Jan 2022 – Dec 2022)

• Desarrollo de equipos PET de alta cobertura de uso clínico
Ref. 20213188
PI: Gabriela Llosá Llácer
80,000 € (May 2021 – Sep 2023)

• ACIRHO 02
Ref. 20214888
PI: Fco. Javier Albiol Colomer
18,150 € (Jun 2021 – May 2022)

• Diseño mecánico y adecuación de sistemas de gas y frío de un prototipo de tomógrafo PET basado en xenón líquido
Ref. IMAS
PI: Neus López March
90,800 € (May 2021 – Sep 2023)

• Convenio de Colaboración GV-CERN para la ejecución del Experimento MoEDAL del LHC en el CERN
PI: Vasiliki Mitsou
30000 € (Jan 2021 – Dec 2022)

• Contrato ENRESA-CSIC para el desarrollo adicional del software de los dispositivos GUALI I y GAULI II para construir un sistema tomográfico pasivo de radiación gamma para la medida de residuos radiactivos
Ref. 20204555
PIs: Francisco J. Albiol Colomer, Luis Caballero Ontanaya
220,640 € (Nov 2020 – Nov 2022)

• Contrato IFIC-IST: Sistema médico de alta precisión para modelos 3D de columna vertebral para diagnóstico y segumiento de patologias raquis
Ref. 20196791
PI: Francisco J. Albiol Colomer
77,440 € (Nov 2019 – Nov 2022)

• Contrato de licencia exclusiva de la patente 201231243 "Dispositivo y procedimiento de obtención de imágenes densitométricas de objetos mediante combinación de sistemas radiológicos"
Ref. 20132089
PI: Germán Rodrigo García
6,171 € (May 2013 – Jul 2032)

Images and vectors references

www.freepik.es, www.pixabay.com, https://www.flaticon.es/autores/darius-dan, www.pexels.com