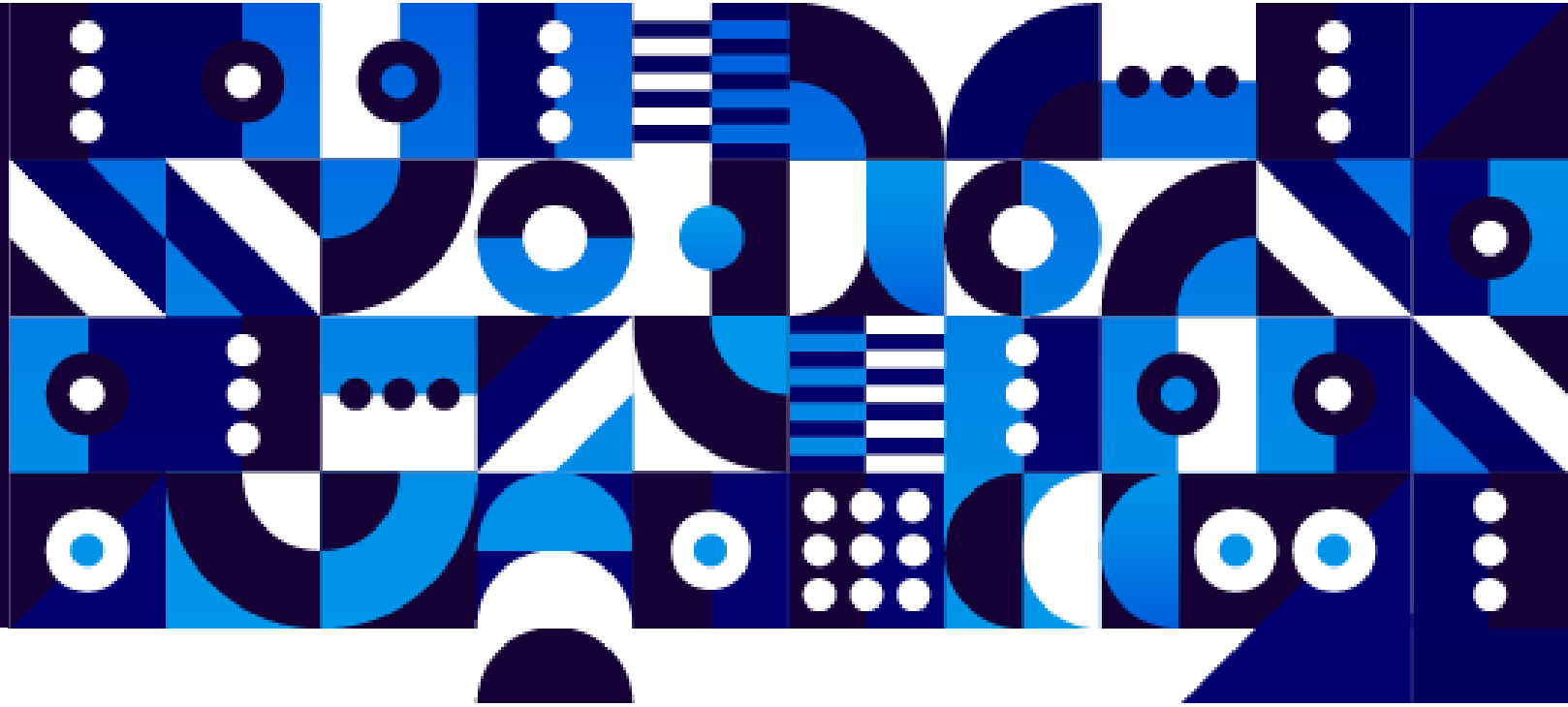
ANNUAL
REPORT
2021

INSTITUTO DE FÍSICA CORPUSCULAR

IFIC
INSTITUT DE FÍSICA CORPUSCULAR

VNIVERSITAT DE VALÈNCIA

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



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WELCOME

1 DIRECTOR LETTER

Español

El año 2021 ha sido un año híbrido, nos hemos acostumbrado a este formato y a los aforos limitados. Afortunadamente se está recuperando poco a poco la normalidad, aunque no tan rápidamente como nos habría gustado, y siempre con mucha incertidumbre sobre si podremos hacer las actividades presenciales o no. De nuevo este año quiero agradecer a todo el personal del IFIC la actitud y responsabilidad ante esta situación anómala causada por la pandemia de COVID19, y vuestra colaboración para mantener el virus controlado, sin menoscabo de la actividad del instituto.

Esta Memoria es la primera estructurada de acuerdo con las nuevas líneas de investigación del IFIC, definidas a finales de 2019:
1.Origen de la masa: entender las leyes fundamentales de la Física
2.Origen de la materia: entender el Universo
3.Instrumentación avanzada y computación: de la Física fundamental a la sociedad

Cada una de ellas tiene varias sublíneas, que descubriréis si seguís leyendo. También hemos optado por separar las tradicionales jornadas científicas del IFIC en distintas temáticas y en 2021 tuvo lugar la primera, dedicada a la línea L1: “The Higgs Force”, en la que los investigadores teóricos y experimentales que trabajan en este tema expusieron los resultados más destacados. Debido a la pandemia, la jornada fue online, pero esperamos que las próximas sean presenciales.

Este año decidimos reestructurar la Oficina de Jóvenes Investigadores, Género y Diversidad, y sus funciones pasaron a repartirse entre la Comisión de Igualdad y Diversidad (CID) y la Oficina de Jóvenes Investigadores (OJI). El objetivo de la CID consiste en tratar de eliminar la discriminación o acoso que pueda tener lugar en el Instituto, asegurando la igualdad de oportunidades de todos sus miembros y favoreciendo las buenas relaciones entre los componentes de todas sus secciones. La OJI se ocupa de acoger e informar a los doctorandos y postdocs del IFIC, en sendas reuniones de bienvenida anuales, así como de organizar jornadas sobre oportunidades profesionales más allá de la investigación pública.

En 2021 la mayor parte de las conferencias han sido virtuales o se han pospuesto. En particular, la 17ª conferencia internacional Topics in Astroparticle and Underground Physics (TAUP 2021), que se organizaba en Valencia por primera vez, tuvo lugar online, con la participación de unos mil físicos de todo el mundo.

Los investigadores del IFIC siguen asumiendo importantes responsabilidades internacionales y nacionales: Arantxa Ruiz es coordinadora del Trigger (selección de datos en tiempo real) del experimento ATLAS en el CERN; Juanjo Hernández es miembro del Large Hadron Collider Experiments Committee (LHCC), un comité internacional que monitoriza el progreso de los experimentos del LHC en el CERN; Germán Rodrigo ha sido nombrado Experto Nacional por la Comisión Europea en la Agencia Ejecutiva del Consejo Europeo de Investigación (ERCEA) de Bruselas, en el área de Ciencias Físicas y Matemáticas; Pilar Hernández es coordinadora del plan nacional de Física de Partículas y Nuclear de la Agencia Española de Investigación.

También quiero resaltar la calidad de las tesis doctorales realizadas en el IFIC: Andrea Caputo y Alejandro Segarra recibieron el premio extraordinario de Doctorado 2020 de la Universitat de València, y Diego Real el premio de la Sociedad Española de Astronomía Tesis 2021 en Instrumentación, Computación y Desarrollo Tecnológico.

A pesar de las dificultades, el IFIC ha seguido involucrado en su compromiso de divulgación

de la ciencia y visibilización de las científicas, y sin duda tengo que destacar en este aspecto el ambicioso Proyecto Meitner, por sus múltiples vertientes y alcance: se colaboró con el Institut Valencià de Cultura y la compañía de teatro CRIT para estrenar por primera vez en España la obra “Recordando a Lise Meitner”, del dramaturgo y catedrático de Historia de la Ciencia Robert Marc Friedman, con la participación de varias investigadoras del IFIC; se organizaron las jornadas de Ciencia y Género “Pioneras en Física Nuclear y de Partículas”, para profesores de Enseñanza Secundaria; y tuvo lugar la primera edición del concurso Express-Arte ConCiencia, un concurso multidisciplinar en el que se mezclan las ciencias, las artes y las humanidades.

Por último, pero no menos importante, quiero reconocer el trabajo y dedicación de los miembros del IFIC, tanto el personal docente e investigador como el personal técnico, de administración y comunicación. Entre todos han hecho posibles las numerosas actividades descritas en esta memoria y son necesarios para que podamos mantener nuestro liderazgo internacional y continuar mejorando.

Nuria Rius

Directora del IFIC

1 DIRECTOR LETTER

Valencià

L'any 2021 ha sigut un any híbrid, ens hem acostumat a aquest format i als aforaments limitats. Afortunadament s'està recuperant a poc a poc la normalitat, encara que no tan ràpidament com ens hauria agradat, i sempre amb molta incertesa sobre si podrem fer les activitats presencials o no. De nou enguany vull agrair a tot el personal del IFIC l'actitud i responsabilitat davant aquesta situació anòmala causada per la pandèmia de COVID19, i la vostra col·laboració per a mantindre el virus controlat, sense menyscapte de l'activitat de l'institut.

Aquesta Memòria és la primera estructurada d'acord amb les noves línies d'investigació del IFIC, definides a la fi de 2019:

1.Origen de la massa: entendre les lleis fonamentals de la Física
2.Origen de la matèria: entendre l'Univers
3. Instrumentació avançada i computació: de la Física fonamental a la societat.

Cadascuna d'elles té diverses sublíneas, que descobrireu si continueu llegint. També hem optat per separar les tradicionals jornades científiques del IFIC en diferents temàtiques i en 2021 va tindre lloc la primera, dedicada a la línia L1: “The Higgs Force”, en la qual els investigadors teòrics i experimentals que treballen en aquest tema van exposar els resultats més destacats. A causa de la pandèmia, la jornada va ser online, però esperem que les pròximes siguen presencials.

Enguany decidim reestructurar l'Oficina de Joves Investigadors, Gènere i Diversitat (JIGD), i les seues funcions s'han repartit entre la Comissió d'Igualtat i Diversitat (CID) i l'Oficina de Joves Investigadors (OJI). L'objectiu de la CID consisteix a tractar d'eliminar la discriminació o assetjament que puga tindre lloc en l'Institut, assegurant la igualtat d'oportunitats de tots els seus membres i afavorint les bones relacions entre els components de totes les seues seccions. La OJI s'ocupa d'acollir i informar els doctorands i postdocs del IFIC, en sengles reunions de benvinguda anuals, així com d'organitzar jornades sobre oportunitats professionals més enllà de la investigació pública.

En 2021 la major part de les conferències han sigut virtuals o s'han posposat. En particular, la 17a conferència internacional Topics in Astroparticle and Underground Physics (TAUP 2021), que s'organitzava a València per primera vegada, va tindre lloc online, amb la participació d'uns mil físics de tot el món.

Els investigadors del IFIC continuen assumint importants responsabilitats internacionals i nacionals: Arantxa Ruiz és coordinadora del Trigger (selecció de dades en temps real) de l'experiment ATLAS en el CERN; Juanjo Hernández és membre del Large Hadron Collider Experiments Committee (LHCC), un comité internacional que monitora el progrés dels experiments del LHC en el CERN; Germán Rodrigo ha sigut nomenat Expert Nacional per la Comissió Europea en l'Agència Executiva del Consell Europeu d'Investigació (ERCEA) de Brussel·les, en l'àrea de Ciències Físiques i Matemàtiques; Pilar Hernández és coordinadora del pla nacional de Física de Partícules i Nuclear de l'Agència Espanyola d'Investigació.

També vull ressaltar la qualitat de les tesis doctorals realitzades en el IFIC: Andrea Caputo i Alejandro Segarra van rebre el premi extraordinari de Doctorat 2020 de la Universitat de València, i Diego Real el premi de la Societat Espanyola d'Astronomia Tesi 2021 en Instrumentació, Computació i Desenvolupament Tecnològic.

Malgrat les dificultats, el IFIC ha seguit involucrat en el seu compromís de divulgació de la ciència i visibilització de les científiques, i sens dubte he de destacar en aquest aspecte l'ambiciós Projecte Meitner, pels seus múltiples vessants i abast: es va col·laborar amb el Institut Valencià de Cultura i la companyia de teatre CRIT per a estrenar per primera vegada a Espanya l'obra “Recordant a Lise Meitner”, del dramaturg i catedràtic d'Història de la Ciència Robert Marc Friedman, amb la participació de diverses investigadores

del IFIC; es van organitzar les jornades de Ciència i Gènere “Pioneres en Física Nuclear i de Partícules”, per a professors d'Ensenyament Secundari; i va tindre lloc la primera edició del concurs Express-Arte ConCiencia, un concurs multidisciplinari en el qual es mesclen les ciències, les arts i les humanitats.

Finalment, però no menys important, vull reconéixer el treball i dedicació dels membres del IFIC, tant el personal docent i investigador com el personal tècnic, d'administració i comunicació. Entre tots han fet possibles les nombroses activitats descrites en aquesta memòria i són necessaris perquè puguem mantindre el nostre lideratge internacional i continuar millorant.

Nuria Rius

Directora del IFIC

1 DIRECTOR LETTER

English

The year 2021 has been a hybrid one. We got accustomed to this format and to venues with limited capacity. Fortunately, we are getting back to normal lives little by little, although not as fast as we would have liked, and always with a lot of uncertainty about whether or not we will be able to do face-to-face activities. Once again, this year I want to thank all the IFIC staff for their attitude and responsibility with regard to this abnormal situation caused by the COVID19 pandemic, and for your collaboration in keeping the virus under control, without undermining the institute's activity.

This Report is the first one structured according to IFIC's new lines of research, defined at the end of 2019:

1. Origin of mass: understanding the fundamental laws of Physics
2. Origin of matter: understanding the Universe
3. Advanced instrumentation and computing: from fundamental Physics to society.

Each line has several sublines, which you will discover if you continue reading.

We have also chosen to split the traditional IFIC scientific meeting into different thematic workshops. In 2021 the first one took place, dedicated to line L1: "The Higgs Force", in which theoretical and experimental researchers working on this topic presented the most important results. Due to the pandemic, the workshop was held online, but we hope that the next ones will be face-to-face.

This year we decided to restructure the Office of Young Researchers, Gender and Diversity. Its functions were divided between the Equality and Diversity Commission (CID) and the Office of Young Researchers (OJI). The objective of the CID consists of trying to eliminate the discrimination or harassment that may take place in the Institute, ensuring equal opportunities for all its members and favoring good relationships between them. The OJI is in charge of welcoming and informing IFIC doctoral students and postdocs, in separate annual welcome meetings, as well as organizing workshops on professional opportunities beyond public research.

In 2021, most of the conferences were held virtually or have been postponed. In particular, the 17th international conference Topics in Astroparticle and Underground Physics (TAUP 2021), which was organized in Valencia for the first time, took place online, with the participation of around a thousand physicists from all over the world.

IFIC researchers continue to take important responsibilities at the international and national levels: Arantxa Ruiz is coordinator of the Trigger (selection of data in real time) of the ATLAS experiment at CERN; Juanjo Hernández is member of the Large Hadron Collider Experiments Committee (LHCC), an international committee that monitors the progress of the LHC experiments at CERN; Germán Rodrigo has been appointed National Expert by the European Commission at the Executive Agency of the European Research Council (ERCEA) in Brussels, in the area of Physical and Mathematical Sciences; Pilar Hernández is coordinator of the national plan for Nuclear and Particle Physics of the Spanish Research Agency.

I also want to highlight the quality of the doctoral theses carried out at IFIC. Andrea Caputo and Alejandro Segarra received the extraordinary doctoral award 2020 from the University of Valencia, and Diego Real received the 2021 Thesis prize in Instrumentation, Computing and Technological Development from the Spanish Society of Astronomy.

Despite the difficulties, IFIC has continued to be involved in its commitment to disseminate science and make female scientists visible. I must certainly highlight the ambitious Meitner Project in this regard, due to its multiple facets and reach. We collaborated with the Institut Valencià de Cultura and the theater company CRIT to premiere for the first time in Spain the play "Remembering Lise Meitner", by the playwright and Professor of History of Science Robert Marc Friedman, with the participation

IFIC, were also held virtually.

of several IFIC researchers. The “Pioneers in Nuclear and Particle Physics” Science and Gender workshop was organized for Secondary School teachers. Finally, the first edition of the Express-Arte ConCiencia contest took place, a multidisciplinary contest in which the sciences, arts and humanities are blended together.

Last but not least, I want to acknowledge the work and dedication of IFIC members, both the teaching and research staff as well as the technical, administrative and communication staff. Together they have made possible the many activities described in this report and they are all necessary to maintain our international leadership and continue to improve.

Nuria Rius

Directora del IFIC

2

HIGHLIGHTS OF THE YEAR

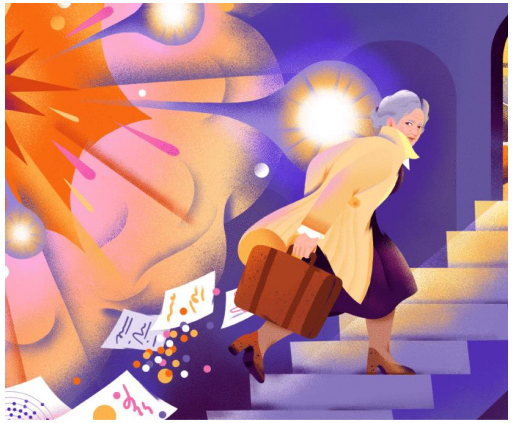
2 HIGHLIGHTS OF THE YEAR

HAWC DETECTS A GALACTIC SOURCE OF GAMMA RAYS THAT IS A CANDIDATE FOR PRODUCING VERY HIGH-ENERGY COSMIC RAYS

IFIC researcher Francisco Salesa Greus, together with other members of the HAWC collaboration, has detected very high-energy photons from a galactic source that could be a candidate for producing cosmic rays. This finding has been published in The Astrophysical Journal Letters. More information here.

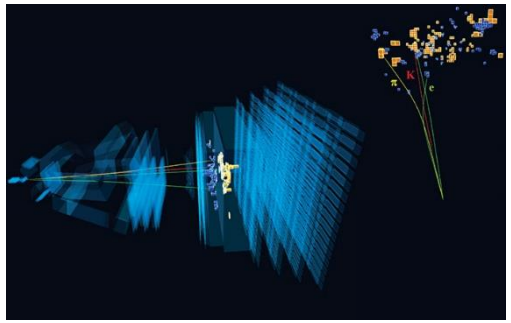
'REMEMBERING LISE MEITNER', THEATER TO MAKE VISIBLE THE ROLE OF WOMEN IN SCIENCE

As a tribute to Lise Meitner, IFIC has adapted a play about her life to bring it to the Spanish public with an extensive program of activities that highlight the role of women in nuclear physics and scientific research. The play 'Remembering Lise Meitner' premiered in Spain at the Rialto theater in Valencia, from March 11 to 14. More information here and here.



2 HIGHLIGHTS OF THE YEAR

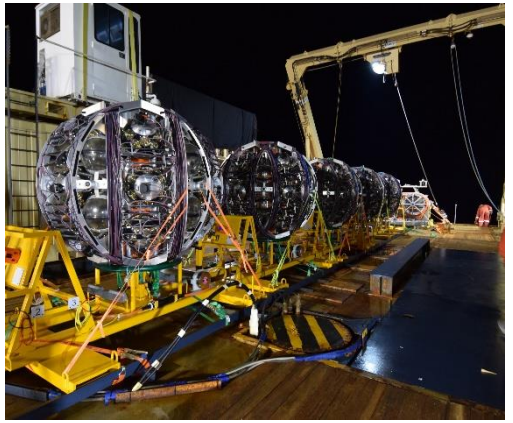
CERN'S LHCB EXPERIMENT YIELDS INTRIGUING NEW RESULTS ON THE STANDARD MODEL OF PARTICLE PHYSICS



The LHCb experiment at CERN announced new results which, if confirmed, would suggest hints of a violation of the Standard Model of particle physics. The results focus on the potential violation of lepton flavour universality. The measurement compares two types of decays of beauty quarks, involving electrons and muons, respectively. More information here.

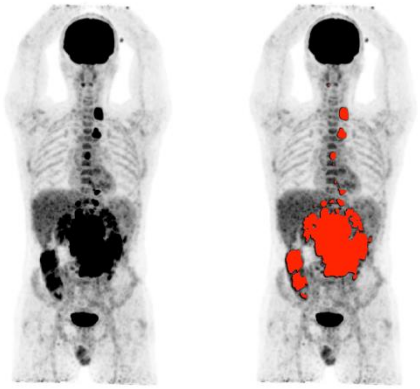
THE KM3NET/ARCA NEUTRINO TELESCOPE HAS SIX DETECTION UNITS IN OPERATION AS OF APRIL 2021

In April 2021, significant progress has been made in the construction of the KM3NeT undeerwater infrastructure. Five new detection units (for a total of six) of the ARCA neutrino telescope have been installed. The units are now operational and collecting data. IFIC has actively contributed to the design, construction and calibration of these lines. More information here.



2 HIGHLIGHTS OF THE YEAR

IFIC PARTICIPATES TOGETHER WITH THE I3M IN A PROJECT TO DEVELOP A NOVEL PET SCANNER



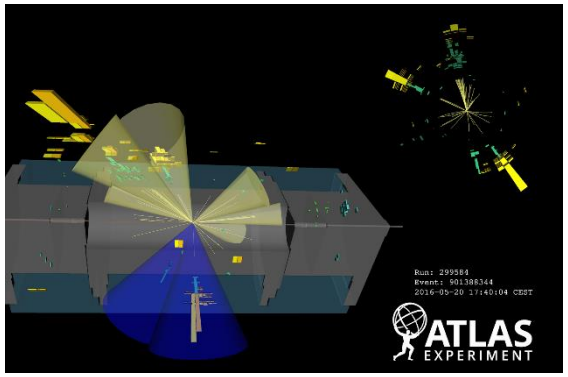
IFIC and the Institute for Molecular Imaging Technologies (i3M) participate in IMAS (High Sensitivity Molecular Imaging), an R&D project promoted by the Generalitat Valenciana. The objective is to develop a new positron emission tomography (PET) device that improves the performance of current equipment, thanks to increased sensitivity and spatial resolution. More information here.

17TH INTERNATIONAL CONFERENCE ON TOPICS IN ASTROPARTICLE AND UNDERGROUND PHYSICS (TAUP 2021)

IFIC has organized the 17th edition of this international conference, TAUP 2021. The event was held in Valencia for the first time, albeit 'virtually' due to the COVID-19 pandemic. A thousand physicists from all over the world have participated in the conference, where the latest results on gravitational waves, the detection of dark matter or neutrinos have been presented. More information here.

2 HIGHLIGHTS OF THE YEAR

ATLAS MEASURES KEY HIGGS BOSON INTERACTION WITH HIGH PRECISION



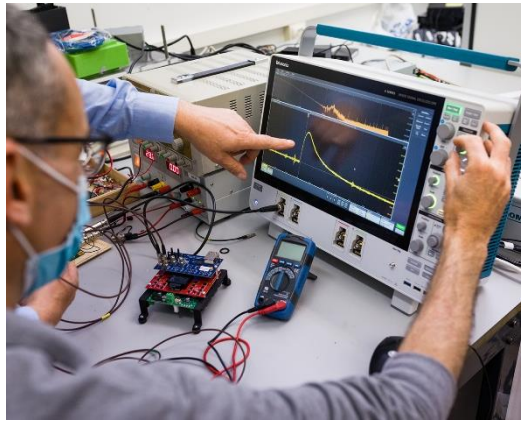
Since the discovery of the Higgs boson in 2012, many of its fundamental properties have been measured. A new ATLAS result presented at the EPS-HEP conference, involving key contributions from IFIC researchers Ximo Poveda and Luca Fiorini, has measured the decay of the Higgs boson into tau leptons using Run 2 data of the LHC. More information here.

ARANTXA RUIZ MARTÍNEZ COORDINATES THE SELECTION OF DATA IN REAL TIME IN THE ATLAS EXPERIMENT AT CERN LHC

Arantxa Ruiz Martínez, Ramón y Cajal researcher at IFIC, has been appointed as Trigger Coordinator of the CERN ATLAS experiment. Her team will be responsible for implementing improvements in the real-time data selection system. The goal is to explore new physics processes when the LHC resumes operations in 2022. More information here.

2 HIGHLIGHTS OF THE YEAR

IFIC DEVELOPS A COMPACT AND PORTABLE DETECTOR WITH MEDICAL AND NUCLEAR SAFETY APPLICATIONS



Researchers from IFIC patent a device capable of simultaneously detecting and imaging gamma radiation and neutrons, over a wide energy spectrum. Both radiations are essential to detect radioactive materials in nuclear safety programs and to minimise the side effects of hadrontherapy, a novel cancer therapy. More information here.

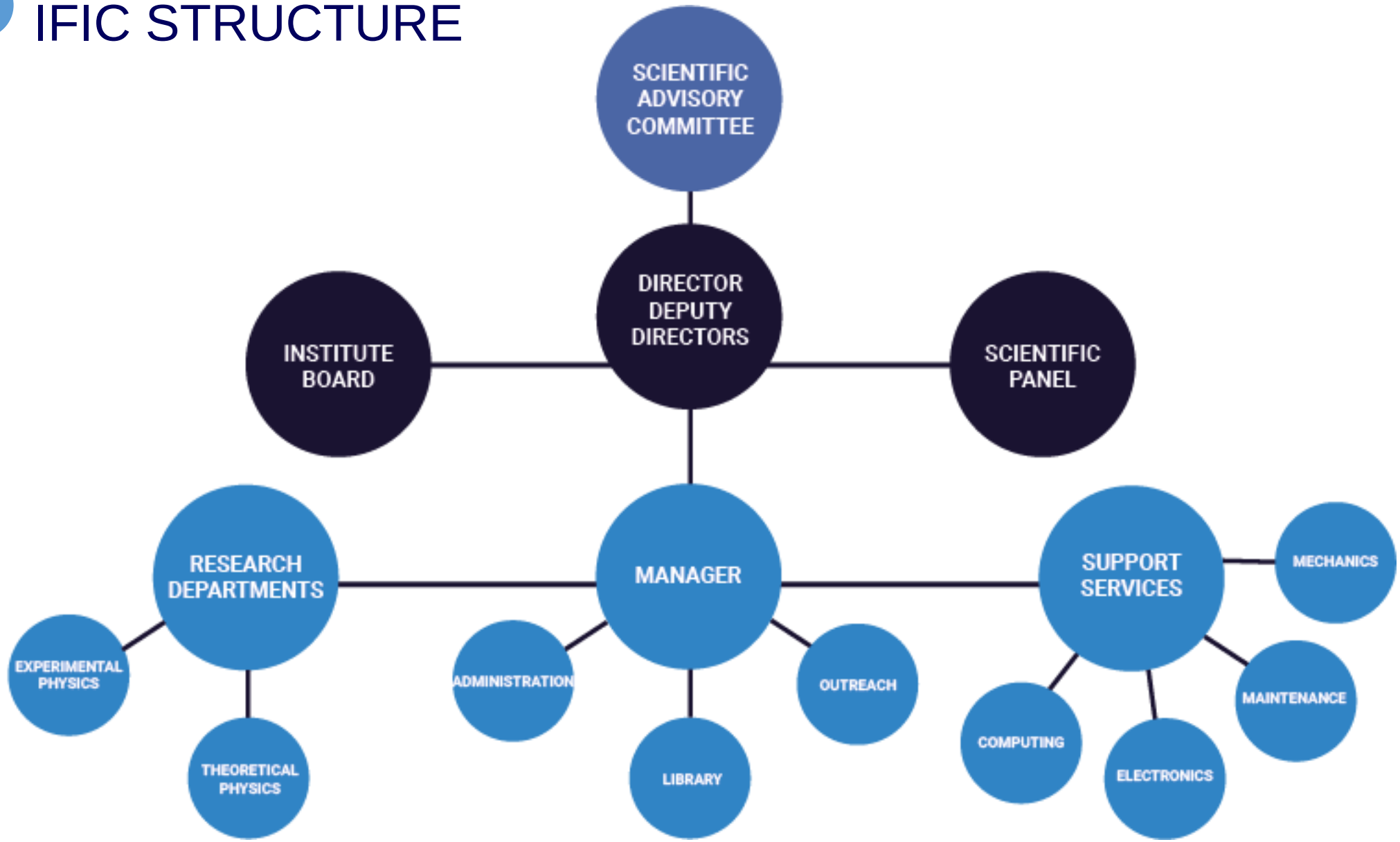
JUAN JOSÉ HERNÁNDEZ-REY, NEW MEMBER OF THE LARGE HADRON COLLIDER EXPERIMENTS COMMITTEE (LHCC)

Juan José Hernández-Rey has been appointed member of the LHCC committee, which reviews the status and progress of the Large Hadron Collider (LHC) experiments at CERN. The committee is made up of about twenty scientists from Europe, the United States, Canada, and Japan. More information here.

3

STRUCTURE AND ORGANIZATIO N

3 IFIC STRUCTURE



3 STRUCTURE


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

3 STRUCTURE

Heads of the research departments

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

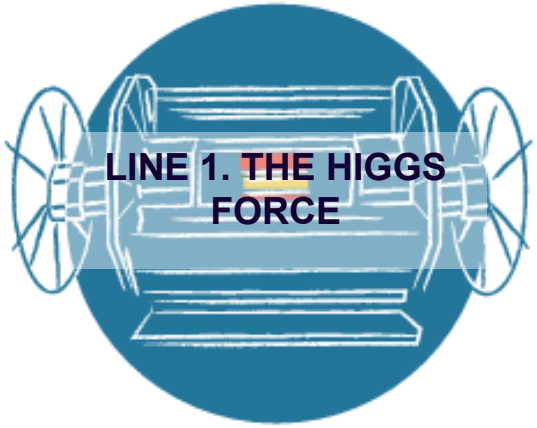
Personnel representatives

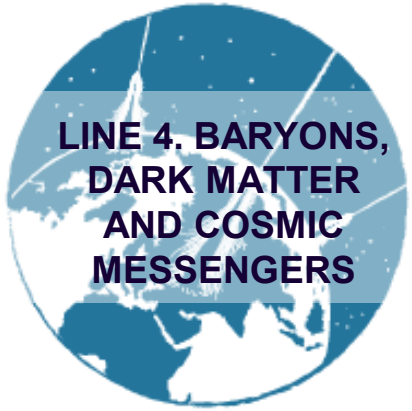
- Non-PhD members — Teresa Cámara
- PhD members — Susana Cabrera

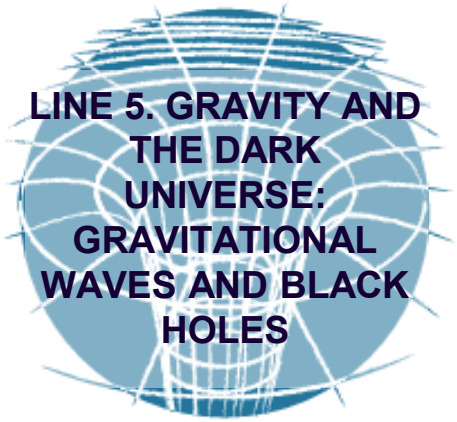
International Scientific Advisory Committee

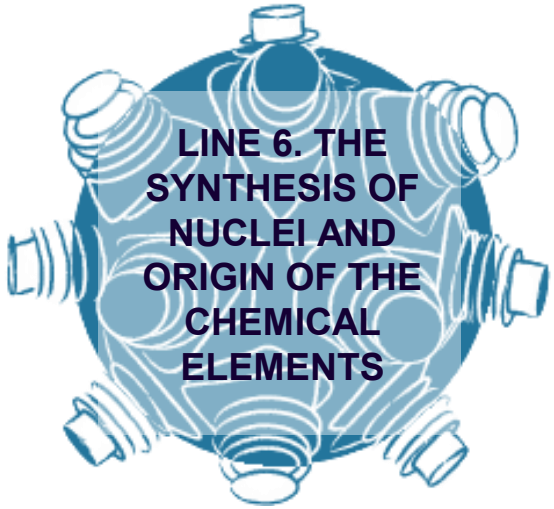
> Gustavo C Branco (CFTP/IST, Univ. Lisbon, Portugal)
> William Gelletly (Univ, Surrey, UK)
> Francis Halzen (Univ. Wisconsin, USA)
> Cecilia Jarlskog (Univ. Lund, Sweden)
> Peter Jenni (Univ. Freiburg, Germany, and CERN, Switzerland)
> Antonio Maseiro (INFN and Univ. Padua, Italy)
> Tatsuya Nakada (EPFL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

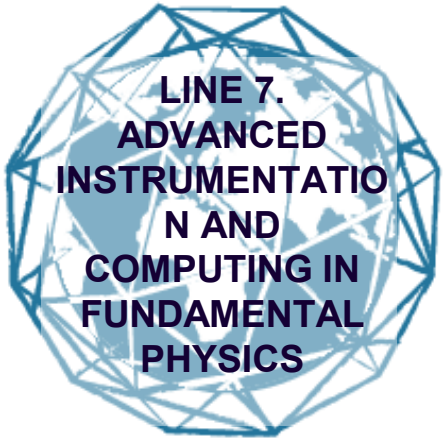
RESEARCH LINES





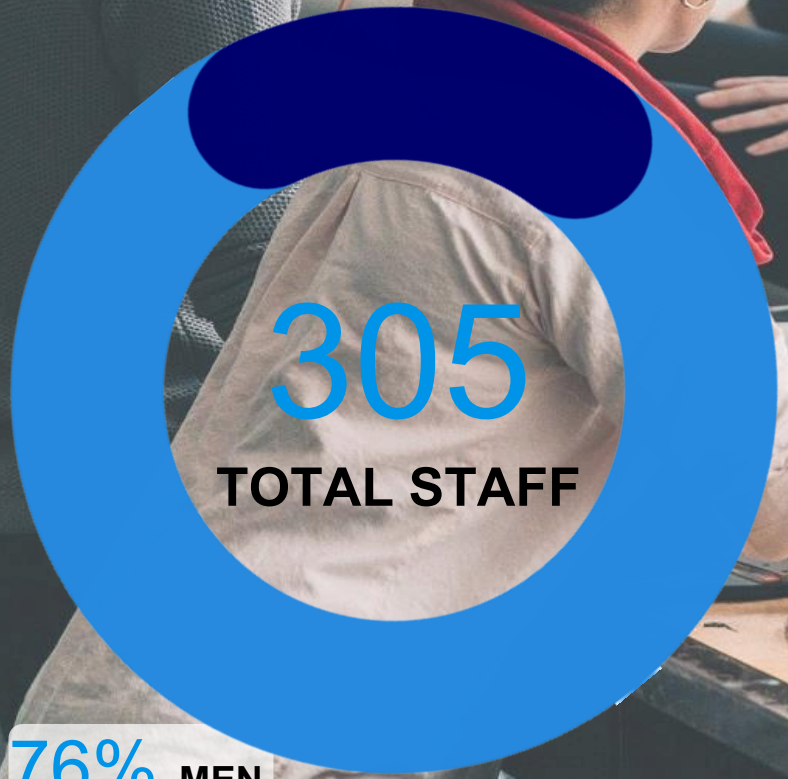






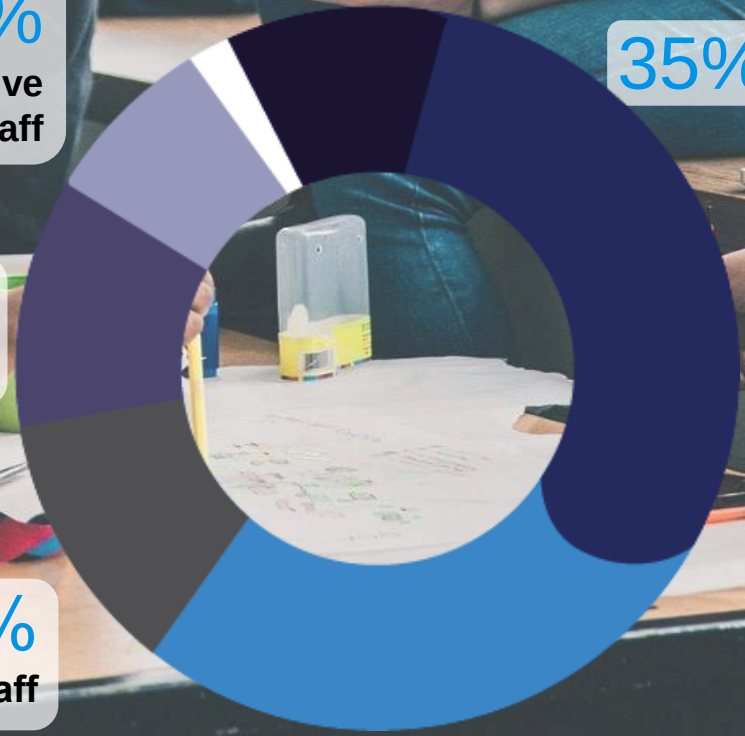
3 PERSONNEL

DECEMBER 2021



24% **WOMEN**

76% **MEN**



4% **Professors emeriti and visiting researchers**

7% **Tenure track researchers**

7% **Administrative staff**

35% **PhD Students**

12% **Post-docs researchers**

12% **Technical staff**

23% **Permanent staff researchers**

Personnel list

4

SCIENTIFIC PRODUCTION

4 SCIENTIFIC OUTCOME

ARTICLES IN INDEXED JOURNALS 411

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

90% **IN FIRST QUARTILE JOURNALS**

(JCR-WoS OR CITESCORE-SCOPUS, 2021)

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

Nature (IF 69.5)	2
Living Reviews in Relativity (IF 42.9)	1
Nature Physics (IF 19.7)	2
Reports on Progress in Physics (IF 17.8)	1
Physical Review Letters (IF 9.2)	22

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

97	Journal of High Energy Physics (IF 6.4)
61	Physical Review D (IF 5.4)
58	European Physical Journal C (IF 5.0)
25	Physics Letters B (IF 5.0)
24	Physical Review C (IF 3.2)

4 CONFERENCES, WORKSHOPS, SEMINARS AND COLLOQUIA

CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS	CONFERENCES AND WORKSHOPS ORGANIZED	'SEVERO OCHOA' COLLOQUIA ORGANIZED	SEMINARS ORGANIZED
351	12	7	95

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 351 contributions were presented in 2021: 321 talks (22 invited, 120 plenaries) and 30 posters.

351

Full list of events

CONFERENCES AND WORKSHOPS ORGANIZED

IFIC members have organized 12 conferences and workshops during 2021. The full listing can be found in annex 3.

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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 2021, IFIC celebrated 7 Severo Ochoa Colloquia. Colloquia in hybrid format (in-person plus online) were resumed in September 2021, after a period of online-only colloquia because of the pandemic. The listing can be found in Appendix C. Organisers: Alejandro Algora, Vasiliki Mitsou, Sergio Palomares Ruiz and Marcel Vos.

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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 2021 we hosted a total of 95 seminars, including 15 student seminars. The complete list can be found in Appendix D.

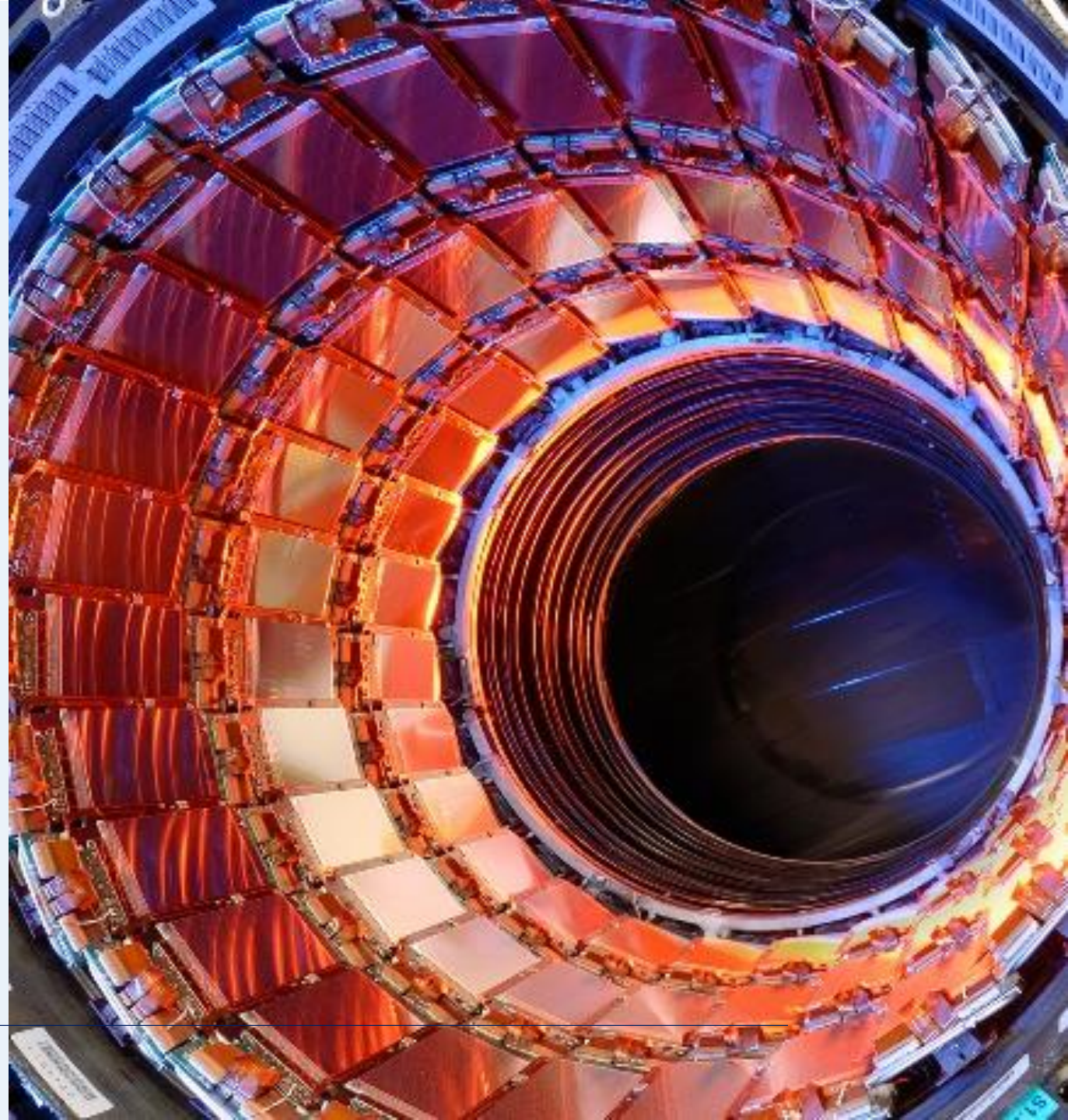
Organisers: Leandro Cieri, Andrea Donini, Daniel G. Figueroa, Martín González Alonso, Fernando Hueso, Adrián Irles, Jacobo López Pavón, Laura Molina, Raquel Molina, Miguel Nebot, Sergio Palomares Ruiz, Emilie Passemar, Ana Ros, Avelino Vicente.

95

Full list of events

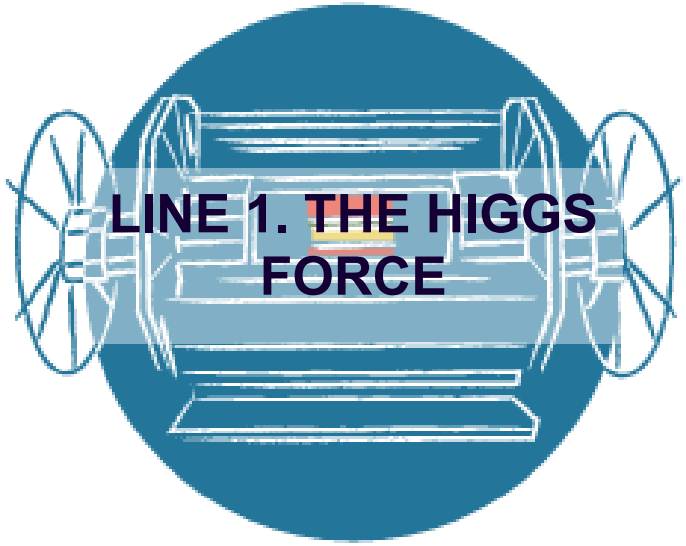
5

RESEARCH REPORT




THE ORIGIN OF MASS

SCIENTIFIC RESEARCH LINES



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, continue the direct search for new particles at the energy frontier.

5 L1: THE HIGGS FORCE

During 2021, The Large Hadron Collider (LHC) at CERN continued in shutdown for the Phase-I luminosity upgrade and maintenance and consolidation of the experiments. Our activity areas in the ATLAS experiment of the LHC dealt with the preparation for the start of the LHC detector operation, software and computing and also to the detector upgrade. At the same time we engaged in intense activities related to the physics exploitation of the ATLAS experiment via the data analysis.

ATLAS Operations

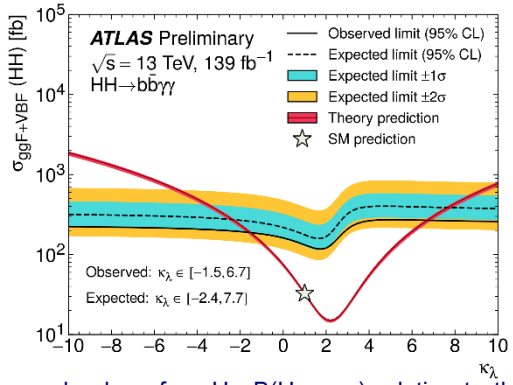
The trigger is a key part of the ATLAS experiment, selecting the events that are kept for permanent storage and subsequent physics analysis. During 2021, the list and definition of the algorithms to select the data during Run 3 has been defined. IFIC members are the deputy coordinator of the ATLAS trigger and among the organizers of the "ATLAS Physics from Run 2 to Run 3 and beyond".

The maintenance and consolidation tasks in the front-end electronics of TileCal have been carried out. The Read-Out Drivers play a key role in the ATLAS data-taking and modules have been repaired to ensure sufficient spares for the Run 3 of the LHC.

Our group plays a leading role in the electron, photon and tau lepton performance studies in ATLAS. In 2021, IFIC members are coordinating the ATLAS E/gamma group and the tau reconstruction and software subgroup. Among other areas, we contribute to the preparation of the tau reconstruction code for Run 3 and to the development of techniques for the reconstruction and identification of leptons (muons, electrons and tau-leptons) within the ATLAS experiment software.

Precision measurements Higgs/Top

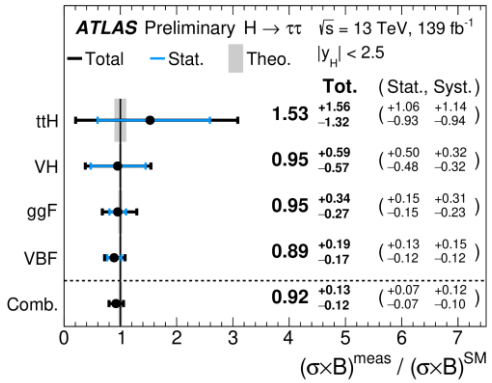
IFIC has greatly contributed to the analysis of the LHC proton-proton collisions data. The precise measurement of the couplings of the Higgs boson to fermions (Yukawa coupling) is one of the priorities of the LHC physics program and also for us. We have been particularly active in the measurement of the Higgs boson coupling to tau leptons and top-quarks with the complete dataset accumulated during 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 and top-quark associated production. Preliminary results from our studies have been shown to conferences in 2021 [ATLAS-CONF-2021-044], achieving a precision of 20% for the Vector Boson Fusion production measurement, demonstrating the strength of this analysis.



The measured values for σH× B(H → ττ) relative to the SM expectations in the Cross-sections per production modes and the Total Cross-section measurements.

IFIC is also involved in the measurement of the self-coupling coupling of the Higgs boson. This is one of the most important properties of the Higgs boson, related to the stability of the electro-waek 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. Preliminary results [ATLAS-CONF-2021-016], presented at the main conferences of 2021, have been combined with similar ATLAS searches in other final states and upper limits of 3.1 times the Standard Model have been set [ATLAS-CONF-2021-052]. The 95% C.L. limits for the Higgs boson self coupling exclude values outside the range $-1.0 \leq \kappa\lambda \leq 6.6$, being the most stringent in the world at the time.

5 L1: THE HIGGS FORCE



Observed and expected limits at 95% CL on the cross section of non-resonant Higgs boson pair production as a function of the Higgs boson self-coupling modifier κλ= λ_HHH/λ^SM_HHH.

We also contributed to the studies of the coupling of the top quark and Z bosons with the so called ttZ production. Measurements of both the inclusive and differential production cross sections of a top-quark–antiquark pair in association with a Z boson were published [Eur. Phys. J. C 81, 737 (2021)]. The measurements were performed by targeting final states with three or four isolated leptons (electrons or muons) and based on the LHC Run2 √s=13 TeV proton–proton collision data collected by ATLAS. The inclusive cross section was measured to be $\sigma_{t\bar{t}Z}$=0.99±0.05 (stat.) ±0.08 (syst.) pb, in agreement with the most precise theoretical predictions.The differential measurements are presented as a function of a number of kinematic variables which probe the kinematics of the $t\bar{t}Z$ system and performed at particle and parton level, shownbg a good agreement with the predictions.

Our group also produced the 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 of 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) [*J. High Energ. Phys*. 2022, 40 (2022)].

We did also published the determination of the b quark running mass [PRL128 (2022) 122001]. The measurement is performed in the $\overline{\text{MS}}$ scheme at the renormalization scale of the Higgs boson mass from measurements of Higgs boson decay rates at the LHC. The obtained value is mb(mH)=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.

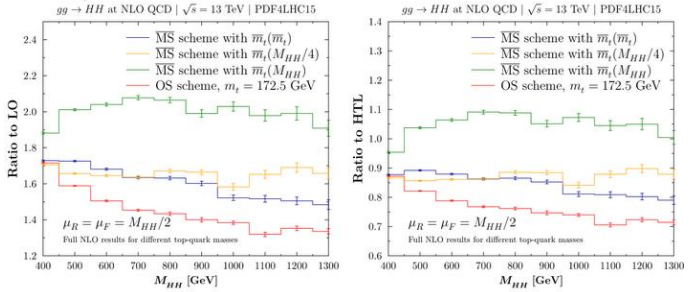
Searches Higgs/Top

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.

gg → HH: Combined Uncertainties

We have analyzed the combination of the usual renormalization and factorization scale uncertainties of Higgs-pair production via gluon fusion with the uncertainties originating from the scheme and scale choice of the virtual top mass in the Yukawa coupling and the propagators. Due to the observation that the latter relative uncertainties are nearly independent of the renormalization and factorization scale choices, the proper combination of the relative uncertainties is provided by a linear addition, resulting in uncertainties ranging from -23% to 6%. Our procedure does not estimate the full uncertainties at NNLO but those at approximate NNLO without the knowledge of the complete NNLO top-mass effects.

5 L1: THE HIGGS FORCE

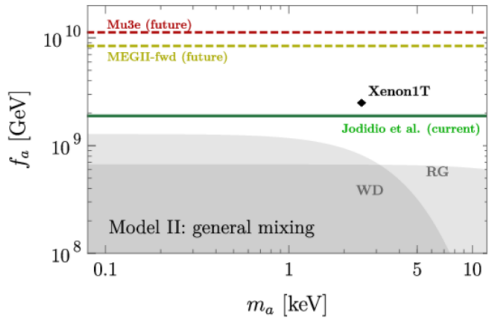


Ratio of the full NLO QCD differential cross section to the LO one(left) and to the NLO HTL (right) for various definitions of the virtual top mass as a function of the invariant Higgs-pair mass.

In a second step we derived the dependence of the uncertainties related to the top-mass scheme and scale choice on a variation of the trilinear Higgs self-coupling λ. The relative uncertainties are again observed to develop only a small dependence on λ. We combined all the uncertainties for √s= 13 TeV with the ones of the present recommendation of the LHC Higgs Working Group, obtaining moderate uncertainties ranging from -9% to 5%. This allows us to obtain state-of-the-art predictions for Higgs pair production cross sections at the LHC including both renormalization/factorization scale and top-quark scale and scheme uncertainties.

Anomaly-free leptophilic axionlike particle and its flavor violating tests

We show that for a general flavor symmetry where large mixings in the charged-lepton sector are possible, a keV ALP explaining the Xenon1T result is still viable for lepton flavor violation and stellar cooling astrophysical limits. On the other hand, if the Xenon1T result is confirmed, future charged-lepton flavor violation measurements can be complementary to probe such a possibility.



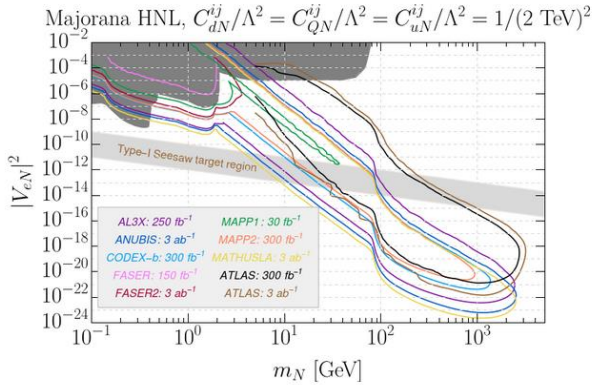
Cosmological and lepton flavor violation bounds on Axion-like Particles compared with the prediction of a general flavor model explaining the Xenon1T anomaly.

DsixTools 2.0: The Effective Field Theory Toolkit

The use of computing tools to automate analytical and numerical calculations in Effective Field Theories has become common practice nowadays. DsixTools 2.0 is a Mathematica package for the matching and renormalization-group evolution from the New Physics scale to the scale of low energy observables.

Heavy neutral leptons in effective field theory and the high-luminosity LHC

Heavy neutral leptons (HNLs) are one of the prime candidates for long-lived particles. We have calculated the sensitivity for the search of HNLS in SMEFT extended by right-handed neutrinos for the high-luminosity run of the LHC. Forecasts are made for both, the main and possible future far detectors.



Sensitivity estimate for the high-luminosity LHC for pair-N operators in the plane mixing squared versus heavy neutral lepton mass.

5 L1: THE HIGGS FORCE

In a second step we derived the dependence of the uncertainties related to the top-mass scheme and scale choice on a variation of the trilinear Higgs self-coupling λ. The relative uncertainties are again observed to develop only a small dependence on λ. We combined all the uncertainties for √s= 13 TeV with the ones of the present recommendation of the LHC Higgs Working Group, obtaining moderate uncertainties ranging from -9% to 5%. This allows us to obtain state-of-the-art predictions for Higgs pair production cross sections at the LHC including both renormalization/factorization scale and top-quark scale and scheme uncertainties.

Selected publications

> L. Fiorini What we learned about the Higgs boson "PoSLHCP2020 (2021) 159". DOI: https://doi.org/10.22323/1.382.0159

> J. Baglio, F. Campanario, S. Glaus, M. Mühlleitner, J. Ronca and M. Spira. gg→HH: Combined Uncertainties Phys. Rev. D 103 (2021) 5, 056002 arXiv:2008.11626. DOI:10.1103/PhysRevD.103.056002

> C. Han, M.L. López-Ibáñez, A. Melis, O. Vives, J.M. Yang Anomaly-free leptophilic axionlike particle and its flavor violating tests Phys.Rev.D 103 (2021) 3, 035028 arXiv:2007.08834 DOI: 10.1103/PhysRevD.103.035028

>Javier Fuentes-Martin, Pedro Ruiz-Femenia, Avelino Vicente, Javier Virto DsixTools 2.0: The Effective Field Theory Toolkit Eur.Phys.J.C 81 (2021) 2, 167 arXiv:2010.1634 DOI:10.1140/epjc/s10052-020-08778-y

>G. Cottin, J.C. Helo, M. Hirsch, A. Titov and Z.S. Wang Heavy neutral leptons in effective field theory and the high-luminosity LHC JHEP09 (2021) 039 arXiv:2105.13851 DOI: 10.1007/JHEP09(2021)039

> Javier Aparisi, Juan Fuster, Adrián Irles, Germán Rodrigo, Marcel Vos et al. mb at mH: The Running Bottom Quark Mass and the Higgs Boson PRL128 (2022) 122001. DOI: https://doi.org/10.1103/PhysRevLett.128.122001

Selected conference talks

>J. Poveda Higgs Spin, Parity and CP at the LHC 40th International Symposium on Physics in Collision 14/07/2021 Aachen (Germany)

> L. Fiorini Lepton Flavor Violation Searches at ATLAS and CMS 16th International Workshop of Tau Lepton Physics (TAU2021) 27/09/2021 Online

> I. Sayago Searches for Higgs boson pair production with the full LHC Run 2 dataset in ATLAS Higgs 2021 18/10/2021 Online

> A. Bailey Searches for additional Higgs bosons in ATLAS SUSY 2021 23/08/2021 Online

> M. Hirsch Neutrinos and long-lived particles Subatomic Physics at the High Energy Frontier (SAPHIR) 01/10/2021 Online

> M. J. Costa Measurement of top-quark cross sections and properties with the ATLAS detector at the LHC Blois 2021 17 oct 2021 Blois (France) http://blois.in2p3.fr/2021/

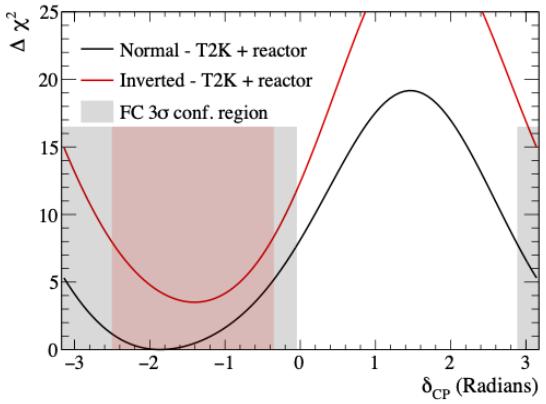
SCIENTIFIC RESEARCH LINES

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.

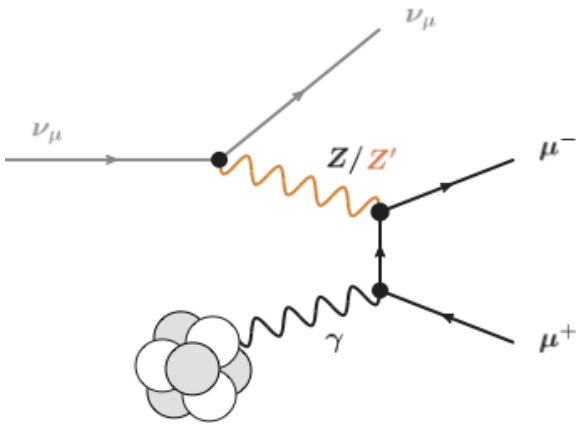
5 L2: NEUTRINOS AND LEPTON FLAVOUR

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 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, as shown by the extensive analysis [1]. IFIC is involved in the design and construction of the DUNE prototypes at the CERN Neutrino Platform and is leading some of the physics groups, including the searches for nucleon decay and beyond the Standard Model physics [2].

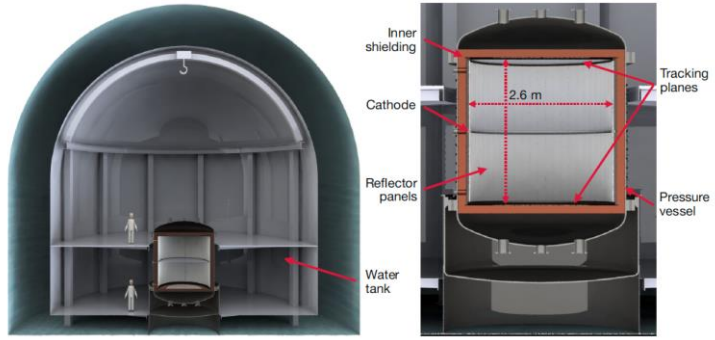


Confidence intervals obtained for the phase parameter δ_{CP} data from T2K and reactor data. Any value different from 0 or π would mean that the charge-parity (CP) symmetry is violated in the lepton sector.



Future DUNE data could probe non-standard neutrino processes such as the example depicted in this diagram, where the interaction of a muon neutrino with a heavy nucleus is mediated by a new Z' gauge boson

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. In 2021, the 5 kg NEXT-White detector successfully completed its physics programme, while the construction of NEXT-100 (100 kg) is ongoing. A scaled-up version of this technology with about 1 tonne of enriched xenon could reach, in less than 5 years of operation, a sensitivity to the half-life of 0 $0\nu\beta\beta$ decay that would improve the current limits by at least one order of magnitude [3].



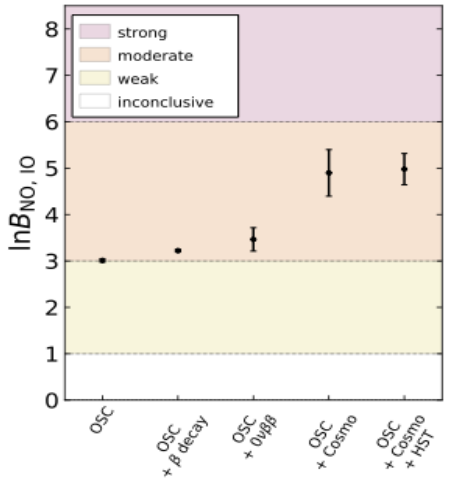
Conceptual design of a tonne-scale NEXT experiment for neutrinoless double-beta decay searches, installed inside a water tank (left), and detail of the internal structures of the detector (right)

Neutrinos produced in cosmic-ray showers in the atmosphere have been essential to

5 L2: NEUTRINOS AND LEPTON FLAVOUR

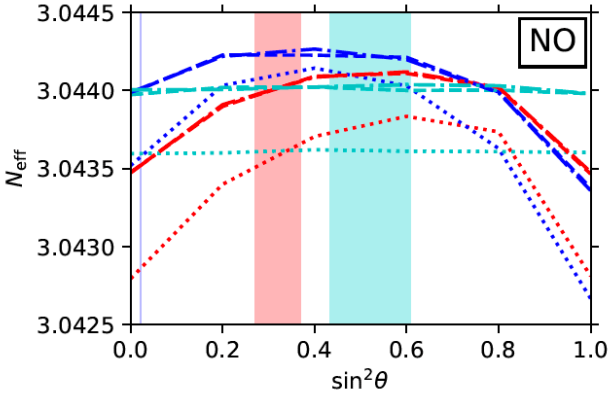
measure neutrino properties. Data from neutrino telescopes such as IceCube or ANTARES/KM3NeT on the highest energy tail of these atmospheric fluxes can be used to study neutrino physics. The ANTARES/KM3NeT group at IFIC has carried out searches for non-standard neutrino interactions (NSI) and neutrino decays, as well as the measurement of neutrino oscillation parameters. In 2021, the results on NSI with ANTARES provided competitive results in the parameter space connected to muon and tau neutrino oscillations.

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. In 2021, the Valencia group updated the global fit of neutrino oscillation data in the simplest three-neutrino framework [4], providing information on the neutrino mass hierarchy, CP violation and the atmospheric octant. In particular, they showed that the analysis still prefers normal neutrino mass ordering, although such a preference is milder than the one found in previous global analyses.



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.

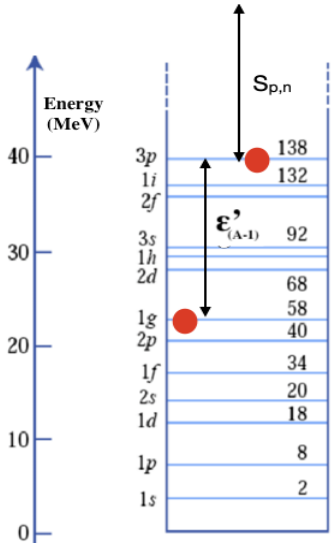
Neutrinos are the second most abundant of all known particles in the cosmos and, surprisingly, their tiny masses can influence the evolution of our Universe. Neutrino masses imprint measurable features in the cosmic microwave background and the distribution of galaxies. In order to find constraints on neutrino properties from cosmology, it is very important to know their relic density. An analysis published in 2021 by IFIC authors and collaborators [5] presented a new calculation of the standard-model benchmark value of the contribution of neutrinos to the relativistic energy density of the Universe, Neff = 3.044 when parameterized with the so-called effective number of neutrinos.



Change in the value of the effective number of neutrinos Neff under variations of the neutrino mixing angles for normal mass ordering.

IFIC research lines on nuclear physics are also relevant for the study of neutrinos. The IFIC nuclear experimental team has proposed a novel approach to estimate reactor neutrino fluxes, which is essential to measure some of the neutrino oscillation parameters, and IFIC nuclear theorists are experts in predicting neutrino-nucleus cross sections in the GeV neutrino energy range, an essential input to present and future accelerator neutrino experiments. For instance, in the work [6], the authors present a full kinematic analysis of neutrino-nucleus charged current quasielastic interactions and compare the predictions to the most recent T2K and MINERvA results.

5 L2: NEUTRINOS AND LEPTON FLAVOUR



Pictorial representation of the excitation energy scheme in a nucleus. When a nucleon is removed from a deep shell, the hole energy remains until the nucleus is de-excited.

Selected publications

>T2K Collaboration, Improved constraints on neutrino mixing from the T2K experiment with 3.13x1021 protons on target, Physical Review D 103 (2021) 112008, DOI: 10.1103/PhysRevD.103.112008 [arXiv:2101.03779]

>DUNE Collaboration, Prospects for beyond the Standard Model physics searches at the Deep Underground Neutrino Experiment, European Physical Journal C 81 (2021) 322, DOI: 10.1140/epjc/s10052-021-09007-w [arXiv:2008.12769]

>NEXT Collaboration, Sensitivity of a tonne-scale NEXT detector for neutrinoless double beta decay searches, Journal of High Energy Physics 08 (2021) 164, DOI: 10.1007/JHEP08(2021)164 [arXiv:2005.06467]

>P.F. de Salas, D.V. Forero, S. Gariazzo, P. Martínez-Miravé, O. Mena, C.A. Ternes, M. Tórtola and J.W.F. Valle, 2020 global reassessment of the neutrino oscillation picture, Journal of High Energy Physics 02 (2021) 071, DOI: 10.1007/JHEP02(2021)071 [arXiv:2006.11237]

>J.J. Bennett, G. Buldgen, P.F. de Salas, M. Drewes, S. Gariazzo, S. Pastor and Y.Y.Y. Wong, Towards a precision calculation of the effective number of neutrinos Neff in the Standard Model. Part II, Journal of Cosmology and Astroparticle Physics 04 (2021) 073, DOI: 10.1088/1475-7516/2021/04/073 [arXiv:2012.02726]

>B. Bourguille, J. Nieves, and F. Sánchez, Inclusive and exclusive neutrino-nucleus cross sections and the reconstruction of the interaction kinematics, Journal of High Energy Physics 04 (2021) 004, DOI: 10.1007/JHEP04(2021)004 [arXiv:2012.12653]

Selected conference talks

>J.D. Zornoza, Status, first data and prospects of KM3NeT-ORCA, IRN Neutrino meeting (online), June 2021

>N.R. Khan Chowdhury, Search for non-standard neutrino interactions with ANTARES and KM3NeT/ORCA, Very Large Volume Neutrino Telescope Workshop - VLVnT 2021 (online), May 2021

>P. Novella, Measurement of the 136Xe two-neutrino double beta decay half-life with NEXT-White, European Physical Society Conference on High Energy Physics - EPS-HEP 2021 (online), July 2021

>L. Álvarez-Ruso, Neutrino interactions with matter, ISAPP 2021: Neutrino Physics, Astrophysics and Cosmology (online), July 2021

>P. Hernández, Theoretical progress in the field of neutrino physics, 22nd Particles and Nuclei International Conference - PANIC 2021 (online), September 2021

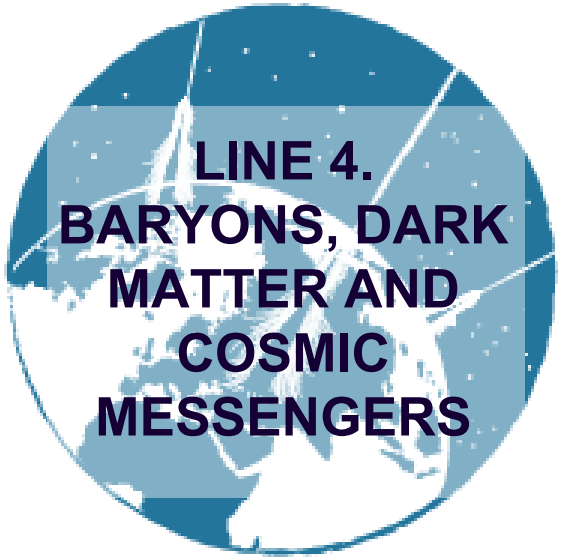
>V. De Romeri, Neutrino quantum decoherence at reactor experiments, 22nd International Workshop on Neutrinos from Accelerators - NuFact 2021, Cagliari (Italy), September 2021

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.


THE ORIGIN OF
MATTER

SCIENTIFIC RESEARCH LINES



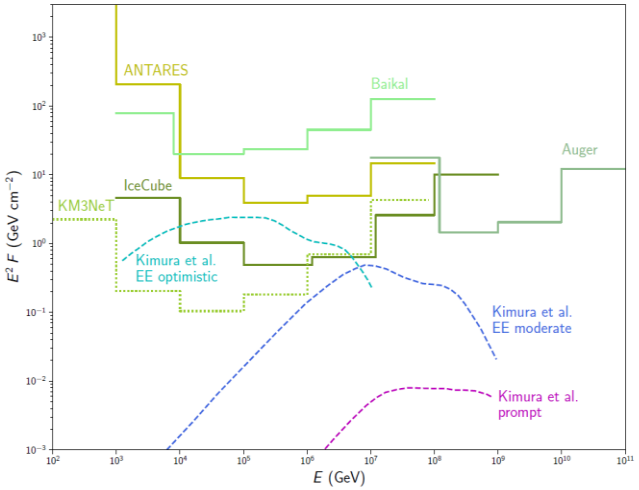
The origin of the matter-antimatter asymmetry in the universe remains an open question. New sources of CP violation are searched for at LHC by the ATLAS team, with a focus in the top-higgs sector. On the other hand, the baryon imbalance may be induced by a lepton asymmetry (leptogenesis). Inputs from 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. BARYOGENESIS, DARK MATTER AND COSMIC MESSENGERS

The research topics of this line include the generation of the baryonic asymmetry, cosmic messengers, specially cosmic neutrinos, and dark matter (DM). IFIC participates in various international collaborations, as ANTARES/KM3NeT, ATLAS, MoEDAL and NA64 and has an active theory group.

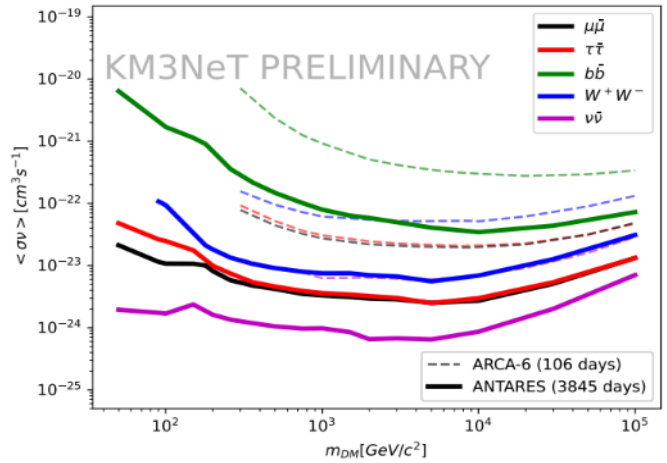
ANTARES/KM3NeT

The work of the ANTARES/KM3NeT group has continued the three lines in which its members are involved: multi-messenger astronomy, search for DM and study of neutrino properties.
Multi-messenger astronomy has become in recent years a very active field after the first signals of cosmic neutrinos and gravitational waves have been detected. The group at IFIC is deeply involved in several of these analyses, both for ANTARES and KM3NeT. During 2021, several papers in which this group had a leading role have been published. For instance, a search for correlations of neutrinos with the first gamma-ray bursts observed by Imaging Atmospheric Cherenkov Telescopes (GRB 190114C, detected by MAGIC, GRB 180720B and GRB 190829A, detected by H.E.S.S.) has been performed both for the prompt and afterglow phases, finding no coincidences [P1]. Another example is the search for correlations with events of the Baikal-GVD detector in addition to the three cascades in the Baikal-GVD sample within an angular distance of less than 5° for three of the ANTARES alerts in a time span of 48 hours. This was one of the analyses presented by this group at ICRC2021 [C1]. Concerning KM3NeT, its potential for detecting the neutrinos from core-collapse supernova explosions has been shown for the Milky-Way. Several of these analyses have been described in a review on multi-messenger astronomy with neutrino telescopes published in the journal Universe and authored by F. Salesa and A. Sánchez.



KM3NeT preliminary sensitivity per flavor on the high-energy neutrino emission around the GW170817 event. Fluence upper limits by ANTARES and other experiments are also shown.

The IFIC group has a leading role in several analyses related to DM. The location of ANTARES (and KM3NeT) in the Northern hemisphere is advantageous when looking at one of the most promising sources for DM: the Galactic Center. This has allowed ANTARES to set better upper limits at large DM masses than IceCube. During 2021, the analysis of secluded DM in the Galactic Center has also been completed. Updated results on this search and others have been presented in several conferences, like [C2]. Also, the first estimation of the sensitivity of ORCA6 (the configuration of ORCA with the first 6 lines, already installed and taking data) has been made. Several of these results have been included in a recent review on the topic of DM searches with neutrino telescopes [P2].



Sensitivity to the averaged DM annihilation cross section for ARCA6, compared to the most recent limits set by ANTARES.

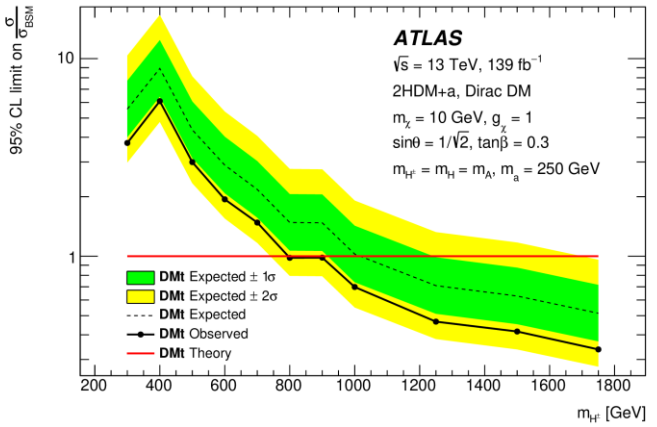
5 L4. BARYOGENESIS, DARK MATTER AND COSMIC MESSENGERS

The deployment of lines of the KM3NeT detector has taken momentum during 2021, with 6 lines of ORCA and 9 lines of ARCA taking data during that period. The IFIC group has also relevant responsibilities in the construction of KM3NeT. During 2021, the group completed the designs for the electronics upgrade of the KM3NeT acquisition system. The DU-Base integration site was also launched, successfully integrating the first complete DU-Base container.

ATLAS

In the context of understanding the observed matter-antimatter asymmetry in the Universe, the LHC data provides an important input to search for new physics modifying the properties of the electroweak phase transition or adding new sources of CP violation. The IFIC ATLAS team has led searches for CP violation in top and Higgs interactions and measurements to constrain the Higgs self-coupling which encodes the properties of the phase transition. The 2021 highlights with the 13 TeV Run-2 data are: the first measurement of top quark polarization vector in the single top t-channel electroweak production, leading to the strongest direct constraints in the complex phase of the tWb operator (ATLAS-CONF-2021-027 released for LHCP2021); the search for Higgs boson pair production in the final state with two bottom quarks and two photons, setting the world's best limits on the size of the Higgs self-coupling (arXiv:2112.11876, released for Moriond2021).

Regarding DM searches at the LHC, a main focus of the ATLAS team is the search for DM produced in association with a top quark and dedicated searches involving long-lived particles (LLPs), which are also related to the matter-antimatter asymmetry puzzle. The 2021 highlights with the analysis of the Run-2 data include: a search for DM in the context of a two-Higgs-doublet model together with an additional pseudoscalar mediator, a, which decays into the dark-matter particles. Processes where the pseudoscalar mediator is produced in association with a single top quark in the 2HDM+a model are explored for the first time at the LHC [P3]. In the context of searches for LLPs, IFIC has been leading the search for exotic scenarios where the Higgs boson (or an exotic new boson) decays into two long-lived pseudoscalars that in turn decay into SM fermions (mainly b-quarks) in the ATLAS calorimeters, giving rise to a pair of displaced jets. IFIC was also involved in the edition of a white paper from the LHC LLP community, describing new triggering opportunities for Run 3 (arXiv:2110.14675). IFIC is also strongly involved in searches for supersymmetric particles, with emphasis on R-parity violating models, analyzing Run 2 data with opposite-sign leptons.



Search for DM in the context of a two-Higgs-doublet model with an additional pseudoscalar mediator, which decays into the DM particles, in association with a top quark

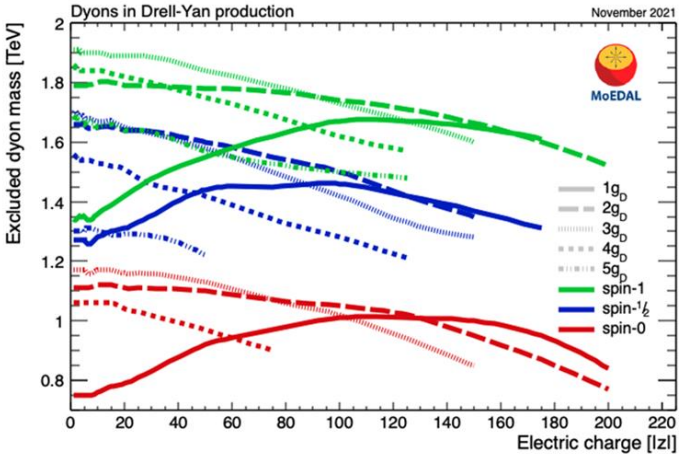
MOEDAL

IFIC has a strong participation in MoEDAL, an experiment designed to search for manifestations of new physics through highly ionizing particles produced at the LHC. Its primary motivation is the quest for magnetic monopoles, yet the experiment is also sensitive to any hypothetical massive, metastable, electrically charged object, using mostly passive detectors. The IFIC group is coordinating the physics analyses 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

5 L4. BARYOGENESIS, DARK MATTER AND COSMIC MESSENGERS

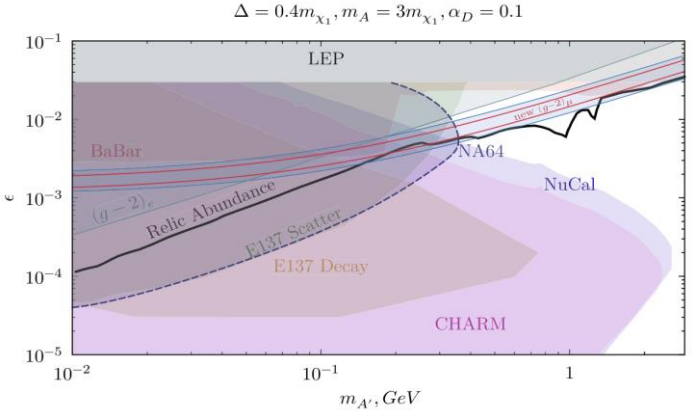
Penetrating Particles (MAPP), approved by the CERN Research Board in December 2021, will extend the MoEDAL physics program to feebly interacting, long-lived messengers of DM scenarios and neutrino portal models.



Dyon mass limits from MoEDAL searches at $\sqrt{s}$ = 13 TeV as a function of electric charge for various spins and magnetic charges, assuming Drell-Yan pair-production mechanism.

NA64

Indeed, the existence of these dark sectors with feeble interactions with the visible sector is an interesting framework to explain the origin of DM. IFIC participates in NA64, a fixed target experiment at the CERN Super Proton Synchrotron (SPS). Once the dark mediator is produced, it could then decay invisibly into light DM particles, or visibly, into SM pairs. After setting the most stringent constraints on this class of models for masses below 200 MeV in 2019, in 2021, NA64 performed, for the first time, an analysis of the experiment sensitivity to dark photons decaying semi visibly (Eur. Phys J. C 81 (2021) 10, 959). This implies a richer DM scenario containing two species and can additionally explain the muon (g-2) anomaly. This work was presented at the ASPEN winter conference [C4]. NA64 resumed running after the LHC long-shutdown (LS2) in 2021 and plans to collect until the next one more than 5x1012 electrons on target, probing these models with unprecedented sensitivity. In 2021, NA64 also started the muon program, NA64μ, looking for dark sectors weakly coupled to muons, where the group is highly involved in the design of the setup and the feasibility studies.



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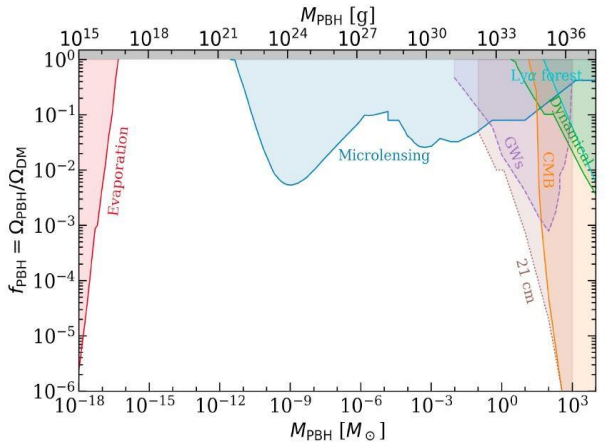
THEORY

In the theory side, the activity in 2021 has been mainly concentrated on studying different DM candidates. In particular, primordial black holes (PBH) represent a natural candidate and in a recent review paper [P5], their formation, abundance and signatures have been briefly discussed. Some of their characteristics, such as the emission of particles due to Hawking evaporation and the accretion of the surrounding matter, were discussed, as well as the most relevant probes capable of constraining their masses and population. In another paper, Phys. Rev. Lett. 127 (2021) 10, 101302, we studied the impact of stochastic noise on the generation of PBH seeds in ultra-slow-roll inflation with numerical simulations. We find that stochastic effects enhance the PBH abundance by a factor of O(10)–O(108), depending on the PBH mass.



Compilation of constraints on the primordial black hole fraction of the total DM density.

5 L4. BARYOGENESIS, DARK MATTER AND COSMIC MESSENGERS

Another work [P6] studied the case of a pseudo-scalar DM candidate which emerges from a complex scalar singlet, charged under a global U(1) symmetry, broken both explicitly and spontaneously. The pseudo-scalar is naturally stabilized by the presence of a remnant discrete symmetry: dark CP. The phenomenology of several simplified models is studied and compared, finding several regions of the parameter space able to reproduce the observed DM abundance, while respecting direct detection and invisible Higgs decay limits. This setup admits a light DM candidate at the sub-GeV scale. The possibility that more than one symmetry breaking term is present is also discussed. Other works of this line have been presented at international conferences as [C5] and [C6].

Selected publications

>[P1] A. Albert et al. [ANTARES Collaboration], “ANTARES upper limits on the multi-TeV neutrino emission from the GRBs detected by IACTs”, JCAP 03 (2021) 092.

>[P2] J. D. Zornoza, “Review on indirect dark matter searches with neutrino telescopes”, Universe 7 (2021) 11, 415.

> [P3] G. Aad et al. [ATLAS Collaboration], “Search for dark matter produced in association with a single top quark in √s=13 TeV pp collisions with the ATLAS detector”, Eur. Phys. J. C 81 (2021) 860.

> [P4] B. Acharya et al. [MoEDAL Collaboration], “First search for dyons with the full MoEDAL trapping detector in 13 TeV pp collisions,”, *Phys. Rev. Lett. 126, (2021) 7, 071801.*

> [P5] P. Villanueva-Domingo, O. Mena, and S. Palomares-Ruiz, “A brief review on primordial black holes as dark matter”, *Front. Astron. Space Sci.* 8 (2021) 87.

> [P6] L. Coito, C. Faubel, J. Herrero-Garcia and A. Santamaria, “Dark matter from a complex scalar singlet: the role of dark CP and other discrete symmetries”,' *JHEP 11 (2021) 202.*

Selected conference talks

> [C1] S. Alves, “ANTARES offline study of three alerts after Baikal-GVD follow-up found coincident cascade neutrino events”, at the 37th International Cosmic Ray Conference (ICRC 2021), July 15-22, 2021, Berlin (Germany).

> [C2] R. Gozzini, “Searches for dark matter using all-flavor neutrino data in ANTARES”, at the 37th International Cosmic Ray Conference (ICRC 2021), July 15-22, 2021, Berlin (Germany).

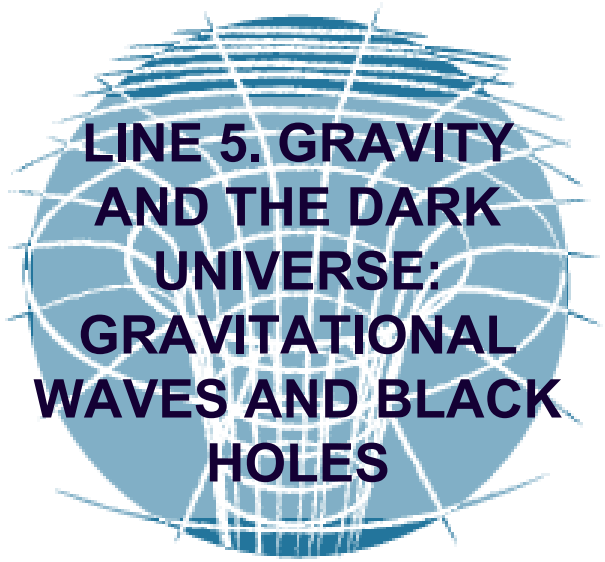
> [C3] V. A. Mitsou for the MoEDAL Collaboration, “Results and future plans of the MoEDAL experiment”, at the European Physical Society Conference on High Energy Physics (EPS-HEP2021), July 26-30, 2021, Germany. Online.

> [C4] L. Molina Bueno, “Dark sector searches with NA64 experiment at CERN”, A rainbow of Dark sectors, March 21 - April 1, 2021. Aspen online winter conference (USA).

> [C5] C. Cosme, “Neutrino portal to FIMP dark matter with an early matter era”, at the 18th MultiDark Consolider Workshop, October 18-20, 2021, La Rábida, Huelva (Spain).

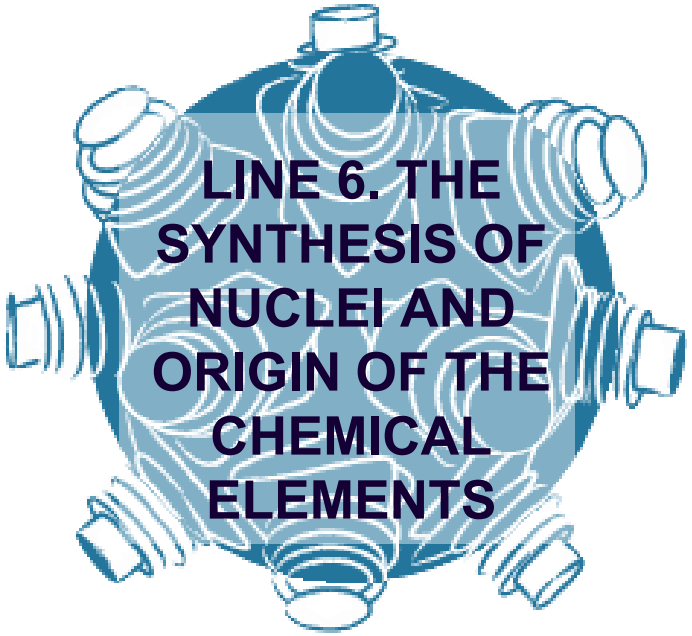
> [C6] S. Palomares-Ruiz, “Dark matter evaporation from celestial bodies”, at the Iranian Conference on High Energy Physics, Deciphering the Universe Ciphers (IRCHEP 1400), November 8-10, 2021, Tehran (Iran). Online.

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.

SCIENTIFIC RESEARCH LINES

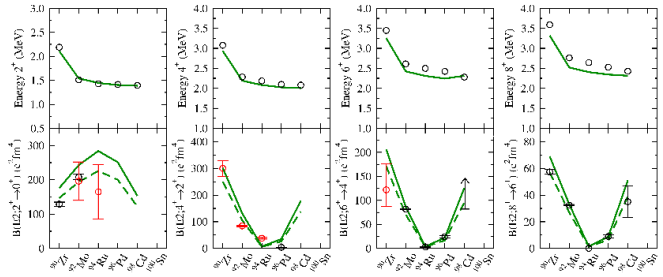


The recent observation of gravitational waves from a merger and the associated electromagnetic emission has led for the first time to the "in vivo" observation of the synthesis of heavy elements. Nuclear physics input from very neutron-rich exotic nuclei is required to pin down the complex processes 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

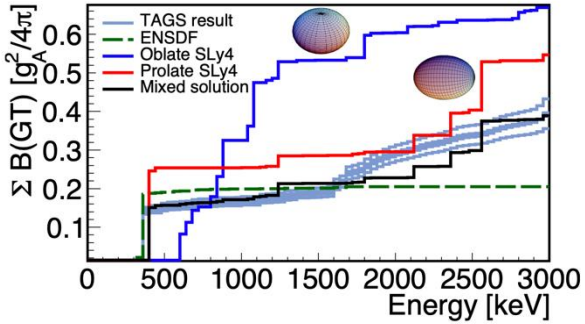
EXPERIMENTAL NUCLEAR PHYSICS

The 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.
In the topic of in-beam research on Nuclear Structure, during this year the AGATA group has contributed to the completion of the experimental campaign at GANIL and has proceeded with the activities of data analysis and dissemination. The results of the experiment E682, on reduced transition probabilities, for low lying states in 90Zr, 92Mo and 94Ru, measured with AGATA coupled to the magnetic spectrometer VAMOS++ and making use of multi-nucleon transfer reactions, performed in the GANIL laboratory, allowed us to conclude that seniority is largely conserved in the first g9/2 orbital. The attached figure shows the agreement of the measurements (new ones in red) with the Large Scale Shell Model calculation that indicates that the low lying states have well defined seniority =2 at the level of 88-90% in 92Mo and beyond 96% in 94Ru, 96Pd and 98Cd. Seniority conservation provides direct evidence of the validity of the short-range pairing interaction, with far-reaching implications for nuclear structure in the validity of the BCS theory and therefore of the quasiparticle representation of the atomic nucleus.



Comparison between Experimental (ours: red circles, previously known black circles) values and LSSM theoretical predictions (green lines) for the N = 50 isotones. Up: excitation energies yrast states up to the 8+. Down: reduced transition probabilities for the transitions de-exciting yrast states up to the 8+.

The work has been submitted to Physical Review Letters and accepted for publication with R.M. Perez Vidal as leading author. Other experimental research on seniority conservation led to the discussion on the manifestation of the Berry phase in the 213Pb nucleus.
The group has also completed the analysis of the E730 experiment, performed at GANIL with AGATA and the complementary NEDA and DIAMANT instruments. This experiment is aimed at the study of the quadrupole and octupole collectivity in the 112Xe nucleus, lying in the vicinity of the N = Z line, via lifetime measurements with the RDDS technique. The analysis and results are part of the PhD thesis of M.L. Jurado Gómez, completed at the end of this year. Regarding instrumental developments, together with the University of Valencia AGATA group, we have progressed in the development of the AGATA pre-processing electronics with the development of the Data Time-multiplexing concept.
One of the most important results of the Gamma and Neutron spectroscopy group this year is related to the application of the total absorption gamma spectroscopy technique (TAGS) to nuclear structure. The existence of eigenstates, in which nucleons arrange themselves in different spatial distributions in their intrinsic reference frame, can be considered a behaviour unique to the nuclear many-body quantum system. The related concept of nuclear shape, plays a key role in our present understanding of nuclear structure.



Comparison of the experimental distribution of the beta strength in the daughter nucleus 186Au with theoretical calculations depending on the nuclear deformation of the parent state in 186Hg. The best description is obtained assuming a mixed prolate-oblate scenario of both parent and daughter nucleus.

In this framework the study of Hg nuclei has attracted considerable attention, since until

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

very recently their isotopic chain was the only one showing a dramatic change in the variations of the mean square charge radii ($\delta\langle r^2\rangle$), which was understood as a change from oblate to more deformed prolate shapes around 186Hg. In the article by Algora et al. published in Physics Letters B we have studied the beta decay of 186Hg to 186Au using the total absorption technique. This study has shown, that contrary to expectations, the beta decay data of 186Hg can only be interpreted in the framework of the QRPA model if we assumed a mixed shape character, with a dominant prolate component in the ground state of 186Hg. The study required the development of a new method of analysis that can be relevant in cases where highly converted transitions are involved in the de-excitation process in the daughter nucleus and (or) beta plus contamination can affect the electron capture (EC) component of the decay.

Another relevant result of the group in 2021 is related to the development of instrumentation. The article by V. Babiano et al., published in the European Physics Journal A, reports on the first experimental demonstration of the applicability of gamma-ray Compton imaging techniques to enhance detection sensitivity in time-of-flight neutron-capture experiments.

This novel methodology and the detection system have been developed at IFIC in the framework of the HYMNS ERC project [1], and is aimed at providing first access to a series of nuclear neutron-capture reactions of relevance for the understanding of the nucleosynthesis of heavy elements in the Universe.

[1] ERC Grant Agreement 681740 HYMNS (High sensitivitY Measurements of key stellar Nucleo-Synthesis reactions).

Selected publications

> J.J. Valiente-Dobón, A. Gottardo, G. Benzoni, A. Gadea et al., Physics Letters B 816 (2021) 136183 https://doi.org/10.1016/j.physletb.2021.136183

> A. Algora, E. Ganioglu, P. Sarriguren et al., Physics Letters B819 (2021) 136438. https://doi.org/10.1016/j.physletb.2021.136438

> V.Babiano, J. Lerendegui-Marco, J. Balibrea-Correa, et al, Eur. Phys. J. A 57, 197 (2021). https://doi.org/10.1140/epja/s10050-021-00507-7

Selected conference talks

> C. Domingo-Pardo "s-process branching points" Neutrons in Science, Technology and Applications Workshop

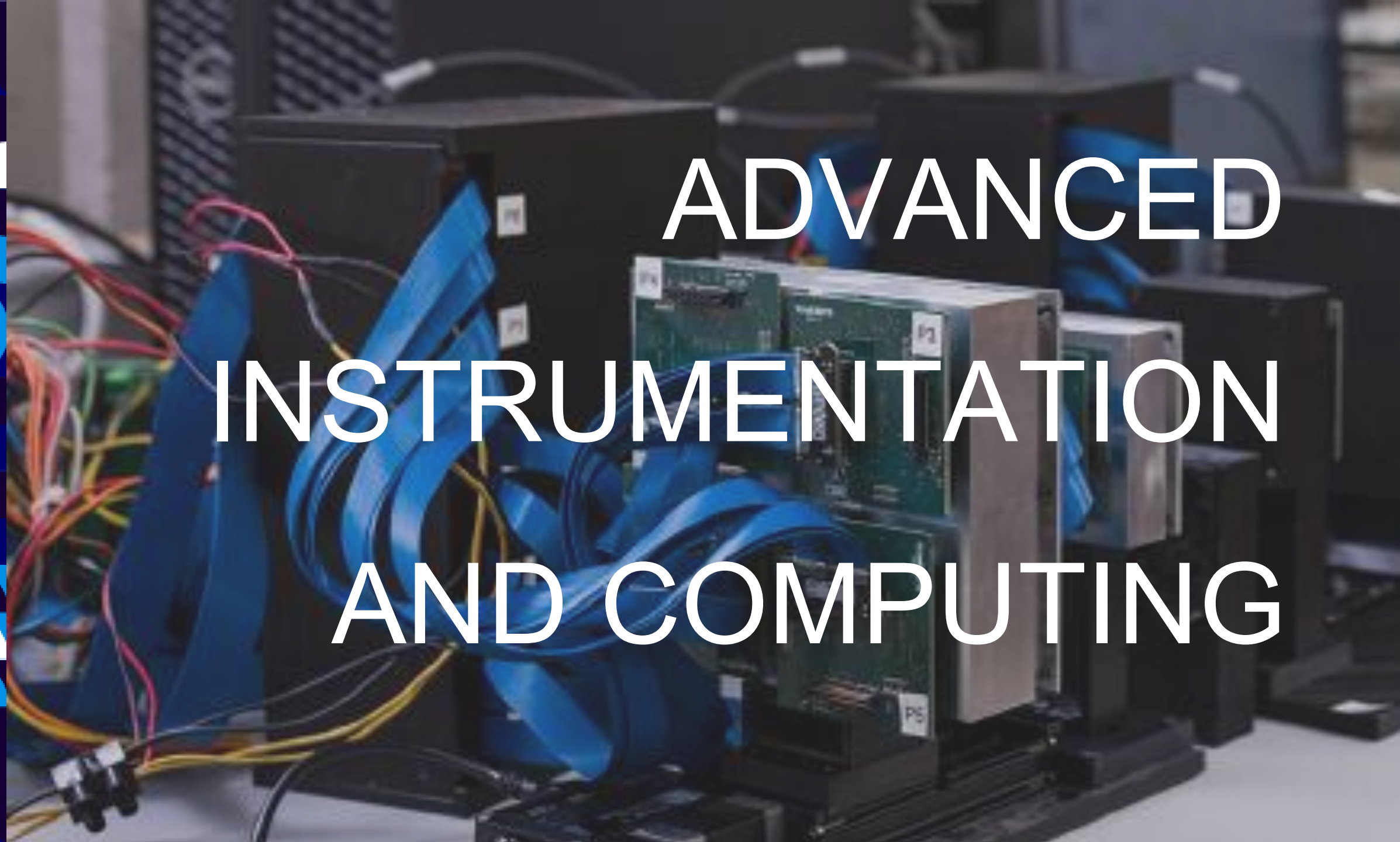
https://indico.cern.ch/event/1073008/contributions/4599076/

> A. Algora "Total Absorption Spectroscopy Measurements for Reactor Applications"

Lockdown and Distancing Nuclear Physics Seminar Series, IOP Nuclear Physics Group Colloquia https://ns.ph.liv.ac.uk/lockdownseminars.html.

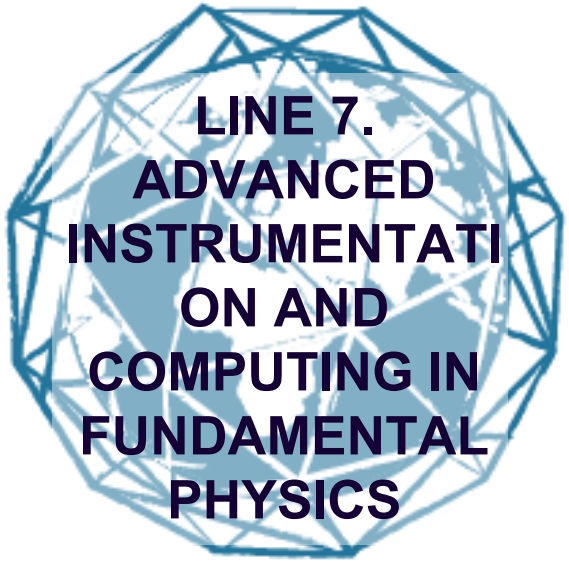
> Berta Rubio, "The large infrastructure Facility for Antiproton and Ion Research, FAIR", 100xCiencia, International Dimension of Science

https://igfae.usc.es/100xciencia.5/index.php/programme/



ADVANCED INSTRUMENTATION AND COMPUTING

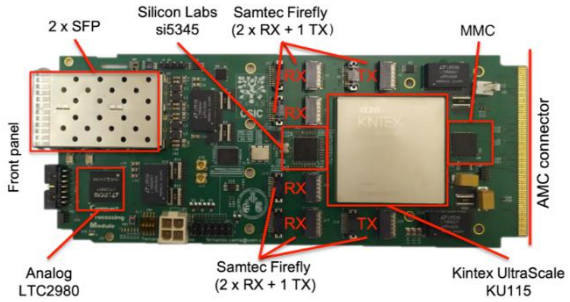
SCIENTIFIC RESEARCH LINES



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.

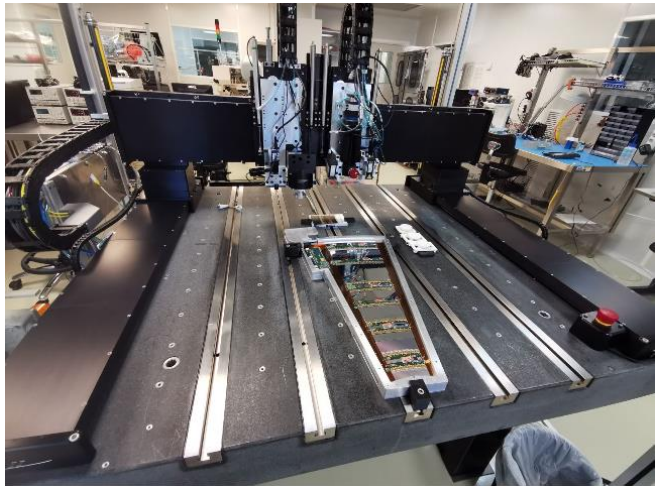
5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

IFIC is one of the main actors in the upgrade of the ATLAS detector for the LHC high luminosity phase in 2 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 2021 and have passed many technical reviews to give green light to production. The TileCal collaboration decided to keep the so-called demonstrator installed during Run 3 of the LHC. The demonstrator is controlled by the Pre-Processor (PPr) designed by our team. Having the demonstrator installed will allow to gather operating experience. On the other hand, all the setups for the ITK-Strips detector are andgetting ready for production of modules,



Picture of the Compact Processing Module version 2 of the ATLAS Tile Calorimeter with the main components labelled.

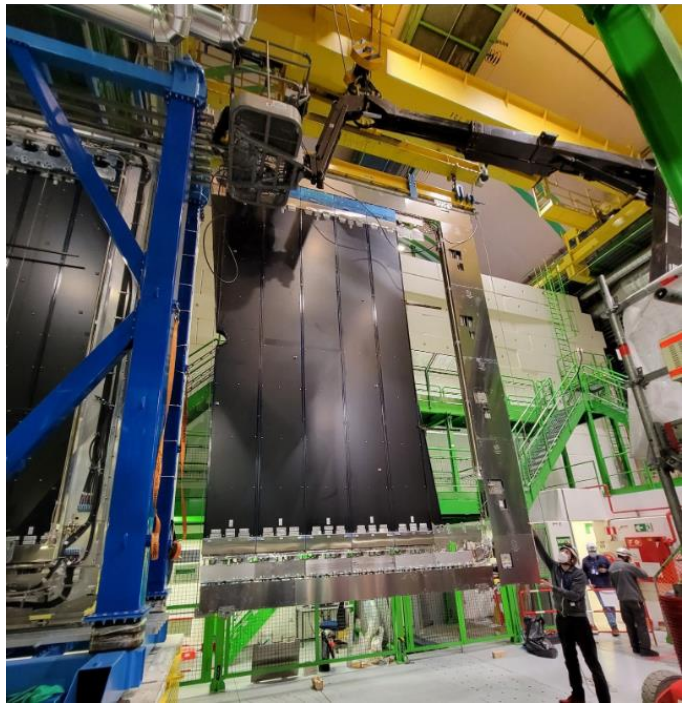
loading support structures (petals) with modules and the service module. First prototypes of modules and petals have been fabricated tested in the clean room of the institute.



Petal core of the ATLAS Inner Tracker being loaded with petals in the gantry of IFIC's clean room.

IFIC has also participated in the design of the readout electronics for the Scintillating Fiber Tracker (SciFi) for the Phase I upgrade of the LHCb experiment at the LHC. The installation and commissioning of this detector at the LHC cavern has started during 2021.

A global R&D programme is ongoing to develop detectors that can cope with the challenges of future facilities in high energy physics. The emphasis of the design and R&D is on the experiments for a future Higgs/EW/top factory, which is recognized as



LHCb SciFi C-Frame being installed in the LHCb cavern

the highest priority of the field. IFIC was involved in the write-up of the European road map for detector R&D, in the AIDAinnova project (EU funded Horizon2020), in the coordination of the International Development Team for the ILC project, in the design of the ILD detector concept and in the development of highly granular calorimetry for the Higgs/top/EW factory in the CALICE collaboration and ultra-transparent CMOS pixel sensors for Belle 2 and the Higgs/top/EW factory. IFIC has set up a laboratory for the characterization of

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

high-gradient radio-frequency accelerating structures and is actively participating in the design of high-energy linear lepton collider and in compact installations for proton therapy.

Finally, IFIC is using the expertise in radiofrequency systems for the development of detection techniques for axion-like particles that are a potential candidate to explain the dark matter abundance in the universe.

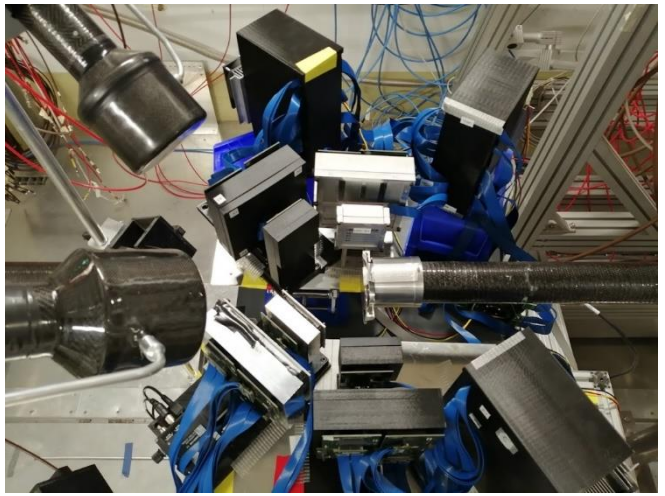
The AGATA array is the European forefront instrument based on position sensitive HP-Ge detectors for high-resolution gamma-ray spectroscopy. AGATA is being constructed in

The AGATA detector.

phases –started with the proof-of-concept AGATA Demonstrator– while maintaining always a high scientific production with the partial sub-arrays. The year 2021 was crucial, since the MoU for the phase 2 of AGATA, aiming for a 3pi solid angle coverage, was signed by the members of the collaboration, including the Spanish institutions. The phase 2 of AGATA will follow a new Project Definition, whose preparation was led by IFIC Valencia. Additionally, the present AGATA sub-array was moved to INFN-LNL (Italy) for the next experimental campaign with stable and radioactive ion beams from SPES.

IFIC has a strong commitment to the instrumentation of the NEXT and DUNE experiments. IFIC has been leading the construction of the NEXT-100 detector, aiming at the competitive search of the neutrinoless double beta decay with the novel NEXT technology, as well as the R&D for the light detection system in a near-future ton-scale detector. The main technological characteristics of this detector have been published in 2021, while the R&D towards the implementation of a barrel fibre detector prototype has been started at the IFIC NEXT laboratory. 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 detector and the far detector. In 2021 IFIC was committed to the R&D on both systems, which will be tested at CERN in two large scale prototypes in 2023. During 2021 an optics laboratory for DUNE R&D has been equipped at IFIC.

The CERN n_TOF facility is one of the most active laboratories worldwide contributing to the development of instrumentation, techniques and measurements of relevance for stellar nucleosynthesis studies. In 2021 the IFIC team was actively involved in the new physics commissioning of the facility after its spallation-target upgrade during LS2. Also, the commissioning of the full i-TED system was performed in the framework of the ERC Consolidator Grant HYMNS. Finally, the IFIC team also contributed to the design and development of the new NEAR station for activation measurements of astrophysical interest at n_TOF.



i-TED array prototype with four large Compton cameras under commissioning at CERN n_TOF EAR1 in 2021 (HYMNS-ERC).

5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

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 2021. The Tier-2 IFIC site has provided 50730 HS06 and 3402 TB of disk. The efficiency of the whole Tier-2 has been about 100%.

b. During 2021 our group has continued the exploitation of MareNostrum 4 HPC (BSC) running conventional ATLAS simulated data production. The computing yield has been more than 20 million CPU hours and more than 330 Million of events of a complete simulation of the detector.

c. The group has continued their duties with the ATLAS Event Index project (ATLAS event catalog). We are in charge of the Data Collection and Data Production. The upgrade of the Event Index Supervisor, the Producer and testing the new Event Index database have been the most important contributions during 2021.

d. In 2021, IFIC has 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.

Selected publications

> J. Abdallah et al., “Study of energy response and resolution of the ATLAS Tile Calorimeter to hadrons of energies from 16 to 30 GeV” Eur.Phys.J.C 81 (2021) 6, 549.

> H. Ye et al. [Belle-II DEPFET and PXD Collaborations], “Commissioning and performance of the Belle II pixel detector,” NIMA 987 (2021) 164875

> Abed Abud et al. [DUNE Collaboration], “Deep Underground Neutrino Experiment (DUNE) Near Detector Conceptual Design Report,” Instruments 5 (2021) 4, 31

> C. Adams et al. [NEXT Collaboration], “Sensitivity of a tonne-scale NEXT detector for neutrinoless double beta decay searches,” JHEP (2021) no.08, 164

> V.Babiano-Suarez et al., “Imaging neutron capture cross sections: i-TED proof-of-concept and future prospects based on Machine-Learning techniques”, The European Physical Journal A, Volume 57, Issue 6, article id.197 (2021)

> A. Fernández Casaní, J. M. Orduña, J. Sánchez, S. González de la Hoz, “A Reliable Large Distributed Object Store Based Platform for Collecting Event Metadata,” Journal of Grid Computing (2021) 19:39

Selected conference talks

> A. Valero, “Front-end electronics and optical links”, invited talk at the 9th Beam Telescopes and Test Beams Workshop, Lecce- Italy (Online), February 2021.

> M. Vos, New concepts/new technologies, ILC Workshop on potential experiments (ILCX2021)

> M.A. García-Peris, “Static temperature gradient monitor at ProtoDUNE-SP,” APS April Meeting 2021.

> J. Lerendegui-Marco et al., ”Compton Imaging and Machine-Learning techniques for an enhanced sensitivity in key stellar (n,γ) measurements,” Nuclei in the Cosmos-XVI Int. Conference, Cheng-du, China

> C. Acosta-Silva et al., “Exploitation of the MareNostrum 4 HPC using ARC-CE,” 25th International Conference on Computing in High Energy and Nuclear Physics (vCHEP21).

SCIENTIFIC RESEARCH LINES

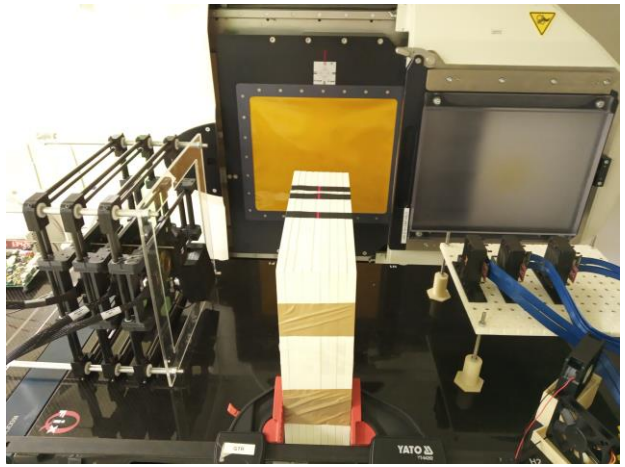
In recent years, the multidisciplinarity and societal impact of IFIC research projects has increased significantly. IFIC is developing various applications in medical therapy, imaging, dosimetry and diagnosis. Several gamma and neutron detectors are being developed with imaging capabilities. Neutron 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 in 2021 are mainly focused on medical applications of the advances on instrumentation and computing.

The IRIS group dedicated to medical physics works on the development of systems for hadron therapy treatment monitoring. In 2021, the group has finished the characterization of two Compton cameras, known as MACACOIII and MACACOp. MACACOIII, with three detector planes and employing the AliVATA readout system, has achieved an energy resolution better than 5% FWHM at 511 keV. MACACOp, with two detector planes and employing the TOFPET2 ASIC from PETSys, has achieved improved timing resolution readout speed and dynamic range. The image reconstruction algorithm developed can combine events from any two or all three detectors. Tests in clinical beams, in the Krakow protontherapy centre have been carried out with both systems. In addition, in collaboration with HUiP La Fe, the group has started to evaluate MACACO III for verification of radionuclide therapy.

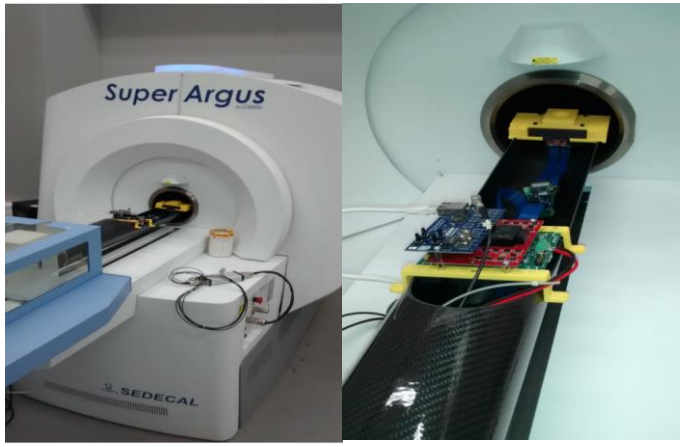
Also in proton therapy monitoring, the group is developing a coaxial prompt gamma-ray detector. The progress includes advanced tests of a 2.5GSPS digitizer and an efficient data acquisition system, showing the capability



MACACOIII and MACACOp systems for hadron therapy treatment monitoring being tested in the clinical gantry of Krakow Protontherapy centre.

of sustained data streaming at GiB/s throughout a typical treatment fraction (1Gy) duration of 1 minute, in accordance to the specifications. SPICE simulations of photomultiplier voltage divider circuits, both passive and active, were performed and experimentally compared. The goal was to optimize the behaviour of the photomultiplier gain in the clinical environment, where it sustains high overall loads as well as quick load variations.

The IRIS group also works on the development of a probe to enhance the resolution of total body PET systems. Within the PROScRiPT project (PRObe for the improvement of the Spatial Resolution in total-body PET) tests of the probe measuring in temporal coincidence with a Preclinical PET/CT scanner (SuperArgus 4R) for small animals (probe-scanner) were performed showing the correct functioning of the prototype.



PROScRiPT probe being tested in the Super Argus 4R PET scanner (left) and detail of the probe (right).

A large effort has been made by the group 42 is the answer in terms of Machine Learning applied to medical applications in two main fields. On one hand, diagnostic, participating in several areas of the CSIC PTI-Salud platform (diagnostic) related to better triage of COVID19 patients, and most important the comparison with real radiologist about the perfomance. On the other hand, 3D reconstruction in medical imaging related with patient coordinates. Currently this group is leading the development of two patents in combination with an SME company, developing tools that integrate AI and the state of the art of medical imaging 3D reconstruction.
The main objective of the medical applications

5 L8: ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

of the group is being able to provide better 3D information in medical devices using external devices such as RGB cameras, in this field industrial applications derived from de use of GAMMA cameras (i.e, cameras with spatial discrimination of the signal) can be incorporated in new algorithms related to 3D reconstruction.

The BRAchytherapy PHYsics Quality Assurance System (BRAPHYQS) working group of GEC-ESTRO aims to present guidance for brachytherapy (BT) high energy (HE) source calibrations, including practical aspects and issues not specifically accounted for in the former current and well-accepted societal recommendations. As Spanish representatives in such organization, the Medical Physics group of the University of Valencia has led the efforts to compile and perform an European survey on the level of agreement between clinical measurements and manufacturer certificates for the source strength determination in iridium-192 and cobalt-60 brachytherapy. These disagreements represent one of the main sources of uncertainty in such clinical treatments. Eighteen clinics from eight European countries were involved in this study that has led to a tighter European-wide new protocol.

The accelerator physics group has continued with the conditioning and testing of a 3 GHz high-gradient compact accelerating cavity for proton-therapy accelerators. By the end of the year, an accelerating gradient of ~39 MV/m was achieved after conditioning the structure with more than 800 million RF pulses. In addition, The group also led the development and construction of technological demonstrators of the RF "online" system for a linear ion injector based on an RFQ cavity. The project is carried out in collaboration with the Valencian companies UVAX Concepts and Thermal Vacuum Projects (TVP), also with the close collaboration of CIEMAT and the advice of CERN.

The PETALO group is developing a prototype of a Positron Emission Tomography scanner based on liquid xenon, read out by silicon photomultipliers. The group has completed the assembly of the first prototype and started taking data, to understand the system. The first run allowed to test the ASIC functioning and make a first measurement of the energy resolution.

In addition, In the last decades, our society has become more interdependent and complex than ever before. It is also highly dependent on the technology, which can be very vulnerable to solar activity and their associated events, which may provoke disturbances, interruptions, and even long-term damage to these technical infrastructures, with drastic social, economic and even political impacts. IFIC members are currently working on an advanced machine-learning based predictive model to develop a real-time early warning system to evaluate the impact of future violent solar storms on Spanish critical infrastructures such as the power transmission grid, railways, and oil and gas pipelines.

PETALO installation in the laboratory

5 L8: ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Selected publications

> E. Muñoz, A. Ros, M. Borja-Lloret, J. Barrio, P. Dendooven, J. F. Oliver, I. Ozoemelam, J. Roser and G. Llosá. Proton range verification with MACACO II Compton camera enhanced by a neural network for event selection. Sci Rep 11, 9325 (2021).

> L. Barrientos, M. Borja-Lloret, A. Etxebeste, E. Muñoz, J.F. Oliver, A. Ros, J. Roser, C. Senra, R. Viegas and G. Llosá. Performance evaluation of MACACO II Compton camera. Nuclear Inst. and Methods in Physics Research, A. 1014 (2021) 165702.

> J. Vijande et al Physics and Imaging in Radiation Oncology 19, 108-111 2021.

> J. Roser, F. Hueso-González, A. Ros, G. Llosá. Compton Cameras and Their Applications. Book chapter in the book Radiation Detection Systems. Publisher: CRC Press, Editors: Jan S. Iwanczyk, Krzysztof Iniewski, 2021, pages 161–198. eBook ISBN 9781003218364.

Selected conference talks

> L. Barrientos, M. Borja-Lloret, J.V. Casaña, J. Garcia López, F. Hueso-González, M. C. Jiménez-Ramos, E. Muñoz, A. Ros, J. Roser, C. Senra, R. Viegas and G. Llosá. Experimental characterization and test-beam results of MACACO III Compton camera. Talk at 2021 IEEE Nuclear Science Symposium and Medical Imaging Conference (IEEE NSS MIC). Virtual (Yokohama, Japan), 16 Oct - 23 Oct 2021.

> A. Ros, L. Barrientos, M. Borja, J.V. Casaña, E. Muñoz, J. Roser, J.M. Udias, R. Viegas, G. Llosá. New probe for the improvement of the Spatial Resolution in total-body PET (PROScRiPT). Talk at 2021 Advancements in Nuclear Instrumentation Measurement Methods and their Applications (ANIMMA), Virtual, (Prague, Czech), 21-25 Jun 2021.

> G. Llosá. Compton and PET. Invited talk at workshop N°3: Forum on Prospective technologies for the future PET imaging in the 7th Intenational Conference on Advancements in Nuclear Instrumentation Measurements and their Applications, ANIMMA, 2021. Virtual (Prague, Czech Republic), 21-25 Jun 2021 Virtual (Valencia, Spain), 14 - 15 Dec 2020.

> P. Ferrario, Status and perspectives of the PETALO project, LIDINE 2021, September 14-18, 2021.

> C. Escobar, C. García et al. Forecasting hazardous geomagnetically induced currents for Spanish critical infrastructures by using AI. Joint Scientific Assembly IAGA-IASPEI 2021 (http://www.iaga-iaspei-india2021.in/).

6

TECHNOLOGY TRANSFER

TECHNOLOGY TRANSFER

IFIC is fully committed to promoting the societal impact of our research. The Scientific Unit for Business Innovation (Unidad Científica de Innovación Empresarial - UCIE) at IFIC, funded by the Valencian Agency for Innovation, become the link between the subject being researched and developed by the center and the needs identified by the technology institutes and the business fabric.

The COVID19 disease has forced UCIE work plans to be restructured, reducing or delaying actions that require presence or unauthorized mobility. As far as possible, telematics and remote work tools have been used and strengthened. In this sense, training actions for agents have been increased through teleconferences. Since September, activity has been recovering, combining teleworking with greater presence.

Innovation Agents

Rosa Rodriguez César Senra
César Blanch Salvador Tortajada

Contact: ucie@ific.uv.es

6 TECHNOLOGY TRANSFER

IFIC is fully committed to promoting the societal impact of our research. The Innovation and Technology Transfer Office (UCIE) at IFIC, funded by the Valencian Agency for Innovation, has become the link between the subject being researched and developed by the center and the needs identified by the technology institutes and the business fabric.

Within this framework, during 2021 UCIE has developed its activity along the following lines:

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

The UCIE maintains relationships with 30 Technological Institutes, Research Centers, companies and business associations. Through the UCIE, IFIC has been present at local, national and international technological forums and meetings:

- Transfiere: Transfer Forum 2021 in Malaga February 2021.
- Regional transfer forums like REDIT SUMMIT 2021 or FTalks Food Summit among others.
- Overall UCIE participated and represented IFIC in about 100 events (courses, conferences, seminars, webinars...).

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

- TECH4CV, a Technologies Alliance of the Valencian Community.
- INNDROMEDA, an Innovative Technologies Alliance of the Valencian Community.
- 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 IFIC UCIE has carried out two training actions (“Innocharlas”) aimed at IFIC researchers but also promoted among the AVI Innoagents network: “LA GESTIÓN DE LA PROPIEDAD INTELECTUAL E INDUSTRIAL” and “MODELOS, BUENAS PRÁCTICAS Y EXPERIENCIAS EN LA TRANSFERENCIA”.

Specific actions to support groups with technological potential and impact

During 2021, innovation projects continued evolving and some new ones were created, a total of eleven were developed in the institute:

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

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

Brainvector: Develops and validates

6 TECHNOLOGY TRANSFER

nanovectors for targeted transport of antitumor agents through physiological barriers. Promotes new lines of diagnosis and therapy in diseases.

Simubreast: Designs a breast simulator dummy manikin and a set of tools for simulating FDG uptake in breast tumors.

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.

COVID: Machine learning project to help in the diagnosis of COVID19 by using chest X-rays.

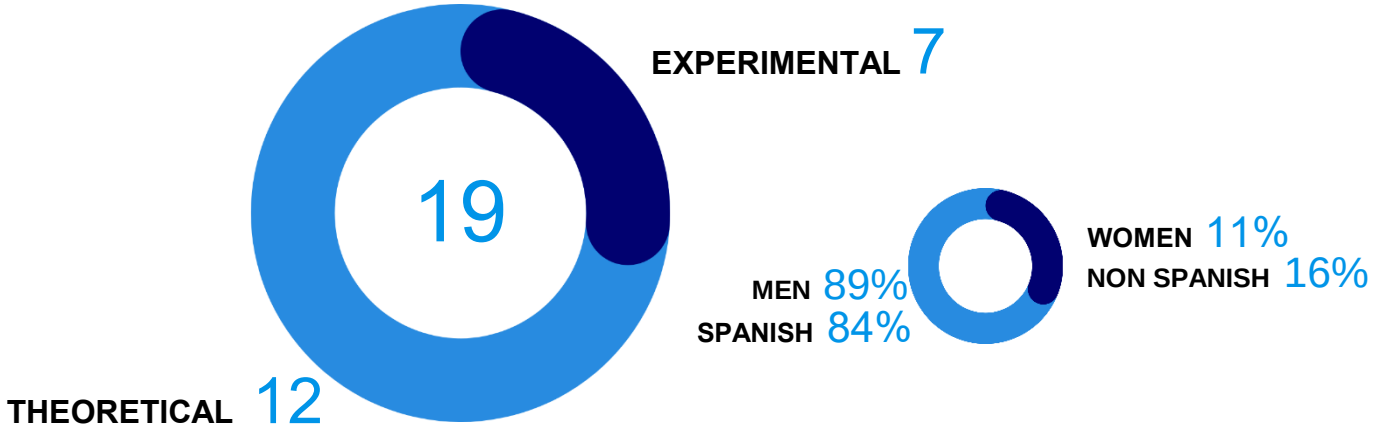
7

TRAINING

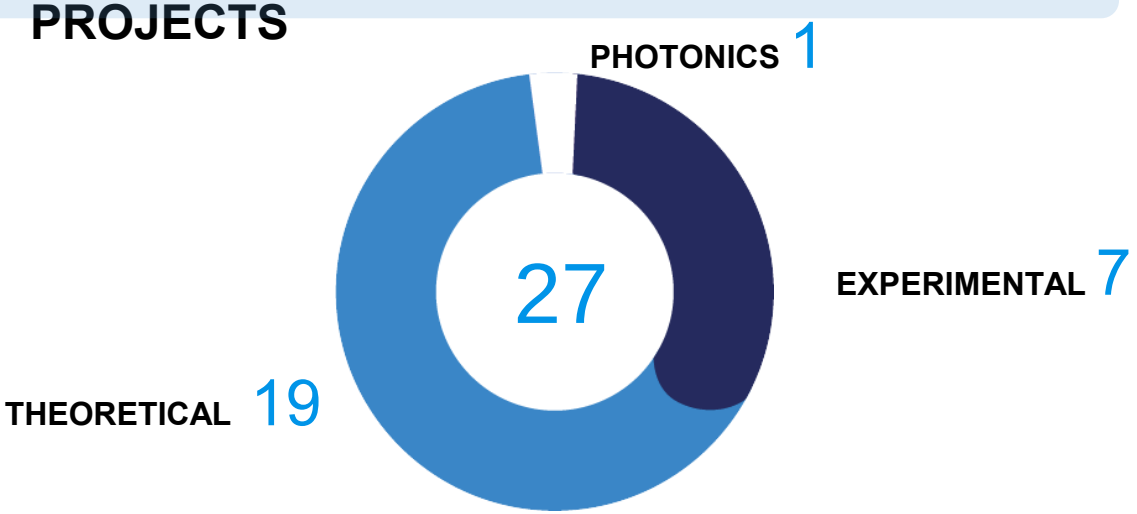
7 TRAINING

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.

PHD THESES WITH IFIC SUPERVISORS



MASTER PROJECTS



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

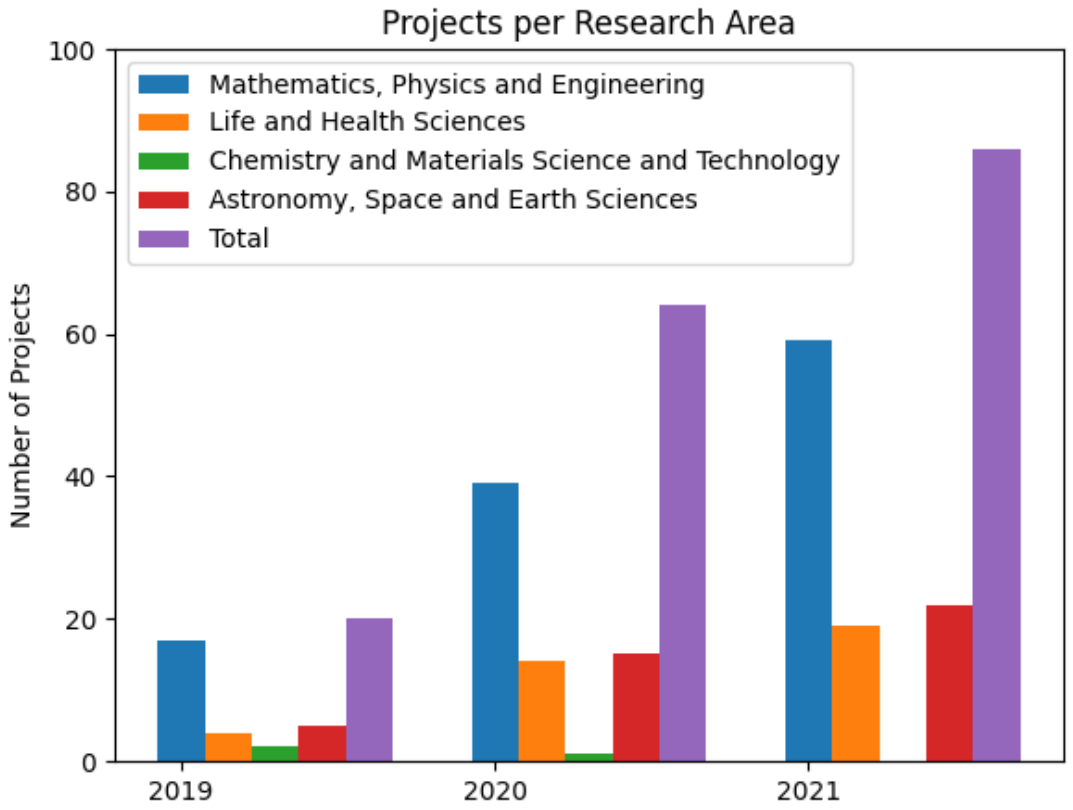
ARTEMISA: Francisco Albiol, Vicente Gimenez, Jose Enrique García, Juan José Hernandez, Arantza Oyanguren, Jose Salt, Javier Sanchez, Veronica Sanz. Director: Nuria Rius, Deputy Director: Santiago Noguera

8 ARTIFICIAL INTELLIGENCE

ARTEMISA

ARTificial Environment for ML and Innovation in Scientific Advanced Computing

During 2021, 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. Since its official launch in 2019, Artemisa has had a constant growing demand, more than doubling the number of projects underway until the end of 2021, with a total of 67 projects in this year.



8 ARTIFICIAL INTELLIGENCE

Artemisa is currently composed of 23 servers that host one NVIDIA GPU Volta V100 each, 11 servers with one GPU NVIDIA Ampere A100 and a server with 8 GPUs of the said model. 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. Artemisa also boasts a last generation CPU and storage system. The A100 servers were installed during 2021. The system has been able to deliver almost 200 thousand hours of GPU to the projects and almost half a million CPU hours.

3400 CPUs

44 GPUs

470000 Hours Delivered

190000 Hours Delivered

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:

Health. Examples: better interpretation of magnetic resonance imaging, development of a non-invasive method for the detection of meningitis, identification of the origin of low back problems.

8 ARTIFICIAL INTELLIGENCE

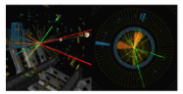
Earth sciences. Examples: prediction of solar storms to provide early warning of these events, improvement of earthquake detection with AI.

Social. Examples: language studies, translation improvements, improving predictions for carpools.

CHEST SCREENING EVALUATION FOR COVID-19 PATIENTS

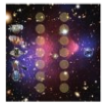
A project funded by Instituto de Salud Carlos III and led by IFIC researchers is carrying out radiological imaging analysis using machine learning techniques with the aim of enhancing patient diagnose and evolution assessment.

MACHINE LEARNING @ ATLAS EXPERIMENT



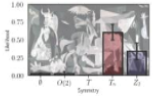
The ATLAS experiment at the Large Hadron Collider (LHC) is looking beyond the Standard Model of particle physics, searching for signs of unknown new physics. An important aspect to be able to find this new physics is the identification of the interesting events within all the events available. Interesting events are called "signal", while others are "background". Individuating these signal events, which are indeed extremely rare, is a really challenging task. The LHC has delivered billions of collisions which have been recorded by the ATLAS detector.

DARK MACHINES



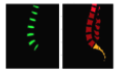
Dark Machines (www.darkmachines.org) is an initiative to develop and apply machine learning methods to accelerate dark matter searches. It is composed of more than 300 high-energy physicists, astroparticle physicists and astrophysicists, from theory and experiment, as well as computer scientists.

IDENTIFYING SYMMETRIES THROUGH AI



Since the dawn of humanity, our species has tried to decipher the world around us, through art, literature, music or science. The skills developed and the tools used are different, as different as the audiences targeted. But the goals are basically the same: to dealing with complexity using the tools at hand.

MACHINE LEARNING IN MAGNETIC RESONANCE



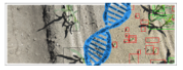
Low back pain (LBP) is a very prevalent pathology and a frequent cause of disability. It is associated with rising costs for the health system and for society in developed countries, affecting 70% of the general population at some time in their lives, with an annual incidence of 40%

The multidisciplinary group lead by María de la Iglesia-Vayá from the Prince Felipe Research Center (CIPF) uses Artemisa to develop the first massive and open-access data repository of lumbar MRI for International collaborative research.

CUSTOM-DHM: DIGITAL HUMAN MODELING APPLICATIONS

The objective of the project is to advance in the integration of 3D models of the body in the development of digital products and applications, developing innovative tools that allow their 3D and / or 4D analysis for the clothing, health and wellness, audiovisual and orthopedic sectors, or any other sector that is interested in incorporating digital information from users.

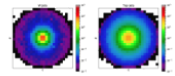
IDENTIFYING WEED SPECIES IN CROP FIELDS



Convolutional Neural Networks (CNN) are currently being implemented in a wide variety of applications. This subdomair of Artificial Intelligence shows a powerful performance in machine vision applications and may be used to categorise and classify objects, amongst other image processing tasks.

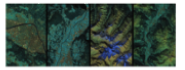
In the Artificial Perception Group of the Centre for Automation and Robotics (CAR) we are interested in identifying and classifying weed species within crop fields, which is a very specific problem, as the system will only need to process images of soil and plants.

ANOMALY AWARENESS



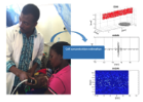
Algorithms that detect anomalies have to learn normal behaviour to be able to identify anomalous behaviour. If broad features of the expected anomalies are known the use of supervised Machine Learning (ML) is in order. But by definition, the most interesting anomalies are those unexpected, and in that case, unsupervised ML should be used. However, unsupervised strategies are substantially less powerful than possible supervised methods –a catch 22 situation.

SENTIFLEX



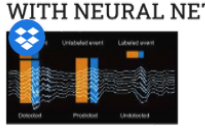
Machine learning is one of the keys in the development of modern Earth Observation satellite missions. Model training requires precise Earth simulation as basis of applications such as vegetation monitoring, prospecting for minerals, soil use and climate change studies, among others.

NON-INVASIVE SCREENING FOR MENINGITIS



165 newborns die every day of Bacterial Meningitis (BM), an aggressive infection that leaves severe sequelae among 30% of survivors. Rapid detection, particularly in this age group, is difficult due to the little specificity and overlap of its symptoms with those of more common and less severe diseases. Current strategy to improve prognosis is the prompt antibiotic treatment after an early diagnosis by means of a lumbar puncture (LP), invasive and potentially harmful procedure.

NEUROCONVO: BRAIN WAVES WITH NEURAL NETWORKS



The brain generates activity in the form of oscillations. Brain waves span from very slow rhythms, typical of sleep, to faster oscillations during attention and cognitive processing. Moreover, changes of brain oscillations are markers of some neurological diseases. Given the dynamism of brain activity, these events are far from stationary and thus their identification in real time is a daunting task.

8 ARTIFICIAL INTELLIGENCE

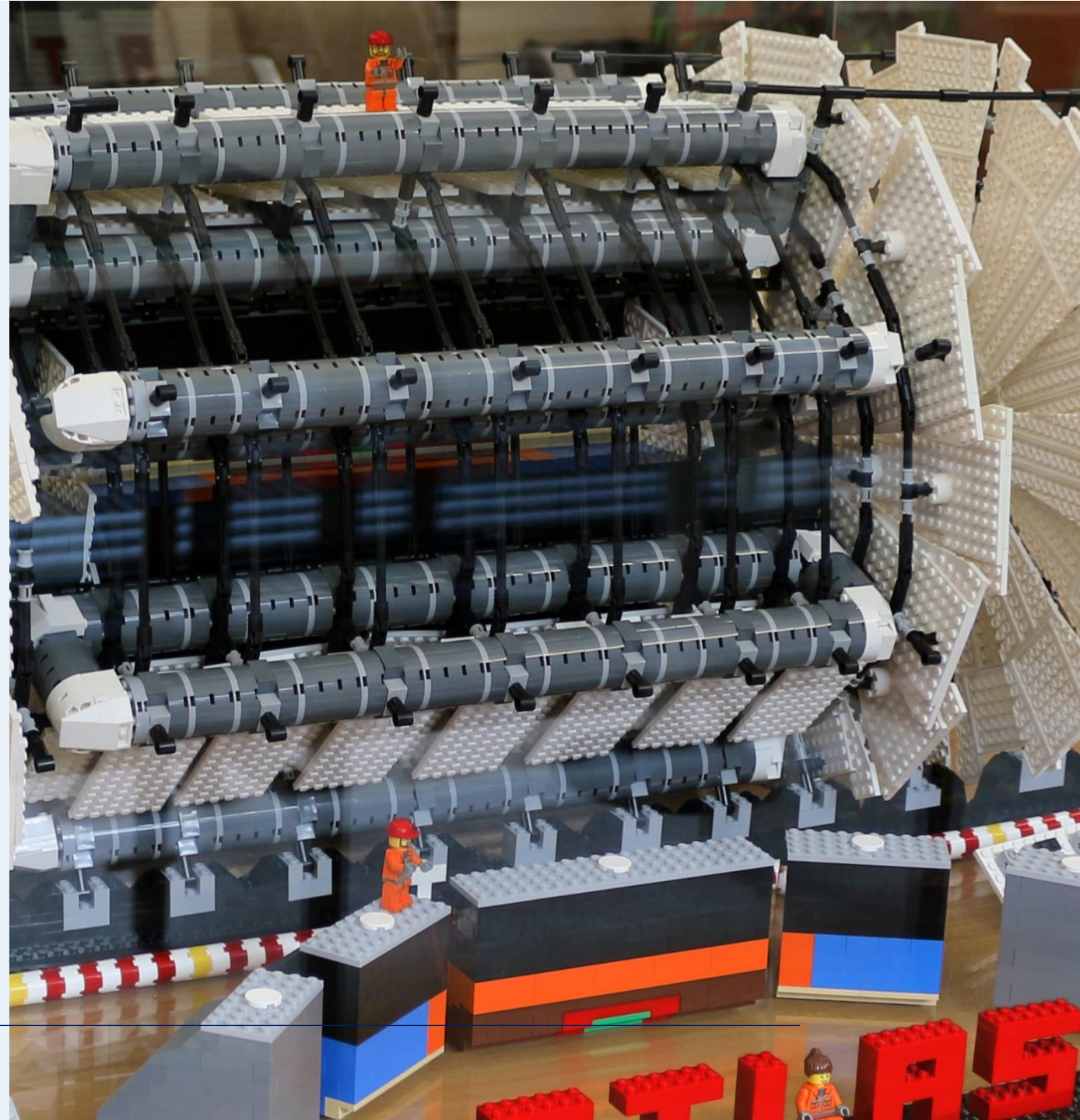
The Artemisa infrastructure is itself an example of a transversal service, which encourages groups of different lines and origins (CV institutes and other communities) to participate in the calls and use the services it offers. Although a large part of the projects originate from IFIC, around 60% are external. Looking at the distribution by region, around 25% are from the Valencian Community (external to IFIC) but there are also percentages around 15% from communities such as Catalonia or Madrid.

During 2021, the work to obtain for Artemisa the ISO 27001 certification has been finalized. ISO 27001 is the international standard on the management of information security. It specifies the requirements for establishing, implementing, maintaining and continually improving an information security management system that makes the information held by the corresponding establishment or infrastructure more secure. With all the work performed, the certification is expected to be granted in 2022. This will be a great feat for the facility.

Several activities related with Artemisa and AI at IFIC have taken place during 2021, it is worth mentioning a few. “2nd COMCHA School” took place at IFIC as part of the COMCHA network, the school included dedicated lectures on Artificial Intelligence and Machine Learning, and programming in new accelerator platforms such as GPUs and FPGAs. “Artificial Intelligence Initiative for Science” was a two-day conference organized by the AI Initiative about Artificial Intelligence and its applications in a broad range of fields: from physics, to quantum computing, biology and other fields. The first of the “CONEXIÓN AIHUB - INDUSTRIA” workshops took place in Valencia as part of the AIHUB network, which brings together more than 400 researchers of CSIC and other Spanish institutions. The “CONEXIÓN AIHUB - INDUSTRIA” workshop gathered representatives of various business sectors to publicize the network and seek synergies and collaborations.

9

OUTREACH



9 OUTREACH COMMITTEE

IFIC participates in and organises numerous scientific dissemination activities that would not be possible without the active involvement of the members of the Institute. These activities range from public talks outside our facilities to opening the doors of our laboratories, and are aimed at both the general public and the educational community. Four people from IFIC were the coordinators of the centre's Outreach Commission, and carried out these activities in 2021. Ángela Molina, who manages our website, as well as our relationship with journalists and press offices of other institutions, Alberto Aparici, who deals with activities and materials aimed at students and the general public, Enrique Nácher, Olga Mena and Avelino Vicente, as scientists involved in the coordination and development of outreach activities.

The work of the committee is complemented by the active participation of a large number of IFIC research and technical staff involved in outreach activities and tasks.
IFIC has a long history of outreach work and each year it aims to improve the agenda of events and involve more IFIC staff. After a tough 2020 of confinement and adaptation of all possible events and materials, 2021 has been a year of caution and transition back to normality. Guided tours, masterclasses and talks have not yet been held in person.

The high impact obtained with the Meitner Project, financed by the FECyT, among other institutions, should be highlighted. Despite the logistical difficulties inherent to the post-pandemic period, all the planned activities have been carried out satisfactorily, both in terms of citizen participation and institutional and social recognition.

Outreach Committee

Ángela Molina
Alberto Aparici
Olga Mena
Enrique Nacher
Avelino Vicente

9 OUTREACH CONTRIBUTIONS

2 Guided tours for students

Due to the situation generated by COVID-19 the guided tours remained cancelled during the whole year, but two special visits of very small groups were hosted, both for special occasions: the winners of the ExpressArte ConCiencia contest and representatives from TEDx Valencia.

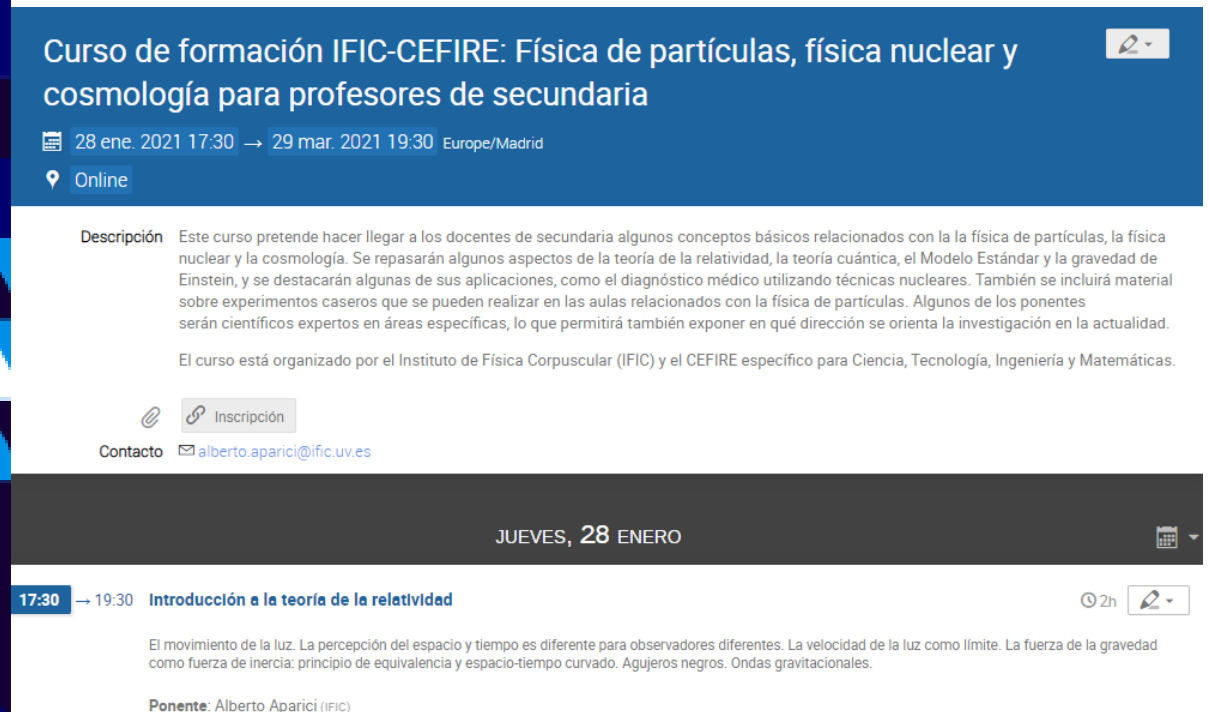
40 High school talks

Many researchers members from IFIC offer outreach talks to local high schools and coordinates their organisation. In 2021 IFIC offered 40 such talks on three different topics: LHC physics, astroparticles and nuclear physics research. Around 1500 students attended these talks.

9 OUTREACH CONTRIBUTIONS

1 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. Fully on-line activity. More than 150 teachers participated, many from the provinces of Castellón and Alicante
Several videos with experiments for the classroom were elaborated as support material



9 OUTREACH EVENTS

1 Armonía Cuántica

"Armonía Cuántica" brought together physicists and musicians to show how science can inspire the arts. IFIC researchers and members of the Joaquín Rodrigo Superior Conservatory of Music in Valencia have worked together for more than a year to create musical pieces based on scientific ideas. The performance took place in the theater of the Museu de les Ciències de Valencia.

3 Dark Matter Day

IFIC celebrates the Dark Matter Day with three different activities: a round-table discussion entitled "The Dark Universe" together with the IAC - Instituto de Astrofísica de Canarias, a lecture "Matter, energy and 'stars'... that never came to shine" at CAC, and the public conference and projection at the Planetarium of Castellón "Dark Matter Day".

9 OUTREACH EVENTS

1 “Centenario” del Nobel de Einstein

Lecture "Einstein, quantum theory and relativity" by José Navarro-Salas, professor at the Department of Theoretical Physics and researcher at the Institute of Corpuscular Physics (IFIC), CSIC-Universitat de València.

1 Experimenta XV

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

3 Interviews on *Entrevistas conCiencia* CSIC Valencia

Gabriela Llosá, María Moreno and Martín González in the series *Entrevistas conCiencia* at CSIC's Casa de la Ciencia in Valencia

Entrevista conCiencia

Casa de la Ciència VALÈNCIA

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

4 New entries to the blog *Entre Científic@s*

Our outreach blog, *Entre cientIFIC@s*, is a platform where the members of IFIC can publish texts aimed at the general public. These texts can be about their research or about broader topics in physics or even the history of science.

9 OUTREACH IFIC IN MEDIA

22 IFIC in the news

Several initiatives and research results involving IFIC reached the news in 2021, and in all cases statements from members of the institute were provided for the journalists.

123 Radio pieces

Several members of IFIC collaborate regularly with radio shows and podcasts that have science as their primary theme. As many such collaborations can be carried out via internet, more than one hundred individual pieces were produced in this context.

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

Theatre: Proyecto Meitner

This is the story that brought the Meitner Project to life, based on the work of Robert Friedman: Remembering Miss Meitner. Friedman is a professor of History of Science at the University of Oslo and a playwright.
More than 3000 people have watched the play.

Conferences

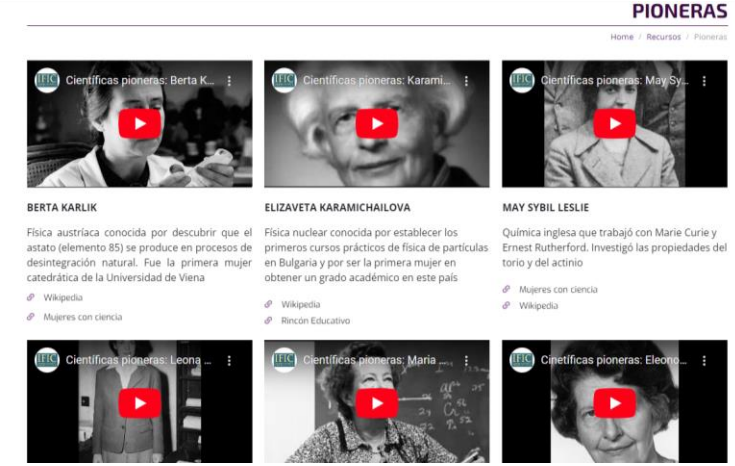
The gender and science conferences were aimed at the general public and secondary school teachers and training cycles through through CEFIRE, more than 180 registrations were made.

Art Contest: ExpressArteConCiencia

The contest was aimed at secondary school and vocational training students. A total of 77 assignments were accepted in the competition. 40 people attended the Awards ceremony and 30 followed the ceremony remotely.

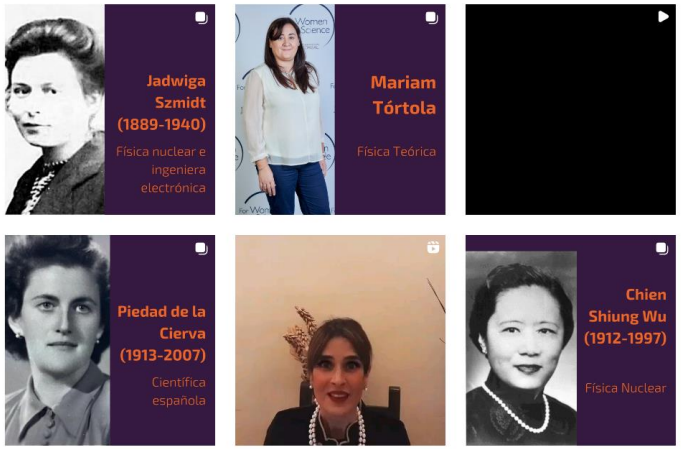
9 OUTREACH-GENDER PROJECT: PROYECTO MEITNER

Materials: Videos



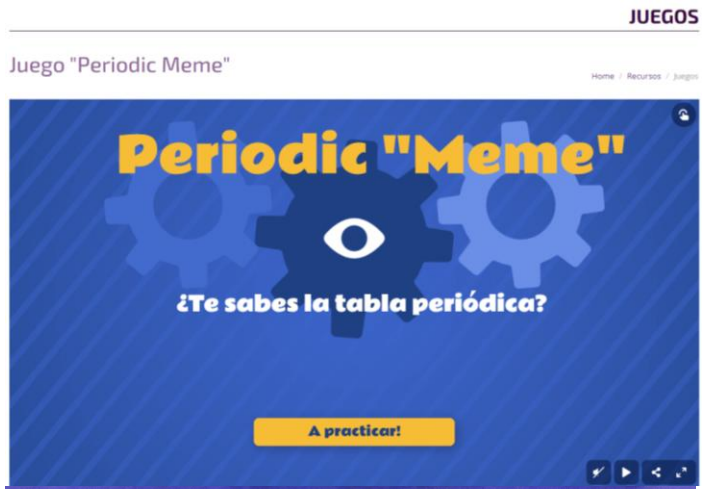
More than Several videos about different pioneering women in nuclear and particles physics have been made.

Social media campaigns



The group have generate a lot of content about different pioneering of nuclear and particles physics as well as current scientifics.

Interactive games, Infographics, etc



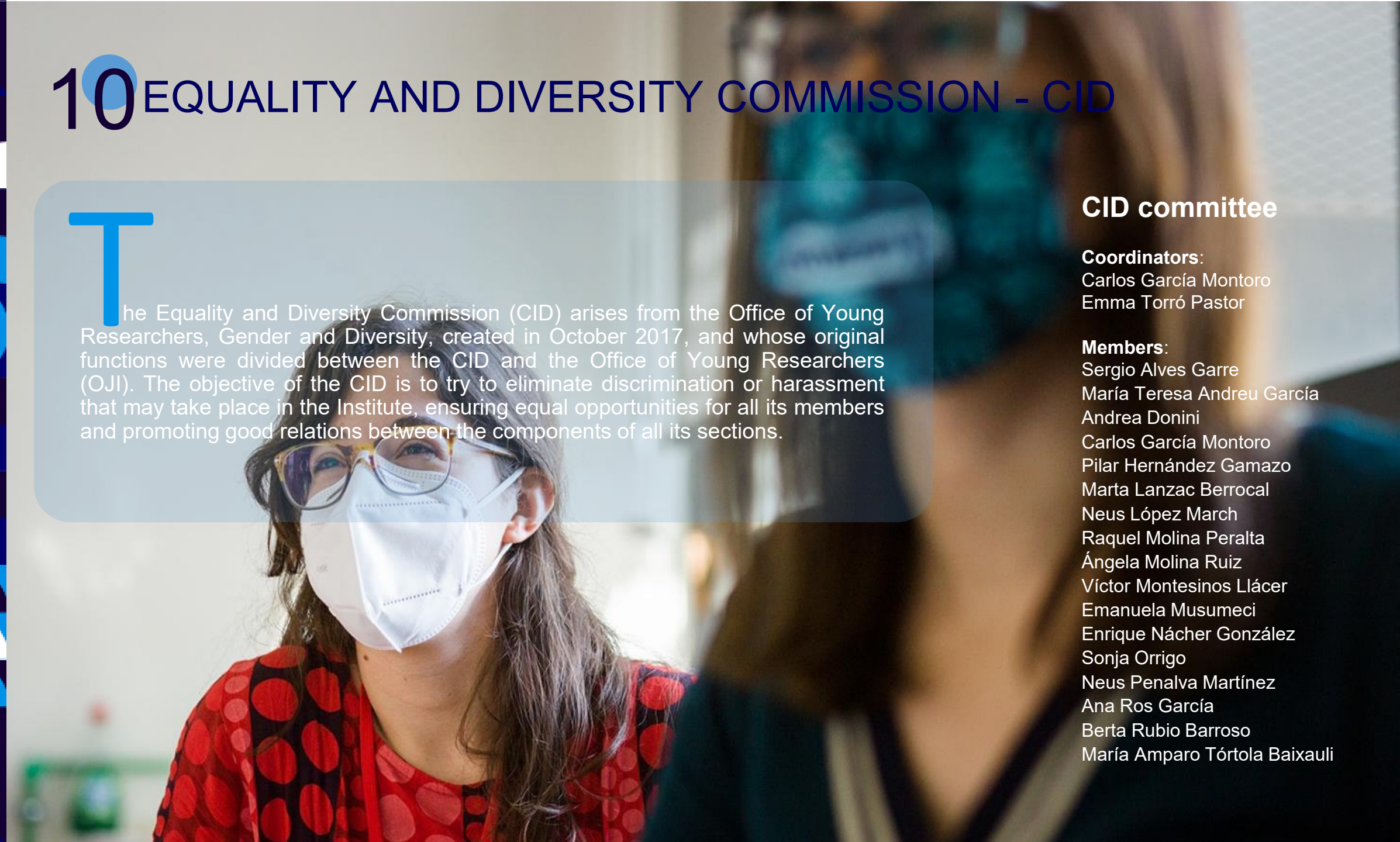
A lot of interactive material has been created to be used by students and teachers at class or at home to learn more about some expecifict contents.

10

EQUALITY AND DIVERSITY COMMISSION

10 EQUALITY AND DIVERSITY COMMISSION - CID

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.



CID committee

Coordinators:
Carlos García Montoro
Emma Torró Pastor

Members:
Sergio Alves Garre
María Teresa Andreu García
Andrea Donini
Carlos García Montoro
Pilar Hernández Gamazo
Marta Lanzac Berrocal
Neus López March
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

11 CID ACTIVITIES AND EVENTS

8 M: El papel de la mujer en la Ciencia - IATA

Every year, IFIC, in collaboration with the Institute of Agrochemistry and Food Technology (IATA - CSIC), organises a conference to celebrate International Women's. This year, a round table on the role of women in Science preceded the scientific talk

8 M: DÍA INTERNACIONAL DE LA MUJER - ICMOL

The activity was organized in collaboration with the Institute of Molecular Science (ICMOL) and included two talks by renowned female researchers who presented their research and experiences working in a preponderantly male environment.

11 CID ACTIVITIES AND EVENTS

11 F: Conferences In High Schools

7 IFIC researchers gave a series of talks, 12 in total, in different secondary schools in the Valencian Community.

28 J: DÍA INTERNACIONAL DEL ORGULLO LGTB

On the occasion of LGTB+ pride day, the IFIC, a mixed CSIC - UV center, through its Equality and Diversity Commission, and with the help of Especter Visible and diversitats, organizes the first exhibition of the works submitted to the "Espectre Visible" contest " for the visibility of the LGTBI+ collective in scientific fields.

EXPOSICIÓN:

"ESPECTRE VISIBLE"

Visibilización del colectivo LGTB+
en ámbitos científicos

Ubicación: Planta baja del IFIC
Catedrático José Beltrán 2

Fecha: 28/6 - 2/7
Horarios: 10-12h y 16-18h

IFIC INSTITUT DE FÍSICA CORPUSCULAR
CSIC
VNIVERSITAT DE VALÈNCIA
Col·lectiu 'Espectre visible'

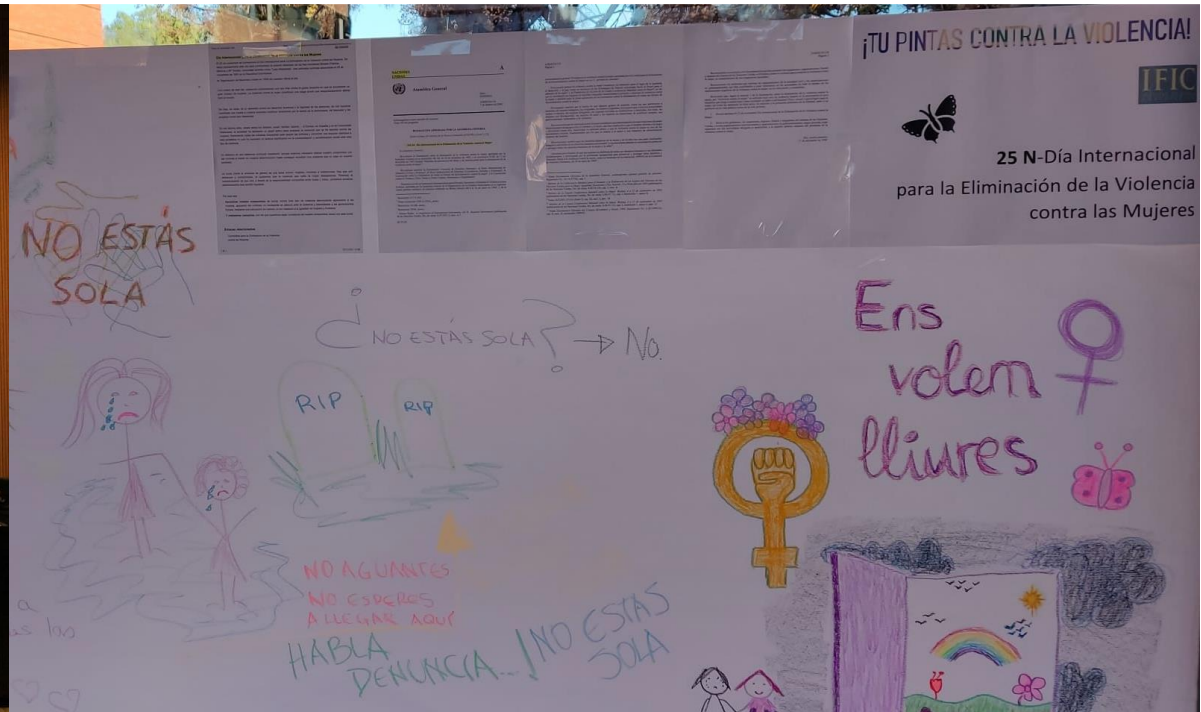
11 CID ACTIVITIES AND EVENTS

WORKSHOP PRISMA LGTB+ IN STEM

Talk-workshop given by PRISMA, Association for affective-sexual and gender diversity in science, technology and innovation. What does science have to say about the LGBT+ fight? What is the situation of LGBT+ people in the scientific environment? What can we do to improve it?
What have LGBT+ researchers contributed to science?

25N: INTERNATIONAL DAY FOR THE ELIMINATION OF VIOLENCE AGAINST WOMEN

Open activity where IFIC personel as well as that from other institutes at Parc Ciecntífic, were able to write and draw their thoughts on a white board called "*Tu Pintas Contra la Violencia*". (“Drawing against violence”)



11

YOUNG RESEARCHER S 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.

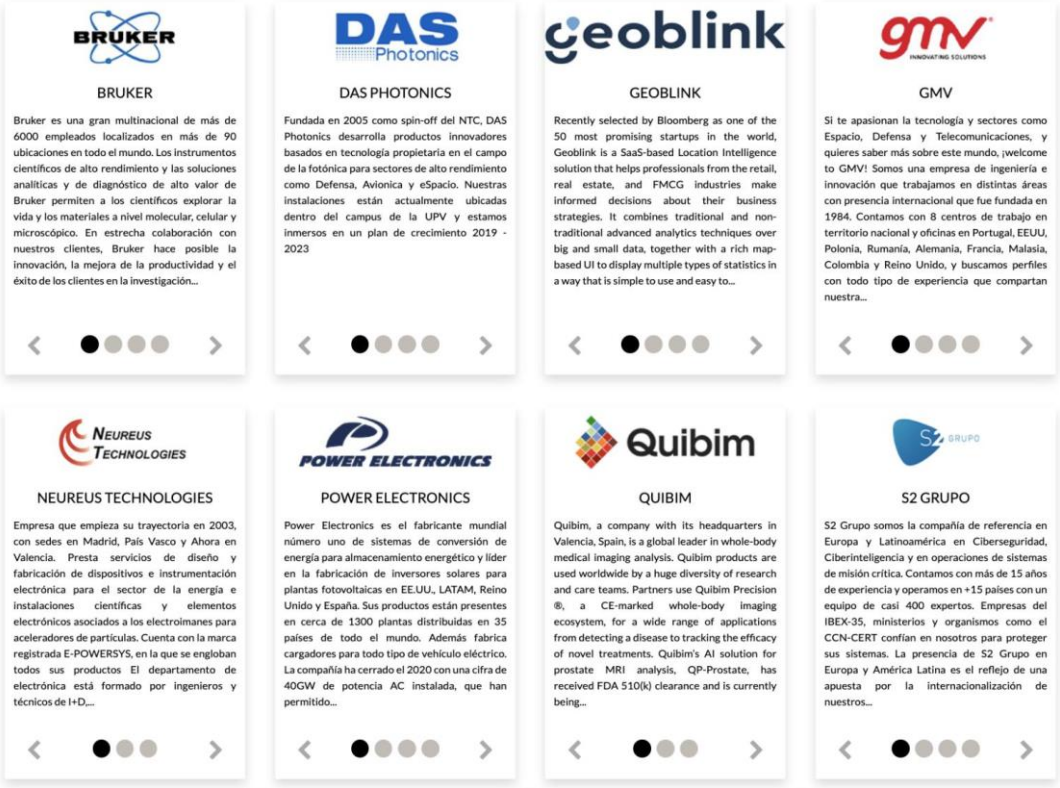
2. Programme to support the integration of PhDs in the workplace: Round table with IFIC PhDs currently working in the world of work, conference with companies, colloquium by an IFIC PhD with a relevant position in a company, ...

YRO committee
María Moreno
Alberto Ramos

11 YOUNG RESEARCHERS OFFICE

Organizing career prospects events

A space of interaction between PhD students/Postdocs and companies with hiring interests in people with abilities typically present in our research. In collaboration with UV Ocupació. Online



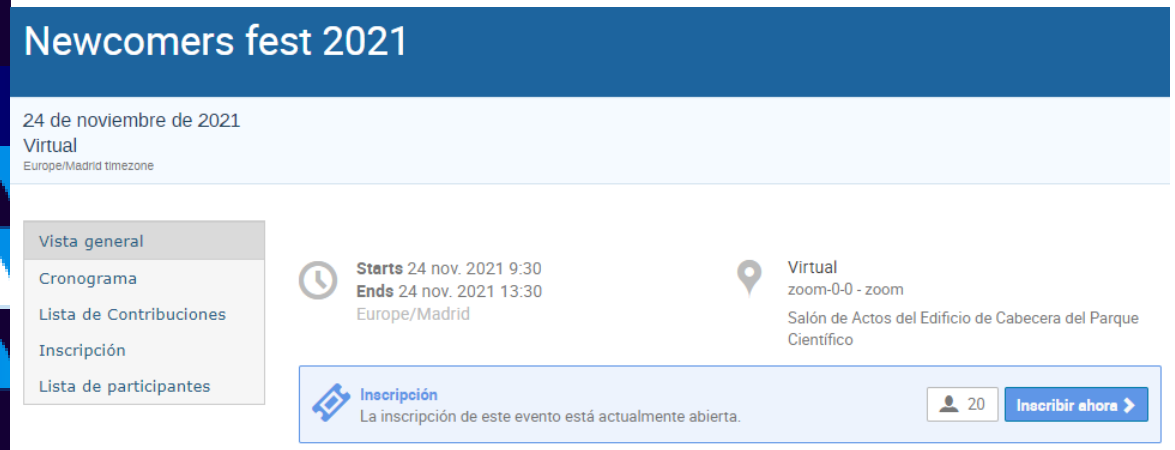
PhD welcome session

An introductory journey for new PhD students to the PhD program at the University of Valencia. A forum for PhD students to present themselves to other students.
Pilar Hernández, coordinator of the PhD program

11 YOUNG RESEARCHERS OFFICE

Newcomers fest

Event to present the scientific interests of new researchers at IFIC to the rest of the members. Also an introduction of the research activities at IFIC for those recently arrived.
November 24th - in person



12

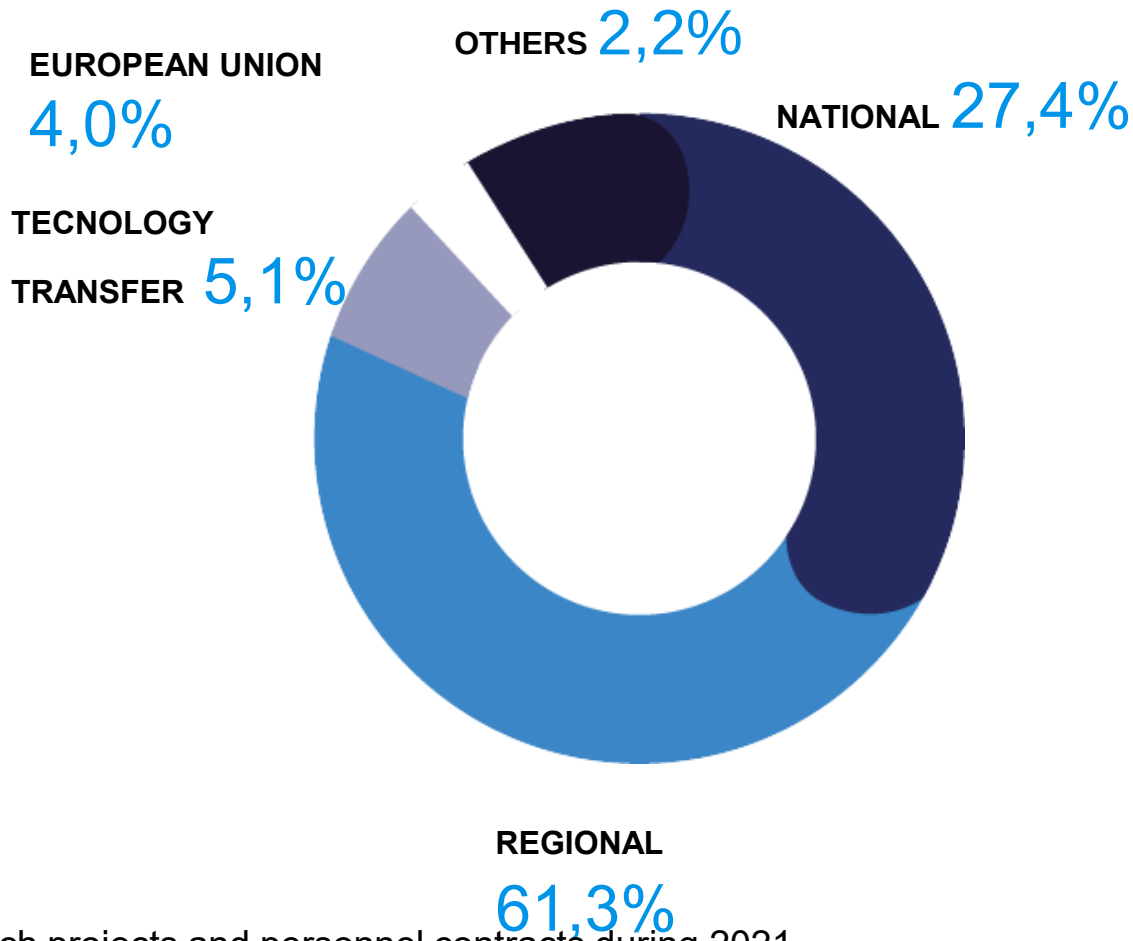
FUNDING

12 PROJECTS

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

12 TOTAL INCOME BY SOURCE

NATIONAL	2.505.113,65 €
EUROPEAN UNION	365.347,48 €
REGIONAL	5.598.154,19 €
OTHERS	199.849,11 €
TECHNOLOGY TRANSFER	468.950,00 €
TOTAL	**9.137.414,43 €**



* The income values refer to the total amount awarded to new research projects and personnel contracts during 2021

ANNEXES

1 ANNEXES Personnel List

Permanent staff researchers: 70

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
Giménez Gómez, Vicente
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
Lopez March, Neus
Marti García, Salvador
Martínez Vidal, Fernando
Mena Requejo, Olga
Mitsou, Vasiliki
Nácher González, Enrique
Navarro Salas, José
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
Portoles Ibañez, Jorge
Rius Dionis, Nuria
Rodrigo García, Germán
Ros Martínez, Eduardo
Rubio Barroso, Berta
Ruiz de Austri Bazan, Roberto
Salt Cairols, José
Sanchis Lozano, Miguel Angel
Santamaría Luna, Arcadi
Sorel, Michel
Taín Enríquez, José Luis
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: 25

Albaladejo Serrano, Miguel
Campanario Pallás, Francisco
Cieri, Leandro Javier
Escobar Ibáñez, Carlos
Figueroa, Daniel G.
González Alonso, Martín
Herrero García, Juan Andres
Irles Quiles, Adrian
Lopez Pavon, Jacobo
Mariñas Pardo, Carlos Manuel
Martín-Albo Simón, Justo
Molina Peralta, Raquel
Moreno Llácer, María
Nebot Gómez, Miguel
Poveda Torres, Joaquin
Ramos Martínez, Alberto
Ruiz Martínez, Arantxa
Salesa Greus, Francisco
Sanchez Losa, Agustin
Sanz González, Veronica
Torró Pastor, Emma
Vicente Montesinos, Avelino
Villaplana Pérez, Miguel
Zaldívar Montero, Bryan
Zurita, José Francisco

Professors emeriti and visiting researchers: 11

Azcárraga Feliu, José Adolfo de
Bernabéu Alberola, José
Fassi Imlahi, Farida
Ferrario, Paola
Ferrer Soria, Antonio
Gómez Cadenas, Juan José
Higón Rodriguez, Emilio
Monrabal Capilla, Francesc
Oset Báguena, Eulogio
Scoccola, Norberto Nerio
Vento Torres, Vicente

Post-doctoral researchers: 36

Albiol Colomer, Francisco Javier
Bailey, Adam John

1 ANNEXES

Balibrea Correa, Javier
Bombacigno, Flavio
Caballero Ontanaya, Luis
Calvo Diaz-Aldagalán, David
Capozzi, Francesco
Cardillo, Fabio
Carrió Argos, Fernando
Casanovas Hoste, Adrià
De Romeri, Valentina
Du, Menglin
Esperante Pereira, Daniel
Feijoo Aliau, Eduardo Alberto
Fullana Torregrosa, Esteban
Fuster Martinez, Nuria
García Soto, Alfonso Andrés
Gozzini, Sara Rebecca
Hueso Gonzalez, Fernando
Landini, Giacomo
Lerendegui Marco, Jorge
Mamuzic, Judita
Mandal, Sanjoy
Molina Bueno, Laura
Molina Sedgwick, Susana
Morales Lopez, Ana Isabel
Orrigo, Sonja Elena Agata
Ros Garcia, Ana
Sabatini, Paolo
Sanderswood, Izaac Gregory
Song, Jing
Teppa Pannia, Florencia Anabella
Titov, Arsenii
Tortajada Velert, Salvador
Vale Silva, Luiz Henrique

PhD students: 105

Albandea Jordan, David
Alcala Escalona, Gustavo Adolfo
Alvarado Alvarez, Fernando
Alves Garre, Sergio
Amos, Kieran
Anglés Castillo, Andreu
Antonova, Maria
Aparisi Pozo, Javier Alberto
Babiano Suarez, Victor
Baeza Ballesteros, Jorge Juan
Barrientos Mauriz, Luis Alfredo
Bas Beneito, Arnau
Beltrán Lloría, Rebeca
Beltran Palau, Pau
Borja Lloret, Marina
Bouchhar, Naseem
Breso Pla, Victor Ernesto
Bruschini, Roberto
Carrasco Mejía, Juliana Mara
Carretero Cuenca, Victor
Cervelló Duato, Antonio
Chitishvili, Mariam
Coito Pereyra, Leonardo
Cornet Gomez, Fernando
Diaz Calderon, David
Didenko, Mariia
Escribano Valiente, Pablo
Esser, Fabian
Esteban Martinez, Alfredo
Ferrando Solera, Sergio
Fontenla Barba, Yanis
Garcia Peris, Miguel Angel
Gil Dominguez, Fernando
Gomez Delegido, Antonio Jesus
Gonzalvo Rodriguez, Galo Rafael
Guerrero Rojas, Jesus
Gutiérrez Camacho, Abel
Hajjar Muñoz, Rasmi Enrique
Herrero Brocal, Antonio
Lazo Pedrajas, Alfonso
Loayza Romero, Nicolas
Manczak, Jerzy Mikolaj
Márquez Hernández, Jesús Pedro
Martín Luna, Pablo
Martinez Agulló, Pablo
Martínez de Lejarza Samper, Jorge Juan
Martinez Mirave, Pablo
Martinez Reviriego, Pablo
Martinez Roig, Marcos
Martins Cosme, Catarina
Masó Ferrando, Andreu Sales
Medina Rosales, Omar
Menéndez Márquez, Abraham
Meneses Felipe, Alba
Miralles Aznar, Victor
Miralles Lopez, Marcos
Miró Arenas, Carlos
Monsonis Romero, Luis
Montesinos Llácer, Víctor
Morell Ortega, Sergio
Muñoz Albornoz, Victor Manuel
Muñoz Candela, Pablo
Muñoz Ovalle, Alejandro
Muñoz Perez, David
Musumeci, Emanuela
Nadal Gisbert, Sergi
Nava, Jacopo
Navarro Gonzalez, Josep
Palacios Gonzalez, Juan
Parra Aedo, Byron Felipe
Pattnaik, Baibhab
Penalva Martinez, Neus
Pérez Curbelo, Javier
Pla Garcia, Silvia
Pompa, Federica
Prades Ibañez, Alberto
Puerta Catoira, Miguel
Ramirez Uribe, Norma Selomit
Rebollo de Miguel, Miguel
Renteria Olivo, Andres Ernesto
Rocabado Rocha, Jose Luis
Rodrigues Sandner, Stefan Marinus
Rodríguez García, David
Romo Luque, Carmen
Roser Martinez, Jorge

1 ANNEXES

Rubio Jiménez, Adrián
Ruiz Vidal, Joan
Saina, Adrian
Sanchez Sebastian, Victoria
Sayago Galvan, Ivan
Senthilkumar, Varsha
Simeó Vinaixa, Mireia
Solomonidi, Eleftheria
Szalkowski, Gabriel Andy
Telo Rodrigues Catumba, Guilherme
Tuzi, Mirald
Ureña González, Julio
Urrea González, Salvador
Usón Andrés, Alberto
Valiente Moreno, Enrique
Varriale, Lorenzo
Vatsyayan, Drona
Victoria Fernandez, Jose Antonio
Viegas Botelho Correia Rego, Rita
Villanueva Domingo, Pablo
Zhuo, Jiahui

Technical staff: 38

Bernabeu Verdú, José
Blanch Gutierrez, Cesar
Burriel Navarro, Helena
Cámara García, María Teresa
Carcel Garcia, Sara
Carrasco de Fez, Rosa
Casaña Copado, Jose Vicente
Civera Navarrete, José Vicente
Delgado Belmar, Vanesa
Elesgaray Susierra, Oihan
Fernández Casaní, Álvaro
Fuentes Castilla, Angel
Gallego Baviera, Francisco Javier
Garcia Montoro, Carlos
González González, Francisco
Gonzalez Iglesias, Daniel
Ladarescu Palivan, Ion
López Cabrero, Araceli
Lopez Redondo, Manuel
Marco Hernández, Ricardo
Martínez Ferrer, Miguel
Martínez Saez, Carlos
Mazorra de Cos, José
Nácher Arándiga, Jorge
Nadal Durà, Joaquin
Platero Garcia, Adrian
Platero Montagut, Vicente
Querol Segura, Marc
Real Máñez, Diego
Rodriguez Cespedosa, Nicolas
Rodriguez Galan, Rosa Maria
Sánchez Martínez, Fco. Javier
Senra Moledo, Cesar
Solaz Contell, Carles
Soldevila Serrano, Urmila
Tchogna Davis, Daniel
Teruel Pardo, Simón
Valero Biot, José Alberto

Administrative staff: 20

Aguilar Argilés, Teresa
Andreu Garcia, Mª Teresa
Aparici Benages, Alberto
Boix Caballero, Pilar
Claramunt Pedrón, Luis Miguel
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, Angela
Montesinos Reig, Leonor
Monzón Herrero, Benjamín
Naval de Jesús, Carmen
Pérez García, José
Salgado Lopez, Oscar
Sánchez Galán, Rocio
Serrano Ruiz, Ana Isabel

2 ANNEXES

Full list of publications

3 ANNEXES Conferences and workshops organized

- Nov 25-26 AI Initiative for Science (conference),
- Nov 22-23 6ª Reunión "Presencial" (ONLINE) del Proyecto VMGRID (ATLAS TIER2 ESPAÑA)
- Nov 19 INNOCHARLA - MODELOS, BUENAS PRÁCTICAS Y EXPERIENCIAS EN LA TRANSFERENCIA DE TECNOLOGÍA CIENCIA - INDUSTRIA
- Nov 12 Taller PRISMA LGTB+ en STEM
- Nov 10 – Dec 10 The month of AI Initiative for Science
- Aug 26 – Sep 3 17th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2021)
- Jul 9 LA GESTIÓN DE LA PROPIEDAD INTELECTUAL E INDUSTRIAL EN LAS COLABORACIONES CIENCIA-INDUSTRIA - Jornada Formativa Virtual
- May 18-21 Very Large Volume Neutrino Telescope Workshop (VLVnT 2021)
- Mar 12 "Día internacional de la mujer" 2021 : mesa redonda y conferencia sobre el papel de la mujer en la ciencia
- Mar 9-10 Jornadas Ciencia y Género: Pioneras en Física Nuclear y de Partículas: Pasado, Presente y Futuro. Proyecto Meitner
- Mar 1-2 5ª Reunión "Presencial" (ONLINE) del Proyecto VMGRID (ATLAS TIER2 ESPAÑA)
- Feb 18 Jornada de Física Médica del IFIC 2021

4 ANNEXES Colloquia organized

- Dec 2, Walter Kutschera, "The ugly and the beautiful: the versatile uses of the 14C bomb peak"
- Nov 18, Licia Verde, "Precision cosmology, now what?"
- Oct 21, Andrea Wulzer, "Why building a muon collider"
- Sep 16, Robert Marc Friedman, "The politics of excellence: Demystifying the Nobel Prizes in science"
- May 27, Ben Nachman, "What can deep learning teach us about particle physics?",
- Apr 22, Werner Hofmann, "Astronomy at the highest photon energies: the Cherenkov Telescope Array"
- Mar 25, Adán Cabello, "Ideal measurements and the problem of understanding quantum mechanics"

5 ANNEXES Seminars organized

- 17 Dec Carlos Marinas, "Red LHC webinar: Thinner, faster and smarter. Semiconductor detectors for high radiation environments in future collider experiments"
- 16 Dec Ivan Esteban, "IFIC Topical Seminar: Sterile neutrinos in 2021, why should we care?"
- 14 Dec Mikhail Shaposhnikov, "HiDDeN webinar: Quantum field theories without infinities and naturalness"
- 14 Dec Michael Trott, "IFIC Seminar: The Geometric SMEFT description of curved Higgs Field Space(s)"
- 10 Dec #Student Seminar Justo Martín-Albo: Searching for BSM neutrino physics at the Deep Underground Neutrino Experiment (DUNE)
- 01 Dec Andrej Saibel, "Topical Seminar: Phenomenology of $t\bar{t}H$ Production with Top Quark Running Mass and the Differential Cross-Section Measurement of $t\bar{t}+jets$ Production in the Dilepton Channel at $\sqrt{s}=$13 TeV"
- 30 Nov Daniele Teresi, "HiDDeN webinar: Sliding Naturalness"
- 30 Nov Andreas Mantziris, "IFIC Seminar: Cosmological implications of EW vacuum instability: constraints on the Higgs-curvature coupling from inflation"
- 29 Nov Víctor Martín Lozano, "IFIC Topical Seminar: Scalar taus at the LHC and simplified models for BSM Higgs searches“
- 26 Nov Espriu Domènec, "IFIC Topical Seminar: Effect of the cosmological parameters on gravitational waves"
- 23 Nov Roberto_Bruschini "#StudentSeminar: Heavy Meson Spectroscopy From Lattice QCD Potentials"
- 22 Nov Ana Ros Garcia, "IFIC Experimental Seminar: PROScRiPT: a probe for the improvement of the spatial resolution in total-body PET"
- 18 Nov Yuber F. Pérez-González, "IFIC Topical Seminar: Neutrinos from Primordial Black Holes, an opera in two acts"
- 17 Nov Redamy Perez-Ramos, "Topical Seminar: Hadron correlations on the search of new physics beyond the Standard Model at the LHC & ILC"
- 16 Nov Josef Pradler, "HiDDeN webinar: The sunny side of dark matter direct detection"

5 ANNEXES Seminars organized

- 16 Nov José Ruiz-Álvarez, "IFIC Seminar: Charm physics confronts high-pT lepton tails"
- 15 Nov Kiko Albiol, "se-fis-med: AI imaging and statistics for medical applications"
- 12 Nov Tyler Corbett, "IFIC Topical Seminar: The geoSMEFT and some applications"
- 09 Nov Miguel Albaladejo, "IFIC seminar: Tcc+ coupled channel analysis and predictions"
- 02 Nov Vedran Brdar, "HiDDeN webinar: Energy-Dependent Neutrino Mixing Parameters at Oscillation Experiments“
- 02 Nov Ricardo Z. Ferreira, "IFIC Seminar: Cosmological probes of the QCD axion -- CMB and gravitational waves"
- 29 Oct Tarak Nath Maity, "IFIC Topical Seminar: Indirect searches for dark matter: gamma rays and neutrinos"
- 26 Oct Bryan Zaldivar, "IFIC Seminar: A road from Dark Matter phenomenology to Artificial Intelligence"
- 25 Oct Victor Miralles "#Student Seminar: Phenomenology in particle physics: Bringing new physics models down to Earth"
- 22 Oct Guillermo Franco Abellán, "Topical Seminar: Cosmological anomalies shedding light on the dark sector"
- 19 Oct Mark Ross-Lonergan, "HiDDeN webinar: Search for anomalous single-photon production in MicroBooNE as a first test of the MiniBooNE low-energy excess"
- 19 Oct Miguel-Angel Sanchis-Lozano, "IFIC Seminar: Searching for New Physics using angular correlations in e+e- colliders"
- 18 Oct Christoph Lerche, "se-fis-med: PET/MR in neuroscience, challenges, potential, and perspectives."
- 13 Oct Salvador Centelles "#Student Seminar: Symmetries as guiding posts in physics“
- 05 Oct Ilaria Brivio, "HiDDeN webinar: The Neutrino Option"
- 05 Oct Luis Miguel Garcia Martin, "IFIC Seminar: Radiative b-baryon decays at LHCb"
- 04 Oct Salvador Marti Garcia, "IFIC Experimental Seminar: Basic concepts in track reconstruction in HEP experiments"
- 01 Oct Xavier Vilasis-Cardona, "Red LHC webinar: Artificial Intelligence at the Large Hadron Collider"
- 28 Sep Guilherme Guedes, "IFIC Seminar: New leptons with exotic decays: collider limits and dark matter complementarity"

5 ANNEXES Seminars organized

- 27 Sep Enrique Nacher, "IFIC Experimental Seminar: X-ray bursts: nucleosynthesis along the N=Z line at CERN-ISOLDE"
- 20 Sep Enrique Nacher, "se-fis-med: Recycling nuclear physics detectors from CERN and FAIR for medical imaging and proton-therapy"
- 14 Sep IFIC Seminar: Progress in multiparticle amplitudes from the lattice
- 22 Jul Leticia Carrión, "#Student Seminar: Optical design of miniature lenses"
- 19 Jul Javier Vijande, "se-fis-med: A patient is a spherical body of water submerged in an infinite water medium. Change my mind.“
- 13 Jul Rodolfo Enrique Canet Albiach, "#Student Seminar: 2D Materials : Distinguishable separation of charged and neutral excitons at room temperature in anisotropic photoluminescence of TMD monolayers integrated in polymer waveguides"
- 06 Jul Clara Remon Alepuz, "#StudentSeminar Radiative decays at LHCb"
- 05 Jul Jorge Lerendegui Marco, "IFIC Experimental Seminar: Compton Imaging for enhanced sensitivity in the measurement of key stellar nucleosynthesis reactions"
- 01 Jul JOSE DE JESUS AGUILERA VERDUGO, "#StudentSeminar Causal structures of scattering amplitudes within Loop-Tree Duality formalism"
- 25 Jun Sergio Lozares, "#StudentSeminar Clinical applications of electronic brachytherapy: endometrial and intraoperative radiotherapy (breast and sarcomas)"
- 23 Jun Abraham de Jesús Loredo Trejo, "#Student Seminar: Broadband tuning of scalar and vector four wave mixing in optofluidic-filled MOFs"
- 21 Jun Abdelkhalek Hammi, "se-fis-med: 4D tool to estimate the dose to the peripheral blood during radiation therapy"
- 18 Jun Joaquim Matias, "Red LHC webinar: B-Flavour Anomalies: status of global fits, next steps and a new non-leptonic anomaly"

5 ANNEXES Seminars organized

- 15 Jun Stephen Dolan, "IFIC seminar: "Neutrinos from Tokai to Kamioka: Oscillations, Interactions and the search for CP-Violation""
- 09 Jun Arsenii Titov, Víctor Ernesto Bresó Pla, "#BSMJournalClub: SMEFT (Neutrino masses and NLO effects)"
- 08 Jun Gregorio Herdoiza , "HiDDeN webinar: Hadronic contributions to the muon g-2"
- 08 Jun Fernando Cornet-Gomez, "#StudentSeminar: Flavour Conservation in 2HDM. A possible explanation for the (g-2) anomalies."
- 07 Jun Paco Salesa, "IFIC Experimental seminar: "Gamma-Ray Astronomy with the HAWC Observatory""
- 01 Jun Assumpta Parreño, "IFIC SEMINAR: Baryon-baryon interactions and the axial charge of the triton at $m_\pi \sim$ 450 MeV"
- 28 May Dermot Moran, "Red LHC webinar: Higgs boson measurements and their Effective Field Theory interpretations"
- 25 May Werner Porod, "IFIC Seminar: Composite Higgs models, from gauge/gravity duality to LHC-phenomenology"
- 19 May Alberto Ramos Martinez, Antonio Pich, "#BSMJournalClub Standard Model determination of the muon anomalous magnetic moment"
- 18 May Junping Tian, "IFIC Seminar: Prospects on Higgs physics at future lepton colliders -- a Higgs-factory isn't enough"
- 17 May Nadia Yahlali, "se-fis-med: Scintillation dosimetry and counting for quality assurance and control in radiation treatments of cancer."
- 14 May Eemeli Tomberg, "Topical Seminar: Stochastic Inflation and Primordial Black Holes"
- 13 May Daniel Díaz, "#StudentSeminar: Experimental and theoretical study of Zn2V2O7"
- 13 May Akun Liang, "#StudentSeminar: High-pressure structural and vibrational study of metal oidates, from experiments and density-functional theory"
- 11 May Zakary Burkley, "IFIC seminars: "Mu-MASS: Towards the first CW spectroscopy of the 1S-2S transition in Muonium""

5 ANNEXES Seminars organized

- 03 May Ricardo Marco Hernández, "IFIC Experimental Seminar: Overview of depleted CMOS sensors for Future Tracking Detectors."
- 29 Apr Gustavo Guerrero, "#StudentSeminar: Pion electro- and photoproduction on nucleons in a covariant Chiral Perturbation Theory"
- 28 Apr Pere Masjuan, "News on the muon g-2 and R_K: an informal discussion"
- 27 Apr Andreas Crivellin, "HiDDeN webinar: Discovering Lepton Flavour Universality Violating New Physics"
- 27 Apr Yutaka Hosotani, "IFIC Seminars - Z' signals at e^-e^+ linear colliders in gauge-Higgs unification"
- 20 Apr Adrian Carmona, "IFIC Seminar: A warped scalar portal to fermionic dark matter"
- 16 Apr Emma Torró Pastor, "Red LHC webinar: Prospects on the search for long-lived particles at the LHC experiments for Run 3"
- 13 Apr Jorge Martin Camalich, "HiDDeN webinar: Implications of the new measurements of b > s mumu decays"
- 13 Apr Jenny List, "IFIC Seminars - Straight to the Future: Physics Opportunities at the ILC"
- 30 Mar Rick. S. Gupta, "HiDDeN webinar: A heavy axion 'massless up' from partial compositeness"
- 30 Mar Feng-Kun Guo, "IFIC seminars: Towards a general understanding of near-threshold structures in heavy-hadron spectrum"
- 29 Mar Fernando Romero López, "#StudentSeminar: Scattering amplitudes from lattice QCD"
- 29 Mar Adrian Irles, "IFIC Experimental Seminar: A review on Particle Flow detectors for high energy collider physics."
- 24 Mar Avelino Vicente, Miguel Escudero, "#BSMJournalClub"
- 23 Mar Patricia Sanchez Lucas, "DARWIN: a next-generation multi-ton xenon observatory"
- 16 Mar Jeff Dror, "HiDDeN webinar: The Cosmic Axion Background"
- 12 Mar Marc Illa, "Topical Seminar: The baryon-baryon interaction with unphysical quark masses"
- 10 Mar Jose Francisco Zurita, "#BSMJournalClub"
- 09 Mar Vivian Poulin, "IFIC seminar: How to resolve the 'Hubble tension'"

5 ANNEXES Seminars organized

- 02 Mar Tongyan Lin , "HiDDeN webinar: Dark matter scattering in dielectrics"
- 02 Mar Pau Amaro Seoane, "IFIC Seminar: A chartography of spacetime around supermassive black holes with extreme-mass ratio inspirals"
- 01 Mar Fernando Hueso Gonzalez, "IFIC Experimental Seminar: Zero dead time data acquisition for proton therapy"
- 24 Feb Veronica Sanz, "#BSMJournalClub"
- 23 Feb Clara Peset, "IFIC Seminar: Atomic spectroscopy as dark sectors probe"
- 16 Feb Jordi Salvado, "HiDDeN webinar: Long Range Interactions in Cosmology & Implications for Neutrinos"
- 16 Feb Juan Cruz-Martínez, "IFIC Seminar: PDFs determination with a quantum computer"
- 09 Feb Ilaria Brivio, "[IFIC Seminar] SMEFT studies of LHC data: status and perspective"
- 03 Feb Luiz Vale Silva, "#BSMJournalClub"
- 02 Feb Matheus Hostert, "HiDDeN webinar: A Dark Seesaw at Low Energy Experiments"
- 02 Feb Diego Blas, "New ideas on quenching and detecting BH rotational superradiances"
- 26 Jan Raquel Molina, "IFIC seminar: Meson-meson scattering in EFT's and new exotic hadrons"
- 19 Jan Gilly Elor, "HiDDeN webinar: Making the Universe at 20 MeV"
- 12 Jan Federico Meloni, "Exploring the lifetime frontier with ATLAS"

6 ANNEXES PhD Theses 2021

THEORETICAL PHYSICS

- *Open problems in the physics of neutrino interactions with nucleons and nuclei* David Eduardo Saúl Sala Advisor: Luis Álvarez Ruso January 12, University of Valencia
  TESEO: 1932423

- *Dynamical Hadrons: Case Studies of Meson-Meson and Meson-Baryon Molecules and Triangle Singularities* Vinicius Rodrigues Debastiani Advisor: Eulogio Oset Báguena March 11, University of Valencia
  TESEO: 1953303

- *Radiative neutrino masses: a window to new physics* Ricardo Cepedello Pérez Advisor: Martin Hirsch March 30, University of Valencia
  TESEO: 1954299

- *Dark matter phenomenology: sterile neutrino portal and gravitational portal in extra-dimensions* Miguel García Folgado Advisors: Roberto Ruiz de Austri Bazan, Nuria Rius Dionis and Andrea Donini March 31, University of Valencia
  TESEO: 1964139

- *NLO double Higgs production beyond the Standard Model* Jonathan Ronca Advisor: Francisco Campanario Pallás April 23, University of Valencia
  TESEO: 1971822

- *Renormalization of Quantum Fields in Curved Spacetime* Antonio Eduardo Ferreiro de Aguiar Advisor: José Navarro Salas July 2, University of Valencia
  TESEO: 2015799

- *Shedding light on Dark Matter through 21 cm Cosmology and Reionization constraints* Pablo Villanueva Domingo Advisors: Olga Mena Requejo and Sergio Palomares Ruiz July 19, University of Valencia
  TESEO: 2024019

- Kaon decays and other hadronic processes in lattice QCD Fernando Romero López Advisors: Pilar Hernández Gamazo and Stephen R. Sharpe September 10, University of Valencia
  TESEO: 2040759

- *Theoretical and Observational Aspects of Metric-Affine Gravity* Adrià Delhom i Latorre Advisors: José Navarro Salas and Gonzalo Olmo Alba October 1, University of Valencia
  TESEO: 2045865

- *Aspects of physics beyond the Standard Model* Mario Reig López Advisor: José W. Furtado Valle October 8, University of Valencia
  TESEO: 2060703

- *Theory and phenomenology of Dirac neutrinos: Symmetry breaking patterns, flavour implications and Dark Matter* Salvador Centelles Chuliá Advisors: José W. Furtado Valle and Rahul Srivastava October 28, University of Valencia
  TESEO: 2061519

- *Taming Flavor in Two Higgs Doublet Models* Fernando Cornet Gómez Advisors: Francisco J. Botella Olcina and Miguel Nebot Gómez October 29, University of Valencia
  TESEO: 2067399

EXPERIMENTAL PHYSICS

- *Dosimetric studies through Monte Carlo methods in surface high-dose-rate electronic brachytherapy* Christian Valdés Cortez Advisors: Facundo Ballester Pallarés and Javier Vijande Asenjo February 13, University of Valencia
  TESEO: 1950891

- Contribución a las medidas de gas radón: metodología, aplicación y estimación de dosis Vanesa Delgado Belmar Advisor: José Díaz Medina February 19, University of Valencia
  TESEO: 1947201

- *Search for neutrino non-standard interactions with ANTARES and KM3NeT-ORCA* Nafis Rezwan Khan Chowdhury Advisors: Juan de Dios Zornoza Gómez and Sergio Navas Concha May 10, University of Valencia
  TESEO: 1978734

- *Contribuciones a la electrónica de adquisición y sincronismo del telescopio de neutrinos KM3NeT* David Calvo Díaz-Aldagalán Advisors: Juan Zúñiga Román and Juan de Dios Zornoza Gómez June 18, University of Valencia
  TESEO: 1991382

- *Study of B^0_s -> phi, gamma decays at LHCb* Clara Remón Alepuz Advisor: María Aránzazu Oyanguren Campos September 28, University of Valencia
  TESEO: 2054796

- *Mètodes de Monte Carlo avançats en dosimetría* Vicent Giménez Alventosa Advisors: Javier Vijande Asenjo and Facundo Ballester Pallarés November 25, University of Valencia
  TESEO: 2083902

- *Dosimetría en ginecología y verificación de tratamientos en braquiterapia electronica* Sergio Alberto Lozares Cordero Advisors: Facundo Ballester Pallarés and Javier Vijande Asenjo November 26, University of Valencia
  TESEO: 2084139

7 ANNEXES Masters 2021

THEORETICAL PHYSICS

• Long-lived particles and neutrino mass models
Rebeca Beltrán Lloría
Advisor: Martin Hirsch

• Matter-antimatter asymmetry and neutrino masses
Lara Blanco Dios
Advisors: Pilar Hernández Gamazo, Stefan Sandner

• Static characterization of radiation hard monolithic active pixel sensors
Daniel Doménech Azorín
Advisors: María Moreno Llácer, Carlos Mariñas Pardo, Ricardo Marco Hernández

• Quantum effects in cosmological black holes
Diego Fernández Silvestre
Advisor: Alessandro Fabbri

• Theoretical and phenomenological studies of left-right symmetric models
Sergio Ferrando Solera
Advisor: Antonio Pich Zardoya

• The scotogenic model of neutrino masses and dark matter in warped extra dimensions
Agustín Matías Galante Cerviño
Advisors: Juan Herrero García, Andrea Donini

• Noise and decoherence phenomena in quantum computers
Rafael Gómez Lurbe
Advisors: Armando Pérez, Mari Carmen Bañuls, Inés de Vega

• Bariogenesis espontanea
Teresa Guallart Naval
Advisor: Gabriela Barenboim

• Particle creation in curved space-times with non-Riemannian geometric structures
Tono Llin Calabuig
Advisors: Gonzalo Olmo Alba, Adrià Delhom i Latorre

• Neutrinos and asymmetric dark matter
Raquel López González
Advisors: Claudia Hagedorn, Jacobo López Pavón

• Clasificación de jets en desintegraciones ttbar de resonancias pesadas usando técnicas de Machine Learning
Jorge Juan Martínez de Lejarza Samper
Advisors: José Francisco Salt Cairols, José Julio Lozano Bahilo

• Two-Higgs-Doublet Models and Flavour Symmetries
Carlos Miró Arenas
Advisors: Francisco J. Botella Olcina, Miguel Nebot Gómez

• T-matrix and effective field theory studies of charm and beauty states
Víctor Montesinos Llácer
Advisors: Juan M. Nieves Pamplona, Miguel Albaladejo Serrano

• Neutrino masses in inverse seesaw models
Andrés Mora Martínez
Advisor: Avelino Vicente Montesinos

• Using neutrino oscillations data to constrain the parameter space of the warped 3+2 seesaw model
Alejandro Muñoz Ovalle
Advisor: Andrea Donini

• Into the Ambiguities of Quantum Field Theory in Curved Spacetime and their Physical Implications
Daniel Alexander Musson Gómez
Advisors: José Navarro-Salas, Antonio E. Ferreiro De Aguiar

• Monopols magnètics primitius
Daniel Queiroz Correa
Advisor: Óscar Manuel Vives García

• Detección de Anomalías aplicada a la búsqueda de Materia Oscura
Víctor Soto Larrosa
Advisor: Verónica Sanz González

• Búsqueda de Simetrías en la Naturaleza con Técnicas de Machine Learning
Gabriel Andy Szalkowski
Advisors: Gabriela Alejandra Barenboim Szuchman, Johannes Hirn, Verónica Sanz González

NUCLEAR AND PARTICLES PHYSICS

• Studies related to new physics searches at the LHC with the ATLAS detector
Sergio Javier Arbiol Val
Advisor: Luca Fiorini

• Caracterización de periodos en curvas de luz: análisis de series temporales y máximum likelihood blocks en curvas de rayos gamma
Javier Beltrán Oltra
Advisors: Juan de Dios Zornoza Gómez, Agustín Sánchez Losa

• Determining supernova properties with coherent elastic neutrino-nucleus scattering in liquid xenon dark matter detectors
Leire Larizgoitia Arcocha
Advisors: Francesc Monrabal Capilla, Sergio Palomares Ruiz

• Track reconstruction algorithms in the ANTARES and KM3NeT neutrino telescopes
Alfonso Lazo Pedrajas
Advisors: Juan Zúñiga Román, Francisco Salesa Greus

• Probing the top quark Yukawa coupling and possible new physics effects in the ttbarH and tH processes
Luis Marcos López Casines
Advisors: María Moreno Llácer, Marcos Miralles López

• Colaboración con el proyecto NEXT: Estudio del comportamiento del plano de tracking
Ana Quintana García

7 ANNEXES Masters 2021

Advisors: Justo Martín-Albo Simón, Neus López March

• Measurement of the Higgs boson produced in association with top quarks snd decaying to tau leptons at sqrt(s) = 13 TeV with the ATLAS detector
Enrique Valiente Moreno
Advisor: Joaquín Poveda Torres

PHOTONICS

• Dynamical analysis of electron transport in RF cavities and photomultipliers tubes
Pablo Martín Luna
Advisors: Benito Gimeno Martínez, Daniel González Iglesias

8 ANNEXES Grants

NATIONAL GRANTS

• 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)

• Red LHC
Ref. RED2018-102340-T
PI: Carmen García García
20,000 € (Jan 2020 − Dec 2021)

• Spanish Participation in European Research Infrastructures in Particle, Astroparticle and Nuclear Physics
Ref. RED2018-102573-E
PI: Antonio Pich Zardoya
60,000 € (Jan 2020 − Dec 2021)

• 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)

• 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)

• Refigerador CO2 y Cámara Infrarrojos para sala blanca del IFIC
Ref. EQC2019-005693-P
PI: Carlos Lacasta Llacer
138,919 € (Jan 2019 − Dec 2021)

• Laboratorio de Certificación Electro-Óptica (CEOLAB)
Ref. EQC2019-006066-P
PI: César Domingo Pardo
399,639 € (Jan 2019 − Dec 2021)

• Infraestructura de Cálculo de 87 nodos con 3480 cores y 16,7 TB Ram. Almacenamiento con capacidad de 1200 TB
Ref. EQC2019-006074-P
PI: José Fco. Salt Cairols
814,885 € (Jan 2019 − Dec 2021)

• Buscando pistas de nueva física de altas energías en el LHC/ATLAS y en colisionadores e+e: Alta precisión y búsquedas directas
Ref. PGC2018-094856-B-100

8 ANNEXES Grants

PI: Juan A. Fuster Verdú
181,500 € (Jan 2019 − Dec 2021)

• Construcción y operación del detector NEXT-100
Ref. RTI2018-095979-B-C42
PI: Michel Sorel
493,680 € (Jan 2019 − Dec 2021)

• Contribución a la operación del Experimento ATLAS del Detector In- terno de Trazas, del Calorímetro Hadrónico y a su Programa de Física
Ref. RTI2018-100863-B-100
PI: Salvador Martí García
1,188,220 € (Jan 2019 − Dec 2021)

• Física Fundamental y Astronomía Multimensajero con telescopios de neutrinos
Ref. PGC2018-096663-B-C41
PI: Juan de Dios Zornoza Gómez
744,150 € (Jan 2019 − Dec 2021)

• Upgrade del detector ATLAS: electrónica del Tile Calorimeter y explotación del Programa de Física
Ref. RTI2018-094270-B-I00
PI: Luca Fiorini
940,170 € (Jan 2019 − Dec 2021)

EUROPEAN UNION GRANTS

• 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 − Sep 2023)

• 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 − May 2023)

• 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 2023)

• 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 2023)

• High-sensitivity Measurements of key stellar Nucleosynthesis reactions
ERC-2015-CoG Ref. 681740
PI: César Domingo Pardo
1,886,558 € (Jun 2016 – May 2021)

• Unraveled new physics at the LHC through the precision frontier
Ref. CA16201
PI: Germán Rodrigo García
560,000 € (Oct 2017 – Sep 2021)
224,856 € (July 2018 – June 2023)

REGIONAL GRANTS

• 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)

• 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)

• Biopsia guiada en cancer de mama mediante un sistema híbrido de imagen gamma y ultrasonidos
Ref. Valoritza i transfereix

8 ANNEXES Grants

(INNVA1/2020/35)
PI: Luis Caballero Ontanaya
149,789 € (Jan 2020 – Dec 2021)

• Diagnostico Inteligente para Radiografías con implementación en circuito integrado (DIRAC)
Ref. Valoritza i transfereix (INNVA1/2020/42)
PI: Francisco J. Albiol Colomer
148,272 € (Jan 2020 – Dec 2021)

• 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)

• Diagnostics and Online System for a Linear Injector of Carbon 6 +ions for hadron therapy
Ref. INNEST/2020/123
PI: Benito Gimeno Martínez
302,334 € (Jan 2020 – Dec 2021)

• 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)

• Astroparticulas y física de Altas Energías
Ref. PROMETEO/2018/165
PI: Mariam Tórtola Baixauli
336,597 € (Jan 2018 – Dec 2021)

• Física de precisión a altas energías: el LHC y futuros colisionadores
Ref. PROMETEO/2018/060
PI: Juan A. Fuster Verdú
252,960 € (Jan 2018 – Dec 2021)

• Nuevas interacciones en la frontera de altas energías
Ref. PROMETEO/2017/053
PI: Antonio Pich Zardoya
392,000 € (Nov 2017 – Oct 2021)

• De la física del LHC a las claves del universo primordial en la era de los datos
Ref. PROMETEO/2017/033
PI: Gabriela Barenboim Szuchman
381,625 € (Nov 2017 – Oct 2021)

• 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)

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• 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)

• 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 Mode
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 GRANTS

• 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)

• Cámaras compton para imagen médica
Ref. 20215CT028
PI: Nuria Rius Dionis
15,000 € (Oct 2021 – Nov 2021)

• Horno de soldadura y estereomicroscopio
Ref. FAS2021_043
PI: José Bernabeu Verdu
45,790 € (Jan 2021 – Dec 2021)

• 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)

• Cosmology, Black Holes, and Metric-Affine Gravity
Ref. COOPB20462
PI: Gonzalo Olmo Alba
22,950 € (Jan 2020 – Dec 2021)

• 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)

• Screening radiográfico de inspección de tórax en pacientes COVID19
Ref. Cov20-0075
PI: Francisco J. Albiol Colomer
130,000 € (May 2020 – Apr 2021)

• Recordando a Lise Meitner. Drama en un acto sobre ciencia y traición
Ref. FECYT
PI: Ana I. Morales Lopez
45,000 € (Jul 2020 – Jun 2021)

• Sistema híbrido de imagen GAMma y UltraSonidos para biopsia guiada en cáncer de mama GAMUS
Ref. VALORITZA I TRANSFEREIX 2020
PI: Luis Caballero Ontanaya
60,000 € (Jul 2020 – Jul 2021)

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

8 ANNEXES Grants

• INCONI-Intercomparison of Compton cameras for nuclear imaging
Ref. PIC2018FR0032
PI: Gabriela Llosá Llácer
10,000 € (Jan 2019 – Dec 2021)

• Apoyo a la Creación de una Unidad Científica de innovación Empresarial en el Instituto de Física Corpuscular
Ref. 201850E066
PI: Juan A. Fuster Verdú
144,000 € (May 2018 – April 2021)

TECHNOLOGY TRANSFER GRANTS

• 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)

• Convenio UCIE 2021
PI: Nuria Rius Dionis
250,000 € (Jan 2021 – Dec 2021)

• 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 para la realización de una tarjeta TileCal Compact Processing Modules para Clermont-Ferrand
Ref. OTR2020-21229 Servi
PI: Luca Fiorini
14,800 € (Jul 2020 – Mar 2021)

• Contrato licencia exclusiva de software "predicciones para el sector eléctrico"
Ref. 20162171
PI: Francisco Albiol Colomer
7,073 € (Apr 2016 – Apr 2021)

• 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)

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Images and vectors references

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