ANNUAL

REPORT

2020

INSTITUTO DE FÍSICA CORPUSCULAR

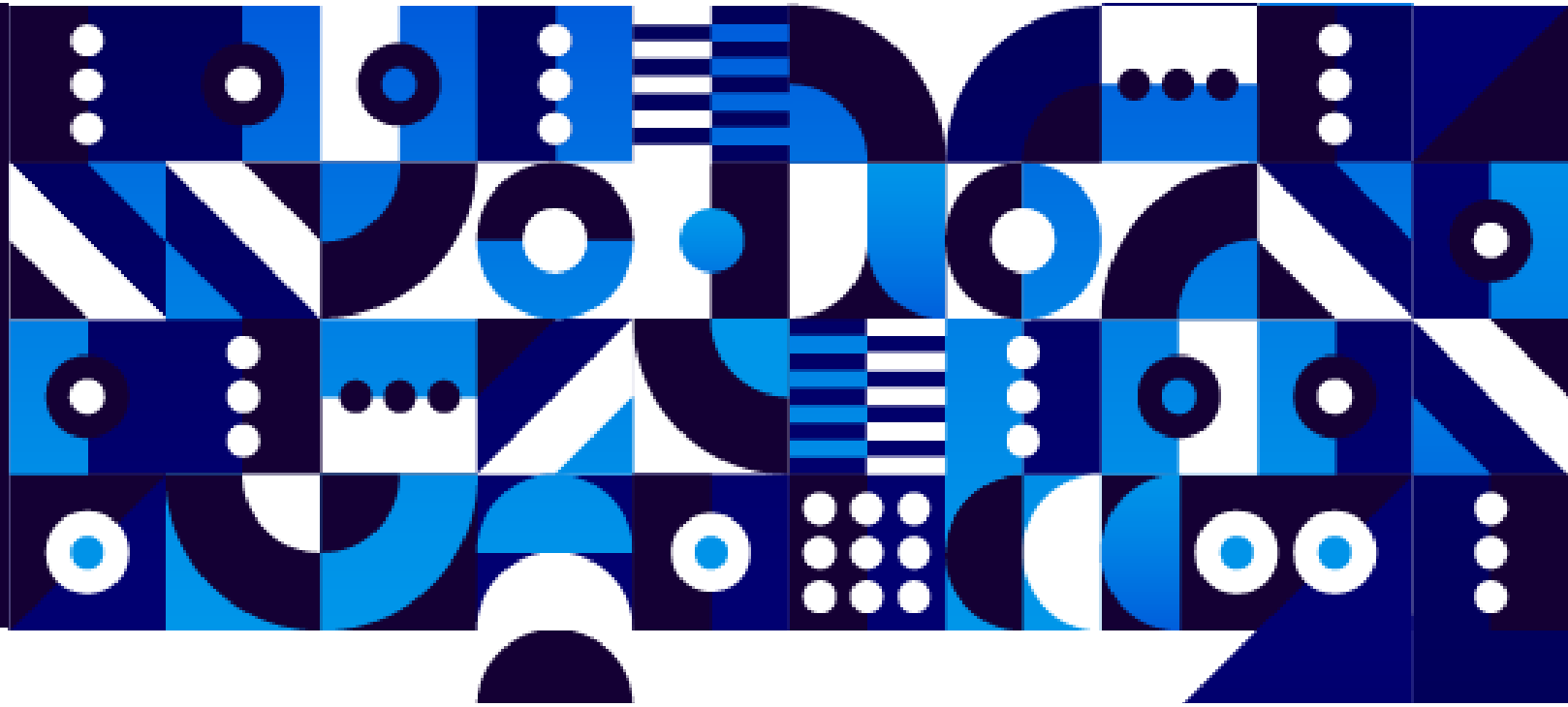
IFIC

INSTITUT DE FÍSICA CORPUSCULAR

VNIVERSITAT DE VALÈNCIA

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



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WELCOME

1 DIRECTOR LETTER

Español

El año 2020 ha supuesto un cambio drástico y totalmente inesperado en nuestra actividad diaria como consecuencia del estallido de la pandemia de COVID19 a principios de marzo. Quiero resaltar el esfuerzo de las unidades de informática y mantenimiento del IFIC desde el primer momento, gracias a las cuales todos los demás pudimos continuar realizando nuestro trabajo desde casa en un tiempo récord, y de forma puntual presencialmente cuando ha sido imprescindible. También agradezco la responsabilidad de todo el personal del IFIC ante esta situación, así como su colaboración y compromiso.

La crisis sanitaria nos ha hecho cambiar de paradigma completamente. A pesar de las enormes dificultades, gracias a la rápida adaptación a la actividad online la producción científica del instituto no ha disminuido por el confinamiento: 392 artículos publicados en 2019 y 421 en 2020. La mayor parte de los experimentos sí que han sufrido retrasos y también la participación en congresos internacionales se ha visto afectada, ya que muchos de ellos fueron cancelados. Algunos en cambio han tenido lugar virtualmente, por ejemplo Neutrino 2020, conferencia bienal a la que investigadores del IFIC han sido invitados ininterrumpidamente desde 1998 hasta 2020.

La pandemia, al poner el foco en la ciencia y en la repercusión de ésta en la sociedad, nos ha sensibilizado más sobre el retorno de nuestra investigación, lo cual también se ha reflejado en las actividades del IFIC en 2020. Durante los meses de confinamiento, se fabricaron soportes para máscaras protectoras para los sanitarios cuando faltaban mascarillas. Se organizaron charlas de divulgación online, tanto para el alumnado de Bachillerato a través del canal de YouTube del IFIC como las “Charlas para el confinamiento”, en colaboración con el Museo de la Ciencia. Los investigadores expertos en Inteligencia Artificial han aplicado su experiencia previa en reconstrucción de imagen para acelerar el triaje de enfermos con COVID-19 y para clasificar las neumonías de pacientes afectados por el coronavirus SARS-CoV-2 (proyecto financiado por el Instituto de Salud Carlos III).

Como consecuencia de mirar más hacia la sociedad, se han reforzado las actividades interdisciplinares y la transferencia de conocimiento, que ya era una prioridad impulsar para el IFIC. Así, en 2020 hemos desdoblado nuestra línea de investigación “Instrumentación avanzada y computación: de la Física fundamental a la sociedad” en dos sublíneas: L7 “Instrumentación avanzada y computación en física fundamental”, que se centra en la investigación básica en física de partículas, astropartículas y nuclear, y L8 “Instrumentación avanzada y computación para la sociedad”, que aglutina todas las aplicaciones de la tecnología frontera desarrollada en la mencionada investigación básica, tanto en instrumentación como en computación y en particular en Inteligencia Artificial, a diferentes sectores de la sociedad, tales como física médica o seguridad nuclear.

En 2020 el CSIC promovió la elaboración de un “Libro Blanco” sobre los desafíos científicos y tecnológicos en todas las áreas de investigación cubiertas por el CSIC. La investigadora del IFIC María José Costa es la coordinadora de la temática estratégica 9, “Comprensión de los componentes básicos del universo, su estructura y evolución” y miembros del IFIC han colaborado en la elaboración de las temáticas 4 ``Retos de Biomedicina y Salud”, 8 ``Energía limpia, segura y eficiente”, 10 ``Información compleja y digital” y 11 ``Inteligencia artificial, ciencia de datos y robótica”.

En 2020 se unieron al IFIC numerosos investigadores dentro de los programas de atracción de talento Ramón y Cajal y GenT de la Generalitat Valenciana. Es vital para el instituto este relevo generacional, manteniendo nuestro liderazgo en las áreas donde somos referentes internacionalmente y reforzando las líneas emergentes.

Dado que las nuevas incorporaciones se produjeron durante un periodo con muy poca interacción debido a las medidas sanitarias, en noviembre organizamos una Jornada de bienvenida para el personal postdoctoral, que tuvo que ser online pero esperamos repetir anualmente de forma presencial. También las Jornadas Tecnológicas en 2020, actividad bienal del IFIC, fueron virtuales.

Investigadores del IFIC han asumido en este año importantes responsabilidades internacionales: Berta Rubio ha sido nombrada co-spokeperson de la colaboración NUSTAR, Pilar Hernández se ha incorporado al comité de política científica del CERN, y Juanjo Hernández es miembro del Consejo Científico asesor del Centro Nacional para la Investigación Científica de Francia (CNRS).

Finalmente, pero no menos importante, quiero reconocer una vez más el trabajo y dedicación de todos los miembros del IFIC, tanto el personal docente e investigador como el personal técnico, de administración y comunicación, que han hecho posibles las numerosas actividades descritas en esta memoria, especialmente en este año tan complicado.

Nuria Rius

Directora del IFIC

1 DIRECTOR LETTER

Valencià

L'any 2020 ha suposat un canvi dràstic i totalment inesperat en la nostra activitat diària com a conseqüència de l'esclat de la pandèmia de COVID19 a principis de març. Vull ressaltar l'esforç de les unitats d'informàtica i manteniment del IFIC des del primer moment, gràcies a les quals tots els altres vam poder continuar fent el nostre treball des de casa en un temps rècord, i de manera puntual presencialment quan ha sigut imprescindible. També agraïsc la responsabilitat de tot el personal del IFIC davant aquesta situació, així com la seua col·laboració i compromís.

La crisi sanitària ens ha fet canviar de paradigma completament. Malgrat les enormes dificultats, gràcies a la ràpida adaptació a l'activitat online la producció científica de l'institut no ha disminuït pel confinament: 392 articles publicats en 2019 i 421 en 2020. La major part dels experiments sí que han patit retards i també la participació en congressos internacionals s'ha vist afectada, ja que molts d'ells van ser cancel·lats. Alguns en canvi han tingut lloc virtualment, per exemple Neutrí 2020, conferència biennal a la qual investigadors del IFIC han sigut convidats ininterrompudament des de 1998 fins a 2020.

La pandèmia, en posar el focus en la ciència i en la repercussió d'aquesta en la societat, ens ha sensibilitzat més sobre el retorn de la nostra investigació, la qual cosa també s'ha reflectit en les activitats del IFIC en 2020. Durant els mesos de confinament, es van fabricar suports per a màscares protectores per als sanitaris quan faltaven mascarete. Es van organitzar xarrades de divulgació online, tant per a l'alumnat de Batxillerat a través del canal de YouTube del IFIC com les "Xarrades per al confinament", en col·laboració amb el Museu de la Ciència. Els investigadors experts en Intel·ligència Artificial han aplicat la seua experiència prèvia en reconstrucció d'imatge per a accelerar el triatge de malalts amb COVID-19 i per a classificar les pneumònies de pacients afectats pel coronavirus SARS-CoV-2 (projecte finançat per l'Institut de Salut Carles III).

Com a conseqüència de mirar més cap a la societat, s'han reforçat les activitats interdisciplinàries i la transferència de coneixement, que ja era una prioritat impulsar per al IFIC. Així, en 2020 hem desdoblegat la nostra línia d'investigació "Instrumentació avançada i computació: de la Física fonamental a la societat" en dues sublíneas:

L7 "Instrumentació avançada i computació en física fonamental", que se centra en la investigació bàsica en física de partícules, astropartícules i nuclear, i L8 "Instrumentació avançada i computació per a la societat", que aglutina totes les aplicacions de la tecnologia frontera desenvolupada en l'esmentada investigació bàsica, tant en instrumentació com en computació i en particular en Intel·ligència Artificial, a diferents sectors de la societat, com ara física mèdica o seguretat nuclear.

En 2020 el CSIC va promoure l'elaboració d'un "Llibre blanc" sobre els desafiaments científics i tecnològics en totes les àrees d'investigació cobertes pel CSIC. La investigadora del IFIC María José Costa és la coordinadora de la temàtica estratègica 9, "Comprensió dels components bàsics de l'univers, la seua estructura i evolució" i membres del IFIC han col·laborat en l'elaboració de les temàtiques 4 ``Reptes de Biomedicina i Salut", 8 ``Energia neta, segura i eficient", 10 "Informació complexa i digital" i 11 "Intel·ligència artificial, ciència de dades i robòtica".

En 2020 es van unir al IFIC nombrosos investigadors dins dels programes d'atracció de talent Ramón y Cajal i GenT de la Generalitat Valenciana. És vital per a l'institut aquest relleu generacional, mantenint el nostre lideratge en les àrees on som referents internacionalment i reforçant les línies emergents.

Atés que les noves incorporacions es van produir durant un període amb molt poca interacció a causa de les mesures sanitàries,

al novembre organitzem una Jornada de benvinguda per al personal postdoctoral, que ha hagut de ser online però esperem repetir anualment de manera presencial. També les Jornades Tecnològiques, activitat biennal del IFIC, en 2020 van ser virtuals.

Investigadors del IFIC han assumit en aquest any importants responsabilitats internacionals: Berta Rubio ha sigut nomenada co-spokeperson de la col·laboració NUSTAR, Pilar Hernández s'ha incorporat al comité de política científica del CERN, i Juanjo Hernández és membre del Consell Científic assessor del Centre Nacional per a la Investigació Científica de França (CNRS).

Finalment, però no menys important, vull reconéixer una vegada més el treball i dedicació de tots els membres del IFIC, tant el personal docent i investigador com el personal tècnic, d'administració i comunicació, que han fet possibles les nombroses activitats descrites en aquesta memòria, especialment en aquest any tan complicat.

Nuria Rius

Directora del IFIC

1 DIRECTOR LETTER

English

The year 2020 has meant a drastic and totally unexpected change in our daily activity as a result of the outbreak of the COVID-19 pandemic at the beginning of March. I want to highlight the effort of IFIC's IT and maintenance units from the very beginning. Thanks to these units, all the rest of us were able to continue doing our work from home in record time, and in-person at IFIC when it was essential. I also appreciate the responsibility of all IFIC staff in this situation, as well as their collaboration and commitment.

The health crisis completely changed our work paradigm. Despite the enormous difficulties, thanks to the rapid adjustment to the online activity, the scientific production of the institute has not diminished due to confinement: 392 articles published in 2019 and 421 in 2020. Most experiments did suffer delays. Participation in international congresses has also been affected, with many of them cancelled. Some instead have taken place virtually, for example Neutrino 2020, a biennial conference to which IFIC researchers have been invited uninterruptedly from 1998 to 2020.

The pandemic, by putting the focus on science and its impact on society, has made us more aware of the outcome of our research, which has also been reflected in IFIC's activities in 2020. During the months of confinement, holders for protective masks were made for health personnel, when masks were missing. Online dissemination talks were organized, both talks for Bachelor students through IFIC's YouTube channel and the "Lockdown Talks", in collaboration with the Science Museum. Researchers who are experts in Artificial Intelligence have applied their previous experience in image reconstruction to accelerate the triage of patients with COVID-19 and to classify the pneumonias of patients affected by the SARS-CoV-2 coronavirus (project funded by the Instituto de Salud Carlos III).

As a consequence of looking more towards society, interdisciplinary and knowledge transfer activities have been reinforced, the latter already being a priority for IFIC to promote. Thus, in 2020 we have divided our line of research "Advanced instrumentation and computing: from fundamental physics to society" into two sub-lines:

L7 "Advanced instrumentation and computing for fundamental physics", which focuses on basic research in particle, astroparticle and nuclear physics, and

L8 "Advanced instrumentation and computing for societal challenges", which brings together all the applications of the frontier technology developed in the aforementioned basic research, both in instrumentation and in computing, and in particular in Artificial Intelligence, to different sectors of society, such as medical physics or nuclear safety.

In 2020, the CSIC promoted the preparation of "White Books" on the scientific and technological challenges for the coming decades in all the research areas covered by CSIC. IFIC researcher María José Costa was the coordinator of the thematic area 9, "Understanding the basic components of the universe, its structure and evolution" and IFIC members have collaborated in the preparation of theme 4 "Challenges in biomedicine and health", 8 "Clean, safe and efficient energy", 10 "Digital and complex information" and 11 "Artificial intelligence, robotics and data science".

In 2020, several researchers joined IFIC through the talent attraction programs Ramón y Cajal and GenT, the latter of the Generalitat Valenciana. This generational transition is vital for the institute, maintaining our leadership in the areas where we are already established internationally and reinforcing the emerging lines.

Given that the new recruitments occurred during a period with very little interaction due to the sanitary measures, in November we organized a Welcome Day for postdoctoral staff. This year the event had to be online, but we hope to repeat it annually in person. The 2020 Technology Days, a biennial activity at

IFIC, were also held virtually.

IFIC researchers have assumed important international responsibilities this year: Berta Rubio has been appointed co-spokeperson of the NUSTAR collaboration, Pilar Hernández has joined CERN science policy committee, and Juanjo Hernández has been appointed member of the Scientific Advisory Board of the French National Center for Scientific Research (CNRS).

Last but not least, I would like to acknowledge once again the work and dedication of all IFIC members, both the teaching and research staff as well as the technical, administrative and communication staff, who have made possible the many activities described in this report. Especially in this difficult year.

Nuria Rius

Directora del IFIC

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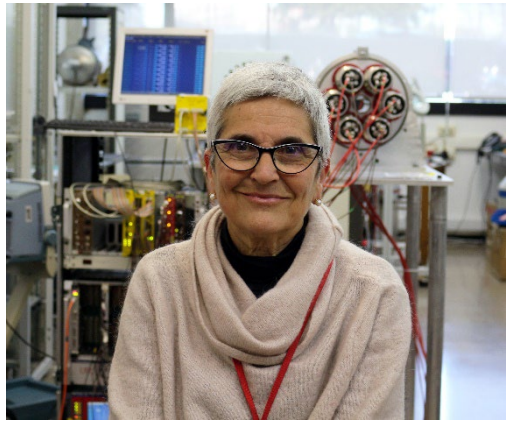
HIGHLIGHTS OF THE YEAR

2 HIGHLIGHTS OF THE YEAR

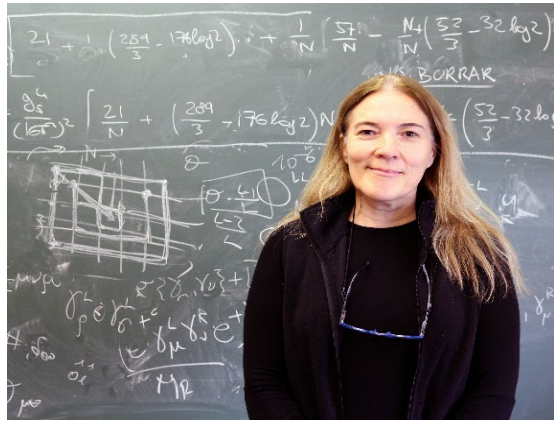
BERTA RUBIO, CO-SPOKESPERSON OF ONE OF THE MAIN EXPERIMENTAL LINES OF THE FUTURE NUCLEAR PHYSICS LABORATORY FAIR



IFIC researcher Berta Rubio Barroso has been elected co-spokesperson of NUSTAR, a scientific collaboration of 700 members and 170 institutions that forms one of the pillars of FAIR, the future nuclear physics research facility being built in Darmstadt (Germany). At FAIR, the most intense beams of radioactive nuclei in the world will be produced. More information here.

IFIC RESEARCHER PILAR HERNÁNDEZ, MEMBER OF THE CERN SCIENTIFIC POLICY COMMITTEE

Pilar Hernández Gamazo, has been appointed member of the Scientific Policy Committee (SPC) of the European Particle Laboratory, CERN, the largest fundamental physics research center in the world. This committee was created at the origins of CERN in 1954 as a consulting body to establish the scientific objectives of the laboratory, and is composed up of prestigious scientists from all over the world. More information here.



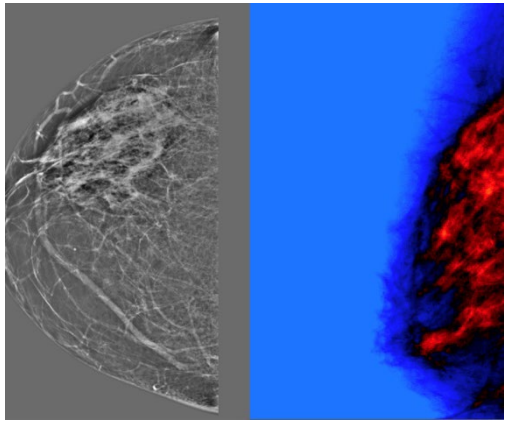
2 HIGHLIGHTS OF THE YEAR

JUAN JOSÉ HERNÁNDEZ REY, MEMBER OF THE SCIENTIFIC COUNCIL OF THE MAIN FRENCH RESEARCH ORGANIZATION

Juan José Hernández Rey has been appointed member of the Scientific Council of the National Center for Scientific Research (CNRS), the main research organization in France. The Scientific Council is the body that advises on the basic lines of research of the CNRS and its strategic planning. It is made up of 30 members, of which 8 are foreign research staff of recognized prestige. More information here.

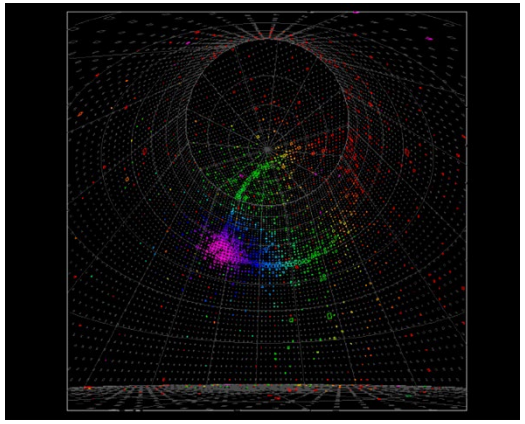
ARTIFICIAL INTELLIGENCE COMBINED WITH RADIOLOGIST EVALUATIONS IMPROVES THE ACCURACY OF MAMMOGRAMS

An international group of researchers, including IFIC members, shows that Artificial Intelligence techniques, used in combination with the evaluation of expert radiologists, improve the accuracy of cancer detection by mammography. The study, published in the Journal of the American Medical Association, is based on the results obtained in the Digital Mammography (DM) DREAM Challenge. More information here.



2 HIGHLIGHTS OF THE YEAR

THE T2K EXPERIMENT PRESENTS THE MOST PRECISE RESULTS ON THE DIFFERENCES BETWEEN MATTER AND ANTIMATTER IN NEUTRINOS



The T2K Collaboration has published new results, the most precise obtained to date, of the parameter that governs the symmetry breaking between matter and antimatter in neutrino oscillations. For the first time, T2K begins to reveal a basic property of neutrinos that has not been measured so far. These results have been published in the scientific journal Nature. More information here.

THE ANTARES EXPERIMENT PUBLISHES ITS RESULTS OF 11 YEARS OF SEARCHING FOR DARK MATTER

The ANTARES collaboration has published its most comprehensive results on the search for WIMPs, one of the most popular candidates for dark matter. These results are based on the analysis of more than 11,000 high-energy neutrinos collected during 11 years of operation of the world's first underwater neutrino telescope located in the Mediterranean Sea, an analysis led by IFIC researcher Rebecca Gozzini. More information here.

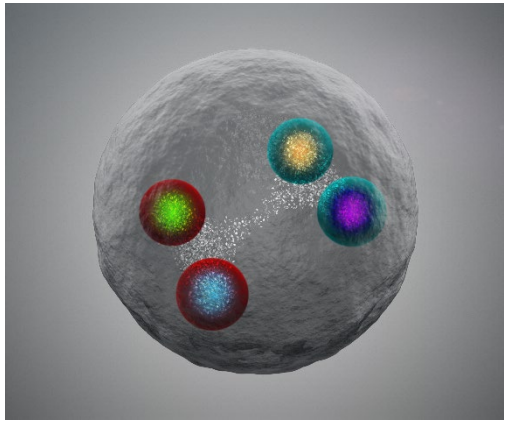
2 HIGHLIGHTS OF THE YEAR

ARTIFICIAL INTELLIGENCE TO ACCELERATE THE TRIAGE OF PATIENTS WITH COVID-19

In the fight against COVID-19, anticipation is key. An international team, with the participation of IFIC researcher Verónica Sanz González, has developed a method that uses Artificial Intelligence techniques to help in the early detection of pathologies associated with COVID-19 in patient X-rays. This system is openly available to the scientific and medical community. More information here.

THE LHCB EXPERIMENT DISCOVERS A NEW TYPE OF TETRAQUARK AT CERN

The LHCb collaboration has observed a type of particle composed of four quarks that has never been seen before. The discovery is likely to be the first of a previously undiscovered class of particles. The finding will help physicists to better understand the complex ways in which quarks are grouped together to form composite particles, such as the protons and neutrons in the nucleus of an atom. More information here.



2 HIGHLIGHTS OF THE YEAR

THE VALENCIAN INNOVATION AGENCY RENEWS THE SCIENTIFIC UNIT FOR BUSINESS INNOVATION AT IFIC

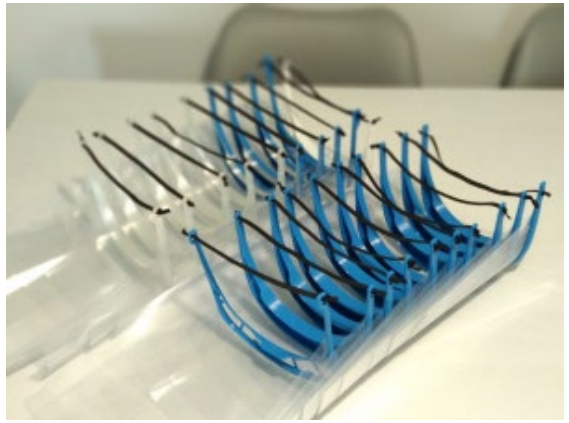
The Valencian Innovation Agency (AVI) has renewed the agreement to maintain IFIC's Scientific Unit for Business Innovation (UCIE). In its two years of existence, IFIC's UCIE has promoted the development of 10 innovative projects in collaboration with companies and with technological and research institutes of the Valencian Community. More information here.

IFIC PARTICIPATES IN A PROJECT TO MEASURE THE FLUX OF NEUTRONS FROM COSMIC RAYS

IFIC researchers participate in the HENSA project, a campaign to measure the flux of neutrons from cosmic rays in various locations in Spain. This flux is associated with specific failures in microcomputer systems that can affect telecommunications, is responsible for part of the radiation received during commercial flights, and can provide information on the interaction of solar activity with the atmosphere. More information here.

2 HIGHLIGHTS OF THE YEAR

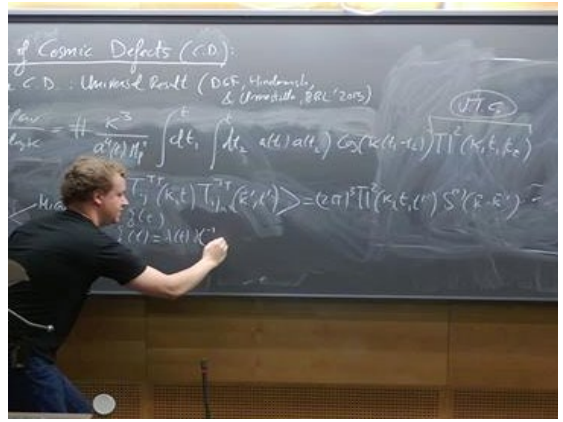
IFIC ACTIONS TO HELP ALLEVIATE THE COVID-19 HEALTH CRISIS



The 3D printers of several IFIC research groups have manufactured protective masks for the health personnel of Valencian hospitals. The IFIC has also made its computing infrastructure for Artificial Intelligence, Artemisa, available to the COVID-19 research community, in addition to developing a project for the early detection of pneumonia by analyzing X-rays with these techniques. More information here.

IFIC ONLINE TALKS IN TIMES OF LOCKDOWN

The Department of Theoretical Physics of the University of Valencia, the Science Museum and IFIC have organized the series of online conferences 'Physics for confinement' to bring physics closer to the general public in an entertaining and informative way. The IFIC outreach commission has organized a series of online talks aimed at students from secondary schools in the Valencian Community. More information here, here and here.



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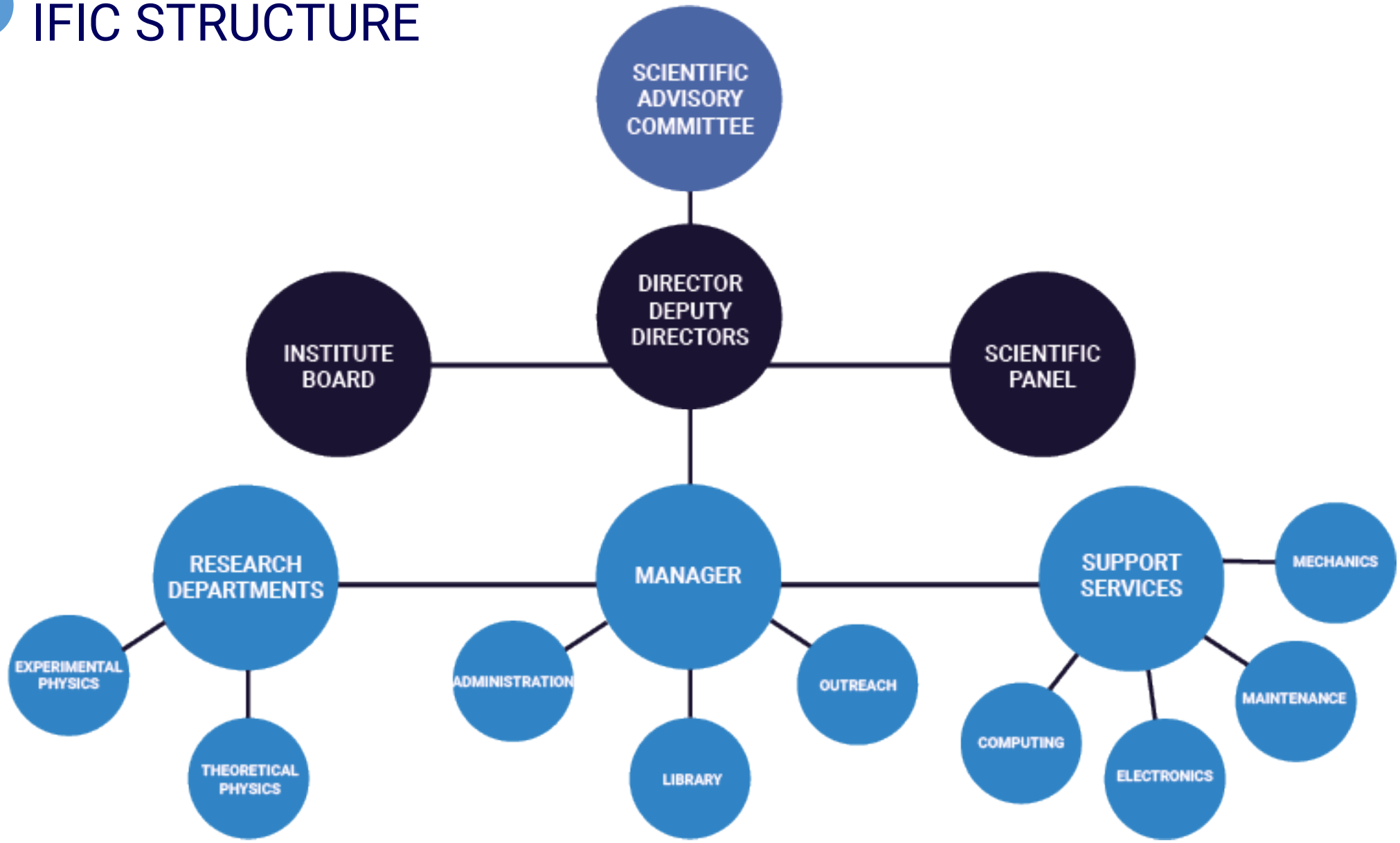
STRUCTURE AND ORGANIZATION

3 IFIC STRUCTURE



3 STRUCTURE


Director
Nuria Rius
Manager
Ana Fandos
Deputy Director
Santiago Noguera
Deputy Director
Berta Rubio
Deputy Director
Michel Sorel

3 STRUCTURE

Heads of the research departments

- Experimental Physics — Luca Fiorini
- Theoretical Physics — Germán Rodrigo

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)
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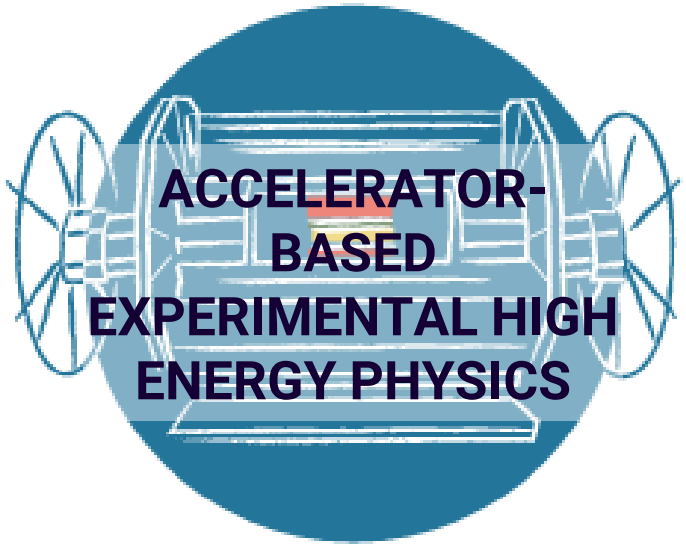
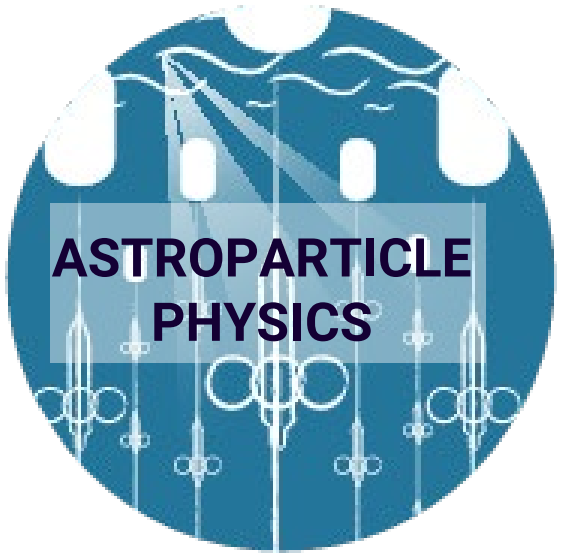
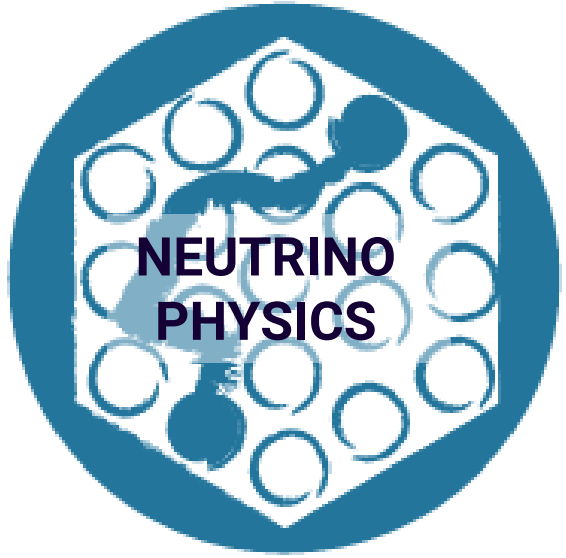
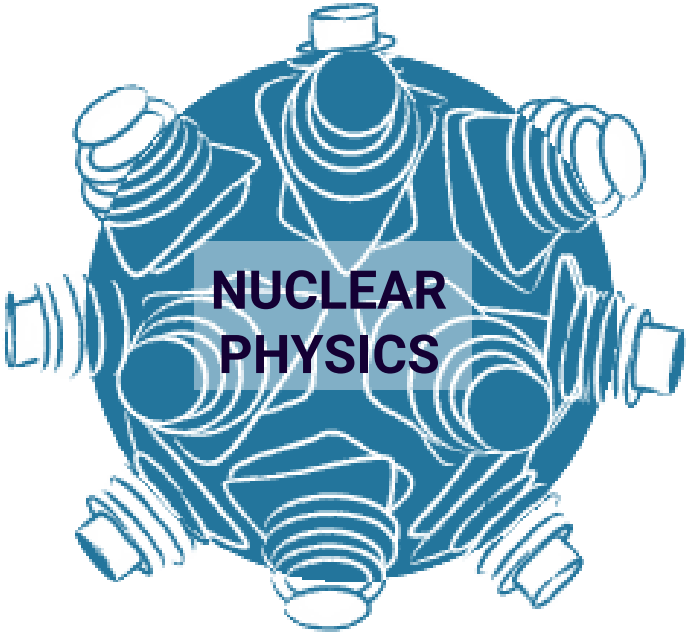
> Peter Jenni (Univ. Freiburg, Germany, and CERN, Switzerland)
> Antonio Maseiro (INFN and Univ. Padua, Italy)
> Tatsuya Nakada (EPFL Lausanne, Switzerland)
> Bing-Song Zou (ITP, Chinese Academy of Sciences, China)

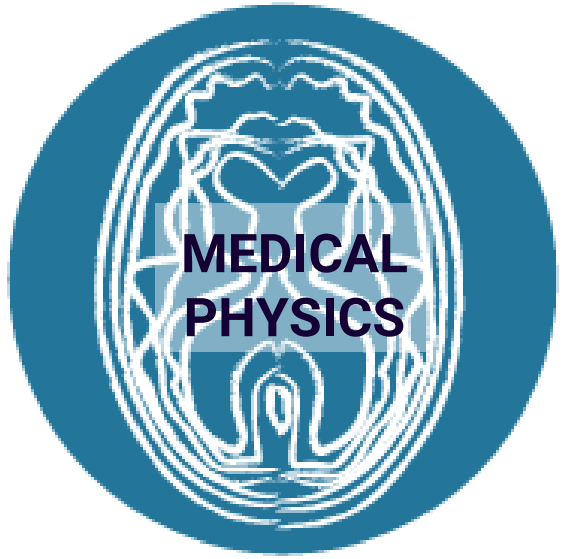
SCIENTIFIC DEPARTMENTS Experimental Physics



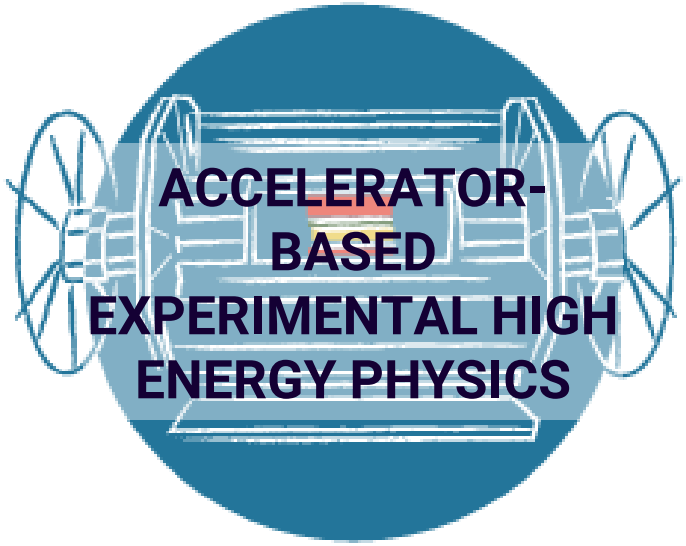




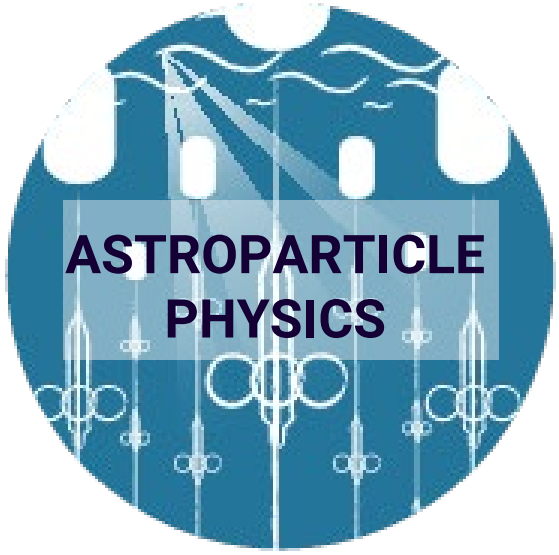




SCIENTIFIC DEPARTMENTS Experimental Physics

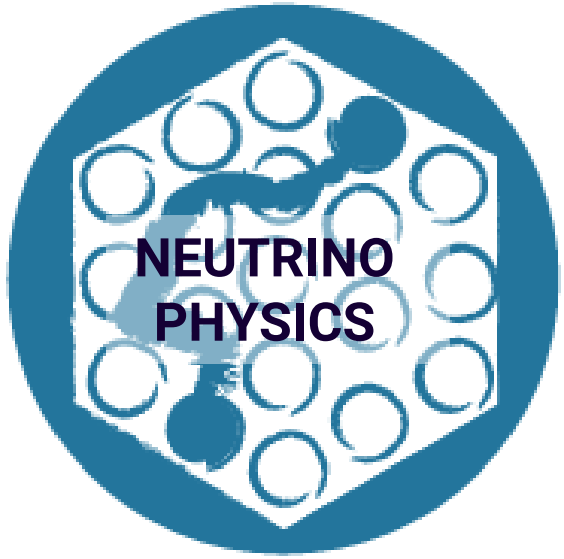


This research line takes advantage of large particle accelerators to study the most elementary components of matter. This line is focused on the Large Hadron Collider (LHC) at CERN. IFIC participates in the construction of several systems of the ATLAS detector at the LHC as well as in ATLAS computing and data management. IFIC also develops a high gradient radio-frequency facility for future linear colliders – such as the ILC and CLIC proposals - and for medical applications. IFIC also participates in the LHCb and MoEDAL experiments at the LHC, and in the Belle II experiment at SuperKEKB.

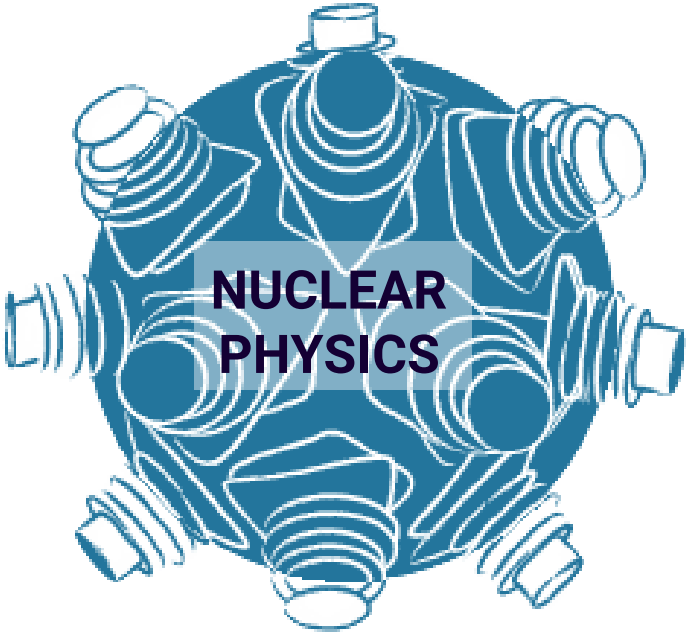


Astroparticle Physics studies the particles coming from the Cosmos in order to investigate both their properties and the Universe. The group at IFIC participates in the neutrino telescopes ANTARES and KM3NeT. The former is installed at a depth of 2500 metres in the Mediterranean seabed in the coast near Toulon, France, and it has been in operation since 2008. The latter, KM3NeT, is also being deployed in the Mediterranean Sea since 2016. Once completed, KM3NeT will have an effective detection volume of several cubic kilometres.

SCIENTIFIC DEPARTMENTS Experimental Physics



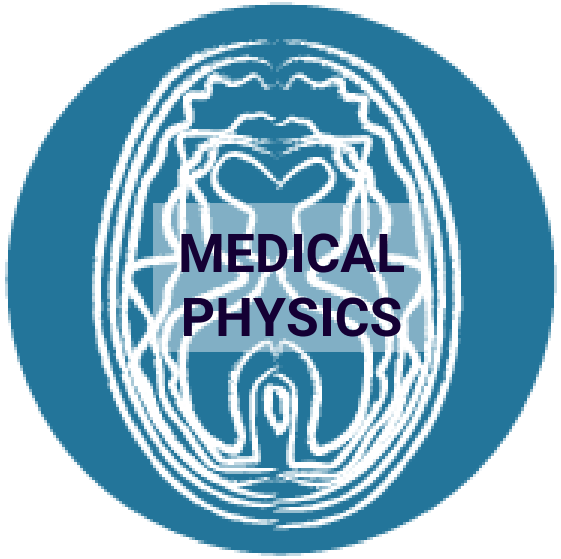
This research line studies the intrinsic properties of the neutrino. The group studies the phenomenon of oscillations between neutrino families. It also tries to elucidate the nature of the neutrino, namely whether the neutrino is a Majorana or a Dirac fermion. IFIC leads the NEXT experiment, searching for neutrinoless double beta decay at the Laboratorio Subterráneo de Canfranc (Spain). IFIC also participates in several accelerator-based oscillation experiments: the currently operating T2K experiment in Japan, and the next-generation DUNE experiment in the United States.



After more than a century since their discovery, atomic nuclei still keep many secrets and there is a wide variety of phenomena not fully understood yet. IFIC researchers in this line work in a broad range of studies in nuclear physics and its applications: gamma spectroscopy, extreme nuclear states, nuclear waste incineration, stellar nuclear reactions. Likewise, they are involved in the construction of the detectors and associated electronics for the AGATA project and for the large European infrastructure FAIR.

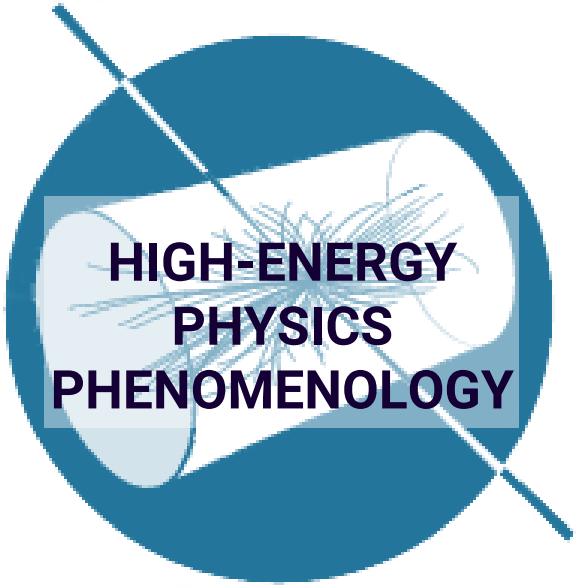
SCIENTIFIC DEPARTMENTS Experimental Physics

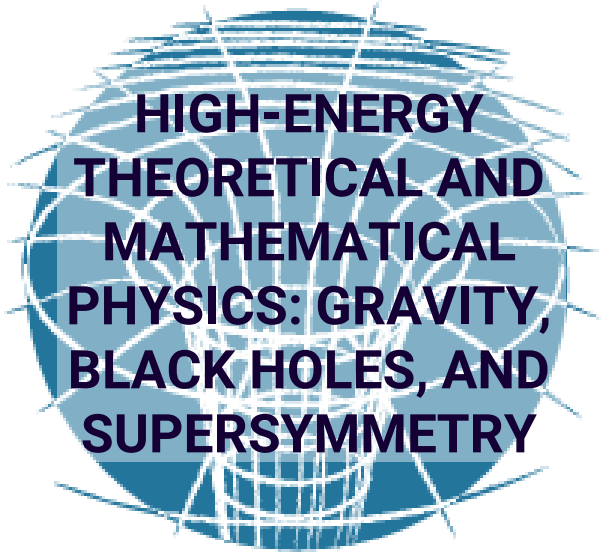
Particle physics experiments such as those of the LHC provide an enormous amount of data that must be recorded and processed. To overcome this challenge, a series of initiatives has been carried out to set up a worldwide network of computing nodes (GRID) communicating among themselves through a series of software protocols. IFIC participates in several of these initiatives with the aim of developing a model of distributed computing in Spain and in Europe. This type of development is also interesting for local industry and for other research fields.

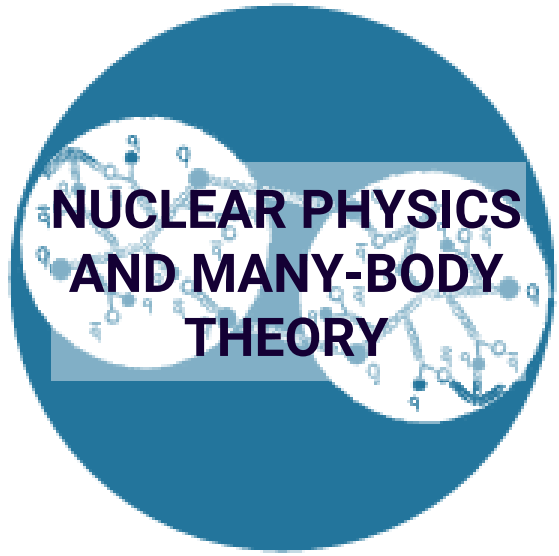


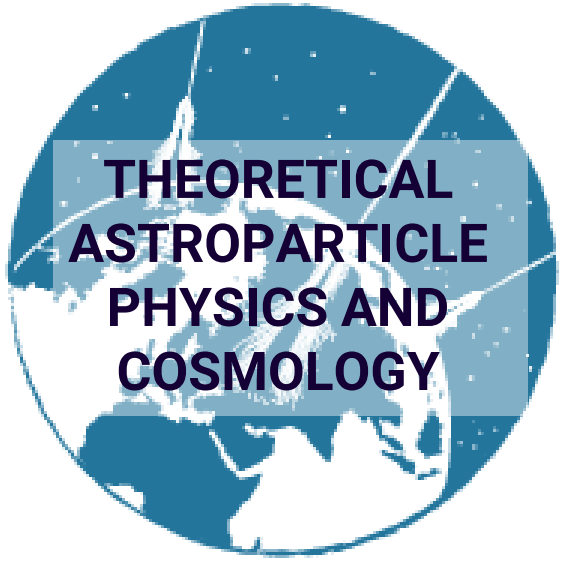
This research line is devoted to the biomedical applications of Particle and Nuclear Physics. Research includes detector development and beam instrumentation for positron emission tomography (PETALO project), as well as for dose monitoring and imaging for hadron therapy (MACACO project). The activities also cover developments in particle accelerating techniques for hadron therapy. Image reconstruction and artificial intelligence techniques are applied for intelligent diagnosis of various pathologies from X-rays. Dose calculation algorithms for internal radiotherapy are developed.

SCIENTIFIC DEPARTMENTS Theoretical Physics

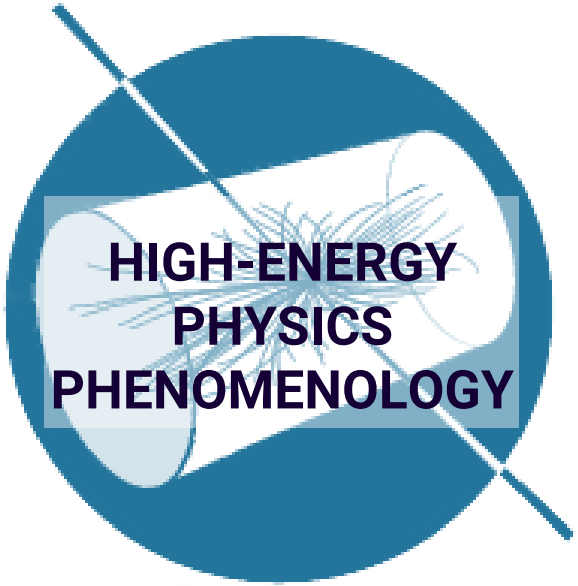




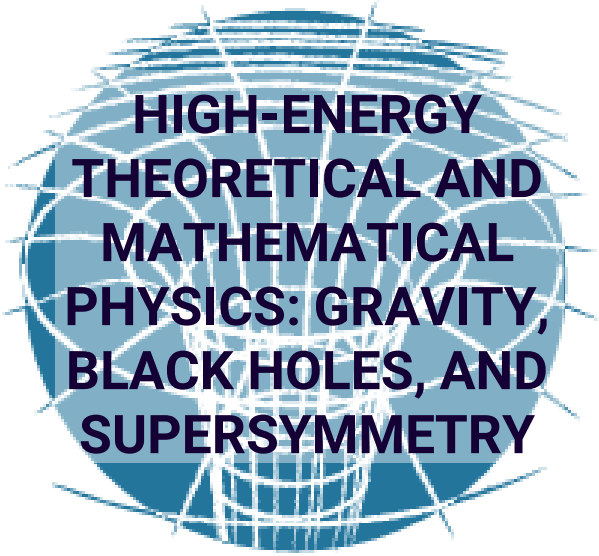




SCIENTIFIC DEPARTMENTS Theoretical Physics

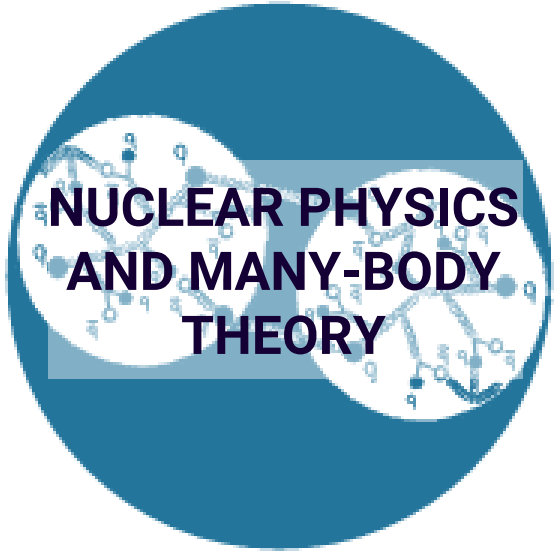


The main goals of high-energy physics phenomenology are the study of the Standard Model (SM) of the strong and electroweak interactions and the search for deviations from its predictions that could arise from SM extensions, such as supersymmetric models. This strategy includes the precise determination of the SM parameters and the phenomenological study of new signals arising from beyond-SM processes, with emphasis on the potential consequences for present and future high-energy experiments.



This line investigates the quantum processes in intense gravitational fields and the appearance of new space-time symmetries. The combination of Quantum Field Theory with General Relativity is studied, as well as its application to black holes (Hawking radiation) and to Cosmology (primitive universe and inflation). The classical and quantum aspects of the modification of Einstein's theory of gravity are also investigated, together with the use of supersymmetry and non-commutative geometries, in the search for a quantum theory of gravity.

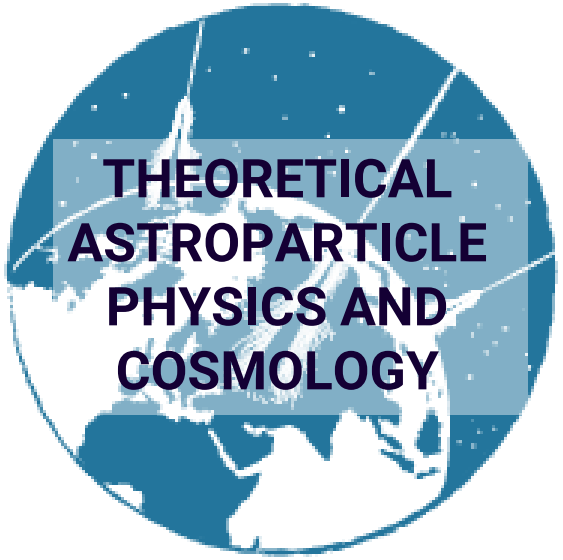
SCIENTIFIC DEPARTMENTS Theoretical Physics



This line studies the interactions between hadrons and within the nuclear medium, using effective theories built from symmetries of Quantum Chromodynamics (QCD), perturbative and non-perturbative methods. The recently discovered exotic hadronic states and their interactions are described and classified. In addition, the response of complex nuclei to electroweak probes is investigated using the hadronic effective formulation together with many-body field theory techniques, with direct impact on current and future neutrino experiments.

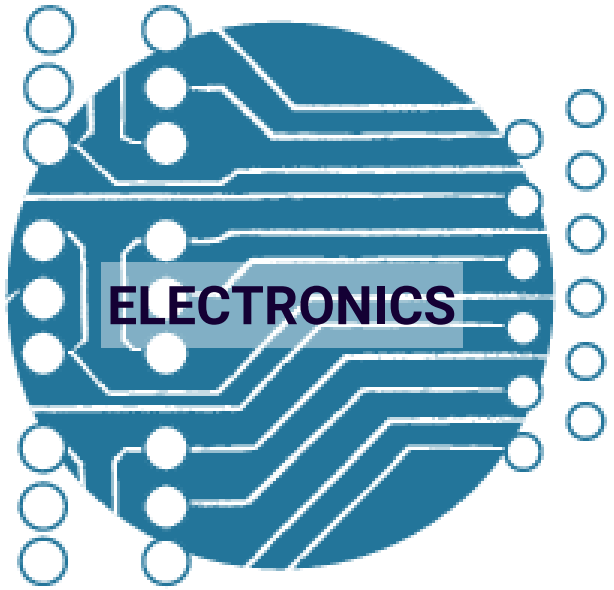
This line studies the strong interaction, the fundamental force describing the interactions between quarks and gluons. Several approaches are used, such as lattice gauge theories, effective field theories, chiral perturbation theory or phenomenological lagrangians. A variety of goals are pursued. For instance, the theoretical and phenomenological study of QCD in hadron colliders, the study of the hadronic phenomenology in the resonance region, such as in the hadron decays of the tau lepton or in the semileptonic decays of the D mesons, and others.

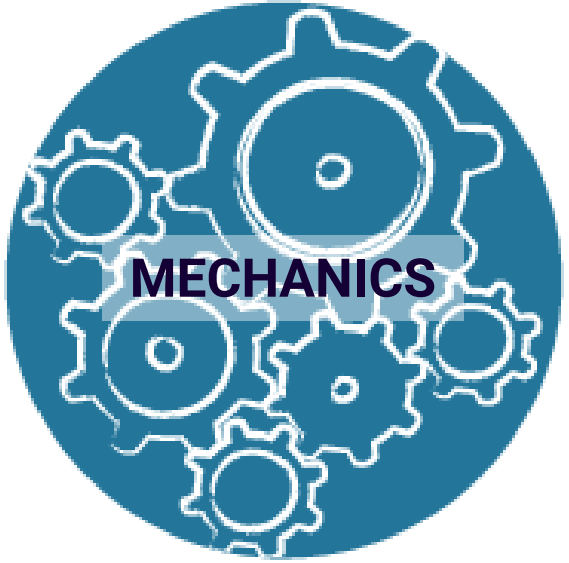
SCIENTIFIC DEPARTMENTS Theoretical Physics



This line covers several interdisciplinary aspects of astroparticle physics and cosmology. Among others it is worth mentioning the basic properties of neutrinos and the future experiments in this field, the origin of neutrino mass and their mixing angles, neutrinos as messengers in astrophysics and cosmology, baryogenesis and leptogenesis, dark matter, ultra-high-energy cosmic rays and others. Although driven by phenomenology, there is space for theoretical ideas on aspects such as inflation, dark matter or dark energy.

SUPPORT UNITS



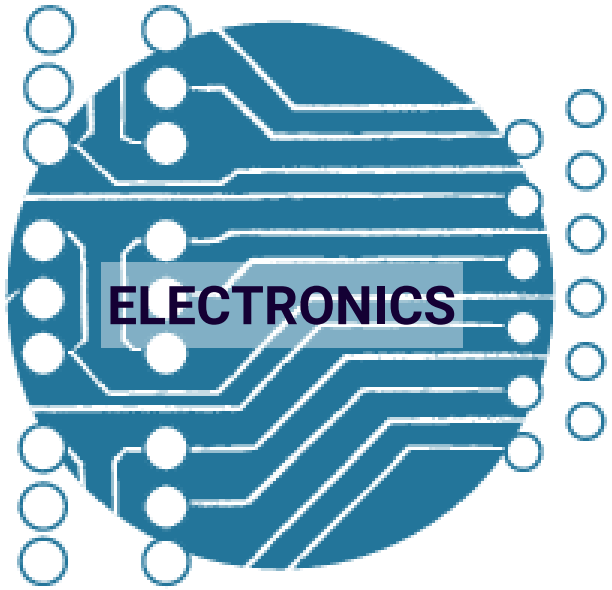


SUPPORT UNITS

The Administration Service manages the daily running of IFIC and the budgets of research grants. These funds are provided by different agencies at different levels (regional, national and European), each of them with its own regulations. At any time, there are around 50 live research grants, implying a wide range of tasks as making employment contracts, launching public tenders, paying invoices, and processing travel expenses. This Service deals with all sorts of matters in a community with staff belonging to two different institutions (CSIC and UV) and encompassing many nationalities.

This Unit provides a wide range of network and computing solutions for IFIC, giving support to users and projects. The service catalogue covers a wide spectrum, ranging from the installation and configuration of desktop and laptop computers to scientific computing. For the latter, the computing centre houses several clusters with a total of 4200 computing cores and 3 PB of disk storage, some of them using GRID technologies. A computer GPU cluster for machine learning applications, Artemisa, has been recently installed.

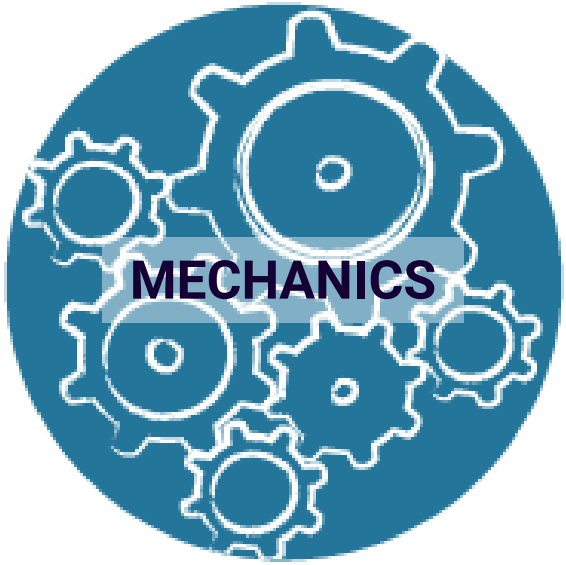
SUPPORT UNITS



The Electronics Unit provides service to any IFIC research project that has demands in electronics through the design, prototyping, manufacturing, testing and validation of electronic systems. It also provides support for sensor technologies using microelectronics, as for instance silicon detectors. This Unit makes use of two infrastructures: the general electronics laboratory and the clean room for support in microelectronics. It also offers service and developments to external companies through contracts and agreements.

IFIC's Library, part of CSIC's Library Network, has a collection of 2,300 monographs both in topics of general interest and specific to our research. Its staff is responsible for managing the access to electronic journals and the book loans. This Service is also responsible for the inventory of theses and dissertations deposited in the library since 1954. The library staff collaborates actively in the preparation of IFIC's annual reports and in the tasks related to the inclusion of our scientific output in the institutional databases.

SUPPORT UNITS



This Unit provides services to projects with mechanical needs, ranging from the conceptual design phase, calculation and simulation to the development of 3D models and drawings. The newly renovated IFIC mechanical workshop enables our contributions to the construction of the mechanical structures of the experiments and to the assembly of the different components. It is equipped with a 10-ton crane, as well as with industrial-type, numerically-controlled, machines. In addition to manufacturing, the Unit carries out measurements and tests on existing components and assemblies.

The tasks of the Maintenance Unit include the maintenance of common facilities and research laboratories of the Institute, as well as the management and logistics of the Clean Room and the Laboratory of Radioactive Sources. This Unit is also in charge of safety issues at IFIC, and of the actions in environmental management (waste disposal and energy efficiency). Finally, this Service is responsible for the implementation of quality standards in the operation of shared facilities, such as the Clean Room.

3 PERSONNEL

DECEMBER 2020

25% **WOMEN**

75% **MEN**

226
SCIENTIFIC PERSONNEL

94
PhD STUDENTS

Personnel list

4

SCIENTIFIC PRODUCTION

4 SCIENTIFIC OUTCOME

ARTICLES IN INDEXED JOURNALS 421

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

93.8% **IN FIRST QUARTILE JOURNALS**

(JCR-WOS, 2020)

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

Nature (IF 50.0)	1
Physics Reports (IF 25.6)	1
Nature Physics (IF 20.0)	1
Science Bulletin (IF 11.8)	1
Physical Review Letters (IF 9.2)	35

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

92	Physical Review D (IF 5.3)
82	Journal of High Energy Physics (IF 5.8)
56	European Physical Journal C (IF 4.6)
35	Physics Letters B (IF 4.8)
35	Physical Review Letters (IF 4.8)

4 CONFERENCES, WORKSHOPS, SEMINARS AND COLLOQUIA

CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS	CONFERENCES AND WORKSHOPS ORGANIZED	'SEVERO OCHOA' COLLOQUIA ORGANIZED	SEMINARS ORGANIZED
186	11	4	53

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 186 contributions were presented in 2020: 160 talks (12 invited, 80 plenaries) and 26 posters.

186

Full list of events

CONFERENCES AND WORKSHOPS ORGANIZED

IFIC members have organized 11 conferences and workshops during 2020. The full listing can be found in annex 3.

11

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 2020, IFIC celebrated 4 Severo Ochoa Colloquia, a lower number than usual because of the pandemic. In-person colloquia were cancelled in March, and online colloquia were resumed in November. The listing can be found in annex 4. Organisers: Vasiliki Mitsou, Sergio Palomares Ruiz, Mariam Tórtola and Marcel Vos.

4

Full list of events

4.3 SEMINARS

SEMINARS ORGANIZED

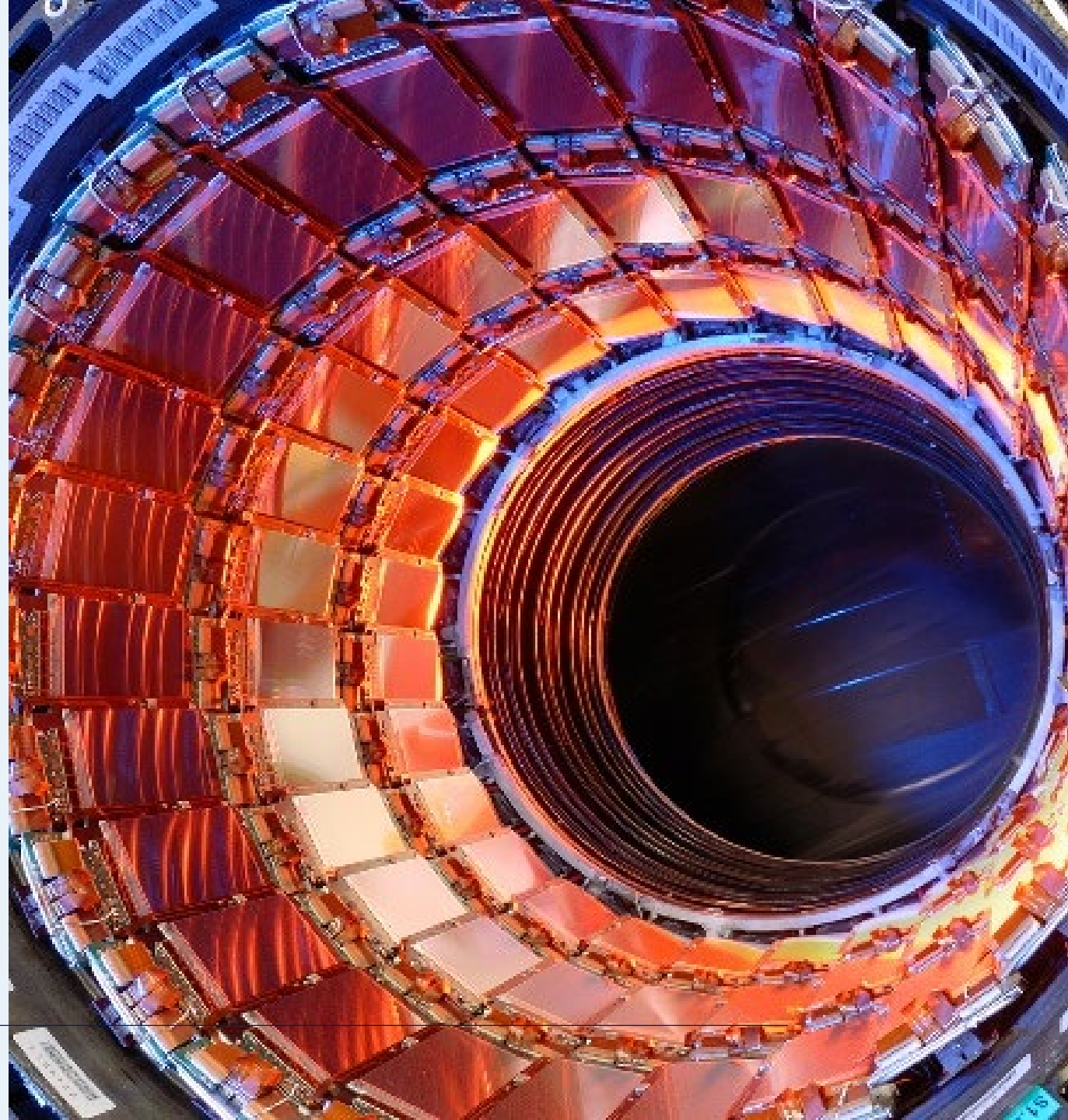
Seminars are more specific research talks given by an invited speaker, usually connected to one of the IFIC research groups. Some of them are more informal talks followed by a discussion session, such as those within the Student Seminars series. In 2019 we hosted a total of 60 seminars, including 17 student seminars. The complete list can be found in annex 5. Organisers: Andrea Donini, Daniel G. Figueroa, Martín González Alonso, Marian Lledó, Jacobo López Pavón, Raquel Molina, Sergio Palomares Ruiz, Avelino Vicente.

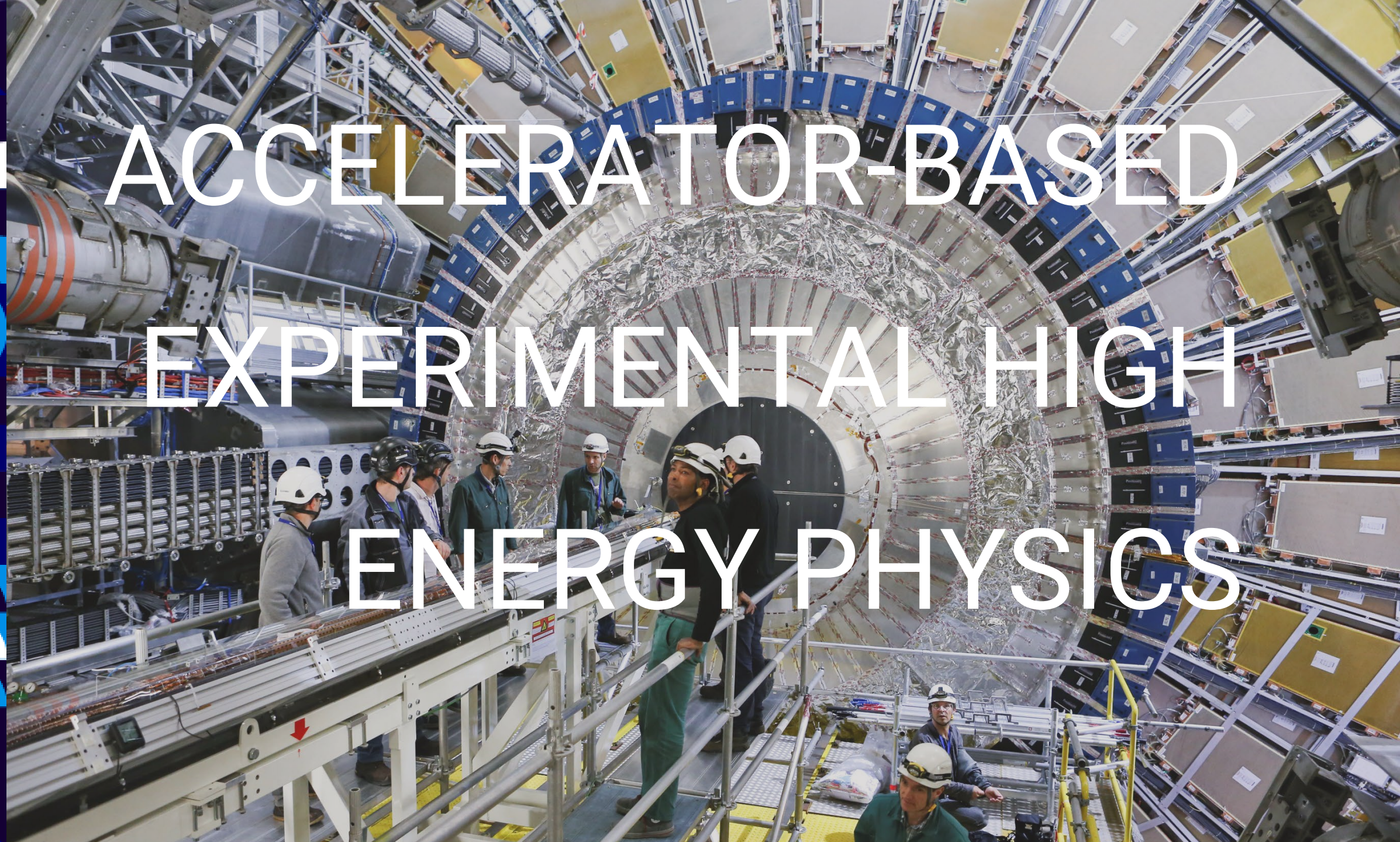
53

Full list of events

5

EXPERIMENTAL PHYSICS DEPARTMENT




ACCELERATOR-BASED
EXPERIMENTAL HIGH
ENERGY PHYSICS

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

This research line comprises the activities in the LHC experiments ATLAS, MoEDAL, LHCb and MATHUSLA, plus the ones related with the Belle II experiment, future colliders, accelerator and detector R&D.

ATLAS EXPERIMENT

During 2020 LHC was in shutdown for the Phase-I luminosity upgrade and maintenance of the experiments. Our activity areas in ATLAS deal with the physics exploitation of the experiment via the data analysis, the detector operation, software and computing and also to the detector upgrade. During 2020, the analysis of the LHC Run 2 (2015-2018) data was a hectic activity.

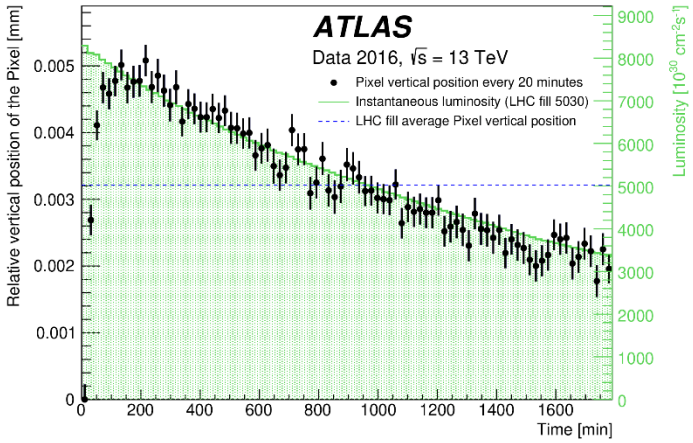
ATLAS: OPERATIONS

The trigger is a key part of the ATLAS experiment, selecting the events that are kept for permanent storage and subsequent physics analysis. IFIC joined the ATLAS Trigger/DAQ project in March 2020. IFIC coordinates the ATLAS trigger since October 2020, holding the role of deputy trigger coordinator, and is leading the substantial upgrade in preparation for Run 3 with brand-new systems and a redesigned software framework to increase the new physics (NP) signal acceptance. This way the ATLAS experiment will access corners of the physics phase space not explored before.

During 2020 maintenance and consolidation tasks in the front-end electronics of TileCal have been carried out. The Read-Out Drivers play a key role in these since they serve to asses the qualification of the repaired modules with specific data integrity and calibration runs. At the same time, these activities are helpful to detect deteriorated components in the Read-Out Drivers which have been repaired in the TileCal IFIC laboratory.

We have also coordinated the Inner Detector alignment activities during the LHC Run 2. In 2020 we published the performance of the Inner Detector alignment during the Run 2 [Eur. Phys. J. C 80] which is the legacy alignment for the Run 2 data. The level of precision attained by the detector alignment is such that the accuracy for the most precise components (Pixel modules) was better than a micron (in the central part of the detector). Track biases originated from systematic detector deformations were also evaluated. The residual sagitta bias and momentum scale bias after alignment are understood better than ~0.1 TeV−1 and 0.9×10−3, respectively.

Our group plays a leading role in the electron, photon and tau lepton performance studies in ATLAS, coordinating the ATLAS E/gamma group and the tau reconstruction and software subgroup. We contribute to software developments and data-driven measurements of efficiency to reconstruct isolated electrons and preparing the tau reconstruction code for Run 3. We also have contributed to the development of techniques for the reconstruction and identification of leptons (muons, electrons and tau-leptons).



The Pixel detector vertical (Ty) movement as a function of the time since the start of an LHC fill. The average Pixel Ty for the entire run (dashed blue line) is compared with its time evolution and with the instantaneous LHC luminosity. The error bars represent the statistical uncertainty.

ATLAS: COMPUTING

The IFIC ATLAS Tier2 contributes with the 4% of the total resources deployed in all Tier-2 sites. Our Tier-2 has the so-called Nucleus state in ATLAS, which implies significant responsibilities and larger work volume. Not only are we contributing to the deployment of CPU and storage resources for the ATLAS experiment but also several research activities are carried out by the teams in the Spanish cloud in order to include the new computing architectures into the Tier 2.

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

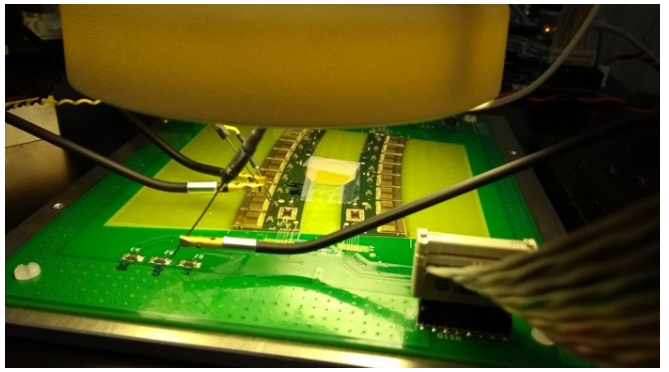
The integration of HPCs (High Performance Computing) into the LHC workflow was possible due to two key elements: the ARC-CE interface and the use of “Singularity”.

ATLAS: PHYSICS PRECISION MEASUREMENTS

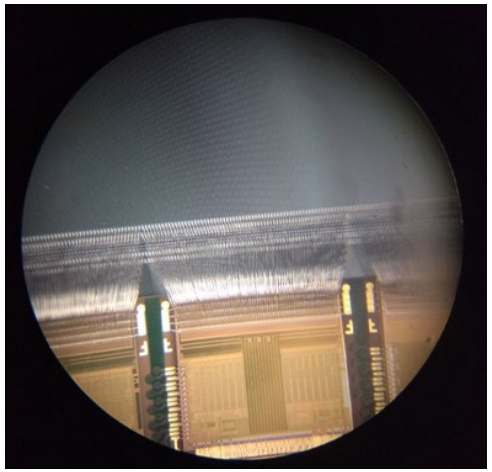
The precise measurement of the couplings of the top quark, the heaviest elementary particle and with the strongest Yukawa coupling to the Higgs boson, is one of the priorities of the LHC physics program and also for us.

Our group coordinated the ATLAS effort towards the first studies probing the CP-structure of the top quark Yukawa coupling in the Higgs decay to photons [Phys. Rev. Lett. 125, 061802 (2020)]. In this context, the exploration of the associated production of a single top quark with a Higgs boson is also highly motivating. The associated Higgs production with a single top quark can measure the magnitude and the sign of the Yukawa coupling. We led and coordinated the first ATLAS analysis, where the exploitation of Machine Learning techniques is essential to distinguish the small signal from the overwhelming background. Such rare process cannot be observed with LHC Run-2 statistics and indeed an observation of this signal would be a clear indication of new physics beyond the SM.

We also led the first differential measurements of top quark pair production in association with a Z using the Run 2 data [ATLAS-CONF-2020-028].



A silicon strip module for the new ATLAS tracker (ITk) under test in a Faraday cage at IFIC clean room.



An image of the bonding wires that link the silicon strips to the readout electronics completed with the IFIC bonding machine.

The measurements were performed using final states with three or four isolated leptons.

The resulting cross section was in agreement with the SM prediction. We also led the studies for improving the tWb vertex characterization in the t-channel single top quark production. We provided the first simultaneous measurement of the 3 components of the top and anti-top polarisation vectors as well as differential measurements within a fiducial region sensitive to these polarisation vectors. We derived exclusion limits for the real and imaginary parts of the Wilson coefficient of the dimension-six dipole operator simultaneously. We have also started the very challenging analysis of the quadruple-differential decay rate in t-channel production to simultaneously determine: the five generalised W boson helicity fractions together with their two phases, the polarisation in three orthogonal directions of the produced top quark, and the t-channel cross-section by using a model-independent framework.

Since the precision of some of these LHC results is already limited by theoretical uncertainties, the team is actively involved in physics modelling studies. A member is responsible for the LHC combinations of all top-quark related analyses, as representative of ATLAS. This work has led to the first publication of the Run-1 combination of W boson polarization measurements in top quark decays performed in ATLAS and CMS [JHEP 08 (2020) 051].

We have also contributed to study very rare

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

processes involving top quarks such as the production of 4 top quarks. This process may be altered by BSM contributions. We found evidence of production of 4-top-quark events and with a cross section compatible with the SM prediction [Phys. J. C 80, (2020)1085].
ATLAS: new physics searches
The discovery of a Higgs boson opens the possibility that NP appears in the Higgs sector. We are deeply involved in the study of the Higgs sector and continue our quest for NP as proposed by other models, e.g. SUSY or Dark Matter (DM).

Concerning the ATLAS searches for new physics in the Higgs sector. We have led the search for violation of lepton flavour conservation in decays of the Higgs boson [Phys. Lett. B 800 (2020) 135069], which is a possible explanation of the flavour anomalies observed a LHC.
We have also led the analysis searching for the existence of additional Higgs boson in the two taus final state [Phys. Rev. Lett. 125 (2020) 051801]. This search, using the complete Run 2 dataset are interpreted in terms of different SUSY models. The article has been chosen as Editor Choice by the journal and highlighted by the CERN Courier [CERN Courier Vol. 60 Number 3, May-June 2020].
Additionally, we are also involved in the search of heavy particles decaying into two Higgs bosons and the measurement of the Higgs boson self coupling.

We are strongly involved in the ATLAS searches for SUSY particles, with emphasis on leptonic signatures and R-parity violating models. We have searched for long-lived neutral particles (LLPs) that decay into displaced hadronic jets in the ATLAS calorimeter. Huge effort was made to understand the beam induced background and to develop dedicated techniques to identify displaced jets produced by LLPs and take into account the kinematic regimes of the targeted LLPs mass.

ATLAS: DETECTOR UPGRADE

The High-Luminosity LHC (HL-LHC) is planned to start in 2027. Our group is the responsible for the Upgrade of the TileCal off-detector electronics. The TilePPR is the core of the HL-LHC TileCal off-detector electronics. Our TilePPR prototypes are able to provide a full digitization of the calorimeter data and transmission at 40 MHz rate, standing an accept rate above 1 MHz. The TilePPR Demonstrator, installed in the ATLAS counting room, has been operated successfully to read out a TileCal module while providing in parallel digital signals to the legacy system. Our group designed and validated the main components of the final version of the TilePPr carrying out high speed tests.

IFIC is one of the leading institutes in the upgrade of the new ATLAS tracker for the HL-LHC, the Inner Tracker (ITk), holding the role of deputy project leader and the responsibility of the services plus grounding and shielding of the detector. We have made key contributions to the design of the endcap support structure, the design and optimization of the cooling, the services distribution to modules along the whole chain (bus tapes, service modules, patch panels, etc.), the local support for the sensors and the design of the endcap sensors.

During 2020, the ITk collaboration has entered in production mode and has gone through an extensive series of reviews of all the design.

MOEDAL EXPERIMENT

The IFIC team is the only Spanish participation in MoEDAL, an experiment designed to search for manifestations of NP through highly ionising particles. Its primary motivation is the quest for magnetic monopoles, yet the experiment is also sensitive to any massive slow-moving particles with single or multiple electric charges. MoEDAL uses a (mostly) passive detector, featuring aluminium Magnetic Monopole Trapping detector volumes (MMTs), plastic Nuclear Track Detectors (NTDs) and TimePix detectors.

We are coordinating the physics analyses of the experiment and we are strongly involved in the development and testing of key theoretical

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

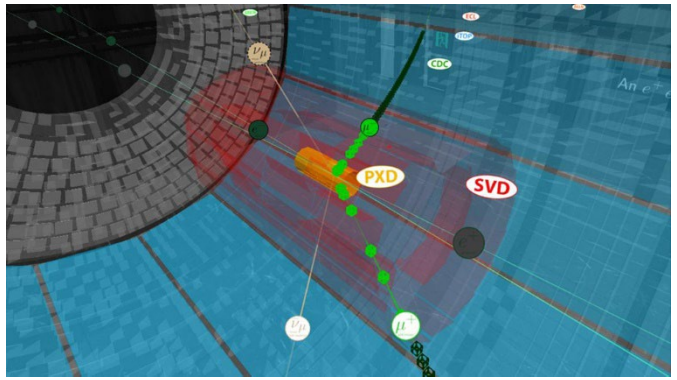
scenarios, such as monopole production processes, supersymmetric models and D-particles. IFIC plays a leading role in the MoEDAL management by holding the Chair of the Collaboration Board.

BELLE II EXPERIMENT

IFIC is the only Spanish institute participating in the Belle II experiment, a detector that surrounds the collision point of the SuperKEKB super flavor factory at KEK (Tsukuba, Japan).

IFIC is co-leading the technical aspects of the current detector system, holding the role of deputy technical coordinator. Additionally, we are leading the upgrade of the vertex detector with depleted monolithic active CMOS pixel sensors, in cooperation with several European partners.

During 2020, the accelerator broke the instantaneous luminosity record previously established in 2018 by the LHC accelerator, reaching 2.4×1034 cm-2s-1. The detector was running smoothly, with an overall data taking efficiency reaching 90%.



Simulation of an e+e- -> mu+ mu- Z' event in Belle II. Here the Z' boson decays to two neutrinos, but it may also decay into a dark-matter particle and its antiparticle.

MATHUSLA EXPERIMENT

This a proposed experiment with the goal of detecting possible LLPs produced at LHC. We led the analysis and the publication of the MATHUSLA demonstrator, built on the surface above ATLAS and taking data during Run 2. The goal was to measurer the rate of muons from LHC collisions reaching the surface above ATLAS.

ACCELERATOR AND DETECTOR R&D

Our group is also deeply involved in the ILC (International Linear Collider, to be hosted in Japan) and CLIC (Compact Linear Collider, led by CERN) and have a representative in the ECFA (European Committee for Future Accelerators). IFIC also coordinates the Spanish network for future colliders.

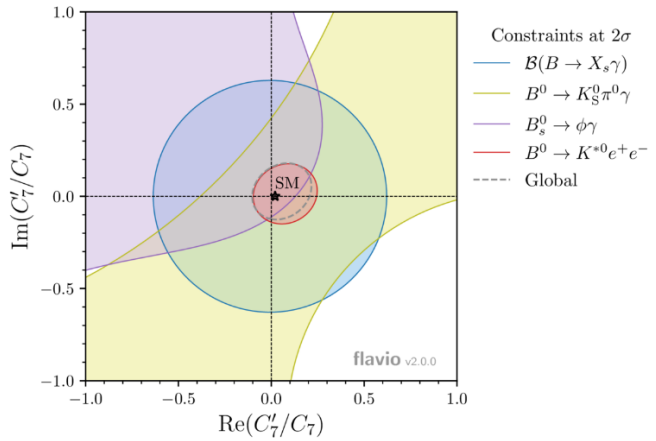
In 2020, IFIC joined the CALICE R&D Collaboration dedicated to R&D developing and leading the novel concept of highly granular calorimetry optimized for particle flow event reconstruction for future energy-frontier electron-positron colliders. IFIC is now part of the SiW-ECAL group of CALICE which has recently built a technological prototype of the SiW-ECAL for the ILC and CLIC detectors.
Within the RD50 collaboration we are working in the design and characterization of CMOS sensors. In 2020 we were working in the RD50-MPW2 chip designed by the U. Liverpool group. For this purpose, we designed ther readout circuit card.

LHCb EXPERIMENT: PHYSICS AND UPGRADE

New results on radiative b-hadron decays, which occur in the standard model via flavour changing neutral currents and are thus sensitive probes for new physics, have been presented using an angular analysis of $B^0 \rightarrow K^{*0}e^+e^-$ decays in the very low dielectron mass region, where the rate is dominated by the $B^0 \rightarrow K^{*0}g$ transition with a virtual photon. The results, illustrated in Fig. 1, are consistent with Standard Model predictions and provide the world's best constraint on the $b \rightarrow sg$ photon polarization. Analyses on other related processes, in particular $B_S \rightarrow fg$ and the baryonic decays $\Lambda_b \rightarrow \Lambda g$ and $X_b \rightarrow Xg$, have continued with results foreseen for 2021. In

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

parallel, experimental studies are being conducted to measure uncharted production and decay polarization properties of charm baryons in largely dominant multihadronic final states, both to shed further light on our poor understanding of polarization mechanisms in the strong interaction, especially at the high LHC energies, and as key inputs for other measurements and generators.



Constraints on the Wilson coefficients (new physics) given by radiative b-hadron analyses.

The detector has continued undergoing its upgrade, to be installed before LHC Run 3. One of the main replacements has been the SciFi tracker downstream of the dipole magnet. IFIC has played a major role in PACIFIC, the chip to readout the light sensors (SiPMs). With Covid-19 pandemics impacting seriously the installation process, a main task has focused on the quality control of the SiPMs power cables after insertion in the C-Frames. The group also had responsibilities in the SciFi Simulation and Software group, in particular with the new tracking algorithms required under the stringent computing upgrade conditions. With a computing model based on the Real Time Analysis (RTA) paradigm, IFIC continued contributing with responsibilities to the development of the new fully GPU-based implementation of the first level trigger, called Allen, completing the description of its implementation to process 40 Tbit/s data rate and perform a wide variety of pattern recognition tasks.

Activities also focused on R&D towards the next upgrade of the detector planned for the HL-LHC era, scheduled to start around 2027. These include, on one hand, first prototyping steps using simulation and test beam data of the readout electronics for the new electromagnetic calorimeter, which will have significantly higher granularity and a temporal resolution around 10 ns. On the other hand, feasibility studies and prototyping of the fixed-target setup with bent crystals for first measurements of magnetic and electric dipole moments of charm baryons, along with other uncharted studies, like very forward production and polarization of heavy hadrons, in dense targets and nuclear medium. Both the next LHCb upgrade and the LHC fixed-target program were endorsed by the 2020 European Strategy Update.

APPOINTMENTS

C. Mariñas Pardo 19.09.2020: C. Marinas appointed Technical Board deputy chair of the Belle II collaboration
The Belle II Executive Board endorsed the nomination of Carlos Marinas as Technical Board deputy chair of the experiment with the mandate of ensuring stable detector operation under high luminosity and background conditions, preparation of the upgrade work in long shutdowns LS1 (2022) and LS2 (2026) and upgrade of the data acquisition system.

In 2020 Arantxa Ruiz has been elected by the ATLAS Collaboration Institutes to lead the ATLAS Trigger activities for the period 2020-2022.

AWARDS

María Moreno Llácer: Premio Científico-Técnico de Algemesí 2020

5.1 ACCELERATOR-BASED EXPERIMENTAL HIGH ENERGY PHYSICS

Selected publications

> ATLAS Collaboration, “Search for Heavy Higgs Bosons Decaying into Two Tau Leptons with the ATLAS Detector Using pp Collisions at √s=13 TeV”, Phys. Rev. Lett. 125 (2020) 051801, DOI: https://doi.org/10.1103/PhysRevLett.125.051801

> ATLAS Collaboration, “Alignment of the ATLAS Inner Detector in Run 2”, Eur. Phys. J. C 80, 1194 (2020). https://doi.org/10.1140/epjc/s10052-020-08700-6

> M. Boronat, E. Fullana, J. Fuster, P. Gomis, A. Hoang, A. Widl, V. Mateu, M. Vos, “Top quark mass measurement in radiative events at electron-positron colliders”, Phys.Lett.B 804 (2020), 135353 [arXiv:1912.01275 [hep-ph]]

> ATLAS Collaboration. “CP Properties of Higgs Boson Interactions with Top Quarks in the $t\bar{t}H$ and tH Processes Using H→γγ with the ATLAS Detector”. [Phys. Rev. Lett. 125, 061802 (2020)]

> ATLAS and CMS Collaborations: “Combination of the W boson polarization measurements in top quark decays using ATLAS and CMS data at √s= 8 TeV”. J. High Energ. Phys. 2020, 51 (2020). https://doi.org/10.1007/JHEP08(2020)051

> D. Felea, J. Mamuzic, R. Masełek, N.E. Mavromatos, V.A. Mitsou, J.L. Pinfold, R. Ruiz de Austri, K. Sakurai, A. Santra, O. Vives, Prospects for discovering supersymmetric long-lived particles with MoEDAL, Eur.Phys.J. C 80, issue 5, 431 (2020) [arXiv:2001.05980 [hep-ph]]

> R. Aaij et al. [LHCb collaboration], Strong constraints on the b → sγ photon polarisation from B0 → K∗0e+e− decays, JHEP 12 (2020) 081.

> R. Aaij et al, Allen: A high level trigger on GPUs for LHCb, Comput Softw Big Sci 4, 7 (2020).

> J. Beacham et al., Physics Beyond Colliders at CERN: Beyond the Standard Model Working Group Report, J. Phys. G 47 (2020) 010501.

Selected conference talks

> L. Fiorini, Plenary talk: “What we have learned about the Higgs sector: production, decay, properties and differential distributions”, 8th Edition of the Large Hadron Collider Physics Conference, LHCP2020. May 2020, Paris (online), France.

> A. Ruiz Martínez, Plenary talk: “Standard Model measurements by ATLAS and CMS”. 5th International Conference on Particle Physics and Astrophysics, ICPPA-2020 Start Date: 09 Nov 2020. Online event.

> M. Moreno Llácer: “Interplay between the Higgs boson and the top quark”. Higgs and Effective Field Theory HEFT 2020. Granada (Spain). Star date: 15 April 2020.

> F. Carrió Argos: “Design of the Compact Processing Module for the ATLAS Tile Calorimeter”. 22nd IEEE Real Time Conference. Start date: 12 October 2020. Online event.

> M. Vos, The Strong interaction: from the LHC to the Higgs factory and beyond, ECT* Colloquium https://www.ectstar.eu/activities/seminars/colloquia/

>V.A. Mitsou, MoEDAL, FASER and future experiments targeting dark sector & long-lived particles, 8th Annual Large Hadron Collider Physics (LHCP2020), 25–30 May 2020. Online event.

> A. Oyanguren Campos, Real-time alignment, calibration, and software quality assurance for the LHCb upgrade, ICHEP 2020, July 2020

(Prague, Czech Republique).

> L. Henry, A 30 MHz software trigger and reconstruction for the LHCb upgrade, Connecting the Dots, Princeton, 20-30 April.

Conference and Workshop Organization

> "ISOTDAQ 2020 – International School of Trigger and Data AcQuisition"

Roles: Alberto Valero Biot (chair of the Local Organizing Committee), Fernando Carrió and Luca Fiorini (members of the Local Organizing Committee)

> Connecting the Dots" CTD/WIT 2020

Roles: José Enrique García Navarro and Salvador Martí García (members of the International Advisory Committee)

> Belle II VXD R&D Upgrade Workshop

Roles: C. Mariñas Pardo (Member of the organizing committee)

ASTROPARTICLE PHYSICS

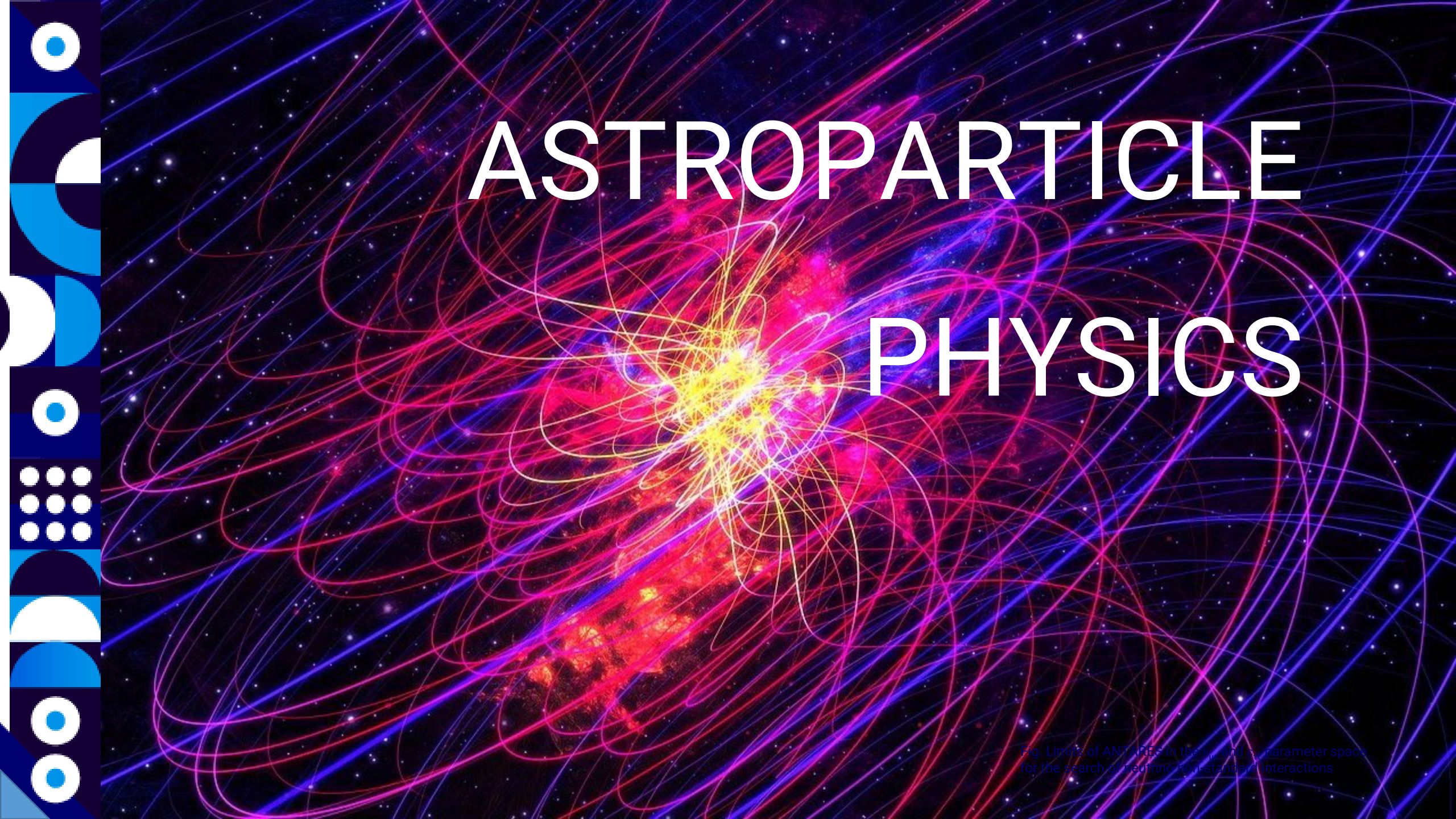


Fig. Limits of ANTARES in the ε' and ε_0 parameter space for the search of neutrino non-standard interactions

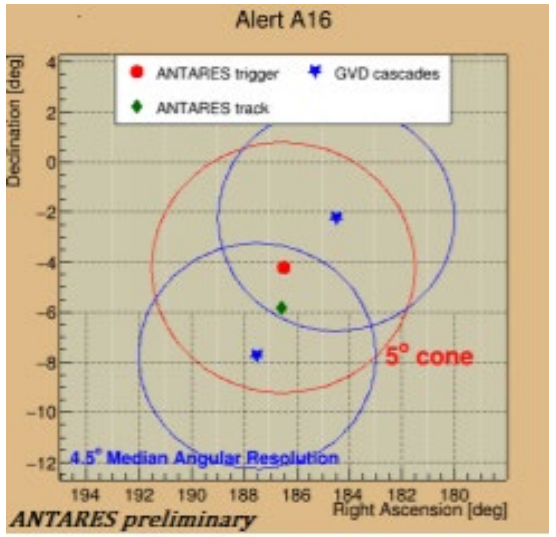
5.2 ASTROPARTICLE PHYSICS

ANTARES and KM3NeT

The year 2020 has been a remarkable year for neutrino astronomy, in particular in the Mediterranean side, with the installation of more lines of KM3NeT, which consolidates as a growing, robust detector. In parallel, ANTARES has continued data taking. In the meantime, the lively activity triggered by the cosmic signals of neutrinos observed by IceCube is increasing as more data are gathered and scientists try to put all pieces together. We are now in the multi-messenger era and this means several new questions stemming from the answers we have recently found. In addition to the search for cosmic neutrinos, neutrino telescopes are great tools for doing particle physics and more and more ideas are proposed to be probed. Our group at IFIC has been closely involved in all of these activities, as described in the following sections.

ANTARES

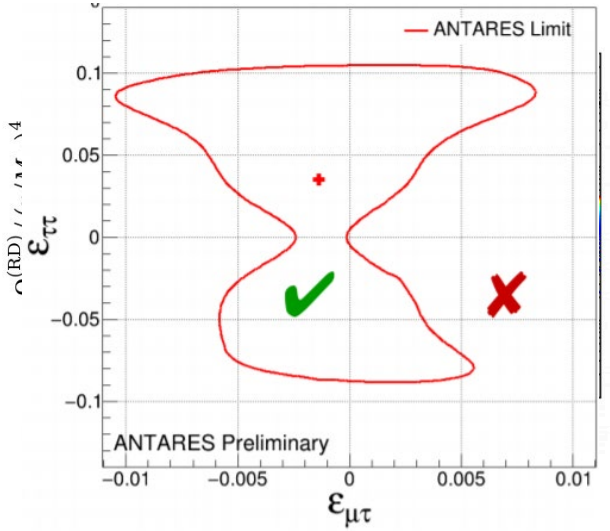
The ANTARES detector is installed at the bottom of the Mediterranean Sea since 2008, which means well more than one decade of data. The year 2020 was supposed to be its last year of operations, but the pandemic has changed these plans, extending its operation for at least one additional year. This has been an opportunity to have more data and receive and send more alerts from/to other observatories. As an example of the efforts of ANTARES in this multi-messenger context, our group has carried out an analysis to look for correlations with six gravitational events and ANTARES data. Efforts continue (now with the addition of KM3NeT, as it will be described in the following section) to observe, for the first time, an event in the three most promising astronomical channels: electromagnetic signal, gravitational waves and neutrinos. Another example of multi-detector analysis is the follow-up of alerts with ANTARES-GVD coincidences. In the meantime, more "standard" searches of cosmic neutrinos (steady sources) have continued, improving our neutrino skymap.



Skymap with the events associated to one of the alerts in ANTARES-GVD analysis

As mentioned above, instruments such as ANTARES are also good tools for studying fundamental physics. A perfect example of this is its capability to look for dark matter, in particular in sources like the Galactic Center (for which detectors in the Northern Hemisphere like ANTARES or KM3NeT are particularly well located) or the Sun. Limits have been updated with new statistics.

Triggered by the study of the capabilities of KM3NeT-ORCA to search for neutrino non-standard interactions (NSIs), an analysis was carried out to obtain limits with the ANTARES data. It turned out that these results are world-wide best limits in certain regions of the parameter space of NSI ($(\varepsilon_{\mu\tau}$ and $\varepsilon_{\tau\tau})$. Moreover, studies on neutrino decay with ANTARES data are in progress.



Limits of ANTARES in the $\varepsilon_{\mu\tau}$ and $\varepsilon_{\tau\tau}$ parameter space for the search of neutrino non-standard interactions

5.2 ASTROPARTICLE PHYSICS

KM3NeT

During 2020 the construction of KM3NeT has reached an important milestone with the deployment of 7 lines. This successfully completes the so-called Phase 1 of ORCA. Data taking with these lines has smoothly proceeded and allowed the production of the first results (like the measurement of the atmospheric neutrino and muon flux). More importantly, this also has shown the robustness of the detector and the deploying program. The COVID crisis has unavoidably impacted the process of construction and deployment, but this has been minimized and at the time of this writing has completely recovered. Among the early physics results produced by our group with KM3NeT, we can highlight the first search for correlations with the gravitational wave event s20014f, candidate to be a core collapse supernova event. We have also carried out studies on the performance of KM3NeT for several physics goals: neutrino NSIs, neutrino decay, supernova detection, dark matter searches, etc.

In addition to our contributions to physics analyses, the IFIC group has an important role in the detector design and construction, in particular to the main electronics elements (the Central Logic Board and the Power Board) and the so-called *nanobeacons*, used for in situ time calibration.

Our labs have been prepared to integrate Detection Unit Bases and integration will start by the end of 2021. This task will have an enormously beneficial impact in the deployment of the detector, as recognised by the KM3NeT Collaboration.

Additional contributions from our group include the roles of coordinators of the Dark Matter and Exotics Working Group and Electronics Working Group in KM3NeT and of the Astronomy Working Group in ANTARES.

HIGHLIGHTS GROUP

ANTARES has published in 2020 the results of a search for dark matter in the Galactic Centre with 11 years of data. This analysis has been led by the IFIC group and takes advantage of the excellent location of ANTARES to look for neutrinos coming the Southern Hemisphere, where the centre of our Galaxy is located, providing best worldwide limits at large mass dark matter particles.

In October 2020, Paco Salesa was appointed as Coordinator of the Astronomy Working Group by the ANTARES collaboration. His duty will focus on the multi-messenger analyses. As discussed above, this is one of the most active fronts in the astroparticle field. Paco re-joined the ANTARES-KM3NeT group with a GenT Excellence grant after postdoctoral stays in Auger, HAWC and CTA, which provided him with a perfect background for this task.

Juan José Hernández Rey was appointed in February 2020 as member of the Scientific Board of the Centre National de la Recherche Scientifique (CNRS) in France, the main French research institution and the second largest in scientific production worldwide, with only 8 foreign members of out a total of 30. Juan José Hernández, former Director of IFIC, is presently also member of ANTARES-KM3NeT and of the Particle Data Group of CERN.

Francisco Salesa

Juan José Hernández

5.2 ASTROPARTICLE PHYSICS

Selected publications

> ANTARES and IceCube Collaborations (A. Albert et al.), Combined search for neutrinos from dark matter self-annihilation in the Galactic Center with ANTARES and IceCube, Physical Review D 102, 082002 (2020)

> ANTARES Collaboration (A. Albert et al.), Search for dark matter towards the Galactic Centre with 11 years of ANTARES data, Phys. Lett. B, 805 135439 (2020)

> ANTARES and IceCube Collaborations (A. Albert et al.), ANTARES and IceCube Combined Search for Neutrino Point-like and Extended Sources in the Southern Sky, A. Albert et al., The Astrophysical Journal, 892:92 (2020)

> KM3NeT Collaboration (M. Ageron), Dependence of atmospheric muon flux on seawater depth measured with the first KM3NeT detection units, Eur. Phys. J. C (2020) 80:99

Selected conference talks

> R. Gozzini, DM combined ANTARES+IC analysis, Neutrino 2020, Chicago (online), July 2020.

> M. Colomer, ANTARES search for all-flavor high-energy neutrinos in correlation with very high-energy gamma-rays, Neutrino 2020, Chicago (online), July 2020.

> N. Khan Chowdhury, Non-standard interactions with Mediterranean neutrino telescopes, Neutrino 2020, Chicago (online), July 2020.

> S. Alves, ANTARES – Baikal-GVD alerts analysis, Neutrino 2020, Chicago (online), July 2020.

> J.D. Zornoza, Gravitational waves and neutrino astronomy with ANTARES and KM3NeT, Iberian Gravitational Wave Meeting, October 2020

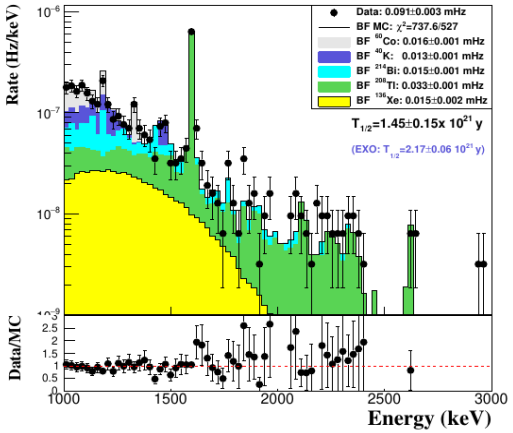

EXPERIMENTAL
NEUTRINO PHYSICS

5.3 EXPERIMENTAL NEUTRINO PHYSICS

Addressing the major open questions in the field of massive neutrinos, the experimental Neutrino Physics group at IFIC has continued delivering significant contributions to the NEXT, T2K and DUNE experiments during 2020.

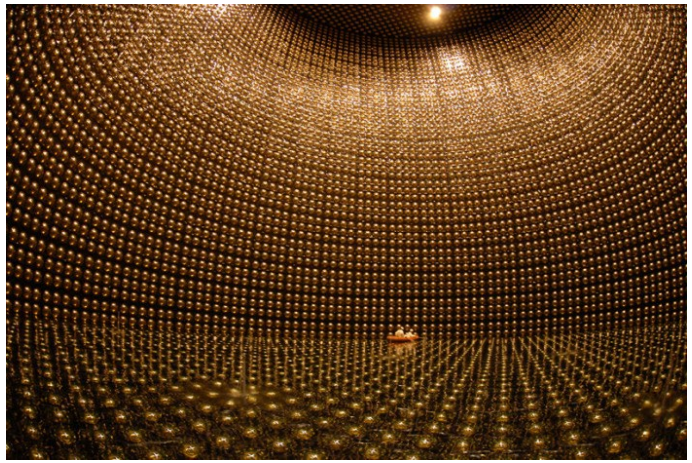
NEXT: PRELIMINARY 2νββ MEASUREMENT AND ROADMAP TOWARDS THE 0νββ SEARCH

The goal of the Neutrino Experiment with a Xenon TPC (NEXT) is the discovery of neutrino-less double beta (0νββ) decay in 136Xe using high-pressure gas TPCs with amplification by electro-luminescence. As previously demonstrated, this technology offers an optimal compromise between energy resolution, background rejection and scalability. A first radio-pure detector, NEXT-White, has operated at the Laboratorio Subterráneo de Canfranc (LSC) since 2016. Apart from the detector maintenance and operation tasks, the IFIC members have led during 2020 different analyses and R&D lines within the NEXT program. Using the NEXT-White data taken with 136Xe-enriched gas until summer, a preliminary measurement of the half-life of the 2-neutrino double beta decay (2νββ) has been released, with a significance above 5σ. A 136Xe-depleted data taking campaign has followed, to be completed in 2021. Relying also on the NEXT-White data, the sensitivity of NEXT to the 2-neutrino double electron capture on 124Xe has been estimated. The results have been published in JHEP, showing a competitive sensitivity with respect to the XENON-1T experiment. In parallel, the smaller detector NEXT-DEMO++ has been operated at IFIC. After exploring the performance of different gas mixtures, NEXT-DEMO++ has been focused on the validation of the tracking plane design to be implemented in the upcoming NEXT-100 detector, to be installed at the LSC by the end of 2021. Beyond the NEXT-100 program, which will provide a competitive 0νββ search, the physics case of a tonne-scale detector has been also studied and the corresponding results made public. This future stage of the NEXT roadmap will reach sensitivities of 1027 year, improving by one order of magnitude that of NEXT-100.



Reconstructed energy spectrum of NEXT-White data showing a preliminary measurement of the 2νββ half-life of Xe-136.

T2K



The Super-Kamiokande detector of the T2K experiment.

T2K is a long-baseline neutrino oscillation experiment, offering the current best sensitivity to the to the CP violation in the leptonic sector and precise measurements of the oscillation parameters in the so-called atmospheric sector. During 2020, the members of the Experimental Neutrino Physics group have continued with their responsibilities in detector operation and calibration, as well as in oscillation analyses. In particular, we are currently in charge of one of the three official analyses, which includes for the first time a complete treatment of reactor experiments.

5.3 EXPERIMENTAL NEUTRINO PHYSICS

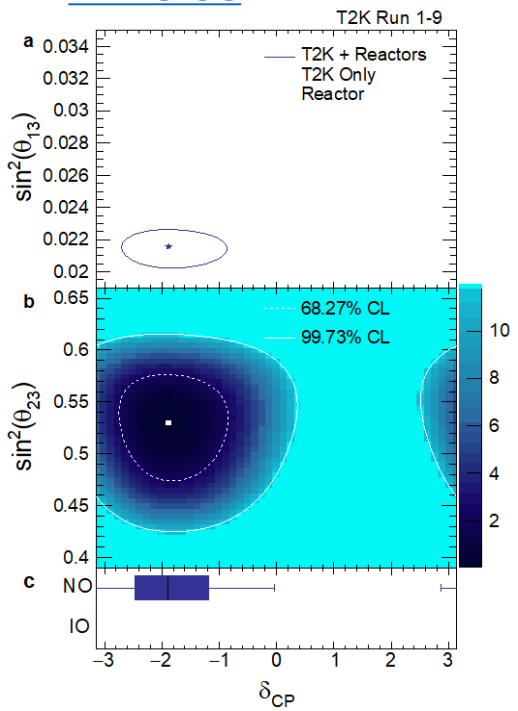
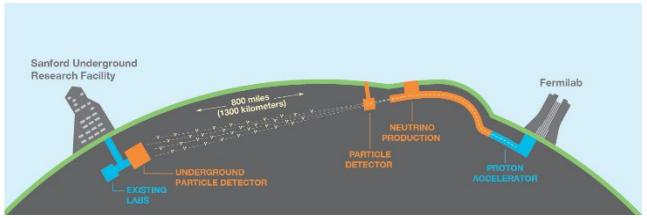


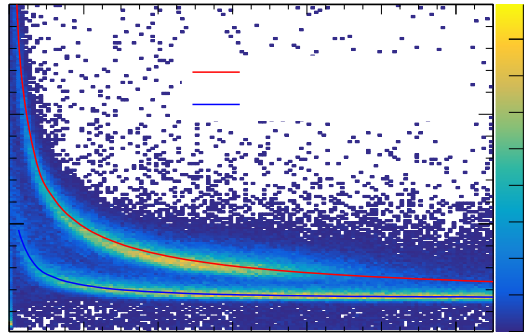
Fig. Constraints on PMNS oscillation parameters obtained with T2K data. Subfigure a shows 2D confidence intervals at the 68.27% confidence level (CL) for δ vs sin 2θ13 in the preferred normal ordering. Subfigure b shows 2D confidence intervals at the 68.27% and 99.73% confidence level for δ vs sin 2θ23 from the T2K + Reactors fit in the normal ordering, with the colour scale representing the value of negative two times the logarithm of the likelihood for each parameter value. Subfigure c shows 1D confidence intervals on δ from the T2K + Reactors fit in both the normal (NO) and inverted (IO) orderings. The vertical line in the shaded box shows the best-fit value of δ, the shaded box itself shows the 68.27% confidence interval, and the error bar shows the 99.73% confidence interval. It is notable that there are no values in the inverted ordering inside the 68.27% interval.

DUNE

The Deep Underground Neutrino Experiment (DUNE), currently under design and construction, will consist of two state-of-the-art neutrino detectors exposed to the world's most intense neutrino beam. The detectors will be based on the liquid-argon time projection chamber (LArTPC) technology, which provides excellent tracking and calorimetry through the detection of the scintillation and ionization signals produced in the argon by interacting particles. DUNE has a very rich scientific programme that includes the precision study of long-baseline neutrino oscillations (including the measurement the neutrino mass ordering and CP violation), searches for phenomena beyond the SM (BSM), and astroparticle physics. This past year has been crucial for DUNE, with the publication of the Conceptual Design Report (CDR) of the near detector, as well as papers describing the physics case of the experiment and the first results of ProtoDUNE, the large-scale prototype of the far detector built at CERN. Members of IFIC have participated in all these activities.



The Deep Underground Neutrino Experiment (DUNE).



Particle identification performance in the ProtoDUNE-SP demonstrator at CERN: energy loss per unit path length as a function of residual range, for proton and muon tracks.

RESEARCH HIGHLIGHT OF THE YEAR

The operation of the NEXT-White detector (shown in the picture) at the Laboratorio Subterráneo de Canfranc (LSC) finishes with the measurement of the half-life of the two-neutrino double beta decay of Xe-136, the slowest radioactive process ever measured.

The NEXT-White detector at the Laboratorio Subterráneo de Canfranc.

5.3 EXPERIMENTAL NEUTRINO PHYSICS

Selected publications

> Martínez-Lema, G. et al. (NEXT Collaboration), “Sensitivity of the NEXT experiment to Xe-124 double electron capture”, JHEP 21 (2020) 203.

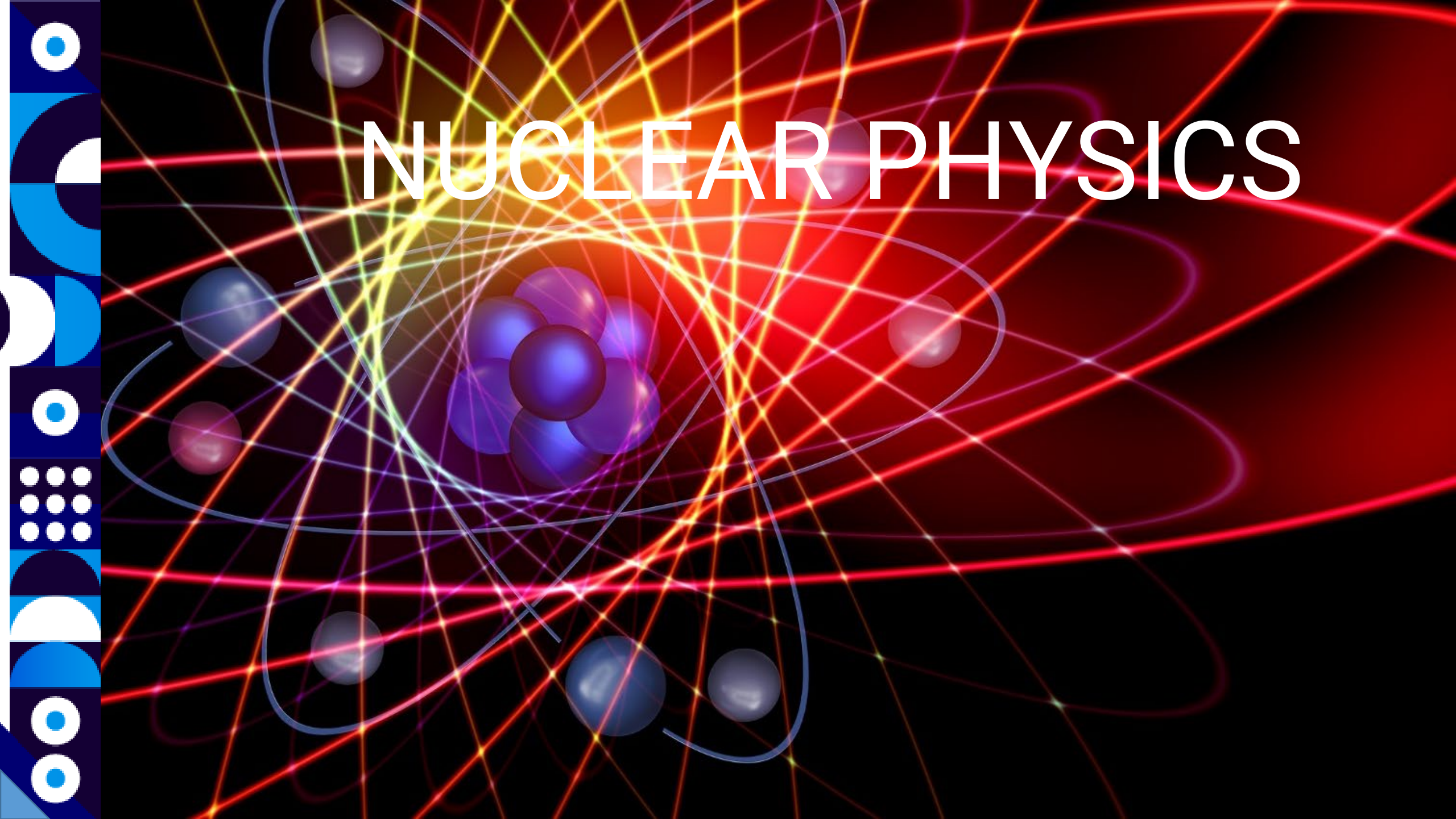
> B. Abi et al. (DUNE Collaboration), “First results on ProtoDUNE-SP liquid argon time projection chamber performance from a beam test at the CERN Neutrino Platform”, JINST 15 (2020) P12004.

> K. Abe et al. (T2K Collaboration), “Constraint on the matter–antimatter symmetry-violating phase in neutrino oscillations”, Nature 580 (2020) 339–344.

Selected conference talks

> “Cryogenic instrumentation at ProtoDUNE” Miguel Ángel García Peris , 40th International Conference on High Energy Physics (ICHEP 2020). (Online)

> M. Colomer, ANTARES search for all-flavor high-energy neutrinos in correlation with very high-energy gamma-rays, Neutrino 2020, Chicago (online), July 2020.


NUCLEAR PHYSICS

5.4 NUCLEAR PHYSICS

The experimental Nuclear Physics activity at IFIC is carried out by two groups, the Gamma and Neutron Spectroscopy group and the AGATA group.

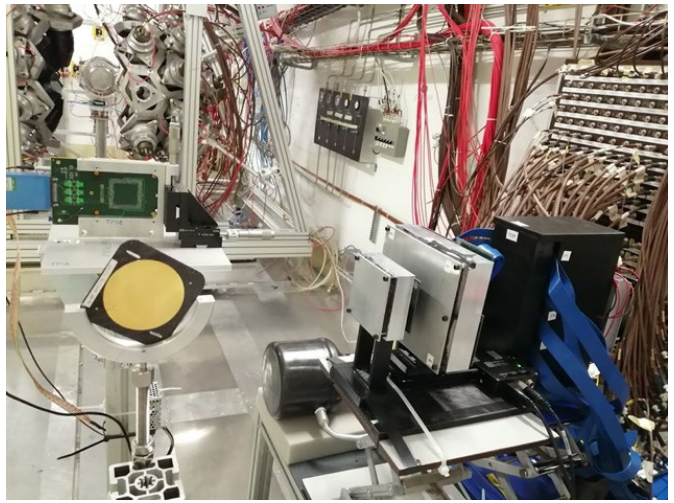
GAMMA AND NEUTRON SPECTROSCOPY

The research of the Gamma and Neutron Spectroscopy Group covers aspects of nuclear structure, astrophysics, applications and the development of instrumentation. One of the research priorities of the Gamma and Neutron Spectroscopy group is centred on the study of beta decays that are relevant for the prediction of the antineutrino spectra from reactors. In this framework, some of the most important fission product decays exhibit important ground state to ground state beta decay branches. The intensity of these transitions is difficult to determine, since they are not accompanied by the emission of gamma rays.

In this context, one relevant result from our group in 2020 is the study published in Physical Review C by Guadilla et al., where an improved method for the determination of the ground state to ground state beta feeding was presented. The new method corrects some limitations of the earlier procedure introduced by Greenwood et al. in the 1990s and extends its application to cases where beta-delayed neutron emission might be present. The procedure is based on a comparison of the number of counts detected in the beta detector and the number of counts registered in coincidence in both the beta detector and the total absorption spectrometer. In this work, ground state to ground state feedings for four decays, that are relevant to the improvement of summation calculations of the antineutrino spectra in reactors, were determined with increased precision. The method is also relevant to nuclear structure applications as well.

In 2020 our group has contributed considerably to the nuclear astrophysics programme of the CERN n_TOF project, with two experimental proposals, approved by the CERN-INTC PAC, aimed at the first ever measurement of the stellar reactions 79Se(n,γ) and 94Nb(n,γ). To accomplish these goals, the first fully operational Compton i-TED detector has been developed (see Fig.1). The work by C. Guerrero et al. shows a remarkable astrophysical reaction, 171Tm(n,γ), that could be investigated thanks to the unique combination of complementary techniques at CERN n_TOF and at SARAF-LiLiT. Similar experiments could be conducted at the future IFMIF-DONES facility, where our group is actively involved. Research and innovation carried out in the scope of the HYMNS ERC Consolidator Grant has also led to a patent application for a “Device for simultaneous detection, identification, quantification and/or location of gamma radiation and neutron sources”, which has attracted great interest.

Finally, it is worth emphasising two additional accomplishments. One of them related to the application of Artificial Intelligence (AI) and Machine Learning (ML) techniques to gamma-ray position reconstruction in large monolithic radiation detectors. Additionally, a breakthrough in the field of neutron capture experiments has been accomplished by the development of the first C6D6 detector-prototype based on SiPM readout. More information can be found at HYMNSERC.



Caption: One of the four high-efficiency i-TED Compton modules (right) installed in the EAR1 experimental room of the CERN n_TOF laboratory

5.4 NUCLEAR PHYSICS

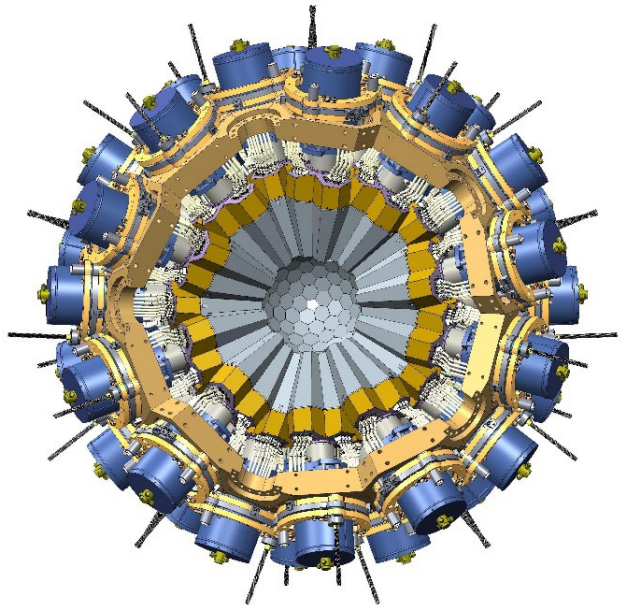
AGATA

In 2020 the the phase1 of the AGATA project has been completed, reaching beyond 1 of solid angle coverage, as well as the preparation of phase 2, where it is aimed to reach 3 by 2031. Our group had contributed to leading the instrumental preparation, that was concluded with the review of the AGATA project by an international panel, and the approval of the project plan.

Our group, together with the AGATA group at ETSE, Valencia University, have completed the R&D of the data Time Multiplexing concept (FPA2017-84756 grant), as well as contributing to the R&D of the pre-processing hardware for AGATA phase 2 (PROMETEO 2019/005 grant).

The IFIC AGATA group has contributed to the success of the MUGAST-AGATA campaign, on-going at GANIL in 2020, with the participation in the experimental activity. We have progressed with the data analysis of the experiment, performed with the AGATA-NEDA-DIAMANT set-up, aimed at investigating the quadrupole and octupole collectivity in the neutron deficient ^{112}Xe, nucleus, relevant for the T=0 proton-neutron pairing topic.

We have made progress on the dissemination of previous experimental results on seniority conservation in the N=50 isotones occupying the $\pi g_{9/2}$ orbital -relevant for the validity of the short-range pairing interaction in the region- and on the ^{52}Fe quadrupole collectivity investigation, performed with a relativistic radioactive ion beam at GSI-FRS. Moreover, Javier Collado, completed the defence of his PhD theses with Cum-Laude qualification.



Caption: One of the four high-efficiency i-TED Compton modules (right) installed in the EAR1 experimental room of the CERN n_TOF laboratory

Selected publications

> V. Guadilla et al., Determination of β-decay ground state feeding of nuclei of importance for reactor applications, Physical Review C 102, 064304 (2020)

> C. Guerrero et al., Neutron Capture on the s-Process Branching Point 171Tm via Time-of-Flight and Activation, Physical Review Letters 125, 142701 (2020)

> Cederwall, B.; Liu, X.; Aktas, Ö.; Ertoprak, A.; Zhang, W.; Qi, C.; Clément, E.; de France, G.; Ralet, D.; Gadea, A. et al., Isospin Properties of Nuclear Pair Correlations From the Level Structure of the Self-Conjugate Nucleus 88Ru. - Physical Review Letters. 124 (2020) 062501

Selected conference talks

> A. Algora, *Total absorption study of ^{100}Sn, NUSTAR Annual Meeting 2020, GSI, Germany*. Invited plenary talk

GRID & E-SCIENCE IN PHYSICS

5.5 GRID & E-SCIENCE IN PHYSICS

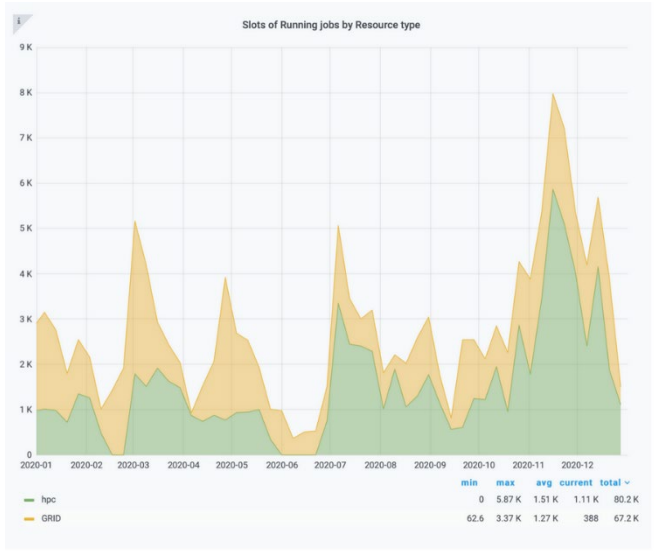
The research topics of this research line include mainly the Spanish ATLAS Tier-2 goals. It also includes several generic activities devoted to the application of Distributed Computing and to improve the performance of the physics analysis work:

- Delivery of the committed resources for 2020 (in April). 2020 has been the first year year funded by the project PID2109-104301RB-C21 of the Spanish HEP Program. During this year, the Tier-2 IFIC site has provided 47021 HS06 and 3089 TB of disk. The efficiency of the whole Tier-2 has been of about 100%.

- On 14th a-15th October took place the Third IFIC Technological Days (Jornadas Tecnológicas) and our group presented several talks about the 'GRID Tier-2' activities.

We have progressed in the main objectives of the project:

a) Exploitation of HPC Resources:
During 2020 our group has continued the exploitation of MareNostrum 4 HPC (BSC) started previous year (2019) running conventional ATLAS simulated data production. We chose to configure a dedicated ARC-CE and interact with the HPC login and transfer nodes using ssh command.
By mid of the year the periods of the Ministry - BSC agreement started after a series of standard BSC calls and the computing yield has been of more than 8 million (check) CPU hours and more than 241 Million of events (check) of a complete simulation of the detector. The 50% of the simulation production assigned to Spain is executing in MN4 resources. It should be noted that in 2020 30% of the IFIC's contribution to ATLAS computing resources has been through MareNostrum 4 HPC.



Slots of running jobs by resource type during 2020

b) Monitoring of Frontier servers:
The monitoring system of the Frontier servers of ATLAS based on the ELK stack (Elasticsearch, Logstash and Kibana) has been working under stable operation for the past years. Millions of job's queries to the ATLAS Conditions Database have been handled daily by this system which accesses log files from servers at 3 different sites: CERN, CC-Lyon and Triumf (Canada). The information gathered has proven very useful in order to detect problematic SQL queries demanding ATLAS Conditions data. As a consequence, there have been many improvements in the construction of the queries and the structure of each subdetector's data within de Oracle Conditions Database. Frontier stress tests performed in the past year showed some limitations on the processing rate of the queries by the monitoring system. This problem has been addressed and a solution based on caching mechanisms will allow to maintain an adequate performance of the filtering step of the monitoring system in the future.

d) Application of Machine Learning Methods methods for Physics Analysis in ATLAS:
Preliminary studies of resonance disintegrations into ttbar pairs performed in 2019 gave rise to one TFM of a student of the Master of Data Science of the U.V. (Ángela García Mínguez). This TFM was defended in July 2020.

Following those studies using publicly available simulated data, we decided to join the efforts of the ATLAS Physics Analysis Group working with ttbar resonance decays producing 1 or 2 leptons. At the end of the

5.5 GRID & E-SCIENCE IN PHYSICS

year 2019 we proposed a contribution with the goal of improving the resolution of the ttbar invariant mass by applying ML/DL techniques. The analysis makes use of a variety of variables of the ttbar decay process to train diverse ML algorithms, e.g. DNN, RF, XGB, in order to classify the produced jets and discard any jet not related with it.

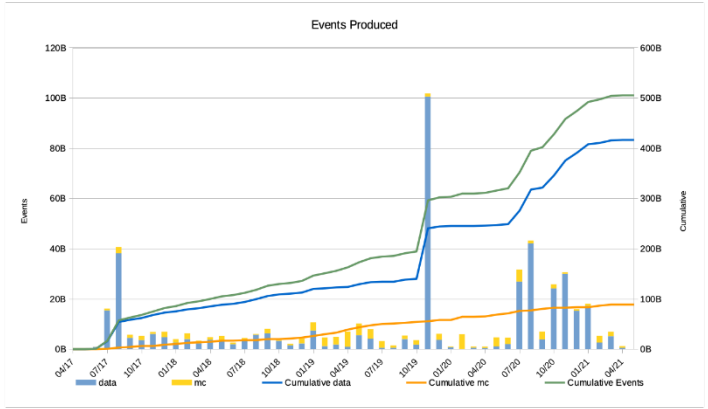
The spectrum of the reconstructed invariant mass allows us to search for ttbar resonances which would show up as an excess of events around the mass of the resonance on top of a slowly decaying spectrum due to other SM sources. Initial results prove a higher reconstruction efficiency of the different pieces of the decay as compared to the χ2 method involving invariant masses and transverse momentum balance, which has been used up to now.

A Master student, Jorge Martínez de Lejarza Semper, who got a JAE/ICU fellowship, has been working on this subject. Most of his work has been performed on the ARTEMISA infrastructure at IFIC.

f) The ATLAS Event Index Project:
The group has continued their duties with the ATLAS Event Index Project. We are in charge of the Data Collection and Data Production. The Event Index Supervisor has been another important contribution during 2020.

We are developing and testing a new Event Index based on HBase and Phoenix. This new Event Index will surpass the actual one optimizing the key of the events. This will improve the data storage, moreover, it will significantly improve the performance of the system for the most common use cases. It will also add a layer of granularity and flexibility compared to the current system.

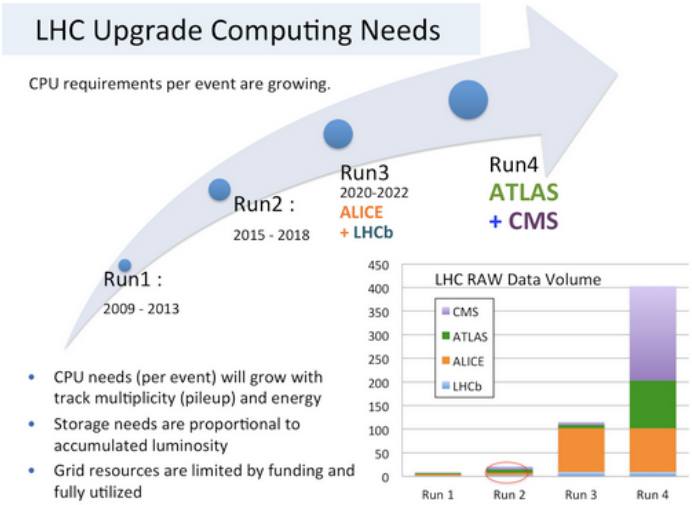
This will satisfy the exigent requirements of data generation during Run 3 and to face with the challenge of high rate (frequency) of the data taking since it will be more than a factor 5. The main line of action has been the implementation of new storage technologies which will able of inserting and storing this ingestion of large amounts of data at such speeds.



Evolution of the number of event produced in the last 4 years with the important increasing at the end 2019 – beginning 2020

GRID COMPUTING AND OTHER COMPUTING PARADIGMS

If the resource demands during the run1 and run2 periods were very high, we currently have prospects for growth for run3 and for HL-LHC (2026) which are of an order of magnitude higher, as it can seen in figure. This circumstance has led to a search for resources from different sources. Although there are efforts in the use of Cloud Computing in centers participating in ATLAS, here we are going to focus on HPC resources. As it is known, many countries have HPC (Supercomputing) centers with heavy investments in such programs. At the Spanish level and at the IFIC (Valencia) in particular, we have taken the necessary steps to be able to use these resources and have the incremental CPU time that we need to fulfill our commitments within the ATLAS collaboration



5.5 GRID & E-SCIENCE IN PHYSICS

Selected publications

> ‘Computing activities at the Spanish Tier-1 and Tier-2s for the ATLAS experiment towards the LHC Run3 and High Luminosity (HL-LHC periods)’. S. Gonzalez de la Hoz, C. Acosta-Silva, J. Aparisi Pozo, A. Pacheco, J. del Peso, A. Fernández, J. Flix, E. FUllana, C. García Montoro, J. Lozano, G. Merino, A. Montiel, A. Pacheco, J. Sanchez, J Salt and A.Vedaee on behalf of the ATLAS Collaboration

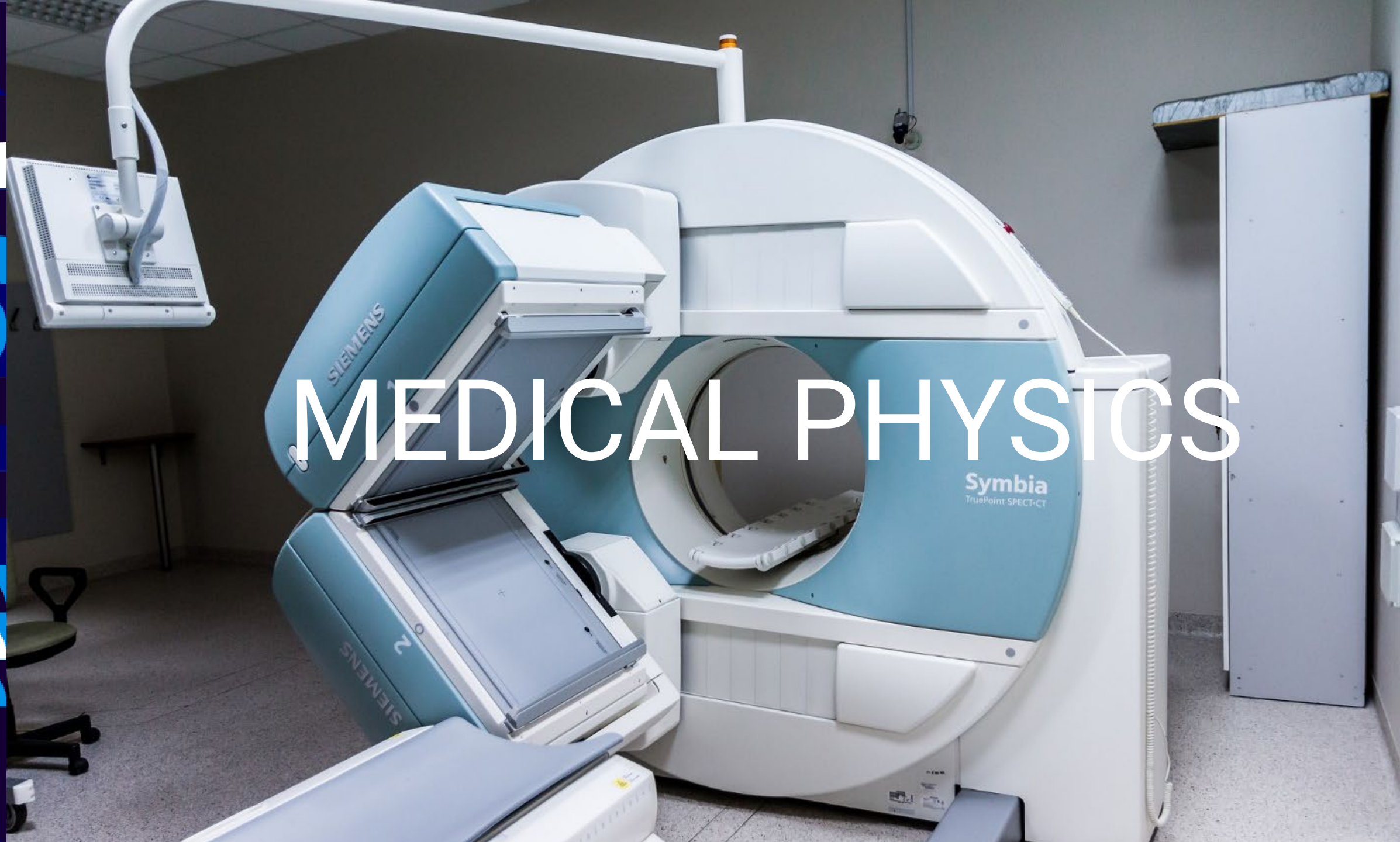
Proceedings of the 24th International Conference on Computing in High Energy and Nuclear Physics (CHEP19) EPJ Web of conference 245, 07027 (2020); ATL-SOFT-PROC-2020-004

> ‘The ATLAS EventIndex for LHC Run 3’. D. Barberis, I. Aleksandrov, E. Alexandrov, Z. Baranowski, G. Dimirov, A. Fernandez, E. Gallas, C. Garcia Montoro, S. González de la Hoz, J. Hrivnac, A. Kazymov, M. Mineev, F. Prokoshinm, G, Rybkin, J. Sanchez, J. Salt and M. Villaplana on behalf of the ATLAS Collaboration

Proceedings of the 24th International Conference on Computing in High Energy and Nuclear Physics (CHEP19) EPJ Web of conference 245, 04017 (2020); ATL-SOFT-PROC-2020-003

> ‘Data-centric Graphical User Interface of the ATLAS Event Index service’ . J. Hrivanic, I. Aleksandrov, E. Alexandrov, Z. Baranowski, G. Dimirov, A. Fernandez, E. Gallas, C. Garcia Montoro, S. González de la Hoz, A. Kazymov, M. Mineev, F. Prokoshinm, G, Rybkin, J. Sanchez, J. Salt and M. Villaplana on behalf of the ATLAS Collaboration

Proceedings of the 24th International Conference on Computing in High Energy and Nuclear Physics (CHEP19) EPJ Web of conference 245, 04036 (2020); ATL-SOFT-PROC-2020-029

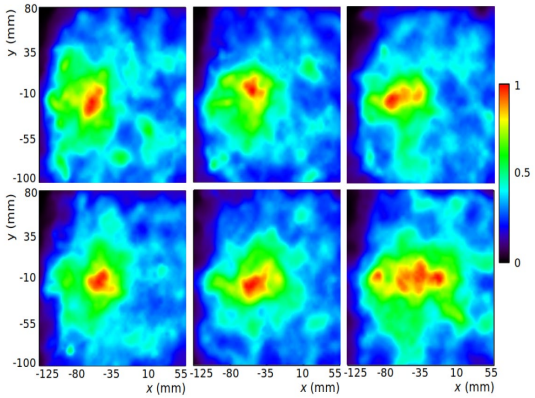


MEDICAL PHYSICS

5.6 MEDICAL PHYSICS

IFIC groups work on physics developments for medical applications, focusing on different aspects from instrumentation to data analysis, modelling, image processing and artificial intelligence (AI).
The group “42 is the answer” has led the research project for the development of machine learning models to support the prognosis and early diagnosis of suspected Covid-19 patients from chest X-rays, with the collaboration of FISABIO and UPV and hospital radiologists from Murcia and Extremadura. This project has been selected and funded by the Spanish reference center for health research Instituto de Salud Carlos III in its effort to fight COVID-19. The models have shown an ability to detect COVID-19 and increase the ability of radiologists to make an early diagnosis using only the first X-ray film and without the use of added clinical information, which allows for a production increase.
The group also works in other AI medical decision support systems, models to help diagnose breast cancer using screening mammographs and software for diagnosis, prognosis and follow-up of patients with spinal pathologies.

The IRIS group works on hadron therapy treatment monitoring, detecting the photons emitted by the irradiated tissue with two different systems. The Compton telescope has detected 3 mm variations in the Bragg peak position with 150 MeV protons impinging a PMMA target. Also, two new prototypes have been developed: MACACO III employs the AliVATA readout board, improving energy resolution and readout rate and MACACOp employs PETsys TOFPET2 ASIC to enhance the timing resolution. Characterization and beam tests have been performed. The second approach consists of a single scintillator crystal coupled to a PMT to be placed coaxially with the proton beam. The system must stand a very high readout rate with uniform response. SPICE simulations of photomultiplier voltage divider circuits, both passive and active, were performed to investigate the behaviour of photomultiplier gain in the strongly changing radiation field present in a proton treatment room.



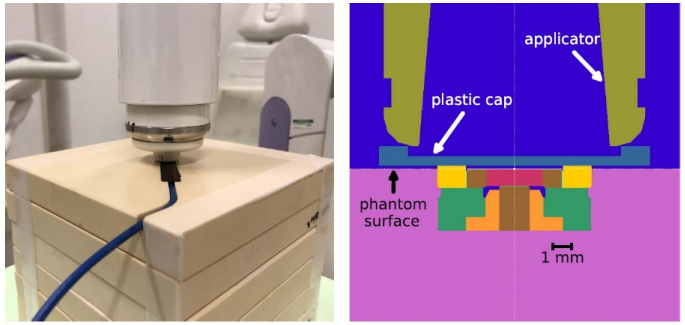
Distribution of photons reconstructed with the Compton telescope, emitted by a PMMA target irradiated with a 150 MeV proton beam in six positions. Shifts of 3 mm in the target position have been detected.

In addition, in positron emission tomography (PET), a probe for the improvement of the spatial resolution in total-body PET scanners has been assembled. The probe is formed by a SiPM and a CeBr3 monolithic scintillation crystal and read out with TOFPET2 ASIC. The characterisation of the probe has been completed and tests to operate it with a PET scanner have started.

Also in PET, the PETALO group is developing a scanner prototype based on liquid xenon, read out by silicon photomultipliers. The excellent scintillator properties of liquid xenon allow for the possibility of building a Time-of-Flight PET scanner, which results in a drastic improvement of the image quality. The construction and assembly of the prototype has been completed. The system is being commissioned and will start taking data soon afterwards.

The procedures to be followed for the calibration of megavoltage photon beams to be used in clinical practice are described by national and international dosimetry protocols. Such protocols ensure a high level of consistency and reproducibility in determining the absorbed dose. Together with The International Atomic Energy Agency (IAEA) and the companies PTW and Elekta Brachytherapy, the Medical Physics group of the University of Valencia has delivered the bean quality correction factors required for the clinical use of their ionization chambers.

5.6 MEDICAL PHYSICS

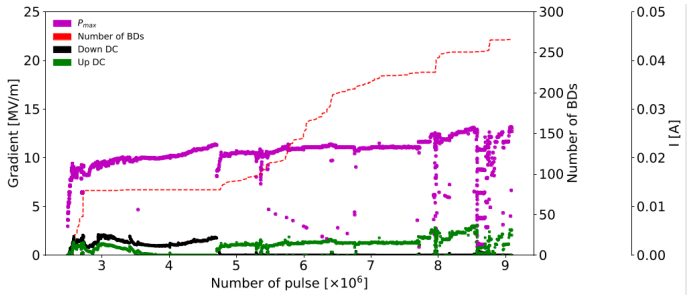


Experimental setup for an electronic brachytherapy photon beam (left) and schematic geometry reproducing the experimental setup for the MC simulation (right).

The accelerator physics group has been deeply involved in the commissioning and testing of a 3 GHz high-gradient accelerating cavity for proton-therapy accelerators. An accelerating gradient of ~13 MV/m was achieved after conditioning the structure with more than 9 million RF pulses. The student A.

The Gamma and Neutron Spectroscopy group also works in hadron therapy and medical imaging applications. In the framework of the PRONTO project, IFIC and IEM have completed a scanner for proton-CT imaging. It consists of a proton tracker made of 2 silicon strip detectors, covering the entrance and exit frames of the field of view. Beyond the exit frame, the total energy detector is comprised by an array of four scintillator detectors in phoswich configuration. The system has been tested with electrons and is ready to receive proton beams. The GAMUS project aims at developing a gamma detection system capable of performing gamma imaging on quasi-real-time of tumors in order to guide the biopsy process in breast cancer and target to more specific samples inside the heterogeneous tumors, thus allowing to more specific treatments improving patient prognosis. A second project called MAGAS, has the objective of integrating the GAMUS demonstrable with an ultrasound probe.

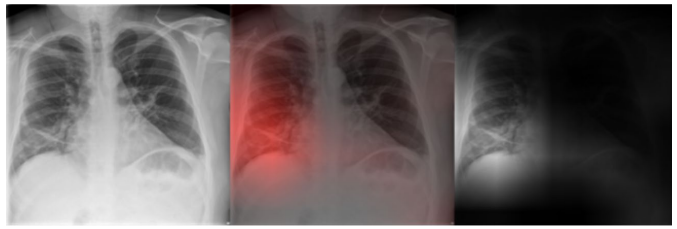
The accelerator physics group has been deeply involved in the commissioning and testing of a 3 GHz high-gradient accelerating cavity for proton-therapy accelerators. An accelerating gradient of ~13 MV/m was achieved after conditioning the structure with more than 9 million RF pulses. The student A. Vnuchenko defended her Ph. D. thesis developed in collaboration with CERN.



Results of cavity RF conditioning at the IFIC RF lab after 9 M RF pulses. The purple line shows the achieved accelerating gradient, the red curve the accumulated number of breakdowns and the green and black curves the generated dark currents.

HIGHTLIGHTS GROUP

IFIC leads a project to support prognosis and early diagnosis of suspected COVID-19 patients from chest X-rays with machine learning models, with the collaboration of FISABIO and UPV and hospital radiologists from Murcia and Extremadura. The models shown an ability to detect COVID-19 and increase the ability of radiologists to make an early diagnosis using only the first X-ray film and without the use of added clinical information.



Chest X-ray radiograph of a suspected COVID-19 patient and the interpretation made by artificial intelligence for its diagnosis.

AWARDS AND APPOINTMENTS OF THE YEAR

> Gabriela Llosá was elected president of the medical physics group of the Spanish Royal Physical Society.

CONFERENCE ORGANISATION

> III Jornadas RSEF / IFIMED de Física Médica 2020. Virtual (Valencia, Spain), 14 - 15 Dec 2020. Organized by the IRIS group.

5.6 MEDICAL PHYSICS

Selected publications

> Schaffter T, Buist DSM, Lee CI, Nikulin Y, Ribli D, Guan Y, Lotter W, Jie Z, Du H, Wang S, Feng J, Feng M, Kim HE, Albiol F, Albiol A, Morrell S, Wojna Z, Ahsen ME, Asif U, Jimeno Yepes A, Yohanandan S, Rabinovici-Cohen S, Yi D, Hoff B, Yu T, Chaibub Neto E, Rubin DL, Lindholm P, Margolies LR, McBride RB, Rothstein JH, Sieh W, Ben-Ari R, Harrer S, Trister A, Friend S, Norman T, Sahiner B, Strand F, Guinney J, Stolovitzky G; and the DM DREAM Consortium, Mackey L, Cahoon J, Shen L, Sohn JH, Trivedi H, Shen Y, Buturovic L, Pereira JC, Cardoso JS, Castro E, Kalleberg KT, Pelka O, Nedjar I, Geras KJ, Nensa F, Goan E, Koitka S, Caballero L, Cox DD, Krishnaswamy P, Pandey G, Friedrich CM, Perrin D, Fookes C, Shi B, Cardoso Negrie G, Kawczynski M, Cho K, Khoo CS, Lo JY, Sorensen AG, Jung H. Evaluation of Combined Artificial Intelligence and Radiologist Assessment to Interpret Screening Mammograms. JAMA Netw Open. 2020 Mar 2;3(3):e200265. doi: 10.1001/jamanetworkopen.2020.0265. Erratum in: JAMA Netw Open. 2020 Mar 2;3(3):e204429. PMID: 32119094; PMCID: PMC7052735.

> A. Ros Garcia, J. Barrio, A. Etxebeste, J. Garcia-Lopez, M.C. Jimenez-Ramos, C. Lacasta, E. Muñoz, J.F. Oliver, J. Roser, G. Llosá. MACACO II test-beam with high energy photons. Phys. Med. Biol. 65 (2020) 245027.

> Giménez-Alventosa V, Giménez V, Ballester F, Vijande J, Andreo P. Monte Carlo calculation of beam quality correction factors for PTW cylindrical ionization chambers in photon beams. Phys Med Biol. 2020 Oct 7;65(20):205005. doi: 10.1088/1361-6560/ab9501. PMID: 32434170.

> A. Vnuchenko et al., High-gradient testing of an S-band, normal-conducting low phase velocity accelerating structure, Phys. Rev. Accel.Beams 23 (2020) 8, 084801.

Selected conference talks

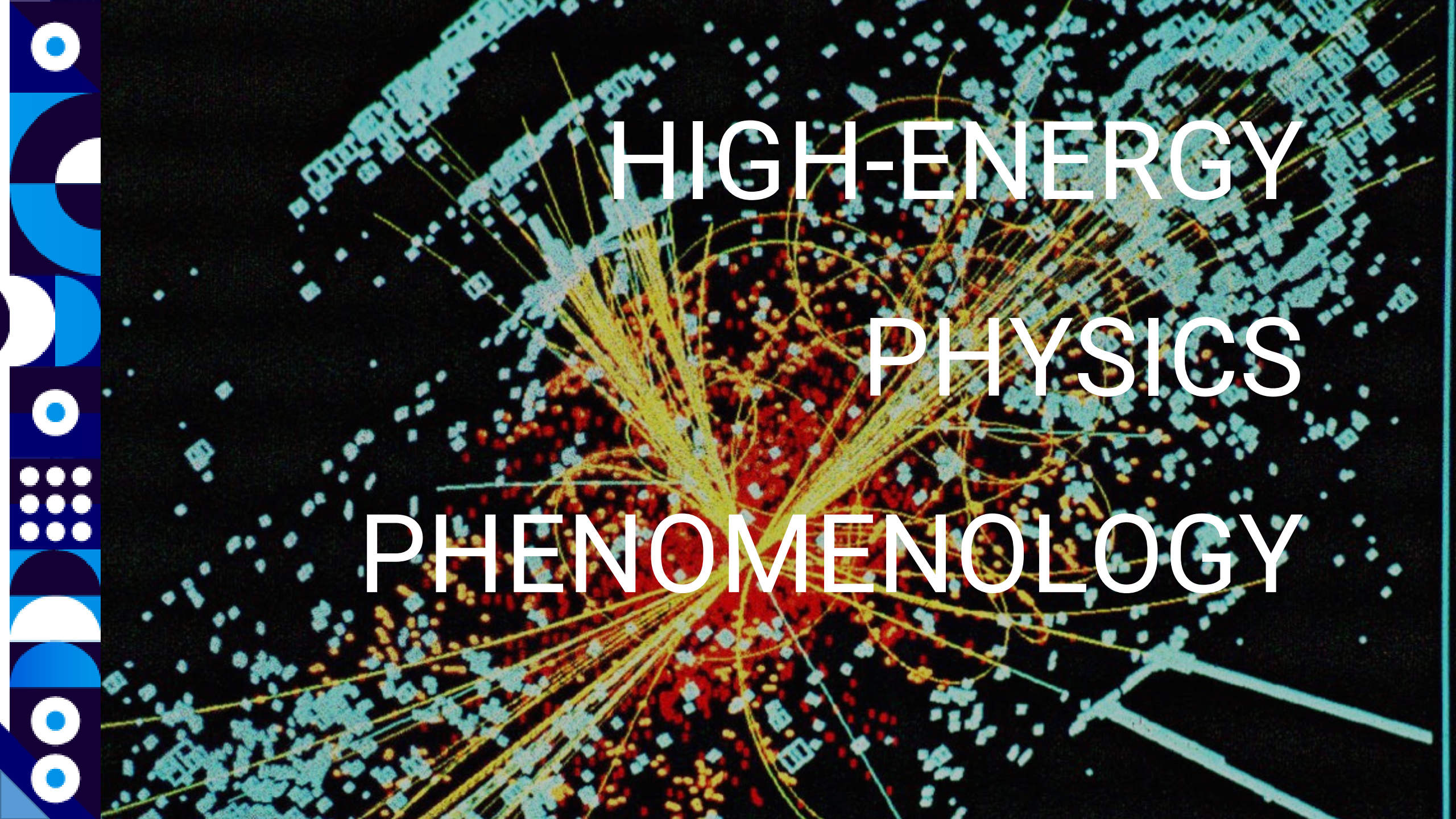
> M. Borja-Lloret, L. Barrientos, J. Bernabeu, J.V. Casaña, C. Lacasta, E. Muñoz, A. Ros, J. Roser, R. Viegas and G. Llosá. Background studies in MACACO Compton camera for hadron therapy. Talk at 2020 IEEE Nuclear Science Symposium and Medical Imaging Conference (IEEE NSS MIC). Virtual (Boston, EEUU), 31 Oct - 7 Nov 2020.

> P. Ferrario, PETALO: Time-Of-Flight PET with liquid xenon. Talk at III Jornadas RSEF / IFIMED de Física Médica 2020. Virtual (Valencia, Spain), 14 - 15 Dec 2020.

> J. Roser, L. Barrientos, J. Bernabéu, M. Borja-Lloret, E. Muñoz, J. F. Oliver, A. Ros, R. Viegas and G. Llosá. Improving the quality of the images obtained by the MACACO Compton telescope by means of a joint reconstruction algorithm. Talk at III Jornadas RSEF / IFIMED de Física Médica 2020. Virtual (Valencia, Spain), 14 - 15 Dec 2020.

6

THEORETICAL PHYSICS DEPARTMENT

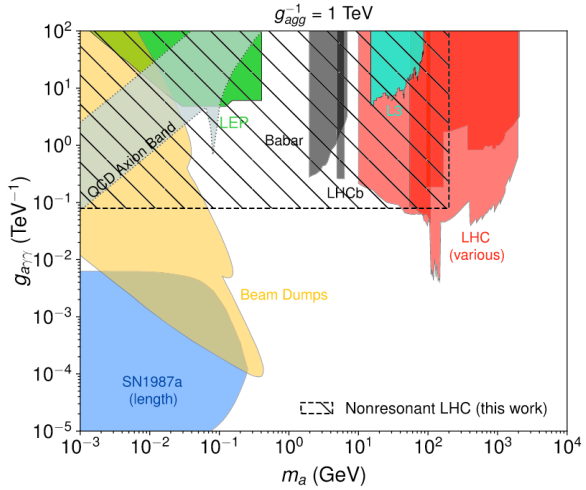

HIGH-ENERGY
PHYSICS
PHENOMENOLOGY

6.1 HIGH-ENERGY PHYSICS PHENOMENOLOGY

LHC SEARCHES

Axion-like particles

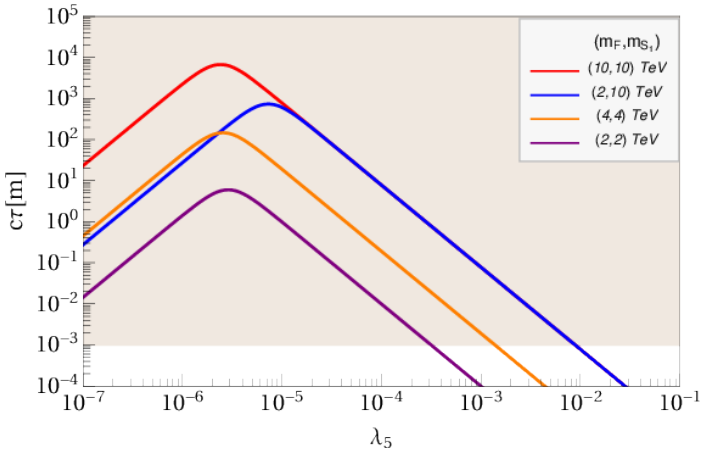
In recent years there has been a renewed interest in axions, axion-like particles and general pseudo-Nambu-Goldstone bosons. The derivative nature of the interactions of these particles makes non-resonant searches at colliders, where the new particles can enter in the s-channel as an off-shell mediator, an appealing probe. Researchers at IFIC have performed an analysis using CMS diboson, diphoton and dijet data.



Bounds on the couplings of axion-like particle to photons as a function of the mass. The hatched region corresponds to the excluded region from non-resonant LHC searches.

Neutrinos at colliders

The origin of neutrino masses remains unknown. Some models generate neutrino masses radiatively, with new particles at low scales accessible at colliders. Researchers at IFIC have studied lepton-number-violating multi-lepton signals, where the high-multiplicity final states have little background at the LHC. Furthermore, the models can have long-lived charged particles that may leave highly ionizing tracks in the detectors. Multiply-charged scalars associated to neutrino mass generation could have visible decay lengths at the LHC.

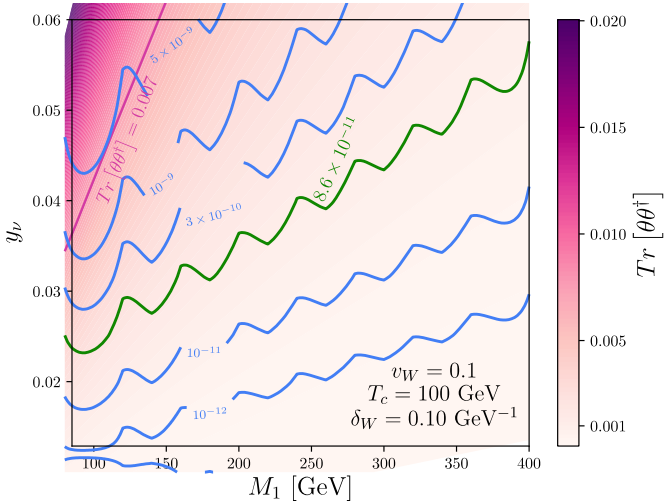


Decay length of triply-charged scalars is shown as a function of another coupling involved in neutrino mass generation for several scenarios.

NEUTRINOS

Baryogenesis

The origin of the baryon asymmetry of the Universe is one of the most pressing questions in particle physics. Researchers at IFIC have shown that one of the needed extra ingredients beyond the Standard Model (enough CP violation) may be linked to the origin of neutrino masses. Within an electroweak scale inverse/linear seesaw scenario, allowing for significant Yukawa couplings and mixings, the baryon asymmetry may be reproduced if flavour effects are included. This scenario evades constraints from electric dipole moments and could be probed at future colliders.

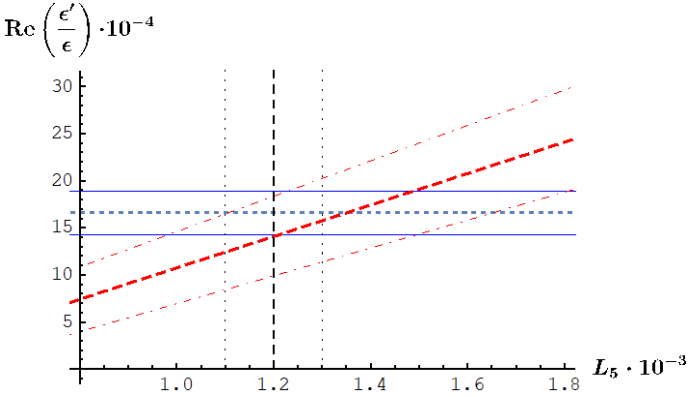


Baryon asymmetry (green curve is the observed value) in terms of the Yukawa coupling and the smallest heavy neutrino mass in the flavoured scenario. The upper limit on the mixing is shown as a magenta line.

6.1 HIGH-ENERGY PHYSICS PHENOMENOLOGY

CP violation in Kaons

There has been a heated debate over the years regarding the direct CP-violating ratio ϵ'/ϵ in the Kaon system. A new analysis of the known isospin-breaking contributions to the K→ππ amplitudes by researchers at IFIC, including the relevant non-perturbative inputs, has been performed. Results shown that the Standard Model prediction is in very good agreement with the observed value.

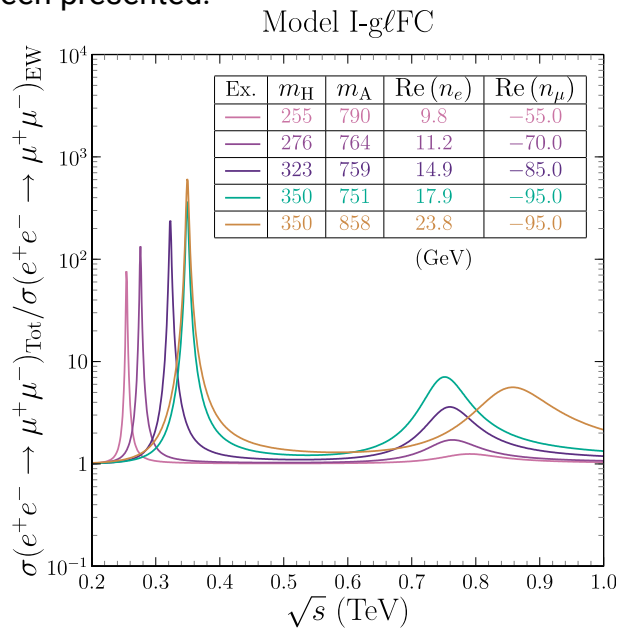


SM prediction for Re(ε'/ε) (red band). The blue band is the measured value of Re (ε'/ε).

ANOMALIES IN FLAVOR PHYSICS

Muon g-2

There is a long-standing anomaly regarding the anomalous magnetic moment of the muon (with fresh new data increasing the significance in 2021). The muon anomaly has opposite sign compared with the (less significant) anomaly present in the anomalous magnetic moment of the electron. Researchers at IFIC have analysed a general flavour conserving two-Higgs doublet model where this needed “decoupling” of electron and muon is possible. Signatures at colliders of different viable solutions of the model have been presented.



Cross section for electron-positron collisions in the case of solving g-2 anomalies within a general two-Higgs doublet model.

AWARDS AND APPOINTMENTS

> Appointed member of the CERN Science Policy Committee. P. Hernández.

> "Steering Group" del "FIPs Physics Centre (FPC)", "Physics Beyond Colliders (PBC)", CERN. J. López Pavón, P. Hernández

> A. Pich, Member of the "Scientific and Strategical Council" of "Laboratoire de Physique des 2 Infinis Irène Joliot-Curie" (IJCLab) [CNRS, Université Paris-Saclay and Université de Paris] (2020-2021)

CONFERENCE ORGANIZATION

> G. Rodrigo. PREFIT School - Precision meets EFT at the LHC (2-13 March 2020; https://indico.cern.ch/event/prefit20) at DESY Hamburg, a joint collaboration between the COST Actions VBSCAN and PARTICLEFACE

Cancelled due to COVID (Moriond EW, Trento School, P. Hernández)

6.1 HIGH-ENERGY PHYSICS PHENOMENOLOGY

Selected publications

> Nonresonant Searches for Axionlike Particles at the LHC. M.B. Gavela, J. M. No, V. Sanz, J. F. Troconiz. Phys. Rev. Lett. 124 (2020) 5, 051802. DOI: 10.1103/PhysRevLett.124.051802

> Long-lived charged particles and multilepton signatures from neutrino mass models. C. Arbeláez, G. Cottin, J.C. Helo y M. Hirsch. Phys. Rev. D 101 (2020) 095033. DOI: 10.1103/PhysRevD.101.095033

> Neutrino electroweak baryogenesis. E. Fernández-Martínez, J. López-Pavón, T. Ota and S. Rosauro-Alcaraz, JHEP 10 (2020) 063. DOI:10.1007/JHEP10(2020)063

> Isospin-Violating Contributions to ε'/ε. V. Cirigliano, H. Gisbert, A. Pich, A. Rodríguez-Sánchez. JHEP 02 (2020) 032. DOI: 10.1007/JHEP02(2020)032

> Electron and muon g−2 anomalies in general flavour conserving two Higgs doublets models. F. J. Botella, F. Cornet-Gómez, M. Nebot. Phys. Rev. D 102 (2020) 3, 035023. DOI: 10.1103/PhysRevD.102.035023

Selected conference talks

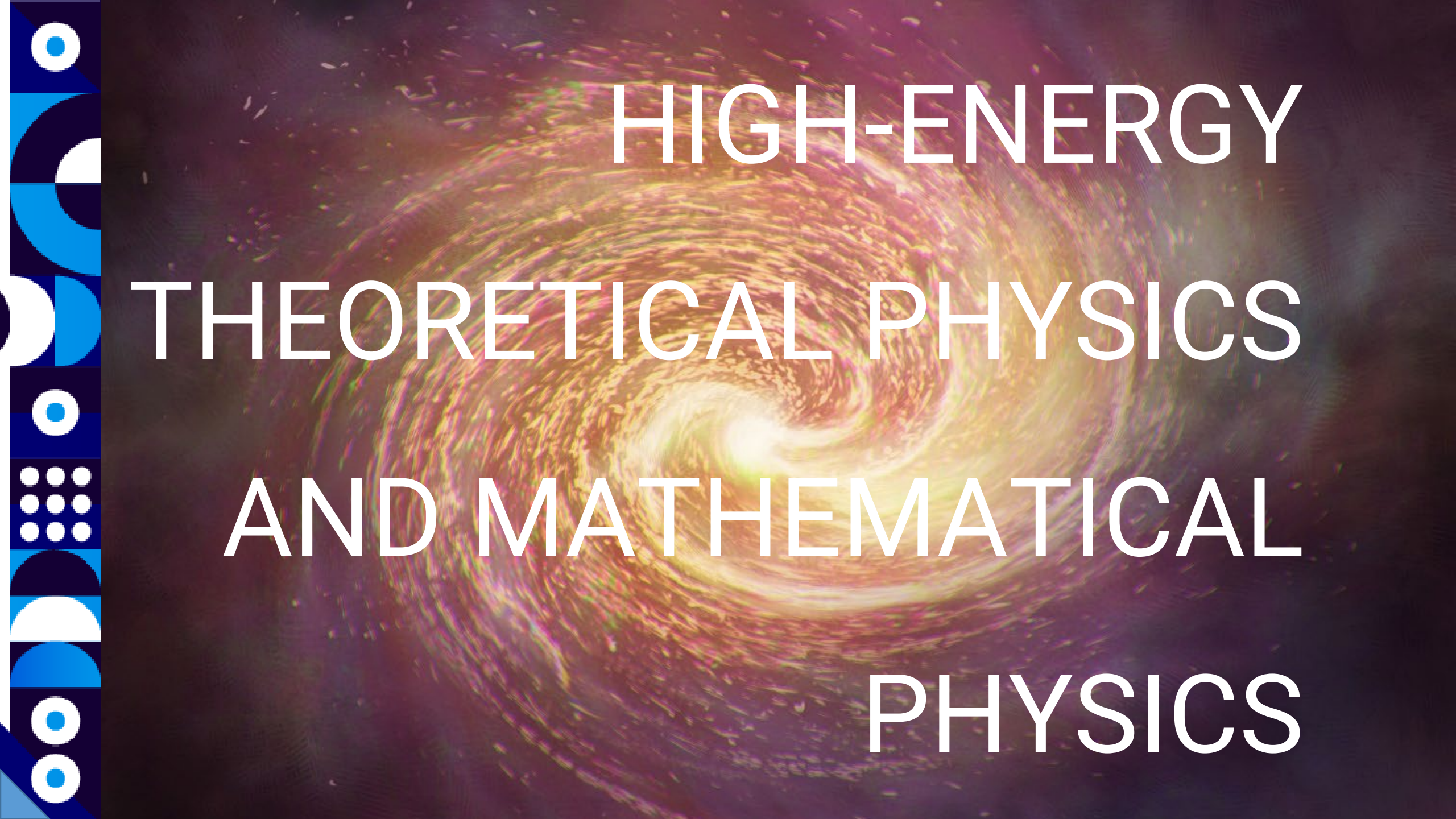
> Kaon decays and CP violation. A. Pich. 18th Conference on Flavour Physics and CP Violation (FPCP) 2020, A Toxa (Spain), 9th June 2020. Invited talk. On-line participation.

> Supersymmetric flavor symmetries and the LHC. O. Vives. International Conference on Neutrinos and Dark Matter (NDM-2020) Hurghada (Egypt), 11-14 January 2020

> Neutrino oscillations, flavor theories and dark matter. J.W.F. Valle. 40th International Conference on High Energy Physics (ICHEP 2020) On-line conference, 28 July - 6 August 2020.

> Electric quantum walks and Bloch oscillations. Armando Pérez. 9th International Conference on Quantum Simulation and Quantum Walks. Marseille, 20-24 January 2020. https://conferences.cirm-math.fr/2161.html

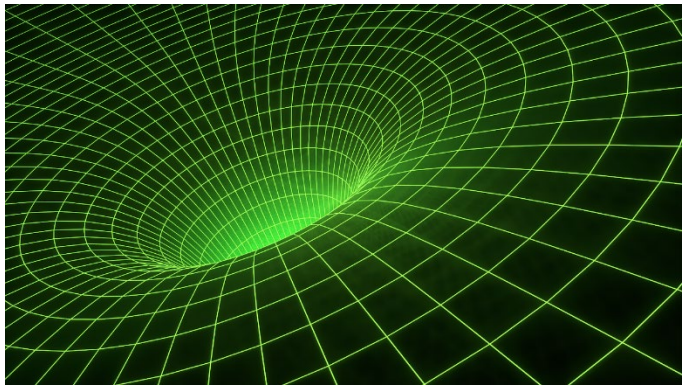
> B-L breaking scenarios. S. Centelles Chuliá. International Conference on Neutrinos and Dark Matter (NDM-2020) Hurghada (Egypt), 11-14 January 2020


HIGH-ENERGY
THEORETICAL PHYSICS
AND MATHEMATICAL
PHYSICS

6.2 HIGH-ENERGY THEORETICAL PHYSICS AND MATHEMATICAL PHYSICS

Quantum black holes, supergravity, and cosmology

Our research activity this year has brought new results in various lines related to mathematical and phenomenological extensions of General Relativity, quantum fields in curved space-time, and water waves that emulate black hole properties.



Wormhole space - time

First of all, we have established that the correct definition of superfields goes through defining the space of superfields by means of a functor. Using tensorial distribution theory we have been able to obtain a consistent set of field equations for metric-affine gravity theories of the f(R) type with boundary layers (thin shells), which has allowed us to clarify a long-standing question in the literature on stellar structure models. We also obtained new exact solutions for rotating compact objects (black holes and wormholes) and even for multicenter configurations (without spatial symmetries). We have made progress in the study of gravity theories with Lorentz symmetry breaking and also showed for the first time that the process of quantum particle creation can take place in wormhole space-times.

In the interphase between gravity and the quantum world, we have established an intriguing relation between chiral anomalies in curved space-times and the radiative content of the gravitational field. In particular, we have shown that a flux of circularly polarized gravitational waves triggers the spontaneous creation of photons with net circular polarization from the quantum vacuum. We have also constructed a generalization of the DeWitt-Schwinger renormalization subtractions in curved space to include an arbitrary renormalization mass scale. The new predicted running for the gravitational couplings are fully consistent with decoupling of heavy massive fields. Furthermore, we have also proposed a new partial resummation of the QED effective action. It is based on the fact that the proper-time series expansion of the one-loop effective Lagrangian of QED can be partially summed in all terms containing the field-strength invariants.

In the context of analogue gravity, we have compared the data of a scattering experiment of surface water waves on an accelerating transcritical flow (analogue black hole) with the theoretical predictions. We numerically calculated the correlations between the Hawking particles and their partners for three different models of acoustic black holes in Bose-Einstein condensates. We also proposed a new method to compute the semiclassical stress-energy tensor for a scalar field in the background of a black hole formed from the collapse of a null shell of radiation.

To conclude we would like to mention that our group organized the 4th Valencia Winter Workshop on Theoretical Physics (Dec. 14-18, 2020), with around 40 speakers. Many of the talks are available on our YouTube channel, which can be accessed via our renovated group's website.

Screenshot from YouTube of one of the talks at the 4th VWW

6.2 HIGH-ENERGY THEORETICAL PHYSICS AND MATHEMATICAL PHYSICS

Selected publications

> P.Euvé, S. Robertson, N. James, A. Fabbri and G. Rousseaux, Scattering of Co-Current Surface Waves on an Analogue Black Hole , Phys. Rev. Lett. 124 (2020), 141101

> G.J. Olmo , D. Rubiera-Garcia, Junction conditions in Palatini f(R) gravity, Class.Quant.Grav. 37 (2020) 21, 215002

> G.J. Olmo, D. Rubiera-Garcia , A. Wojnar ,Stellar structure models in modified theories of gravity: Lessons and challenges, Phys.Rept. 876 (2020), 1-75

> A. Ferreiro, J. Navarro-Salas, Running gravitational couplings, decoupling, and curved spacetime renormalization, Phys. Rev. D102 (2020) 4, 045021.

> P. Beltrán-Palau, J. Navarro-Salas, S. Pla, “Adiabatic regularization for Dirac fields in time-varying electric backgrounds”, Phys.Rev.D 101 (2020) 10, 105014.

Selected conference talks

> Gonzalo J. Olmo, "Particle creation by wormholes? A 1+1 model", Workshop "Models of Gravity", March 2-4, 2020, at ZARM (University of Bremen, Germany).

> María A. Lledó, “Superfields and superschemes”, Superday Workshop, May 5-7, Università del Piemonte Orientale, Alessandria (Italy).

> Silvia Pla Garcia, “Validity of the semiclassical approximation for pair production due to an electric field in 1+ 1 dimensions”, APS April Meeting 2020, April 18-21, Washington D.C. (Online).


EFFECTIVE FIELD
THEORIES IN HADRON
AND NUCLEAR PHYSICS

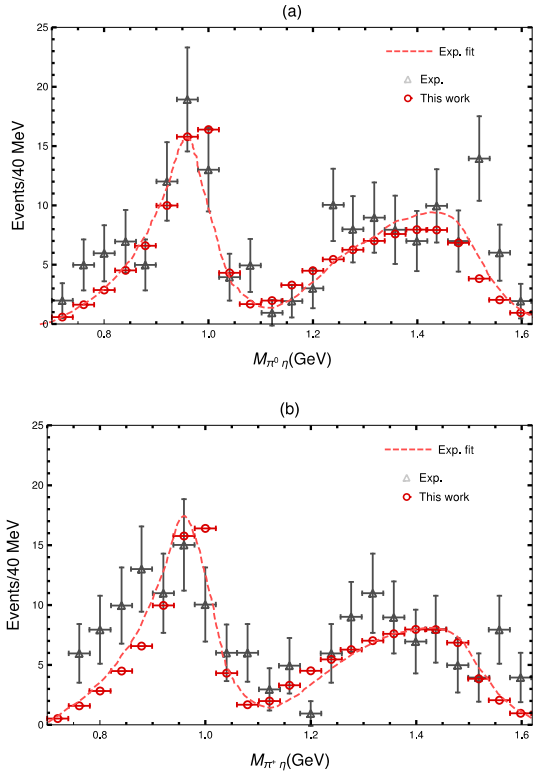
6.3 EFFECTIVE FIELD THEORIES IN HADRON AND NUCLEAR PHYSICS

Quantum Chromodynamics (QCD), the theory of the strong interactions, does not prevent the existence of states out of standard hadrons, the so-called exotics. However, in the light (u,d,s) quark sector, these are difficult to disentangle in general. The LHCb has announced in 2020 the discovery of the first open-flavor exotic tetraquark, named X0(2866). This observation confirms predictions of IFIC's researchers on the existence of molecular states based on the Hidden Gauge Formalism (HGF), which have been recently refined.

The combination of Effective Field Theories with lattice QCD simulations can also provide an important source of information regarding the properties of hadrons. The most studied hadron in lattice QCD is the lightest vector meson, the ρ(770). IFIC's researchers have conducted a combined analysis of all available pseudoscalar meson masses, decay constants, and phase shifts in several chiral trajectories which involve the variation of the u(d) and s quark masses, thus, determining the quark mass dependence of the ρ(770) meson, which mass gets reduced to 680 MeV around the chiral limit.

Production mechanisms are also essential to study hadron properties. The BESIII Collaboration has reported recently the so-called first observation of pure W-annihilation decays of Ds mesons to pions and the a0(980) resonance. IFIC's researchers have evaluated Ds+ decay into π+π0η via internal emission from Unitarized Chiral Perturbation Theory (UChPT), where the a0(980) is dynamically generated, which should be dominant compared to W-annihilation according to the topological classification of weak decays, reproducing the experimental data well. They have also shown that triangle singularities, which develop from triangle loop diagrams when all the intermediate particles can be put on shell, can be used to discriminate whether the X(3872) is below or above the threshold for pair production of D mesons.

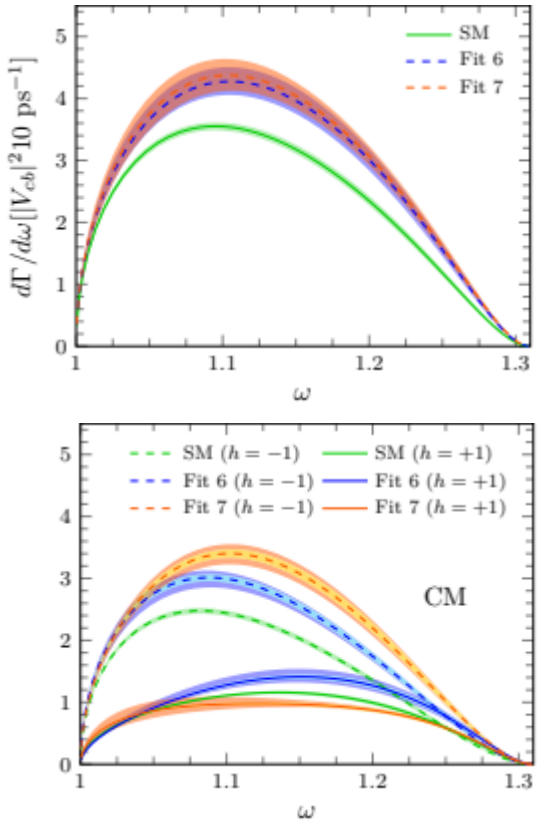
The nucleon axial form factor, a fundamental property of the nucleon which contains information on the spin distribution, is also relevant for the analysis of neutrino oscillations. Precise values of the axial coupling and radius have been obtained from an analysis of lattice QCD from several groups using one-loop ChPT, supporting smaller values of the radius compared to the empirical one.



Event distributions of Ds+ decay into π+π0η compared with experiment. The dashed lines correspond to the experimental data after the non πa0 events are removed.

6.3 EFFECTIVE FIELD THEORIES IN HADRON AND NUCLEAR PHYSICS

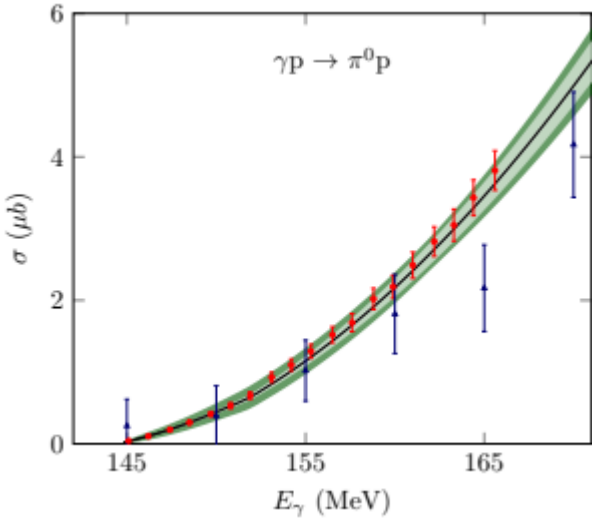
Recently, some tension between experimental data and SM results has been observed in semileptonic B meson decays, which might lead to new physics (NP). Since there is no evidence of similar discrepancies in transitions involving the two first quark and lepton families, it is usually assumed that possible NP contributions only affect the third quark and lepton generations, being responsible for lepton flavour-universality violation (LFUV). When comparing to SM predictions, these violations are observed semileptonic decays of B to D mesons. According to the Heavy Flavour Average Group (HFLAV) this tension is around 3.1σ. Researchers at IFIC have developed a general framework to study any (unpolarized) hadron semileptonic decay based on the SM Effective Field Theory scheme including NP contributions, where scalar, pseudoscalar and tensor NP terms, as well as corrections to the SM vector and axial contributions are allowed. The new formalism was applied to obtain complete NP effects to semileptonic decays where LFUV is expected. The proper consideration of the Wilson coefficient standard correlations from various types of decays can drastically reduce the errors in the new predictions.



Differential decay width of Λb in the SM and NP (top panel). Contributions corresponding to τ leptons with well-defined helicities (h = ±1) in the W−CM reference system (bottom panel).

The nucleon axial form factor, a fundamental property of the nucleon which contains information on the spin distribution, is also relevant for the analysis of neutrino oscillations. Precise values of the axial coupling and radius have been obtained from an analysis of lattice QCD from several groups using one-loop ChPT, supporting smaller values of the radius compared to the empirical one.

The study of electromagnetic pion production on nucleons is essential to improve our knowledge on the pion-nucleon interaction and is also crucial for the properties of several baryonic resonances. Researchers at IFIC have analysed recent experimental data on electromagnetic pion production close to threshold using ChPT up to third order in the extended-on-mass-shell scheme, with the explicit inclusion of the Δ resonance. The model describes well all available data on angular distributions, total cross section, and numerous polarization observables. In particular, the agreement of the cross section for γp → π0p close to threshold is excellent.



Cross section for γp → π0p close to threshold compared to experimental data.

6.3 EFFECTIVE FIELD THEORIES IN HADRON AND NUCLEAR PHYSICS

Selected publications

> R. Molina and E. Oset, Molecular picture for the X0(2866) as a $D*\bar{K}*$ $J^P = 0^+$ state and related $1^+,2^+$ states, Phys. Lett. B 811 (2020), 135870

> R. Molina and J. Ruiz de Elvira, Light- and strange-quark mass dependence of the ρ(770) meson revisited, JHEP 11 (2020) 017

> S. Sakai, E. Oset and F. K. Guo, Triangle singularity in the $B^- \to K^-\pi^0 X(3872)$ reaction and sensitivity to the X(3872) mass, Phys. Rev. D 101 (2020), 054030-10pp

> N. Penalva, E. Hern´andez and J. Nieves, Hadron and lepton tensors in semileptonic decays including new physics, Phys. Rev. D 101 (2020), 11300424pp

> G. H. Guerrero Navarro and M. J. Vicente Vacas, Threshold pion electro- and photoproduction off nucleons in covariant chiral perturbation theory, Phys. Rev. D 102 (2020), 113016-23pp

Selected conference talks

> E. Oset, Predicted molecular states recently found: LHCb pentaquarks, X0(2866) and Ω(2012). Workshop on Theoretical aspects of Hadron Spectroscopy and Phenomenology, Valencia, December 15-17, 2020.

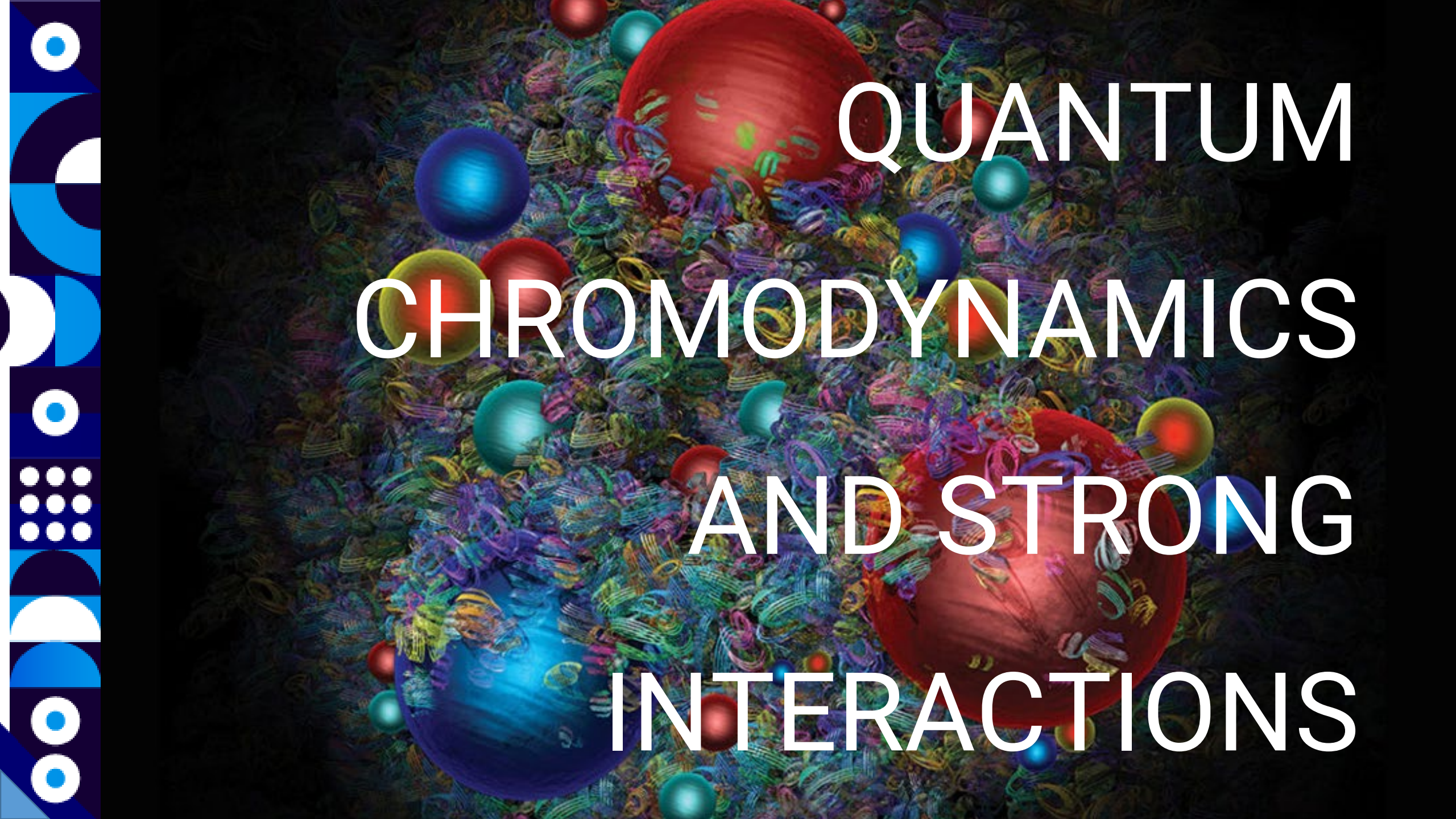
> R. Molina, Implications of the $D_s^+ \to \pi^+\pi^0\eta$ decay in the nature of a0(980) and molecular interpretation of the new X0(2900) (online), Hadron in Nucleus 2020, Yukawa Institute for Theoretical Physics, Kyoto University, Japan.

> F. Alvarado, L. Alvarez-Ruso, The nucleon axial form factor in chiral perturbation theory, MiniWorkshop on Neutrino Theory, September 21-23, 2020 (online)

Conference organization

> Juan Nieves and Raquel Molina participated in the organization of the Workshop on Theoretical aspects of Hadron Spectroscopy and Phenomenology, Valencia, December 15-17, 2020.

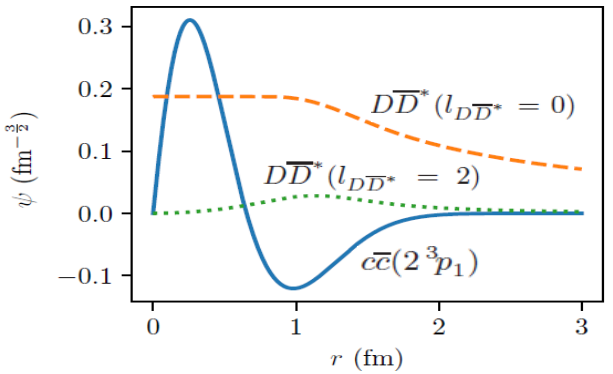
> Luis Alvarez Ruso has been a member of the International Advisory Committee of the The XXIX International Conference on Neutrino Physics and Astrophysics (Neutrino 2020), Fermilab (online), June 22 to July 2, 2020.


QUANTUM
CHROMODYNAMICS
AND STRONG
INTERACTIONS

6.4 QUANTUM CHROMODYNAMICS AND STRONG INTERACTIONS

This research line is devoted to the study of the fascinating properties of Quantum Chromodynamics (QCD), the quantum field theory that best describes the strong interactions between quarks and gluons, the fundamental components of protons, neutrons and many other hadrons. QCD explains with incredible detail a multitude of intriguing physical effects on a wide range of energy scales, ranging from the nuclear force at low energies to the hard-scattering processes taking place at high-energy colliders. The strong interactions are ubiquitous at hadron colliders like the CERN's Large Hadron Collider (LHC), and, therefore, their accurate study is essential for precision measurements and searches for new physics beyond the Standard Model. To provide a comprehensive description, various approaches are considered such as perturbative and non-perturbative methods, lattice gauge theories, effective field theories, chiral perturbation theory, and phenomenological models. Furthermore, theoretical techniques developed in QCD also find applications to the study of gravity.

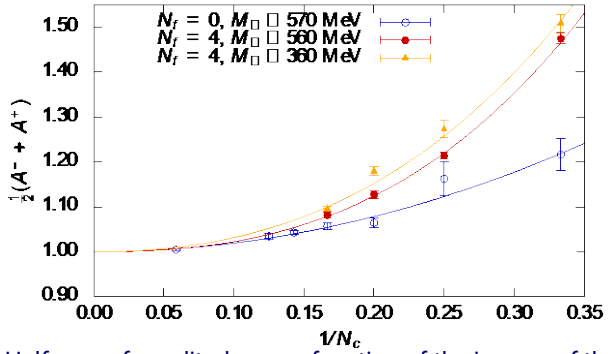
The description from QCD of unconventional charmoniumlike states discovered in the last two decades (X(3872), X(3915), X(4260)…) is a current challenge in hadron physics. For this purpose, a diabatic formalism, first used in molecular physics, has been adapted to the description of charmoniumlike states as made of quark-antiquark and meson-meson components interacting through a static potential derived from lattice QCD. The formalism has been successfully applied by IFIC´s researchers to calculate the mass spectrum and the Okubo-Zweig-Iisuka (OZI) allowed strong decay widths.



Components of the radial wave function of X(3872)

Apart from atomic nuclei, there is no indisputable evidence, so far, for stable multiquark states in the hadronic spectrum. The first lattice QCD study of dibaryons with heavy quark flavours was reported last year, in which the authors concluded that several structures were clearly below the corresponding two-baryon threshold and should therefore exist as reasonably long-lived stable particles and could therefore be measured. Researchers at IFIC, Salamanca and Lyon have analysed these systems from the perspective of constituent quark models, a very successful approach in determining the properties of hadrons, and concluded that, when treated without imposing radical and rather problematic approximations, there is no evidence for any stable superheavy hexaquarks.

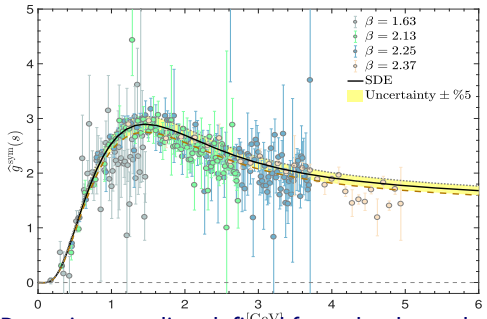
Lattice field theory allows to investigate the low energy, strongly coupled, regime of QCD. One long-standing puzzle in QCD phenomenology is the ΔI = 1/2 rule, that is, the large hierarchy of isospin amplitudes in the K→ππ weak decay. Researchers at IFIC have been able to reconcile the large enhancement with coefficients that are large in the 1/Nc expansion. They have also contributed to the development and application of the finite-volume three-particle formalism. This recent extension allows one to treat generic three-pion systems, including those with resonant interactions. Lattice simulations have been carried out to extract three-body scattering parameters in the ϕ^4 theory and in QCD.



Half-sum of amplitudes as a function of the inverse of the number of colours for three different lattice configurations (quenched and dynamical).

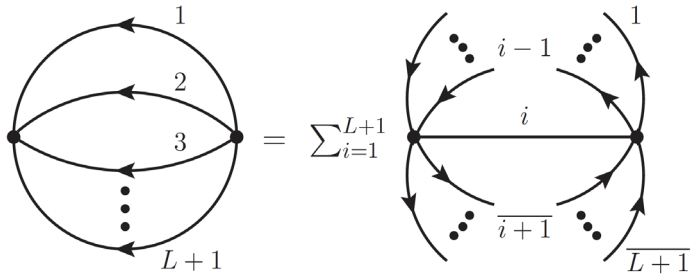
6.4 QUANTUM CHROMODYNAMICS AND STRONG INTERACTIONS

Results obtained from lattice simulations for the nonperturbative determination of the three-gluon vertex fully corroborate the dynamical picture that has been put forth in a series of articles by IFIC's researchers. Further progress on the understanding of the emergence of a mass gap in the gauge sector of QCD through the study of Schwinger-Dyson equations and gauge-fixed lattice simulations has also been achieved, and the nonperturbative generalization of the QCD effective charge obtained from the pinch technique. This quantity constitutes the most natural non-Abelian extension of the famous Gell-Mann—Low effective charge and represents a process-independent measure of the interaction strength of QCD, at any energy scale.



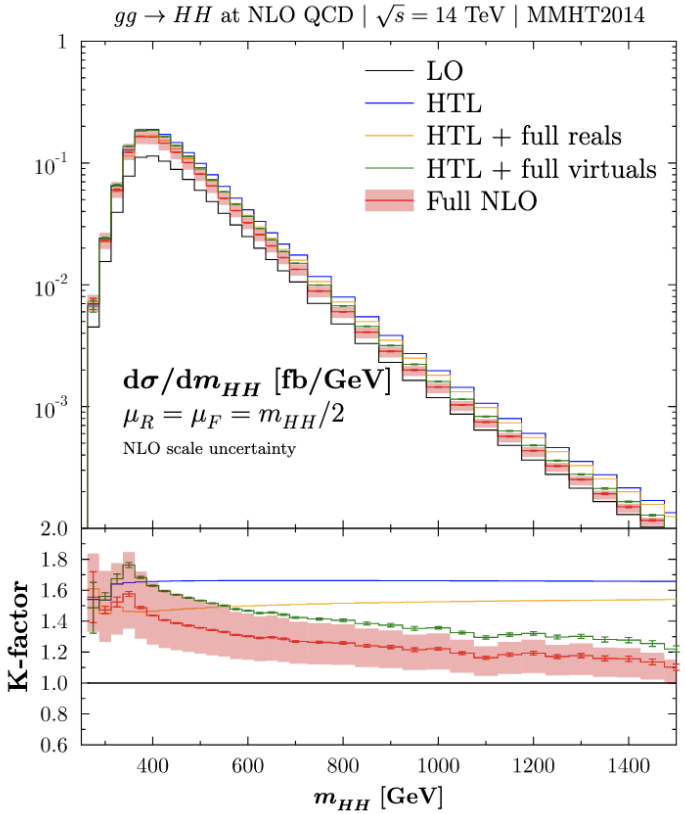
The QCD running coupling defined from the three-gluon vertex. The Schwinger-Dyson computation is compared to the result obtained from a lattice simulation

Multiloop scattering amplitudes describing the quantum fluctuations in high-energy scattering processes are the main theoretical bottleneck in perturbative quantum field theory. IFIC's researchers have proposed a novel method, called loop-tree duality, which aims to overcome this bottleneck by opening loop amplitudes in tree diagrams to combining them seamlessly with the tree amplitudes encoding the emission of extra radiation. A turning point in the development of this method has been the extension of the loop-tree duality to all perturbative orders, and the discovery of a causal representation which is manifestly free of nonphysical singularities. The absence of nonphysical singularities allows for more stable numerical implementations and opens the way to better theoretical predictions. Researchers from IFIC also participate in the MUonE theory initiative aimed at providing the most accurate theoretical predictions for elastic muon-electron scattering to the proposed MUonE experiment.



Opening of a multloop scattering amplitude into a sum of tree diagrams.

Theoretical predictions at second order in the perturbative expansion (next-to-leading order NLO) for Higgs-pair production by gluon fusion and diphoton production in vector-boson scattering at the LHC have been presented by IFIC's researchers. Higgs-pair production is particularly relevant, as this process is sensitive to the self-interaction of the Higgs boson, whose strength has not yet been measured at the LHC.



Differential distribution for Higgs-pair production at the LHC.

6.4 QUANTUM CHROMODYNAMICS AND STRONG INTERACTIONS

Selected publications

> J.J. Aguilera-Verdugo, F. Driencourt-Mangin, R.J. Hernandez-Pinto, J. Plenter, S. Ramirez-Uribe, A.E. Renteria-Olivo, G. Rodrigo, G.F.R. Sborlini, W.J. Torres Bobadilla and S. Tracz, *Open loop amplitudes and causality to all orders and powers from the loop-tree duality,* Phys. Rev. Lett.124 (2020) 211602, e-Print2001.03564 [hep-ph]

> J.M. Richard, A. Valcarce and J.Vijande, *Very Heavy Flavored Dibaryons*, Phys. Rev. Lett. 124 (2020) 212001, e-Print: 2005.06894 [hep-ph]

> J. Baglio, F. Campanario, S. Glaus, M. M. Muhlleitner, J. Ronca, M. Spira, J. Streicher, *Higgs-Pair Production via Gluon Fusion at Hadron Colliders: NLO QCD Corrections*, JHEP 2004 (2020) 181, e-Print 2003.03227 [hep-ph]

> A. C. Aguilar, F. De Soto, M. N. Ferreira, J. Papavassiliou, J. Rodríguez-Quintero and S. Zafeiropoulos, *Gluon propagator and three-gluon vertex with dynamical quarks*, Eur. Phys. J. C 80 (2020) 2, 154, e-Print 1912.12086 [hep-ph].

> A. Donini, P. Hernández, C. Pena and F. Romero-López, *Dissecting the ΔI=1/2 rule at large N_c*, Eur. Phys. J. C 80 (2020) 7, 638, e-Print 2003.10293 [hep-lat]

> R. Bruschini and P. González, Diabatic description of charmoniumlike mesons, Phys. Rev. D 102 (2020) 7, 074002, e-Print: 2007.07693 [hep-ph]

Selected conference talks

> G. Rodrigo, Numerical approach to multiloop calculations: overview, 3rd FCC Physics and Experiments Workshop 13-17 January 2020, CERN (Switzerland).

N.S. Ramírez Uribe, Exploring causality of loop amplitudes with the loop-tree duality, PARTICLEFACE 2020: Working Group Meeting and Management Committee Meeting of the COST Action CA16201, Krakow, 11-13 February 2020, Krakow (Poland).

J. Ronca, Update on the top-quark mass scheme uncertainty, LHC-HH Subgroup meeting, 27th April 2020, online conference.

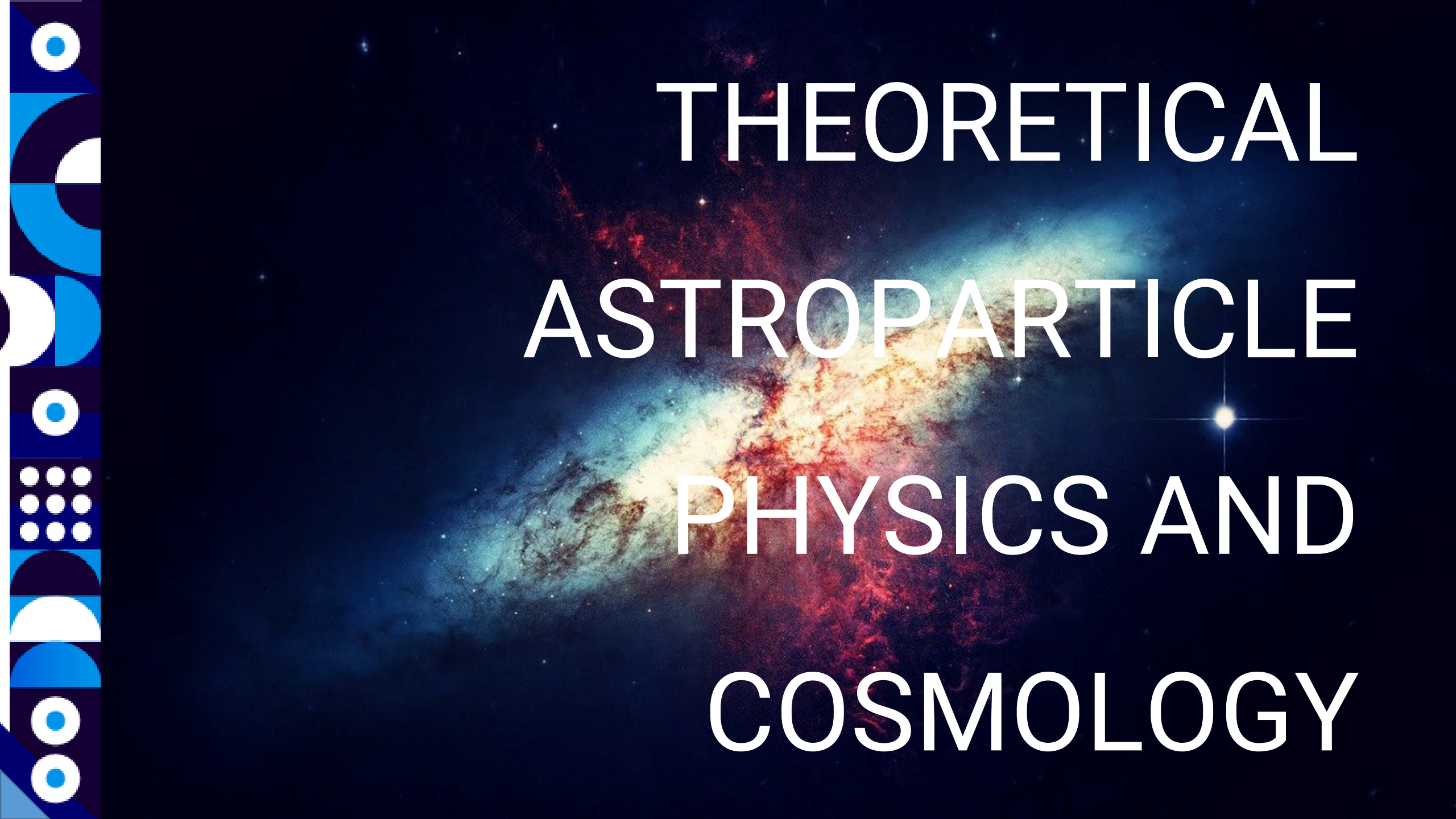
J. Papavassiliou, Emergence of a gluon mass, Perceiving the Emergence of Hadron Mass through AMBER@CERN(II) 6-7 August 2020, CERN, Geneva (Switzerland), online conference.

P. Hernández and F. Romero-López, The large Nc limit of QCD on the lattice. Review contribution to Lattice 2020.

Conference organization

> G. Rodrigo, PARTICLEFACE 2020: Working Group Meeting and Management Committee Meeting of the COST Action CA16201, Krakow, 11-13 February 2020, Krakow (Poland)

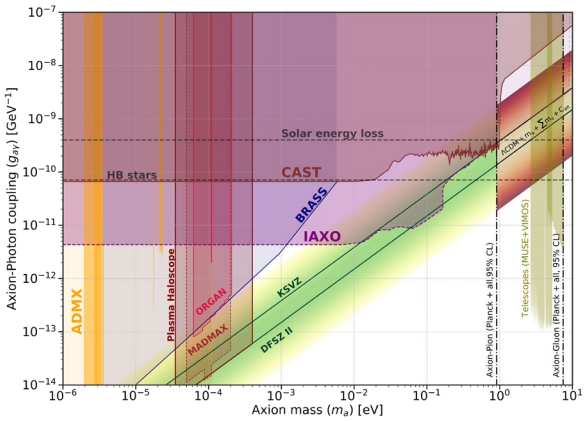
> W.J. Torres Bobadilla, EFT Methods from Bound States to Boundary Systems, 28-30 October 2020, online conference


THEORETICAL
ASTROPARTICLE
PHYSICS AND
COSMOLOGY

6.5 THEORETICAL ASTROPARTICLE PHYSICS AND COSMOLOGY

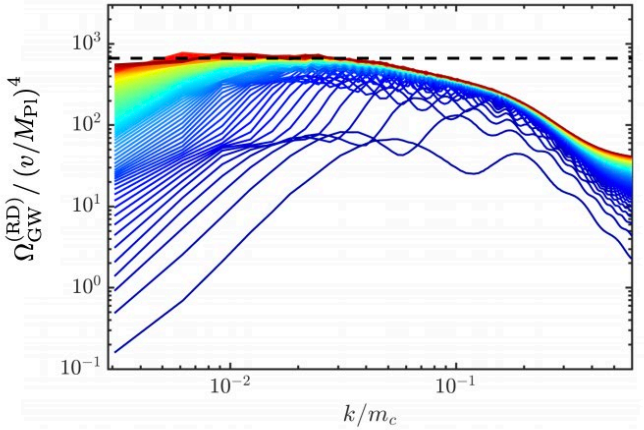
The research topics of this line include inflationary cosmology, early universe phenomenology, primordial gravitational waves, neutrinos, dark matter, dark energy, and cosmic rays. IFIC's members participating in this line of research are involved in international collaborations, e.g. studying neutrino oscillations and CP violation searches in DUNE (Deep Underground Neutrino Experiment), searching for a direct detection of the relic neutrino cosmic background in PTOLEMY, forecasting 21cm observations to study the role of dark matter, neutrinos and dark energy with the future telescope Square Kilometer Array (SKA), and characterising the ability of the will-be first gravitational wave detector in space, LISA (the Laser Interferometry Antenna), to detect primordial gravitational wave backgrounds from the early universe.

One of the topics of this research line is the study of axions. If realised in nature, they can be copiously produced in the early universe via thermal processes, contributing to the mass-energy density of thermal hot relics. In light of the most recent cosmological observations, IFIC's researchers in collaboration with other colleagues, have analysed different thermal processes within a realistic mixed hot-dark-matter scenario, including also massive neutrinos. Considering the axion-gluon thermalisation channel, the most constraining bounds to date on the hot relic masses have been derived, obtaining: $m_a < 7.46$ eV and $\sum m_\nu < 0.114$ eV, at 95 % CL. Studying the axion-pion scattering, without assuming any specific model for the axion-pion interactions and remaining in the range of validity of chiral perturbation theory, the bounds are improved to $m_a < 0.91$ eV and $\sum m_\nu < 0.105$ eV, again at 95 % CL.



Summary of current axion searches

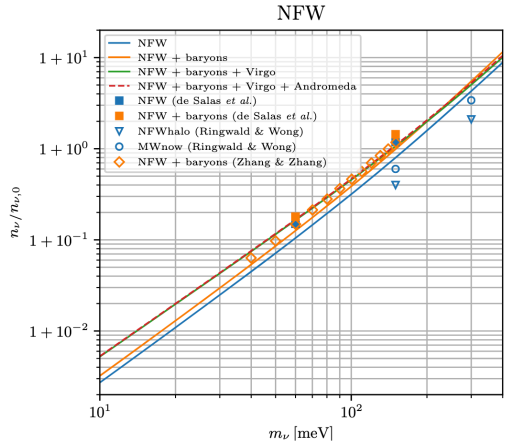
Another topic investigated in this line of research is the use of lattice techniques for the simulation of out-of-equilibrium field dynamics in the early universe. IFIC's researchers in collaboration with colleagues from Swiss institutions, have presented a comprehensive monograph where numerical algorithms, ranging from methods of $O(dt^2)$ to $O(dt^{10})$ accuracy, are adapted for their use in classical lattice simulations of the non-linear dynamics of (bosonic) gauge theories in an expanding grid in n+1 dimensions, including the case of `self-consistent' expansion sourced by the fields' energy and pressure densities. Lattice formulations of canonical cases have been presented, including interacting scalar fields, Abelian U(1) gauge theories, and non-Abelian SU(2) gauge theories. In all three cases novel symplectic integrators have been provided (in the case of non-Abelian gauge theories this is actually the first time). Remarkably, all the methods created for gauge theories respect the Gauss constraint to machine precision, even when `self-consistent' expansion is considered. All algorithms have been made publicly available in CosmoLattice, a modern C++ MPI-based package for scalar-gauge field dynamics, publicly available at www.cosmolattice.net.



Gravitational wave energy density spectrum from a large volume numerical simulation of the self-ordering dynamics of O(4) global textures, computed with CosmoLattice. The expected emergence of a scale-invariant spectrum in the infrared is clearly observed.

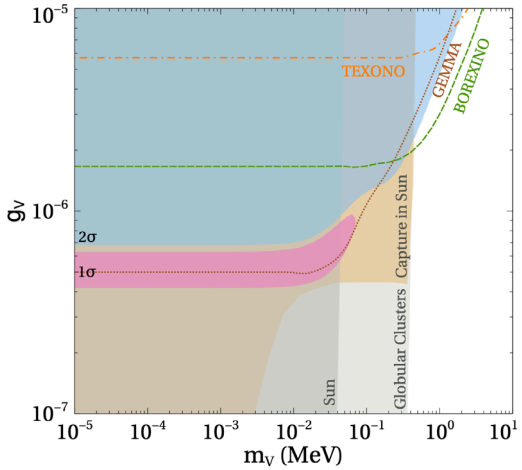
6.5 THEORETICAL ASTROPARTICLE PHYSICS AND COSMOLOGY

The standard model of cosmology predicts the existence of a Cosmic Neutrino Background in the present Universe, not yet observed. The tiny kinetic energy of the cosmological relic neutrinos renders their detection incredibly challenging, although there are ongoing efforts such as the PTOLEMY project. Researchers at IFIC have improved past calculations of the local neutrino clustering factor by considering the distribution of matter in the Milky Way and effects of nearby objects like the Virgo cluster. Their analysis showed that the local neutrino clustering is enhanced by 12% (50%) for neutrino masses of 50 (100) meV.



Cosmic Neutrino Background over density at the Earth's position as a function of the neutrino mass.

In 2020, an excess has been observed in low-energy electronic recoils by the XENON1T collaboration. Given the large exposure, detection efficiency and energy resolution the XENON1T detector is sensitive as well to solar neutrino backgrounds. Scientists at IFIC, in collaboration with researchers from other worldwide institutions, have investigated whether this excess can be explained in terms of new neutrino interactions with leptons mediated by a light vector particle. This interpretation is consistent with experimental data for vector masses below $\lesssim 0.1$ MeV, but a severe tension remains with astrophysical bounds and cosmological observations.



XENON1T excess. Allowed 1σ and excluded 2σ regions in the mass-coupling plane for light vector mediators.

Precision cosmological observations has proven to be a very useful tool in probing the fundamental properties of neutrinos. Besides constraining the absolute neutrino mass scale, cosmological observations can shed light also on the neutrino lifetime. Neutrino decay is a typical phenomenon of many theories that contain non-standard neutrino interactions. Researchers at IFIC and collaborators have revisited the topic of invisible neutrino decay in the precision cosmological context, via a first-principles approach to understanding the cosmic microwave background and large-scale structure phenomenology of such a non-standard physics scenario. Their analysis implies a significant revision of the cosmological limit on the neutrino lifetime.

Another hot topic in this research line is the study of neutrino oscillations. Researchers at IFIC have been working on an updated global fit of neutrino oscillation data in the simplest three-neutrino framework, including new experimental data as reported in the Neutrino 2020 conference. They first analysed global data both only from neutrino oscillation experiments and in combination with direct neutrino mass probes such as β decay, neutrinoless double β decay and cosmological observations.

6.5 THEORETICAL ASTROPARTICLE PHYSICS AND COSMOLOGY

Selected publications

> W. Giarè, E. Di Valentino, A. Melchiorri, O. Mena, *New cosmological bounds on hot relics: Axions & Neutrinos*, Mon.Not.Roy.Astron.Soc. 505 (2021) 2, 2703-2711, (arXiv: 2011.14704 [astro-ph.CO]), DOI: 10.1093/mnras/stab1442

> N. Bernal, A. Donini, M. G. Folgado, N. Rius, *Kaluza-Klein FIMP Dark Matter in Warped Extra-Dimensions*, JHEP 09 (2020) 142, 103516 (arXiv: 2004.14403 [hep-ph])

> P. Mertsch, G. Parimbelli, P. F. de Salas, S. Gariazzo, J. Lesgourgues and S. Pastor, *Neutrino clustering in the Milky Way and beyond*, JCAP 01 (2020) 015 (arXiv: 1910.13388 [astro-ph.CO]), DOI: 10.1088/1475-7516/2020/01/015

> D. Aristizabal, V. De Romeri, L. Flores, D. Papoulias, *Light vector mediators facing XENON1T data*, Phys. Lett. B 809 (2020) 135681 (arXiv: 2006.12457 [hep-ph]), DOI: 10.1016/j.physletb.2020.135681

> L. López-Honorez, O. Mena, S. Palomares-Ruiz, P. Villanueva-Domingo and S. Witte, *Variations in fundamental constants at the cosmic dawn*, JCAP 06 (2020) 026, (arXiv: 2004.00013 [astro-ph.CO]), DOI: 10.1088/1475-7516/2020/06/026

Selected conference talks

> "Global fits to neutrino masses and mixings", M. Tórtola, 40th International Conference on High Energy Physics (ICHEP 2020) online conference, 28th July - 6th August 2020.

> "Cosmological relic neutrinos, from A to Z", S. Gariazzo, INT Program Neutrinos from the Lab to the Cosmos Seattle (USA), 13 January - 7 February 2020.

> "HNLs and their relation (or non-relation) to active neutrino physics", J. López-Pavón, FIPs 2020 - Feebly Interacting Particles 2020, 31 August - 4 September 2020.

>"Indirect dark matter searches with neutrinos", S. Palomares Ruiz, XXIX International Conference on Neutrino Physics and Astrophysics (Neutrino 2020). June 22 - July 2, 2020, online conference, Chicago (USA). Invited plenary talk.

> "Lattice formulation of axion inflation: application to preheating", D. G. Figueroa, Zooming in on Axions in the Early Universe, 22-26 June 2020, online conference, CERN, Geneva.

7 TECHNOLOGY TRANSFER

7 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

7 TECHNOLOGY TRANSFER

Within this framework, during 2020 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:

- The Transfer Forum 2020 in Malaga February 2020.
- The 11th International Particle Accelerator Conference (IPAC 2020, Caen, Francia, May 2020.
- The *Desayuno de Induciencia* on the topic "El Futuro de los Aceleradores en España", December 2020. Juan Fuster (IFIC) has been one of the speakers.
- Up to 56 events (courses, conferences, seminars, webinars…).

The UCIE has worked for the inclusion of the IFIC in the following alliances and forums:

- TECH4CV, a Technologies Alliance of the Valencian Community.
- INNDROMEDA, an Innovative Technologies Alliance of the Valencian Community.
- Our incorporation to ITEMAS, Platform for Innovation in Medical and Health Technologies promoted by the Carlos III Health Institute has been requested.
- An agreement has been signed with INEUSTAR and INDUCIENCIA with the aim of promoting the technological transfer of knowledge and technologies developed in IFIC towards the national industry, both in the Science Industry sector, and in the search for transversality towards other sectors.

Other actions

- During 2020, the IFIC-UCIE website was launched.
- Through the CSIC, the IFIC has been incorporated into the map of Artificial Intelligence in Spain drawn up by the Ministries of Science and Innovation and of Universities.
- The UCIE has collaborated in the international dissemination of the calls of the Artemisa Platform for AI and ML of the IFIC.
- The UCIE has collaborated in the set-up of the IFIC PET/CT facility.

Actions related to COVID-19

The IFIC's fundamental research objective is nuclear and particle physics and its applications. The themes of COVID-19 appear, in principle, as distant. However, in the IFIC there are two groups with experience in the use of artificial intelligence in aids to medical diagnosis, in particular, through X-rays. These two groups have developed different actions related to COVID-19.

Group led by Francisco J. Albiol

- Radiographic screening, chest inspection in COVID-19 patients. Machine Learning Project. Funded by the Carlos III Health Research Institute (2020COV2000750).
- COVID-TOOLS, application to the CDTI in collaboration with a private company for the implementation of Machine Learning tools to control the pandemic.
- EKOVID, application to the CDTI, in collaboration with a private company, for the implementation of Machine Learning tools in the healthcare environment.

Group led by Verónica Sanz

- Development, together with the Fundación Instituto San José, of a tool to help diagnose chest X-ray images. First freely accessible prototype here. A collaboration agreement has been signed between the Fundación Instituto San José and the UV to continue the research.

7 TECHNOLOGY TRANSFER

Specific actions to support groups with technological potential and impact

Along 2020, fourteen singular innovation project were developed in the institute:

- **Notac**: a 3D reconstruction of the spine of patients with idiopathic scoliosis.
- **BioLight**: Measures the emitted light by biological samples through the detection of photons emitted by cells stimulated by various chemical agents.
- **Radon**: environmental radioactivity measurement and radiological monitoring. Promotes measurement of radon in air for the prevention of lung cancer.
- **HGRF**: study and characterization 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 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.
- **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.
- **UCNA0H**: 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.

Innovation projects approved throughout 2020

- Sistema híbrido de imagen gamma y ultrasonidos para biopsia guiada en cáncer de mama (GAMUS). Aid granted in the call for the «Valoritza i Transfereix» Program of the University of Valencia.
- Diagnóstico inteligente para radiografías con implementación en circuito integrado (DIRAC). Aid granted by the Agencia Valenciana de Innovación (INNVA1/2020/42).
- Biopsia guiada en cáncer de mama mediante un sistema híbrido de imagen gamma y ultrasonidos (MAGAS). Aid granted by the Agencia Valenciana de Innovación (INNVA1/2020/35).
- Diagnostics and Online System for a Linear INjector of Carbon 6+ ions for hadrontherapy (DosLINC6+). Aid granted by the Agencia Valenciana de Innovación (INNEST/2020/123) in collaboration with Thermal Vacuum Projects, S.L. y UVAX Concepts, S.L.
- Screening radiográfico, de inspección de tórax en pacientes de COVID-19. Aid granted by the Instituto de Investigación Sanitaria Carlos III (2020COV2000750).

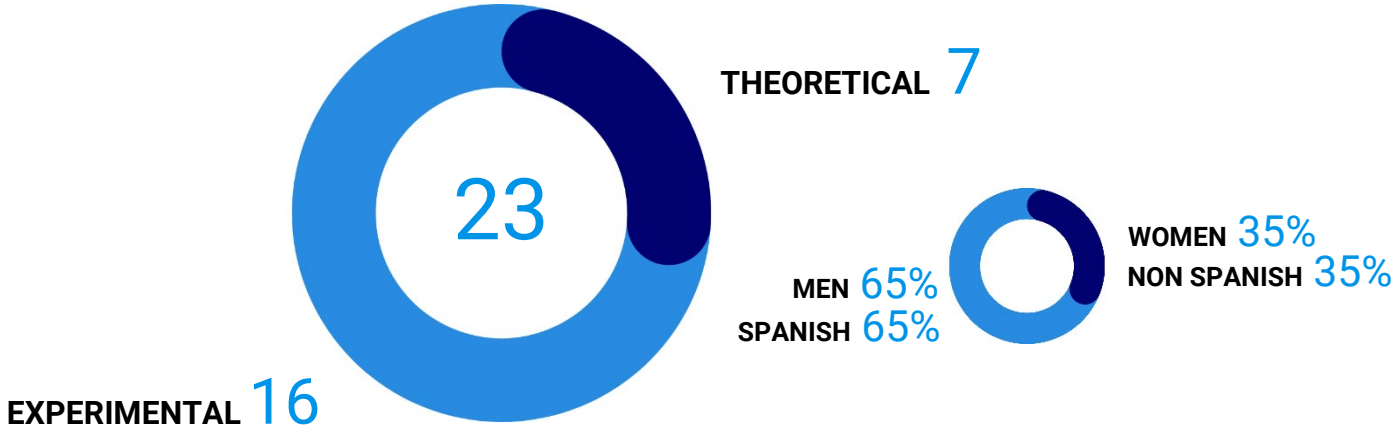
8

TRAINING

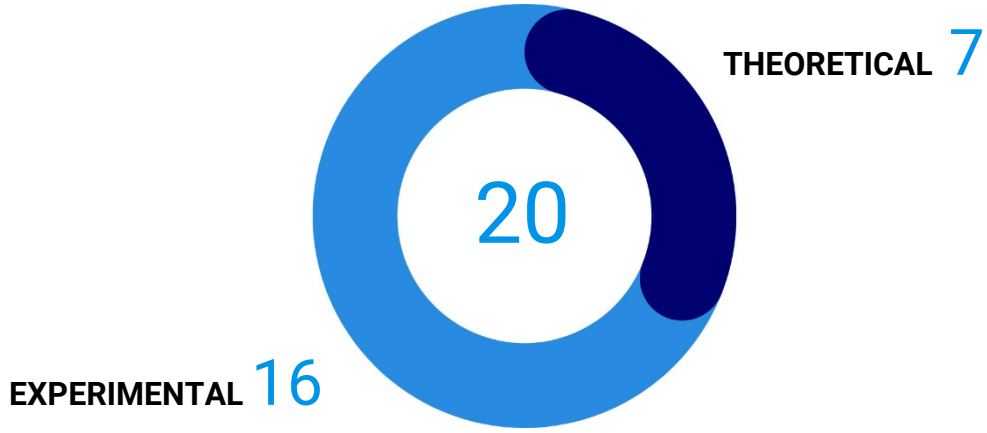
8 TRAINING

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

9

ARTIFICIAL INTELLIGENCE

9 ARTIFICIAL INTELLIGENCE

IFIC is no stranger to the revolution that is taking place in the field of artificial intelligence (AI) and big data. AI-related activities at IFIC are becoming more numerous and better coordinated. In addition, they jump more and more frequently from the area of pure science to that of innovation and applications in daily life.

A unique IFIC facility related to AI is Artemisa.

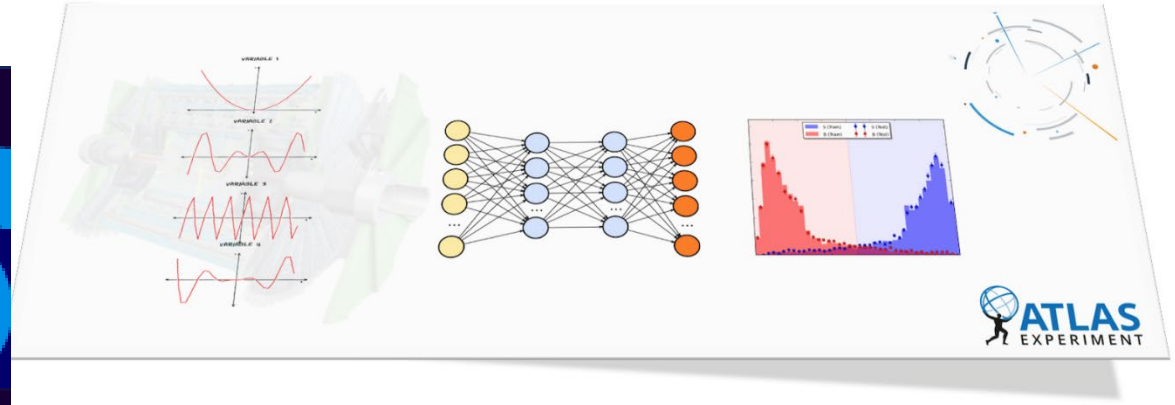
Artemisa is a High Performance Computing Facility oriented to Machine Learning and Artificial Intelligence research assisted by GPUs coprocessors.
It uses state-of-the-art CPUs and GPUs to allow computing projects to develop and run their most advanced algorithms.
The facility is composed by two user interface machines in which they can develop and tests their workflow and 23 machines to send batch jobs. All batch machines contain an NVIDIA GPU Volta V100 to assist with their AI algorithms.
Fast storage is also provided to save data collections and make big data processing a reality.

Members

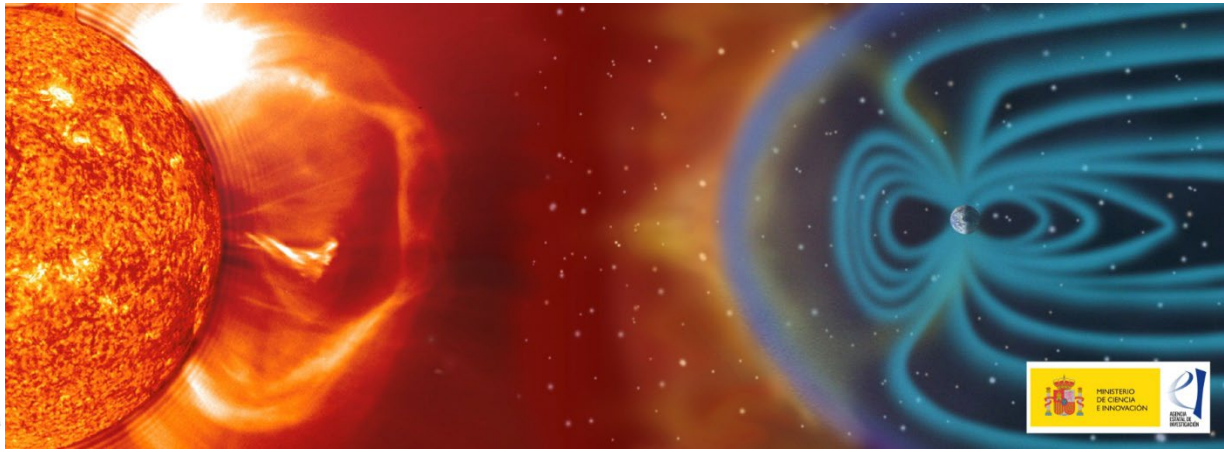
ARTEMISA: Francisco Albiol, Vicente Gimenez, Juan José Hernandez, Arantza Oyanguren, Jose Salt, Javier Sanchez, Veronica Sanz. dirección: Nuria Rius, vicedrección: Santiago Noguera

Artificial Intelligence: Francisco Albiol, Arantza Oyanguren, Veronica Sanz

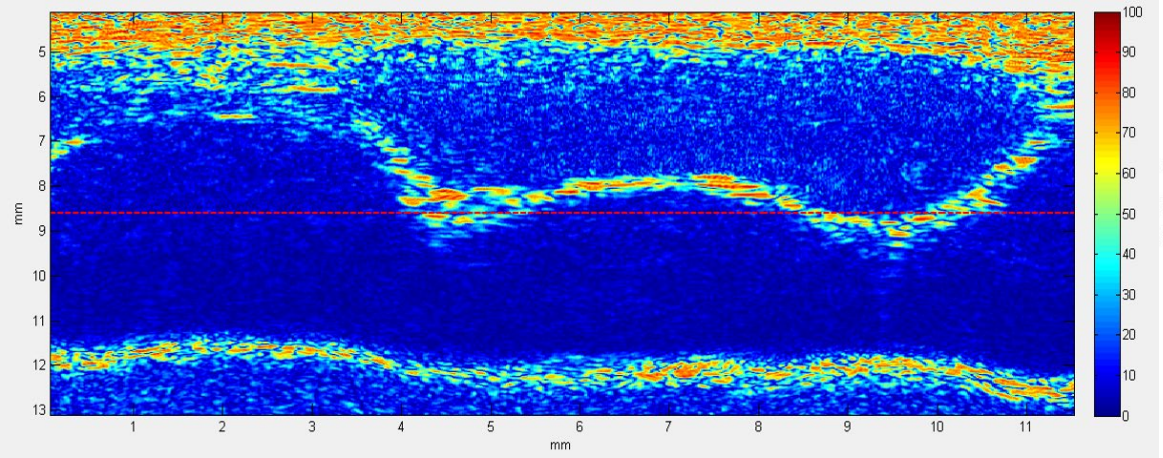
AI HL



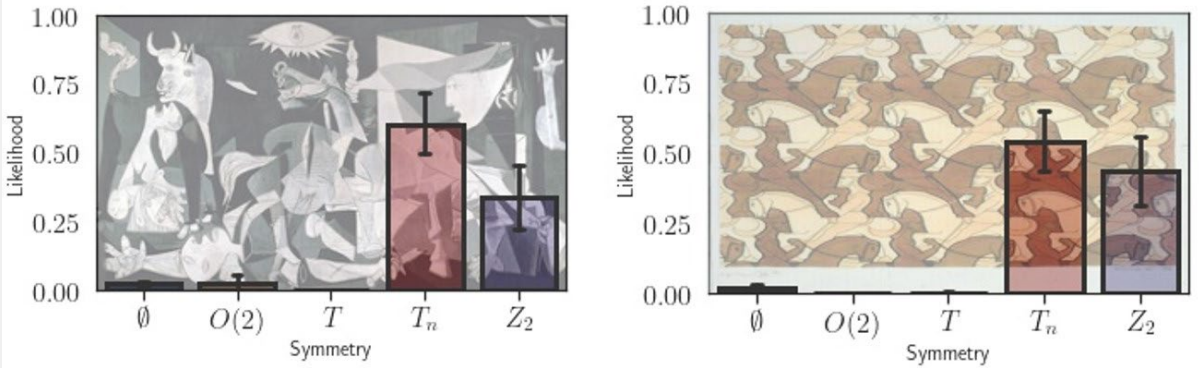
MACHINE LEARNING @ ATLAS EXPERIMENT



SOLAR STORMS AND THE SPANISH CRITICAL INFRASTRUCTURES



NON-INVASIVE SCREENING FOR MENINGITIS



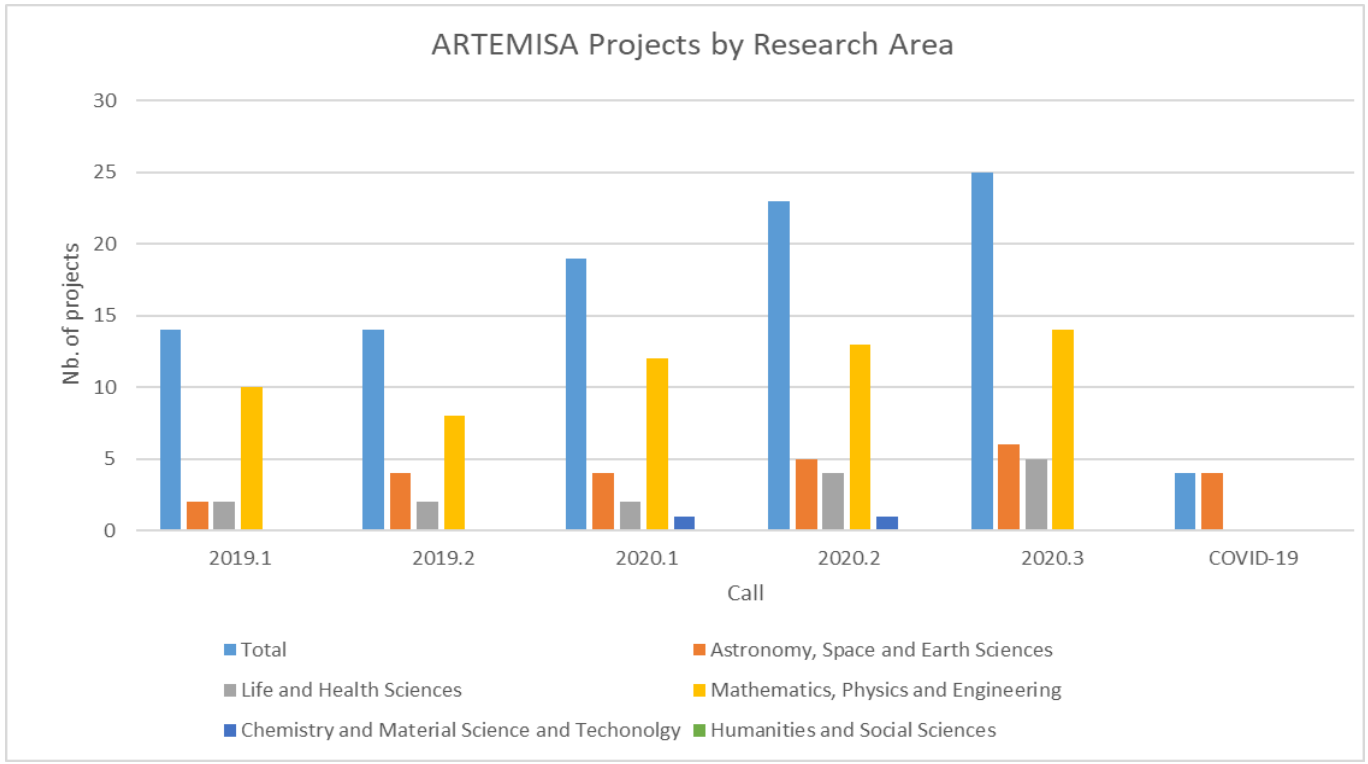
IDENTIFYING SYMMETRIES THROUGH AI

9 ARTIFICIAL INTELLIGENCE

ARTEMISA, the GPU-based computing platform for studies that use artificial intelligence, ran continuously during 2020. There were three regular calls for applications and one exceptional call devoted to COVID19-related studies. In contrast to 2019, in which only applications from IFIC groups and selected outside test-groups were accepted, during 2020 the platform opened to all applicants from the University of Valencia and CSIC institutes in the Valencian Community in a first stage and then to applicants from any public research organization. Both the number of applications and the number of GPU hours used by the applicants steadily increased during the year.

ARTEMISA

ARTificial Environment for ML and Innovation in Scientific Advanced Computing



9 ARTIFICIAL INTELLIGENCE

Due to the pandemic the upgrade of ARTEMISA planned for 2020 had to be postponed to 2021. However, the system could cope with the increasing demands for resources thanks to the upgrading that had taken place at the end of 2019. During 2020 the facility was composed of two user-interface machines, where users could develop and test their workflow, and 23 machines where they could send their batch jobs. All the batch machines were equipped with an NVIDIA Volta V100 GPU. ARTEMISA included in 2020 almost half a petabyte of disk space.

Front view (left image) and rear view (right image) of ARTEMISA racks. Those on the right (left) in the front (rear) view contain the GPU units.

9 ARTIFICIAL INTELLIGENCE

During 2020, the work to obtain for ARTEMISA the ISO 27001 certification started. 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 hold by the corresponding establishment or infrastructure more secure. In our case, the process for the certification is expected to take at least the whole of 2021. This certification will be an important asset for ARTEMISA.

Concerning the activities related to Artificial Intelligence at IFIC, there were two special events worth mentioning. In February, a hackday devoted to predicting renewable energy output with machine learning was organised [1]. A total of 31 participants were present. The participants had to mine a set of data of clean energy production and demand in a period of a year from the village of Aras de los Olmos, in the interior of the Valencian community. The data was provided by the village council. The participants sent their best solutions to the organisers, and four people were selected as providing the best predictions for energy demand. This hackday and the results from the initial mining led to a follow-up collaboration with the council, still in progress.

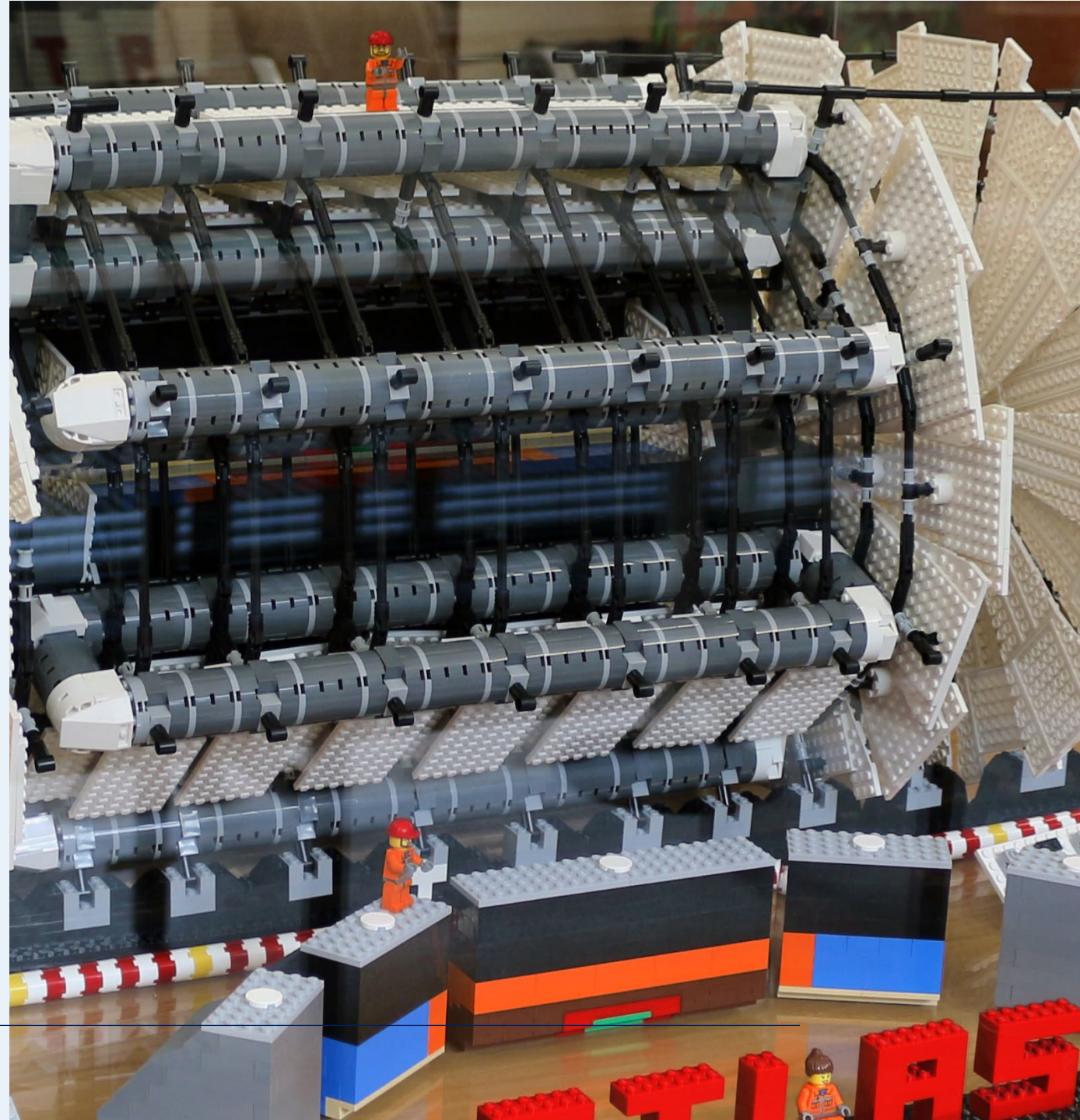
In addition, in November there was a meeting of IFIC's scientists interested in AI [2]. Around 40 scientists participated and 20 groups presented their Machine Learning related projects. We observed that there had been a lot of progress with respect to a similar event we organised in 2019, with many more groups actively using Machine Learning in their analyses. We collected feedback on training needs from the participants, and as a follow-up from the event, the IT group is preparing a video tutorial on the use of ARTEMISA.

> [1] ARTEMISA AI@IFIC Hackday: Predicting renewable energy outputs using Machine Learning, 27/02/2020, https://indico.ific.uv.es/event/4020/

> [2] AI@IFIC (Artificial Intelligence at IFIC), 28/11/2020, https://indico.ific.uv.es/event/5999/

10

OUTREACH



4 OUTREACH COMMITTEE

The IFIC participates and organises many activities of science dissemination that would not be possible without an 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 both at the general public and the educational community. Four people at IFIC coordinated and conducted these activities in 2020: Isidoro García, who manages our web, as well as our relation with journalists and press offices of other institutions, and Alberto Aparici, who deals with activities and materials aimed at students and the general public, and Enrique Nácher and Olga Mena, as scientists involved in the coordination and development of the outreach activities.

IFIC has a long history of outreach work and each year aims to improve the agenda of events and involve more IFIC staff. Given the circumstances of the COVID - 19 pandemic, outreach activities have been severely hampered. The centre has been forced to cancel many face-to-face events such as masterclasses, talks, guided tours... but at the same time it has been an opportunity to experiment with new online formats that have allowed the centre to adapt to the new circumstances.

Outreach Committee

Isidoro García
Alberto Aparici
Olga Mena
Enrique Nacher
Avelino Vicente

outreach@ific.uv.es

4 OUTREACH CONTRIBUTIONS

9 Guided tours for students

Due to the situation generated by COVID 19, the guided tours were cancelled, but a few were possible during the first weeks of the year. IFIC received around 200 people, mainly high school and physics students from the University of Valencia.

3 International Masterclasses

The masterclasses are an international event in which high school students learn about particle physics and analyse real data from experiments such as ATLAS, LHCb and MINERvA. They are an on-site event and three of them were possible before the lockdown.

4 OUTREACH EVENTS

1 Expociencia 2020

Full online format, with two talks each morning and schools connecting to individual talks.
IFIC offered one talk, A world of particles: from neutrinos to medical physics, and provided the chairperson for the event.

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, which had to be adjourned and adapted to a partially online format due to the COVID-19 pandemic.

4 OUTREACH CONTRIBUTIONS

20 On site Public lectures and On line Public lectures

Though many public conferences had to be cancelled due to the COVID-19 situation, some of them could be carried out, either partially on-site or fully online. These include talks in high schools and a conference celebrating the 2020 Nobel Prize in Physics.

9 Online Lockdown talks

When Spain went on lockdown in mid-march all students saw their classes interrupted, and then substituted by full online lectures. To alleviate this tense situation and provide the students with some extra motivation, IFIC organised several talks via YouTube that soon reached more than 60.000 views.

4 OUTREACH EVENTS

3 Dark Matter Day

Every year on October 31st many science institutions around the world join the Dark Matter Day, a celebration of the scientific quest to unveil the nature of dark matter. IFIC organised a talk in the Science Museum of Valencia which was also broadcasted through the internet.

5 Participations in science festivals

Several members of the institute participated in science festivals outside Valencia during 2020. From Spanish events like the Astroparticle Marathon to international ones like the European Night of Researchers and CERN's Women in STEM.

4 OUTREACH CONTRIBUTIONS

1 Interview on *Entrevistas conCiencia* CSIC Valencia

Álvaro Fernández, CSIC specialist in the Computer Services Unit of IFIC, talks about the computing infrastructure in a research centre in the series *Entrevistas conCiencia* at CSIC's Casa de la Ciencia in Valencia

13 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.

4 OUTREACH IFIC IN MEDIA

20 IFIC in the news

Several initiatives and research results involving IFIC reached the news in 2020, and in all cases statements from members of the institute were provided for the journalists. The pieces were thematically varied, from new discoveries to actions related to the COVID-19 pandemic.

88 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 eighty individual pieces were produced in this context.

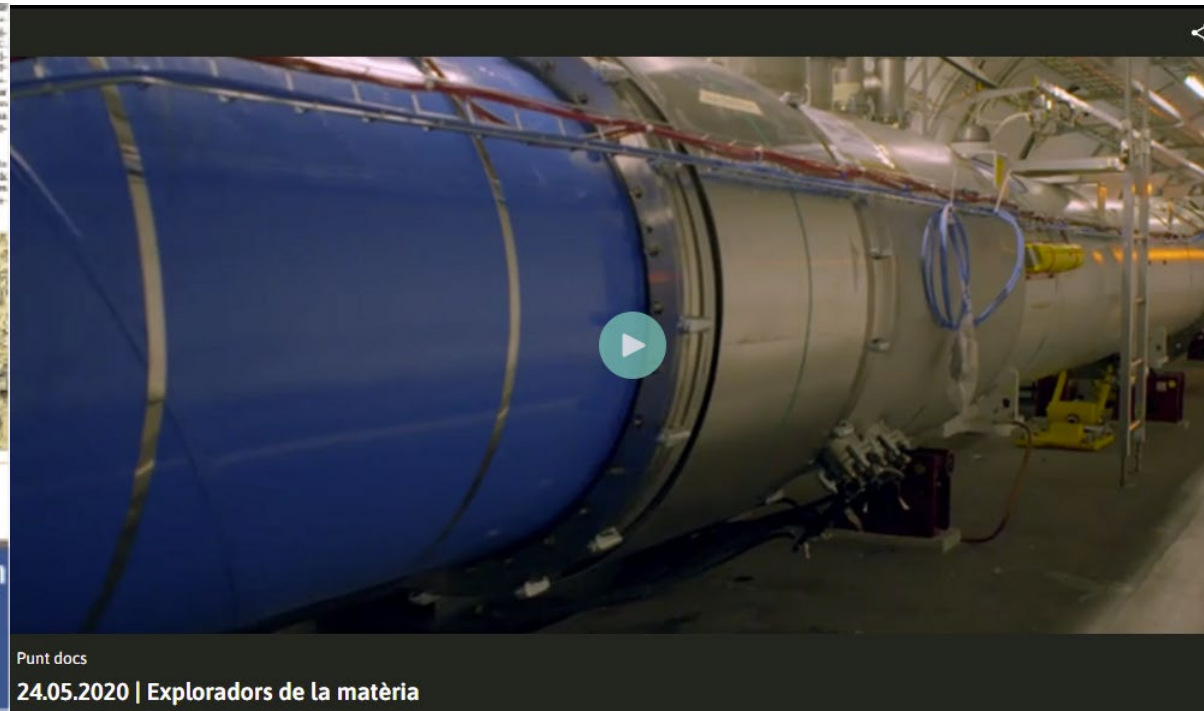
4 OUTREACH IFIC IN MEDIA

52 Articles authored by IFIC members

Some members of IFIC collaborate on a regular basis with written media, both printed and online. During 2020 more than fifty pieces were produced in the context of such collaborations.

1 TV documentary: Exploradors de la matèria

The regional TV channel À Punt produced a documentary about the Large Hadron Collider and the Valencian scientists that participate in the experiments at CERN. It was broadcasted in the show Punt docs.



11

YOUNG RESEARCHERS, GENDER AND DIVERSITY

11 YOUNG RESEARCHERS, GENDER AND DIVERSITY COMMITTEE

IFIC's Office for Young Researchers, Gender and Diversity (Jóvenes Investigadores, Género y Diversidad, JIGD) was launched in October 2017.

The main objective of this pioneering initiative is to try to eliminate any kind of discrimination or harassment that may take place in the Institute, ensuring equal opportunities for all its members and fostering good relations between the components of all its sections.

IFIC's JIGD Office is coordinated by two researchers with a two-year mandate.

JIGD committee
Mariam Tórtola
Enrique Nacher

IFIC JIGD Jóvenes Investigadores, Género y Diversidad

11 JIGD ACTIVITIES AND EVENTS

11 F: Particle physics Masterclass

During the event, dedicated to 3rd and 4th ESO students, they studied the signals of the Z boson and the famous Higgs boson with real data from the ATLAS experiment at CERN's LHC and discussed the results with other students from Barcelona, the Czech Republic, Germany and the United Kingdom. In addition, IFIC offered a colloquium on the role of women in science.

11 F: Cinema fórum “El Enigma Agustina”

The screening was followed by a discussion of the film. The activity, in collaboration with the Institute of Molecular Science (ICMOL), was very well received by the staff of the University of Valencia Science Park and was attended by around 60 people. Produced by the Astrophysics Institute of Andalusia (IAA-CSIC).

11 JIGD ACTIVITIES AND EVENTS

11 F: Conferences In High Schools

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

MEITNER PROJECT IS GRANTED BY FECYT

The FECYT grants the Meitner Project. With it, IFIC will recover and revalue the contribution of the great female pioneers of Nuclear and Particle Physics through the figure of Lise Meitner. The story of her great discovery, nuclear fission, will be brought to Spanish theatres by the theatre company CRIT in 2021.

10 JIGD ACTIVITIES AND EVENTS

8 M: "Invisibles en el Cosmos... e Invisibles en la Ciencia"

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, Olga Mena, a research scientist at CSIC, presented a talk on cosmology and women in the history of this discipline.

IV Women Researcher Day

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 JIGD ACTIVITIES AND EVENTS

Women's Empowerment & Leadership workshop

As part of the Women Researcher Day (split in two days due to COVID), IFIC and ICMOL jointly organised a workshop on women's empowerment and leadership in science. The workshop was given by Professor Eva Cifre, gender expert from Universitat Jaume I.

Video: "*El núcleo atómico no es así*" Quantum Fracture

This video is the outcome of the FGCSIC's "Science Counts" project. Aimed at the general public and, specifically, at secondary school students, the activity, of an informative nature, aims to raise awareness of the role of women in science through historical references and current female researchers of different ages.

11 JIGD ACTIVITIES AND EVENTS

II Conference on Professional Perspectives beyond Public Research

Conference aimed especially at students and young postdocs, that will count on the participation of the Employment Service of the University of Valencia (UVOcupació) and three of our former doctors who now work out of public research, who will tell us about their trajectory and give us their vision on professional prospects beyond the purely academic world.

Web

In 2020 we have performed several updates to IFIC's website concerning equality and diversity. On the front page, We have added a direct link to the Equality section at the main page of IFIC's website. , where we have included documents about specific regulations and resources on equality as well as statistical information on gender balance at IFIC. Finally, IFIC's staff list has been updated using inclusive language.

12

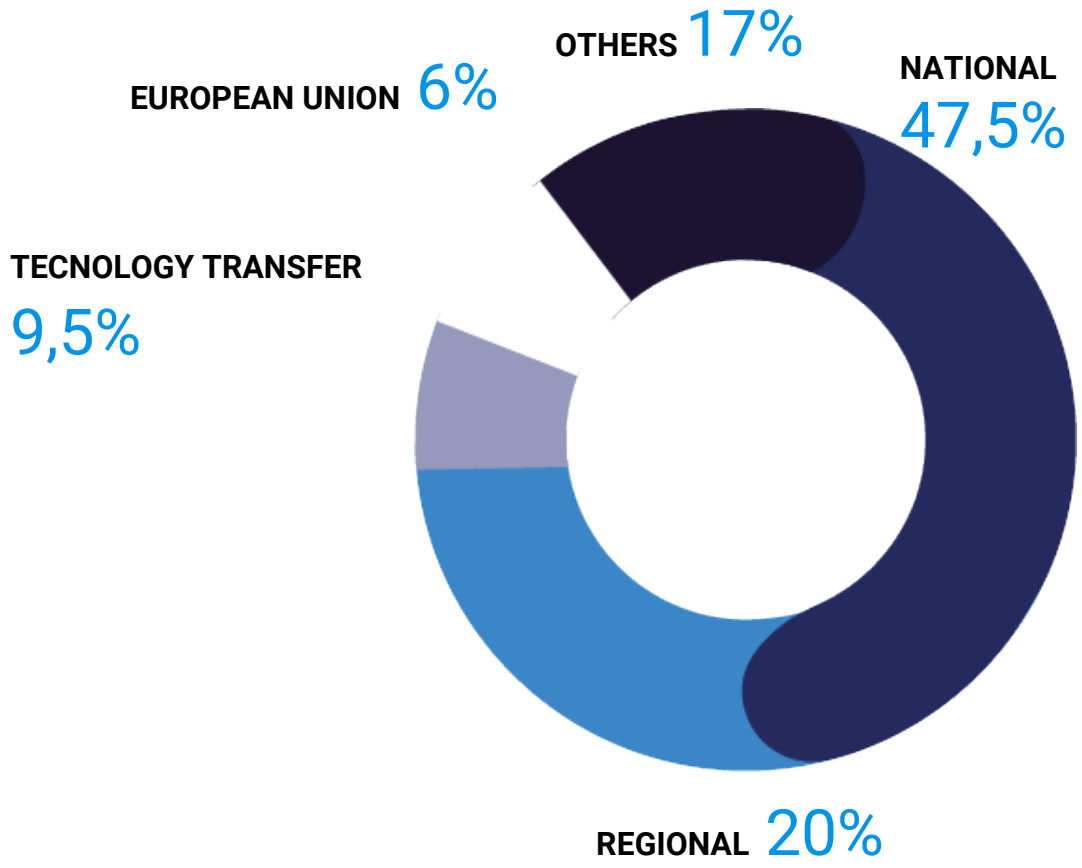
FUNDING

12 PROJECTS

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

12 PROJECTS BY SOURCE

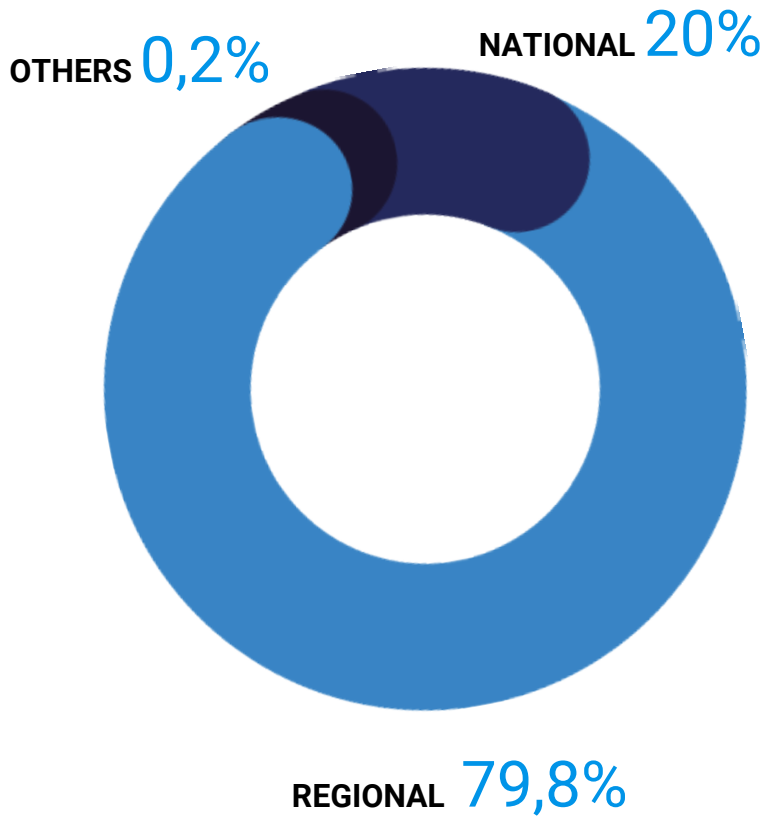
NATIONAL	3.016.065,00 €
EUROPEAN UNION	382.174,80 €
REGIONAL	1.259.542,36 €
OTHERS	1.096.429,74 €
TECHNOLOGY TRANSFER	598.592,58 €
TOTAL	**6.352.804,48 €**



* The income values refer to the total amount awarded to new research projects and personnel contracts during 2020

12 PERSONNEL BY SOURCE

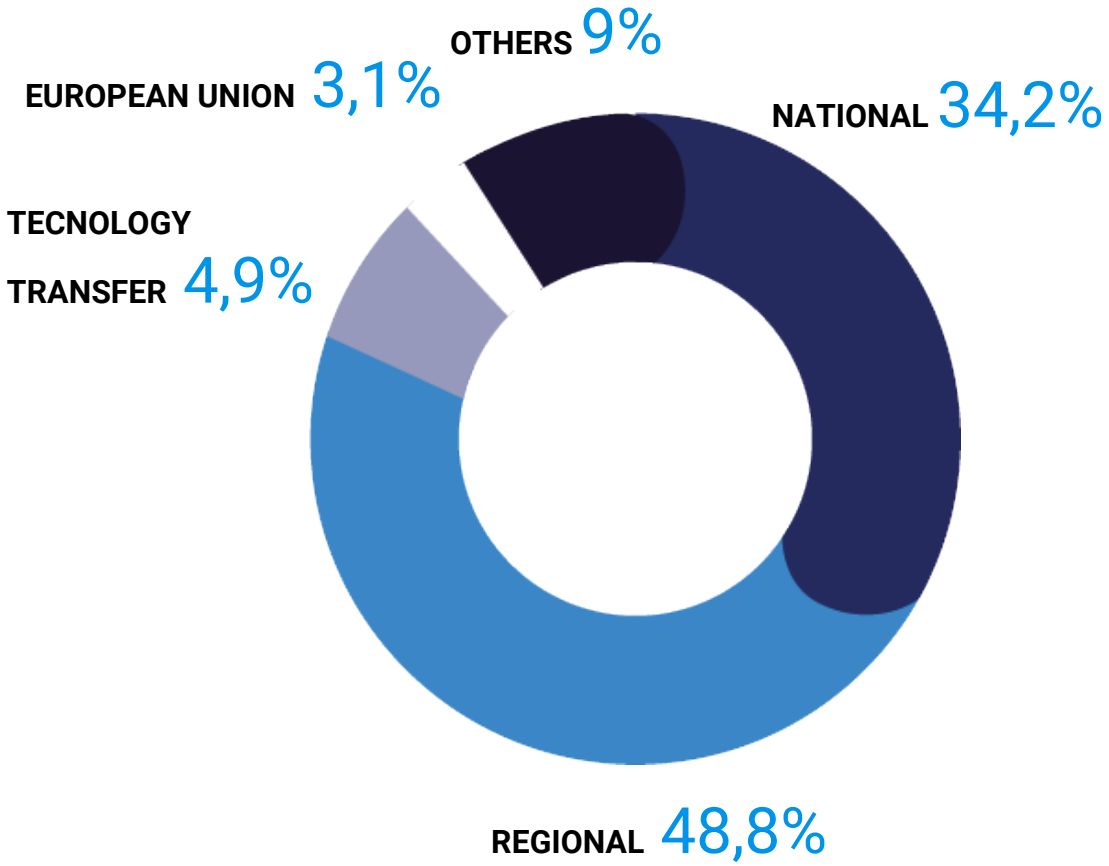
NATIONAL	1.189.377,31 €
REGIONAL	4.731.180,24 €
OTHERS	12.000,00 €
TOTAL	**5.932.557,55 €**



* The income values refer to the total amount awarded to new research projects and personnel contracts during 2020

12 TOTAL INCOME BY SOURCE

NATIONAL	4.205.442,31 €
EUROPEAN UNION	382.174,80 €
REGIONAL	5.990.722,60 €
OTHERS	1.108.429,74 €
TECHNOLOGY TRANSFER	598.592,58 €
TOTAL	**12.285.362,03 €**



* The income values refer to the total amount awarded to new research projects and personnel contracts during 2020

ANNEXES

1 ANNEXES Personnel List

ALPHABETICAL ORDER

Aguado Cebrià, Gema
Aguilar Argilés, Teresa
Aguilera Verdugo, Jose de Jesus
Albandea Jordan, David
Albiol Colomer, Francisco Javier
Alcala Escalona, Gustavo Adolfo
Algora, Alejandro
Alvarado Alvarez, Fernando
Alvarez Puerta, Vicente
Alvarez Ruso, Luis
Alves Garre, Sergio
Amos, Kieran
Andreu Garcia, Mª Teresa
Anglés Castillo, Andreu
Aparici Benages, Alberto
Aparisi Pozo, Javier Alberto
Ayet San Andres, Samuel
Ayuste Coronado, Pablo
Azcárraga Feliu, José Adolfo de
Babiano Suarez, Victor
Baeza Ballesteros, Jorge Juan
Bailey, Adam John
Balibrea Correa, Javier
Barenboim, Gabriela
Barrientos Mauriz, Luis Alfredo
Beltrán Lloria, Rebeca
Beltran Palau, Pau
Bernabéu Alberola, José
Bernabeu Verdú, José
Blanch Gutierrez, Cesar
Boix Caballero, Pilar
Bordes Villagrasa, José Manuel
Borja Lloret, Marina
Botella Olcina, Francisco J.
Breso Pla, Victor Ernesto
Bruschini, Roberto
Burriel Navarro, Helena
Caballero Ontanaya, Luis
Cabrera Urbán, Susana
Calvo Diaz-Aldagalán, David
Cámara García, María Teresa
Campanario Pallás, Francisco
Carcel Garcia, Sara
Cardillo, Fabio
Carrasco de Fez, Rosa
Carretero Cuenca, Victor
Carrió Argos, Fernando
Carrión Burguete, Jose Vicente
Casaña Copado, Jose Vicente
Cases Ruiz, Ramón
Castillo Giménez, M. Victoria
Castillo, Florencia
Catalan Benavent, Ana
Centelles Chulia, Salvador
Cepedello Perez, Ricardo
Cervelló Duato, Antonio
Cervera Villanueva, Anselmo
Chitishvili, Mariam
Civera Navarrete, José Vicente
Claramunt Pedrón, Luis Miguel
Coito Pereyra, Leonardo
Collado Ruiz, Javier
Cornet Gomez, Fernando
Costa Mezquita, María José
Da Silva Leite, Julio Rafael
De Romeri, Valentina
Delgado Belmar, Vanesa
Delhom i Latorre, Adrià
Diaz Calderon, David
Díaz Medina, José
Didenko, Mariia
Domingo Pardo, César
Donini, Andrea
Escobar Ibáñez, Carlos
Escribano Valiente, Pablo
Esperante Pereira, Daniel
Esser, Fabian
Fabbri, Alessandro
Fandos Lario, Ana María
Fassi Imlahi, Farida
Feijoo Aliau, Eduardo Alberto
Fernández Casaní, Álvaro
Ferrando Solera, Sergio
Ferrario, Paola
Ferreiro de Aguiar, Antonio Eduardo
Ferrer Lazaro, Jose Manuel
Ferrer Soria, Antonio
Fillol Ricart, Amparo
Fiorini, Luca
Fuentes Castilla, Angel
Fullana Torregrosa, Esteban
Furtado Valle, José Wagner
Fuster Verdú, Juan A.
Gadea Raga, Andrés
Gallego Baviera, Francisco Javier
Garcia Figueroa, Daniel
García García, Carmen
Garcia Gonzalez, Soledad
Garcia Montoro, Carlos
Garcia Navarro, José Enrique
Garcia Peris, Miguel Angel
Gil Dominguez, Fernando
Giménez Gómez, Vicente
Gimeno Martinez, Benito
Gómez Cadenas, Juan José
Gomez Delegido, Antonio Jesus
Gomez Ferrer, Julio Jose
Gómez Lurbe, Rafael
González Alonso, Martín
González de la Hoz, Santiago
González González, Francisco
Gonzalez Iglesias, Daniel
González Marhuenda, Pedro
Gonzalez Romeu, Maria Teresa
Gonzalvo Rodriguez, Galo Rafael
Gracia Vidal, Maria Jose
Guerrero Navarro, Gustavo Hazel

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Guerrero Rojas, Jesus
Hagedorn, Claudia
Hernández Gamazo, Pilar
Hernández Rey, Juan Jose
Hernando Recuero, Maria Luisa
Herrero García, Juan Andres
Higón Rodriguez, Emilio
Hirsch, Martin
Hueso Gonzalez, Fernando
Hüyük, Tayfun
Ikeno, Natsumi
Irles Quiles, Adrian
Jordan Coronado, Jose Luis
Jurado Gomez, Maria de la Luz
Khan Chowdhury, Nafis Rezwan
Lacasta LLacer, Carlos
Ladarescu Palivan, Ion
Lazo Pedrajas, Alfonso
Lerendegui Marco, Jorge
Lledó Barrena, Mª Antonia
Llosá Llácer, Gabriela
Loayza Romero, Nicolas
López Cabrero, Araceli
Lopez March, Neus
Lopez Pavon, Jacobo
Lopez Redondo, Manuel
Lozano Bahilo, José Julio
Mamuzic, Judita
Manczak, Jerzy Mikolaj
Mandal, Sanjoy
Marco Hernández, Ricardo
Mariñas Pardo, Carlos Manuel
Marti García, Salvador
Martín Luna, Pablo
Martín-Albo Simón, Justo
Martinez Agullo, Pablo
Martínez de Lejarza Samper, Jorge Juan
Martinez Mirave, Pablo
Martinez Reviriego, Pablo
Martinez Roig, Marcos
Martínez Saez, Carlos
Martínez Vidal, Fernando
Martins Cosme, Catarina
Masó Ferrando, Andreu Sales
Mavromatos, Nikolaos
Mazorra de Cos, José
Mena Requejo, Olga
Miralles Aznar, Victor
Miralles Lopez, Marcos
Miró Arenas, Carlos
Mitsou, Vasiliki
Molina Bueno, Laura
Molina Peralta, Raquel
Molina Sedgwick, Susana
Monrabal Capilla, Francesc
Monsalvez Pozo, Kevin
Monsonis Romero, Luis
Montesinos Reig, Leonor
Morales Lopez, Ana Isabel
Moreno Llácer, María
Muñoz Albaladejo, Enrique
Muñoz Albornoz, Victor Manuel
Muñoz Ovalle, Alejandro
Muñoz Perez, David
Muñoz Vidal, Javier
Nácher Arándiga, Jorge
Nácher González, Enrique
Nadal Durà, Joaquin
Nadal Gisbert, Sergi
Navajas Alba, Ximo
Naval de Jesús, Carmen
Navarro Faus, Jesús
Navarro Gonzalez, Josep
Navarro Salas, José
Nebot Gómez, Miguel
Nieves Pamplona, Juan Miguel
Noguera Puchol, Santiago
Novella Garijo, Pau
Olmo Alba, Gonzalo
Orrigo, Sonja Elena Agata
Oyanguren Campos, Arantza
Palacios Gonzalez, Juan
Palomares Ruiz, Sergio
Papavassiliou, Ioannis
Pastor Carpi, Sergio
Pastor Clérigues, Elena
Penalva Martinez, Neus
Peñarrocha Gantes, José Antonio
Pérez Cañellas, Armando
Pérez García, José
Pich Zardoya, Antonio
Pieterse, Camiel
Pla Garcia, Silvia
Platero Garcia, Adrian
Platero Montagut, Vicente
Plenter, Judith
Pompa, Federica
Portoles Ibañez, Jorge
Poveda Torres, Joaquin
Prades Ibañez, Alberto
Querol Segura, Marc
Ramirez Uribe, Norma Selomit
Ramos Martínez, Alberto
Real Máñez, Diego
Reig Lopez, Mario
Renteria Olivo, Andres Ernesto
Rius Dionis, Nuria
Rodrigo García, Germán
Rodrigues Sandner, Stefan Marinus
Rodriguez Bosca, Sergi
Rodriguez Galan, Rosa Maria
Rodriguez Samaniego, Javier
Romero Lopez, Fernando
Romo Luque, Carmen
Ronca, Jonathan
Ros García, Ana
Ros Martínez, Eduardo
Rosario Bonastre, Ivan

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Roser Martinez, Jorge
Rubio Barroso, Berta
Rubio Jiménez, Adrián
Ruiz de Austri Bazan, Roberto
Ruiz Martínez, Arantxa
Ruiz Vidal, Joan
Sabatini, Paolo
Salesa Greus, Francisco
Salgado Lopez, Oscar
Salt Cairols, José
Sánchez Martínez, Fco. Javier
Sanchez Sebastian, Victoria
Sanchis Lozano, Miguel Angel
Santamaría Luna, Arcadi
Sanz González, Veronica
Sayago Galvan, Ivan
Senra Moledo, Cesar
Senthilkumar, Varsha
Serrano Perez, Carmen
Simeó Vinaixa, Mireia
Solaz Contell, Carles
Solomonidi, Eleftheria
Sorel, Michel
Tadeo Ortiz, Hector
Taín Enríquez, José Luis
Tchogna Davis, Daniel
Telo, Guilherme
Torró Pastor, Emma
Tortajada Velert, Salvador
Tortola Baixauli, Mª Amparo
Tracz, Szymon
Urrea González, Salvador
Usón Andrés, Alberto
Vale Silva, Luiz Henrique
Valero Biot, José Alberto
Valiente Moreno, Enrique
Valls Ferrer, Juan Antonio
Varriale, Lorenzo
Velasco González, Jorge
Vento Torres, Vicente
Vicente Montesinos, Avelino
Vicente Vacas, Manuel
Victoria Fernandez, Jose Antonio
Vidal Bueno, Guillem Ramon
Vidal Perona, Jorge
Viegas Botelho Correia Rego, Rita
Vijande Asenjo, Javier
Villanueva Domingo, Pablo
Villaplana Pérez, Miguel
Vives García, Oscar
Vos, Marcel
Yahlali Haddou, Nadia
Yamamoo, Hitoshi
Zornoza Gómez, Juan de Dios
Zuñiga Román, Juan

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[Full list of publications]

3 ANNEXES Conferences and workshops organized

- 14-17 Dec 4th Valencia Winter Workshop on Theoretical Physics
- 14-15 Dec III Jornadas RSEF / IFIMED de Física Médica
- 25 Nov IV Jornada Mujer Investigadora ICMOL-IFIC (charlas)
- 20 Nov IV Jornada Mujer Investigadora ICMOL-IFIC (taller) ,
- 28-30 Oct EFT methods from Bound States to Binary Systems
- 6-7 Oct Jornadas (virtuales) de la red española de futuros colisionadores
- 6-9 Apr FunQCD 2020: from first principles to effective theories
- 6 Mar Mini workshop NUPECC
- 27-28 Feb 4ª Reunión Presencial del Proyecto VMGRID (ATLAS TIER2 ESPAÑA)
- 27 Feb ARTEMISA AI@IFIC Hackday: Predicting renewable energy outputs using Machine Learning
- 10-11 Feb Jornadas de la red española de futuros colisionadores

4 ANNEXES Colloquia organized

- 17 Dec Laura Patrizii, "Magnetic monopoles: do they exist?"
- 5 Nov Rainer Schödel, "The 2020 Nobel Prize in Physics - The massive Black Hole at the Centre of the Milky Way"
- 13 Feb Eberhard Widmann, "Testing CPT Symmetry with Antihydrogen"
- 23 Jan Ángel Gómez de Agreda , "Cómo afecta la tecnología a la ética del siglo XXI"

5 ANNEXES Seminars organized

- 15 Dec Gilly Elor, "HiDDeN webinar: Making the Universe at 20 MeV"
- 01 Dec Julia Harz, "HiDDeN webinar: Constraining lepton-number violating interactions in rare kaon decays."
- 01 Dec Laura Molina, "IFIC Seminar: Dark matter searches with NA64 experiment"
- 27 Nov James Alvey, "Topical Seminar: Gravity and Global Symmetries"
- 24 Nov Alberto Ramos, "IFIC seminar: Old and new lattice determinations of alpha_s"
- 19 Nov Nafis Rezwan Khan Chowdhury, "[#Student Seminars] Neutrinos beneath the waves"
- 17 Nov Juraj Klaric, "HiDDeN webinar: Uniting low-scale leptogeneses"
- 17 Nov José Ramón Espinosa, "IFIC Seminar: A fresh look at the calculation of tunneling actions"
- 13 Nov Maria de la Luz Jurado Gómez, "#StudentSeminar Shell evolution of neutron-deficient Xe isotopes: Octupole and Quadrupole Correlations above 100Sn"
- 10 Nov Christoph Hanhart, "IFIC Seminar: "Theoretical insights about the XYZ states ... and beyond""

5 ANNEXES Seminars organized

- 09 Nov Ricardo Cepedello, "#StudentsSeminar: Classifications of radiative neutrino mass models"
- 06 Nov Pierre Auclair, "Topical Seminar: Constraints on cosmic strings from gravitational waves, diffuse gamma-ray background and dark matter"
- 03 Nov IFIC Newcomers' Fest
- 20 Oct Martín Novoa-Brunet, "IFIC Seminar: Lepton universality tests in b decays"
- 14 Oct Fernando Romero López, Mario Reig, "#BSM Journal Club"
- 13 Oct Xavier Siemens, "IFIC Seminar: The NANOGrav search for nanohertz gravitational waves"
- 13 Oct Jonathan Ronca, "#StudentSeminar: Higgs-pair production via gluon fusion @NLO SM and Beyond"
- 06 Oct Evgeny Akhmedov, "IFIC Seminar: Coherent scattering and macroscopic coherence: Implications for neutrino, dark matter and axion detection"
- 23 Jul Iván Rosario, "#StudentSeminar: Diphoton production in vector-boson scattering at the LHC at next-to-leading order QCD"

5 ANNEXES Seminars organized

- 09 Jul Joan Climent, "#StudentSeminar: Stellar and sub-stellar objects in radio and infrared interferometry"
- 07 Jul Juri Smirnov, "Webinar: New Directions for Thermal Dark Matter"
- 16 Jun Leonardo Coito, "#StudentSeminar: Composite Higgs bosons from neutrino condensates in an inverted seesaw scenario."
- 16 Jun Yasaman Farzan, "Webinar: Unravelling richness of dark sector by FASERν"
- 15 Jun Aurora Melis, #StudentSeminar A flavon solution to muon and electron g-2
- 04 Jun Christian Valdés , "#StudentSeminar: Effects of photoelectric cross-section uncertainties on Monte Carlo simulations: in-water dosimetry of low-energy x-rays (< 100 kV) in radiation therapy."
- 02 Jun Marta Losada, "Webinar: Impact of LHC Higgs physics and EDMs on Baryogenesis in the Standard Model EFT with dim 6 terms"
- 27 May Alvaro Tolosa Delgado, "#StudentSeminar Introduction to nuclear astrophysics. From the lab to the stars"
- 19 May Gilad Perez, "Webinar: Searching for dark sectors with Kaon factories"
- 12 May Daniele Gaggero, "Dark and shiny dresses around black holes"
- 05 May Ryan Plestid, "Webinar: Millicharged particles in neutrino detectors"

5 ANNEXES Seminars organized

- 04 May Andrea Caputo, "#StudentSeminar Looking for Axion Dark Matter: from Dwarf Galaxies to Pulsars"
- 30 Apr julien alcaide de wandeleer, "#StudentSeminar: Probes of the standard model effective field theory extended with right handed neutrinos"
- 21 Apr Bradley Kavanagh, "Webinar: Detecting (Axion?) Dark Matter around Black Holes with Gravitational Waves"
- 07 Apr Pilar Coloma, "New physics searches using neutrino oscillation experiments"
- 24 Mar James Cline, "Webinar: A little theory of everything"
- 10 Mar Asimina Arvanitaki, "Webinar: Dark Matter halos from parametric resonance and their signatures"
- 04 Mar Ara Ioanissyan, "A Standard Model explanation for the excess of electron-like events in MiniBooNE"
- 03 Mar Susana Molina Sedgwick, "Precision-era Neutrino Studies at Super-Kamiokande and Hyper-Kamiokande“
- 21 Feb Dijana Dominis Prester, "Gamma Ray Telescopes MAGIC and CTA: The Multimessenger Challenge"
- 18 Feb Pablo Fernández de Salas, "Local dark matter density from recent observations"
- 14 Feb Anatael Cabrera, "Unitarity: the last Discovery using Neutrino Oscillation?"
- 11 Feb Jessica Turner, "Webinar: Neutrino masses from gravity"
- 10 Feb Juan Antonio Aguilar Saavedra, "Top antitop is a disgrace and I cannot help it"

5 ANNEXES Seminars organized

- 04 Feb Paola Ferrario , "PETALO: a Positron Emission Tomography Apparatus with Liquid xenOn."
- 30 Jan Ana Peñuelas Martínez, "#StudentSeminar: Flavour Anomalies in b->cτν transitions"
- 28 Jan Samuel J. Witte, "Webinar: Probing the Neutrino Mass Mechanism with the CMB"
- 24 Jan Galo Rafael Gonzalvo Rodríguez, "#StudentSeminar: Probing the tWb structure in t-channel single top-quark production using the ATLAS detector at the LHC"
- 21 Jan Martin Perello, "#StudentSeminar: Top quark couplings in past, present and future colliders"
- 25 Feb Xiaoping Wang, "Webinar: Long-lived particle search @ LHC"
- 25 Feb Masato Shiozawa, "Severo Ochoa Seminar: The Hyper-Kamiokande project"
- 21 Feb Sergi Rodriguez Bosca, "#StudentSeminar: Measurement of the Yukawa coupling to leptons with the ATLAS detector"
- 14 Jan Clara Murgui Galvez, ""#StudentSeminar: The QCD Axion and Unification""
- 14 Jan Joachim Kopp, "Webinar: Filtered Dark Matter: Setting the Dark Matter Abundance Through a First Order Phase Transition"

6 ANNEXES PhD Theses 2020

THEORETICAL PHYSICS

• *Neutrino masses and their implications for low energy experiments and the LHC*
Julien Alcaide de Wandeleer
Advisors: Arcadi Santamaria Luna and Mikael Rodríguez Chala
22 July, University of Valencia
TESEO: 1896285

• Neutrino oscillation phenomenology in the standard model and beyond
Christoph Andreas Ternes
Advisors: Mariam Tórtola Baixauli
23 July, University of Valencia
TESEO: 1895127

• Topics in Physics Beyond the Standard Model
Andrea Caputo
Advisor: Pilar Hernández Gamazo
24 September, University of Valencia
TESEO: 1902789

• Dynamics of charmed and bottomed meson and baryon resonances
Rafael Pereira Pires Pavao
Advisors: Eulogio Oset Báguena and Juan Nieves Pamplona
1 October, University of Valencia
TESEO: 1910043

• The origin of flavor in physics beyond the Standard Model. Aurora Melis
Advisors: Óscar Vives García and María Luisa López Ibáñez
7 October, University of Valencia
TESEO: 1910919

• Phenomenology of the LHC and flavour factories
Ana Peñuelas Martínez
Advisor: Antonio Pich Zardoya
16 October, University of Valencia
TESEO: 1908108

• Phenomenological and cosmological aspects of electroweak models beyond the Standard Model
Clara Murgui Gálvez
Advisors: Antonio Pich Zardoya and Pavel Fileviez Pérez
27 October, University of Valencia
TESEO: 1912518

EXPERIMENTAL PHYSICS

• Development of the Pixel Detector for the Belle II experiment and top quark mass measurement in radiative events at the future electron-positron linear collider
Pablo Gomis
Advisors: Juan Antonio Fuster Verdú and Carlos Manuel Mariñas Pardo
27 January, University of Valencia
TESEO: 1842348

• Uso de detectores de la radiación para el desarrollo de técnicas de reconstrucción espacial en residuos radiactivos
José Luis Leganés Nieto
Advisors: Francisco Javier Albiol Colomer and Luis Caballero Ontanaya
31 January, University of Valencia
TESEO: 1848252

• Contributions to phase two of AGATA Electronics
Javier Collado Ruiz
Advisors: Andrés Gadea Raga and Vicente González Millán
27 March, University of Valencia
TESEO: 1852599

• Searches for cosmic neutrino sources with ANTARES, KM3NeT and Icecube and time calibration of ANTARES
Giulia Illuminati
Advisors: Alexis Coleiro and Juan de Dios Zornoza Gómez
27 March, University of Valencia
TESEO: 1859751

• Search for radiative b-baryon decays and study of their anomalous photon polarization at LHCb
Luis Miguel García Martín
Advisors: Fernando Martínez Vidal and María Aranzazu Oyanguren Campos
29 May, University of Valencia
TESEO: 1877619

• High Gradient Issues in S-band RF acceleration structure and Radio Frequency Quadrupoles for hadron therapy accelerators
Anna Vnuchenko
Advisors: Benito Gimeno Martínez and Ángeles Faus Golfe
19 June, University of Valencia
TESEO: 1855179

• Study of the Yukawa coupling to leptons using LHC pp collisions at sqrt(s) = 13 TeV with the ATLAS detector
Sergi Rodriguez Bosca
Advisor: Luca Fiorini
22 June, University of Valencia
TESEO: 1887648

• Top quark couplings in past, present and future colliders
Martín Perelló Roselló
Advisors: Marcel Vos and Gauthier Durieux
26 June, University of Valencia
TESEO: 1853619

• Alignment of the ATLAS Inner Detector and probing the top quark polarization in single top t-channel production
Óscar Estrada Pastor
Advisors: María José Costa Mezquita and Salvador Martí García

6 ANNEXES PhD Theses 2020

30 June, University of Valencia
TESEO: 1884837

• Electrónica de adquisición de KM3NeT e instrumentación de calibración temporal para telescopios de neutrinos submarinos
Diego Real Máñez
Advisors: Juan Zúñiga Román and Juan de Dios Zornoza Gómez
16 July, University of Valencia
TESEO: 1891251

• Search for transient sources with the ANTARES and KM3NeT neutrino telescopes in the multi-messenger astronomy era
Marta Colomer Molla
Advisors: Juan de Dios Zornoza Gómez and Antoine Kouchner
29 September, University of Valencia
TESEO: 1902771

• Dark matter search in the top-quark sector with the ATLAS detector at the LHC
Florencia Luciana Castillo
Advisors: Carlos Escobar Ibáñez and José Enrique García Navarro
23 October, University of Valencia
TESEO: 1916700

• Neutron capture cross section measurement of the heaviest s-process branching 204Tl and of 203Tl at CERN n_TOF
Adrià Casanovas Hoste
Advisors: César Domingo Pardo and Francisco Calviño Tavares
27 October, Polytechnic University of Catalonia

• Study of beta-delayed neutron emitters in the region of 78Ni and its impact on r-process nucleosynthesis
Álvaro Tolosa Delgado
Advisor: José Luis Taín Enríquez
27 October, University of Valencia
TESEO: 1908591

• Beta-decay of 8B into highly excited states of 8Be: isospin mixing and proton-halo contributions
Sílvia Viñals Onsès
Advisors: Olof Tengblad and Enrique Nácher González
11 December, University of Valencia
TESEO: 464169

• The NEXT experiment: DAQ, backgrounds and medical applications
José María Benlloch Rodríguez
Advisors: J.J. Gómez Cadenas, Paola Ferrario and Javier Muñoz Vidal
18 December, University of Valencia
TESEO: 1927734

7 ANNEXES Masters 2020

THEORETICAL PHYSICS

• Simetría de espín y la interacción de mesones pseudoescalares y vectoriales con un quark pesado
Daniel Canillas Martínez
Advisors: Juan Miguel, Nieves Pamplona

• Active-sterile neutrino oscillations in low-reheating scenarios
Mario Fernández Navarro
Advisors: Sergio Pastor Carpi

• Neutrino – Dark Energy interplay
Rasmi Enrique Hajjar Muñoz
Advisors: Stefano Gariazzo, Olga Mena Requejo

• Radion contribution to gravity-mediated dark matter in clockwork/linear dilaton extra dimensions out of the rigid limit
Jesús Pedro Márquez Hernández
Advisors: Andrea Donini

• TeV-Scale bull neutrino in wrapped extra dimensions as a DM candidate
Francisco Martínez López
Advisors: Andrea Donini, Miguel García Folgado

• Leggett-Garg inequality in neutrino oscillations
Josep Martinez Romeu
Advisors: María Amparo Tórtola Baixauli

• Flavour Symmetries from extra dimensions
Omar Medina Rosales
Advisors: José W.F. Valle

• Phenomenology beyond the sm: neutrino masses and dark matter in scotogenic models
Miguel Puerta Catoira
Advisors: Avelino Vicente Montesinos

• Leptogenesis through the Type-I SeeSaw mechanism
Diego Ruiz Andrés
Advisors: Oscar Vives

• Solar neutrino oscillation
Salvador Urrea González
Advisors: Pilar Coloma Escribano

• Searching for exotic physics with 21cm cosmology
Estanislao Utrilla Ginés
Advisors: Olga Mena Requejo, Sam Witte

• Gravedad de torsión
Gerard Villarroya Piqué
Advisors: María Antonia Lledó, Alessandro Fabbri

• $B_s^0 - \overline{B_s^0}$ System evolution and decay measurements
Miguel Rebollo de Miguel
Advisors: Francisco J. Botella Olcina, Miguel R. Nebot Gómez

NUCLEAR AND PARTICLES PHYSICS

• Pseudorapidity dependence of the average transverse momentum in ppb, pbp and pp collisions at LHCb.
Imanol Corredoira Fernández
Advisors: Abraham Antonio Gallas Torreira, Fernando Martínez Vidal

• Search for lepton-flavour-violating decays of the Higgs Boson to $e\tau$ and $\mu\tau$ with 136 fb^{-1} of $\rho\rho$ collisions at $\sqrt{s}$= 13 TeV with the atlas detector
Antonio Jesús Gómez Delegido
Advisors: Luca Fiorini

• Numerical study of photocathode rf electron gun and dark currents with vsim
Pablo Martínez Reviriego
Advisors: Benito Gimeno Martínez, Daniel Esperante Pereira

• Non-standard neutrino interactions with the km3net-orca detector
Juan Palacios González
Advisors: Juan de Dios Zornoza Gómez, Juan Zúñiga Román

• Search for New Physics classifying events with convolutional neural networks.
Adrián Rubio Jiménez
Advisors: José Enrique García Navarro, María Moreno Llácer, Fernando Mateo Jiménez

• Optimización en la búsqueda de la producción resonante de dos bosones de Higgs en el estado final $\gamma\gamma b^{-}b$ con el experimento ATLAS
Cecilia María Morcillo Pérez
Advisors: Arantxa Ruiz Martínez, Luca Fiorini

• Determination of the KM3NeT-ARCA sensitivity to transient sources
David Muñoz Pérez
Advisors: Francisco Salesa Greus, Juan de Dios Zornoza Gómez

8 ANNEXES Grants

NATIONAL GRANTS

• 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
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)

• Experimentos de estructura Nuclear y Astrofísica con haces radioac- tivos y neutrones y aplicaciones
Ref. FPA2017-83946-C2-1-P
PI: José Luis Taín Enríquez
217,800 € (Jan 2018 – Dec 2019)

• Estudios contemporáneos teóricos y experimentales de estructura nu- clear, construcción y I+D instrumentales para AGATA, un instrumento para Hispec/Fair
Ref. FPA-2017-84756-C4-1-P
PI: Andrés Gadea Raga
121,000 € (Jan 2018 – Dec 2020)

• Teorías efectivas en física nuclear y de hadrones
Ref. FIS2017-84038-C2-1-P
PI: Juan M. Nieves Pamplona
102,850€ (Jan 2018 – Dec 2020)

• Física de Partículas en el LHC y las factorías de sabor
Ref. FPA2017-84445-P
PI: Antonio Pich Zardoya
217,800 € (Jan 2018 – Dec 2020)

• Física Nuclear y de hadrones a energías intermedias
Ref. FIS2017-84038-C2-2-P
PI: Manuel Vicente Vacas
72,600 € (Jan 2018 – Dec 2020)

• Partículas elementales: El Modelo Estándar y sus extensiones
Ref. FPA2017-84543-P

8 ANNEXES Grants

PI: Oscar Vives García y Sergio Palomares
193,600 € (Jan 2018 – Dec 2020)

• 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)

• Astropartículas y física de altas energías
Ref. FPA2017-85216-P
PI: José Furtado Valle
127,050 € (Jan 2018 – Dec 2020)

• Sabor y Origen de la materia
Ref. FPA2017-85985-P
PI: Pilar Hernández Gamazo
157,300 € (Jan 2018 – Dec 2020)

• Campos cuánticos y gravitación
Ref. FIS2017-84440-C2-1-P
PI: Gonzalo Olmo Alba
60,500 € (Jan 2018 – Dec 2020)

• Gravedad, Quiralidad de fotones y emisión estimulada
Ref. FIS2017-91161-EXP
PI: José Navarro Salas
36,300 € (Jan 2018 – Jun 2020)

• Investigación de técnicas Compton para aplicaciones médicas
Ref: FPA2017-85611-R
PI: José Bernabéu Alberola
60,500 € (Dec 2018 – Dec 2020)

• Redes de Excelencia
Ref: FPA-2017-90687-REDC
PI: Antonio Pich Zardoya
30,000 € (Dec 2018 – Dec 2020)

EUROPEAN UNION GRANTS

• 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)

• CompactLight H2020-INFRADEV-2017-1 Ref. 777431 PI: Juan A. Fuster Verdú
80,000 € (Jan 2018 – Dec 2020)

• ENCORE H2020-MSCA-IF-2017 Ref. 796941 Fellow: Stefano Gariazzo
PI: Sergio Pastor Carpi 158,121 € (April 2018 – March 2020)

• 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)

• European Nuclear Science and Applications Research (ENSAR2)
H2020-INFRAIA-2014-2015 Ref. 654002
PI: Andrés Gadea Raga
159,625 € (Mar 2016 – Feb 2020)

• Optimization of Medical Accelerators (OMA) H2020-MSCA-ITN-2015 Ref. 675265
PI: Juan A. Fuster Verdú
247,872.96 € (Feb 2016 – Jan 2020)

• INVISIBLESPLUS H2020-MSCA-RISE-2015 Ref. 690575 PI: Pilar Hernández Gamazo
198,500 € (Feb 2016 – Jan 2020)

• ELUSIVES H2020-MSCA-ITN-2015 Ref. 674896
PI: Pilar Hernández Gamazo
454,402.92 € (Apr 2016 – Mar 2020)

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

• INVISIBLESPLUS H2020-MSCA-RISE-2015 Ref. 690575 PI: Olga Mena Requejo
103,220 € (Feb 2016 – Jan 2020)

• Unraveled new physics at the LHC through the precision frontier Ref. CA16201
PI: Germán Rodrigo García

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560,000 € (Oct 2017 – Sep 2021)

REGIONAL GRANTS

• 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 (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)

• Estimación de dosis en terapia hadrónica
Ref. AICO/2019/070
PI: Carlos Lacasta Llácer
39,957 € (Jan 2019 – Dec 2020)

• Desarrollo de dosimetría de precisión en radioterapia
Ref. AICO/2019/132
PI: Javier Vijande Asenjo
33,000 € (Jan 2019 – Dec 2020)

• 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)

• Infraestructuras y Equipamiento. Machine learning y big data en física de partículas y sus aplicaciones a los retos de la sociedad
Ref. IDIFEDER/2018/048
PI: Juan José Hernández Rey
999,860 € (Jan 2018 – Oct 2020)

• 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)

• Búsqueda de Nueva Física a través del Sabor
Ref. SEJI/2018/033
PI: Avelino J. Vicente Montesinos
208,167 € (Jan 2018 – Dec 2020)

• 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)

OTHER GRANTS

• Campus Verano Girls4STEM-CSIC
Ref. FGCC-2020-0017
PI: Enrique Nacher González
2,000 € (Jul 2020 – Jul 2020)

• 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

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Collider" (LHC-ATLAS) y su evaluación prospectiva en futuros colisionadores
Ref. PIE:202050E040
PI: Juan A. Fuster Verdú
108,500 € (Jan 2020 – Dec 2022)

•Ayuda extraordinaria para instituto, centros y unidades que han solicitado menciones de excelencia "Severo Ochoa" o "Maria de Maeztu" en la convocatoria 2019
Ref. 20205CEX009
PI: Nuria Rius Dionis
357,954 € (Jan 2020 – Dec 2020)

• 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)

• Fabricación de PCB prototipo y control de calidad
Ref. FAS2020_004
PI: José Bernabéu Verdú
46,626 € (Jan 2020 – Dec 2020)

• 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)

• Equipamiento para microsoldadura electrónica
Ref. FAS-19-0030
PI: José Bernabéu Verdú
89,740 € (Jan 2019 – Dec 2020)

• 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)

• Geometry and Quantum Simulation
Ref. PICS2017
PI: Armando Pérez Cañellas
10,000 € (March 2018 – Dec 2020)

• Impulso a las nuevas fases de los experimentos del IFIC (ATLAS upgrade, Km3NeT Fase 2,0, NEXT 100, DUNE, IFIMED)
Ref. 2017050E070
PI: María José Costa Mezquita
130,200 € (Jan 2017 – Jun 2020)

TECHNOLOGY TRANSFER GRANTS

• 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)

• Convenio de Colaboración GV-CERN para la ejecución del Experimento MoEDAL del LHC en el CERN
PI: Vasiliki Mitsou
30,000 € (Jan 2020 – Dec 2020)

• Creación de una Unidad Científica de Innovación Empresarial en el IFIC.
PI: Juan A. Fuster Verdú
250,000 € (Jan 2020 – Dec 2020)

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

• Study potential upgrades for the high-gradient S-band test facility
Ref. 20185988
PI: Juan A. Fuster Verdú
166,000 € (June 2018 – June 2020)

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

Images and vectors references

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