Science @ IFIC

INSTITUT DE FÍSICA CORPUSCULAR

EXCELENCIA SEVERO OCHOA

Summary of research lines

Luis Alvarez Ruso

Prelude

- Big research center:
  - Total staff: **374**
  - **74% researchers** (experiment & theory)
    - 58 postdocs
    - 102 PhD students
  - Annual Report 2024
    https://webific.ific.uv.es/web/sites/default/files/memoria_ific_2024-.pdf

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- Broad range of scientific interests…
- … and activities:
  - Colloquia
  - Seminars
  - Scientific meetings
  - (PhD) Courses
- Visitors

SEE CALENDAR OF EVENTS

FEATURED EVENTS

Forthcoming Colloquia

An instrument for discovery at the High-Luminosity LHC. The ATLAS Inner Tracker.
Dr. Francisca Muñoz Sánchez
Thursday, 11 December, 2025 - 12:30 | Salón de Actos

Forthcoming Seminars

Polymer Cosmology with Polymer Matter
Aleena Sra. Aleena
Friday, 12 December, 2025 - 11:00 | Seminari Física Teòrica

La piragua de Gamow
Prof. Antonio Lallena Rojo
Monday, 15 December, 2025 - 15:00 | Paterna. Seminario

#StudentSeminar: Gravitational Dark Matter in Warped Extra Dimensions: From Realistic Three-Brane Models to the Evanescent-Brane Limit
Alejandro Muñoz Ovalle
Wednesday, 17 December, 2025 - 15:30 | Paterna. Seminario

Thesis Defense

Properties of exotic mesons in vacuum and embedded in a medium
Víctor Montesinos Llácer
Friday, 12 December, 2025 - 10:00 | Paterna. Seminario

Advanced electromagnetic studies for particle acceleration applications: magnets, photomultiplier tubes and carbon nanostructures
Pablo Martín Luna
Friday, 12 December, 2025 - 11:00 | Sala Lise Meitner

Forthcoming Events

IFIC Newcomers Fest 2025
Friday, 12 December, 2025 - 09:00

Quantum Sensors and applications in Fundamental Physics
Clara Murgui Galvez
Monday, 15 December, 2025 - 09:30 | Paterna. Seminario

Quantum Sensors and applications in Fundamental Physics
Clara Murgui Galvez
Tuesday, 16 December, 2025 - 09:30 | Paterna. Seminario

IFIC leads a study that reveals new evidence about how the Higgs boson interacts with the top quark

The ATLAS experiment has taken an important step toward understanding how the Higgs boson, the particle that gives mass to the others, interacts with the top quark, the heaviest elementary...

Wed, 10/12/2025

IFIC organizes the 2025 edition of the TeVPA International Conference on Particle Astrophysics, held for the first time in Spain

This edition of TeVPA has broken the series' attendance record, with over 370 international participants.

Fri, 05/12/2025

The upcoming ASFAE–IFIC colloquium will reveal the key aspects of the new ATLAS Inner Tracker of the LHC

On Thursday, December 11, the IFIC will host an ASFAE–IFIC colloquium that will bring us closer to the new tracking detector of the ATLAS experiment at CERN, the ATLAS Inner Tracker.

Thu, 04/12/2025

Jorge Baeza Ballesteros, awarded the First National University Graduation Prize by the Ministry of Science, Innovation and Universities

In his outstanding academic career highlights his doctoral thesis, carried out at the IFIC (2020–2024), which obtained the highest distinction of *Cum Laude*.

Wed, 03/12/2025

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VISITANTES

Mon, 01/12/2025	Professor Einan Gardi visits IFIC from 1 to 5 December 2025
Thu, 20/11/2025	Yuber Ferney Pérez González visits IFIC from 24th-26th November 2025
Mon, 10/11/2025	Professor Sven-Olaf Moch visits IFIC from 10th-12th November 2025
Fri, 24/10/2025	Dr. Paolo Abiuso visits IFIC from 27th-31st October 2025

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Sc

2025

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- … and activities:
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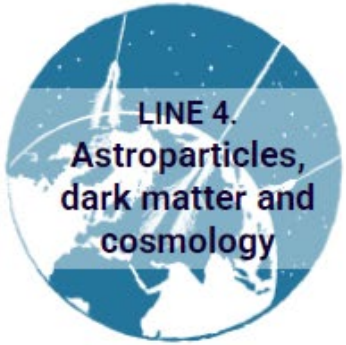
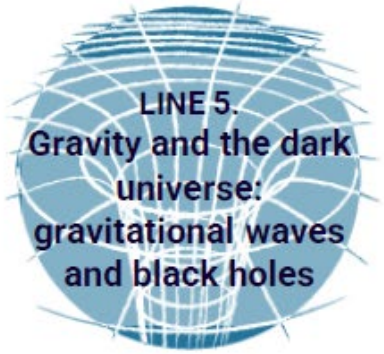
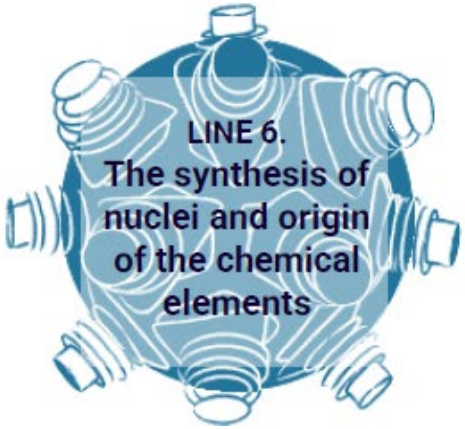
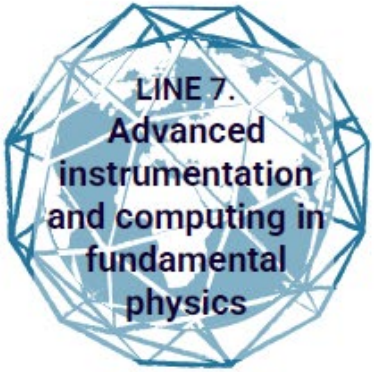
- **Opportunities for collaboration**

Research Lines



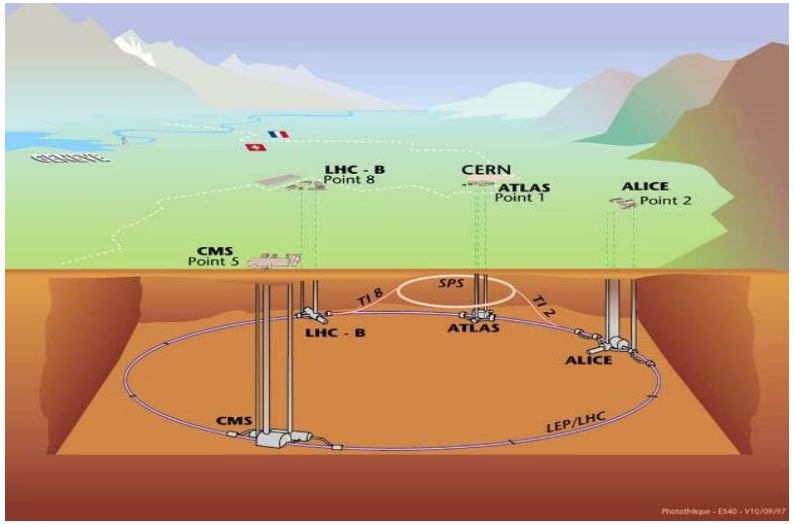




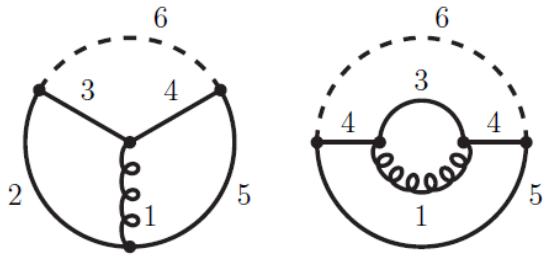


L1. The Higgs Force

- **Experiment:**
- ATLAS @ LHC, CERN
  - Detector operation and calibration
  - Software & computing
  - Precision measurements:
    - Higgs properties and interactions
    - Top quark production
  - BSM searches and constrains:
    - LFV
    - W', Z'



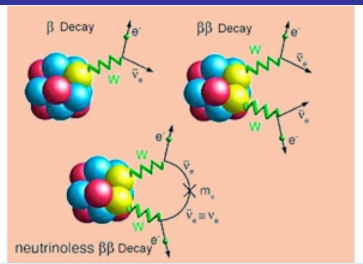
- **Theory:**
  - Higher orders in perturbative QFT (EW & QCD)
  - EFT for BSM & Pheno
    - Machine learning
    - Quantum computing

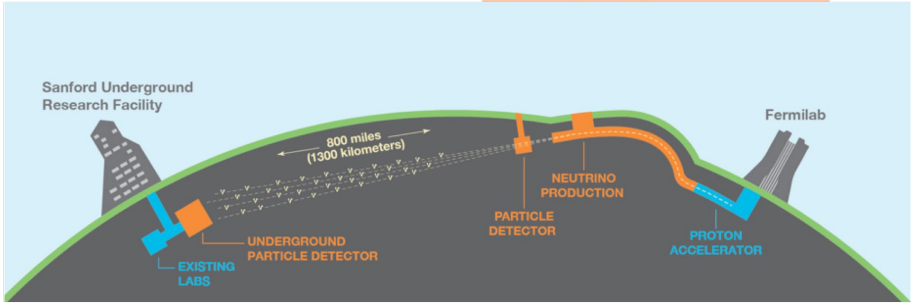


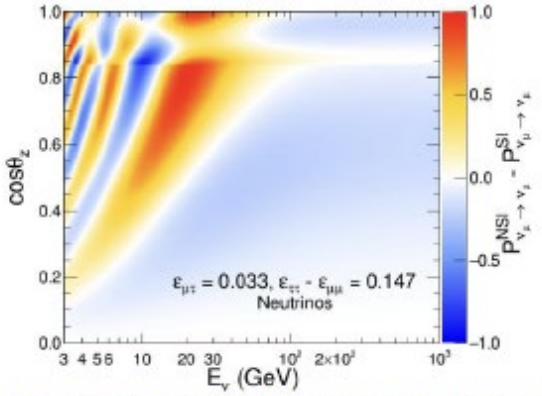
Representative three-loop vacuum diagrams contributing to the Higgs decay into a quark-antiquark pair at NLO

L2. Neutrinos and lepton flavor

- **Experiment:**
- NEXT @ LSC: NEXT-100 construction and data taking
  - Search for $\beta\beta0\nu$ decay
- T2K measurements
  - ν fluxes, cross sec., osc. param.
- DUNE & ProtoDUNE @ CERN
  - Design and construction
  - Analysis strategies: proton decay
- ANTARES & KM3Net-ORCA
  - Monte-Carlo & algorithm development
  - Atmospheric ν: oscillations, NSI, ν decay
- **Theory:**
  - Global analyses of ν oscillations
  - ν mass models, ν in cosmology
  - ν interactions with matter, including CEνNS, NSI



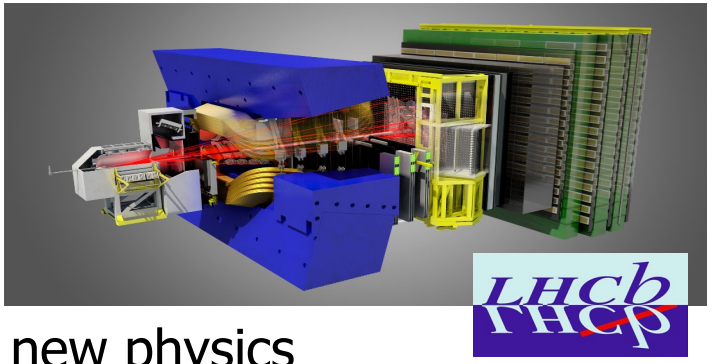




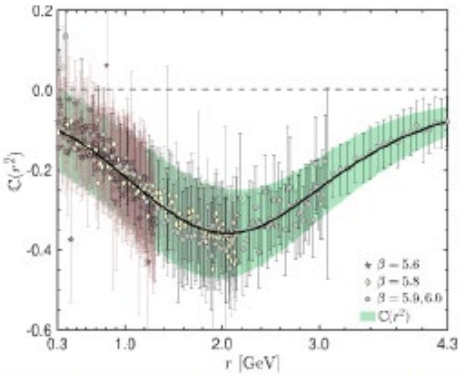
Example of the modifications induced by non-standard neutrino interactions on the disappearance probabilities of muon neutrinos, as a function of the true neutrino energy and cosine of the zenith angle, that can be studied with data from ANTARES.

L3. Flavor and quark matter

- **Experiment:**
- LHCb, ATLAS @ CERN, Belle-II @ KEK
  - b- and c-baryon (rare) decays
    - Asymmetries, polarization observables
    - Sensitive to non-perturbative QCD and new physics
    - FCNC, flavor anomalies
  - Searches: baryon EDM, HNL, Hexaquarks



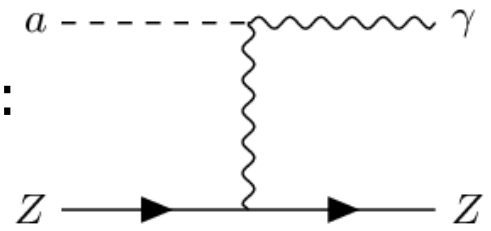
- **Theory:**
- New physics in hadron and τ decays
- EFT in hadron physics:
  - Exotic states, hadronic molecules
  - Baryon properties and interactions with ChPT
- Lattice QCD
- Synergy between LQCD and continuum methods:
  - Dyson-Schwinger eqs., hadrons @ finite volume, quark mass dep.



The activation of the Schwinger mechanism hinges on the formation of composite massless poles, which modify the analytic structure of the fundamental vertices of the theory and induce smoking gun displacements in the corresponding Ward identities. This displacement, denoted by C(r2), is obtained using central fits for the lattice data (black solid curve). The green band expresses the uncertainty in this result. The dashed gray line represents the null result, i.e., no Schwinger mechanism.

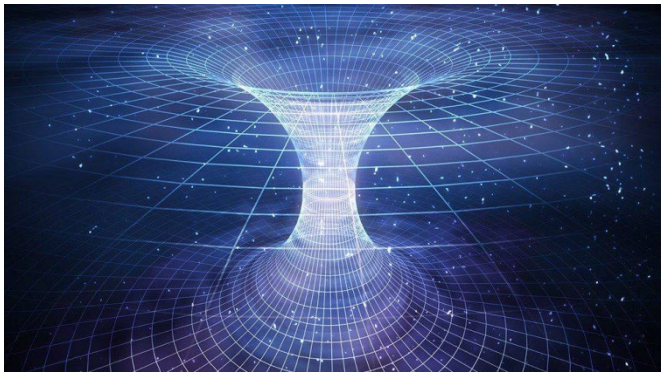
L4. Astroparticles, DM and cosmology

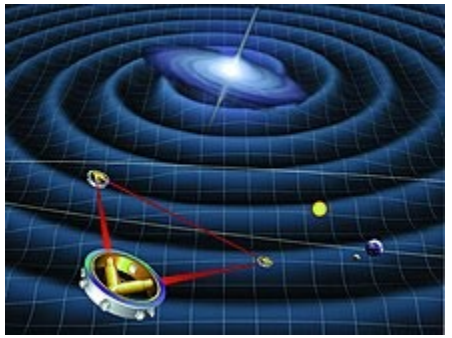
- **Experiment:**
- ATLAS, LHCb, MATHUSLA, MAPP-MoEDAL, NA64 @ CERN
- Searches:
  - CP-violation, SUSY, long-lived particles
  - light DM, magnetic monopoles
- ANTARES & KM3Net-ARCA, HAWC
  - Cosmic neutrino detection, multi-messenger astronomy
  - Neutrinos from DM
- RAD.ES, babyIAXO, CADEx, ALPS II
  - Axion searches using inverse Primakoff mechanism:
- **Theory:**
- Dark matter models and pheno.
- Production of long-lived particles
- Leptogenesis



L5. Gravity and the dark universe: gravitational waves and black holes

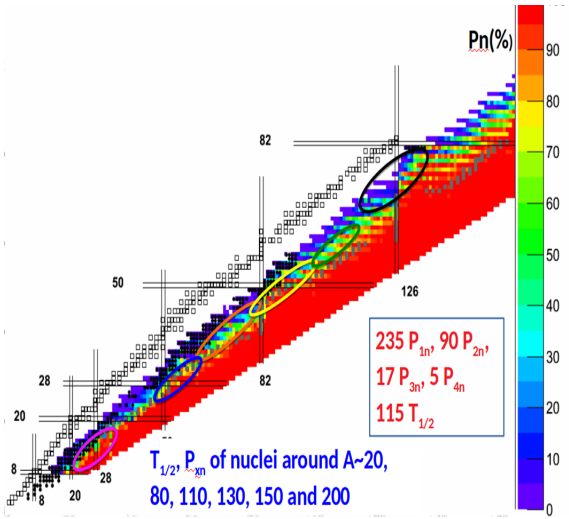
- **Theory:**
- Primordial black holes
- Modified gravity
- Quantum effects in gravity
- Gravitational waves as probes of this physics
- QFT in curved spacetime
- Participation in exp. projects:
  - Laser Interferometer Space Antenna (LISA):
  - Einstein Telescope
  - SKA radio telescope





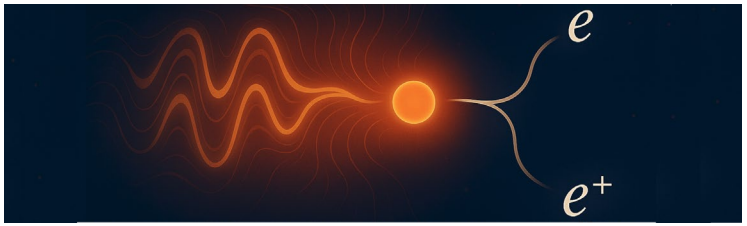
L6. The synthesis of nuclei and origin of the heavy chemical elements

- **Experiment:**
- ISOLDE, n_TOF @ CERN, AGATA @ LNL, FAIR @ GSI, HENSA @ LSC, RIKEN, GANIL, IGISOL
- Gamma and neutron spectroscopy
- Nuclear structure, astrophysics & applications:
  - Exotic nuclei at driplines
  - β decays, $\bar{\nu}$ reactor fluxes
  - Stellar nucleosynthesis
  - Ambient neutron rates
  - (α, n) reactions
- Development of instrumentation
- **Theory:**
- Precision & BSM physics with β decays
  - CKM unitarity tests



L7. Advanced instrumentation and computing in fundamental physics

- Instrumentation development for different experiments:
  - TileCal, ITk for ATLAS
  - ECAL for LHCb
  - Calorimeters for LUXE (strong-field QED)
  - Detector R&D for future colliders
  - New electronics for AGATA
  - Active detectors and novel materials for n_TOF
  - Cryogenics and photon detection system for DUNE
  - NEXT-100 detector



- Computing:
  - ATLAS-GRID
  - ARTEMISA infrastructure for ML and AI
  - GLUON HPC system

- Quantum information and technologies

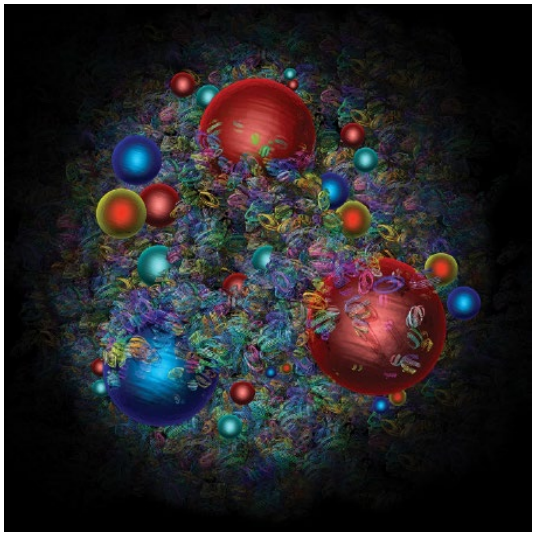
L8. Advanced instrumentation and computing for societal challenges

- Medical applications:
  - Positron Emission Tomography (PET), Liquid Xenon PET (PETALO)
  - Hadron therapy: monitoring and C6+ injector
  - Molecular & ultrasound imaging for guiding cancer biopsies in real-time (MAGAS)
  - Gamma & neutron imaging
  - AI applied to medical image reconstruction:
  - Simulations for risk reduction in brachytherapy

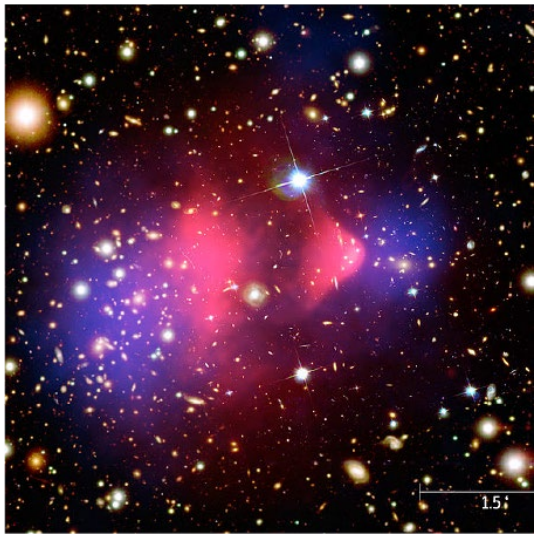
- (Real time) radioactivity monitoring:
  - In water (TRITIUM)
  - Gamma imaging for nuclear waste classification (GUALI):
  - Radiotracers for the study of marine ecosystems (REMO)

- Space Weather: AI-based early warning system for solar storms

Summary



Origin of mass: understanding the fundamental laws of physics



Origin of matter: understanding the Universe

Advanced instrumentation and computing: from fundamental physics to society

Summary

- **Theoretical research** includes: particle physics phenomenology in the Standard Model and beyond (including collider, flavor, Higgs and neutrino physics), astroparticle physics, cosmology, gravitation and black holes, QCD and strong interactions, hadron and nuclear physics, quantum info

Summary

- **Experiments:**

Enjoy!