MINISTERIO
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IFIC - INSTITUTO DE FÍSICA
CORPUSCULAR

IFIC

Instituto de Física Corpuscular

Centro Mixto CSIC-Universitat de València

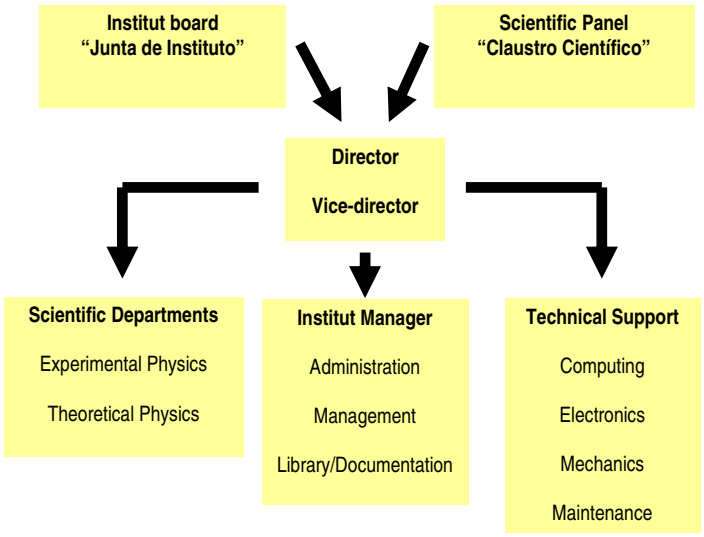
Executive Summary of the proposal for Strategic Plan

1. Strategic Plan for the Centre/Institute

The *Instituto de Física Corpuscular, IFIC,* from Valencia is a *Joint Institute* belonging to two Institutions: *the Spanish Research Council*, CSIC (Consejo Superior de Investigaciones Científicas) and *the University of Valencia,* UVEG (Universitat de València). It was founded in the autumn of 1950 by Profesor Joaquin Catalá to study atomic nuclei and elementary particles. IFIC, hence, is one of the oldest Spanish Institutes in Experimental Physics and the oldest studying particle and nuclear physics.

During many years, the Institute shared the building, offices and facilities, with the University department of Física Atómica, Molecular y Nuclear, FAMN, (called Física Fundamental before 1990) which has been the traditional link with the University. Around the year 1985 most of the researchers of the Theoretical Department of the University of Valencia joined the Institute and configured its present structure which benefits from the knowledge of both fields: theory and experiment.

All groups at IFIC have a long and deep tradition in international cooperation. In particular they have solid and visible collaborations in most of the leading laboratories and experiments of the field like CERN (Geneva-Switzerland), GSI (Darmstad-Germany), Stanford (California-USA), FERMILAB (Chicago-USA), etc..



Present IFIC organization:

- Scientific Departments
- Management
- Technical Support

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Theoretical Department: Research activities

Effective Field Theory

- EQFT grounds
- Chiral perturbation theory
- Heavy quark effective theory
- Dynamical symmetry breaking
- Effective theories and new physics
- QFT at finite temperatures

QCD

- QCD jets
- Tau decays and QCD
- Heavy quark masses
- Lattice QCD
- Quark masses in the lattice
- QCD sum rules

Weak interactions

- Flavour Dynamics
- B-quark physics
- CP violation
- Electroweak Radiative Corrections
- Neutrino physics
  - Analysis of neutrino properties
  - Theories of neutrino mass

Beyond the SM

- Supersymmetry and the origin of mass
- Supersymmetry Phenomenology
- New physics signatures at colliders
- Lepton flavor and lepton number violation
- Dual Models
- Extra dimensions (b-physics, neutrino masses, GUT in extra dimensions, effects in colliders)

Astroparticle Physics

- Neutrino astrophysics and cosmology
- High energy cosmic ray physics
- CMB and structure formation
- Compact objects in astrophysics
  - Supernovae
  - Neutron Stars
- Baryogenesis
- Dark matter and dark energy

Hadronic Physics
Many Body Theory

- Hypernuclei
- Nuclear Drell Yan
- Interactions of photons, electrons and neutrinos in nuclei
- Static properties and variation density
- Spectrum of exotics
- Parton distributions
- Bosonization
- Effective theories for nucleons
- Nucleon dynamics
- Nuclear matter
- Quantum liquids

Mathematical HEP-TH

- Strings and M-theory
- Supergravity
- Quantum gravity and black holes
- Symmetries and quantization
  - Gauge theories and anomalies
  - Deformation of symmetries
- Dynamical systems
  - Sympletic integrators
  - Non linear systems
  - Evolution of quantum and classical systems

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Experimental Department: Research Projects

High Energy Physics

- LEP-Delphi
- LHC-ATLAS:
  - TiCal
  - SCT
  - GRID
- Neutrino Oscillations
- Antares
- BaBar
- Accelerator Physics
- Detector R&D

Nuclear Physics

- γ–Spectroscopy
- nTOF
- Hades, TAPS
- Integral

Medical Applications

- Nuclear Medicine
- Compton Imaging
- Brachyterapy

Strengths:

The present IFIC structure with two strong departments one in theory and the other in experiment has a direct impact to the research work of the Institute as it provides an excellent atmosphere for scientific cooperation between the two fields, mainly in the phenomenological and experimental areas. This is certainly an advantage of this Institute with respect to others in both the national and the international scene. There are very few Institutes with such composition.

The fact that IFIC is a *Joint Institute* between the CSIC and the University of Valencia is also very positive. This feature gives a close contact of CSIC personnel with University students, allowing them to recruit among the best PhD students, participate in lecturing (though this should be improved) at the post-graduate level, share the scientific administration and complement funding for equipment and infrastructures from the contributions of both Institutions.

Weaknesses

As a general comment and despite the effort of the last 20 years, the Spanish researchers still need to considerably increase their human resources in order to reach the same level of participation as other European countries of our environment (France, UK, Italy,…). In particular for IFIC this means to incorporate more Scientific and Technical staff.

The technical support is mainly based on non stable positions and furthermore the salaries are not competitive with industry for equivalent jobs. There is a clear lack of a technical career path in CSIC such that engineers/technicians can perform their work to their best and be motivated. In particular at IFIC, this makes the normal operation of the Institute extremely vulnerable as the technical expertise achieved can be lost at any moment. If this would happen it will have a very negative impact to the normal work of the Institute and future projects would suffer drastically. This applies mainly to the experimental department but not only.

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Objectives and mission

The mission of our Institute covers a wide range of subjects. In a broad sense, we study the fundamental interactions (gravitational, electroweak and strong) and the building blocks of matter in the Universe in both the theoretical and experimental aspects. Our aim is to understand the nature of these interactions and their phenomenological consequences in the laboratories, to predict the behaviour in future experiments and, as final goal, to search for a unified theory of all of them. In parallel, we wish to know which physical processes occur in the Universe, and how it has evolved from its initial conditions. The variety of the existing groups at IFIC and the different research subjects provides the Institute with a unique character, where our studies cover from the smallest to the largest objects. As can be seen from the published results, in all energy ranges and evolution phases there exist concrete achievements by IFIC researchers.

Most of the research activities are included in the framework of the national programmes of Particle Phyiscs and Physics within the *Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica* of the Spanish government. Summarizing, our goals are:

- to scrutinize the basic structure of matter up to the energy scale of TeV (the energy range measurable in the future LHC at CERN),
- to advance in our knowledge of the flavour structure and CP violation, both in the quark and the lepton sectors,
- to confront new theoretical ideas such as supersymmetry, extra dimensions, etc...
- to develop effective theories for QCD and nuclear physics,
- to study particle interactions in the early Universe and astrophysical scenarios, such as supernovae and neutron stars,
- to study neutrino astrophysics and cosmology
- to study the dynamics of complex systems,
- to improve our knowledge on the quantum aspects of the gravitational interaction,
- to understand better the structure of hadrons through the analysis of data from the TJNAF, DESY or GSI experiments.
- to develop ideas in the field of Quantum Information, with applications to spin systems or quark networks,
- to participate in the most relevant experiments of the fields covered by the research activities of the groups at CERN, SLAC, GSI, Fermilab, DESY, KEK, GANIL, etc..
- to follow a long-term activity in particle and nuclear instrumentation, in particular in semiconductor radiation detectors, calorimetry, electronic design, data acquisition, software, etc..
- to develop tools for GRID and e-Science mostly motivated by our physics needs but keeping opened to go to further applications,
- to support initiatives in connection with Medical Applications related to our know-how achieved by working in our fundamental research.

The main impact of the IFIC research is the knowledge of the laws that rule the interactions among elementary particles, their symmetries and implications on Cosmology and Astrophysics. This is a very active field, at the frontier of basic research, where crucial discoveries are expected in the near future towards understanding the ultimate theory that describes the physical laws of the Universe.

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Since we deal with basic research, it is difficult to also look for immediate technological applications, but history shows that discoveries that initially where purely theoretical have often lead to technological applications that none had previously dreamt of. As it is often said, "*in order to develop applied physics we first need physics to apply*". The development of Quantum Mechanics is a clear example, but there are many others. For what concerns our institute, IFIC has played an important role, through the University and the outreach activities, in the development of a scientific culture and the diffusion of Science. In these sense the fields of Medical Applications and GRID e-Science are certainly a good investment which comes along in parallel and in a natural way from our basic research.

2. Actions to Achieve Objectives

To achieve the above objectives and taking into account our constraints, the main need we have now is to stabilize the young and good researchers and to consolidate the technical know-how by at least keeping the present manpower resources. As an indication, it is worth mentioning the number of present post-doc contracts at IFIC which is 19, 14 from the *Ramón y Cajal* program, 1 from the CSIC I3P program and 4 from national and European projects and networks. Therefore we believe we should be provided with the following new positions during the next five years:

New technical positions:

- Computing: Titulado Superior (2 positions)
- Electronics: Titulado Superior (1 position) + Técnico Medio (1 position)
- Mechanics: Titulado Superior (1position)

New positions in theoretical physics:

- Phenomenology of Effective Theories in non-perturbative QCD (1 position)
- Perturbative QCD in colliders (1 position)
- High Energy Physics: phenomenology (4 positions)
- Astroparticle Physics (2 positions)
- Mathematical and Theoretical High Energy Physics (1 position)
- Theoretical Nuclear Physics (1 position).

In addition to the positions above, we also request one position at the "Investigador Cientifico" level, in the area "Física Teórica, Nuclear, o de Partículas", "por concurso libre".

New positions in experimental physics:

- Experimental High Energy Physics:
  - ✓ Accelerator physics: ATLAS, CDF, BABAR, Linear Collider (3 positions)
  - ✓ Non accelerator and Neutrino physics: ANTARES-KM3, K2K-T2K (2 positions)
- Experimental Nuclear Physics for FAIR (1 position)
- Medical Physics necessary to consolidate this line (1 position).
- GRID and e-Science (1 position)
- Detector development and instrumentation (1 position)
- Accelerator physics (1 position)

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