

FROM PARTICLES TO THE COSMOS



IFAE

Institut de Física
d'Altes Energies

Report
of Activities
Summary 2025

annualreport.ifae.es



FUNDAT PER | FOUNDED BY



Generalitat
de Catalunya

UAB
Universitat Autònoma
de Barcelona

A visualization of particle tracks, likely from a bubble chamber or similar detector, showing numerous colorful lines (yellow, orange, red, green, blue, purple) radiating from a central point on the left side of the image. The background is a dark, starry space.

FROM **PARTICLES** TO THE **COSMOS**

In 1991 the Institut de Física d'Altes Energies (IFAE) was founded as a consortium of the Generalitat de Catalunya and the Universitat Autònoma de Barcelona.

For more than 30 years we have been exploring the cosmic and high energy frontiers to address fundamental questions about our Universe.



IFAE AT A GLANCE

founded in 1991

170 people

three divisions: theory, experimental, technical; and administration

basic research in fundamental physics and
applied research in instrumentation, medical applications,
and quantum technologies

research lines: Particle Physics, Astroparticle Physics, Cosmology, Medical Imaging, Physics Instrumentation and Quantum Computing Technologies

one large engineering group (30+ engineers and technicians)

collaboration in 11 international experiments in high impact / leadership positions
(ATLAS, MAGIC, DES, DESI, T2K, PAU, CTA, Euclid, LSST, Virgo, Einstein Telescope)

facilities: chip packaging & assembly, clean rooms, shielded room,
electronics labs, optical lab, quantum computing technologies lab,
mechanical workshop (300 m²)

one large data-processing centre: **PIC** (LHC Tier-1)

member of **Barcelona Institute of Science and Technology**

awarded the **Severo Ochoa** accreditation of excellence three times
(2012, 2016, 2024)



SCIENCE AT IFAE

At IFAE we conduct experimental and theoretical research at the frontiers of fundamental physics, namely in Particle Physics, Astrophysics and Cosmology.

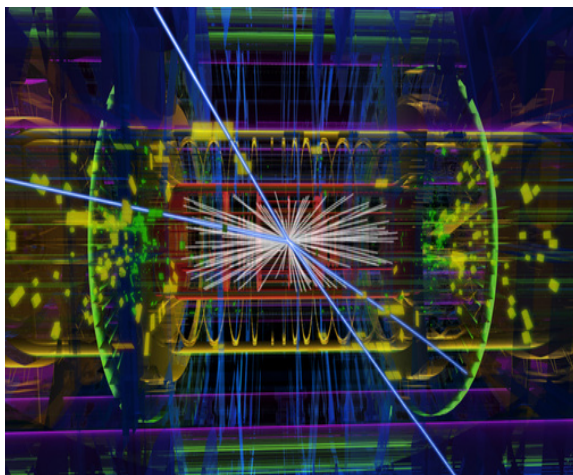
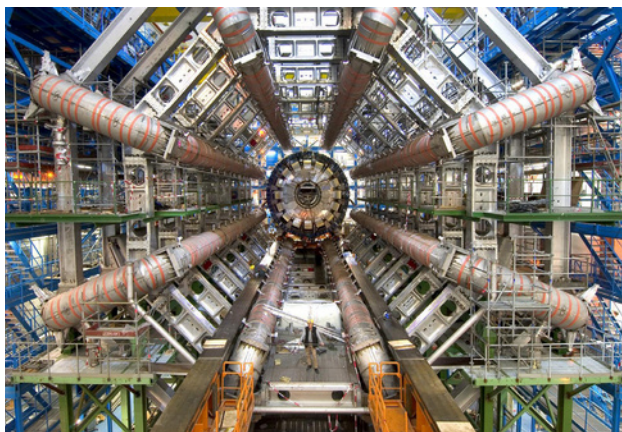
We are involved in the ATLAS project at the LHC, the T2K neutrino experiment in Japan, the MAGIC telescopes in La Palma, the Dark Energy Survey project in Chile, the Cherenkov Telescope Array in La Palma and Chile, the Virgo interferometer near Pisa, the future Einstein Telescope, among others.

We focus our research on the hottest topics in fundamental physics from particles to the cosmos.

PARTICLE PHYSICS
ASTROPHYSICS
& COSMOLOGY
APPLIED PHYSICS

COLLIDER PHYSICS

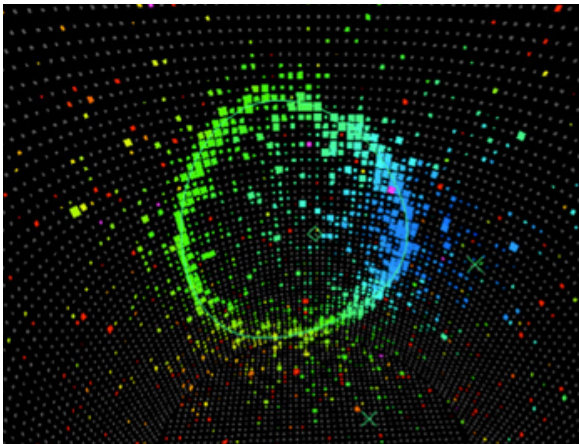
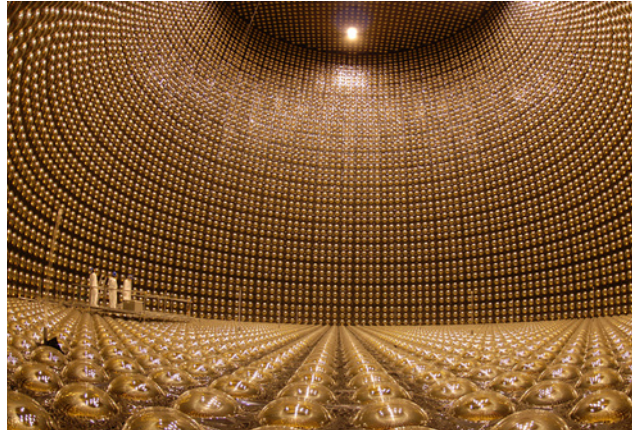
ATLAS is the largest general-purpose detector at LHC, involving 3000 scientists to investigate a wide range of physics, from the Higgs boson to extra dimensions and particles that could make up dark matter.



For more than 30 years we have been making important instrumentation contributions to ATLAS and have deployed a strong and rich physics analysis program.

NEUTRINO PHYSICS

We study the “ghost particle” among the fundamental particles and search for answers to why there is more matter than anti-matter in the Universe.



We have been involved since the beginning in the leading experiment in long-baseline neutrino oscillations: T2K in Japan. We contributed to the design and construction of the near detector and made important contributions to the data analysis.

GAMMA-RAY ASTRONOMY

Our goal is to understand the most energetic phenomena in the Universe and address open questions in fundamental physics.

We lead the most relevant Gamma-ray Astronomy international collaborations (MAGIC, CTA).



We are leaders in the construction of cutting-edge instrumentation: the Gamma-ray group has led the construction of the photosensor cameras for the MAGIC-1 telescope and the CTA Large Sized Telescopes (LST).

GRAVITATIONAL WAVES

In 2019, we initiated a long-term experimental involvement in the Virgo ground-based Fabry-Perot interferometer, with the emphasis of studying fundamental physics using GWs.

We are now a member institution in the Virgo & LIGO collaborations and we have consolidated a long-term research line related to GWs detection using terrestrial interferometry.



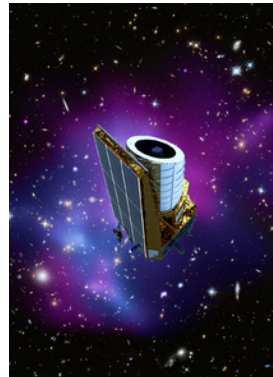
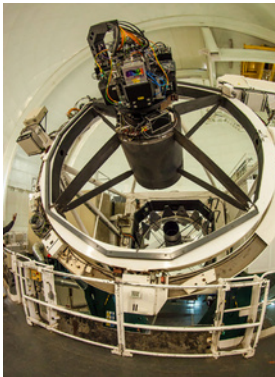
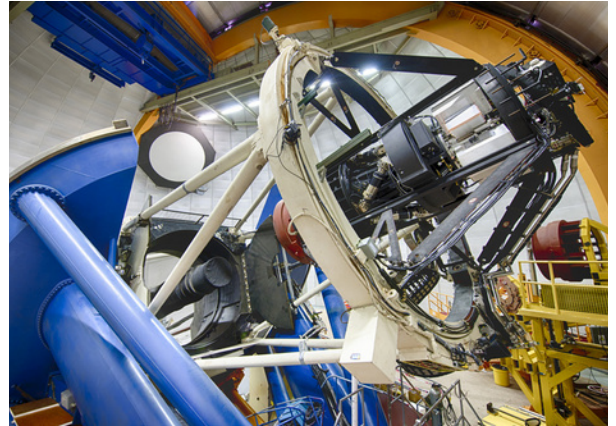
We are also involved in Einstein Telescope (ET), a project recognized in the ESFRI roadmap.

IFAE researchers cover the role of Chair of the ET Collaboration Board and leaders of the European project ET-Preparatory Phase to address the prerequisites for the approval, construction and operation of ET.

OBSERVATIONAL COSMOLOGY

Our main goal is to shed light on the nature of the mysterious dark energy, responsible for the current accelerated expansion of the Universe.

We participate in the leading international collaborations such as DES, DESI, Euclid, LSST and we are a partner of PAUS.

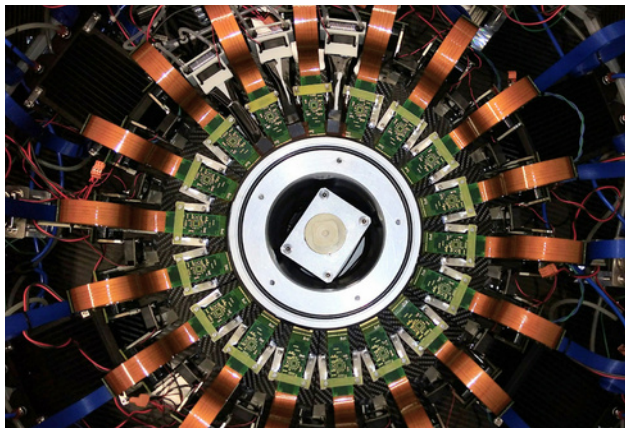
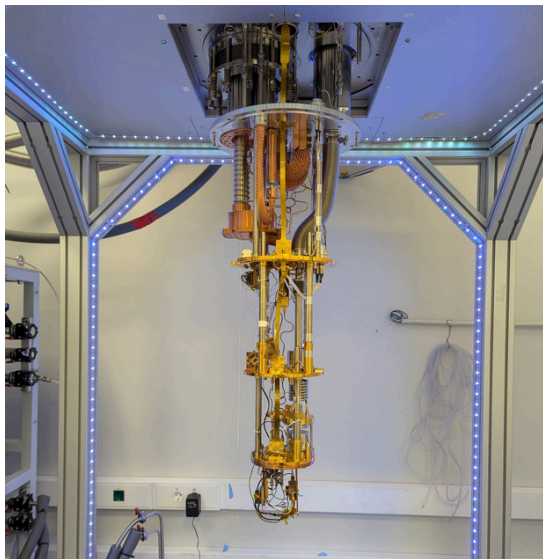


APPLIED PHYSICS

MEDICAL PHYSICS

Since 1999, we are using our expertise with sophisticated radiation detectors to develop advanced medical imaging devices.

We've developed 3 spin-off companies and several patents with our technologies.



QUANTUM COMPUTING TECHNOLOGIES

We are the leading national laboratory developing superconducting qubits for quantum computing applications in quantum annealing and the interaction of qubits with high energy radiation.

We've developed 1 spin-off with our technologies.

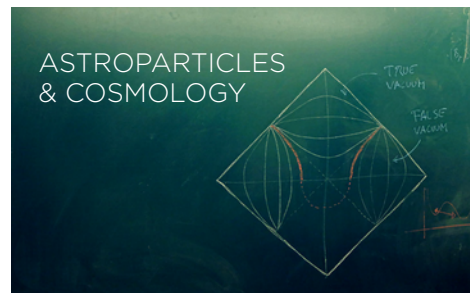
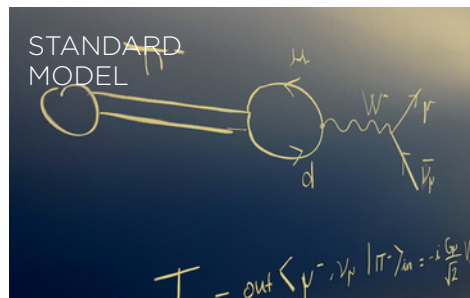
THEORY DIVISION

Our Theory Division works on the most intriguing open questions in fundamental physics.

Research topics of the Standard Model group include applying effective field theories to different physical systems, using flavour physics as a tool for discovery, or improving the hadronic contributions to the muon anomalous magnetic moment, among others.

The Beyond the Standard Model group focuses on research topics needed to understand mysteries such as the origin of the Universe properties, the origin of baryons and dark matter, the hierarchy problem, and the strong CP problem, among others.

Dark energy, dark matter models, baryogenesis, gravitational wave physics, and gravity and condense matter physics are the research topics addressed by the Astroparticles and Cosmology Group.





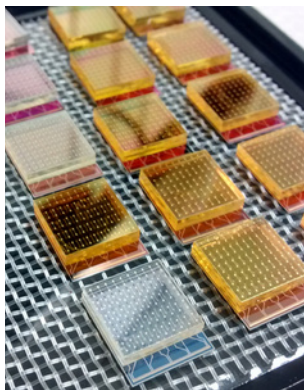
TECHNOLOGY AT IFAE

At IFAE we work at the cutting edge of detector technology, developing pixel detectors for High Energy Physics, telescope cameras, detectors for medical imaging and quantum computing technologies.

Our facilities include a microelectronics laboratory with state-of-the-art packaging and assembly technologies, clean rooms, a data center, a mechanical workshop, electronics labs, an optical room, a shielded room and a quantum computing technologies lab.

FRONT-END ELECTRONICS
GRID COMPUTING
CONTROL SYSTEMS
CRYOGENICS
READ-OUT ELECTRONICS
DETECTORS

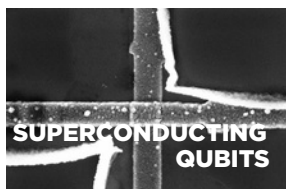
TECHNOLOGIES



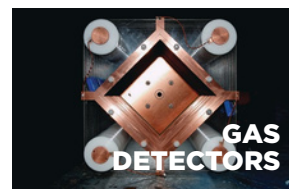
**SOLID STATE
DETECTORS**



**PIXEL
DETECTORS**



**SUPERCONDUCTING
QUBITS**

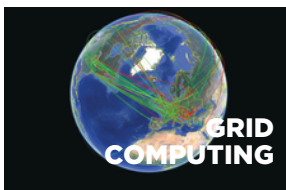


**GAS
DETECTORS**

DATA CENTER



PIC
port d'informació
científica

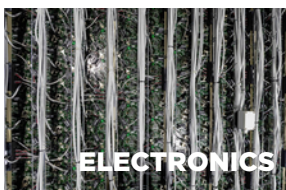


**GRID
COMPUTING**

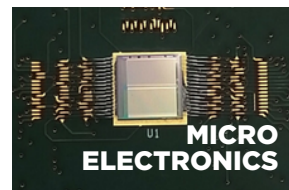


**SCIENTIFIC-DATA
CENTER**

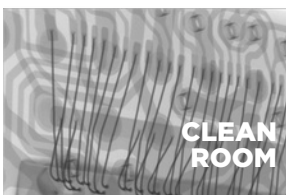
ENGINEERING



ELECTRONICS



**MICRO
ELECTRONICS**



**CLEAN
ROOM**

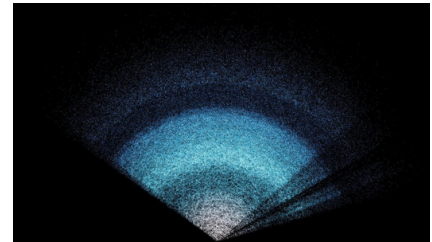


**MECHANICAL
WORKSHOP**

HIGHLIGHTS OF THE YEAR

DESI RESULTS STRENGTHEN EVIDENCE FOR EVOLVING DARK ENERGY

In 2025, new results from the DESI Collaboration used the largest 3D map of the Universe to trace the influence of dark energy over the past 11 billion years. Combining observations of nearly 15 million galaxies and quasars with other cosmological probes, the analysis strengthened indications that dark energy may evolve over time rather than remain constant, challenging the standard cosmological model.



IFAE RECEIVES THE SEVERO OCHOA EXCELLENCE AWARD FOR THE THIRD TIME

In 2025 IFAE awarded the Severo Ochoa Centre of Excellence accreditation for the third time, recognizing its international leadership in fundamental physics research.

The distinction includes €4.5 million over four years to support its strategic scientific programme and talent development.



LST-1 PROVIDE NEW CLUES ABOUT GAMMA-RAY BURST JETS

In 2025 IFAE contributed to the LST-1 study of GRB 221009A, the exceptionally bright gamma-ray burst known as the “BOAT”, providing new constraints on very-high-energy emission and new clues about the structure of gamma-ray burst jets. The observations also demonstrated LST-1’s capability to follow transient events under challenging observing conditions.



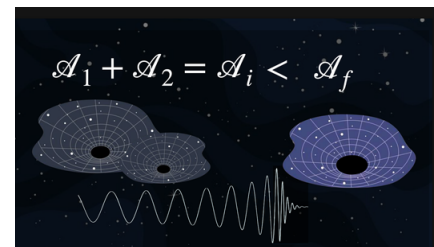
AURELIO JUSTE APPOINTED ATLAS PHYSICS COORDINATOR

In 2025, Aurelio Juste, ICREA Research Professor at IFAE, was appointed Physics Coordinator of the ATLAS experiment at CERN. As one of ATLAS’s most senior scientific roles, the position oversees the experiment’s physics programme and the coordination of its scientific results.



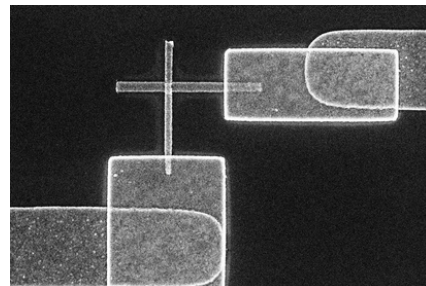
GRAVITATIONAL WAVES CONFIRM HAWKING’S BLACK HOLE AREA THEOREM

In 2025, the exceptionally clear gravitational-wave signal GW250114 enabled the most precise observational test to date of Hawking’s black hole area theorem, confirming that the total area of black hole horizons does not decrease after a merger. IFAE, as a member of the LIGO and Virgo collaborations, contributed to the analysis of the post-merger ringdown signal used to determine the properties of the final black hole.



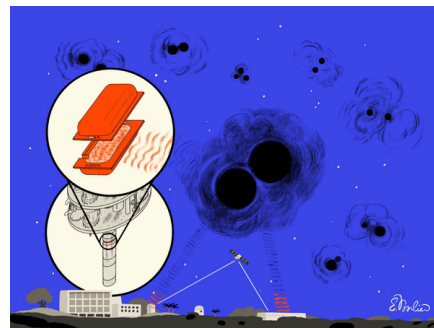
FIRST FULLY IN-HOUSE SUPERCONDUCTING QUANTUM DEVICE AT IFAE

In 2025, the QCT group reported the first superconducting quantum device fully designed, fabricated and measured at IFAE. The experiment demonstrated ultrastrong coupling between a flux qubit and a resonator, marking an important milestone in the development of IFAE's in-house capabilities for superconducting quantum technologies.



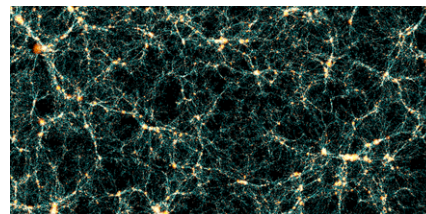
ERC SYNERGY PROJECT GRAVNET BEGINS

In 2025, the ERC Synergy project GravNet began developing the first global detector network dedicated to the search for high-frequency gravitational waves. Led in part by IFAE, the project combines gravitational-wave science with quantum sensing technologies to explore the largely uncharted MHz-GHz frequency range and search for signals linked to fundamental questions such as dark matter, inflation and quantum gravity.



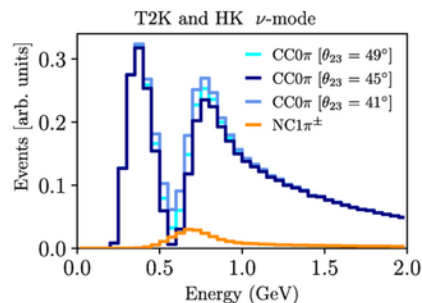
COSMOHUB ADVANCES TOWARD MULTIMESSENGER DATA ANALYSIS

In 2025, PIC released a new CosmoHub frontend with improved visualization tools, HEALPix map support and a new Workbench environment. The upgrade marks a major step toward transforming CosmoHub into a modern, interoperable platform for multimessenger analysis and FAIR scientific data access.



FIRST DOUBLE-DIFFERENTIAL MEASUREMENT OF SINGLE π^+ PRODUCTION

In 2025, the IFAE Neutrino group contributed to the first double-differential measurement of single π^+ production in neutrino neutral-current interactions, performed by the T2K Collaboration with the ND280 detector. The result provides new constraints on neutrino interaction models and helps reduce systematic uncertainties in precision measurements of neutrino oscillations and CP violation.



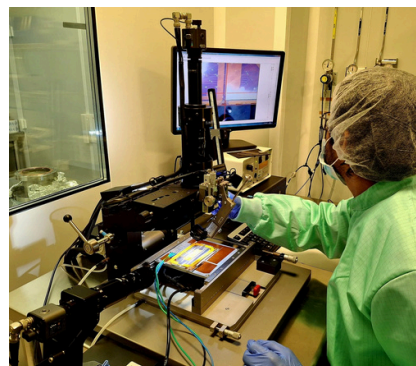
FIT PROTOTYPE VALIDATED AT CERN

In 2025, IFAE's Gamma-ray group successfully validated the Scintillating Fiber Tracker (FIT) prototype in a high-energy beam test at CERN, recording more than 150 million proton and muon events. The technology is central to an IFAE-led concept for a future ESA mission targeting improved sensitivity and angular resolution in the 10-100 MeV gamma-ray range.



FIRST PRODUCTION-READY ITK PIXEL MODULES FABRICATED AT IFAE

In 2025, IFAE successfully fabricated and tested the first production-ready ITk Pixel linear triplet modules using the final ITkPixV2 readout chip. Designed for the innermost layer of the upgraded ATLAS tracker, these modules will provide the high-precision tracking required for the High-Luminosity LHC, with IFAE responsible for producing around 130 modules through early 2027.





SCIENTIFIC OUTPUT IN 2025

373

NUMBER
OF INDEXED
JOURNAL
ARTICLES

87%

% ARTICLES
IN FIRST QUARTILE
JOURNALS

5.4

AVERAGE
JOURNAL
IMPACT
FACTOR (IF)

TOP 5 JOURNALS WHERE IFAE PUBLISHED MOST FREQUENTLY IN 2025

NUMBER OF
ARTICLES

Monthly Notices Of The Royal Astronomical Society	55
Journal Of High Energy Physics	48
Astronomy & Astrophysics	44
Physical Review D	41
Astrophysical Journal Letter	19

TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2025

Science Bulletin	1
Journal Of High Energy Astrophysics	2
IEEE Transactions On Medical Imaging	1
Astrophysical Journal Letters	19
Astrophysical Journal Supplement Series	3

DOCTORAL THESES: 16

NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: 227

HUMAN RESOURCES IN 2025

EXPERIMENTAL DIVISION

29

FACULTY

30

POST-DOCTORAL
RESEARCHERS

59

DOCTORAL
STUDENTS

THEORY DIVISION

16

FACULTY

11

POST-DOCTORAL
RESEARCHERS

12

DOCTORAL
STUDENTS

TECHNICAL SERVICES

22

30

PIC

RESEARCH SUPPORT

25

7 ICREA Professors.

3 ERCs in the last 2 years.

The Chair of Scientific
Committee is a Nobel
Laureate (Barry Barish).

IFAE investigators have
participated in recent
discoveries that have been
awarded 3 Nobel Prizes
(Higgs boson, astrophysical
neutrinos, GW). Two
researchers have been
awarded the Breakthrough
Prize.

IFAE has been awarded
the Severo Ochoa
accreditation of excellence
three times (2012, 2016
and 2024).

PROJECTS IN 2025

81

MINISTERIO DE
CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

19

EUROPEAN
COMMISSION

21

AGÈNCIA DE
GESTIÓ D'AJUTS
UNIVERSITARIS I
DE RECERCA

INTERNATIONAL COLLABORATIONS



OUTREACH IN 2025



Hundreds of students and members of the public take part in IFAE outreach activities every year. Our programme includes school visits and talks, year-round educational activities, summer workshops, science festivals and public events, including the European Researchers' Night through the European PICO project.

Our programmes for secondary-school students include Bojos per la Física, BIYSC and the International Physics Masterclasses, bringing students into direct contact with researchers and contemporary physics.



The IFAE Summer Fellowship programme offers undergraduate students a one-month research experience alongside IFAE scientists, often as a first step towards a research career.

TECHNOLOGY TRANSFER IN 2025

The KTT unit at IFAE promotes the valorisation and exploitation of new technological solutions for societal and industrial challenges.

€13M+

IN PUBLIC AND PRIVATE
INVESTMENT AND CAPITAL
INCREASES SECURED BY
IFAE SPIN-OFFS.

1

NEW EU PATENT
APPLICATION FILED FOR
MULTIMODAL SPECTRAL
NUCLEAR MEDICINE.

150K€

IN PUBLIC FUNDS AWARDED
FOR TECHNOLOGY
VALORIZATION

SPIN-OFFS IN 2025



Qilimanjaro's mission is to develop fast-to-market app-specific analog quantum computers with true quantum benefits by co-designing chips & algorithms and bypassing the qubit fragility barrier.

www.qilimanjaro.tech



Deep Detection develops multispectral x-ray cameras with photon counting techniques for industrial inspection and material separation.

deepdetection.tech



Baretek offers microelectronic services for research, health and industry. The microelectronic assembly services include: state-of-the-art ASIC, FPGA and microcontroller assembly technologies.

baretek.eu.com

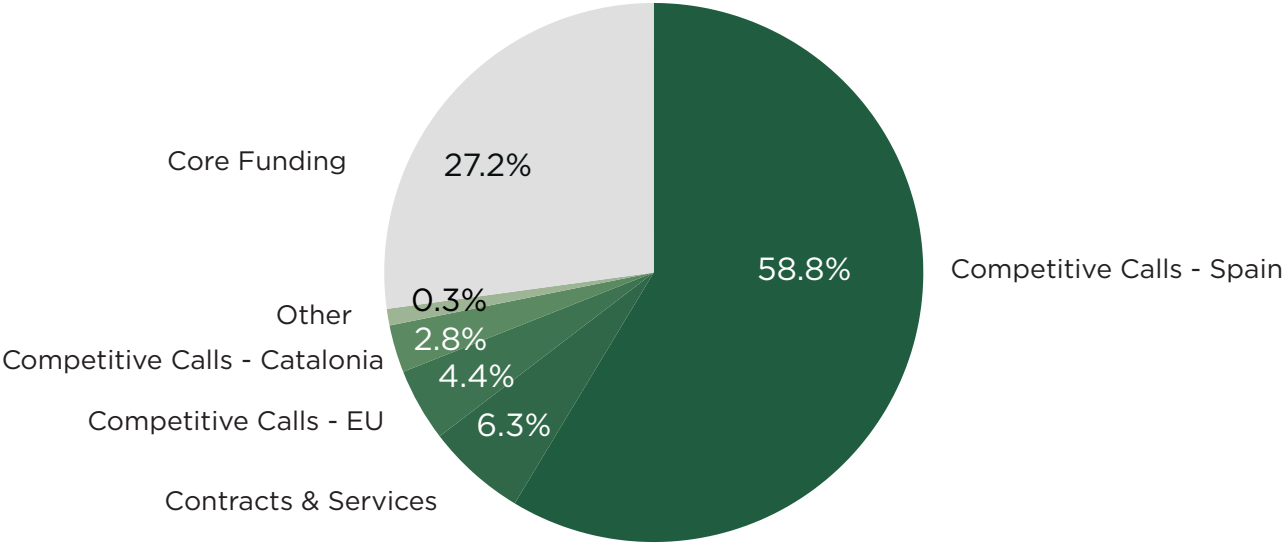
FUNDING IN 2025



IFAE receives its core funding from Generalitat de Catalunya. Most of the overall funding, however, comes from competitive calls at the Catalan, Spanish and European levels.

As shown in the pie chart below, in 2025 the ratio of competitive to core funding was about 3.

14.1 M€ TOTAL FUNDING IN 2025





Institut de Física d'Altes Energies Edifici Cn
Universitat Autònoma de Barcelona (UAB)
E-08193 Bellaterra (Barcelona) Spain
[@_ifae](http://www.ifae.es)

FUNDAT PER | FOUNDED BY



CENTRE DE | CENTER OF



MEMBRE DE | MEMBER OF



AMB EL SUPORT DE | SUPPORTED BY



EUROPEAN UNION
European Regional
Development Fund



European Research Council
Established by the European Commission

