FROM PARTICLES TO THE COSMOS

IFAE

Institut de Física d'Altes Energies

Report
of Activities
Summary 2019

annualreport.ifae.es

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 25 years we have been exploring the cosmic and high energy frontiers to address fundamental questions about our Universe.

IFAE

Institut de Física d'Altes Energies

EXCELENCIA SEVERO OCHOA

BIST Barcelona Institute of Science and Technology

IFAE
AT A GLANCE

founded in **1991**

150 people

three **divisions**: theory, experimental, technical; and administration

basic research in fundamental physics and
applied research in instrumentation, medical applications
and quantum computing 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 **10 international experiments** in high impact / leadership positions
(ATLAS, MAGIC, DES, T2K, PAU, CTA, DESI, Euclid, LSST, Virgo)

facilities: chip packaging & assembly, clean rooms, shielded room,
electronics labs, optical lab, mechanical workshop (300 m^2)

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

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

twice awarded with the **Severo Ochoa** accreditation of excellence (2012, 2016)

SCIENCE AT IFAE

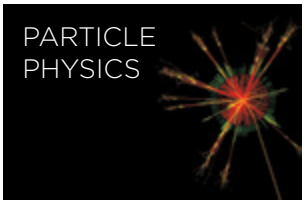
At IFAE we conduct experimental and theoretical research at the frontiers of fundamental physics, namely in Particle Physics, Astrophysics and Cosmology.

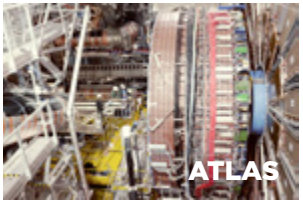
We are involved in the ATLAS project at the LHC, the T2K neutrino experiment in Japan, the MAGIC telescopes in La Palma, the Dark Energy Survey project in Chile, the Cherenkov Telescope Array in La Palma and Chile, the Virgo interferometer, among others.

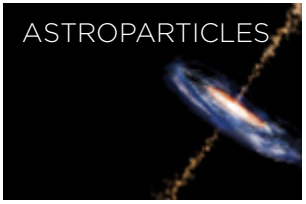
We focus our research on the hottest topics in fundamental physics from particles to the cosmos.

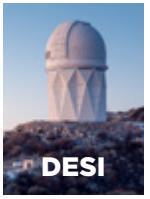
HIGGS PHYSICS
ANTIMATTER
DARK **MATTER**
DARK **ENERGY**
EXTREME **UNIVERSE**

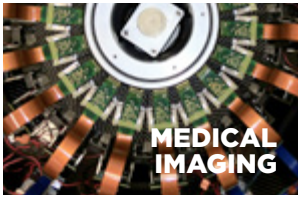
EXPERIMENTAL division



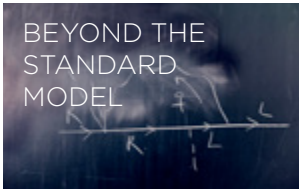


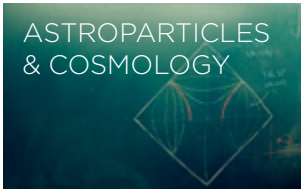






THEORY division





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 and a shielded room.

FRONT-END ELECTRONICS

GRID COMPUTING

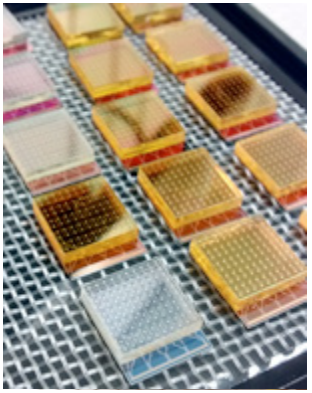
CONTROL SYSTEMS

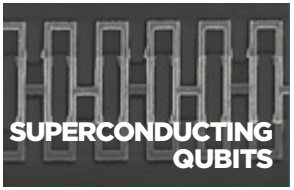
CRYOGENICS

READ-OUT ELECTRONICS

DETECTORS

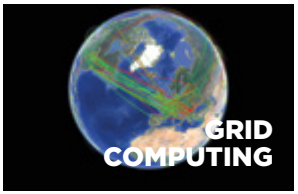
TECHNOLOGIES



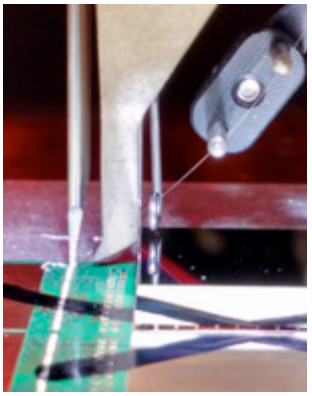


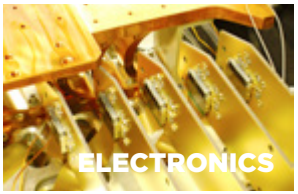
DATA CENTER

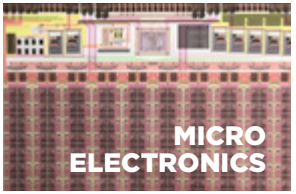
PIC
port d'informació científica



ENGINEERING





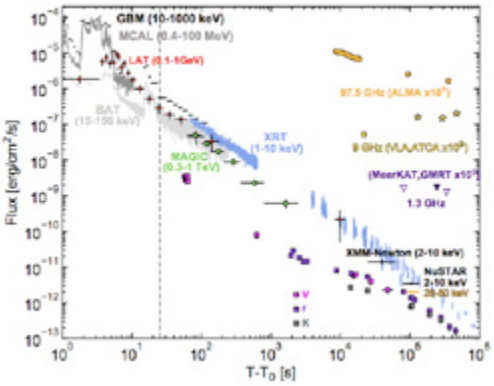


HIGHLIGHTS OF THE YEAR

DETECTION OF TEV PHOTONS FROM GRB190114C BY THE MAGIC TELESCOPES

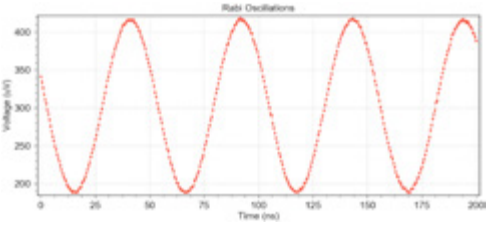
On January 14th, 2019, a GRB was discovered by two space satellites. The MAGIC Telescopes were able to start its observation just 50 seconds after it began. The analysis of the resulting data for the first tens of seconds revealed emission of photons in the afterglow reaching TeV energies.

The detection of TeV photons from GRB190114C by the MAGIC Telescopes has provided the first proof of the long-sought inverse compton component in the spectra of GRBs and resulted in the publication of two Nature papers, co-lead by an IFAE researcher.



THE QCT GROUP ACHIEVED COHERENT CONTROL OF THE FIRST SUPERCONDUCTING QUBIT

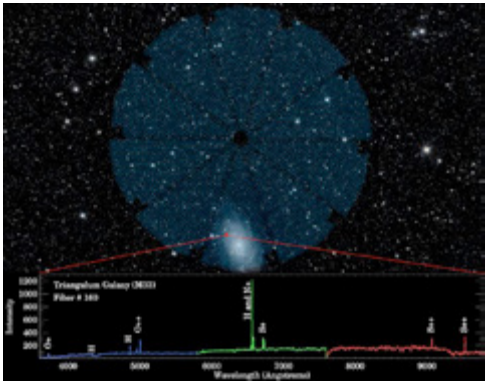
For the first time in Spain, the QCT group has demonstrated in 2019 the observation of Rabi oscillations in a superconducting circuit that exhibits a discrete energy level spectrum in the microwave domain of frequencies. The observation of the Rabi oscillations in an actual quantum system in the lab demonstrates the ability to control the quantum state of that particular system, and is thus the first step into implementing quantum information protocols. With this demonstration, the QCT group is currently implementing the first novel quantum algorithms.



THE DESI INSTRUMENT SEES FIRST LIGHT

During early 2019, the IFAE group finished the delivery of all the Guiding, Focusing and Alignment (GFA) cameras to DESI, complete with mechanical enclosures, filters, CCDs, readout electronics, thermal control, etc. Ten of them were then mounted in the focal plane of the DESI instrument.

The commissioning of the instrument started in late summer 2019, with first light observed on October 22, 2019.

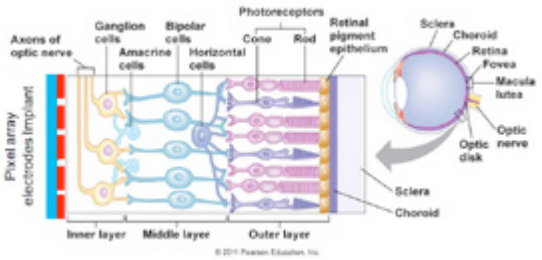


IFAE CONTRIBUTES TO THE ATLAS HADRONIC CALORIMETER UPGRDE

During 2019, members of the IFAE-ATLAS group and the IFAE Technical Division made significant contributions to the upgrade of the Tile Calorimeter (TileCal), a key element of the ATLAS experiment at the Large Hadron Collider (LHC). Mechanical structures designed and produced at IFAE are used to hold new scintillator detectors, which are now installed in the detector in preparation for the start of LHC Run 3 in 2021.

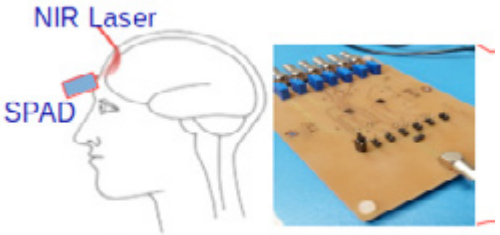
In addition, the IFAE mechanical workshop successfully produced twelve mini-drawers that will hold the new readout electronics, as a pre-production towards the TileCal upgrade for the high-luminosity LHC phase, to start in 2027.

THE I-VISION PROJECT AWARDED A “LA CAIXA” HEALTH RESEARCH GRANT



In 2019 the project Adaptive Retinal Implant Technology for Vision Restoration (i-VISION) was awarded a “la Caixa” Health Research Grant with 1 million euros. ICN2, IFAE, ICFO, Barraquer Foundation and Institut de la Vision (University of Sorbonne) are the partner institutions forming the i-VISION research consortium. This three-year project will design the next generation of retinal prostheses using graphene-based electrodes to provide artificial vision to patients blinded by retinal degeneration.

PIXEL SENSORS FOR NEUROMONITORING

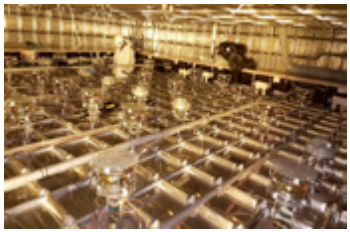


The pixel group has been exploring the usage of silicon detectors beyond high energy physics. One interesting application of the HV-CMOS technology is for neuromonitoring. This medical technique consists of using a laser to shine infra-red light in the brain, and obtain information about blood flow through the scattered photons.

The IFAE pixel group, after obtaining a BIST Ignite grant with ICFO, developed several single photon avalanche detectors that are at the core of this neuromonitoring technique. The success of the effort is reflected in the fact that in early 2020 the project obtained further support through the BIST Ignite Award.

PROTODUNE-DP COMMISSIONING AND FIRST TRACKS

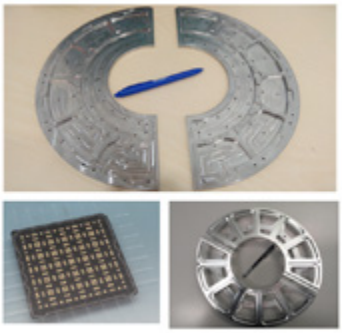
During summer 2019, the protoDUNE-DP detector started the final installation steps and commissioning at CERN. The detector was successfully commissioned and the first track could be observed. The Spanish groups, IFAE together with CIEMAT, provided the photon detection system based on 36 PMTs.



NEW INSTRUMENTED BAFFLE FOR VIRGO DESIGNED AT IFAE

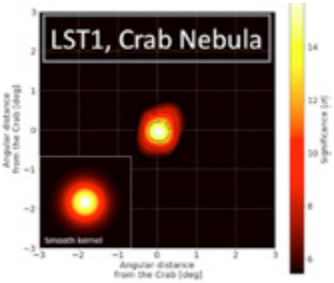
IFAE initiates the production of the new-instrumented baffle for Virgo after concluding its design and passing successfully Virgo's production readiness review in 2019. The stainless steel mirror-polished baffle with anti-reflecting coating will be instrumented with 76 photo-sensors mounted in two large PCBs.

The device will be installed under ultra-high vacuum conditions in 2020 at EGO.



THE LST-1 DETECTS ITS FIRST GAMMA-RAY SIGNAL

The LST-1 successfully detected its first gamma-ray signal on 23 November 2019 when it pointed to the Crab Nebula. The camera could record gamma ray events from the Crab Nebula and detect it with high significance in a very short time immediately after pointing in its direction, a real highlight in the progress of the LST1 commissioning.



SCIENTIFIC OUTPUT IN 2019

209

NUMBER OF INDEXED JOURNAL ARTICLES

95.2%

% ARTICLES IN FIRST QUARTILE JOURNALS

5.6

AVERAGE JOURNAL IMPACT FACTOR (IF)

TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2019	NUMBER OF ARTICLES
Nature	2
Reviews of Modern Physics	1
Phys. Rev. Lett.	11
Astron. Astrophys.	4
JHEP	33

TOP 5 JOURNALS WHERE IFAE PUBLISHED MOST FREQUENTLY IN 2019	
Phys. Rev.	41
Mon. Not. Roy. Astron. Soc.	40
JHEP	33
Eur. Phys. J.	28
Phys. Lett.	17

DOCTORAL THESES: **5**

NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: **120**

HUMAN RESOURCES IN 2019

EXPERIMENTAL DIVISION

20 FACULTY

20 POST-DOCTORAL RESEARCHERS

32 DOCTORAL STUDENTS

THEORY DIVISION

12 FACULTY

8 POST-DOCTORAL RESEARCHERS

10 DOCTORAL STUDENTS

TECHNICAL SERVICES

25

19 PIC

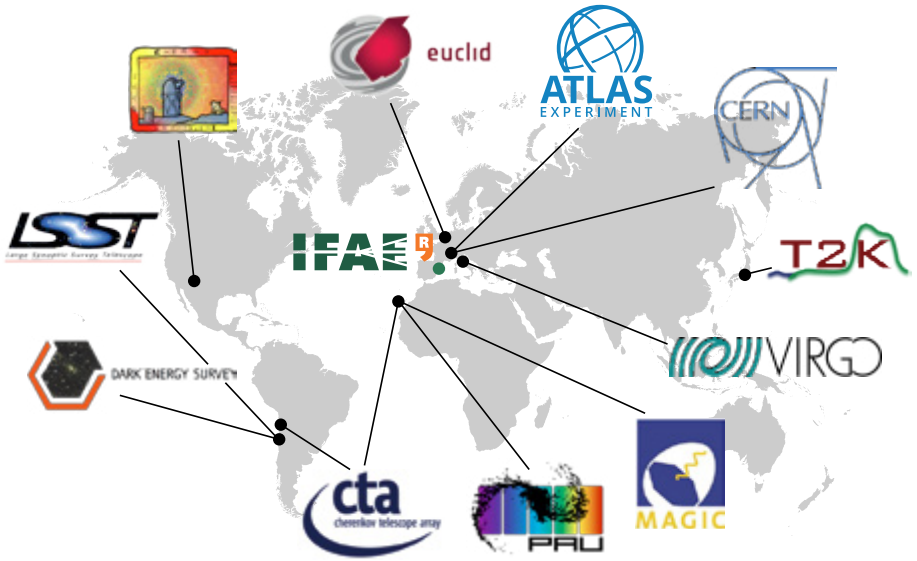
RESEARCH SUPPORT

10

PROJECTS IN 2019

18	14	4	2	1	1	1	1
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD	EUROPEAN COMISSION	AGÈNCIA DE GESTIÓ D'AJUTS UNIVERSITARIS I DE RECERCA	FUNDACIÓ BANCARIA LA CAIXA	BIST	FEDER	FECYT	CERN*

INTERNATIONAL COLLABORATIONS



*Contract Research

TECHNOLOGY TRANSFER IN 2019

IFAE performs frontier research in particle physics, astrophysics, and cosmology, fields of knowledge requiring advanced engineering, electronics and software technologies not existing in the market. IFAE research & engineering teams develop their own technology, transferring it to industry by means of joint ventures, partnerships, R&D agreements, technical services based on singular scientific infrastructures, training sessions, consultancy, licensing and spin-off creation. The KTT unit at IFAE promotes the valorisation and exploitation of new technological solutions for societal and industrial challenges, by increasing its technology readiness level to finally transfer it to the market.

369k€

COMPETITIVE FUNDS FROM COLLABORATIVE RESEARCH AND INNOVATION ACTIONS WITH PRIVATE SECTOR

51k€

NON COMPETITIVE FUNDS COMING FROM INDUSTRIAL AGREEMENTS AND SERVICES OFFERED TO EXTERNAL ENTITIES

352k€

COMPETITIVE FUNDS FOR THE VALORISATION OF NEW TECHNOLOGIES AND INVENTIONS WITH HIGH MARKET POTENTIAL

1

PCT ENTRY INTO NATIONAL PHASES

1

NEW SPIN-OFF CREATED

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ACER Associació Catalana d'Entitats de Recerca

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Obra Social "la Caixa"