

FROM PARTICLES TO THE COSMOS


# IFAE

Institut de Física  
d'Altes Energies

Report  
of Activities  
**Summary 2018**

[annualreport.ifae.es](http://annualreport.ifae.es)



A starburst of colorful particle tracks (yellow, green, blue, orange, red, purple) radiating from a central point on the left, set against a dark, starry background. The tracks are composed of small dots connected by thin lines, creating a sense of motion and energy.

# 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.



Institut de Física  
d'Altes Energies



BIST Barcelona Institute of  
Science and Technology

# IFAE AT A GLANCE



founded in **1991**

**160** people

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

**basic research** in fundamental physics and  
**applied research** in instrumentation and medical applications

**research lines**: Particle Physics, Astroparticle Physics, Cosmology,  
Medical Imaging & Physics Instrumentation

one large **engineering** group (33 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<sup>2</sup>)

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.

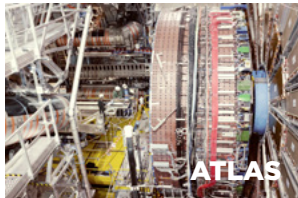
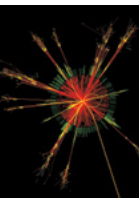
We are involved in the ATLAS project at the LHC, the T2K neutrino experiment in Japan, the MAGIC telescopes in La Palma, the Dark Energy Survey project in Chile, the Cherenkov Telescope Array in La Palma and Chile, the Virgo interferometer, among others.

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

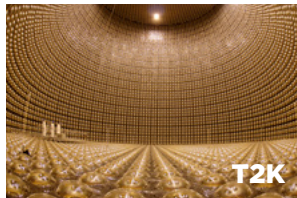
**HIGGS** PHYSICS  
**ANTIMATTER**  
DARK **MATTER**  
DARK **ENERGY**  
EXTREME **UNIVERSE**

## EXPERIMENTAL division

PARTICLE  
PHYSICS



ATLAS



T2K

ASTROPARTICLES



MAGIC



CTA

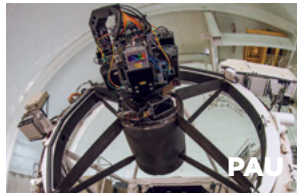


Virgo

COSMOLOGY



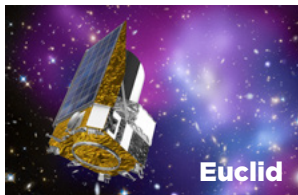
DES



PAU



DESI



Euclid



LSST

## THEORY division

STANDARD  
MODEL

$$\vec{p} = (p_x, p_y, p_z)$$
$$p^0 = \frac{E}{c}$$
$$p^\mu = \begin{pmatrix} p^0 \\ \vec{p} \end{pmatrix}$$

Majorana  
 $\psi^c = \psi$   
73

BEYOND THE  
STANDARD  
MODEL



ASTROPARTICLES  
& COSMOLOGY





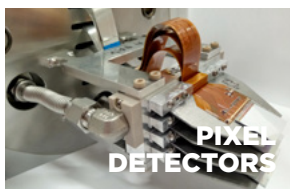
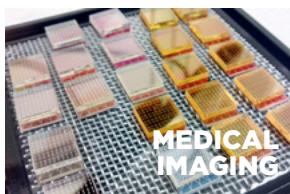
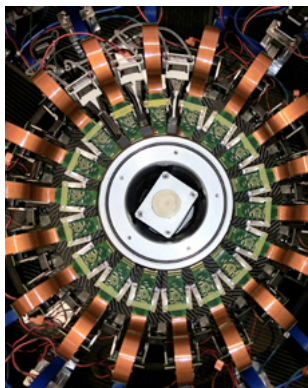
# TECHNOLOGY AT IFAE

At IFAE we work at the cutting edge of detector technology, developing pixel detectors for High Energy Physics, telescope cameras and detectors for medical imaging and other scientific and industrial fields.

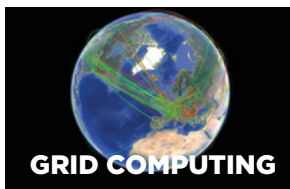
Our facilities include a microelectronics laboratory with state-of-the-art packaging and assembly technologies, a data center, a mechanical workshop, electronics labs, an optical room and a shielded room.

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

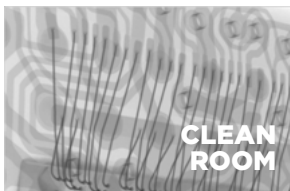
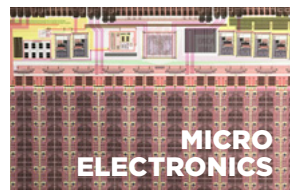
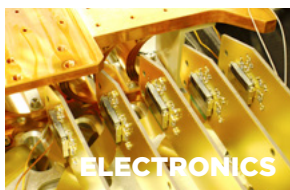
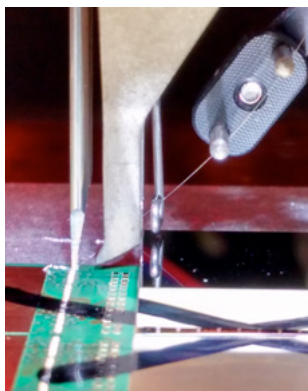
**APPLIED**  
physics



**DATA  
CENTER**



**ENGINEERING**



# HIGHLIGHTS OF THE YEAR

## THE LST1 INAUGURATION AND CAMERA INTEGRATION AT IFAE

On Wednesday, 10 October 2018, more than 200 guests from around the world gathered on the northern array site of the Cherenkov Telescope Array (CTA) to celebrate the inauguration of the prototype Large-Sized Telescope (LST). The telescope, named LST-1, is intended to become the first of four LSTs on the CTA-North site.

The LST-1 camera was assembled and integrated at the IFAE workshop in 2018 before shipping it to La Palma



## IFAE JOINS THE VIRGO COLLABORATION



In 2018 IFAE became a new member institution in the VIRGO collaboration. This opened a new long-term research line in IFAE related to GWs detection using terrestrial interferometry.

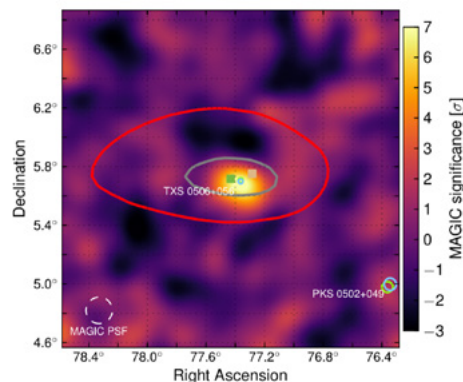
A group of researches from IFAE has taken significant responsibilities in the VIRGO experiment related to the control of the stray light inside the experiment, which is considered a limiting factor for its sensitivity. The group plans for playing an important role in the ongoing commissioning, operations and upgrade of the interferometer.



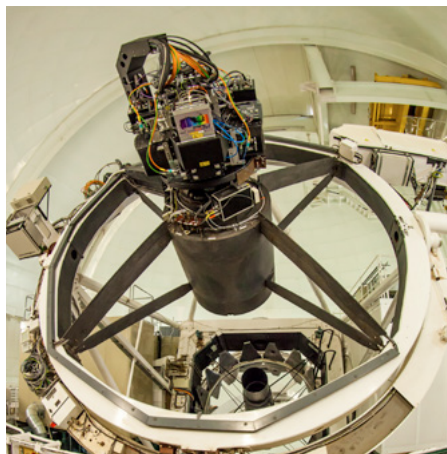
## THE MAGIC TELESCOPES TRACE ORIGIN OF A RARE COSMIC NEUTRINO

For the first time, astrophysicists have localized the source of a high energy cosmic neutrino originating outside the Milky Way. It is highly likely that the neutrino comes from a blazar in the Orion constellation.

Scientists reached this interesting finding by combining a neutrino signal from IceCube with measurements from other instruments, e.g. the Fermi-LAT and MAGIC telescopes. This multi-messenger observation provided a clue to an unsolved mystery: the origin of cosmic rays.



## PAUS PHOTOMETRIC REDSHIFT PERFORMANCE GOAL REACHED

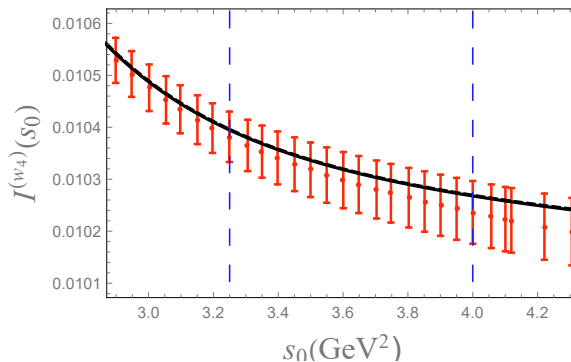


The distinctive feature of PAUS with respect to other wide-field surveys is the high resolution in the measurement of redshift by photometric means, made possible by imaging the sky in 40 narrow band filters (100 Angstrom wide).

In 2018 it was shown that PAUS meets its design goals with a resolution of  $0.0035(1+z)$  for a fraction of the data as shown in the paper “The PAU Survey: Early demonstration of photometric redshift performance in the COSMOS field”

## STRONG COUPLING FROM ELECTRONIC HADRON PRODUCTION BELOW CHARM

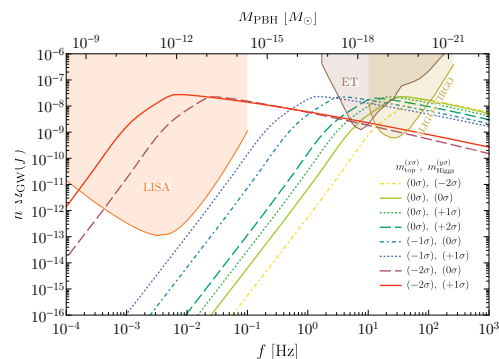
The IFAE theory group has carried out a new analysis to extract the value of the strong coupling constant  $\alpha_s$  using a recent compilation of the experimental data for the process  $e^+e^- \rightarrow \text{hadrons}$ . The analysis uses the method of Finite-Energy sum rules which enable the assessment, for the first time, of the impact of deviations from the Operator Product Expansion known as Duality Violations. These results obtained confirm a recent determination from the OPAL and ALEPH data for hadronic  $\tau$  decays also performed by the group.



## A COSMOLOGICAL SIGNATURE OF THE STANDARD MODEL HIGGS VACUUM INSTABILITY

The 2018 Buchalter Cosmology First Prize was awarded to José Ramón Espinosa, Davide Racco and Antonio Riotto.

The judging panel selected their paper “A Cosmological Signature of the Standard Model Higgs Vacuum Instability: Primordial Black Holes as Dark Matter” published in Physical Review Letters and recognized it as “a fascinating and novel approach putting forth an exotic option for dark matter, arising from primordial black holes produced from large-scale instability in the Higgs potential during inflation, that does not require new particles beyond the Standard Model.”



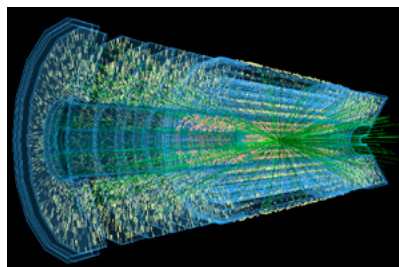
## EUCLID'S FILTER WHEEL INSTALLED IN THE NISP STRUCTURE



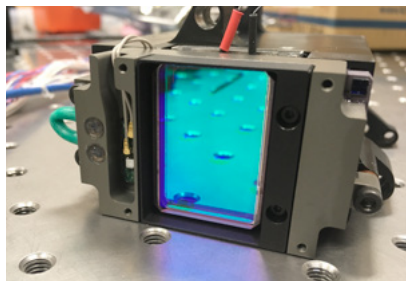
On December 2018, the Euclid's Filter Wheel was successfully installed in the NISP structure. This milestone finish the hardware contributions of the first IFAE project funded directly by the Space program. The group at IFAE had a large responsibility in the management and the engineering design and was responsible for the construction, integration, and control of the assembly and testing equipment.

## FIRST PROTOTYPE CHIP FOR THE ATLAS ITK PIXEL UPGRADE FOR THE HL-LHC

The RD53A ASIC, a first prototype chip for the ATLAS ITk Pixel upgrade for the HL-LHC became available in 2018. The IFAE ATLAS Pixels group carried out the hybridization and assembly of the first 3D RD53A devices. Also the first studies of these devices before and after irradiation were performed.



## PRODUCTION OF THE GFA CAMERAS FOR THE DESI PROJECT



During 2018, the IFAE group finished the production of the Guiding, Focusing and Alignment (GFA) cameras, complete with mechanical enclosures, filters, CCDs, readout electronics, thermal control, etc. The units were shipped to Lawrence Berkeley National Laboratory (LBNL), USA, for their integration in the DESI (Dark Energy Spectroscopic Instrument) focal plane. The GFA units use 2x k Teledyne-e2v CCD detectors to focus the optical fibres of DESI, align these 5,000 fibres with the objects to be observed and to do the guiding during the exposure time.

# SCIENTIFIC OUTPUT IN 2018

235

NUMBER  
OF INDEXED  
JOURNAL  
ARTICLES

96.1%

% ARTICLES  
IN FIRST QUARTILE  
JOURNALS

5.2

AVERAGE  
JOURNAL  
IMPACT  
FACTOR (IF)

## TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2018

	NUMBER OF ARTICLES
Science (IF:41.1) .....	1
Phys. Rev. Lett. (IF:8.8) .....	11
Astrophys. J. Suppl. (IF:8.6) .....	2
Astrophys. J. Lett. (IF:6.6) .....	2
Phys. Dark Univ. (IF:6.5) .....	1

## TOP 5 JOURNALS WHERE IFAE PUBLISHED MOST FREQUENTLY IN 2018

Phys. Rev. (IF:4.4) .....	55
JHEP (IF:5.5) .....	40
Mon. Not. Roy. Astron. Soc. (IF:5.2) .....	28
Eur. Phys. J. (IF:5.3) .....	26
Phys. Lett. (IF:4.3) .....	22

**DOCTORAL THESES: 11**

**NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: 135**

\*Data from Scopus & Web of Science

# HUMAN RESOURCES IN 2018



## EXPERIMENTAL DIVISION

21

FACULTY

23

POST-DOCTORAL  
RESEARCHERS

31

DOCTORAL  
STUDENTS

## THEORY DIVISION

12

FACULTY

9

POST-DOCTORAL  
RESEARCHERS

10

DOCTORAL  
STUDENTS

## TECHNICAL SERVICES

30

22

PIC

## RESEARCH SUPPORT

10

# PROJECTS IN 2018

20

MINISTERIO DE  
ECONOMÍA Y  
COMPETITIVIDAD

9

EUROPEAN  
COMMISSION

3

AGÈNCIA DE  
GESTIÓ D'AJUTS  
UNIVERSITARIS I  
DE RECERCA

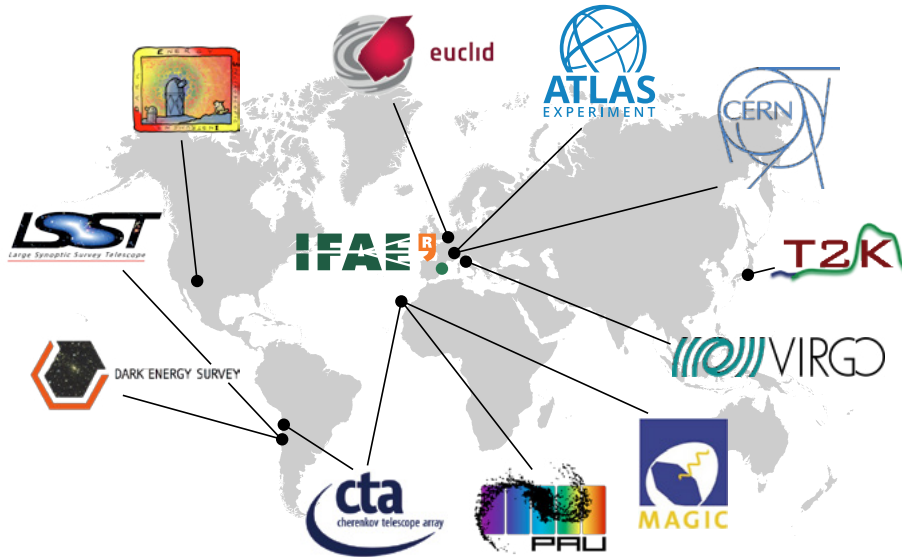
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BIST

1

ACCIO  
RIS3CAT

## INTERNATIONAL COLLABORATIONS



# TECHNOLOGY TRANSFER IN 2018



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.

**645k€**

COMPETITIVE FUNDS  
FROM COLLABORATIVE  
RESEARCH AND  
INNOVATION ACTIONS  
WITH PRIVATE SECTOR

**67k€**

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

**55k€**

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

**1**

EU PATENT  
APPLICATION FILED



FUNDAT PER | FOUNDED BY



MEMBRE DE | MEMBER OF



AMB EL SUPORT DE | SUPPORTED BY



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European Regional Development Fund



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