

FROM PARTICLES TO THE COSMOS


IFAE

Institut de Física
d'Altes Energies

Report
of Activities
Summary 2017

annualreport.ifae.es



A starburst of colorful particle tracks (yellow, green, blue, orange, red, purple) radiating from a central point on the left side of the image, 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 **9 international experiments** in high impact / leadership positions
(ATLAS, MAGIC, DES, T2K, PAU, CTA, DESI, Euclid, LSST)

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

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.

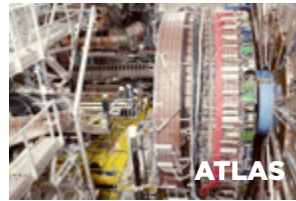
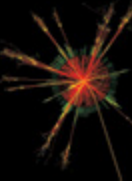
We are involved in the ATLAS project at the LHC, the T2K neutrino experiment in Japan, the MAGIC telescopes in La Palma, the Dark Energy Survey project in Chile and the Cherenkov Telescope Array in La Palma and Chile, among others.

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

COSMOLOGY



DES



PAU



DESI



Euclid



LSST

THEORY
division

**STANDARD
MODEL**

$$\vec{r} = (x, \vec{r})$$
$$\vec{r} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

$(0, 0)$
 u, \vec{r}
 u, \vec{r}
 u, \vec{r}
 u, \vec{r}

**BEYOND THE
STANDARD
MODEL**

**ASTROPARTICLES
& COSMOLOGY**



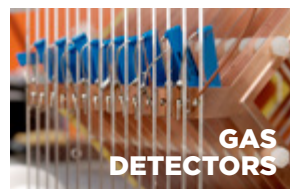
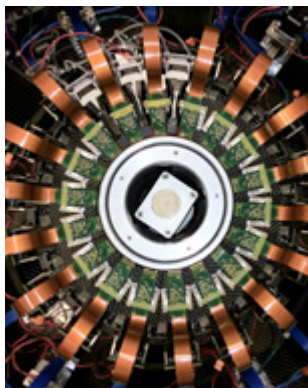
TECHNOLOGY AT IFAE

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.

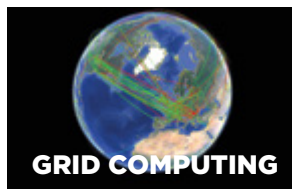
Our facilities include a microelectronics laboratory with state-of-the-art packaging and assembly technologies, a data center, a mechanical workshop, electronics labs, an optical room and a shielded room.

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

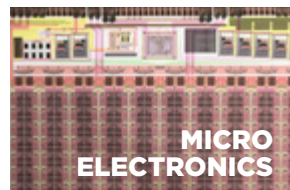
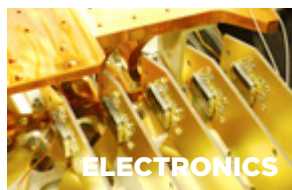
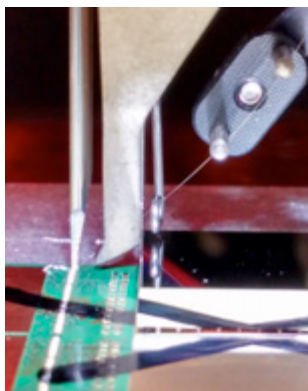
APPLIED
physics



**DATA
CENTER**



ENGINEERING

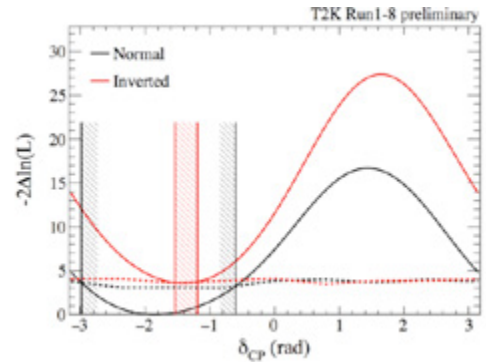


HIGHLIGHTS OF THE YEAR

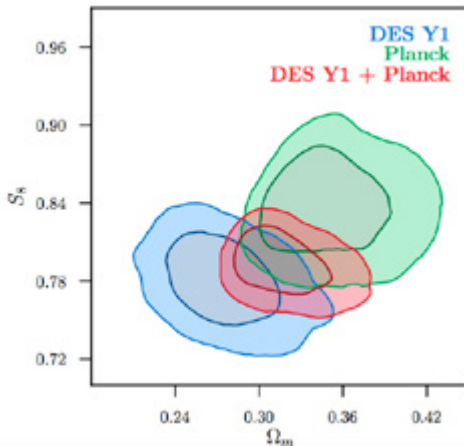
T2K PRESENTS HINT OF CP VIOLATION BY NEUTRINOS

The international T2K Collaboration strengthened its previous hint that the symmetry between matter and antimatter may be violated for neutrino oscillation.

A preliminary analysis of T2K's latest data rejects the hypothesis that neutrinos and antineutrinos oscillate with the same probability at 95% confidence (2σ) level.



MOST ACCURATE MEASUREMENT OF DARK MATTER STRUCTURE IN THE Universe

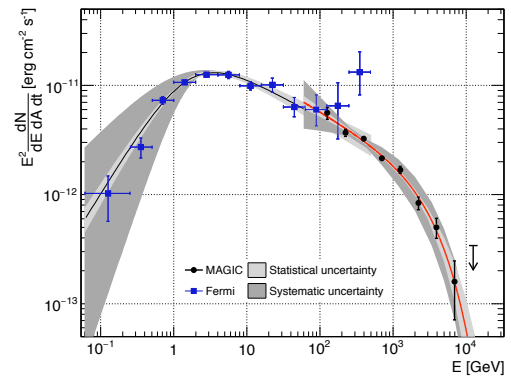


In summer 2017, DES published a series of 12 papers containing the main cosmological results from the analysis of the first-year data of the survey, covering some 1500 sq. deg. The results included measurements of the matter distribution of the present Universe that, for the first time, can compete in precision with those made by the Planck satellite. Planck measures the tiny inhomogeneity of the early Universe at redshift ~ 1100 , and extrapolates to the current epoch assuming the Λ CDM cosmology. The agreement between DES and Planck is, then, a test of the validity of Λ CDM.

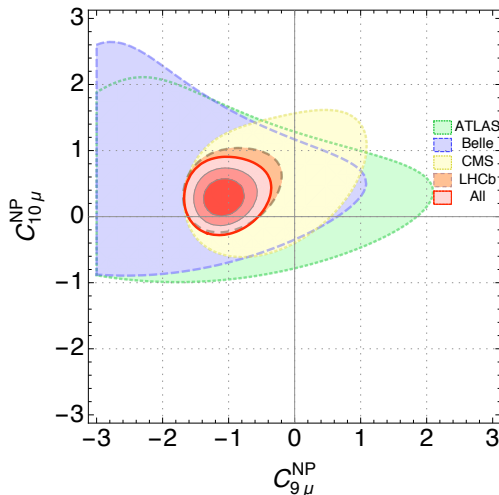
PRIME CANDIDATE TO EXPLAIN THE COSMIC-RAY SEA RUNS SHORT OF ENERGY

Cassiopeia A was considered the perfect object to be an accelerator of Galactic cosmic rays of the highest energies: it is young, bright, with a shock expanding at great velocity and with large magnetic field. New MAGIC observations show that Cassiopeia A is indeed accelerating cosmic rays, although only up to a rather low energy (a few TeV). At these energies, the radiation suddenly drops, and the emission stops abruptly.

Either the remnant cannot accelerate the particles to higher energies, which challenge our knowledge of shock acceleration or maybe the fastest ones escaped quickly the shock, leaving only the slowest ones for us to observe.



FIRST SIGNALS OF LEPTON FLAVOR UNIVERSALITY VIOLATION

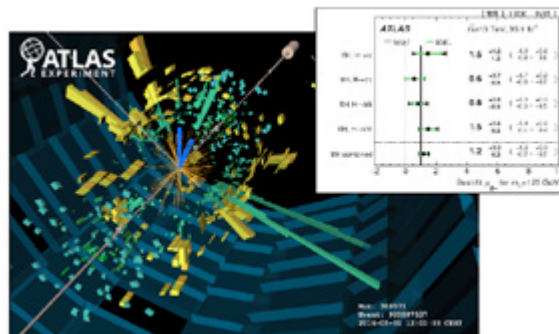


Global analysis of a set of observables related to one type of rare B decays measured in different experiments, mainly LHCb, Belle and also preliminary results from ATLAS and CMS, found evidence of lepton flavour universality violation in flavour changing neutral transitions in a range between 3 and 4 sigmas.

The analysis also concludes that there is a substantial increase in the coherence among the different anomalies and tensions, specially between those of LFUV type (like R_K) and those governed only by the transition $b \rightarrow s\mu\mu$ (like P_5').

EVIDENCE OF THE HIGGS BOSON PRODUCED IN ASSOCIATION WITH A PAIR OF TOP QUARKS

Using the data set of proton-proton collisions at 13 TeV collected in 2015 and 2016, the combination of all ATLAS searches has recently established first evidence for $t\bar{t}H$ production with a significance of 4.2 standard deviations, a milestone result that opens the door to the observation of this process in the very near future.

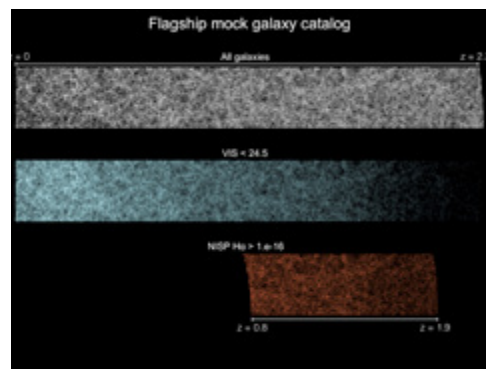


This measurement, when combined with other Higgs boson production and decay studies, will shed more light on the possible presence of physics beyond the Standard Model in the Higgs sector.

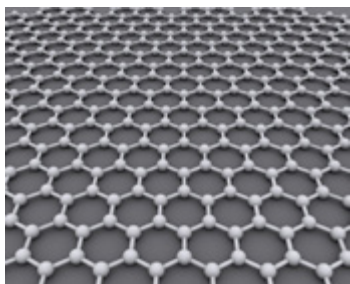
RELEASE OF THE LARGEST SIMULATED GALAXY CATALOGUE EVER BUILT

The simulated catalog of the Euclid Flagship contains more than 2 billion galaxies, the largest number to date. It has been developed by researchers from the Institute of Space Sciences (ICE, IEEC-CSIC) and the Port d'Informació Científica (PIC), with researchers from the University of Zurich.

The catalog closely mimics the properties of observed galaxies and is based on simulations of dark matter distributions. The work will prepare the observations of the ESA's Euclid Mission.



THEIA AWARDED THE BIST IGNITE GRANT



THEIA (“Towards the implementation of a multi-electrode array for retinal prosthesis”), led by ICFO, ICN2, and IFAE and in collaboration with Barraquer Ophthalmological Center, aims at developing a new generation of retinal prostheses based on multi-electrode array graphene devices. The high photosensitivity of the material will allow great improvements to the vision of people treated with this type of technology.

IFAE OBTAINS SEVERO OCHOA AWARD RENEWAL

The award recognizes excellent research centres that stand out for their scientific impact and the international relevance of their results. IFAE initially obtained the recognition in 2012, the renewal is for the period 2017-2020.



25 YEARS ANNIVERSARY CELEBRATION



On Friday, July 7th 2017, IFAE celebrated its 25th Anniversary at MACBA, Barcelona. The event included the participation of the Secretary of State for Research, Development and Innovation, Carmen Vela; the Secretary of Universities and Research of the Generalitat of Catalonia, Arcadi Navarro; the Vice President for Innovation and Strategic Projects of the UAB, Francisco Javier Lafuente; and the president of the Board of the BIST, Andreu Mas-Colell.

The keynote talk was given by Hitoshi Murayama, Director of the Kavli Institute for Physics and Mathematics of the Universe at the University of Tokyo and MacAdams Professor of Physics at the University of California at Berkeley.

SCIENTIFIC OUTPUT IN 2017

190

NUMBER
OF INDEXED
JOURNAL
ARTICLES

92.1%

% ARTICLES
IN FIRST QUANTILE
JOURNALS

5.5

AVERAGE
JOURNAL
IMPACT
FACTOR (IF)

TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2017

	NUMBER OF ARTICLES
Nature (IF 38.6) _____	1
Nature Physics (IF 19.3) _____	1
Astrophysical Journal, Supplement Series (IF 16.2) _____	2
Nature Communications (IF 10.0) _____	1
Physical Review Letters (IF 7.9) _____	4

TOP 5 JOURNALS WHERE IFAE PUBLISHED MOST FREQUENTLY IN 2017

Journal of High Energy Physics (IF 5.6) _____	38
European Physical Journal C (IF 5.2) _____	33
Physical Review D (IF 4.7) _____	33
Monthly Notices Of The Royal Astronomical Society (IF 5.5) _____	28
Astrophysical Journal (IF 6.7) _____	13

DOCTORAL THESES: 5

NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: 124

*Data from Scopus & Web of Science

HUMAN RESOURCES IN 2017



EXPERIMENTAL DIVISION

21

FACULTY

25

POST-DOCTORAL
RESEARCHERS

30

DOCTORAL
STUDENTS

THEORY DIVISION

12

FACULTY

8

POST-DOCTORAL
RESEARCHERS

11

DOCTORAL
STUDENTS

TECHNICAL SERVICES

33

21

PIC

RESEARCH SUPPORT

12

PROJECTS IN 2017

16

MINISTERIO DE
ECONOMÍA Y
COMPETITIVIDAD

9

EUROPEAN
COMMISSION

3

AGÈNCIA DE
GESTIÓ D'AJUTS
UNIVERSITARIS I
DE RECERCA

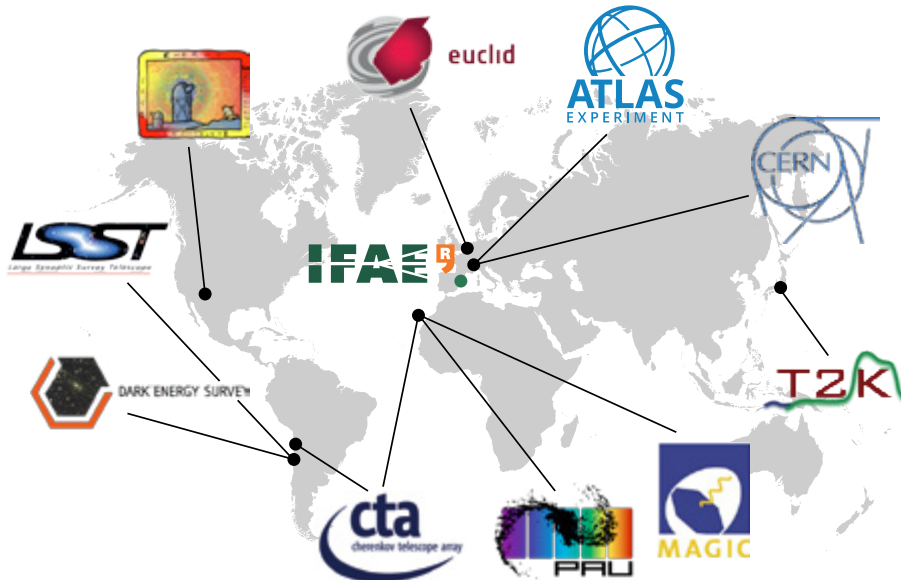
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BIST

1

ACCIO
RIS3CAT

INTERNATIONAL COLLABORATIONS



TECHNOLOGY TRANSFER IN 2017



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.

117k€

COMPETITIVE FUNDS
FROM COLLABORATIVE
RESEARCH AND INNO-
VATION ACTIONS WITH
PRIVATE SECTOR

77k€

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

1

PCT APPLICATION
FILED



FUNDAT PER | FOUNDED BY



MEMBRE DE | MEMBER OF



AMB EL SUPORT DE | SUPPORTED BY



EUROPEAN UNION
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Established by the European Commission



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