FROM PARTICLES TO THE COSMOS

IFAE

Institut de Física
d'Altes Energies

Report
of Activities
Summary 2021

Institució CERCA
Centres de Recerca de Catalunya

BIST
Barcelona Institute of Science and Technology

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 30 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

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, 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, DESI, T2K, PAU, CTA, Euclid, LSST, Virgo)

facilities: chip packaging & assembly, clean rooms, shielded room, electronics labs, optical lab, quantum computing technologies 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

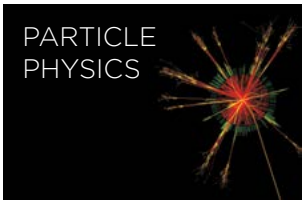
At IFAE we conduct experimental and theoretical research at the frontiers of fundamental physics, namely in Particle Physics, Astrophysics and Cosmology.

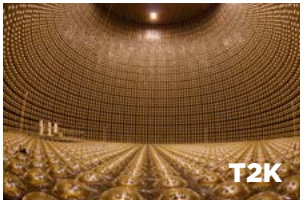
We are involved in the ATLAS project at the LHC, the T2K neutrino experiment in Japan, the MAGIC telescopes in La Palma, the Dark Energy Survey project in Chile, the Cherenkov Telescope Array in La Palma and Chile, the Virgo interferometer near Pisa, among others.

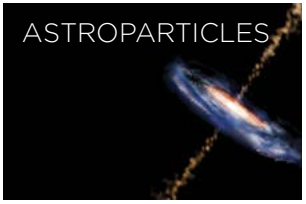
We focus our research on the hottest topics in fundamental physics from particles to the cosmos.

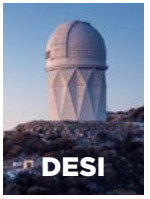
HIGGS PHYSICS
ANTIMATTER
DARK **MATTER**
DARK **ENERGY**
EXTREME **UNIVERSE**

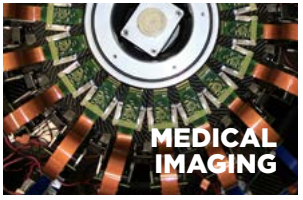
EXPERIMENTAL division



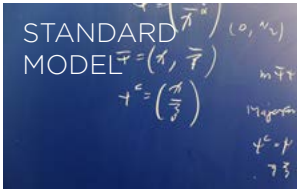


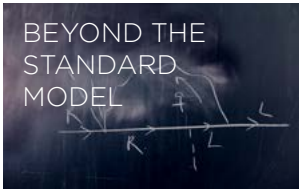


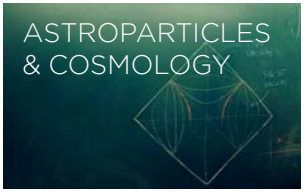




THEORY division







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, a shielded room and a quantum computing technologies lab.

FRONT-END ELECTRONICS

GRID COMPUTING

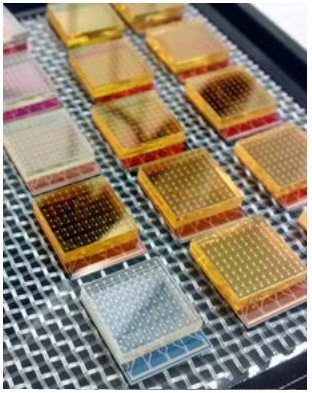
CONTROL SYSTEMS

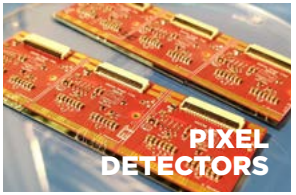
CRYOGENICS

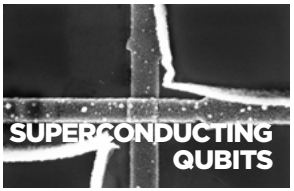
READ-OUT ELECTRONICS

DETECTORS

TECHNOLOGIES

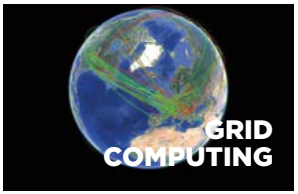




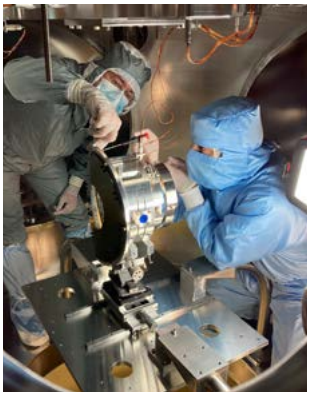


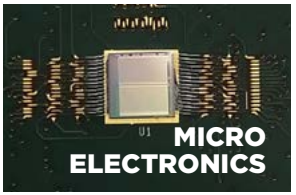
DATA CENTER

PIC
port d'informació científica



ENGINEERING



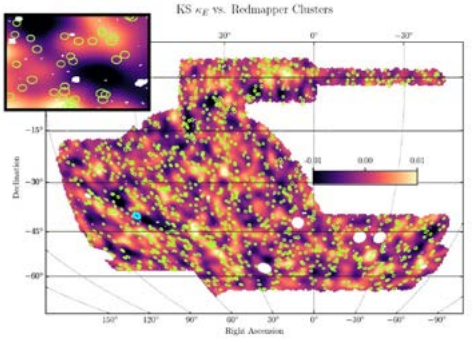


HIGHLIGHTS OF THE YEAR

DES RELEASES MOST PRECISE LOOK AT THE UNIVERSE'S EVOLUTION

The Dark Energy Survey (DES) collaboration created in 2021 the largest ever maps of the distribution and shapes of galaxies. These maps trace both ordinary and dark matter in the universe out to a distance of more than 7 billion light years.

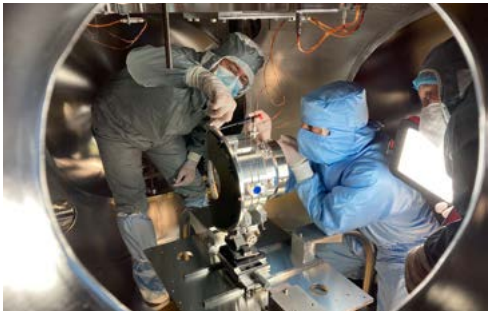
The analysis, which includes the first three years of data from the survey, is consistent with predictions from the standard cosmological model. Nevertheless, there remain hints from DES and other experiments that matter in the current universe is a few percent less clumpy than predicted.



NEW INSTRUMENTED BAFFLE INSTALLED AT VIRGO

As part of the upgrade program, Virgo installed in 2021 a new instrumented baffle with photosensors surrounding the end mirror of the Input Mode Cleaner at EGO.

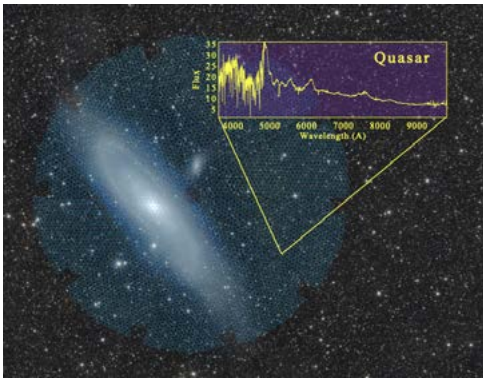
This culminates more than two years of work at IFAE for the design and construction of a novel and innovative device to control and monitor the stray light inside the experiment, a persistent source of noise at interferometers.



DESI CREATES LARGEST 3-D MAP OF THE COSMOS

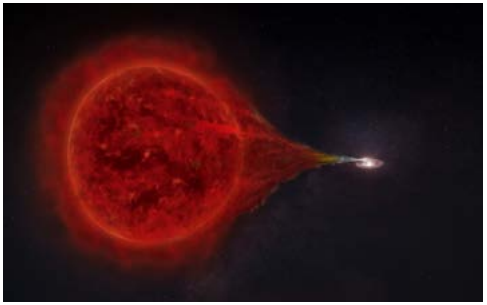
After a successful commissioning during 2020, the Dark Energy Spectroscopic Instrument (DESI) finished the phase of Survey Validation in May 2021, and started the main survey observations. After a few months of observations DESI was already the largest spectroscopic survey ever, with more than 10 million galaxy redshifts obtained.

During the next 5 years, DESI will build the largest 3D map of the distribution of galaxies in the universe. This will allow us to unravel the mysteries of dark energy, the repulsive force that drives the accelerated expansion of the universe.



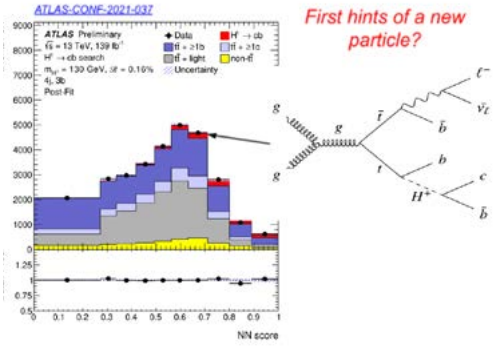
DETECTION OF VHE PHOTONS FROM RS-OPHIUCHI BY THE MAGIC TELESCOPES

Researchers from the MAGIC collaboration detected in 2021 very high-energy gamma rays from Rs-Ophiuchim a recurrent nova in the Milky Way. This event is the first one detected at these energies and allows a better understanding of these class of eruptions and their potential role in the production of the mysterious cosmic rays that inhabit the Milky Way. The detection of very high energy photons from RS-Ophiuchi by the MAGIC telescopes identifies novae as a new type of very high-energy gamma-ray source and reveals proton acceleration in thermonuclear nova explosions.



EXPANDING PROGRAM OF SEARCHES FOR AN ELUSIVE CHARGED HIGGS BOSON IN ATLAS

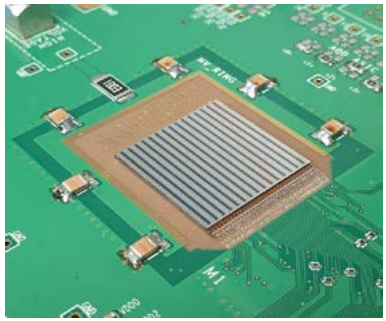
In 2021 the ATLAS Collaboration reported a possible weak hint for a light charged Higgs boson produced from top quark decays and that couples to a charm and a strange quark. The data presents a 3 standard deviations excess compared to the Standard Model (SM) background predictions. This possible signal is elusive and suffers from a large amount of SM background. For this reason, a sophisticated data analysis strategy involving substantial use of machine learning techniques was deployed.



The IFAE-ATLAS team has not only contributed to this result, but is also completing a search for this process in a complementary channel featuring only one lepton or two opposite-charge leptons.

FIRST FULL SIZE LGAD PROTOTYPE CHIP FABRICATED AT IFAE

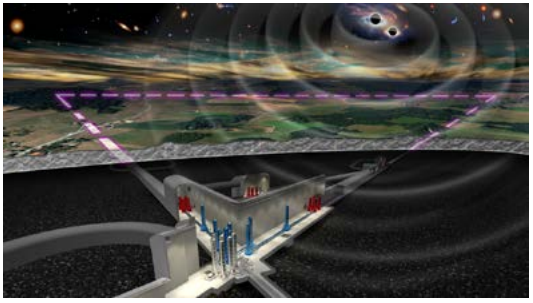
IFAE has been deeply involved in the R&D effort to design and fabricate a timing detector to mitigate the effect of pile-up at the HL-LHC. IFAE plays a leading role in the High-Granularity Timing Detector (HGTD) activities, leading the sensor, module assembly and test-beam groups, and with a member of IFAE acting as the sub-Project Leader. IFAE is also playing a critical role in the digital design of the final HGTD readout chip.



The first full size prototype chip was fabricated in 2021 and IFAE was the first institute to bump-bond the chip to LGAD sensors.

EINSTEIN TELESCOPE APPROVED FOR ESFRI ROADMAP 2021

In 2021 the European Strategy Forum on Research Infrastructures (ESFRI) decided to include the Einstein Telescope (ET) in the 2021 update of its roadmap. This confirms the relevance of this major international project for a next generation gravitational waves observatory for the future of research infrastructures in Europe and gravitational wave research at global level.



DEEP DETECTION RAISES 1M€ IN FUNDING

IFAE's spin-off Deep Detection was founded in July 2020 and its main domain of activities is X-ray detectors for industrial quality control and security. In 2021 Deep Detection achieved a one million euros pre-seed investment round mainly contributed by two venture capital companies. The company ended the year with 5 full-time workers.

Deep Detection

deepdetection.tech

Deep Detection is preparing to launch its first product, PhotonAI, an X-ray camera with deep learning capabilities. The backbone of the technolog is the know-how obtained by IFAE from having invented and developed novel instruments to explore fundamental science and address technological challenges.

QILIMANJARO RAISES 2M€ IN FUNDING AND CONTRACTS

IFAE spin-off Qilimanjaro Quantum Tech secured in 2021 nearly one million euros in grants from the CDTI and the Misiones program. On top of this funding the turnover of the first customers of Qilimanjaro in 2021 was another million euros, a growth of 100% compared to 2020.

In 2021 Qilimanjaro was selected in the 5 top Quantum Computing Startups to watch in 2022 by StarUS Insights.

QILIMANJARO
QUANTUM·TECH

qilimanjaro.tech

SCIENTIFIC OUTPUT IN 2021

248

NUMBER OF INDEXED JOURNAL ARTICLES

77%

% ARTICLES IN FIRST QUARTILE JOURNALS

5.51

AVERAGE JOURNAL IMPACT FACTOR (IF)

TOP 5 JOURNALS (BY IF) WHERE IFAE PUBLISHED IN 2020	NUMBER OF ARTICLES
Nature Physics	2
Progress In Particle And Nuclear Physics	1
Physical Review Letters	12
Astrophysical Journal Supplement Series	5
Astrophysical Journal letters	4

TOP 5 JOURNALS WHERE IFAE PUBLISHED MOST FREQUENTLY IN 2020	
Monthly Notices Of The Royal Astronomical Society	48
Physical Review D	36
Journal Of High Energy Physics	35
European Physical Journal C	29
Astrophysical Journal Letters	16

DOCTORAL THESES: *7*

NUMBER OF PRESENTATIONS AT INTERNATIONAL CONFERENCES: **180**

HUMAN RESOURCES IN 2021

EXPERIMENTAL DIVISION

22 FACULTY

17 POST-DOCTORAL RESEARCHERS

31 DOCTORAL STUDENTS

THEORY DIVISION

12 FACULTY

7 POST-DOCTORAL RESEARCHERS

13 DOCTORAL STUDENTS

TECHNICAL SERVICES

27

21 PIC

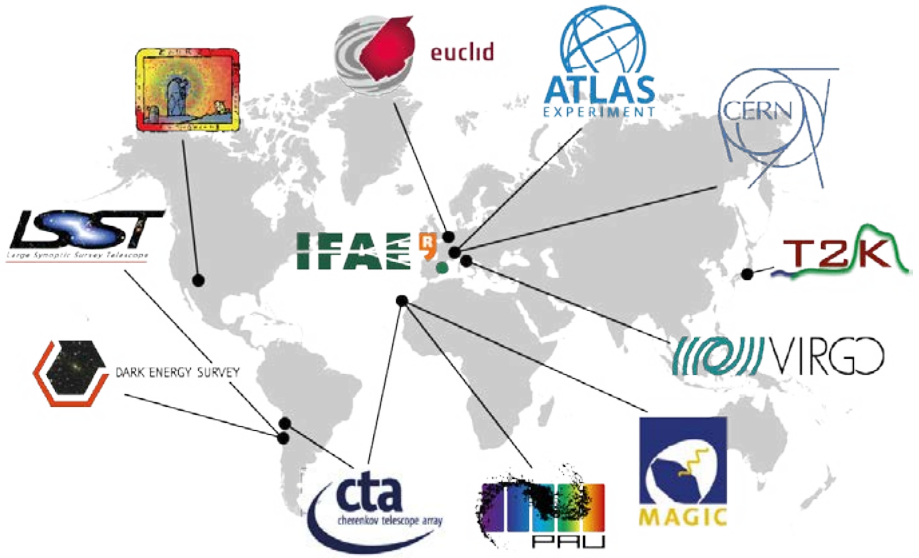
RESEARCH SUPPORT

12

PROJECTS IN 2021

18	11	3	4	2	2	1
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD	EUROPEAN COMISSION	AGÈNCIA DE GESTIÓ D'AJUTS UNIVERSITARIS I DE RECERCA	FUNDACIÓ BANCARIA LA CAIXA	BIST	FEDER	FECYT

INTERNATIONAL COLLABORATIONS



TECHNOLOGY TRANSFER IN 2021

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.

133k€
COMPETITIVE FUNDS FROM COLLABORATIVE RESEARCH WITH PRIVATE SECTOR

59k€
NON COMPETITIVE FUNDS FROM ENGINEERING PROJECTS AND SERVICES OFFERED TO EXTERNAL ENTITIES

151k€
COMPETITIVE FUNDS FOR THE VALORISATION OF NEW TECHNOLOGIES & LICENSING REVENUES

600k€
SPIN-OFF INVESTMENT ROUND

1
PRIORITY PATENT APPLICATIONS FILED

3
PORTFOLIO PATENTS GRANTED

1
PATENT LICENSED

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

FUNDAT PER | FOUNDED BY

Generalitat de Catalunya

Universitat Autònoma de Barcelona

CENTRE DE | CENTER OF

Institució CERCA Centres de Recerca de Catalunya

MEMBRE DE | MEMBER OF

BIST Barcelona Institute of Science and Technology

SOMM EXCELLENCE ALLIANCE

ACER Associació Catalana d'Entitats de Recerca

AMB EL SUPORT DE | SUPPORTED BY

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

EUROPEAN UNION
European Regional Development Fund

ICREA

AGAUR Agència de Gestió d'Ajuts Universitaris i de Recerca

erc European Research Council
Established by the European Commission

Obra Social "la Caixa"