

# Innovation by Collaborative Research with Big Science Research Organizations



ET-PP INFRA-DEV

Annual Meeting

Barcelona, 12/06/2023



# IFAE at a glance

Fundat per | Founded by



Membre de | Member of



Amb el suport de | Supported by



European Research Council

consortium between the **Catalan Government** and **UAB**

founded in **1991**: celebrated our 30<sup>th</sup> birthday in 2021.

**160** people \_ Only 44 structured personnel:  
16 researchers, 13 research support (Technical Division + PIC)  
12 management and administration area

**three divisions**: theory, experimental, technical + 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, Quantum Computing

collaboration in **10 international experiments** in high impact / leadership positions (ATLAS, T2K, Hyper-K, MAGIC, CTA, HERD, DES, PAU, DESI, Euclid, LSST, Virgo, Einstein Telescope)

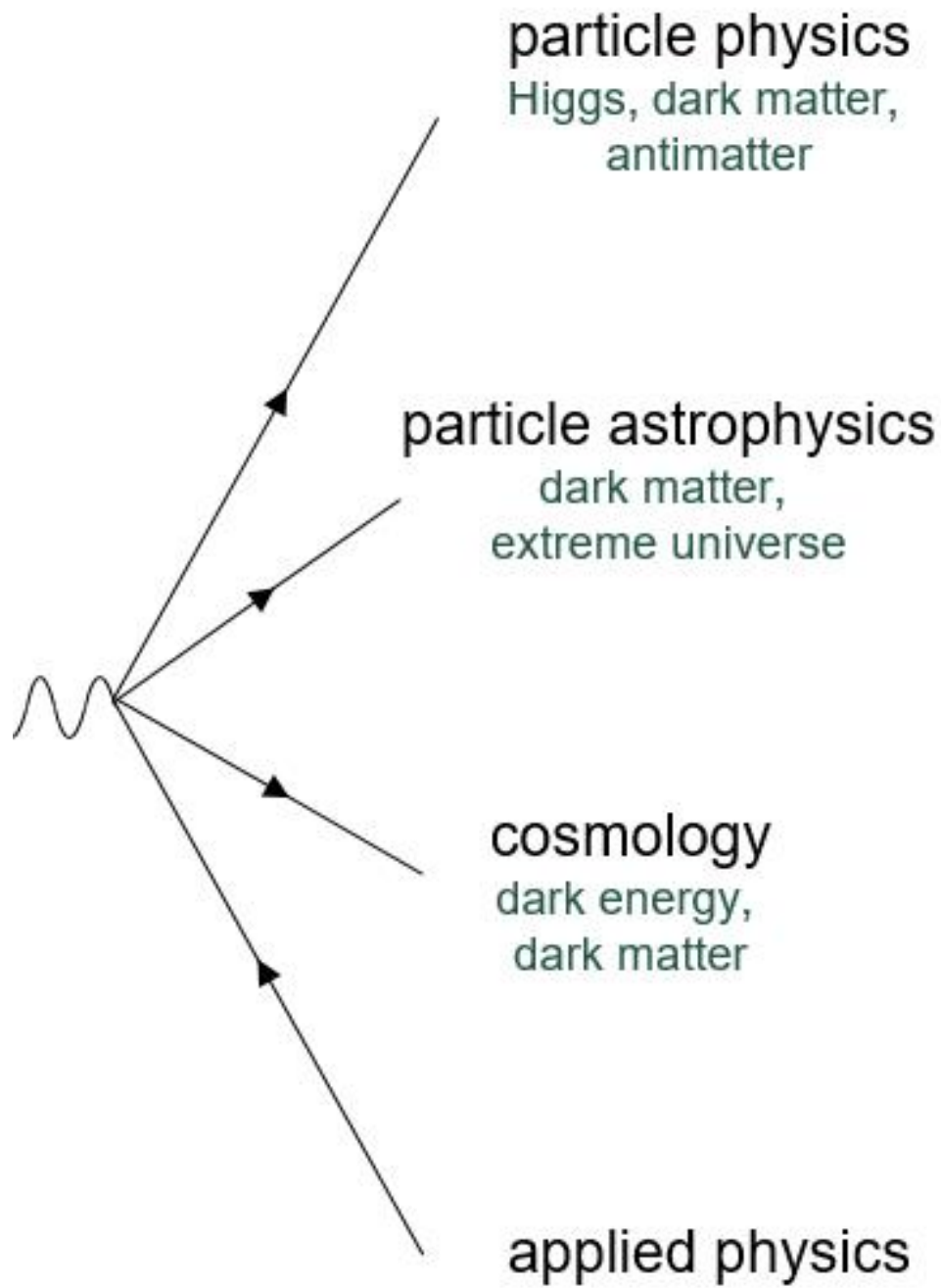
**one large engineering group (30+ engineers and technicians)**

**facilities**: chip packaging & assembly, clean rooms, shielded room, electronics labs, optical lab, cryogenic lab, mechanical workshop (300 m<sup>2</sup>)

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



# Experimental division



ATLAS



T2K



ATLAS PIXELS



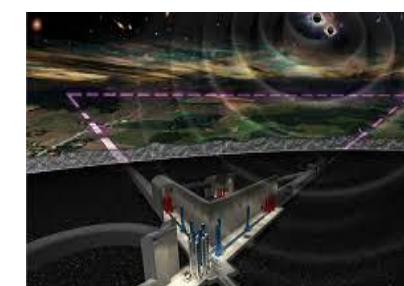
MAGIC



CTA



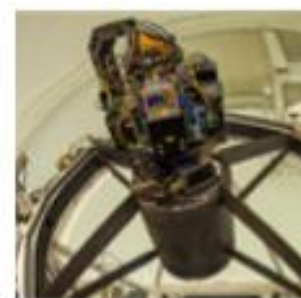
VIRGO



ET



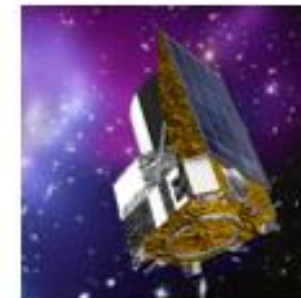
DES



PAU



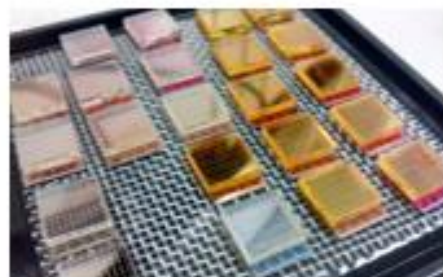
DESI



EUCLID



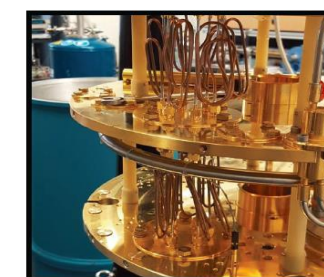
LSST



MEDICAL IMAGING



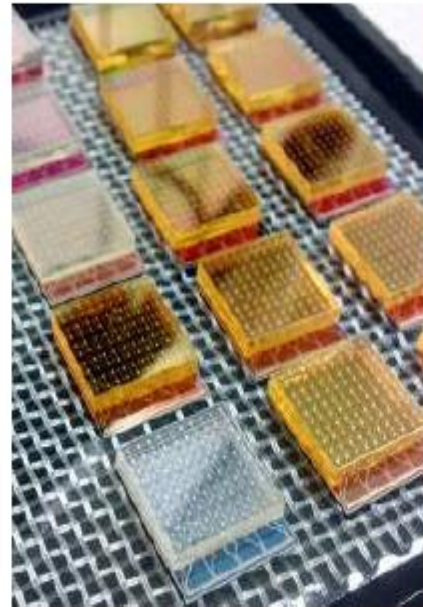
NEW DETECTORS



QUANTUM COMPUTING

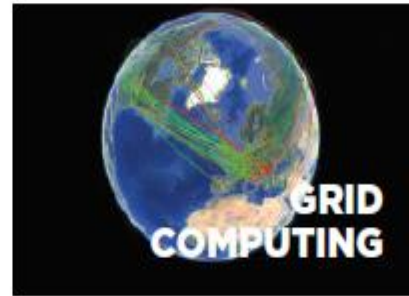
# Technology and Infrastructure

TECHNOLOGIES



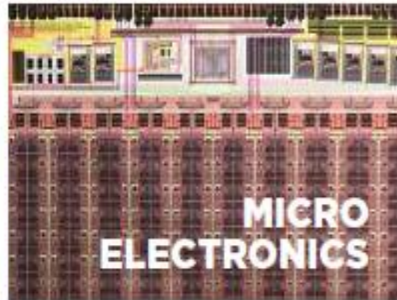
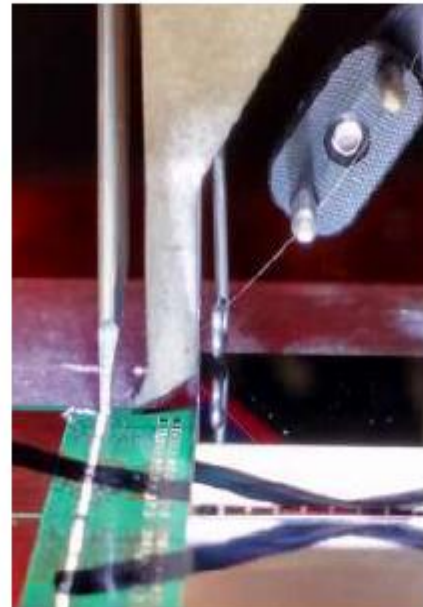
THERMAL SIMULATIONS  
 PROJECT MANAGEMENT  
 VACUUM SYSTEMS  
 CRIOGENIC SYSTEMS  
 DETECTORS MECHANICS  
 FLUID DYNAMICS  
 OPTOMECHANICS

DATA CENTER



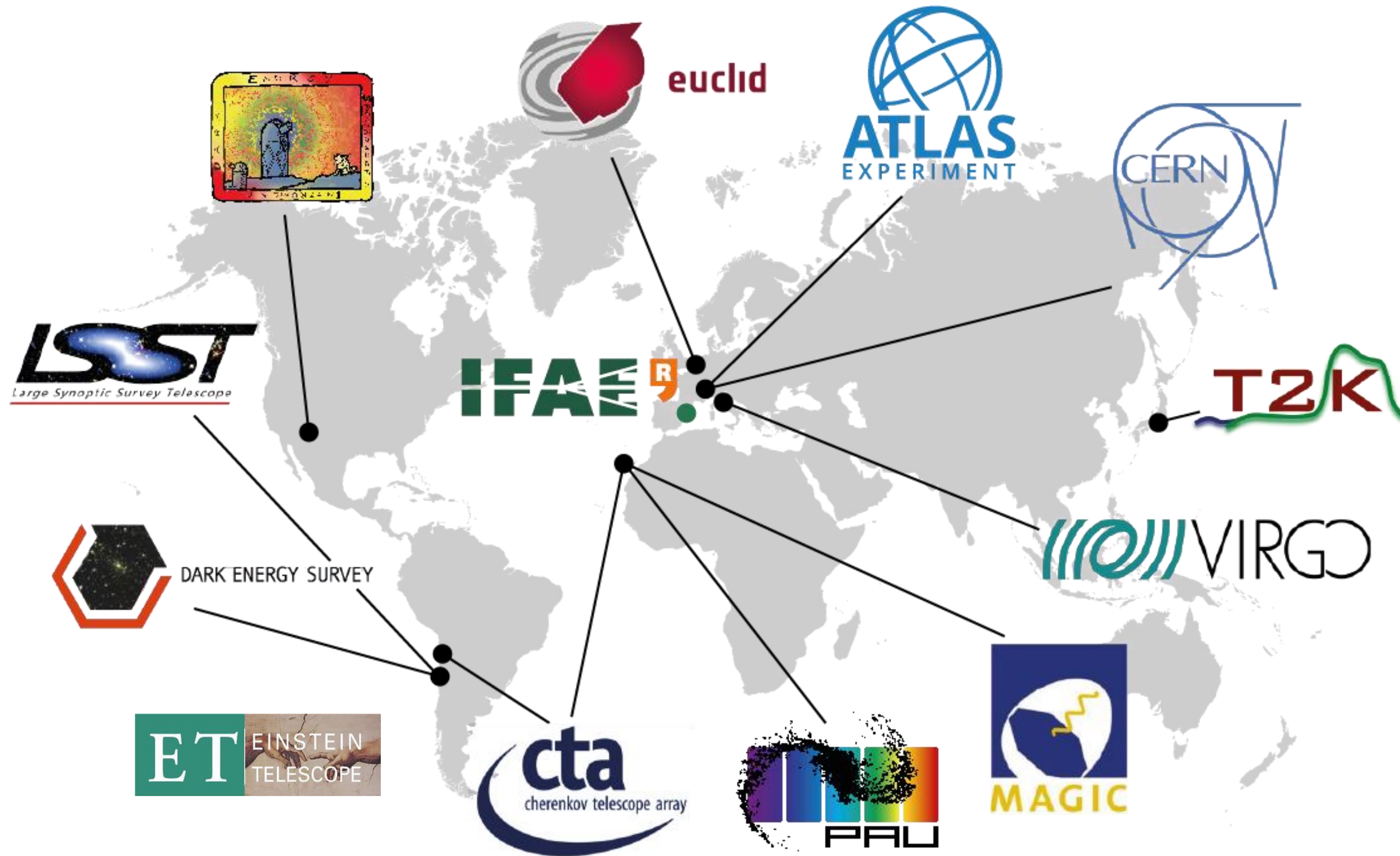
MEDICAL IMAGING  
 QUALITY CONTROL & INSPECTION  
 ENVIROMENTAL MONITORING  
 COMPUTING  
 BIG DATA & IoT DEVICES  
 TELECOMMUNICATIONS  
 AUTOMOTIVE

ENGINEERING



CHIP ASSEMBLY  
 BUMP BONDING  
 WIRE BONDING  
 FLIP-CHIP  
 DEVICE INSPECTION  
 PACKAGING SYSTEMS  
 CLEAN ROOM

# IFAE Collaborations



**12**  
INTERNATIONAL  
COLLABORATIONS

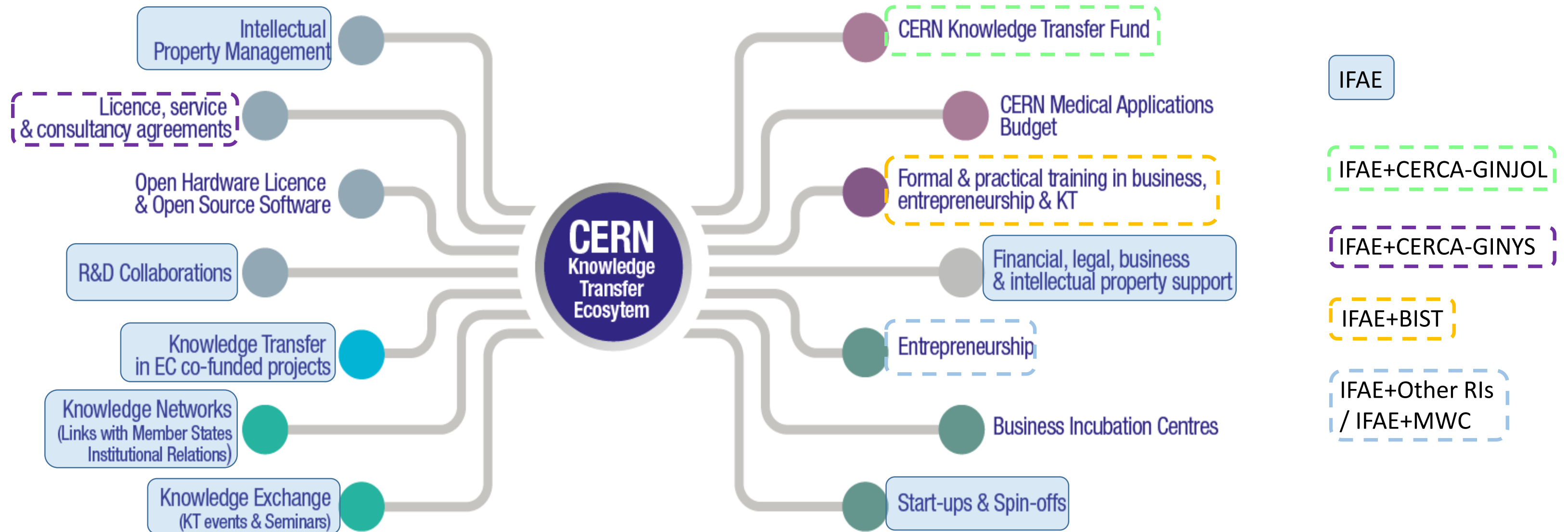
**11**  
EUROPEAN COMMISSION  
PROJECTS

**34**  
NATIONAL & REGIONAL  
PROJECTS

**6**  
PUBLIC-PRIVATE  
PROJECTS

# Knowledge Transfer

IP and much more

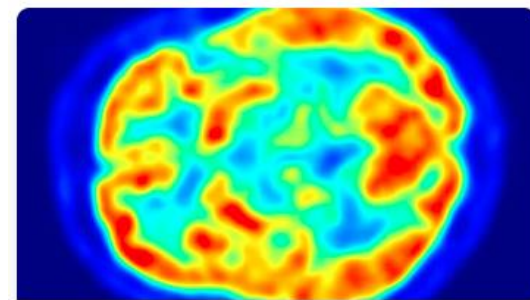


IFAE's **Knowledge and Technology Transfer Unit (KTTU)** supports the whole process from disruptive research results identification, novelty & economic valuation, tech valorisation advise, IP protection management, tech exploitation assessment and spin-off creation & growth support.

# HEP applications beyond science

mainly **Medical** solutions at IFAE

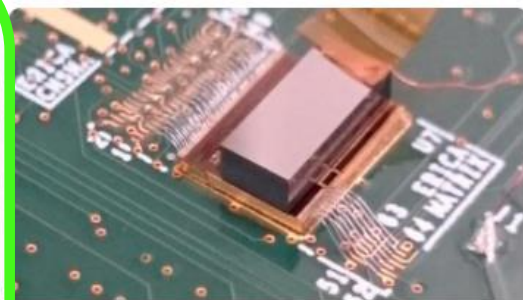
IFAE's **Innovation Portfolio** is composed of **10+ technologies** and **know-how** protected by patent (or industrial secret). Some inventions are granted worldwide (EU, US, CN, JP).



Market  
**Medical Devices  
Technologies**

Medical devices have a fundamental role in saving lives by providing innovative healthcare solutions for the diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease. IFAE contributes to this sector developing image diagnostics detectors, biopsy systems and vision prostheses.

[Read More](#)



Market  
**Industry 4.0 Technologies**

Industry 4.0 refers to the intelligent networking of machines and processes for industry with the help of information and communication technology. IFAE develops Industry 4.0 solutions such as non-destructive testing, quality control & inspection detectors and production control softwares

[Read More](#)



Market  
**Information &  
Communication  
Technologies**

IFAE & PIC's experience in High Volume Data Management & Storage allows us to offer solutions for High data transfer communications systems and low energy consumption servers

[Read More](#)

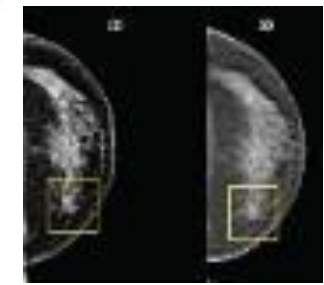
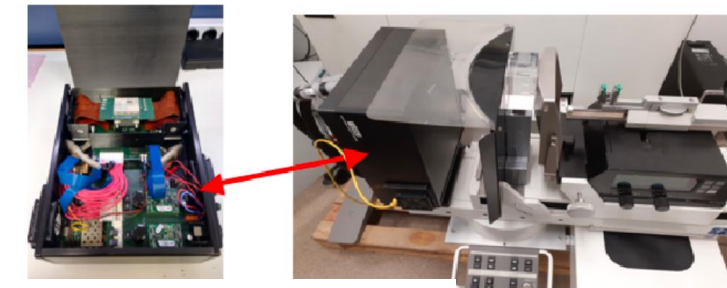


Market  
**Climate Change  
Technologies**

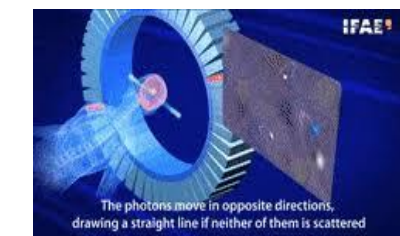
Technology solutions that could help address the climate crisis such as the pollutant hunter based on Atmospheric LIDAR technologies

[Read More](#)

3D BIOPSY machine



VOXEL IMAGING PET  
scanner

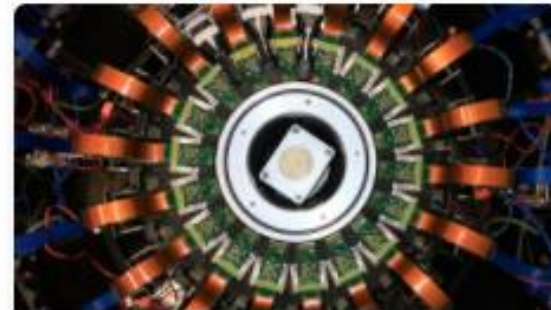


RETINAL IMPLANT



# IFAE Technology Portfolio

Patents are needed to reach the market

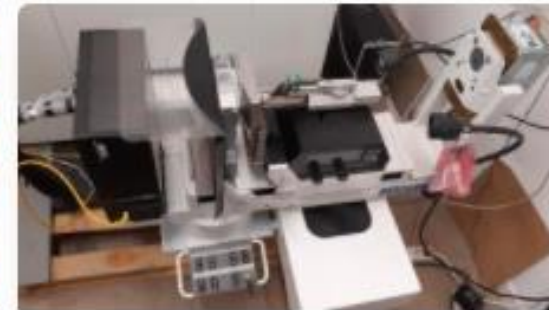


Technology  
**Voxel Imaging PET (VIP)**

TRL 4

A High Spatial and Energy Resolution (FWHM 1-2%) for Nuclear Imaging Diagnostics

[Read More](#)

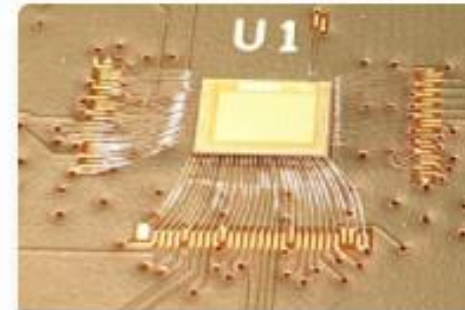


Technology  
**Digital stereotaxic biopsy system**

TRL 4

This technology allows for new developments in 3D biopsy on Tomosynthesis

[Read More](#)

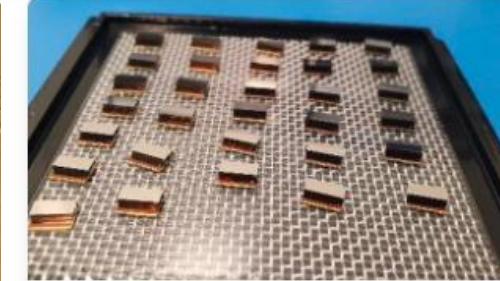


Technology  
**Artificial Vision System**

TRL 3

An image processor connected to a retinal prosthesis using a power / data wireless transmitter

[Read More](#)



Technology  
**LINE Detector with Novel Photon Counting (LINDA)**

TRL 4

X-ray inspection tool used as quality control in the food industry to detect contaminants in food & beverages, as well as foreign objects identification in luggage for the security market.

[Read More](#)



Technology  
**Data Logger Control Software**

TRL 4

Software to monitor and control systems based on the event subscription methodology

[Read More](#)

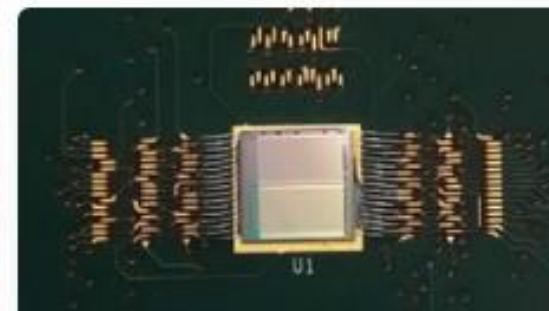


Technology  
**Compton PET**

TRL 2

The high spatial and energy resolutions of the Voxel Imaging PET detector developed at IFAE enables the way to construct a large Field Of View (FOV) Compton Gamma Camera at room temperature.

[Read More](#)



Technology  
**Low cost HVCMOS pixel detector**

TRL 3

Development of radiation detectors based on the HV/HR-CMOS technology

[Read More](#)



Technology  
**Photonic system for liquid biopsy (PHIL)**

TRL 3

Photonics device for direct and fast detection of altered genetic material (tumors, covid19, ...)

[Read More](#)



Technology  
**Novel PSK modulation method and demodulator that doubles transfer data rates**

TRL 2

New method of modulation and demodulation of Binary PSK and Quadrature PSK signals that doubles the data rate of current communication systems based on BPSK or QPSK modulations.

[Read More](#)



Technology  
**Ultra Dense Immersed Servers**

TRL 3

The project consist of designing a computer compatible with the immersion cooling infrastructure that allows to maximize the efficiency of data centers.

[Read More](#)



# IFAE's spin-offs

X-Ray Cameras, Quantum Tech & Pixel Detectors



**IFAE's spin-offs staff**

**37** Jobs created since 2019



**Total Fundraising**

**5M€** in last 3 years



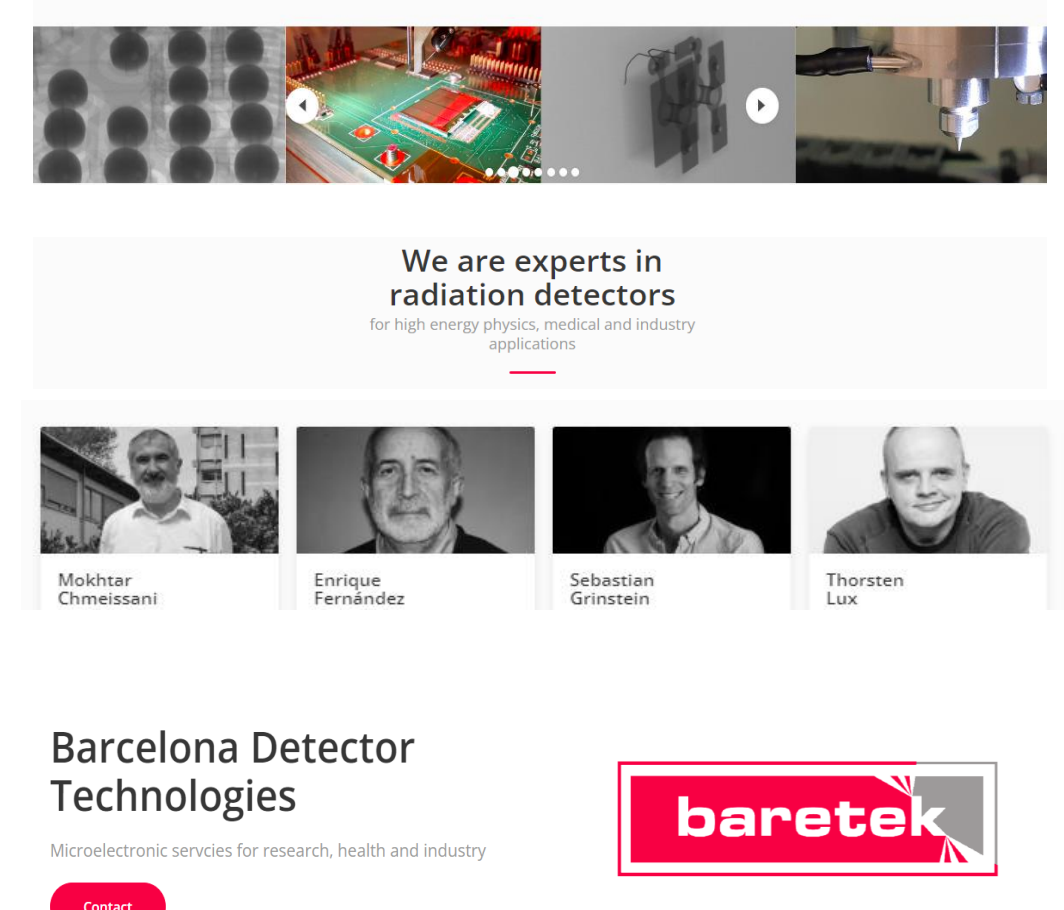
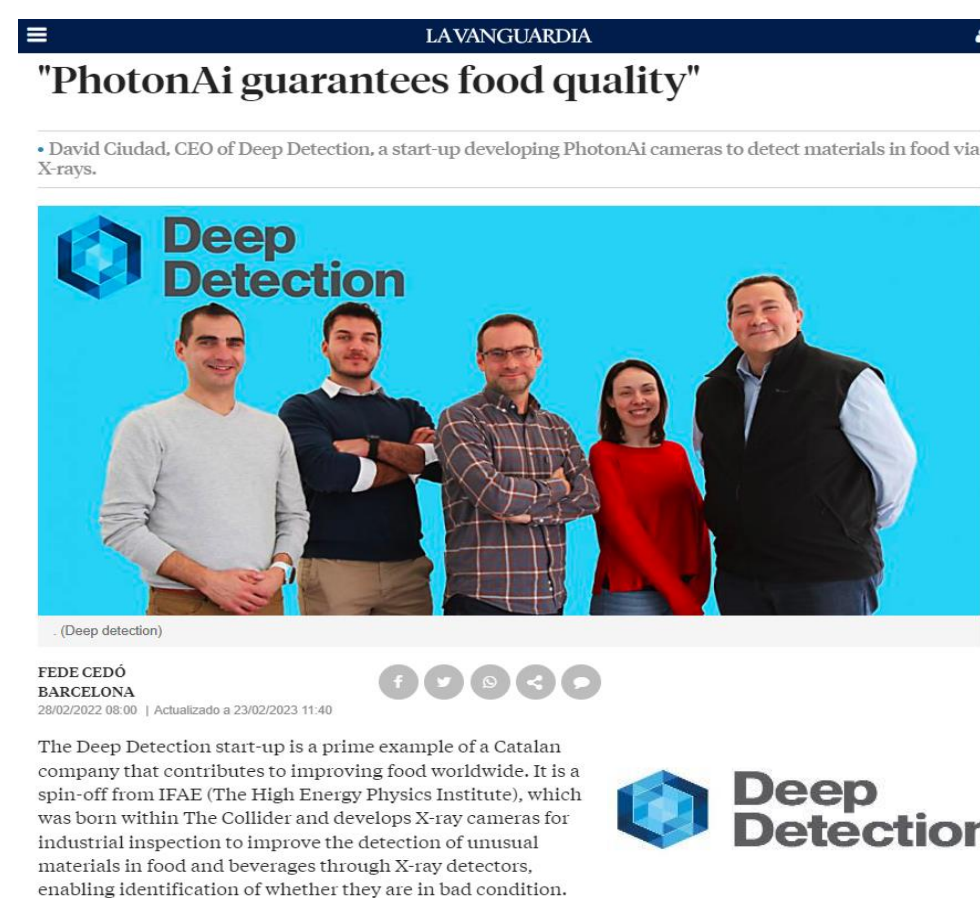
**Collaboration with IFAE**

**2CAs** signed



**BAs/VCs Investment Rounds**

**1** closed **2** ongoing



3 Spin-offs active / 4 spin-offs created

# ESADE / BIST Science-Business course



Promoting the **innovation & entrepreneurship**



## SURVEY RESULTS

<b>General assessment</b>	
What is your opinion of this program?	4,5/5
How do you rate its applicability?	4/5
To what extent did this program meet your expectations?	4,4/5

<b>Entrepreneurial Willingness</b>	
How likely are you to create a start-up in the next 5 years?	3,2/5 (possible)



5/20 IFAE participants involved later in innovation actions  
  
(1 spin-off created, 3 patents filed, 4 collaborative research projects joined)

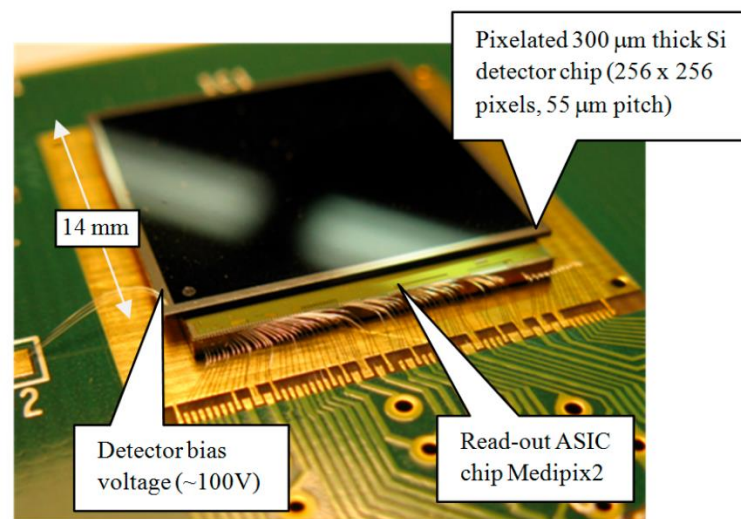
<b>Professors' assessment</b>	
Content and relevance of the topics addressed?	4,3/5
How would you rate the teaching methodology?	4,6/5
To what extent did this topic meet your expectations?	4,5/5
Overall evaluation of the faculty?	4,5/5

# Technology Transfer case study

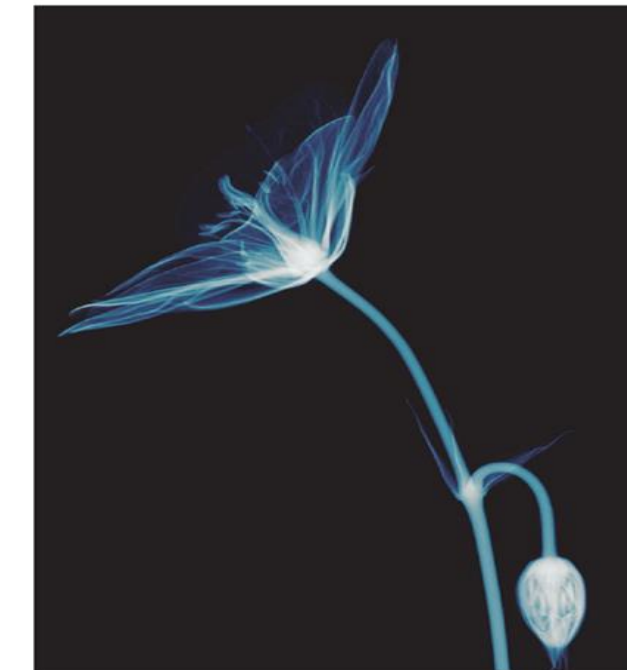
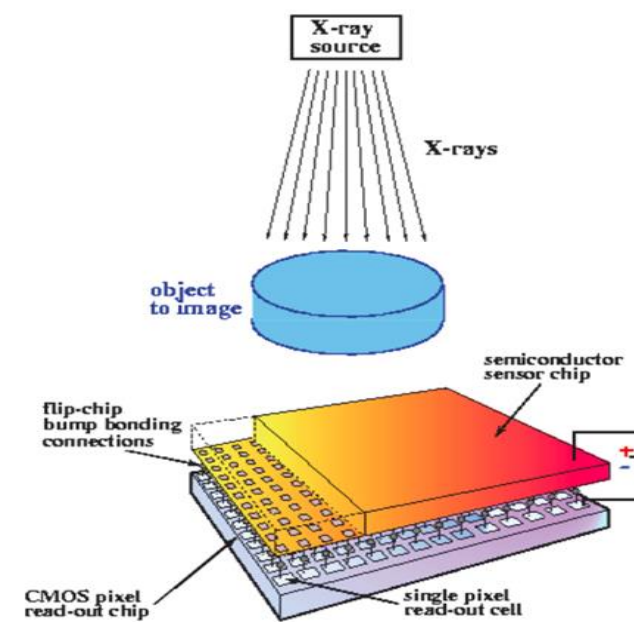


The Medipix Collaboration was formed in the 1990's at CERN to develop **hybrid pixel detectors** (sensor + readout electronics), noise-free, **single-photon counting technology**, for applications such as medical imaging, materials characterization or space dosimetry, among others.

Initially operated at LHC for particle detection purposes.



Medipix device operated at LHC Run-1.



X-ray material analysis	Gamma camera	CT imaging
Read-out board1	Read-out board 2	Software
Medipix chip		
High Z sensors	Conversion method 1	Conversion method 2
Electron microscopy	Dosimetry	Radiation monitoring



# Technology Transfer case study

- Exclusive license to a PANalytical in the field of X-Ray diffraction analysis
- More than 1000 detectors/systems commercialized

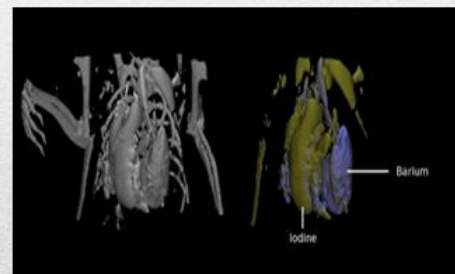


(courtesy of PanAnalytical)

## Dissemination

B. Denis - CERN Knowledge Transfer Group

- Exclusive license to a start-up company from New-Zealand in the field of small animal CT
- First prototypes delivered to research institutes



(courtesy of MARS Bioimaging Ltd)

## Dissemination

B. Denis - CERN Knowledge Transfer Group

**Medipix1 Collaboration**  
 The Medipix1 collaboration was formed in the 1990's when the potential of the new technology to provide noise-free single-photon counting was demonstrated.

**Medipix2 Collaboration**  
 The Medipix2 Collaboration was formed in 1999 with the aim of developing a single photon counting pixel detector readout chip using a 0.25  $\mu\text{m}$  CMOS process.

**Medipix3 Collaboration**  
 The Medipix3 Collaboration was formed in 2005 to develop the Medipix3 chip and the Timepix3 chip: now permitting colour imaging and dead time free operation.

**Medipix4 Collaboration**  
 The Medipix4 Collaboration was launched in 2017. The aim is designing pixel read-out chips fully prepared for TSV processing that may be tiled on all four sides.

- Development of the chips co-financed by the collaboration members
- The Intellectual Property related to the chips is vested to CERN
- Exploitation agreements have to be approved by the collaboration board
- Revenue from exploitation are shared according to the following scheme:
  - 50% to the IP owner
  - 10% to the deal initiator
  - 40% to the other collaboration members

## Collaboration agreement

B. Denis - CERN Knowledge Transfer Group

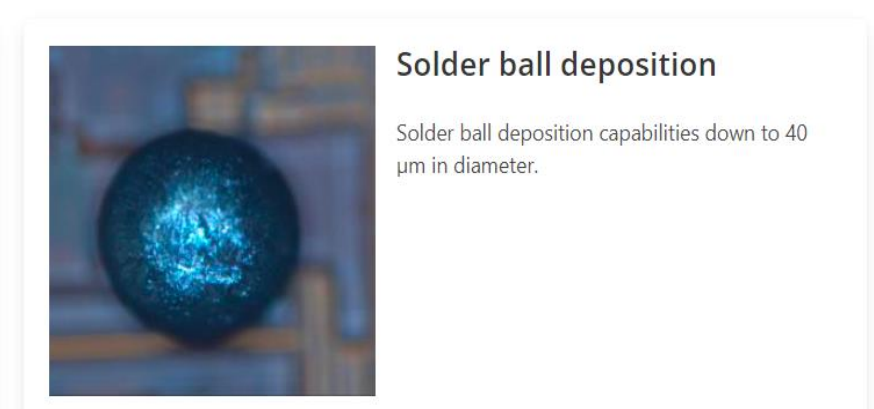
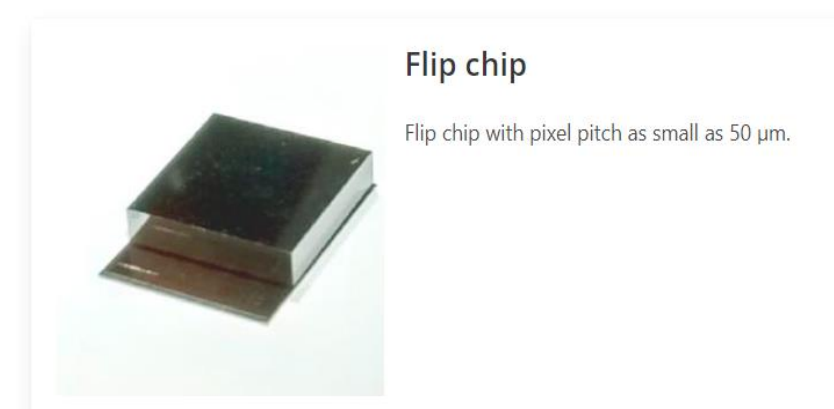
# IFAE collaboration in Medipix

The development of pixel sensors at CERN, lead to the creation of Medipix collaboration.

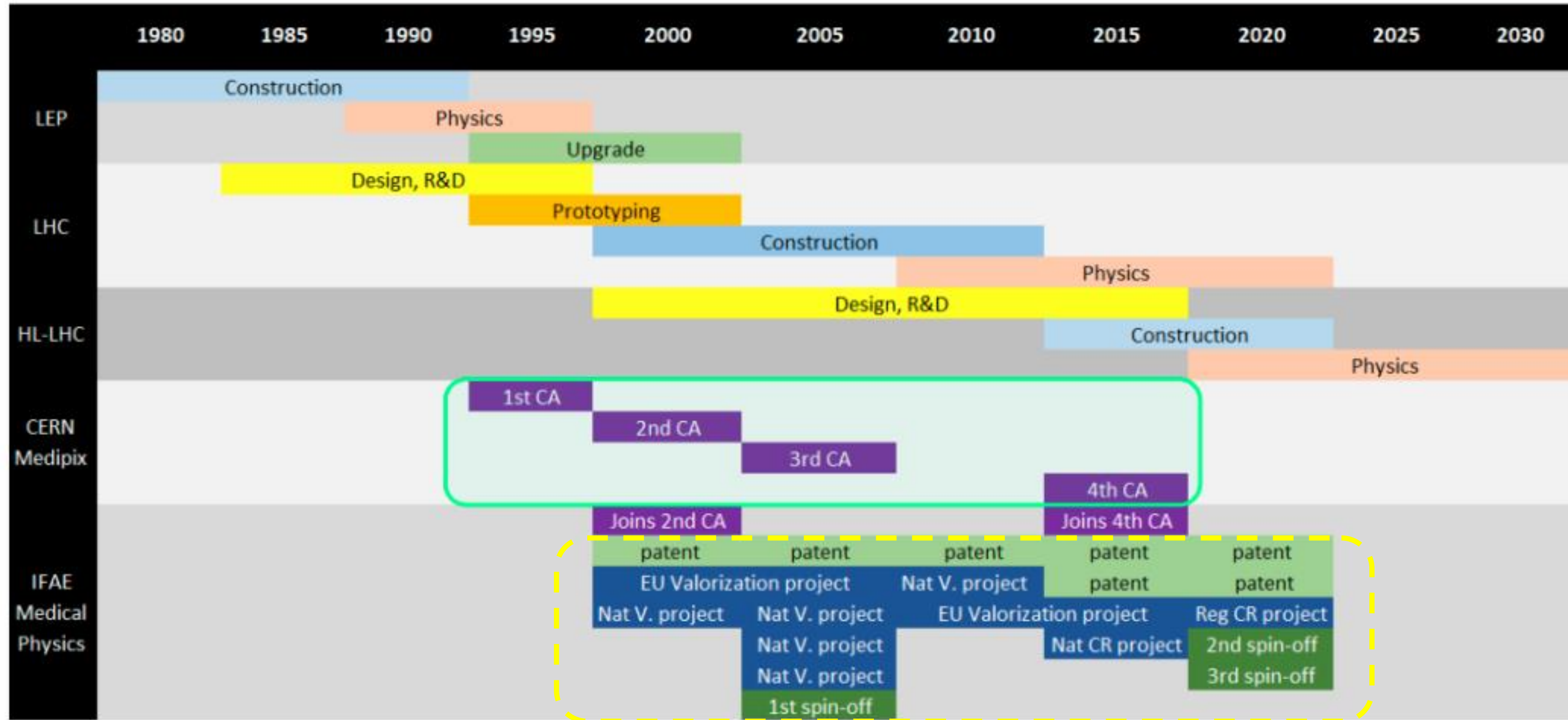
IFAE joined Medipix 2 collaboration and this opened a great opportunity for the IFAE team to delve into the technology of pixel sensors. As a result IFAE created a valuable own portfolio of know-how and IPR in packaging pixel sensors (40% portfolio licensed; 85% patents granted).

IFAE has the most advanced pixel sensor packaging facility in Spain and was shortlisted and recognized as “Top 10 Microelectronics Solutions Provider in Europe 2022” by *Semiconductor Review Europe* magazine.

The IFAE pixel sensor patent families cover key industrial regions, mainly the EU, the US, and China. IFAE has managed to coordinate an FP5 project based on Medipix2 chip and an ERC advanced Grant to develop a PoC PET scanner based on pixel CdTe. The deep-tech activities in pixel sensor has lead to the creation of 3 start-up companies: X-Ray Imatek, Deep Detection and Baretek.



# IFAE collaboration in Medipix



Example of innovation outputs generated by a RI (IFAE) collaborating with CERN in the Medipix collaboration

# KTT in collaboration with CERN (I)



IFAE's membership in "TALENT" H2020 MSCA – ITN public-private (2015).

Development of business models for disruptive R&D results.



## 2014



Institutional presentation of IFAE's portfolio & services in the SPAIN at CERN industrial meeting 2014 organized by CDTI (Spanish Science Ministry).

## 2015



**Network**  
Research facilities, Universities, Industrial partners

- CERN, Switzerland
- Fraunhofer IZM, Berlin, Germany
- Wirtschafts Universität Wien, Austria
- NIKHEF, Amsterdam, The Netherlands
- Universität Bonn, Germany
- Bergische Universität Wuppertal, Germany
- CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Germany
- Atostek Oy, Finland
- Université de Genève, Switzerland
- University of Oslo, Norway
- IBA Dosimetry GmbH, Germany
- Institute de Física d'Altes Energies, Spain
- Composite Design SA, Switzerland
- Bgator Oy, Finland
- Centro Nacional de Microelectrónica, Spain
- CIVIDEC Instrumentation GmbH, Austria
- A.D.A.M SA, Switzerland
- CPPM Marseille, France

X-Ray Imatek, an IFAE's spin-off licensee of the Medipix Tech, sells an x-ray detector to Houston University, for testing in the International Space Station.

NASA selects the MediPix2/TimePix CERN's Technology in 2015 to be employed as space radiation monitors and dosimeters for the Orion Spacecraft.

# KTT in collaboration with CERN (II)



**IFAE MICROELECTRONICS LABORATORY**

IFAE has wide experience, know-how and singular infrastructure for ASIC design, FPGA and microcontroller programming and ASIC, FPGA and microcontroller assembly.

The IFAE Microelectronics laboratory is equipped with state-of-the-art packaging and assembly technologies, including **bump deposition, flip-chip, automated wire-bonding and inspection systems.**

WE COVER THE WHOLE **MICROELECTRONICS ASSEMBLY PROCESS** INCLUDING DESIGN, PROTOTYPING AND QUALITY CONTROL

<b>ASSEMBLY LINE</b>	SOLDER BUMP DEPOSITION	BUMP BONDING	REFLOW OVEN
	DEVICE ASSEMBLY	WIRE BONDING	
<b>QUALITY CONTROL</b>	X-RAY INSPECTION	PROBE STATION	PULL & SHEAR BOND TESTER

2016

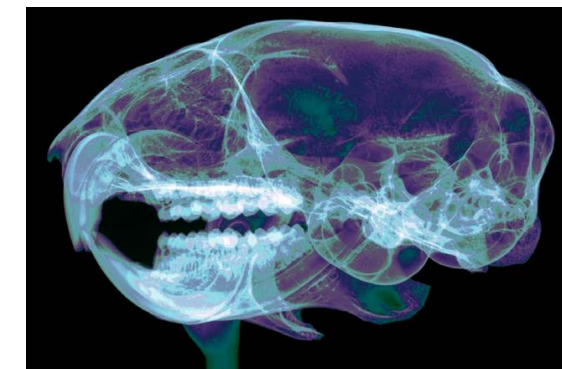
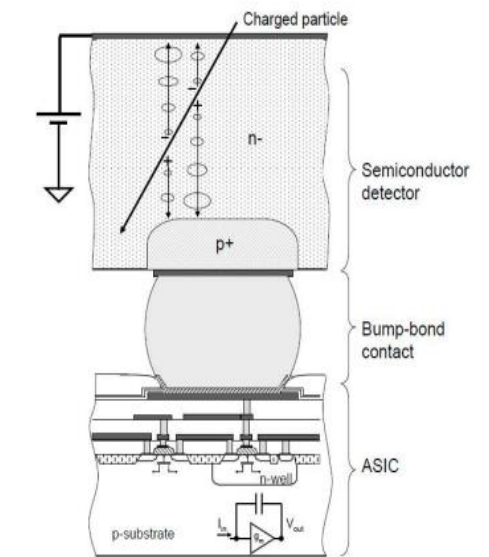
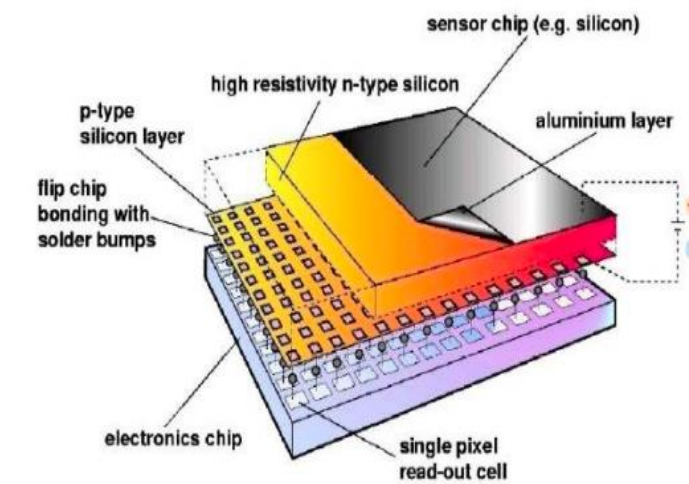


IFAE presents the microelectronics services for industry to the CDTI's Industrial Liaison Office at CERN.

2017



IFAE joined the CERN's Medipix4 collaboration in 2017, an applied research initiative oriented to the design and development of medical imaging and materials characterization detectors. IFAE is participating in the design of the Timepix4 chip.





# KTT in collaboration with CERN (III)



€17M to fund  
170 breakthrough ideas

To bridge the gap between basic research and real market needs, ATTRACT called for researchers, entrepreneurs and companies to bring forward breakthrough projects on pioneering imaging and sensor technologies.

The call opened on 1st August 2018 and the deadline for applicants to submit their ideas was 31st October, 2018 23:59 hrs CET.

2019



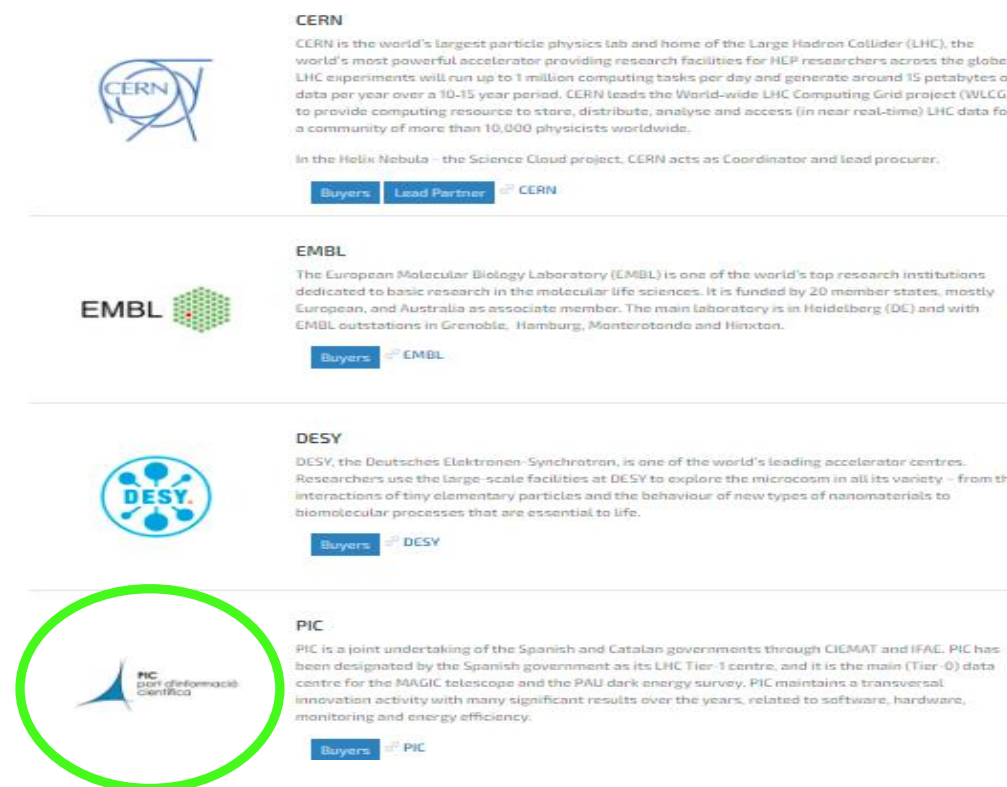
IFAE's valorization projects granted in the ATTRACT call (EC funded CERN initiative). Fire detection device and Liquid biopsy system.



2020



H2020-ICT pre-commercial procurement Archiver project granted in 2020 for archiving and preservation of scientific petabyte range data.



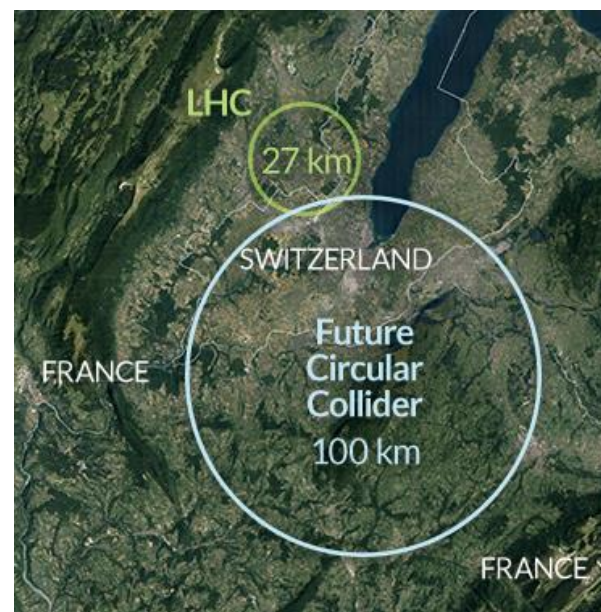
**CERN**  
CERN is the world's largest particle physics lab and home of the Large Hadron Collider (LHC), the world's most powerful accelerator providing research facilities for HEP researchers across the globe. LHC experiments will run up to 1 million computing tasks per day and generate around 15 petabytes of data per year over a 10-15 year period. CERN leads the World-wide LHC Computing Grid project (WLCG), to provide computing resource to store, distribute, analyse and access (in near real-time) LHC data for a community of more than 10,000 physicists worldwide.

In the Helix Nebula - the Science Cloud project, CERN acts as Coordinator and lead procurer.

**EMBL**  
The European Molecular Biology Laboratory (EMBL) is one of the world's top research institutions dedicated to basic research in the molecular life sciences. It is funded by 20 member states, mostly European, and Australia as associate member. The main laboratory is in Heidelberg (DE) and with EMBL outstations in Grenoble, Hamburg, Monterotondo and Hinxton.

**DESY**  
DESY, the Deutsches Elektronen-Synchrotron, is one of the world's leading accelerator centres. Researchers use the large-scale facilities at DESY to explore the microcosm in all its variety - from the interactions of tiny elementary particles and the behaviour of new types of nanomaterials to biomolecular processes that are essential to life.

**PIC**  
PIC is a joint undertaking of the Spanish and Catalan governments through CIEMAT and IFAE. PIC has been designated by the Spanish government as its LHC Tier-1 centre, and it is the main (Tier-0) data centre for the MAGIC telescope and the PAU dark energy survey. PIC maintains a transversal innovation activity with many significant results over the years, related to software, hardware, monitoring and energy efficiency.



Contract Research Agreement signed for IFAE's engineering activities in the Future Circular Collider Project (CERN).

# Technology Transfer & Society

*Science leads to technology innovation.*

*High tech industry is the backbone of economy.*

*Society relies on technology.*

*Discoveries alone are no longer sufficient to substantiate the investment level of Member States in fundamental science\*.*

*Particle Physics is required to demonstrate its importance to Society:*

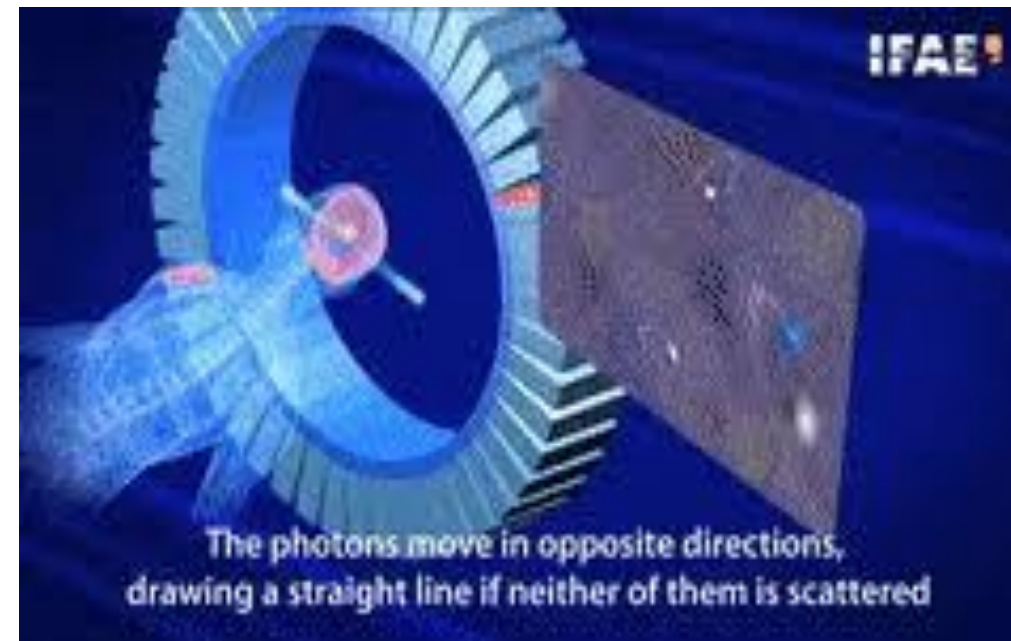
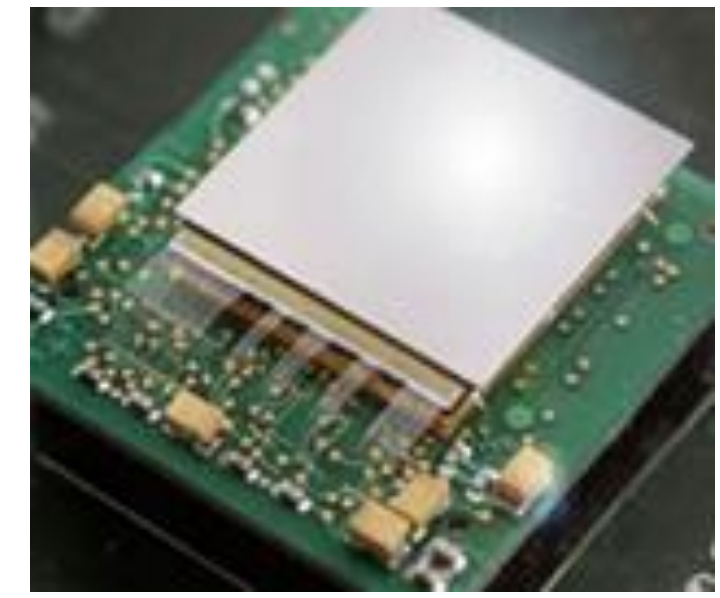
- Communication is key to reach this objective

*Particle Physics is required to demonstrate its usefulness to Society:*

- TT is a key mean to reach this objective.



(\*) CERN Council in charge of the European Strategy for Particle Physics



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