

# External Scientific Advisory Committee meeting

CIEMAT (Madrid), January 11-12, 2024

## CIEMAT- Particle Physics Unit Overview

N. Colino

# Welcome

- Thanks for coming to new face to face meeting of our Scientific Advisory Committee
- Welcome to CIEMAT
  - Public research center (OPI) for Energy, Environment and Technology with a Basic Research department
  - Depends of Science Innovation and Universities Ministry
  - 75 years old
  - About 1,400 employees. Several centers geographically distributed (**Madrid**, Almeria, Soria, Barcelona, Trujillo)
  - Total budget ~ 120 M€ (35% external fondly from competitive projects)
  - Mechanic and electronic workshops, big assembly hall, clean room, data center, fast network access

# CIEMAT and Particle Physics Unit facilities



Clean room (B. 20)



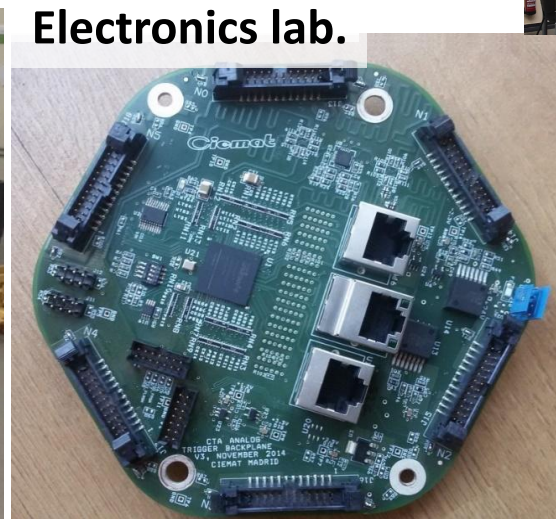
Assembly Hall (B. 75)



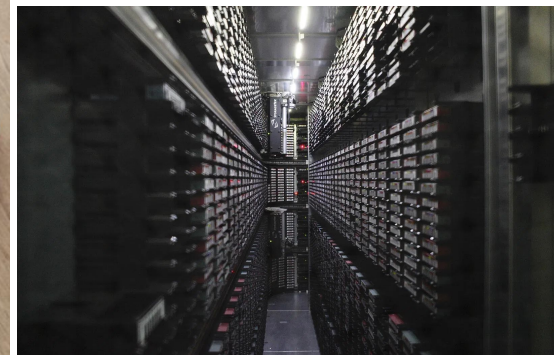
Computing facilities



Mechanical workshops



Electronics lab.



# Contents

- CIEMAT Particle Physics Unit background
- Structure of the Unit
- Overview of the research lines
- Highlights of the Unit from 2020 to mid 2023
- Funding sources
- Working groups
- Concluding remarks

# CIEMAT Particle Physics Background

Emerged from JEN's collaboration with CERN in the 1960s.

Pioneer in Spanish experimental particle physics, participating in experiments like MARK-J at DESY and UA1 at CERN .

Recognized for its contributions to international projects in particle and astroparticle physics: Maria de Maeztu excellence accreditation in 2016-2019.

Pioneered the introduction of high throughput and distributed computing in Spanish particle physics field.

Participation in major worldwide experiments like LHC, leading to recognition and increased resources.

Multidisciplinary Research and Output: Engages in diverse scientific fields, publishing numerous high-impact articles and contributing to technological development.

# CIEMAT Particle Physics Objectives

CIEMAT-FP goal is to contribute in solving basic pending questions in Fundamental Physics through:

**Participating in major experiments in particle and astroparticles.**

Engaging in diverse fields contributing to science and technological development.



# Structure of the CIEMAT Particle Physics Unit

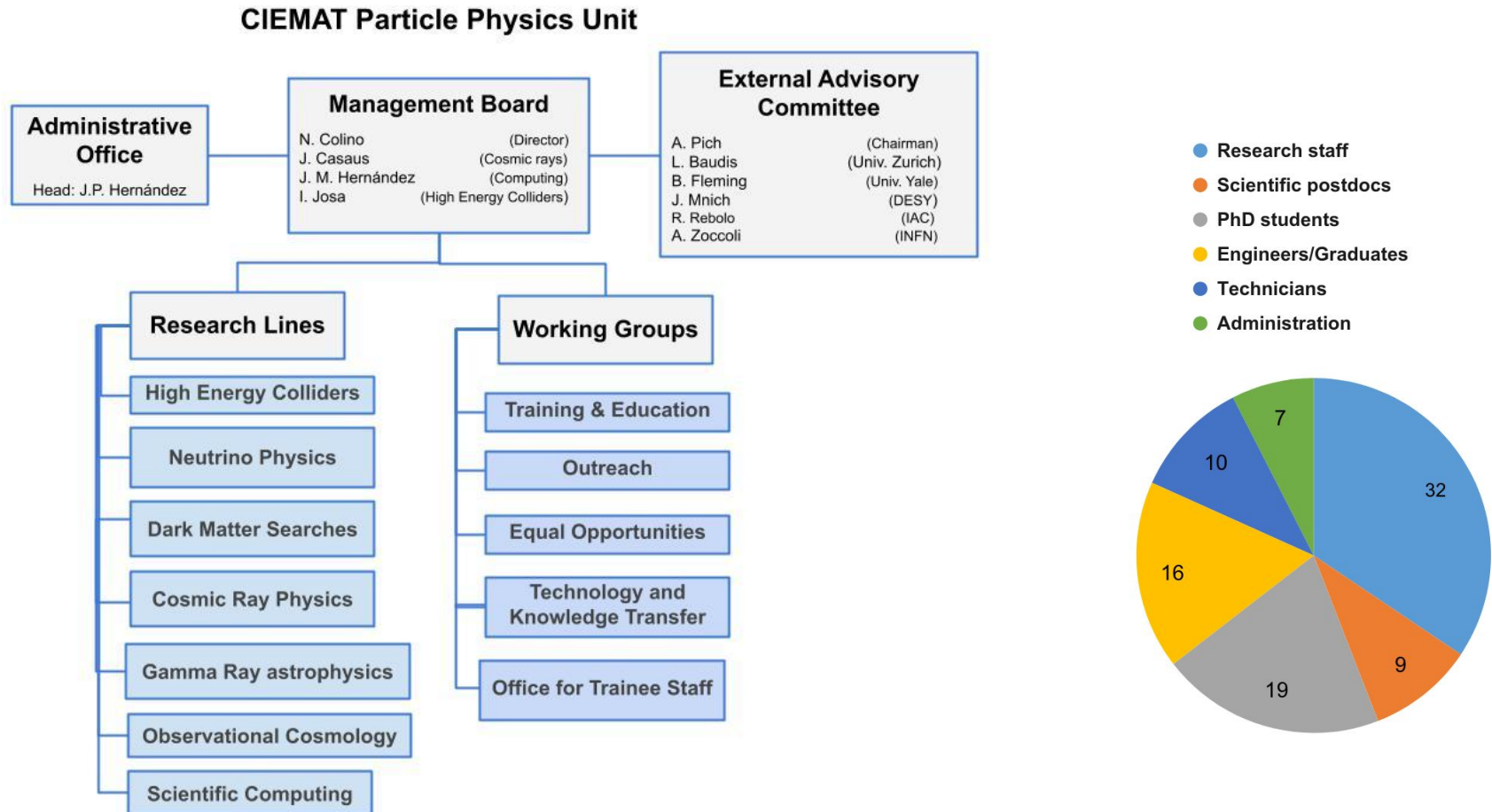
CIEMAT-FP consists of the Experimental High Energy Physics and the Astroparticle Physics divisions, and Scientific Computing Unit.

Most of the research program is developed in six well consolidated research lines.

As of 2023, comprises 93 members, actively involved in various research lines, supported by a dedicated administrative and IT team.

Several transversal Working Groups focus on training, outreach, equal opportunities, technology transfer, and support for early career personnel.

# Structure of the CIEMAT Particle Physics Unit





# Overview of the Research Lines

Our research program has 7 main lines:

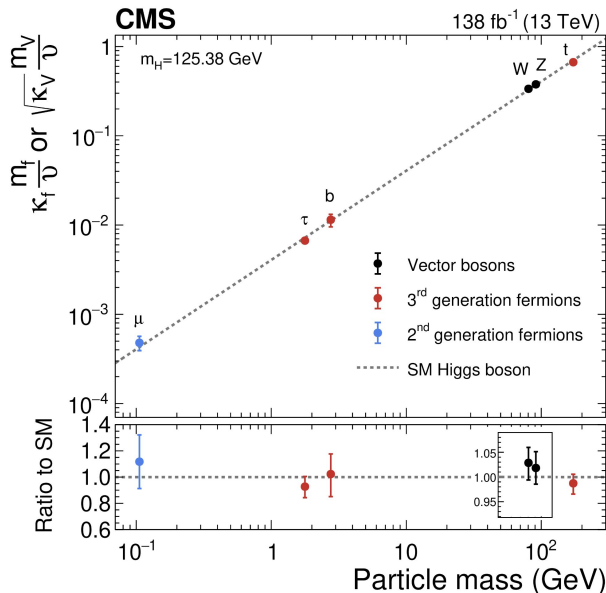
- **High Energy Colliders:** Probing the constituents of the matter  
CMS@LHC: Test the SM to the higher precision and look for new Physics
  - **Neutrino Physics:** Unveiling the properties of neutrinos  
Dchooz, DUNE: Determination of neutrino oscillation parameters
  - **Direct Dark Matter Detection**  
ArDM, DarkSide: look for hints of dark matter scattering. Synergy using Liquid Ar technology
  - **Cosmic Rays Detection:** Dark matter and antimatter  
AMS@ISS: Understanding the origin and history of the cosmic rays and using them to study the physics beyond the standard model
  - **Physics with very high energy gamma rays**  
MAGIC, CTA
  - **Cosmology**  
DES, PAU, DESI, LSST-DESC, Euclid: Most competitive constraints to cosmological parameter of the universe through large scale galaxy surveys.
  - **Advanced Computing Technology**  
WLCG: R+D+i in computing technologies and infrastructure for processing and analyzing huge volumes of scientific data: big science => big data => big computing
- + Emerging line in Gravitational waves (Adv. Virgo and ET)**

# Highlights of the Unit activities: 2020 to mid 2023

# Highlights of the Unit activities: 2020 to mid 2023

## High Energy Colliders

The LHC has surpassed expectations in the measurement of Higgs production and decay.



[Nature 607 \(2022\) 60-68](#)

## A portrait of the Higgs boson 10 years after the discovery

*A comprehensive summary of our understanding of the Higgs boson on the 10 year anniversary of the discovery*

Measurements of **Higgs cross section** (including differentials and double differentials)

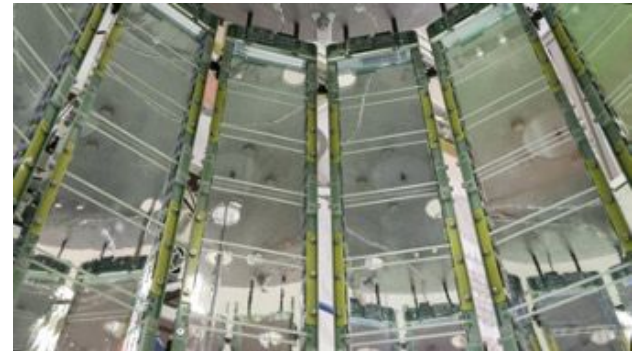
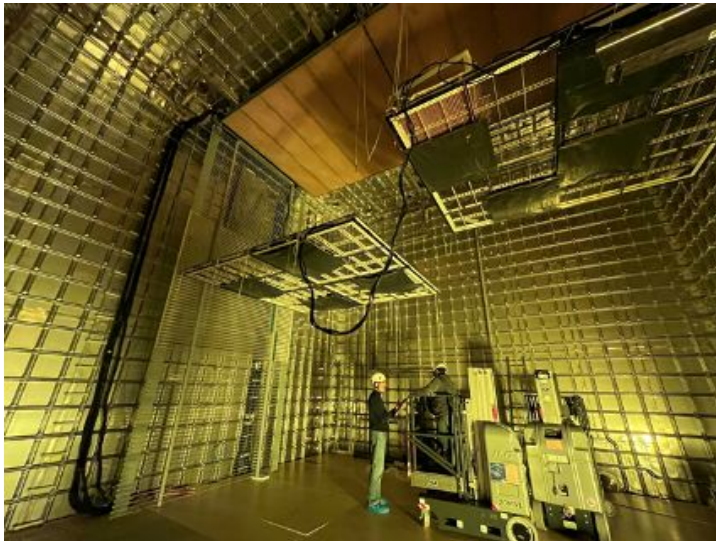
- **Rare decay** modes getting closer (second generation: evidence in muons, revolution in charm prospects; almost arriving at Zgamma)
- **Precision in Higgs Properties**: first measurement of the width, best individual measurement so far of the mass (0.11%), extensive study of CP properties
- **HH production**: 3xSM, sensitivity surpassing previous predictions

CIEMAT contributed directly to this milestone (**HH→ $\tau\tau$ bb**, **Higgs Convensionship**) as a part of our leadership in the Higgs sector

**Engineering System Review of DT electronics Upgrade successfully passed.** HL-LHC production launched

# Highlights of the Unit activities: 2020 to mid 2023

Neutrinos: Photon Detection System (PDS) validation for DUNE far detector



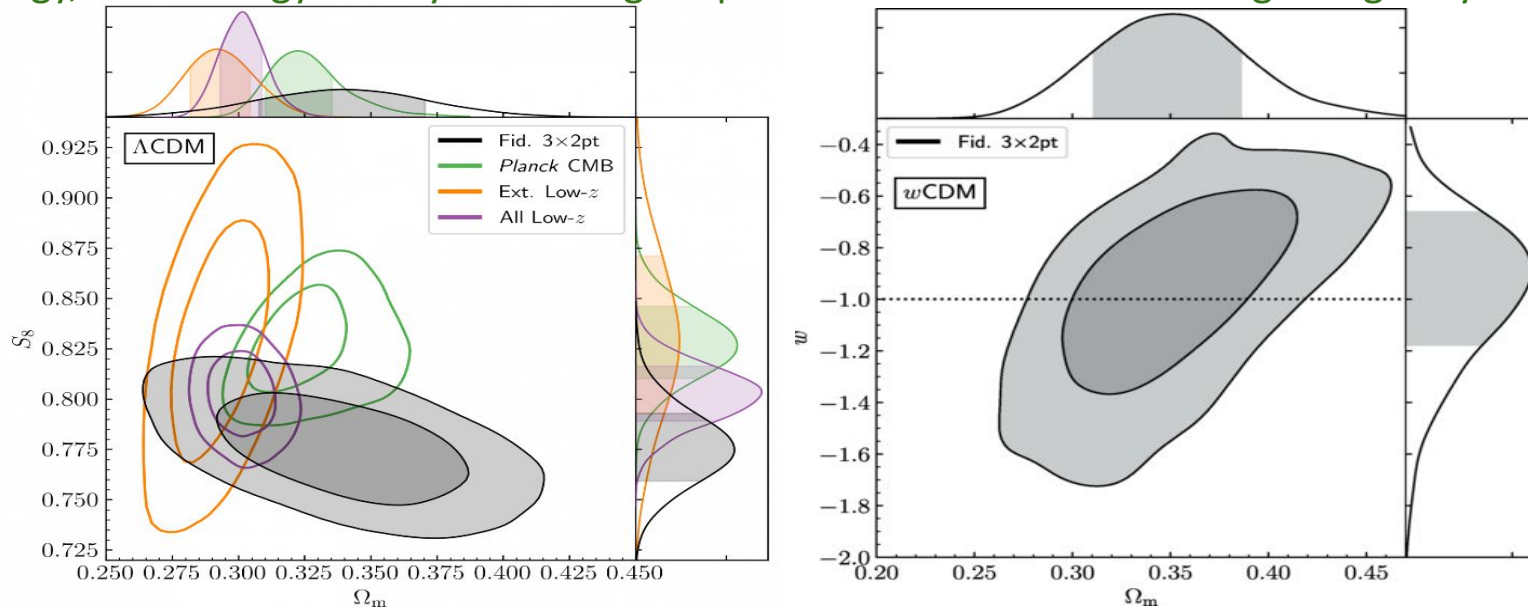
## PDS of the DUNE far detector modules optimized to fulfill DUNE physics requirements

Design, characterization and installation of the PDS in the ProtoDUNEs at the CERN Neutrino Platform  
CIEMAT led:

- Characterization of X-ARAPUCAs at CIEMAT cryogenic laboratory
- Installation of systems at the CERN Neutrino Platform prototypes
- Contributions to simulation and design for FD-2 TDR
- LAr scintillation light production and propagation modelling in ProtoDUNE phase I

# Highlights of the Unit activities: 2020 to mid 2023

Cosmology, Dark Energy Survey: cosmological parameters from weak lensing and galaxy clustering



**$\Lambda$ CDM is a good description of DES-Y3 data, with the dark energy being the cosmological constant**

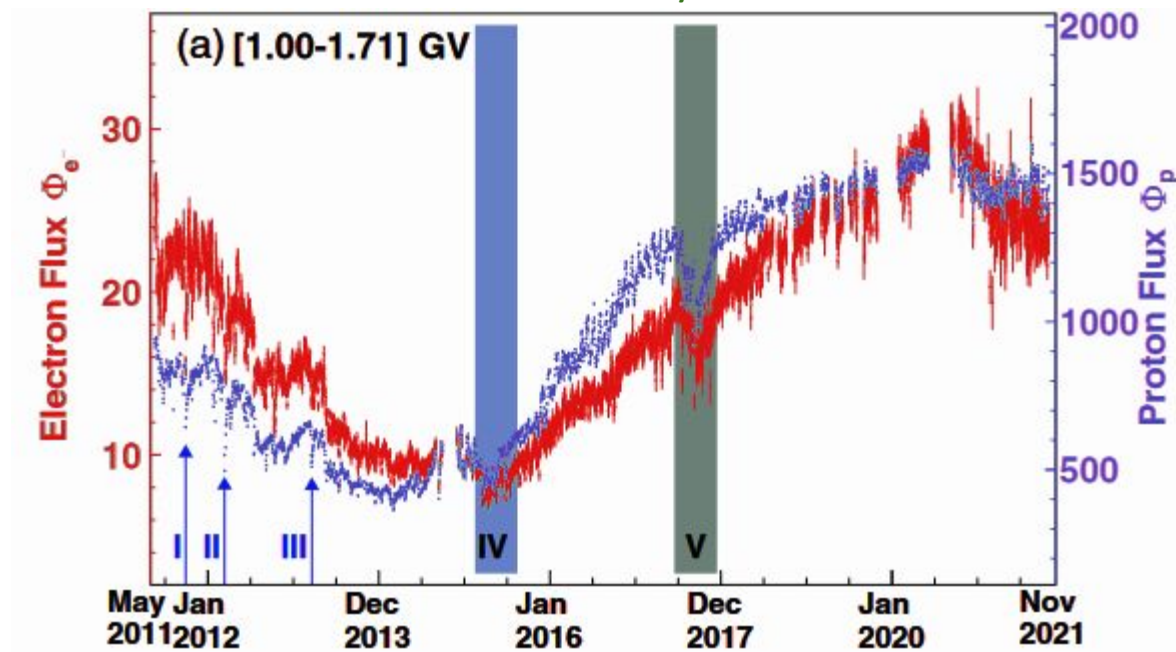
DES-Y3 are the most precise measurement of the cosmological parameters ever done by any imaging survey  
 CIEMAT led:

- The preparation and calibration of the Gold Catalog.
- The full analysis of lens galaxy clustering
- Development of new methods to deal with observational systematic errors that became state-of-the-art
- The determination of the baryon acoustic oscillations scale



# Highlights of the Unit activities: 2020 to mid 2023

Cosmic Rays, Alpha Magnetic Spectrometer AMS: Temporal Structures and Charge Sign Effects in Galactic Cosmic Ray Electrons



**First observation of a distinctly different time variations of electron and proton fluxes over a complete 11-year solar cycle**

AMS provides the first precise measurement of charge-dependent solar effects on galactic cosmic rays  
 CIEMAT led:

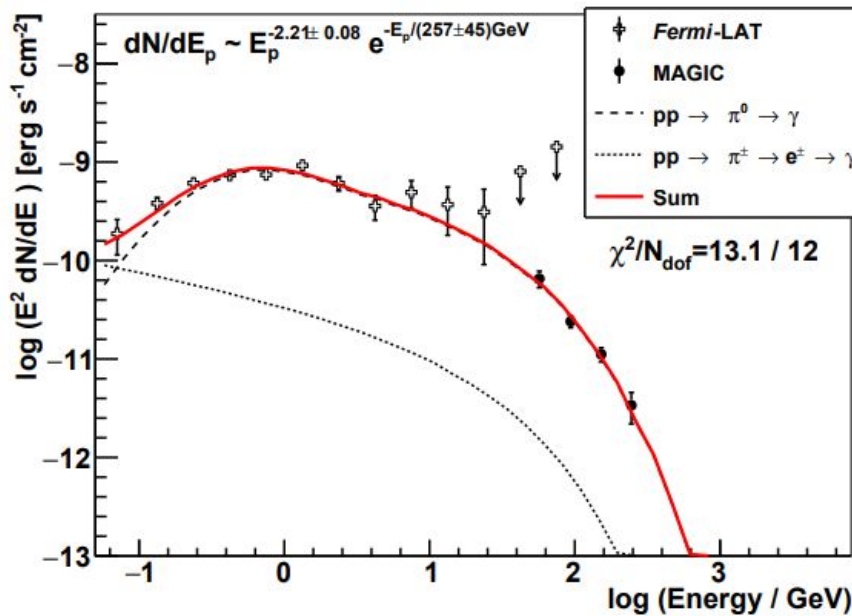
- The development of the selection and analysis of the electron samples
- The evaluation of the hysteresis between the electron flux and the proton flux



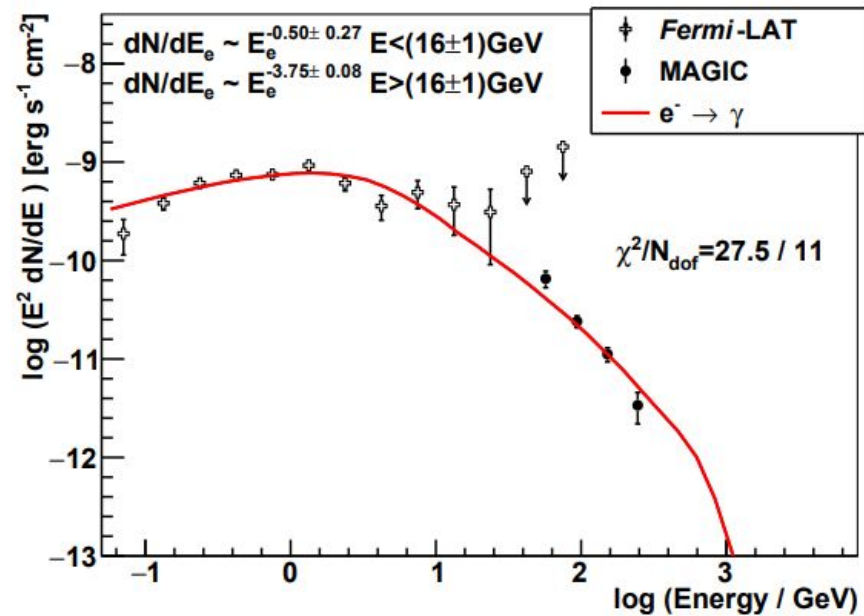
# Highlights of the Unit activities: 2020 to mid 2023

Physics with very high energy gamma rays: proton acceleration in thermonuclear nova explosions revealed by gamma rays

## Hadronic



## Leptonic

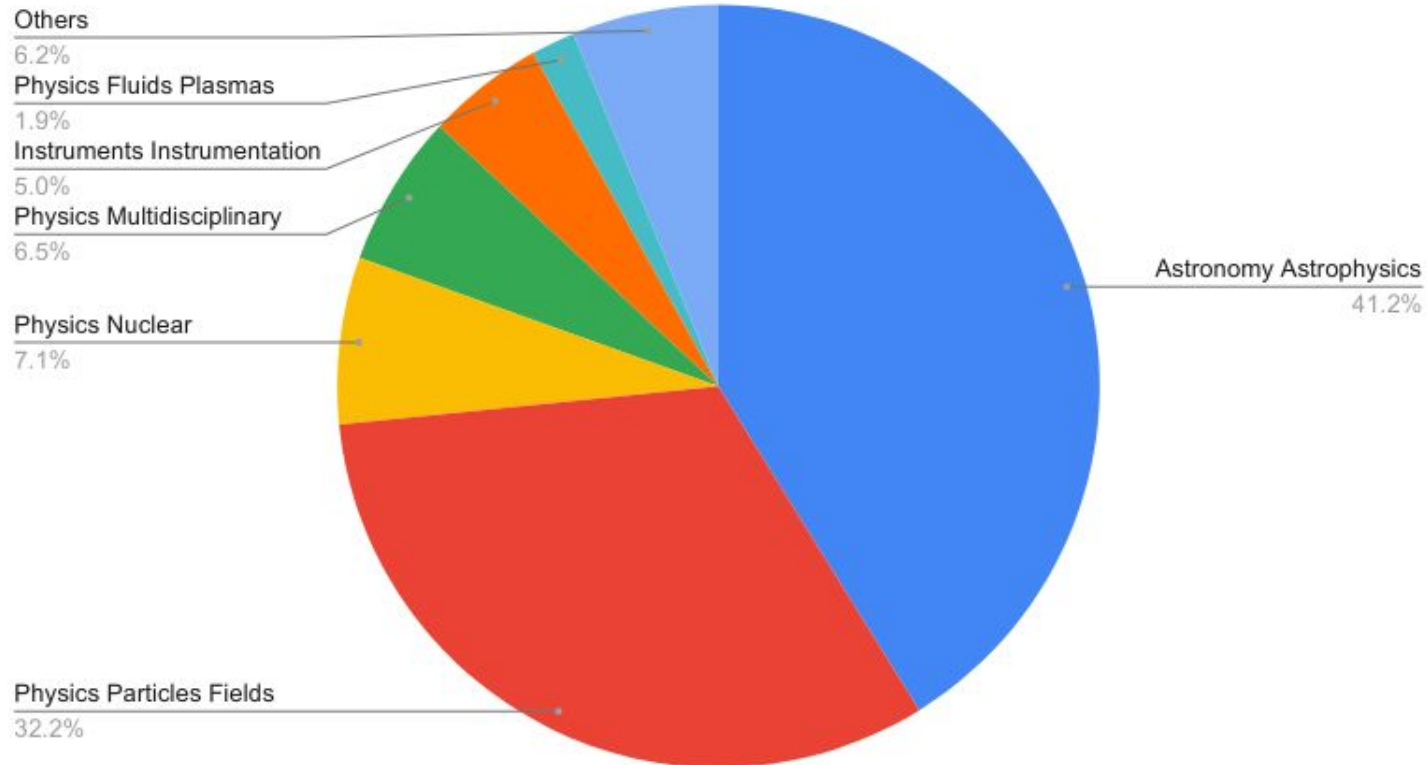


The detection and analysis of VHE gamma rays with MAGIC from the 2021 outburst of the recurrent nova RS Ophiuchi shows that protons are accelerated to hundreds of GeV in the nova shock.

# Highlights of the Unit activities: 2020 to mid 2023

## Distribution of the >150 yearly publications

Journal Category



# Funding sources

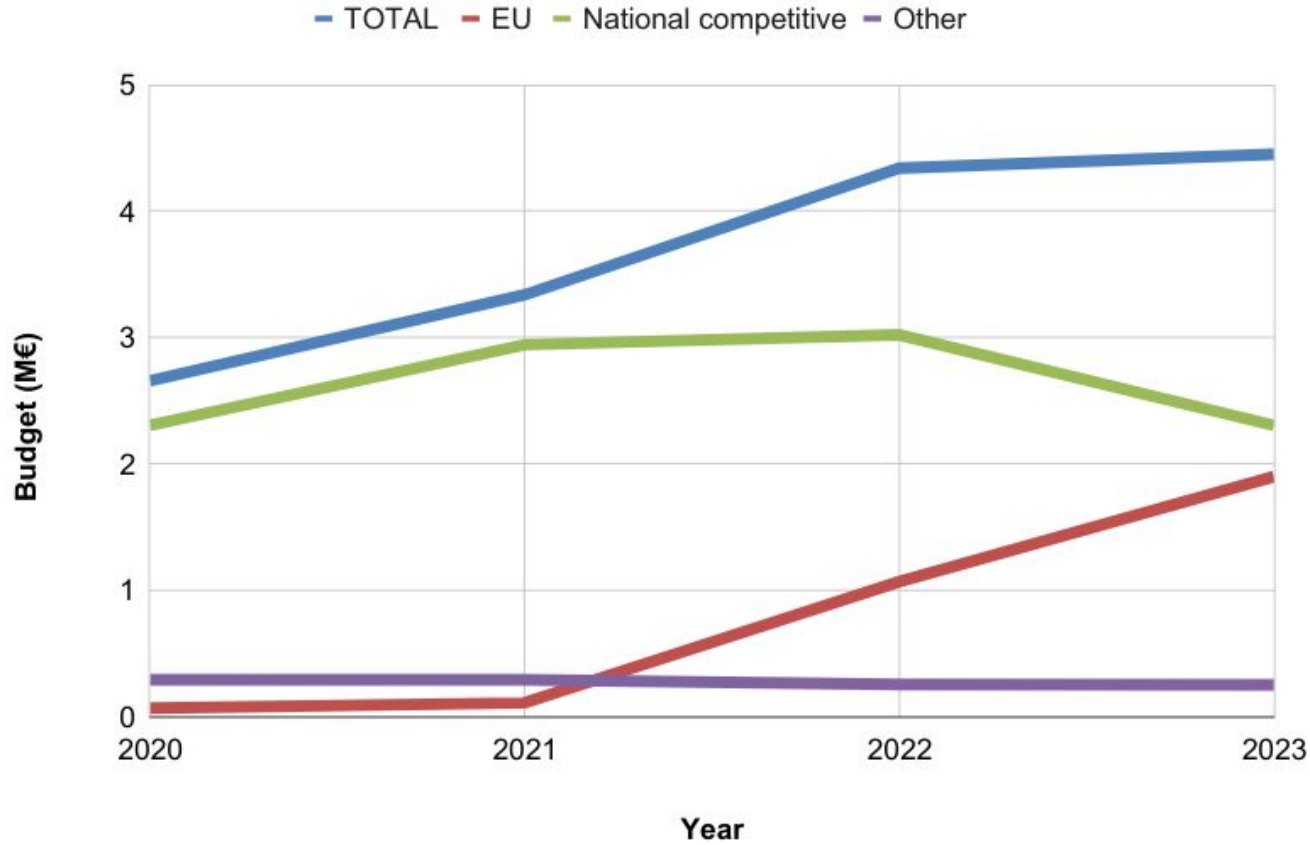
The primary Funding Source is through the Spanish General State Budget provides foundational funding, covering staff salaries and some predoctoral contracts, as well as ~600k€ for M&O and PIC operations.

About 3.5M€ annually of external funding is from competitive sources, with AEI as a key contributor.

Marked growth in European Union funding from 2020 to 2023, reaching ~50% of the Unit total budget in 2023.

In summary, it includes regional funding, national allocations for specific projects, and contributions from private organizations.

# Funding sources



# Funding sources

The EU grants that the Unit has obtained since 2020 are:

- Monitoring nuclear reactions with an opaque detector, AntiMatter-OTech (HORIZON-EIC-2021-PATHFINDEROPEN-01/101047028).
- H2020 and Horizon Europe grants: AIDAInnova (Advancement and Innovation for Detectors at Accelerators).
- Scintillation Light For New Physics with Liquid Argon Neutrino Detectors (H2020-MSCA-IF-2019/892933).
- Search for new physics and technology advancements from neutrino experiments at the high intensity frontier (HORIZON-MSCA-2021-SE-01/101081478).
- Particle Physics Experiments at the High Intensity Frontier (MSCA-ITN-2019/858199).
- Extreme time and angular resolution in the optical with Cherenkov telescopes (ERC Starting Grant /101076533).
- Enabling Weak lensing Cosmology (H2020 grant/776247)

# Working groups

In addition to the scientific research lines

**Five** working groups to address specific goals:

- Training & education
- Outreach
- Equal opportunities
- Knowledge and technology transfer
- Office for trainee staff



# Concluding remarks

CIEMAT-FP continue its commitment to excellence through rigorous research, interdisciplinary collaboration, and innovative discoveries.

Since the end of the Maria de Maeztu accreditation, funding increased and diversified with more international contributors.

We continue our active engagement in Particle and AstroParticle Physics experiments, with new focus on Gravitational Waves research.

We have reinforced the recruitment of young researchers and established the Early Career Personnel office, emphasizing growth and development.

# End

# Research lines

- Our **research program** has 4 main lines and 2 transversal ones:
  - **Hadron Colliders**, the high energy frontier:
    - CMS@LHC: Test the SM to the higher precision and look for new Physics
  - **Neutrino Physics** and Direct **Dark Matter** Searches:
    - Dchooz, ArDM, Dune, DarkSide: Determination of neutrino oscillation parameters and look for hints of dark matter scattering. Synergy using Liquid Ar technology
  - **Cosmic and Gamma Rays Physics**:
    - AMS@ISS, Magic, CTA: Understanding the origin and history of the cosmic rays and using them to study the physics beyond the standard model
  - **Observational Cosmology**:
    - DES, PAU, Starbursts: Most competitive constraints to cosmological parameter of the universe through large scale galaxy surveys.
  - **Detector R&D**:
    - CMS upgrade@HL-LHC, LAr, CaloCube, Calice: Constant developments of new detector technologies for present and future experiments
  - **Scientific Computing**:
    - WLCG: R+D+i in computing technologies and infrastructure for processing and analyzing huge volumes of scientific data: big science => big data => big computing

# General Objectives

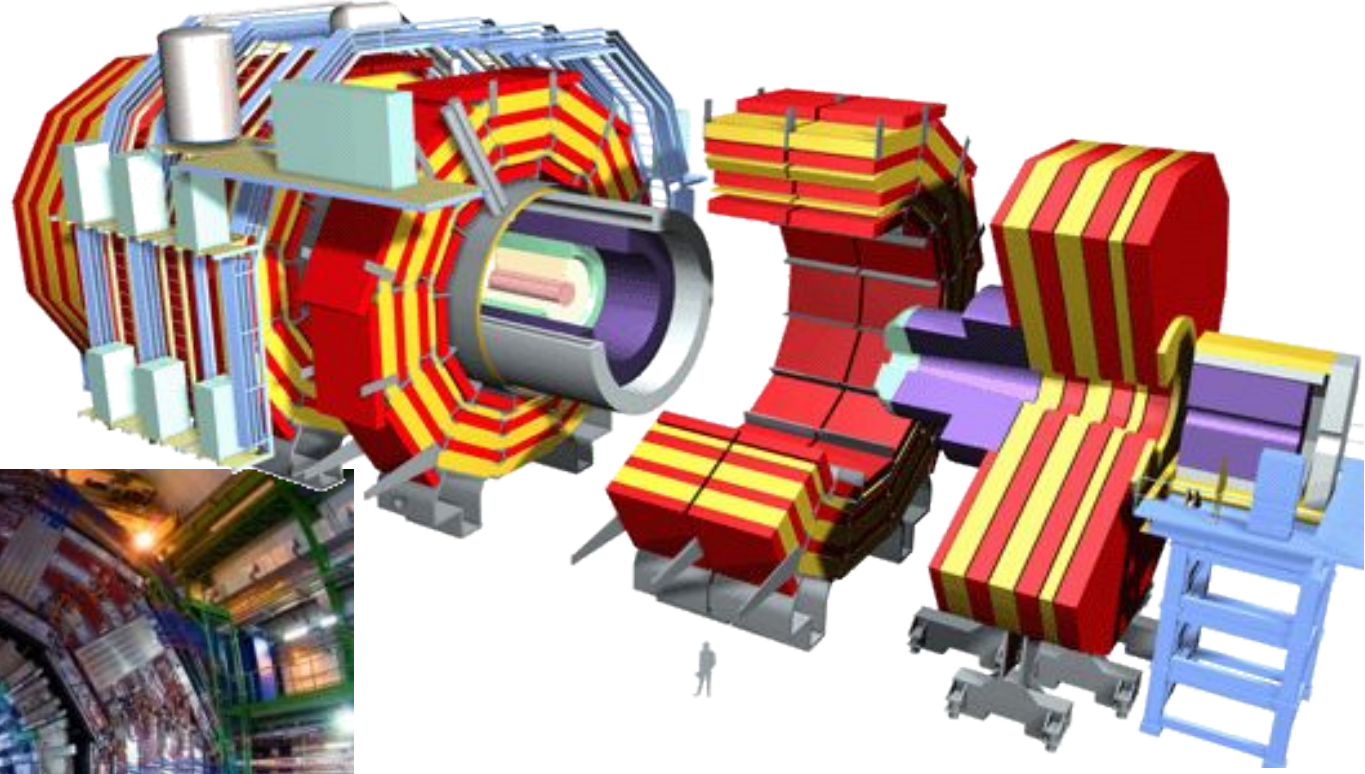
Our main scientific objective is to contribute to the solution of some of the most basic pending questions in Fundamental Physics:

- Is there physics beyond the Standard Model of particle physics?
- Are neutrinos a window to new physics?
- What is the nature of dark matter?
- What is dark energy?

The experimental approach required to solve these questions implies the participation in **big international collaborations** and the use of significant **technological resources** in hardware and computer development



# Hadron Colliders: **CMS** detector



Study of particle physics standard model and searches for new physics

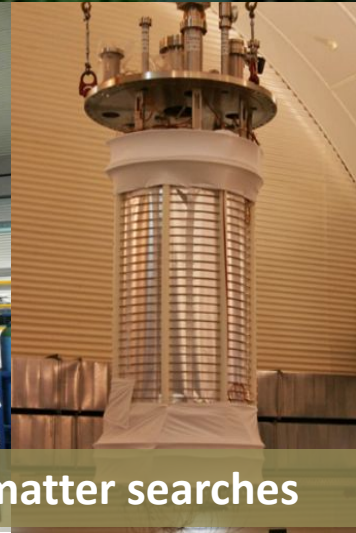
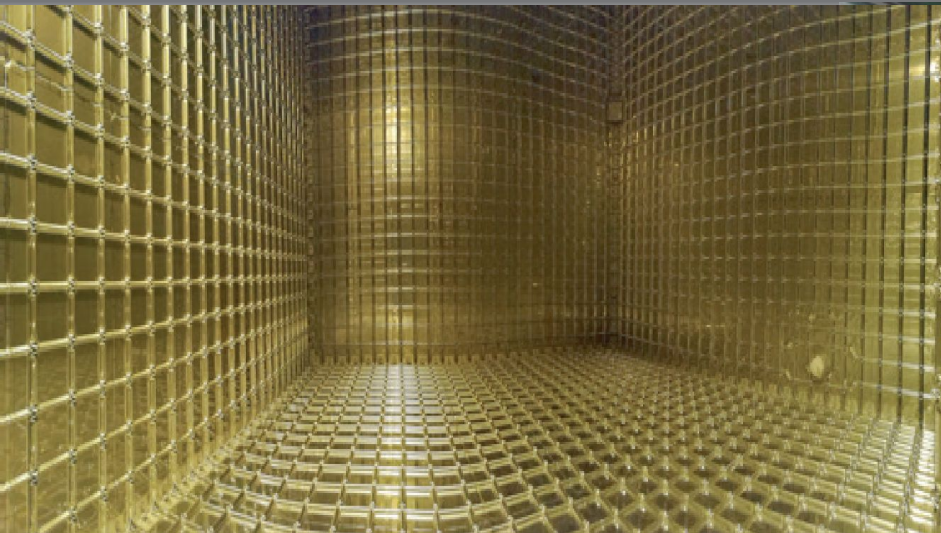
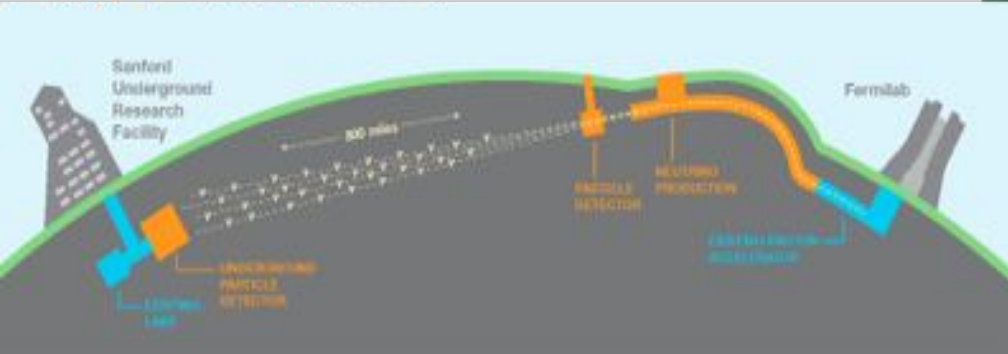


# Neutrino Physics & Direct Dark Matter

Neutrino oscillation studies in nuclear reactors and accelerators



**DUNE** DEEP UNDERGROUND NEUTRINO EXPERIMENT



Direct dark matter searches





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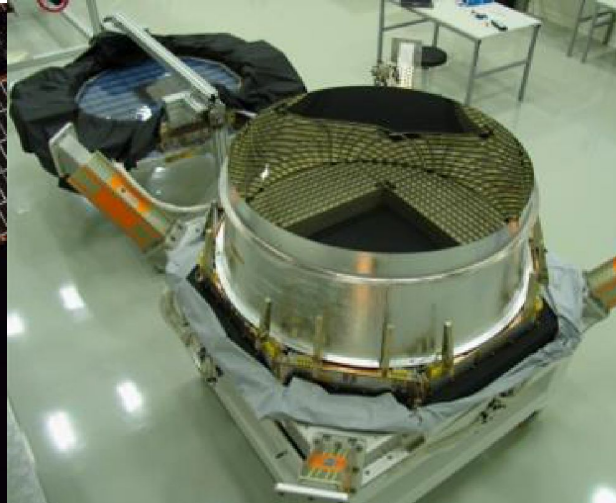
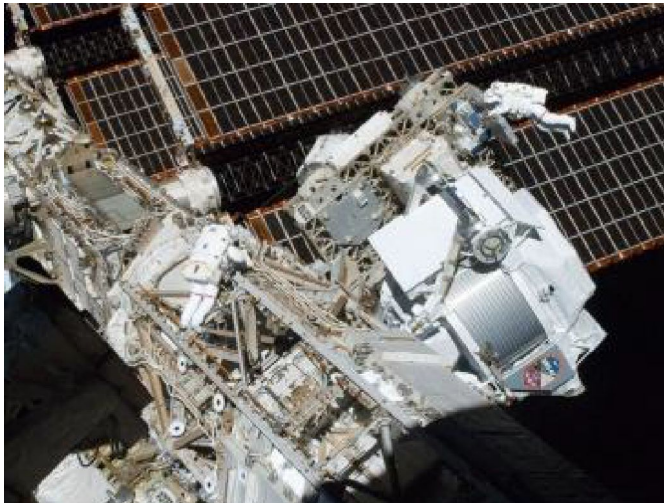
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Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas



física de partículas

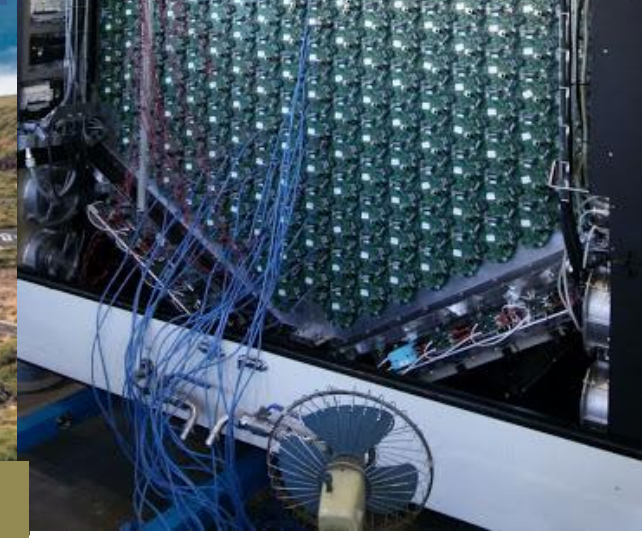
# Cosmic and Gamma Rays Physics



Search for dark matter, antimatter and cosmic rays in space

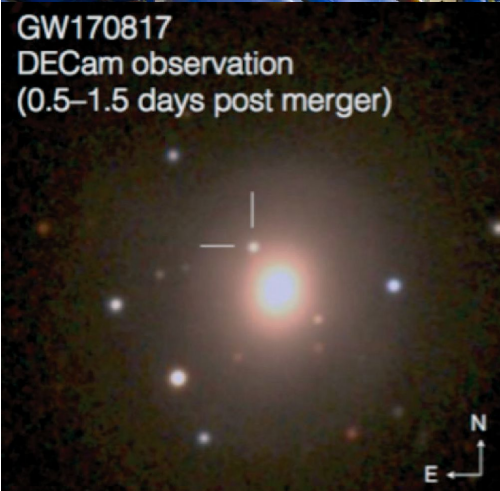


Study of high energy cosmic rays





# Observational Cosmology



**Study of dark matter, dark energy and cosmological parameters**





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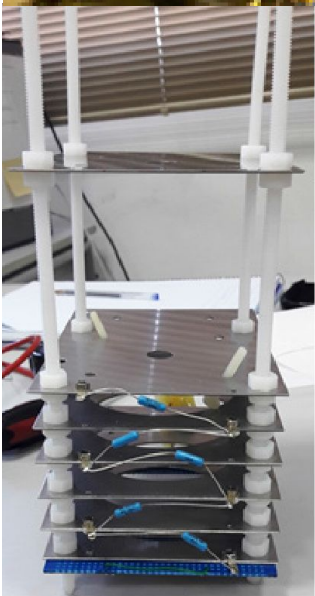
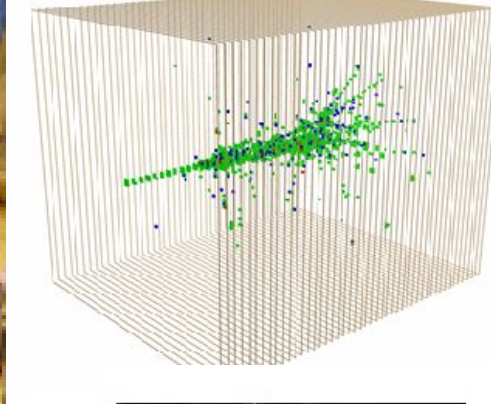
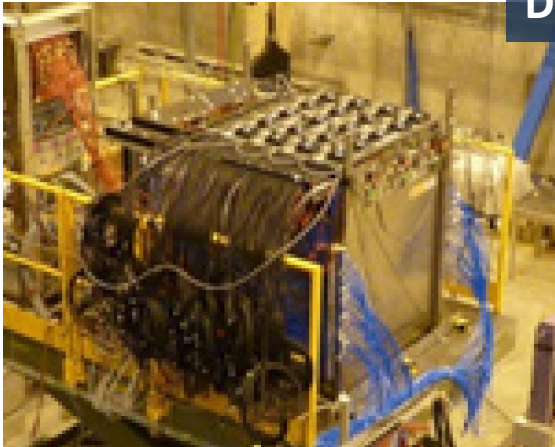
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# Detector R&D

## Detectors for next generation colliders

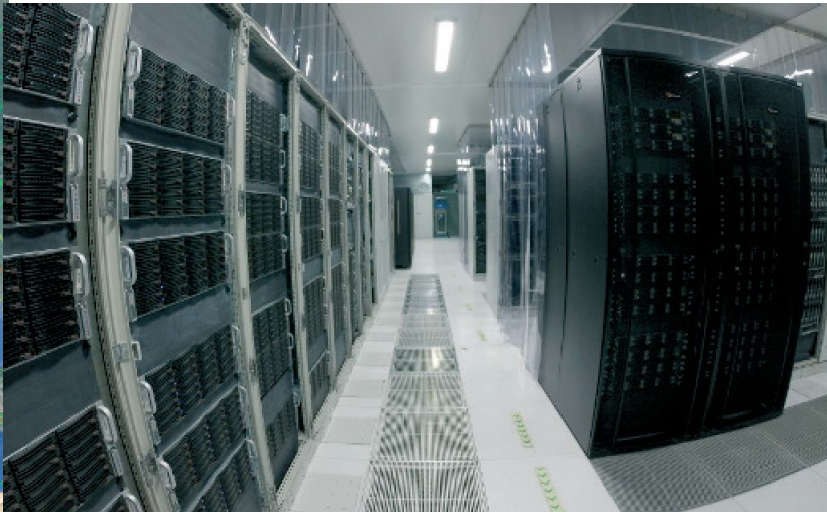
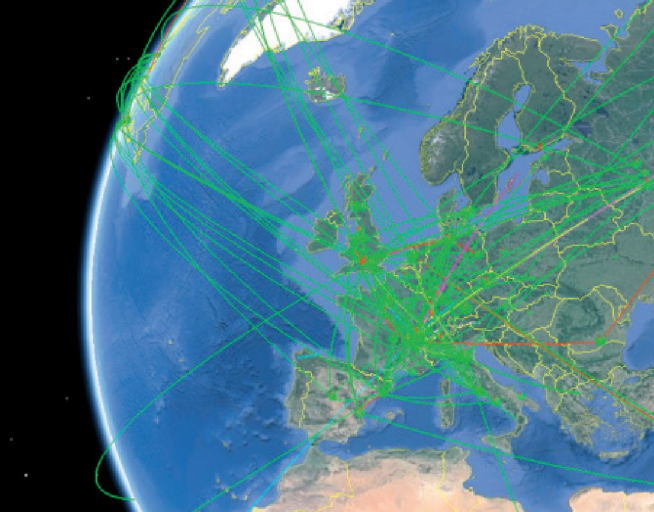




# Scientific Computing



Data intensive distributed computing



# María de Maeztu Unit of Excellence (2016-2019)

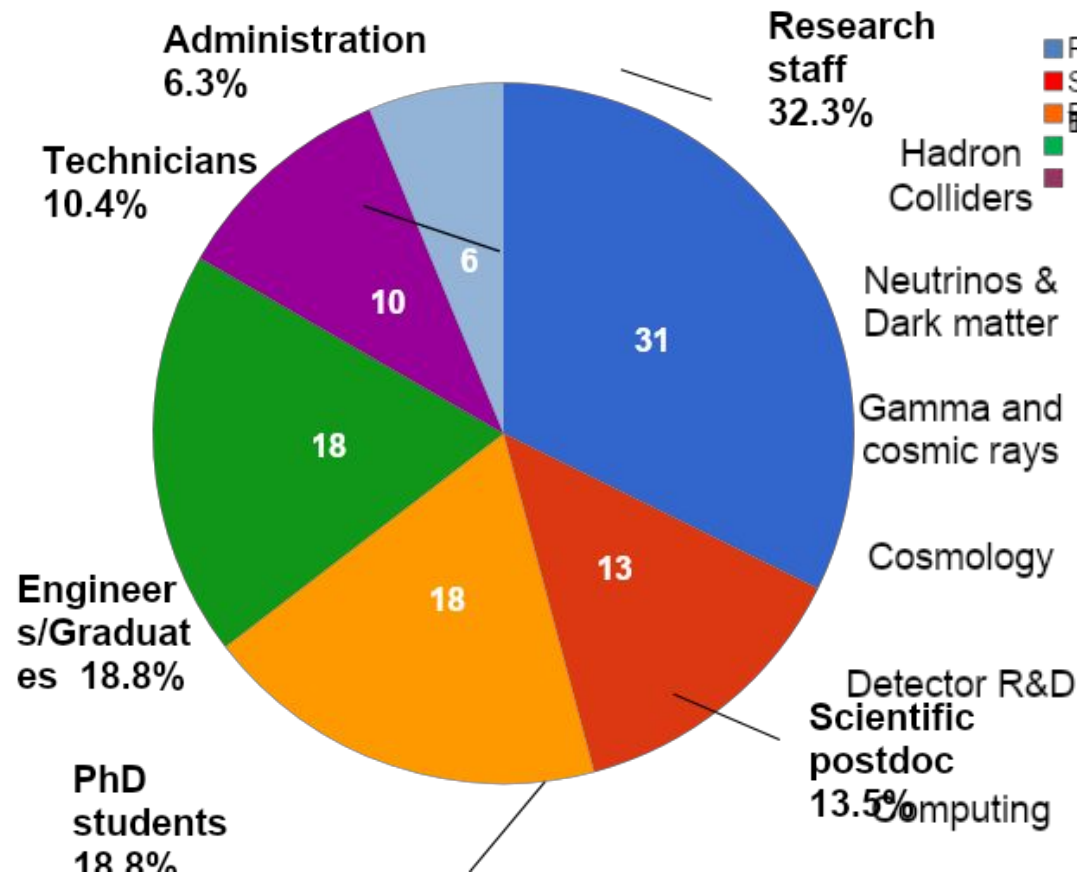
- **Accreditation** in 2015 as María de Maeztu Unit of **Excellence** by the Spanish R&D&I programme
  - Distinguishes the **best research groups in Spain** that stand out for the relevance and impact of their research outcomes at an international level, significantly contributing to expand the frontiers of knowledge, as well as to the leadership of Spanish science.
  - **Competitive process** based on international standards
  - Provides **funding** for the implementation of the research programme
  - Aimed at strengthening the scientific-technical capacities, promoting synergies that attract resources and increase research potential at an international level



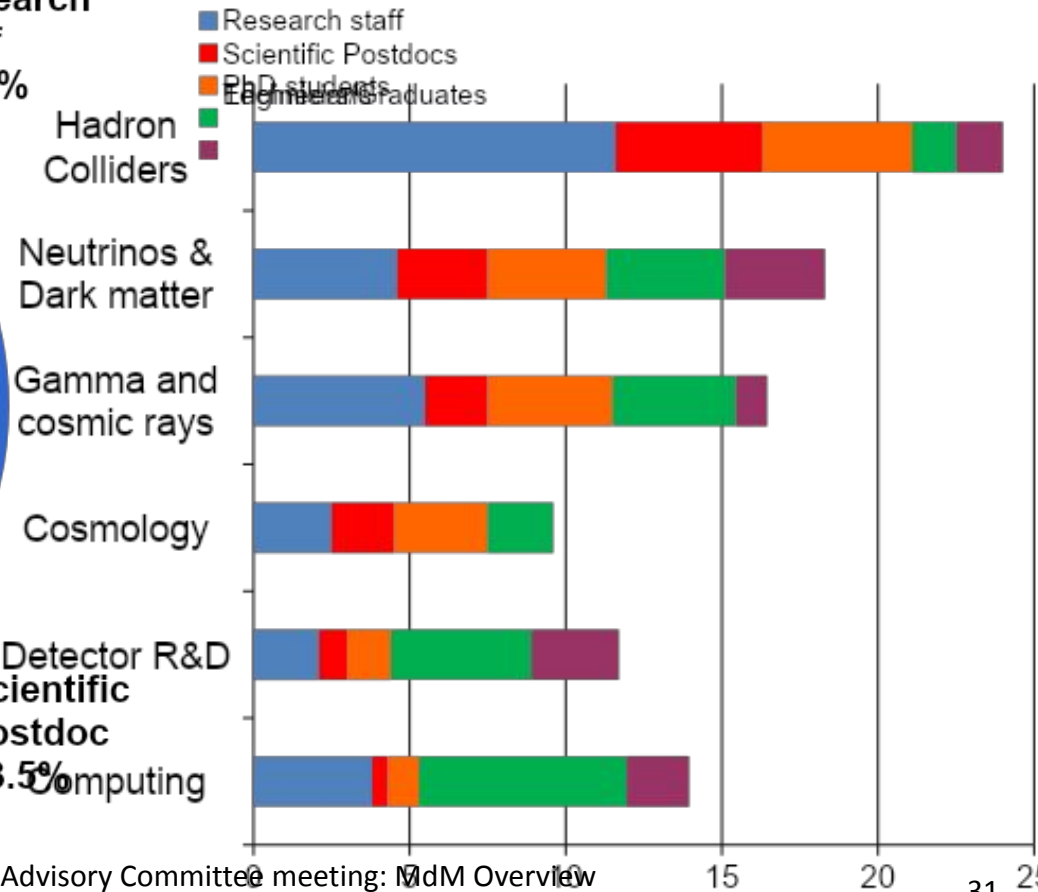
# CIEMAT-Particle Physic Unit (CFP)

96 people, 24% women, 51% PhDs, 51% staff (as of 30/09/2019)

Personnel by type



Personnel by research line (FTE)





# Some indicators of scientific production

## (2018-2019)

354

Articles on indexed journals

79%

Articles in Q1

5.40

Average journal impact

12

Internships

20

Master Thesis

3

PhD Thesis

125

Presentations at international conferences

# Statement about the charge of the External Scientific Advisory Committee

- We expect that this Committee will elaborate a brief report summarizing the evaluation of our activities during the last couple of years and guidance about our strategic research plan for the next years
- What we would like to learn from you, is basically the following:
  - 1) Your view about the relevance of our scientific program. Essentially, how do you see our program in the frame of the current status and challenges of the field of particle and astroparticle experimental physics?
  - 2) How well do you think that we are we doing our work? How important is the impact of our activities in each of the research lines? Is this impact internationally recognized?
  - 3) Considering the prospects we have in each line for the near future, would you think that we are following the right track?
  - 4) Any observation and recommendation you may make us about the way to improve the performance of our Unit, from the point of view of scientific issues and/or at the level of organization and management.
- We need your feedback to optimize our future research program to face the new request for the MdM excellence accreditation

# End

# María de Maeztu Unit of Excellence

## award

- CFP Unit was recognized as MdM Unit of excellence in 2015 by the Ministry
  - Best research groups at international level and leadership of Spanish science

- **Strengths:**

- Unit with the **highest international standing**, among the 5-6 best centers in Europe.
- **Unique capabilities in Spain** for two aspects: know-how for large experiment equipment, and scientific computing.
- **Research program is coherent** focusing on the fundamental questions ... is well balanced with a good complementary between the research lines, reinforced by the transversal activities.
- The level of participation, the **visibility** of the team members and their **responsibilities** in those collaborations **are impressive**.
- The senior **scientists are highly respected** in the field.

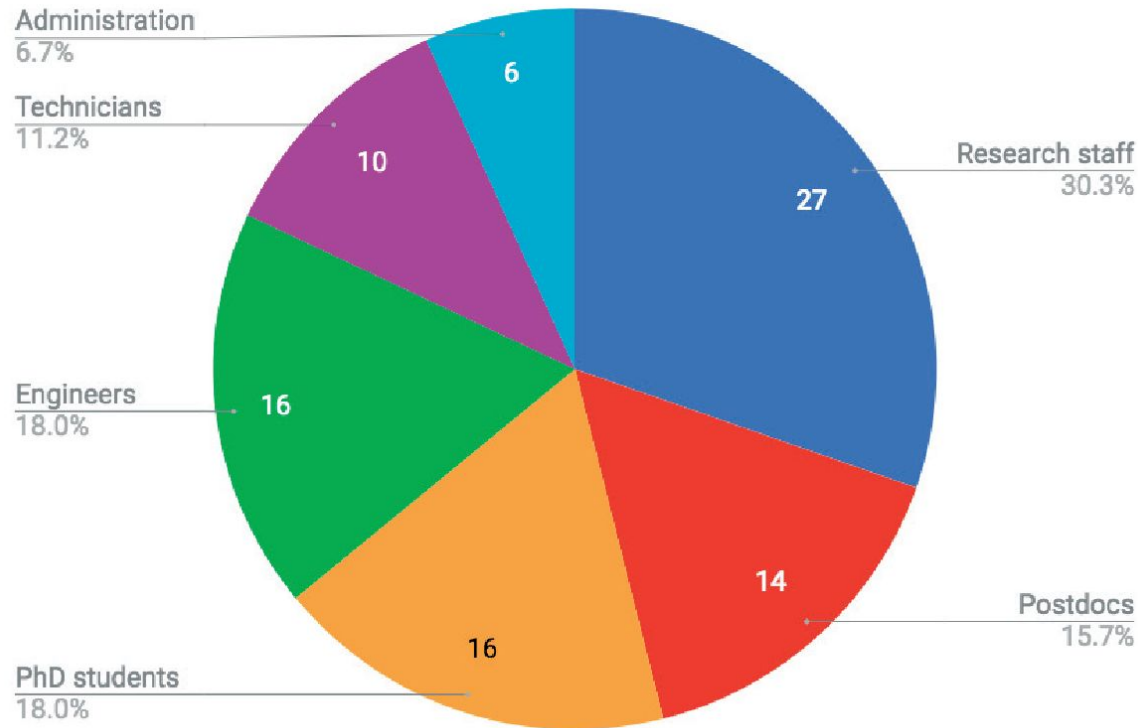
- **Weakness:**

- The open positions are announced at international scale in order to attract the best candidates. However, there have been **difficulties for hiring postdocs**.
- **Small number of PhD students and all of them are from Spain**.
- A stronger **liaison with the industry** (spin-offs, patents) could be expected, in particular from the two more technological sectors, detector R&D and computing.
- Participation to **EU programs** is still limited.
- Does not benefit from **private funding**.

# CIEMAT-Particle Physic Unit, (CFP)

89 people, 25% women, 54% with a PhD, 49% staff

Personnel by type



# Some indicators of scientific production

- The overall impact of the MdM accreditation in the activities of the specific research lines will be presented during this meeting

380

Articles on  
indexed  
journals

91,6%

Articles in  
Q1

5.28

Average  
journal  
impact

12

Master  
Thesis

6

PhD Thesis

80

Presentations  
at international  
conferences