R&D on Liquid Argon TPCs: Overview and DUNE-Spain interests

CIEMAT, Granada, IFIC, Santiago, Vigo

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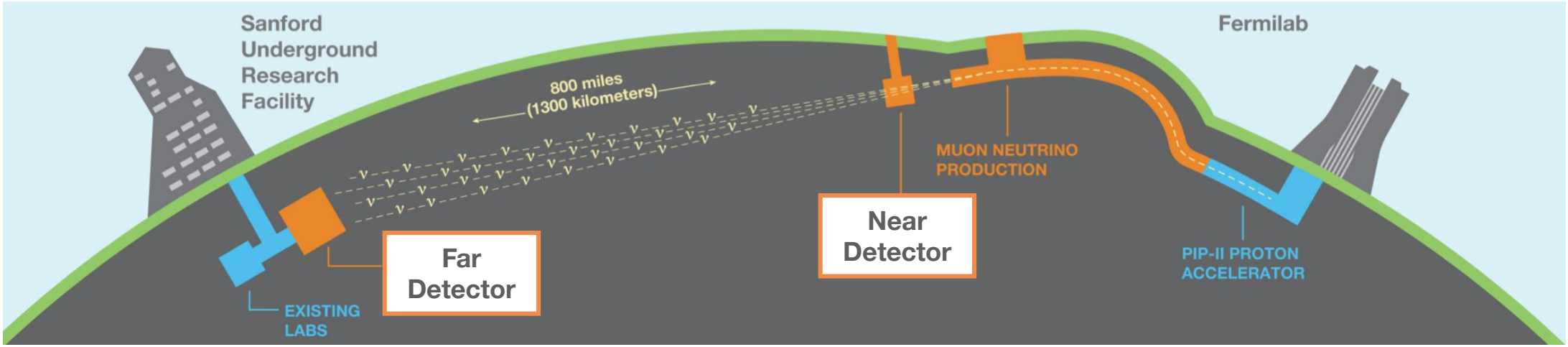
LArTPCs for Neutrino Physics: Status

DUNE: The flag-ship for the upcoming decades



DUNE Physics Coordinator, Inés Gil Botella (CIEMAT)

DUNE MILESTONES:

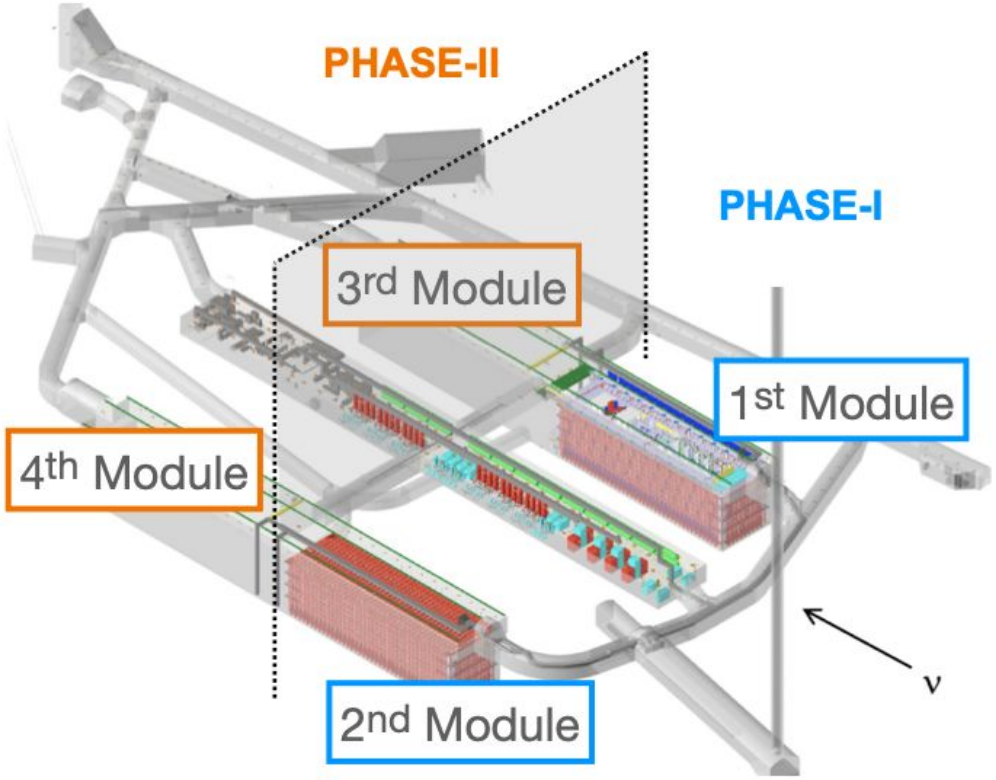
-> Precision Oscillation Measurements (neutrino mass ordering and δ_{CP})

-> Low energy Neutrinos (supernova neutrinos) Clara Cuesta (CIEMAT), working group convener

-> Beyond Standard Model Physics Justo Martín-Albo (IFIC) , working group convener

LArTPCs for Neutrino Physics: Status

DUNE Far Detector (FD): 4 LArTPC Modules



- **PHASE-I:** technology already decided. Single-Phase LArTPCs

  -> Room for final adjustments and optimisation of some components

- **PHASE-II:** opportunity for further detector development in liquid-argon or alternate detector technologies in support of the DUNE physics goals

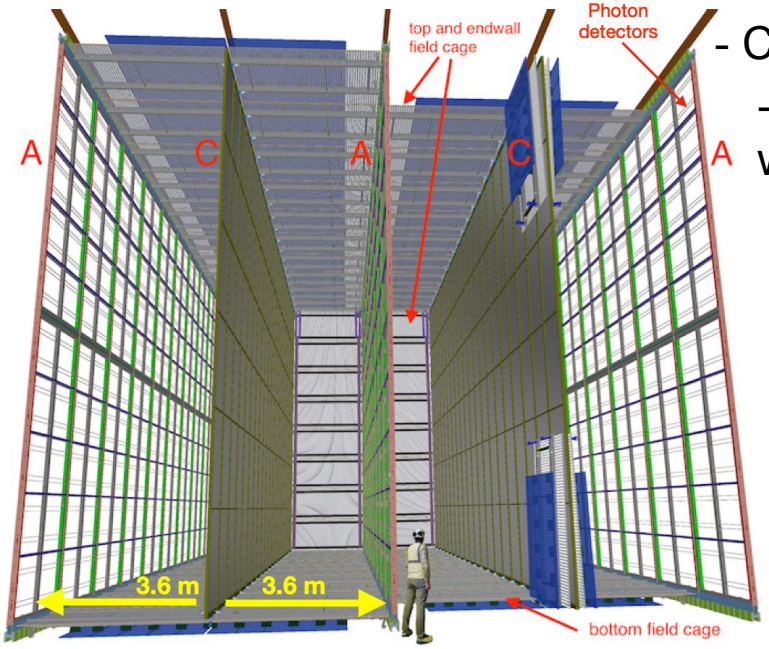
  -> Michel Sorel (IFIC), deputy-coordinator of the PHASE-II working group

DUNE FD PHASE-I

Configuration of the first two modules

DUNE FD1 (HD)

Single Phase + Horizontal Drift

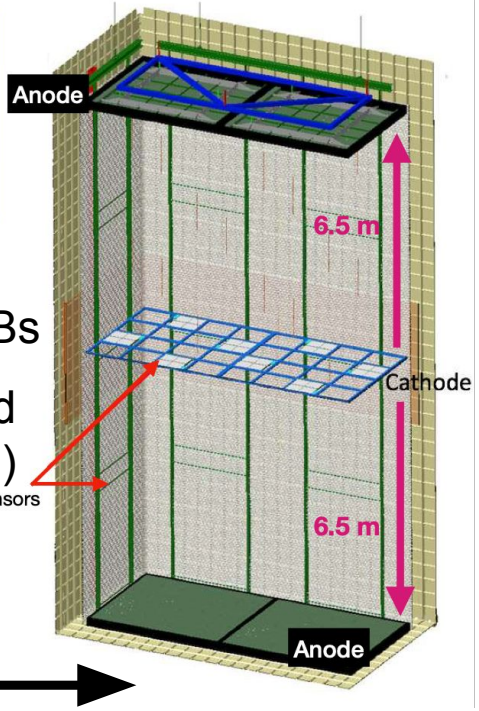


- Charge readout based on wires
  - Light detection between the wires based on SiPMs

DUNE FD2 (VD)

Single Phase + Vertical Drift

- Charge readout based on perforated PCBs
  - Light detection on the cathode and the walls (based on SiPMs as well)



Move to a cheaper and more efficient configuration →

Spain responsibilities in DUNE PHASE-I

Photo Detection System (PDS)

- SiPMs: Development of technology with manufacturers
- SiPMs: Procurement and test (200.000 units for FD1 & FD2)
- Cold Electronics
- Assembly of PDS units & quality centers in Spain
- Optical components of the PDS for FD2
- Mechanics & warm electronics for FD2
- Calibration of the PDS for FD2

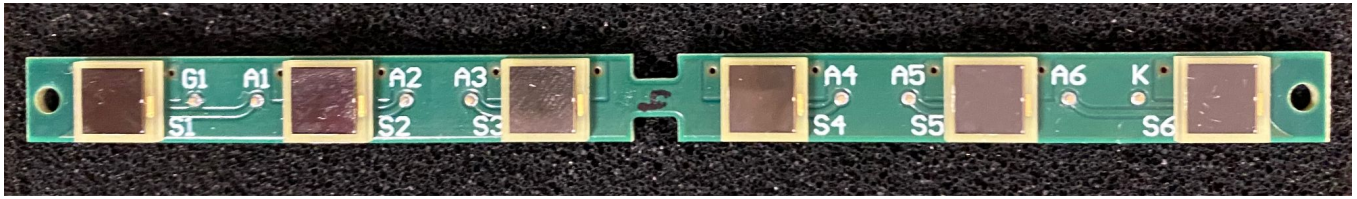
Cryogenic Instrumentation → Temperature Monitoring System (TMS)

ProtoDUNEs → Design, construction, tests, installation of the PDS & TMS, analysis…

SiPMs for the FD1 and FD2

Spain is in charge of the procurement (HPK & FBK) of half of the SiPMs to be installed in the first DUNE Modules (FD1-HD & FD2-VD)

responsibility shared together with INFN



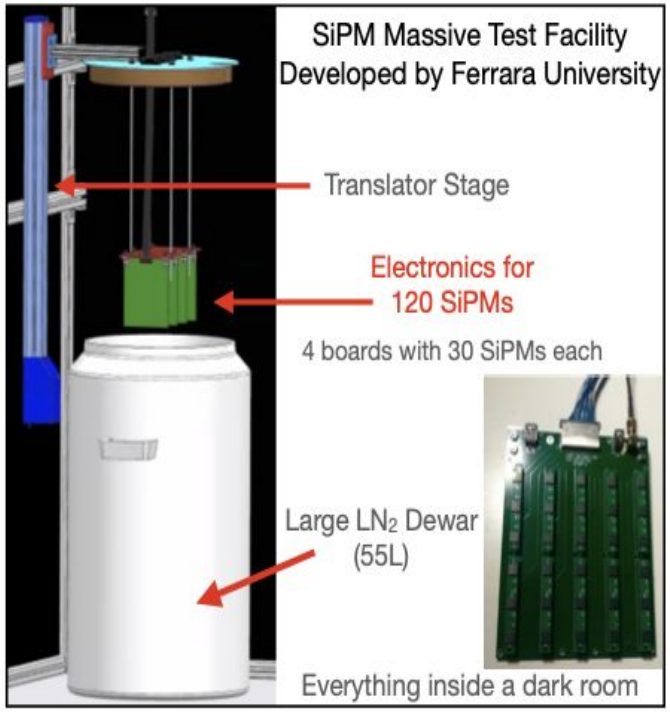
SiPM Array for the FD1

SiPM Array for the FD2

Massive testing of the SiPMs

We will install two facilities (Granada, IFIC) to characterize and check the performance of thousands of SiPMs per month prior their final installation in the detector

Granada will test 20% of of the total number of SiPMs for DUNE



The DUNE collaboration needs 5 of these facilities around the world

- Ferrara ✅
- Bologna ✅
- Granada
- Prague
- Milano Bicocca

WORK IN PROGRESS

We are just waiting for the electronics to install the system

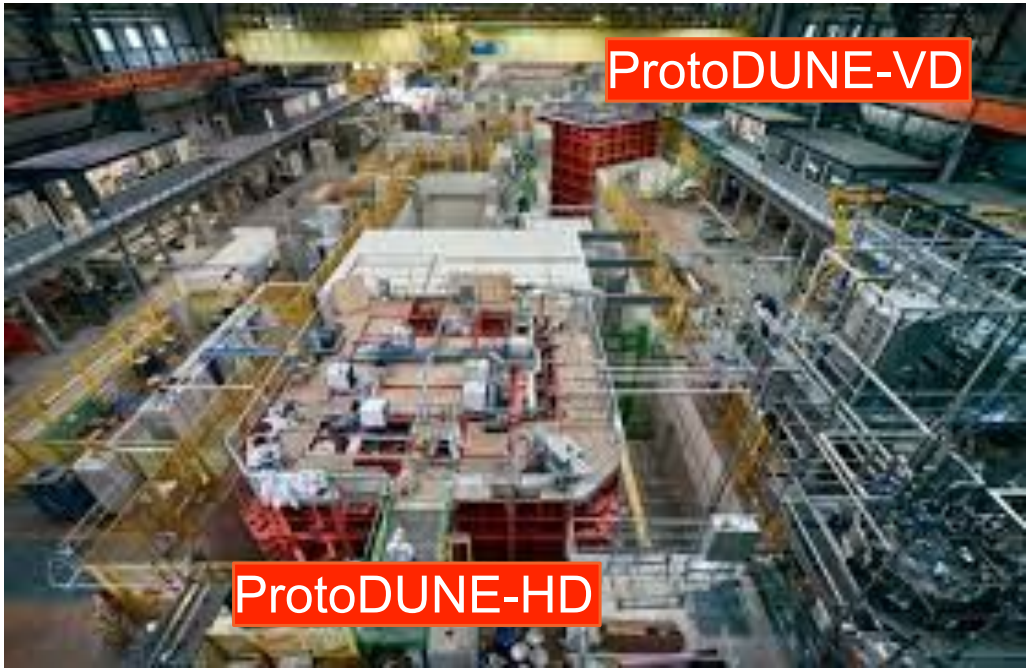
shortage of components 😔😔

IFIC will perform a detailed study of 5% of of the total number of SiPMs for DUNE

The installation of the infrastructure is almost ready. The campaign of testing will extend over 2 years

DUNE FD PHASE-I Prototypes

Technology choices based on the performance of the 2 ProtoDUNEs at CERN



The first run of the ProtoDUNEs helped to choose the single phase technology as the most convenient one for the PHASE-I

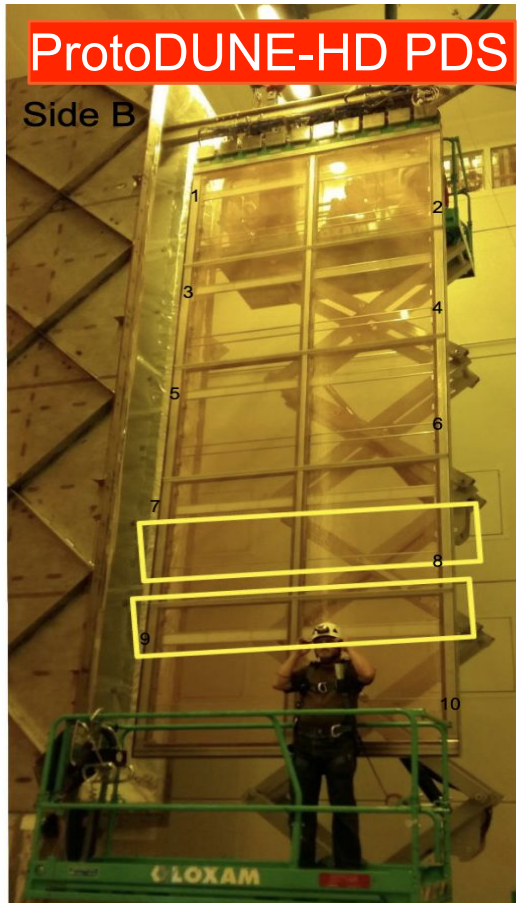
ProtoDUNE-HD next run: assembly and testing of final DUNE-size components

ProtoDUNE-VD next run: test of the VD concept at large scale

The Spanish groups hold important responsibilities in both ProtoDUNEs (Coordinators of PDS & TMS installation)

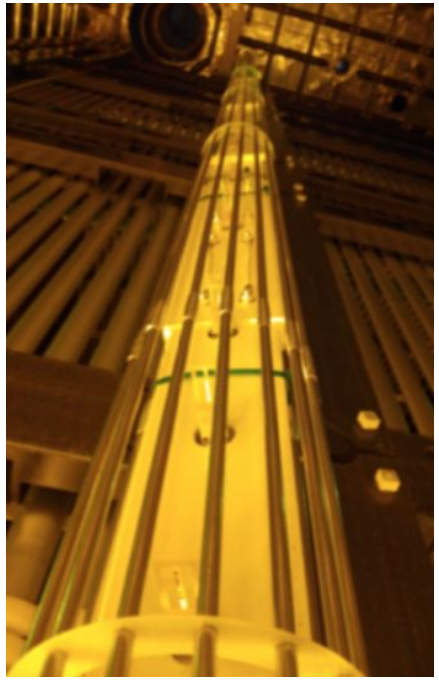
DUNE FD PHASE-I Prototypes

ProtoDUNE-HD PDS



ProtoDUNE-VD PDS

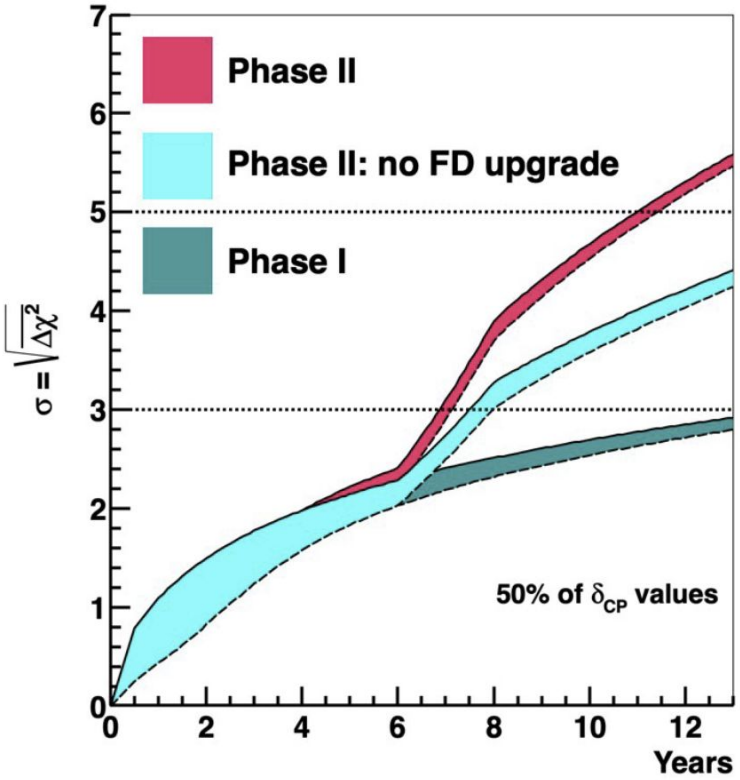
ProtoDUNE-HD TMS



Crucial responsibilities on the design, construction and installation of the PDS & TMS of both ProtoDUNEs at CERN

DUNE PHASE-II

GOAL: Expand DUNE physics program



- The DUNE PHASE-II is essential to achieve the DUNE physics potential

  —> Beam 2.4 MW + Near Detector with a gas argon detector + FD3 & FD4

- In addition is an excellent opportunity to expand the DUNE physics program to lower energies with aggressive modifications of the detectors FD3 and FD4

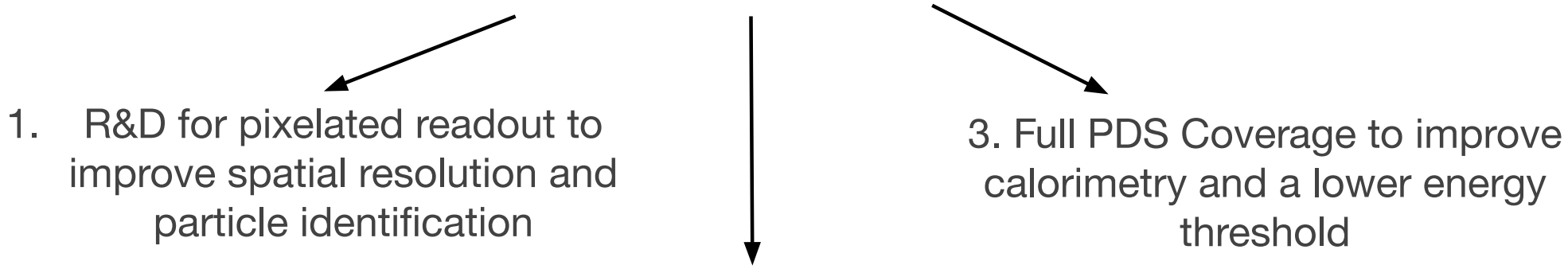
  —> Strong R&D programme starting

- Possible expanded physics scope:

  —> Solar neutrinos, low mass dark matter, neutrinoless double beta decay …

DUNE FD PHASE-II R&D Challenges

A better performance of the detector requires R&D to address 3 main areas



The DUNE-Spain R&D interests follow these 3 lines

DUNE-Spain R&D Interests

1. Photon Trapping Techniques
2. Wavelength-shifting Techniques
3. Cryogenic Instrumentation
4. Optical Characterization of materials
5. Cryogenic photosensors
6. Scaling-up Challenges
7. Monolithic light-charge pixel-based readout
8. Simulation and Reconstruction Techniques

see talk by Justo

see talk by Clara

Total number of people in DUNE from Spain: 52

Current FTE in R&D CIEMAT, IFIC, Granada: Scientific (12.3) + Engineers (4) + Technicians (4.5)

Modest Funding for R&D: European and Autonomic Founds (AIDAinnova, Gen. Valenciana …)

DUNE-Spain Infraestructures

We have 3 labs in Spain (CIEMAT, IFIC, Granada) with optical and cryogenic instrumentation to contribute significantly to the DUNE R&D effort

Ciemat

IFIC
INSTITUT DE FÍSICA CORPUSCULAR

UNIVERSIDAD DE GRANADA