



# Fermilab Strategic Plan and Latin American Collaborations

Lia Meringa  
August 26, 2024

III LASF4RI for HECAP Symposium: Update of the Strategic Plan

ICTP SAIFR FAPESP ICTP unesp PT-UNESP PRINCIPIA



August 26 – 29, 2024  
ICTP-SAIFR, São Paulo, Brazil  
Venue: Principia Institute



# Fermilab at a glance

- America's particle physics and accelerator laboratory
- Operates the largest U.S. particle accelerator complex
- ~2,100 staff and
- 6,800 acres of federal land
- Facilities used by 4,000 scientists from >50 countries
- As we move into the next 50 years, our vision remains to solve the mysteries of matter, energy, space, and time for the benefit of all.





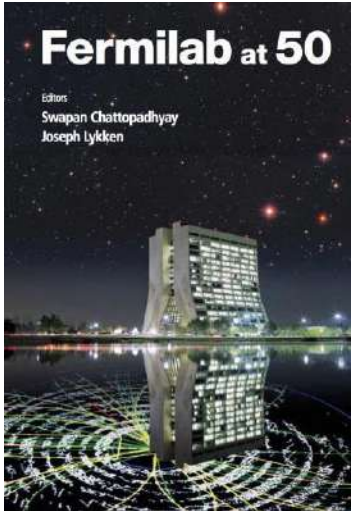




# A history of discoveries with collaborations spanning the Americas

In the 1980s, Director and Nobel Laureate Leon Lederman invited Latin American physicists to join Fermilab experiments.

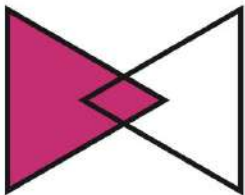
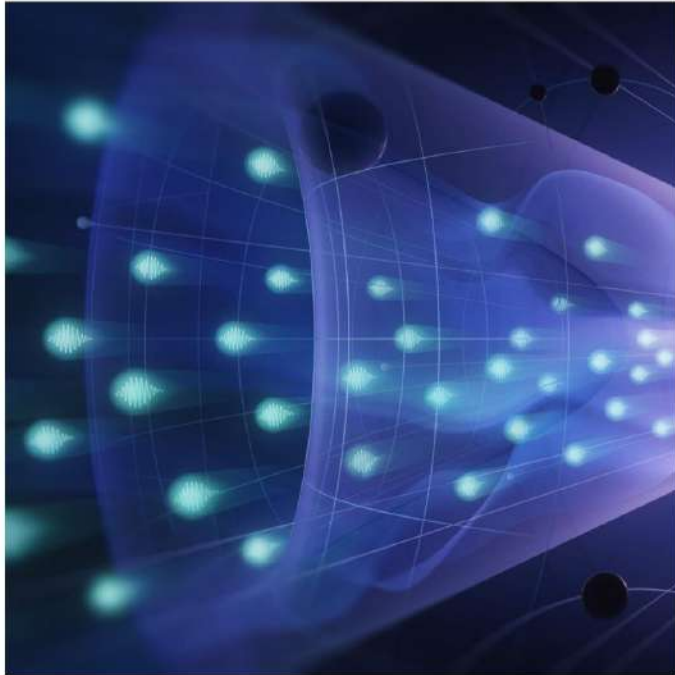
In the 1990s, this led to leadership roles in the discovery of the top quark at the Fermilab Tevatron.



The discovery was achieved by collaborations that included Argentina, Brazil, Canada, Colombia, Ecuador, Mexico, U.S., Europe, and Asia

1989 - Jose Sarney, President of Brazil and Deputy Secretary of Energy, Henson Moore visit Fermilab

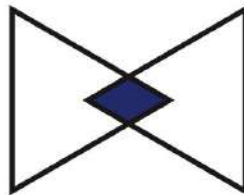
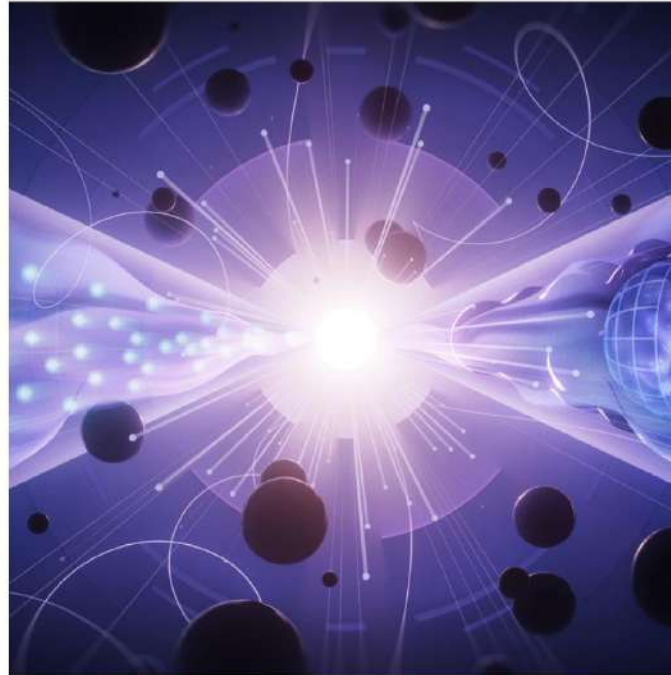
# P5 2023 Science Drivers



Decipher  
the  
Quantum  
Realm

Elucidate the Mysteries  
of Neutrinos

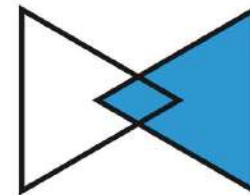
Reveal the Secrets of  
the Higgs Boson



Explore  
New  
Paradigms  
in Physics

Search for Direct Evidence  
of New Particles

Pursue Quantum Imprints  
of New Phenomena



Illuminate  
the  
Hidden  
Universe

Determine the Nature  
of Dark Matter

Understand What Drives  
Cosmic Evolution



# Fermilab Science and Technology Strategy

## Major Particle Physics Initiatives

- Neutrinos
- Higgs and the Energy Frontier
- Muons
- The Dark Universe
- Accelerator Science and Technology



## Emerging Technology Initiatives

- Quantum Science and Technology
- Microelectronics
- Artificial Intelligence for Science

## User and Stakeholder Engagement Initiative

- Discovery on the Prairie



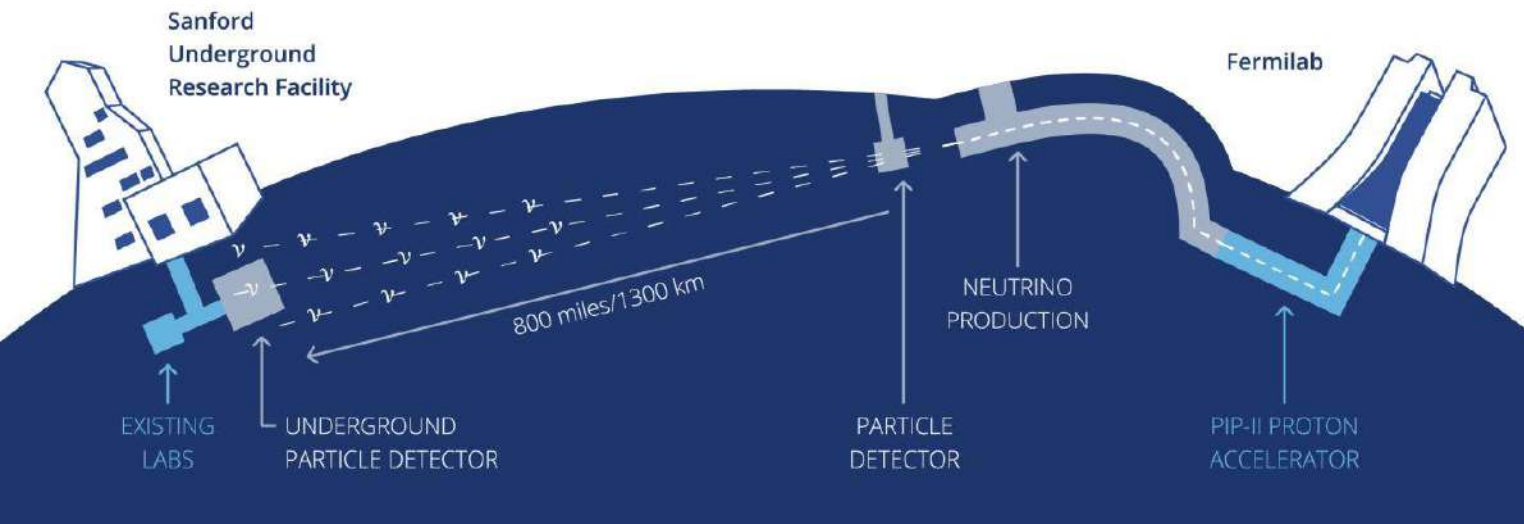


### The *definitive* neutrino oscillation experiment, driven by LBNF and PIP-II



#### Discovery Potential

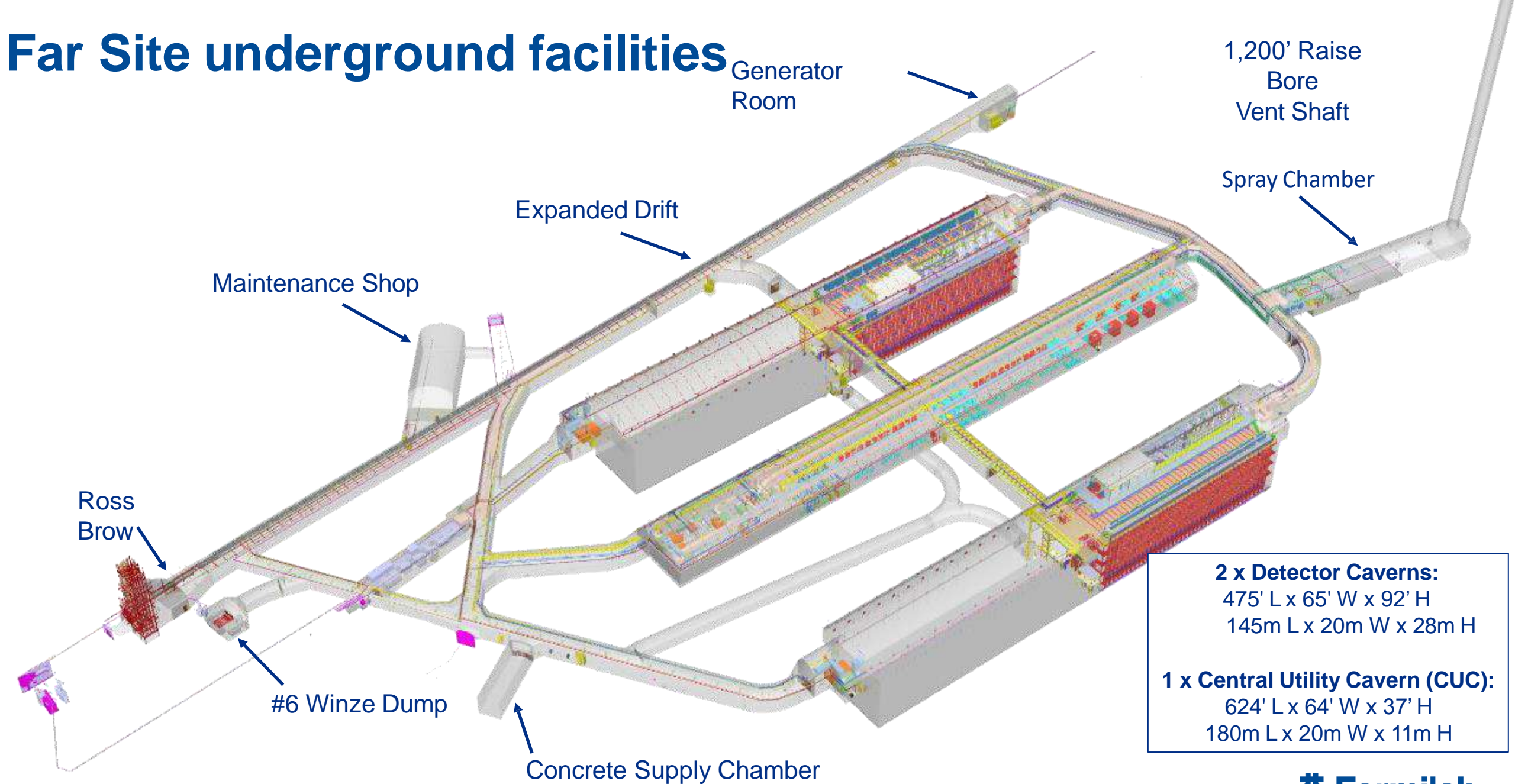
- **Neutrino CP violation**
  - The origin of matter in the universe
- **Supernova neutrinos**
  - Origins of neutron stars and black holes
- **Neutrino surprises**
  - New forces, particles, or laws of nature connected to neutrinos
- **Proton decay**
  - Unified origins of particles and forces



*The LBNF/DUNE project is the first internationally conceived, constructed, and operated mega-science project hosted by the Department of Energy on U.S. soil*



# Far Site underground facilities



**2 x Detector Caverns:**  
475' L x 65' W x 92' H  
145m L x 20m W x 28m H

**1 x Central Utility Cavern (CUC):**  
624' L x 64' W x 37' H  
180m L x 20m W x 11m H



# Far Site excavation completed 2024





# Celebrating the completion of the Far Site excavation



Fermilab Director Lia Meringa (center) and SURF Director Mike Headley (center right) cut the ribbon to mark the completion of the three-year excavation of the caverns for the Long-baseline Neutrino Facility/Deep Underground Neutrino Experiment. Other dignitaries include LBNF/DUNE–US Federal Project Director Adam Bihary, CERN Senior Scientist and Neutrino Platform Project Leader Francesco Lanni, DUNE Collaboration Co-spokesperson Sergio Bertolucci, President and CEO of URA, Associate Director DOE-OHEP Regina Rameika, DOE Principal Deputy Under Secretary for Science and Innovation Derek Passarelli, DOE Chief of Staff to the Secretary of Energy Christopher Davis, Acting DOE Director of the Office of Science and Deputy Director for Science Programs Harriet Kung, South Dakota Lt. Governor Larry Rhoden, U.S. Senator for SD Mike Rounds, U.S. Representative for SD Dusty Johnson, University Of Campinas Rector Antonio José De Almedia Meirelles, LBNF/DUNE-US Project Director Jim Kerby.



# The LBNF/DUNE vision is achieved by groundbreaking international partnerships

- The U.S. is a partner of choice in international science
- For the first time the U.S. is executing and hosting an international experiment
- For the first time CERN contributes to infrastructure outside Europe
- Partner contributions total more than \$1B

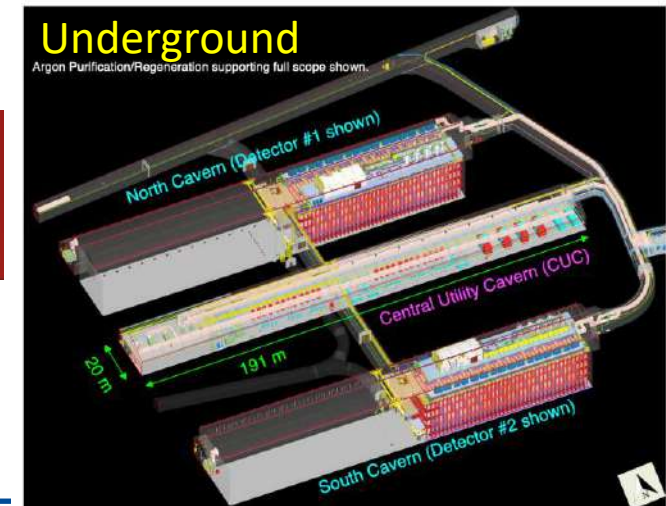
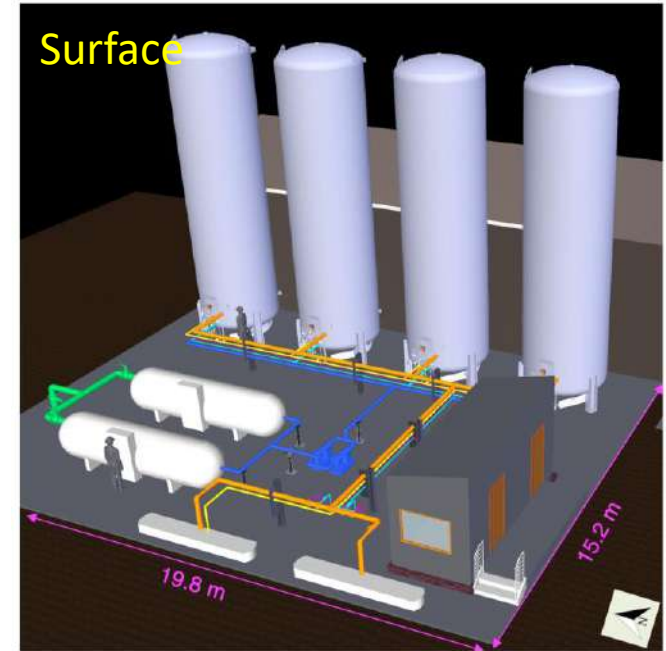
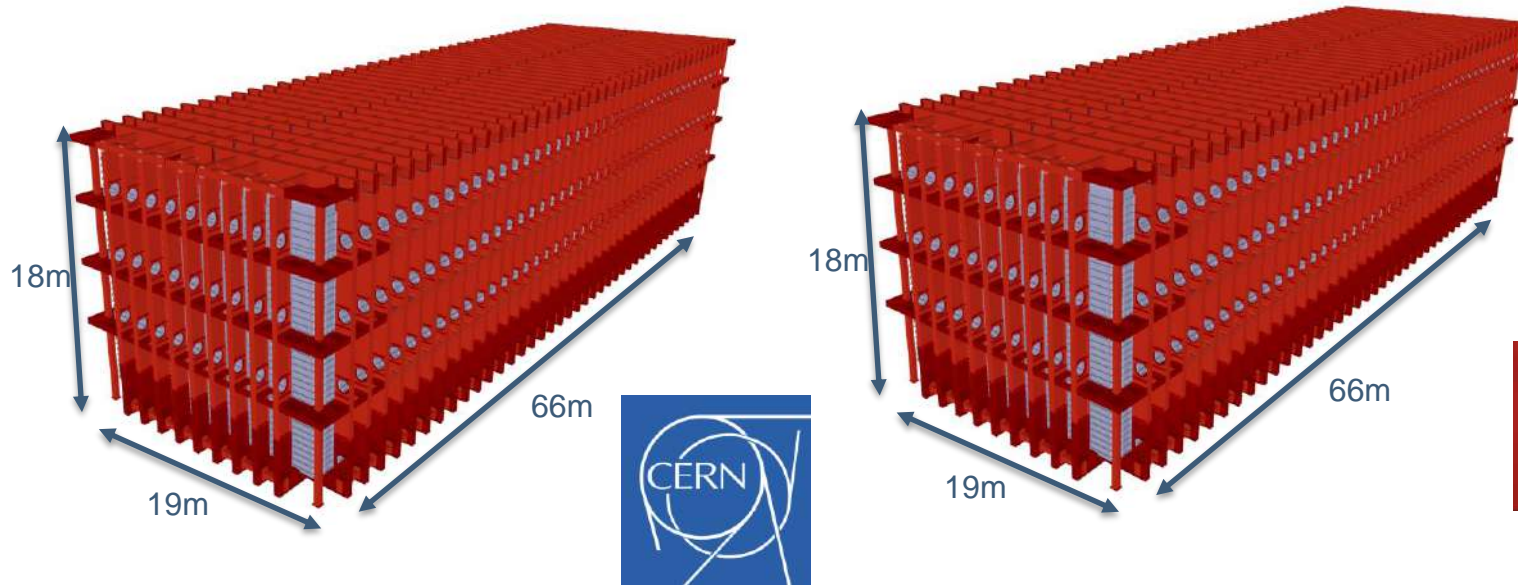




# The Far Site Facility – Includes significant in-kind contributions

The far site facility includes

- 3 caverns
- 2 cryostats
- 2 detectors
- Cryogenic infrastructure



Delivery of LBNF hardware components by CERN has begun

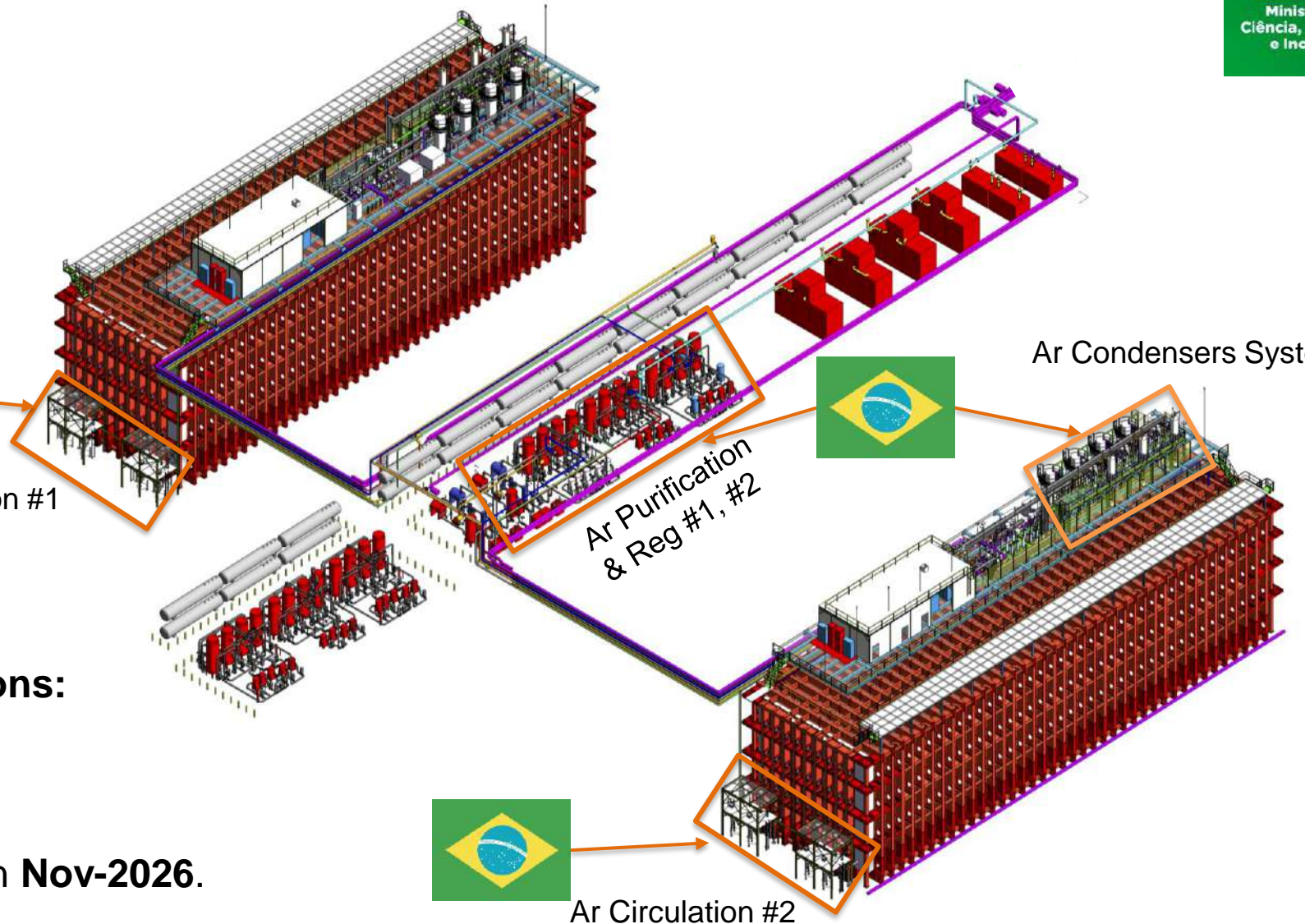




# UNICAMP Proposed Contributions to LBNF/DUNE



Ar Circulation #1



Ar Condensers System #2



Ar Circulation #2

## UNICAMP Proposed Contributions:

- Purification vessels and media.
- LAr Circulation Systems.
- Argon Condensers System.
- Installation scheduled to start in **Nov-2026**.

*Thank you to FAPESP and MCTI for their timely and impactful decision to provide in-kind contributions to LBNF/DUNE Project*



# The DUNE experiment is managed by the international DUNE Collaboration



## International Collaboration



DUNE Collaboration meeting at Fermilab - May 2023

### Collaboration statistics

- 1,400 collaborators, 50% at U.S. institutions & 50% non-US
- 206 institutions from 35 countries including CERN

### Demographics (not including computing)

- Facility/Senior staff: 654
- Grad Students: 324
- Post Docs: 249
- Engineers: 154

Armenia, Brazil, Bulgaria, Canada, CERN, Chile, China, Colombia, Czech Republic, Spain, Finland, France, Greece, India, Iran, Italy, Japan, Madagascar, Mexico, Netherlands, Paraguay, Peru, Poland, Romania, Russia, South Korea, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States

***DUNE will be the first internationally conceived and operated mega-science experiment hosted by the DOE in the U.S.***



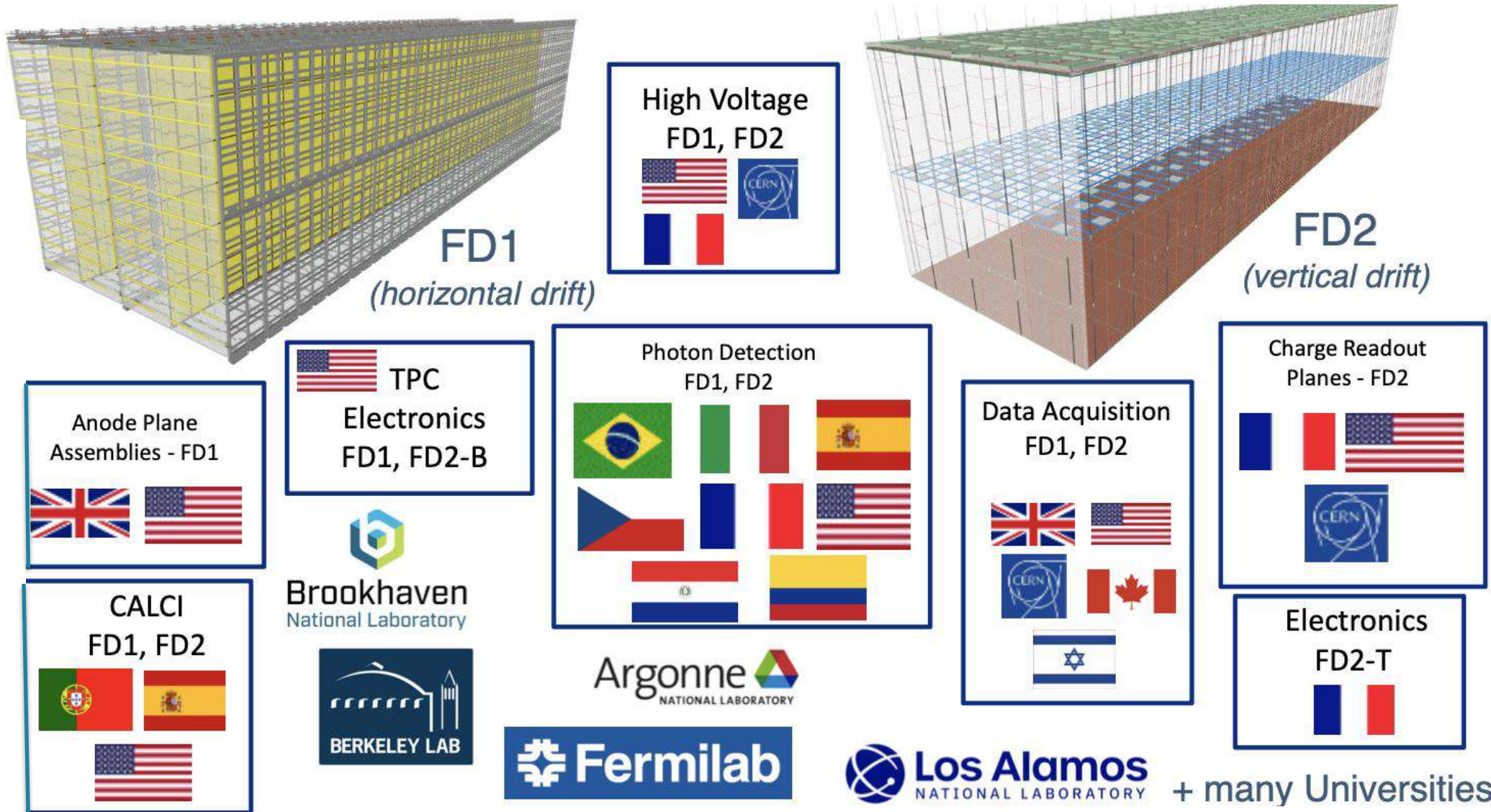
# DUNE Partners sign multi-institutional MOU

- International science organizations sign agreement to provide hardware for the Deep Underground Neutrino Experiment





# The DUNE Far Detectors – A Model of International Partnership





# ProtoDUNE Detectors (Far Detectors 1 and 2) at CERN





# CERN Neutrino Platform: first time CERN invests outside Europe





# Latin American participation in DUNE



Brazil: 13 institutions



Chile: 2 institutions



Colombia: 7 institutions



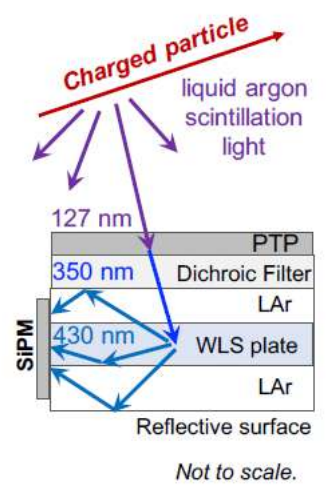
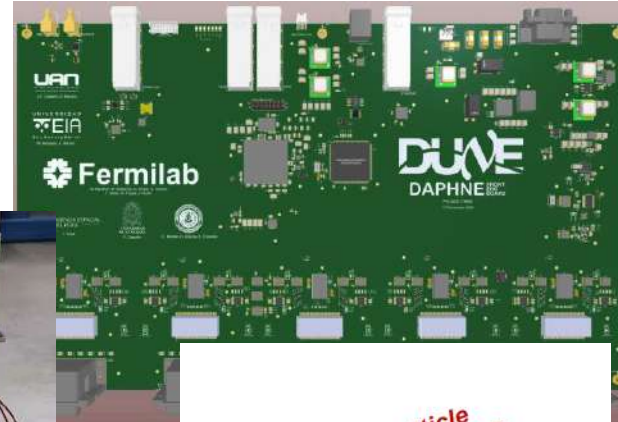
Mexico: 3 institutions



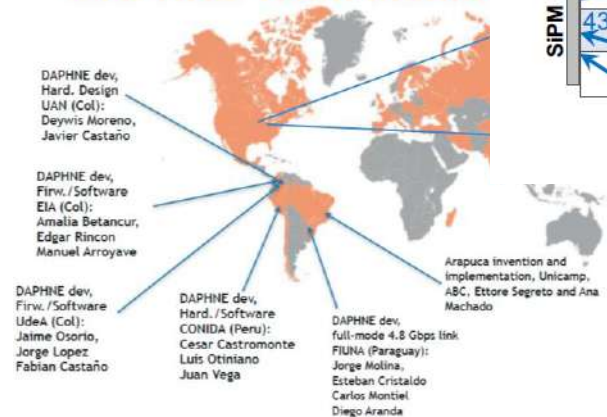
Paraguay: 1 institution



Peru: 3 institutions



## DAPHNE Team Members



FD1: Anode Plane Assemblies  
 TPC Electronics  
 Photon Detection System  
 High-Voltage System  
 Data Acquisition  
 Calibration and Cryogenics  
 Instrumentation

FD2: Top Drift Electronics  
 TPC Electronics  
 Photon Detection System  
 High-Voltage System  
 Data Acquisition  
 Calibration and Cryogenics  
 Instrumentation  
 Charge Readout Planes

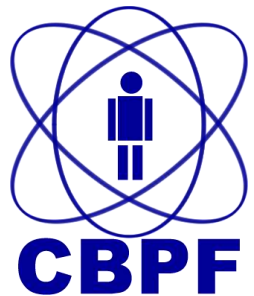




# 47 Brazilian collaborators from 13 institutions



## DUNE-BR



UNIVERSIDADE  
FEDERAL DE JUIZ DE FORA



UNIVERSIDADE FEDERAL DE SÃO PAULO

1933



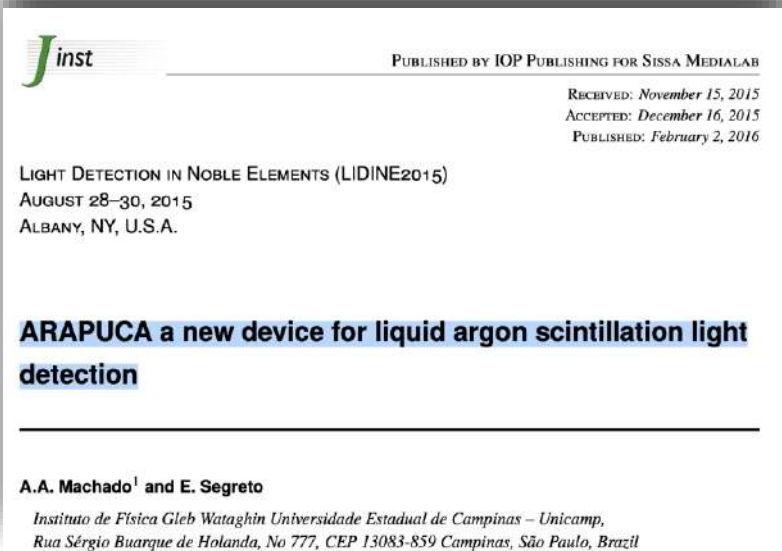
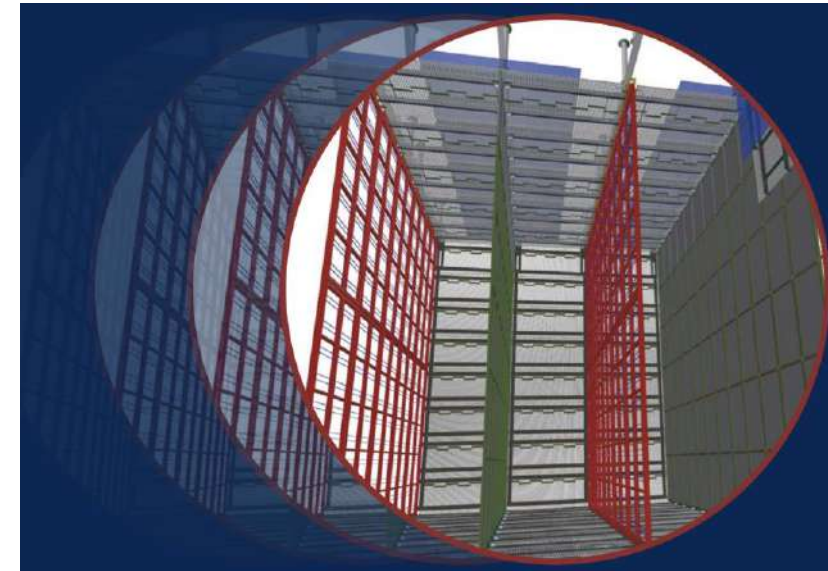


# DUNE FD1 and FD2 – Liquid Argon PDS with X-Arapuca: A novel light detection technology for HEP

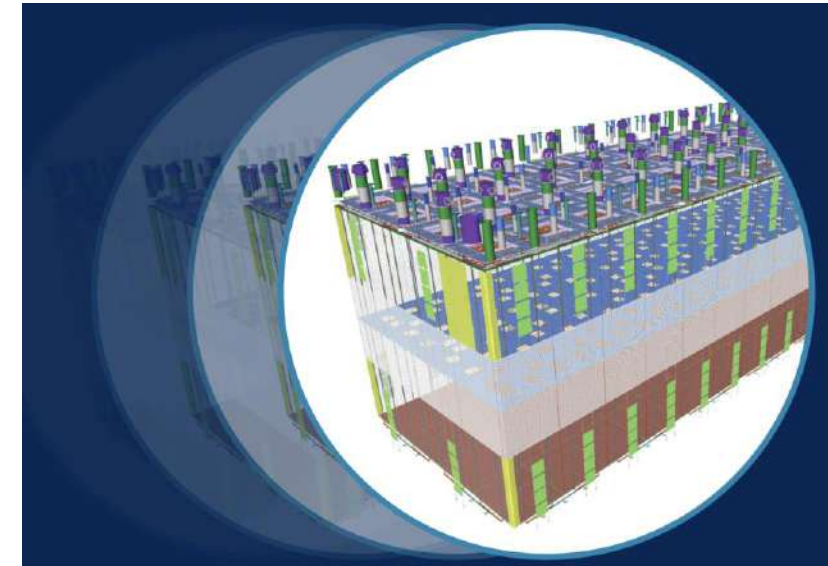
Led by Ana Machado, ARAPUCA (Argon R&D Advanced Program at UNICAMP) is a novel photon detection system for DUNE based on two-stage wavelength-shift and a dichroic mirror in between to trap liquid argon scintillation light and detect photons with silicon photosensors.

- A system with 192 X-Arapuca installed on SBND detector
- Assembled by several UNICAMP students stationed at Fermilab for 3-9 months.

*This advanced technology, originally conceived (2016) and developed at UNICAMP in Brazil, proposed and implemented in ProtoDUNE-SP at CERN in 2018, is now the baseline technology choice for both DUNE Far Detectors (FD1 and FD2).*



An international consortium is built around ARAPUCA technology for the realization of the DUNE photon detector project.



DUNE FD2 cryostat containing the VD-LArTPC. The X-Arapuca are represented in green on the walls of the cryostat and on the cathode surface.



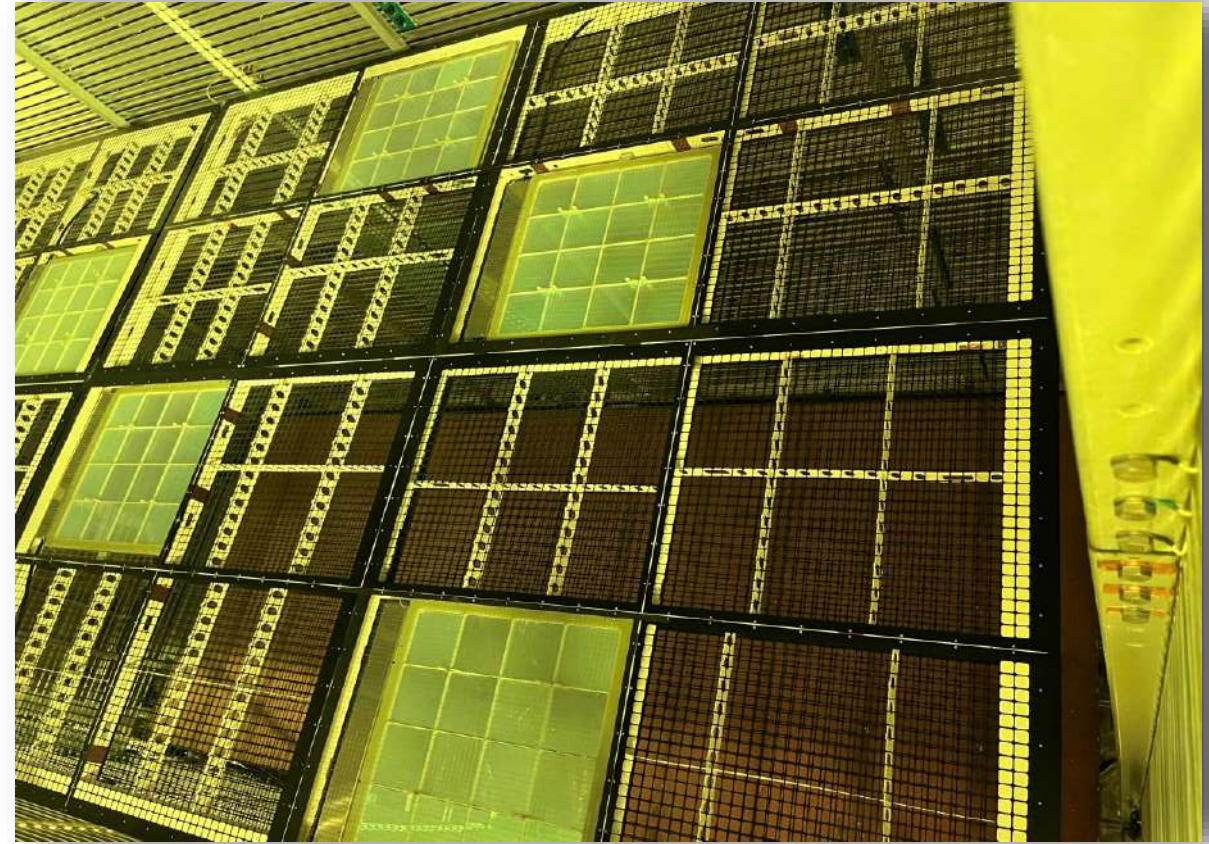
# DUNE FD1 and FD2 – Liquid Argon PDS with X-Arapuca



The PDS consortium is the largest among the DUNE consortia and has

- 49 international institutions including
  - **17 from Latin America** (9 Brazil - led by UNICAMP, 4 Colombia, Paraguay, and Peru)
  - 15 from U.S. (led by FNAL)
  - 4 from Europe (Italy, Spain, France, Czech Republic)
- About 200 active collaborators

X-Arapuca modules (60x60cm<sup>2</sup>) mounted on the HV Cathode (with PoF/SoF - power/signal transmission via optical fibers) for ProtoDUNE VD at CERN for FD2



Detector design and design quality assurance has been pursued and successfully achieved by the PDS consortium collaborative effort from 2017 to 2023. The PDS consortium is now fully engaged with production and assembly quality assurance and quality control.

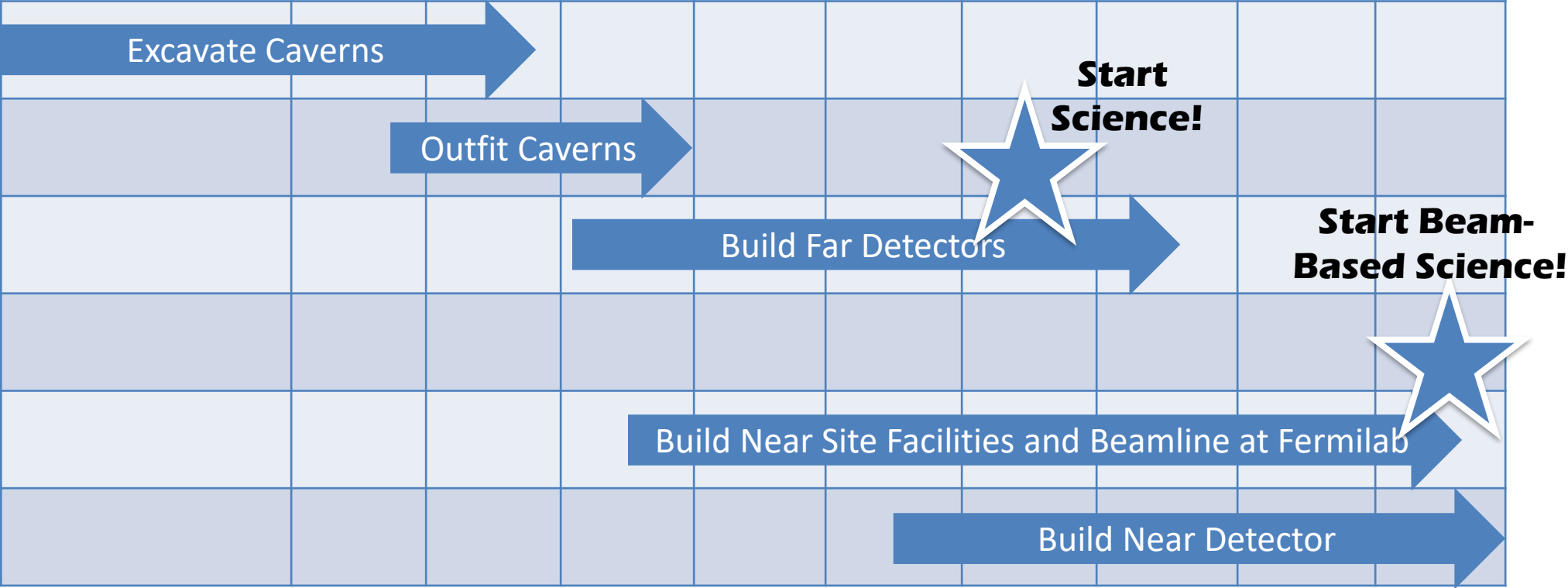


# Cost & Schedule Summary

LBNF/DUNE-US Cost  
\$3,277M

## LBNF/DUNE-US Project Funding Profile (\$M) / Schedule

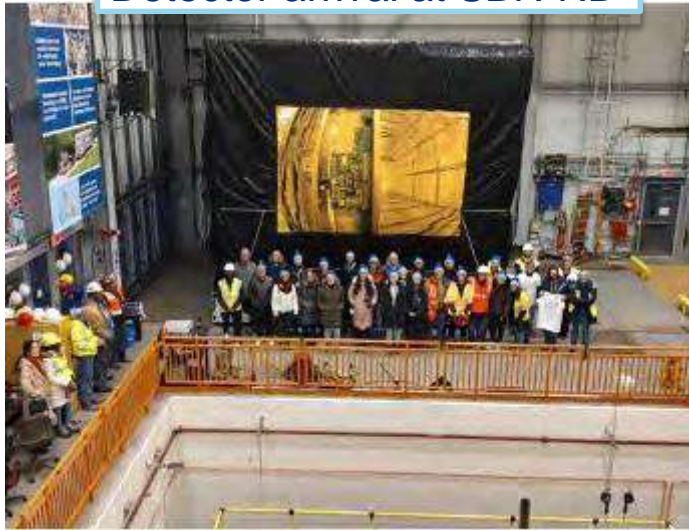
Thru 2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
\$955	\$180	\$255	\$280	\$305	\$305	\$305	\$305	\$262	\$0	\$3,277



LBNF /DUNE is the largest domestic project in DOE Office of Science

# Short Baseline Neutrino Detector (SBND)

Detector arrival at SBN-ND



Completed SBND Cryostat

## First physics summer 2024



Rigging detector into cryostat



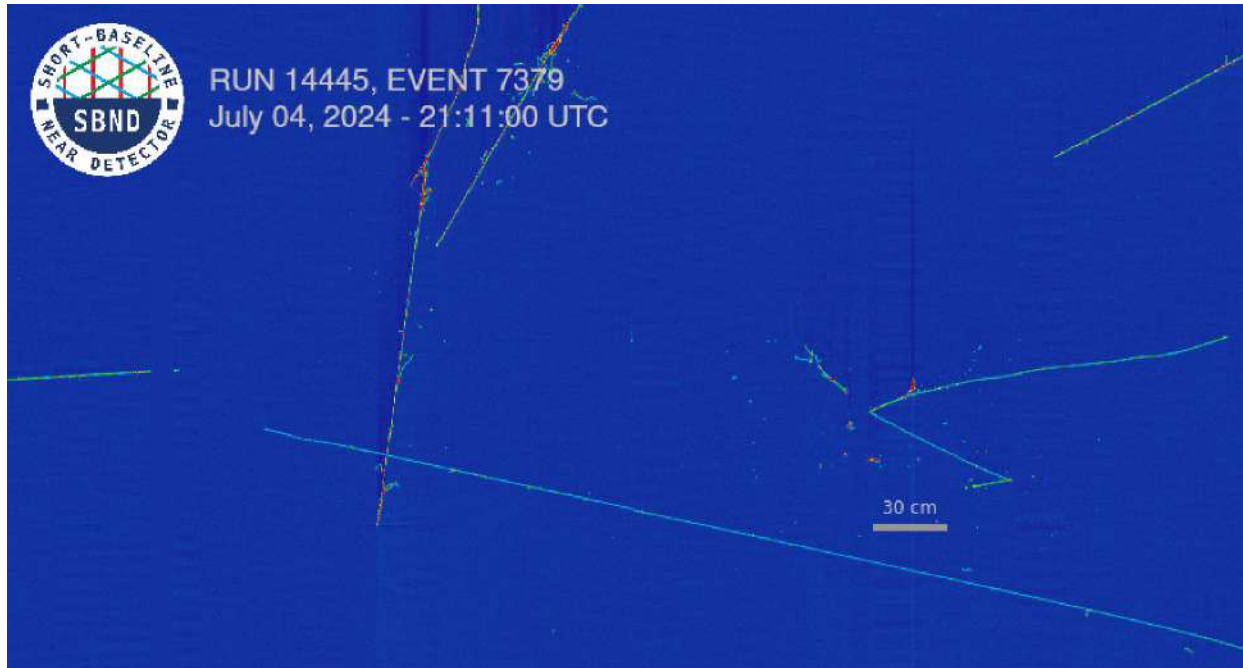
Cryostat welded closed and cabling installed

CERN  
Neutrino  
Platform



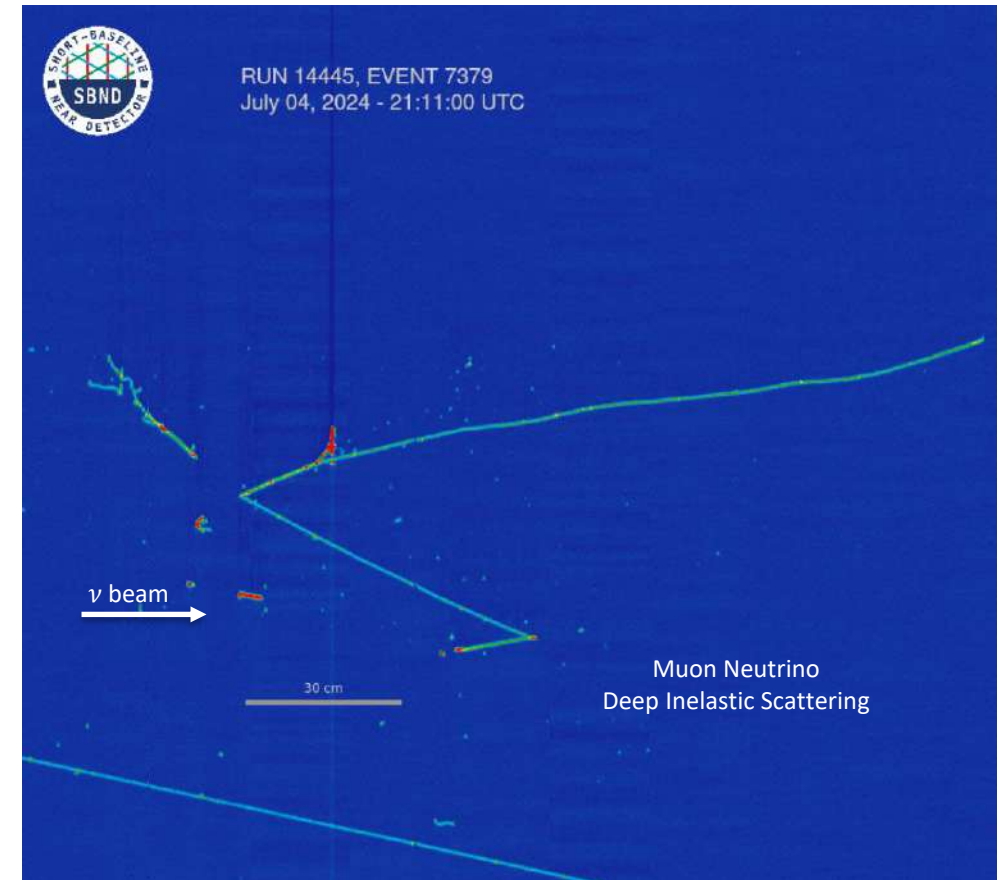


# First SBND neutrino events!



Full image

Zoomed in image







# Higgs and Energy Frontier



**Vision:** Fermilab is the leading U.S. center for CMS and second leading center in the world after our partner CERN, and has leadership roles in off-shore Higgs Factory R&D

## Major initiatives

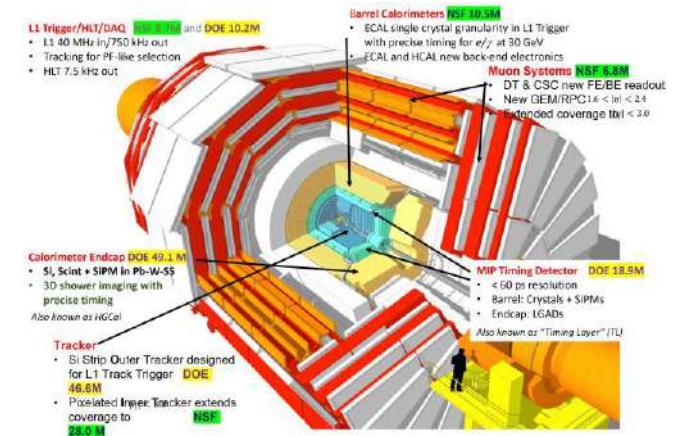
- LHC CMS operations
- HL-LHC AUP and CMS Detector Upgrade Projects
- FCC-ee accelerator & detector R&D



LHC Remote Operations Center (ROC) at Fermilab  
*CMS online shifts*



HL-LHC AUP 1<sup>st</sup> CryoAssembly at Fermilab



HL-LHC CMS scope





# Higgs and Energy Frontier

## HL-LHC Upgrade Projects

- First U.S.-built cryoassembly for LHC upgrade shipped to CERN
  - On Dec. 18, CERN (Switzerland) received a 13-meter-long magnet assembly
- HL-LHC CMS Detector Upgrade Project achieved CD-3 ESAAB!

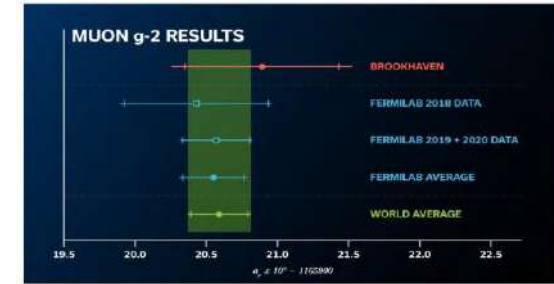




# Physics with Muons

## Two major initiatives

- **Muon g-2:** Data taking concluded, statistics goal achieved
  - World's most precise measurement of muon g-2 was released in August 2024
  - Final result, updates from theory initiative expected in 2025 timescale
- **Mu2e project:** Project under construction ~91% complete, start science in 2026



Movable collimator inserted into inner bore of downstream transport solenoid

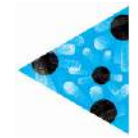


Detector solenoid in progress



Tracker plane assembly





# Dark Universe

**Vision:** Fermilab is an essential partner in cosmic science experiments and is contributing innovative R&D efforts toward future dark energy, dark matter, and cosmic microwave background (CMB) experiments.

## Strategy:

- Search for dark matter across a wide mass range leveraging Fermilab's instrumentation facilities/capabilities
- Support the advancement of CMB experiments while playing key roles in current and upcoming surveys to study cosmic acceleration

## Priorities:

- Support current operations: Rubin/LSST, SPT-3G, SCDMS
- ADMX-G2: Continue run searching for the QCD axion
- Dark Matter New Initiatives (DMNI)



South Pole Telescope during 2022 Austral winter survey observations  
(Credit: Aman Chokshi)

# Dark Energy Survey

Cosmology through studies of weak gravitational lensing, Type 1a SN, growth rate of galaxy clusters, Baryon Acoustic Oscillations through imaging data taken by the Dark Energy Camera

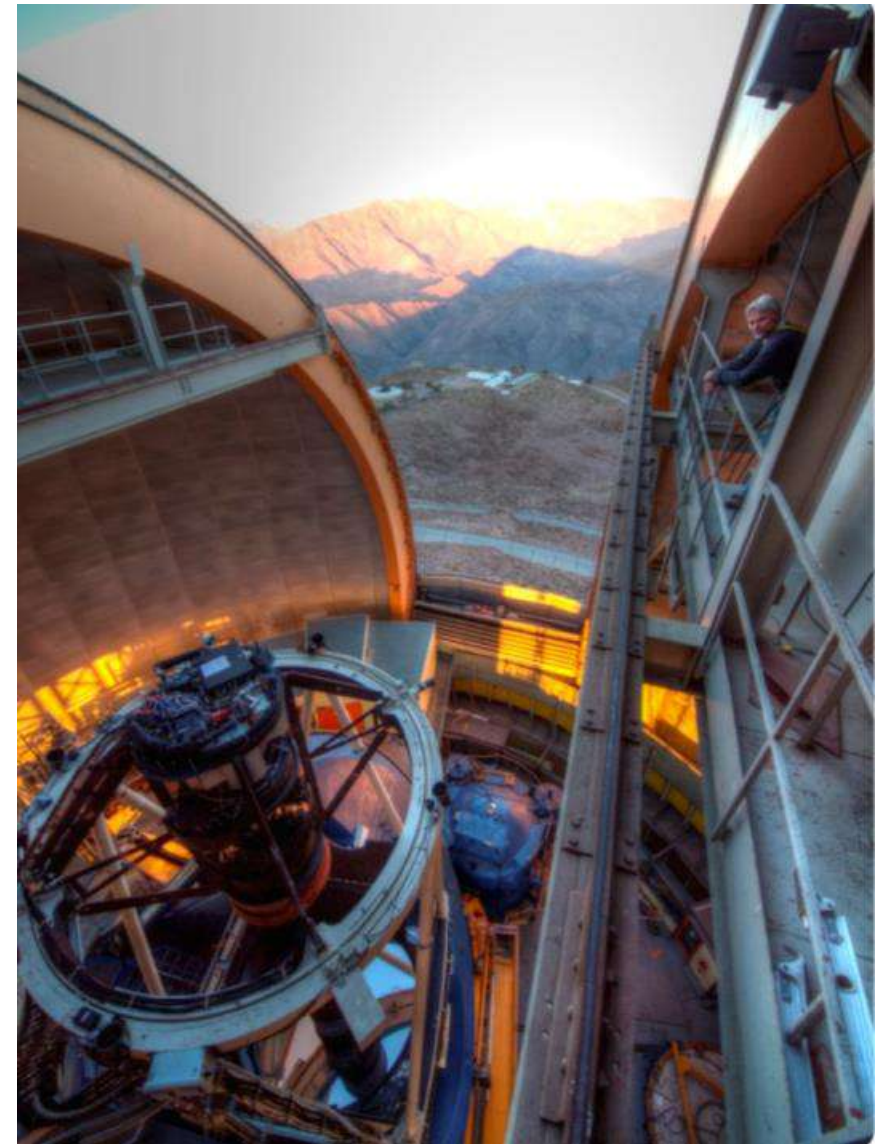
Countries: Chile & Brazil

Institutions: Cerro Tololo Inter-American Observatory (La Serena, Chile), Laboratório Interinstitucional de e-Astronomia & Observatório Nacional (Rio de Janeiro), Universidade de Sao Paulo, Universidade Estadual de Campinas (Brazil)

Total collaborators ~ 65



DARK ENERGY  
SURVEY



The Dark Energy Camera on Cerro Tololo outside La Serena, Chile



# Cosmic Science from the Dark Energy Survey

## Areas of collaboration/engagement

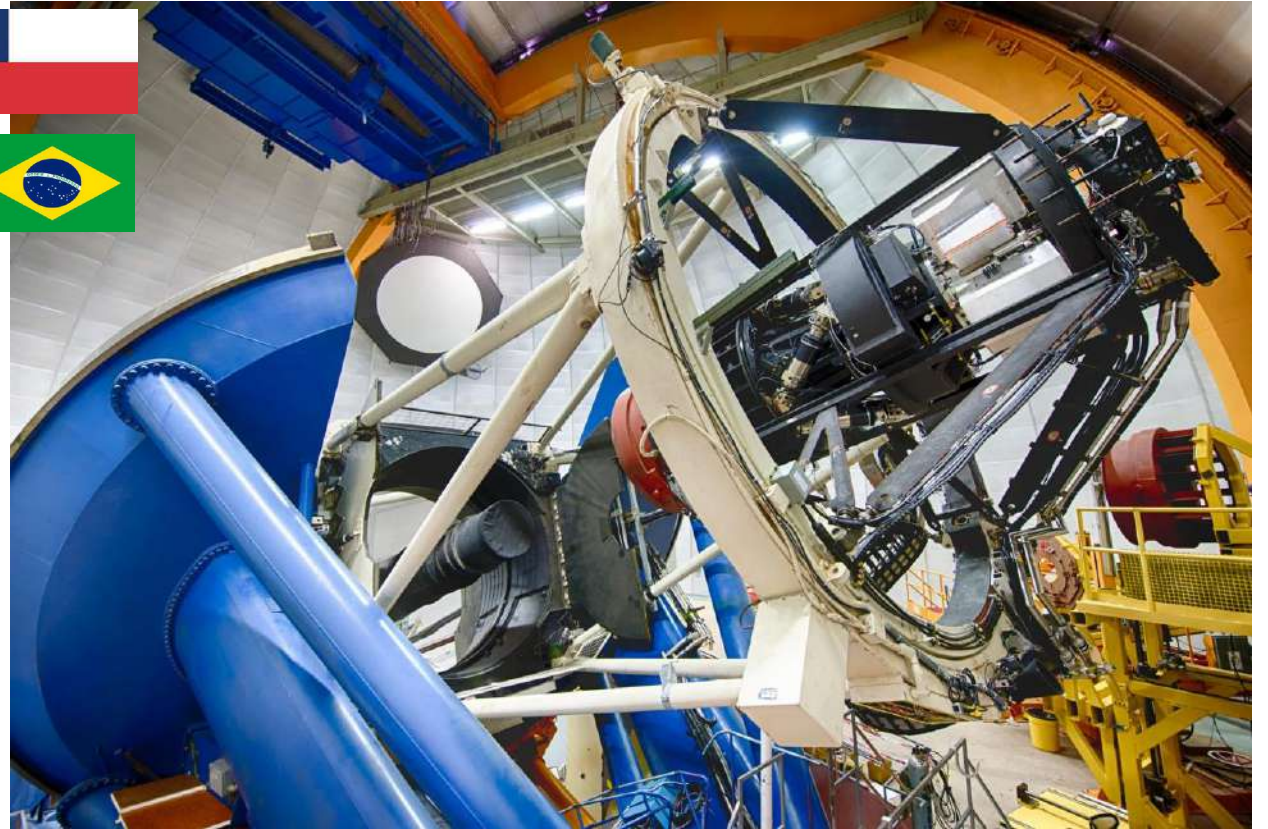
DES acquired data with the Blanco Telescope in Chile, partnering with NSF's NOIRLab/Cerro Tololo Interamerican Observatory.

Operations software and database systems were created by partners in Brazil (DES-Brazil).

Latin American countries: Chile and Brazil

Number of institutions: 2 (Chile) and 12 (Brazil)

Total collaborators: 10 (Chile) and 71 (Brazil)



Dark Energy Camera on the Blanco Telescope at Cerro Tololo, Chile  
(Photo credit: Reidar Hahn, Fermilab)

# CCDs and skipper-CCDs for Dark Matter

LA groups were early participants of CCDs for dark matter.

- Started with DAMIC experiment ~ 2012
- Strong support from researchers and students in Mexico, Argentina and Paraguay to get the program started (before formal funding in USA).
- This has now become a program that has 3 running experiments (DAMIC, SENSEI, DAMIC-M), and 1 planned experiment (Oscura).

## Some Data:

1. Countries involved now: Argentina, Brazil, Mexico and Paraguay.
2. The current program has more than 100 researches overall.



First collaboration meeting in 2013 in UNAM Mexico with Argentina, Mexico, Paraguay (+ US, Switzerland)



Jorge Molina in 2012 at SNOLAB fixing the noise of DAMIC (Molina is now Government Minister in Paraguay).



# Oscura experiment

The future DM experiment with skipper, part of the DOE Dark Matter New Initiatives at FNAL

Countries: Argentina, Brazil, Mexico and Paraguay

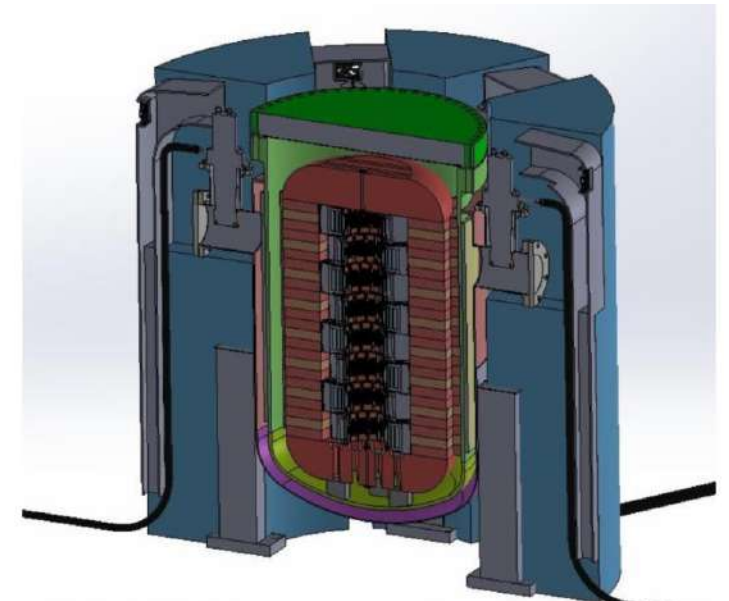
Critical technical Contributions:

- ASIC design (lead in Argentina, Bariloche, Fabricio Alcalde).
- Electronics design (lead in Argentina, Cordoba, Miguel Sofo-Haro).
- Sensor testing/characterization (Argentina, Mexico, Brazil, Paraguay).
- DAQ design (lead in Argentina, Bariloche, Xavier Bertou).
- Calibration and HW database (lead in Argentina, UBA, Dario Rodrigues).

Students:

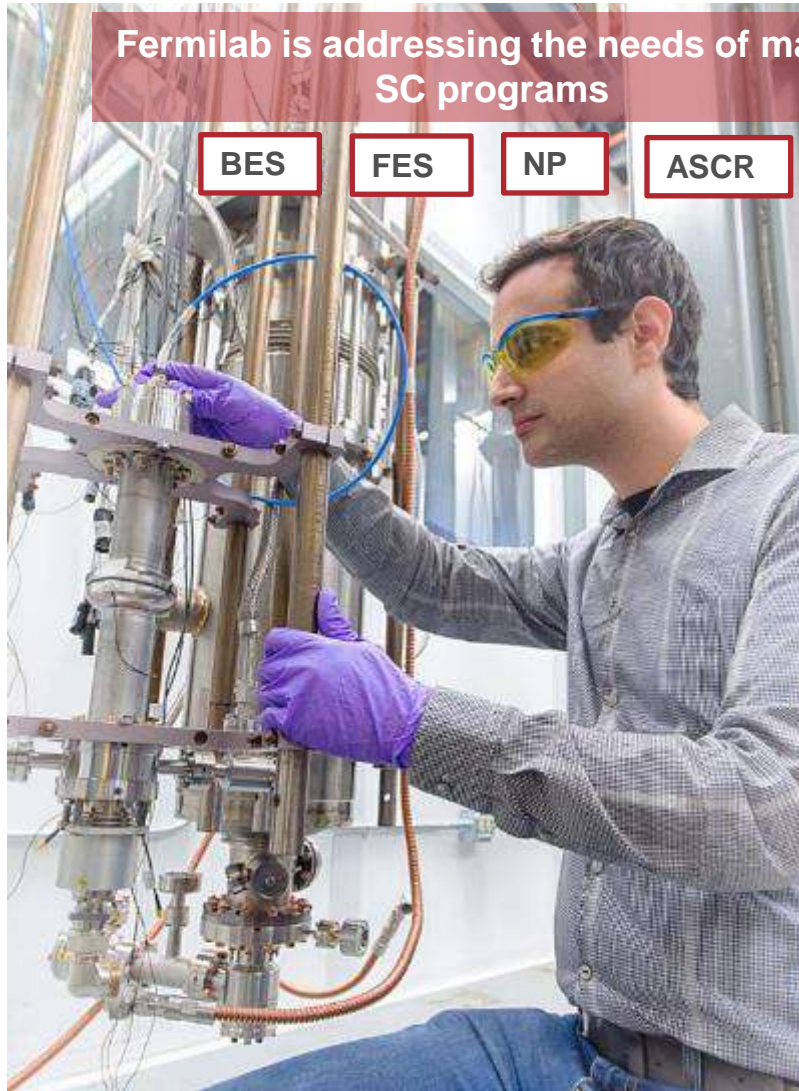
- FNAL scientists (Juan Estrada, Javier Tiffenberg and Guillermo Fernandez-Moroni) are PhD advisors of students in Universidad de Buenos Aires, and Universidad Nacional del Sur.
- Several undergraduate students from Latin America come to work at IERC (CCD lab) every year.
- Remote work on CCD data analysis is ongoing in Brazil, Mexico, Argentina, Paraguay.

Largest CCD camera ever built. 33 Gigapixel



96 SM in vessel = 12.62 kg  
24,576 CCDs

# Accelerator S&T – World-leading Capabilities



Fermilab is addressing the needs of many SC programs

BES

FES

NP

ASCR

## Accelerator and Beam Physics

- IOTA/FAST beam-test facility advances critical R&D enabling next-gen accelerators for DOE/SC

## Superconducting Radio-frequency

- Fermilab continues to produce world-class cryomodules for LCLS-II HE, PIP-II, applying developments to FCC-ee

## High-power Targetry

- Fermilab leads the Radiation Damage in Accelerator Target Environments (RaDIATE) collaboration

## High-field Magnets

- HEP and FES: New high field magnet cryogenic test stand at Fermilab to perform R&D of high-temp superconducting cables for future fusion reactors



# Fermilab Accelerator Complex Evolution (ACE)



## Accelerator Complex

Campaign of upgrades, modernization, investments critical for the success of DUNE

## PIP-II Project

Other projects, e.g. ACORN, to ensure accelerator complex is compatible with PIP-II

## ACE-MIRT

Faster delivery of DUNE science: capability  $\times$  capacity  $\times$  reliability

## 20-year strategic plan

ACE-BR, Muon Collider



**Deliver  
groundbreaking  
science & technology  
innovation**

# Emerging Science & Technology Capabilities

Quantum Information Science & SQMS  
Artificial Intelligence / Machine Learning  
Microelectronics



# Emerging Science & Technology Initiatives

## Quantum Information Science

Fermilab is pursuing a multi-pronged and vibrant QIS&T program:

- Lead **SQMS** - 1/5 DOE National QIS Centers
- Strong participation at QSC
- Broad research program aiming to enable HEP science and advance QIS&T. Our approach:
  - Quantum sensors; systems; simulation; computing

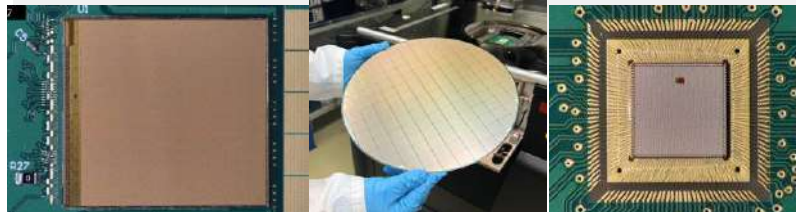


## Microelectronics

HEP experiments set the grand challenge for enabling next generation microelectronics.

Our vision is to leverage our core capabilities while working with academia and industry to develop microelectronics to meet our scientific goals and achieve societal impact through disruptive technologies. Our approach:

- Integrated precision sensing with computing and communication technologies
- Impactful hardware development for Quantum, AI at the edge, 6G and beyond
- Microelectronics workforce
- Support and develop US-based advance manufacturing technology



## Artificial Intelligence

Unique HEP challenges will spur innovation in AI techniques and technology that will **transform HEP** and **advance discoveries in other sciences, society, industry.**

Major synergy with our strength in microelectronics and with the upgrade of the accelerator complex

- **Accelerators**
- **Experiments**
  - AI-enabled automation/optimization
  - Experiment design
  - Readout and control
  - Data processing and simulation
  - Automated data mining, analysis, and interpretation



# Discovery on the Prairie

*An integrated, long-term vision for Fermilab that expands our impact for the nation, high-energy physics, and our state and local communities*

## Plan

- Revitalization of campus and infrastructure driven by community needs in the DUNE era
  - Reimagined Fermilab Village
  - **Phase-I housing development - \$30M investment from State of IL**
  - Modern daycare, recreational and community amenities
  - A new, world-class STEM and community-outreach facility
- Technology and Innovation Park with university and industrial partners for maximizing Fermilab's impact in science, society and industry





# Fermilab hosts 235 Interns this summer!



Fermilab hosting summer internship pipeline programs for 50+ years  
INFO: <https://internships.fnal.gov/>



# Fermilab International Student Program

## Overview of the Program

- Undergraduate students supported for up to 6 months
- Graduate students supported for up to 3 years to conduct Ph.D. research
- Fermilab provides students with scientific supervision, on-site housing, per-diem, and a shared rental car

## Since 2017 (Latin America Only):

- 20 students from 7 institutions and 3 countries have completed a Ph.D. under this program
- 20 undergraduate students from 2 countries conducted 3-6 months of research
- Over 95% of students went on to either a Postdoctoral position in neutrino research or to graduate school to pursue their Ph.D. in physics



*Cathode installation at SBND in the D0 building.  
Pictured: Mônica Nunes, Vincent Basque.  
Photo: Ryan Postel*



*Engineers from Paraguay Working on SENSEI Experiment*



*Minerba Betencourt working on MINERvA in the MINOS cavern*



# Latin American participation in Fermilab programs

**Countries: 11**  
**Collaborators: 424**  
**Institutions: 76**  
**Agreements: 8**



Argentina: 5 institutions, 25 collaborators and employees, 1 agreement

- astrophysics, computing, DZero, DAMIC, detector R&D, theory



Brazil: 13 institutions, 156 collaborators and employees, 3 agreements

- astrophysics, CMS, CEvNS, DZero, DAMIC, DES, detector R&D, DUNE, particle astrophysics, HASCO, INSS, LArIAT/liquid argon, LBNF, MINERvA, Minos+, neutrino division, NOvA, particle theory, SBND, theory



Chile: 2 institutions, 19 collaborators and employees

- CMS, DAMIC, DES, DUNE, FQI, FQNET, MINERvA, test beam



Colombia: 7 institutions, 55 collaborators and employees

- CMS, DZero, DAMIC, DUNE, MicroBooNE, NOvA, open science grid, particle theory, SQMS-QSC summer school, theory



Ecuador: 5 institutions, 9 collaborators and employees

- CMS, DZero, theory



Guatemala: 5 institutions, 1 collaborator

- MINERvA



Honduras: 5 institutions, 1 collaborator

- REDTOP



Mexico: 3 institutions, 88 collaborators and employees, 3 agreements

- accelerator directorate, Auger project R&D, CMS, CEvNS, computational science, AI directorate, COUPP at SNOLAB, DZero, DAMIC, DES, detector R&D, DUNE, EMPHATIC, FQI, ICARUS, INSS, SELEX, MINERvA, neutrino division, Noble R&D – PPD, NOvA, REDTOP, theory



Paraguay: 1 institution, 19 collaborators and employees, 1 agreement

- DAMIC, DUNE, SBND



Peru: 3 institutions, 13 collaborators and employees

- DUNE, MINERvA, neutrino division



Puerto Rico: 5 institutions, 38 collaborators and employees

- CMS, DUNE, internships, neutrino division, SBND, test beam

# Software and Computing (S&C) for HEP

## FNAL Geant4 group Collaboration with UNESP – São Paulo, Brazil (Prof. Sergio Novaes)

- Geant4 re-engineering for modern computing architectures – GeantV prototype (2014-2018)
  - Visits to Fermilab by UNESP postdocs Guilherme Amadio and Caleb Bianchini

## FNAL Geant4 group Collaboration with UBA – Buenos Aires, Argentina (Prof. Rodrigo Castro)

- Alternative integration methods for Geant4 transport (2015 – Present)
  - Visit to Fermilab by UBA postdoc Lucio Santi

## Fermilab co-organized “Latin American Workshop on Software and Computing (S&C) Challenges in High-Energy Particle Physics (LAWSCHEP 2019) – Mexico City

- Participants from Argentina, Brazil, Colombia, Ecuador, Mexico, Peru, ..., and U.S. and Europe

## Outcome

- Numerous technical publications, UBA joining the Geant4 Collaboration, training of young people on S&C for HEP
- LAWSCHEP: summary and conclusions document presented at the LASF4RI Symposium - July 6th 2020, Sao Paulo, Brazil



# Fermilab engagement with LASF4RI and LAA-HECAP

- Fermilab's Marcela Carena was part of the initial process, in 2018, that led to the mandate to create the Latin American Scientific Forum for Research Infrastructure (LASF4RI)
- Carena is also a member of the Preparatory Group for the Latin American Strategy for High Energy Physics, Cosmology and Astrophysics and co-author of the Latin American HECAP Physics Briefing Book: <https://arxiv.org/pdf/2104.06852>
- Carena has represented Fermilab as a board member of the Latin American Association for High Energy, Cosmology and Astroparticle Physics (LAA-HECAP) since its inception in 2021



## LASF4RI for Particle Physics and Cosmology: Closing Remarks



# Exploring Connections

LAA-HECAP and Fermilab can explore new ways to seed collaborations to further increase the impact and involvement of LA researchers in science connected to Fermilab

**Example:** possible idea of the Fermilab-LAA/HECAP Mobility Initiative

- Identify areas that are of mutual interest to Fermilab and LA scientists.
- Match making between LA PIs and Fermilab groups interested in cooperation
- Proposals for new collaborative projects evaluated by a joint committee integrated by LAA-HECAP and Fermilab.
- Successful proposals funded through the Fermilab LDRD program or other direct funding.





# Strong partnership Latin American countries



<https://news.fnal.gov/2024/05/brazilian-funding-agency-representatives-visit-fermilab/>



*DOE/HEP and Fermilab delegation visit Ministério da Ciência, Tecnologia e Inovação, Ministério das Relações Exteriores & FAPESP, May 2024*



# Strong partnership with Brazil



<https://news.fnal.gov/2024/05/brazilian-funding-agency-representatives-visit-fermilab/>





# Strong partnership Latin American countries



*Fermilab delegation visits UNICAMP & Akaer, March 2022*

*The Rector of UNICAMP visits Fermilab, August 2024*



*FAPESP and UNICAMP delegation at the Far Site excavation ribbon cutting event in Lead, SD, August 2024*





# Strong partnership Latin American countries



*A visit by Jaime Cortés-Monroy Rojas, Consul General of Chile and Universidad Técnica Federico Santa María (USM)*



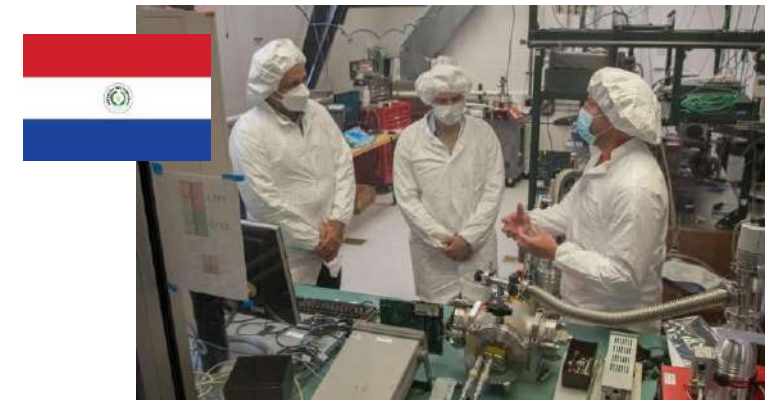
*A visit by MA José Eduardo Hernández Nava, Rector of Universidad de Colima and Consul General Carlos Martin Jimenez Macias of Mexico*



*A visit of Consuls General from Latin American Countries - Venezuela, Argentina, Costa Rica, Brazil, Dominican Republic, El Salvador, Peru*



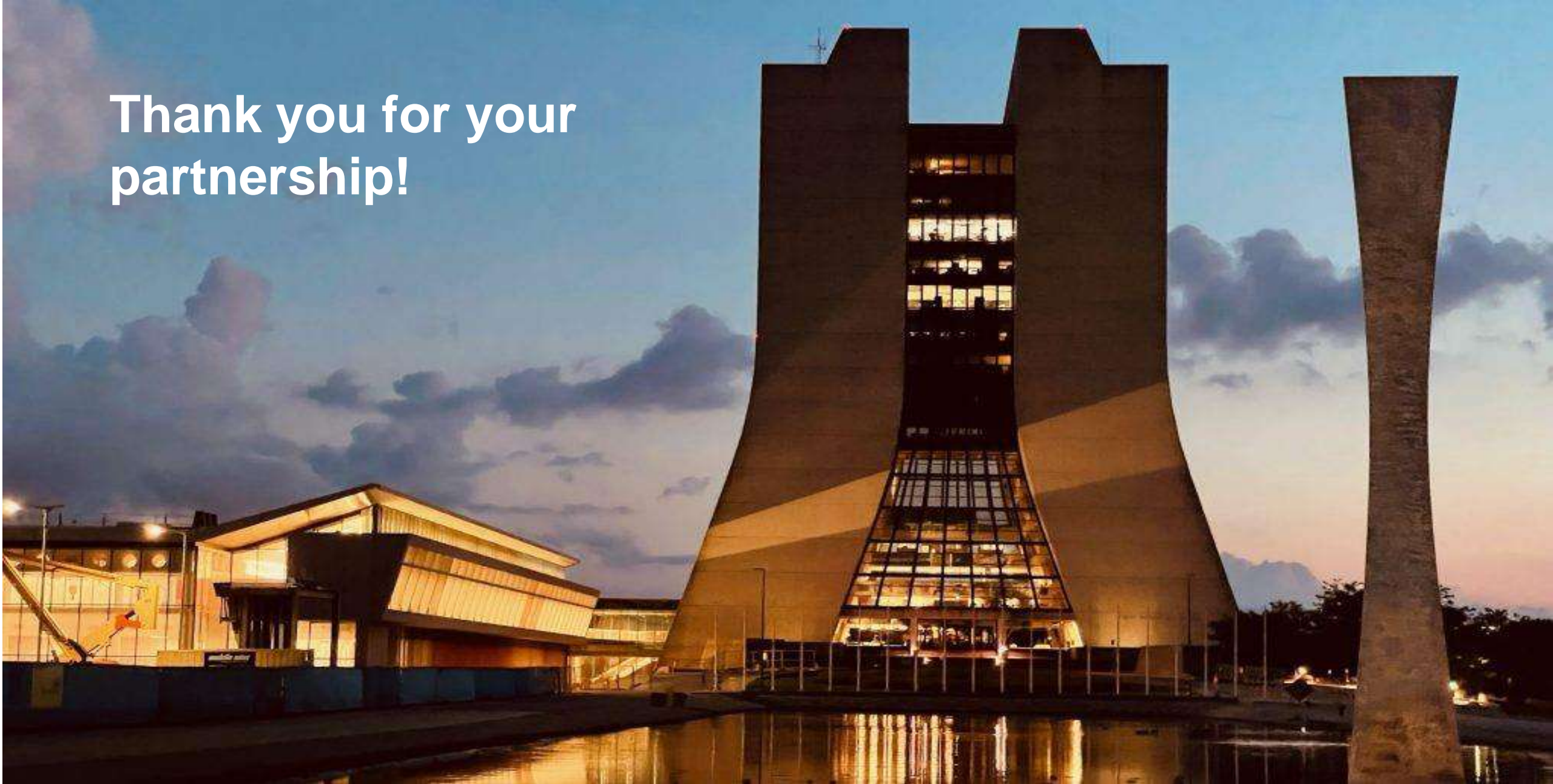
*Ambassador of Argentina Jorge Arguello visits Fermilab*



*Prof. Juan Manuel De Egea from National University of Asuncion's School of Engineering, Paraguay*



Thank you for your  
partnership!





# Proton Improvement Plan – II (PIP-II)



*PIP-II is an essential upgrade to the Fermilab accelerator complex to enable powerful, wideband neutrino beam to LBNF/DUNE, and a broad physics research program for decades to come*



# PIP-II Cryogenic Plant



# PIP-II: Successful transportation test of HB650 cryomodule



U.S. – Batavia, IL



UK - Daresbury



U.S. – Batavia, IL





# Oscura experiment

The future DM experiment with skipper, part of the DOE Dark Matter New Initiatives at FNAL

Countries: Argentina, Brazil, Mexico and Paraguay

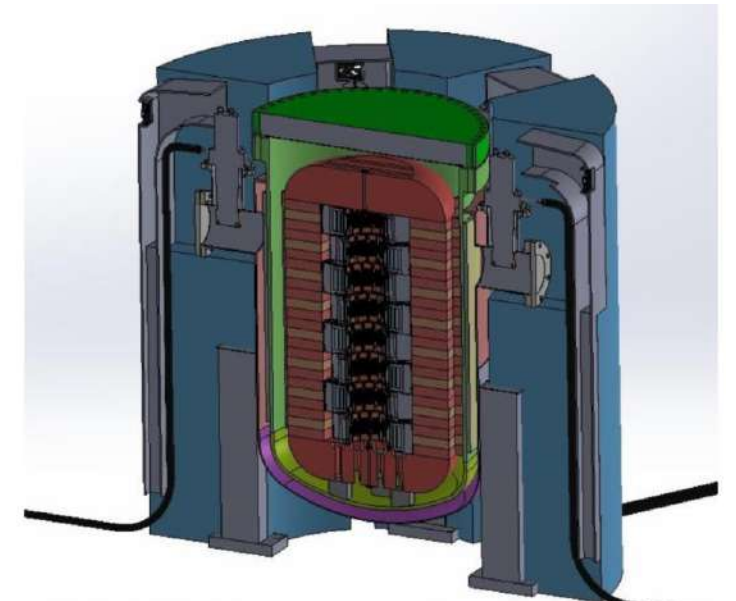
Largest CCD camera ever built  
33 Gigapixel

Critical technical Contributions:

- ASIC design (lead in Argentina, Bariloche, Fabricio Alcalde).
- Electronics design (lead in Argentina, Cordoba, Miguel Sofo-Haro).
- Sensor testing/characterization (Argentina, Mexico, Brazil, Paraguay).
- DAQ design (lead in Argentina, Bariloche, Xavier Bertou).
- Calibration and HW database (lead in Argentina, UBA, Dario Rodrigues).

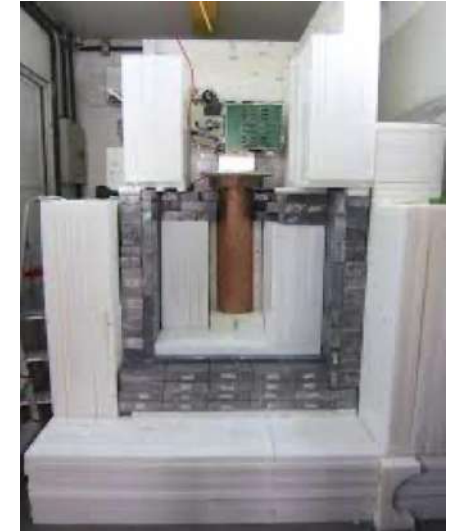
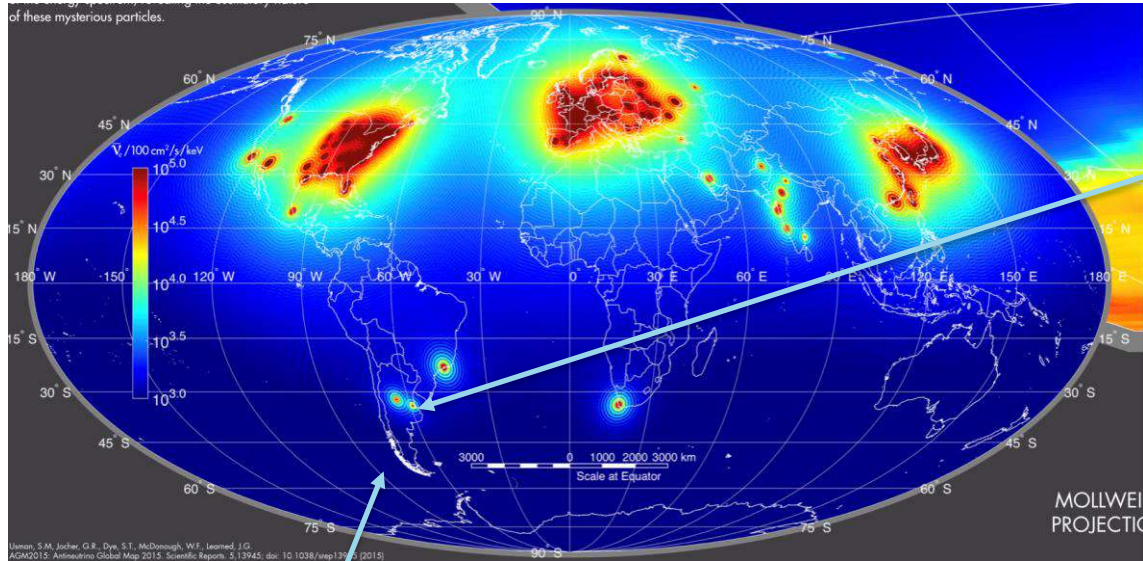
Students:

- FNAL scientists (Juan Estrada, Javier Tiffenberg, and Guillermo Fernandez-Moroni) are PhD advisors of students in Universidad de Buenos Aires, and Universidad Nacional del Sur.
- Several undergraduate students from Latin America come to work at IERC (CCD lab) every year.
- Remote work on CCD data analysis is ongoing in Brazil, Mexico, Argentina, Paraguay.



96 SM in vessel = 12.62 kg  
24,576 CCDs

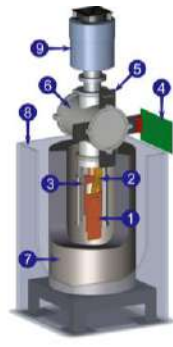
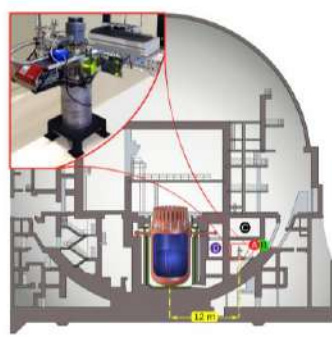
# Skipper-CCD Reactor experiments in Brazil and Argentina



Skipper-CCDs (and CCDs) installed by FNAL and LA collaborators at nuclear reactors in Argentina (Atucha) and Brazil (CONNIE).

Operations totally lead by LA groups (UFRJ, CBPF, UBA, Bariloche).

Students, postdocs, scientists





# Reactor experiments with skipper-CCDs led by LA groups using technology developed in partnership with Fermilab



Irina Nasteva comemorando a instalação da eletrônica do detector



Energy & Environment | New Nuclear | Regulation & Safety | Nuclear Policies | **Corporate** | Uranium & Fuel

## Atucha 2 supports neutrino experiment

07 December 2021



Neutrino detection kit has been installed within the containment of Argentina's Atucha 2 reactor in support of a US-Argentine experiment to learn more about the mysterious particles.



Installing the detectors at Atucha 2 (Image: Nucleoelectrica Argentina)

Atucha 2 is a 693 MWe pressurised heavy water reactor owned and operated by Nucleoelectrica Argentina SA (NA-SA) which has been in operation since 2014. Iván Sidelnik of the Bariloche Atomic Center said, "We chose Atucha II because it has more power and provides us with a suitable place very close to the reactor core."

symmetry

topics



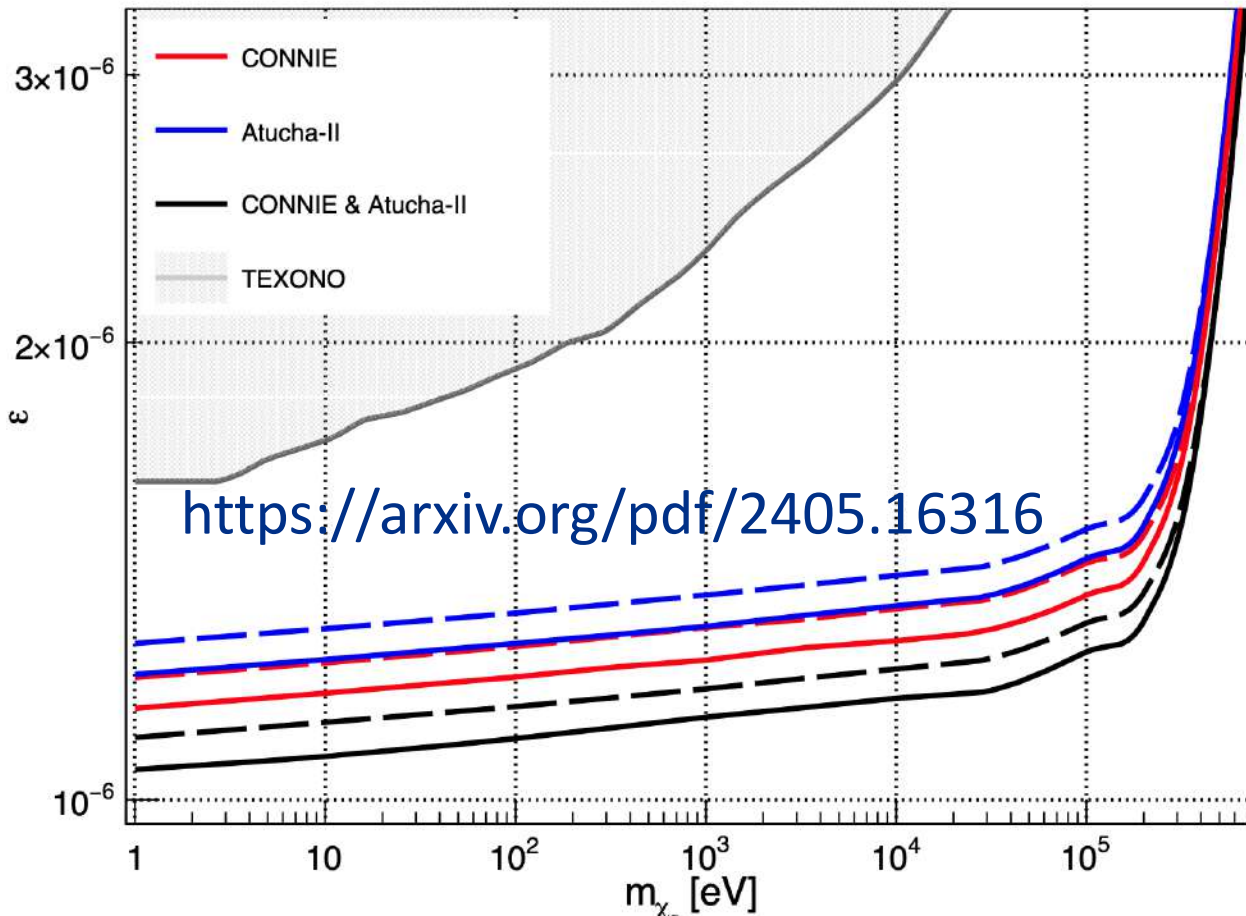
Illustration by Sandbox Studio, Chicago with Steve Shanabrook

### Skipper CCDs

The CCDs that specialist fabricators at Lawrence Berkeley National Laboratory and Fermilab initially designed for CONNIE were extraordinarily thick and wide. That gave low-energy neutrinos plenty of space in which to bounce or scatter off atoms via the aforementioned CEvNS process. And when they send the CCD's silicon atoms recoiling, these have the chance of knocking out electrons from other atoms—an electric charge

# Skipper-CCD at reactors

Search for reactor-produced millicharged particles with Skipper-CCDs at the CONNIE and Atucha-II experiments



Millicharged particles, proposed by various extensions of the standard model, can be created in pairs by high-energy photons within nuclear reactors and can interact electromagnetically with electrons in matter. Recently, the existence of a plasmon peak in the interaction cross-section with silicon in the eV range was highlighted as a promising approach to enhance low-energy sensitivities. The CONNIE and Atucha-II reactor neutrino experiments utilize Skipper-CCD sensors, which enable the detection of interactions in the eV range. We present world-leading limits on the charge of millicharged particles within a mass range spanning six orders of magnitude, derived through a comprehensive analysis and the combination of data from both experiments.

The LA groups shared the data from the 2 reactor experiments with skipper-CCD and produced a new world-leading result.

An example is FNAL+LA groups working on a true partnership that produces world-leading results.



# Astrophysics Detector R&D partnership with LA

- SiSERO : new low noise fast sensor developed with by LBNL, FNAL, MIT-LL, Bariloche (Argentina) and Cordoba (Argentina). The sensor was a success and was selected for funding as part of the NASA strategic technology program for future space telescopes.
- Skipper-CMOS : new low noise sensor developed with SLAC, Bariloche, Universidad Nacional del Sur as part of the microelectronics effort at FNAL.
- MAS-CCD: This “faster” version of skipper-CCD developed as part of the QIS effort at FNAL and selected for funding at NASA for future space telescopes. Heavy involvement of Universidad de Buenos Aires and Universidad Nacional del Sur (Argentina).
- Skipper-CCDs in high energy beams: effort with Universidad de Buenos Aires for applications at CERN, MINOS and PIP-2.

# The Lambda Laboratory at Universidad de Buenos Aires

**New lab in the physics department focused on the use of low threshold detectors. Emphasis on skipper-CCDs.**

- Participates on the skipper-CCD experiments lead by FNAL (SENSEI + Oscura).
- Trains graduate and undergraduate students to work on this technology (several have now moved to FNAL, UC, other HEP groups).
- HUB to sharing skipper-CCD technology with other groups in Argentina and Latin America.
- Leads its own projects with these sensors (reactor experiment).
- Skipper-CCD classes available as educational lab in UBA.
- School, workshops.

Leads (Dario Rodrigue - UBA, Javier Tiffenberg FNAL)

20+ students at all levels

