DUNE
Deep Underground Neutrino Experiment
Status of the experiment

IN2P3 Scientific Council
March 2nd , 2026

C.Cerna (PPC Chicago)
On behalf of the DUNE/IN2P3 team

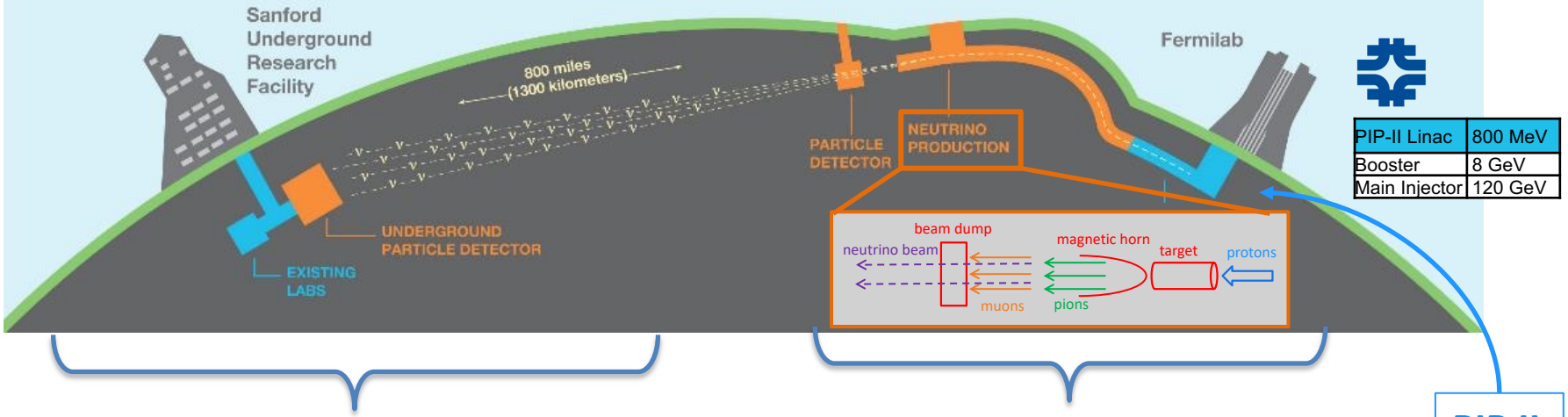
LBNF / DUNE
Overview and Status

LBNF / DUNE Project Scope

- 1,300 km baseline enables unambiguous measurement of the neutrino mass ordering
- The detector's on-axis location provides for a wide-band energy spectrum of neutrinos enabling detailed fitting of the oscillation parameters, including delta CP
- The liquid Argon technology for the Far Detector is a robust and mature technology to exploit the wide-band neutrino spectrum
- The near Detector complex provides control of the systematics uncertainties

Far Site – SURF in Lead, SD
Facility/Infrastructure and Far Detectors

Near Site – FNAL in Batavia, IL
Facility/Infrastructure, Neutrino Beamline, and Near Detectors



- **FSCF-EXC** – Far Site Excavation
- **FSCF-BSI** – Far Site Building & Site Infrastructure
- **FDC – Far Detectors** and Cryogenic Infrastructure

DUNE Far Detectors

- **NSCF -** Near Site Conventional Facilities
- **Beamline –** Proton Beam and Neutrino Beam
- **ND** – Near Detector

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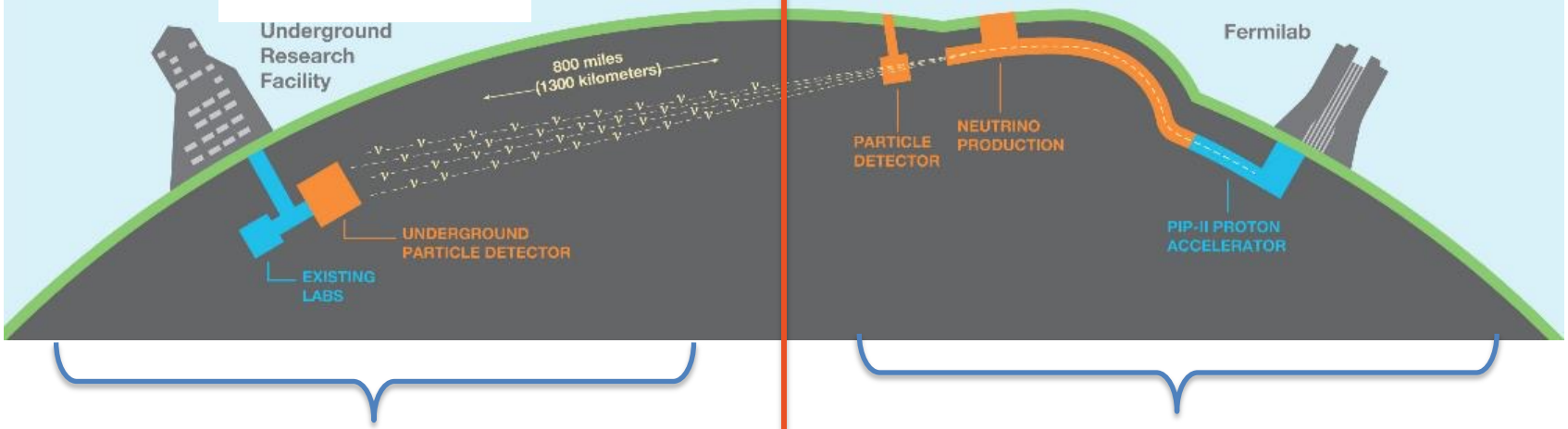
THIS TALK



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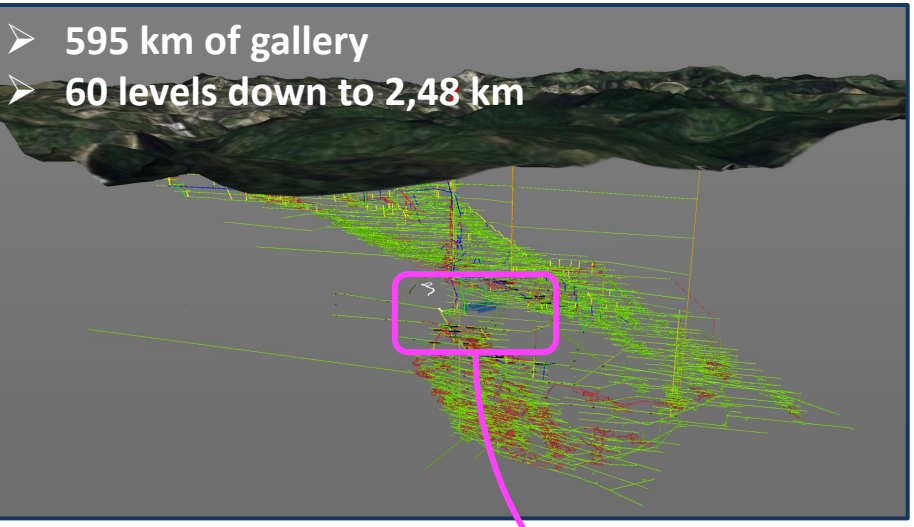
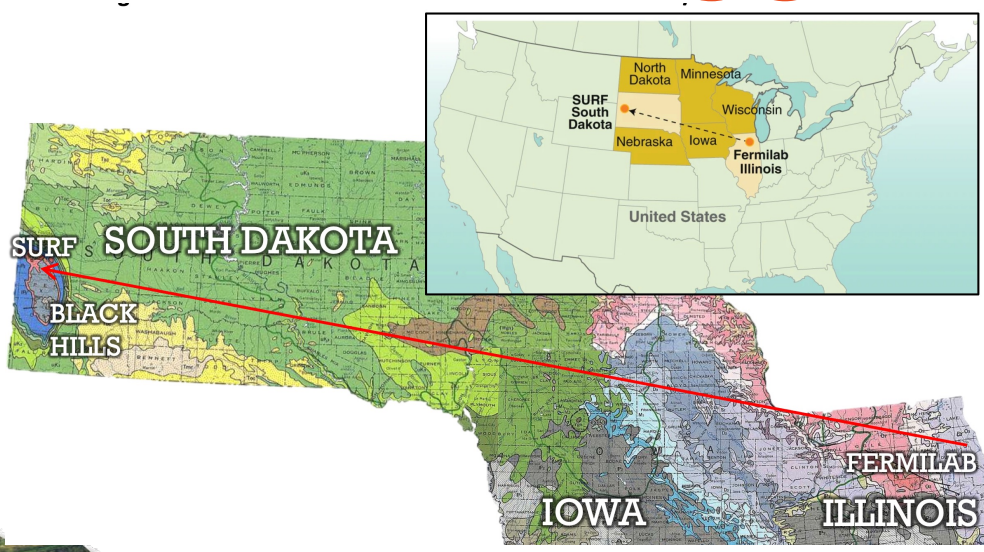
SURF Sanford Underground Research Facility

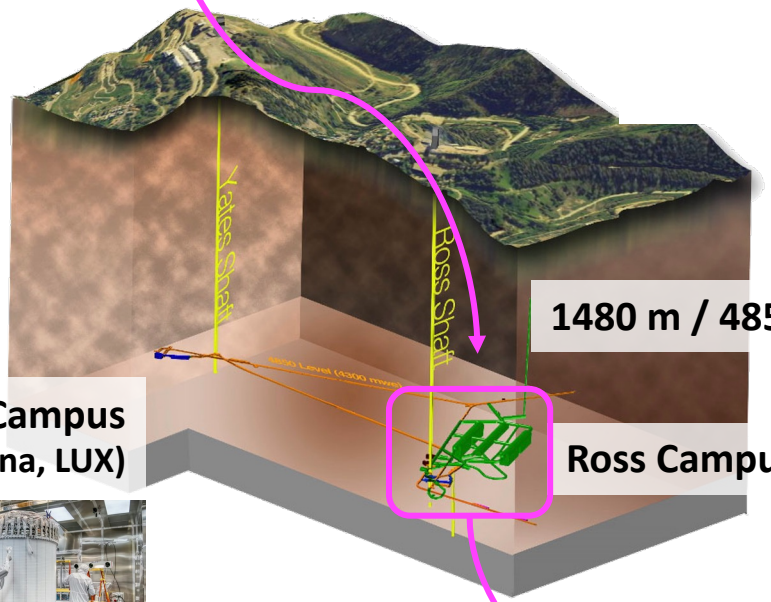
- Homestake gold mine in the Black Hills
- Site of the mythical Davis & Bahcall Solar Neutrino Experiment (1970-94)
- Donated to South Dakota Science and Technology Authority (SDSTA) in 2006
- Lease agreement in 2016 between SDSTA and US DOE for LBNF/DUNE

SURF

- 595 km of gallery
- 60 levels down to 2,48 km

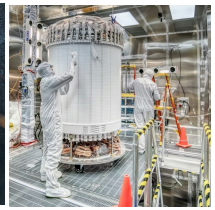




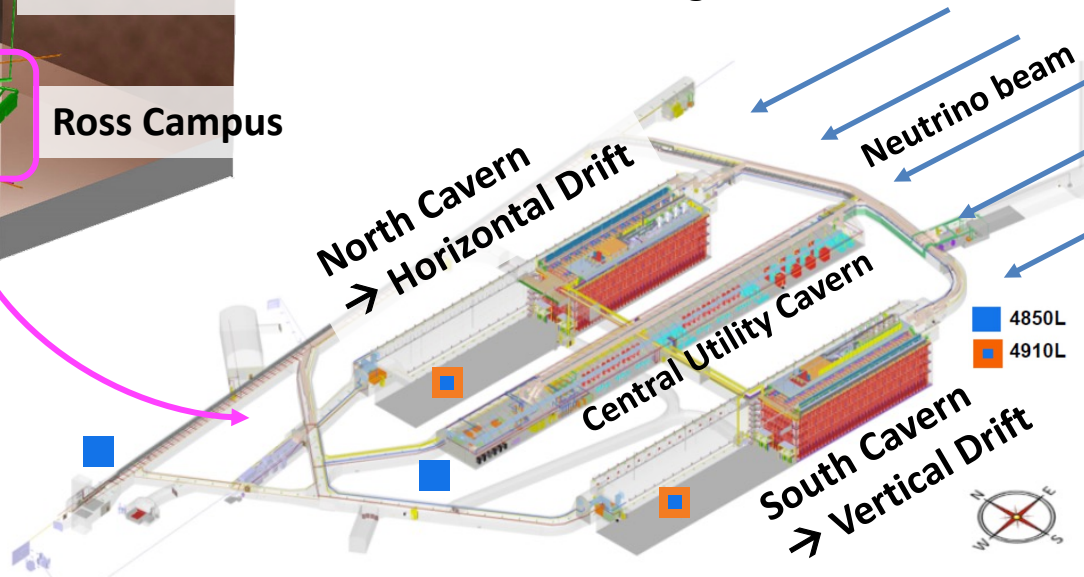


1480 m / 4850 ft /4300 m.w.e. underground

Historical Davis Campus
(Chlorine, Majorana, LUX)



Ross Campus

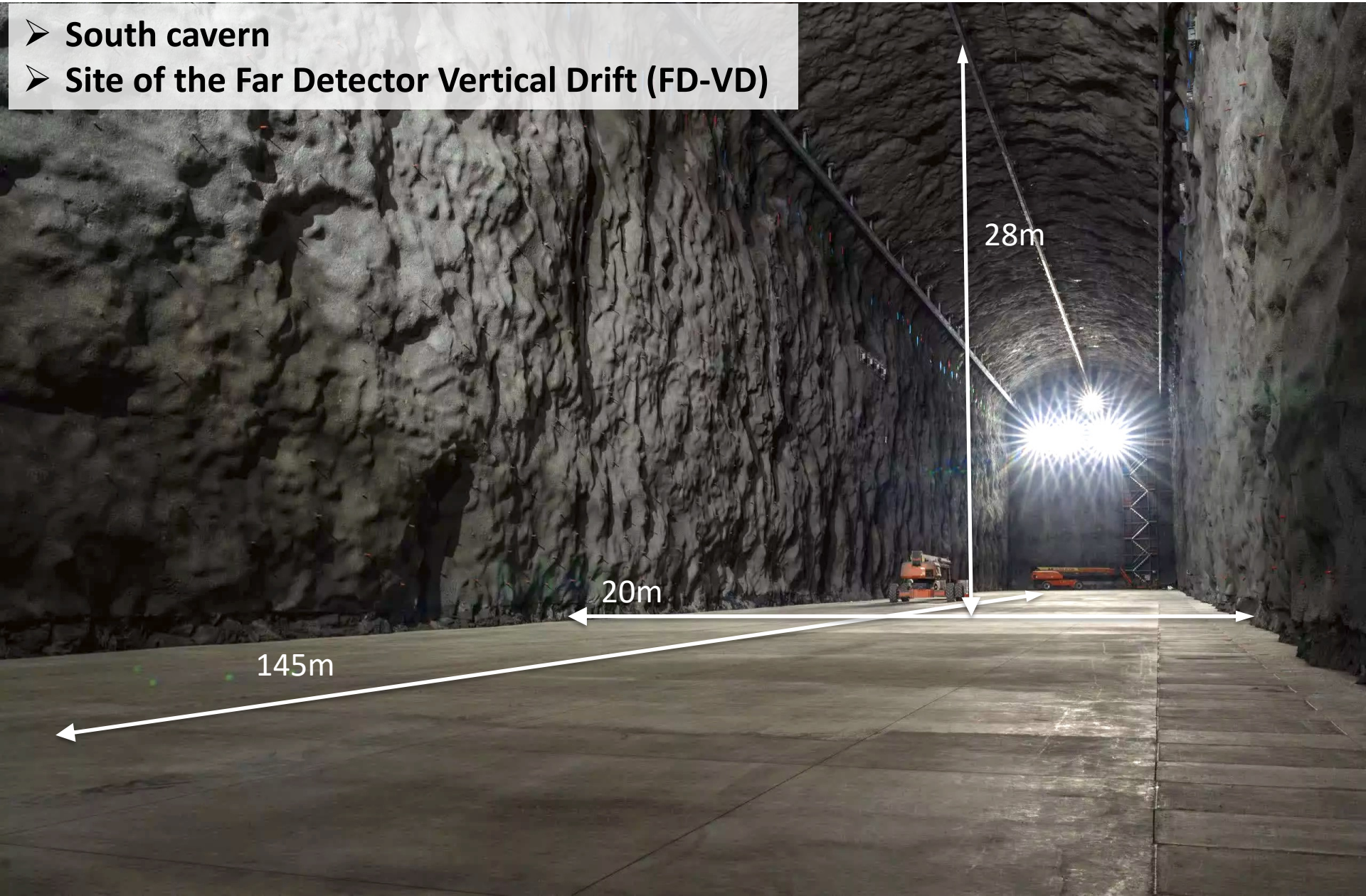


Far Site Excavation (EXC)

- 1480 m / 4850 feet below the surface
- Caverns completed in 2024 on budget and on-schedule
- Massive excavation of 800,000 tons of rock

Far Site Excavation (EXC)

- South cavern
- Site of the Far Detector Vertical Drift (FD-VD)

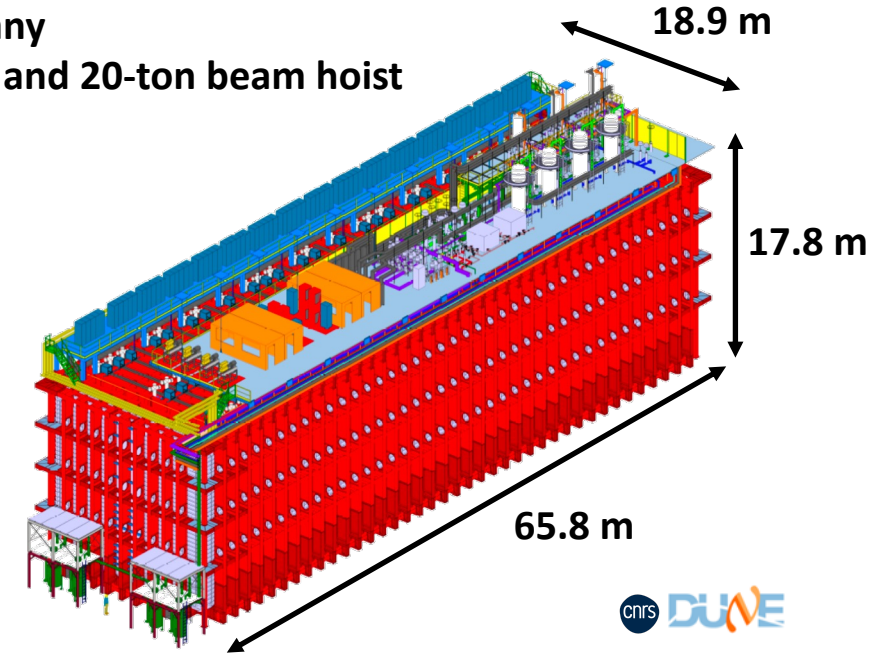


Building & Site Infrastructure (BSI)

- Cavern outfitting to support far detectors well underway
- South Cavern Availability (AUP): February 2026
- VD Cryostat Erection: Expected to start August 2026

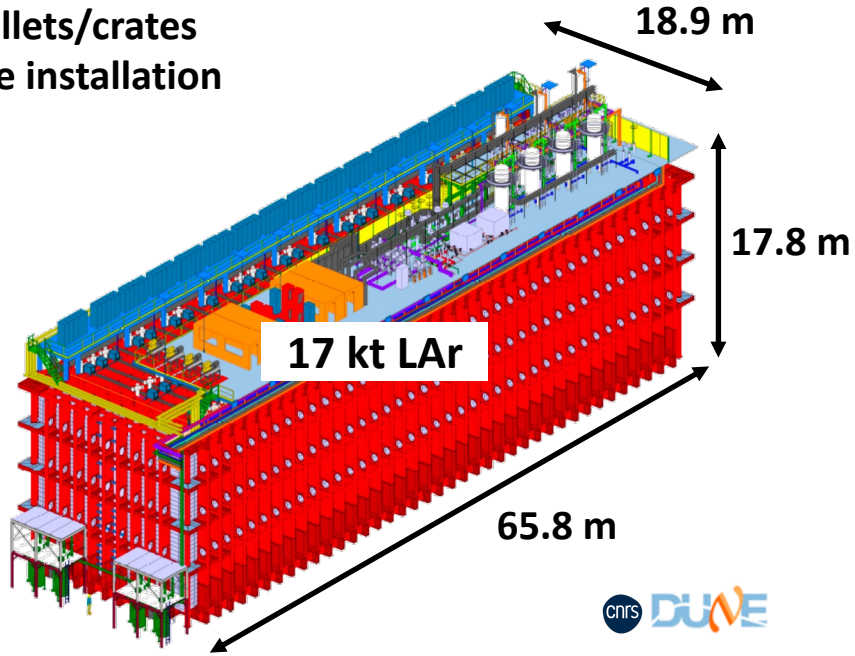
Status of (warm) Cryostats

- 6250 tons of Steel delivered in South Dakota (~800 trucks) = 2 cryostats
- Installation contract signed by CERN with a US company
- Cryostats will be erected using a 35-ton mobile crane and 20-ton beam hoist



Status of (cold) Cryostats

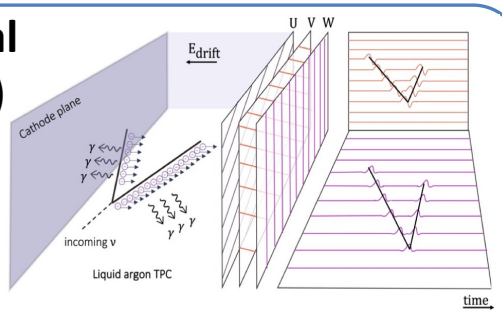
- Shipment of both cryostats arrived in the US
- ~117 sea containers arrived in South Dakota = 1968 pallets/crates
- CERN to prepare to contract an expert company for the installation

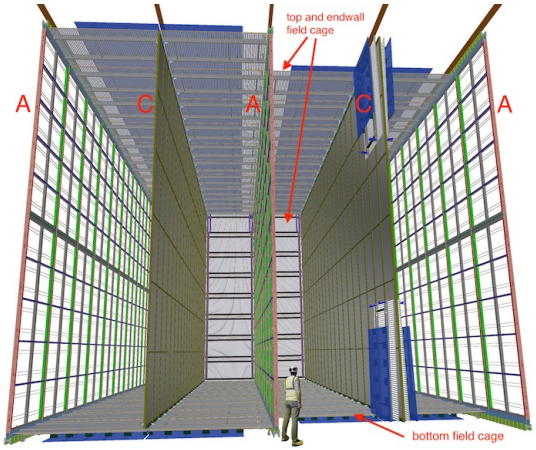


DUNE Far Site Detectors

- **Horizontal Drift (FD-HD)**: horizontal drift detector with anode wire planes (APA) readout
- **Vertical Drift (FD-VD)**: vertical drift detector with perforated PCBs electrodes strips as Charge Readout Plane (CRP)

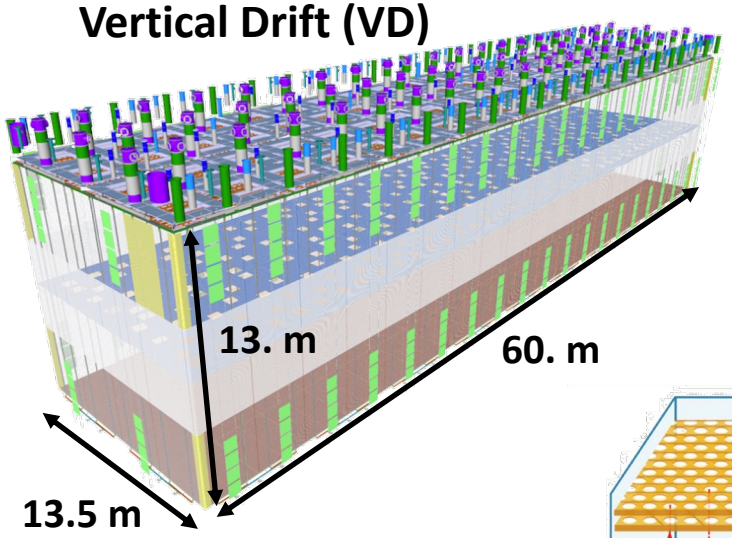
Horizontal Drift (HD)

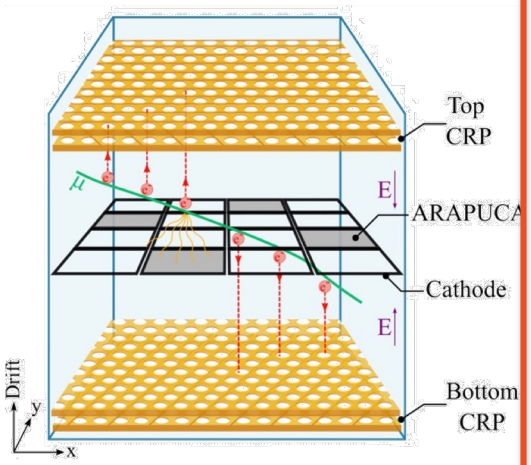




- Drift length ~ 350 cm
  - HV on cathode ~ 180 kV
- Wire readout plane (APA) technology
- Photon detectors integrated in anode planes
- **~ 13.6 kt of Instrumented Volume in LAr**

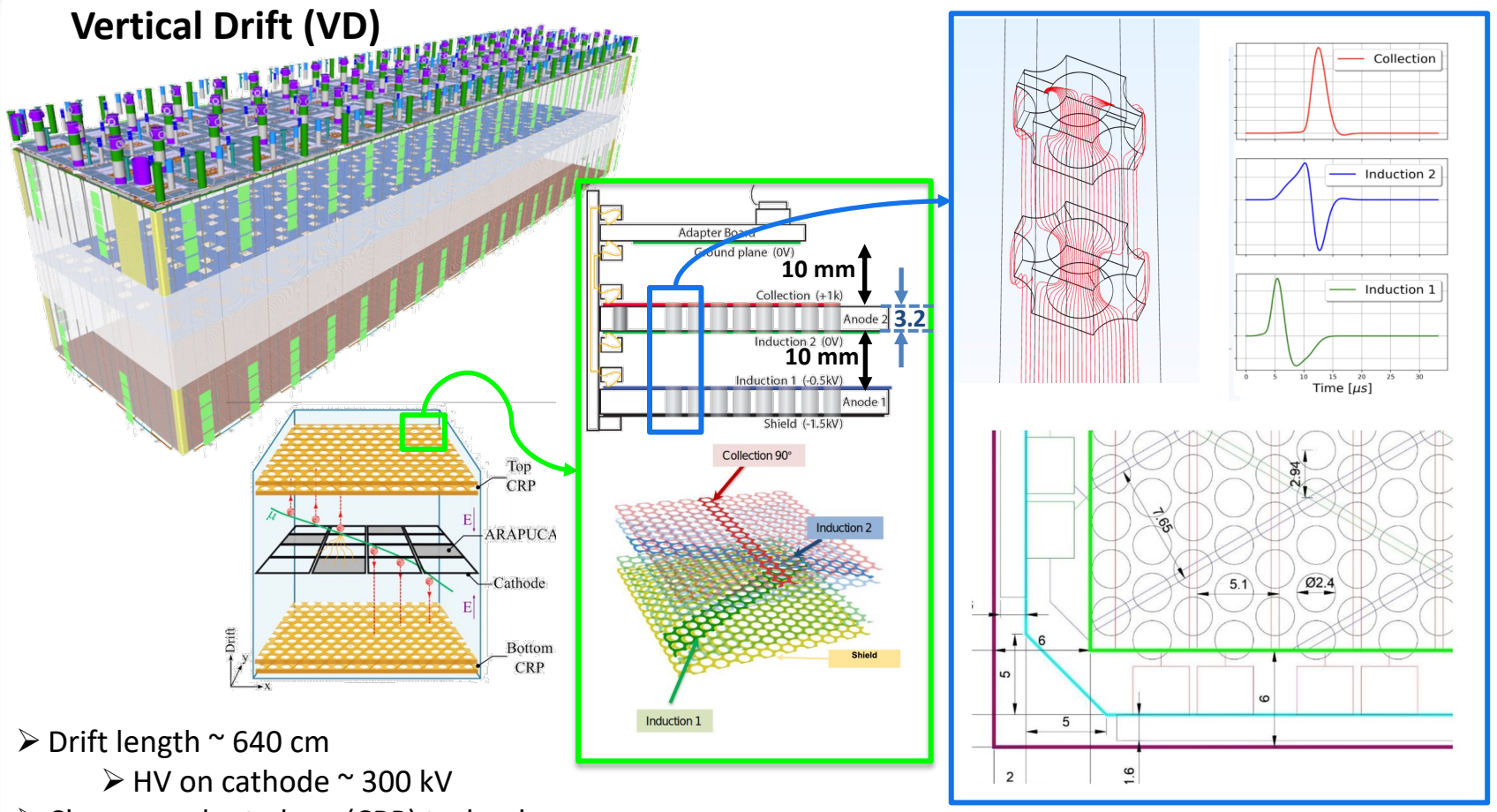
Vertical Drift (VD)





- Drift length ~ 640 cm
  - HV on cathode ~ 300 kV
- Charge readout plane (CRP) technology
- Photon detectors integrated in cathode plane and membrane walls
- **~ 14.7 kt of Instrumented Volume in LAr**

DUNE Vertical Drift (VD)



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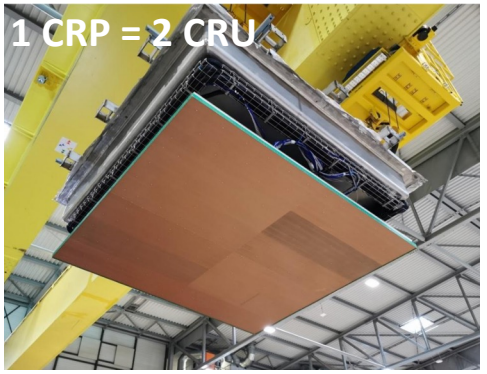
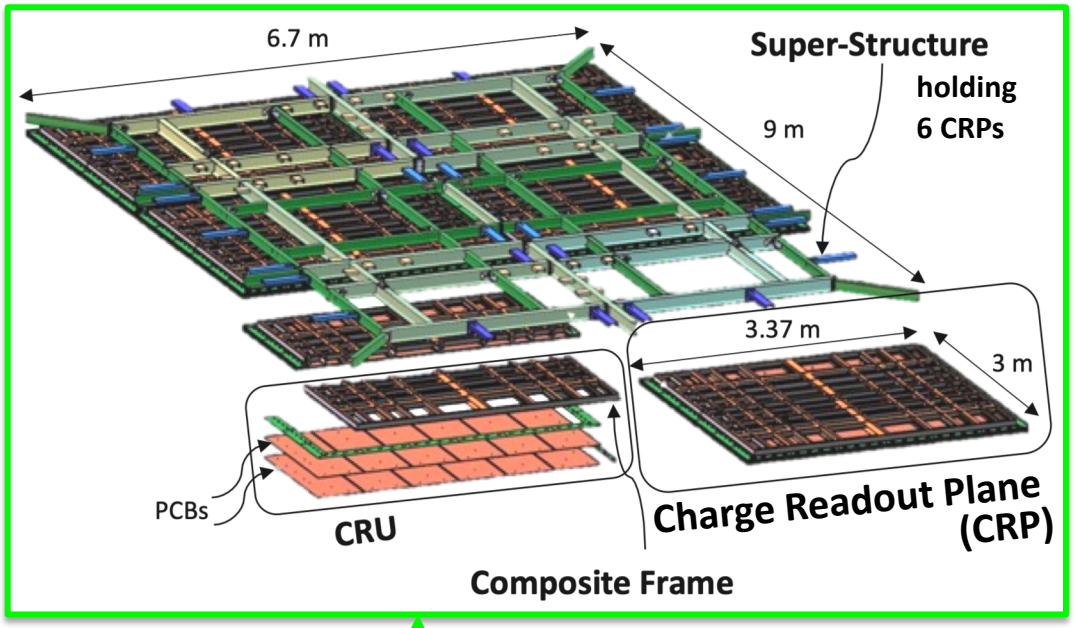
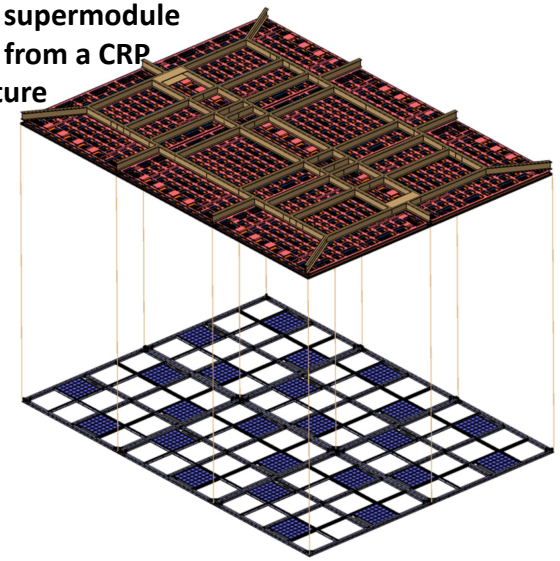
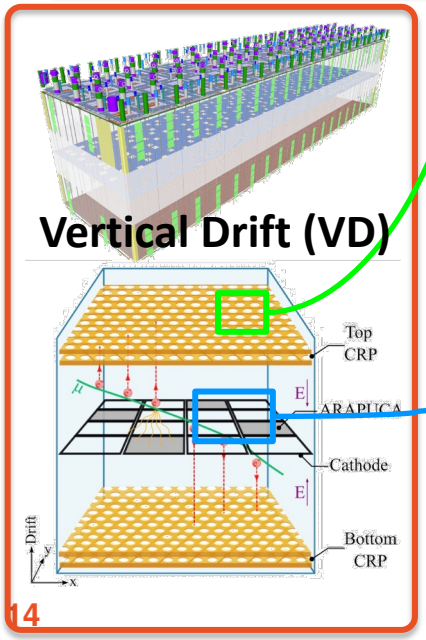


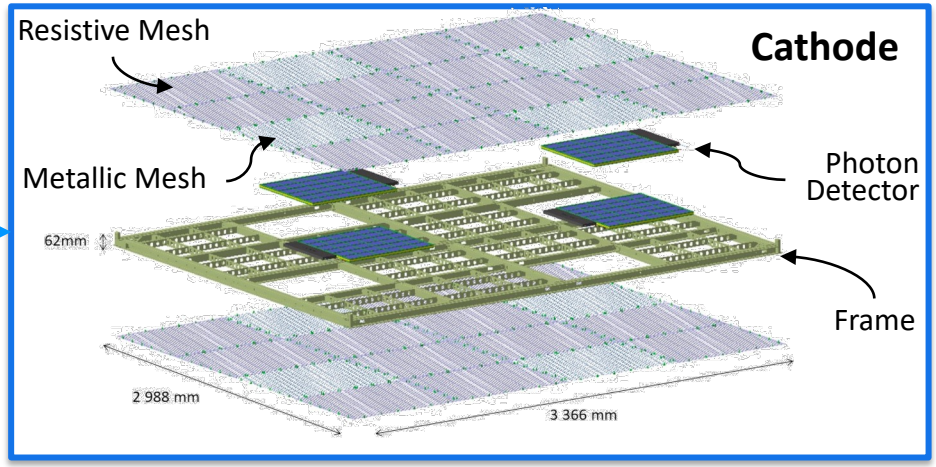


6 cathodes supermodule suspended from a CRP superstructure



for illustration only





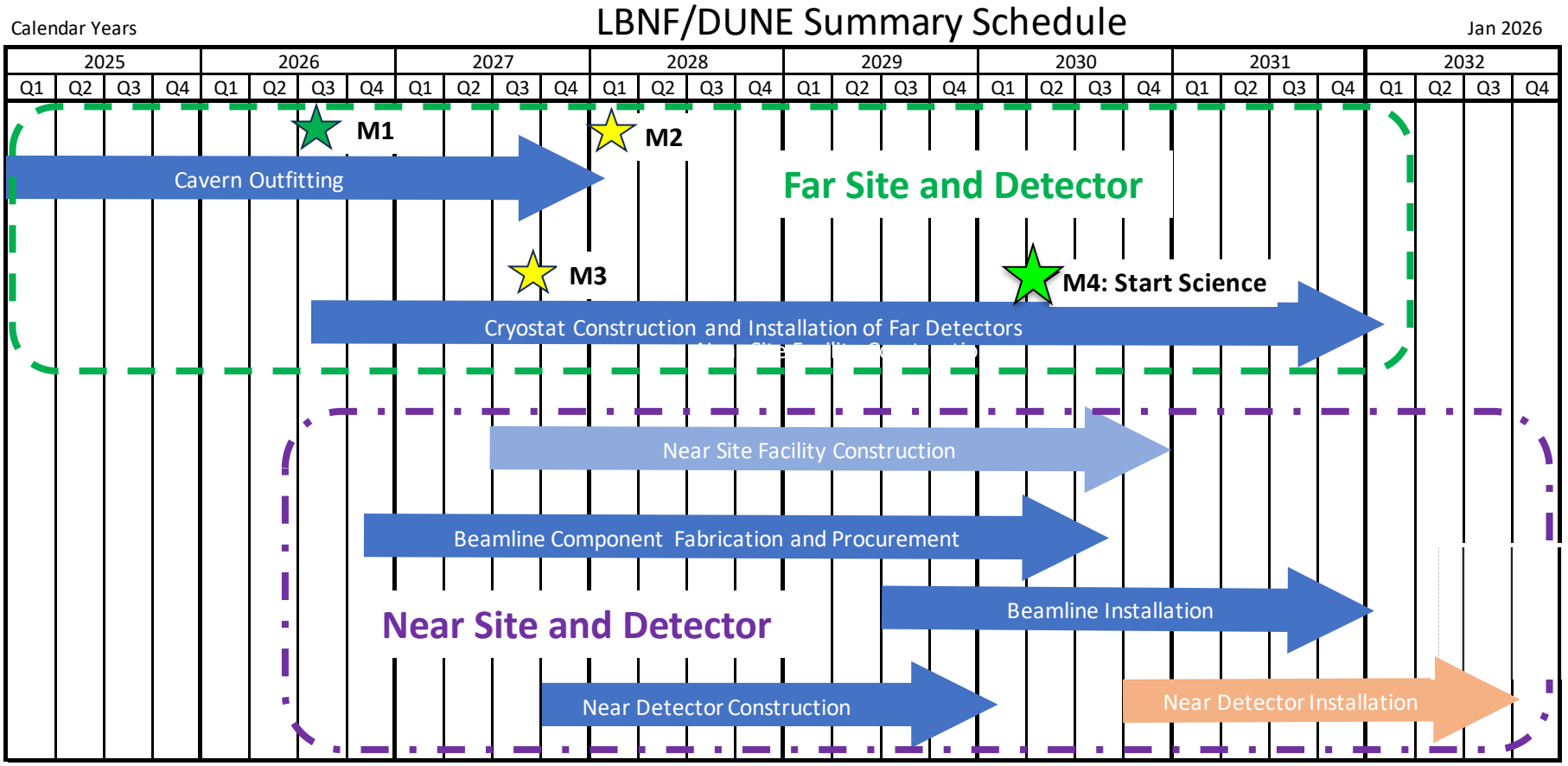
LBNF/DUNE Schedule

M1: Start of far site cryostat construction

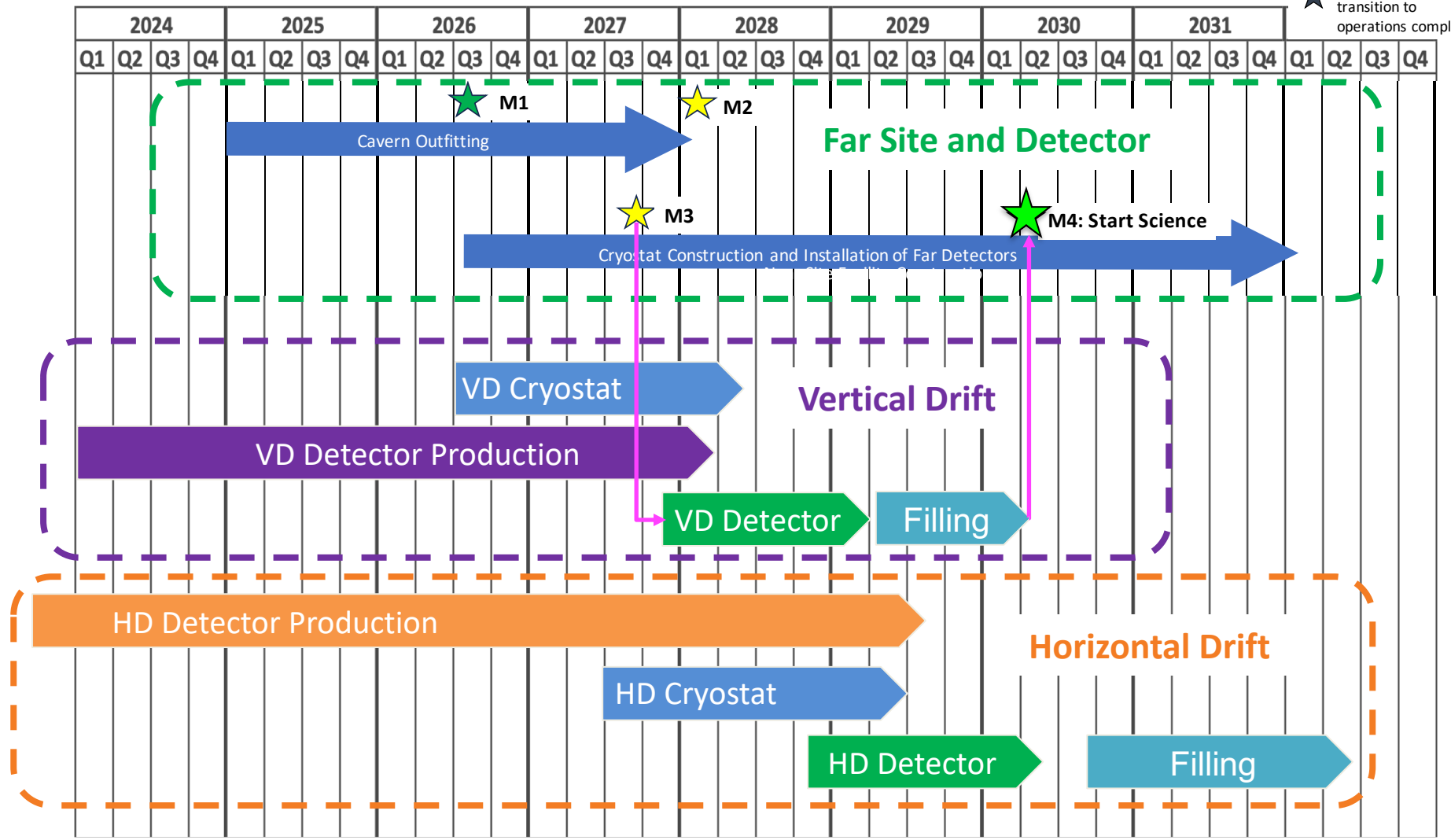
M2: Far site conventional facility transition to operations complete

M3: Start of far detector construction

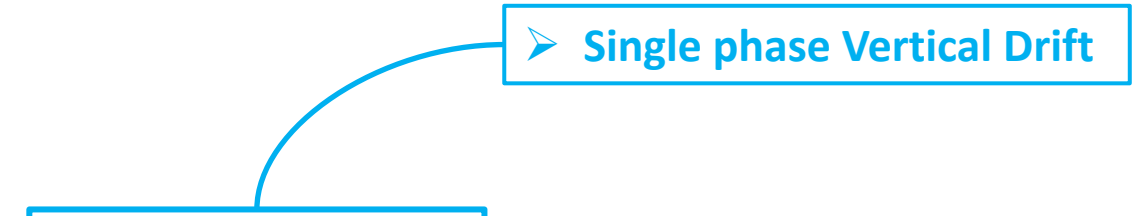
M4: First far detector transition to operations complete



Schedule (Far Site focus)



Last DUNE Scientific Coucil



« En cas de succès de ce nouveau concept, et dans la mesure où le CERN s'est engagé à fournir le second cryostat, le Conseil est d'avis que le retour pour l'institut en termes de visibilité et de fiabilité sur ses contributions techniques sera exceptionnel, d'autant qu'il inspirera peut-être les troisième et quatrième détecteurs dans un futur plus ou moins lointain »

« le Conseil estime qu'une étude complète des risques liés aux défis technologiques, et de leurs conséquences potentielles sur les mesures et les retours scientifiques serait nécessaire pour identifier les actions susceptibles de les modérer.»

Development of the DUNE-IN2P3 project

- Approval of DUNE TGIR 2020 (IR* funding since 2022)
- Dual-phase → Vertical Drift 2020
- CNRS IN2P3 CS 2021
- NP02 protoDUNE 2021-2022 → 300kV + 6m drift length + single phase readout
- FD-VD CDR/PDR/FDR reviews 2021-2023
- IN2P3 KDP#2 review March 2023 → Approval of Project Assessment of Resources
- DUNE MoU 2023
- TDR DUNE – VD Dec 2023
- NP02 protoDUNE VD + Cold Box 2023-26 → Integration / Interfaces Engineering validations / LAr Purity
- FD-VD PRR reviews 2023-2026
- Start of Production at IN2P3 Dec 2023
- Installation Mockup 1:1 2025 → Installation / Interfaces
- CNRS IN2P3 CS 2026
- Installation (IN2P3 teams) end 2027 to 2028

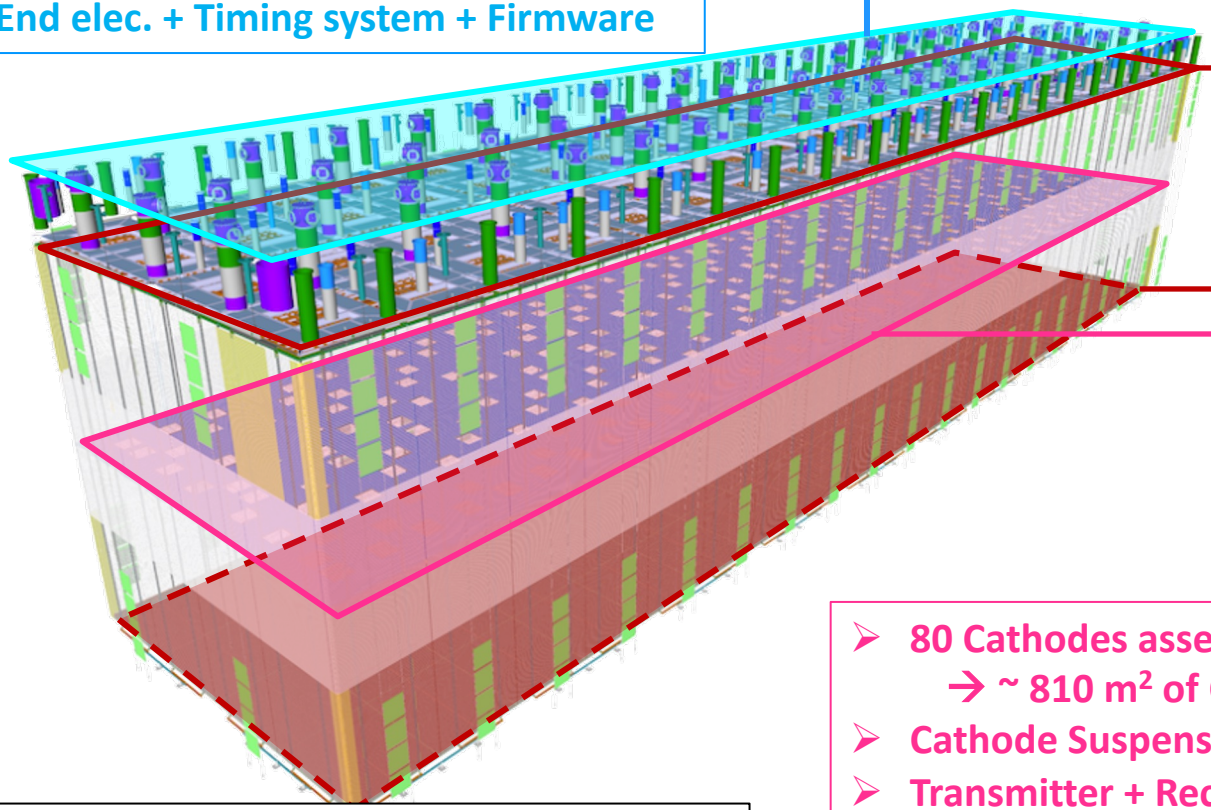
VD detector

Top Drift Electronics (TDE)

- 105 Chimneys cryostat penetrations + Cabling
- 245 760 Complete chain readout channels
  - → ASICs + Front-End electronics
  - → Back-End elec. + Timing system + Firmware

Charge Readout Plane (CRP)

- 90% - 72 Top CRP assembly + tests
  - → ~ 730 m^2 of Top CRP detectors
- Top CRP Suspension + Cabling + Position control
- 160 Top+Bottom CRP Composite Frames



Cathode System

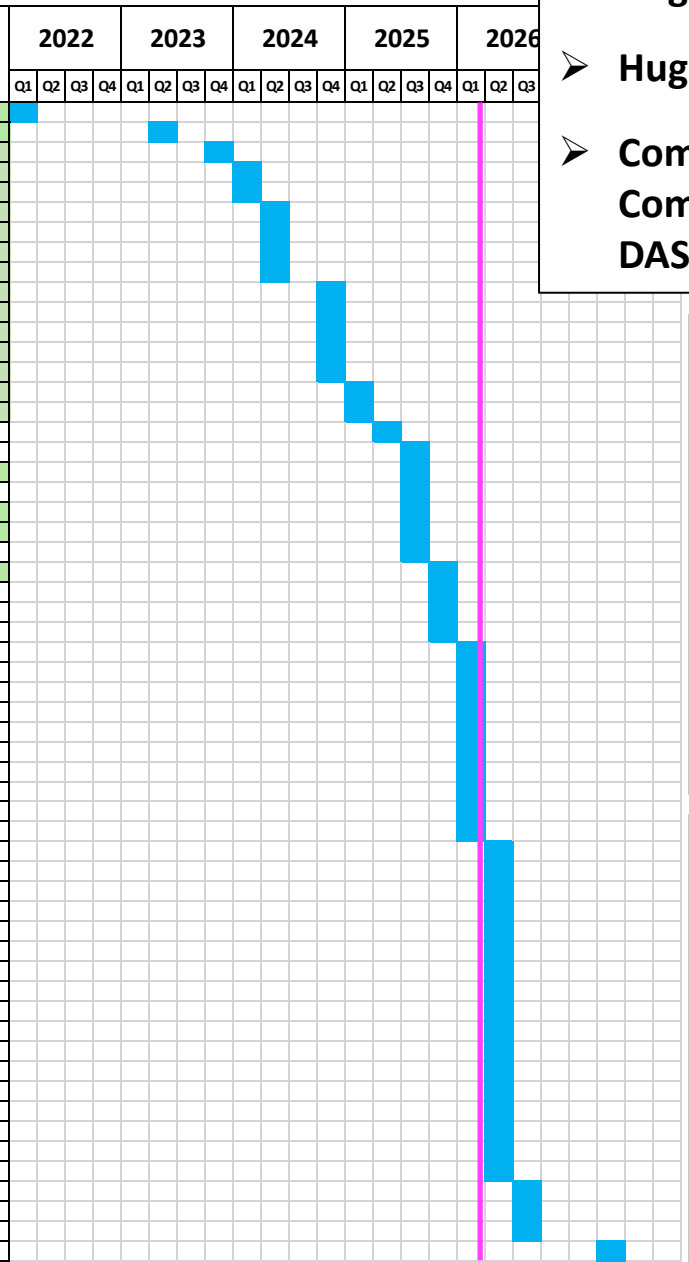
- 80 Cathodes assembly and test
  - → ~ 810 m^2 of Cathode
- Cathode Suspension + Position control
- Transmitter + Receiver for the 320 Cathode mounted Photon modules
  - → Photon readout for 106 x 2 m^2

- FD – Vertical Drift splits in 7 sub-systems (consortia)
- 2 consortium leaders:
  - TDE: Dario Autiero
  - CRP: Dominique Duchesneau

DUNE
CNRS IN2P3 contributions status

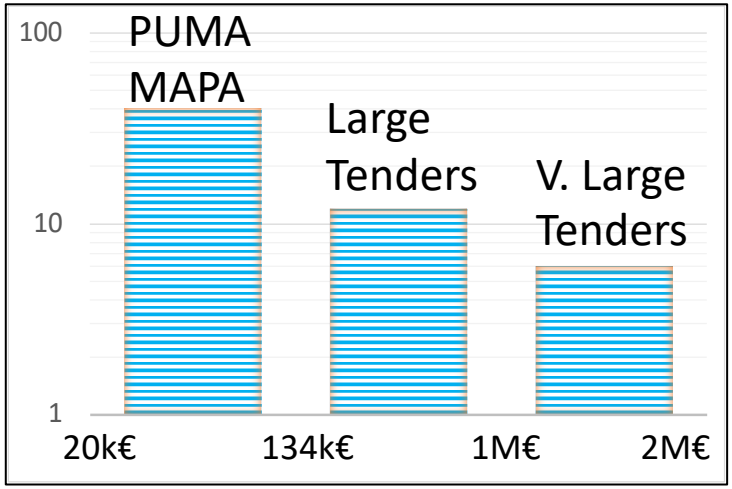
PRR → Procurement

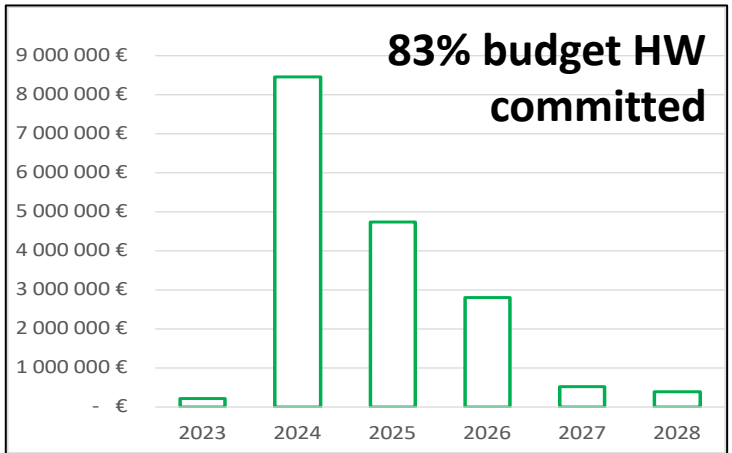
Cons	Review		Scheduled	Documents	Report	Recom	Closeout
BDE	LArASIC Production						
BDE	ColdADC/COLDATA Production						
PDS	PDS DAPHNE components						
TDE	TDE AMC components						
BDE	BDE PTC components						
HVS	HVS Cathode frame & mesh						
TDE	TDE AMC & uTCA crates						
TDE	TDE chimney vessel						
DAQ	DAQ DTS components						
CRP	CRP composite frame						
TDE	TDE FEB						
PDS	PDS SoF driver						
TDE	TDE MCH						
BDE	BDE cold cable						
PDS	PDS SiPM						
HVS	HVS divider boards						
CRP	CRP Grenoble factory						
BDE	BDE FEMB						
HVS	HVS/BDE Bias supplies/cables						
CRP	CRP adaptor/edge cards						
PDS	PDS WLS						
HVS	HVS cathode suspension						
PDS	PDS SoF receiver						
BDE	BDE WIB/WIEC						
CI	Purity Monitor						
DAQ	DAQ Timing System						
BDE	BDE PTC						
BDE	BDE Low Voltage supplies						
HVS	HVS power supply & FC profiles						
TDE	TDE chimney guide system						
HVS	HVS divider boards						
HVS	HVS cathode assembly						
CI	Temperature Sensors						
PDS	PDS module mechanics						
CRP	CRP anode procurement &						
CRP	CRP adaptor board QC factories						
PDS	PDS cold electronics						
CRP	Top CRP shipping frame						
HVS	HVS Cathode installation						
CRP	top CRP cable trays						
HVS	HVS FC production						
DAQ	DAQ readout, network, storage						
CRP	Top CRP system						
TDE	TDE Low Voltage power						
BDE	BDE cable assembly						
PDS	PDS fiber/flange						
CRP	top CRP installation tools						
CRP	CRP Bottom Ground plane						
CRP	Top CRP suspension						
BDE	BDE mechanical						
CRP	Bottom CRP system						
PDS	PDS DAPHNE						
HVS	HVS Feedthrough system						
CRP	CRP Bottom support & tooling						
CRP	Bottom CRP shipping frame						
CRP	CRP York factory						
CRP	CRP Indiana factory						
CRP	CRP CERN factory						



By Q2 2026 95% of IN2P3's PRR will be passed

- **Huge work from Final to Production Design**
- **Huge work of Procurement**
- **Commitment of IN2P3 DUNE teams, Companies, Laboratories, DUs, DRs, DAS/DAT, DDAI, DAJ and DSFIM**





Cathode

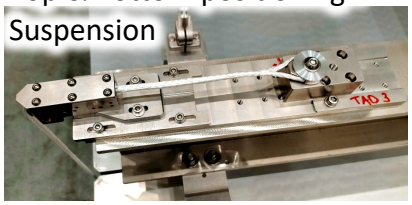
- IN2P3 PI Fabien Cavalier
- IN2P3 PM Véronique Puill
- Mech. Leader Philippe Rosier

- ½ frames : 120 (70%) Received and Validated
- Resistive Grid: 555 (25%) Received and Validated
- Metallic Grid: 720 (100%) Received and Validated
- Suspension Cables In production
- Positionning (top+bottom) In Procurement
- Transportation Box Final Design
- Integration + Installation tools In production

- 400 m² hall assembly

- **All deliveries expected for Q1 2027**

Top & Bottom positioning + Suspension



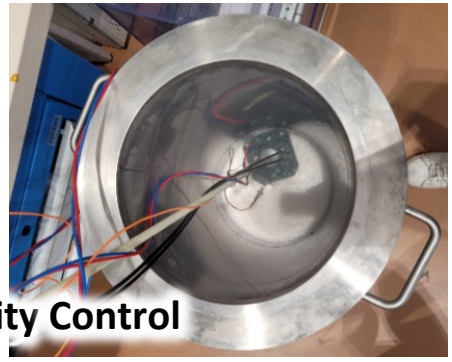
Signals Transmitters + Receivers
Cathode Photon Detectors

- IN2P3 PI Jaime Dawson
- IN2P3 PM Sylvie Blin

APC, CNRS, FRANCE

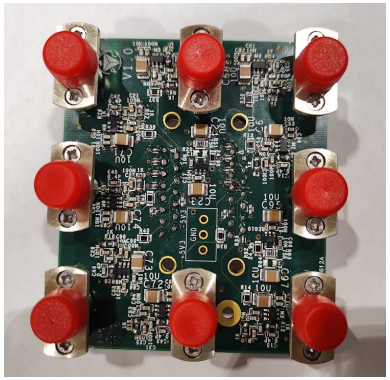
2-channels optical transmitter

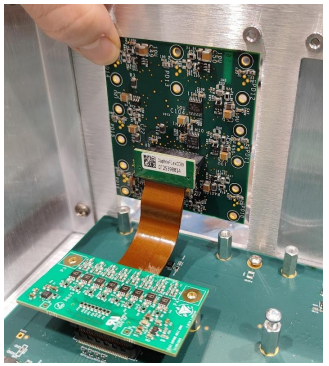
- 700 custom IR lasers
  - → Production ongoing (batches) 50/700
- x 320 Transmitter boards
  - → Cold electronics PRR March 2026
  - → Delivery Q1 2027



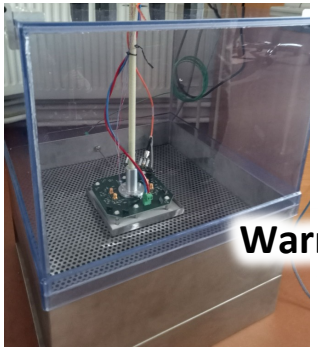
Liquid Argon Quality Control

8- channels optical receiver





- 700 photodiodes
  - → PRR Sept 2025 → Procurement ongoing
- x 80 8-channel receivers
  - → Warm electronics PRR June 2026
  - → Delivery Q1 2027



Warm electronics Quality Control

CRP

- **CRP Consortium Leader Dominique Duchesneau (IN2P3 PI)**
- **FR Mechanical Design Leader Nicolas Geffroy +IN2P3 PM**
- **Top CRP HWDB liaison Jean-François Muraz**

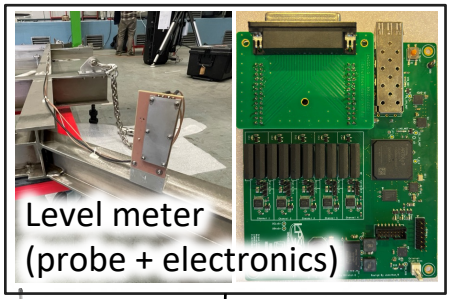
- **320 Composites Structures (Top & Bottom)**
  - *PRR 2024 → Procurement 2025*
  - *Production ongoing → until end of 2027*

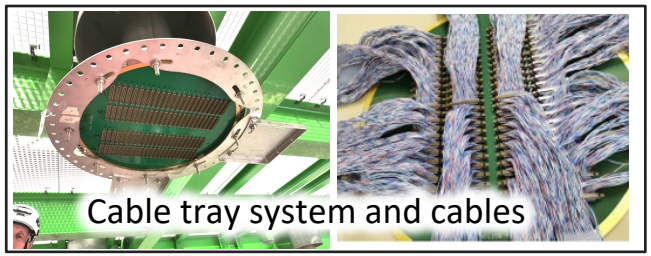
For CRP Factories (2026)

- **Decoupling system for the Top CRPs**
- **Suspension system for the superstructures**
- **Positioning → level meter**
- **Cabling of the top CRPs**
- **Tooling & Installation procedures**

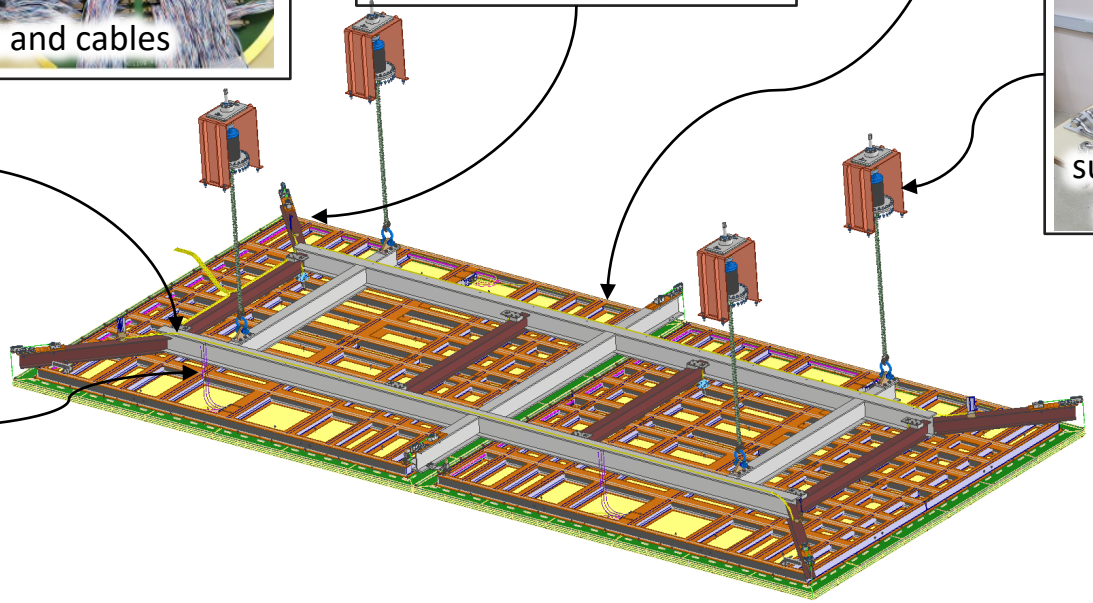
For Installation (2028) Production after Mockup validation

All component design being finalized and production start by end of 2026





Design of the **Super-Structures**



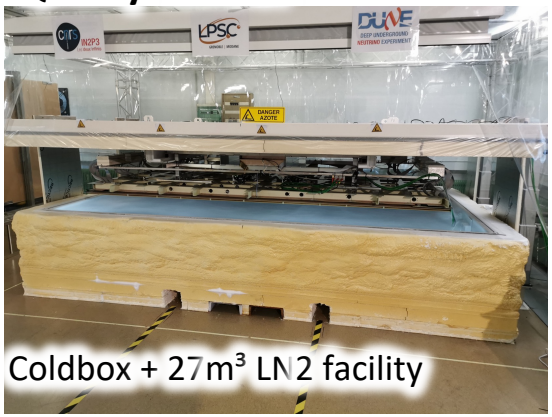
TOP CRP Factory

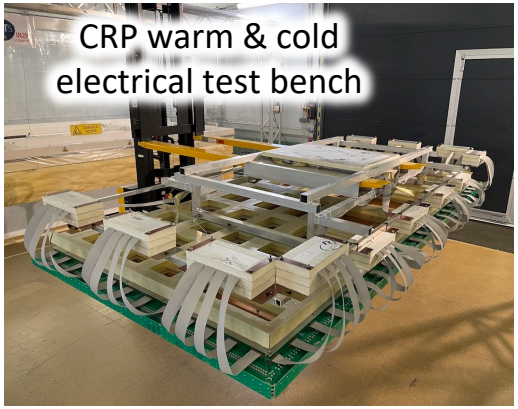
- IN2P3 PI Jean-Sébastien Réal
- IN2P3 PM Jean-François Muraz

- Assembly & test of 71/80 Top CRP (90%)
- PRR successfully passed in June 2025
  - Secured trained manpower
  - Assembly tools, procedure
  - 1 CRP fully assembled & tested
- Production starts in 2026 & ends Q1 2028
- Shipmnt. in batches at SURF with 3-6 m. float to installation.

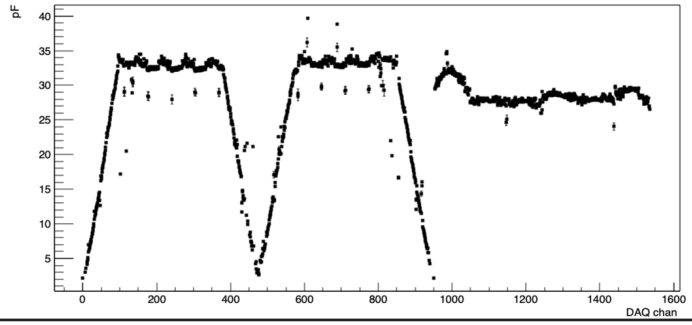
Assembly

Quality Control

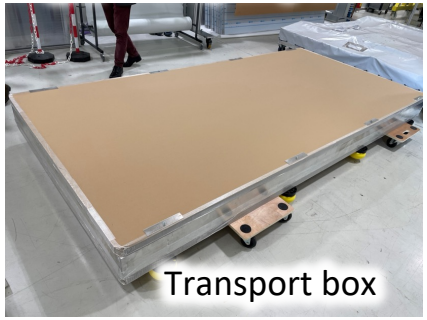




Strip capacitance measurement
(C ∝ strip length)



Storage, Transport, Installation tools

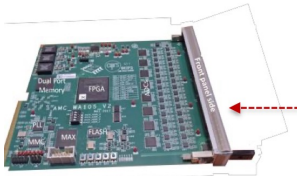


Top Drift Electronics architecture

- **TDE Consortium Leader Dario Autiero**
- **QC/HWDB liaison Vyacheslav Galymov**

x 63 chimneys V48
x 42 chimneys V24
+ Cold and warm flanges
+ guiding system
+ FEB insertion blades

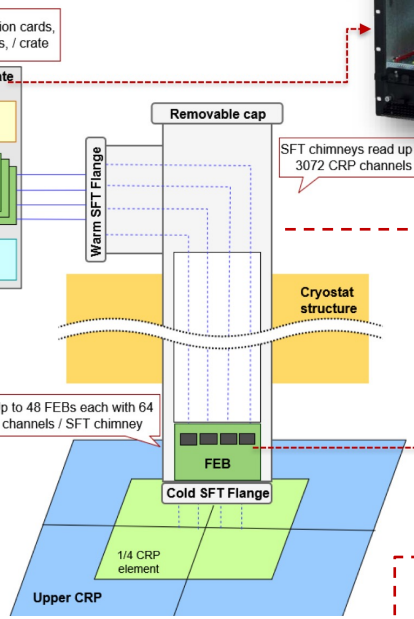
x 320 WR-MCH



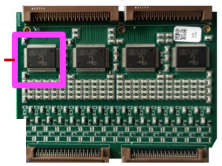
x 3840 AMC

x 320 MCH Controler

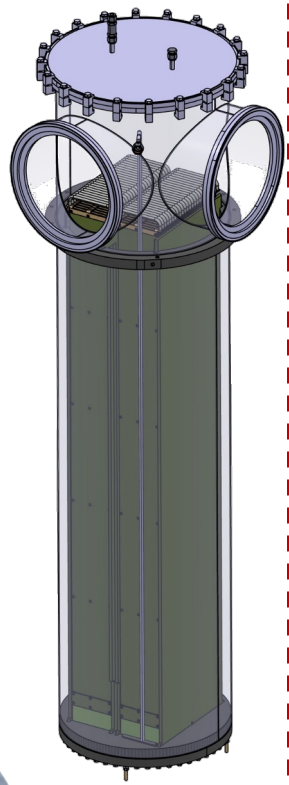
Syste

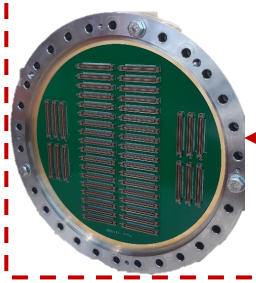


x 3840 FEB



x 15360 LARZIC ASIC

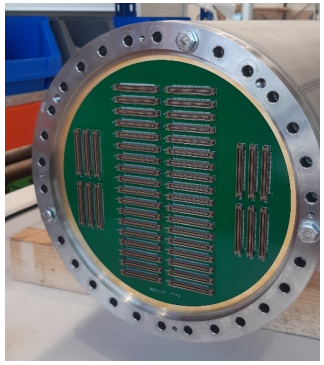


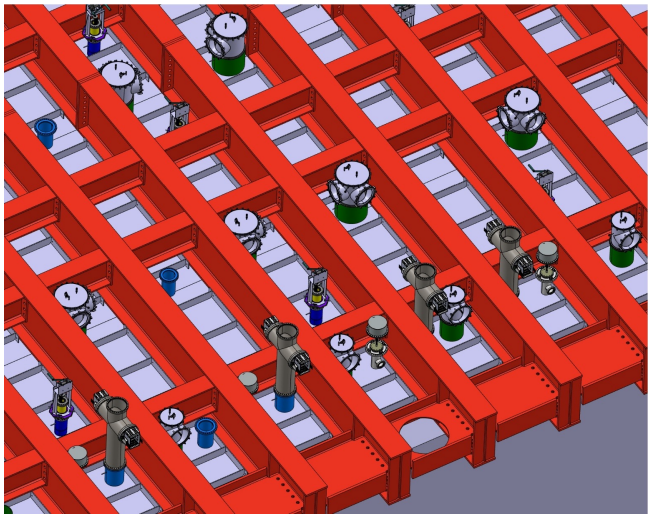


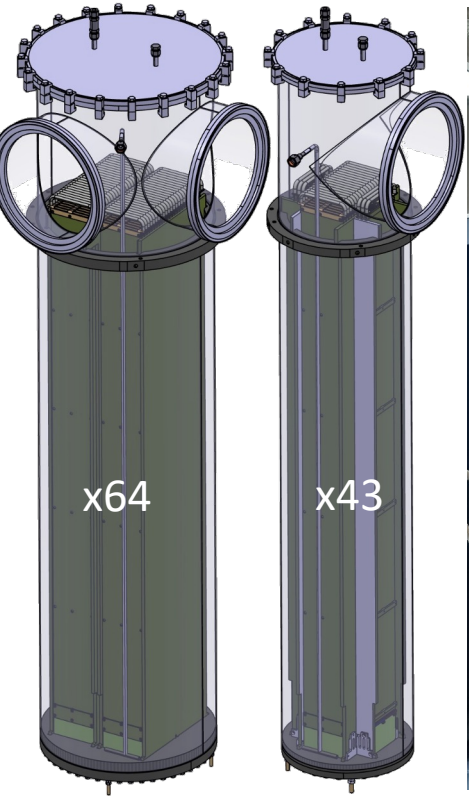
Chimneys

- IN2P3 PI Fabien Cavalier
- IN2P3 PM Véronique Puill
- Mech. Leader Rodolphe Marie

- Chimneys V24 : 40/(42+1) (100%) Received + QC OK
- Chimneys V48 : 55/(63+1) (86%) Received + QC OK
- Cold PCB: Procurement in process + PRR
- Warm PCB: validation ongoing before PRR
- Guiding system: Procurement in process
- Blades: validation ongoing before PRR
- Transport Box : validation ongoing
- 400 m^2 hall assembly and QC







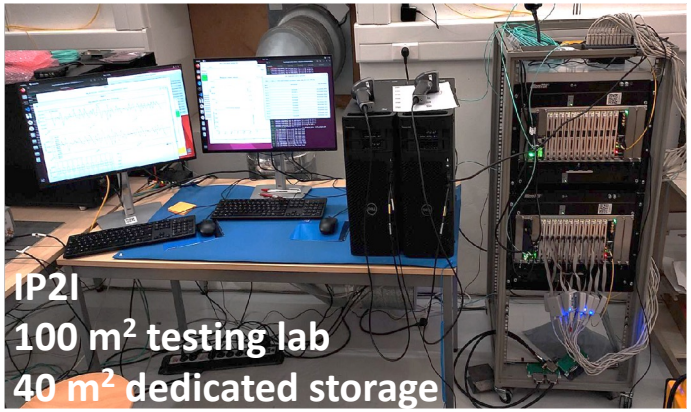
Top Drift Electronics

- IN2P3 PI Dario Autiero / Anselmo Meregaglia
- IN2P3 PM Hervé Mathez / Patrick Hellmuth

- **250k readout channels: cryogenic low-noise amplifiers + digital readout system at 8Tbit/s**
- Productions/procurements started at the end of 2023, large tendering activities 2024/2025
- Strict QC tests at production companies + full functional tests with unified equipment at IP2I/LP2I

- ✓ **Cryogenics ASICS LARZIC**: AMS dedicated Run with 6 wafers **completed in 2024**
- ✓ **Main AMC components** (COTS: FPGA, ADCs, Buffers) **completed in 2024**
- ✓ **microTCA crates** (COTS) **completed in December 2025**
- ✓ **WR timing end-nodes** (COTS) **completed in Jan. 2026**
- ✓ **MCH controller** (COTS) **completion of deliveries by June 2026**
- ✓ **Analog Front-End Boards** **43% produced including spares → June 2026**
- ✓ **AMC Digitization Boards** **75% produced including spares → June 2026**

Production yield of AMC/FEB ~100%
~2% channels response uniformity

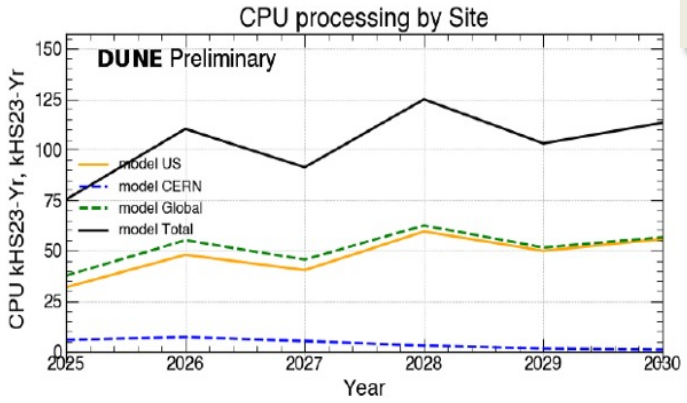


Computing

➢ **IN2P3 PI Elisabetta Pennacchio**

- ➢ Structured systematic IN2P3 involvement since the birth of DUNE
- ➢ Computing Plan at K2P2 defined next multi-year IN2P3 ~10% of "*Global*" effort (*Global*=on top of FNAL+CERN)
- ➢ CCIN2P3 is one of the main computing centers in DUNE providing:
  - Disk space (third contributor after FNAL and CERN)
  - CPU for data processing and simulations
  - Tape storage (with FNAL and CERN)
  - Replica at CCIN2P3 of FNAL software/analysis environment for IN2P3 groups
- ➢ Leading IN2P3 roles in Computing Consortium management:

Coordination of DUNE Production Group and ProtoDUNE VD Computing activities

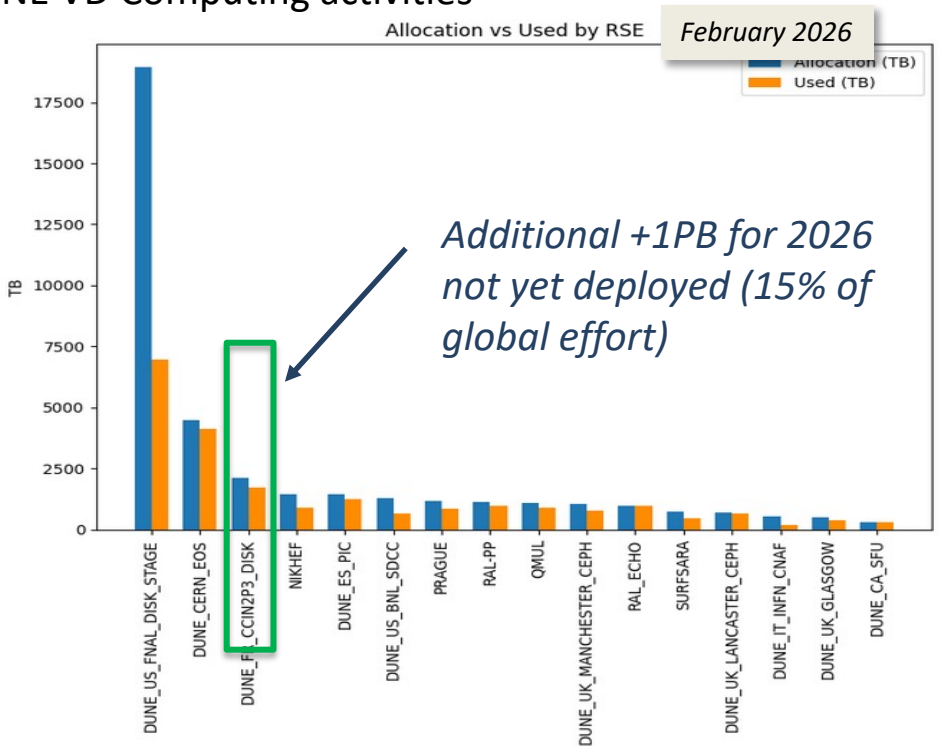


February 2026

Locations	2025	2026	2027	2028	2029	2030
US	31.9	48.0	40.4	59.5	50.0	55.7
CERN	5.8	7.2	5.2	3.0	1.6	0.9
Global	37.7	55.1	45.6	62.4	51.6	56.6
Total	75.3	110.3	91.3	124.9	103.1	113.3

KHS23 y

- *31.5 M HS23 h provided by CC-IN2P2 in 2025 corresponding ~ 10% (Global) contri*
- *50 M HS23 h provided by CC-IN2P2 in 2026 corresponding ~ 10% (Global) contributi*



February 2026

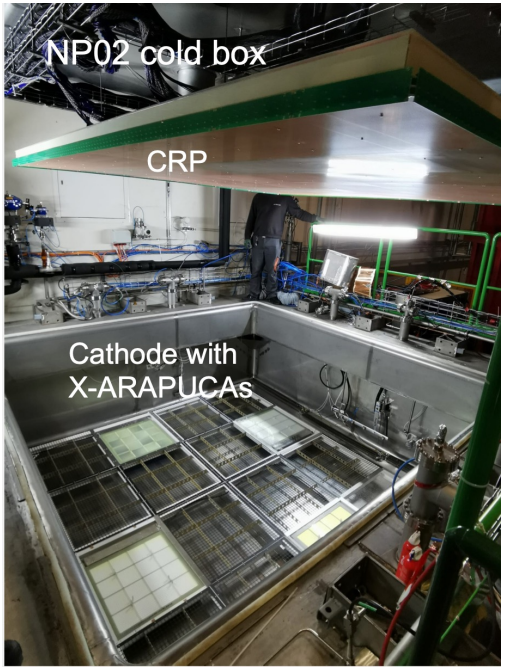
Additional +1PB for 2026 not yet deployed (15% of global effort)

DUNE
Neutrino Platform activities at CERN

Activities at CERN
The Neutrino Platform

Cold Box TPC

- 1 CRPs at a time
- Cathode + PDS
- ~ 0.3 m drift

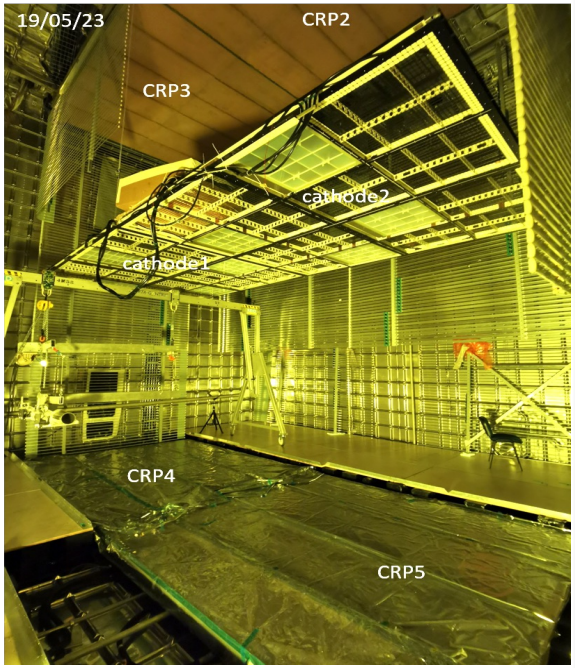


ProtoDUNE NP02

- 1/40 DUNE Vertical slice

Top + Bottom CRP + Cathode + Field cage + PDS + TDE + BDE + DAQ

- 2 x ~ 3.4 m vertical drift

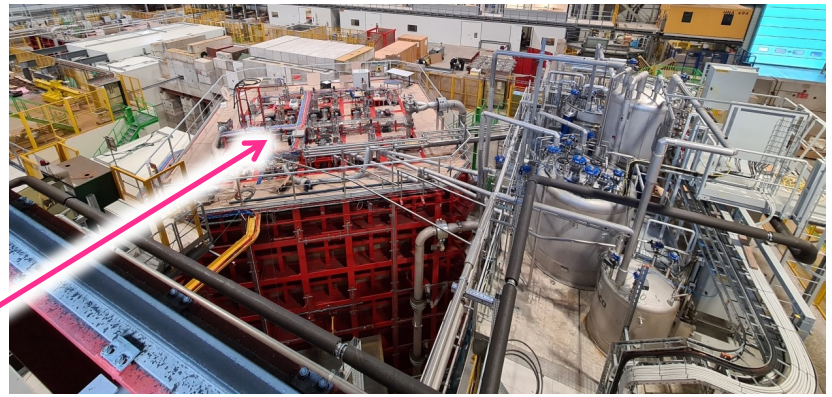


Installation Mockup 1:1

- Mechanical Model
- Size 1:1
- 13 m high
- Installation / Interfaces / Training
- Top + Bottom CRP + Cathode + Field cage + PDS + Chimney interface + Cabling

Tests Facilities @CERN
VD ProtoDUNE NP02

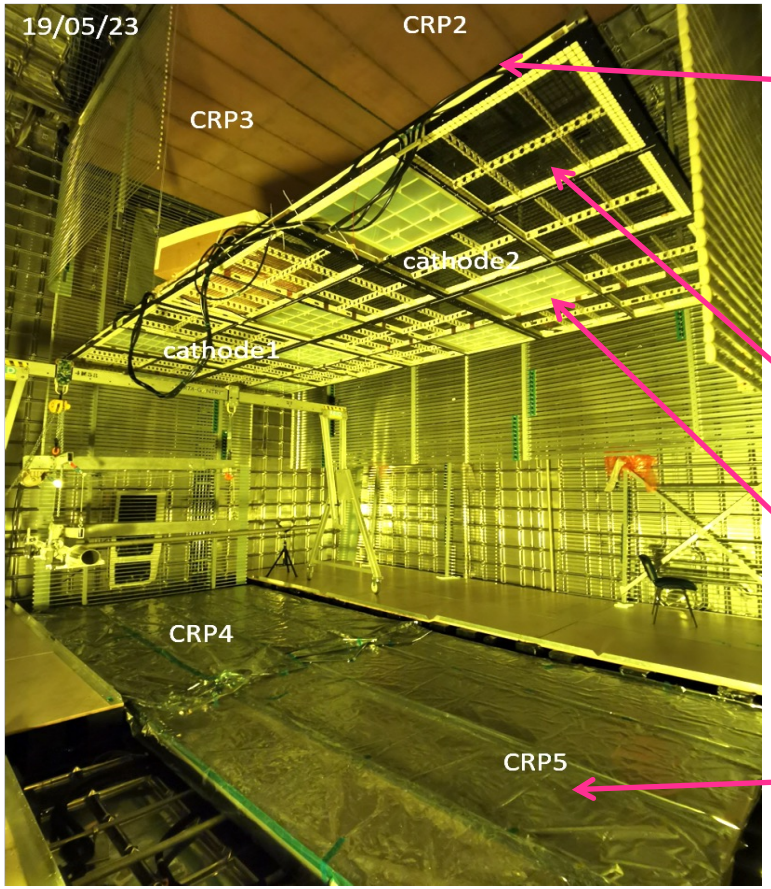
- 2 Top CRPs + 2 Bottom CRPs
- 2 Cathodes modules
- Field cage
- 8 Photon Detectors on the Cathode
- 8 Photon Detectors on the Walls



Top Drift Electronics

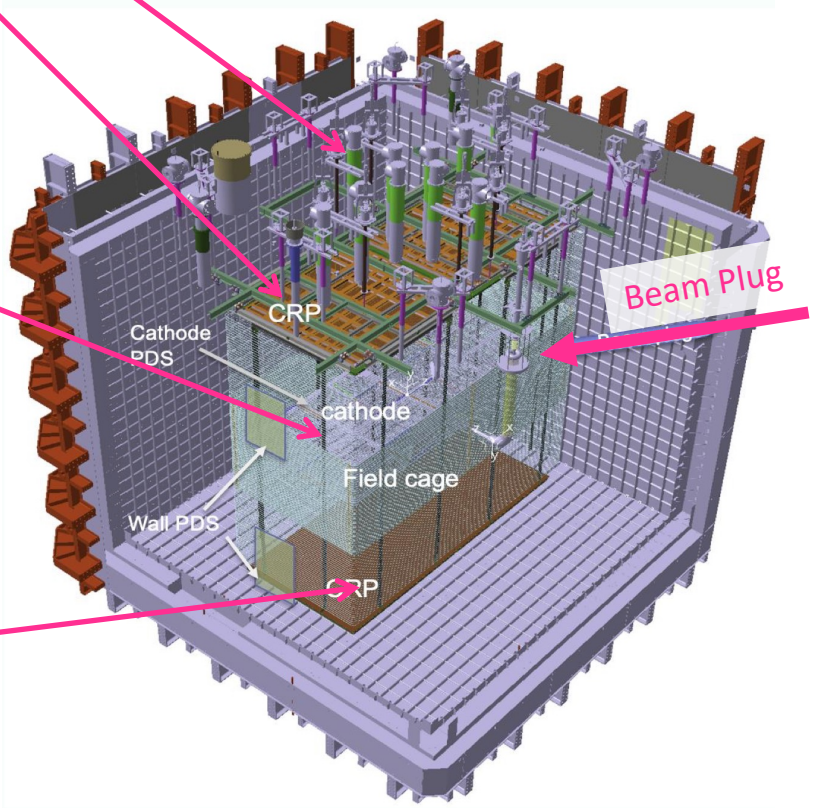
Chimneys

Top CRP



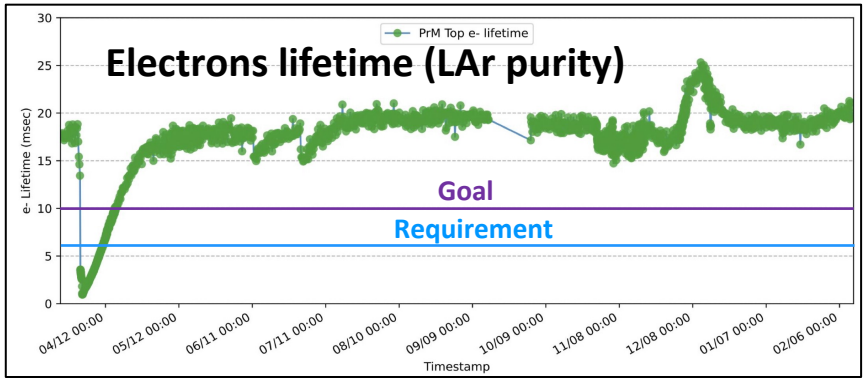
Cathode

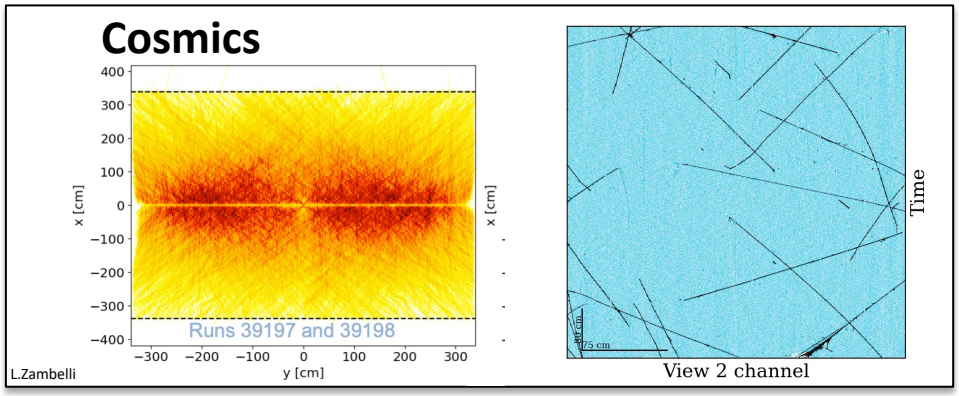
Cathode PDS

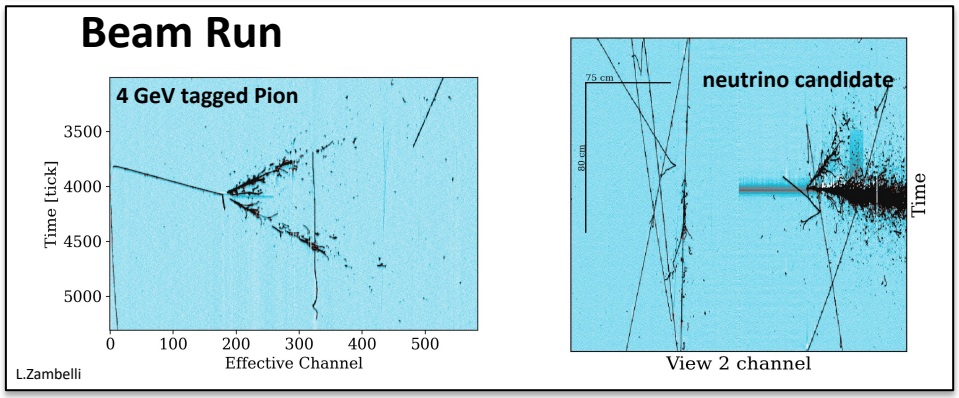


Bottom CRP

Tests Facilities @CERN
VD ProtoDUNE NP02

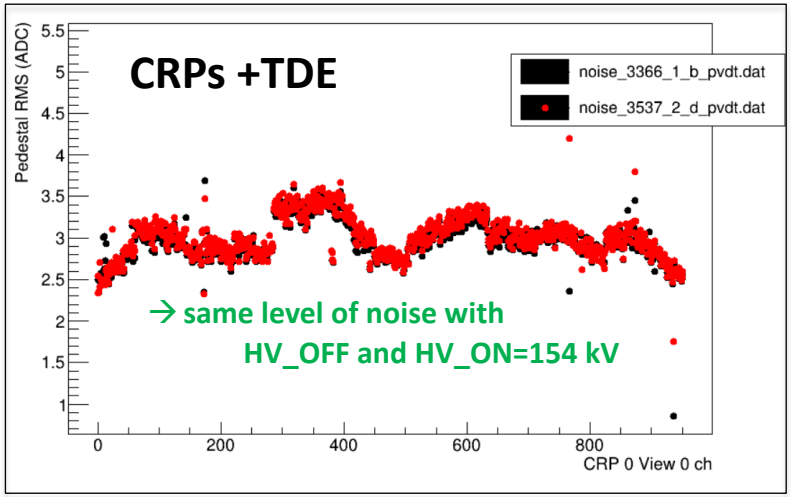


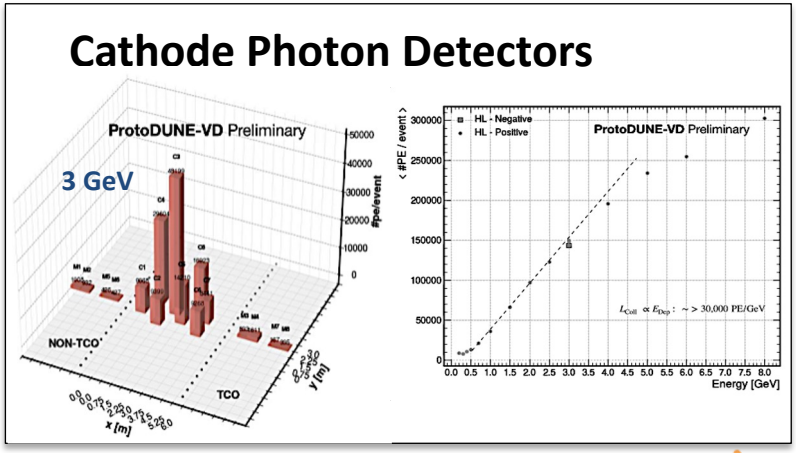




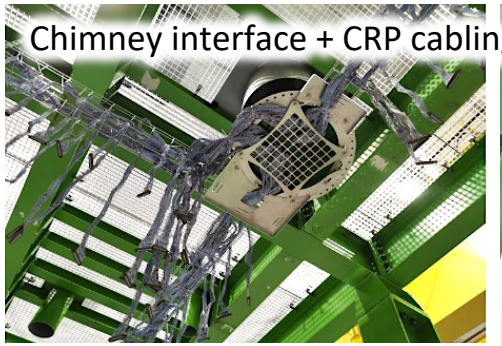
Many tests and verifications

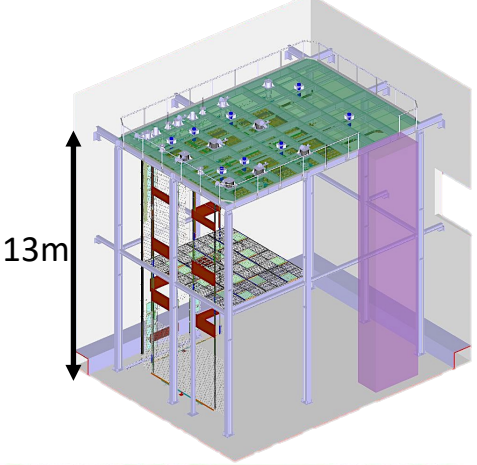
- CRPs Top and Bottom (2 drifts)
- Photon Detectors both on Cathode and Walls
- Noise induced between sub-systems
- Cosmics, Beam, Laser, neutron sources
- Purity and lifetime
- High voltage
- Readout and DAQ integration



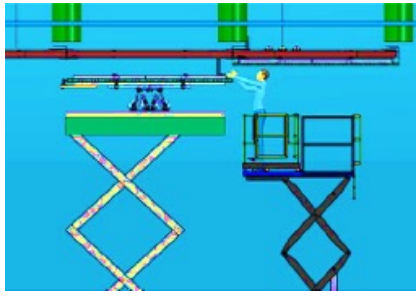


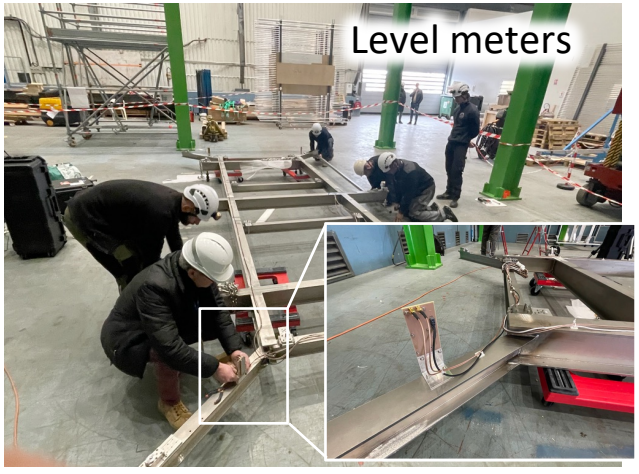
1:1 Mockup @CERN B185





- **Interfaces**
- **Access & installation envelopes**
- **Installation tools and procedures**
- **Tasks duration**
- **Training facility**





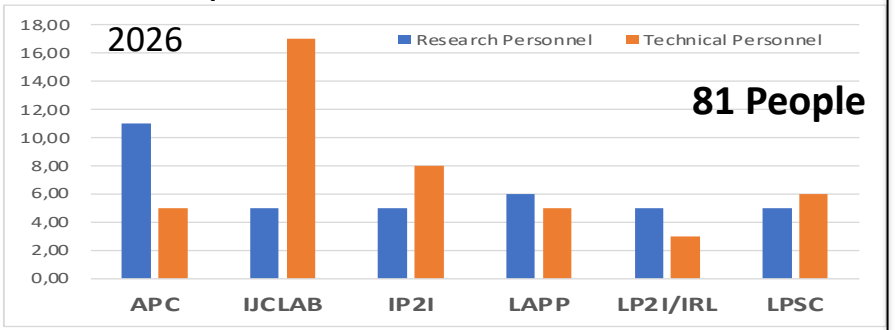
DUNE and the CNRS/IN2P3

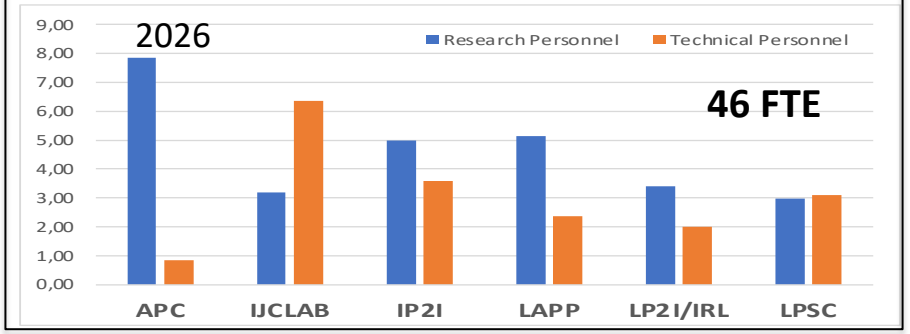
- 1548 collaborators
- 222 institutions
- 40 countries + CERN

- Collaboration meetings 3/y.
- Installation meetings twice/y.

CNRS/IN2P3 Manpower

- 27 PhD equivalent





Challenges ahead addressed:

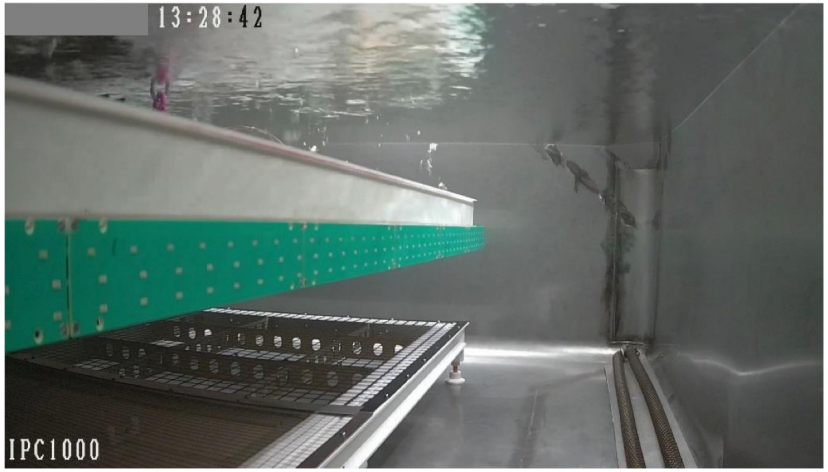
- Start Top CRP assemblies
- Transportation, Storage
- Installation
  (Procedures, Access, Manpower, Travels)

CONCLUSION

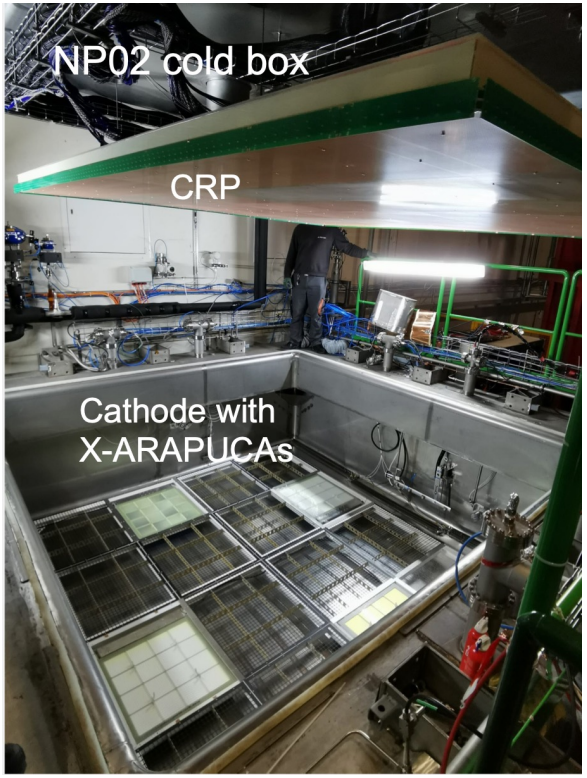
- **CNRS/IN2P3 played a pivotal role** in the **invention and introduction of the vertical drift single-phase**
- The **simplicity, robustness, cost effective and proven success** of this detector technology led to its adoption for the first module of DUNE, underscoring CNRS/IN2P3's leadership in detector development.
- **Large IN2P3 contributions** to the the Far Detector Vertical Drift
- The **transition from Final Design to Production Readiness and Procurement** has been successfully completed
- **Production of all CNRS/IN2P3 subsystems and facilities** in progress and **on schedule for installation and with the required quality**
- Many **challenges remain for the installation and are addressed**
- **Installation is planned for 2027/28**, with the detector expected to be **fully operational and ready to take data by 2030**

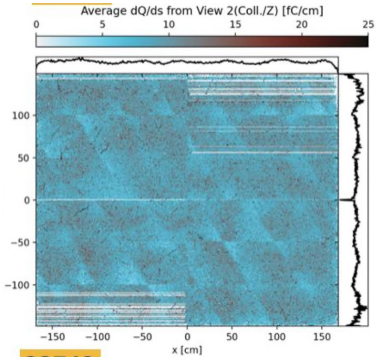
SPARE

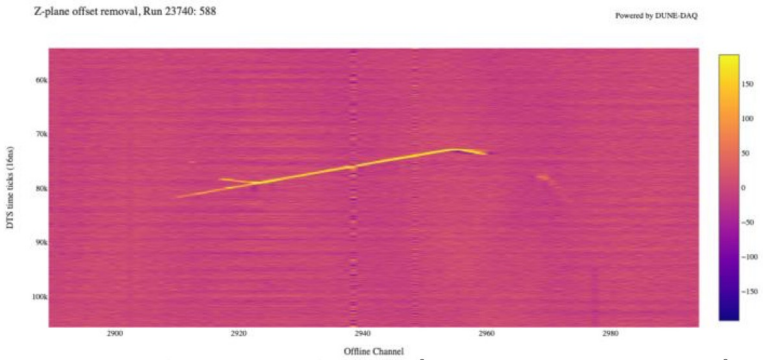
Tests Facilities @CERN
VD Cold Box

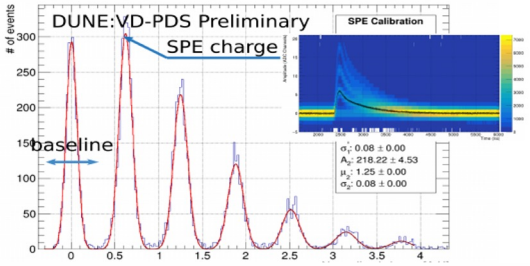


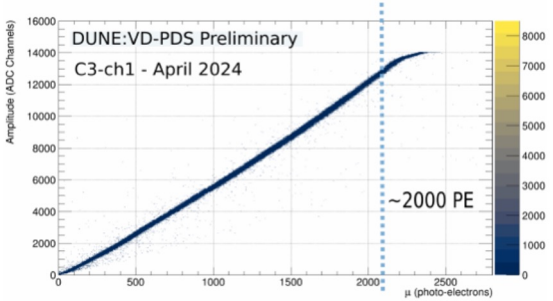
CRP6 in January 2024 when the coldbox has been filled with Liquid Argon











DUNE-CNRS Project Office

Dario AUTIERO
Cédric CERNA
Fabien CAVALIER
Dominique DUCHESNEAU

CNRS Local Responsibles

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RT : Hervé MATHEZ (IP2I)
RS : Fabien CAVALIER (IJCLab)
RT : Véronique PUILL (IJCLab)
RS : Dominique DUCHESNEAU (LAPP)
RT : Nicolas GEFFROY (LAPP)
RS : Jean-Sébastien REAL (LPSC)
RT : Jean-François MURAZ (LPSC)
RS : Anselmo MEREGAGLIA (LP2IB)
RT: Patrick HELLMUTH (LP2IB)
RS : Jaime DAWSON (APC)
RT : Sylvie BLIN (APC)
RS : Cédric CERNA (PPC)

cnrs
NUCLEI & PARTICLES

DUNE Master Project

PI : Dario AUTIERO (IP2I)
PM : Cédric CERNA (PPC)

Far Detector VD

- Charge Readout Planes Mechanics
  PI: Dominique DUCHESNEAU / PM: Nicolas GEFFROY (LAPP)
- Charge Readout Planes Factory
  PI: Jean-Sébastien REAL / PM: Jean-François MURAZ (LPSC)
- Top Electronics
  PI: Dario AUTIERO / PM: Hervé MATHEZ (IP2I)
- Chimneys
  PI: Fabien CAVALIER / PM: Rodolphe MARIE (IJCLab)
- Cathode
  PI: Fabien CAVALIER / PM: Philippe ROSIER (IJCLab)
- PDS Signal over Fibers
  PI: Jaime DAWSON / PM: Sylvie BLIN (APC)

CERN Test activities

PI : Dominique DUCHESNEAU (LAPP)

Computing

PI : Elisabetta PENNACCHIO (IP2I)

Software, Performance & Physics

PI : Anselmo MEREGAGLIA (LP2IB)

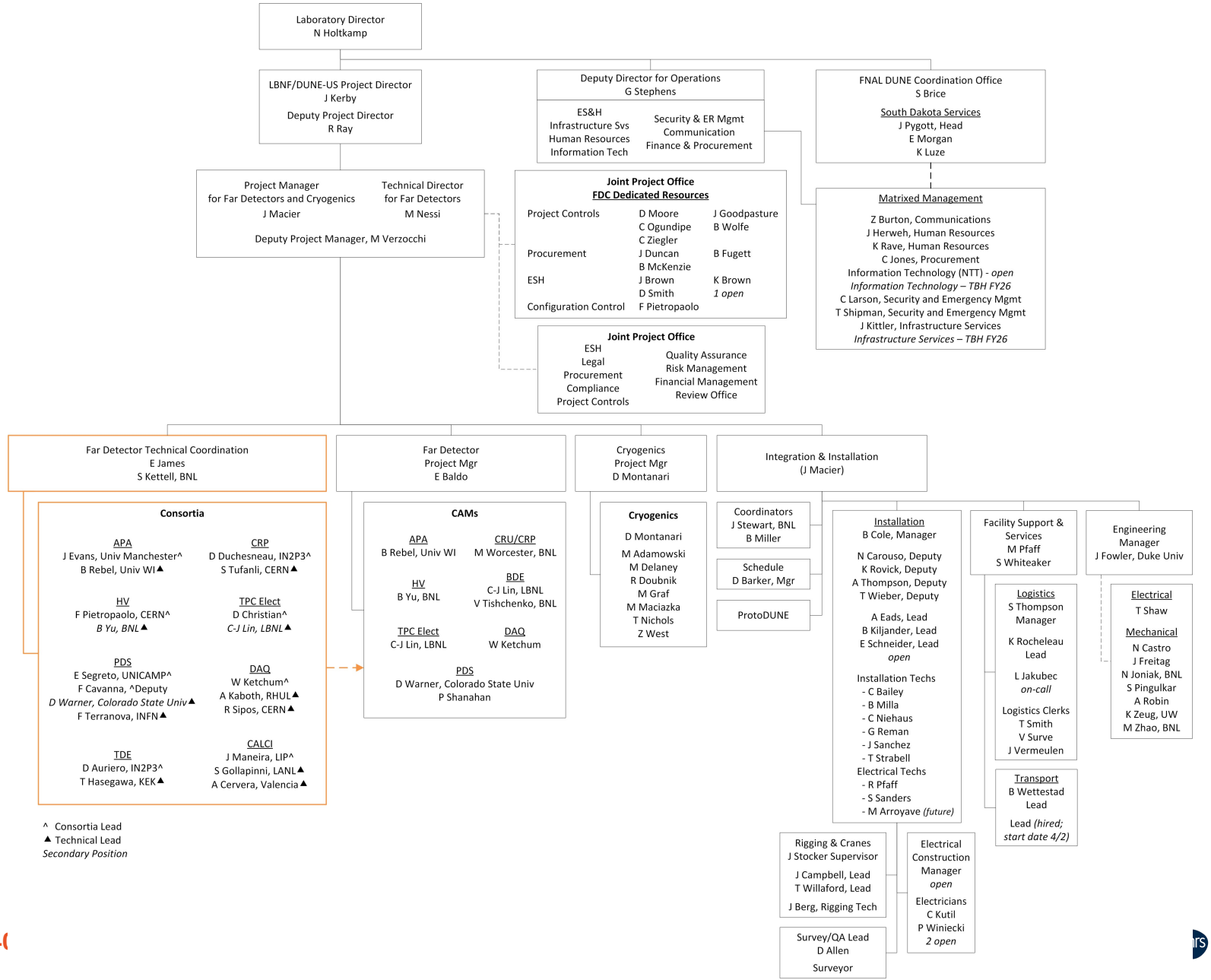
CNRS-NUCLEI & PARTICLES MANAGEMENT CHART

JUNE 2025

DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

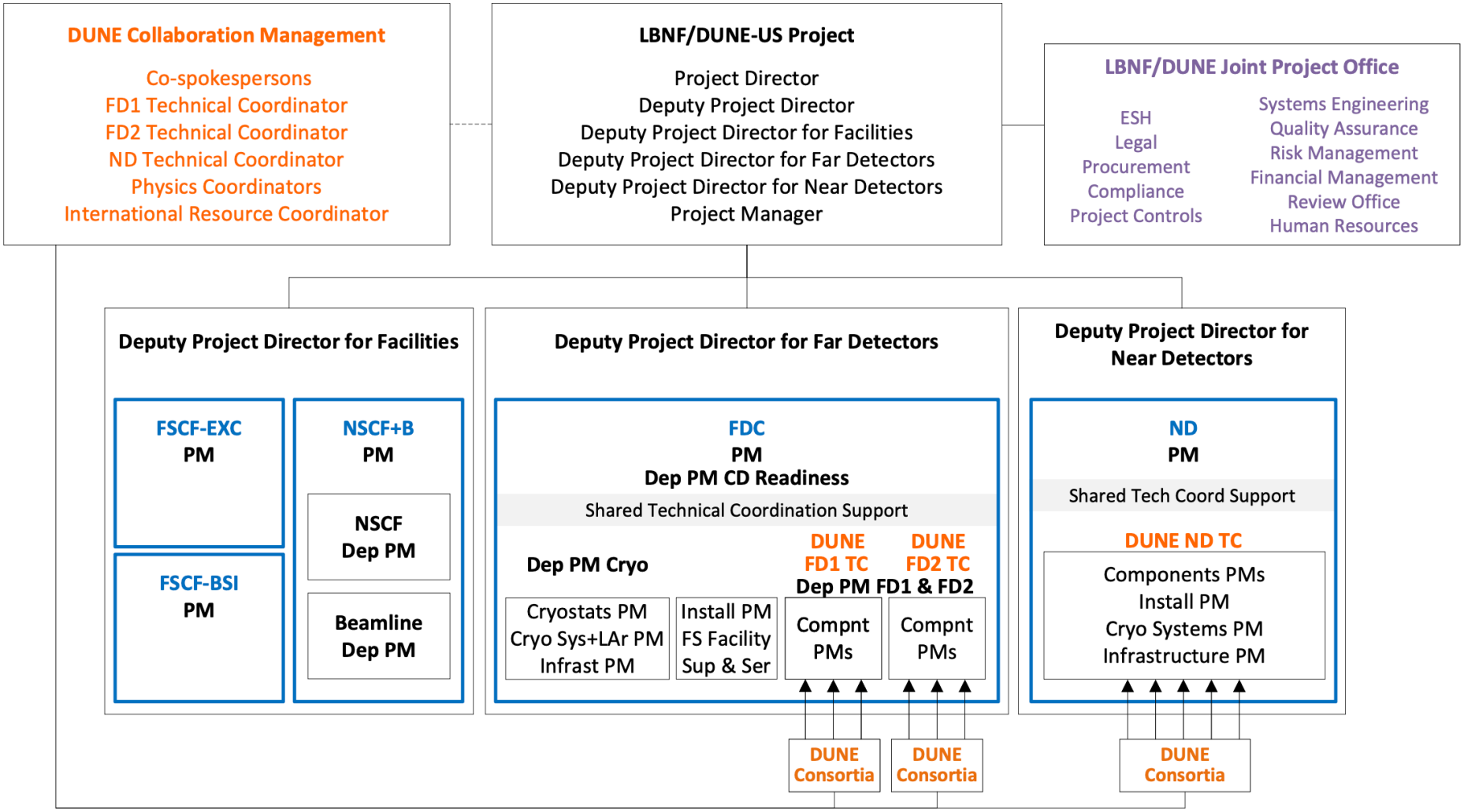
Cédric CERNA
Responsable Technique

FDC Management chart



^ Consortia Lead
▲ Technical Lead
Secondary Position

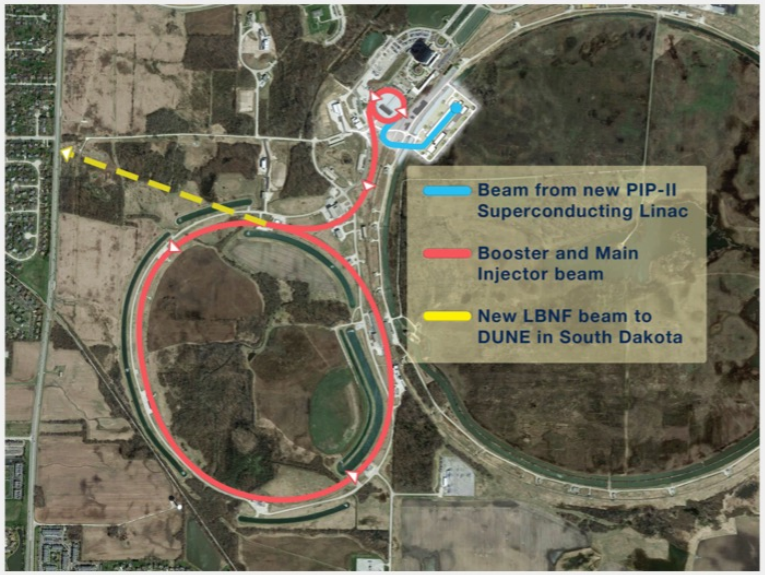
LBNF/DUNE coordination chart

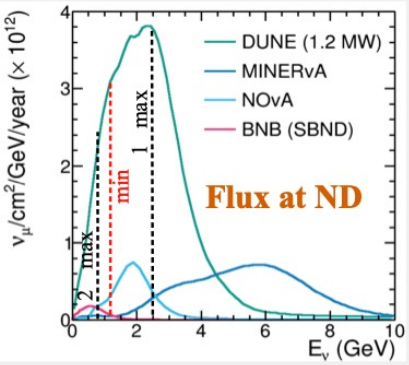


The Neutrino Beam

LBNF beam at Fermilab: world-leading intensity

- Very high flux between oscillation minimum and maximum, with coverage of second maximum
- ACE-MIRT upgrade enables >2 MW beam by ~doubling frequency of spills, and can be achieved before operations begin
- Design phase is expected to complete in 2026





- DUNE's beam covers a **wide range of energies** from **0.5 GeV to 7 GeV.**
- The **beam utilizes 60-120 GeV** protons from PIP-II (Proton Improvement Plan II).
- Power Milestones:
  - Phase I: Starts with a **1.2 MW proton beam**.
  - Phase II: **Upgradeable to > 2MW** (potentially 2.4MW).
- **5.8º downward pitch** to aim straight through the Earth's mantle **toward the Far Detector**.

PIP II

PIP-II Mission

PIP-II is an essential upgrade to Fermilab accelerator complex to enable the world's most intense beam of neutrinos to LBNF/DUNE, and a broad physics research program for decades to come.

PIP-II Capabilities

Beam Power

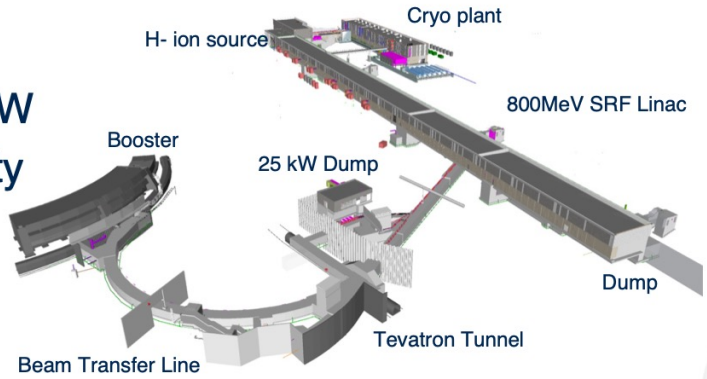
- 1.2 MW proton beam
- Upgradeable to multi-MW

Flexibility, multi-user capability

- CW-compatible
- Customized beams
- Multi-user delivery

Reliability

- Modernizes Fermilab accel complex



The PIP-II scope enables the accelerator complex to reach 1.2 MW proton beam on LBNF target

PIP-II Scope

800 MeV H– SRF linac CW

RF Operations

Linac-to-Booster transfer line

Accelerator Complex Upgrades:

- Booster
- Recycler
- Main Injector

Conventional Facilities

Space reserved for two CMs for 1 GeV Upgrade

PIP II

International Partnership

India: DAE - BARC, RRCAT, VECC; and IUAC (started 2009)

Substantial engineering / manufacturing experience; Superconducting magnets for LHC; 2 GeV synchrotron light source

Italy: INFN (started 2016)

Internationally recognized leader in superconducting RF technologies SRF cavity and cryomodule fabrication for XFEL; SRF cavities for ESS

UK: STFC UKRI (started 2017)

Substantial engineering and manufacturing experience; Construction, operation of synchrotron light and neutron sources SRF cavity processing and testing for ESS

France: CEA, CNRS/IJCLab (started 2017)

Internationally recognized leader in large-scale CM assembly
CM assembly for European XFEL and ESS; SSR2 cavities and couplers for ESS

Poland: WUST, WUT, TUL (started 2018)

Substantial engineering / manufacturing experience; CDS, LLRF, QC for XFEL, ESS

PIP-II is the U.S. first accelerator project to be built with major international contributions; benefits from world-leading expertise, capabilities.

PIP II

Summary

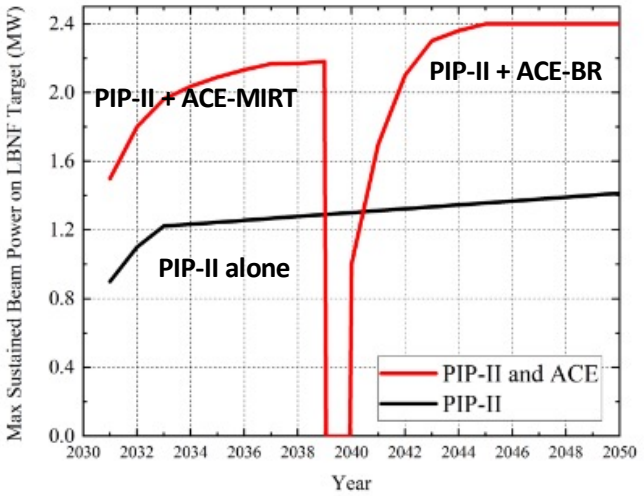
- PIP-II is leveraging the **worldwide accelerator community**'s experience through successful domestic and international collaborations.
- The project has been in the construction phase since 2022, and **completion** is planned for the end of **2029**.
- All key technologies have been demonstrated, and production **hardware is arriving at Fermilab**.
- Civil construction is well underway, and the connection to the **booster** is planned for **2028**.
- The PIP-II team, including international partners, is **highly motivated** and eager to deliver this essential upgrade to the laboratory.

An increase in beam power to > 2 MW is a primary requirement for DUNE to achieve its P5 physics goals.

→Fermilab has in place an **Accelerator Complex Evolution (ACE)** plan to realize the beam power required. It will be delivered in two phases:

- The first phase, known as **ACE-Main Injector Ramp and Targetry** (**ACE-MIRT**), will raise the beam power to just beyond 2 MW by reducing the cycling time in the Main Injector (MI) from 1.2 sec to 0.7 sec (available in 2031 !)
- This is to be followed by the **replacement of the Booster and an extension of the Linac to 2 GeV** (**ACE-BR**), which will eventually allow the beam power to rise to 2.4 MW.

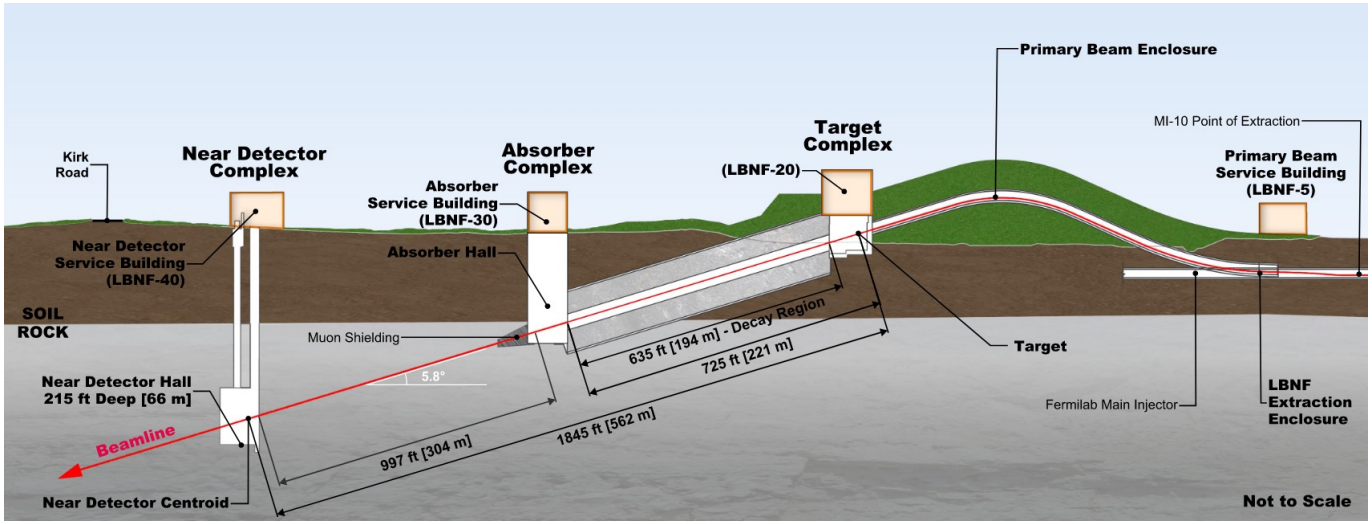
The importance of these upgrades for faster and more reliable delivery of protons on target can be seen below:



While the ACE-MIRT upgrade is primarily motivated by DUNE science, ACE-BR targets a broader physics program at FNAL, serving as a robust and reliable platform for the future.

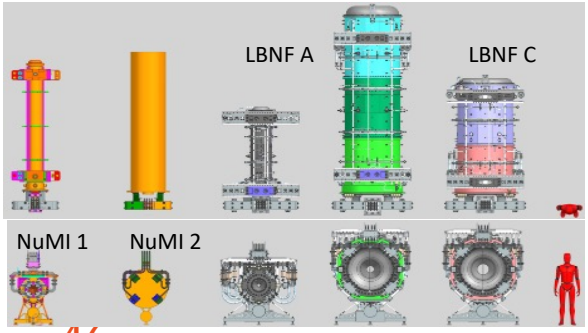
The Near Site

NSCF - Near Site Conventional Facilities



The NSCF is currently the largest source of cost and schedule uncertainty in the overall project

Beamline - Proton Beam and Neutrino Beam



Beamline

- Design phase expected to complete in 2026
- request for long-lead items planned for early 2026

Horns

- Design phase expected to complete in 2026
- Horns forging complete, other parts in fabrication

DUNE ND

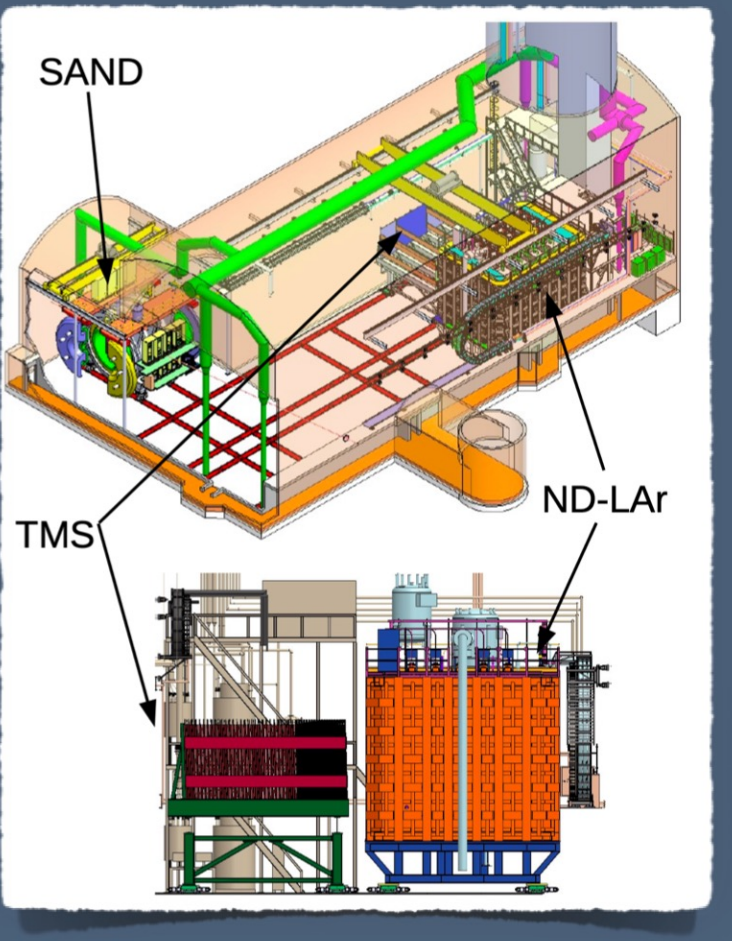
- DUNE will have a ***Near Detector complex critical starting from early physics goals*** to reduce flux and cross sections uncertainties and have the most accurate prediction of neutrino spectrum at the Far Detector.

- ***System for on-Axis Neutrino Detection (SAND):*** On-axis magnetized low-density tracker and calorimeter to control and monitor the neutrino beam on axis.

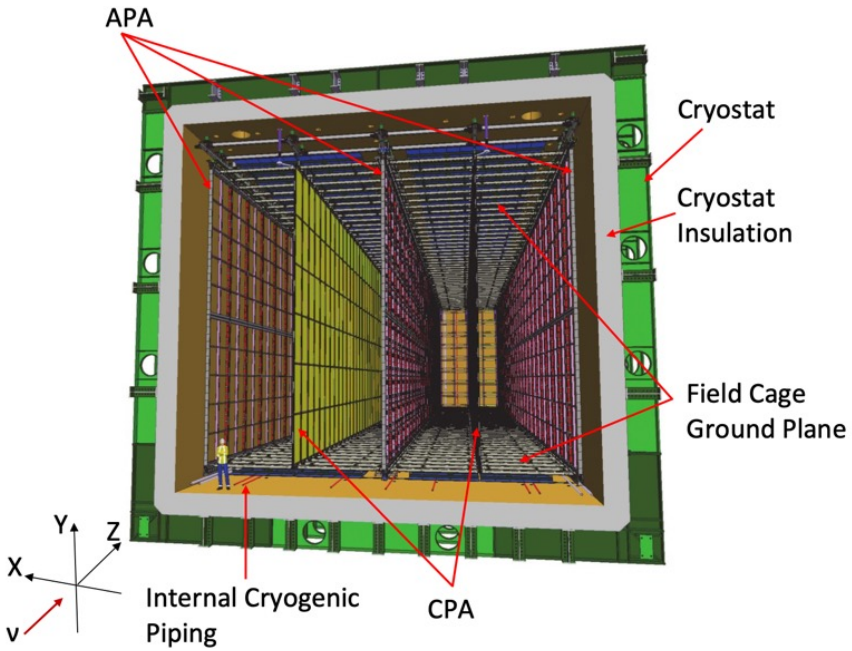
- ***Near Detector Liquid Argon (NDLAr):*** Liquid Argon Detector (50t fiducial) with the same target and technology as FD.

- ***The Muon Spectrometer (TMS):*** detector to measure muons escaping from NDLAr.

- ***NDLAr+TMS*** are a ***movable*** detector and exploit the ***PRISM technique***: they measure neutrino flux at different angles (i.e. different energies) for a ***better extrapolation at the FD reducing the dependency on the accuracy of interaction models***.



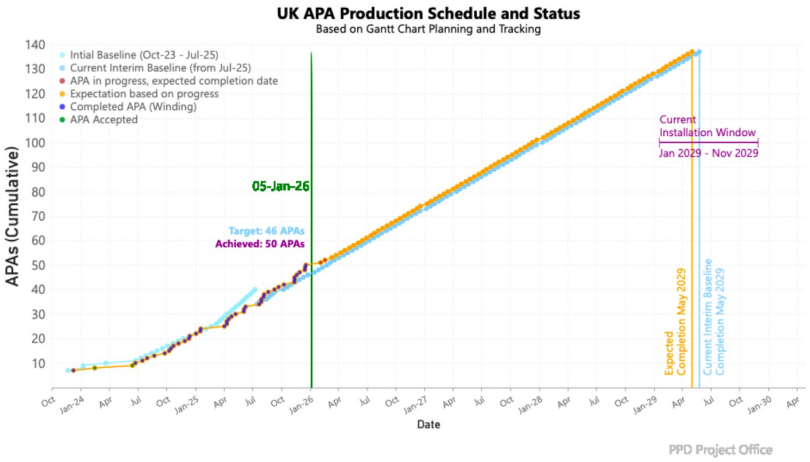
Horizontal Drift Deliverables



Drift length ~ 350 cm → HV on cathode ~ 180 KV

UK APA Production

January Statusing



Deliverables

APA consortium (WBS 131.FDC.02.02)

- 150 APAs (136 UK, 14 US, CERN eng.)

HV consortium (WBS 131.FDC.02.03)

- 100 CPA cathode modules (US support structure, CERN panels material)
- HV & field cage (US support structure, CERN components and HV power supply)

Photon detectors consortium (WBS 131.FDC.02.05)

- 1500 photon detector bars (US mechanical components & cold electronics, IT, IS, CZ, BR: SIPMs, filters, various mech. components and warm electronics)

Cold electronics consortium (WBS 131.FDC.02.04)

- 150 cold electronics units (US)

DAQ consortium (WBS 131.FDC.02.06)

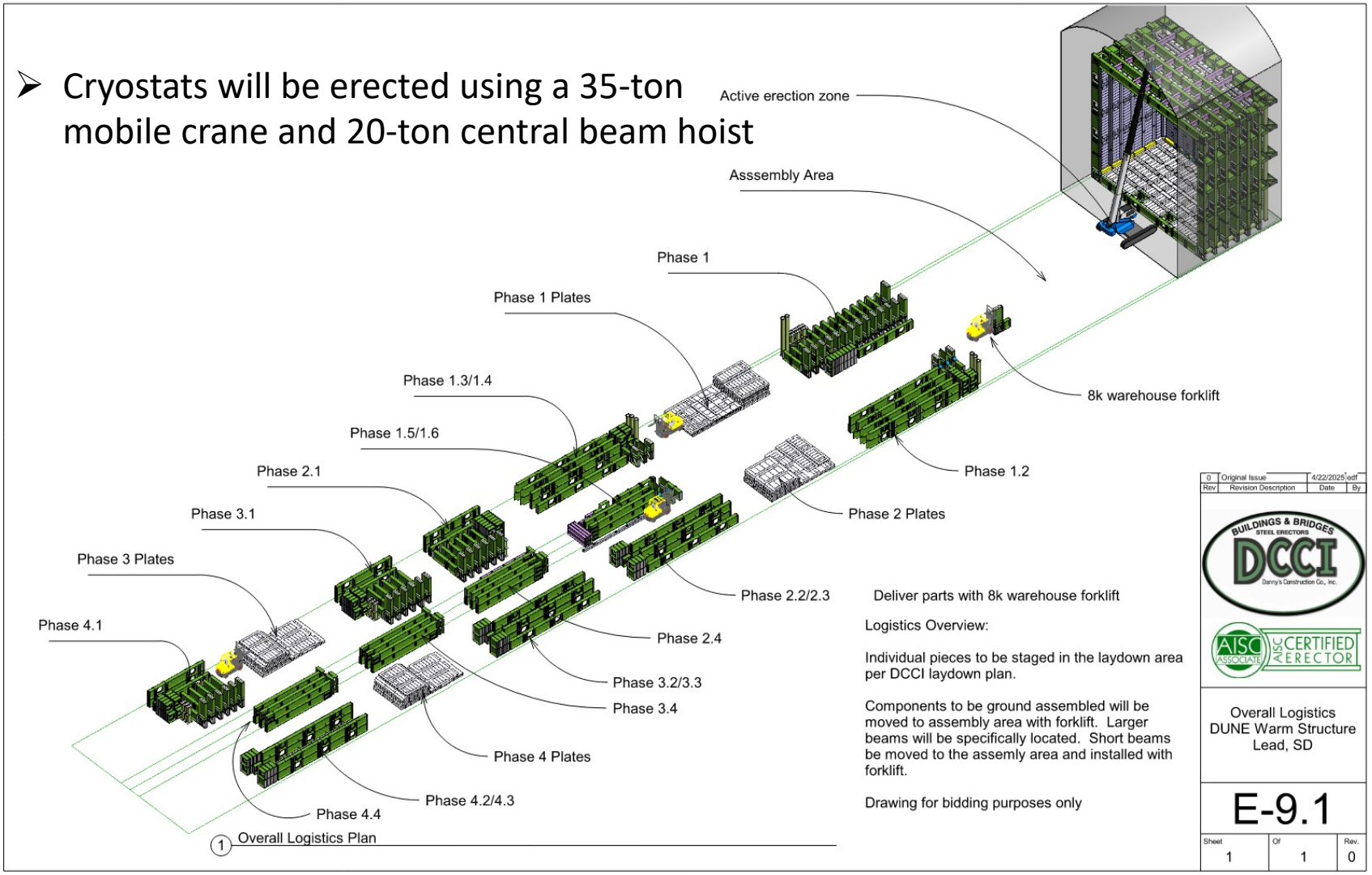
- DAQ (US, UK, CERN, CAN : trigger system, CORE infrastructure and servers)

Cryogenics instrumentation consortium (WBS 131.FDC.02.07)

- CI purity monitors (US), T sensors (IS)

Cryostat Installation

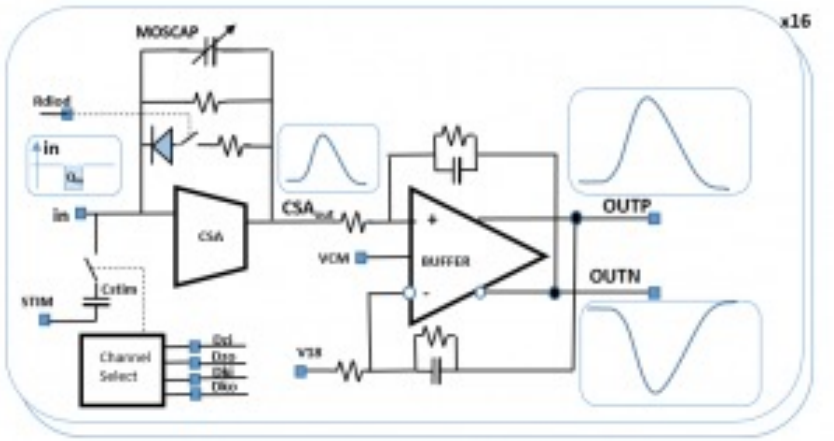
- Cryostats will be erected using a 35-ton mobile crane and 20-ton central beam hoist

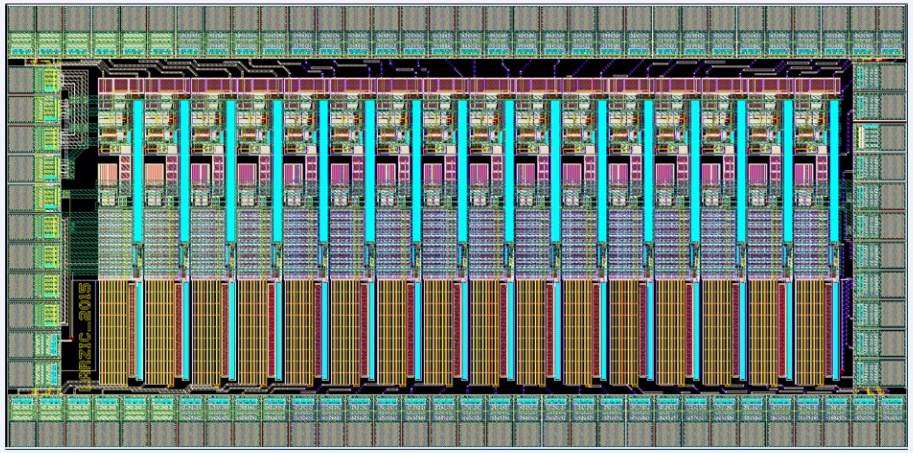


LARAZIC ASIC

LARZIC (Liquid Argon Zygote IC)

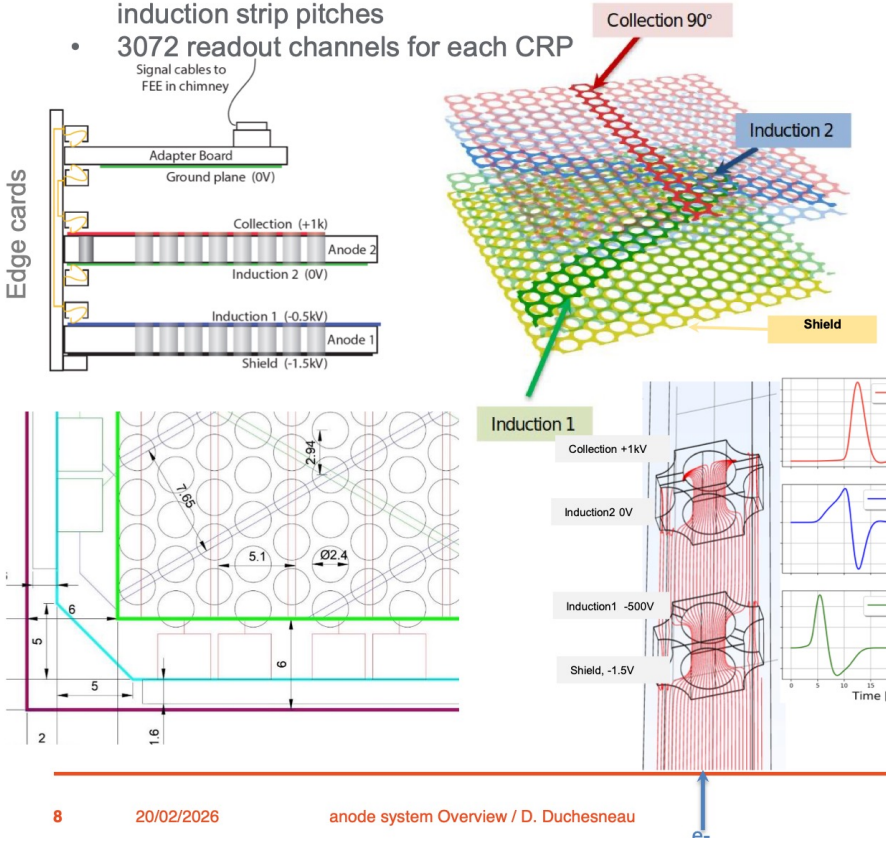
- 16 channels
- Able to measure 15,000 electrons arriving in 500 ns with a noise lower than 1,000 electrons at 160°C
- For detector capacity 250 pF
- Crosstalk lower than 1%
- Charge preamp followed by a differential buffer
- 280mW power consumption equivalent to 17.5 mW/channel for a supply bias of 3.3V





CRP Design: validated with 6 prototypes from 2022 to 2024

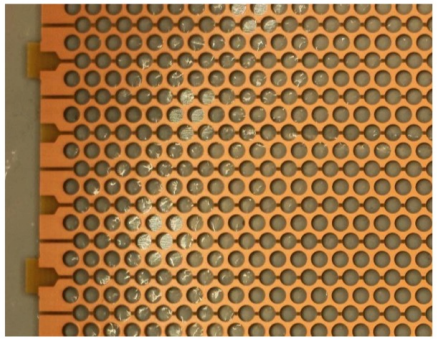
- Three view anode layout with perforated PCBs
  - +30°, -30°, 90° strip orientation with 5.1mm collection, 7.65mm induction strip pitches
  - 3072 readout channels for each CRP



CRP anode planes

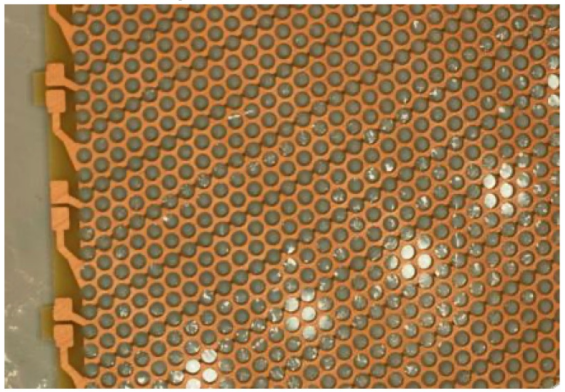
Collection strips: 5.1mm

Each anode: 3.2mm thick PCB



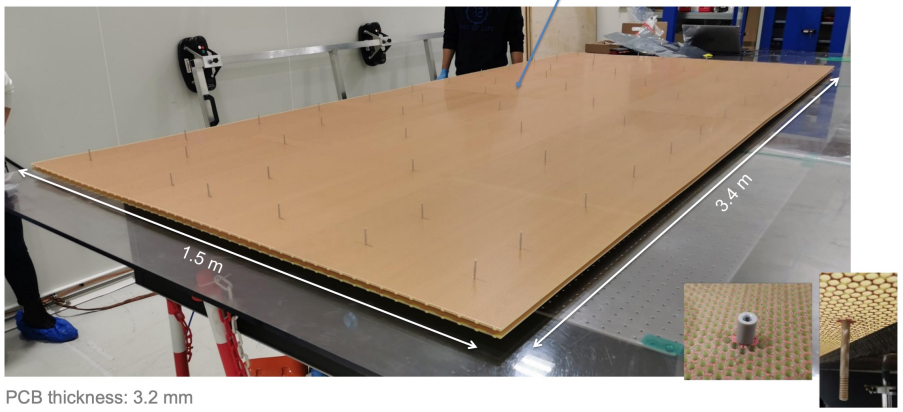
35 um thick copper

Induction strips: 7.65mm



CRP anode planes

Anode-1 and Anode-2 attached together with the 61 support holes (4mm diameter) => 1 CRU (Charge Readout Unit)
Anodes are vertically spaced by 10 mm



PCB thickness: 3.2 mm