Opportunities in DUNE

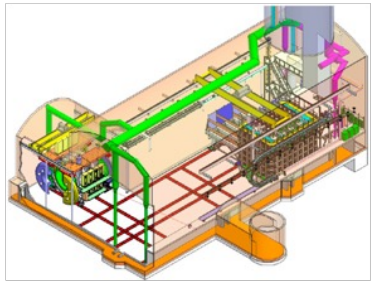
Sowjanya Gollapinni, Dave Newbold
DUNE Co-Spokespeople

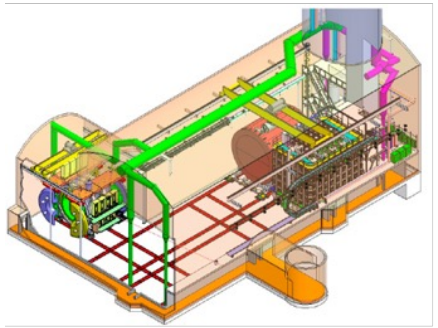
Korea-DUNE Workshop @ NNN2026
Chung Ang University
Seoul, South Korea
October 30, 2026

Los Alamos NATIONAL LABORATORY

DUNE

DUNE will be Built in Two Phases



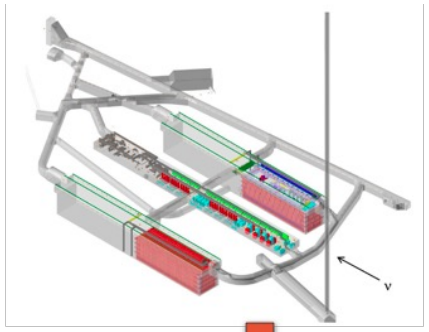


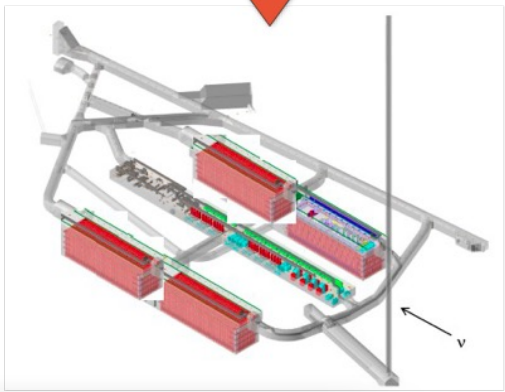
Phase-I

- **FD:** 2 x 17 kt LArTPCs
- **ND:** LArTPC + Muon Spectrometer (with PRISM) + On-axis Beam Monitor
- **Beam:** 1.2 MW (PIP-II)

Phase-II

- **FD:** 2 additional modules (total = 4 x 17 kt LArTPCs)
- **ND:** LArTPC + GArTPC (with PRISM) +On-axis Beam Monitor
- **Beam:** > 2MW beam





The dual facilities built by LBNF support both Phase-I and Phase-II scope

Parameter	Phase I	Phase II	Impact
FD mass	2 FD modules (20 kt fiducial)	4 FD modules (40 kt fiducial LAr equivalent)	FD statistics
Beam power	1.2 MW	Up to 2.3 MW	FD statistics
ND configuration	ND-LAr+TMS, SAND	ND-LAr, ND-GAr, SAND	Systematics

Opportunities in DUNE: General Context

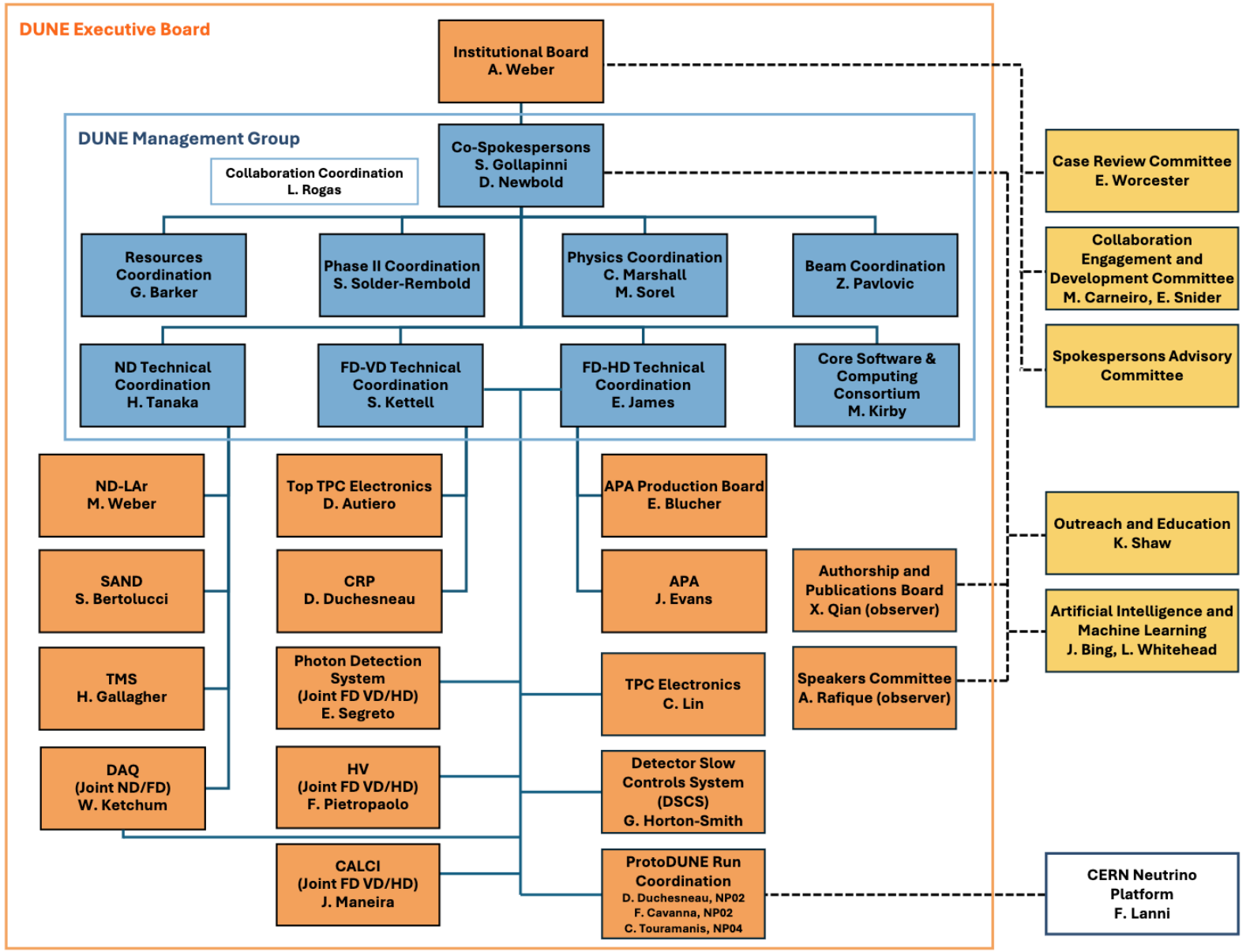
- **Phase-I**
  - We are in the installation phase for Far detectors and final design and pre-production phase for near detectors.
    - No big hardware opportunities exist for FD. Small-scale contributions to some production efforts, testing, QA/QC possible – will need discussions with Technical coordinators
    - For ND, there maybe some moderate to big hardware opportunities for the SAND detector
  - In the near to medium term, big opportunity to get involved in **installation** and **commissioning** activities and take leading roles (requires moving to South Dakota or long-term stays) including getting involved in ProtoDUNE-VD operations at CERN
  - Several opportunities exist for non-hardware elements e.g., DAQ/Trigger, DQM, Core Software & Computing, Slow Controls etc.
  - Big opportunities to get involved in reconstruction, simulation and analysis activities (includes AI/ML) along with ND and FD prototype data analyses
  - Last two items are critical to prepare for first data and to ensure physics readiness
  - I am not saying much on theory but contributions and collaboration span all areas

Opportunities in DUNE: General Context

- Phase-II
  - Timescale: mid to late 2030s
  - Plan to low-hanging fruit improvements for FD3 but big improvements in technology for FD4
  - Replace Muon Spectrometer in Phase 1 ND with gaseous argon detector
  - FD3 and FD4 cryostats
  - Active R&D and prototyping ongoing along with a ProtoDUNE-III run at CERN to test key technologies (2029-2030)
  - Big opportunities exist for existing and new groups to take key roles and make big hardware contributions

- We understand most national communities seek to build a balanced program of hardware, physics, operations, allowing optimal training opportunities for early career members – *the Phase-I and II of DUNE offer this.*
- As Korea aims to expand their footprint on DUNE, It is important for the national community to come together as one team with a coherent strategy and develop a strong proposal to maximize the overall impact

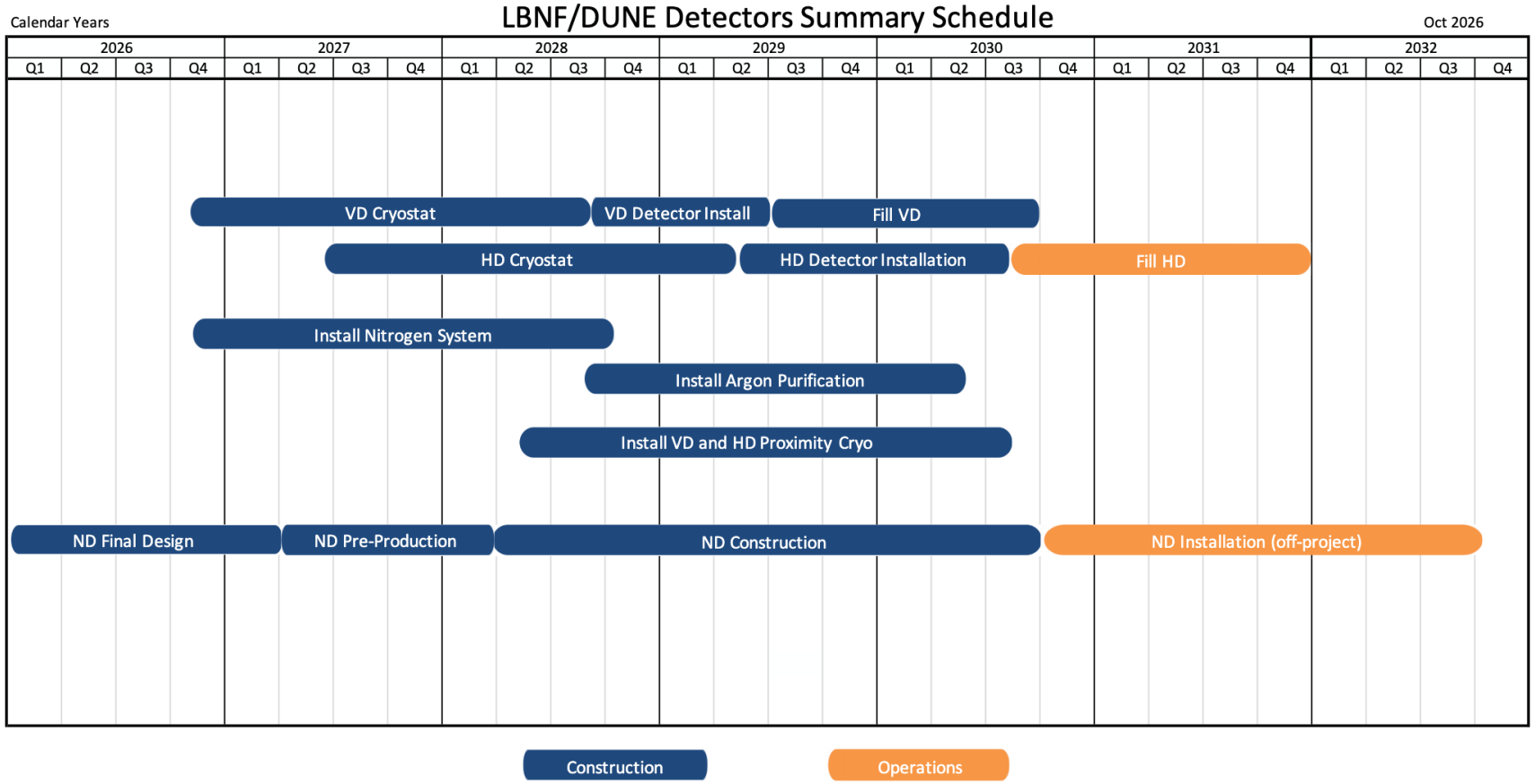
We welcome new Institutes/collaborators to join DUNE



DUNE Org Chart

- 3 Near Detector Consortia
- 3 FD consortia
- 6 FD/ND Joint Consortia
- 1 Core Software & Computing Consortium
- 1 Phase-II Coordination
- 1 Beam Coordination
- 10 Physics WGs

DUNE Top-Level Schedule



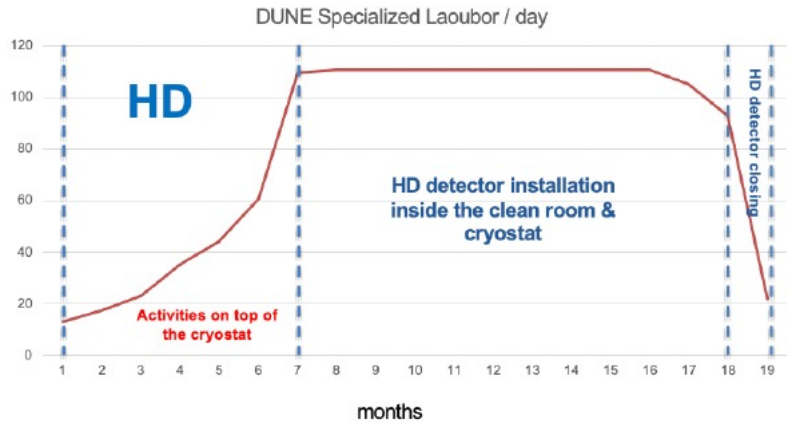
Note overlap between different phases in FD and ND

- Cryostat Installation at far site in South Dakota has started
- First Detector installation starts in 2028 and second in 2029
- Data taking (without beam) at far site 2030
- ND installation starts 2030
- Neutrino beam in 2031
- Beam data taking end of 2032

Installation/Commissioning Activities at Far Site

- **Ample opportunity** to get involved to installation, integration and commissioning activities at the far site
  - During peak installation period (e.g., when both HD and VD are installed), we need 150+ people at a minimum underground working
- An excellent opportunity for students and postdocs to go to SURF for long term stays
- Also, opportunity to help lead efforts if move to South Dakota is possible e.g., coordinating activities, providing onsite support etc.
- Plan to provide subsistence (travel, housing etc.) support for those who move or go for long-term stays (threshold to be defined)

Contact Spokes if interested



Specialized Labour
- *Scientists*
- *Engineers*
- *Technicians*
- *Grad. Students*
- *PHDs*

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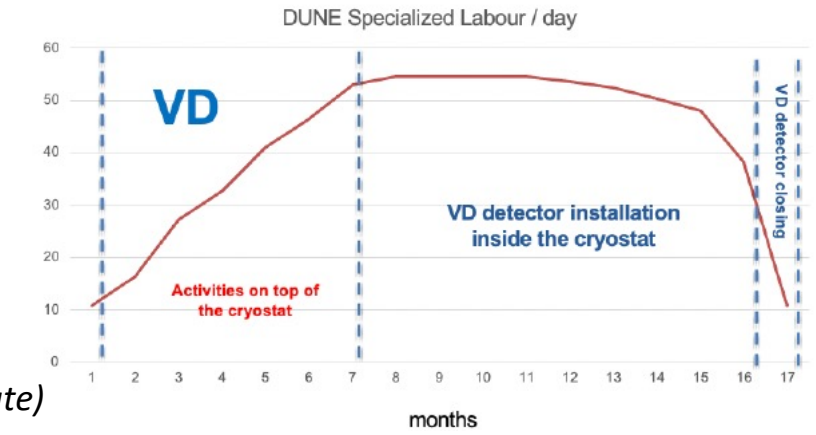


Far & Near Detectors

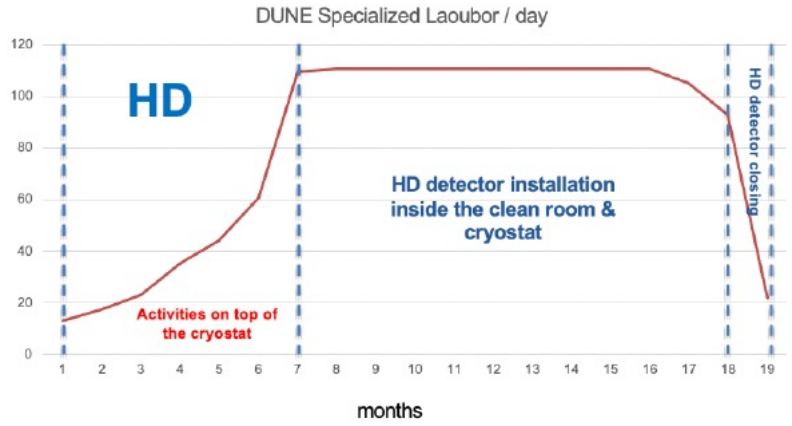
- **Contact points**
  - FD-HD Technical coordinators
    - Eric James FNAL (jameseb@fnal.gov)
    - Anselmo Cervera IFIC (anselmo.cervera@cern.ch)
  - FD-VD Technical coordinators:
    - Steve Kettell (BNL) kettell@bnl.gov
    - Filippo Resnati CERN (Filippo.Resnati@cern.ch)
  - ND Technical coordinator
    - Hiro Tanaka SLAC (tanaka@slac.stanford.edu)
  - Can also provide contact points for FD and ND consortia leaders as needed when specific contributions are being understood
- South Korea is already making solid contributions to FD cold electronics
  - there maybe scope to expand in this direction (Chung Ang is the lead)

Far & Near Detectors

- There are no opportunities for big hardware contributions on far or near detectors. However, there are some gaps (e.g., supporting QA/QC of components, assembly and testing efforts, help production efforts for small-scale components) where new groups can contribute
  - This has to be understood case by case and if it is feasible for new groups to contribute given the rapid turn around times needed (prior expertise will help greatly)
  - Technical coordinators will be better placed to provide specifics and have discussions
  - One exception to this might be the SAND near detector where big hardware contributions might exist
- Supporting installation, assembly and commissioning activities at near site is also an area to contribute or help lead efforts if members can stay long-term at Fermilab
- Good number of opportunities exist to make impactful contributions to software elements e.g., DAQ/Trigger, Core Software and Computing, Databases, Slow Controls etc.
  - Slow Controls is a newly formed joint ND/FD Consortium with renewed effort. HanYang already taking a role. More opportunities likely exist both for FD and ND.
    - For specifics, contact: Glenn Horton-Smith KSU (gahs@ksu.edu), Vivian O'Dell FNAL (odell@fnal.gov)
  - See next slides for opportunities on other topics

Far & Near Detectors

- Ample opportunity to get involved to installation, integration and commissioning activities at the far site
  - During peak installation period (e.g., when both HD and VD are installed), we need 150+ people at a minimum underground working
- An excellent opportunity for students and postdocs to go to SURF for long term stays. Also, opportunity to help lead efforts if stationed at SD e.g., coordinating activities, providing onsite support etc.
- Plan to provide subsistence (travel, housing etc.) support for those who move or go for long-term stays (threshold to be defined)
- ProtoDUNE-VD operations at CERN continue until end of 2027, another place to get involved



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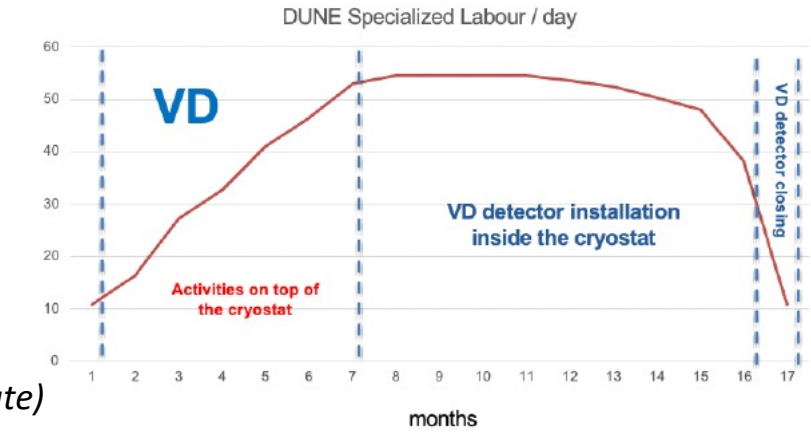

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DAQ-Related Opportunities (1)

(not an exhaustive list)

- DUNE DAQ overview (see backup)
  - For more info, DAQ Consortium Leader: Wes Ketchum (wketchum@fnal.gov)
- **Data Quality Monitoring (DQM)**
  - some effort needed on both FD and ND.
  - Specific areas: processing framework (how we cleanly integrate different algorithms / modules into DQM), visualization.
- **Control, Configuration & Monitoring System (CCM)**
  - Interfaces to both slow controls from CCM operational monitoring and to offline condition databases need additional work and effort.
  - Largely part of the UK plan for FD, but there is scope of contributions outside.
  - For ND, this is largely uncovered so great opportunity for new groups to come in

DAQ-Related Opportunities (2)

(not an exhaustive list)

- **Data filter**
  - Fair bit of effort needed in many areas
  - e.g., processing framework (potential overlap with Flex / offline workflows to know if those are suitable), algorithm development, and bookkeeping of results etc.
  - Additional FD server hardware contributions are also available (data filter servers). Also, a prime area for potential future AI/ML deployment in the online, so would be an appealing strategy for future hardware contributions alongside specific processing needs.
  - Primarily FD-focused but on ND, understanding what of a data filter may be needed would be an exercise.
- **File transfer to offline**
  - Some additional effort needed.
  - New contributors will also need to build strong connections to the overall data management teams as part of the job and take some effort there also

Core Software & Computing (1)

(not an exhaustive list)

- DUNE CS&C overview/scope (see backup)
  - For more info, DAQ CS&C Consortium leader Mike Kirby (mkirby@bnl.gov)
- Mainly listing Operational tasks especially in view of DUNE's plan to adopt the Worldwide LHC Computing Grid (WLCG) model for DUNE computing pledges.
  - https://wlcg.web.cern.ch/
- **CRIC integration**
  - CRIC: Computing Resource Information System
  - DUNE CRIC exists but has only information on compute sites right now. Need to add all the storage and all the contact info for DUNE sites.
  - CRIC also used to track computing pledges so updating and maintaining is a high priority in the coming year.
- **Allocation monitoring**
  - Allocations will need to be tracked in CRIC. Need effort to monitor which sites we have allocations and ensure effective use of those allocations.

Core Software & Computing (2)

(not an exhaustive list)

- **Accounting**
  - There are several automated processes which are supposed to populate the European Grid Infrastructure (EGI) accounting system via what is now the APEL gateway and will change to PEAR.
  - The European side of this is working, the US side is not. This software is not maintained or installed by DUNE, but we must keep on filing tickets if it does not work and check to confirm. A continuous exercise.
- **Ticketing Unification**
  - Recent improvements in Global Grid User Support (GGUS) for WLCG require us to unify on that front. Effort needed for coordinated integration into GGUS and making sure that the ticketing works for sites and DUNE Computing Contributions Board (CCB) contacts.
- **R&D**
  - Development to make the various supercomputing sites usable including any potential sites in South Korea in the future

Analysis/Reconstruction/Software

- Contact points DUNE Physics Coordinators: Chris Marshall U. of Rochester (chris.marshall@rochester.edu), Michel Sorel IFIC (sorel@ific.uv.es)

Beam BSM
Justo Martin-Albo
Alex Sousa

Calibration
Rhiannon Jones
Viktor Pec

FD sim/reco
Dom Brailsford
Laura Paulucci

Atm. and Exotics
Josh Barrow
Pierre Granger

Long-baseline
Luke Pickering
Jeremy Wolcott

Low-Energy
Daniele Guffanti
Amanda Weinstein

ND Prot. Analysis
J. Pedro Ochoa
Zoya Vallari

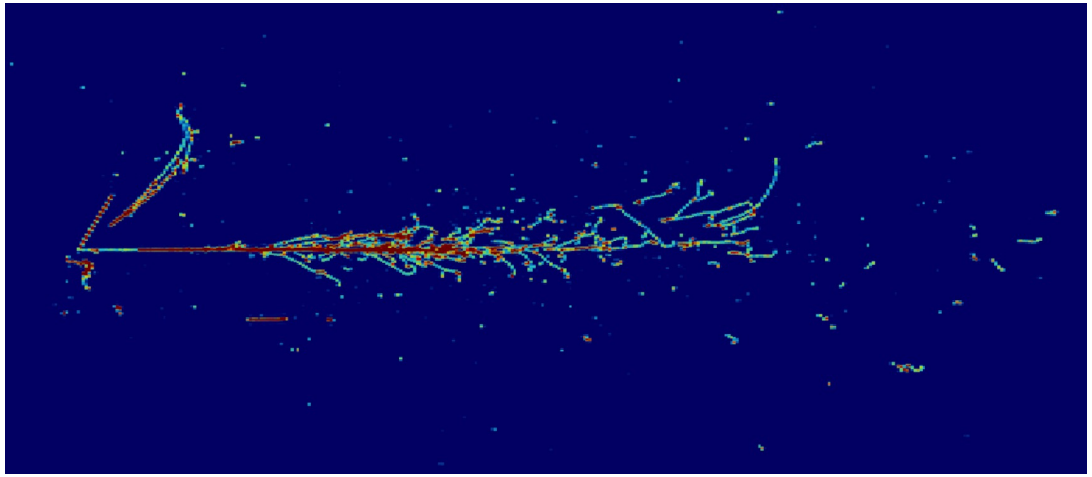
ND sim/reco
Alex Booth
Matteo Tenti

Neutrino Interactions
Jaesung Kim
Laura Munteanu

ProtoDUNE Analysis
Jake Calcutt
Stephen Dolan
Laura Zambelli

- 10 working groups
- 50% of DUNE is currently students/postdocs and they are driving these efforts
- Collectively DUNE has published about 100 papers so far
- DUNE has many theorists and contributions span all areas

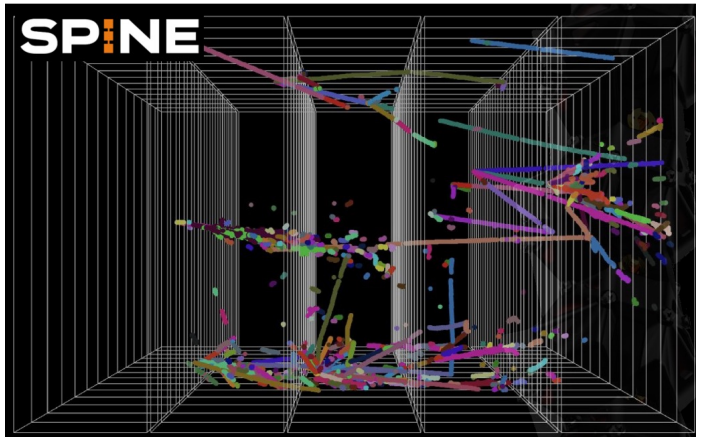
Plenty of Opportunities on AI/ML developments

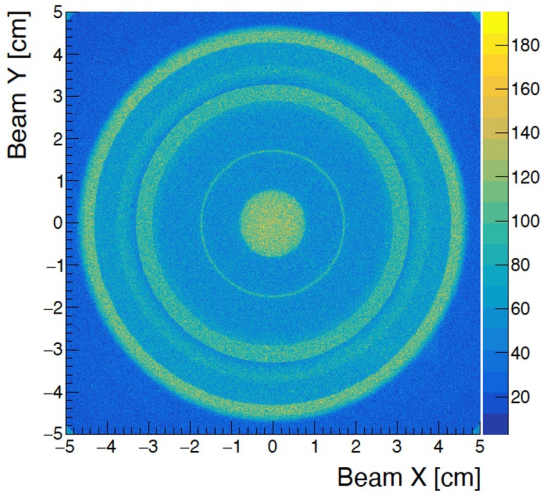


- Detector scale unprecedented generating tens of PB of data
- DUNE is developing state-of-the-art AI models (e.g., LLMs, Foundation models, Agentic AI) and plans to leverage infrastructure around the world

DUNE AI/ML forum conveners:
Jianming Bian UCI (bianjm@uci.edu)
Leigh Whitehead Cambridge
(leigh.howard.whitehead@cern.ch)

- Simulation/Reconstruction/Analyses
- Trigger & Data Acquisition
- Beam design and monitoring
- Computing workflow
- Documentation search pipeline
- Quality Control & Assurance



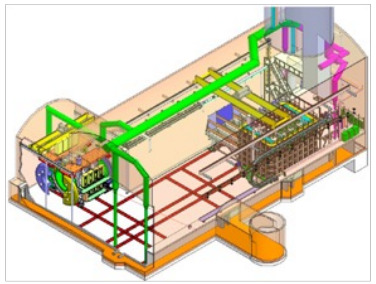


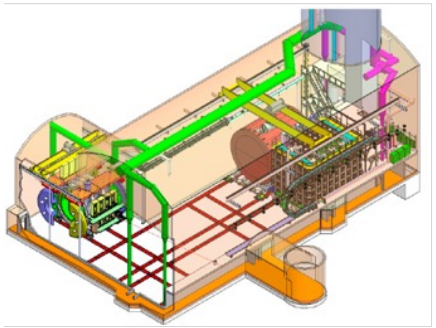
Analysis/Reconstruction/Software

(not an exhaustive list)

- Several opportunities exist with simulation and reconstruction efforts, specific areas can be identified based on interest
- Analysis efforts to develop full chain analysis workflows, sensitivity projections etc. are areas to contribute that has opportunities
- DUNE has data! (see backup for more details)
  - ProtoDUNEs at CERN (3 detector configurations; 2 run periods; 50M+ events with test beam and cosmics; 13 papers already published and several in pipeline)
  - ND-LAr 2x2 prototype (3 run periods and includes NuMI neutrino beam events. More neutrinos data to come)
  - Excellent opportunity for students and postdocs to contribute and take leading roles in cross section analyses, detector validation, calibration techniques etc.
- See talks by Sungbin and Jay Jo from last week's KPS meeting: https://www.kps.or.kr/conference/event/content/program/search_result_session.php?id=2560

Big Opportunities for DUNE Phase-II





Phase-I

- **FD:** 2 x 17 kt LArTPCs
- **ND:** LArTPC + Muon Spectrometer (with PRISM) + On-axis Beam Monitor
- **Beam:** 1.2 MW (PIP-II)

Phase-II

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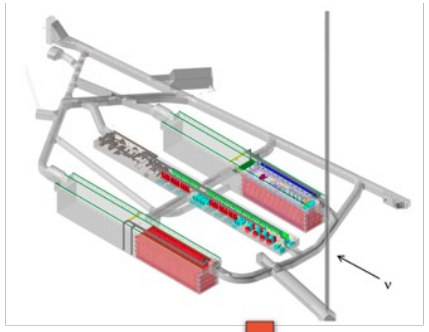
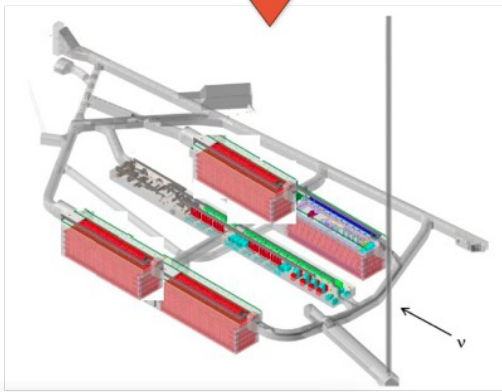
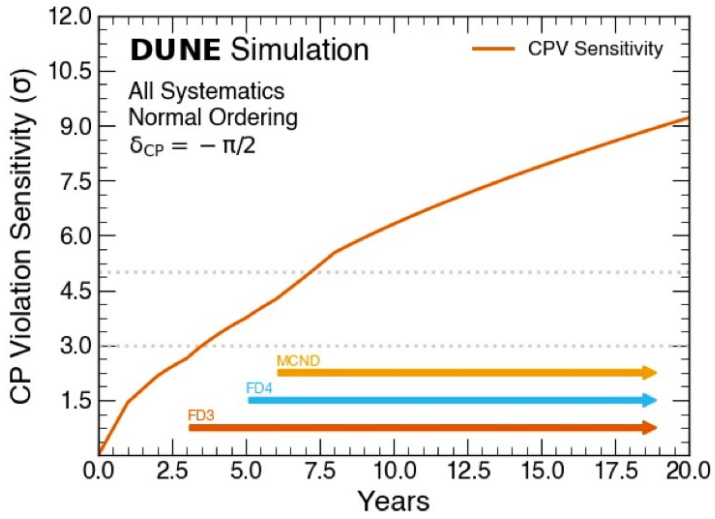




- The dual facilities built by LBNF support both Phase-I and Phase-II scope
- Cryostats for FD3 and FD4 uncommitted so far
- Phase-II timeline: mid to late 2030s



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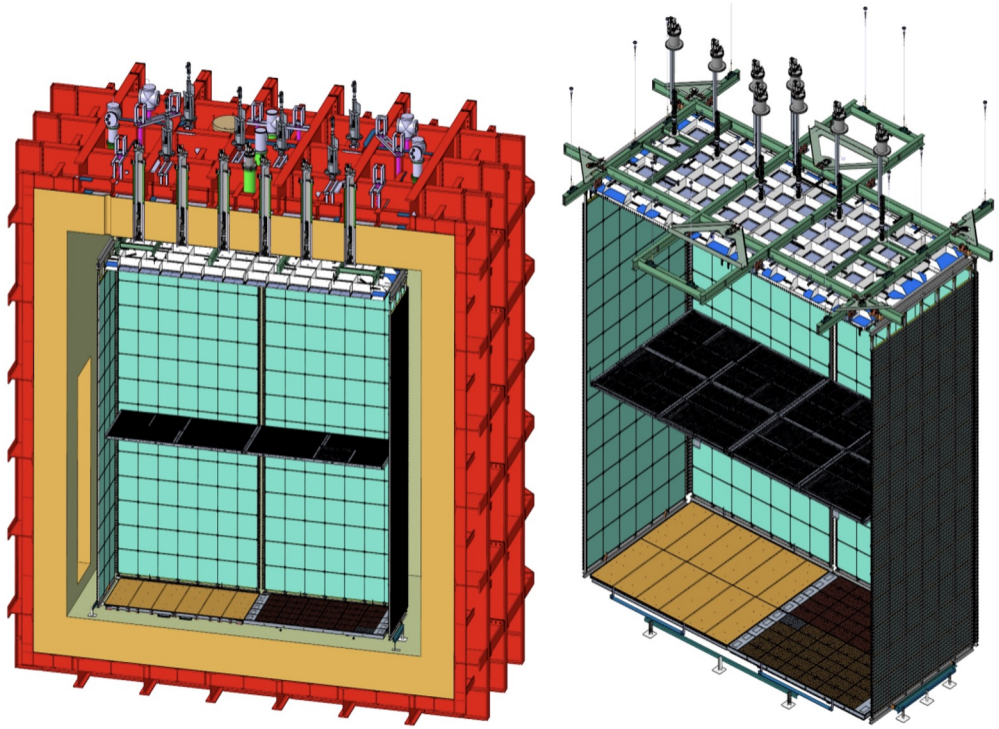
Opportunity: ProtoDUNE-III

- Considering several technologies that meet DUNE's core physics goals while expanding physics reach
  - Argon gas near detector (ND-GAr)
  - Optimized Light/Charge Readout for FD
  - Non-Argon FD Option (THEIA)
  - Improved Background Mitigation
- An ProtoDUNE-III proposal has been submitted to CERN to test a subset of these technologies – *currently under review by CERN*
- ProtoDUNE-III is expected to start installation in 2029-30

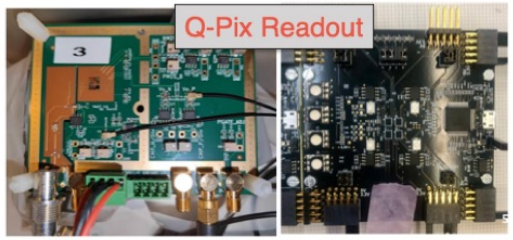


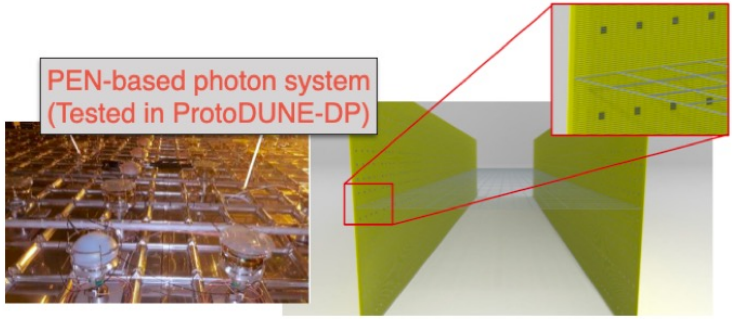
DUNE Phase-II White Paper
JINST 19 P12005 (2024)

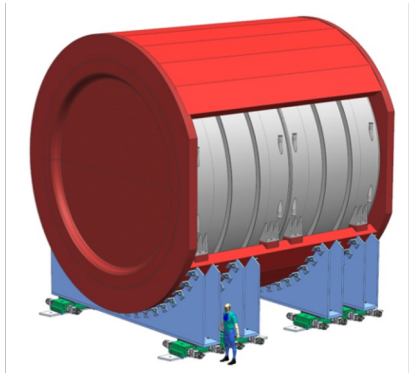
Active R&D and Prototyping for Phase-II

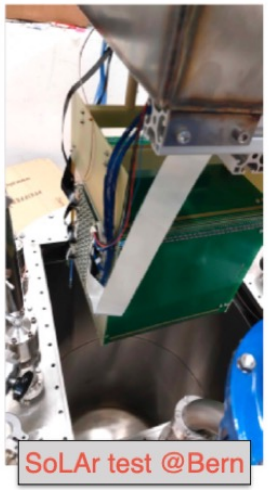
- An excellent place for new collaborators to make contributions and take leading roles

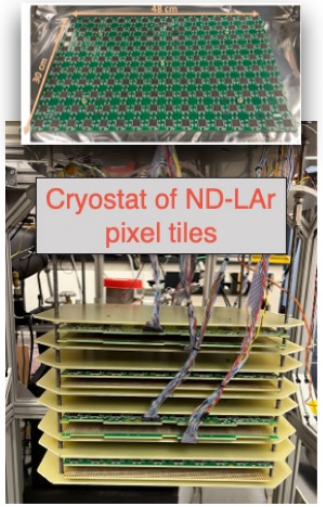






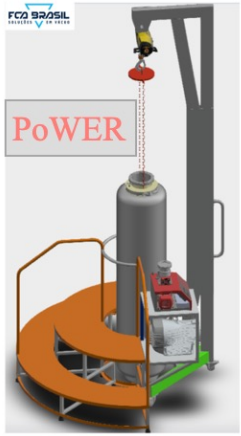


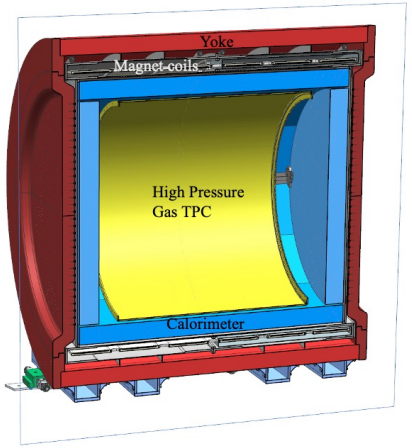












Active R&D and Prototyping for Phase-II

Contact points: Phase-II Coordinators

- Stefan Soldner-Rembold (Manchester) s.soldner-rembold@imperial.ac.uk
- Laura Fields (Notre Dame) lfields2@nd.edu
- Francesco Terranova (INFN Milan-Bicocca) francesco.terranova@mib.infn.it

Process/Timeline for New Institutes to Join DUNE

- We hold IB meetings almost every month and a petition to join DUNE can be submitted for any of these meetings.
- The IB chair is Alfons Weber (a.weber@uni-mainz.de) and Deputy IB chair is Mayly Sanchez (mayly.sanchez@fsu.edu)
- Petition materials will need to submitted at least 2 weeks before an IB meeting for consideration
  - A 1-2 page write up that summarizes the institute's scientific and technical interests, team, institutional/group's strengths, plans including potential funding avenues
  - All of this is aspirational and is not binding. There is also no requirement to secure funding before submitting a petition. It is understood that plans and funding situations evolve and only best effort is expected
  - A CV from each senior PI (faculty/scientist-level) will need to be attached. No documentation needs to be submitted for students, postdocs or technical staff members

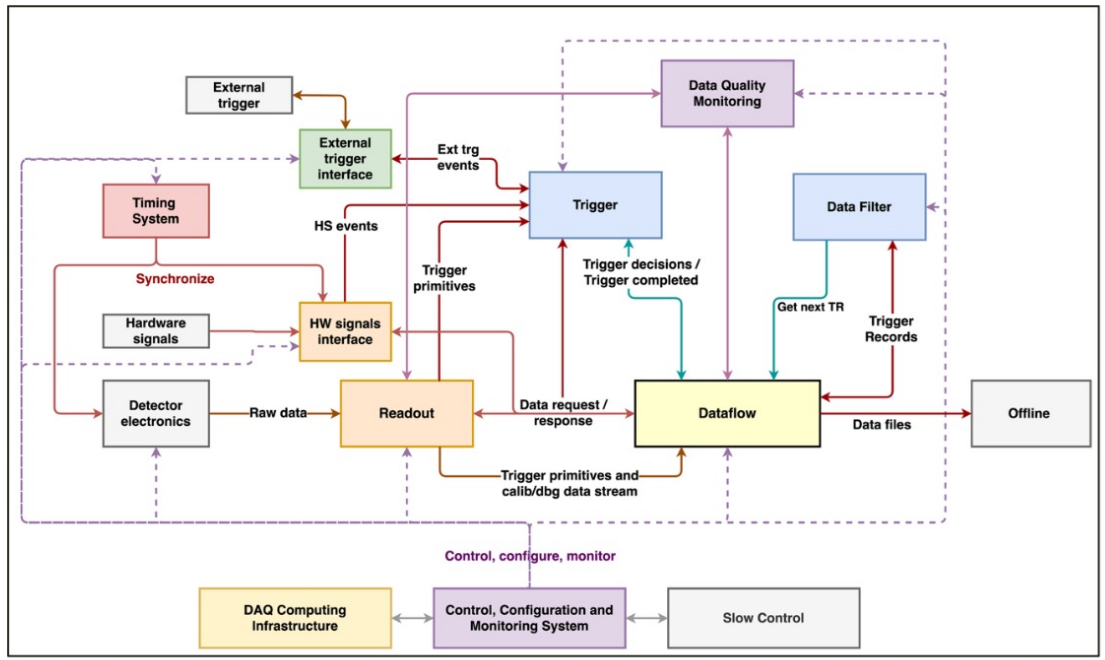
Process/Timeline for New Institutes to Join DUNE

- We will likely hold one more IB meeting before the end of the year (likely late November or early December).
- The first IB meeting in the new year will be in January during the collaboration meeting week (Jan. 25-29)
- Please contact Spokes or IB chair for further information

BACKUP SLIDES

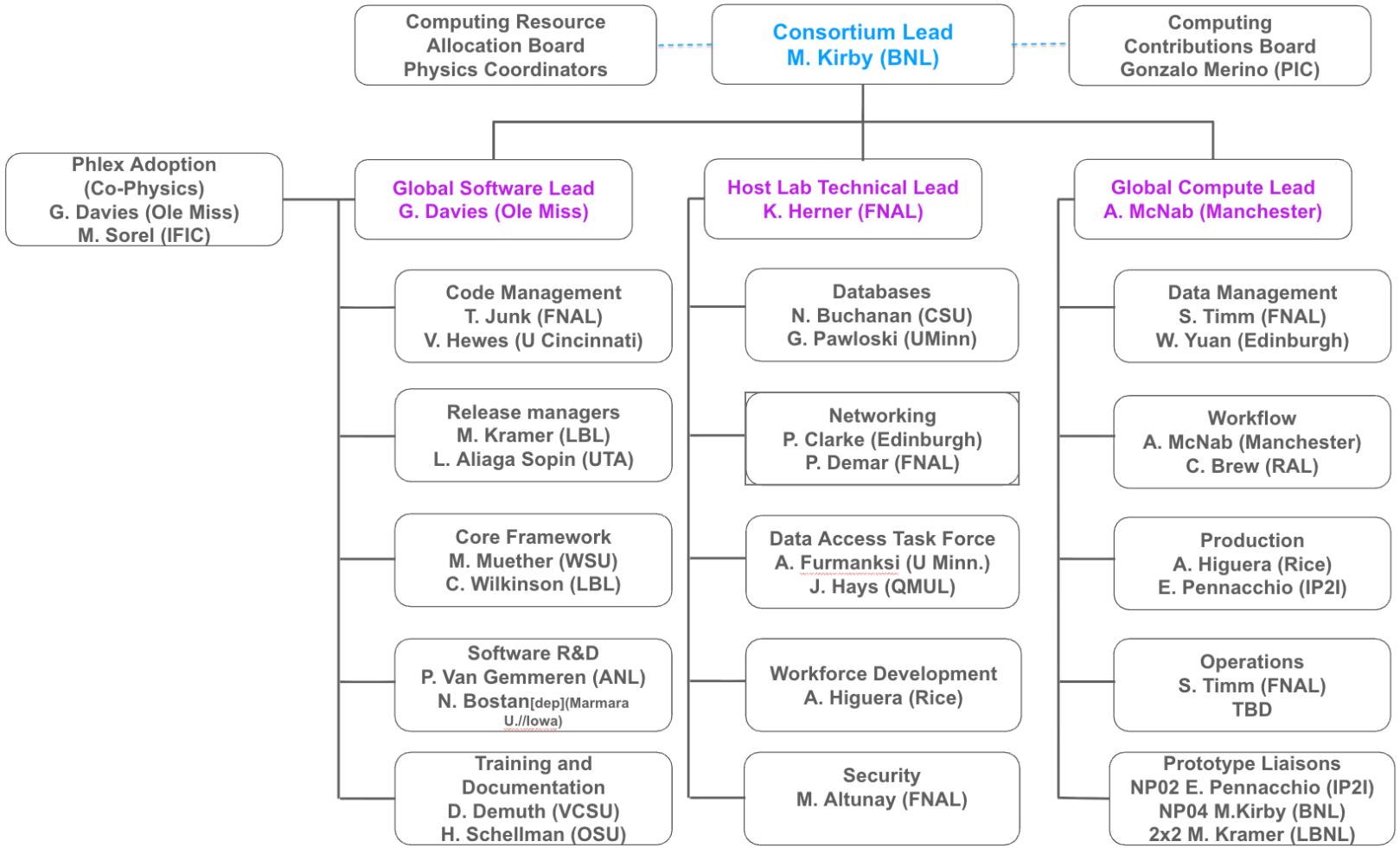
DUNE DAQ Overview

- DUNE DAQ system is responsible for hardware and software providing:
  - **Timing signals** for electronics synchronization / time-stamping of data
  - **Readout and buffering** of data from detector electronics
  - Processing of data to form **trigger decisions**
  - On positive trigger decisions, **acquire, filter, and store data** until transfer to offline computing / data storage

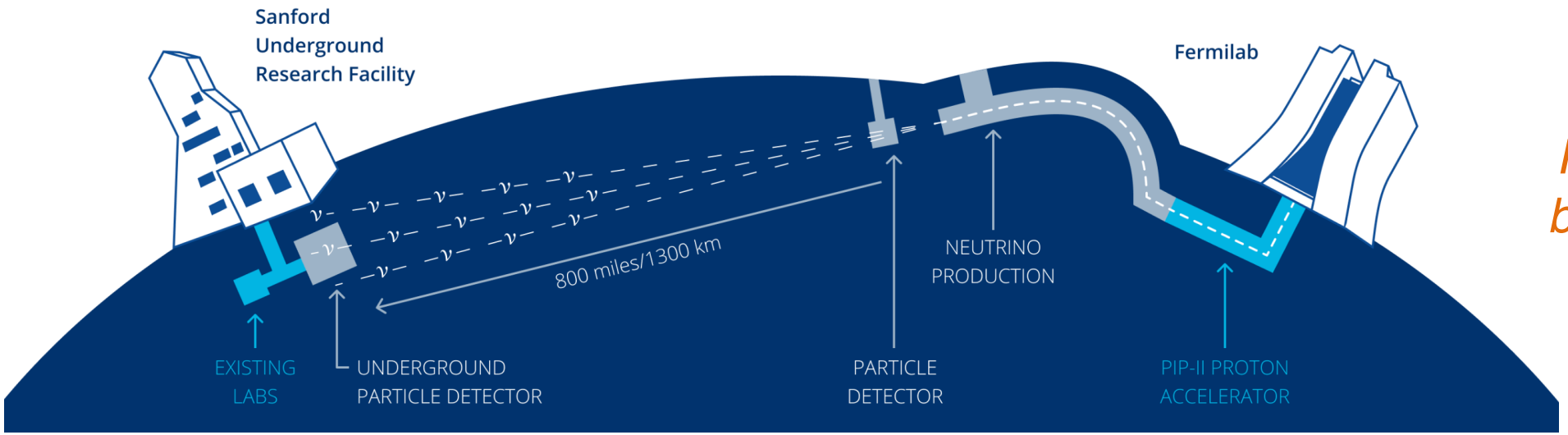


- VD and HD DAQ systems designed to be functionally identical
  - Difference only in detector electronics supported and exact system scale

DUNE Core Software & Computing Overview



DUNE in a Nutshell



Installation has begun at the far site!

LBNF: Long Baseline Neutrino Facility

The Science (DUNE)

- Charge-Parity Violation in neutrinos
- neutrino mass ordering
- Test 3-flavor paradigm
- New Physics
- Astrophysics

The Technology (DUNE)

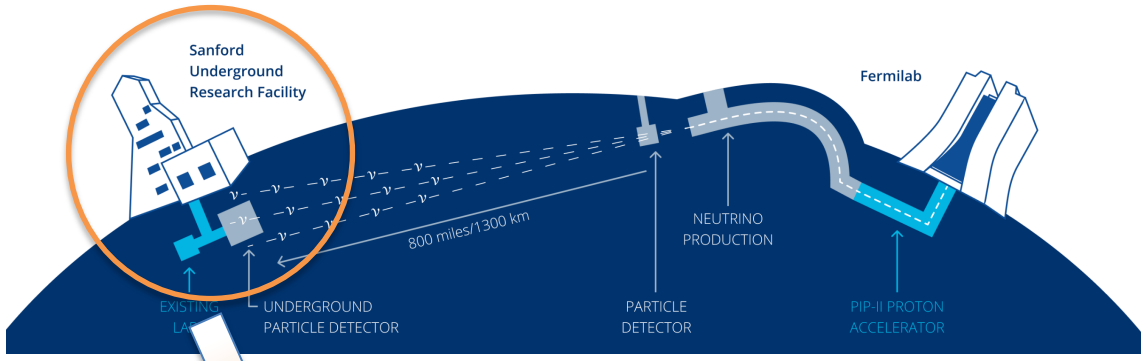
- Four 17 kiloton LAr detectors – largest of its kind!
- A movable near detector

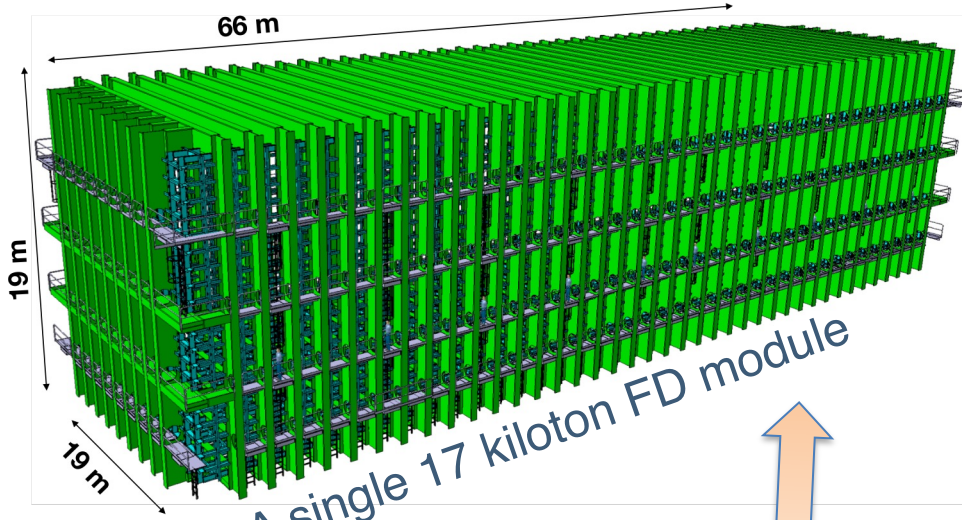
DUNE will be built in two phases (DUNE Phase-I and Phase-II)

The Facility (LBNF)

- Colossal caverns at 1.5 km underground
- World's most intense neutrino beam (> 2 MW) and wide-band
- longest distance accelerator neutrinos ever traveled

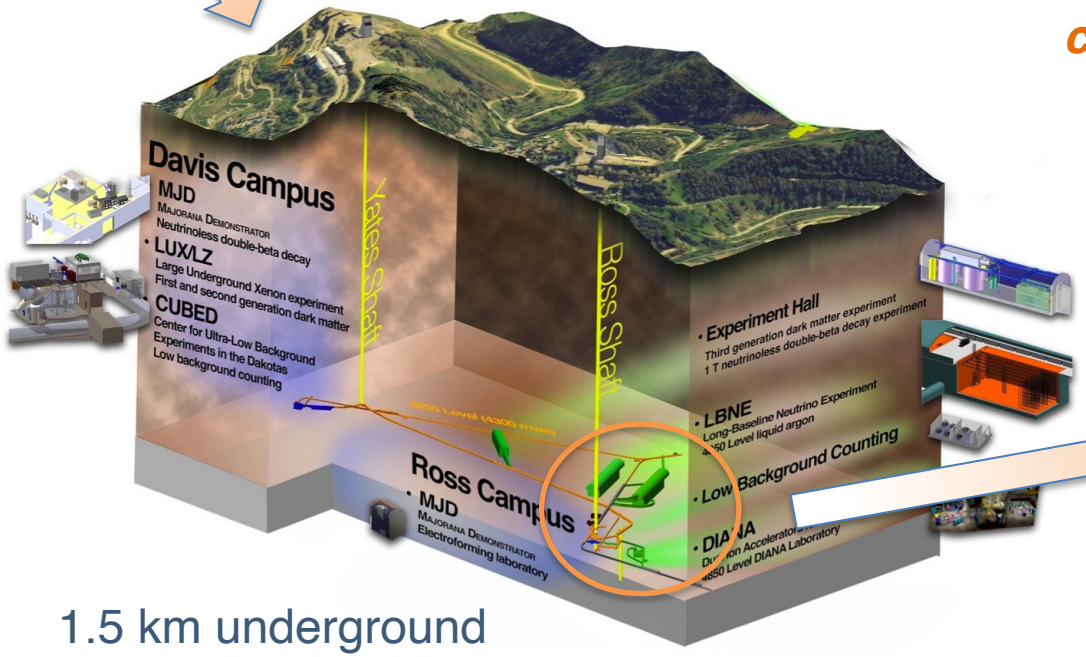
DUNE Far Site



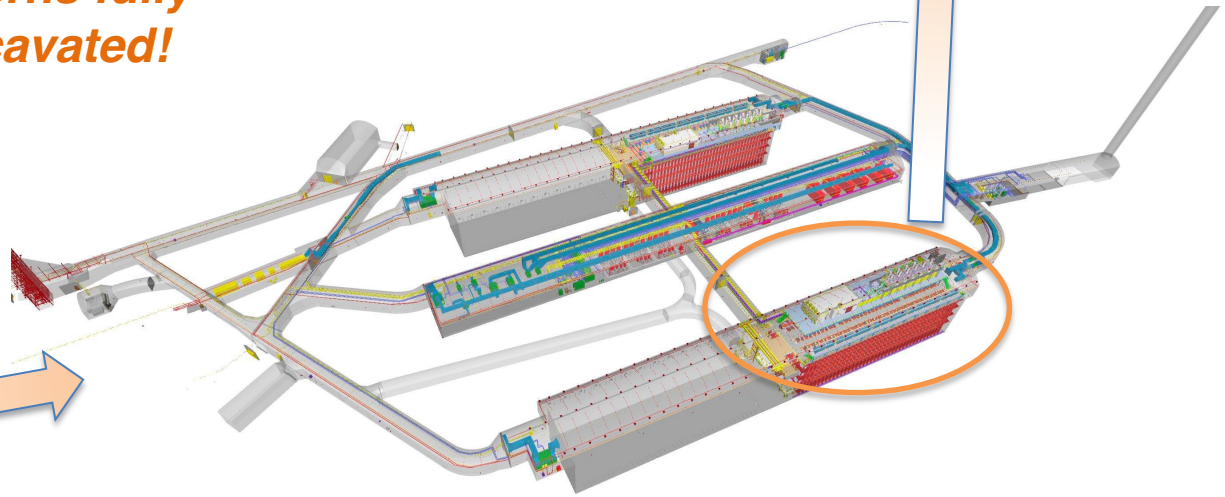


A single 17 kiloton FD module

Far Site caverns fully excavated!



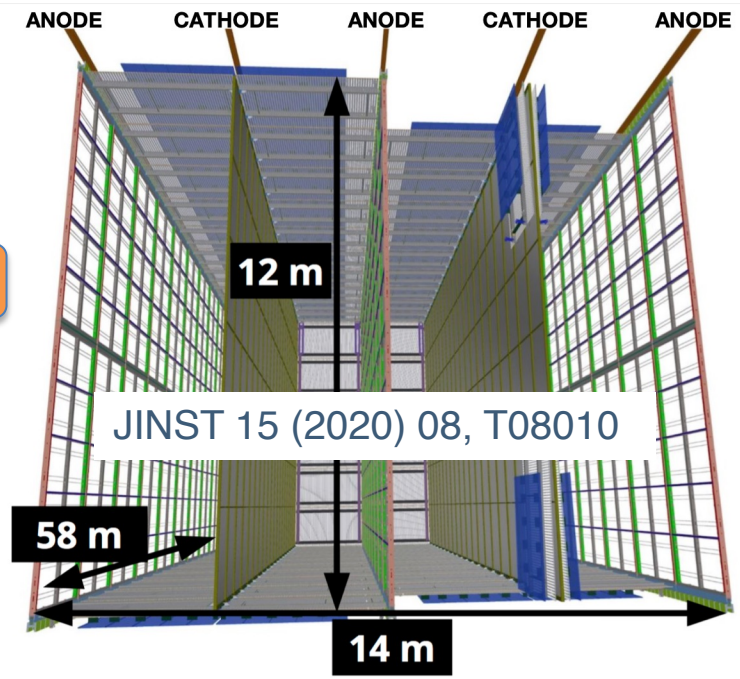
1.5 km underground



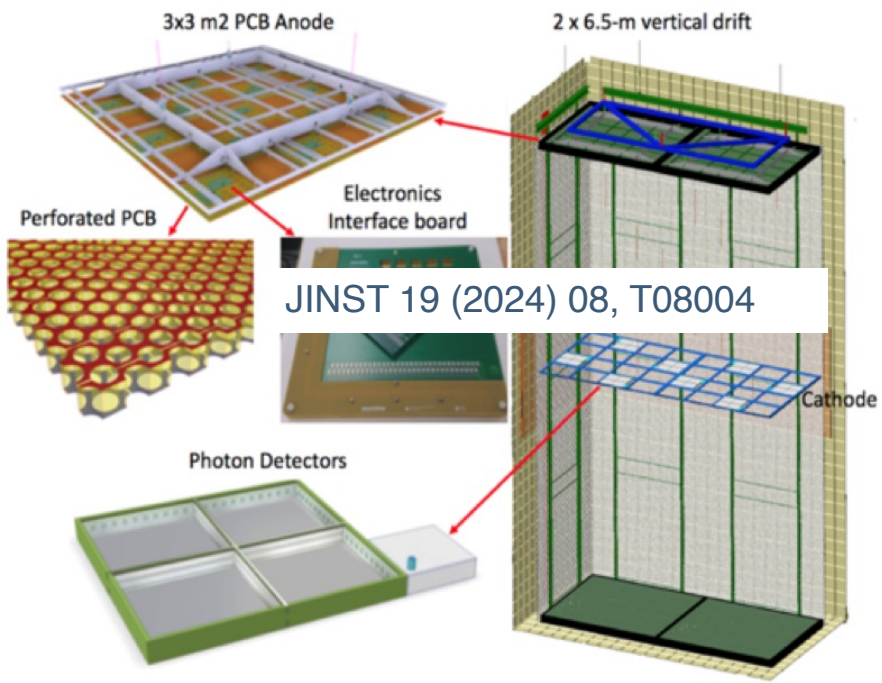
3 caverns, 4 detectors

DUNE Far Detectors

FD-HD



JINST 15 (2020) 08, T08010



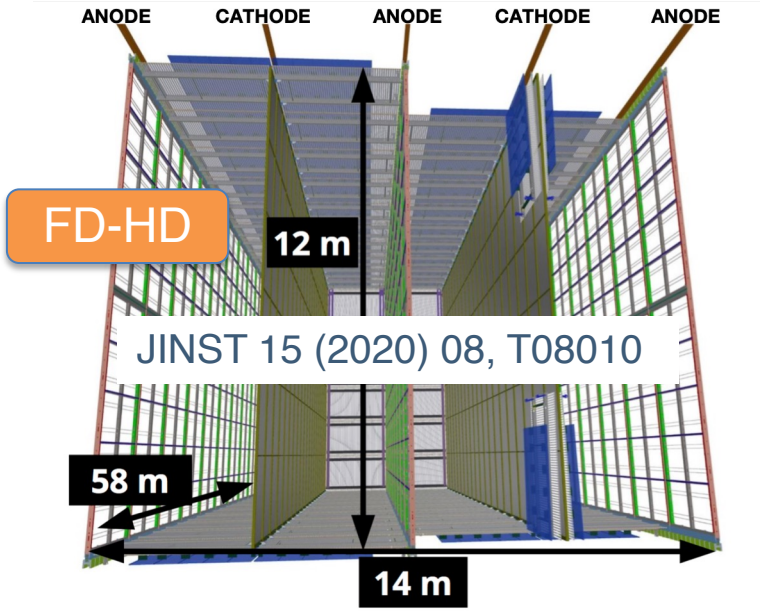
JINST 19 (2024) 08, T08004

FD-VD

Two LArTPC technologies,

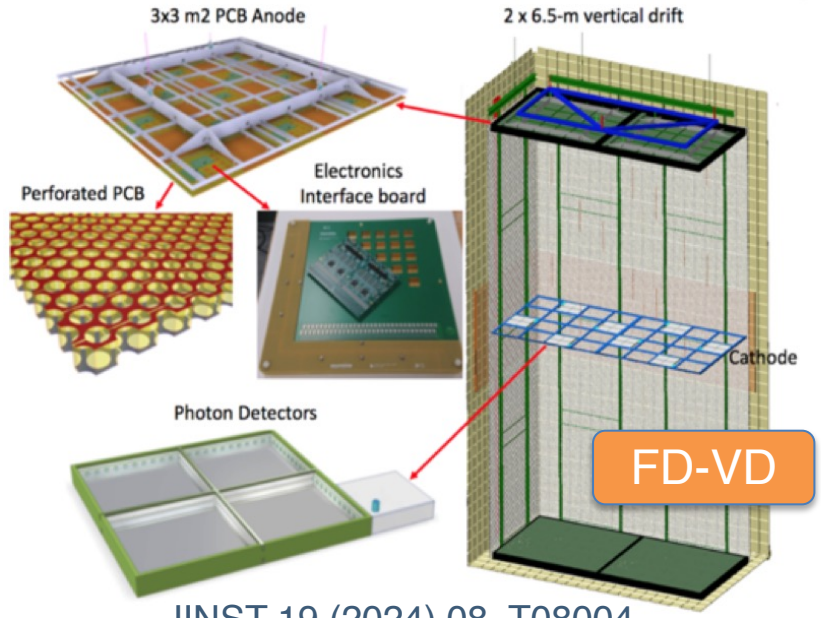
- **Horizontal-Drift (HD):** shorter drift; more segmented; wire readout
- **Vertical-Drift (VD):** longer drift; less segmentation; strip readout

DUNE Far Detectors





- Both technologies successfully demonstrated at scale in ProtoDUNE (770-tons) along with physics performance resulting in 13 papers!
- All far detector components in production
- Installation of far detectors to start next year once cryostat assembly concludes

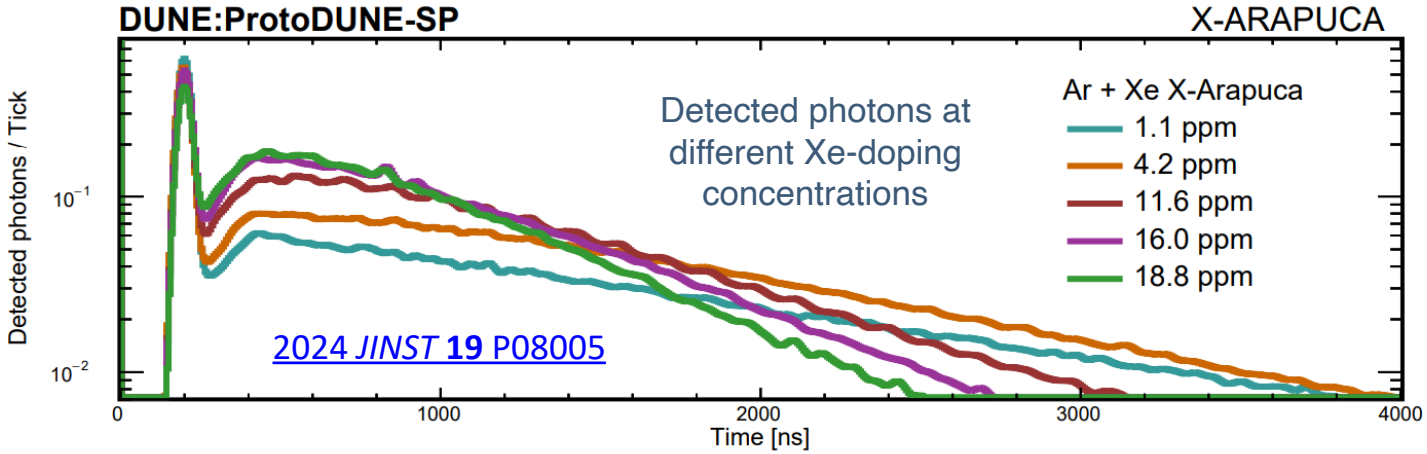


JINST 19 (2024) 08, T08004

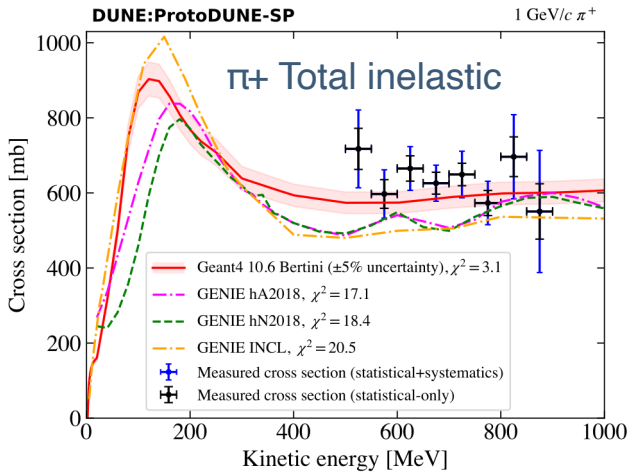


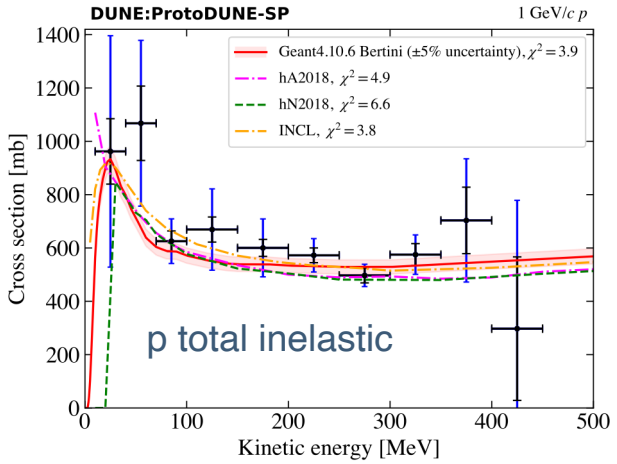
ProtoDUNE Phase-I

- **13 papers and counting!** (technical, detector performance, cross section papers etc.)
- Data has provided an important test of Geant4 and GENIE Argon scattering models
- Room for more analyses

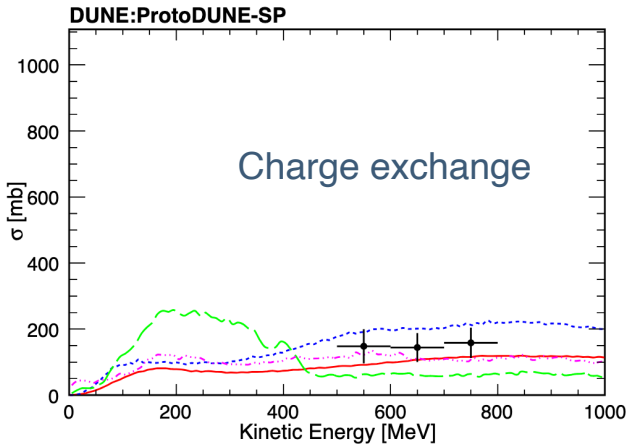


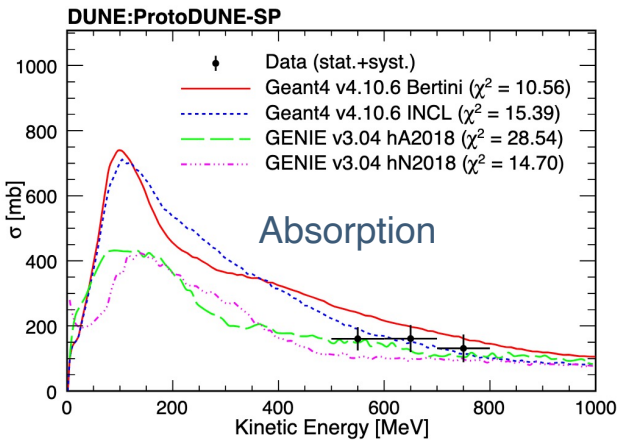
https://arxiv.org/abs/2511.11925





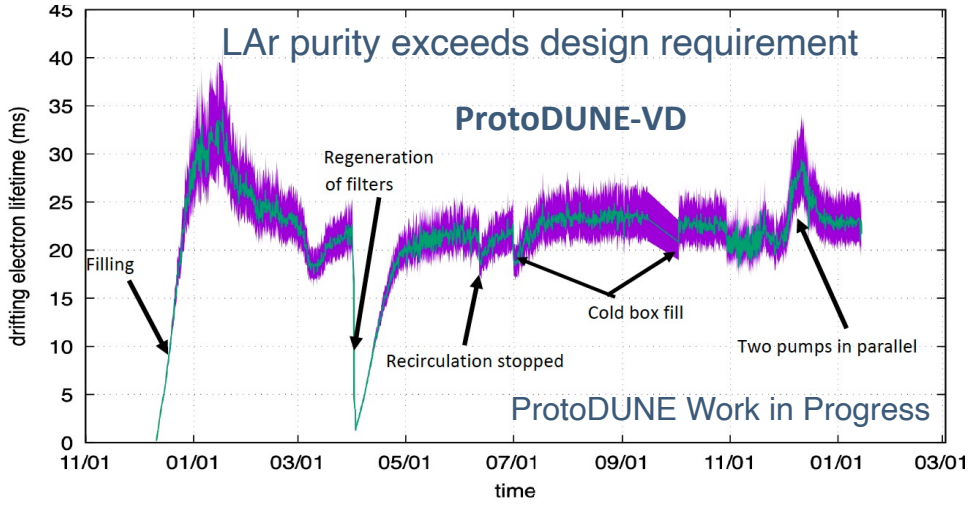
https://arxiv.org/abs/2511.13462 **(Pion Exclusive)**

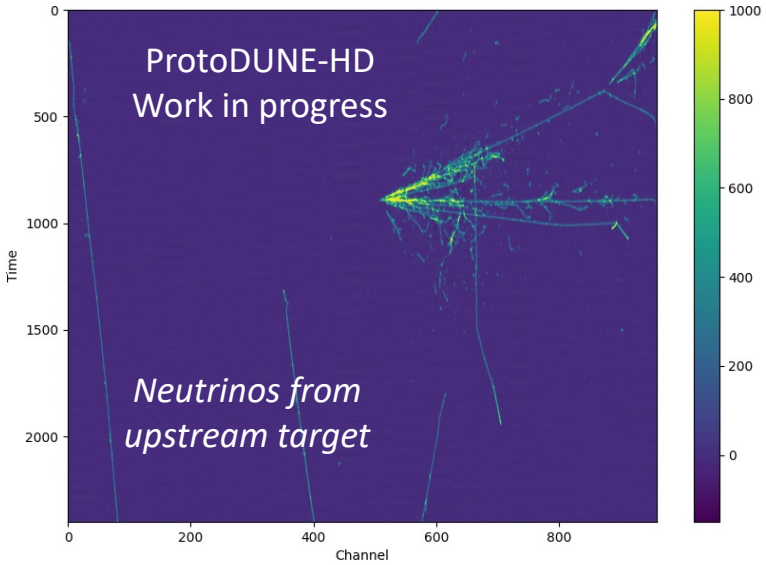


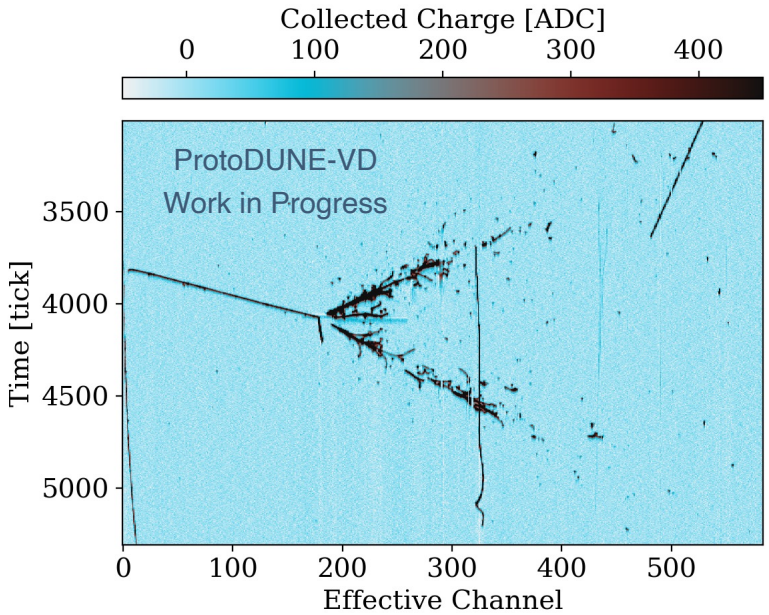


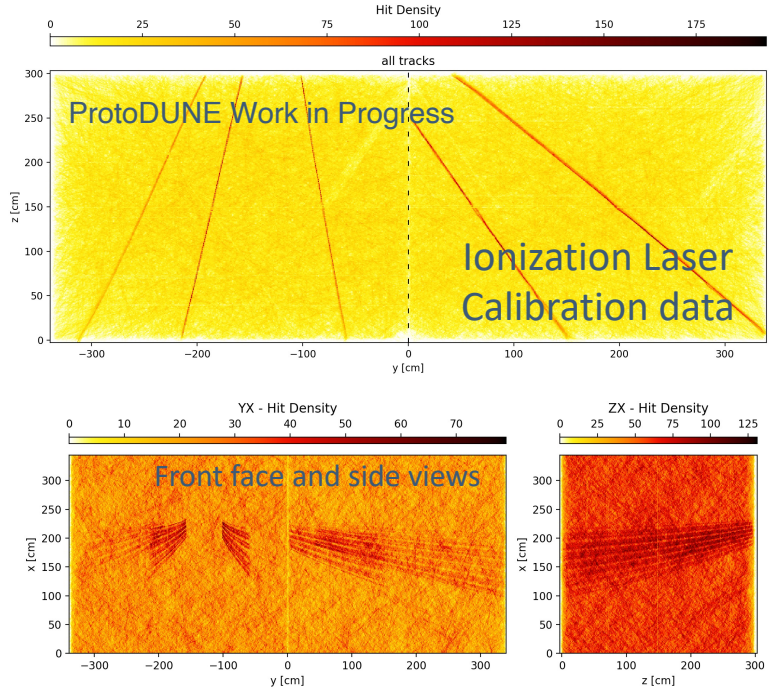
ProtoDUNE Phase-II

- **ProtoDUNE-HD:** 23M events (2024)
- **ProtoDUNE-VD:**
  - > 4M events (July-Sept 2025)
  - Post-beam operations continue to end of 2027: HV stress tests, Xe doping, neutron source calibration etc.
- Excellent overall performance; data analyses ongoing



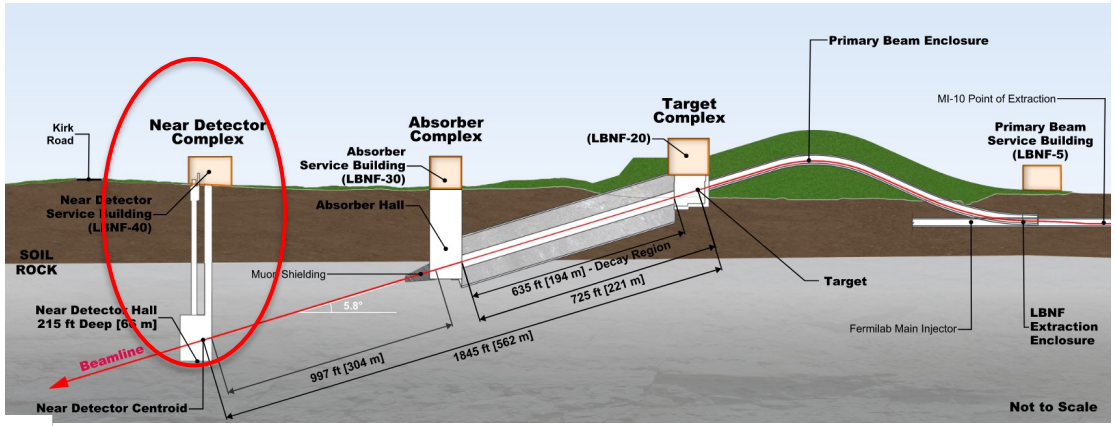




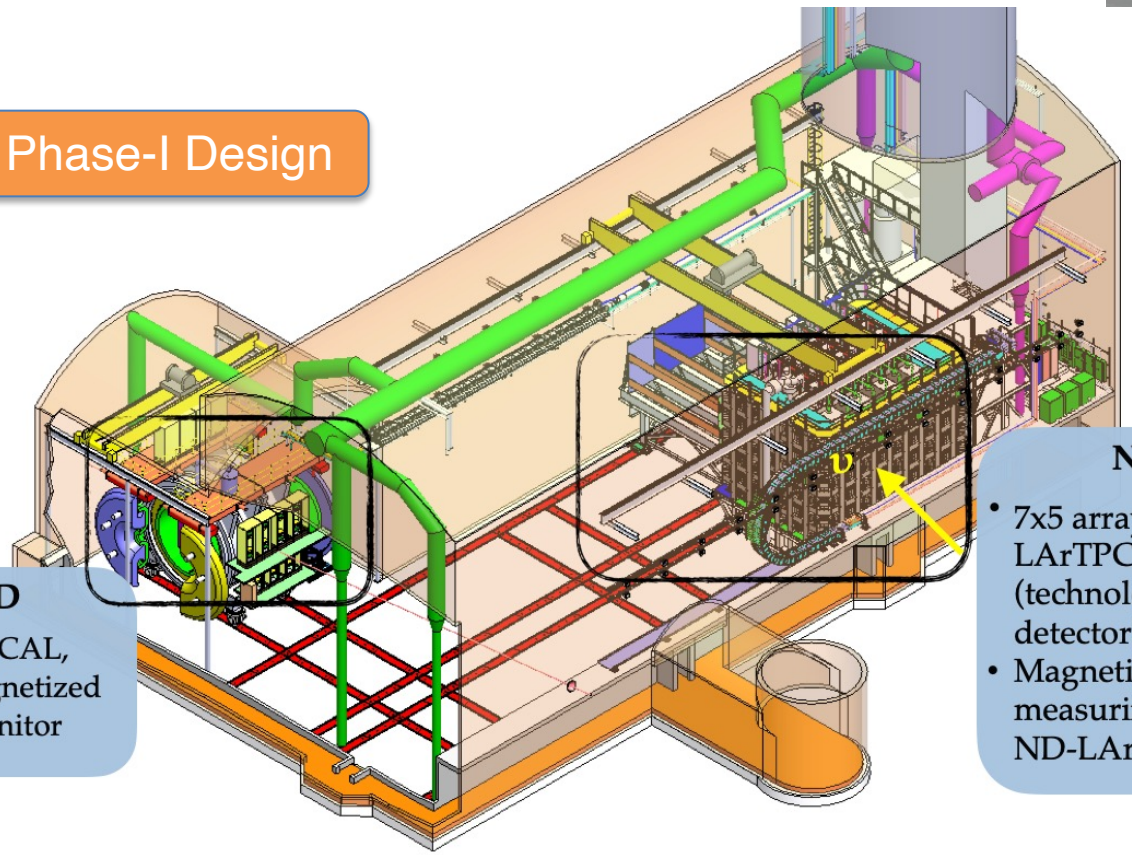


DUNE Near Detector

- Located **60 m** underground at Fermilab
- **574 m** from neutrino beam target
- Comprised of two major components



Phase-I Design



SAND

Tracker, ECAL, On axis magnetized beam monitor

ND-LAr + TMS

- 7x5 array of modular 1x1x3 m^3 LArTPCs with pixel readout (technology closest to far detector)
- Magnetized steel range stack for measuring muons that exit ND-LAr

Primary Goals

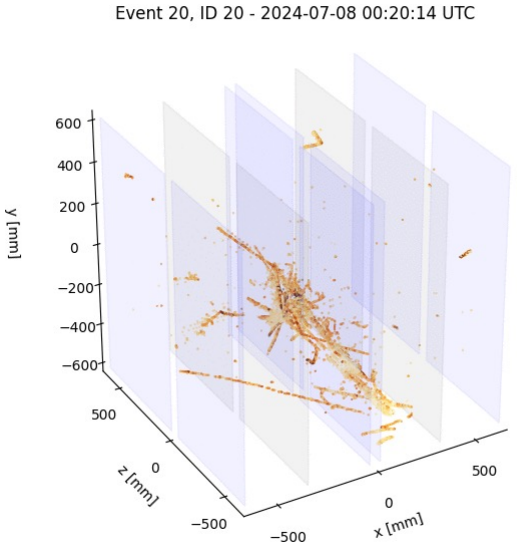
- Characterize neutrino beam
- Constrain neutrino cross sections on argon for precision oscillation physics
- Perform in a high-rate environment

Near Detector will see about ~50 neutrino interactions per spill!

ND-LAr “2x2” Demonstrator at Fermilab

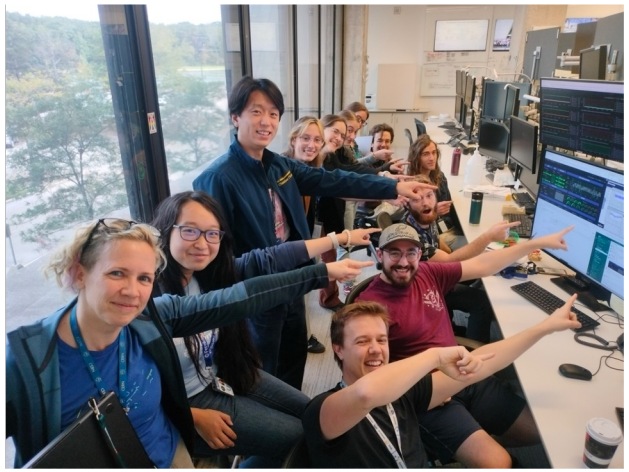
- **Run 1:** 4.5 days of NuMI data in 2024
  - Submitted operations paper to JINST https://arxiv.org/abs/2509.07012
- **Run 2:** cosmic runs, Oct. – Dec. 2025. 3 types of source calibrations deployed along with other improvements (e.g., cryogenics)
- **Run 3:** Preparations complete for the NuMI neutrino beam run starting this month *(~12 weeks of beam time and possibly more)*

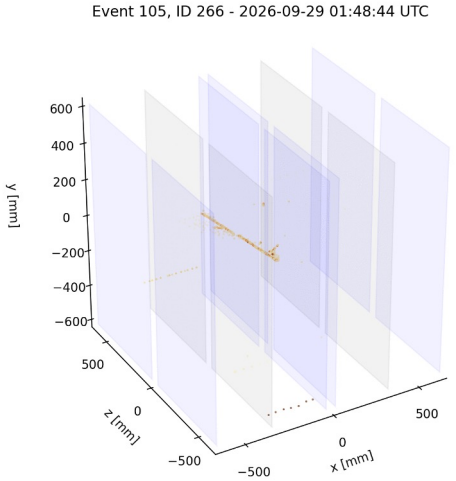
Instruments 8 (2024) 3, 41
(Neutrino events)





ND-LAr “2x2” prototype





Cosmic events in 2026



DUNE Publication Highlights

- DUNE is actively publishing on physics, software and technical topics, both collaboration-wide papers and small-author technical papers
- About 165 conference proceedings by DUNE so far

Topic	Published	Under Review
Physics	13	4
Detector	10	1
Simulation & Reconstruction	8	2
Design reports & White Papers	14	-
Other	1	1
FULL-AUTHOR PAPERS	46	8
Small-author technical papers	53	1

About 100 papers published and 9 in review!