

DUNE Status

Ed Blucher

Stefan Söldner-Rembold

LBNC Meeting

5 December 2019



THE UNIVERSITY OF
CHICAGO



Topics

- TDR
- Collaboration news
- Far Detector Strategy
- ProtoDUNEs
- Module of Opportunity Workshop
- Near Detector
- LBNC Recommendations
- Schedule and Summary

Since the last LBNC meeting

- September 19-20, 2019: RRB Meeting
- September 23-27, 2019: DUNE Collaboration Meeting
- October 21-23, 2019: DESY Near Detector Workshop
- October 29-31, 2019: DOE Independent Project Review of LBNF/DUNE
- November 12-13, 2019: Module of Opportunity Workshop, BNL
- November 14, 2019: International Neutrino Council and Near Site Groundbreaking
- November 21, 2019: LBNF and DUNE HEPAP presentations
- Dec 5-7, 2019: LBNC meeting at CERN
- January 27-31, 2020: DUNE Collaboration Meeting at CERN

DUNE Technical Design Report

Deep Underground Neutrino Experiment (DUNE)
Technical Design Report

Volume I
Introduction to DUNE

July 2019
The DUNE Collaboration

Deep Underground Neutrino Experiment (DUNE)
Technical Design Report

Volume II
DUNE Physics

July 2019
The DUNE Collaboration

Deep Underground Neutrino Experiment (DUNE)
Technical Design Report

Volume IV
DUNE Far Detector Dual-phase Technology

July 2019
The DUNE Collaboration

Deep Underground Neutrino Experiment (DUNE)
Technical Design Report

Volume V
DUNE Far Detector Technical Coordination

July 2019
The DUNE Collaboration

Deep Underground Neutrino Experiment (DUNE)
Technical Design Report

Volume III
DUNE Far Detector Single-phase Technology

July 2019
The DUNE Collaboration

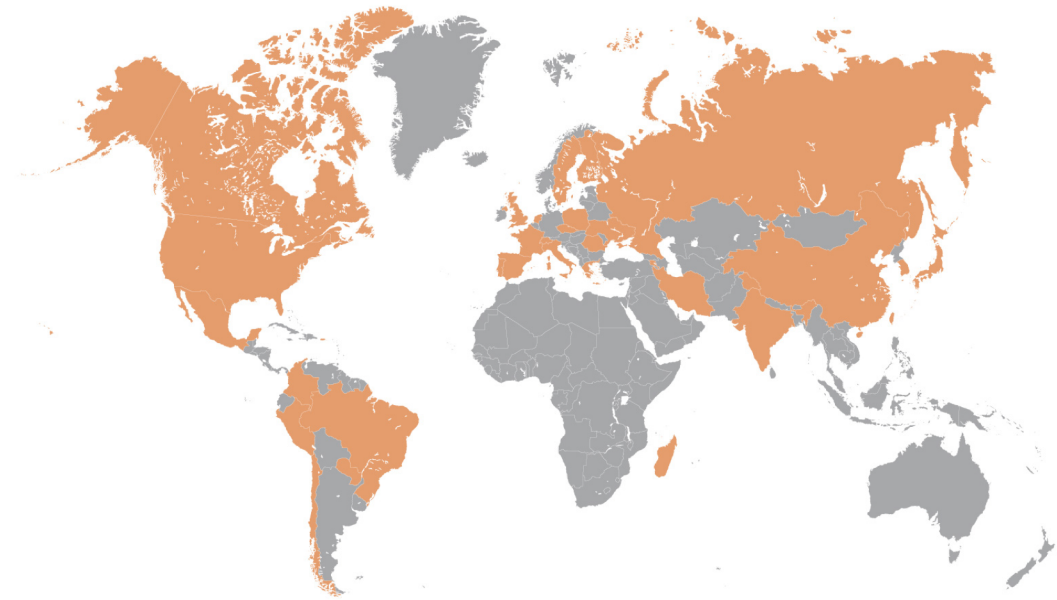
A major milestone for the collaboration

- LBNC recommended approval of Intro, Physics, SP and TC volumes of TDR on Nov. 27
- Revised version of DP volume submitted to LBNC on Nov. 8, 2019. The DP volume will be finalized based on input from ProtoDUNE-DP.
- **Thank you to Mont and all of the LBNC members and consultants for their careful review of the TDR.**

TDR Publication Plans

- LBNC-approved volumes will be posted on archive following implementation of last corrections from LBNC.
- 3 papers based on physics TDR will be submitted to international physics journal
 - Long baseline physics
 - Supernova physics
 - BSM physics
- Introduction, Single Phase, and Technical Coordination volumes will be submitted to international instrumentation journal

DUNE Collaboration Status



~1100 collaborators from
188 institutions in
31 countries + CERN

4 new institutions joined at
September 2019 Collaboration
Meeting



DUNE International Progress

- **Americas:**

- US DOE: advancing toward CD-2/3 in 2020; continued unwavering support
- US NSF: submission to mid-scale 2 program for 150 APAs + data selection system; Reverse Site Visit last month
- Latin America: increasing involvement from Latin America. In Brazil, new funding proposal to FAPESP for SP photon system just submitted
- Canada: joint FNAL-York position on DUNE; U Toronto joined last month

- **Asia:**

- India: Annex 2 for cooperation on neutrinos was signed; involved in different aspects of ND
- Korea: ICRADA with Chung Ang University
- Japan: HyperK announcement expected soon; DUNE still eager to have broader involvement of Japanese groups

DUNE International Progress

- **Europe:**
 - CERN: Commitment to ProtoDUNE I,II; DUNE DAQ, HV systems
 - UK STFC: £65M DUNE grant for 150 APAs, DAQ, etc. fully awarded
 - France: Strong support of DUNE project by IN2P3/CEA; expect ministerial approval in 2020
 - Germany: Joint Fermilab/Mainz DUNE faculty position; DESY hosted DUNE Near Detector Workshop last week
 - Italy INFN: Committed to ND (KLOE magnet + calorimeter and MPD magnet), plus photon detector sensors and HV
 - Portugal: leading role in calibration system. ERC Advance Grant submitted
 - Spain: engaged in photon detection, cryo instrumentation; funding requests in preparation
 - Switzerland: DUNE on Swiss road map; recent award of 1MCHF to Bern for 2x2 ArgonCube demonstrator (+2.3 MCHF to LBNF)
 - Georgia: Joined in 2019 and will contribute to ND; strong support at ministerial level.
- Several DUNE-related EOIs submitted to Advanced European Infrastructures for Detectors at Accelerators (AIDA) program

Annual update of physics working group leaders

Physics Coordination

Ryan Patterson
Elizabeth Worcester

FD Sim/Reco

Chris Backhouse
Alex Himmel
Leigh Whitehead

Long Baseline

Chris Marshall
Mayly Sanchez
Callum Wilkinson

LBL/NDDG Liaison

Dan Cherdack

Low Energy

Alex Friedland
Inés Gil-Botella
Kate Scholberg

High Energy

Lisa Koerner
Vitaly Kudryavstev
Yun-Tse Tsai

BSM/Pheno

Alex Sousa
Jae Yu

ν Interactions & SM

Mike Kordosky
Steve Manly
Cheryl Patrick

Calibration

David Caratelli
Mike Mooney

PRotoDUNE Analysis

SP	DP
George Christodoulou	TBD
Tingjun Yang	TBD

Far Detector Consortia update

We have decided to move the two components of the Cryogenic Instrumentation and Slow Controls (CISC) Consortium into the DAQ and Calibration Consortia:

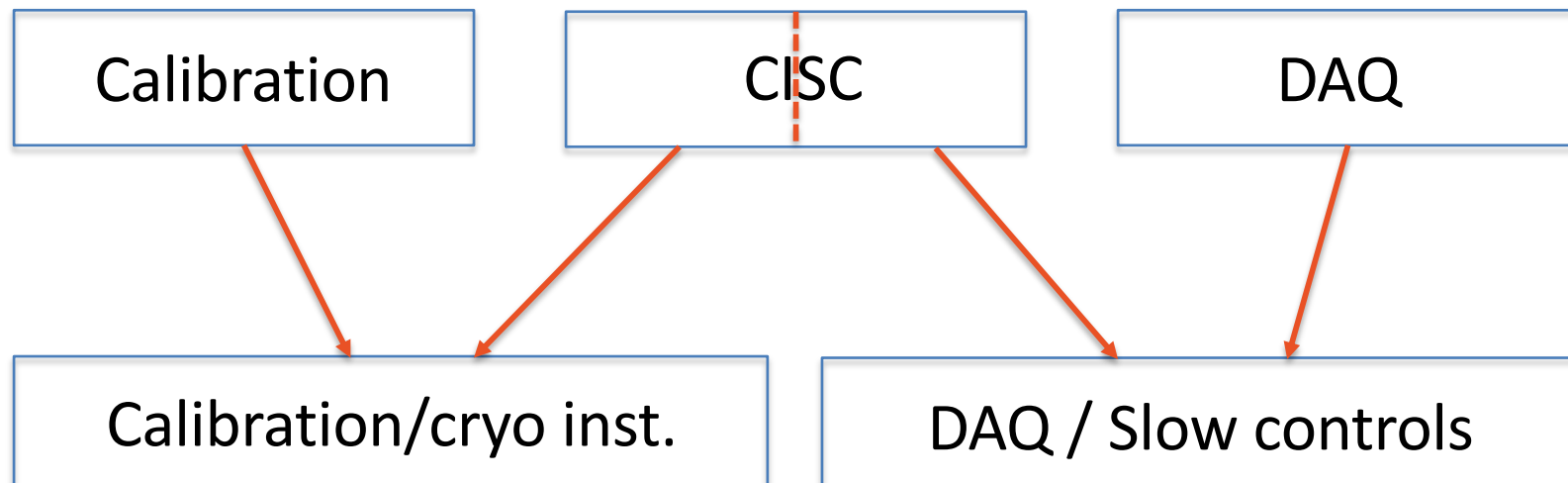
Calibration

CISC

DAQ

Far Detector Consortia update

We have decided to move the two components of the Cryogenic Instrumentation and Slow Controls (CISC) Consortium into the DAQ and Calibration Consortia:



Far Detector Consortia

Single-Phase

- APA: Christos Touramanis (Liverpool)
- Photon Detection System: Ettore Segreto (Campinas)
- TPC Electronics: Dave Christian (FNAL)



Dual-Phase

- CRP: Dominique Duchesneau (LAPP)
- Photon Detection System: Ines Gil Botella (CIEMAT)
- TPC Electronics: Dario Autiero (IPNL)

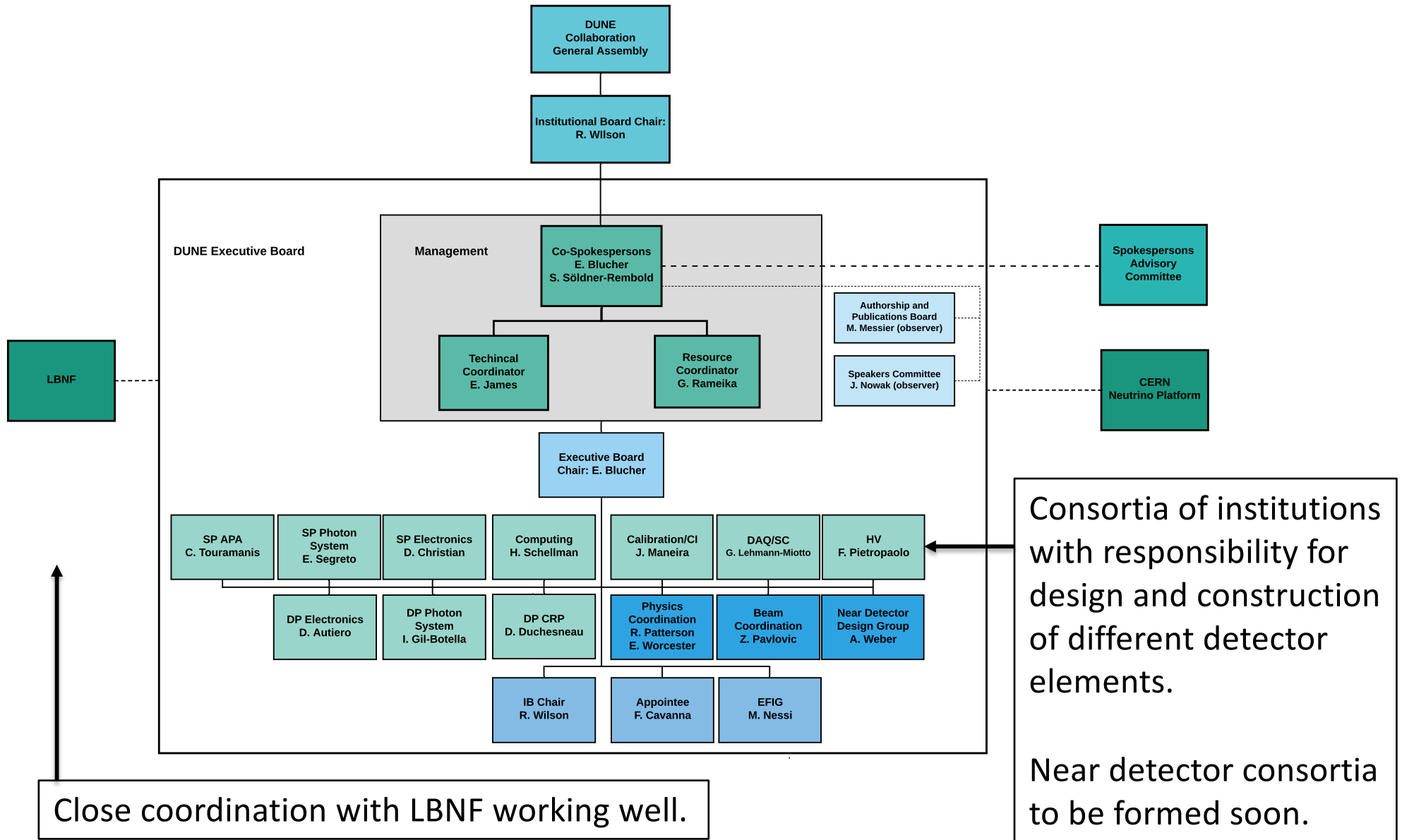


Joint SP/DP

- HV System: Francesco Pietropaolo (CERN)
- DAQ/Slow Controls: Giovanna Lehmann Miotto (CERN)
- Computing: Heidi Schellman (Oregon State)
- Calibration/Cryogenic Instrumentation: Jose Maneira (LIP)



Collaboration Management



Consortia of institutions with responsibility for design and construction of different detector elements.

Near detector consortia to be formed soon.

Close coordination with LBNF working well.

Education and Outreach Committee

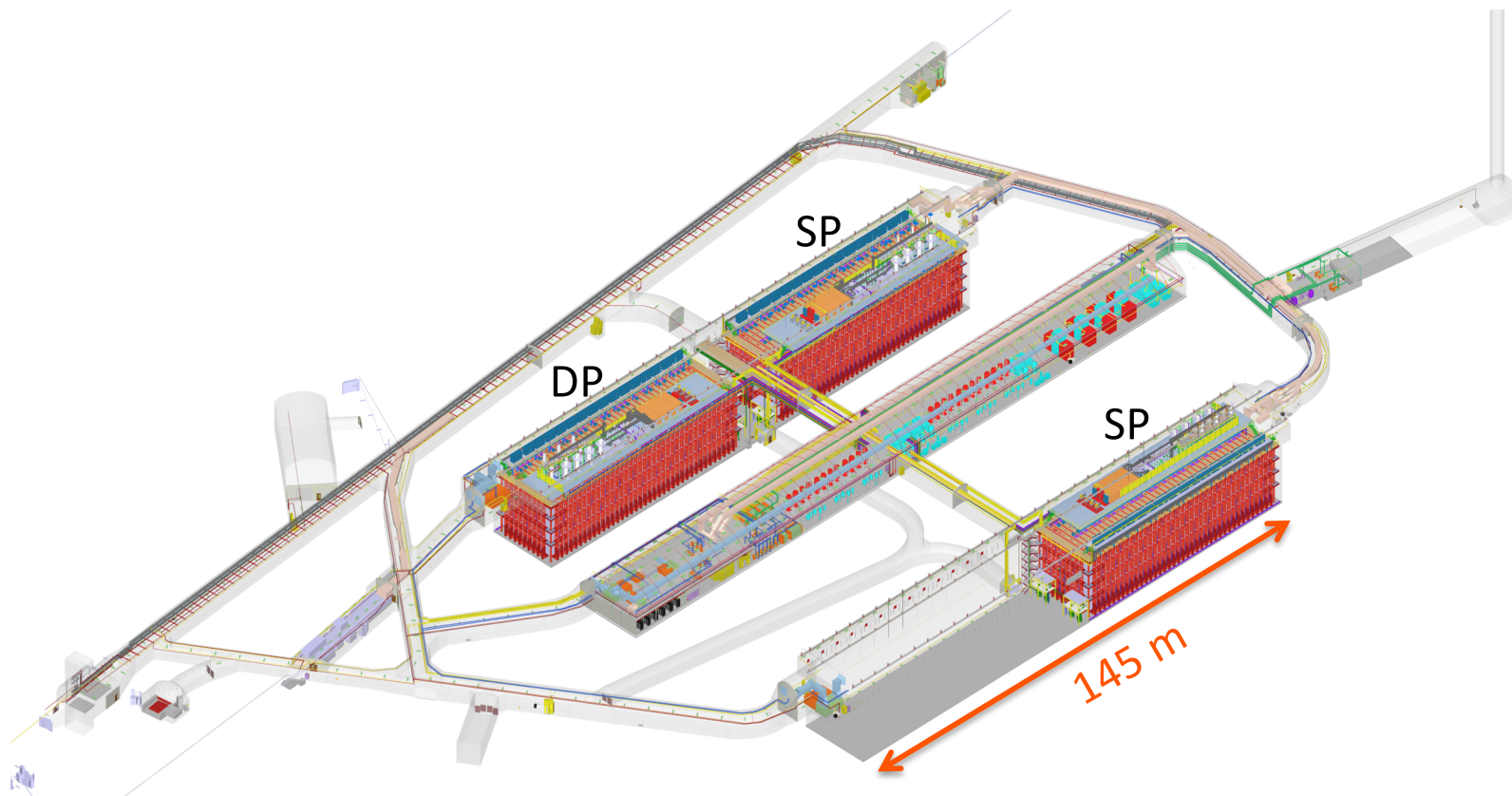
We have formed an Education and Outreach Committee to work with DUNE management to coordinate DUNE education and outreach activities.

Membership:

- Mateus Carneiro (BNL)
- Linda Cremonesi (UCL)
- Helio da Motta (CBPF)
- Albert de Roeck (CERN)
- Kirsty Duffy (Fermilab)
- Maxine Hronek (Fermilab)
- + spokes (ex-officio)

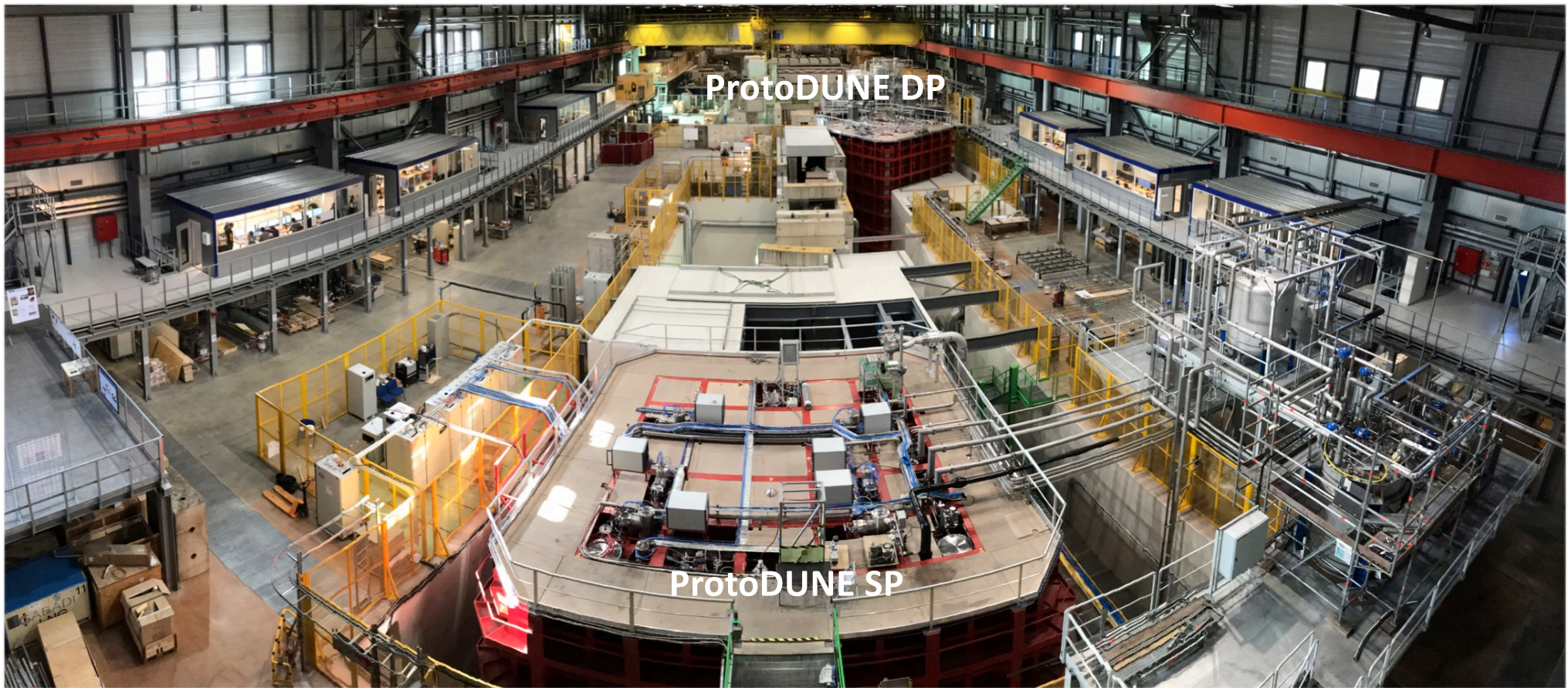
DUNE Far Detector (FD)

- Four separate 17 kt (> 10 kt fiducial) LAr TPCs
- 4 identically sized cryostats: 2 single phase (SP) + 1 dual phase (DP) +1 “opportunity” (this 2+1+1 plan is described in TDR)

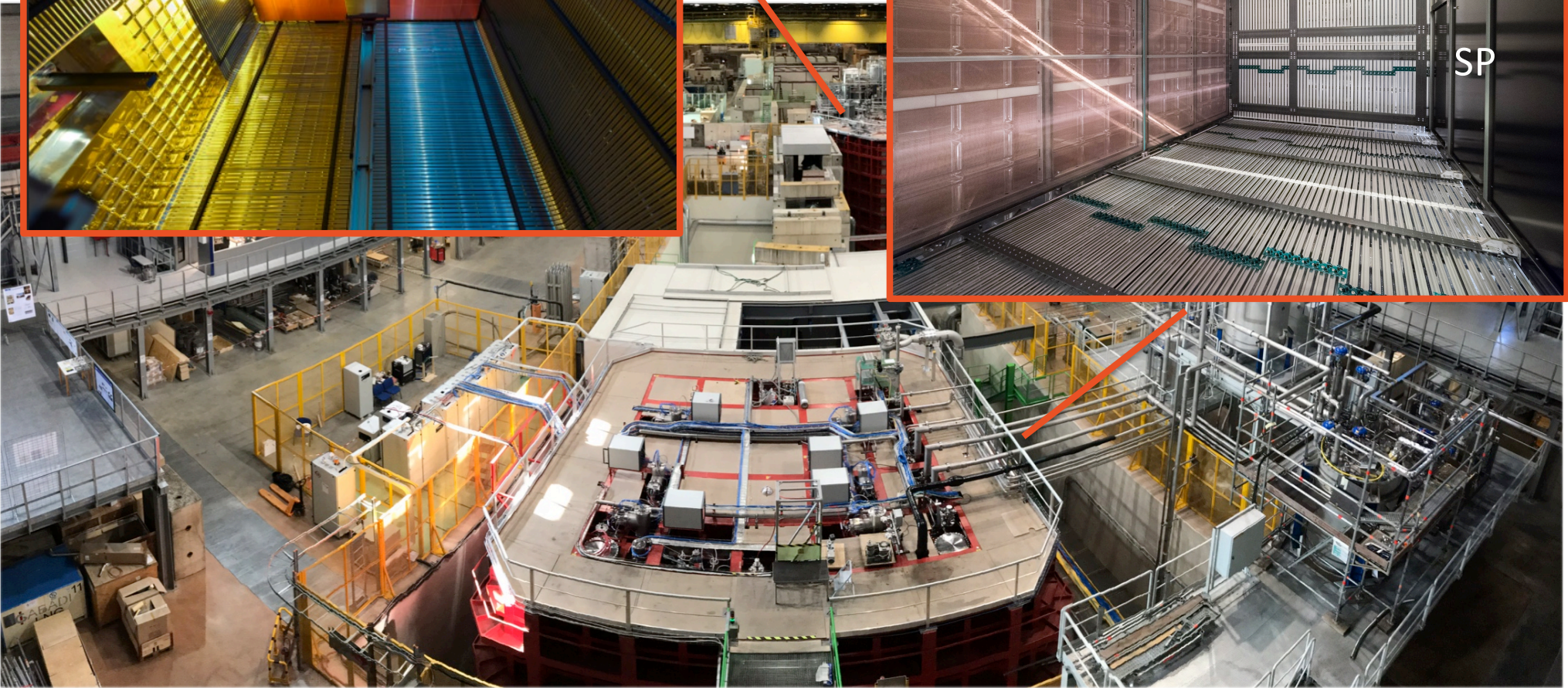
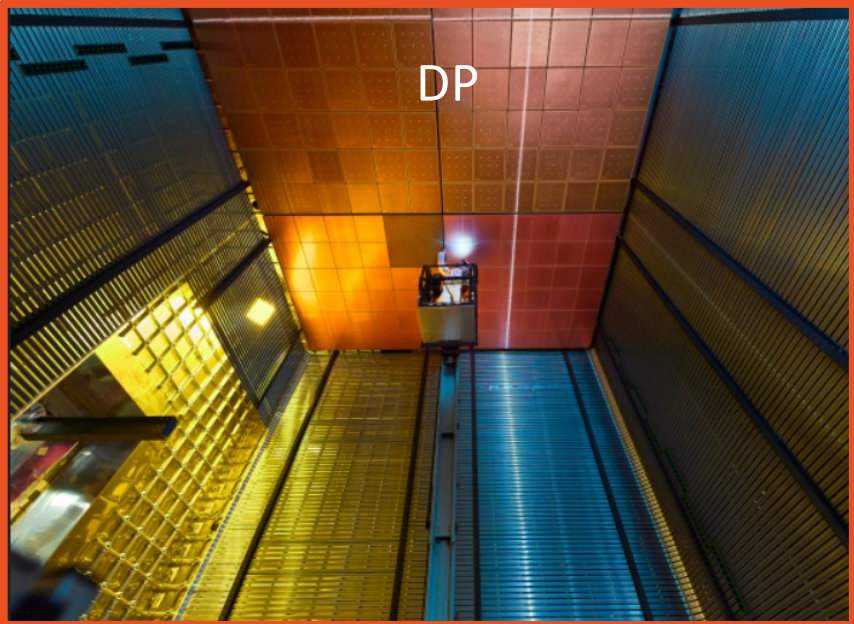


ProtoDUNEs

Construction and operation of 1 kton-scale SP and DP prototypes at CERN -- critical to demonstrate viability of technology, and that the DUNE Collaboration can implement a major construction activity



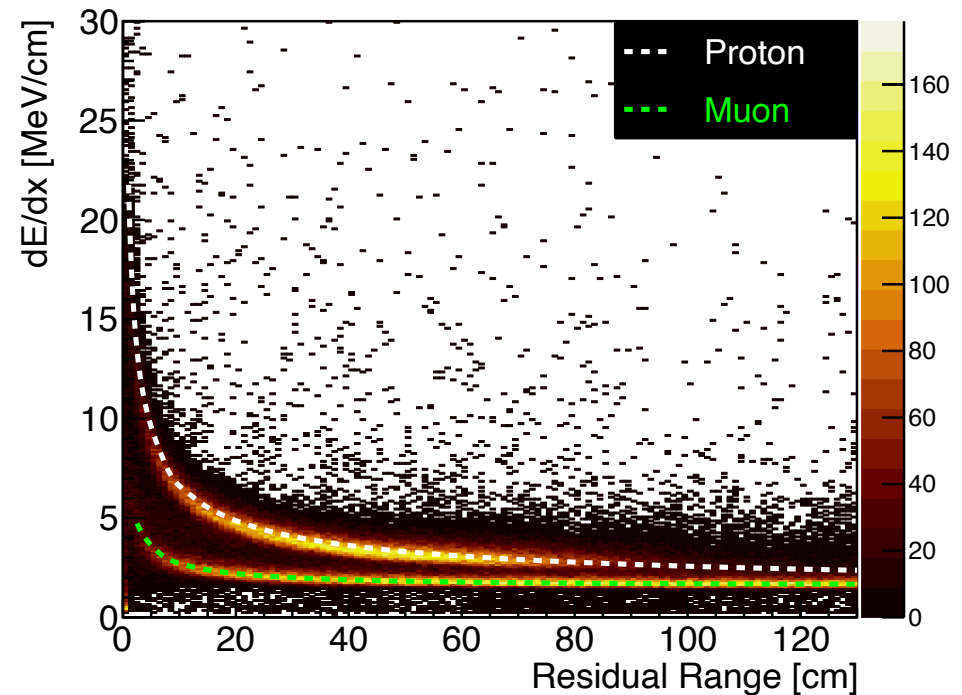
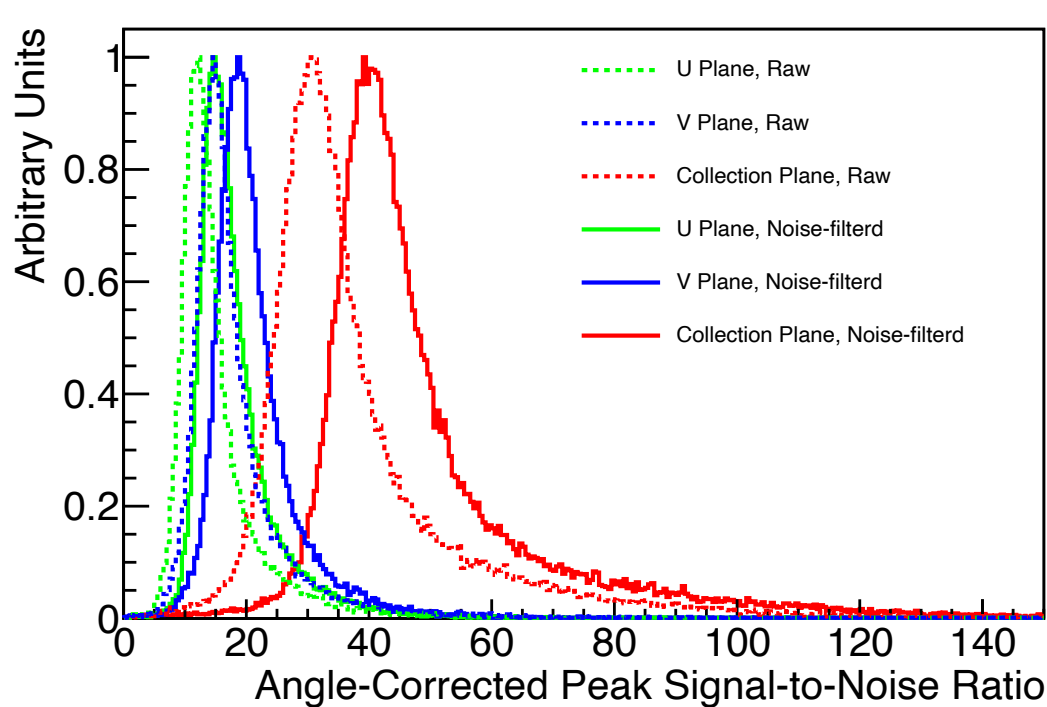
ProtoDUNE_s



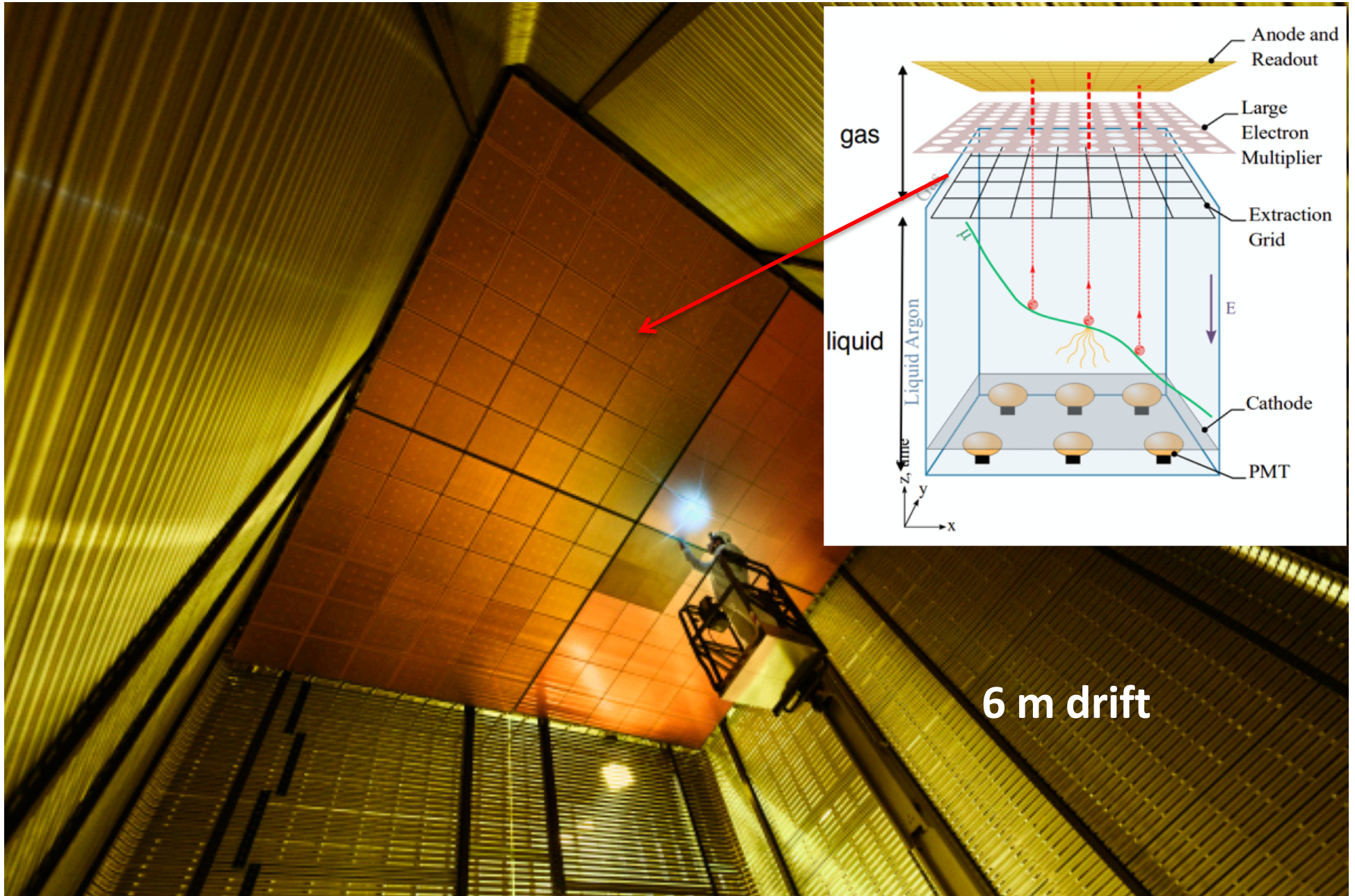
ProtoDUNE-SP data

2 GeV electron shower

- > 1 year of stable data taking, including 2 months of beam data
- Excellent performance: HV, liquid argon purity, and signal-to-noise
- First publication in preparation (see Flavio's talk)

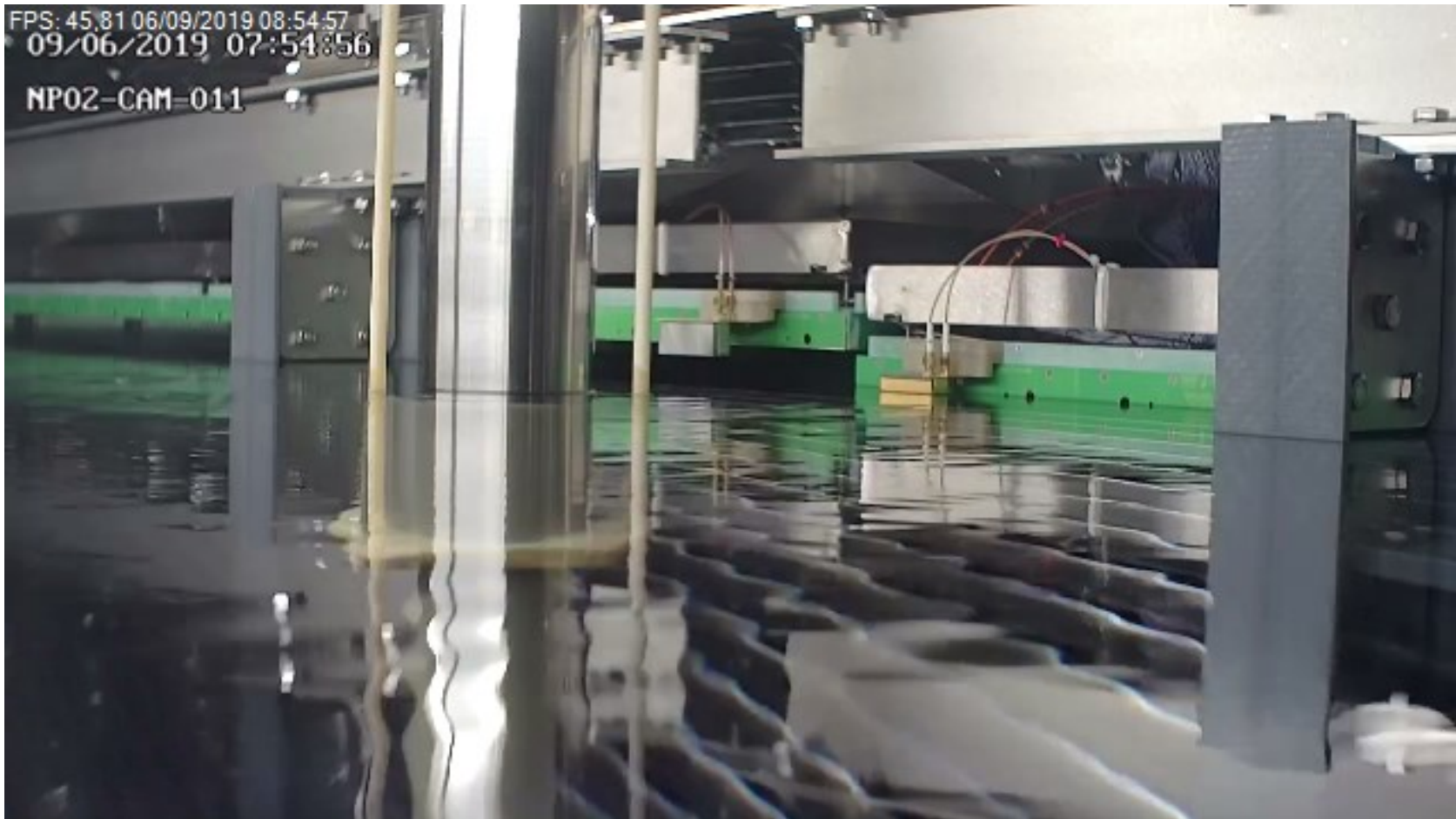


ProtoDUNE-DP (focus of this LBNC)



ProtoDUNE-DP (focus of this LBNC)

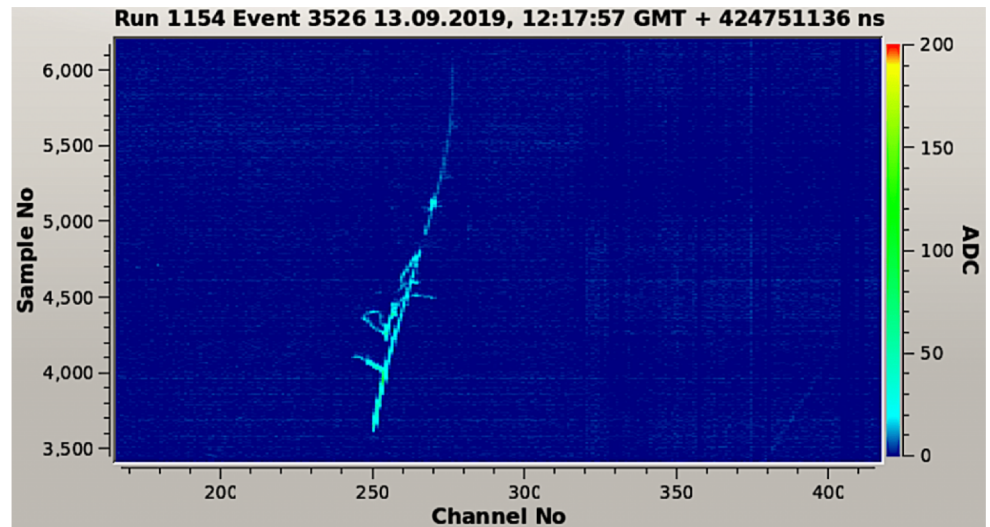
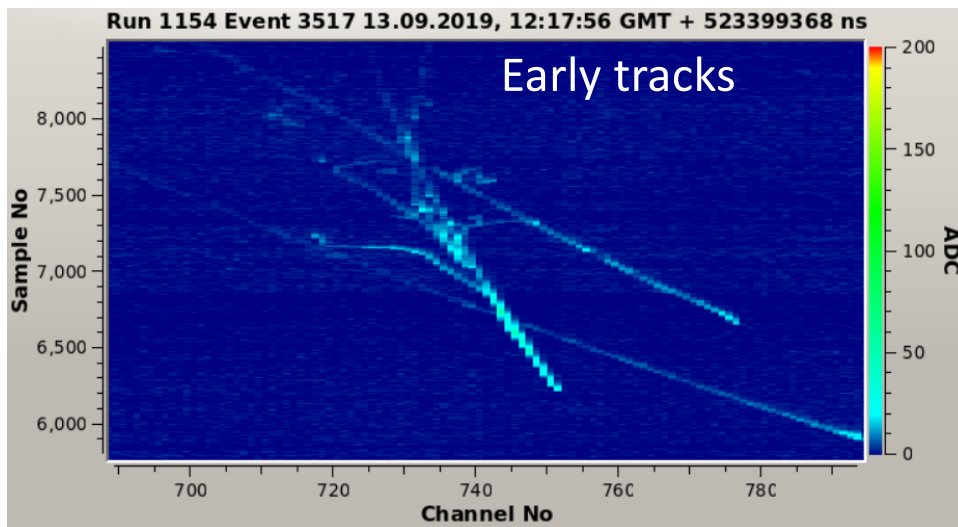
- Filling with liquid argon completed in first week of August 2019.



ProtoDUNE-DP (focus of this LBNC)

- Filling with liquid argon completed in first week of August 2019.
- First tracks seen on 30 Aug 2019
- Debugging / data taking underway
- Many issues to understand / study
- Debugging/ commissioning will continue for several months.

➔ see this afternoon's talks



Overview of ProtoDUNE-DP Agenda

- Overview of Operations and System Stability (Dominique)
- HV (Francesco)
- Cryogenics and purity (Filippo)
- CRPs (Eduardo)
- Electronics and DAQ (Dario)
- Photon System (Inés)
 - Break
- Computing and Analysis Status (Elisabetta)
- LEM R&D (Eduardo)
- Plans for coming 6 months, and for ProtoDUNE-II (Marzio)
 - Will include summary of current issues

Motivation to run ProtoDUNE after LS2

- Full characterization of "Module 0"s for DUNE Far Detector; improved APAs, CRPs, cold electronics, photon detectors etc.
- Increase beam data statistics (cross section measurements, particle identification, calibration, reconstruction).
- Complete data sets with different polarities for electrons, muons, pions, kaons, and protons in momentum range 0.3-7 GeV.
- Develop, implement, and demonstrate new calibration techniques including a laser calibration system and a pulsed neutron source.

Additional resources will be required from CERN and other funding agencies

ProtoDUNE → DUNE



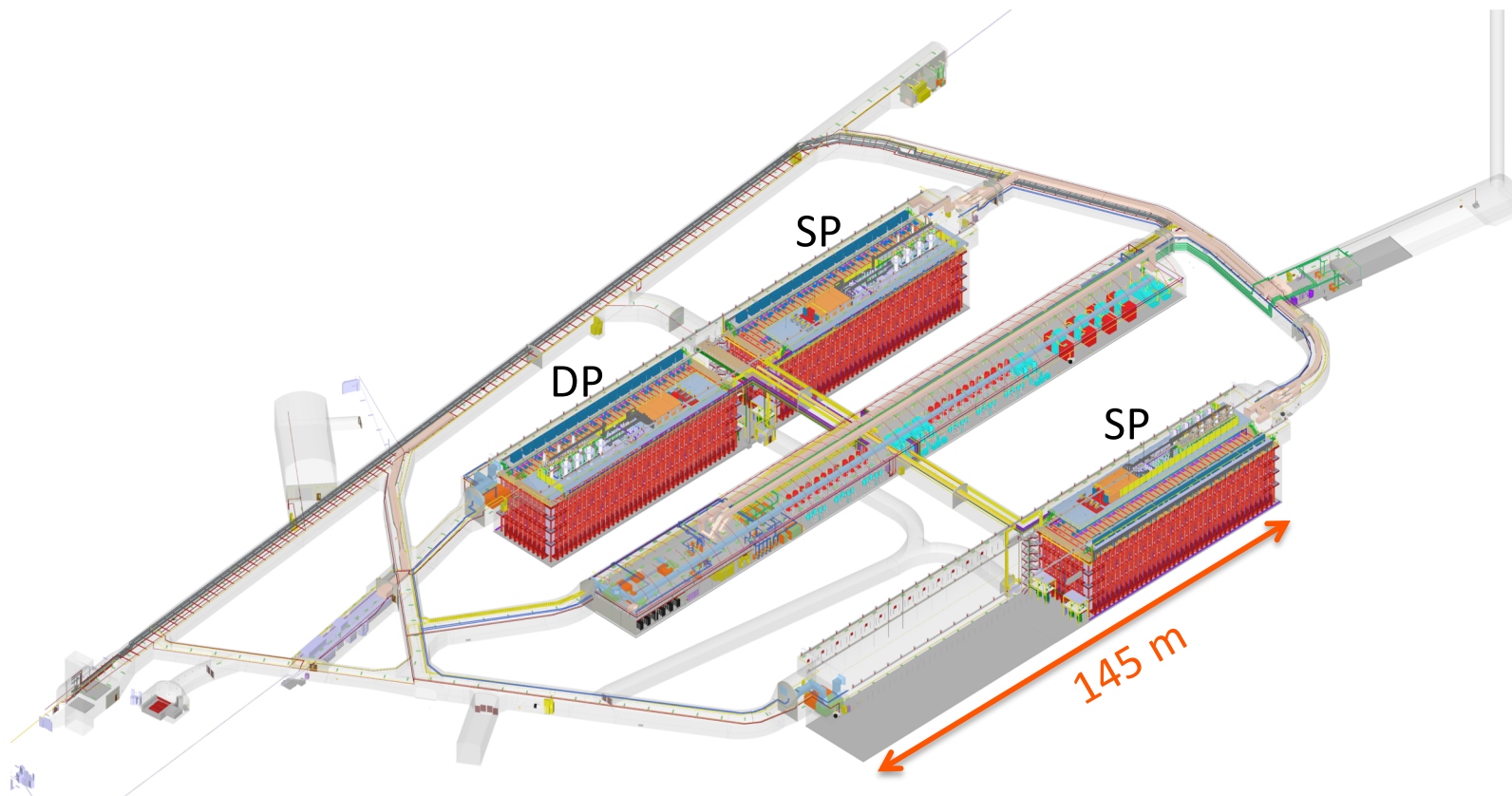
Impressive progress in planning and prototyping for detector installation at SURF

- Successful test of APA doublet assembly at Ash River
- Validation of cable routing



DUNE Far Detector (FD)

- Four separate 17 kt (> 10 kt fiducial) LAr TPCs
- 4 identically sized cryostats: 2 single phase (SP) + 1 dual phase (DP) +1 “opportunity” (this 2+1+1 plan is described in TDR)



Module of Opportunity Workshop at BNL



- Very well attended and exciting workshop at BNL this week.
- Workshop will form basis for Concept Papers.
- Consider advanced liquid-argon (or alternate) technologies.

Module of Opportunity
for **DUNE**

DUNE
DEEP UNDERGROUND
NEUTRINO EXPERIMENT

November 12-13, 2019

Location: Brookhaven National Laboratory
<https://www.bnl.gov/dmo2019/>

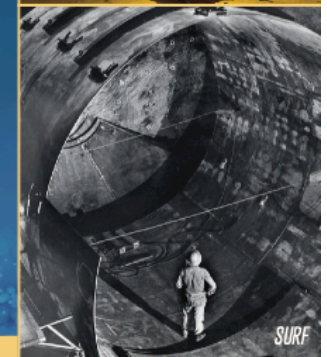
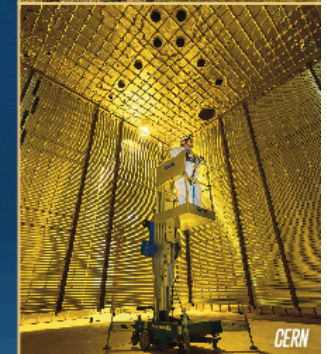
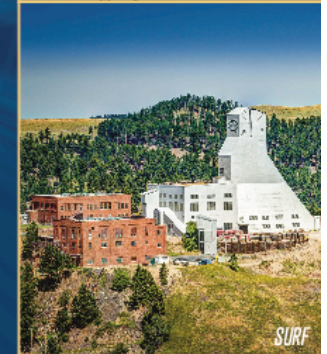
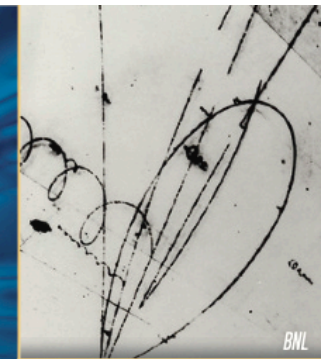
The DUNE Collaboration invites the broader community to explore opportunities for novel detector technologies for the fourth DUNE for detector module. Advanced liquid-argon (or alternate technology) detector concepts that can satisfy and expand DUNE physics goals are encouraged. Workshop topics include:

- Tracking
- Photon detection
- Electronics
- High voltage
- Data-acquisition
- New ideas!

The international organizing committee is:

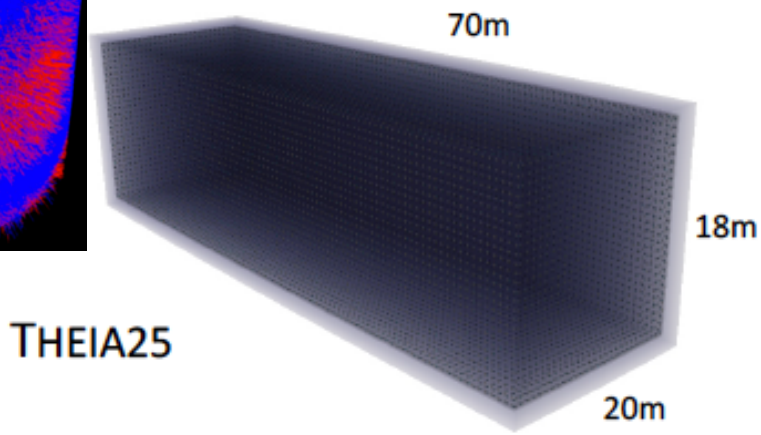
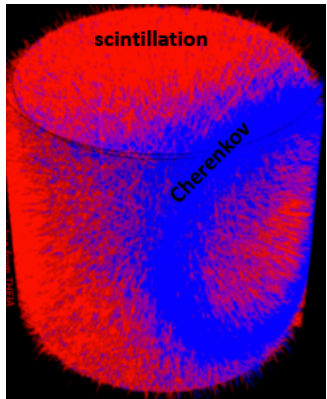
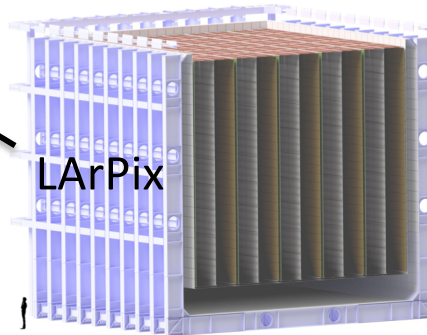
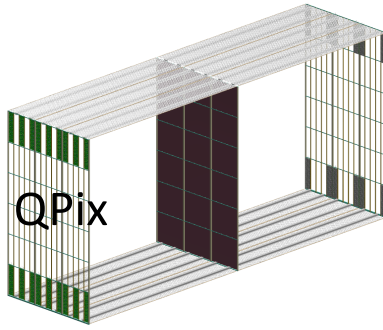
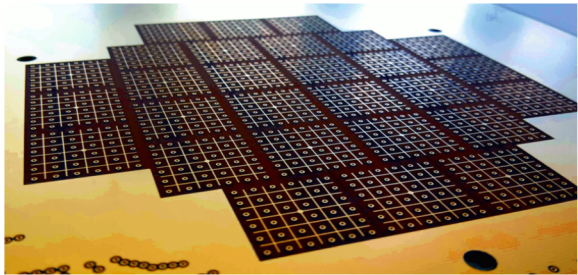
Edward Blucher, Chicago	Christopher Mauger, Penn	Stefan Soldner-Rembold, Manchester
Dominique Duchesneau, LAPP	Kostas Mavroukidis, Liverpool	Jim Stewart, BNL
Bonnie Fleming, Yale	Marzio Nessi, CERN	Michele Weber, Bern
Roxanne Guenette, Harvard	Francesco Pietropaolo, CERN	Hanyu Wei, BNL
Eric James, FNAL	Stephen Pordes, FNAL	Michael Wilking, Stony Brook
Georgia Karagiorgi, Columbia	Xin Qian, BNL	Elizabeth Worcester, BNL
Steve Kettell, BNL	Filippo Resnati, CERN	Bo Yu, BNL
Ana Machado, Unicamp	Mitch Soderberg, Syracuse	

Organizational inquiries: Deborah Kerr (dkerr@bnl.gov)

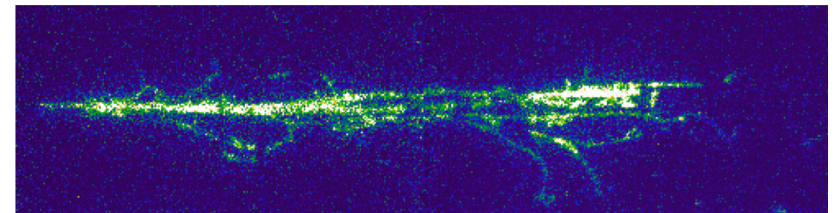
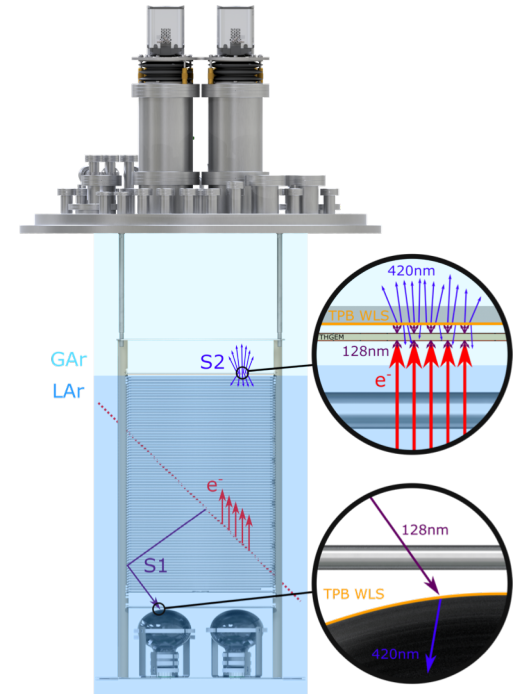


Wide variety of technology ideas

Pixel readout of SP TPCs

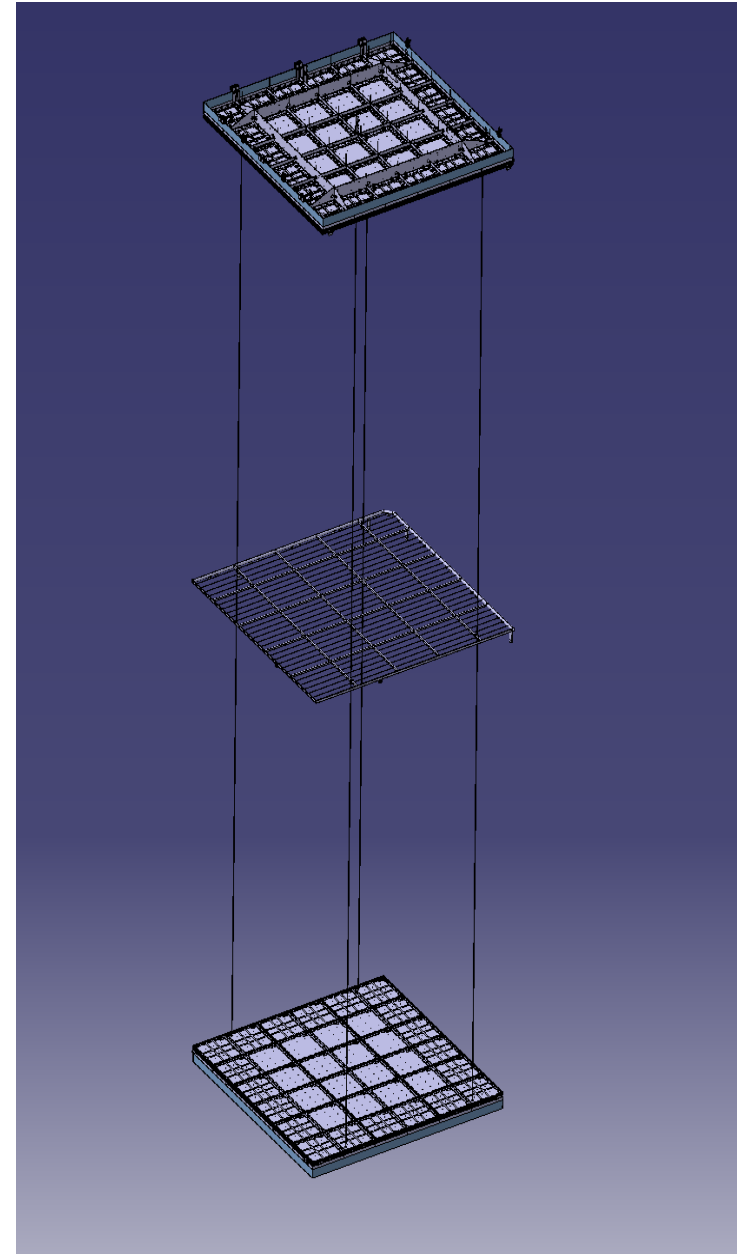
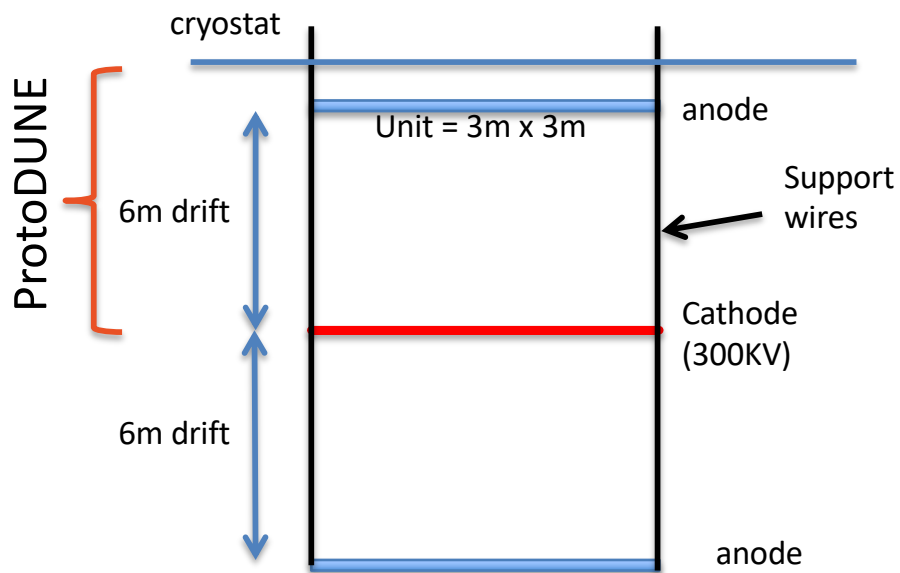


Optical readout of DP TPCs (ARIADNE)

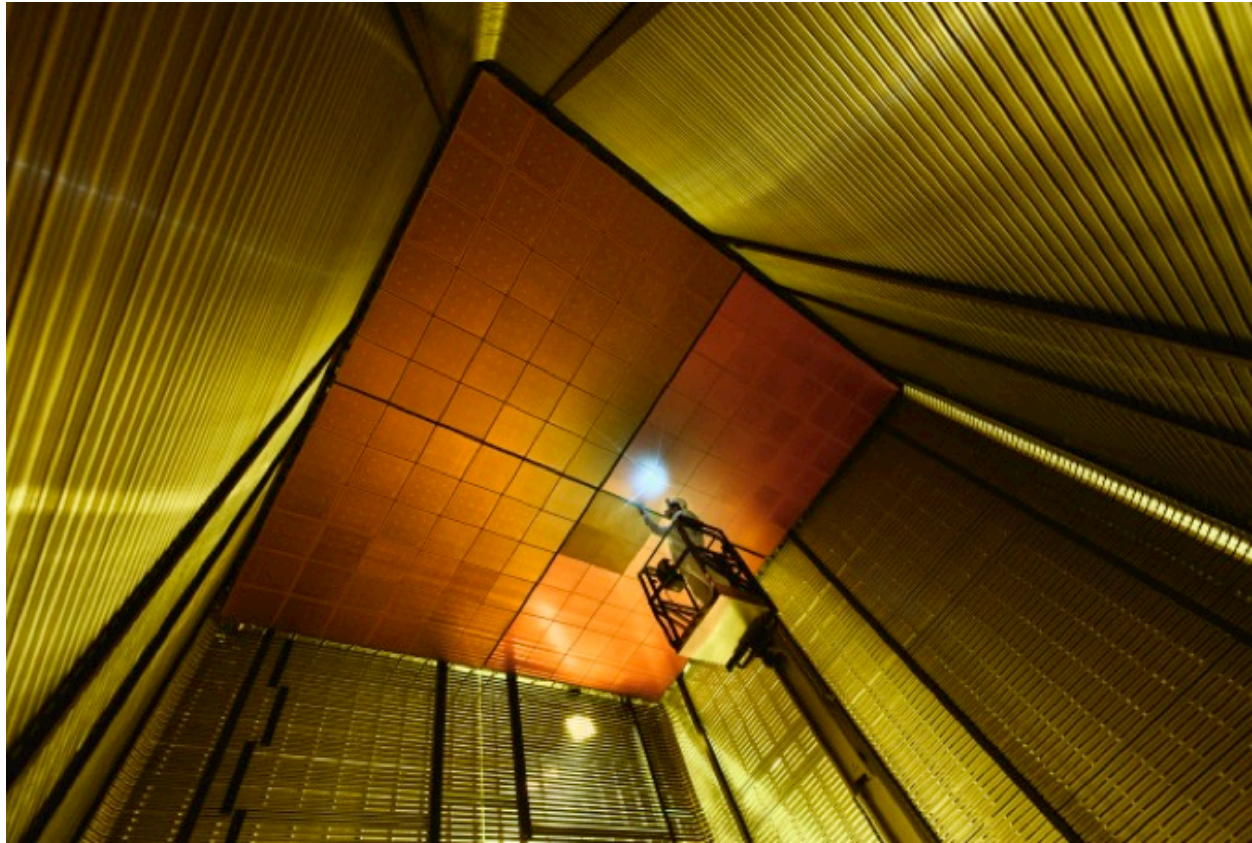


Vertical drift SP TPC

- Based on DP field cage design
- Would use 3x3 m readout modules; same dimensions as CRPs
- Readout units could be pixels, projective PCBs, etc.
- Drift cell is ~identical to that of ProtoDUNE-DP (6 m drift)

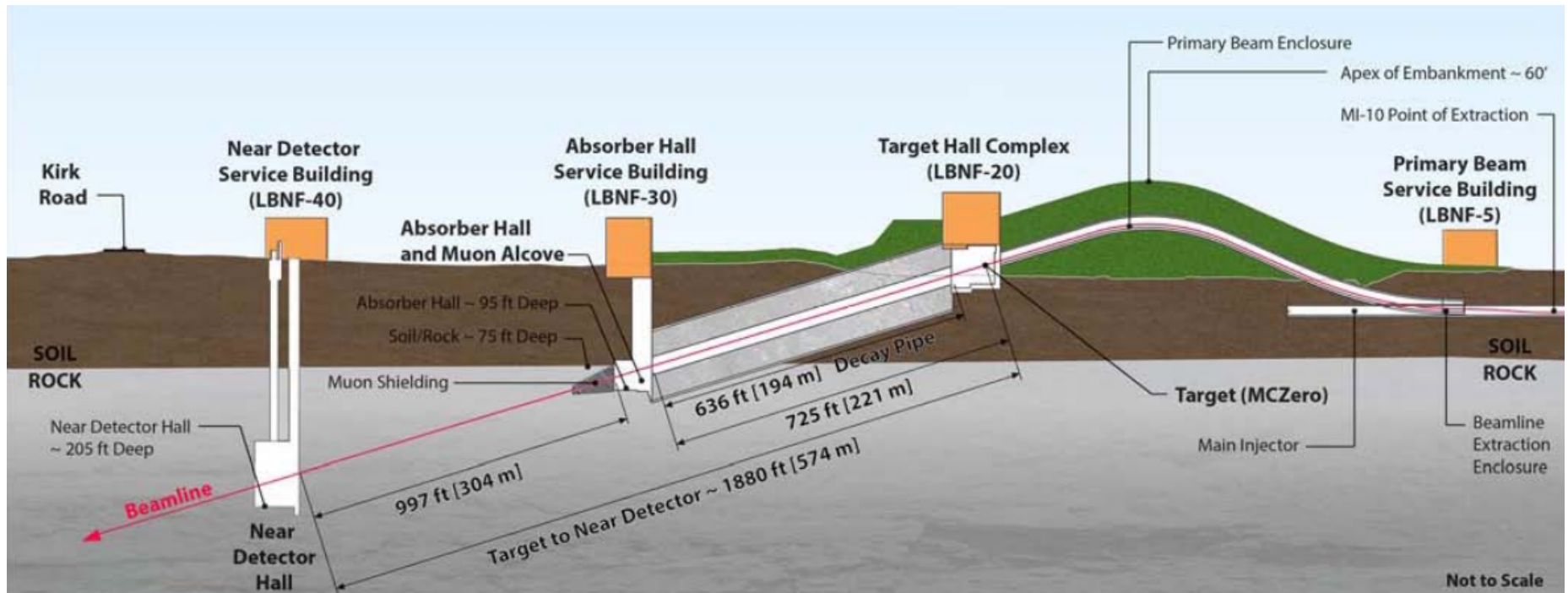


Vertical drift SP TPC



- Modular design of ProtoDUNE-DP readout gives us the opportunity to use NP02 ProtoDUNE-II to test one or two new “module-of-opportunity” readout technologies in parallel with next generation CRPs.
- Marzio will discuss this option in more detail.

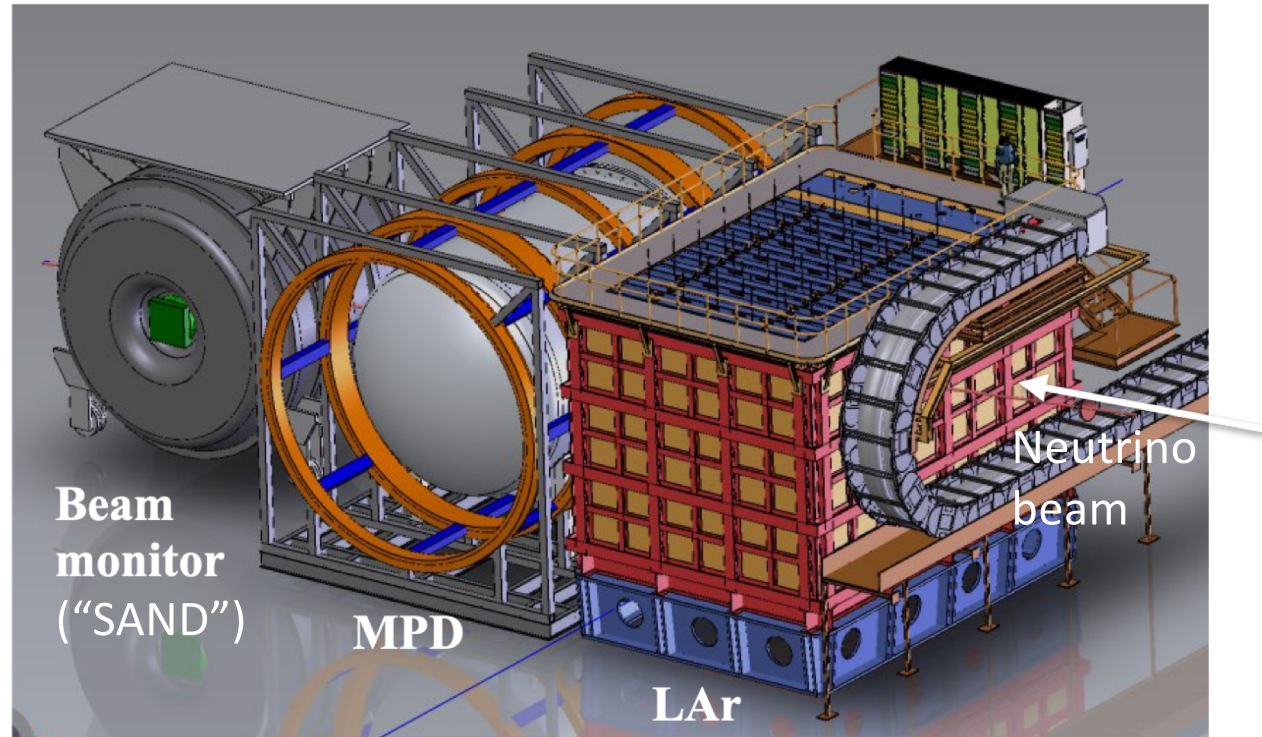
DUNE Near Detector



Goals:

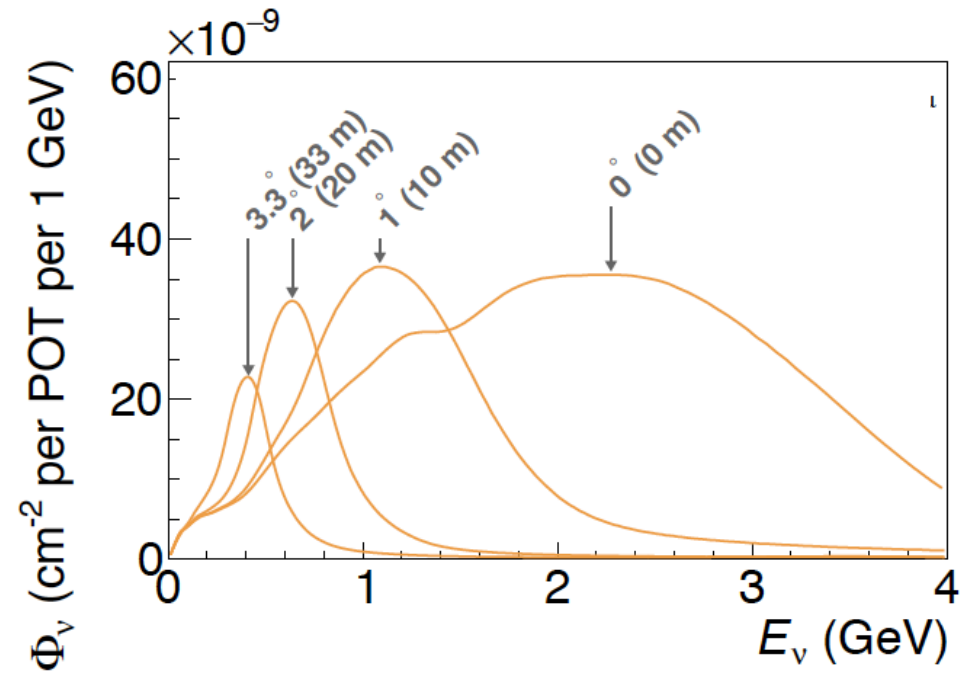
- Measure the neutrino beam rate and spectrum to predict un-oscillated event rates in the far detector
- Constrain systematic uncertainties for oscillation measurements
 - minimize differences between near and far detectors
 - measure neutrino interactions on same nuclei

DUNE Near Detector

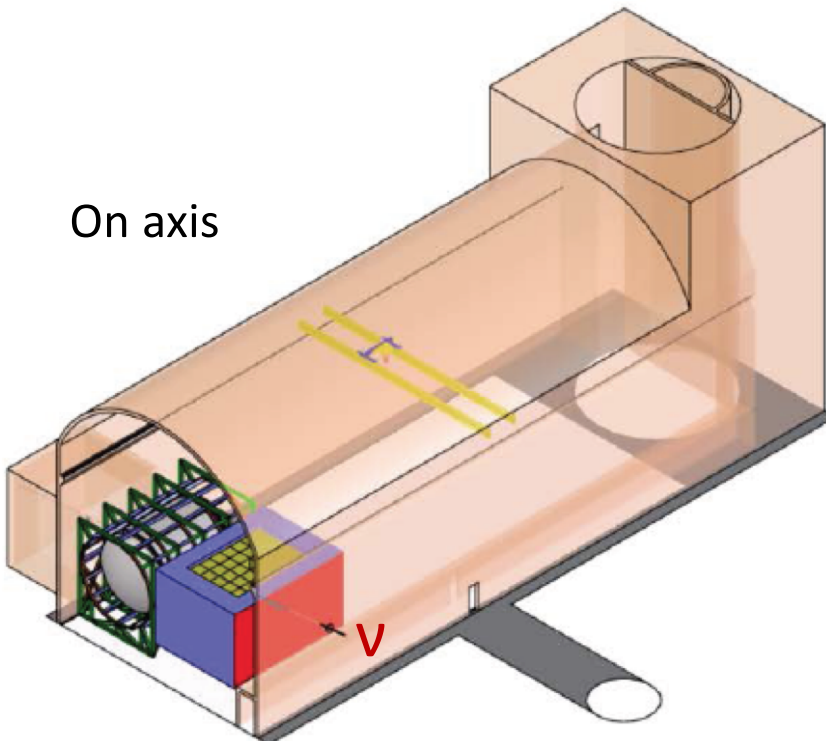


- LAr: Highly segmented LAr TPC (ArgonCube)
- MPD (Multi-purpose detector): High Pressure Gas Argon TPC, Calorimeter, and muon system magnetized by superconducting coils
- SAND beam monitor: High density plastic scintillator detector with tracking chambers and calorimetry in KLOE magnet
- DUNE-PRISM: Movement of LAr+MPD transverse to the beam, sampling different E_ν

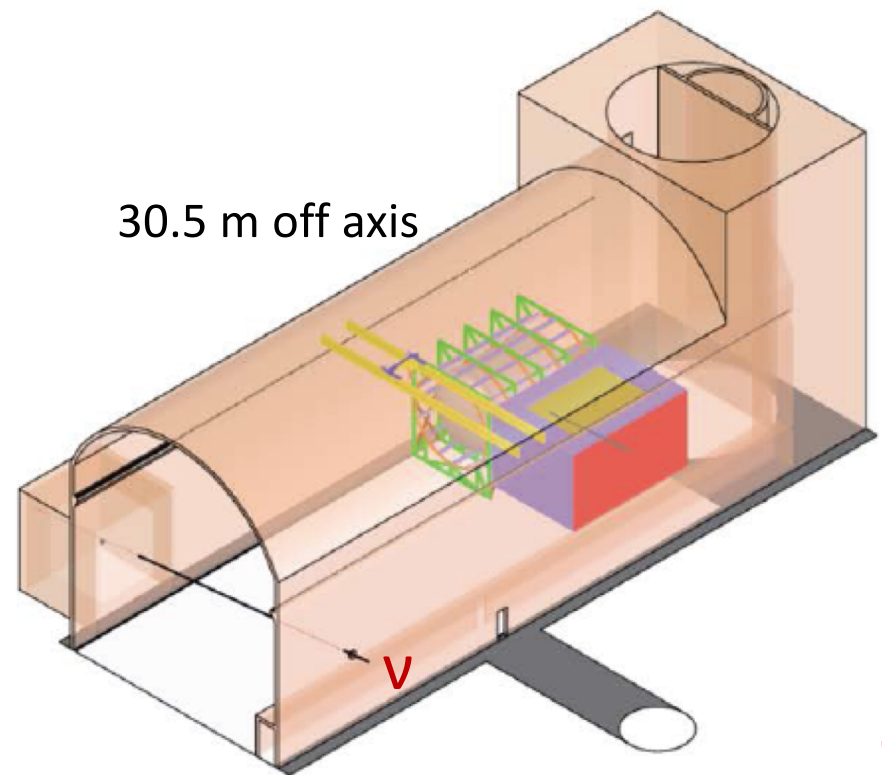
DUNE-PRISM



On axis

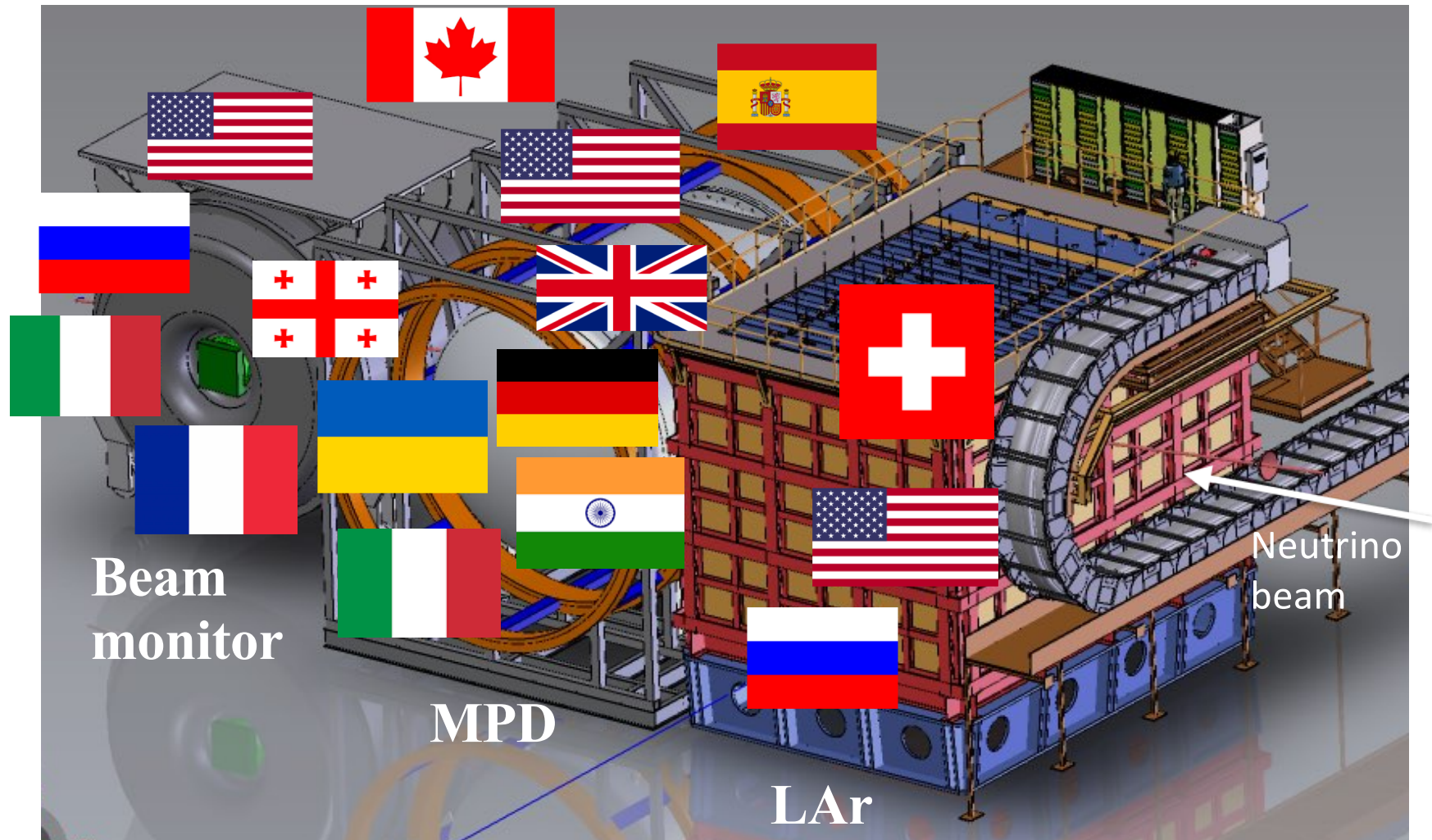


30.5 m off axis



DUNE Near Detector

An integrated system composed of multiple detectors



Broad international involvement

DUNE Near Detector Workshop

21 - 23 October • DESY Hamburg

<https://indico.fnal.gov/event/21340/>

You are invited to attend this open workshop to learn about opportunities and potential for international participation!

Physics opportunities • High pressure gas TPC • Detector magnets • Calorimetry

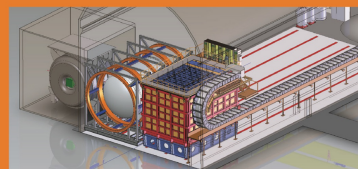
Local Organizers

Eldwan Briante (DESY)
Matthias Kasemann (DESY)
Lucia Masetti (Mainz)
Krisztian Peters (DESY)
Felix Sefkow (DESY)
Frank Simon (MPP)
Marcel Stanitzki (DESY), Chair
Anita Teufel (DESY)

International Organizers

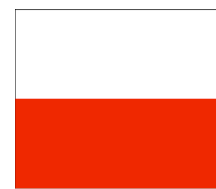
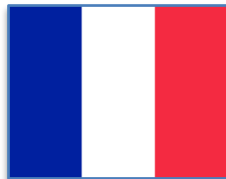
Alan Bross (FNAL)
Asher Kaboth (Royal Holloway London)
Marco Pallavicini (INFN Genova)
Frank Simon (MPI Munich)
Hiro Tanaka (SLAC)
Alfons Weber (Oxford and UKRI/STFC/PPD)

Contact: marcel.stanitzki@desy.de
+49 40 8998-4930



- Very well attended ND workshop at DESY
- Participation from Germany, Italy, Switzerland, UK, Ukraine, France, India, US, and Georgia (remote)
- See tomorrow's talks for discussion of workshop

LBNF Near Site Groundbreaking – Nov. 14, 2019



DUNE Near Detector Summary

- Excellent progress during the last year, leading to reference design
- DUNE and LBNF have agreed on an initial set of requirements for the Near Detector Facility that will accommodate the reference design.
- Collaboration is working to assemble international resources to complete near detector – making steady progress.
- We will follow LBNC recommendations regarding prioritization of components if resource constraints require staging. We are evaluating impact of temporary use of
 - simple muon spectrometer in place of MPD
 - KLOE magnet + calorimeter in place of full SAND detector
- Next steps
 - CDR in early 2020 (see Steve Manly talk)
 - ArgonCube 2x2 demonstrator → ProtoDUNE-ND (at Bern and FNAL)
 - Form ND consortia in Jan. 2020 – detailed plan to be approved by EB next week
 - IDR in fall 2020 (preliminary design level, as required for NS CD-2 in US)
 - TDR about 1 year after IDR

LBNC Recommendations

- We continue to track and act on all LBNC recommendations.
- In total, 227 recommendations so far.
- Status of recommendations maintained in a central document.
- Open DUNE recommendations (8)
 - Physics and Reconstruction (1)
 - ProtoDUNE-DP (1)
 - Technical Coordination (2)
 - Near Detector (1)
 - Calibration Plan (3)

(Many previous recommendations were related to TDR and are now closed.)

Feedback from November DOE IPR

Charge question 2: Are the DUNE collaboration's plans and proposed resources needed to sufficiently advance technical design of both far and near detectors by the respective CD-2's reasonable and achievable? **Yes**

- Successful implementation and operation of proto-DUNE provides important validation of design and collaboration capabilities
- Near detector- Substantial progress in past year including initial requirements needed to assure conventional facilities will meet the ND needs

Schedule

- For planning of DUNE activities, we have adopted the following working schedule:

Start of Module 1 Installation: August 2024

Start of Module 2 Installation: August 2025

- Baselineing of US project in 2020 will define final schedule.
- Physics data will start as soon as first module is complete
 - start of an exciting long-term physics program

Summary

- Approval of Introduction, Physics, SP, and TC volumes of TDR is a major step for Collaboration. DP volume will be finalized based on input from ProtoDUNE-DP.
- ProtoDUNE-SP nearing end of a successful run. First publication to be submitted soon.
- Great progress and encouraging results from ProtoDUNE-DP – challenges remain. Coming months will be used for continued investigation of several issues.
- We have a near detector reference design, and are working toward CDR in early 2020 and an IDR later in 2020.
- The Collaboration is functioning well, and will be ready to install detectors at the earliest availability of caverns.