DUNE Status

Stefan Söldner-Rembold

LBNF/DUNE-UK Meeting

24 August 2021

Management Updates

DUNE Science @DUNEScience · 12h

Please join us in congratulating our new co-spokesperson Regina Rameika of @Fermilab. Gina was essential in the building of ProtoDUNE and her knowledge and expertise will be a great asset for DUNE. Congratulations Gina! #dunescience #movingforward #neutrinos

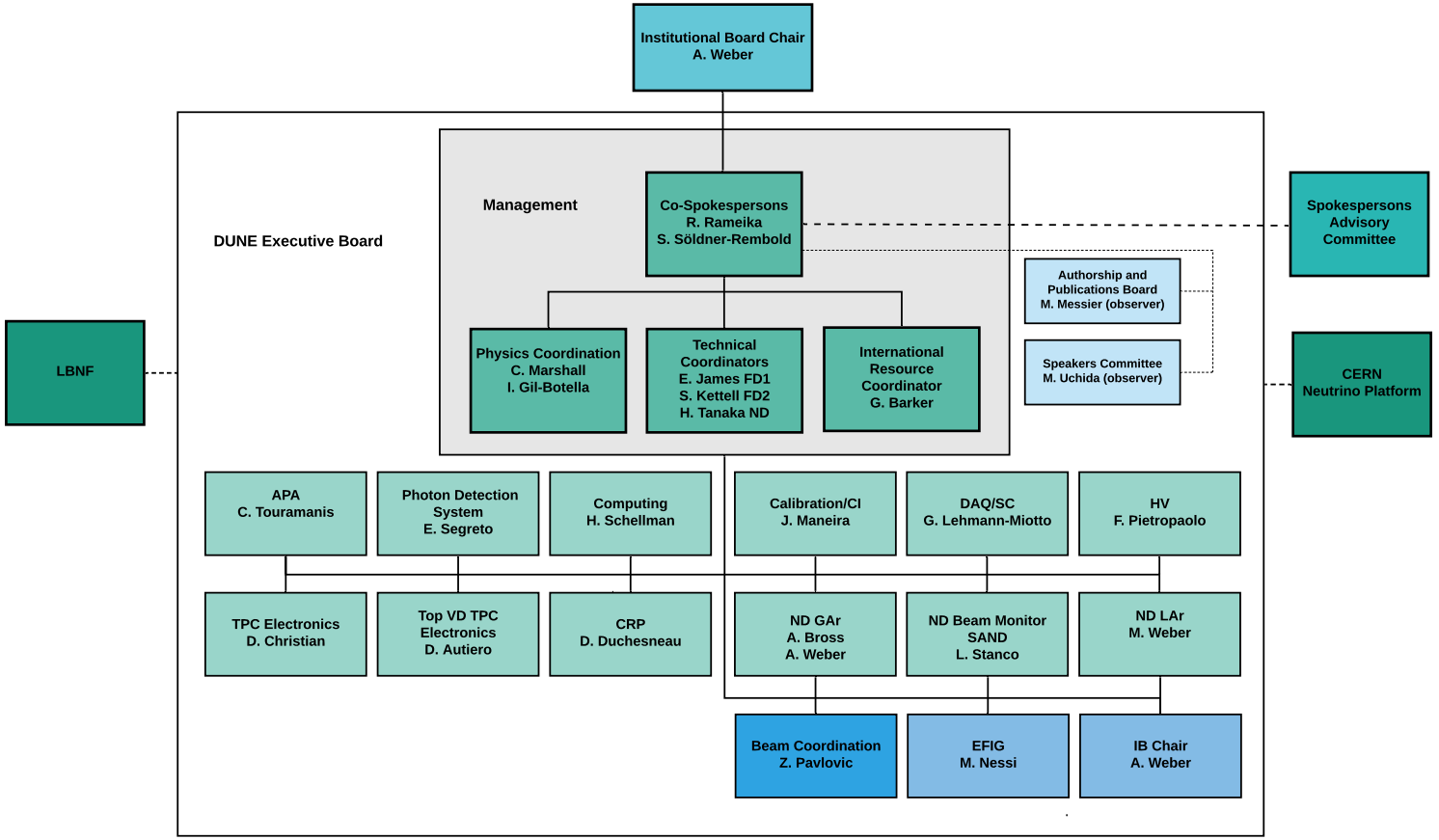
- Regina Rameika (Fermilab) took over from Ed Blucher (UChicago) on March 1.
- My term runs out in March 2021 election coming up soon.
- We also recently updated the structure of the DUNE Management team.

Management Updates

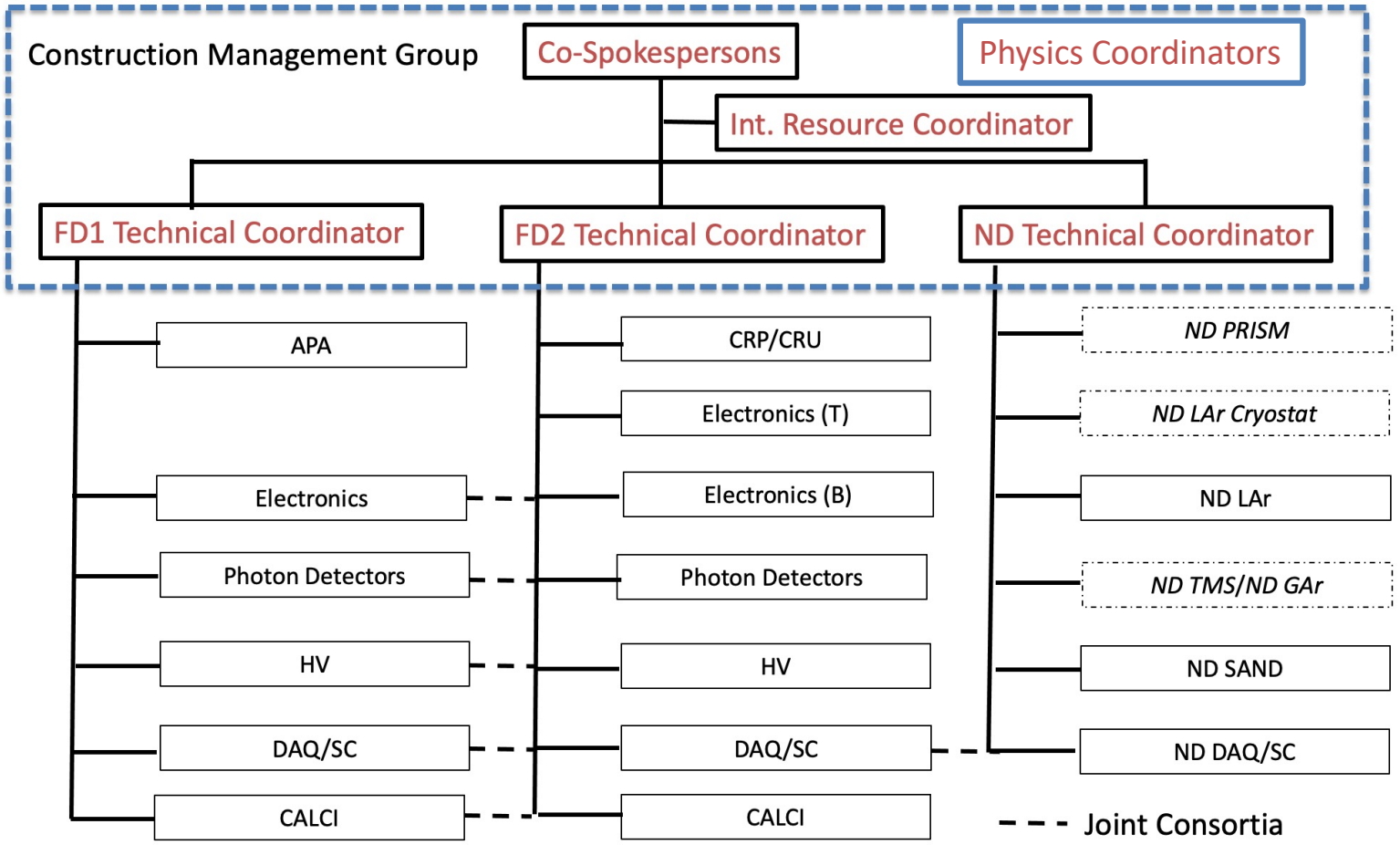
- Physics Coordinators
  - September 20, new Physics Coordinators will be :
    - Ines Gil Botella (CIEMET, Spain) and Chris Marshall (Rochester, USA)
  - Many thanks to Ryan Patterson (Caltech) and Elizabeth Worcester (BNL) for their years of service in this role and the many accomplishments that have been achieved under their leadership
- International Resource Coordinator
  - Effective immediately:
    - Gary Barker (Warwick, UK)
- This completes the new management team, together with the TCs: Eric James (FNAL, FD1), Steve Kettell (BNL, FD2), and Hiro Tanaka (SLAC, ND).

DUNE Management

Executive Board

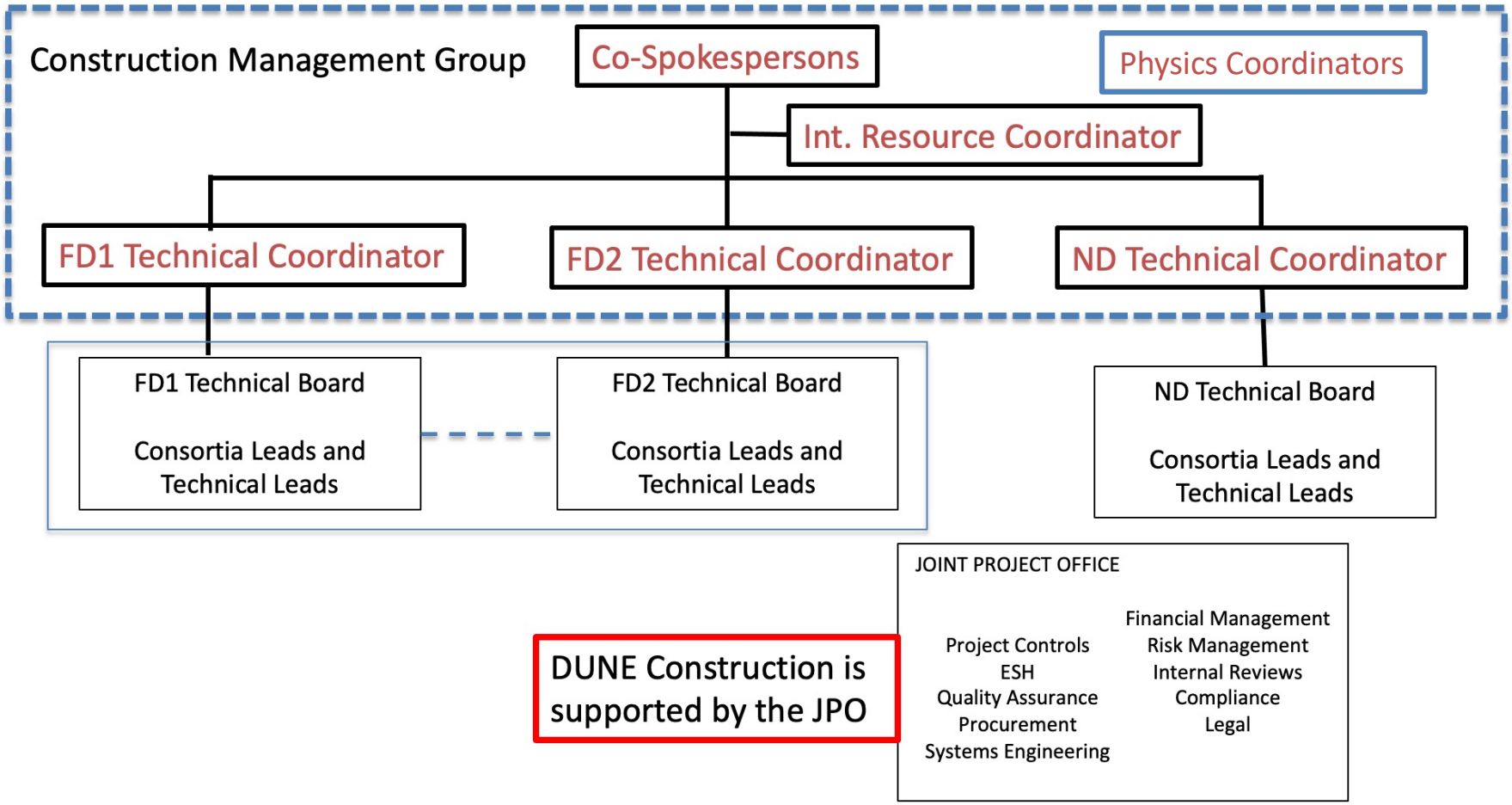


DUNE Management



New model mirrors the sub-project strategy of the US-DOE DUNE project.

DUNE Management



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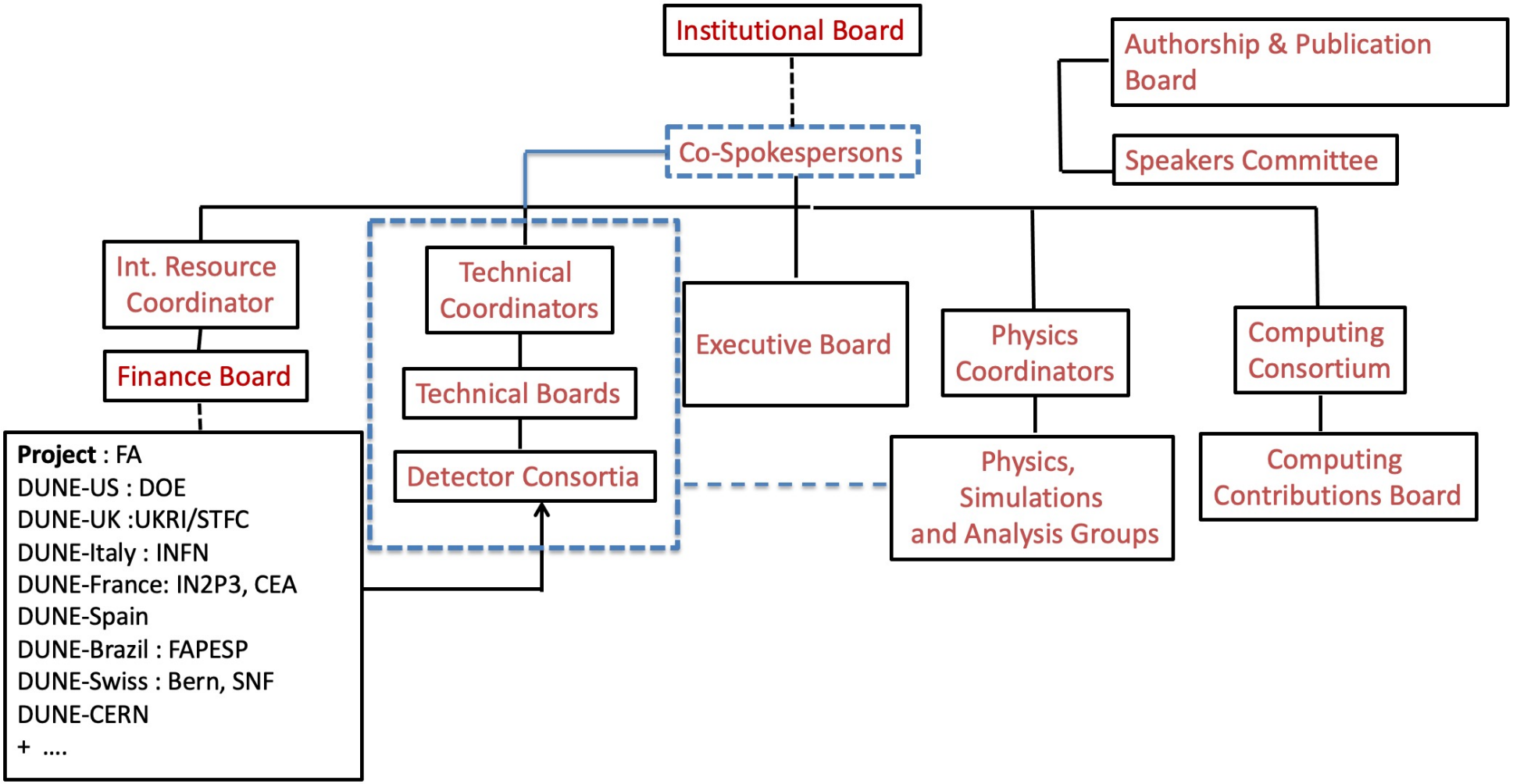
DUNE Management



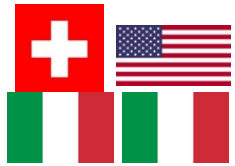
DUNE Detector Consortia

CL/TLs

Far Detector: FD1: E. James (FNAL), FD2: S. Kettell (BNL)

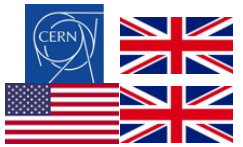
- APA: C. Touramanis (Liverpool), TLs: B. Rebel (Wisconsin), J. Evans (Manchester)
- PDS: E. Segreto (Campinas), TLs: D. Warner (CSU), F. Terranova (INFN Milano)
- TPC Electronics: D. Christian (FNAL), TL: M. Verzocchi (FNAL)
- CRP: D. Duchesneau (LAPP), TL: S.Tufanli (CERN)
- Top VD TPC Electronics: D. Autiero (IPNL), TL: T. Hasegawa (KEK)
- HV System: F. Pietropaolo (CERN), TL: Bo Yu (BNL)
- Calibration/Cryogenic Instrumentation: J. Maneira (LIP), TLs: S. Gollapinni (LANL), A. Cervera (Valencia)

Near Detector: H. Tanaka (SLAC)



- Liquid-argon Detector: M. Weber (Bern), TL: D. Dwyer (LBL)
- Beam Monitor – SAND: L. Stanco (INFN Padova), TL: C. Montanari (Pavia)

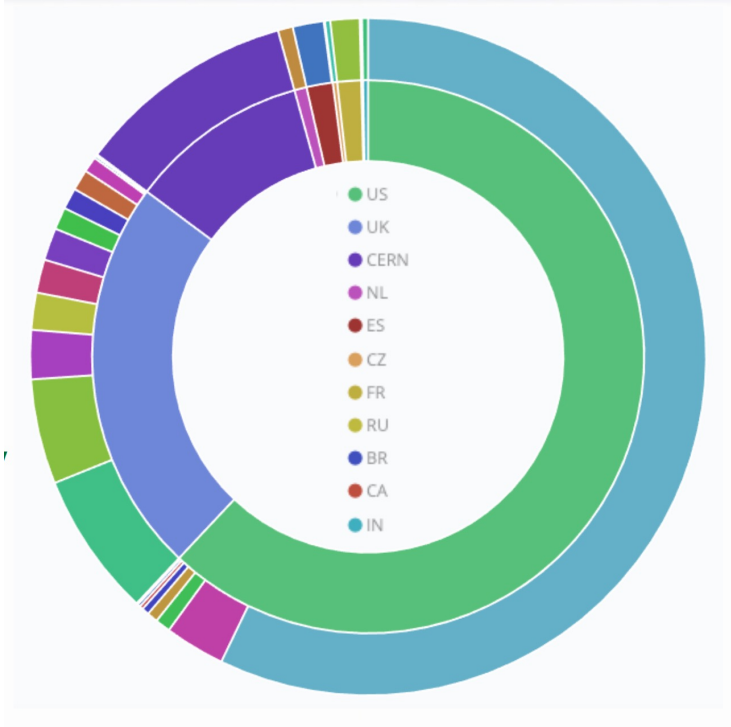
Joint Near/Far

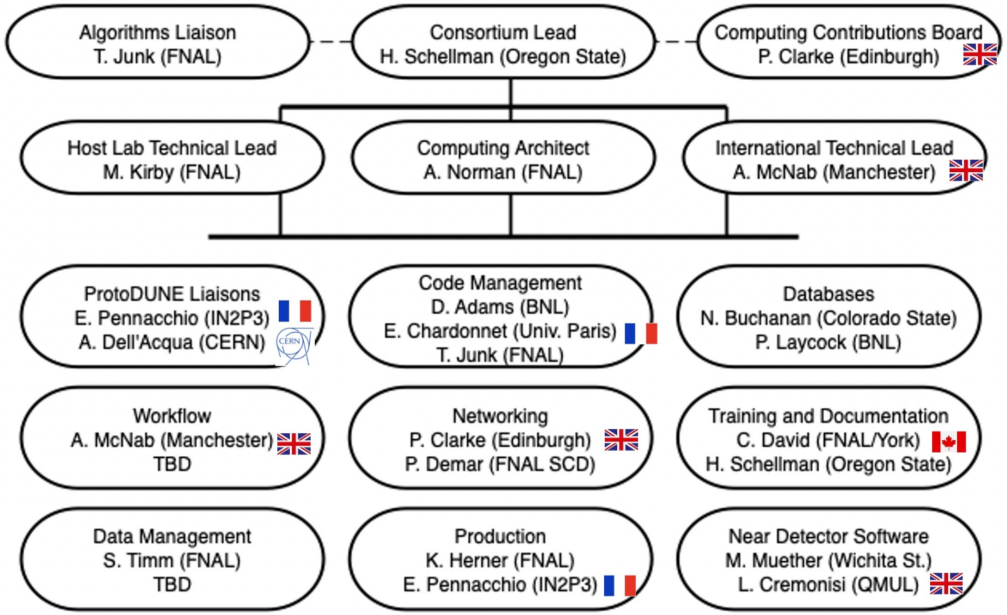


- DAQ/Slow Controls: G. Lehmann Miotto (CERN), TLs: A. Thea (RAL), A. Kaboth (RHUL)
- Computing: H. Schellman (Oregon State), TLs: M. Kirby (FNAL), A. McNab (Manchester)

Computing

- Computing Resources per country/sites
- Computing Consortium Management

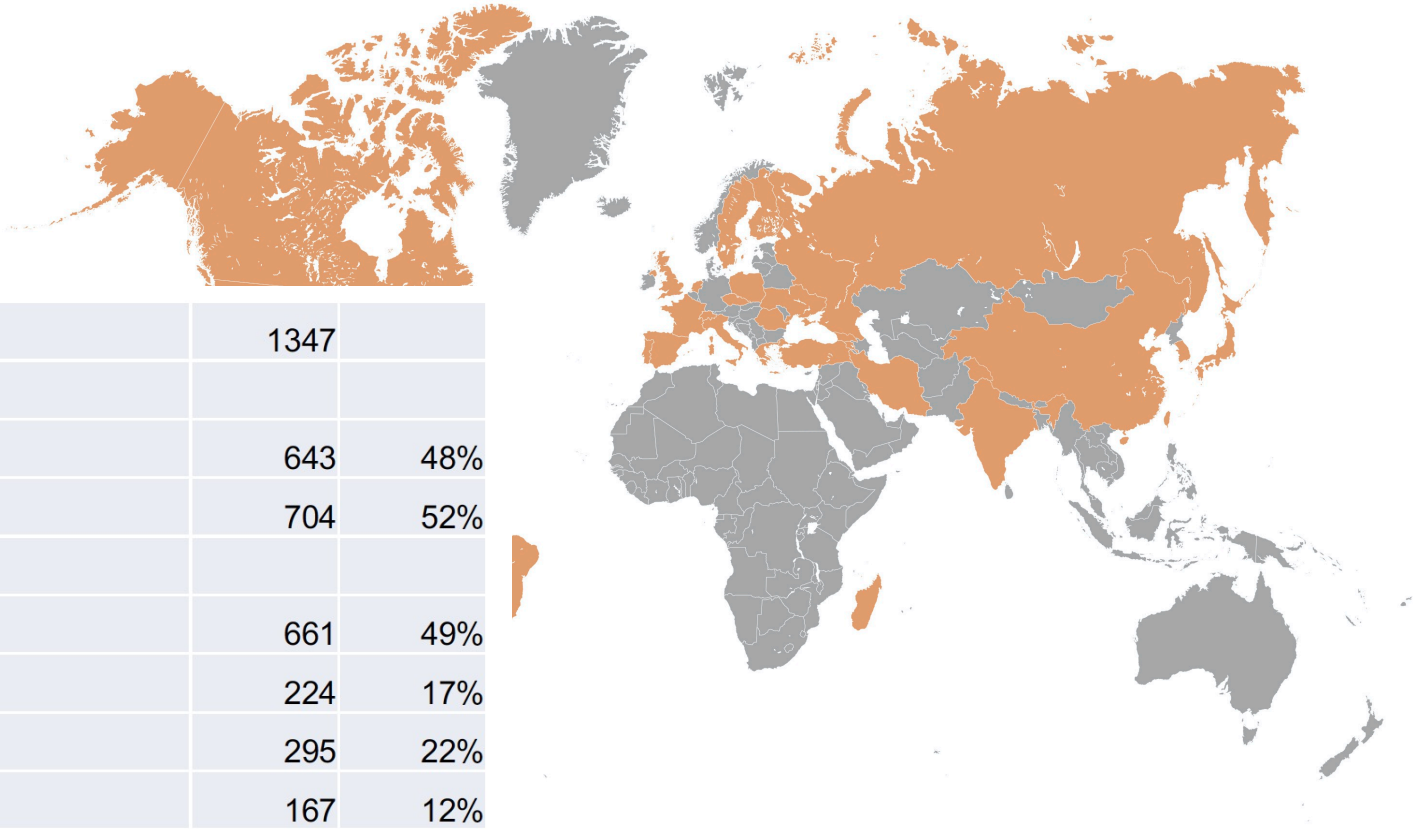




An international effort with strong UK participation/CDR in preparation

DUNE – a global collaboration

1347 collaborators from
204 institutions in 33 countries (plus CERN)



Number of Collaborators	1347	
U.S.	643	48%
non-US	704	52%
Faculty	661	49%
Post Docs	224	17%
Grad Students	295	22%
Eng & CP	167	12%
		100%

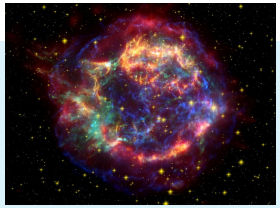
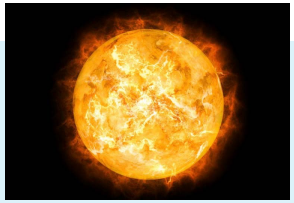
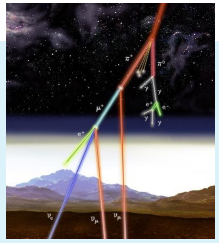
DUNE Effort Reporting

from 2020 Census :		
FTE Effort on DUNE Topics	487	36%
Other	296	22%
Non-DUNE Neutrino Effort	284	21%
No Entry	280	21%
		100%
		100%

DUNE Topics :		
Near Detector	95	20%
Horizontal Drift	94	19%
Vertical Drift	78	16%
Physics	59	12%
ProtoDUNES (SP,DP, Ops, Analysis)	55	11%
LBNF	38	8%
DAQ	31	6%
Dual Phase	15	3%
Collaboration Management	11	2%
Project Management	6	1%
Technical Coordination	5	1%
Total	487	

- Please take effort reporting seriously, important to calibrate DUNE effort in the future.
- We will further improve system for next year

DUNE – the final frontier

The full DUNE experiment envisions the following components

- Four far detector modules, 17 kt of liquid argon each
- The Near Detector Reference Design described in CDR
- A neutrino beam upgradable from 1.2 to 2.4 MW

How do we get there?

TDR described 4 identically sized cryostats:

2 single phase (SP) + 1 dual phase (DP) + 1 “module of opportunity”, each about 17 kt

OPEN ACCESS

Volume I. Introduction to DUNE

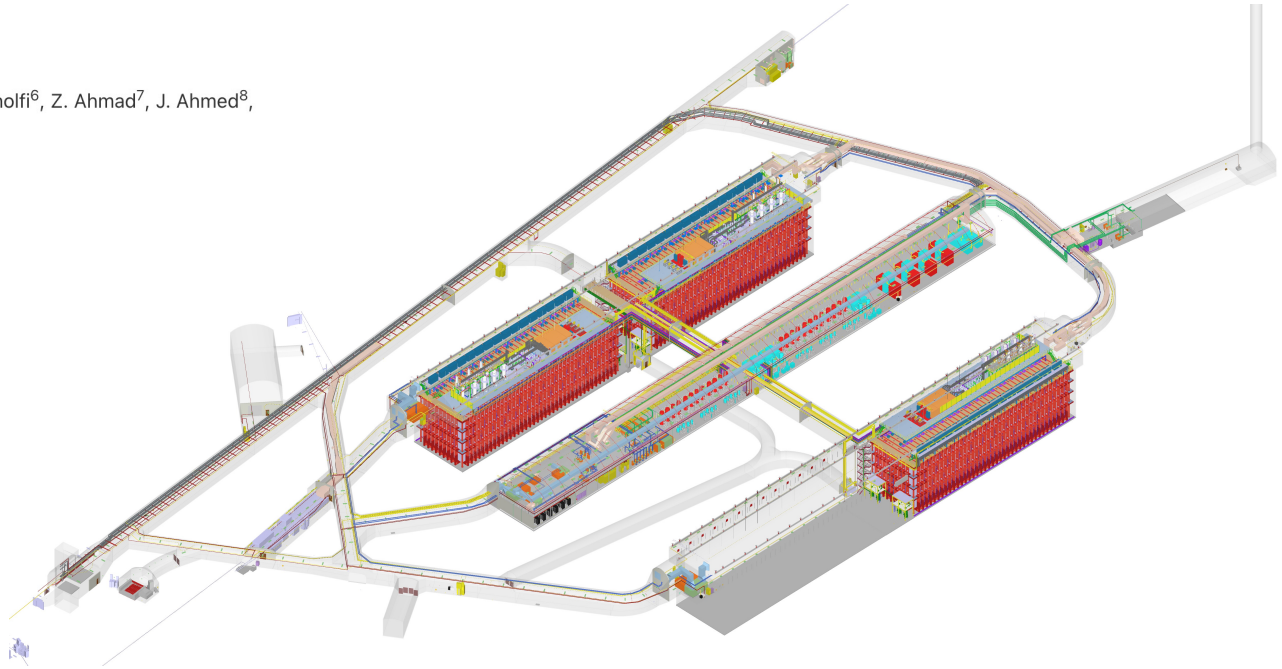
B. Abi[1], R. Acciarri[2], M.A. Acero[3], G. Adamov[4], D. Adams[5], M. Adinolfi[6], Z. Ahmad[7], J. Ahmed[8], T. Alion[9], S. Alonso Monsalve[10] + Show full author list

Published 27 August 2020 • © 2020 CERN

Journal of Instrumentation, Volume 15, August 2020

DUNE Far Detector Technical Design Report, Volumes I, III, and IV

Citation B. Abi *et al* 2020 *JINST* **15** T08008



Changing landscape

- Far Detector strategy has been developing post-TDR.
- The LBNF/DUNE-US baseline will include the full LBNF facility, two Far Detector modules, and a Day-1 Near Detector, and integration & installation of the detectors
- The LBNF/DUNE-US strategy for DOE baselining (CD-2) will proceed by sub-projects (FD-1, FD-2, ND..) based on their maturity, beginning in early 2022
- US project working towards a “CD1 reaffirm” (CD1-RR) to increase the TPC beyond the current upper limit of $2.79B.
- We have adapted DUNE management structure to reflect these changes.

DUNE FD Strategy

- Construct ProtoDUNE-SP Module 0 for FD Module 1 (based on APA technology).
  - Main goals: full characterization of Module 0; demonstrate calibration system.
  - First APAs being constructed at Daresbury Lab in UK – progress on plan.
- Focus DUNE effort on completing the VD development programme, with demonstrator and HV tests ongoing, and a full-scale prototype (2023) with VD concept described in a TDR.
  - Consortium structure has been adjusted to meet VD prototyping requirements.
  - VD Physics Task Force led by Physics Coordinators to demonstrate that we can achieve P5 physics goals with VD design
  - CDR in collaboration review (imminent)
- No backup capability to build an APA-based detector as FD Module 2.
  - Long lead time for APA production is a challenge to retaining this flexibility – creating extra APA capacity not supported by US project
  - US project will build 20 APAs and UK project 130 APAs.
- Continue work to assemble resources and develop technologies to build Modules 3 and 4.
  - Explore new technologies for future modules that would expand physics scope in addition to contributing to P5 physics goals

Building APAs

UK Research and Innovation

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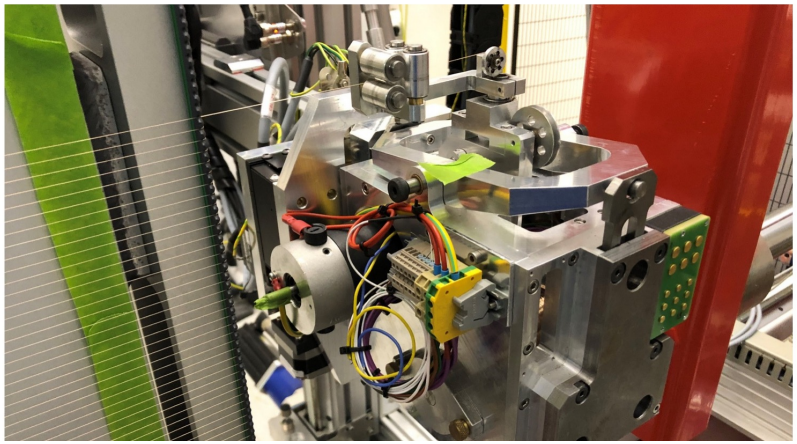
Home > News > UK scientists build core components of global neutrino experiment

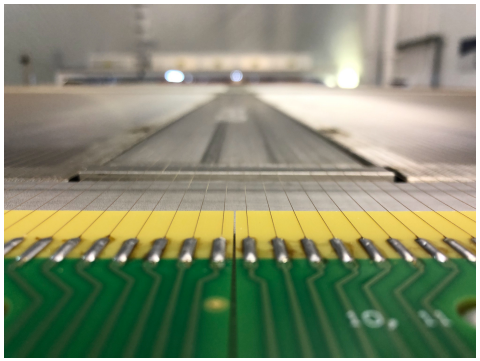
UK scientists build core compo global neutrino experiment

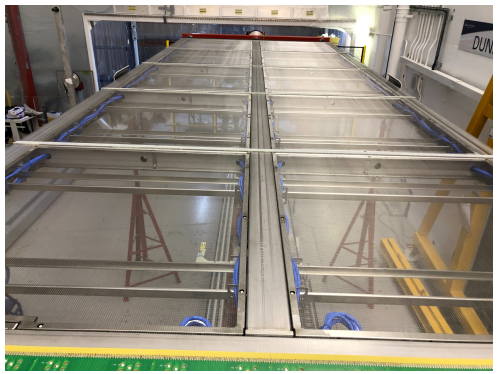


Fermilab MANCHESTER 1824 DUNE

Goals for ProtoDUNE-HD Phase II (2022)

- Full characterization of ”Module 0”s for DUNE Far Detector; improved APAs, cold electronics, photon detectors etc.
- Develop, implement and demonstrate new calibration techniques including a laser calibration system and a pulsed neutron source.

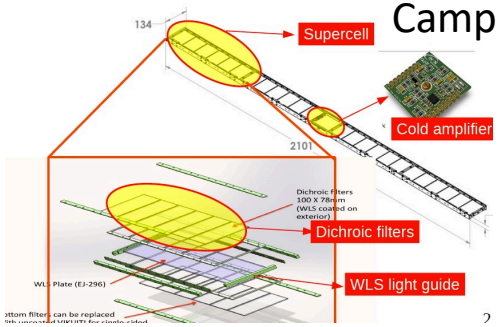




Pre-production APA-1 at Daresbury, UK (frame and boards from PSL, Madison)

SPPD: X-ARAPUCA module

Campinas, Brazil



Supercell Tests in Italy, Spain

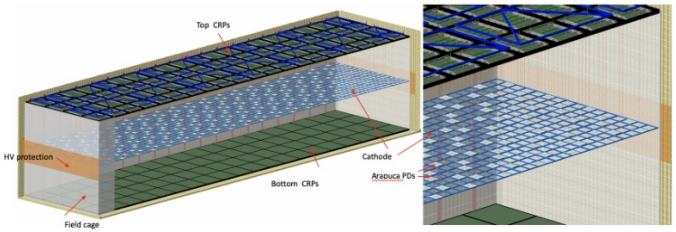
VD CDR ready to go

- Overall TPC design being finalized
- Photon Detector system still under development with different options being considered

Deep Underground Neutrino Experiment
Far Detector Conceptual Design Report

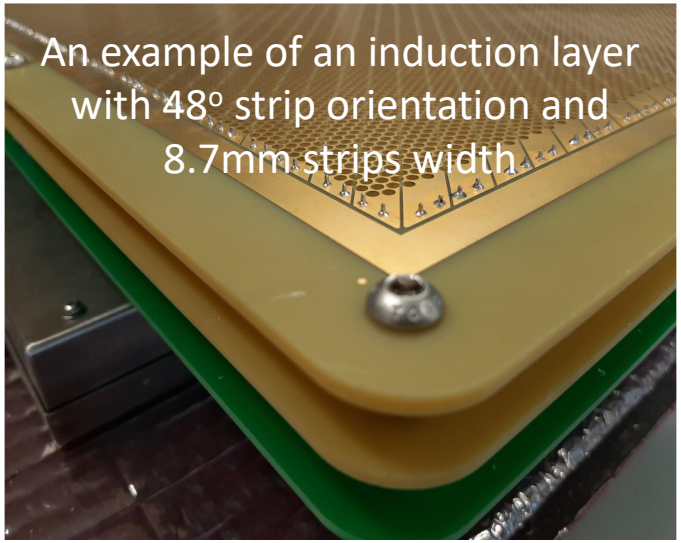
Single-Phase Vertical Drift Technology

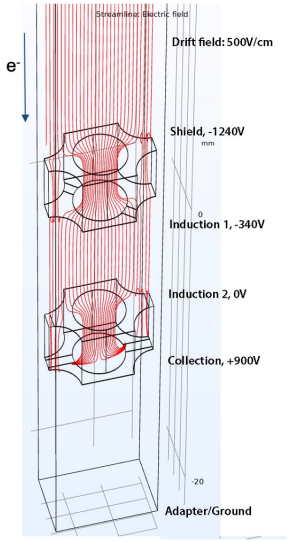
August 10, 2021



DRAFT

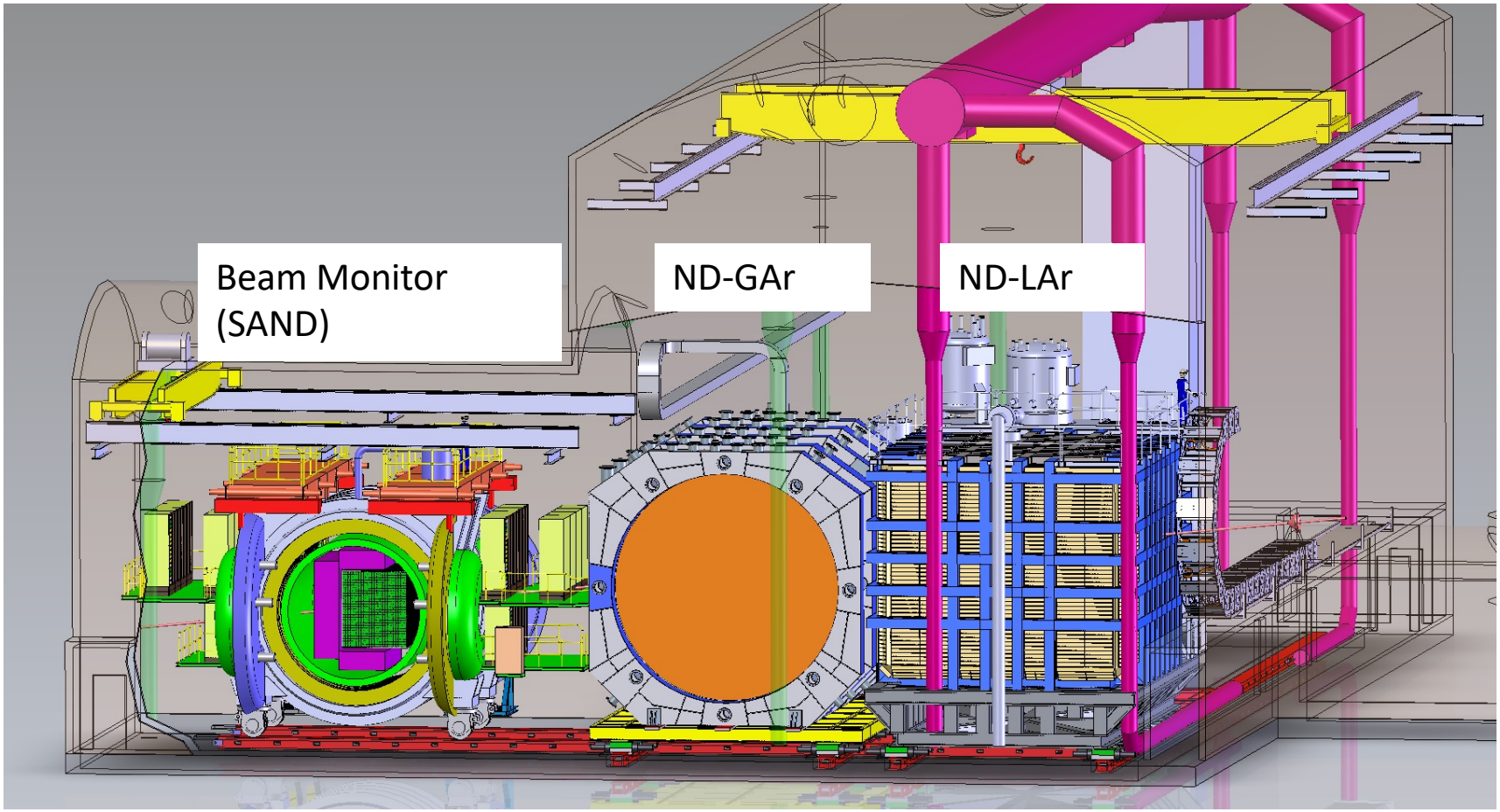
DEEP UNDERGROUND NEUTRINO EXPERIMENT





Electron paths from a line charge in a 3-view configuration

DUNE ND CDR Reference

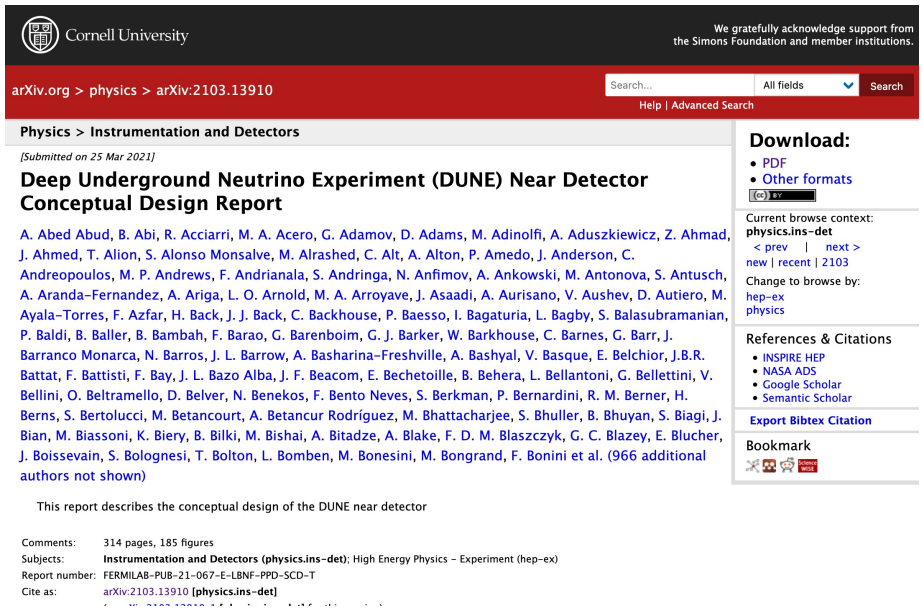


- Measures the neutrino beam rate and spectrum to predict un-oscillated event rates in the far detector
- Constrains systematic uncertainties for oscillation measurements

Near Detector CDR → PDR → TDR

- We will now transition to producing the Near Detector TDR (2022).
- In addition, a PDR (Preliminary Design Report) is being written for the US CD2 process in 2021, which describes a Day-1 ND concept that can be constructed with US and currently committed international resources

Final version of CDR published on arXiv



Cornell University

We gratefully acknowledge support from the Simons Foundation and member institutions.

arXiv.org > physics > arXiv:2103.13910

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Physics > Instrumentation and Detectors

[Submitted on 25 Mar 2021]

Deep Underground Neutrino Experiment (DUNE) Near Detector Conceptual Design Report

A. Abed Abud, B. Abi, R. Acciarri, M. A. Acero, G. Adamov, D. Adams, M. Adinolfi, A. Aduszkiewicz, Z. Ahmad, J. Ahmed, T. Alion, S. Alonso Monsalve, M. Alrashed, C. Alt, A. Alton, P. Amedo, J. Anderson, C. Andreopoulos, M. P. Andrews, F. Andrianala, S. Andringa, N. Anfimov, A. Ankowski, M. Antonova, S. Antusch, A. Aranda-Fernandez, A. Ariga, L. O. Arnold, M. A. Arroyave, J. Asaadi, A. Aurisano, V. Aushev, D. Autiero, M. Ayala-Torres, F. Azfar, H. Back, J. J. Back, C. Backhouse, P. Baesso, I. Bagaturia, L. Bagby, S. Balasubramanian, P. Baldi, B. Baller, B. Bambah, F. Barao, G. Barenboim, G. J. Barker, W. Barkhouse, C. Barnes, G. Barr, J. Barranco Monarca, N. Barros, J. L. Barrow, A. Basharina-Freshville, A. Bashyal, V. Basque, E. Belchior, J.B.R. Battat, F. Battisti, F. Bay, J. L. Bazo Alba, J. F. Beacom, E. Bechetoille, B. Behera, L. Bellantoni, G. Bellettini, V. Bellini, O. Beltramello, D. Belver, N. Benekos, F. Bento Neves, S. Berkman, P. Bernardini, R. M. Berner, H. Berns, S. Bertolucci, M. Betancourt, A. Betancur Rodríguez, M. Bhattacharjee, S. Bhuller, B. Bhuyan, S. Biagi, J. Bian, M. Biassoni, K. Biery, B. Bilki, M. Bishai, A. Bitadze, A. Blake, F. D. M. Blaszczyk, G. C. Blazey, E. Blucher, J. Boissevain, S. Bolognesi, T. Bolton, L. Bomben, M. Bonesini, M. Bongrand, F. Bonini et al. (966 additional authors not shown)

This report describes the conceptual design of the DUNE near detector

Comments: 314 pages, 185 figures
Subjects: **Instrumentation and Detectors (physics.ins-det)**; High Energy Physics - Experiment (hep-ex)
Report number: FERMILAB-PUB-21-067-E-LBNF-PPD-SCD-T
Cite as: arXiv:2103.13910 **[physics.ins-det]**

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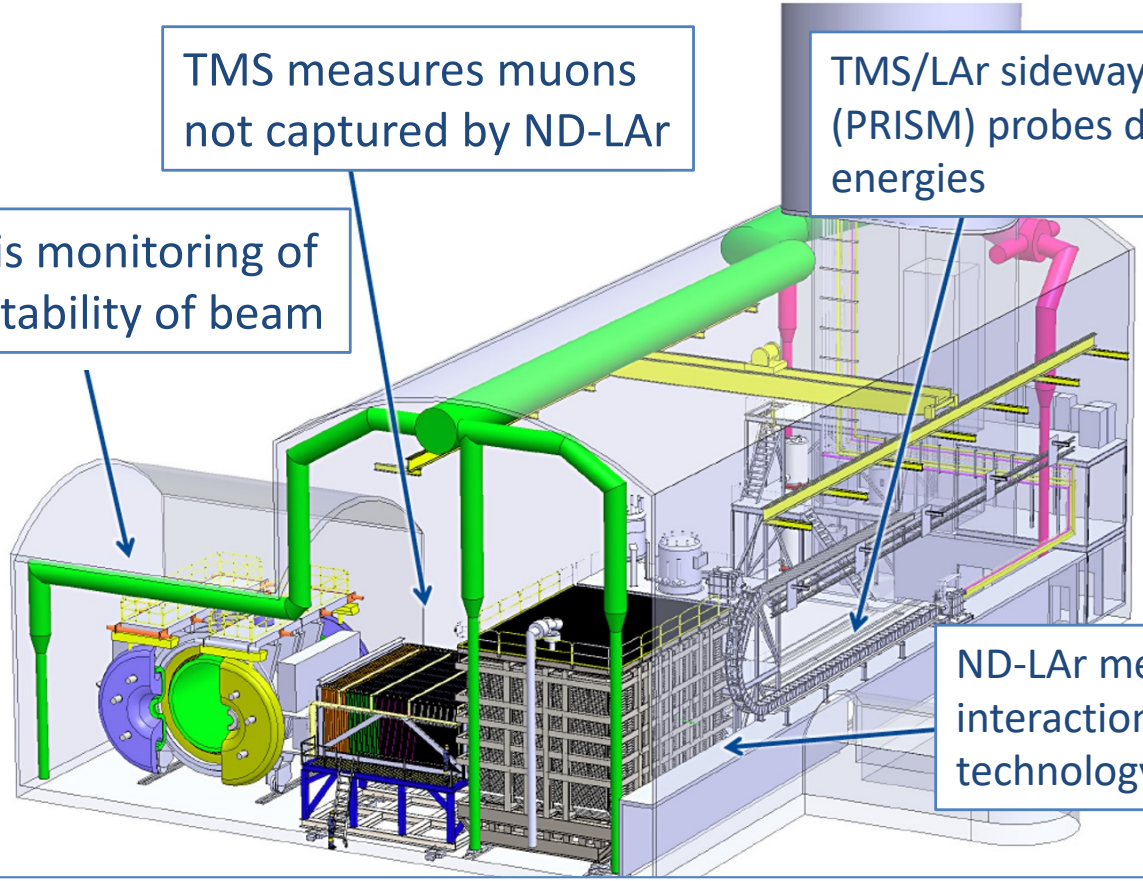
Thank you and best regards,

Nigel S. Lockyer,
Director of Fermilab

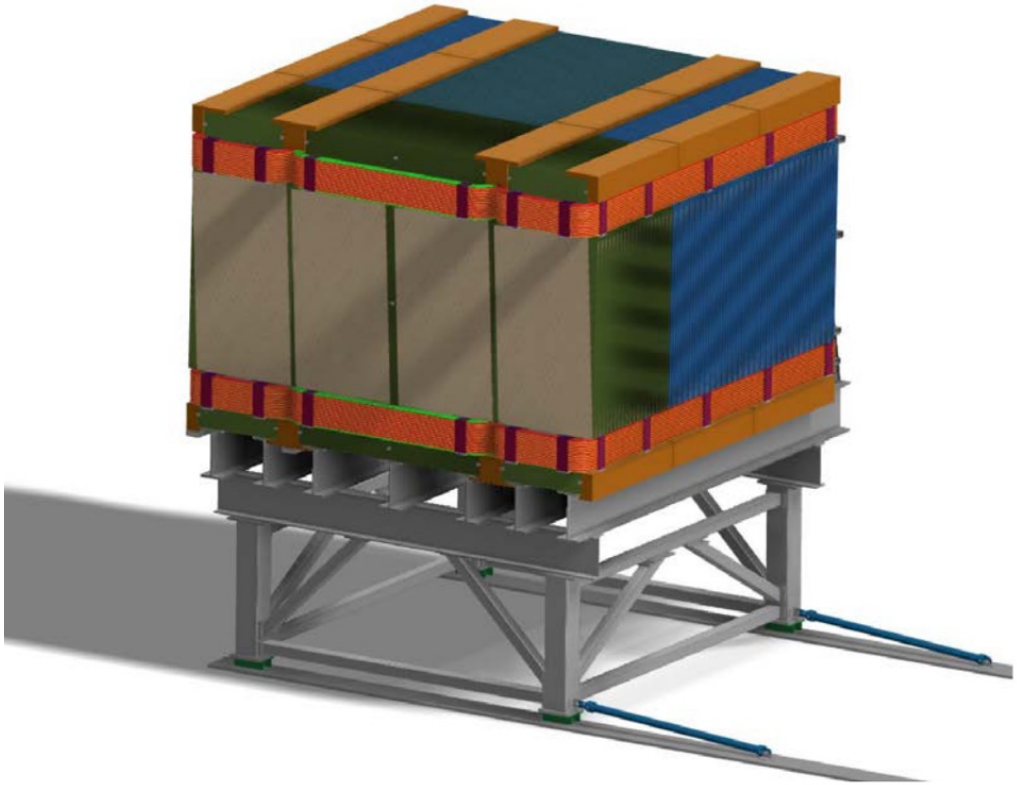
Day 1 Near Detector



- Beyond Day-1: Replace TMS with ND-GAr (gas argon TPC) that will allow us to constrain interaction models.
- There is significant interest from international partners to support ND-GAr but requires additional commitment to fund ND-GAr magnet.

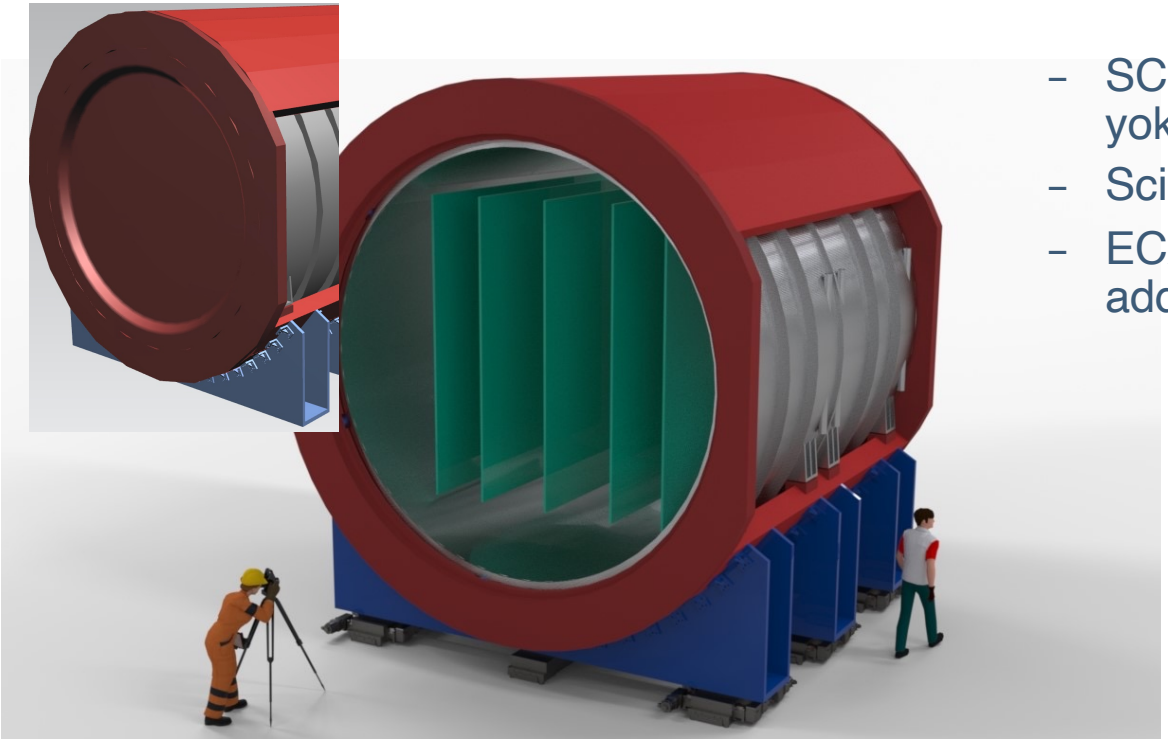
Temporary Muon Spectrometer

- Magnetized range stack with 100 layers
- Located between SAND and ND-LAr
- Scintillator and steel
- Designed to measure muons ranging out from ND-LAr
- Entirely DUNE-US scope

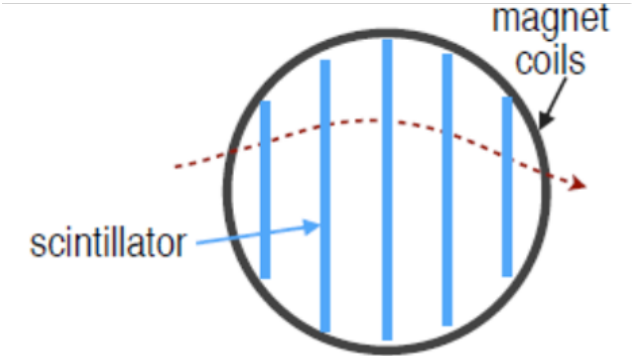


7.4m wide x 5.0 m tall x 7m deep
~850 tons + base

Alternative to TMS: ND-GAr-Lite



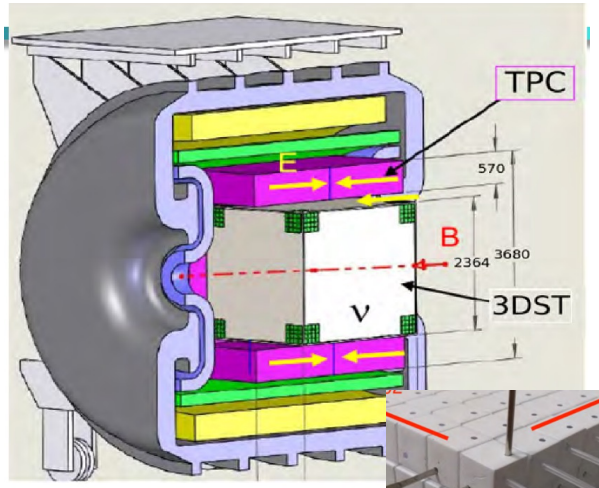
- SC Magnet including partial return-yoke – to be built in Italy
- Scintillator tracking planes
- ECAL modules (Germany) could be added

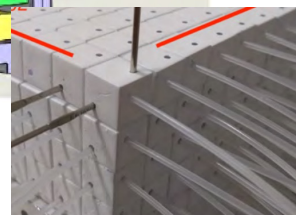


- Advantages:
  - Spend US resources planned for TMS more efficiently
  - Avoid technical and schedule problems caused by TMS replacement
- Currently not part of project, requires additional support from interested funding agencies

SAND Tracker

SAND will serve as Beam Monitor, with additional physics capabilities:





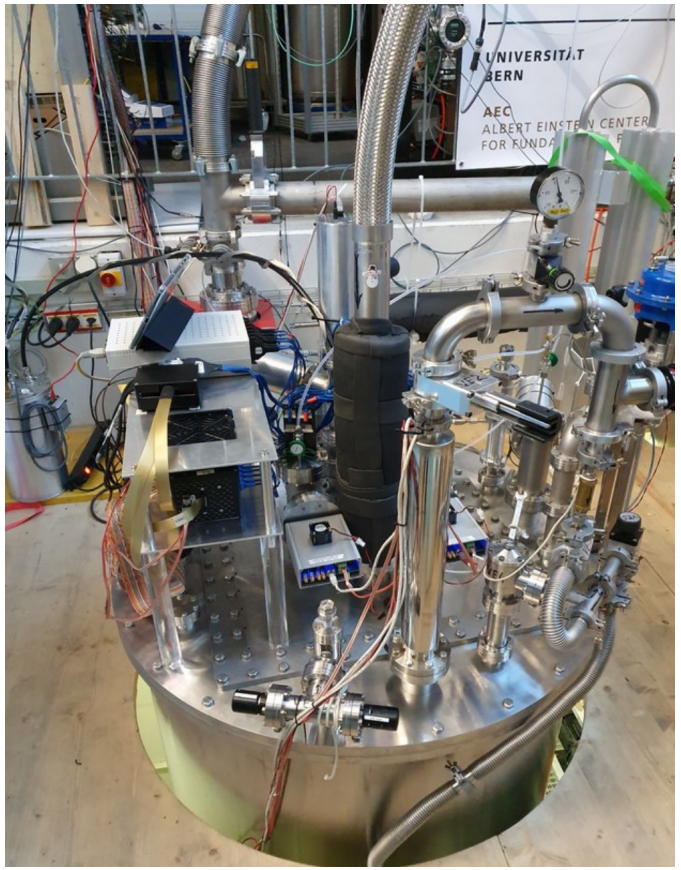
Options for tracker:

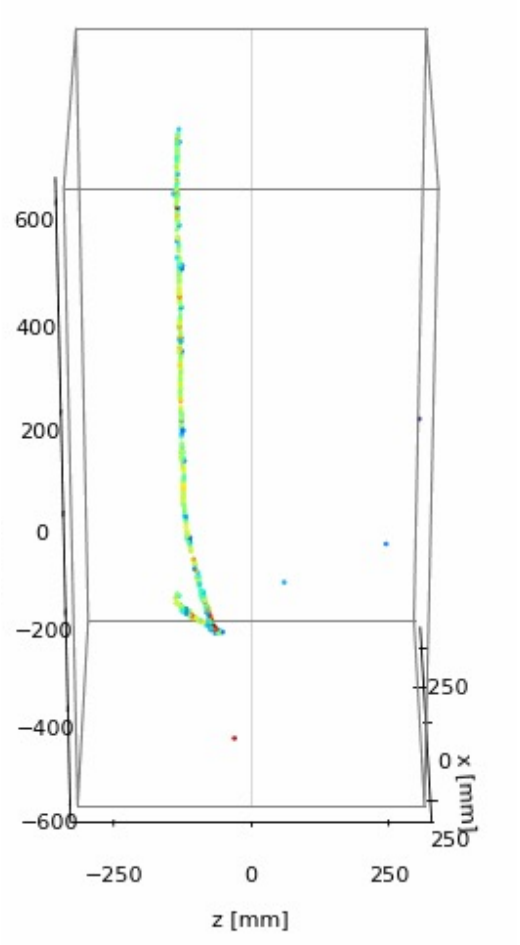
- 3DST+TPC: scintillator cubes and TPC, similar to T2K ND280 upgrade technology.
- STT: Straw Tube Tracker with interspersed C/CH_2 targets.
- A possible "hybrid" retaining the main features and enabling full physics programme (e.g., A dependence, neutron measurements, interactions on free "proton" through subtraction method..)

- Consortium review of different options with external experts, and chaired by Dmitri Denisov (BNL) was not conclusive.
- "Both options are good and will make an excellent SAND detector which makes the choice even more challenging."
- Options studied by a Design Group, chaired by Josh Klein, which has recently produced a report.
- We will make a decision on how to proceed very soon.

Towards a Module-0 for ND-LAr

- Full instrumented Module 0 test performed at the University of Bern
- ArgonCube detector delivered to Fermilab for further testing
- Additional R&D and testing programme at LBNL and SLAC

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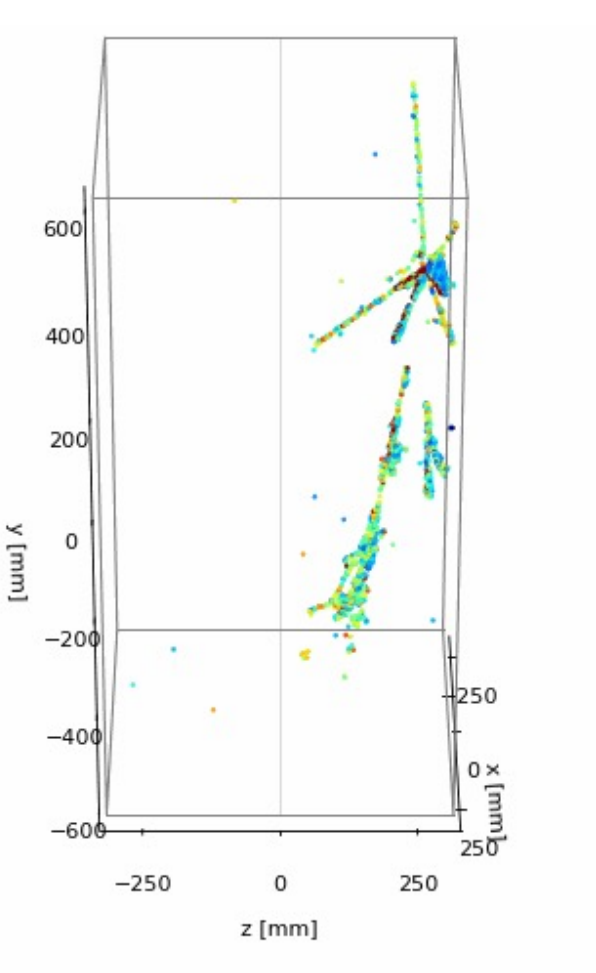
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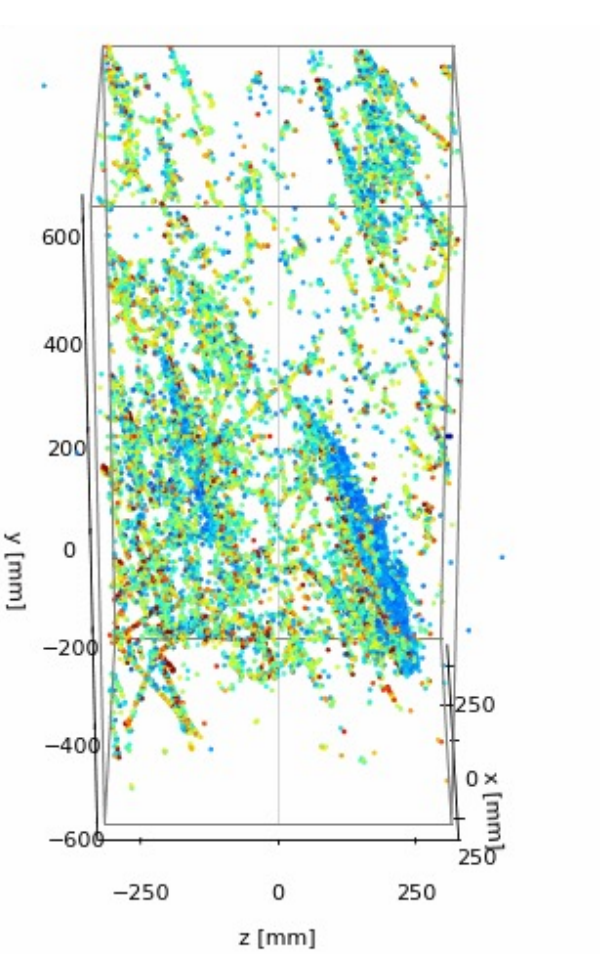
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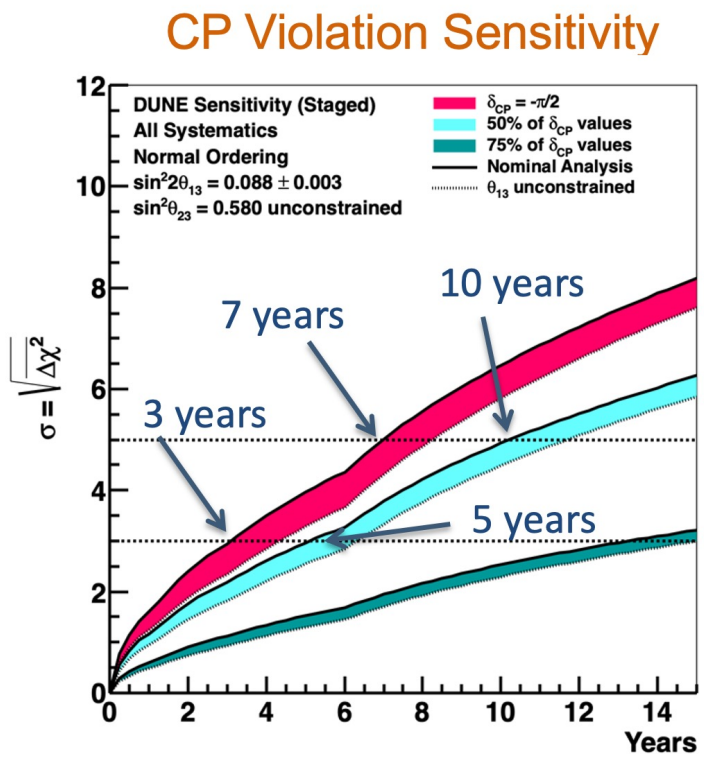
DUNE Sensitivity vs time



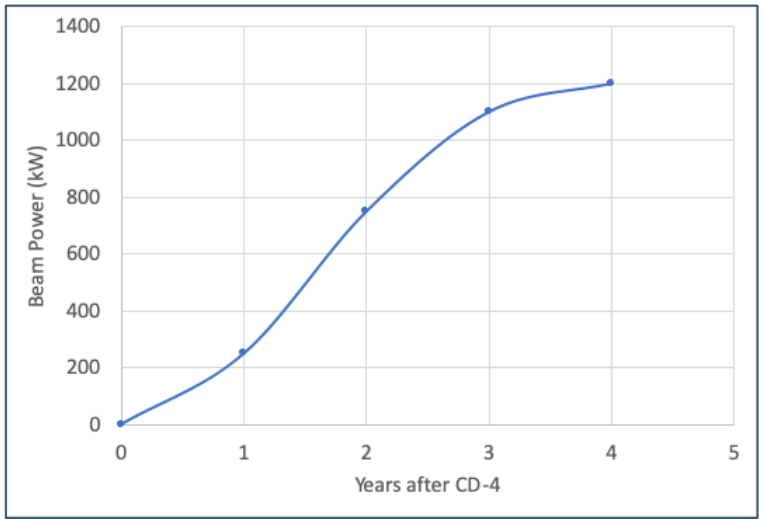
TDR Staging

- 1.2 MW × 20 kton at start
- 1.2 MW × 30 kton after 1 yr
- 1.2 MW × 40 kton after 3 yr
- 2.4 MW × 40 kton after 6 yr
- No “power ramp” – assume full beam power on day 1

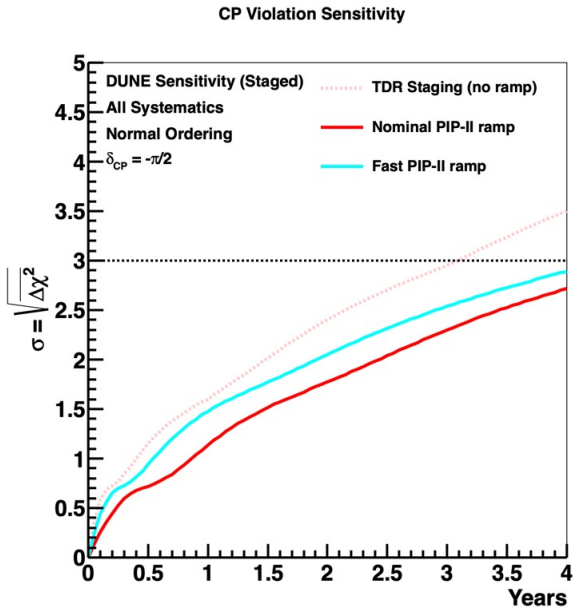
Assumes TDR staging (“2+1+1 model”) and doubling of beam power after 6 years – evolving strategy.

DUNE Sensitivity vs time

- PIP-II expected power ramp
- This assumes LBNF is ready for PIP-II upgrade

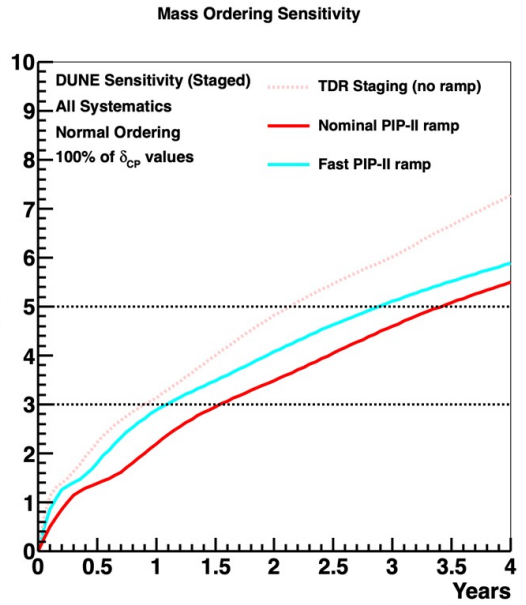


Q1FY29



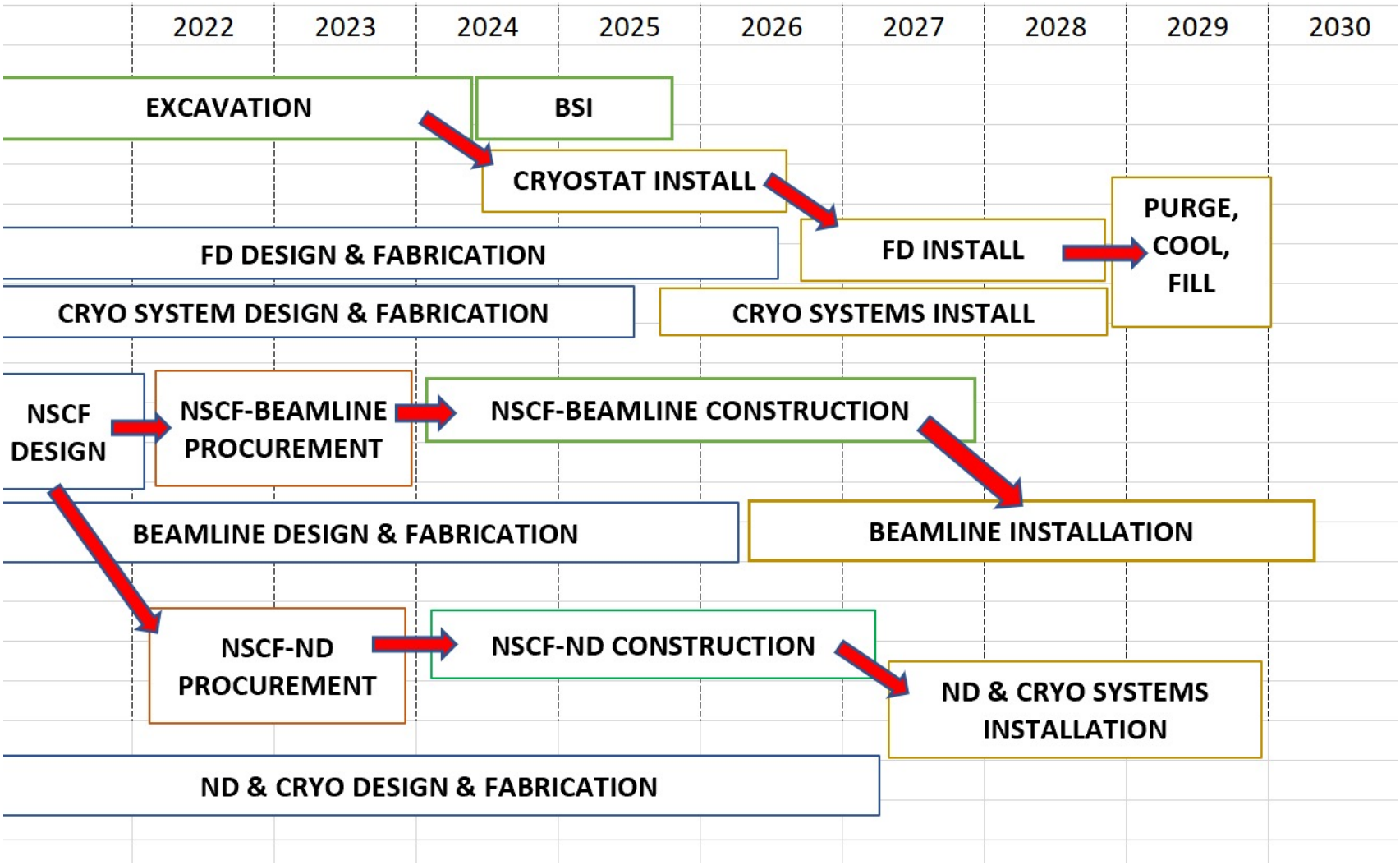
CP Violation
$\delta_{CP} = -\pi/2$

Mass Ordering
100% δ_{CP} values



- New staging scenario with two far detectors and beam power ramp.
- Initial physics goals: mass order and 3σ sensitivity for maximal CPV.

Technically driven Timeline



DUNE Timeline

- We are currently working with DOE on optimizing the timeline, the technically driven scenario is not likely.
- Main problem is the issue of funding profile, with peak funding in 2024 and 2025 exceeding the maximum amount that we expect to get in US, mainly driven by Near Site Conventional Facility – but not a problem of Total Project Cost (TPC).
- Logical sequencing is FD → Beam → ND.
- “Sequencing is not prioritization”. Lots of work still going in parallel.
- Ongoing discussions in preparation of next Resources Review Board (RRB).

DUNE Publications 2021

Design, construction and operation of the ProtoDUNE-SP Liquid Argon TPC

DUNE Collaboration • A. Abed Abud et al. (Aug 4, 2021)

e-Print: 2108.01902 [physics.ins-det]

pdf cite 0 citations

Searching for Solar KDAR with DUNE

DUNE Collaboration • A. Abed Abud et al. (Jul 19, 2021)

e-Print: 2107.09109 [hep-ex]

pdf cite 1 citation

Deep Underground Neutrino Experiment (DUNE) Near Detector Conceptual Design Report

DUNE Collaboration • Adam Abed Abud (Liverpool U. and CERN) et al. (Mar 25, 2021)

e-Print: 2103.13910 [physics.ins-det]

pdf links cite 10 citations

Experiment Simulation Configurations Approximating DUNE TDR

DUNE Collaboration • B. Abi (Oxford U.) et al. (Mar 8, 2021)

e-Print: 2103.04797 [hep-ex]

pdf cite 6 citations

Prospects for beyond the Standard Model physics searches at the Deep Underground Neutrino Experiment

DUNE Collaboration • B. Abi (Oxford U.) et al. (Aug 28, 2020)

Published in: *Eur.Phys.J.C* 81 (2021) 4, 322 • e-Print: 2008.12769 [hep-ex]

pdf links DOI cite 27 citations

Supernova neutrino burst detection with the Deep Underground Neutrino Experiment

DUNE Collaboration • B. Abi (Oxford U.) et al. (Aug 15, 2020)

Published in: *Eur.Phys.J.C* 81 (2021) 5, 423 • e-Print: 2008.06647 [hep-ex]

pdf links DOI cite 20 citations

DUNE Publications 2020

First results on ProtoDUNE-SP liquid argon time projection chamber performance from a beam test at the CERN Neutrino Platform

DUNE Collaboration • B. Abi (Oxford U.) et al. (Jul 13, 2020)

Published in: *JINST* 15 (2020) 12, P12004 • e-Print: 2007.06722 [physics.ins-det]

pdf links DOI cite 37 citations

Neutrino interaction classification with a convolutional neural network in the DUNE far detector

DUNE Collaboration • B. Abi (Oxford U.) et al. (Jun 26, 2020)

Published in: *Phys.Rev.D* 102 (2020) 9, 092003 • e-Print: 2006.15052 [physics.ins-det]

pdf links DOI cite 14 citations

Long-baseline neutrino oscillation physics potential of the DUNE experiment

DUNE Collaboration • B. Abi (Oxford U.) et al. (Jun 26, 2020)

Published in: *Eur.Phys.J.C* 80 (2020) 10, 978 • e-Print: 2006.16043 [hep-ex]

pdf links DOI cite 32 citations

Deep Underground Neutrino Experiment (DUNE), Far Detector Technical Design Report, Volume II: DUNE Physics

DUNE Collaboration • Babak Abi (Oxford U.) et al. (Feb 7, 2020)

e-Print: 2002.03005 [hep-ex]

pdf links cite 148 citations

Deep Underground Neutrino Experiment (DUNE), Far Detector Technical Design Report, Volume IV: Far Detector Single-phase Technology

DUNE Collaboration • Babak Abi (Oxford U.) et al. (Feb 7, 2020)

Published in: *JINST* 15 (2020) 08, T08010 • e-Print: 2002.03010 [physics.ins-det]

pdf links DOI cite 51 citations

Deep Underground Neutrino Experiment (DUNE), Far Detector Technical Design Report, Volume I Introduction to DUNE

DUNE Collaboration • Babak Abi (Oxford U.) et al. (Feb 7, 2020)

Published in: *JINST* 15 (2020) 08, T08008 • e-Print: 2002.02967 [physics.ins-det]

pdf links DOI cite 113 citations

Deep Underground Neutrino Experiment (DUNE), Far Detector Technical Design Report, Volume III: DUNE Far Detector Technical Coordination

DUNE Collaboration • Babak Abi (Oxford U.) et al. (Feb 7, 2020)

Published in: *JINST* 15 (2020) 08, T08009 • e-Print: 2002.03008 [physics.ins-det]

pdf links DOI cite 20 citations

Next Collaboration Meetings

- September 20-24, 2021 – Virtual
- January 24-28, 2022 - CERN
- May 2022 –
  - Dates and location to be discussed at the IB meeting. We are looking to have the meeting in South Dakota.

Summary

- DUNE has made significant progress so far in 2021
  - Publication of Near Detector CDR
  - Construction of first Horizontal Drift detector components (APAs)
  - CDR for FD-2 based on Vertical Drift technology
  - Development of international computing model leading to a CDR
  - Several DUNE publications
- Other important milestones
  - Start of Far Site excavation and Near Site facilities
  - Support for second cryostat from CERN
  - LBNF/DUNE-US project progressing with baselining strategy – full facility, two Far Detector modules, Day-1 Near Detector.