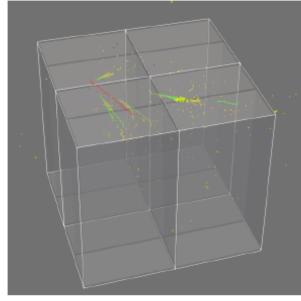


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2x2 in the ND-LAr consortium

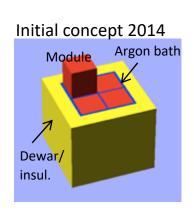


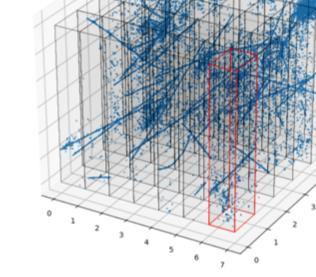
(b) $E_{\nu} = 3.36 \text{ GeV}$

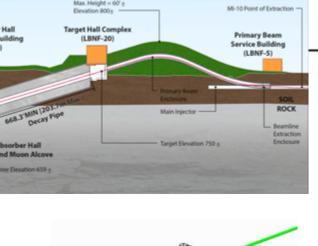
M. Weber LHEP/AEC, University of Bern

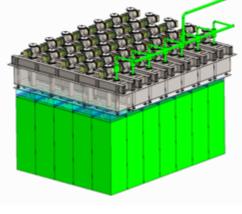
DUNE/LBNF near detector

- Neutrino oscillations are measured from the distribution of vμ,e CC events at the far detector (FD) and the near detector (ND)
 - ND predicts distributions at the FD from production, oscillation, interaction, and detector response
- Challenge
 - High event density
 - High event rate (pile-up)
- Modular approach
 - Reduced risks
 - Contained light
 - Distributed production
 - LArTPC V2.0









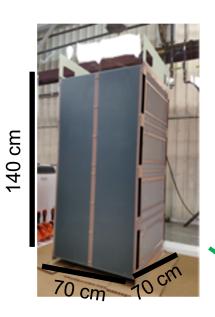
"The core of the near detector is a liquid argon TPC based on the ArgonCUBE design [developed and originally proposed by the Bern group]"

ND LArTPC: From Prototyping to Production to Installation u^b

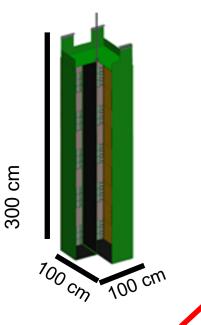
2019-2021

Module 0 SingleCube, then 1 module (Module 0), then 4 modules (2x2) Operated in cryostat at Bern.

then FNAL in NuMI beam



2022-2023 **Full-scale ND Demonstrator**



ArgonCube 2x2 (2021--)



2024-2027 **Production and testing**

35 (+5) Production modules Each fully tested in single-module cryostat LAr Test at MATF @ FNAL

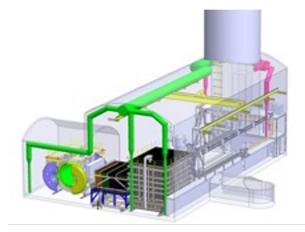


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2028-2029 Installation

Assemble rows of 5 modules Support of TPC module installation in Near Site

Activity driven by Near Site Integration (NSI)



Neutrino event Reconstruction

Timeline and high-level dependencies

- u^{t}
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- Module-0 test are completed
 They informs the Preliminary Design Review PDR, calendar Q4 2021
- 2x2 analysis from NuMI events
 will inform the Final Design Review (FDR) -> Q3 CY 2023
 - Goal: satisfy the reconstruction and physics requirements
- Will need to iterate over reconstruction and simulation
- Will need initial data from the neutrino beam in CY 2022
 High level milestone
- Start of neutrino beam operation underground at NuMI in October/November 2022 is critical





ProteDUNE-ND: proposal to place the ArgonCube 2x2 Demonstrator on-sale in NuMI

S. Dineri, M. Demercos, J. Xie, S. Nigili, A. Rabye and M. Gredens Arguma National Enterestry, Argume, Elliste Wells, USA Strini, E. Chen, M. Strom, F. Larni, V. Li, D. Limmer, X. Gio, Y. Rabble and S. Vi. Brookharen National Enforcines (SNL), Union, NV 11875-5888, USA

W. Novey Coherolic Basic Calmordity, Fact Collins, CO 86525, USA From S. Felin, D. A. Barin, S. Marchand, T. Wan, J. L. Rae' and J. Dommon, Perma Nazional Accelerator Laboratory (FNSA), Sanaria, H. 60107-1743.

R. Couptin and J. Nario-Line Barrard Taiwentin Combridge, 169, 60184, UKs

C Associe, S. S. Sho and J. Silver. BN, Physics Department, University of decises, 2009 DN Arches, Partingel N. Jadisson, A. Chilerolli, S. Salponto, S. Salponto and A. Satalino Joint Institute for Nuclear Research (ACNS), John Clark S, 14200 Dalon, Homes-rogalists, Stanley

N. Seriek Nicole East Technical University (NETU), TR-6800, Autora, Techno H. Correy, L. Denim, B. Sur, K. Siarpon, E. Tonin, K. Tene, Y.-S. Tol and T. Urier, H.A. Norbond Annihombre Laboratory and Headed University, 2079. Send 4031 St., Mondy Park, Co. 4000, URA.

C.S. Jung, C. Vilde, W. Wilsing and E. Wood, Name Breeck University, Street, Breeck, NY 11794, VRA D. A. Deyer, D. Gaset, C. Gaset, S. Robe, M. Erenner, S. Kringet, K. B. Leit, P. Niedgas and C. Niedelsch. Varbenstep of California and Laurence Berkeley. National Laboratory. Burkeley, Cit. 14908,

D. 1986, N. Controvat, J. Sachtman, Y. Clark and A. Prano Cacherolity of Lowe High Energy Physics Group, Reva City, St. 18843, VSA

J. Clares and C. M. Marger University of Photosylvania Philadelphia, PA, 1998a, UKa H. Stald, S. Harly, K. S. McForland, D. Bestelmins and C. Y. C. Woot, University of Revisions, Bankester, NY 19827 USA

Barler, A. C. Eserbe, Y. Guette, N. McCanter, N. J. C. Sponner, M. Theren, E. Eyler and M. H. Warght.
 Windowsky of Hardfold, Worstern Hands, MacRoid 849 1778, UK

J. Joseph and H. Sullivan. University of Terror at Artington, Artington, VK Water, USA D. Dening and S. Tuladi. Tale University, Weight Laboratory, New Hores, CT 88500 URA.

ProtoDUNE-ND proposal

Bern: Lead institute, R&D, overall design, controls, readout, cryostat, module construction, integration, tests, shipping

BNL: module, HV Argonne: computing

Colorado: lab tests

Fermilab: host, cryogenics, infrastructure, integration

JINR: light readout

Harvard: simulations, cosmic rays

Michigan state: calibration

SLAC: reconstruction, E-Field, HV

Stony Brook: operation, ND integration

Berkeley: Pixel readout

Pennsylvania: flux

Rochester: Trigger/DAQ, muon tagging

Sheffield: module mechanics

UTA: lab tests, module R&D

Yale: simulations, lab tests

29.1.19 M. Weber

FLARE Panel Presentation DUNE



Wildhainweg 3, Postfach 8232, CH-3001 Bern

Application form mySNF

Part 1: General Information

2x2 funded by Swiss Grant (2019-2021)

Basic data

Project Title FLARE: The DUNE/LBNF neutrino experiment Project title in English FLARE: The DUNE/LBNF neutrino experiment

Research Field Mathematics, natural sciences 20403 Particle Physics Main Discipline University Universität Bern - BE

Applicant(s)

Michael Weber Other applicant(s) Antonio Ereditato Igor Kreslo

| Grant Application | | | |
|--|----------------------------|-----------|--|
| Amount requested (CHF) | Total | 1'120'000 | |
| Related to project no. Requested starting date Duration (months) | 173599 01.04.2019 24 | | |

Proposal document to Fermilab ND (Jan 2019, DUNE-DocDB-12571)



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iCRADA 2019 for DUNE and 2x2

INTERNATIONAL

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

FOR

BASIC SCIENCE COOPERATION

(HEREINAFTER "CRADA") NO. FRA-2018-0032

BY AND AMONG

FERMI RESEARCH ALLIANCE, LLC UNDER ITS U.S. DEPARTMENT OF ENERGY CONTRACT NO. DE-AC02-07CH11359 TO MANAGE AND OPERATE FERMI NATIONAL ACCELERATOR LABORATORY (HEREINAFTER "LABORATORY")

AND

UNIVERSITY OF BERN

(HEREINAFTER "PARTICIPANT")

LABORATORY AND PARTICIPANT COLLECTIVELY REFERRED TO

AS THE "PARTIES" AND SEPARATELY AS A "PARTY"

2021: 2x2 as FNAL/PAC approved test experiment



Prototyping plan and DUNE-ND CDR

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ND-LAr Consortium Prototyping Plan

Last Updated: 10 Sep. 2020 by D. Dwyer

Overview

The prototyping plan for the Near Detector LArTPC detector will address a specific set of technical targets between now and the initiation of detector production. Prototyping activities fall into two categories: component-level and integration-level prototyping. Component prototyping is generally addressed via stand-alone small-scale tests, and the majority of these tests have been completed over the recent years of the ArgonCube R&D program. Integration prototyping addresses how these components come together and function coherently within the ND LArTPC design, as well as demonstrating the large-scale production and assembly processes necessary to construct the Near Detector.

Integration Prototyping Plan

There are two stages to the integration prototyping plan: the ArgonCube 2x2 Demonstrator stage and the subsequent Full-scale Demonstrator stage. The 2x2 Demonstrator is a complete, but sub-scale, LArTPC detector system focused on verifying technical readiness of the ND LArTPC design before the completion of the Near Detector design phase. The Full-scale Demonstrator is a single production-scale LArTPC module that will validate the full-scale component production, assembly, and testing processes before the Consortium proceeds to Near Detector production.

Deep Underground Neutrino Experiment (DUNE)

Near Detector Conceptual Design Report

DUNE ND CDR arxiv:2103:13910

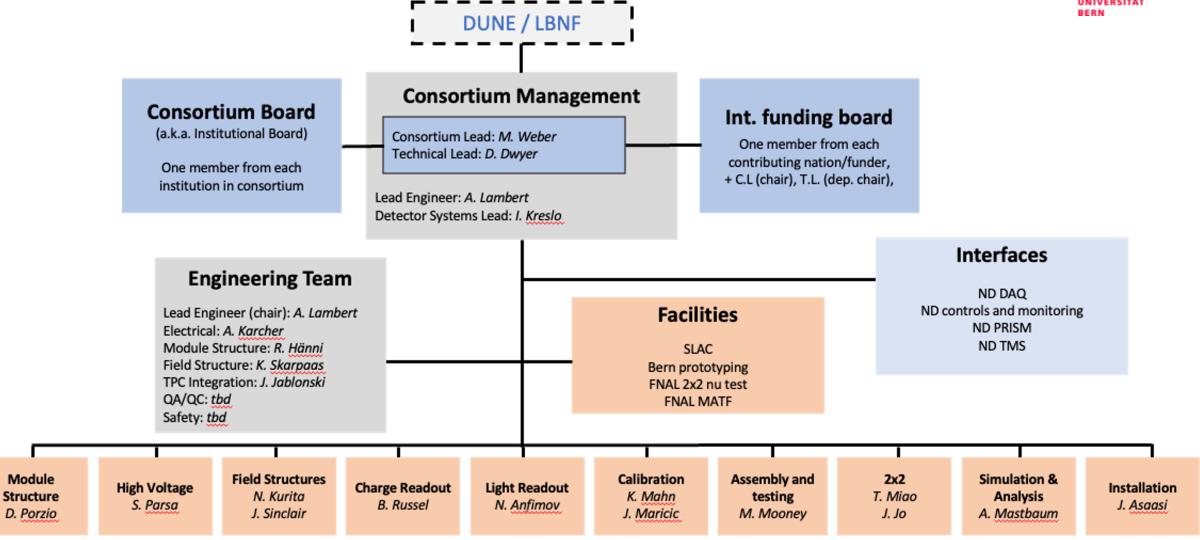
ZOZ LEW March 26, 2021

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| | | | | |

Organization: DUNE International – ND-LAr Consortium



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ND LAr Consortium (red = 2x2 involvement)



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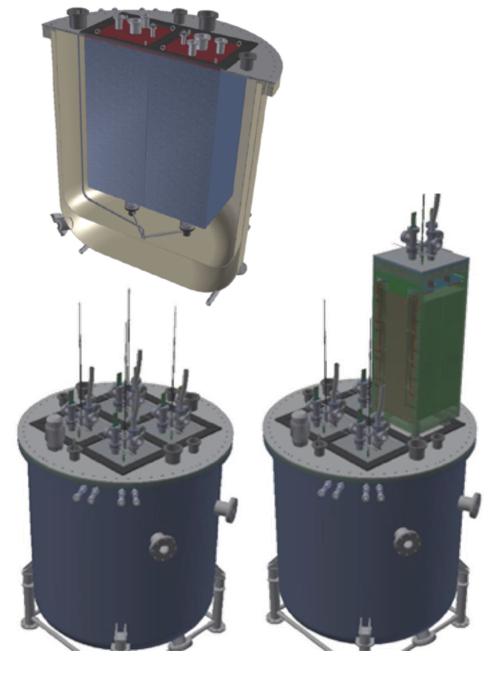
- ANL
- U Bern
- BNL
- Caltech
- U Cambridge
- CSU
- UColorado
- Fermilab
- Houston
- lowa
- JINR
- Lancaster

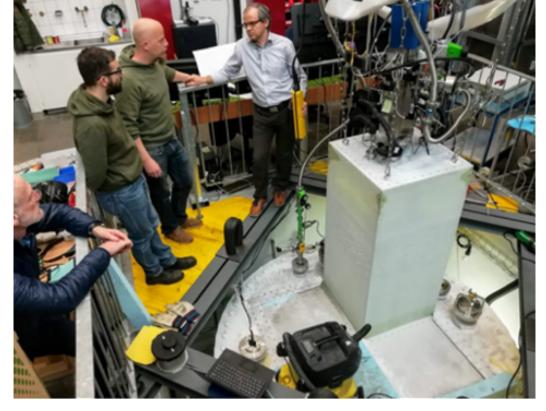
- LBNL
- Manchester
- Minnesota Duluth
- MSU
- Penn
- Rochester
- Rutgers
- Sheffield
- SLAC
- Tufts
- UC Berkeley

- UC Davis
- UC Irvine
- UC Santa Barbara
- UTA
- Warwick
- Wichita State
- William&Mary
- Yale
- York



b Universität Bern





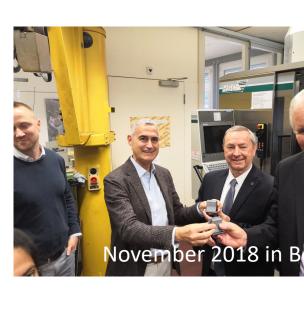
Operation in Bern 2019

Cryostat (2x2)

- Cryostat arrived in Bern in 2015
- Initial tests and rebuild 2016
- Cryogenics setup 2017
- Initial run 2018
- Runs for module extraction 2019



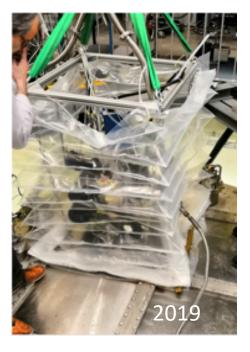






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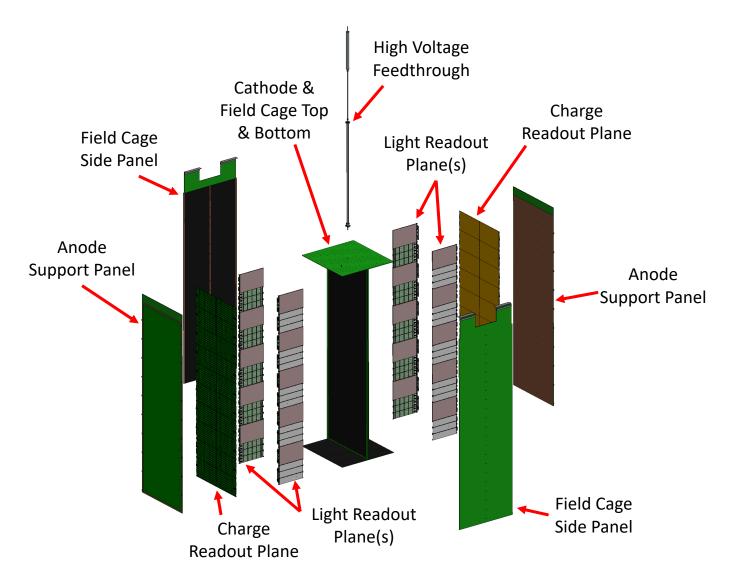


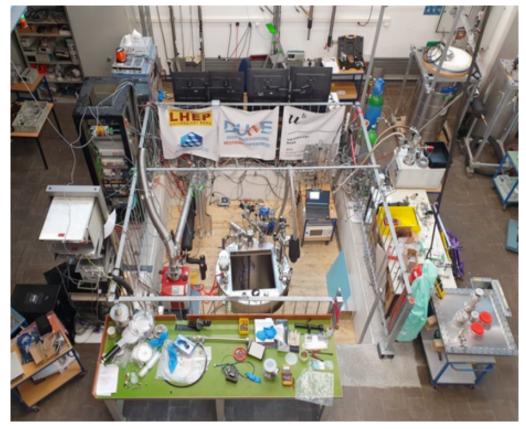


Pressure/vacuum test successful 6/8/2021 Arrival at FNAL in July 2021



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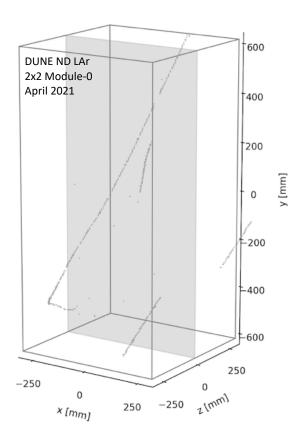




Successful Module-0 runs (first of 4 modules)

April and June 2021













July 2021, module inserted in the single-module cryostat Waiting-position for shipping

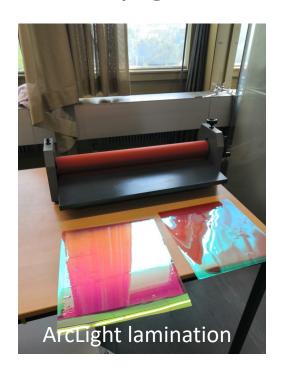
Building more modules (light and charge collection)



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ETA September 2021



Material ordered LBNL

ETA 2021 for one additional module Early CY 2022 for all modules







Top flange also serves as cryostat seal Will ship back to Bern as new modules arrive at FNAL



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G10 support ordered

DR8 resistive foil 50% delivered

End 2021/early 2022 with same technology

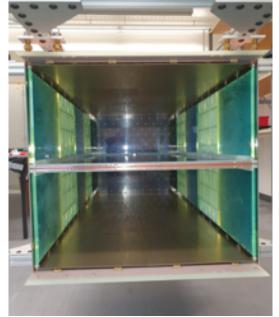
$u^{\scriptscriptstyle b}$

Module assembly and testing











ETA 1 week per module + 1 week checkout

Timeline defined by cooldown-warmup of testing setup

Readout & powering

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Several components: either ship what we have in Bern and duplicate for Bern; or wait for new copy and deliver to FNAL















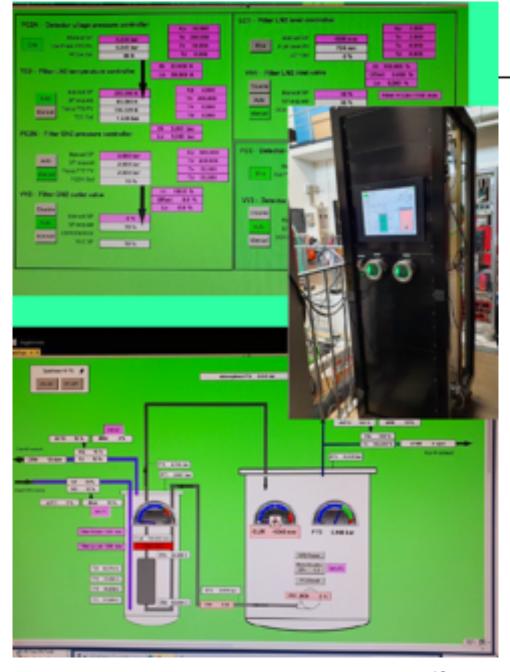
Light r/o

Readout and controls

Readout server (standard with ethernet)
Slow-control & PLC systems ready and used in Bern

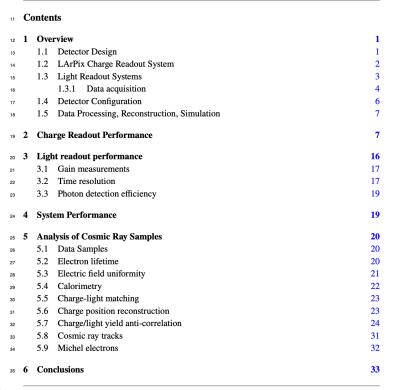
Will be shipped to FNAL A replica for Bern being built

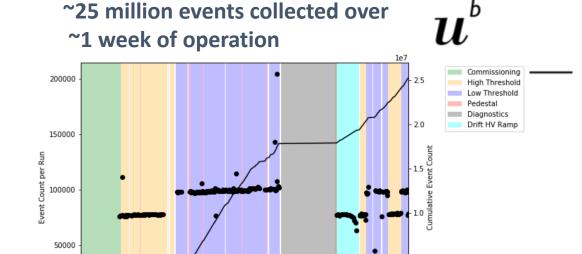




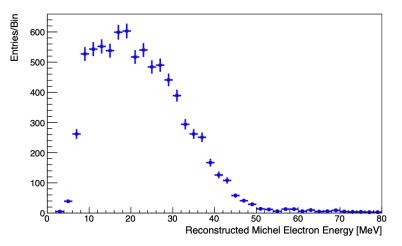
ArgonCube reconstrcution and analysis

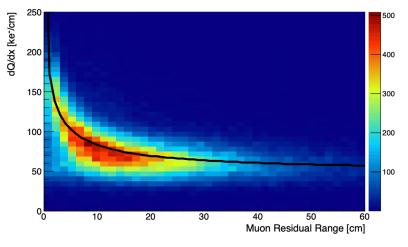
- Paper on analysis of Module-0 data
- Initial reconstruction of charge/light track/shower





High-stats stopping muon sample: Michel e- spectrum and muon energy loss.







End-to-end analysis by end CY 2021

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(Mini-)Workshop

- Integrate light+charge in simulation
- Complete reco chain: from basic (energy, light deposition) to high level (neutrino vertex/event) reco
- ML + conventional
- Neutrino + rock

| | | | | (wini-) workshop |
|-------------------------|--|--|---|---|
| [ML] Reco (2) | | Interfaces (1) | Light (1) | Pileup (1) |
| | Revisit numu CAF analysis | Truth matching | Basic light simulation integration | Revisit G4 |
| Read | | ND-LAr sample | | Adapt MicroBooNE |
| simulation | Revisit nu+e CAF analysis | Truth matching | algorithms | |
| M0 Data/MC | | CAr/MDD metabling | M0 Data/MC | Smeared Q + L |
| Full-chain on det. sim. | | GAR/MPD matching | Model tuning | analysis |
| raining | Revisit det. opt. | Model dist'n/VCS | Electronics sim | Integrate reco Q |
| nue reco | Implement numu | Q/L data model | Model tuning Light system Q/ position reco | Reco Q + smeared L analysis |
| | Implement nue | Metadata & DBs | | |
| nu+e reco | Implement | | | Optimization |
| Michel reco | hadron & mis-IDs | | M0 Data/MC | |
| | | | | |
| Documentation | | Documentation | Documentation | Documentation |
| | Read detector simulation M0 Data/MC n det. sim. raining nue reco nu+e reco Michel reco | Read detector simulation M0 Data/MC n det. sim. raining Revisit numu CAF analysis Revisit nu+e CAF analysis Revisit nu+e CAF analysis Revisit low-nu Revisit det. opt. Implement numu Implement nue Implement nue Implement hadron & mis-IDs | Read detector simulation Revisit numu CAF analysis Revisit nu+e CAF analysis MO Data/MC Revisit low-nu Revisit low-nu Revisit det. opt. Revisit det. opt. Model dist'n/VCS Implement numu Implement numu Implement numu Metadata & DBs ND-LAr sample production GAr/MPD matching GAr/MPD matching Model dist'n/VCS Umplement numu Long-term production strategy | Read detector simulation Revisit nume CAF analysis MO Data/MC Revisit nu+e CAF analysis n det. sim. Revisit low-nu Revisit det. opt. Implement numu Implement numu Implement numu Michel reco Revisit nu+e CAF analysis Revisit nu+e CAF analysis GAR/MPD matching MO Data/MC Model tuning Model tuning Light system Q/ position reco MO Data/MC Model tuning Light system Q/ position reco MO Data/MC |



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Summary

- 2x2 a main activity of the ND-LAr consortium
- Critical to record good quality NuMI neutrino data starting in Nov 2022, mission critical for DUNE
- Effort ongoing for 4+ years, internationally funded, getting to the final phase (neutrino beam)
- Most detector components in hand or can be assembled as needed
 - charge readout and field shell on critical path
- Analysis / reconstruction / simulation effort to ramp up for being ready on day-1