ND-LAr consortium
Biweekly general meeting

INTRO June 9th 2022

M. Weber
D. Dwyer

Upcoming events

- *June 13–17* FNAL Users Meeting
- *June 16–22* FNAL New Perspectives
  - Practice talk Livio Jun 10th, 9:15-CDT
- *June 27–29* ND-LAr PDR
  - See slides
- *July 6–13* ICHEP 2022
  - General poster, more ND-LAr related presentations being circulated
- *July 11–15* CD1RR
- *July 17–26* SNOWMASS

Volunteer for coordinating
talks/posters ?
Let Dan/Michele know

News 2x2

James and Louise join the 2x2 coordination team at FNAL (thank you !), in charge of the activities related to the modules

Together they bring many-year experience in developing, constructing and testing modules with the argoncube technology and on-site coordination for consortium students/postdocs

Ting and Jay to continue in their roles (thank you !!)

Tight coordination with consortium subsystems and in particular QA/QC (Mooney) [no parallel org-chart]

Overall 2x2 status

- Dedicated talk in the agenda today
- Separated several high-level "threads"
    - Cryostat, cryogenics, underground setup
        - Cryo system (connections, recirculation, filter) by external company, ETA Nov on-track
        - Underground area, Minerva, Racks, infrastructure good progress
    - Module-0
        - Rework (new module flange) underway, then goes through final QC
    - LArTF setup and module reception tests
        - Working on light-readout setup
    - Module assembly and cryo testing
        - 2 module completed and sent to FNAL, 2 modules to go (delay due to war)
- Goal is to finish module construction, shipping and testing by end September
    - Depends on geopolitical situation
    - Teams stretched in reviews

High level schedule and milestones (where does the PDR fit it ?)

31.3.2022

PDR Charge

The ND-LAr Consortium
is responsible for the design, prototyping, production, and assembly of the detector system,
while other organizations are responsible for the cryostat in which ND-LAr is deployed, the cryogenics required for its operation, the DUNE-PRISM system which moves the detectors transverse to the beam axis, and TMS.
ND-LAr must also integrate with ND-wide systems such as data acquisition and slow control, as well as the overall installation and integration effort.

The review will assess the preliminary design of ND-LAr in achieving its goals and its readiness to proceed to the final design phase. It should also assess the plans and activities of the consortium in relation to risk mitigation, prototyping, production, QA/QC, and integration and installation.

The review is run by the DUNE review office and technical coordination

Charge questions

1. Is there sufficient confidence that the preliminary design of ND-LAr will meet the technical requirements and performance specifications such that it achieves the primary goal of a LArTPC detector that performs comparably to DUNE FD in the high rate environment of DUNE ND?
2. Are interfaces adequately identified and documented at a level suitable for preliminary design, particularly with regard to:
    a. Maintaining adequate reconstruction capabilities for muons exiting the ND-LAr active volume?
    b. Installation and integration into the ND-LAr cryostat?
    c. Cabling and detector motion with DUNE-PRISM?
    d. Integration into the central data acquisition and slow controls?
3. Does the risk mitigation strategy suitably employ engineering and prototyping to address design challenges? In particular, does the prototyping plan leading to the construction and operation of a full scale module and the operation of multiple smaller modules in the "2x2" setup suitably address the major technical risks and inform the final design process?
4. Are codes and standards relating to engineering, ES&H, QA/QC suitably applied at this stage?
5. Is there adequate confidence on cost and schedule estimates to proceed to final design?
6. Have recommendations from previous reviews been adequately addressed and approved by the relevant authority?
7. Is the design maturity at a satisfactory level for this stage to recommend the ND-LAr Consortium to proceed to final design?

PDR June 27-28-29

ND-LAr held a dry-run in May 2021. One “day” per subsystem with drill-downs.

PDR = 3 days 9am-CDT to about 2pm-CDT (27-29 June)

Day 1: overview, simulation/analysis (design choices), system engineering (mech, mgmt, elec), module structure, field structure

Day 2: calibration, HV, charge readout, light readout

Day 3: A&T, I&I, prototyping, technical maturation, path to FDR

PDR

- Documentation in EDMS
  - https://edms.cern.ch/project/CERN-0000217521

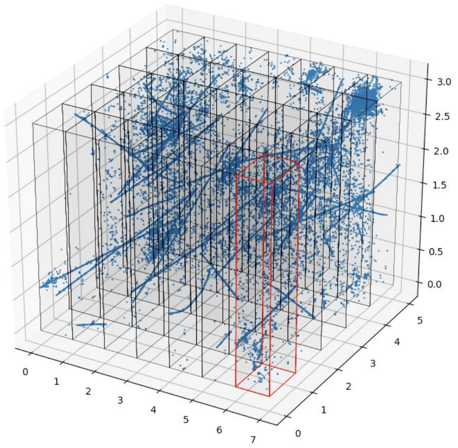
- Requirements
  - Flow down from DUNE requirements
  - Defines ND requirements

ND-O0	Predict the observed neutrino spectrum at the FD	With available external information, the ND must predict observables at the FD needed for the oscillation analysis in the presence of oscilllation effects	In combination with available external information, the long baseline analysis requires that we predict the number, spectrum, and flavor of neutrinos observed at the far detector, as well as backgrounds, along with any other information about these events that are used in the analysis.
ND-O1	Transfer measurements to the FD	Measurements at the ND must be transferable to the FD in order to minimize systematic uncertainties	The ND must be able to measure interactions on a Ar target, and furthermore transfer observables as they would be seen in the FD LArTPCs. The transfer must be performed accounting for uncertainties arising from detector modelling, including thresholds, efficiencies, purities, and resolution in the context of observables that are used in the far detector, the neutrino interaction model, the flux, as well as the differing operating conditions in the near and far site (cosmic rate, beam interaction rate/backgrounds, etc.).
ND-O2	Constrain the cross section model	Systematic errors from cross section modeling couple the FD response to the neutrino energy/flavor	The FD response couples the modelling of outgoing particles in nu-Ar interactions in terms of the mulitplicity, topology, and kinematics, to the ability to reconstruct these particles. The near detector must sufficiently measure and constrain the uncertainties in this modelling to minimize their impact on the oscillation measurement.
ND-O3	Measure the neutrino flux	The ND must verify and constrain the flux beyond what is achieved by ab initio modeling of the neutrino beam	The ab initio prediction of the neutrino flux is based on Monte Carlo simulation which has uncertainties arising from particle production, beam optics, operational variation, etc. that must be verified and constrained by the near detector. Secondary components of the flux give rise to irreducible backgrounds in the FD which must be constrained
ND-O4	Obtain measurements with different fluxes	The ND must verify that model predictions are robust with different neutrino fluxes	The flux and spectrum of neutrinos can be varied by moving the detectors off-axis or changing the horn currents. The near detector must verify that its model predictions and constraints are robust against these variations, which would otherwise give rise to degenerate tunings that bias the FD predictions and the resulting oscillation parameters.
ND-O5	Monitor time variations of the neutrino beam	The ND must detect potential variations in the neutrino flux	The flux and spectrum of neutrinos delivered by the beam can vary due to operational variations as well as unexpected

ND-LAr key requirements

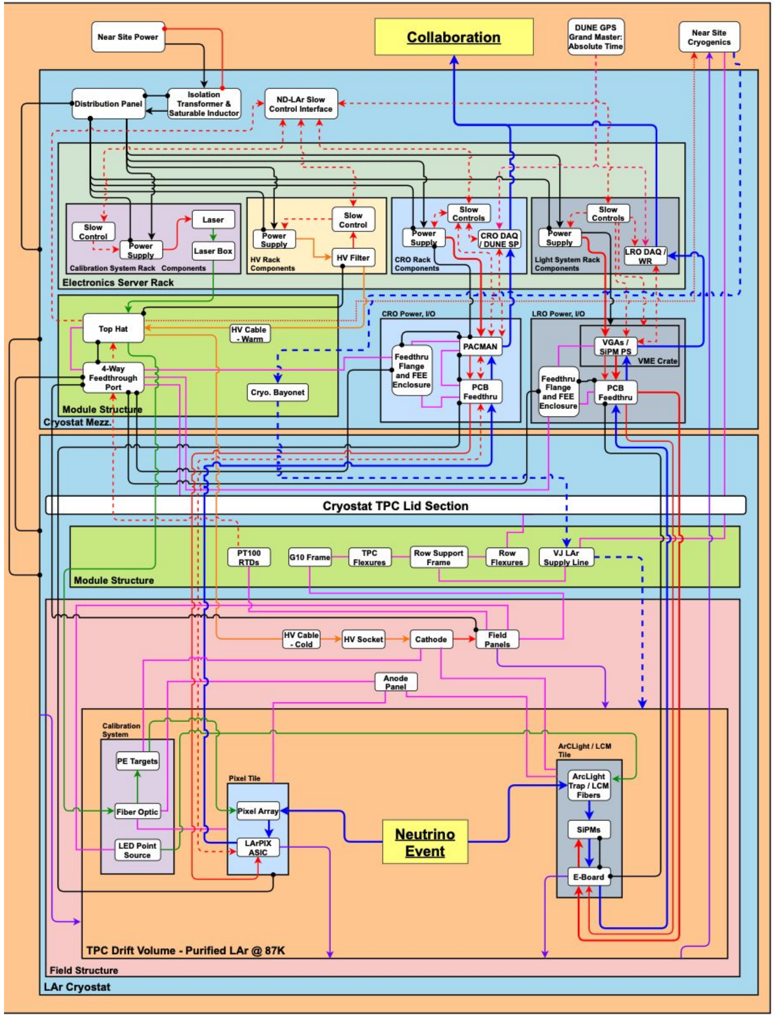
Examples first 5 (goes to SYS-023 and also extends to each subsystem, tot ~60)

SYS-001	ND LArTPC Fiducial Mass	The ND LArTPC shall provide >20 tons fiducial liquid argon target mass		To deliver the required statistical precision (<2%) for the measurement of neutrino-electron elastic scattering
SYS-002	ND LArTPC Active Size	The ND LArTPC active volume shall be ≥ 5 m in the beam direction, and ≥ 7 m x 3m in transverse directions		To sufficiently contain the ionization signal from beam neutrino interactions on argon, except for forward-going muons and energetic neutrons. The size is driven by maintaining sensitivity to the kinematic phase space of the cross-section, not by detector efficiency. Detector efficiencies as low as ~5% can be tolerated, as long as the detector is not blind to substantial (few-%) regions of the cross-section phase space.
SYS-003	Pileup Rejection Efficiency	The ND LArTPC shall be able to associate ionization signals to fiducial neutrino interactions with a purity, averaged over interactions, of > 97% by energy .		After the rejection of pileup, the residual pileup systematic uncertainties should be sub-dominant to other uncertainties in the prediction of the far detector signal based on near detector data.
SYS-004	3D Charge Imaging Accuracy	The ND LArTPC shall be able to associate ionization signals to fiducial neutrino interactions with completeness, averaged over interactions, of > 97% by energy .		Accurate 3D charge signal imaging is required in order to correctly associate charge depositions to their parent neutrino interactions in the high-pileup ND environment.
SYS-005	Charge-Light Signal Matching Efficiency	The ND LArTPC shall be able to associate scintillation light signal times to ionization signal clusters from fiducial neutrino interactions with an efficiency, averaged over interactions, of > 97% by energy .		Efficient matching of the charge signals with the fast (~ns-scale) light signals enable accurate discrimination of the charge signals from the approximately 50 neutrinos contributing to the charge signals per ~10us-wide beam spill.



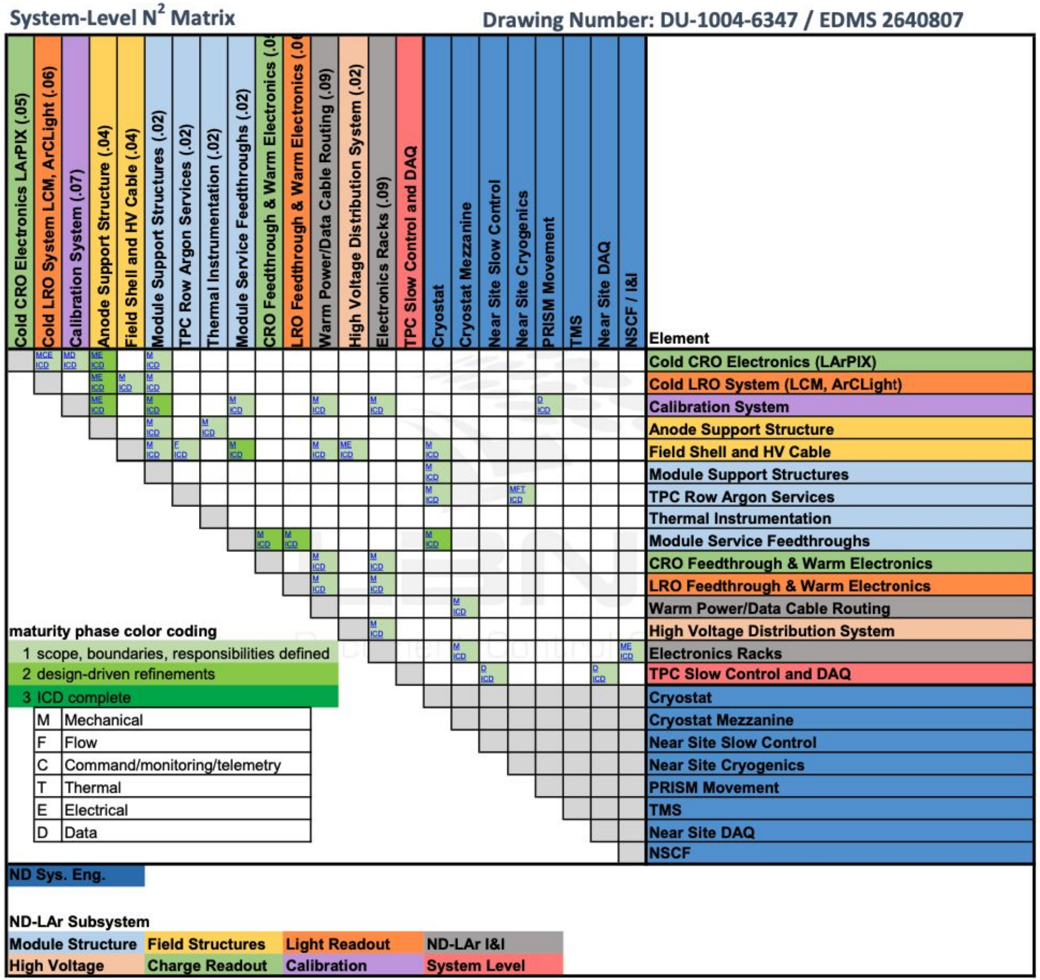
Internal system interfaces

- Documentation in EDMS
  - https://edms.cern.ch/project/CERN-0000217521
- System interface flow, interfaces
  - Overall flow diagram defined

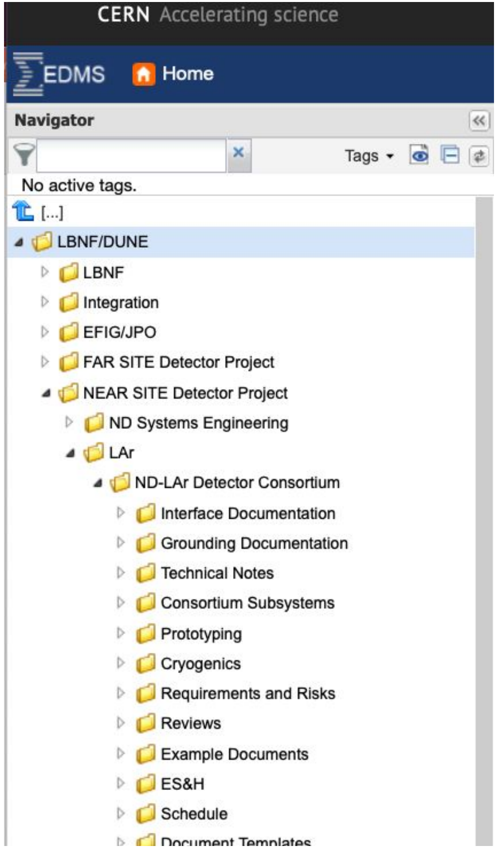


Interface matrix

Each box is a separate document listing the details, documentation, drawings of that interface



PDR



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Grounding Documentation
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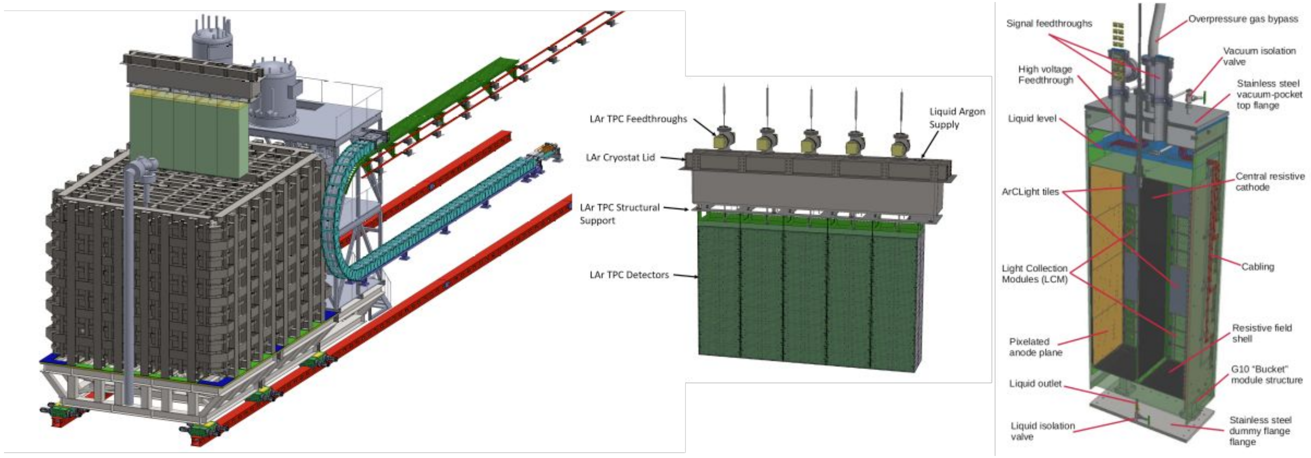
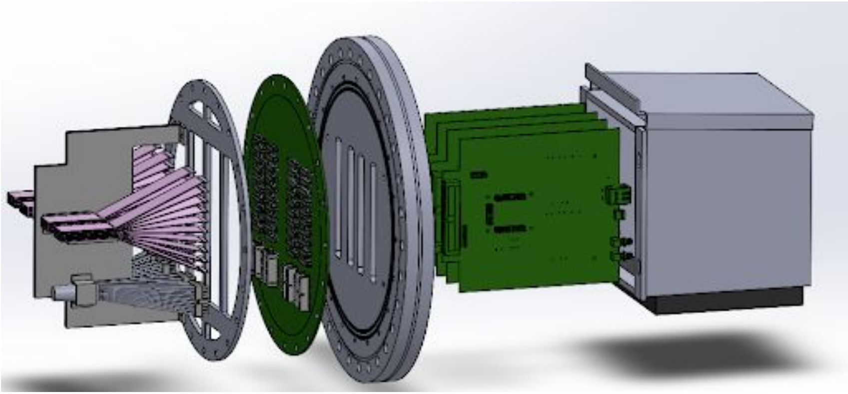
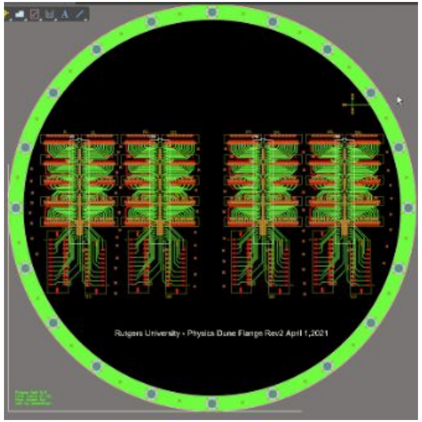
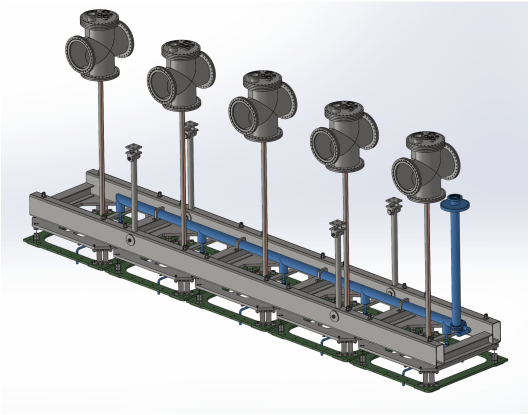


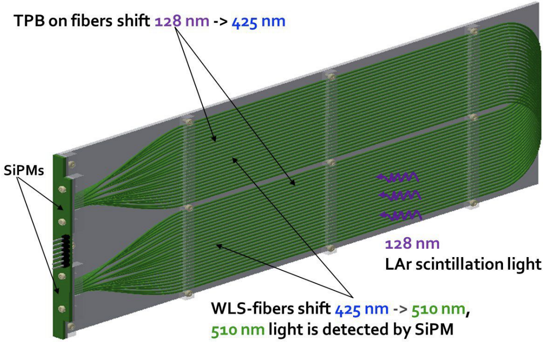
LAr TPC Feedthroughs
Liquid Argon Supply
LAr Cryostat Lid
LAr TPC Structural Support
LAr TPC Detectors
Signal feedthroughs
Overpressure gas bypass
Vacuum isolation valve
High voltage Feedthrough
Stainless steel vacuum-pocket top flange
Liquid level
Central resistive cathode
ArCLight tiles
Cabling
Light Collection Modules (LCM)
Resistive field shell
Pixelated anode plane
G10 "Bucket" module structure
Liquid outlet
Stainless steel dummy flange flange
Liquid isolation valve

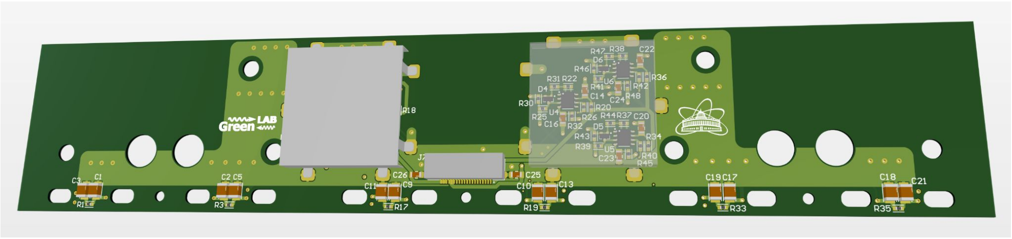
Full 3D CAD and electrical drawings



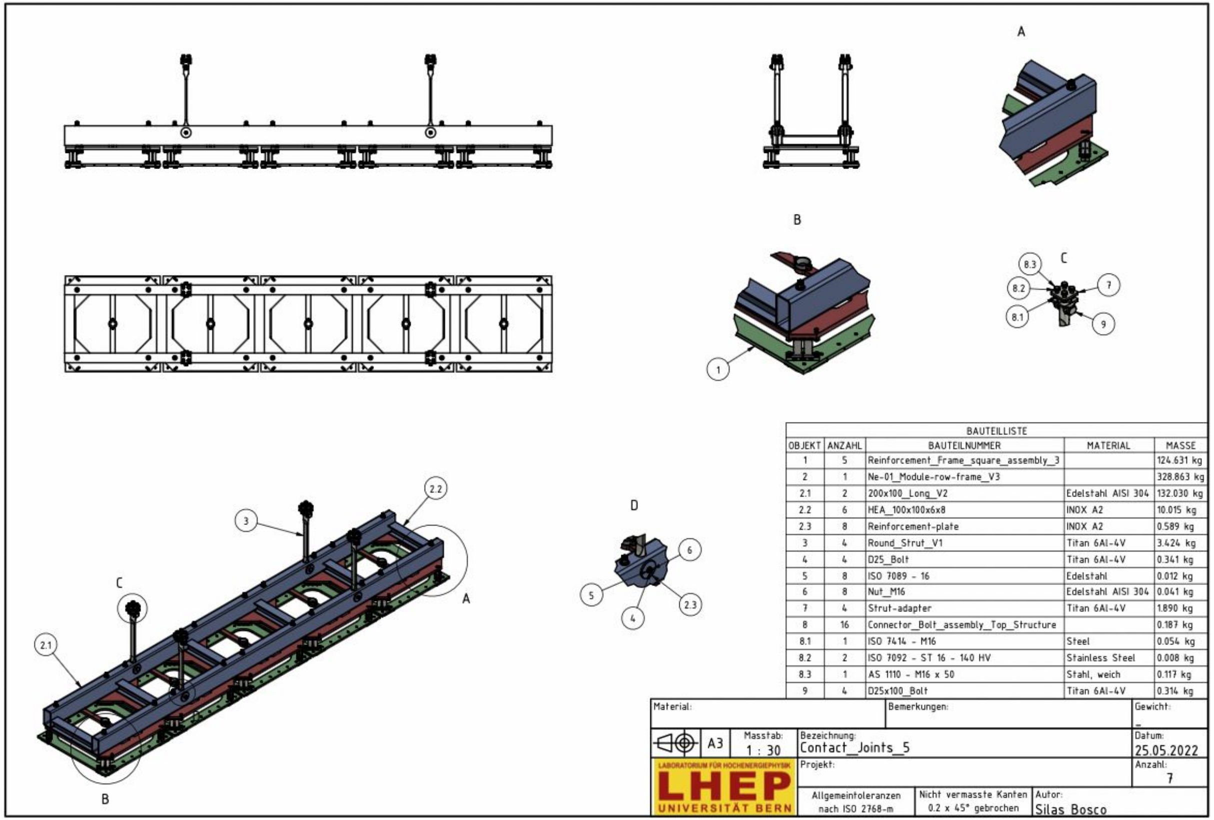






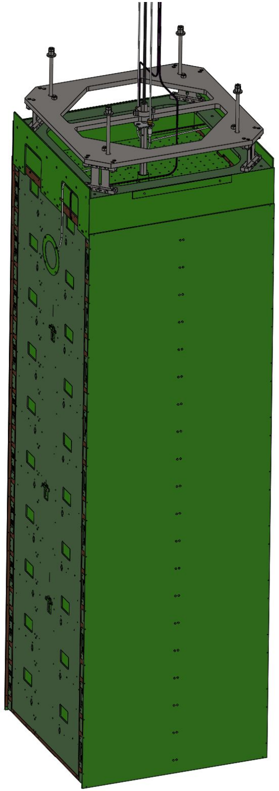


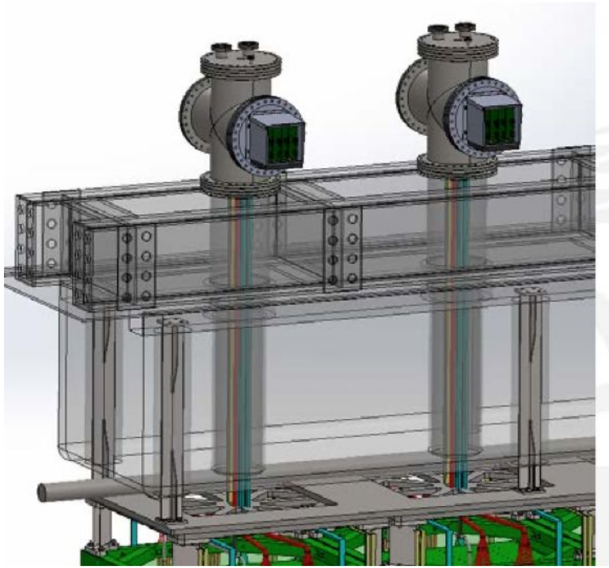
Parts engineered (example module strc=ucture)



BAUTEILLISTE				
OBJEKT	ANZAHL	BAUTEILNUMMER	MATERIAL	MASSE
1	5	Reinforcement_Frame_square_assembly_3		124.631 kg
2	1	Ne-01_Module-row-frame_V3		328.863 kg
2.1	2	200x100_Long_V2	Edelstahl AISI 304	132.030 kg
2.2	6	HEA_100x100x6x8	INOX A2	10.015 kg
2.3	8	Reinforcement-plate	INOX A2	0.589 kg
3	4	Round_Strut_V1	Titan 6Al-4V	3.424 kg
4	4	D25_Bolt	Titan 6Al-4V	0.341 kg
5	8	ISO 7089 - 16	Edelstahl	0.012 kg
6	8	Nut_M16	Edelstahl AISI 304	0.041 kg
7	4	Strut-adapter	Titan 6Al-4V	1.890 kg
8	16	Connector_Bolt_assembly_Top_Structure		0.187 kg
8.1	1	ISO 7414 - M16	Steel	0.054 kg
8.2	2	ISO 7092 - ST 16 - 140 HV	Stainless Steel	0.008 kg
8.3	1	AS 1110 - M16 x 50	Stahl, weich	0.117 kg
9	4	D25x100_Bolt	Titan 6Al-4V	0.314 kg

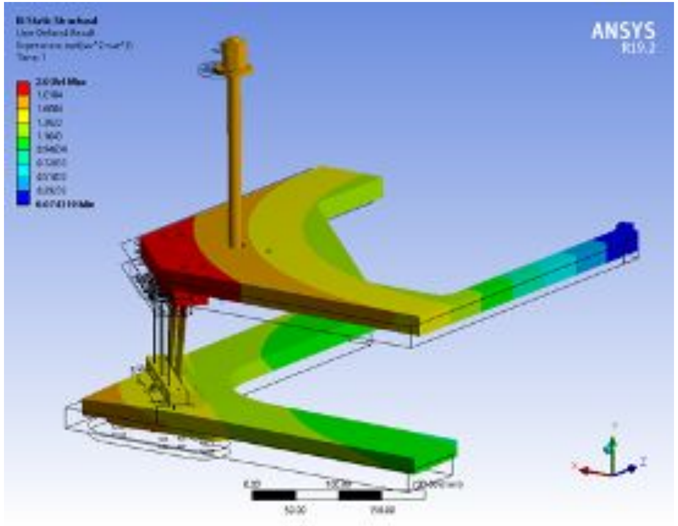
Fully integrated CAD





For some components (HV, actual prototypes available and tested)

FEA studies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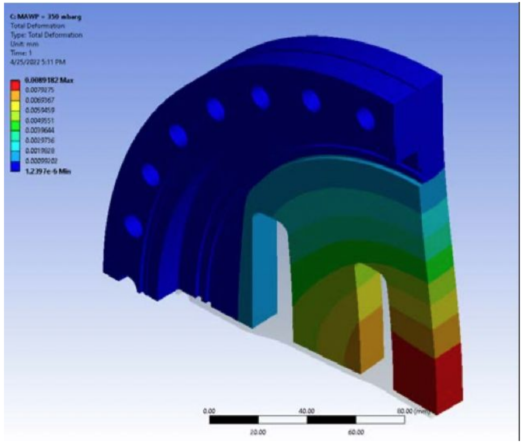
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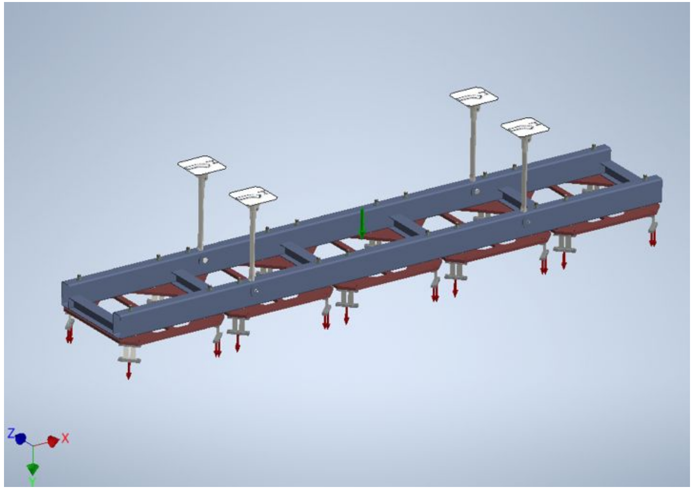

Agenda being prepared

DUNE: ND-LAr Preliminary Design Review

Jun 27 – 29, 2022
Remote
America/Chicago timezone

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Support

maxine@fnal.gov

ND-LAr, a ~100 ton LArTPC system, is a core element of the DUNE Near Detector (ND). The primary aim of its design is a neutrino detector that is functionally identical to the DUNE Far Detector (FD) LArTPCs with comparable performance in the high neutrino interaction rate environment of the DUNE ND hall. ND-LAr has a modular design consisting of a 7x5 array of 1x1x3 m3 units which provide independent dual charge drift regions with a pixelated charge detection scheme that also serve as isolated optical detection regions with tiled photon detection systems. A dedicated downstream muon spectrometer (TMS) supports ND-LAr in reconstructing muons which exit ND-LAr downstream.

The ND-LAr Consortium is responsible for the design, prototyping, production, and assembly of the detector system, while other organizations are responsible for the cryostat in which ND-LAr is deployed, the cryogenics required for its operation, the DUNE-PRISM system which moves the detectors transverse to the beam axis, and TMS. ND-LAr must also integrate with ND-wide systems such as data acquisition and slow control, as well as the overall installation and integration effort.

The review will assess the preliminary design of ND-LAr in achieving its goals and its readiness to proceed to the final design phase. It should also assess the plans and activities of the consortium in relation to risk mitigation, prototyping, production, QA/QC, and integration and installation. While the cryostat, DUNE-PRISM, TMS, data acquisition, and slow control are outside the scope of the consortium, interfaces should be suitably defined.

A conceptual design review of DUNE ND which included ND-LAr was conducted in July 2020. The ND-LAr consortium also held a PDR readiness review in May 2021.

Review Information
Review Home

Charge Letter

Starts Jun 27, 2022, 10:00 AM
Ends Jun 29, 2022, 1:00 PM
America/Chicago

Remote
Zoom

Dan Dwyer
Daniel Dwyer
Michele Weber

There are no materials yet.

Module-0 paper

Article

Performance of a modular ton-scale pixel-readout liquid argon Time Projection Chamber

DUNE Collaboration

† In memory of our colleague, Dr. Davide Salvatore Porzio, who is no longer with us.

Abstract: The Module-0 Demonstrator is a single-phase 600 kg liquid argon time projection chamber operated as a prototype for the DUNE liquid argon near detector. Based on the ArgonCube design concept, Module-0 features a novel 80k-channel pixelated charge readout and advanced high-coverage photon detection system. In this paper, we present an analysis of a eight-day data set consisting of 25 million cosmic ray events collected in spring 2021. We use this sample to demonstrate the imaging performance of the charge and light readout systems, as well as the signal correlations between the two. We also report argon purity and detector uniformity measurements, and provide comparisons to detector simulations.

Will be sent to DUNE APB, then DUNE review

Technical Design Document (PDReport)

Being prepared in parallel to the technical/engineering drawings

Will circulate to the consortium shortly

Please read and comment on MAJOR flaws and major presentation issues (language editing and figure fixes going on)

Deep Underground Neutrino Experiment (DUNE)

DUNE Near Detector

Preliminary Design Report (DRAFT)

ND-LAr Chapter

June 9, 2022

The DUNE Collaboration

THANK YOU !

A huge amount of work by the consortium

A huge amount of progress and documentation

Preliminary design review is an important step, thank you for all the work !