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## Status of 2x2 Installation at Fermilab

Jen Raaf January 19, 2023





#### **Overview**

- Installation of ND-LAr 2x2 in MINOS also requires infrastructure upgrades and other supporting systems work:
  - Upgrades
    - AC electrical
    - ODH fans & venting
    - Networking equipment
  - Supporting systems
    - MINERvA module installation & checkout
    - Mechanical support structures, access platform, & lifting fixtures
    - Cryogenics & monitoring
    - Racks & cable management
- Documentation for safety reviews



#### **Current Status**

- All MINERvA modules are
   installed and checked out
- Cryostat installed
  - Access platform placed, railings/steps in progress
  - Internal cryogenics installation planned to start soon
- Mod-0 & Mod-1
  - Reinserted in sleeves
  - Pulser tests in progress
- Mod-2 arrived at FNAL
- AC electrical work contract bid in progress
  - Procurement Dept. awards bid, then contractors do the work

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#### **Cryogenic Systems**

- DeMaCo portion of cryo system nearly ready for shipment
  - Most spools are finished and tested, remaining few will be finalized this week
  - Filter vessel passed cold test yesterday
- Delivery expected to Fermilab by ~end of February
- Fermilab portions of cryo system in progress
  - Major equipment procured: cryocoolers, chiller, vacuum pump, heater/vaporizer, gas analyzers
  - Additional small parts & equipment in procurement process now: piping, fittings, flanges, etc.
  - Engineering notes in progress for FNAL + DeMaCo systems

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### **Mechanical Support Structures**

- Cryostat access platform mostly installed (steps and railings in progress)
- Lifting fixtures (single-module and 4-module) designed, reviewed, built, and tested
- Procedures for modules insertion/extraction in progress







	۳	Title	Prerequi sites Start	Durati on End	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023
	•	1) Electrical Infrastructure	10/17/2	160 6/8/23	•								
		1.1) AC Distribution Liberado Work	2	d 2h									
		FILT) AC DISTIBUTION OPPRAGE WORK	12/1/22	2h									
		1.2) DC Distribution	12/1/22	70d 3/20/23		•							
		· 10) Deels kuilde	10/1/00	2h									
		► 1.3) Hack builds	12/1/22	2h 4/25/23		•							
		1.4) Underground installation of racks	4/19/23	36d 6/8/23							► Č	· · · ·	
		1.5) Network upgrade work	10/17/2	159 6/7/23	•			_					*
	_	2) Machanical Infrastructure	2	d 2h		_							
	•	2) Mechanica milastructure	12/1/22	d 2h		· · · ·							
		2.1) Finalize rack locations	12/2/22	1d 12/2/22									
		+ 2.2) Complete installation of MINERvA module	12/23/2	12/23/22			▲ ▲	- I					
		sets	2 2 1/3/23	10d 1/17/23									
		(incl. gates & steps)	2.2 1/3/23	100 1/17/20									
السلا		+ 2.4) Four-module lifting fixture ready for use	12/1/22	12/1/22			◆						
		▶ 2.5) Cable trays	1/18/23	78d 5/5/23				► Ű					
Ο		<ul> <li>2.6) Condenser support structure</li> </ul>	12/2/22	45d 2/13/23				_					
		2.7) Oil containment for HV filter box	12/2/22	15d 12/22/22									
			12/2/22	d									
_		2.9) ODH fan upgrade work	12/2/22	138 6/26/23		)							
	_	2) Chioganic Systems	10/1/00	d		_							
	•	3) Gryogenic Systems	12/1/22	d 2h		•							
		3.1) Receive Demaco system	2/24/23	2/24/23					•				
I		<ul> <li>3.2) Internal cryogenics</li> </ul>	12/2/22	51d 2/21/23		•							
		<ul> <li>3.3) Condenser and VJ Transfer Lines</li> </ul>	12/1/22	60d 3/6/23 2h		•	9						
		3.4) Install/interface with Demaco system	12/2/22	87d 4/12/23		•							
		<ul> <li>3.5) Gas Analyzer System</li> </ul>	12/2/22	70d 3/20/23		•							
		<ul> <li>3.6) Cryostat vacuum system</li> </ul>	12/2/22	79d 3/31/23		•					<b></b>		
Ο		<ul> <li>3.7) Other feedthrough work</li> </ul>	12/2/22	75d 3/27/23		•	•						
		<ul> <li>3.8) Controls</li> </ul>	12/2/22	88d 4/13/23		•	•						
7		<ul> <li>3.9) Cryostat &amp; misc venting and ODH (non- FESS)</li> </ul>	12/2/22	120 5/30/23 d		•							
•		<ul> <li>3.10) Water cooling system</li> </ul>	2/21/23	15d 3/13/23					▶ <b>(</b>				
		3.11) Instrument Air system	2/28/23	21d 3/28/23					•				
$\cdot$		▶ 3.12) LAr Fill Manifold	3/8/23	64d 6/6/23						► Ŭ			
	•	4) Modules	12/2/22	77d 3/29/23		•							
		4.1) Module-0	12/2/22	33d 1/26/23									
V		<ul> <li>4.2) Module-1</li> <li>4.3) Module-2</li> </ul>	1/10/23	16d 2/2/23									
			1/10/20	2h									
		▶ 4.4) Module-3	2/13/23	14d 3/3/23					▶ [				
		<ul> <li>4.5) Install ponchos for water protection</li> </ul>	1/12/23	5d 1/19/23									
Ο		during transport											
Ā		<ul> <li>4.6) Design 4-module alignment &amp; support structure (potentially external designer?)</li> </ul>	1/12/23	1d 1/12/23				0					
U		4.7) FNAL engineer reviews design of 4-	4.6 1/13/23	1d 1/13/23				Ŭ_					
		module alignment and support structure						- 7					
		<ul> <li>4.8) Build alignment and support structure (80/20)</li> </ul>	4.7 1/17/23	1d 1/17/23				0					
		4.9) Design 4-module top plate support for	1/12/23	1d 1/12/23				0,					
		seal surface preparation (potentially											
<b>U</b>		• 4.10) Review alignment and support structure	4.9 1/13/23	1d 1/13/23				ň					
		<ul> <li>4.11) Build 80/20 alignment and support</li> </ul>	4.10 1/17/23	1d 1/17/23									
		structure											
		<ul> <li>4.12) Four 2x2 modules ready for transfer underground</li> </ul>	4.1.6, 3/3/23 2.4.	3/3/23									
			4.2.7,										
			4.3.0, 4.4.5,										
			4.5										
າ∪າ		<ul> <li>4.13) Module transfer to underground</li> <li>4.14) Module installation in succession</li> </ul>	12/2/22	68d 3/16/23		•							
202		4.14) Module Installation in cryostat	1/12/23	490 3/22/23						1			
		<ul> <li>4.15) Underground 4-module testing in cryostat</li> </ul>	1/12/23	540 3/29/23									

#### Milestones (1<sup>st</sup> draft – not final)

Title	Prerequi sites Start	Durati on End		Dec 2022	Jan 20	23	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023
<ul> <li>1.1.2) Submit AC distribution upgrade work Description of Work</li> </ul>	1.1.1 12/13/2 2	12/13/22		•							
• 1.1.6) AC distribution upgrade work completed	1.1.5 4/18/23	4/18/23							<b>\</b>		
<ul> <li>1.2.3) Complete LArTF testing of DC distribution</li> </ul>	1.2.2 1/31/23	1/31/23									
<ul> <li>1.2.7) DC Distribution system ready for underground installation</li> </ul>	1.2.6, 3/20/23 1.2.5	3/20/23						<b>.</b>			
<ul> <li>1.3.4) Delivery of VME crates</li> </ul>	2/24/23	2/24/23					•				
<ul> <li>1.3.12) Racks ready to move underground</li> </ul>	1.1.6- 4/5/23 10d, 1.2.7, 1.3.11	4/5/23							•		
<ul> <li>2.2) Complete installation of MINERvA module sets</li> </ul>	12/23/2 2	12/23/22		•							
2.4) Four-module lifting fixture ready for use	12/1/22	12/1/22		•				_			
<ul> <li>2.6.4) Condenser support structure ready to install</li> </ul>	2.6.3 2/13/23	2/13/23					•				
<ul> <li>2.7.3) Oil containment for HV filter box ready to install</li> </ul>	2.7.2 12/22/2 2	12/22/22		•							
<ul> <li>2.9.11) ODH fan upgrade complete</li> </ul>	2.9.10 6/26/23	6/26/23									•
3.1) Receive Demaco system	2/24/23	2/24/23					•				
<ul> <li>3.2.6) Pump and internal piping installation completed</li> </ul>	3.2.4, 2/21/23 3.2.2.4 , 3.2.5	2/21/23					•				
<ul> <li>3.3.1) Receive Cryomech documentation for cryocoolers &amp; condenser (have 50%)</li> </ul>	12/1/22	12/1/22	<	•							
3.3.8) Condenser system installation complete	3.3.6, 3/6/23 3.3.7	3/6/23						•			
3.4.5) Demaco system installation complete	3.4.3, 4/12/23 3.4.4	4/12/23							•		
3.5.6) Gas analyzer system complete	3.5.3, 3/20/23 3.5.5, 3.5.4	3/20/23						•			
<ul> <li>3.6.5) Cryostat vacuum system installation complete</li> </ul>	3.6.4 3/31/23	3/31/23									
3.8.5) Controls system installation complete	3.8.4 4/13/23	4/13/23							•		
<ul> <li>4.1.6) Mod-0 ready for installation</li> </ul>	4.1.5 1/26/23	1/26/23						_			
<ul> <li>4.2.7) Mod-1 ready for installation</li> </ul>	4.2.6 1/27/23	1/27/23						_			
<ul> <li>4.3.1) Receive Mod-2 at FNAL</li> </ul>	1/10/23	1/10/23			•						
<ul> <li>4.3.6) Mod-2 ready for installation</li> </ul>	4.3.5 2/2/23	2/2/23				<	•	_			
<ul> <li>4.4.1) Receive Mod-3 at FNAL</li> </ul>	2/13/23	2/13/23					•				
<ul> <li>4.4.5) Mod-3 ready for installation</li> </ul>	4.4.4 3/3/23	3/3/23						•			
<ul> <li>4.12) Four 2x2 modules ready for transfer underground</li> </ul>	4.1.6, 3/3/23 2.4, 4.2.7, 4.3.6, 4.4.5, 4.5	3/3/23						•			

#### Converging to the finish line: "ready to fill"

- Still optimizing tasks in this draft schedule
  - Likely some things can be a bit more parallelized
  - Need to better understand the dependencies/connections between the major areas (Electrical, Mechanical, Cryo, Modules)
- Some task timelines are outside control of the 2x2 project team
  - ODH upgrade work
  - AC distribution upgrade work
- External constraints on timeline are still under negotiation, but we're probably not going to shave an entire month or more off of the schedule

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#### **Considerations**

- Pumps require maintenance every 5000 hours (~6-7 months)
  - To do maintenance work on our internal pump
    - All 2x2 modules would need to be removed
    - Some of the cryo piping above the vessel platform must also be removed in order to remove the modules
- If we don't manage to get the "ready to fill" schedule moved significantly earlier in time, we may not be ready for beam before the shutdown (or may only be able to operate for a short time before the shutdown starts)
  - Given the pump maintenance schedule, it is worth considering whether it makes more sense to wait until partway through the shutdown before filling and turning on the pump
  - Commissioning plan? Would that take 3 months?

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#### Getting to "ready for beam data"

- A major missing item is DAQ
  - Currently 3 independent systems:
    - MINERvA DAQ
    - 2x2 Light Readout
    - 2x2 Charge Readout
  - Ideally, we will make a unified system using DUNEDAQ
    - Dedicated DAQ/ND-LAr session at DUNE collaboration meeting next week
    - Need more people involved with this effort!

#### Summary

- Moving forward in all 4 major areas to get to "ready to fill"
- DeMaCo system expected to arrive in ~1 month
- Many activities in parallel!
  - Thanks to collaborators who have been helping with module checkout, etc. at Fermilab
  - Next big need for collaboration help will likely be in cabling up underground & developing commissioning/calibration plan

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#### **Additional Slides**





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### Layouts: Floor Footprint (below Catwalk)

# ArgonCube

#### DUNE-doc-23244





## Layouts: Footprint for above Catwalk DUNE-doc-23244



#### Layouts: Rack Layout DUNE-doc-23244





## Layouts: Cryostat Port Assignment DUNE-doc-23308





List of feedthroughs Labels for modules: A, B, C and D

Summary of cryostat ports:

- Sizing for large ports: 2, 4 and 8 (Port 6 unusable)
  - Nozzle inner diameter (ID): 5.91" (150 mm)
  - Flange: 8" OD CF (DN160CF)
  - Height: 5.80"
- Sizing for small ports: 1, 3, 5 and 7
  - Nozzle inner diameter (ID): 4.02" (102 mm)
  - Flange: 6" OD CF (DN100CF)
  - Height: 4.53"
- Labels/Usage (List of feedthroughs):
  - 1: Cryostat Vent [Demaco]
  - 2: Instrumentation (FNAL to integrate all together: Liquid Level Probe [Demaco], Temperature [Bern], Pump Electrical Line & Pressure [FNAL], etc.)
  - 3: LAr Pump Discharge [Demaco]
  - 4: Purity Monitor [FNAL]
  - 5: LAr Pump Suction [Demaco] / Condenser Return [FNAL]
  - 7: Cryostat Boil-off Gas Collection [FNAL]
  - 8: Cryostat Safety Relief Valve [FNAL]

#### The status of feedthroughs 2, 4, 5, 7 & 8 will be covered by M.Z. presentation (?).

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### Status Update: Cryogenic Equipment Procurement



Equipment/Service	Status
<u>1.8 kW cryocoolers</u> (Cryomech AL600), condenser and other ancillary components (custom design by Cryomech)	PO #679663, Received
Water chiller (Haskris R1600)	PO #680020, Received
Vacuum pumping station (Pfeiffer Vacuum, P/N: PM S48 811 00)	PO #679749, Received
Cryostat safety relief valve (Anderson Greenwood 9300H low pressure pilot operated relief valve, P/N: 9390HP03RSTTHHM)	PO #680598, Received
Heater and <u>Vaporizer</u>	Recycle from PC4
Gas analyzers	PR #336649 submitted in Sep. 2022; PO #xxxxx, Estimated Delivery by Jan. 2023 (?)
Purity monitor feedthrough and its readout electronics	In progress
Vent Line	Most parts available onsite; In progress
Implementation of ODH measures (including exhaust fan replacement)	Working with ISD; In progress
LAr filter vessel (Univ. of Bern/Demaco Deliverables)	Delivery Estimate by Jan/Feb 2023
Argon transfer lines (Univ. of Bern/Demaco Deliverables)	Delivery Estimate by Jan/Feb 2023
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#### **Status Update: Mechanical Installation**



#### As of Dec. 5, 2022



A collection of pictures associated with installation activities for DUNE ND-LAr Demonstrator prototype test stand in MINOS (ArgonCube 2x2) in the following link: <u>https://photos.app.goo.gl/P1eCuaYacsv22N3C7</u>

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#### **Cable Management**



- A preliminary plan for main cable trays is shown.
- Issues: As-built designs are somewhat different from the CAD model. A lot of details still need to be worked out.



#### **High-voltage Cable Routing and Protection**



## **Remaining mechanical work: resource plan**



- Remaining mechanical work (and, also as cryogenic/electrical installation support):
  - Design, construction and installation of condenser support on the cryostat access platform (target completion in Mar/Apr).
  - Oil containment for High-voltage filter box in compliance to FESHM.
  - Infrastructure design and installation for purity monitor (PM).
  - Design, construction and installation of main cable trays.
  - Installation of cryogenic equipment and piping, and its support structures as needed.
  - Support for rack move from LArTF and rack installation in the cavern.
  - Module transfer to the underground cavern (a baseline concept exists and being communicated with consortium).
  - Final clean up of cryostat internal surface; module insertion to the cryostat.
  - Support for safety reviews of sub-systems.
  - Support for safety reviews of work plan.
  - Readied for Operational Readiness Clearance (ORC) reviews and safety walk-throughs when all the system is installed.
  - Establishing a plan for Initial fill with portable 160 liter LAr dewars involving relevant experts; delivery of more than 60 dewars in elevator from the surface to the underground cavern.

## Layouts: Module Port Assignment



#### DUNE-doc-23308



List of feedthroughs Labels for modules: A, B, C and D Summary of module ports:

- $\circ~$  Sizing for large ports: a, b, c and d
  - Nozzle inner diameter (ID): 2.83" (72 mm)
  - Flange: 4.625" OD CF (DN75CF)
  - Height: 3.15" (80 mm)
- Sizing for small ports: e
  - Nozzle inner diameter (ID): 1.40" (35 mm)
  - Flange: 2.75" OD CF (DN35CF-DN40CF)
  - Height: 4.79" (122 mm)
- Sizing for vacuum port: f
  - Nozzle inner diameter (ID): 0.63" (16 mm)
  - Flange: 1.33" OD CF (DN16CF)
  - Height: 1.08" (27 mm)
- Labels/Usage (List of Feedthroughs):
  - a, c: Signal (Charge/Light) Feedthroughs
  - b: Liquid Return [Demaco]
  - d: Instrumentation Control (RTDs [Bern])
  - e: High-voltage [SLAC]
  - f: Module top flange vacuum



#### Layouts: Cryostat Entry/Exit Ladder





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#### **Layouts: Side View from East**



#### Layouts: Side View from North



#### Layouts: Side View from South









#### **Design of Cryostat Transfer Cart**



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#### **Design of Cryostat Transfer Cart (continued)**



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