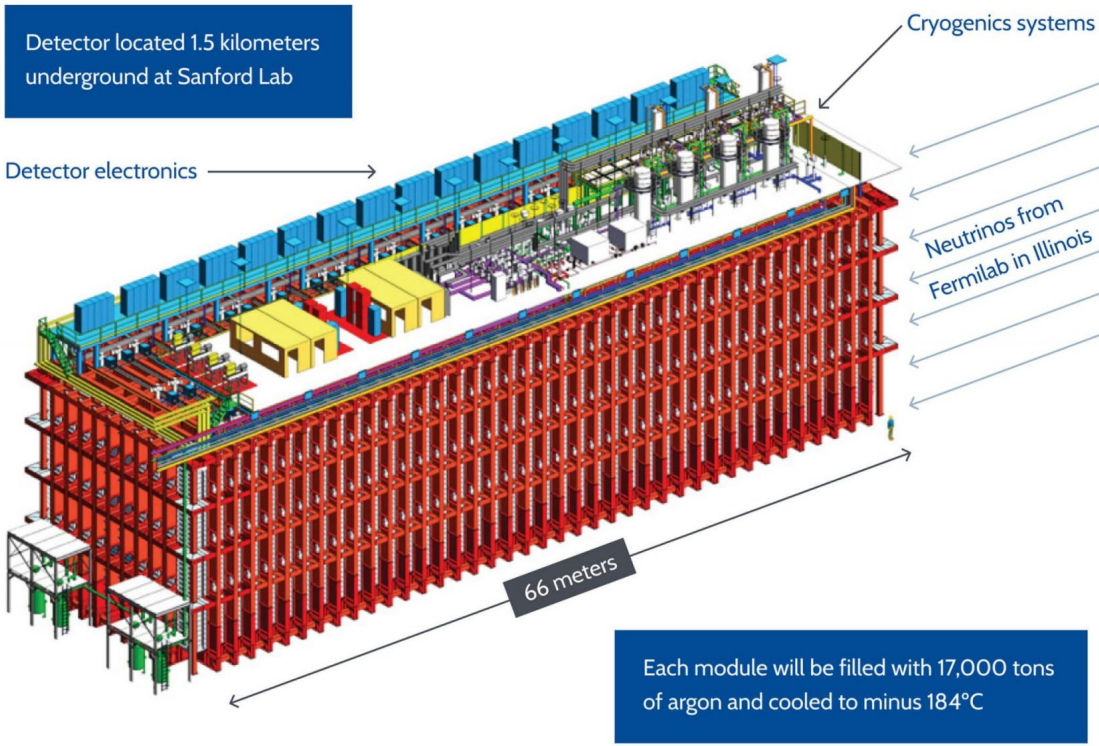
Schedule and Financial Constraints

13 April 2022
DUNE FD2 PDS - BNL CE Workshop
Ryan Rivera & Flavio Cavanna

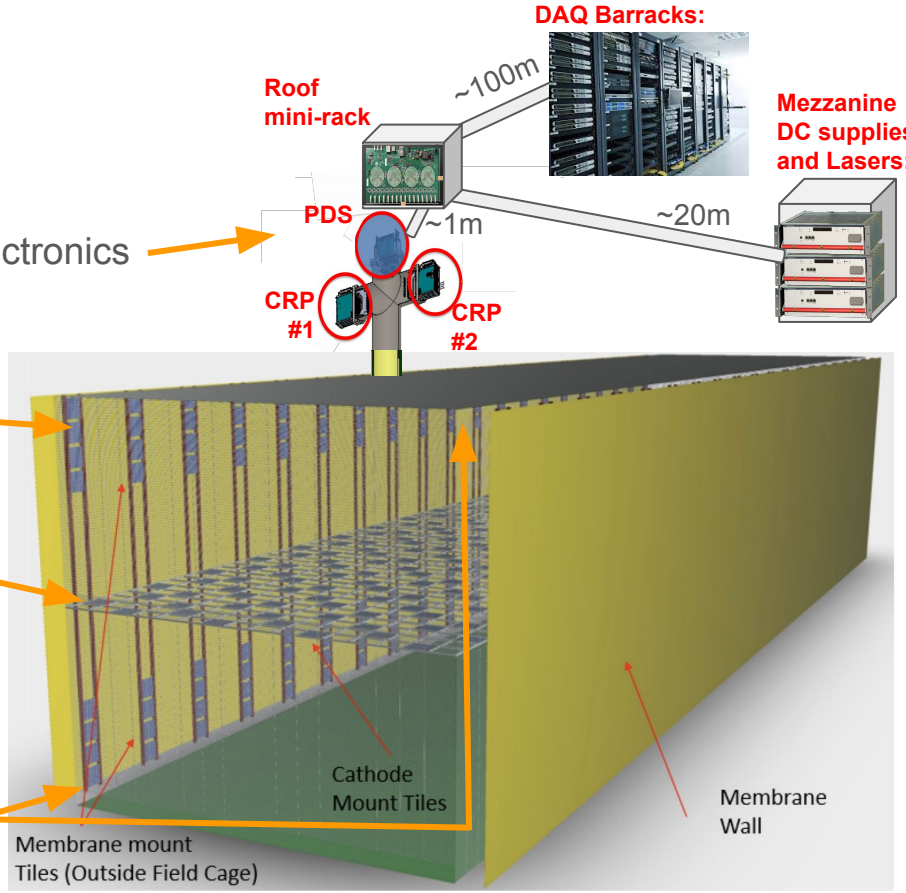
Motivation

- Far Detector cold electronics sit in Liquid Argon at 80K
- Target 30-year Operation



PDS Scope

1. Warm electronics
2. Membrane-mounted modules
3. Cathode-mounted modules
4. Response & monitoring system



2022 and Beyond (Note PDS Cold Box naming A, B, C, D)

Parasitic ARIADNE run run complete!

Cold Box A Uninstalled 04 April; PDS install is 18 April 2022

Preliminary Design Review (PDR) is 1st week of May 2022

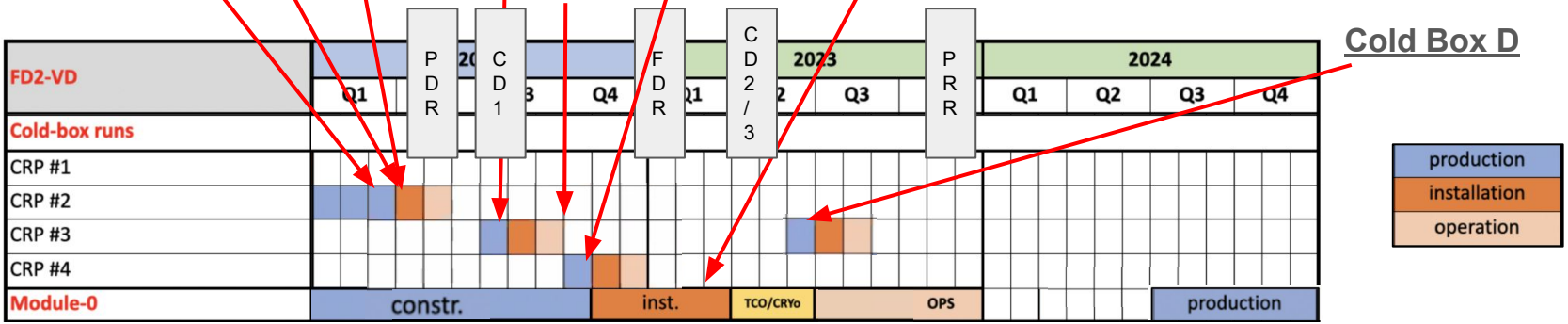
Cold Box B PDS install is July 2022

Cold Box C PDS install is October 2022

FD2 PDS Module-0 install thru March 2023

Cold Box D

Cold Box B+



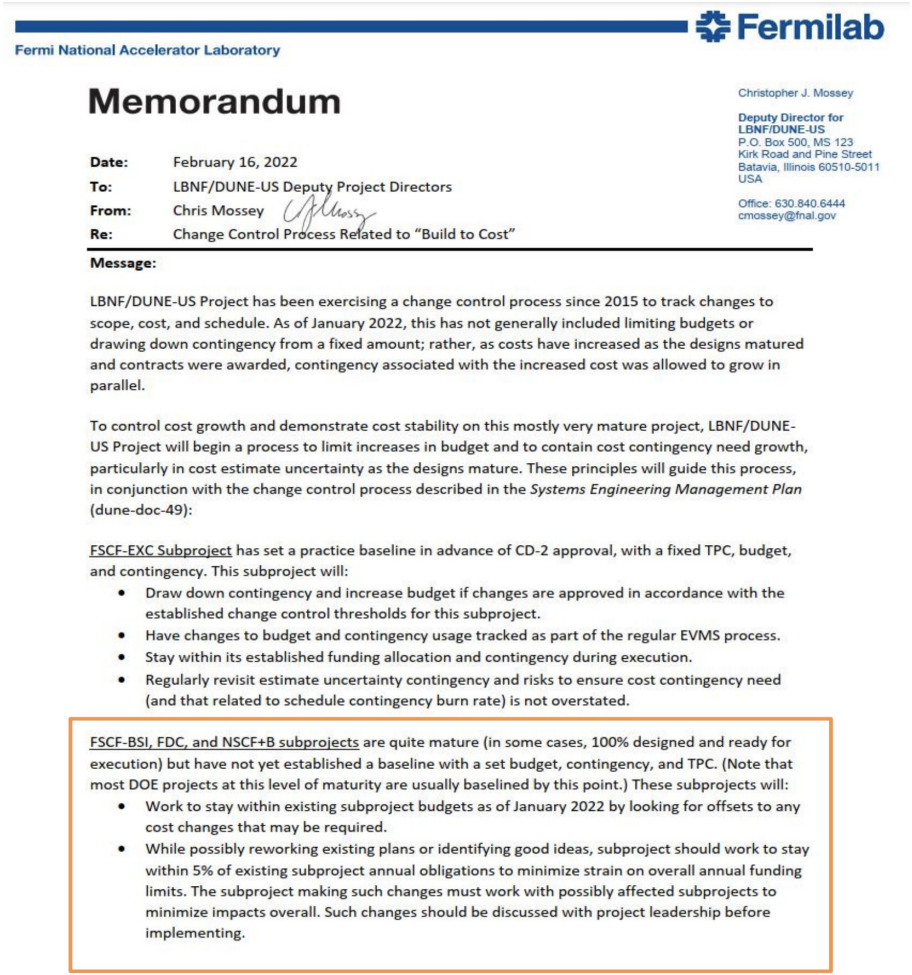
Far site installation

- April 2026
  - Warm Electronics installation starts
  - X-ARAPUCA receiving starts
- April 2027
  - Cathode module installation starts into Cathode
  - Feedthroughs, fibers, cables installed
  - Membrane module installation start into Cryostat
- November 2027
  - Commissioning complete

Scope Split with EU/Brazil

Core M&S/Labor Line Item	Cathode	Membrane
Production SiPMs w/9% spare	EU/Brazil	EU/Brazil
Production Dichroic Filters w/9% spare	EU/Brazil	EU/Brazil
Production WLS plates w/9% spare	EU/Brazil	EU/Brazil
Production Warm Electronics w/9% spare	EU/Brazil	EU/Brazil
Production Support Structure Mechanics	US	EU/Brazil
Production Monitoring System w/9% spare	US	EU/Brazil
Production xARAPUCA mechanics w/9% spare	US	US
Production Cold Electronics w/9% spare	US	US
Production Power-over-Fiber w/9% spare	US	-
Production fibers/cables/flanges w/9% spare	US	EU/Brazil
module-0 SiPMs w/20% spare	EU/Brazil	EU/Brazil
module-0 Dichroic Filters w/20% spare	EU/Brazil	EU/Brazil
module-0 WLS w/20% spare	EU/Brazil	EU/Brazil
module-0 Warm Electronics w/20% spare	EU/Brazil	EU/Brazil
module-0 Monitoring System w/20% spare	US	EU/Brazil
module-0 xARAPUCA mechanics w/20% spare	US	US
module-0 Cold Electronics w/20% spare	US	US
module-0 Power-over-Fiber w/20% spare	US	-
module-0 fibers/cables/flanges w/20% spare	US	US

DOE ‘Build to Cost’ policy:



Fermi National Accelerator Laboratory

Fermilab

Memorandum

Christopher J. Mossey
Deputy Director for LBNF/DUNE-US
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Kirk Road and Pine Street
Batavia, Illinois 60510-5011
USA
Office: 630.840.6444
cmossey@fnal.gov

Date: February 16, 2022
To: LBNF/DUNE-US Deputy Project Directors
From: Chris Mossey
Re: Change Control Process Related to “Build to Cost”

Message:

LBNF/DUNE-US Project has been exercising a change control process since 2015 to track changes to scope, cost, and schedule. As of January 2022, this has not generally included limiting budgets or drawing down contingency from a fixed amount; rather, as costs have increased as the designs matured and contracts were awarded, contingency associated with the increased cost was allowed to grow in parallel.

To control cost growth and demonstrate cost stability on this mostly very mature project, LBNF/DUNE-US Project will begin a process to limit increases in budget and to contain cost contingency need growth, particularly in cost estimate uncertainty as the designs mature. These principles will guide this process, in conjunction with the change control process described in the *Systems Engineering Management Plan* (dune-doc-49):

FSCF-EXC Subproject has set a practice baseline in advance of CD-2 approval, with a fixed TPC, budget, and contingency. This subproject will:

- Draw down contingency and increase budget if changes are approved in accordance with the established change control thresholds for this subproject.
- Have changes to budget and contingency usage tracked as part of the regular EVMS process.
- Stay within its established funding allocation and contingency during execution.
- Regularly revisit estimate uncertainty contingency and risks to ensure cost contingency need (and that related to schedule contingency burn rate) is not overstated.

FSCF-BSI, FDC, and NSCF+B subprojects are quite mature (in some cases, 100% designed and ready for execution) but have not yet established a baseline with a set budget, contingency, and TPC. (Note that most DOE projects at this level of maturity are usually baselined by this point.) These subprojects will:

- Work to stay within existing subproject budgets as of January 2022 by looking for offsets to any cost changes that may be required.
- While possibly reworking existing plans or identifying good ideas, subproject should work to stay within 5% of existing subproject annual obligations to minimize strain on overall annual funding limits. The subproject making such changes must work with possibly affected subprojects to minimize impacts overall. Such changes should be discussed with project leadership before implementing.

P6 WBS

Far Detectors + FS Cryogenic Infrastructure

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float
131.FDC	Far Detectors + FS Cryogenic Infrastructure	2574.0d	30-May-19	01-Oct-29	433.1d
131.FDC.01	FDC PM	2574.0d	30-May-19	01-Oct-29	309.1d
131.FDC.03	Far Detector 2 (FD2)	2158.0d	01-Mar-21	01-Oct-29	433.1d
131.FDC.03.01	FD2 Project Management	1949.0d	01-Mar-21	30-Nov-28	642.1d
131.FDC.03.02	FD2 Charge Readout Units (CRU)	1505.0d	01-Oct-21 A	30-Sep-27	935.1d
131.FDC.03.03	FD2 Charge Readout Plane (CRP)	1546.5d	01-Oct-21 A	01-Dec-27	893.6d
131.FDC.03.04	FD2 Top Drift Electronics (TDE)	1999.0d	01-Oct-21 A	01-Oct-29	308.1d
131.FDC.03.05	FD2 Bottom Drift Electronics (BDE)	1951.0d	01-Oct-21 A	12-Jul-29	365.1d
131.FDC.03.06	FD2 High Voltage (HV)	1842.0d	14-Jun-21 A	29-Sep-28	597.1d
131.FDC.03.07	FD2 Photon Detector System (PDS)	1862.0d	03-May-21	29-Sep-28	684.1d
131.FDC.03.07.01	PDS Management	1756.0d	01-Oct-21 A	29-Sep-28	684.1d
131.FDC.03.07.02	PDS R&D	763.0d	03-May-21	15-May-24	129.2d
131.FDC.03.07.03	Cathode PDS	854.1d	16-May-24	11-Oct-27	173.9d
131.FDC.03.07.05	Membrane PDS	872.3d	16-May-24	04-Nov-27	155.7d

Responsibility Matrix (1 of 3)

- All 2022 SOWs have been written (most are established)
- 2023 SOWs should be written in July-August 2022 timeframe
- 2024 SOWs will be for Production (i.e., junior technicians/engineers)

Responsibility Matrix (2 of 3) [link]

Breakout Meetings / Tasks / Subtasks Activity Matrix	Flavio Cavanna	Min Jeong Kim	Paul Rubinov	Ryan Rivera	Bill Pellico	Hucheng Chen	Larry Minjoo Lee	John Harton	Vishnu Zutshi	Xiao Luo	Josh Spitz	Yasar One	Marcos Turqueti	Jon Urheim	Sabrina Sacerdoti	David Martinez Caicedo
End-of-February Tasks and Subtasks	**FNAL-ND Sci**	**FNAL-ND Mech**	**FNAL-PPD/EED**	**FNAL-SCD/FDE**	**FNAL-AD**	**BNL**	**UIUC**	**CSU**	**NIU**	**UCSB**	**UMich**	**Iowa**	**LBL**	**Indiana**	**Paris**	**SDSMT**
Photo-collector" -- biweekly Wednesdays 12:00 CST 19:00 CET led by Carla Cattadd	X			X				X	X	X		X			X	
-- SiPM Mounting								X	X			X				
-- Cathode Frame design								X	X							
-- Cathode Frame CPA interface									X			X				
-- Cathode Frame Electronics interface									X			X				
-- Membrane Frame design																
-- Membrane Frame CPA interface																
-- Membrane Frame Electronics interface																
-- WLS bars acquisition																
-- WLS sculpting R&D									X							
-- Dichroic Filters																
-- SiPM acquisition																
-- SiPM Selection	X					X			X	X					X	
"Analog Readout" -- Thursdays 09:00 CST 16:00 CET led by Dave Christian	X			X		X			X	X	X	X	X		X	
-- CB#3 Cathode module cold electronics repackaging design	X			X						X		X	X		X	
3. -- Reliability analysis	X			X		X				X	X	X	X	X	X	
---------- define how to qualify and quantify reliability	X			X		X				X	X	X	X	X	X	
---------- conduct tests to qualify and quantify reliability		X								X		X				
-- Reliability optimization						X				X			X		X	
2. -- Understand which analog readout components have warm/cold variation	X									X				X	X	
-- S/N optimization									X	X					X	
-- Warm electronics integration									X	X					X	
-- Membrane cold electronics repackaging									X		X				X	
~~1. -- Evaluate need for Electrical pulse calibration~~	X			X					X		X				X	
"Digital Readout" -- Thursdays 10:00 CST 17:00 CET led by Ryan for now	X			X							X	X	X			
-- Active/passive warm vessel prototype characterization				X												
-- Cold digital prototype characterization				X							X	X	X			
"Mechanical Design" -- Wednesdays 13:00 CST 20:00 CET led by Vishnu Zutshi		X		X				X	X		X	X			X	
1. -- External Cathode Fiber/Conduit Routing		X							X						X	
-- Internal Cathode Fiber Routing		X							X						X	
-- Internal Cathode Copper Cable Routing		X						X	X							
-- External Membrane Copper Cable/Conduit Routing																
-- Internal Membrane Copper Cable Routing																
2. -- Cathode Flange and Feedthrough		X						X				X				
-- Membrane Flange and Feedthrough								X			X					
-- Warm Class 4 laser routing		X														
10. -- Warm rack location and cable/fiber routing		X							X		X					
"Power-over-Fiber" -- biweekly Tuesdays 12:00 CST 19:00 CET led by Ryan for now	X			X	X		X						X			X
-- Efficiency optimization	X				X		X									
-- Cost estimates for topology scenarios	X			X	X											
-- Apply reliability analysis to PoF topology	X			X	X											
1. Evaluate need to control bias voltage																
-- Receiver Reliability analysis	X				X		X						X			X
---------- define how to qualify and quantify reliability	X				X		X						X			X
---------- conduct tests to qualify and quantify reliability																X
-- Fiber Reliability analysis (bending radius, conduit, light leakage)	X				X								X			X
---------- define how to qualify and quantify reliability	X				X								X			X
---------- conduct tests to qualify and quantify reliability																X
-- Fiber Connector Reliability analysis	X				X								X			X
---------- define how to qualify and quantify reliability	X				X								X			X
---------- conduct tests to qualify and quantify reliability																X
"Cathode HV impact" -- monthly led by Ryan for now	X		X	X		X										
-- Understand implications of sim on xARAPUCA layout			X			X										

Responsibility Matrix (3 of 3) link

Breakout Meetings / Tasks / Subtasks Activity Matrix	Bill Pellico	Hucheng Chen	Larry Minjoo Lee	John Harton	Vishnu Zutshi	Xiao Luo	Josh Spitz	Yasar One	Marcos Turqueti	Jon Urheim	Sabrina Sacerdoti	David Martinez Caicedo	Chang-Kee Jung	Dave Newbold	Ines Gil-Botella	Carla Cattadori	Francesco Terranova	Jaroslav Zalesak	Ettore Segreto	Zelimir Djurcic	Santosh Parajuli
End-of-February Tasks and Subtasks	FNAL-AD	BNL	UIUC	CSU	NIU	UCSB	UMich	Iowa	LBL	Indiana	Paris	SDSMT	SBU/S. Korea	UK/RAL	Spain	INFN Milano	INFN	Cz	Brazil	ANL	SMU
Photo-collector" -- biweekly Wednesdays 12:00 CST 19:00 CET led by Carla Cattad				X	X	X		X			X				X	X			X		
-- SiPM Mounting				X	X			X								X					
-- Cathode Frame design				X	X																
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-- WLS bars acquisition																X					
-- WLS sculpting R&D					X											X					
-- Dichroic Filters															X	X			X		
-- SiPM acquisition															X		X	X			
-- SiPM Selection		X			X	X					X				X		X	X			
"Analog Readout" -- Thursdays 09:00 CST 16:00 CET led by Dave Christian		X			X	X	X	X	X		X				X		X				
-- CB#3 Cathode module cold electronics repackaging design						X		X	X		X										
3. -- Reliability analysis		X				X	X	X	X	X	X										
---------- define how to qualify and quantify reliability		X				X	X	X	X	X	X										
---------- conduct tests to qualify and quantify reliability						X		X													
-- Reliability optimization		X				X			X		X										
2. -- Understand which analog readout components have warm/cold variation						X				X	X										
-- S/N optimization					X	X					X										
-- Warm electronics integration					X	X					X						X				
-- Membrane cold electronics repackaging					X		X				X				X		X				
~~1. -- Evaluate need for Electrical pulse calibration~~					X		X				X										
"Digital Readout" -- Thursdays 10:00 CST 17:00 CET led by Ryan for now							X	X	X					X							
-- Active/passive warm vessel prototype characterization														X							
-- Cold digital prototype characterization							X	X	X												
"Mechanical Design" -- Wednesdays 13:00 CST 20:00 CET led by Vishnu Zutshi				X	X		X	X			X				X		X		X		
1. -- External Cathode Fiber/Conduit Routing					X						X										
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-- Internal Cathode Copper Cable Routing				X	X																
-- External Membrane Copper Cable/Conduit Routing															X		X				
-- Internal Membrane Copper Cable Routing															X						
2. -- Cathode Flange and Feedthrough				X				X													
-- Membrane Flange and Feedthrough				X			X								X						
-- Warm Class 4 laser routing																					
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---------- conduct tests to qualify and quantify reliability												X									
"Cathode HV impact" -- monthly led by Ryan for now		X																			
-- Understand implications of sim on xARAPUCA layout		X																			
-- Understand resulting light yield and physics performance implications																X					

R&D in FY22-23

- This is optimization and qualification
- How to give ourselves the best chance to survive 30-years?
  (and then convince reviewers at the Production Readiness Review)

1. Peer-reviewed qualification studies (e.g., leverage hot carrier effect)
   a. Component-level (possible), System-level (not possible?)
2. Brute force statistical studies
   a. e.g., show 10 units working for 1 year and 10 thermal cycles
3. Redundancy
   a. Avoid single points of failure

We hope converging on a plan for FY22-23 is an outcome of this workshop!