Far Detector & Cryogenics (FDC) Subproject Introduction

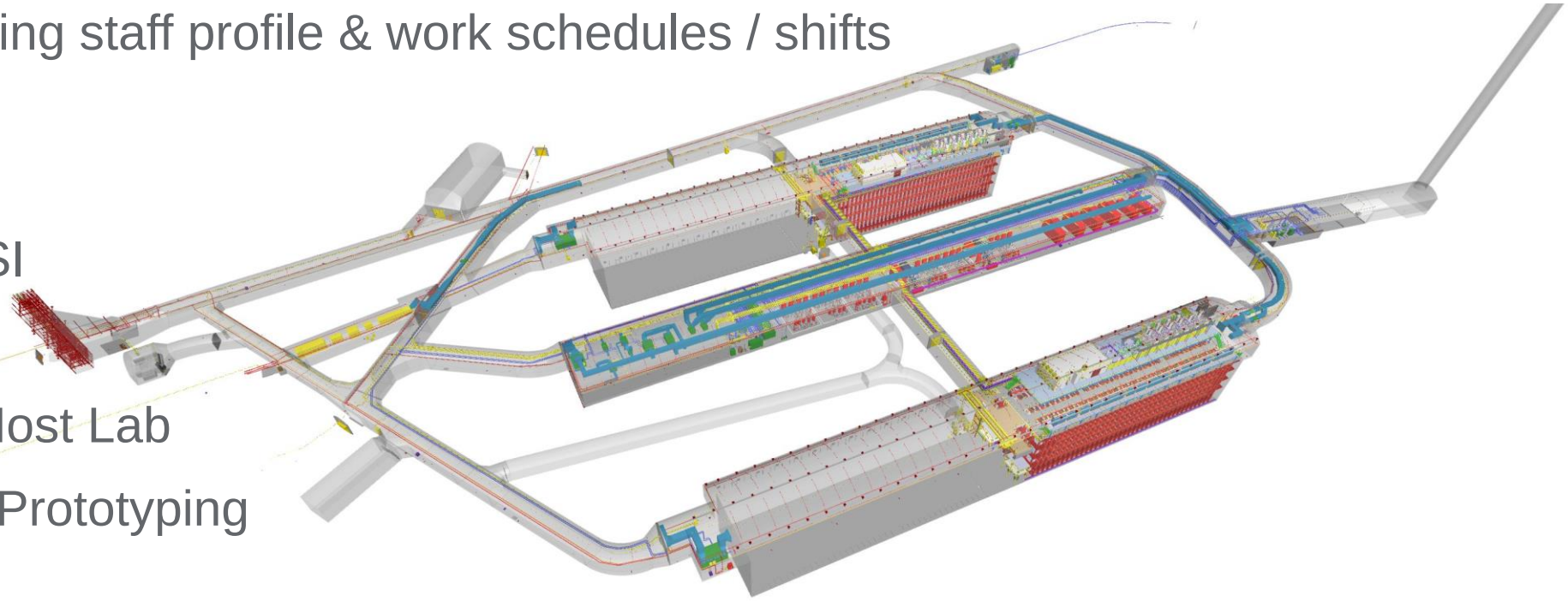
Jolie Macier, FDC Subproject Manager

LBNF/DUNE-US FDC Risk Workshop

16-17 January 2024

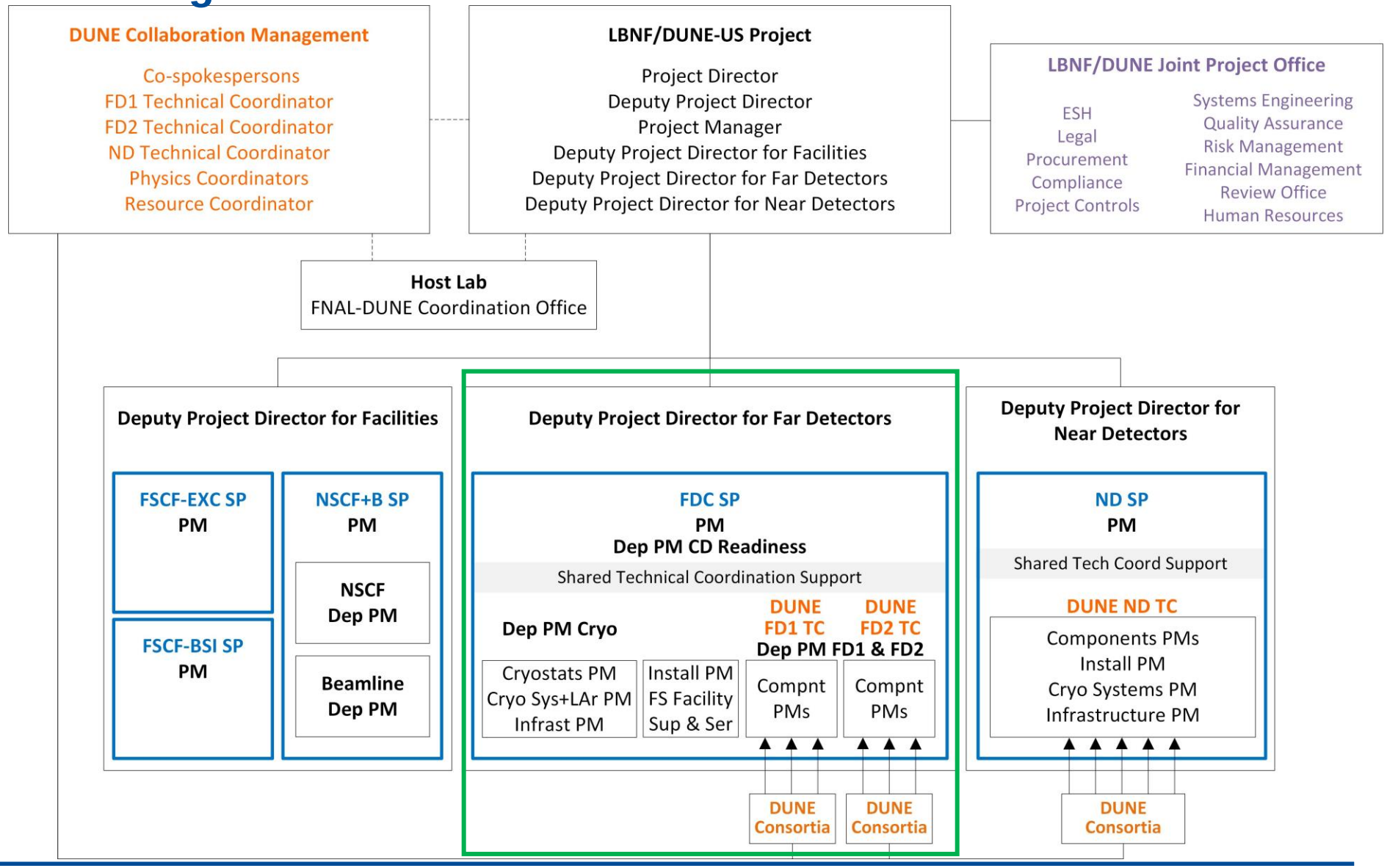
Outline

- FDC I&I Scope & Schedule, including key assumptions & installation phases
- Risk Summary & Methodology
- Labor Overview, including staff profile & work schedules / shifts
- Logistics Planning
- Dependencies on FSCF/EXC & FSCF/BSI
- Facility Dependencies
- Services provided by Host Lab
- Detector & Installation Prototyping
- Q&A



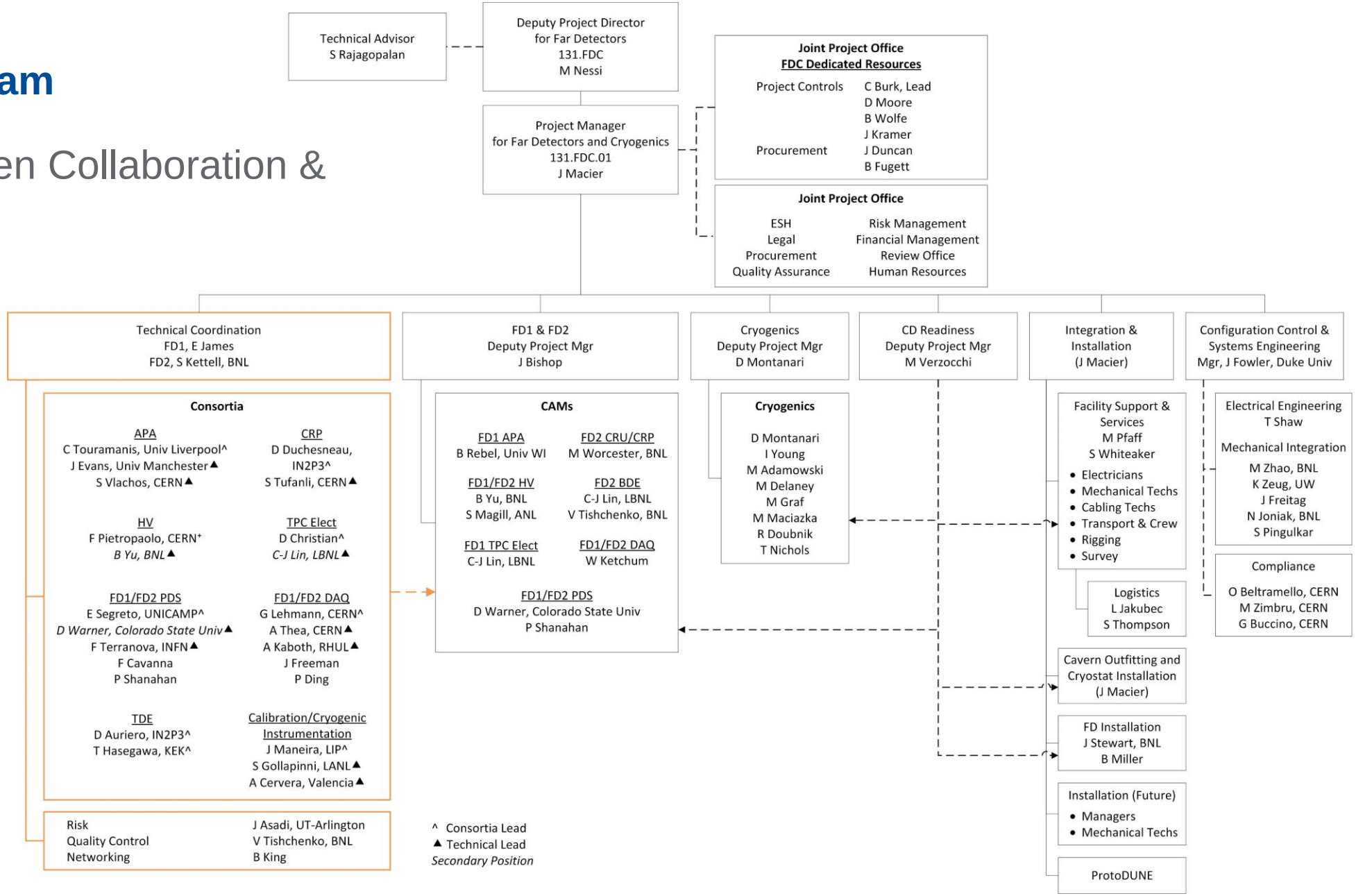
FDC as part of LBNF/DUNE Organization

- Integrated team includes DUNE Collaboration and LBNF/DUNE-US Project
- Support from Joint Project Office



FDC Integrated Team

- Interaction between Collaboration & DOE Project
- Support from JPO
- Dedicated Project Controls & Procurement
- Building SD-based team

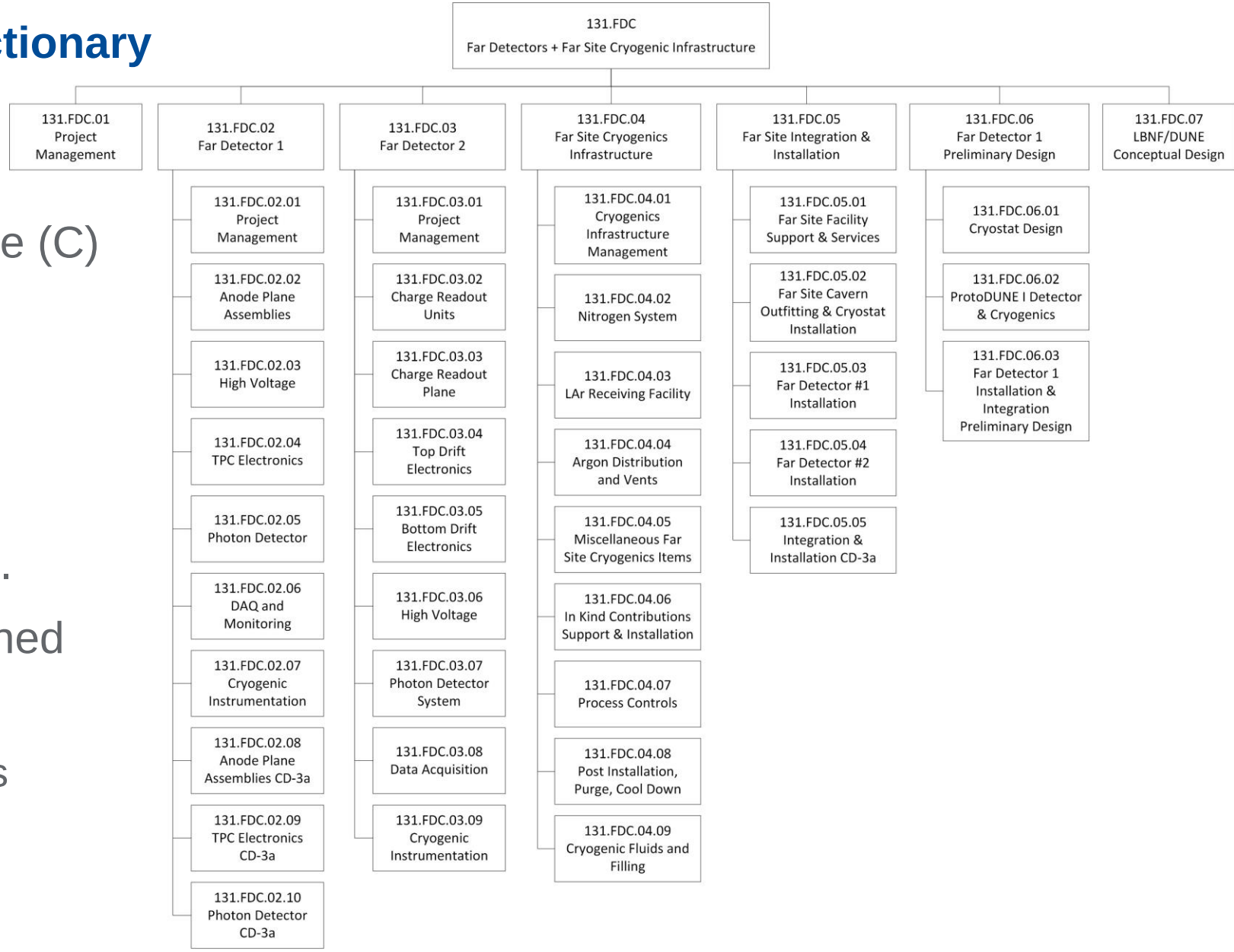


Personnel Risks (i)

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-181	[PM] Loss of key personnel	20%	0 – 125 – 250 k$	0 – 1 – 4 months

FDC Scope defined in WBS Dictionary

- The Far Detectors (FD1 and FD2) and Far Site Cryogenic Infrastructure (C) project management, design, fabrication, construction, and installation, for the LBNF/DUNE-US Project.
- Control Account Managers defined
- Defines DOE/non-DOE scope
  - See also DUNE MOU annexes



131.FDC.02 - Far Detector 1 (FD1)

- Completed final designs
- Fabrication at labs & universities
- Major procurements from Fermilab and Brookhaven National Lab
- Full-scale prototypes completed
- Custom hardware developed "in house" (national laboratories and universities) from the design to the manufacturing
- Component descriptions have been prepared to assist with ICE

WBS DICTIONARY

Design, prototyping, procurement, fabrication, and installation of one 10kT Liquid Argon (LAr) detector to be built underground at SURF in South Dakota. Far Detector 1 (FD1) will utilize horizontal drift technology. FD1 will be funded by both DOE and international partners. This effort include the management, oversight and travel.

DOE: Assembly of 15/152 Anode Plane Assemblies (APAs) including fabrication of necessary components and cable harnesses and CR, G-bias, CE adapter and SHV boards for all APAs. Component fabrication (with exception of resistive panels) for and assembly of Cathode Plane Assemblies (CPAs). Component fabrication (with the exception of profiles) for and assembly of Field Cage Modules. Electronics and supporting infrastructure needed to read out all of the active TPC channels including both cold front-end and warm readout electronics. Photon Detector (PD) rails and cables for all APAs. PD warm readout electronics and monitoring system. DAQ dataflow server hardware and system software development. Component fabrication for and assembly of cryostat purity monitors. Contributions to the conceptual designs of FD1 elements are captured in WBS 131.FDC.07. Contributions to the preliminary designs of FD1 elements and the fabrication of ProtoDUNE-I detector components are captured in 131.FDC.06.

non-DOE: Assembly of 137/152 APA modules including fabrication of necessary components as well as geometry boards and mesh grounding panels for all APA modules. Resistive panels for CPAs and profiles for Field Cage Modules. Detector high-voltage delivery system (Power Supply, Cables, Filters, and feedthrough). Photon Detector photosensors and cold front-end electronics for 1500 PD Modules. Component fabrication for and assembly of 1500 PD modules. Hardware for DAQ timing, readout, and high-level data filtering systems. Software development for control, configuration, and monitoring systems. Component fabrication for and assembly of cryostat temperature monitors.

131.FDC.03 – Far Detector 2 (FD2)

- Completed final designs
- Fabrication at labs & universities
- Major procurements from Fermilab and Brookhaven National Lab
- Full-scale prototypes completed

- Mostly custom hardware developed "in house" (national laboratories and universities) from the design to the manufacturing

WBS DICTIONARY

All phases of design, prototyping, procurement, fabrication, and installation of one 10kT Liquid Argon (LAr) detector to be built underground at SURF in South Dakota. Far Detector 2 (FD2) will utilize vertical drift technology. FD2 is funded by both DOE and international partners. This effort includes the management, oversight, travel and support for installation in South Dakota.

DOE: Assembly of 80/160 Charge Readout Planes (CRP) (bottom) including fabrication of necessary components (anodes, adaptor boards, support feet), but excluding the composite support frame and the assembly of anode panels into an anode plane. Component fabrication (with the exception of profiles) for and assembly of Field Cage Modules. Electronics and supporting infrastructure needed to read out all of the CRP channels including both cold front-end and warm readout electronics. Photon Detector System (PDS) x-Arapuca mechanical frames and cold electronics and assembly of 320 cathode PDS modules. DAQ dataflow servers (42) and software. Component fabrication and assembly of five (5) purity monitors.

non-DOE: Assembly of 80/160 CRP modules (top) including fabrication of necessary components (anodes, adaptor boards, composite support frame, suspension system) and design of the CRP support superstructure. Cold and warm electronics for readout of the 80 top CRP modules. Profiles for Field Cage Modules, 80 cathode modules and suspension system. Detector high-voltage delivery system (Power Supply, Cables, Filters, and feedthrough). Photon Detector photosensors, dichroic filters, wavelength shifting plates and warm electronics for all 640 PDS Modules. Assembly of 320 membrane mounted modules. Hardware for DAQ timing, readout, and high-level data filtering systems. Software development for control, configuration, and monitoring systems. Component fabrication and assembly of cryostat temperature monitors.

131.FDC.04 – Far Site Cryogenics Infrastructure

- Infrastructure Cryogenics includes Argon Receiving facilities, Nitrogen System, Argon distribution (pipes/valves), Cryostat Pressure control system, GN2 supply to cryostat insulation.
- Process controls includes readout modules, PLC architecture, HMI/SCADA, ODH, Integration.
- LAr procurement for two 17.5 kton modules with ability to conduct additional purchases for future modules.
- The FDC Cryo scope is acquired using an engineering/manufacturing/installation/testing (or startup/commissioning) approach. The documentation that we have prepared is adequate for acquiring the systems with this method (SOW, Interface documents, 3D envelope models, etc.).
- Process controls is "in house"

WBS DICTIONARY

Design, procurement, on-site installation, integration and testing of Infrastructure and Proximity cryogenic systems to support two 17-kt total mass detectors. Infrastructure includes LAr procurement as well as installation of the In-Kind Contributions. Includes design of the internal cryogenics, which will be provided as In-Kind Contribution.

DOE: The Infrastructure cryogenics (a DOE responsibility) includes the Nitrogen System (Refrigeration System, LN2 buffer tanks, LN2/GN2 distribution, Nitrogen generation), Argon receiving facilities on the surface, Argon distribution, miscellaneous items (GN2 purge of the cryostat insulation and cryostat pressure control system), and the installation of the Proximity Cryogenics delivered as In-Kind-Contribution, as well as assistance to partners delivering In-Kind Contributions. Design, procurement, installation and testing of the process controls are included. Labor and M&S Travel supporting purge, cool down and fill are also included.

Non-DOE: The Proximity cryogenic system includes reliquefication and purification sub-systems, associated instrumentation and monitoring equipment and LAR circulation pumps.

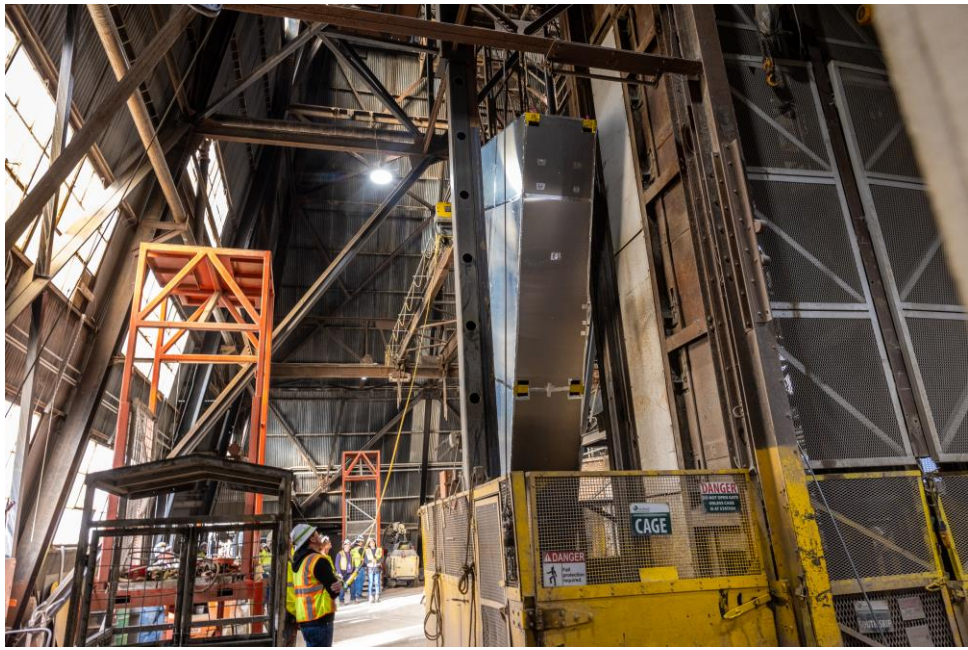
131.FDC.05 – Far Site Integration & Installation

- Labor and material to support installation of cryostats (In-Kind Contribution), infrastructure and detectors
- Includes labor for services as well as dedicated installation activities
- Final design complete for infrastructure
- Procurements include COTS, fabrication and services
- Significant installation prototyping activities completed to inform labor and material estimates
- Some aspects are close to facility construction (cavern outfitting)

WBS DICTIONARY
Integration and installation coordination at SURF. Includes M&S and labor to support cryostat installation and detector installation support for two 10kT Liquid Argon (LAr) detectors. Also includes post-FSCF cavern enhancements such as bridges, stairs, mezzanines, barracks and CUC control room outfitting. Cryogenics installation activities included in 131.FDC.04. Cryostats and Internal Cryogenics are nonDOE deliverables. FD consortia also provide support for detector installation.

Finalizing designs, building technical readiness and preparing for work in SD

- Final Design Complete
  - Technical Design Reports
  - Prototyping activities & testing processes
- Planning
  - Procurement
  - Updated estimates
  - Coordinating with our team -> October workshops!
  - Settling scope with partners -> MOUs signed!
  - Documenting our plans
- At CERN, Universities, BNL, FNAL



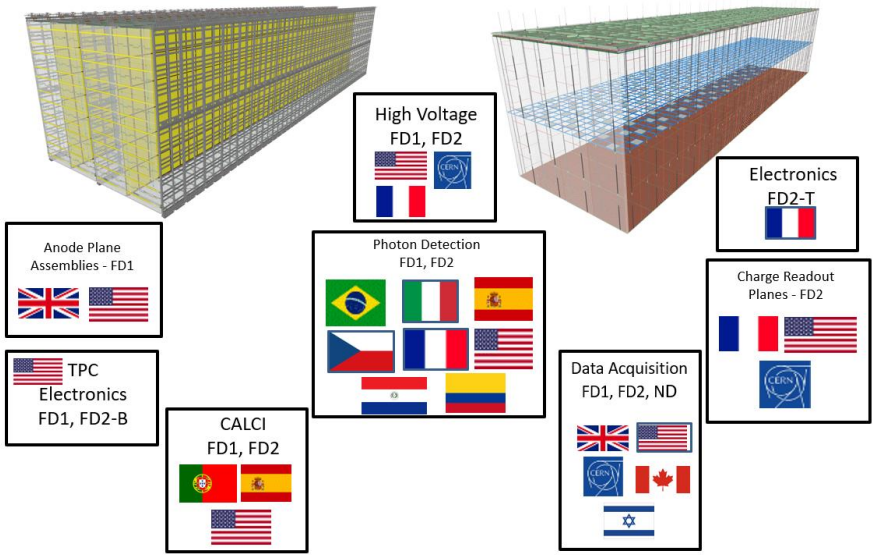
FDC Design Maturity

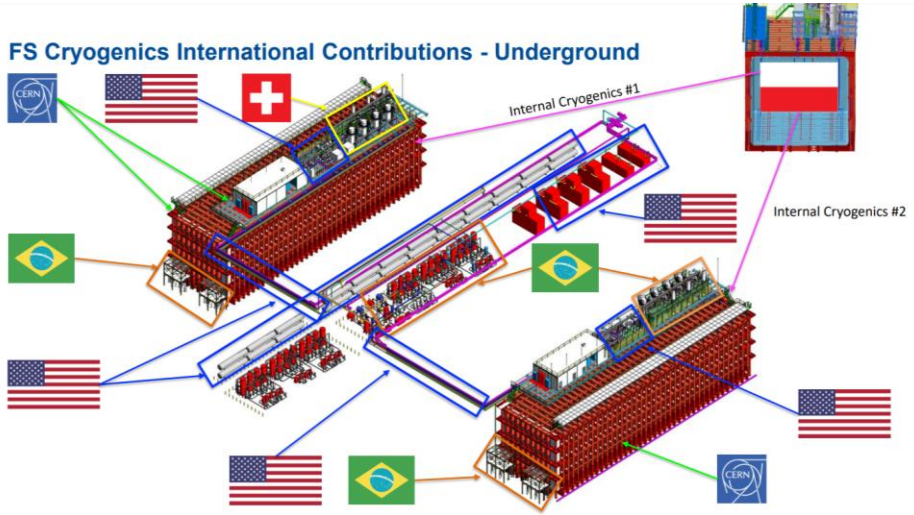
In this summary, I&I is fully assigned to FD1 and FD2			
Design Status as of May 31, 2023			
3-May-23	**Design Status**	**% Design Maturity**	**Comment**
131.FDC.02.02 FD1 Anode Plane Assemblies (APA)	Final	98%	PRR in March 2022
131.FDC.02.03 FD1 High Voltage (HV)	Final	90%	FDR in Oct 2022
131.FDC.02.04 FD1 TPC Electronics (TPC Elec)	Final	93%	partial PRR in March 2022; FDR in Aug 2022
131.FDC.02.05 FD1 Photon Detector (PDS)	Final	93%	FDR in March 2023; SiPM PRR Nov 22; Rails/Cables Oct 22
131.FDC.02.06 FD1 DAQ and Monitoring (DAQ)	Final	90%	FDR in Feb 2023
131.FDC.02.07 FD1 Cryogenic Instrumentation	Final	90%	FDR Jan 2023; Final Prototypes in ProtoDUNE-HD-Module 0
131.FDC.03.02 FD2 Charge Readout Units (CRU)	Final	90%	FDR in Apr 2023
131.FDC.03.03 FD2 Charge Readout Plane (CRP)	Final	90%	FDR in Apr 2023
131.FDC.03.05 FD2 Bottom Drift Electronics (BDE)	Final	93%	FDR in March 2023
131.FDC.03.06 FD2 High Voltage (HV)	Final	90%	FDR in Apr 2023
131.FDC.03.07 FD2 Photon Detector System (PDS)	Final	90%	SiPM PRR Nov 22; FDR in April 2023
131.FDC.03.08 FD2 Data Acquisition (DAQ)	Final	90%	FDR in Feb 2023
131.FDC.03.09 FD2 Cryogenic Instrumentation	Final	90%	FDR Jan 2023
131.FDC.04.02 Nitrogen System	Final	100%	Subcontract signed.
131.FDC.04.03 LAr Receiving Facility	Final	100%	Acquisition document prep completed; FDR completed.
131.FDC.04.04 Argon Distribution and Vents	Final	86%	FDR completed. Finalizing acquisition documents.
131.FDC.04.05 Miscellaneous FS Cryogenics Items	Final	61%	FDR completed. Finalizing acquisition documents.
131.FDC.04.06 In Kind Contributions Support and Installation	Final	93%	FDR completed. Finalizing documents for partners.
131.FDC.04.07 Process Controls	Final	77%	FDR completed. Working on logic specs, typically after Final Design completed.
131.FDC.04.08 Post Installation, Purge, Cool down	Final	62%	Requirements well defined. Statement of Work in progress.
131.FDC.04.09 Cryogenic Fluids and Filling	Final	80%	Requirements well defined. Statement of Work in progress.
131.FDC.05.01 FS Facility Support & Services	Final	90%	mostly LOE; Rigging design needed
131.FDC.05.02 FS Cavern Outfitting and Cryostat Installation	Final	90%	FDR in Apr 2023
131.FDC.05.03 Far Detector #1 Installation	Final	90%	FDR in Apr 2023
131.FDC.05.04 Far Detector #2 Installation	Final	90%	FDR in Apr 2023
131.FDC.02.08 FD1 Anode Plane Assemblies (APA) CD-3a	Final	100%	PRR in March 2022
131.FDC.02.09 FD1 TPC Electronics (TPC Elec) CD-3a	Final	100%	PRR in March 2022
131.FDC.02.10 FD1 Photon Detector (PDS) CD-3a	Final	100%	
131.FDC.05.05 Integration and Installation CD-3a	Final	100%	
FDC Overall Design Maturity		**92%**	

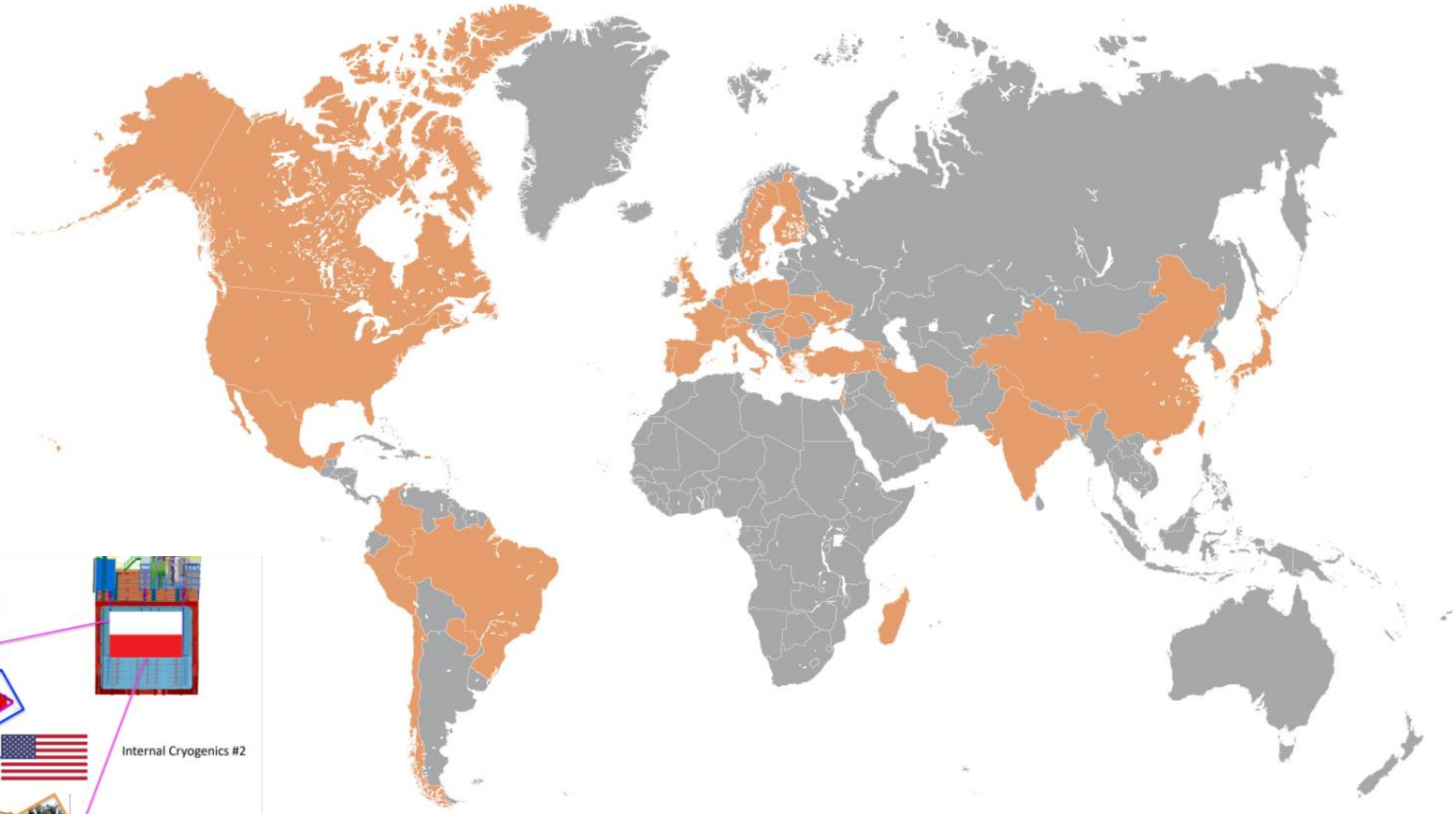
$$\text{Subproject Design Maturity} = \frac{\Sigma(\text{WBS element Design Maturity x cost of associated WBS element})}{\text{total cost of all associated WBS elements}}.$$

DUNE Participation (orange) + LBNF (Cryogenics) in-kind contributors

Far Detector Partners







DUNE Far Detector consortia are responsible to deliver their scope. DUNE-US is a contributor to DUNE.

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Cryostat & Cryogenics are in-kind contributions to LBNF

The world is coming to Lead

LBNF excavation at Sanford Lab on schedule for June 2024 completion

By Wendy Pitlick Black Hills Pioneer May 13, 2023 0

A drill and mucker are seen excavating for the Deep Underground Neutrino Experiment at the 4850 Level at SURF. Photo by Matthew Kapust, Sanford Underground Research Facility

Matthew Kapust

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LEAD — The world is coming to Lead and anxiously awaiting the excavation and outfitting of the Long Baseline Neutrino Facility that will house the Deep Underground Neutrino Experiment.

On Wednesday, representatives from Fermilab, along with scientists and engineers involved with building DUNE and officials from the Sanford Underground Research Facility hosted a community information meeting to provide updates about progress for the massive facility and experiment, and answer any questions. Lead residents and interested stakeholders filled the conference room at the Sanford Lab Homestake Visitor's Center.

"The world is coming to Lead," Fermilab's Jolie Macier, who is involved with building the DUNE experiment, told the residents as she explained the global involvement for DUNE that includes 1,300 collaborators from 33 countries and CERN, and 200 institutions. DUNE is being hailed as the largest neutrino experiment in the world.

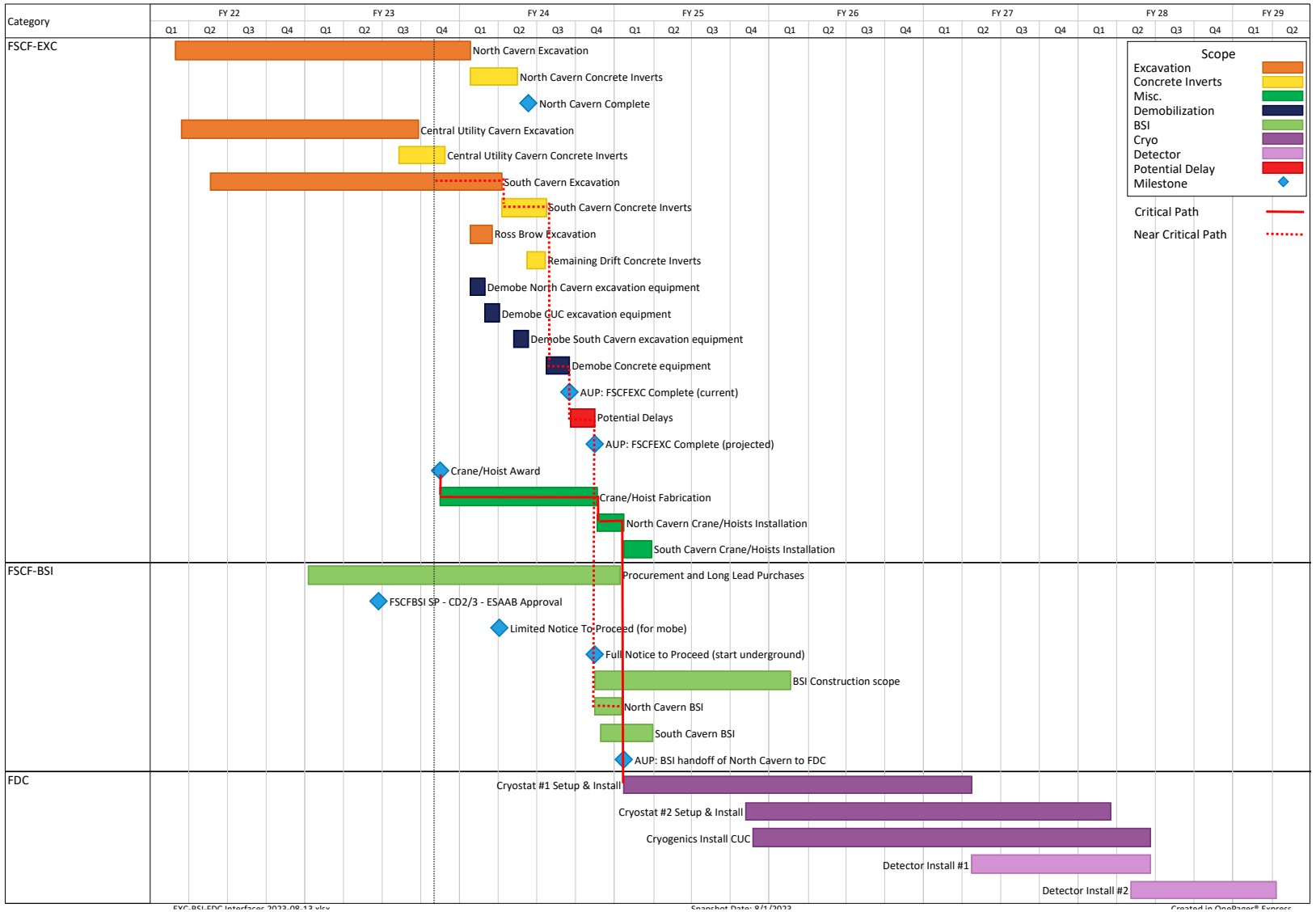
LBNF/DUNE

LBNF/DUNE Far Site Summary Schedule

Excavation (EXC) subproject creates the underground cavern space, installs cranes, wall supports & ceiling anchors for cryogenics mezzanine

Buildings & Site Infrastructure (BSI) subproject installs all house services: electrical, ventilation, architectural, chilled water, fire protection

FDC subproject installs cryostats, detectors & cryogenics; LAr filling



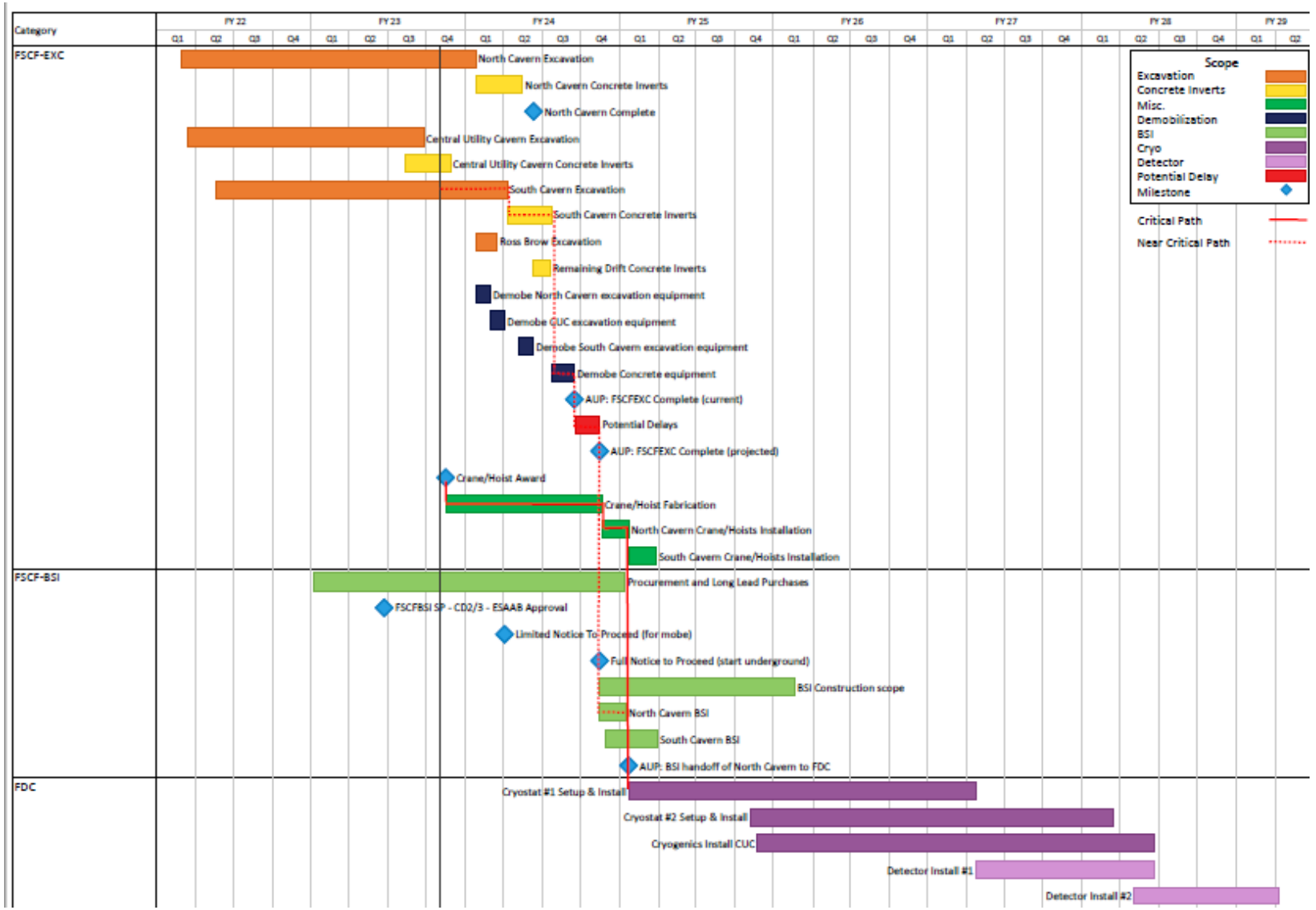
Interfaces

- Multi-layered interfaces reflect our integrated team
- Interface Summary defines subproject interfaces
  - FDC to FSCF/EXC and FSCF/BSI
  - Consortia to consortia
  - Consortia to I&I
- Supplemental documents
  - FDC & Host Lab – MOA & Host Lab Plan
  - FDC & SDSTA - MOU
  - FDC within LBNF/DUNE-US - PMP
- Interfaces include interactions
  - Weekly FDC management team meeting
  - FDC bimonthly meeting (CAMs + JPO + PCS)
  - Far Detector Installation monthly meeting (cryo, consortia, I&I)
  - Awkward Material Transport Team, includes Project, SDSTA, SMEs from FNAL, CERN

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-FI-101	[I&I] Scope is missing due to poor interface definition at Far Site	20 %	500 -- 2000 -- 5000 k$	0 -- 1 -- 3 months

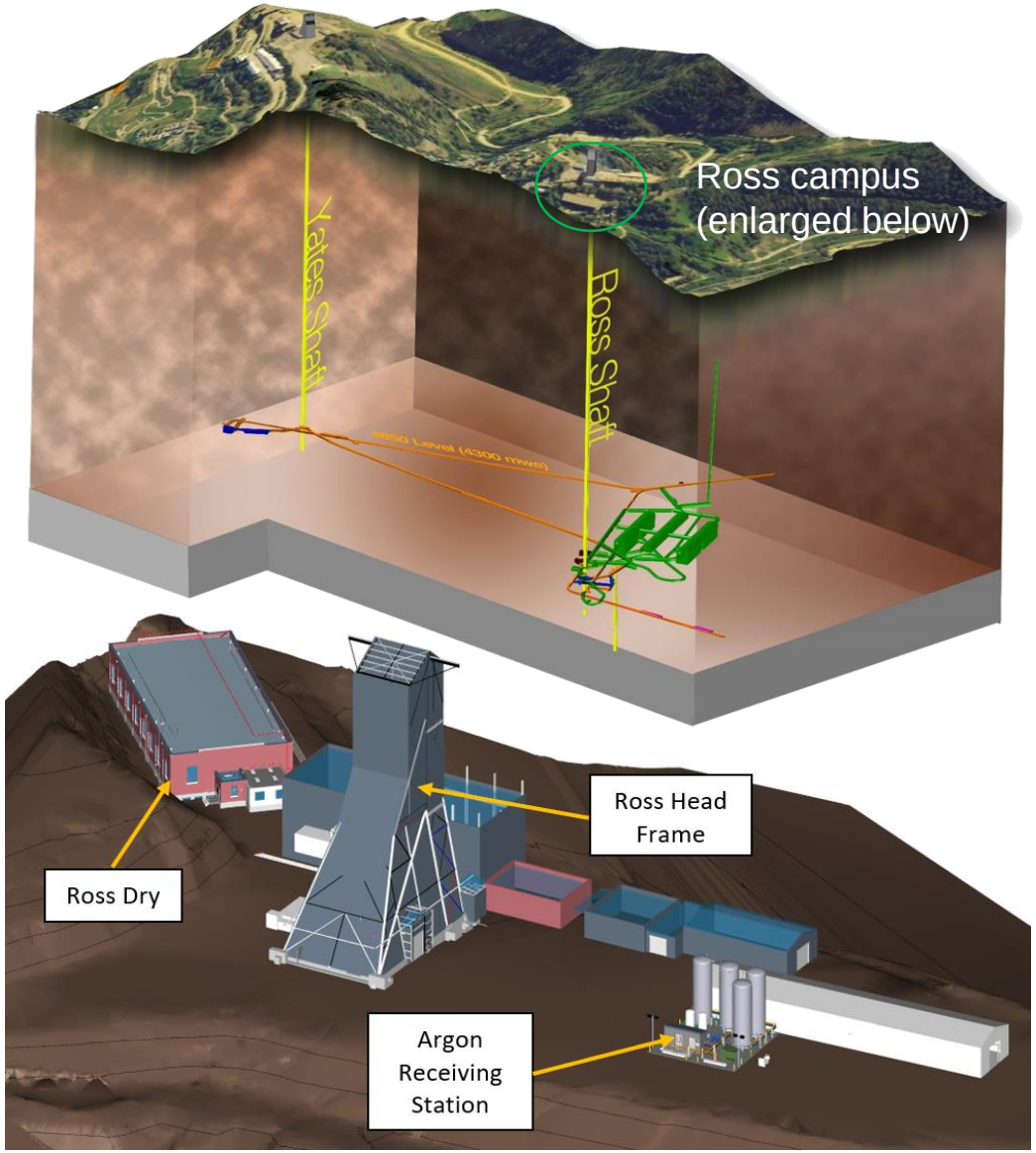
LBNF/DUNE-US Far Site Schedule

- Handoffs from FSCF/EXC and FSCF/BSI are very clear
- FDC work begins in North Cavern with warm structure #1 installation (Oct 2024)
- Significant planning to understand and define conditions at handover and during co-working timeframe
- FDC interfaces to FSCF/EXC, FSCF/BSI defined
- Phased Transition to Operations for LBNF/DUNE



Key FDC Assumptions (i)

- Contributions to LBNF are documented in Project Planning Documents; DUNE deliverables are delineated in the DUNE MOU Annexes
- Installation activities take place in Lead, SD, at Sanford Underground Research Facility (SURF)
- At SURF, FDC activities (surface & underground) occur in DOE-leased space, adhering to Fermilab ESH governance (10 CFR 851)
- SURF's Ross Shaft is available for LBNF/DUNE-US Project use; Yates Shaft is for emergency secondary egress
- Underground activities occur in the LBNF campus at 4850 and 4910 levels, beginning first in the North Detector Cavern. There will be a period of concurrent work at SURF with FSCF/BSI



Key FDC Assumptions (ii)

- There is insufficient laydown space at the SURF site; FDC must provide its own SD regional storage
- Shift work is optimized to support partners & compliance with underground headcount limits. SDSTA refuge chamber will be expanded to support 250 persons
- FDC access at SURF must comply with the requirements of the Risk Transfer Protocol including insurance. Costs are supported by Host Lab.
- FDC costs include power & Ross Shaft hoisting. Costs are supported by Host Lab.
- The LBNF/DUNE-US Joint Project Office provides overarching management support
- Maintenance of conventional facilities is the responsibility of Fermilab's Neutrino Division and Infrastructure Service Division, based on the FSCF/BSI Transition to Operations
- DUNE Coordination Office & SDS facilitate host lab services to FDC

Facility Risks - Access

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-010	[PM] Unavailability of SURF-/FRA-supplied systems at SURF - High P / Low impact	50 %	375 -- 750 -- 1500 k$	0.5 -- 1 -- 2 months
RT-131-FDC-PM-006	[PM] Ross skip hoist brakes failure	30 %	500 k$	2 months
RT-131-FDC-PM-012	[PM] Unavailability of SURF-/FRA-supplied systems at SURF - Low P / High impact	20 %	750 -- 1500 -- 4500 k$	1 -- 3 -- 6 months
RT-131-FDC-PM-007	[PM] Ross skip drum cracks require repair	15 %	687 k$	1.5 months
RT-131-FDC-PM-182	[PM] Oro Hondo shaft ventilation path is blocked (FDC)	5 %	0 -- 50000 k$	0 -- 24 months

Facility Risks – SURF expansion

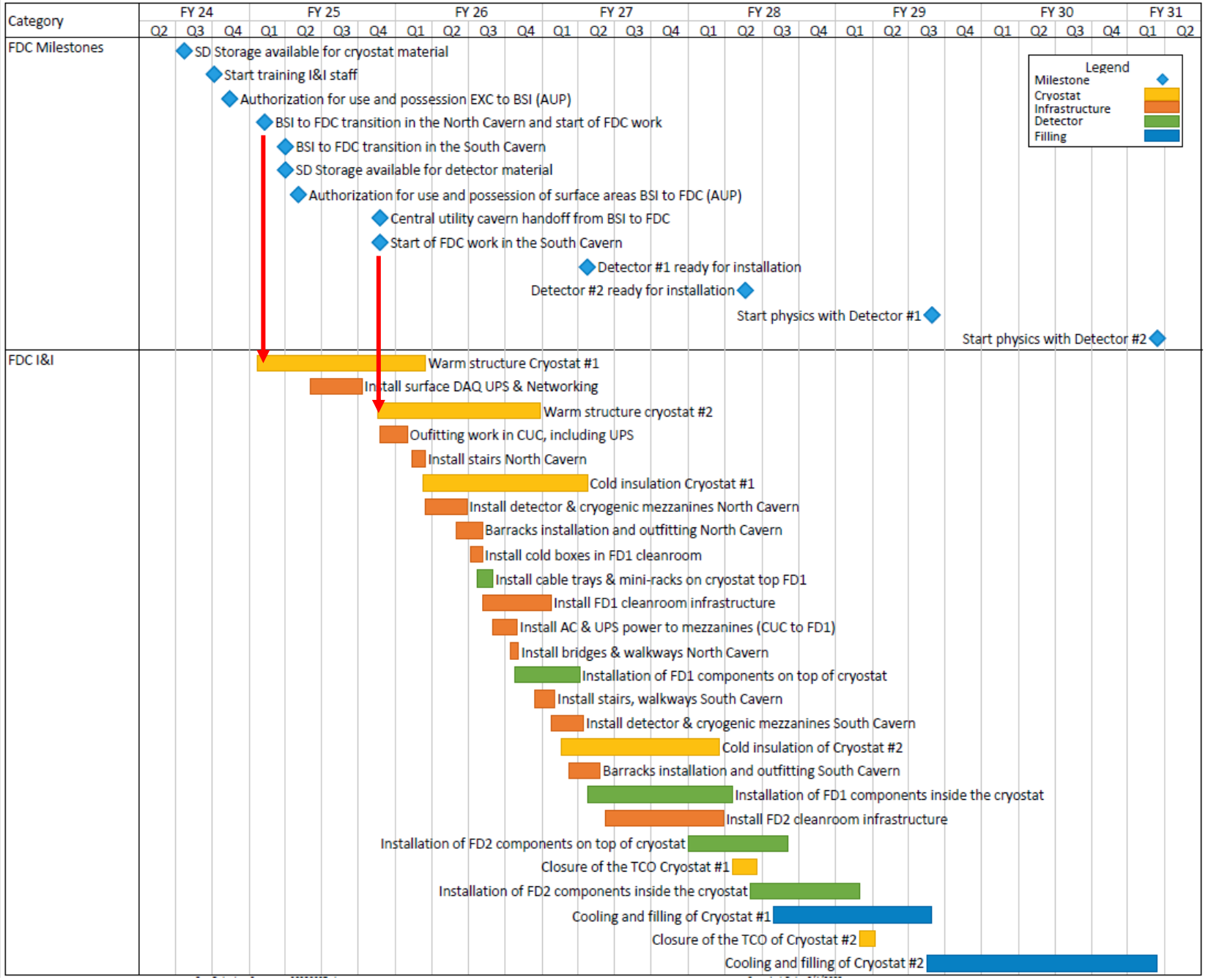
Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-009	[PM] SURF underground cavern expansion project impacts LBNF/DUNE project	15 %	5700 -- 11400 -- 22800 k$	1.5 -- 3 -- 6 months
RT-131-FDC-PM-126	[PM] SURF underground drift expansion project impacts LBNF/DUNE project	20 %	400 -- 800 -- 1600 k$	0.5 -- 1 -- 2 months

Facility Risks - occupancy

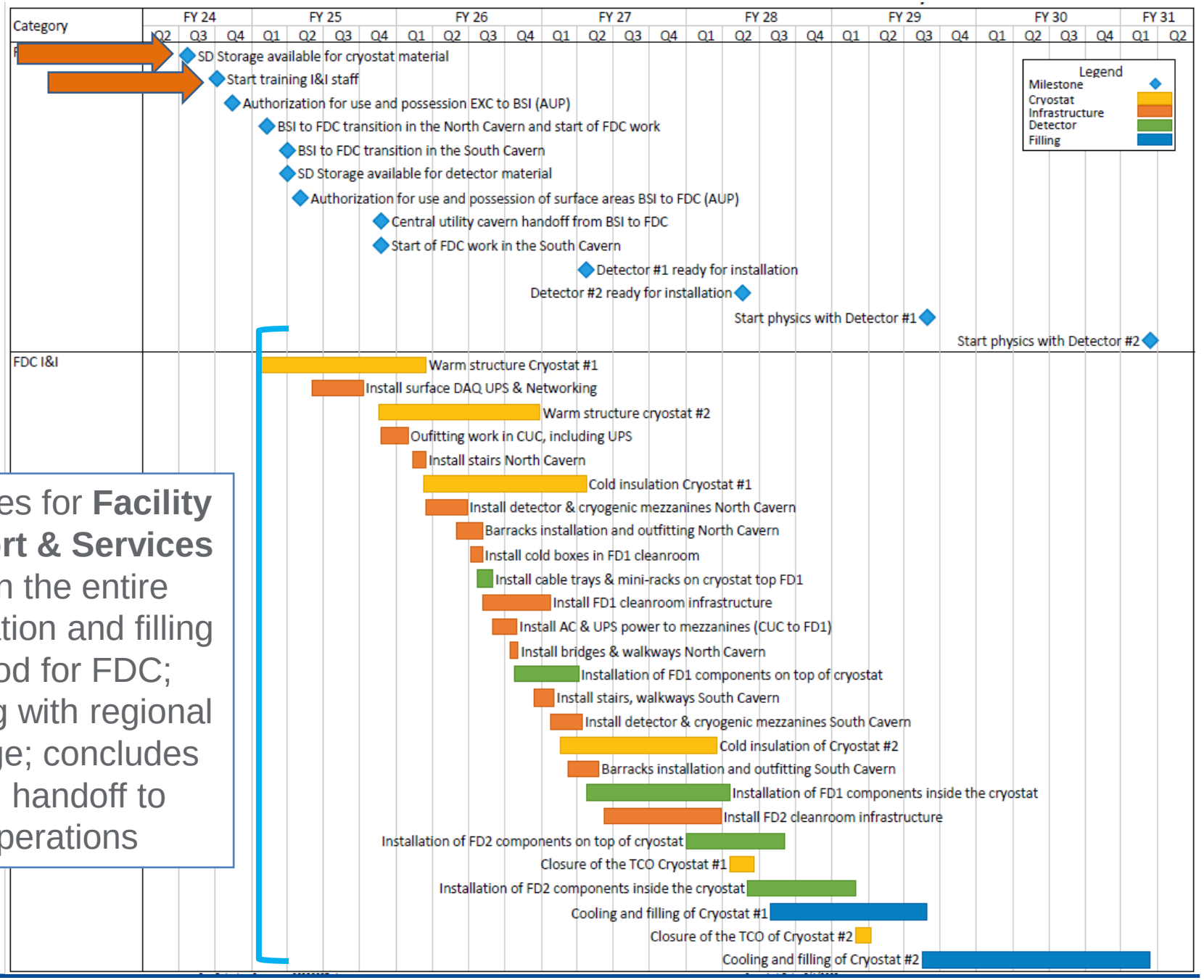
Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-FD-301	[DAQ] FD1 SURF infrastructure stability impacts DAQ uptime	10 %	0 k$	0 -- 1 -- 3 months
RT-131-FDC-FI-004	[I&I] Underground Occupancy limit not enough to execute work as planned	10 %	0 k$	0 -- 3 -- 6 months
RT-131-FDC-FI-001	[I&I] Membrane Cryostat damaged during Detector Installation	5 %	100 -- 500 -- 1000 k$	3 -- 6 months
RT-131-FDC-PM-011	[PM] General Security at SURF	4 %	0 -- 1000 k$	0 -- 6 months
RT-131-FDC-CR-112	[CRYO] Oxygen deficiency hazard (ODH) incident caused by rock fall from the cavern	1 %	0 -- 50 -- 100 k$	0 -- 2 -- 4 months
RT-131-FDC-FI-028	[I&I] Fire inside the cryostat during installation	1 %	500 -- 5000 k$	1 -- 12 months

Installation Schedule

- FDC underground work in SD begins in North Cavern with warm #1 cryostat (CERN In-Kind Contribution) installation
- Storage supports delivery of cryostat components prior to start of underground work
- FDC activities continues surface and underground as FSCF/BSI is completed
- Detector installation activities supported by FD1/FD2 consortia



Schedule Summary: Facility Support & Services 131.FDC.05.01

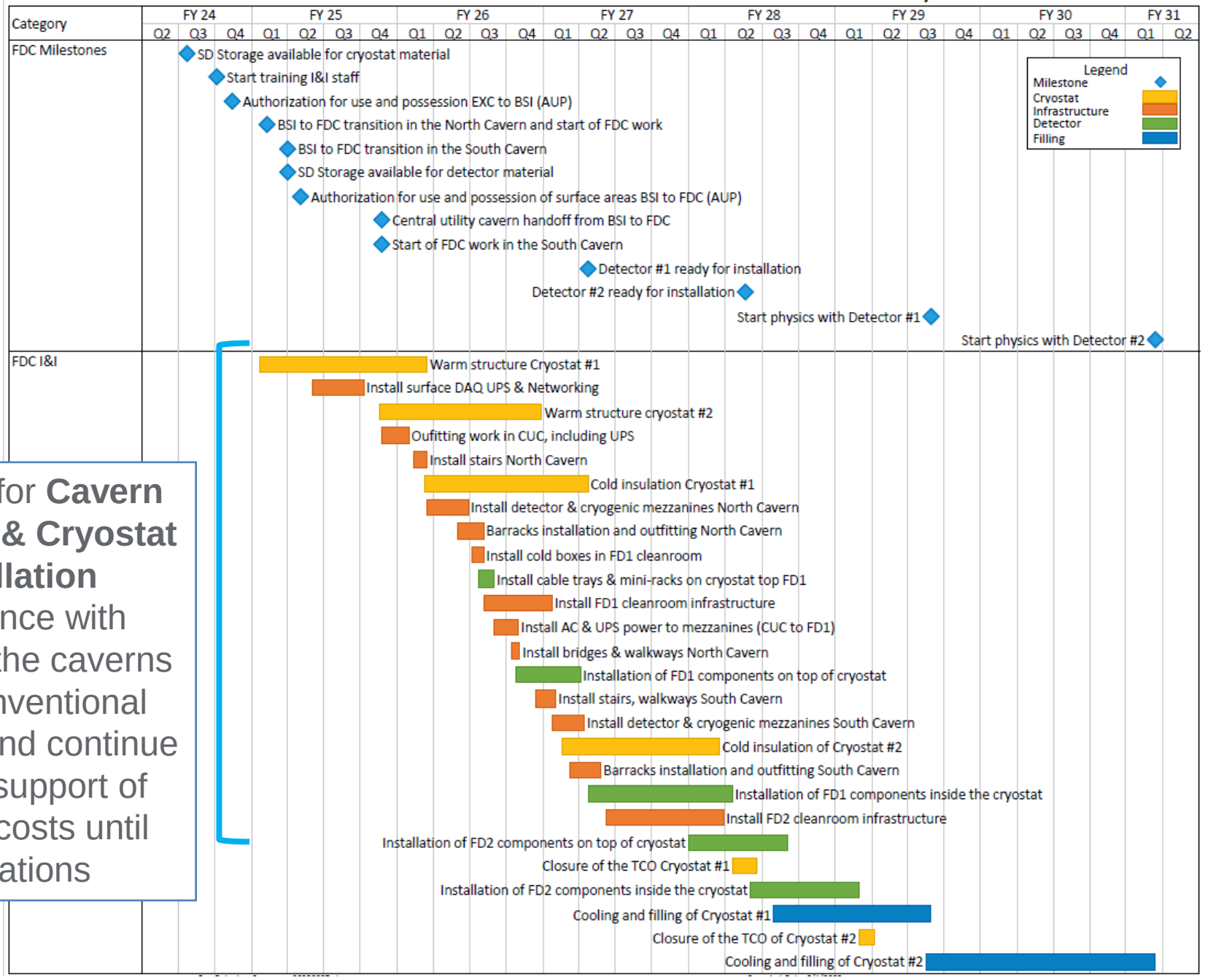


Activities for **Facility Support & Services** span the entire installation and filling period for FDC; starting with regional storage; concludes with handoff to Operations

Facility Support & Services- 131.FDC.05.01

- Supports all Installation activities, starting with cryostat installation and continuing though LAr filling (Cryogenics scope)
- Regional storage (warehouse & laydown yard) are the first services organized by FDC; requirements established through engagement with FDC team: cryostat, cryogenics & detector consortia
- Provides Logistics services support storage, transportation from interim storage to SURF and delivery to caverns
- Logistics planning considers movement of materials and personnel
- Material Handling Equipment + Repair
- General Consumables + ESH PPE
- Equipment maintenance, office space, janitorial services, portable restroom, trash, recycling

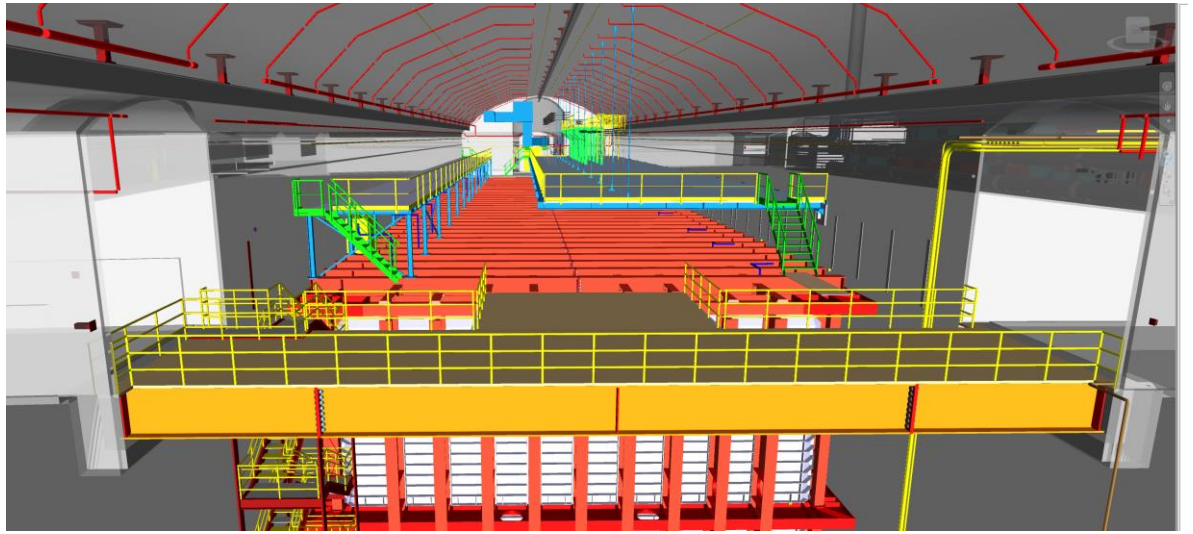
Schedule Summary: Cavern Outfitting & Cryostat Installation 131.FDC.05.02

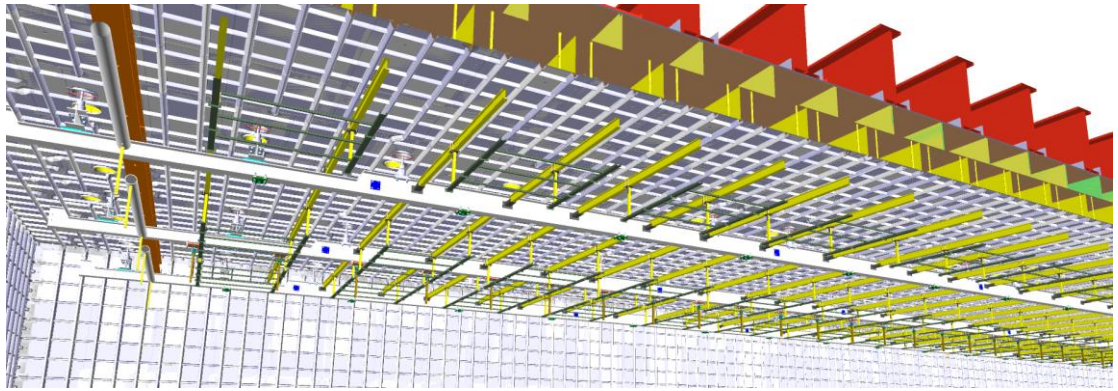


Activities for **Cavern Outfitting & Cryostat Installation** commence with receipt of the caverns from Conventional Facilities and continue through support of network costs until Operations

Cavern Outfitting & Cryostat Installation - 131.FDC.05.02

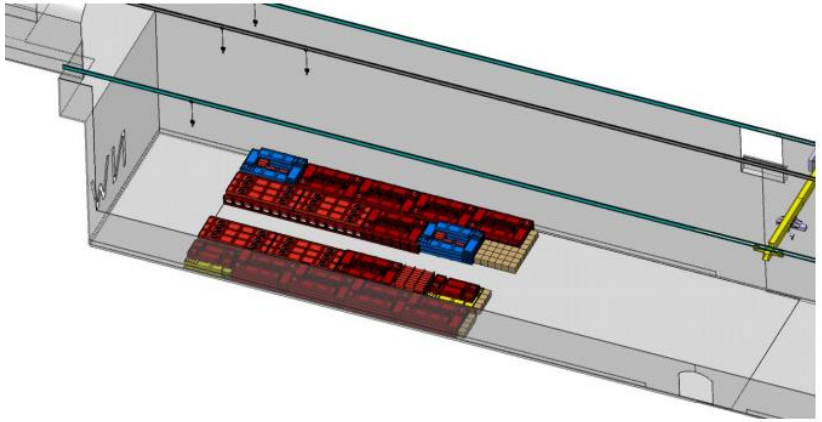
- Cryostat Installation support: G10 & elastomeric bearing pads; shims & ventilation
- Mezzanines, bridge, walkways
- Central Utility Cavern outfitting (UPS, racks, furnishings)
- Barracks & outfitting
- Electrical racks, UPS
- Permanent Stairs
- (HD) Detector Support System (rails & feedthroughs)
- Underground and surface networking equipment, in coordination with FNAL Computing & DUNE DAQ consortium; Slow Controls

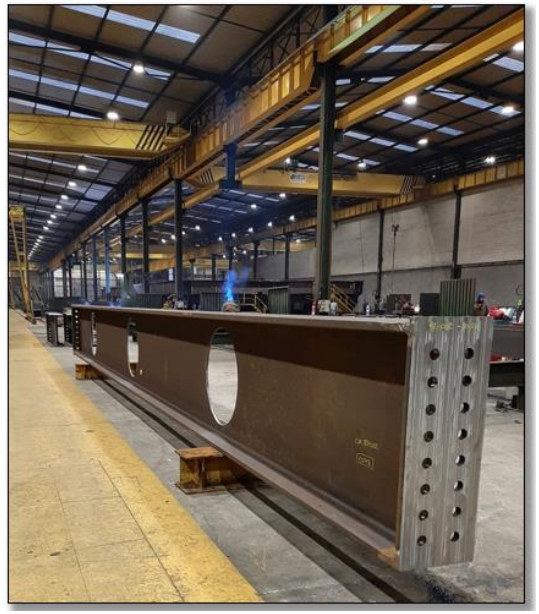




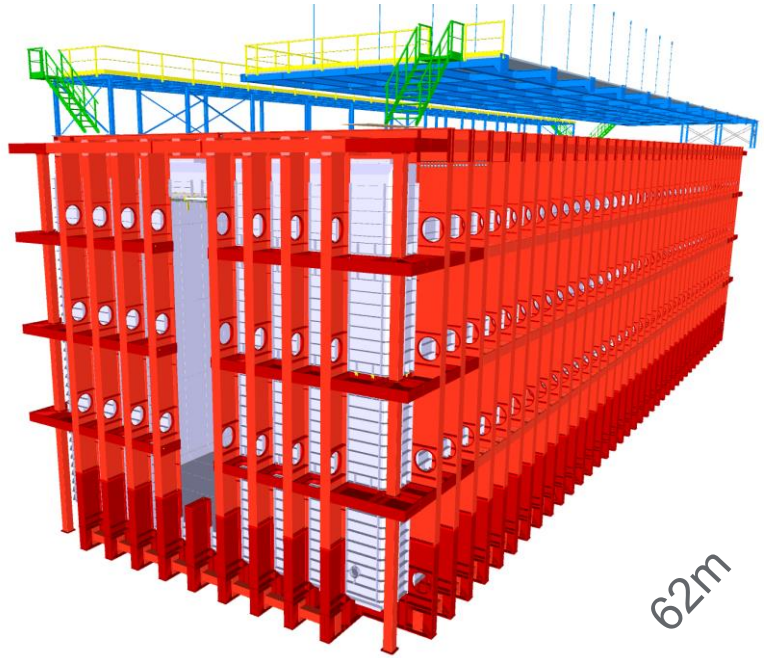
Top of cryostat (top); Detector Support System

Cryostats – a CERN in-kind contribution (IKC)

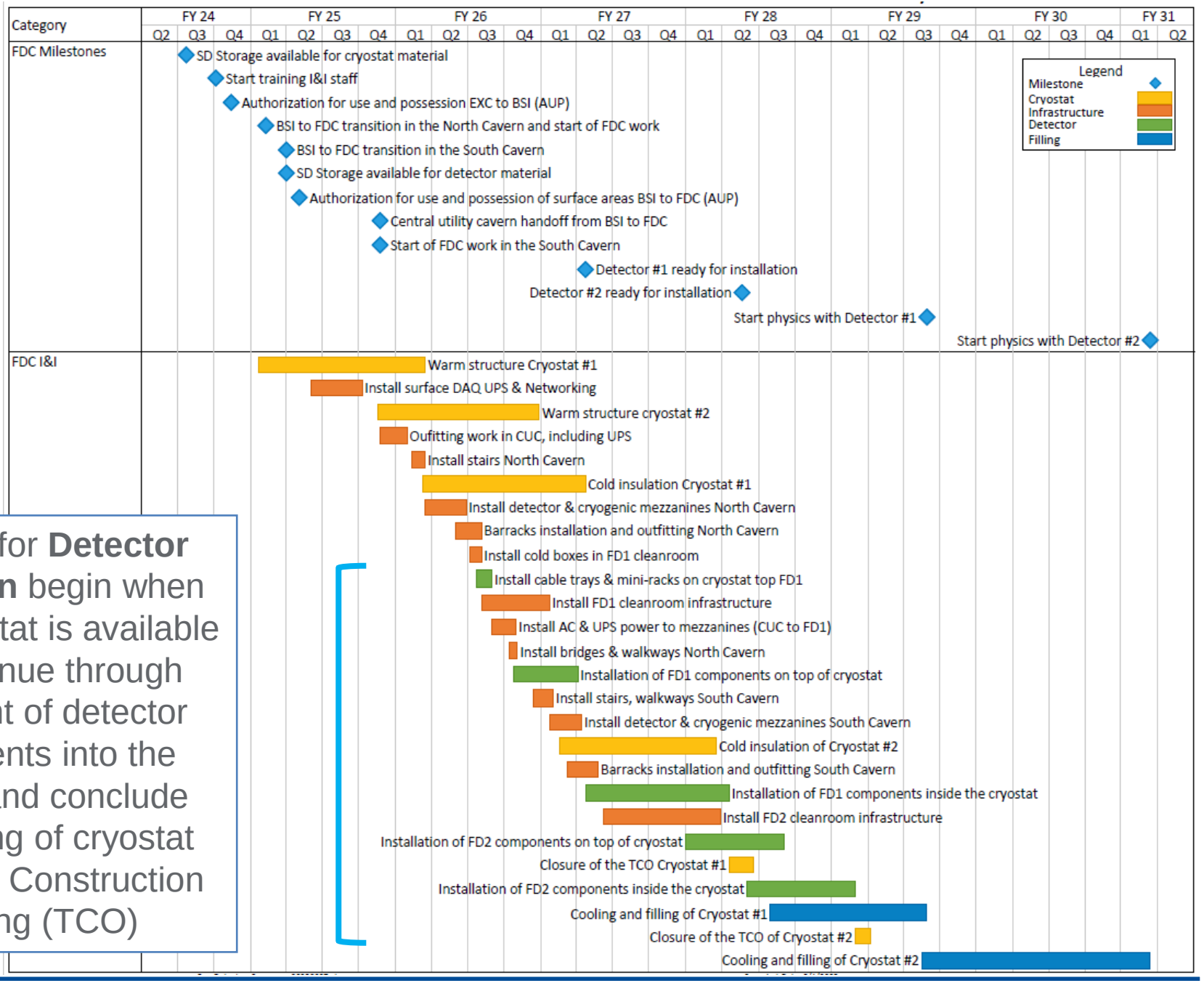




- Steel frame = warm structure
- Internal insulation = cold structure
- Fabrication in process
- Material shipments begin in 2024
- **First I&I underground activity**
- Installation also IKC; I&I provides technician support & interfacing infrastructure
- Sequential installation, starting in north cavern (~1 year each)
  - Warm structure – North Cavern
  - Cold structure – North Cavern & Warm structure – South Cavern
  - Cold structure – South Cavern
- Temporary Construction Opening allows access for detector installation

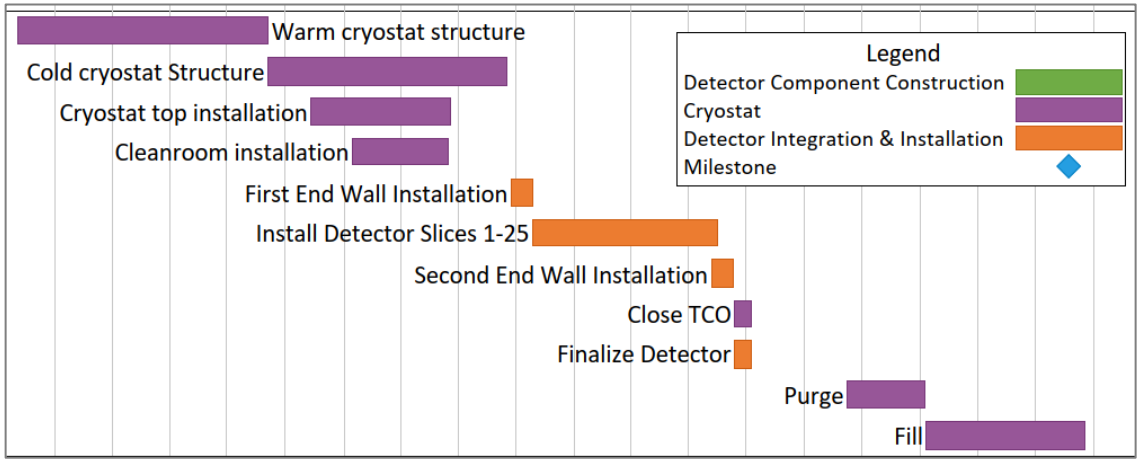


Schedule Summary
Detector Installation
131.FDC.05.03
131.FDC.05.04

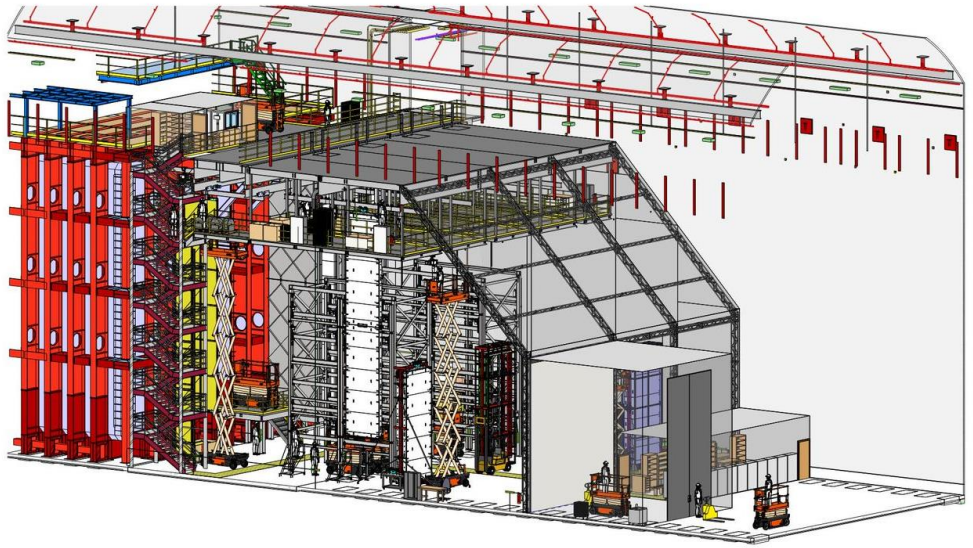


Activities for **Detector Installation** begin when top of cryostat is available and continue through movement of detector components into the cryostat and conclude with closing of cryostat Temporary Construction Opening (TCO)

Far Detector #1 (HD) Installation 131.FDC.05.03

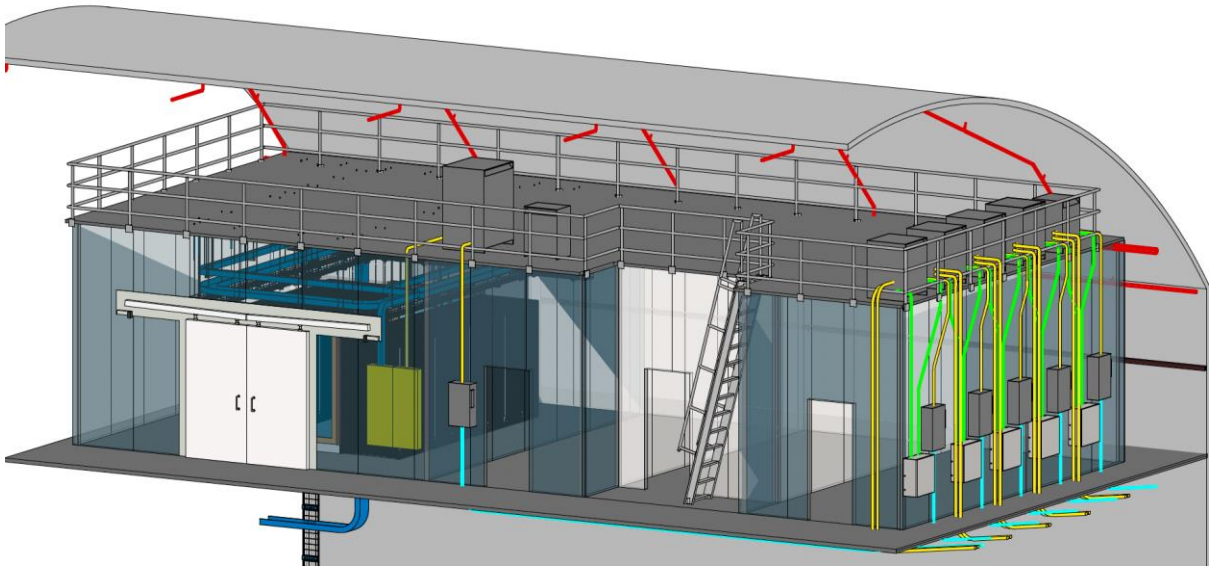


- Detector components:
  - Anode Plane Assemblies
  - High Voltage System, including Field Cages and Cathode Plane Assemblies
  - Photon Detector System, which are integrated into each Anode Plane Assembly
  - Cold Electronics cabling and feedthroughs
  - Data Acquisition System
  - Cryogenic instrumentation
- Includes work on top of cryostat & inside cryostat
  - Installation activities inside cryostat occur using TCO
- Includes significant temporary installation infrastructure
  - Structural steel cleanroom
  - 12m' high cold boxes for integrated testing
  - Work platforms
- Approximately 12 months installation period



FD1 Cleanroom & APA Towers adjacent to cryostat TCO

Far Detector Installation – Top of Cryostat
131.FDC.05.03
131.FDC.05.04



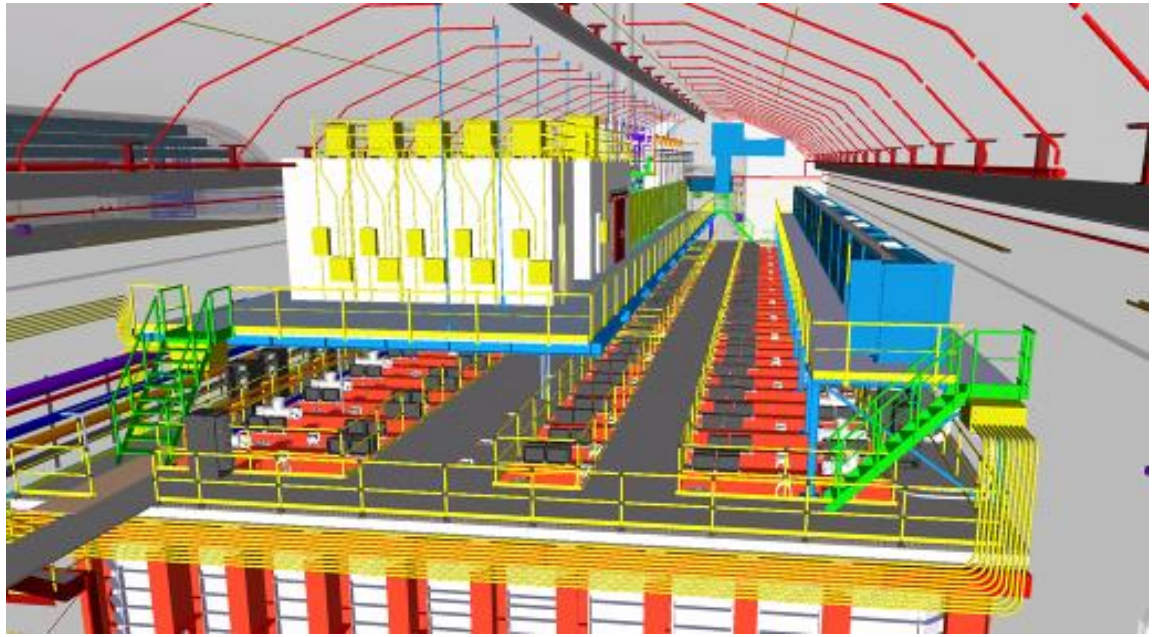
Barracks on cryostat mezzanine

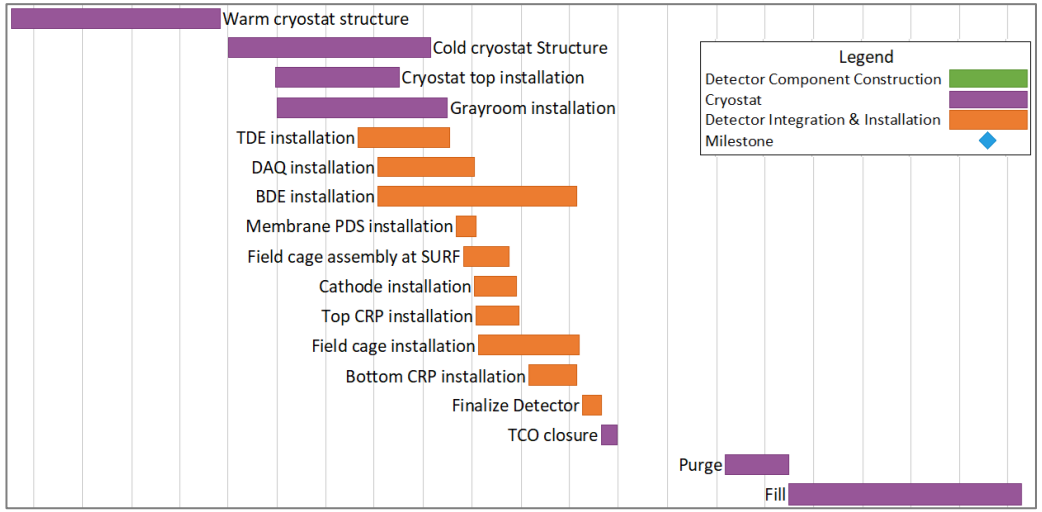
- Detector installation starts during cold cryostat installation, with work on top of the cryostat:
  - DAQ equipment is installed in the barracks
  - Racks are installed on the detector mezzanine for detector electronics
  - Mini racks are installed on the cryostat surface
  - Cable trays from the racks to the DAQ & electronics feed-throughs
  - Gaseous Argon purge lines are installed to the feed-throughs
  - Flooring and railing is added to the cryostat and mezzanines
- TPC installation progresses sequentially

Far Detector #2 (VD) Installation 131.FDC.05.04

- Detector components:
  - Data acquisition (DAQ)
  - High Voltage (HV)
  - Charge readout planes (CRP)
  - Top Drift electronic readout (TDE)
  - Bottom drift electric readout (BDE)
  - Photon detection (PD)
  - Cryogenic instrumentation
- Includes work on top of cryostat & inside cryostat
- Includes temporary installation infrastructure
- Approximately 12 months installation period

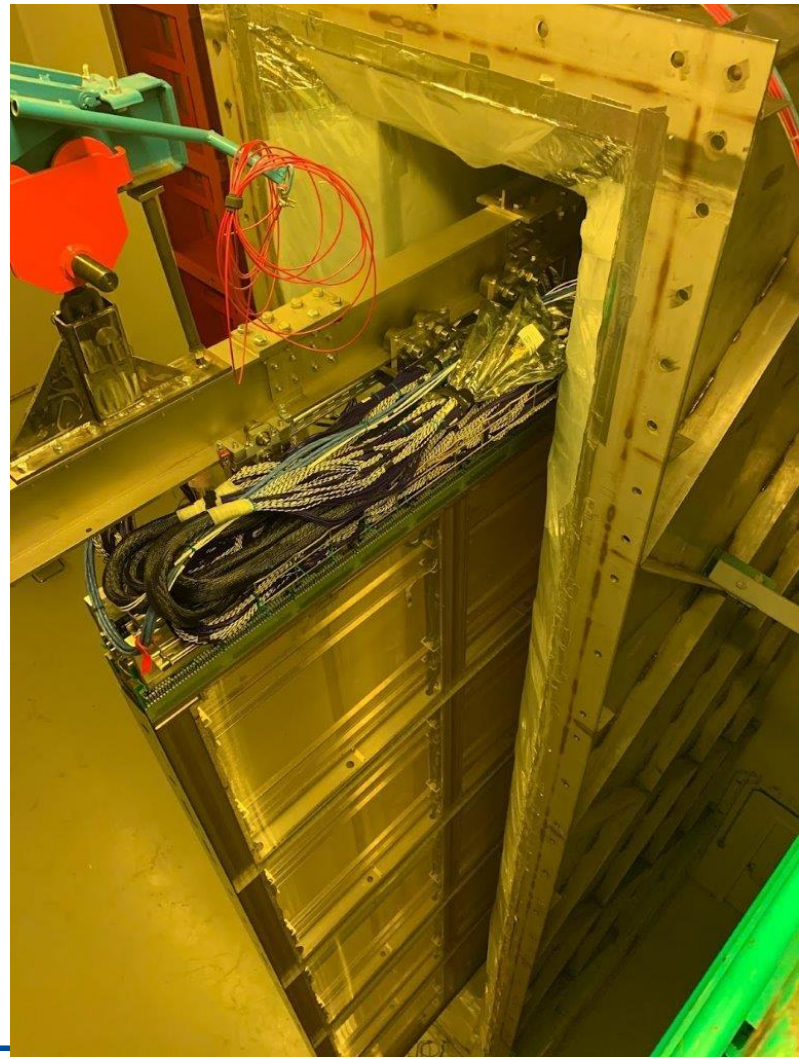
Detector Infrastructure on top of FD2 cryostat





Prototyping – ProtoDUNE NP04 & NP02 at CERN Neutrino Platform

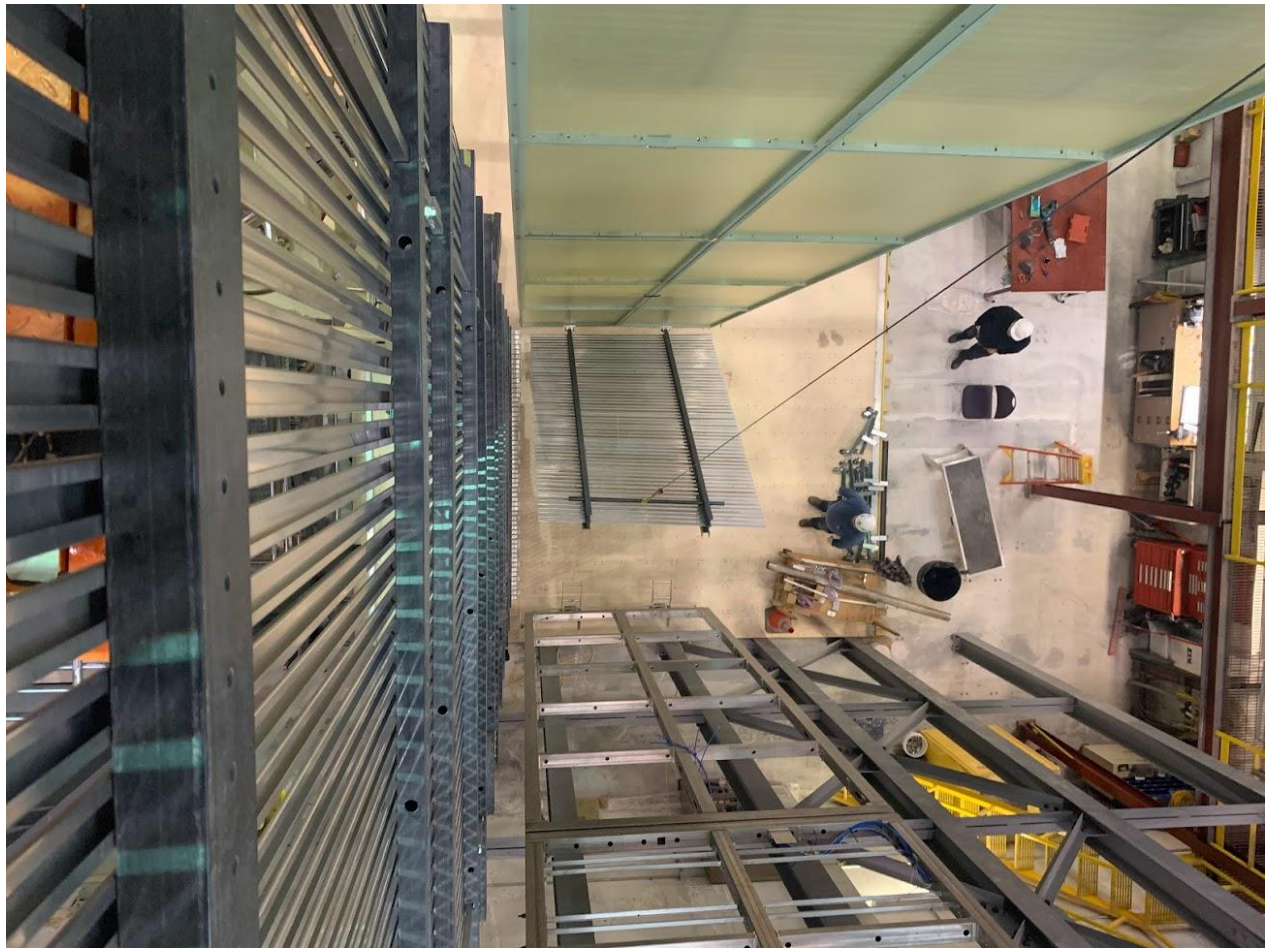
- Full-scale detector components
- Cryogenics system
- Installation processes
- Integrated teams accomplishing work
- 1/20th scale cryostats



Anode Plane Assemblies (APA) in ProtoDUNE NP04; Integrated APA in NP04 cold box

Installation Prototyping – Ash River, Minnesota

- Prototyping set-up at NOvA far detector
- Full-scale testing
- Participation from across consortia and installation planning teams
- Identify lessons learned
- Informs procedures and labor estimates



Full-height (12 meter) prototyping at Ash River, Minn (NOvA Far Detector)

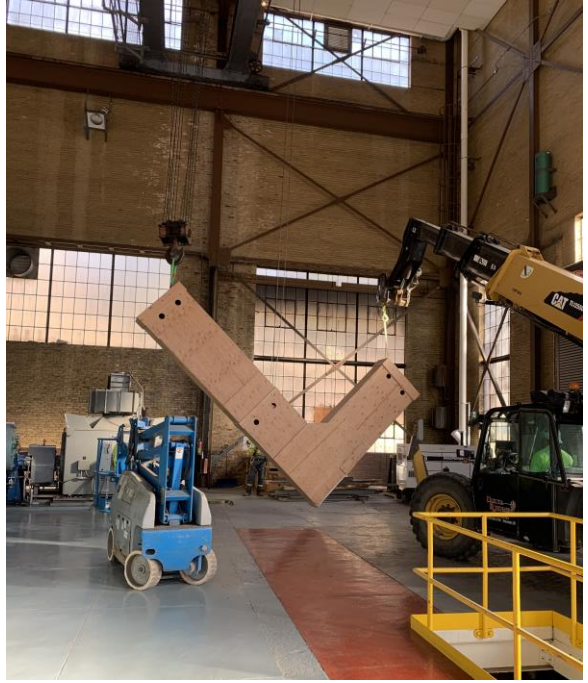
I&I Prototyping – APA Shipping Frame

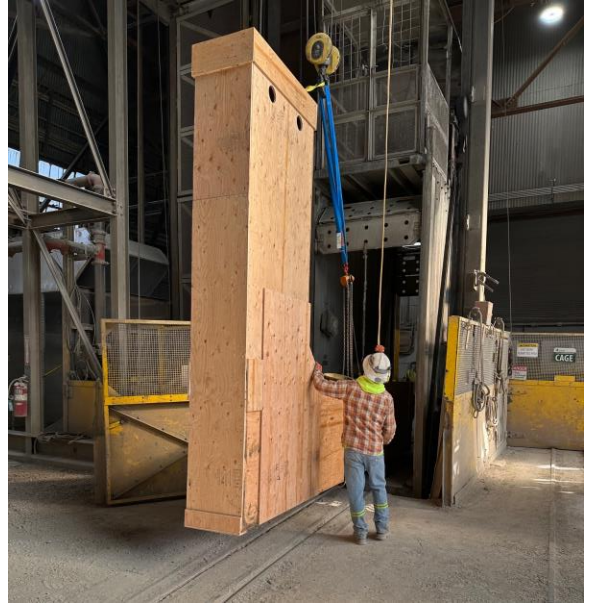
- November 2022
- Critical Transport (FESHM 10300)
- Critical Handling (DOE-STD-1090)
- Structural behavior
- Shipping
- Ross Shaft lowering
- Coordination of teams
- UK -> FNAL -> SURF

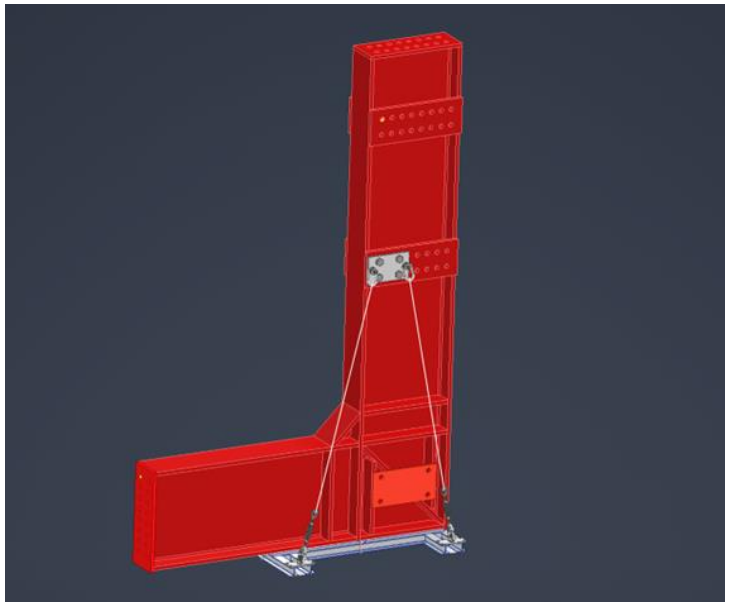
APA Shipping Frame (ASF) Test Lift at Ross Shaft (SURF), Nov 2022

I&I Prototyping – Cryostat Steel

- Preliminary movement trials performed by SDSTA with wood model.
- Design and engineering underway for tooling/ carts for manipulation and movement of L beam in/out of cage for transport underground
  - Cart design moving towards use of air casters
  - AMTT working group advancing carts for trial manipulations and movements in preparation for installation.
- First L beam and I beam arrives at SURF Jan. 9th for trial manipulations and test lifts

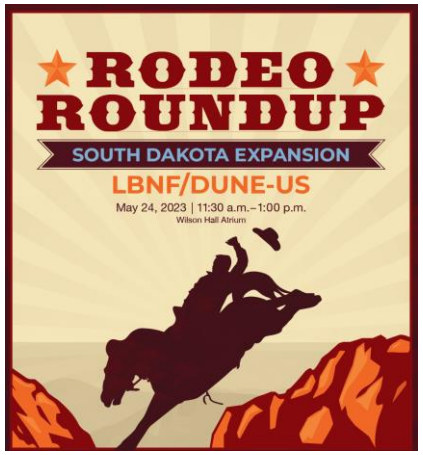


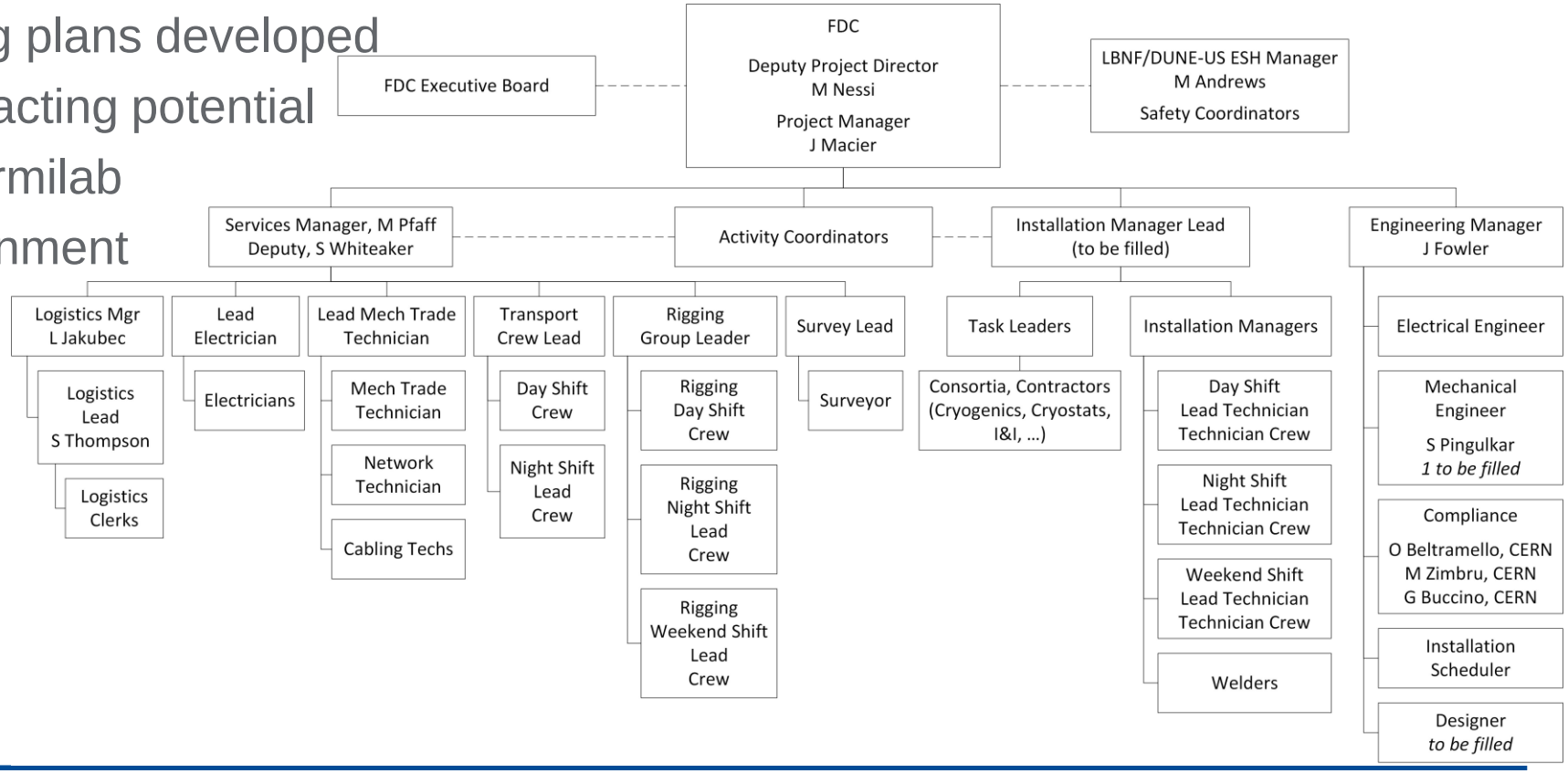




Planning for FDC I&I Staffing

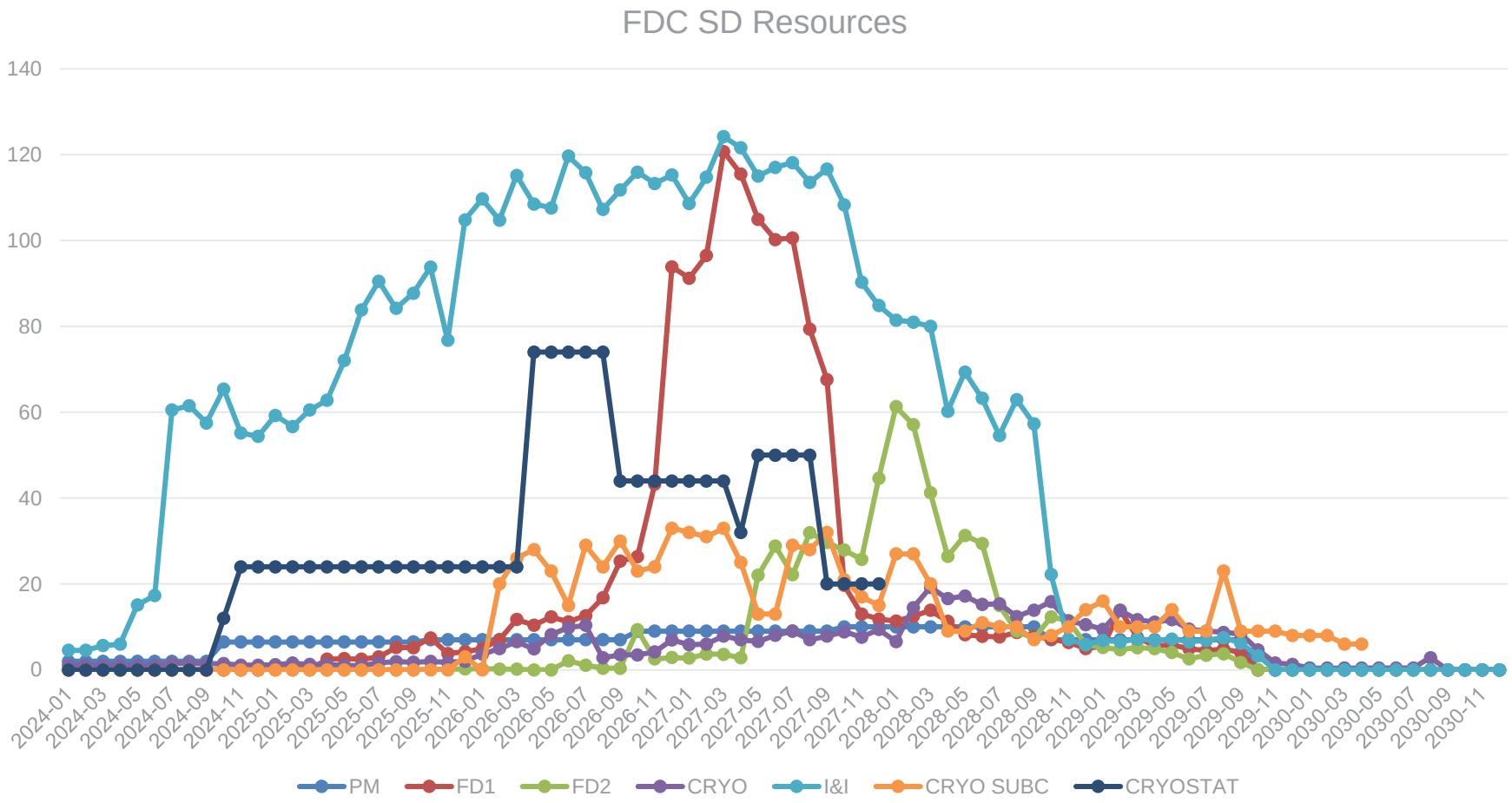
- SD-based team includes LOE services & activity-based personnel for installation
- Working to build the team
- Hiring underway with strong engagement from Fermilab HR
  - Job descriptions & training plans developed
  - Proceeding with subcontracting potential
  - Deliberate outreach at Fermilab
  - Domestic Extended Assignment policy approved





FDC South Dakota Resources

- FDC I&I
- FDC Cryogenics
- FD consortia/scientific



HR hiring planning

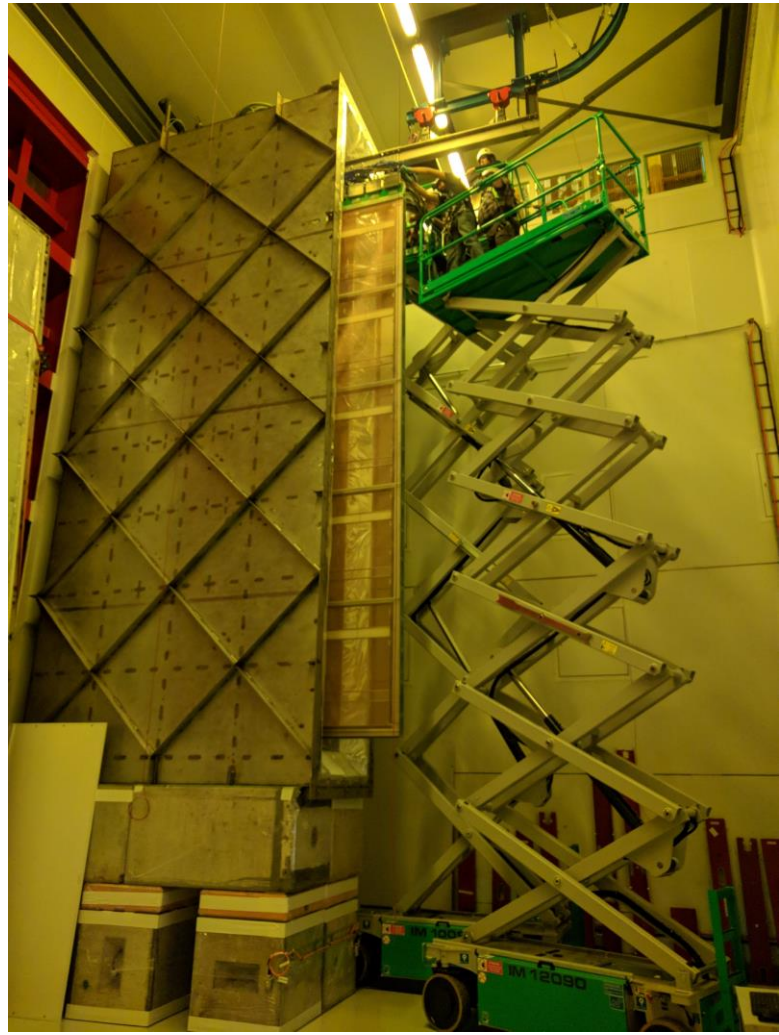
		FY 24										Fy25			
		Q2				Q3			Q4			Q1			
Title	Number of Hires	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25
Electrical Engineer	1														
Designer	1														
Logistics Clerk	2														
Rigging Group Lead	1														
Rigging Lead	2														
Installation Scheduler Manager	1														
Installation Manager	3														
Electrician Lead	1														
Mech Technician Lead	1														
Survey Lead	1														
Transport Crew Lead	2														
Safety Coordinator	3														
mechanical technician	2														
Rigging	14														
Surveyor	1														
Transport Crew (Day)	12														
mechanical technician	1														
mechanical technician	2														
Recruiting Events															
Black Hills Job Fair															
Tapps															
Hire the hills															
Internal Event															
Gillette Job Fair															
School Of Mines Job Fair															
Fermilab Job Fair Lead															

Personnel Risks (II)

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-FI-014	[I&I] Unavailability of FS Integration Labor		IN REVISION	
RT-131-FDC-FD2-034	[FD2-PDS] Additional on-project labor required during installation	30%	100 – 500 $k	1 month
RT-131-FDC-PM-171	[PM] Insufficient scientific personnel for the FD1 integration and installation	30%	450 – 1800 k$	0 – 3 months
RT-131-FDC-PM-172	[PM] Insufficient scientific personnel for the FD2 integration and installation	30%	300 – 750 k$	0 – 3 months
RT-131-FDC-FD2-034	[FD2-PDS] Additional on-project labor required during installation	30 %	100 -- 500 k$	1 months
RT-131-FDC-FD2-059	[FD2-CRP] Insufficient contributed labor for the installation of bottom CRP in FD2	30 %	25 -- 75 k$	0.5 -- 2.5 month

Environment, Safety, Health & Quality

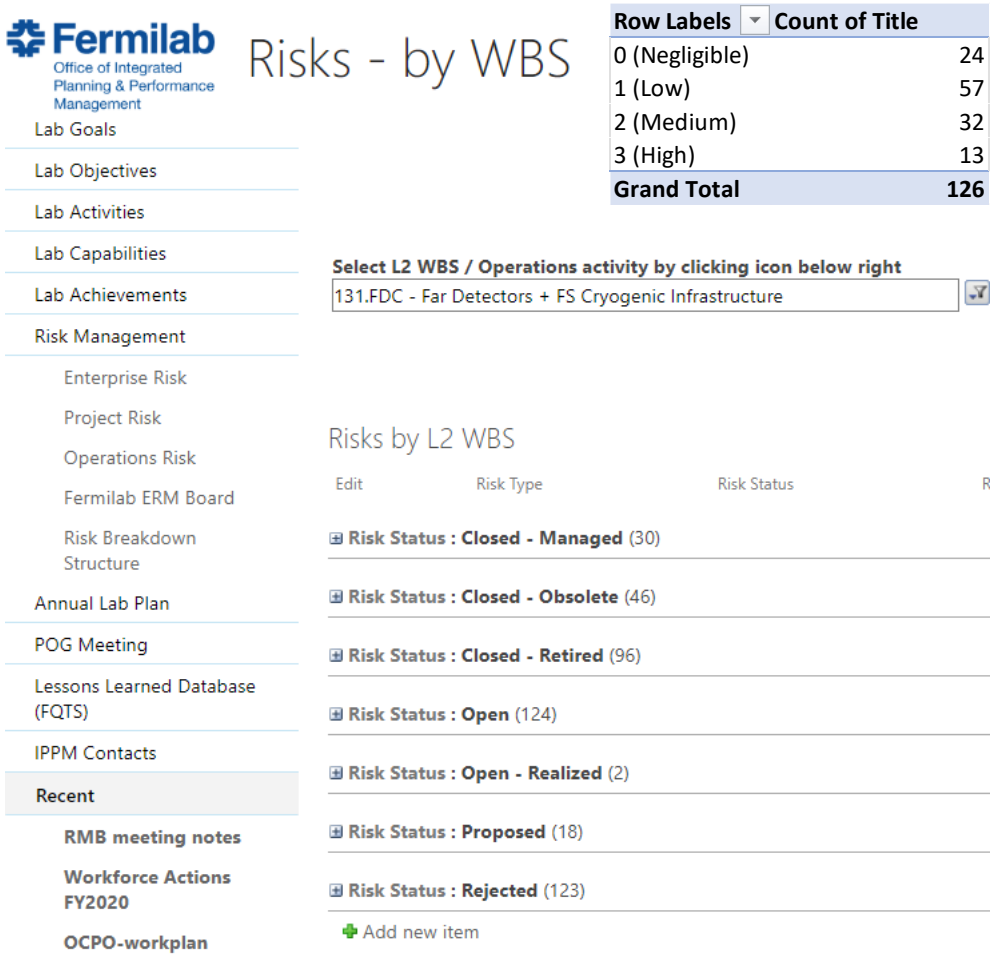
- ESH Plan & QA Plan address all work phases: design, prototyping, production as well as planning for underground installation
- ESH team to manage programmatic oversight, conduct training and work each shift to be attentive to work activity planning & execution
- Specific plans attentive to new era, where installation work will occur underground
  - Construction (cryostat & cryogenics)
  - Detector installation
  - Training requirements identified for all workers during Installation



Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-003	[PM] ESH Incident Stops Work Temporarily	40%	200 -- 500 k$	0.5 -- 1 -- 6 months

Risk/Contingency

- Active Risk Management across FDC
- Leverage enterprise tool with consistent processes
- LBNF/DUNE Monthly Risk Management Board with full Project participation & JPO coordination
- Project Management risks dominated by SD work
- Deliberate interface with FSCF/EXC and FSCF/BSI to capture correlated risks

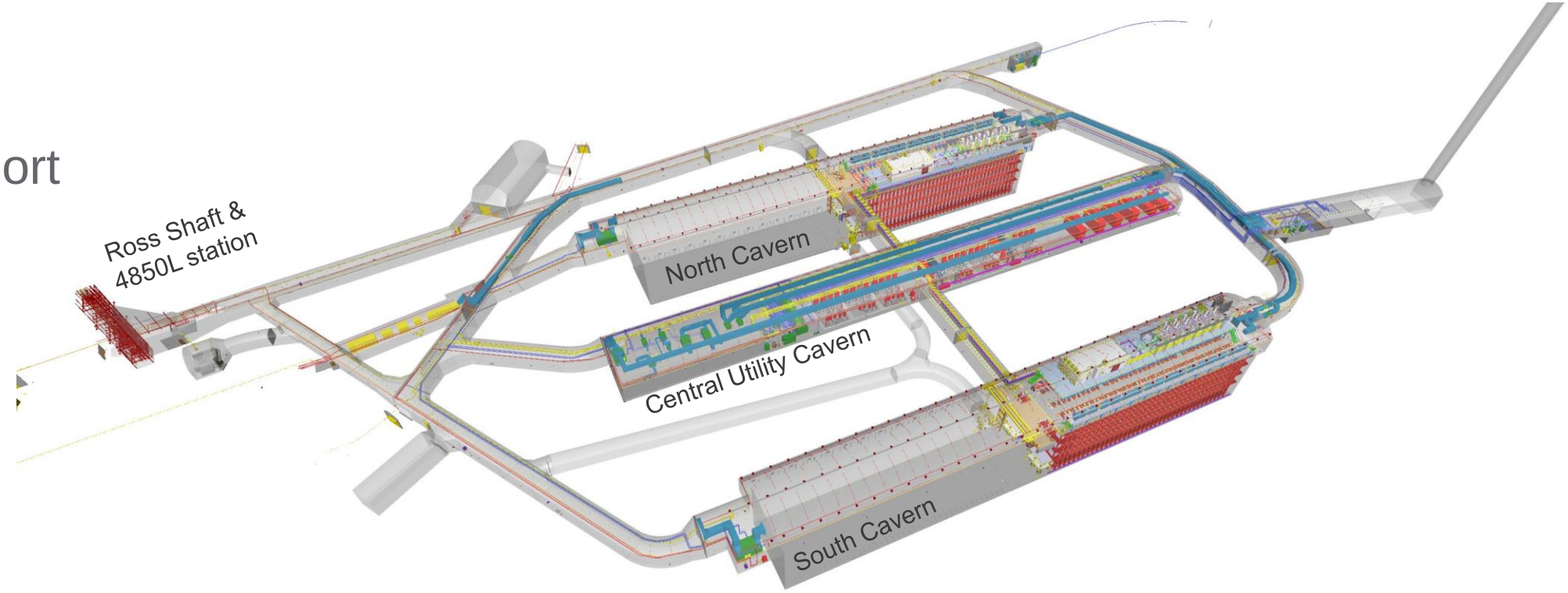


FDC PM risks reflect South Dakota based installation impacts

RI-ID	Title	Owner	Probabili	Cost Impact	Schedule Impac	Risk Rank	P * Impa	P * Impac
RU-131-FDC-PM-099	[PM] Future escalation rates are uncertain	Jolie R Macier	100.00%	-12752 -- 0 -- 21094 k$	0 months	3 (High)	2,781	0.0
RT-131-FDC-PM-024	[PM] FS long-term housing unavailable	Jolie R Macier	40.00%	2200 -- 5000 k$	0 months	3 (High)	1,440	0.0
RU-131-FDC-PM-103	[PM] Partner Insurance at SURF	Jolie R Macier	100.00%	-200 -- 1500 -- 3000 k$	0 -- 0.25 -- 1 months	3 (High)	1,433	0.4
RT-131-FDC-PM-026	[PM] US reinstates duties on steel imports from Europe	Jolie R Macier	50.00%	1747 -- 3494 k$	0 months	3 (High)	1,310	0.0
RU-131-FDC-PM-005	[PM] Changes to the Estimate of Duties for Imports	Jolie R Macier	100.00%	-200 -- 500 -- 1500 k$	0 months	3 (High)	600	0.0
RT-131-FDC-PM-010	[PM] Unavailability of SURF-/FRA-supplied systems at SURF - High P / Low impact	Jolie R Macier	50.00%	375 -- 750 -- 1500 k$	0.5 -- 1 -- 2 months	3 (High)	438	0.6
RU-131-FDC-PM-215	[PM] Fluctuations in exchange rates cause variations of the costs of detector	Cheng-Ju Stephen Lin	100.00%	-1500 -- 1500 k$	0 months	3 (High)	0	0.0
RU-131-FDC-PM-114	[PM] Offsite Indirect Rates uncertainty	Jolie R Macier	100.00%	-2667 -- 0 -- 2621 k$	0 months	3 (High)	-15	0.0
RT-131-FDC-PM-009	[PM] SURF underground cavern expansion project impacts LBNF/DUNE project	Jolie R Macier	15.00%	700 -- 11400 -- 22800 k	1.5 -- 3 -- 6 months	2 (Medium)	1,995	0.5
RT-131-FDC-PM-182	[PM] Oro Hondo shaft ventilation path is blocked (FDC)	Marco Verzocchi	5.00%	0 -- 50000 k$	0 -- 24 months	2 (Medium)	1,250	0.6
RT-131-FDC-PM-109	[PM] FS Medical Services Needed on-site	Jolie R Macier	20.00%	5500 k$	0 months	2 (Medium)	1,100	0.0
RT-131-FDC-FI-023	[PM] [CD3a] South Dakota Taxes for cryostat #1 warm structure and labor	Jolie R Macier	50.00%	977 k$	0 months	2 (Medium)	489	0.0
RT-131-FDC-PM-012	[PM] Unavailability of SURF-/FRA-supplied systems at SURF - Low P / High impact	Jolie R Macier	20.00%	750 -- 1500 -- 4500 k$	1 -- 3 -- 6 months	2 (Medium)	450	0.7
RT-131-FDC-FI-051	[PM] South Dakota Taxes for I&I Outfitting & Detector Installation Labor	Jolie R Macier	50.00%	734 k$	0 months	2 (Medium)	367	0.0
RT-131-FDC-PM-171	[PM] Insufficient scientific personnel for the FD1 integration and installation	Marco Verzocchi	30.00%	450 -- 1800 k$	0 -- 3 months	2 (Medium)	338	0.5
RT-131-FDC-PM-126	[PM] SURF underground drift expansion project impacts LBNF/DUNE project	Jolie R Macier	20.00%	400 -- 800 -- 1600 k$	0.5 -- 1 -- 2 months	2 (Medium)	187	0.2
RT-131-FDC-PM-003	[PM] ESH Incident Stops Work Temporarily	Michael P Andrews	40.00%	200 -- 500 k$	0.5 -- 1 -- 6 months	2 (Medium)	140	1.0
RT-131-FDC-PM-008	[PM] Extended U.S. Congressional Continuing Resolution after CD-2	Jolie R Macier	30.00%	0 k$	1 -- 3 -- 9 months	2 (Medium)	0	1.3
RT-131-FDC-PM-113	[PM] Ross shaft logistics scheduling challenges impact FDC installation schedule	Jolie R Macier	40.00%	0 k$	3 -- 4 -- 6 months	2 (Medium)	0	1.7
RT-131-FDC-PM-172	[PM] Insufficient scientific personnel for the FD2 integration and installation	Marco Verzocchi	30.00%	300 -- 750 k$	0 -- 3 months	1 (Low)	158	0.5
RT-131-FDC-PM-006	[PM] Ross skip hoist brakes failure	Jolie R Macier	30.00%	500 k$	2 months	1 (Low)	150	0.6
RT-131-FDC-PM-007	[PM] Ross skip drum cracks require repair	Jolie R Macier	15.00%	687 k$	1.5 months	1 (Low)	103	0.2
RT-131-FDC-PM-004	[PM] Codes or standards change resulting in scope increases FS	Jolie R Macier	5.00%	0 -- 2950 k$	0 -- 2 months	1 (Low)	74	0.1
RT-131-FDC-PM-011	[PM] General Security at SURF	Jolie R Macier	4.00%	0 -- 1000 k$	0 -- 6 months	1 (Low)	20	0.1
RT-131-FDC-PM-014	[PM] Detrimental Changes to the Overall DOE funding profile before CD-2 Baselining	Christopher J. Mossey	15.00%	0 k$	0 -- 3 months	1 (Low)	0	0.2
RT-131-FDC-PM-125	[PM] Lack of Agreement on international codes/standards affects partner design	Jolie R Macier	15.00%	0 k$	0 -- 0.5 -- 6 months	1 (Low)	0	0.3
RT-131-FDC-PM-131	[PM] Non-US Workers Visa Delays	Jolie R Macier	10.00%	0 k$	1 -- 3 months	1 (Low)	0	0.2
RT-131-FDC-PM-173	[PM] International partners fail to provide personnel for FD1 and FD2 installation	Marco Verzocchi	20.00%	0 k$	0 -- 3 months	1 (Low)	0	0.3
RT-131-FDC-PM-002	[PM] Union Work Stoppage Delays Project at Far Site	Jolie R Macier	10.00%	0 k$	-- 0.25 -- 0.5 month	0 (Negligible)	0	0.0

FDC Challenges

- EXC/BSI schedule impacts on FDC
- Concurrent work with FSCF/BSI (Ross Shaft coordination)
- I&I Labor
- Procurement
- Host Lab Support



Ross Shaft Utilization

- Double/single deck cage
- Skip transport included
- Travel speeds in accordance with SDSTA standard operation
- Staffing levels and shift schedule from installation plan
- Materials list
- Calculated roundtrips times for lift types
- Total capacity adjusted for maintenance and other anticipated stoppages

Shaft & Logistics Risks

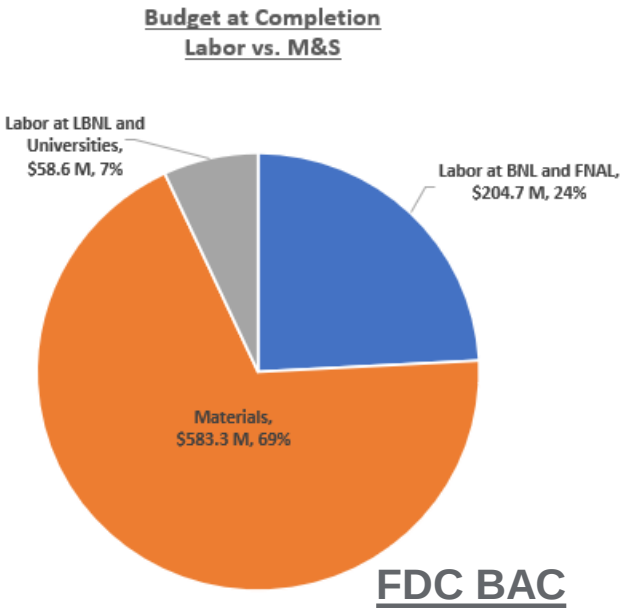
Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-113	[PM] Ross shaft logistics scheduling challenges impact FDC installation schedule	40 %	0 k$	3 -- 4 -- 6 months
RT-131-FDC-FI-115	[I&I] Complications with internal supply chains and logistics	10 %	0 k$	0 -- 0.5 -- 3 months
RT-131-FDC-FI-108	[I&I] Customs delays	30 %	10 -- 250 -- 500 k$	0 -- 1 -- 3 months
RT-131-FDC-FI-013	[I&I] Goods Damaged during Shipment	10 %	200 -- 500 -- 5000 k$	3 -- 6 -- 18 months

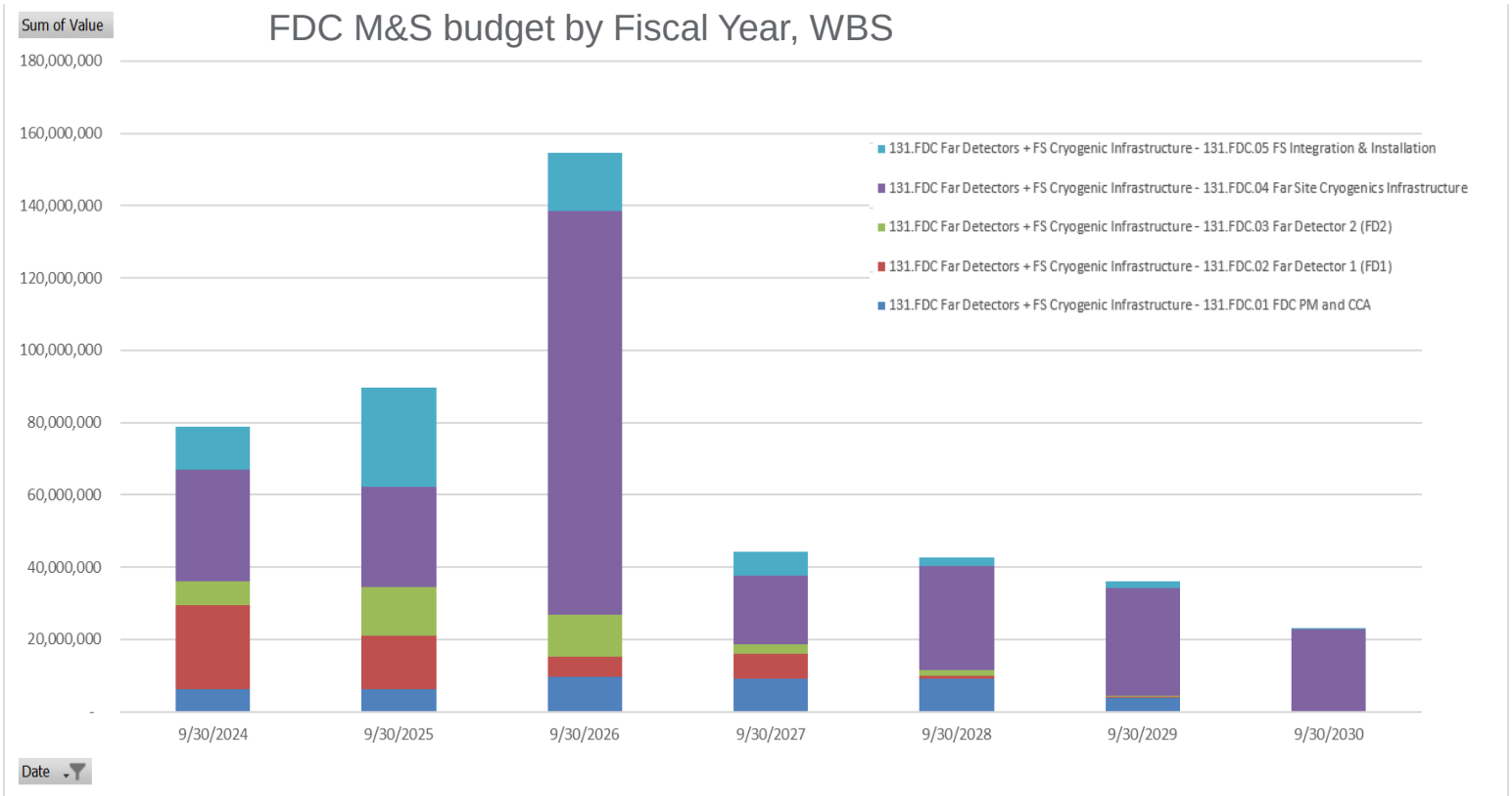
Regulatory Risks

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RU-131-FDC-PM-005	[PM] Changes to the Estimate of Duties for Imports	100 %	-200 -- 500 -- 1500 k$	0 months
RT-131-FDC-PM-026	[PM] US reinstates duties on steel imports from Europe	50 %	1747 -- 3494 k$	0 months
RT-131-FDC-FI-051	[PM] South Dakota Taxes for I&I Outfitting & Detector Installation Labor	50 %	734 k$	0 months
RT-131-FDC-FI-023	[PM] [CD3a] South Dakota Taxes for cryostat #1 warm structure and labor	50 %	977 k$	0 month
RT-131-FDC-FI-024	[IPM] South Dakota Taxes for cryostat#1 cold M&S/labor & cryostat#2 warm/cold M&S/labor	50 %	3206 k$	0 months
RT-131-FDC-CR-175	[CRYO] South Dakota Taxes for In-Kind Contributions to Cryogenics	50 %	2605 k$	0 months

FDC Procurement Overview

- Procurement Planning activities included in P6 schedule; planning timelines informed by published Procurement Acquisition Lead Times (PALT); informed by value, contract type, approvals needed
- FDC supported by FNAL Central Procurement as well as LBNF/DUNE JPO Procurement team, including SD-based FTE
- Two Procurement actions selected for MA approval (N2, LAr supply)





Procurement Risks

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-CR-158	[CRYO] Difficulties in finding suitable installation subcontractor #1 and #2	10.00%	934 -- 2629 k$	1 -- 6 months
RT-131-FDC-CR-172	[CRYO] Need alternate LN2 supply for APA integrated cold boxes	20.00%	655 k$	0 months
RT-131-FDC-CR-176	[CRYO] IDIQ IKC installation and Argon distribution review & approval takes longer than planned	40.00%	0 k$	2 -- 4 -- 6 months

Implementation of the Host Lab Plan

- Host Lab Task Force initiated July 2022; Host Lab Plan (2 volumes) published May 2023
  - Volume 2: Identification of services by Mission Support Divisions of Fermilab
- Establishment of the FNAL - DUNE Coordination Office
- Includes the South Dakota Services team
  - Working on solutions for more office space; Conducting a Request for Information for local housing resources and solutions
  - Working with SDSTA on joint approach for several services and host responsibilities.
  - Mission Support Workshops
  - Host Lab Plan, Mission Support document updates
  - Working to better understand Quality of Life/User Support functions needed in SD

Implementation of the Host Lab Plan

- Communications: Hired a Lead-based Communications & Community Relations Manager to continue to build local relationships.
- ESH: Understanding occupational medical service needs and working towards a solution.
- Emergency & Security Management
  - Continue to manage and improve the badging process and Site Access requirements.
  - Hired Physical Security Manager and an individual to manage the badging process in SD.
- Finance/Procurement: Working to understand increased travel arrangements and hotel agreements; Rental car process and agreements
- Human Resources
  - Full team in place to support hiring in SD.
  - Continue to participate in outreach and job fair events.
- Information Technology: Launching procurement process for surface & underground networking.
- Infrastructure Services: Continue to explore service contract needs and support; Ross Dry remodel

Host Lab-Related Risks

Risk ID	Risk Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-PM-024	[PM] FS long-term housing unavailable	50 %	2200 -- 5000 k$	0 months
RU-131-FDC-PM-103	[PM] Partner Insurance at SURF RETIRED	100 %	-200 -- 1500 -- 3000 k$	0 -- 0.25 -- 1 months
RT-131-FDC-PM-109	[PM] FS Medical Services Needed on-site RETIRED	20 %	5500 k$	0 months
RT-131-FDC-PM-131	[PM] Non-US Workers Visa Delays	10 %	0 k$	1 -- 3 months
RT-131-FDC-PM-XX	[PM] Operations funding is insufficient to support Host Lab services delivery NEW	20 %	[to be calculated]	[to be calculated]