SURF Installation, CRP Factory, Cost and Schedule

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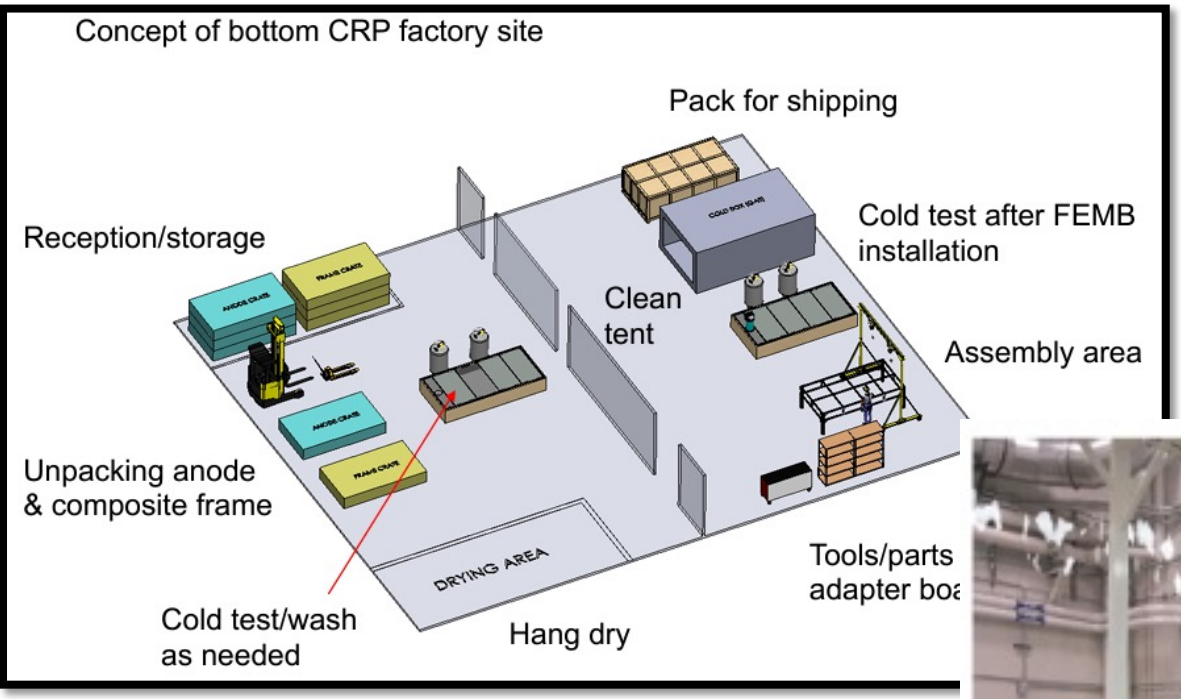
FD2 BDE Final Design Review
16 May 2023

FD2 BDE Installation

- A signficant fraction of the BDE installation is done ahead time at the CRP Factories (Yale U. and U. of Chicago)
- BDE provides FEMBs, patch panels, short signal and power cables (connection from FEMB to the patch panels)
- BDE also provides the QC test-stand for testing the FEMBs after they installed on the FEMBs
- Full assembled CRU (half CRP) will be tested in LN2 at the CRP Factories
- Installation of the FEMBs and QC at the CRP Factories will be done by the CRP Consortium with technical support from BDE
- CRP Consortium is also responsible for the transportation of the CRUs from the factories to SURF
- Prior to installation in FD2, all CRPs will be tested again by BDE crew in the underground clean room (warm test only)

Bottom CRP Factories

FD2 CRP FDR https://indico.fnal.gov/event/58650/



CRP4 was assembled and tested at the Yale CRP Factory

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SURF Installation

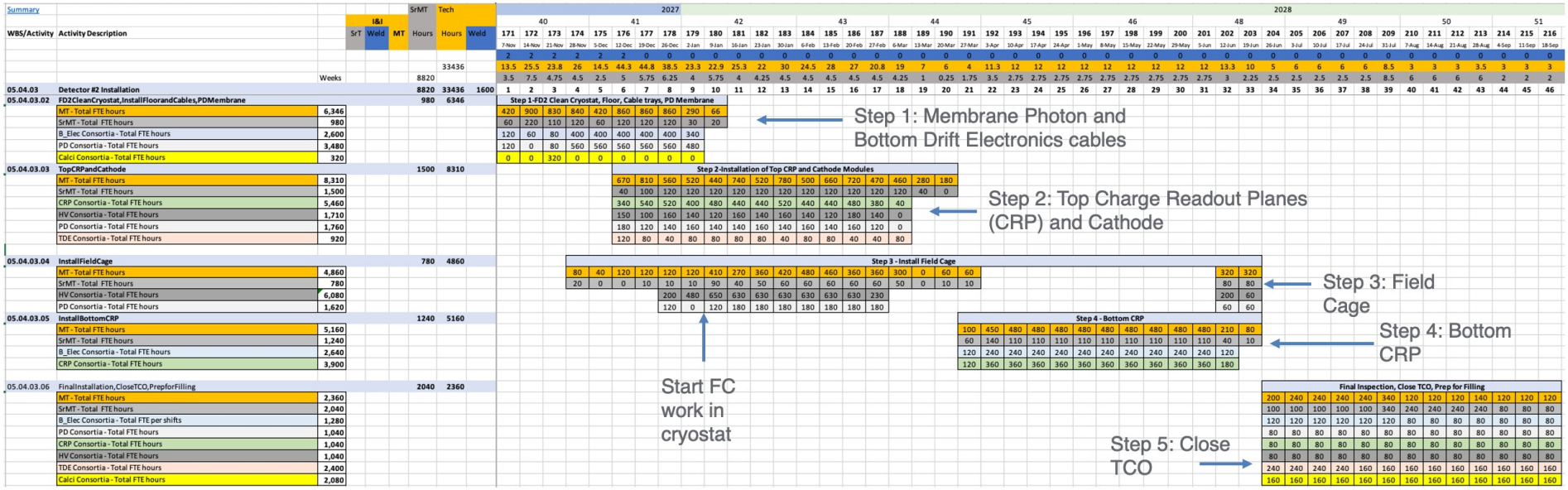
FDC Integration & Installation FDR https://indico.fnal.gov/event/59023/

- Target to have all BDE components arrive at SURF warehouse at least 6 months before the start of the installation
- BDE SURF installation has four main steps:
  1) Installation of the power supplies and safety interlock system in the rack on the detector mezzanine
  2) When the top of the FD2 cryostat is available for installation, install the penetration and warm electronics crates and boards
  3) When inside the cryostat is available, install the cable tray along with the long 27 m cables. Connect cables to the WIECs and test with FEMBs (on a cart). Cables are then temporarily stored under the false floor
  4) When CRPs are moved inside the cryostat, connect the long cables to the patch panels and perform QC test

- Detailed installation schedule and labor estimates are available in https://edms.cern.ch/document/2523457/LAST_RELEASED

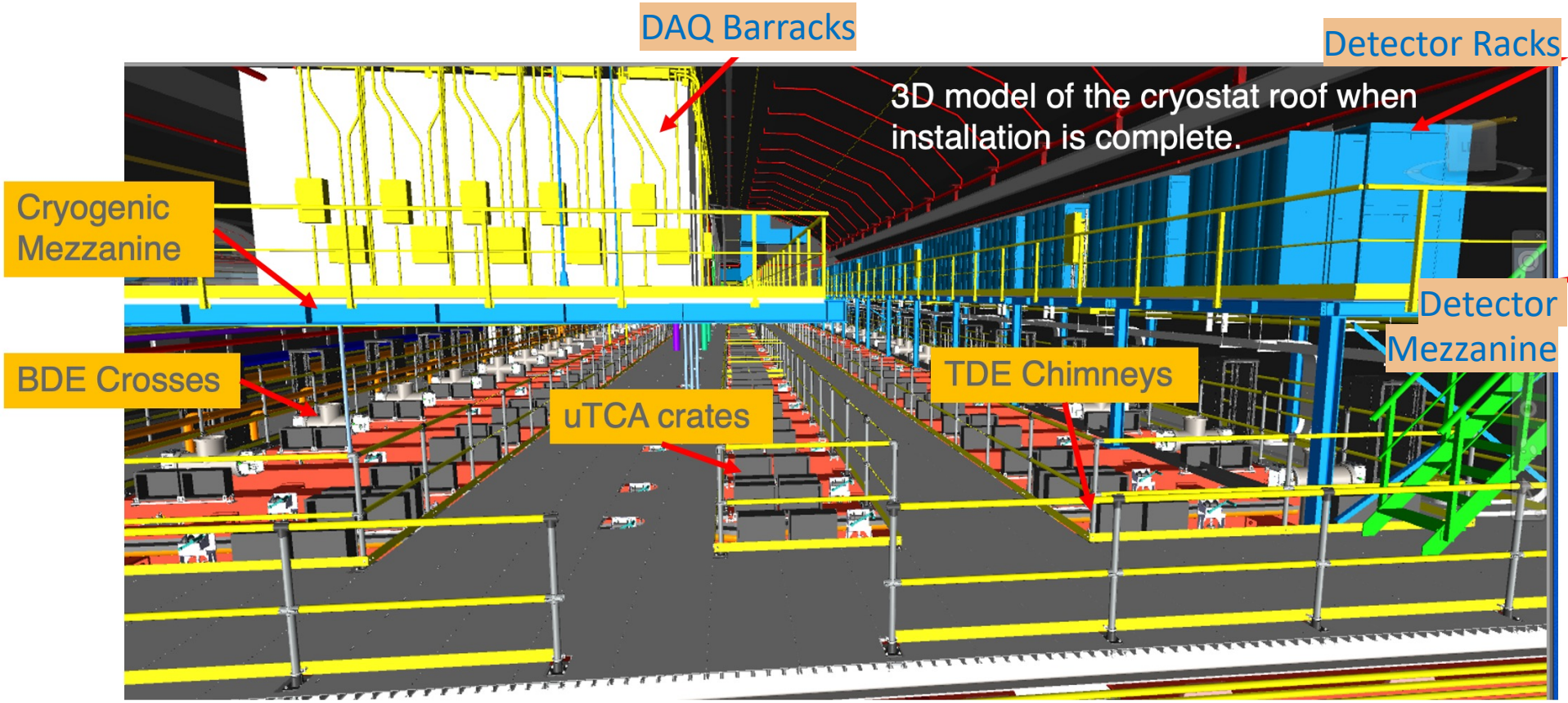
- Division of responsibility between I&I and BDE, CRP and BDE, PDS and BDE are defined in the interface documents

- 1 working week is 6 days with 2 shifts per day

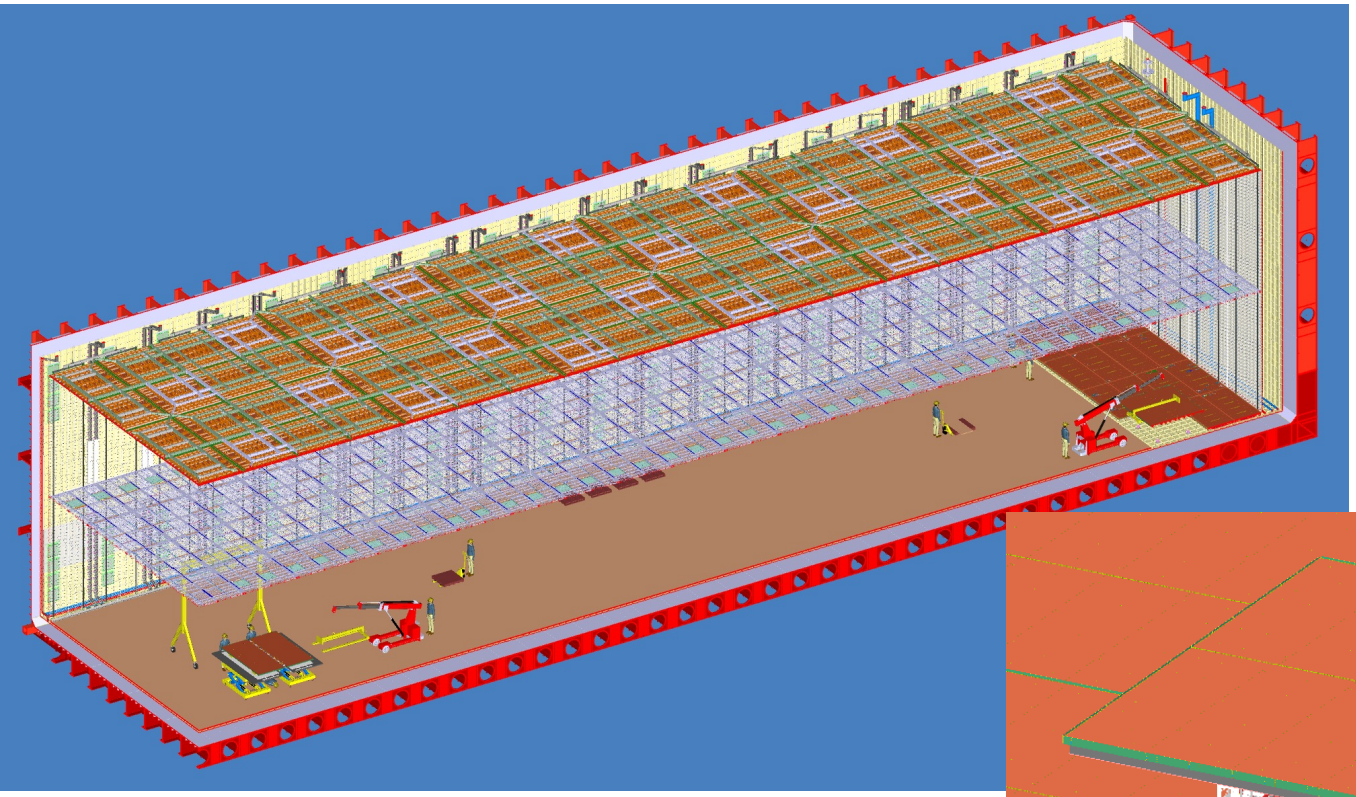


Cryostat Roof Installation

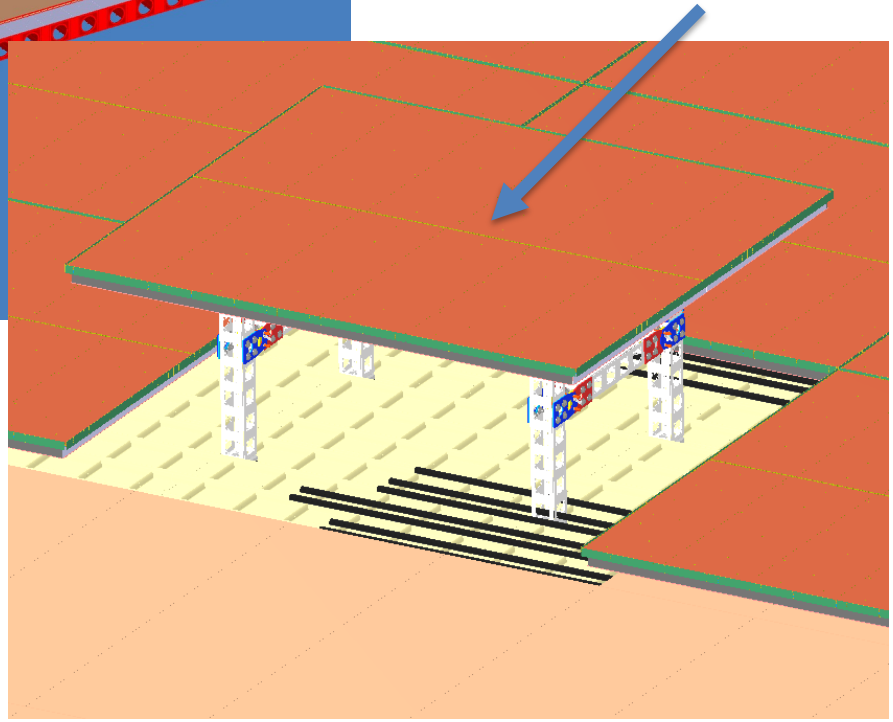
- 4 weeks are planned for the power supply and safety interlock installation in the detector racks
- 8 weeks are planned for the penetration and warm electronics installation



Bottom CRP Installation Inside Cryostat



CRP elevated on a supporting truss for long cable connection to the patch panels



Many aspects of the BDE SURF installation are exercised at CERN module-0

FD2 BDE Production/Procurements

Quantity listed does not include the typical 10% spare

- ASICs (see ASICs PRRs)
- 1920 x FEMBs
- 1920 x Cold cables (27 m): Samtec signal/clck, LV power cables, HV bias
- 1920 (2.5 m) x cold cables: miniSAS and LV power cables
- 320 x patch panels
- 40 x cryostat penetration assembly and cable strain relief
- 80 x Warm Interface Electronics Crates and mounting hardware
- 530 x Warm Interface Boards
- 80 x Power & Timing Cards
- DAQ fibers and ethernet cables
- 16 x PL506 LV power supplies and 80 LV warm power cables
- Beckhoff safety interlock system
- + many other smaller items (e.g. screws, gaskets, tools) that are needed for the production and installation

Procurement Strategy

- FD2 procurement largely follows the same strategy as FD1 procurement. Using the same vendor, etc.
- Due to resource constraints (both funding and people), most FD2 production/procurements start after the completion of the corresponding FD1 production. This logic relation is built into the P6 schedule
- For large procurements (e.g. cold cables, power supplies, etc.), plan to combine FD1 and FD2 into a single contract with firm order for FD1 and option to buy FD2 when FD2 funds are available
- Starting the procurement process >1 year before when we need to send out the POs
- Already having discussions with various procurement offices to start the process. Many items will need to go out for bids

Summary of FD2 BDE Production and Installation Schedule

(Taken from P6 Schedule as of May 2023)

- Start fabrication of FEMB PCBs (Aug 2025)
- Start fabrication of cryostat penetration (Oct 2025)
- Start production of WIB (Jan 2026)
- Start production of PTC (Jan 2026)
- Start production of WIEC (Jan 2026)
- Purchase low voltage power supplies (Jan 2026)
- Start production of cold cables (Mar 2026)

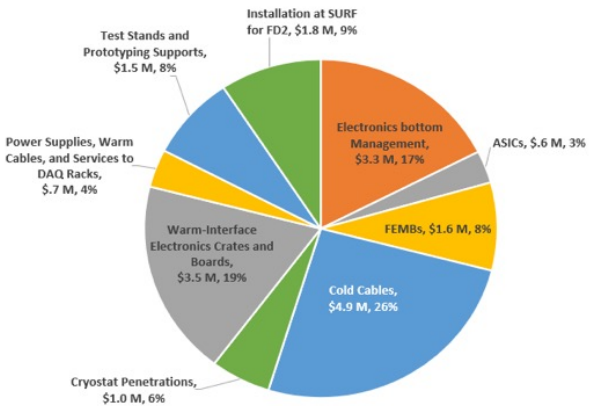
- Start installation of low voltage power supplies (May 2027)
- Start installation of CE safety interlock (May 2027)
- Start installation of penetration and warm electronics (Sep 2027)
- Start installation of cold cables inside cryostat (Jan 2028)
- Start installation of cold cables on CRP (Apr 2028)

BDE Cost Summary

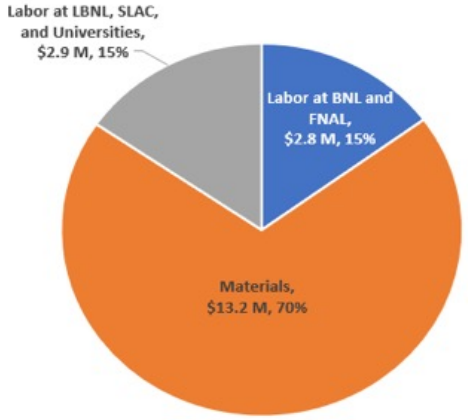
Cost summary from CD-1RR (Jul 2022). Updated cost (for CD-2/3) is about 15% higher mostly due to higher costs of components

WBS 4	WBS 5	Actuals thru Mar-22	Budget-at-completion (BAC)	Estimate-to-completion (ETC)	Contingency (EUC)	Contingency % on ETC	ETC + EUC	WBS Total Cost
131.FDC.03.05 FD2 Bottom Drift Electronics (BDE)	FD2 Bottom Drift Electronics (BDE)	$.3 M						
	Electronics bottom Management		$3.3 M	$3.2 M	$.1 M	4%	$3.3 M	
	ASICs		$.6 M	$.6 M	$.1 M	20%	$.7 M	
	FEMBs		$1.6 M	$1.6 M	$.3 M	20%	$1.9 M	
	Cold Cables		$4.9 M	$4.9 M	$1.0 M	21%	$5.9 M	
	Cryostat Penetrations		$1.0 M	$1.0 M	$.5 M	50%	$1.6 M	
	Warm-Interface Electronics Crates and Boards		$3.5 M	$3.5 M	$1.4 M	40%	$5.0 M	
	Power Supplies, Warm Cables, and Services to DAQ Racks		$.7 M	$.7 M	$.2 M	36%	$.9 M	
	Test Stands and Prototyping Supports		$1.5 M	$1.5 M	$.6 M	42%	$2.1 M	
	Installation at SURF for FD2		$1.8 M	$1.8 M	$.9 M	50%	$2.6 M	
	Total	**$.3 M**	**$18.9 M**	**$18.7 M**	**$5.3 M**	**28%**	**$24.0 M**	**$24.2 M**

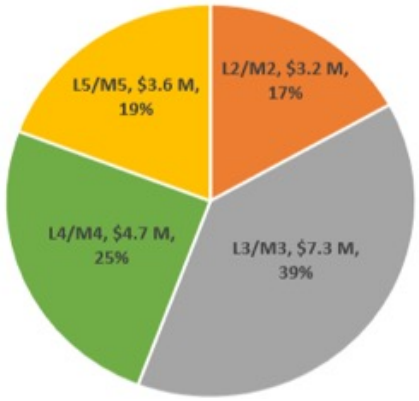
Budget-at-completion (BAC) By WBS



Budget at Completion Labor vs. M&S



ETC by Contingency Rule



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- Institutional responsibilities for fabrication, QC testing, and installation are similar to FD1
- See https://edms.cern.ch/document/2708334/ for the complete list

Subsystem	Description	Quantity (FD1)	Contributing Institutions
LArASIC	FE amplifier, design and procurement	24,320	BNL
LArASIC testing	QC process		BNL, Michigan State University, Stony Brook University, Iowa State University
ColdADC	Digitizer ASIC, design and procurement	24,320	BNL, Fermilab, LBNL
ColdADC testing	QC process		LBNL, Louisiana State University, Iowa State University, University of California Irvine
COLDATA	Serializer ASIC, design and procurement	6,480	BNL, Fermilab
COLDATA testing	QC process		Fermilab, University of California Irvine, Iowa State University
FEMB	Front-End Motherboard, design and procurement	3,040	BNL
FEMB testing	QC process		BNL, University of Florida, University of Cincinnati,
			Fermilab, Stony Brook University, plus one additional institution (TBA)
FEMB mechanical supports	Fabrication and QC	3,040	Colorado State University
Cold Signal Cables	Design, procurement, and QC	3,040	BNL
Cold Low Voltage Power Cables	Design, procurement, and QC	3,040	BNL
Cold Bias Voltage Cables	Design, procurement, and QC	658	BNL
Cable Trays Systems inside the Cryostat	Design, procurement and assembly	75	BNL
Temporary Cable Trays for Installation	Design, procurement and assembly	10	BNL
Cryostat Penetrations, including Cross Shaped Spool Pieces, Crossing Tubes	Design, procurement, assembly, and QC	75	BNL
CE flanges	Design, procurement, and QC	150	BNL
Warm Interface Electronics Crates	Design, procurement, and QC	150	BNL
Warm Interface Boards	Design procurement, and QC	750	BNL, University of Pennsylvania
Firmware and Software for the WIBs	Development and maintenance		University of Florida, University of Pennsylvania, BNL
Power and Timing Cards	Design, procurement, and QC	150	University of Pennsylvania
Firmware and Software for the PTCs	Development and maintenance		University of Pennsylvania, University of Florida
Interface to the DUNE Detector Safety System	Design and procurement, including development of software and action matrix	31 panels, includes hardware interlocks, power supplies for heaters and fans	Fermilab
Low voltage power supplies	Procurement and QC	25 modules	Fermilab
Bias voltage supplies	Procurement and QC	5 racks, with 45 HV modules, 45 fanout panels	Fermilab
Low voltage warm cables	Procurement and QC	25	Fermilab
Bias voltage warm cables	Procurement and QC	658	Fermilab
Readout fiber patch cords	Procurement and QC	150	Fermilab
Slow control patch cords	Procurement and QC	150	Fermilab
Clock distribution fibers	Procurement and QC	150	Fermilab
Integration test at BNL with the 40% APA prototype	System tests of new FEMBs, vertical slice test of readout	<10 combinations of different FEMBs and WIBs	BNL
Integration tests at ICEBERG	System tests of new FEMBs, vertical slice test of readout	<10 combinations of different FEMBs and WIBs	BNL, Fermilab, LBNL
Integration tests at NP04	System tests of new FEMBs, vertical slice test of readout	1-2 tests	BNL, Fermilab, LBNL
Support for APA integration tests at CERN	System tests of final APA and FEMBs in the cold box of NP04	Up to 20 APAs	BNL, LBNL, Fermilab,
Installation and Commissioning of ProtoDUNE-2	Integration of the FEMBs on the four APA, cold box testing, installation of the APAs inside the cryostat, cabling, and commissioning	4 APAs	BNL, Fermilab, LBNL, Louisiana State University
ProtoDUNE-2 Operations	Maintenance of TPC electronics during operations	2 years of data taking	BNL, Fermilab, LBNL, Louisiana State University
Installation of Detector Components on top of the Cryostat	Install cryostat penetrations, warm interface crates complete with WIBs and PTCs, all power and bias voltage supplies, connections; initial testing	75 cryostat penetrations and150 warm interface crates with all the services	All institutions from the TPC Electronics consortium
Integration of FEMBs on APAs and QC tests	Integrate FEMBs on APAs and perform tests in the cold boxes	3,000 FEMBs on 150 APAs	All institutions from the TPC Electronics consortium
APA QC Tests during Installation	Final readout test of the FEMBs through the DUNE DAQ after installation of the APAs in the cryostat	150 APAs	All institutions from the TPC Electronics consortium

FD2 BDE Risk Registry

- Four BDE risks in the registry
- Mostly to cover personnel shortage concerns

RI-ID	Title	Probability	Cost Impact	Schedule Impact
RT-131-FDC-FD2-022	[FD2] ASICs storage surcharge	30 %	70 k$	0 months
RT-131-FDC-FD2-071	[FD2-BDE] FD2 CE damage to the FEMBs / cold cables during or after CRP installation at SURF	5 %	25 -- 70 k$	0.25 -- 1 months
RT-131-FDC-FD2-019	[FD2-BDE] insufficient personnel for QC of cold electronic components during production	30 %	25 -- 50 -- 75 k$	1 -- 2 -- 3 months
RT-131-FDC-FD2-007	[FD2-BDE] Insufficient un-costed labor at SURF for installatiion	30 %	97 -- 194 -- 292 k$	0 months

- In addition, there are a number of risks for FD1 TPC electronics that are relevant for FD2 (e.g. single source vendor). Those risks are not included separately in FD2 to avoid double counting risks

Thank You !