

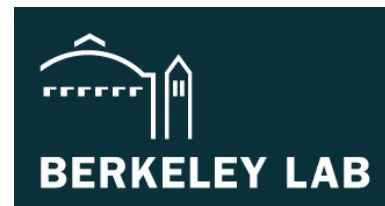
Procurement Strategy Cost and Schedule

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Lawrence Berkeley National Lab

FD2 BDE Preliminary Design Review

25 April 2022



Deliverables

ASICs:

- LArASIC_P5B: 15360
- ColdADC_P2 : 15360
- COLDATA_P4: 3840

Electronic Boards:

- Frontend motherboard : 1920
- Warm Interface board : 480

Warm crates (WIEC): 80

Cryostat penetration assemblies: 40

Power supplies:

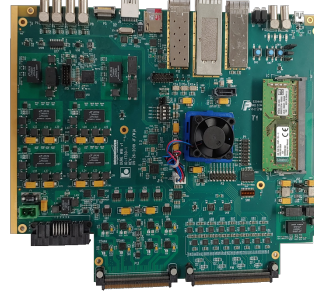
- Low voltage (PL506): 80 channels
- Warm Low voltage cable: 80

Cables, Patch Panel:

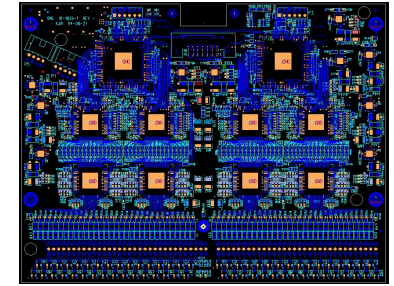
- SAMTEC signal/clck cable (25m): 1920
- Cold low voltage cable: 1920 (25m) + 1920 (4m)
- Cold bias SHV cables: 480
- MiniSAS cable: 1920
- Patch panel: 160 (or 320)

In addition, ~10% spares are planned

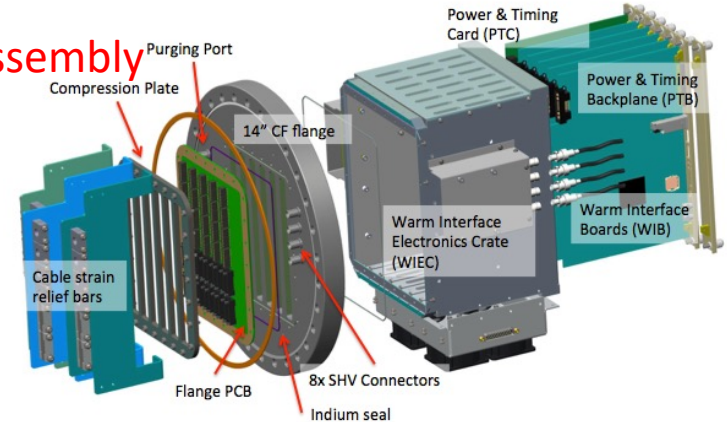
Warm Interface Board



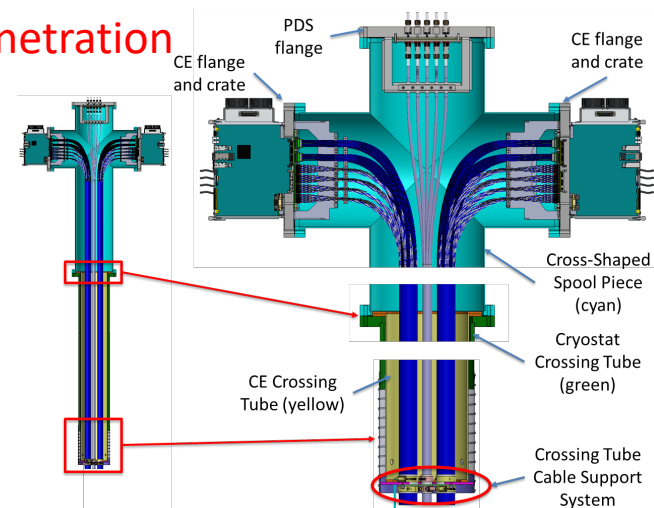
Frontend Motherboard



Warm Crate Assembly



Cryostat Penetration



Production Schedule

- Production of Bottom CE components for FD2 start soon after the end of FD1 production. All items will be sent to SURF except Frontend Motherboards, which will be delivered to the CRP Factories

Component	Fabrication Source	Start Date (in P6)	End Date (in P6)
ColdADC/COLDATA	Industry	Oct 2024	Jul 2025
Frontend Motherboard	Industry	Oct 2024	Jan 2026
Cold Cables	Industry	Apr 2025	Jun 2026
Cryostat Penetrations	Industry and Homemade	Feb 2025	Apr 2026
Warm Interface Electronic Crates and Electronic Boards	Industry	Apr 2025	Jun 2026
Power Supplies and Warm Cables	Industry	Apr 2025	Apr 2026

- Production dates are planned to minimize conflict with FD1 production and installation activities. FD1 and FD2 activities are linked in P6 Schedule

LArASIC Production

- ASIC industry is starting to restrict access to 180nm production line. LArASIC is using 180nm technology
- Decision of the CE Consortium is to go ahead and purchase all the LArASIC that we need for FD1, FD2, + spares ASAP before we get locked out of the production line
- LArASIC Production Readiness Review (7-8 March 2022). Review home page is at [Indico 53072](#)
- Production order for 250 Wafers → ~77K LArASIC_P5B (before yield) will go out to the vendor soon

Number of ASICs Needed (assume 10% of spare FEMBs)

ASIC	FD1 (3,000 FEMBs)	FD2 (1,920 FEMBs)	FD1+FD2
LArASIC	26,400	16,900	43,300

Cost Estimate

- Resource loaded cost+schedule is fully implemented in P6
- Most M&S estimates are based on actual vendor quotes
- Most electronics design costs are absorbed by FD1
- All NRE production charges (e.g. ASIC masks) are absorbed by FD1
- Labor estimate for QA/QC are based on ProtoDUNE-1 experience
- FD1 installation labor costs have large uncertainty (~50% assigned)
- Overall FD2 BDE Budget-at-Completion cost has ~30% uncertainty (cost contingency)

Sample Basis of Estimate

Frontend Motherboard M&S

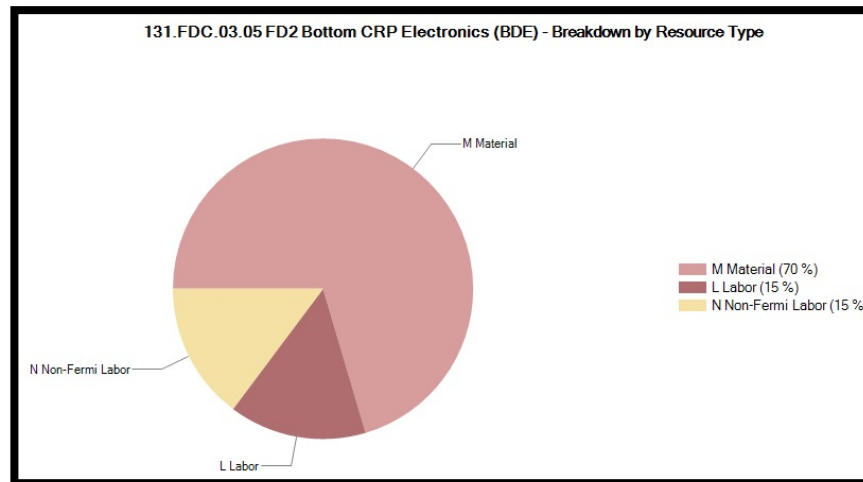
4	This sheet contains the M&S estimates that are contained in the FEMBs CB Detail spreadsheet					
5	Last updated on 23 September 2021 - Cheng-Ju Lin					
6	Production phase - FD2					
7	Component number / Component cost	CORE cost	Numbers/cost	Non recurring costs	Notes	Vendor Quote Link
8	Number of FEMBs per detector			1,920	80 CRPs in FD-2. Each CRP requires 24 FEMBs for 3-view	
9	Number of FEMB spares			200	Number of spare FEMBs based on assumption of minimal rework during construction (10%)	
10	Total number of FEMBs			2,120	Sum of two previous numbers	
11	Total number of CE boxes and mailers			2,120	One each per FEMB	
12	Fabrication cost for the printed circuit boards for the FEMBs			\$ 34.00	Follow hyperlink for quote	Link to quotes
13	Component cost for the FEMBs			\$ 170.60	Cost of printed circuit boards, discrete components, follow hyperlink for quote	Link to quotes
14	Assembly cost for the FEMBs			\$ 125	Expert estimate, based on economy of scale and ProtoDUNE quote, non recurring costs during pre-production only	
15	Unit cost of DUNE FEMB			\$ 329.60	Sum of the three previous lines	
16	Cost of a single DUNE CE box			\$ 131.47	\$95.64 Follow hyperlink for quote; Manhong has updated quote for AI version (see email from 05/07/2021)	Link to quotes
17	Cost of a single mailer for the DUNE CE box plus FEMB			\$ 16.14	Follow hyperlink for quote	Link to quotes
18	Unit cost of DUNE CE boxes and mailers			\$ 147.61	Sum of two previous lines	
19	Hardware for the connection between the FEMB and the CE box			\$9.31		
20	Hardware for securing the data cable to the FEMB			0.89		
21	Unit cost of mounting hardware (CE box to CRP Adaptor board)			\$0.50	Estimated	
23	Total cost of discrete components for FD2			\$361,672.00	Cost of discrete components for one FEMB times the total number of FEMBs for FD2	
25	Total cost of blank PCBs for FD2			\$72,080.00	Cost of one blank PCB times the total number of FEMBs for FD2	
26	Cost for 1 batch of blank PCBs			\$18,020.00	Assume production split in four batches of 25% each.	
28	Total cost of CE boxes, G10 mounting hardware, and mailers			\$ 335,617.20	Multiply the unit cost by the total number of FEMBs for FD2	
29	Procurement cost for 1 batch of CE boxes, mounting hardwares and mailer for FD2			\$ 83,904.30	Assume production split in four batches of 25% each.	
31	Total cost of FEMBs assembly for FD2			\$ 265,000.00	Multiply the assembly cost for one FEMB by the total number of FEMBs for FD2	
32	Assembly cost for 1 batch of FEMBs			\$ 66,250.00	Assume production split in four batches of 25% each.	
34	Total shipping costs from FEMB QC Site to CRP factories			\$ 32,000.00	Assumes 160 shipments, each 15 FEMBs at ~\$200 per shipment	
35	Shipping cost per batch per site			\$2,000.00	There are four FEMB QC sites. Assume each site ships FEMB in four batches. Total shipping cost / 4 batches / 4 institutions	

Similar spreadsheets for other BDE components and labor estimates

32	23	40	R1206R1207R1208R1209	CR0402	0	Digi-Key	311-0-0478L-ND	Yageo	RC0603R-0720RL	132000	50,000	2	5	16.40	\$	163.20
33	24	7	R178R182R254R350	CR1206R1208	0.1	Digi-Key	5081206PFR100R48-ND	Stackpole	CSR1-17R100	23100	5,000	5	5	272.00	\$	1,360.00
34	25	4	R544R546R554R556	CR1206R1208	1	Digi-Key	1378-5618-2-ND	Samsung	RC3210-10CS	13200	10,000	2	5	93.83	\$	187.66
35	26	24	R254R257R258R363	CR0402	50	Digi-Key	118-0000000000000000-ND	Yageo	RT0402BTR05	79200	30,000	3	5	1,185.65	\$	3,556.95
36	27	102	R138R180R255R256	CR0402	100	Digi-Key	311-10048TR-ND	Yageo	RC0402TR-0710RL	336600	10,000	34	5	18.60	\$	632.40
37	28	17	R149R150R151R154	CR0603	100	Digi-Key	541-3951-2-ND	Vishay	CRW0603100R05	56100	5,000	12	5	23.38	\$	280.56
38	29	2	R163R173	CR0603	1.8K	Digi-Key	P1-604TR-ND	Panasonic	ER-18EF1401V	6600	5,000	2	5	24.04	\$	48.08
39	30	3	R166R169R1107	CR0603	1.875	Digi-Key	RMCF0503118L78-ND	Stackpole	RMCF0503118L7	9900	5,000	2	5	10.92	\$	21.84
40	31	2	R160R175	CR0603	1.8K	Digi-Key	P1-80XTR-ND	Panasonic	ER-18EF1801V	6600	5,000	2	5	24.04	\$	48.08
41	32	2	R153R168	CR0603	1.96K	Mouser	503-80050TR-07146EL-ND	Yageo	RC0603TR-07146EL	6600	5,000	2	5	10.00	\$	20.00
42	33	1	R1124	CR0603	16K	Digi-Key	311-16048TR-ND	Yageo	RC0603TR-0716KL	9900	5,000	1	5	15.62	\$	15.62
43	34	1	R1120	CR0603	1K	Digi-Key	311-14048TR-ND	Yageo	RC0603TR-07402L	3300	5,000	1	5	15.62	\$	15.62
44	35	48	R259R260R261R262	CR0402	2.2K	Digi-Key	Y0214078-ND	Yageo	RT0402BR072K2L	15840	30,000	6	5	1,186.46	\$	7,118.76
45	36	5	R105R109R103R107	CR0603	3.5K	Digi-Key	P2-48XTR-ND	Panasonic	ER-38EF291V	16500	5,000	4	5	24.01	\$	96.04
46	37	3	R152R167R1103	CR0603	3.57K	Digi-Key	311-3-5748TR-ND	Yageo	RC0603TR-073K57L	9900	5,000	2	5	15.62	\$	31.24
47	38	5	R158R161R171R1104	CR0603	2K	Digi-Key	P2-004TR-ND	Panasonic	ER-38EF201V	16500	5,000	4	5	24.04	\$	96.16
48	39	1	R1122	CR0603	4K	Digi-Key	311-4-2248TR-ND	Yageo	RC0603TR-07402L	3300	5,000	1	5	15.62	\$	15.62
49	40	1	R1123	CR0603	8K	Digi-Key	311-8-0648TR-ND	Yageo	RC0603TR-078K06L	3300	5,000	1	5	15.62	\$	15.62
50	41	4	R157R170R1106R1108	CR0603	4.99K	Digi-Key	311-4-8948TR-ND	Yageo	RC0603TR-07499L	13200	5,000	3	5	15.62	\$	46.86
51	42	8	R103R205R127R229	CR0603	2.2K	Mouser	503-80050TR-072K2L-ND	Yageo	RC0603TR-072K2L	26400	5,000	6	5	15.00	\$	90.00
52	43	4	R1219R1221R1235R1236	CR0402	10K	Digi-Key	C08032-20-133G12KX-ND	Bourns	CR0402-JW-103ELF	13300	3,000	2	5	9.87	\$	19.74
53	44	1	R1125	CR0603	32K	Mouser	652-CR0603FX-3321ELF	Bourns	CR0603-FX-3321ELF	3300	5,000	1	5	15.00	\$	15.00
54	45	128	L122L123L124L125L126L127	CR4010	18H	Mouser	S5081R03400	Semtech America	S5081R03400	422400	45,000	10	5	9,270.00	\$	92,700.00
55	46	108	D122D123D124D125D126D127	BAV99	50128	Digi-Key	BAV99-11A03TR-ND	ON Semiconductor	BAV99-11A	424400	75,000	6	5	1,286.25	\$	7,717.50
56	47	2	H12	-132-21132-21-G-T	-G-T	Santec Inc.	SSW-132-21-G-T	Santec Inc.	SSW-132-21-G-T	6600	1	6600	5	3.81	\$	25,146.00
57	48	5	U30U31U32U33U34	AS813	SC-48	Digi-Key	NI4581120724C05048-ND	ON Semiconductor	NI4581120724G	16500	3,000	6	5	332.32	\$	1,993.92
58	49	11	U4U5U6U9U12U14U15U16U17	SP420	SP420	Mouser	315-78742018000	Texas Instruments	TPS742018000	18300	3,000	13	5	9,200.00	\$	117,000.00
59	50	2	P2P3	HAER1HAER12		Santec	T5W-106-07-G-D	Santec	T5W-106-07-G-D	6600	1	6600	5	0.32	\$	2,076.00
60	51	1	P5	4-01-L-D-RE1-K		Santec	FP1-104-01-L-D-RE1-K	Santec	FP1-104-01-L-D-RE1-K	3300	1	3300	5	1.50	\$	4,950.00
61	52	1	P1	FP1-01-L-D-RE1-K		Santec	FP1-01-L-D-RE1-K	Santec	FP1-01-L-D-RE1-K	3300	1	3300	5	1.60	\$	5,280.00
62	53	1	ASP-191885-01	ASP-19	ASP-19	Santec	ASP-191885-01	Santec	ASP-191885-01	3300	400	3300	5	1,940.00	\$	17,460.00
63	54	128	R1R2R3R4R5R6R7R8	CR0603	20603	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
64	55	256	R20R20R21R22R22	CR0203	20203	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
65	56	19	R13R13R13R13R13R13	CR0603	20603	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
66	57	1	R177	CR1206R1208	0.1	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
67	58	11	R181R1216R1217R18	CR0402	0.1	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
68	59	33	C21C114C116C213	CR0402	0.1	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	DNI	\$	-
69	60	8	U3U7U11U17U19	ASIC	6FP128	BNL	LAR ASIC P4	BNL	LAR ASIC P4	26400	5	5	-	-	\$	-
70	61	8	U6U10U18U28	ADC	6FP128	DUNE	COLD ADC P2	DUNE	COLD ADC P2	26400	5	5	-	-	\$	-
71	62	7	U102	IC024	6FP128	Femtech	COLDATA P3	Femtech	COLDATA P3	6600	7	7	-	-	\$	-
72	73														\$	170.60
74																

BDE Budget-At-Completion

Sum of Value	Column Labels									
Row Labels	9/30/22	9/30/23	9/30/24	9/30/25	9/30/26	9/30/27	9/30/28	9/30/29	Grand Total	
131.FDC.03 Far Detector 2 (FD2)	1,086,889	1,651,269	581,532	6,839,870	5,777,311	1,561,122	1,079,052	329,427	18,906,472	
131.FDC.03.05 FD2 Bottom Drift Electronics (BDE)	1,086,889	1,651,269	581,532	6,839,870	5,777,311	1,561,122	1,079,052	329,427	18,906,472	
131.FDC.03.05.01 Electronics bottom Management	319,027	432,746	424,521	435,495	458,851	395,037	605,668	237,817	3,309,161	
131.FDC.03.05.02 ASICs				541,673	43,755				585,429	
131.FDC.03.05.03 FEMBs	92,318	98,282		1,080,951	316,801				1,588,352	
131.FDC.03.05.04 Cold Cables	22,330			2,482,622	2,372,729				4,877,681	
131.FDC.03.05.05 Cryostat Penetrations	49,808	240,289		546,880	203,984				1,040,960	
131.FDC.03.05.06 Warm-Interface Electronics Crates and Boards		19,024	19,595	1,280,251	2,051,592	21,413	100,924	42,634	3,535,433	
131.FDC.03.05.07 Power Supplies, Warm Cables, and Services to DAQ Racks	75,694			455,031	155,419				686,144	
131.FDC.03.05.08 Test Stands and Prototyping Supports	527,713	860,928	137,417						1,526,058	
131.FDC.03.05.09 Installation at SURF for FD2				16,967	174,179	1,144,673	372,459	48,975	1,757,254	
Grand Total	1,086,889	1,651,269	581,532	6,839,870	5,777,311	1,561,122	1,079,052	329,427	18,906,472	



Thank You !