Procurement Strategy Cost and Schedule

Cheng-Ju Lin 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

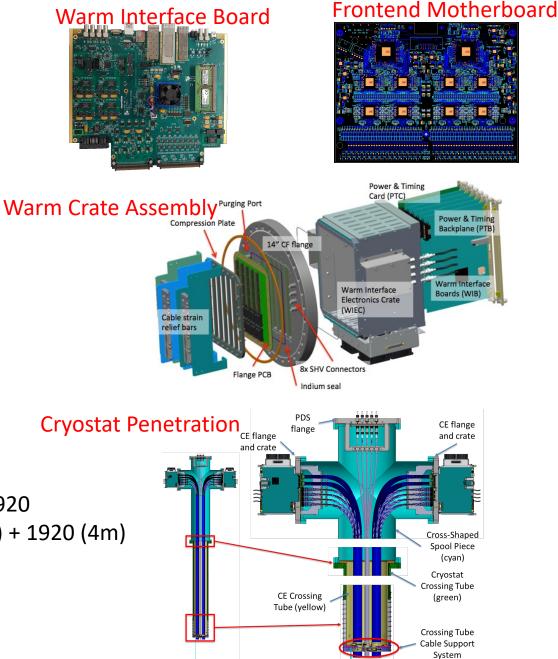
Power supplies:

- 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



BERKELEY LAB

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 <u>Indico 53072</u>
- 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



Sample P6 Schedule (13 pages total)

· · ·	Activity Name	Planned Start	Finish	Total Float	2021	2022	2023	2024	2025	2026	2027	2028	202
		Duration			22 Q3 Q4	Q1 Q2 Q3	Q4 Q1 Q2 Q3 Q	4 Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4		Q1 Q2 Q3	Q4 Q1 Q2
13124.1.4.13	Project coordination efforts at BNL (FY28)	251d 06-Oct		422d							06-Oct-27		06-Oct-28
13124.1.4.16	Integration engineering efforts (FY29)	94d 06-Oct		422d								06-Oct-28	26-Fe
13124.1.4.15	Project coordination efforts at BNL (FY29)	94d 06-Oct	28 26-Feb-29	422d								06-Oct-28	26-Fe
131.FDC.03.05.02 ASIC		290d 02-Oct-	24 26-Nov-25	138d				· · · · ·	· · · · · · · · · · · · · · · · · · ·	26-Nov-25			
131.FDC.03.05.02.01	LArASIC procurement and testing	90d 30-Dec		279d					▼ 07-May-2				
13124.2.1.4	Chip level testing of LArASIC production run, 25 wafers - UN	90d 30-Dec		279d					07-May-2	1		1	1
13124.2.1.3	Chip level testing of LArASIC production run, 25 wafers - BNI	90d 30-Dec	24 07-May-25	279d				30-Dec-24	07-May-2	5			
	ColdADC/COLDATA procurement and testing	290d 02-Oct		138d				-	1	26 Nov-25			
13124.2.2.1	ColdADC/COLDATA production run, first batch of 25 wafers -	100d 02-Oct-		138d				02-Oct-24	27-Feb-25				
13124.2.2.8	Chip level testing of COLDATA production run, first batch of 2	90d 28-Feb		148d				28-Feb-2		1			
13124.2.2.7	Chip level testing of COLDATA production run, first batch of 2	90d 28-Feb	25 08-Jul-25	148d				28-Feb-2	5 🔲 08-Jul	25			
13124.2.2.4	Chip level testing of ColdADC production run, first batch of 25	90d 28-Feb	25 08-Jul-25	148d				28-Feb-2					
13124.2.2.3	Chip level testing of ColdADC production run, first batch of 25	90d 28-Feb	25 08-Jul-25	148d				28-Feb-2	5 🚃 08-Jul	25			
13124.2.2.2	ColdADC/COLDATA production run, second batch of 25 wafe	100d 28-Feb	25 22-Jul-25	138d				28-Feb-2	5 📃 22-Ju	1-25			
13124.2.2.10	Chip level testing of COLDATA production run, second batch	90d 23-Jul-	5 26-Nov-25	138d	1	[2	3-Jul-25	26-Nov-25	[····
13124.2.2.9	Chip level testing of COLDATA production run, second batch	90d 23-Jul-	5 26-Nov-25	138d	-			2	3-Jul-25	26-Nov-25			
13124.2.2.6	Chip level testing of ColdADC production run, second batch c	90d 23-Jul-	5 26-Nov-25	138d	-			2	3-Jul-25	26-Nov-25			
13124.2.2.5	Chip level testing of ColdADC production run, second batch c	90d 23-Jul-		138d	-			1	3-Jul-25	1		8	
131.FDC.03.05.03 FEN		1091d 01-Apr		84d						11-4	ug-26		
131.FDC.03.05.03.01		135d 01-Apr		224d	+		▼ 12-Oct-22			1 114	9		
13124.3.1.1	Design FEMB modification for cold box - BNL	60d 01-Apr		224d	01-Apr-2								
13124.3.1.2	Fabricate modified FEMBs for cold box - BNL	60d 28-Jun		224d		un-22							
13124.3.1.3	Test FEMBs modification for cold box - BNL	15d 22-Sep		224d			12-Oct-22						
131.FDC.03.05.03.02		95d 13-Oct		224d	-	- Job - F	03-Mar-23						
13124.3.2.4	Pre-production and testing of FEMB for NP02 - BNL	20d 13-Oct		224d	+	13 Oct-22	09-Nov-22		+	· • · · · · · · · · · · · · · · · · · ·		+	
13124.3.2.5	Fabricate modified FEMBs for NP02 - BNL	60d 10-Nov		224d	-		10-Feb-23						
13124.3.2.6	Test FEMB modification for NP02 - BNL	15d 13-Feb		224d	-		b-23 03-Mar-23			1			
131.FDC.03.05.03.03		320d 02-Oct		178d		13-16	Lo Lo Hidi 20	_		V 15-Jan-26			
13124.3.3.10	Procure CE boxes, mounting hardware, and mailers, first 259	60d 02-Oct		258d	-			02-Oct-24	30-Dec-24	10-Jair 20			
13124.3.3.8	Procure all discrete components for FEMB - BNL	30d 02-0ct		230d 318d	+			02-Oct-24		+			
13124.3.3.7	Fabrication of blank FEMB PCBs, first 25 % - BNL	30d 02-0ct		318d 328d	-				12-Nov-24				
13124.3.3.11	Fabrication of blank FEMB PCBs, second 25 % - BNL	30d 12-0cl		328d	-			13-Nov-24					
13124.3.3.11 13124.3.3.14	Fabrication of blank FEMB PCBs, second 25 % - BNL Fabrication of blank FEMB PCBs, third 25 % - BNL	30d 13-Nov 30d 02-Jan		328d 338d	-				30-Dec-24				
					-				-				
13124.3.3.13	Procure CE boxes, mounting hardware, and mailers, second	60d 02-Jan		258d					27-Mar-25				
13124.3.3.12	Populate production FEMBs, second 25% - BNL	30d 02-Jan		328d	-				13-Feb-25				
13124.3.3.17	Fabrication of blank FEMB PCBs, last 25 % - BNL	30d 14-Feb		348d	-			1	27-Mar-25	1			
13124.3.3.18	Populate production FEMBs, last 25% - BNL	30d 28-Mar		348d	-				25 🔲 08-May-2				
13124.3.3.16	Procure CE boxes, mounting hardware, and mailers, third 25	60d 28-Mar		258d	-				25 🛄 23-Jun	F			
13124.3.3.19	Procure CE boxes, mounting hardware, and mailers, last 259	60d 24-Jun		258d				i	Jun-25 🔜 17			ļ	
13124.3.3.9	Populate production FEMBs, first 25% - BNL	30d 09-Jul-		158d				09	Jul-25 🔲 19-/	-			
13124.3.3.15	Populate production FEMBs, third 25% - BNL	30d 01-Dec		138d					01-Dec-25	15-Jan-26			
131.FDC.03.05.03.04		170d 05-Dec		84d	-					11-A	ug-26		
13124.3.4.7	Test production quantity of FEMBs at site D, first 25% - UNI	40d 05-Dec		84d						05-Feb-26			
13124.3.4.5	Test production quantity of FEMBs at site C, first 25% - UNI	40d 05-Dec		84d						05-Feb-26			
13124.3.4.3	Test production quantity of FEMBs at site B, first 25% - UNI	40d 05-Dec	25 05-Feb-26	84d					05-Dec-25	05-Feb-26			
13124.3.4.1	Test production quantity of FEMBs at site A, first 25% - BNL	40d 05-Dec	25 05-Feb-26	84d					05-Dec-25	05-Feb-26			
13124.3.4.15	Test production quantity of FEMBs at site D, second 25% - U	40d 06-Feb	26 02-Apr-26	84d					06-Feb-26	02-Apr-26			
13124.3.4.13	Test production quantity of FEMBs at site C, second 25% - U	40d 06-Feb	26 02-Apr-26	84d					06-Feb-26	02-Apr-26			



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		\$1	.25	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		<u>\$ 131</u>	47 \$95.64	Follow hyperlink for quote; Manhong has updated quote for Al 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			
20 Hardware for securing the data cable to the FEMB		(.89		
21 Unit cost of mounting hardware (CE box to CRP Adaptor board)		\$0	.50	Estimated	
22					
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	
24					
25 Total cost of blank PCBs for FD2		\$72,080		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.	
27					
28 Total cost of CE boxes, G10 mounting hardware, and mailers		\$ 335,617		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.	
30					
31 Total cost of FEMBs assembly for FD2		\$ 265,000		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 a four batches of 25% each.	
33					
34 Total shipping costs from FEMB QC Site to CRP factories		\$ 32,000		Assumes 160 shipments, each 15 FEMBs at ~\$200 per shipment	-
35 Shipping cost per batch per site		\$2,000	0.00	There are four FEMB QC sites. As ume each site ships FEMB in four batches. Total shipping cost / 4 batches / 4 institutions	
75.	J1 24 J16	*****************	201,00201 0 018009		

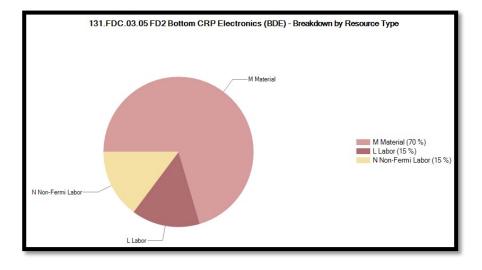
Similar spreadsheets for other BDE components and labor estimates

32	23	40	R1206.R1207.R1208.R1CR04	403 00401 0	digi-key	311-0.0LRTR-ND	Yapeo	RC04 2FR-070RL	132000	50.000	2 4	54.40	\$ 163.20	
	23	40	R1208,R1207,R1208,R1208,R1208			CSR1206FTR100DKR-ND	Stackpole	CSR12 FTR100	23100	5.000	5 5		\$ 1,360.00	
	24	/	R178,R182,R548,R550,CR1 R544,R546,R554,R556,CR12					RC32161 R0C5	13200	5,000	2 5		\$ 1,360.00	
		4	R544,R546,R554,R556 CR1 R254.R257.R258.R365.CR04		Digikey	1276-5618-2-ND	Samsung		79200	10,000	2 5		\$ 3,556,95	
	26	24	R254,R257,R258,R365, CR04 R138,R180,R255,R256, CR04			13-RT0402BRE0750RLTR-ND	Yageo							
	27	102				311-100LRTR-ND	Yageo	RC0402FR-0710 RL	336600	10,000	34 \$		\$ 632.40	
	28	17	R149,R150,R151,R154,CR06			541-3951-2-ND	Vishay	CRCW0603100RFK	56100	5,000	12 \$		\$ 280.56	
	29	2		603 R0601 1.6		P1.60KHTR-ND	Panasonic	ERJ-3EKF1601V	6600	5,000	2 \$		\$ 48.08	
	30	3		603 R060 1.8		RMCF0603FT1K87TR-ND	Stackpole	RMCF0603FT1K87	9900	5,000	2 \$		\$ 21.84	
	31	2		603 R060 1.8		P1.80KHTR-ND	Panasonic	ERJ-3EKF1801V	6600	5,000	2 \$		\$ 48.08	
	32	2		603 R060 1.9		603-RC0603FR-071K96L	Yageo	RC0603FR-071K96L	6600	5,000	2 \$		\$ 20.00	
	33			603 R060 16		311-16.0KHRTR-ND	Yageo	RC0603FR-0716KL	300	5,000	1 \$		\$ 15.62	
	34	1		603 R060 1		311-1.00KHRTR-ND	Yageo	RC0603FR-074K02L	33 1	5,000	1 \$		\$ 15.62	
	35	48	R259,R260,R261,R262, CR04			YAG1402TR-ND	Yageo	RT0402BRD072K2L	15840	30,000	6 \$		\$ 7,118.76	
	36	5	R1105,R159,R162,R172CR06			P2.49KHTR-ND	Panasonic	ERJ-3EKF2491V	16500	5,000	4 \$		\$ 96.04	
46	37	3		603 R060 3.5		311-3.57KHRTR-ND	Yageo	RC0603FR-073K57L	9900	5,000	2 \$	15.62	\$ 31.24	
47	38	5	R158,R161,R171,R1104 CR06			P2.00kHTR-ND	Panasonic	ERJ-3EKF2001V	16500	5,000	4 \$		\$ 96.16	
48	39	1		603 R060 4		311-4.02KHRTR-ND	Yageo	RC0603FR-074K02L	3300	5,000	1 \$		\$ 15.62	
49	40	1	R1123 CR06	603 R060 8	digi-key	311-8.06KHRTR-ND	Yageo	RC0603FR-078K06L	3300	5,000	1 \$	15.62	\$ 15.62	
50	41	4	R157,R170,R1106,R110 CR06	603 R060 4.9	K digi-key	311-4.99KHRTR-ND	Yageo	RC0603FR-074K99L	13200	5,000	3 \$	15.62	\$ 46.86	
51	42	8	R193,R205,R217,R229,ICR06	603 R0601 2.2	K Mouser	603-RC0603FR-072K2L	Yageo	RC0603FR-072K2L	26400	5,000	6 \$	15.00	\$ 90.00	
52	43	4	R1219.R1221.R1235.R1CR04	402 R0401 10	Digikey	CR0402-JW-103GLFDKR-ND	Bourns	CR0402-JW-103GLF	13200	1 000	2 5	9.87	\$ 19.74	
53	44	1	R1125 CR06	603 R0601 32	Mouser	652-CR0603FX-3321ELF	Bourns	CR0603-FX-3321ELF	3300	5.00	1 \$	15.00	\$ 15.00	
54	45	128	L1.L2.L3.L4.L5.L6.L7.L8. 6E+	+10 ##### 18:	H Mouser	55081803400	Sumida America	55081803400	422400	45.00	10 \$	9,270.00	\$ 92,700.00	
55	46	128	D1.D2.D3.D4.D5.D6.D7 BAV	V99 SOT23	Digikey	BAV99LT1GOSTR-ND	ON Semiconductor	BAV99LT1G	422400	75.000	6 5	1,286.25	\$ 7,717.50	
56	47	2	J1J2 -132	2-21132-21-G-1	Samtec Inc.	SSW-132-21-G-T	Samtec Inc.	SSW-132-21-G-T	6600	1	6600	3.81	\$ 25,146.00	3.81 \$/unit while > 2500 pcs
57	48	5	U30.U31.U32.U33.U34 LASB	3315 SC-88	Digikey	NLASB3157DFT2GOSDKR-ND	ON Semiconductor	NLASB3157DFT2G	16500	3.000	6 5	332.32	\$ 1,993,92	
58	49	11	U4.U5.U8.U9.U12.U14.IPS74	42010EN20	Mouser	595-TP574201RGWR	Texas Instruments	TPS74201RGWR	36300	3.000	13 \$	9.000.00	\$ 117,000.00	expect lower price for order over 10,000
59	50	2	P2.P3 EAD	ER1EADER12	Samtec	TSW-106-07-G-D	Samtec	TSW-106-07-G-D	6600	1	6600	0.41	\$ 2,706.00	0.41 \$/unit while > 5000 pcs
	51	1		1-L-D-RE1-K	Samtec	IPL1-104-01-L-D-RE1-K	Samtec	IPL1-104-01-L-D-RE1-K	3300	1	3300		\$ 4,950.00	1.5 \$/unit while > 2500 pcs
	52	1		1-L-D-RE1-K	Samtec	IPL1-105-01-L-D-RE1-K	Samtec	IPL1-105-01-L-D-RE1-K	3300	1	300		\$ 5,280.00	1.6 \$/unit while > 2500 pcs
	53	1		-191 ASP-11 ASP		ASP-191865-01	Samtec	ASP-191865-01	3300	400			\$ 17,460.00	quote
	54	128	R1.R2.R3.R4.R5.R6.R7.RICR00			DNI	DNI	DNI		400		2,340.00	\$	Component not to be installed
	55	256	R219.R220.R221.R222.ICR02			DNI	DNI	DNI					5 -	Component not to be installed
	56	19	R131.R132.R135.R136.CR00			DNI	DNI	DNI					5 -	Component not to be installed
	57	1		206CR1200 DI		DNI	DNI	DNI					¢ .	Component not to be installed
	58	11	R181 R1216 R1217 R12CR04			DNI	DNI	DNI					\$.	Component not to be installed
	59	33	C213.C214.C216.C233.CC00			DNI	DNI	DNI					\$.	Component not to be installed
	60	8	U3. U7. U11. U17. U19. R AS		BNL	LAR ASIC P4	BNL	LAR ASIC P4	26400					Covered under ASICs tab
	61	8	U6. U10. U13. U18. U20LD A		DUNE	COLD ADC P2	DUNE	COLD ADC P2	26400				\$.	Covered under ASICs tab
	62	2		DAT OFP216L	Fermilab	COLDATA P3	Fermilab	COLDATA P3	6600				<u> </u>	Covered under ASICs tab
72	02	4	01,02 DLDL	DAILPT216L	refinitab	COLDAIA_P3	remillab	COLDAIA P3	0000					Total cost of the discrete components for all the FEMBs
73													\$ 170.60	
73													\$ 170.60	Cost of the discrete components for one FEMB
14														



BDE Budget-At-Completion

Sum of Value	Column Labels .T								
Row Labels	J 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
H 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
H 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
B 131.FDC.03.05.07 Power Supplies, Warm Cables, and Services to DAQ Racks	75,694			455,031	155,419				686,144
I31.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 !

