

Installation schedule and labor estimates

Task	Group	Month	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46	49	51	54	57	60	64	67	70			
Logistics Facility	DUNE										LF Infra		Logistics Facility Operations																										
Excavation Cavern #1	CF	41	North Cavern & CUC BSI										BSI																										
Excavation Cavern #3	CF	20									South Cavern					BSI																							
Install Warm Dec #1	CERN	15												Warm 1																									
CUC Infrastruc and DAQ	DUNE	20												CUC Infra	DAQ																								
Install Cold Dec #1	GTT	12																Cold Struct. #1																					
Det #1 Installation Setup	DUNE	13															Det #1 Setup																						
Assembly SP Dec #1	DUNE	10																				Detector #1 SP																	
TCO Closing	CERN	2																							TCO														
Complete Detector #1	DUNE	3																																					
Purge/Fill Dec #1	CERN	18																											Pur										
Install Warm Dec #2	CERN	9															Warm 1														Fill Det #1								
Install Cold Dec #2	GTT	12																					Cold Struct. #2																
Det #2 Installation Setup	DUNE	12																					Det #2 Setup																
Assembly Dec DP #2	DUNE	10																								Detector #2													
TCO Closing	CERN	2																													TCO								
Complete Detector #2	DUNE	3																																					
Purge/Fill Dec #2	CERN	20																															Pur	Fill Det #2					
Install Cryo Equipment	CERN	36																Cryogenic Installation																					
Estimated Number of FTEs Underground per shift-Assume 2 shifts per day																																							
CF-Day			80	80	80	80	80	80	80	80	80	55	55	55	55	40																							
CF-Night			70	70	70	70	70	70	70	70	70	55	55	55	55	35																							
LBNF/CERN-Warm-Day													25	25	25	25	25	25	25	25	20	20																	
LBNF/CERN-Warm-Night													25	25	25	25	25	25	25	25	15	15																	
GTT-Cold-Day																	25	25	25	25	25	25	25	25	25					10									
LBNF/CERN-Cryo														10	10	20	20	20	20	20	20	20	20	20	20	20	20	4	4	4	4	4	4	4	4	4			
I&I-Underground Day												11	29	29	29	29	46	46	46	46	46	46	46	46	46	46	46	46	46	46	27	27	27	27	27	27			
I&I-Underground Night												11	29	29	29	29	46	46	46	46	46	46	46	46	46	46	46	46	46	46	27	27	27	27	27	27			
DUNE-Consortia-Day														5	5	5	10	10	36	36	36	36	36	36	36	36	36	36	36	30	20	20	5	5	5				
DUNE Consortia-Night																5	10	10	35	35	35	35	35	35	35	35	35	35	35	30	20	20	5	5	5				
SURF-Day			15	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20			
SURF-Night			5	5	5	5	5	5	5	5	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10			
Total FTEs Underground per Day Shift			95	95	95	95	95	95	95	95	95	86	129	129	129	129	106	141	146	146	166	166	146	146	146	146	121	121	105	115	105	81	71	71	56	56	56		
Total FTEs Underground per Night Shift			75	75	75	75	75	75	75	75	75	76	119	119	119	99	81	86	91	91	105	105	90	90	90	90	90	90	90	90	67	57	57	42	42	42			

Cleanroom Design

As we continue to test mechanical installation procedures at Ash River, we have modified the cleanroom design. Major changes include:

- Going to a single level work platform for easy access to the TBP CE on the top and access via scissor for the middle connection
- Moved secondary emergency egress path from work platform to ladder and trap door to cleanroom roof
- Added small personnel SAS for people to move directly from the 4850 level to the work platform



APA Assembly Towers allow staging of up to 8 APA Doublets

Installation Process

- TPC CE cable tests on the APA Assembly tower at Ash River have shown the slotted cable conduit concept works successfully and allows the installation of PDs
 - This eliminated 3 shifts of extra labor per APA Doublet underground
- Successfully tested APA Doublet assembly at Ash River and have also improved PD connection between top and bottom APA. Improved access requirements for the cleanroom
- Have added both PD and HV equipment and workspace required in cleanroom



Working with APA & CE Consortia we have updated labor estimates for DUNE-APA Assembly

									Week 1																Week 1															
									Day 1				Day 2				Day 3				Day 4				Day 5				Day 6				Day 7							
	Labor Force								Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2					
	Task					Surv		Location	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00				
		APA	CE	PD	HV	Cal	INT																																	
	Line # 1																																							
1	Move APA Bottom and top to APA Assembly frame	2						line#1	2																															
						3			3																															
2	Connect PD Cables, test, connect linkage test and form APA doublet	2						line#1		2																														
						3			3																															
3	APA wire tension, Install CR Boards, install bias voltage Hareness	4						line#1			4	4	4	4																										
4	Install CE FEBMs top and bottom APA		4					line#1							4	4	4	4																						
5	Move APA Doublet to cabling station and install cable trays		4																	4																				
6	Install top and bottom CE cables		4					line#1													4																			
7	CE Cable management/PD Cable		4					line#1													4																			
8	Test electronics warm +Bias test/PD test		4					line#1														4	4																	
9	Remove Protective panels move to front of Cold Box	3						line#1																																
						3																																		
10	Photogrammetry/survey	1						line#1	1	1																														
						2			2	2																														
11	Move to cold box and cable		2					Cold Box #1			2	2																												
12	Warm check APA and close box		2						2	2																														
13	Cool down Cold Box		2					Cold Box #1					2	2	2	2																								
14	Cold test Cold Box		2					Cold Box #1									2	2	2	2																				
15	Warm up Cold Box		2					Cold Box #1																																
16	Move out of cold box and uncable, move to switchyard		2					Cold Box #1	2	2																														
						2			2	2																														

PD Labor estimates Underground

									Week 1															
									Day 1				Day 2				Day 3				Day 4			
	Labor Force								Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2	
	Task					Surv		Location	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00
		APA	CE	PD	HV	Cal	INT																	
	Photon Detector Integration	# FTE	# FTE	# FTE	# FTE	# FTE	# FTE																	
1	Photon Detector Supervisors-1 per shift			1					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	Photon Detector Scientist/Postdoc-1 per shift			1					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	Test PD in scanner			4				cleanroom	4	4													4	4
6	Install PD top APA and test-APA#1			4				PD Area			4	4												
7	Install PD Bottom APA and Test-APA #1			4				PD Area					4	4										
8	Install PD top APA and test-APA#2			4				PD Area							4	4								
9	Install PD Bottom APA and Test-APA #2			4				PD Area									4	4						
10	Install PD top APA and test-APA#3			4				PD Area											4	4				
11	Install PD Bottom APA and Test-APA #3			4				PD Area													4	4		

Potential labor reduction after extensive trial and motion studies at Ash River

HV Consortia

									Week 1																					
									Day 1				Day 2				Day 3				Day 4									
Labor Force									Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2							
Task									6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00						
									Surv	Location																				
									APA	CE	PD	HV	Cal	INT																
	HV Consortia Supervisor/Scientist-1 per											1																		
	CPA Pair #1																													
1	Bring CPA & FC boxes in											2	Mat Han		2															
2	Lift CPA1A and bolt to frame											4		CPA 1	4	4														
3	Lift CPA1b and bolt to frame											4		CPA 1			4	4												
4	Add Field Shaping at profiles											4		CPA 1			4													
5	Add disfuser and Top FC											4		CPA 1				4												
	CPA Pair #2																													
1	Bring CPA & FC boxes in												2	Mat Han			2													
2	Lift CPA2A and bolt to frame											4		CPA 2				4	4											
3	Lift CPA2b and bolt to frame											4		CPA 2					4	4										
4	Add Field Shaping at profiles											4		CPA 2						4										
5	Add disfuser and Top FC											4		CPA 2							4									
	Build FC and End Walls																													
1	Bring in Frames, profiles, electrical												2	Mat Han				2												
2	Build FC Frame											2			2	2				2	2		2	2						
3	Install Profiles and test											2					2	2			2	2		2						
4	Clean, removal of boxes, repair and test											4										4	4	4						
														Total HV FTE	7	7	7	7	7	7	7	7	7	7						

Potential labor reduction after extensive trial and motion studies at Ash River

APA Cabling in the cryostat-Does include FTEs on top

										Week 1																						
										Day 1				Day 2				Day 3				Day 4										
Labor Force										Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2								
Task										6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00							
										APA	CE	PD	HV	Surv	Cal	INT																
Cabling of TPC Electronics in Cryostat																																
APA Pair #1																																
1	Move APA to cryostat-Position												3	3																		
2	Final Cable-Cryostat-in & out									2					2	2	2	2														
														2	2	2	2															
3	DAQ Test/seal flange/He Leak check									2								2	2													
														2				2	2													
CPA Pair#1																																
4	Move CPA to cryostat-Position													3	3																	
APA Pair #2																																
5	Move APA to cryostat-Position															3	3															
6	Final Cable-Cryostat-in & out									2								2	2	2	2											
																	2	2	2	2												
7	DAQ Test/seal flange/He Leak check									2				2	2																	
														2				2	2													
CPA Pair#1																																
8	Move CPA to cryostat-Position																	3	3													
APA Pair #3																																
5	Move APA to cryostat-Position																			3	3											
6	Final Cable-Cryostat-in & out									2												2	2	2	2							
																										2	2	2	2			
7	DAQ Test/seal flange/He Leak check									2																						
																		2	2													

APA & CE Supervisor, APA Rotation, Weekends

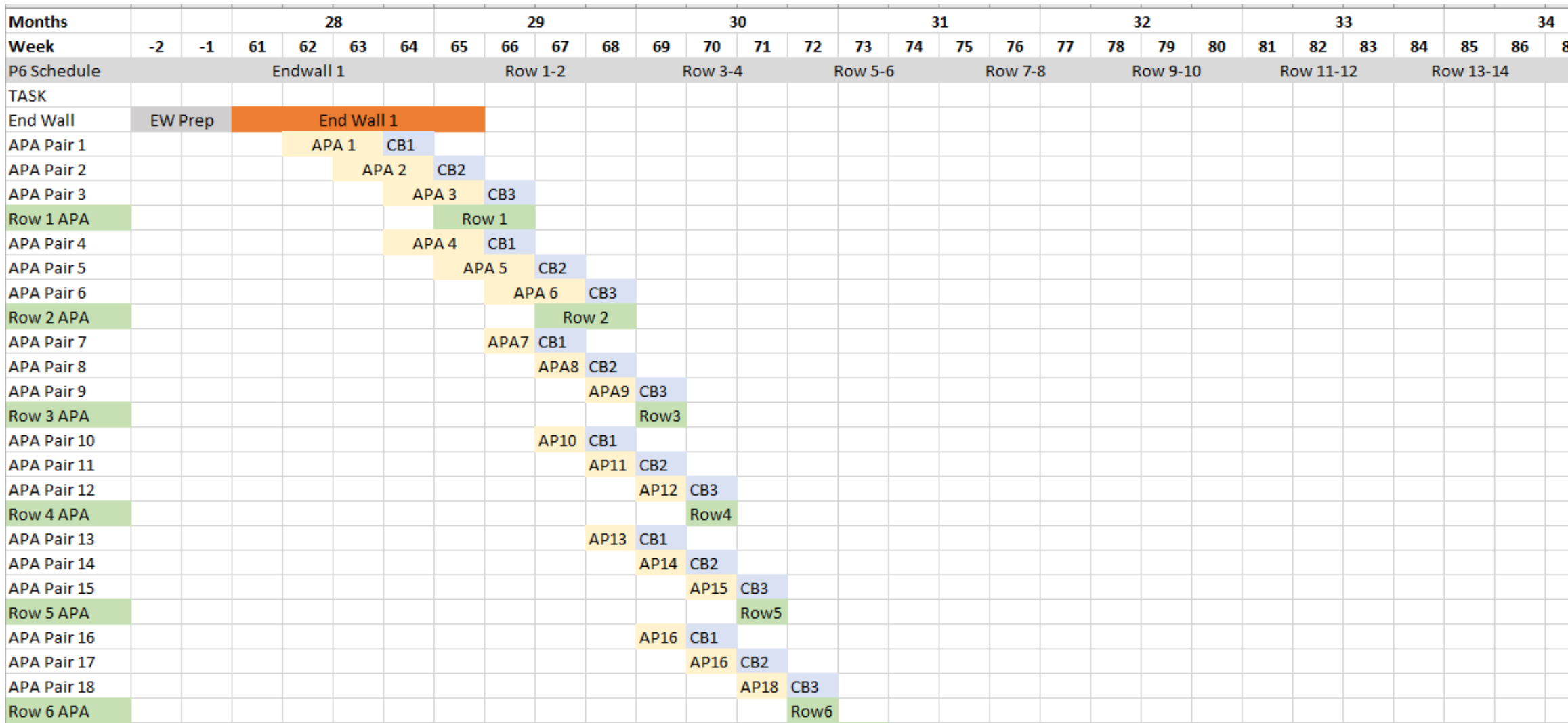
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- Both APA and CE consortia have a steady state supervisor on each shift
- Steady state I&I technicians on both shifts over the weekend
- Steady state 2 “cleaning technicians or contract” afternoon shift during the week and day shift on the weekend
- The APA rotation is done by the by the rigging crew with the help from the APA consortia

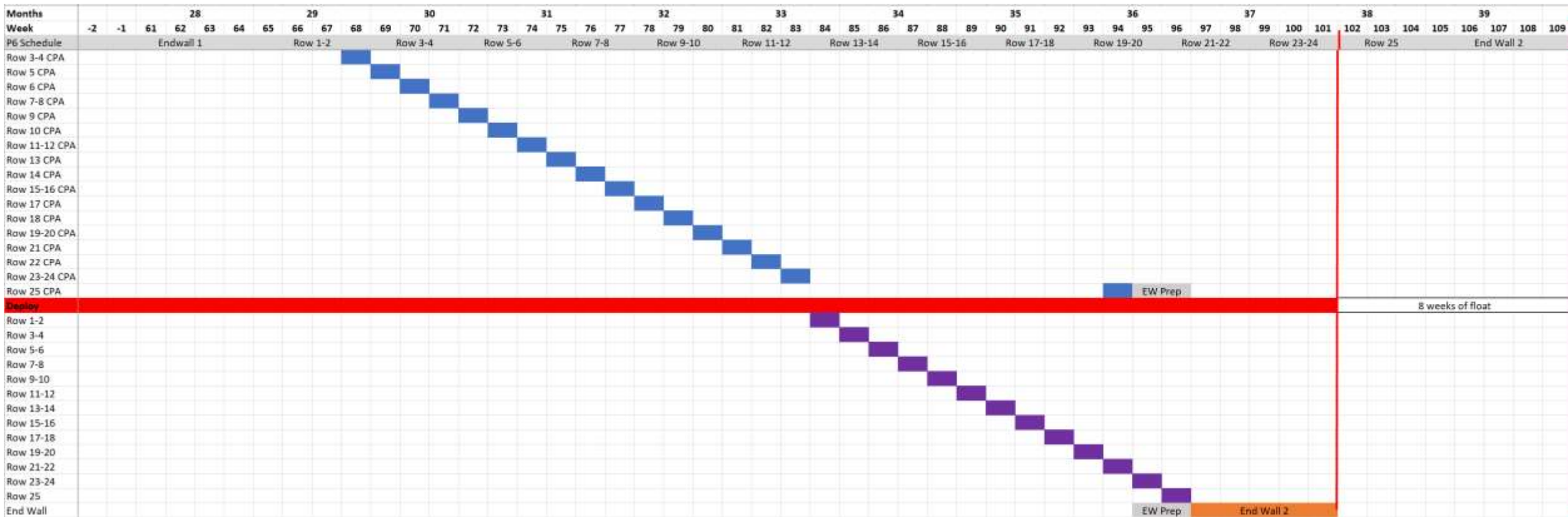
Updates to the labor schedule

- We have redone with the appropriate consortia the step by step procedures in the cleanroom as we have learned from our experience with the Ash River Trial Assembly
- Jim worked in project with Filippo and worked out a detailed set of tasks for the Installation Infrastructure on top of the cryostat and cleanroom setup.
 - This was a several month-long process with numerous modifications to get all the tasks, durations and predecessors reasonable
 - I have then taken these tasks and attempted a **FIRST PASS** estimate to resource load for each task.
- There is still some details to work out on how the schedule for the swap from SP 1 to SP 2. These tasks have not had the same vetting, I just took all the same estimates for the first infrastructure setup, we know that some of these will change.
- Added a worksheet to show the Field Cage deployment at the end of the CPA installation
- Confirmed that most tasks match closely with P6 estimates, still getting additional feedback at this collaboration meeting

Deployment Plan-Wait till ~Row 19



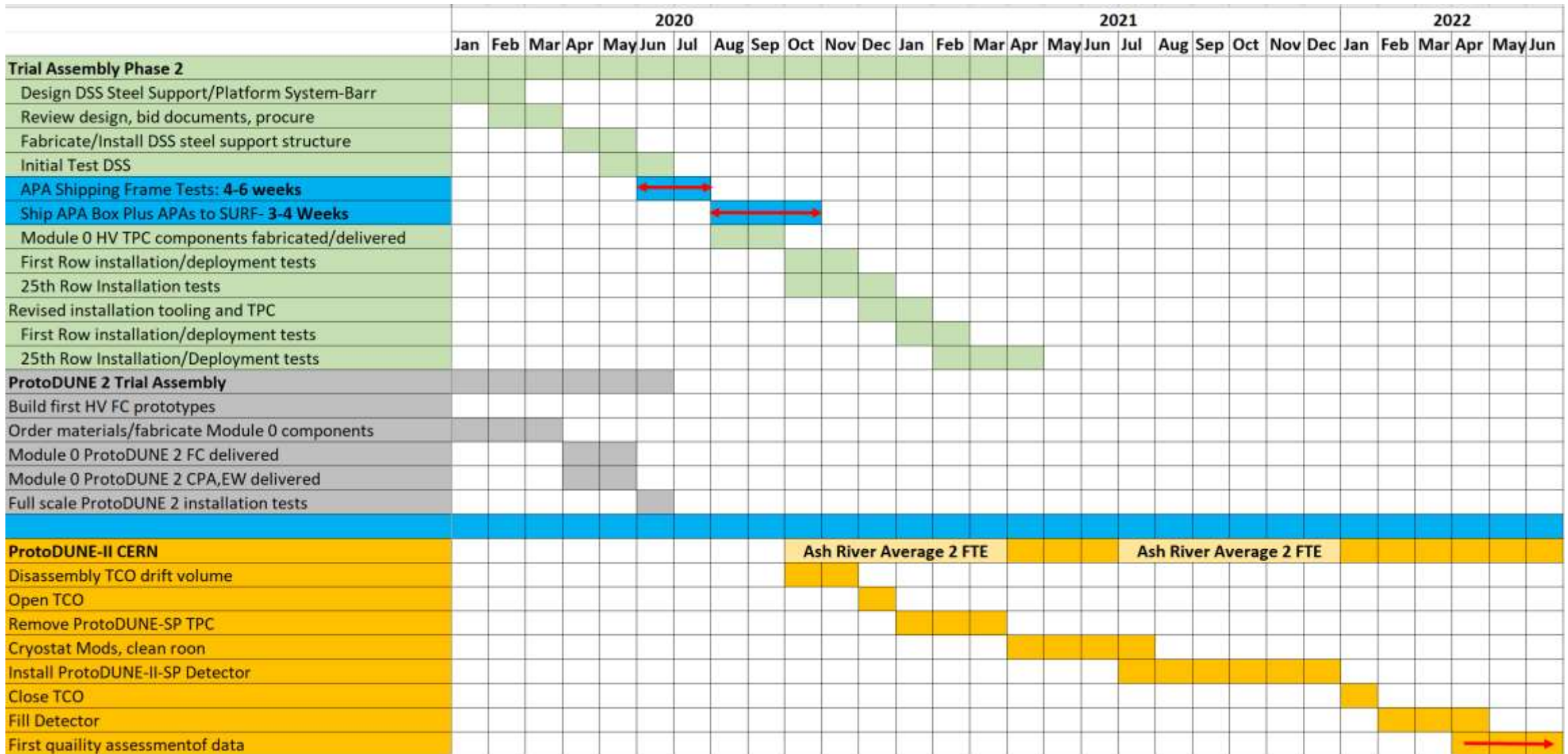
Complete HV Row 24-Start FC deployment



Deployment sequence-Does not show the people on the cryostat

								Week 1															
								Day 1				Day 2				Day 3				Day 4			
Labor Force								Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2	
Task								6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00	6:00	11:00	17:00	22:00
								Row 1								Row 2							
Deployment of Drift Volume-In Cryostat																							
Drift Volume 1																							
1	Remove floor, clean, install temp, test				1		Cryo	1	1							1	1						
						3		3								3							
2	Deploy T&B FC Drift Volume 1					3	Cryo		3								3						
3	Final Test and HV Elec Connections		2		2		Cryo			2	2							2	2				
Drift Volume 2 & 3																							
4	Remove floor, clean, install temp, test				1		Cryo					1	1							1	1		
						3						3								3			
5	Deploy T&B FC Drift Volume 2					3							3								3		
6	Final Test and HV Elec Connections		2		2		Cryo							2	2							2	2
4	Remove floor, clean, install temp, test				1							1	1							1	1		
						3						3								3			
5	Deploy T&B FC Drift Volume 3					3	Cryo						3								3		
6	Final Test and HV Elec Connections		2		2		Cryo							2	2							2	2
Drift Volume 4																							
1	Remove floor, clean, install temp, test				1		Cryo	1	1							1	1						
						3		3								3							
2	Deploy T&B FC Drift Volume 1					3	Cryo		3								3						
3	Final Test and HV Elec Connections		2		2		Cryo			2	2							2	2				

Updated Ash River Trial Assembly Schedule



Food for thought-Shift Change

- With ~144 FTE coming underground at shift change, ~30-minute trip cycle and 36 FTE it means 4 staggered shifts and it takes ~2 hours to get everyone underground!
- This complicates morning work planning and safety meetings with the different work groups

<u>Head - Frame</u>	<u>Lift Type</u>	Load Ross Frame	Unload 4850	Load 4850	Unload Ross Frame	Total Round- trip Loading	Shift Time 1200 ft/min 600 ft/min 500 ft/min		
							Down	Up	TTL Round trip Time
		Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Ross Cage	Personnel Lift	5.0	5.0	5.0	5.0	20.0	5.36	5.36	30.71
Ross Cage	In-Cage Lift	20.0	20.0	5.0	5.0	50.0	5.36	5.36	60.71
Ross Cage	Over-High Lift	30.0	30.0	5.0	5.0	70.0	5.36	5.36	80.71
Ross Cage	Under Cage	30.0	30.0	5.0	5.0	70.0	11.79	5.36	87.15
Ross Skip	Suspended	30.0	30.0	0.0	0.0	60.0	9.95	5.36	75.31

Task	Group	Month	-2	-1	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46	49	51	54	57	60	64	67	70
			Estimated Number of FTEs Underground per shift-Assume 2 shifts per day																									
CF-Day			80	55	55	55	55	40																				
CF-Night			70	55	55	55	55	35																				
LBNF/CERN-Warm-Day					25	25	25	25	25	25	25	25	20	20														
LBNF/CERN-Warm-Night					25	25	25	25	25	25	25	25	15	15														
GTT-Cold-Day										25	25	25	25	25	25	25	25				10							
LBNF/CERN-Cryo								10	10	20	20	20	20	20	20	20	20	20	20	4	4	4	4	4	4	4	4	4
I&I-Underground Day				11	29	29	29	29	46	46	46	46	46	46	46	46	46	46	46	46	46	46	27	27	27	27	27	27
I&I-Underground Night				11	29	29	29	29	46	46	46	46	46	46	46	46	46	46	46	46	46	46	27	27	27	27	27	27
DUNE-Consortia-Day								5	5	5	10	10	36	36	36	36	36	36	36	36	36	36	30	20	20	5	5	5
DUNE Consortia-Night										5	10	10	35	35	35	35	35	35	35	35	35	35	30	20	20	5	5	5
SURF-Day			15	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
SURF-Night			5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total FTEs Underground per Day Shift			95	86	129	129	129	129	106	141	146	146	166	166	146	146	146	121	121	105	115	105	81	71	71	56	56	56
Total FTEs Underground per Night Shift			75	76	119	119	119	99	81	86	91	91	105	105	90	90	90	90	90	90	90	90	67	57	57	42	42	42