



Fabrication Plan and Schedule

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Fixed Dates, Milestones
TPC Configuration
Production
Installation
Effort Profile
Issues

Fixed Dates and Milestones

- 8/15/2024 – Start of installation of HVS components in cryostat
 - In the next 5 years . . .
 - Ash River installation trials
 - Multiple factory setups
 - ProtoDUNE SP II modifications and operation
 - Production Readiness Reviews
 - Component parts ordering and distribution
- 6/4-5/2019 – HVS 60% Design Review

10 kton TPC

1 (2?) 10 kton Single Phase TPCs for DUNE

58 m long (beam direction)
X 12 m tall X 14 m wide
-> 4 - 3.5 m e drift regions

Configuration:

EndWall FC (4 - 3.5 m wide X 12 m tall)

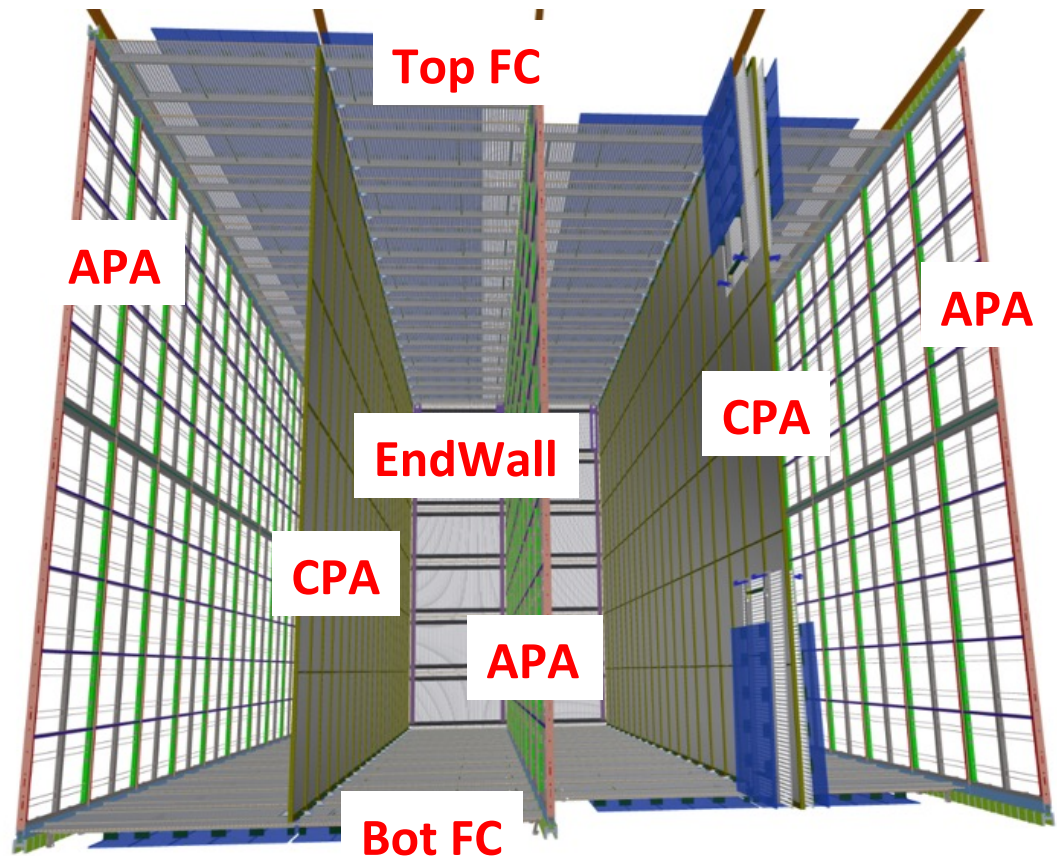
APA-T/B FC-CPA-T/B FC-APA-T/B FC-CPA-T/B FC-APA

APA-T/B FC-CPA-T/B FC-APA-T/B FC-CPA-T/B FC-APA

. Total of 25 rows

APA-T/B FC-CPA-T/B FC-APA-T/B FC-CPA-T/B FC-APA

EndWall FC



Cathode Plane Assembly (CPA)

CPA for 10 kton TPC

HV wall of -180 kV opposite APA

Hanging from DSS

2 CPA Arrays

-> 25 CPA Planes (50 CPA Planes)

-> 2 CPA Panels (100 CPA Panels)

-> 3 CPA Units (300 CPA Units)

-> 2 CPA modules (600 CPA RPs)

Production rate: 2 Panels/week/factory

-> 2 factories - ~6 months production

Shipping Unit : 2 connected modules (1 CPA Unit)

Shipping crate : 6 CPA Units (2 CPA Panels -> 1 CPA Plane)



Top/Bottom, EndWall FCs

Top/Bottom FCs

CPA/APA hinge connections

100 Top, 100 Bottom Modules

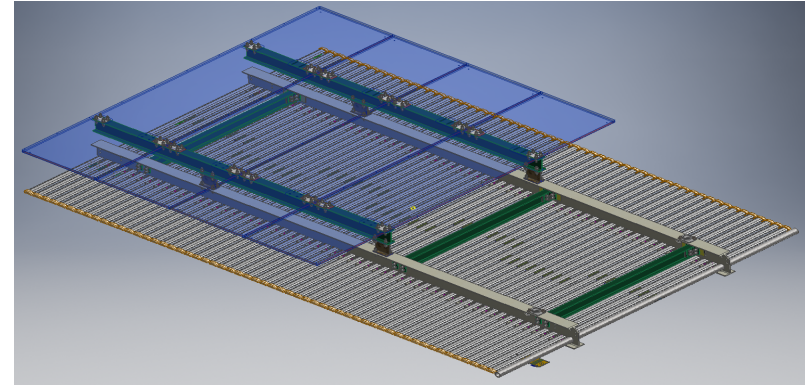
(3.5 m X 2.3 m)

-> 57 Profiles per Module

-> 7 RDBs per Module

Production rate: 2 Panels/week/factory

-> 2 factories - ~ 1 year production



EndWall FCs

Hanging from DSS

2 EndWall FC Planes

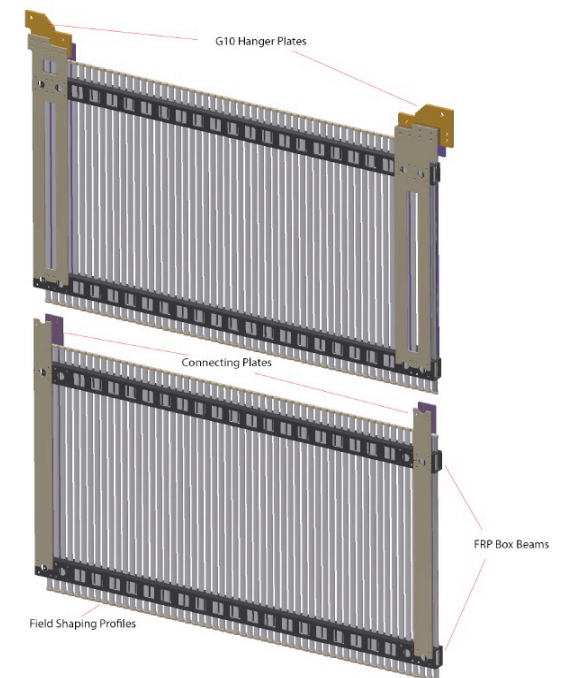
-> 32 EndWall FC modules per EndWall FC Plane

(3.5 m x 1.5 m)

-> 57 Profiles per Module

Production rate: 2-3 modules/week/factory

-> 1 factory - ~ 8 months production



Excerpt from CPA Production

		Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	W
100 Panels needed 2 Factories														
16 Panels is 1 month inventory assuming 4 install														
Assume 2 produced per week per factory														
2 Panels per Shipping Crate - 4 crates per shipment														
CPA	Factory 1	Total Produced	6	8	10	12	14	16	18	20	22	24	26	28
	Production	2	2	2	2	2	2	2	2	2	2	2	2	2
	Inventory	4	6	8	2	4	6	8	2	4	6	8	2	
	Ship			8				8				8		
	Crates at Factory	10	10	10	6	6	6	6	2	2	2	6	2	
	Returned Crates	0	0	0	0	0	0	0	0	0	4	0	0	
	Factory 2	Total Produced		1	1	1	2	4	6	8	10	12	14	16
	Production		1			1	2	2	2	2	2	2	2	2
	Inventory		0	1	1	1	2	4	6	8	2	4	6	
	Ship									8				
	Crates at Factory				10	10	10	10	10	10	6	6	6	
	Returned Crates				0	0	0	0	0	0	0	0	0	
	LW	Inventory (Panels)			0	8	8	8	8	16	10	14	10	14
	Ship to SURF (Panels)									6	4	4	4	4
Install in cryostat									4	4	4	4	4	
Full crates at LW				0	4	4	4	4	8	5	7	5		
MT crates at LW				0	0	0	0	0	3	1	3	5		
Return Crate Shipment F1									4					
Return Crate Shipment F2														
MT crates to factories				0	0	0	0	0	0	4	0	0		

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Top/Bottom, EndWall FC Production

200 FC needed + 2 Factory model 32 FC is 1 month inventory assuming 8 installed per week Assume 2 produced per week per factory 4 FC per crate and 3 crates per shipment		Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36
Factory 1	Total Produced	27	29	32	35	38	41	44	47	50	53	56	59
	Production	2	2	3	3	3	3	3	3	3	3	3	3
	Inventory	2	4	6	9	12	3	6	9	12	3	6	9
	Ship					12				12			
	Crates at factory	4	4	4	4	4	1	4	4	4	1	1	5
	Returned crates					0	3	0	0	0	0	4	0
Factory 2	Total Produced	21	23	25	27	29	32	35	38	41	44	47	50
	Production	2	2	2	2	2	3	3	3	3	3	3	3
	Inventory	8	10	12	2	4	6	9	12	3	6	9	12
	Ship			12					12				12
	Crates at factory	9	9	9	6	6	6	6	9	6	6	6	10
	Returned crates					0	0	3	0	0	0	4	0
LW	Inventory	36	36	36	48	40	44	36	28	32	36	28	20
	Ship to SURF				8	8	8	8	8	8	8	8	8
	Install in cryostat					8	8	8	8	8	8	8	8
	MT crates at LW					2	4	3	2	4	6	8	2
	Return crates to F1						3					4	
	Return crates to F2							3				4	
Crate disposal													

64 EW needed 1 Factory model Assume 3 produced per week 4 EW per crate and 2 crates per shipment		Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 2
Factory 1	Total Produced	8	11	14	17	20	23	26	29	32	35	38	41
	Production	3	3	3	3	3	3	3	3	3	3	3	3
	Inventory	5	8	3	6	9	4	7	2	5	0	3	6
	Ship		8			8		8		8			
	Crates at factory	8	8	6	6	6	4	4	2	2	0	4	8
	Returned crates								0	0	4	4	
LW	Inventory	0	0	8	8	8	16	8	8	0	0	0	0
	Ship to SURF						8	8	8	8			
	Install in cryostat (Row 0)								8	8	8	8	
	Install in cryostat (Row 26)												
	Return crates to F1										4	4	

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HVS Schedule List

Milestones listed at the top
 Color code links common WBS levels
 Input to TDR

Table 1.8: High level Milestones and Schedule for the production of the HV System of the SP module

Milestone	Date (Month YYYY)
Technology Decision	
CPA/FC/EndWall 60% Design Review	June 2019
CPA/FC/EndWall Mod 0 (for tests at Ash River)	June 2019 - June 2020
Final Design Review	June 2020
Start of module 0 component production for ProtoDUNE-II	June 2020
End of module 0 component production for ProtoDUNE-II	March 2021
Start of ProtoDUNE-SP-II installation	March 2021
Start of ProtoDUNE-DP-II installation	March 2022
South Dakota Logistics Warehouse available	April 2022
Beneficial occupancy of cavern 1 and central utility cavern (CUC)	October 2022
CUC counting room accessible	April 2023
Top/Bottom FC production readiness review (PRR)	July 2023
Start of Top/Bottom FC production	September 2023
CPA PRR	October 2023
Start of CPA production	December 2023
Top of detector module #1 cryostat accessible	January 2024
EndWall FC PRR	February 2024
Start of EndWall FC production	April 2024
End of CPA production Detector #1	August 2024
End of Top/Bottom FC production Detector #1	August 2024
End of EndWall FC production Detector #1	August 2024
Start of detector module #1 TPC installation	August 2024
Start of detector module #1 TPC installation	August 2024
Top of detector module #2 accessible	January 2025
End of detector module #1 TPC installation	May 2025
Start of detector module #2 TPC installation	August 2025
End of CPA production Detector #2	September 2025
End of Top/Bottom FC production Detector #2	October 2025
End of EndWall FC production Detector #2	January 2026
End of detector module #2 TPC installation	May 2026

MILESTONES

CPA/FC/EW 60% Design Review	6/4/19	5	6/9/19
CPA/FC/EW Final Design Review/ProtoDUNE II PRR	6/14/20	5	6/19/20
CPA/FC/EW Mod 0 (for tests at Ash River)	6/15/19	365	6/14/20
CPA Production Readiness Review	10/22/23	5	10/27/23
Top/Bottom FC Production Readiness Review	7/16/23	5	7/21/23
EndWall FC Production Readiness Review	2/11/24	5	2/16/24
Start Procurement for CPA	1/4/23	5	1/9/23
CPA Factory Setup	7/28/23	5	8/2/23
Start CPA Production	12/21/23	5	12/26/23
Field Cage Profiles Order	1/4/23	5	1/9/23
Start Procurement of T/B FC Parts	1/4/23	5	1/9/23
T/B FC Factory Setup	3/17/23	5	3/22/23
Start T/B Factory Production	9/14/23	5	9/19/23
Start Procurement of EW FC Parts	1/4/23	5	1/9/23
EW FC Factory Setup	10/20/23	5	10/25/23
Start EW FC Production	4/11/24	5	4/16/24
Start of Installation at SURF	8/15/24	5	8/20/24

CPA/FC/EW R&D Efforts

CPA/FC/EW R&D Efforts	1/1/19	560	7/14/20
PROTODUNE SP II ACTIVITIES			
TCO open for pDUNE SP II modifications	9/1/20	365	9/1/21
Close TCO pDUNE SP II	9/1/21	14	9/15/21
Test Beam data-taking, analysis	9/15/21	560	3/29/23

2.8.4 PRODUCTION SETUP

2.8.4.1 CPA Production Setup	7/28/23	40	9/22/23
2.8.4.2 T/B FC Production Setup	3/17/23	65	6/16/23
2.8.4.3 EW FC Production Setup	10/20/23	60	1/12/24
2.8.4.4 HV Components Cold Test Setup			

2.8.5 PRODUCTION

2.8.5.2 FC Common Component Production	1/4/23	182	7/5/23
2.8.5.2.1 FC Profile Order	1/4/23	182	7/5/23
2.8.5.2.2 FC Profile Endcaps	1/4/23	182	7/5/23
2.8.5.2.3 FC Hardware Fabrication	1/4/23	182	7/5/23
2.8.5.2.4 Voltage Divider Test Components + Manufacture	1/4/23	182	7/5/23
2.8.5.2.5 FC Termination			

2.8.5.1 CPA PRODUCTION

2.8.5.1.1 RP Fabrication			
Kapton Order	1/4/23	182	11/23/23
FSS Order	1/4/23	182	11/23/23
Resistive Panel Order	1/4/23	182	11/23/23
2.8.5.1.2 HV Bus and Jumpers Order	1/4/23	182	11/23/23
2.8.5.1.3 CPA Frames Order	1/4/23	182	11/23/23
CPA Shipping crates	5/25/23	150	12/21/23
Production			
Factory #1	12/21/23	160	8/1/24
Factory #2	1/18/24	140	8/1/24

2.8.5.3 T/B FC PRODUCTION

2.8.5.3.1 Order FC Frames	1/4/23	182	9/14/23
2.8.5.3.2 Order Ground Planes	1/4/23	182	9/14/23
FC Shipping crates	5/11/23	90	9/14/23
Production			
T/B FC Factory #1	9/14/23	230	8/1/24
T/B FC Factory #2	10/5/23	215	8/1/24

2.8.5.4 EndWall FC PRODUCTION

2.8.5.4.1 Order EndWall FC Frames	1/4/23	245	12/13/23
EndWall FC Shipping crates	2/29/24	30	4/11/24
Production			
Factory #1 - Row 0	4/11/24	80	8/1/24
Factory #1 - Row 26	8/1/24	80	11/21/24

2.8.5.5 HV COMPONENT PRODUCTION

2.8.5.5.1 HV FT			
2.8.5.5.2 HV PS			
2.8.5.5.3 HV Distribution			

2.8.6 INTEGRATION

2.8.6.1 CPA activities LW	8/1/24	150	2/27/25
2.8.6.2 T/B FC activities LW	8/1/24	150	2/27/25
2.8.6.3 EW FC activities LW	8/1/24	160	3/13/25
2.8.6.4 HV Component activities LW	4/3/25	25	5/8/25

2.8.7 INSTALLATION

2.8.7.0 Install EndWall Row 0	8/15/24	190	5/8/25
8/15/24	20	9/12/24	
2.8.7.1 CPA Installation	8/29/24	130	2/27/25
2.8.7.1.3 CPA/FC Assembly in clean room	8/29/24	130	2/27/25
2.8.7.1.4 CPA/FC into cryostat	8/29/24	130	2/27/25
2.8.7.2 T/B FC Installation	8/29/24	130	2/27/25
Install EndWall Row 26	2/13/25	20	3/13/25
2.8.7.4 HV PS and Distribution Installation	4/10/25	20	5/8/25

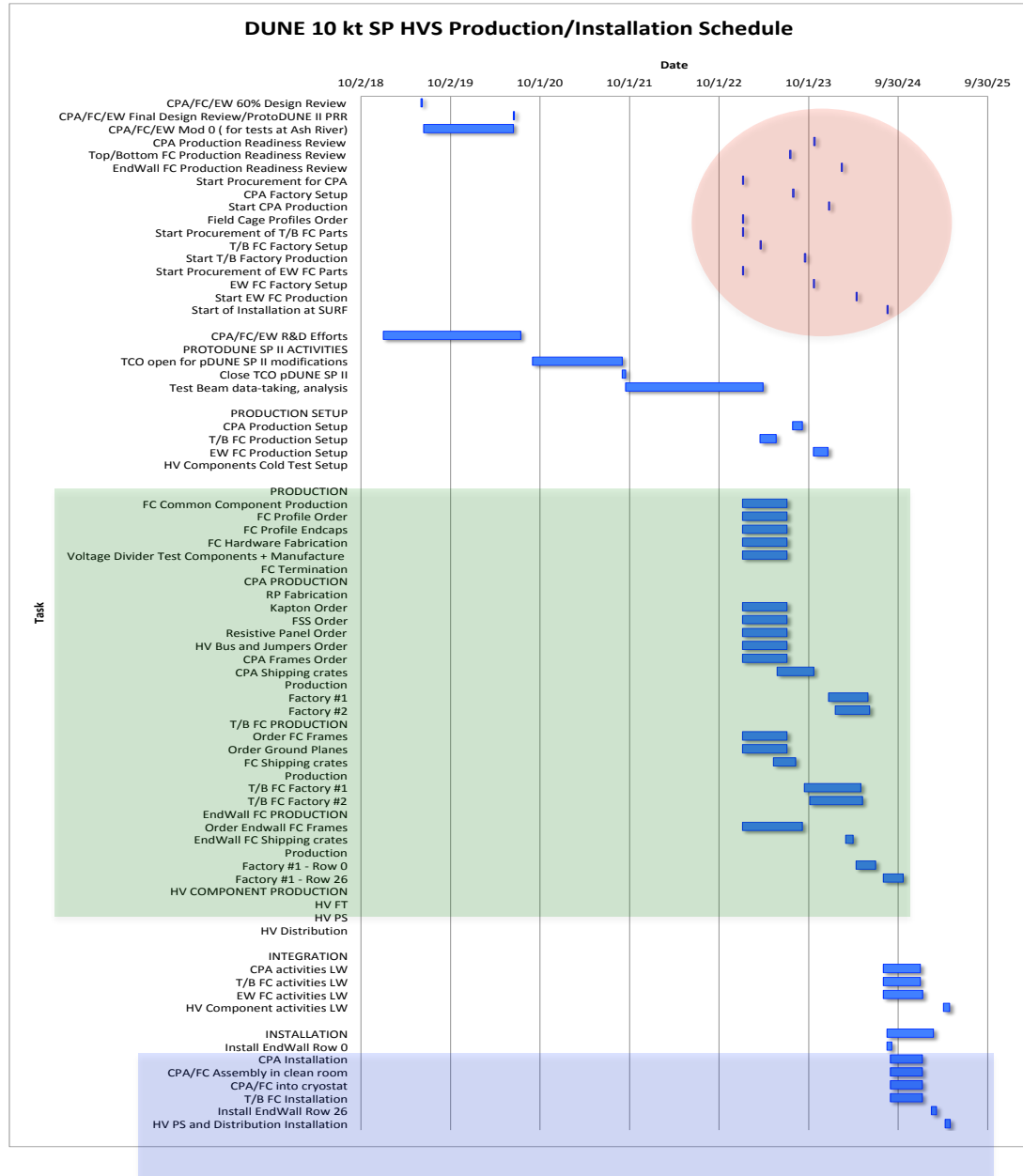
HVS Timeline

Gantt chart of milestones, schedule – FY intervals

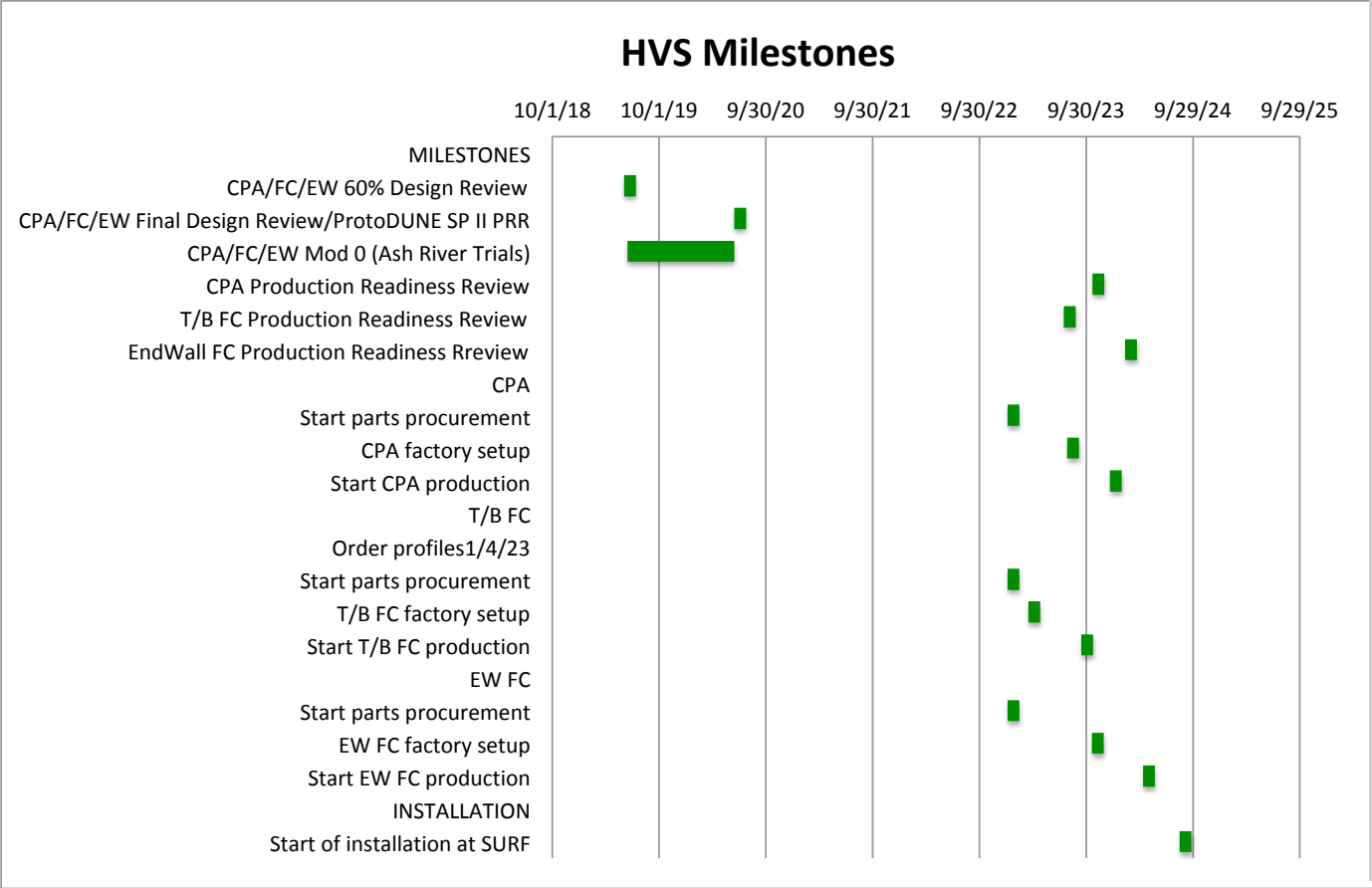
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Starts from start of installation – 08/24
 -> Using duration of efforts, works backward to produce production schedule, forward for installation

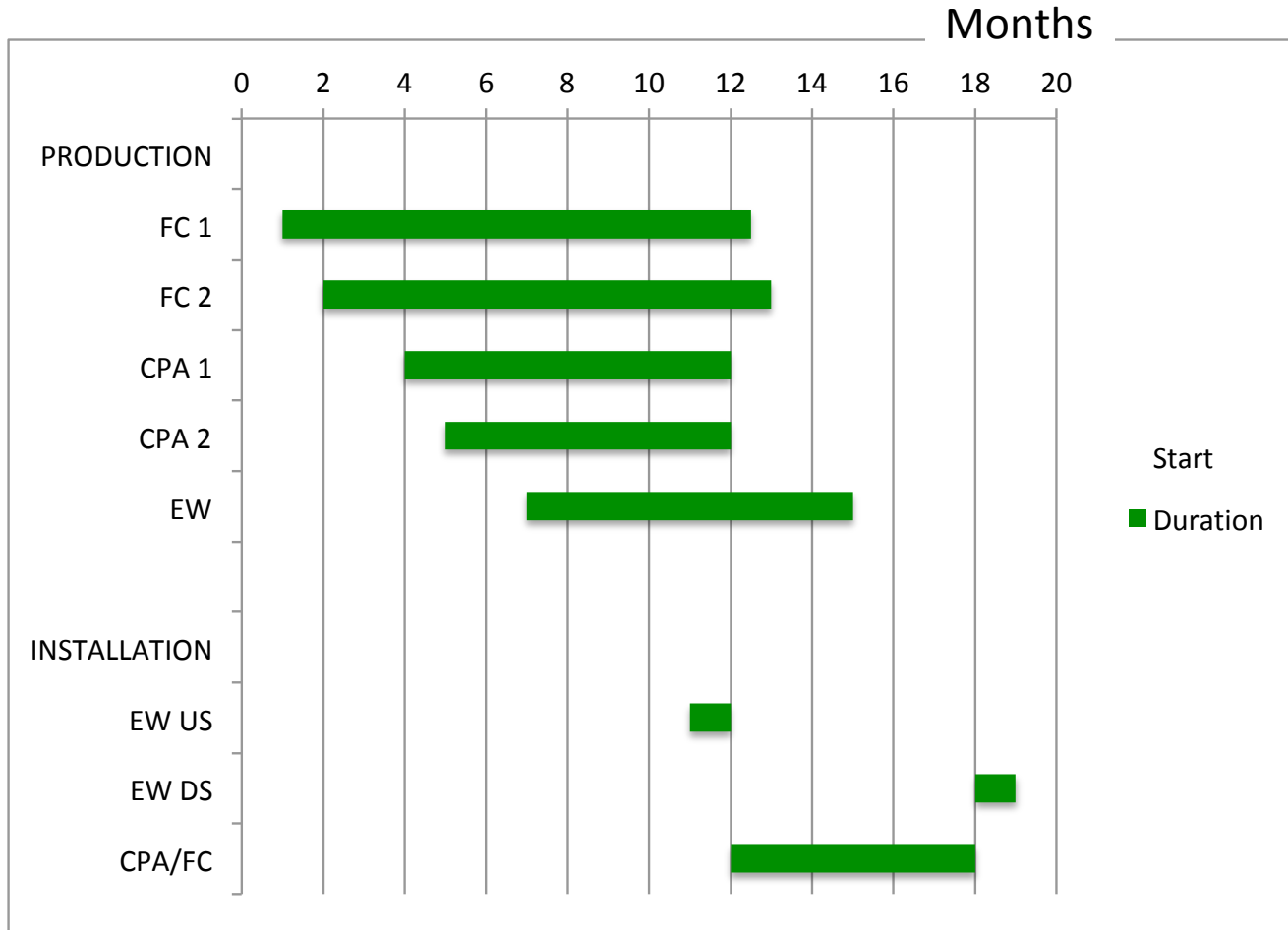
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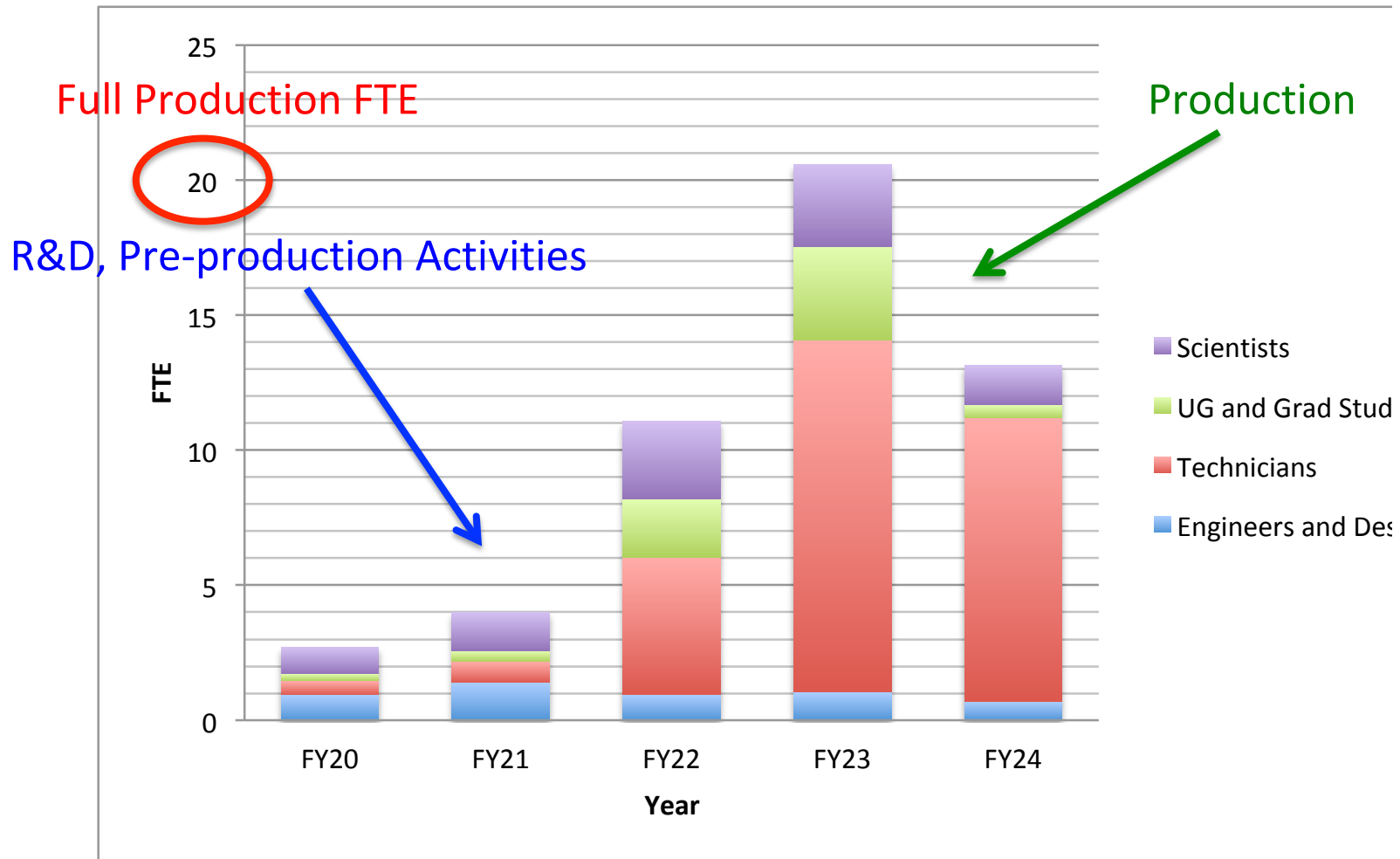
HVS Milestones Focus



Production/Installation Focus



Effort Profile



The present HVS consortium institutions have adequate infrastructure, expertise and manpower to build the HVS system for the SP far detector.

References

- [DUNE-doc-10452](#) Materials for Design Review
 - Component drawings
 - Design Report (HVS details)
 - Production and Installation Procedures
 - QC (procedures, checklists)
 - Scheduler (factories, production, shipping, storage, installation, timeline)
- [DUNE-doc-8246, -11212](#) Lessons Learned from ProtoDUNE-SP
- [DUNE-doc-9919](#) Scheduler for HVS

Summary

- ***Very successful prototype HVS demonstrated by ProtoDUNE SP in 2018 – met/exceeded all requirements!***
- What we are doing until production/installation:
 - Ash River trials (were very helpful to ProtoDUNE-SP)
 - ProtoDUNE SP II (electrons, pi-)
 - Factory setup (Standard tooling, practice runs)
 - PRRs (optimized schedule)
- How many factories? (currently 2 CPA, 2 T/B FC, 1 EW)
- Cost savings (ProtoDUNE lessons learned, streamlined production, installation, parts/tools uniformity)
- Production and Installation - Just-in-Time vs sequential