

PROTON POWER UPGRADE (PPU) PROJECT

Monthly Progress Report



May 2021

Report Due Date: **June 30, 2021**
Project Director: **John Galambos**

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Approved by: _____
Mark Champion, PPU Project Management Group Leader

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Overall Assessment

Proton Power Upgrade Project highlights for the month of May 2021 are as follows:

- *The project continues to proceed as planned with good earned-value performance metrics. However, it is becoming increasingly apparent that vendor schedules are being impacted by supply chain disruptions caused by the COVID-19 pandemic. The project team is working closely with the vendors to accommodate and/or mitigate these delays where feasible.*
- *The PPU Installation Coordinator has taken over responsibility for work conditions and requirements in the klystron gallery from the construction contractor. Installation work is underway and the first major cable pulls have been completed. Electrical system upgrades are in progress in the target building basement to support PPU target utilities and mercury off-gas treatment system upgrades.*
- *The following reviews were conducted in May:*
 - *SCL controls racks procurement readiness review, May 10th*
 - *Target gas panel 10 final design review, May 13th*
 - *Target in-cell gas supply hardware final design review, May 26th*
- *Final design completeness is at approximately 98% (versus 92% at CD-2/3 review).*

Annual DOE Milestones

Seventeen milestones were selected by the project and DOE to monitor FY21 progress. The status of the milestones is summarized in the following table and presented in the associated technical sections. Two milestones were successfully completed in May.

System	Milestone Name	Planned Finish	Actual Date	Current Forecast	Owner
P.2	Super Conducting Linac (SCL) Systems				
P2319MS05	Completion of Cryomodule Shipping Tests (Jlab)	20-Jun-21	23-Feb-21		Matt Howell
P228MS197	Award Contract for Inner Extension, Outer Extension, and Waveguide Cover	01-Aug-21	27-Apr-21		Matt Howell
P.3	Radio Frequency (RF) Systems				
P362P90	Award of Remaining High Voltage Converter Modulator (HVCM) Transformers Complete	12-Apr-21	18-Dec-20		John Moss
P333MS002	Receipt of 3MW Klystron Test Article	03-Aug-21		18-Aug-21	John Moss
P342MS50	Fabrication of Low Level Radio Frequency (LLRF) Platform Complete	15-Sep-21		01-Sep-21	John Moss
P.4	Ring Systems				
P422P175MS	Award Contract for Fabrication of Chicane 2/3 (and Spare), Injection Dump Septum Magnets and Spare Coil Sets	04-May-21	28-Apr-21		Nick Evans
P462D384	Preliminary Design Review of Beam Power Limiting System (BPLS) Complete	04-May-21	04-Mar-21		Nick Evans
P432DFDC	Final Design of Injection Dump Imaging System Complete	29-Jun-21	18-May-21		Nick Evans
P462D454	Final Design of PPS Interface Complete	06-Sep-21		22-Jun-21	Nick Evans
P432P979	Fabrication of Injection Dump Window Full Assembly for Installation Complete	30-Sep-21		24-Aug-21	Nick Evans
P.5	First Target Station (FTS) Systems				
P5921MS006	Award Contract for 2MW Target	29-Nov-20	30-Oct-20		Bernie Riemer
P5921MS140	Fabrication of PPU Front Body Development Test Article Complete	01-Mar-21	26-Feb-21		Bernie Riemer
P5942MS145	Fabrication of PPU Test Target 1 Shroud Complete	12-Jul-21		07-Sep-21	Bernie Riemer
P542MS230	Award Contract for Ortho/Para Converter Vessel Assembly	18-Jul-21		19-Jul-21	Bernie Riemer
P582MS10	Fabrication of Second Carbon Delay Bed Vessel and Cartridge Complete	30-Sep-21	03-May-21		Bernie Riemer
P.10	Long Lead Procurements (LLPs)				
P222MS06	Receipt of Last Five Production Cavities at Jlab	13-May-21	25-Feb-21		Matt Howell
P621PM01	Conventional Facilities (CF) Construction of Klystron Gallery Complete	13-May-21	06-Apr-21		Mark Connell

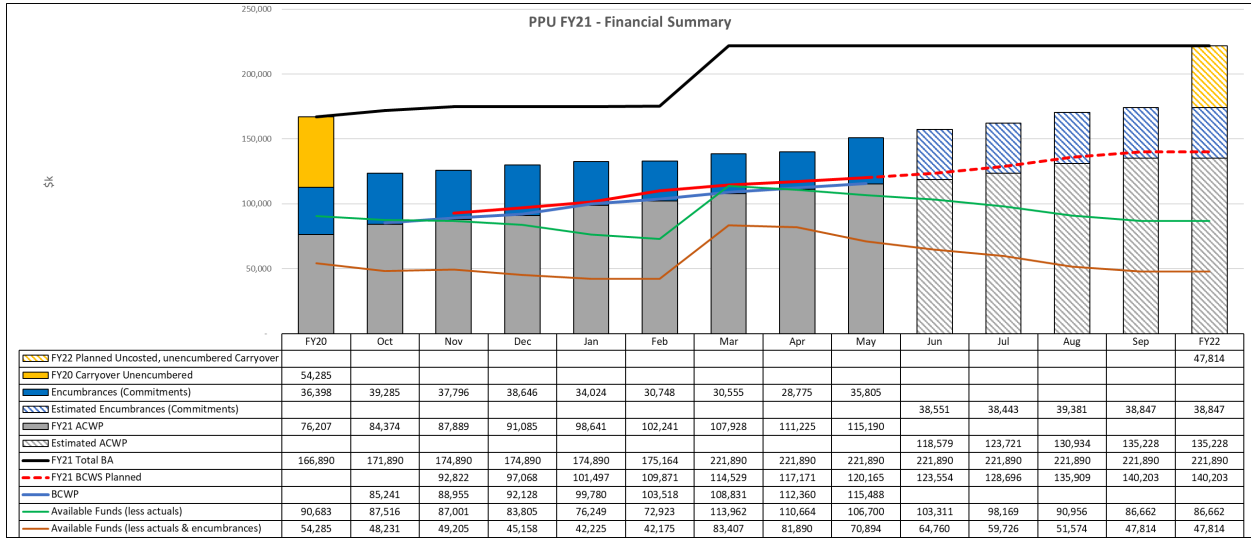
Legend: Green - On/Ahead of Schedule, Yellow - Moderately Late (<3 months), Red - Very Late (>3 months) or Critical Path (>1 month)

Project Cost Overview

Level 2 Cost Summary

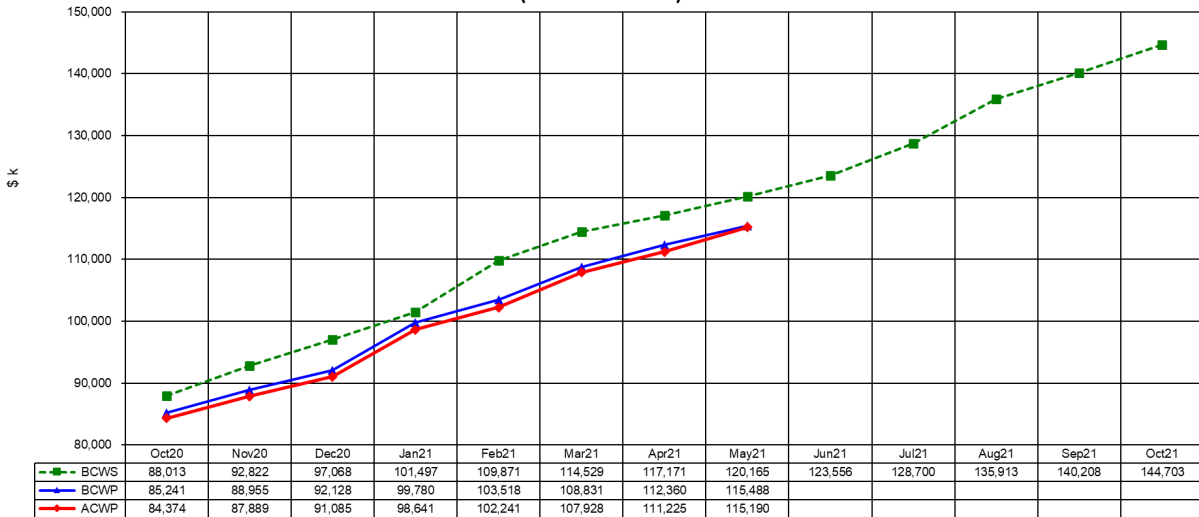
WBS Description	Prior Costs	Prior FY21 Costs	May Costs	Total FY21 Costs	Total Costs to Date	Commits (with OH)
P.1 Project Management	5,883,425	2,169,137	384,880	2,554,017	8,437,441	808,152
P.2 SCL Systems	5,924,975	2,188,148	331,075	2,519,223	8,444,199	9,181,309
P.3 RF Systems	12,347,958	6,231,573	952,369	7,183,942	19,531,900	10,069,607
P.4 Ring Systems	6,980,063	2,385,202	327,449	2,712,651	9,692,714	2,624,063
P.5 First Target Station Systems	10,224,569	5,557,542	1,248,754	6,806,296	17,030,865	6,907,014
P.6 Conventional Facilities	2,522,645	266,126	56,933	323,059	2,845,704	44,617
P.7 R&D (OPC)	2,265,525	14,238	48,255	62,492	2,328,017	1,070
P.8 Pre-Ops (OPC)	56,292	17,138	2,774	19,911	76,203	-
P.9 Pre-CD1 Activities (OPC)	7,249,768	-	-	-	7,249,768	-
P.10 Long Lead Procurements	22,751,625	16,189,395	612,572	16,801,967	39,553,592	6,169,484
Total PPU	76,206,845	35,018,497	3,965,061	38,983,559	115,190,404	35,805,317

Detailed Financial Plan



Earned Value Performance Charts

PPU
Total Project
Cost/Schedule Performance Chart
(Cumulative Data)



As shown in the following Contract Performance Report, the project performance indices are SPI = .96 and CPI = 1.00.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (WBS Level 2)															
May 2021 (\$k) ITEM	CURRENT PERIOD					CUMULATIVE TO DATE							AT COMPLETE		
	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE				BAC	EAC	VAC
				SV	CV				SV	SPI	CV	CPI			
P.01 - PPU Project Management	347	363	385	16	(22)	8,832	8,816	8,437	(16)	1.00	378	1.04	22,169	21,791	378
P.02 - SCL Systems	449	254	331	(194)	(77)	9,241	8,875	8,444	(366)	0.96	430	1.05	24,082	23,652	430
P.03 - RF Systems	685	928	952	244	(24)	19,180	19,596	19,532	416	1.02	64	1.00	43,696	44,098	(402)
P.04 - Ring Systems	539	271	327	(268)	(57)	9,959	9,206	9,693	(753)	0.92	(486)	0.95	20,662	22,382	(1,721)
P.05 - First Target Station Systems	566	668	1,249	101	(581)	17,584	16,463	17,031	(1,120)	0.94	(567)	0.97	34,544	35,119	(575)
P.06 - Conventional Facilities	22	55	57	33	(2)	2,758	2,772	2,846	13	1.00	(74)	0.97	10,900	10,974	(75)
P.07 - R&D	0	48	48	48	(0)	2,267	2,315	2,328	48	1.02	(13)	0.99	2,476	2,488	(12)
P.08 - Pre-Ops	4	4	3	0	2	87	87	76	0	1.00	10	1.14	1,137	1,127	10
P.09 - Pre-CD-1 Activities	0	0	0	0	0	7,250	7,250	7,250	0	1.00	0	1.00	7,250	7,250	0
P.10 - Long Lead Procurements	382	536	613	154	(76)	43,007	40,108	39,554	(2,899)	0.93	554	1.01	49,785	49,346	438
TOTAL	2,994	3,128	3,965	135	-837	120,165	115,488	115,190	-4,677	0.96	297	1.00	216,701	218,229	-1,529
Cumulative Thresholds:												5,105	5,105		
• Red: CPI/SPI <0.85 or >+1.20 AND >\$100k												Management Reserve			
• Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k												Contingency			
												TPC			
												271,567	271,567		

Project Change Requests

The project continues appropriate configuration management to incorporate PCRs to ensure the project maintains an accurate baseline against which project performance can be accurately measured. The impact of PCRs implemented this month was a net increase to the baseline of \$958K.

The impacts by L2 are shown in the following table.

	April 2021 Baseline	May 2021 Baseline
P.01 Project Management	22,078	22,169
P.02 SCL Systems	23,976	24,082
P.03 RF Systems	42,881	43,696
P.04 Ring Systems	20,608	20,662
P.05 First Target Station Systems	34,736	34,544
P.06 Conventional Facilities	10,886	10,900
P.07 R&D	2,453	2,476
P.08 Pre-Ops	1,137	1,137
P.09 Pre CD-1 Activities	7,250	7,250
P.10 Long Lead Procurements	49,738	49,785
Revised Baseline	215,743	216,701
Management Reserve	5,246	5,105
Contingency	50,578	49,762
PPU - Total with Contingency	271,567	271,567

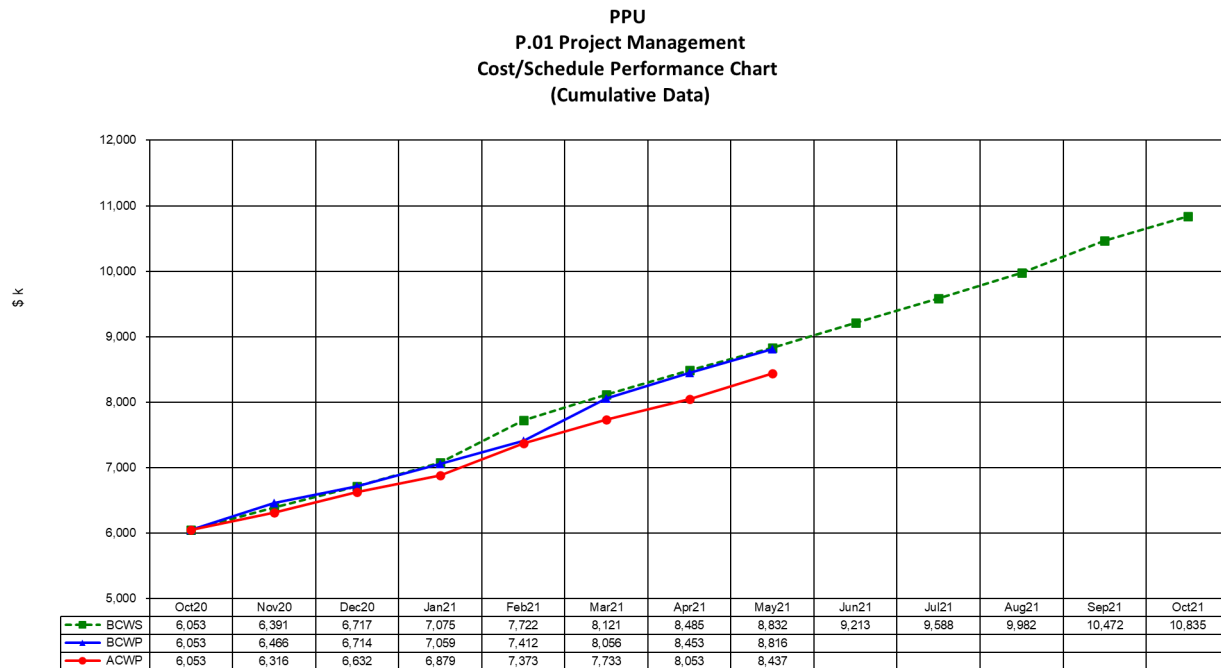
P.1 Project Management

The Neutron Sciences Directorate selected the five-year operations and maintenance plan that prioritizes the PPU early finish. As a result, the early finish has moved from January 24th, 2025, to February 12th, 2025, a schedule slip of three weeks compared to the CD-2/3 baseline plan. A project change request to align PPU with the five-year plan has been completed and approved.

Preparations are underway for the Director’s Review that will be conducted the first week of August. Committee members have been invited, charge questions have been drafted, and the detailed agenda is under development.

The risk register has been reviewed and updated, and the top ten risks will be communicated to BES in the June conference call.

Earned Value Performance Charts



As shown in the following Contract Performance Report, the Project Management performance indices are SPI = 1.00 and CPI = 1.04.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)																
May 2021 (\$K) ITEM	CURRENT PERIOD						CUMULATIVE TO DATE						AT COMPLETE			
	BCWS	BCWP	ACWP	VARIANCE		CV	BCWS	BCWP	ACWP	VARIANCE			BAC	EAC	VAC	
SV	CV	SV	SPI	CV	CPI											
P.01 - PPU Project Management	347	363	385	16	(22)		8,832	8,816	8,437	(16)	1.00	378	1.04	22,169	21,791	378
P.01.01 - Project Management	57	73	72	16	1		1,989	1,973	1,964	(16)	0.99	8	1.00	4,572	4,563	8
P.01.02 - Project Support	250	250	258	0	(7)		5,761	5,761	5,384	0	1.00	378	1.07	14,778	14,400	378
P.01.03 - ESH&Q	40	40	55	0	(15)		1,082	1,082	1,089	0	1.00	(8)	0.99	2,820	2,828	(8)

Cumulative Thresholds: * Red: CPI/SPI < 0.85 or >= 1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

P.2 Superconducting Linac (SCL) Systems

Fifteen cavities have been qualified and twelve cavities have been installed in helium vessels. Four cavities have been qualified for the first cryomodule. Three cavities have been qualified for the second cryomodule. Testing and evaluation is in progress to determine the cause of field emission in the tanked

cavity process. Cavity string instrumentation is in progress.

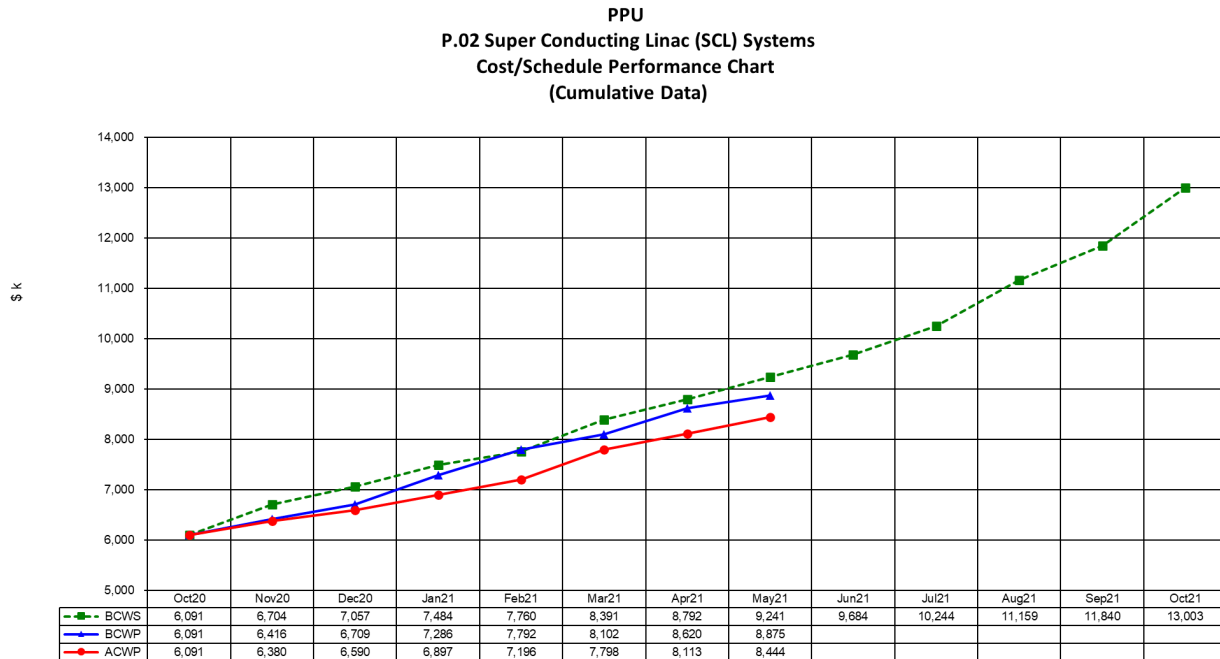
Plasma processing for SNS cryomodule 11 was completed in April and the cryomodule has been staged in the LINAC for installation in June.

Fourteen couplers have been processed and delivered to Jefferson Lab. Additional processing has begun.

Milestone Table

P.2 SCL Systems	Planned Finish	Actual Finish	Current Forecast	Owner
Completion of Cryomodule Shipping Tests (JLab)	20-Jun-21	23-Feb-21		Matt Howell
Award Contract for Inner Extension, Outer Extension, and Waveguide Cover	01-Aug-21	27-Apr-21		Matt Howell

Earned Value Performance Charts



As shown in the following Contract Performance Report, the Superconducting Linac Systems performance indices are SPI = .96 and CPI = 1.05.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k) ITEM	CURRENT PERIOD						CUMULATIVE TO DATE						AT COMPLETE		
	BCWS	BCWP	ACWP	VARIANCE SV CV		BCWS	BCWP	ACWP	VARIANCE SV SPI CV CPI			BAC	EAC	VAC	
P.02 - SCL Systems	449	254	331	(194)	(77)	9,241	8,875	8,444	(366)	0.96	430	1.05	24,082	23,652	430
P.02.01 - Management and System Integration	26	26	20	0	6	898	898	839	0	1.00	60	1.07	1,122	1,063	60
P.02.02 - Cavities	89	42	43	(48)	(1)	1,724	1,270	1,293	(454)	0.74	(23)	0.98	2,675	2,708	(33)
P.02.03 - Cryomodule Integration (Partner Laboratory Scope)	298	151	206	(148)	(56)	5,188	5,241	4,934	53	1.01	308	1.06	14,186	13,878	308
P.02.04 - Cryogenics	3	3	0	0	3	67	67	35	0	1.00	33	1.95	826	794	33
P.02.05 - Utility Systems	5	7	1	1	5	110	111	85	1	1.01	27	1.31	1,022	983	39
P.02.06 - System Integration	5	5	35	0	(30)	296	403	339	107	1.36	64	1.19	2,229	2,165	63
P.02.07 - SCL Controls	22	22	26	(1)	(4)	957	884	920	(73)	0.92	(36)	0.96	2,021	2,061	(39)

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

Title: P.02.02.07.05 / ORNL- Testing – HTA Testing (SPI = .00)
Cause: Due to delays in delivery of the qualified dressed cavity from JLab, testing of the horizontal cavity with coupler in a cryostat has not started. The cavity has now been received. Assembly and preparation for testing will begin July 2021 after the June maintenance down.
Impact: None. Does not impact downstream activities. The variance will resolve itself upon completion of testing.
Recoverable: Yes.
Corrective Action: None.

Title: P.02.06.05.04 / ORNL - Installation - Plasma Process MB Cryomodule in Tunnel (SPI = 2.08)
Cause: Plasma processing was completed ahead of schedule due to an opportunity that occurred when a medium beta cryomodule was removed and taken to the Radio Frequency Test Facility (RFTF) for repairs. After repairing the cryomodule, there was an opportunity to the perform plasma processing in the RFTF without requiring a maintenance down. Work was fully completed.
Impact: None.
Recoverable: Yes.
Corrective Action: None.

P.3 Radio Frequency (RF) Systems

The combined Low-Level RF (LLRF) and controls team continued iterating the LLRF software to include all functions needed for the SCL-23D operational test planned for later this summer. Currently, all software amplitude and phase controls are complete and operational. Firmware for the new system is complete pending further software verification.

The LLRF team also completed testing 26 of 30 total Frequency Conversion Chassis (FrCC), received all of the new arc detector systems from Advanced Ferrite Technology (AFT), and completed the fabrication of the associated driver boards for the arc test system. The team has started receiving the hardware components for the new LLRF platform including the μ TCA crate, shelf manager, and filler cards. The field-programmable gate array carrier cards are still pending.

The High Voltage Converter Modulator (HVCM) team continued testing the new radiofrequency quadrupole/drift tube linac prototype at full duty at the SNS Beam Test Facility (BTF). Results look promising as the HVCM was capable of producing 132kV. However, the team discovered that the inductance of the output transformers was lower than designed, reducing the klystron combinations that

the new HVCM can support. In order to achieve the full design capability, the HVCM team has started redesigning the transformer secondaries.

Technical equipment installation activities started with the installation of two of the three medium voltage Loxarmor cables used for the input to the HVCM silicon-controlled rectifier power supplies.

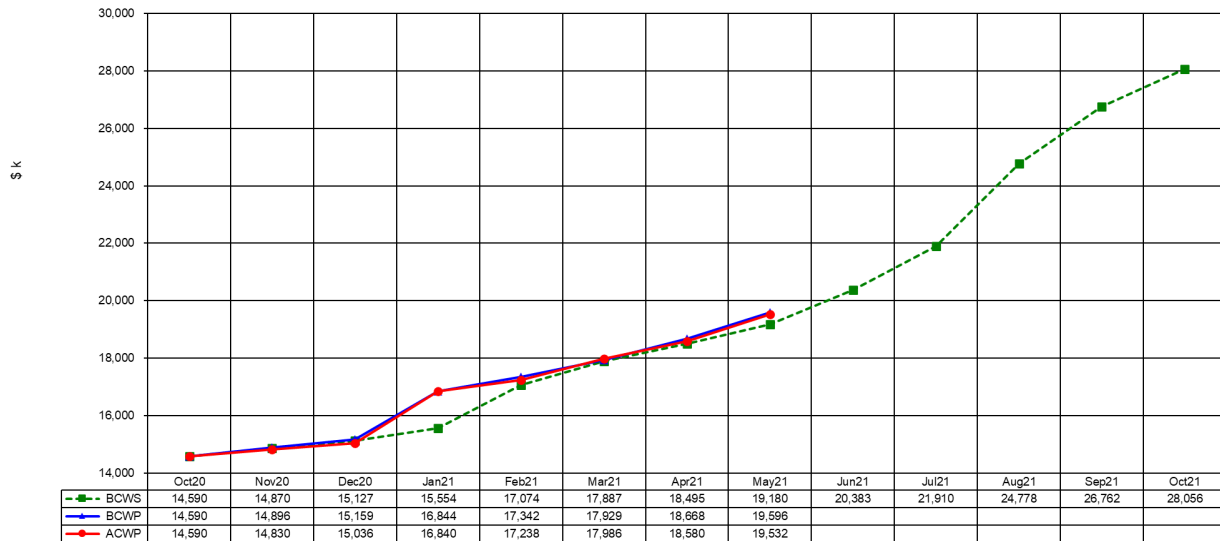
Milestone Table

P.3 RF Systems	Planned Finish	Actual Finish	Current Forecast	Owner
Award of Remaining HVCM Transformers Complete	12-Apr-21	18-Dec-20		John Moss
Receipt of 3MW Klystron Test Article	03-Aug-21		18-Aug-21*	John Moss
Fabrication of LLRF Platform Complete	15-Sep-21		01-Sep-21	John Moss

**3MW klystron schedule delays are being caused by bottle-necking at the CPI cold test facility, a dynamic fabrication load at the factory, and a leak found in the vacuum oven at the start of the klystron processing. CPI has put in parallel cold testing lines to alleviate the bottleneck and repaired the vacuum leak. The PPU RF team is actively working with CPI to recover the lost time and will be making a factory visit at the end of July during the 3MW factory acceptance testing.*

Earned Value Performance Charts

PPU
P.03 RF Systems
Cost/Schedule Performance Chart
(Cumulative Data)



As shown in the following Contract Performance Report, Radio Frequency Systems performance indices are SPI = 1.02 and CPI = 1.00.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k)	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETE				
	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE			BAC	EAC	VAC	
ITEM				SV	CV				SV	SPI	CV	CPI			
P.03 - RF Systems	685	928	952	244	(24)	19,180	19,596	19,532	416	1.02	64	1.00	43,696	44,098	(402)
P.03.01 - Management and System Integration	9	9	11	0	(2)	365	365	358	0	1.00	6	1.02	534	528	6
P.03.02 - SCL HPRF	0	8	0	8	8	4,918	4,919	4,889	1	1.00	30	1.01	13,048	13,019	29
P.03.03 - NCL HPRF	24	0	0	(24)	0	1,122	1,097	1,083	(24)	0.98	15	1.01	4,985	4,967	18
P.03.04 - LLRF	133	562	558	429	4	3,704	4,575	4,490	872	1.24	85	1.02	5,944	5,885	59
P.03.05 - Existing Linac Modulators	32	76	37	44	40	3,117	3,051	3,204	(66)	0.98	(153)	0.95	4,869	5,022	(153)
P.03.06 - New Linac Modulators	60	40	30	(20)	10	2,647	2,542	2,445	(104)	0.96	97	1.04	5,313	5,282	31
P.03.07 - Utilites	393	211	212	(183)	(1)	2,312	2,083	2,142	(228)	0.90	(58)	0.97	7,296	7,731	(435)
P.03.08 - RF Controls	13	11	25	(2)	(14)	555	552	500	(2)	1.00	52	1.10	980	928	52
P.03.09 - RF/SCL Global Controls	20	11	79	(9)	(68)	442	411	420	(31)	0.93	(9)	0.98	726	736	(10)

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

Title: P.03.04.02.03 / ORNL - Procure/Fab - LLRF System (SPI = 3.25)

Cause: This positive schedule variance is due to early receipt of all Frequency Conversion Chassis (FrCC) components (~\$220K), as well as early partial receipts of both LLRF Platform components (~\$143K) and picoammeter components (~\$55K).

Impact: No negative impact is expected due to early full and early partial shipments being received. Testing of the FrCC devices has begun in order to mitigate schedule pressure in June due to accelerator maintenance. The early receipt of LLRF platform components does not mitigate schedule pressure because we need to receive at least portions of all components to allow for testing.

Recoverable: Yes.

Corrective Action: None, this positive variance will go away as the scheduled receipt dates of these items occur. The largest part (FrCC) will be in June 2021. If a PCR is done before then, the items could be pulled forward so the positive variance will go away earlier.

P.4 Ring Systems

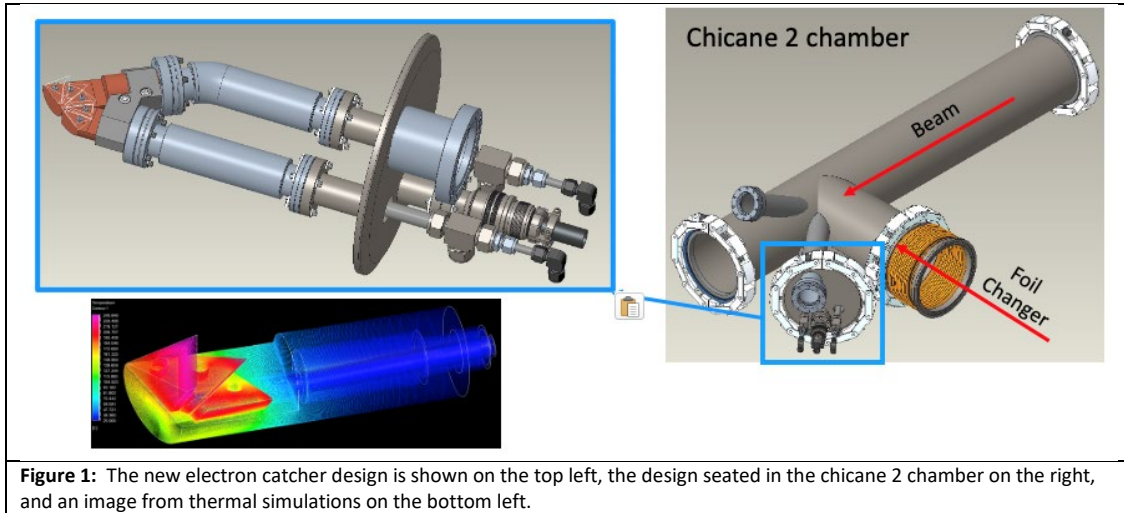
Fermilab is proceeding with procurement of materials for the injection region magnets. Magnet steel, conductor, and winding and potting tooling procurement packages are in preparation. The detailed fabrication schedule presented by Fermilab was incorporated into the PPU baseline.

Solicitations for the injection region quadrupole magnet have been sent to vendors, and the team is responding to questions. The deadline for bids has been extended to the end of June to accommodate long response times from subcontractors.

The possible design changes for the primary stripper foil mechanism were reviewed and determined to not be worth the risk of changing a device which has been working well. With the several month absence of the lead project engineer due to COVID-19, the decision was made to not pursue any design changes in the primary stripper mechanism. PPU will order a unit identical to the currently operating foil changer to be installed with the new injection region magnets.

As part of the new vacuum chamber design in the injection region, the decision was made to avoid the electron catcher cooling plate brazed to the bottom of the chamber. Fabrication of this chamber was previously difficult. The new chamber will have a large port with a vacuum feed through that will allow insertion of an electron catcher which is decoupled from the vacuum chamber. This should simplify

fabrication and the eventual replacement of the catcher. Thermal simulations of the new electron catcher design are underway. Figure 1 shows the new catcher and chamber designs. The carbon wedges of the catcher itself are not being modified from the existing design.



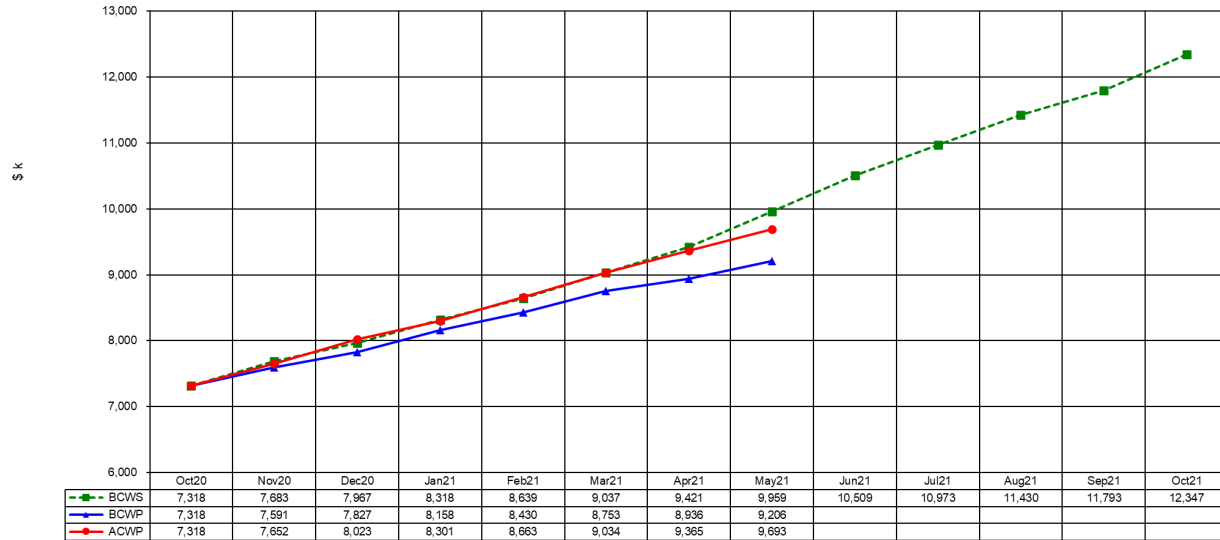
Orders were placed for long-lead digital equipment from Vadatech needed for the Beam Power Limit System (BPLS). This equipment is a core part of the design and not expected to change between now and installation. The BPLS team also held a follow-on meeting to the March preliminary design review to present the design changes that were made in response to the review committee. The committee was pleased with the simplification of the safety critical portion of the design and approved the implementation.

Milestone Table

P.4 Ring Systems	Planned Finish	Actual Finish	Current Forecast	Owner
Award Contract for Fabrication of Chicane 2/3 (and Spare), Injection Dump Septum Magnets and Spare Coil Sets	04-May-21	28-Apr-21		Nick Evans
Preliminary Design Review of Beam Power Limiting System (BPLS) Complete	04-May-21	04-Mar-21		Nick Evans
Final Design of Injection Dump Imaging System Complete	29-Jun-21	18-May-21		Nick Evans
Final Design of PPS Interface Complete	06-Sep-21		22-Jun-21	Nick Evans
Fabrication of Injection Dump Window Full Assembly for Installation Complete	30-Sep-21		24-Aug-21	Nick Evans

Earned Value Performance Charts

PPU
P.04 Ring Systems
Cost/Schedule Performance Chart
(Cumulative Data)



As shown in the following Contract Performance Report, Ring Systems performance indices are SPI = .92 and CPI = .95.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k)	CURRENT PERIOD						CUMULATIVE TO DATE						AT COMPLETE		
	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE			BAC	EAC	VAC	
ITEM				SV	CV				SV	SPI	CV	CPI			
P.04 - Ring Systems	539	271	327	(268)	(57)	9,959	9,206	9,693	(753)	0.92	(486)	0.95	20,662	22,382	(1,721)
P.04.01 - Management and System Integration	9	9	12	0	(4)	557	557	584	0	1.00	(27)	0.95	1,176	1,203	(27)
P.04.02 - Injection Region	90	38	117	(52)	(79)	3,128	3,081	3,237	(47)	0.99	(156)	0.95	7,927	9,299	(1,372)
P.04.03 - Injection Dump	120	45	18	(75)	27	983	901	903	(81)	0.92	(2)	1.00	1,421	1,436	(16)
P.04.04 - Extraction Region	7	8	6	0	1	1,251	1,245	1,289	(7)	0.99	(44)	0.97	2,217	2,261	(45)
P.04.05 - Utilities	4	3	1	(1)	3	446	445	421	(1)	1.00	24	1.06	1,767	1,743	24
P.04.06 - Ring Control Systems	306	166	171	(140)	(4)	3,512	2,896	3,182	(617)	0.82	(286)	0.91	5,883	6,174	(291)
P.04.07 - RTBT Stub	0	0	0	0	0	35	35	35	0	1.00	0	1.00	165	165	0
P.04.08 - Accelerator Physics	2	2	2	0	(0)	47	47	41	0	1.00	5	1.13	107	102	5

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

Title: P.04.06.02.02 / ORNL - Design - Beam Power Limit System (SPI = .81)

Cause: In order to address the comments and recommendations from the BPLS Preliminary Design Review the plan for the digital portion of the design was reworked, delaying planned activities.

Impact: While the design changes are understood and have been communicated to the review committee with positive feedback, the corresponding documents also need to be updated so a further delay will occur. While the re-design activity has caused a schedule delay, the new design is simplified so the meeting the original scheduled installation dates is still possible.

Recoverable: Yes.

Corrective Action: A to-go forecast will be finalized in June and a PCR will be processed in July to reflect the schedule adjustments needed to implement the new design approach and meet the installation schedule.

P.5 First Target Station (FTS) Systems

A final design review was conducted in May for target gas supply in-cell hardware. This scope is part of the Mercury Process Systems and the equipment will provide the connection to the target for the nose injector from the the service bay wall (Figure 2). The equipment is a near duplicate of what is now used for supplying gas to the 1.4 MW target bubblers. Positive responses were received on all charges and no recommendations were given.

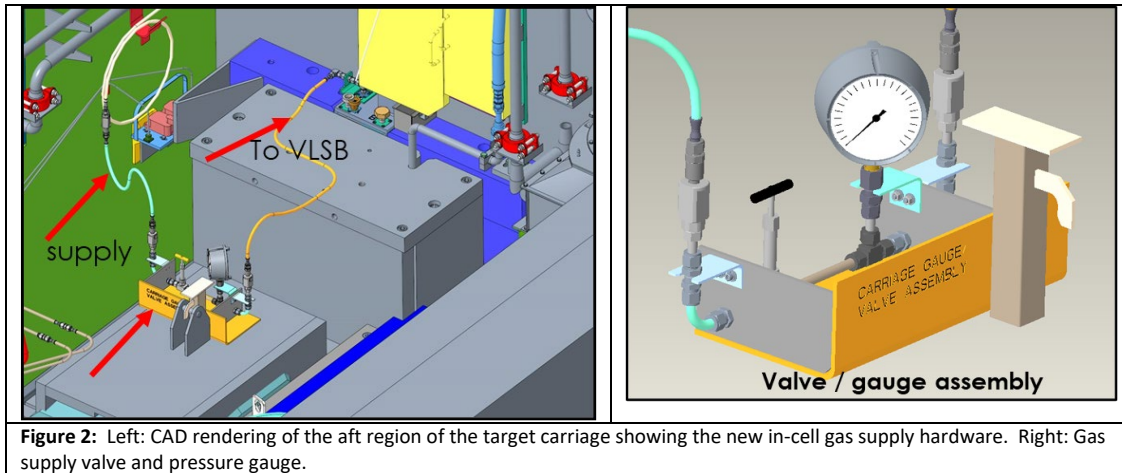


Figure 2: Left: CAD rendering of the aft region of the target carriage showing the new in-cell gas supply hardware. Right: Gas supply valve and pressure gauge.

A final design review was also conducted for Target Utilities gas panel 10 in May. This new panel in the high-bay provides once-through gas capability for the PPU target nose injector. The design is based on existing gas panel 9 (Figure 3, for the target bubblers). Once-through capability is provided as a necessary operational alternative to gas recycling. All review charges received positive responses. There is one recommendation regarding calibration of instruments which will be implemented.

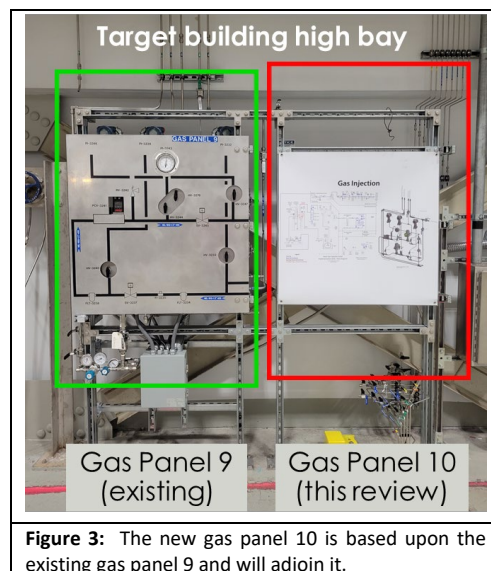
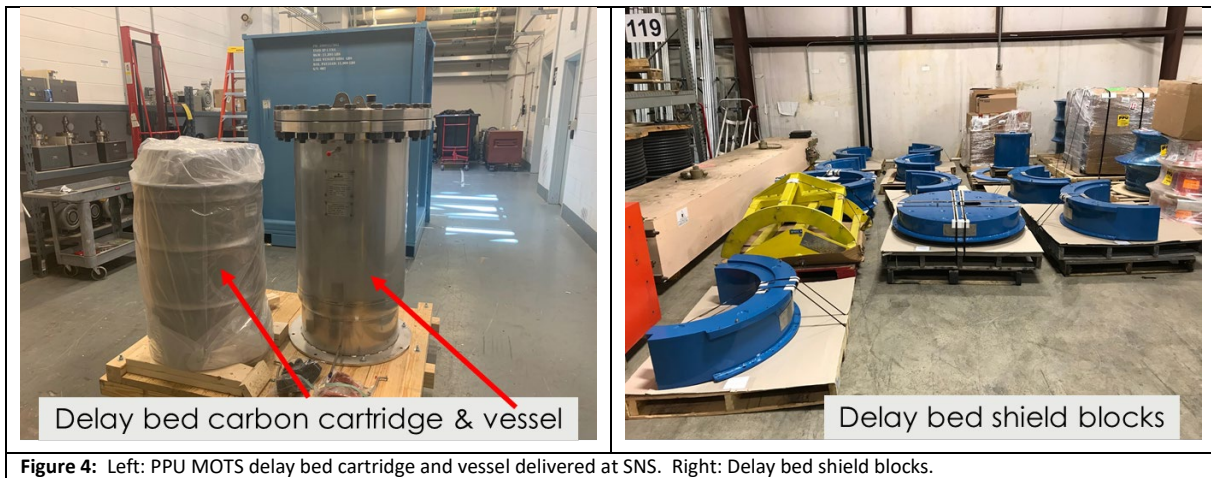


Figure 3: The new gas panel 10 is based upon the existing gas panel 9 and will adjoin it.

The Mercury Off-gas Treatment Systems (MOTS) room temperature delay bed hardware was delivered to SNS ahead of schedule and will be installed in the June outage (Figure 4). The purchase order for the MOTS cold trap was also awarded.



Weld defects in the final electron beam weld of PPU Test Target #1 (TT#1) water-cooled shroud (Figure 5) were found by ORNL inspectors. The defects were excavated, and carefully repaired with TIG welding by ORNL craft. The repair passed reinspection. All work was done at ORNL to maximize control and save time. Delivery of TT#1 is now anticipated near the end of August due to the success of the repair.



Development of the new PPU mercury vessel weld was successfully completed. The tapered geometry of the PPU target front (Figure 6, left) requires new electron beam weld process parameters for the outer window to front body joint. Results have been positive, and the vendor is ready for production target welds.

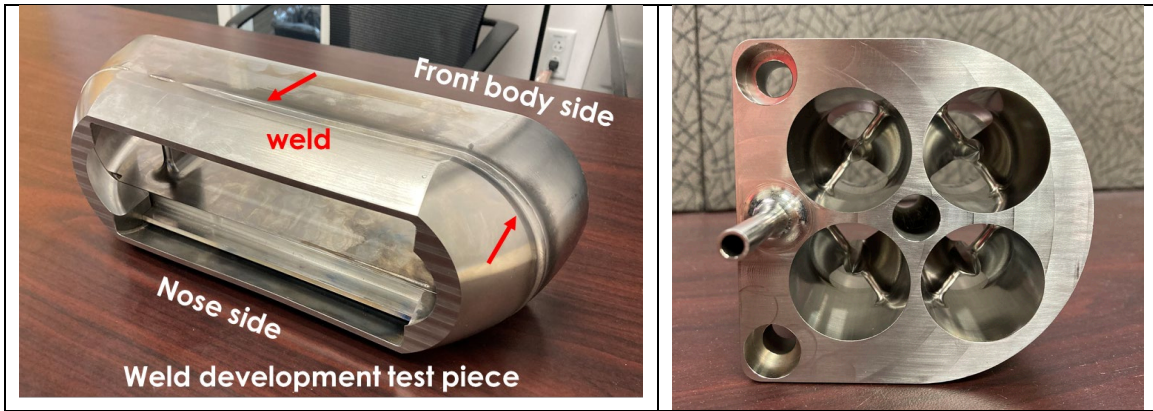


Figure 6: Left: Target water-cooled shroud (before assembly into a target module). Right: Swirl bubbler for mercury inlet (upstream side shown).

Swirl Bubbler for PPU Test Target 2 (TT#2) were received at SNS (Figure 6, right). TT#2 bubblers are identical to PPU production target bubblers. These are machined components (not 3D printed) by a local Tennessee shop. ORNL will complete welding of supply tubes and leak testing before shipping them to the target vendor.

Milestone Table

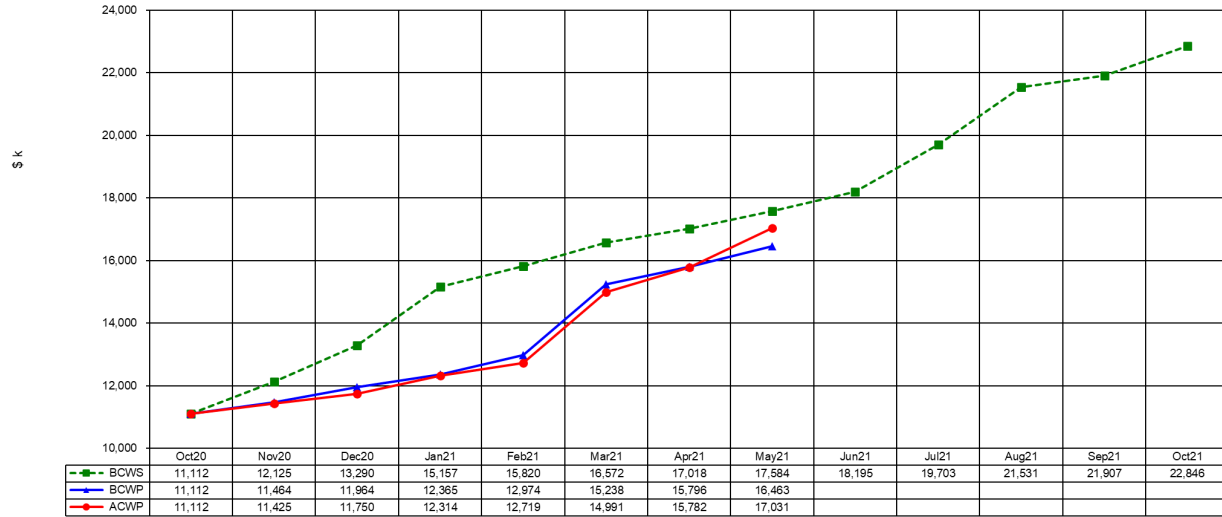
P.5 First Target Station Systems	Planned Finish	Actual Finish	Current Forecast	Owner
Award Contract for 2MW Target	29-Nov-20	30-Oct-20		Bernie Riemer
Fabrication of PPU Front Body Development Test Article Complete	01-Mar-21	26-Feb-21		Bernie Riemer
Fabrication of PPU Test Target 1 Shroud Complete	12-Jul-21		07-Sep-21*	Bernie Riemer
Award Contract for Ortho/Para Converter Vessel Assembly	18-Jul-21		19-Jul-21**	Bernie Riemer
Fabrication of Second Carbon Delay Bed Vessel and Cartridge Complete	30-Sep-21	03-May-21		Bernie Riemer

*Weld defects in the final electron beam weld of PPU Test TT#1 water-cooled shroud were found by ORNL inspectors. After repair and reinspection, delivery of TT#1 is now anticipated near the end of August or beginning of September.

**The solicitation for the Ortho/Para Converter Vessel Assembly missed being issued in May. Issues with procurement package documents were resolved; the solicitation was issued in early June. Eight companies have been approached.

Earned Value Performance Chart

PPU
P.05 First Target Station Systems
Cost/Schedule Performance Chart
(Cumulative Data)



As shown in the following Contract Performance Report, First Target Station Systems performance indices are SPI = .94 and CPI = .97.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k)	CURRENT PERIOD					CUMULATIVE TO DATE						AT COMPLETE			
	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE			BAC	EAC	VAC	
ITEM				SV	CV				SV	SPI	CV	CPI			
P.05 - First Target Station Systems	566	668	1,249	101	(581)	17,584	16,463	17,031	(1,120)	0.94	(567)	0.97	34,544	35,119	(575)
P.05.01 - Management and System Integration	36	36	30	0	6	1,083	1,083	1,084	0	1.00	(1)	1.00	2,798	2,799	(1)
P.05.02 - Neutronics	0	0	0	0	0	473	473	474	0	1.00	(1)	1.00	473	474	(1)
P.05.03 - Mercury Process Systems	49	16	78	(33)	(62)	1,828	1,720	1,953	(107)	0.94	(233)	0.88	2,496	2,729	(233)
P.05.04 - Moderator Cryogenic Systems	9	18	7	8	10	1,448	1,336	1,410	(112)	0.92	(74)	0.95	2,513	2,590	(77)
P.05.05 - Vessel and Shielding Systems	0	0	0	0	0	446	446	446	0	1.00	0	1.00	446	446	0
P.05.06 - Target Utility Systems	240	203	118	(38)	85	2,010	1,687	1,309	(323)	0.84	378	1.29	3,819	3,439	379
P.05.07 - Instrument Systems	0	0	0	0	0	40	40	40	0	1.00	0	1.00	40	40	0
P.05.08 - MOTS	79	307	260	228	46	694	803	768	109	1.16	35	1.05	2,065	2,030	35
P.05.09 - 2 MW Target	123	81	667	(41)	(585)	6,665	6,459	7,044	(205)	0.97	(584)	0.92	15,103	15,688	(586)
P.05.10 - Safety, Controls and Operations	30	7	81	(22)	(74)	1,284	825	1,050	(460)	0.64	(225)	0.79	3,180	3,410	(230)
P.05.11 - Gas Injection Development	0	0	7	0	(7)	1,613	1,591	1,453	(22)	0.99	138	1.09	1,613	1,475	138

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

Note: Although the SPI for P.05.06 – Target Utilities Systems is highlighted at a level 3 WBS, the underlying control accounts do not exceed the variance thresholds.

Variance Explanations

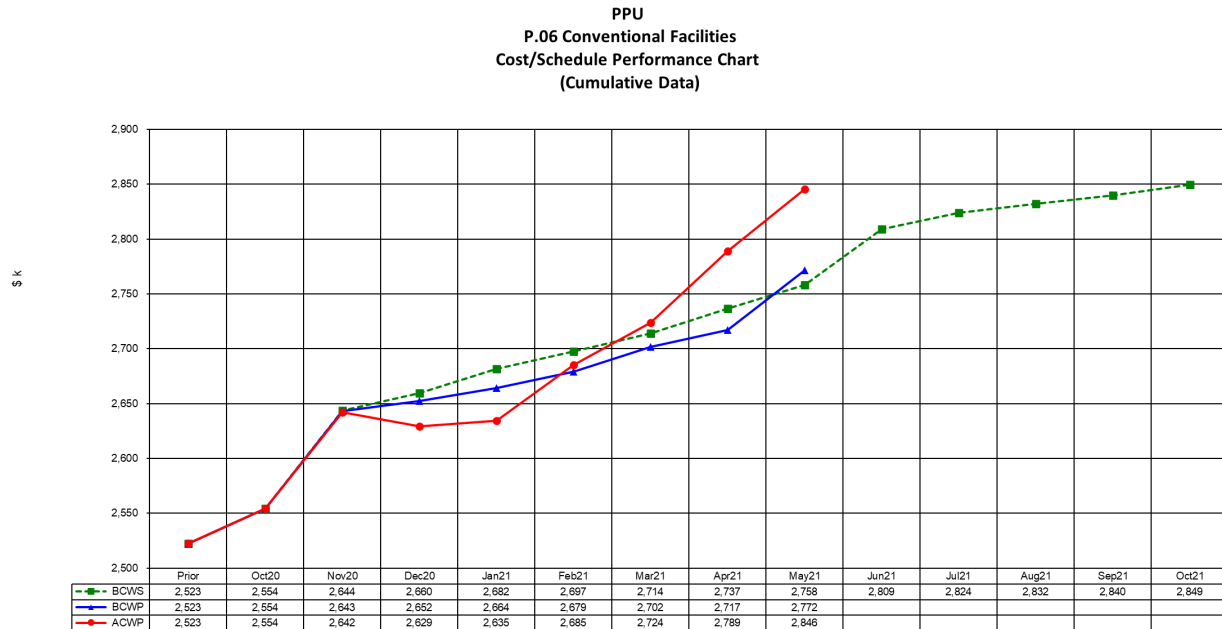
Title: P.05.06.04.02 / ORNL - Design - Upgrades for Gas Injection (CPI = 1.33)
Cause: Subcontractor and internal staff design effort continued to ramp up in May. Additional subcontractor resources are expected to help remediate the variance.
Impact: None. The variance will likely resolve itself over time.
Recoverable: Yes.
Corrective Action: None.

Title: P.05.10.03.02 / ORNL - Design - Controls Integration (SPI = .43; CPI = .59)
Cause: Target Controls design work is behind schedule due to late completion of requirements (P&ID, PCD) from other target subsystems. In particular, there is a resource shortage to provide mechanical information which needs to be resolved for parts of the Controls Design. The cost has increased due to design changes which increased the number of I/O points to be controlled.
Impact: Delays in starting design work could lead to delays in implementation and installation.
Recoverable: Partially.
Corrective Action: Additional resources (1 contract engineer and 1 contract designer) have been added to allow more Target Controls work to proceed in parallel in an effort to minimize schedule delays, but some requirements are still being developed. A PCR was processed in March to increase the budget for the additional I/O points and should reduce the cost variance over time. When more requirement information is completed, additional contract labor may be added to minimize schedule delays.

P.6 Conventional Facilities

The focus of Conventional Facilities is on klystron gallery construction, which is CD-3B scope and covered in WBS P.10.06. RTBT Stub Modifications are scheduled to begin in FY22.

Earned Value Performance Chart



As shown in the following Contract Performance Report, Conventional Facilities performance indices are SPI = 1.00 and CPI = .97.

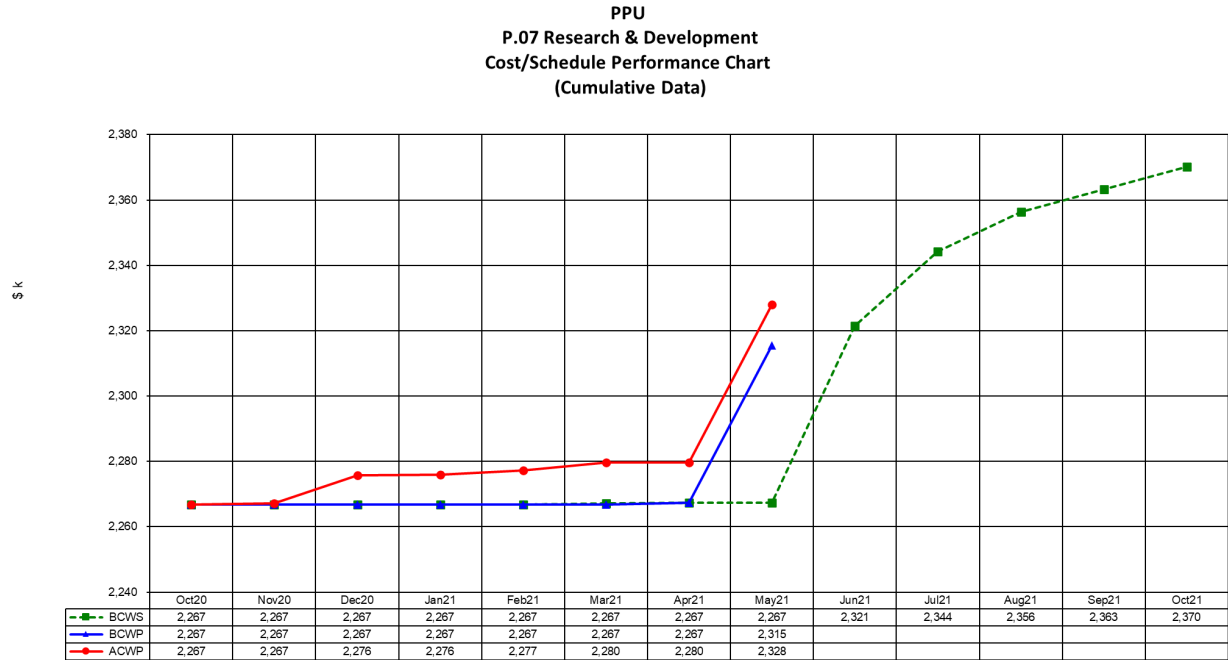
CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k) ITEM	CURRENT PERIOD						CUMULATIVE TO DATE						AT COMPLETE		
	BCWS	BCWP	ACWP	VARIANCE SV CV		BCWS	BCWP	ACWP	VARIANCE SV SPI CV CPI			BAC	EAC	VAC	
P.06 - Conventional Facilities	22	55	57	33	(2)	2,758	2,772	2,846	13	1.00	(74)	0.97	10,900	10,974	(75)
P.06.01 - Management and System Integration	6	6	3	0	3	173	173	161	0	1.00	12	1.07	309	297	12
P.06.02 - Building Modifications	16	49	54	33	(5)	2,586	2,599	2,685	13	1.01	(86)	0.97	10,591	10,677	(86)

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

P.7 R&D

Cameras for the 2D pyrometer were ordered in May and have been received.

Earned Value Performance Chart



As shown in the following Contract Performance Report, R&D performance indices are SPI = 1.02 and CPI = .99.

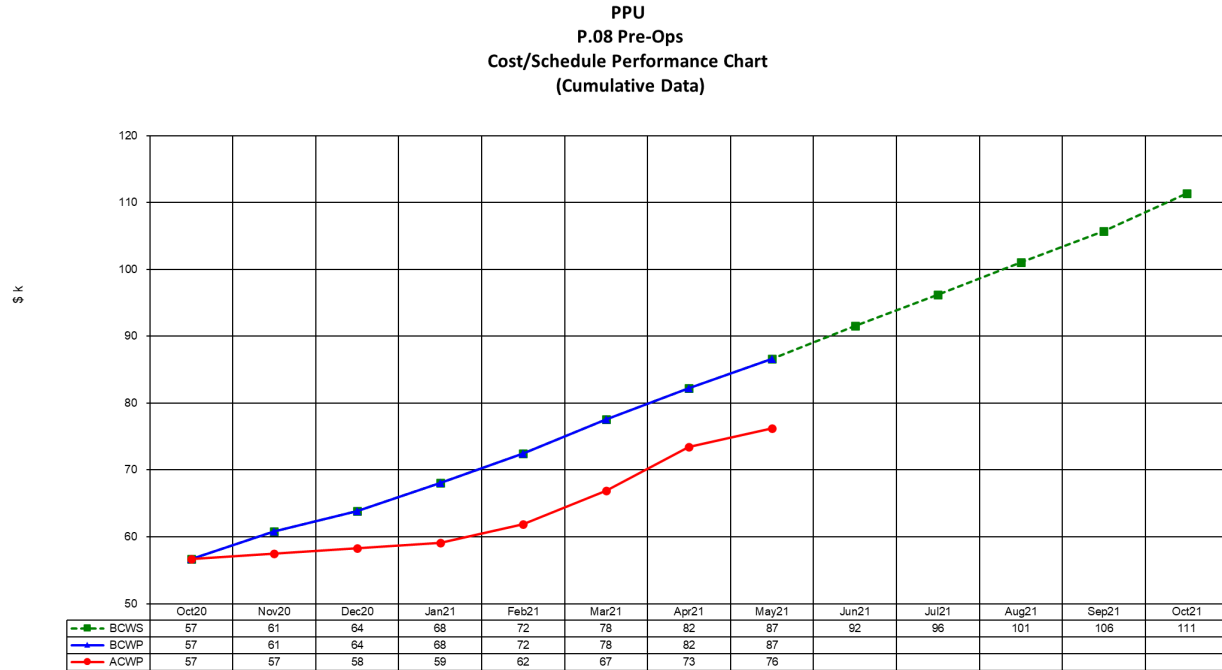
CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)																
May 2021 (\$k)	CURRENT PERIOD					CUMULATIVE TO DATE							AT COMPLETE			
	ITEM	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE				BAC	EAC	VAC
					SV	CV				SV	SPI	CV	CPI			
P.07 - R&D	0	48	48	48	(0)	2,267	2,315	2,328	48	1.02	(13)	0.99	2,476	2,488	(12)	
P.07.01 - Gas Injection Development	0	0	0	0	0	1,992	1,992	1,992	0	1.00	0	1.00	1,992	1,992	0	
P.07.02 - Foil Development	0	48	48	48	(0)	276	324	336	48	1.17	(13)	0.96	484	497	(12)	

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

P.8 Pre-Ops

The Pre-Ops team finalized and published the 5-year plan which aligns the PPU outages with the SNS operations and maintenance plan.

Earned Value Performance Chart



As shown in the following Contract Performance Report, Pre-Ops performance indices are SPI = 1.00 and CPI = 1.14.

CONTRACT PERFORMANCE REPORT FORMAT 1 - WORK BREAKDOWN STRUCTURE PERFORMANCE DATA (Control Account)															
May 2021 (\$k) ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETE				
	BCWS	BCWP	ACWP	VARIANCE SV CV		BCWS	BCWP	ACWP	VARIANCE SV SPI CV CPI			BAC	EAC	VAC	
P.08 - Pre-Ops	4	4	3	0	2	87	87	76	0	1.00	10	1.14	1,137	1,127	10
P.08.01 - Commissioning	0	0	0	0	0	0	0	0	0		0		933	934	(0)
P.08.03 - Regulatory Compliance	4	4	3	0	2	87	87	76	0	1.00	10	1.14	204	193	10

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

P.10 Long Lead Procurements (LLP)

P.10.2 SCL Systems

- The partner lab has awarded 91 contracts for CD-3B scope. Deliveries have been completed for 84 of the awarded contracts.
- Supply end can #1 was returned to the vendor for rework. Supply end cans #2 and #3 have arrived at JLab. Supply end cans #4, #5, and #6 are in final testing. Supply end can #7 is being welded.
- Return end can #1 is in leak checking but hindered due to a high helium background.
- Vacuum vessel #1 has been received at JLab. Vacuum vessel #2 is due to ship in June. Vacuum vessel #3 has been through final welding and will enter final post weld machining. Vacuum vessel #4 is awaiting final welding. Vacuum vessel #5 is in the first stage of welding. See Figure 7.

P.10.3 RF Systems

- The High-Power RF (HPRF) team completed the site acceptance testing for the first SCL klystron. The new tube produced the PPU required 660kW at 805MHz at full duty factor without any anomalies. The second SCL klystron is onsite with four more units expected in early summer.
- The HPRF team also spent time monitoring the progress on the repair of the first article circulator at Microwave Techniques. The circulator is expected to ship in June.
- Transmitter fabrication activities continued at L3-Harris with significant progress made on the control consoles and the transmitter cooling carts (TRCC). Work on the klystron high voltage tank is expected to start this summer. Overall, the transmitter contract is 70 percent complete as measured by the number of finished activities.
- Alternate-topology high-voltage converter modulators (AT-HVCM) fabrication activities continued at Alpha-Omega, with switch plate fabrication and testing imminent.

P.10.6 Conventional Facilities

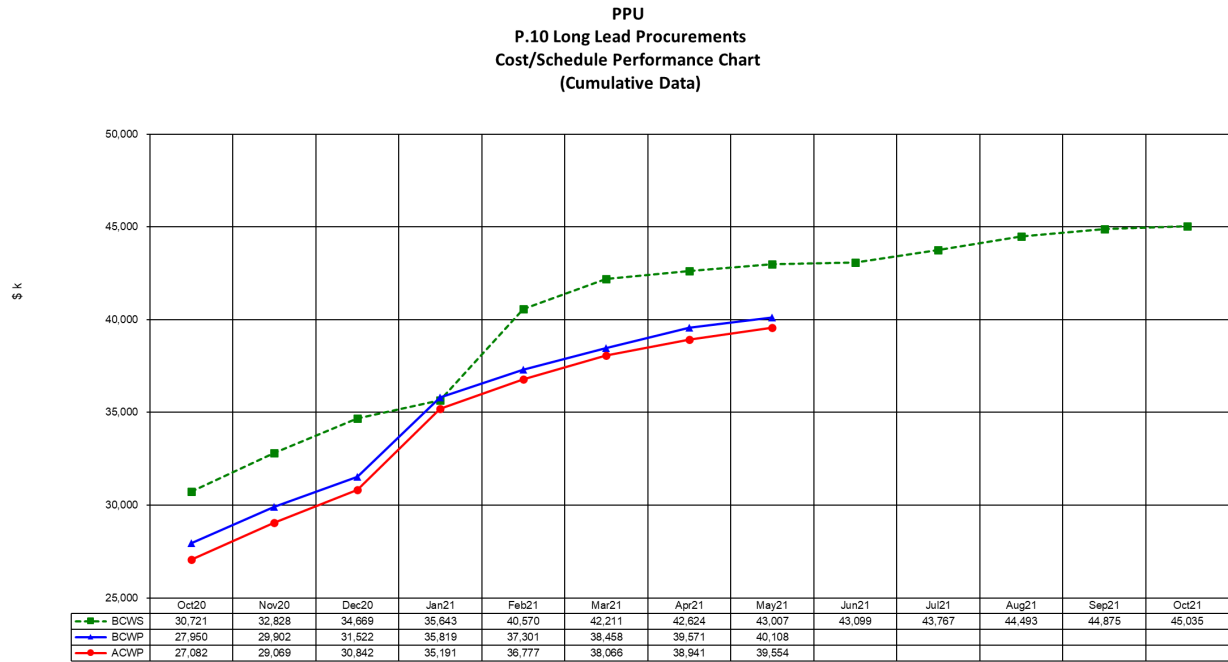
- The deionized water and heating, ventilation, and air-conditioning (HVAC) controls installation is complete and start-up is scheduled for the week of June 1st.
- Final site work is complete including asphalt paving and site restoration to pre-construction conditions.
- The sump pump start-up has been delayed. The material is on order and to be completed by June 4th.
- A test and balance for the HVAC is scheduled for June 3rd- 4th.
- Punch list resolution by subcontractors is ongoing.
- As-builts, operation and maintenance manuals, and warranty submittals are in progress.
- Multiple change orders remain open and are awaiting pricing from the subcontractor.
- The contract has been extended to June 30th to allow for contract closure.
- The technical installation subcontractor has mobilized and taken control of the Klystron Gallery area.



Milestone Table

P.10 LLPs	Planned Finish	Actual Finish	Current Forecast	Owner
Receipt of Last Five Production Cavities at JLab	13-May-21	25-Feb-21		Matt Howell
CF Construction of Klystron Gallery Complete	13-May-21	06-Apr-21		Mark Connell

Earned Value Performance Chart



As shown in the following Contract Performance Report, Long Lead Procurements performance indices are SPI = .93 and CPI = 1.01.

CONTRACT PERFORMANCE REPORT															
FORMAT 1 - WORK BREAKDOWN STRUCTURE															
PERFORMANCE DATA (Control Account)															
May 2021	CURRENT PERIOD						CUMULATIVE TO DATE						AT COMPLETE		
	(\$K)	BCWS	BCWP	ACWP	VARIANCE		BCWS	BCWP	ACWP	VARIANCE				BAC	EAC
ITEM	SV				CV	SV				SPI	CV	CPI			
	382	536	613	154	(76)	43,007	40,108	39,554	(2,899)	0.93	554	1.01	49,785	49,346	438
P.10 - Long Lead Procurements															
P.10.02 - SCL Systems	22	50	302	28	(252)	19,737	18,294	17,981	(1,443)	0.93	314	1.02	19,848	19,535	313
P.10.03 - RF Systems	312	169	224	(143)	(55)	15,175	13,827	13,372	(1,347)	0.91	455	1.03	21,748	21,293	454
P.10.06 - Conventional Facilities	49	317	87	269	231	8,095	7,986	8,201	(109)	0.99	(215)	0.97	8,189	8,518	(329)

Cumulative Thresholds: * Red: CPI/SPI <0.85 or >=1.20 AND >\$100k * Yellow: CPI/SPI between 0.85-0.90 or 1.15-1.20 AND >\$100k

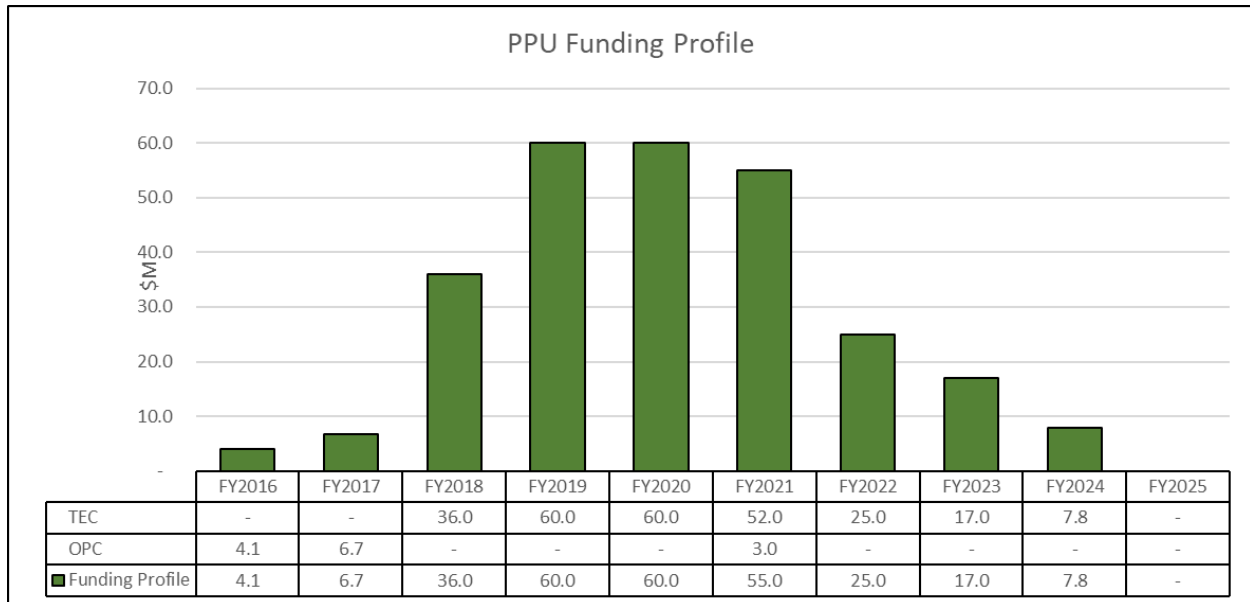
Appendices

PPU – Cost Report (thru May 2021)

WBS Description	Prior Costs	May Costs	Total Costs to Date	Commits (with OH)	Costs plus Commits
P Proton Power Upgrade	111,225,343	3,965,061	115,190,404	35,805,317	150,995,720
P.1 Project Management	8,052,561	384,880	8,437,441	808,152	9,245,594
P.2 Super-Conducting Linac Systems	8,113,124	331,075	8,444,199	9,181,309	17,625,508
P.02.01 Management & Systems Integration	818,882	20,010	838,892		838,892
P.02.02 Cavities	1,251,850	43,103	1,294,953	659,586	1,954,539
P.02.03 Cryomodule Integration (JLab Scope)	4,727,138	206,364	4,933,502	8,521,724	13,455,225
P.02.04 Cryogenics	34,619	-	34,619		34,619
P.02.05 Utility Systems	83,528	1,263	84,791		84,791
P.02.06 System Integration	302,942	34,553	337,495		337,495
P.02.07 SCL Controls	894,164	25,782	919,946		919,946
P.3 RF Systems	18,579,531	952,369	19,531,900	10,069,607	29,601,507
P.03.01 Management and System Integration	347,429	10,932	358,361		358,361
P.03.02 SCL HPRF	4,889,151	-	4,889,151	5,545,326	10,434,477
P.03.03 NCL HPRF	1,082,800	-	1,082,800	625,219	1,708,020
P.03.04 LLRF	3,932,082	558,100	4,490,182	626,645	5,116,827
P.03.05 Existing Linac Modulators	3,167,080	36,645	3,203,725	70	3,203,795
P.03.06 New Linac Modulators	2,415,407	30,027	2,445,434	1,692,382	4,137,816
P.03.07 Utilities	1,929,832	211,818	2,141,650	1,469,465	3,611,115
P.03.08 RF Controls	474,716	25,470	500,187	49,812	549,999
P.03.09 Global Controls	341,032	79,377	420,409	60,689	481,098
P.4 Ring Systems	9,365,265	327,449	9,692,714	2,624,063	12,316,776
P.04.01 Management and System Integration	571,226	12,453	583,679		583,679
P.04.02 Injection region	3,120,423	116,592	3,237,015	2,226,109	5,463,124
P.04.03 Injection Dump	884,488	18,429	902,917	217,206	1,120,124
P.04.04 Extraction region	1,282,862	6,498	1,289,361	19,584	1,308,945
P.04.05 Utilities	420,545	561	421,106	21,545	442,651
P.04.06 Ring Control Systems	3,011,190	170,569	3,181,760	139,619	3,321,379
P.04.07 RTBT Stub	35,481	-	35,481		35,481
P.04.08 Accelerator Physics	39,049	2,346	41,395		41,395
P.5 First Target Station Systems	15,782,111	1,248,754	17,030,865	6,907,014	23,937,879
P.05.01 Management and System Integration	1,053,726	30,118	1,083,844		1,083,844
P.05.02 Neutronics	482,984	-	482,984		482,984
P.05.03 Mercury Process Systems	1,933,211	78,002	2,011,213	10,125	2,021,338
P.05.04 Moderator Cryogenic Systems	1,403,263	7,232	1,410,495	7,310	1,417,806
P.05.05 Vessel and Shielding Systems	436,756	-	436,756		436,756
P.05.06 Target Utility Systems	1,190,519	118,074	1,308,593	341,534	1,650,127
P.05.07 Instrument Systems	40,315	-	40,315		40,315
P.05.08 MOTS	508,057	260,240	768,298	296,725	1,065,023
P.05.09 2 MW Target	6,318,759	666,558	6,985,317	6,241,691	13,227,007
P.05.10 Safety, Controls and Operations	968,805	81,153	1,049,958	77	1,050,035
P.05.11 Gas Injection Development	1,445,714	7,378	1,453,092	9,552	1,462,644
P.6 Conventional Facilities	2,788,770	56,933	2,845,704	44,617	2,890,321
P.06.01 Management and System Integration	157,648	3,275	160,923	419	161,342
P.06.02 Building Modifications	2,631,123	53,658	2,684,781	44,198	2,728,979
P.7 R&D (OPC)	2,279,762	48,255	2,328,017	1,070	2,329,087
P.07.01 Gas Injection Development	1,991,752	-	1,991,752		1,991,752

WBS Description	Prior Costs	May Costs	Total Costs to Date	Commits (with OH)	Costs plus Commits
P.07.02 Foil Development	288,011	48,255	336,265	1,070	337,335
P.8 Pre-Ops (OPC)	73,429	2,774	76,203	-	76,203
P.08.03 Commissioning	73,429	2,774	76,203	-	76,203
P.9 Pre-CD1 Activities (OPC)	7,249,768	-	7,249,768	-	7,249,768
P.09.01 Pre-CD-1 Activities	7,249,768	-	7,249,768	-	7,249,768
P.10 Long Lead Procurements	38,941,021	612,572	39,553,592	6,169,484	45,723,076
P.10.02 SCL Systems	17,678,113	302,395	17,980,508	1,931,549	19,912,057
P.10.03 RF Systems	13,148,397	223,539	13,371,937	4,153,770	17,525,706
P.10.06 CF Systems	8,114,510	86,638	8,201,148	84,165	8,285,313

PPU – Funding Profile



Note: This profile includes FY2021 actual funding, which is \$10M higher than documented in the Project Execution Plan. The outyears have been reduced accordingly to maintain a total project cost of \$271.6M.

PPU – Critical Decision Schedule

Level 1 Milestones	Schedule
CD-0, Approve Mission Need	Jan 2009 (A)
CD-1, Approve Alternative Selection and Cost Range	Apr 2018 (A)
CD-3A, Approve Long Lead Procurement	Oct 2018 (A)
CD-3B, Approve Long Lead Procurement	Sep 2019 (A)
CD-2, Approve Performance Baseline and Long Lead Procurement	Oct 2021 (A)
CD-3, Approve Start of Construction	Oct 2021 (A)
CD-4, Approve Project Completion (Level 0 Milestone)	Q4 FY2028