High Magnetic Field X-Ray Facility

A partnership between **CHESS**, the **MagLab**, and the **University of Puerto Rico**

Project Year 1 — **DMR - 1946998/Brock**

HMF technical crew test fitting a new accelerator dipole vacuum chamber.

Photo: Leila Aboharb

NSF HMF High Magnetic Field Facility | National MAGLAB | Cornell University

520.1 Project Office: HMF Beamline Construction

Project Director (PI):	J. Brock
Deputy PD (Co-PI), X-ray Science:	TBD
Deputy PD (Co-PI), Magnet Science:	E. Palm
Deputy PD (Co-PI), Education:	J. L. Colón
Project Scientists:	J. Ruff, L. Debefve, B. Ramshaw
Project Finance, Administration:	K. Jacoby, J. Roncek, C. Rice
Safety Director, Safety Manager:	J. Shanks, R. Lochner
Project Manager, Safety Review Man.:	E. Fontes, E. Bodnaruk
Facility Engineer:	R. Gallagher
Mechanical Eng/Fab Manager:	T. O'Connell

- **520.1.4 Student Training (UPR sub-award)** — L2: J. L. Colón
- **520.1.5 Magnet Systems Advising (FSU sub-award)** — L2: E. Palm

- **520.2 CESR, Tunnel Mods** — L2 Manager: J. Codner
  - 520.2.4 Insertion Devices — L3M: A. B. Temnykh, A. Lyndaker
  - 520.2.5 Vacuum/Beampipes — L3M: Y. Li
  - 520.2.6 Shielding/Layout — L3M: D. Spurgin
  - 520.2.7 Instrumentation/Controls — L3M: J. Barley, M. Forster
  - 520.2.8 CESR Mechanical Systems — L3M: L. Aboharb
  - 520.2.9 CESR Utilities/Electrical — L3M: K. Miller
  - 520.2.10 CESR Tunnel Cryogenics — L3M: D. Sabol
- **520.3 HMF Beamline** — L2 Manager: C. Conolly
  - 520.3.4 Front End, Apertures — L3M: A. Lyndaker
  - 520.3.5 Enclosures/Shielding — L3M: D. Richter
  - 520.3.6 Instrumentation/Controls — L3M: E. Edwards
  - 520.3.7 X-ray Heat-loaded Optics — L3M: A. Pauling
  - 520.3.8 HMF Mechanical Systems — L3M: L. Aboharb
  - 520.3.9 HMF Utilities/Electrical — L3M: K. Miller
  - 520.3.10 HMF Beamline Cryogenics — L3M: D. Sabol
- **520.4 Experimental Equipment** — L2 Manager: J. Ruff
  - 520.4.3 Science Method Tests — L3M: L. Debefve
  - 520.4.4 Magnet/Cryogenics — L3M: M. Bird
  - 520.4.5 Diffractometer — L3M: A. Pauling
  - 520.4.6 Custom X-ray Optics — L3M: Lyndaker
  - 520.4.7 Detectors/Sensors — L3M: J. Ruff
  - 520.4.8 Computing/Controls — L3M: W. Sun
  - 520.4.9 Commissioning — L3M: J. Ruff

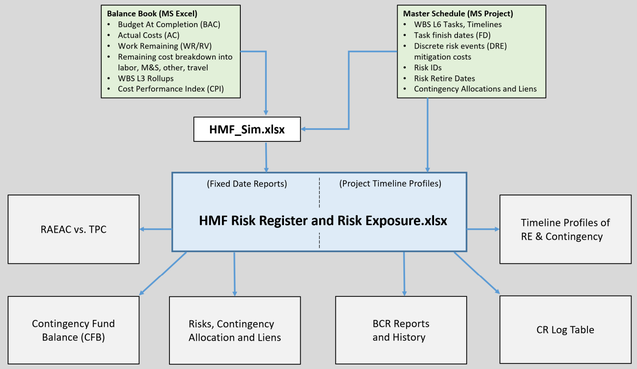
The HMF PEP as a structured document, built on a platform of MS Project/Excel/Word*,**

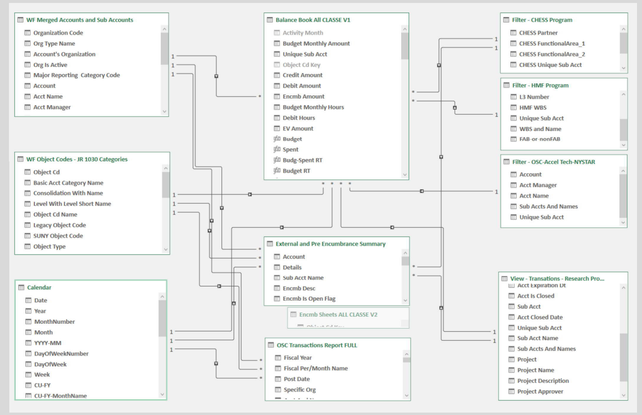
Ernie Fontes, Joel Brock

Cornell University
Cornell High Energy Synchrotron Source

*with also KFS Oracle Database and home-built Timesheet hour log

**Note: figures captions intentionally left off as a test for PMs and NSF POs





Project Execution Plan for the HMF Beamline Construction Project

TABLE OF CONTENTS

1 INTRODUCTION 11
1.1 Scientific Objectives 11
1.2 Scientific Requirements and Integration into Existing Facility/Infrastructure 12
1.3 Transition to Operations Planning (replaces Divestment Plan) 14
2 ORGANIZATION 15
2.1 Internal Governance & Organization and Communication 15
2.2 External Organization, Partnerships and Communication 16
2.3 Roles and Responsibilities 17
3 CONSTRUCTION PROJECT DEFINITION 21
3.1 Summary of Total Project Definition 21
3.2 Work Breakdown Structure (WBS) 26
3.3 WBS Dictionary 26
3.4 Scope Management Plan and Scope Contingency 31
3.5 Baseline Budget and Budget Contingency 36
3.6 Funding Profile 41
3.7 Schedule Baseline 42
3.8 Schedule Contingency 43
4 RISK AND OPPORTUNITY MANAGEMENT 46
4.1 Risk Management: Overview, Changes in this revision 46
4.2 Risk Management Process 46
4.3 Risk Register 56
4.4 Contingency Management Plan 66
5 CONFIGURATION CONTROL 78
5.1 Configuration Control Plan 78
5.2 Change Control Plan 79
5.3 Document Control Plan 80
6 ACQUISITIONS 81
6.1 Acquisition Plans 81
6.2 Acquisition Approval Process 81
7 PROJECT MANAGEMENT CONTROLS 82
7.1 Performance Measurement and Project Management Process 82
7.2 Earned Value Management System (EVMS) 85
7.3 Financial and Business Controls 87
8 CYBER-INFRASTRUCTURE 88
8.1 Cybersecurity Plan 88
8.2 Code Development Plan 88
8.3 Data Management Plan 88
9 INTEGRATION AND COMMISSIONING 89
9.1 Integration and Commissioning Plan 89
9.2 Acceptance / Operational Readiness Plan 95

APPENDICES

A PEP Appendix A - Revision 6 - Master Schedule GANTT ..... eJacket
B PEP Appendix B - Revision 3 - Cost Book Sheets ..... eJacket
C PEP Appendix C - Revision 1 - Vendor Quotes ..... eJacket
D PEP Appendix D - BoE Full Documentation ..... eJacket
E PEP Appendix E - Revision 1 - Risk Register and Analysis ..... eJacket
F Glossary of Terms ..... (attached)
G Example of Change Request form: CR-008 ..... (attached)
H Example of HMF Monthly Report ..... (attached)
I Example of HMF Risk Analysis Report ..... (attached)
J HMF BABA Compliance Plan – June 2022 ..... (attached)

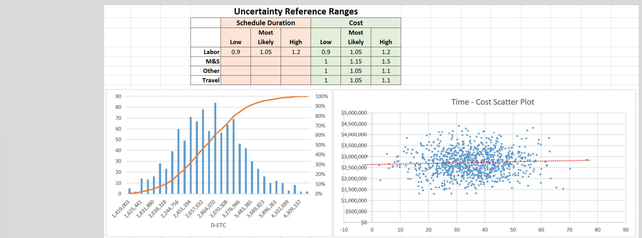
List of Figures

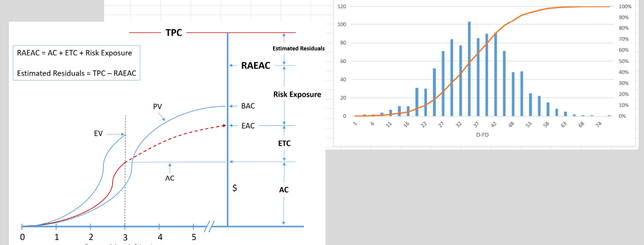
An easy one

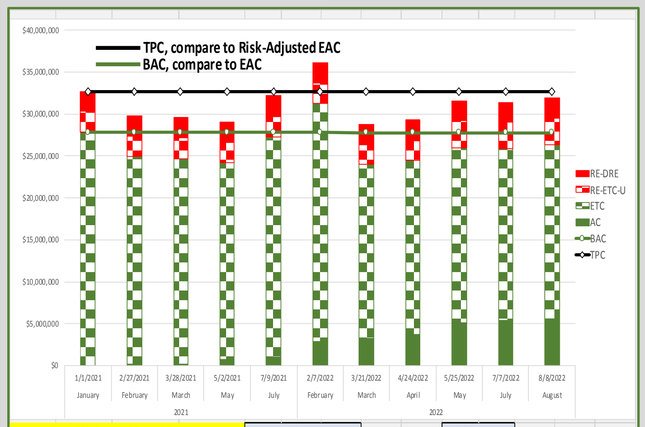
Figure 1: Organization and Work Breakdown Structure (OBS and WBS) 15
Figure 2: Schedule of Major Project Phases (GANTT) 23
Figure 3: HMF Project L1/L2 Milestones and schedule contingency (GANTT) 24
Figure 4: External constraints to the HMF project schedule (GANTT) 25
Figure 5: Change Request Log table which also tracks Schedule Contingency 45
Figure 6: Overview of risk management process from figure 6.2.4-1 in RIG (NSF 21-107) 46
Figure 7: Excerpt from Safety Review document showing risk and hazard identification and controls 47
Figure 8: Schedule contingency "heads-up" display for L1 Milestones 52
Figure 9: EV and Risk-Adjusted Estimate At Completion (RAEAC) 53
Figure 10: RAEAC vs. TPC Report History 54
Figure 11: Monte Carlo simulation results for HMF cost-schedule model 55
Figure 12: Risk Register summary of risk exposure and contingency mitigations items tracked 68
Figure 13: Contingency View table from the Master Schedule 70
Figure 14: BAC History table, tracking differences across multiple Change Request actions 71
Figure 15: Risk Exposure profiling, including a time-phase plot of actual allocations and expected liens 72
Figure 16: Contingency Liens List example 73
Figure 17: Technical Design Document (TDD) draft table of contents 78
Figure 18: Project Control System for HMF Beamline Construction 83
Figure 19: Data sources and data flow for Risk Exposure tracking and modeling 84
Figure 20: Example Earned-Value plots included in monthly reports 86
Figure 21: Control Account Structure for HMF Project 87
Figure 22: Example of CESR accelerator Integration Acceptance Testing 91
Figure 23: Example of X-ray Station Integration Acceptance Testing 92
Figure 24: Example of X-ray Beamline Integration and Commission Procedure 93
Figure 25: Example of Operational Readiness Certification 94

List of Tables

Table 1: Science Requirements (SRs) of the HMF project 12
Table 2: Key Performance Parameters (KPPs) of the HMF project 13
Table 3: Total Project Scope Definition 21
Table 4: Total Project Costs at time of award 21
Table 5: Construction Project Schedule Narrative 22
Table 6: De-scope Options 33
Table 7: Example of evaluating cost impacts of de-scoping option SR4 34
Table 8: Examples of up-scoping opportunities 35
Table 9: Total Project Costs – Construction and Contingency - defined at award 36
Table 10: Contingency Budget and three types of Risk Exposure defined at award 36
Table 11: HMF Cost Estimating Methodology 38
Table 12: Non-routine Risk Exposure defined at award 39
Table 13: Routine Risk Exposure defined at time of award 40
Table 14: Probability and Contingency Rate table for Routine Risks 40
Table 15: Contingency held for ICE Cost Variances, defined at time of award 41
Table 16: Funding Profile for HMF Project at award 41
Table 17: Description of the five largest external project constraints 43
Table 18: Risk management processes for routine risks and uncertainties 48
Table 19: Risk management processes for non-routine risks and discrete risk events 49
Table 20: Risk Exposure quantities and how they are modeled in HMF_Sim 50
Table 21: Components of the HMF cost-schedule model 51
Table 22: Contingency Management Plan elements 66
Table 23: Custom fields added to Master Schedule for risk and contingency tracking 67
Table 24: Science Requirement scope option dependencies on major equipment packages 69
Table 25: Documentation and Reporting of Contingency Use 74
Table 26: TPC, BAC, and CFB quantities tracked and reported on Change Request forms 77
Table 27: Change Control Matrix 80
Table 28: Integration Tasks and WBS Categories 89

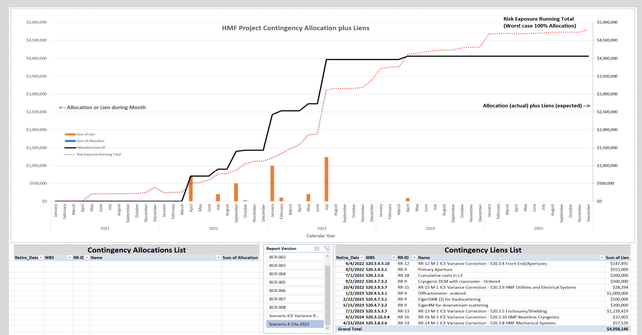


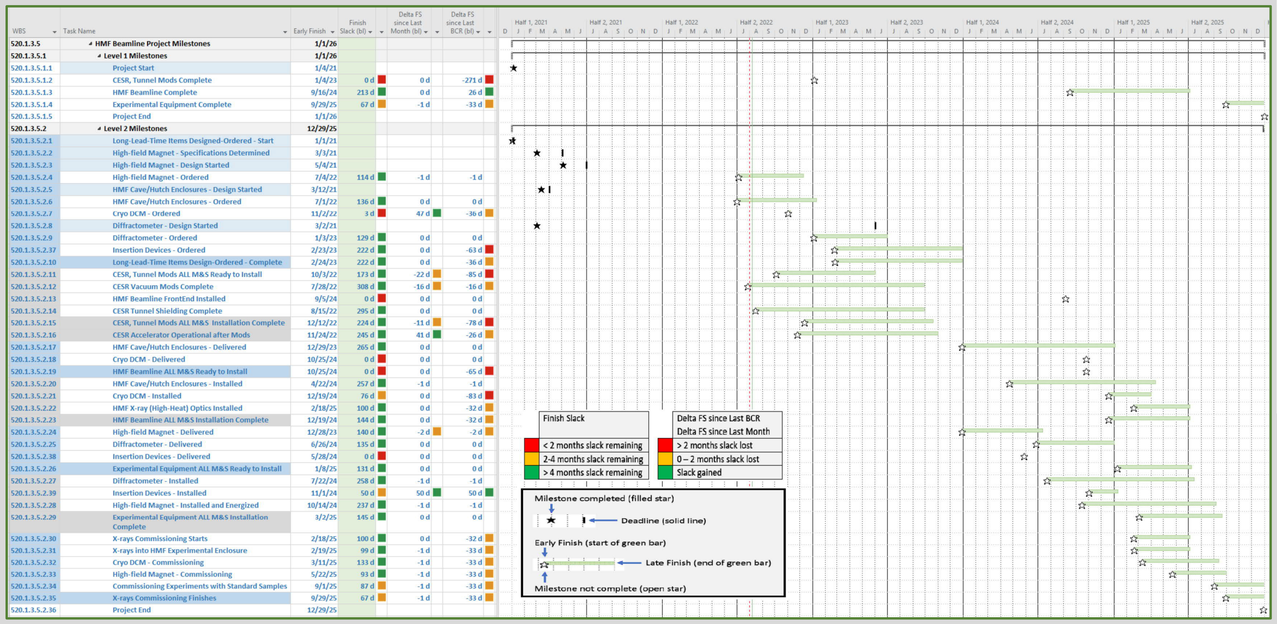




Report History and Report Calendar

Year	Month	DateColumn	Report Version	EAC	ETC	EAC	BAC	VAC	Risk Exposure RE-ETC-U	RE-DRE	TPC	RAEAC	Residuals
2021	January	1/1/2021	BCR-000	$0	$27,801,207	$27,801,207	$27,801,207	($0)	$2,412,693	$2,450,699	$32,664,899	$32,664,899	$0
		1/18/2021	BCR-001	$87,066	$24,740,620	$24,827,666	$27,830,623	$3,002,957	$2,414,047	$2,450,699	$32,694,899	$29,692,412	$3,002,487
	February	2/22/2021	BCR-002	$169,104	$24,740,620	$24,909,724	$27,829,984	$2,920,260	$2,413,897	$2,450,699	$32,694,899	$29,774,320	$2,920,579
		2/27/2021	BCR-003	$169,104	$24,740,620	$24,909,724	$27,830,794	$2,921,070	$2,413,978	$2,450,699	$32,694,899	$29,774,401	$2,920,498
	March	3/28/2021	BCR-004	$262,908	$24,438,385	$24,701,293	$27,830,652	$3,129,359	$2,413,964	$2,450,699	$32,694,899	$29,565,957	$3,128,942
	May	5/2/2021	BCR-005	$757,746	$23,432,435	$24,190,180	$27,830,646	$3,640,466	$2,413,964	$2,450,699	$32,694,899	$29,054,843	$3,640,056
	July	7/9/2021	BCR-006	$1,033,391	$26,229,609	$27,263,000	$27,830,647	$567,646	$2,412,994	$2,450,699	$32,694,899	$32,126,693	$568,206
2022	February	2/7/2022	BCR-007	$2,933,299	$28,367,169	$31,300,467	$27,830,647	($3,469,820)	$2,352,658	$2,450,699	$32,694,899	$36,103,824	($3,408,925)
	March	3/21/2022	BCR-008	$3,254,605	$20,715,348	$23,969,953	$27,790,800	$3,820,847	$2,347,618	$2,450,699	$32,694,899	$28,768,270	$3,926,629
	April	4/24/2022	Scenario 4-23a-2022	$3,668,832	$20,806,255	$24,475,087	$27,790,800	$3,315,713	$2,347,618	$2,450,699	$32,694,899	$29,273,406	$3,421,495
	May	5/25/2022	Scenario 5-25-2022	$5,070,635	$20,839,582	$25,910,217	$27,790,800	$1,880,583	$3,275,000	$2,318,000	$32,694,899	$31,503,217	$1,191,682
	July	7/7/2022	Scenario 7/7/2022	$5,336,740	$20,455,940	$25,812,680	$27,790,800	$1,978,120	$3,250,000	$2,305,000	$32,694,899	$31,367,680	$1,327,219
	August	8/8/2022	Scenario 8/8/2022	$5,595,303	$20,684,949	$26,280,252	$27,790,800	$1,510,548	$3,210,000	$2,403,000	$32,694,899	$31,893,252	$801,647





WBS	Task Name	Early Finish	Finish Slack (bl)	Delta FS since Last Month (bl)	Delta FS since Last BCR (bl)
520.1.3.5	HMF Beamline Project Milestones	1/1/26			
520.1.3.5.1	Level 1 Milestones	1/1/26			
520.1.3.5.1.1	Project Start	1/4/21			
520.1.3.5.1.2	CESR, Tunnel Mods Complete	1/4/23	0 d	0 d	-271 d
520.1.3.5.1.3	HMF Beamline Complete	9/16/24	213 d	0 d	26 d
520.1.3.5.1.4	Experimental Equipment Complete	9/29/25	67 d	-1 d	-33 d
520.1.3.5.1.5	Project End	1/1/26			
520.1.3.5.2	Level 2 Milestones	12/29/25			
520.1.3.5.2.1	Long-Lead-Time Items Designed-Ordered - Start	1/1/21			
520.1.3.5.2.2	High-field Magnet - Specifications Determined	3/3/21			
520.1.3.5.2.3	High-field Magnet - Design Started	5/4/21			
520.1.3.5.2.4	High-field Magnet - Ordered	7/4/22	114 d	-1 d	-1 d
520.1.3.5.2.5	HMF Cave/Hutch Enclosures - Design Started	3/12/21			
520.1.3.5.2.6	HMF Cave/Hutch Enclosures - Ordered	7/1/22	136 d	0 d	0 d
520.1.3.5.2.7	Cryo DCM - Ordered	11/2/22	3 d	47 d	-36 d
520.1.3.5.2.8	Diffractometer - Design Started	3/2/21			
520.1.3.5.2.9	Diffractometer - Ordered	1/3/23	129 d	0 d	0 d
520.1.3.5.2.37	Insertion Devices - Ordered	2/23/23	222 d	0 d	-63 d
520.1.3.5.2.10	Long-Lead-Time Items Design-Ordered - Complete	2/24/23	222 d	0 d	-36 d
520.1.3.5.2.11	CESR, Tunnel Mods ALL M&S Ready to Install	10/3/22	173 d	-22 d	-85 d
520.1.3.5.2.12	CESR Vacuum Mods Complete	7/28/22	308 d	-16 d	-16 d
520.1.3.5.2.13	HMF Beamline FrontEnd Installed	9/5/24	0 d	0 d	0 d
520.1.3.5.2.14	CESR Tunnel Shielding Complete	8/15/22	295 d	0 d	0 d
520.1.3.5.2.15	CESR, Tunnel Mods ALL M&S Installation Complete	12/12/22	224 d	-11 d	-78 d
520.1.3.5.2.16	CESR Accelerator Operational after Mods	11/24/22	245 d	41 d	-26 d
520.1.3.5.2.17	HMF Cave/Hutch Enclosures - Delivered	12/29/23	265 d	0 d	0 d
520.1.3.5.2.18	Cryo DCM - Delivered	10/25/24	0 d	0 d	0 d
520.1.3.5.2.19	HMF Beamline ALL M&S Ready to Install	10/25/24	0 d	0 d	-65 d
520.1.3.5.2.20	HMF Cave/Hutch Enclosures - Installed	4/22/24	257 d	-1 d	-1 d
520.1.3.5.2.21	Cryo DCM - Installed	12/19/24	76 d	0 d	-83 d
520.1.3.5.2.22	HMF X-ray (High-Heat) Optics Installed	2/18/25	100 d	0 d	-32 d
520.1.3.5.2.23	HMF Beamline ALL M&S Installation Complete	12/19/24	144 d	0 d	-32 d
520.1.3.5.2.24	High-field Magnet - Delivered	12/28/23	140 d	-2 d	-2 d
520.1.3.5.2.25	Diffractometer - Delivered	6/26/24	135 d	0 d	0 d
520.1.3.5.2.38	Insertion Devices - Delivered	5/28/24	0 d	0 d	0 d
520.1.3.5.2.26	Experimental Equipment ALL M&S Ready to Install	1/8/25	131 d	0 d	0 d
520.1.3.5.2.27	Diffractometer - Installed	7/22/24	258 d	-1 d	-1 d
520.1.3.5.2.39	Insertion Devices - Installed	11/1/24	50 d	50 d	50 d
520.1.3.5.2.28	High-field Magnet - Installed and Energized	10/14/24	237 d	-1 d	-1 d
520.1.3.5.2.29	Experimental Equipment ALL M&S Installation Complete	1/2/25	145 d	0 d	0 d
520.1.3.5.2.30	X-rays Commissioning Starts	2/18/25	100 d	0 d	-32 d
520.1.3.5.2.31	X-rays into HMF Experimental Enclosure	2/19/25	99 d	-1 d	-33 d
520.1.3.5.2.32	Cryo DCM - Commissioning	3/11/25	133 d	-1 d	-33 d
520.1.3.5.2.33	High-field Magnet - Commissioning	5/22/25	93 d	-1 d	-33 d
520.1.3.5.2.34	Commissioning Experiments with Standard Samples	9/1/25	87 d	-1 d	-33 d
520.1.3.5.2.35	X-rays Commissioning Finishes	9/29/25	67 d	-1 d	-33 d
520.1.3.5.2.36	Project End	12/29/25			

WBS	Task Name	Contingency Rate	% Complete	Baseline Cost	Retire Date	Risk ID	Routine Risk	Non-Routine Risk	Allocation	Lien	
520.2.5	Vacuum and Beampipes (LI)	10	80%	$191,488	7/5/22	0	$93,749	$0	$0	$0	$200,000
520.2.5.6	Cumulative costs in L3	0	0%	$0	7/1/22	18	$0	$0	$0	$0	$200,000
520.2.5.1	Scope	10	100%	$2,360	4/2/21	0	$236	$0	$0	$0	$0
520.2.5.1.1	Collect information and quotes	10	100%	$2,360	4/2/21	9	$236	$0	$0	$0	$0
520.2.5.2	Design	10	100%	$9,858	3/5/21	0	$986	$0	$0	$0	$0
520.2.5.2.1	Refine Dipole A Design	10	100%	$6,310	3/3/21	9	$631	$0	$0	$0	$0
520.2.5.2.2	Confirming vacuum layout	10	100%	$3,548	3/5/21	9	$355	$0	$0	$0	$0
520.2.5.3	Acquire or Fabricate	10	100%	$164,676	2/9/22	0	$16,468	$0	$0	$0	$0
520.2.5.3.1	Dipole A vacuum chamber fab	10	100%	$83,825	2/8/22	9	$8,383	$0	$0	$0	$0
520.2.5.3.2	Crotch assembly fab	10	100%	$25,326	8/31/21	9	$2,533	$0	$0	$0	$0
520.2.5.3.3	Vacuum Pumps	10	100%	$55,525	1/31/21	9	$3,333	$0	$0	$0	$0
520.2.5.4	Install	10	0%	$28,862	4/23/22	0	$2,886	$0	$0	$0	$0
520.2.5.4.1	Secure and vent sections	10	0%	$1,513	5/31/22	9	$151	$0	$0	$0	$0
520.2.5.4.2	Removing SCW beampipes	10	0%	$4,837	6/6/22	9	$484	$0	$0	$0	$0
520.2.5.4.3	Install new dipole A chambers w/ crotches	10	0%	$6,708	6/13/22	9	$671	$0	$0	$0	$0
520.2.5.4.4	Vacuum instrumentations (pumps and gauges, TCs, etc.)	10	0%	$12,005	6/20/22	9	$1,201	$0	$0	$0	$0
520.2.5.4.5	Pump down, leak check, NEG activation	10	0%	$3,778	6/23/22	9	$378	$0	$0	$0	$0
520.2.5.5	Commission	10	0%	$7,732	7/5/22	0	$773	$0	$0	$0	$0
520.2.5.5.1	Vacuum performance monitoring	10	0%	$4,112	6/30/22	9	$411	$0	$0	$0	$0
520.2.5.5.2	Re-activation NEGs (3 times)	10	0%	$3,620	7/5/22	9	$362	$0	$0	$0	$0