



Project Update

John Corlett (LBNL)
Interim Project Director
August 9, 2021

Who Am I

- 30 years at LBNL
- Involved in scientific contributions and project management of DOE projects for last 30 years
 - Advanced Light Source
 - PEP-II B-Factory
 - Linear Colliders
 - LCLS-II
 - LCLS-II HE
- LBNL projects portfolio since 2018
 - Diverse science and facility construction projects

Outline

- Key Project Goals Over the Next Year
- Project Organization
- Project Reviews
- Preliminary Baseline Design
- Detectors Request for Information
- Cost & Schedule Update Plans
- Project Tools
- MOUs/MOAs/SOWs
- Timeline
- Conclusion

Key Near-term Project Goals

- Obtain Funding

- DOE

- FY21 funding \$5M + carry-forward from FY20 has been distributed
- Made FY22 request. Overall DOE->SC->OHEP->CMB-S4 funding not known
 - House and Senate appropriations both have \$20M for CMB-S4

- NSF

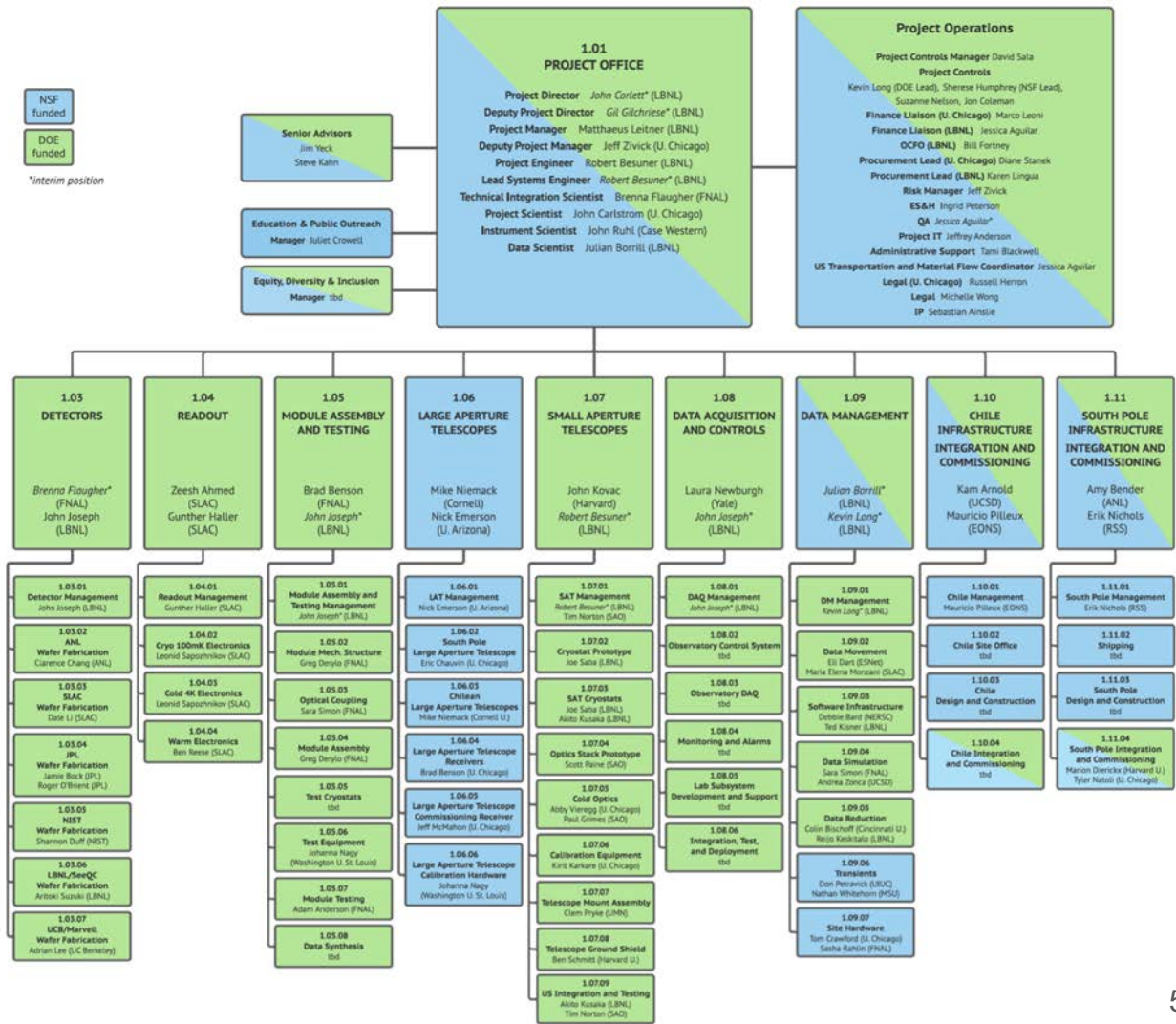
- MSIP & MSRI-1 supplemental funds support ongoing work through CY21
- Proposal for Final Design work, CY22-24, to be submitted in August
 - Anticipating an MREFC award that will fund construction starting in CY25
 - The ASTRO 2020 report, due in August, will inform NSF priorities including CMB-S4

- Complete Status and Gate Reviews

- Director's Status Review November 16-19
- DOE-led Status review February 15-17 (planning to extend to 4 days) 2022
- NSF Preliminary Design Review - CRITICAL milestone
 - Will be informed by ASTRO2020
- DOE Critical Decision 1 (CD-1) Review - CRITICAL milestone, target Q4FY22

Org Chart

- Developed to L3
- Approved by L1
- Appropriate for this stage of the project
- Several interim roles to be filled when funds are available



Agency and Director's Reviews

- MSRI-1 status review held May 18-19, charged to assess path to Preliminary Design Review for NSF scope
 - “... team is excellent and includes many leaders in this scientific field...”
 - “... team is on a credible path to deliver a draft Preliminary Project Execution Plan and proposal for review...”
 - The review addressed only the MSRI-1 scope and highlighted the need to present a coherent integrated DOE/NSF project overview in future
- DOE Project Status review by the Office of Science, Office of Project Assurance
 - February 15-19, 2022 (plan to extend to 4 days)
- LBNL Director's Review November 16-19, 2021
- An NSF review of the Preliminary Design is required before an MREFC award can be initiated
 - Tentatively scheduled to align with the DOE Status Review, February 2022
 - Coordination to be initiated by the NSF after ASTRO2020 report is released

L2 technical reviews mostly completed

- Each L2 subsystem is being reviewed at the Conceptual Design level
- 7 reviews completed, 2 scheduled for September
- Highly expert review committees for each, predominantly external to CMB-S4
- Provide documentation of technical readiness and refine plans using comments and recommendations from subject matter expert reviewers
- Design Reviews and Reports:
 - South Pole and Chile Sites: [CMBS4-doc-741](#)
 - South Pole and Chile Large Aperture Telescopes (LATs): [CMBS4-doc-746](#)
 - Data Management (DM): [CMBS4-doc-742](#)
 - Small Aperture Telescopes (SATs): [CMBS4-doc-749](#)
 - Readout: [CMBS4-doc-762](#)
 - Module Assembly and Testing: [CMBS4-doc-756](#)
 - Large Aperture Telescopes Receivers (LATR): CMBS4-doc-(tbd)
 - Detectors: CMBS4-doc-(tbd)
 - Data Acquisition and Controls (DAQ): CMBS4-doc-(tbd)

Preliminary Baseline Design

- The Preliminary Baseline Design Report (PBDR) captures the science goals and technical requirements that lead to a scope and design for the experiment
- Draft posted May 2021 [CMBS4-doc-716](#)
 1. Science Case
 2. Science and Measurement Requirements
 3. Preliminary Baseline Design
 4. Science Analysis
 5. Project Overview
 - (6) Appendices
- Working with the Science Council and L2s on revisions to restructure with clearly defined flowdown, and updates where necessary
- Update to be provided to the Director's Review committee in November
- Goal of published version by early CY2022

Detectors Request For Information (RFI)

- Detectors are a major cost driver and critical technology to develop into production
- Three detector layout workshops completed in May
- Resolved issues in the way of production detector wafer layouts
 - ½ day workshops held in March, April, May
 - Darks, RF coupling, interfaces
 - Specifications, layout, and fabrication capabilities
- Each potential fabrication site has presented resources and capabilities
- RFI distributed to SLAC, ANL, NIST, Caltech, UC Marvell, and LBNL (for SeeQC)
 - Gather information from each potential fabrication site
 - Update detector cost and input to next iteration of fabrication schedule
 - Interplay among requirements flowdown, detectors, readout and modules
 - Keep costs (including risks) at forefront of technical development
 - Manufacturability, minimize complexity of detectors/readout ... think cheap

Brenna Flaughner, Technical Integration Scientist
John Joseph, Detectors L2 CAM

Production
Batch = 4 units

Production
Batch = 6 units

Production
Batch = 12 units (SAT)
Batch = 85 units (LAT)

WBS 1.03 Detector Production

Module Assembly Module Testing

Receiver Assembly

Telescope Installation Commissioning

SAT LF	24
SAT MF	144
SAT HF	48
LAT LF	24
LAT MF	162
LAT HF	64
TOTAL	471
SAT SUM	216
LAT SUM	255

Project Schedule Has Significantly Matured

- Detector/Readout/Modules include detailed information from potential fabrication and assembly sites
- Schedule is fully traceable from single detector wafer and frequency to individual telescopes
- Consistency between requirements, detector fab needs, and P6 schedule
- Procurement and SOW timelines are included

 **CMB S4**
Production Flow

Readout Electronics Production

100 mK Board




471 units + overage
10 batches

4 K Board & Cables




471 units + overage
10 batches

300 K Electronics




471 units + overage
10 batches

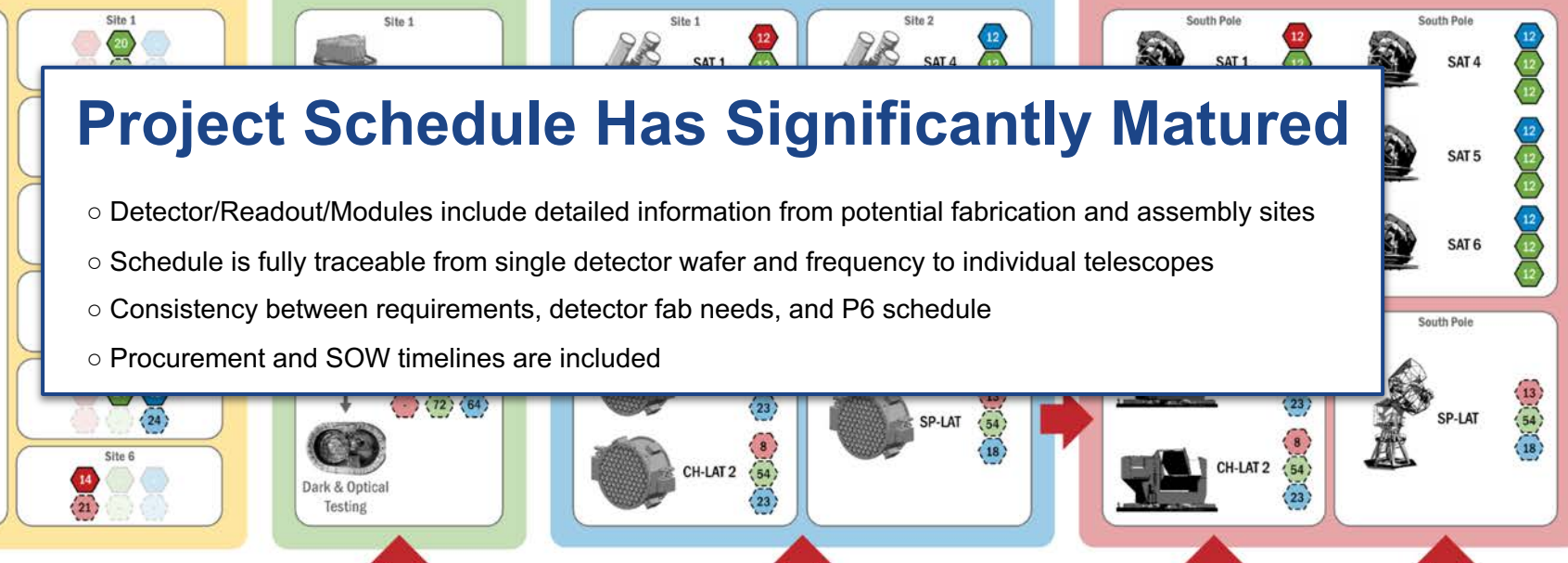
Northern Hemisphere Integrated Telescope Tests



SAT 1
(with receiver)



SP-LAT
(no receiver)



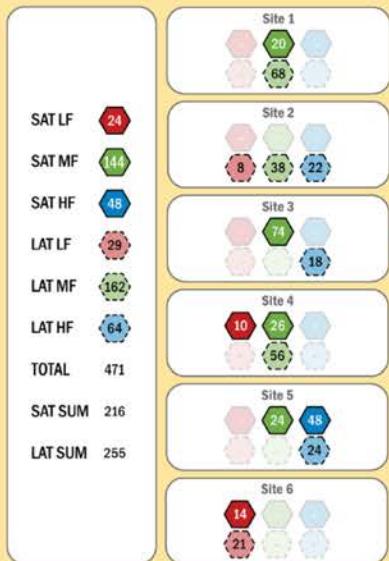
Production
Batch = 4 units

Production
Batch = 6 units

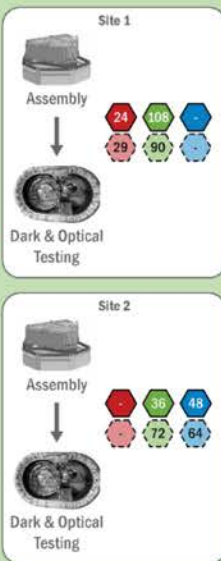
Production
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Batch = 85 units (LAT)

Matthaeus Leitner, Jeff Zivick, Project Managers

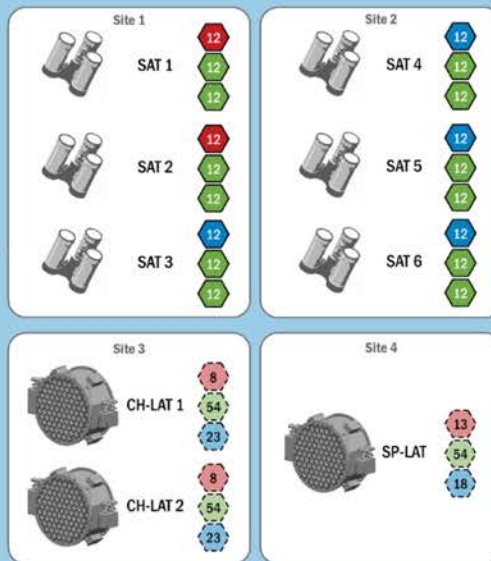
WBS 1.03 Detector Production



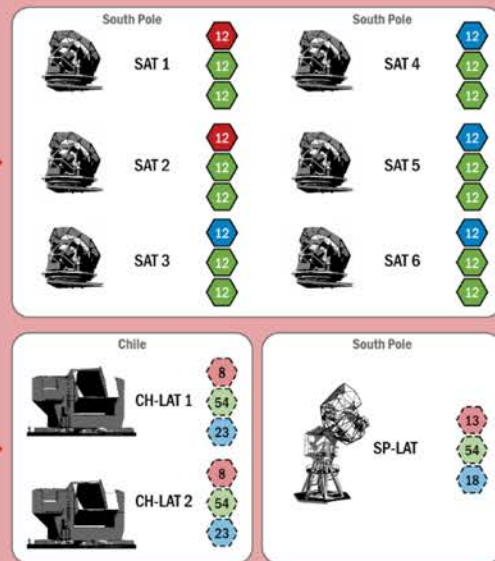
Module Assembly Module Testing



Receiver Assembly



Telescope Installation Commissioning



 **CMB S4**
Production Flow



471 units + overage
10 batches



471 units + overage
10 batches



471 units + overage
10 batches

Readout Electronics Production



SAT 1
(with receiver)



SP-LAT
(no receiver)

Northern Hemisphere Integrated Telescope Tests

Integrated Project Schedule Captures Scope And Forms The Basis For Cost Development

- Includes all production details
- Based on a nominal fabrication plan based on
 - Six detector fabrication sites
 - Two module assembly and testing sites
 - One readout assembly site
 - Two SAT receiver and two LAT receiver assembly sites
 - Two Northern Hemisphere telescope test assembly sites
 - Chile and South Pole Installation and Commissioning

Pixels/wafer		Number Wafers	name
12 SAT 30/40GHz		24	SAT LF
27 LAT 20GHz		4	LAT LUF
48 LAT 30/40GHz		26	LAT LF
147 SAT 85/145		72	SAT MF1
147 SAT 95/155		72	SAT MF2
432 LAT 90/150		162	LAT MF
469 SAT/LAT 225/278		112	SAT/LAT HF
		471	
SATs		216	
LATs		255	

Yield Assumption - Need to produce 6 wafers per detector line. DOES NOT INCLUDE OVERAGES - EXPECT REFERENCE DETECTOR TASK FORCE PHASE 1. 4 batches of 4 wafers/year/line. 16 science wafers per detector line. 4 batches come out every 12 weeks from each line. 8 wafers/half year for one line.

Assume max production lines/site, AS LISTED. REVISIONS DEC. 2020 ANL = 1 LINE based on discussion. CMB-S4 will use 4 lines at SLAC DMF for SQUID and Detector production. The number of SQUID and detector lines will be optimized in FY23, the year prior to Production. Discussed with JH, KJ, BF, Dec. 15, 2020.

MAX RATE IN TABLE IS <28 Science grade WAFERS/ YEAR = 2 LINES FOR SEEQC, JPL, NIST AND SLAC.

NIST Dual Tc demo in FY21, 1-2 wafer demo in 22, ramp up S4 prod in 23. Discussion Dec. 18 BF, HR, SD.

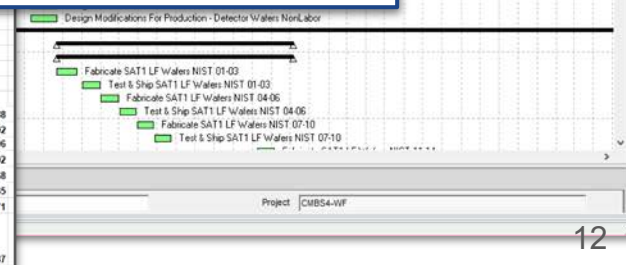
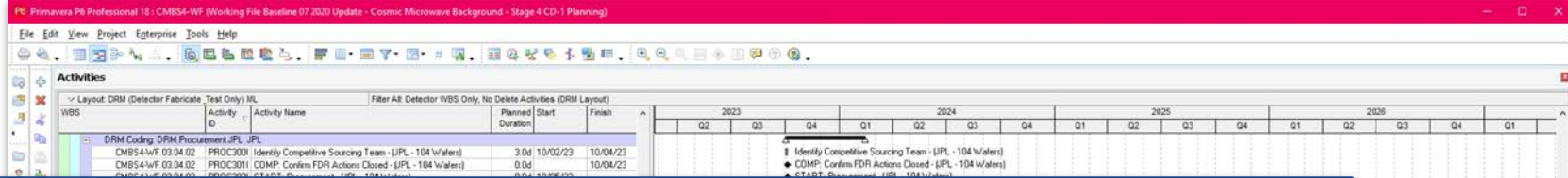
JPL 2 wafers/person in 2 months. Have 4 people now so could produce 8 wafers every 8 weeks. pi

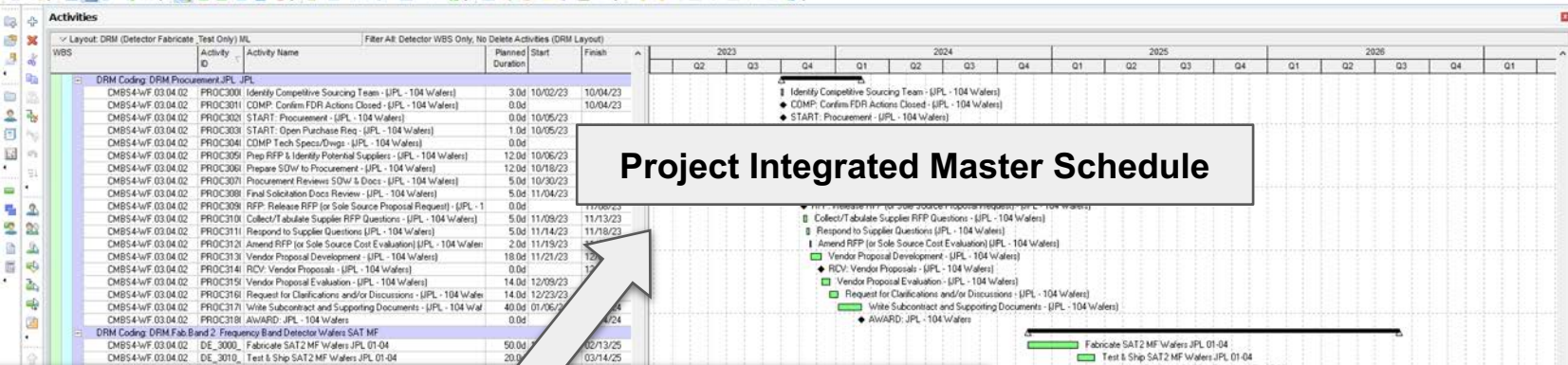
PRODUCTION

FY22 demonstrate capabilities of 5 sites
FY23: start producing science grade wafers, ramp to full production rate, ramp up S4 prod in 23.

FY24 optimize detector fab plan: more than 2 lines/site?, less sites? CD3, P
FY25-27 full production

Site	FY22A	FY22B	FY23A	FY23B	FY24A	FY24B	FY25A	FY25B	FY26A	FY26B	FY27A	FY27B	Total
Site 1			2	8	8	10	10	10	10	10	10	10	88
Site 2			2	8	10	10	12	10	10	10	10	10	92
Site 3			2	8	10	10	14	11	11	11	11	11	96
Site 4			2	8	10	12	10	8	9	10	12	12	92
Site 5					11	11	8	9	10	10	14	14	68
Site 6			2	4	2	4	4	4	4	3	4	4	35
Total Science Grade	0	0	10	36	40	46	61	54	51	56	59	58	471
~ Number of wafer modules to test (inc. 12% overage and 67% yield)	0	0	17	60	67	77	102	90	85	94	99	97	787





Project Integrated Master Schedule

Nominal Production Plan

Poles/water	Number	name	Wafers	Area	Site	Start	Finish	Wafers	Wafers	Total Science Wafers	number per tube or cryostat
12 SAT 30/40GHz	24	SAT LF	Rhomb	6	Site 6			14	24	SAT 30/40GHz	24
27 LAT 29GHz	4	LAT LUF	Rhomb	4				4	25	SAT 85/145, 95	144
48 LAT 30/40GHz	26	LAT LF	Rhomb	8				17	4	SAT 220/280	48
147 SAT 85/145	72	SAT MF1	Hex/Rhomb					72	72	SPLATR	
147 SAT 95/155	72	SAT MF2	Hex/Rhomb					72	72	LAT 202GHz	4
432 LAT 90/150	162	LAT MF	hex	1728				162	162	LAT 30/40GHz	9
469 SAT/LAT 225/278	112	SAT/LAT HF	HEX	1872				112	112	LAT 90/150	54
	471							471	471	LAT HF	18
										CHLATR	
										LAT 39/40GHz	16
										LAT 90/150	108
										LAT HF	46
											471

Yield Assumption - Need to produce 6 wafers to get 4 science grade. Table only counts science grade
 DOES NOT INCLUDE OVERAGES - EXPECT ~ 10% needed
REFERENCE DETECTOR TASK FORCE PHASE 1 REPORT
 4 batches of 4 wafers/line (16 science wafers/line/year)
 batches come out every 12 weeks from each line at each site.
 8 wafers/half year for one line

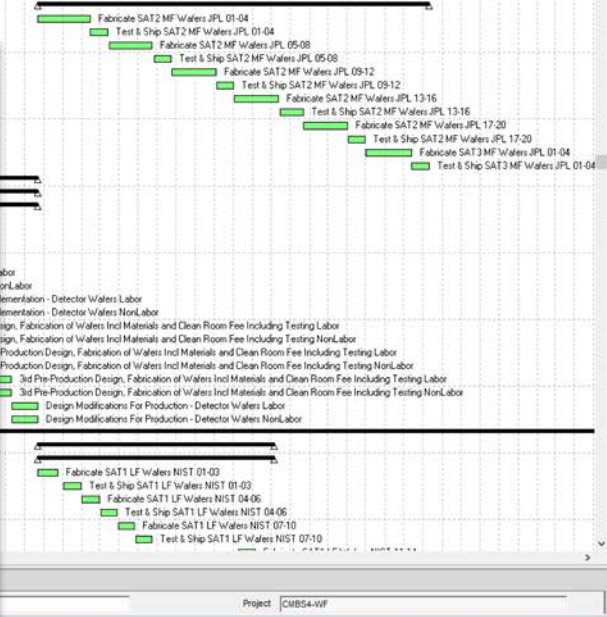
Assume max production lines/site, AS LISTED IN THE TASK FORCE REPORT TABLE 2: ANL = 4, SLAC = 4, NIST = 3, JPL=3, GSFC=1, UBC=2, SOC=1???
 REVISIONS DEC. 2020 ANL = 1 LINE based on discussion RY, SH, CC, TC, BF Dec. 11, 2020
 ANL = 1 LINE based on discussion, MAX 20 wafers/year RY, SH, CC, TC, BF Dec. 11, 2020
 CMB-S4 will use 4 lines at SLAC DMF for SQUID and Detector production. The number of SQUID and Detector production lines will be optimized in FY23, the year prior to Preproduction. Discussed with JH, KJ, BF, Dec. 15, 2020

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 NIST Dual Tc demo in FY21, 1-2 wafer demo in 22, ramp up 54 prod in 23. Discussion Dec. 18 BF, PH, SD
 JPL 2 wafers/person in 2 months. Have 4 people now so could produce 8 wafers every 8 weeks. **PRODUCTION**

FY22 demonstrate capabilities of 5 sites
FY23: start producing science grade wafers, ramp to full production rate, ramp to full production

FY24 optimize detector fab plan: more than 2 lines/site?, less sites? CD3, P
FY25-27 full production

Finish Cryostat Plan	Split years into part A and B for transition to new detector type												Total	
	FY22A	FY22B	FY23A	FY23B	FY24A	FY24B	FY25A	FY25B	FY26A	FY26B	FY27A	FY27B		
Site 1				2	8	8	10	10	10	10	10	10	10	88
Site 2				2	8	10	10	12	10	10	10	12	8	10
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- Number of wafer modules to test (inc. 12% overage and 67% yield)	0	0	17	60	67	77	102	90	85	94	99	97	787	



Cost Estimate in Progress

Cost Estimating Form

Project: CMB-S4 | WBS: 1.01.01.02 Project Office - DOE | Work Package: DOE-PMO-MGT-1000 Project Management Project Office - DOE

Last Updated: 6/30/2021 7:23:30 PM - By Kevin Long | Start Date: 07/01/2019 | End Date: 03/31/2030

Details

CAM: Matthaeus Leitner | Earned Value Technique (EVT): | Level of Effort: |

WP Statement of Work

Manage the CMB-S4 schedules, budgets, plans, organization, procedures, policies, partnering, and resources.

Maintain offices for Director, Project Manager, and all key staff in the Organization.

Covers all Recruiting and staff relocation.

Manage the Headquarters physical assets (hardware, software, facilities, documents) during the Construction Phase, as well as preparing for the same activities during the Operations Phase. This includes:

1. Managing software and document repositories
2. Procuring, configuring, administering, and maintaining computing, communications and storage infrastructure documentation library (developmental and production configurations)
3. Configuration control and asset management for all physical assets.
4. Infrastructure for PMCS and EVMS systems.
5. Domestic and international travel expenses for all key staff not covered in focused activities.
6. Office equipment, including enterprise computing equipment and personal computing for the PMO staff.
7. Communications service for Project Management office.

OBS: LBNL - Lawrence Berkeley National Lab

Labor Estimate

ID	Resource ID	Description	Start	Finish	Hours	Cost	
29322-Budget	A40.3 - LBNL Administrator - Sr	PM_3400 Management - CD0103A to FY23 - DOE	04/01/2021	09/30/2022	Hours: 9,041.00	\$ 962,847.00	
29323-Budget	A40.3 - LBNL Administrator - Sr	PM_3500 Project Controls - CD0103A and beyond	04/01/2021	10/31/2028	Hours: 45,384.00	\$ 5,481,164.38	null
29324-Budget	A40.3 - LBNL Administrator - Sr	PM_4100 QA/Safety Support - DOE	10/01/2022	03/31/2030	Hours: 7,564.00	\$ 965,154.55	null
29325-Budget	A40.3 - LBNL Administrator - Sr	PM_4200 Management - FY23 and beyond - DOE	10/01/2022	11/30/2028	Hours: 18,168.00	\$ 2,262,026.23	null
29326-Budget	S13.4 - LBNL Sci/Eng - Physicist Staff	PM_3400 Management - CD0103A to FY23 - DOE	04/01/2021	09/30/2022	Hours: 3,014.00	\$ 533,056.68	null
29327-Budget	S13.4 - LBNL Sci/Eng - Physicist Staff	PM_4200 Management - FY23 and beyond - DOE	10/01/2022	11/30/2028	Hours: 3,028.00	\$ 626,088.43	null

- **First Iteration of WBS Dictionary Implemented**
- **Cost and BoE Updates Initiated**
 - Cost Estimate Training held June 30
 - Cost Drill-Down Training held Aug 4
 - Implemented Dash360 to collect input
 - Basis of Estimate
 - Estimate Uncertainty Factors
 - WBS Dictionary
- **Upcoming: Risk workshop planned Aug 26**

Cost Estimate in Progress

DASH360 Cost Estimating Form

Project: CMB-S4 | WBS: 1.01.01.02 Project Office - DOE | Last Updated: 6/30/2021 7:23:30 PM - By Kevin Long

Details

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29325-Budget	A40.3 - LBNL Administrator - Sr	PM_4200 Management - FY23 and beyond - DOE	10/01/2022			
29326-Budget	S13.4 - LBNL Sci/Eng - Physicist Staff	PM_3400 Management - CD0103A to FY23 - DOE	04/01/2021			
29327-Budget	S13.4 - LBNL Sci/Eng - Physicist Staff	PM_4200 Management - FY23 and beyond - DOE	10/01/2022			

Basis of Estimates

Collected in Cost Tool

Estimate Uncertainties

BOE summary spreadsheet for workpackage

Sum of hours and dollars need to match with Dash360 data

- Excel spreadsheets
- Excel or pdf files from Google sheets

Detailed cost information for each resource loaded activity

- Spreadsheets
- Quotes
- Engineering estimates for labor

Old quotes need to be escalated to current baseline year

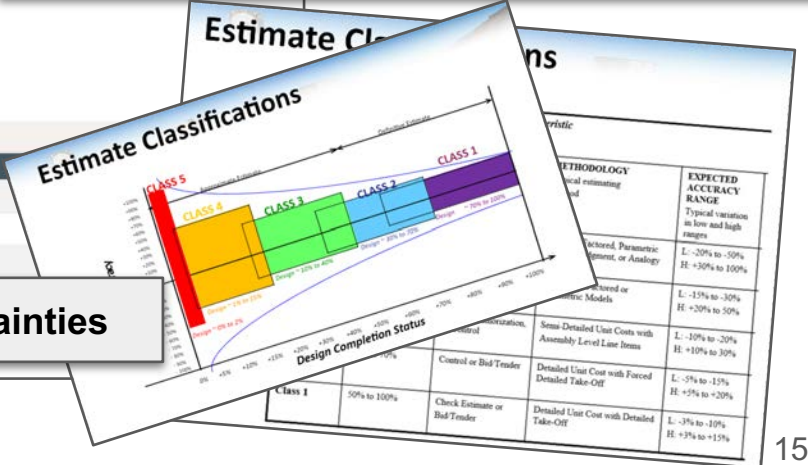
- Use standard escalation table provided by project controls

Labor (hrs)

- separated by labor category
- Engineering estimates
- Previous projects
- Required to justify labor estimate (e.g. a nominal schedule for mass-produced items)

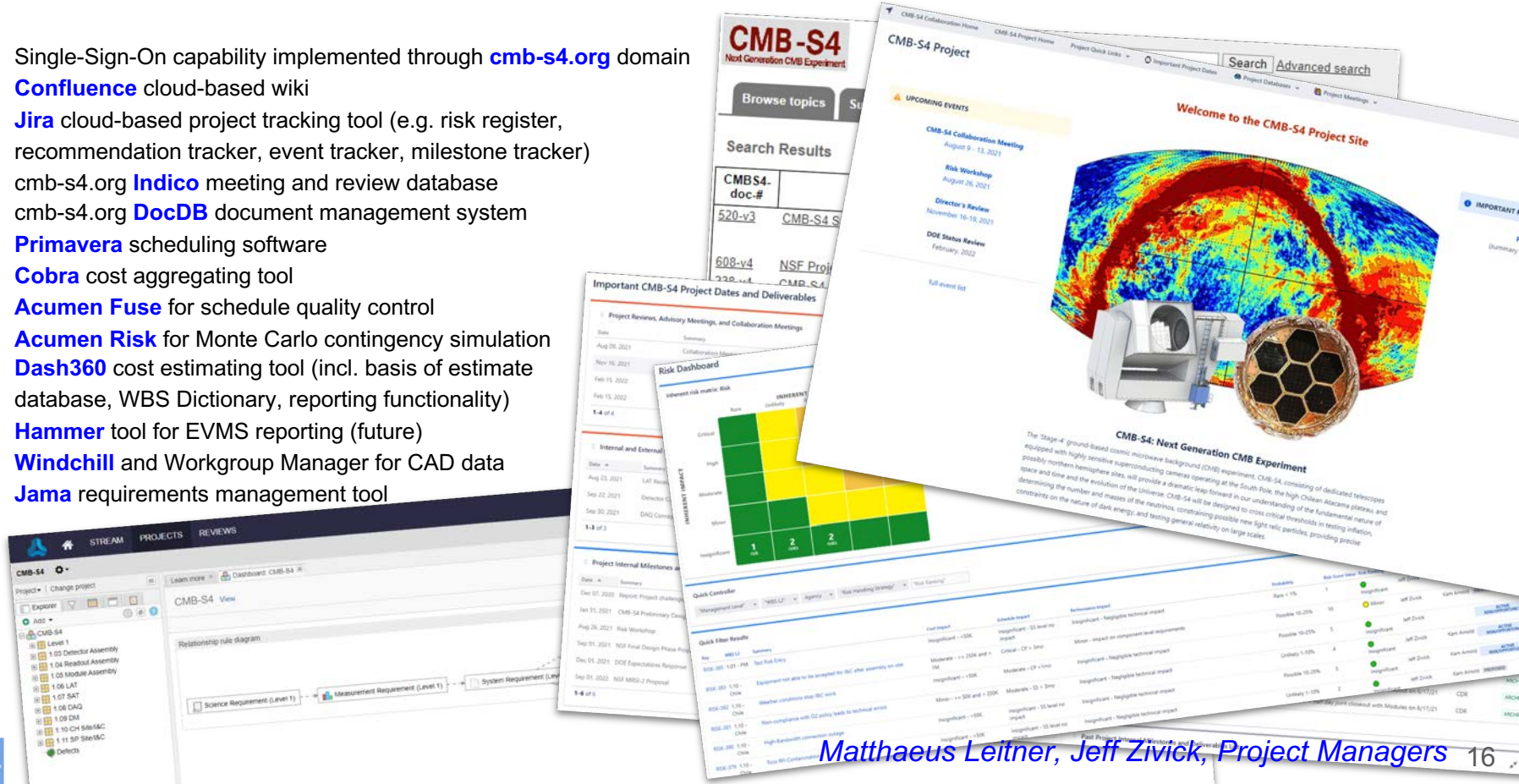
Procurements (\$)

- Vendor quotes or online quotes
- Previous purchases
- Email quotes



Suite of Project Tools Implemented

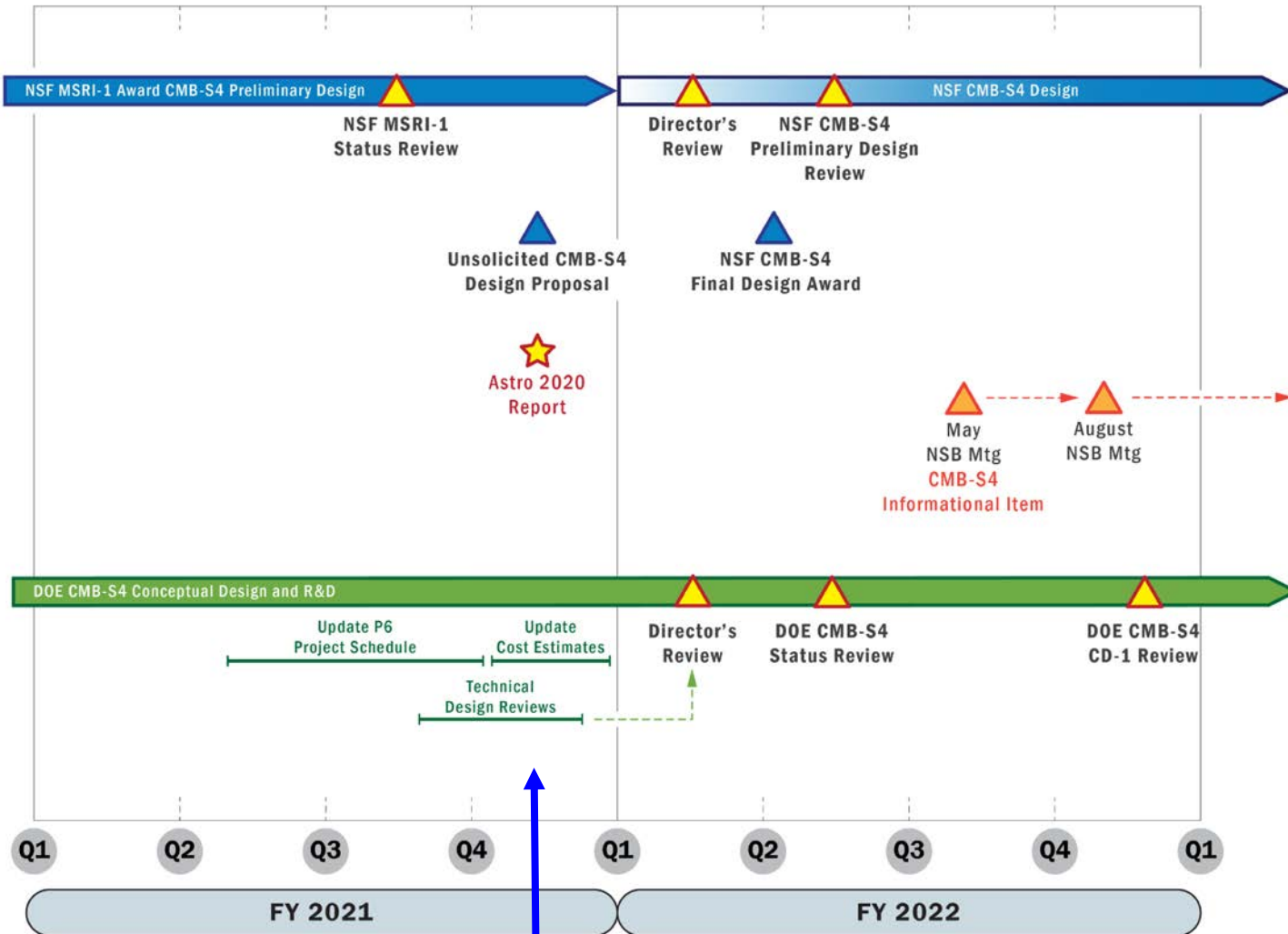
- Single-Sign-On capability implemented through cmb-s4.org domain
- **Confluence** cloud-based wiki
- **Jira** cloud-based project tracking tool (e.g. risk register, recommendation tracker, event tracker, milestone tracker)
- cmb-s4.org **Indico** meeting and review database
- cmb-s4.org **DocDB** document management system
- **Primavera** scheduling software
- **Cobra** cost aggregating tool
- **Acumen Fuse** for schedule quality control
- **Acumen Risk** for Monte Carlo contingency simulation
- **Dash360** cost estimating tool (incl. basis of estimate database, WBS Dictionary, reporting functionality)
- **Hammer** tool for EVMS reporting (future)
- **Windchill** and Workgroup Manager for CAD data
- **Jama** requirements management tool



MOUs/MOAs/SOWs

MOU: Memorandum of Understanding
MOA: Memorandum of Agreement
SOW: Statement of Work
IPMP: Intellectual Property Management Plan

- MOUs (standard format)
 - Legal framework for work in Chile. U of Chicago: completed
 - Framework for potential in-kind contributions to CMB-S4
 - Harvard-Smithsonian: completed
 - CCAT Prime Observatory, Inc. and U. Chicago: completed
 - Simons Observatory and U. Chicago: in progress
- MOAs (bespoke format)
 - Detector fab sites MOA completed, IPMP in progress
 - Institutional MOAs (signed once) + FY Appendix (update each FY):
 - LBNL, ANL, FNAL, SLAC completed
 - Caltech and CfA | Harvard in progress
- SOWs (key part of contracts between LBNL and DOE funded institutions)
 - Complete for FY21
 - To be renewed for FY22, based on budget and capabilities



Conclusions

- CMB-S4 Project structure is in place and will be developed over time
- Project “machinery” is in place and is being used to prepare for agency status (one completed) and gate reviews in the coming year
- Most major elements have undergone formal technical design reviews, remainder to be completed this summer
- Cost and schedule are being updated this summer
- Preliminary Baseline Design Report revisions under way, next draft by November 1
- Preparations for agency reviews are well under way