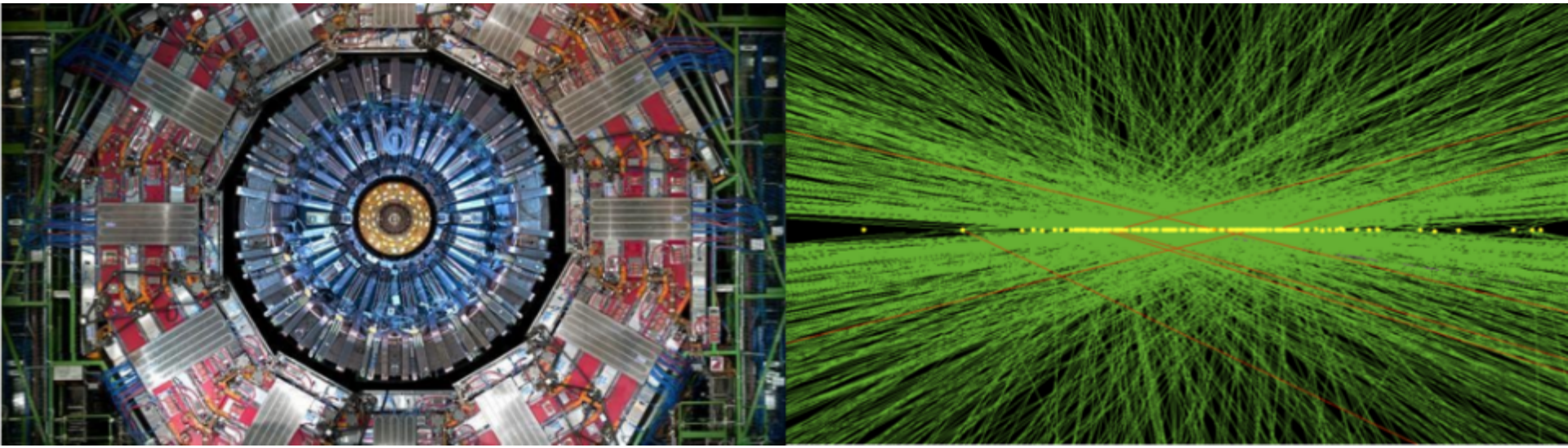
B06: 402.02 Path to Baseline

Steve Nahn and Petra Merkel and all

CD1 Director's Review

March 20, 2019



Outline

- Technical Progress not covered elsewhere
- Managerial Progress since June 2018 IPR
- Plan to get to Baseline

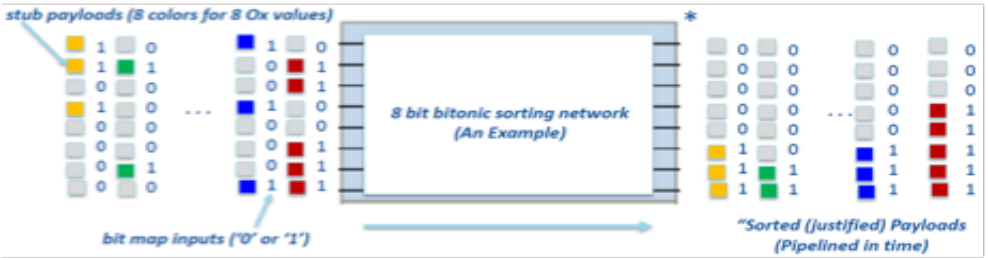
Technical Progress since June 2018 IPR

- 402.23 Sensors — Dedicated Breakout
  - With iCMS – Sensor final design thickness, last decision for CD3a
  - Development of Sensor testing
  - Fermilab ITA
- 402.24 Electronics
  - Further prototyping of MaPSA — Dedicated Breakout
  - Final versions of Test Systems — Dedicated Breakout
  - Development of DAQ and Firmware
  - Proto-Module testing — Dedicated Breakout
- 402.25 Modules
  - Development of Module Assembly Sites — Dedicated Breakout
  - Feasibility of partial automation of assembly — Dedicated Breakout
  - Construction of first functional modules
  - Construction Materials studies
- 402.26 + 402.27 Mechanics and Integration
  - Flat Barrel design refinement
  - Prototype Plank and Ring fabrication

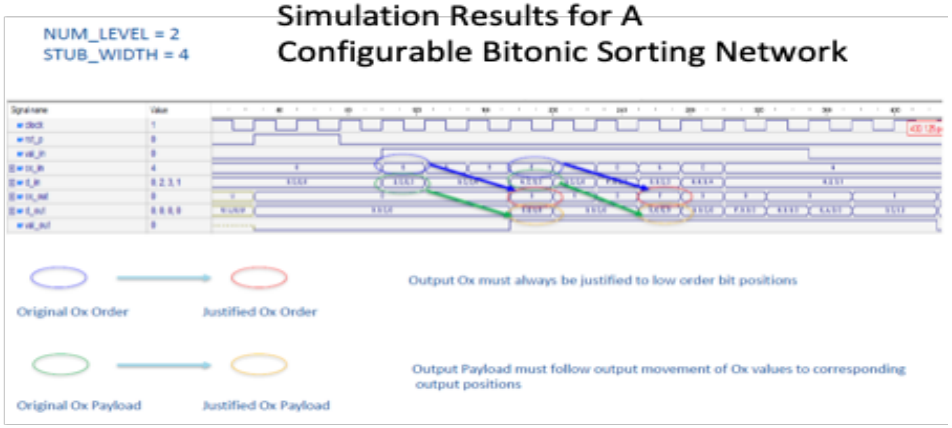
Electronics - DTC Firmware

- DTC is ATCA board between module and L1T/Central DAQ
- U.S. CMS participating in Firmware Development for DTC
  - CIC Decoder: Receives CIC data in various formats, sorts into packets with common BX ID and Offset field
    - Configurable for multiple input lines, stub widths, bent information
    - Requires multiple copies of FW, so must minimize resources
  - Status: Unsparsified CBC L1 data and CBC and MPA stub data decoding delivered

Configurable Bitonic Sorting Network



Simulation Results for A
Configurable Bitonic Sorting Network



Post Synthesis Resource Utilization Estimate
64 inputs, stub width = 21

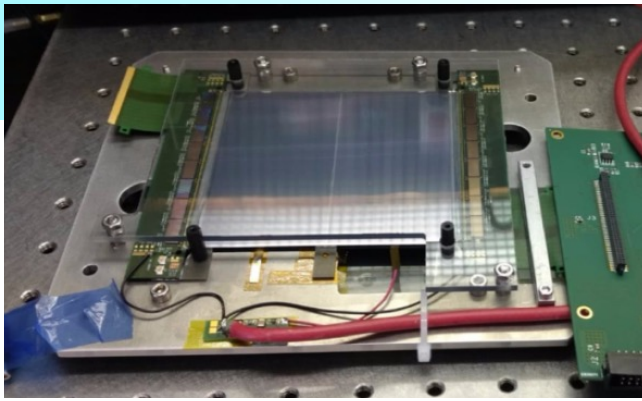
Utilization - Post-Synthesis

Resource	Estimation	Available	Utilization %
FF	29692	407600	7.28
LUT	15672	203800	7.69
I/O	2820	500	564.00
BUFG	1	32	3.12

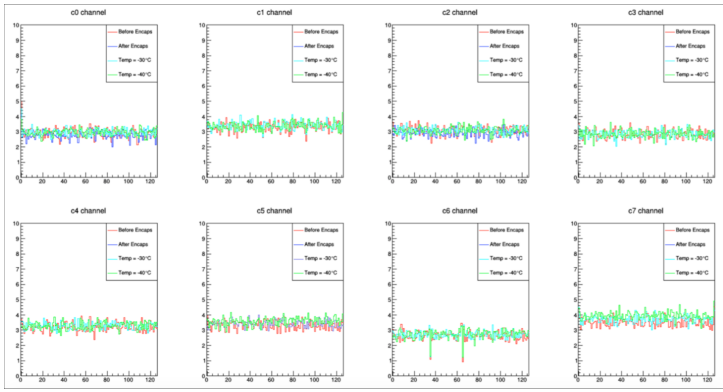
Electronics - DAQ Middleware

- Coordination of OT Middleware development
  - High level software has state machine logic interfacing to CMS DAQ
  - Middleware is specific interface to hardware, defines configuration and calibration procedures, data processing, etc
- Test stands set up at SiDet using assembled prototypes for development
  - Diverse calibrations with different authors consolidated into consistent and maintainable platform
  - Calibration based on generic register scans allows rapid implementation of new calibrations and extension to other ASICs
- 2S Module software tools implemented, used in prototype testing
  - PS modules under development, MaPSA essentially complete and SSA making progress

Functional 2S Modules

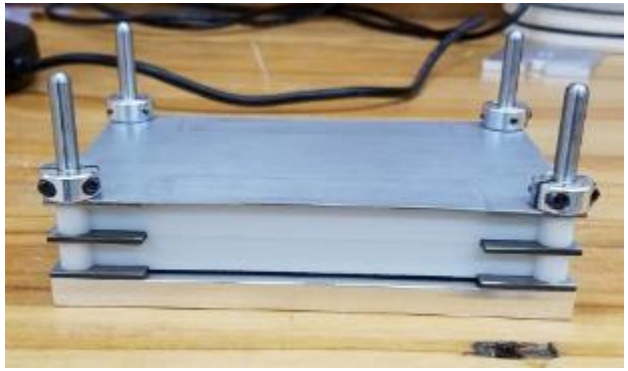


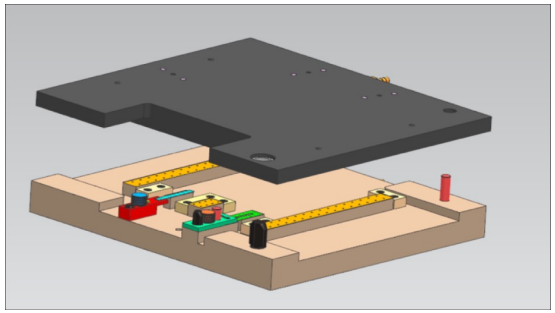
- One per site since June 2018 IPR, limited by availability of 8CBC2 hybrids and prototype 2S sensors
  - FNAL module used for study of encapsulant stiffening with thermal cycles
    - Based on issues seen with 2S minimodule
  - East Coast assembled 12/18, wirebonded at Princeton
    - Delayed by focus on PS and to await final HV connection
  - Fewer than originally planned due to issues with both 2nd batch of prototype sensors and especially 8CBC2 hybrids
    - Suffering from a combination of warping and delamination, solution will be tested with next batch
- 8CBC3 hybrids and 2S sensors becoming available for more Module Assembly in CY19Q2
  - Aim is to do 5 2S modules per site in 2019

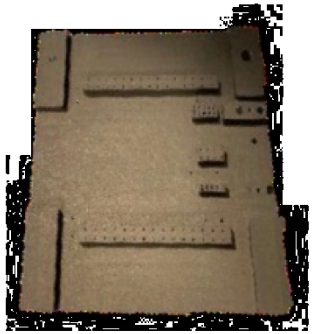


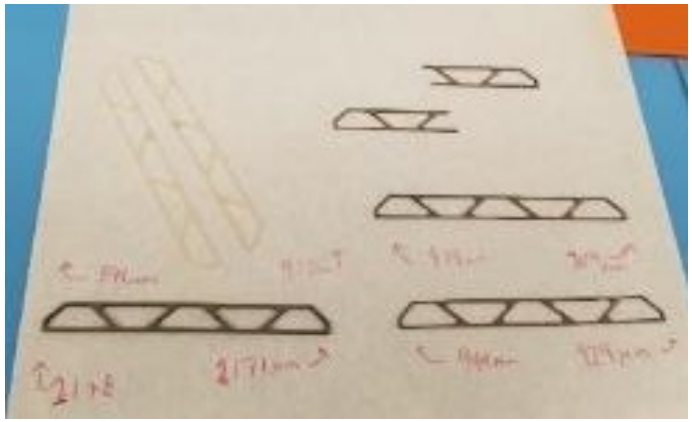
Module Material/Tool studies

- Jigs and Fixtures
  - Ongoing development as experience with assembly accrues
    - PS carrier for East Coast assembly transfer
    - 2S Carrier plate
    - Kapton fixtures, coated with NiTuff
- Spacer material studies
  - Testing modules with AlN vs. Al-CF spacers
    - Al-CF much more fragile, AlN shows similar thermal properties





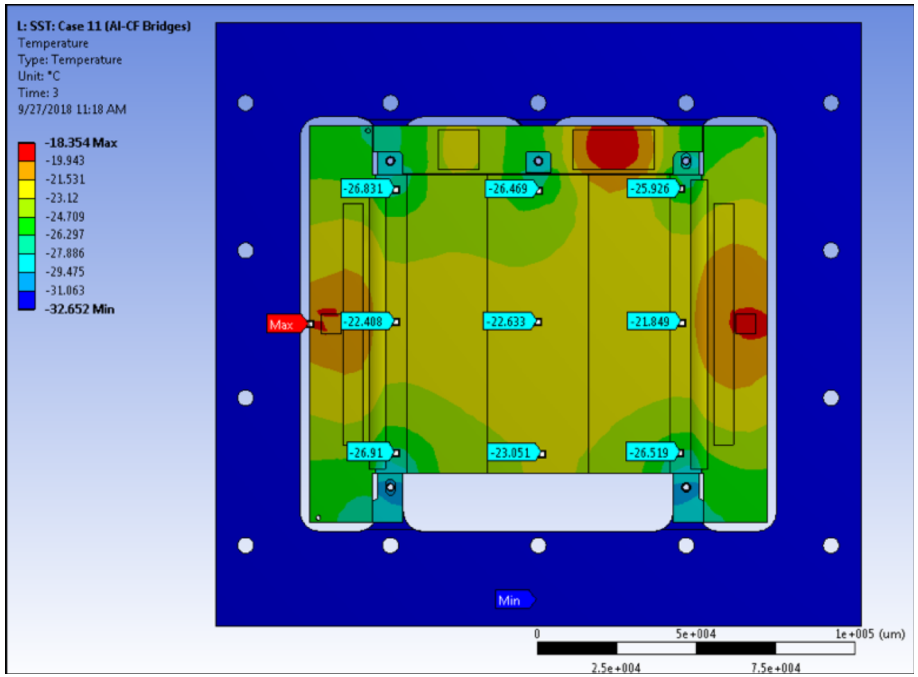




Module Thermal Studies

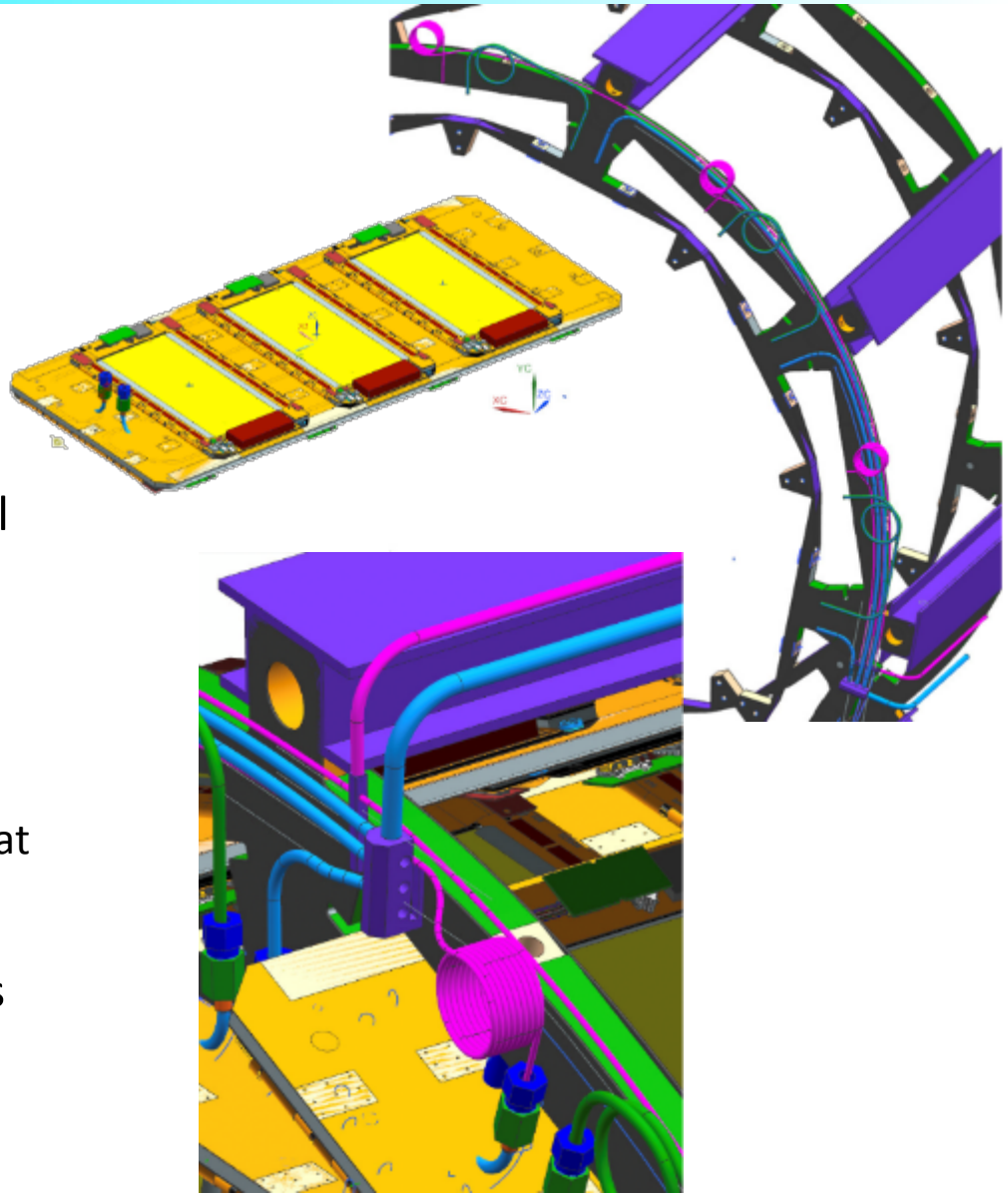
- 2S module fully simulated in FEA
  - Al ⟹ Al-CF bridges decreases ΔT 0.5 °C
  - K13C2U ⟹ K13D2U prepreg: ΔT 0.8 °C
- K13D2U thermal properties measured
  - In plane: 515 ± 72 W/m-K
- Validation gives confidence in cooling performance after 3000 fb^{-1} dose
  - CMS Note DN-18-009

Item	Power (W)
Sensors	0.80
CBC	1.1
CIC	.31
Optics	.81
DC/DC	1.77
Total	**4.79**



Progress on System Layout

- Cooling tube routing
  - Default routing and location of CO_2 manifolds finished
    - Manifolds located between TEDD and Tilted Barrel
  - Optimization: integrating manifolds within Flat Barrel
    - Less piping along tilted barrel
    - Fewer connections to be made at integration time
    - Makes flat barrel more self-contained
      - Final manifold-to-loop connections can be tested at FNAL
    - Integrated manifolds include interconnect piping to planks
      - Simplifies plank loops (for same number of couplers)

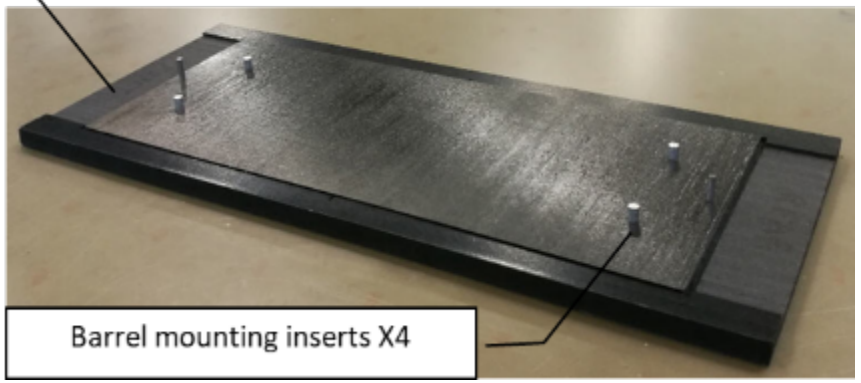


Flat Barrel QC Planning

- Assumption: Module and Plank QC already done
- Plank Loading QC
  - Functionality test of each Module after placement on plank
    - Single Module test apparatus, no cooling, sacrificial extensions still attached
    - Done in batches before curing adhesive, at most a day's worth
  - After all Modules placed, adhesive cured
    - Optical Gauge probe verification of position
    - Cold box installation, environment set to operating point
    - Fast "module present" test
    - Extended module functionality test and infrared temperature verification
- Layer Loading QC
  - Alignment check of plank in Layer
  - Single module functional verification for modules on inserted plank
  - Multi-module Cold Test
    - Full calibration at operational point
- Flat Barrel QC
  - Cosmic Rays through top/bottom 60° sections of all 3 layers at operating temperature

Mechanical Prototypes

- Mechanical planks have been prototyped since before June 2018
  - Thermal studies led to optimization of cooling routing inside plank
- Recently created full Layer 1 mockup
  - G10 for planks
  - Prototype Ring design
  - Tests design feasibility, fixturing for plank insertion



402.2 Technical Design Maturity

- Design has been essentially complete since Jan 2018 IPR
  - Changes now driven by either prototyping experience, either from performance or fabrication perspective, or by cost
  - Maturity estimate went from 60% to 80% between March and December, 2018

Design	Completion
PS-P Sensor Design	70
PS-S Sensor Design	70
2S Sensor Design	80
Process QC Design	30
Sensor QC Design	60
Irradiation QC design	60
Burnin Box Design	80
Single Module Test Design	40
Hybrid Test Design	40
MaPSA Testing Design	70
MaPSA Design	70
DAQ Firmware	15
DAQ Software	80
PS Module Design	60
2S Module Design	80
PS Module Assembly Design	50
2S Module Assembly Design	70
Plank Design	80
Ring Design	60
Integration Design	30
Cooling Design	50

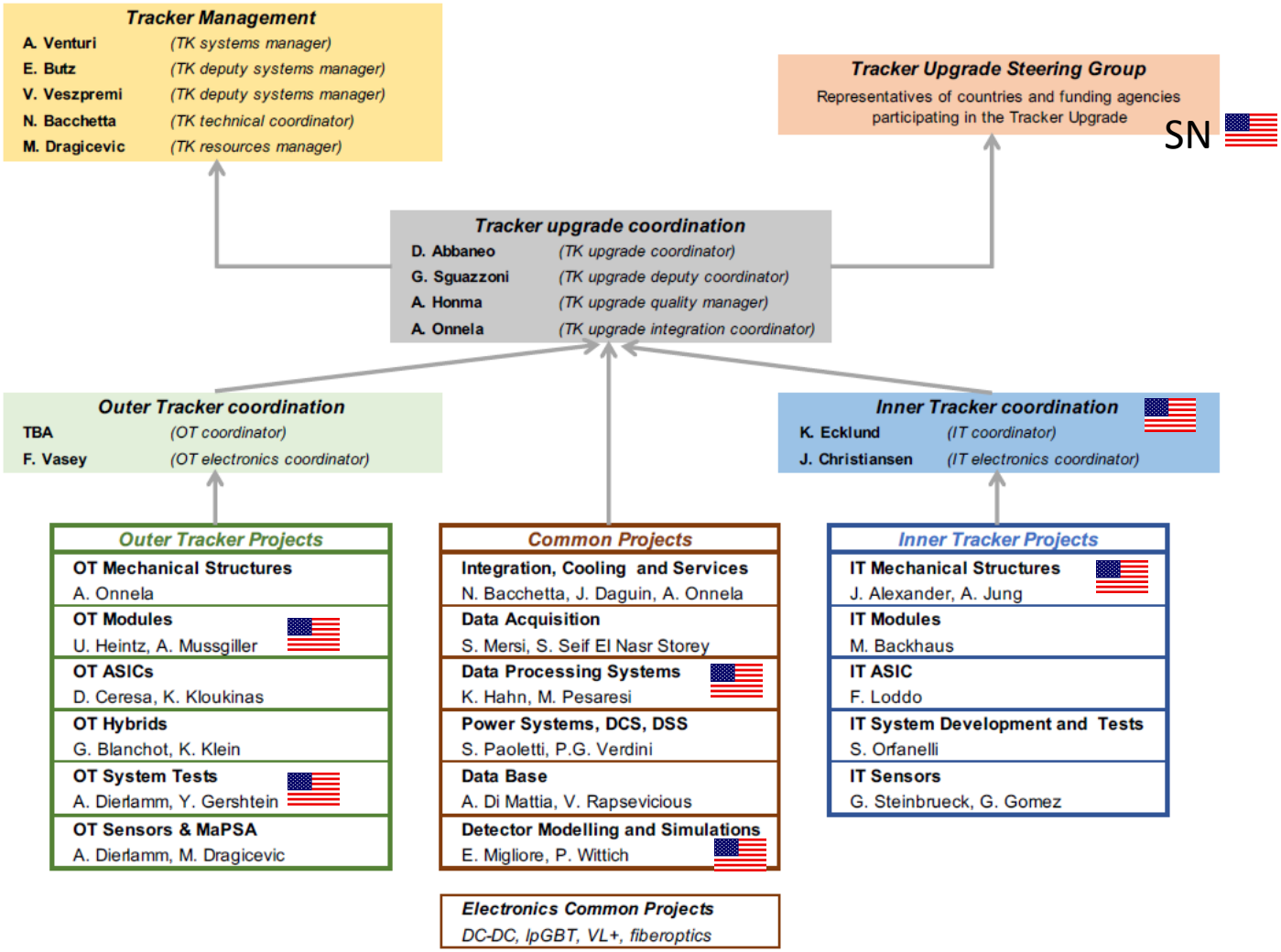
Change in Maturity Estimate between March and December

Completion	Open investigation
90	Thickness
90	Thickness
90	Thickness
60	Final test structure design, exact measurement procedure
95	Optimization, documentation of procedure and compliance
90	Establishment of ITA, interplay with Sensor QC process
90	Carrier card and cooling interface for PS
80	Optical connection, dark box
60	
100	
75	Continued validation of vendors, including testing plan
80	Includes simulations to verify the performance and also synthesis in the FPGA
80	
65	Mounting points, Hybrid design and spacer design and materials, delamination
85	Spacer design and materials, delamination
60	Pending design issues, influencing jigs and glues, Automation, limited prototype parts
80	Pending design issues, influencing jigs and glues, Automation, limited prototype parts
80	Electrical and Mechanical verification
80	Mechanical verification
60	Grounding, Detailed interface and electical/optical/cooling layout
90	Formal concurrence within iCMS

Managerial Progress since June 2018

- June 2018 Review went well for OT
  - All managerial structures in place, well developed
- RLS after June 2018 fairly stable at ~ 3900 activities
  - Will need several refinement iterations before CD-2/3
- Next steps
  - Strengthen formal communication with iCMS OT and documentation base
  - Continue to ramp up formal Project Manager Procedures, a.k.a Earned Value Management
    - Main purpose: acclimate new CAMs to the rigors of EVMS, practicing well ahead of reporting to agencies
      - Can educate CAMs about poor structure in RLS before baseline
      - Also allows reduction of Estimate Uncertainty for completed activities
    - Results are not yet ready for Agency consumption
      - Not productive to raise false alarms this far from production
      - Inputs not always reliable either – this is why you practice!

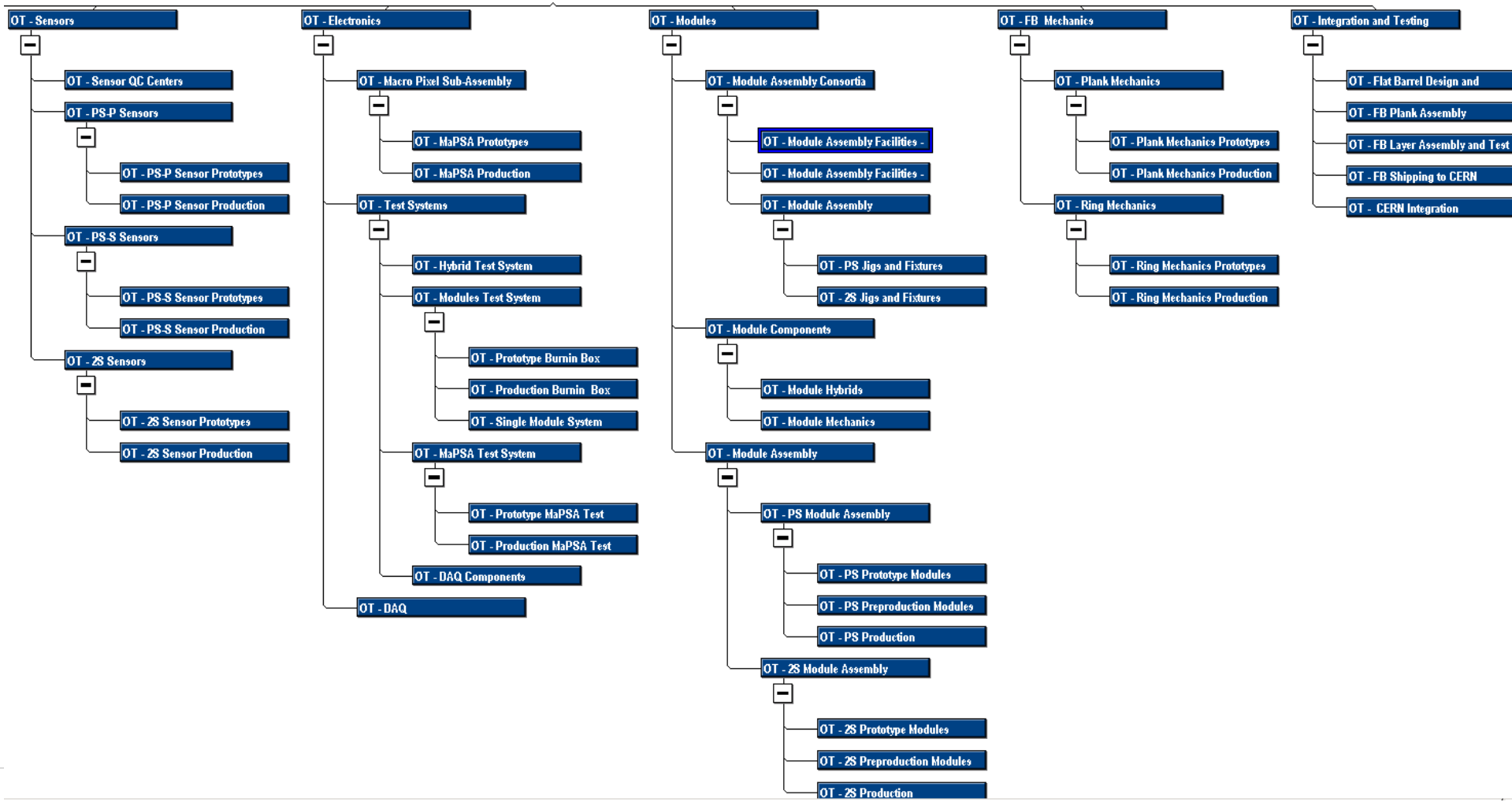
International Organization



- Interface through bi-weekly coordinator meetings and quarterly Tracker Week comprehensive updates plus one-off dedicated workshops

Full Outer Tracker WBS

- Org chart filled to L3, with co-L3s except in sensors
  - Scope at L4 not substantial enough for additional manager except in certain places
    - MaPSA – R Lipton



Documentation improvement opportunities

- Requirements and Interfaces cms-docdb-13388
  - Requirements document conflates specifications with requirements, needs factorization
    - Requirements derive from physics performance, specifications dictate how to meet requirements from an engineering standpoint
      - Requirement: *PS modules must be tolerant to a max fluence of ~ 10^{15} neutron eq/cm^2 and 56 Mrad TID*
      - Specification: *PS Module mechanical structure shall have high thermal conductivity and material's coefficient of thermal expansion matched to silicon sensors*
  - Interfaces document needs considerable overhaul before CD-2
    - Interfaces are known, discussed at least quarterly if not more frequently
    - Document control is not adequate, needs buy-in of iCMS to make valuable
- Project Maturity Estimate cms-docdb-13417
  - Current paradigm mixes pure technical design with project preparedness – should try to make distinction clear
  - Strengthen the quantitative estimate in some places
    - List of required designs and estimate of completeness already started as a result of this review

Earned Value Mandate

- DOE O413.3B

An EVMS is required for all projects with a TPC greater than or equal to $20M. In accordance with FAR Subpart 52.234-4, a contractor's EVMS will be reviewed for compliance with EIA-748C, or as required by the contract. (Further details on establishing, employing, and maintaining a compliant EVMS are found in DOE G 413.3-10A, EIA-748C, and DOE Integrated Program Management Report (IPMR) Data Item Description (DID)).

- NSF LFM

2.3.3 Final Design Phase

2.3.3.1 Introduction – Final Design Phase

The goal of the Final Design Phase is to meet the requirements necessary to advance the proposed project to the subsequent Construction Stage. Budgetary and administrative requirements for entry include NSF review and approval of the project's preliminary design as described in the PEP, and NSB approval to include the project in a future NSF budget request.

Technical requirements include:

- Delivery of designs, specifications and work scope that can be placed for bid to industry;
- Refined bottom-up cost estimates and contingency estimates;
- Implementation of a PMCS for project technical and financial status reporting, including Earned Value Management Systems (EVMS);

- There is no escape
  - See also OMB Circular A-11 and FAR Subpart 34.2 and Parts 234 and 52

Earned Value Management paradigm

- EVMS is a whole system for execution of a project
  - Project planning: WBS, OBS, RAM, WAD, BOEs, Gannt…
  - Project monitoring: Statusing, PMTs, VARs, CPR5, CPI, SPI
  - Project modification: Change Control
- Focusing on "statusing"
  - Monthly process of updating the working schedule, comparing it to the baseline, and analyzing/explaining deviations from the plan
  - Full DOE project intends to start EVMS at FY20 boundary
    - One year before CD-2
    - OT is ahead of the game
  - Previous discussions/trainings
    - OPSS EVM training (Required!)
    - CAM Bootcamp, July 3 2014 (Phase 1, Mu2e, g-2)
    - Phase 1 - HL LHC Workshop, April 5, 2016

Statusing pre-requisites

- Stability
  - Cannot being doing rapid developments and maintain consistent baseline
- Factorization into Control Accounts (reporting level) which are subdivided into Chargable Task Codes (collection level)
  - By CD-2, will need
    - each discrete activity will need to have an associated "Performance Measurement Technique"
    - Discrete activities have "limited duration" (< 60 working days)
      - no matter how one calculates the status, it is done in 3 cycles

Your L2 WBS here

CTC: 402.2L.FnnnST

L = L3: 2=MGMT, 3 = Sensors…

F= Funds: 1 = OPC, 2 = MIE

nnn just counts CTCs

S is Site: 0=CERN, 1 = FNAL, 9= UNIV

T = Type: 1 = Labor, 2 = M&S, 3 = Travel, 4= COLA

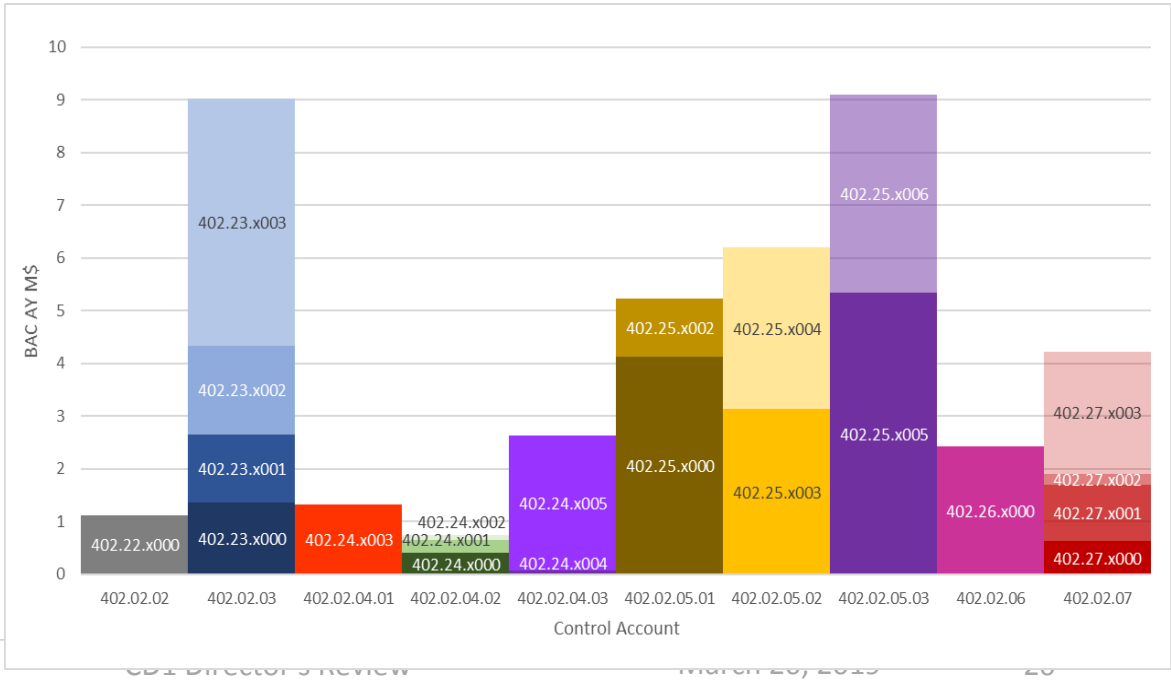
Code Value	Description
A	Level of Effort Task
B	Milestones
C	% Complete
D	Units Completed
E	50-50
F	0-100
H	User Defined
K	Planning Package

OT RAM and CTC distribution

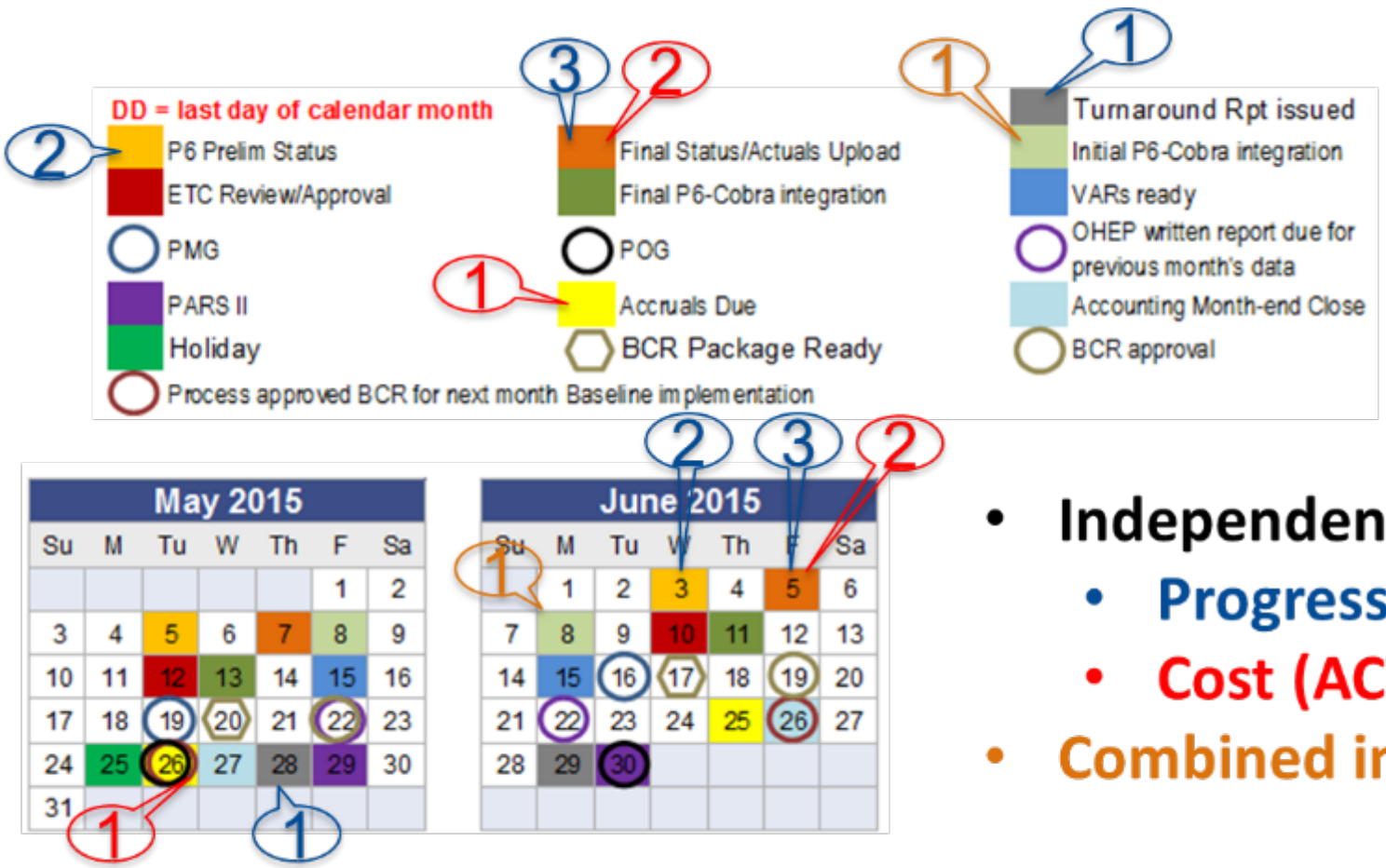
- 10 Control Accounts
- 7 CAMs
- 22 CTC Categories
  - 528 (!) CTCs with all the multiplicity

Control Account	Control Account	Chargeable Task Code	Fu Ty	A ID	Activ Name	Planned Material Cost	Planned Labor Units	Planned Labor Cost	Planned Nonlabor Units	Planned Nonlabor Cost	Planned Total Cost
⊟ Control Account Manager: Nahn, Steve						$1,122,115	30056	$0	10608	$0	$1,122,115
⊞ 402.02.02 OT - Management						$1,122,115	30056	$0	10608	$0	$1,122,115
⊟ Control Account Manager: Heintz, Ulrich						$7,300,159	1848	$127,629	28616	$1,590,139	$9,017,927
⊞ 402.02.03 OT - Sensors						$7,300,159	1848	$127,629	28616	$1,590,139	$9,017,927
⊟ Control Account Manager: Gershtein, Yuri						$495,522	2954	$290,747	2080	$42,079	$828,348
⊞ 402.02.04.02 OT - Test Systems						$495,522	2954	$290,747	2080	$42,079	$828,348
⊟ Control Account Manager: Gruenendahl, Stefan						$3,498,442	45693	$2,932,467	9816	$207,783	$6,638,692
⊞ 402.02.06 OT - FB Mechanics						$746,537	13329	$1,468,503	6960	$207,783	$2,422,824
⊞ 402.02.07 OT - Integration and Testing						$2,751,904	32364	$1,463,964	2856	$0	$4,215,869
⊟ Control Account Manager: Canepa, Anadi						$1,186,807	22357	$2,308,876	4802	$406,339	$3,902,022
⊞ 402.02.04.01 OT - Macro Pixel Sub-Assembly						$1,167,115	4485	$151,771	0	$0	$1,318,886
⊞ 402.02.04.03 OT - DAQ						$19,692	17872	$2,157,105	4802	$406,339	$2,583,136
⊟ Control Account Manager: Spiegel, Lenny						$6,032,659	1669	$150,369	1003	$18,744	$6,201,772
⊞ 402.02.05.02 OT - Module Components						$6,032,659	1669	$150,369	1003	$18,744	$6,201,772
⊟ Control Account Manager: Narain, Meenakshi						$4,748,874	48967	$3,941,869	150533	$5,649,725	$14,340,468
⊞ 402.02.05.01 OT - Module Sites						$2,908,797	12157	$912,256	14438	$1,415,829	$5,236,882
⊞ 402.02.05.03 OT - Module Assembly						$1,840,077	36810	$3,029,613	136095	$4,233,896	$9,103,586
⊞ No Control Account Manager						$0	0	$0	0	$0	$0

CA	CA Name	Sche	Schema Name
⊟402.02.02	⊟OT Management	⊟000	Management
⊟402.02.03	⊟OT Sensors	⊟000	Sensors QC Sites
		⊟001	Sensors PS-P
		⊟002	Sensors PS-S
		⊟003	Sensors 2S
⊟402.02.04.01	⊟OT MaPSA	⊟003	Electronics MaPSA
⊟402.02.04.02	⊟OT Test Systems	⊟000	Electronics Module Test
		⊟001	Electronics MaPSA Test
		⊟002	Electronics Hybrid Testing
⊟402.02.04.03	⊟OT DAQ	⊟004	Electronics DAQ Components
		⊟005	Electronics DAQ Systems
⊟402.02.05.01	⊟OT Module Sites	⊟000	Modules Site Infrastructure
		⊟002	Modules Common Infrastructure
⊟402.02.05.02	⊟OT Module Components	⊟003	Modules Hybrids
		⊟004	Modules Mechanics
⊟402.02.05.03	⊟OT Module Assembly	⊟005	Modules PS
		⊟006	Modules 2S
⊟402.02.06	⊟OT Mechanics	⊟000	Mechanics
⊟402.02.07	⊟OT Integration	⊟000	Integration Flat Barrel Design
		⊟001	Integration Assembly
		⊟002	Integration Shipping
		⊟003	Integration Integration at CERN



Earned Value (Monthly) Cycle



- **Independently Updated**
  - **Progress (BCWP)**
  - **Cost (ACWP)**
- **Combined in Cobra**

- Rather relentless cycle, cannot be skipped post-baseline
  - Results go into DOE PARS every month, are reported to Agencies every month
  - Non-intuitive for most new CAMs – good to get experience early

Collection of Work Performed

- Turnaround report = google sheet extracted from P6
- CAM Instructions:
  - Was this activity started in the current period?
    - If so, enter actual start date
  - Was this activity finished in the current period?
    - If so, enter actual finish date
    - If not, optionally enter expected finish date
  - Was any progress made at all in the current period?
    - Update Percent complete, based on the PMT
  - Use comment field to indicate actions like “reduce duration to keep end date fixed” etc

Activity ID	Activity Name	Activity Type	Activity Status	Planned Duration	BL Start	BL Finish	Start	Finish	Actual Start	Actual Finish	Expect. Finish	Act. % Comp.
OT310092	Setup PQC infrastructure (Rochester)	Task Depe	In Progress	250d	2-Oct-17	28-Sep-18	02-Oct-17 A	1-Mar-19	2-Oct-17			42%
OT310260	Supervise Rochester QC Center - FY18	Task Depe	In Progress	250d	2-Oct-17	28-Sep-18	02-Oct-17 A	28-Sep-18	2-Oct-17			92.00%
OT310270	Maintain Rochester QC Center - FY18	Task Depe	In Progress	250d	2-Oct-17	28-Sep-18	02-Oct-17 A	28-Sep-18	2-Oct-17			92.00%
OT310280	Maintain Brown QC Center - FY18	Task Depe	In Progress	250d	2-Oct-17	28-Sep-18	02-Oct-17 A	28-Sep-18	2-Oct-17			92.00%
OT310290	Purchase semiautomatic prober	Task Depe	Not Started	30d	2-Jan-18	13-Feb-18	1-Aug-18	12-Sep-18				0%
OT310300	Supervise Brown QC Center - FY18	Task Depe	In Progress	250d	2-Oct-17	28-Sep-18	02-Oct-17 A	28-Sep-18	2-Oct-17			92.00%
OT310320	Irradiate Novati SBIR phase 2 material with neutrons - Lab	Task Depe	Not Started	10d	3-Nov-17	16-Nov-17	1-Aug-18	14-Aug-18				0%
OT310325	Irradiate Novati SBIR phase 2 material with neutrons - M&	Task Depe	Not Started	10d	3-Nov-17	16-Nov-17	1-Aug-18	14-Aug-18				0%
OT310330	Measure Novati SBIR phase 2 wafers (Brown)	Task Depe	Not Started	60d	3-Nov-17	5-Feb-18	1-Aug-18	24-Oct-18				0%
OT310340	Measure Novati SBIR phase 2 wafers (Rochester)	Task Depe	Not Started	60d	3-Nov-17	5-Feb-18	1-Aug-18	24-Oct-18				0%
OT310350	Train personnel on semiautomatic prober	Task Depe	Not Started	20d	14-Feb-18	13-Mar-18	13-Sep-18	10-Oct-18				0%
OT310360	Irradiate Novati SBIR phase 2 material with protons - Labo	Task Depe	Not Started	10d	20-Nov-17	5-Dec-17	1-Aug-18	14-Aug-18				0%
OT310365	Irradiate Novati SBIR phase 2 material with protons - M&S	Task Depe	Not Started	10d	20-Nov-17	5-Dec-17	1-Aug-18	14-Aug-18				0%
OT310390	Evaluate neutron-irradiated Novati SBIR phase 2 material	Task Depe	Not Started	30d	19-Dec-17	5-Feb-18	13-Sep-18	24-Oct-18				0%
OT310420	Purchase process QC equipment (Brown)	Task Depe	In Progress	60d	2-Jan-18	27-Mar-18	02-Jul-18 A	8-Oct-18	2-Jul-18			40%
OT310450	Evaluate proton-irradiated Novati SBIR phase 2 material	Task Depe	Not Started	30d	7-Mar-18	17-Apr-18	8-Nov-18	21-Dec-18				0%
OT310470	Revise Labview code for interstrip tests	Task Depe	In Progress	60d	2-Apr-18	25-Jun-18	02-Apr-18 A	21-Aug-18	2-Apr-18	21-Aug-18		100%
OT310480	Write Labview code for process QC	Task Depe	In Progress	60d	25-Apr-18	19-Jul-18	25-Oct-17 A	9-Nov-18	25-Oct-17			80%
OT310490	T5 - Novati SBIR Phase 2 Complete	Finish Mil	Not Started	0d		17-Apr-18		21-Dec-18				0%
OT310520	Write code to automate visual inspection	Task Depe	Not Started	60d	1-Oct-18	27-Dec-18	12-Nov-18	12-Feb-19	1-Aug-18			10%
OT310530	Maintain Rochester QC Center - FY19H1	Task Depe	Not Started	123d	1-Oct-18	29-Mar-19	1-Oct-18	29-Mar-19				0%
OT310540	Supervise Rochester QC Center - FY19H1	Task Depe	Not Started	123d	1-Oct-18	29-Mar-19	1-Oct-18	29-Mar-19				0%
OT310550	Maintain Brown QC Center - FY19H1	Task Depe	Not Started	123d	1-Oct-18	29-Mar-19	1-Oct-18	29-Mar-19				0%
OT310560	Supervise Brown QC Center - FY19H1	Task Depe	Not Started	123d	1-Oct-18	29-Mar-19	1-Oct-18	29-Mar-19				0%
OT310580	Define and setup tracking system for sensor QC	Task Depe	Not Started	60d	2-Jan-19	27-Mar-19	13-Feb-19	8-May-19				0%
OT310721	T5 - Sensor QC Site Setup Complete (Rochester)	Finish Mil	Not Started	0d		28-Sep-18		1-Mar-19				0%
OT310860	Purchase long term test setup (Rochester)	Task Depe	Not Started	20d	28-Mar-18	24-Apr-18	25-Oct-18	21-Nov-18				0%
OT310870	Purchase PQC setup (Rochester)	Task Depe	Not Started	60d	2-Jan-18	27-Mar-18	1-Aug-18	24-Oct-18				0%
OT310880	Purchase switch matrix and probe cards for process QC (B	Task Depe	Not Started	40d	28-Mar-18	22-May-18	9-Oct-18	5-Dec-18	1-Aug-18			20%
OT310890	Purchase long term test setup (Brown)	Task Depe	Not Started	20d	23-May-18	20-Jun-18	6-Dec-18	8-Jan-19				0%
402.2W.3.2 OT - PS-P Sensors				**174d**	**20-Jul-18**	**13-Feb-19**	**4-Sep-18**	**15-May-19**				
402.2W.3.2.1 OT - PS-P Sensor Prototypes				**174d**	**20-Jul-18**	**13-Feb-19**	**4-Sep-18**	**15-May-19**				
OT320100	Perform process QC for HPK prototype PS-P sensors (Lot (	Task Depe	Not Started	60d	20-Jul-18	12-Oct-18	12-Nov-18	12-Feb-19	1-Aug-18	31-Aug-18		100%
OT320110	Perform process QC for HPK prototype PS-P sensors (Lot (	Task Depe	Not Started	60d	20-Jul-18	12-Oct-18	12-Nov-18	12-Feb-19	1-Aug-18	31-Aug-18		100%
OT320120	Irradiate HPK prototype PS-P sensors with protons - M&S	Task Depe	Not Started	15d	17-Aug-18	7-Sep-18	12-Dec-18	7-Jan-19	1-Aug-18	8-Aug-18		100%
OT320130	Irradiate HPK prototype PS-P sensors with protons - Labor	Task Depe	Not Started	15d	17-Aug-18	7-Sep-18	12-Dec-18	7-Jan-19	1-Aug-18	8-Aug-18		100%
OT320140	Irradiate HPK prototype PS-P sensors with neutrons- M&S	Task Depe	Not Started	10d	31-Aug-18	14-Sep-18	28-Dec-18	14-Jan-19	1-Aug-18	8-Aug-18		100%

Collection of Actuals

- Financial information available from Project Office financial officer
- Three sources
  - Invoices to FNAL – each PO Line has a CTC
  - Fermilab labor charging to CTCs
    - CAM ensure it is the correct one, or at least in the same Control Account
      - So too many CTCs is confusing
    - Make sure no one is charging for unbudgeted work
  - Accruals: L2s/PIs estimate invoice lag
    - Many Variance reports attributed to missing inaccurate (both over- and under-) accruals

HL-LHC CMS DETECTOR UPGRADE PROJECT 402
All Purchase Order (excluding FINAL Closed POs/lines) Report By Vendor
As of 11/6/18
CTC/Task (Multiple Items)

Row Labels	$ Ordered	$ Billed	$ Real Open	Remaining funds
IOWA UNIVERSITY OF	20,000.00	20,000.00	0.00	0.0%
BOSTON UNIVERSITY	75,502.00	72,822.08	2,679.92	3.5%
ROCHESTER, UNIVERSITY OF	250,817.00	246,049.15	4,767.85	1.9%
PURDUE UNIVERSITY	8,791.00	2,500.00	6,291.00	71.6%
PRINCETON UNIVERSITY	152,143.00	119,251.41	32,891.59	21.6%
CALIFORNIA AT DAVIS UNIVERSITY OF	106,711.00	39,482.46	67,228.54	63.0%
RUTGERS, STATE UNIVERSITY	317,923.00	166,203.40	151,719.60	47.7%
BROWN UNIVERSITY	961,189.00	405,142.00	556,047.00	57.8%
Grand Total	**1,893,076.00**	**1,071,450.50**	**821,625.50**	**43.4%**

HCAL POs — 401 — Contact: Jay Dittmann (Jay_Dittmann@baylor.edu)

Vendor Name	PuS	Task Number	Pu Line $	PO SHIP $	PO DIST $	Item Description	Total Obl.	OCT18-19 INVOICE	NOV18-19 INVOICE	TOTAL INVOICED	NOV18-19 ADD'L ACCRUALS	Amt. Remaining
BROWN UNIVE	615706	401.20001	1	1	1	401.02.02.01REIMBURSEMEI	$4,000.00			4,000.00		$0.00
BROWN UNIVE	615706	401.20011	2	1	1	401.02.03.04.05.02 REIMBUI	$3,000.00			3,000.00		$0.00
BROWN UNIVE	615706	401.20011	3	1	1	401.02.03.04.05.03 REIMBUI	$1,500.00			1,500.00		$0.00
BROWN UNIVE	615706	401.20031	4	1	1	401.02.05.15.04REIMBURSEI	$47,700.64			47,700.64		$0.00
BROWN UNIVE	615706	401.20013	5	1	1	401.02.03.10 · OPTICAL FIBE	$33,140.00			33,140.00		$0.00
BROWN UNIVE	615706	401.20003	6	1	1	401.02.02 · HCAL MANAGEI	$10,000.00			10,000.00		0.00
BROWN UNIVE	615706	401.20003	7	1	1	401.02.02 · HCAL MANAGEI	$9,000.00			9,000.00		0.00
BROWN UNIVE	615706	401.20013	8	1	1	401.02.03.10 · OPTICAL FIBE	$17,200.00			17,200.00		0.00
BAYLOR UNIVE	621759	401.20143	1	1	1	401.02.04.09 · HB/HE NGCC	$3,200.00			3,200.00		$0.00
BAYLOR UNIVE	621759	401.20133	2	1	1	401.02.04.12 · INTEGRATEC	$9,700.00			9,700.00		$0.00
BAYLOR UNIVE	621759	401.20023	3	1	1	401.02.04.07 · CJE CARDS T	$5,000.00			5,000.00		$0.00
BAYLOR UNIVE	621759	401.20023	4	1	1	401.02.04.07 · CJE CARDS N	$3,000.00			3,000.00		$0.00
BAYLOR UNIVE	621759	401.20133	5	1	1	401.02.04.12 · INTEGRATEC	$8,000.00			8,000.00		$0.00
BAYLOR UNIVE	621759	401.20133	6	1	1	401.02.04.15 · RBX LEVEL TE	$8,000.00			8,000.00		$0.00
BAYLOR UNIVE	621759	401.20003	7	1	1	401.02.02 · HCAL MANAGEI	$23,348.00			23,348.00		$0.00
BAYLOR UNIVE	621759	401.20003	8	1	1	401.02.02 · HCAL MANAGEI	$34,500.00			34,500.00		$0.00
BAYLOR UNIVE	621759	401.20023	9	1	1	401.02.04.06 · HBHE RADIA	$201,762.00	2,354.52		201,762.00		$0.00
BAYLOR UNIVE	621759	401.20003	10	1	1	WBS 401.02.02 · HCAL MAN	$44,000.00	7,454.15		23,140.12		20,859.88
IOWA UNIVER	615650	401.20011	1	1	1	WBS 401.02.03.04.04 PROTC	$24,810.00			$24,810.00		$0.00
IOWA UNIVER	615650	401.20011	2	1	1	WBS 401.02.03.04.04 PROTC	$22,500.00			$22,500.00		$0.00
IOWA UNIVER	615650	401.20011	3	1	1	WBS 401.02.03.04.05 HF FR	$40,823.00			$40,823.00		$0.00
IOWA UNIVER	615650	401.20011	4	1	1	WBS 401.02.03.04.05 HF FR	$4,578.00			$4,578.00		$0.00
IOWA UNIVER	615650	401.20011	5	1	1	WBS 401.02.03.04.05 HF FR	$9,000.00			$9,000.00		$0.00
IOWA UNIVER	615650	401.20011	6	1	1	WBS 401.02.03.04.05 HF FR	$2,500.00			$2,500.00		$0.00
IOWA UNIVER	615650	401.20071	7	1	1	WBS 401.02.04.08 CALIBRAT	$26,724.00			$26,724.00		$0.00
IOWA UNIVER	615650	401.20071	8	1	1	WBS 401.02.04.10 COOLING	$26,928.00			$26,928.00		$0.00
IOWA UNIVER	615650	401.20071	9	1	1	WBS 401.02.04.11 READOUT	$24,684.00			$24,684.00		$0.00
IOWA UNIVER	615650	401.20013	10	1	1	WBS 401.02.03.07 CALIBRAT	$5,880.00			$5,880.00		$0.00
IOWA UNIVER	615650	401.20013	11	1	1	WBS 401.02.03.07 CALIBRAT	$9,630.00			$9,630.00		$0.00

Quantitative Earned Value

Outer Tracker file for Status Testing

May 31, 2018

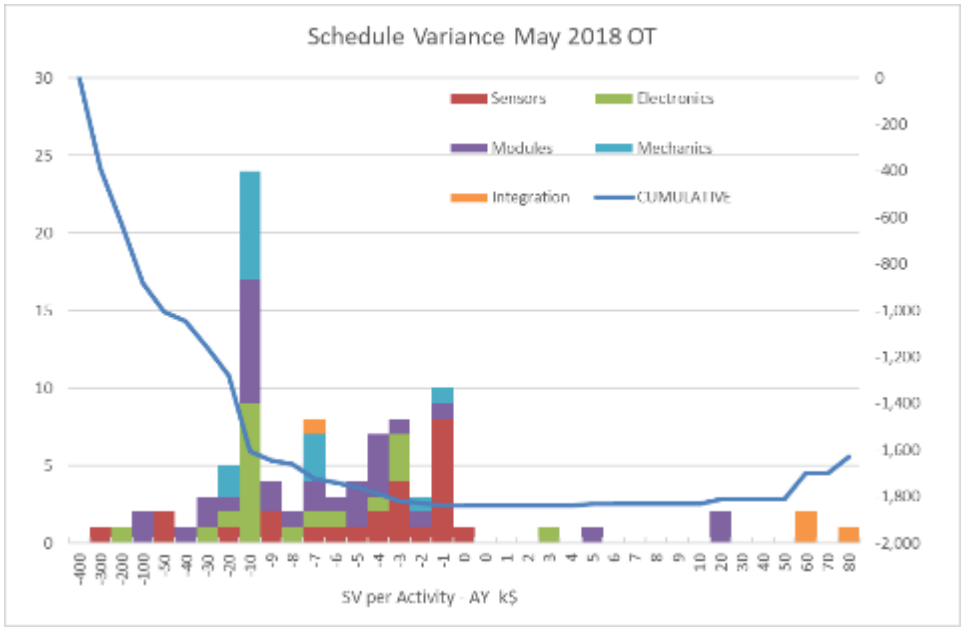
Currency in: Fully Burdened AY$

	Current Period							Cumulative to Date									At Complete				
Cntrl Acct	**Budget**	**Earned**	**Actuals**	**SV ($)**	**SV (%)**	**CV ($)**	**CV (%)**	**Budget**	**Earned**	**Actuals**	**SV ($)**	**SV (%)**	**CV ($)**	**CV (%)**	**SPI**	**CPI**	**BAC**	**EAC**	**VAC**	**% Spent**	**% Complete**
402.02.02 OT Management	9,517	9,517	7,816	0	0%	1,701	18%	71,813	71,813	48,828	0	0%	22,985	32%	1.00	1.47	852,489	829,505	22,985	6%	8%
402.02.03 OT Sensors	19,779	16,710	0	(3,070)	-16%	16,710	100%	1,020,824	411,461	261,066	(609,363)	-60%	150,395	37%	0.40	1.58	9,573,949	9,427,133	146,816	3%	4%
402.02.04.01 OT MaPSA	45,934	46,736	1,331	802	2%	45,404	97%	164,529	70,358	26,713	(94,171)	-57%	43,645	62%	0.43	2.63	3,151,183	3,110,514	40,669	1%	2%
402.02.04.02 OT Test Systems	15,366	36,039	3,616	20,672	135%	32,423	90%	400,974	316,960	626,799	(84,013)	-21%	(309,839)	-98%	0.79	0.51	1,114,968	1,425,183	(310,215)	44%	28%
402.02.04.03 OT DAQ	36,504	82,979	18,008	46,475	127%	64,972	78%	617,687	343,566	115,552	(274,121)	-44%	228,013	66%	0.56	2.97	1,331,511	1,108,693	222,817	10%	26%
402.02.05.01 OT Module Sites	20,443	20,443	37,707	0	0%	(17,263)	-84%	770,048	421,869	656,701	(348,180)	-45%	(234,833)	-56%	0.55	0.64	4,782,847	5,018,020	(235,173)	13%	9%
402.02.05.02 OT Module Components	3,393	3,520	6,529	127	4%	(3,009)	-85%	100,473	86,206	47,172	(14,266)	-14%	39,035	45%	0.86	1.83	6,511,645	6,460,854	50,792	1%	1%
402.02.05.03 OT Module Assembly	61,866	48,146	2,990	(13,720)	-22%	45,156	94%	1,033,993	831,005	73,997	(202,988)	-20%	757,008	91%	0.80	11.23	9,527,900	8,777,360	750,540	1%	9%
402.02.06 OT Mechanics	15,933	4,381	36,688	(11,553)	-73%	(32,308)	-738%	393,663	217,109	688,210	(176,554)	-45%	(471,101)	-217%	0.55	0.32	2,074,787	2,571,521	(496,735)	27%	10%
402.02.07 OT Integration	2,588	61,477	15,245	58,889	2275%	46,233	75%	28,960	201,101	15,245	172,141	594%	185,856	92%	6.94	13.19	1,757,616	1,568,227	189,390	1%	11%
Total	**231,325**	**329,949**	**129,929**	**98,624**	**43%**	**200,019**	**61%**	**4,602,963**	**2,971,449**	**2,560,284**	**(1,631,514)**	**-35%**	**411,165**	**14%**	**0.65**	**1.16**	**40,678,896**	**40,297,010**	**381,886**	**6%**	**7%**
Management Reserve																	0	0			
TAB																	40,678,896	40,297,010			

- Current period (example from July 2018)
  - BCWS 231k, BCWP 330k -> Positive SV of 99k – catching up
    - Integration contributes 59k, DAQ 47k, Test Systems 21k
  - ACWP 130k, BCWP 330k -> Positive CV of 200k – not costing as much
    - Lots of sizable contributions
- Cumulative
  - BCWS 4.602M, BCWP 2.971M -> Negative SV of 1.6M
    - Much in procurements, see next slide
  - ACWP 2.560 M, BCWP 2.971M -> Positive CV of 411k
  - Considerable imbalance at Control Account level (except management ;))
- Control Accounts with RED write Variance Analysis
  - Sometimes Control Accounts with Yellow write Variance Analysis
  - OT will start in 2019

Schedule Variance

- Can examine activity by activity
  - Cost is harder!
- Overall -1.6M on 4.5M earned
  - 1M in worst 6 activities
  - Much is procurement, which hadn't happened quite yet



Activity	Budget	Earned	SV
Purchase semiautomatic prober	392		-392
Develop optical link w/ FC7-based CIC-emu - FN	361	123	-238
Receive and install gantry upgrade	136		-136
Receive optical measurement tool (Brown)	119		-119
Purchase PQC setup (Rochester)	66		-66
Purchase switch matrix and probe cards for process	54		-54
Validate 2S wire bonding procedures/fixtures (RU)	45	4	-40
Develop FW DTC V2 - RU	46	7	-39
Build automated PS assembly stage (Brown) Labor	51	13	-38
Receive and install multi-axis stages (Brown)	37		-37
Perform mechanical FEA - Ring Prototype	24		-24
Perform thermal FEA - Ring Prototype	24		-24
Validate type 2 assembly procedures (FNAL) Labor	82	58	-24
Purchase process QC equipment (Brown)	23		-23
Vendor assemble dummy MaPSAs	78	55	-23
Test functional prototype MaPSAs (Brown) Labor	19		-19
Design prototype ring insertion tooling	18		-18
Design prototype ring-plank mounting tooling	18		-18
Receive and install Module Assembly Infrastructure	17		-17
Automate type 1 PS prototype assembly (Brown) La	22	5	-16
Underfill studies on dummy MaPSAs (FNAL)	16		-16
Test dummy MaPSAs (FNAL)	16		-16
Design tooling for module mounting - Inner Prototy	31	16	-16
Design mechanical components for Burnin Final (FN	21	7	-14
Design test setup for prototypes (FNAL)	13		-13
Design fixturing for Outer Prototype	13		-13
Vendor assembles prototype MaPSAs - Vendor 1	13		-13
Vendor assembles prototype MaPSAs - Vendor 2	13		-13
Deliver 3 x FC7 and BE Board for single module testi	13		-13
Design fixturing for Middle Prototype	13		-13
Design tooling for module mounting - Middle Proto	13		-13
Design tooling for module mounting - Outer Prototy	13		-13
Receive and install auxiliary test equipment - FY18	12		-12
Receive miscellaneous lab equipment - FY18 (Brow	12		-12
Investigate parylene coating (BR) Labor	20	9	-11
Design cryo components for Burnin Final (FN)	16	5	-11
Deliver cryo components for Burnin Proto (PU)	10		-10
Validate 2S wire bonding procedures/fixtures (PU)	17	7	-10
Assemble functional prototype - CBC2 (BR) M&S	19	8	-10
Purchase long term test setup (Brown)	10		-10
Purchase long term test setup (Rochester)	10		-10
Vendor delivers PS Al-CF spacer prototypes - FY18	14	5	-10

Shows up in milestones too

- Milestones reportable to DOE
  - 6 month window, not the nominal current period ± one month
  - Can see knock on effects here
  - Here, planning looks over-optimistic on many fronts

Baseline in past

>1 month behind

>1 month ahead

Activity Name	Activity Status	Baseline Date	Working Date
T3 Milestone - Fermilab Directorate		**Baseline**	**Forecast**
T3 - Ring Prototype Design Complete		11-Sep-18	17-Apr-19
T3 - Plank Prototype Design Complete		19-Jul-18	27-Jun-19
T4 Milestone - Project Manager		**Baseline**	**Forecast**
T4 - Completion of Prototype MaPSA test system design iteration 1	Completed	5-Mar-18	1-May-18
T4 - Prototype Burn-in system complete		29-Mar-18	4-Dec-18
T4 - Plank Prototype Design Complete		24-Apr-18	3-Apr-19
T4 - Gantry Upgrade Delivered		24-May-18	23-Oct-18
T4 - Ring Prototype Design Complete		15-Jun-18	23-Jan-19
T4 - Sensor QC Site apparatus procurement complete		19-Jul-18	19-Dec-18
T4 - Plank Mechanics Prototype Design Complete		19-Jul-18	27-Jun-19
T4 - Single Module test system complete		26-Jul-18	4-Dec-18
T4 - Completion of Prototype MaPSA test system design	Completed	22-Aug-18	1-May-18
T4 - FInal design of Burn-in system complete		27-Aug-18	8-May-19
T4 - Conceptual Design of Flat Barrel Services complete		28-Aug-18	26-Nov-18
T4 - Prototype Ring Design Complete		11-Sep-18	17-Apr-19
T4 - First functional 2S Module fabrication complete		1-Oct-18	11-Mar-19
T4 - Functional 2S Module Prototype Completed		28-Dec-18	4-Jun-19

Baseline Change Requests

- Using Fermilab standard BCR tool for RLS modification
  - 17 BCRs at least in Draft or further since July 2018
  - Can prototype changes in P6, but pushing everything through Cobra is the time consuming part

BCR Number	Title	Status	WBS Number	Affected Control Accounts	Creation Date	Approval Date
HL-LHC CMS Detector Upgrade_0004	OT BCR 01 - FNAL Funding in FY18	Closed	402.2	402.02.04.01 - OT - MaPSA, 402.02.04.02 - OT - Test Systems, 402.02.05.01 - OT - Module Sites, 402.02.05.02 - OT - Module Components, 402.02.05.03 - OT - Module Assembly	7/25/2018	7/25/2018
HL-LHC CMS Detector Upgrade_0005	OT BCR 05 - Bethel Funding FY19	Closed	402.02.05.03	402.02.05.03 - OT - Module Assembly	8/7/2018	8/28/2018
HL-LHC CMS Detector Upgrade_0006	OT BCR 06 -Princeton Funding FY18 change	Closed	402.02.05.03	402.02.05.03 - OT - Module Assembly	8/7/2018	8/28/2018
HL-LHC CMS Detector Upgrade_0008	Flat Barrel BCR August 2018	Closed	402.2	402.02.02 - OT - Management, 402.02.07 - OT - Integration	8/13/2018	9/17/2018
HL-LHC CMS Detector Upgrade_0010	Schedule Modifications for OT	Closed	402.2	402.02.02 - OT - Management, 402.02.03 - OT - Sensors, 402.02.04.01 - OT - MaPSA, 402.02.04.02 - OT - Test Systems, 402.02.04.03 - OT - DAQ, 402.02.05.01 - OT - Module Sites, 402.02.05.02 - OT - Module Components, 402.02.05.03 - OT - Module Assembly, 402.02.06 - OT - Mechanics, 402.02.07 - OT - Integration	8/29/2018	9/26/2018
HL-LHC CMS Detector Upgrade_0011	Change request for OT Modules - Assembly Facilities Fermilab, Mechanics, and 2S Jigs and Fixtures	Closed	402.2.5	402.02.05.01 - OT - Module Sites, 402.02.05.02 - OT - Module Components	8/30/2018	9/24/2018
HL-LHC CMS Detector Upgrade_0012	Hybrid cold box for Brown to be purchased through Rutgers (East Coast Consortium)	Closed	402.2.4.2.1	402.02.04.02 - OT - Test Systems	8/31/2018	9/24/2018
HL-LHC CMS Detector Upgrade_0013	uTCA crate for module burn in system for Princeton to be purchased through Rutgers (East Coast Consortium)	Closed	402.2.4.2.2.2	402.02.04.02 - OT - Test Systems	8/31/2018	9/24/2018
HL-LHC CMS Detector Upgrade_0015	Testbeam Support FY19	Closed	402.2.4.3	402.02.04.03 - OT - DAQ	8/31/2018	9/24/2018
HL-LHC CMS Detector Upgrade_0016	Cost reduction to match funding guidance	Closed	402.2	402.02.02 - OT - Management, 402.02.03 - OT - Sensors, 402.02.04.01 - OT - MaPSA, 402.02.04.02 - OT - Test Systems, 402.02.04.03 - OT - DAQ, 402.02.05.01 - OT - Module Sites, 402.02.05.02 - OT - Module Components, 402.02.05.03 - OT - Module Assembly, 402.02.06 - OT - Mechanics, 402.02.07 - OT - Integration	12/3/2018	1/3/2019
HL-LHC CMS Detector Upgrade_0021	OT - Milestones for CMS component availability	Draft	402.2	402.02.03 - OT - Sensors	1/15/2019	
HL-LHC CMS Detector Upgrade_0022	Hybrid Testing Rescheduling	Approved	402.2.4.2.1	402.02.04.02 - OT - Test Systems	1/16/2019	1/22/2019
HL-LHC CMS Detector Upgrade_0023	Cost reduction to match funding guidance - Reprise - January 2019	Approved	402.2	402.02.02 - OT - Management	1/25/2019	1/29/2019
HL-LHC CMS Detector Upgrade_0024	Adjustment to sensor prototype schedule	Draft	402.2.3	402.02.03 - OT - Sensors	1/27/2019	
HL-LHC CMS Detector Upgrade_0025	Mini-rebaseline prior to CD1 - sequel	Draft	402.2	402.02.04.01 - OT - MaPSA, 402.02.04.02 - OT - Test Systems, 402.02.04.03 - OT - DAQ, 402.02.05.01 - OT - Module Sites, 402.02.05.02 - OT - Module Components, 402.02.05.03 - OT - Module Assembly, 402.02.06 - OT - Mechanics	2/6/2019	
HL-LHC CMS Detector Upgrade_0027	Release film for carbon fiber plate production	Draft	402.2.5.2	402.02.05.02 - OT - Module Components	2/22/2019	
HL-LHC CMS Detector Upgrade_0028	OT BCR 0028 - Change for Rutgers Funding FY19	Draft	402.02.05	402.02.05.01 - OT - Module Sites, 402.02.05.03 - OT - Module Assembly	2/23/2019	

Statusing effort so far

- OT has been attempting to status monthly since January 2018
  - Succeeded in collecting and turning crank in January, February, April, May, June, July, August
    - Lessons learned about how to status, what it means
    - Hindered by an outdated schedule and reviews
  - Since August many many BCRs to get SOW ~ RLS, adjust schedule, etc
    - Also Project Controls busy with higher priority items
    - Probably an indication that we started this too early
- Plan going forward
  - Realign current schedule and restart statusing (after review)
  - Add missing pieces
    - Accrual collection – next step to getting accurate statusing results
    - VAR analysis – next step to getting CAMs to grok the system
- Main issue
  - Sustained statusing requires continuity in baseline – so baseline changes and change requests (requirement of EVMS), which take a lot of time and hinder timely RLS development
    - Project Controls resource is a limiting factor, Project Office knows

Summary

- Technically we continue to make progress in all areas
  - Main worry: Lack of parts to work with for Module Assembly -- the next iteration of parts seems to be flowing now
- Managerially,
  - We do have some documentation to clean up
  - For EVMS we are (perhaps too far) ahead of the game
    - Worthwhile to practice formal management
      - Machinery and constructs in place to perform EVMS
      - CAMs are getting accustomed to how EVMS works with the RLS, how the SOWS tie into the RLS, and how they will monitor and modify the plan
      - Learn where resources and processes need to be bolstered early
  - We are beyond CD-1 level (still), and on the way to CD-2