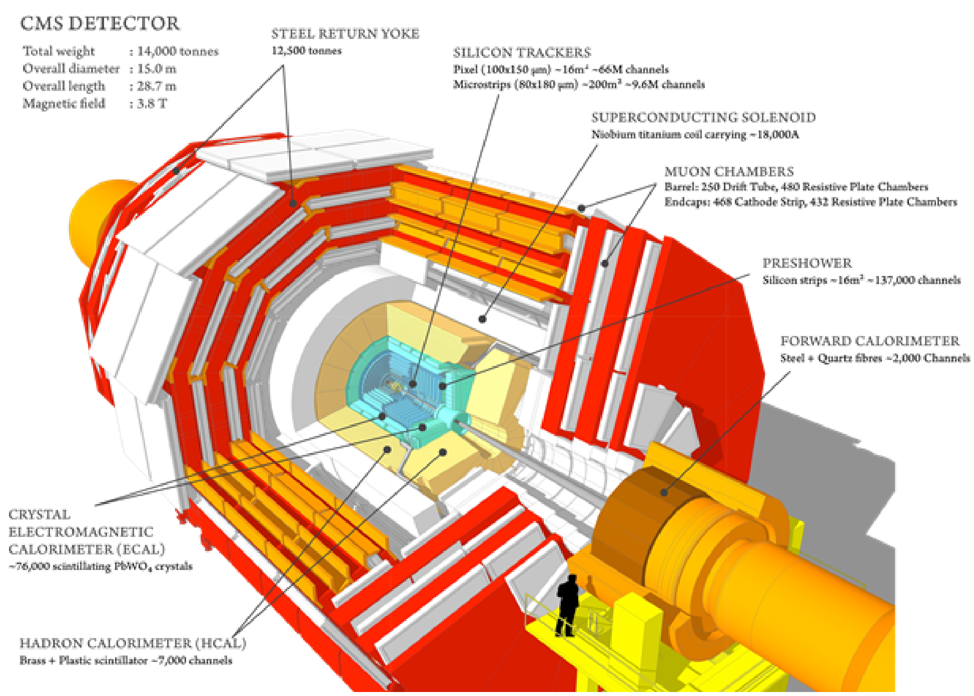
U.S. CMS Compact Muon Solenoid Operations Program
Quarterly Report for the Period Ending June 30, 2018

U.S. CMS Operations Program



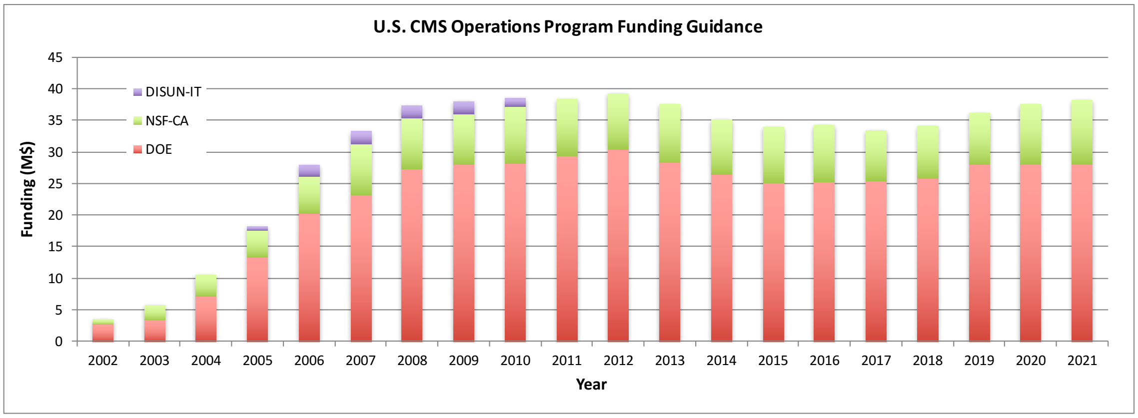


Figure 1: The annual U.S. CMS Operations Program funding provided by DOE and NSF. For 2002 through 2018 the chart shows the actual funding, while for 2019 onward the current funding guidance is shown.

Report of the U.S. CMS Resource Manager

The funding provided by DOE and NSF to the U.S. CMS Operations Program for 2002 through 2018, as well as the funding guidance for 2019 through 2021, is shown in Figure 1. The allocations shown for 2018 and beyond do not include any funds designated for HL-LHC OPC in the case of DOE or HL-LHC R&D in the case of NSF.

Resources are distributed and tracked across the three areas through which the Operations Program is implemented: Detector Operations (DetOps), Software and Computing (S&C), and Common Operations (ComOps). ComOps is a category for items that would otherwise belong in both, or neither, of the other two categories.

Internal budget reviews for calendar year 2018 took place in September of 2017. As an additional source of input to the planning process, the Resource Allocation Advisory Board met in the Fall of 2017, and issued a report of findings and recommendations. Through these processes, U.S. CMS Management developed a detailed spending plan, while taking into account updated information from the funding agencies.

Primarily during the first quarter of the calendar year, Statement of Work (SOW) agreements were established with each institution that is providing a deliverable in exchange for Operations Program funding. The SOWs specify the tasks to be carried out, as well as any portions of salaries, materials and services (M&S), travel funding, or cost of living adjustments (COLA) to be paid from the Operations Program budget. The SOWs must be approved by U.S. CMS Operations Program management, by the Fermilab Director Designee, and by representatives of the collaborating group and institution. Through June of 2018, a total of 86 SOWs (52 DOE and 34 NSF) were produced and approved. After a SOW is approved, any additional changes are considered and, if approved, enacted through a Change Request procedure.

Figure 2 shows the Spending Plan Change Log which captures revisions that were made prior to SOW approvals, as well as modifications implemented through Change Requests. The information is reported here down to the level-2 subsystem categories within DetOps, S&C, and ComOps. The CY18 spending plan, as of the end of Q2, is shown for DOE and NSF funds in Figure 3.

U.S. CMS Detector Operations Change Control Activity						
WBS	**Subsystem**	**Change Request Number**	**Description of Change**	**CY18 Q2 Plan**	**Change $**	**CY18 Q3 Plan**
11	Endcap Muon	CR-034	UC Riverside, Wisconsin, Northeastern COLA	$1,802,183	$28,429	$1,830,611
	Endcap Muon MEX/1	Adjust, CR-035	Labor rate adjustments prior to SOW; Ohio State M&S for prototype adaptor boards	$2,106,618	$3,269	$2,109,887
12	Hardon Calorimeter	CR-049, 050, 051, 052, SOW	Brown, Riverside, Maryland COLA; Reduce Notre Dame labor and M&S; Add Princeton Labor and M&S for ngCCM boxes	$2,105,120	$40,189	$2,145,309
13	Trigger	CR-024, 025, 026	M&O-B; Labor cost reduction for Florida; COLA changes; New SOW for FNAL engineering labor	$843,318	$58,751	$902,069
14	Data Acquisition	CR-010	CERN TA Labor support for Online Monitoring System	$1,125,360	$11,561	$1,136,920
15	Electromagnetic Calorimeter	CR-021, 022	Notre Dame, Minnesota, FSU COLA changes; FSU COLA increase	$755,615	$14,063	$769,677
16/17	Tracker (Fpix & SiTrk)	CR-013, 014, 015, 016	M&O-B payment change and exchange rate; FNAL labor and travel; Rutgers labor for Token Bit Manager chip	$976,961	$8,589	$985,550
18	Detector Support			$121,058	$0	$121,058
19	BRIL	CR-005	Tennessee labor for PLT operations and testing	$299,339	$58,915	$358,254
11-19	**Detector Operations**			**$10,135,572**	**$223,765**	**$10,359,337**

U.S. CMS Common Operations Change Control Activity						
WBS	**Subsystem**	**Change Request Number**	**Description of Change**	**CY18 Q2 Plan**	**Change $**	**CY18 Q3 Plan**
21.2	Common Costs (M&OA)	CR-016, 018	M&O-A exchange rate favorable for all three installments	$4,373,615	($292,474)	$4,081,142
21.3	Run Coord. and Monitoring			$162,881	$0	$162,881
21.4	LHC Physics Center			$772,936	$0	$772,936
21.5	Operations Support	CR-113, 114, 115, 117, SOW	Reduce FNAL labor; KSU MTD CC prototype labor and M&S; MIT labor; CERN TA MTD sensor Labor; FNAL MTD engineering; SMU MTD ASICs engineer	$1,023,000	$821,548	$1,844,548
21.6	Program Office			$1,057,448	$0	$1,057,448
21.7	Education and Outreach			$110,585	$0	$110,585
21	**Common Operations**			**$7,500,465**	**$529,074**	**$8,029,539**

U.S. CMS Software and Computing Change Control Activity						
WBS	**Subsystem**	**Change Request Number**	**Description of Change**	**CY18 Q2 Plan**	**Change $**	**CY18 Q3 Plan**
22.1	Fermilab Facilities			$6,141,149	$0	$6,141,149
22.2	University Facilities	Adjust	Reduced Tier-2 equipment funding plan prior to SOWs	$3,707,159	($678,251)	$3,028,909
22.3	Computing Operations	CR-023	Nebraska M&S for server as part of OSG bridging	$877,578	$11,009	$888,587
22.4	Computing Infra. and Services	Adjust	Personnel changes	$2,730,531	$27,559	$2,758,090
22.5	Software and Support			$2,488,770	$0	$2,488,770
22.6	S&C Program Management & CMS Coordination	Adjust	Adjustment prior to SOW	$415,542	$4,881	$420,423
22	**Software and Computing**			**$16,360,728**	**($634,801)**	**$15,725,928**
U.S. CMS Operations Program Total				**$33,996,766**	**$118,038**	**$34,114,804**

Figure 2: Spending Plan Change Log for CY18 Q2.

WBS	Subsystem	DOE Funds	NSF Funds	Total
11	Endcap Muon	$1,492,722	$337,889	$1,830,611
	Endcap Muon MEX/1	$2,109,887	$0	$2,109,887
12	Hadron Calorimeter	$2,097,509	$47,800	$2,145,309
13	Trigger	$669,831	$232,238	$902,069
14	Data Acquisition	$1,136,920	$0	$1,136,920
15	Electromagnetic Calorimeter	$769,677	$0	$769,677
16/17	Tracker (Fpix & SiTrk)	$823,787	$161,763	$985,550
18	Detector Support	$121,058	$0	$121,058
19	BRIL	$175,519	$182,735	$358,254
11-19	**Detector Operations**	**$9,396,912**	**$962,425**	**$10,359,337**
21.2	Common Costs (M&OA)	$3,181,301	$899,841	$4,081,142
21.3	Run Coordination and Monitoring	$54,945	$107,936	$162,881
21.4	LHC Physics Center	$772,936	$0	$772,936
21.5	Operations Support	$1,588,888	$255,660	$1,844,548
21.6	Program Office	$955,148	$102,300	$1,057,448
21.7	Education and Outreach	$0	$110,585	$110,585
21	**Common Operations**	**$6,553,217**	**$1,476,322**	**$8,029,539**
22.1	Fermilab Facilities	$6,141,149	$0	$6,141,149
22.2	University Facilities	$120,904	$2,908,005	$3,028,909
22.3	Computing Operations	$417,330	$471,258	$888,587
22.4	Computing Infrastucture and Services	$1,819,558	$938,532	$2,758,090
22.5	Software and Support	$1,450,849	$1,037,920	$2,488,770
22.6	S&C Program Management and CMS Coordination	$156,852	$263,571	$420,423
22	**Software and Computing**	**$10,106,641**	**$5,619,286**	**$15,725,928**
U.S. CMS Operations Program Total		**$26,056,770**	**$8,058,033**	**$34,114,804**

Figure 3: Spending plan at the end of CY18 Q2, for funds from DOE, NSF, and the total.

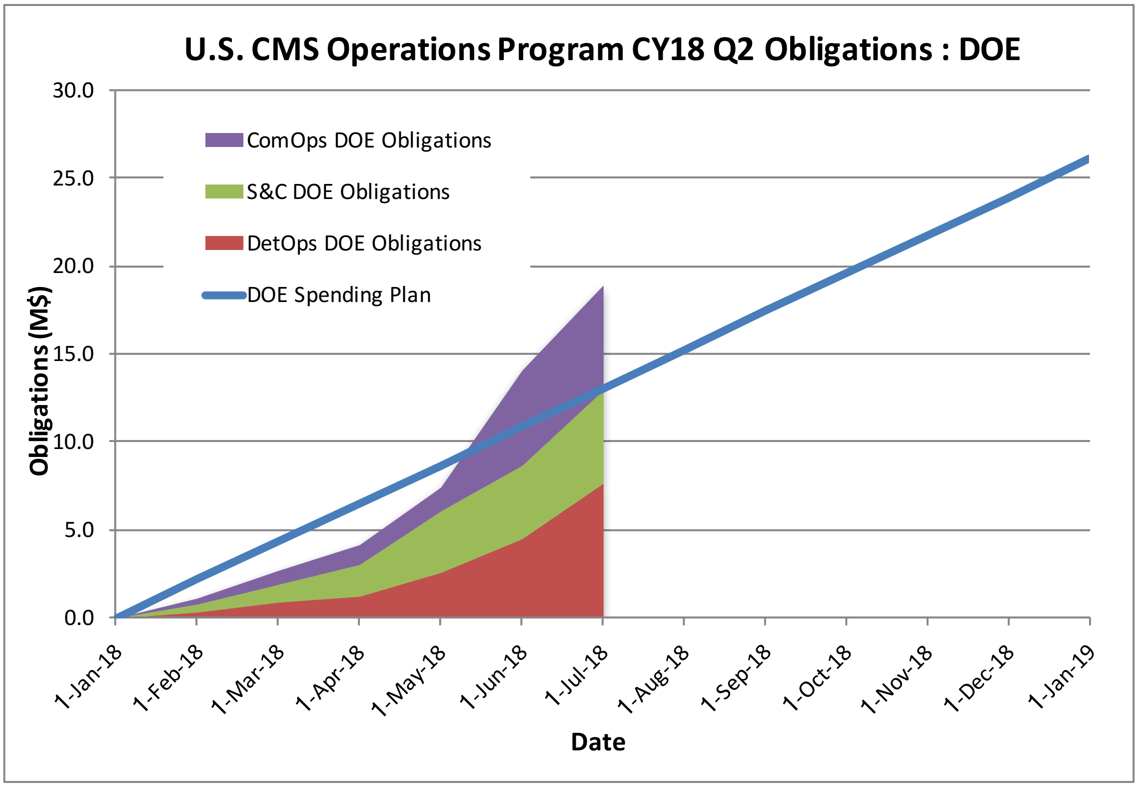


Figure 4: Obligations and spending plan for DOE funds. The spending plan is indicated with the assumption of equal monthly increments just as a rough guide.

Once funds have been committed through purchase orders, in the case of DOE, and sub-awards, in the case of NSF, they are considered obligated. Figure 4 shows the obligations in the areas of DetOps, S&C, and ComOps, as compared to the spending plan, for DOE funds. The spending plan is plotted as if expenditures are carried out in even allocations each month, but this is intentionally not the case due to equipment purchases and the larger of the transfers to CERN-based Team Accounts, the latter of which are targeted for when exchange rates are favorable. Spending through Universities and CERN Team Accounts is budgeted and tracked according to the calendar year. Spending at Fermilab has historically been budgeted according to the fiscal year, however this is the fourth year that we are reporting all activities based on calendar year. Figure 5 shows the total obligations and the spending plan, for NSF funds. Of the $8.4M in NSF funding, $1.8M in subawards went out this quarter, in addition to spending directly at Princeton.

Resources deployed at CERN, and paid directly in Swiss francs, account for approximately 26% of the 2018 spending plan. This carries considerable exposure to the exchange rate. A rate of 0.9 CHF/USD has been used for planning, while the actual rate in CY18 Q2 averaged 0.99 CHF/USD. Figure 6 shows the allocated budgets and year-to-date spending through the Team Accounts that are used for expenditures at CERN. Spending for labor and cost of living adjustments occurs at a fairly constant rate. Figure 6 does not include the 3,859K CHF M&O-A payments, as these are made through multiple payments to a separate Team Account.

A Risk Management Plan is being implemented for the U.S. CMS Operations Program, with many

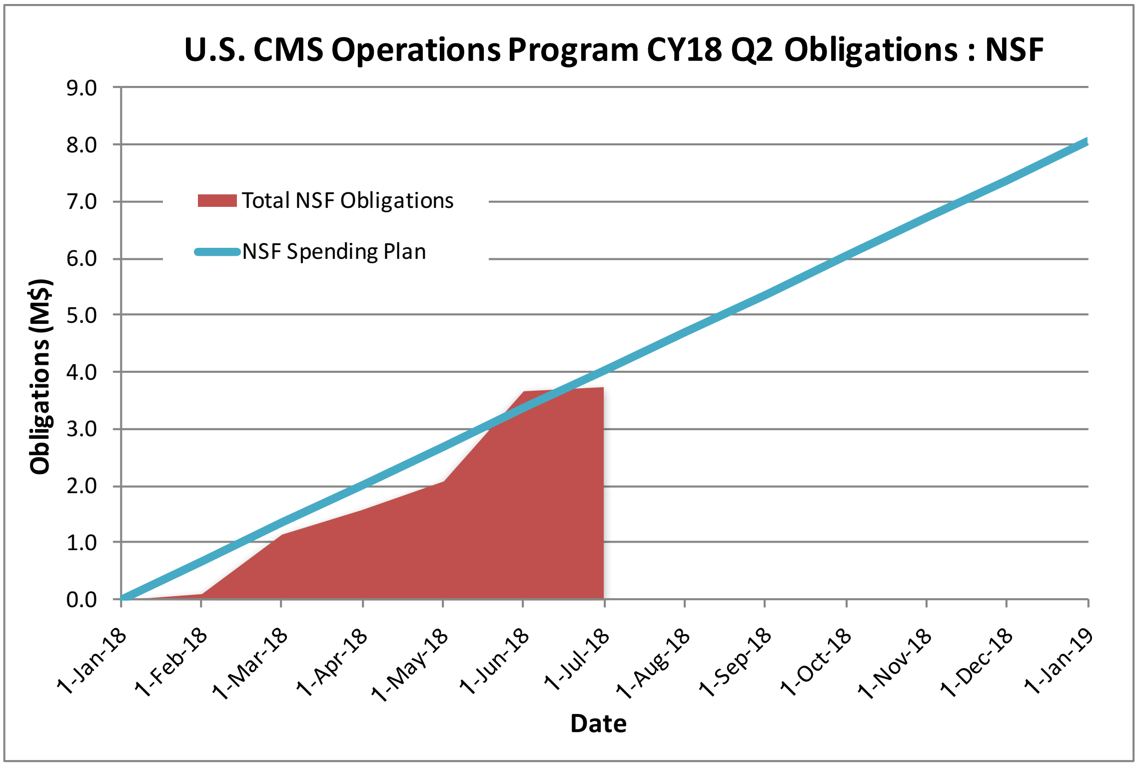


Figure 5: Obligations and spending plan for NSF funds. The spending plan is indicated with the assumption of equal monthly increments as a rough guide.

aspects drawn from the Fermilab Risk Management Plan. A Risk Register is updated quarterly, according to the workflow described in the following subsection. At the start of the quarter, the Risk Register contained 35 open risks spread across the program. At the end of the quarter, there were 36 risks, with threats summing to \$8.4M and opportunities summing to \$0.5M. Figure 7 shows the top few risks at the end of the quarter, ranked by *Probability* × *Cost Impact*, as well as any risks closed or added this quarter.

Workflow for Risk Management Plan

The following procedures have been put in place to carry out the workflow for the U.S. CMS Operations Program Risk Management Plan. The workflow is divide into two paths: (1) updates that are made at any time, and (2) a review of risks once per quarter. In all of the following, *updates* mean adding new risks, realizing risks, retiring old risks, or modifying existing risks. In all cases, it is the program office team that edits the Risk Register. The following descriptions are also summarized in Figure 8.

(1) At any time:

Any member of the management team (including Program Manager, Deputy Program Manager, L1 Managers, L2 Managers, Resource Manager, and program office lead) shall alert the program office of any updates. The program office informs the corresponding L1 manager, and the L1 man-

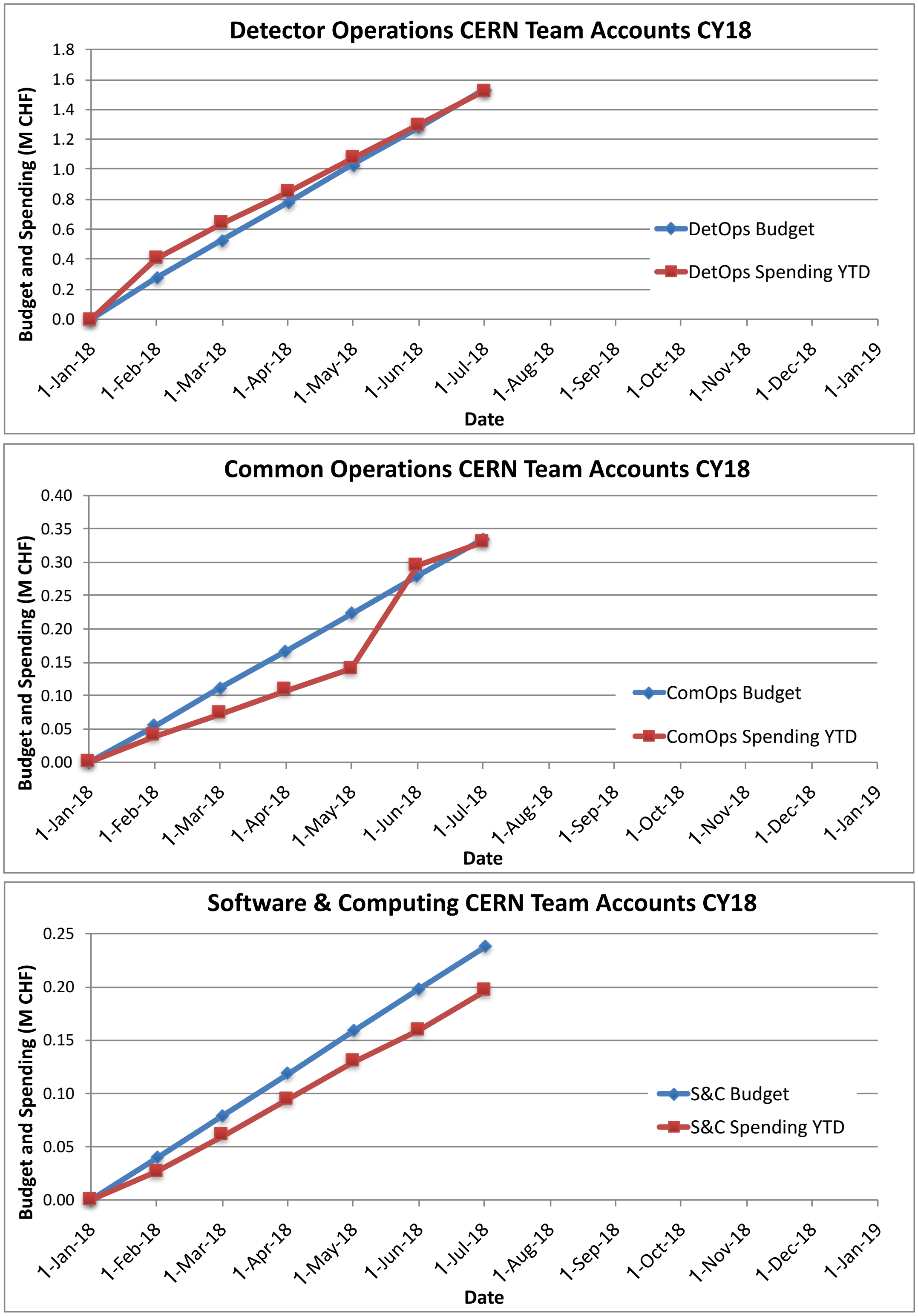


Figure 6: Budget plan and year-to-date spending, in Swiss francs, through DetOps (top), ComOps (middle), and S&C (bottom) Team Accounts.

CY18 Q2 Risk Register Summary Table			
	Probability	**Schedule Impact**	**Cost Impact**
Top Risks (ranked by Probability x Cost Impact)			
EMU – EPROM failures on DCFEBs	20%	3 months	$1,000k
ECAL - Laser fails	20%	0 months	$250k
S&C - Bridge OSG technology evolution staff to new funding	25%	0 months	$200k
Risks Closed Managed this quarter			
Tracker - Pixels repairs/mods in 2017 Year End Tech. Stop	10%	0.5 months	$100k
Risks Closed Retired this quarter			
Trigger - CMS TriDAS project COLA Payments	10%	0 months	$50k
DAQ - Perform. degrad. due to larger evt size & more chnnls	5%	0 months	$0k
HCAL - Scint. Rad. Dam. & No Ph1 HE Elec. Upgrd until LS2	10%	0 months	$0k
HCAL - LV Supplies	5%	0 months	$35k
ComOps - Fermilab overhead rates decrease (opportunity)	5%	0 months	-$40k
Risks Added this quarter			
Tracker - New Heavy Ion Firmwares do not perform as expect	50%	0 months	$0k
HCAL - link errors in HE, might imply possible problems with H	20%	3 months	$50k
HCAL - Other problems with Phase 1 Upgrade HB electronics	10%	3 months	$50k
HCAL - problems with Phase 1 HB Upgrade installation	20%	3 months	$50k
EMU - Optical transmitter failures on DCFEBs	75%	0 months	$75k
S&C - Oracle increases maintenance fees for tape libraries and	50%	0 months	$100k
S&C - New library not in operation for heavy ion run	25%	0 months	$100k

Figure 7: Summary of the U.S. CMS Operations Program Risk Register. Only the top few risks are shown, as well as any risks that were closed or added this quarter.

ager approves, rejects, or modifies the proposed updates. This can also involve iterating with the L2 manager. If updates are accepted, the management team reviews the risk mitigations and risk responses that are associated with the updates. The management team takes into account the risk rank and/or position in the risk rank matrix and takes any necessary pre-emptive actions to incorporate mitigation activities into the plan. If appropriate (again factoring in the probability and impact of the risk), the operations program plan is also adjusted to account for the estimated resources required to execute the risk responses related to the updated risks.

(2) Once per quarter:

Within one month prior to the end of each quarter, the program office lead asks the L2 managers whether they have any updates to the risks in their L2 area. The program office then informs the corresponding L1 manager of any such updates, and the L1 manager approves, rejects, or modifies the proposed updates. As above, this can involve iterating with the L2 manager. As part of the quarterly workflow, the management team reviews *all* of the current risks, and takes any necessary actions and adjusts the program plan if appropriate.

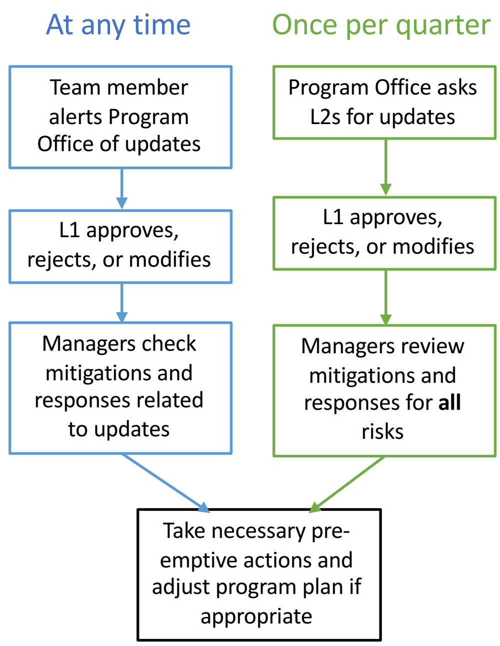


Figure 8: Summary of the two Risk Management Plan workflow paths.

Detector Operations

During the 3^{rd} quarter the LHC and CMS have returned to physics production running. The performance of the accelerator has been excellent and the accumulation of luminosity has been ahead of schedule. Towards the end of the quarter the accelerator had a planned technical stop followed by a series of special runs and studies. During this quarter, as reported below, significant progress has been made in understanding the previously reported issue with DC/DC converters in the pixel system.

Luminosity, delivered by the LHC and recorded by CMS, through July 6.

BRIL

The Pixel Luminosity Telescope (PLT) together with the fast beam condition monitor (BCM1F) and HF provide online luminosity measurements continuously. The PLT was kept in cold storage, and reinstalled in the last week of February. The fast readout for all telescopes works but two telescopes exhibit degraded full pixel information that is used for track-based studies. Reconstructed tracks are also used for fast measurements of the beam spot and allow tracking of beam conditions. Basic commissioning happened during the low luminosity period end of April.

To overcome the degradation in charge collection in the silicon pixels due continuous radiation damage, the electric field strength was raised. To be able to reach higher strengths (max. HV on power supplies was 500V) new modules were installed and the operation voltage was set safely above the turn over point. Below this point charge collection is reduced. The point is monitored by repeated HV scans, and the procedure has been automated. Recovery procedures for SEU are in place; in the first iteration a reset of the readout loop, for severe SE upsets a full power cycle.

PLT participated successfully in the VdM campaign end of June and the visible cross section is obtained for the ongoing data taking. The relative behavior of the visible cross section is monitored by analyzing micro-VdM scans that occur at the beginning and at the end of a fill. Changes are due to loss of efficiency. Measurements of efficiency and accidentals are also obtained from analysis of tracks offline, and with fast turnaround after completion of each fill.

With increasing irradiation, the operation will become more challenging; it is expected that the turn-over point will reach the max. voltage for safe operation before end of the run. From then on the efficiency will need to be parameterized and applied as online correction.

The first planes for the refurbishment of the PLT during the LS are arriving and readout cards are assembled. The laboratory is setup at P5 with 4 telescopes and with the plane test stand plane testing using a radioactive source started.

Table 1: BRIL Metrics

Working Metric	Performance
Fraction of telescopes fully operational	90%
Efficiency of delivery of lumi histograms	99%
Uptime of lumi histogram production	$>$ 99%
Lumi lost	0 /pb

[BRILMetrics]

Table 2: BRIL Milestones

Subsystem	Description	Scheduled	Achieved
BRIL	Pixel Luminosity Telescope reinstalled	March	March
BRIL	Update Lumi for 2017	March	March
BRIL	Ready for Beams	April	March
BRIL	Preliminary Luminosity for Conferences	July	
BRIL	Improve 2018 Lumi numbers	December	

[BRILMIlestones]

Tracker

The start up this year was very smooth and we were able to take physics data fairly quickly. The DCDC replacement in the phase 1 pixels was a success, and the nature of the DCDC failures was determined well enough to avoid DCDC losses so far in 2018. Alignment and physics performance is good and we are hoping operations will continue to be as uneventful as they are currently. Recently, a tracker monitoring group has been formed to share strips and pixels resources in monitoring online detector conditions, such as temperatures and error conditions and operations on a DCDC test setup on the Castor table. The idea is to make it easier to access and analyze conditions information as well as monitor long term trends. We are also revisiting the criteria for requesting urgent accesses to replace things like a malfunctioning power supply. The current High Level Trigger/reconstruction has more mitigation possible now than in 2017, some due to real-time conditions information we include in the data stream from the detector and some due to taking advantage of the detector redundancy. In the 2018 detector, it is not as crucial to have all the tracker taking data all the time.

Pixels

We have had to power off part (2.7%) of the BPiX due to what looks like a connection issue in the power system on the detector. The impact on physics is very small since the areas effected are non-overlapping. Additionally, 2 (of 96) layer 1 modules were lost when we attempted to raise the high voltage (HV) as a radiation damage mitigation. Further attempts to raise the HV are stopped while we investigate in the lab. During the layer 1 HV investigations, we improved the procedure for power supply replacement and used some previously untapped capability in the voltage distribution system to limit the impact of a shorting module.

Substantial progress has been made in understanding the causes of DCDC converter losses in 2017. We have adopted the findings into our detector operations. In order to stop the DCDCs from breaking, we run the DCDC with 9V (lower) input voltage and we toggle the power for stuck modules using the low voltage power supplies (LVPS) rather than the enable/disable feature of the DCDC. After about 7 kGy, it was found that the DCDC becomes vulnerable to damage from an uncompensated leakage current causing an overvoltage inside the DCDC chip when the DCDC is disabled. We have also added an automatic ramping of the HV when we toggle the LVPS to prevent the ROCs from being damaged. The tally of unrecoverable/noisy/low efficiency ROCs from damage due to HV on and LV off in 2017 is about 0.3% of the FPiX, with most of the damage occurring in areas overlapped by working adjacent modules.

The deployment of a much faster firmware for the downloading of constansts to the modules has shortened the module configure time by as much as a factor of 30. The fast firmware also substantially shortens the time we spend recovering from Single Event Upsets (SEU's) and allows us to fully download all the constants to each module for each SEU recovery. This is a substantial advantage for maintaining detector efficiency for some types of SEU's which formerly resulted in a dynamic masking of 1-2% of the FPiX/SEU.

Strips

We have masked about 0.5% of the strips due to control rings which become non-responsive during collisions. These rings are operating in a redundant mode and it appears and SEU can sometimes force the control ring into a difficult to recover state. Rather than carve out the time needed to reconfigure the ring during collisions, we have decided to mask the channels until a less invasive recovery procedure can be developed.

Table 3: Tracker Metrics

	Pixels	Strips
% Working channels	95.1	95.7
Downtime attributed in pb^{-1}	67.4	116.7
Fraction of downtime attributed (%)	12.1	21.0

[TrackerMetrics]

Table 4: Tracker Milestones

Subsystem	Description	Scheduled	Achieved
Tracker	Pixel Phase 1 Detector Removed	Jan 20	Jan 20
Tracker	New pixel DC-DC converters installed	Jan 30	Jan 30
Tracker	Pixel Phase 1 Detector Re-installed	Feb 21	Feb 21
Tracker	Strips and Pixel Phase 1 Detector Ready for Collisions	May 11	Apr 19

[TrackerMilestones]

ECAL

In the run up to physics operations, all of the now standard procedures for bringing the ECAL into operation were performed with US personnel involved in many different areas. Some new features were the optimization of new Data Concentrator Card (DCC) firmware which exploits the larger s-link buffer and fixes a problem with CRC errors in the data transmission. Also the auto-masking of hot trigger towers which is managed by a software package called COKE was retuned.

During the commissioning of the L1 trigger and unusually high prefiring rate was observed increasing in eta. This is now understood to be due to the effects of radiation damage changing the pulse shape casuing timing drifts. It is mitigated by adjusting the timing delays. The inotial energy intercalibrations were those from the 2017 run. These provided a very stable $Z \to ee$ mass peak in the initial running. The full 2018 calibration is rather involved and takes several months to complete.

After commisssioning the running has been very stable with just minor DAQ issues causing some downtime and two incidents of problems with the MARATON low voltage power supplies.

Table 5: ECAL Metrics

Metric	Performance
Fraction of channels operational: EB	99 %
Fraction of channels operational: EE	98.3 %
Fraction of channels operational: ES	99.9 %
Downtime attributed pb^{-1}	19
Fraction of downtime attributed	2.59 %
Resolution performance	2%

[ECALMetrics]

Table 6: ECAL Milestones

Subsystem	Description	Scheduled	Achieved
ECAL	ECAL fiully powered on with HV/LV fully functional	March 1	March 1
ECAL	Complete sLINK upgrade and tests	March 21	April 1
ECAL	Initial thresholds and calibrations set	April 1	April 1
ECAL	Ready for Beam	April 15	April 1
ECAL	Preliminary Calibration	June 15	

[ECALMilestones]

HCAL

During the second quarter of 2018, the HCAL Operations group focused on smoothly taking data, specifically including with the upgraded HE.

The decision to proceed with the full HE Phase 1 Upgrade was taken in January 2018. (The upgrade has silicon photomultipliers (SiPMs) instead of HPDs and has the new version of the QIE frontend chip, the QIE11. In addition, the longitudinal segmentation of the HE is increased to allow for radiation damage compensation.)

The HE upgrade was successfully installed in the first quarter of 2018. The installation proceeded smoothly due to the excellent performance of the HE upgrade team, and to the careful planning and numerous tests that were done prior to the installation.

Aside from the increased longitudinal segmentation, the upgraded HE has been shown to have a more uniform response by a factor of 3, drastically improved signal-to-noise with MIP signals now above noise. In addition the the effects of radiation damage increase due to increased integrated luminosity will be smaller.

The HCAL was ready for the start of data taking in spring 2018, and has been running smoothly with a few rare issues. Data losses during offline certification due HCAL problems were 223 pb^{-1} out of the first 21.5 fb^{-1} collected or 1.0% . Data recording inefficiency due to HCAL data acquisition issues was 70 pb^{-1} or about 13% of all CMS data collection downtime.

Work on HCAL calibration continues and and calibration accuracy is already at the few percent level.

The concerns about the DCDC converters in HCAL have now been shown not be an issue. Problems with the DCDC converters have been shown to start above 7 kGy of radiation. The pixel detector where problems were observed in 2017 received about 10 kGy that year. However, the DCDC converters in the HCAL are expected to receive several orders of magnitude less radiation even in high Luminosity LHC running and so the DCDC converters should not be a problem for HCAL.

February 28 Milestone
HE Phase 1 Installed and Co-60 Calibration completed. This milestone was achieved Feb. 24.

April 1 Milestone
HE Detector Commissioned. This milestone was achieved March 15.

June 1 milestone
Data losses due to HCAL less than 1%. This milestone was achieved at the end of June.

Table 7: HCAL Metrics

tric	Performance
Fraction of channels operational: HF	100%
Fraction of channels operational: HE	99.92%
Fraction of channels operational: HB	99.88%
Fraction of channels operational: HO	99.72%
Downtime attributed to HCAL pb^{-1}	70
Fraction of CMS downtime due to HCAL	13%
Abs Energy Calibration	2-3%
Inter-calibration Uniformity	2%

[HCALMetrics]

Table 8: HCAL Milestones

Subsystem	Description	Scheduled	Achieved
HCAL	HE Phase 1 Installed & Co-60 calibration completed	Feb 28	Feb 24
HCAL	HE Detector Commissioned	Apr 1	March 15
HCAL	Ready for Physics	Apr 15	April 1
HCAL	Data Loss $< 1%$	June 1	June 30
HCAL	1% to 2% Calibration	July 1	

[HCALMilestones]

EMU

Operations at CERN

The CSC system was ready for the first collision data of 2018 and generally ran smoothly and efficiently in this quarter. Some isolated incidents caused a small amount of downtime (2% of the CMS total downtime of 6%) or lost data. These included a case where one endcap went out of synchronization and another where a LV power supply shut down spontaneously.

New firmware was installed in the ODMB card to detect and disable channels where the optical link data is corrupt. This has allowed the CSC to continue running until an appropriate opportunity arises to recover the bad link.

Occasional interrupt errors are seen in the CSC FED system every since the upgrade of the online operating system and libraries (to CENTOS7 and XDAQ14) during the year end technical stops. Investigation continues. Only once did these errors cause any downtime.

We have continued to see some of the Finisar optical transceivers in the DCFEBs fail in a way that cannot be recovered with resets and power cycles. A total of 19 of these transceivers have failed since 2016, out of a total of 1008 in use on the detector. We are exploring the possibility of replacing all of these transmitters during LS2. A design has been made at OSU for an adapter board that would allow a CERN VTTx transmitter to be put in place of the Finisar transceivers.

There was longstanding problem where a time marker (BC0) was not being reported from some chambers to the EMTF triggers system. This was understood and corrected during the June Technical Stop.

At the end of June, 98.7% of the channels in the CSC system were working and being read out. This is down slightly from 99.0% at the beginning of the quarter. There are two chambers off due to low voltage issues, inherited from 2017, and these will not be accessible for repair until Long Shutdown 2.

Just before the start of the collider run, additional shielding was installed in the forward beam region to try to reduce the observed excess of segments in top of ME4/2 ring. The excess was not expected to be eliminated and the quantitative effect has being assessed and found to be very marginal (<10% improvement).

The CSC spatial resolution was measured in all CSC types from 2018 data. The resolutions were consistent with those measured in the 2017 data and earlier. For the first time, the resolution was measured as a function of instantaneous luminosity; a gradual degradation, between 1% and 5% depending on the chamber type, of the spatial resolution was seen with luminosity increasing from 0.6×10^{34} to 2.0×10^{34} Hz/cm^2.

In the GIF++ facility, an ME1/1 chamber is being irradiated with a reduced fraction of CF_4 (2% instead of 10%) and performance studies with a muon test beam were carried out there in in late April.

Table 9: CSC Metrics

% Working channels	98.7%
Downtime attributed pb^{-1}	8.0
Fraction of downtime attributed	2%
Median spatial resolution	127 μm

% Working channels	98.7%

[CSCMetrics]

Table 10: EMU Milestones

Subsystem	Description	Scheduled	Achieved
EMU		April 4	March 29
EMU	New HV settings for reduced gain	July 31	

[EMUMilestones]

MEX/1 Detector Improvement

In April, a workshop was held at Texas A&M University to discuss the work on electronics in the CSC and GEM systems. About 40 physicists and engineers attended. The scope of the discussions included the MEX/1 detector improvement projects, and allowed some final technical choices to me made, including the power management of the GBTx chips, the optical fiber configuration, and the elimination of legacy copper connections that are being replaced with optical connections.

The ALCT mezzanine prototypes of both types (LX100 and LX150T) were received at UCLA and tested. The bench tests were successful, and the ALCT had USCMS Production Readiness Review on June 8th. The review was positive, with one requirement to carry out successful integration tests with the prototypes at CERN before proceeding to production. These tests are currently underway.

After some delays in getting the funding in place, the second prototypes for the DCFEBv2 were fabricated and assembled. A small modification was needed to the boards to eliminate clock reflections, but after this change the boards passed all bench tests at the Ohio State University. One of the boards was sent to CERN for integration tests and another to Rice for additional bench tests and online software development. The quotes for the full production of DCFEBv2 boards were requested in mid June after the funding was in place. There is still concern about components with long lead times.

The low voltage power requirements were calculated in detail for currents and voltages expected with the new electronics. These calculations confirmed that twelve new Maraton supplies will be needed, and this order was placed at the end of June.

The low voltage distribution boards (LVDB), which are a Russian responsibility, progressed according to schedule with the production fabrication completed and all components procured.

A well-attended workshop was held at CERN (and by video conference) on 7 June for planing and team formation for the CSC work in LS2 for the installation and testing of the new electronics.

The CMS Electronics System Review for the LS2 CSC on-chamber electronics improvement is scheduled for 2 July. The main focus of this review is the ALCT mezzanine boards and the DCFEBv2 boards, but it also covers the LVDB5, HV and LV infrastructure, and optical fiber additions. The USCMS Production Readiness Review for the DCFEBv2 board is being held in conjunction with the ESR.

ef1.5{1.5}
Subsystem Description Scheduled Achieved

EMU-MEX/1 ALCT mezzanine prototype Apr 30 Apr 6 received

EMU-MEX/1 Second xDCFEB prototype May 1 Jun 1 received

EMU-MEX/1 CSC On-chamber Jun 15 Jul 2 Electronics System
Review completed

EMU-MEX/1 Order placed for Maraton Aug 31 Jun 25 LV supplies

EMU-MEX/1 Production of xDCFEB Sep 2 PCBs released

EMU-MEX/1 CSC on-chamber optical Nov 1 fibers ready for
installation

EMU-MEX/1 CSC LV junction boxes Jan 15 ready for installation (2019) ————————————————————————-

: EMU Milestones - MEX/1 Detector Improvement

[EMUMilestones-MEX1]

DAQ

The data taking was mostly smooth during the reporting period. LHC fills typically started at a L1 trigger rate of 80 kHz. The event size before HLT compression is about 1.4 MB. The HLT output does not exceed 4 GB/s, which includes additional data providing an unbiased sample of B decays. These triggers are gradually enabled when the luminosity drops during the fill. From measurements carried out in DAQ emulator mode at the beginning of the reporting period, we estimate that we can record up to 5 GB/s and simultaneously transfer this rate to Tier 0 when the Lustre storage occupancy is below 50%. The available throughput to Tier 0 became more predictable since EOS has been reconfigured at the beginning of June to place the second replica instead of Wigner also in Meyrin. We implemented a “stop button” which enables the shift crew to switch off the B-physics streams in case of problems transferring to or processing the data at Tier 0. This action would be taken when the Lustre occupancy reaches 45% to avoid any repercussions on the core physics program. However, the Lustre occupancy has not exceeded 35% so far.

The only major problem concerns the file distribution from the builder units to the filter units. Since the data taking resumed this year, the locking of files over NFS is no longer reliable. This results in an occasional (few in a week) loss of a LS and requires manual intervention to close the affected run. This is likely related to the upgrade of CentOS/NFS versions on the filter units early 2018. This upgrade was needed to support the new Skylake HLT nodes installed earlier this year. We are working on a new solution for the file distribution which does not rely on any file locking.

The throughput from a builder unit to the new Skylake HLT nodes has been confirmed to be about 3 GB/s. We found no measurable difference from the CC7.4 upgrade nor Meltdown/Spectre mitigations deployed on the filter units. We also measured the available CPU capacity on the HLT. For this we removed filter units from an ongoing physics run until the DAQ/HLT asserted backpressure. Assuming a linear scaling of the CPU load with luminosity, the HLT farm would be saturated at a L1 trigger rate of 100 kHz and a luminosity of $2 \times 10^{34} cm^{-2} s^{-1}$. A detailed analysis is ongoing by TSG to calibrate the offline HLT timing measurements to the online findings.

In preparation of the heavy-ion run planned for November, we measured the event-builder performance for the estimated heavy-ion fragment-size distribution. The main difference with respect to previous Pb-Pb running is the data reduction in the outer tracker (strips) back-end electronics. The achievable L1 trigger rate for the expected event size of 3.2 MB is about 50 kHz. This is well above the target rate of 30 kHz. Therefore, no changes are necessary to the standard event-builder configuration.

A second version of the online monitoring system (OMS) has been released. The new version provides besides many bug fixes and additional features, new L1 trigger pages with historical and live rates and plots. The user can select which quantities are displayed. A review of the OMS took place during the CMS week in June. The user-interface development is on a good track, and the most important pages should become available during the remainder of the year. However, the development of the backend has stalled due to manpower issues. It is unlikely that a new backend system can be tested before the LHC stops operating for 2 years in Long Shutdown 2 (LS2).

The HLT online cloud was ramped up during the reporting period. It is now using 87% of the HLT nodes (63k virtual cores) during interfill and technical stops. It contributes a significant amount of CPU time for offline processing. During the recent technical stop, the online cloud processed more jobs in a week than the Fermilab Tier-1 site.

The DAQ group developed a plan for the LHC long shutdown 2 in 2019/20. During this period, most computer and network equipment has to be replaced as it reaches the end of its useful life. The downtimes of the central services and of the DAQ system during the switch-over from the current DAQ to the new run-3 DAQ system require a careful scheduling in order to minimize the impact on the work carried out by the subsystem during this time.

The first step in commissioning the testbed for the run-3 DAQ system has been taken. 16 Skylake-based computers have been connected to 100 Gbps Infiniband (EDR). Initial measurements using the event-builder software look promising. The commissioning of the Ethernet network will be done during July.

Table 12: DAQ Metrics

Dead time due to backpressure	0.7%
Downtime attributed pb^{-1}	6.5
Fraction of downtime attributed	1.3%

[DAQMetrics]

Table 13: DAQ Milestones

Subsystem	Description	Scheduled	Achieved
DAQ	First version of OMS GUI with limited functionality deployed	Mar 1	Mar 6
DAQ	Specification and design outline for DTH prototype P1	Apr 1	Mar 13
DAQ	New HLT nodes commissioned	May 1	Apr 5

Subsystem	Description	Scheduled	Achieved
DAQ	Testbed for DAQ 3 installed	Jun 1	
DAQ	First DTH prototype P1 board	Oct 1	
DAQ	Event-builder and SMTS ready for heavy-ion run	Oct 31	
DAQ	All relevant WbM pages migrated to new OMS GUI	Dec 31	

[DAQMilestones]

Trigger

During this quarter the US groups continued their work on the Layer-1 calorimeter (CaloL1) trigger and the endcap muon trigger systems providing improvements and reliable running during 2018 data taking operations.

Endcap Muon Trigger

The Northeastern, Rice University, and University of Florida groups have continued to make improvements to the EMTF, and have provided operational support that led to smooth data-taking operations during the 2018 proton collider run so far. The firmware on the MPCs and the EMTF were updated, and this allowed to unmask 6 CSC optical links that previously were masked during 2017 because of errors. The ability to mask RPC links was also added, in case problems are encountered. Additionally, the EMTF firmware implemented several options to recover a CSC link that has lost or otherwise has a mistimed BC0 orbit timing marker. A rare bug that caused the PT LUT to be corrupted during the resynchronization of optical links was also fixed.

The online SWATCH software for EMTF was modified to monitor every link for a lost BC0 timing marker, and to launch a procedure to attempt to recover it if so (in conjunction with firmware). Additionally, the functionality to accommodate new registers to mask RPC links and to configure new algorithm settings in the EMTF was added to the software.

Progress on the new "Auto-DQM" used to make spotting problems in DQM plots easier continues, and has helped identify a few problems for the CSC group to follow up. Additionally, data recorded by the EMTF was used recently for a study to project the DAQ needs of the CSC system during HL LHC. One spin-off from that study is that the LCT occupancy in each chamber type has been measured, and can be used to project the input LCT rate for an HL LHC endcap muon trigger.

Layer-1 Calorimeter Trigger

The Layer-1 Calorimeter Trigger (CaloL1), built by the University of Wisconsin - Madison, is a part of the completed Calorimeter Phase-1 Trigger Upgrade. CaloL1 has been operated smoothly since being powered on after the Year-End Technical Stop (YETS) on January 25, 2018. The University of Wisconsin - Madison group is responsible for the maintenance and operation of the CaloL1.

During first quarter 2018 a discussion with HCAL led to decision to use linear scale for trigger primitives compression, it required updating the LUTs in CaloL1 and producing a new calibration. The LUTs were updated, the calibration was done in April and May 2018 and was used in CaloL2 calibration. Both systems updated their calibration constants.

The CaloL1 successfully operated with first beam tests in April and provides now a smooth data taking in collisions and cosmic running for tests. No dead time is due to CaloL1, in the data from approximately 22 fb-1 of luminosity is collected thus far.

The MIcroSD cards on two CTP7's were replaced since they failed during the first operations period after extensive diagnostics were undertaken before data-taking requiring many cycles of writing information on the cards to investigate local network problems which were solved. The card replacement did not cause any delay in data taking, since they were swapped during the time when the LHC was preparing for the beam operation. No other microSD cards have failed since then and changes to the software and firmware have been made to prevent writing to the MicroSD cards until all are replaced with more robust cards. All spare CTP7s not in operation at P5 have had their MicroSD cards replaced.

A CaloL1 study of pre-firing of the ECAL endcap Trigger Primitives identified a small problem with higher eta ECAL endcap deposits incorrectly associated with the previous bunch crossing that was fixed and a method of addressing this in data where it occurred was provided by the ECAL group.

Table 14: Trigger Metrics

Frac of MPC Channels	100%
Frac of Upgrade EMUTF Channels	100%
Deadtime attributed to EMTF pb^{-1}	8.4
Fraction of deadtime attributed to EMTF	0.9%
Frac of Calo. Layer-1 Channels	100%
Deadtime attributed to Calo. Layer-1 pb^{-1}	0
Fraction of deadtime attributed to Calo. Layer-1	0%

[TriggerMetrics]

Table 15: Trigger Milestones

Subsystem	Description	Scheduled	Achieved
TRIG	EMTF commissioned with endcap RPC input	April 1	April 27
TRIG	EMTF ready for Physics	May 1	May 29
TRIG	Calo. Layer-1 commissioned with new ECAL/HCAL/HF Calib	April 1	May 19
TRIG	Calo. Layer-1 Ready for physics	April 1	May 19

[TriggerMilestones]

Software and Computing

The second quarter of 2018 saw the start of the final year of LHC operations before Long Shutdown 2, and a major push within CMS to complete all analysis of data recorded in 2016 in preparation for summer conferences. CMS data-taking currently includes about 2 kHz of "parked" data, which will not be reconstructed until after the run. The triggers for the parked datasets are designed to capture b hadron production, to address anomalies observed in the B system. This has gone smoothly, along with the rest of data taking, and the general operations of the distributed infrastructure as a whole. As usual, these operations were supported by the strong performance of the U.S. computing facilities, whose utilization has been as high as ever. The facilities did have an unusual situation to contend with: transitions within the Open Science Grid organization that have led to changes in operations and support. Overall this transition has been managed with very little disruption of the sites. In addition, Fermilab chose a vendor for a new tape archive, which will be deployed in the coming months. The development areas made progress on a number of fronts. Usage of NERSC resources in production mode was ramped up. A review of workflow management systems was kicked off, and preparations were made for a data management review to be held in July. Pre-mixed pileup samples are now useable for HL-LHC simulations, a major step that will speed the production of samples for physics studies. Revised estimates of HL-LHC computing needs give us a better understanding of the innovations that will be needed to sustain the future physics program.

Major milestones achieved this quarter

Date	Milestone
10 April 2018	Preliminary report on Rucio investigation delivered.
1 April 2018	Demonstrate use of HTTP as replacement to GridFTP at two Tier-2 sites.
10 May 2018	CMS Workflow Management Review, Part 1
1 June 2018	Evaluate performance metrics on CPUs for Machine Learning Benchmark 1
15 June 2018	CRAB3 able to trigger orderly recall from archive.
30 June 2018	First full implementation of pre-mixing for HL-LHC MC PileUp Digitization
30 June 2018	GPU vectorized tracking - Working track building version for simplified geometry and Monte-Carlo simulated events

Fermilab Facilities

Q2 of 2018 covered the restart of LHC physics operations and large scale data processing in preparation of physics results for upcoming summer conferences. Throughout this quarter the Fermilab Facilities continued to provide reliable custodial storage, processing and analysis resources to U.S.

CMS collaborators. The site was well utilized, with the facility providing 43.4 million wall-clock hours of processing to CMS.

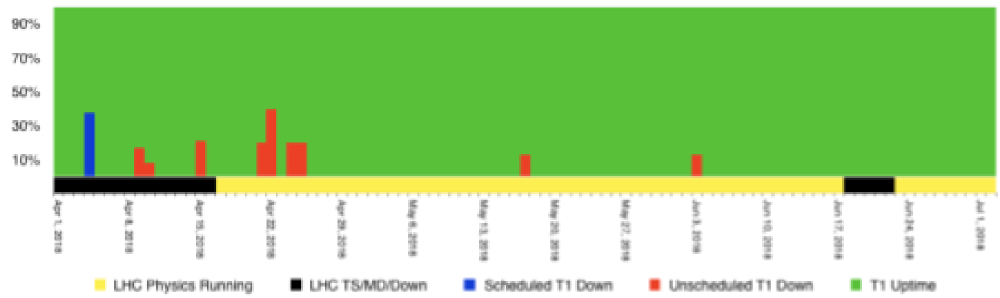


Figure 1: Fermilab readiness metrics for Q2 of CY18. Green indicates a passing metric, red a failing metric, and blue a scheduled downtime. The height of a red bar indicates how much of the day services were affected. Black and yellow across the bottom indicates LHC machine running. This quarter LHC transitioned to physics running. FNAL passed metrics 98.0% during the quarter.

Figure 1 shows the site readiness metrics for the quarter. During this quarter the Tier 1 facility passed CMS site availability metrics 98.0% of the time. In the beginning of the quarter, prior to LHC operations, all storage machines were rebooted, and a handful developed hardware problems afterwards, which resulted in lower data transfer efficiencies and the red metrics visible in April. We worked with the hardware vendor to provide backup servers onsite to prevent similar problems from happening in the future.

During this quarter Fermilab reviewed proposals for new tape libraries and made the decision to move to an IBM TS4500 tape library with LT08 media to replace the current aging Oracle SL8500 libraries. Work has begun to prepare for delivery of the CMS library early next quarter.

University Facilities

As seen in Figure 2, CMS production and analysis activities this quarter continued to run at full capacity and even exceeded purchased processing power, taking advantage of the sizable opportunistic processing available at the U.S. CMS Tier-2 sites. During this period of heavy usage, analysis processing consumption by U.S. physicists continued at the level of 68% of the total analysis CPU delivered by our sites during the last quarter.

All of the U.S. CMS Tier-2 sites operated successfully last quarter. On our two official performance metrics based on CMS test jobs, all sites were at least 97% “available” and 90% ”ready”. The CMS requirement for each of these metrics is 80%, but the U.S. CMS performance goal is 90%, which all sites met.

The U.S. CMS Tier-2 centers delivered 48.1% of all computing time by Tier-2 sites in CMS last quarter. This is a further decrease of 1.2% from the previous quarter, indicating that our pressure on CMS to diversify the geographical spread of production work may be having a positive effect. However, given that ~70% of our U.S. processing resources for analysis are used by local U.S. physicists, as seen in Figure 2, and that we also take our fair share (~30%) of non-U.S. Tier-2 analysis usage, U.S.-based researchers are doing approximately 50% of the global analysis work in CMS, commensurate with our ~50% T2 resource usage overall.

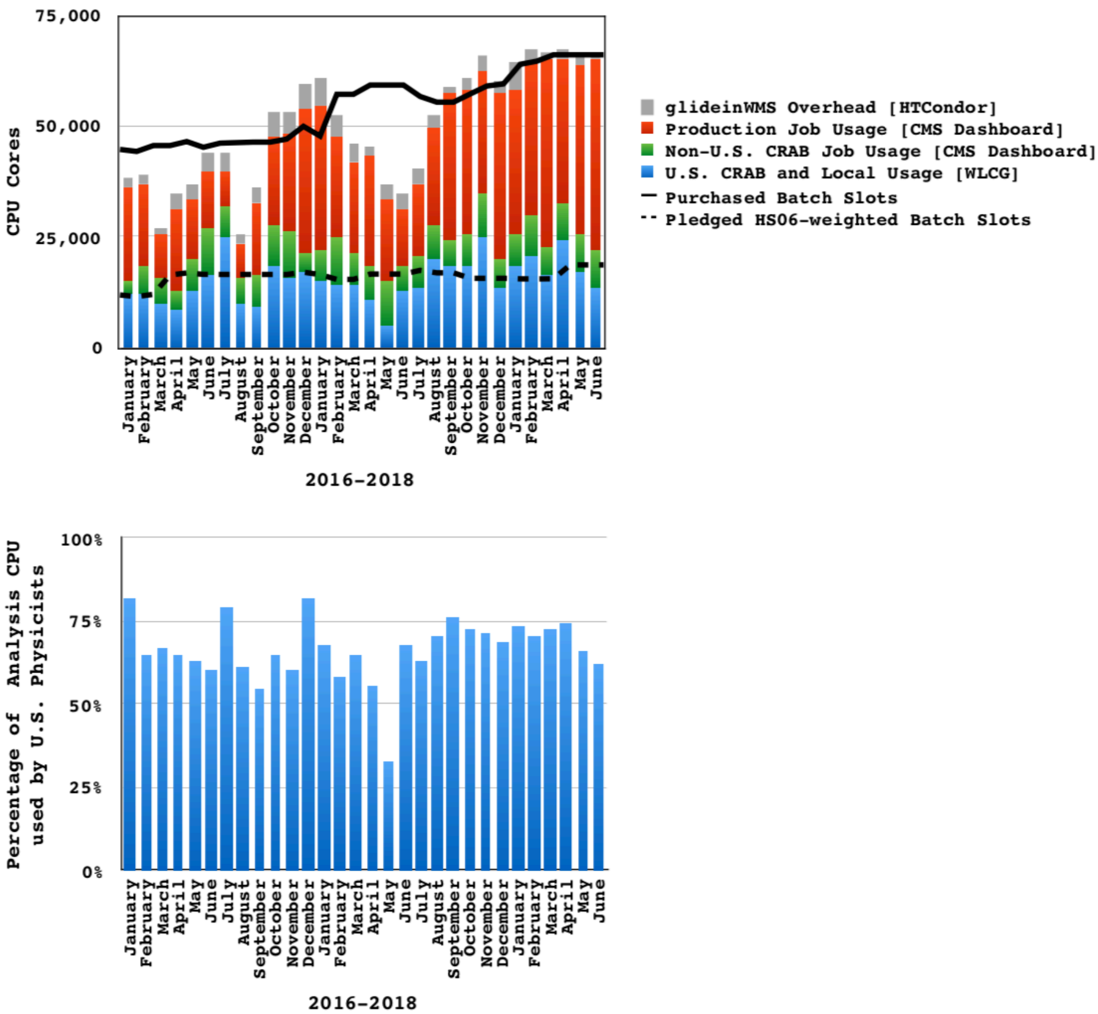


Figure 2: How processing resources were used at the U.S. CMS Tier-2 sites, by month.

No new previously planned Tier-2 milestones were completed during the last quarter. However, steady progress is being made on many fronts, especially for data storage and transfer milestones. The University Facilities were largely focused on the OSG transition during the quarter, especially migrating the ticketing system to GGUS and preparing for the end of life of the OSG certificate authority.

The U.S. CMS Tier-3 support team provided help to six sites on a number of issues. The biggest concern was the transition away from the OSG GOC. For Tier-3 sites, the two main impacts were in the procedures for obtaining host certificates with the OSG certificate authority ending, and the closing of the GOC ticketing website and transition to GGUS tickets. In addition, routine user support for CMS Connect was provided, as well as integration work for the Tier-3 in a Box program and some automation for the central Tier-3 PhEDEx service.

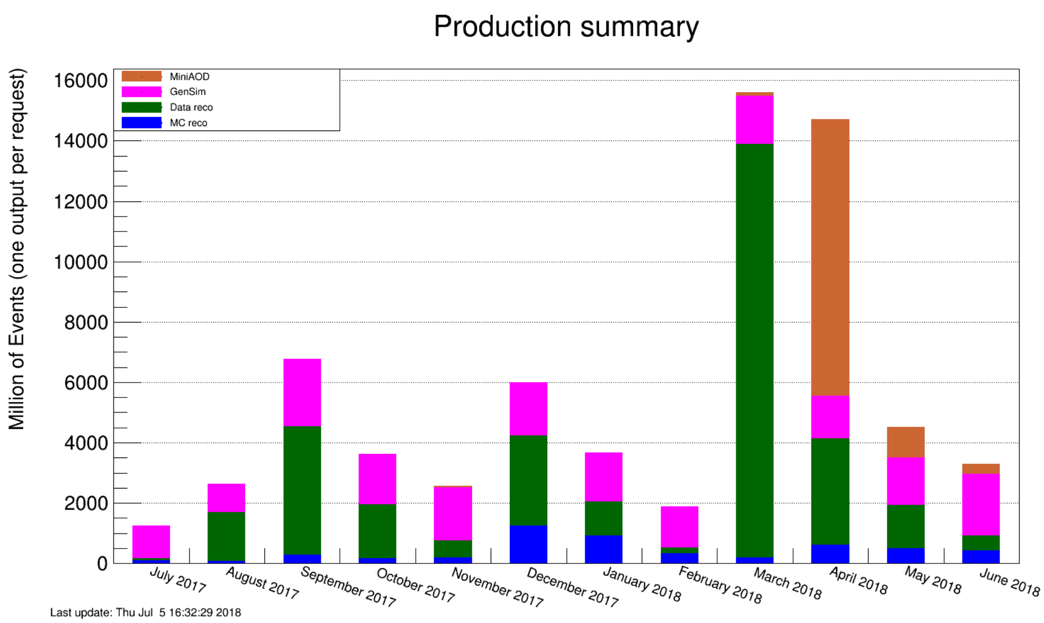
Computing Operations

Digitizing and simulating Monte Carlo events for the 2017 data analyses was the largest processing activity in the quarter. Close to 10 billion events were processed, about 2/3rd of the requested Monte Carlo events. All processing used the resource-efficient, pre-mixing pile-up method and honored the requested priorities.

Monte Carlo generation for the 2018 detector configuration started in the quarter. A small 0.9 billion pre-production sample was created. Requests for the full production campaign are currently being submitted, 1.7 billion events so far.

The Tier-0 reformatted and reconstructed data from the detector as they were recorded. The baseline trigger rate remains 1 kHz, but there are now additional triggers for B physics data that are not processed directly but stored for parking, adding about another 2 kHz of total trigger rate. While the Tier-0 is dealing with those rates without real problems as of yet they push the system into a more busy state. The LHC is running very well and luminosity delivery about two weeks ahead of schedule. Distribution of RAW data to the Tier-1 sites is keeping up. Transfers to the largest Tier-1, the U.S. site, fell behind for a few weeks. The bottleneck was identified to be in the metadata handling of an old transfer component and eliminated. Calibration and offline reconstruction of the 2018 data is also keeping up.

Since the middle of May processing has been limited by available computing resources. Including Tier-0 resources at CERN which are now part of the global CMS resource pool, between 200k (beginning of the quarter) and 300k cores (end of the quarter) were used. Processing requests exceed available resources and only high priority requests are currently executed. Analysis load has been constant at about 50k cores during the quarter.

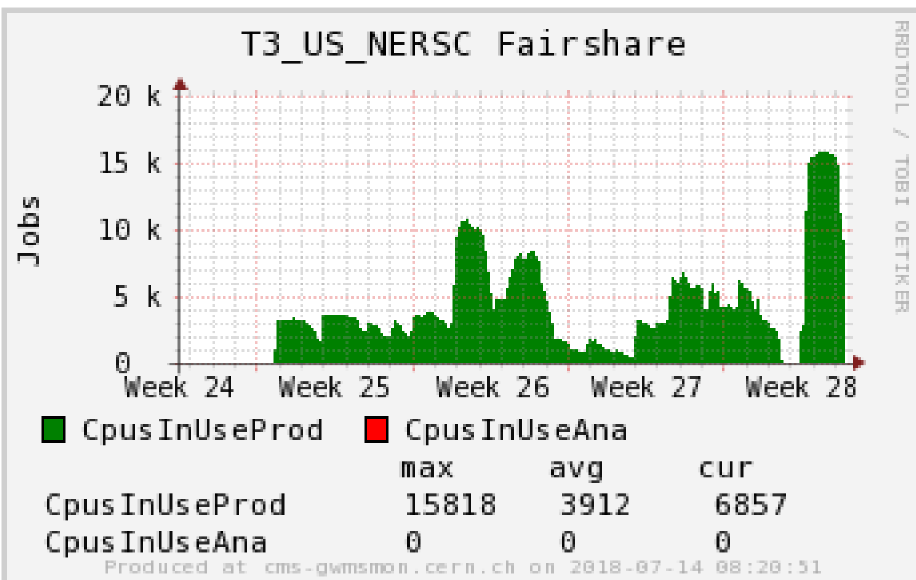


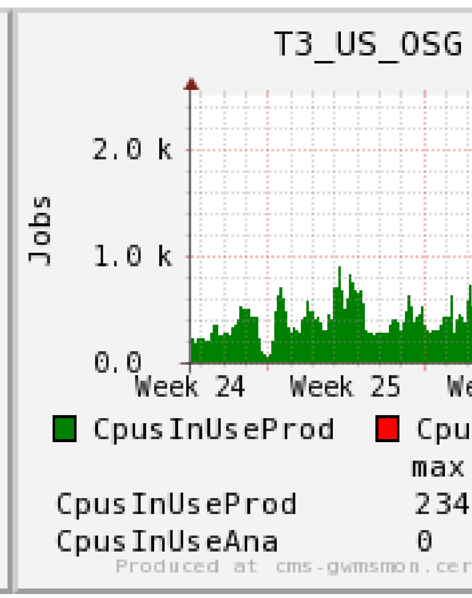
New probes for the WLCG site evaluation framework, SAM, were deployed and integrated into the performance metric. The roll out of Singularity was completed before data taking started and urgent updates, due to discovered security vulnerabilities, handled.

Computing Infrastructure and Services

In this quarter, the WMAgent production workflow system began the improvements necessary to finish transition of "StepChain" into production; the last pieces needed are improvements to the metadata registered with the Data Bookkeeping System (DBS) when workflows are run in this mode. We expect this to be finished next quarter. The job logging improvements begun last quarter have been deployed and are beginning to be integrated in the higher layers, allowing operators to more easily retrieve log files of failed jobs. A first version of the "fast draining" patch (allowing improved operational efficiencies) has been finished and is expected to be deployed next quarter. We have begun an external review of the future plans of the CMS Workflow Management system; we believe this will be completed with a committee report in one to two quarters.

Use of NERSC-based resources in production mode ramped up this quarter. This work heavily utilized the HEPCloud effort within the CIAS area. We have integrated this resource into the CMS "global pool", meaning the production system can run workflows into NERSC without any special setup (such as partitioning the workflows to only run at NERSC). This has been a significant step in the resource's evolution and will allow us to turn our focus to other HPC resources next quarter. Along with the usage of OSG-based opportunistic resources, this has allowed us to deliver significant value to the CMS experiment beyond traditional WLCG resources. The figures below illustrates the activity over the last month:





The evaluation of Rucio as a future data management system is proceeding toward the data management review in the next quarter. We have demonstrated the ability to include several additional sites in the Rucio testbed and the ability to do CMS-style generation of transfer URLs (necessary for a smooth transition to production). For analysis users, the Dynamo system has been modified to allow the orderly staging of datasets when a CRAB job requests a dataset that is on tape only.

For data management through caching, we have added support of direct access for fully downloaded files when XCache is running on a shared file system (such as Lustre, as requested by NERSC). The latest release has also improved open request processing, allow higher open rate needed to support higher levels of activity at UCSD. Finally, the collaboration with UCSC continues through studies of CMS data access patterns.

Software and Support

In the second quarter of calendar year 2018, data taking commenced at the LHC for the last year of the Run 2 period. The software teams released the main 2018 data taking and simulation release, as well as releases for simulation and re-processing of analysis samples (MINIAOD) of 2016 data. Special support was needed for the high β^* test running of the LHC.

We achieved a major milestone in finishing the first complete implementation of pre-mixing of pileup for HL-LHC MC studies, enabling us to produce HL-LHC simulation at all sites and not only special sites with extraordinary high I/O capabilities. We achieved several minor milestones from improving the threading efficiency of data quality monitoring plots in the framework, to finalizing the configurations to build CMSSW with cmake, to achieving an order of magnitude reduction in error and warning log messages from the application.

Our investment in the C++ standard and the community, C++ modules, was integrated into CMSSW. This reduces both memory consumption and speed of building a release and allows us to validate releases more quickly and efficiently. We are also leading the community solution Frontier to serve alignment and calibration constants to all CMS applications.

We made progress in using the free tier of the commercial caching provider Cloudflare and are using it now for LHC@Home workflows (running on Boinc like SETI@Home). This will be used for the OpenData project in the future, providing access for analysis of CMS public data for everyone. We are investigating the evolution of the EVE event display solution for ROOT 7, which will transition to web-based graphics solution. A prototype of a client-server implementation was developed and is being tested. We also made significant progress in developing a machine learning benchmark to both characterize resources as well as normalize resource requests. The other half of machine learning, the inference of training models, is a problem of distributing a model to the grid and using it from an application. We developed a prototype for the most popular framework and deployed it on a testbed for everyone to evaluate: TensorFlow-as-a-Service

The R&D for HL-LHC continues together with our partners. We tested ROOT I/O improvements on Cori and Cori II, and in general improved the interface of the CMSSW framework to use accelerators like GPUs. The Joint NSF/Operations Program team investigating vectorized tracking took part in the 3rd Patatrack hackathon at CERN to better understand the parallel kalman filter algorithm mkFit on GPUs and to investigate new profiler metrics to develop a performance model on GPUs. We are profiling mkFit on new 2018 HLT nodes (Intel Skylake architecture with 64 HT cores) with very encouraging results investigating to run the first iteration of tracking (pixel seed and inside-out pattern recognition) on level 1 triggered events. Next quarter, we will report on feedback from many CHEP presentations with contributions from the program.

Other activities

The U.S. CMS cybersecurity team handled a major task, the transition away from the OSG Certificate Authority (CA). They worked with all U.S. CMS sites to renew their OSG CA certificates, and then solved various issues before the shutdown, such as installing the new inCommon CA, getting the new certs, checking whether new certs works with grid resources and so on. There were no major tickets or issues after the shutdown. The team worked with the Tier-2 sites to start getting InCommon certificates. The team also wrote a document gathering information about job traceability and monitoring at CMS, responded to CMS Security Officer's questionnaire about sites' cybersecurity status, and read InCommon Certificate service API documentation.

Blueprint activity accomplishments for Q2 included a major update to the U.S. CMS projections for computing needs through the startup phase of HL-LHC (up to 2030). Work included developing a model for analysis resource requirements based on monitoring data, incorporating changes due to the production and usage of NANOAOD (a newly developed data tier in CMS that is O(1kB) per event for analysis, as well as incorporating results from recent progress on simulation, premixing for digitization, and reconstruction processing time improvements due to ongoing R&D. This update was presented at the DOE roundtable meeting in May.

Subsequent work has focused on developing new model components for HL-LHC projections. Work in progress includes cost-modeling and projections of network requirements for both national and transatlantic networks.