Fermilab

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CMS Budgets
Constraints and Challenges
—Research/Operations/Project

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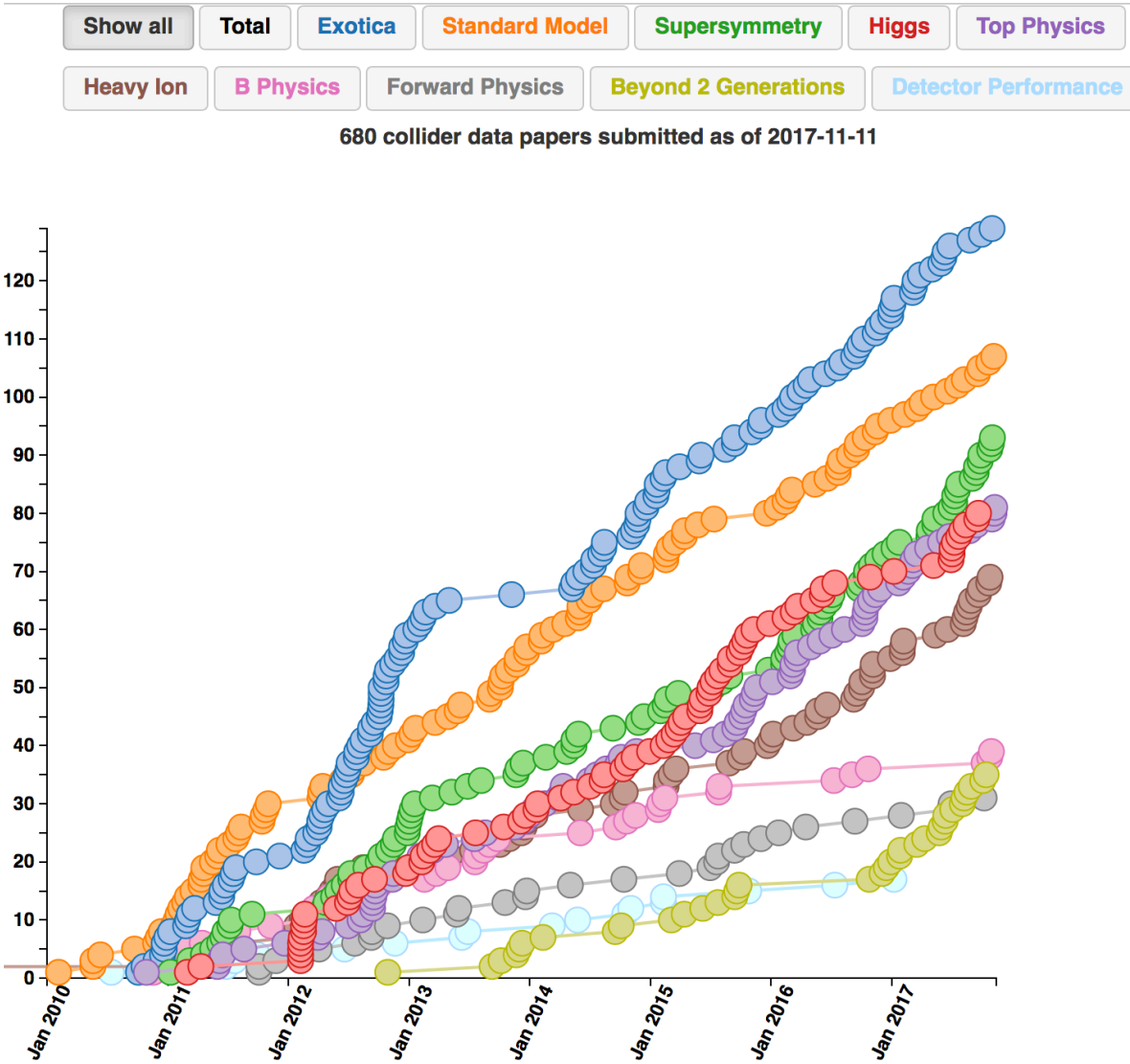
Fermilab PAC Meeting

November 16, 2017

CMS Deliverables: ~ 700 Publications 2010 - 2017

- 680 physics papers submitted to Journals
  - An additional ~20 ready for submission
  - Many Approaching approval



US Contributions and US CMS Ops Priorities

- Fermilab is the Host Lab for 50 US Universities participating in the CMS program
  - Supported by DOE and NSF through the Proton Research Program, NSF grants, the US CMS Operations Program (USCMS Ops), the Phase1 Upgrade Program, and the HL-LHC Upgrade Project

- For US CMS, priorities are set to ensure we can meet our obligations
  - to the CMS collaboration, including common costs and computing pledges
  - to maintain and operate US detector components that were US-led during construction ("you build it, you maintain it") and components that were upgraded and installed as part of the US Phase1 upgrade project
  - to support US physicists to effectively participate in LHC physics
    - US CMS provides computing resources at the Fermilab Tier-1 and LPC analysis facility, and Tier-2 centers at 7 US Universities, at agreed levels of service availability and quality, and provides support for Tier-3 computing at US Universities
    - US CMS contributions to process and host data and MC, operate computing infrastructure and services, and maintain and develop the software and computing infrastructure and services needed to process and analyze the data
    - Physics support and support for the LHC Physics Center: physics, computing, event support, and a G&V Program, organized through the LPC
  - to support upgrade R&D and preparation for the HL-LHC upgrade project
    - through the NSF-CA, and through transfer of DOE funds to HL-LHC OPC

USCMS and Fermilab CMS Sources of Funding

- DOE Operations Funds
  - $25.634M funding guidance for FY18 “Plan-A”
    of which $25.5K are for operations, and $0.13M for the US LHC Communicator
    - —> although, CR “initial FinPlan” has only **$24.9M**
  - Expect the addition of $1.0M from “savings” on Phase1
  - Also plan to spend down $600K of carry-over in 2018 (EMU electronics)

- NSF Cooperative Agreement for CMS operations and preparations of HL-LHC
  - with **$8.4M** for 2018 operations, and $3.35M to go towards prep’s for HL-LHC

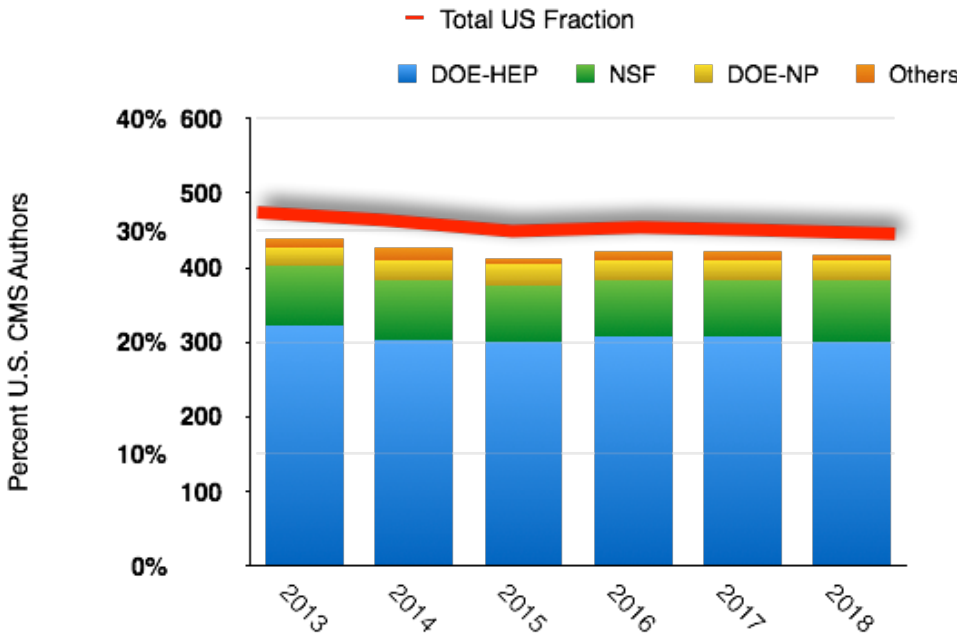
- NSF and DOE research program funds.
  - These are nominally decoupled, but operations and research have many points of contact
  - Fermilab proton research budget in FY18 is **$13.7M**, for support of scientists and the LHC Physics Center

- Phase 1 CMS Detector Upgrade Project
  - Almost finished: remaining **$3.5M** DOE in FY18/19 out of $30.4M DOE total and $9.3M NSF total

- HL-LHC CMS Upgrade Project
  - HL-LHC “OPC” started last year, ramping from $2.75M in FY17 to **$12.0M** in FY18
  - Since FY18 decoupled from Ops, although Ops is contributing **$2M** for Muon electronics upgrade
  - also, NSF “prep for MREFC” budget is part of USCMS Ops CA, at **$3.35M** in 2018

U.S. CMS Demographics and M&O-A Cost

- DOE and NSF fund ~50 Universities + Fermilab
  - this number stays almost constant
  - 1 new full member in 2017
    - Catholic U of America, PI A.Dominguez
  - 2 new associate/cooperating members
    - Simon Center for Data Analysis, PI I.Fisk
    - Northern Illinois U, PI V.Zutshi

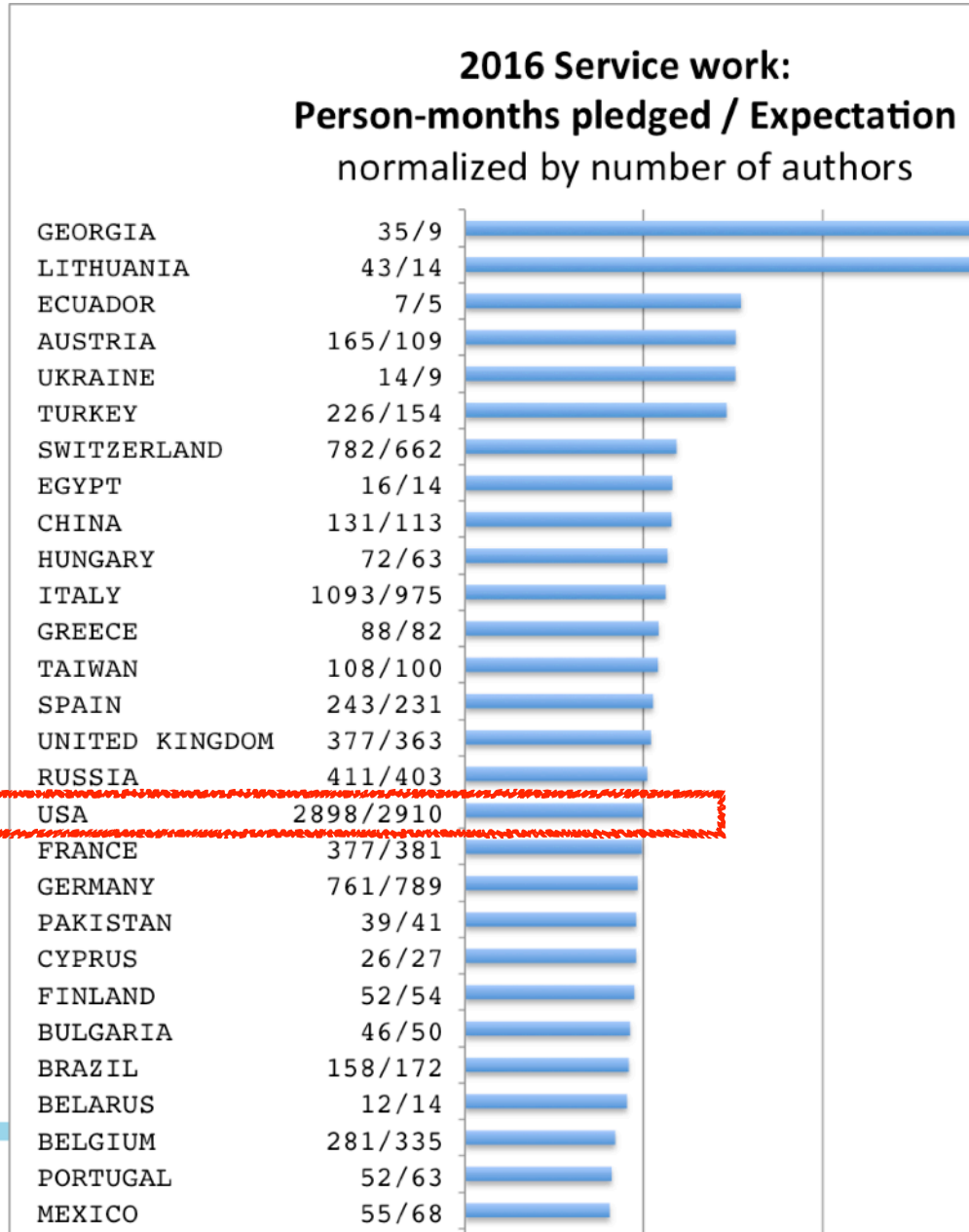


- The U.S. fraction remains almost constant at **30% of CMS**
  - as measured in # PhD physicists
    - ★ DOE 301 authors (21.5%)
    - ★ NSF 81 authors (5.8%)
    - ★ DOE Nuclear 27 authors (1.9%)
    - ★ Others 7 (0.5%)
  - GrandTotal: U.S. 416 of 1401 CMS authors (or 29.7%)

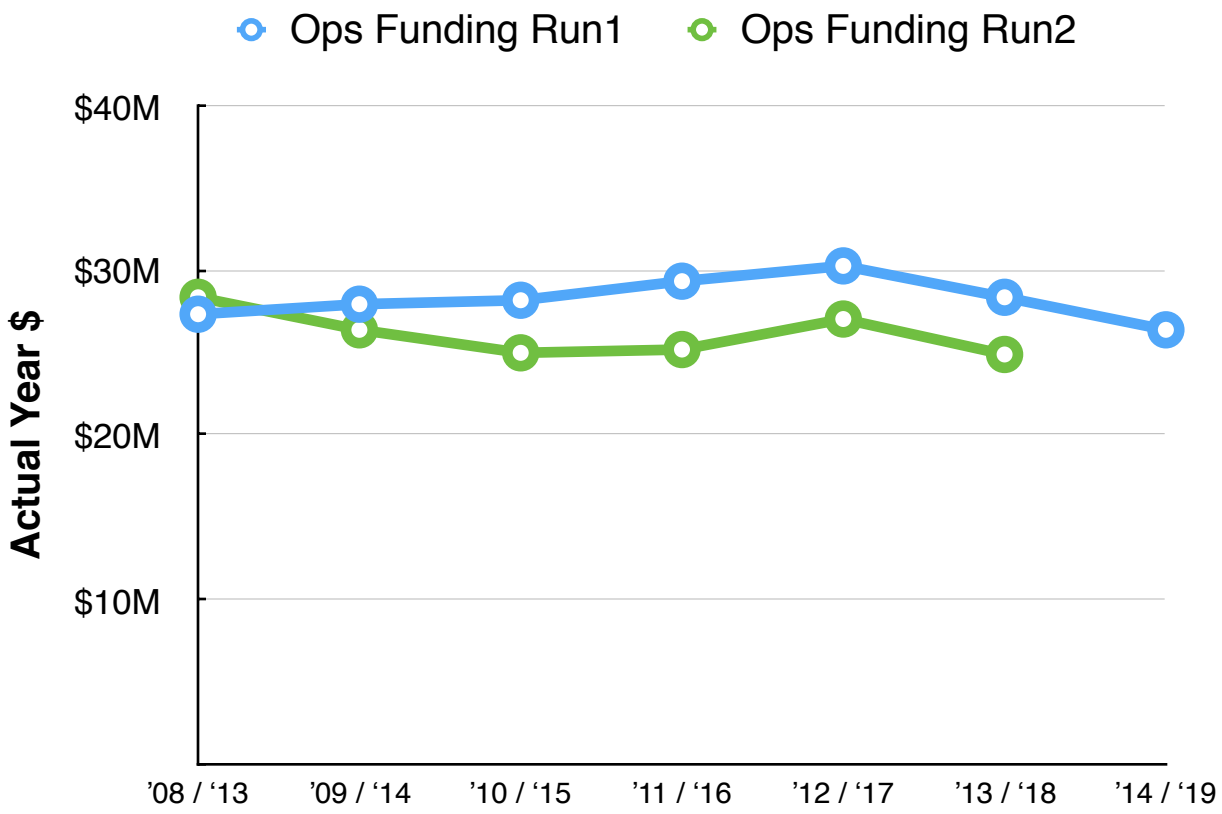
- M&O payments to CERN is per author, 2018 DOE cost is **$4.83M** (Cat-A + Cat-B)

CMS Service Work (EPR)

- Significant cost factor to participate in CMS, borne by Research and Ops
  - In 2016, U.S. delivered 2,898 months of “service work”, as CMS required
  - In 2017, CMS expects a contribution of ~2,500 months
    - no longer account for contributions to HL-LHC!
    - per author: 3 months core tasks and 8.9 central shift credit points, total equiv. to 3.4 EPR months
- Fermilab pledges 289 person months across ~50 individuals in 2017
- For 2018: proposal to again include needs for upgrades —> CMS-MB:
  - Estimated at one additional month per author!



Comparing DOE Funding for USCMS Ops, Run1 vs Run2



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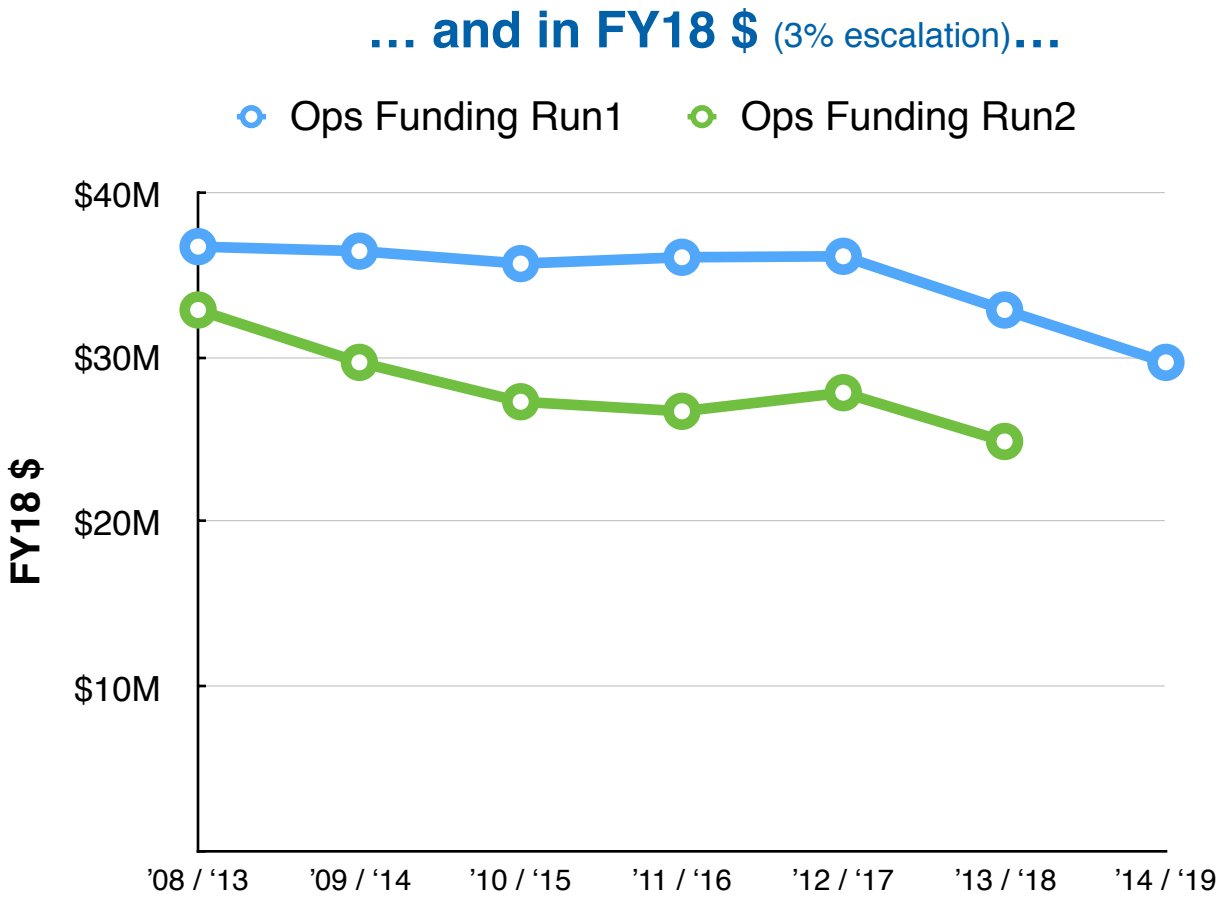
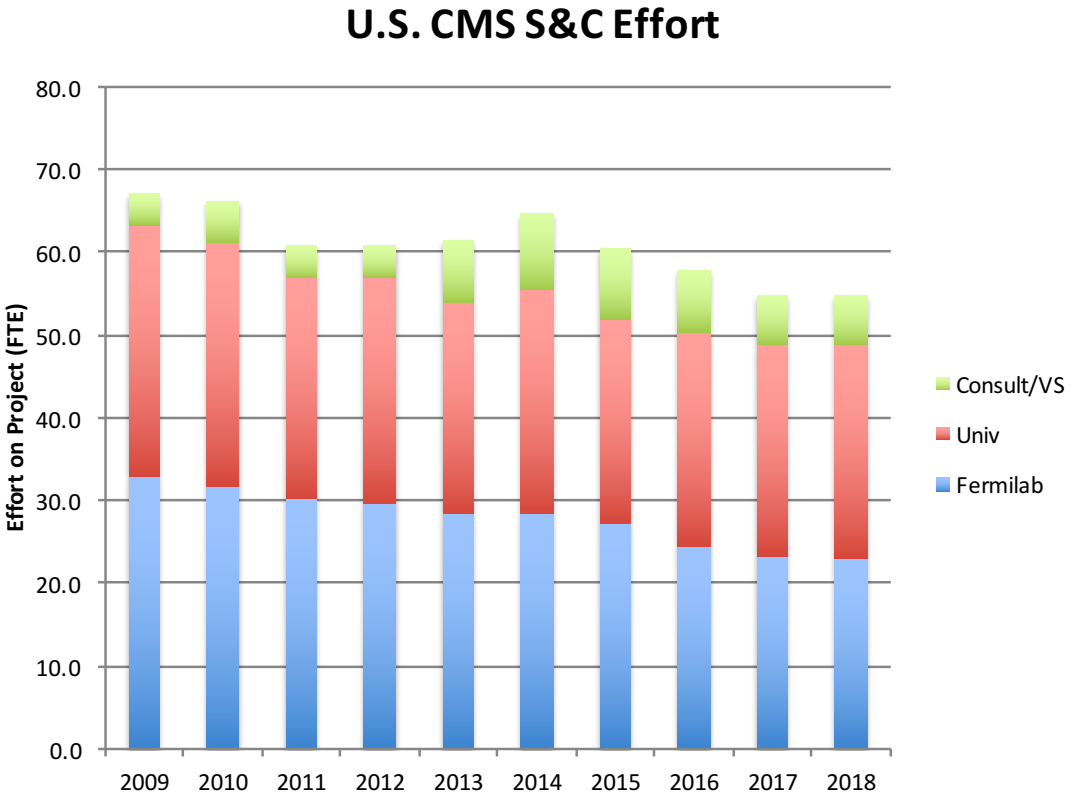


- Level of effort available for USCMS Ops in Run2, compared to Run1 is ~25% less!
  - using 3% escalation

Effort available for USCMS Ops is Declining

- Example: US CMS Efforts on Software and Computing
  - 54.8 FTE funded by program, lowest headcount in history
  - Fermilab headcount down 30% over the course of Run1 and Run2



- It's not less effort to run in Run2!
  - But have significantly less resources
- "Task pileup" is straining resources
  - Installing and commissioning Phase1 detector upgrades
  - Operating an aging detector
  - Taking and processing data with excellent quality for physics analysis
  - Preparing for HL-LHC operations, like software and computing systems

2018 US CMS Ops Spending Breakdown

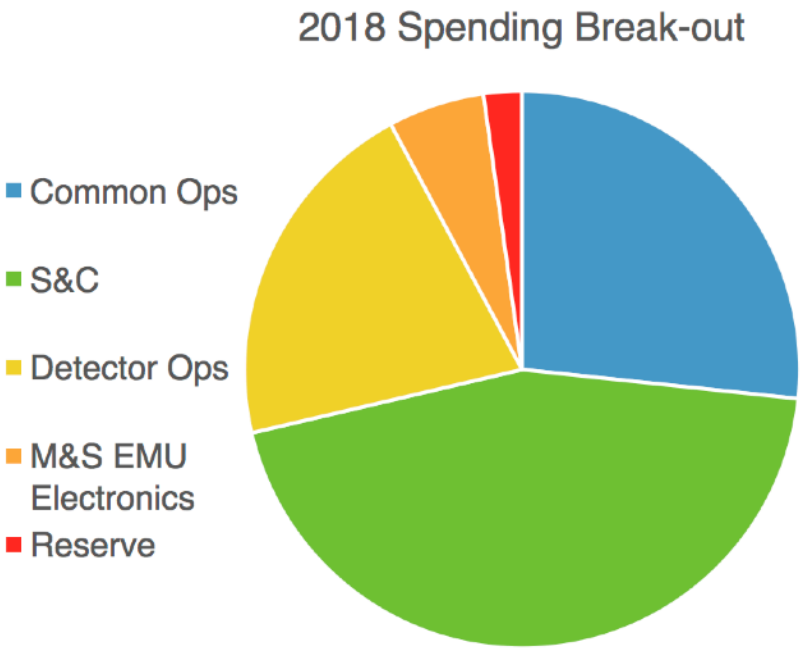
Preliminary

- Spending plan developed through a series of budget reviews, focussing on the priorities and balancing needs, while freeing funds for EMU electronics

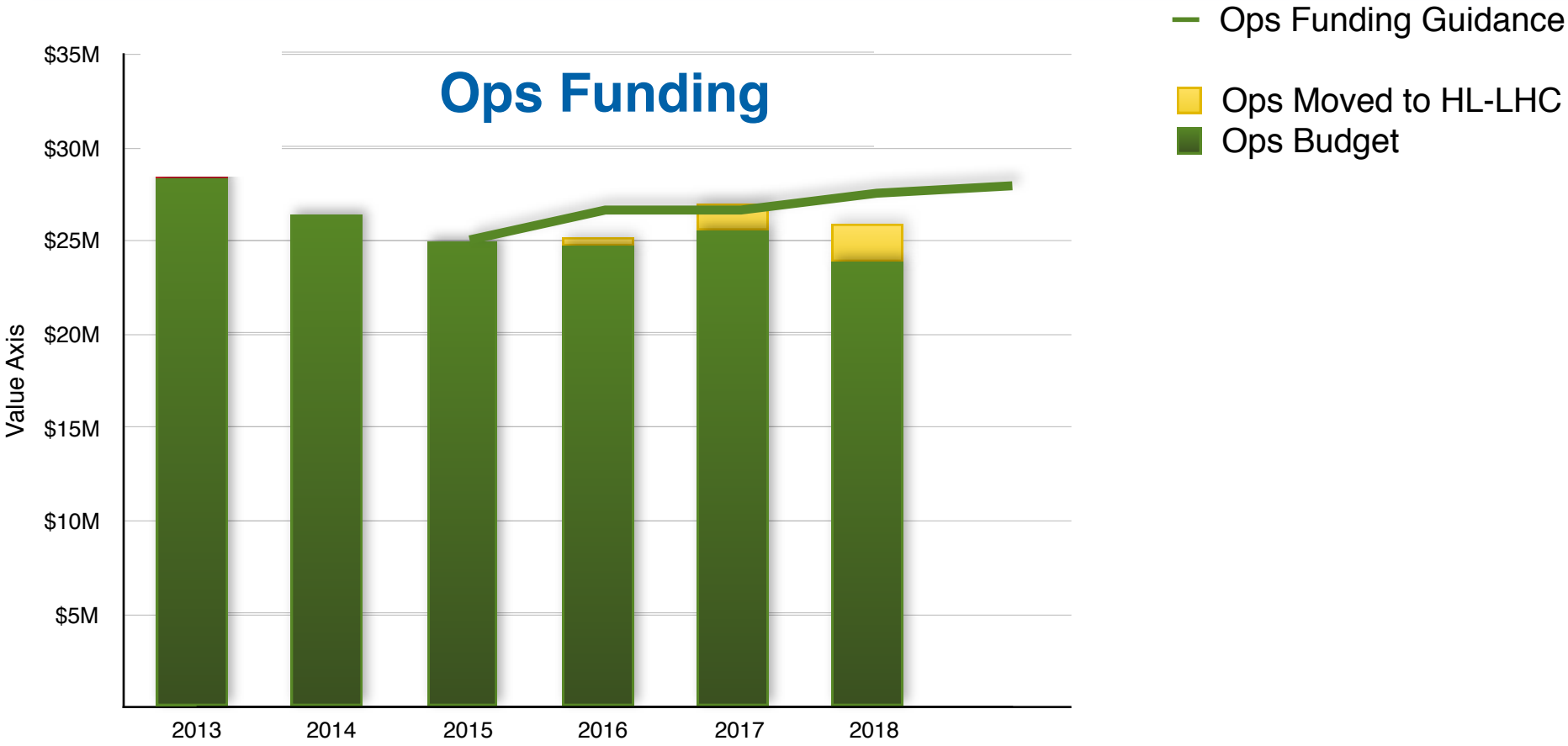
- Total planned spending **$35,507K**
  - 2017: $33,064K

DOE Initial FinPlan: $750K lower

- Break down into activity areas
  - Common Operations, $9,471K
    - @Fermilab $1,943k
  - Detector Operations, $7,389K
    - @Fermilab $460k (including $112k overhead on pass-thru)
  - Software and Computing, $15,862K
    - @Fermilab $6,097K Labor + $2,826K M&S
  - Leaves $785K reserve



Overview "External" DOE Budget for US CMS at Fermilab



- USCMS Operations Budget vs. guidance
  - DOE took back ~$2M in FY16, to bring down carry-over
  - Ops moved funds to HL-LHC OPC in FY16/17, also executes and funds Muon electronics upgrade in FY18
- Dip in Ops budget coming out of LS1 coincides with Ops struggling to find funds to start HL-LHC effort

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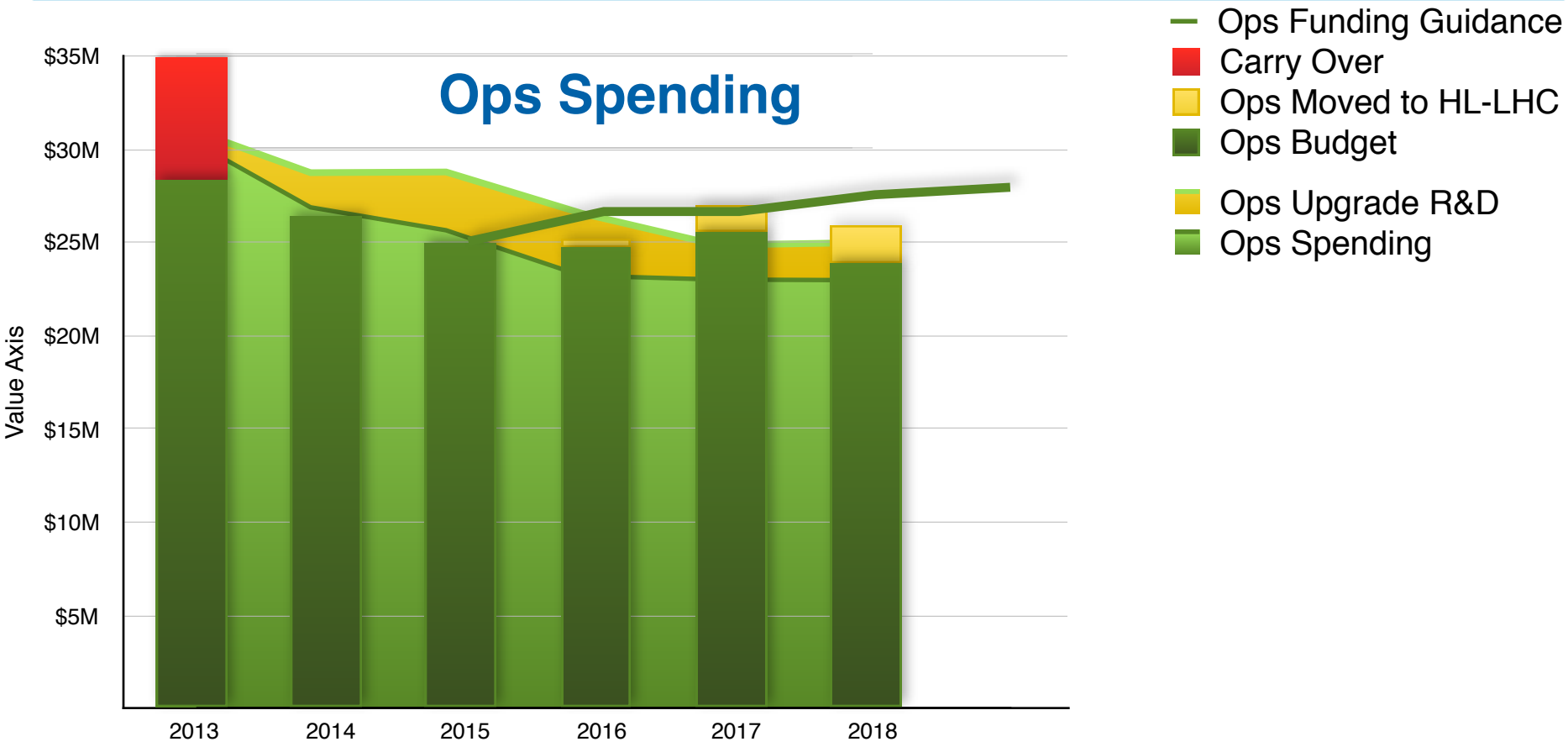

- Ops program funding was dramatically squeezed, spending level higher than new funding
  - carry-over fueled operations during budget dip FY14 — FY16
  - was a huge challenge to Run2 and to pulling together a credible HL-LHC upgrade R&D program
- Now need to catch up w/ delayed repairs, computing cuts, staff reductions, and re-fill important positions, etc
  - With the end of HL-LHC upgrade R&D, Ops will need to bring back operations efforts to the level of ~$27M

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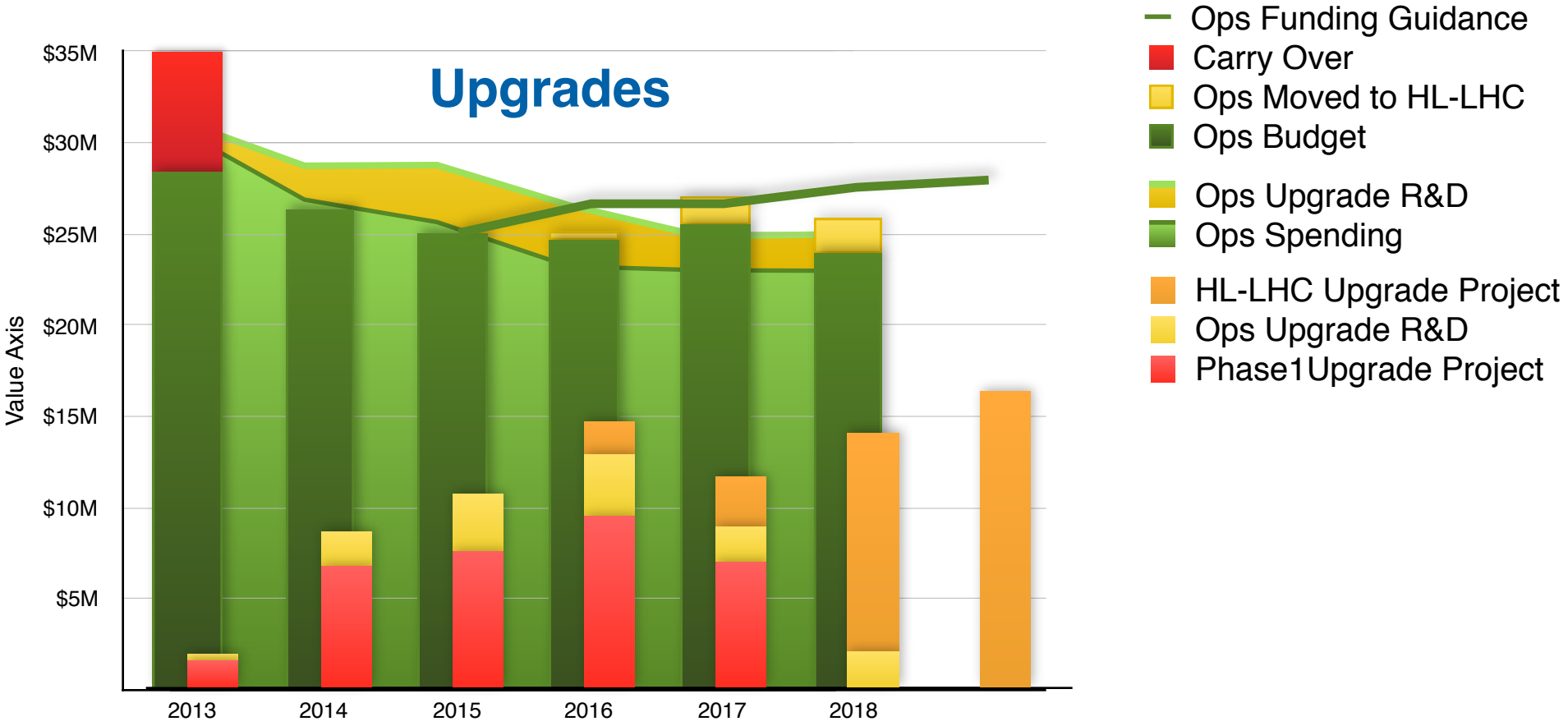

- At the end of LS1, USCMS successfully delivered a significant "detector improvement program" in FY15
- The Phase1 CMS detector upgrade started in FY13 and is now >90% delivered
  - Ops is responsible for commissioning and operating new detector components (Pixel, HCal) and L1 Trigger
- Ops funded upgrade R&D and initial "OPC" for HL-LHC, with HL-LHC project funds taking over in ~FY18
  - integrated ops contribution to HL-LHC upgrade is $16.6 M during FY13 — FY18

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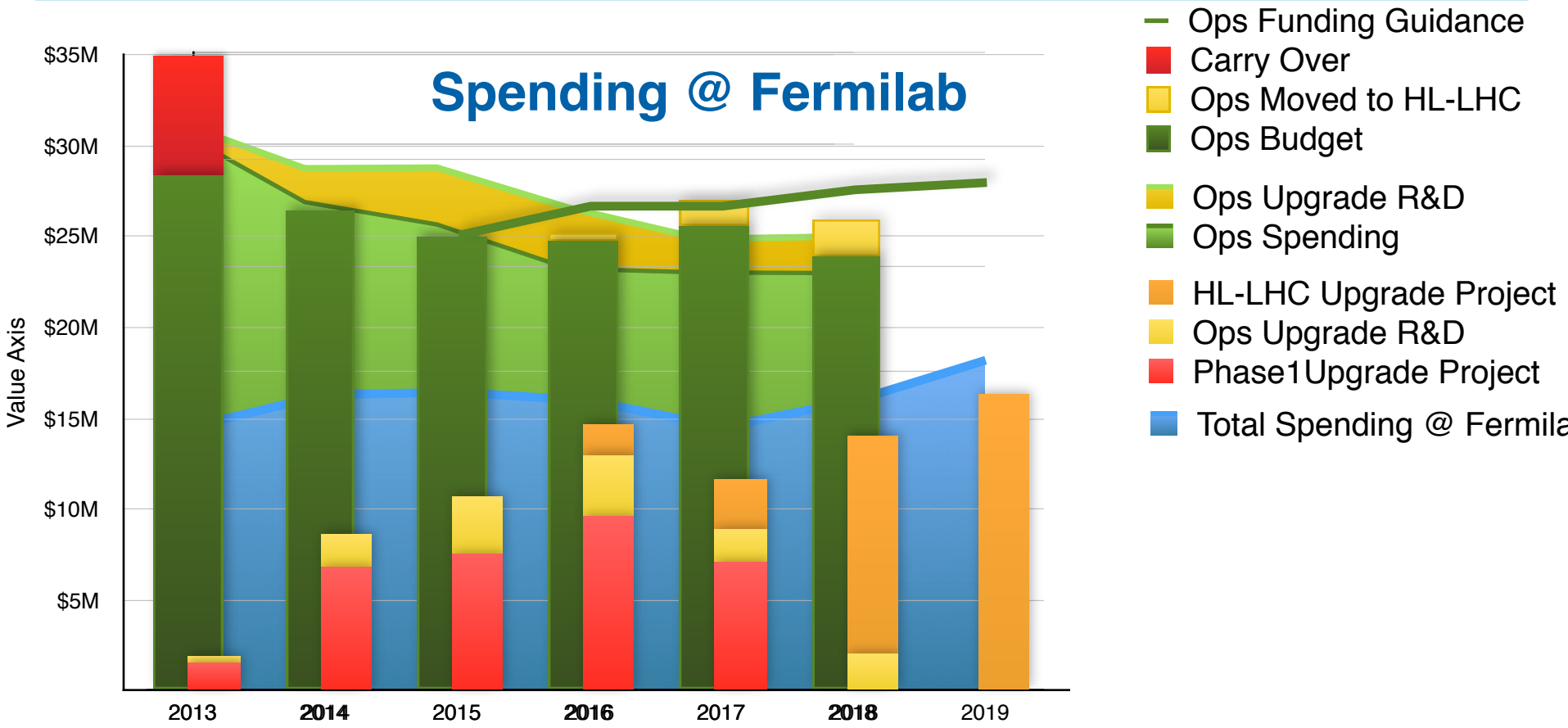
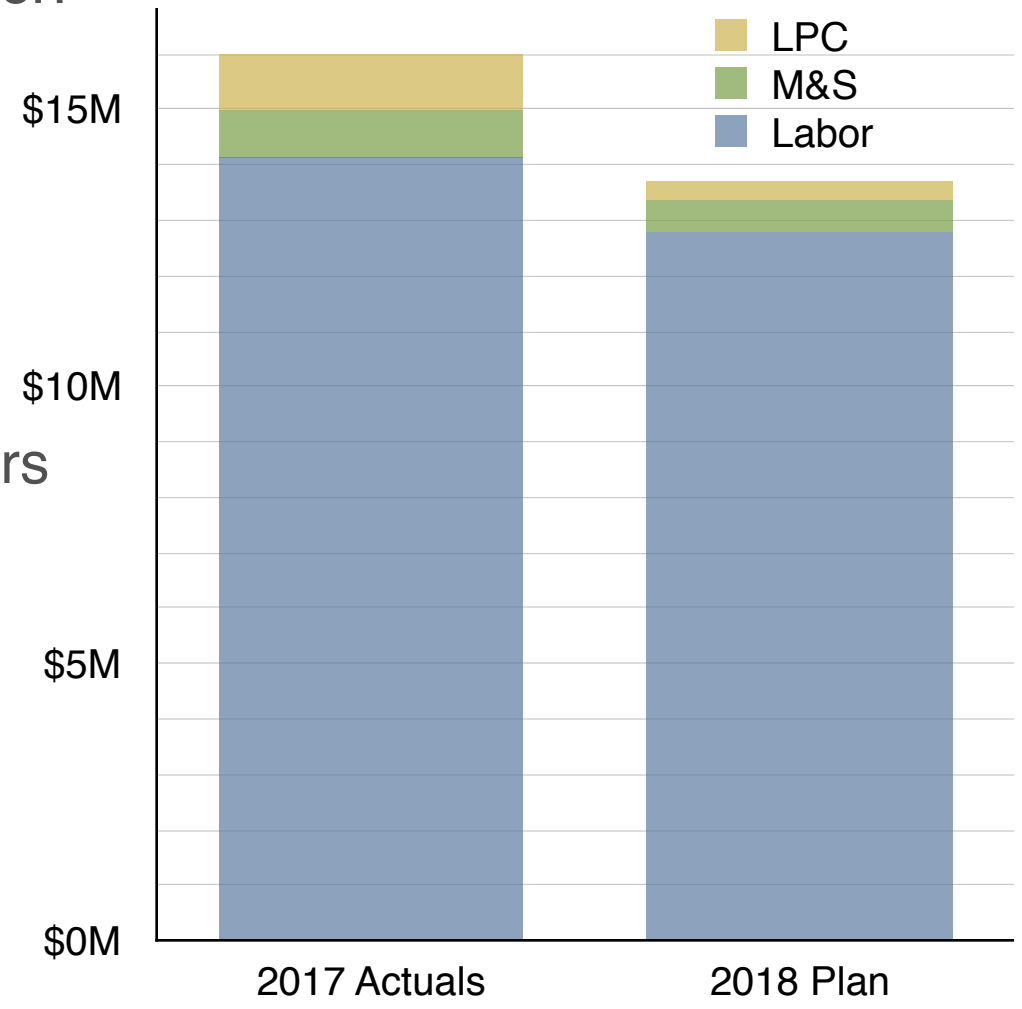


- Fermilab provides major effort to US CMS Ops and Upgrades
  - USCMS Ops and Upgrades spending at Fermilab was ~$14.5M in FY17, expected to be $15.9M in FY18
  - pays for "technical labor", M&S, overheads, support for Tier-1 and LPC, etc, but NOT scientist effort
- Proton Research funding (not shown) adds CMS scientists/RA efforts and LPC support
  - Budget was $16.4M in FY17, and expected to be $13.7M in FY18

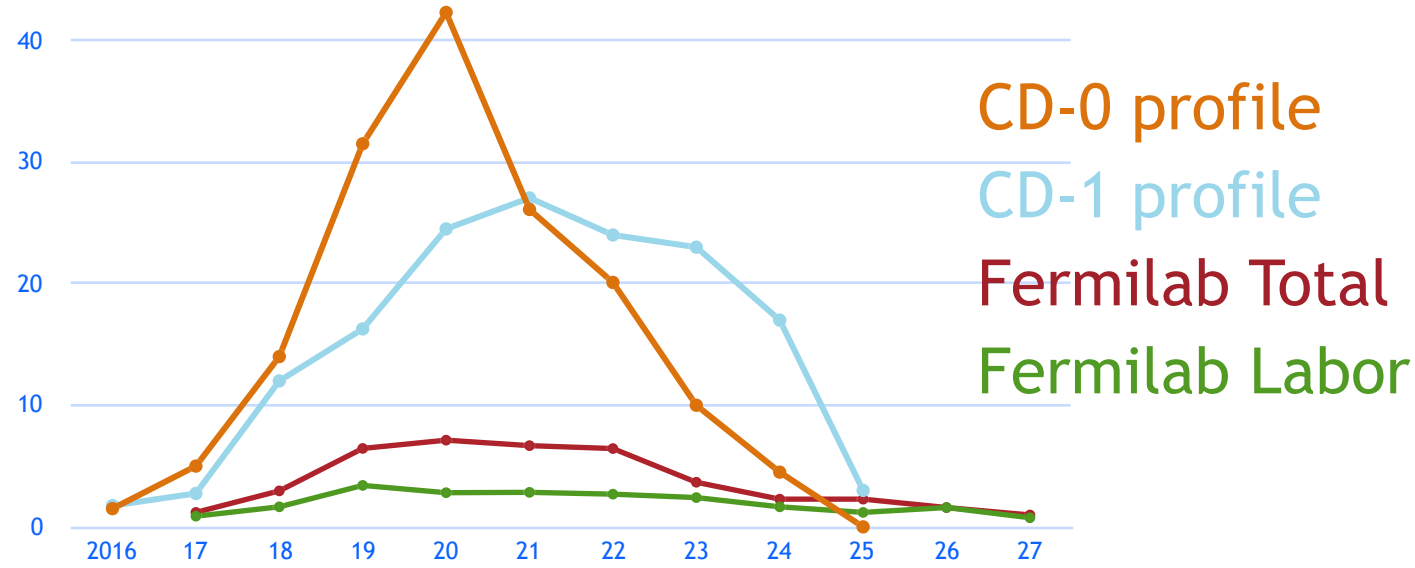
Funding of CMS Research @ Fermilab

- B&R DOE Proton Research
- Funds ~50 science FTE (69 CMS authors)
  - Scientists and RAs
  - M&S for Travel etc
  - LPC support (Distinguished Researchers Program etc)
- Devastating cuts in this year's "initial FinPlan"
  - $16,031K in FY17
  - $13,700K in FY18



HL-LHC Project Budget Profile: Total and Fermilab

FY	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Totals
CD-0 Profile	1.5	5.0	14.0	31.5	42.3	26.1	20.1	10.0	4.5	0			***155.0***
CD-1 profile	1.75	2.75	12.0	16.28	24.5	27.05	24.0	23.0	17.0	3.0			**151,330**
FNAL labor		0.88	1.65	3.41	2.81	2.84	2.69	2.41	1.65	1.19	1.59	0.75	**21.44**
FNAL Total		1.19	2.96	6.45	7.13	6.68	6.44	3.67	2.28	2.28	1.59	0.98	**41.62**



- Total budget reduced from **$155M** to **$151.33**
- And stretched out in time (**escalation / exchange rate risks hit**)

Conclusions

- Fermilab is the Host Lab for the US CMS program
  - Provides vital contributions to the CMS effort
  - Important responsibility for **managing and advocating for the CMS efforts** in the US, for US CMS Operations, Upgrades, and for LHC physics research at Fermilab

- CMS efforts employ a substantial amount of Fermilab staff and represent much of Fermilab expertise and talent

- Expects to be at the end a tough 4-year period of very squeezed budgets
  - While starting the HL-LHC detector upgrades , US CMS has significantly squeezed operations costs and delayed efforts and investments,

- However, FY18 Initial FinPlan budgets look very uncomfortable for USCMS Ops, and budgets threaten to be devastating for the lab's CMS research efforts

- Given the squeezed budgets, it will be more difficult for the U.S. to fulfill expected LHC contributions, and this should be a matter of concern

The End