C75 Schedule and Resources Cavity and Cryomodule

Reilly/Davis/Legg/McEwen

Contents

- Updated cost comparison C50/C75/C100
- Schedule and resources for C75-01
  - Based on C50-11 and C50-12
- Infrastructure changes
- High level plan for C75-02
- A preliminary plan for doing two C75 per year
- Quality systems in SRF for cryomodules
- Summary

C50/C75/C100

Update - February 2018, with new vendor quotes for C75 & C100

	# Cav	cells /cav	cav length m	Active Length m	fill factor %	MV	volts /cav (MV)	gradient (MV/m)	klystron power	unit cost (FY18 M$ Direct)	*RF Cost	Total Cost FY18 Direct	MV (gain)	V(gain) /$
C50	8	5	0.5	4	48.1	50	6.25	12.5	6	1.42		1.42	20	14.1
C75†	8	5	0.5	4	48.1	75	9.4	18.8‡	8	1.76	0.84	2.60	45	17.3
C100‡	8	7	0.7	5.6	64.4	100	12.5	17.9‡	13	4.57	1.81	6.38	70	11.0

†New cells or new processing required to achieve higher Q's and gradients
*Engineering required at additional cost (not included)
‡Digital LLRF required

C50 Estimate

- Based on C50-11 + escalation
- Added Mag shielding & NEG Pumps

C75 Estimate

- Based on C50-11 with C75 Cavities
- Includes Actual Vendor Quotes as of June2017 for Cavity Fab, Ingot & Ingot Slicing (reusing end groups)
- Includes Mag shielding & NEG Pumps

C100 Estimate

- Includes updated quotes from Vendors for one Cryomodule as of August 2017 for the following major procurements
  - Nb & Cavities, He Vessel, Tuners, Thermal Shield, Magnetic Shield, Vac Vessels (End cans were not requoted).
- All other procurements used escalation + scaling factor (+15%) due to low volume buys
- C75 & C100 - LL RF for C75 & C100 and High power (for C100) based on cost estimate from C. Hovator (June2017)

What is not included

- One time R&D costs for Cavity Development (already done)
- One time cost for LL RF Development to address obsolesce (same design for c50, C75 and/or C100 zones)
- Wave Guide Vendor Development + 8 Wave Guides

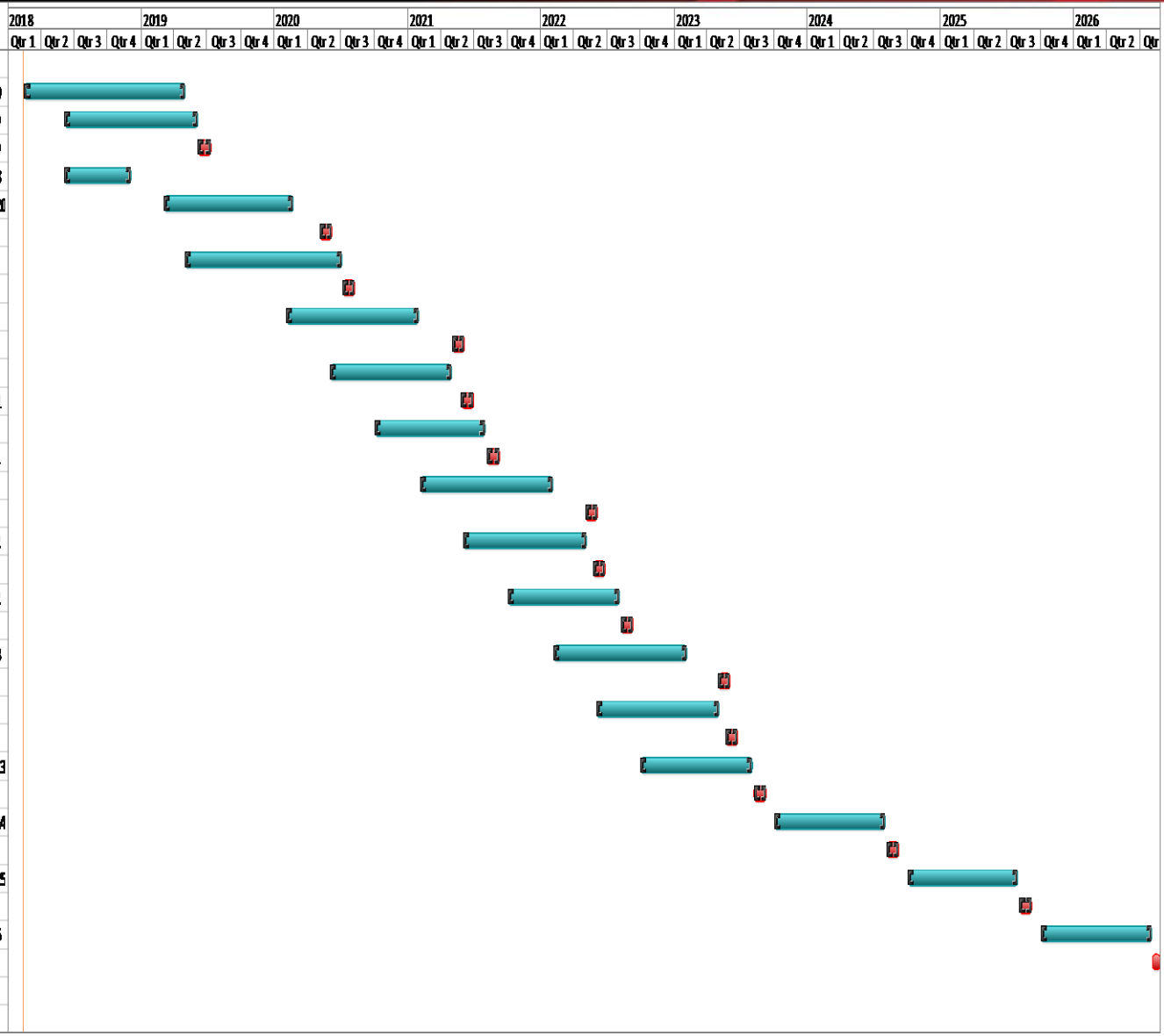
Ref. DRAFT C50 vs C75 vs C100 Rev 49- 13Feb2017

Adjusted CPP Schedule

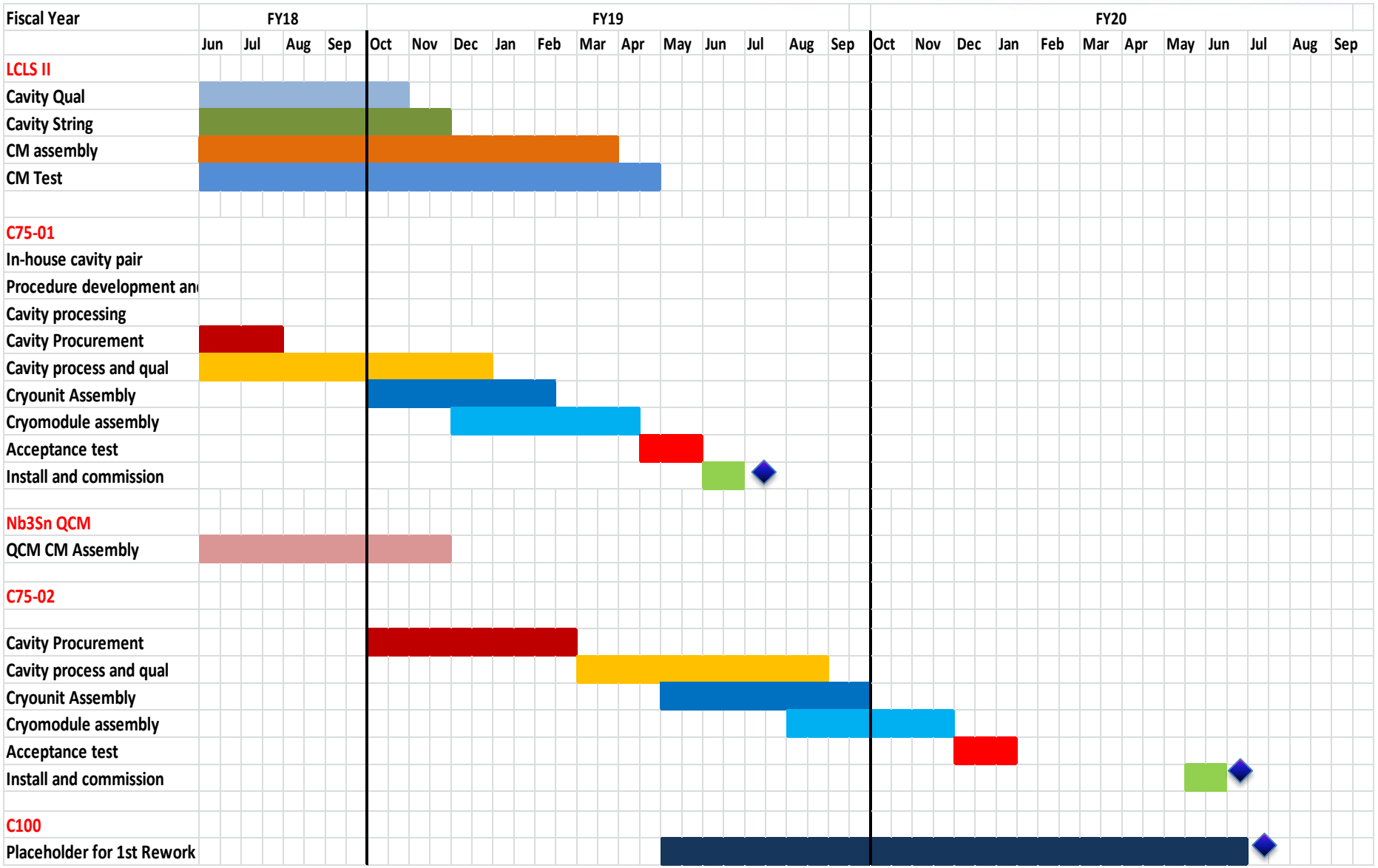
Fiscal Year	Modules Installed during SAD
FY18	F100, SL21
FY19	C75-01
FY20	C75-02, C100-Refurb-0
FY21	C75-03, C75-04, C100-Refurb-1
FY22	C75-05, C75-06, C100-Refurb-2
FY23	C75-07, C75-08, C100-Refurb-3
FY24	C100-Refurb-4
FY25	C75-09
FY26	C100-Refurb-5
FY27	C75-10

CPP Cryomodule Plan

ID	Task Mode	Task Name	Duration	Start	Finish
1					
2		LCLS II Assembly	315 days	Wed 2/14/18	Tue 4/30/19
3		C75-01 CM Assemble and Tes	261 days	Mon 6/4/18	Mon 6/3/19
4		C75-01 Install and Commissio	25 days	Tue 6/4/19	Mon 7/8/19
5		Nb3Sn QCM Assemble and Te	130 days	Mon 6/4/18	Fri 11/30/18
6		C75-02 CM Assemble and Tes	253 days	Mon 3/4/19	Wed 2/19/20
7		C75-02 Install and Commissio	25 days	Mon 5/4/20	Fri 6/5/20
8		C100-01 CM Assembly and Te	308 days	Wed 5/1/19	Fri 7/3/20
9		C100-01 Install and Commissi	25 days	Mon 7/6/20	Fri 8/7/20
10		C75-03 CM Assembly and Tes	260 days	Mon 2/3/20	Fri 1/29/21
11		C75-03 Install and Commissio	25 days	Mon 5/3/21	Fri 6/4/21
12		C75-04 CM Assembly and Tes	240 days	Mon 6/1/20	Fri 4/30/21
13		C75-04 Install and Commissio	25 days	Wed 5/26/21	Tue 6/29/21
14		C100-02 CM Assembly and Te	217 days	Thu 10/1/20	Fri 7/30/21
15		C100-02 Install and Commissi	25 days	Tue 8/3/21	Mon 9/6/21
16		C75-05 CM Assembly and Tes	260 days	Wed 2/3/21	Tue 2/1/22
17		C75-05 Install and Commissio	25 days	Mon 5/2/22	Fri 6/3/22
18		C75-06 CM Assembly and Tes	240 days	Tue 6/1/21	Mon 5/2/22
19		C75-06 Install and Commissio	25 days	Mon 5/23/22	Fri 6/24/22
20		C100-03 CM Assembly and Te	217 days	Fri 10/1/21	Mon 8/1/22
21		C100-03 Install and Commissi	25 days	Mon 8/8/22	Fri 9/9/22
22		C75-07 CM Assembly and Tes	260 days	Thu 2/3/22	Wed 2/1/23
23		C75-07 Install and Commissio	25 days	Mon 5/1/23	Fri 6/2/23
24		C75-08 CM Assembly and Tes	240 days	Wed 6/1/22	Tue 5/2/23
25		C75-08 Install and Commissio	25 days	Mon 5/22/23	Fri 6/23/23
26		C100-04 CM Assembly and Te	217 days	Sat 10/1/22	Mon 7/31/23
27		C100-04 Install and Comission	25 days	Mon 8/7/23	Fri 9/8/23
28		C100-05 CM Assembly and Te	217 days	Sun 10/1/23	Mon 7/29/24
29		C100-05 Install and Commissi	25 days	Mon 8/5/24	Fri 9/6/24
30		C75-09 CM Assembly and Tes	217 days	Tue 10/1/24	Wed 7/30/25
31		C75-09 Install and Commissio	25 days	Mon 8/4/25	Fri 9/5/25
32		C100-06 CM Assembly and Te	217 days	Wed 10/1/25	Thu 7/30/26
33		C100-06 Install and Commissi	25 days	Mon 8/3/26	Fri 9/4/26
34		C75-10 CM Assembly and Tes	217 days	Thu 10/1/26	Fri 7/30/27
35		C75-10 Install and Commissio	25 days	Mon 8/2/27	Fri 9/3/27

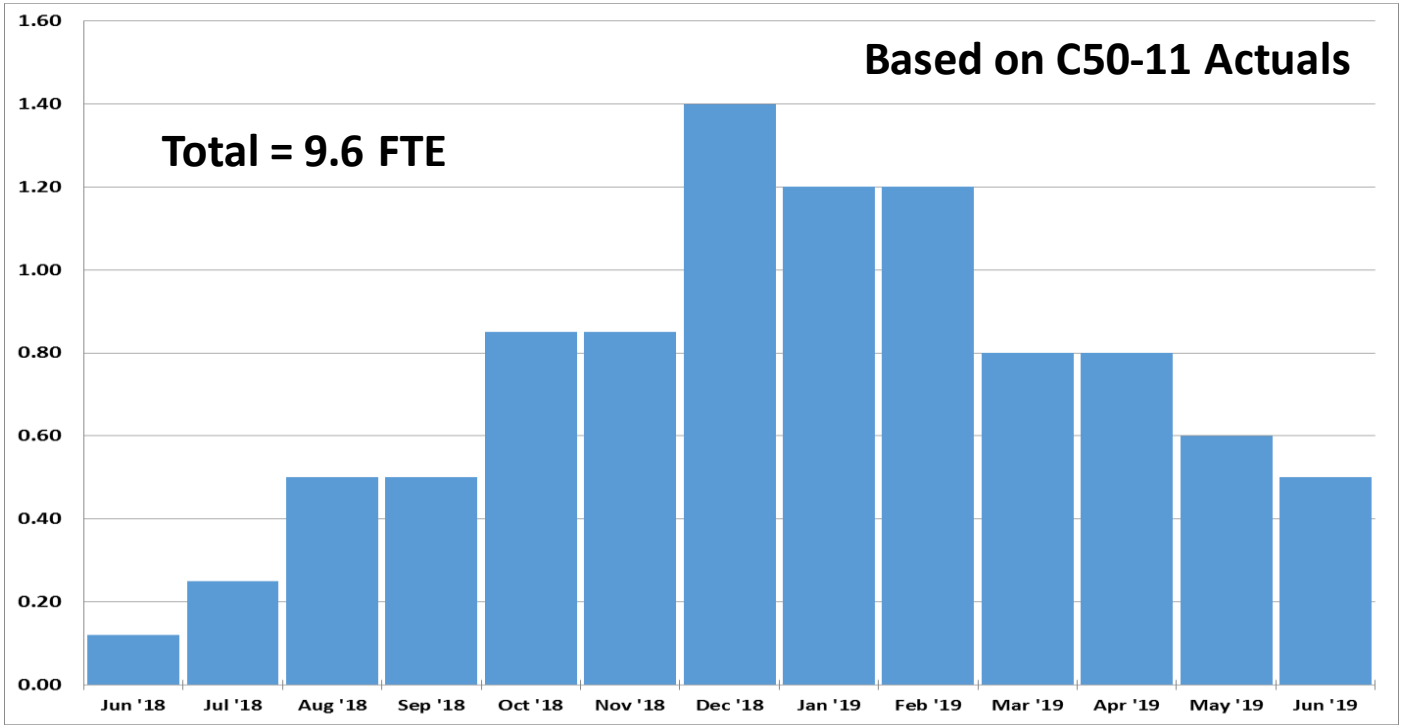


Plan C75-01 and C75-02

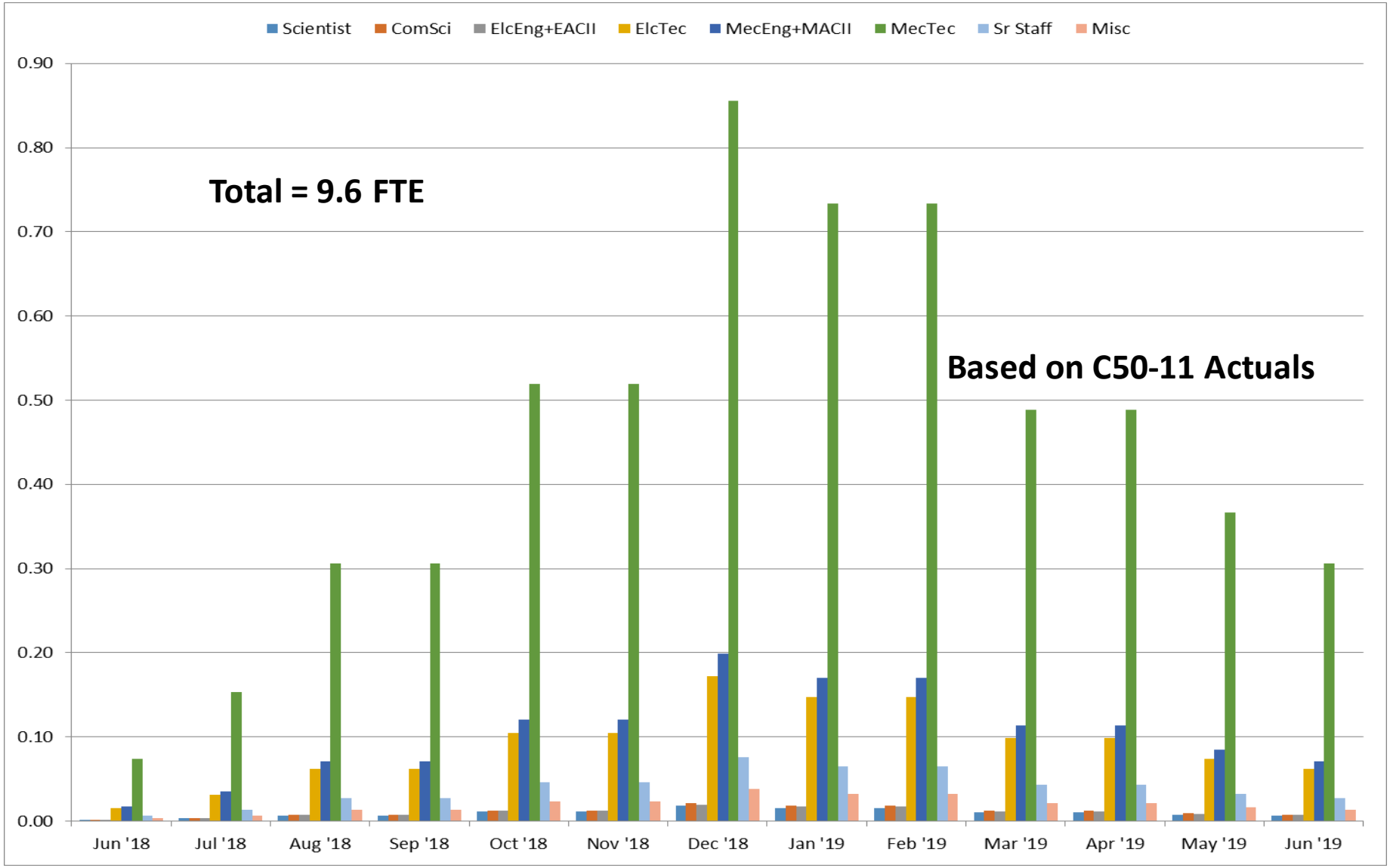


Forecasted C75-01 FTE per Month

Fiscal Year	FY18				FY19									
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
C75-01														
Cavity Procurement														
Cavity process and qual	7 months													
Cryounit Assembly					4 months									
Cryomodule assembly							5.5 months							
Acceptance test											1.5 months			
Install and commission													1 month	
Total FTE	0.12	0.25	0.5	0.5	0.85	0.85	1.4	1.2	1.2	0.8	0.8	0.6	0.5	

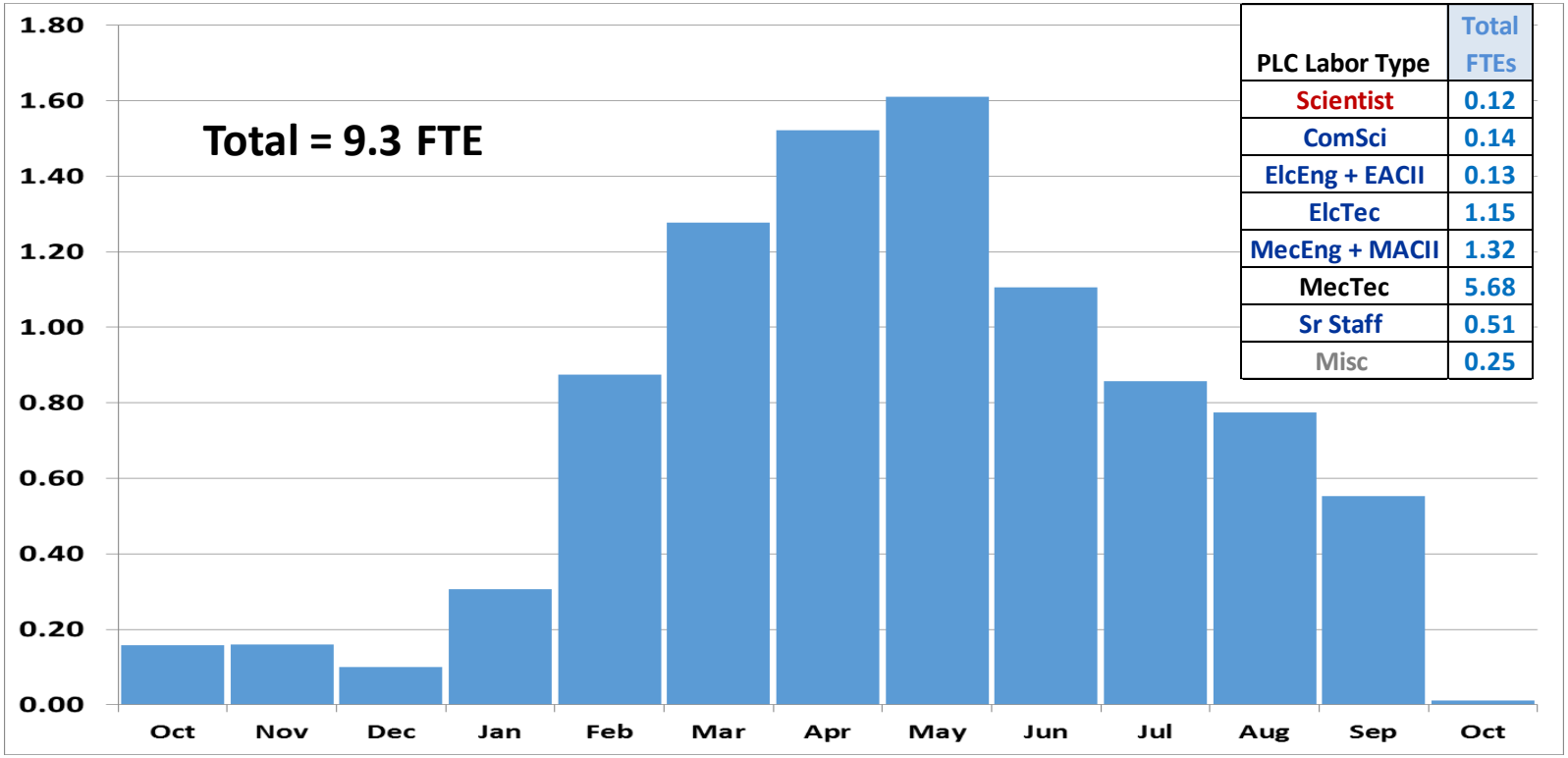


Forecasted C75-01 FTE per Month



C50-11 Actual FTE per Month

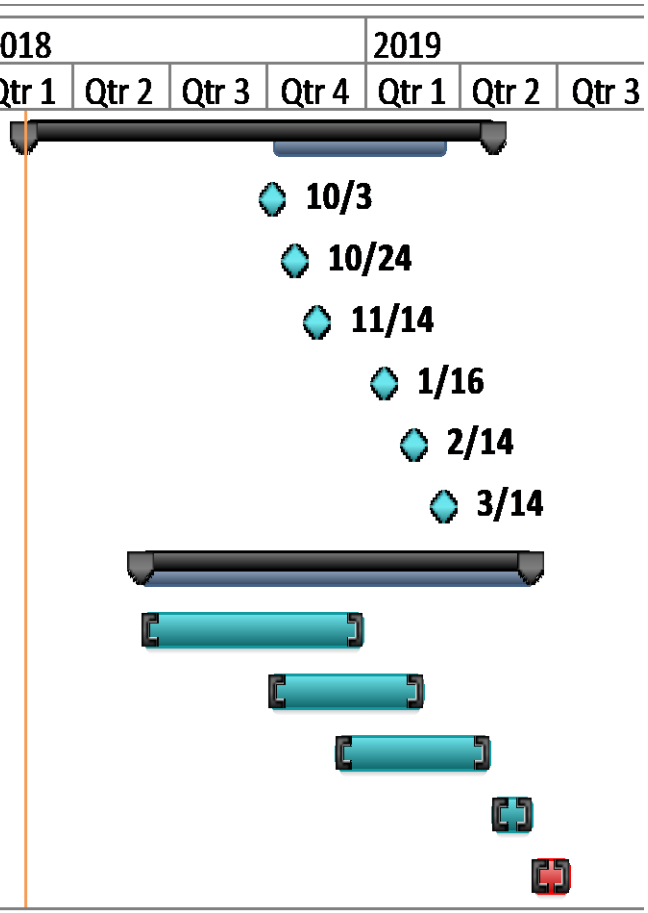
FY13/14	Oct '12	Nov '12	Dec '12	Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13
C50-11													
CM Disassembly													
Cavity process and qual													
Cryounit Assembly													
Cryomodule assembly													
Acceptance test													
Install and commission													
Total FTE	0.16	0.16	0	0.31	0.88	1.28	1.52	1.61	1.11	0.86	0.77	0.55	0.1



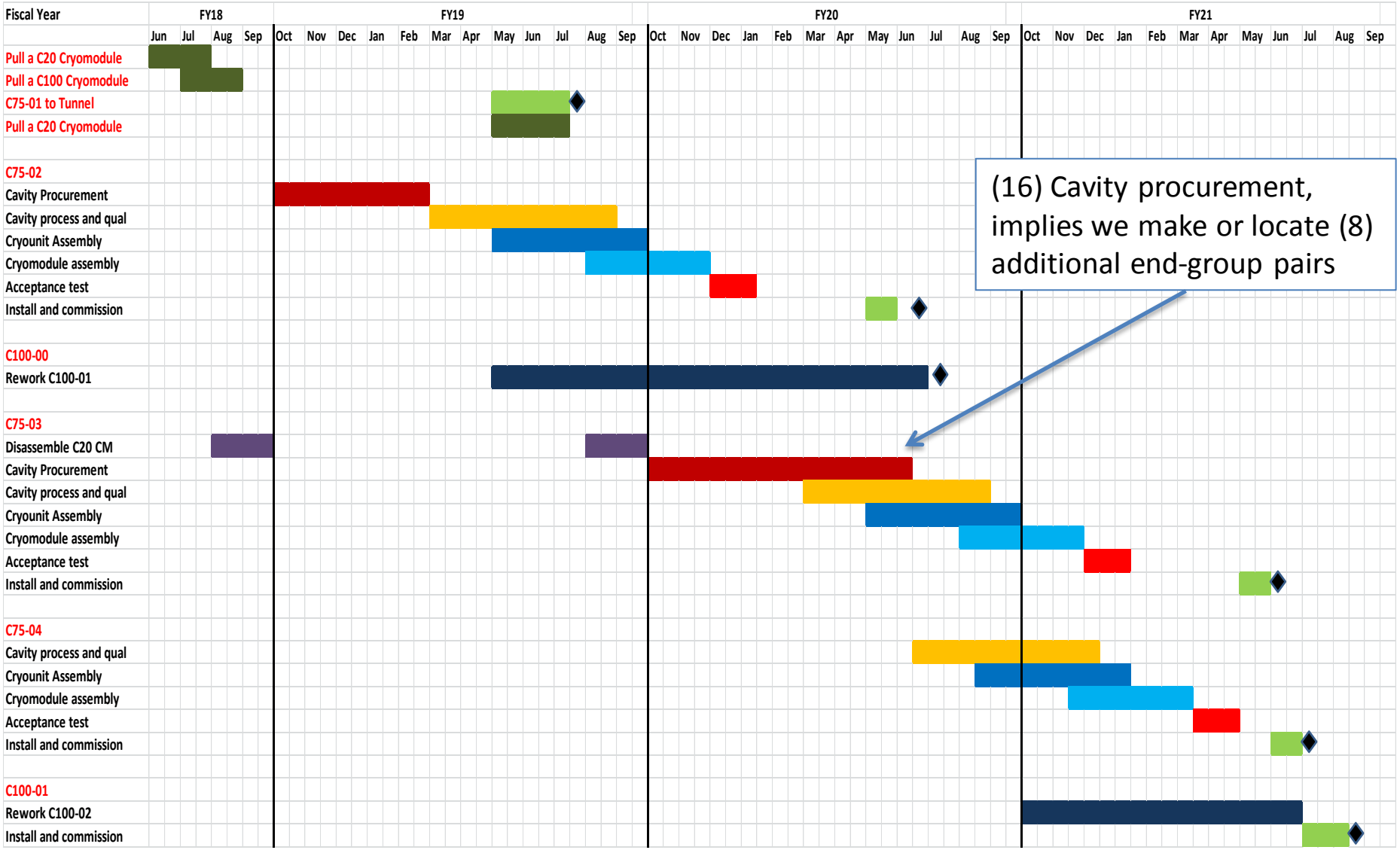
PLC Labor Type	Total FTEs
Scientist	0.12
ComSci	0.14
ElcEng + EACII	0.13
ElcTec	1.15
MecEng + MACII	1.32
MecTec	5.68
Sr Staff	0.51
Misc	0.25

LCLS II Ramp Down and C75-01

Task Name	Duration	Start	Finish
LCLS II Assembly	**315 days**	**Wed 2/14/18**	**Tue 4/30/19**
CM15 Assembly Completec	0 days	Wed 10/3/18	Wed 10/3/18
CM16 Assembly Completec	0 days	Wed 10/24/1	Wed 10/24/1
CM17 Assembly Completec	0 days	Wed 11/14/1	Wed 11/14/1
CM18 Assembly Completec	0 days	Wed 1/16/19	Wed 1/16/19
CM19 Assembly Completec	0 days	Thu 2/14/19	Thu 2/14/19
CM20 Assembly Completec	0 days	Thu 3/14/19	Thu 3/14/19
C75-01 CM Assemble and Tes	**261 days**	**Mon 6/4/18**	**Mon 6/3/19**
Cavity Pair Qualification	150 days	Mon 6/4/18	Fri 12/28/18
Cryounit Assembly	103 days	Mon 10/1/18	Wed 2/20/19
Cryomodule Assembly	105 days	Mon 12/3/18	Fri 4/26/19
Acceptance Test	26 days	Mon 4/29/19	Mon 6/3/19
C75-01 Install and Commissio	**25 days**	**Tue 6/4/19**	**Mon 7/8/19**

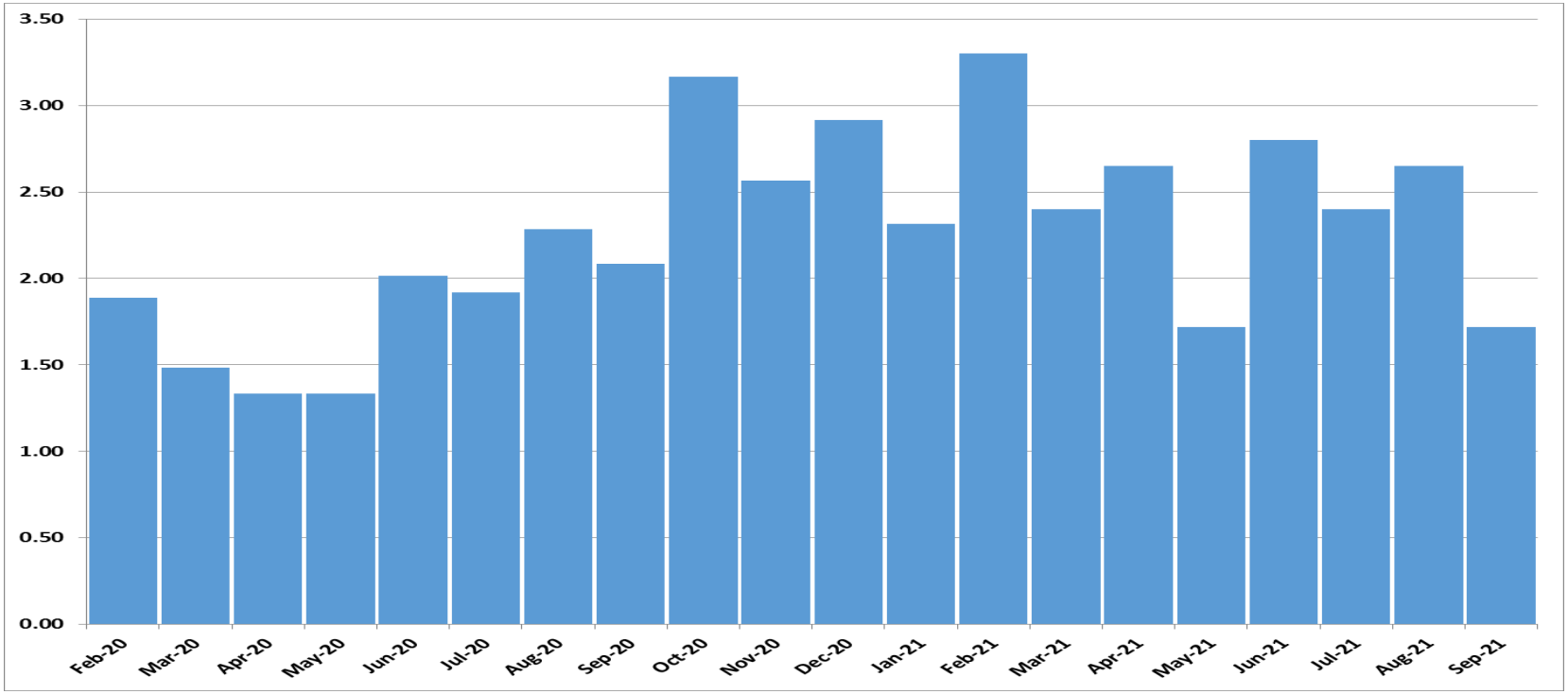


A Plan for Completing (2) C75 + (1) C100



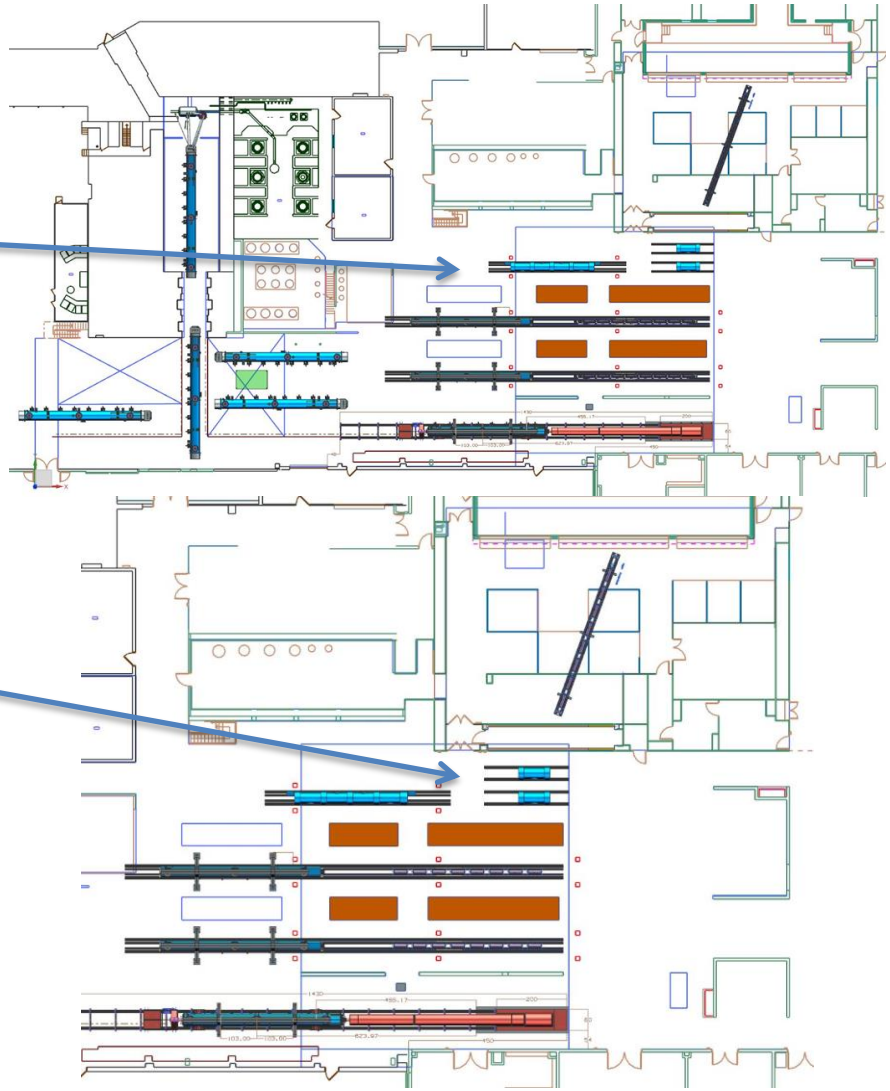
Forecast FTE per Month at Peak

Fiscal Year	FY20								FY21											
	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21
C75-02 Cryomodule																			
C100-01 Cryomodule																			
C75-03 Cryomodule																			
C75-04 Cryomodule																			
C100-02 Cryomodule																			
C75-05 Cryomodule																			
C75-06 Cryomodule																			
C75-02 Cryomodule	0.53																		
C100-01 Cryomodule	1.23	1.23	0.83	0.83	0.63	0.53													
C75-03 Cryomodule	0.12	0.25	0.50	0.50	0.85	0.85	1.40	1.20	1.20	0.80	0.80	0.60	0.50						
C75-04 Cryomodule					0.53	0.53	0.88	0.88	1.43	1.23	1.23	0.83	0.83	0.63	0.53				
C100-02 Cryomodule									0.53	0.53	0.88	0.88	1.43	1.23	1.23	0.83	0.83	0.63	0.53
C75-05 Cryomodule													0.53	0.53	0.88	0.88	1.43	1.23	1.23
C75-06 Cryomodule																	0.53	0.53	0.88
Total FTE per Month	1.89	1.48	1.33	1.33	2.02	1.92	2.28	2.08	3.17	2.57	2.92	2.32	3.30	2.40	2.65	1.72	2.80	2.40	2.65

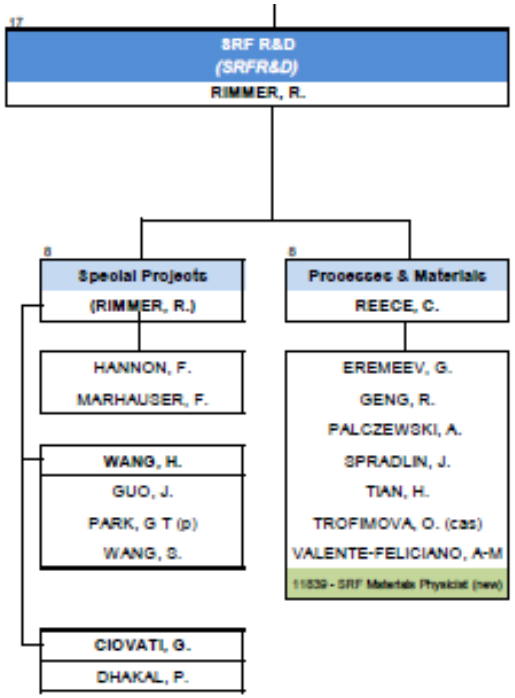


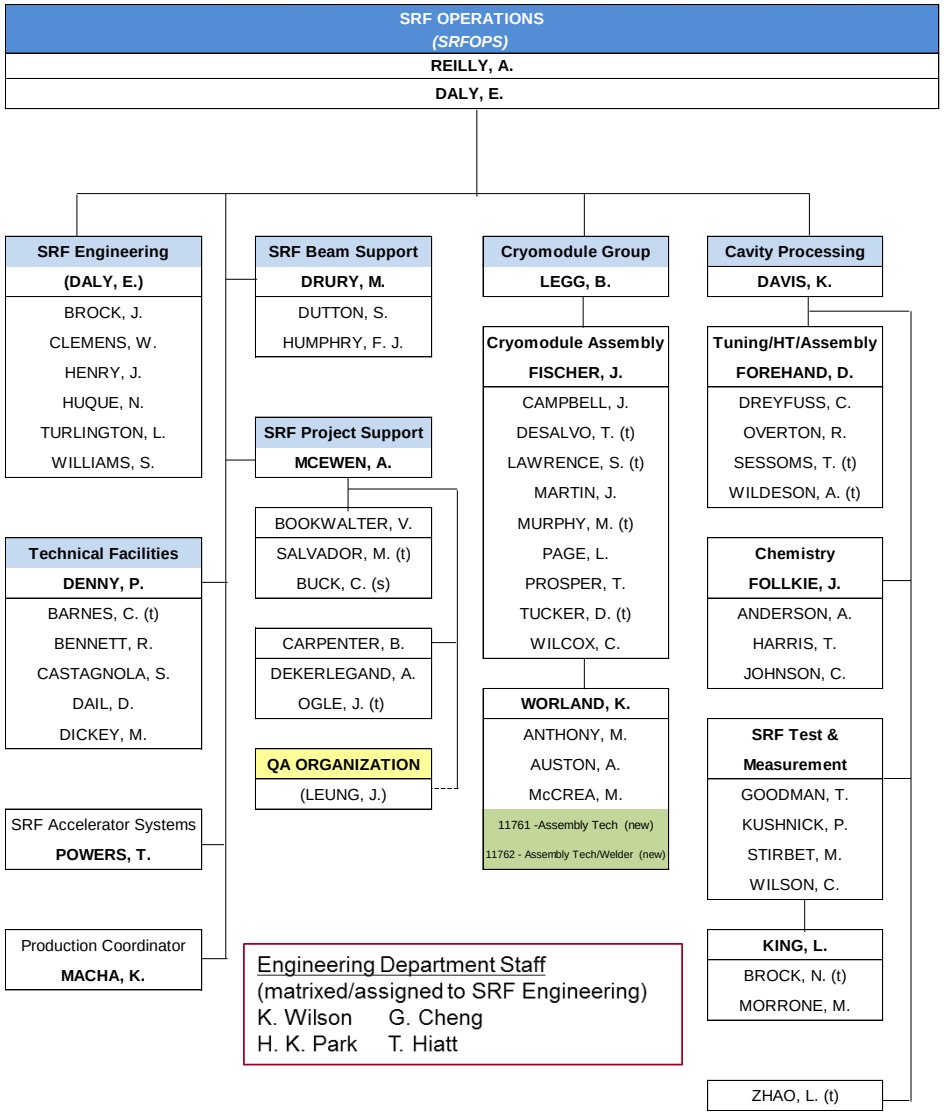
Infrastructure for C75 Cryomodules

- Space to add a 4th rail for CEBAF modules during LCLS II
- Decision not to add for C75-01
  - Plan to use exisitng rails similar to C50-13
- Cryo-unit rails will be added for C75-01
- Timing for adding 4th rail will be driven by future work



SRF Organization

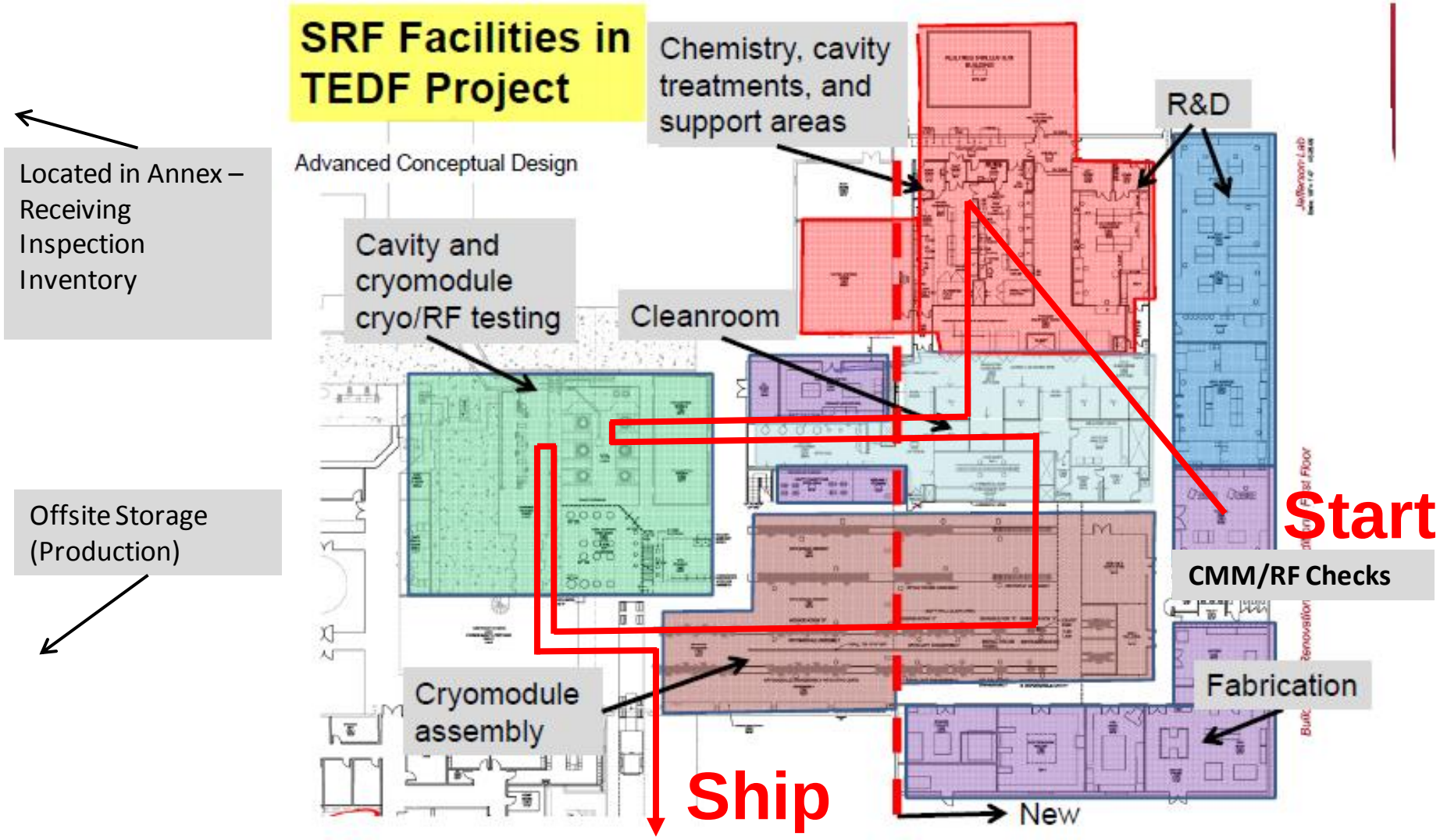




Key Points

- Cavities/Cryomodules move through work centers
- Work centers have leads
- Do not have project based dedicated teams
- Work is prioritized scheduled in weekly planning sessions
- Schedule is reviewed daily (twice)

SRF Facilities at JLab



SRF Quality Management System

- Goal to enable high quality, highly effective and efficient operations in fulfilling the SRF Mission.
  - Models the ISO 9001 Quality Standards.
  - Supplements the Jlab lab-wide Quality Assurance Plan.
- Structured deployment of quality assurance practices through quality policy and procedures.
- System is being implemented and continually improved.

Quality Policy: SRF Quality Manual QA-M-001

A "Road Map" describing the SRF Mission, the quality assurance/control systems, and mechanism to produce high quality deliverables.

Highlights:

a) Process elements are based on **ISO 9001**

b) Lists a full set of quality process procedures (section 2).

c) Explains different levels of process documents (section 3).

d) Supplements lab-wide **Jlab Quality Assurance Plan** (section 3).

e) Describes SRF **process interactions** (section 4.2.2.1).

f) Captures SRF **Mission Statement** (section 5.3).

g) Explains SRF quality objectives (section 5.4.1).

h) …… and the **quality processes** (section 5.5 to section 8.5).

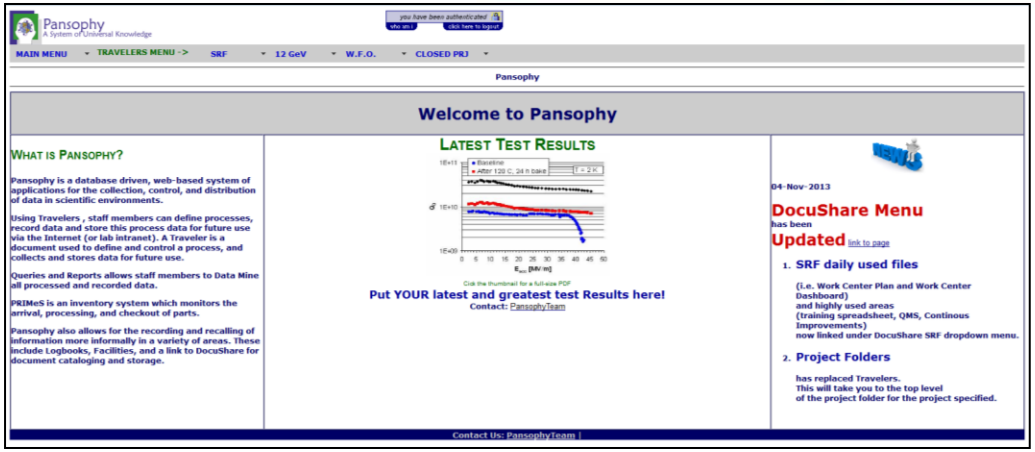
Data, Document & Process Management

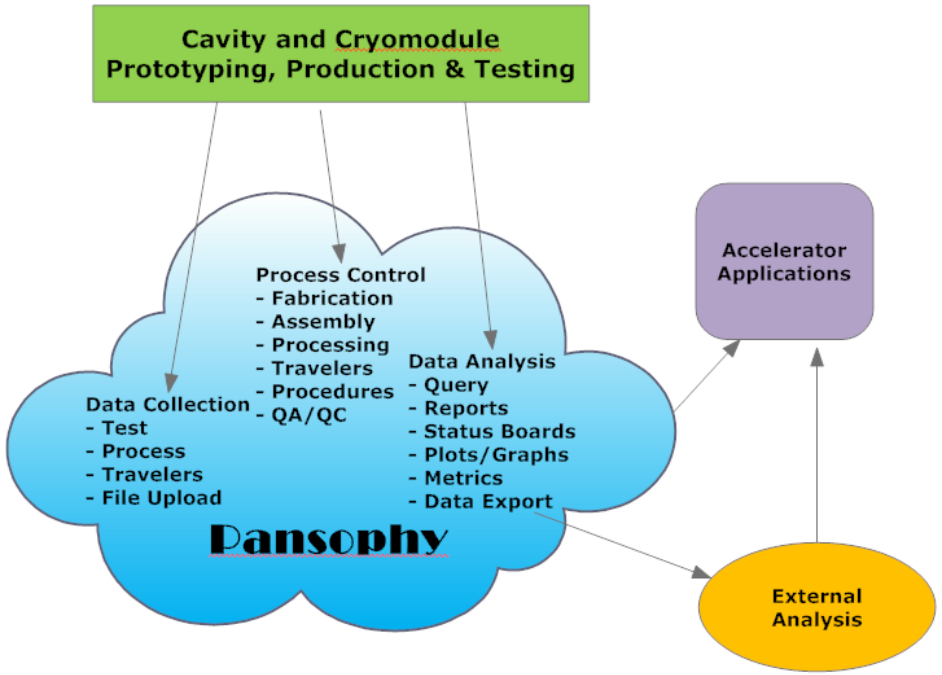
PANSOPHY

A Process & Data Management Tool

- **Data Management & Storage**
  - subcomponent test data
  - processing & testing procedures
  - Inventory
  - R&D and Production

- **Knowledge Management**
  - to Maximize learning from expensive prototyping and low-volume production
  - **Adopted by other DOE Lab**
  - SNS (Spallation Neutron Source)
  - LCLS-II Cryomodules at JLAB

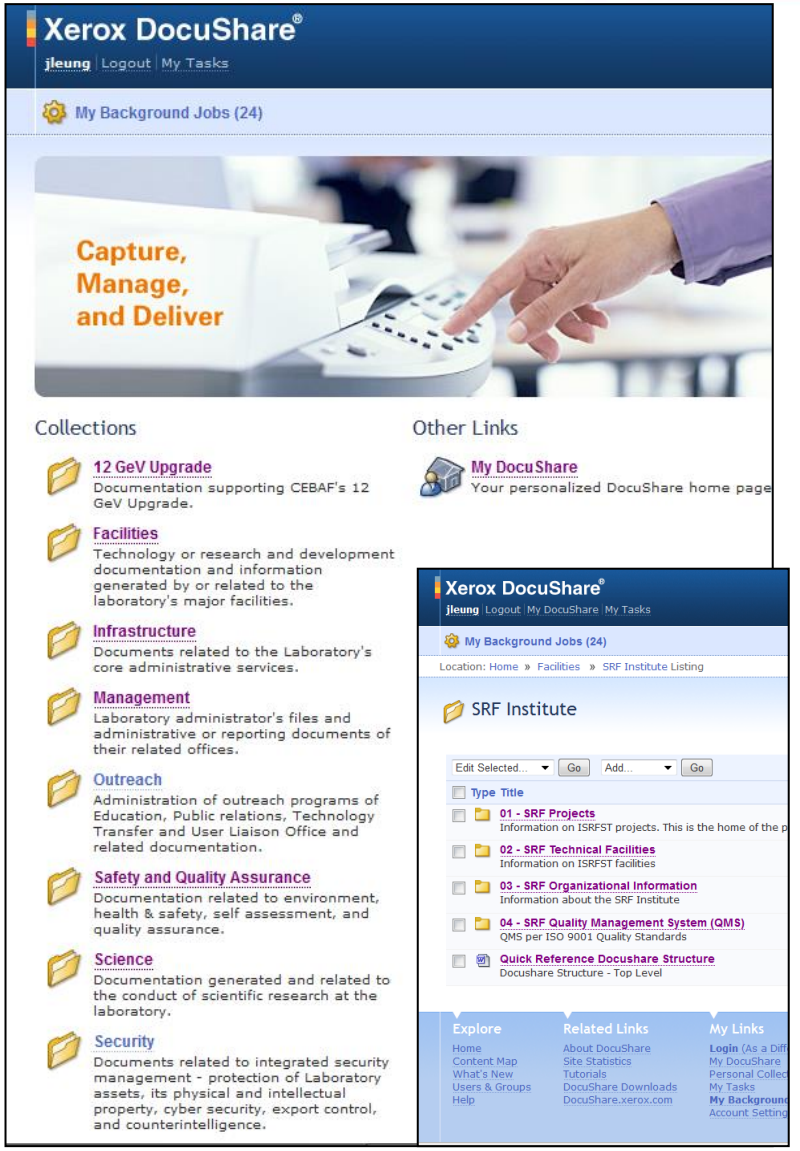




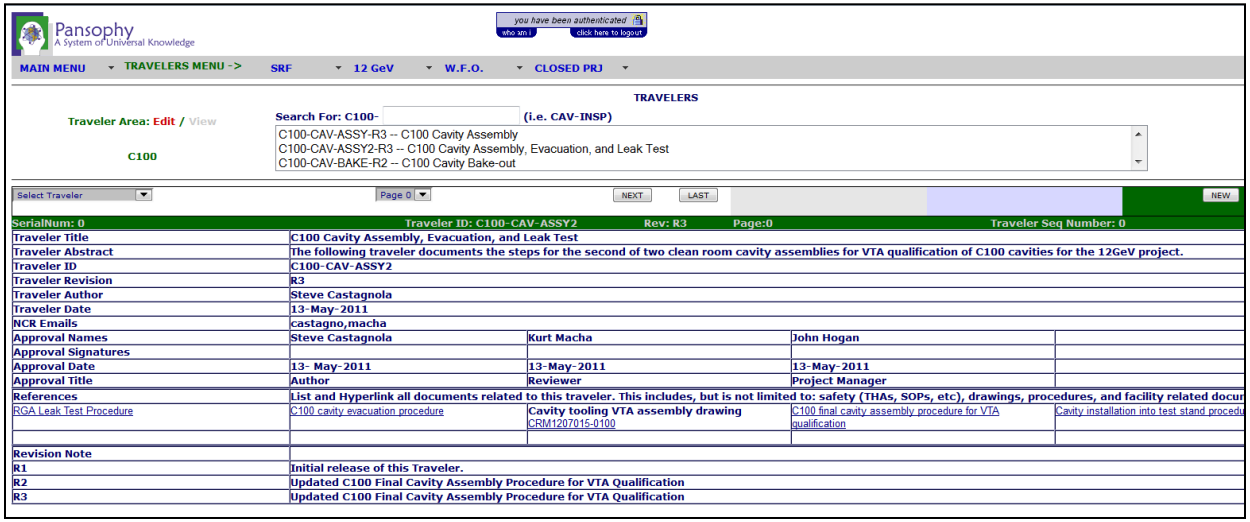
Data, Document & Process Management

DocuShare Tool

- Web-accessible centralized file storage database (Lab-wide & SRF).
- **Controlled-Sharing** access to site content.
- **Collection-Based** filing structure.
- Files for SRF organizational info, Quality Management System, Project Management, procedures, travelers, etc.
- Plus other account and content features.



Pansophy Traveler – An Example



Pansophy
A System of Universal Knowledge

you have been authenticated
who am i | click here to logout

MAIN MENU | TRAVELERS MENU -> | SRF | 12 GeV | W.F.O. | CLOSED PRJ

TRAVELERS

Traveler Area: Edit / View

C100

Search For: C100- (i.e. CAV-INSP)

C100-CAV-ASSY-R3 -- C100 Cavity Assembly
C100-CAV-ASSY2-R3 -- C100 Cavity Assembly, Evacuation, and Leak Test
C100-CAV-BAKE-R2 -- C100 Cavity Bake-out

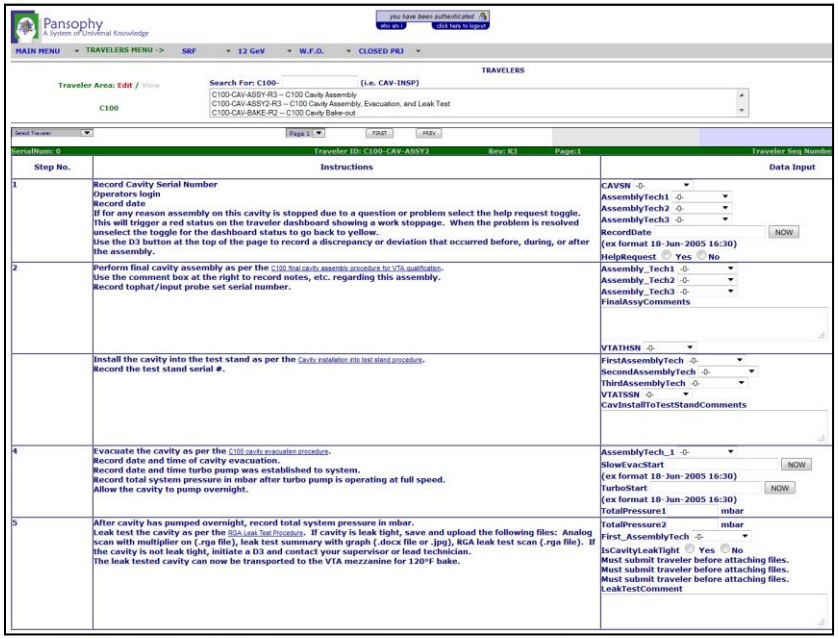
Select Traveler | Page 0 | NEXT | LAST | NEW

SerialNum: 0 | Traveler ID: C100-CAV-ASSY2 | Rev: R3 | Page:0 | Traveler Seq Number: 0

Traveler Title	C100 Cavity Assembly, Evacuation, and Leak Test			
Traveler Abstract	The following traveler documents the steps for the second of two clean room cavity assemblies for VTA qualification of C100 cavities for the 12GeV project.			
Traveler ID	C100-CAV-ASSY2			
Traveler Revision	R3			
Traveler Author	Steve Castagnola			
Traveler Date	13-May-2011			
NCR Emails	castagno,macha			
Approval Names	Steve Castagnola	Kurt Macha	John Hogan	
Approval Signatures				
Approval Date	13- May-2011	13-May-2011	13-May-2011	
Approval Title	Author	Reviewer	Project Manager	
References	List and Hyperlink all documents related to this traveler. This includes, but is not limited to: safety (THAs, SOPs, etc), drawings, procedures, and facility related docur			
RGA Leak Test Procedure	C100 cavity evacuation procedure	Cavity tooling VTA assembly drawing CRM1207015-0100	C100 final cavity assembly procedure for VTA qualification	Cavity installation into test stand procedu
Revision Note				
R1	Initial release of this Traveler.			
R2	Updated C100 Final Cavity Assembly Procedure for VTA Qualification			
R3	Updated C100 Final Cavity Assembly Procedure for VTA Qualification			

Traveler ***Cover Page:***

- Descriptions & approvals.
- ***Links to associated procedures.***
- Revision history.



Pansophy
A System of Universal Knowledge

MAIN MENU | TRAVELERS MENU -> | SRF | 12 GeV | W.F.O. | CLOSED PRJ

TRAVELERS

Traveler Area: Edit / View

C100

Search For: C100- (i.e. CAV-INSP)

C100-CAV-ASSY-R3 -- C100 Cavity Assembly
C100-CAV-ASSY2-R3 -- C100 Cavity Assembly, Evacuation, and Leak Test
C100-CAV-BAKE-R2 -- C100 Cavity Bake-out

SerialNum: 0 | Traveler ID: C100-CAV-ASSY2 | Rev: R3 | Page:1 | Traveler Seq Numbe

Step No.	Instructions	Data Input
1	Record Cavity Serial Number Operators login Record date If for any reason assembly on this cavity is stopped due to a question or problem select the help request toggle. This will trigger a red status on the traveler dashboard showing a work stoppage. When the problem is resolved unselect the toggle for the dashboard status to go back to yellow. Use the D3 button at the top of the page to record a discrepancy or deviation that occurred before, during, or after the assembly.	CAVSN AssemblyTech1 AssemblyTech2 AssemblyTech3 RecordDate NOW (ex format 18-Jun-2005 16:30) HelpRequest Yes No
2	Perform final cavity assembly as per the C100 final cavity assembly procedure for VTA qualification. Use the comment box at the right to record notes, etc. regarding this assembly. Record tophat/input probe set serial number.	Assembly_Tech1 Assembly_Tech2 Assembly_Tech3 FinalAssyComments VTATHSN
	Install the cavity into the test stand as per the Cavity installation into test stand procedure. Record the test stand serial #.	FirstAssemblyTech SecondAssemblyTech ThirdAssemblyTech VTATSSN CavInstallToTestStandComments
4	Evacuate the cavity as per the C100 cavity evacuation procedure. Record date and time of cavity evacuation. Record date and time turbo pump was established to system. Record total system pressure in mbar after turbo pump is operating at full speed. Allow the cavity to pump overnight.	AssemblyTech_1 SlowEvacStart NOW (ex format 18-Jun-2005 16:30) TurboStart NOW (ex format 18-Jun-2005 16:30) TotalPressure1 mbar
5	After cavity has pumped overnight, record total system pressure in mbar. Leak test the cavity as per the RGA Leak Test Procedure. If cavity is leak tight, save and upload the following files: Analog scan with multiplier on (.rga file), leak test summary with graph (.docx file or .jpg), RGA leak test scan (.rga file). If the cavity is not leak tight, initiate a D3 and contact your supervisor or lead technician. The leak tested cavity can now be transported to the VTA mezzanine for 120°F bake.	TotalPressure2 mbar First_AssemblyTech IsCavityLeakTight Yes No Must submit traveler before attaching files. Must submit traveler before attaching files. Must submit traveler before attaching files. LeakTestComment

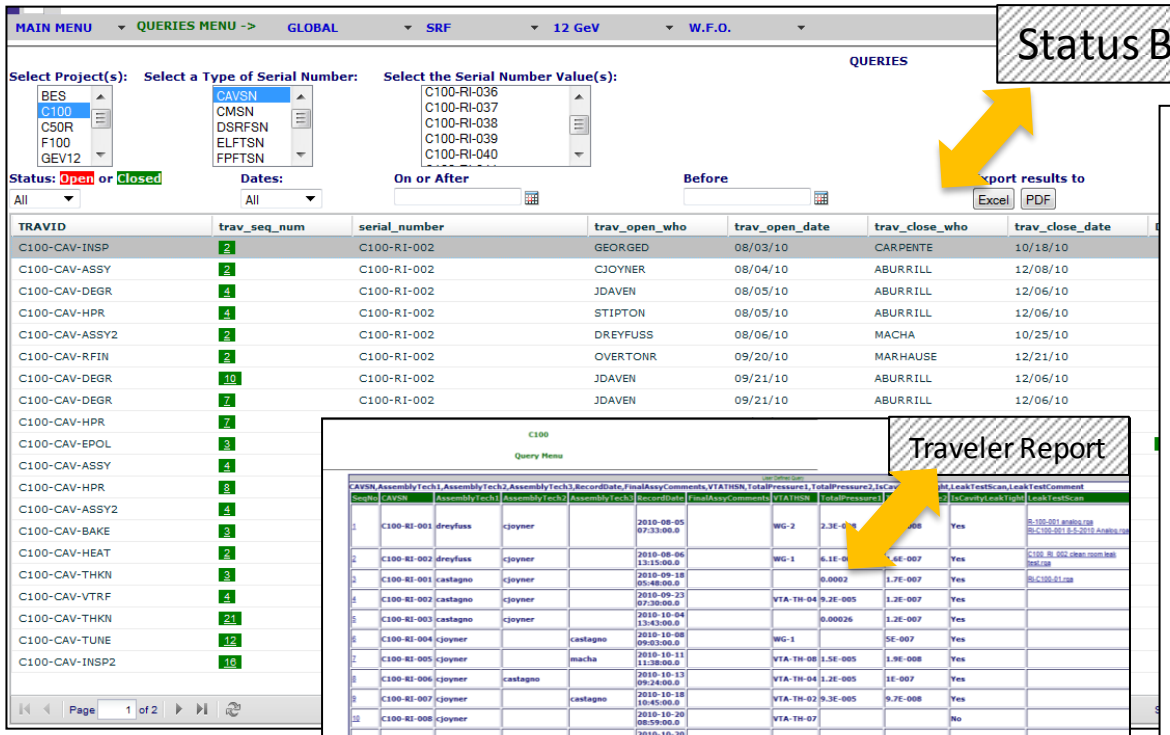
DATA INPUT –

1. Process instructions & steps to guide work flow.
2. Data Input – **data entry and comments** made by user at prescribed process points.
3. 'Hooks' to inventory system – **automatic serial number push** and **I.D.s** for individual components and assemblies.

Pansophy Traveler – An Example (cont.)

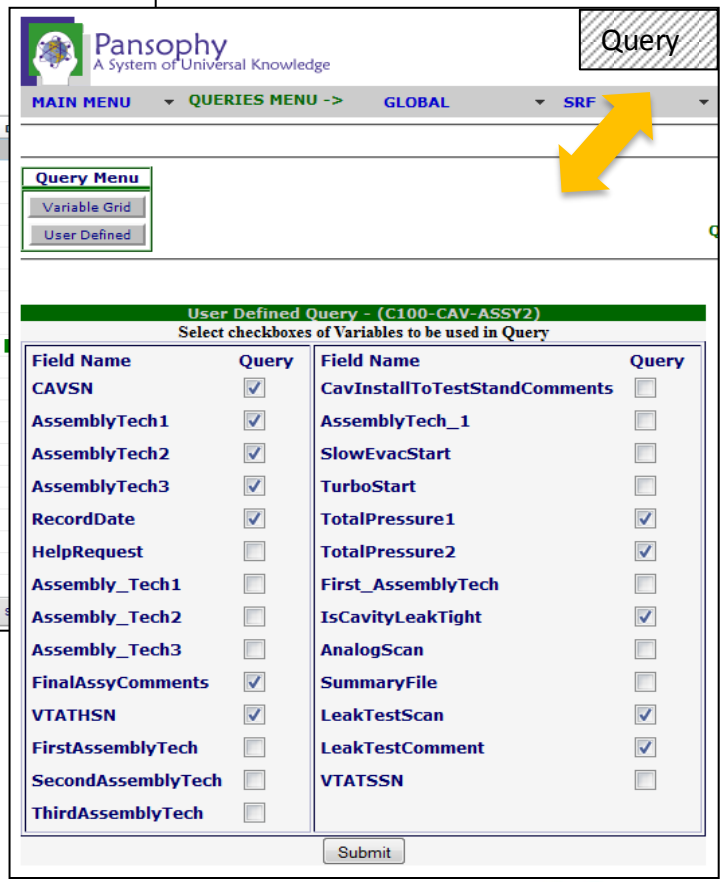
DATA OUTPUT

- **Status Board** - provides snapshot of work-in-process.
- Data Query and Filter Functions for **REPORTs** on selected parameters.
- **Export function** to MS Excel for other data analyses.



Status Board

Traveler Report



Query

Control of Non-Conforming Product (MAI-P-004)

Non-Conforming Reports (NCRs):

- Formal process for **identification and disposition** of Non-Conforming products.
- **Process Integration** between quality control, inventory control, and the production Travelers.
- Tie-ins to Pansophy for **automatic Non-Conforming Reporting**.

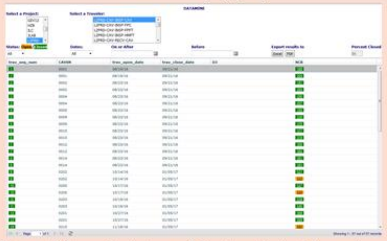
Detours, Deviations and Discrepancies (D3s):

- A **Supplemental Tool** for capturing "Off-Normal" events that occur before, during or even after the production process.
- Tie-ins to Pansophy for automatic **reports and search query**.

Traveler Reports

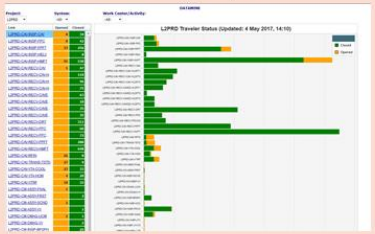
Travelers

Travelers (Op/Cl)



Open/Closed status of instantiated travelers

Travelers by Project

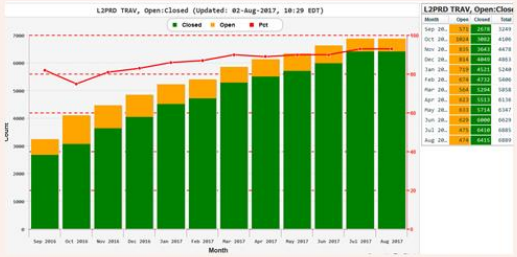


Project view of open/closed status of all instantiated travelers

Travelers by Workcenter

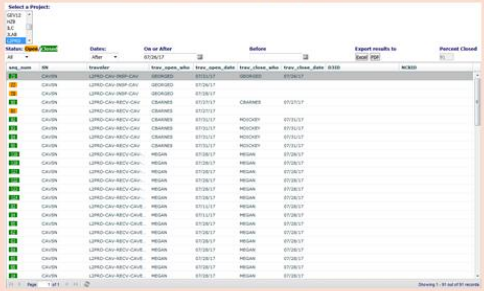
Workcenter view op/cl status of instantiated travelers

Travelers Open/Closed by Month



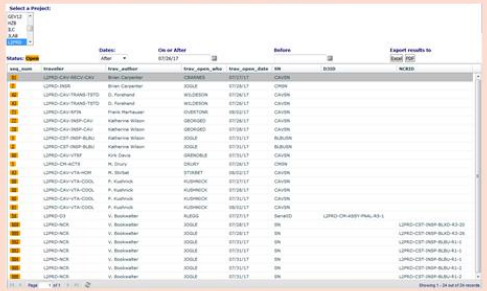
Monthly op/cl status of travelers and accumulate percentage closed

Traveler Weekly Report



Op/cl status for a given week

Traveler Weekly Owners



Currently open travelers listed by authors

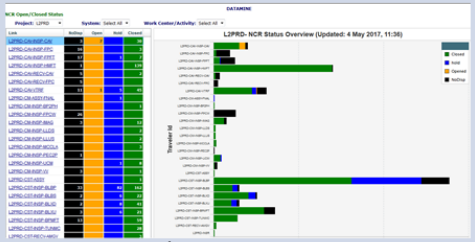
NCR Reports

NCRs

NCRs (Op/Cl)

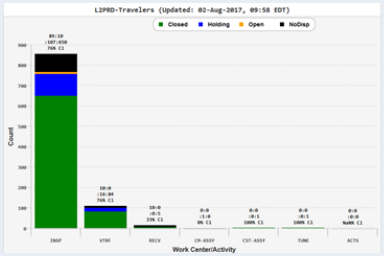
Open/Closed status of instantiated NCRs

NCRs by Project



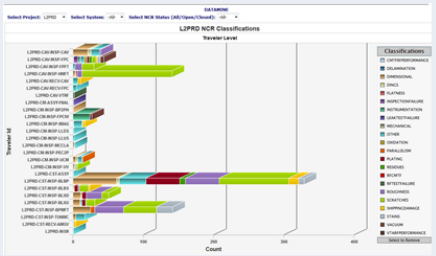
Project view of open/closed status of all instantiated NCRs

NCRs by Workcenters



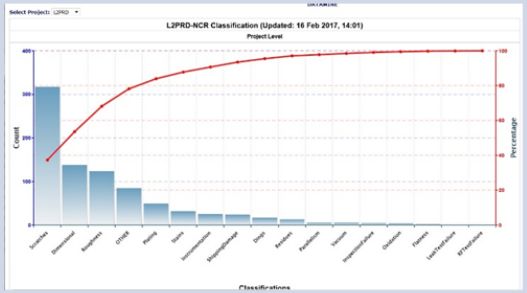
Workcenter view op/cl status of instantiated NCRs

NCR Classification (Traveler)



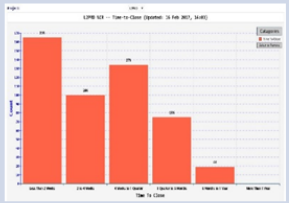
NCR classifications listed by traveler with filters on system and op/cl status

NCR Classification (Project)



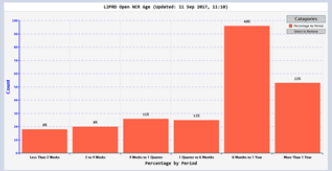
Pareto chart of NCR classifications

NCR Closure Periods & Age



NCR time elapsed from instantiation to closure

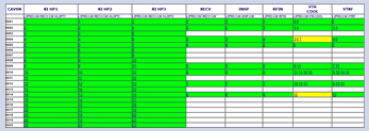
NCR time elapsed from Instantiation to present time



Status Boards and Drilldowns

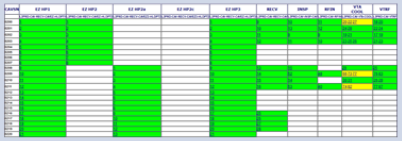
Status Boards and Drilldowns

Status Boards



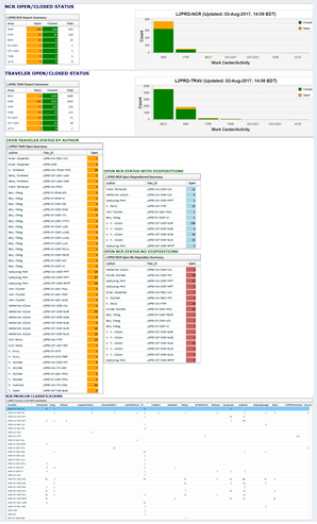
Status of cavities from RI

Status of cavities from EZ



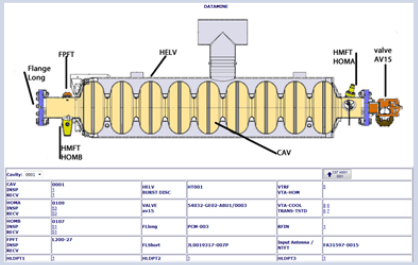
Status of cryomodule completion

Monthly Statement



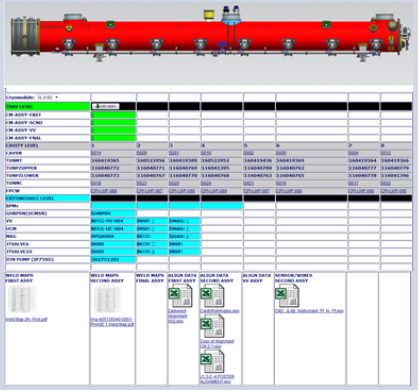
A one page view of the open and and closed status of Travelers and NCRs, open travelers status by author, open NCRs with dispositions, open NCRs without dispositions, and classifications of NCR problems.

Drilldowns



Cavity level components and key parameters.

Cavity String level components and key parameters.



Cryomodule level of key parameters and serial numbers, allowing a user to drilldown to subcomponents.

Summary

- Resources for C75 cryomodules are well understood
  - Based off of C50 refurbishment program – 13 CM completed
  - C75 introduces new cavity shape, modifications to tuner ends and supports for HOM elbows
- LCLS II will bring challenges to C75-01 (and possibly C75-02)
  - C50-13 was completed on schedule in the midst of LCLS II
  - CPP is top priority for the Lab, LCLS II is also a high priority
  - Stretching out C75-01 helps manage resource loading
  - May need to add resources depending on LCLS II future work
    - If LCLS II is extended, HE is added
- A plan has been made to meet the CPP for FY18 and beyond
  - Strategically start cryomodules ahead of FY installation dates
- The SRF organization and means for completing cryomodule assembly projects is well established and experienced
  - Completed about 60 cryomodules
  - Currently working on C75-01(currently in the books as C50-13)
- SRF quality systems are established, C75 specific in progress

Backup

Back Up - C50/C75/C100

From Accelerator "STAY Treat" July2015) - see Slide 6

	# Cav	cells /cav	cav length m	Active Length m	fill factor %	MV	volts /cav (MV)	gradient (MV/m)	klystron power	unit cost (FY16 M$ Direct)	RF Cost	Total Cost FY16 Direct	MV (gain)	V(gain) /$
C50	8	5	0.5	4	48.1	50	6.25	12.5	6	1.51			20	13.3
C75†	8	5	0.5	4	48.1	75	9.4	18.8‡	8	1.91			45	23.6
C100‡	8	7	0.7	5.6	64.4	100	12.5	17.9‡	13	4.77			70	14.7

Update - January 2016

	# Cav	cells /cav	cav length m	Active Length m	fill factor %	MV	volts /cav (MV)	gradient (MV/m)	klystron power	unit cost (FY16 M$ Direct	*RF Cost	**Total Cost FY16 Direct**	MV (gain)	V(gain) /$
C50	8	5	0.5	4	48.1	50	6.25	12.5	6	1.23		**1.23**	20	16.3
C75†	8	5	0.5	4	48.1	75	9.4	18.8‡	8	1.73	0.77	**2.50**	45	18.0
C100‡	8	7	0.7	5.6	64.4	100	12.5	17.9‡	13	4.30	1.56	**5.85**	70	12.0

Update - February 2018, with new vendor quotes for C75 & C100

	# Cav	cells /cav	cav length m	Active Length m	fill factor %	MV	volts /cav (MV)	gradient (MV/m)	klystron power	unit cost (FY18 M$ Direct	*RF Cost	**Total Cost FY18 Direct**	MV (gain)	V(gain) /$
C50	8	5	0.5	4	48.1	50	6.25	12.5	6	1.42		**1.42**	20	14.1
C75†	8	5	0.5	4	48.1	75	9.4	18.8‡	8	1.76	0.84	**2.60**	45	17.3
C100‡	8	7	0.7	5.6	64.4	100	12.5	17.9‡	13	4.57	1.81	**6.38**	70	11.0

What changed from August 2015 to January 2016 ?

- C75 & C100 - Addition of RF (assumes C50 still usable)
- C75 - Improved estimate for in House Fabrication and other costs

†New cells or new processing required to achieve higher Q's and gradients
*Engineering required at additional cost (not included)
‡Digital LLRF required

Ref. DRAFT C50 vs C75 vs C100 Rev 49- 13Feb2017

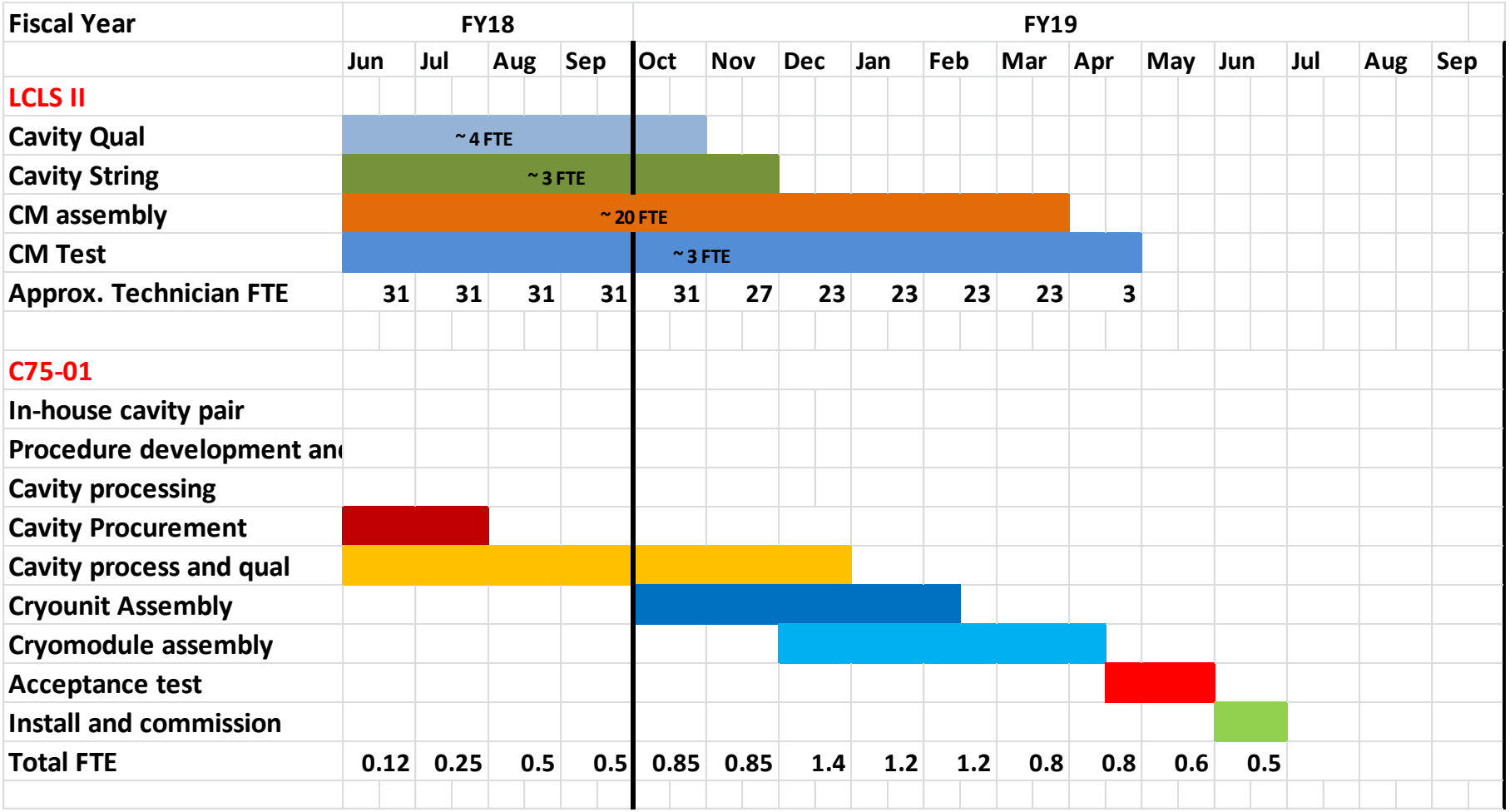
What changed from January 2016 to February 2018 ?

- C50 & C75 - Mag shielding & NEG Pumps added
- C75 - Actual Vendor Quotes for Cavity Fab, Ingot & Ingot Slicing (reusing end groups)
- C75 & C100 - LL RF based on cost estimate from C. Hovator (June2017)
- C100 New Vendor (1-CM) quotes (Aug2017) for Nb & Cavities, He Vessel, Tuners, Thermal Shield, Magnetic Shield, Vac Vessels

What is not included ?

- One time R&D costs for Cavity Development (already done)
- One time cost for LL RF Engineering & Development to address obsolesce (same design for C50, C75 and/or C100 zones)
- Wave Guide Vendor Development + 8 Wave Guides

Approx. Labor for CM Projects



Projected C75 Labor by Resource Type

C75-01 FTE													
	Jun '18	Jul '18	Aug '18	Sep '18	Oct '18	Nov '18	Dec '18	Jan '19	Feb '19	Mar '19	Apr '19	May '19	Jun '19
Scientist	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
ComSci	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
ElcEng+EACII	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
ElcTec	0.01	0.03	0.06	0.06	0.10	0.10	0.17	0.15	0.15	0.10	0.10	0.07	0.06
MecEng+MACII	0.02	0.04	0.07	0.07	0.12	0.12	0.20	0.17	0.17	0.11	0.11	0.09	0.07
MecTec	0.07	0.15	0.31	0.31	0.52	0.52	0.86	0.73	0.73	0.49	0.49	0.37	0.31
Sr Staff	0.01	0.01	0.03	0.03	0.05	0.05	0.08	0.06	0.06	0.04	0.04	0.03	0.03
Misc	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.01
	0.12	0.25	0.50	0.50	0.85	0.85	1.40	1.20	1.20	0.80	0.80	0.60	0.50

Derived from C50-11 actuals

Cost and FTE for C50-11, 12 and 13

								Direct $
1.04.09.002	C50-11		FY13	FY14	FY15	FY16	FY17	Total Cost
		Labor	$ 762.250	$ 74.155	$ 13.023	$ -	$ -	$ 849.428
		Non-Labor	$ 263.372	$ 4.788	$ -	$ -	$ -	$ 268.160
		Total	$ 1,025.622	$ 78.943	$ 13.023	$ -	$ -	$ 1,117.588
		FTEs	8.59	0.57	0.09	-	-	9.25
1.04.09.004	C50-12		FY13	FY14	FY15	FY16	FY17	Total Cost
		Labor	$ -	$ 153.683	$ 153.070	$ 519.033	$ 36.468	$ 862.254
		Non-Labor	$ -	$ 62.269	$ 105.208	$ 161.721	$ 0.907	$ 330.105
		Total	$ -	$ 215.952	$ 258.278	$ 680.754	$ 37.375	$ 1,192.359
		FTEs	-	1.39	1.38	5.87	0.38	9.02
1.04.09.010	C50-13		FY13	FY14	FY15	FY16	FY17	FY18	Total Cost
		Labor	$ -	$ -	$ -	$ -	$ 363.508	$ 18.504	$ 382.012
		Non-Labor	$ -	$ -	$ -	$ -	$ 211.607	$ -	$ 211.607
		Total	$ -	$ -	$ -	$ -	$ 575.115	$ 18.504	$ 594
		FTEs	-	-	-	-	4.07	0.16	4.23

C50-13 NP Actuals ($575k direct)

C50-11 and C50-12 actuals were each ~ $1,150k direct

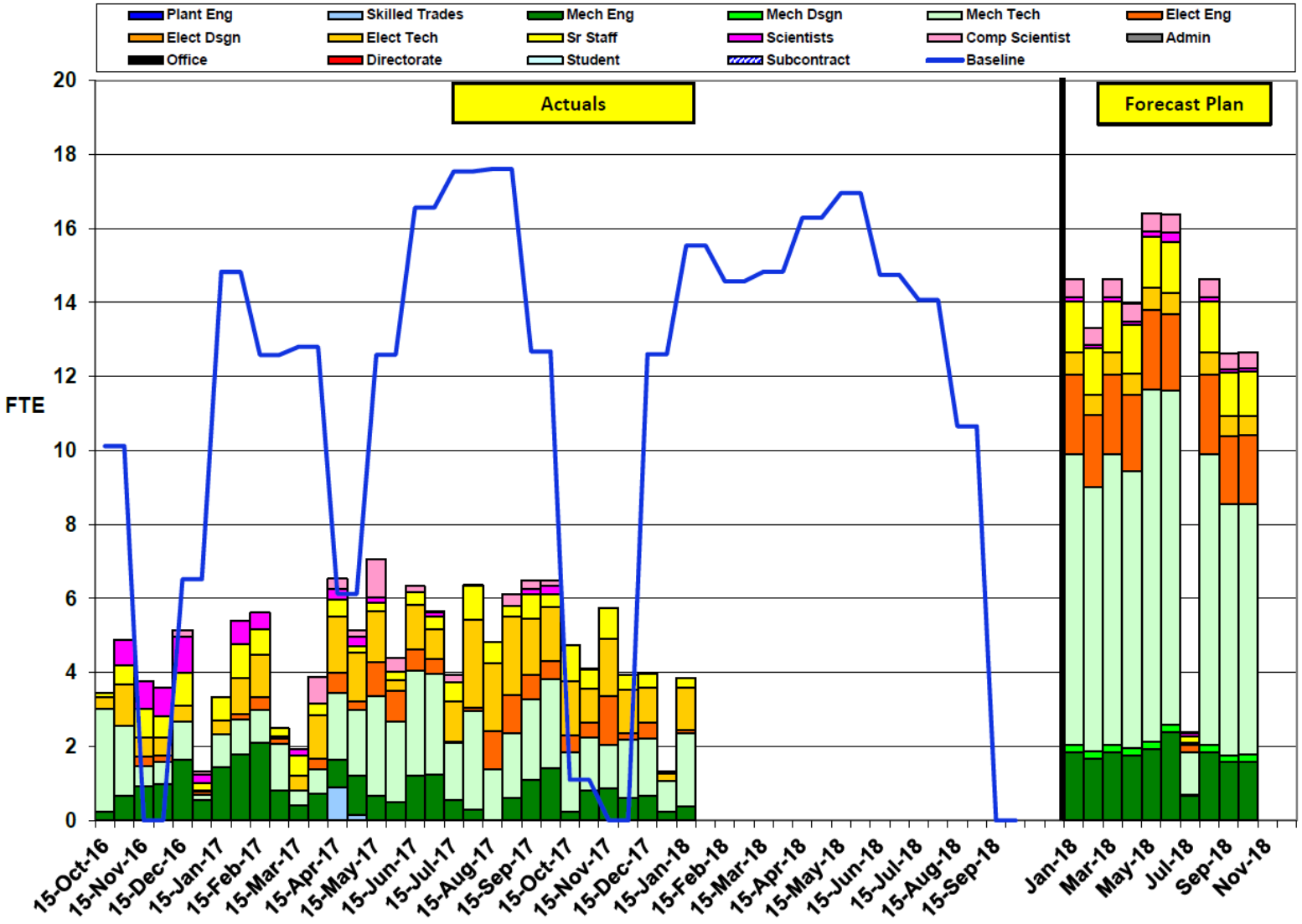
Differences with C50-13 explains cost

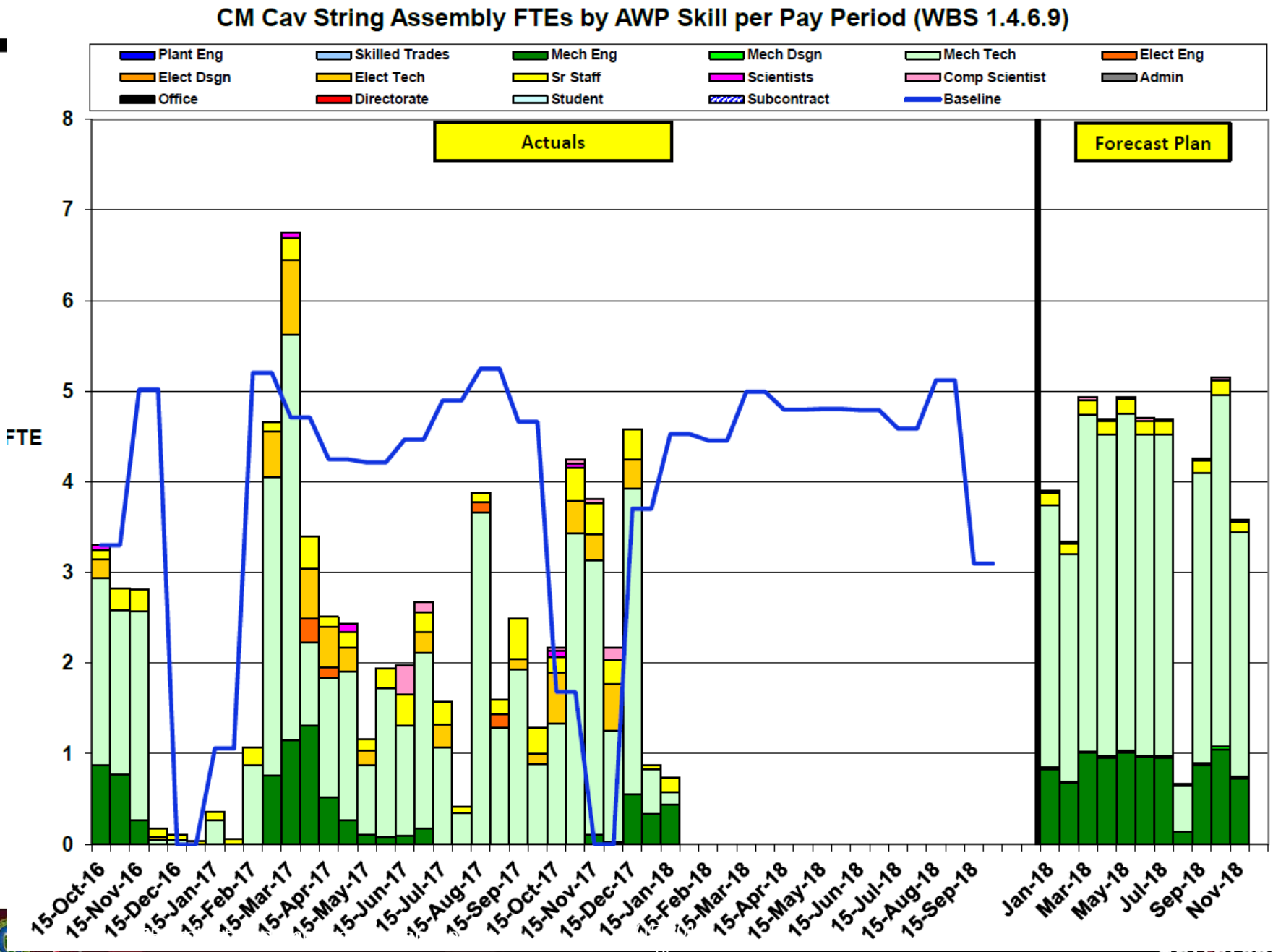
- Started out as a C50 cryomodule (C50-7), not a C20
  - Minimal cavity processing was required to regain the gradient
    - Lower cost to recover the cavities ($108k for C50-13 vs. $370k for C50-12)
- AIPNCP was created and used to cover the cost of the "C75" cryounit
  - Cost for roughly one-fourth of the module refurbishment was shifted to AIP($324k direct in FY17)
- Acceptance testing was not preformed in the CMTF (~ $47k direct)
- Commissioning will be done in FY18 (~ $34k)

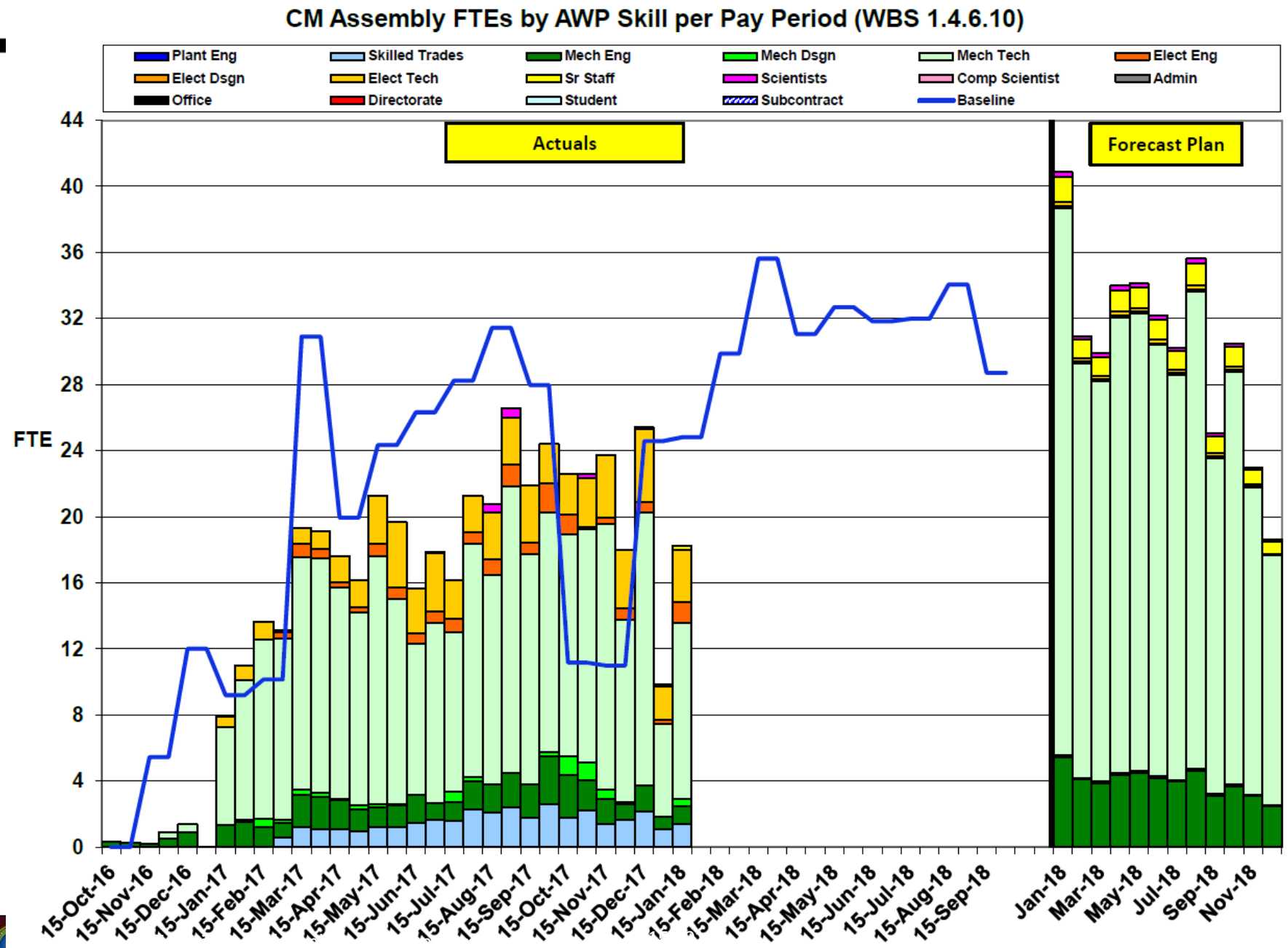
FY18 Plan for CM Refurbishment

- Cost for C50-11 and C50-12 was about $1150k, each
- Use AIP funds to purchase and qualify (8) upgraded cavities
  - Industry provides fabricated cavities
  - Process and test in house
- Use NP funds to refurbish the C20 cryomodule
  - Same as C50-12 for example minus cavity processing and testing
- Amount needed from NP is $1185k-$350k = $835k
- Amount needed from AIP is $250 (buy) + $370k = $620k

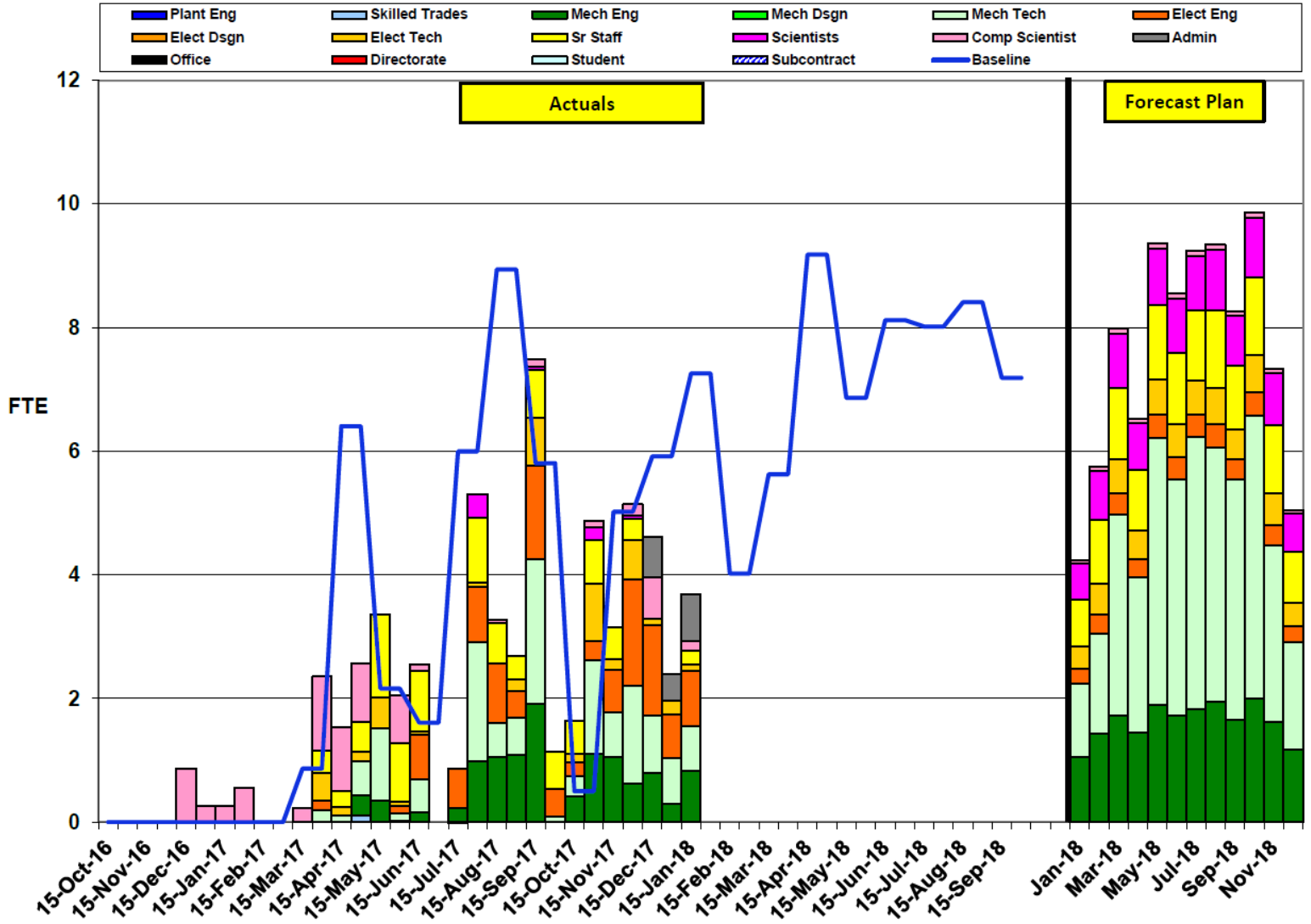
CM Prep-Test FTEs by AWP Skill per Pay Period (WBS 1.4.6.8)




CM Cav String Assembly FTEs by AWP Skill per Pay Period (WBS 1.4.6.9)
Plant Eng
Skilled Trades
Mech Eng
Mech Dsgn
Mech Tech
Elect Eng
Elect Dsgn
Elect Tech
Sr Staff
Scientists
Comp Scientist
Admin
Office
Directorate
Student
Subcontract
Baseline
Actuals
Forecast Plan
FTE
0
1
2
3
4
5
6
7
8
15-Oct-16
15-Nov-16
15-Dec-16
15-Jan-17
15-Feb-17
15-Mar-17
15-Apr-17
15-May-17
15-Jun-17
15-Jul-17
15-Aug-17
15-Sep-17
15-Oct-17
15-Nov-17
15-Dec-17
15-Jan-18
15-Feb-18
15-Mar-18
15-Apr-18
15-May-18
15-Jun-18
15-Jul-18
15-Aug-18
15-Sep-18
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18


CM Assembly FTEs by AWP Skill per Pay Period (WBS 1.4.6.10)
Plant Eng
Skilled Trades
Mech Eng
Mech Dsgn
Mech Tech
Elect Eng
Elect Dsgn
Elect Tech
Sr Staff
Scientists
Comp Scientist
Admin
Office
Directorate
Student
Subcontract
Baseline
Actuals
Forecast Plan
FTE
44
40
36
32
28
24
20
16
12
8
4
0
15-Oct-16
15-Nov-16
15-Dec-16
15-Jan-17
15-Feb-17
15-Mar-17
15-Apr-17
15-May-17
15-Jun-17
15-Jul-17
15-Aug-17
15-Sep-17
15-Oct-17
15-Nov-17
15-Dec-17
15-Jan-18
15-Feb-18
15-Mar-18
15-Apr-18
15-May-18
15-Jun-18
15-Jul-18
15-Aug-18
15-Sep-18
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18

CM Test FTEs by AWP Skill per Pay Period (WBS 1.4.6.11)



M:\LCLS-II\PMO\Manpower\PMO Working Files\LCLS-II Semi-Monthly FTEs Skill Mix Chart_FY18-Master_Extended.xlsx 1/24/2018