

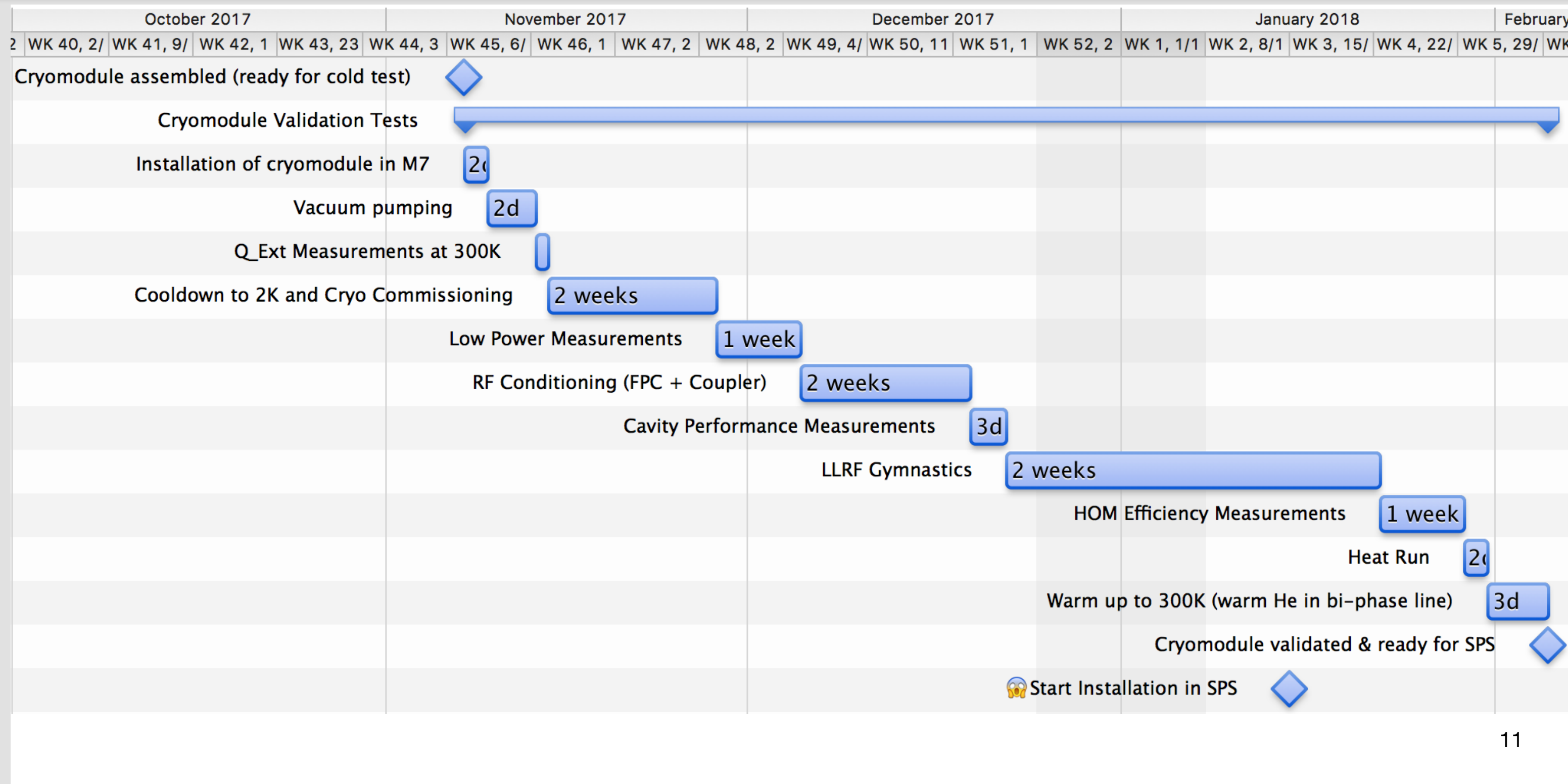


Crab Cavity CM status towards SPS test

Frank Gerigk, 15 Sep 2016, 15th HL-LHC TCC

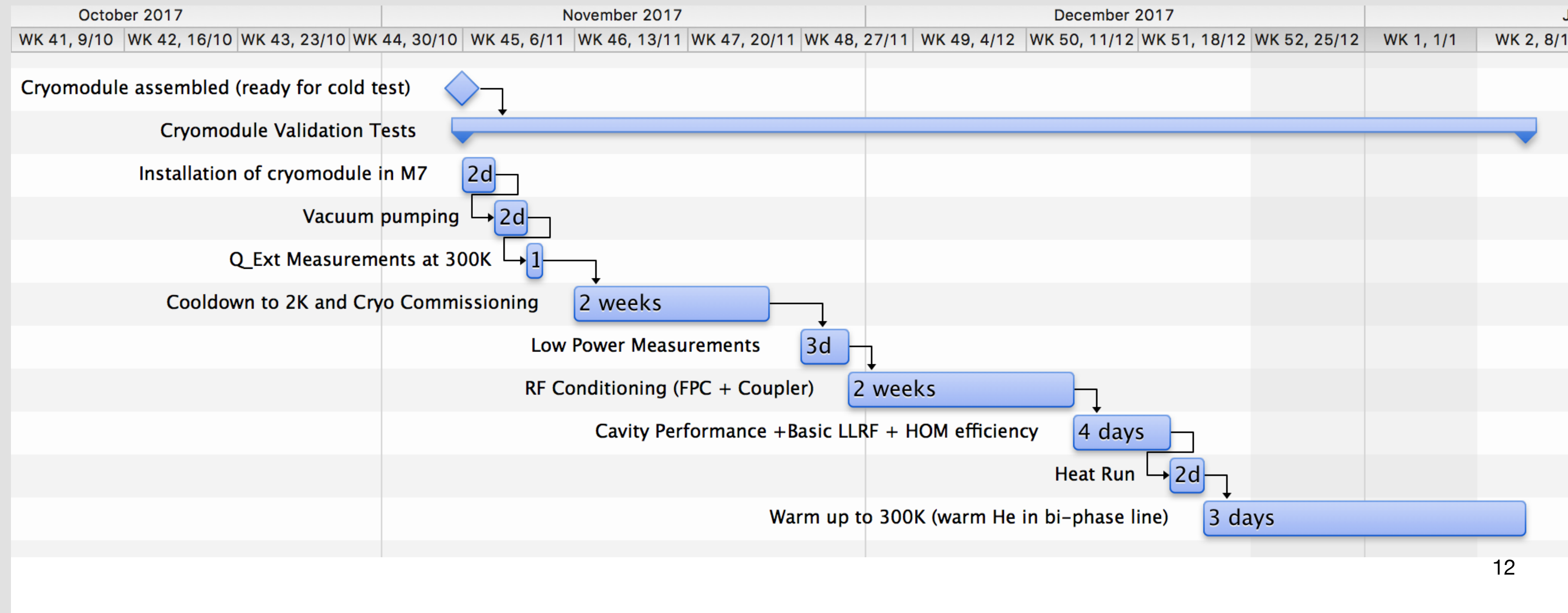
- Status March 2016, Crab Cavity for SPS planning management review
- Actions taken
- Status today, options for Crab Cavity SPS test

March 16, SPS planning baseline



- 100% success oriented baseline planning ~1 month late
- Testing over Christmas was assumed
- Planning was based on top-down milestones but still late

March 16, SPS planning proposal



This option was still to be confirmed by detailed workflows and planning involving MME, RF, VSC

Compression by:

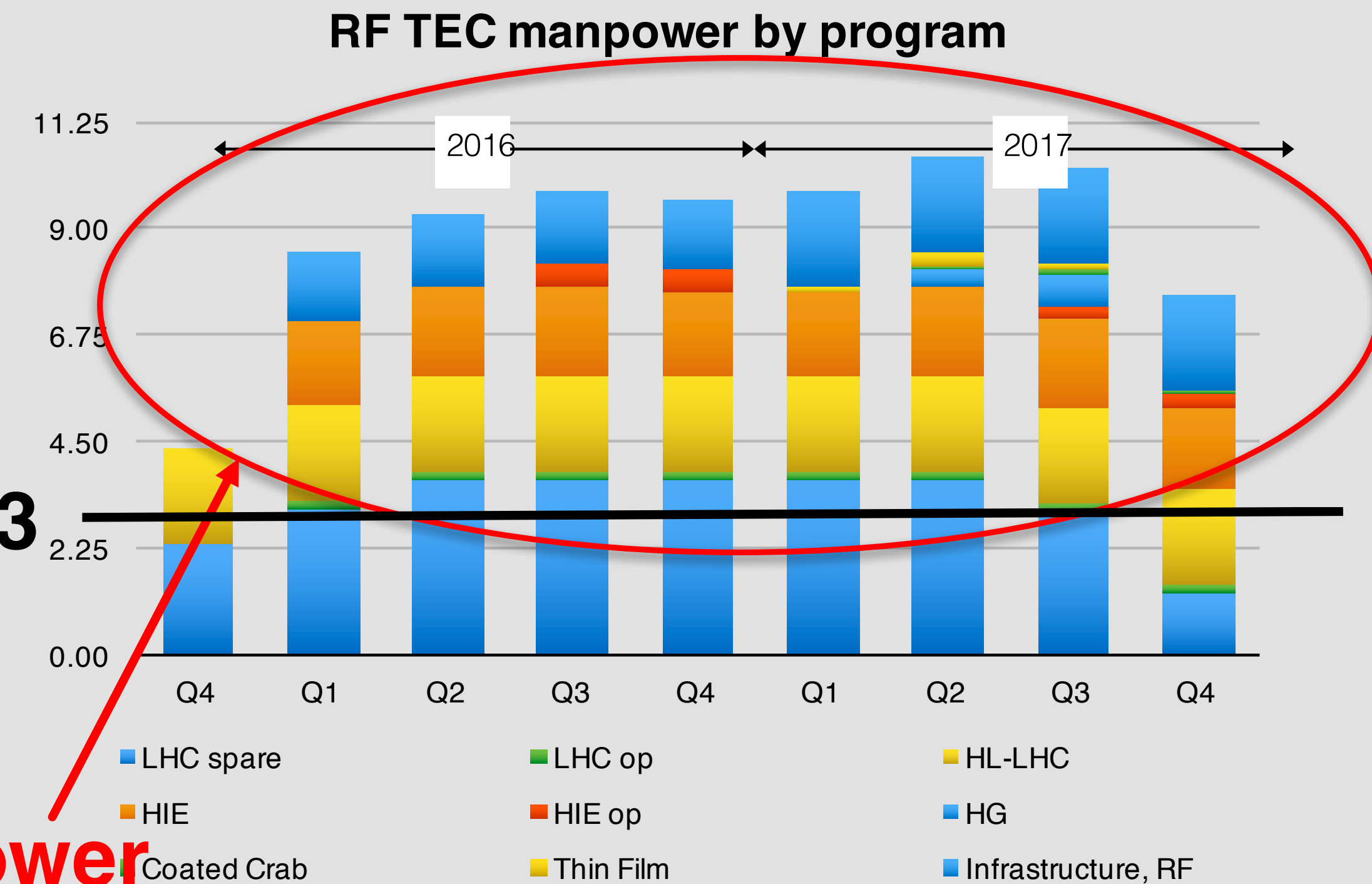
- cutting LLRF tests in SM18,
- reduced HOM coupler testing,
- testing still over Christmas period & no difficulties at any stage
- using top-down planning milestones

missing manpower

- RF group has a serious lack of SRF technicians.
- Their work also supports: HIE-ISOLDE, LHC spare cavities, LHC operation, SRF infrastructure, all the SRF R&D projects

Existing manpower: 3

Missing manpower



Actions taken



- Start of Crab Cavity Technical Coordination meeting on 30 May, every 2 weeks, 8 meetings so far.
- Development of detailed workflow and milestone plan:
 - ➔ clear responsibilities for each milestone
 - ➔ bottom-up time estimates,
 - ➔ tooling readiness plan,
- Planning support by EN-ACE (Aurelio Berjillos)
- Options for additional manpower

Establishment of workflow



- A 94 step workflow details all cavity and CM production steps between the shaping of cavity pieces until transport to the SPS.
- Link person, location, concerned pieces, transport, and needed time has been identified for each step.
- The steps have been divided into 22 activity blocks/milestones with 1 responsible person for each milestone.
- QA is associated with milestones.
- A milestone plan has been extracted.

	Task	Location	Object	Link person	Tests	Tools	Activity block/ Milestone	Milestone link person	Main group	Time estimation (days)	Transport Time (days)	Total time estimation (days)
1	Separate pieces shaping	72	cavity pieces	Marco		Tools Available	Cavity pieces production	Marco	EN-MME	03/10/2016	0	0
2	Light BCP	B118	cavity pieces	Leonel			Cavity trimming and welding	Marco	EN-MME	20	0	48
3	Intermediate welding	112	cavity pieces	Marco		Tools Under Production. No further input from stakeholders needed					0	
4	Intermediate Leak Tests (Extremities, before last weld)	112				Tools being Designed. No further input from stakeholders needed				5	0	
5	RF frequency	72	cavity pieces clamped (+ one HOM coupler, optional)	Rama		Clamps				5	1	
6	1 st trimming	72	cavity pieces	Marco		Tools being designed.					0	
7	2nd last weld	72	cavity pieces	Marco						3	0	
8	RF frequency	72	cavity pieces clamped	Rama		Clamps				5	0	
9	2nd trimming	72	cavity pieces	Marco		Tools being designed.					0	
10	RF frequency	72	cavity pieces clamped	Rama		Clamps				1	0	
11	Light BCP for welds	B118	cavity pieces	Leonel						7	1	
12	Final welding	112	bare cavity	Marco		Tools Under Design/Production. No further input from stakeholders needed	0					
13	Cavity inspection	112	bare cavity	Marco		NO tools	Cavity finalization, inspection and metrology	Marco	EN-MME	0	0	11
14	Leak test	112								2	0	
15	RF frequency	72	bare cavity	Rama						1	0	
16	Alternative Tuning	72	bare cavity	Marco						8	0	
17	RF frequency	72	bare cavity	Rama							0	
18	Metrology	72	bare cavity	Marco, Mateusz	including bead-pull measurement of the electric center, visual inspection	Visual Inspection means Endoscope? If so needs to be procured						
19	Mount handling frame	72	bare cavity + frame	Marco		Frame for handling	Cavity cleaning and treatment (BCP, heat)	Leonel	EN-MME	1	0	36.5
20	Cleaning + Heavy BCP	B102 + B118	bare cavity + frame	Leonel	bath etching speed vs bath speed (July to september)	PVDF/PVC flanges + Support at height to allow gravity emptying + tool for bath etching speed vs bath speed				15	1	
21	RF frequency, with antenna for cold tests	72	bare cavity + frame	Rama/ Alick?						1	1	
22	Alternative Tuning	72	bare cavity + frame	Marco						5	0	
23	RF frequency	72	bare cavity + frame	Rama								
24	Metrology	72	bare cavity + frame	Marco, Mateusz						3	0	
25	Cleaning	B102	bare cavity + frame	Leonel						1.5	0	

15 days for Cavity1
10 days for Cavity2

Bottom up planning I



- When all the steps were counted for the first time, we ended up with July 2018 as readiness date for the installation in the SPS...
- 1st planning iteration was done:
 - ➔ fabrication and testing steps (e.g. cold test of dressed cavity) for the 2nd cavity have been reduced in time.
 - ➔ time slots allocated for cavity fabrication, chemical treatment & cleaning, RF tests, transports have been reduced.
 - ➔ preparatory steps have been introduced to reduce time for critical path, e.g: preparation of BCP plumbing with printed cavity & preparation of different plumbing layouts for the different positions of BCP, LLRF is tested on DQW POP cavity, HOMs to be tested on BNL cavity before mounting on CERN Crabs, etc.
 - ➔ possible temporal overlaps have been identified and applied.
 - ➔ some activities can be done over weekends: heat treatments, cool down, warm up, etc.
 - ➔ last possible installation slot for SPS has been defined: 23 January 2018 (5 weeks before end of YETS)
 - ➔ minimum cryogenic test period in SM18 is identified: 5 weeks

—> this brought us to 29. March... still 34 days too late

Bottom up planning II

- Further optimisation of clean room assembly & metrology checks proposed by Alick.
- Removal of any RF test on the completed CM, but maintaining the cryogenic cold testing of CM + service module.
- **Still to be fixed: CM is cold over Christmas, but no one has to work on non-working days.**
- **Some further optimisation on surface treatments possible but TE-VSC fears clash with other activities (TIDVG)**

—> **24th January**

still t.b.c!

Option 1: YETS17-18

- No RF test of cold CM.
- Full cryo & vacuum qualification of CM before installation.
- Fully success oriented planning
- Some small margins still exist for fabrication (MME) and surface treatment (VSC), but it would be unrealistic to remove them at this point in time.
- Risks: RF performance unknown at time of installation. Potential repairs to be done in subsequent TS.

in case of delays:

Option 2: TS 18

- Installation in 1-2 technical stops after YETS 17-18.
- Full RF, cryo & vacuum qualification of CM in SM18 before installation.
- Take more time for preparation to ensure that everything works in the SPS.
- Risks: potential delays during SPS installation may kill the test. Less likely because of better preparation.

Strategy:
aim for option 1
continue schedule
optimisation

Manpower, etc.



Disclaimer: The elaborated workflow and planning represents the minimum time needed for consecutive steps. It assumes that nothing goes wrong and that there are enough skilled people to actually do the work.

- Ilan Ben-Zvi (BNL) at CERN to help optimising workflow, planning, assembly & test procedures
- 12-13 October: **Review of clean room procedures for the HL-LHC Crab Cavity Program** (<https://indico.cern.ch/event/555785/>) John Mammoser (ORNL), Stephane Berry (CEA), Mathieu Therasse (CERN), Vittorio Parma (CERN).
- SM18 building extension will ease the space problems, but may not be usable by end of 2017.
- **Manpower in SRF section (since March):**
 - Technician (Ester Sancho Cabrera) started.
 - Fellow (Hernan Furci on cold temperature measurements) started in March 2016
 - Fellow (Anastasia Xydou, for LHC spares) started in September 2016
 - VISC (Nicolas Shipman on ???) started in June 2016, 1 year
 - Engineer from RRCAT (Kunver Singh) started last month to support cold test activities in SM18, 6 months stay
 - COAS/EXT to start in October/Nov for CRAB follow-up in SM18 for 1 year,
 - replacement of Pierre Maeson is agreed, date not yet clear (new hire or transfer from other group)
 - IFJ-PAN: meeting in June at CERN to get support for cold test preparations of cavities and cryo-modules. RF engineers will be available from early 2017 onwards (people who have worked for XFEL before). Agreement in preparation.
 - Option to prolong the external team working on HIE-ISOLDE CM assembly

Summary



- Planning remains tight and relies on success at all stages.
- Very few margins remain.
- Complete workflow exists, meaning there should be no surprises of unplanned extra activities. Sequence of steps and responsibilities are clear.
- Milestones are defined and will be tracked in the CCTC meeting.
- SPS installation date during YETS 17/18 can only be kept if we sacrifice the RF test of the complete CM. Cavities will be cold tested and CM + service box will be cold tested.
- Alternative: install later, do the CM RF cold test and do some more testing to ensure that everything works before installation (or everyone works over Xmas).
- Manpower issues are being tackled.

Extra slides

complete work flow

	Task	Location	Object	Link person	Tests	Tools	Activity block/ Milestone	Milestone link person	Main group	Time estimation (days)	Transport Time (days)	Total time estimation (days)	
1	Separate pieces shaping	72	cavity pieces	Marco		Tools Available	Cavity pieces production	Marco	EN-MME	03/10/2016	0	0	
2	Light BCP	B118	cavity pieces	Leonel			Cavity trimming and welding	Marco	EN-MME	20	0	48	
3	Intermediate welding	112	cavity pieces	Marco		Tools Under Production. No further input from stakeholders needed				5	0		
4	Intermediate Leak Tests (Extremities, before last weld)	112				Tools being Designed. No further input from stakeholders needed				5	0		
5	RF frequency	72	cavity pieces clamped (+ one HOM coupler, optional)	Rama		Clamps				5	1		
6	1 st trimming	72	cavity pieces	Marco		Tools being designed.				3	0		
7	2nd last weld	72	cavity pieces	Marco						5	0		
8	RF frequency	72	cavity pieces clamped	Rama		Clamps				1	0		
9	2nd trimming	72	cavity pieces	Marco		Tools being designed.				7	1		
10	RF frequency	72	cavity pieces clamped	Rama		Clamps				0	0		
11	Light BCP for welds	B118	cavity pieces	Leonel						Tools Under Design/Production. No further input from stakeholders needed	2		0
12	Final welding	112	bare cavity	Marco						Cavity finalization, inspection and metrology	Marco		EN-MME
13	Cavity inspection	112	bare cavity	Marco		NO tools	1	0					
14	Leak test	112					8	0					
15	RF frequency	72	bare cavity	Rama			1	0					
16	Alternative Tuning	72	bare cavity	Marco			including bead-pull measurement of the electric center, visual inspection	Visual Inspection means Endoscope? If so needs to be procured					
17	RF frequency	72	bare cavity	Rama			Cavity cleaning and treatment (BCP, heat)	Leonel	EN-MME	1	0	36.5	
18	Metrology	72	bare cavity	Marco, Mateusz						15	1		
19	Mount handling frame	72	bare cavity + frame	Marco		Frame for handling				1	1		
20	Cleaning + Heavy BCP	B102 + B118	bare cavity + frame	Leonel	bath etching speed vs bath speed (July to september)	PVDF/PVC flanges + Support at height to allow gravity emptying + tool for bath etching speed vs bath speed				5	0		
21	RF frequency, with antenna for cold tests	72	bare cavity + frame	Rama/ Alick?						3	0		
22	Alternative Tuning	72	bare cavity + frame	Marco						1.5	0		
23	RF frequency	72	bare cavity + frame	Rama									
24	Metrology	72	bare cavity + frame	Marco, Mateusz									
25	Cleaning	B102	bare cavity + frame	Leonel									

15 days for Cavity1
10 days for Cavity2

26	Heat treatment		B153		bare cavity	Leonel		To be defined depending on RRR tests.				3	0	
27	Light BCP		B118		bare cavity + frame	Leonel						5	0	
28	HP Water Rinsing		SM18		bare cavity + frame	Alick			Bare cavity validation	Alick	BE-RF	3	1	24
29	Assembly bare cavity		SM18	clean room	bare cavity + frame	Alick						1	0	
30	Transfer cavity to insert		SM18		bare cavity + frame	Alick		Frame for supporting the cavity during cold test				1	0	
31	Bakeout		SM18		bare cavity + frame	Alick						3	0	
32	Cold RF test		SM18		bare cavity + stiff. frame	Alick						10	0	
33	Warmup		SM18		bare cavity + stiff.	Alick						4	0	
34	Removal of test antenna and preparation for transport		SM18	clean room	bare cavity + frame	Alick						1	0	
35	RF frequency		72		bare cavity + frame	Rama			Assembly of Cavity with helium tank, pre-tuning, fiducialization	Marco	EN-MME	1	1	38
36	Assembly of cavity with tank and magnetic shield		72		cavity + magnetic shield + tank	Marco						25	0	
37	Tank welding + final joining tank-cavity		72		cavity + magnetic shield + tank	Marco						2	0	
38	Pressure test		72 (?)		cavity + magnetic shield + tank	Marco						1	0	
39	RF frequency		72		cavity + magnetic shield + tank	Rama						5	0	
40	Pre-tuning		72		cavity + magnetic	Marco						3	0	
41	RF frequency		72		cavity + magnetic shield + tank	Rama								
42	Metrology and tank fiducialisation		72		cavity + magnetic shield + tank	Marco, Mateusz	Metrology: 3 days	Not for metrology						
43	HP Water Rinsing		SM18		cavity + magnetic shield + tank	Alick			Cavity assembly with HOM couplers and pickup	Alick	BE-RF	4	1	7
44	Assembly of cavities with HOM couplers and pickup		SM18	clean room	cavity + magnetic shield + tank + HOM + pickup	Alick						2	0	
45	Leak test		SM18		cavity + magnetic shield + tank + HOM + pickup	Alick			Dressed cavity validation (cold test)	Alick	BE-RF	2	0	17
46	RF cold test		SM18	V3	cavity + magnetic shield + tank + HOM + pickup	Alick						10	0	
47	Warmup		SM18	V3	cavity + magnetic shield + tank + HOM + pickup	Alick						4		
48	Preparation for cleanroom		SM18		cavity + magnetic shield + tank + HOM + pickup	Alick						1		
49	Mount FPCs		SM18	clean room	string assembly	Alick			String Assembly	Alick	BE-RF	2	1	22
50	Install components on trolley		SM18		string assembly	Alick						1	1	
51	String alignment adjustment		SM18	clean room	string assembly	Mateusz	EDMS 1578808, chapter 3.4					3	0	
			SM18	clean room	string assembly	Alick								

52	Cavity string assembly	Transfer chariot to ISO5 and clean	SM18	clean room	string assembly	Alick							8	0	
		Transfer to ISO4	SM18	clean room	string assembly	Alick									
		Assemble string	SM18	clean room	string assembly	Alick									
		Transfer to ISO5	SM18	clean room	string assembly	Alick									
53	Alignment survey		SM18	clean room	string assembly	Mateusz						1	0		
54	Leak test		SM18	clean room	string assembly	Alick						5	0		
55	Alignment survey		SM18		string assembly	Mateusz			Alignment check, RF frequency check	Mateusz	EN-ACE	2	0	3	
56	RF frequency		SM18		string assembly	Rama						1	0		
57	Mounting tuner frame		SM18		string assembly + tuner frames	Marco			Assembly (pt.0) with tuners and cryolines	Marco	EN-MME	9	0	9	
58	Mounting cryolines		SM18		string assembly + tuner frames +	Marco									
59	Leak test		SM18		string assembly + tuner frames + cryolines										
60	X-rays		SM18		string assembly + tuner frames + cryolines										
61	Assembly Cryomodule pt. 1		SM18		Partially assembled cryomodule	Marco			Assembly (pt. 1) of systems under top plate until alignment survey of system without trolley	Marco	EN-MME	11	0	15	
		string assembly + cryolines attached to top plate	SM18		Partially assembled cryomodule	Marco									
		support for vacuum valves	SM18		Partially assembled cryomodule	Marco									
		thermalisations 2K from tank (HOM, tuner)	SM18		Partially assembled cryomodule	Marco									
		instrumentation + check	SM18		Partially assembled cryomodule	Marco									
		removal of string assembly trolley	SM18		Partially assembled cryomodule	Marco									
62	RF frequency		SM18		Partially assembled cryomodule	Rama						1	0		
63	Alignment survey		SM18		Partially assembled cryomodule	Mateusz						2	0		
64	Pre-tuning		SM18		Partially assembled cryomodule	Marco, Kurt						1	0		
65	Assembly Cryomodule pt. 2		SM18		Partially assembled cryomodule	Marco			Assembly (pt. 2) – first leak check	Marco	EN-MME	19		19	
		RF lines (HOM top all + pickup/HOM bottom partial)	SM18		Partially assembled cryomodule	Marco									
		thermalizations 70K (FPC + HOM top + supports)	SM18		Partially assembled cryomodule	Marco									
		BCAM tubes/targets			Partially assembled cryomodule	Marco, Mateusz	EDMS 1578808, chapter 3.5								
		cryolines bottom welding	SM18		Partially assembled cryomodule	Marco									
66	Leak test		SM18		Partially assembled cryomodule										
67	X-rays		SM18		Partially assembled cryomodule										
68	Assembly Cryomodule		SM18		Partially assembled cryomodule	Marco									
		mounting jumper	SM18		Partially assembled cryomodule	Marco									
		tuner actuation	SM18		Partially assembled cryomodule	Marco									

68	pt. 3	MLI 2K	SM18	Partially assembled cryomodule	Marco	Assembly (pt. 3) – second leak check	Marco	EN-MME	20	0	20	
		thermal shield	SM18	Partially assembled cryomodule	Marco							
		welding pipe for thermal shield	SM18	Partially assembled cryomodule	Marco							
69	Leak test		SM18	Partially assembled cryomodule								
70	X-rays		SM18	Partially assembled cryomodule								
71	Assembly Cryomodule pt. 4		SM18	Partially assembled cryomodule	Marco	Assembly (pt. 4) and closure of cryomodule	Marco	EN-MME	14	0	14	
		thermalizations 70K (HOM bottom + supports line cryo)	SM18	Partially assembled cryomodule	Marco							
		instrumentation finalization	SM18	Partially assembled cryomodule	Marco							
		MLI 70K	SM18	Partially assembled cryomodule	Marco							
		insertion in vacuum vessel	SM18	Partially assembled cryomodule	Marco							
		RF lines bottom (HOM + PU)	SM18	Partially assembled cryomodule	Marco							
72	Systems check for cryomodule closure		SM18	Partially assembled								
73	Cryomodule closure		SM18	Cryomodule	Marco							
74	Leak tests		SM18	Cryomodule								
75	Cryomodule fiducialisation		SM18	Cryomodule	Mateusz	Alignment validation of closed cryomodule	Mateusz	EN-ACE	2	0	16	
76	Alignment adjustment and validation		SM18	Cryomodule	Mateusz				10			
77	Vacuum cycles survey		SM18	Cryomodule	Mateusz				3			
78	Alignment adjustment		SM18	Cryomodule	Mateusz				1			
79	Welding of internal lines with CM & VM	SM18		Cryomodule+SM	Krzysztof	Cryogenic test preparation	Krzysztof	TE-CRG			22	
80	Leak test of new connections	SM18		Cryomodule+SM	Krzysztof							
81	Insulation and welding of interconnections external envelope	SM18		Cryomodule+SM	Krzysztof							
82	Vacuum pumping	SM18		Cryomodule+SM	Krzysztof							
83	Leak test under vacuum	SM18		Cryomodule+SM	Krzysztof							
84	Cooldown and commissioning	SM18		Cryomodule+SM	Krzysztof							
85	RF power connections	SM18		Cryomodule+SM	Eric	RF test preparation	Eric	BE-RF	2		2	SKIPPED
86	Low power measurements	SM18		Cryomodule+SM+RF power	Alick	Cryomodule RF validation	Alick	BE-RF			15	SKIPPED
87	RF conditioning	SM18		Cryomodule+SM+RF power	Alick							SKIPPED
88	High power performance	SM18		Cryomodule+SM+RF power	Alick							SKIPPED
89	Cryomodule warmup	SM18		Cryomodule+SM	Krzysztof	Exit from tests	Krzysztof	TE-CRG			5	
90	Cutting lines	SM18		Cryomodule+SM	Krzysztof							
91	Alignment survey AT401	SM18	bunker		Mateusz	Final alignment steps	Mateusz	EN-ACE		0	1	
92	Alignment survey RF	SM18	bunker		Mateusz				0			
93	Alignment adjustment	SM18	bunker		Mateusz				0			
94	Transport preparation	SM18		Cryomodule+SM	Giovanna	Transport Preparation	Giovanna	BE-RF			2	

Including some weekends