

SM18 test operation, focused on HL-LHC deliverables

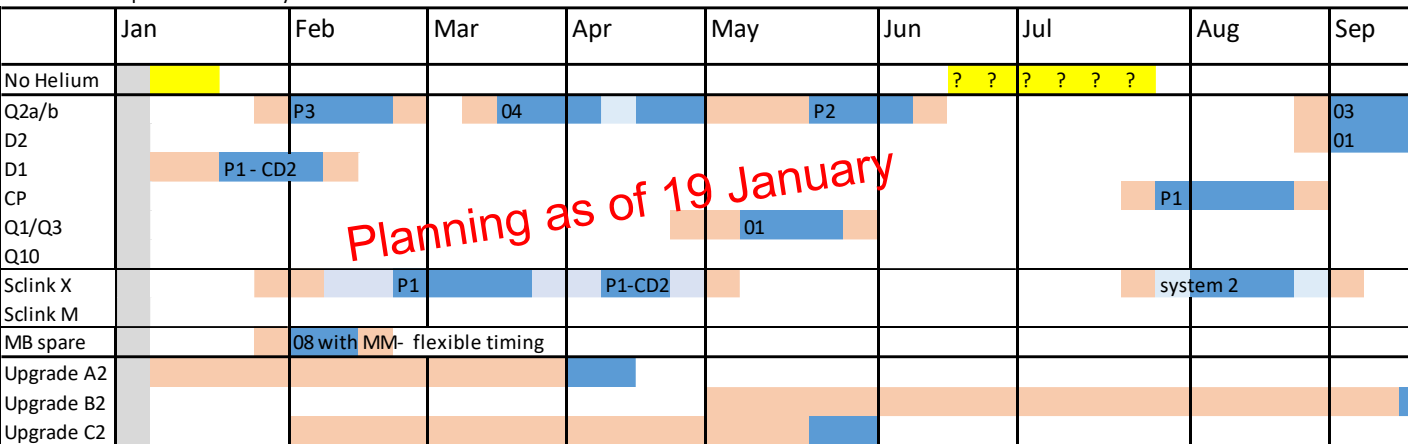
14 May 2024

Gerard Willering for TE-MS-C-TM

Franco Mangiarotti, Stephan Russenschuck, Marco Buzio, Lucio Fiscarelli
Gaëlle Ninet, Jerome Feuvrier, Guillaume Pichon, Stian Juberg, Olivier Ditsch, Patrick Viret.

What happened since the last meeting?

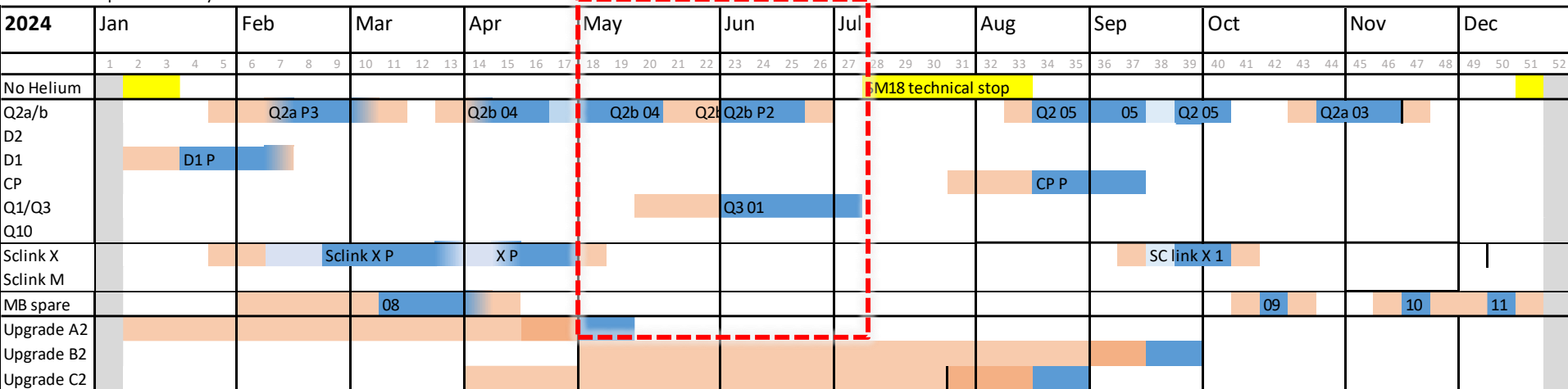
2024 updated 19 January 2024



Planning as of 19 January

- D1 test completed following plan.
- First SC-link tested: Successfull, smooth operation, no non-conformities, following the planning. SC-link test setup fully optimized and here investments paid off. Very good collaborative effort, including commissioning of the bench.
- SC-link series test should be possible in 4 weeks (2 weeks cold) if all goes smooth. The interference with the Q2 tests is rather small and manageable.
- Q2 P3 had a 1.5 week delay at the start (NC investigation P2 ongoing), but then kept the rhythm. Q2 04 started therefore 2 weeks later than planned.
- Upgrade A2 shuffling module pressure test moved to April 15th full commissioning to May 13th. Clear learning curve.
- Q3 test plan was not ready and underestimated in January: It will require 5 weeks cold test starting first week of June.
- Technical stop starts on July 5th. This allows to test the Q2 P2 and Q3 before shutdown (although tight for Q3).



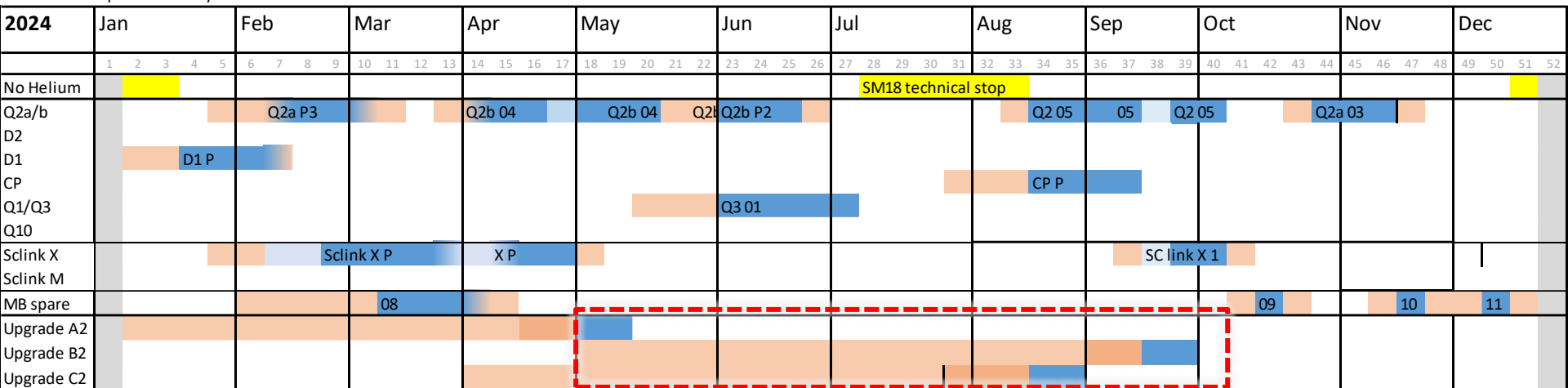


High priority tests until July technical stop.

- Cluster A2 bench upgrade and commissioning without magnet successful in reasonable time. 1 month later than foreseen in January.
- Q3 Magnet will be placed on the bench end of this week. Test throughout June until technical stop starts. In time for delivery to CMI in July for String installation.
- Q2b 04 tests completing this week. Qualified for HL-LHC installation (so far OK).
- Q2b P2 tests in June. In time for delivery to CMI in July for String installation.

Resources OK for tests until July technical stop.

Test time for Q3 test is reasonably tight, but without contingency for non-conformities.



Upgrades

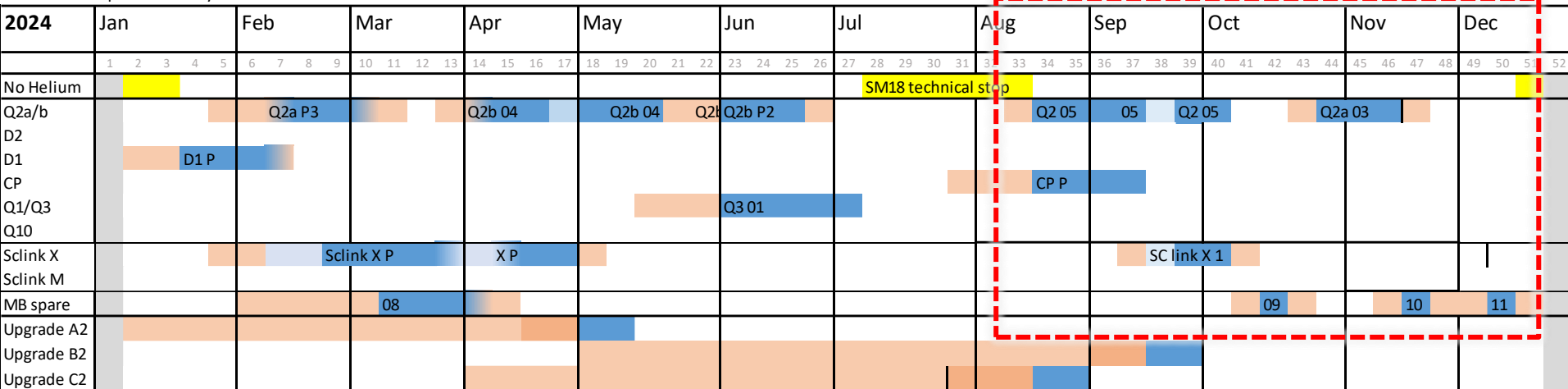
- Bench B2 upgrade started with preparing all components, pressure test them, etc. Shuffling module by MSC-CMI.
- Bench C2 upgrades well underway, with most components completed. Shuffling module by MSC-LMF.

For bench A2 the full electrical system (interlock, protection, 2 kA powering and EE, cabling, etc.) was replaced, which took a lot of resources from MSC-TM.

For bench B2 and C2, much less work from the MSC-TM team is needed. All electrical systems will stay as they are.

Goal C2: finish in July. Commission in august. D2 magnet test only in 2025

Goal B2: Finish in September followed by commissioning. D1 magnet test only in 2025.



High priority tests after July technical stop.

- CP prototype test directly after technical stop.
- Q2 05 directly after technical stop.
- SC link first of series. No issue for test end of September. Test plan already optimized, only little interference with Q2 tests.

Resources OK for tests and upgrades for August to December, but September is a bit busy so possibly some of the commissioning will be pushed into October.

Dashboard Horizontal test planning – Start of 2025

2025 - preliminary forecast

updated 7 May 2024 _based on V.46.19

2025	Jan					Feb				Mar				Apr				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
No Helium																		
Q2a/b																		
D2																		
D1																		
CP																		
Q1/Q3																		
Q10																		
Sclink X																		
Sclink M																		
MB spare																		

Start of 2025

- All planned horizontal tests can be done without problem.

D2 test ~ March 2025

D1 test ~ March 2025



Vertical bench, Cluster D

2024 updated 14 May 2024

2024	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1 2 3 4 5	6 7 8 9	10 11 12 13	14 15 16 17	18 19 20 21 22	23 24 25 26	27 28 29 30 31	32 33 34 35	36 37 38 39	40 41 42 43 44	45 46 47 48	49 50 51 52
No Helium	1 2 3 4 5							SM18 technical stop				
MCBRD in Cluster D			12	P2c 04						11		03
MCBXF in Cluster D						B05			A1		B06	
MQML in Cluster D	1		1			2		3	4	5		
MBHDP301					11T	11T 11T						

All HL-LHC qualification tests are planned in cluster D.

- 5 HL-LHC tests done to date + 11T test ongoing.
- 9 more tests requested for this year.

Main challenge:

- Vertical tests generally lower in cryo-priority than horizontal tests.
- Until April no RF tests which helped to advance, but this changed.
- No helium inventory available for HFM and Cluster D at the same time.

The team and our vertical test station will likely be able to handle more test than helium volume is available. The re-installation of the 25000 liter dewar during the technical stop may help to test more efficiently.

2024 updated 13 May 2024

Cluster D	status	HFM	status
MQML42 test 1	Done February	MQXFS8	Done - Feb 2024
MQML42 test 2	Done March	EESD at 20 K	Done - Feb 2024
MCBRD12	Done March	MQXFS7j	In test
MCBRDP2b	Done April	MQXFS8	
MCBRD04	Done April	RMM1c	
MBHDP301	In Test		
MQML-2		SP107 - FCC beam screen	
MCBXFB05		Fusillo full scale	
MQML-3		11T MBH301	
MQML-4		MQXFS4	
MCBXFB06			
MQML-5			
MCBXFA1			
Future tests:		Future tests:	
MCBXFB 07, 08, 09, 10, 11, 12			
MCBXFA 2, 3, 4, 5			
MCBRD11, 05, 06, 07, 08, 09, 10			



Longer term outlook

Dashboard for HL-LHC magnet and SC link testing.

14/05/2024

Dashboard horizontal magnets/SCLinks to be tested in SM18 for LS3

Object	Test completed	In test	To be tested
WP3 6 / 6	MQXFB - test P1 P2 P3 MT4 02 03		
21% 1 / 11	Q2a/b P3	04	P2 03 05 06 07 08 09 10 02b
1 / 7	D2 P1		1 2 3 4 5 6
1 / 7	D1 P1		1 2 3 4 5 6
0 / 5	CP		01 02 03 04 05
0 / 2	Q1/Q3		01 04
0 / 4	Q10		1 2 3 4
WP6a 1 / 5	SC-link type X P		1 2 3 4
10% 0 / 5	SC-link type M		P 1 2 3 4
Other 8 / 15	MB spares 1 2 3 4 5 6 7 8		9 10 11 12 13 14 15

tests in 2024 in red

Horizontal to be tested:

41 full assemblies HL-LHC + 7 LHC dipoles

In **red** the items still to test in 2024

14/05/2024

Dashboard horizontal magnets/SCLinks to be tested in SM18 for LS3

Object	Test completed	In test	To be tested
WP3 1 / 7	MCBXFA P1		1 2 3 4 5 6
37% 6 / 14	MCBXFB P1 P2 01 02 03 04		05 06 07 08 09 10 11 12
8 / 16	MCBRD P1 P3 P4 01 02 P2c 12 04		11 03 05 06 07 08 09 10
1 / 5	MQML 1		2 3 4 5
1 / 4	MSCB 1		2 3 4
1 / 6	IT-diode stack P1		1 2 3 4 5

Vertical to be tested:

13 MCXBF

8 MCBRD

4 MQML

3 MSCB

5 IT-diode stacks

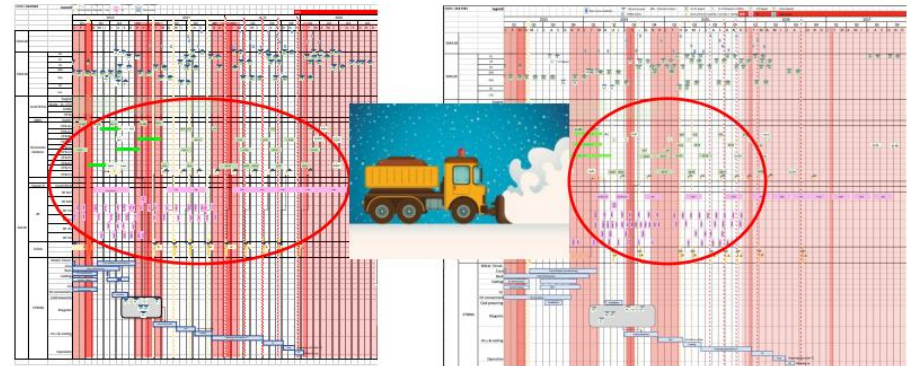


Little outlook towards second half of 2025

Manageable workload early 2025 due to shifts in schedule, however, the risk of snowplough effect as shown by Luigi in Chamonix is becoming more likely.

If mid-2025 the String is operational (taking half the 1.9 K pumping capacity of the building) and we need to share the remaining 50 % of capacity with RF testing, the impact on available test time will be high.

⚠ Tests are being delayed and the schedule margins (flexibility) is eroded (snowplough effect)



Resources

Conclusions from Jan 2023 review:

Critical for operation

2023 is the most critical for the operation team (5 staff, 2 FSU), and still critical up to 2026.

- Bench F1, F2, A2, B2 upgrades to be done and commissioned.
- Vertical bench has a full test program, see slides Franco
- Same operators that do testing also need to do the upgrades.
- 1 operator will be replaced by a new operator, to be trained for 6-12 months before fully operational.
- 4 Magnets/SCLink that arrive will be first of a kind, which typically doubles or triples test time to standardize the bench and perform prototype testing.

2023 is the most critical for support from:

- PLC hardware (1 staff) and cabling (2 FSU required)
- Electromechanical support (magnet preparation, bench modifications, anti-cryostat preparation)

Test engineers will be on the critical path

- Two test engineers is not enough to manage all tests well, including reporting, feedback to all projects, managing the test team.
- The test engineer needs to be onsite to be able to deblock test situations, make decisions based on the discussed test plan and ensure test efficiency and validity.
- Support from a fellow for reporting and analysis is good, but not with autonomy or responsibility during the 2-3 years that a fellow is given to do the job.

New operator starting in July 2024, operational output end of the year.

OK for operators.

Critical, no change foreseen.
Impact on reporting, quality, analysis, etc.

Conclusions

Bench upgrades:

- F1, F2 and A2 completed.
- B2 and C2 ongoing and we want to finish it, but not critical due to late magnet delivery.

Test planning

- Less work on upgrades and commissioning gives more focus on tests and operation.
- Q2 tests not on critical path.
- Q3 test tight before technical stop.
- CP after technical stop should pose no problems.

Challenges

- Large number of tests in cluster D, limited cryogenic capacity/limited priority.

Possible issue

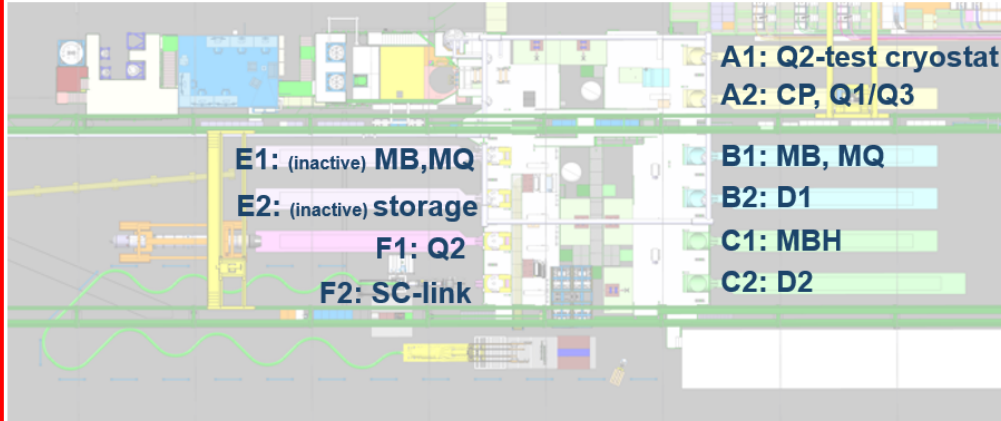
- Snowplough effect, calm until first quarter of 2025. Cryogenics may become critical with String operation ongoing.

Critical

- Two test engineers is not enough to manage all tests well, analysis, analysis tools, reporting, feedback to all projects, etc.

Backup slide. Bench status

SM18 horizontal benches



Bench	Primary configuration	Backup
A1	Q2 in test cryostat	Q1, Q3, D1
A2	Q1, Q3, CP	Q2
B1	MB, MQ Q10?	
B2	D1	
C1	MBH	
C2	D2	
E1	(inactive, PC used for SC-link)	MB, MQ
E2	(inactive) shaft storage	MB, MQ
F1	Q2	CP
F2	SCLink	

OK

OK

OK

Shuffling module ongoing

OK

Shuffling module ongoing

OK

Assembly after delivery

OK

OK

As discussed in the SM18 scrutiny group:

Strong preference to have a **single magnet type per bench**

- test efficiency (bench modification can limit bench up-time).
- Safety and risk reduction (wiring, PLC, uQDS modifications are critical for magnet protection)
- human resources (modifications take considerable time for doing and documentation follow up).

Most important backup bench is A2 for the Q2 magnet.

Test bench occupancy and choices were discussed in detail in the scrutiny group, see <https://indico.cern.ch/event/1036798/>

Infrastructure readiness presented in Chamonix workshop 2022 by S. Russenschuck, see <https://indico.cern.ch/event/1097716/contributions/4618917/>



