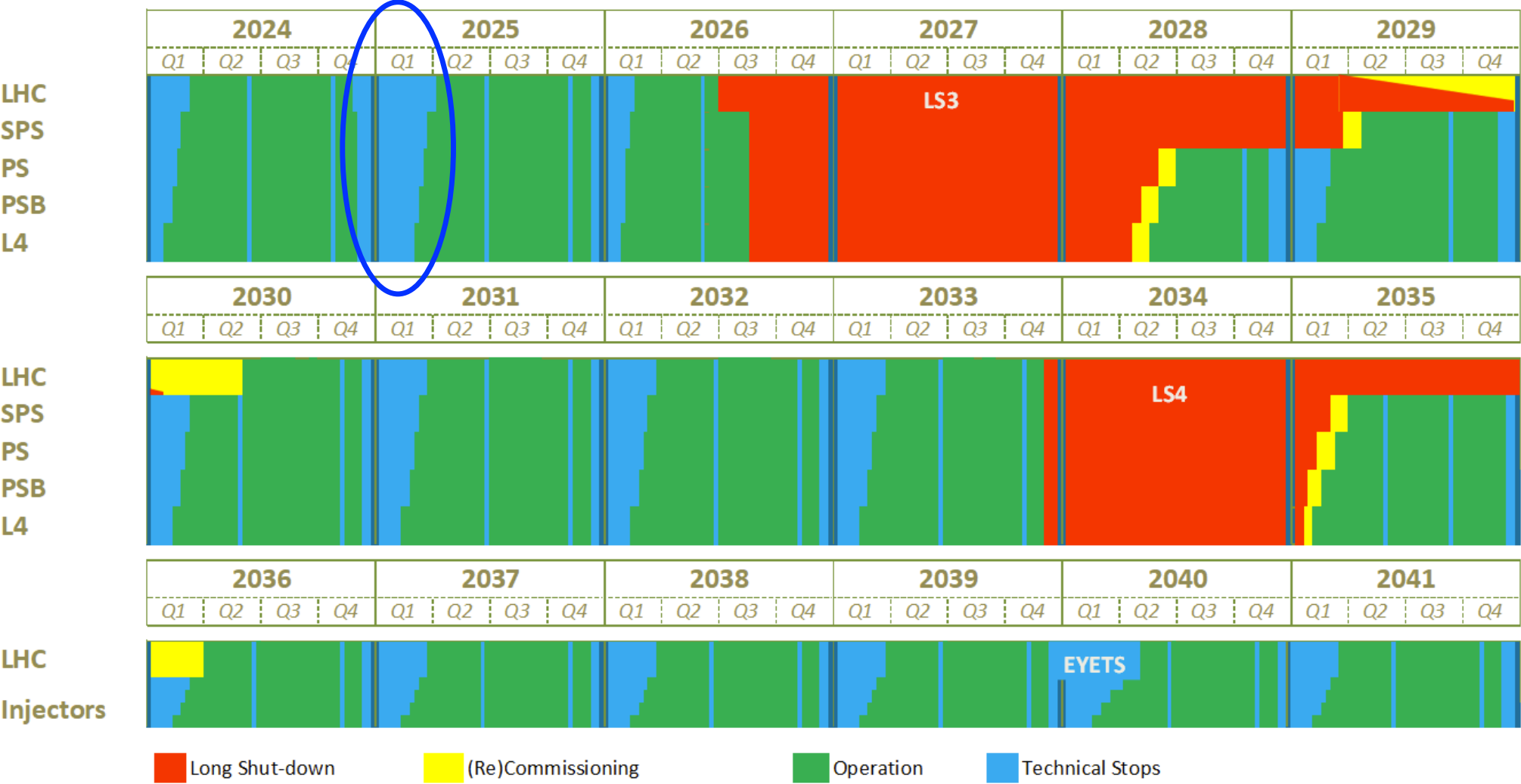




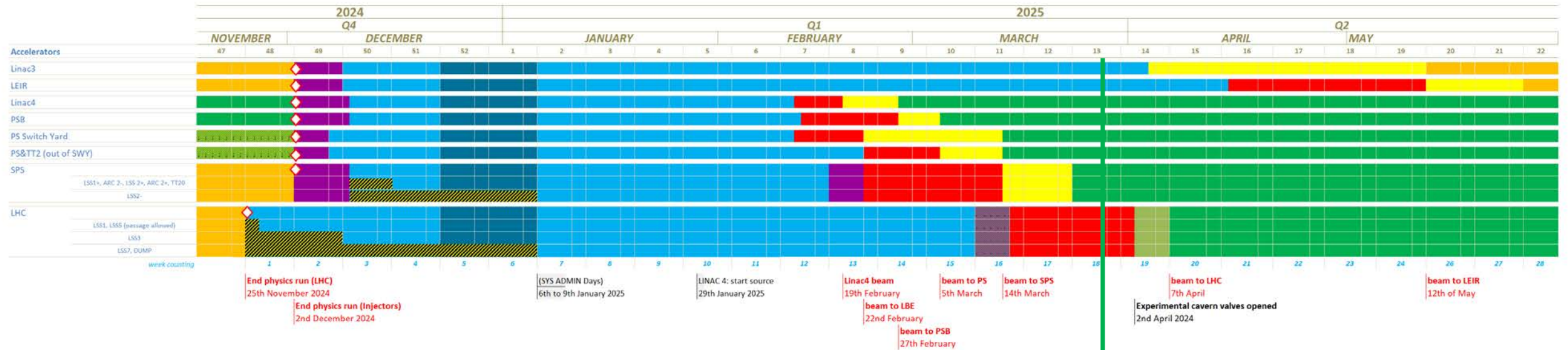
Status of the accelerator complex and upgrade

Mike Lamont

Long Term Schedule for CERN Accelerator complex



24/25 Extended Year End Technical Stop (EYETS)



Successfully negotiated

Machine

- LINAC3
- LEIR
- LINAC4
- PSB
- PS & TT2
- SPS
- LHC

Experimental area

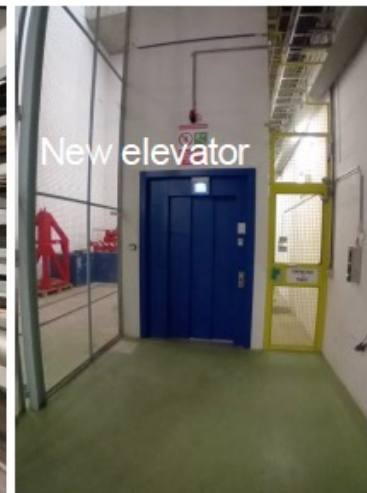
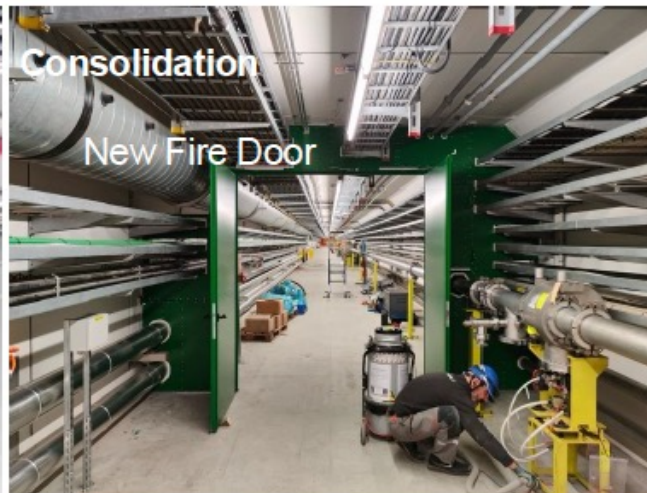
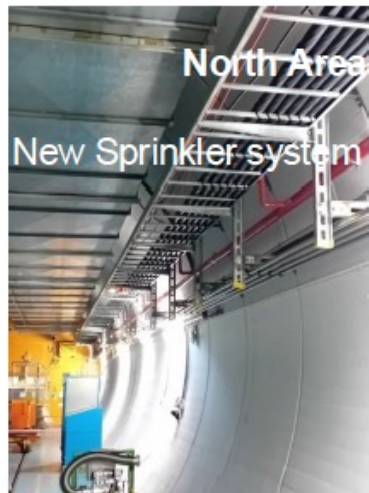
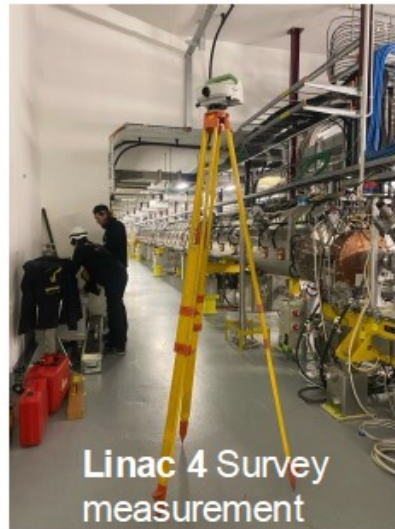
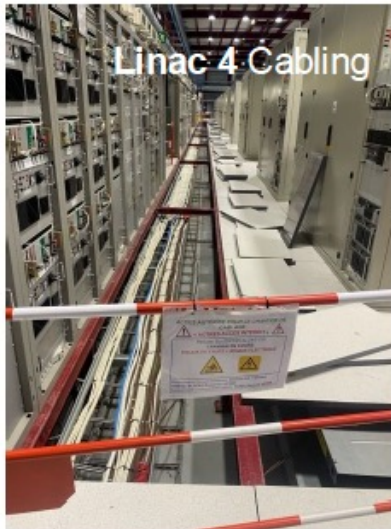
- East Area
- AD/ELENA
- HiRadMat
- North Area
- n_TOF
- ISOLDE

Today

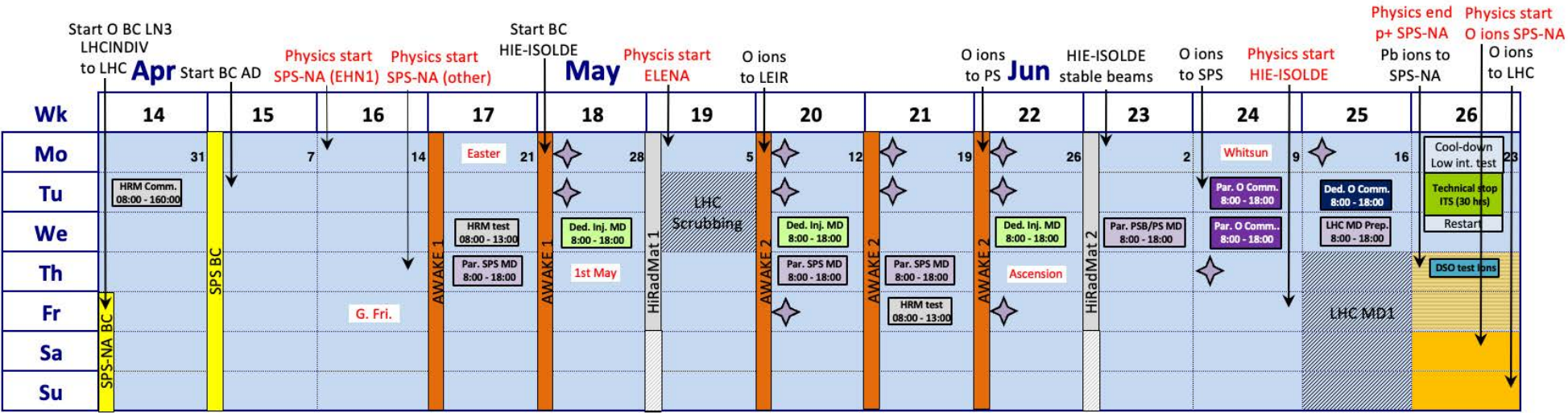
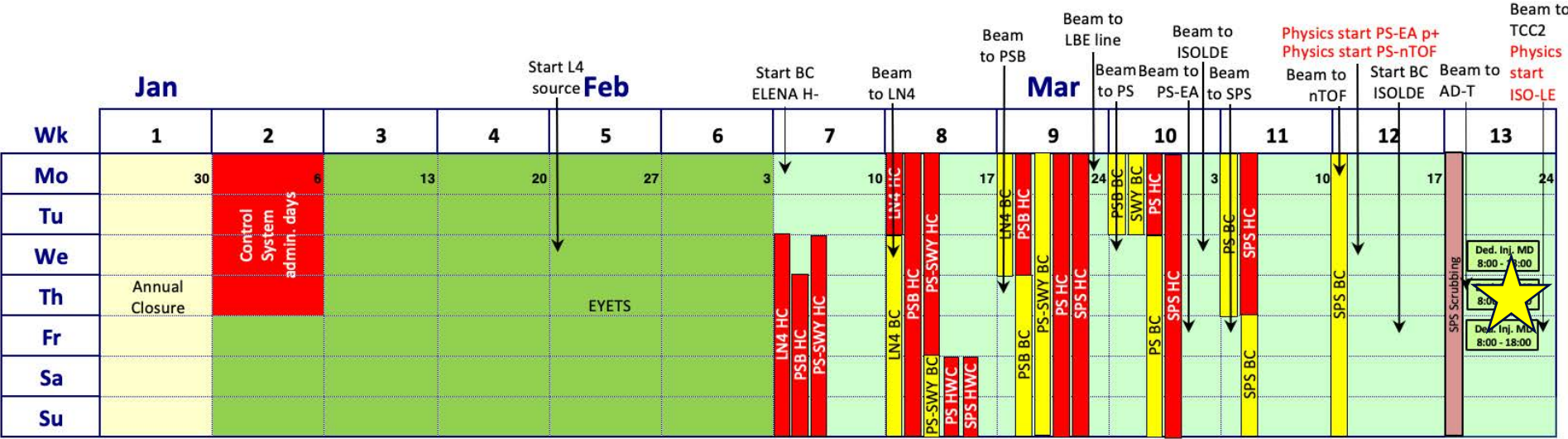
legend

- ◊ stop of the beam
- ▨ RP survey before access
- Year End Closure
- Proton beam operation
- technical stop (access to be defined)
- Equipment test at operation conditions
- hardware commissioning + cold check-out
- beam commissioning
- hardware commissioning (including IST) and/or works
- Powering test and Training quench in the LHC
- Check-out
- Pb - Pb Ion/ proton physics run
- Pb - Pb Ion physics run
- Winter Physics
- Electron beam operation

Executing YETS and preparing for LS3 and HL-LHC installation and operation



Injector schedule 2025 – Q1/Q2



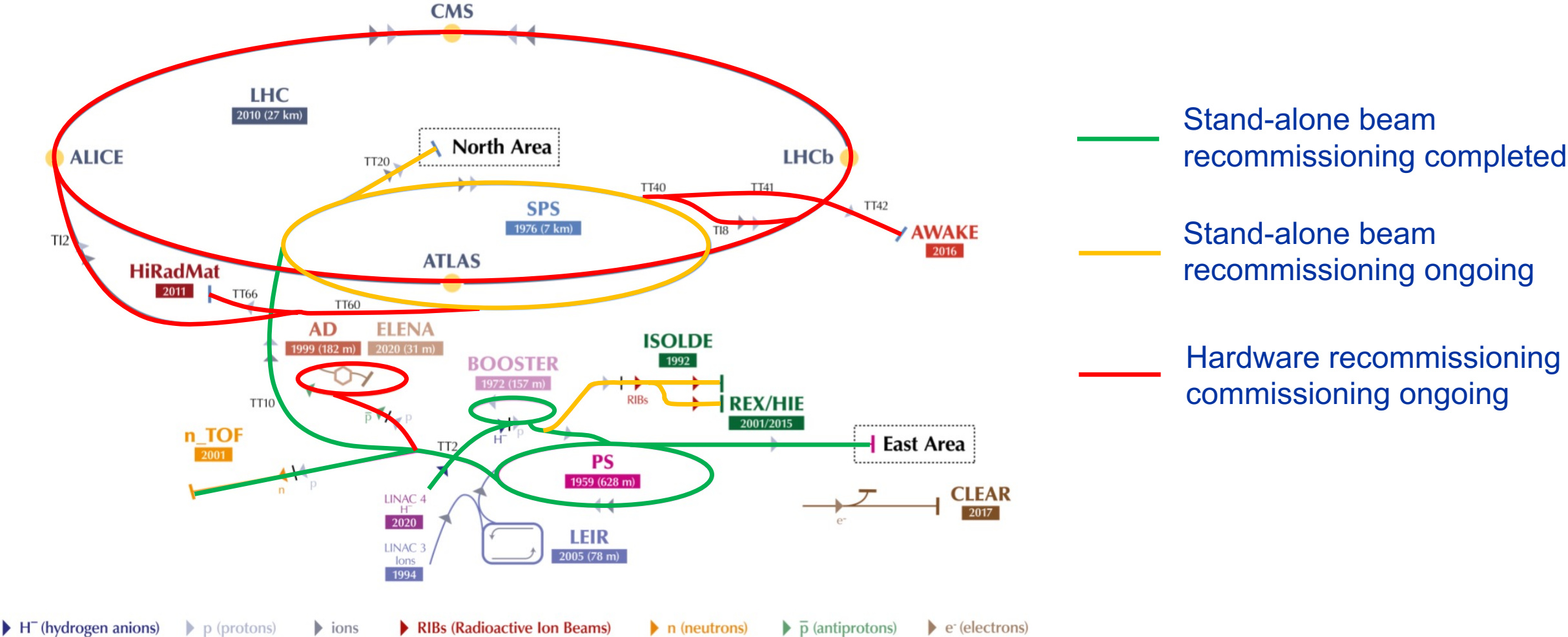
2025 Injectors Schedule in numbers

Experimental facility	Beam to	Start physics	End physics	Duration [days]*	
ISOLDE	05.03	28.03	08.12	241	
nTOF	17.03	19.03	08.12	264	
PS East Area p ⁺	07.03	19.03	08.12	264	
PS East Area Pb ions	-	17.11	08.12	21	
SPS North Area p ⁺	28.03	14.04	26.06	73	213
	-	07.07	24.11	140	
SPS North Area O ions	07.07	28.06	07.07	9	
SPS North area Pb ions	24.11	28.11	08.12	10 (+4)	
AD-ELENA	27.03	05.05	08.12	217	
HiRadMat	-	05.05	21.09	22 (+8)	

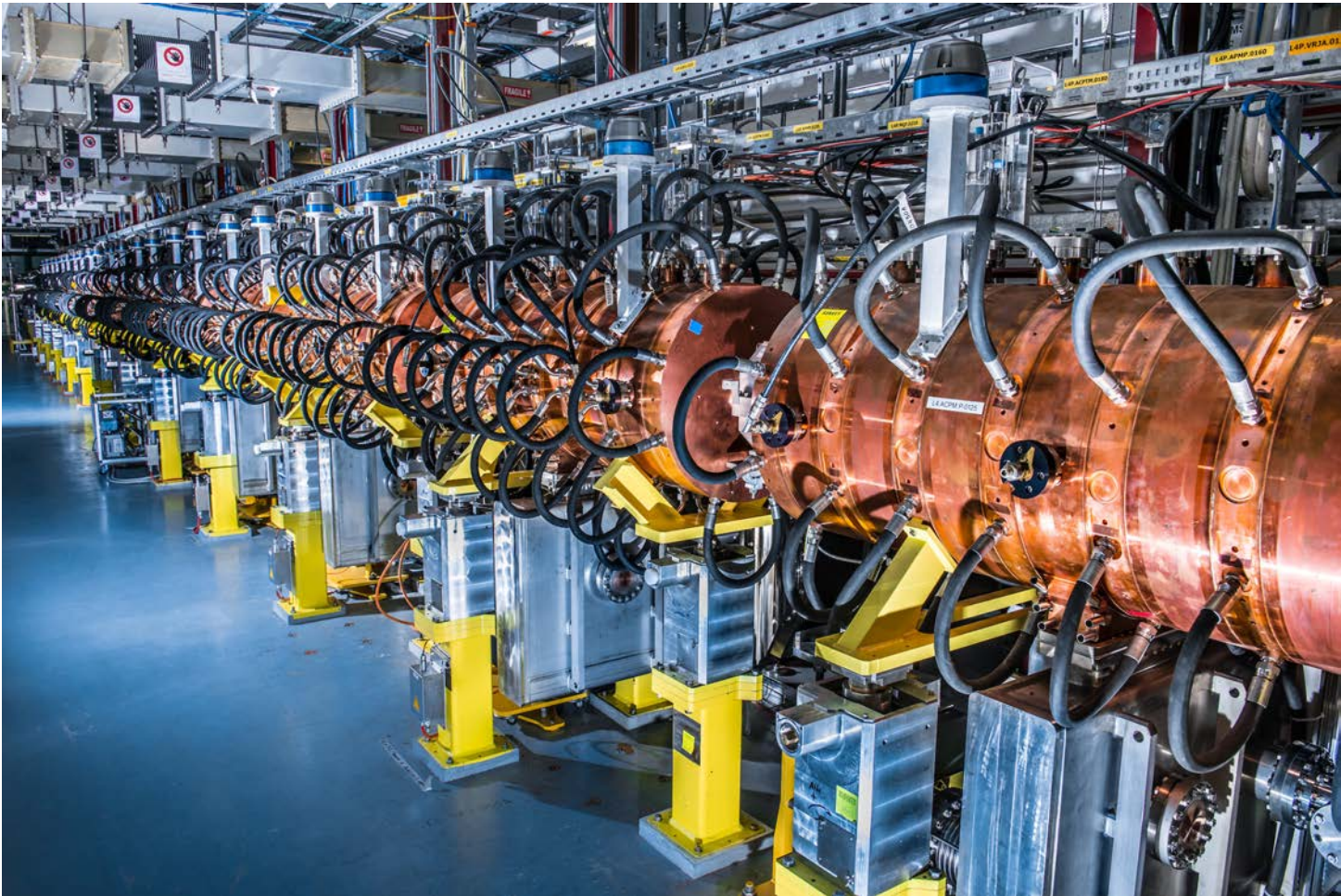
*TS and MD time etc. not deducted

*TS and MD time etc. not deducted

Beam re-commissioning status end week 12



Linac4



- Beam commissioning started on schedule on 19th February.
- Source at **higher current** (up to **40 mA**) wrt to previous year (up to **35 mA**) with **constant RFQ transmission**.
- Good availability





PSB

Protons to PS

H⁻ from Linac4

PS Booster (PSB)

PSB Fixdisplay - W 9							
27-Feb-2025 16:18:55							
Comments (27-Feb-2025 13:15:19)							
Coordinator : G.P. Di Giovanni (16774)							
Operator : CCC: 76671, 160357							
BP	User	Pls	Inj.	Acc.	b.Ej.E10	Ej.E10	Dest.
18	MD_160MeV_2025	15	○○○○	○○○○	0.00	0.13	BDUMP
19	LHCINDIV_2025	10	●●●●	●●●●	58.85	62.06	BDUMP
20	TOF_2025	23	○○○○	○○○○	1017	1019	BDUMP
21	ISOGPS_1_7GeV_2	22	●●●●	●●●●	235	243	BDUMP
22	MTE_2025	20	●●●●	●●●●	160	165	BDUMP
23	ISOGPS_2025	18	●●●●	●●●●	3183	3119	BDUMP
24	---ZERO---	1	○○○○	○○○○	0.00	4.04	BDUMP
25	LHC25A_2025	4	●●●●	●●●●	526	533	BDUMP
26	AD_2025	24	●●●●	●●●●	2087	2133	BDUMP
27	LHCINDIV_2025	10	●●●●	●●●●	58.88	63.17	BDUMP
28	ISOGPS_2025	18	●●●●	●●●●	3177	3092	BDUMP
30	LHCINDIV_2025	10	●●●●	●●●●	158	163	BDUMP
	MD_160MeV_2025						BDUMP
30/36 No Message							

- Current **PSB standalone availability at > 98% in the first 3 weeks of commissioning.**
- **Extensive main quadrupole maintenance campaign** during the YETS, to address the issue with the (water) leaking brazing of the magnets, following leak tests:
 - **4 quadrupole magnets replaced, 2 quadrupole magnets repaired in situ**
- Impressive work by the teams involved, BE-GM, TE-MSD and TE-VSC.

Super-Cycle composition after ~1 day from the start of PSB Beam Commissioning

PS – looking good at 66

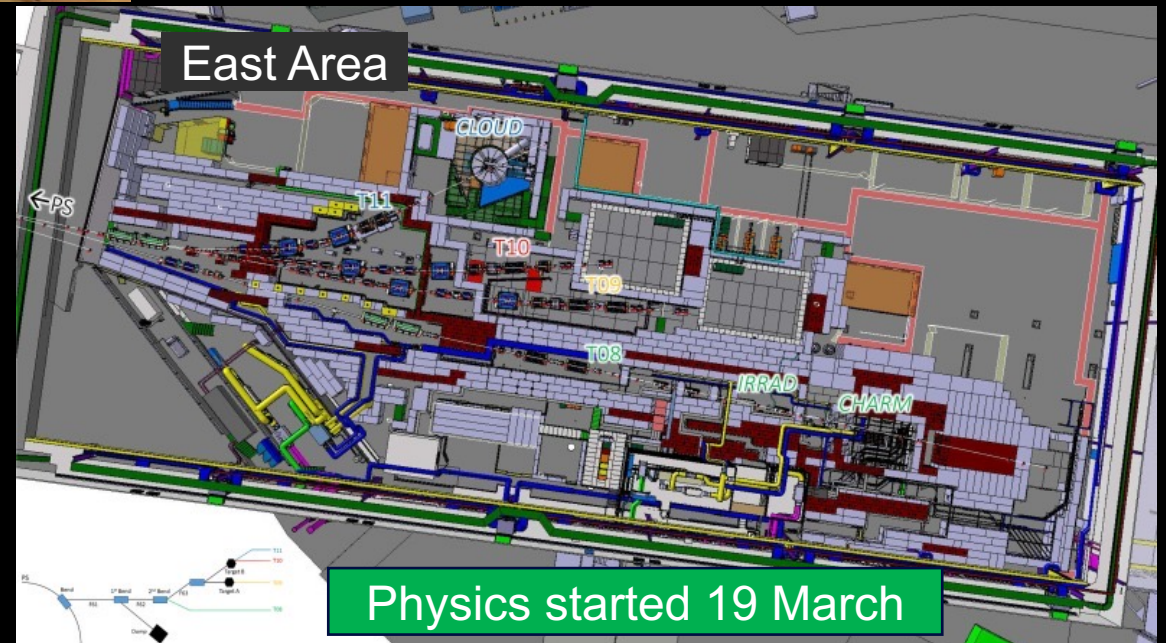
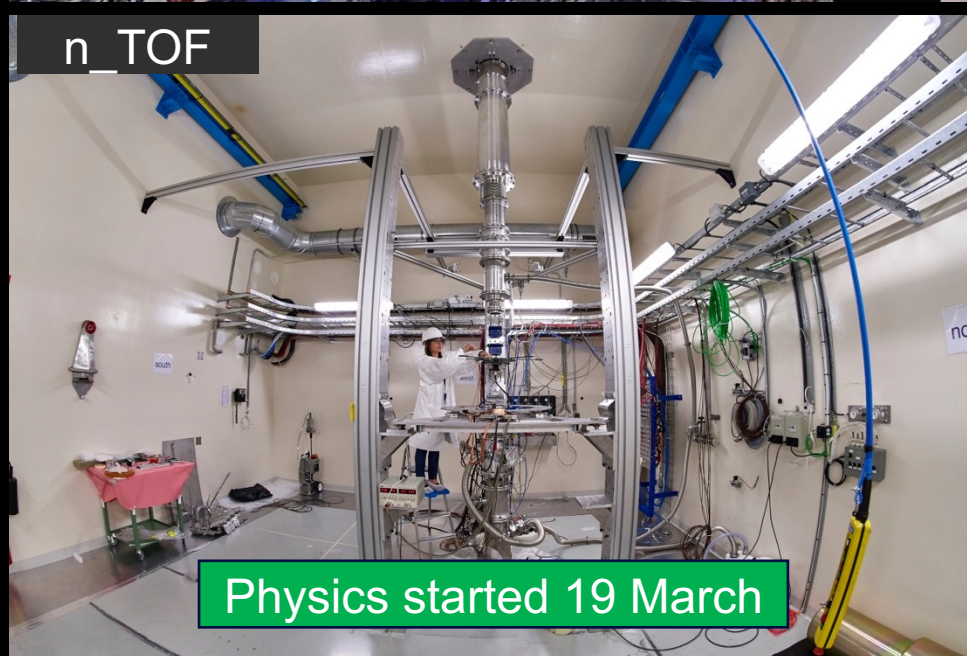
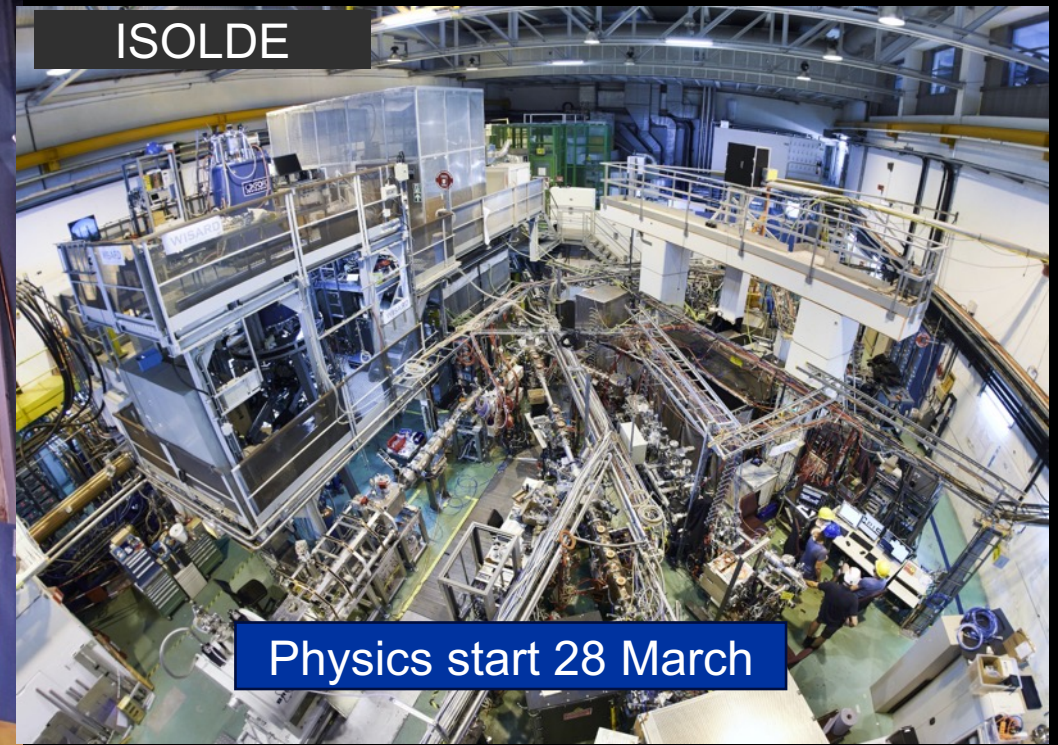
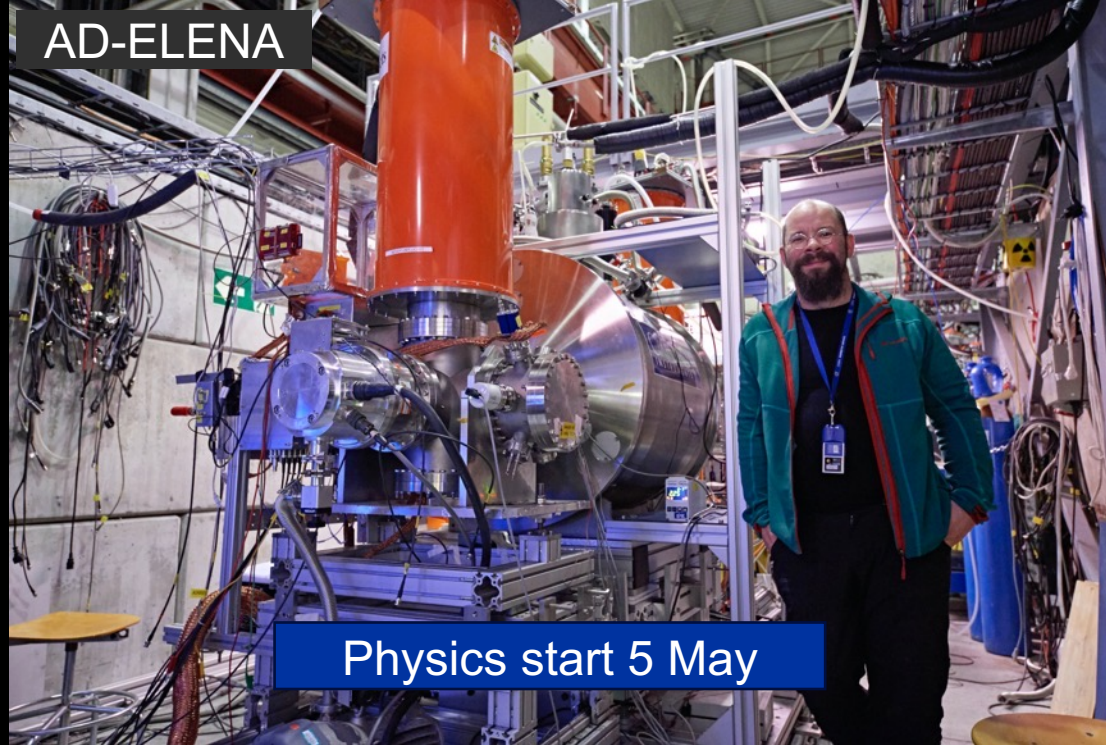


PS Hardware commissioning phase successfully completed on 4th March, following various maintenance and upgrade activities during the YETS

PS standalone beam commissioning started on 4th March, a few hours ahead of schedule

Sent first beams to SPS as planned on 14th March

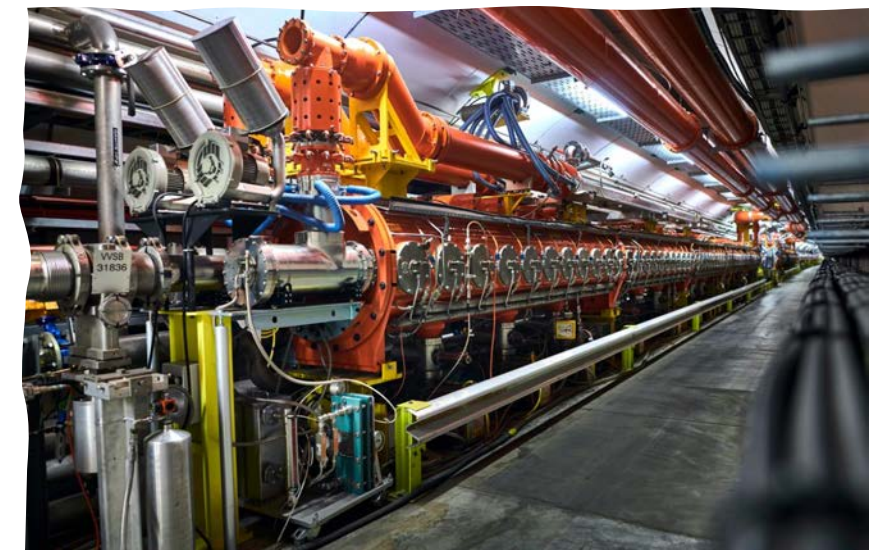
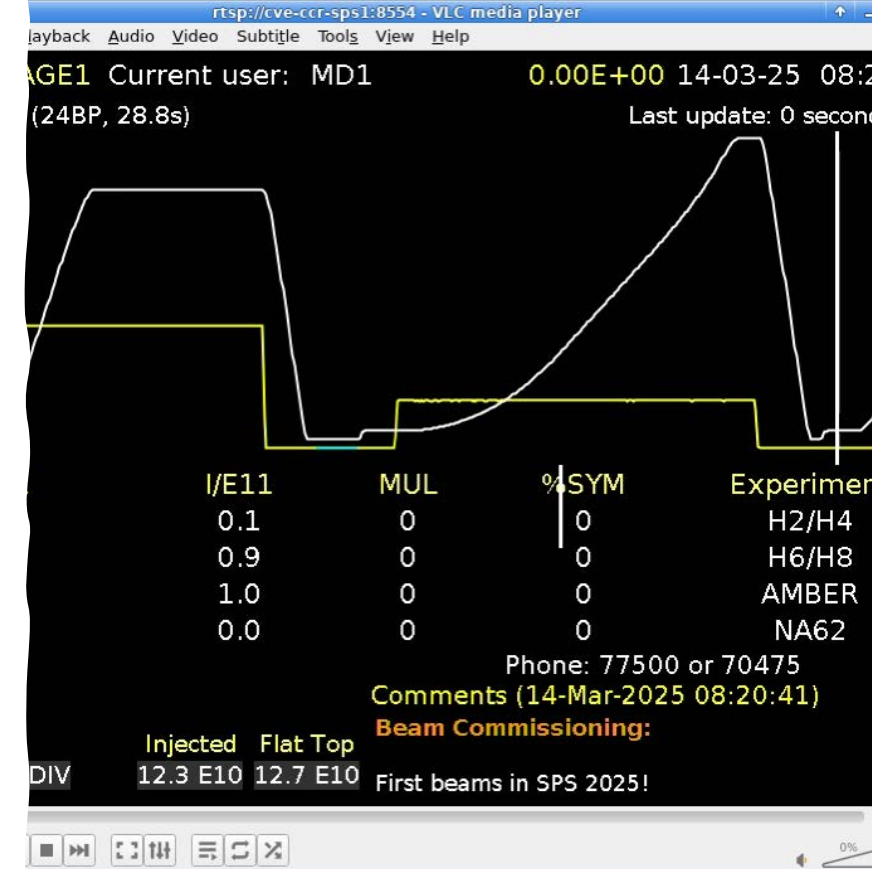
Beam delivered as planned on 19th March to first physics users, EAST Area and n_TOF



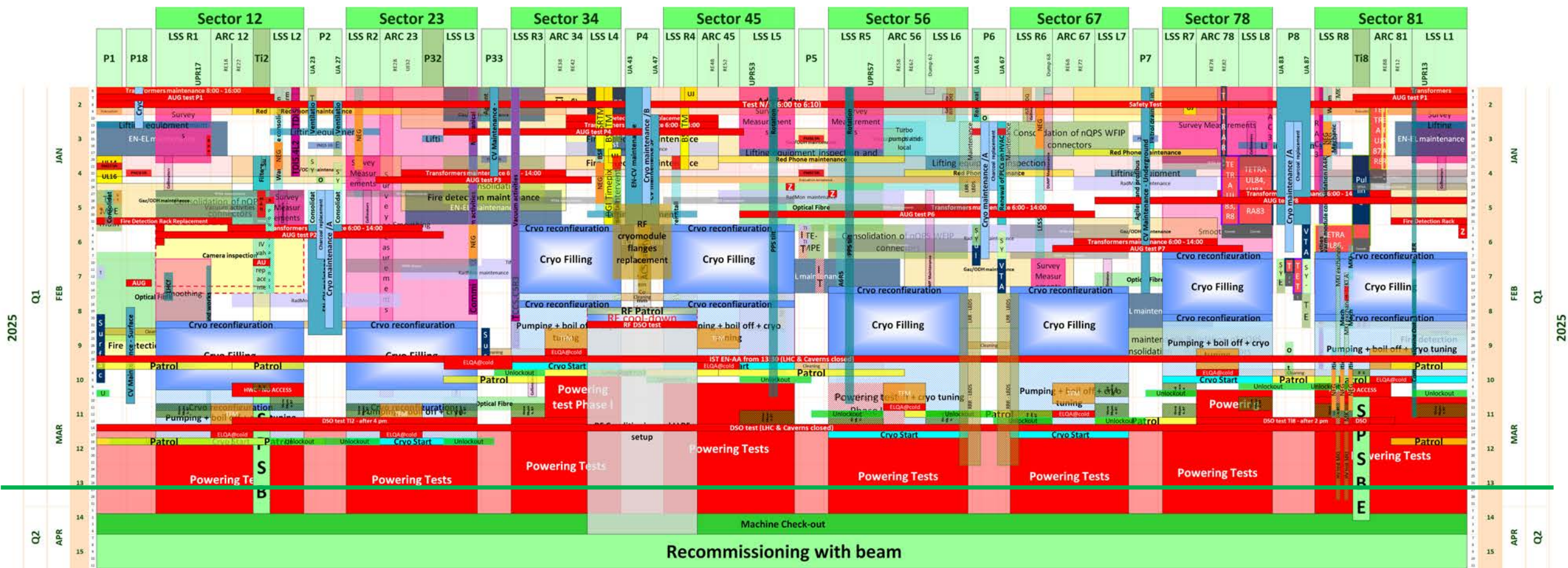
SPS - First beam Friday 14th March

- HWC successfully completed within time for DSO tests – close to 12'000 tests successfully completed; machine ready to take beam by Thursday evening
- Beam injected from PS on Friday morning – quickly established circulating beam on both SFTPRO and LHCINDIV
- Established ramp to top energy within an hour for both SFTPRO and LHCINDIV

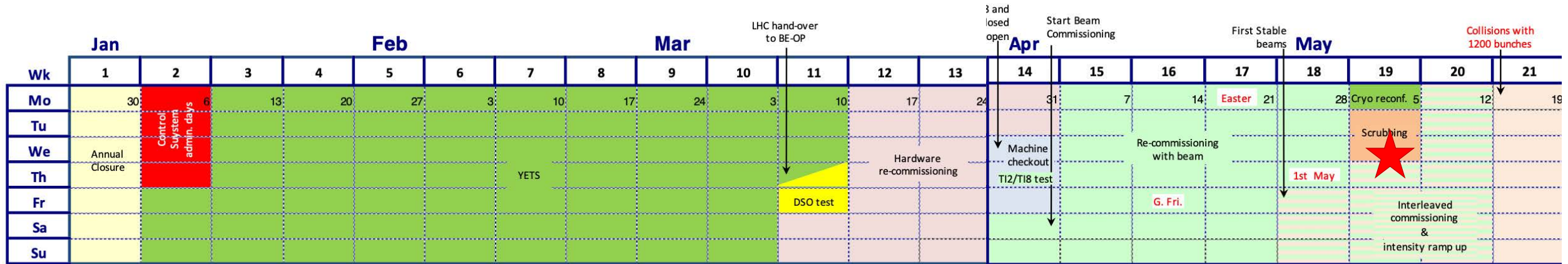
SFTPRO – SPS fixed target protons
LHCINDIV – LHC individual bunches



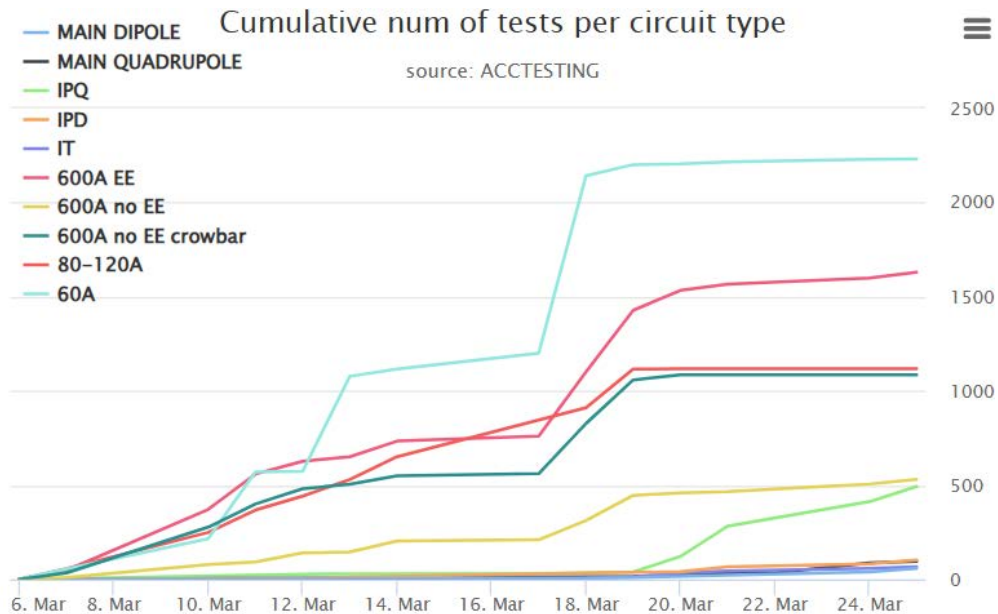
LHC EYETS 2024-25 Global Schedule



LHC Status and Plans

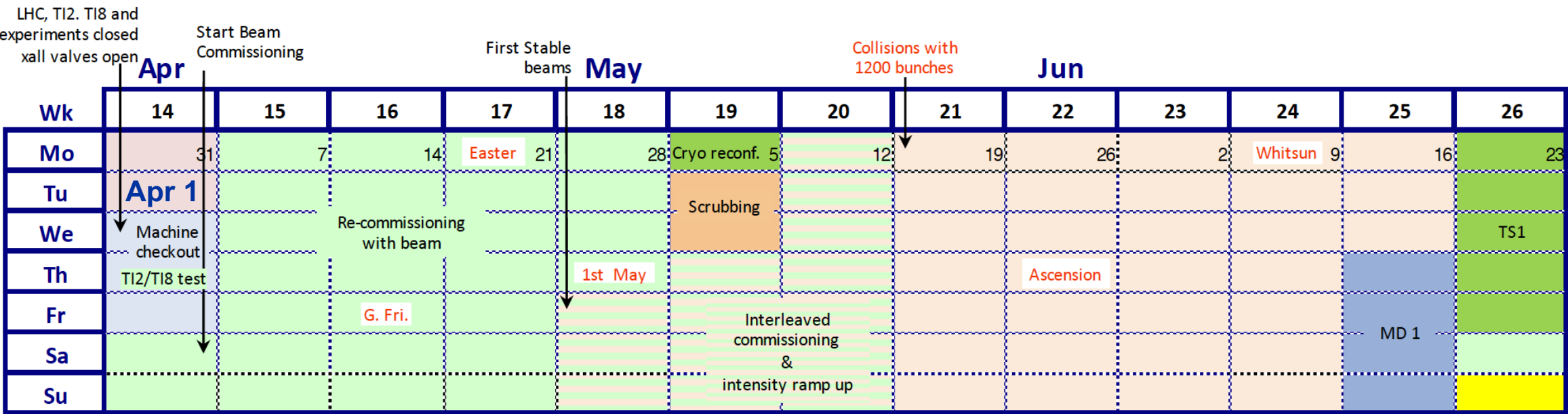


- Departmental Safety Officer (DSO) tests successfully completed:
- Individual system tests nearly completed
- Powering tests
- Concurrent preparation for machine check-out
- First table beams 5th May



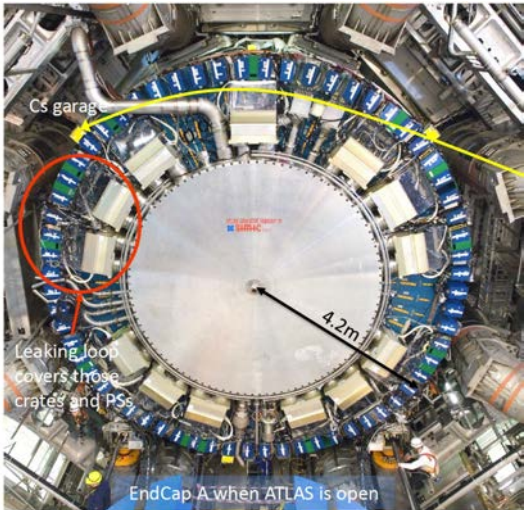
- Almost **1600 superconducting circuits**
- **Over 10,000 tests** to be executed and analysed
- Sophisticated tools to ensure **robustness reproducibility and traceability** throughout the execution process
- **Enhanced automation** for increased efficiency
- **Cross-departmental effort:** a two weeks campaign involving approximately 10 groups across the ATS sectors

LHC – Incoming – Q2



However...

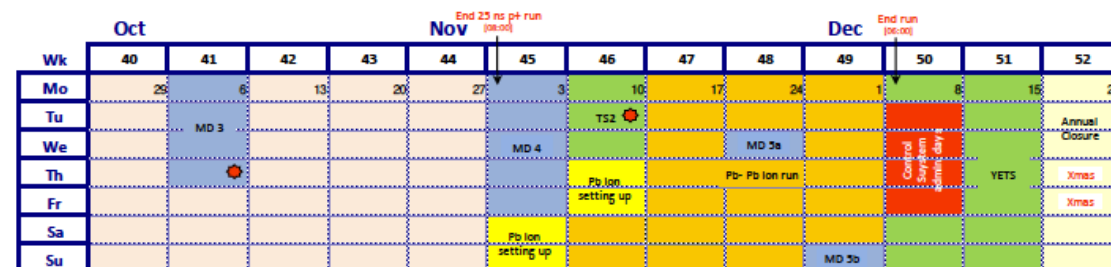
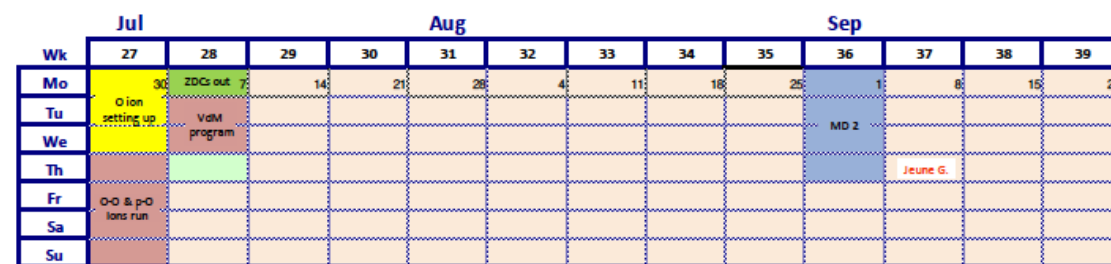
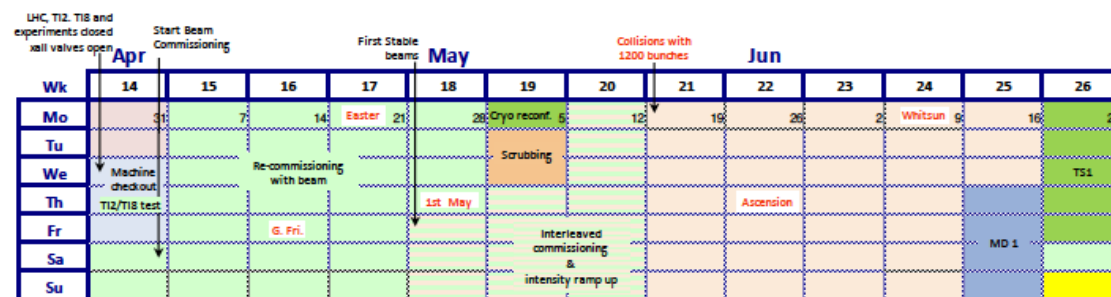
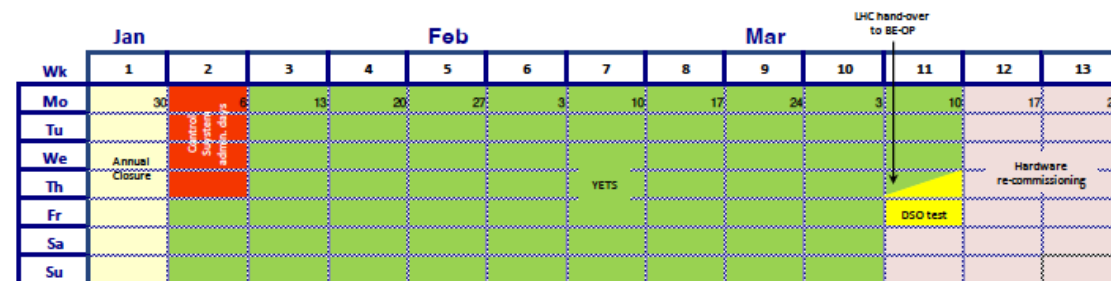
- Location of the leak very likely within the red circle
- Currently inaccessible (see right picture)
- → ATLAS requested re-opening



LHC 2025 Schedule

Important dates in 2025:

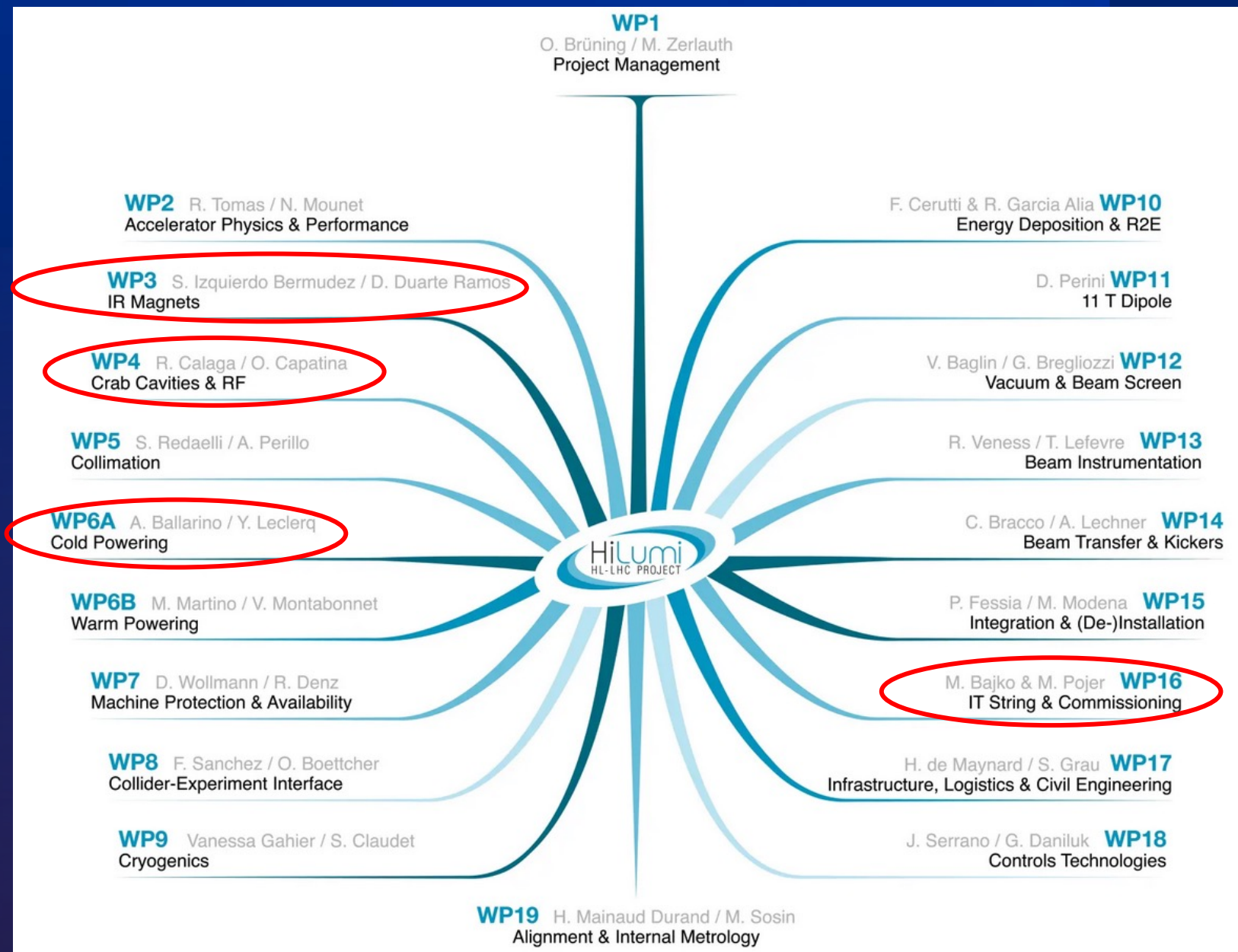
- March 13th – LHC handover to OP
- April 5th – Start of beam commissioning
- May 2nd – First stable beams
- May 19th – Collisions with >1200 bunches (start of physics)
- June 19th – 22nd – Machine Development I
- June 23rd – 27th – Technical stop I
- June 29th – July 6th – p-O & O-O Run + Ne-Ne
- July 8th – 9th – VdM program (all 4 experiments)
- September 1st – 4th Machine Development II
- October 6th – 9th – Machine Development III
- November 3rd – 7th Machine Development IV
- November 8th – Start of PbPb commissioning
- November 10th – 12th Technical stop II
- November 15th – December 6th Pb-Pb Run (inc. MD 5a)



Challenging/realistic targets for 2025

proton-proton	120 fb⁻¹ for ATLAS/CMS 12 fb⁻¹ for LHCb 50 pb⁻¹ for ALICE
Pb-Pb	2.4 nb⁻¹ for ATLAS/CMS/ALICE 0.8 nb⁻¹ for LHCb
p-O	Original Targets: 2 nb ⁻¹ for LHCb and 1.5 nb ⁻¹ for LHCf/ATLAS. (ALICE/CMS; no official target but hope for >~5 nb ⁻¹ , CMS target 3 nb ⁻¹)
O-O	Original Targets: 0.5 nb ⁻¹ for ATLAS/CMS/ALICE. LHCb also request 0.5 nb ⁻¹ , extremely challenging
Ne-Ne	>0.1 nb ⁻¹ expected

It's going to be an interesting year!



Series Production

5 DQW cryomodules (Europe)

- 10 Cavities to be manufactured at Research Instruments (DE) & CERN
- 4 CMs by UK (STFC) & 1 CM at CERN
- All cavities & CMs cold tested at CERN

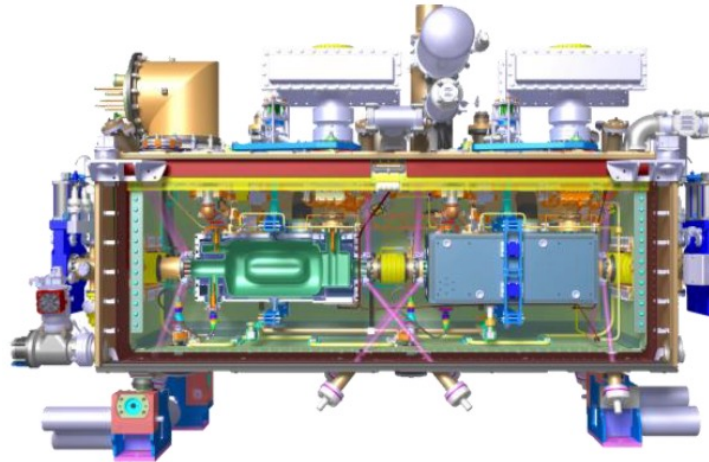
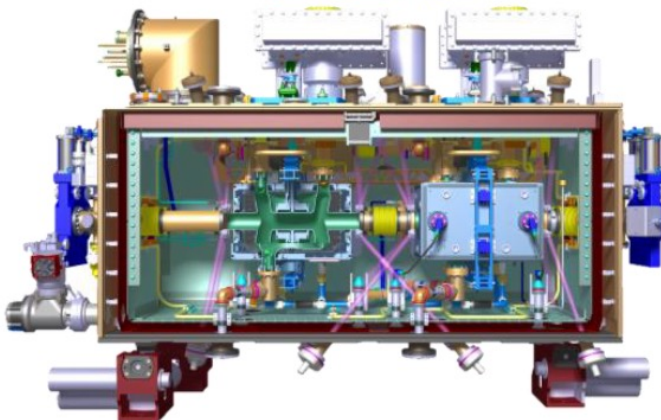
5 RFD cryomodules (North America)

- 10 (+2) Cavities to be manufactured at Zanon (IT) under US-AUP
- 5 CM by TRIUMF-Canada
- CM cold tested at TRIUMF & CERN



20 RF Systems (Asia, CERN)

- 20 High power amplifiers (IOT) & RF chain lines CERN-KEKB
- LLRF (μ TCA platform) by CERN

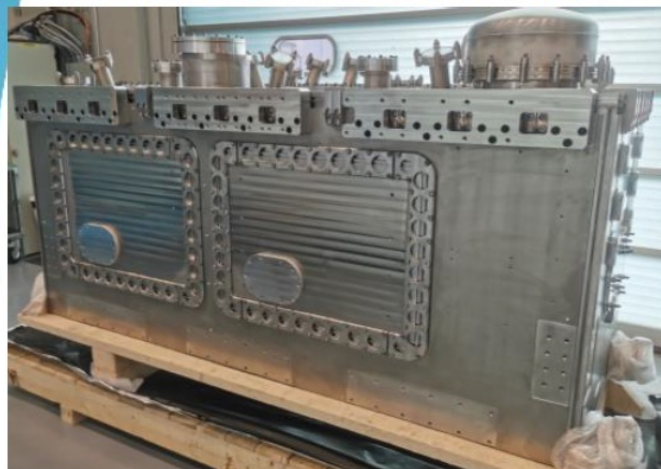


* Many critical components designed & manufactured at CERN (EN-MME, TE-CRG/VSC, BE-GM, SY-RF...) and provided to collaborations

Series Production, CM Components

Series procurement & manufacturing in full swing for CERN-CM and for collaborations

Outer Vacuum Vessel for CERN-DQW



FSI, Alignment

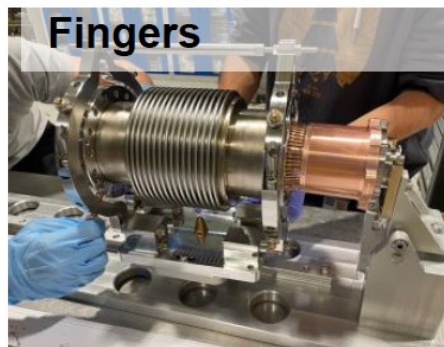


Cryolines for TRIUMF

Beam Screens crab series



PIMS & RF
Fingers

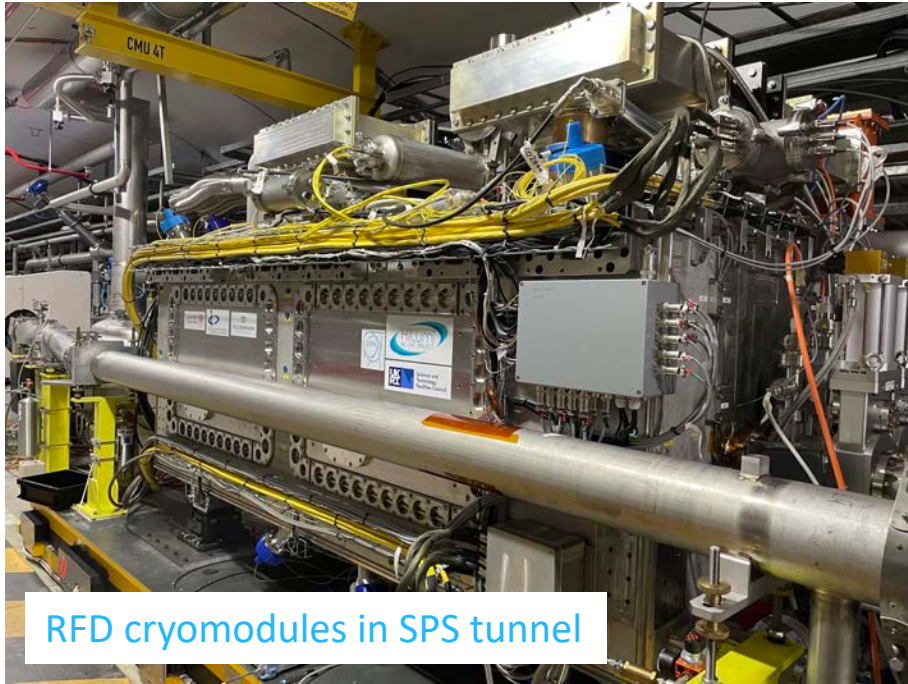


Pumping crosses



Excellent collaboration
with involved groups
BE-GM, EN-MME, SY-
RF, TE-CRG, TE-VSC,
& collaborations...

Crab cavities and international contributions



RFD cryomodule in SPS tunnel

- Prototype cryomodule (UK contribution) successfully installed in SPS for beam tests
- Canadian contribution kick-off at TRIUMF with delivery of first prototype RF dipole crab cavity from US collaboration



TRIUMF team with cavity prepared for cold tests

Sc links - series assembly progressing

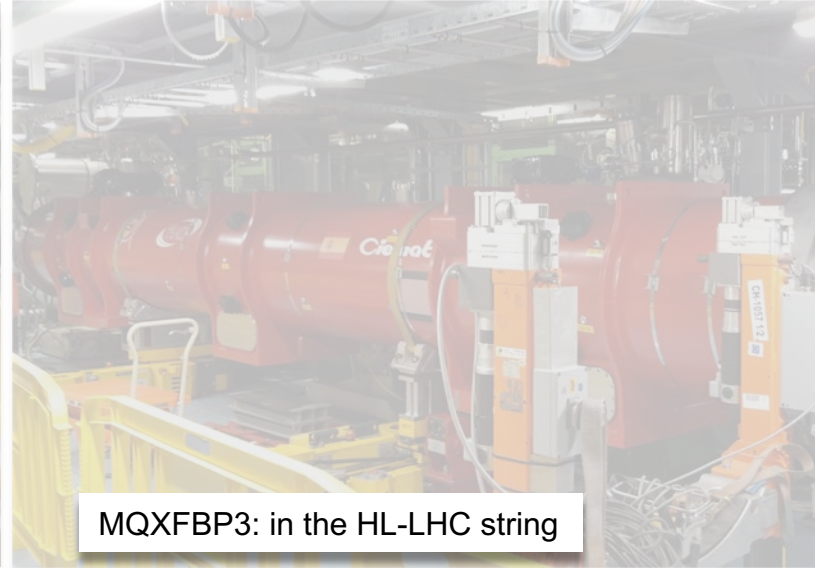


- Assembly of first series cold powering systems (inner triplet configuration) ongoing in SM18
- Cold tests planned in May/June
- 2nd series system being prepared in parallel on Prévessin site (b927)

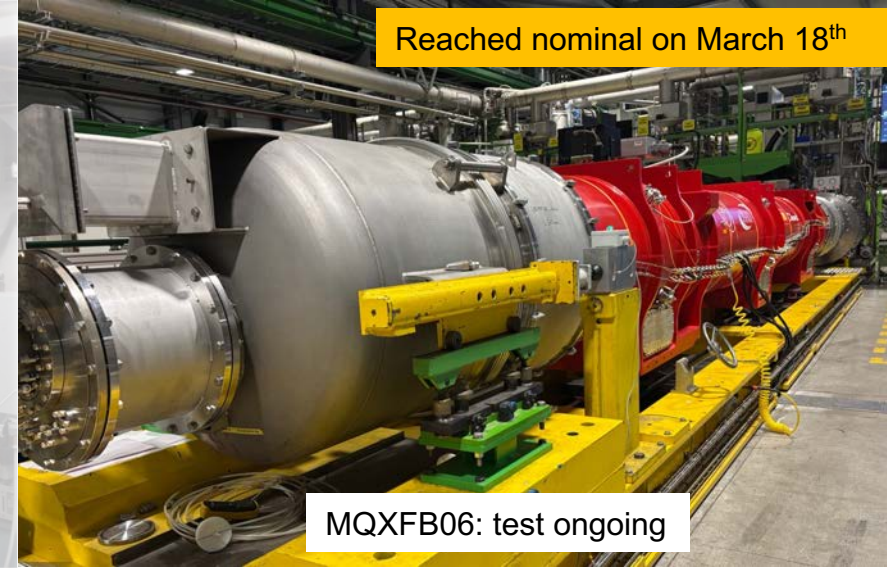
We are at full production speed! Achievements in last 3 months



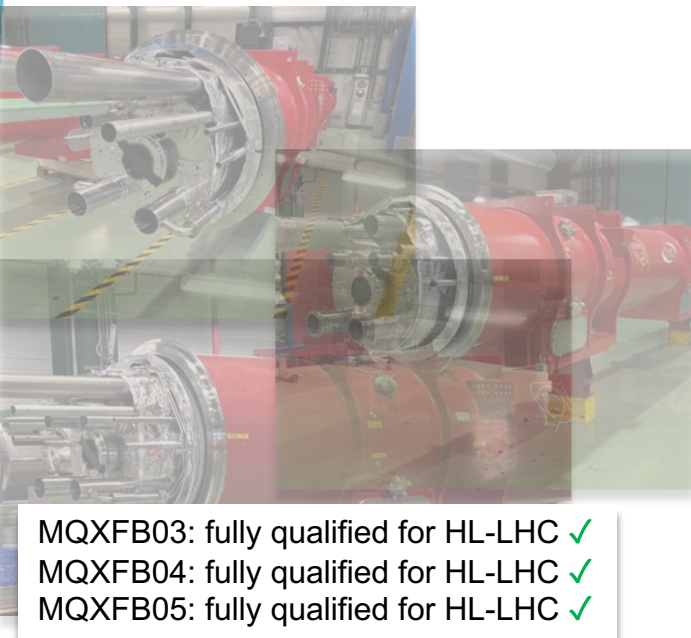
MQXFBP2: in the HL-LHC string



MQXFBP3: in the HL-LHC string



MQXFB06: test ongoing



MQXFB03: fully qualified for HL-LHC ✓
MQXFB04: fully qualified for HL-LHC ✓
MQXFB05: fully qualified for HL-LHC ✓



MQXFB07: cryostating ongoing



MQXFB08: welding ongoing



MQXFB09: assembly ongoing

Status and progress of US contribution

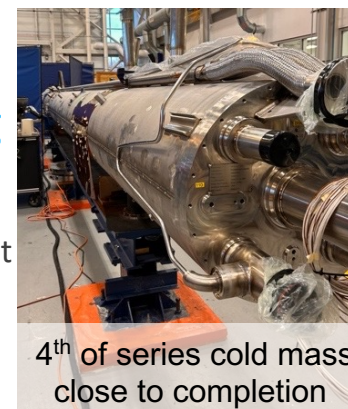
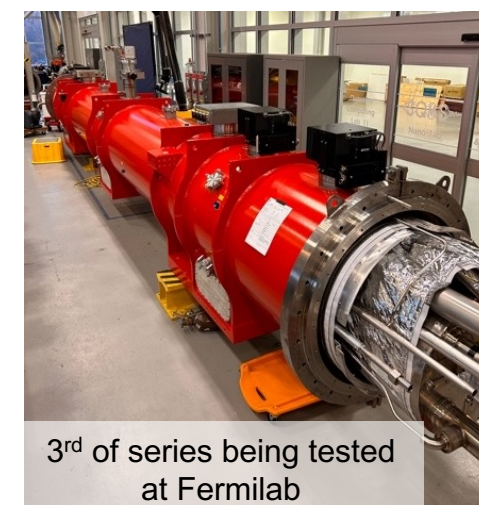


Achievements in the last 3 months:

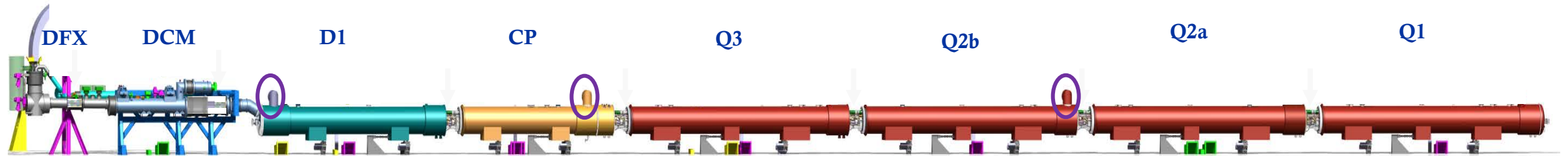
- The second cryo-assembly has been successfully tested at Fermilab and arrived at CERN in January '25.
- 3rd of series completed and undergoing cold tests at Fermilab
- 4th of series close to completion, planned to arrive at CERN in May '25 for cold tests

Issues and concerns:

- Virgin magnets have failed during vertical testing, requiring coil replacement
- Last magnet for installation (#10) arrives beginning of 2027
- Flattop quenches observed in one of magnets of 1st cryo-assembly tested at CERN.



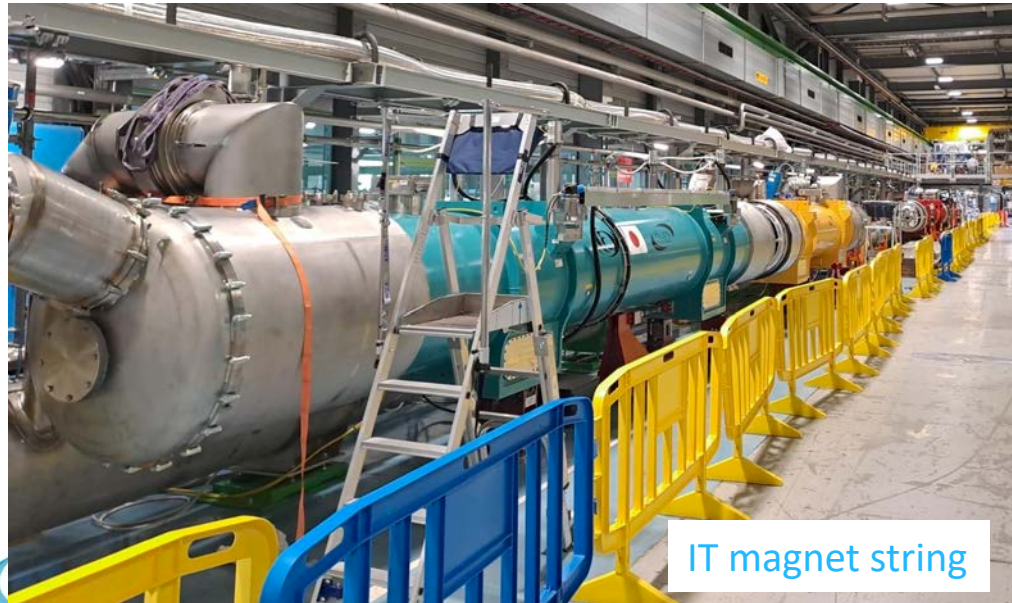
Inner Triplet String



Towards IT String operation in 2025



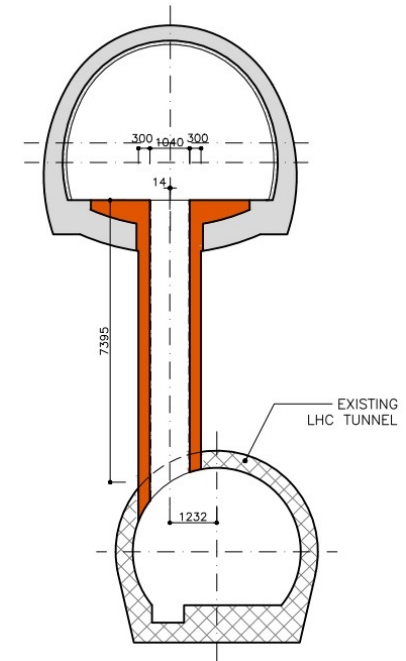
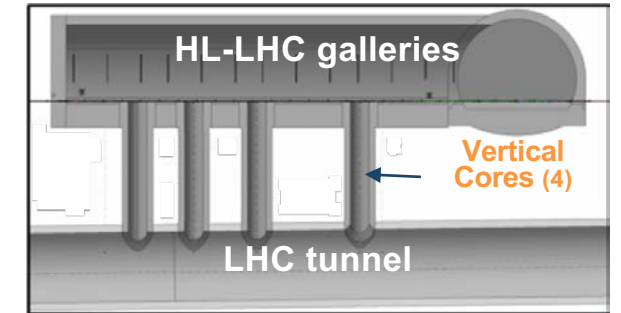
- Installation and validation of Mg_2B superconducting link completed, feedbox for magnet connection under final assembly
- Corrector Package and 2nd CERN quadrupole installed as planned in February
- Q3 (1st cryomagnet from US collaboration) to be installed by end of March, Q1 (2nd US cryomagnet) in May



- Interconnection work for magnets to start end March
- IT String could be ready for cool-down as soon as September'25, with powering tests as of November'25

28 vertical cores between HL galleries and LHC tunnel

- Site tests confirmed drilling tools and methodologies as input to 2nd invitation to tender, dispatched in January 2025
- Replies expected by March, evaluation starting in early April, feedback for LS3 schedule optimization in mid May
- Adjudication in FC of September 2025, with letter of intent in June 2025
- On-site demonstration by chosen contractor in YETS 25/26

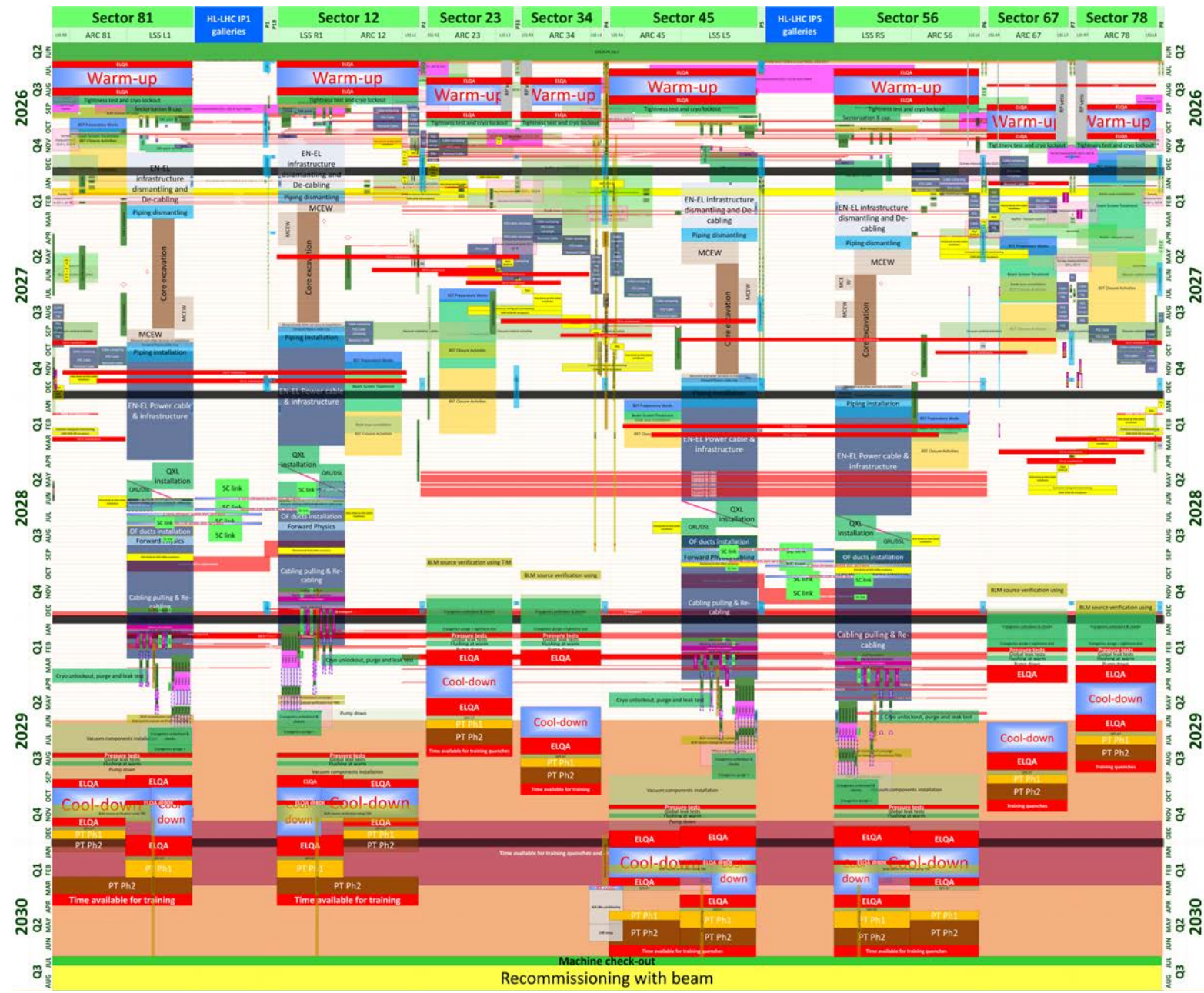


HL-LHC LS3 Schedule

The goal of fitting LHC LS3 into 47 months is within reach (currently at 48.5 months); further actions are being pursued:

- Reducing the duration of the **cores**
- Maximizing **co-activities** during cores drilling.
- Advancing **patch panel installation** in galleries during Run 3.
- Continuing **installation in HL surface buildings and galleries**.
- Ensuring **sufficient resources** for LHC and Injectors during LS3 (notably EL).

LHC LS3 schedule In Work (January 2025)



Safety during LS3 in the LHC Machine

3 Main risks

Electrical risk → **Electrical lockout** as first step

- Interleave **work permits** and **tests permits** (according to needs) all along the LS3
- Focal point (as during previous Long Shutdowns) to centralize the **electrical status** on continuous basis
- **Electrical Safety Project** & HSE would clarify roles and responsibilities by mid 2025 (work in progress)
- **Work and Services Supervisors** are in charge of the risk assessment

Cryogenics risk → **Cryogenics lockout** at the completion of tests at warm in the LHC Machine

- In the new HL galleries, at the completion of the commissioning (in 2026)
- **Co-activities** in proximity of cryo equipment, to be validated by the cryogenics safety officer if needed, after cool down

Radiological risk → See following slides

- **Cool down period** of **4 months** in LSS1 and LSS5
- Key to keep 4-5 weeks of radiological cool down at the end of Run 3: **ION run**, low intensity beams, MD...
- Remove asap the “hot spot” equipment as collimators, TAN, ...

Safety Dedicated LS3 Committee - Wednesday 14th May



Chamonix 25 - key areas

Run 3: Strong Performance, Preparing for the Future

- Goals, Perspectives, Performance, Availability, Issues
- Anticipate potential HL-LHC performance limitations and their mitigation
- Post LS4 operation – Complex and HL-LHC

LS3: A Major Transformation Across the Complex

- Construction and deployment of **HL-LHC**, Phase II upgrades, Hostlab
- **BST, NA-CONS, HI-ECN3, CNGS, AWAKE, ISOLDE, PSS-CONS, TG-CONS, EL-CONS, ACC-CONS, CEPS...**

Exploiting the Upgraded Complex: A Diverse Programme

- Physics, medical, test facilities...

Looking Ahead: Future Colliders and Accelerator R&D

- **FCC Feasibility Study, Other future collider options:** Muon collider, linear colliders, novel ideas
R&D focus: High-field magnets, SRF, plasma acceleration, sustainability.

Summary remarks

Successful Year End Technical Stop

The accelerator complex is restarting (more-or-less) on schedule

HL-LHC Upgrade

- Good progress across all key technologies of the HL upgrade
- LS3 installation schedule is being optimised – progress made, more in Q2 2025

Chamonix 2025 programme

- Covered the full arc from current Run 3 performance through to the challenges of LS3 and the HL-LHC upgrade, with a strong focus on planning, technical risks, and operational readiness.
- It also looked beyond LS3 to the diverse exploitation of the upgraded complex and the strategic outlook for future facilities and accelerator R&D.

“Impressed by the energy, spirit, and the new generation stepping up at CERN.” — Ralph Assmann