

Session 6: Operational Scenario 2018

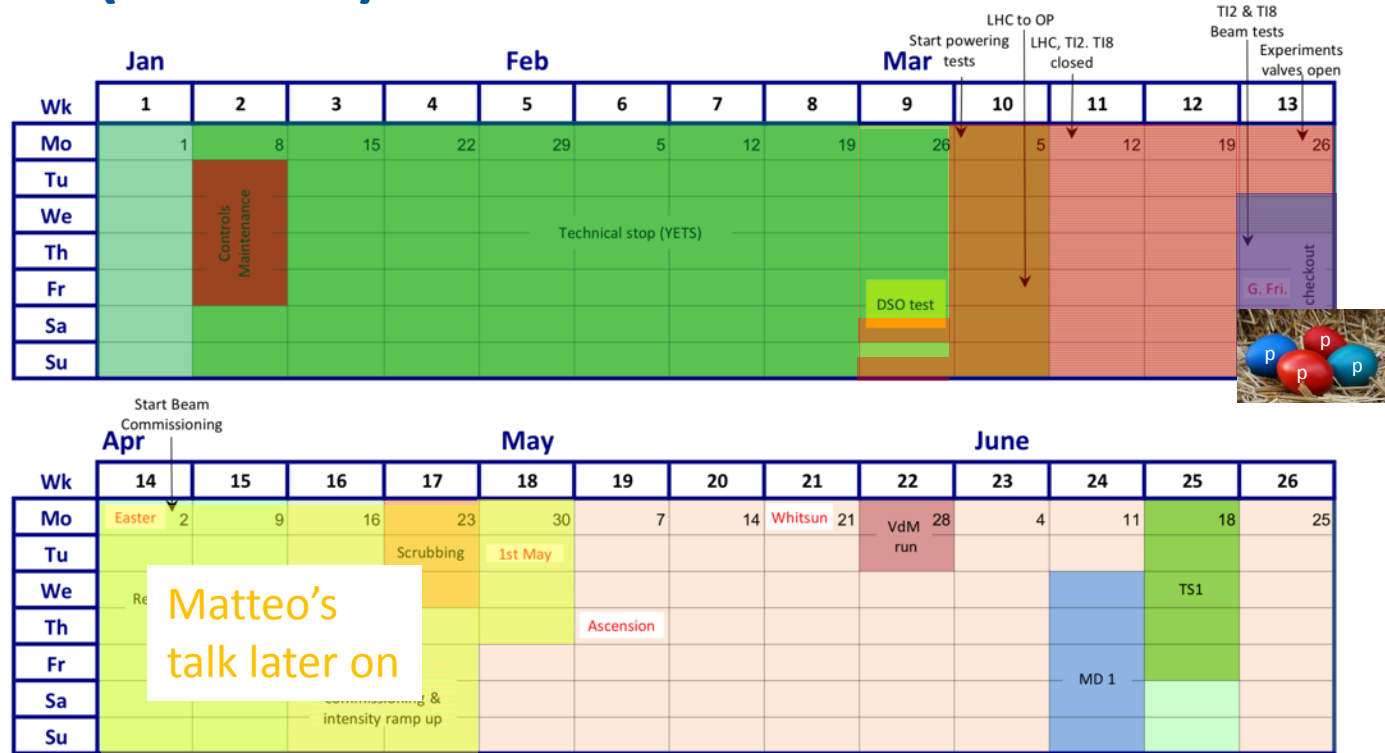
Recovery and re-qualification

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Outline

- Timeline and main activities during YETS
- Warming-up (or not?) sector 12 + risk of thermal cycle
 - Observations from warm-up and gas analysis in S12
- Hardware commissioning and special ELQA investigations and powering tests
- Machine check-out

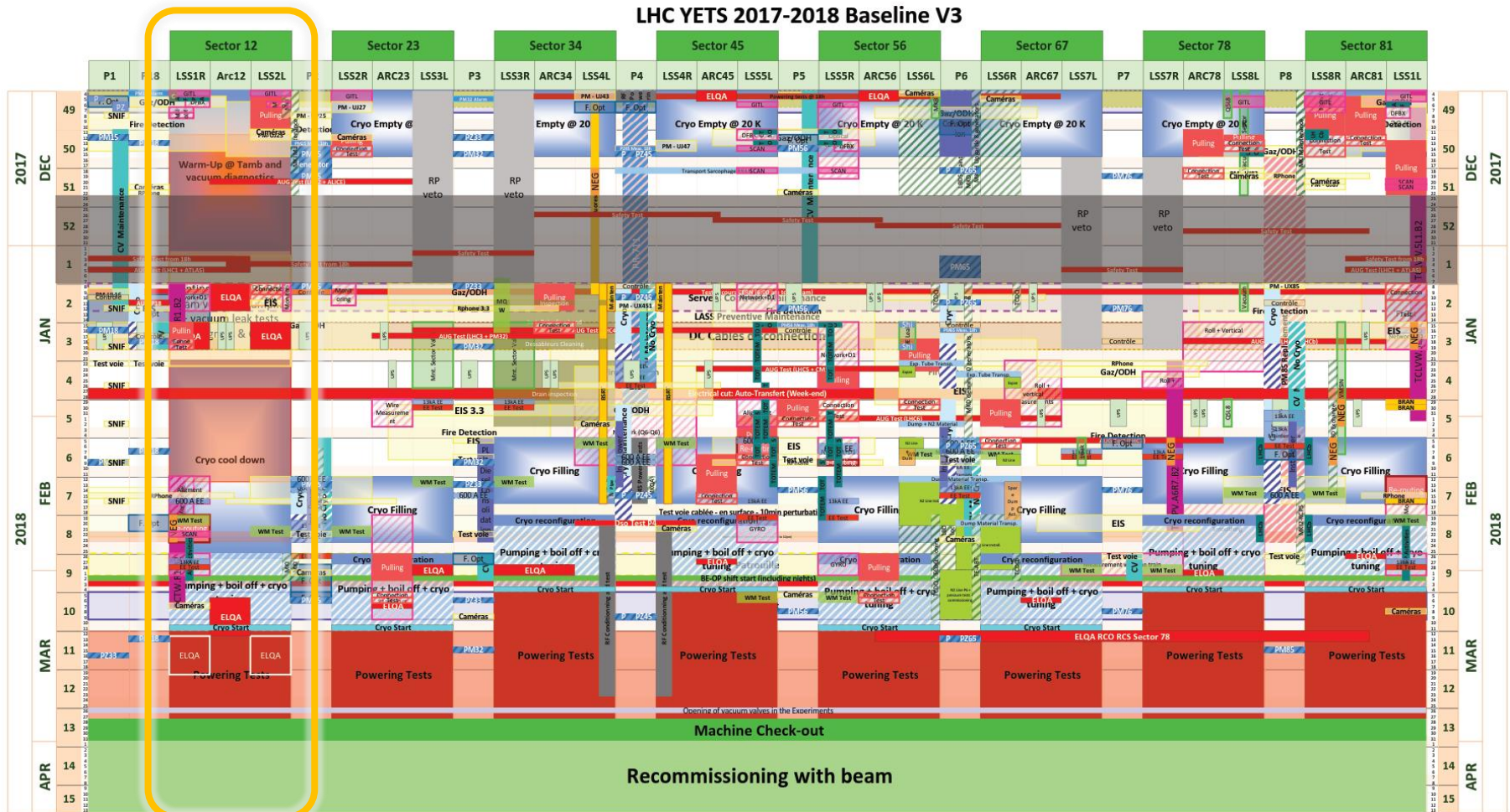
LHC (draft) schedule 2018



- 3 + 12 weeks until the start of beam-commissioning for YETS activities, powering tests and machine checkout
 - Powering tests start on Saturday 3rd March (outside normal working hours)
 - LHC back to BE-OP on Friday 9th March
 - Opening of EXP vacuum valves on 26th of March

LHC-YETS: linear schedule Baseline

([Link to plannings](#))



YETS 2017-2018: Sector 1-2 - Critical path

W49 - Access in the area

DONE

GILT survey measurement on ITs, temporary measurement system on Q1, Cables disconnection for ELQA @warm in S. 1-2, Chicane removal in LSS1, Extraction of the 2 AFP detector packages, Cable campaign on LSS2L

Monday 11th December (W50): 1st Insulation Vacuum degradation
Between Friday 8th and Tuesday 13th : vacuum gas analysis in cell 16L2 (between 60K-80K)

W50, 51, 52 and 1 → warm up @ T_{amb} 80-300K

Tuesday 19th or Thursday 21st: 2nd Vacuum degradation

Wednesday 20th December (W51): AUG tests in P2

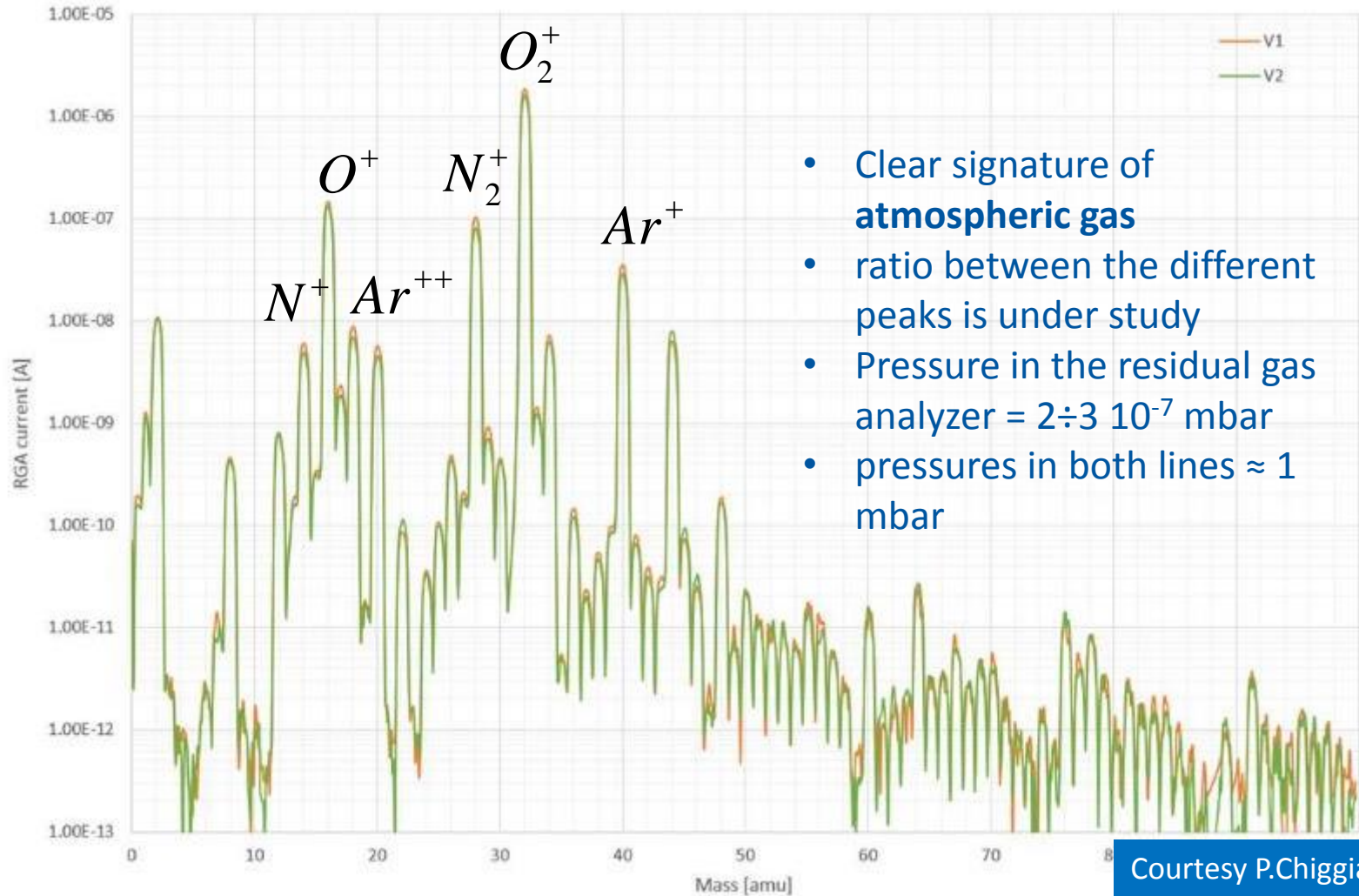
In case of access request → cryo reduces Helium flow to < 300 g/s (max 2 interruptions foreseen)

PM25 interruption from Wednesday 13th December to Monday 18th December (PX24 available)

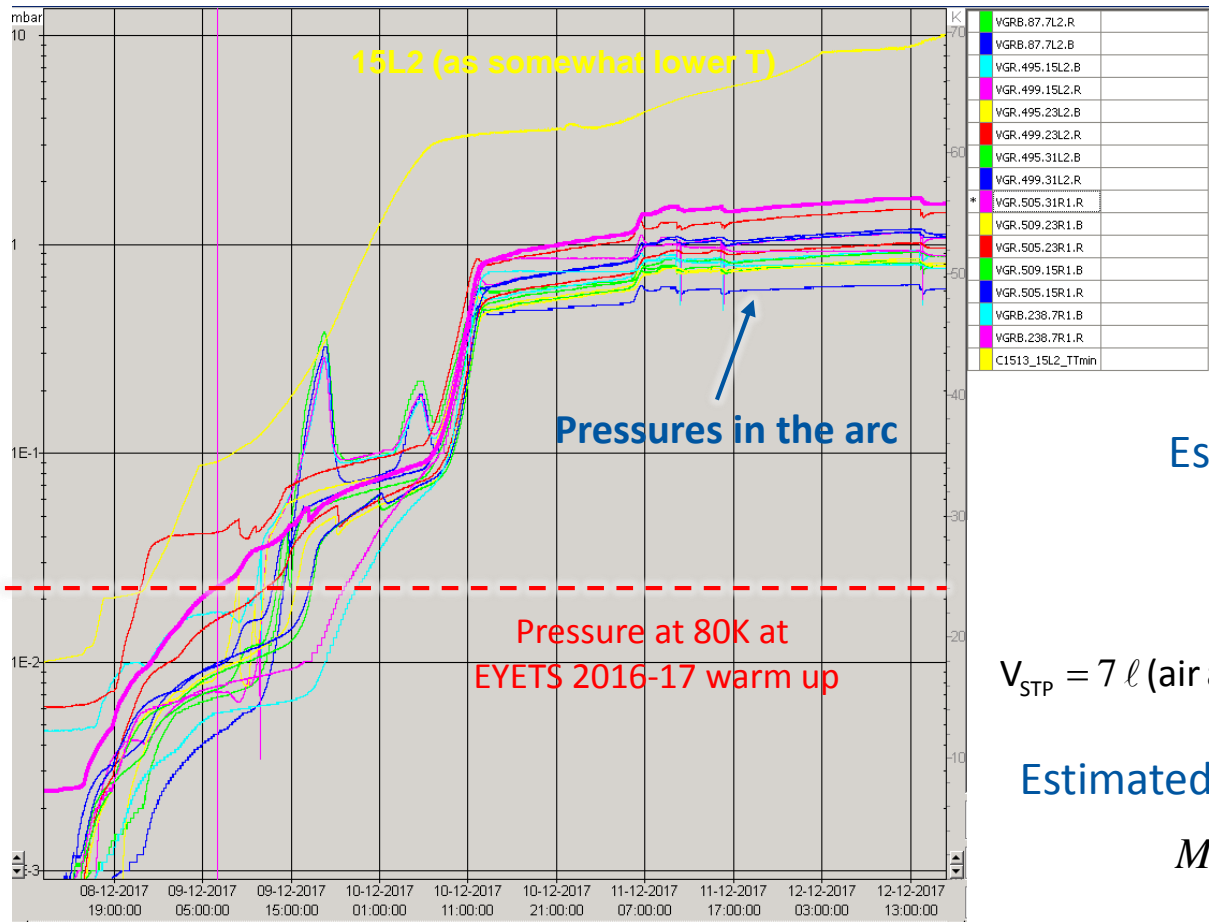
End of warm up at ambient temperature on Wednesday 3rd January



Results from gas analysis in 16L2



Results from pumping in 16L2



Estimated quantity of air

$$M_{N_2} = 8.4 \text{ g}$$

$$V_c = 10.5 \text{ cm}^3 \text{ per beamline}$$

$$V_{\text{STP}} = 7 \text{ l (air at 1 bar, room temperature, per beamline)}$$

Estimated quantity of water vapour

$$M_{H_2O} = 0.1 \text{ g (per beamline)}$$

Courtesy P.Chiggato

YETS 2017-2018: Sector 1-2 - Critical path

W49 - Access in the area

DONE

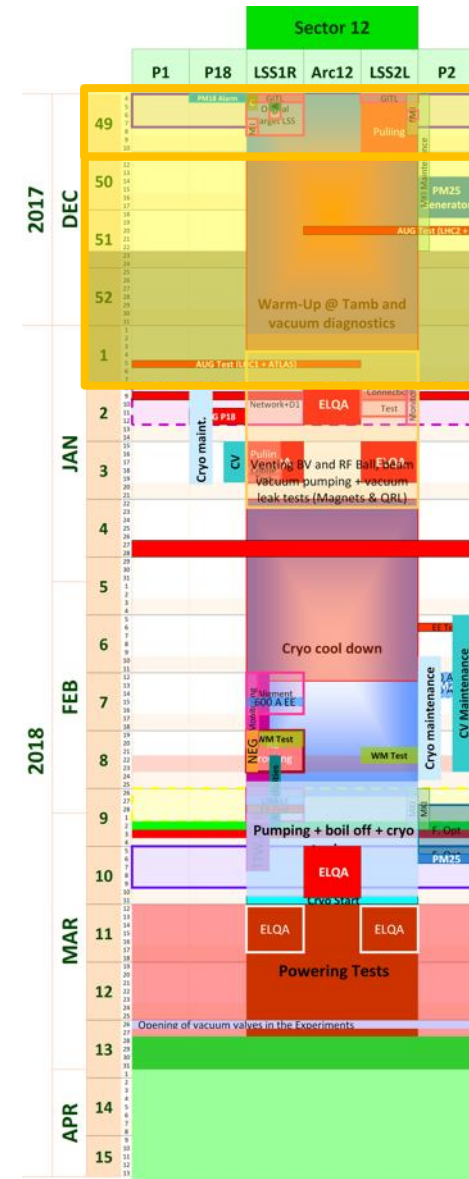
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- Monday 11th December (W50): 1st Insulation Vacuum degradation
- Between Friday 8th and Tuesday 13th : vacuum gas analysis in cell 16L2 (between 60K-80K)

WED 13/12- Decision by management to stop cool-down of S12

W50, 51 → T_{amb} 80-20K

- Stabilize and maintain the sector S12 at 80 K
- Continue pumping until early next week
- Cooldown starting on TUE 19/12 to reach 20-30K for Christmas closure



YETS 2017-2018: Sector 1-2 - Critical path

W1

Cryo Lock-out

Thursday 4th : RF ball B1 (N2)

Friday 5th : AUG test at P1 and start pumping BV for leak tests (late afternoon)

W2

Monday 8th : RF ball B2 (N2)+ installation new mechanical pumping groups

Tuesday 9th : safety tests 10 min + BV leak tests +

start pump down BV arc 1-2

From Tuesday 9th → beam vacuum pumping in arc 1-2

(completed on Monday 22nd Jan.)

ELQA @warm in the arc 1-2

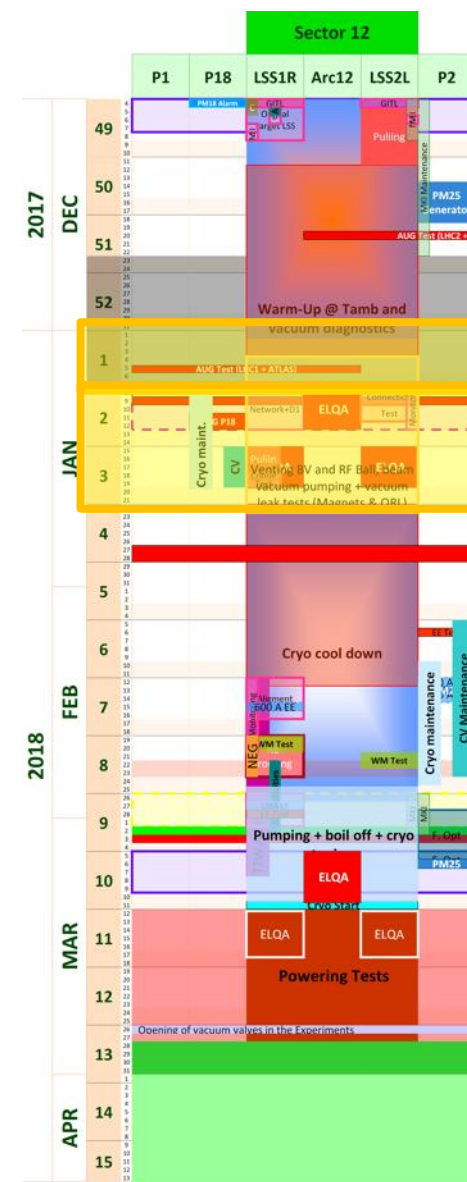
Survey measurement in LSS1R, tomography (during nights) and endoscopies in LSS1R and LSS2L, wire Collimator removal TCTPV.4R1.B2, MKI Maintenance

AUG tests in P18: Thursday 11th January

W2 and W3:

beam vacuum pumping → End of BV pumping 22nd January , stop the vacuum pumping groups and pinch off

ELQA @ warm in LSS1R and 2L, Installation and alignment of new collimator TCTW.4R1.B2



YETS 2017-2018: Sector 1-2 - Critical path

W4+5+6 → cool down @ 300K-80K

End of BV pumping Monday 22nd January ,
stop the vacuum pumping groups and pinch off

In case of access request → cryo reduces Helium flow to < 300 g/s
(no interruptions foreseen)

W7-8-9-10 → various activities

Survey alignment in LSS1R , Wire collimators bake out; AFP activities;
HL-LHC cable rerouting (access restriction from 4pm when needed)
Chicane reinstallation

W10 → ELQA @ cold in Arc 1-2

W11

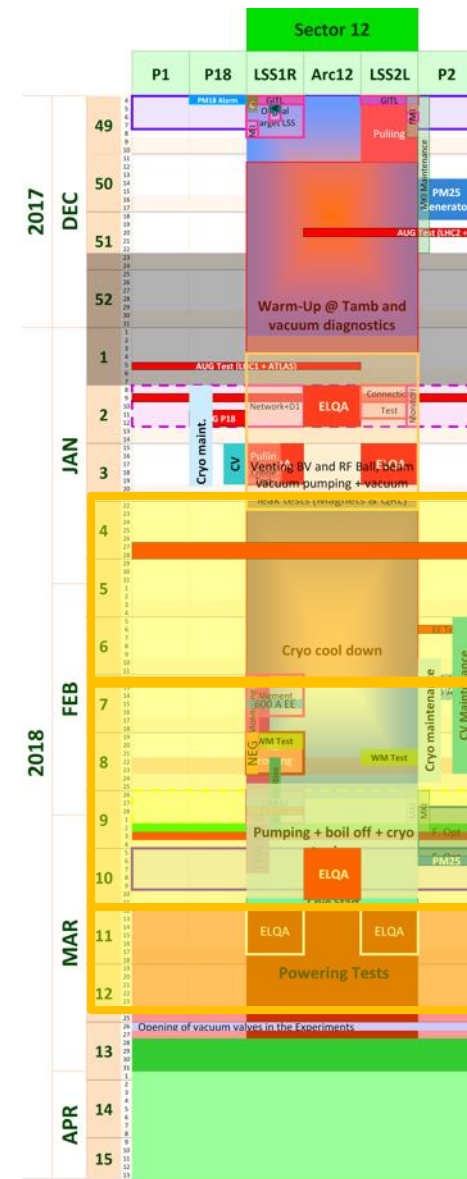
ELQA @cold in LSS1R and 2L -> Tbc as function of temperature
reached during warm-up

IST & powering tests in S.1-2 outside normal working hours

From W12

IST, powering tests & training quenches

26. March opening of vacuum valves in EXP



Magnet circuits – main activities

- QPS
 - Primarily preventive maintenance activities and few type tests during powering: PROJOINT, didt sensors
 - Interlock tests for all circuits with QDS (focus on main circuits); includes mapping of the QPS interlock loop cabling (LS2 preparation)
 - Verification of device parameters especially for IPQ and 600 A
 - Deployment of next generation remote reset units in a few places + additional spares
- EE
 - Preventive maintenance of 600A and 13kA EE systems
 - pin replacement campaign to mitigate events on BCM of RQD.A12
 - Inspection of 30 600A systems with increased number of closing failures
 - Installation of new measurement + FPA boards in all systems
 - Full functional validation at 0A, then cycles and EE to 760A, 6kA and nominal
- EPC - Link
 - Replacement of ½ thyristor bridge on RB.A12 (water leak in 2017)
 - Short circuit tests to be foreseen before HWC + PCC, PLI1.b2, heat run of several hours after completion of powering tests
 - Installation of two new 600A converters in point 1 for LRBB
 - New FIPMaster (addressing issue of GW disconnections)
 - Removal of 16L2 solenoid -> To be re-considered in light of S12?

Powering Tests

- No thermal cycle in S12 (always bearing risk of additional non-conformities during ELQA @ cold!) and no major changes in sc magnet circuits
- Test program (apart few singularities) comparable to YETS 2016/17

- 60A
 - All tests 2200
- 80-120A
 - PIC2 600
 - PNO.d1 300
- 600A
 - PIC2 2000
 - PLI3.b1-SOF 200
 - PNO.d3 400
 - PNO.a3 400
- IPQs
 - PIC2 400
 - PNO.a7 80
 - All tests (excluding PNO.f4) for RQ4.L/R1
- IPDs
 - PIC2 80
 - PNO.a8 16
- ITs
 - PIC2 40
 - PNO.a9 8
- RQs
 - PIC2 100
 - PNO.b3 (4h) 16
- RBs
 - PIC2 48
 - PNO.b2 (4h) 8

Courtesy M.Pojer/M.Solfaroli/MP3

Almost 7000 tests!!!

Specific Powering Tests / ELQA Investigations

- Recent HW campaigns and operational years indicate the possibility of performance degradation due to radiation, thermal cycles and electromagnetic coupling
- MP3 proposed a series of special powering tests to be done during the YETS 2017-18 to
 - Understand / localise **shorts and/or performance degradation** in the corrector circuits (primarily spool-piece correctors)
 - Reduce the probability of **fast secondary quenches** in the main dipoles (in anticipation of future training campaigns)
 - Understand / localise circuit parts with **high resistances** (as input for LS2 consolidation)

Specific Powering Tests – High Priority

#	Description	Test duration *	Period	Cryo
1	Local (30 m) localisation of shorts in RCS.A78B2, RCO.A78B1, RCO.A78B2	2 days	End of the powering tests.	1.9 K
2	Global (400 m) localisation of short in RCO.A45B1	1 day	Start YETS (DONE)	1.9 K
3	Change in EE delay of RB circuits	0.5 day	During powering tests	1.9 K
4a	Voltage pick-up of the QPS due to current in the bypass diode	2 days	Anytime during YETS	<20 K
4b	Heater-induced quench on 2 MB's	0.5 day	Start YETS (DONE)	1.9 K
5	Quench heaters test in S12	0.5 day	End of YETS, during the QPS IST	1.9 K
6	Resistance in RQF.A23 and RQD.A78	1 day	End of powering tests	1.9 K

*: not including the time for installation & removal of equipment

Specific Powering Tests – Medium Priority

#	Description	Test duration *	Period	Cryo
7	Change in EE delay of RQD/F circuits	0.5 day	During powering tests	1.9 K
8	Resistance in ROD.A56B1	1 day	Start of YETS (DONE)	1.9 K
9	Internal resistance of 3-6 MB's	1 day	Start of YETS or during powering tests	1.9 K
10	Investigate degradation of RCBXH/V in IR1/5	0.5 day	Start of YETS (DONE)	1.9 K

Results of investigations priori to YETS:

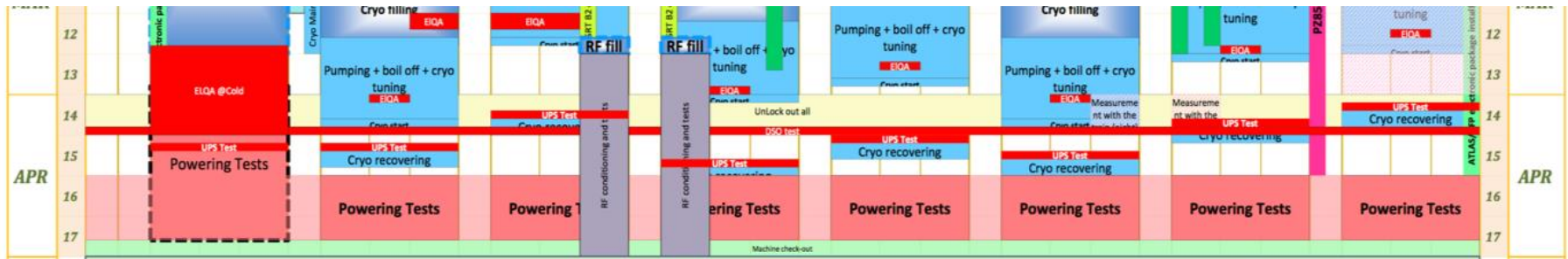
- Short could not be reproduced in RCO.A45B1 (only few 100kOhms occasionally visible)
- 2 heater induced quenches performed in S45
- Location of increased resistance in ROD identified, segment in question to be bypassed in LS2
- None of the 12 RCBXH/V circuits showed any visible degradation after having been cycled many times and after having seen quite a bit of radiation. Final conclusions will be made after the powering test in March 2018.

*: not including the time for installation & removal of equipment

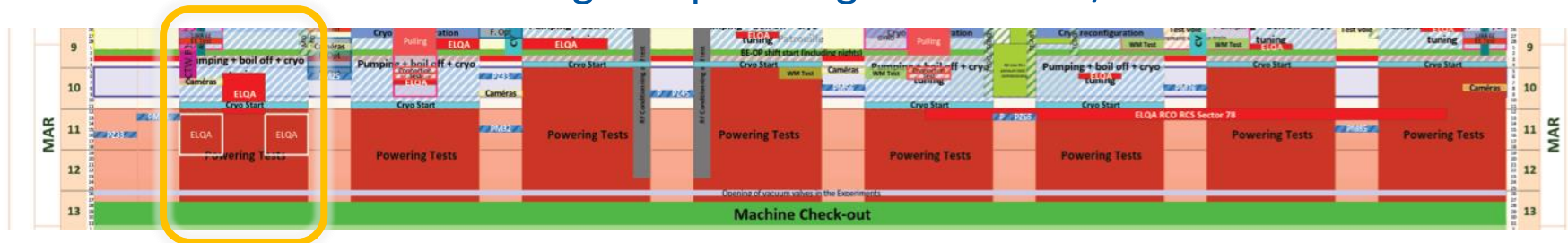
Powering tests 2016 vs 2017



- (As usual) very limited time for powering tests (but comparable to 2016/17)
- Beware of overlap with other activities (machine checkout, ELQA,...) as this will further eat into an already very tight schedule (in particular for S12)
- Early start of powering tests has proven vital for efficient campaign



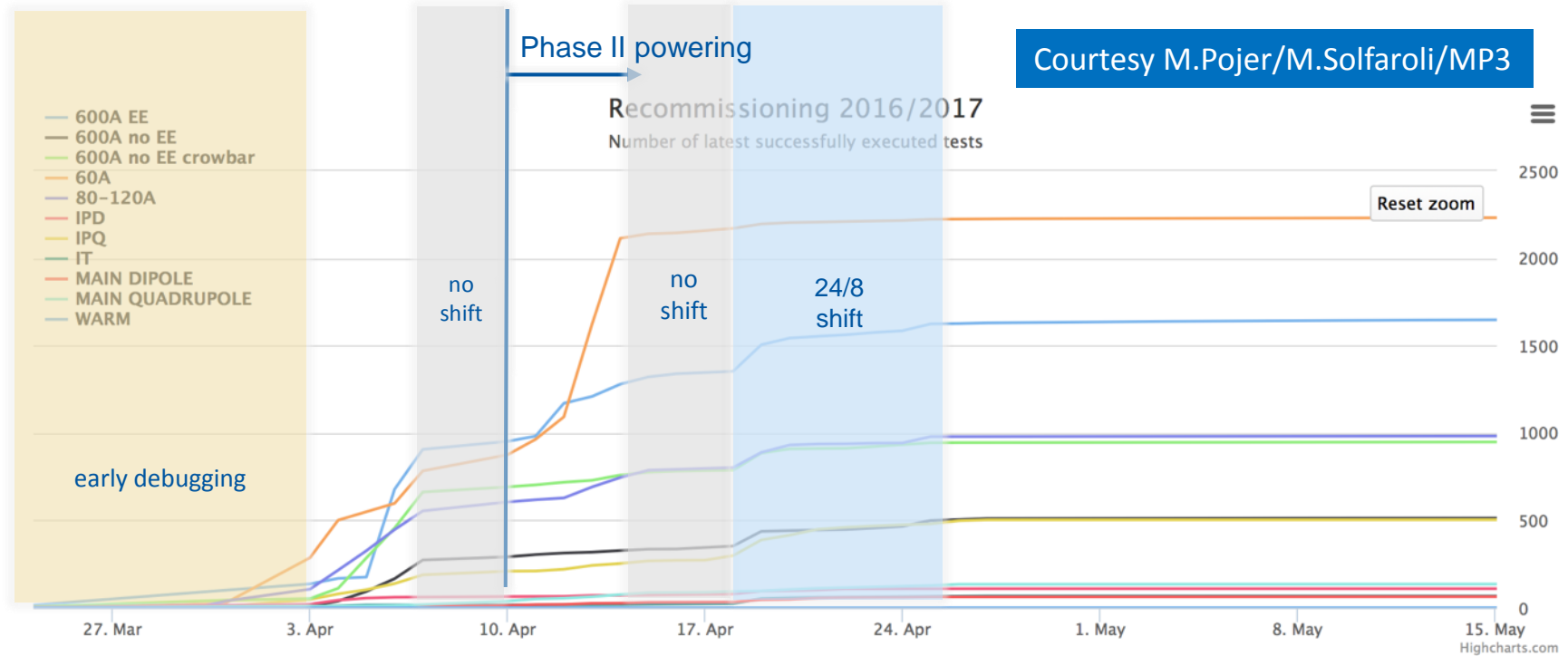
Powering test planning EYETS 2016/2017



Powering test planning YETS 2017/2018

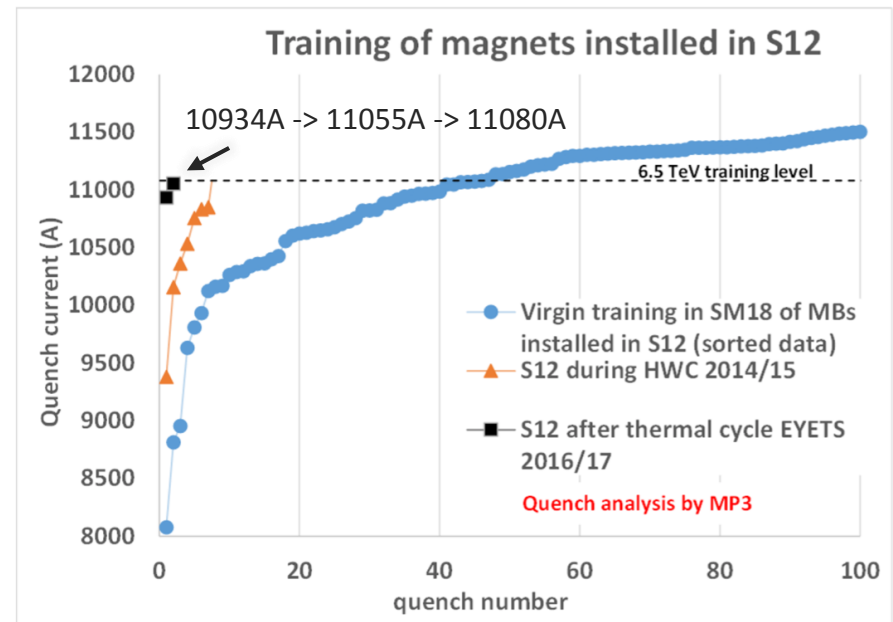
Powering Tests performed in 2017

- 10 days of early powering proved to be extremely important
- Phase II powering started after DSO tests (7th April) and completion of UPS tests
- Late preparation of S12, due to short to ground during EIQA tests on RB circuit (edms.1775466v.1) --> one week delay in start of powering tests in that sector



Main magnet training S12

- Main dipole and quadrupole circuits of S12 were commissioned in 12, respectively 13 days following the unlocking of the power converter (compared to an average of 15 working days)
- 2 quenches observed in S12 to reach again 6.5 TeV training value of 11080A
- Planning is extremely tight but should be feasible in absence of major non-conformities
- Timely completion of QPS IST is a priority!



Machine checkout

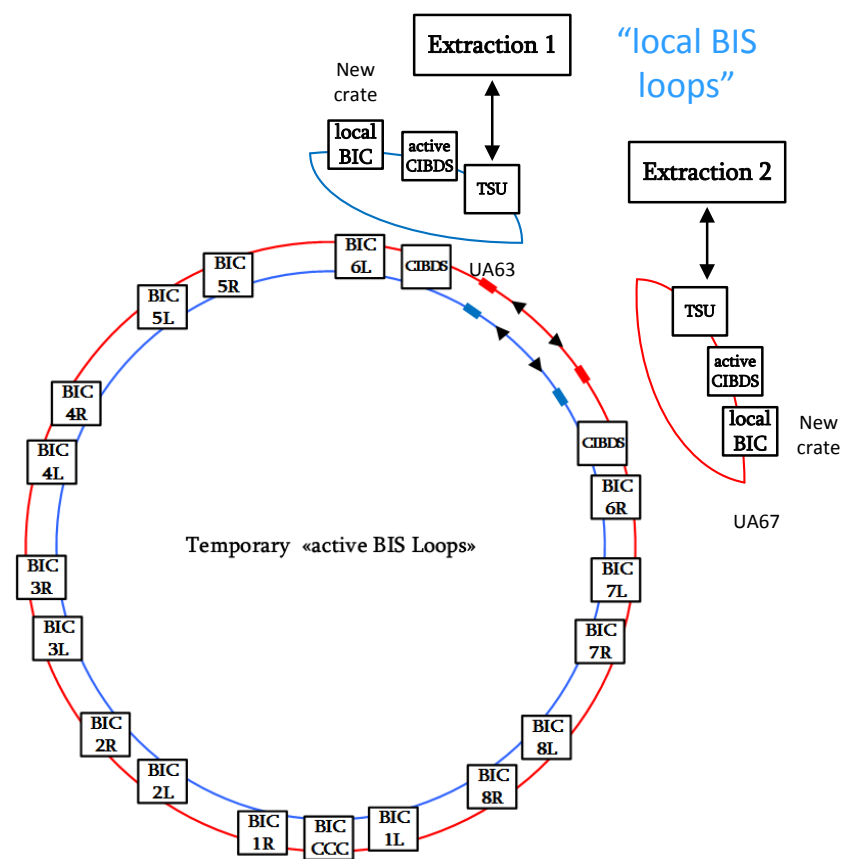
- **Affirm the readiness of the LHC to inject and accelerate a low intensity beam**
 - Machine protection and interlock systems (without beam)
 - Check functionality of the control system
 - Validate beam instrumentation
 - Drive all systems in synchronized way through the standard operational sequence
 - All system have to be declared operational
- **Main constraint: beam can only be injected and circulated with closed Beam Permit Loops of the BIS -> Same constraint applies to many validations during YETS/checkout!**
 - In nominal conditions:
 - LHC access Key on Beam mode
 - LHC Vacuum valves open
 - Hardware commissioning finished; all circuits ON and no faults
 - No interlock from non-maskable BIS clients
- Mitigation deployed since last EYETS to increase flexibility of testing during YETS and checkout phases -> Local Beam Permit Loop in IR6

A lot of work still
during/after HWC!

See as well M.Albert/M.Pojer (Evian 2014/15)

Local BIS Loops

- Major ‘clients’ are LBDS, BIS and LHC sequencer
- No major changes foreseen on the LBDS nor BIS during the YETS, nevertheless a lot of preventive and curative maintenance activities will take place.
- LOCAL reliability run at 7 TeV foreseen over the Christmas period
- LOCAL BIS loop will be re-established towards end of the YETS to perform a REMOTE reliability run of ≥ 3 weeks (as in 2017).
- Local UPS tests to be scheduled when LBDS is in REMOTE reliability run at the end of the YETS
 - See recommendation from LMC # 305
- Also for other systems (BLMs, BI..) no major changes reported, hence standard commissioning program to be repeated



Courtesy E.Carlier, C.Martin et al

Each ‘Local BIC’ includes one CIBG and one CIBM, and each ‘Local BIC’ hosts one CIBDS

Conclusions

Despite a 'short' YETS, numerous smaller modifications and consolidation that require similar (re-)commissioning and validation efforts as after EYETS

- Timely completion of QPS ITS tests and early powering tests key in maintaining tight planning
- Shall we decide to switch off MCO's for 2018?
- Shall we leave the solenoid in place?

Cancelled warm-up of S12 will

- not change start date of beam commissioning (defined by opening of CMS vacuum valves)
- Allow additional flexibility from some of the remaining activities
- but allow to complete necessary validations with reasonable planning
- Limit the risk of additional non-conformities while on critical path
- Updated schedule to arrive soon...

Many thanks for your attention!

Questions?



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