Session 6: Operational Scenario 2018

Recovery and re-qualification

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

**Note:**
Matteo’s talk later on
LHC-YETS: linear schedule Baseline
YETS 2017-2018: **Sector 1-2** - Critical path

**W49 - Access in the area**

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

Monday 11\(^{th}\) December (W50): 1\(^{st}\) Insulation Vacuum degradation

**Between Friday 8\(^{th}\) and Tuesday 13\(^{th}\): vacuum gas analysis in cell 16L2** (between 60K-80K)

**W50, 51, 52 and 1 \(\rightarrow\) warm up @ \(T_{amb}\) 80-300K**

- Tuesday 19\(^{th}\) or Thursday 21\(^{st}\): 2\(^{nd}\) Vacuum degradation
- Wednesday 20\(^{th}\) December (W51): AUG tests in P2
- In case of access request \(\rightarrow\) cryo reduces Helium flow to < 300 g/s (max 2 interruptions foreseen)
- PM25 interruption from Wednesday 13\(^{th}\) December to Monday 18\(^{th}\) December (PX24 available)

**End of warm up at ambient temperature on Wednesday 3\(^{rd}\) January**
Results from gas analysis in 16L2

- Clear signature of atmospheric gas
- Ratio between the different peaks is under study
- Pressure in the residual gas analyzer = $2 \div 3 \times 10^{-7}$ mbar
- Pressures in both lines $\approx 1$ mbar

Courtesy P. Chiggiato
Results from pumping in 16L2

Estimated quantity of air

\[ M_{N_2} = 8.4 \text{ g} \]

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

\[ V_{\text{STP}} = 7 \ell \text{ (air at 1 bar, room temperature, per beamline)} \]

Estimated quantity of water vapour

\[ M_{H_2O} = 0.1 \text{ g (per beamline)} \]
W49 - Access in the area

- GILT survey measurement on ITs, temporary measurement system on Q1, Cables disconnexion 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)

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 4\(^{th}\): RF ball B1 (N2)**

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

**W2**

**Monday 8\(^{th}\): RF ball B2 (N2)** + installation new mechanical pumping groups

Tuesday 9\(^{th}\): safety tests 10 min + BV leak tests + start pump down BV arc 1-2

From Tuesday 9\(^{th}\) → beam vacuum pumping in arc 1-2 (completed on Monday 22\(^{nd}\) 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 11\(^{th}\) January

**W2 and W3:**

beam vacuum pumping → End of BV pumping 22\(^{nd}\) 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

- **80-120A**
  - PIC2
  - PNO.d1

- **600A**
  - PIC2
  - PLI3.b1-SOF
  - PNO.d3
  - PNO.a3

- **IPQs**
  - PIC2
  - PNO.a7
  - All tests (excluding PNO.f4) for RQ4.L/R1

- **IPDs**
  - PIC2
  - PNO.a8

- **ITs**
  - PIC2
  - PNO.a9

- **RQs**
  - PIC2
  - PNO.b3 (4h)

- **RBs**
  - PIC2
  - PNO.b2 (4h)

*Almost 7000 tests!!!*

Courtesy M.Pojer/M.Solfaroli/MP3
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

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

*: not including the time for installation & removal of equipment
## Specific Powering Tests – Medium Priority

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

Results of investigations prior 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 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 ElQA 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

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, B1..) no major changes reported, hence standard commissioning program to be repeated

Catalogue of Number CIBG and CIBM for Local BIC

Extraction 1

Extraction 2

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

Courtesy E.Carlier, C.Martin et al
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 form 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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