





Chamonix Workshop
25-28 January 2016

LHC YETS recovery

- A glance at the planning
- Powering tests and the critical activities
- Machine check-out objectives

Mirko Pojer

on behalf of the Powering Test and Machine Check-out teams

With many kind inputs by a several people, in particular M. Bernardini, V. Montabonnet, H. Thiesen, R. Denz, B. Salvachua, G. Valentino, E. Carlier, E. Bravin, T. Lefevre, E. Piselli, C. Zamantzas, B. Puccio, J-C. Garnier



The schedule drivers: key dates

See Session 3: G. Ferlin, "Cryogenics"

See LMC on 11/11/15: V. Chareyre, "Re-validation of redundant UPS power distribution"

Cooling&ventilation
Cooling towers maintenance

Cryogenics
Heavy maintenance on cold boxes
All magnets and DFBs " $\ll 80K$ "

UPS tests
Powering redundancy check

See LMC on 20/01/16: M. Bernardini, YETS status and update
"The regular maintenance and test activities are proceeding well and without delay"

-
- DSO tests (machine in general mode before)
 - DSO tests on February 26 (and 27)
 - **Both machine and experiments will be closed!**
 - **No activity can be planned on these dates!**
 - March, 1 – start of UPS tests
 - March, 4 – LHC **tunnel closed** and **start of powering tests**
 - March, 16 – end of powering tests, **experiments closed** and (official) **start of machine check-out**
 - March, 21 – start of beam commissioning

It would be important to close the experiments already from Mon.14 during night time

EPC: impact on PT

See Session 3: V. Montabonnet, "Power converters"

- FGC CPLD & Software upgrade
- Current Calibration of
 - 13 kA circuits (main dipoles and quadrupoles, ITs)
 - RMSIs
- Additional intervention of maintenance / power module replacement
 - RB.A56, RQD-RQF.A56
 - **Earth Fuse - Change from 1A to 200mA as discussed with TE-MPE for better localisation of an earth fault on the cold part**
 - LHC4-6-8kA
 - Change of FWD fault (too sensitive) into warning
 - LHC120A-10V
 - Change of WATCHDOG fault (SEE sensitive) into warning
 - LHC600A
 - Over I – Current switch selector to be replaced by a PCB
 - Check the fans for RPHx, RPHGx 1Q converters

**No major impact on re-commissioning (precise procedures and follow-up)
Required validation tests already in the baseline**

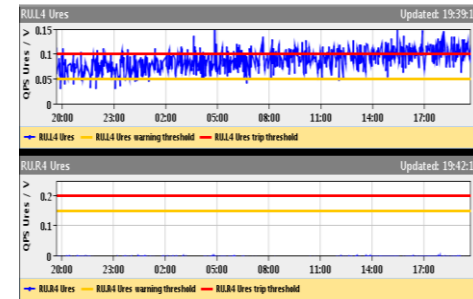
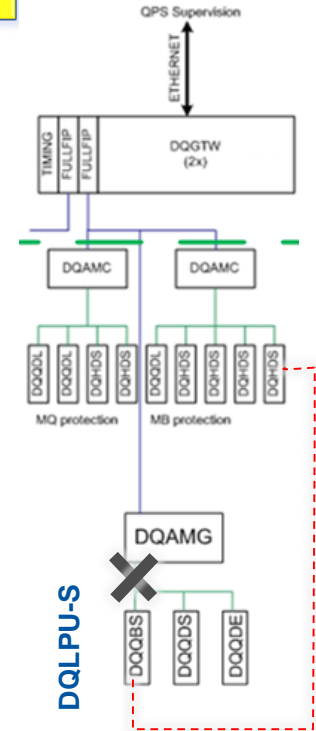
MPE – QPS:

Important to get a sector to test ASAP!
Test bench for HW and SW is needed!

See Session 9: R. Deniz, Quench Detection System

Could strongly impact the commissioning time!!

- Installation (this week?) & commissioning (QPS-IST, interlock tests and powering tests) of **radiation tolerant detection systems for 600 A circuits**
 - Two 2 cases (causing beam dumps) were observed in 2015 (RR13 17/10/2015, RR57 31/10/2015)
 - Installation foreseen in RR13, 17, 53, 57, 73 and 77
- Upgrade of the firmware for the nQPS DAQ systems allowing easier recovery from local bus errors (436 units concerned) --> no more QH firing
 - Locations: 8 sectors (**COMPLETED**) **Impact to be assessed**
- Installation & commissioning of new detection systems for circuits RU.L4 and RU.R4 ('undulator').
 - New detection boards developed
 - Upgrade of the corresponding current sensors performed by EE team (replacement of LEMs by DCCTs)



Detection boards suffer from meas. drift and very noisy signal due to high inductance and LEM hall probe sensor

-> Might be able to ramp faster (ACCESS!), no more drift/dumps

All must be up and running for the UPS tests!

MPE - EE+EIQA: impact on PT

See Session 3: F. Rodriguez, "Electrical Performance of Magnet Circuits"

- A general and specific overhaul of the 32 installations of energy extraction in the LHC main dipole and quadrupole circuits is **in progress**
 - A 500 VDC voltage withstand test has been requested, involving the warm and cold part of the circuits; plus extraction at different current level
- All quench heater PS are switched off during the YETS; those with anomalies discovered in 2015 have been repaired or replaced
 - No global QH firing; only test of those affected by intervention
 - The QPS team foresees as well a test of the QPS interlocks

Additional verification to be done

- ELQA investigations of the earth fault on the circuit RCS.A78B2 (near DFB)
 - Decision taken by LMC to do the type test
 - Final test to be discussed later

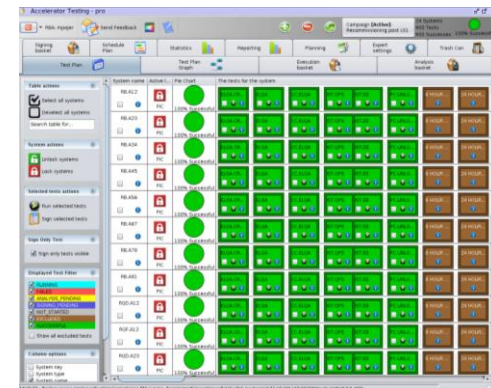
Would require more extensive test!

- ELQA integrity verifications at the end of YETS
 - Depending on the temperature variations and the interventions on the circuits
 - Discussions have been started to assess the need for circuits hi-potting

The necessary validation tests have been included in the baseline
Impact on re-commissioning depends on the list of EIQA tests

Organization

- We could test some circuits just before the UPS tests (**February, 28-29**) for **debugging purpose** (1 week to roll-back in case of issues...)
 - A 120 A test bench is being made available by EPC, but it would be important to test SW and HW modifications on all circuit types!
- **From March 4, the machine will be closed (excluding urgent, spot interventions)**
- Powering tests will be executed all around the clock
 - **More than 7000 tests in 12 days** (typically, interlock tests+ramp to training current)
- Tunnel accesses (exclusively related to powering) will be during the normal working hours
- Sequences and SW
 - Powering procedures have been updated by MP3 colleagues
 - Test sequences will be modified according to the latest needs
 - MTF campaign is being created
 - Acc_Testing campaign is being edited



Warm magnets

EIS circuits

No intervention on power part; powering (**1 day per converter hors-chaine**) and EIS interface

- **RMSI Point 2 and 8**
 - Installation of a new Control Crate for a better reliability and an optimisation of the spare card management
 - Rework at the level of the EIS for a better diagnostics
- **RD34.LR7**
 - Change of a DIVISOR MODULE card to solve a voltage measurement issue
- **RD34.LR3**
 - Change of the ACTUATOR board; MCB Fault to be investigated

Experiments

- **LHCB Dipole: 1 day for test**
 - RPTI.SR8.RBLWH.R8
 - Installation of a new Control Crate to solve the issue of PC PERMIT bad contacts
 - RBXWSH.R8
 - Partial DC cable replacement (EN/EL)
- **Alice Solenoid**
 - PC flow-meter to replace the internal flowmeter which failed in Run2
 - Replacement of all water hoses of the thyristor cooling circuits
 - SX2 FGC Spare to put on WorldFip network

Exchange of some coil retainers in point 3 and possibly point 7 on all MQW magnets

- Foreseen from mid-February
- Verification by **powering the circuits (ramp up and down)**
- No cable disconnection → **no polarity check needed**

EPC

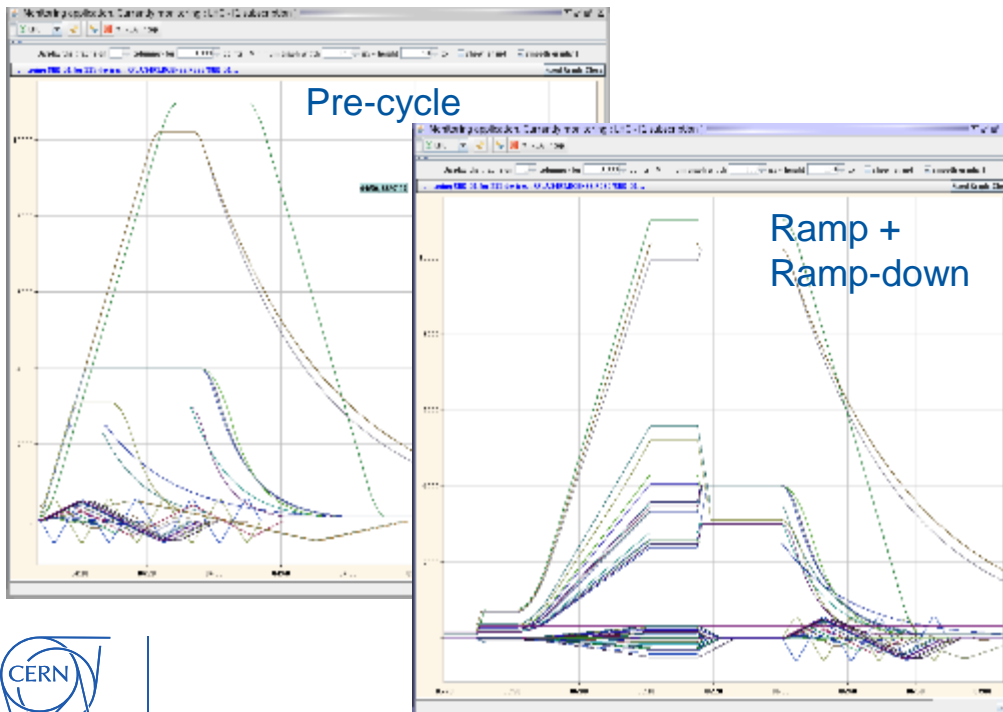
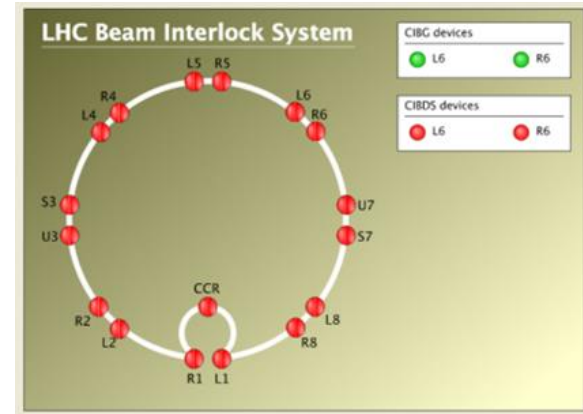
MSC

Machine check-out in a nutshell I

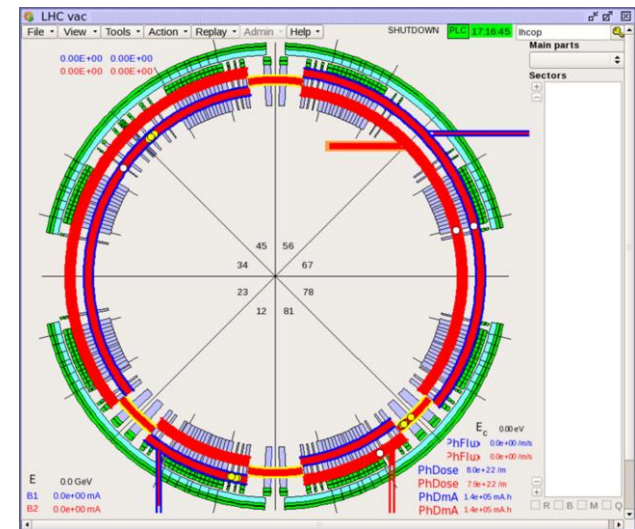
- Check all equipment control functionality
 - Check the synchronization
 - Check the beam instrumentation acquisition chain
 - Drive all relevant systems, in a synchronized way, through the standard operational sequence
 - Check the functionality of the control system from the control room high level applications
 - Check machine protection and interlock systems
 - During this phase many machine protection test without beam are accomplished
 - **All system have to be declared operational**
- **Test the readiness of the LHC to inject and accelerate a low intensity beam**

Machine check-out in a nutshell II

- **The beam can not be injected and circulate without closing the BIS loop**
 - LBDS connected
 - All clients connected to the loop
 - LHC access key on beam mode
 - LHC vacuum valves open
 - Hardware commissioning finished; all circuits ON and no faults
 - No interlock from non-maskable clients



Interlocks will be tested by VSC and OP



LBDS

- Replace MKD generator side panels (full closure for improved dust protection)
- Replacement TSDS ELMA crates (redundant power supplies monitoring)
- Visual inspection MKD/MKB generators
- Replacement of 2/3 GTO switches (bad switch ratio)

- Full revalidation of the system needed during machine check-out
- **Full recalibration** at the end of the YETS
- **Short reliability run** in local

- **UPS tests at the end of the YETS**

- The different functionalities have to be checked
 - BETS
 - XPOC
 - Synchronization LBDS and RF
 - Full check-out tests needed with system fully connected
 - Energy tracking tests up to 6.5 TeV
 - Arming the system connected to BIS once beam permits are OK
 - Circulate and dump sequence
 - Machine protection tests with loop closed

TCDQ

- Calibration verification

Kickers

MKI

- Replace terminating resistors (MKI2 & MKI8)
- Deploy acquisition system for magnet capacitive pick-ups (precise location of HV breakdown inside the magnet)
- Upgrade thyatron heating system
- Implement fast vacuum acquisition of MKI interconnects
- Surveillance low voltage power supply in timing system
- Replacement fine delay V850 module by SVEC-FD module
- General software maintenance

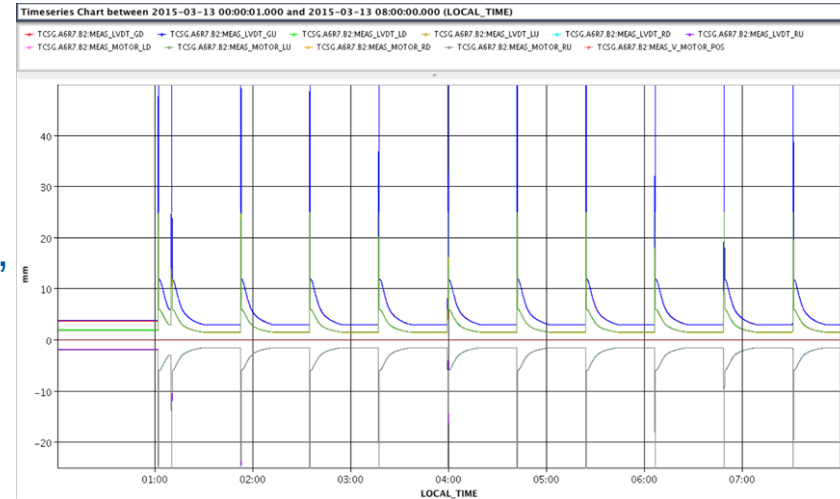
MKQAc

- Upgrade from RIO3/LynxOS to MEN-A20/SLC6
- Verification HV contacts in AC-Dipole generators
- General software maintenance

Will be fully tested before machine closure

Collimators

- Hardware and FESA should be tested with systematic ramps
- **Machine protection tests** to check position, energy and beta-star interlocks
- Injection protection tests (to check also the interlock chain)
- Additional tests will be done without beam, using a simulator to optimize the BLM alignment
 - during 3-4 hours without beam with as many collimators, to move them in parallel



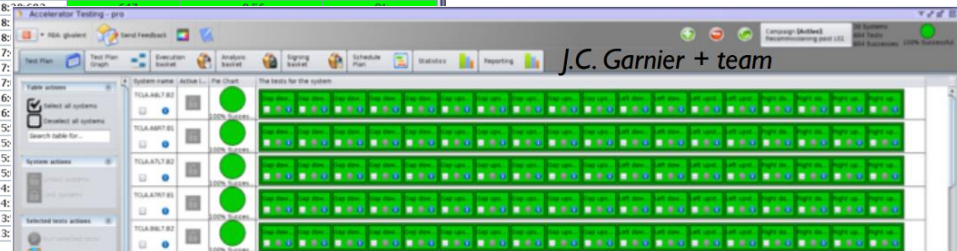
Status of TCSG.A5L7.B1 connection to CIB.TZ76.U7.B1

Collimator MP sequence for: TCSG.A5L7.B1 / TCSG.IP7.B1.3S

Information on monitoring: TCSG.A5L7.B1 / CollimatorStatus/PrsErrors / CIB.TZ76.U7.B1 / COLLPOS input (CH8)

Sequence start time: 19/03/2015 13:13:19

Sensor - Limit violated	BIC fault	BIC time	Prs fault	Prs time	Delay (ms)	LVDT - Limit (mm)	Result
GAP DOWNSTREAM - BETA L...	OK	13:19:12:096	OK	13:19:12:694	-588	-6.45	OK
GAP UPSTREAM - BETA LIM ...	OK	13:18:54:936	OK	13:18:55:694	-758	-6.45	OK
GAP DOWNSTREAM - BETA L...	OK	13:18:38:046	OK	13:18:38:694			OK
GAP UPSTREAM - BETA LIM ...	OK	13:18:21:105	OK	13:18:21:694			OK
GAP DOWNSTREAM - ENERG...	OK	13:18:01:125	OK	13:18:01:694			OK
GAP UPSTREAM - ENERG...	OK	13:17:44:205	OK	13:17:44:694			OK
GAP DOWNSTREAM - IN	OK	13:17:20:295	OK	13:17:20:694			OK
GAP DOWNSTREAM - OUT	OK	13:17:01:554	OK	13:17:01:694			OK
GAP UPSTREAM - IN	OK	13:16:39:794	OK	13:16:39:694			OK
GAP UPSTREAM - OUT	OK	13:16:21:084	OK	13:16:21:694			OK
RIGHT DOWNSTREAM - IN	OK	13:15:59:464	OK	13:15:59:694			OK
RIGHT DOWNSTREAM - OUT	OK	13:15:40:704	OK	13:15:40:694			OK
RIGHT UPSTREAM - IN	OK	13:15:18:984	OK	13:15:18:694			OK
RIGHT UPSTREAM - OUT	OK	13:15:00:174	OK	13:15:00:694			OK
LEFT DOWNSTREAM - IN	OK	13:14:38:423	OK	13:14:38:694			OK
LEFT DOWNSTREAM - OUT	OK	13:14:19:703	OK	13:14:19:694			OK
LEFT UPSTREAM - IN	OK	13:13:57:853	OK	13:13:57:694			OK
LEFT UPSTREAM - OUT	OK	13:13:39:103	OK	13:13:39:694			OK



Beam instrumentation

■ BLM

- Test of the successful **transition of USER_PERMIT [T→F]** (5'x8 sectors) and the signal arrival at the BIC
- Test the **change of the threshold values according to the beam energy** signal received (1h)
 - Sectors 45, 56, 67 and 78 ramped to 6.5 TeV or in a simulation energy ramp (timing system fully operational)
- Check of the correct detection and propagation to the SIS for requesting a beam dump due to **missing HV power supply** on the system's detectors (1h)

■ BPM

- Will do **BPM Fibre connectivity tests** and software checks as much as they can to **validate the new FESA3 server** (BPMD class and BPMLHC class)
- Intensive check of FW and SW:
 - Calibration, logging process, Post-Mortem buffers

■ WS (mostly qualified with beam)

- Check of the movements
- Check of the FESA class
- Check of the new functionalities of the FESA class

■ Standard checks on BTV images/movements, applications get data, sequences work etc.



RF

- Must have 4 weeks available for RF conditioning and commissioning,
 - Major controls validation on the new FESA3 software with some conditioned cavities
 - For the LLRF, **2 weeks (without beam) to complete the setting-up of the loops after some cavities are conditioned**

- Additional time is requested for **conditioning the klystron with higher cathode current**
 - At present the power is sufficient because the voltage is reduced to 10 MV in physics (we used 12 MV during run 1 and the LHC design assumed 16 MV!)
 - To **increase the voltage above 12 MV, the 250 kW saturation will not be sufficient** and we will need the design 300 kW.

Controls

From V. Baggiolini:

- Smooth upgrades are proceeding as planned:
 - Major Controls upgrades (OS, Middleware, RBAC, Databases, Timing, LSA/InCA, etc) done successfully
 - Other upgrades (FESA classes, FGCs, PLC code, Firmware, etc) are ongoing
 - No problems anticipated for re-commissioning

 - Up-to-date information here

<https://wikis.cern.ch/display/SUWG/YETS+2015-16+Follow-up>

We'll have to test extensively before beam!
We'll profit from the experience (and debugging) of the injectors!

Concluding remarks

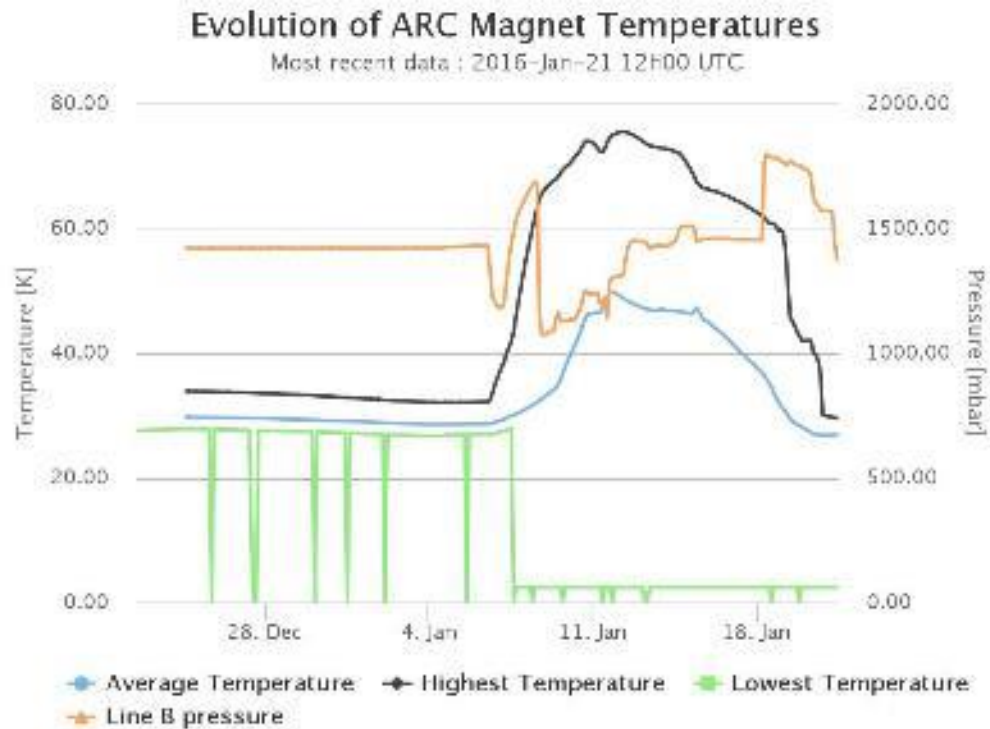
- The boundary conditions for the YETS are well defined; however
 - Few critical activities could have an impact
 - 7000 tests have to be done in 12 days
- As usual, the good coordination between PT and machine check-out will be fundamental for a smooth transition to the operational mode
 - A lot of tests and verifications to be done
 - All the systems finally connected together
- All experts are already working on their systems to get ready for beam; machine check-out coordination will kick in starting from mid-February
- Ways can be studied to reduce the time for commissioning, but this has to be done without forgetting the priorities (S-Q-P), since the rigorosity of the process is the key for a safe and successful operation of the machine throughout the year

Thank you for the attention!



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Temperature drifts during YETS...



Activities that could impact the PT

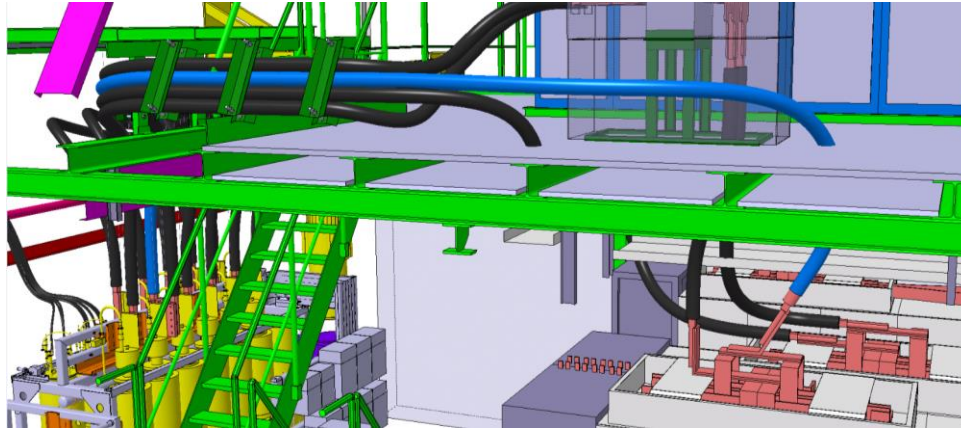
- Prerequisites:
 - Cryogenics – CS/CM should be there at the beginning
 - Services (CV, EL,...)
 - Electricity, water, ventilation
 - The UPS tests will have to be (successfully) completed in the sectors under powering

- Power converter
- MPE
 - QPS
 - EE
 - EIQA
- ~~PIC~~ No intervention foreseen during YETS
- EN/EL
 - Visual inspection on warm bus-bars should be conducted by EN/EL to avoid surprises when restarting (consolidation already done during 2015 TSs)



RQ4.L/R1 modification

- ALFA project: adding one more WCC per RQ on Q4 circuit around point 1



Add plan for this/nc
Add photo from ins

Short-circuit test + 24h heat run to be done during the YETS
Complete re-commissioning of the 2 circuit during powering

- For RR17, the installation is already completed and the tests are on-going
 - Electrical insulation test “à sec”, PC connection and interlock test, water reconnection and insulation test are done
 - 24h heat run on-going
- For RR13, the tests will be around mid-February

List of powering tests to be done

Update!!

Accelerator Testing - pro

RBA: mpojer Send Feedback Campaign [Active]: Recommissioning post LS1 24 Systems 900 Tests 900 Successes 100% Successful

Signing basket Schedule Plan Statistics Reporting Planning Expert settings Trash Can

Test Plan Test Plan Graph Execution basket Analysis basket

System name	Active	Pie Chart	The tests for the system							
RB.A12	PIC									
RB.A23	PIC									
RB.A34	PIC									
RB.A45	PIC									
RB.A56	PIC									
RB.A67	PIC									
RB.A78	PIC									
RB.A81	PIC									
RQD.A12	PIC									
RQF.A12	PIC									
RQD.A23	PIC									

18:20:33 - Binding service 'rmiServerRunStateController' to RMI registry: RegistryImpl[UnicastServerRef [liveRef: {endpoint:[172.18.200.167:60230](local),objID:[0:0:0, 0]}]]



MPE critical changes

- Normal checks before beam
- BIS – no additional tests needed
 - Displacement of many socket-outlet blocks (reglettes)
 - in all cases these units prevent the access to the VME redundant power supplies (namely ‘Wiener’ P.S.) (to be coordinated with EN-EL)
 - Locations: all UAs, US15, UJ33, USC55, TZ76, SR2 and SR8
- ~~WIG~~
 - ~~WIG upgrade to new generic code base: remote download followed by (partial) re-commissioning of the system – max half a day / point....~~
 - ~~Locations: US15, UA23, UJ33, UA47, USC55, US65, TZ76 & US86~~
- SMP – only SW change, no HW – no additional tests
 - Replacement of the VME-bus master module family : ‘RIO3’ type replaced by ‘MenA20’ type (this depends on successful lab tests still to be confirmed)
 - Location: CCR
- Misc
 - Various SW upgrades (e.g. FMCM FESA class, QPS Swiss Tool, ACCTESTING,...) – time certainly needed to deploy and test!
 - **All issues should be cleaned before start of powering tests**

