



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



## **Outline**

### The present schedule

- Driving activities defining the length of YETS '15-'16
- The critical activities that could impact the time of restart

### The powering tests

- Activities with a possible impact
- The list of powering tests for next year re-commissioning
- The organization

### Machine check-out

- Machine check-out objectives
- Preliminary list of requested checks
- Concluding remarks



# Driving activities (machine side)

### Cooling & Ventilation

 3 weeks of stop for the SF, SU, UW (mechanical cleaning of the cooling towers, mechanical and electrical maintenance, bugs fixing)

### Cryogenics

- The maintenance is needed on all cryo-plants
  - Heavier maintenance and consolidation are needed in IP4 (A) & IP6 (A), heavy corrective maintenance (repairs) is needed in IP8 (B)
- The baseline is to keep the Helium in the arcs except sectors 7-8 and 8-1
  - o the magnets will be filled with LHe in cold standby at 3.5 K − 4 K
  - The LSSs will be in GHe at 20 K.
  - The DFBs will be empty with the current leads in cold standby
- The Sectors 7-8 and 8-1 will be emptied, and in cold stand by with Ghe
- RF cryo start on 22nd of February to allow the RF conditioning (4wks requested)
- The last cryostarts will be back on 4th of March (earlier in Sectors 1-2, 3-4, 4-5, 7-8)

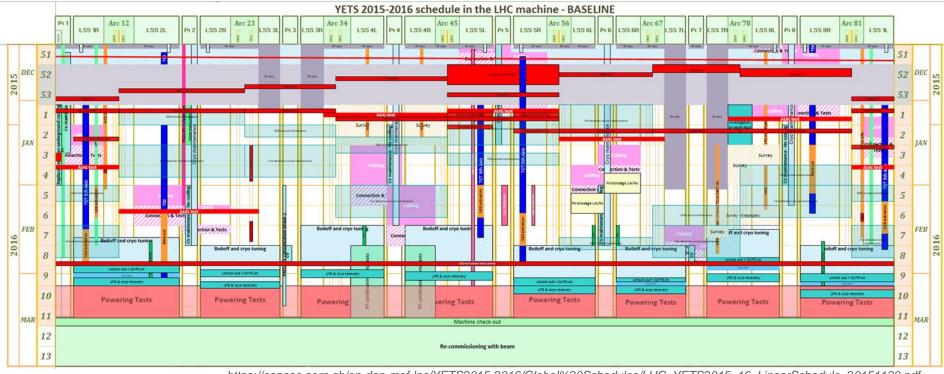
#### UPS TESTS on the whole machine

- Recently approved by LMC
- The tests can be done only after the cryo start
- The UPS tests constitute a hard limit for the readiness of all systems



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# The present schedule



https://espace.cern.ch/en-dep-mef-lpc/YETS2015-2016/Global%20Schedules/LHC\_YETS2015\_16\_LinearSchedule\_20151130.pdf

#### Key dates:

- DSO tests (machine in general mode before)
  - Patrol scheduled on W8 for the DSO tests
  - DSO tests on February 26 (and 27)
- March, 1 beginning of UPS tests (could be integrated in the general AUG tests?)
- March, 4 LHC tunnel closed and beginning of powering tests
- March, 16 end of powering tests, experiments closed and (official) beginning of machine check-out
- March, 21 beginning of beam commissioning



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

# An example from Run I

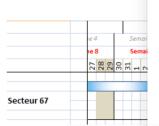
#### **FUNDAMENTAL DATES**

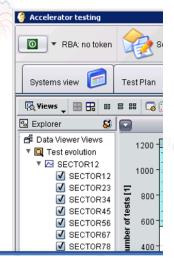


- Starting from w.6 (Feb.6) t
- From Feb.6, start of ElQA
- From Feb.8, start of powes and PC unlocking



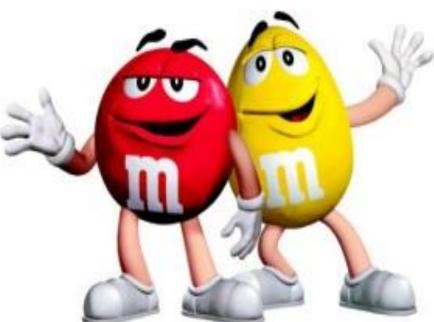
- A shift (17:00-23:00) for
- 2 shifts (M+A 7:00-15:0
- 2 shifts starting from w.8
- PIC on call







In total, 8185 tests steps including preparations of powering tests



10/20/2011

- A lot done in usual time frame
  - Don't think to squeeze it dow
  - Most of the time spent in tunnel intervention
  - Powering was always done in the shadow

onditions



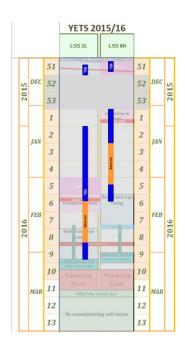
Critical activities with possible impact

#### Collimators 5<sup>th</sup> Axis

- 12 Collimators will be removed and re-installed in LSS1 and in LSS5
- Vacuum layout to be modified, to recover the TCTP collimators' 5th axis translation
- Due to RP issue, the activity can only start on 4th January

### TDI replacement

- Minor contingencies are included in the baseline
- Both TDI removed during W51 and reinstalled during W1&W2



### Change of ferrite of the Beam Wire Scanner in LSS4

Due to the late delivery of ferrite, the **final decision about the installation will be taken by end of January** 



3D integration view 4L1

15/12/2015



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  - Preliminary list of req
- Concluding remarks





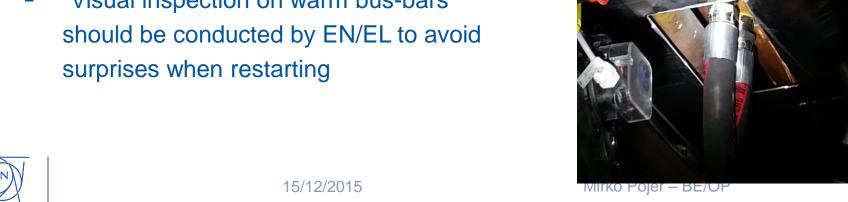
# Activities that could impact the PT

- CS/CM should be there at the beginning
- Must be OK for the UPS tests Services (CV, EL,...)
- Power converter
- **MPE** 
  - EIQA
  - **QPS**
  - EE

No intervention foreseen during YETS

EN/EL

Visual inspection on warm bus-bars surprises when restarting



## **EPC**

### FGC CPLD & Software upgrade

- FGC CPLD Upgrade
  - Need local access all over the machine for the reprogramming
  - Version already tested in S78
  - Test: PIC2 PERMIT / POWERING FAILURE to be repeated
- FGC Software Upgrade
  - Correction of bugs seen during Run 2
  - Tests to be foreseen

#### Current Calibration of

- the main dipoles
- the main quadrupoles.
- the inner triplets
- the RMSIs
- Additional intervention of maintenance / power module replacement

No major impact on re-commissioning PIC tests already in the baseline



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# MPE - QPS

### Could strongly impact the commissioning time!!

- Installation & commissioning of radiation tolerant detection systems for 600 A circuits
  - o RR13, 17, 53, 57, 73 and 77

Important to get a sector ASAP!

Test bench for HW and SW is needed!

- Installation & commissioning of new detection systems for circuits RU.L4 and RU.R4 ('undulator'). Activity in conjunction with the upgrade of the corresponding current sensors performed by EE team
- Upgrade of the firmware for the nQPS DAQ systems allowing easier recovery from local bus errors (436 units concerned).
  - Locations: 8 sectors

Impact to be assessed

- Installation of a test system for the measurement of conical joints in the warm 13 kA circuits.
  - Location: UA23 (t.b.c.)
  - Requires lock-out and grounding of the associated power converter.
- All DQHDS will be switched off during the YETS. Locations: 8 sectors
  - The QPS team foresees as well a test of the QPS interlocks.

All **must** be up and running for the UPS tests!



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## MPE - EE

- General and specific overhaul of the 32 installations of energy extraction in the LHC main dipole and quadrupole circuits.
  - Locations: UAs (even points), RRs (13,17,53,57,73,7) & R34, R37
  - Requires lock-out and grounding of the associated power converters
- Supervision of a general overhaul of the energy extraction breakers of the 'Atlas' powering circuits for the superconducting Solenoid and Toroid.
  - This task will be performed by an IHEP team of specialists.
  - Location: Atlas ("power cavern")

All **must** be up and running for the UPS tests!



# MPE - EIQA

### Check is part of the cryo tuning

Study of a possible relocation in point 6 of the CL heater sources and the Proximity Equipment related to a possible displacement of the RQ5.L6 quad

### To be verified before powering (IST)

Checking and re-making, if required, the signal transmission line from the DQLCT of B23.L7, heater #1

### 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!**

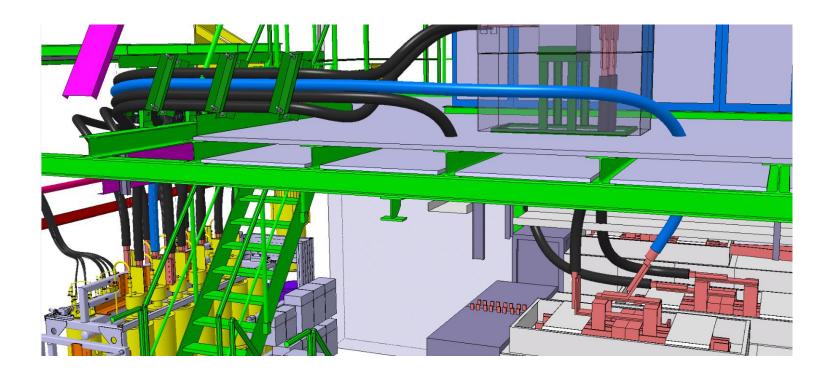
- ELQA integrity verifications at the end of YETS
  - Depending on the temperature variations and the interventions on the circuits.

Impact on re-commissioning depends on the list of EIQA tests



# RQ4.L/R1 modification

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

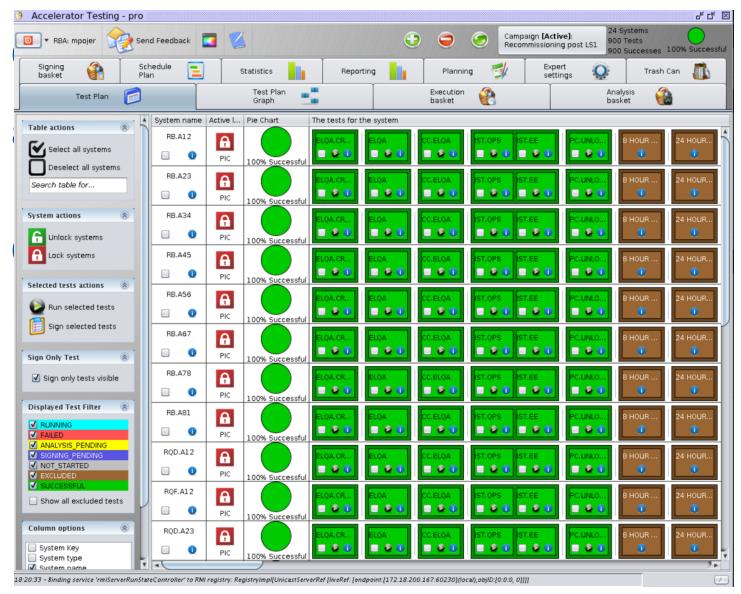


Short-circuit test + 24h heat run to be done during the YETS Complete re-commissioning of the 2 circuit during powering



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# List of powering tests to be done





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# Warm magnets

#### RMSI Point 2 and 8 [EIS]

- Installation of a new Control Crate for a better reliability and an optimisation of the spare card management (Analog Card will become Standard)
- Rework at the level of the EIS for a better diagnostics
- o 1 day of test per converter: mise-hors-chaine will be needed
- No intervention on power part

#### RD34.LR7 [EIS]

- Change of a DIVISOR MODULE card to solve a voltage measurement issue
- 1 day of test: mise-hors-chaine will be needed
- No intervention on power part

#### RD34.LR3 [EIS]

- Change of the ACTUACTOR board
- o 1/2 day of test: mise-hors-chaine will be needed
- No intervention on power part

#### LHCB Dipole

- RPTI.SR8.RBLWH.R8
  - o Installation of a new Control Crate to solve the issue of PC PERMIT bad contacts
  - Tests to be foreseen
- o RBXWSH.R8
  - Partial DC cable replacement (EN/EL)
  - 1 day for test (EN/EL)

#### Exchange of some coil retainers in point 3 and possibly point 7 during the YETS on all the MQW magnets

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

**EPC** 

**MSC** 

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# Organization

- From March 4, the machine will be closed (excluding urgent, spot interventions)
- Powering tests will be executed all around the clock
- Team availability
  - $\circ$  OP 3x8h
  - $\circ$  MP3 3x8h
  - EPC 2x8h (7:00-23:00) + 1 shift on call
  - PIC 1 extended shift
- Tunnel accesses (exclusively related to powering) will be during the normal working hours



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## Machine check-out in a nutshell I

- Drive all relevant systems in a synchronized way through the standard operational sequence
- Check functionality of the control system from the control room high level applications
- Check the beam instrumentation acquisition chain
- Check synchronization
- Check all equipment control functionality
- 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
- The Beam can not be injected and circulate without closing the BIS loop



## Machine check-out in a nutshell II

### BIS system:

- LBDS connected
- All clients connected to the loop

#### Condition to close the BIS LOOP in nominal condition:

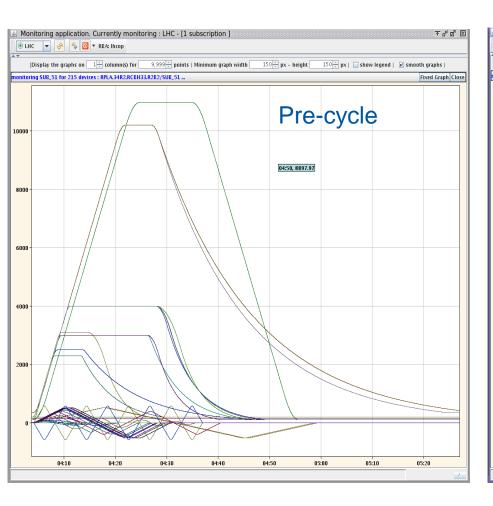
- LHC access Key on Beam mode
- LHC Vacuum valves open
- Hardware commissioning finished; all circuits ON and no faults
- No interlock from non-maskable clients

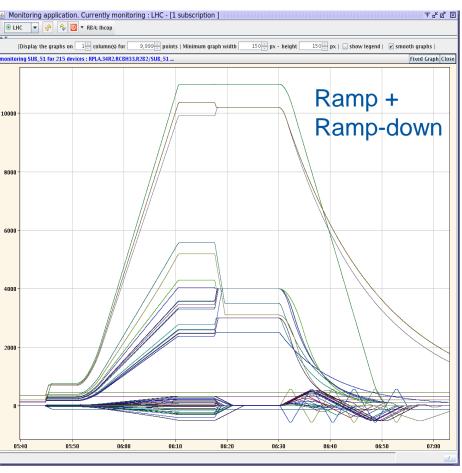
#### LBDS

- BETS
- O 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



# Final global powering with op. functions

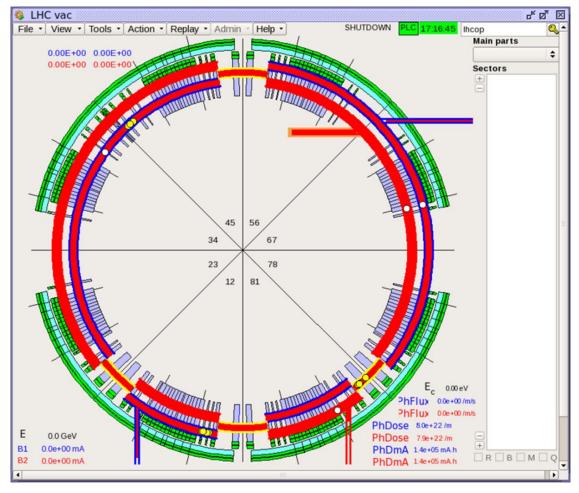






# Vacuum

 Ring and expts': all sectors valves will have to be operational and interlocks will be tested by VSC and OP

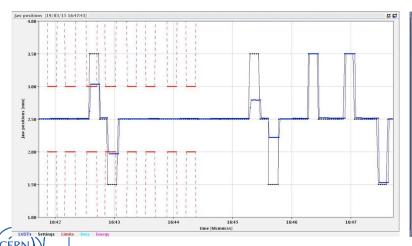


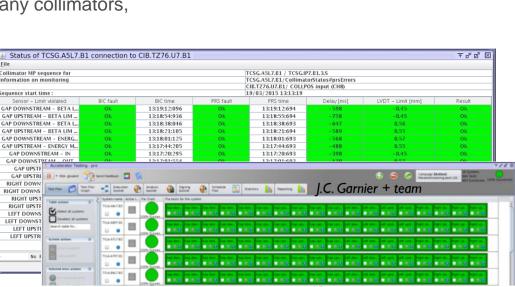


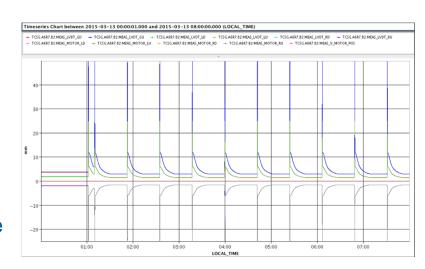
# Collimators

- Hardware and FESA should be tested with systematic ramps
- Machine protection tests to check position, energy and best-star interlocks
- Injection protection tests (to check also the interlock chain)
- Collimators with BPMs: no special test before beam
  - However a simulator to optimize the BLM alignment is available, and could be tested during 3-4 hours without beam with as many collimators, to move them in parallel

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## **LBDS**

#### **LBDS**

- Replacement TSDS ELMA crates (redundant power supplies monitoring)
  - Full revalidation of the system needed during cold checkout
- Visual inspection MKD/MKB generators
  - Revalidation by short reliability run in local at the end of the EYETS
- Replacement of 2/3 GTO switches (bad switch ratio)
  - Revalidation by short reliability run in local at the end of the EYETS
- UPS tests at the end of the YETS
- Full recalibration at the end of the YETS
- General software maintenance

#### **TCDQ**

Calibration verification



### **Kickers**

#### MKI

- Upgrade thyratron 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



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## Beam instrumentation

#### BLM

- Test of the successful transition of USER\_PERMIT (5'x8 sectors)
  - The BLM system sets its USER\_PERMIT to FALSE
  - The transition of each separate connection of BLM USER\_PERMIT to FALSE and the signal arrival at the BIC
  - The test must be performed on at the centre crate of each sector (i.e. device cfv-s\*\*-blmc).
     Results are to be documented in MTF
- Test the change of the threshold values according to the beam energy signal received (1h)
  - The main dipoles circuits in sectors 45, 56, 67 and 78 are ramped from injection to physics energy (7 TeV or less) or a simulation energy ramp is transmitted by the timing system
- 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)
  - Using the expert tools reduce the value of all HV power supplies to values lower or equal to 900 V

#### 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)
- o Intensive check of FW and SW:
  - Calibration, logging process, Post-Mortem buffers



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### Beam instrumentation

- WS (mostly qualified with beam)
  - Check of the movements
  - Check of the FESA class
  - Check of the new functionalities of the FESA class: background suppression, threshold limit, for ions and protons. The idea is to fake the TGM in order to test different conditions
- Standard checks on BTV images/movements, applications get data, sequences work etc.

Acc\_testing GUI being used and more and more systems should be added





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# RF

- Must have 4 weeks available for RF conditioning and commissioning,
  - Need to do some major controls validation on the new FESA3 software with some conditioned cavities before proceeding with full LLRF setting-up
  - No big activity for LLRF, just the usual 2 weeks (without beam) to complete the setting-up of the loops after cavities are conditioned (the setting-up of RF synchro and capture is then done in the background of machine setting-up)
- 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!). If, for any reason, we have to increase the voltage above 12 MV, the 250 kW saturation will not be sufficient and we will need the design 300 kW.



# MPE critical changes

- Normal checks before beam
- BIS no additional tests needed
  - Displacement of many socket-outlet blocks (reglettes)
    - o 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

#### <del>-</del>WIC

- WIC 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

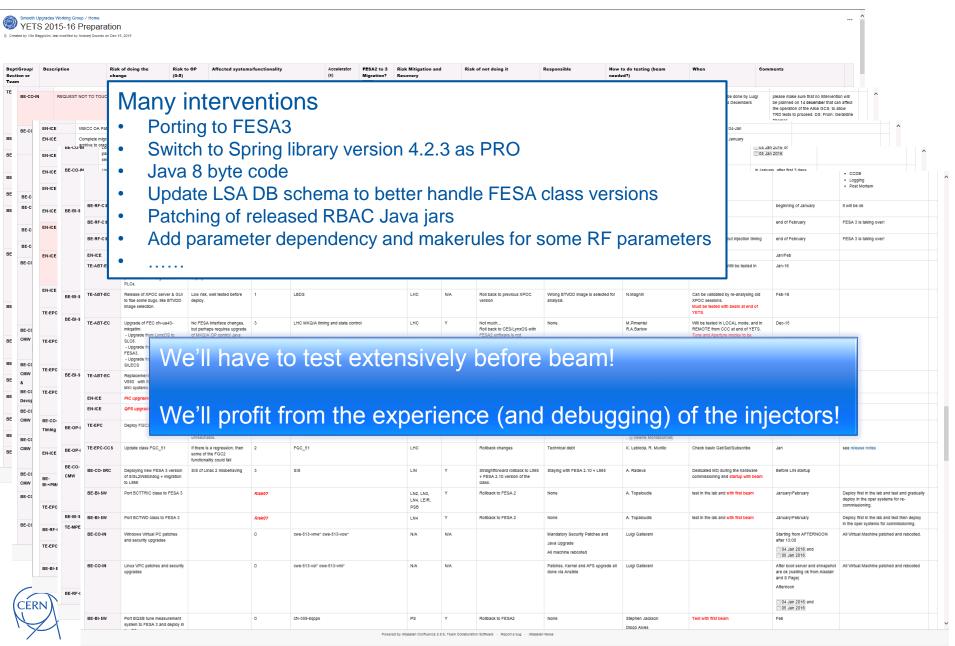


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**LHC Beam Interlock System** 

# **Controls**



# 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 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
- We'll have to work hard to prepare the machine in a coordinated and efficient way...also improving the communication in the LHC island...



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