



Validation of Redundant Powering for Machine Protection Systems After LS1

LHC Machine Protection Panel

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Outline

- ▶ Redundant powering for machine protection systems
- ▶ Why shall we test redundant powering?
- ▶ Feedback from the recent test performed on LBDS
- ▶ Test procedure
- ▶ Where shall we apply this test?
- ▶ When shall we test redundant powering?
- ▶ Impact on the other users
- ▶ Conclusion



Redundant Powering for Machine Protection Systems

- ▶ Machine protection systems powered by **Uninterruptible Power Supply (UPS) systems** via **2 independent and redundant power paths**

- ▶ F3 distribution line powering all the users (since the beginning)
- ▶ F4 distribution line powering redundant MP systems (since 2009)

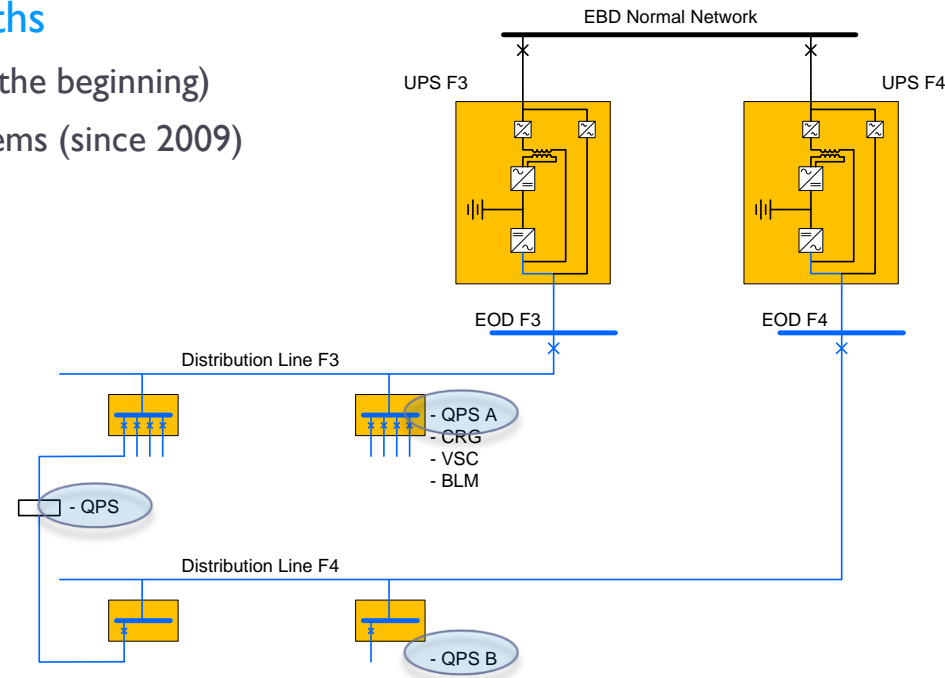
- ▶ **2 types of redundancy:**

- ▶ Single equipment with dual input power supplies
- ▶ Independent and redundant equipment A and B
Ex: *iQPS* and *nQPS*

- ▶ **Possible mistakes (already happened):**

- ▶ Single equipment with dual input power supplies connected to the same distribution line!
- ▶ Redundant equipment powered from the same distribution line!

- ▶ In case a complete distribution line is lost (already happened): protecting systems may be lost (one-in-two chance)





Why to Test Redundant Powering?

- ▶ In case a complete distribution line is lost:
No redundant powering → machine protection NOT guaranteed
- ▶ Verify that single protecting systems have redundant power supply, i.e. they are supplied by true independent power distribution lines
- ▶ Verify that redundant systems are powered from the correct power path
- ▶ Verify that machine protection is still fully operational even if a complete distribution line is lost (although protected by UPS)
- ▶ Find out interdependencies between systems!
- ▶ Verify that the magnet powering is also stopped in these conditions (as the PIC may not be triggered by the UPS systems!)
- ▶ Verify or discover the impact for the other users (not having redundant systems nor redundant powering). They are or will be interested by this test!
- ▶ Always mentioned but never done!
Many consolidation works during LSI, so it's high time to do it!



Test Performed on the LBDS in April 2013

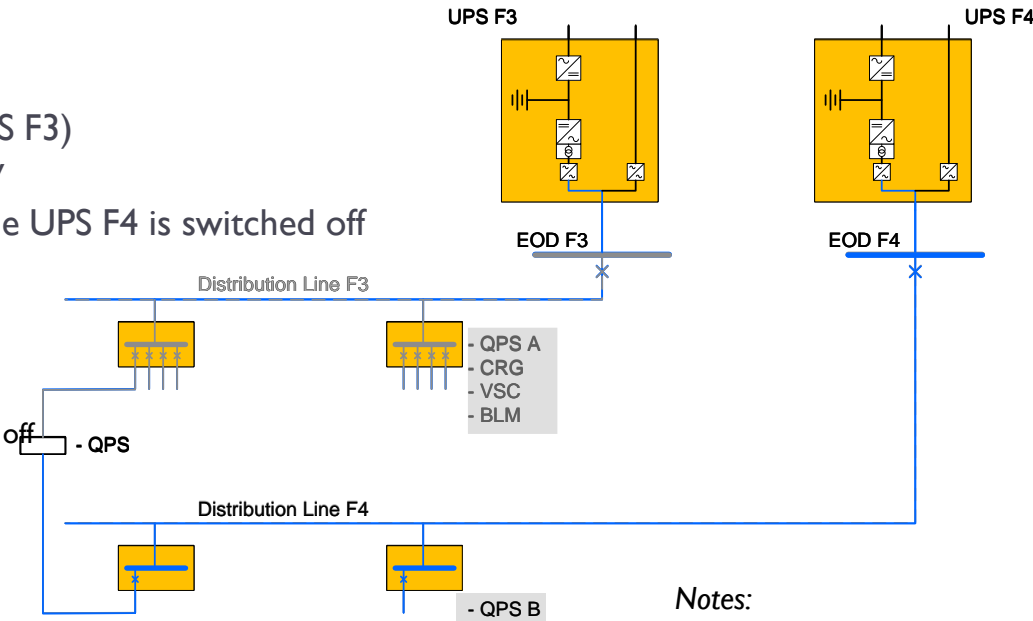
- ▶ **Different goal:**
Verify that a beam dump is triggered in case of total power cut (UPS network and standard normal network at the same time)
- ▶ **Simple and fast procedure (for EN-EL):**
 - ▶ Transfer everything to one single switchboard (UPS systems on manual bypass and switched off)
 - ▶ Open the input circuit-breaker on the switchboard: all equipment powered by this switchboard OFF!
- ▶ **To be noted:**
 - ▶ First test in UA63 cancelled due to cryogenics conditions not compatible in arc 5-6
 - ▶ Rescheduled 6 weeks later
 - ▶ Changed to UA67 (less impact on arc 6-7)
 - ▶ IT star-point rack (powered by the same UPS) to be changed to another power supply
 - ▶ One server did not restart after transferring (with power cut) the IT star-point rack to a temporary power supply
- ▶ **Successful test: repeated several times (at 500 GeV and 5000 GeV),
Always got synchronous beam dump!**



How to Test Redundant Powering

▶ Test procedure:

- ▶ The IT star-point rack (powered by the UPS F3) is transferred to a temporary power supply
 - ▶ The switchboard (EOD F4) downstream the UPS F4 is switched off
 - ▶ MP users verify that:
 - ▶ Their equipment remain powered by the F3 distribution line
 - ▶ And/or their redundant equipment A are still powered while equipment B are switched off
 - ▶ Then the switchboard (EOD F4) is powered again
 - ▶ The switchboard (EOD F3) downstream the UPS F3 is switched off
 - ▶ MP users verify that:
 - ▶ Their equipment remain powered by the F4 distribution line
 - ▶ And/or their redundant equipment B are still powered while equipment A are switched off
 - ▶ The other users (without redundant powering) can only see and note the impact!
 - ▶ Then the switchboard (EOD F3) downstream the UPS F3 is powered again
 - ▶ The IT star-point rack is transferred back to its initial power supply coming from the UPS F3
- ▶ Test procedure to be repeated in each UPS zone with redundant powering

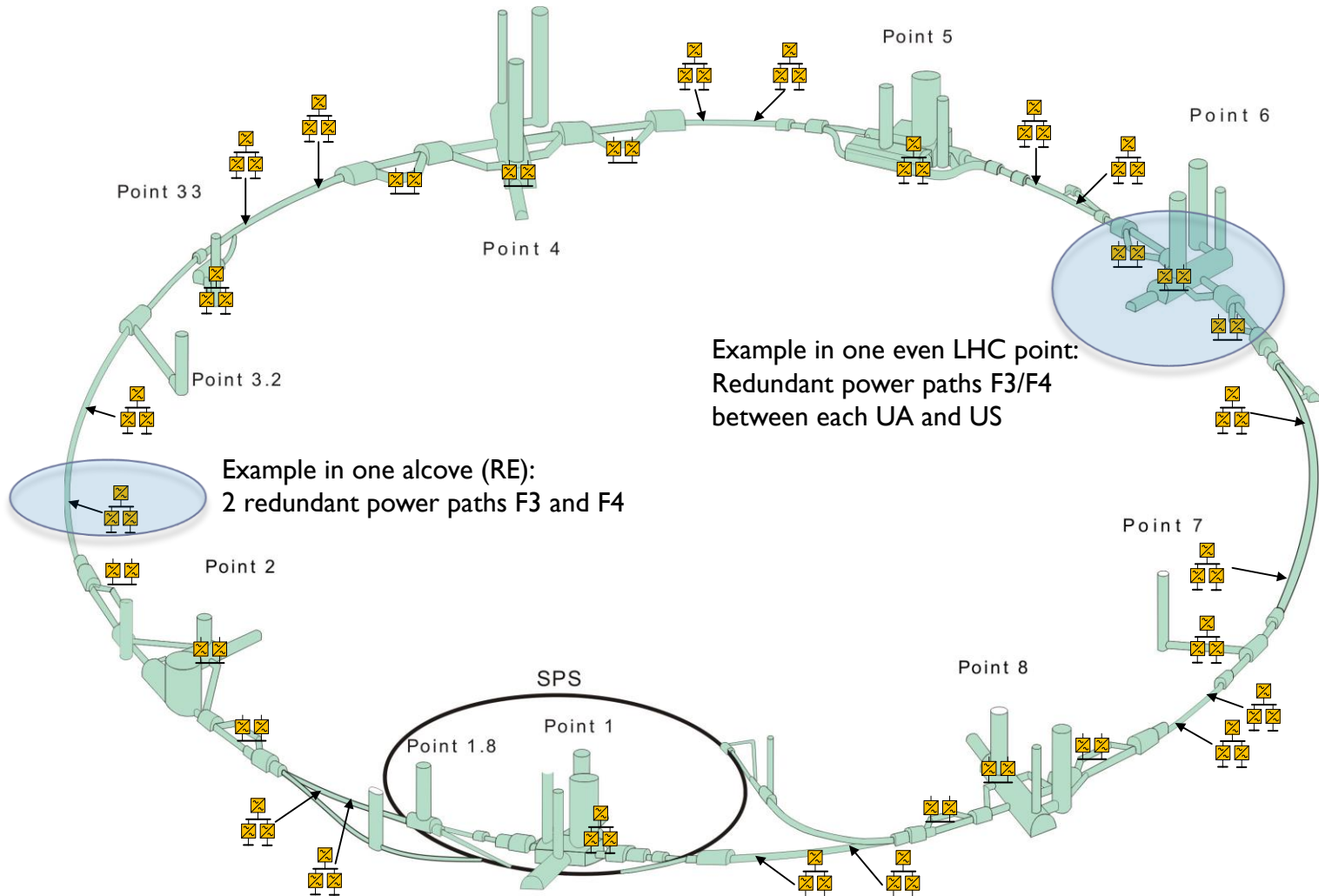


Notes:

- 'Backup UPS' in the alcoves and odd points
- No operation on the UPS systems
- PIC not triggered!



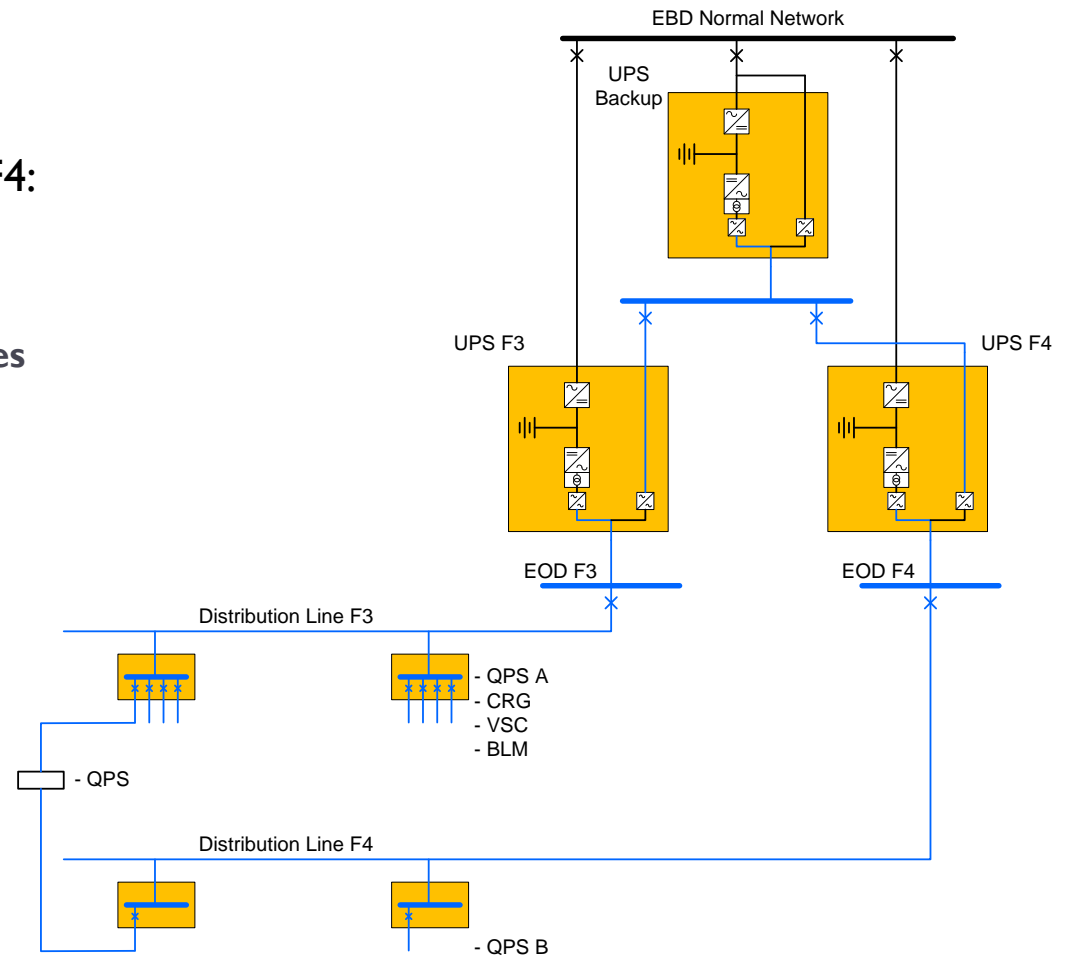
Where to Test Redundant Powering?





Test in the Alcoves and LHC Odd Points

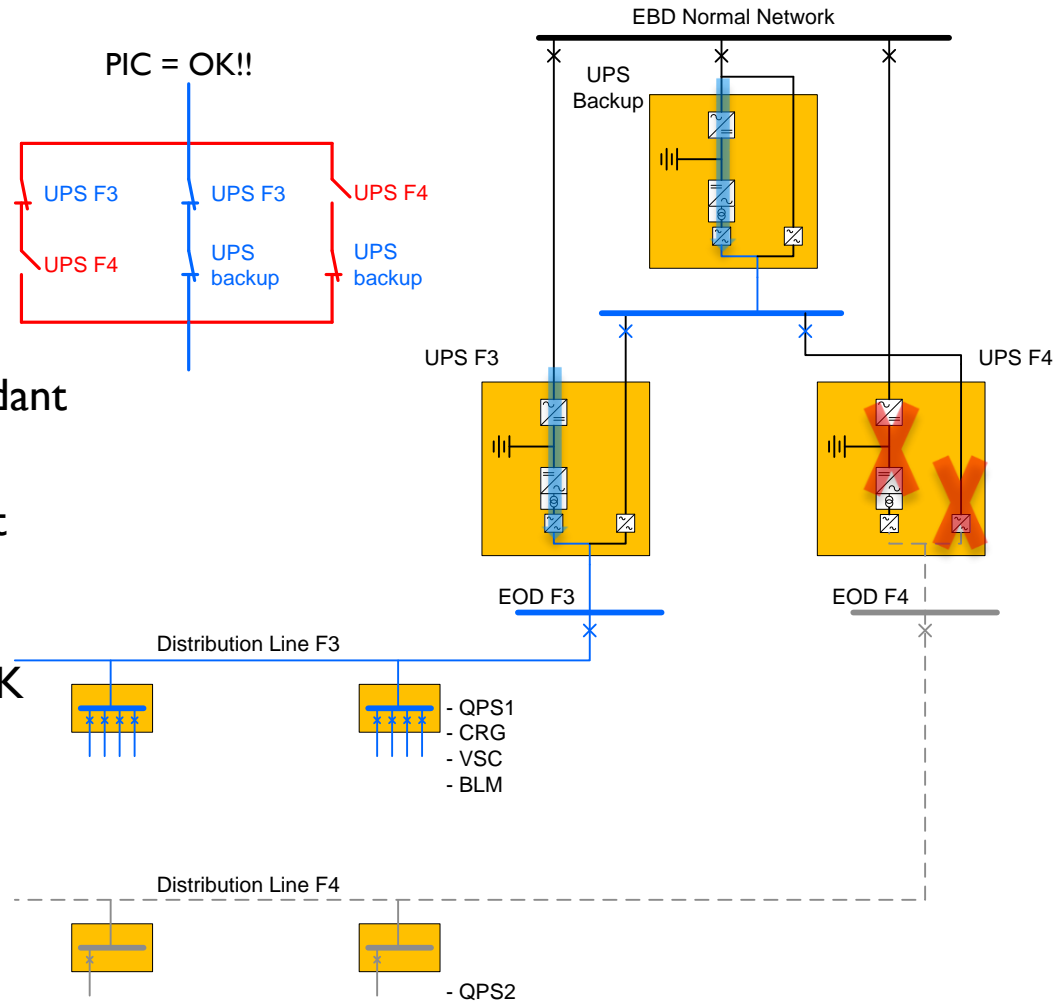
- ▶ New configuration with 3 UPS systems and 2 redundant power paths F3/F4:
 - ▶ Each RE alcove → x 16
 - ▶ Each odd LHC point → x 4
 - ▶ Test procedure to be applied **20 times**
- ▶ Each RE covers 1/2 arc, impact from half-cell 11 up to 34
- ▶ Each LHC odd point covers from half-cell 10L up to 10R





Magnet Powering Stop in All Conditions?

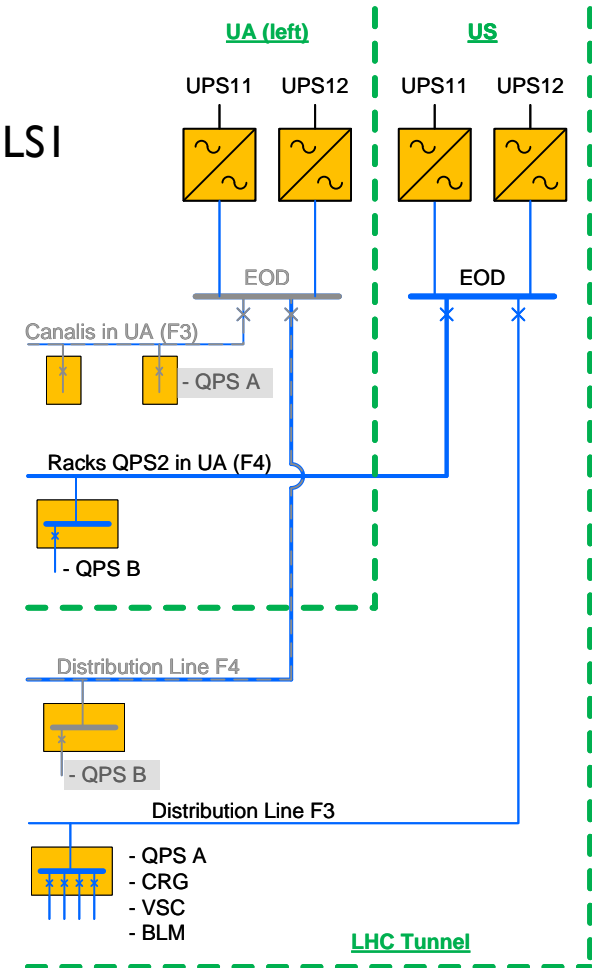
- ▶ PIC may not be triggered in the following cases:
 - ▶ UPS failure without bypass
 - ▶ Short-circuit on the switchboard
- ▶ Result: one power path lost
- ▶ Same conditions than testing redundant powering for MP systems
- ▶ This test must be used to verify that magnet powering STOP is triggered by the equipment itself (e.g. QPS) while the UPS PIC signal remains OK





Test in LHC Even Points

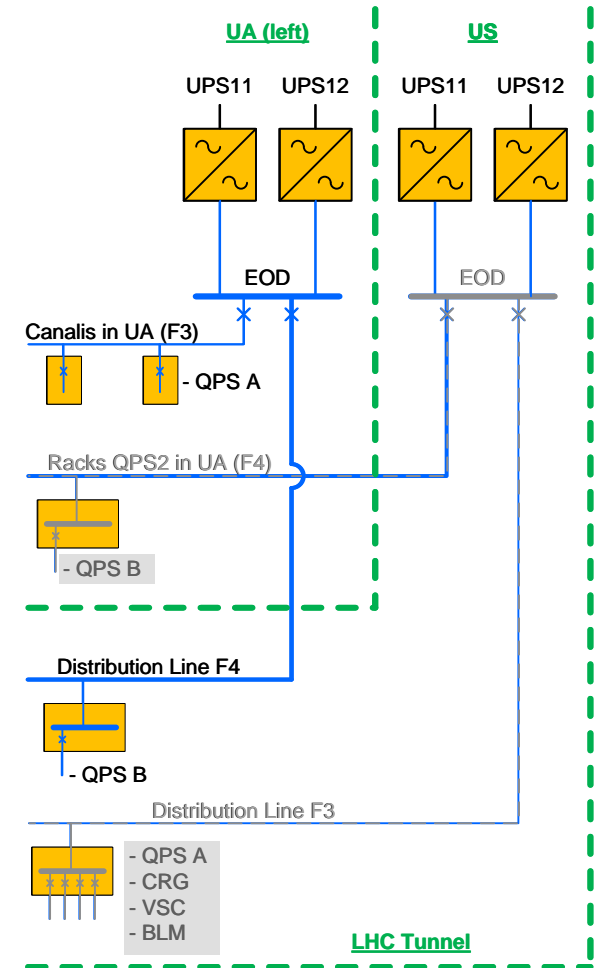
- ▶ Existing UPS configuration in the LHC even points is conserved with the UPS replacement project during LSI
 - ▶ Redundant distribution line for F3 from UA is coming from the UPS systems in US and inversely
- ▶ Similar procedure, phase one:
 - ▶ The IT star-point rack(s) in UA to be transferred to temporary power supply before and after the power cut
 - ▶ The switchboard (EOD UA) downstream the UPS systems in UA is switched off
 - ▶ MP users verify that:
 - ▶ Their equipment remain powered by the redundant distribution lines
 - ▶ And/or their redundant equipment B (resp. A) are still powered while equipment A (resp. B) are switched off
 - ▶ The other users (without redundant powering) can only see and note the impact!
 - ▶ Then the switchboard (EOD UA) downstream the UPS systems in UA is powered again





Test in LHC Even Points (cont'd)

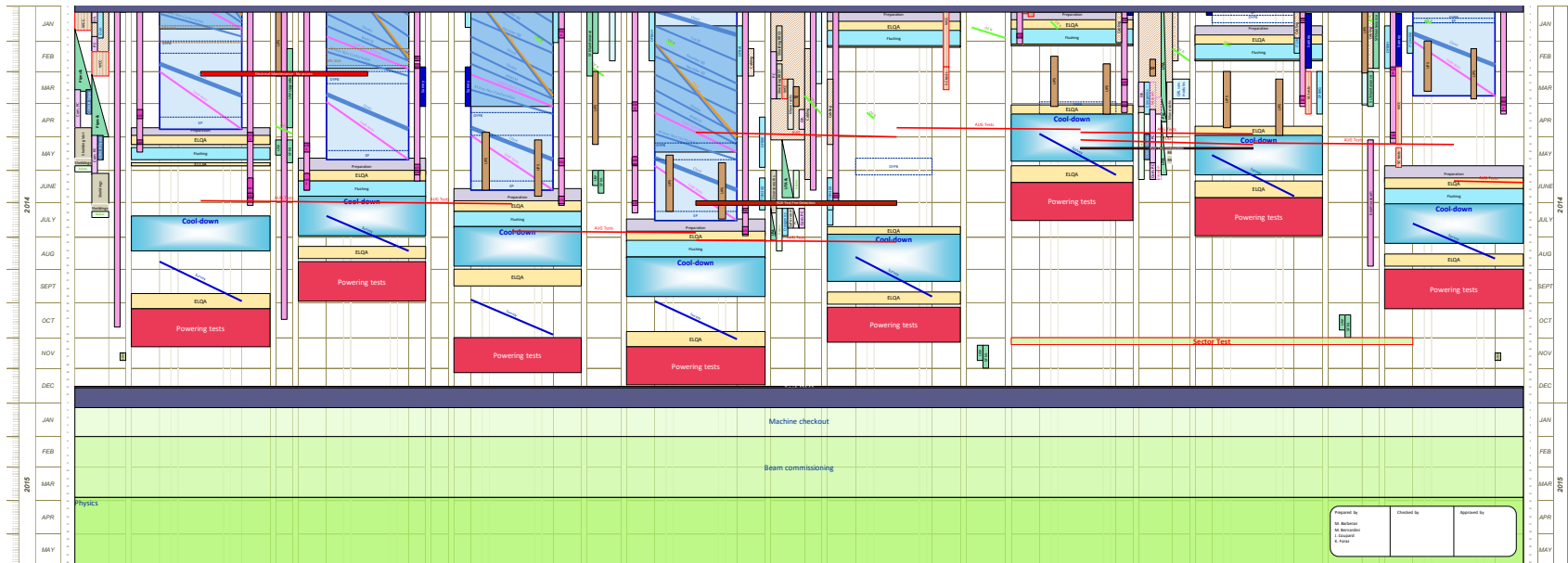
- ▶ Phase two:
 - ▶ The IT star-point rack(s) located in US to be transferred to temporary power supply before and after the power cut
 - ▶ The switchboard (EOD US) downstream the UPS systems in US is switched off
 - ▶ MP users verify that:
 - ▶ Their equipment remain powered by the redundant distribution line
 - ▶ And/or their redundant equipment A (resp. B) are still powered while equipment B (resp. A) are switched off
 - ▶ The other users (without redundant powering) can only see and note the impact!
 - ▶ Then the switchboard (EOD US) is powered again
- ▶ Test procedure in three phases for each even point:
 - ▶ Phase I has to be repeated on the right side
 - ▶ Each LHC even point → x 4
- ▶ Half-cells from I0L up to I0R in the even points + all user racks on UPS in UAs impacted!





When to Test Redundant Powering

- ▶ Obviously when all systems are present and connected → during hardware commissioning
- ▶ For each RE alcove and LHC odd point: 1 day to perform the test
- ▶ For each LHC even point: 2 days
- ▶ Strong impact on all users (especially cryogenics, vacuum and star-point racks)
- ▶ Tests to be organized with LHC coordination team (already informed)





Impact: Feedback from Cryogenics

- ▶ Cryogenics impacted when testing the F3 distribution lines
- ▶ UPS systems dedicated to cryogenics (in the 4 US zones) are not included in this test campaign (24V DC control for cryogenics not impacted)
- ▶ Feedback (courtesy S. Claudet):
 - ▶ No safety issue nor expected hardware damage
 - ▶ UPS zones to be tested one by one
 - ▶ if one $\frac{1}{2}$ arc tested at once and if well prepared: impact is rather small
 - ▶ They should be able to recover in less 4 h for a 30 min duration power cut
 - ▶ Except if some equipment do not restart or cryogenics expert intervention is required...
 - ▶ Can be done during hardware commissioning but preferably before (not to impact the other users)



Conclusion

- ▶ Assess the impact with other users (waiting for feedback from Vacuum group)
- ▶ Coordination is essential
- ▶ Use the first test as a pilot before launching the series
- ▶ In total, 24 UPS zones to be tested
- ▶ Equipment not restarting after the power cut has to be considered!