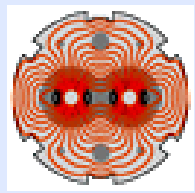


Upgrade, IST and Powering tests of the 600A Energy Extraction Systems

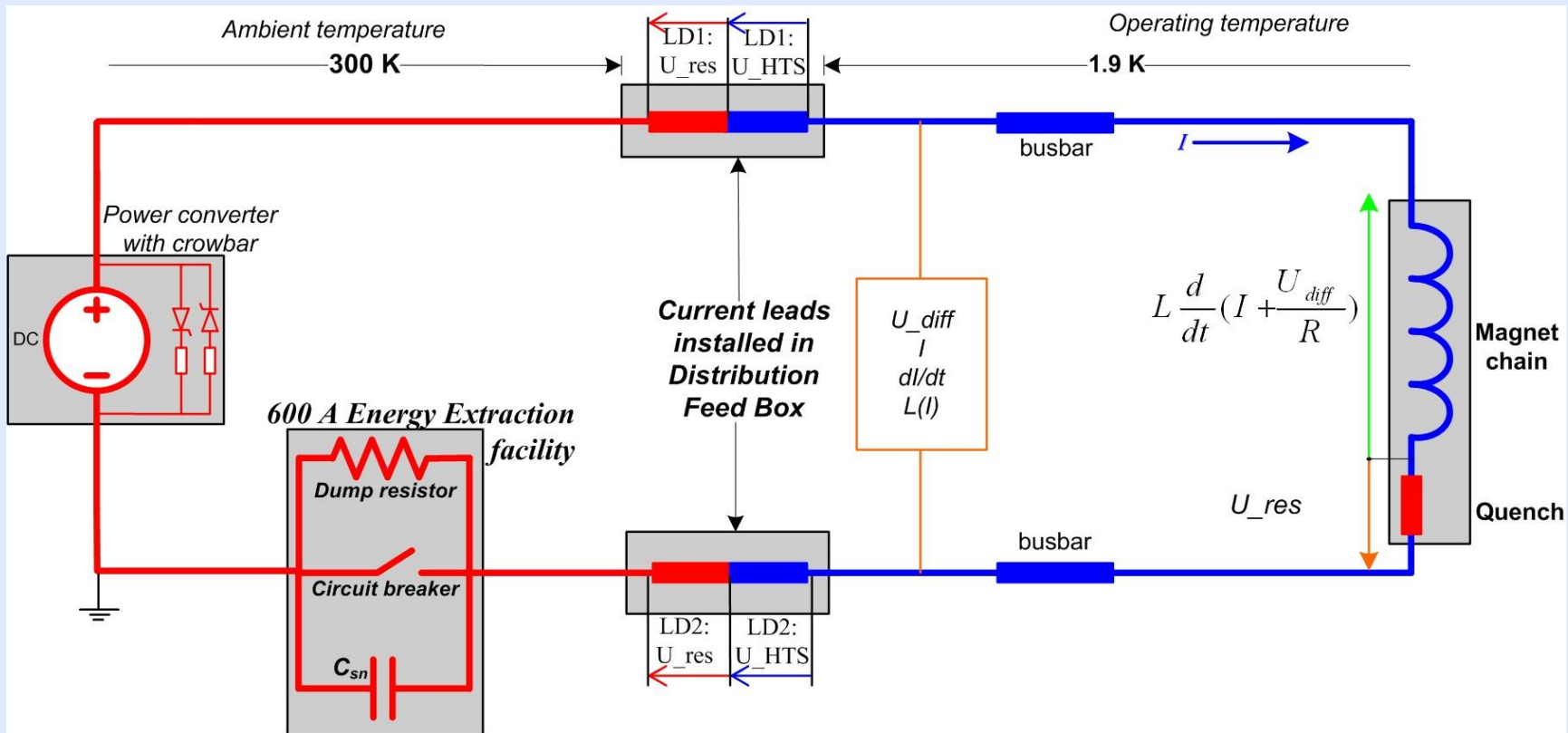
On behalf of all EE teams involved



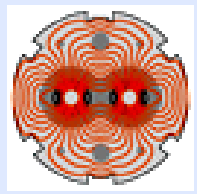
OUTLINE

1. EES introduction.
2. Planning and resources.
3. What was done during LS1, achievements / problems.
4. HWC, achievements / problems.
5. What should be learned, improved, changed.

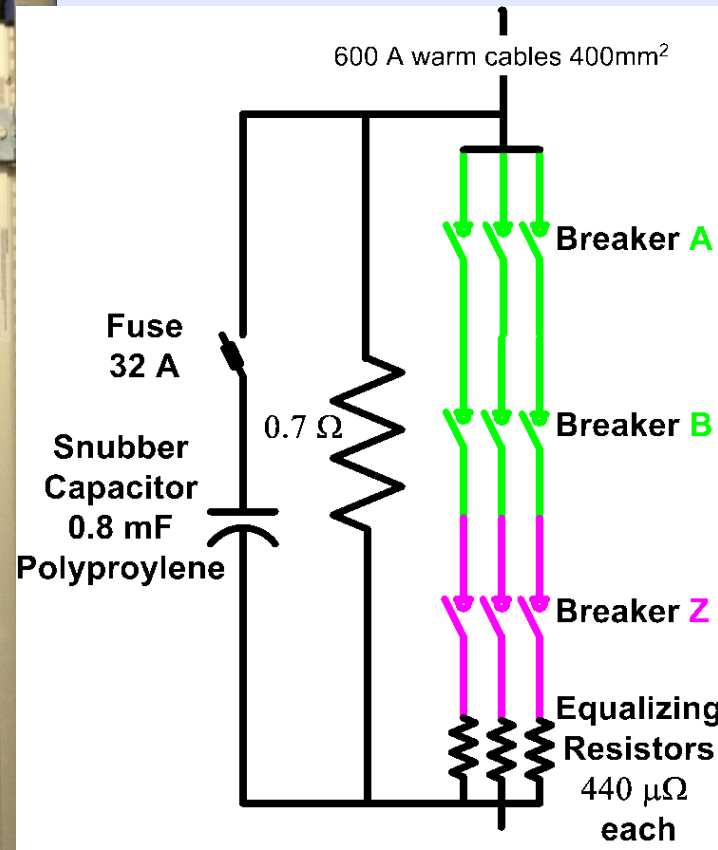
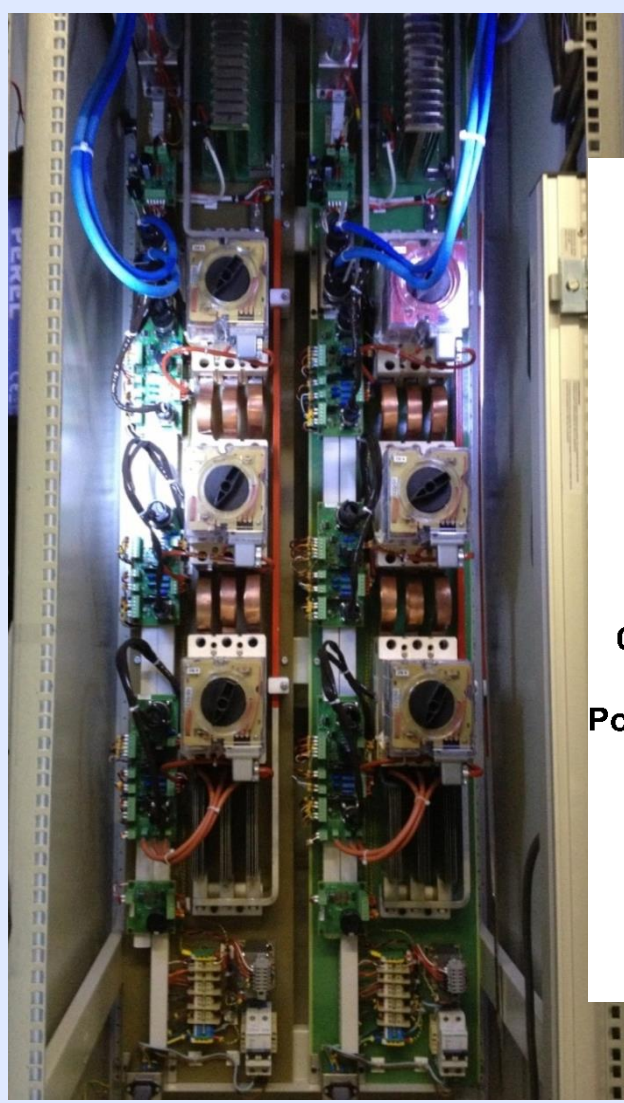
600A Energy Extraction Systems

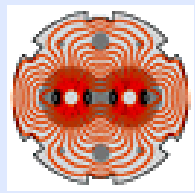


- ◆ 202 systems installed in the LHC tunnel in corrector circuits with stored energy between 2.2 and 150 kJ.
- ◆ In 15 different locations:
 - 8 x UA parallel service tunnel and 6 x RR and 1 x UJ tunnel caverns.
- ◆ Systems developed in close collaboration between CERN and the Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia. Delivered to CERN in 2005.



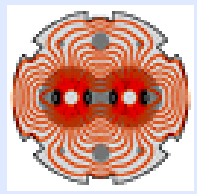
600A Energy Extraction Systems



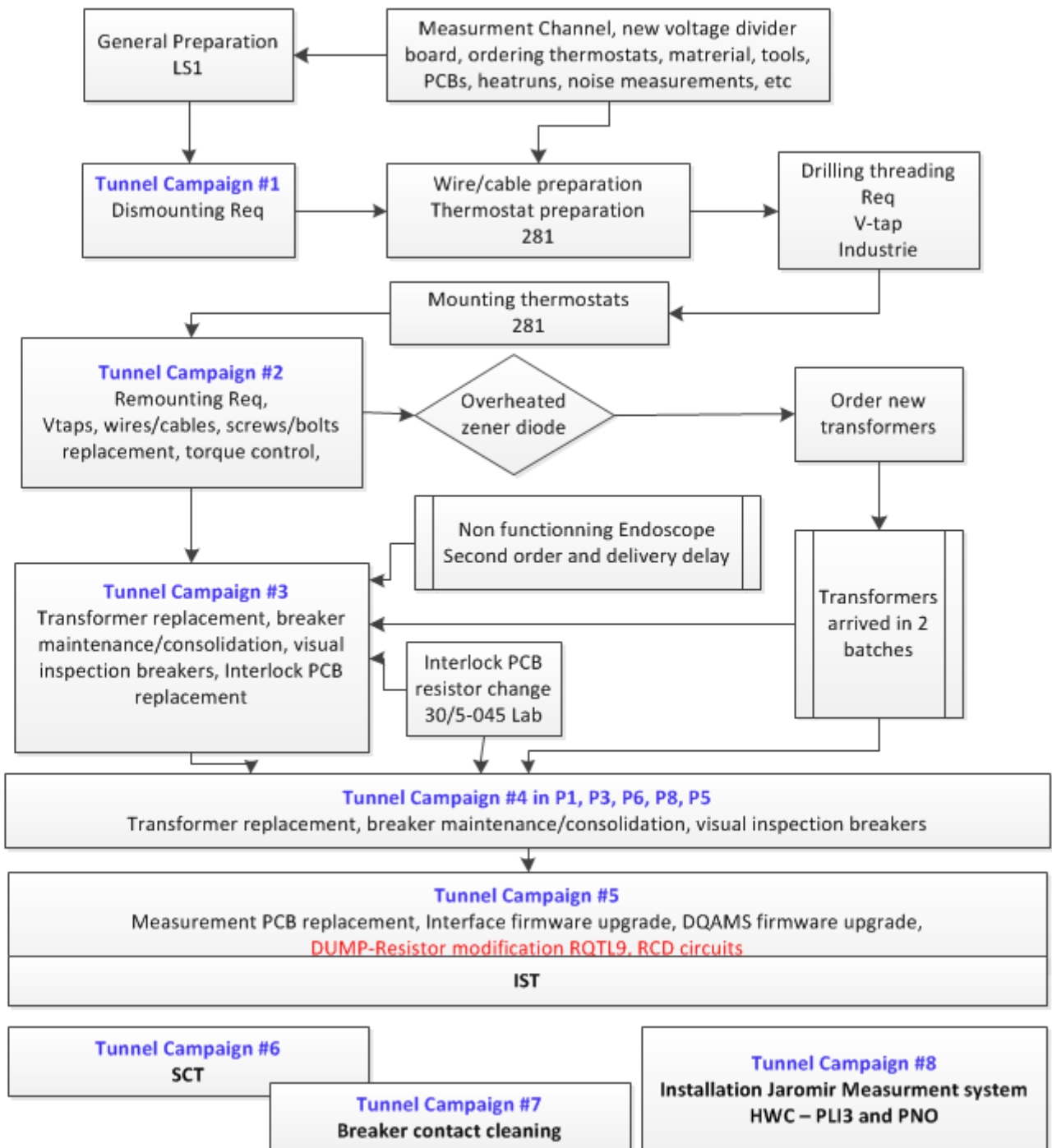


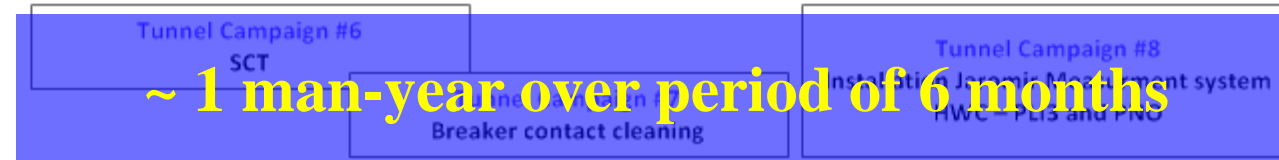
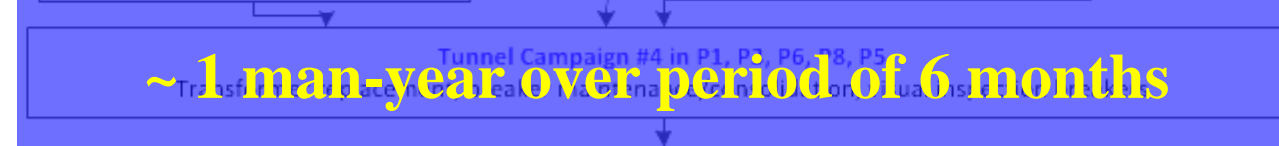
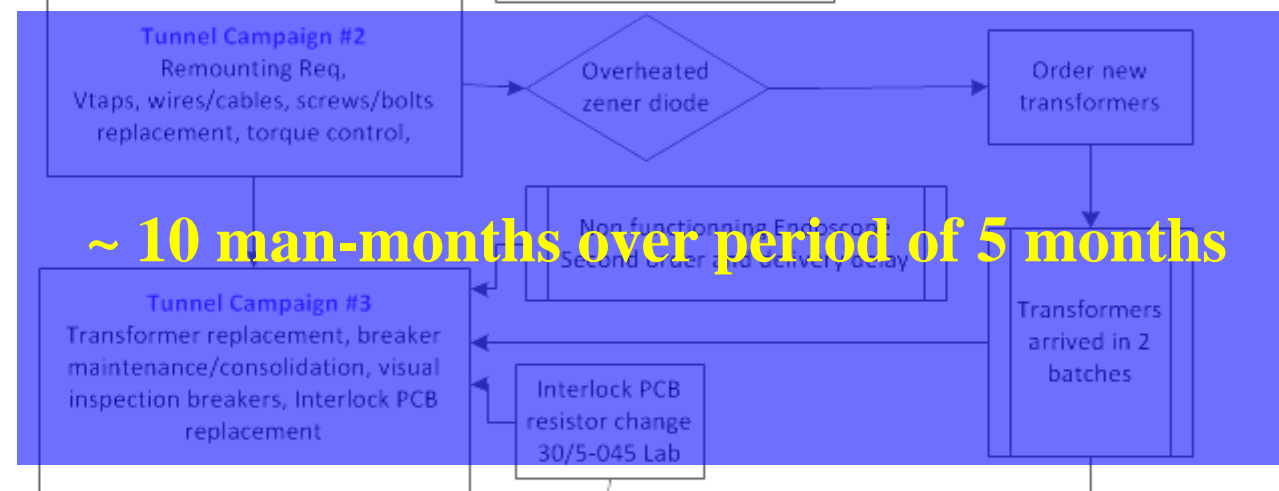
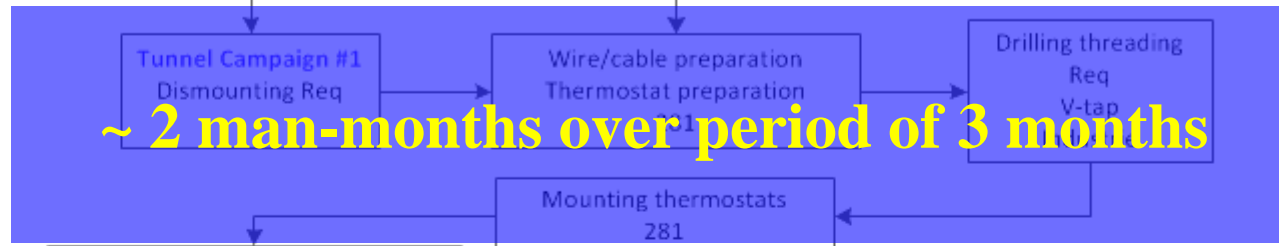
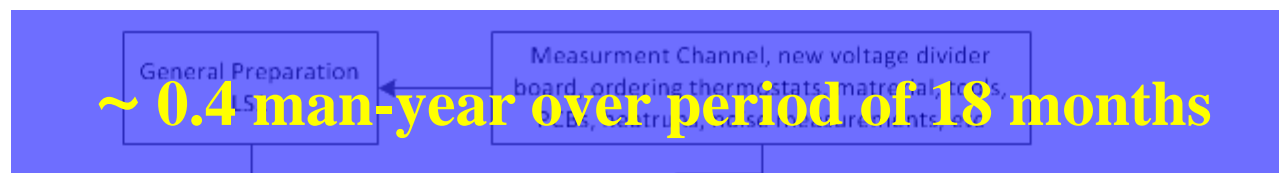
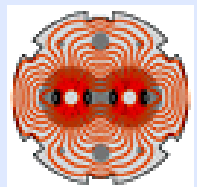
LS1 Actions

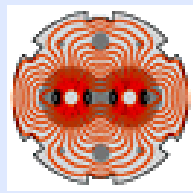
- ◆ Breakers - Regular maintenance and Consolidation.
- ◆ Equalizing Resistors – Installation & wiring of Thermostats.
- ◆ Voltage measurement channel improvement.
- ◆ Visual inspection of main axles – Endoscope.
- ◆ Individual System Test (IST) and Short Circuit Test.
- ◆ Hard-Ware Commissioning (HWC).



2011
 2012
 April 2013
 Mai 2013
 June 2013
 July 2013
 August 2013
 September 2013
 October 2013
 November 2013
 January 2014
 /
 June 2014
 /
 March 2015



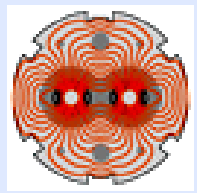




LS1 problems

- ◆ **“Internal” problems**
 - Breaker contacts: Increasing number of breakers towards the end of SCT period:
 - P6, P7, P1, P2: < 5%. “short” time between maintenance and SCT
 - P8 & P3: 30%. Reasons: One year after cleaning, high humidity (or water on the floor during long time) systems unpowered and breakers opened
 - P4 and P5: 10 % of breakers. Reason: almost one year after cleaning systems unpowered and breakers open).
 - Changing transformers (overheating of zener diodes with the old ones).

- ◆ **“External” problems:**
 - At many points AC power (UPS) was not present – hard to check the systems after interventions.
 - “water damage” in UA67 – 16 systems were replaced by spares which were just delivered 2 months before – reducing the number of new spares from 20 to 4.
 - Dust on top of the racks and water under the racks is often event => influence on the systems reliability and breakers contacts.



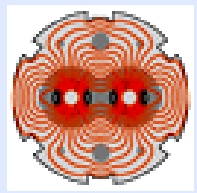
LS1 problems found

Water damages in UA67



MPE Review – June 2, 2015

A. Erokhin, TE-MPE-EE



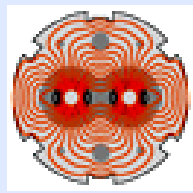
LS1 problems found

Water on the floor in UA83_87



Dust on top of the racks in UA67

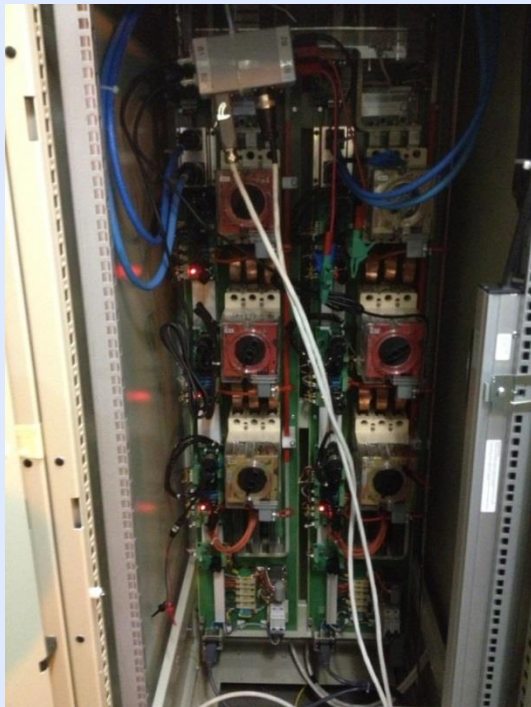
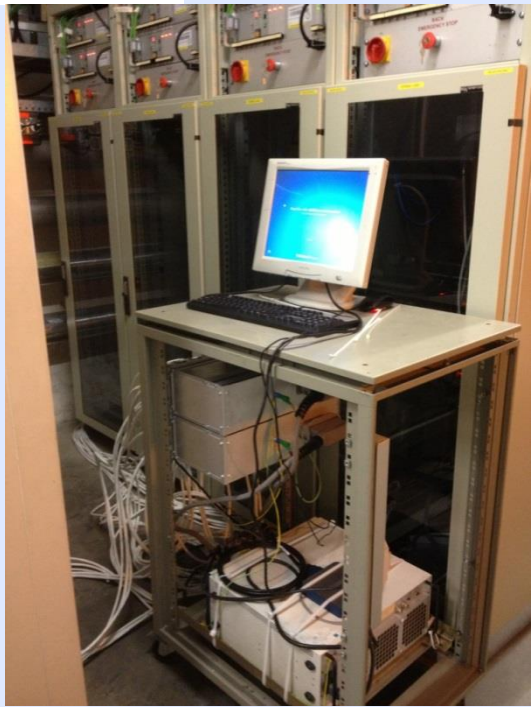
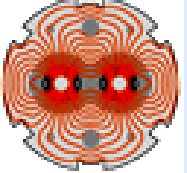




Hardware Commissioning

- **Circuits powering tests PLI3.b1 (200A) and PNO.b1 (nominal):**
EE role was to participate in PLI3.b1 and PNO.b1 tests to validate EE systems.
- **Automatic measurements in the tunnel:**
With the help of ELQA team we checked our “most worried” parameters of the systems.
- **Automatic analysis tool:**
helped to optimize the analysis efforts and delegate it to the CCC shifts

Hardware Commissioning



Automatic measurement system based on PXI

perform_the_measurement.vi

Steady state measurement | Steady state measurement analysis and saving | Opening time measurement | Opening time measurement analysis and saving | Debug | About

Power converter current [A]: 550
 Equating resistance [ohm]: 410u
 EE resistance [ohm]: 700m
 Long bus bar resistance [ohm]: 42.5u
 Short bus bar resistance [ohm]: 0

Averaged voltages: EE System 250.424m
 R1: 60.4191m
 R2: 85.1395m
 R3: 67.605m

Switch resistances [ohm]: 747.561u, 683.395u, 966.97u
 Currents in branches [A]: 196.144, 207.655, 164.69
 Dump resistor current [A]: 357.749m
 Current in branches using R_eq_calc [A]: 189.575, 200.7, 159.367

Result:
 Contacts resistance: 424.209u
 Calculated eq resistance [ohm]: 424.209u
 Total system resistance: 569.047
 Sum of calculated currents [A]: 569.047

Voltage test comments: ok
 Voltage test passed: Voltage test for report:

Application log:

Status	Action	Time
OK	R3 DMM init	17:46:09
OK	SW DMM init	17:46:09
OK	Channel switch to 1 B2	17:46:09
OK	Fetched 3 points from MEASDB with PC readouts	17:57:51
OK	Saving voltage measurement, TEST_ID = 70	17:58:28

Analysis start: 17:56:50, 09/03/2015
 Analysis end: 17:57:50, 09/03/2015

Reverse polarity: EE system under test: DQENC-UA43.RQTD.A34B2

EXIT

perform_the_measurement.vi

Steady state measurement | Steady state measurement analysis and saving | Opening time measurement | Opening time measurement analysis and saving | Debug | About

Monitor the voltages: EE system, R1, R2, R3

Measured voltages:
 EE System: 250.745m
 R1: 60.4676m
 R2: 85.1898m
 R3: 67.7939m
 Trigger: 2.11235

Voltage history graph showing voltage [V] vs Time [s].

Application log:

Status	Action	Time
OK	R2 DMM init	17:46:09
OK	R3 DMM init	17:46:09
OK	SW DMM init	17:46:09
OK	Channel switch to 1 B2	17:46:09
OK	Fetched 3 points from MEASDB with PC readouts	17:57:51
OK	Saving voltage measurement, TEST_ID = 70	17:57:51

Analysis start: 17:56:50, 09/03/2015
 Analysis end: 17:57:50, 09/03/2015

Reverse polarity: EE system under test: DQENC-UA43.RQTD.A34B2

EXIT

perform_the_measurement.vi

Steady state measurement | Steady state measurement analysis and saving | Opening time measurement | Opening time measurement analysis and saving | Debug | About

Timing Graph showing Voltage [V] vs Time [s].

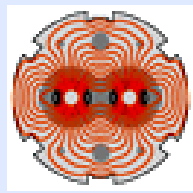
Application log:

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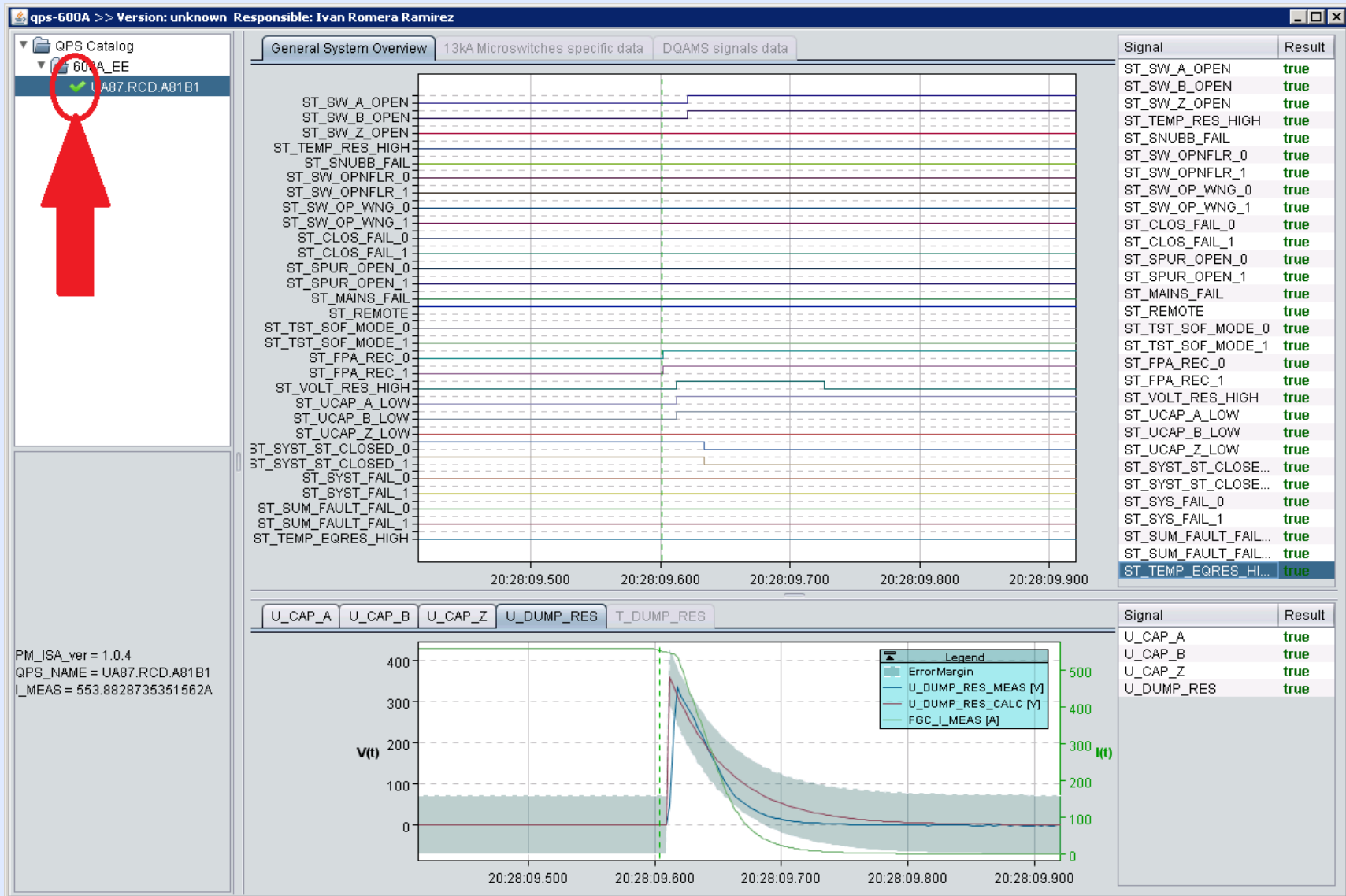
Reverse polarity: EE system under test: DQENC-UA43.RQTD.A34B2

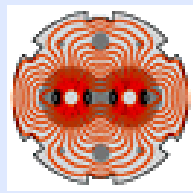
EXIT



Hardware Commissioning

Automatic analysis tool





Lessons learnt for future

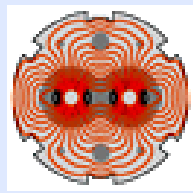


■ Positive/good to repeat

- Good planning and preparations well in advance.*
- Automatic measurement system is very useful (in and de-installation in the shadow).
- Automatic analysis tool is very useful (less need for expert presence in CCC).
- Teams involved showed lots of goodwill and worked hard.

**Preparations before LS1*

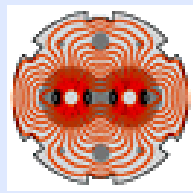
- jobs and procedures were discussed and frozen more than 1.5year before start of LS1.
- resources and time needed were calculated 1 year in advance.
- All documents (manuals for the teams detailed to minor operation including guides/pictures) were prepared approx. one year before start of LS1.
- All components and parts were ordered and received in advanced.
- All tools sets (optimized for each type of job) were prepared before start of LS1.
- Few minor items were not in time (delivering of endoscope), but did not influence the schedule.



Lessons learnt for future



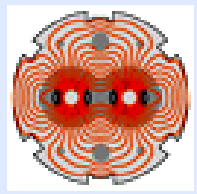
- **Less positive/ better not to be repeated**
 - External factors (listed before).
 - Too often too many breakers to clean – procedure should be optimized.
 - Rotation of personnel was not very efficient (training “on the job” in case of external short term personnel => unforeseen increase of workload of the experts); external personnel must be experienced to execute the tasks they are hired for.
 - Wi-Fi absent or bad reception in many points.
 - WorldFip and PM not operational during IST and SCT.



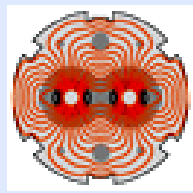
Lessons learnt for future

- **To improve**
 - More people should be trained on constant base (mostly CERN staff or long-term external personnel).
 - Automatic measurement system – should be integrated into sequencer and PM generation and analyser.
 - Automatic analysis tool – reference curves should be closer to the reality: more detailed simulations, “field” measurements results implementation.
 - Signature rights and analysis procedures (improved at the end of HWC).
 - High resolution AMS cards are still in the pipe-line.
 - Treat non-conformities on the same base as ELQA team does.
 - Start late(r) with nominal infrastructure and conditions prior to HWC (maintenance of breakers) - breakers should be cleaned as close to the HWC as possible. If SCT is needed there is only one way to do it – after the cleaning campaign.

- **To have in mind:** we have 5 sets of Jaromir’s measurements systems – should be carefully stored and kept until next campaigns, to be tested several months prior the next use.



Thanks for your attention!



LS1 actions LIST

- 1 **New Voltage divider board**
- 2 **New voltage measurement wires + Vtap**
- 3 **Thermostats on equalizing Resistors**
- 4 **New Thermostat connection PCB**
- 5 **Wiring Thermostat PCB to connector SK24**
- 6 **Replacement of A and Z imbus to hexag. Screws**
- 7 **Screwed connections "torque" check**
- 8 **Breaker maintenance general and Breaker plate gluing**
- 9 **Visual inspection main axle**
- 10 **Interlock PCB resistor change**
- 11 **Interface card firmware upgrade**
- 12 **Acquisition and Monitoring board (firmware) upgrade**
- 13 **New measurement PCB**
- 14 **Replacement of transformer (- overheated zener)**
- 15 **Dump Resistor modification - RQTL9**