

SESSION 3 – LHC HARDWARE PERFORMANCE – DISCUSSION NOTES

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Abstract

Session 3 and 4 of the 2016 LHC Performance Workshop focussed on aspects of LHC Hardware performance with a focus on system dependability (safety, availability and maintainability) in view of goals to maximize the machine's physics output in the coming years. This first of two sessions was split into six talks as follows:

- Accelerator Fault Tracker & Availability Working Group – Where do we go from here? (B.Todd)
- LHC availability – Status and Prospects (A.Apollonio)
- Cryogenics (G.Ferlin)
- Quench detection system (R.Denz)
- Electrical Performance of Magnet Circuits (F.Rodriguez Mateos)
- Power Converters (V.Montabonnet)

The aim of the session was to critically review the machine performance during the 2015 run and to discuss possibilities for further availability improvements for the coming operational years. In the following, the discussion and questions arising during and after the talks are summarised.

ACCELERATOR FAULT TRACKER & AVAILABILITY WORKING GROUP – WHERE DO WE GO FROM HERE? – B. TODD

E.Elsner commented that it is really a pleasure to have these availability figures available, which are important input for the HL-LHC and FCC: with a huge number of components this will be a truly important predictive tool for FCC studies.

R.Schmidt commented that a huge effort is done to develop a tool which could be used as well for the FCC, using LHC as a benchmark.

V.Kain asked what details are today being recorded of the faults from LHC injectors?

B.Todd replied that no detailed information is being captured for the moment, since the tool is not yet ready to record the details of the injector complex.

L.Ponce stressed that what is recorded is a generic “injectors not available”; she also added that it would be fundamental to import the same tracking philosophy to the injectors.

L.Pontevorvo expressed the interest from experiments in using this tool and asked whether it is customizable.

B.Todd answered favorably to this.

R.Losito reminded that a similar tool is available for the infrastructures (used by the TIOC) and asked whether there

is a link between the two. Everyone agrees that the two WG should work together and assess similarities in the tools used.

LHC AVAILABILITY – STATUS AND PROSPECTS – A. APPOLONIO

O.Bruning commented that the analysis done is very nice and complete. He insisted on the fact that 2015 was rather a mixture of 2011 and 2012 and cannot be compared only with 2012; in order for the management to decide on the β^* to be used this year, we should be careful in linearly extrapolating the reliability data.

M.Zerlauth on the other side pointed out that, with the main aim of increasing integrated luminosity in mind, a less aggressive choice of β^* conservative approach could maximize availability and hence integrated luminosity.

N.Holtkamp asked how one can you reduce “lost time” in ‘beam in’ mode. **M.Solfaroli** answered that possible solutions are reducing the precycle time, but also optimizing the other beam parts.

N.Holtkamp asked by how much the 21% ‘beam in’ could be reduced. **Matteo** replied that 5% could be feasible, the remaining time also includes injection.

S.Redaeli asked whether the analysis was done only for scheduled time in physics. **A.Apollonio** confirmed. **S.Redaeli** asked then whether this also includes the time lost for cryogenics to stabilize from e-cloud; **A.Apollonio** replied positively; he stressed on the fact that we could as well improve availability by reducing this time.

A.Ball reminded that getting a figure about the experiments availability is important to motivate people, above all those working at night where “good physics is typically produced”.

G.Rumolo insisted on the fact that the cryogenics optimization was obtained very late: it is therefore not easy to extrapolate from 2015 to 2016 for cryogenic availability.

W.Hofle enquired whether in “beam in” mode also a missed injection is counted. **A.Apollonio** replied positively, but without knowing exactly which fraction this would account for.

N. Holtkamp asked which are the targets for the main subsystems on which we are relying. **A.Apollonio** replied that those on slide 26 are general targets to be applied to all different systems.

F.Gianotti stressed on the predictions for 2016 and HL-LHC and asked whether we can draw a projection for the end of the run (2018). Andrea answered that a quantitative extrapolation is very difficult before having seen the impact of the YETS corrections, however the trend should remain positive.

O.Bruning reminded that for HL-LHC, one big part of the upgrade involves the alcoves and this should result in a shortening of the time for interventions.

R.Schmidt stressed on the fact that these analysis are really new and any extrapolation to longer term targets has to be considered cautiously. Without ageing, we could linearly scale for 2025 operation.

CRYOGENICS – G. FERLIN

M.Lamont stressed the fact that on slide 7, for the mitigation actions on the DFBs, the word “should” is used instead of “shall”. **G.Ferlin** insisted on the fact that tests and discussions among the experts are still required on this subject.

J.Weninger commented that the IT.R8 is displacing radially by 2 μm every 8h; when we empty, it stops moving. In 3 days of test, one could try several possible configurations to investigate the origin of this movement.

G.Arduini asked whether, on slide 18, it is correctly stated that with the new configuration, one could gain 30% in available beam screen power. **G.Ferlin** answered positively, stressing nevertheless on the prior need to intervene on the 2K valves and the consequent need to warm up the sectors to ambient temperature.

E.Chapochnikova asked whether, for beam-induced heat load, it wouldn't be useful to retrieve information about the incoming load. **G.Ferlin** observed that cryogenics is already tracking all injections to anticipate the heat load. **E.Chapochnikova** stressed on the fact that the beam energy is not the sole factor impacting electron cloud, but that intensity measurements would rather be the vital ingredient. **G.Ferlin** agreed and insisted that this is the main reason why a minimum of 3 fill are requested by cryogenics to tune their systems.

N.Holtkamp asked whether a 98% availability would be an achievable value. **G.Ferlin** answered that this could be pretty difficult, as the associated cost would be considerable. **M.Zerlauth** stressed on the fact that one of the next goals of the AWG is to quantitatively answer these exact questions, i.e. to estimate the physics gain versus the investments.

QUENCH DETECTION SYSTEM – R. DENZ

F.Bordry enquired whether somebody is keeping track of the whole statistics of QH discharge (also including run I). **R.Denz** answered positively, even if the data are not comparable due to the continuous upgrades and changes, also in terms of quality and accuracy.

F.Bordry wanted to know the basis of the stated value of 96% QDS availability to guarantee smooth operation – obviously any increase to say 98% or beyond would be even better.

N.Holtkamp asked how much it would cost to have a fully redundant QDS. **R.Denz** answered that doubling the QDS could cost several millions, mostly due to the considerable additional cabling and HW cost.

E.Bravin asked what would be the impact on operation following the change of the undulator protection. Will it improve the possibility of more frequent cycling or just allow higher ramp speed? **R.Denz** stressed that the planned

upgrade will already bring faster didt's for the circuit, allowing to ramp it up/down in ~ 30 min. The EE section is furthermore working on installing dedicated DCCTs to measure the didt in the circuits which would result in easier compensation. It still needs to be assessed how much this would gain for protection.

ELECTRICAL PERFORMANCE OF MAGNET CIRCUITS – F. RODRIGUEZ MATEOS

M.Pojer observed that the idea of a “circuit separator” is clever and certainly useful for punctual interventions during operation (i.e. earth fault investigations). During long(er) stops, the usual disconnection of the water cooled cables from the current leads should be done, since the water pressure is fluctuating a lot (being reduced), potentially resulting in undesired big huge forces on the current leads.

M.Solfaroli, referring to slide 11, observed that in the event of icing of a current lead, no interlock is being triggered. It is important to understand whether such an event is dangerous and whether (and at what point) one should stop operation to intervene. **F.Rodriguez Mateos** agreed that this point should be clarified with the responsible team.

Q.King commented on the ongoing studies concerning solid state switches to replace the mechanical energy extraction switches. **F.Rodriguez Mateos** confirmed that this is an important ongoing activity and developments are well advanced in view of a first deployment in SM18. However, there was no time to report in detail on this subject during this workshop.

N.Holtkamp observed that there is a large number of systems to be maintained and asked if written procedures for the maintenance of each component exist. **F.Rodriguez Mateos** confirmed that such procedures exist for the EE systems and for the switches, but for Quench Heater Power Supplies (QHPS) only procedures for equipment replacement exist today. The effect of aging still needs to be understood and addressed in detail.

POWER CONVERTERS – VALERIE MONTABONNET

F.Bordry asked whether MTBF estimates for the different power converter types exist and whether they can be reliably quantified? **V.Montabonnet** replied that 50.000 hours is a rough estimate.

R.Schmidt observed that the proposed (active) orbit correction strategy will not be required next year, which is why he questioned the effort of such an investment. **J.Weninger** agreed and stressed the fact that most of the dumps occur in stable beams, where a too coarse correction cannot be applied. Concerning the realignment of quadrupole magnets to reduce the kick strengths, he observed that a recent realignment did not change the situation considerably.