DISCUSSION SUMMARY AND ISSUES TO BE FOLLOWED UP FOR SESSION 6: SYSTEMS OPERATIONAL PERFORMANCE

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Abstract

Three contributions were presented in this session: *Tune and Orbit Feedbacks Performances: A User Perspective* by Laurette Ponce, *Beam Instrumentation Performance Overview* by Mariusz Sapinski and *LHC RF 2011 and beyond* by Philippe Baudrenghien.

This contribution recapitulates the outlooks given for 2012, the points to be followed up and the discussions originating in the "Systems Operational Performance" session.

TUNE AND ORBIT FEEDBACKS PERFORMANCES: A USER PERSPECTIVE

Outlook, Follow-up and Discussion Summary

One of the three main causes of beam dumps due to feedback issues during 2011 was the triggering of the quench protection system (QPS) by the real time trims sent by the tune feedback (QFB) oscillating at high frequency or sending too large corrections to the trim quadrupoles. Two mitigation measures were presented. The first one is to increase the QPS threshold U_res during the winter technical stop. This would be possible since, according to recent simulations, the system still allows for some relaxed values. Presently, the system is configured such that below 50 A the U_res threshold is at +/-2 V and then above 50 A the threshold is decreased to +/-100 mV. The system triggers if the threshold is exceeded for more than 190 ms. The proposed change is to keep the threshold at +/-2 V up to 100 A. At and above 100 A the U_res threshold will be +/-100 mV and the maximum current remains 200 A. This solution raised a possible issue from the Machine Protection point of view during the discussion session by R. Schmidt who pointed out that this could give time to the beam to develop instabilities and that the beams are dumped in any case. R. Denz replied that other less aggressive values are possible but all this needs testing time.

The second proposed mitigation measure is to reduce the tune feedback response bandwidth by a factor of 5. This was already successfully tested with ions in 2011 and remains to be tested with protons, possibly after a feed forward correction. The original high feedback gain was motivated by the initial specification to keep the tune deviation below 0.001. This specification will have to be relaxed accordingly.

At several occasions the tune feedback was switched off either manually or due to its automatic instability detection, especially during the last part of the squeeze. But recently there has been a problem in the horizontal plane during a sizable number of fills: the orbit feedback was pushing the orbit to one side as if trying to compensate a "non-physical" energy offset, which modifies the tune. With the tune feedback off, this offset is not corrected. During the talk and the discussion session it was stressed that the origin of this problem is not yet understood and needs to be solved.

During the talk, a review of the upgrades foreseen for 2012 in order to improve the tune measurement quality was performed. Adapting the dynamic range for higher bunch intensities will solve the saturation problem. Commissioning time will be required to find more adequate settings of the transverse damper (ADT) and the tune measurement (BBQ), which would allow for better tune measurements while actively damping the beam. Three alternatives were presented: beam excitation (chirp) could be used to enhance the tune signal; the ADT signal might be used to measure the tune; or a gating of the ADT and the BBQ system could implemented. The ADT system was already tested in a configuration where the first 12 bunches are not damped, and a BBQ setting which is exclusively measuring the first 12 bunches would need to be implemented. S. Redaelli reminded that when the tune feedback is on, it is very difficult to reconstruct off-line the coupling measurement. R. Steinhagen mentioned that certain functionalities of the system are improved by certain parameter settings while the performance of others is scarified. Therefore, a list of requirements and priorities should be passed to the feedback team so that the system can be optimized accordingly.

The proposed mitigation strategy for the orbit excursions during the squeeze (around the match points) is to apply the following procedure: perform one squeeze with high gain and low intensity and apply a feedforward based on the recorded feedback trims of this squeeze; if successful, the orbit feedback can then be operated with a lower gain.

BEAM INSTRUMENTATION PERFORMANCE OVERVIEW

Outlook for 2012 and Follow-up

The following improvements can be expected for 2012 (mostly for the start-up already):

BPM:

- LSS BPMs: selecting bunches without nearby parasitic encounters with the opposite beam by using masks to avoid crosstalk
- Automatic selection of integration time - improved orbit position resolution (1 μm)

- Temperature dependence still there: improvement of the software correction algorithm to be worked on during 2012; one thermally stabilized rack installed in SUX1 since November 2011 for testing (if successful, replacement of all racks planned for LS1).

LDM:

- Fully automatic and improved fixed display

Wire scanner:

- Automatic gain/filter setting

BSRT:

- 20 times faster bunch-by-bunch measurement
- Better accuracy (will require further MDs in 2012 to improve this)

BGI:

- Independent continuous emittance measurement

Schottky:

- Bunch-by-bunch tune measurement

Since the problem of the variation of the BPM readings with the temperature cannot be mitigated in 2012, the speaker reminded that the BPM calibration should be just before injecting beam. In case too much time has passed since the BPM calibration, it would be beneficial to repeat the calibration.

During special runs with low intensity bunches (MDs for example), the interlock BPMs in IP6 have triggered beam dumps because the intensity of some bunches fell below the threshold of 3 10^{10}. The threshold can be adapted for 2012 to approximately 2 10^{10}. This might give more spurious triggers at high bunch intensity due to cable reflections. A maximum bunch intensity of 1.6 10^{11} should be considered for 2012.

Beam commissioning time will be requested for:

- Calibration of BSRT at 450 GeV and 4 TeV
- Calibration of BGI from 450 GeV to 4 TeV
- Systematic study of LSS BPM accuracy and linearity

A number of GUIs would need the designation of an OP responsible:

- Improved WS GUI including automated scan possibility
- BSRT bunch-by-bunch control and display
- More advanced BGI GUI
- LDM GUI

Discussion Summary

One of the aims of the BSRT team for 2012 is to publish corrected beam sizes with an error in the order of ±10 %. G. Arduini asked what is the best precision that can be achieved with the BSRT for relative measurements. F. Roncarolo answered that all depends on the wire scanners since they are used to cross-calibrate the BSRT.

G. Papotti asked if the BPM post-mortem data is available for IP5; the answer was that yes, it has been already there during 2011.

One reported wire scanner issue is the noise which appeared for beam 1. E.B. Holzer asked if the origin of the noise has been identified. The answer was that no, it has not been identified, but a solution has been put in place which consists of automatically suppressing the noise at the level of the front-end.

One concern expressed by V. Kain was when the beam instrumentation (BI) machine developments (MD) will take place since, for the proper analysis and understanding of the BI data, it is crucial to have devices well calibrated. M. Lamont answered that in 2012 the MD for BI are scheduled for the first MD block that will take place five weeks after the start up.

LHC RF 2011 AND BEYOND

Outlook and Follow-up

First results were shown on an ongoing investigation of more gentle techniques for longitudinal blow-up. The aim is to reduce the high frequency part of the beam spectrum and make the blow-up even more versatile. This would allow its use at constant energy: for example batch per batch blow-up at injection to reduce intra beam scattering (IBS) effects during filling. This could be especially interesting as a smaller longitudinal emittance is expected from the SPS with the low γ_t optic. It is proposed to do a few physics fills with different lengths at the beginning of 2012 to find the optimal bunch length as a compromise between good beam lifetime in physics and heating problems.

Filling has been made easier in 2011 by the increased capture voltage, the injection gap cleaning, and the installation of shielding. But injection losses are expected to increase again with the 25 ns operation, as the SPS parameters will vary more along the batch. As a mitigation measure, the longitudinal damper will be commissioned in 2012. For 25 ns operation the present RF system can (probably) cope with nominal beam intensity. But for above nominal intensity in 25 ns operation, additional work on the low level RF is required in addition to careful studies of the effects of a trip on the major RF components. It is important to start this work before LS1. RF commissioning and MD time will be needed.

Two hardware upgrades during LS1 were presented: the klystron heaters which have been recuperated from LEP will be upgraded; the RF module 1B2 will be replaced, as field emission in the 3B2 cavity is believed to cause the HOM problems in the adjacent 2B2 and 4B2 cavities.

Discussion Summary

The beginning of the discussion session on this topic concentrated on the intensity limits foreseen for 2012 from the RF point of view (G. Arduini). P. Baudrenghien answered that the RF can perform with 1.7 10^{11} protons per bunch for 50 ns, which is the equivalent bunch current

for nominal LHC. I. Papaphilippou asked if 2 10^{11} protons per bunch for 50 ns would be fine as well. P. Baudrenghien answered that yes, because what matters is the total current in the machine.

Another point of interest for G. Arduini was the expected configuration of the RF interlocks for 2012. Currently, due to the klystron trips experienced at the beginning of July that dumped the beam, the RF beam interlock input dumps the beam if one klystron trips. P. Baudrenghien explained that for the moment the same configuration would be kept during 2012, nevertheless, during the Christmas stop the RF team will think about a more flexible configuration for protons. Concerning ions the situation is a bit more understood since in 2011 the machine was operated successfully with some transmitters off. Therefore, there is more margin there.

During the presentation P. Baudrenghien presented a new method for driving the longitudinal blow-up which seems promising. Nevertheless, J. Jowett expressed that for ions, the classic way of blowing up the beam is better from the intra-beam scattering point of view. J. Jowett asked as well if for proton-lead operation it is possible to have two different blow-ups. According to P. Baudrenghien this is not a problem.

During the presentation it was made clear that the performance of the RF system had decreased significantly during the ion run with respect to the proton run. More beam dumps provoked by RF failures happened during the ion run than during the proton run. O. Brüning asked if the reasons are understood. P. Baudrenghien explained that part of the equipment was recuperated from LEP and starts to age/fail; D. Valuch added that the most critical parts will be changed for the start-up in 2012 and it is expected that the situation will improve.

Concerning the bunch length M. Lamont asked if it could be increased, and P. Baudrenghien answered that yes, but an increase of bunch length comes together with more beam losses as could be observed during a RF MD where the BCT losses as a function of the bunch length clearly showed a correlation.

S. Fartoukh asked about the minimum bunch length that can be achieved at 7 TeV since a smaller bunch length reduces the Piwinsky angle, and therefore keeps the luminosity loss factor as close as possible to 1 when reducing β^*. For the most likely beam parameter scenario discussed for next year: $\beta^* = 70$ cm, $\sigma_s \sim 9$ cm r.m.s. (or 1.2 ns) and a beam separation of 9.3σ at full crossing angle, the luminosity loss factor is around 0.85, already 15% lower compared to purely head-on collisions. E. Chapochnikova answered that at 7 TeV and 12 MV capture voltage the minimum σ_s is 0.8 ns ($4\ \sigma$) from Landau damping considerations. The value quoted in the design report of 1 ns was determined by the intrabeam scattering effect in the transverse plane. The operational value in 2011 of 1.25 ns was determined by the problem of heating but reduces the lifetime as demonstrated in recent MD with single beams.