DISCUSSION SUMMARY OF SESSION 5: HIGH INTENSITY: PRESENT AND FUTURE

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Abstract

This paper summarizes the discussions that followed the presentations of the "High Intensity: Present and Future" session at the LHC Performance Workshop, Chamonix 2011. The identified action items are also summarized.

INTRODUCTION

The fifth session of LHC Beam Commissioning Workshop was dedicated to the present and future of high intensities at the LHC and included six talks:

1) **Beam Cleaning and Collimation: Too Bad or Too Good?**, by Ralph Assmann (BE-ABP);
2) **Limits for Beam-Induced Damage: Reckless or too Cautious?**, by Alessandro Bertarelli (EN-MME);
3) **Radiation to Electronics: Reality or Fata Morgana?**, by Markus Brugger (EN-STI);
4) **Radiation Protection: How (radio)active are we going to be?**, by Stefan Roesler (DGS-RP).
5) **Collimator Improvements 2011 and Upgrade 2012: What Do We Plan?**, by Stefano Redaelli (BE-OP).
6) **RF System: Is It Working Well Enough?**, by Philippe Baudrenghien (BE-BI).

For each presentation of the session, summaries of the discussion that followed the presentations are given. A summary of the critical points and open actions is also given.

BEAM CLEANING AND COLLIMATION: TOO BAD OR TOO GOOD? (R. ASSMANN)

L. Rossi asked what are the limitations for going below 1.4-1.5 m in β^* in 2011. R. Assmann replied that β^* is limited by the aperture in the triplet. In particular, the uncertainty on the orbit in the interaction regions is one of the main sources of concern (orbit drifts reduce the effective aperture). *R. De Maria* asked if the present situation could be improved. Ralph replied that the orbit stability is already excellent but might be improved further. *J. Wenninger* clarifies that further improvements will only be possible if the BPM stability could be reduced: a control to better than 50 μm is required (assuming collimator retractions down to 0.5 σ).

S. Myers welcomed the good news that in the first year of operation we have a collimator performance that ensures already 30 % of the required performance for nominal intensities at 7 TeV (with intermediate collimator settings). Do we really need to change the layout and move the magnets in the dispersion suppressors or can we hope to achieve the nominal performance with the present system? *F. Bordry* shared the same question and asked whether the initial assumptions were too pessimistic. R. Assmann replied that his predictions for 7 TeV assume the same peak loss rates seen at 3.5 TeV. We cannot know at the moment if this good conditions will be maintained at higher energy. *S. Myers* also commented that the extrapolations to higher energy and intensities shall take into account the global picture, for example that we can now operate the machine with emittances well below nominal so we could have tighter collimator settings. There might be margin for further improvements of cleaning.

Referring to previously announced figures of collimation performance, compatible with only 40 % of nominal intensity at 7 TeV (cleaning without imperfections), *L. Rossi* asked where is the gain coming from. Possibly from smaller imperfection than assumed? R. Assmann replied that the predictions for imperfections actually match well the observed cleaning. The overall gain in cleaning comes essentially from the good beam lifetime that is much better than what originally assumed.

R. Schmidt commented that the 7 TeV operation will not be achieved immediately after the splice consolidation. Operation at a lower energy, e.g. 6.5 TeV, looks achievable in a shorter time scale. What are the performance estimates for energies below 7 TeV? R. Assmann replied that the estimates are included in the plots of his slides. The gain for small energy changes is not significant. The largest uncertainty remains the scaling of loss rates.

V. Shiltsev wondered if the collimation cleaning depends on any single-bunch parameter, like bunch intensity or emittance. R. Assmann replied that the collimation setup is validated by loss maps that are done with individual nominal bunches, then blown up by 3rd resonance crossing. The maximum loss rates with different bunch parameters and configurations have so far shown a similar behaviour of what is observed for single bunches. *S. Redaelli* pointed out that this is not the case for UFOs. More details about this topic are discussed in Session 6.

Considering the collimator upgrade programs, *S. Myers* commented that in the light of the good collimation performance, it seem reasonable to put more priority on speeding-up the collimation setup time rather then on improving the cleaning performance. For example, we should put more pressure on the production of collimators with BPM integrated.

B. Dehning asked if the possibility to reduce the setup time with faster BLM acquisitions is still being pursued. *S. Myers* asked if we could consider for example to use fast acquisition from diamond detectors. R. Assmann replied that optimized alignment based on faster BLM acquisitions are still being pursued. On the other hand, BLM-based setup will require still dedicated fills because one cannot "touch" the beams with many MJ stored whereas the BPM-based solution does not. The discussion on the possible scenarios for the different upgrade strategies was then postponed until the talk by S. Redaelli.

LIMITS FOR BEAM-INDUCED DAMAGE: RECKLESS OR TOO CAUTIOUS? (A. BERTARELLI)

L. Rossi pointed out that, the assumption that all the bunches of one train hit the collimator jaw on the same spot on the callimator jaw, is not realistic. A. Bertarelli agrees but commented that in this stage of simulations, the exact bunch distribution in not relevant. The difference between bunch positions is anyway in the order of a fraction of a beam size (*B. Goddard*).

S. Myers recommended to repeat the simulations for the final 2011 beam parameters that will be agreed as an outcome of this workshop (bunch spacing, energy, emittance, ...). A. Bertarelli commented that the dependence on individual parameters has been addressed but he agreed to repeat the studies with the final parameter set. Results can be obtained in about 1 month. *R. Assmann* commented that then onset of damage threshold was not addressed by these studies and should be addressed in future work. For example, the emittance can have an impact can have an impact on the damage onset whereas the presented static simulations depend only on the deposited energy distribution (that has limited dependence on the emittance).

L. Rossi asked if the case of ion losses has been addressed as well. A. Bertarelli commented that studies are possible but not yet done. The difference between particle types are handled by FLUKA, which is used to generate energy deposition maps, then used as input the the simulations. R. Assmann reminded that ion losses are predicted to affect only the surface of the collimator.

R. Losito commented that at present we have no means to detect beam impacts on a collimator. He also asked if it is possible to experience collateral damage, e.g. vacuum leaks, even if the collimator itself remain without damage. A. Bertarelli replied that risks of water leaks were excluded in the simulated failure scenarios. *A. Dallocchio* reminded that was can use temperature sensors mounted on the collimators. *R. Assmann* said that serious damage levels can also be seen operationally from the collimator response on beam losses.

B. Goddard asked if the figure of 1 failure per 300 years given in the presentation covers the setup case periods. R. Assmann replied that this figure is calculated for standard operation. He also commented that during the setup the triplet remains protected in all cases because the alignment is carried out for small collimator gaps.

J. Wenninger reminded that the failure scenarios discussed involved combined failures and very big offsets between jaws and beam. At every beam dump we can cross check the relative alignment of the various collimators and a proper analysis should allow us to minimise the risk that such big errors occur (quality control by operation). R. Assmann agreed and states that this is indeed the reason while we have insisted to have regular loss maps during standard beam operation.

G. Arduini asked if there is a limit in the energy density of the beam that applied for the operation in 2011 and for the future years. This does not appear to be an important parameter according to the simulations presented. R. Assmann stressed that he expects that the onset of damage must depend on the beam emittance.

In response to the statement by A. Bertarelli that models could be improved if the material data from other laboratories were publicly available, *S. Myers* recommended that we must try to get material data from the Los Alamos laboratory.

RADIATION TO ELECTRONICS: REALITY OR FATA MORGANA? (M. BRUGGER)

S. Myers asked if R2E issues can potentially limit the LHC peak luminosity. M. Brugger that this is indeed the case in the IRs, were dose to electronics scale with the luminosity. *S. Myers* also asked whether 3 months of work will be sufficient in the next shutdown to make significant improvements. M. Brugger reply that we cannot re-locate everything during 3 months but this time could certainly help fixing some weakest points to be identified during the 2011 operation. S. Baird commented that this aspect should be reviewed critically because it can potentially stop other foreseen activities in the IRs.

S. Myers also commented that in some cases the estimates are 3 times worst than originally predicted. M. Brugger warned that the error bars are also larger for the cases with a few data points.

J. Jowett asked about the understanding of the ion losses that caused some issue during the short ion operation in 2010. Are there serious problems that can be anticipated for 2011? M. Brugger commented that the problems encountered have been partly addressed by the QPS team (e.g., automatic reboot of QPS servers) and should not represent a limitation for the next year of operation. *R. Assmann* also commented that a different location of losses was found for B1 and B2, caused by a different dispersion function. The optics could be re-matched to reduce these difference and to optimize the loss pattern. *M. Giovannozzi* confirmed that the ABP optics team is looking into this problem.

P. Collier asked if the sensitivity of equipment could depend on the total absorbed dose. M. Brugger replied that this effect exist but in principle we will remain far from the regime where this becomes important.

L. Rossi commented that, according to simulations, we will need an access every 2 days in 2012. M. Brugger warned again that these figures depend critically on the equipment sensitivity, which could not yet be addressed experimentally due to the low statistics in 2011.

RADIATION PROTECTION: HOW (RADIO)ACTIVE ARE WE GOING TO BE? (S. ROESLER)

In response to a question by *L. Rossi*, S. Roesler reiterated the there should be no issue in 2011 or 2012 for people to carry out the splice work.

A. Siemko asked whether all the radioactive components will be marked as such in the tunnel. S. Roesler replied that the most radioactive components will be marked. In general, all the components in the tunnel should be considered as radioactive.

R. Assmann asked if the present baseline that foresee implementation of a fully remote collimator handling in 2015-16 is still acceptable. S. Roesler confirmed that this is the case.

COLLIMATOR IMPROVEMENTS 2011 AND UPGRADE 2012: WHAT DO WE PLAN? (S. REDAELLI)

R. Losito asked if we need to replace all collimators (or at least all TCTs) with BPM-integrated collimators. S. Redaelli replied that the gain in time for the alignment clearly goes linearly with the number of collimators equipped with BPMs. According to the 2010 experience, the bottleneck during operation are the IRs, mainly due to the frequent configuration changes requested by the experiments, so priority should clearly be put on the TCTs (16 collimators in total).

Referring to results from the impedance team that show how a few collimators can have significant impact on the total impedance, *O. Brüning* asked what is the impact on inefficiency by opening the gaps of a few collimators critical for impedance. S. Redaelli replied that this needs to be addressed. As a general figure, the global cleaning depends moderately on individual TCSG collimator positions.

In response to a question by *R. Schmidt*, S. Redaelli commented that R2E estimates predict that the radiation to electronics in IP3 will be about a factor 100 smaller than in IP7. This is the leading motivation behind the proposal of a combined betatron/momentum cleaning in IP3.

M. Lamont commented that in 2010 we also spend a lot of time for loss maps used to validate the collimation system settings. Any improvements foreseen there? S. Redaelli replied that there is work ongoing to use the transverse damper to blow-up individual bunches. This could enable performing loss maps for several cases within one single fill. This work has also to be combined with special configurations for setup beam flags as it does not help to have many bunches at top energy if we cannot mask the BLM to perform loss maps.

P. Collier encouraged to work on understanding the relation between measured orbit at the collimators and offsets found in the beam-based alignment campaigns. It should be possible to extrapolate the collimator settings at different times in the cycle. S. Redaelli agreed. This activity will be followed up. *R. Assmann* warned that an attempt was made for the TOTEM Roman pots but it was not success full and finally we had to use in all cases the settings established with beam-based alignment.

S. Bertolucci asked what is the time line for the production of collimators with BPM integrated. A. Bertarelli replied that for the moment this option was not given priority and was considered as less urgent than the activity on the dispersion suppressor in IP3. One could change priorities but still there is a need for a significant amount of work for prototyping and testing. *P. Collier* asked whether one should consider installing normal BPMs, not integrated into the jaw, next to the TCTs. *R. Jones* stated that this will not be a viable solution because the temperature effects on the BPM reading is still too larger. *S. Weiss* also commented that one must envisage early on additional cabling for the new BPM.

As a general conclusion after a lively discussion about the project priorities, it was agreed to follow-up with higher priority the option of installing collimators with BPM integrated already at the first long shutdown. The final choice on the project strategy will be agreed upon at the review foreseen for mid-2011.

V. Kain said that one could consider a BPM-integrated design also for the collimators in the transfer line. S. Redaelli asked if the study of line stability is not sufficient to address orbit issues in the collimators. V. Kain replied that there are relatively few BPMs that can be used for that.

RF SYSTEM: IS IT WORKING WELL ENOUGH? (P. BAUDRENGHIEN)

P. Collier asked if the 200 MHz capture system would reduce the injection losses further. *E. Ciapala* commented that even the capture system will not get it down to zero. Tolerance on injection losses are really tight due to the BLm thresholds. The 200 MHz system was dismissed due to operational risks and it should be be considered as an option. P. Baudrenghien also commented that the transfer to the 400 MHz system would then engender losses.

In view of possible issues for higher energies, P. Baudrenghien also commented that the controlled blow up stability does not depend on energy. The required voltage will be (slightly) increased at higher energy as well when full klystron power is available. But there should be no major issue.

R. Assmann asked how much time will be required for commissioning higher voltage. P. Baudrenghien replied that they would need some dedicated time needed at the start up. Time estimates are not available yet.

ACTION ITEMS

The following action items were identified for this session:

- **Future simulation of W collimator damage**:
  1) Realistic simulation with the 2011 operational parameters.
  2) Simulate onset of damage: damage threshold (emittance).
  3) Can we get additional material properties from Los Alamos?

- **Radiation to electronics**:
  1) Prepare as much improvement as possible for 2011/12 shutdown.
  2) Change B2 dispersion (IR7L): shorten region with cleaning losses into DS (ions).
  3) Continue efforts to reduce uncertainty in equipment sensitivity.
  4) Perform beam tests (quench test location + injection region) to improve radiation field calibration.

- **RF**:
  1) Allocate dedicated beam time for higher voltage commissioning in 2011.
  2) Above half nominal: Interlock strategy for RF trips (cavity, klystron, ...) to be decided but probably require beam dump.

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