I.Bejar Alonso / M.Zerlauth

5th Meeting of the HL-LHC Technical Committee

Participants: Vicent Baglin; Stephane Bally, Philippe Baudrenghien, Isabel Bejar Alonso, Alessandro Bertarelli, Jean Pierre Billon Grand, Krzysztof Brodzinski; Rama Calaga, Jean Pierre Corso, Riccardo De Maria, Bruno Feral, Paolo Fessia, Wolfgang Hofle, Rhodri Jones, Valerie Montabonnet, Yvon Muttoni, Serge Oliger, Philippe Orlandi, Diego Perini, Tatiana Pieloni, Stefano Redaelli, Bruce Roderik, Lucio Rossi, Hugues Thiesen, Markus Zerlauth

Excused: Ilias Efthymiopoulos, Ofelia Capatina, Mike Lamont, Oliver Bruning, Brennan Goddard, Daniel Wollmann, Gianluigi Arduini

The slides of all presentations can be found on the website and Indico pages of the PLC:

HL-LHC PLC/TC homepage: https://espace.cern.ch/HiLumi/PLC/default.aspx

Indico link: https://indico.cern.ch/event/312697/

Collimation strategy for active halo excitation at LHC and HL–LHC (S.Redaelli - slides)

S.Redaelli recalled the overall strategy of the collimation team for the active halo excitation at the LHC and HL-LHC. He recalled experience concerning the halo population and beam lifetime during Run 1 and the associated uncertainties for future 25ns operation. For most colliders beam losses during the operational cycle have been a major concerns, especially temporary loss spikes occurring during the squeeze, when starting collisions,

Last years collimation review has strongly recommended pursuing the studies of hollow e-lenses as a way to mitigate the effects of beam losses.

Active halo control would be beneficial for the current collimation system as well as it would complement active machine protection techniques for HL-LHC (when operating with crab cavities). The answer on whether this technique will ultimately be needed will only partially come during Run2 (when operating with 25ns).

S. Redaelli recalled the recent time-line for the hollow e-lens study, with the next milestone being the visit of CERN experts to FNAL to get in contact with the hardware and engineering teams of either side.

As an installation of the FNAL hardware was not possible during LS1 (due to CRYO constraints), the current plan is to have a solution ready for implementation in LS2 if proven necessary. A more optimized and final solution would then be installed for HL-LHC (LS3).

CERN will focus in the next years on building the competence on hollow e-beam hardware as well as to continue the work on alternative methods for halo diffusion enhancement. The highest priority will however remain an improvement of the halo diagnostic at the LHC to allow for an educated decision based on the Run2 experience.

S.Redaelli concluded by confirming that the progress is well on track wrt to the roadmap proposed 1 year ago, in the meanwhile two alternative methods were proposed – tune modulation and narrow-band transverse excitation – which will be addressed urgently as they might be the only viable option for deployment and initial MDs before LS2 (despite a number of drawbacks which have been presented in the recent collimation review in Nov 2012).

Status of Halo Excitation Studies at CERN – (R.Bruce - slides)

R.Bruce summarized the status of the halo excitation studies at CERN by introducing briefly the alternatives of halo removal wrt to the electron lens. The control of halo population (and the associated losses created) is most important during the squeeze and preparation of collisions. No operational solution is yet ready for the 2015 operation, hence the immediate goal is to define what needs to be studied in MDs during Run2.

The first alternative is the one of modulating the tunes at fixed frequencies, introducing resonance sidebands, which – if wisely chosen – could put a resonance line on the halo population only while leaving the beam core unaffected. A pre-study of the tune footprints and resonance lines will give a first hint on which frequencies could be suitable. In the following such a first look at tune footprints at injection (for MDs) and flat-top, end of squeeze and collisions where shown.

The studies showed that most likely several frequencies will be needed depending on the operational cycle one would like to act on, with an additional big spread between 50-800Hz.

From an initial guess a dQ of around 1e-4 would be needed, which would translate into a modulation amplitude of 0.6A if using a single warm quadrupole in IR7 (MQWB.5R7.B1). If additional strength would be needed one could consider using either all MQWA or using the cold quadrupoles in the arc (compatibility with QPS to be verified!!). The required modulation depth remains to be verified with additional detailed simulations.

First feedback from the EPC group confirms that the power converter is capable of performing such a modulation on top of the existing current without any HW modifications (max 500Hz, 1A peak-peak).

Action: H.Thiesen commented that a final validation of the hardware will be done by EPC during the upcoming hardware commissioning phase.

Action: The transfer function power converter -> magnetic field inside the beam screen needs to be verified. M.Buccio will perform detailed measurements on a spare magnet during the year.

M.Zerlauth commented that such measurements have been performed on a MBW magnet (D1) during the development of the Fast Magnet Current Change Monitor (FMCM), yielding a delay of the magnetic field wrt to the applied current by around 1ms (but no major effect on the amplitude).

Provided all ingredients are completed and available, the goal is to carry out first MDs in the LHC during 2015.

The 2nd available alternative – still relying on detunig with amplitude - is a narrow-band excitation using the transverse damper (ADT). By knowig the fractional tune of the halo particles one could apply a resonant kick using coloured noise. The ADT hardware would need no modifications, a theoretical feasibility study remains to be done with Sixtrack before planning MDs for 2015.

Tune modulation with the above setup affects both beam simultaneously, however the ADT offers the possibility to act independently on different planes and beams and most importantly single bunches. Both methods rely on a good knowledge of the tune and detunig with amplitude (knowing tunes during squeeze, requiring validation with beam in the LHC,…).

The hollow e-lens has the advantage of being completely independent of the tune as it only extracts particles based on their amplitude (And is hence robust against changes in machine configuration, optics, filling patterns,…). On the contrary the e-lens can only act on different trains and is not available until after LS2.

R.Bruce concluded that all available options are and should be further studied to set as an immediate goal a consistent set of parameters at the LARP/HiLumi Collaboration Meeting with Fermilab colleagues.

Based on theoretical studies and hardware capabilities, one should plan MDs on tune modulation and ADT excitation that can be carried out in 2015 while in parallel continue to work on the development of hollow e-lenses.

Crab cavity requirements in terms of phase control and maximum acceptable distance between cavities and klystrons and control racks – (P.Baudrenghien - slides)

P.Baudrenghien Recalled the basic principle of RF feedback as a widely used regulation system to compensate for unknown perturbations like tune fluctuations, mechanical vibrations and beam loading. As the principle is based on a measurement of the voltage in the cavity (and following comparison with the reference to regulate the drive of the power amplifier), the reaction can only be applied on the cavity once the perturbation has been measured and processed. The performance of the RF feedback is hence limited by the loop delay.

Large gains in the feedback loop will be beneficial to reduce perturbations (noise and beam induced voltage), however the stability in presence of the loop delay will be the limiting factor. The final performance will only depend on the Loop delay T and the cavity geometry R/Q but not on the actual Q.

The lessons learnt are hence to keep the delays as short as possible and the broadband to avoid group delays.

Estimates for the loop delay to be expected for the 3 viable integration options of the crab cavity controls were presented, namely

- New galleries with LLRF, TX, circulator next to the cavities, yielding a **local regulation of 660ns and a cross-IP regulation of 1960ns**
- Installation of LLRF, TX, circulator in the existing RRs, yielding a **local regulation of 1230ns and a cross-IP regulation of 2530ns**
- Installation of LLRF, TX, circulator in the existing IP caverns (US), yielding a **local regulation of 1970ns and a cross-IP regulation of 1970ns**

It is evident that new galleries have a definitive advantage for the local loop (bandwidth a factor of 2-3 higher), while all 3 options have similar performances for cross-IP regulation.

Bandwidth is hereby required to quickly modulate the CC field or to react to high frequency noise sources, which at constant CC voltage come from the 3 μs long abort gap.

Other constraints which have to be considered for the final choice of integration is the need of accessing the LLRF and power plant with RF in the cavities during commissioning (requiring shielding between cavities and manned area), which appears challenging for the RR option.

Similarly, radiation issues for the LLRF electronics are considered challenging if integrated into the existing RRs due to the powerful processing FPGAs required in the LLRF.

In conclusion, a precise regulation of the cc field is important mainly for the reduction of RF noise in constant field mode. This is easiest in the new gallery option while it is not clear if the full achievable bandwidth will be required. Cross-IP regulation will reduce beam losses in the interval between a quench and the beam dump (3 turns max due to the MPS reaction time). The chosen layout will not have a significant influence on the cross-IP regulation performance.

The present modular design with one TX per cavity is ideal for regulation. Using a single TX for several cavities we cannot avoid synchronized oscillations. The equipment (mainly TX and LLRF) must remain accessible with RF in the cavities at least during commissioning and radiation-hard designs need to be studied if electronics will have to be installed close to the tunnel (RRs).

Integration of 3D models belonging to different WPs and services – (Y.Muttoni - slides)

The presentation by JP Muttoni introduced the aim of integration at CERN and how it manages CAD data in the HL-LHC project. The Mandate of the integration section is to provide a 3D CAD data environment to realize new equipment studies, centralize the data produced by the different design offices involved and by these means help to guarantee the correct installation of the equipment.

Among the deliveries of the section there are the 3D integration assemblies of the service for the machine, the layout in 3D and in 2D and the check between the laser scans and the 3D models. From the other side 5 design offices in the service and infrastructure groups provide 3D models and 2D specification and installation drawings. Y. Muttoni stresses the importance of a common methodology to guarantee a correct integration of the models. To those design offices we have to add the EN/MME mechanical design office that provides the 3D models and 2D drawings of mechanical equipment.

He then describes how the different input is integrated in the ICL meetings and how they share 3D data with external design offices.

Concerning the HL-LHC project among the strongest points of the Integration office is the good relation existing with the other design offices, the ICL meetings, the use of the same CAD 3D software and the present methodology to deliver integration information.

P. Fessia stresses the need to write an official procedure for the validation of 3D models.

Y. Muttoni indicates the importance to stabilize the teams in the external design office and to have persons designated for each one of the equipment. The CAD data must have an owner for what exists and for what will exist.

Another important point to consider already now is that the project will have to face a software migration before its end. In the past, only a few groups have “cleaned” their models, as there is no signature process in the models. L. Rossi reinforces that the 3D models need also to be controlled and verified in the same way as it is done for the 2D drawings. P. Fessia points out that it is also necessary to control the quality of the models.

Y. Muttoni retakes the problem of the future migration of the software and indicates that the best moment for integration is during the operation of the machines when there is less work on the models. L. Rossi asks why we have to migrate. Y. Muttoni says that we have not leverage on the software producers. L Rossi insists that we should then change in 2016 – 2017 so that the change occurs is when we are moving between R&D and production. For him we have time to plan for this but the central services should take a decision before end 2015.

Y. Muttoni also explains the role of the PLM Working Group, the CAEC and the GUCS. He finishes concluding the importance of all design offices working with the same CAD software and the same Product Data Management, the need of putting in place at CERN the correct process to produce CAD data to exchange it with external firms/collaboration.

I. Bejar Alonso adds that also all objects today installed must have an owner and that all alternative 3D models must be put in obsolete so that only one valid version remains. She also stresses that for the new equipment we shall follow an approval process that already includes the “reservation of space” procedure.