WP2 Meeting #147

Tue 14 May 2019, 09:00 – 12:00

Chair: R. Tomás

Speakers: J. Coello de Portugal, A. Kurtulus, N. Magnin, F. Sanchez Galan, G. Sterbini,

Participants: S. Antipov, N. Biancacci, R. Bruce, X. Buffat, H. Burkhardt, F. Carra, R. De Maria, D. Gamba, A. García-Tabarés, H. García-Morales, M. Giovannozzi, L. Fiscarelli, A. Mereghetti, N. Mounet, V. Olsen, B. Salvant, F. Van Der Veken

AGENDA

The meeting was devoted to various pending beam dynamics issues, including TAXS/TAXN, AC dipole limitations and flux jumps. Apart from that, there was a report on the status and plans for collimator coating measurements and a practice IPAC talk on the beam-beam long range compensation.

MEETING ACTIONS

Nicolo Confirm the beam intensity used in the study of radiation damage impact on collimator coating performance

Adnan Extend the study of radiation damage impact on the collimator coatings to lower beam intensities tested at HiRadMat in order to identify at what intensity the beam has to be exposed to a fresh coating (the 5th axis has to be activated)

Davide Provide an estimate of the impact of flux jumps on the orbit stability.

Gianluigi Discuss AC dipole upgrade plans and budget issues with Mike and Brennan

General information (R. Tomás)

Minutes of the two previous meetings, 145th and 146th have been circulated. **Rogelio** reviewed the action items of the 145th meeting.

1 Update on resistivity measurements of coated collimators and control procedure (A. Kurtulus)

Adan presented a summary of DTI Molybdenum (Mo) coating measurements. The tests were performed using a pillbox cavity with H011 mode which is insensitive to contacts thanks to its particular field distribution. Cavity quality factor is used as a measure of resistivity with Copper (Cu) being used for calibration.

Measurements of DTI coated blocks taken on samples in Dec, Jan, and Feb are close to expectations of Mo conductivity: 58±7.4 nΩ-m vs 53 nΩ-m. No significant impact of thermal treatment on coating conductivity has been found.

The proposed procedure for future sample testing is as following: first, a thermal treatment will be done on of MoGr blocks and MoGr samples by EN-MME, then RF impedance measurement will be performed on samples, then outgassing measurements by TE-VSC-BVO, and finally coating thickness and adhesion measurements. A new small cavity is needed for future small samples; it has been designed and is currently under fabrication.

Measurements on impacted blocks show around factor two increase in resistivity of impacted surface: 1400 vs 800 nΩ-m for Mo coating on Graphite (Gr) and 140-160 vs 70 nΩ-m for Cu coating on Gr. Next step is to simulate the radiation damage impact numerically in CST.

For alternative coatings, Mo on Gr coating by DTI shows a resistivity of around 100 nΩ-m. DC measurements done by Carlotta indicate a larger resistivity, probably due to a significant roughness of the surface. Cu on Gr coating by DTI shows a resistivity of 20 nΩ-m, in agreement with the DC method.

A plan for production collimator jaw is to first perform visual inspection for potential damage, then conduct RF probe measurements. Finally, if probe measurements indicate potential issues, a wire measurement will be performed at various collimator openings.

- **Roderick** raised the question on beam intensity used for impacted blocks, emphasizing one needs to relate to the intensities present in the machine. **Nicolo** suggested checking the exact values with Christina. **Federico** supposed the energy density must be equivalent to HL-LHC injection error. **Rogelio** concluded the numbers have to be checked (Action: **Nicolo**).
- **Roderick** pointed out that several beam intensities have been tested at HiRadMat, while what is shown is probably the largest one, and asked about the plans to measure the impact at the lower intensities. **Adnan** replied such checks can be done (Action: **Adnan**). **Roderick** clarified that what is important in the end is to know when to use the 5th axis to expose the fresh surface to the

beam. **Rogelio** asked by how much one needs to move the 5th axis. **Roderick** replied that the scratches are usually small, a few mm should be sufficient.

- **Roderick** inquired about the possibility of contamination being introduced to the jaw during impedance measurements. **Nicolo** replied this is one of the main motivations to refrain from wire tests, in case of a probe measurement a significant margin is guaranteed by design.
- **Sergey** asked if there is any secondary collimator where Cu coating can be tolerated, since is shows at least two times lower resistivity than Mo. **Federico** noted this way one loses a bit in robustness as the radiation damage scratches on Cu are typically larger. **Roderick** replied one needs to look at the losses, the most favorable (if any) would likely be the skew collimators.

2 Follow up on TAXS - TAXN (F. Sanchez Galan)

The major difference between TAX and TAXN is the former is uncooled, whereas the TAXN has to be water cooled. Accordingly, the transverse dimensions are increasing from around 300x200 mm to 400x340 mm. The design is based on v1.3 optics.

At the moment, discussions with BINP on manufacturing are under way. The work is put on hold until v1.5 optics is released. The new optics will required a redesign of the Y-chamber. The present Y-chamber design has been validated with Impedance WG, the new one will have to pass review again. For a timely production the manufacturing drawings have to be ready by next year.

TAXS is comparatively simpler than the TAXN. The design of a water cooled TAXS is complete, studies are under way to relocate some vacuum modules around it. The team is discussing a slight relocation of TAXS due to a position non-conformity in ATLAS (EDMS 1137878) – it is 29 mm further away from the IP with respect to the nominal on one side and 21 mm on the other side. Large 80 mm apertures are planned for VAX to reduce impedance and alignment needs.

- **Rogelio** raised the question how to fully confirm the TAXN aperture. **Riccardo** replied they are waiting for results on energy deposition from F. Cerutti, the work should be ready sometime in June. **Francisco** confirmed the timeline is OK with them.
- **Helmut** commented that the TAXS/TAXN work is also followed up by simulations on aspects of background and failure scenarios, performed in WP8 in close collaboration with other work packages. The goal is to minimize backgrounds and risks by fast beam losses for the interaction regions that become more exposed in HL-LHC due to an increase in apertures. **Rogelio** proposed discussing results in terms of background vs aperture or failure scenarios vs aperture within WP2. **Roderick** pointed out that failures of crab cavities and asynchronous beam dump have been addressed in previous studies, no issue has been found.
- **Benoit** noted there is a sharp edge in the design of Y-chamber that will have to be rounded to avoid field emission – that will likely be done anyway during welding. He further emphasized the danger of unshielded bellows. **Francisco** replied they are aware of the problem and will make sure to notify the impedance team in case of any changes.

3 AC DIPOLE LIMITATIONS AND OPTIONS FOR ITS UPGRADE (N. MAGNIN)

Nicolas an overview of AC dipole performance, limitations, and upgrade plans. Currently the max pulse repetition rate is 1/60 Hz. It is limited by a power transformer that was designed to yield no more than 1 pulse per minute. The maximum flat-top is 600 ms, and is limited by the memory of the FPGA that stores the pulse. The maximum current is1700 – limited by an amplifier. The bandwidth is limited by a fixed capacitor bank.

There were both hardware and software problems observed in operation, such as not being able to reach 100% strength due to broken amplifiers (hardware) or nonzero kicks for 0 A strength settings or repeating the previous kick occasionally (software).

New requirements coming from HL-LHC demand an increase in the repetition rate to 1/10 or 1/30 Hz, maximum pulse duration up to 3600 turns, and a demanding tune bandwidth of 0.26-0.34 in the Horizontal and 0.28-0.34 in the Vertical plane. To satisfy these requirements new power generators are needed.

For the LS2 a software migration and upgrade is planned along with a revision of maximum voltage vs frequency limits, which is needed to ensure good availability. Further work is divided into 3 Work Packages: (1) fixing software bugs; (2) software and hardware upgrade of FPGA's; (3) renovation of the generators to ensure the maximum pulse length, pulse current, and pulse rate – 4 generators and 1 spare in total. Specification from the Work Package are needed.

- **Rogelio** inquired any tests would be feasible during Run 3. **Nicolas** replied that due to shortage of manpower the upgrade work likely to be done during Run 3. A technical stop could be enough to download new software.
- **Rogelio** proposed discussing budget and planning issues with Mike and Brennan (Action: **Gianluigi**)

4 FLUX JUMPS IMPACT ON EMITTANCE GROWTH (J. COELLO DE PORTUGAL)

Measurements of magnetic flux reveal fast jumps in flux that are characterized by a rapid rise and slow recovery afterwards. Flux jumps produce dipolar kicks that may lead to an increase of emittance. The impact of flux jumps on emittance has been studied using a simplified model where the jump is represented as a linear ramp-up of the flux. According to data on 145 jumps, observed as an error of magnetic flux, the average strength is around 0.2 units and duration – 40 ms. The jumps seen as a current error in a regulation circuit have a significantly lower amplitude. Two energy scenarios were analyzed: 450 GeV and 3.2 TeV. For both cases the effect seems to be insignificant – it would take around 1 day to blow up beam emittance by 1 %.

- **Riccardo** asked to clarify the impact of flux jumps on orbit stability. **Davide** replied the impact should be minor and suggested to come back with an estimate (Action: **Davide**).

- **Michele** pointed out the assumption of inductance variation used in the analysis. He further clarified that a flux jump is an instability of a superconductor, which is not observed in steady state but only in the Ramp, therefore the presented estimates are pessimistic. **Rogelio** summarized that flux jumps do not seem to pose a threat for beam emittance.

5 Summary of the BBLR compensation tests in the LHC and prospects for HL-LHC (G. Sterbini)

Guido presented his contributed oral talk for IPAC. The principle of wire compensation takes advantage of the fact that an electro-magnetic kick of a beam matches well with an electro-static kick of a wire at large distances. 4 wires have been installed in LHC in IPs 1 and 5 since with an idea of exploring the potential for HL-LHC. The wires are 1-m-long Cu conductors capable of carrying up to 350 A.

The wires are installed on the jaws of tertiary collimators that imposes certain constraints on their performance. In a Low Intensity (LI) experiment the wire was put in the shadow of only primary collimators, whereas in a High Intensity (HI) a full collimation hierarchy had to be respected leading to a greater distance to the wire: 5.5 vs 8.5 collimation units. 1 jaw was powered in LI test and both in HI.

The study attacked the 1st order amplitude detuning Resonance Driving Terms (RDTs): (4,0) and (0,4) with an objective to demonstrate a positive effect on a bunch affected by long range in terms of beam lifetime, beam losses, and bunch effective cross-section.

Analysis shows that the compensation reduces the losses by 20% in operational conditions. Corresponding numerical simulations predict a large compensation of (4,0) and (0,4) RDTs leading to an increase of Dynamic Aperture (DA) by up to 1.5 σ and an increased area of large DA in the tune plane. Based on these findings the wires are proposed for routine use in LHC.

Simulations predict that for HL-LHC one can gain up to 2 σ of DA. Design of wires for HL-LHC has started. Contrary to the LHC design the wires are planned to be installed on a vacuum chamber. The next immediate objective of the project is drafting a proposal for a technical review.

- **Sergey** inquired how large the benefit for crossing angle reach is. **Guido** replied that at the moment the team is not investigating cases with Crab Cavities or Flat Optics at the moment. It is therefore hard to give such a number. **Rogelio** inquired if the 20% reduction of beam loss remains during an 8 hour Collision. **Guido** replied the overall improvement might be somewhat smaller, but pointed out that what is clear is that the steady state of losses are increasing with the reduction of the angle without the compensation (as shown by the Blue line in Slide 17). **Xavier** noted that what is shown is the gain in a configuration, pushed to exaggerate the losses. **Adriana** emphasized the whole idea of the experiment was to show that wire compensation allows pushing the performance further.

Reported by S. Antipov