Minutes of the 117th WP2 Meeting held on 20/03/2018

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1. Agenda:

1. Approval of minutes and general information
2. Update on e-cloud in TDIS (G. Skripka, G. Iadarola)
3. HL-LHC operations with LHCb at high luminosity operations (R. De Maria, N. Karastathis)
4. Round table

1 Approval of minutes and general information

GA summarizes the topics of the last two meetings. GA mentions that in the minutes of the 13/03, it should be added that the optimization of the D2 field quality should be carried out for 7.0 TeV to allow operation up to ultimate energy. Ezio will also check what is the expected dependence of the field quality on the dipole field. Besides, there are no comments related to the minutes of the two previous meetings and the minutes are approved.

RDM introduces Fabien Plassard, a new fellow working on HL-LHC Optics.

2 Update on e-cloud in TDIS (G. Skripka, G. Iadarola)

GS recalls the request for the e-cloud simulations in TDIS. It was requested to simulate different SEY configurations. First, with uniform SEY, secondly with non-uniform SEY. GS presents the different non-uniform SEY parameters she used in the simulations. She describes the geometry change from a geometry with wide jaws to a new geometry with narrower jaws. The simulations are carried out at injection energy (450GeV), assuming a 25ns bunch spacing and 2.2e11 protons/bunch. She simulates two counter-rotating beams and performs a half-gap scan from 1 to 50mm and a SEY scan from 1.0 to 1.6.

For the uniform SEY parameters, the simulations have already been carried out, but for a different geometry. The non-uniform scenario includes a simulation set with realistic settings (tank 1 and tank 2 with graphite jaws and SEY 1.0 and SEY 1.6 elsewhere and in tank 3 a SEY of 1.6) and a simulation set with a coated 3rd jaw. The coating is Ti+Cu and in all tanks the jaws have a SEY of 1.0 and 1.6 elsewhere. It is common to all simulations (uniform and non-uniform) that the half-gap is scanned from 1mm to 50mm.

GS shows the longitudinal electron current/heat load profiles for uniform SEY. Multipacting is stronger at the positions where the two beams are not synchronized (12.5ns equivalent spacing). She shows the profiles for different half gaps (50mm to 4mm). At the smallest gaps there is still a non-zero electron current and heat load for SEY=1.5 and SEY=1.6.

GS illustrates the build-up at small gap and high SEY. With SEY 1.5 and 1.6 there is build-up (4mm half gap). With SEY=1.6 the build-up is concentrated on the beam screen while the current density at the jaws is comparatively low.

GA asks what happens if we open the jaw even further. GS answers that the maximum is seen at around 40mm (half gap) and then the effect decreases again.

GS continues the presentation and shows the electron flux on different segments (uniform SEY) for different half gaps with SEY=1.4. At the locations of the long range encounters the e-cloud builds up mainly on the flat part of the beam screen. Between long-range encounters the e-cloud builds up on the flat part of the beam screen and of the jaws and on the rounded beam screen part. She shows the electron current segment by segment with uniform SEY. At the long-range encounters the largest contributor is the beam screen. Between long-range encounters the largest contributors are the jaws. The flat and round parts of the beam screen account for more than half of the total current. The contribution of the jaws is highly dependent on the delay. Opening the half gap from 40 to 50 mm reduces slightly the total current. The contribution of the jaws is lowered by 30%. The contribution from the beam screen (round and flat parts) is roughly unchanged.

GA asks what the present baseline for the opening is. CB answers that they plan to go up to 55mm.

GS shows the total electron current vs SEY for uniform SEY. It is visible that the electron current increases with SEY and, between a half-gap of 4mm and 40mm, also with the half-gap. The maximum of 750mA (with the old geometry 680mA) is reached at a half-gap of 40mm with SEY 1.6. The multipacting threshold is very high for small gaps and decreases when the jaws are opened.

The next chapter is the simulation of electron-cloud with non-uniform SEY. These simulations assume SEY=1.0 for the jaws in the tanks 1 and 2 (made of graphite), and 1.6 elsewhere. The baseline is to have no coating for the metallic jaws in tank 3. GS shows the longitudinal current/heat profiles with non-uniform SEY (jaws 1.0 in tank 1 and 2). The maximum is reached for a half-gap of 40mm with a total of 514 mA e-current, this is lower than the 750mA with the uniform SEY. For the scenario with non-uniform SEY and SEY=1.0 for the jaws in tank 1, 2 and 3, the maximum current is 457mA. The non-uniform SEY distribution significantly reduces the contribution from the jaws (from a maximum of 235mA to a minimum of 49mA with uncoated J3 and from a maximum of 55mA to a minimum of 21mA with coated J3).

Given that the contribution of the beam screen is large, GS suggests to coat the beam screen. Simulations indicate that with a coated beam screen, almost no electron current is left. If both beam screen and jaws in T3 are coated with SEY 1.0 there is no e-current.

Lastly, GS presents coating scenarios. The electron flux on the walls increases for large gaps. The maximum is reached at half gaps of roughly 40mm. Coating the jaws in tank 3 allows gaining roughly 30% with a 50mm half-gap. Coating the beam screen lowers the current by one order of magnitude and kills multipacting at small gaps. GS gives a summary of the presentation.

GA concludes that coating is desired for both jaws and beam screen. CB asks if this is a problem in terms of impedance. EM answers that there is no problem. BS adds that the impedance is dominated by uncoated graphite jaws, while metallic jaws do not contribute much.

IE asks if HiRadMat tests were carried out with coated collimator jaws, CB answers that this has been done, but there could be additional tests.

3 HL-LHC OPERATIONS WITH LHCB AT HIGH LUMINOSITY OPERATIONS (R. DE MARIA, N. KARASTATHIS)

RDM presents a proposal of machine settings to operate LHCb with high luminosity (1e34 to 2e34) starting from run 5. He discusses the constraints for the choice of beta* and crossing angle. Beam-beam effects impose a lower boundary on the crossing angle, optics limitations limit the lower boundary for beta*, and finally aperture limitations and orbit corrector strengths impose an upper limit on the crossing angle.

GA asks if the limitations can be easily quantified. RDM answers that for the orbit corrector strength there is a clear limit at a half crossing angle of 320urad. For the aperture different scenarios have to be compared and it is difficult to draw a line.

RDM discusses aperture limitations in collision. He shows the maximum crossing angle as a function of beta*. It is discussed if the beam screen should be rotated to gain aperture.

The aperture at injection, the beam-beam separation and the horizontal and vertical orbit are presented at injection for different scenarios:

- a positive spectrometer field, a horizontal crossing angle of -170urad and +3.5mm orbit offset at IP8
- a negative spectrometer field, a horizontal crossing angle of -170urad and +3.5mm orbit offset at IP8
- a positive spectrometer field, a vertical crossing angle of -170urad and +3.5mm orbit offset at IP8 (with rotated beam screen)
- a negative spectrometer field, a vertical crossing angle of -170urad and +3.5mm orbit offset at IP8.

The first two configurations are the same as for the LHC, but with double the intensity in HL-LHC. They still need to be validated in terms of beam-beam. The last two configurations require a rotation of the beam screen and introduce additional close beam-beam encounters in particular close to the IP. They are not compatible with operation with different ion-species (because the BB encounters move). They are not compatible with the present orbit tolerance specifications.

GA asks if we are confident to be able to operate with -170um. YP answers that there are no DA simulations including beam-beam effects, this configuration has to be checked. They will be carried out as soon as possible by Nikos (**Action: Nikos**).

RDM presents options with vertical crossing, negative spectrometer field at 1000GeV (during ramp), -200urad and +1mm separation. The BB encounter close to the IP moves with energy which needs strict control of the orbit during the ramp. If the spectrometer could be ramped with energy, a vertical crossing would be straightforward. One further option would be a horizontal crossing scheme with small crossing angle (-120urad) and a separation of +7mm. This solution is more robust at injection, but uses about 3 times the typical orbit corrector at injection. As the energy increases, the separation offset and bias would need to be reduced quickly.

GA points out that we must emphasize that the option with 2sigma BB separation at a long range encounter (occurring for certain orbit errors) is not possible.

RT mentions that the orbit uncertainty of 2mm is only valid for un-measured and un-corrected beams. Reproducibility is important and can be provided with measurements and corrections. RDM answers that there are no orbit correctors inside the spectrometer, so we are blind and can control the orbit only from outside. This could take a long time to set up.

The presentation continues with an overview of beam-beam limitations at collision, based on simulations by Nikos. One can see that the area of large DA reduces in size with decreasing crossing angle. It is a small effect when reducing from 250urad to 200um but becomes important when moving to 180urad. The spectrometer polarity has an impact of minimum external crossing angle. Possible IR8 external half-crossing angles with horizontal crossing are -200urad with negative polarity (smaller total crossing angle) or -150urad with positive polarity (larger total crossing angle).

RDM presents tentative scenarios for the luminosity vs bunch population and the integrated luminosity vs the maximum luminosity. There is no strong advantage of designing the detector for for a luminosity of 2e34. It is not necessary to rotate the beam screen for the configurations (beta*=1.5m, horizontal crossing ±200urad and negative polarity, or horizontal crossing ±150urad with positive polarity or vertical crossing with +-160urad positive or negative polarity). A small crossing angle is also better for the triplet radiation dose at constant luminosity. The change of the external crossing at each polarity swap, proposed this year in the LHC, will have some overhead, but it would give more integrated luminosity than a pure vertical crossing. RDM emphasizes that the effect of saturation in integrated luminosity with increasing peak luminosity comes from the fact that the luminosity decreases during a fill. He illustrates this with four graphs.

IE asks about the impact of a change in crossing angle on the radiation and eventual impact on shielding requirements. RDM answers that in his scenarios less luminosity induces more radiation.

YP says that a baseline scenario should be specified and then simulations should be carried out to validate the chosen scenario.

RDM says that we need simulations to specify whether to use a crossing angle of 150urad or 170urad.

GA asks what the advantages/disadvantages of the ±160urad solution with vertical crossing are. RDM answers that the vertical crossing gives more separation in the triplet and even more in the IP. The only difficulty is the differently shaped tune footprint, so the optimization of the working point will be affected. But from a theoretical point of view this solution gives larger BB separation than other solutions.

RT asks if the rotation of the beam screen is already discarded. RDM answers yes, but anyway a finer choice is needed to perform validation simulations. YP says that the full validation will take some time, but single points could be simulated rather quickly.

RDM mentions that based on the 2012 experience from machine operation, it would be preferable to have horizontal crossing. GA agrees.

RDM concludes, we do not need beam screen rotation. Horizontal crossing is preferebale and we accept a potential operational overhead from two external crossings. A full validation and quantification is needed.

RT asks FC about the present status on simulations on the dose on the triplets. FC answers that they did simulations with a crossing angle of 250um. RDM answers that this is the worst case scenario while in reality it is just a fraction.

4 Round table

The meeting is closed. The next meeting will be on the 10th of April.