Minutes of the 111th WP2 Meeting held on 24/11/2017 joint with WP5

Participants: A. Alekou, G. Arduini, L. Barraud, C. Bracco, R. Bruce, X. Buffat, R. De Maria, S. Fartoukh, H. Garcia, L. Esposito, F. Galluccio, S. Gilardoni, M. Giovannozzi, G. Iadarola, S. Kostoglou, G. Mazzacano, E. Metral, A. Mereghetti, D. Mirarchi, Y. Papaphilippou, D. Pellegrini, A. Perillo, A. Poyet, S. Redaelli, A. Rossi, R. Rossi, B. Salvant, K. Skoufaris, G. Sterbini, R. Tomas, C. Vallgren, F. Van Der Veken.

General Information (G. Arduini)

The minutes of the previous meeting have been circulated. Gianluigi summarises the outcomes and the actions of the previous meeting. The minutes are approved without comments.

Status of the TDIS vacuum studies and inputs for e-cloud simulations (C. Y. Vallgren)

Christina quickly shows the layout of the TDIS (segmented in three parts) that will replace the current TDI (see C. Bracco, 100th WP2). The vacuum pumping system is composed by two NEG pumps and two ion pumps for each segment installed on the bottom and on the top respectively (12 pumps in total). The resulting pumping capacities are reported. She notes that CH_4 is only pumped by ion pumps.

e-cloud simulations by Galina and Gianni showed that the electron flux in the TDIS is doubled compared to the current TDI. Cu-like SEYs were considered, scanning up to a worst case scenario of 1.6. The maximum electron flow is observed in the flat part of the vacuum screen. Christina asks if the e-cloud is generated within the jaws. Gianni replies that this is the case, but the resulting electron density depends on how the SEY is distributed, he reminds that a scan of the SEY between 1.0 and 1.6 was made for the jaws. It was also noted that the SEY for graphite should be normally close to 1.1.

In addition to the layout, vacuum simulations require two inputs:

1. Thermal degassing rates defining the static pressure, without beam.
2. Electron stimulated desorption (ESD) which is defined as the number of molecules of a specific gas which leaves the surface per incident electron. Together with thermal degassing, the ESD allows computing the dynamic pressure, in the presence of beam.

The static pressure without beam is 0.98e-11 mbar and it is dominated by thermal degassing of H_2. The dynamic pressure with beam, including an electron flux of 607.7mA from the worst case SEY (2.0), is 1.2e-5 mbar and is dominated by CH_4. Within 5 minutes of scrubbing the SEY is expected to drop to 1.6, resulting in a dynamic pressure of 1e-6 mbar. The best case scenario with SEY of 1.0 presents an extremely good vacuum of 4.75e-11 mbar.

Recent studies allowed correlating the SEY to the ESD for various the species. Therefore, Christina was able to convert the electron fluxes computed by Galina and Gianni to pressures as a function of the SEY and the jaws gap. Considering a realistic scenario:

- half-gap of 50 mm
- SEY = 1.3 for Tank 1 and 2 (uncoated graphite jaws)
- SEY = 1.6 for Tank 3 (titanium jaws)

one gets a maximum pressure of 1.03e-6 mbar (dominated by CH_4), which is unacceptable.

Gianluigi asks if 1e-7 mbar, reached for an SEY of 1.3, could be acceptable for the TDIS. Christina replies that such value still generates background in ALICE and that 5e-9 mbar is required by them. The jaws opening could be reviewed. Christina proposes to keep it fully opened during the scrubbing, reducing it in operation. Gianluigi asks if a smaller aperture could lead to impedance heating. Benoit confirms. Gianni points out that we cannot close too much as we need to avoid producing debris. Gianluigi asks if one could coat the Titanium/Copper jaws and the stainless steel shield. Gianni and Christina agree that aC will be possible and better than NEG. Everything could be coated: the screen and the titanium/copper blocks. Gianni is worried about scraping the copper, Chiara clarifies that this is not an issue as it is retracted. Gianluigi suggests that in order to keep the residual pressure low coating is needed.

Antonio Perillo asks if something can be measured in the lab. Christina points out the possibility of using microwaves for multipacting studies. Gianni replies that the conditions are very different from the ones with beam and that, although something could be learnt, it will probably be inconclusive.

Gianluigi asks if one could increase the pumping speed. Christina replies that one could add more pumps, but this alone will not be enough to reduce the pressure by a factor 20.

Gianni suggests going for aC coating which is anyway foreseen for the triplet area, he adds that adding a coated TDIS in LS2 will also produce experience for the more extended coating foreseen in LS3. Gianluigi proposes to take the discussion offline. Chiara agrees.

Stefano asks if the jaw gap requirements from Alice will be fixed for all the high intensity operation. Chiara confirms.

Update on crystal collimation MDs (R. Rossi)

A highly pure silicon crystal showing a regular structure can trap particles between the crystalline planes. Mechanically bent crystals produce a net kick of the particle’s trajectory. Four bent crystals are installed in IR7 for crystal collimation tests. Crystal collimation devices were installed in both LHC beams and tested both with protons and ions, keeping them in also during the ramp. When the orientation of a bent crystal is parallel to the beam envelope, one observes a drop of the losses downstream of the crystal. In this case, the halo is channelled and can be intercepted with one single collimator absorber (per beam per plane).

The typical MD consists in properly orienting the crystal in order to minimise the local losses, performing then loss maps and evaluating the collimation efficiency for the case when a crystal replaced the function of a primary collimator.

The strip crystal mounted for B1-H showed positive results in a recent MD with xenon ions, decreasing the leakage of losses outside the collimation area by up a factor 60 with tight collimator settings, although showers were observed to increase in other magnets (typically IR7 Q7). Quasi-Mosaic crystals (B1-V, B2-H) did not behave as well, although still providing improvements of a factor 2. Unfortunately, the crystal B2-H (quasi-mosaic) is not usable because of problems with its alignment.

With protons, being only a factor 4 above the critical radius, significant de-channelling is observed for the strip crystals. This is not the case for quasi-mosaic crystals.

Stefano adds that one would like to confirm the benefits with lead ions. In 2016 MDs, we did not manage to improve the cleaning compared to the standard system, but we did not have enough time to test collimator settings as tight as this year for Xe. Better understanding of the reasons for reduced efficiency in specific locations should also be attained in order to try to improve.

Brainstorming on hollow e-lens position, and possible alternatives (S. Fartoukh)

The integration of the e-lenses in IR4 is appealing for the larger separation between the two beams and the cryogenics availability, in addition this is a low-radiation insertion and the optics can be kept nearly constant during the squeeze. However Stephane points out that the optics is over constrained. In particular it is hard to guarantee round beams. Riccardo asks if the beam size should be kept constant with the optics during the whole cycle. Stefano replies that this would be better, in particular at flat top, and that this conditions is respected in the present baseline squeeze (with betas of ~200 m at the lens locations). The electron beam size can be made larger in order to switch them on at some point in the ramp, cleaning the 30 MJ expected in the tails before going in collision. At injection, they might be used for commissioning purpose although this might require adding a dipole magnet to compensate the static kick from the bent solenoids. Gianluigi stresses that it is important to operate the lens already during the ramp to minimize the impact of loss spikes when the collimators are tightened during the ramp.

A. Rossi recalled that other important motivations to go to IR4 are that the electronics for the HV modulator can be installed close to the electron beam source and that radiation levels are low.

Stephane lists the various factors constraining the optics:

1. Aperture. Could be mitigated by:
   - Tightening the collimators at injection in order to free more aperture.
   - Changing the optics of IR4 during the ramp.
2. Zero dispersion due to the presence of the RF cavities.
   Gianluigi asks about the reason. Stephane replies that one wants to avoid synchrobetatron motion. Rogelio comments that the dispersion could go up to 1 m. Riccardo points out that already 0.5 m leaks from the crossing angle. Stefano recalled that in the present design the dispersion in low.
3. Constant betas during the full cycle for beam instrumentation and diagnostics.
4. High beta at the instruments (ADT, BSRT, WS).
   Stefano points out that these aspects are not related to hollow e-lens and he asks if the present HL-LHC optics fulfils the requirements from BI. Stephane replies that currently it does not at the BSRT.
5. Tele-squeezability at constant Twiss parameters at IP4.
6. Round aspect ratio at the e-lens position.

Stephane shows how the IR4 optics has been changed during Run 2 in order to better accommodate the requirements from BI. Animations of IR4 during the deployment of the telescope for round and flat optics show how it is possible to maintain constant optics between D3L and D3R. This however is significantly different going from LHC to HL-LHC; in particular some of the betas at the BSRT are significantly smaller.

Stephane proposes three different approaches:

1. Relax the requirements from BI by improving the hardware.
2. Change the IR4 optics over the cycle.
3. Move the lenses in IR1/5.

Riccardo comments that approach 2 seems without drawbacks and it was indeed the proposed solution as part of the review of the optics in point 4 (taking into account the WP5 requirements for e-lenses). Stephane points out that it has severe implications on operation: beam measurements need to be synchronised with the cycle and could suffer from larger optics uncertainties, in addition this reduces the flexibility in the ramp/local-squeeze/tele-squeeze sequence and the beta* levelling could only be performed with the local squeeze. Gianluigi notes that the measurement accuracy and the control of the optics obtained in the LHC indicate that this is not an issue.

Stefano asks if the requirements from BI were made public or if the present baseline is adequate in light on the improvements planned for HL. Gianni comments that some instruments such as the BSRL and abort gap are independent of the beta function and could be eventually relocated.

Concerning option 3, Stephane shows how in IR1 and IR5, between Q6 and Q7, a point exists where the horizontal and vertical beta are almost equal along the entire squeeze, although their value changes significantly towards the final part of the squeeze (from below 100 m to above 200 m). This point moves during the pre-squeeze and therefore this would make it difficult to use the electron lens during the ramp.
Riccardo is sceptical on the possibility of having this also for flat optics, although Stephane confirms that this is the case. Adriana comments that betas around 100 m are difficult for the stability of the electron beam, in addition the distance between the two beams makes it hard fitting the solenoid. Riccardo points out that from the operational point of view one also needs to adjust the size of the electron beam during the beta* levelling.

On the comment by Stephane that e-lenses should be used only in collision, Stefano clarifies that instead they are also designed to work before collisions. This is an important feature that will allow controlling tail population anytime at top energy, with no constraints from the operational strategy for collisions.

Stephane proposes alternatives to the e-lenses acting in physical space, e.g. various types of bumps (orbit, beta beating, dispersion).

Roderick comments that bringing the beam close to the collimator is detrimental in general and in particular in case of failure of the crab cavities and the electron lenses are exactly aiming at avoiding that. Stefano comments that a dispersion beat will not allow cleaning the on momentum halo. Stephane replies that that would help in the case of CC failure.

Gianluigi notes that the e-lenses allow halo monitoring by cleaning selectively on bunch trains and leaving tails in a selected number of bunches. Roderick adds that witness bunches (with halo) are actually requested by machine protection.

Gianluigi is worried that masking the area where the bump takes place could have implications in machine protection. Stefano thinks that a test with bumps could be done, but he is convinced that this is not a good solution for halo controls. Bringing the beam so close to the collimator makes any failure much more catastrophic. What for example if a corrector trip that could affect the orbits happens when the bumps are on?

Roderick comments that for cleaning the halo (without considering the CC failure) both the IR1/5 options and the orbit bumps are not viable options. Stephane replies that betas can be increased in IR1/5 during the squeeze. Stefano mentions that IR1 and 5 feature high levels of radiation and they might not be compatible with the installation of certain pieces of hardware of the electron lens (e.g. HV modulator).

Gianluigi summarises that IR4 remains the best choice for an e-lens whose main purpose is to clean the tails during the ramp in a controlled fashion. This aims at avoiding loss spikes and mitigating the effect of crab cavity failures while keeping the tails in a selected number of bunches for diagnostics and machine protection purposes.

Riccardo suggests that a ramp of IR4 could be prepared and tested already during 2018 in MD aiming at decoupling the collision optics from the constraints at injection. Gianluigi fully supports this proposal.

ATS activities for MD4 (S. Fartoukh)

Stephane presents the activities planned for MD4, taking place next week. The choices and the results will be presented in separated meetings e.g. LSWG.

AOB: Computations for the long-range compensation with octupoles in MD4 (X. Buffat)

Xavier comments on the possibility of observing instabilities when crossing the octupoles polarity.

Reported by Dario, Gianluigi, Hector, Rogelio, Roderik and Stefano.