Electron cloud meeting #44, 14/07/2017

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Arising matters (Giovanni Iadarola)

GI reminds that there will be a talk at the LMC (30th August) on cryogenics / heat load issues. An e-cloud meeting will take place in preparation for that.

Scrubbing run summary (Lotta Mether)

The filling patterns used during the scrubbing run are summarized. The issues that arose every day are recapped, most of them related to high losses on injection for B1. In the first 3 days, the bunch intensity was also limited at ~1.1e11 p/bunch due to poor longitudinal beam quality from the SPS.

Reference fills were performed in order to compare the heat loads from this scrubbing run to past years.

Damper and Octupole settings were similar to 2015/16. The new kicker MKI2D conditioned quickly. The maximum average heat load for any sector never exceeded 140 W per cryogenic cell, while the limit is at 160 W.

Beam quality was good for the first ~30 minutes after injection, but there were high losses due to e-cloud after longer storage at injection energy (as expected).

Overall it has been a very efficient scrubbing run. The performance of the cryogenics was excellent, instabilities were under control. The integrated heat loads for the 6 day of scrubbing in 2017 were higher than those from the 14 day long scrubbing run in 2015.

It was suggested to point out at the LMC meeting, that the scrubbing was performed with a different beam type with respect to 2017 physics.

Analysis of heat loads during the scrubbing run and intensity ramp up (Giovanni Iadarola)

This talk puts the heat loads observations into context of other observations and events during the EYETS.

The recalculation of the heat loads for run 2 is outlined, which is a joint effort of the cryogenics and the electron-cloud team.

The procedure for a systematic analysis of the scrubbing run is explained: first the heat loads for every fill are extracted at a moment after the cryogenic system has stabilized (long enough after the last injection). Then the heat loads are plotted together with beam properties, such as the number of bunches.

Sector 12, which has been vented in the EYETS, quickly reconditioned to the status it had by the end of 2016. It remained one of the high HL sectors.

Unfortunately, trains of 288 bunches did not improve the scrubbing. After 7 days of scrubbing, the status of 2016 was recovered for all sectors.

The heat loads between 2012 and 2017 are compared. The large differences between sectors were evidently introduced in LS1. The HL in the three lower heat load sectors did not increase notably, while it significantly increased for the other five sectors.

The members of the cryo team assure it is not a calibration issue.

It was underlined that it would be instructive to compare this data against simulations. Philipp is working on this and results will be presented in a future meeting.

The cell by cell heat load pattern of S12 is compared for two fills, one at the end of 2016 and the beginning of scrubbing 2017. The pattern at the beginning of scrubbing is almost uniform, whereas large differences are obvious in late 2016. This is also the exact same pattern visible at the end of scrubbing, this means that the venting and cooling down of the sector did not have a lasting effect.

Afterwards, the error bars are discussed, and it is stated that there is little measurement noise, but there could be systematic errors. (An error analysis was presented by B. Bradu in December 2016 at EC meeting 36).

Data from the scrubbing run suggests that in the future a single day will be sufficient in case none of the arcs is vented, 4 days will be needed in case only a single sector is vented, while a longer scrubbing run (~7 days) should be allocated when the full machine is de-conditioned, e.g. after a long shutdown, as the impact on beam stability is stronger. Still longer trains should be used in order to maximized the scrubbing efficiency. Nevertheless, as the impact seems to be small for the quick reconditioning after a YETS, also the BCMS could be used if this is more convenient in terms of preparation.

Observations from the scrubbing run seem to indicate that the difference between sectors is not affected when changing bunch pattern. As a consequence it is quite unlikely that an improvement will be observed when using doublet beams.

The increase in heat loads during the energy ramp of the first physics fills in 2017 is shown, which for S12 is higher than in 2016 even after the scrubbing run. This shows that the scrubbing run at injection energy did not completely cover the high energy case. One reason for this could be photoelectrons, as these are not there at injection. Nevertheless this effect has been conditioning during intensity ramp-up in physics.

It was suggested to perform a cell distribution comparison beginning-end of physics fills, to check if this a uniform effect or depends on cells.

The heat loads against bunch intensity during physics fills in 2017 is compared to a fill in late 2016. The deconditioning for S12 seems to have a larger effect at high bunch intensity.

Special instrumented cells are explained, there are 4 of them in the LHC where heat loads can be measured magnet by magnet. One of the cells has been equipped with the additional sensors in the last EYETS. One of the 3 dipoles in this cell has been replaced.

When this one is compared to the other two old dipoles, it is worth noting that after the scrubbing run, the new magnet shows a much lower heat load than the old ones, even though it has seen much less beam over its lifetime. It seems that finally have “ill” magnets equipped with dedicated sensors.

The removed magnet must have been a low heat load magnet, as the total cell heat load is almost identical now compared to 2016. The new magnet follows the same scrubbing curve (heat load plotted against integrated heat load) as the other low heat load dipoles did in 2015.

It is mentioned that the comparison of single magnet heat loads is a good way to assert the quality of the heat load measurements. It was suggested that different heat loads for B1/B2 would affect the mass ratio between the flows that cool the beam screens for B1/B2, which affects the calculation. This is confirmed by the cryo team.

Heat loads of the quadrupoles in the special cells are compared. According to the measurements, heat loads at injection are lower than at high energy. This is consistent with simulations, as there is a region of low SEY with this behavior.

It was suggested to analyze the quadrupole heat loads in the beginning of 2015.

A comparison between two scrubbing fills in 2017 is shown, for one of which the machine was filled only with B1, and the other fill that only featured B2. It is shown that there is a difference in the cell by cell pattern, as the heat load hierarchy of sectors is changed. In the presentation, there is a link to additional material. In S12, the heat loads for the B1-only fill are much higher for most cells.

There is a magnet in the new instrumented cell, that apparently only shows heat load in B1. The cryo team checked the asymmetry between the responsible temperature sensors and they yield identical temperatures when there is no beam. This is a strong indication that these measurements are trustworthy, and there are indeed different contributions from B1 and B2.

The upcoming work includes the LSS magnets (triplets, Q5, Q6 etc.) in order analyze the heat loads also there.

In the discussion it was underlined that, as it is evident that the difference between sectors appeared after LS1, the activities performed during the long shutdown should be analyzed to identify possible causes.

Cryogenics observations and analysis (Benjamin Bradu)

This presentation shows a comparison of heat loads for two fills, one from 2016 and 2017. In normalized heat loads, only arc S12 shows a larger difference.

The feed forward heuristic is explained. There are three parameters to model the expected electron cloud heat load. They are also responsible for the slope of the heat load decrease during a fill. It is shown how the feed forward parameters have to be adjusted for the different sectors. It turns out that some of the parameters are different for S12 with respect to the year before, however this may be an artifact due to different fill length (a linear interpolation between the first and last point at high energy is used to identify the thresholds).

For the instrumented cells, it is explained what has been done in the EYETS. Some sensors are not functioning, but the others have been recalibrated and should give good results this year.

It is shown that the quadrupole heat loads during scrubbing fills (injection energy) are much higher that during physics fills. In the former case, the quadrupole heat loads exceed the arc average per meter, in the later case they are lower. It was suggested to perform reference fills to avoid differences introduced by filling patterns. The dipoles of the instrumented cells are compared as well.

Update on Tune Shifts at injection (Lee Carver)

Work is ongoing in order to be able to infer the local electron density from the tune shift along the batch measured using injection oscillations.

Bunch by bunch, turn by turn injection oscillations have been saved since mid of 2016 and also during this scrubbing run.

This presentation does not feature a complete study yet as still large uncertainties are present in the data. Adjacent fills show different tune shift patterns along an injected batch. The plan for the continued analysis is to define a

rigid set of criteria for data quality and also include the effect of Laslett shift correction. Only then, meaningful conclusions will be possible.
Soon, there will be the option to excite single bunches, which will enable to take data at flat top as well.

Update from laboratory measurements (V. Petit)
These measurements are performed in order to improve the SEY modeling of electron-cloud simulations.
SEY measurements are presented for a sample from the removed dipole. The SEYs are measured for different positions in the beam screen, both axially and radially for both extracted beam screens.
Low energy measurements have been conducted because this region is especially critical. The measurement technique is explained. The low energy scale between 5 and 30 eV of primary electron energy is resolved very well. The results show differences to what was available from the literature from beforehand.
Problems arise during the conditioning in the laboratory, because the electron gun energy profile is not homogeneous. With the effect of a large SEY spread between measurements. Measurements with a different setup should reduce this uncertainty.
It is suggested to already use the results in the simulations, they are subsequently passed to the electron-cloud team.

Adjournment

The next meeting will be on Monday, 17/07/2017.

P. Dijkstal and G. Iadarola, 14/07/2017