LHC e-cloud simulations Meeting

Date: 28 April 2011
Meeting Room: 6-2-004

Attendees: Chandra Bhat (CB), Humberto Maury Cuna (HM), Octavio Dominguez (OD), Giovanni Rumolo (GR), Frank Zimmermann (FZ)

Excused: Gianluigi Arduini, Elias Metral

Agenda

1) Comments on the minutes and actions of the last meeting (25^{th} March 2011)
2) Update on benchmarking → OD
3) Heat load in LHC arcs and straight sections → HM

Minutes and actions of the last meetings (25^{th} March 2011)

Past Actions:

- Horizontal displacement of daughter particles, still pending (potential **ACTION** for Ubaldo Iriso or HM).

- Send LHC parameters to Fatih Yaman, to be done (**ACTION** → FZ)

- Revision of a paper by V. Baglin on solenoid installation in the LHC (**ACTION** → OD)

- W. Hoefle is scheduled for the 9^{th} May to talk about the e-cloud feedback.

Update on benchmarking

Concernign the benchmarking of 2010 pressure-rise data with various gaps between trains, OD first reported on a new approach based on polynomial fits of the flux “surfaces” generated with the SEY/R scan for each batch spacing. 3^{rd} and 5^{th} order fits to the logarithm of these surfaces have been done and the ratio between surfaces has been considered for comparison with experimental pressure ratios. Results for the gauge VGI.141.6L4.B.PR were shown. Several solutions ([1.84, 0.08], [1.77, 0.05], [1.94, 0.05]) were found depending on the order of the fit ([1.84, 0.25] had been the solution found from the raw data without fitting). In addition, an arbitrary ±10% error in pressure has been assumed and a corresponding region in the SEY-R plane defined to obtain possible solutions for the 3^{rd} order fits. The solution for the raw data did not lie inside this region, butclose to it.

Intensity thresholds have been found for the aforementioned 4 possible solutions. In all cases no evidence of e-cloud was found for $N_b=0.6\cdot10^{11}$ ppb, but small effects for $N_b=0.8\cdot10^{11}$ ppb and a clear effect for $N_b=1.1\cdot10^{11}$ ppb can be seen, consistent with the observations in 2010. Nevertheless, the ratio between the experimental pressures ($P_{0.8}/P_{1.1}=1.6\cdot10^{-2}$) is about one order of magnitude greater that the flux ratios for the simulations in all the 4 cases tested. FZ pointed out that the experimental pressure rise with **N_b=0.8·10^{11} ppb** perhaps was too small and that by **subtracting the background pressure** the result might be improved and be closer to the values obtained with the simulations (**ACTION** → OD). FZ also wondered if the first 12 bunches should have an effect. OD replies that the distance between the 12-bunches train and the 36-bunches train should be more than enough (35.7 μs) to neglect the effect of the 12 bunches. To finish with this part, OD posed 3 questions: Are the pressure values accurate enough for our purposes? How could we better fit our data? Are the results obtained with the fits more reliable than the countour plots for the raw simulation data?

Next point of the presentation was the same study in a different location of the ring, more concretely the gauge VGI.319.5L3.B.PR, which has the same geometry as the previous one (round chamber, 40 mm radius). Some cuts (solutions) appear when using the raw data. One of these points presents similar values of SEY and R as in the previous gauge ([1.85, 0.19]). GR pointed out that at least two other solutions are visible ([1.72, 0.4] and [2.05, 0.05]). 3rd and 5th order fits to the logarithm of these surfaces have been done also for this case. Certain agreement with raw data could be seen using the 5th order fit and considering a 10% error in the pressure. OD insisted on the fact that all these results had to be taken just as tentative values and that none of them was definitive. **Intensity threshold studies** need to be done for the different solutions (**ACTION** → OD).

The last point was the "variation of the batch spacing" experiment carried out during the first night of the scrubbing run (6/04/2011). Unfortunately the experiment could not be developed as planned due to several reasons. First, at that point it was not possible to inject 2 batches of 36 bunches separated by 225 ns from the SPS. So one of the foreseen points was not possible to achieve. Problems with satellite bunches delayed the course of the experiment and finally the filling scheme has to be slightly changed (shifted by 5000 RF buckets). For beam 2 we could not get usable data because we only could measure one point since the pressure values were too close to the thresholds and vacuum people preferred not to risk. For beam 1 we could measure only 3 points (i.e. yielding only 2 relative usable curves). The 4th one was not possible to achieve due to an injection interlock caused by a BIC sanity check that had not been performed in the last 25 hours. The results for the experiment were shown. It was seen that the pressure had not stabilized in the time used for the measurement of the first batch spacing (6 and 4 μs). For future experiments it was mandatory to increase this time. The separation between "double trains" was

11.5 μs. If this time is enough to clean the e-cloud, the pressure increases when injecting new "double batches" should be linear. For that reason a comparison between the pressure rise for the 2 μs "double batch" was compared with the first batches injected in the following experiment done later on. For all gauges checked, the pressure increase in the first experiment was always greater than in the second (the value depends on the gauge, but was double for some gauges, although normally the ratio was a bit lower than 2). That could mean that some scrubbing effect had occurred during the first experiment and/or that 11.5 μs are not enough to clean completely the e-cloud. FZ proposed to **study the linearity of the pressure rises for different gauges in the second experiment** in which several batches of 36 bunches were injected with a distance of 2 μs (**ACTION** → OD).

Doing the same analysis in the VGI.141.6L4.B.PR as for the data taken in 2010 and choosing as seed pressure for the simulations the ΔP for each batch spacing (assuming linearity in the pressure rises) we obtain multiple solutions. In addition, a 3rd point would be necessary for a verification. Nevertheless, one of the solutions ([1.86, 0.21]) is close to the one obtained for the 2010 data and shown in the first part of the presentation. 3rd and 5th order fits to the logarithm of these surfaces have been done also for this case, but no consistent solutions are found.

FZ suggested to **simulate of 10 trains of 36 bunches with 2 μs batch spacing** to get additional constraints (**ACTION** →OD). CB asked if it would be possible to take an average pressure for this study. OD answered that the conditions for different gauges might not be so similar (despite an equal geometry). So, in principle, an average value would not ease the extrapolation of results.

Heat load in LHC arcs and straight sections

HM reported on a scan in SEY and R done for analysis of heat loads in the LHC arcs. The explored values were SEY=[1.6-2.2] and R=[0.2-0.6]. All the simulations have been done with 50 ns bunch spacing. The filling scheme considered in the simulation consisted of 6 trains of 36 bunches separated by 200 ns (instead of 225; so it was slightly pessimistic). Furthermore, during the actual measurements the space between two "double trains" of 36 bunches each was 1.2 μs instead of 200 ns. Two energies (injection and 3.5 TeV) have been tested. For injection energy the primary electrons source is considered to be gas ionization while for top energy this source is photoemission (the primary photoemission rate was set to $1.23\cdot10^{-4}$). The seed pressure was 1 nTorr. GR pointed out that using **32 nTorr** should be more realistic (**ACTION** → HM).

The average value of the heat load over the 6 trains was considered. Only dipoles and drifts were taken into account and the average value of both situations was shown. At injection energy it is necessary to have an SEYvalue larger than 2.05 at R=0.6 in order to obtain heat load values over 10mW/m. These values slightly decrease for top energy. FZ pointed out that the **filling factor** of about 1/10 had to be taken into account when comparing with measurements, so that the inferred SEY values would be even higher.

Regarding the e-cloud build up, R seems to be more important at injection energy than at top energy (for lower SEY values the build up is bigger with higher R at 450 GeV). The SEY behaves in the opposite way, being more important at 3.5 TeV. There is no build up in the drifts. At injection energy we start finding multipacting with SEY=2.2 and R=0.5 or SEY=2.1 and R=0.6. At top energy we start finding multipacting with SEY=2.2 and R=0.4 or SEY=2.0 and R=0.6. FZ proposed to add **simulations for SEY=2.3 and 2.4** (**ACTION** → HM). FZ proposed also to show plots results as **contour plots in SEY-R plane** for a number of heat load levels (10 mW/m, 20 mW/m,… 70 mW/m) similar to what is being done with the benchmarking by OD (**ACTION** → HM). GR mentioned that in earlier simulations he had found a multipacting threshold for 50 ns spacing at δ_{max}=1.8 for R=0.8 which would be consistent with the new results of HM.

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Next, CB presented a **plan to simulate flat bunches**. e-cloud for different profiles will also be measured in a PS MD with e-cloud diagnostics.

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The next meeting will be held in 6-2-004 on Monday 9 May at 16:00 (note unusual day!). In this extraordinary meeting W. Hoefle will talk about the e-cloud feedback.

Reported by Octavio Dominguez and Frank Zimmermann