LHC e-cloud simulations Meeting – Draft Minutes

Date: 28 October 2011
Meeting Room: 6-R-012

Attendees: Chandra Bhat (CB), Alexey Burov (AB), Octavio Domínguez (OD), Humberto Maury (HM), Giovanni Rumolo (GR), and Frank Zimmermann (FZ).

Excused: Gianluigi Arduini, Elias Metral, Giovanni Iadarola

Agenda

1. LHC arc's simulations update, **Humberto Maury**
2. Heat load data and benchmarking for 25 ns operation, **Frank Zimmermann**
3. Status of the SEY/R benchmarking with 25 ns, **Octavio Dominguez**
4. HP vs. water bag distributions at the LHC, **Chandra Bhat**

Minutes and actions of the last meeting (30 September 2011)

Actions from the last meeting:

- Redo plot of density versus bunch intensity for 50 ns, e.g. with Gaussian bunches (HM)
- Look at the electron energy spectra (HM)
- Updated heat-load curves for LHC (including for 3.5 TeV) (HM)
- Review talk by Vincent Baglin at CERN-GSI e-cloud workshop and possibly contact vacuum group for further information about the change in photoelectron yield (FZ)
- Do simulation for ideal flat bunch and compare with a Gaussian profile (CB)
- Repeat simulation for R=0.25 (HM)
- Initial excitation of single modes in HEADTAIL (HTWG, GR)

In the next meeting the actions and minutes from this and the previous meeting will be reviewed.

Arc e-cloud build-up simulations – a bug in ECLOUD

Humberto Maury presented two topics regarding e-cloud build up simulations (a bug in ECLOUD and quadrupole heat-load oscillations). First he pointed out a possible bug in the ECLOUD code evidenced by the final x-y macroparticle distribution in the case of dipoles using photoemission as primary electron source. He presented the distributions for drift spaces,

quadrupole fields, and dipole fields. An unusual left-right asymmetry was observed for the dipole field with photoelectrons, but not for any other field, nor for the dipole field with gas ionization. FZ wondered whether the particles are produced, or redistributed (e.g. after hitting the chamber or when "cleaning"), only in the right part of the chamber (to be further investigated). It could also be just a problem of the x-y distribution output file.

GR proposed to repeat simulations at 7 TeV (i.e. B=8.33 T) using gas ionization to see whether it is a problem of the dipole field or whether it is related with photoemission (**ACTION** → HM).

It was also suggested by AB to check whether there is a left-right asymmetry in the flux on the wall (**ACTION** → HM).

In other simulations, for a very weak dipole field (0.01 T) with gas ionization a lot of macroparticles are seen in the horizontally outer corners of the vacuum chamber, which could be due to energy gain in the horizontal plane during a bunch passage. The Lamor frequency is 0.3 GHz at 0.01 T.

In addition, Humberto Maury will meet Giovanni Iadarola the following week to examine this problem with GI's new code (PyECLOUD) (**ACTION** → HM and GI).

All simulations were done with two batches of 72 bunches (25 ns bunch spacing) separated by 200 ns.

Next, **HM** talked about some oscillations observed in quadrupole heat-load simulations. He listed the simulation parameters. The number of particles was increased from 500 to 2500 and the time steps from 300 to 3000, compared with earlier quadrupole heat-load simulations. The simulated heat load shows a funny oscillatory pattern as a function of bunch population for higher values of SEY. To check for a statistical effect, the simulation for highest SEY was redone with half the time steps. The oscillation pattern is shifted in this case. GR points out that the heat load values are very high. The main contribution to the arc heat load now comes from the quadrupoles in some cases, so that this issue should be understood. Next steps consist on changing #time steps, #macroparticles, and quadrupole option (**ACTION** → HM).

It could be also interesting to look at the flux on the wall to see if these oscillations are also present in that case (**ACTION** → HM).

At the end, HM showed the x-y distribution for ibend=6 (instead of ibend=2), which looked even worse, with a funny distribution on the right side and a vertical line at the center. This does not look compatible with the quadrupole field.

AB proposed to do periodical codes benchmarking, i.e. routinely compare results of several codes. This would help to control possible mistakes that might slip in during the code development.

Heat-load data & benchmarking for 25-ns run

Frank Zimmermann presented slides from Laurent Tavian about the heat loads observed in the LHC arcs during the MD that took place on 24-25 October 2011. The expected EC heat load shown in some of these plots seems to be not very reliable since they are based on simplistic scaling laws.
CB wondered what happens when considering the real length of the magnets in simulations instead of 1 m. FZ answered that other input parameters, like the number of primary electrons, would have to be changed at the same time to correspond to the modified length considered, and that the effect/result should be the same.

ACTION: Study heat load simulations for 25 ns at injection for different values of SEY and R to infer the present surface condition of the arc chamber **(HM)**

AB and **FZ** discussed the synchrotron radiation flux and photoemission in the LHC straight sections.

Status of SEY-R benchmarking with 25-ns data

Octavio Domínguez presented the status of the 25 ns benchmarking based on observations done during the MD sessions held on 14 October and 24/25 October. First he showed the vacuum measurements for the 14 October MD pointing out the “unexpected” behavior of the pressure, i.e. sudden decreases just after a pressure rise following each injection instead of achieving a steady state value. This behavior is due to the many parameters changing simultaneously due by the strong e^- cloud effects, in particular beam losses. Some scrubbing effect is also considered to be happening during the course of a night, the benchmarking study which makes even more difficult.

CB asked for the time scale of pressure rise after an injection. OD answers that the effect is almost immediate (<20 s).

Next he presented two short studies about the dependence of the e^- flux on the vertical emittance and on the input pressure. The vertical emittance was scanned from 4 to 18 μm maintaining the horizontal one to 3.5 μm, and, the result is that this dependence can apparently be neglected. The dependence on the input pressure is more important. Varying this pressure from 5 nTorr to 200

nTorr (both values achieved during the MD) the flux difference is around 30%, which I quite significant for benchmarking the simulations against observations.

Despite the lack of good data, OD carried out a tentative benchmarking study using 4 different relative measurements along the night. No agreement is found when considering pressure ratios. As an attempt, OD considered also the ratios using the pressure normalized to the total intensity, achieving this way lines for two of the four configurations considered, but without any match. FZ pointed out that the normalization by the total intensity might not be very reliable. It would be reasonable for synchrotron-radiation induced pressure rises, but not for the electron cloud. The vacuum gauge shown is the VGI.141.6L4.B (at point 4).

One conclusion could be that the benchmarking method cannot be applied when the electron cloud effects are very strong and causes simultaneous variations in many parameters.

The next steps include a study of the dependence of the e^- flux on the detailed bunch-by-bunch intensity patterns along the batch, which can be done thanks to the PyECLOUD code, under development by G. Iadarola (**ACTION** → OD, GI).

Next OD presented the results from the most recent 25 ns MD. During almost the whole MD, the filling pattern was the same, consisting in 72-bunch trains separated by 925 ns. For individual pipes, the pressure behavior was roughly the same as the one observed in the previous MD. However some gauges in the common beam pipes show that the pressure continued to decrease despite new injections, which can be an indication of scrubbing.

At the end of the MD, half an hour was used to repeat the benchmarking experiment to study the dependence of the e-cloud on the batch spacing. At this occasion, the pressure tended indeed to a steady state value, indicating that some scrubbing had been performed before. Even if the waiting time at different values of batch spacing should have been a bit longer in order to really achieve the “steady-state pressure”, the results look good enough to do a new benchmarking study with 4 different beam configurations (**ACTION** → OD).

HP and Water-Bag distribution at the LHC

Chandra Bhat reviewed the HP and water-bag distribution, the former also including the effect of impedance. Simulations were performed for LHC at 7 TeV considering 50 ns bunch spacing with the three different distributions. There is almost no difference in the e-cloud build up, but up to 20-25% difference in heat load (being lower for the water-bag distribution). This could point to a different energy spectrum. In addition to HP and water-bag distribution also a case with double-harmonic RF and V2/V1= -0.5 was included in the heat-load comparison. The first conclusion is that the water-bag distribution would not bring much advantage from the e-cloud point of view.

A next step in the study will include the variation of the grid size, i.e. increase/decrease the number of slices for the beam bunches to see e-cloud dependence for water-bag, HP and distribution with Z/n from ESME (**ACTION** → CB).

AOB

The next e-cloud meeting will be announced in due time.

Reported by Octavio Dominguez and Frank Zimmermann