# LHC ecloud simulations Meeting

Date: 17 January 2011
Meeting Room: 354-1-001

**Attendees:** Chandra Bhat, Elias Metral, Giovanni Rumolo, Kevin Shing Bruce Li, Humberto Maury Cuna, Octavio Dominguez, Tatiana Pieloni, Frank Zimmermann, Gianluigi Arduini, Ubaldo Iriso

***Minutes and actions from the previous meeting:***
Frank Zimmermann commented on the previously reported skew wake, which is most likely wrong according to symmetry (argument from Daniel Schulte).
Elias Metral remarked that the tune split was expected, and that Karel Cornelis had an explanation in terms of coupled-bunch instability.
Frank Zimmermann commented that the "unperturbed" tune was not expected from electron-cloud alone, and might be related to resistive-wall impedance.
Gianluigi Arduini's analytical model, reported in ECLOUD'04, might already have the full explanation. Action: set RW part to 0 and see if unperturbed "rigid" tune disappears (***ACTION Gianluigi Arduini***)

**Kevin Li** presented an update on LHC electron cloud instability studies.
Previous bunch length referred to ion operation. Simulations were now updated to a 4-sigma bunch length of 1.2 ns instead of 0.77 ns.
**Case 1**: 0.77 ns, 0.8 eVs (same as at injection), 4 TeV, 1.1e11 scan over e- density, stable up to about 5e11 m^-3.
Elias Metral asked if we can be sure that 5e11 m^-3 is stable. Kevin Li suggested one could fit to a straight line and determine the "linearity" of each line.
Simulating one case takes 4 days. Several simulations can run in parallel.
100 kicks per turn were applied. Q'=2 unless scanned.
6e11 m^-3 stabilized by Q'=4.
**Case 2**: 1.2 ns, 1.9 eVs, 4 TeV, 1.1e11, 2.5 micron.
Instability occurs below 3e11m^-3. No stable situation was found.
6e11 m^-3 again stabilized by Q'=4. This could be because the resonant frequency is lower, given the dependence (1+f_xi/f_r).
Might be nice to show that 2e11 m^-3 is stable. (***ACTION Kevin Li***)
**Dipole field acts stabilizing**. 1.2 ns, 6e11 m^-3 is stable. 3e12 m^-3 is unstable in y.
2.5 to 2.51 in 1024 turns (4e-3 in 1000 turns).
Simulations for dipoles at 450 GeV are still needed (***ACTION Kevin Li***)
**Conservative goal: a density of 1e11 m^-3 should not be reached at any place along any train (with 900 bunches).**
Question: Did Elena find a threshold if 6e11 m^-3 for dipoles or for field-free region?
**Preliminary conclusion:**
**4 TeV threshold: <3e11 m^-3 field free, ~6-7e-11 m^-3 in dipole (tbc), 1.2 ns**

**450 GeV threshold: <4e11 m^-3 field free, ~6e11 m^-3 in dipole (from Elena; tbc), ~1.2 ns (sigma_z=0.1 m)**
Gianluigi Arduini suggested to also simulate for 450 GeV with 1.5 ns, field-free and dipole.

Footprints for field free case and dipole field were shown. With a dipole field the horizontal tune spread was squeezed, and much smaller than the vertical or the one for the field-free situation (scale 1e-3 versus 1e-4). There was almost no shift in the x plane.
Tatiana Pieloni clarified that the damper had been on during the LHC measurements.
Kevin Li provided a qualitative explanation for the low horizontal spread: there are two e- “hot spots” whose effects cancel each other in the horizontal plane.

**Octavio Dominguez** reported on simulations for IR3, and on two LHC arc simulations (emittance scan etc).
The flux versus batch spacing is to be simulated and the measured dependence of pressure on bunch spacing to be reproduced by adjusting R and delta_max, plus possibly other parameters.
Depending on the value of R a small change of delta_max has either a big or a small effect.
Epsilon_max=230 eV and the baseline pressure of 1 ntorr had not yet been varied.
There was an energy threshold for electrons hitting the wall.
Curves for a constant flux ratio in delta-R space for different batch spacings should intersect.
One could later vary epsilon_max and base pressure to improve the intersection of various curves in R-delta space if needed, and/or to see the dependence on these parameters.
A discussion on R and delta values from the past SPS benchmarking exercise followed. Gianluigi Arduini remarked that some R-delta values referred to the situation after 4 A-h, and others the final numbers after 22 A-h.

Next Octavio Dominguez summarized recent LHC arc dipole simulations, wth Nb=1.1e11.

A near-term task was to determine **which delta_max is needed to get density <1e11 m^-3 for 50 ns and 75 ns, R=0.5**; dipoles and field-free (***ACTION Humberto Maury, Ubaldo Iriso***); goal is to determine how much scrubbing is needed

The onset of multipacting as a function of emittance, at R=0.7, revealed only small **impact of the emittance in the LHC**. The small dependence on emittance might or might not be in contradiction to the earlier. For the SPS, the emittance was important for the speed of build up close to the threshold. In the LHC case there is a factor 2 reduction in e- density for 10 times bigger emittance, with an SEY of 2.4, somewhat above the threshold. Previous SPS simulations were presented for comparison.

The originally suggested scrubbing strategy was to start with larger emittance and then reduce the emittance. With bunch length as parameter, on the other hand, a shorter bunch length would stabilize against e-cloud instability and also enhance the scrubbing.

Electron energy distributions for the emittance scan were shown.

Intensity scan was performed with an emittance of 2.3 micron. The maximum number of electrons was obtained for Nb=5e10 at R=0.7.

The x distribution shows no stripes, only a peak at 0. Frank Zimmermann argued that this should be due to the fact that the electrons are generated inside the beam volume. The best scrubbing at the center of the chamber could be obtained with bunch intensities of 5-7e10.

There could be a problem with the presently envisioned scrubbing at injection energy if stripes start to occur only during the ramp or at top energy.

The dependence of the horizontal flux distribution on magnetic field and beam size should be checked for the LHC (***ACTION Octavio Dominguez***).

The question was raised whether one can explain the SPS observations, which showed stripes at top energy in the strip detector, with a field of 0.12 T.
The following actions were suggested: Check simulation results for SPS at extraction and look for stripes, in particular simulate SPS at injection. Check results for different magnetic fields. (**ACTION Octavio Dominguez**)

Elias Metral and Frank Zimmermann suggested that one may need a large transverse emittance to populate the stripes.

**Plan for Ubaldo Iriso's studies.**
Goal is to go below 1e11 m^-3.
Assume R=0.5. What secondary emission yield is needed to get below 1e11 m-3?
For 450 GeV (0.5 T) and 3.5 TeV (~4.2 T) or 4 TeV. Sensitivity to parameters is of great interest.

Extract SEY needed to stay below 1e11 m^-3 for 50 ns and 75 ns spacing (***ACTION: Humberto Maury, Ubaldo Iriso***); consider Nb=6-13e10.
For 75 ns spacing, the filling pattern should have gaps of 225 ns between batches, with 936 bunches maximum, and bunch intensities of Nb=1.1-1.3e11.

It was argued that the main limitation for LHC operation might be the pressure, and that scrubbing at 450 GeV might not avoid the stripes at top energy.

The next meeting will be held after the Chamonix workshop.

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Reported by Frank Zimmermann