LHC e-cloud simulations Meeting – Draft Minutes

Date: 11 January 2013
Meeting Room: 6-R-012

Attendees: Roberto Cimino (RC), Octavio Domínguez (OD), Giovanni Iadarola (GI), Humberto Maury (HM), Sergio Rioja (SR), and Frank Zimmermann (FZ)

Excused: Gianluigi Arduini (GA), Elias Metral (EM), and Giovanni Rumolo (GR)

Agenda

1. Minutes and actions from the last meeting
2. Review of some scrubbing run & 25-ns results: vacuum benchmarking, **Octavio Dominguez**; heat load at 4 TeV, **Humberto Maury Cuna**; overview of the scrubbing run and arc benchmarking at injection (Giovanni Iadarola)
3. Plan/progress for photon distribution, **Humberto Maury Cuna** (included in 2.)
4. E-cloud news from Frascati, **Roberto Cimino** (included in discussion of 2.)
5. AOB

Outstanding actions from the last meeting

Actions from the last two meeting on 10 August and 1 October:

- **E-cloud simulations, for a long train w/o gap, of central density, line density and heat load, with the full version of PyECLOUD and ECLOUD** (**ACTION HM**) – This had been done by HM, but has not yet been presented.
- Repeated simulations of **multipacting thresholds at 25-ns spacing as a function of chamber radius using both ECLOUD and the complete version of PyECLOUD** (**ACTION HM**) – Also this had been done by HM, but had not yet been presented.
- A new filling scheme with trains of 4 PS batches had been prepared by OD.
- GI has checked and solved the issue of the time step with HM's input files.
- ECLOUD-PyECLOUD differences in a dipole field (**ACTION → GI**: **Check Humberto Maury's PyECLOUD simulation for SEY=1.5**). This is still pending.
- Also 35% higher heat load for **PyECLOUD in the drift sections** is to be further investigated (**ACTION CB**).

- **Different behaviour** (especially regarding the build-up phase) **of ECLOUD and PyECLOUD for the LHC arcs by CB and HM** with ECLOUD for CB showing a faster build up, saturating earlier and at a lower lev**el** (**ACTION: CB and HM**).

Review of some scrubbing run & 25-ns results

Octavio Dominguez reported on the scrubbing run with 25 ns spacing. Unfortunately, **the plan to inject dedicated filling patterns for pressure benchmarking in the straight sections had been dropped** due to slippages in the schedule. Instead, the available, non-dedicated fills had to be used for the analysis. The first half of fills had suffered too much beam loss and too much variation in time to be easily used for reliable benchmarking. The second half of the scrubbing run had provided fills with more stable conditions, and was used for the analysis.
The pressure increases with newly injected groups of PS batches (with 925 ns between subsequent injections) had been almost constant, which was exploited in the benchmarking. Assuming R=0.2, an **initial maximum SEY of delta_max=1.3** and a subsequent **conditioning evolution down to 1.22** was deduced. S**crubbing effects had been visible even from fill to fill**.

Giovanni Iadarola asked if the pressure evolution for the injection phase of the 4 TeV fills was also consistent with the derived delta_max values. **Octavio Dominguez** replied that the 4 TeV runs had featured 72 bunches per injection instead of 144 or 288 bunches, and had, as a result, exhibited insignificant pressure increases only. Therefore, the **4-TeV fills could not be used for pressure benchmarking**.

In one example fill, **no pressure increase had been observed with 144 bunches, but a clear pressure increase for 288 bunches**. Independent simulations revealed that this requires delta_max<1.24 for any R, based on a completely different analysis. This result is c**onsistent with the result of the pressure benchmarking**, i.e. the delta_max was identical for the same R.

Giovanni Iadarola commented that **further similar checks could be done for other moments of the scrubbing run,** e.g. for cases where the cloud collapsed during a fill with degraded beam. He also highlighted that **desorption yield was changing as well as delta_max**. **Roberto Cimino** remarked that pressure increases are a challenging indicator indeed.

ACTION: Benchmarking for other phases of scrubbing run? (OD, GI)

The revised **multipacting threshold in these straight sections** at 25 ns was **delta_max=1.16** for the filling pattern used during the scrubbing run instead of the previous 1.25.

Frank Zimmermann asked if zero information could be obtained from 4 TeV operation. **Octavio Dominguez** confirmed that this was the case. **Giovanni Iadarola** pointed out that there

had been **one more reference fill at injection energy**, with the same pattern as in the scrubbing run, **towards the end of the 4-TeV operation period.**

ACTION: Pressure benchmarking for the last reference fill during 4-TeV operation (OD)

Humberto Maury Cuna reported on the **heat-load benchmarking for the arcs with 4 TeV data at 25-ns spacing**. **Only dipoles** were considered. The values of *R* and delta_max were scanned for the benchmarking. Heat-load numbers for three fills had been obtained from Laurent Tavian. Results of the simulation benchmarking **for *R=0.5*** were **delta_max=1.58, 1.54, and 1.51**, respectively, i.e. showing a conditioning effect. Values for delta_max corresponding to other values of R (0.7) and to a different photoemission yield (3 times higher) were also presented. The increase in the number of photoelectrons lowers the corresponding SEY by about 3%. **RC** confirmed that changing the number of photons due to a different beam energy would not necessarily imply a change in the number of photoelectrons by the same factor, due to the photon-energy dependence of the photo-emission. The baseline number of photoelectrons corresponded to the unconditioned value at 7 TeV (delta_max=2.0) divided by a factor of 10 to roughly take into account the lower beam energy of 4 TeV. Nevertheless, the number of photoelectrons at 4 TeV could possibly be underestimated still.

Roberto Cimino commented that the **variation of the photoemission yield with energy** and the related issue of work function with a cryosorbed layer were under study.

A new code **Synrad3D** developed at Cornell had been presented at ECLOUD12 by Gerry Dugan. This code can track the photons and provide the **photon distributions around the ring**. Example simulations for Cesr-TA were presented.

Roberto Cimino remarked that the photon distribution/divergence is a strong function of the photon energy.

Octavio Dominguez asked if Giovanni Iadarola got the same values for the delta_max. **Giovanni Iadarola** replied yes, the agreement was better than 0.1, but details needed to be checked. Close to the threshold even small changes were important. **Roberto Cimino** remarked that **reflectivity has a shape and is not only a value.** The SEY shape for the lowest 50 eV is what determines the memory effects and not only the value at zero incident primary electron energy.

Giovanni Iadarola commented further on this memory effect showing his results from February 2012. Build up can be monitored by the measurement of the **bunch-by-bunch stable phase** with respect to the RF. The saturation level is well reproduced in the simulation. **Discrepancies for the start-up phase are puzzling.** There seems to be a **memory effect,** possibly due to

uncaptured beam or due to a difference in reflectivity function from the assumed shape. Could there be a remaining charge on the surface? **Roberto Cimino** commented on physisorbed gases on the cryogenic surface as a possible explanation. This layer certainly is not a metal and it could charge up. **Giovanni Iadarola** asked whether there could be any contact or charging effects between the different materials that could also generate some voltage. **Roberto Cimino** answered that in the accelerator this would be very difficult to know.

Roberto Cimino reported on the plans at Frascati for SEY studies on pure crystals at low energy.

Giovanni Iadarola presented his slides from the Evian workshop, reviewing the main observations from the scrubbing run. **Rapid conditioning was observed in the first stages. Later the conditioning slowed down significantly. Final delta_max values saturated at 1.43 for *R*=0.7.** Scrubbing resulted in an efficient improvement of the beam lifetime. Results from the physics fills were also presented. **At 4 TeV there is no indication of further emittance degradation due to the electron cloud**. The main difficulties arise in the ramp since the model used by the cryogenic group is a steady-state one and this generates false responses of the calculated heat load during the transient. In some fills a high brightness beam (H9) was injected, ramped and squeezed, which is an important achievement. Possible running scenarios for 2015 were shown.

Roberto Cimino pointed out that in lab measurements the **carbon conditioning of the surface could come from the hot filament**.

Giovanni Iadarola mentioned that at the MSWG Mauro Taborelli and Karel Cornelis had discussed the possibility of a dirty coating with gas injection into the SPS, and that this option is presently under consideration within the LIU.

Roberto Cimino highlighted that e-cloud studies are done best at places where e-cloud is a problem. At the moment Frascati work was focusing on building up a homogenous, amorphous graphite layer, including warming up.

AOB

The next meeting will be announced in due time.

Reported by Octavio Dominguez and Frank Zimmermann