CEI section meeting 15-08-2024

Present: Chiara Antuono, Elena de la Fuente Garcia, Lorenzo Giacomel, Dora Gibellieri, Miguel Gonzalez Torre, Fredrik Grønvold, Gianni Iadarola, Christophe Lannoy, Szymon Łopaciuk, Lotta Mether, Elias Métral, Nicolas Mounet, Konstantinos Paraschou, Giovanni Rumolo, Luca Sabato, Roxana Soos

Online:

Excused: David Amorim, Xavier Buffat, Leonardo Sito, Carlo Zannini

Scientific secretary: Lorenzo Giacomel

General information (G. Rumolo)

Communications and Arising matters

- LS3 schedule
  - So far LS3 is planned to start in November 2025 for the whole CERN accelerator complex and last till mid-2027 for PS complex, mid-2028 for SPS and mid-2029 for LHC
  - Currently an extension by six months of LS3 has been requested by HL-LHC to allow for unscheduled activities and some additional civil engineering work
  - Furthermore, run 3 could also be extended by 6 months to one year further increasing the total delay. A decision will be taken in September 2024.
  - Gianni: Would the injectors also be affected? Giovanni: the duration of the LS for the injectors would not change, but the start would be obviously delayed in case of Run 3 extension.
  - Lorenzo: Does the LHC HW commissioning include magnet training? Giovanni: Yes, it is part of the machine commissioning.
  - Nicolas: The current plan does not include the beam screen treatment, which will happen, so the extension is probably really needed
- CERN school of computing
  - It will take place on November 4-8 in Ferney Voltaire in France and it will be

nonresidential
    - Target: provide the tools to use efficiently the services provided by the CERN IT department
    - A list of people intersted should be sent soon
- News from LMC
    - At the moment the option to start dipole training before LS3 in order to reach 7 TeV is being considered
    - The other options are that we stick to 6.8 TeV or train to 7 TeV at the beginning of run 4
    - The probability that a major failure happens during the training and a sector needs to be warmed up, repaired and cooled again was evaluated and is higher in the case we push the training to 7 TeV. The failure sceanario would result in a 3.5 months delay
    - No decision was taken though training to 7 TeV before LS3 seems unlikely due to the unfavorable benefit to risk ratio. The HL project considers restarting LHC in Run4 with the same energy as end of Run 3, i.e., 6.8 TeV is the current baseline.
    - Nicolas: actually the official tables report a target energy of 7 TeV
    - Elias: it would be a pity to not go to 7 TeV energy because this is the only LHC parameter which was not attained together with the total number of bunches (Gianni underlines that this was attained only during scrubbing at injection, but not in operation)
- Injectors:
    - No dedicated MDs took place due to the HIRADMAT run, but some time is being invested in the preparation of the LHC MD beams for next week, when there will be an MD block
- LHC:
    - This week is still dedicated to physics production, next week a block of MDs will take place
    - The luminosity production has been high lately thanks to good availability (80% availability and 60% of time spent in stable beams) and lots of fruitful fills
    - Only one UFO dump after a cluster of them, which is reassuring after a cluster of UFO dumps in one of the previous weeks
    - Currently important capture losses are being seen at the beginning of the ramp regardless of the time spent at 450 GeV

- Gianni: Stefano Redaelli underlined that if this is due to uncaptured beam intercepted in IR3, then the BLM thresholds can be slightly relaxed
- In terms of schedule we are a couple of days early with respect to the prediction
- No important change of heat load and beam parameters (in particular emittances are quite stable after they changed a lot in the first part of the run)
- Actually, one could argue that there is a minimal decrease of normalized heat load. Gianni: if there is a minimal gain here, would that improve with longer trains and more total integrated e-cloud? Giovanni agrees that this is likely and that's why we tried to puch the 48b filling schemes as much as possible at the beginning of 2024
- Gianni: Maybe this slight decrease is due to the fact that scrubbing wasn't so effective at the beginning as it could have been
- Lotta: It could be possible to reopen the discussion with the LBOC to go to 4x36 trains
- LHC MDs:
  - Latest schedule available on ASM
  - 4 CEI MDs: octupole threshodl sweetspot width, e-cloud coupled-bunch tune shift at injection, negative octupole polarity and e-cloud at injection energy, impact of longitudinal impedance and betatron coupling on Shottky spectrum

E-Cloud studies for FCC-ee (Luca)

- Introduction
  - E-cloud is always probelmatic for positively charged beams. Therefore for the FCC this is an issue for the positron beam and it can induce heat loads and instabilities
  - The FCC-ee beam paramters have been updated several times in the past so it has been difficult to keep up, but now there are the Mid-Term review parameters and these are the ones used in this presentation
  - Giovanni: Does everyone in the project now agree with these parameters? Luca: Yes, especially for the Z-configuration, which is the more problematic for e-cloud

    - Filling schemes: Two options are proposed, 20 ns bunch spacing and 25 ns bunch spacing, so both are studied here

- SEY Multipacting Thresholds

    - Idea: define material properties needed to avoid avalanche multiplication of electrons (ideally having SEY<1)
    - Currently the multipacting tresholds are defined based on the total electron density rather than on the central electron density since this is a more noisy quantity
    - The most critical bunch intensities are found to be in the range 1-1.5e11 positrons per bunch
    - It seems that the multipacting SEY threshold is very low in the order of 1, which cannot be achieved with the chosen material (NEG)
    - A possible effective mitigation would be to increase the bunch spacing: 50ns would push the threshold to 1.3
    - On the other hand if the bunch spacing was increased to 50 ns then also the bunch intensity would have to be increased in order to keep the total intensity, and this would be problematic for impedance-induced instabilities (TMCI, see work of Roxana Soos)
    - Another mitigation would be to avoid the critical intensities (1-1.5e11 positrons per bunch) during the charge accumulation phase
    - Two options based on staggered injections would achieve this and were presented by Hannes Bartosik at the FCC week
    - These two options were analysed in terms of SEY threshold
    - With the special injections scheme the SEY threshold is increased above 1.3 in the drifts and and dipoles but quadrupoles and sextupoles remain critical (SEY = 1.1)

- Heat Loads

    - Dipoles are the main contributors to total heat load. If we assume that the SEY is larger than the SEY threshold the estimated heat load amounts to about 5-7% of that induced by synchrotron radiation, while if the SEY is lower than the threshold the e-cloud induced heat load is negligible

- Stability Studies

    - It is important to estimate the stability threshold in terms of electron density
    - This was estimated theoretically with Ohmi's formula and numerically with PyECLOUD-PyHEADTAIL. The two approaches are found to agree in the order of magnitude.
    - It is seen that if the SEY in the dipoles is above the multipacting threshold, then the central electron density is above the stability threshold
    - Elias: Why is the vertical plane more critical for stability? Luca: This is due to the fact that the beam is very flat (factor 10 smaller in V than in H)
    - The same conclusion applies to drifts and quadrupoles while in the sextupoles the beam could be also stable also in the multipacting regime

- Photoemission

    - In all studies shown before the photoemission was never considered
    - This can be evaluated with PyECLOUD, which includes a model for photoemission depending on one main paramater, which is the number of photoelectrons generated per beam particle (positron) and per unit length
    - With photoemission we reach more quickly the ecloud saturation and the saturation density is higher
    - With photoemission the central electron density can be higher than the stability threshold also with the SEY being below the multipacting threshold
    - The photoemission flux needs to be evaluated carefully with codes like Synrad+
    - The flux could be decreased increasing the length of the beam chamber winglets
    - Another solution could be to insert new synchrotron radiation absorbers with a saw-tooth profile along the primary facet, which are being designed by the vacuum group

- Nested Magnets

    - An idea to reduce the emitted synchrotron radiation would be to combine dipole and quadrupoles or sextupoles. This would allow to increase the dipole filling factor and reduce the magnetic field in each dipole (and the local radius of curvature...)
    - Dipole + quadrupole: the study was carried out for both focusing and

defocusing quadrupoles. In this case the electron distribution changes but the impact on the central density is minor
    - Dipole + sextupole: positive setupolar component helps with respect to the negative and reduces a lot the central e-cloud density
    - Quadrupole + sextupole: this solution is not really currently considered but it could move away from the center of the chamber the highest electron density
    - Kostas: What's the beam size in horizontal? Is it small enough to not overlap with the highest density anymore? Luca: Rms size is 500 micrometers, therefore in the shown example the beam would not overlap with the highes density anymore

- Outlook
    - A new synchrotron radiation absorber is being developed by the vacuum team and it could help for photoemission
    - More photoemission simulations will be carried out when a more realistic estimate of the photoemission fluxes will be given by the vacuum team (probably they will be obtained with ray tracing codes)
    - More nested magnets configurations will be studied to check how the observables depend on the different magnetic field configurations

- Questions
    - Elias: Can we have materials with SEY<1? Lotta: Currently we are bound to consider NEG for the vacuum system and for this we cannot go below 1
    - Giovanni: Is photoemission also high for NEG? Lotta: It is assumed that it is but no measurements seem to be available
    - Nicolas: What about the RF cavities? Lorenzo: Not a problem because the longitudinal fields dominate and the RF multipacting is mitigated by RF conditioning
    - Nicolas: What kind of instabilities are being predicted? TMCI-like? Luca: yes and not much can really be done. Giovanni: We are assuming that coupled-bunch instabilities can be mitigated by the damper. Lotta: Indeed, although the limitations should be investigated
    - Kostas: Can the interplay between photoemission and beamstrahlung be an issue? Giovanni: Beamstrahlung electrons are meanly emitted longitudinally so probably the two don't interplay

- Giovanni: Is the E-cloud in the booster being studied? Luca: The booster is being studied by the Frascati colleagues and it is less problematic especially in the filling options propsoed by Hannes.
- Lorenzo: Recently the radius of the beam pipe was changed from 35 mm to 30 mm, is it worse for e-cloud? Luca: this never analyzed alone because when the chamber size was changed, other parameters were also changed at the same time. At that point the e-cloud situation worsened indeed but it could just be because of the changes in the beam parameters
- Kostas: Can there be an interplay between impedance and and e-cloud instabilities? Elias: This was checked in the past but no clear conclusions. Lotta: It will be investigated by the next PhD student. Lorenzo: In the LHC it is not so relevant because the two effects are typically dominant at different times in the cycle, so it makes sense that the interplay was not studied in too much detail. Elias: Some computations could be done with DELPHI+eDELPHI

AOB and end of the meeting

The next meeting will take place on the 22nd of August. Dora will present the impedance model studies for FCCee.