Minutes of the HSC section

147th meeting on Monday 09/07/2018 (10:30, 6/R-012)

Present: See https://docs.google.com/spreadsheets/d/1fZiu3vtf546odhd2ONxtW0mx9p8cV-fURT9Kxi7QCys/edit#gid=0

1) Newcomers / visitors / departures

- MauroM will leave us next Friday (and come back next year in February for another 6 months). Many thanks for all MauroM!

2) Comments on the minutes of the previous 146th meeting + Actions

- No comment.

- Actions from last meetings:

  - Action 1 (SergeyAnt et al.): HL-LHC tolerances to beam position offsets at the Crab Cavities => To be followed up by/with RamaC.

  - Action 2 (BenoitS, NicoloB et al.): Provide the (current) impedance model (and wake function model) of all the CERN machines.

    => Ongoing. 2 non-mbs Summer Students joined to help in this activity.

  - Action 3 (XavierB, BenoitS et al.): Follow-up of LHC instabilities (with automatic tools) => See LHC_TIM meetings (https://indico.cern.ch/category/10168/) and web site (http://lhcinstability.web.cern.ch/lhcinstability/).

  - Action 4 (Gianni et al.): Follow-up of heat load differences in the LHC sectors => On-going.

  - Action 5 (LeeC et al.): SPS horizontal instability studies => On-going (KevinL and MichaelS could also help in the future). CarloZ will follow this up.

  - Action 6 (MauroM et al.): PS horizontal instability at 26 GeV with adiabatic bunch shortening => To be followed-up by e-cloud team.

  - Action 7 (TatianaR, MauroM, EiriniK): PSB impedance model and related instabilities => Talk by MauroM at the LIU-PSB beam dynamics on 23/04/2018. Talk today (25/06/18) by TatianaR. Following past studies from MauroM about some

missing dipolar impedances, one should try and study the effect of a HOM (scanning the different parameters) with DELPHI to see how we can reproduce the observations and give more quantitative info about the possible missing impedance.

- Action 8 (ClaudiaT et al.): LHC BTF studies and possible instabilities due to noise

    1) Try and explain the factor 3-4 between 2016 and 2017 (whereas the impedance model should be the same within ~ 10-20%).

    2) What is the exact mechanism leading to instability? Is it the one from XavierB (with the white noise), drilling a hole in the stability diagram?

    3) To be studied also in the presence of ADT and see if the modes observed are those from impedance as well as the rise-time.

    => Discussed at the LBOC on 27/03/18. To be continued to fully understand the mechanism behind.

- Action 9 (AdrianO): Continue and finalize the space charge studies on SPS TMCI => Discussed on 09/04/18, on-going and on-going discussions with A. Burov et al.

- Action 10: GianniI raised the question about the bunch length to be used for HL-LHC instability studies. Until now we have been using the rms value from a Gaussian distribution => To be reviewed in the future in case there are good arguments to use another function (such as the q-Gaussian).

- Action 11 (LottaM et al.): Detailed simulation studies to try and explain the 16L2 instabilities in 2017 => Some first simulation results were discussed on 23/04/2018 and others today (09/07/2018). To be continued. Some update discussed today (09/07/18).

- Action 12 (MarioB et al. and MichaelS): SPS coherent tune shift bunch-by-bunch: can we reproduce this from theory/simulation using the SPS impedance model (staring first with the resistive-wall)? => To be done by MichaelS after his PHD (as COAS).

- Action 13 (OlavB): Detailed simulation of the quadrupolar impedance to be performed for the 4-pole structure => Done.

- Action 14 (DavidA et al.): Try and solve the numerical issue in https://indico.cern.ch/event/712792/contributions/2937067/attachments/1619147/2574980/LandauDampingForISRinstability_EM_19-03-18.pdf and compare the results with other codes.

- Action 15 (DavidA et al.): Check the TMCI results with tune spread (same numerical issue as above still to be solved) and compare the results with other codes.

- Action 16 (SergeyAnt): Check the effect on Im[Z/n] of the HL-LHC coated inner triplets.

- Action 17 (OlavB): Understand why a 4-pole structure has exactly the same dipolar impedance as the one with 2 parallel plates.

- Action 18 (OlavB): Finalize the work on multi-polar impedances and document it.

- Action 19 (DavidA): Plot the increase in real and imaginary parts of the impedances (dipolar and quadrupolar) for 2016, 2017 and 2018 compared to 2015. Plot also the case 2017 compared to 2016 for ClaudiaT and her LBOC talk on 27/03/2018 => Done.

- Action 20 (DavidA): Finalize the impedance and related instability studies for the EOS and do the same for Injection and Flat-Top.

- Action 21 (NicoloB, DavidA and XavierB): Summarize all the past comparisons between predictions and measurements of LHC transverse instabilities at high-energy vs Q' WITHOUT ADT.

- Action 22 (Everybody): Some volunteers (2-3 people) for the ABP BBQ on 28/06/18 => Done: we have 2.

- Action 23 (NicolasM): Try and answer to the request from RogelioT's team to estimate the amplitude-detuning contribution of collimators.

- Action 24 (XavierB for week starting on 21/05/18): Beam stability studies for HL-LHC => Try and make the scenarios more robust by ensuring enough spread for the small BCMS emittance also during the collapse of the separation. Subsequent simulation work is needed by RiccardoDM and YannisP's team => Done but new version still to be read/commented (see Action 29 below) => Done.

- Action 25 (FrancescoG): In the framework of the beam-induced RF heating, collect somewhere all the "maximum temperatures" for all the different equipment, e.g. due to interlock or past observations, etc.

- Action 26 (Instability team): Organise and perform the tests at injection (to try and reduce the coherent activity and associate emittance blow-up) and high energy (to continue and check the margins) => Done but settings to be optimized.

- Action 27 (BenoitS et al.): Finalize the HL-LHC impedance report and send it to GA asap => Done by BenoitS et al. Next: I have to re-read it before sending it to GA => Done (a 2nd time) and comments will be given tomorrow (07/08/18) to the impedance team before sending the new version to GA.

- Action 28 (SergeyA et al.): Scaling of impedance and related stability for collimators vs. gap and resistivity (assuming only 1 collimator; all collimators; all the machine)? => On-going.

- Action 29 (EliasM): Final reading of HL-LHC paper from XavierB => Done.

- Action 30 (BenoitS et al.): Possible use of a solenoid in the SPS ZS? => It seems that

there is still the suspicion of electromagnetic fields inducing the sparking. Do we have an EM model of the ZS? It would be great if we could understand the origin of this limitation. Remark:

- Sparking in the ZS mainly occurs mainly when the bunch length of the LHC beams becomes very short, i.e. during the last part of the ramp and at flat top. This conditions slowly with time.

- Had also lots of sparking with the 8b4e beam (which was also slightly improved with time, but still it was relatively strong). This points more towards electromagnetic fields induced by the beam rather than electron cloud.

MarioB could help in this activity. CarloZ will follow this up.

- Action 31 (BenoitS et al.): EDMS document "Continuous Transfer Decommissioning in the PS Ring" Under Approval => There is a couple of points related to impedance (potential reduction) that would be good to answer.

- Action 32 (BenoitS et al.): Participation and follow-up of PaoloF's meetings for impedance aspects. BenoitS mentioned that the integration with the wrong layout was checked by BenoitS and RiccardoDM and noticed at the ECR level.

- Action 33 (SergeyAnt): Check DQW Crab Cavity impedance and related effects after new simulations (with new CST software), if the latter are confirmed/understood.

- Action 34 (YannisP and EliasM): Review the situation of machine settings for starting after TS1 (tunes, chromaticity, octupoles) in view of continuing the studies on the beam 1 / beam 2 lifetime difference => Done by GianniI.

- Action 35 (SergeyAnt and EliasM): TMCI measurements and implications for HL-LHC => What would be the impact of the various impedance scenarios (with present collimation system, with upgraded collimation system after LS2 and with full collimator upgrade) on TMCI threshold and implications in terms of stability?

- Action 36 (AdrianO): Re-simulate the SPS Q26 optics as this is where we have the largest disagreement with AlexeyB.

- Action 37 (EliasM): Follow-up of the issue with the mouse of the 6/R-012 room.

- Action 38 (EiriniK): Compare the pictures of the nTOF gammat-jump before and after optimization.

- Action 39 (DavidA et al.): TMCI for HL-LHC at WP2 ~ mid July (exact date tbd).

- Action 40 (SergeyAnt et al.): Detailed explanation of the effect of coating collimators at WP2 ~ mid August (exact date tbd) => Linked to Action 28 above.

- Action 41 (NicolasM and SergeyArs): Check that the CFC conductivity of the

collimators is the smallest one in the direction of the beam (it should be a factor 5 larger in the transverse plane, according for instance to NicolasM's PHD thesis on p.183).

- New actions from this meeting:

- Action 42 (XavierB and instability team): continue to try and decrease the Landau octupole current at flat-top to see where the limit is. We are at 450 A at the moment…

- Action 43 (XavierB and instability team): feedback from ABP about the use of the ADTObsBox => I will answer to DanielV on 07/08/18.

3) General infos and follow-up (EliasM)

- SLM

  - LMC talk by XavierB this Wednesday on noise effect on instabilities.

- LHC

- LHC back to 25 ns since yesterday (after 90 m run) => 2 weeks of physics production before MD2 block.

- LHC instability follow-up => Many thanks to all the team!

- Injection instabilities observed on fill. 6904 => We increased the chromas on B1V and B2V from 15 to 18 in a 1st step and then to 20 in a 2nd step => To be followed up.

- WP2 meeting

  - Request for unshielded VAX bellows for HL-LHC by BenoitS

    - The request for unshielded bellow is clear and motivated

    - The design of the area and of the bellows took impedance optimization into account:

      - Straight section at 80 mm instead of changes to 63 mm

      - New valve at 80 mm in the baseline (still to be confirmed though)

      - Bellow at large diameter (80 instead of 60 mm) with much smaller corrugation length compared to usual bellows

        - Impact on impedance is visible (depends on beta function at the TAS) but should remain manageable provided there are not too many of these requests

    - Impact of a-C coating on impedance by SergeyAnt

        - Beam screen is responsible for a large portion of machine's impedance at injection

        - Resistive wall component is not the main part of its impedance and can be safely increased without significant effect on beam stability

        - While the proposed coatings do increase the transverse impedance in the high frequency range (above 100 MHz) that is relevant for the single-bunch stability, the overall impact is minor compared to the over sources of beam impedance

        - aC coating of the beam screens does not lead to a significant change of longitudinal impedance => Except for the case of coating the whole ring – over 10%

- LSWG meeting with talks from

    - ClaudiaT on "MD 3290: Instability threshold measurements in the presence of a controlled external excitation".

    - DavidA on "MD3310: Complex tune shift as a function of the intensity for single bunches at top energy".

    - XavierB on "MD3288: Instability latency with controlled noise".

- E-cloud meeting

    - E-cloud observations from the LHC Vacuum Pilot Sector by Elena Buratin

        - In drift they observed a decrease with shorter bunch length and we would have expected the opposite => Let's see what simulations will reveal…

        - After all these years they still see activity…

    - Scrubbing observations at SPS with high intensity 25 ns beams by Hannes Bartosik

        - Clear scrubbing observed, which is a good news for LIU.

    - Impact of the Secondary Emission Model on e-cloud build-up by Loizos Bitsikokos

$$\delta_{elas}(E) = R_0\left(\frac{\sqrt{E}-\sqrt{E+E_0}}{\sqrt{E}+\sqrt{E+E_0}}\right)^2 \qquad \delta_{true}(E) = \delta_{max}\frac{s\frac{E}{E_{max}}}{s-1+\left(\frac{E}{E_{max}}\right)^s} \qquad \frac{d\,n_{true}}{d\,E} = \frac{1}{E\,\sigma_{true}\sqrt{2\pi}}\,e^{-\frac{(\ln(E)-\mu_{true})^2}{2\,\sigma_{true}^2}}$$

- $E0$ (controls the elastic component of the SEY) → no significant difference in heat-load ratio 50ns/25ns.
- $R0$ (controls the elastic component of the SEY) → only minor difference in heat-load ratio despite unphysical case of $R0$ = 0 (no elastically scattered electrons).
- s → Significant change of true secondary component but no visible difference in heat-load ratio.
- E → Minor impact on heat-load ratio.
- $\mu true$ parameter of the energy spectrum of true secondaries has a significant impact on heat-load ratio of 50ns/25ns beams => And this is something, which is almost never discussed.

- Impedance meeting

- M. Migliorati: "Transverse space charge in elliptic chamber"

- SC and 1-layer RW (in classical regime) done.

- Next: multi-layer chamber.

- S. Arsenyev: "Update on holes impedance simulations"

- The two simulation methods (CST and traveling waves) always agree within ~15%.

- Kurennoy's formula correctly predicts $Zdip$ dependence on M and $Rholes$ for all M, lacking only a correction factor.

- Gluckstern's formula only applies for $M \geq 3$ and gives a factor of 2 lower impedance for M = 1 or 2. Previous agreement with Gluckstern's formula was a coincidence due to the correction factor being ≈ 1/2.

- Correction factor is close to 1 for widely spaced holes and a thin wall, but can be up to 1/4 for realistic beam screens.

- N.Biancacci: "Eddy Current Testing on Cu coated CFC and MoGr samples"

- Summary and next steps:

- ECT was applied with success to standard bulk elements (Al, Stainless

steel).

- Measurements on naked CFC sample in agreement with expectations.
- MoGr sample exhibits higher resistivity: it was cut on the not favorable direction!!!
- Coated blocks exhibit better coating resistivity for Cu on MoGr case (~50nOhm).

- Next steps:

- ECT looks reliable => Standard procedure to be written in view of the application to the measurement campaigns on new HL collimators jaws (Mo on MoGr).
- ECT can be applied also on “finished” structures (collimators, TDIS) to check resistivity of jaws.
- Use of coils on PCB could allow for larger frequency ranges.

- Brief update on PT100 measurements by FrancescoG

- The pb: Many collimators, in particular the ones with 2 beams inside give unreliable temperature data. Possible electromagnetic interference between the beam and the probes has to be investigated.

- Next

- Understand if the electromagnetic coupling has a impact on the temperature readout of the probes:

Measure the temperature readout while the current intensity in the wire increases:

1) In the lab 4-tank with the VNA as source.

2) Using a more powerful source able to provide current from 1kHz up to 3GHz.

3) Final test on a collimator.

- Understand if the source of coupling is the probe itself or just the wire (some test already points to the wire).

- Understand the impact of the position of the probes with respect of the beam on the coupling.

- Replace the PT100 with optic fibre (S. Danzeca).

=> BenoitS (WP14): Idea would be that TDIS will profit from this.

=> GianniI (WP14): GianniI reported Galina's work and they agreed with what we requested.

- Maximum allowed resistivity of Mo coating for production samples? (NicoloB suggested to specify 100 nOhm-m as the maximum allowed value) => To be discussed at a WP2 meeting, where SergeyAnt will present the detailed explanation of the amount of Landau octupole current we gain by coating the collimators (trying to answer, as we discussed, to all the questions which are raised for some time).

- OlavB's presentation on impedance during his visit in China (Lanzhou, May 2018): https://indico.cern.ch/event/741568/contributions/3062099/attachments/1682423/2706655/China_Presentation.pdf

- PyHEP 2018 Workshop => Talk from LottaM.

- Reminder: Football / Molki / apero this evening ;-)

4) Electron Cloud effects in the Circulant Matrix Model (Emmanuel Markus Gottlob):
https://indico.cern.ch/event/741568/contributions/3062100/attachments/1683366/2705653/ecloud-presentation5.pdf

- EPFL semester project with XavierB => Focus on single-bunch instability in drift space.

- EMG mentioned 2 approaches for e-cloud effects studies

  - Macroparticles model (Computationally intensive)

  - Broadband resonator model (Phenomenological model)

=> In fact there is also a 3rd one: Vlasov approach from Perevedenstev et al. extending also the notion of wake-field from an e-cloud (depending not only on z-z' but on both z and z'…) => See http://cds.cern.ch/record/585578/files/p171.pdf (Head-Tail instability caused by e-cloud, presented at the 2002 e-cloud workshop).

- The purpose of this project was to develop a simplified linearized model, taking into account the movement of the electrons along their interaction with the cloud.

- Different steps of the study

  - Analytical derivation of the electron cloud transverse kick
  - Numerical implementation in Circulant Matrix Model Python algorithm (BimBim)
  - Algorithm benchmarking
  - Preliminary results in High-Luminosity LHC at injection parameters

- Linearized force used first => This exaggerates a bit but gives the physics.

- Kick from the e-cloud is a focusing lens centered around cloud centroid.

- CMM operators used. Finally, computed the 1-turn matrix and then analyzing the real and imaginary parts of the eingenvalues gives all the required info.

- Simulated TMCI threshold for HL-LHC at injection => ~ 7.5E12 e-/m^3.

- First analysis of the effect of chromaticity revealed that some modes are stabilized by chromaticity while others get unstable (as with impedance…) => To be continued.

- Future work

    - Extension to dipolar and quadrupolar sections => Comparison with measurement data.

    - Comparison with macroparticles and broadband resonator simulations.

    - Investigation of the CMM artifacts.

    - Etc.

5) 16L2 modelling: status and plans (LottaM):
https://indico.cern.ch/event/741568/contributions/3063431/attachments/1683439/2705838/HSC_meeting_20180709_16L2_status.pdf

- Comment about the fact that maybe N2 was removed but water is still remaining.

- Plan: starting from the assumption that there is a high (uniform) gas density in the beam chamber, can we reproduce the observations in a consistent manner?

- Reminder: central density is within 1 mm radius around the beam (as usual).

- Studies with single species (either e- or ions) suggest that it is not possible to generate high enough e- densities to induce the observed effects => To study the problem and try to reproduce the observations, the simulation tools needed to be extended to be able to simulate both species together.

- To enable multiple species in PyECLOUD, the concept of clouds was introduced:

    - Each cloud has its own macro-particle system, dynamics, impact and generation processes (secondary emission, photoemission, generation through gas ionization).

    - Clouds interact with each other only through their space charge, for now => May be extended with cross-species interactions, e.g. electron-induced ionization.

- The multi-species build-up studies confirm that the e- and ions do significantly influence each other

    - The average density of both species builds up over several bunch passages.

- e- densities are enhanced by roughly an order of magnitude, ions less (the effect depends also on the beam energy, gas density and SEY).

- However, the densities in the centre of the chamber during the bunch passage seem to stay roughly constant after the first few bunch passages.

- Slide 13: it is for a single bunch but with values at the beginning of the train=> 1st bunch

- To be redone for case at end of train.

- Slide 14 : Average density is ~ linear with gas density.

- Slide 22 : p is the pressure.

- Conclusions

- Started to try and reproduce the instability observations for densities predicted by losses

- To be confirmed with the instability simulations along the train, but based on simple extrapolation it seems that we are not quite matching the observations yet.

- e- - induced ionization could significantly affect the e- and ion densities that are produced with a given gas density, which may get our model closer to the observations => To be looked at in detail.

- Another consistency check that could be done is to estimate the heat load from the e- and ions in this model => It should not be visible on the cell heat load, since no change was observed there.

- Other effects that could be important

- It has been suggested by the vacuum team that the pressure is dynamically changing (due to outgassing from e- and ion impacts) which should be taken into account

- Can this effect be relevant on the time scale of a few bunch trains?

- How would an evolving pressure affect the gas density estimates from the losses?

- Are collisions (with neutrals) negligible as we are assuming in the model?

- Next

- Further possible studies that could be done include

- The effect of the solenoid, 8b4e

- The effect of different ion species

- Other applications of the tools

  - To study the role and effect of ions during a standard e-cloud build-up process

    - Heat load from ions, effect on e- dynamics

    - Systematic scans for different magnetic fields, SEY and vacuum pressure

  - We have been asked to study the effect on stability of a PBC-FT experiment, where they want to inject gas up to 10^{18} m-3

- In addition the new code capabilities can be useful also for other purposes

  - Dividing e- into several clouds could help to overcome the re-occurring problem of poor macro-particle resolution outside of the main multipacting regions

  - Fast beam-ion instability studies with realistic vacuum compositions

6) Benchmarks between GALACLIC and tracking code SBSC on 3 cases (EliasM and MauroM):
https://indico.cern.ch/event/741568/contributions/3062099/attachments/1682423/2705132/BenchmarksOn3casesBetweenGALACLICandSBSC_EMandMM.pdf

- The 3 cases correspond to the interaction between 1 bunch (assuming as longitudinal distribution a PLD, i.e. Parabolic Line Density) and a broad-band resonator impedance above transition, with

  - fr * taub = Infinity

  - fr * taub = 2.7

  - fr * taub = 1.0

1) fr * taub = Infinity

  - All the lines observed from SBSC (by the new mode analysis by MauroM) are reproduced by GALACLIC.

  - No instability observed until 2.2E11p/b.

2) fr * taub = 2.7

  - Most of the SBSC lines are reproduced by GALACLIC, and in particular all the low-order ones seem to be in perfec agreement => There seems, however, to be a small shift for the higher modes.

- Mode-coupling is predicted by GALACLIC between modes 6 and 7, as it seems to be also the case from SBSC.

- The intensity threshold in both GALACLIC and SBSC is ~ 1.2E11 p/b.

=> Mode-coupling seems therefore to be clearly the reason for the instability.

3) fr * taub = 1.0

- Here again mode-coupling (between modes 2 and 3) is predicted by GALACLIC and observed also with SBSC, leading to an intensity threshold which is very close in both cases (~ 2.2E11 p/b).

- However :

  - The lines are now much larger with SBSC compared to GALACLIC and GALACLIC seems to describe only the bottom of these thick lines.

  - There is a radial mode of the azimuthal mode 2, which is very strong with SBSC, which is not predicted by GALACLIC => This significant difference should be fully understood.

- Reminder: The PWD is computed in GALACLIC assuming a constant inductive impedance (which is OK for a bunch sufficiently long) => To be updated when the bunch length becomes too small…

7) Progress/status in the different activities/projects and reports from meetings and in particular the issues/successes in the different machines (Everybody)

- LHC_TIM (XavierB)

  - Not discussed.

- ATS-IWG (BenoitS)

  - Not discussed.

- HSC-IWG (NicoloB):

  - Not discussed.

- E-cloud (GianniI)

  - Not discussed.

- Beam-beam (XavierB)

  - Not discussed.

- Space charge (AdrianO)
    - Not discussed.
- ABP-CWG (GiovanniR):
    - Not discussed.
- PyHEADTAIL (KevinL)
    - Not discussed.
- DELPHI (DavidA)
    - Not discussed.
- NHTVS (SergeyAntipov)
    - Not discussed.
- LIU (GiovanniR):
    - Not discussed.
- HL-LHC
    - TCC:
        - Not discussed.
    - WP2:
        - Not discussed.
- FCC
    - Not discussed.
- PBC (EiriniK)
    - Not discussed.
- Machines
    - Not discussed.
- MDs (past and future)
    - Not discussed.

8) Miscellaneous

- The next (148th) meeting will take place on Monday 06/08/2018 (in room 6/R-012 at 10:30) => Current agenda:

1) General info and follow-up (EliasM)

2) Highlights from LHC MD2 (Everybody involved)

3) Intensity record in LEIR (NicoloB)

4) A high-performance synchrotron model with pipelined coherent multi-bunch interactions (SondreF)

5) Progress/status in the different activities/projects, reports from meetings and in particular issues/successes in the different machines (Everybody)

- Important events and dates for HSC: https://espace.cern.ch/be-dep/ABP/HSC/SitePages/EventsAndDates.aspx.

- Web site: https://espace.cern.ch/be-dep/ABP/HSC/default.aspx.

Minutes by E. Metral, 01/08/2018.