Minutes of the 103rd WP2 Meeting held on 12/09/2017

Participants: F. Antoniou, H. Bartosik, R. Calaga, L. Carver, D. Gamba, J. Barranco, W. Hofle, G. Iadarola, R. De Maria, E. Metral, D. Pellegrini, B. Salvant, K. Sjobaek, R. Tomas, F. Van Der Veken, G. Zhu.

General Information (R. Tomas)

The minutes of the previous meeting will be soon circulated.

Concerning the measurement of the multipolar component of the CC, Rama reported in the TCC that there is no easy way to have it. The limitation comes from the experimental setup which does not allow to rotate the cavity. Any idea that can help fixing an upper boundary will be good.

Riccardo asks if a statistical analysis of the deformation can help establishing the multipolar component. Rama replies that this was done already. The most sensitive part is the capacitor plate: half millimetre variation has a large impact on b3 (+/-100 units) at the electrical centre, which can also be displaced. This is to be compared with the tolerance of 1000 units on b3 from dynamic aperture considerations.

Plans for the CC test in the SPS (R. Calaga)

Rama summarises the contribution of the 1st of Sept at IEFC meeting (https://indico.cern.ch/event/663036/). The plan for CC test consists of 5 phases:

1. CC powering, commissioning and conditioning with no beam.
2. Making the CC work with beam. When ramping the beam the frequency of the cavity cannot move fast enough. The present idea is to fix the frequency of the CC to the top energy (270? GeV) and bring the beam to that frequency.
3. Transparency to the beam in term of frequencies
4. Performances & long term stability
5. High intensity RF operation

Each item can be naively expected to take about 2 days (points 1. and 2. require dedicated operation), but the accurate planning is on-going.

Wolfgang asks about the frequency of the cavities, Rama clarifies that the full required range can be covered.

Experience from the SPS MDs for the CC test preparation (F. Antoniou)

Several MDs have been performed, aiming at establishing good conditions in terms of emittance preservation for the CC test. Studies were already initiated before 2012 to assess the impact of the energy, intensity and number of bunches. The conclusion was that one needs high energy, low intensity and single bunch to maintain small emittance.
The tests performed after 2015 observed different H/V growth rates. In 2015 it was also noted saturation in the wire profiles. Rama stresses that this might have been there also before. Hannes points out that the acquisition chain is now completely different and this problem is solved.

The 2016 MD took into account two different intensities and values of the chromaticity. Clear dependencies have been observed. Plans for 2017 were made. The list, presented in the injector MD days, includes a continuation of the program of the emittance growth measurements, investigations of the head-tail monitor, orbit correction and stability, collimation studies and studies with shorter bunch length.

The analysis of the IBS impact was started in 2016. Since then it has been consistently observed that the IBS model underestimates the growth by a similar amount in both planes. The unexplained contribution could originate from vacuum and power supply (PS) ripple. Rogelio points out that PS should give a larger effect in the horizontal plane due to the dipoles, Hannes replies that quadrupole PS are suspected. Rogelio suggests checking the tune ripples to quantify their impact. Hannes replies that there is a problem at the moment that is going to be fixed. Fanouria adds that the horizontal and vertical growth rates are sensitive to chromaticity, which hints for the PS. She adds that the vacuum was much better during the SppbarS time; therefore a combined effect is expected. As this extra growth is now consistently observed, more detailed investigations are possible.

The RF feedback has been observed to create extra losses although the emittance (transverse and longitudinal) is not affected. In order to understand this, Schottky profiles were taken, the analysis is on-going.

MDs were performed also for Q20 optics finding very similar results with Q26, it was therefore decided to stay with the much more consolidated Q26.

Fanouria reports that today the instrumentation behaves very nicely, rotational wire scans are well reproducible, the BSRT was tested, the BGI is in the queue as well. The head-tail monitor required some interventions but is now producing encouraging results. The transverse damper was excluded in the past, as it was behaving badly, however the setup was very time restricted; a new setup is now planned so that it could be used in the next MDs.

Elias asks how much the recent measurements of emittance compare to the oldest ones. Fanouria replies that the main discrepancy appears to be the different HV growth rates that appeared in 2015, Rama adds that it took a long time to find a good set of parameters and one could look again into the old data.

The PS ripple shows different amplitudes of the 50 Hz harmonics until 400Hz for consecutive cycles. A technical student will start in October on this topic. Elias suggests looking at 50 GeV cycles from 2009. Hannes adds that a 55 GeV cycle is available also today. Rogelio asks if it would be possible to measure even higher frequencies of the PS ripple. Rama replies that they are checking if some high frequency scopes can be hooked somewhere to perform a measurement. Hannes adds that the vacuum chamber shielding will damp high frequencies. Riccardo points out that there are formulas for the cut-off frequency which involve the surface conductivity. Fanouria concludes that there are also plans to simulate the impact of high frequencies. Elias shared some data with Fanouria concerning the 55 GeV run. Fanouria observed a large emittance growth for that reduced energy.

Concerning the simulation side, several studies were performed by Androula for the 6.8 MV case, to be repeated at reduced voltage. The CC and the head tail monitor do not have a 90° phase advance, the reading on the HT monitor looks however well enough. Wolfgang asks how much the current phase advance is. Rama remembers ~60°; he adds that some phase advance can be recuperated by adjusting the tune. The aperture was checked in the presence of a strong kick from the CC, revealing no particular limitations even at 55 GeV. The profiles from the wire scan could also be used to infer the amount of crabbing. From simulations it also appears that few degrees of CC phase error result in significantly different profiles.

A summary slide collects the plans for the next MDs. Rogelio points out that there are no plans for impedance studies. Elias replies that one does not expect any impact. One may have heating of a specific mode but Benoit adds that this requires a very long storage time to have significant effect. The possibility to reduce the HOM damping was also discussed. Rama replies that there are limitations to the HOM power that can be extracted, he points out that it would be nice to develop a filling pattern to specifically hit a mode in order to check the heating. Benoit clarifies that one should be able to see the crab cavities on top of the already large SPS impedance model only if the higher order mode damping is worsen by moving or removing the HOM couplers.. **Action: Elias to identify possible tests that could be used to benchmark the impedance (longitudinal and transverse) and stability models.**

Rogelio asks if there is an e-cloud observable. Gianni and Rama reply that this will be seen as an increase of the cryomodule power. Rogelio asks if there are other signatures unrelated to the CC hardware. Gianni replies that one can eventually look at vacuum and tune shift, but they are difficult observables for the e-cloud. **Action: Gianni to identify possible tests and observables that can be used to characterize electron cloud effects in the crab cavities.**

Rogelio stresses the importance of fixing a detailed timeline for the experiments in the SPS. It was unknown who will present this topic in the TCC.

Aperture of a possible beam screen in the crab cavity cryomodule (R. De. Maria)

The CC cryomodule hosts two cavities for one beam and an empty cold pipe for the other beam. As the pipe is cold it should receive a beam screen. The point consists in determining the aperture with this screen.

One important aspect is the alignment of the two modules which is forced by the cavities and can therefore reduce the aperture in the other pipe. The aperture of the pipe is nevertheless very large and in the current design there is still 5 mm margin in radius to fit the screen. The extreme case considers a 7.5 cm beta* which corresponds to an extreme flat optics. Even in this case enough aperture is observed.

Rama asks if the 84 mm aperture, which fits in the current design, is considered safe or will require future reviews. Riccardo replies that it looks fine. One needs to confirm with the design of the beam screen, but there is margin.

Riccardo points out that there are strict orbit constraints at the CC due to beam loading, which implies that the orbit must have been kept more stable in the neighbouring area more that it is presently assumed in the aperture studies. Rogelio asks if these constraints also apply to the transparent mode of operation of the CC. Rama replies that even in this case beam loading is still dominating but maybe when detuning the crab cavity these constraints would be relaxed.

Faltin kicker for HL LHC wideband transverse feedback (W. Hofle)

The broadband transverse feedback is not currently in the HL baseline, although few statements have been added in the design report. A design is being carried on for tests in the SPS; the impedance is a factor of concern.

Wolfang summarises that transverse instability such as TMCI and e-cloud driven can be very well mitigated by a wideband system, allowing pushing the intensity limit above the current 1.4e11 p/bunch for Q26.

A schematic of the Faltin kicker is shown. It adopts a slotted line structure which allows using the magnetic field to kick at low frequencies while avoiding the interference between electric and magnetic field at high frequencies. For specific power inputs a very flat response can be achieved; a stripline kicker, instead, shows significant degradation at high frequencies, no matter the power input.

For the SPS a frequency of 1 GHz is enough, but for the LHC one would like to reach 3 to 4 GHz. This can be accomplished with a shorter design. It is also possible to have H/V asymmetry to compensate for the different beta functions at the installation location.

Different geometries of the kicker have been investigated, without observing significant advantages from the most complicated ones. A simple square structure has been parameterised and studied in more details.

Preliminary investigations of the beam coupling impedance have been completed, more refined analysis are on-going. Benoit asks if one would like to maximise the beta function. Wolfgang replies that for a fixed design it would be good to increase the beta as much as possible; but, given a smaller beta, the design could be adapted to that, going closer to the beam and gaining at high frequency. Riccardo points out that the aperture needs to accommodate the beam also at injection. He asks Wolfgang to provide some bounds for the beta functions.

Rogelio points out that there is not much spare space available for the installation; Wolfgang replies that one of the current kickers can be replaced, plus there is space in the doglegs as this device is transversely small. Riccardo points out that going close to the arc the aperture will be imposed by the beam screen. He points out that one could go to other insertions to get more freedom in the beta function, for example next to Q7 in IR2.

Wolfang asks to provide a couple of plots of IR4 to investigate possible locations. Rogelio suggests investigating the requirements for the structure in order to eventually find additional locations.

Reported by Dario, Gianluigi, Riccardo and Rogelio.