

## Minutes of the 68<sup>th</sup> WP2 Meeting held on 03/05/2016

Participants: X. Buffat, R. Calaga, E. Shaposhnikova, M. Crouch, R. De Maria, J. Esteban, S. Fartoukh, D. Gamba, G. Iadarola, J. Jowett, K. Li, M. Martino, L. Medina, E. Métral, Y. Papaphilippou, G. Rumolo, G. Sterbini, F. Van Der Veken, R. Tomas.

### Minutes, Follow-up of Actions, General Information (Rogelio)

The approval of the minutes have been postponed. Next meeting will be on 31<sup>st</sup> of May.

### 200 MHz Scenario: performance (L. Medina)

Luis presented the parameters of the 200MHz scenarios under consideration. Elias asked the assumption on the longitudinal emittance and 200 MHz voltage. Rama, Juan, Kevin agreed with the longitudinal emittance of 3.6-3.8eV and 6 MV for the 200 MHz RF system. Elias asked if an official parameter table could be produced. **Actions: Rogelio.**

John asked what is the limiting factor for the maximum voltage of 6 MV and Rama replied that is dominated by the power requirements and constraints of fitting the cavity in the existing cryostat. 3 MV is the minimum needed to bring the beam to flat top. The estimated power is compatible with  $2.5 \cdot 10^{11}$  proton per bunch. Nevertheless, the baseline is to keep the 400 MHz RF system, which should be OK for ions.

The interest of the 200 MHz option relies primarily as an e-cloud mitigation strategy that gives more integrated luminosity with respect to the 8b+4e scenario. In addition it could allow more bunch charge in the LHC, but only if the SPS limitation in the ramp are solved, which is a scenario that is presently excluded.

The integrated luminosity has been calculated taking into account burn-off, IBS and SR. The bunch length is not allowed to shrink below the baseline. A comparison with nominal shows that there is a loss of 5% which is small compared to the 8b+4e scenario. The nominal performance can be recovered with 10% additional bunch charge. Another alternative to restore performance is to recapture at 400MHz and reduce the bunch length. These options have been discussed in the following talk from the point of view of e-cloud.

### 200 MHz Scenario: e-cloud (G. Iadarola)

Gianni presented the heat-load aspects of the 200 MHz scenarios, while the studies on stability issues will start as new tools will be available for studies.

Heat load in dipoles increase with bunch shortening as observed in the SPS and in simulations. Elias asked if bunches could be shortened in the LHC to validate the model. Gianni replied that it should be feasible.

For the quadrupoles the dependence of heat load on bunch length and bunch charge is more complicated and non-monotonous.

Two scenarios with e-cloud suppression in dipoles (SEY 1.3) and without (SEY 1.4) have been presented.

In the first case, since e-cloud is suppressed in the dipoles, heat load comes mostly from the impedance and synchrotron radiation. In this scenario the 200 MHz does not make a big difference.

Stephane asked whether one could evaluate the maximum bunch charge to be injected in the LHC. Elena proposed to rephrase it as what is the minimum bunch length for the design bunch charge. **Action: Gianni.**

In the second scenario (SEY 1.4), which could represent the beginning of a run after a long shutdown or a general situation in case scrubbing would never be sufficient, the machine cannot be operated at the specified bunch charge and bunch length. The 200MHz alternative with constant bunch length of 15cm demonstrates to be feasible in simulations with margin at the end of the fill for bunch shortening. This implies that a scenario in which one varies the bunch length at constant heat load could be developed.

Elena also asked to simulate long bunch length at 400 MHz, to see the potential gain. Gianni planned to perform the study with realistic bunch profiles since the Gaussian approximation is likely not sufficient. In terms of bunch profile, lowering the peak density has the biggest effect, while the tail distribution is not that important.

In conclusion the 200 MHz alternative allows to scrub adiabatically with the maximum number of bunches up to the cooling capacity, while with 400 MHz the only knob is the number of bunches which provides lower luminosity during the scrubbing process plus an SEY of 1.3 has not been demonstrated yet. For instance if one had 200MHz in the LHC, the machine could have been filled in 2015.

Stephane asked about an upgrade of the cooling capacity. Gianni replied that the limit is the capillaries in the arc, while the quadrupoles could be upgraded. **Action: Gianni, check with cryogenic team.**

Guido asked about the luminous regions at 200 MHz. Stephane replied that the region is defined by crab cavity frequency and hourglass effect.

Guido asked whether having missing bunches in longer PS trains could help. Gianni and Rogelio commented that this is indeed the spirit of the 8b+4e alternative.

Elias asked whether capturing at 200 MHz in the LHC would increase the bunch charge. Elena replied that the limit at the moment is in the ramp of the SPS.

Stephane asked whether it is possible that a resonance can make the heat load dependence on bunch length non-monotonous. Elias confirmed it may happen that unknown resonances may appear but it is considered not likely.

#### 200 MHz Scenario: stability (K. Li)

Old results on TCM thresholds have been compared with new (updated parameters and new impedance model). The new thresholds in single RF mode are:  $5 \cdot 10^{11}$  ppb for 400 MHz and  $4 \cdot 10^{11}$  for 200 MHz. The previous factor 2 difference has disappeared as the current 200 MHz main alternative keeps a bunch length of 15cm. In bunch shorting mode, the thresholds are slightly higher (larger  $Q_s$  compensates shorter bunches).

With the damper on, the TMCI threshold is not so well defined and there are cases for which the growth rate is bigger below the threshold without damper. This effect should be taken into account when approaching the threshold.

Stephane asked about measuring TMCI threshold with high bunch charge and low RF voltage in the LHC. Elias confirmed that it is a good point. Giovanni confirmed that a measurement of the TCMI threshold can validate the impedance models. **Action: Elias**

Elena commented that the advantage of the 200MHz is in the range of bunch length that can be operated thanks also to the 400 MHz and the various modes of operation. Kevin stressed that bunch lengthening is not good for TCMI because of the smaller  $Q_s$ .

Elena recommended a presentation on limitations from the longitudinal plane by Juan in a future WP2.

Stephane added that an important point to check is the cohabitation of crab cavities at 400 MHz and main RF at 200 MHz for beam-beam.

Kevin will report in SLAC the main points of this meeting.

*Reported by Rogelio and Riccardo*