Impedance meeting
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Presents: A.Mark Arnold (AA), D.Amorim (DA), S.Antipov (SAnt), S.Arsenyev (SArs), M.Beck (MB), E. Belli (ElB), O.Berrig (OB), N.Biancacci (NB), A.Gilardi (AGil) F.Giordano (FG), A.Grudiev (AGru), E.Métral (EM), G.Mazzacano (GM), M.Migliorati (MM), A.Passarelli (AP),

The slides can be found at https://indico.cern.ch/event/623679/.

Impact of laser treatment on the impedance of the FCC-hh beam screen (SArs)

Sergey Arsenyev presented theoretical considerations on the impedance of the laser treated copper coating. This type of treatment is a possible way to mitigate the electron cloud by reducing the SEY (Secondary Electron Yield). Associated simulations results were also presented.

For the FCC-hh beam pipe coating, the laser treatment is considered as the baseline. If the performance is too low, carbon coating is considered as the backup solution.

The laser treatment determines two levels of roughness: grooves (of the order of 100µm depth) and micro-roughness (of the order of 3µm). There is no clear indication on which one is more important with respect to the impedance contribution.

Two possibles ways to estimate the beam impedance were considered:

1. Treat the grooves as a series of small cavities. This method would give only the geometric impedance. There would be no temperature dependence and the µm roughness would not be accounted for.

2. Consider the rough surface as a smooth surface but with a generalized impedance. The issue is to find the surface impedance. This is done considering either a two layers model or a gradient model.

In the gradient model (presented slide 9), the erf distribution is chosen to follow the distribution of the grooves provided by a normal laser treatment.

On slide 10, the plot shows the impedance (as the ratio of the electric field over the magnetic field) along the position inside the material. The plot is for a certain frequency value. The beam coupling impedance would be the value at the surface of the material (on the far left). We see that the imaginary part of the impedance is much higher than the real part. This is coherent with the purely geometrical model of a series of cavities (slide 5).

Slide 11 shows the surface impedance as a function of bulk conductivity for a certain frequency. We see that the impedance coming from the roughness (blue and red curves) is much larger than the impedance without the roughness (green curve).

AGru noted that other parameters such as the RRR of the grooves could influence the impedance. SArs precised that the gradient model is used to look at the influence of the grooves distribution.
NB noticed that the roughness parameter $R_q$ showed in the plots is much lower than the depth of the grooves (2µm versus 100µm). SArs explained that these plots are used to study the effect of the micro-roughness distribution and not the effect of the grooves.

Slide 17 presents the estimated TMCI threshold for a two layers model. The resistivity ratio of the surface layer versus the bulk material is plotted on the x-axis. The ratio of 18 highlighted is obtained from current experimental data. SArs indicated that this resistivity ratio could be even higher (up to a factor 200), degrading further the TMCI threshold.

New surface impedance measurements are planned. These would be done in a quadrupole resonator cooled to cryogenic conditions and in the SPS COLDEX.

**Hollow Electron Lens impedance simulation (GM)**

Giacomo Mazzacano presented the results of CST simulations for the Hollow Electron Lens (HEL). The HEL represents a possible scenario for the HL-LHC to further improve the collimation system.

In the longitudinal plane, all modes were found to be beyond cut-off frequency. The broad-band impedance contribution of 0.021$m\Omega$ is well bellow the LHC impedance of 90$m\Omega$.

In the transverse vertical plane, the broadband impedance of 800 Ω/m is well below the LHC impedance budget (2$M\Omega/m$ and 20$M\Omega/m$ at injection and top energy respectively).

Investigations on a mode at 2.1GHz are ongoing as this mode is below cut-off. This could be a quadrupolar mode but it needs to be checked.

AGru underlined that this mode is a combination of a dipolar and quadrupolar mode because of the asymmetry of the structure. Also, in an asymmetric structure, a parabolic fit of the shunt impedance versus beam displacement (as in slide 12) still indicates a combination of a dipolar and quadrupolar mode.

In the transverse horizontal plane, the broadband impedance of 500 Ω/m is well below the LHC impedance budget.

However there are three dipolar modes below cut-off, the worst one having a shunt impedance of 32$k\Omega/m$.

GM pointed that the device position in the machine is not yet defined so the weighting of the impedance with the $\beta$ function could not be done yet (average $\beta$ is assumed).

Looking at the picture on slide 9, NB noted that a resonance between the two cavity like structure could be present. A test to detect this resonance would be to shorten the pipe.

In conclusion, the device should not pose an issue for beam stability in the transverse planes. In the longitudinal plane, the resonance frequency of the most prominent modes fall beyond the Gaussian beam spectrum. Thus negligible power losses in the structure are expected.

*Minutes written by: D. Amorim*