Instability risks at the ESRF-phase II

At the actual ESRF the β-weighted vertical impedance is around **12MΩ** (based on the vert. TMCI threshold of 0.7mA and the actual machine parameters δ=1.06e-3, α=1.86e-4 and E=6.04GeV (parameters from the Orange book)

$$\frac{\Delta \upsilon_\beta}{I \upsilon_s(I)} = \frac{\beta Z_{eff}}{(E/e)(\omega_s \sigma_\tau)(I) 4\sqrt{\pi}} = \frac{\beta Z_{eff}}{(E/e)\alpha \delta 4\sqrt{\pi}}$$

The TMCI is reached if $\Delta \upsilon_\beta \approx \upsilon_s(I)$

Passing to the new machine δ=0.95e-3, α=0.87e-4 and E=6GeV with the same β-weighted vertical impedance the threshold decreases **to I=0.29mA/bunch.**

Moreover, the β-weighted **vertical resistive wall impedance will substantially increase**.

In the whole talk I keep the low-gap sections as they are.

Achromat	length[m]	halfgap[mm] b	β_v [m]	$(\beta Z_{RW})_{eff}$ [MΩ]
up & downstream cell	495.6	10.0	8	**1.91**
central cell	186.0	6.5	8	**2.61**
total	681.6			**4.52**
actual achromat OLD	681.6	16.5	24	**1.75**

The vert. resistive wall impedance will increase by 2.77MΩ

Thomas Guenzel, 23.4.2015

Instability risks at the ESRF-phase II

On this slide it's only about geometrical (broadband impedance)

But the broadband impedance (BBI) will decrease, won't it ??

The tapers of the low-gap chambers will be smoother, BBI will decrease.

But at the ends of straight sections there are

bellows, flanges, absorbers, pump grids, soldering joints, fast BPMs etc.

If they are in the standard vac-chamber, the BBI of these elements will increase.

The impedance of such elements often scale ~ b^{-k} with k=2,3 or 4. b=gap $(\frac{16.5}{10})^k = 2.7, 4.5, 7.4$

Furthermore, the β-fct. at the ends of low-gap chambers are similar to the actual β-fct. Values.

The β-weighted BB-impedance of elements in the MB-achromat will decrease due to smaller β-function, but this relief is partly eaten up by the BB-impedance increase due to smaller pipe.

The cavities will have less impedance too, however, the cavity tapers will be much steeper
So the cavity-improvement is partly eaten up by the cavity tapers.

In total, there will be decrease on BB-Impedance, but in fact not so much.

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May be there is compensation from the BBI for RW-impedance increase, but it is not sure, so let' s assume the total β-weighted impedance will be 14.8MΩ

$$\frac{1}{I} = \frac{\beta Z_{eff}}{\left({}^{E}/_{e}\right)\alpha\delta 4\sqrt{\pi}}$$

$$I_{thres} \approx 0.23mA/bunch$$

for ξ=0 in multi-bunch mode (MBM) at 200mA the beam is almost TMCI-unstable !
(and if not, change a low-gap chamber against a even lower-gap chamber it will be)

For ξ>0 the machine would be exposed to the Head-tail instability in MBM@200mA, since the HT-threshold is usually even lower than the TMCI-threshold.

Sure, the HT-instability can be damped by a trans. feedback system, but the feedback has not only to damp the MBM RW-instability but on the top of it the HT-instability.

I know that the HT-instability is (some kind of) damped at the actual ESRF.
The question is if this damping mechanism will still work under the new constellation.

I think, it's a critical issue for all low-emittance sources and has to be studied in detail.

Thomas Guenzel, 23.4.2015