Tutorial for the course of Beam Instabilities

(CAS, Advanced Accelerator Physics Course – Warsaw, Poland, 27 September – 9 October, 2015)

Parameter	Symbol	Unit	Value
Circumference	C	m	6911
Momentum	p_0	GeV/c	26
Momentum spread rms	$\delta p/p_0$		2.1×10^{-3}
Cavity voltage	V	MV	4
Harmonic number	h		4620
Momentum compaction	α		0.00192
Norm. emittance rms	$\epsilon_{x,y}$	μm	2
Tunes	$Q_{x,y}$		26.13/26.18

Consider the proton accelerator with the beam and machine parameters at injection defined in the table above.

1. If the maximum acceptable space charge tune spread is 0.21, what is the maximum population that a matched Gaussian bunch can have? (Assume beam radius $a = \sqrt{2}\ \sigma_{x,y}$)
2. The accelerator can be represented longitudinally with a broad-band impedance having $R_s = 230$ kΩ, $Q = 1$ and $f_r = \omega_r/2\pi = 1.4$ GHz. What is the energy loss per particle per turn due to this impedance, if one bunch with the intensity calculated at the point 1. is circulating in the machine? Would it be different if several bunches with the same intensity were circulating? What is the associated stable phase shift?
3. A 1 m long vertical collimator made of graphite ($\sigma = 5 \times 10^4$ S/m) is installed at a dispersion free location with $\beta_y = 20$ m. The collimator has a horizontal aperture of 10 cm and the vertical gap is closed to a half-height $g = 5\sigma_y$. What is the average orbit kick received by the bunch above, if it goes through the collimator: a) with a horizontal displacement $x_0 = 1$ cm; b) with a vertical displacement $y_0 = 2$ mm.
4. The accelerator can be modeled with a transverse wake function per unit length of 440 GV/(Cm^2). Please give an estimate of the TMCI threshold. By how much would this threshold change if a new optics is implemented with integer part of the tune of 20 and $\gamma_t = 18$?