Single bunch electron cloud instability for a round beam (memo)

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For single interaction point in the ring, we got emittance growth due to the electron cloud as shown in Fig. 1.

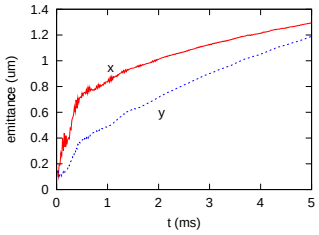

Figure 1: Growth of emittance of the beam for single interaction point.

When we exchange the horizontal and vertical tunes, we got emittance growth as shown in Fig. 2. The horizontal and vertical growths are completely exchanged. We know the growth depend on the tune. We did not find any coherent motion in the beam. This phenomenon is incoherent effect related to the tune.

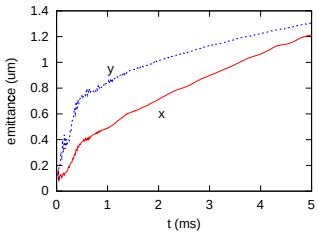

Figure 2: Growth of emittance of the beam for single interaction point. The horizontal and vertical tunes are exchanged.

We put more interaction points in the ring. Fig. 3 shows the horizontal and vertical emittance growth for various num,ber of the interaction points. The emittance growth are reduced by increasing the number of interaction points. Fig. 1 does not show a right result if electron cloud distributes whole of the ring uniformly.

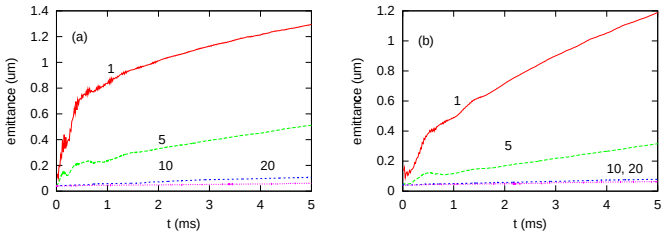

Figure 3: Growth of emittance of the beam for various interaction points. (a) horizontal (b) vertical.

Discussion

Why a coherent instability occur for a round beam? The trajectories of electrons (example) are shown in Fig. 4. It may be due to that the horizontal and vertical motion are mixed.

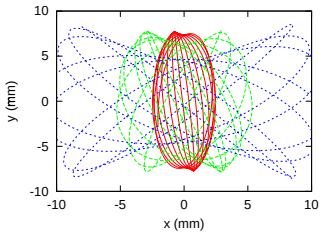

Figure 4: Trajectories of electron samples. Note: These calculations were done for J-PARC.

Is the incoherent effect weak in this model? We transfer the beam particles using a linear transformation between the interaction with the electron cloud. The simulation code knows only integrated cloud density along the longitudinal direction. When we put more interaction points, the integrated cloud density become smaller. It is natural that the emittance growth become weaker for increasing the number of interaction points.

We put nonlinearity (Octapole component) in the ring. The octapole was installed at a position of the ring. We guessed that the octapole may induce resonances, and may causes a emittance growth. However we do not get any emittance growth yet for the additional nonlinear component.

I think there are some kind of incoherent effect if coherent effect is prevented by some reasons. It may be like space charge effect. In some case, it (incoherent electron cloud effect) may be canceled by the space charge effect.