Radial position shift due to synchrotron oscillation

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What is the largest radial beam position shift possible at a dispersive location in the Recycler due to synchrotron oscillation? We recall that

$$x = D\frac{\Delta p}{p}.$$

The largest radial position shift results from a beam momentum at the limit of the acceptance of the ring. The momentum acceptance of thr Recycler is

$$\left(\frac{\Delta p}{p}\right)_{\max} = \frac{1}{\beta^2}\sqrt{\frac{2\beta^2 eV}{\pi h\eta E_s}} = \sqrt{\frac{2eV}{\beta^2\pi h\eta E_s}},$$

where

V = 2000 volts is the Recycler RF cavity voltage,
β^2 = 0.988 for 8.9 GeV beam,
h = 28,
η = -0.0086 is the Recycler slip factor, and
E_s = 8.9 GeV is the recycler synchronous energy.

Then the acceptance in fractional momentum is

$$\left(\frac{\Delta p}{p}\right)_{\max} = 7.8\times10^{-4}.$$

A change in radial position due to this momentum deviation at a dispersive location with a dispersion function of, say, 0.2 meter, turns out to be about 0.15mm.

On the Recycler test BPM, we observed position oscillations at roughly the correct synchrotron frequency but with magnitude about 10 times larger than possible due to synchrotron oscillation, assuming the lattice model does not have large error. We conclude that this is either instrumentation artifact or due to other beam physics process not understood at this point.

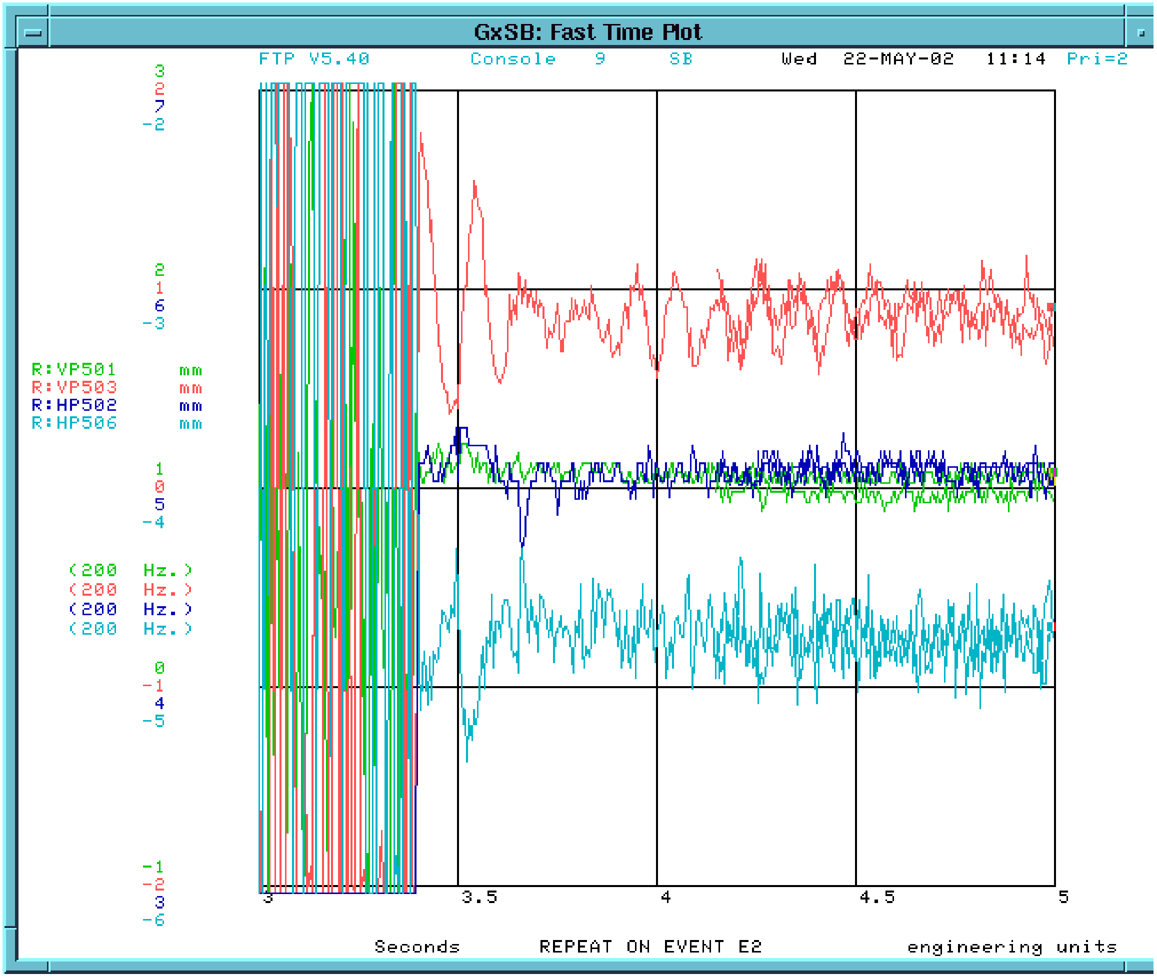

Figure 1: BPM position fast-time plotted at 200 Hz. Horizontal scale for each BPM is one mm per division.