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Investigation of Tail-Dominated Instability in the Fermilab Recycler Ring

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THAFP04

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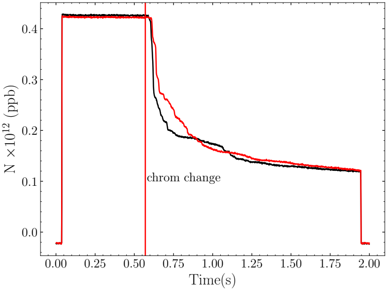
Single bunch instability in RR

During this run, in our study event, we had issue with keeping the beam stable during our event, although the same parameters were used last year:

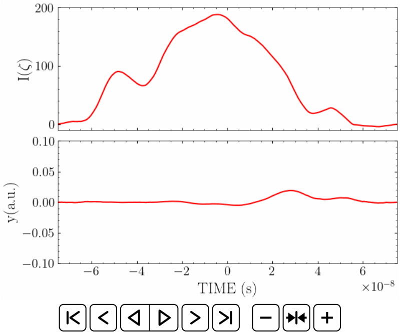
- The instability occur with a single bunch, at 8 GeV and around zero chromaticity.
- The instability appears at $> (\tilde{0}.35 \times 10^{12}$ ppb) and was very consistent throughout the run (well until the last days).
- Initially, we thought orbit changes may have caused issues for us but that was not the case.



Intensity vs time in our event

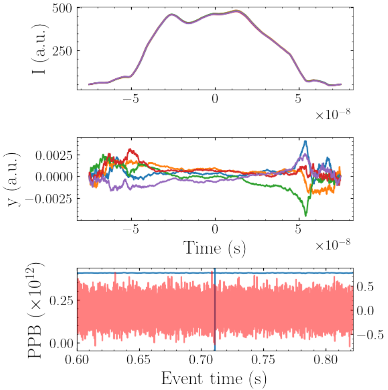
Beam motion

- The top plot is the A+B signal from a stripline and is related to intensity $I(\zeta)$.
- The bottom plot is A+B/A-B is related to the vertical motion $y(\zeta)$.



Temporary cure

- The instability vanishes by changing the beam ν_y from 0.44 to 0.46 and ν_x from 0.40 to 0.39.



typical $E1 timeline

Questions remain

- What is this instability, is it TMCI or convective?
- How does this instability depend on space-charge?
- What is the source of tune dependence?

Fermilab

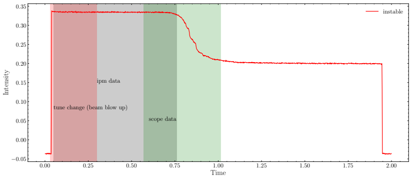
Space-charge effect

To examine the effect of space-charge, we were able to blow up the beam size in both planes and look into the effect. We increased the beam size by 1 mm in both planes by driving the beam into resonance for a short period of time and then driving it back to normal tunes.

Space-Charge detuning

$$\Delta\nu = \frac{-Nr_oRS}{8\sigma_z M\beta\gamma^2\epsilon_{N,rms}}F \qquad (1)$$

$$q = \frac{\Delta\nu}{Q_s} \qquad (2)$$

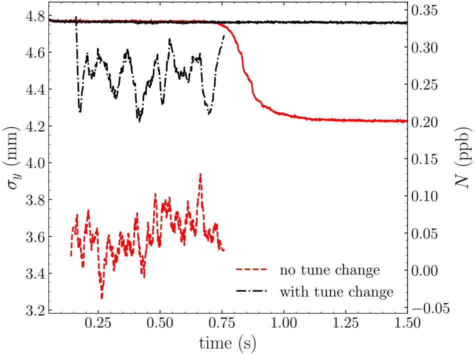


typical $E1 timeline

Space-charge effect: II

Increasing the beam size by 1mm seems to clear our the instability completely.

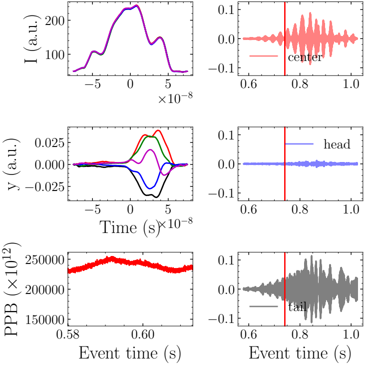
- For the same intensity, the instability disappear if we increase the beam size by 1mm.
- the 1mm increase change our space-charge parameter from $\sim$ 16 to $\sim$ 10
- In theory, more space-charge will stabilize the beam more in the case of TMCI, however, we clearly do not see this, so maybe this is not TMCI?



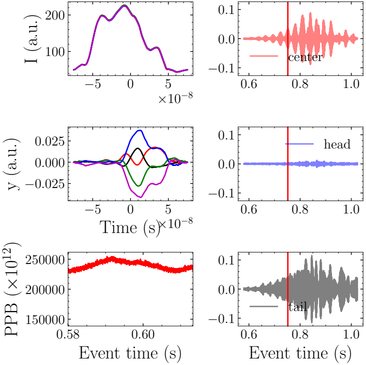
Beam loss

Evolution of the bunch motion

Taking a look into the scope data:



at 14500



at 15500

Questions?

Visit my poster to discuss more

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