0.1 Bunch patterns

0.1.1 BNL Proposal (even harmonic)

This scheme assumes an even number of 1.3GHz RF wavelengths in the CBETA circumference so that a 650MHz frequency eRHIC prototype cavity can replace the current cryomodule at the end of the project. With an even number of wavelengths, this only requires the 4th (highest energy) splitter line to be lengthened from a 1.3GHz/2 phase slip to a 650MHz/2 one. In contrast, an odd number of 1.3GHz wavelengths would not function at all with a 650MHz cavity so the circumference for all energies would have to be enlarged, requiring a complete rebuild of the splitters.

Main features of the scheme:

- 334 RF period circumference.
- **Commissioning mode**: Probe bunch injected every 336*4 periods (∼4 turns). There would be two at any time, one accelerating, one decelerating, separated by 8 periods. This 8 period gap is sufficient for conventional diagnostics to resolve the two bunches.
- **eRHIC-like mode**: The above probe bunches, *plus* main bunches injected at a factor of 336 (there is a choice), for example 336/6 = 56, for a 1.3GHz/56 frequency and 6 bunch trains in the ring. Within each train the bunch-to-bunch separation is 650MHz.
- **High-current mode**: Inject every 1.3GHz/8. 334 is equivalent to -2 (modulo 8), so each bunch set would slip 2 RF wavelengths (rather than one in the odd-circumference case), then during deceleration half of the decelerating troughs would also be filled. So in total half the available RF peaks and troughs would be used.

0.1.2 BNL Proposal (odd harmonic)

This scheme allows the initial 1.3GHz configuration of the machine to have an odd harmonic number, on the assumption that reconfiguring the splitter lines for a 650MHz machine with one wavelength larger circumference is not too difficult.

Main features of the scheme:

- 333 RF period circumference.
- **Commissioning mode**: Probe bunch injected every 336*4 periods (∼4 turns). There would be two at any time, one accelerating, one decelerating, separated by 12 periods. This 12 period gap is sufficient for conventional diagnostics to resolve the two bunches.
- **eRHIC-like mode**: The above probe bunches, *plus* main bunches injected at a factor of 336 (there is a choice), for example 336/6 = 56, for a 1.3GHz/56 frequency and 6 bunch trains in the ring. Within each train the bunch-to-bunch separation is 433MHz (1300/3), with an extra half-wavelength at the top energy, giving 8 bunches spread over 21.5 wavelengths.

- **High-current mode**: Inject every 1.3GHz/4. 333 is equivalent to 1 (modulo 4), so each bunch set would slip 1 RF wavelength and fill every RF peak, then during deceleration all the decelerating troughs would also be filled. So in total all the available RF peaks and troughs would be used (at 2.6GHz total rate).

If a 650MHz rate is desired within the trains, the eRHIC-like mode could be based on 335, so injecting every 335/5=67 RF periods, for 5 trains in the ring. The probe bunches could similarly be injected every 335*4 periods, going back to a spacing of 8 wavelengths between them. The only proper factors of 335 are 5 and 67, so the only options are 1 or 5 bunch trains at 650MHz rate, whereas 1,2,3,4,6,7 trains are possible at 433MHz rate (more, if the probe bunch replaces one train rather than being inserted between them).

0.1.3 Cornell Proposal

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