POSSIBLE EFFECTS OF LOWERING THE PERIODICITY IN ISABELLE

G. Parzen

Brookhaven National Laboratory

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The replacement of one or more of the standard insertions by either a low- β or high- β insertion will reduce the periodicity of ISABELLE, with resulting effects on the particle dynamics. Some of the possible dynamics effects are listed and discussed below.

Beam-Beam Interaction

A measure of the beam-beam interaction is the Δv per insertion caused by the beam-beam interaction. This has been computed¹ to be $\Delta v = 1.4 \times 10^{-3}$, $\Delta v = 0.7 \times 10^{-3}$ and $\Delta v = 2.3 \times 10^{-3}$ for the standard, low- β , and high- β insertions respectively. This measure of the beam-beam interaction does not appear to be appreciably larger for the non-standard insertions.

The nonlinear resonances driven by the beam-beam interaction depend on the differences between the beam interaction in the eight interaction regions. At first sight, the driving term would appear to be larger for the lower periodicity ISABELLE. The beam-beam interaction is different in the low or high- β insertions than for the standard insertion, because of differences in the beam size, crossing angle and interaction length. This effect deserves further study. The ISR does not appear to notice any difficulties with the beam-beam excited nonlinear resonances when running with a periodicity of one.²

$\beta(p)$ Effect

It has been computed by A. Garren³ that the ISABELLE lattice with just one low- β insertion results in an appreciable variation of β with momentum. A variation of $\Delta\beta/\beta = 100\%$ is found for $\Delta p/p = \pm 1.8\%$. However, at 200 GeV, the beam Δp is $\Delta p = \pm 0.22\%$, with $\Delta\beta/\beta = 10\%$.

1. M. Month, BNL Formal Report ISA 75-10 (1975).
2. B. Zotter, private communication.
3. A. Garren, Proc. 1975 ISABELLE Summer Study, Brookhaven, BNL 20550, p. 372.

The 10% variation in β would decrease the luminosity somewhat, by about 5%. There is a slight loss in the aperture since the beam is everywhere larger by about 5%, which does not seem important as the beam is quite small, $\Delta x = \pm 0.35$ cm, compared with the vacuum tank dimensions of ± 4 cm.

The variation of β with momentum also affects the ability to correct nonlinear resonances if this proves desirable. The driving term for these resonances depends on β and thus one can correct the resonance with a given set of correction coils at only one value of the momentum. At present, there are no plans to correct the nonlinear resonances, and it is not believed to be necessary to do so. A 10% variation in β still allows the driving term of the resonance to be reduced by 90%. Further, the variation of β with momentum can be reduced by introducing more families of sextupoles, which can be separately excited, than the present 2 families of sextupoles which are used to control the chromaticity. This is being studied at this workshop by Garren and Wiedemann.

$\nu(p)$ Effect

The variation of ν with momentum computed by Garren for the case of one low- β insertion is different but not worse than was found for the standard case. The working line correction coils in ISABELLE, which can correct the ν variation up to terms which go like p^4 , can provide the required working line shape.

Machine Nonlinear Resonance

In the case of the ISABELLE lattice with reduced periodicity, one might expect that the machine nonlinear resonances which are driven by nonlinearities in the magnetic field would be considerably stronger. In particular, the structure resonances, driven by the essential periodicity of the machine, would be much more dense for the reduced periodicity ISABELLE.

The main source of nonlinearities is the sextupoles in the ring. It is found³ that these resonances have a width of about $\nu \leq 1 \times 10^{-3}$. Because of the small size of the working line at 200 GeV, $\Delta\nu \approx 0.013$, it does not appear difficult to avoid the resonances introduced by the sextupoles.

These sextupole resonances are relatively strong, and further computer study is merited to back up the result found by the simple calculation of the resonance width. Another feature of these resonances that may be troubling, is that they are accompanied by a relatively strong variation of β across the aperture, which makes it difficult to correct these resonances over more than a small portion of the aperture.

Conclusions

There appears to be no overwhelming difficulty to operating ISABELLE with reduced periodicities. However, the following three topics are suggested for further study:

- 1) The nonlinear resonances excited by the beam-beam interaction. The lower periodicity appears to make these resonances stronger by a large factor.
- 2) A system of several families of sextupoles all separately excited, so that the sextupoles can control both the chromaticity and the variation of β across the aperture. Without this, the available aperture at 200 GeV may be severely limited.
- 3) A computer study of the resonances introduced by the sextupole system.