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INTERSECTING STORAGE ACCELERATOR NOTES

Momentum and Timing Tolerances for AGS-ISABELLE
Single-Bunch Transfer Scheme

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MASTER

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INTRODUCTION

In the proposed bunch-by-bunch transfer from the AGS to ISABELLE three longitudinal-type problems can be distinguished.

- A. Momentum error of a transferred bunch with respect to the ISA RF buckets.
- B. Coarse timing of transfer, to inject the AGS bunch into the neighborhood of the correct ISA bucket.
- C. Final phasing of transfer, to place the AGS bunch close to the center of the bucket.

The present note examines the tolerances required with respect to these aspects. Bunch matching tolerances are not considered here.

Since, at the moment of transfer, there is only one bunch circulating in the AGS, it is clearly desirable to do any momentum and timing gymnastics here, rather than in ISA where up to 30 bunches or so may be present. It is assumed, therefore, that the ISA RF system is held at fixed frequency (momentum) and that the AGS momentum and timing is controlled with respect to the ISA.

A. Momentum

Assume we can accept, at most, 10% dilution of longitudinal phase space in the ISA due to a momentum error. This corresponds to the bunch center being displaced by 5% of the bunch half-height (in momentum) with

respect to the center of the ISA bucket. The half-height of the bunch is:

$$\left(\frac{\Delta p}{p}\right)_{\text{bunch}} = 2.5 \times 10^{-3}$$

leading to a tolerance

$$\left(\frac{\Delta p}{p}\right)_{\text{error}} < 1.25 \times 10^{-4}$$

The same tolerance is imposed on the AGS magnet field for the combined effects of ripple and cycle-to-cycle fluctuations:

$$\left(\frac{\Delta B}{B}\right)_{\text{total}} < 1.25 \times 10^{-4}$$

B. Timing

Since the AGS pulses are to be injected into successive ISA buckets (or at least identifiable buckets), the gross timing of ejection and transfer must be achieved to a precision of one RF period in the ISA, i.e. about ± 100 nanoseconds. This is a comfortable timing precision to expect with the proposed deuterium thyratrons producing the quasi-sawtooth bunching waveform.

At least two alternative strategies are possible. If the AGS and ISA revolution frequencies are commensurate, i.e. 5:2 in the present proposal, the firing of the thyratrons can be controlled from the start of the bunching process by a timing signal derived from the ISA RF system, this signal effectively identifying the next ISA bucket to be filled, modulo 5. This is a sort of sawtooth phase-lock system between ISA and AGS and ensures that, during the 60 msec bunching time, the rings are locked together. Additional timing pulses remove the modulo 5 ambiguity and ensure that the AGS ejection kicker is triggered at the right moment. The kicker timing tolerances are very easy since the bunched AGS pulse occupies only a small fraction of the circumference.

If the AGS and ISA have incommensurate revolution frequencies the situation is more complicated since there is a continuous slip between AGS bunch and ISA RF. In this case one either has to accelerate or decelerate the AGS bunch with a homing system towards the end of the bunching process or, if the degree of uncommensurability permits, to wait until the synchronism is sufficiently close and accept some variation in the degree of bunching.

In both situations it seems unlikely that the timing precision of the thyratrons is sufficient to achieve the final phasing, as we now see.

C. Final Phasing

The AGS bunch will have a phase width $\Delta\theta$ of about $\pm \frac{2\pi}{50}$ in azimuth, i.e. approximately ± 50 nanoseconds. To keep the longitudinal phase-space dilution to less than 10%, the phase error on trapping should be less than 5% of the bunch half-width, i.e. less than ± 2.5 nanoseconds. This sort of tolerance does not seem to be feasible using the deuterium thyatron scheme above.

One way out would be to use the quasi-sawtooth method until bunching is partially achieved and the bunch is short enough to lie within the linear part of a sine waveform. One would then switch abruptly to a normal first-harmonic RF acceleration system, phase-locked to a frequency-divided signal from ISA, to complete the bunching process and control the phase prior to transfer. This method could probably use the same RF cavity but would require a normal RF amplifier in addition to the thyratrons. With the phase lock there should be no serious problem in achieving the required phase tolerance on transfer.