A RESONANT INJECTION FOR AN ELECTRON RING COMPATIBLE WITH A RESONANT EXTRACTION

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Abstract

The following paper describes a short investigation on "inhalation" injection for an electron storage ring that was suggested to us at the 1971 Particle Accelerator Conference in Chicago**. We recall, very briefly, the characteristics of the electron pulse stretcher (E.P.S.) design that are relevant to the present study. Computational data are presented that show that such a process is theoretically feasible. They are followed by considerations of the advantages and disadvantages and a conclusion of rejection of the idea for our project.

1. Main Characteristics of the E.P.S.

The E.P.S. ring was designed for the 140 MeV electron linac of Saskatoon. Among its many components are two pulsed quadrupoles that induce the 1/3 resonance responsible for the smooth extraction of the beam. A coupled injection,using four dipole pulsed perturbators, gives a hollow stored beam (in the horizontal phase space) required for the complete extraction of the beam.

Two modes of extraction exist: one is achromatic (the triangle separatrix is not energy-dependent) and the other is energy selective. More details can be found in previous publications[1]).

2. Inhalation Injection (or Resonant Injection)

A hollow beam, with a size not dependent on energy, can be successfully injected in the E.P.S. ring only when the achromaticity conditions for the extraction are met.

In Fig. 1a, 1b we show successive positions of the beam in the horizontal phase space, at the injection septum and at the extraction septum respectively. The septum shadows are also indicated.

The inhalation injection process goes as follows.

a) The beam is injected at 1 when the tuning is $\nu_x = 3.330$ (near the 1/3 resonance and a very small triangle separatrix). After 18 turns the beam occupies the position 2.
b) The tuning is then shifted to the value $\nu_x = 3.322$ such that the triangle separatrix contains the beam which then performs a stable movement as shown in Fig. 1.
c) The beam being injected and having the required shape, the extraction process then begins, the tuning being slowly shifted towards the initial value $\nu_x = 3.330$.

Fig. 2a, 2b is similar to Fig. 1 and shows the successive position of particles during extraction (only the most unfavourable case is shown). Comparing Figs. 1 and 2 shows that the particles during the injection and extraction processes are always out of the way of the septums. But this was achieved by placing the extraction septum at 40 mm instead of 25 mm [1]). The main computations needed to establish the graphs of Figs. 1 and 2 were done with the beam transport program OSECO [2]).

3. Conclusions

The advantages are:

a) Vertical beam size is 3.2×10^{-6} m.rad instead of $25\text{-}30 \times 10^{-6}$ m.rad.
b) The four pulsed dipole perturbators are suppressed. Only two pulsed elements remain.

The disadvantages are:

a) Overall increase of the horizontal beam envelope by about 50% (during extraction).
b) Only the achromatic extraction process is possible (unless 8 of the 10 hexapoles be pulsed).
c) The injection process is very critical because it is very sensitive to mistuning. The area of the stored beam varies as ε^4 where $\varepsilon = \nu_x - \nu_r$ where ν_x is the tuning at injection and ν_r is the resonance tuning.
d) A change of 10^{-5} radians in the beam shape at injection will produce a 10% change in beam size.

In spite of its appealing simplicity of principle, we shall not use the inhalation injection in the E.P.S.

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References

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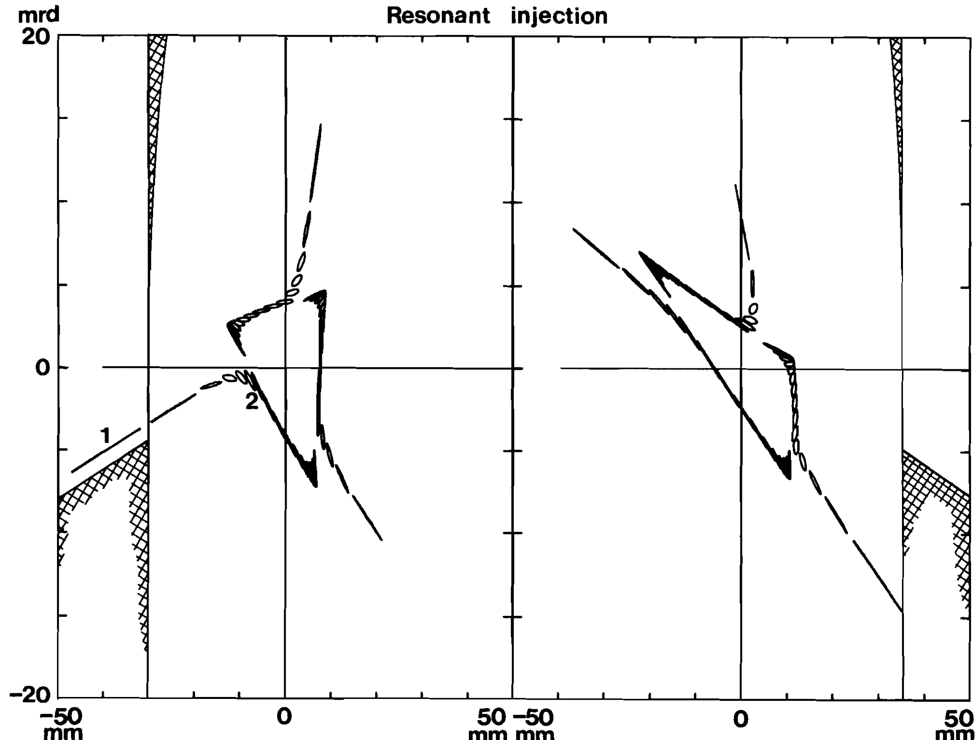

figure 1a figure 1b

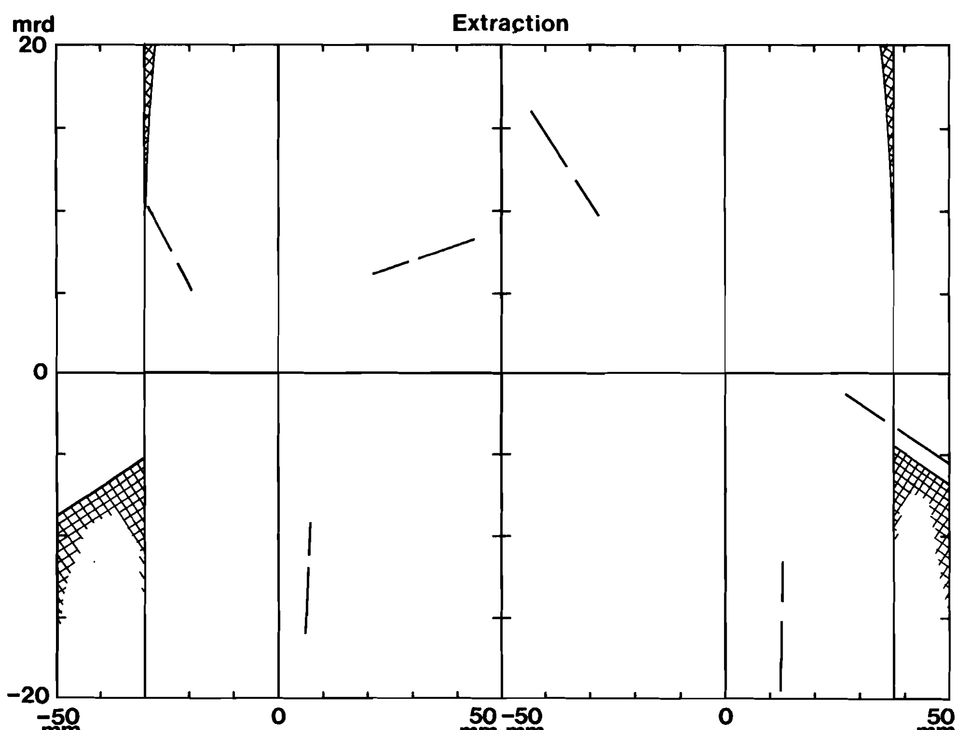

figure 2a figure 2b