Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

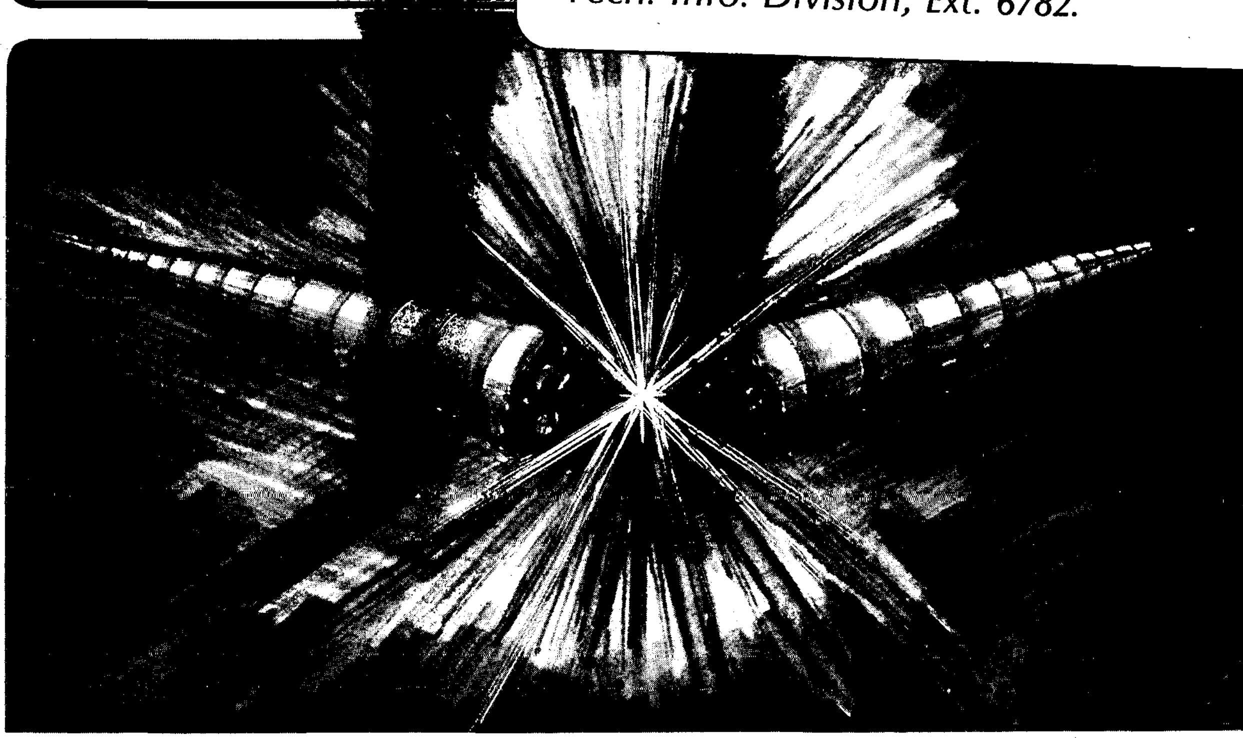
Accelerator & Fusion Research Division

Presented at the 7th Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 8-10, 1982

BETATRONS WITH KILOAMPERE BEAMS

Jack M. Peterson

November 1982



Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

LBL-15206

BETATRONS WITH KILOAMPERE BEAMS*

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*This work was supported by the Defense Advance Research Projects Agency under Contract No. N60921-81-LT-W0031 and the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

for the induction core as well as the image currents. Thus the system of image conductors replaces the normal betatron induction coil.

As a result of using the method of image compensation the vacuum aperture can be reduced considerably. For example, using only a modest factor of 4 as the reduction of the image force effects, we can reduce height of the vacuum chamber by a factor of 2. The smaller vacuum chamber produces a lower longitudinal impedance, and thus the longitudinal collective instability is also alleviated by the use of image compensation. This instability typically has a lower threshold than the transverse collective (resistive wall) instability (which favors a large vacuum chamber). In summary, the method of image compensation has provided a basis for designing a betatron system for accelerating a 10-kilo-ampere electron beam to several hundred MeV. In this arrangement all of the known instabilities can be controlled with a reasonable amount of energy spread.

The ion-electron type of collective instability can be avoided through good vacuum technique. This translates to a vacuum requirement of about 2×10^{-8} torr for an acceleration time of one millisecond.

IV. High-Current Betatron Model

A high-current betatron has been designed to test the concepts that we have developed for accelerating electron beams in the kilo-ampere range. It was designed to use the 10-kilo-ampere, 50-MeV Advanced Test Accelerator at the Lawrence Livermore National Laboratory as an injector.

The proposed machine is illustrated in Figure 3. It consists of a stack of three betatron rings with a common induction core. The three beams are accelerated simultaneously to 250 MeV and extracted in a controlled sequence during the magnetic flat-top.

The magnet is divided into three 120° sectors separated by three 1.8-meter straight sections, which provide field-free regions for the injection and extraction magnets. Each system has a vertically-deflecting iron-septum magnet plus a horizontally-deflecting full-aperture kicker magnet separated by 90 degrees in betatron phase. The orbit circumference is 18.0 meters, and the bending radius is 2.0 meters. The peak magnetic field at 250 MeV is 4.18 kilogauss. The stored energy in the magnetic field is 1.0 megajoule. The height of the magnet is 2.8 meters and its radial width is 1.3 meters. The magnet weight is 260 tons.

The ceramic vacuum chamber has a vertical aperture of ± 20 cm and a horizontal aperture of ± 25 cm. The injected beam has a vertical width of ± 4.4 cm, a horizontal width of ± 19 cm, and a momentum spread of ± 3.5%.

V. Betatron Study Group

The group that studied the use of betatrons for accelerating kiloampere beam included Robert Avery, William Barletta (LLNL), Andris Faltens, Donald Kerst (Univ. of Wisconsin), Robert Kuenning, L. Jackson Laslett, Edward Lee, Jack Peterson, Andrew Sessler, and Lloyd Smith.

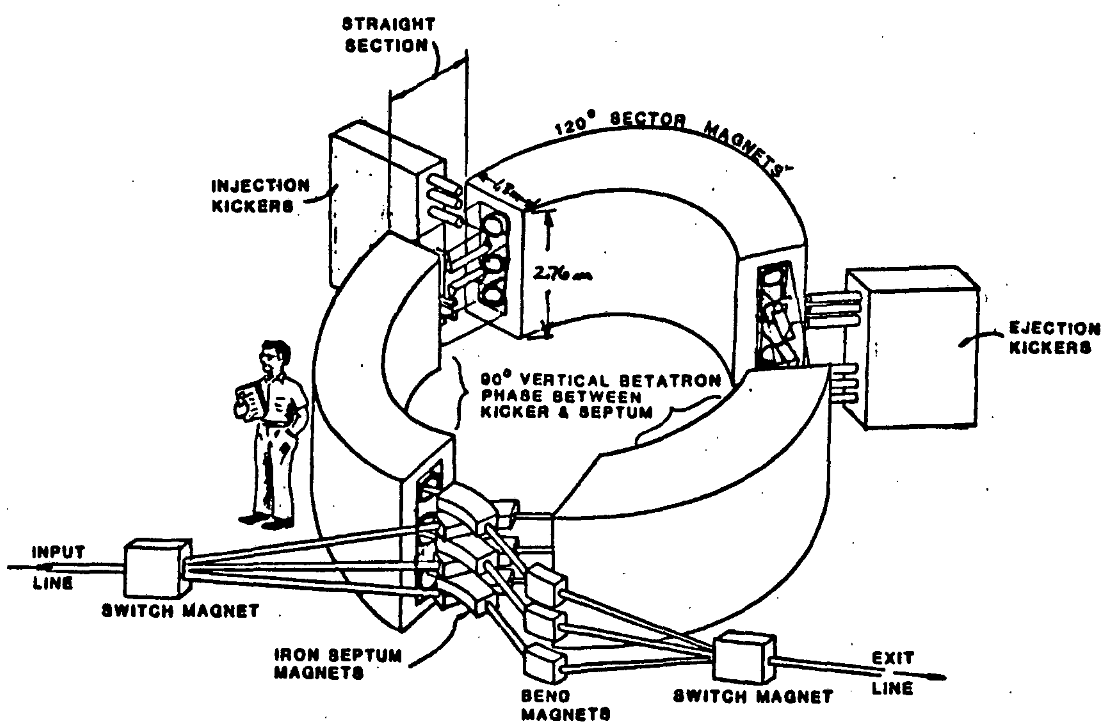

Fig. 3. INJECTION & EXTRACTION SYSTEM for 3 RING ATA ADD-ON.

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