Status of the MIT-Bates South Hall Ring Commissioning*

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I. INTRODUCTION

The MIT-Bates South Hall Ring construction project is now nearly complete. At this time the Energy Compression System, the SHR Injection Line and the South Hall Ring itself are complete. The SHR Extraction Line is complete but has not been connected to the ring. Commissioning with beam of the completed beam lines has been started.

The MIT-Bates South Hall Ring (SHR) is an electron storage ring used with the 1 GeV Bates electron accelerator [1] to increase the effective duty factor and luminosity. A beam can be stored for use with an internal target, thus allowing for high duty factor, high luminosity experiments. External beams with high duty factor can be obtained using resonant extraction. References [2] and [3] describe some aspects of the SHR design features. A layout of the 190m circumference ring and associated new beam lines is shown in figure 1.

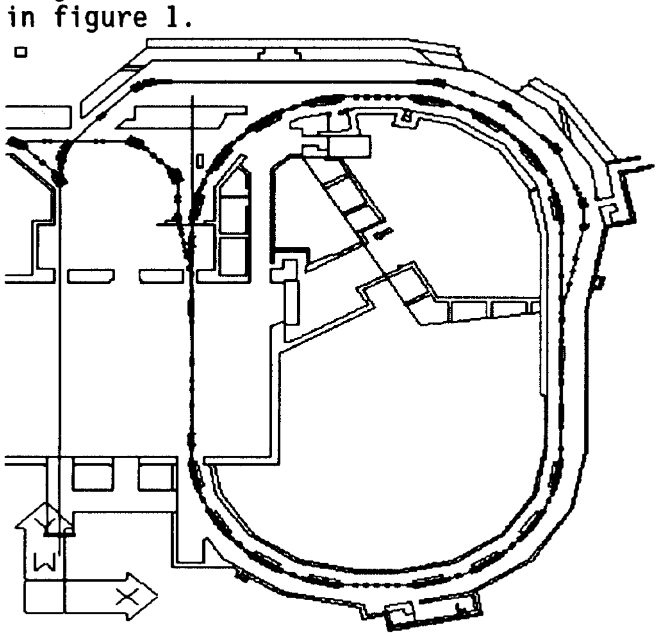

Figure 1. SHR Layout, Injection from the left.

The new systems associated with the SHR include the Energy Compression System (ECS)[4], the Injection line, and the Extraction line. We have commissioned the ECS, the new injection line and the SHR without Rf. This includes transporting beam, measuring beam phase space parameters, using critical injection elements including a high voltage electrostatic septum, and a fast beam kicker, and storing a beam in the SHR.

II. Injection Line Commissioning

The injection line directs the beam to the ring and prepares the beam phase space for appropriate SHR injection. It uses two achromatic bends and a phase space telescope as shown in figure 1. The instrumentation in the injection line allows automatic phase space measurements and adjustment for optical matching to the ring.

Beam has been transported through the injection line to the ring. The phase space has been measured and adjusted with the appropriate quadrupoles [5]. The method of phase space measurement includes the vary quad technique [6], and using three lutes within the beam line [7]. Part of the commissioning studies has been devoted to understanding the sensitivities of these measurements. The measurements have verified a beam emittance of 0.02π mm-mrad at 330 MeV, with beta functions below 100 meters.

III. ECS Commissioning

The ECS uses a four dipole chicane and accelerating section to convert energy spread to phase spread thereby reducing the beam energy spread and energy centroid fluctuation. Thus far there has been one shift devoted to ECS commissioning. The results in that time have been very encouraging. A target was used at a location with high dispersion (10cm/%) to observe the beam spot. The beam was transported through the ECS without complication. The resulting beam spot is shown in figure 2 below. The energy defining slits were set to allow

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transmission of a beam with energy spread of 0.4%. The beam spot on target was consistent with that.

Turning on the Rf power to the appropriate level for energy compression resulted in a reduction of the beam spot size as shown in figure 3.

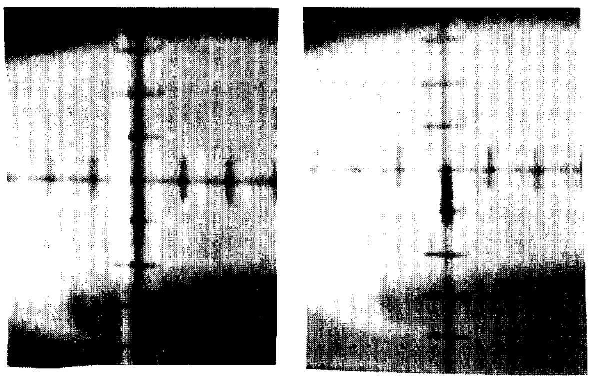

Figure 2 and 3. Dispersed beam spot without and with ECS Rf

The final energy compressed beam spot size was consistent with about 0.04% full energy spread. However this spot size was also consistent with the monochromatic beam spot size. This was proven by reducing the opening of the energy defining slits without seeing a further reduction in the beam spot size.

IV. SHR Commissioning

The SHR has sufficient hardware and controls for initial beam injection and storage studies. This includes one magnetic and one electrostatic septum for injection, and a fast (20nsec) kicker with a 1.3 usec flatop. Ten button type BPMs and ten low impedance stripline type BPMs [8] were installed along with 11 TV flip targets. There were six sets of BPM electronics. Without Rf, it was expected that the storage time would be determined by synchrotron radiation losses. At the 330 MeV injected beam energy and a ±0.8% energy aperture, this corresponds to roughly 23000 turns or about 15 msec of beam storage time.

A. First Turn

Transporting beam for the first turn was straightfoward. All quadrupoles were set at design values. Once the dipole values were set in the first 90^o arc, the dipoles in the other arcs were set to the same values. The beam was transported easily (with minimal steering corrections) to each screen. It was found that in one arc, three quadrupoles (out of 85 installed in the ring) were incorrectly wired. The entire procedure lasted a few hours and the beam was successfully transported through one turn.

B. Storage

The first turn was accomplished using a pair of steering correctors to obtain the required kick. Even so, the first turn beam immediately appeared to circulate three turns (with some beam loss). With a small adjustment of the closed orbit (ring correction dipoles) the beam circulated for several turns.

When the kicker was activated and properly timed, the beam stored for several milliseconds. With appropriate matching of the beam energy and the SHR dipole settings and closed orbit adjustments, the beam was stored for a time consistent with synchrotron radiation losses or about 30,000 turns. The total procedure lasted several hours.

Examination of the beam storage behavior with the instrumentation available proved useful. Figures 4, 5 and 6 below, show the stored beam using three different monitors. One of these monitors was a toriod current transformer. This measured the AC component of the current in the ring. Another monitor used was a BERGOZ DCCT which had a response time of several microseconds and measured the DC current. The third was a BPM which was sensitive to the rf structure of the beam and responded only as long as the rf structure was sufficient. The SHR has a momentum compaction of 0.029 and therefore it was not expected that this signal would last long.

The DCCT showed a constant current stored in the ring until the synchrotron energy losses caused the beam to be lost on the walls in the region of large dispersion. The toroid showed no visible losses in the first hundreds of turns. The toriod did indicate a pulse shortening (which was reduced when using the ECS). This may be indicative of a time dependence of beam energy in that region. The current output from the BPM lasted for a few milliseconds, longer than had been expected. However this is not inconsistent with; a) a smaller energy spread of the beam within a single pulse

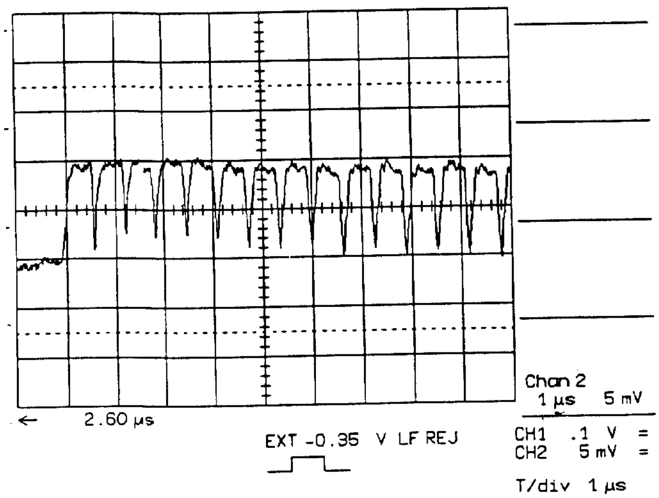

Figure 4. Toroid signal of stored beam current for first several turns.

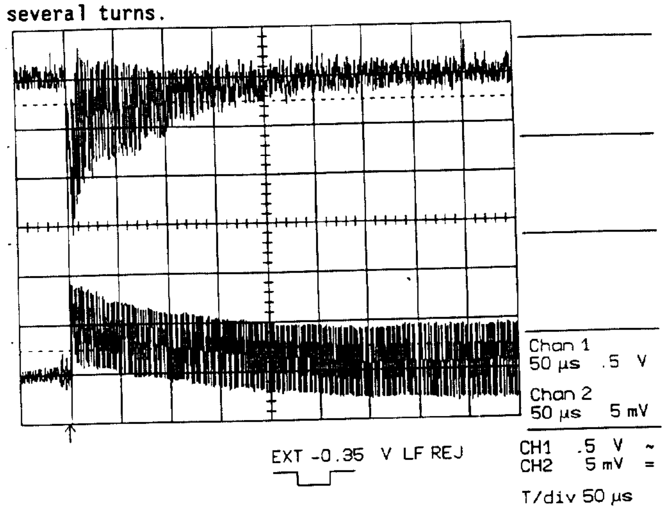

Figure 5. Upper trace is beam current signal from stripline BPM, lower trace is current signal from toriod.

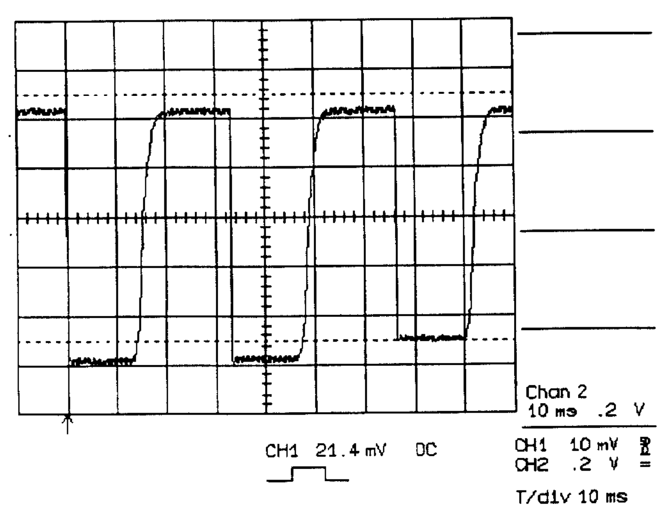

Figure 6. Currect signal of Stored Beam from DCCT for three successive injections.

than the average energy spread integrated over many pulses (as the energy spread is normally characterized) or b) a larger component of the charge located in a smaller part of the longitudinal phase extent of the beam. Test were made with up to 40 mA peak injected current.

V. Plans

The ring rf cavity has recently been completed and delivered. When installed storage times will no longer be limited by synchrotron losses and can be measured. The second fast kicker which will allow two turn injection is nearly completed. Within a few months, this will allow commissioning with the full design 80ma. The SHR octupoles are currently under test and the extraction septa are also under construction. Within a few months the first extraction studies should commence.

VI. References

* Work supported by the US Department of Energy
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