THE RHIC BEAM ABORT KICKER SYSTEM*

H. Hahn,† A. Dunbar, C. I. Pai, R. T. Sanders, N. Tsoupas, J. E. Tuozzolo, BNL, Upton, NY

Abstract

The energy stored in the RHIC beam is about 200 kJ per ring at design energy and intensity. To prevent quenching of the superconducting magnets or material damage, the beam will be safely disposed of by an internal beam abort system, which includes the kicker magnets, the pulsed power supplies, and the dump absorber. Disposal of heavy ions, such as gold, imposes design constraints more severe than those for proton beams of equal intensity. In order to minimize the thermal shock in the carbon-fiber dump block, the bunches must be laterally dispersed. The nominal horizontal beam deflection angle is required to vary from ~1.7 to 2.5 mrad, which is obtained from five 1.22 m long kicker modules operating at a magnetic field of ~3.5 T. The kickers are constructed as window frame magnets with an 50.8 by 76.2 mm aperture and are operated in the ring vacuum. The pulsed power supplies run at 33 kV and deliver the 12.8 μs long pulse. The peak current required is ~21 kA and the 50% modulation is generated by means of a pulse forming network with non-uniform characteristic impedance.

1 INTRODUCTION

The Relativistic Heavy Ion Collider, RHIC, is a machine with two superconducting magnet rings capable of accelerating and storing particles at energies from 10 to 100 GeV/u in each beam. There are nominally 60 beam bunches with a total stored energy of ~200 kJ at top energy and design intensity of 10⁹ ions in the case of gold. This energy is large enough to quench the superconducting magnets or cause material damage if lost in an uncontrolled manner but it is small enough to be disposed of in an economical internal dump.

The stored beam energy can be disposed of within the constraints of the lattice without damage to the machine equipment or operation, provided that certain precautions are taken. Disposal of gold beams imposes more severe constraints on the dump block design than protons due to the large, Z² dependent, dE/dx and short interaction length of the Au ions. This problem is handled by adopting at the dump entry a special carbon-carbon absorber material having extremely high thermal shock resistance.¹ The absorber is located in the beam vacuum, but properly pumped. Minimizing the thermally induced stress is achieved by lateral dispersion of the beam on the face of the C-C block.

The beam abort systems are located in the 34-m long warm straight sections of the outer rings down stream of the 10 o'clock intersection point. At this location, the lattice properties favor horizontal deflection. In addition to the dump absorber proper, the beam abort system includes the kicker magnet and the pulsed power supply subsystems. The principle requirements and design features of the kicker magnets and the pulsed power supplies are presented in this paper.

2 DESIGN REQUIREMENTS

The kick strength is determined by the transverse dimensions of the C-C block and the distance between kicker and dump face. The C-C block is 0.5 m long with a cross section of 58 × 58 mm. Its distance from the nominal closed orbit is 19 mm. In order to fully use the C-C block, and given the limited distance of 23.7 m between kicker center to dump face, the deflection angle of a single ion can cover the range from of 0.82 to 3.22 mrad. The deflection is provided by 5 separate kickers; allowing for malfunction of one unit and to accommodate a ~7π mm.mrad (unnormalized) dump aperture, the beam center is scanned over the range from 1.68 to 2.52 mrad, thereby spreading ions laterally over ~42 mm.

One kicker unit is 1.22 m long and has an aperture of 50.8-mm horizontal x 76.2-mm vertical. Deflecting the beam at full energy of 100 GeV/u by 2.52/5 mrad is achieved with a magnetic field of 0.35 T, corresponding to a current of 21 kA. The pulsed power unit generates the current pulses with a voltage of 33 kV.

The beam structure imposes several basic design constraints on the abort system. The rotation time of the bunches is 12.8 μs which determines the length of the deflecting pulse. The spacing of bunches is 0.213 μs and the total bunch length is expected to be ≤16 ns under normal operating conditions. Thus, allowing for a gap in the beam created by 4 missing bunches, the rise time of the deflecting kick must be ≤1 μs. Spreading of the beam over the C-C block could be achieved by a wiggler; a more economical solution is obtained by adopting a pulse forming network with non uniform characteristic impedance.

* Work performed under the auspices of the U. S. Dept. of Energy.
† E-mail: hahnh@bnl.gov
The conceptual design of the beam abort system was finalized by Michael Harrison and the preliminary design of the pulsed power supply was done by Eric Forsyth and Chris Pappas. It is with pleasure to acknowledge consultations on the pre-fire problem with Ron Sheldrake (EEV), Ron Navroty and Joe Sheehan (NSNLS), Laurent Ducimetiere (CERN), Chris Jensen (FNAL), and our colleagues from the AGS and RHIC.

6 REFERENCES