The Booster Beam-Whacker

Milorad Popovic and Johnathan Walters
Fermilab

February 23, 2009

The Booster Beam-Whacker, a novel solution for the measurement of beam profiles in rapid-cycling synchrotrons, is described. The idea is conceptually similar to a Weed-Whacker [1], a device for cutting weeds in a garden. A device using a motor from a PC hard-drive (Whacker Drive?) is used to measure the beam emittance in the Fermilab Booster during 15 Hz operation. That example illustrates the basic principle and demonstrates the practicality of the rotating Beam-Whacker as a beam profile monitor. Similar implementations may be useful as an internal target or as a primary collimator.

Introduction

At the present time ion profile monitors are used in fast cycling synchrotrons to measure beam sizes and deduce the transverse emittances of the beam. One of the outstanding problems with this type of measurement is the influence of intensity-dependent effects on the precision of the measurements. In this note we describe a device that can be used to measure beam size directly during the whole acceleration cycle.

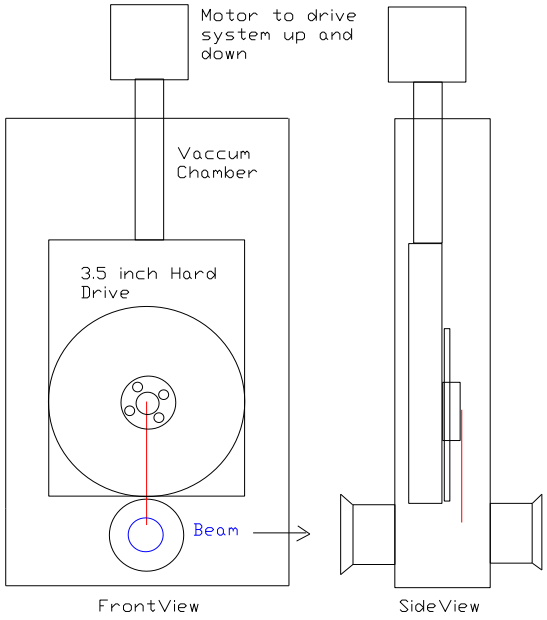

Fig. 1: Conceptual picture of the Beam-Whacker

.

The Beam-Whacker installed in the Fermilab Booster is shown schematically in Figure 1. In this diagram, a 5 cm radius compact disk drive from an ordinary personal computer has a wire

attached to become the “target” that passes through the beam. The motor with the disk plate is attached on a fork so that the whole assembly can be lowered into the beam.

Operation of the Beam-Whacker

When the device is not in use, the system is pulled up into a parked position so that the wire is out of the beam pipe. Once the motor is started, it takes about 30 seconds to achieve full speed, up to 7200 rpm, or 120 Hz. The position of the wire must be synchronized using a laser and light diode to the beam injection or extraction time. Once synchronization is achieved, the wire assembly can be inserted into the chamber.

Booster Beam-Whacker

The system was installed in the Fermilab Booster where it is used for measurements of the vertical profile of the beam during the acceleration cycle. The Booster is a 15 Hz machine and the beam measurement whacker runs at 30 Hz for the beam size measurement of the whole cycle. For more precise measurements in the first part of the beam cycle when the beam is largest, there are plans to run the measurement whacker even faster. Figure 2 shows the reduction of the Booster charge as the beam is hit by the whacker wire at different times in the beam cycle. Different reductions in the charge correspond to the various depths that the wire goes into the beam.

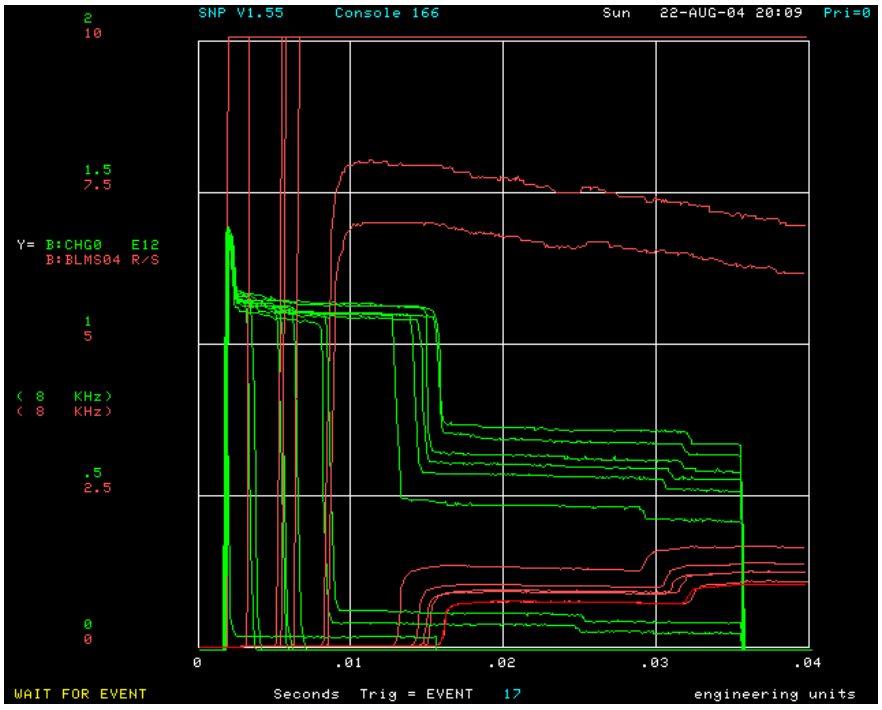

Fig. 2: Fast time plot of Booster intensity on successive 33 ms beam cycles as the beam profile monitor wire passes through the beam at different depths.

Next to the Whacker there are two monitors, a beam loss monitor and a photomultiplier. The intent is to try to register the existence of the halo as well as to find the beam size, correlating the magnitude of the beam loss signal with the reduction of the beam intensity. The hope is also that this device will allow us to reconstruct real particle distributions of Booster beam during the whole acceleration cycle.

Figures 3 shows the measurement whacker installed in the Fermilab Booster tunnel.

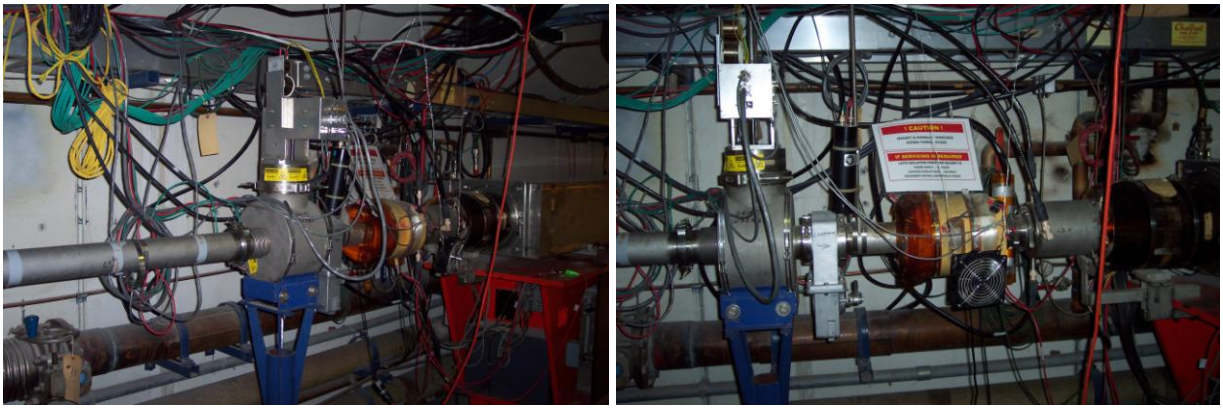

Fig. 3: Photo of Fermilab Booster beam measurement whacker.

[1] http://www.consumerdemocracy.com/phelp/cd4/listPosRevs2B.aspx?catId=148