Direct measuring system of the time dependence of the beam size by a non-destructive beam profile monitor

E. Kadokura, T. Kawakubo
National Laboratory for High Energy Physics (KEK)
1-1 Oho, Tsukuba-shi, Ibaraki, 305, Japan
and
T. Ishida
Mitsubishi Electric Company
1-7-4, Iwamoto-cho, Chiyoda-ku, Tokyo-to, 101, Japan

Abstract

In order to measure the beam profiles circulating in the KEK-PS without effecting the beam, we use a non-destructive beam profile monitor (NDPM) system which consists of an ion collecting field, a micro-channel plate (MCP) with multi anodes, an A/D converter and a computer. Since it takes more than one minute to obtain the time dependence of the beam size after a computer calculation, it is inconvenient to tune the machine condition by observing the beam size. In order to measure it directly, we made a new electric circuit system which can display the time variation of the beam size on an oscilloscope in the real time. The results are in good agreement with those obtained by a computer calculation.

1. INTRODUCTION

In the KEK-PS booster, there are two sets of NDPMs [1], one of which is for a horizontal beam profile measurement, and the other for a vertical measurement. After a computer calculation, we can display a mountain view of the beam profile from injection to extraction of the booster synchrotron, as well as the time dependence of the beam size and beam center. In the main ring, on the other hand, there are two horizontal NDPMs and one vertical NDPM. By using two beam profiles measured by two horizontal NDPMs, we can obtain not only the above-mentioned measuremental results, but also the time dependence of $\Delta p/p$ [2]. Observing the time dependence of the beam size in real time is important for tuning the machine condition; however, it is difficult since the output calculated by a computer takes more than one minute. By adding comparator circuits to the NDPM system, we can directly measure the time variation of the beam size on the oscilloscope.

2. MEASURING SYSTEM

2.1 Computer-aided system (conventional type)

Mechanical and Electric systems: The mechanical plan of the NDPM is illustrated in figure 1. Circulating proton beams hit the residual gas in the vacuum chamber and produce ion-electron pairs. The ions are led perpendicular to the beam direction by an ion-collecting electric field, and reach the surface of the MCP in which electrons are amplified in proportion to the number of ions; 32 anodes are set on the output surface of the MCP. Every anode is connected to a low-pass filter (LPF),

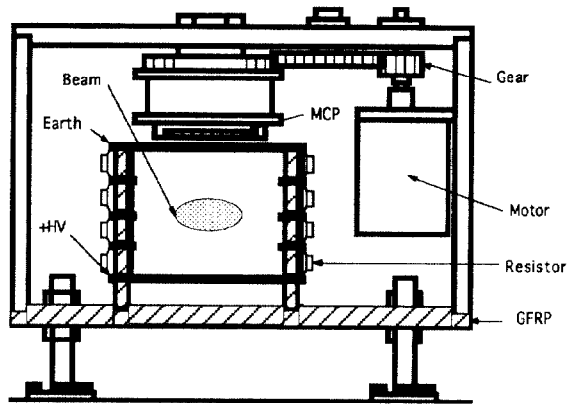

Figure 1. Plan of NDPM using an MCP

pre amplifier (AMP), voltage frequency converter (V/F), F/V, main amp. and memory, which is illustrated at the left-hand corner (conventional type) of figure 2.

After rearranging the signals from 32 anodes by computer, a mountain view of the beam profiles, the time dependence of the beam size and the beam center are displayed. Not only the half beam width at half maximum (HWHM), but also the half width at any % height of the peak beam profile can be obtained.

Calibration: In this system, it is most important to calibrate the gain of the 32 channel. During the measurement, the MCP connected to the 32 anodes is set as shown in the left side of figure 3. During the calibration stage, however, it is rotated by 90 degrees, which means that the direction of the anodes is perpendicular to the beam direction, as shown at the right side of figure 3. Since it can be thought that every anode takes the same quantity of ions, the calibration constants of each anode channel are obtained by comparing the computer output signal of each channel. In the measuring stage, the output of every channel should be divided by the calibration constant.

2.2 Real-time measurement system (new type)

The new electric circuit is connected to the conventional type, as shown in the lower part of figure 2.

Calibration: After setting the direction of the MCP anode perpendicular to the beam direction, we tune the gain adjustment of the IC(A) of every channel in order that the output

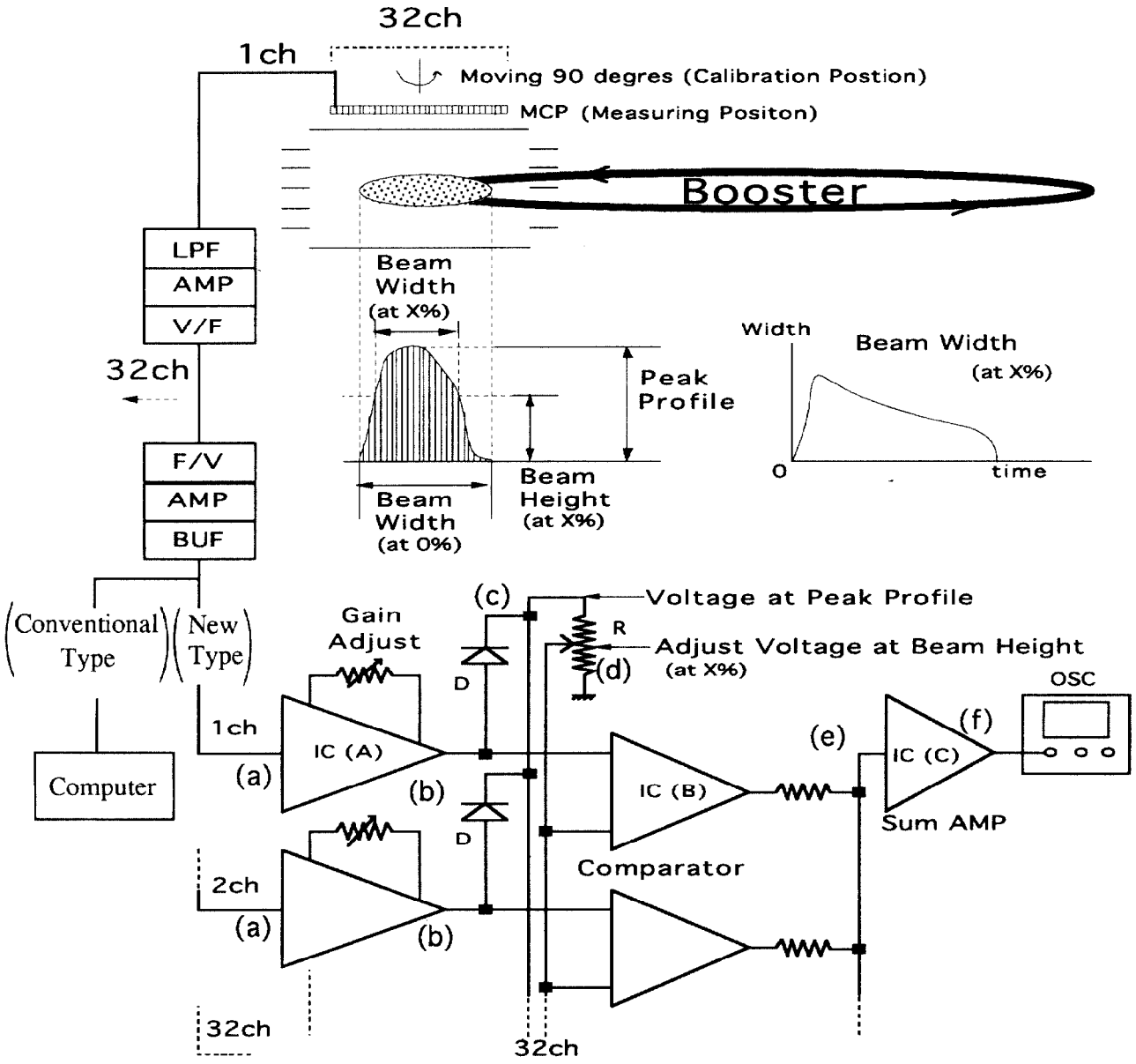

Figure 2. Conventional system for NDPM and new electric circuit for measuring the beam size in real time

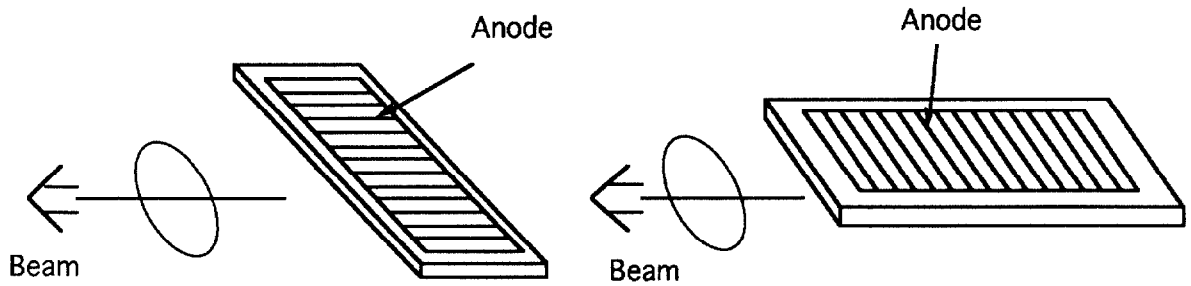

Figure 3. Relationship between the direction of the MCP anode and the beam (left, during the measurement; right, during the calibration)

signals of all of the channels (at point (b) in figure 2) become same figures.

Measurement: The signal at (c) is the highest signal at any time among the outputs of all the IC(A). We can therefore set any % of the peak profile by adjusting the voltage at (d). The comparator (IC(B)) turns on when the input signal at (b) exceeds the threshold level set by the voltage at (d). The signal at (f) through sum amp (IC(C)) is proportional to the number of the turned-on comparators, which means the channel number having a signal larger than the % of the peak profile. The beam size at any % of the peak profile equals the channel number multiplied by the anode distance.

The vertical axis in figure 5 shows the % of the peak beam height in the conventional system; the horizontal axis shows the heripot value in the new system at which the output figure in the oscilloscope becomes the same as the computer display by the conventional system. The reason why the relation line is not linear causes a non-linearity of the electric circuit in the new system.

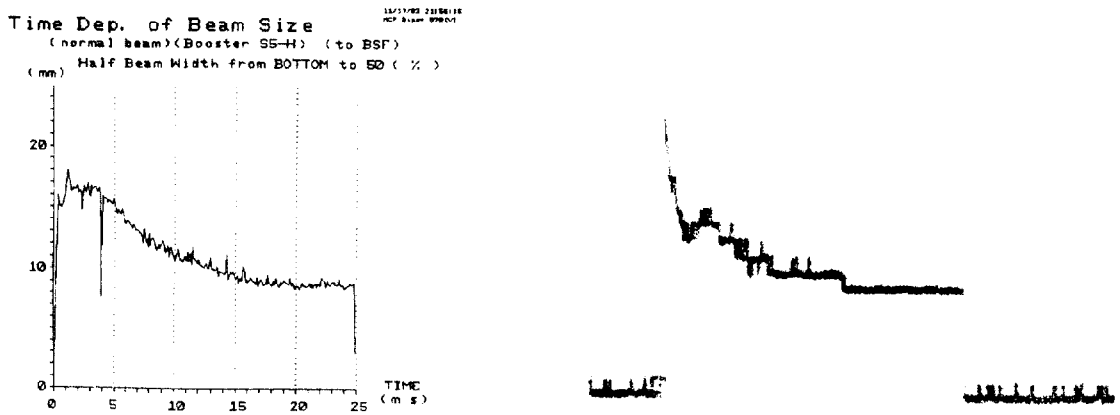

Figure 4. Time dependence of the beam size at 50% of the peak height (left, by the conventional system; right, by the new system)

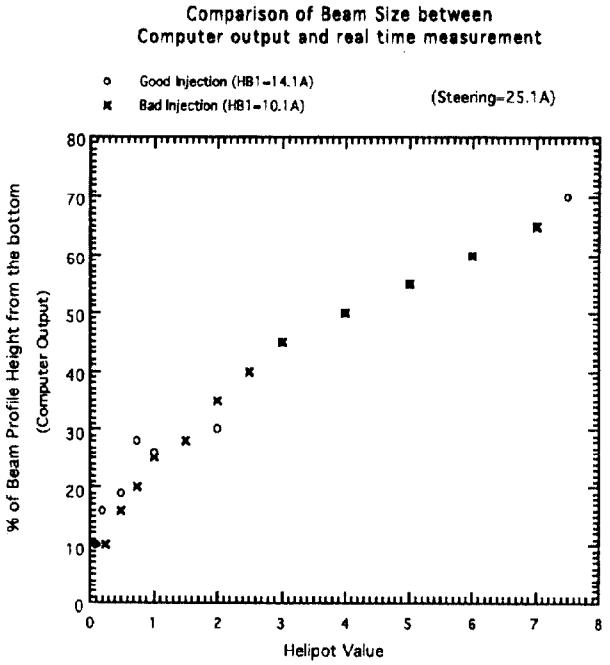

Figure 5. Relationship between the % of the peak height in the conventional system and the heripot value in the new system in order to obtain the same time dependence of the beam size.

3. MEASUREMENT RESULTS

The time dependence of the 50% beam size obtained by the conventional type is shown at the left side of figure 4. The output of the oscilloscope under the same condition (new-type system) is also shown at the right side. In this case, the helipot value which set the voltage at (d) in figure 2 is 4.0. These figures are in good agreement with each other.

4. CONCLUSIONS

A real-time measurement of the time dependence of the beam size by adding new electric circuit to the conventional system is in good agreement with the computer output in the conventional system. Since the new system can show any change in the beam size directly, it is very convenient for machine tuning.

5. REFERENCES

[1] T. Kawakubo, T.Ishida, E.Kadokura, Y.Ajima and T.Adachi,"Fast data acquisition system of a non-destructive profile monitor for a synchrotron beam by using a micro channel plate with multi-anodes", Nucl. Instr. Meth., A302, pp. 397-405, 1991.

[2] T. Kawakubo, E.Kadokura, T.Ishida, Y.Ajima and T.Adachi, "Non-destructive fast data taking system of beam profile and momentum spread in KEK-PS", ICALEPS'91, KEK, Tsukuba, Japan, Nov. 11-15, 1991.