WALL CURRENT MONITOR FOR PROTON BEAM

Hidetoshi Nakagawa and Shinkichi Shibata

National Laboratory for High Energy Physics

Abstract

In order to observe the beam fine structure in KEK proton synchrotron main ring, the wall current monitor has been tested. So far, 1 ns structure in the beam bunch was observed.

Introduction

The electromagnetic field of the bunched beam induces currents of opposite polarity on the inner surface of the vacuum chamber. Using a gap and shunt resistors, we can measure the currents.

The characteristic time resolution of the monitor is dependent on the beam velocity "v", giving the time of the order of $a/\gamma c$, where "a" means the pipes radius, $\gamma=1/\sqrt{(1-(v/c)^2)}$. It is about 0.3 ns ∿ 0.03 ns at 0.5 GeV ∿ 8 GeV. Thre is another limitation of the time resolution τ, which occurs from resistance "R" and gap capacitance "C", τ=CR.

When the beam is not at the center of the pipe, the initially non-uniform current distirbution decays to a uniform azimuthal distribution. For 1Ω resistor, decay time is a new nanosecond. Therefore in order to see natural shape of the beam, the output signals from four terminals -up, down, left, right- must be added. Further more to determine the beam position preciesely some adders and integrators must be used.

Test of the monitor

The construction of the monitor is shown in Fig.1. The capacitance of the gap is 40 pF, the shunt resistance consists of 48 carbon resistors in parallel, each having a resistance of 48Ω for a total resistance R=1Ω.

The output from the monitor is shown in Fig.2. We see pulses of 1 ns rise, when the pulse generator supplied pulses of 1 ns rise.

Second, the decay of the transverse voltage is shown in Fig.3. The decay time is about 3 ns.

Beam wave shape of the main ring

A comparison of the output signal from the wall current with the fast current transformer is shown in Fig.4 and Fig.5.

At the injection, the two signals are identical. Gains of the two monitors are not equal.

Second, at the phase transition where the bunch width becomes narrowest, the current transformer shows different wave shape from the wall current monitor.

Detail structure of the beams, at the phase transition, is shown in Fig.6 and Fig.7, where about 1 ns structure is observed. The structure is not clearly explained, but it is said that the oscillation is one source of the beam loss.

Conclusion

The wall current monitor can be used to see the fine structur of the proton beam. The time resolution is better than 1 ns.

References

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↓ Fig.2
UP : Pulse of 1 ns rise from generator.
DOWN : Signal from the wallcurrent monitor with test pulse. 1 ns / div

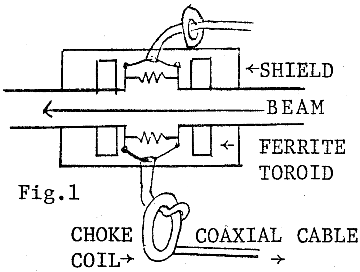


Fig.1

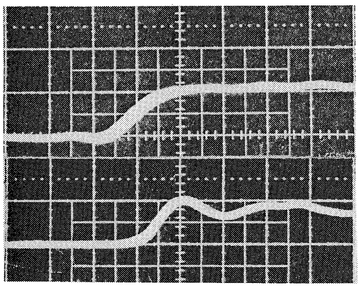
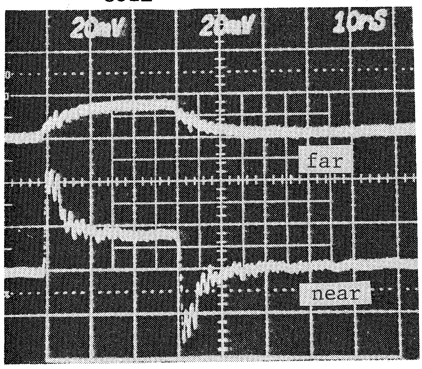
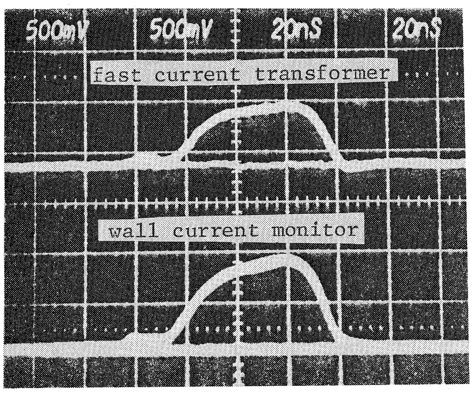


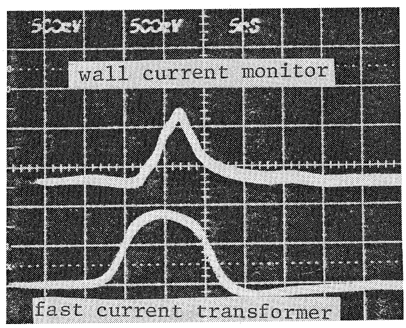
Fig.3 → Transverse decay of the signal.



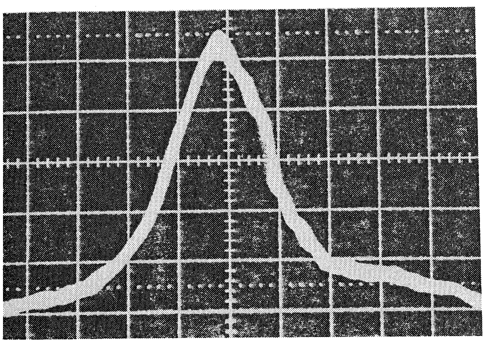
↓ Fig.4
Output signal at the injection.
20 ns/ div.



↓ Fig.5
Output signal at the phase transition . 5 ns/ div.



↓ Fig.6
Output signal at the phase transition.
2 ns / div.



↓ Fig.7
Output signal at the phase transition. 2 ns / div