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ABSTRACT

This report covers a new method of displaying the signal from a beam-induction electrode signal in a synchrotron. A dual-axis time display is produced by using a ramp and a series of trigger pulses, generated from the rf, to produce a raster on an oscilloscope. The results give a picture that retains the details of a fast sweep and at the same time covers a relatively long time period.

The circulating beam in a synchrotron is normally observed by means of an induction electrode system. For time analysis, the signal from the electrodes is normally displayed on an oscilloscope. If a fast sweep is used on the oscilloscope, the details of the bunch can be observed over a period of several rotations around the machine (Fig. 1). For observations over a longer period of time the oscilloscope trace is slowed down. The details of the bunch are lost and only the peak amplitude can be observed (Fig. 2). A new technique has been used at the Bevatron, in which the bunch details can be observed for extended periods of time (several milliseconds). The results give some rather remarkable pictures.

The method uses a trigger pulse from each rf cycle or beam pulse. The trigger pulses come through a gate circuit so as to provide a series of pulses only during the time interval one wishes to observe. These pulses trigger the oscilloscope sweep in a series of sweeps. The successive sweeps are displaced vertically by putting a dc ramp on one channel of the vertical preamplifier of the oscilloscope. This provides a raster on the oscilloscope in which time is represented by the vertical displacement of the sweep as well as by the horizontal position of the trace.

In our case the ramp was generated by putting a dc gate into an RC circuit. The induction electrode signal is then put on the other channel of the dual-input preamplifier on the oscilloscope. The preamplifier is run "A minus B" to mix the two signals (ramp and induction electrode signal). The circuit is shown in block diagram in Fig. 3.

The following method can be used to set the vertical time sweep. To observe the electrode signal for a period of 2 msec, set the horizontal sweep speed to give 2 msec for 10 cm, then adjust the RC circuit in the ramp generator and the gain of the oscilloscope preamplifier to give the desired rise in the ramp signal (6 cm vertical for 10 cm horizontal). The vertical shift is then 6 cm for 2 msec. The oscilloscope can then be swtiched to fast sweep (0.5 μsec for our case), the preamplifier switched to "A minus B", and the induction electrode signal displayed with two time bases.

Following are some pictures that were taken by the above method. Figures 4, 5, and 6 were made putting the triggers directly into the oscilloscope sweep circuit. The vertical sweep of 6 cm in Fig. 6 represents 2 msec. The same 2 msec are shown in Figs. 7 and 8, but the triggers are put into A sweep delayed by B on the Textronix 535A oscilloscope that was used. This separates the vertical displacement traces in time by eliminating some of the pulses. The individual pulses can then be examined in more detail.

Figures 4 through 8 start at the beginning of rf acceleration, and show the initial bunching and subsequent loss of the beam. Figure 6 shows beam being lost from the stable bunch at about 1 msec and just more than 1.3 msec after "rf on".

At present this technique of observing the phase oscillations has contributed no new information as to the nature of the initial beam loss at the Bevatron.[1] But comparison of Figs. 1 and 2 with Figs. 4 through 8 makes it apparent that this new method observing the phase oscillations gives a much more graphic display of what is happening to the bunch shape.

ACKNOWLEDGEMENTS

I wish to thank John J. Barale for providing the necessary electronic circuits used in this system.

FIGURE LEGENDS

Fig. 1 Normal display; sweep speed 0.5 μsec/cm

a) Trigger: 0.1 msec after start of rf

b) Trigger: 1. msec after start of rf

c) Trigger: 2. msec after start of rf

Fig. 2 Normal display

a) Sweep speed 0.1 msec/cm

b) Sweep speed 0.2 msec/cm

Fig. 3 Block diagram of electronic circuits used in this system.

Fig. 4 Dual axis time display

0.5 msec/cm horizontal

6 cm vertical for 1 msec

Fig. 5 Dual axis time display

0.5 msec/cm horizontal

6 cm vertical for 1.5 msec

Fig. 6 Dual axis time display showing beam loss

0.5 msec/cm horizontal

6 cm vertical for 2 msec

Fig. 7 Dual axis time display

0.5 msec/cm

6 cm vertical for 2. msec

Sweep delay "dead time" about 30 μsec

FIGURE LEGENDS

Fig. 8 Dual axis time display

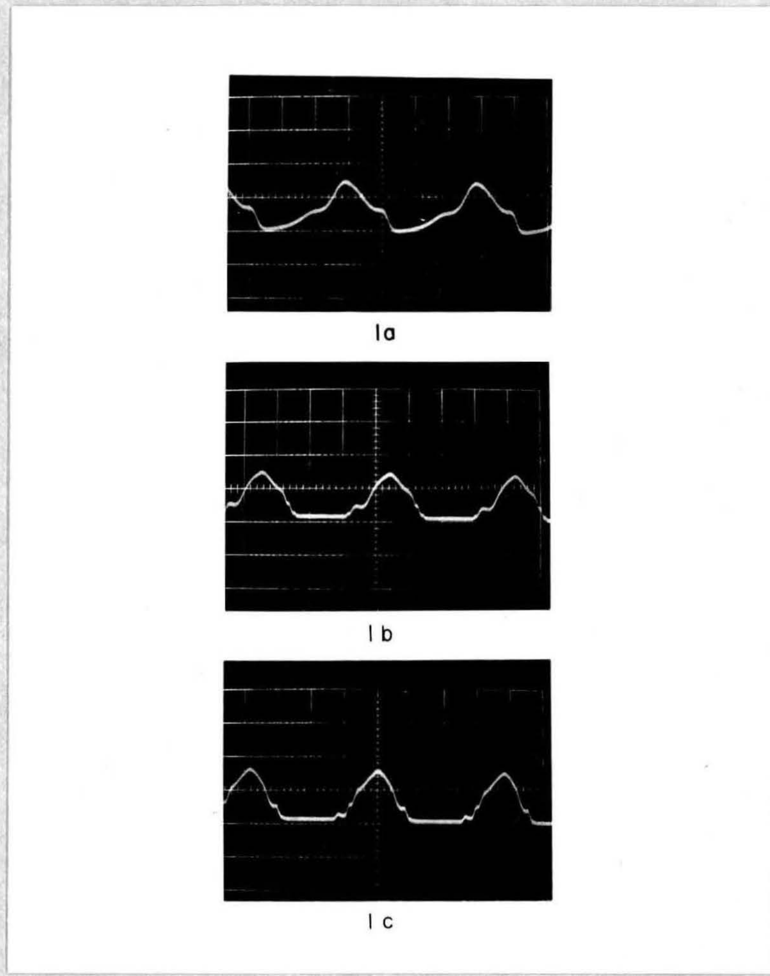
0.5 msec/cm

6 cm vertical for 2. msec

Sweep delay "dead time" about 60 μsec

REFERENCES

1. Glen R. Lambertson, High Intensity Phenomena at the Bevatron, Lawrence Radiation Laboratory Report UCRL-10867, July 3, 1963 (unpublished).



1a

1b

1c

Fig. 1

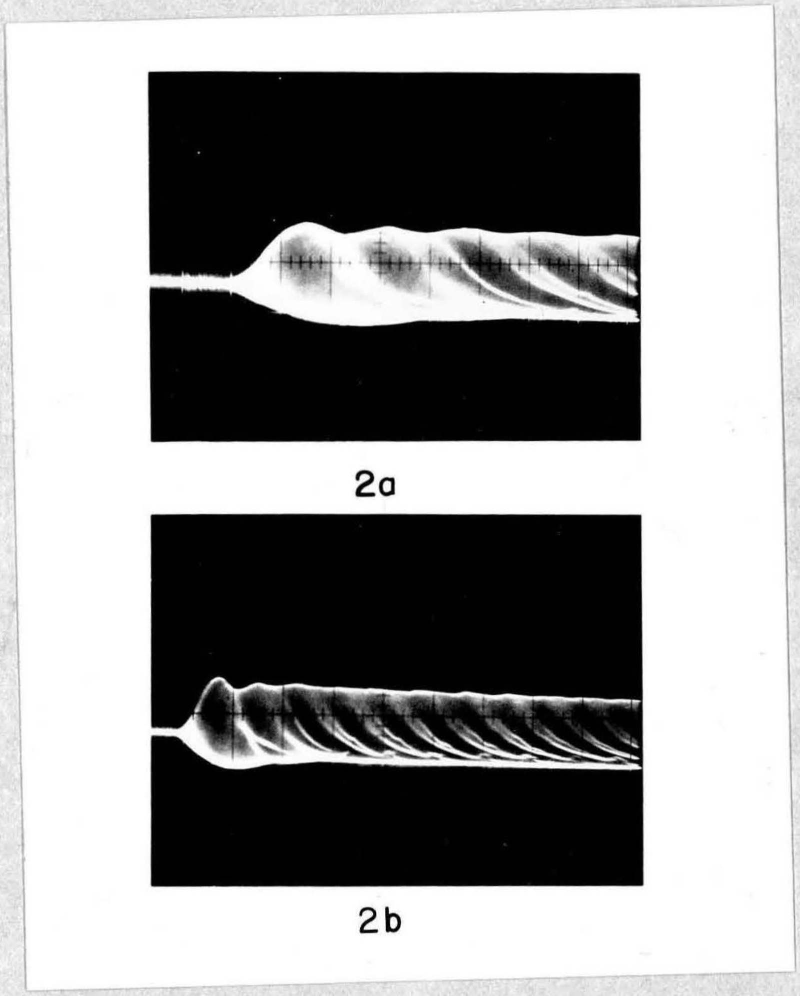


Fig. 2

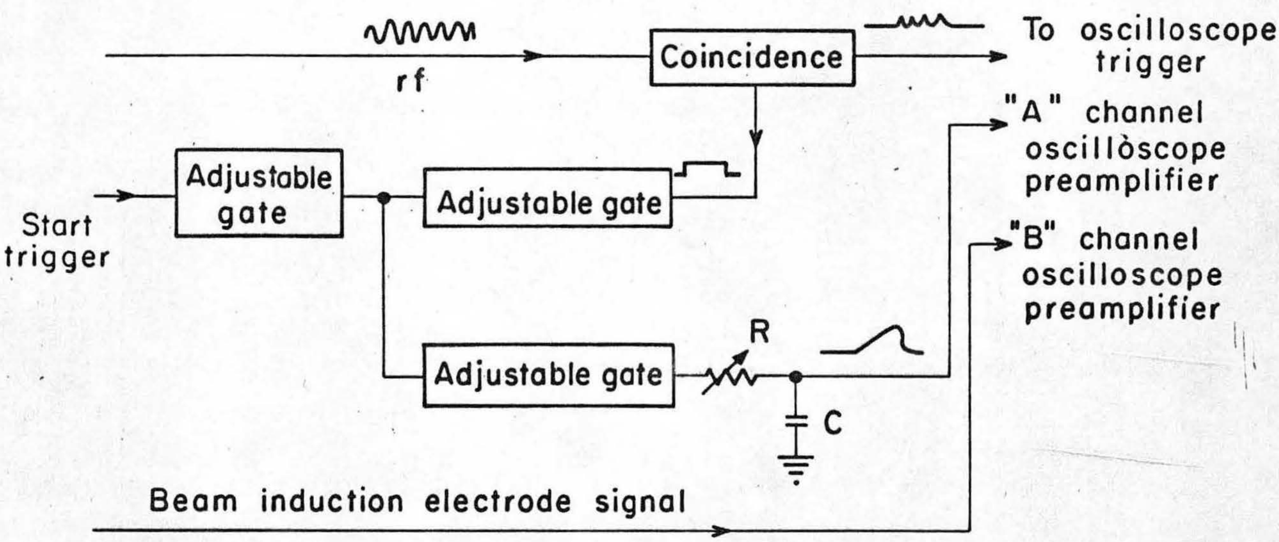


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Fig. 3

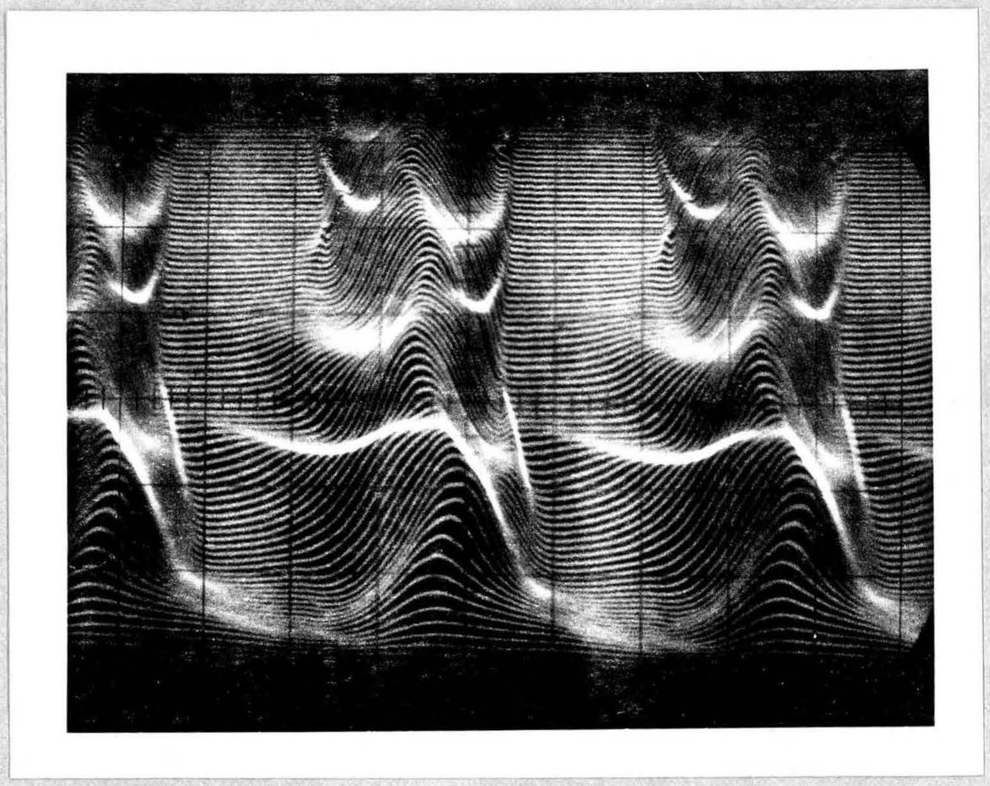

Fig. 4

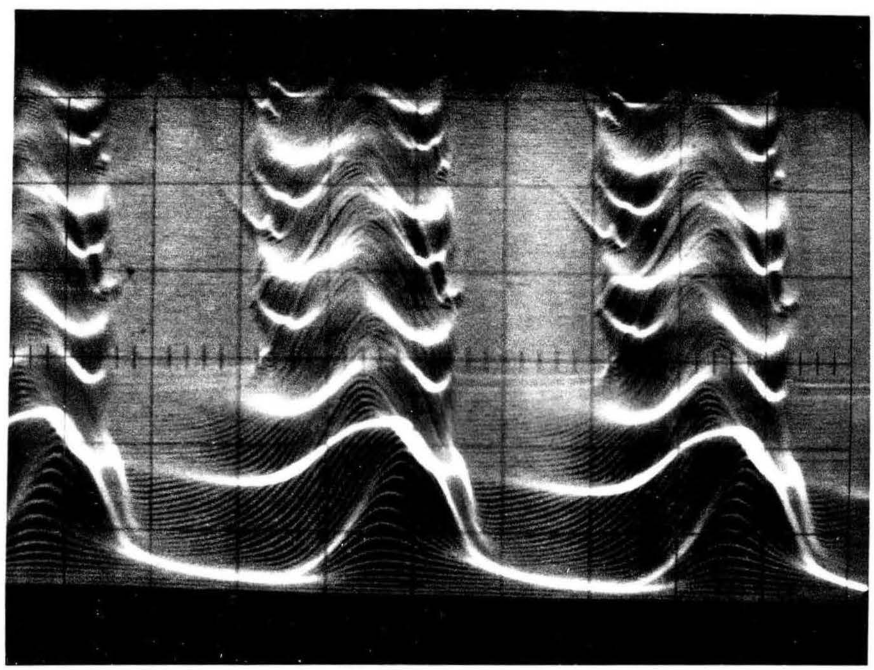

Fig. 5

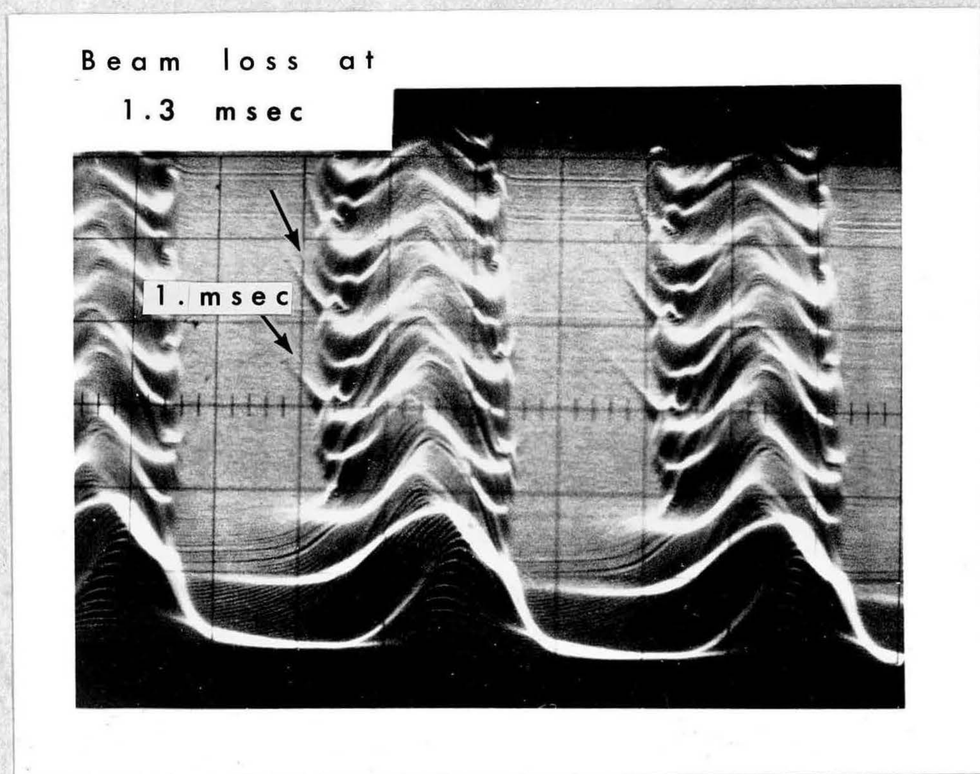

Fig. 6

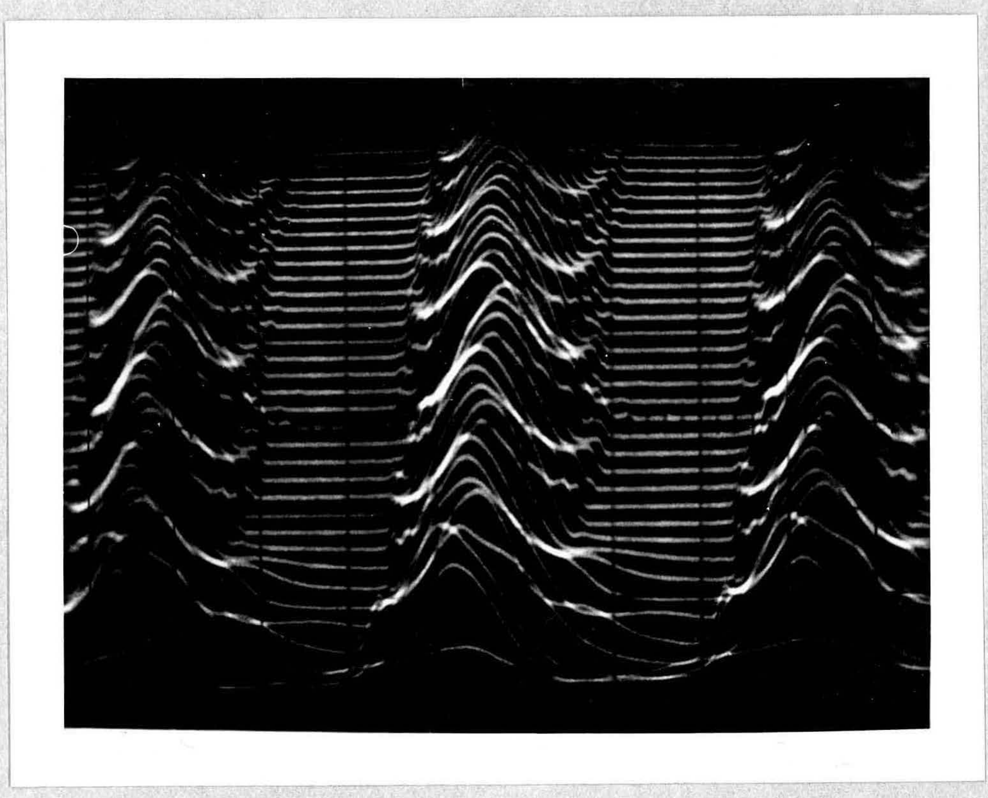

Fig. 7

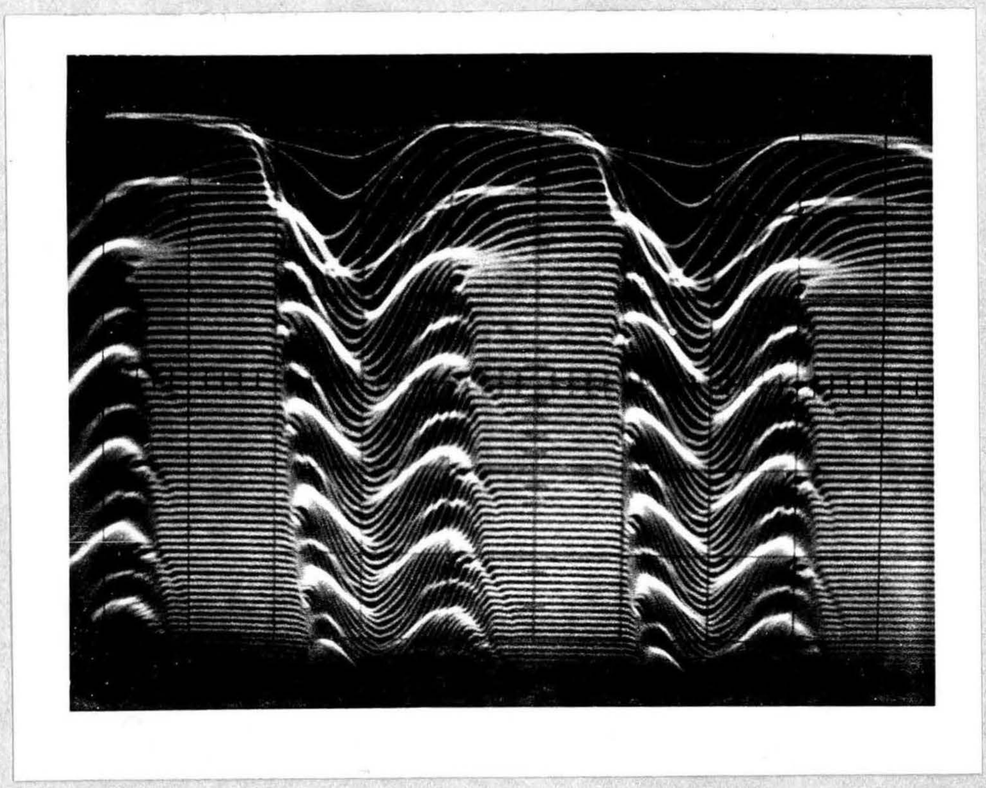

Fig. 8