Title
PRODUCTION OF PROLONGED SECONDARY PARTICLE BEAMS IN THE BEVATRON WITH THIN FOILS

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ABSTRACT

A thin energy-loss foil located on the outer radius of the Bevatron aperture has been used to produce a secondary-beam pulse of up to 1/2-sec duration. The secondary beam pulse is reproducible from pulse to pulse and shows no time dependence due to the radio-frequency accelerating voltage. An extension of this technique permits the production of an additional short beam pulse as the current in the proton synchrotron magnet decreases.

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INTRODUCTION

In many experiments of the scintillation-counter type it is desirable to produce a moderately high flux of secondary particles over a counting period of the order of 1/10 to 1/2 sec. This secondary beam should be reproducible from pulse to pulse and should not fluctuate markedly during a given pulse. In the past, such beams have been produced by two methods, (a) by allowing phase oscillations to grow by reducing the voltage on the accelerating electrode, or (b) by driving phase-oscillation amplitudes beyond the stability limit by phase modulation of the frequency-tracking oscillator.[1] It has been found that a better method of producing such secondary beams is by the use of thin foils.

1 Harry G. Heard, Slow and Fast Structure of Secondary-Particle Beams of the Bevatron, UCRL-3428, July, 1956.

FOIL TECHNIQUE

If the circulating proton beam of the Bevatron strikes a foil on the outer radius of the aperture, the foil being within a region where the field index $n<0.8$, the betatron oscillation amplitudes increase, and the particles no longer remain in the phase synchronism. If, in addition, a target is placed on the inside radius of the aperture, some of the beam will strike the target on an inward excursion of a radial betatron oscillation.

The rate of production of the secondary beam may be controlled by varying the frequency of the tracking oscillator to cause the orbit of the circulating beam to expand slowly onto the foil. If the thickness and atomic number of the foil are kept small, for example 0.00025 in. of aluminum, scattering does not cause the beam to become too diffuse. The energy losses sustained by the primary beam in passing through the foil will cause the phase of some of the protons to fall out of synchronism with the phase of the radio-frequency accelerating voltage. The asynchronous particles circulate within the aperture several millisec before the magnetic field shrinks their orbit and causes them to strike the inner-radius target. As the phase structure of the circulating beam is lost within approximately 1 millisec after striking the outer-radius foil, the resultant secondary beam has no radio-frequency structure. A lip on the inner-radius target is used to damp the radial betatron oscillations, so that the main target is struck at a relatively small angle. Fig. 1 illustrates a typical secondary-beam pulse of 275 millisec duration.

This same foil can be used for producing beam pulses for bubble-chamber and cloud-chamber experiments. The technique is somewhat different, however. The primary beam is accelerated to the peak magnet current before the radio-frequency voltage is turned off. This beam continues to circulate within the aperture until the magnet current decreases and causes the orbit to expand. If the circulating beam expands upon an outer-radius foil target, the energy losses sustained cause the orbit to contract in opposition to the decrease in magnet current. Multiple scattering causes radial oscillations to build up rapidly. An inner-radius target may be struck as the beam oscillates within the aperture. This technique produces a beam pulse of 3 to 5 millisec half width for the normal rate of decay of magnet current in the Bevatron. Fig. 2 shows a typical beam pulse of 4-millisec half width.

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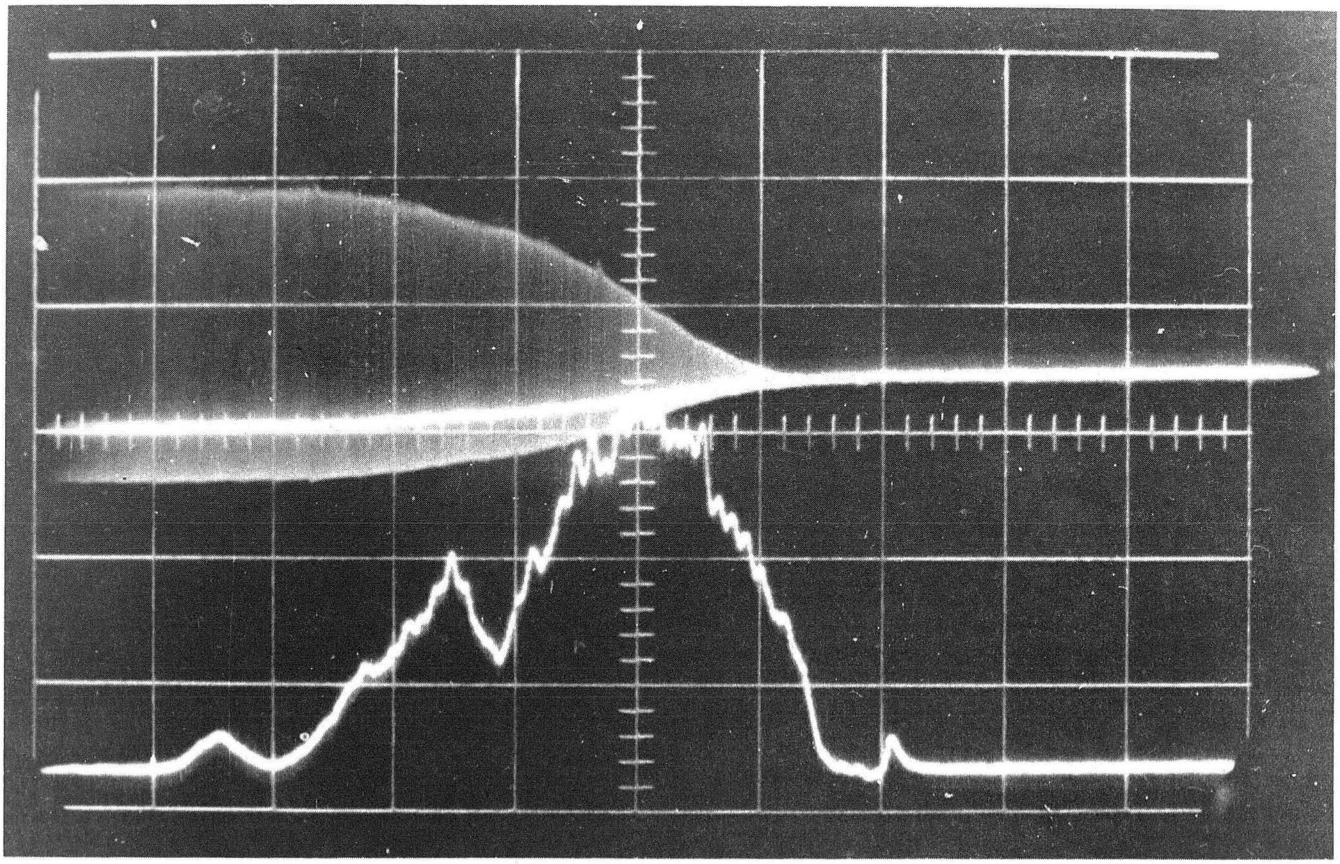

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Fig. 1. Secondary pion-beam flux produced by a 0.00025-in. aluminum foil. Top trace: beam-induction electrode signal. Bottom trace: envelope of the secondary pion beam from the 3° copper target. Time scale: 50 millisec/cm. Small pip near the end of the lower trace is the beam which is scattered into the 3° target by the foil as the magnet current decreases. The beam represented by the small pulse is used for a bubble chamber, thus permitting concurrent operation of two experiments on the same beam pulse.

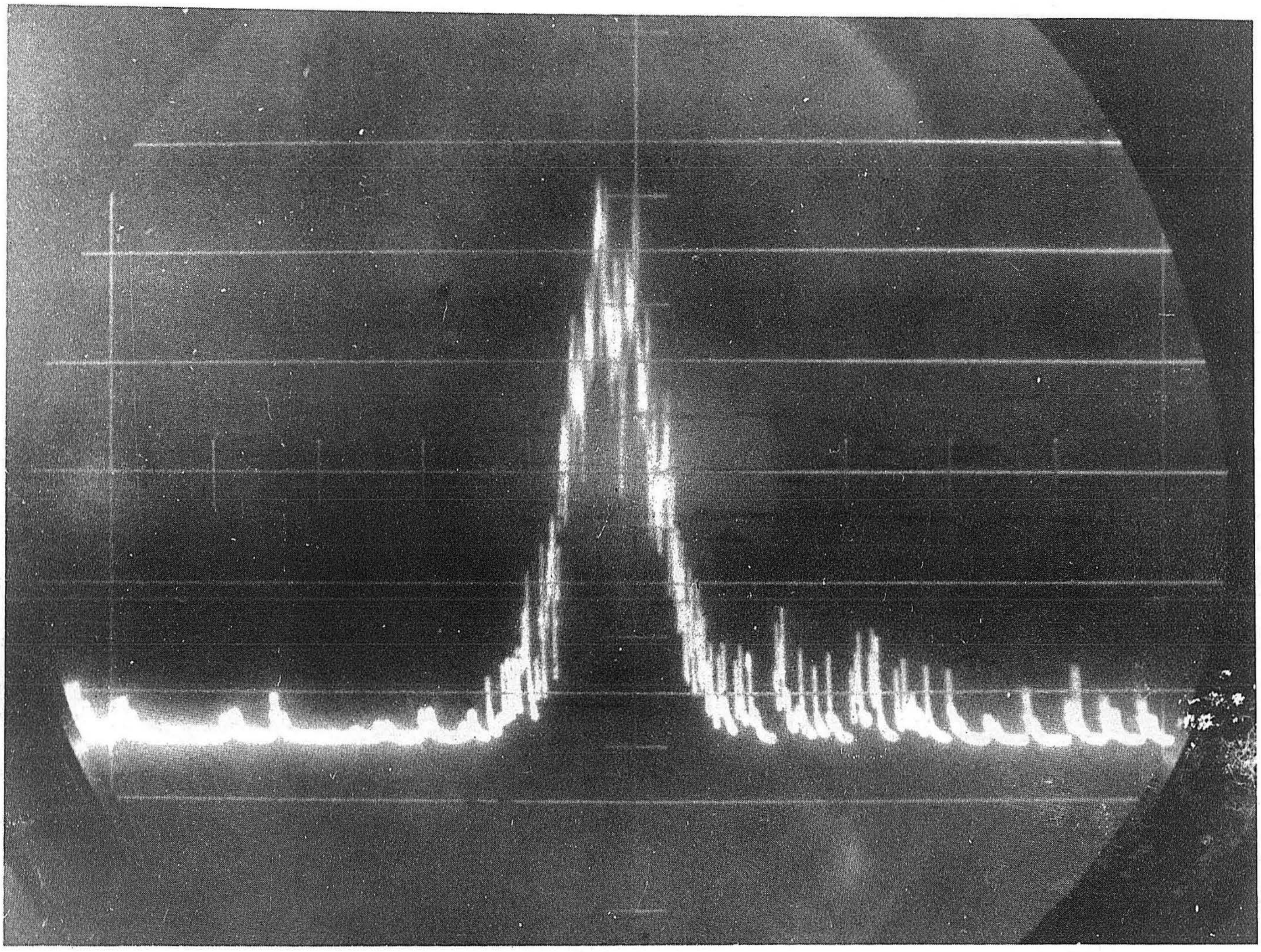

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Fig. 2. Typical integrated pion-beam pulse produced by the 73° copper target during inversion. Pulse width at half amplitude approximately 4 millisec.