Title
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There has been a growing interest at this laboratory in the question of the existence of radiofrequency fine structure of the photon beam of the 322 Mev electron synchrotron. Knowledge of such fine structure is of interest not only from the point of view of synchrotron theory, but from the very practical use of such information in experimental design of high speed electronic synchrotron experiments, particularly in the problems of background in set-ups involving coincidences or delayed coincidences, and those involving high counting rates.

Madey, Bandtel, and Frank (UCRL-2052) have recently performed an experiment measuring this fine structure using fast coincidence between pulses from two scintillation counters looking at a thin lead target in the beam. When they delayed one of the pulses by the addition of coaxial line into the system, they found a marked cyclic variation in the coincidence rate presumably due to coincidences between non-correlated particles from different radiofrequency bursts. By unfolding their coincidence resolution from the experimental curve they were able to estimate the azimuthal spread of the electrons in the internal synchrotron beam.

Because of the importance of this fine structure in experimental design, it was felt that a verification by another method of the beam structure found in the above experiment would be of value. This was done by the following method. The "spread-out" photon beam (caused by a slow decay of the rf) was used as opposed to Madey's use of the natural short beam. A full intensity beam was used. This photon beam was collimated and passed through a lead sheet (See Fig. 1). Directly behind this sheet was a large stilbene crystal viewed by a 1P21 photomultiplier tube. Pulses from this tube were amplified by Hewlett-Packard fast amplifiers and placed directly on the vertical plates of a Tektronix 517 oscilloscope. The scope was triggered by one of the timing pulses of the synchrotron, delayed so that the sweep would occur during the beam. Accurate synchronization of this trigger was not necessary. Sweeps of 1, 2.5, and 5 x 10^{-8} sec/cm were used. The oscilloscope was viewed by a camera with an open shutter and the film moving at a constant rate, so that the scope traces recorded themselves as they occurred. The film used was Kodak Linagraph Pan.

The 47.7 megacycle frequency of the rf oscillator was picked-up by the phototube as a low lying sine wave and formed a convenient time calibration marker. This calibrated the scope sweep and also gave the time position of each pulse relative to the rf.

The film was developed by standard methods and scanned using a Recordak viewer. The time interval between each pulse and a convient rf pulse was recorded. Care was taken in accepting pulses whose meaning was not ambiguous; for instance, scintillation pulses were used only if they were at least twice the height of the rf sine wave.

This data is shown in Fig. 2. The peak is artificially repeated to show the cyclic effect of the fine structure. The delay of the peak from "zero" is not significant and results from the various delays caused by the equipment and time of flight. All the data for this figure was reduced by intervals of the radiofrequency time to correspond to the nearest rf pulse. This, in a way, inherently assumed the existence of a fine structure, but no peak would have appeared if there were no fine structure. It should be noted that these measurements were made on the beginning part of the spread out beam.

To justify the above handling of the data and to insure that the experimental effect was not some subtle result of the manner in which the pulse was measured relative to the rf, a set of measurements were taken in which the pulses were measured relative to each other. One would expect a much more washed out effect since the width of the fine structure would be folded in twice. The fine structure was still clearly seen. (See Fig. 3.) The relative heights of the peaks in this figure have no significance since they are the result of the fact that more short interval measurements will be seen on a scope sweep than long interval ones.

This method is capable of considerable improvement, and if interest in this phenomena continues, an improved experiment would be a worthwhile problem. While the present experiment was only intended as a qualitative check, refinements could be made to give good quantitative measurements; at least equal to those of Madey, et al. The best improvement that comes to mind would be the use of a pulsed-voltage photomultiplier tube to detect the stilbene pulses. This would give a very strong, sharp pulse capable of being directly applied to the fast oscilloscope tube, thus eliminating the need for distributed amplifiers and their inherent broadening.

The scope could be triggered at various points along the spread out beam and would not only follow the washing out of the fine structure as the rf dies off, but could, in conjunction with a beam monitor, give a fairly accurate envelope of the spread-out beam, which is a much needed experimental quantity.

It is of interest to note that with the large collimator and the full beam that the pulses were very rarely seen to overlap, indicating that experiments with fast equipment need not fear pile-up under ordinary conditions.

The author wishes to express his appreciation to Gordon W. Repp for his help and advice. Thanks are due to Roy Kerth, for the loan of the camera.

SCHEMATIC & BLOCK DIAGRAM OF EXPERIMENT

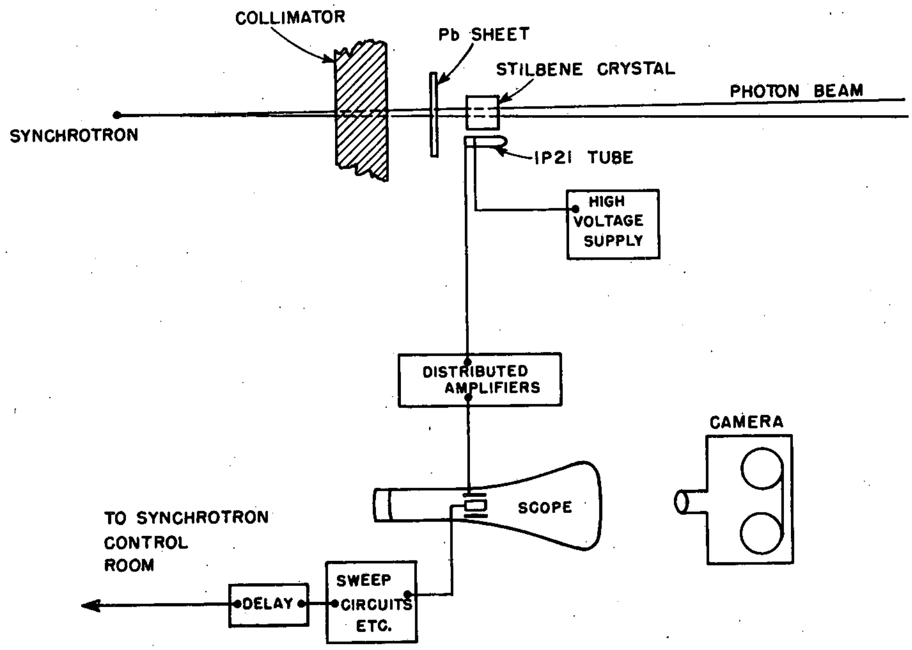

FIG. 1

MU-5188

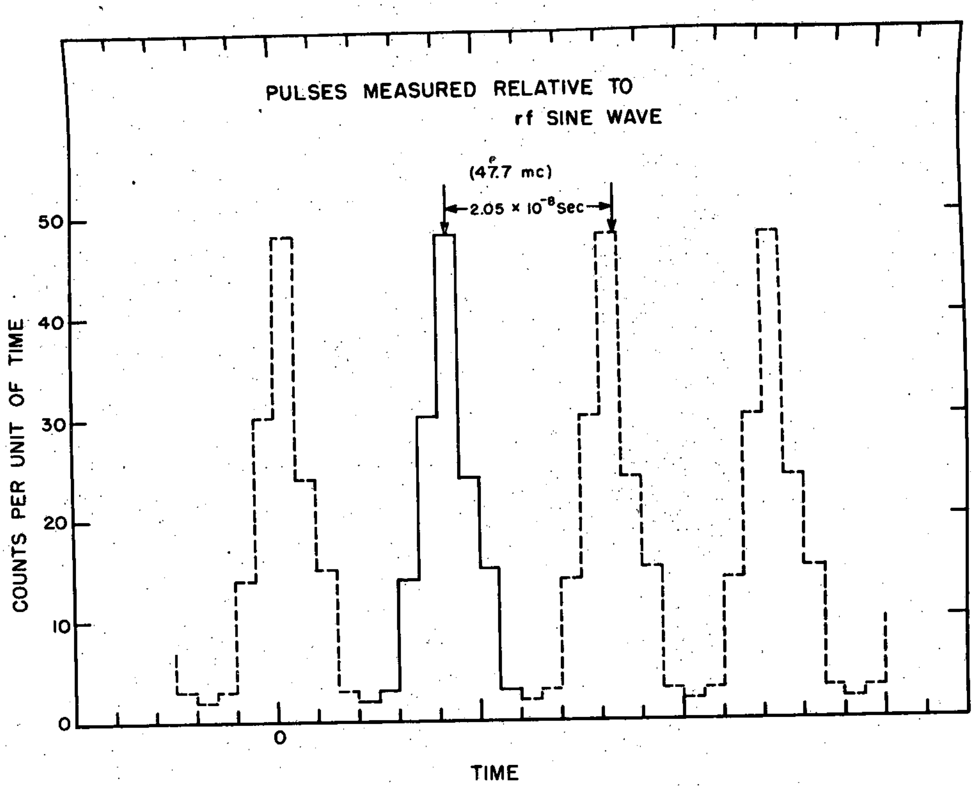
PULSES MEASURED RELATIVE TO
rf SINE WAVE
(47.7 mc)
2.05 × 10⁻⁸ Sec
COUNTS PER UNIT OF TIME
50
40
30
20
10
0
0
TIME

FIG. 2

MU-5187

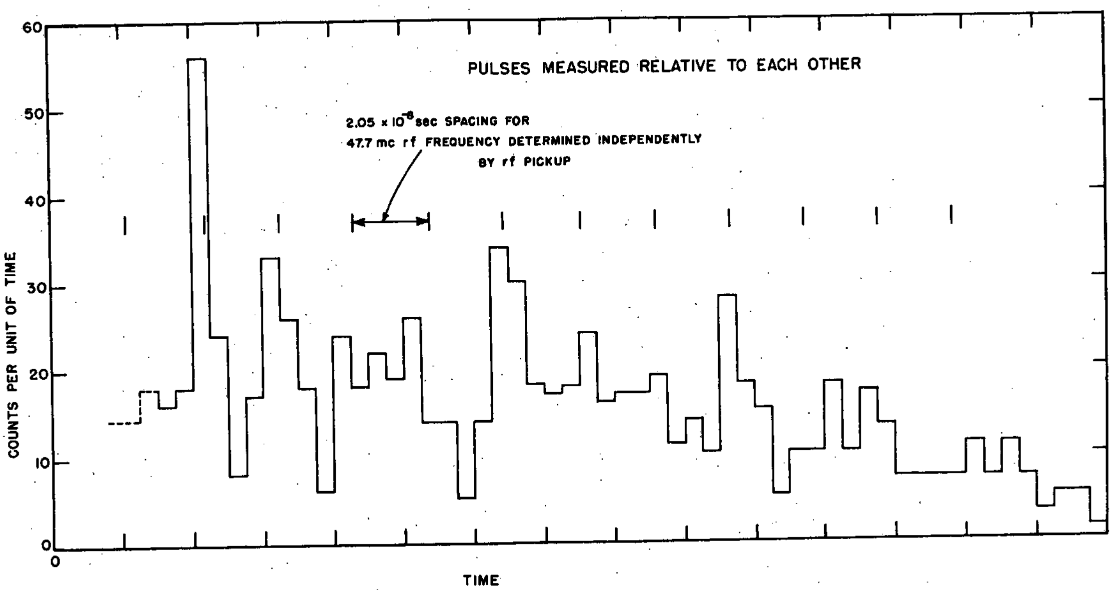
PULSES MEASURED RELATIVE TO EACH OTHER
2.05 x 10⁻⁸ sec SPACING FOR
47.7 mc rf FREQUENCY DETERMINED INDEPENDENTLY
BY rf PICKUP
COUNTS PER UNIT OF TIME
TIME
0
10
20
30
40
50
60

FIG.3

MU-5189