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MEASUREMENT OF SINGLE BUNCH PURITY IN THE SRS

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Abstract

During single bunch operation of the Daresbury SRS it is necessary to reduce the population of empty r.f. buckets to less than 1 part in 10^3. Measurement of the bunch intensity is by single photon counting using the synchrotron light emitted by the electrons. This technique is described, which is capable of resolving relative intensities of 1 part in 10^4 at the bunch spacing of 2 ns.

1. Introduction

Some experiments using the Daresbury SRS require the so-called single bunch mode of operation. In this mode the source produces a 200 ps burst of radiation at a repetition period of 320 ns, by filling just one of the 160 r.f. buckets around the circumference of the storage ring. These features are ideal for studying relaxation times in fluorescence spectroscopy, for mass resolution in time of flight mass spectroscopy and in time resolved anisotropy measurements. However the light pulses must be clean for these applications and this requires that there are fewer than 1 part in 10^4 of electrons populating the 159 "empty" r.f. buckets.

The accumulation of electrons into the desired bucket is described elsewhere[1]. It requires precise settings of sensitive parameters in the injection system and is highly intolerant of drifts or timing jitters. A few pulses of electrons from the injection system captured into the wrong storage ring r.f. bucket is sufficient to exceed the required bunch purity.

Stripline pick-ups in the storage ring are capable of resolving ~ 3% population of the empty buckets and the image dissector[2] used to measure the bunch length can resolve ~ 0.3%. However these methods fall far short of that required. This paper describes how the bunch purity is measured using the single photon counting technique in the synchrotron light monitoring station.

2. Experimental Technique

The distribution of electrons around the circumference of the SRS is found by measuring the time of arrival of single photons from the electron beam with respect to a reference time which is synchronised to the orbit period. In order to ensure that the single photons are representative of the electron distribution their measurement rate must be much lower than the reference pulse rate. For the SRS the reference pulse rate is 3.1×10^6 pulses/s and the optimum single photon rate was found to be $\sim 2 \times 10^4$ pulses/s.

The layout of the measuring system is shown in Fig.1. Visible radiation from the electron bunches is reflected into the synchrotron light station where it is attenuated to the required intensity and detected using a Mullard XP 2020 fast phototube. The signal from the tube is processed locally to give two pulses: a "start" logic pulse and a pulse capable of driving a ratemeter, which are fed back to the control room.

The reference pulse is derived from either the orbit clock pulse of the SRS timing logic system[1] or from a pickup strip detecting the single bunch itself. Each method has its disadvantages. The orbit clock is generated by T.T.L. logic and has a time jitter of ~ ± 1 ns. Since the bucket spacing in the SRS is 2 ns this makes resolution of adjacent buckets difficult. The pickup strip signal has ideal time qualities, but

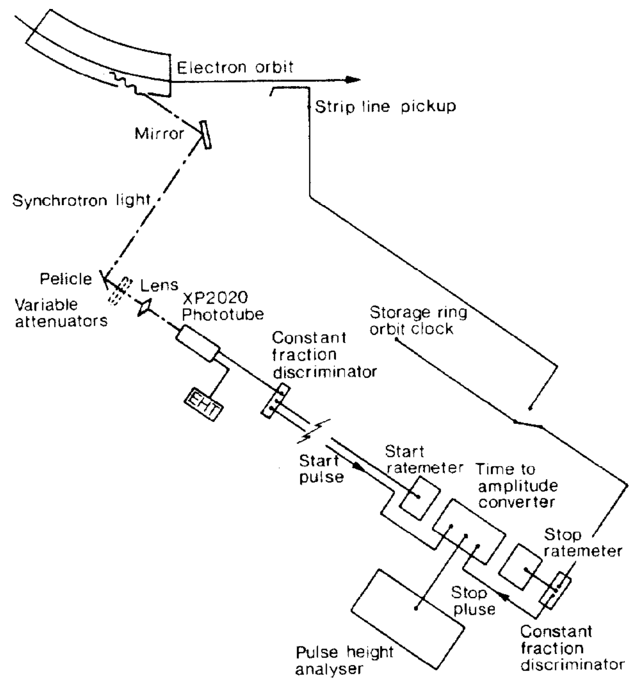

Fig.1. Schematic diagram of the single photon counting system.

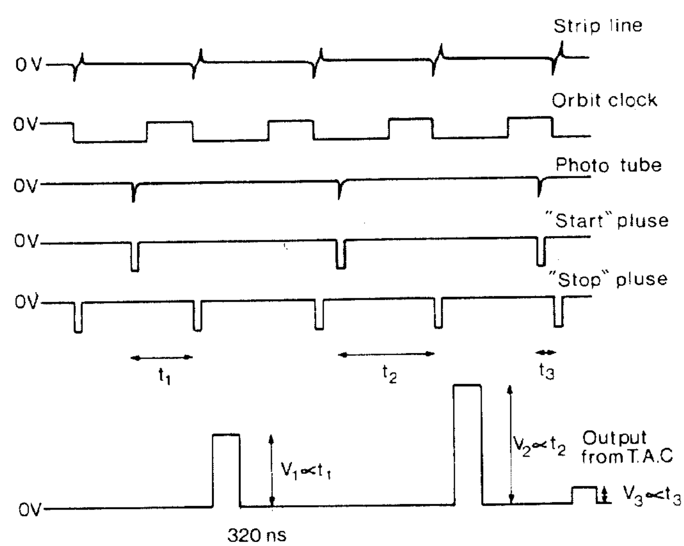

Fig.2. Timing pulses in the single photon counting technique.

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its bipolar nature is incompatible with the processing electronics. To date simple amplification and clipping has been used to "shape" the signal but this is to be refined in the near future. Using the strip signal adjacent pulses are readily resolved. These signals are processed in the control room to give a "stop" pulse and to drive signals for a second ratemeter.

The start and stop signals are analysed in the time-to-amplitude converter which produces a pulse with amplitude proportional to the difference in time between signals. These pulses are then accumulated in the multichannel analyser giving a direct display of bunch intensity vs time. The various timing pulses are shown in Fig.2.

3. Results

In the single photon counting technique it is very important that the event rate is set so that no "masking" of the orbit occurs. To check this the system was set up to look at a multibunch beam, where all 160 buckets are filled.

Figure 3(a) shows the density of electrons around the orbit as measured by a strip line pickup electrode. Figure 3(b) shows the same beam measured by the single photon counting technique. Note that "time" runs in the opposite direction in this case since the reference pulse is used as the "stop" pulse. The scale is linear in both cases and shows that the technique provides an excellent representation of the relative beam density: there is no masking.

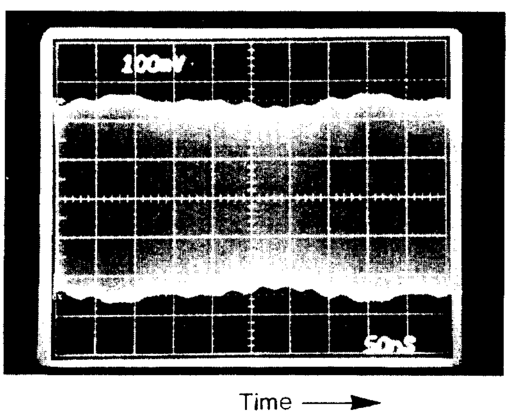

Fig.3(a). Storage ring fill measured by a stripline pickup.

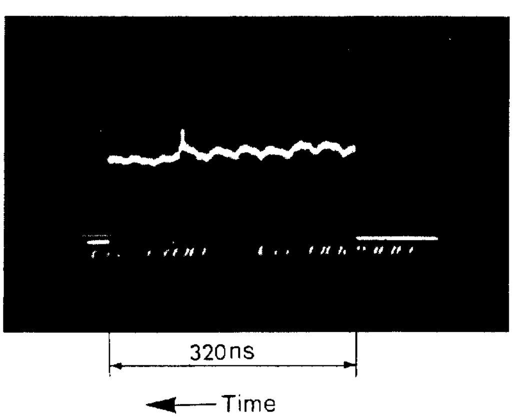

Fig.3(b). Measured by the single photon technique.

Figure 4 shows the system response to two bunches in the storage ring with a separation of 6 ns (3 r.f. buckets apart) and with a relative density of $1:10^3$, achieved by timing the fills. In this case the vertical scale is logarithmic and it clearly shows the resolving power of the technique.

Figure 5 shows the same part of the orbit containing a "single" bunch.

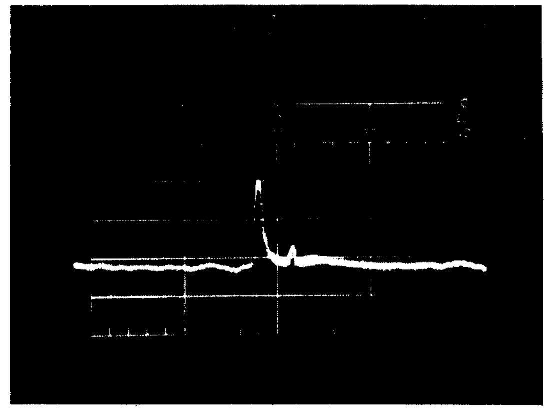

Fig.4. Two bunches, 6 ns apart, relative density $1:10^3$. Vertical scale logarithmic.

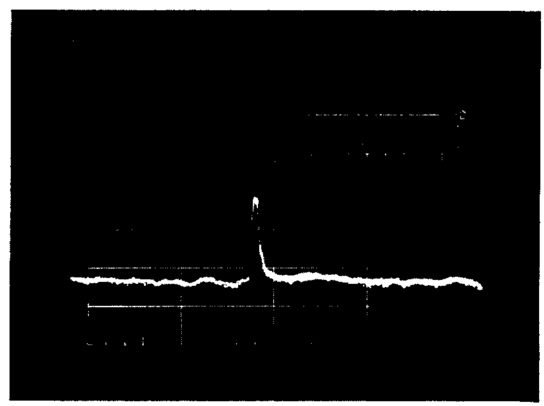

Fig.5. Typical clean single bunch, same scale as Fig.4.

4. Conclusions

The technique described has proven itself to be the most sensitive method of measuring bunch purity in the SRS. The system is relatively simple to set up and check and is capable of resolving empty buckets to a level of 1 part in 10^4 - sufficient for all foreseeable uses of the SRS single bunch mode.

5. Acknowledgements

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References

1. E.A. Hughes, T. Ring and B. Taylor. A single bunch system for the Daresbury SRS. Paper presented at this conference.
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