Broadening Beams in Time

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It is well known that in any counter experiments, except for those involving time of flight, it is advantageous to have a maximum duty cycle. The duty cycle of the machine, particularly in a cyclotron, depends on the resolving time. It your experimental equipment has 5 m s resolution, the r-f fine structure is seen, and the effective duty cycle of the machine is just the phase bunching, say 3 or 4 percent. I would like to have you consider the problem of how to increase this figure.

I want to point out that such experiments do exist. The experiments that are being done now at Seattle, the coincidence experiments, already see this, and the rate at which they can get data is limited by duty cycle. Even experiments which do not appear to be coincidence experiments can still have this difficulty. For instance, it is common to have problems about accidental coincidences in a single counter between the big pulses being studied and the small pulses on the baseline. This really holds true in all experiments. The only exceptions are experiments involving time of flight, in which you want to have a short burst.

While sitting here the past couple of days, I have come to the conclusion that from this point of view the experimentalist is at cross purposes with the machine designer, who always seems inherently to feel that it is advantageous to have sharp phase bunching. Well, just so that my comments won't be vacuous let me propose a way that we might be able to do this. Not being a machine designer, I only have courage to make such a proposal because I have already talked it over with the Michigan people who say it is not totally impossible.

One way to lengthen the r-f burst would be to put it into some sort of storage ring where either the inherent phase oscillations, or some induced phase oscillations, would have time enough to work on the bunch and spread it out. One might possibly consider having the storage ring concentric with the cyclotron itself; that is, having the field continue beyond the dees, Fig. 274. Then, if you can accelerate the beam into the storage ring, and let it wiggle around long enough before extracting it, the bunch will be spread out.

Of course, there are some experiments in which you want to preserve the phase bunching, that is, the ones in which you want to do time in flight. In this case all you have to do is place the extractor at the exit of the dees and pick them up before they get into the storage ring. With such a machine one could meet these two conflicting demands.

BLOSSER: It seems to me that probably an easier way to do this is to put a third harmonic in the r-f voltage. But the experimentalists almost has to give up something here. With a third harmonic it would be extremely difficult to get any energy variation.

EISBERG: You will probably also lose beam. But, whenever you are duty-cycle limited you normally don't need the beam. Look at the numbers quoted; people use such little beams strictly because they are duty-cycle limited. In some of these schemes clearly it is going to hurt you one way or the other; this suggests that you don't mind losing some beam.

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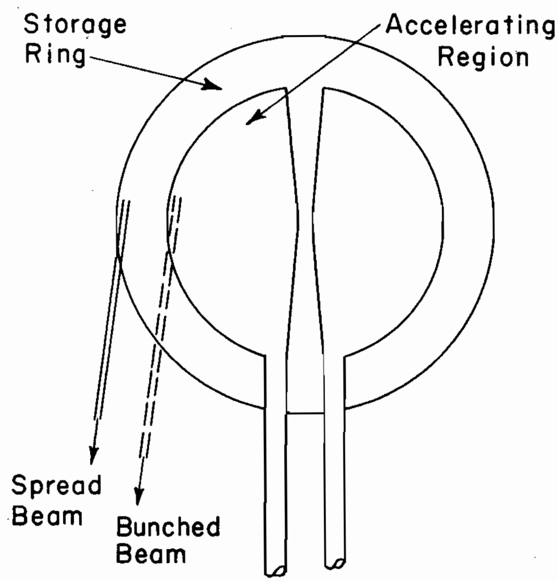

Fig. 274. Cyclotron with storage ring.

WELTON: A number of the cyclotrons described apparently have fairly long flight paths attached. It is not customary in the cyclotron business to worry about debunching, but I just wonder how it works out with reasonable voltage in the cavity and flight paths that seem feasible.

SCHMIDT: For our machine and it turns out it is 58.5 ft. from the deflector to our scattering chamber. This corresponds to only 0.5 mμs for ΔE = 0.5 Mev.

EISBERG: Presumably one might attempt to induce some kind of phase oscillation in the beam as it goes into the storage ring. Just as an example, with existing commercial equipment one can count pulses every 50 mμs; if you build it yourself, you can count one every 20 millimicroseconds. It is easy to anticipate that a few years hence all equipment will be 5 mμs, and the duty cycle of a cyclotron will be 3%, not unity. Then to a certain extent people will have defeated their own purpose in going to the trouble of building these lovely things.

SCHMIDT: I think there is a good chance that within a few years we will be getting 0.1 mμs with coincidence circuits and, therefore, it is possible that we can pick out a coincidence event within the same pulse, and distinguish between two such non-coincidence events within a pulse.

CHAIRMAN HAVENS: I think this is being belabored. I once had an idea for spreading pulsed beams out in time. I proposed pathing a linear accelerator on the end of the cyclotron to debunch the beam. The linear accelerator turned out to be just as expensive as the initial cyclotron. It can be done but it might not be worth it.

BROBECK: This is perhaps something that can be done by sending parts of the pulse over different lengths of paths.

CHAIRMAN HAVENS: A Mobley magnet is the sort of thing of which you are thinking. In this magnet the portion of the beam which is incident on the magnet at an earlier time travels around the outside radius of the magnet and that portion which arrives later in time travels around the inside radius of the magnet to change the beam distribution in time. Schemes like this were published by Mobley in 1952 for the purpose of sharpening up beam pulses, but they could be inverted to lengthen out the pulses. I don't know of any results that have been published from using these schemes. Mobley is constructing such a magnet.