PROPOSED P.S. BEAM-LIFE EXPERIMENT.

The possibility of a project to build proton storage rings for the C.P.S. makes it of interest to look at the life of a high-energy circulating beam, to compare the behaviour with the predictions of theory, and to see whether anything unexpected happens.

These notes have been put down as a basis for discussion and comment.

A. Schedule.

It is suggested that the experiment should be done sometime in the next three months or so. Preliminary tests, not involving acceleration, could profitably be done in the near future during normal working hours.

The beam-on time for the experiment would probably be one or two sessions of 30 minutes, for verifying all arrangements, and a session of say 2 hours for making serious measurements.

B. Theory.

The decay-time due to nuclear collisions at a mean pressure of $5 \times 10^{-6}$ Torr air equivalent is about 3 minutes. At an energy around 10 GeV, small-angle scattering is also appreciable: after about the first factor $\gamma/e$ in the decay the beam may be as big as the aperture, and the decay rate will increase.

C. Measurements Desired.

At constant energy and \( E \), measure the beam intensity at intervals of say 5 seconds, until most of it has decayed. This should give the initial mean-life and disclose any departure from exponential decay.

At some time when the beam has decayed by a factor of say 3, it would be useful to measure its diameter or radial width.

Bunch shapes should be watched to see whether they change.
D. Machine Regime.

The proton energy should be well away from transition and as high as conveniently possible. A value around 9 – 10 GeV, determined by the fact that the magnet and its power supply must be comfortably capable of working D.C., seems appropriate. (In case unexpected phenomena show up, it could be interesting to repeat the experiment on the other side of transition.)

At present there seems no virtue in attempting to do the experiment with R.F. off. With R.F. and beam-control on, the magnet current does not need to be very stable, and so far as is known the high ripple on a normal flat-top will not be troublesome. (If it is, the use of 25 o/o rate of rise could be considered.)

It seems unlikely that any of the normal machine corrections, quadrupoles, poleface windings, would need to be changed.

E. Experimental Procedure.

One would envisage conducting the experiment in something like the following way:

1. Set up the magnet power supply in some pulsed regime with a fairly long flat-top at the desired energy. For example:

- Rate of rise 90 o/o
- Peak current 2000 A
- Flat-top say 200 ms
- Repetition rate 1 pulse per 3 or 2 seconds.

2. Check that timing, injection, trapping, transition, etc. are all behaving normally.

3. If necessary, make adjustments to the R.F. system to ensure that the beam lasts reliably to the end of the flat-top, and is reasonable central in the vacuum chamber. One hopes that this flat-top is long enough for the beam (e.g. bunch-shape, radial position) to settle into a steady state.

4. Organise the accelerated-beam monitor to read and print-out at a time near the end of the flat-top.

5. Measure beam-size with a fast-flip wire target near the end of the flat-top. Say at X1 + 170 ms.

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When all the above is working smoothly the Power House Control Centre would be asked to make a pulse which has a flat-top that continues indefinitely. In other respects this pulse should be identical to those set up at (1) and used for (2) to (5).

On this long flat-top one would: -

(6) Print-out the beam intensity, as at (4) above, followed by further regular print-outs at say 5 second intervals. It would be convenient if the digital display in the MCRR also displays a new reading at 5 s intervals.

(7) Watch various oscilloscope displays; especially the synchronised broad-band picture of the bunches, to see whether there is any significant bunch broadening.

This long flat top can very well be allowed to continue until the beam-control system switches itself out for lack of beam. This might take some 6 to 10 minutes. The P.H. would then come back to the pulsed regime (1).

After repeating the above once or twice we would have good data on beam decay. A few more long pulses would be used for (8) and (9): -

(8) Measure the beam-size, at X₁ + 170 ms as at (5) above, and also at some chosen time where the beam has decayed by say 1/3.

(9) If (7) discloses much bunch broadening, a check on the decay rate can be made by use of the circulating-beam current transformer and a target to destroy the beam completely after a suitable time.

(10) At the beginning and the end of the period scheduled for this run, the necessary vacuum-gauge reading should be taken.

F. Preparation and Facilities.

The work that would be required of the various MPS sections seems to be roughly the following: -

(a) Power House

Use "magnet test" time to develop a suitable machine cycle, E(1), and to find a way of extending its flat-top indefinitely on demand.

Possibly check that this cycle works with injection (spiralling beam), or with injection and acceleration to a few hundred MeV.

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(b) R.F.
Organise facilities for the repetitive point-out, E(6).
Possibly some adjustments, E(3).

(c) Targets.
Fast-flip wire target, facilities for observing (preferably photographing) the
associated counter burst, E(5), E(8).
Some other target, E(9).

(d) Vacuum.
Decide on the best way of estimating the average vacuum, organise the necessary
gauges, calibrations etc., and the taking of readings.

My impression is that the total amount of work involved is reasonably modest,
but each of F(a) to F(d) seems to require the assistance of some suitable
specialist for the experiment itself.

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