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Remarks to serve for a discussion on flat top operation of the P.S.

Since it is felt by everybody that the "flat top" situation should be discussed and the possibilities looked into, I have put down here some remarks which could perhaps contribute to the discussion.

1. Requirements.

a) According to requirements collected, foreseen and mentioned by M.G.N. Hine, universal flat top operation of the P.S. has to be investigated. To keep the machine up to date a flat top of any energy level should be provided.

b) As constant magnet fields ($B = 0$) will be required anyway, also slow rates of rise or decrease during the "flat top" can be provided without additional implications.

c) Handling of the beam during flat top by means of an accelerating voltage, R.F. knock-out, targets, ejection equipment, etc., should be foreseen.

d) Timing pulses before and during the flat top have to be provided, which are well related to its beginning (X_1) and perhaps also to F without jitter from pulse to pulse. (Experiments by M.G.N. Hine, K.H. Reich and W. Schnell).

e) The magnet field (that means the proton energy) should reach a defined value without jitter from pulse to pulse.

2. Implications.

a) The length of the flat top at a given magnet field level and repetition rate of the magnet cycle is limited by the average power dissipation, which can be supplied by the MPS set.

b) Switching over from the magnet rise voltage to any adjustable lower magnet voltage during the flat top would be required (voltages $\leq$ 33 o/o of 6 kV would be necessary because the highest current 6400 A occurs a voltage drop of $\approx$ 2000 V in the resistance 0,3 ohm of the magnet coils).

c) The stable phase angle of the accelerating voltage should be adjustable round 90° in a range of ± 60°. (90° angle has bunching but not accelerating effect). A state of vanishing influence of the accelerating voltage to the particles will mainly be required.

d) The switching over moment from magnet rise to flat top is determined by the phase of the AC voltage from the MPS set (revolution frequency of it). Therefore, any timing pulses, which are not derived from this revolution frequency of the MPS set, will have a jitter of ± 3,3 ms in relation to the beginning of the flat top (X_1). (3-phase rectification).

e) As the average revolution frequency of the MPS set is floating by about ± 3 o/o at present, no defined flat top fields without jitter can yet be obtained, if the flat top switching is derived from the revolution frequency (M-timing). If it is derived from the magnet field (B-timing), the jitter of ± 3,3 ms mentioned above will remain. A modification will be necessary to the present system.

f) If we continue to control the MPS set from its revolution frequency, the Linac timing procedure foreseen is somewhat influenced.

3. Some outlooks.

a) The big ripple on the magnet ($\approx$ 25 o/o of 6 kV) moves the beam by a fraction of 1 mm in the vacuum chamber. Future interference from this is difficult to foresee It can only be stated already that programmed acceleration requires a ripple of $\leq$ 1 o/o. Filtering problems may be worth studying.

c) W. Schnell prepared or has already foreseen the devices needed for beam controlled acceleration (±) and vanishing influence of the accelerating voltage during flat top.

The R.F. section is preparing programmed acceleration ($\pm$) at high energy levels.

The following two outlooks d) and e) mention possibilities which must of course be discussed with the designers of the present equipment.

d) As in principle the flat top field can be adjusted in steps of 6,6 ms (3-phase rectification), it looks reasonable to provide a timing pulse frequency (M-timing) of $\approx$ 150 c/s rather than $\approx$ 100 c/s. (Modification of the order for the new BBC timer may be necessary - Urgent).
For the general distribution of the M-pulses a frequency of $\approx$ 2 x 150 = $\approx$ 300 c/s may be adequate.

e) There seems to be 2 possibilities to reach defined magnet fields at flat top :

α) Control of the magnet rise voltage from the average revolution frequency (M) in order to compensate time jitter by a small change of $\dot{B}$.

β) To keep the average revolution frequency (M) constant for a given state of operation by means of an additional servo system. This servo system would control in very small limits ($\pm 10^{-3}$) the power fed into the motor of the MPS set.

The second method looks more promising :

We can suppose that the amount of energy ΔE per pulse (kWh) exchanged between MPS set and magnet has no more jitter from pulse to pulse than $\pm$ 2 o/oo. The amount of this energy ΔE represents only 10 o/o of the energy stored in the flywheel. With $E \sim n^2$ we could expect a jitter of the average revolution frequency of about $\pm 1 \times 10^{-4}$.
It is not difficult to measure this frequency with an accuracy of $\approx 10^{-5}$. There is a reasonable hope that the reproducibility of the magnet field at flat top could reach $\approx \pm 10^{-3}$.

f) With the servo system mentioned above Linac timing would be all right.

H. Fischer.

Distribution : (open)
Machine Group Committee
F. Grütter R. Mosig
M.G.N. Hine K. Zilverschoon
W. Schnell.

ac/.
PS/1313.