SOME SUPPLEMENTARY DATA ABOUT THE SERPUKHOV PS TIMING SIGNALS TO BE USED

V. Komarov

TIMING SYSTEM

1. B-train

The B-train is started by a 73 oe pulse (see Appendix A) and within the energy range of 30 ÷ 70 GeV its frequency is changed from 5 to 3.5 KHz, respectively. The jitter of the time interval between different pairs of the preselected B-pulses was measured by R. Bossart (see TN-135).

As an important consequence of these results, the B-train cannot be used for the generation of the pre-pulse which provides the triggering of the firing pulse delays of the BTS magnets, since the flat-top duration of the BTS pulse is less than the B-pulse jitter. The energy dependence of the B-train frequency creates an additional inconvenience. Actually, under these circumstances, the preservation of the same pre-time at different ejection energies is possible only by means of the variation of the B pre-pulse number. But, in this case, the pre-pulse system loses its attraction for such applications. This is confirmed by the measurements (see Appendix B), which have been carried out during the last visit to IHEP.

Obviously, to have a practically constant delay between the BTS firing pulses and ejection pulse, we are obliged to use T-train, which has a frequency stability better than $\pm 1 \cdot 10^{-4}$. One of the possible solutions of FES and BTS synchronization problem is shown in Appendix C.

The B-pulse indicating the beginning of the flat top is preselected by the operator from the B-train by means of the IHEP scaler situated in the LCR. This is the ordinary method of B+T pulse preselection, corresponding to the synchronization system accepted by IHEP. Of course, one can feed this pulse from the MCR (now) or the Supply Building (in the future) where it is preselected, but this does not seem to be urgently necessary.

2. T-train

The T-train is started by the pulse corresponding to the beginning of the guiding field in the ring magnet and finished by the reset pulse (about a 100 ms before the new magnetic cycle).

In the LCR there is a possibility of preselecting an independent reset pulse from the T-train to guarantee enough time for the setting-up of the pre-scalers by means of the prerun.

3. R.F. synchronization

The accelerating voltage is switched on before injection, 9,2 ms after the beginning of the magnetic cycle. The frequency of this voltage is changed from 2.5 to 6.05 MHz being practically constant within the energy range of 30 ÷ 70 GeV (6.05 MHz $\pm$ $2.5 \cdot 10^{-4}$). The R.F. signals from the capacitor dividers inserted into the accelerating gaps (in all 54) are vector summed and will be used for measurement of the total accelerating voltage in the ring with an accuracy better than $\pm$ 5°/o. This sum signal seems to be suitable for the R.F. synchronization purpose as well. Its parameters on the load of 75 ohms are the following :

amplitude $\geqslant$ 5 V
signal/noise ratio $\geqslant$35 dB.

Within the fast ejection energy range, the stability of the phase shift between the total accelerating voltage and sum RF signal is expected to be $\pm$ 0.09 rad (see Appendix D) i.e. $\pm$ 2.5 ns.

As for the synchronization of the RF/30 train with the loss "inflector" bunch, there are two aspects of the problem. On one hand, at present, the intensity of such a bunch is already 70 ÷ 100°/o of the normal value. In future, after the completion of the improvement program foreseeing the synchronization of the inflector fall time with the R.F. voltage, this intensity will be close to 100 °/o. Hence, there is no need to distinguish the "inflector" bunch. But, on the other hand, if the presence of such a pulse is still desirable, we can obtain it. However, the source and the parameters of this pulse must be considered jointly with IHEP during the execution of the above-mentioned improvement program.

The situation concerning the $\dot{B}$-signal generation is not yet clear, as there is no free space in the gap of the reference magnet unit to place the electromagnetic pick-up. A proposal exists to use for this the supplementary winding on the magnet yoke. Since the source of the $\dot{B}$-signal is indefinite at the moment, its exact parameters may be determined later but in any case the $\dot{B}$-signal corresponding to $\dot{B}$ = 3500 oe/s will be not less than 5 V ($\dot{B}$ is changed from 5000 to 3500 oe/s within the energy range of 30 ÷ 70 GeV) and the signal/noise ratio $\geqslant$ 35 dB.

PULSES AND TRAINS AT SERPUKHOV PS

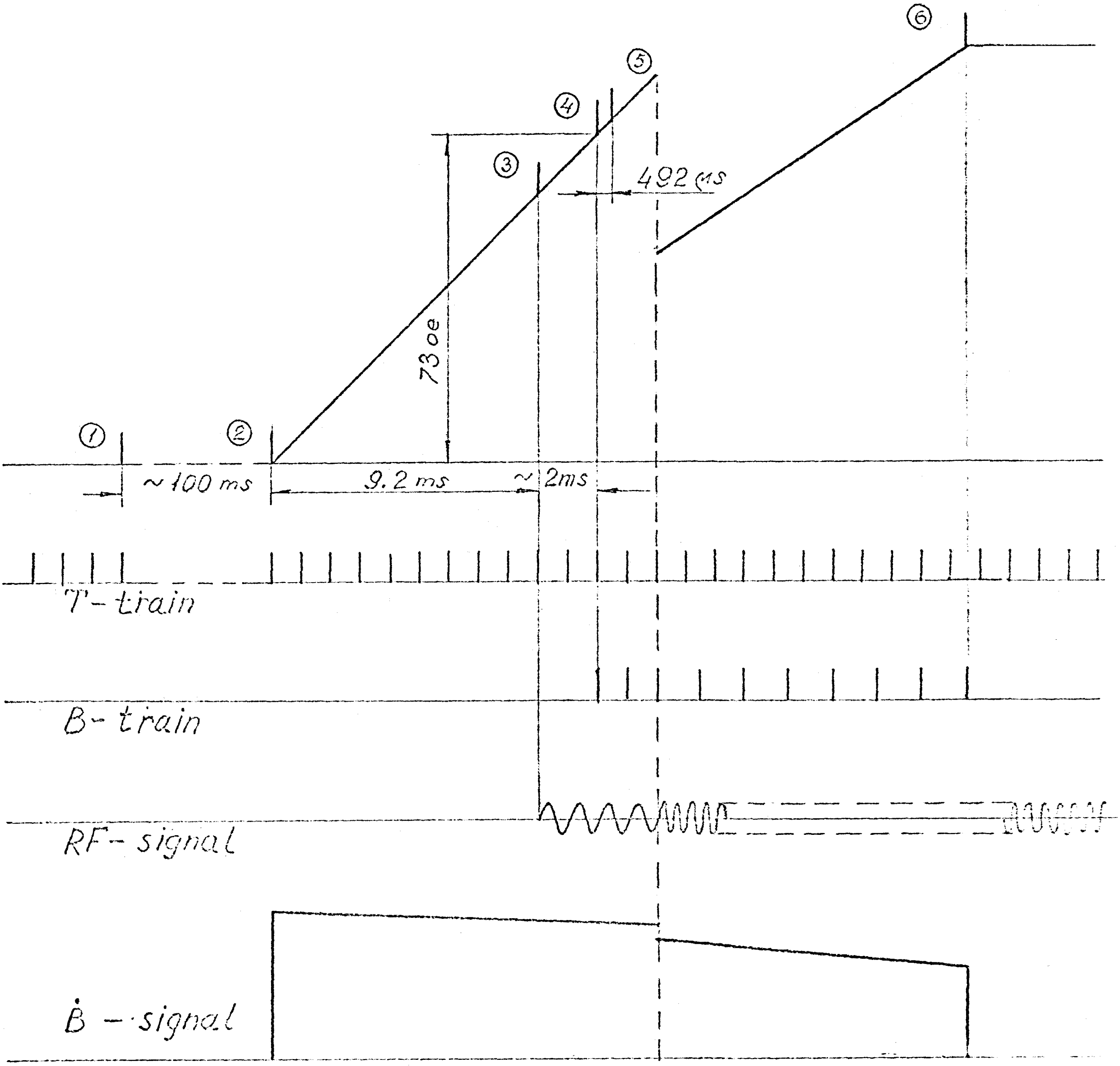

FIG. 1

Pulses :

1 - "Reset" distributed within the synchronization system
2 - "Start of cycle"
3 - "Start of RF"
4 - "73 oe" distributed within the synchronization system
5 - "Start of injection"
6 - "Start of flat top"

APPENDIX B

Time intervals (μs) between preselected B ejection pulse and two B pre-pulses

Table 1

preselected eject. pulse (ejection energy)	30 GeV		50 GeV		70 GeV	
corresponding number of B pulses	5087		8527		11977	
preselected pre-pulse (see note 1)	A	B	A	B	A	B
corresponding number of B pre-pulses	3	25	2	21	2	18
cycle No 1	539	5049	526	5144	623	5099
2	531	5131	538	5234	711	5135
3	569	5053	413	5169	535	5324
4	546	5121	379	5152	443	5351
5	541	5072	437	5098	468	5209
6	473	4998	423	5132	598	5304
7	554	4991	414	5115	655	5294
8	525	5060	428	5269	654	5152
9	488	5041	433	5130	574	5193
10	559	5050	416	5135	434	5190
max. jitter (μs)	± 48	± 70	± 80	± 86	± 139	± 108

Note

1) The pre-pulses A and B simulate the trigger of the firing pulse delays for two cases, when the maximum duration of the BTS magnet pulses is 1 ms (A) and 10 ms (B).

2) The flat-top duration has been defined as 100 μs (± 50 μs).

FES AND BTS SYNCHRONIZATION (PROPOSAL)

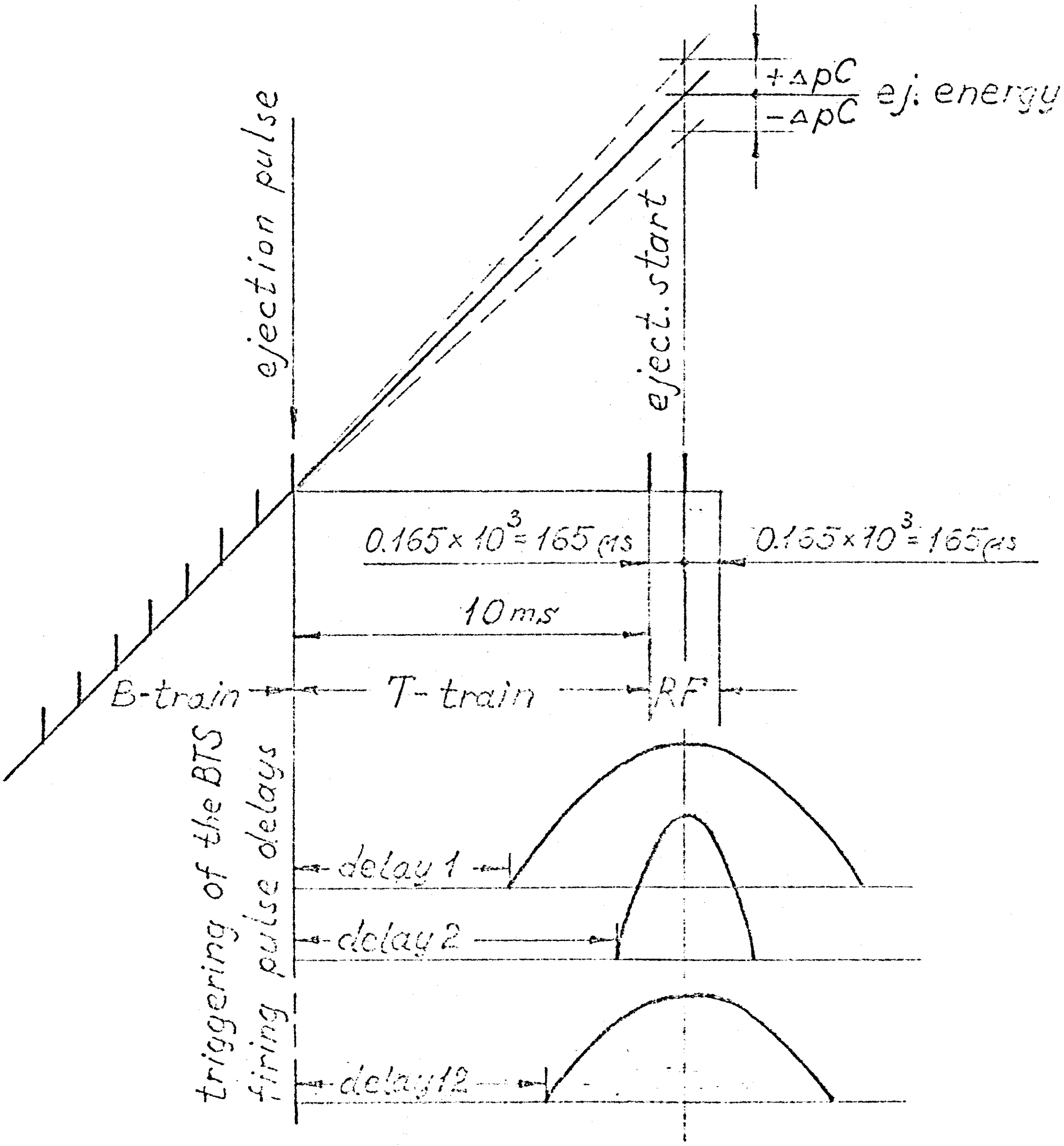

FIG. 2

The modification of the timing system implies including the constant delay between the ejection pulse and the start of the RF pre-pulse train. The variations of the ejection energy due to unstable $\dot{B}$ will be in this case :

$$\frac{\Delta p}{p} = \frac{\Delta B}{B} = \frac{\dot{B}\Delta t}{B}$$

Substituting in this equation $\dot{B}$ = 5000 oe/s, B = 5000 oe and $\Delta t = \pm 150$ μs, we obtain the negligible energy variation of $\pm 1{,}5 \cdot 10^{-4}$ which is better than energy level stability of the B-train ($\pm 5 \cdot 10^{-4}$).

APPENDIX D

ESTIMATION OF THE STABILITY OF THE RF-TRAIN PHASE SHIFT

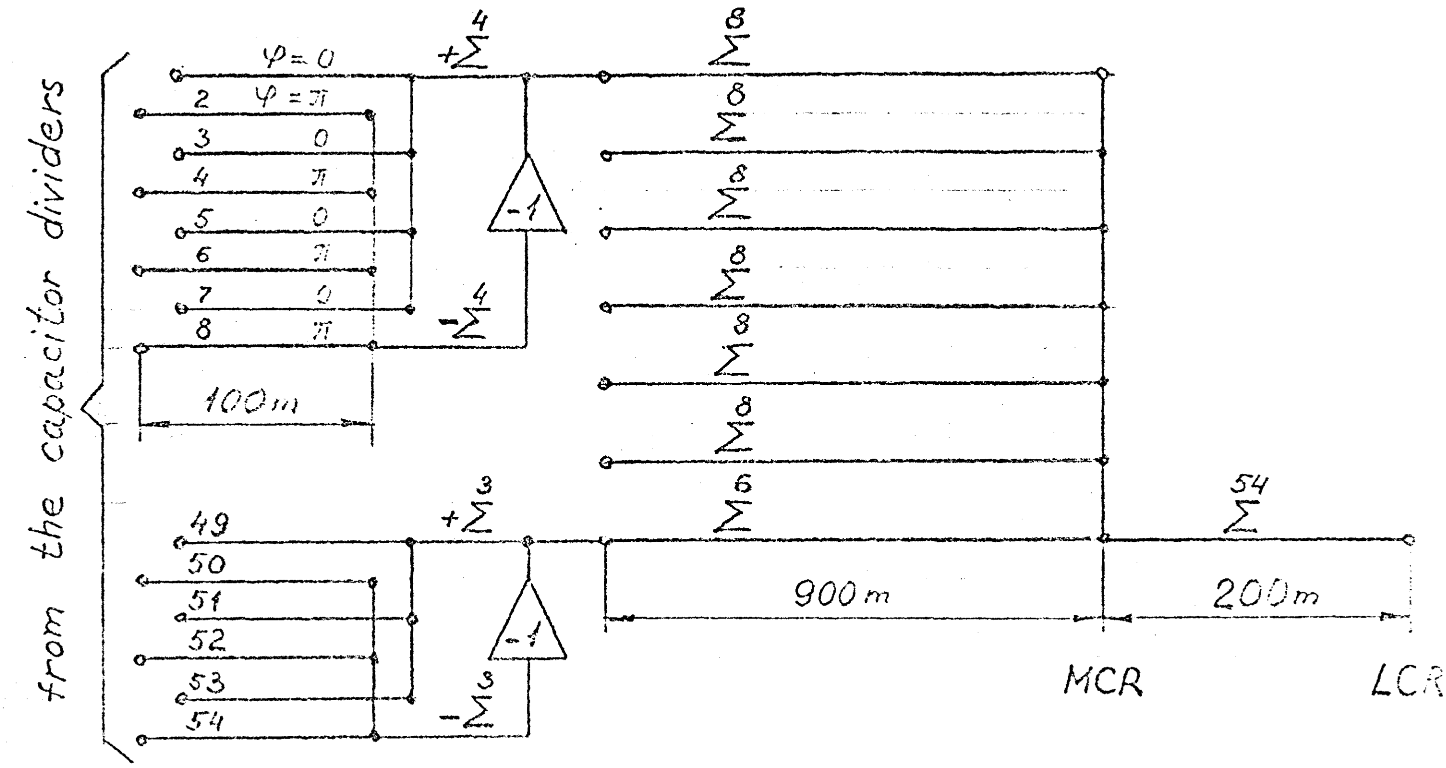

Fig. 3

SUM NETWORK DIAGRAM

In accordance with Fig. 3, the common length of the cable between the capacitor divider and the LCR is 1.2 km. Therefore, for the 6.05MHz signal the phase shift in this way is

$$\varphi = \frac{\omega l \sqrt{\varepsilon}}{c} = \frac{2\pi \cdot 6.05 \cdot 10^{6} \cdot 1.2 \cdot 10^{3} \cdot 1,23}{3 \cdot 10^{8}} = 187 \text{ rad}$$

The variations of phase shift are

$$V \quad \frac{d\varphi}{\varphi} = \underbrace{\frac{dl}{l} + \frac{1}{2}\frac{d\varepsilon}{\varepsilon}}_{a} + \underbrace{\frac{d\omega}{\omega}}_{b}$$

a) Temperature coefficient of phase caused by temperature changes of the cable length ℓ and the permittivity ε is equal to $1 \cdot 10^{-4}/^{\circ}C$ for the cable type used. The temperature fluctuation during a fortnight run is expected to be less than $\pm$ 2,5°C in the region of the cable ways, i.e. the temperature phase stability is estimated as $\pm 2.5 \cdot 10^{-4}$.

b) Increase of the energy from 30 to 70 GeV gives an increment of the revolution frequency which has been calculated by means of the well-known equation

$$\beta^2 = \frac{E^2 - E_o^2}{E^2}$$

the result obtained is $5 \cdot 10^{-4}$ i.e. $\pm 2,5 \cdot 10^{-4}$.

So, the possible range of relative phase variations is $\pm 5 \cdot 10^{-4}$, which gives,

$$\Delta\varphi = 187 \cdot 5 \cdot 10^{-4} = \pm 0.09 \text{ rad}$$

or

$$\Delta t = \Delta\varphi/\omega = \pm 2.5 \text{ ns.}$$