EJECTION ENERGY SPREAD MEASUREMENTS AT THE IHEP ACCELERATOR

(Preliminary results)

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The timing system of the fast ejection has to be synchronized with the acceleration cycle so as to provide :

a) the energy reproducibility at the moment of extraction better than $\pm 10^{-3}$;

b) the required precision of the delays between the preselected pre- and post-pulses and the moment of extraction (see TN-208).

Obviously to satisfy both requirements ("a" and "b") the timing system has to be based on the compromise combination of the B and T trains (see TN-166). The ejection energy spread δE caused by the application of the T train in the pre-pulse zone under the real reproducibility of the guiding field in the ring magnet was measured by IHEP for the rise, transition and flat top regions of the acceleration cycle (see Fig. 1).

Rise of the magnetic field

The ejection energy spread was directly determined as variations of an energy increment ΔE for a given time increment Δt with respect to a preselected B-pulse B_0.

The time increment was provided by a preset 1MHz T-scaler started by the pulse B_0 and could be expressed as

$$\Delta t = N_T \underbrace{\left(1 \pm \frac{0.5}{N_T}\right)}_{1} \underbrace{\left(1 \pm 10^{-4}\right)}_{2} \underbrace{10^{-6}}_{3} \text{ sec} \qquad (1)$$

where N_T - number set on the 1 MHz T-scaler preselector.

1st multiplier - time jitter caused by the absence of synchronization between the B- and T-trains;

2nd multiplier - slow time variations caused by the long term stability of the pulse repetition rate of the T-train;

3rd multiplier - time resolution of the T-train.

The energy increment was measured by a B-counter started by the pulse B_o and stopped by the preselected T-pulse from the 1 MHz T-scaler. It could be expressed as

$$\Delta E = \underbrace{N_B \left(1 \pm \frac{0.5}{N_B}\right)}_{1} \underbrace{\left(1 \pm 5.10^{-4}\right)}_{2} \underbrace{5.8 \cdot 10^6}_{3} \text{ eV} \qquad (2)$$

where N_B - readout of the measurement B-counter;

1st multiplier - measurement error caused by the finite resolution of the B-train;

2nd multiplier - measurement error caused by the long term stability of the energy link of the B-train;

3rd multiplier - energy resolution of the B-train.

An accuracy of these rather delicate energy measurements can easily be estimated from the formula (2) as :

time increment \ ejection energy	30 GeV ($\dot{B}$=5000 oe/s)	70 GeV ($\dot{B}$=3500 oe/s)
300 ms	$\pm$ 5.2 MeV	$\pm$ 4.2 MeV
150 ms	$\pm$ 4.6 MeV	$\pm$ 3.3 MeV

A supplementary energy spread produced by the unstability of the time increment (see formula 1) being equal to $\pm$ 0.9 MeV for the worst case can be neglected.

The results obtained show that the measured energy spread at the simulated moment of ejection t_{ej} is comparable with the accuracy of the measurements. For the time increments up to 300 ms it is not more than $\pm$ 1 B-pulse ($\pm$ 5.8 MeV) within the ejection energy range 30 to 70 GeV, i.e. $\pm$ 2.10^{-4} for the low margin.

Rise to flat top transition

In order to estimate the energy spread at the ejection moment chosen within the transition region, the time interval between B_1 and B_2 pulses was measured by a 1 MHz T-counter started by the pulse B_1 and stopped by the pulse B_2.

The maximum energy spread under the most unsuccessful choice of the ejection moment t'_{ej} can be found as

$$\delta E \max = \Delta E \frac{\Delta t_{max} - \Delta t_{min}}{2 \Delta t_{max}}$$

Substituing the real dàta of one of the transition mode

$$\Delta E = 40 \quad oe$$
$$\Delta t_{max} = 70 \text{ ms}$$
$$\Delta t_{min} = 30 \text{ ms},$$

we obtain the expected energy spread at the transition region of not more than $\pm$ 67 MeV, i.e. $\pm 0.95 \cdot 10^{-3}$ for the ejection energy of 70 GeV. The accuracy of the measurements in this case is obviously high enough, (see previous paragraph).

Flat top of the magnetic field

The fast (overshoot, undershoot, etc.) and slow deviations of the flat top energy from the reference value provided by the preselected pulse B_2 do not exceed $\pm$ 30 MeV, i.e. $\pm 4.5 \cdot 10^{-4}$ for the energy of 70 GeV. The measurements were executed with 5.8 MeV resolution by means of a B-counter started by the pulse B_2 and stopped in a preselected moment limiting the investigated zone.

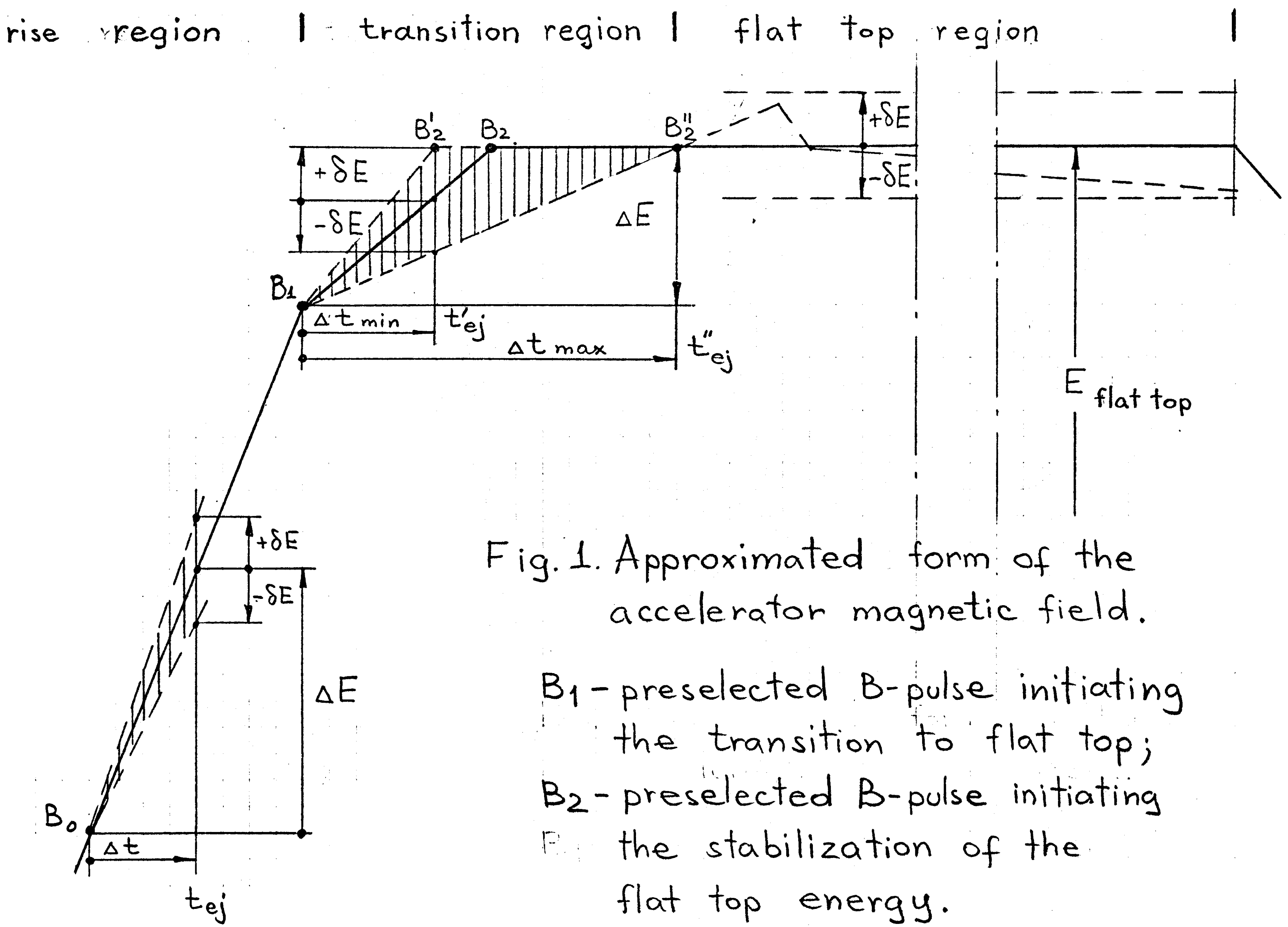

Fig. 1. Approximated form of the accelerator magnetic field.

B_1 - preselected B-pulse initiating the transition to flat top;
B_2 - preselected B-pulse initiating the stabilization of the flat top energy.