MONITORING CHANNEL OF THE TECHNOLOGICAL LINAC BEAM CROSS-SECTION

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In recent years at the Science Research Complex “Accelerator” of NSC KIPT the power current technological electron linacs are developed and put into operation. Their energy varies from 8 MeV to 30 MeV [1], the pulse current does not exceed 1A and the operating frequency is 150-300 Hz. One accelerating structure linacs, KUT and LU-10, and two accelerating structure linac EPOS are used primarily for technological aims. The technological object zone irradiated by accelerated electrons is created with a magnet scanning system [2]. Irradiated samples are situated in the ambient air of a linac bunker. The wide-aperture magneto-induction transducer is used for position control of the electron beam [3]. A special secondary emission monitor is developed for the operative control of the beam cross-section at the linac exit. The monitor signals are used by a linac control system.

1 CONSTRUCTION OF THE BEAM PROFILE MONITOR

The beam profile monitor consists of three aluminium lames of 2 mm width and 0.15 mm thick (Fig. 1). The series-connected lames are locked in the hetenax cadre. The spacing of lames is 50 mm. The lame planes are parallel to one another and perpendicular to the beam moving plane. In the high-energy electron passage through the lames, the positive signal with an amplitude no more than 800 mV comes due to the secondary electron emission. The beam profile monitor signal by the RK75 cable 40 m in length is fed to the digitizer entry. Simplicity of the monitor construction is conditioned by a high level of induced activated radiation in the working zone. The employment of the traditional collector electrode with an accelerating potential was not necessary for electron beams we have used [5, 6]. The beam profile monitor is installed in the air at 60 mm from the plane of the scanner exhaust foil.

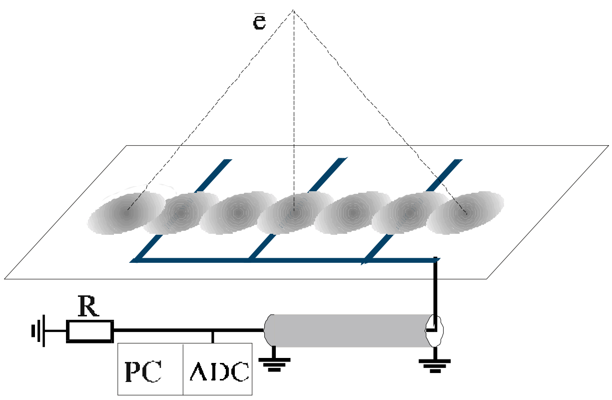

Fig. 1. The profile monitor structure scheme.

In the air a relationship between a charge on the beam profile monitor lames and the primary beam intensity can not be linear as a result of deposition of charge atmosphere particles and secondary electrons with a low energy on the lames.

A relationship between the total beam profile monitor signal and the primary electron beam intensity was investigated to the estimate characteristic linearity. In Figure 2 the channel for measurement of the total monitor signal is shown, the measurement results are given in Figures 3 and 4. It is shown that in the vicinity of scanner exhaust foil the signal level drops and characteristics very depend on the beam current.

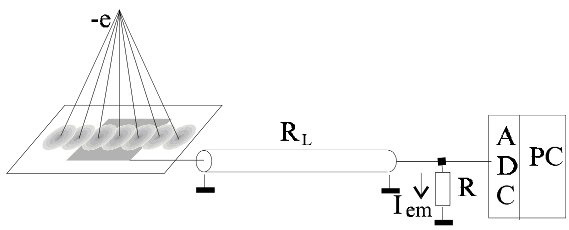

Fig. 2. Structure schematic of the channel for measurement of the total beam profile monitor signal: R - matching resistance in the end of the coaxial cable, R_L - resistance RK75 cable, PC - personal computer, ADC - digitizer.

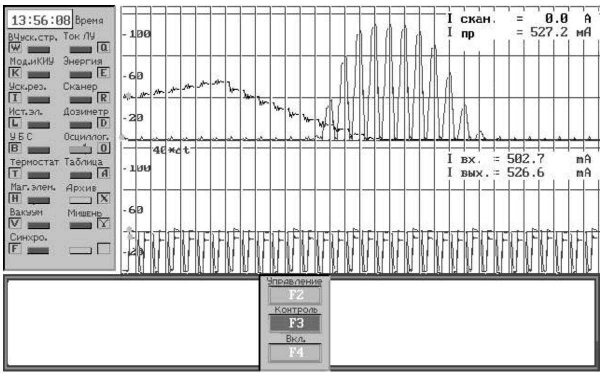

Fig. 3. Videogram of the total beam profile monitor signal measurement (pulse train at the top of videogram).

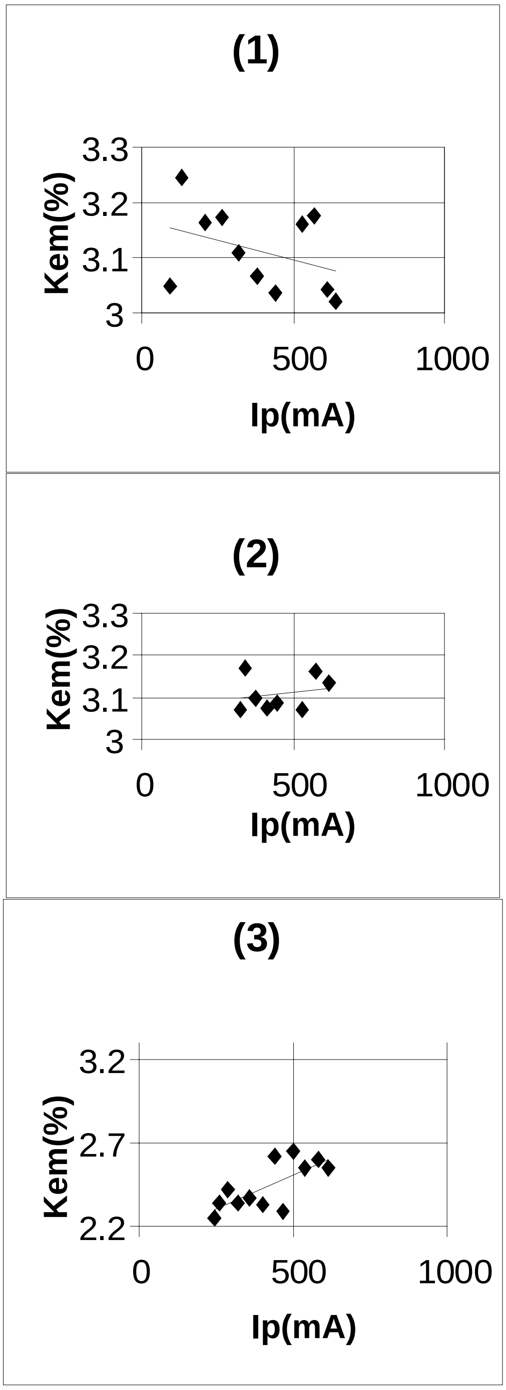

Fig. 4. Secondary emission coefficient (in %) versus pulse beam current I_P (in mA) and the distance (h) between the monitor plane and scanner exhaust foil. (1) h=125 mm, (2) h= 65 mm, (3) h=2 mm. Electron energy is equal to 7-11 MeV.

2 MONITORING SECTION AND POSITION OF THE ELECTRON BEAM

At our linacs in the plane of the beam profile monitor, the cross-section diameter (*D*) of the electron beams used for process of target irradiation ranges up to about 10-15 mm and the distance between the centers of the beam deflected by the scanner at the extreme positions may be equal to 100-150 mm. As an excitation current of the scanner magnet changes linearly, the average value of beam center movement (*R*) within the span of two linac pulses is defined by the relation

$$R = 2\, F_S\, S/F_r,$$

where F_S is the change frequency of the deflecting scanner excitation current,

S is the beam center movement swing,

F_r is the frequency of linac current pulses.

For our case *R* is equal to 2 – 4 mm. Based on this the lame width of 2 mm was selected. Figure 5 and Figure 6 show the results of monitoring the beam position and the section at the linac EPOS. The signal amplitudes from the middle lame allows to estimate a beam section along the axis of the beam center movement. With the known distance between the first and last lames and the linac pulse value between the first and last signals from these lames, one can determine the beam center movement swing.

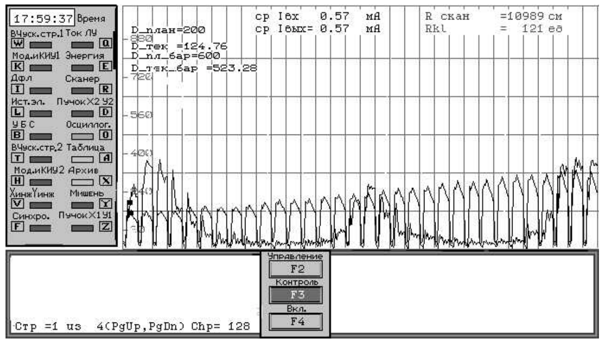

Fig. 5. Videogram of profile monitor signals and signals of magneto-induction transducer of position.

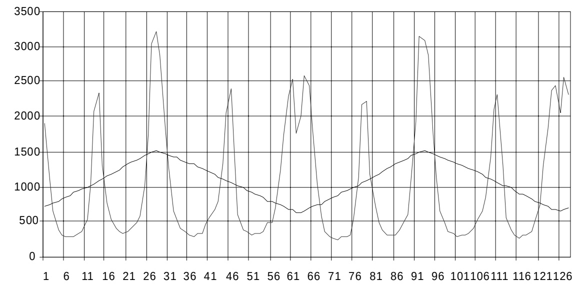

Fig. 6. The total values of the signals induced by the electron scanning beam into the magneto-induction transducer of position (saw-tooth signal) and into the beam profile monitor. The pulse beam current, pulse frequency and scanning frequency of the linac "EPOS" were equal to 760 mA, 200 Hz and 3 Hz respectively.

The familiar X-shaped construction of the beam profile monitor [7] is used for two-dimension beam profile control (Fig. 7).

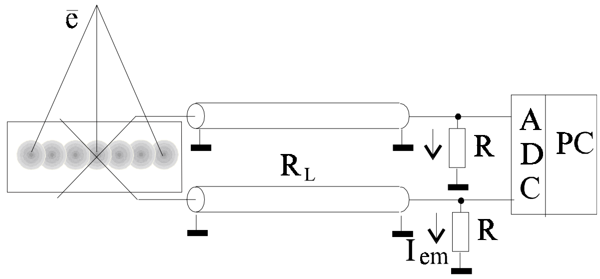

Fig. 7. Structure schematic for two-dimension beam profile measurement.

The results of two-dimension beam profile control in the linac “EPOS” are presented in Fig. 8.

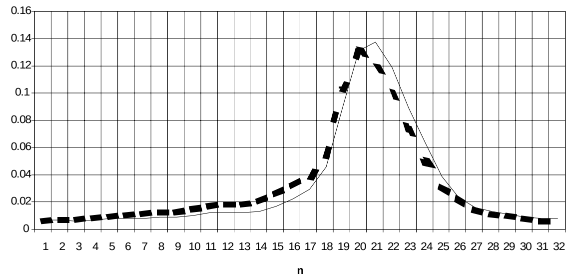

Fig. 8. The plots of two-dimension beam profile changing in the linac “EPOS”.

For the described measuring channel the measurement error of the beam profile and position is determined chiefly by the ratio of D, S and R quantities. For our case the error is no better than 20 %.

Summary. The on-line channel for measurement of the beam profile and of the beam position has been in successful operation for over two years as a part of the linac “EPOS” control system. Authors are grateful to M.I. Aizatsky, A.N. Dovbnya, V.A. Kushnir and V.L. Uvarov for helpful discussion.

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