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DETERMINATION OF THE SPECTRUM OF A PULSED ION BEAM

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An algorithm for calculating the energy spectrum of a pulsed ion beam generated by a direct-acting accelerator is presented. The ion spectrum is calculated using the oscillograms of the accelerating voltage, the experimental ion-current density, the one-dimensional Child–Langmuir (1D C–L) ratio, and the total current in the diode. The results of studying the ion spectrum generated by the TEMP-4M accelerator (250–300 kV, 150 ns) are presented. A good coincidence of the spectrum of ions that were calculated from the experimental ion-current density and 1D C–L equation is obtained. For ions whose energy is 95% of the total energy of the ion beam per pulse, the divergence between the spectra does not exceed 10% and is most significant in the region of low ion energies. The error in calculating the ion spectrum from the total current in the diode is much greater.

The ion spectrum from the experimental ion-current density was calculated for a small part (less than 5%) of the beam ions (local ion spectrum). The local ion spectrum was calculated in a similar way as the electron spectrum [1]. The full spectrum of ions per pulse was obtained by multiplying the local ion spectrum by the ratio of the total ion beam energy to the energy density at the point of measurement of the ion current density. The total beam energy was calculated by integrating the energy-density distribution over the beam cross section. The results of calculating the full spectrum of ions are shown in figure 1.

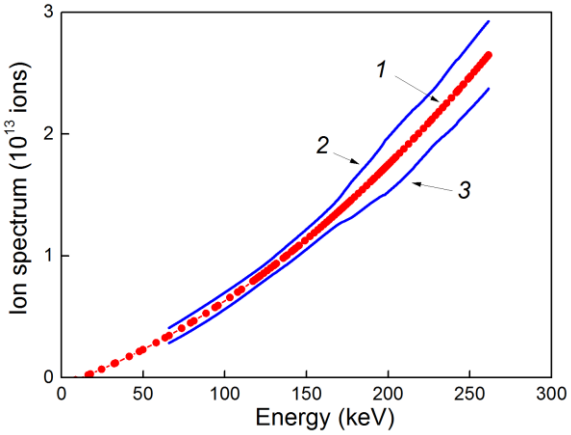

Fig.1. The full spectrum of ions generated by the diode per pulse (*1*), and the confidence interval taking the errors in the spectrum calculation into account (*2*, *3*)

Figure 1 shows the confidence interval for the full ion spectrum per pulse; it was determined taking the discrepancy of the spectra calculated from the experimental ion-current density and the 1D C–L ratio into account, as well as with consideration for the discrepancy of the local ion spectra over the ion beam cross section.

The total PIB energy that was calculated from the full spectrum of ions by summing (over the entire spectrum) the products of the number of ions with the energy E and their energy for the data presented in fig. 1 was 58 J. The total ion beam energy that was calculated by integrating the energy-density distribution over the beam cross section is 64 J. The calculation of the total ion beam energy from the ion spectrum gives underestimated values due to the contribution of fast atoms to the target heating.

The developed algorithm for calculating the energy spectrum of a pulsed ion beam that is generated by a direct-acting accelerator makes it possible to quickly control the beam spectrum with a small error during the target irradiation. To control the spectrum of ions, additional equipment and time-consuming processing of measurement results are not required.

REFERENCES

[1] A. Pushkarev, A. Prima, V. Ezhov, I. Miloichikova, E. Petrenko. “Determination of the pulsed electron beam spectrum by current and voltage oscillograms,” Laser and particle beams, article ID 881569, 2021.