Propagation of a monoenergetic beam of relativistic electrons in vacuum

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The generation of high-current, narrow-beam relativistic electron beams has become possible due to the use of low-density foamed polymers, which allow the generation of relativistic electrons through the interaction of an intense laser pulse with a plasma with an electron concentration close to the critical value. The high absorption of a relativistic-intensity laser pulse in a plasma with a near-critical density and the efficient direct laser acceleration (DLA) of electrons in the plasma channel result in the efficient conversion of laser energy into the energy of the relativistic electron beam.

The work considers an analytical model of the propagation of a monoenergetic homogeneous beam of relativistic electrons with an infinite longitudinal length and a finite initial distribution radius in a vacuum. The parameters of the model were selected based on experimental data obtained using the PHELIX laser facility [1]. The results of PIC simulations for this problem showed qualitative differences from the experiment, with a monotonic increase in concentration with increasing beam radius, which does not match the experimental maximum concentration on the beam axis. This increase in concentration towards the edges of the beam is due to the peculiarities of relativistic mechanics, which postulates a limit on the speed of light. This phenomenon was previously studied in an analytical paper [2] using the model of an infinitely long beam.

[1] Tavana P, Bukharskii N, Gyrdymov M, Spillmann U, Zähter S, Cikhardt J, Borisenko N, Korneev P *et al.* 2023 *Front. Phys.* **11** 1178967

[2] Iankhotov D, Kuznetsov S and Andreev N 2025 *VESTNIK JIHT RAS* **18** 32–36