Characterization of a Relativistic Electron Beam Generated by 250 mJ Ultrashort Laser Pulses

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The advanced Ti:Sapphire laser system ATLAS at the Max-Planck-Institut für Quantenoptik delivers 250-mJ/180-fs pulses at a repetition rate of 10 Hz at 790 nm. Focusing such a laser pulse into a helium gas jet at an intensity greater than 10^{18} W/cm^2 gives rise to relativistic-pondermotive self-focusing and channel formation.

In such a channel, electrons are accelerated in the forward direction forming an electron beam and reaching energies of up to several MeV. Different mechanisms like betatron oscillations and self-modulated wakefield are responsible for this acceleration [1].

We have measured the beam profile as well as the electron energy spectrum. fig. 1 shows the experimental setup for the profile measurement. The lineout of the rotationally symmetric beam profile corresponds to a Lorentzian-like distribution with a divergence angle of 15° FWHM (see fig. 2).

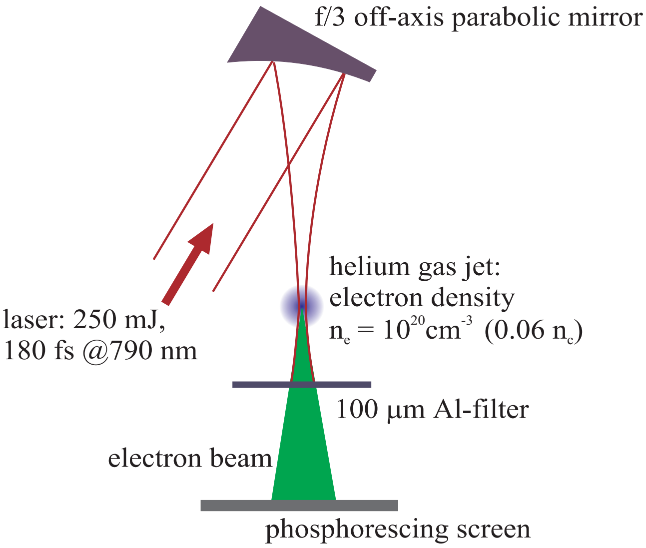

Fig. 1: Experimental setup of the profile measurement.

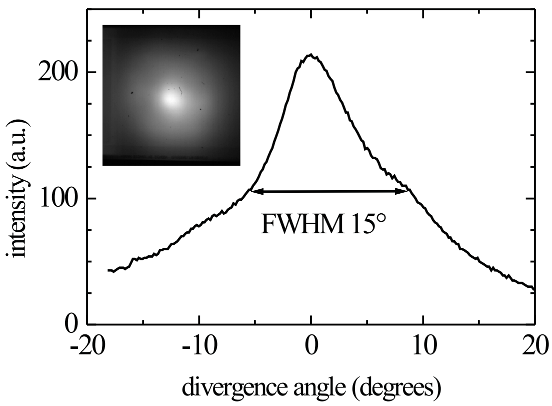

Fig. 2: Lineout of the beam profile (inset: image on screen).

By replacing the phosphorescing screen by an electron spectrometer we have determined the energy spectrum (see fig. 3). The electrons are dispersed by an 150-mT-strong dipole magnet and detected by 45 scintillating and light-guiding fibers which are coupled to a cooled CCD-camera.

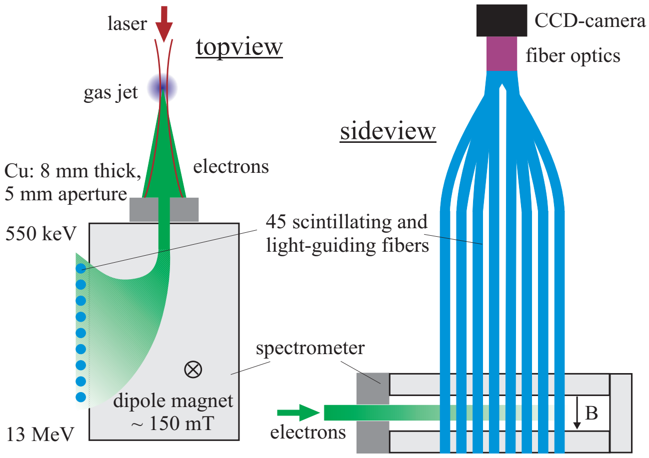

Fig. 3: Experimental setup of the energy spectrum measurement.

The measured spectrum follows a Boltzmann energy distribution with two temperatures: 0.8 MeV and 3.5 MeV (see fig. 4). The total number of MeV electrons amounts to 7×10^{10}.

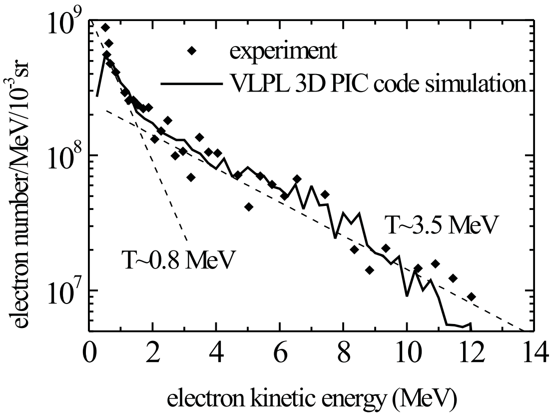

Fig. 4: Electron energy spectrum.

The exact nature of the accelerating mechanisms and their contributions to the electron energy distribution is not yet clear and hence needs further investigation. An improved understanding is expected from the measurement of the angular dependence of the energy spectrum and its dependence on the gas (electron) density and laser power.

References

[1] A. Pukhov and J. Meyer-ter-Vehn, Phys. Plasmas **5** (1998) 1880