# Relativistic laser pulse peak intensity evaluation based on vacuum acceleration of electrons

K.A. Ivanov[1], I.N. Tsymbalov[1], O.E. Vais[2], S.G. Bochkarev[2] and A.B. Savel'ev[1]

[1] *Physics faculty of M.V. Lomonosov MSU, Moscow, Russia*

[2] *P.N. Lebedev Physical Institute of RAS, Moscow, Russia*

Recent results on acceleration of electrons in the electromagnetic field of tightly focused relativistically strong femtosecond laser radiation are presented. The vacuum acceleration of free electrons by laser pulse is characterized by direct connection between laser radiation characteristics and accelerated electron distributions with no influence of additional plasma collective effects. It opens the opportunity to evaluate the main pulse parameters for ultra-high power laser systems by means of measurement of high energy electrons properties.

In our work we used the radiation of a Ti:Sa laser system (805nm, 10Hz, 100 mJ, 50 fs) focused by an off-axis parabolic mirror (F/D=3) to a focal diameter D=2.2 microns (FWHM), which provided the estimated peak intensity $>10^{19}$ W/cm$^2$. The focusing optics was mounted inside a vacuum chamber filled with noble gas (Helium or Argon) at pressure of $\sim10^{-1}$ mb (gas purity >99%). Electrons appearing due to nonlinear ionization by the EM field of the pulse were registered in the polarization plane by energy calibrated MediPix matrix detector which covered angles from $0^o$ to $90^o$ in respect to the beam propagation axis. It was found that electrons are dominantly emitted in a relatively narrow range of angles. With the growth of laser pulse energy the direction of electron scattering moves closer to the beam axis. Particles residual energy exceeded 500 keV.

Numerical simulations of relativistic laser interaction with particles using two independent models (PIC code and test particles method) revealed that electrons gain energy dominantly due to the ponderomotive action of the pulse. A good agreement between numerical and experimental data was observed for electrons angular and energy distributions. Moreover in the considered range of laser peak intensity ($10^{18}$-$10^{20}$ W/cm$^2$) the results are weakly depended on beam transvers profile and we found a direct correlation between the peak intensity and the scattered particles properties. This gives the opportunity to build a simple method of *in-situ* single shot peak intensity measurement at full energy of the pulse. With the use of our technique the peak intensity of the laser pulse with 70 mJ energy was evaluated on the level of $2.9\mathrm{x}10^{19}$ W/cm$^2$, being very close to $2.6\mathrm{x}10^{19}$ W/cm$^2$, obtained from beam diameter and energy. The work was supported by RFBR grant 16-32-60174.