Preplasma characterization at PHELIX

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Introduction

The temporal contrast of high-power laser systems like PHELIX is a critical parameter for laser plasma experiments. The generation and amplification of short pulses using the chirped pulse amplification (CPA) scheme thereby entails a contrast degradation leading to an uncontrolled target pre-ionization. A preplasma is generated which strongly influences the interaction with the main pulse. To ensure well-defined initial parameters for laser plasma experiments as well as computer simulations a detailed knowledge about the preplasma expansion is required.

Temporal contrast at PHELIX

The temporal contrast of the PHELIX short-pulse system has been significantly increased within the last years. An optical parametric amplifier with a pump pulse duration of $1\ \mathrm{ps}$ has been developed and implemented at PHELIX. Using this device, we are able to tune the level of ASE between 10^{-6}, which is a typical value for a CPA system, and 10^{-11}. Moreover, all the compressed prepulses have been successfully removed ensuring an undisturbed target before the impact of the main pulse at the lowest ASE level. For more detailed information about the temporal contrast control at PHELIX see Ref. [1, 2].

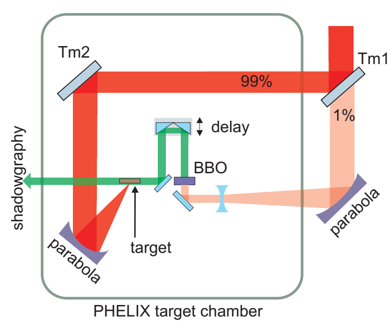

Figure 1: Setup of the preplasma diagnostics

Preplasma shadowgraphy

To evaluate the influence of different ASE levels on the preplasma, defining the initial conditions for laser-plasma experiments, we have developed a new preplasma diagnostics for the PHELIX target chamber which is depicted in figure 1. The main part of the beam is reflected by two turning mirrors (Tm1 and Tm2) and then focused onto the target to achieve an intensity of $10^{20}\ \mathrm{W/cm^2}$ while the transmission of $1\,\%$ through Tm1 is used as a probe beam. After being down collimated and frequency doubled this probe beam backlights the target and the target plane is imaged to a camera located outside the chamber. The temporal separation between the main pulse and the probe beam can be varied in the range of $\pm 200\ \mathrm{ps}$ allowing for the evaluation of the plasma expansion at different times before and after the impact of the main pulse.

Using this setup we took shadow images from flat copper targets with thicknesses around $5\ \mu\mathrm{m}$ for three different contrast levels. In figure 2 the size of the preplasma shadow is shown for different times. Time $0\ \mathrm{ps}$ corresponds to the impact of the main pulse. For an ASE level of $2 \cdot 10^{-7}$ we could identify a preplasma shadow which is nearly constant between $-230\ \mathrm{ps}$ and $0\ \mathrm{ps}$. The size of this shadow decreases by a factor on the order of two when the ASE contrast is increased by two orders of magnitude. At an ASE level of 10^{-10} no preplasma shadow was detected.

This measurement confirms that our maximum contrast level is high enough to prevent any major preplasma expansion. In a next step the measured data will be compared to simulations to link the shadow sizes to an actual plasma density.

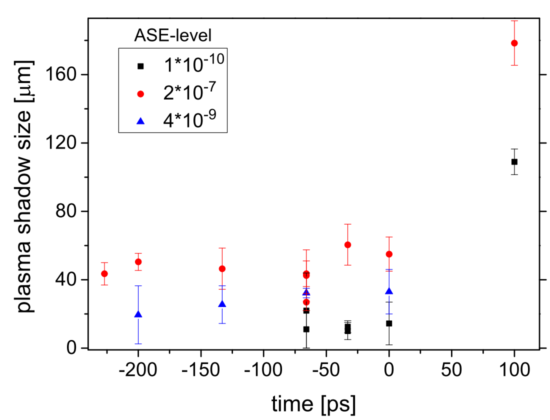

Figure 2: Size of the preplasma shadow for different times and three different ASE-levels

References

[1] F. Wagner et al, “Temporal contrast control at the PHELIX petawatt laser facility by means of tunable sub-picosecond optical parametric amplification”, Appl. Phys. B. DOI 10.1007/s00340-013-5714-9 (2013)

[2] F. Wagner and V. Bagnoud, “Prepulse removement at the PHELIX short-pulse beam”, GSI Scientific Report 2012 (2013)

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