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Alignment system for SGII-Up laser facility

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ABSTRACT

The SGII-Up laser facility in Shanghai is one of the most important high-power laser facilities in China. It is designed to obtain 24 kJ (3ω) of energy with a square pulse of 3 ns using eight laser beams (two bundles). To satisfy the requirements for the safety, efficiency, and quality, an alignment system is developed for this facility. This alignment system can perform automatic alignment of the preamplifier system, main amplifier system, and harmonic conversion system within 30 min before every shot during the routine operation of the facility. In this article, an overview of the alignment system is first presented. Then, its alignment characteristics are discussed, along with the alignment process. Finally, experimental results, including the alignment results and the facility performance, are reported. The results show that the far-field beam pointing alignment accuracy is better than 3 μrad, and the alignment error of the near-field beam centering is no larger than 1 mm. These satisfy the design requirements very well.
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1. Introduction

The SGII-Up laser facility in Shanghai is one of the most important high-power laser facilities in China. It includes eight laser beams (two bundles, four in each bundle), and the output aperture of each beam is 310 mm × 310 mm. It is designed to obtain an energy 24 kJ (3ω, 3 ns square pulse). It consists of numerous subsystems, including the front end, preamplifier, main amplifier, final optics subsystem, target chamber and diagnostic subsystem, beam control and diagnostic subsystem, and integrated computer control subsystem [1–8].

The preamplifier and main amplifier of one beam line of the SGII-Up laser facility are shown in Figs. 1 and 2, respectively. The laser pulse (λ = 1053 nm) from the front end—where its pulse shape, pulse duration, and pulse energy are adjusted to the expected values—is injected into the preamplifier subsystem. The first part of the preamplifier is a beam-shaping unit, where the beam aperture is first magnified and then the beam passes through an apodized aperture located in the first image-relay plane. The beam becomes square-shaped and exhibits a super-Gaussian distribution after passing through the beam-shaping unit and the first spatial filter (SF1). Next, the laser pulse enters the first rod amplifier (A1), where its energy is amplified by a factor of ~200. It then passes through a Faraday magneto-optical isolator, which is used to eliminate the harmful back-reflection beam. After that, the laser pulse passes through the next two amplifiers (A2 and A3). Then, the beam is split into four individual beams by two stages of polarization beam splitters. Each beam passes through its corresponding fourth amplifier stage, and its energy is increased to ~1 J. The whole preamplifier subsystem of this facility includes two parts: the north part and the south part. Fig. 1 shows the south part, and the north part is similar. The two parts offer eight injection beams for the eight main amplifiers. After leaving the fourth amplifier stages, the pulses enter the injection unit, which includes the optical path adjustment, near-field reference NR5, and sensors for power, energy, and near-field optical profile.

Leaving from the injection unit, a horizontal polarization beam is first injected into pinhole #1 in the transport spatial filter (TSF) by the injection lens In-L and two small mirrors In-M1 and In-M2. After passing through spatial filter lens TSF-L1 and the boost amplifier, it is reflected into the cavity-amplifier part by mirrors RM1, RM2, RM3 and polarizer PM1. Then, it passes through the non-energized plasma electrode Pockels cell (PEPC), cavity spatial filter (CSF) lens CSF-L1, pinhole #1, and lens CSF-L2. Next, the beam is amplified once during its first pass through the cavity amplifier, after which it is reflected by the deformable mirror DM and amplified again by the cavity amplifier. Subsequently, it passes through CSF-L2, pinhole #2, and CSF-L1 and is switched to vertical polarization by an activated PEPC superseded by a half-wave plate near the CSF pinhole plane during alignment. It can then pass

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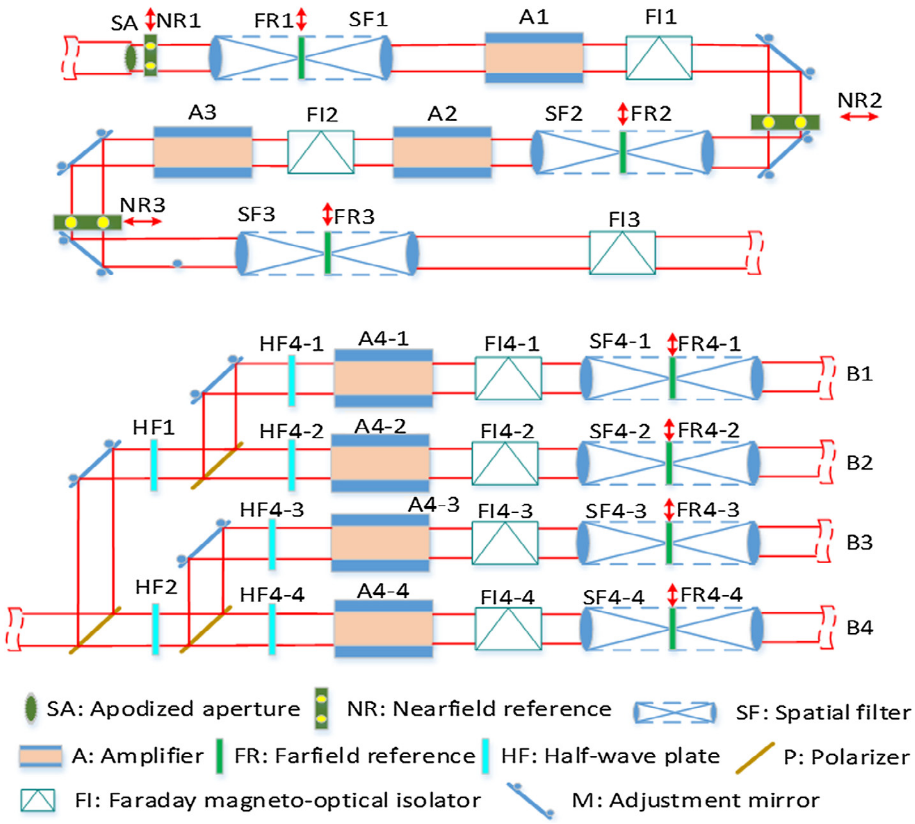

Fig. 1. Preamplifier of the SG-II-Up laser facility.

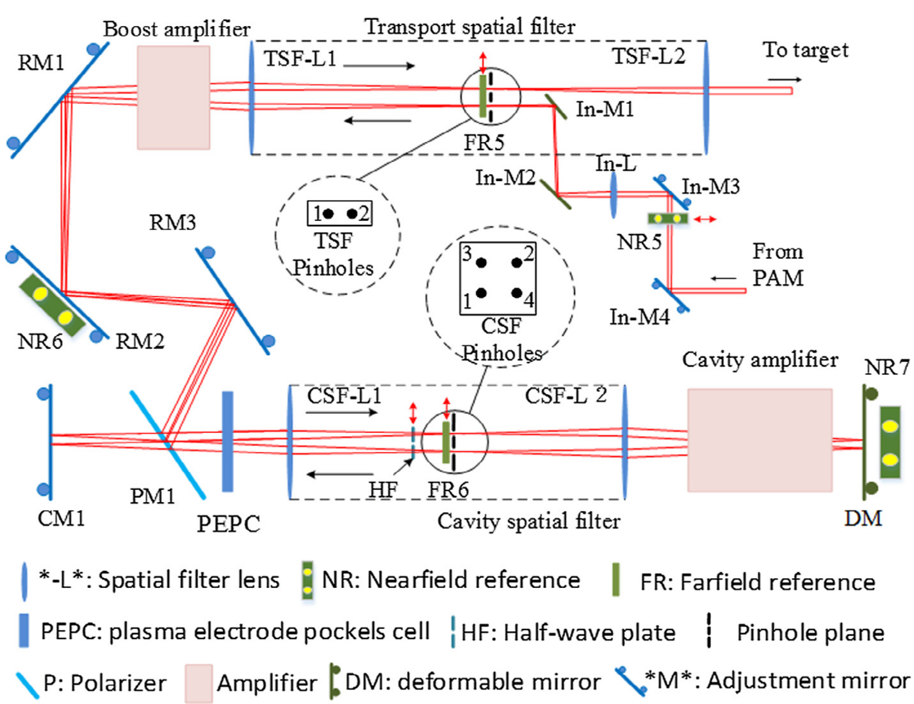

Fig. 2. Main amplifier of the SG-II-Up laser facility. The transport spatial filter, boost amplifier, RM1, RM2, and RM3 are located in the same horizontal plane. The cavity spatial filter, cavity amplifier, PEPC, DM, CM1, and PM1 are located in another horizontal plane. The part comprising the transport spatial filter, boost amplifier, RM1, and RM2, is illustrated by a top view. The part comprising the cavity spatial filter, cavity amplifier, RM3, PM1, CM1, PEPC, and DM is illustrated by a front view.

through the polarizer PM1. After that, it is reflected off cavity mirror CM1, passes through PM1 again, and passes through the activated PEPC again. This returns the polarization to horizontal. The beam is amplified twice again during the third and fourth cavity amplifier passes. When the beam finishes its fourth pass and reaches the PEPC which becomes inactivated again, it passes

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