Precise diagnostics for SG-II facility

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Abstract. Diagnostics is important for large laser facilities to monitoring laser status and to analyzing physics phenomena on target. SG-II facility in Shanghai is setup in 2001 with eight beams. Each beam’s energy is 300J at 351nm, and its pulse width is 1ns. SG-II ninth beam is setup in 2005, its energy is 2700J at 351nm, and its pulse width is 1ns too. In recent years, it is an important international user facility for laser research with precise diagnostics system. With the development of SG-II, a new calorimeter is designed to 400×400mm² in order to measure absolute energy up to 6400J at 351nm. Fast photodiode and 12GHz oscilloscope is used to analyze nanosecond pulse shape. In order to analyze petawatt laser pulse, a single shot auto-correlator is designed to measure pulse width between 0.5~18ps. And pulse contrast is obtained by a cross-correlation with fiber-array, which dynamic range is ~10⁶ when pulse is 1mJ and 10ps. Quality of far-field measurement is 1.1DL for nanosecond pulse, and that is 1.5DL for picosecond pulse.

1. SG-II laser facility
SG-II (ShenGuang-II) laser facility is setup in 2001 with eight beams. Energy of each beam is 300J at 351nm, and pulse width is 1ns. These beams have good focusing ability that 70% energy is encircled in 3DL (3 times Diffraction Limitation).

SG-II ninth beam is setup in 2005. Its energy is 5000J at 1053nm or 2700J at 351nm when pulse width is 1ns. It also can output 300J at 100ps or 30J at 30ps. 70% energy of SG-II ninth beam is encircled in 5DL.

SG-II laser facility is an international user facility for laser research. Its operation rate is 6 shots per day. A highlight experiment is published on Nature Physics [1].

Diagnostics is important for large laser facilities to monitoring laser status and to analyzing physics phenomena on target, such as such as LLNL, OMEGA and GEKKO [2, 3]. In SG-II facility, there are both diagnostics for nanosecond pulse and that for picosecond pulse.

2. Diagnostics for nanosecond pulse
Diagnostics for nanosecond pulse can provide laser parameters such as energy, pulse shape and far field.

A calorimeter is used to measure absolute energy of laser pulse. Its aperture is φ 400mm, which is bigger than laser diameterφ 310mm. This calorimeter has a capability to measure 5000J at 1053nm and 351nm. Fast photodiode and 3GHz oscilloscope are used to analyze pulse shape. And Far-field
Measurement is used to diagnose focusing ability of laser pulse. Its quality is 1.5DL. This means that 70% energy is encircled in 1.5 times diffraction.

With the development of SG-II, diagnostics for nanosecond pulse have improved its abilities. A new calorimeter is designed to 400×400mm² in order to measure 16kJ at 1053nm and 6400J at 351nm. Its uncertainty is below 5%. Fast photodiode and 12GHz oscilloscope are used to analyze pulse shape. Far-field measurement and near-field measurement are fit into a package. The quality of far-field measurement is 1.1DL with its view range is 1.7mrad. The resolution of near-field measurement is 0.45mm when beam size is 310×310mm².

3. Diagnostics for picosecond pulse

Diagnostics for picosecond pulse can provide laser parameter such as energy, pulse width, pulse contrast, far-field and spectrum.

Calorimeter with stainless steel shell is designed in order to avoid of leakage and pollution in vacuum compressor. A single shot auto-correlator is designed to measure pulse width between 0.5–18ps. Its resolution is 0.07ps. Tolerance of this auto-correlator is below 12.3% by mirror images and wider size [4]. Pulse contrast is measured by a single shot cross-correlator with fiber-array [5]. Its dynamic range is ~10⁶ when pulse is 1mJ and 10ps in our experiment. The experiment data on petawatt laser is shown in Fig.2 when energy is 100J, whereas maximum energy of petawatt laser is 377J [6]. Far-field measurement is used to diagnose focusing ability of laser pulse. Its view range is 5mrad, and its quality is 1.5DL. The spectrum of chirped laser is adopted by SP2750 of Princeton Instruments.

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