The Thomson scattering diagnostic system for the XuanLong-50 experiment

Hongyue Li$^{1,2}$, Songjian Li$^{1,2}$, Qifeng Xie$^{1,2}$, Jiahe Liu$^{1,2}$, Renhua Bai$^{1,2}$, Renyi Tao$^{1,2}$, Xiuchun Lun$^{1,2}$, Nan Li$^{1,2}$, Xiaokun Bo$^{1,2}$, Chunqi Liu$^{1,2}$, Lei Han$^{1,2}$, minsheng Liu$^{1,2}$ and Bihe Deng$^{1,2}$

$^1$ Hebei Key Laboratory of Compact Fusion, Langfang 065001, China
$^2$ ENN Science and Technology Development Co., Ltd., Langfang 065001, China
Corresponding Author Email: dengbihe@enn.cn

A 15-point Thomson scattering system is developed for ENN’s spherical torus experiment XuanLong-50 (EXL-50). A BeamTech laser with 3J/pulse (1064 nm wavelength) at 50 Hz repetition rate is chosen for measurements in the up to 10 s EXL-50 plasma operations. To enable measurements at low density ($\sim 5 \times 10^{18} \text{ m}^{-3}$) plasma operations, a large aperture 0.27m diameter collection lens system is professionally designed and built with a collection solid angle of 0.032 sr. In addition, several measures are taken to minimize the stray light: 1. An iris to block the high order transverse mode of the laser output, which turns out to be the most important factor; 2. Baffles tubes to block scattering stray light from entering the vacuum chamber of EXL-50; 3. Absorbers inside the vacuum chamber walls to absorb stray light entering the vacuum chamber but smearing outside the exiting baffles tube due to large port-to-port distance and the required finite numerical aperture of the baffles tubes; 4. Beam dump system with longer than 7.5m flight time to prevent the back scattered light from interfering with the TS signal; 5. Proprietary polychromator with minimum cross-talk; and 6. Zemax software is used to analyze the stray light suppression effectiveness. The V1742B data acquisition system is used to record the scattering waveforms with a sampling rate of 2.5 GHz. Rayleigh scattering (RS) test signal with 5 Torr of Argon gas is significantly higher than the stray light as shown in the figure below. Details of the diagnostics system development and initial experimental results will be presented.

Fig. 1 Rayleigh scattering signals of a polychromator with 5 Torr of Ar gas. The filter bands are designed to measure electron temperature of 0.05-2 keV. The stray light is minimized to < 100 mV and is offset in time, enabling optimum stray light subtraction. No stray light is observed other than the spectral channel centered at the laser wavelength of 1064 nm.