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Present status of the Nd:YAG Thomson scattering system development for time evolution measurement of plasma profile on Heliotron J (1)

Heliotron J プラズマの分布時間発展計測のための Nd:YAG トムソン散乱計測装置開発の現状 (1)

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A new high repetition rate Nd:YAG Thomson Scattering system is developed for the Heliotron J device. Two high repetition Nd:YAG lasers ($> 550mJ@50Hz$) realize the measurement of the time evolution of the plasma profile with $\sim 10ms$ time intervals. The system can measure at 25 spatial pints with $\sim 10ms$ resolution . Scattered light is collected with a large concave mirror ($D = 800mm, f/2.25$) with a solid angle of $\sim 100mstr$. The interference filter polychromators are used as a spectrometer for the scattered light. The signal detected by an APD is amplified by a fast OP amplifier with a DC and AC output. The signals are digitized with Multi-event QDCs, fast gated integrators. The data acquisition is performed by the VME based system which is operated by the CINOS.

1 Introduction

A time evolution measurement of a plasma profile is essential for an investigation of a transport physics of a magnetic confinement fusion device. Therefore, we are developing a new Nd:YAG Thomson scattering system for the Heliotron J device[1]. Because of the investigation for the internal transport barrier or the edge transport barrier physics[2], we determine the goal of the new Nd:YAG Thomson scattering system for the time evolution profile measurement on Heliotron J plasma (major radius: $R_{ax} = 1.2m$, averaged minor radius: $\langle a \rangle = 0.17m$, plasma volume: $V = 0.7m^3$) as follows :

- Spatial resolution: $\sim 1cm$
- Spatial channels: 25
- Time interval of measurement: $\sim 10ms$
- Range of T_e: $10eV - 10keV$
- Range of n_e: $> 0.5 \times 10^{19} m^{-3}$

In this paper, we report the overview of the new Thomson scattering system design and the present status of the development and construction of the Thomson scattering system.

2 Design overview

As shown in Fig.1, the laser beam is injected obliquely from bottom to top and obliquely backscattered light (scattering angle is 160°)

is observed to avoid interference with a coil and support structure of the Heliotron J device. The laser beams are combined closely together along a common beam path by the mirror and overlapped in the plasma center where they are focussed to a common point.

The design of an observation port is optimized for achieving high transmission efficiency. The scattered light is collected with a large concave mirror (D=800mm, f/2.25) with a solid angle of $\sim 80 - 100mstr$. The optical system is optimized for high transmission and low noise in order to maximize the signal to noise ratio. The collected scattered light is transferred to the 25 polychromators by 25 optical fiber bundles.

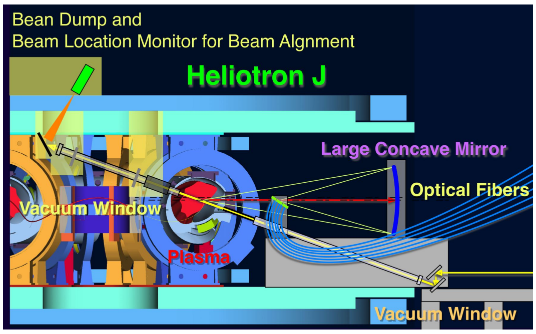

Fig. 1: Schematic diagram of Nd:YAG Thomson scattering system of Heliotron J

3 Overview of Polychromator and Data Acquisition System

The Nd:YAG Thomson polychromator has 5 wavelength channels for the scattering light measurement, and one channel for density calibration by the Rayleigh scattering method. The band-path combination of the interference filters is optimized by a performance simulation code. The error of the temperature measurement which is caused by the bremsstrahlung is below $\sim 2\%$ from 10eV to 10keV. Though the error of the density measurement ($\sim 3\%$) is larger than the temperature, the value is low enough for achieving our experimental objective.

The ADA4817 (Analog Devices) is chosen as a preamplifier of the detected signal. The circuit simulation by the SPICE shows the decay time is less than 80ns, which reduces the error from the background light due to the short gate width available. The amplifier has two outputs: one is a direct coupled signal and the second is the scattered light signal which is reduced by the low frequency background light using a RC filter. The DC signal is used for a calibration and background light measurement which used for estimation of a statistical error of the detected signal. The signals are digitized with CAEN V792 32 Channel Multi-event QDC, fast gated integrators. A real-time VME computer system is used for a data acquisition system. The system is operated by a CINOS(CHS Integrated No Operation System)[3]. The CINOS is not a multi-task operating system, but a system software that performs a time invariant data acquisition without OS.

4 Summary

We have described the design and present status of the new Nd:YAG Thomson scattering system which is developed in the Heliotron J for the study of the improved confinement physics. Two high repetition Nd:YAG lasers realize the measurement of the time evolution of the plasma profile with $\sim 10ms$ time intervals. The system has 25 spatial points with $\sim 10mm$ resolution using the large concave mirror (D=800mm) and the interference filter polychromatos. The goal of the measurable temperature range is from 10eV to 10keV and the minimum detectable density is approximately $5 \times 10^{18} m^{-3}$.

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