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TOMOGRAPHIC SPECTROSCOPY SYSTEM FOR H-1NF HELIAC

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Abstract

A multi-channel tomographic spectroscopy system capable of time-resolved imaging has been installed and calibrated in preparation for its intended use to obtain detailed evolution of ion temperature, flows and spectral emissivity of H-1NF plasmas.

Based on the Modulated Optical Solid-State (MOSS) spectrometer[1], a modulated Fourier-transform device which characterises Doppler-broadening of an isolated emission line, the system images a poloidal cross-section. Bulk flow velocities can also be estimated from measurements at five poloidal-angular positions around the plasma.

Careful in situ measurement of the spatial response of the system has been completed. These measurements are essential for correct tomographic inversions of the measured plasma parameters.

Introduction

The development of a diagnostic for ion temperatures, spectral emissivity and flows which utilises the 2D spectroscopic imaging capability of the MOSS spectrometer is being carried out within the H-1NF heliac program. The system, labelled TOMOSS (TOmographic MOSS), combines an in-vacuum light collection system with a multiple channel imaging spectrometer for visible Doppler spectral analysis. Figure 1 shows a schematic overview of the TOMOSS system and its subsystems.

System Design

A large stainless steel ring of approximately 800mm diameter, with embedded lens-coupled optical fibres is installed in-vacuum and encircles the plasma poloidally. Five 45°-sectioned viewing modules, each containing 11 lens-coupled fibre sets, are bolted to a two-piece carrier ring which is supported by a C-frame. The carrier ring can be rotated up to 200°, via a

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SYSTEM OVERVIEW

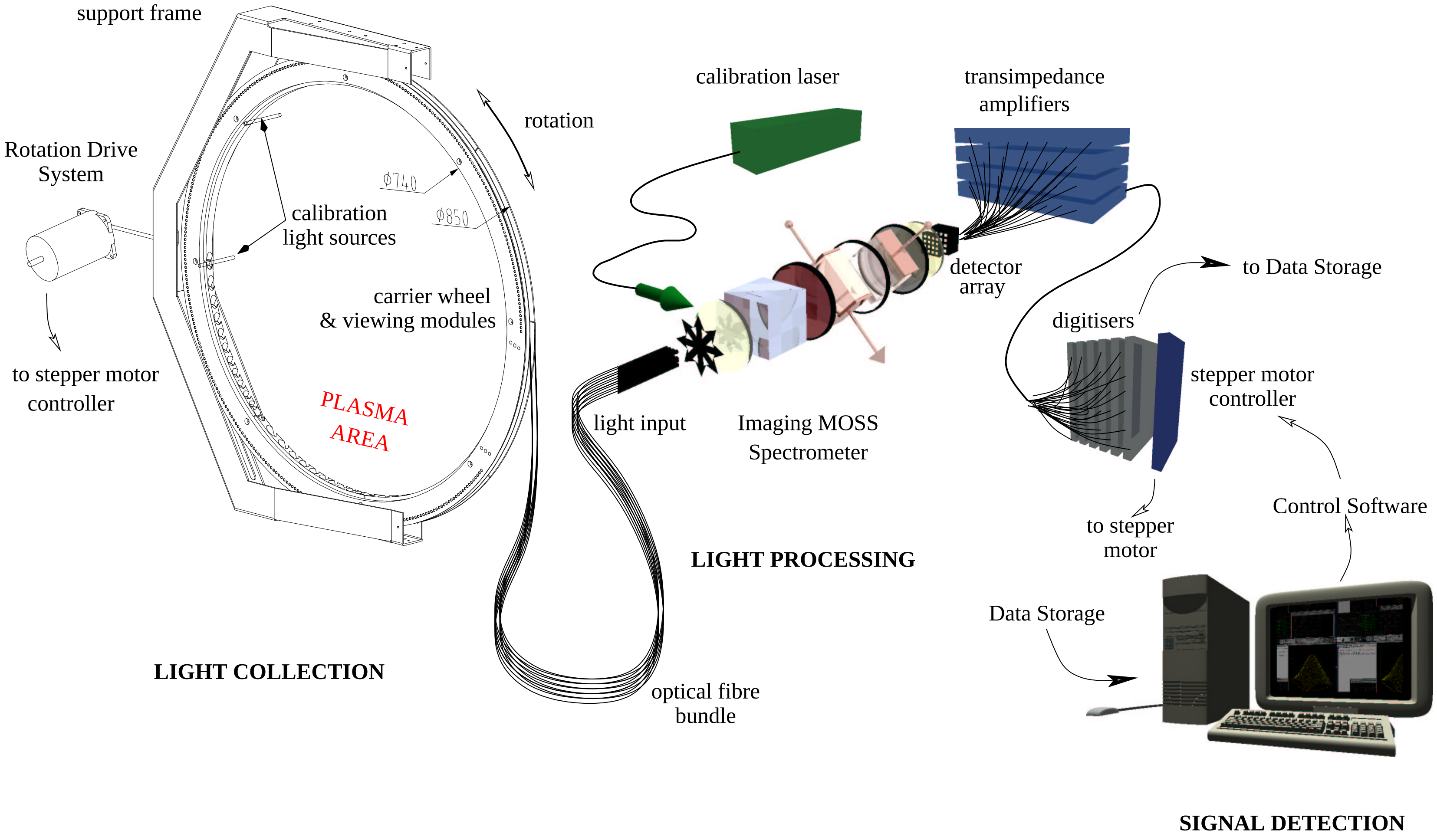

Figure 1:

stepper motor driving system, to enable flexible views, in-situ calibration and protection of the lenses when the system is not in use. Light from plasma spectral lines is collected and transmitted, via the large core ($1000\mu m$ diameter) optical fibres, to the external MOSS spectrometer.

Blackened stainless steel viewing dumps are fitted to the inner circumference of the wheel, as well as field coil surfaces that are within the veiwing area. Stainless steel surfaces of the viewing dumps, viewing modules, carrier ring and the support C-frame have also been bead-blasted to create a diffuse surface. Figure 2 show the installed light collection subsystem.

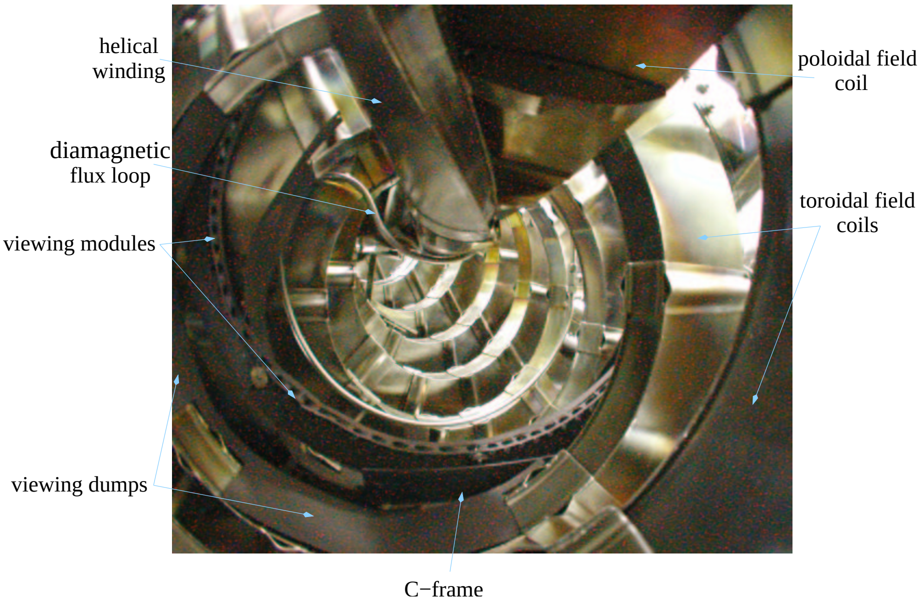

Figure 2: A view of the installed light collection system from below the poloidal field coil, inside the plasma region. The centre of H-1NF is to the left of the photograph.

A MOSS spectrometer (a modulated delay Fourier transform device) can determine emitted intensity, ion temperature and bulk flow vorticity from the ionic spectoscopic emission. The spectrometer allows a good signal-to-noise ratio on low light levels due to its high optical throughput. Electro-optic and birefringent, lithium niobate ($LiNBO_3$) crystals provide the optical path length delay and modulation. An imaging MOSS spectrometer, which is able to analyse multiple input channels simultaneously, is well suited to the large number of data channels required for tomography. Optical components of the light collection system and the spectrometer are carefully chosen to maximise the system étendue.

The optical fibres from the light collection system, approximately 6 metres in external length, lay inside a protective PVC conduit and are terminated inside a single stainless steel connector plate which arranges the fibres into an 8x8 array. The fibre array is imaged through the MOSS spectrometer onto an 8x8 multi-anode photomultiplier tube array.

Calibration

The spatial response of each of the channels has been measured in situ by placing a thin fluorescent tube in a fixed position, perpendicular to the plane of the wheel, rotating the carrier ring the full 200° and simultaneously recording the response of each channel. By measuring the system's response at many light source positions in the viewing plane of the wheel, the full spatial response for each channel can be measured. This measurement was performed during an opening of the vacuum vessel, with the light source position controlled by two stepper-motor driven translation stages.

The measurement of the spatial response allows for several aspects of the system calibration to be determined. Primarily, it is used in the tomographic inversion routines for an accurate measurement of the light collected. When used in conjection with a single rotational scan of permanent in situ light sources, it can also be used to calculate relative channel sensitivities, which may change over time. In addition, it also provides for the unravelling of cross-talk in the detector elements of the multi-anode photomultipier tube.

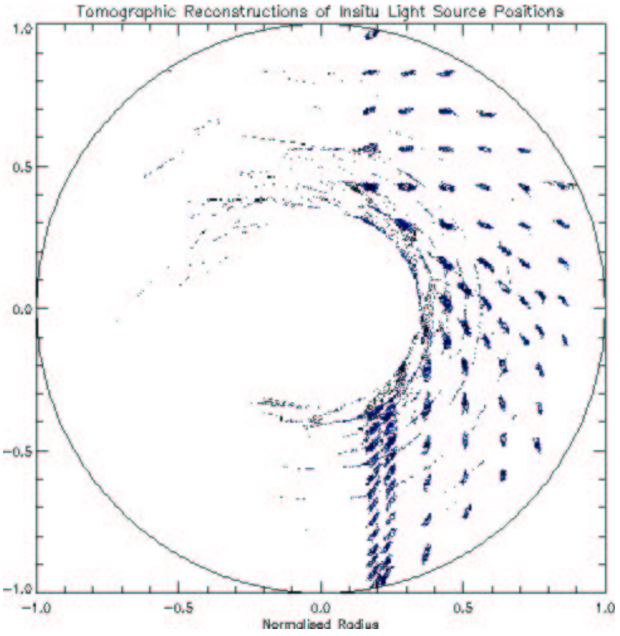

Figure 3: Tomographic reconstructions, using an Arithmetic Reconstruction Technique (ART), of the in situ light source positions, used to characterise the system spatial response.

References

[1] Howard, J., *et. al.* "Optical coherence techniques for plasma spectroscopy", *Rev. Sci. Instrum.* **72**, 888-897, (2001)