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1. INTRODUCTION

From discussions with the EFDA-JET Task Forces in early 2000, a range of requirements emerged for higher spatial resolution T_e and n_e Thomson scattering measurements in various specific regions of JET plasmas. These requirements are summarized in table 1 and seek significantly better spatial resolution than is achieved or is achievable with the two LIDAR Thomson scattering systems[1,2] currently working on JET (4Hz core LIDAR ~12cm; 1Hz Edge LIDAR 2-3cm, outer ~10cm only). Two High Resolution Thomson Scattering (HRTS) proposals were received from the Associations, one from C J Barth, (FOM)[3] and one from P Nielsen and R Pasqualotto, (RFX)[4]. These, in their final form, used almost identical "90 degree" scattering geometry (see fig.1).

The feasibility of making HRTS measurements is dependent upon successfully resolving several key issues, which are common to both schemes. For example: achieving a sufficiently low stray laser light level; achieving a sufficiently low background plasma light level; achieving relatively high collection and detection efficiency. Estimates of the first two of these items based on measurements taken on JET, are presented and discussed below. The issue of the collection window is also discussed briefly.

2. STRAY LASER LIGHT

As usual with a Thomson scattering system, stray laser light could swamp the scattered light signals making measurements difficult or impossible to interpret. In addition on JET it is difficult to make all the refinements used on smaller machines to minimise stray light levels. The LIDAR Thomson scattering advantage of being able to discriminate against stray light signals by their time of arrival at the detector and gate them out, is not available for the conventional imaging systems proposed. Assessment of the expected stray laser light levels is best undertaken experimentally and we report here the results from such an experimental investigation.

The proposed HRTS laser path was simulated by using the existing Core LIDAR ruby laser, fig.1. This enters the vessel via a window on the pumping chamber door, as shown and hits a simple grooved carbon beam dump fixed to the inner wall. The collection system in this test experiment was a 50mm diam, 100mm focal length lens mounted just above a window on the upper vertical port. The light collected was imaged on to an Avalanche Photodiode (APD)[4]. The geometry is such that the detection system cannot see the laser beam dump directly. This reduces the stray light level considerably. The stray light levels, were scaled with laser energy and collection solid angle giving an expected n_e equivalent level with the new system of ~$2x10^{23}m^{-3}$. The results indicate that, despite the simplicity of the scheme, with the addition of notch filters (attenuation ~$5x10^4$) in the collection path the stray light levels should be tolerable without additional measures.

3. PLASMA LIGHT BACKGROUND

High resolution Thomson scattering measurements require very good signal to noise ratio for the scattered signals. The level of plasma light background could be so intense that the ratio of Thomson scattered signals to plasma light background renders high resolution measurements impossible. Estimates of the expected plasma light levels have been made by measuring the level of plasma light on the signals of the Core LIDAR system on representative plasmas. For a high performance Deuterium-Tritium pulse (#42676) with $T_e(0)$ of 12keV, $n_e(0)$ 4.e19m^{-3} the plasma light intensity equated to about 20 times that expected for pure H-H bremmstrahlung whereas for an optimised shear pulse of similar $T_e(0)$ and $n_e(0)$ (#47413) a value of about 40 times was obtained. These numbers are essential input to simulation codes so that accurate estimates of the expected signal /noise for the new system (e.g. reference 4) can be made.

However, since the HRTS system uses a vertical collection line of sight, some parts of the field of view can see the divertor. Intense plasma light from the divertor is potentially an additional serious problem. Measurements of plasma light using different vertical sight lines of the visible spectroscopy diagnostic have been carried out. Sight lines with and without a divertor view have been compared, fig.2, for representative plasmas. These indicate that for the outer half of the profile (R=3.0 -3.9m) where the image does not include the divertor, the plasma light levels should be tolerable without degrading the signal-to-noise ratio significantly. For measurements at R<3 m the signal noise ratio could be significantly degraded, particularly by ELM's. However, the region of the plasma called for in table 1 is still adequately covered.

4. COLLECTION WINDOW

To have sufficiently strong scattered signals, a high collection efficiency is required for the HRTS system. To achieve the required collection F/no of 16 for measurements near the plasma axis and 25 for the edge region, a new large window is required on the upper vertical port. The development of such a window is a key element in the development of the system. This window is approximately twice the diameter of the largest window currently in use on JET and is therefore identified as a key technological development for the HRTS system. However, since the clear aperture through the vertical port is not in fact circular, it has been suggested[4] that it may be possible to utilise two adjacent standard large windows and still achieve almost as high a collection solid angle.

5. CONCLUSION

The experimental assessment of the stray laser light and background plasma light levels reported here indicates that, in the geometry proposed, High Resolution Thomson scattering measurements are feasible on JET. This geometry requires the development of a large double vacuum window to achieve the collection solid angle required (but see reference 4 for further comments on this).

ACKNOWLEDGEMENTS

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Region	Spat. Resol.	Coverage	Accuracy	Frequency	Min. density
Edge (G Matthews)	2 mm in midplane X	2 cm region	5-10% ?	10 pulses/ discharge	1e18 m-3 ?
Edge (W Suttrop)	1 cm in midplane	(-5, +15cm) at LCFS	10% ?	10 Hz	5e18 m-3
ITB (A Becoulet)	< 2 cm	R=3.3 till 3.7m	5-10%	10 Hz	1e19 m-3
MHD (T Hender)	< 2 cm	Full chord?	<<10% X	10 kHz ?	1e19 m-3

Table 1. Specification by the task forces (those marked with ✓ are met by the proposals, X are not met, ? are maybe met in some modes of operation but not simultaneously i.e. 10% accuracy can be achieved but not at a density of 5e18 m-3.)

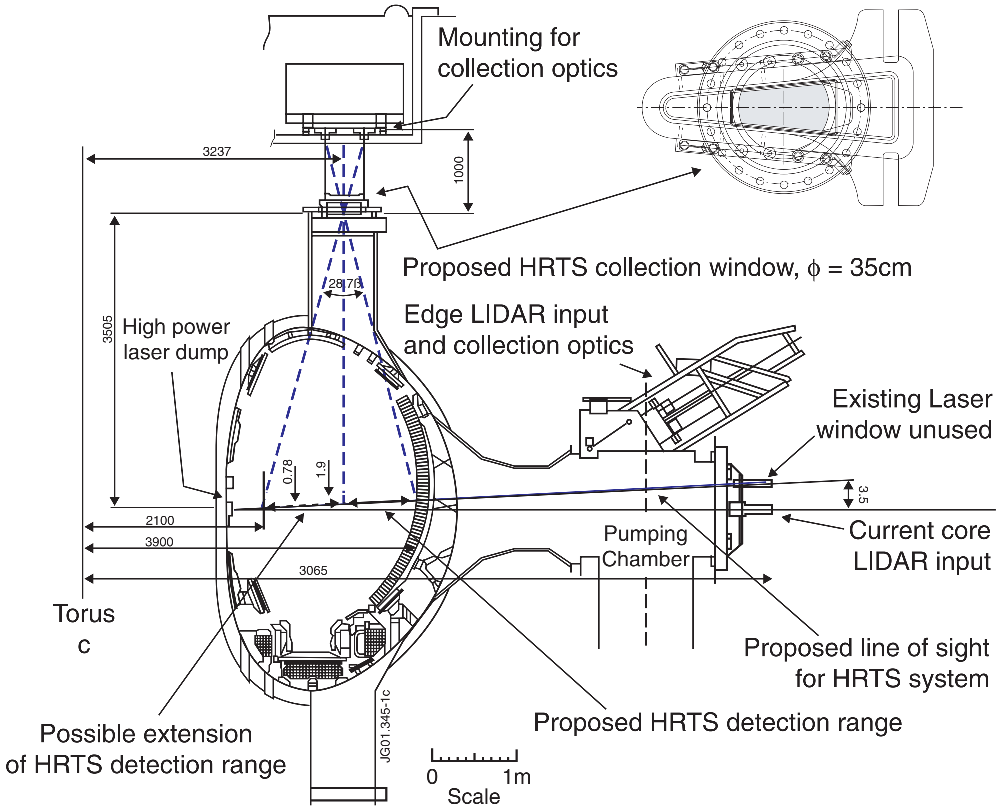

Fig.1: The proposed scattering geometry for the HRTS superimposed on the existing LIDAR systems

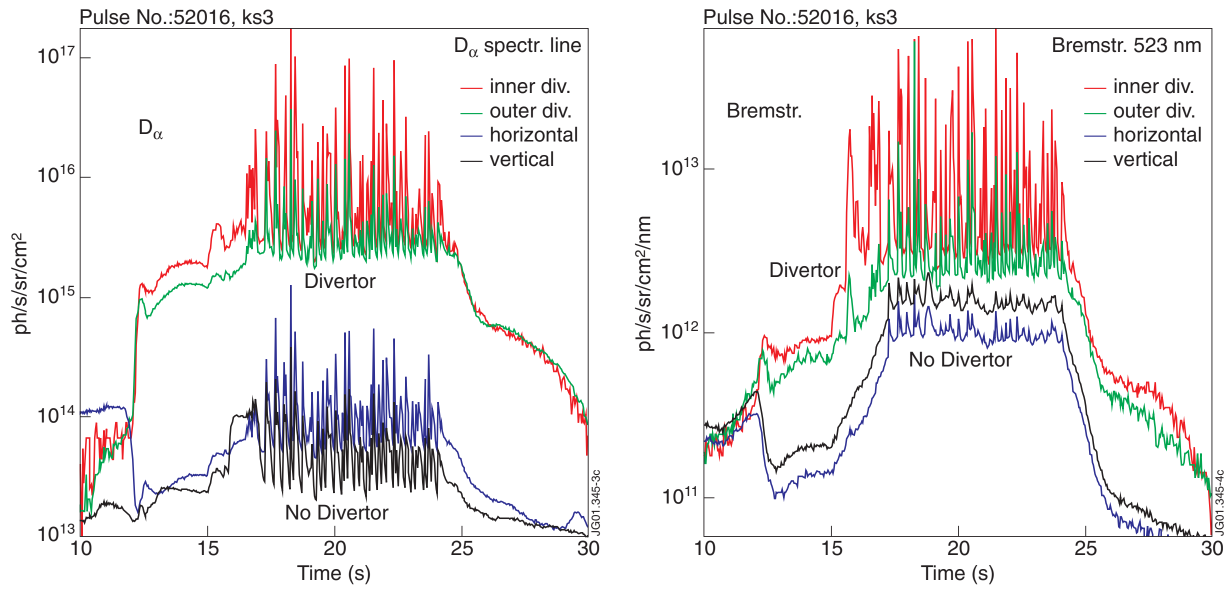

Fig.2: Time traces of plasma $D_{\pm}$ and bremsstrahlung in a neutral-beam heated ELMy H-mode along four lines of sight. The horizontal and vertical l.o.s. without divertor closely correspond to the current core LIDAR l.o.s. and the proposed HRTS collection l.o.s. Clearly, inside 3.0 m (Fig. 1) the increased plasma light level will disturb the TS measurement.