Fast ion collective Thomson scattering (CTS) is an important alpha particle diagnostic, since it enables measurements of the fast ion distribution in space, time, direction, and velocity. The spatially localized measurements (~10 cm resolution) over the plasma cross-section have a typical integration time of 2 ms, and give the ion velocity distribution function resolved in a chosen direction in the range from near perpendicular to near parallel to the magnetic field. For a description of the background and theory for CTS please refer to http://www.risoe.dk/euratom/cts, or e.g. ref. 1. For more information on using gyrotrons for millimeter wave CTS refer to ref. 2.

The first CTS measurements of MeV range fast ions were made at JET as reported in refs. 3 and 4. Following the success at JET and the closure of the diagnostic there, the work on the CTS system continued at TEXTOR (in IPP at FZ Jülich) as a joint effort between TEC and MIT, which was later (2001) joined by Risø National Laboratory [4, 5].

The TEXTOR fast ion CTS diagnostic system achieved initial successful results during past operations in 2000 using a ~100 kW, 200 ms, 110 GHz gyrotron [6]. Currently, major elements of the CTS diagnostic are being upgraded at Risø including a new quasi-optical receiver antenna, a universal polarizer, updated receiver electronics, and a new data acquisition system. In Figure 1 we present the beam line and layout of the upgraded TEXTOR CTS system. The calculations, design, manufacture, and testing of the quasi-optical mirrors are all done at Risø as the schematic in Figure 2 shows. The receiver electronics are upgraded by a new low loss PIN switch and importantly an extra diplexer splitting the central part of the spectrum from the upper frequency band. This additionally

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required an extra set of low noise amplifiers, but it will help preventing saturation of the amplifiers.

**Figure 1** The new beam line and layout of the TEXTOR CTS system.

**Figure 2** Calculations, design, manufacture, and testing of quasi-optical mirrors for the TEXTOR and ASDEX Upgrade CTS systems are all done at Risø.
The new data acquisition system samples the signal simultaneously in 40 channels with 24-bit resolution at a rate of 100 k sample. This will allow complete acquisition of the double sideband scattered spectrum over an ion velocity distribution range corresponding to an energy range of approximately 0.5 to 200 keV for deuterium. The upgraded CTS diagnostic system will be reinstalled on TEXTOR in the autumn of 2003.

A new 50-channel receiver system is currently being fabricated for fast ion CTS on ASDEX Upgrade (in IPP Garching). The installation of this CTS system follows the installation of a new ECRH system that is currently in progress. The source of the probing beam will be the 105 GHz frequency (still to be confirmed) of a new 1 MW, 10 s dual frequency gyrotron. In Figure 3 we present the beam line and the layout of the CTS system at ASDEX Upgrade. Note that when the CTS system is in operation the neighboring gyrotron is switched off and its quasi-optical transmission line is used by the CTS system by intersecting the beam after the polarizer by a rotating mirror. The arrangement is shown in Figure 4.

**Figure 3** The beam line and layout of the ASDEX Upgrade CTS system. The orange beam is the gyrotron beam and the green is the scattered CTS beam.
The CTS system is expected to be installed at ASDEX Upgrade by the end of 2003. The performance of CTS, and fast ion distributions resulting from NBI and ICRH will be investigated in the following campaigns.

With the first successful operation at TEXTOR, the reinstallation at TEXTOR and the installation at ASDEX Upgrade, the CTS diagnostic technology is maturing towards being a possible diagnostic at ITER. Furthermore, it has great potential for improving the fast ion physics base, which will help shape and motivate experimental scenarios for ITER.