H-1NF Tomographic Spectroscopy System

FIRST RESULTS

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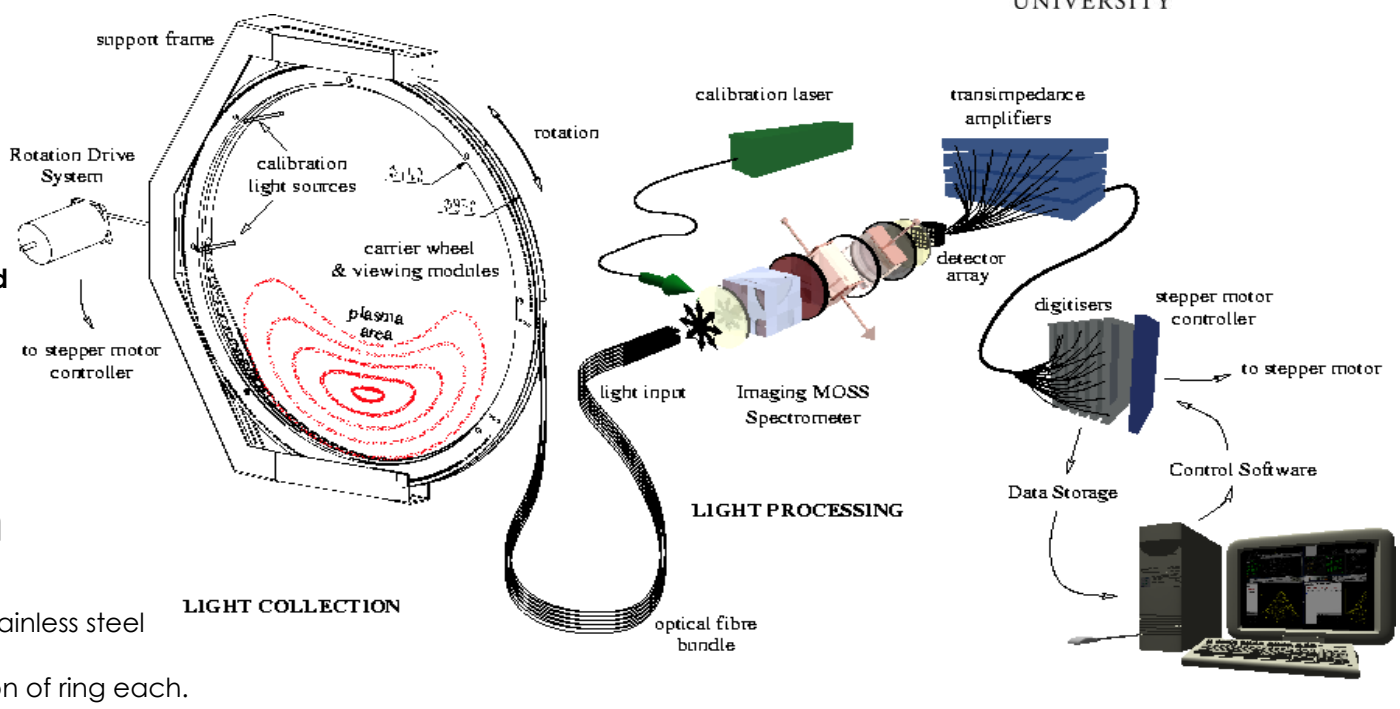
Summary

. 2D tomographic imaging of **spectral emissivity** and **ion temperature** of a poloidal cross-section.
. **Bulk flow velocities** estimated from five poloidal positions.
. Uses a **multiple channel** Modulated Optical Sold-State (MOSS) spectrometer[1], with **time-resolved line integrated** measurements.
. In-vacuum light collection system.
. System is **fully calibrated**, including detector cross-talk removal and transmission and spectral line filter attenuation.



System Design

Light Collection

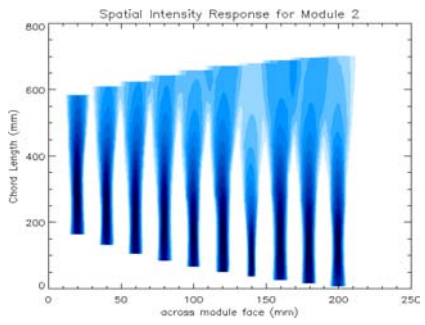
. Lenses, mirrors and optical fibres located in a rotatable stainless steel ring (800 mm diameter), poloidally encircling plasma.
. 5 identical viewing modules each occupying a 45° section of ring each.
. Each module contains 11 parallel-aligned channels, giving a total of 55 optical channels.
. Each channel consists of:
. A focussing lens (15 mm diameter; 12.5 mm aperture; f=22.5 mm) coupling the light, via a mirror (polished stainless steel rod), into a large core (1000 µm) optical fibre.
. Stepper motor drives the rotation of the ring via a sprocket-ended shaft which passes through the vacuum vessel wall.
. The ring rotation allows:
. 1. Views of plasma at different angular orientations.
. 2. Lenses to be removed from close plasma proximity when unused.
. 3. Viewing of in-situ intensity calibration light sources. (See Calibration)
. Ring rotation range: 200°

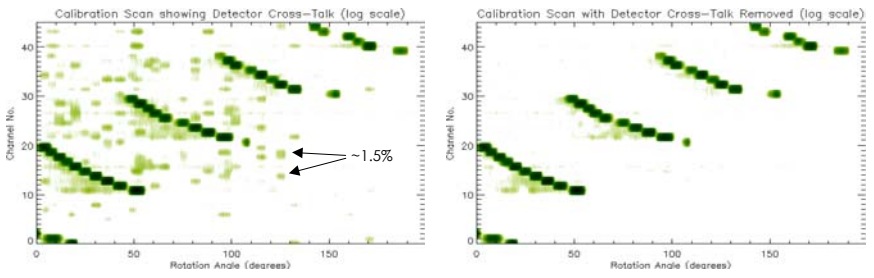
Multiplexed MOSS Spectrometer

SIGNAL DETECTION

. Time-resolved measurements of: spectral emissivity, ion temperature and bulk flow velocity using Doppler spectroscopy.
. Spatial multi-plexing of all 55 optical channels.
. 50 mm optics used throughout spectrometer; 40 mm aperture.
. Closely packed array (8x8 grid) of fibres at focus of collimating lens (Nikon f/# =1.8; f=85 mm)
. Collimated output of MOSS spectrometer imaged directly onto an 8x8 multianode photomultiplier assembly (Hamamatsu H7546)
. Imaging lens (Nikon f/# = 1.8; f=105 mm) magnifies fibre array image to match photomultiplier assembly.
. Due to high optical throughput, good signal-to-noise ratio on plasma edge channels.

Calibration





In situ Spatial Response

. Essential for correct tomographic inversions.
. Carried out *in situ*.
. Wheel is rotated 200°, recording each channel's response to a long, thin (3mm dia.) fluorescent tube in viewing region.
. Reponses over many light source positions mapped to a single response for each channel.

Detector Cross-Talk

. Detector: 8x8 multi-anode photomultiplier tube array.
. Pixel to pixel cross-talk: typically ~2%
. Total contribution to a single pixel: ~15%
. Extracted from a scan of permanent in-situ light sources.

Relative Channel Attenuation

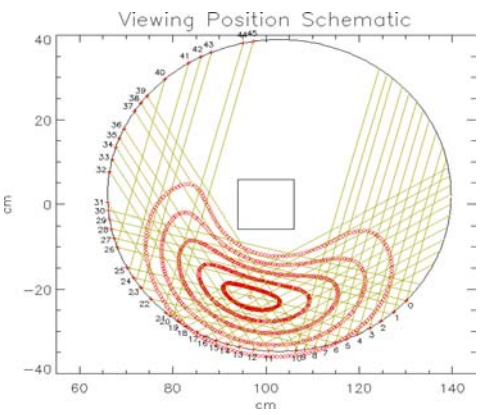
Fibre-Spectrometer Attenuation

. Channels are attenuated depending on fibre transmission, patching and most significantly, position in the spectrometer fibre array.
. Relative re-scaling is extracted from individual spatial responses and scans of permanent in-situ light sources.

Line Filter Attenuation

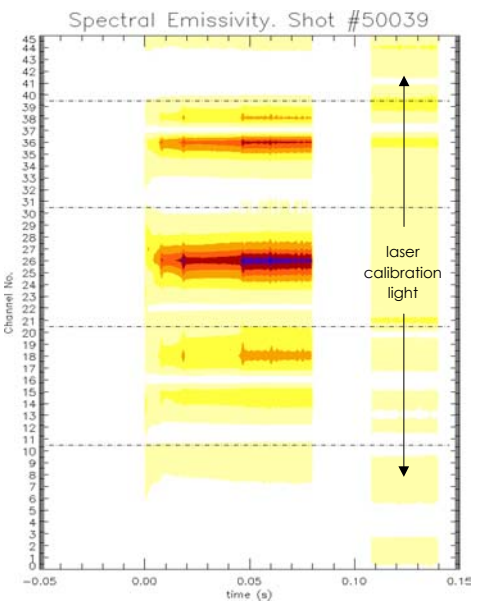
. Bandwidth centre is strongly angular dependent.
. Relative channel attenuation is calculated using manufacturer's line centre-shift formula.

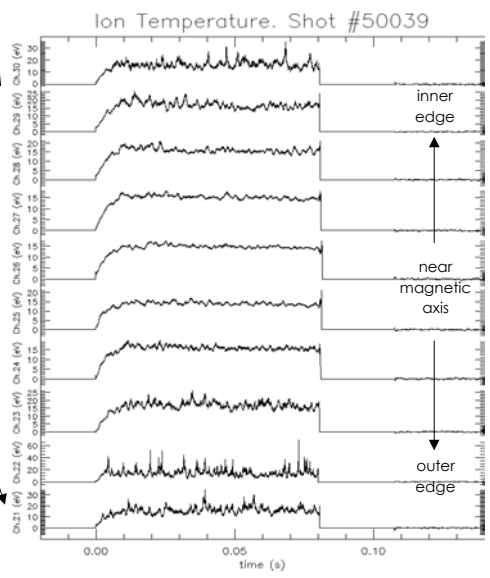
Results

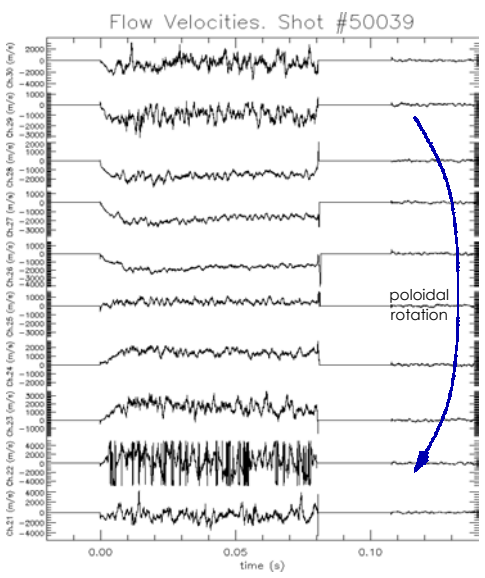


Plasma Parameters

. Gas: Argon
. Spectral Line: 488nm
. B-Field (max): 0.1T
. RF Heating: 7MHz, 80kW







What's Next?

. Tomographic inversions using Fourier-Besel basis functions and utilising individual channels' spatial response measurements.
. Study of low order poloidal mode oscillations, in conjunction with the tomographic scanning density interferometer. (see S. Collis, "Plasma Formation and Fuelling in the H-1NF Heliac", Thursday Poster #534)

References

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

Acknowledgments

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