Thomson Scattering on COMPASS Tokamak – Plasma Edge Profile

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Abstract

Thomson scattering diagnostic (TS) on the COMPASS tokamak is designed to measure electron temperature and density profiles with high spatial resolution (Δa≈100) in the edge plasma region and about 1 cm in the core plasma. The TS system with the core collection optics is operational since 2010, commissioning of the edge TS and it’s integration with the core TS is presented now. Procedure of spatial calibration was performed for both systems. The system is now capable to observe profile of elongated plasma and allows determination of H-mode plasma pedestal parameters.

COMPASS Tokamak

- a compact experimental device (R = 0.56 m, a = 0.2 m)
- divertor plasma configuration with ITER-like plasma cross-section ([1],[2])
- plasma current up to 250 kA (presently)
- toroidal magnetic field in the range 0.9 – 1.8 T (presently)
- elongation 1.8
- two neutral beam injectors – 2 x 0.4 MW power
- both Chmonic and NBI assisted H-mode successfully achieved [3]
- L-H transition followed either by – ELM-free period
- ELMs with frequency in the range of 150 – 1000 Hz

Thomson scattering on COMPASS

- two Nd:YAG lasers, 1064 nm, 1.5, 30 Hz each
- two collection lenses – core and edge plasma
- fibre bundles, duplexed (two spatial points into one polychromator, different fibres length)
- 29 polychromators (5 spectral channels, 4 of them digitized)
- 54 spatial points
- 120 channels 1 GS/s data acquisition
- details in [4]

Edge TS collection lens

- 7 lens elements
- around 1/6 in the centre of FOV
- installed in 2012
- resolution ≈4 mm achieved

Spatial calibration

- collection lens can be retracted on a trolley, reconstructing the geometry outside the vessel
- fibres back-illuminated, image of fibre bundles on a screen placed at the position of laser beam
- using visible light – chromatic aberration – TS operates in NIR (760 – 1064 nm)
- core TS simulations in Zemax: image of fibre bundles 5 mm closer in VIS compared to NIR
- vacuum window thickness has to be included in alignment as well
- IR LED (970 nm) for fibres back-illumination and IR-sensitive camera (ordinary IP camera with IR filter removed) viewing the screen with fibre bundles images

Edge collection lens port shutter

- driven by piezo motor
- mount on DN100 size port plug
- 51 mm travel range, 16 mm overall shutter thickness

Plasma Pedestal

- plasma pedestal observed by edge TS lens during H-mode
- pedestal profile fitted and described by modified tanh function ([8], [9], [10])

Collection optics alignment

Longitudinal alignment (focusing)

- similar to spatial calibration – collection optics retracted, fibre back-illumination
- core TS simulations in Zemax: image of fibre bundles 5 mm closer in VIS compared to NIR
- recently IR illumination and viewing hardware (same as for spatial calibrations) were used for this purpose

Transverse to the laser beam

- rough alignment with fibres back-illumination
- fine alignment during Raman calibration using “split fibre”
- spilt fibre
- fibre bundle divided into halves vertically
- signal ratio in the halves indicates laser position
- during TS measurements – information about alignment
- originally, 1 split fibre per lens (see below), now upgraded to 2/lens

Ideal alignment

- signal ratio in split fibre halves: 1:1

Shift

- tilt already in calibration
- lens already in calibration – data sensitivity to shift
- even though signal ratio ≈1.1

Solution: 4 split fibres (2 per collection lens)

Trigerring unit

New triggering unit was developed and built [8] (inspired by [9]):
- based on FPGA (Xilinx Spartan 6) – higher speed and versatility compared to previous triggering unit developed for COMPASS TS (based on dSPIC)
- allows synchronisation of two 30 Hz lasers to operate at
  - 60 Hz
  - 30 Hz double pulse (variable delay between pulses)
  - 30 Hz double energy (laser pulses overlapping, for higher TS signal)
- graphical user interface on PC connected through USB, basic functions on device front panel
- re-synchronization of TS timing to tokamak time
- hardware is ready to accept external triggers to plasma events

References


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