Radially resolved thermal and fast-ion dynamics with collective Thomson scattering at ASDEX Upgrade

T. Verdier[1], J. Rasmussen[1], T. Jensen[1], S. K. Nielsen[1], and the ASDEX Upgrade team*

[1] *Technical University of Denmark, Dept. of Physics, Lyngby, Denmark*

* *See author list of U. Stroth et al., 2022 Nucl. Fusion **62**, 042006*

1. Introduction For magnetically confined plasmas, fast ions and their behavior will play a key role in the performance of reactor-grade machines. To monitor their dynamics, Collective Thomson Scattering (CTS) has been chosen as a primary fast-ion diagnostic in ITER for diagnosing fusion-born alpha particles across their full energy range [1]. In current machines such as ASDEX Upgrade (AUG), various plasma properties can be inferred with CTS [2], providing a reliable tool to study thermal- and fast-ion transport in preparation for ITER operation. However, despite its versatility, CTS at AUG is usually confined to a single measurement volume, thus limiting its use in obtaining spatially resolved measurements.

Here we present the first highly radially-resolved CTS measurements at AUG, obtained by repeatedly sweeping a single measurement volume from the plasma core to mid-radius ($\rho_p \in [0.1;0.7]$) for a sweep duration of 0.7 s. This results in 70 measurement locations, in which the fast-ion velocity distribution, ion temperature and rotation velocity can be inferred with CTS, in a moderate-density ($n_e \approx 6 \times 10^{19}$ m^{-3}) H-mode discharge, with both on- and off-axis neutral beam (NBI) deposition. The plasma conditions (notably magnetic equilibrium, plasma pressure and stored energy) being remarkably stable across many confinement times allow the inference of radial profiles for thermal- and fast-ion velocity distributions.

2. Measurements and analysis Our measurements are based on AUG discharge #41238, with the time trace of the relevant plasma properties shown in figure 1a. The discharge employed 2.1 MW of ECRH power and 5 MW of NBI heating, split between sources Q6/Q8 (interspersed) and Q3 (throughout, allowing FIDA measurements). This is shown in figure 1b. With such input power, we reached a remarkably stable H-mode discharge. Magnetic coil data suggests the presence of a (1,1) mode in the plasma but no evidence of NTMs, and the mode does not seem to strongly affect the fast-ion contribution to the measured CTS spectra as shown below.

During the discharge, we swept the CTS probe gyrotron mirror to vary the location of the CTS measurement volume, as shown from ray-tracing in figure 2. It was swept from the core of the plasma ($\rho_p = 0.1$) to the high field side ($\rho_p = 0.7$) in 0.65 s, starting at $t = 2.0$ s. A second sweep