Thomson Scattering Diagnostic on the ETE Tokamak: Status and Progress

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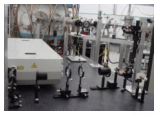
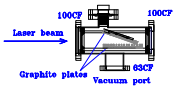
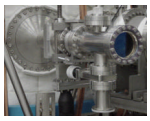
A conventional one-channel Thomson scattering (TS) system was implemented to measure the electron temperature and density profiles on the ETE tokamak plasma with a resolution of 15 mm along 50 cm inside the plasma. The TS is based on a 10 J Q-switched ruby laser that probes the plasma horizontally at the mid-plane. An f/6.3 lens images the scattered light on a 7 m long fiber bundle with effective cross-section of 4.5mmx1.5mm that is spectral analyzed by a 5-channel filter polychromator. Temperatures from 20 eV to 160 eV with densities as high as $3.5x10^{19}$ m^{-3} were measured during the optimization phase of the ETE plasma discharge. Presently, the TS diagnostic is being upgraded aiming at the simultaneous measurement of electron temperature and density of a plasma profile with 10 spatial points per polychromator. This multipoint Thomson scattering (MTS) diagnostic is based on the time-delay technique that consists in using fibers of different lengths to relay the light signals to the same polychromator. The proposed system uses large core monofibers (d = 0.8 mm, NA = 0.39, average attenuation: 7 dB/Km) with micro-lenses (d = 3 mm, f = 15 mm) allowing a resolution inside the plasma of 4 mm. For this MTS setup the estimated length of the fibers increases 14 m progressively from channel to channel, from a minimum of 8 m to the maximum length of 134 m. The overall transmission is estimated to be 52% for the first fiber and 42% for the last one.

Thomson Scattering System - Present Setup

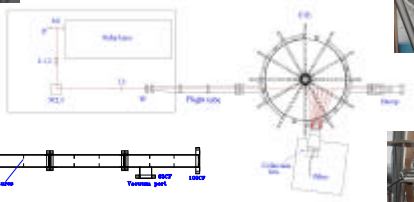


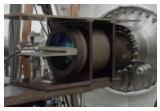


Dump

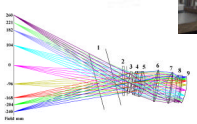


Laser



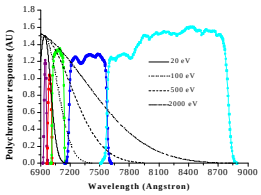


Flight tube



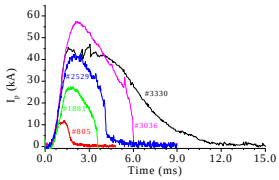
Lens

Polychromator Response



Detection / Acquisition

Evolution of the Plasma Current



#805 : First plasma;

#1881 : Ohmic heating improvements;

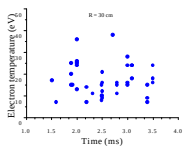
#2529 : External parameters optimization;

#3036 : Toroidal and ohmic banks upgrade;

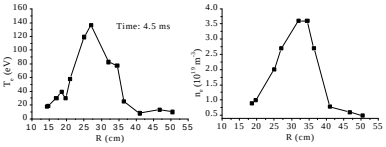
#3330 : Glow discharge cleaning

Thomson Scattering Measurements

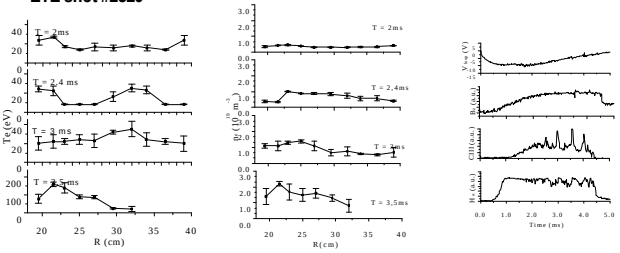
ETE shot #1881



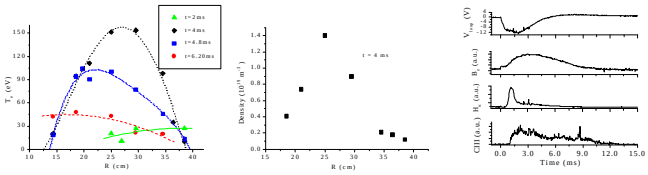
ETE shot #3036



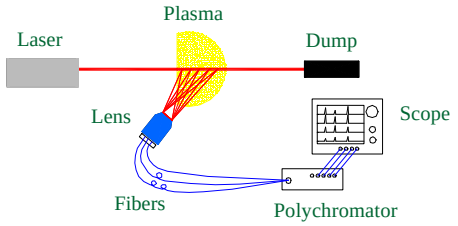
ETE shot #2529



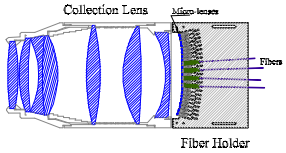
ETE shot #3330



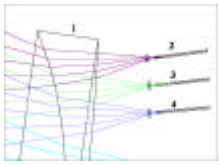
Multipoint Thomson Scattering System - Upgrade

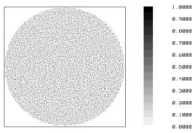


Lens	R1 (mm)	R2 (mm)	R3 (mm)	f (mm)	Thickness (mm)
1	429.0	-285.0		112.0	18.0
2	175.0	469.0		122.3	15.0
3	-140.5	719.7	-145.9	122.3 132.0	6.0 26.0
4	350.0	-350.0		165.0	24.0
5	160.0	-848.0		162.0	30.0
6	-145.0	-719.0		142.0	7.5



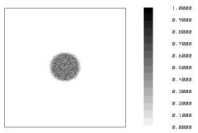
MTS Ray-Tracing





Spot diagram of a test object

f = 4 mm, field: -168 mm



Spot diagram of the imaged object

Fiber 4

Simulations

Present TS System

Te (eV)	Ne (m^{-3})	Nº of scat. Photons in W	Nº of photons	Estimated signals (mV)
40	1x10^{19}	4.5x10^{5}	CH2: 1.9x10^{4} CH3: 2.4x10^{4} CH4: ---------	64 80 ------
150	2x10^{19}	9.1x10^{5}	CH2: 2.2x10^{4} CH3: 5.5x10^{4} CH4: 1.9x10^{4}	74 178 60
300	5x10^{19}	2.3x10^{6}	CH2: 4.1x10^{4} CH3: 1.1x10^{5} CH4: 9.3x10^{4}	134 370 290

Laser energy: 4J, objective NA: 0.0833, Transmission: 31%

MTS System

		Nº of scat. photons in W		Nº of photons and estimated signals		
Te (eV)	Ne (m^{-3})		CH	Fiber 1	Fiber 5	Fiber 10
40	1x10^{19}	1.2x10^{5}	2 3 4	8,9x10^{3} (30 mV) 1.1x10^{4} (37 mV) ----------	8.2x10^{3} (27 mV) 1.0x10^{4} (34 mV) ----------	7.3x10^{3} (24 mV) 9.3x10^{3} (30 mV) ----------
150	2x10^{19}	2.5x10^{5}	2 3 4	1.0x10^{4} (35 mV) 2.5x10^{4} (83 mV) 8,8x10^{3} (28 mV)	9.5x10^{3} (32 mV) 2.3x10^{4} (76 mV) 8.0x10^{3} (25 mV)	8.5x10^{3} (28 mV) 2.1x10^{4} (68 mV) 7.2x10^{3} (22mV)
300	5x10^{19}	6.2x10^{5}	2 3 4	1.9x10^{4} (62 mV) 5.3x10^{4} (172 mV) 4.3x10^{4} (135 mV)	1.7x10^{4} (57 mV) 4.8x10^{4} (157 mV) 3.9x10^{4} (123 mV)	1.5x10^{4} (51mV) 4.3x10^{4} (140mV) 3.5x10^{4} (110 mV)

Laser energy: 7J, objective NA: 0.0711, Transmission: 42 - 52%

First Results

Fiber 1: 8 m

Fiber 2: 112 m

Time delay: 512 ns

Transmission : 82 %

Peak value : 61 %