Tokamak GOLEM for fusion education - chapter 14

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The GOLEM tokamak is the oldest still operational experimental device in the high temperature tokamak plasma physics. Currently, its main mission is to be an educational device to train future thermonuclear fusion specialists. GOLEM is unique thanks to its remote-control system [1], which allows to carry out the discharge and instantly process experimental data remotely. This contribution is devoted to the current projects:

The distribution of REs in SOL was measured with two semiconductor strip detectors. Setup with two opposite-oriented sensors (see Fig. 1) was chosen so it is possible to observe trapped particles and RE backscattering from the limiter. During the discharge, REs are usually detected near the limiter edge or with a uniform distribution (Fig. 1, right side, 3.2 - 11.8 ms). At the end of the discharge, most of the energy is typically deposited on the LFS side of the limiter (12 ms).

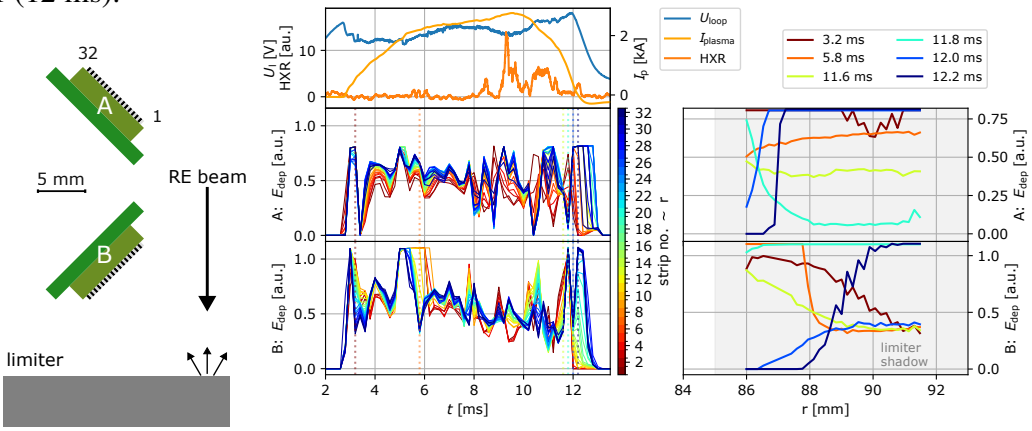

Figure 1: Left) Schematic of two detectors for measurement of RE distribution. Right) Deposited energy in the strip detectors on the left and resultant distribution RE on the right.

One of the diagnostics routinely used at the GOLEM tokamak **dedicated to runaway electron investigation, is a pair of scintillation detectors** with $CeBr_3$ crystals ($1'' \times 1''$). These detectors are used for detection of produced bremsstrahlung radiation, which is dominantly caused by RE impact on the molybdenum poloidal limiter. For proper analysis of data, detectors need to be periodically calibrated. For this purpose, methods for automatic peak detection in the measured spectrum were explored and applied to calibration data (Fig. 2). An illustrative

spectrum of bremsstrahlung radiation recorded during discharge #42243 is shown in In Fig. 2.

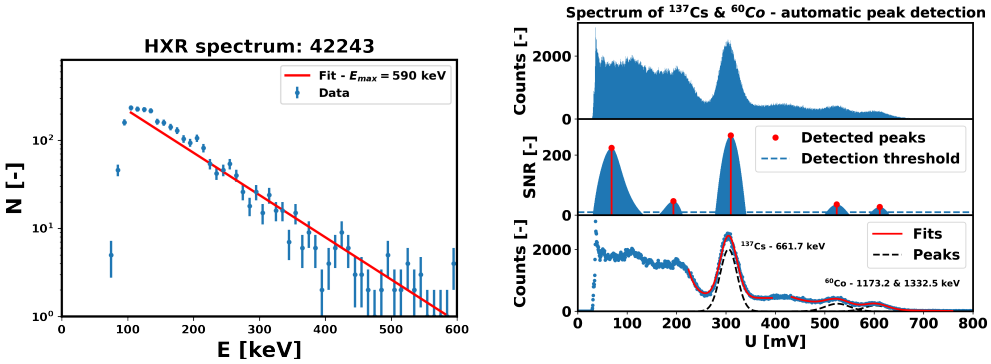

Figure 2: Left) Example of recorded bremsstrahlung spectrum by $CeBr_3$ scintillation detector. Right) Detector energy calibration.

Figure 3: Left) Comparison of thin plasma model and experimental ECE signal. Right) Comparison of HXR energy distribution and electron energy distribution from ECE measurements.

The 26.5 – 40 GHz ECE radiometer was placed radially on LFS at GOLEM. Due to low electron temperature and density in the GOLEM tokamak, the ECE radiometer cannot be used for electron temperature measurements. The radiometer is, however, sensitive to non-thermal high energy electrons and the plasma parameters allow simulating radiation from plasma as a combination of single electron radiation. Matching this model to experimental signal via variation of electron energy distribution function allows to estimate the distribution function.

According to HXR measurements by scintillation detectors with $CeBr_3$ crystals, the distribution can be expressed as $f \sim \mathrm{e}^{(-E/E_0)}$, and E_0 can be estimated from comparison of simulation and experiment. The Fig. 3 demonstrates matching of shape for experimental and simulated signal with $E_0 = 4\mathrm{e}4$ eV before 9.2 ms of the discharge and $E_0 = 1.8\mathrm{e}5$ eV afters. Comparison of obtained distribution functions with HXR distribution is also presented.

An educational video about the GOLEM tokamak vacuum system was created as the first in a newly emerging series serving as an introduction and an overview of the systems and diagnostics of the GOLEM tokamak [2]. The series is intended as an introduction to the tokamak technology for both students and a wider audience. The following episode is planned