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Radiation losses studies in Globus-M tokamak

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The recent studies of radiation losses in Globus-M spherical tokamak [1] are presented in the contribution, going on previous publications [2,3].

Sensors.

Bolometer diagnostics of Globus-M tokamak consists of 1 wide angle sensor and pinhole camera with 3 collimated channels. Both the wide angle sensor and the pinhole camera are mounted on the tokamak flange of one of horizontal ports. Photo of the pinhole camera without cover to show units inside is presented on fig.1.

Angle between channels of the pinhole camera is 30° and collimation angle of every channel is 1°. Photoes of the pyroelectric sensor and collimation unit are presented on fig.2 and 3 correspondingly. The wide angle channel of the bolometer has view

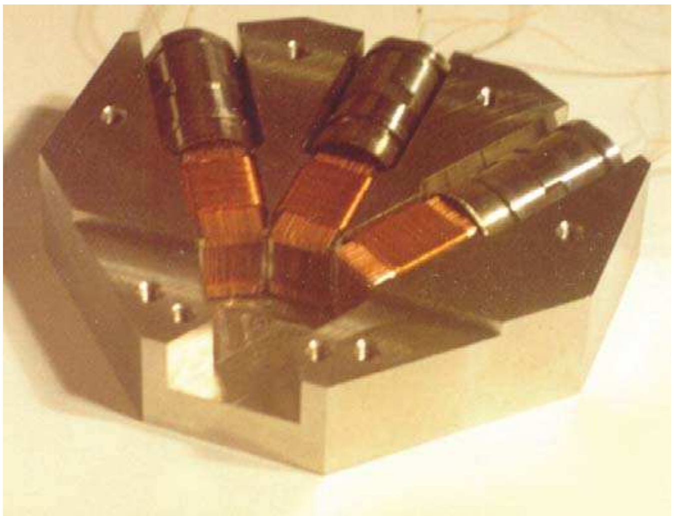

Fig.1. Photo of pinhole camera of bolometer diagnostics of Globus-M tokamak (cover is removed to show units inside). Every of three collimated channels contains pyroelectric sensor in SS steel case and multislit collimator.

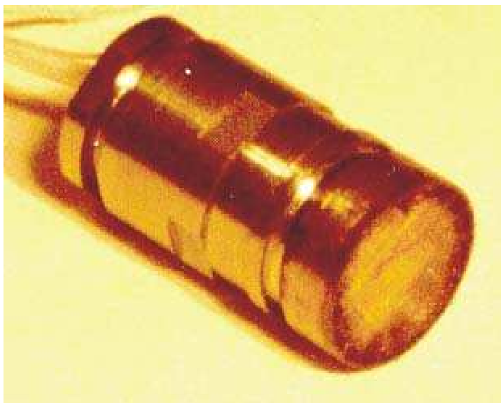

Fig. 2. Photo of pyroelectric sensor in SS steel case. Face side of the sensor is shielded with a grid.

angle 112° and can directly observe about 80% of plasma taking into account shadow of central solenoid rod.

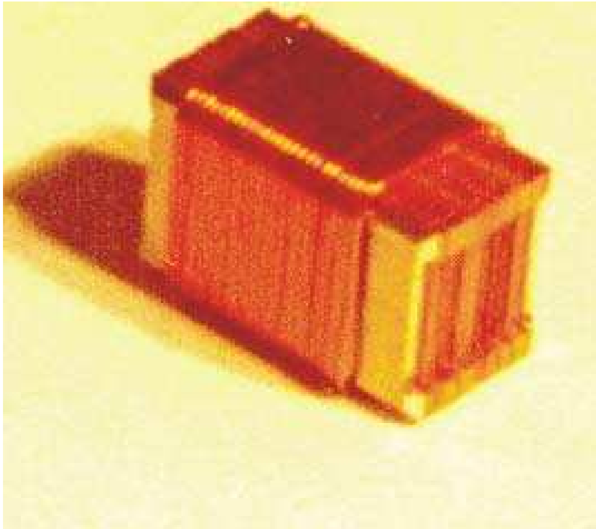

Fig.3. Photo of the multislit collimator. Parameters: 50 slits; 1 cm^2 cross-section; collimation angle - 1°.

The pinhole camera is mounted on the axis and can be rotated in vertical plane for ±30°. The outermost channels can be rotated to observe any direction in the range 0° - 60° from equatorial plane. A new drive was developed to change the vertical angle of the camera from shot to shot. This will allow us to register a more detailed distribution of radiation sources for a set of shots with similar plasma parameters.

Radiation losses in ICRH and NBI.

Typical signals measured by the bolometer on Globus-M tokamak in discharges with NBI are presented on fig.4.

Bottom plot on fig.4 presents density evolution, and the upper plot presents output of the wide angle channel of the bolometer. NBI source start operation at 159 ms and after that there are growth of both radiation losses and density. NBI power was about 450 kW and about 90 kW of this additional heating losses with radiation.

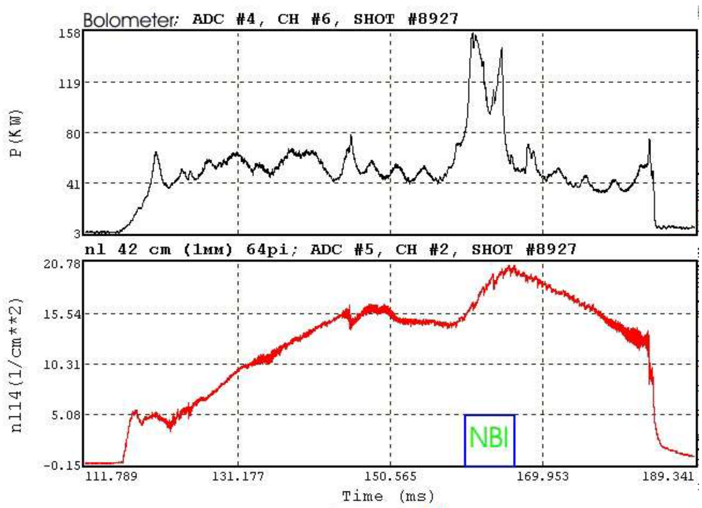

Fig 4. Evolution of radiation losses (upper plot) and central density (bottom plot) in discharge #8927 of Globus-M tokamak with NBI operation.

Fig.5 represents evolution of radiation losses in discharge with ICRH operation. Wide angle bolometer signal is shown on the upper plot. Three transient phases may be separated. The first is increasing radiation losses at the start of ICRH (159 – 164 ms), after

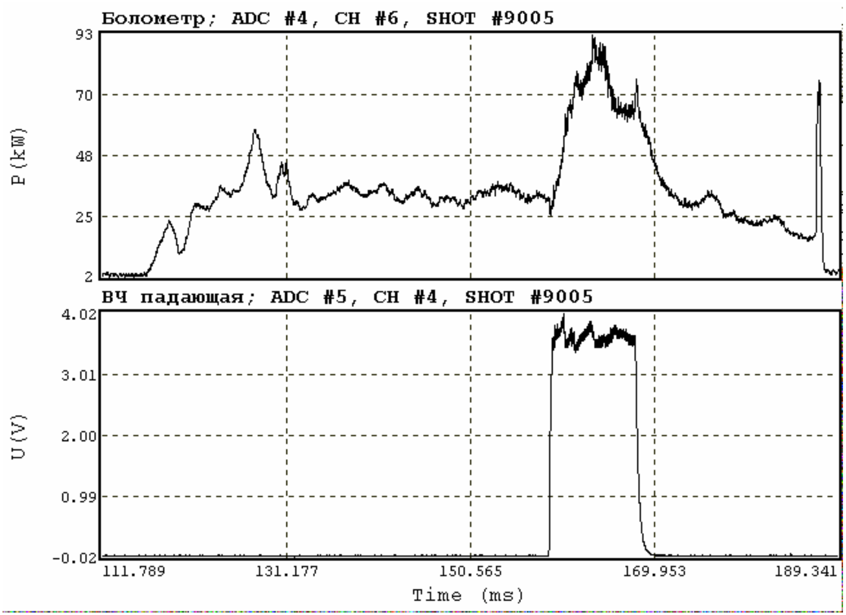

Fig.5 Evolution of radiation losses (upper plot) and ICRH operation (bottom plot) in discharge #9005 of Globus-M tokamak.

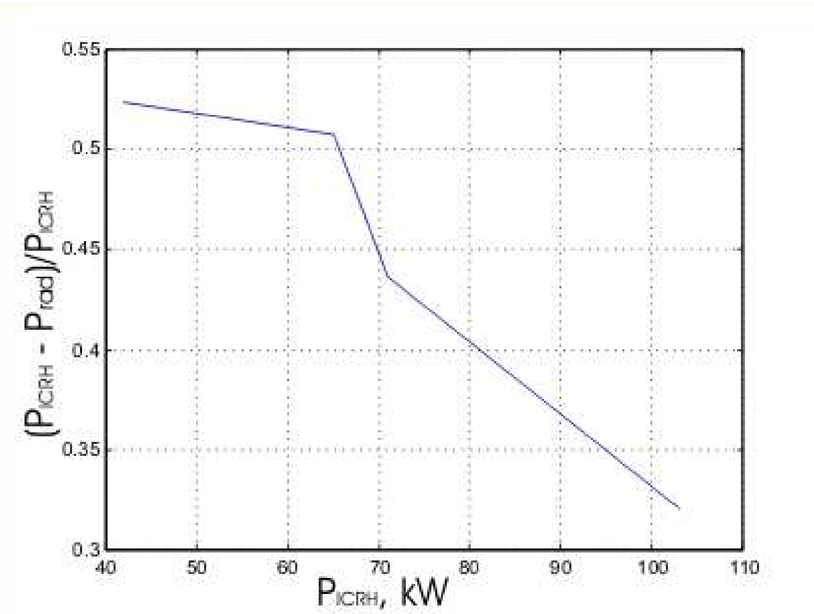

Fig.6. Dependence of ratio of not radiated additional power ($P_{ICRH} - P_{rad}$) to ICRH power P_{ICRH} on power source P_{ICRH}.

that the second phase with decreasing radiation losses to new stationary conditions (164-167 ms) and the last is transition after switching off the power source (168 - 173 ms).

Dependence of ratio of not radiated absorbed power to total absorbed heating power on the absorbed power is shown on fig.6. This dependence demonstrates that with growth of absorbed ICRH power more and more power losses with radiation (up to 65%). The similar value for NBI heating is about 20%.

Estimation of radiation sources movements.

The following model task was investigated to estimate possibility of registration of radiation source movements. At the first step we assume realistic profiles of radiation losses and plasma poloidal velocity. Next we calculate signals for 32 bolometric channels and add noise to calculated signals. So we receive imitation of experimental bolometer signals. At the third step we use inverse

Abel procedure to reconstruct 2D distribution and evolution of radiation sources. The fourth step includes correlation analysis. For two points placed on the same magnetic surface we calculate cross-correlation function and estimate time lag. We assume that this delay corresponds to plasma movement from the first point to the second one. This allows calculating of the poloidal velocity.

Space correlation may be used instead of time correlation analysis. In this option after the third step one can use poloidal distribution of radiation sources on the same magnetic surfaces at two time moments. Phase angle between these two distributions may be found using space cross-correlation function. It also allows calculating of the poloidal velocity.

As a result of our model task investigation we found that up to 10% noise allows to perform reliable reconstruction of poloidal velocity profile .

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References.

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