PLASMA ELECTRON TEMPERATURE DETECTOR

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The application of any semiconductor or scintillation detectors for plasmas with thermonuclear parameters which are placed near an installation is absolutely except. This fact needs to design the diagnostics which are tolerant to the gamma and neutron hard radiation.

In this report the description of the developed *simple* detector for plasma electron temperature measurements in the presence of the hard radiation is given and using its on T-10 tokamak is described.

For such measurements the standard variant of the filter absorption method was used [1]. As it known in the standard method the penetration of x-ray photons in the target fabricated from some materials with known thickness is measured.

So to use this method we need to measure two values - the flux intensity on the entrance in the filter – I_0 and the flux intensity after filter penetration – I_f. The ratio of these values give us the possibility to measure the photon energies.

In the standard method we need to use *two* individual detectors with the same characteristics.

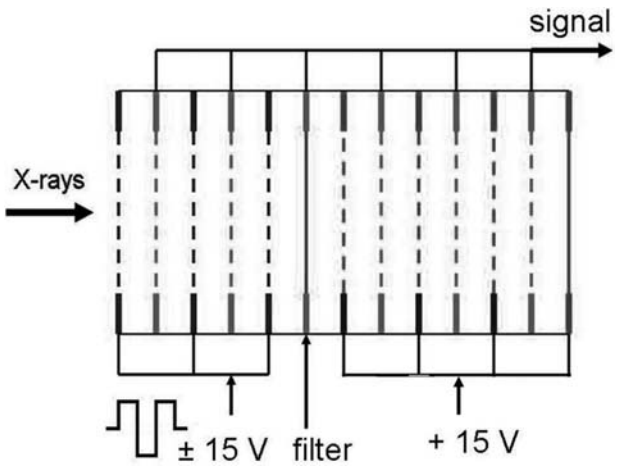

Fig.1.

In the described detector (DET) the only *one* sensor is used.

This detector is composed from 12 low-voltage ionization chambers [2] with wire mesh electrodes placed one by one. These chambers are divided into two blocks. The first block has 5 chambers and the second has 7 ones. These meshes are mounted such a way that the transparency of all blocs was maximal. The distance between meshes is 3 mm.

The schematic picture of the developed detector is given in Fig.1 and its photo is given in Fig.2. The female ring in this figure is given as a scale.

Fig.2.

The current-voltage characteristic of DET is symmetric relative to the bias voltage sign. This characteristic one can see in Fig.3.

This feature give possibility to realize the next method for electron plasma measurements. The first block is connected to the DC bias voltage with value U. For the second block the meander with voltage amplitude $\pm U$ is used. The one amplifier is supplied for signal measurements from both blocks. When the bias voltages of both blocks have the same sign, the resulting signal is equal to sum of both signals. If the bias voltages have opposite signs, the resulting signal is equal to difference of two individual signals. So we have two equations with two unknown functions - I_0 - which is the value of x-ray flux from a tokamak and I_f - which is the value of x-ray flux after the filter. The first of it is

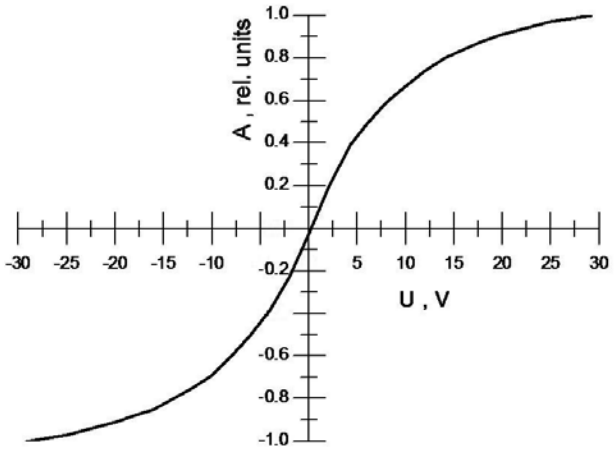

Fig.3.

$$I^{+} = I_0 + I_f \tag{1}$$

and the second one is

$$I^{-} = I_0 - I_f \tag{2}$$

The solutions of these equations are

$$I_0 = \frac{I^+ + I^-}{2} \tag{3}$$

$$I_f = \frac{I^+ - I^-}{2} \tag{4}$$

From Eqs.(3) and (4) we can obtain the value of absorption coefficient η

$$\eta = \frac{I_f}{I_0} \tag{5}$$

The described detector with 10 μ Al filter was calibrated with help of x-ray radiation from X-ray tube. The result one can see in Fig.4.

The described detector was used for electron temperature measurements in the tokamak T-10. The typical signal of DET T-10 tokamak is given in Fig.5. In this case the meander with 20 Hz frequency was used.

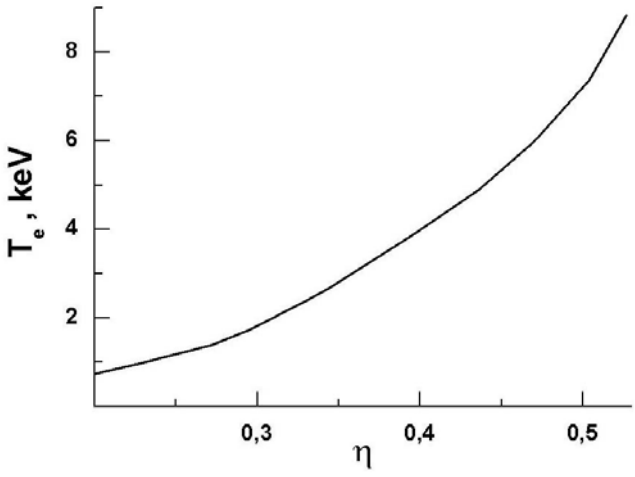

Fig.4.

From this figure one can see that after 500 ms from discharge start the values of I^+ and I^- practically stop to change and we can say that plasma temperature approach to its maximum. Unfortunately to found the absolute value of the electron temperature was impossible because of the strong influence of a line radiation.

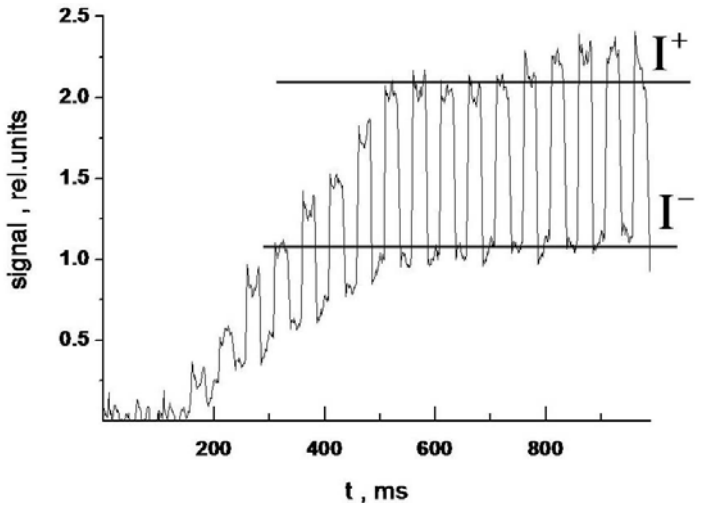

Fig.5.

The photon spectrum in T-10 measured with the semiconductor spectrometer is given in Fig.6. The slope of the line in this figure give possibility to find the electron temperature.

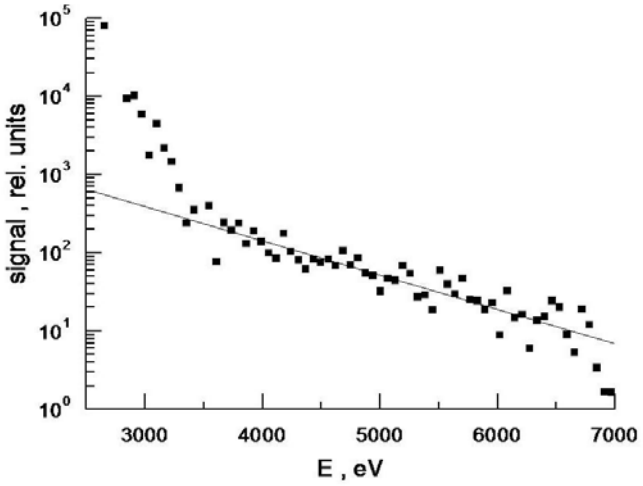

Fig.6.

From Fig.6 one can see that the flux of photons with energies less than 3.5 - 4 keV is much greater than the values which can be used for plasma temperature estimation. That part of the flux is defined by line radiation. For removing the influence of this radiation it is possible to use, for example, the 20 – 30 μm Al filter on the DET entrance. To great regret for the most operation regimes on T-10 the signals will be too small to be measured.

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2. Yu.V.Gott, M.M.Stepanenko. Instruments and Experimental Techniques. V.52. P.260. 2009.