DOI: 10.34854/ICPAF.51.2024.1.1.223

ION TEMPERATURE MEASUREMENTS USING A COLLIMATED NEUTRON SPECTROMETER FOR DIFFERENT DISCHARGE SCENARIOS IN ITER *)

Pankratenko A., Kormilitsyn T., Reviakin P., Semenov T., Kashchuk Yu.

ITER RF DA, 11-2 Raspletina st., Moscow, 123060, Russian Federation,
a.pankratenko@iterrf.ru

This paper presents the results of direct modeling of the response of a neutron spectrometer as part of the ITER Neutral Particle Analyzer during several scenarios of discharges in D- and DT-plasmas, testing the algorithm for calculating the ion temperature based on this response and an analyzing the errors in the obtained results.

The ITER NPA includes a neutron dump; on the front part of the dump the neutron spectrometer is installed. The spectrometer includes two detectors: the first is based on an organic scintillator - stilbene, the second is based on an artificial diamond single crystal grown by the CVD method. Particles are registered in the first detector using elastic scattering of neutrons on hydrogen atoms. It is more sensitive and is planned for use in deuterium plasma discharges, as well as in trace tritium scenarios. Registration of neutrons in a diamond detector occurs using the threshold reaction $^{12}C(n,\alpha)^{9}Be$; this detector is planned to be used in scenarios with a high neutron yield. A more detailed description of such detectors is given in [2] and [3].

The Neutron transport simulations were carried out using several different computational codes. The neutron flux at the spectrometer position was calculated using Monte Carlo methods as part of the neutron analysis of equatorial port No. 11 [4]. The response of the detectors was simulated using the GEANT4 code [5]. The neutron spectrum was reconstructed from the noisy model amplitude-height spectra of the detectors, and the ion temperature of the plasma was estimated from its characteristics.

This work proves the feasibility of the algorithm for ion temperature calculations based on spectrometer response. The analysis results show that for the D- and trace tritium scenarios, the neutron flux at the spectrometer location is too low for the diamond detector to be usable. In the case of DT plasma discharges, a diamond detector is capable of operating with sufficient accuracy. A detector based on stilbene, on the contrary, due to its high sensitivity, is not operational in this case. In addition, to correctly reconstruct the ion temperature, it is necessary to take into account the contribution of epithermal neutrons to the observed spectrum. These results are confirmed by other studies [1].

The work was carried out within the framework of the R&D agreement under State Contract No. N.4a.241.19.23.1014 dated January 18, 2023.

References

[1]. Afanasyev V.I. et al., (2022). Development of the NPA based diagnostic complex in ITER. *Journal of Instrumentation*, *17*(7). https://doi.org/10.1088/1748-0221/17/07/C07001

[2]. Kaschuck Y.A. et al. (2002). Fast neutron spectrometry with organic scintillators applied to magnetic fusion experiments. In *NIM: A* (Vol. 476).

[3]. A.V. Krasilnikov et al. (2002). Study of D-T neutron energy spectra at JET using natural diamond detectors, Nucl. Instrum. Meth. A 476, 500

[4]. 55.QB - Neutron shielding, nuclear loads and radiation damage calculations and analyses (ITER_D_YTXP4Q v1.3)

[5]. Agostinelli S. et al. (2003). GEANT4 - A simulation toolkit. *NIM: A*, *506*(3), 250–303. https://doi.org/10.1016/S0168-9002(03)01368-8

*) abstracts of this report in Russian