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On Fast Ions Diagnostics with Gamma-Ray Spectrometry in ITER

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Gamma ray spectrometry (GRS) is a mature technique implemented on many past and present tokamaks, including EAST, TFTR, JET etc. that can provide detailed data on the distribution functions (DF) of the plasma fast particles.

In several stages it was undertaken a fusion plasma gamma emission sources (GES) study. Firstly, data on main reactions relevant to alpha particles diagnostics were analyzed[1]. The key reactions for this case are d(t,gamma)^5He and ^9Be(alpha,ngamma)^1^2C which gives accordingly information on the source and confinement of mentioned plasma component. When the GRS project was suggested for the ITER Neutral Particles Analyzer one of the main points of interests became ability to support complex measurements of the d- to t-densities ratio with information derived from data on emission caused by reaction with the knock-on ions. Reactions with impurities, mainly ^9Be, were analyzed by modelling of the GES in the plasma and registration of generated quanta with detectors in order to obtain expected spectra and estimate performance of the spectrometer[2]. During preparation of the conceptual and preliminary designs of the ITER GRS further more detailed investigation of the emission was undertaken, particularly involving a complex n- and gamma background study. Later, another important GES was discussed for ITER and DEMO[3], which includes mechanisms of the consecutive reactions: d(p,gamma)^3He, d(t,gamma)^5He, d(^3He,gamma)^5Li and t(p,gamma)^4He where on going particles can be originated from another reaction (dd). The latter reactions are also suggested to be used for obtaining fuel ratio and the DFs of fast ions and the electrons temperature. Uniting of the ITER GES most recent analysis results, comparison of the different GES impacts and application of these data for diagnostic tools development constitutes the main purpose of the current work and reflected in the report. Within the work data on nuclear reactions cross-sections were summarized, plasma emission models for different discharges scenarios suggested. Obtained results used in the MCNP calculations performed in order to estimate count rates of ITER GRS detectors and in the design optimization workflow.

1. Chugunov, I.N., et al., Nucl. Fus., 2011. 51(8): p. 083010
2. Gin, D., et al., AIP Conf. Proc., 2014. 1612: p. 149-152
3. Kiptily, V.G., Nuc. Fus., 2015. 55(2): p. 023008

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