Test and Validation of TRANSP "Kick"-Model Predictive Capability of Neoclassical Tearing Mode Induced Fast Ion Transport in ITER Relevant DIII-D Plasmas

L. Bardoczi[1], M. Podesta[2], W.W. Heidbrink[3], M. A. Van Zeeland[4]

[1]Oak Ridge Associated Universities, Oak Ridge, Tennessee 37831, USA
[2]Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543, USA
[3]University of California, Irvine, California 92697, USA
[4]General Atomics, P. O. Box 85608, San Diego, California 92186-5608, USA

E-mail: bardoczil@fusion.gat.com

A newly available analysis tool of island structure determination [1] has been integrated for the first time with the TRANSP "Kick" reduced transport model [2] to study Neoclassical Tearing Mode driven energetic particle transport in ITER relevant DIII-D plasmas

Magnetic islands are implemented in the "Kick"-model through the perturbed flux ψ of a 3D helical Gaussian current filament with m and n mode numbers, centered at $q = m/n$ (r_s). The radial and helical structure is derived from first principles and the tearing amplitude is set to match the experimental island width (W). Next, ψ is used to calculate the "Kick" probability matrix $P(\Delta E,\ \Delta P)$ of ΔE energy and ΔP momentum kicks experienced by energetic particles in different parts of phase space with the ORBIT code. This P is used in TRANSP's NUBEAM module to modify the fast ion distribution. Initial TRANSP runs of ITER baseline, hybrid and steady state plasmas with the "Kick" matrix are encouraging with the model quantitatively predicting measured neutron rates in contrast to the classical model [Fig.1.]. The level of transport varies by scenario and island size with observed neutron deficit up to 20% in hybrid plasmas. The "Kick"-model retains all TRANSP functionality and is also able to self-consistently predict the NTM impact on beam ion torque, current drive and heating, which will also be discussed for the various scenarios.

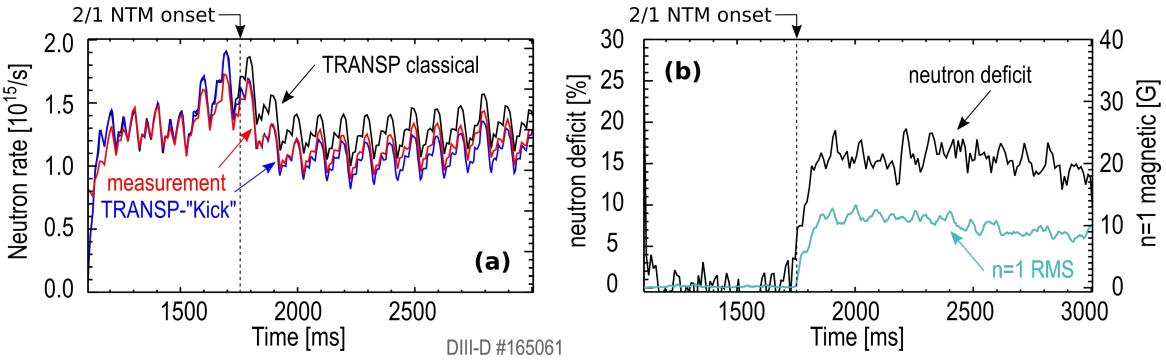

Figure 1: (a) Measured and TRANSP neutron rates with and without Kick-matrix in a hybrid DIII-D plasma with a $m/n = 2/1$ NTM. (b) Neutron deficit and NTM magnetic amplitude.

This research was supported by the General Atomics Postgraduate Research Participation Program administered by ORAU under contract number DE-AC05-060R23100 and by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences under contract numbers DE-AC02-09CH11466 and DE-FC02-04ER54698.

[1] L. Bardoczi *et al*, PoP **23** 052507 (2016), [2] M. Podestá, PPCF 56 055003 (2014)