Synthetic NPA diagnostic for energetic particles in JET plasmas

J. Varje¹, P. Siren², H. Weisen³, J.M. Fontcuberta⁴, T. Koskela¹,⁵, T. Kurki-Suonio¹, M. Santala¹, S. Akasloompolo¹ and JET Contributors*

EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK

¹Department of Applied Physics, Aalto University, P.O. Box 11100, 00076 AALTO, Finland
²SPC, station 13, EPFL, 1015 Lausanne, Switzerland
³NESRC, Lawrence Berkeley National Laboratory, Berkeley, CA 94720
⁴See the author list of "Overview of the JET results in support to ITER" by X. Litazdon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016)

JET tokamak outfitted with low-energy neutral particle analyzer [1]
- Simultaneous measurement of hydrogen, deuterium, tritium fluxes on a radial line-of-sight along the outer midplane
- Incoming neutral particles ionized in a stripping foil and accelerated, separated inside the diagnostic with parallel magnetic and electric fields
- For NBI measurements, H energy range 4-97 keV, D 5-41 keV, T 5-22 keV
- Properties of the fast ion distribution can be inferred from the measurements via synthetic diagnostics

NPA signal from NBI ions simulated with synthetic NPA diagnostic [2]
- Monte Carlo integration of fast neutrals and attenuation from 4D distribution, 1D profiles
  \[ \Gamma = \int n_n(x)v(x)e^{-\frac{L}{\lambda}} d\lambda \]

For rapid analysis, plasma profiles obtained from the JETPEAK database
- Comprehensive set of data from flat-top phases in the 2016 hydrogen campaign (C37)
- Neutral profiles pre-calculated for a range of typical plasma parameters

Synthetic NPA from NBI ions was simulated for discharges with simultaneous H and D NBI injection
- Both species simultaneously fitted to measurements to account for uncertainty in neutral profiles (up to 60%)

Simulated signal agrees with measurements at high energies
- Model reproduces 80 keV H beam, 120 keV D beam slowing-down characteristics
- Fraction of fast H, D ions reproduced for different beam power fractions
- Low energies (< 20 keV) dominated by thermal ions depending on plasma H fraction

Conclusion and future work
- ASCOT-based synthetic NPA diagnostic for NBI ion slowing-down agrees with measurements in various discharges in the 2016 hydrogen campaign
- Model will be expanded for high-energy NPA, RF-accelerated particles
  → Validation of ICRH codes
- Characterizing fast ion fluxes can help distinguish signal from bulk thermal ions
  → Isotope ratio measurements


This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the European research and training programme 2014-2018 under grant agreement No R33053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.