EUROfusion

ID: 694

Comparison of Particle Transport and Confinement Properties between the ICRH and NBI Heated Dimensionless Identity Plasmas on JET

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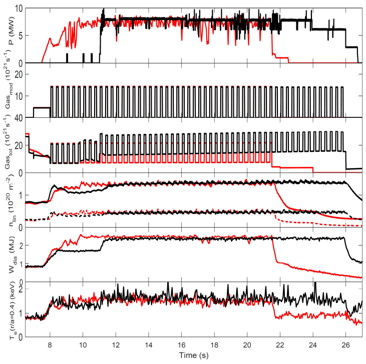
INTRODUCTION

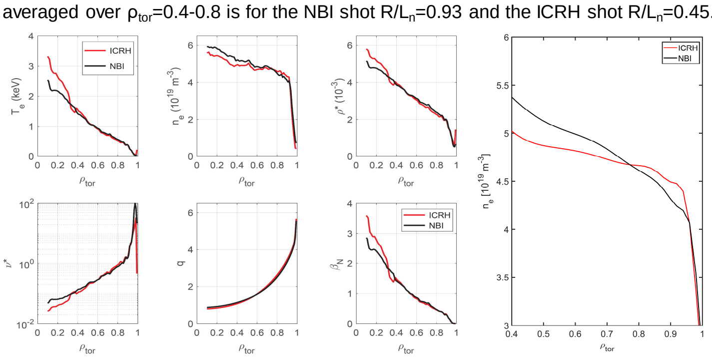
- Particle transport and fuelling are one of the major open issues in understanding the ITER physics [1]
- Core density profile peaking and particle transport have been recently extensively studied on several tokamaks [1,2,3].
- Earlier database studies in JET, AUG, C-Mod etc showed that density peaking scales with several plasma parameters, the most dominant ones being collisionality, Greenwald fraction and NBI fuelling [4,5,6].
- While the database studies suggested the dominant role played by the collisionality in affecting density peaking, other particle transport analyses in JET emphasized the importance of the particle sources [7,8,9,10].
- What complicates the analysis is that Ti/Te and NBI source are strongly correlated, and at the same time have opposite effects on the density peaking.
- Target to quantify the role of NBI fueling in contributing to density peaking in JET by executing identity discharges between the ICRH and NBI heated plasmas.
- Both the ICRH and NBI discharges are complemented with gas puff modulation so that we can extract the perturbative particle transport coefficients for each discharge.
- Study how the different heating systems and their effects in the plasma affect plasma confinement, MHD, impurities, radiation, pedestal, ELMs and the gas puff modulation.

NBI AND ICRH IDENTITY PLASMA IN JET H-MODE CONDITIONS

Pulse	95097 (ICRH)	95272 (NBI)
P_{NBI} (MW)	0	8.0
P_{ICRH} (MW)	7.9	0
B_t (T)	2.15	2.15
I_p (MA)	1.8	1.8
τ_E (s)	0.23	0.21
H_{98y}	0.8	0.7
P_{rad} (MW)	4	2
Z_{eff}	1.25	1.3
ρ^* (10^{-3})	2.8	2.8
υ^*	0.36	0.36
β_n	1.3	1.1
β_{th}	1.1	1.05
W_{fast}/W_{th}	0.11	0.08
f_{ELM} (Hz)	75	40
$f_{savteeth}$ (Hz)	6	3
v_{tor} (km/s)	-10	110

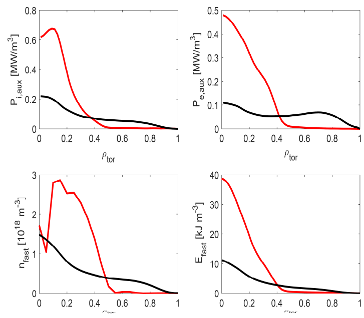


- 15s long H-mode plasmas with 8MW of ICRH power achieved, resulting in JET record high injected ICRH energy 108MJ.
- The dimensionless profiles of q, ρ^*, υ^*, β_n and $T_i/T_e \approx 1$ were matched within 5% difference except in the central part of the plasma ($\rho_{tor}<0.3$).
- Factor of 2 more peaked for the NBI discharge than for the ICRH pulse – R/L_n averaged over ρ_{tor}=0.4-0.8 is for the NBI shot R/L_n=0.93 and the ICRH shot R/L_n=0.45.

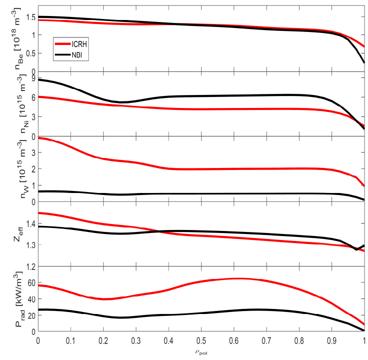


EXPERIMENTAL COMPARISON BETWEEN THE NBI AND ICRH IDENTITY PULSES

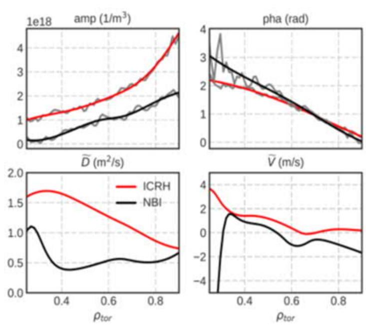
- The main differences between the discharges are the toroidal rotation (10km/s counter-Ip in ICRH pulse and 110km/s co-Ip for the NBI pulse), confinement, power deposition profiles, fast ion content and profiles (shown also in βn), ELM characteristics, radiation and heavy impurity concentration.
- Total integrated power (ICRH) to electrons is 3.8MW and ions 4.1MW and the 4.0MW and 3.9MW (NBI), respectively. Explains why T_i/T_e ratio is very close to 1.



- The Beryllium density is 20% higher for the NBI discharge in the core region at 0.4<ptor<0.8.
- Large difference in W density between the pulses, the ICRH pulse having a factor of 6 higher n_W.
- The Nickel density, representing the intermediate charge of plasma impurities, is a factor of 1.5 higher for the NBI pulses than for the ICRH one.
- However, yield similar Zeff profile in the confinement region at 0.4<ptor<0.8
- Total radiation of approximately 4MW for the ICRH shot and 2MW for the NBI shot.



- The phase profile (top right) is flatter in the case of ICRH, giving rise to higher perturbative diffusion
- Although these profiles represent the perturbative transport coefficients, this suggests that the steady-state particle transport could also be different
- In order to verify whether the power balance particle transport coefficients are the same or not, modelling is needed to obtain the relation between the experimentally determined perturbative transport coefficients and the power balance ones. This is left for future work.



SUMMARY AND CONCLUSIONS

- The NBI fuelled discharge has a factor of 2 higher density peaking (R/L_n=0.93 for the NBI shot and R/L_n=0.45 for the ICRH shot), yielding similar plasma parameters and performance in the confinement region (0.3<ρ_{tor}<0.8).
- The differences between the ICRH and NBI plasmas are the toroidal rotation, plasma fast ion density and energy and heavy impurity densities of Tungsten and Nickel. In order to clarify whether particle transport is the same, modelling is needed.
- This result 2 is valid at 8MW of heating power level. These are low power H-modes and some of the physics processes influencing particle transport, like rotation, turbulence, fast ion content scale with power, and therefore, can be different in full power (30MW) conditions.

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This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.