TC-11 He and impurity profiles and transport coefficients

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| **TG priority:** Critical  | **Start date:**   | **Status:**  On-going | **Personnel exchange:**   |
| **IO priority:**  | **End date:**   | **Motivation:**   |

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| --- | --- | --- | --- |
| **Device /****Association** | **Contact****Person** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| JET  | P.ManticaC. Giroud | Desirable | Committed | Not doing | Not doing | Analysis |  |
| DIII-D | C. Petty | Desirable | Analysis | Analysis | Analysis | Analysis |  |
| C-Mod | J. RiceW. Rowan | Desirable | Analysis | Analysis | Analysis | Analysis |  |
| AUG | C. AngioniR. McDermottA.Kappatou | Desirable | Not doing | Committed | Committed | Committed |  |
| JT-60U | M. Yoshida | Desirable | Done | Analysis | Analysis |   |  |
| TCV | H. Weisen | Desirable | Considering | Committed | Analysis | Analysis |  |
| Tore Supra | C. Bourdelle | Desirable |   | Considering | Considering |   |  |
| MAST | M. Valovic | Desirable | Considering | Committed | Committed |   |  |
| NSTX-U | W. Gutten-felder | Desirable | Analysis | Analysis | Analysis | Considering |  |

**Purpose:** Measure and understand with theoretical models impurity transport (from He to W) in various operational regimes. From the diagnostics standpoint, we separate low-Z impurities whose profiles can be measured through CXRS and high-Z impurities, which are measured through radiation diagnostics. This separation applies also in terms of physical models which are required for their description. In usual tokamak scenarios, low Z impurity density profiles are not affected by poloidal asymmetries due to centrifugal effects or induced by heating systems. In contrast, the modeling of high Z impurities (e.g. W) has to include these effects.

**Results for 2015**

* AUG: Further analysis and modelling of the He and boron density profiles measured in NBI and ECRH power scans in ASDEX Upgrade (Kappatou EPS 2015) has revealed that in the majority of cases, the shapes of the He density profiles closely follow those of the electron density. This trend is reproduced by linear gyrokinetic modelling, although the predicted peaking factors are significantly smaller than the measurements. Also the peaking of the B density profile is usually under-predicted by theory, although differences in trends between He and B are qualitatively consistent with predictions. However, there is also a subset of cases (NBI power scan) where the logarithmic gradient of the He density around mid-radius is observed to decrease with increasing logarithmic gradient of the electron density. The reasons behind this different trend, which is not reproduced by theoretical predictions, are still under investigation. So far, sensitivity scans on input parameters as well as nonlinear gyrokinetic simulations did not clarify the origin of the disagreement.
* JET: An extensive gyrokinetic modelling of the JET database of C density profiles (Manas EPS 2015) has shown that in conditions of low collisionality (low density) and high rotation gradients the theoretical predictions approach the experimental measurements (provided the modelling includes roto-diffusion), whereas the C peaking factors are over-predicted in conditions of high collisionality (and low rotation gradients), where C density profiles are observed to be hollow. The origin of this collisionality dependence is currently under investigation (neoclassical transport was already reported to be practically negligible).
* C-Mod: Investigations of core impurity transport have been performed in C-Mod, demonstrating that impurity confinement times in L-mode and I-mode are comparable, have similar dependencies, and are much shorter than in the enhanced *Dα* H-mode. There is a strong positive relationship between core impurity confinement time and the edge density gradient across all these confinement regimes. A weak mass dependence of the impurity confinement time has been observed in these regimes, in particular Ca18+ and W44+ have comparable confinement times in the EDA H-mode.
* Modelling of W transport in predicted ITER plasmas confirms that in both the 15 MA and 7.5 MA scenarios no significant central peaking of the W density is expected to occur. The predicted small W peaking is direct consequence of core transport assumed to be neoclassical at ion level in the centre. Transient phases of H-L transitions appear to be more challenging, due to transient peaking of the density profiles.
* Further analysis and modelling of the W density behavior in JET has further confirmed the beneficial role of ICRH in counteracting W accumulation and predicted a high sensitivity of the efficiency of the W accumulation avoidance on the central localization of the ICRH power density. A parallel activity on AUG observations has focused on the impact of central ECH and shown that this is predicted to significantly increase the turbulent W diffusivity when ECH is applied in typical conditions of NBI heated H-modes.

**Plans for 2016**

* AUG: Additional experiments are being performed on AUG to better characterize the role of MHD activity at q = 1 on the W behavior as well as differences between W accumulation avoidance obtained by central ECH and central ICRH.
* JET: Future experiments in JET (in particular in hybrid scenario) are planned to validate the predicted high sensitivity of W behavior on the location of the IC resonance and the ICRH power density profile.
* C-Mod: Experiments on high Z impurity transport (Xe) are also planned in the next C-Mod campaign (2016).
* NSTX-U: Experiments are planned in the first run campaign of NSTX-U (2015/2016) to measure low-Z impurity transport at reduced collisionality, to investigate the influence of rotation, and to validate neoclassical and micro-turbulence predictions.
* New analyses and modelling (exploring impact of additional transport mechanisms) of AUG and JET low Z measurements are planned, in combination with a closer comparison of plasma conditions in the two devices.
* Improve integrated modelling tools for heavy impurity transport in transport codes and thereby also enable the modelling of the evolution of the W behavior in transient phases.
* Predictions of W behavior in ITER depend on modelling assumptions of main plasma close to magnetic axis. Physics basis and experimental validation of core transport processes in the innermost region are required to refine W predictions.