EXP/P5-04

Longterm Evolution of Impurity Composition and Transient Impurity Events with the ILW at JET

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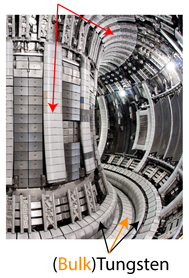
**See App. of F. Romanelli et al., Proc. of the 24th IAEA Fusion Energy Conf. 2012, San Diego, USA

Abstract

This paper covers the aspects of the longterm evolution of impurities in the main plasma and divertor of the JET Tokamak with respect to the newly installed ITER-Like Wall (ILW). Three main aspects considered are, firstly, the changes related to the switch over from the carbon dominated JET (pre 2011) to the ILW with beryllium as the main wall material and an all tungsten (W) divertor, secondly the evolution of impurity fluxes in the newly installed W divertor to monitor material migration and establishment of a steady state divertor surface composition, and thirdly the statistical analysis of irregular impurity events causing significant plasma contamination and radiation losses.
The main findings comprise of a drop in carbon emissions of a factor of 20, immediate low oxygen content comparable to levels obtained previously after campaign long conditiong due to the beryllium main wall. Despite the attempts of reaching steady state divertor conditions after the initial 1600 plasma seconds the divertor is still evolving due to increasing heating power applied through out the campaign. The levels of carbon released are increasing while beryllium levels in the deposition dominated inner divertor are dropping, hinting at a change in Mixed Material/ beryllium layer composition.

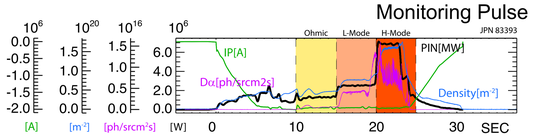
Methodology & Diagnostics



Study and describe the changes connected to the installation of the ITER-like Wall (ILW)
at JET

- Carbon vs Beryllium as main impurity
- Evolution since the installation of the ILW
- Study the impact of spurious impurity / radiation events

Monitoring Pulse



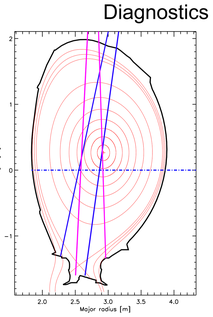
Three main aspects

1. Monitoring Pulses (ohmic cond.)
2. Overall trends (divertor phase)
3. Impurity Events (statistics)

- Overall trends will show high variability due to different plasmas conditions
- Monitoring pulses represent identical measurement conditions

Visible spectroscopy in the Divertor
UV spectroscopy in the main chamber
Additional Parameters: CXRS, Z_{eff},P_{IN}, ...

Diagnostics



Monitoring Pulses

Constant plasma parameters allow to study the longterm evolution

- Equilibrium is established after ~ 300 JET pulses

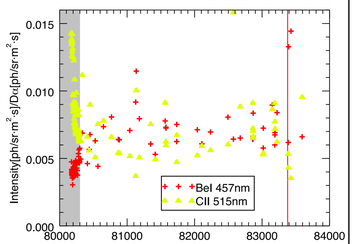
Carbon drops by at least a factor of 3 during the initial operation

- Slight increase in carbon levels in both the inner and outer divertor (20%) until the end of the campaign

- Beryllium levels are stable in the outer divertor (erosion dominated?)

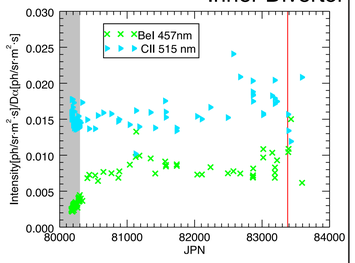
- Beryllium levels seem to decrease in the inner divertor - layer composition/ deposition changes

Outer Divertor



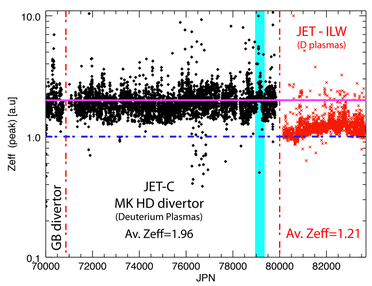
Be evaporation

Inner Divertor



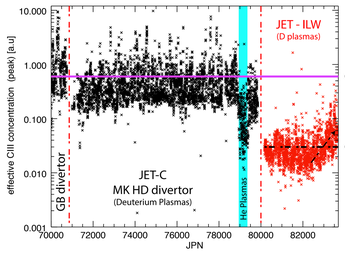
Change in the material mix, layer composition seems to be correlated with the change in plasma operation
Monitoring pulses display 'history', e.g. Be Evaporation

Overall Trends

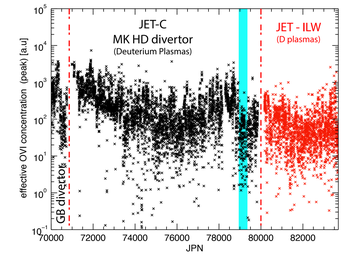


$$c_{imp} = \frac{Z_{eff} - 1}{Z_{imp} \cdot (Z_{imp} - 1)}$$

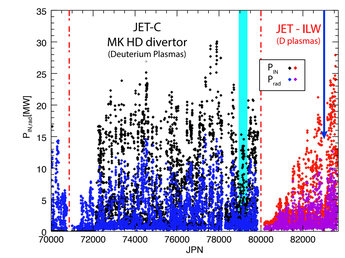
	3% Carbon	***2% Beryllium***
CXRS measurements:	***2-3% Carbon***	***2-3 % Beryllium***
		0.1-0.2% Carbon



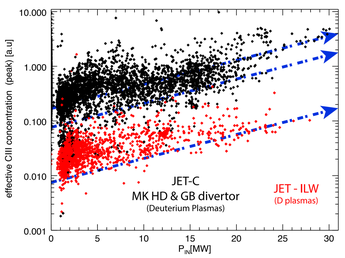
A clear drop in the CIII emissions of a factor 20 is visible when comparing the CFC JET phase with the JET ILW operation (compatible with CXRS).
With increasing power the carbon emissions rise.



Even after the major ILW shutdown low oxygen levels are observed immediately after restart. They are 10-20 lower then usual



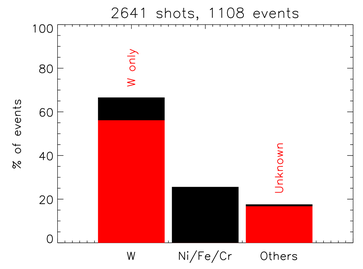
During the ILW campaign the levels of input power are increased incrementally from an ohmic initial phase up to high-power H-Modes



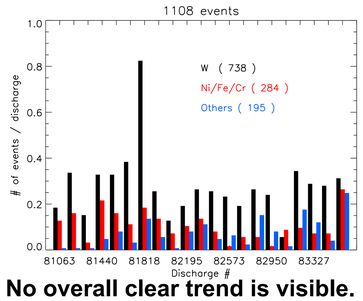
Both the CFC and ILW JET show the same increase in carbon emissons with power at significant lower levels

Beryllium becomes the main impurity during the ILW operation at JET, a clear conditioning is visible with respect to oxygen.
No apparent additional carbon sources so far

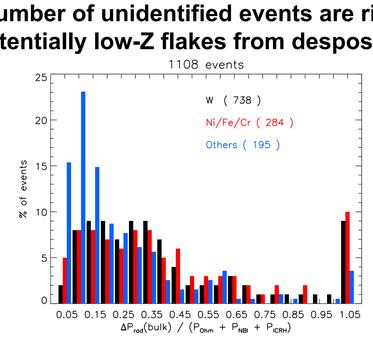
Impurity Events



Most impurity events are comprised of W or Ni,Fe,Cr potentially originating from machining of W/Inconel&Steel components



No overall clear trend is visible.
The number of unidentified events are rising - potentially low-Z flakes from desposits



The radiation signature of most events is similar. unidentified flakes however radiate less.

Impurity Events are impacting operation due to radiation losses and impurity accumulation.
No conditioning is seen unless from repetitive operation

Conclusion

The carbon concentration has reduced by at least a factor of 10-20 compared to the carbon dominated JET. Carbon emissions in the ILW show the same trend as with CFC PFCs (albeit at lower levels). No aparrent additional sources of carbon were observed, despite a slight increase in carbon in the divertor emissions - potentially from background carbon still remaining. The divertor composition, especially the inner divertor material mix is still evolving despite the early repetitive operation trying to establish a steady state divertor composition. Changes in plasma operation and especially heating power and density are likely to be the root cause for the observed behavior. In contrast to the CFC JET a large number of impurity events from W and nickel are observed impacting on plasma operation due to large radiation spikes. Repetitive plasma operation with similar plasmas improves the situation, however a long term conditioning is not observed. Generally, a steady state with the ILW seems to be reached despite minor changes in divertor and main chamber emissons since early on in the ILW campaign.

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