

Assessment of the use of injected impurities for heat flux mitigation in JET ELMy H-modes.

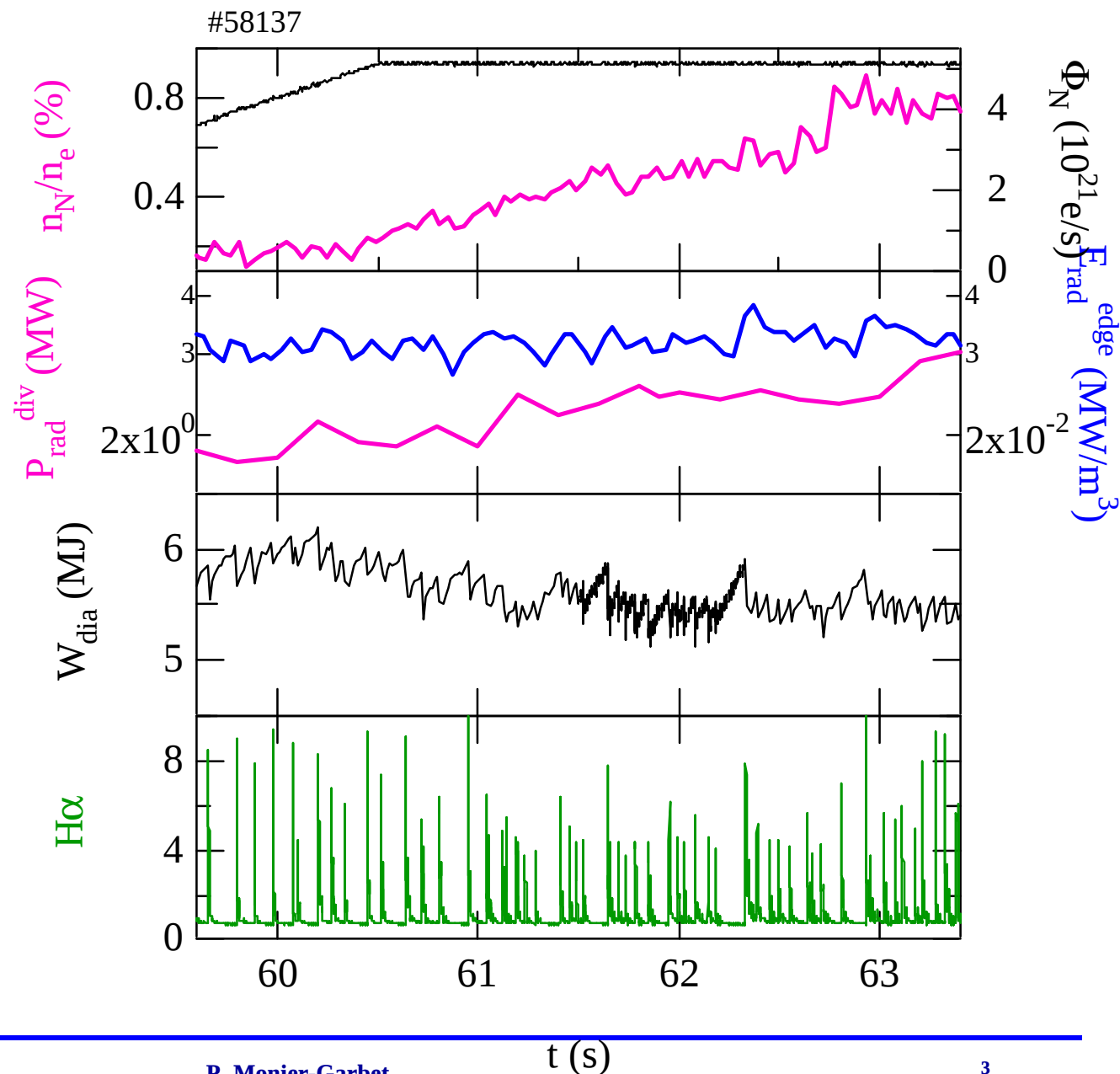
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and JET EFDA contributors.**

Introduction

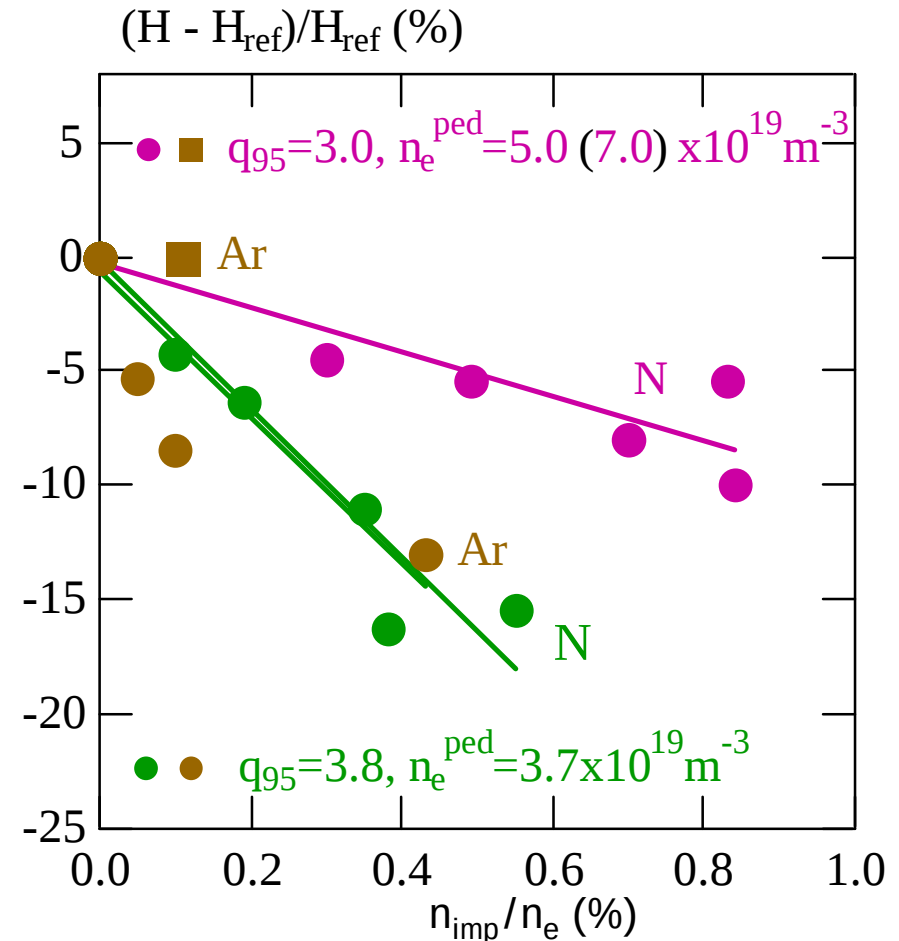
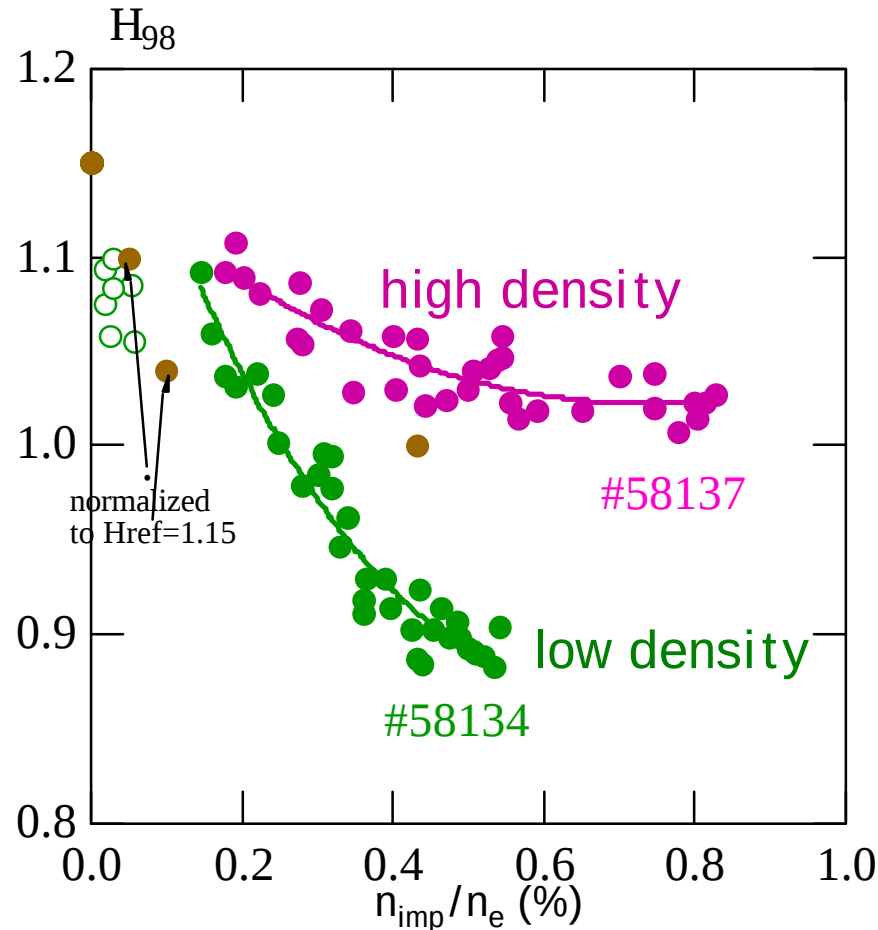
- One of the most severe problems for the operation of next step fusion devices in H-mode is the transient power load to the divertor target plates.
- Purpose: assess the use of impurity seeding to reduce Type I ELM heat fluxes through enhanced radiation, while maintaining good core confinement.
- Divertor radiation /edge radiation : **'buffering' effect ?**, What fraction of the ELM energy can be radiated away before reaching the target plates ?
- Experimental results are modelled using time-dependent SOLPS5.0 code.

Experimental scenario

- DOC-L for good edge diagnostic coverage, **in particular IR.**
- 2.0MA/2.4T
 - $q_{95} = 3.8$
 - $n_e^{\text{ped}} = 3.7 \times 10^{19} \text{m}^{-3}$
- 2.5MA/2.4T
 - $q_{95} = 3.0$
 - $n_e^{\text{ped}} = 5 \times 10^{19} \text{m}^{-3}$
- 14MW NBI
- low levels of N or Ar seeding



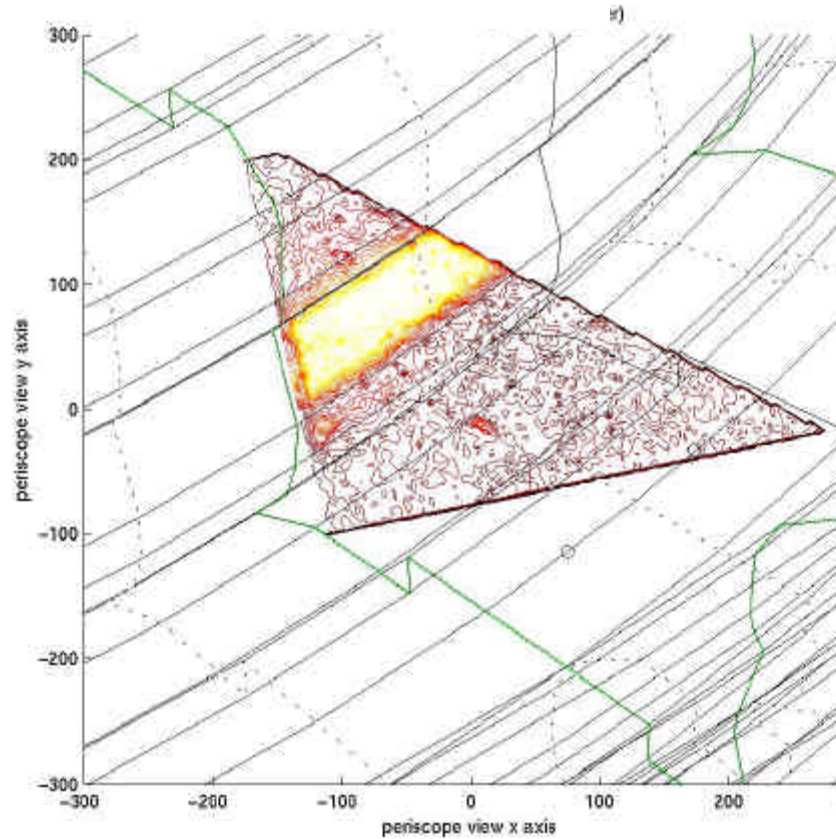
A weaker loss of confinement is observed in the high edge density case.



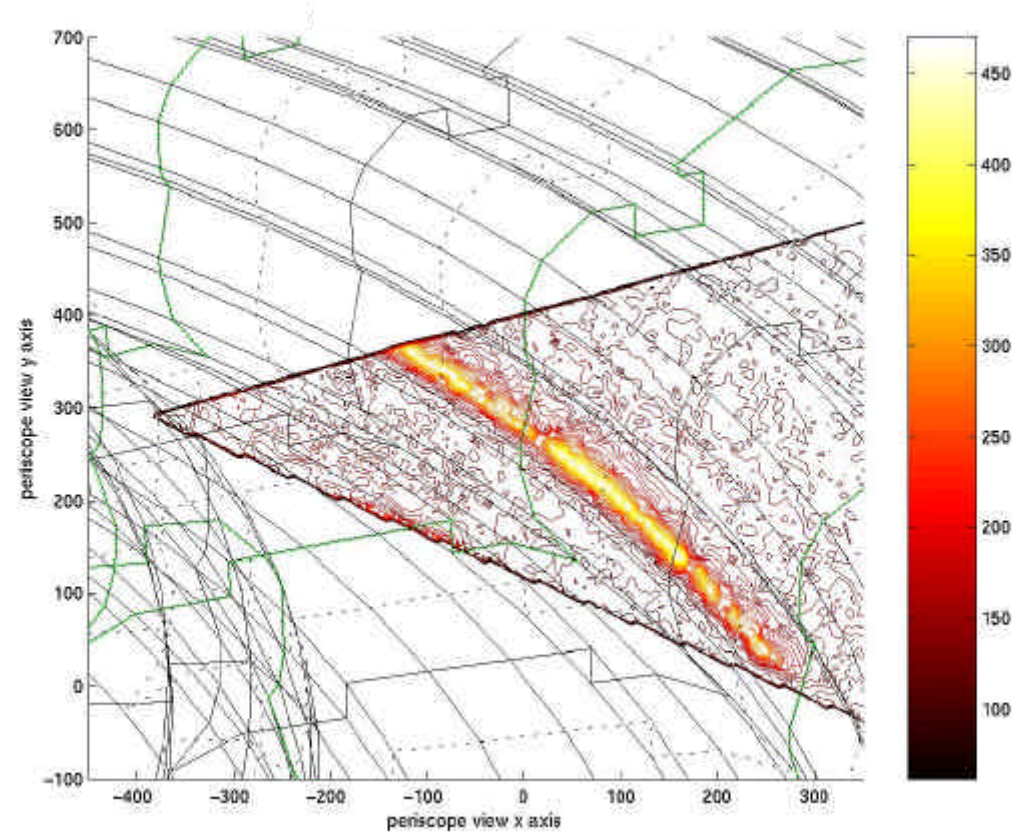
Low density case $\Rightarrow$ enhanced penetration of N ions $\Rightarrow$ enhanced radiation inside the separatrix $\Rightarrow$ modification of pedestal $\Rightarrow$ loss of confinement

The DOC-L config. provides a good view for IR camera.

Inner divertor view

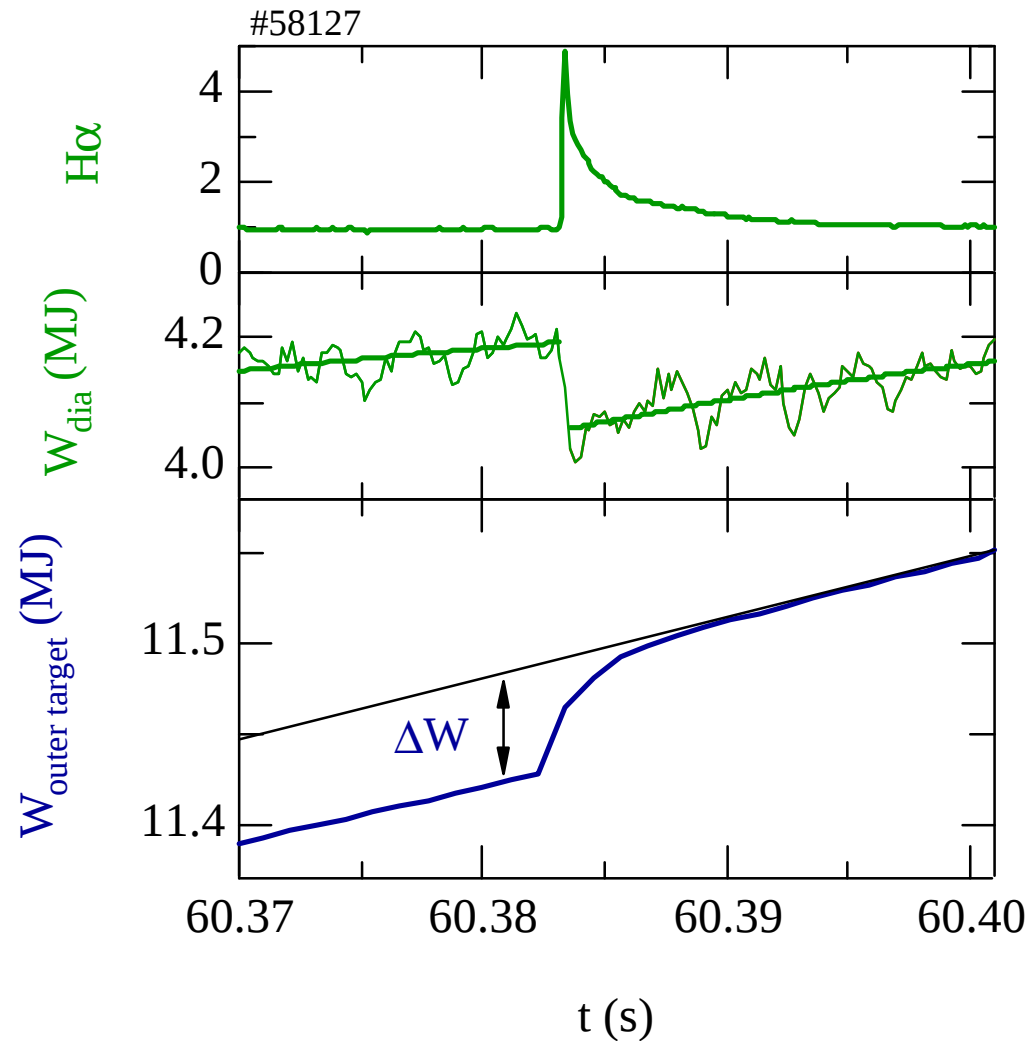


Outer divertor view

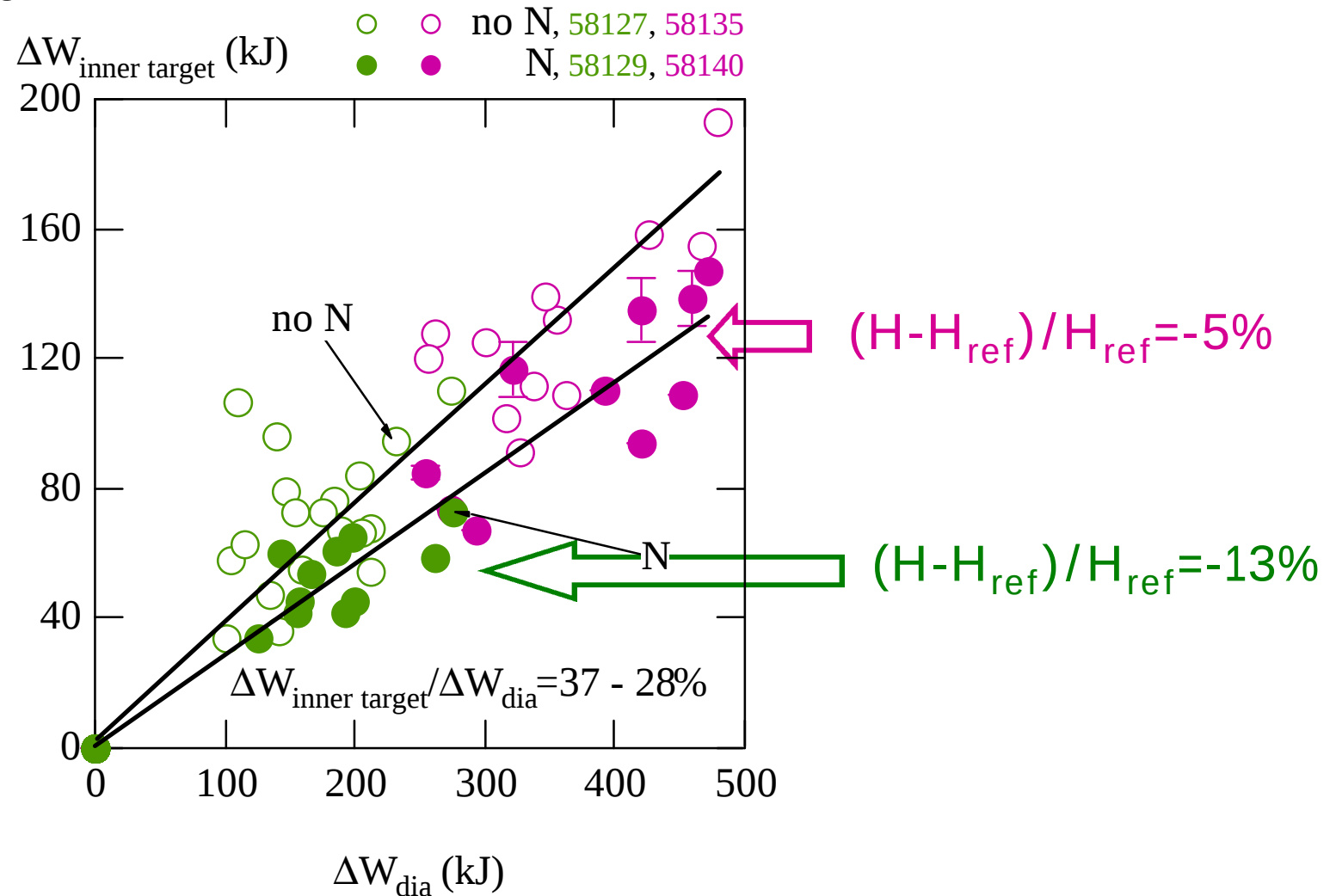


The energy deposited on the target plates is deduced from the surface temperature measurement: the presence of a codeposited layer on the inner target is taken into account.

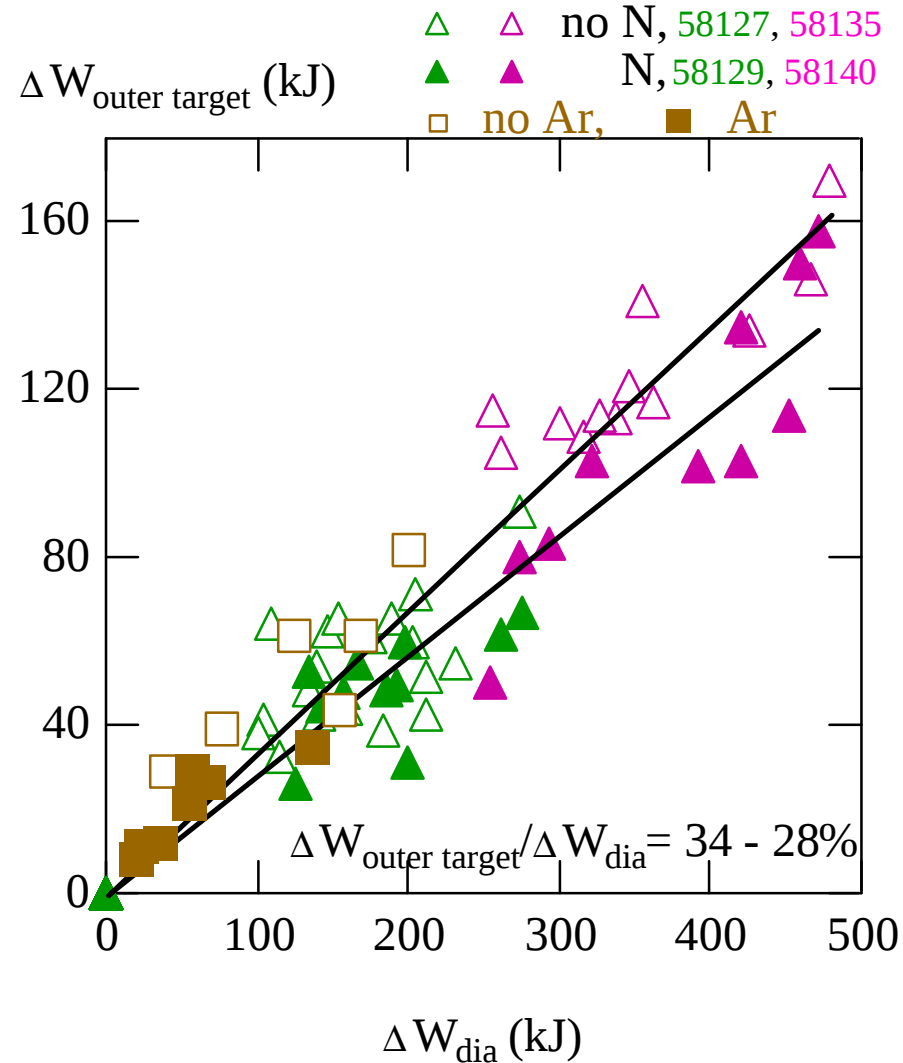
Target energy increase during an ELM : ΔW_{target}



The inner target energy increase during an ELM is reduced by 24% with N seeding.



The outer target energy increase during an ELM is reduced by $\approx 18\%$ with N seeding.



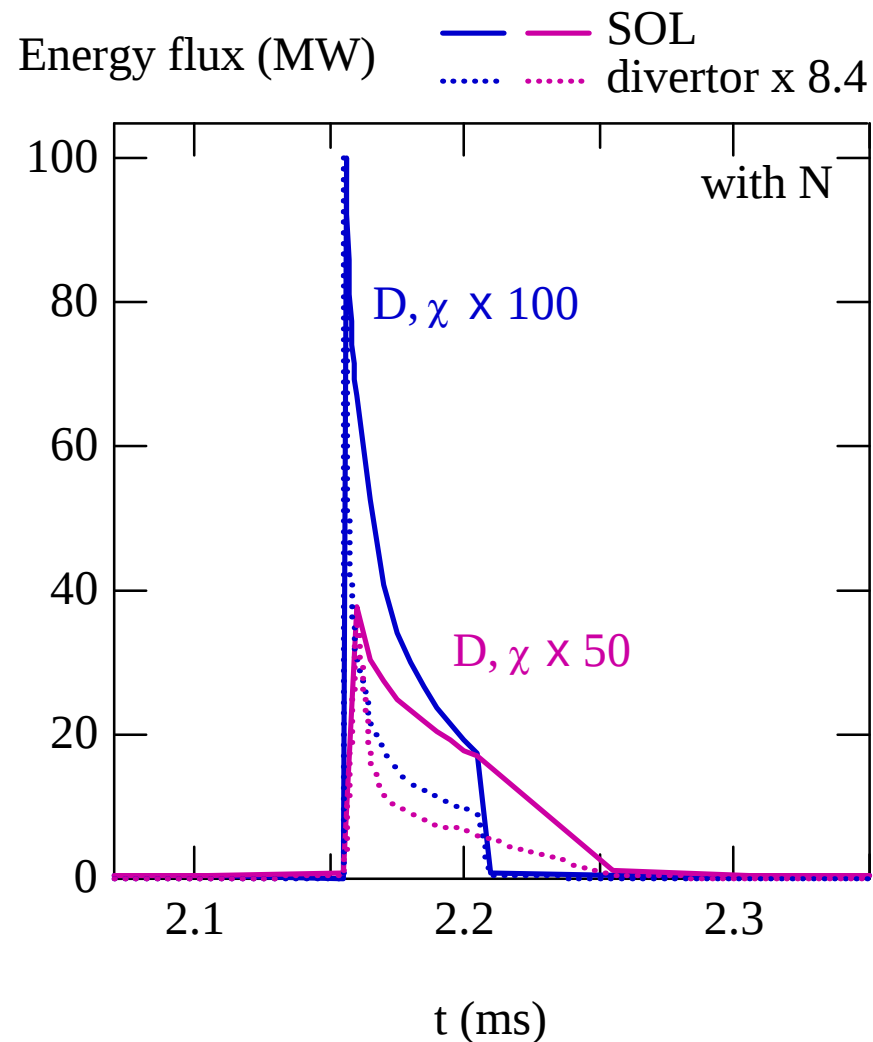
Modelisation with SOLPS5.0

D+C+N are included in the model.

ELMs are described by an increased particle and heat diffusivity:
D and χ s.s. = $1\text{m}^2/\text{s}$, increased to 50 or $100\text{m}^2/\text{s}$ to model an ELM.

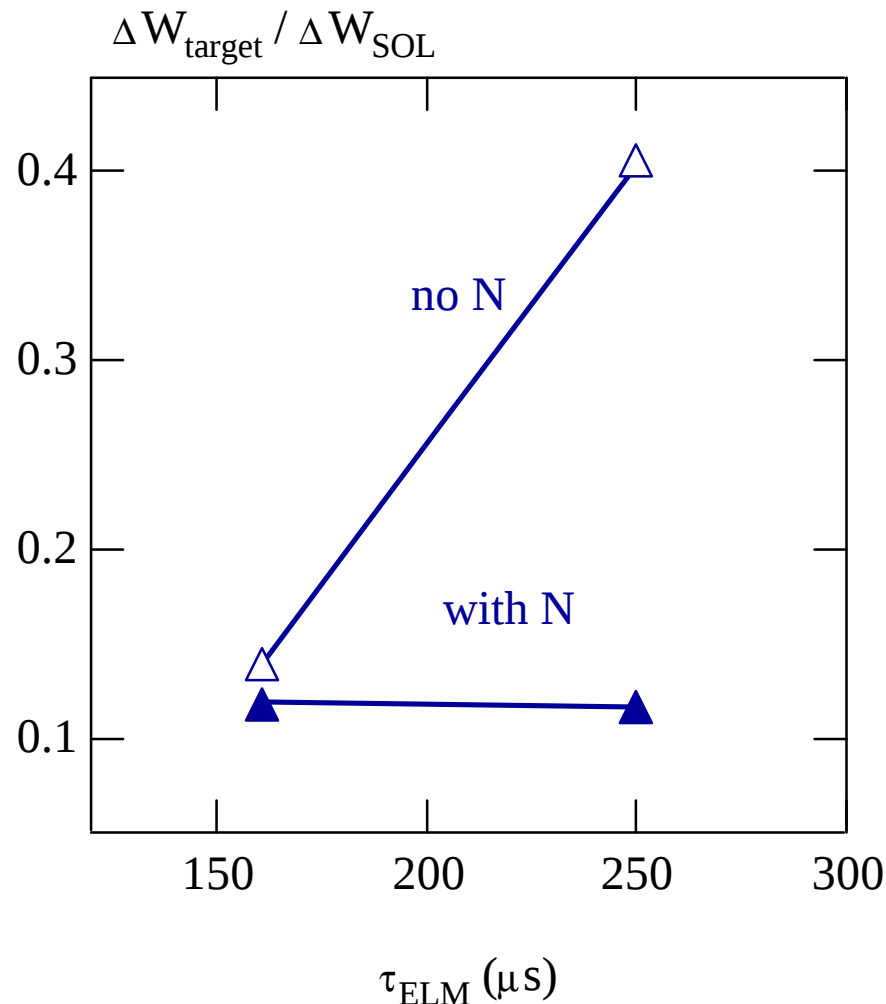
Experimental data from 58135 (without N) and 58139 (with N).

ELM model: enhanced transport coefficients



Same plasma energy loss ($W_{\text{dia}} = 400 \text{ kJ}$), but the higher (D, χ) enhancement case $\Rightarrow$ smaller τ_{ELM}

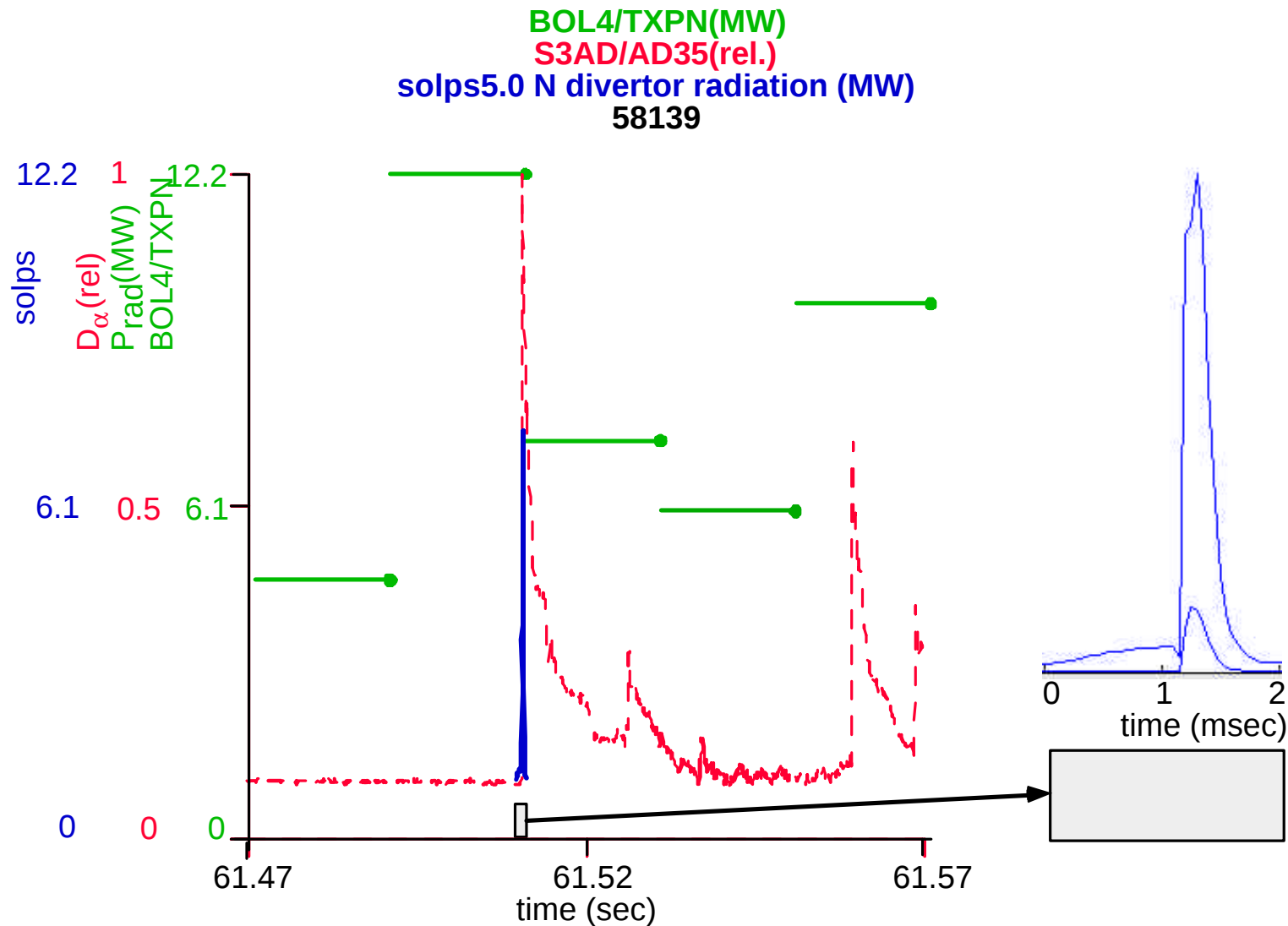
- The calculated fraction of the ELM energy reaching the target is smaller than that actually observed.



- The reduction of $\approx 15\%$ of $\Delta W_{\text{target}} / \Delta W_{\text{SOL}}$ with N seeding which is calculated for $\tau_{\text{ELM}} \approx 150 \mu\text{s}$ is consistent with the exp. results, and with previous calculations (Rapp et al., submitted to NF).

τ_{ELM} = time needed to remove the energy from the pedestal.

Sensitivity study: increase of N radiation associated to an ELM is too small to be measured by bolometry.



Conclusion (1/2)

1) 18 to 24% decrease of the energy to the target plates during Type I ELMs is measured with low levels of N seeding.

2) This is obtained with a loss of confinement that may be limited to $\approx 5\%$ when the edge electron density is high, favouring low core penetration of the radiating N ions, and high divertor radiation.

At lower edge density, the same reduction of $\Delta W_{\text{target}} / \Delta W_{\text{dia}}$ is obtained with a loss of confinement $>13\%$.

3) Higher triangularity configuration (as ITER-like) should be beneficial, since even higher edge densities are then achieved with good confinement. Experiments at high triangularity and high density are scheduled in C12, to determine whether $\Delta W_{\text{target}} / \Delta W_{\text{dia}}$ can be further reduced.

Conclusion (2/2)

4) SOLPS calculations suggest that some fraction (15% ?) of the ELM energy is indeed radiated before it reaches the target plates.

This is consistent with previous code results for JET (Rapp et al.).

- Bolometric measurements are not fast enough to resolve any radiation increase that might correspond to individual ELMs.

- More work is needed to understand the discrepancy which is found between code and experiment for the absolute value of $\Delta W_{\text{target}} / \Delta W_{\text{SOL}}$.