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

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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.

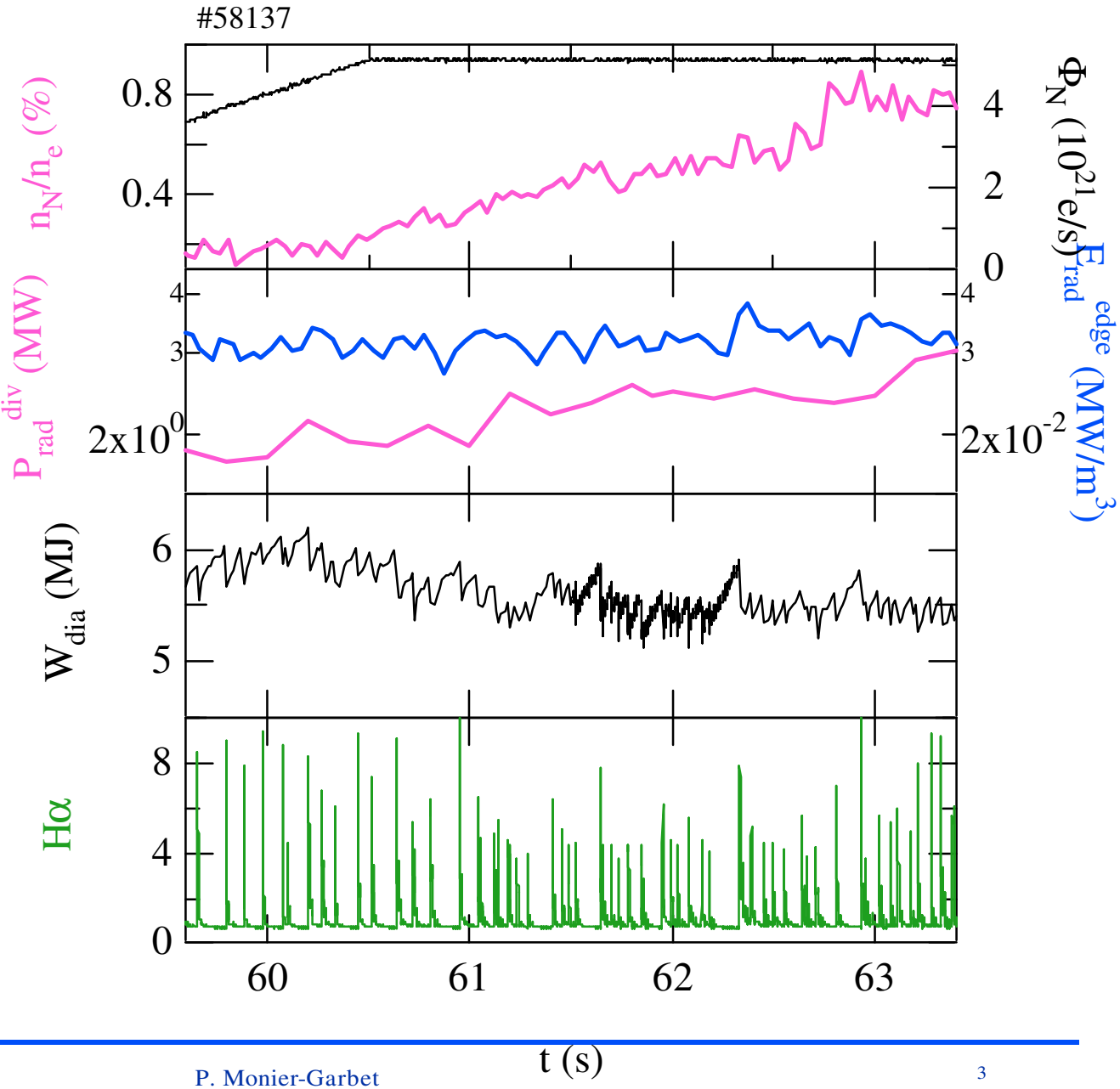
• Purpose: assess the use of impurity seeding to reduce Type I ELM heat fluxes through enhanced radiation, while maintaining good core confinement.

• Divertor radiation /edge radiation : 'buffering' effect ?, What fraction of the ELM energy can be radiated away before reaching the target plates ?

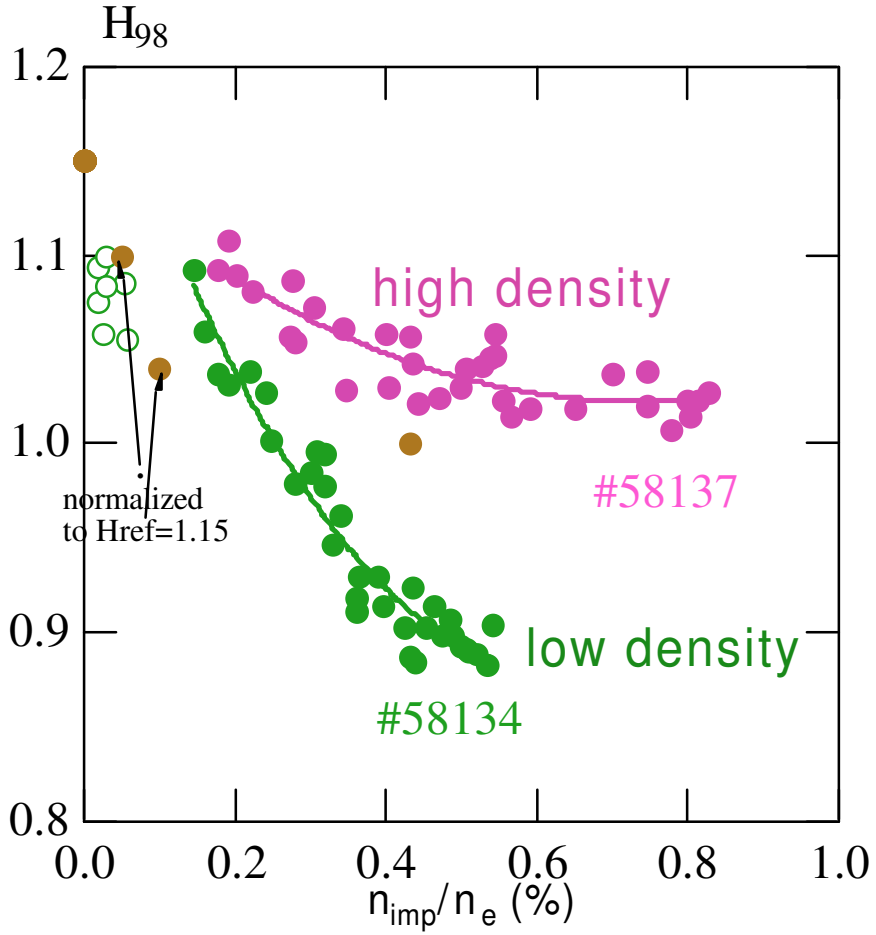
• Experimental results are modelled using time-dependent SOLPS5.0 code.

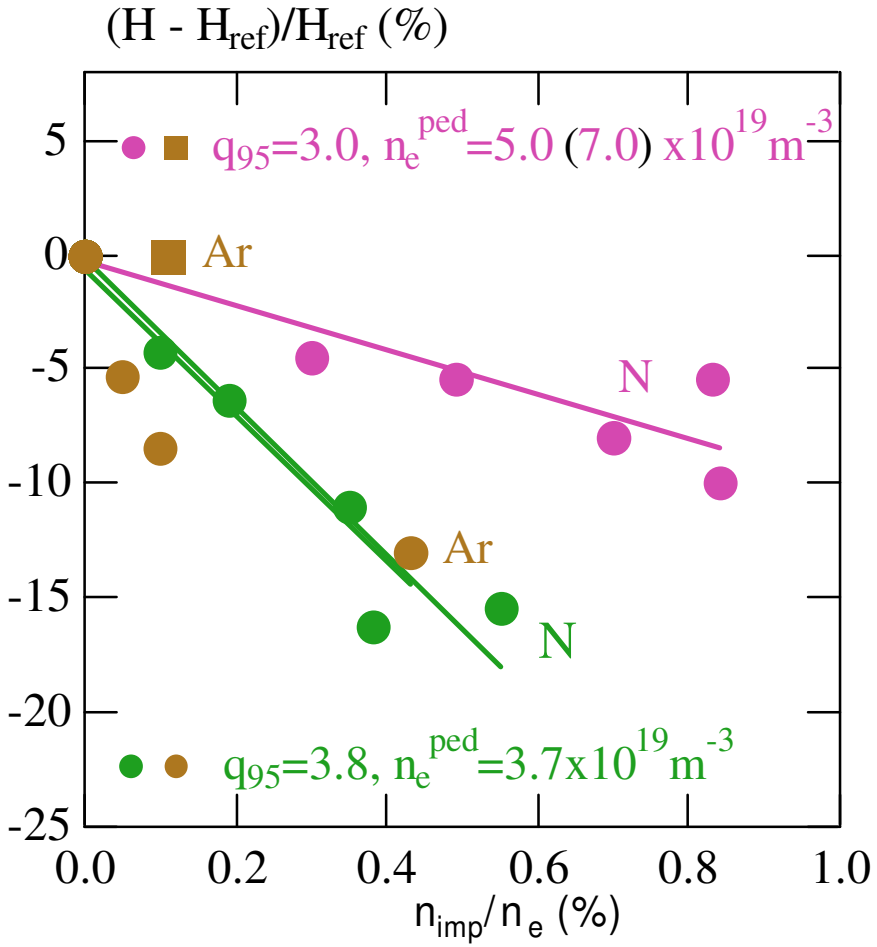
Experimental scenario

- DOC-L for good edge diagnostic coverage, in particular IR.
- 2.0MA/2.4T
  - q_{95} = 3.8
  - n_e^{ped} = 3.7x10^{19}m^{-3}
- 2.5MA/2.4T
  - q_{95} = 3.0
  - n_e^{ped} = 5x10^{19}m^{-3}
- 14MW NBI
- low levels of N or Ar seeding



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

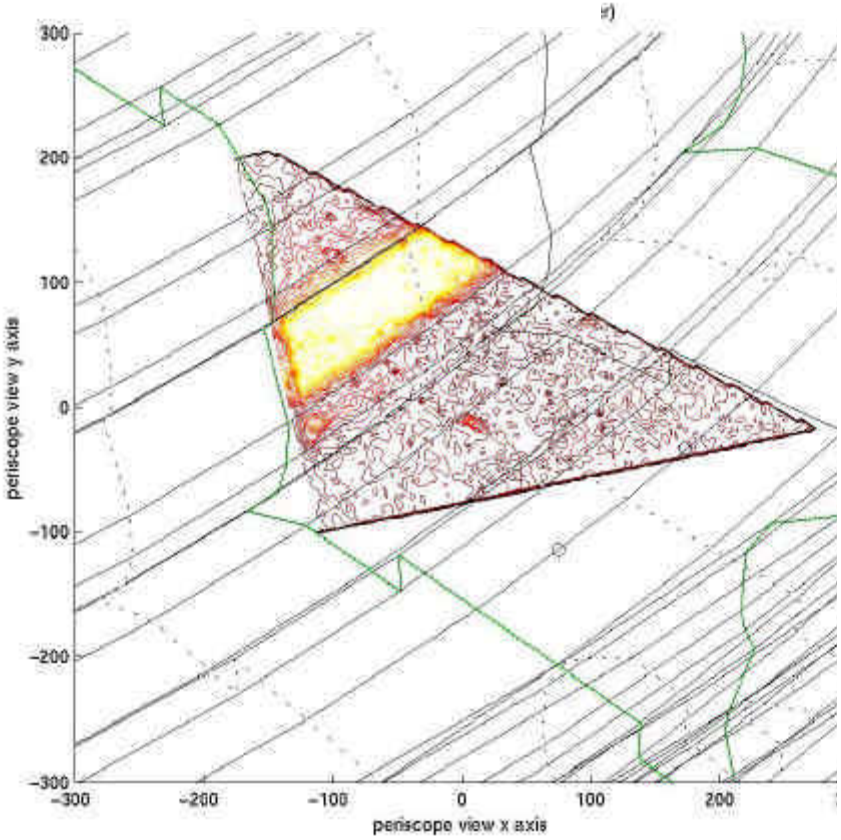




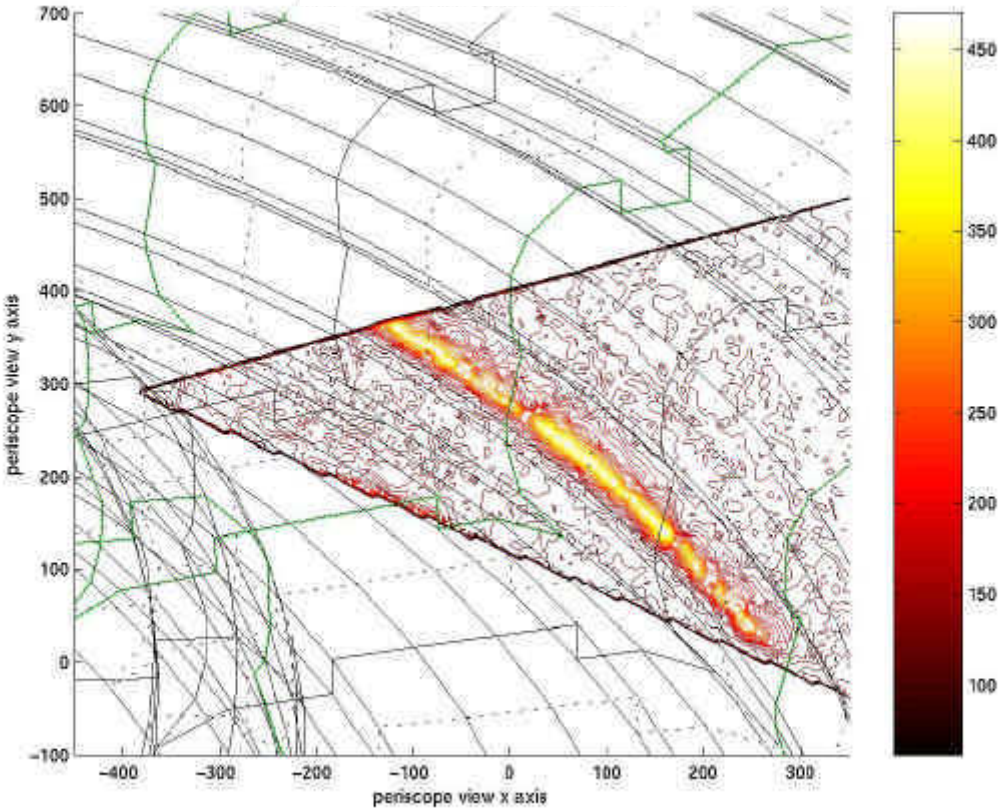
Low density case ⇒ enhanced penetration of N ions ⇒ enhanced radiation inside the separatrix ⇒ modification of piedestal ⇒ loss of confinement

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

Inner divertor view

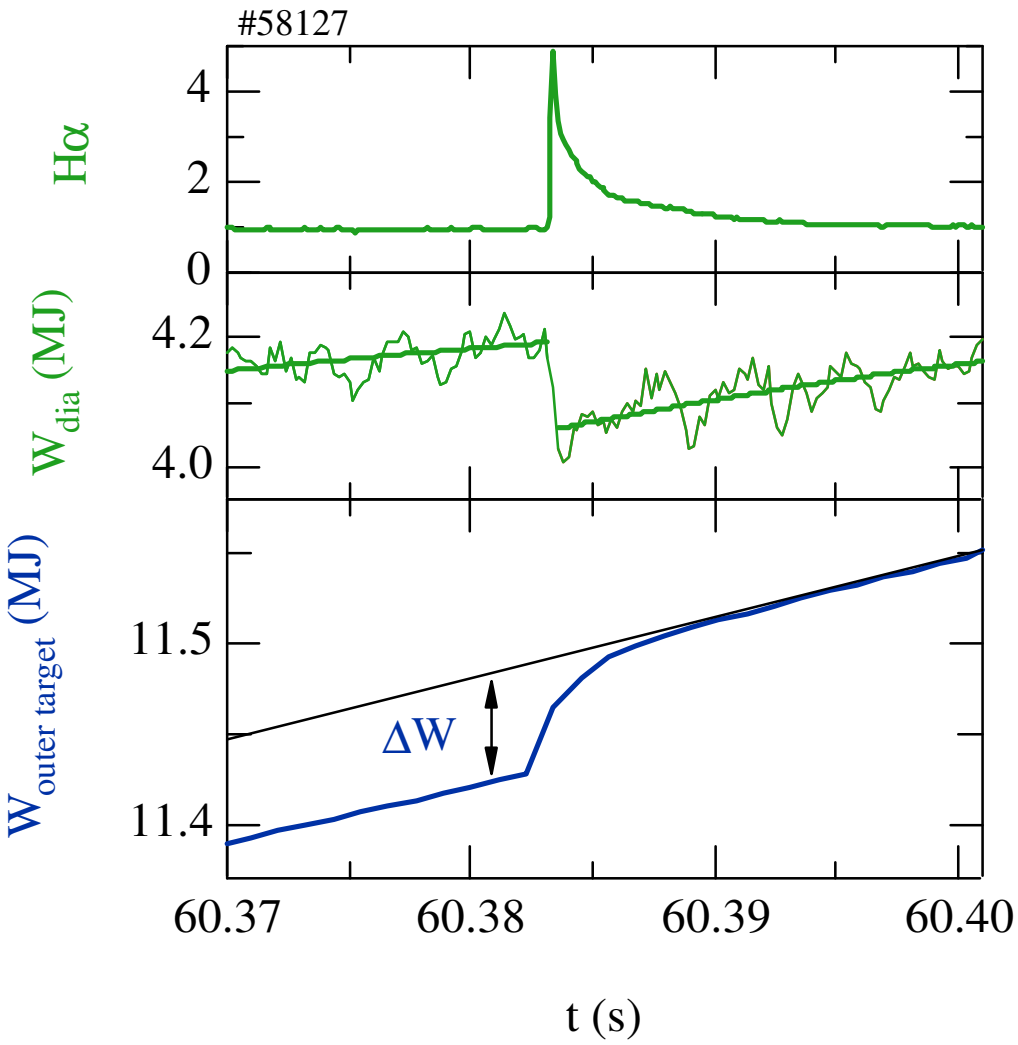


Outer divertor view

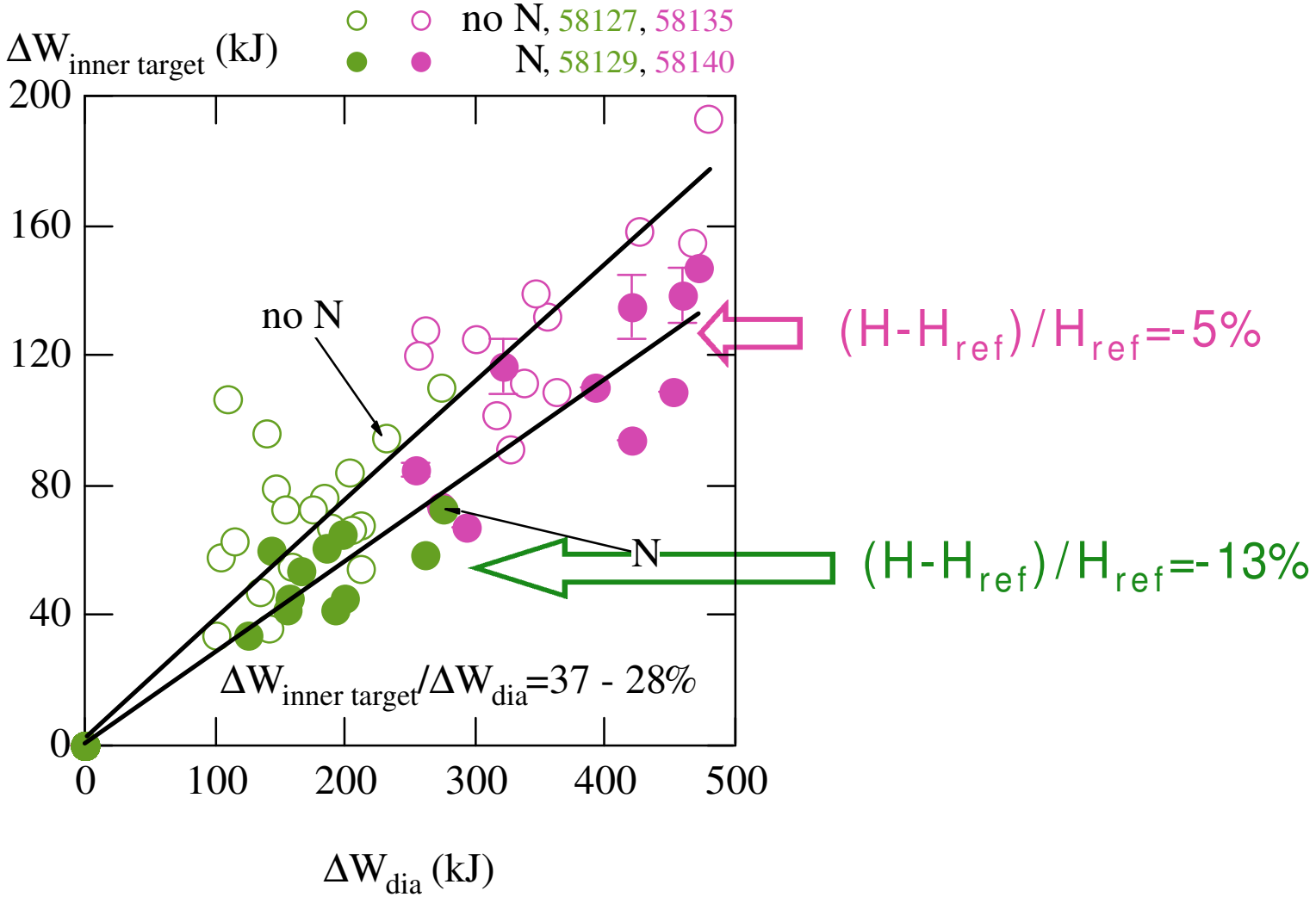


The energy deposited on the target plates is deduced from the surface temperature measurement: the presence of a codeposited layer on the inner target is taken into account.

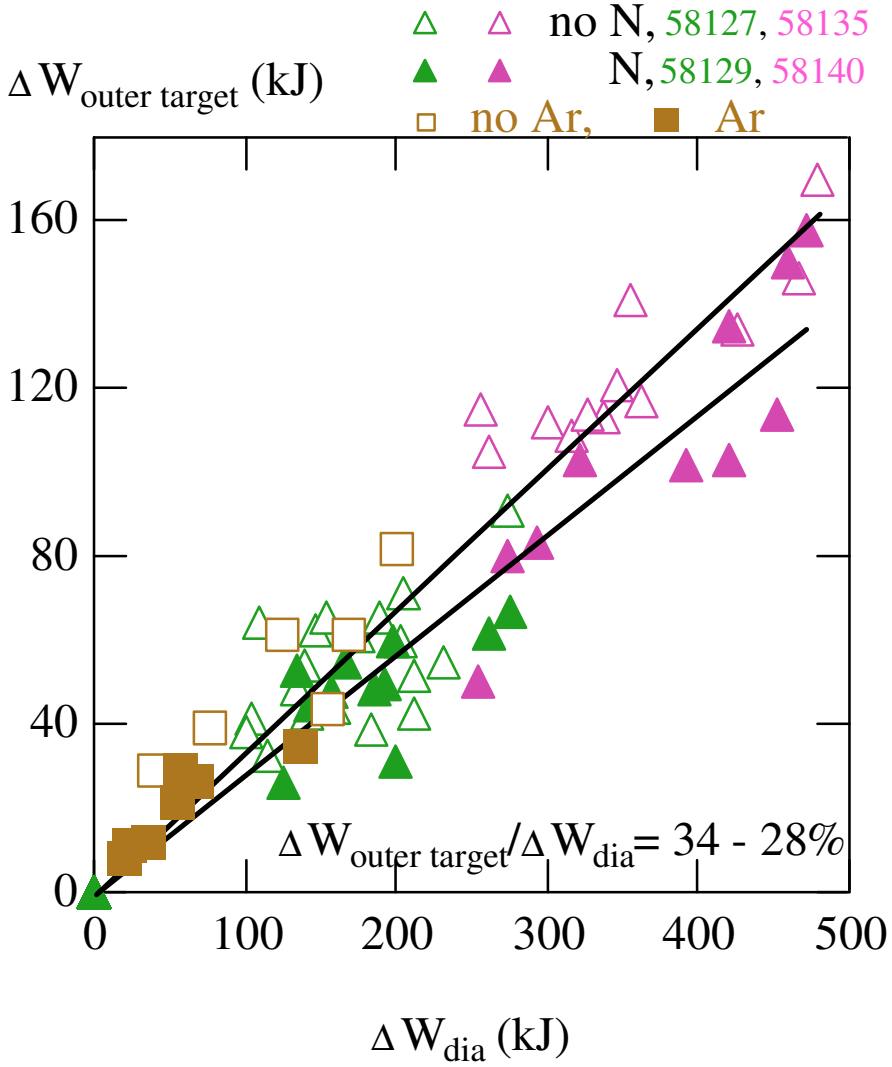
Target energy increase during an ELM : ΔW_{target}



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.



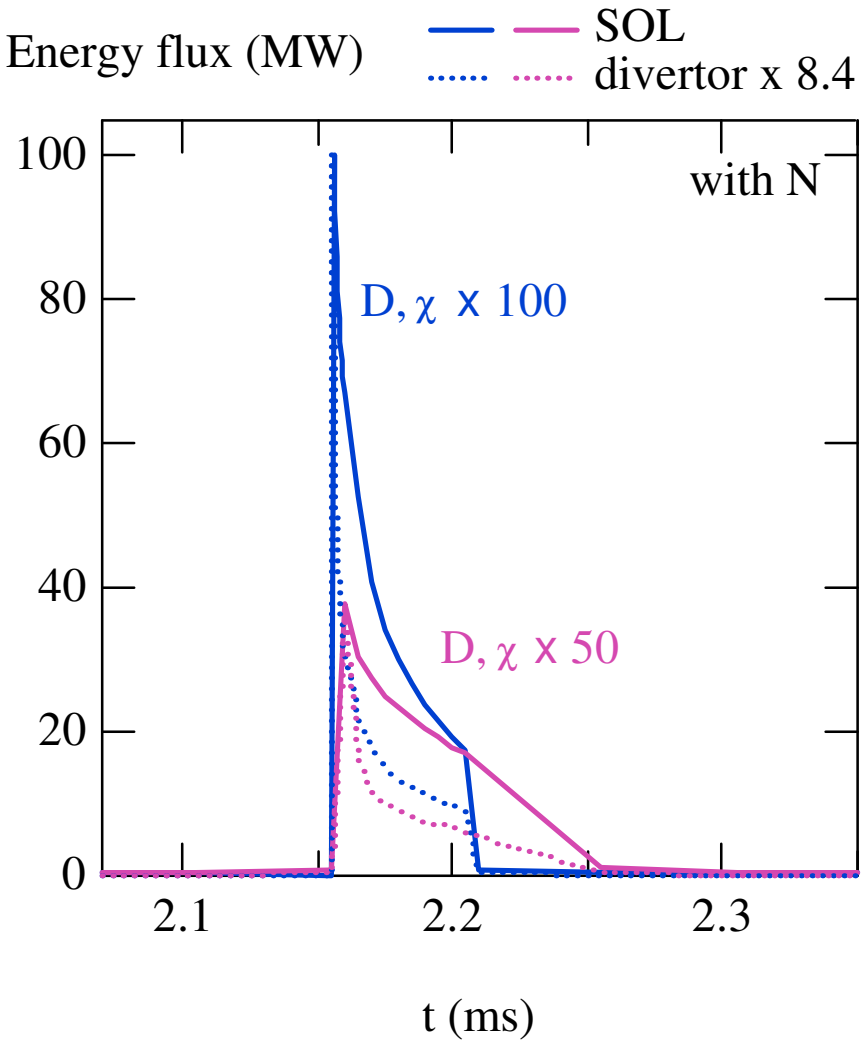
Modelisation with SOLPS5.0

D+C+N are included in the model.

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

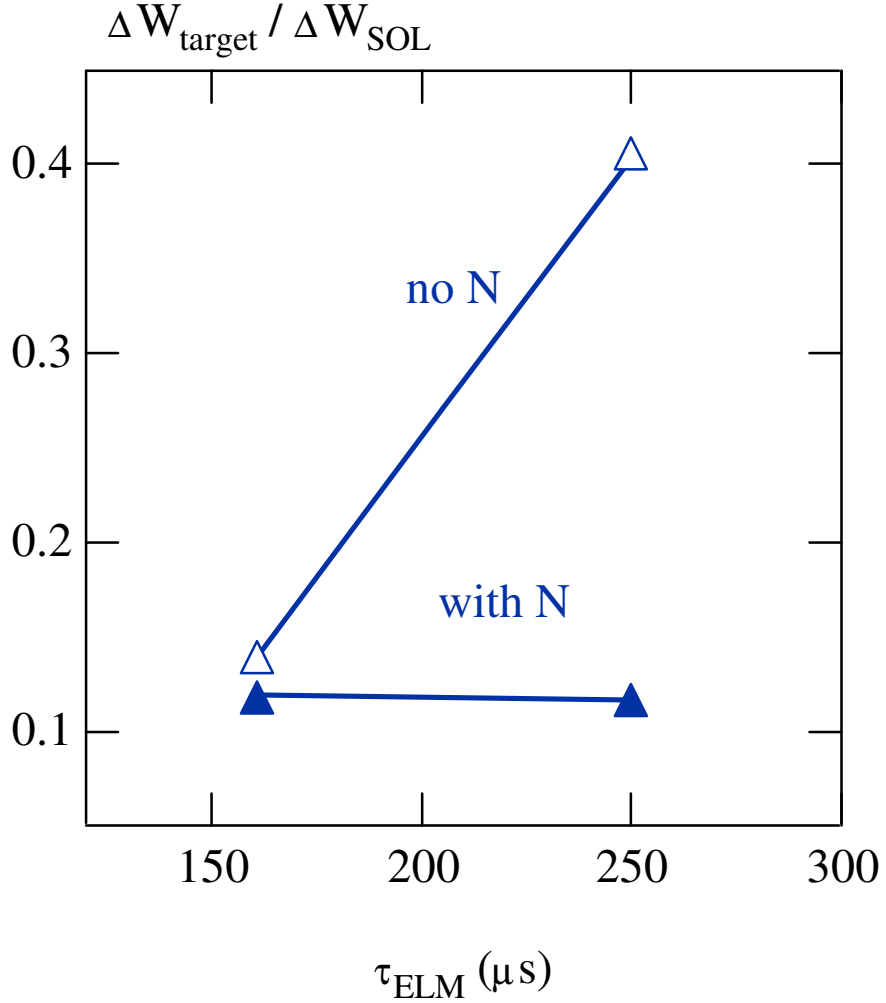
Experimental data from 58135 (without N) and 58139 (with N).

ELM model: enhanced transport coefficients



Same plasma energy loss (Wdia = 400 kJ), but the higher (D,χ) enhancement case ⇒ smaller τ_{ELM}

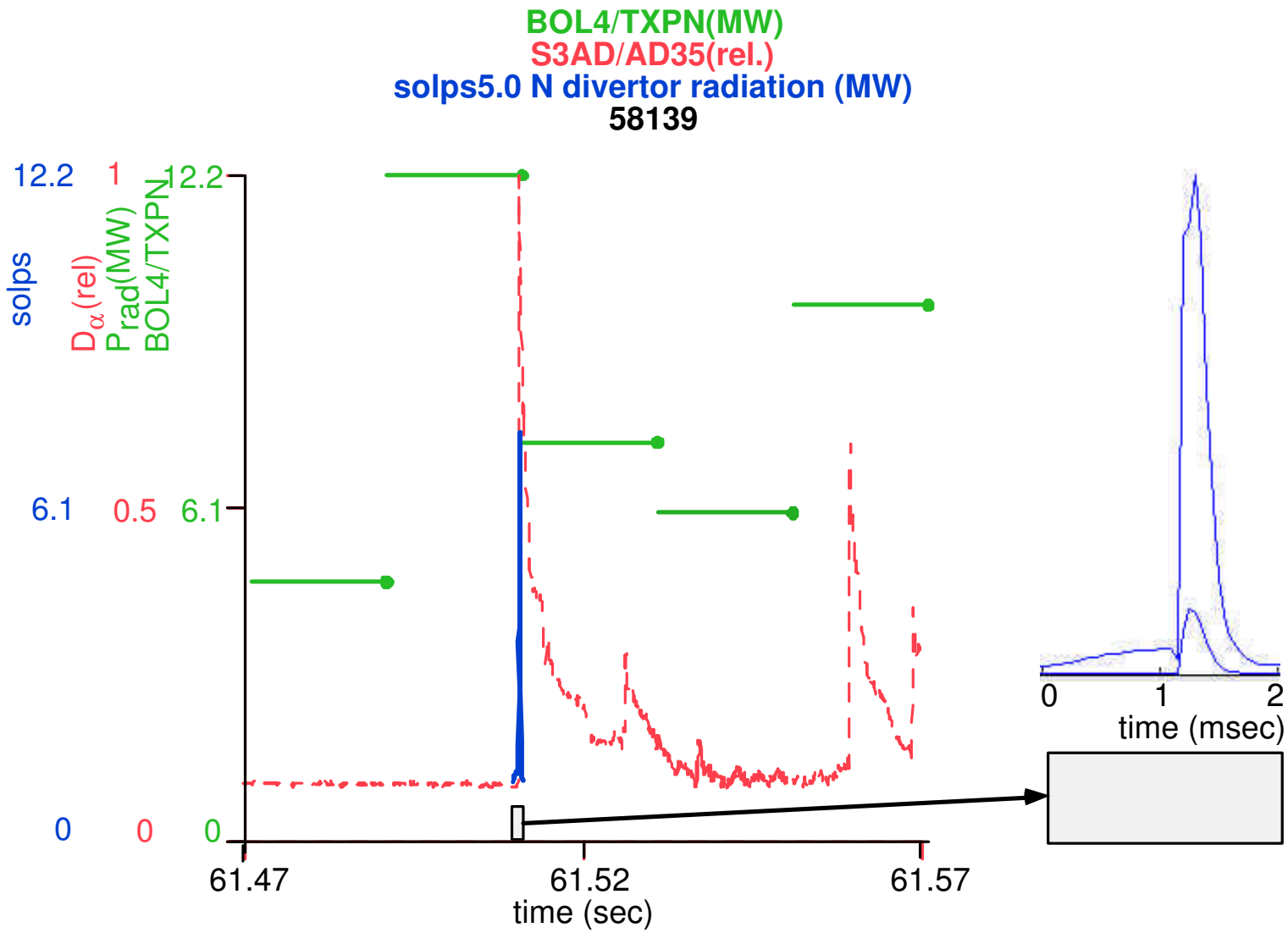
• The calculated fraction of the ELM energy reaching the target is smaller than that actually observed.



• The reduction of $\approx 15\%$ of $\Delta W_{target} / \Delta W_{SOL}$ with N seeding which is calculated for $\tau_{ELM} \approx 150 \mu s$ 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 TypeI ELMs is measured with low levels of N seeding.

2) This is obtained with a loss of confinement that may be limited to $\tilde{\approx} 5\%$ 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 $\Delta W_{target}/\Delta W_{dia}$ 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 $\Delta W_{target}/\Delta W_{dia}$ 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 correpond to individual ELMs.

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