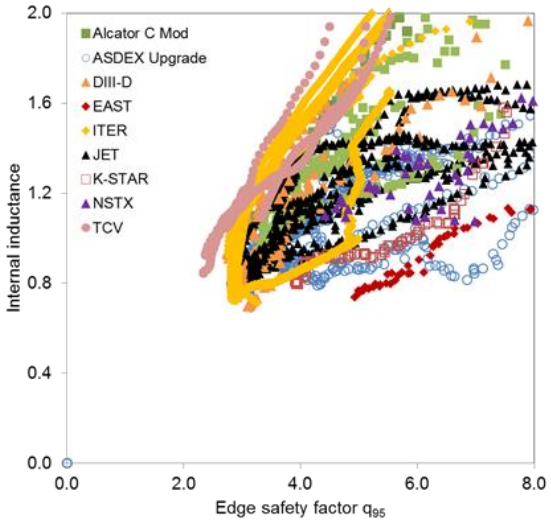
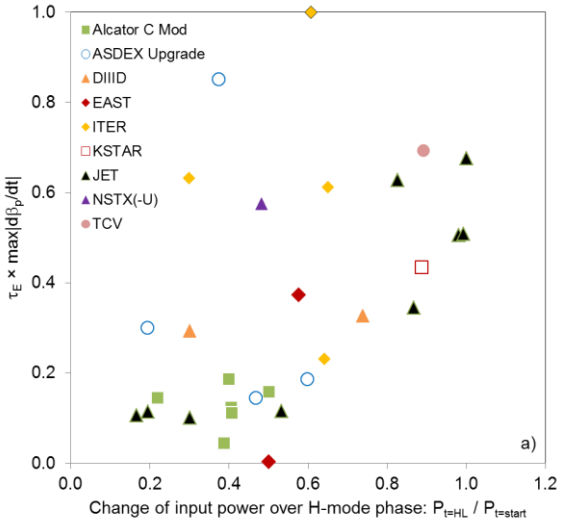
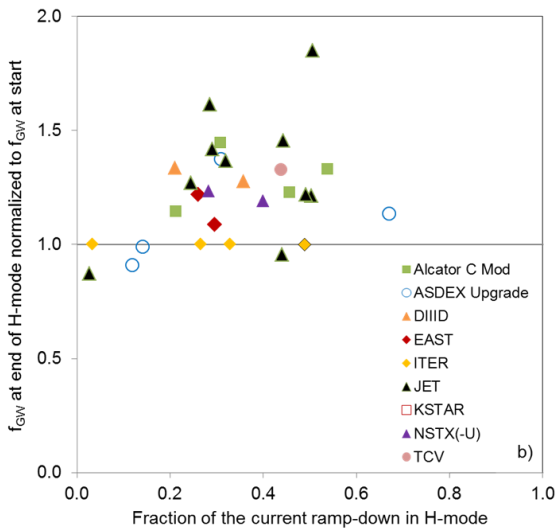
Multi-machine analysis of termination scenarios, … P6-41

The study aims to show that the specific ITER design features allow a stable well-controlled termination. This is a joint effort in control, exception handling development and physics modelling [2,3]. Relevant for ITER is to maintain vertical, radial position, and shape control during the termination, especially at the time of the relatively fast H-L transition. The analysis of a database, built using a selected set of experimental termination cases, showed:

- ITER will ramp down faster (relative to the L/R time) than most present-day devices
- VS control is manageable in ITER, even at high li, because of a strong elongation reduction
- This means that ITER remains longer, at lower q (q_{95}~3) than most present-day devices
- In H-mode, the density decays slower than the plasma current ramp-down
- The consequential increase in f_{GW}, limits the duration of the H-mode phase
- Fast power ramp-down leads to a larger change in β_p at the H-L transition ➔ radial control







Aim of the research

To improve our understanding of the dynamics and control of ITER terminations, a study has been carried out on data from existing tokamaks.

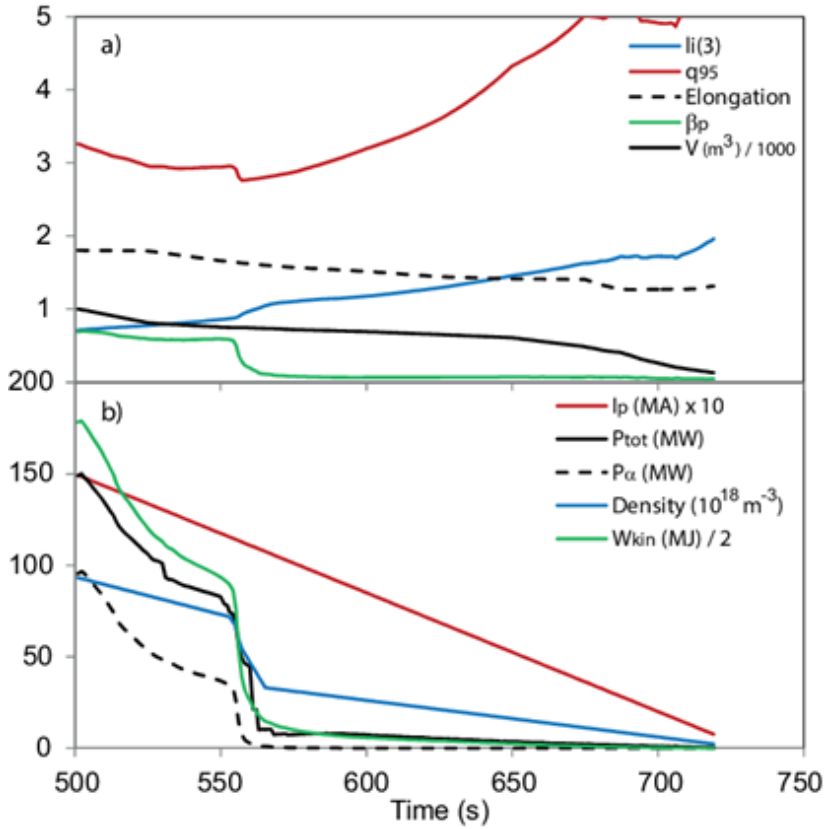
The aim of this joint analysis is to compare the assumptions for ITER terminations with the present experience basis.

The study examined the parameter ranges in which present day devices operated during their terminations, as well as the dynamics of these parameters.

ITER termination scenarios: restrictions and example

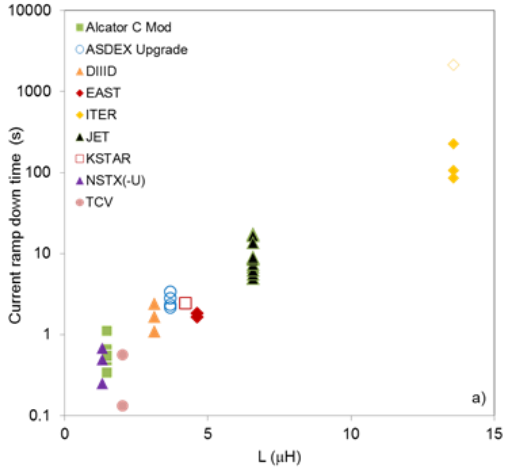
The paper describes the many constraints related to tokamak terminations and specifically those for ITER, especially those related to VS stability and the H to L back transition

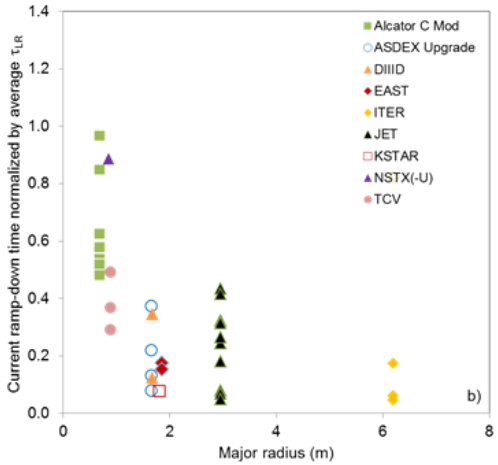
Modelled ITER terminations are described.

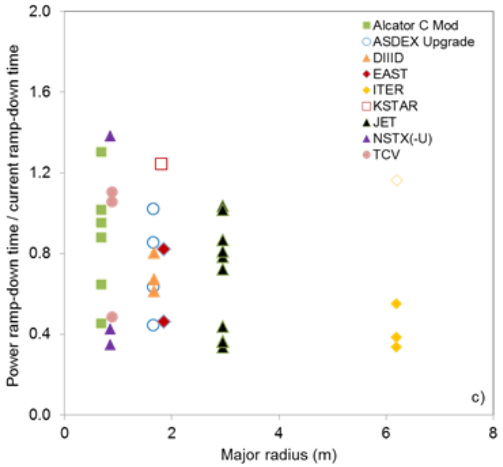


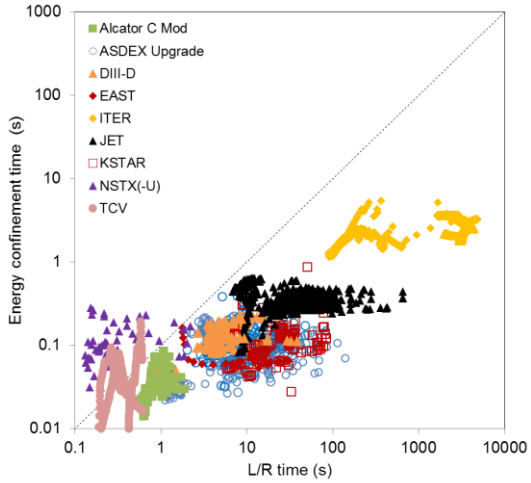
Database of tokamak terminations

A database has been created consisting of typical, special and ITER-like, terminations from Alcator C-Mod, ASDEX Upgrade, DIII-D, EAST, JET, KSTAR and NSTX/NSTX-U and TCV.



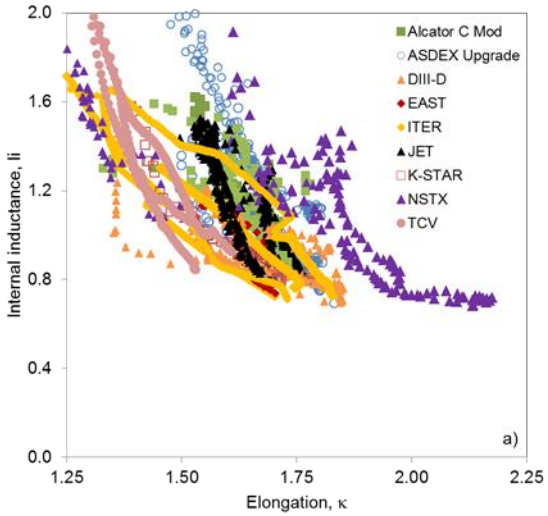


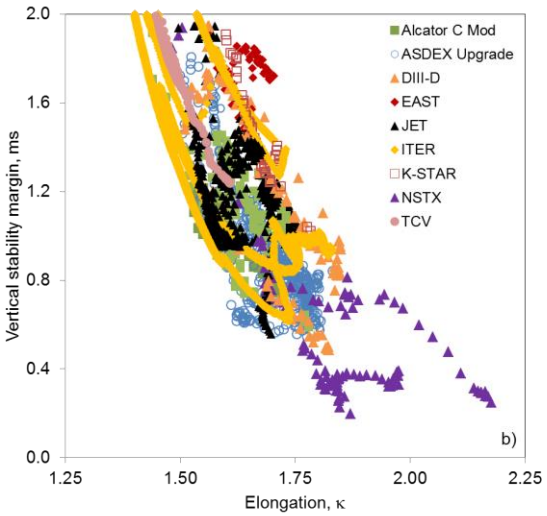


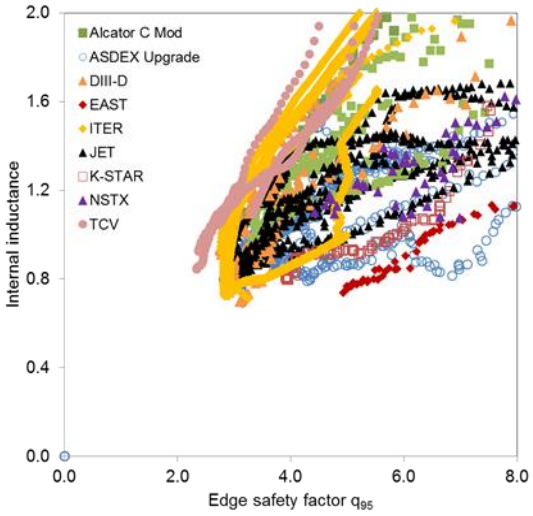


Comparison of stability aspects

Maintaining VS is an important aspect for a termination. The VS of the plasma depends on a complex function of li, βp and elongation, and, furthermore, on the proximity of the plasma to stabilizing passive components, such as the vacuum vessel in ITER, and on the capability of the VS control circuit.

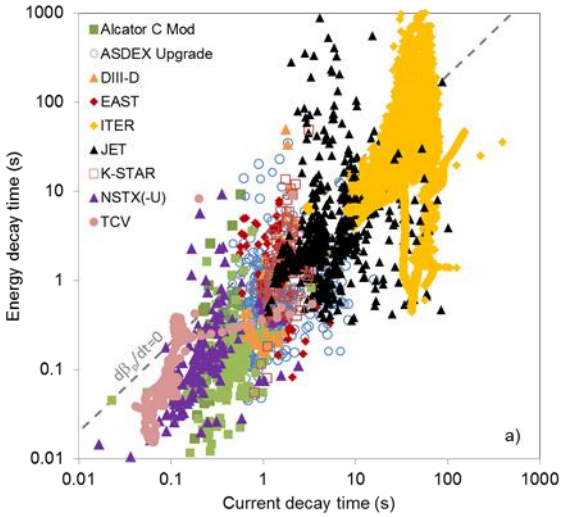


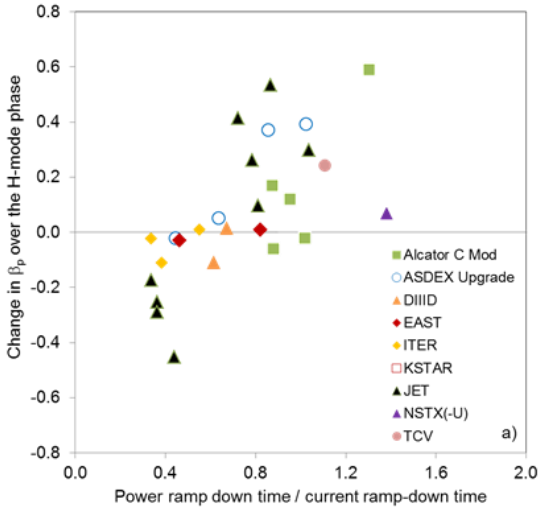


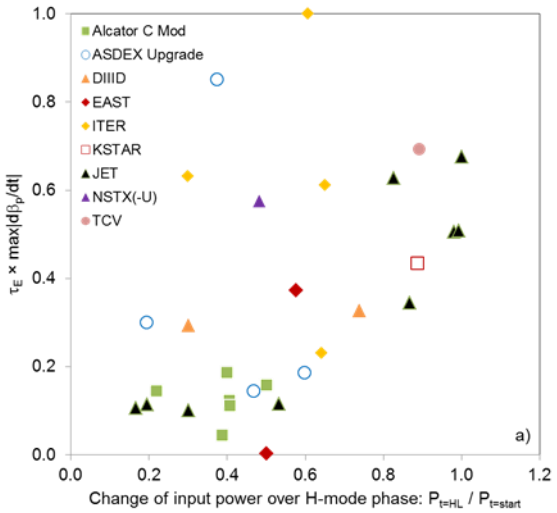


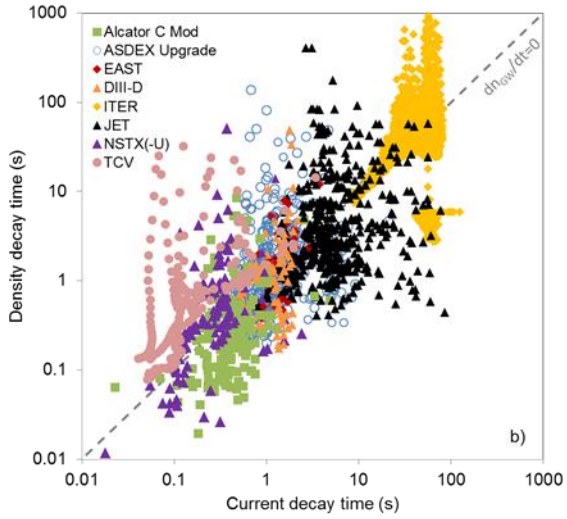
Comparison of dynamics

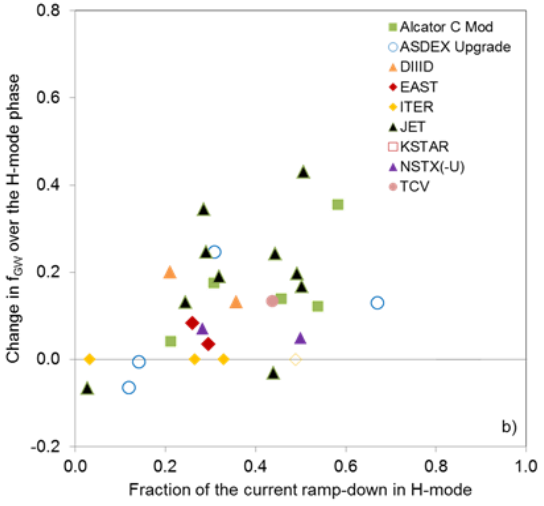
While in most cases the current is ramped down at a constant rate, the decay rates of thermal energy, or β_p, density or Greenwald fraction, f_{GW} will vary.

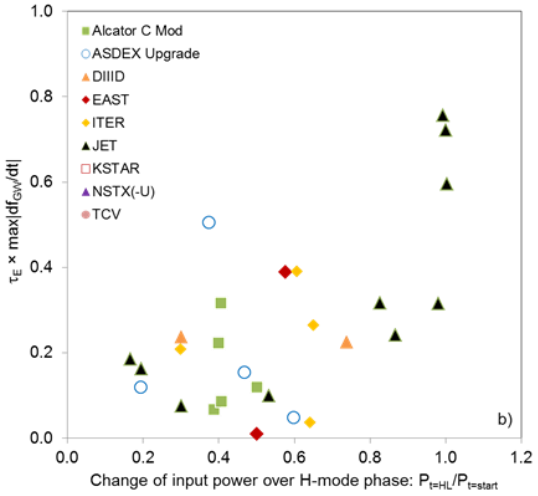












Conclusions

Characteristic parameters (τ_E, $\tau_{R/L}$, exhaust) do not scale similarly.

The duration of the H-mode phase, as a fraction of the current ramp-down, is limited by the auxiliary power capacity at ITER and the increase in f_{GW}.

The magnitude of the change in β_p and f_{GW} during the HL transition has been determined.

The results from this analysis can be used to better prescribe the inputs for the detailed modelling and preparation of ITER termination scenarios.