DEVELOPING HIGH PERFORMANCE RF HEATING SCENARIOS ON THE WEST TOKAMAK

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INTRODUCTION

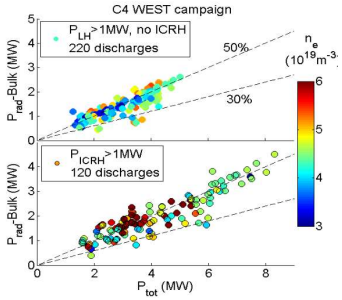
WEST: Bt=3.7T, R=2.5m, a=0.45m, R/a=5-6, k~1.3, Ip≤1MA

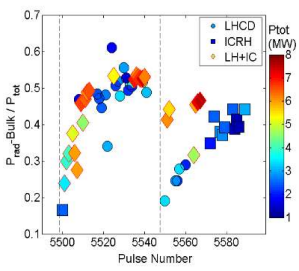
- Fully actively cooled (Divertors, 2 LHCD and 3 ICRH antennas)
- Full Tungtsen machine (Divertors and limiters)
- No NBI: No strong toroidal rotation and no central particle source => no expected tungsten accumulation

2019 campaign (C4):

- 5MW/1s coupled from each HCD system, 8MW/3s (8.8MW/0.5s)
- 53-second pulse with 3MW of LHCD

PLASMA RADIATION DURING HIGH RF INJECTION

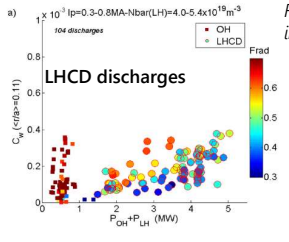




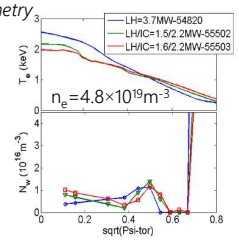
- Fraction of power radiated in the bulk plasma Frad-Bulk is rather constant for Pin= 1-6MW : Frad-Bulk~50%
- LHCD + ICRH pulses: more scattering around 50%, average value increases from 47 (LHCD) to 49% (LHCD+ICRH)
- No effect of density on Frad-bulk

Boronisation of the vessel:

- Strong decrease of Frad-bulk after fresh boronisation to 20-30%
- Frad-bulk>40% recovered after ~10 pulses (depends on injected energy)

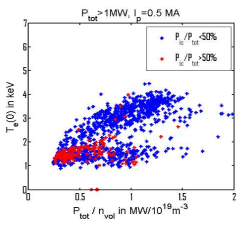


From Bolometry inversion



- Core W increases with P_{LH} and Frad-bulk
- No correlation between core W and confinement
- Flatter Te profile with LHCD+ICRH
- More peaked core W density

ELECTRON HEATING AND ENERGY CONFINEMENT

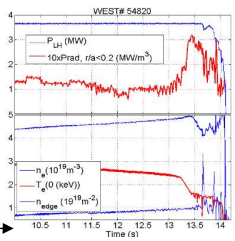


Burn through tungsten

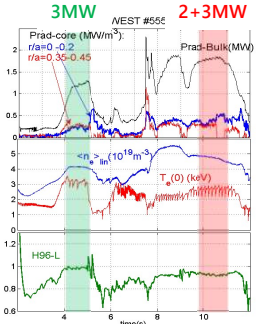
- 2 regimes :
  - Te increases with P_{tot}/n_e
  - Te <1.5keV for all P_{tot}/n_e

W cooling factor is maximum at 1.5keV and constant for Te>3keV

- Radiative collapse occurs when Te decreases →

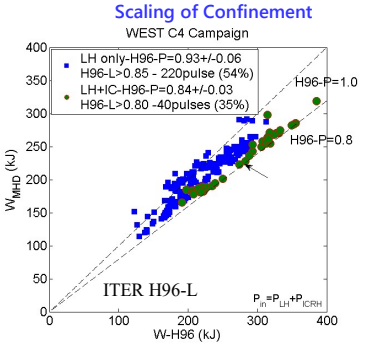


LHCD 3MW — LHCD+ICRH 2+3MW

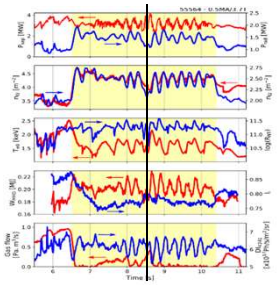


- Low core W and total radiation for both phases
- Lower core Te and global confinement for LH+IC phase

Scaling of Confinement



- Confirm that A=R/a (WEST: 5-6) is not a scaling factor
- Below scaling at high density
- Combining ITER and WEST data bases: $W \sim n_e^{0.24}$ (instead of $n_e^{0.4}$)

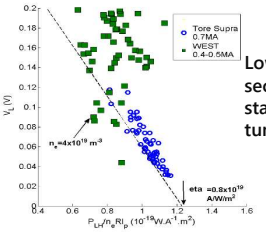


H-mode access

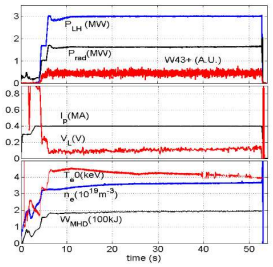
- Martin scaling: close to transition
- Line-averaged density increases by 30%
- Neutrons increases by ~50%
- Stored energy by ~10%

- Higher density is expected to minimize $P_{threshold}$ (Ryter, NF2014)

LOWER HYBRID CURRENT DRIVE



Low Vloop allows 53-second discharge with stationnary Prad and tungsten content →



- Vloop~0.1V achieved at medium density
- 'Global' efficiency (including Bootstrap current) ~$0.8 \times 10^{19} AW^{-1}m^{-2}$

CONCLUSION

- Bulk Radiation of LHCD or LHCD+ICRH discharges are almost identical
- Good global confinement (H96-L)>0.9 for ~70% od the discharges
- n_e and P_{RF} ramps need to be well adjusted to burn through tungsten
- With P_{LH}=6MW , long pulses (>150s) are foreseen at higher density.

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