DIVERTOR POWER LOADS AND SCRAPE OFF LAYER WIDTH IN THE LARGE ASPECT RATIO FULL TUNGSTEN TOKAMAK WEST

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ABSTRACT

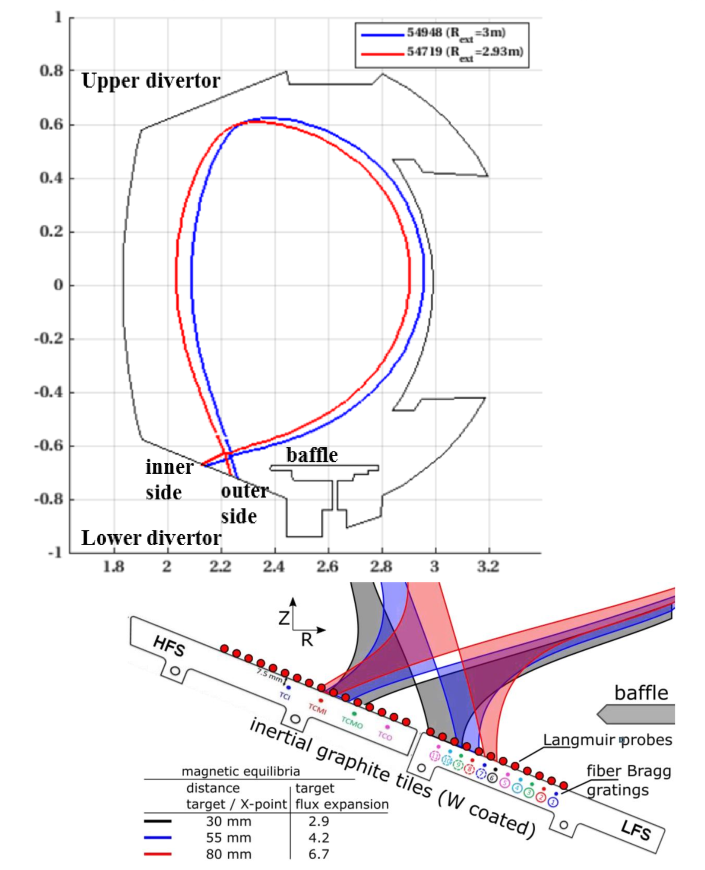
- A large database including different magnetic equilibrium and input power is investigated to compare the heat load pattern (location, amplitude of the peak and heat flux decay length) on the inner and outer regions as function of the continuous progress achieved in WEST : from the first ohmic diverted plasma (obtained during the second experimental campaign C2 in 2018) up to the high power (up to 8 MW total injected) and high energy (up to 90 MJ injected energy in lower single null configuration) steady state experiments performed in the last experimental campaign (C4 in 2019).

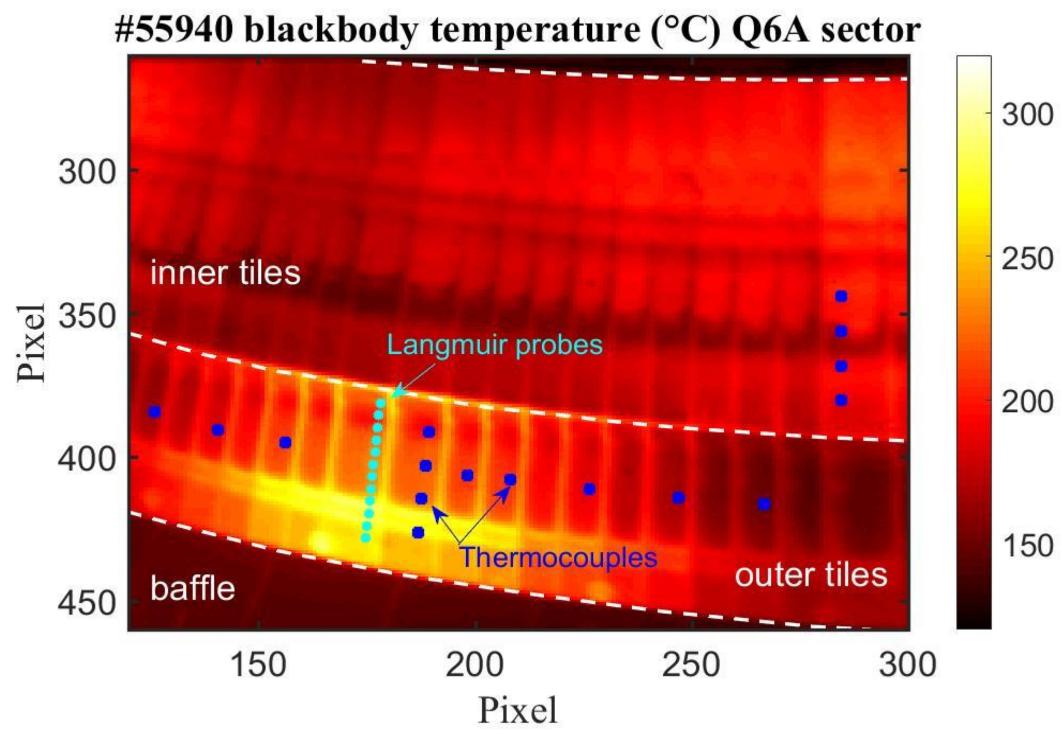
Diagnostic set-up

WEST: full metallic tokamak + extensive set of diagnostics for heat load measurement on lower divertor W tiles (W coated uncooled graphite tiles):

- Flush mounted Langmuir probes (LP) $q_{//} = \gamma j_{SAT} T_e$ with $\gamma \approx 7$
- Infra-red (IR) thermography $q_\perp$ estimated with TEDDY code
- Embedded thermal sensors (TC & FBG) $q_\perp(x,t) = q_0(t) exp\left[\left(\frac{S^t}{2\lambda_q^t}\right)^2 - \frac{s-s_0}{\lambda_q^t}\right] \times erfc\left(\frac{S^t}{2\lambda_q^t} - \frac{s-s_0}{S^t}\right) + q_{BG}(t)$

Estimated parameters though inversion

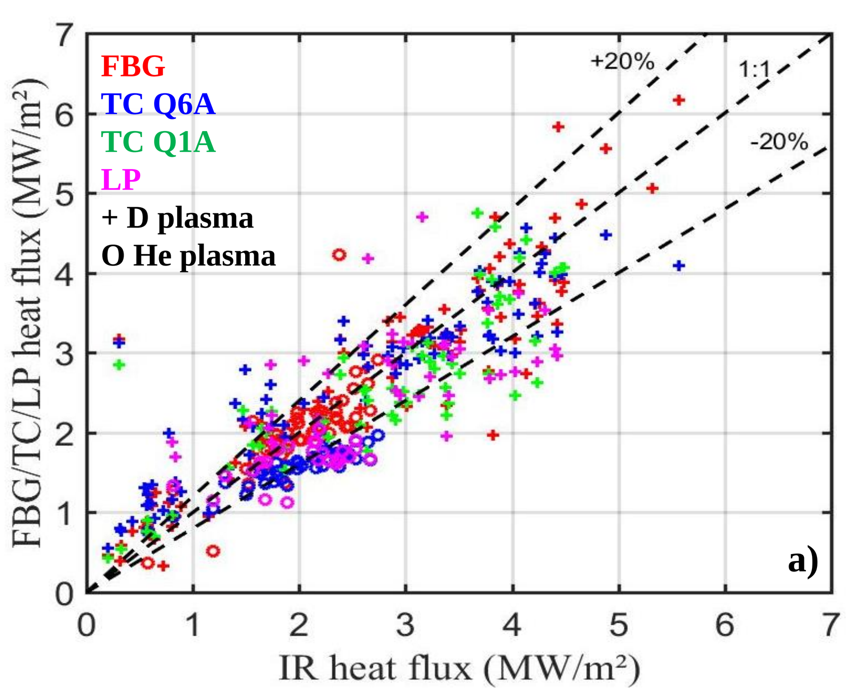


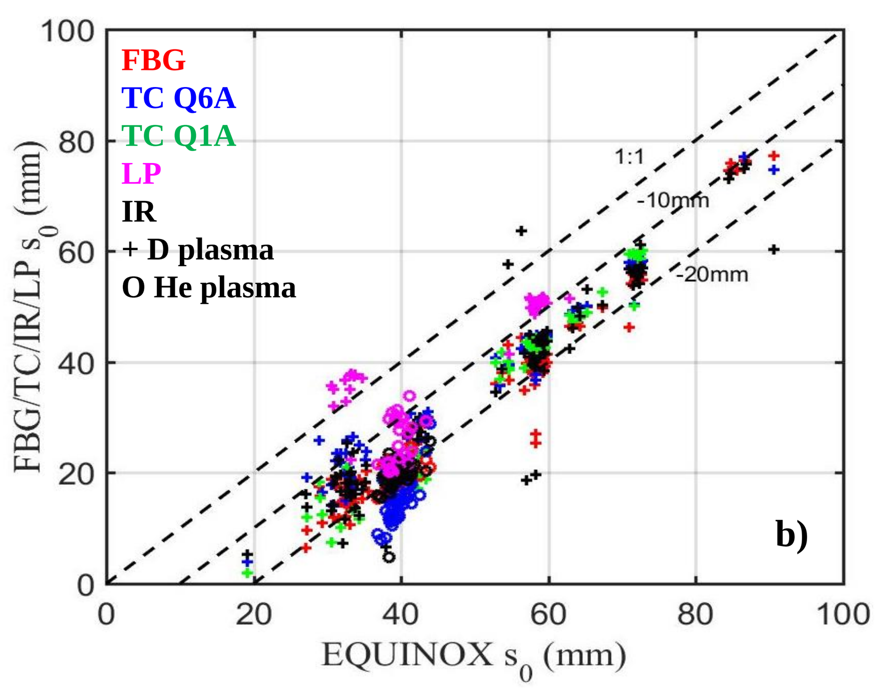


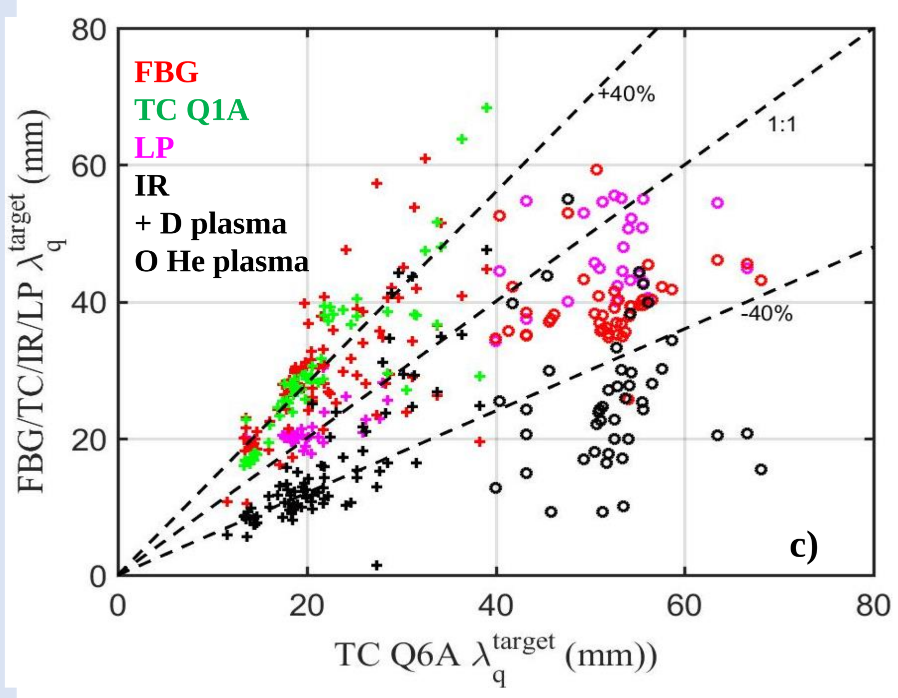
Heat flux comparison FBG/TC/LP/IR

Database

165 L-mode Lower Single Null (LSN) discharges with P_{tot} from 1 to 8 MW $B_T \approx 3.7$ T and Ip from 300 to 700 kA (corresponding q_{95} from 3.2 to 7.8)







Crosscheck

IR inversion and LP measurement fitted with Eich formula (see above) with averaged data over 1s to extract q_{peak}, λ_q^t and s_0 for comparison to TC/FBG

Fig a): good agreement for q_{peak} with all diagnostics in the range ± 20%

Fig b): Inward shift from 1 to 2 cm between the diagnostics and the magnetic reconstruction.

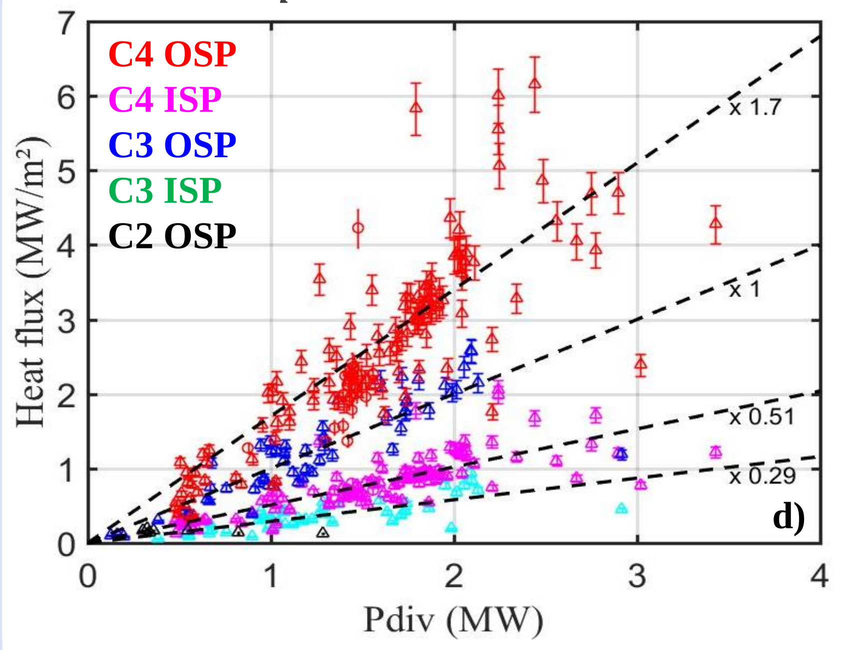
Fig c): 3 groups of λ_q^t appears:

- TC_{Q6A} & LP (Q6A) (consecutive PFCs) [middle]
- IR (same PFC as TC_{Q6A}) [– 40%]
- FBG (Q3A) & TC_{Q1A} [+40%] (180° and 60° toroidally spaced with other diag)

Divertor heat load steady progress during WEST phase 1

Divertor heat flux increase over the campaigns from about 0.2 MW/m² with 2.3 MW of Low Hybrid Current Drive (LHCD) during C2 to 6 MW/m² with 4MW of LHCD during C4 (Fig d))➔ **10MW/m² can be reached with ≈7MW of RF heating in L-mode**

The ≈*1.7 increase from C3 to C4 is observed for all pulses on outer and inner side (Fig d)), despite equivalent plasma parameters (Ip, density, magnetic field) and estimated λ_q^t (Fig e)).



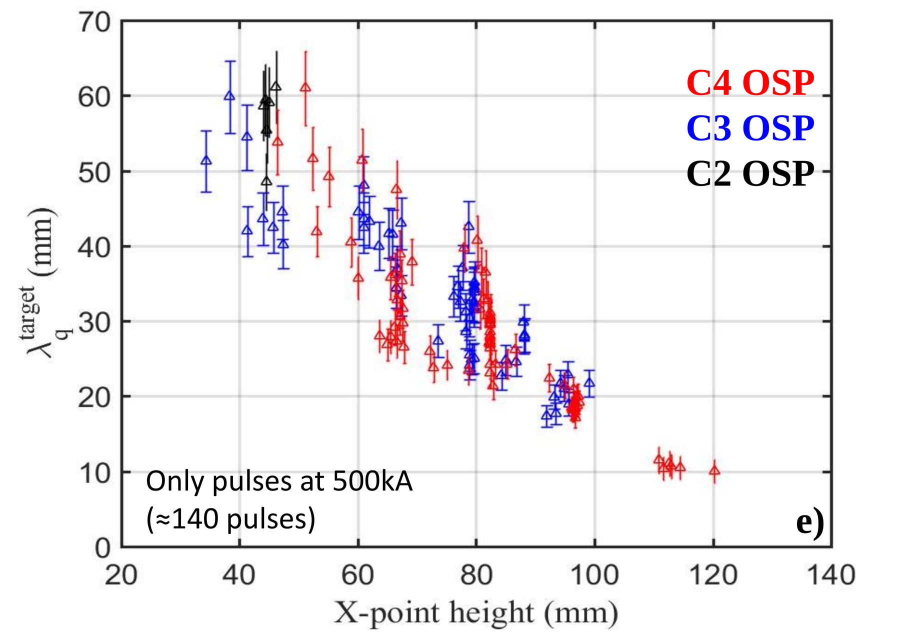
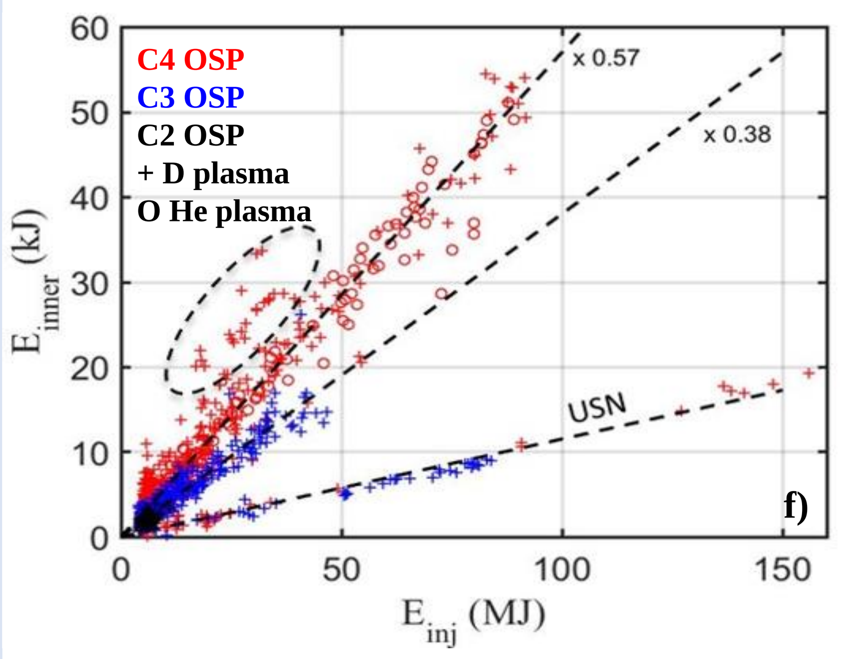


Fig f) and g): The divertor heat load increase is also observed with the increase of the absorbed energy for 1272 pulses of the different campaigns (E calculated from the cooling phase of the inertial PFC).

Same trend for C3 & C4 for the absorbed energy versus Einj in USN ➔ equivalent radiated and neutral loads in USN



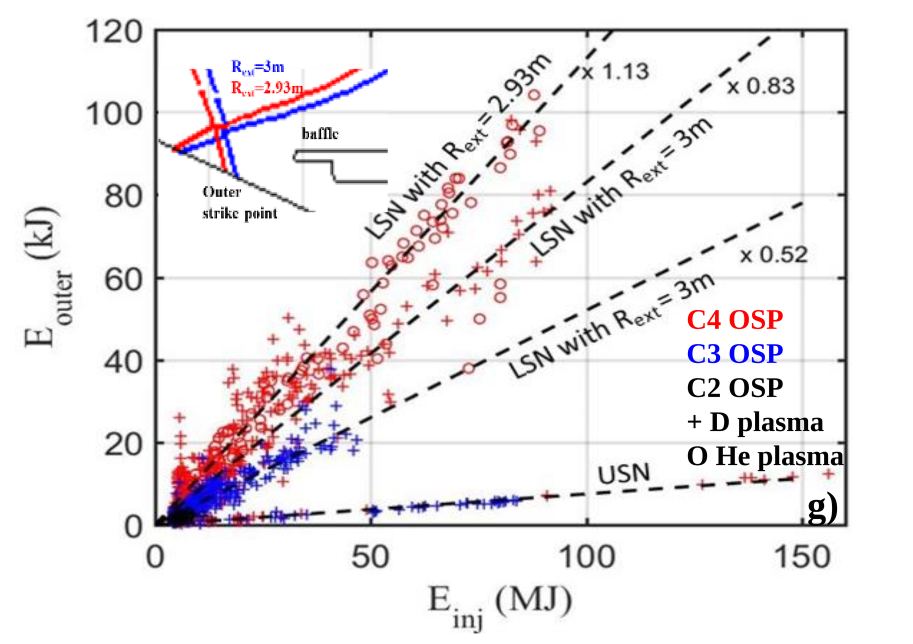
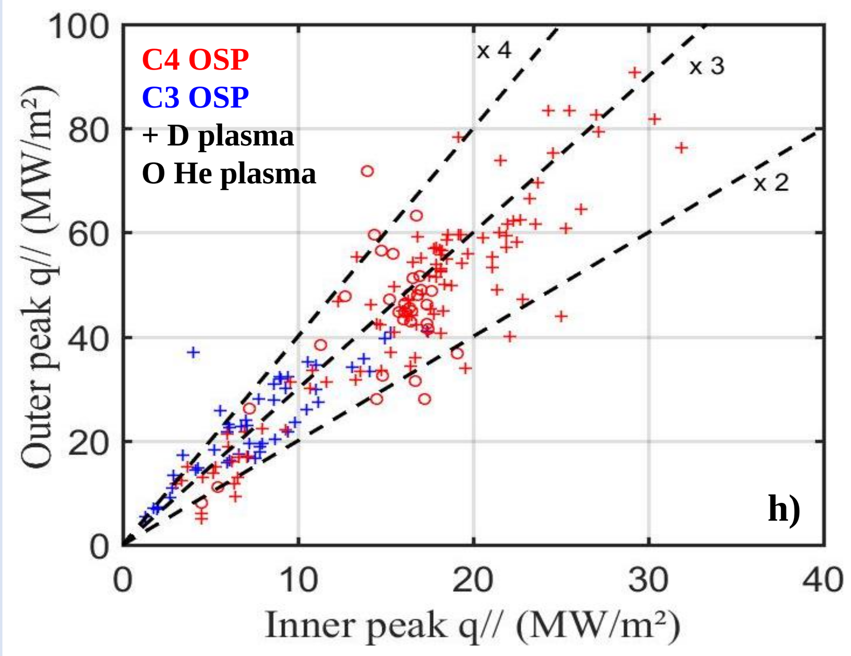
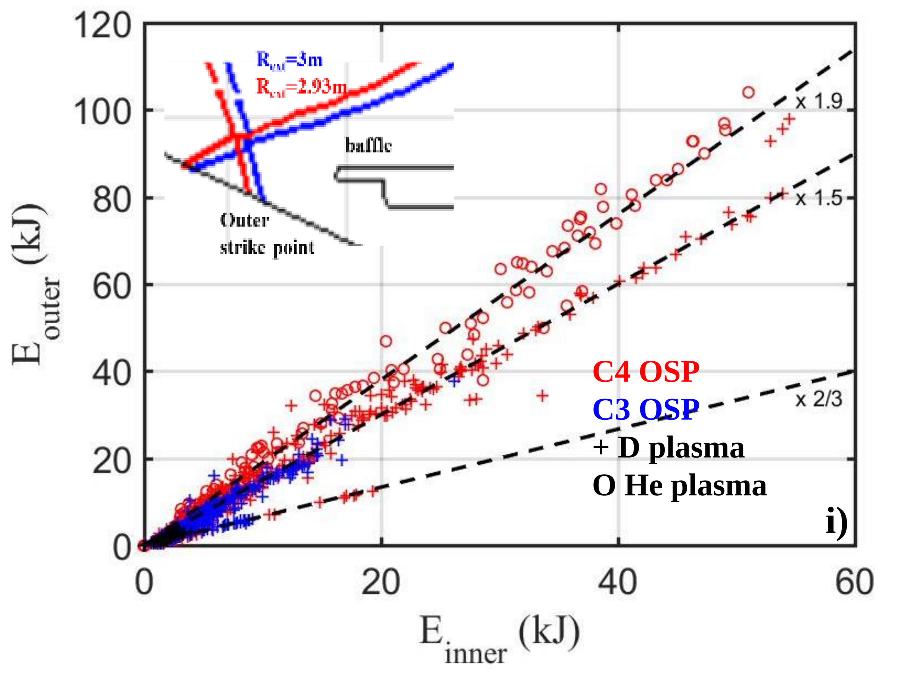


Fig h): Peak $q_{//}$ asymmetry about 3 (3/4 1/4) and equivalent for the whole database no depency found with Pdiv, density or q95 but pulses mainly at 500kA and 300kA with small density variation at same Ip.

Fig i): E_{outer}/E_{inner} equivalent for the campaigns but affected by the baffle screening





CONCLUSION

- q_{peak} from the whole set of diagnostics is in good agreement in the ± 20% range
- λ_q^t and s_0 scale quite linearly with the X-point height as expected
- But λ_q^t shows significant discrepancy between diagnostics and location in the machine (± 40% range). ➔ improve IR processing (ε(s,**T**) and post-mortem analysis TC/FBG
- q_{peak} has followed the continuous progress achieved in WEST and increase over the campaigns from 0.2MW/m² to 6MW/m² ➔ 10 MW/m² steady state accessible with ≈ 7 MW of additional power in L-mode discharge
- Heat load distribution is clearly asymmetric with a 3/4 and 1/4 distribution for $q_{//}$ higher on the outer region as commonly observed in forward-B configuration

ACKNOWLEDGEMENTS

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