Time-dependent modelling of ELMing H-mode at TCV with SOLPS5

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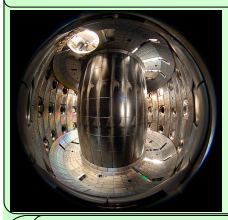
Tokamak à Configuration Variable

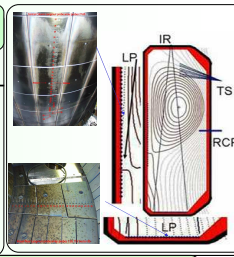


R=0.875 m, a=0.25 m, Bφ=1.43 T

All-graphite machine

Number of open diverted configurations

Edge diagnostics in TCV



Targets

LP : Langmuir probes => j_{sat}, T_e, n_e at the targets

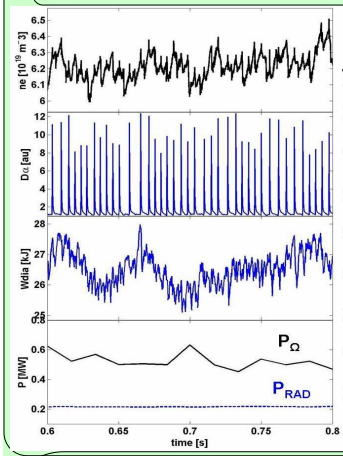
IR: fast Infrared thermographic camera =>perpendicular heat flux at outer target

Upstream

RCP: fast reciprocating Langmuir probe => T_e, n_e upstream

TS: edge Thomson scattering system => T_e, n_e upstream

Typical ELMing H- mode



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SNL

$\bar{n}_e = 6.10^{19}$ m^{-3}

I_p = 430 kA

f_{ELM} = 200 Hz

κ_{95} = 1.65

δ_{95} = 0.4

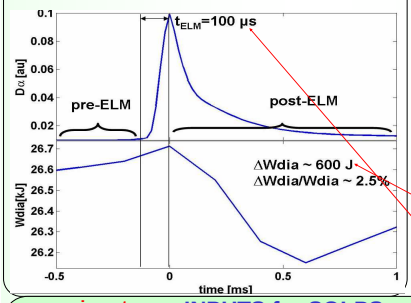
q_{95} = 2.5

n/n_{GW} ~ 0.3

W_{dia} ~ 26 kJ

$P_{SOL} = P_\Omega - P_{RAD}$ = 350 kW

Type III ELM



Scrape-Off Layer Plasma Simulation

SOLPS 5 = coupled EIRENE + B2.5

B2 - solves 2D multi-species fluid equations on a grid given from magnetic equilibrium

EIRENE - kinetic transport code for neutrals based on Monte - Carlo algorithm

ELM model Ansatz

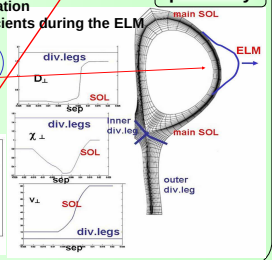
$D_\perp$, $\chi_\perp$ - variation

Cross-field radial transport ⇒ approximate estimation of transport coefficients during the ELM

$$\frac{E_{ELM}}{2\pi t_{ELM} A_{ELM}} = -n.\frac{dT}{dr}.\chi_\perp - \frac{5}{2}T.\frac{dn}{dr}.D_\perp$$

poloidally

radially



experiment

INPUTS for SOLPS

parameters

D^0 D^{1+} C^0 C^{1+} C^{2+} C^{3+} C^{4+} C^{5+} C^{6+}

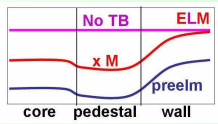
magnetic equilibrium

$P_{sol} = P_{heat} - P_{rad}^{core}$

upstream separatrix density n_e

E_{ELM}

cross-field transport coefficients ($D_\perp$, $\chi_\perp$, $v_\perp$) systematically adjusted until agreement of simulation with experiment is achieved



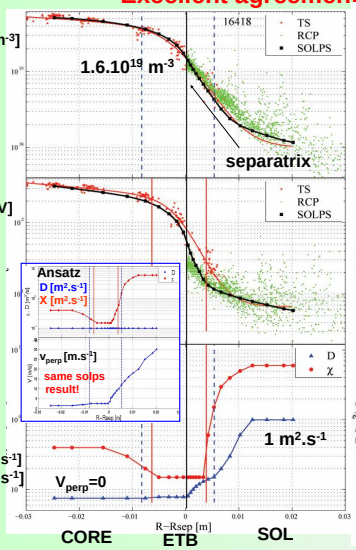
SOLPS vs EXPERIMENT

Upstream | **Inner target** | **Targets** | **Outer target**

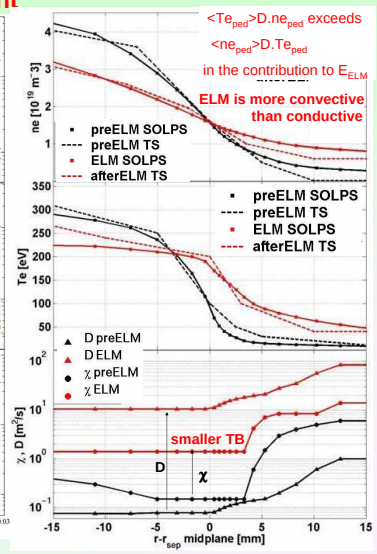
preELM

[B. Gulejova et al.,JNM **363-365** (2007) 1037]

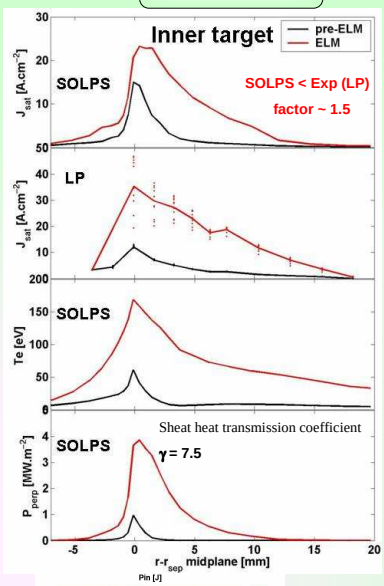
Excellent agreement

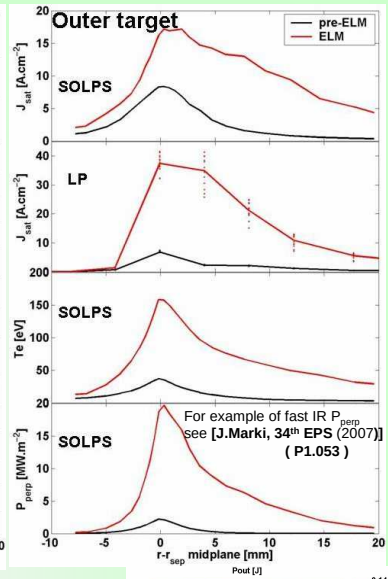


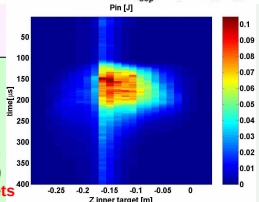
ELM vs pre ELM



TS from [**R. Behn** et al., accepted in PPCF (2007)]







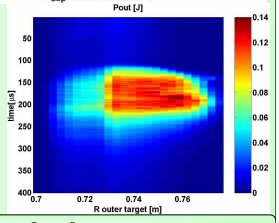
SOLPS

P (outer target) ~ 240 J

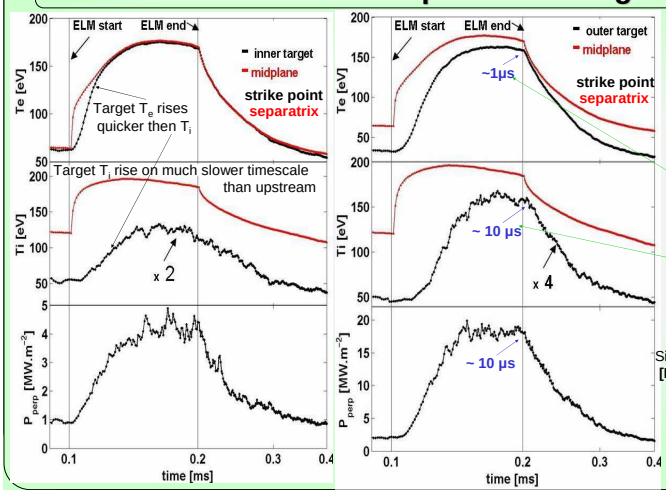
P (inner target) ~ 100 J

⇩

~ 55% of E_{ELM} (620 J)



Time evolution of SOLPS profiles during ELM



Little drop of T_e along $L_{||}$ ~ 18 m (outer target) ~ 14 m (inner target) from upstream to targets

T_i decrease ~ 4.5 x (outer target) ~ 3 x (inner target)

⇩

strong ion cooling

outer target transit times :

$\tau_e = L_{||}/v_{the}$ ~ 2 µs

$\tau_i = L_{||}/c_{s(ped)}$ ~ 120 µs !!

Similar to1D kinetic PIC ELM simulations [D. Tskhakaya, **34th EPS**, Warsaw (2007)] (P2.118)

ELM = inherently kinetic event => Simulations with kinetic code BIT1 = necessary next step for TCV

Profiles broadening during ELM

Profiles of target j_{sat} during the ELM rise are steeper <=> agreement with [R. A. Pitts et al., Nucl. Fusion 43 (2003) 1145]

LP close to outer target strike point