Kinetic simulations of the plasma edge - needs for ITER

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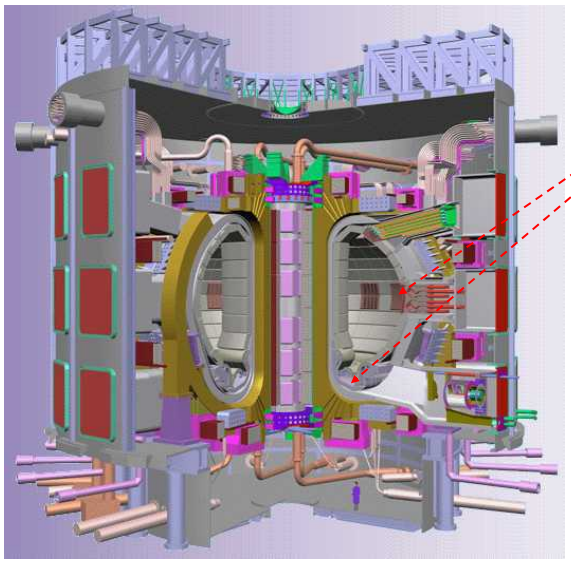
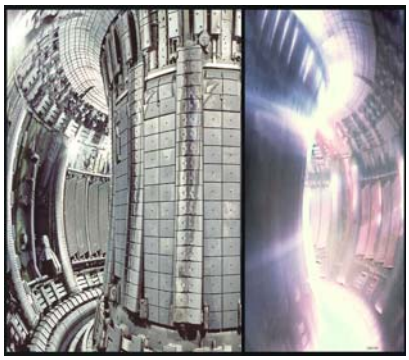
Tokamak of the next generation - ITER

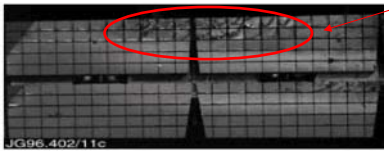


Plasma Surface Interactions

Power loads to the plasma facing components are assumed to be one of the **main threats** for the **ITER**

JET – Joint European Torus

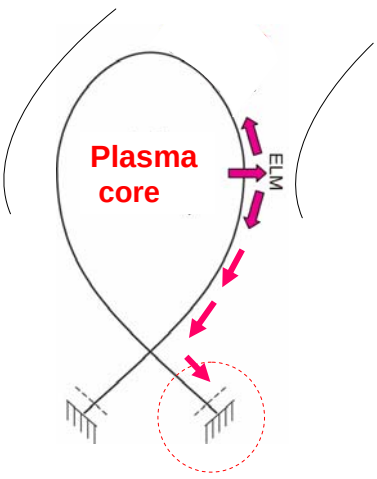


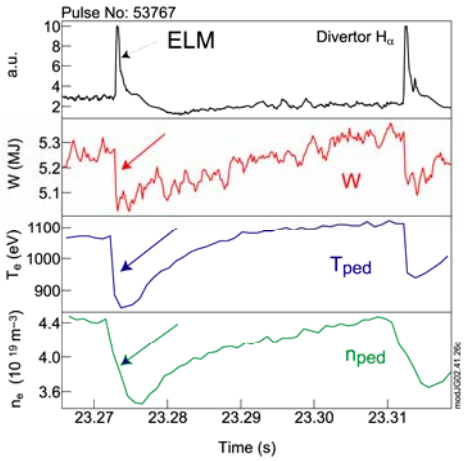


Damage caused by ELMs

Loarte TF-S1 meeting 2006

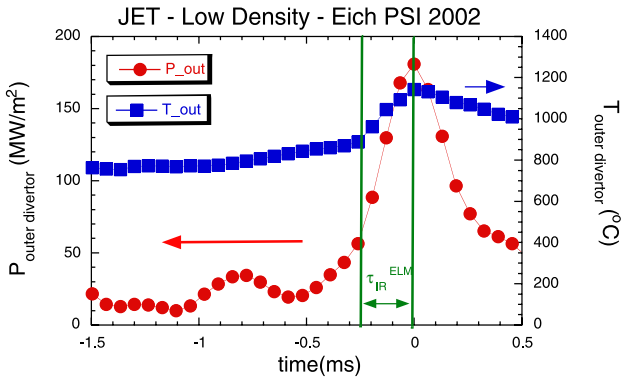
Edge Localized Modes





JET – Type I ELM (Saibene 2002)

Heat loads to the divertor



$\Delta T \sim \Delta W(0 < t < \tau_{IR})$, q_{peak}

$\Delta W(0 < t < \tau_{IR}) < 0.4\Delta W_{ELM}$

JET: ΔW_{ELM}<1 MJ

ITER: ΔW_{ELM}~10 MJ

→ We need estimations for ITER

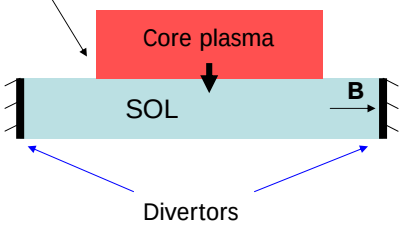
Kinetic (PIC) simulations

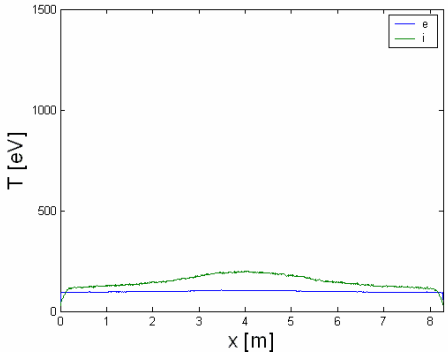
Why kinetic simulations? → $\frac{\tau_{ELM}}{\tau_{th}} \sim \frac{n}{T}, < 1$

Simulation geometry

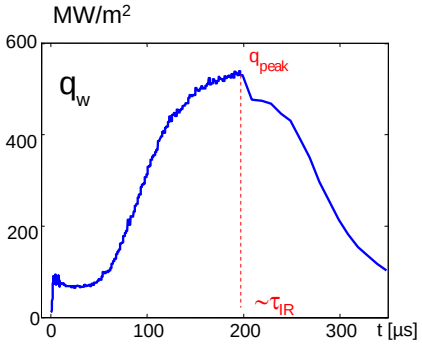
Input parameters:

T and strength of the particle source

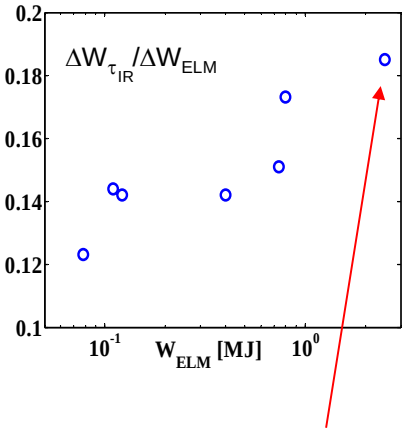




Results for JET SOL (I)



History of the heat loads to the divertor



Small type-I ITER ELM

Results for JET SOL (II)

Kinetic simulations → Kinetic factors →

Large fluid codes (B2 / EDGE2D / UEDGE)

- Boundary conditions

$$q_{div} = \gamma T \Gamma,$$

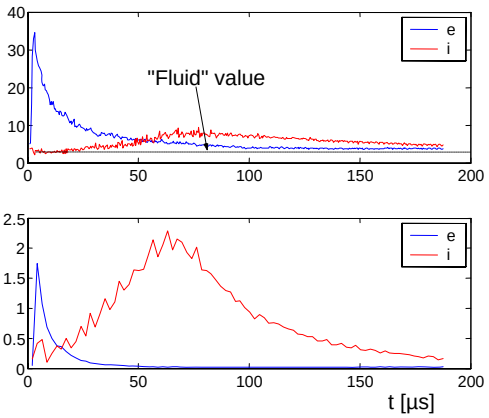
$$\gamma_e \approx 5, \quad \gamma_i = 2.5 \div 3.5$$

- Flux limiters

$$q_{\parallel} = \left(\frac{1}{q_{SH}} + \frac{1}{\alpha\, q_{FS}} \right)^{-1},$$

$$q_{FS} = nVT, \; q_{SH} = -\chi_{\parallel} \frac{\partial}{\partial z} T$$

$$\alpha_{i,e} \sim 0.1$$



History of γ and α in a JET ELMy SOL.

Code updates needed for ITER simulations

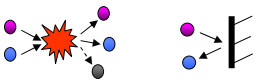
- Physics:
  Nonlinear transport of the plasma and neutrals,
  Linear model of plasma recycling,
  Linear model of plasma-impurity interactions,
  2D code: $10^4 \times 10^2 = 10^6$ meshes, 10^8 particles

- Numerics (~1000 h. of CPU):
  Optimization of the code, parallelization

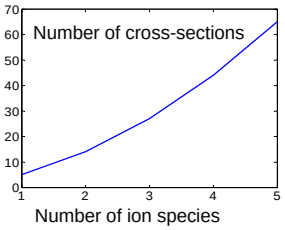
BIT1 code (D. Tskhakaya 2002)

$$\frac{dV}{dt} = \frac{F_{macro}}{m}, \quad \frac{dX}{dt} = V$$

$$\Delta\varphi = -\rho / \varepsilon_0$$



- Atomic, molecular and plasma-surface interaction data:
  Plasma-neutral interactions,
  Plasma-surface interactions,
  Plasma-impurity interactions,



- Completed updates
- Principal updates
- Updates planned in 2008

Collaborations

- JET, Culham, UK
- IPP Garching, Greifswald, Germany
- ITER team, Garching, Germany
- TCV, Lausanne, Switzerland
- NIFS, Toki, Japan