

Fusion Reactor Technology II

(459.761, 3 Credits)

Prof. Dr. Yong-Su Na
(32-206, Tel. 880-7204)

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Week 1. Review of Tokamak Reactor Concept

Week 2-4. Tokamak Reactor Critical Issues

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Week 9. Radioactivation

Week 10. Blanket Structure and Breeding Materials

Week 11-12. Types of Blanket in ITER and DEMO

Week 13. Plasma Facing Components

Week 14. Fuel Cycle System

Fusion Plasma Technology

Reactor Technology

Blanket and Material Technology

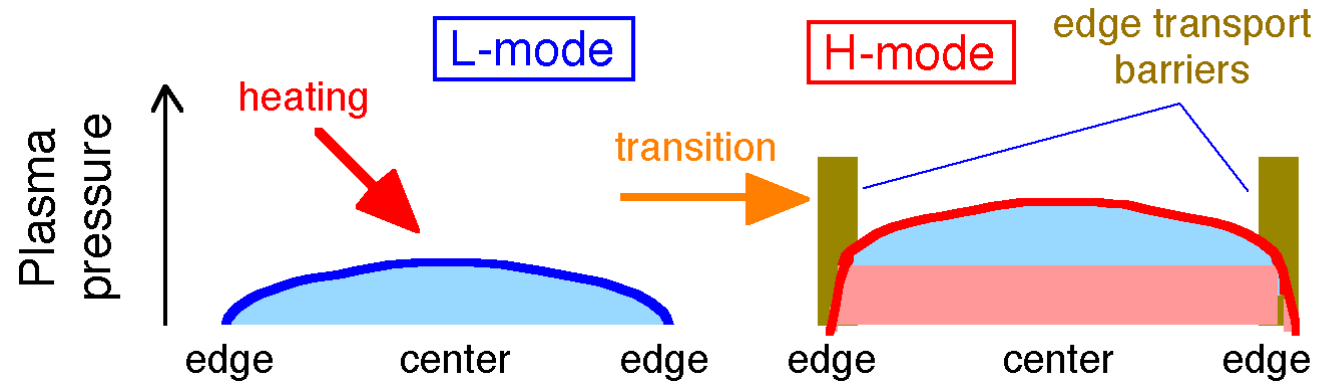
Safety Technology

Operation and Maintenance

Technology

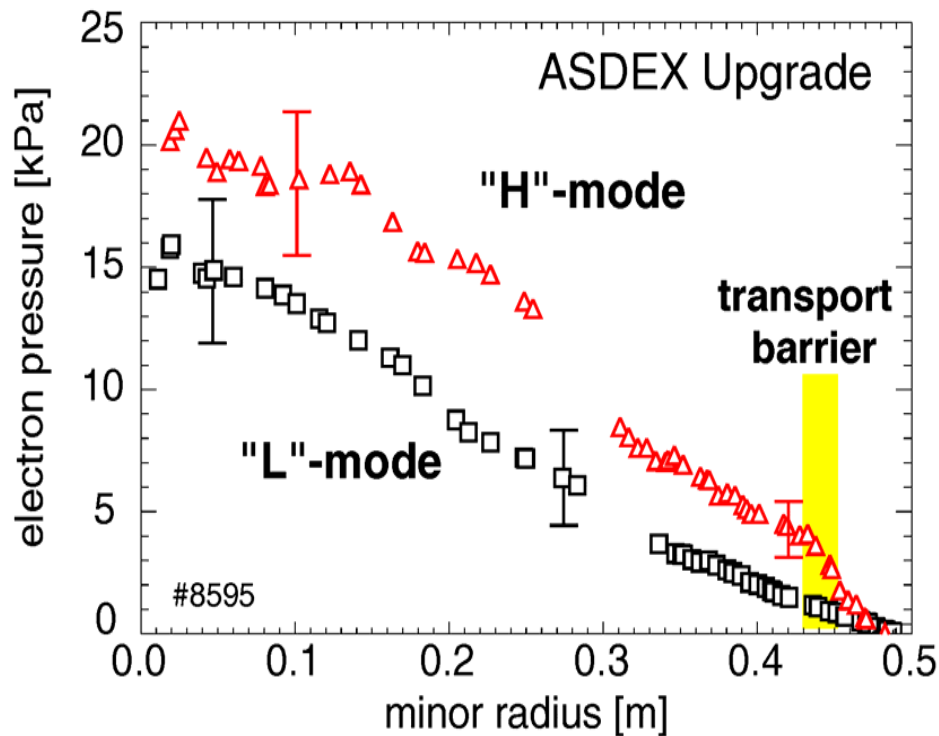
Issues and prospects for confinement performance

Confinement scaling



H-mode

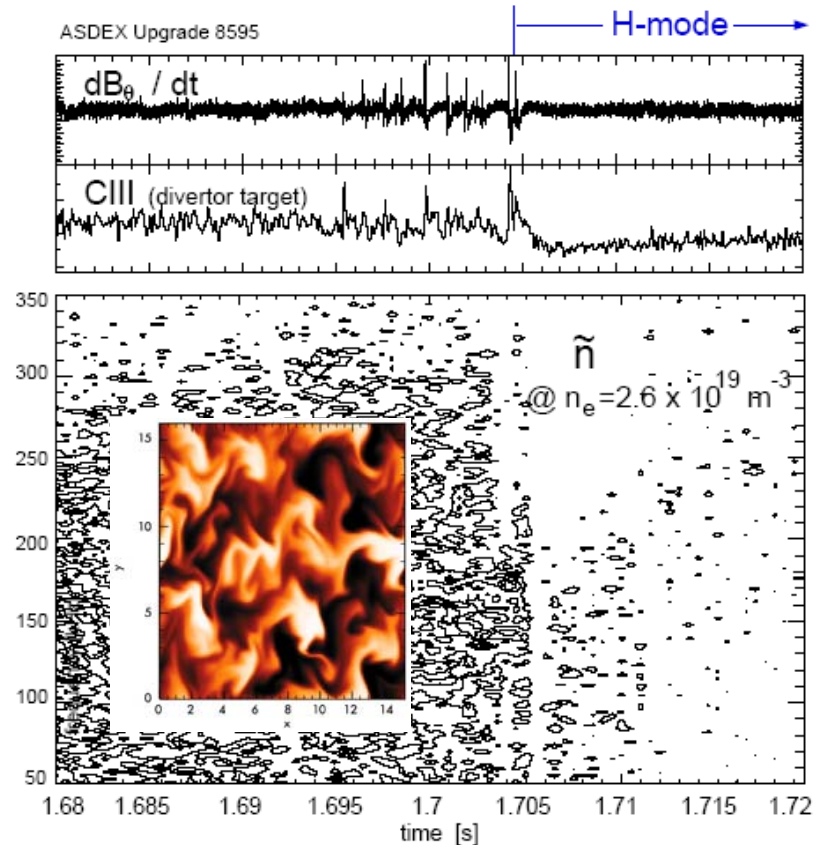
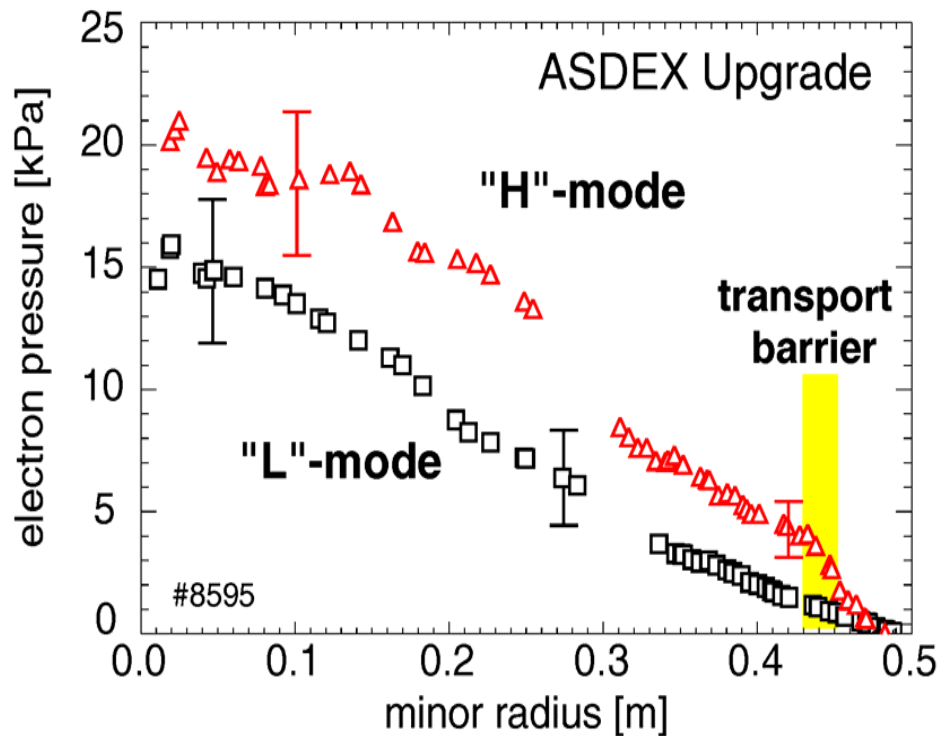
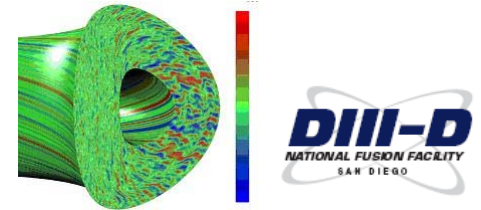
- 1982 IAEA F. Wagner et al. (ASDEX)



Hoover dam

H-mode

- 1982 IAEA F. Wagner et al. (ASDEX)



H-mode

- Turbulence Stabilisation

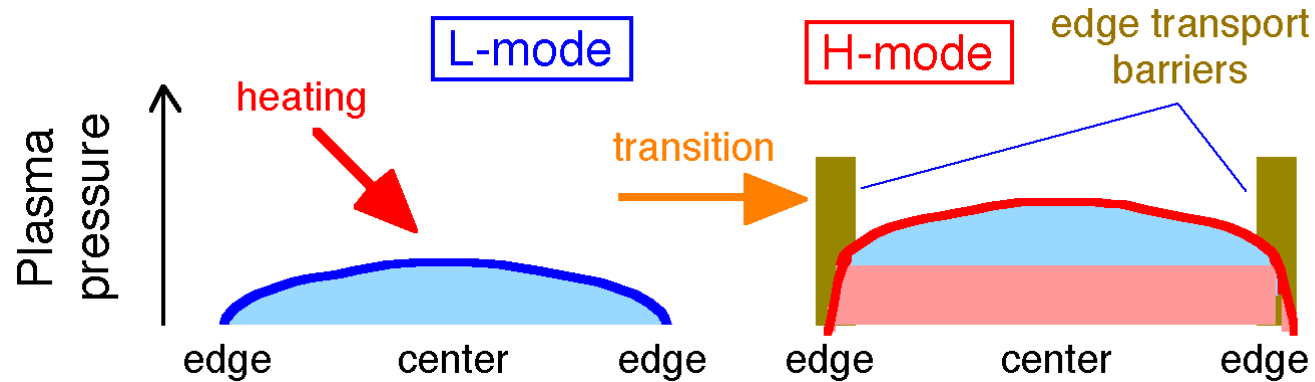
**Gyrokinetic Simulations
of Plasma Microinstabilities**

simulation by

Zhihong Lin et al.

Science 281, 1835 (1998)

Confinement scaling



$$\tau_E^{\text{ITER89P}} = 0.048 M^{0.5} I_p^{0.85} B_t^{0.2} R^{1.2} a^{0.3} \kappa^{0.5} n_{20}^{0.1} P^{-0.5}$$

M for DT mixture?

$$\chi \sim \frac{a^2}{\tau_E} \sim \chi_{\text{Bohm}} (\rho^*)^\mu F(\beta, \nu^*): \text{ nearly "Bohm" scaling } (\mu \sim 0)$$

Why?

$$\chi_{\text{Bohm}} = \frac{cT}{eB}$$

HW: τ_E in dimensionless parameters

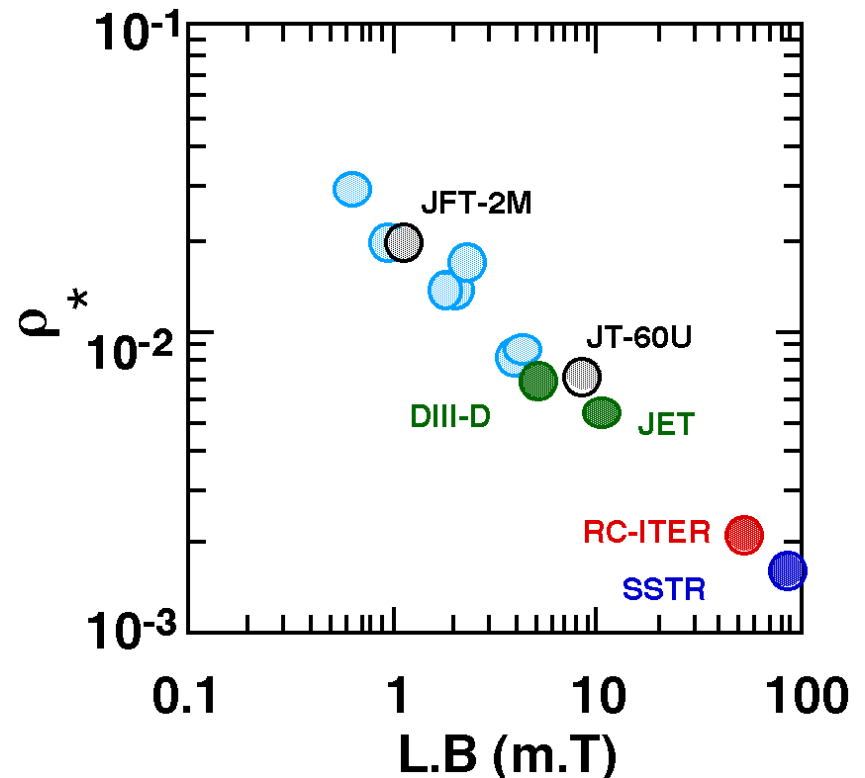
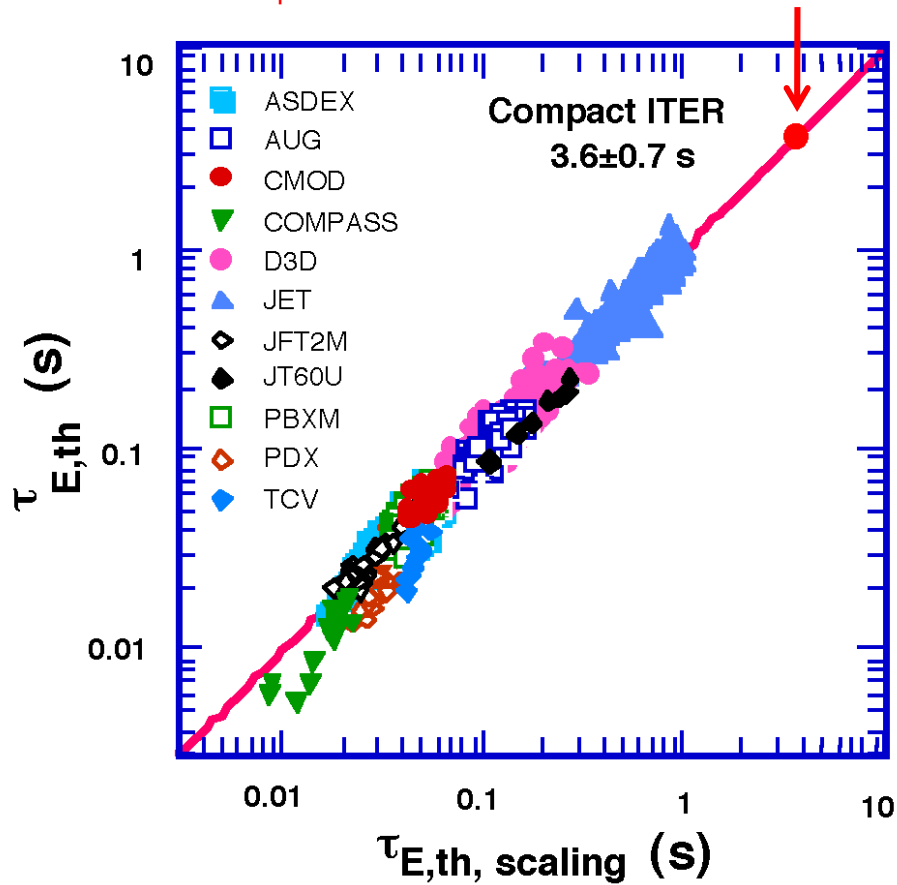
$$\tau_{E,\text{th}}^{\text{IPB98(y,2)}} = 0.0562 M^{0.19} I_p^{0.93} B_t^{0.15} R^{1.39} a^{0.58} \kappa_a^{0.78} n_{19}^{0.41} P^{-0.69}$$

$$\chi \sim \frac{a^2}{\tau_E} \sim \chi_{\text{Bohm}} (\rho^*)^\mu F(\beta, \nu^*): \text{ close to "gyroBohm" scaling } (\mu \sim 1)$$

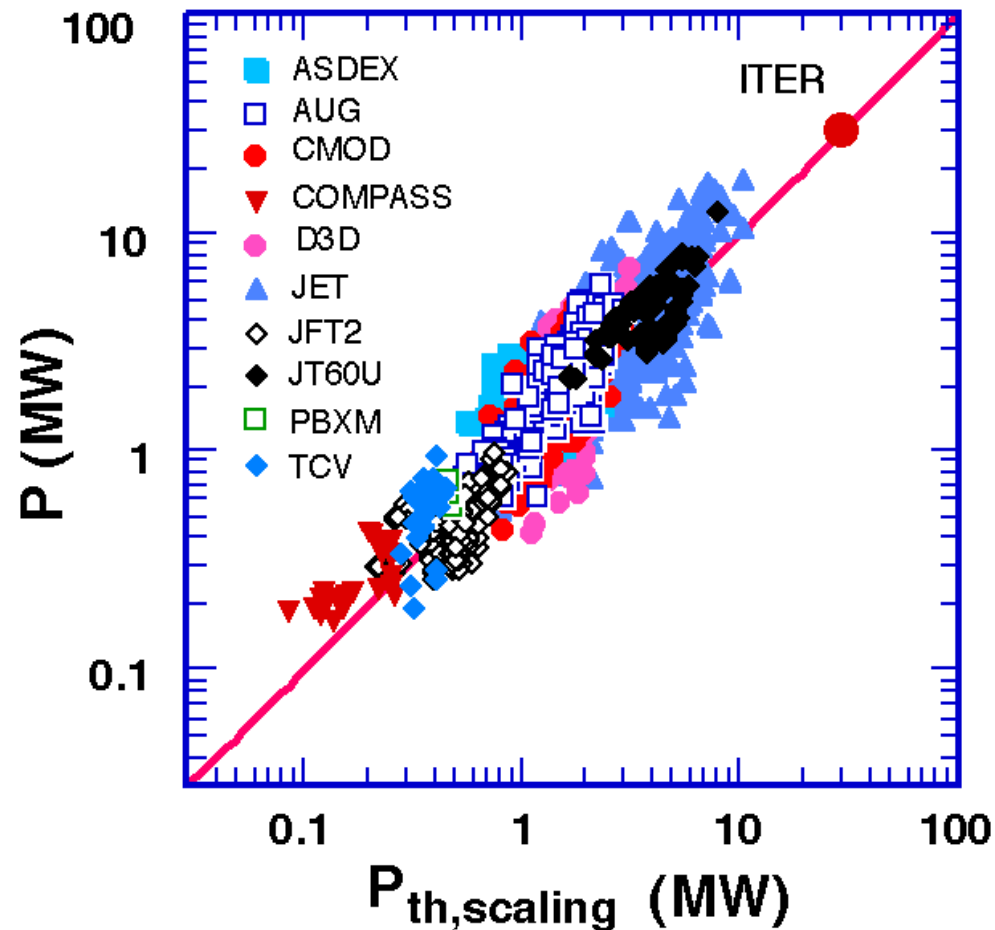
$$\chi \sim \left(\frac{\rho_i}{L} \right) \left(\frac{cT_i}{eB} \right) \quad \left(\frac{\rho_i}{L} \right) \ll 1$$

Confinement scaling

$M=2.5$, $I_p=15\text{MA}$, $B_t=5.3\text{T}$, $R=6.2\text{m}$, $a=2.0\text{m}$, $\kappa_a=1.75$, $n_{19}=10$, $P=90\text{MW}$



L-H transition threshold power



$$P_{th} = 2.84 M^{-1} B_t^{0.82} n_{20}^{0.58} R^{1.0} a^{0.81}$$

L-H transition threshold power

Progress in R&D - H-mode Access

Helium H-modes

- Access to type-I ELMy H-modes during the non-active phase would have a significant impact on the ITER Research Plan:

- would allow, e.g., investigation and demonstration of ELM control
- impacts on divertor changeout and deuterium operation \Rightarrow accelerates progress towards DT plasmas

- AUG finds: $P_{\text{thresh}}(\text{He}) \sim P_{\text{thresh}}(\text{D})$

- JET finds:

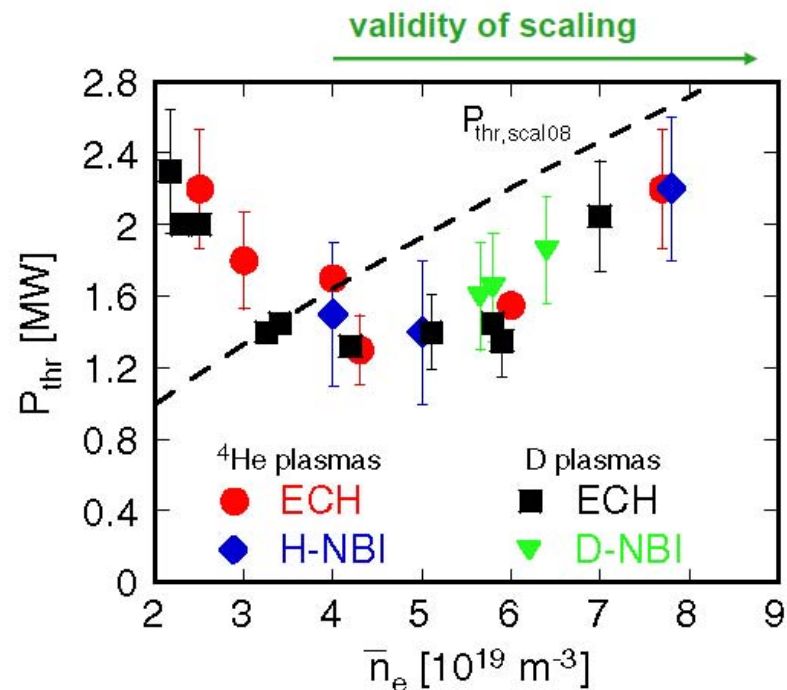
$$P_{\text{thresh}}(\text{He}) \sim 1.4 - 1.5 P_{\text{thresh}}(\text{D})$$

- Recent C-Mod results find:

$$1.2 < P_{\text{thresh}}(\text{He})/P_{\text{thresh}}(\text{D}) < 1.8$$

- More detailed studies are required

ASDEX Upgrade Results



F Ryter et al, NF (2009) 062003