Preliminary Consideration on Physics & Technology for CFETR

X.R. Duan

Southwestern Institute of Physics (SWIP)

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Mission of CFETR

- Demonstrate tritium self-sufficiency
- Test materials and components in integrated fusion nuclear environment
- Demonstrate efficient heat extraction
- ……
- Train scientists and engineers

Reasonable scale/cost

clear mission

Preliminary consideration on basis

- Geometry based on tokamak equilibrium configuration;
- The plasma parameters based on the scaling law;
- The thickness of Breeding blanket, Shielding blanket and Vacuum vessel based on the calculation of tritium blanket;
- The current drive power for steady-state operation based on share of bootstrap current and current drive efficiency;
- …….

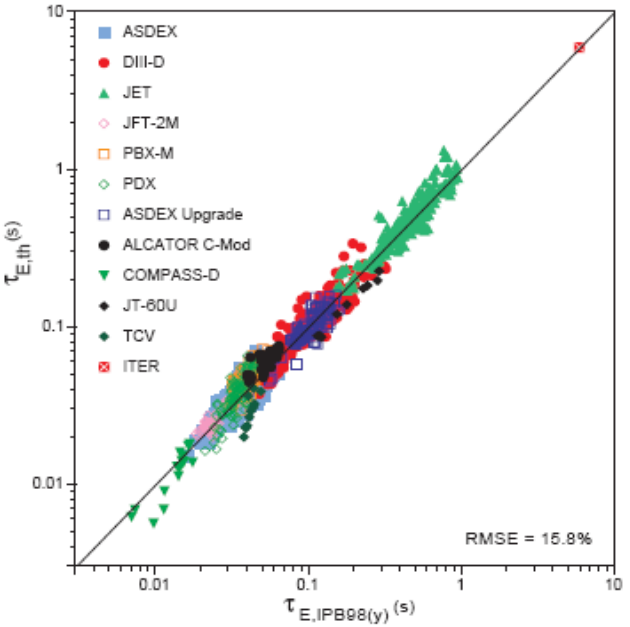
Performance Analysis Basis

Thermal energy confinement time

$$\tau_E = 0.00562 H_{H98(Y,2)} I_P^{0.93} R^{1.97} n^{0.41} P^{-0.69} B_T^{0.15} \kappa_a^{0.78} \varepsilon^{0.58} M^{0.19}$$

Radiation correction for energy confinement time

$$P = P_\alpha + P_{OH} + P_{ADD} - (P_{brem} + P_{cycl} + P_{line}/3)$$

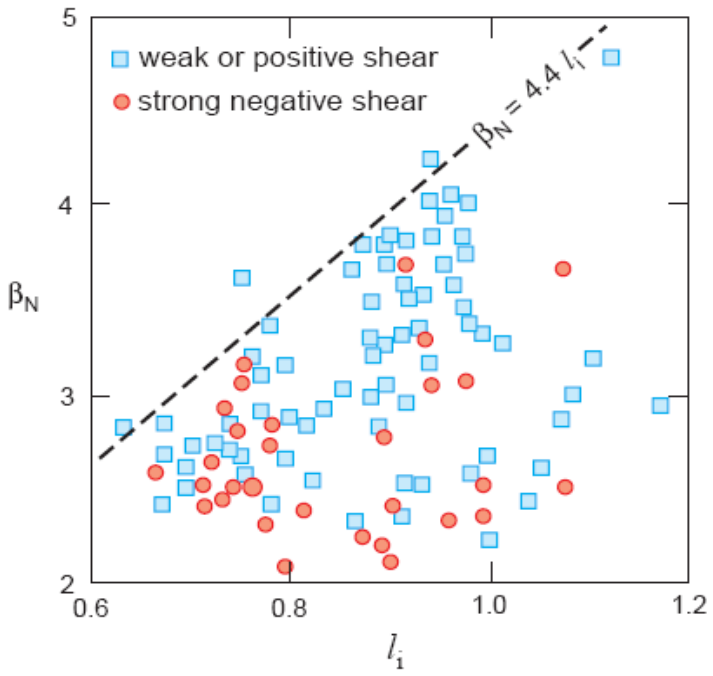


Nuclear Fusion, Vol. 39, No. 12 (1999)

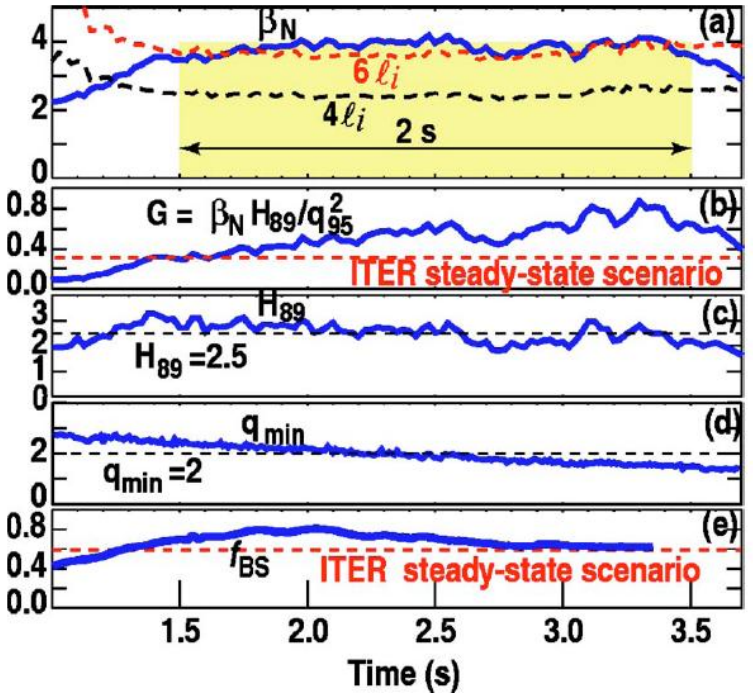
Troyon limit

$$\beta\% = \beta_N \frac{I_p(\mathrm{MA})}{\mathrm{a(m)B(T)}} \qquad \beta_{N.\max} \approx 4l_i$$

When l_i is 0.6~1.0, Beta limits is 2.4~4.0



Phys. Plasmas 1 (1994) 1415



Phys. Plasmas 13 (2006) 056110

Greenwald limit

$$n_e \le n_{GW} = \frac{I_p}{\pi a^2}$$

Safety factor

$$q_{95} = \frac{5a^2 B_0}{R_0 I_p}\left(\frac{1.17-0.65\varepsilon}{(1-\varepsilon^2)^2}\right)[1+\kappa^2(1+2\delta^2-1.2\delta^3)]$$

Fusion Power Calculation

Plasma density and temperature profiles

$$n(r) = (1 + a_n) < n > (1 - \frac{r^2}{a^2})^{a_n}$$

$$T(r) = \frac{(1 + a_n + a_T)}{(1 + a_n)} < T > (1 - \frac{r^2}{a^2})^{a_T}$$

Deuterium tritium plasma fusion power

$$P = 7.1 \times 10^{21} V \frac{2}{a^2} \int_0^a r n_e^2(r) < \sigma v >_{DT} dr \; f^2$$

$$< \sigma v >_{DT} = 9 \times 10^{-22} e^{[-0.476 \left| \ln(\frac{T}{69}) \right|^{2.25}]}$$

Consideration :
learned from prominent speakers yesterday

fill gaps to DEMO

If decided now, the only way is TOKAMAK

in the future, ST？ ……

Knowledge/Know-how – physics & technology

ready for design

new technology R&D

-challenging

R&D cycle (test, discover, improve/inovate…)

Thank you！