JT-60 Modification Program

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On behalf of the Technical Committee of JT-60 Modification Program

2002 Fusion Summer Study
July 8-19, 2002
Snowmass Village, Colorado

Technical Committee of JT-60 Modification Program

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• ITER JCT,
• Nagoya University,
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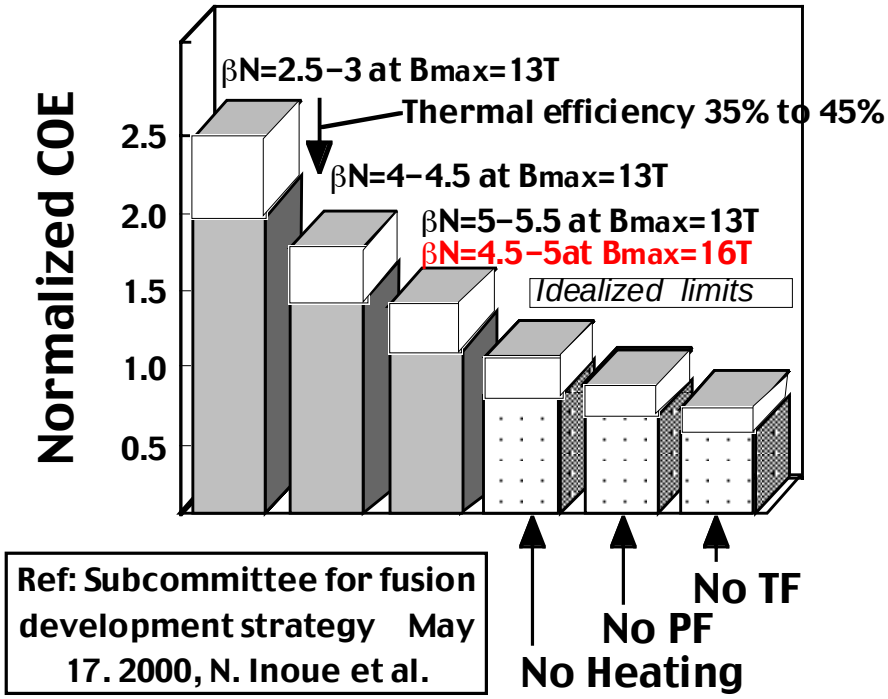
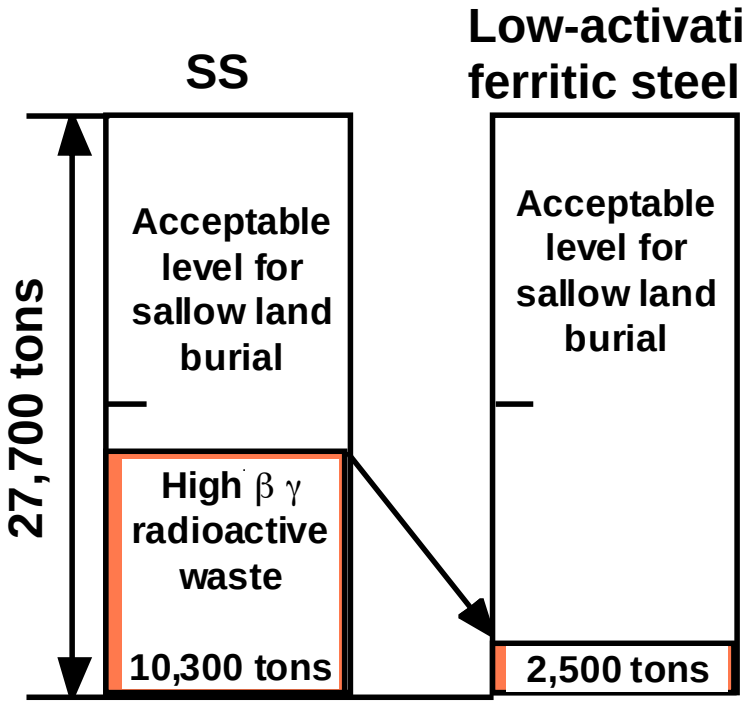
• National Institute of Advanced Industrial Science and Technology

JT-60SC, JAERI, Snowmass 2002 presentation, Jul/8-19/2002

Future Direction of JT-60 Program





Economy

Environment

Significant improvement in economical and environmental attractiveness is necessary for a fusion reactor beyond ITER.

Mission and Issues on Modification

- **Mission :**
  to establish high performance steady state operation and to demonstrate plasma applicability of low activation ferritic steel

- **Issues :**

1) ESTABLISHMENT OF HIGH PERFORMANCE STEADY STATE OPERATION
   - HIGH BETA PLASMA CONTROL (β_N = 3.5 – 5.5)
   - STEADY STATE PLASMA CONTROL (f_{BS}=50 – 90%)
   - DIVERTOR HEAT&PARTICLE CONTROL (f_{rad}~95%, τ_{He}^*/τ_E~5)
   - DISRUPTION CONTROL (avoidance, mitigation)

2) PLASMA APPLICABILITY TEST OF ADVANCED MATERIALS
   - **for practical use of the advanced material of low activation ferritic steel**

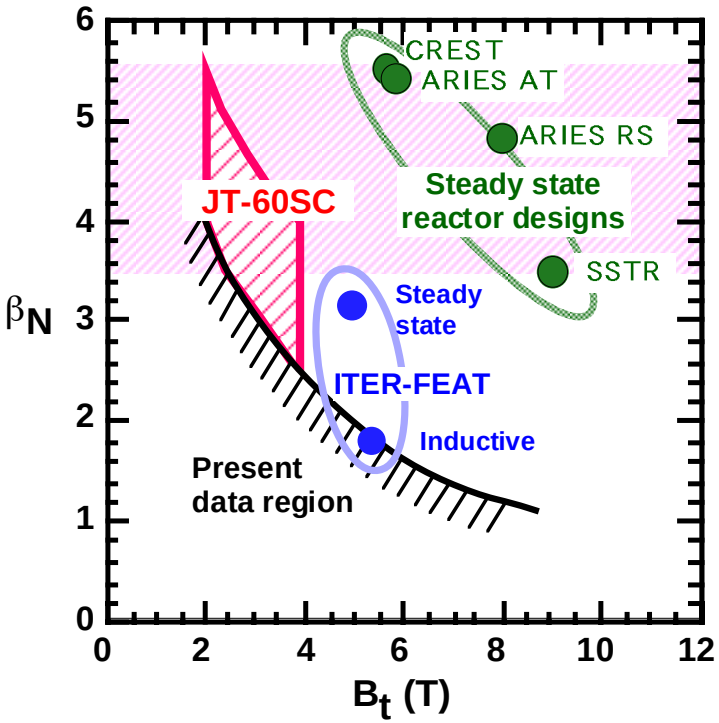
Machine design is progressed in nation-wide collaboration with universities, institutes and industries.

Parameters of JT-60SC

- **Sufficiently low (ρ^*, ν^*) plasmas close to DEMO** ⇢ **R_p ~3 m**
- **Sufficiently longer duration than current diffusion time** ⇢ **~100 s**

Modification to a superconducting tokamak, JT-60SC.

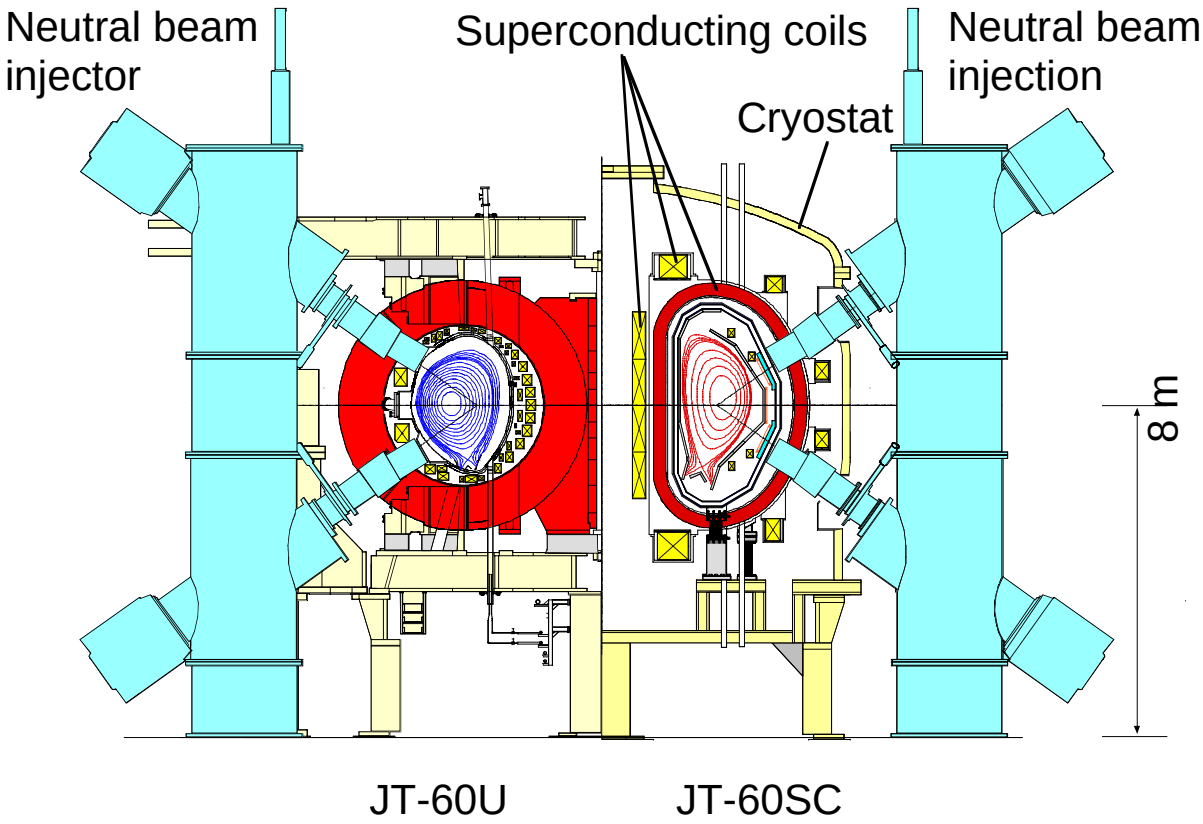
- **JT-60SC pursues plasma parameters deduced from DEMO concepts using low activation ferritic steel in the vacuum vessel.**

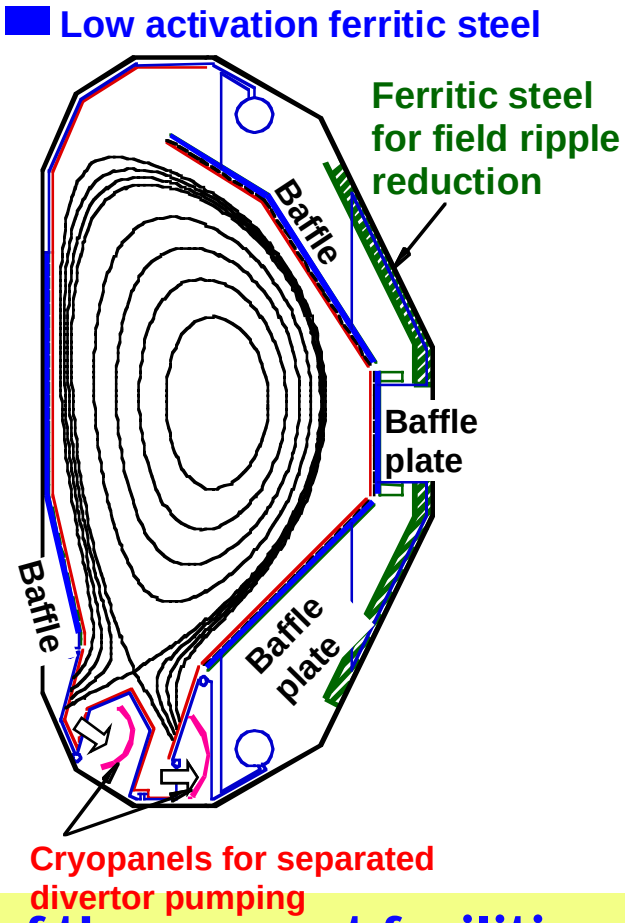


Parameter	JT-60U	JT-60SC
Pulse length	15 s	100 s
Max. input power	40 MW (10 s)	44 MW (10 s)
		15 MW (100 s)
Plasma current I_p	3 MA	4 MA
Toroidal field B_t	4 T	3.8 T (R_p=2.8 m)
Major radius R_p	3.4 m	2.8 -3 m (2.8 m*)
Minor radius a_p	0.9 m	0.7-0.9 m (0.85 m*)
Elongation κ_{95}	1.8 (δ_{95}=0.06)	≤ 2 (1.8*)
Triangularity δ_{95}	0.4 (κ_{95}=1.33)	≤ 0.5 (0.35*)

* Nominal

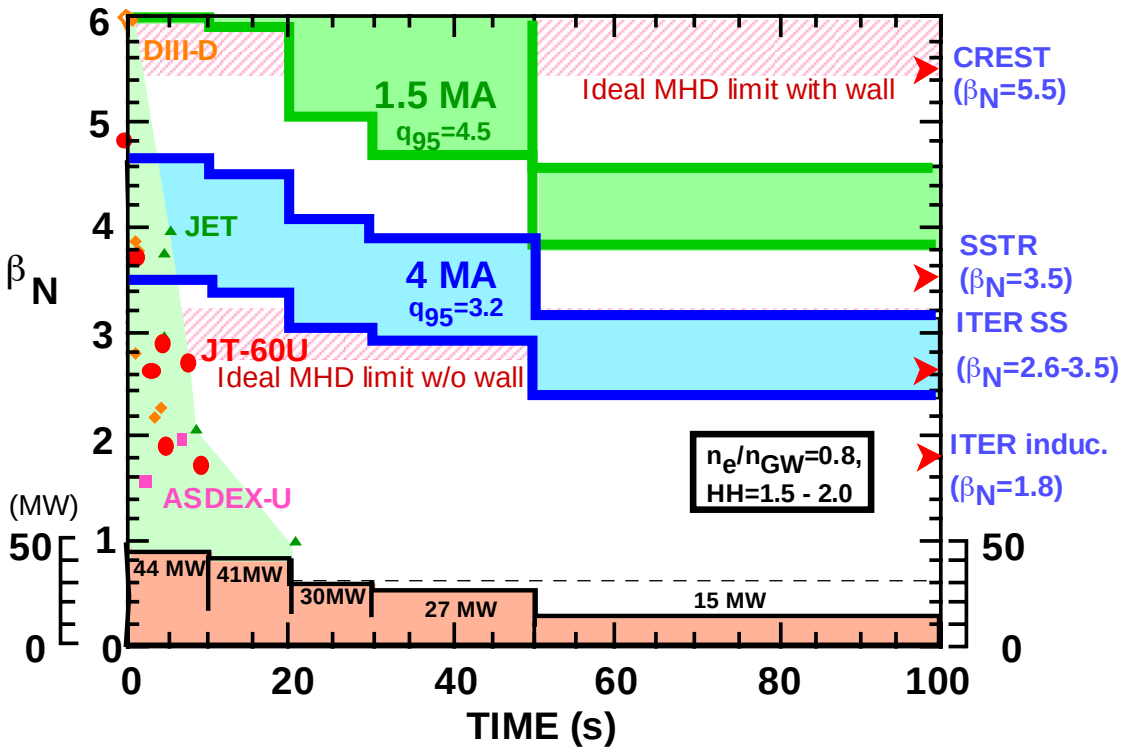
Modification to Superconducting Tokamak





To be modified with maximum utilization of the present facilities such as torus building, heating systems and power supplies

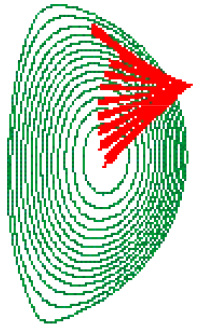
High Beta Plasma Control



Attainable β_N in JT-60SC for long-pulse and high-power heating capabilities.

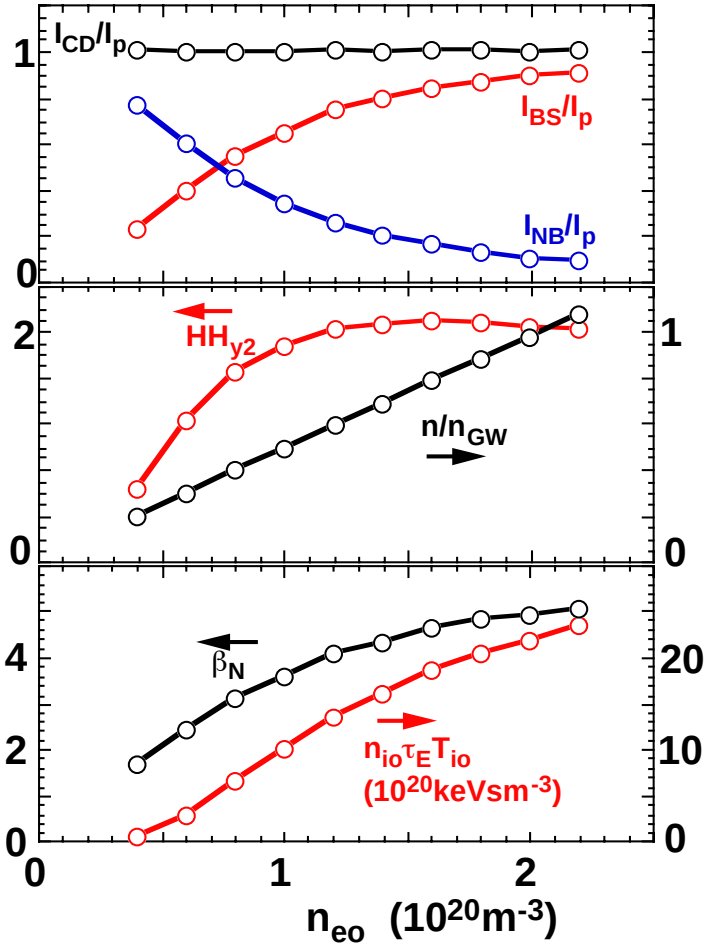
Physics Issues

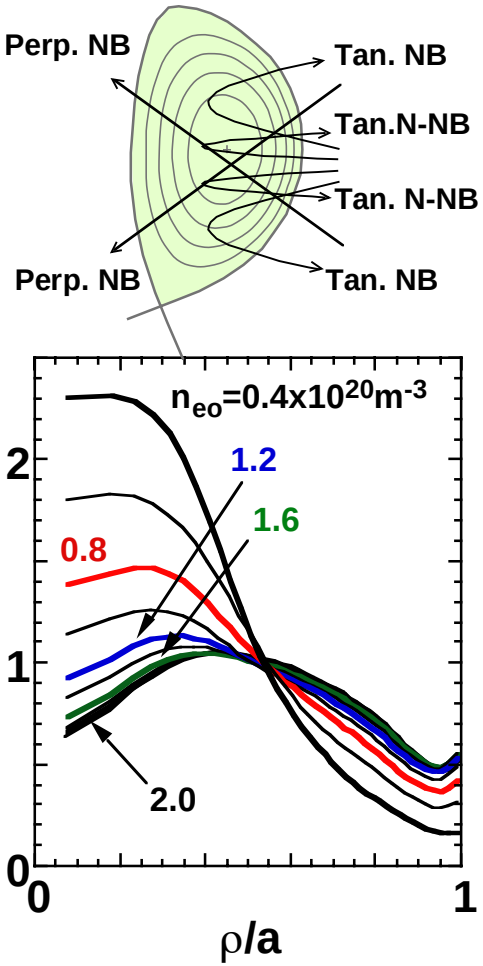
Neoclassical tearing mode stabilized by ECCD.



Resistive wall mode stabilized by invessel 18 sector coils.

High Performance Full Current Drive

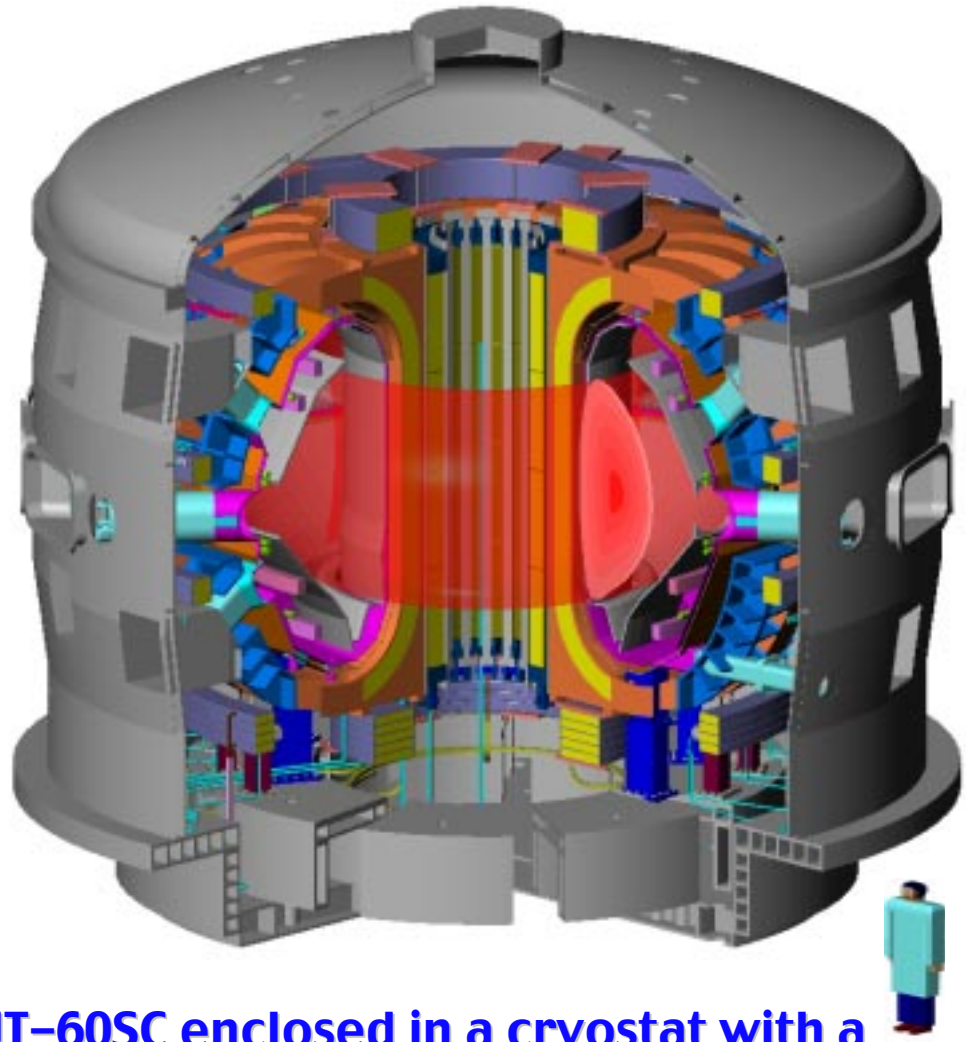




ACCOME code analysis for 3 MA, 3.8 T, P_{NB}=30 MW, Z_{eff}=2

- **Capability of full current drive of a plasma with $I_{bs}/I_p>0.8$, $\beta_N>4$ and $n\tau_E T\sim 1x10^{20}$ keVsm^{-3} for HH~2 at $n/n_{GW}>0.8$**

Bird's Eye View of JT-60SC



JT-60SC enclosed in a cryostat with a diameter of 12 m.

Superconducting coils

Toroidal field coils

Number	18
B_{max}	7.4 T
Conductor	Nb_3Al
Total energy	1.7 GJ
Weight	23.5 tons/coil

Center solenoid

Number	4
B_{max}	7.4 T
Conductor	Nb_3Sn
Weight	41 tons

Equilibrium field coils

Number	6 (div. coil)
B_{max}	5 T (7.4 T)
Conductor	NbTi (Nb_3Sn)
Max. diameter	10.6 m

Summary

- JT-60 modification to a fully superconducting tokamak (JT-60SC) is being planned under nation-wide collaboration with universities, institutes and industries.
- The objectives are to realize high performance steady state operation and to demonstrate plasma applicability of ferritic steel in reactor-relevant plasma regimes of a break-even class.
- Basic design has been completed and detailed design is under way.
- Now under discussion at governmental committees.