

# **JT-60 Modification Program**

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Naka Fusion Research Establishment**

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

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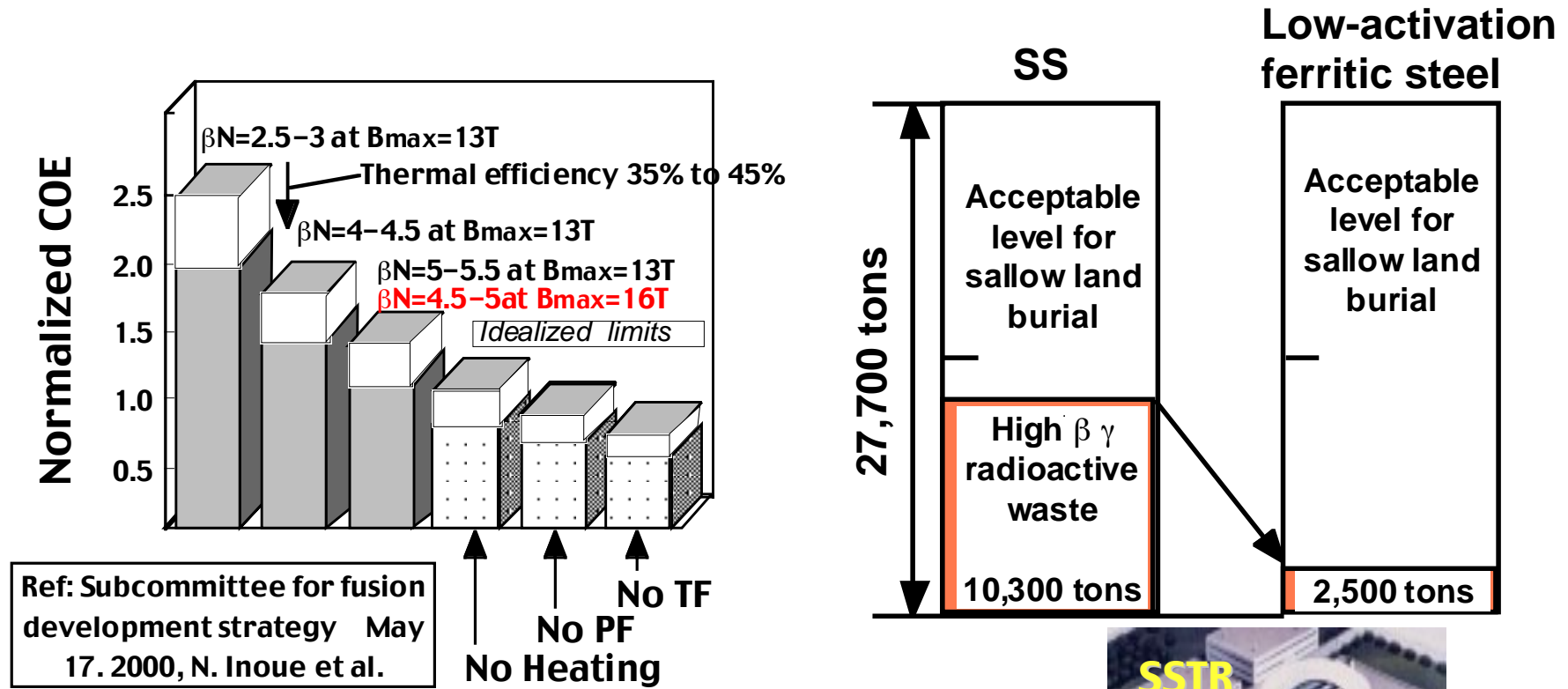
## Technical Committee of JT-60 Modification Program

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- Hiroshima University,
- Central Research Institute of Electric Power Industry,
- Ibaraki University,
- ITER JCT,
- Nagoya University,
- National Institute for Fusion Science,
- National Institute of Advanced Industrial Science and Technology

# 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 ( $\beta_N = 3.5 - 5.5$ )
- STEADY STATE PLASMA CONTROL ( $f_{BS}=50 - 90\%$ )
- DIVERTOR HEAT&PARTICLE CONTROL ( $f_{rad}\sim 95\%$ ,  $\tau_{He^*}/\tau_E\sim 5$ )
- DISRUPTION CONTROL (avoidance, mitigation)

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

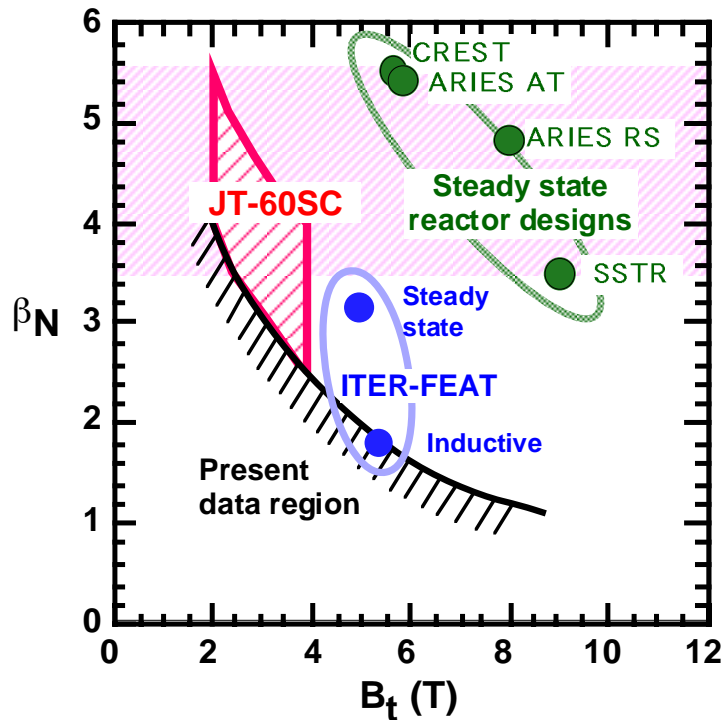
Machine design is progressed in nation-wide collaboration with universities, institutes and industries.

# Parameters of JT-60SC

- Sufficiently low ( $\rho^*$ ,  $\nu^*$ ) plasmas close to DEMO  $\rightarrow R_p \sim 3$  m
- Sufficiently longer duration than current diffusion time  $\rightarrow \sim 100$  s

**Modification to a superconducting tokamak, JT-60SC.**

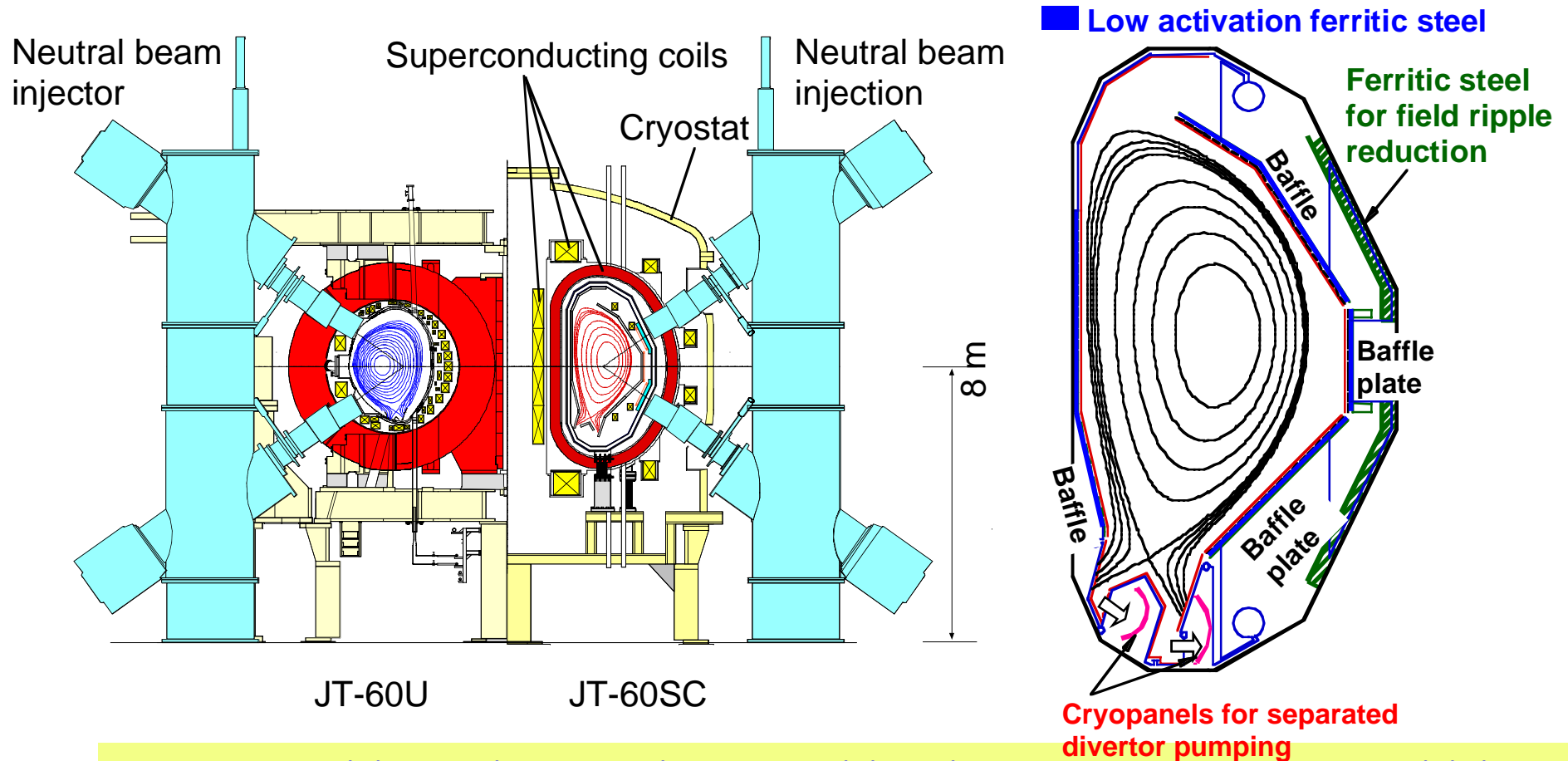
- JT-60SC pursues plasma parameters deduced from DEMO concepts using **low activation ferritic steel** in the vacuum vessel.



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

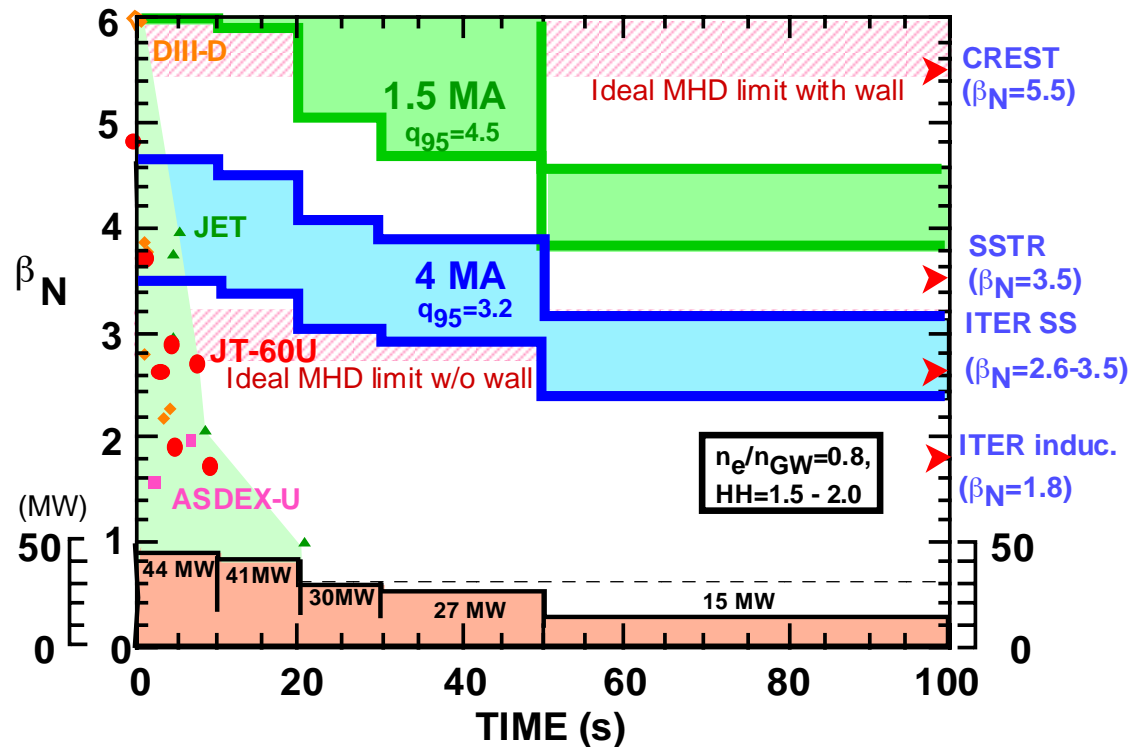
\* Nominal

# Modification to Superconducting Tokamak



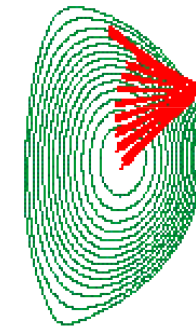
To be modified with maximum utilization of the present facilities such as torus building, heating systems and power supplies

# High Beta Plasma Control



## Physics Issues

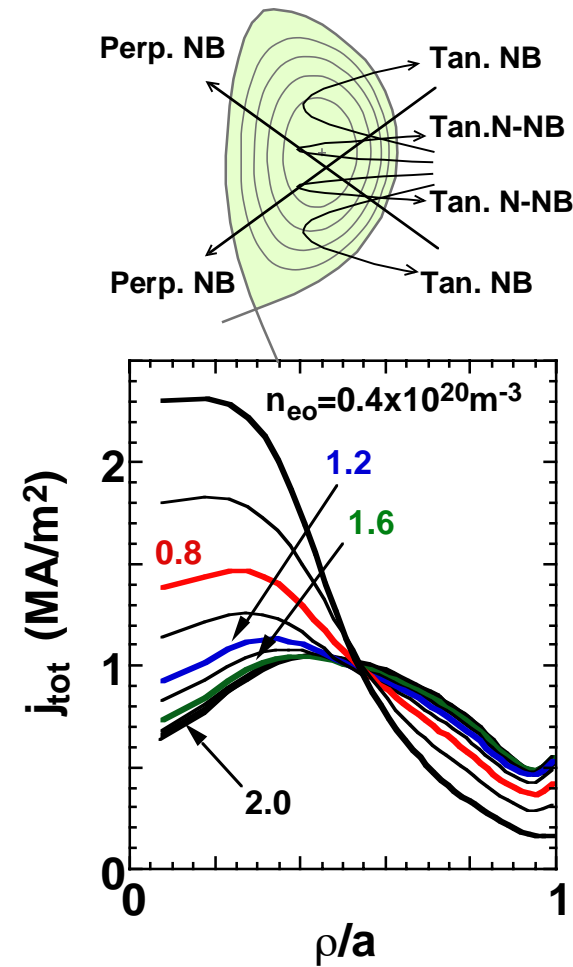
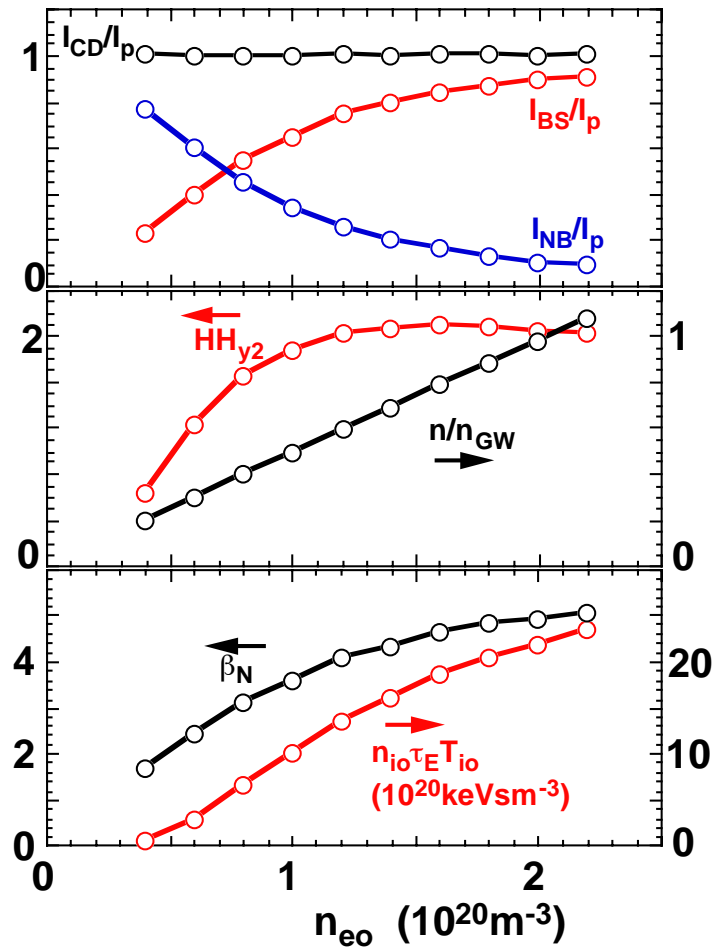
Neoclassical tearing mode stabilized by ECCD.



Resistive wall mode stabilized by invessel 18 sector coils.



# High Performance Full Current Drive

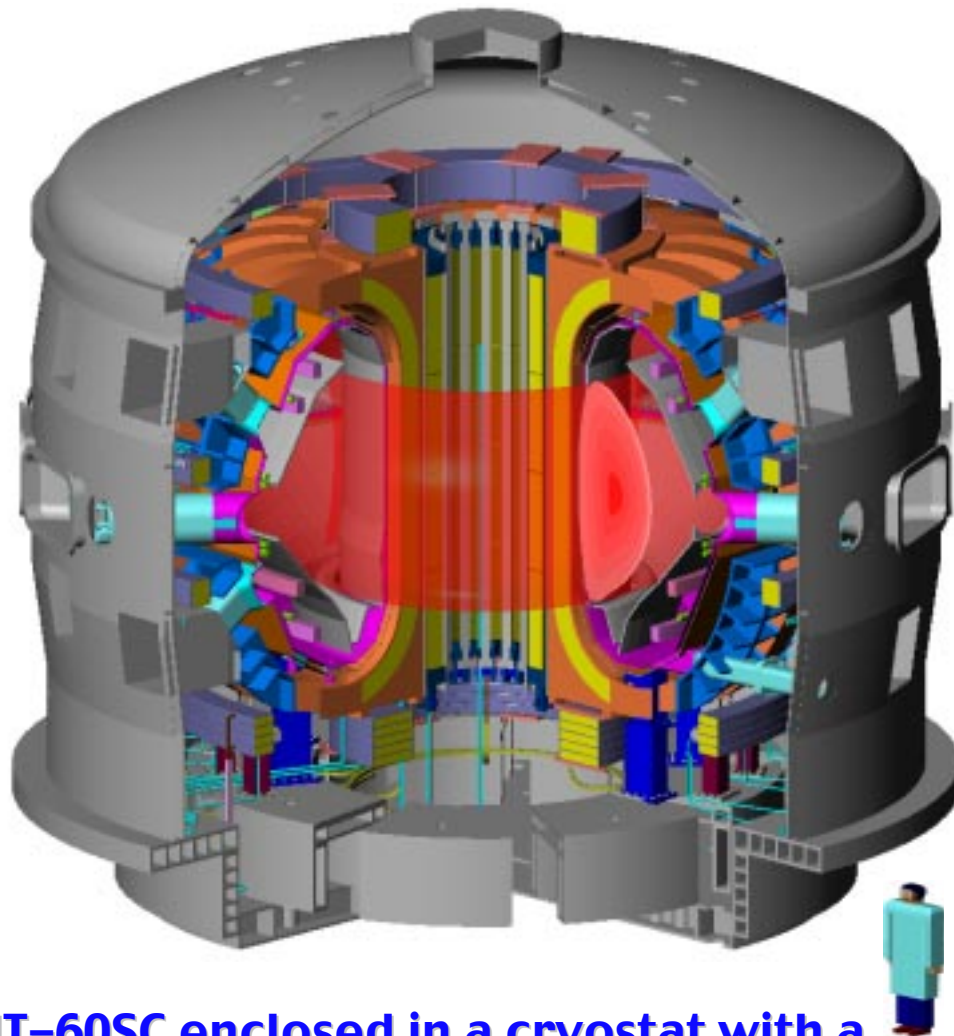


ACCOMME code analysis for 3 MA, 3.8 T,  $P_{NB}=30$  MW,  $Z_{eff}=2$

- Capability of full current drive of a plasma with  $I_{bs}/I_p > 0.8$ ,  $\beta_N > 4$  and  $n\tau_E T \sim 1 \times 10^{20}$  keVsm<sup>-3</sup> for HH $\sim$ 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 <sub>3</sub> Al
Total energy	1.7 GJ
Weight	23.5 tons/coil

### Center solenoid

Number	4
$B_{\max}$	7.4 T
Conductor	Nb <sub>3</sub> Sn
Weight	41 tons

### Equilibrium field coils

Number	6 (div. coil)
$B_{\max}$	5 T (7.4 T)
Conductor	NbTi (Nb <sub>3</sub> Sn)
Max. diameter	10.6 m

# Summary

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- **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.**