Overview of Modification of JT-60U for the Satellite Tokamak Program as one of the Broader Approach Projects and National Program

M. Kikuchi, JA-EU Satellite Tokamak Working Group and JT-60SA Design Team

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JT-60SA

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JAEA , National collaborators, International collaborators

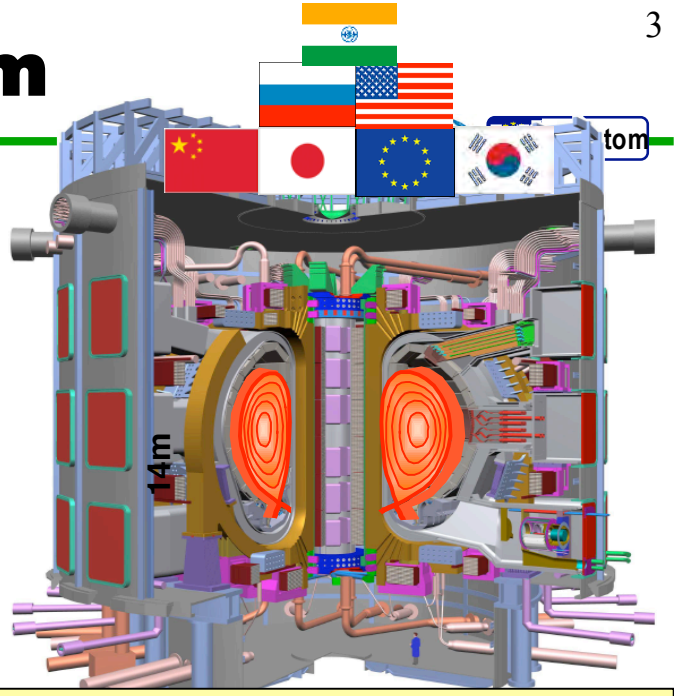
1st satellite tokamak WG at NAKA

National Review Committee

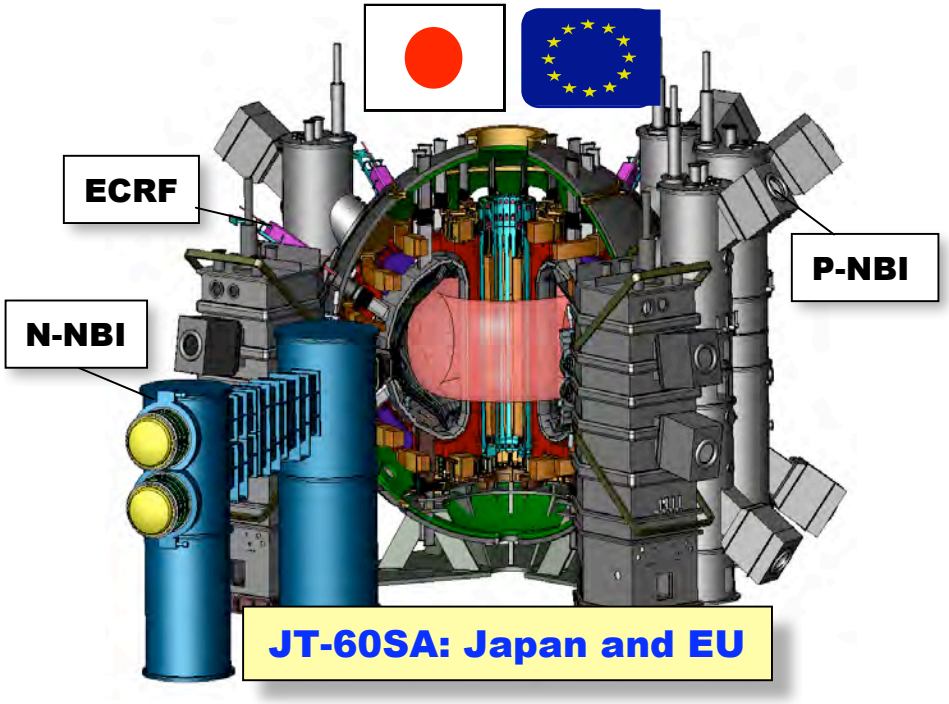
1. Mission of JT-60SA Program

JT-60SA (JT-60 Super Advanced)
is a combined program of

- ITER Satellite Tokamak Program of JA-EU
- Japanese National Program



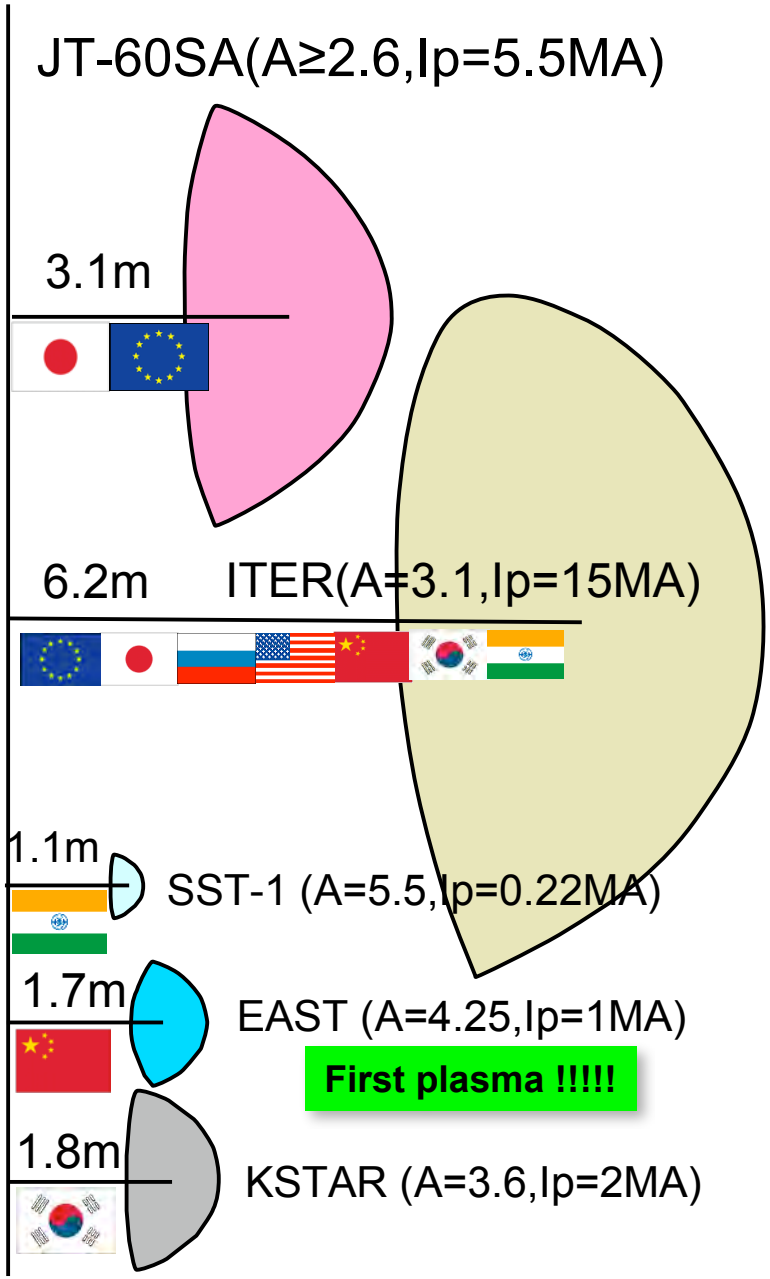
ITER : India, China, Korea, US, Russia, EU, Japan



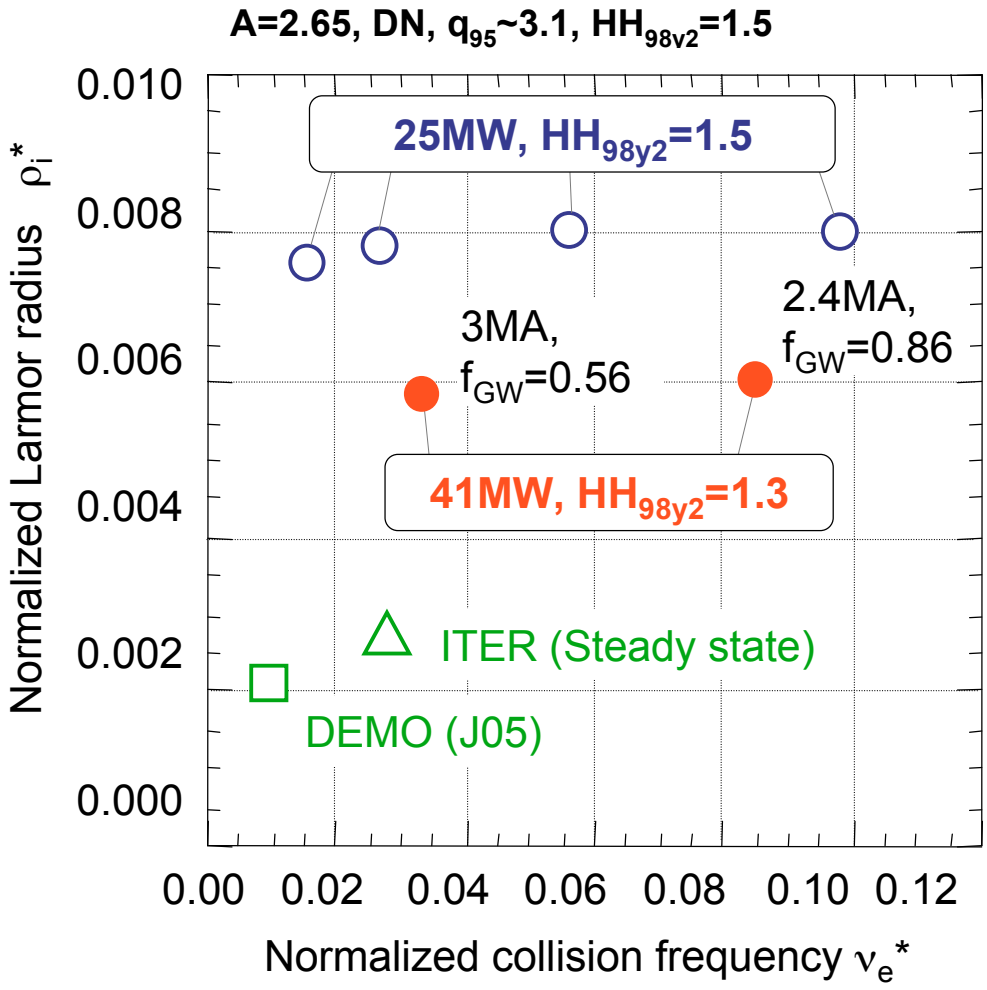
JT-60SA: Japan and EU

Mission of JT-60SA
is
to support
and supplement
ITER toward DEMO.

World families of fully superconducting tokamaks



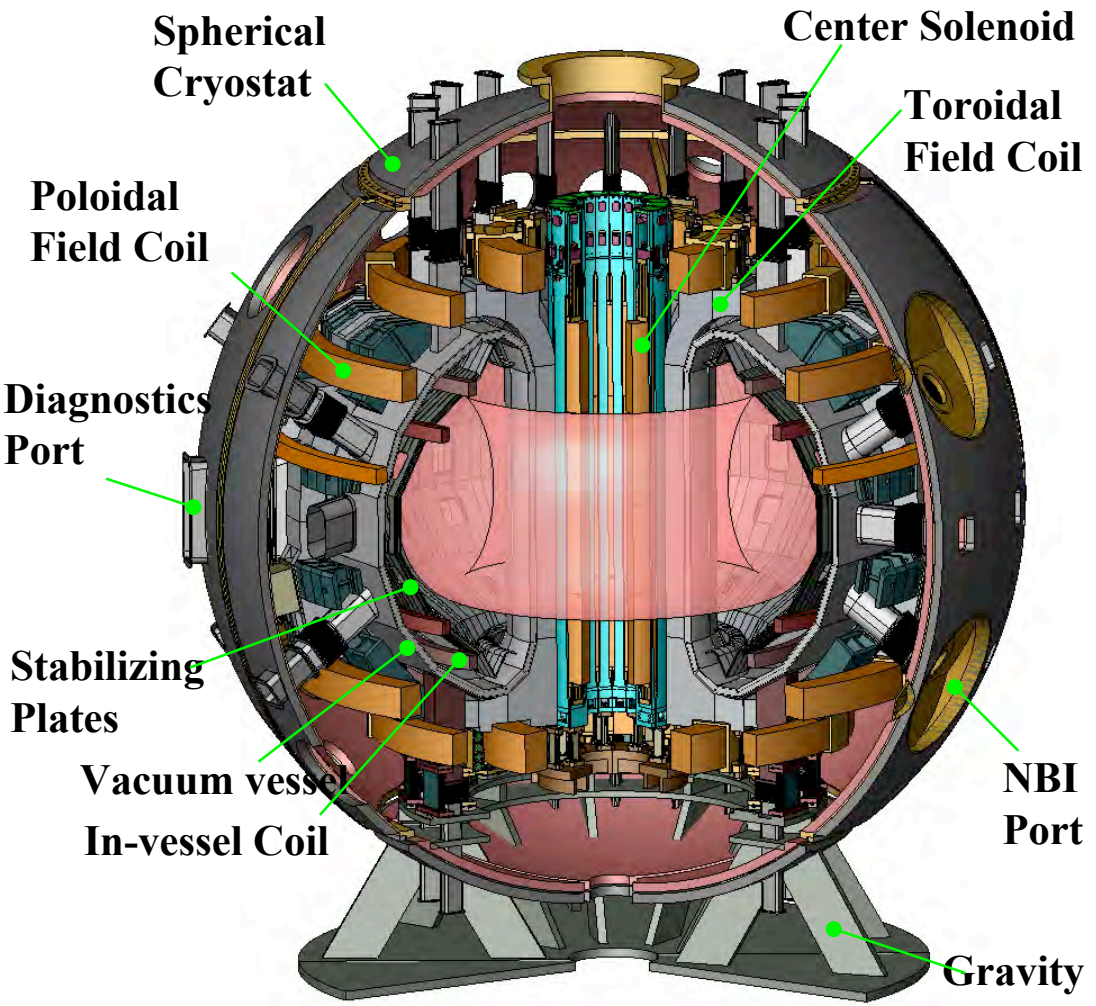
JT-60SA is capable to approach collision-less small gyro-radius plasma.



Basic Machine Parameter of JT-60SA

JT-60SA

See M. Matsukawa, FT/P7-5, this afternoon

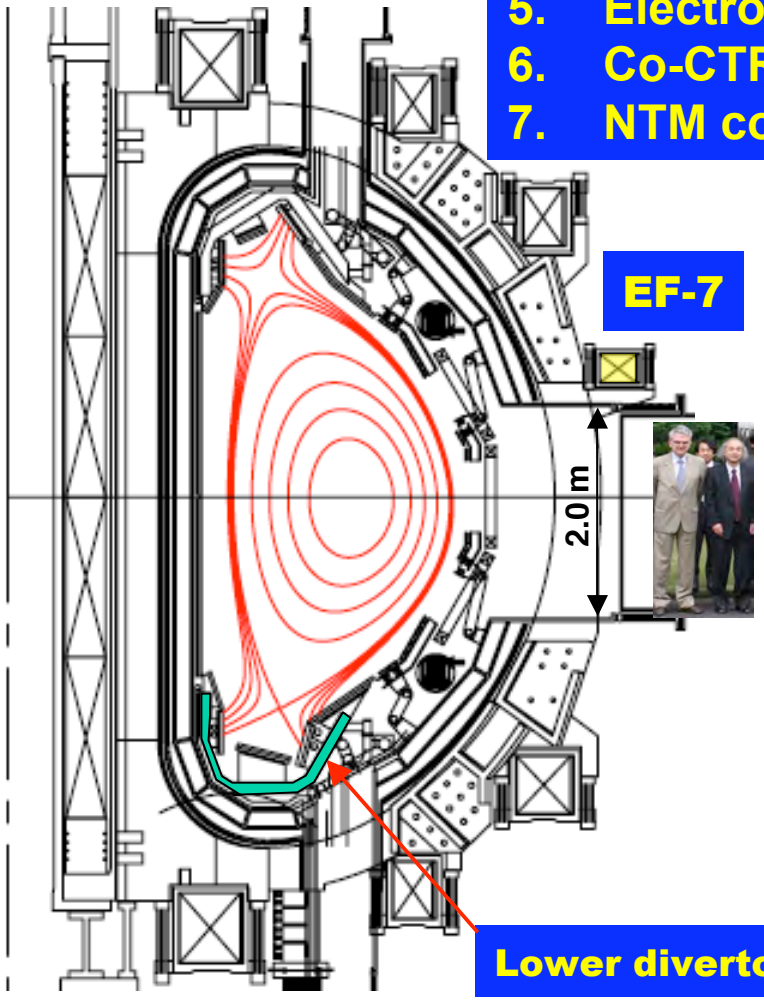


D_2 main plasma + D_2 beam injection
Remote handling is required.

Plasma Current I_p	5.5MA
Toroidal Field B_t	2.68T
Major Radius R_p	3.06m
Minor Radius a_p	1.15m
Elongation κ_{95}	1.76
Triangularity δ_{95}	0.45
Safety Factor q_{95}	3.11
Volume Vp	127m^3
Flattop Duration	100 s (8Hr)
Heating & CD power	41MWx100 s
Perpendicular NBI	16 MW
Tangential Co NBI	4 MW
Tangential CTR NBI	4 MW
N-NBI	10 MW
ECRH	7 MW
PFC wall load	15 MW/m^2
Annual Neutron	4 x 10^{21}

JT-60SA is optimized for contribution to ITER

1. EF-7 coil is added to produce ITER-shape plasma.
2. Almost same Greenwald density of ITER
3. Lower divertor to match ITER triangularity.
4. ITER type mono-block divertor for outer target.
5. Electron heating with 10MW N-NB+7MW ECRF
6. Co-CTR rotation control by tangential-NBI
7. NTM control at two ECRF frequency (110&140GHz)



European & Japanese

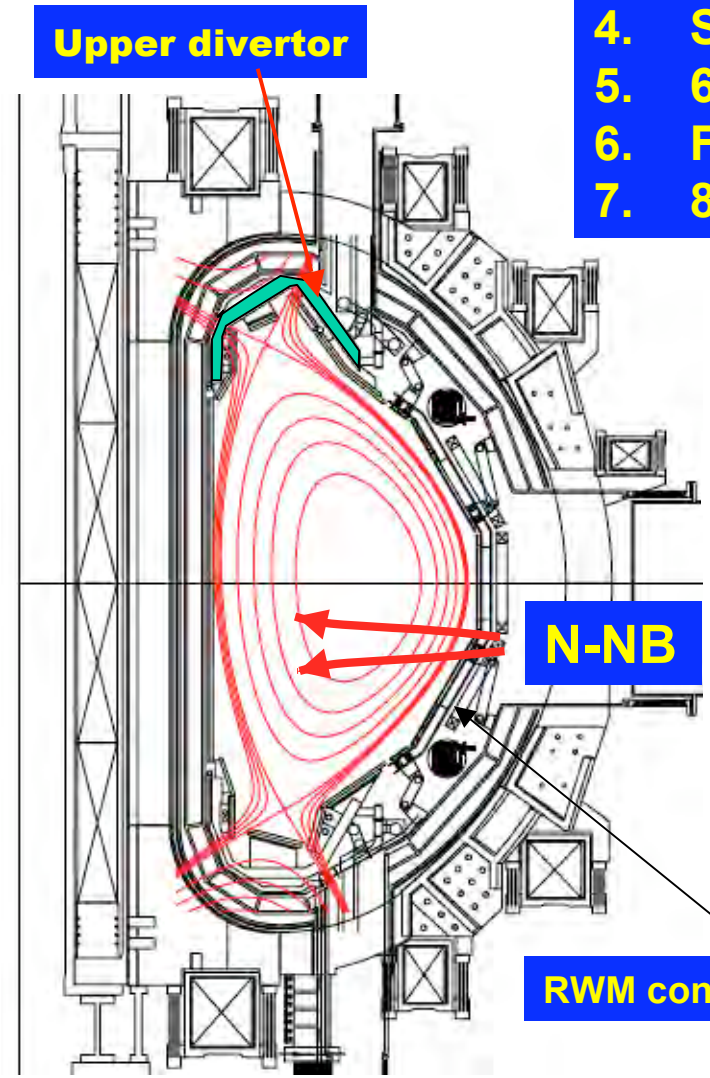
Parameter	ITER	JT-60SA
Plasma Current Ip	15 MA	3.5MA
Toroidal Field Bt	5.3T	2.59T
Major Radius Rp	6.2 m	3.16 m
Minor Radius a	2.0 m	1.02 m
Aspect Ratio A	3.1	3.1
Elongation κ_{95}	1.70	1.7
Triangularity δ_{95}	0.33	0.33
Safety Factor q_{95}	3.0	3.0
Greenwald density n_G	$1.2\times10^{20}m^{-3}$	$1.1\times10^{20}m^{-3}$

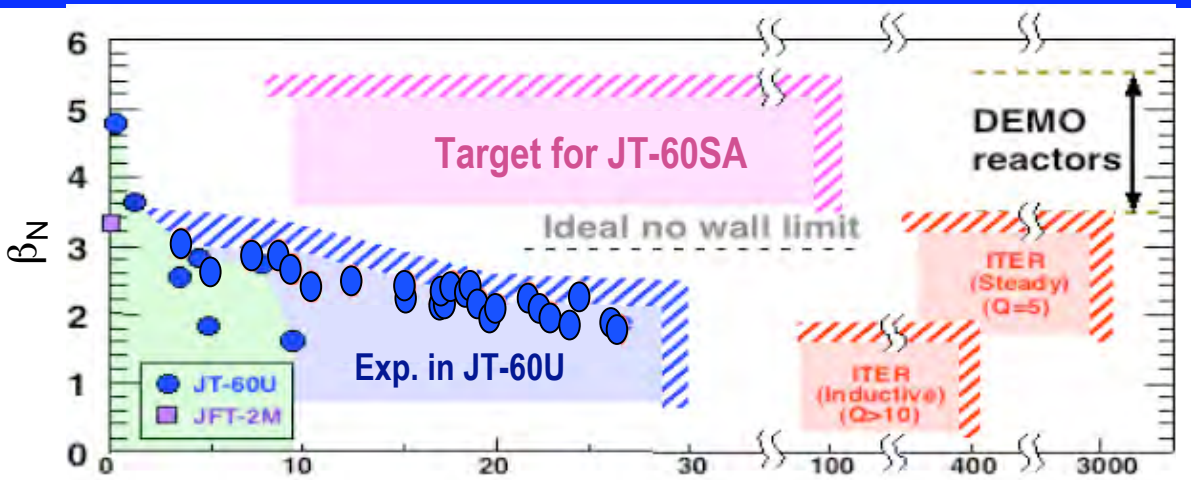
$P=41MW >> P_{th}^{L-H} \sim 20MW$

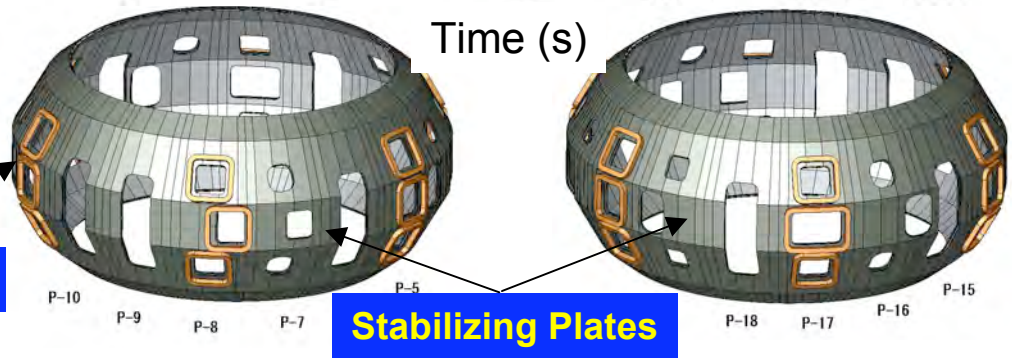
JT-60SA has various features to supplement ITER for DEMO

High beta steady-state operation for DEMO

1. Wider shaping opportunities (low A~2.6, DN)
2. Upper divertor to match high triangularity
3. Down-shifted N-NBCD to form reversed shear
4. Stabilizing plates (SP) for RWM control
5. 6 set of 3 poloidal n=1,2 RWM control coils
6. Ferritic steel on SP to simulate DEMO
7. 8 hours of continuous operation as long term target





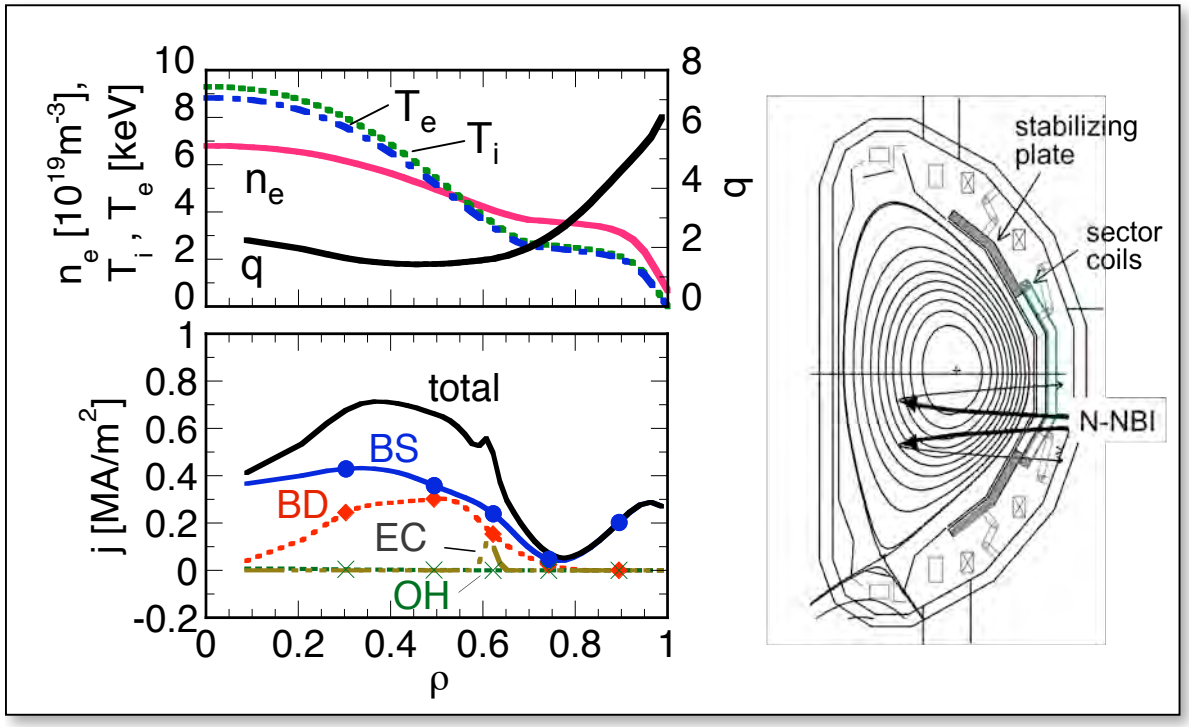


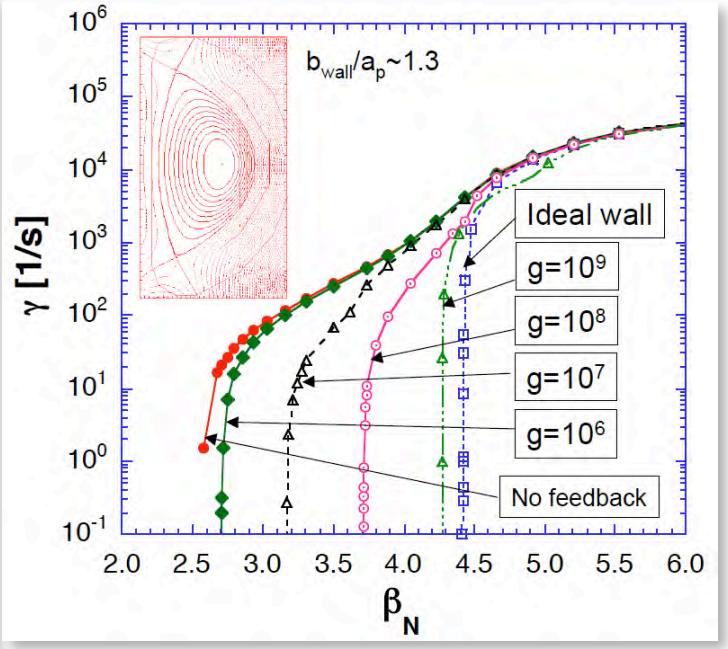
High beta full noninductive operation

JT-60SA

See T. Fujita et al., FT/P7-4, this afternoon

- 2.4 MA full current drive with A = 2.65, β_N = 4.4, f_{GW} = 0.86, f_{BS} = 0.70 for H_{H98y2} = 1.3 with P_{tot} = 41 MW
- Normalized parameters are close to those required in DEMO (J05, slim CS)
- RWM analysis by VALEN code for b/a=1.3 shows stability at β_N = 4.3.



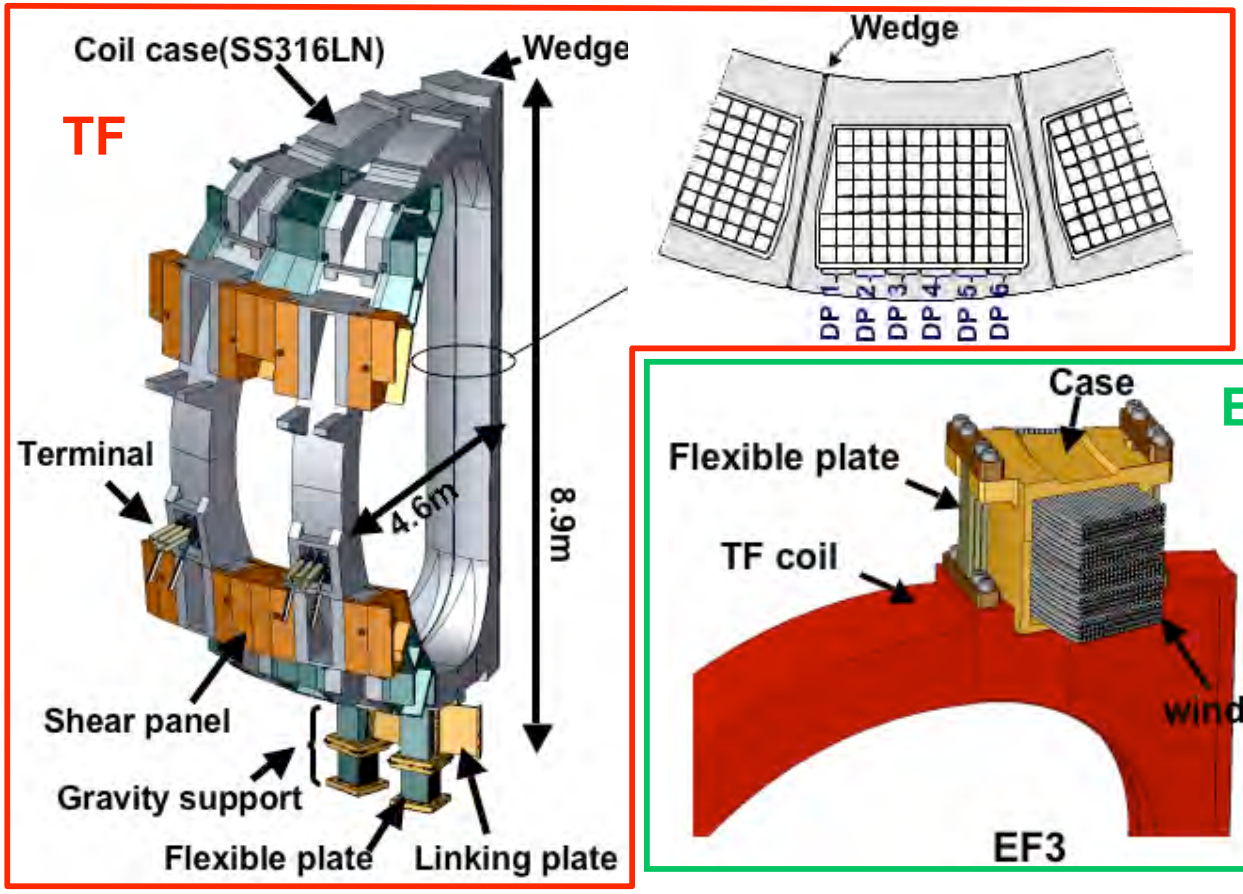


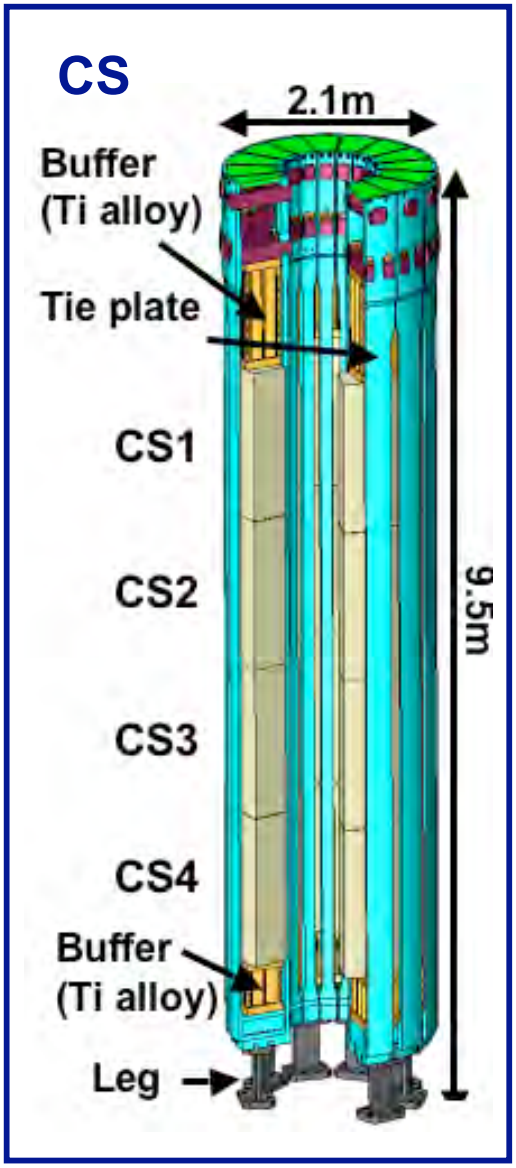
By Bialek, Navratil: Columbia U.

JT-60SA equips with full superconducting coils

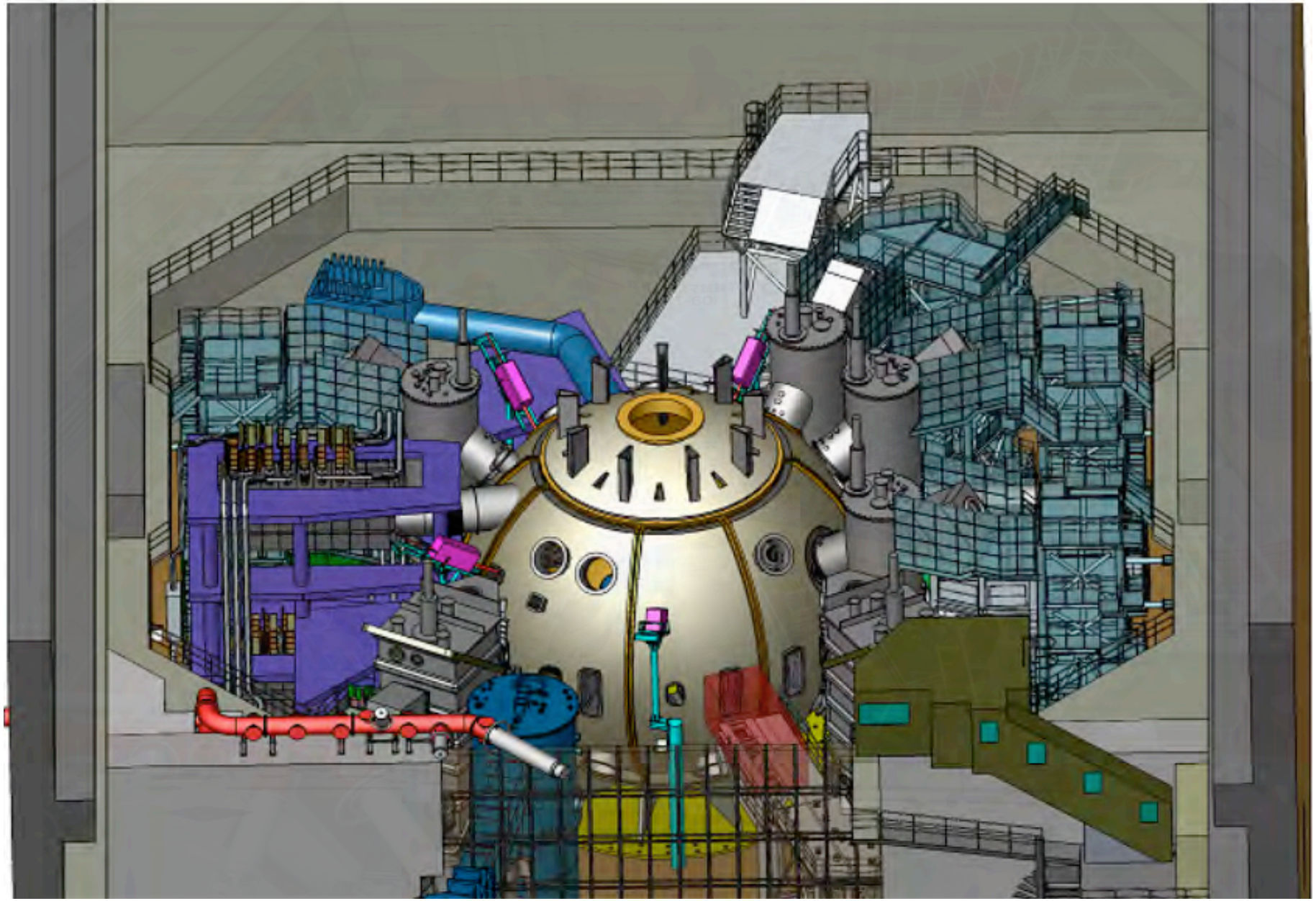
JT-60SA

	TF	CS	EF
strand	NbTi	Nb_3Sn	NbTi
conductor	cable-in-conduit		
B_{max} (T)	6.5	10	6.1
T_{op} (K)	4.6	5.0	4.8
I_{op} (kA)	26.5	20	20





JT-60 to JT-60SA Torus Hall



Sharing of Construction of JT-60SA between JA and EU

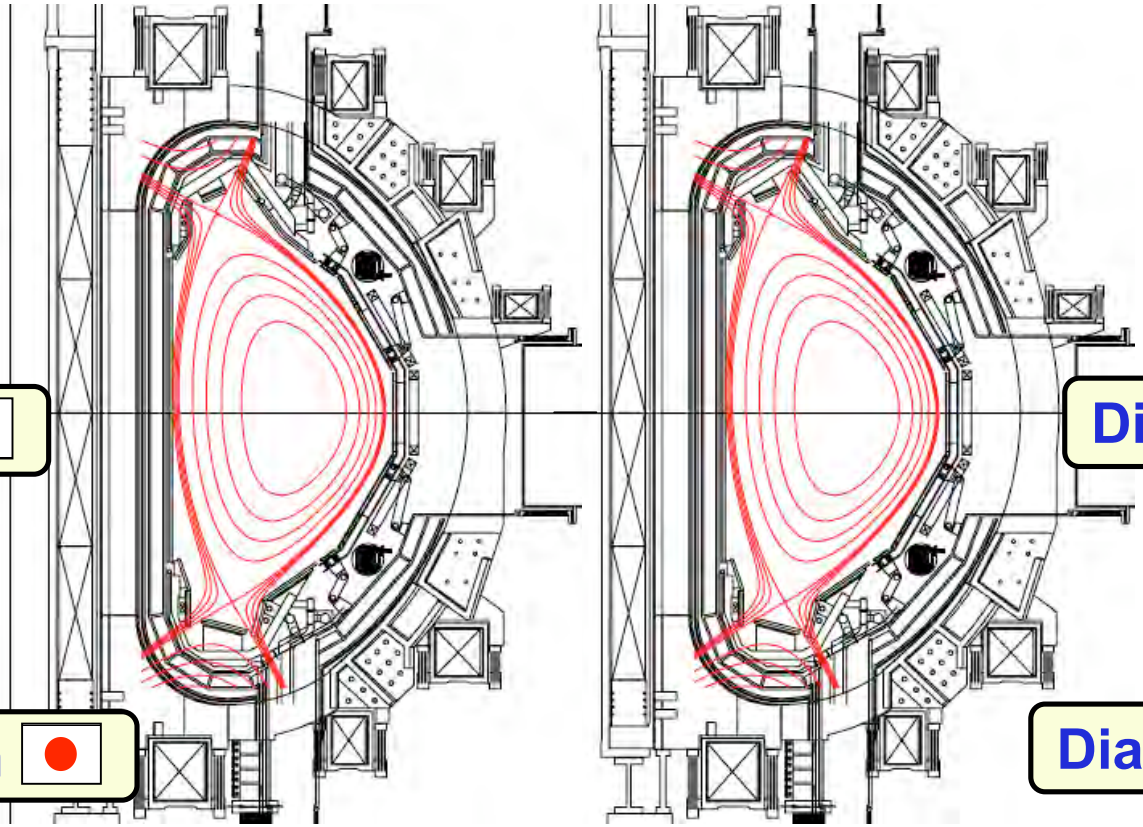
Power supplies

ECRF system

Toroidal Coils

Cryostat

Cryogenic



Assembly

Disassembly

NBI system

Diagnostics

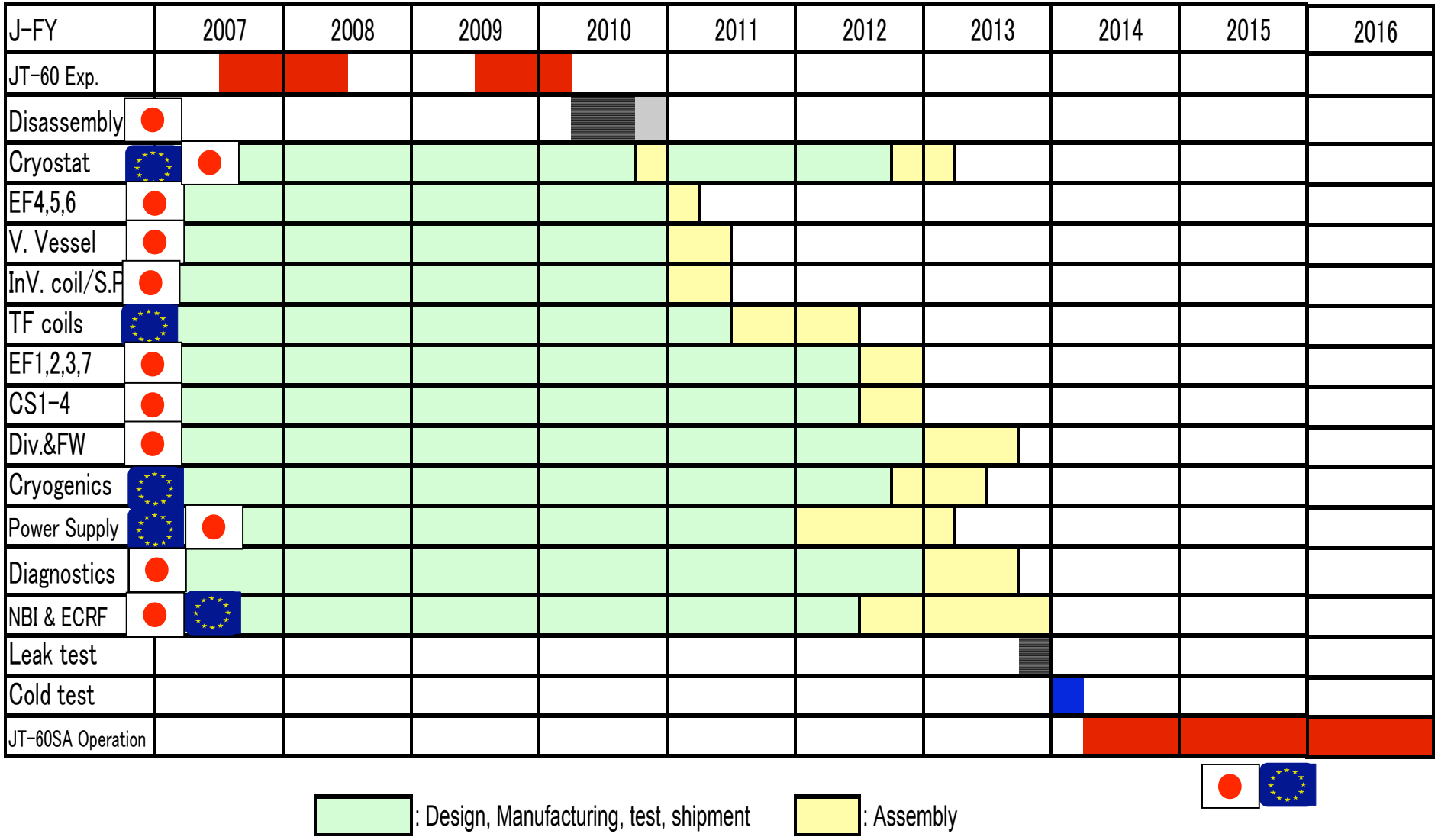
In vessel comp. & Remote Handling

Poloidal coils

Vacuum vessel

Construction plan of JT-60SA

Construction :7 years , experiments : 3 years for BA period



Summary

1. JT-60SA is a largest SC tokamak to support and supplement ITER toward DEMO.

2. JT-60SA design is optimized to contribute to ITER.

3. JT-60SA also incorporate capability not foreseen in ITER toward DEMO.

4. JA and EU are working extensively to start this program from 2007 in parallel with ITER.

5. The construction of JT-60SA will take 7 years and 3 years of experiments are foreseen in 10 years of BA period.

Appendix

Utilization of existing JT-60 facilities (Buildings, Central substation, Coil power supplies, Plasma heating systems, Water cooling system, etc.)

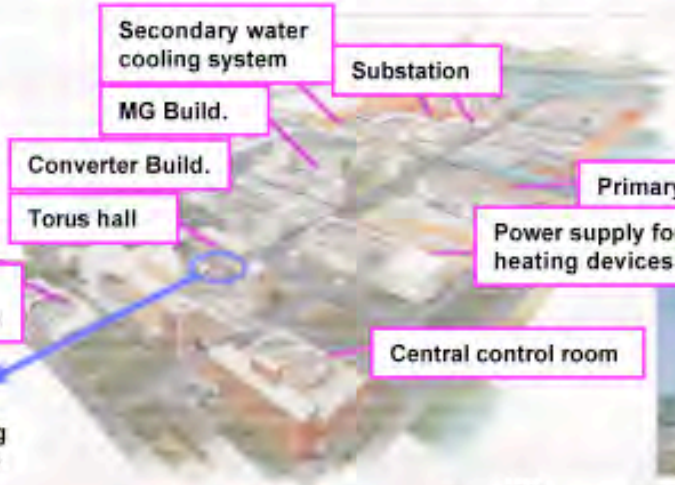
ICRH

RF heating devices of 3 different frequencies (IC: 120MHz, LH:2GHz, EC:110GHz) with the largest power class in the world

N-NBI ion source

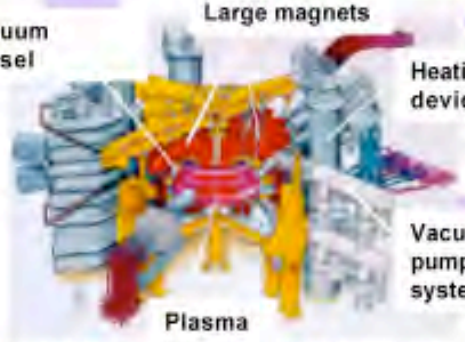
P-NBI of 40 MW (Largest power in the world), N-NBI with 500 keV (Highest energy in the world)

Purchase of the new thyristor converter is suppressed as less as possible by reuse and modification of the existing thyristor converters and diode rectifiers.



Central substation

275 kV Power Grid



JT-60, one of the largest tokamak experimental devices in the world, with magnetic field of 4 T and plasma current of 3 MA

Transformer yard

Step down transformers (total installed power of ~1.3 GVA)

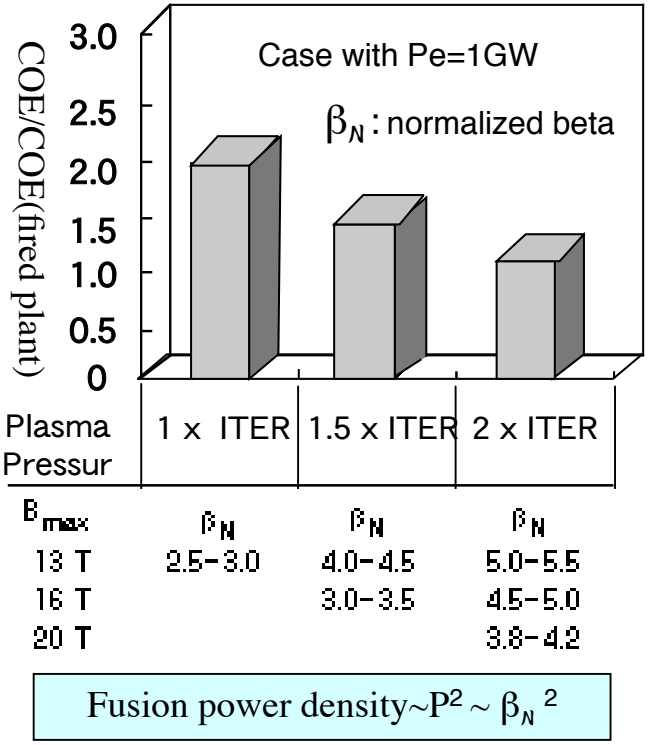
MG Build.

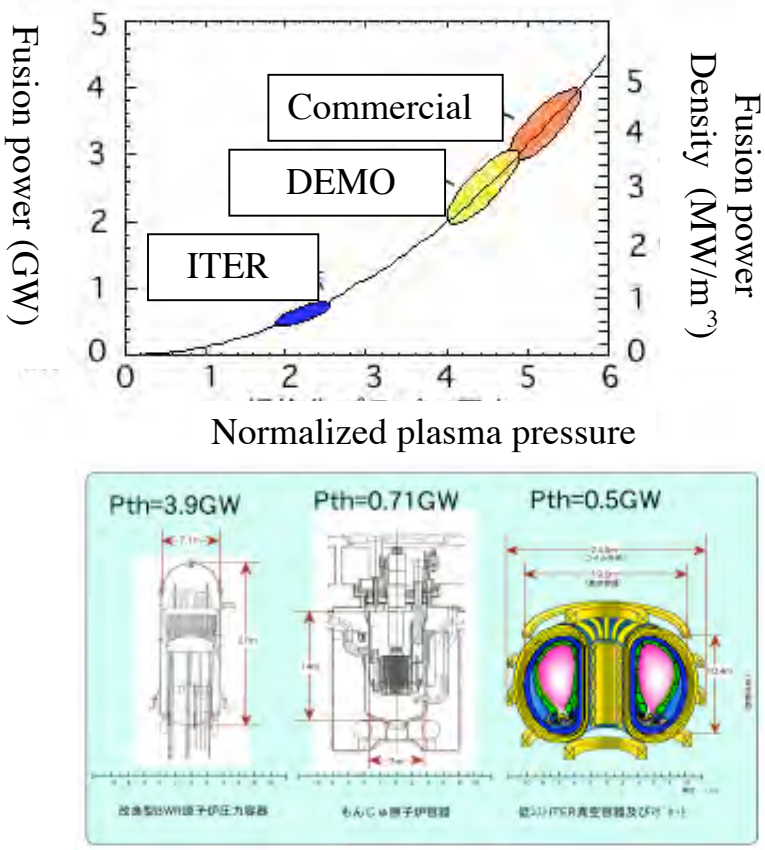
3 Motor-Generator sets (total installed power of ~1.1 GVA)

JT-60 storage Build.

"DEMO" definition was modified to have Certain Economical Prospect

-AEC Study Subcommittee on Basic Issues of Fusion Research and Development:
DEMO should have "certain economical prospect" with ITER-like size and Pf~3GW (Aug. 16,2005)
-AEC Advisory Committee on Fusion Research revised the report and approved (Oct.26,2005).
-AEC approved ACFR report as basis for 3rd phase basic program (Nov.1,2005).





Scientific Mission (II) (long term)

Expand operation regime of high beta steady-state for DEMO

Long pulse operation : ~8 hours

1. Particle exhaust for long pulse and development of DEMO relevant PFC
2. Development of reliable operation and reduction of disruption probability