Experimental Advanced Superconducting Tokamak (EAST) Design, Fabrication and Assembly

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Introduction

EAST is one of Chinese national fusion project

The main mission of the project is to develop an advanced superconducting tokamak

- **Explore and demonstrate of steady-state operation with high plasma performance.**
- **Investigate of advanced tokamak physics and demonstration of stationary H-mode operation.**
- **Investigate of particle and heat fluxes handling on a time scale much longer than the wall equilibration time.**

The construction begun in 2000 and will be completed in 2006, total budget is about 300 million Yuan.

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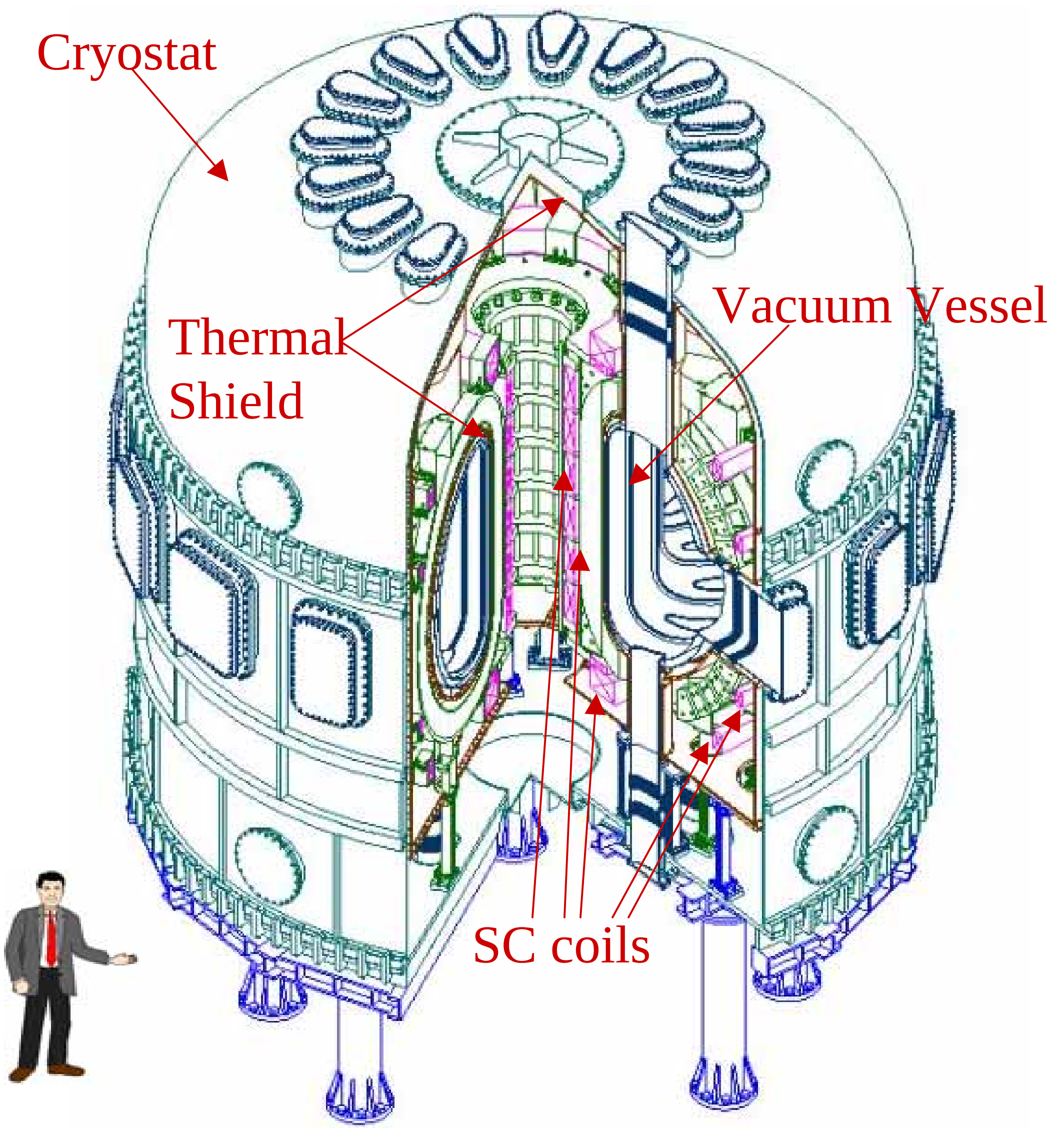


Major Radius R_o **1.7 m**

Minor Radius a **0.4 m**

Toroidal Field B_o **3.5 T**

Plasma Current I_P **1 MA**

Elongation K_x **1.2 - 2**

Triangularity d_x **0.2-0.5**

Pulse length **1000 s**

Heating and Driving:

(first phase)

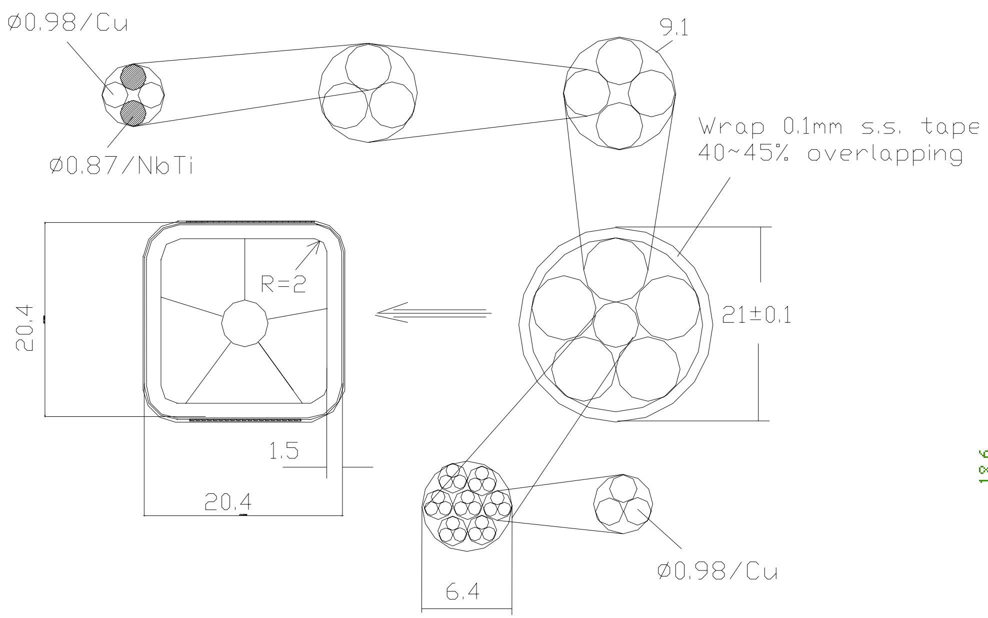
ICRF	**3 MW CW**
LHCD	**3.5 MW CW**
ECRH	**0.5 MW**

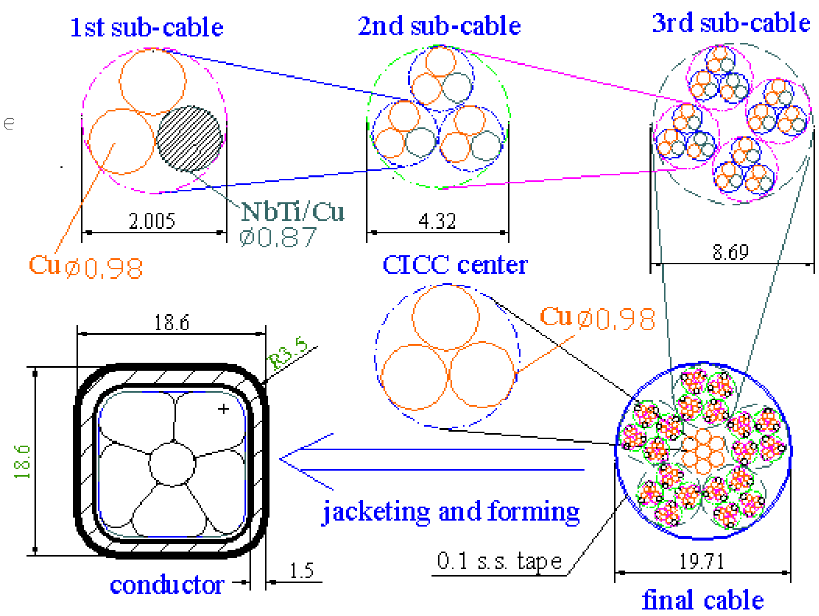
Configuration:

Single null divertor

Double-null divertor

Conductor design and R&D





	TF	CS and PF 7-10	PF 11-14
Size	20.4 × 20.4	20.4 × 20.4	18.5 × 18.5
Number of SC strands	120	120	60
Coating	Sn alloy	Ni	Sn alloy
Cu / non-Cu	4.91	4.91	8.23
Void fraction	0.34	0.34	0.36

Total weight of NbTi strands: 20 tons

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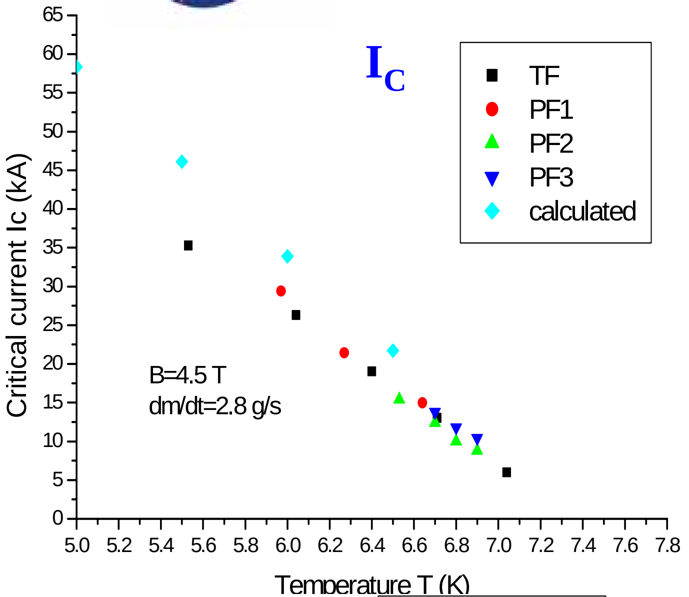

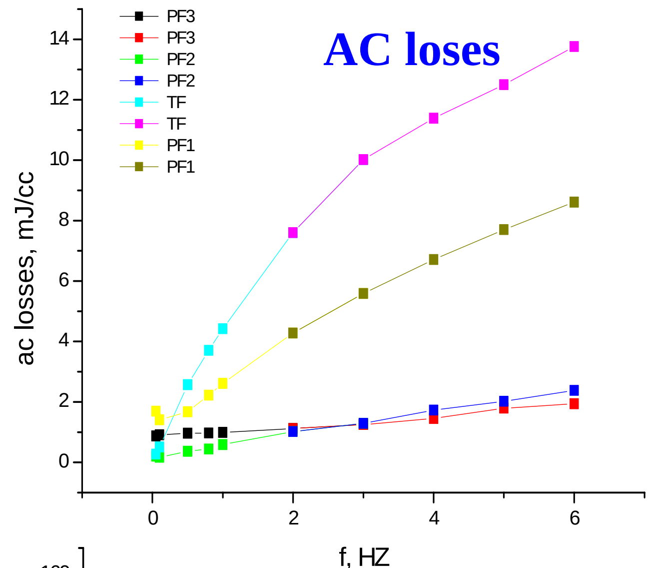

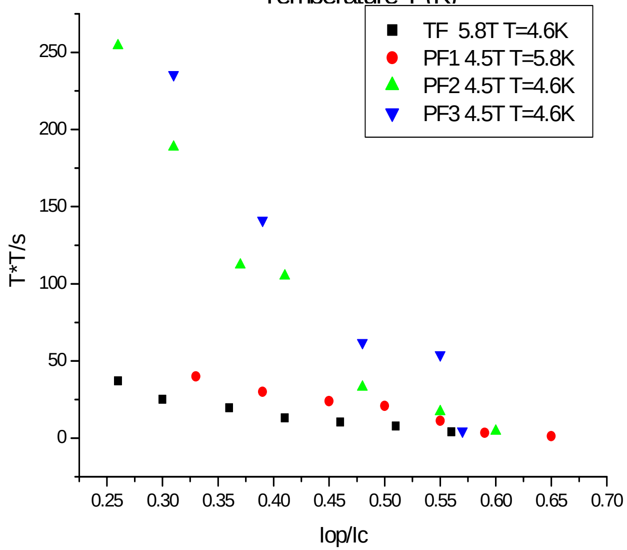

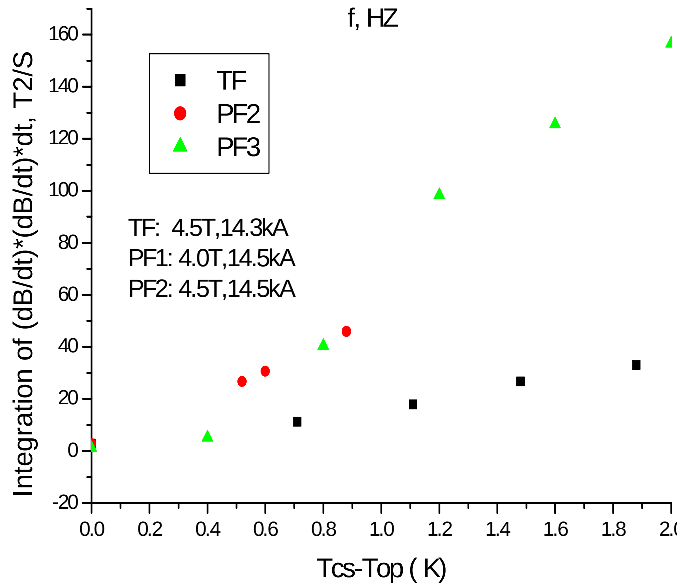

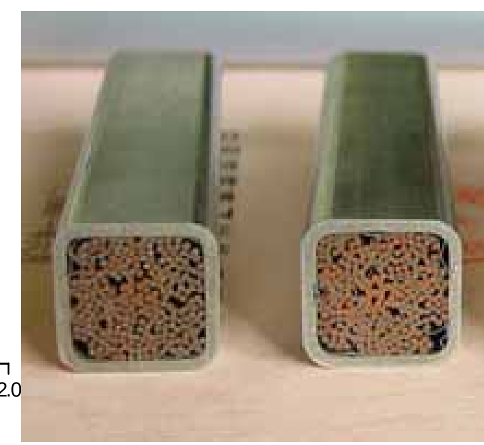

Transient stability against magnet field disturbance

Short Sample test

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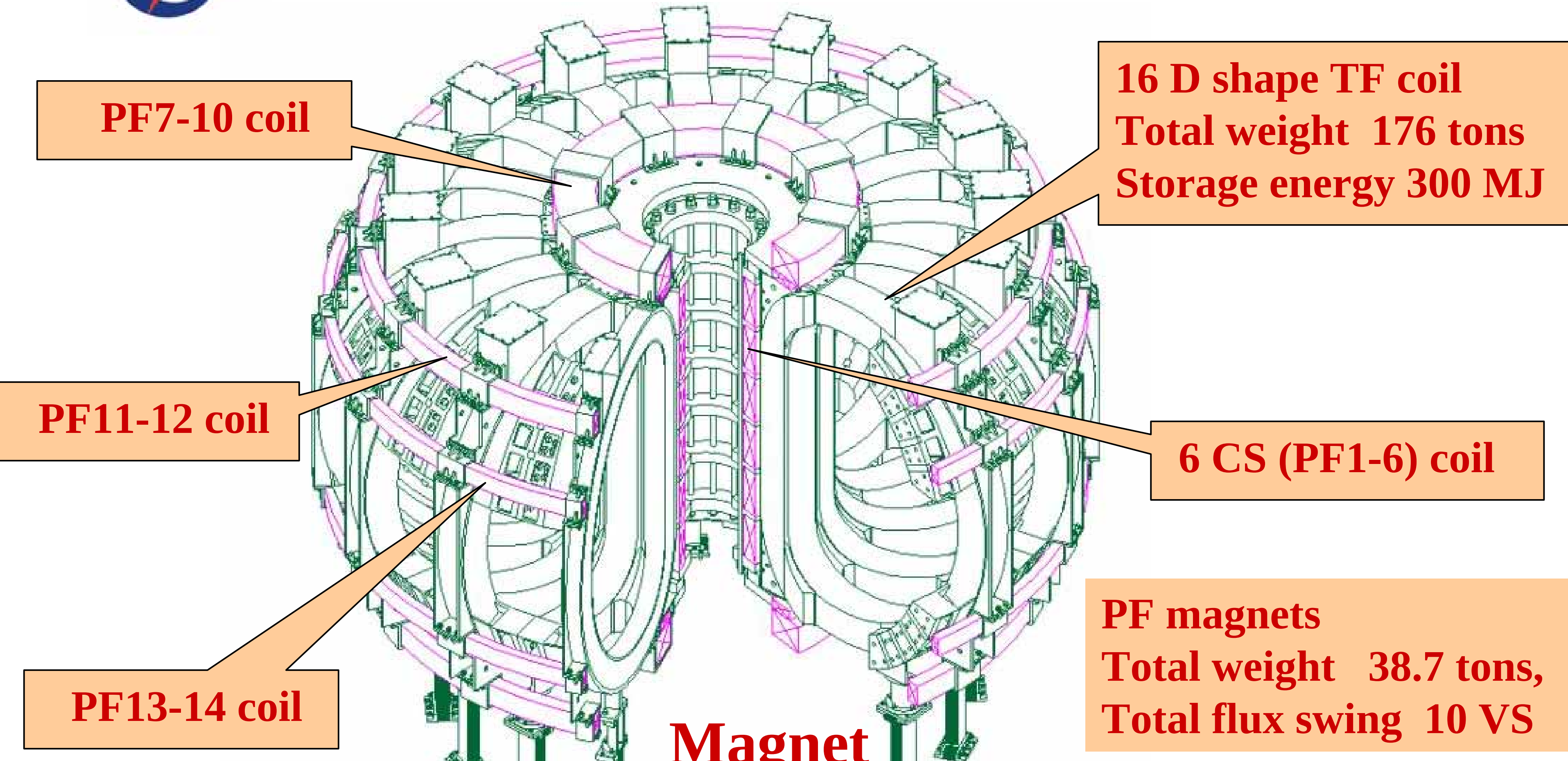
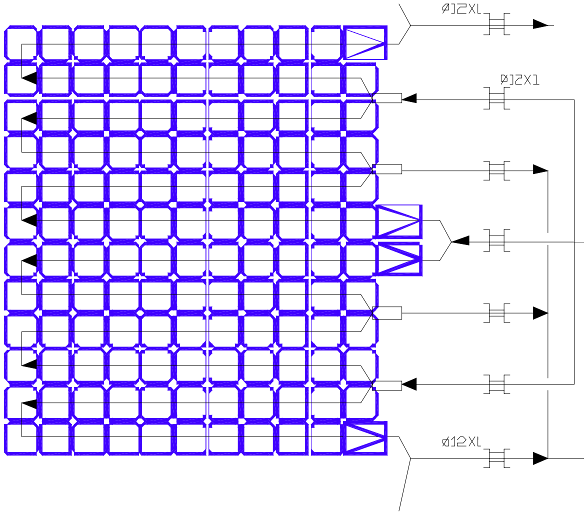
CICC jacketing line **58 conductors (35 km) have been fabricated**



Magnet system

Superconducting coils; CIC conductor; Uninterrupted multi-pancake winding; VPI; low rigidity support; Supercritical helium forced flow

TF coil



16 D shape TF coil

Turns/coil	130
Size	3.52 × 2.51 m
Pancakes	2× 6
I_{nom}	14.3 kA
B_{max}	5.8T
T_{in}	4.5 /3.8 K

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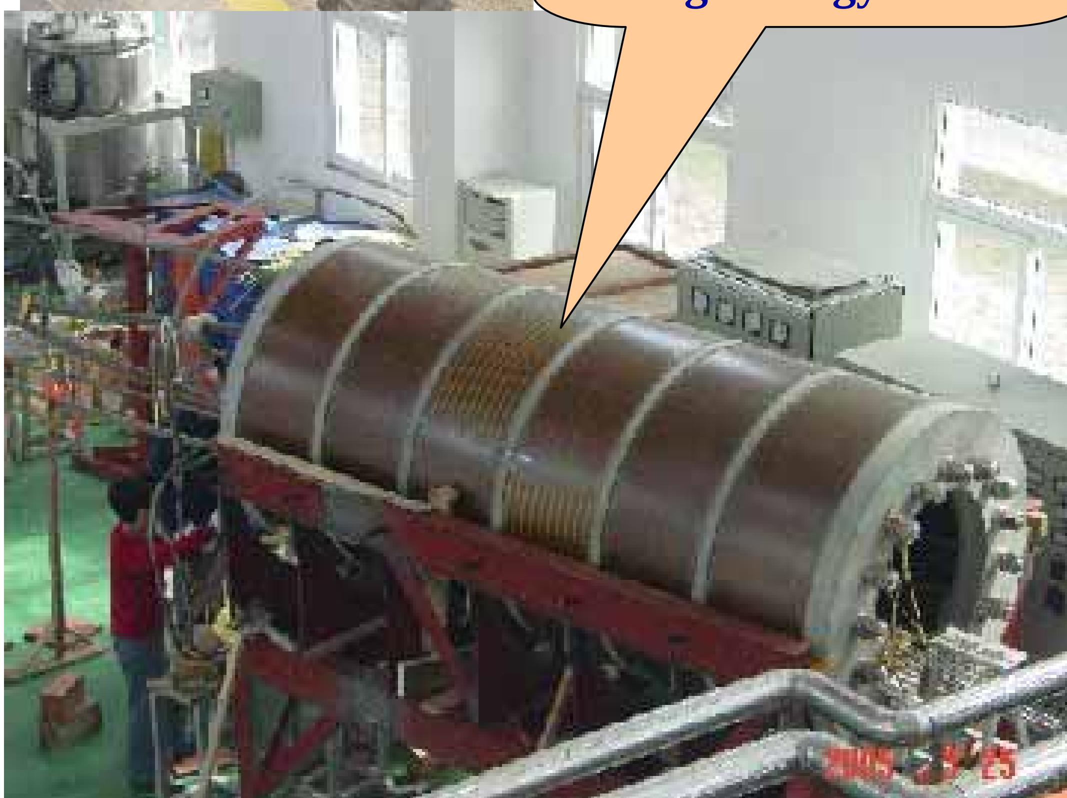
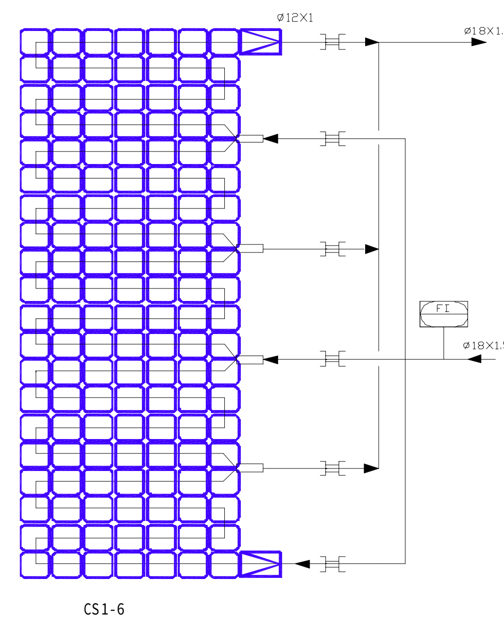
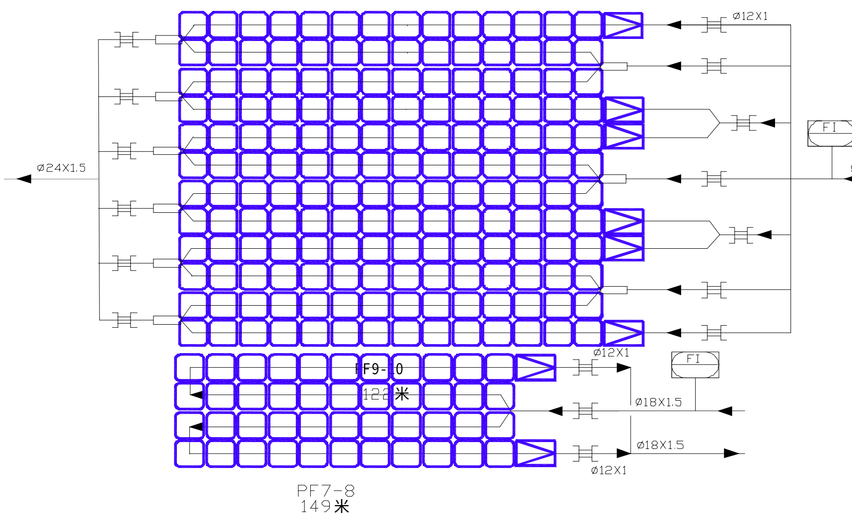
CS coil after VPI

CS Assembly consists of 6 coils
Storage energy 30MJ



Turns	140
Size	1.42× 0.48 m
Pancakes	20
I_{max}	14.5 kA
B_{max}	4.3T
dB/dt	6.8T/s
T_{in}	4.5 /3.8 K





PF7 and PF9 assembly

Turns 248

Pancakes 20

I_{max} 14.5 kA

dB/dt 3.5 T/s

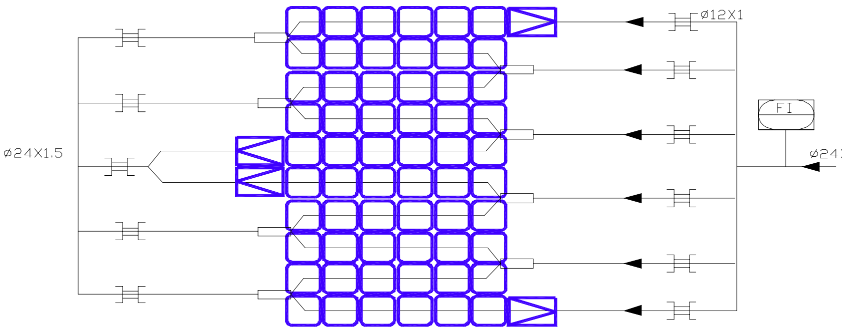
Storage energy 19 MJ

Size 2.67× 0.39 m

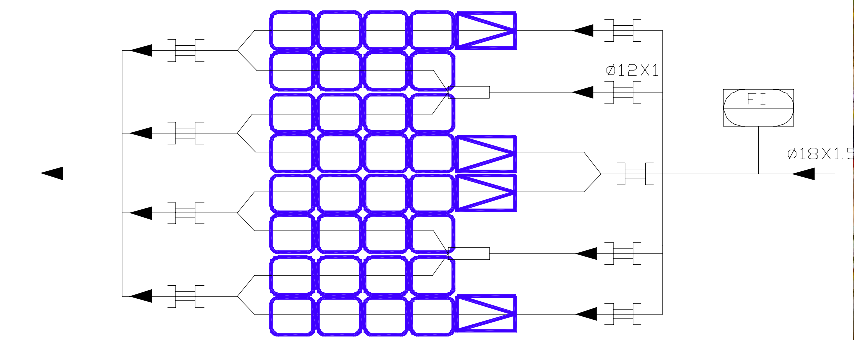
Weight 5.8 ton

B_{max} 5 T

T_{in} 4.5 /3.8 K



PF 11-12



PF 13-14

	Turns	Size (m)	Pancake	I_{max} (kA)	B_{max} (T)	dB/dt(T/s)	T_{in} (K)
PF 11-12	60	6.05 × 0.22	10	14.5	1.5	0.7	4.5 /3.8
PF13-14	32	6.65 × 0.18	8	14.5	1.5	0.7	4.5 /3.8

PF coils

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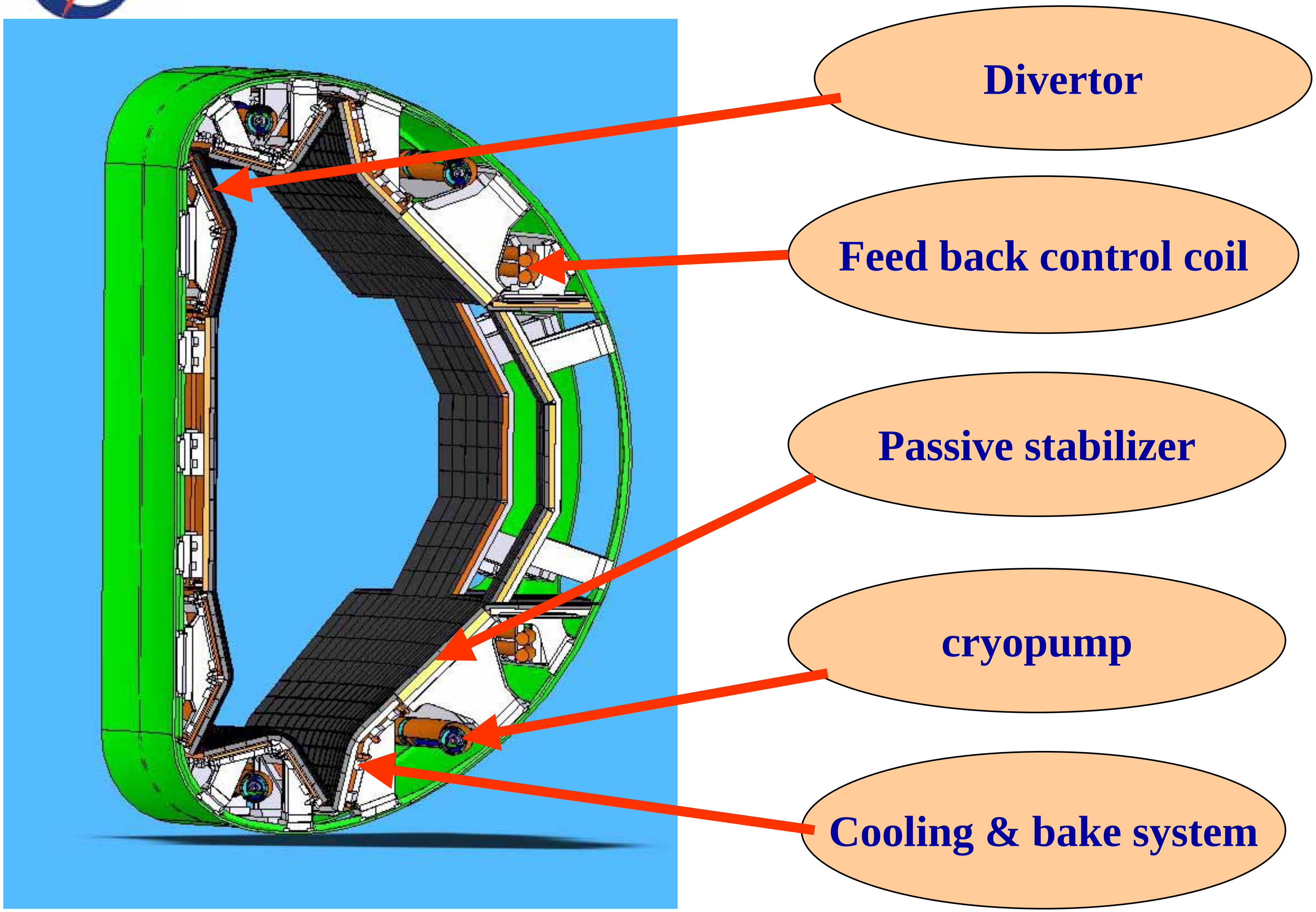
Coil fabrication

Design feature Vacuum Vessel

- Full welded double wall structure
- 16 horizontal & 32 vertical ports
- Low rigidity gravity supports
- Volume 38 m^3 ; Ultimate Vacuum $1.3\times10^{-5} P_a$



In vessel components

VV and CS Thermal shield

Consist of
- vacuum vessel thermal shield
- cryostat thermal shield
- transition thermal shields

Insulation break	8
Sandwich structure	
wall thickness	25/40 mm
panels thickness	3 /5 mm
cooling pipe	19×19 ×2
Total surface area	310 m^2
Total weight	22 tons
Cooling media	He gas
Mass flow rate	110g/s
Inlet temperature	60 /80 K.
Pressure drop	< 0.4 bar

Cryostat

Consists of upper head, middle cylinder and bottom section.

Provide the vacuum environment and support for all of magnets, vacuum vessel and thermal shield

48 penetrations for the vacuum vessel ports extension

19 penetrations for feeder line and maintain access

Diameter	**7.6 M**
Height	**7.1 M**
Weight	**78 tons**
Volume	**180 m^3**
Ultimate pressure	**$5\times10^{-4}P_a$**

Coil Test

16 TF coils, one CS coil, CS assembly, PF 7-9, PF 8-10 and PFMC have been tested.
Test program :

- **Insulation**
- **Cryogenic & thermal-hydraulic behavior**
- **Resistance of coil internal joints**
- **Coil exiting to nominal current**
- **Quench current measurement.**
- **Simulate Plasma initiation**
- **AC losses test**

Test facility

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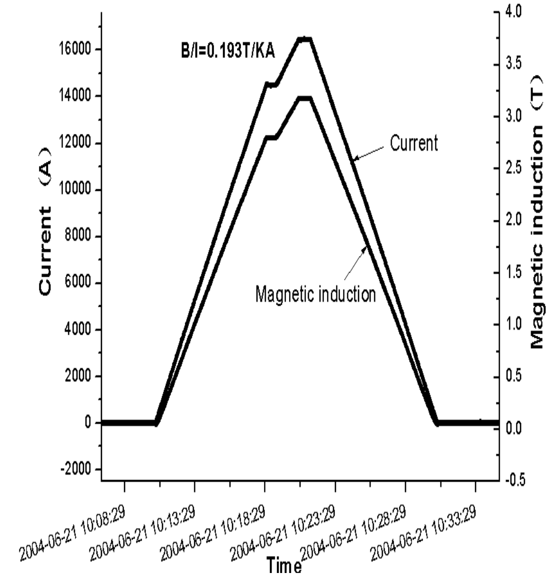
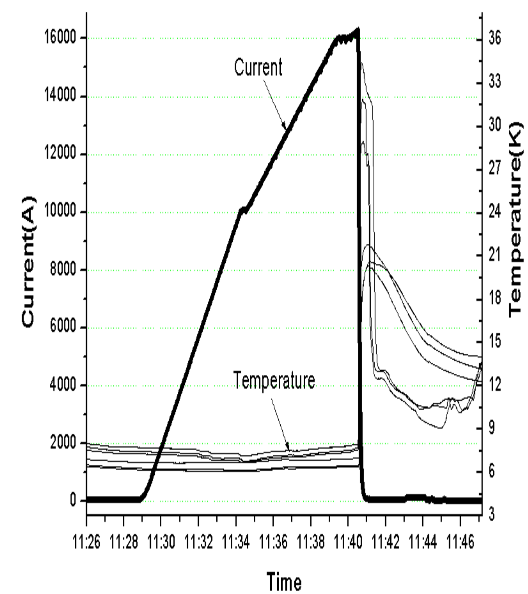
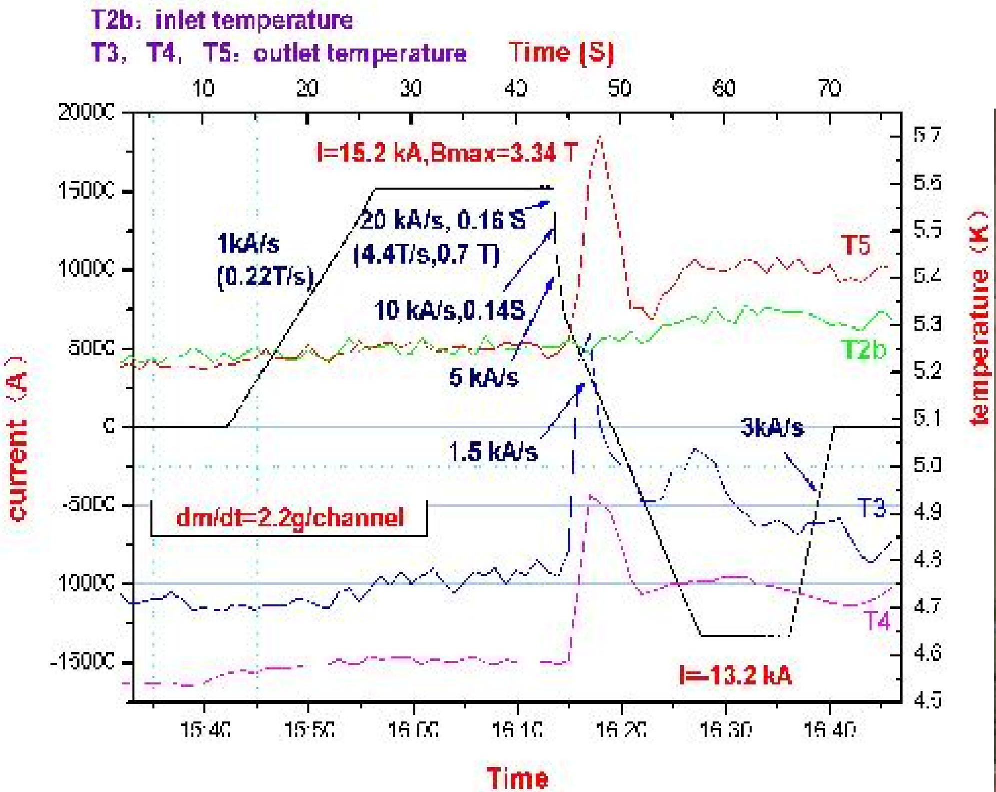




TF coil in test facility

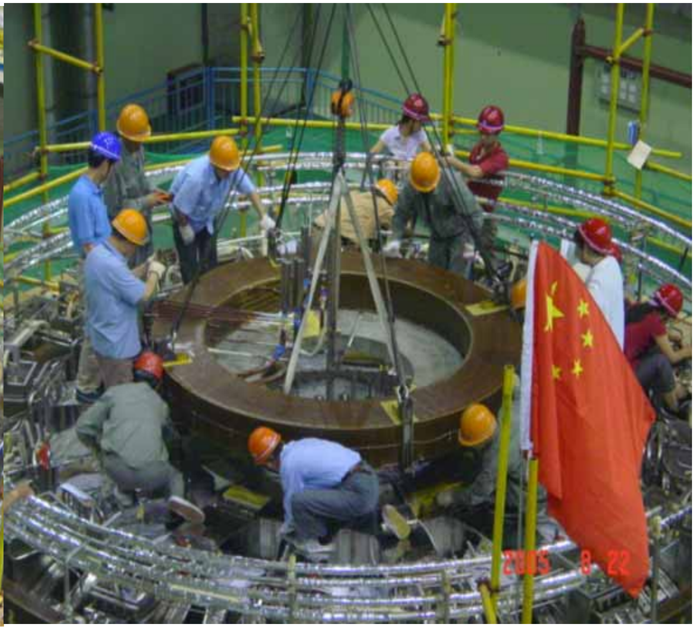


CS coil test

PF 7-9 coil test

CS assembly in test facility

Assembly



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Cryogenic system

2kW/4.4K+11kW/80K refrigerator

Helium distribution
valve box

Power supply system for magnet

36 group of 15 kA AC-DC convertor
total nominal power 210 MVA

13 sets of power supply system for TF, CS and PF magnets.

Summary

- Except the in vessel components, the fabrication of all parts is completed. All of magnets, except 4 of big PF coils, have been tested and the results show that the magnets are accepted.
- It is planned to complete the assembly and make the first cool down around the end of this year. The commissioning will begin in 2006.
- The experiment in first stage will be focused on the steady state operation with 1 MA plasma, it will be a challenge for us and ASIPP welcome for cooperation.
- China participate ITER, the technology developed for EAST will be useful during the fabrication of ITER parts in China.