Progress of the EAST Project in China

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1. Introduction

In 1998, a superconducting tokamak project, HT-7U, was approved by Chinese government.

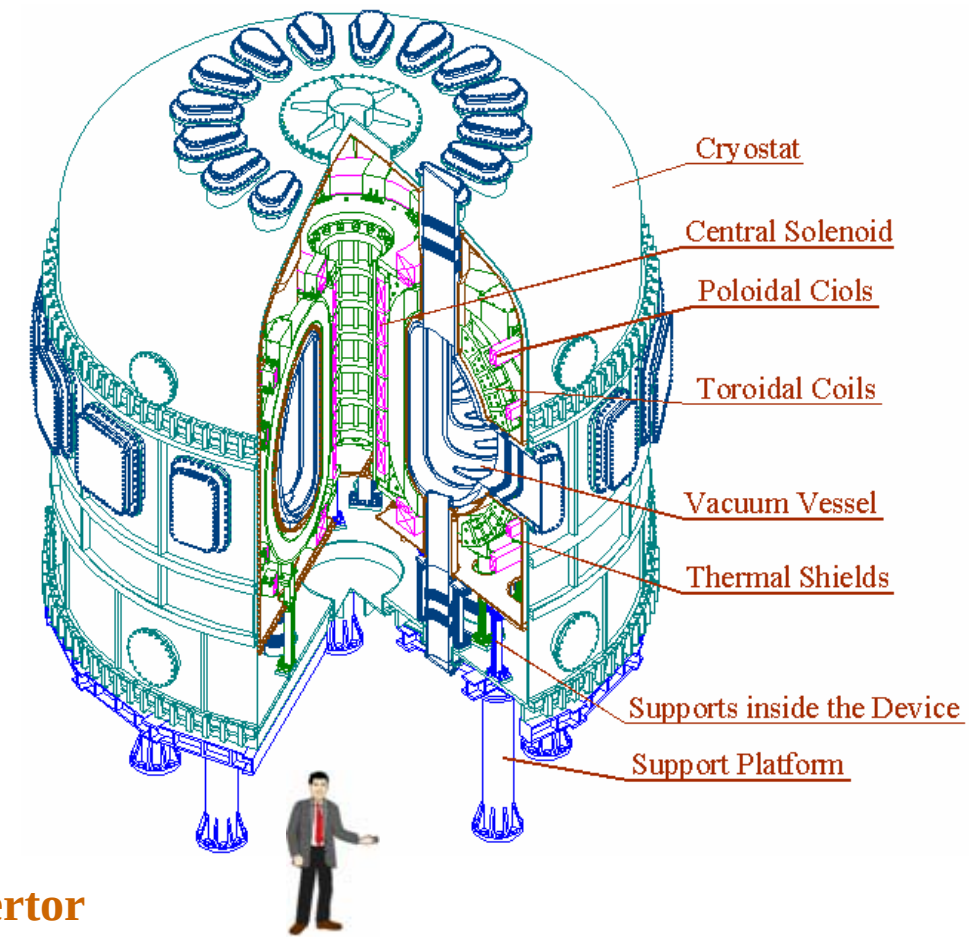
The name of HT-7U was changed to Experimental Advanced Superconducting Tokamak (EAST)

The Scientific and Engineering Missions of the EAST Project are:

- to study physical issues of the advanced steady-state operation modes
- to establish technology basis of full superconducting tokamaks for future reactors

Main Parameters of the EAST

	Nominal	Upgrade
B_o	3.5 T	4.0 T
I_P	1 MA	1.5 MA
R_o	1.7 m	1.7 m
a	0.4 m	0.4 m
R/a	4.25	4.25
K_x	1.2-1.5	1.5-2
δ_x	0.2-0.3	0.3-0.5
Heating and Driving:		
ICRH	3 MW	6 MW
LHCD	3.5 MW	8 MW
ECRH	0.5 MW	1.5 MW
NBI		8 MW
Pulse length	1000 s	
Configuration:	Double-null divertor Single null divertor	



Main design features of EAST

- Full superconducting magnets;
- CW non-inductive current driven and heating systems;
- Individual powered PF system and non-circle cross-section design offer flexibility and reliability to shape and control plasmas of single-null, quasi double-null and double null configurations;
- Real time data collection and feedback for steady-state profile control
- Active cooling and changeable plasma facing components (PFC) and divertors
- Advanced diagnostics

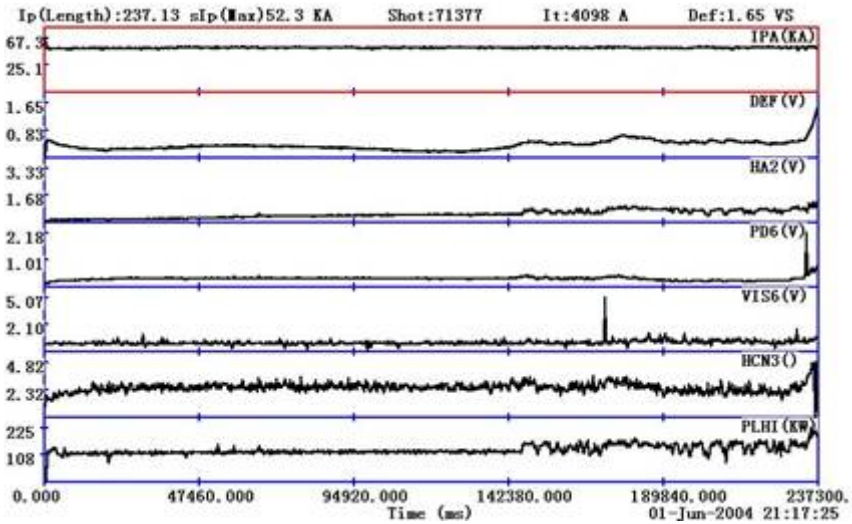
The key tasks of the EAST construction

- Superconducting tokamak device, including In-vessel components
- EAST buildings, including EAST machine hall and other appurtenant buildings
- 110 kV/83 MVA transmission line and transformer substation
- 2 kW/4.5 K Cryogenic and refrigerator system
- Power supply systems for TF, PF and plasma fast control
- LHCD system, ICRH system and ECRH
- Cryogenic test facility system
- Vacuum pumping and gas puffing system
- Diagnostic systems
- Plasma control and data acquisition systems
- Water cooling system

2. Important Progresses

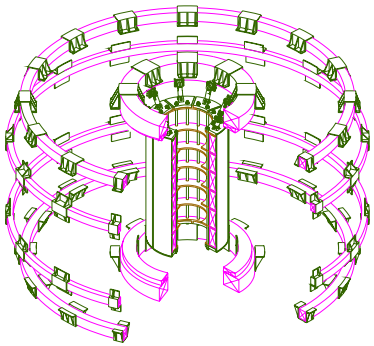
Pre-physics Experimental Program (OV/5-1Rb, Wan, B.N.)

- A so-called **Pre-physics Experimental Program** have been achieved on the HT-7 superconducting tokamak, especially by achieving about 240 s long pulse in the last operation campaign.

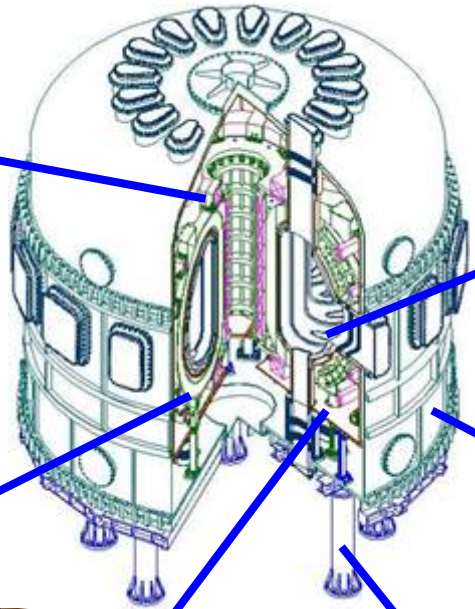


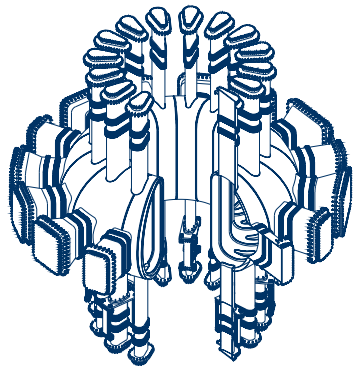
- The technologies of long pulse discharges for plasma initiation with low loop voltage, wall conditioning, plasma facing material, non-inductive current drive and heating, plasma control and data acquisition and processing have been developed very well.

Main Components of the EAST Machine

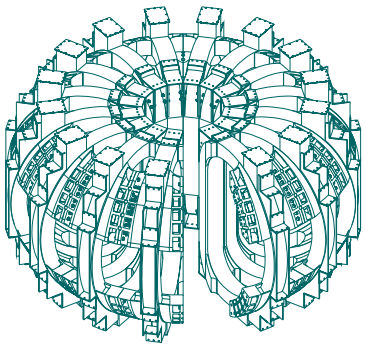


PF magnet system

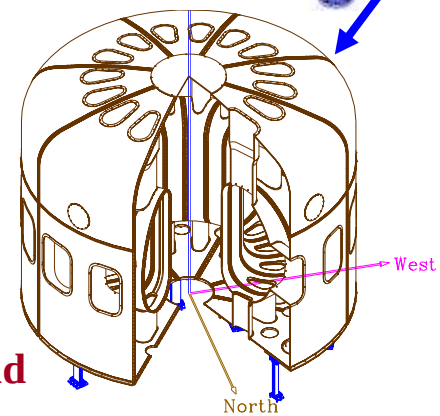




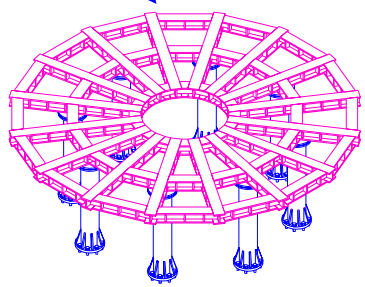
Vacuum Vessel



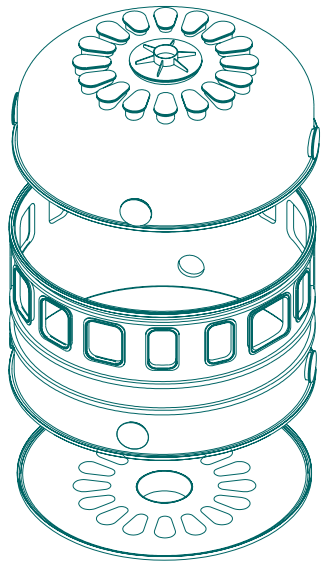
TF magnet system



Thermal shield



Support system



Cryostat vessel

CICC design and jacketing

SC magnets design & winding

SC coil insulation treatment

Most of key technologies are developed by ASIPP

SC magnet test

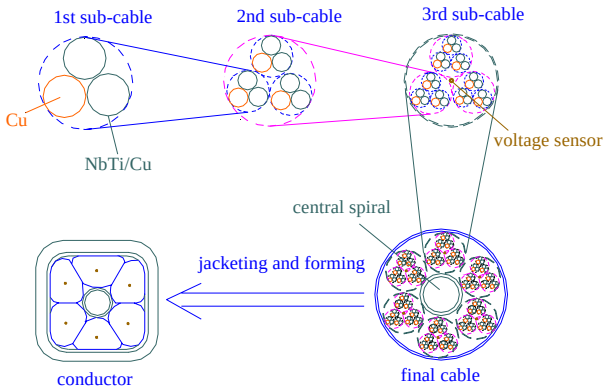
Coil case machining

Cryogenic & refrigerator system design and integration

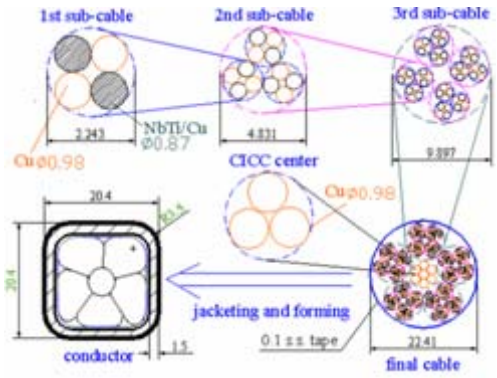
Power supply system design and integration

Much attention has been paid on NbTi superconductivity engineering development

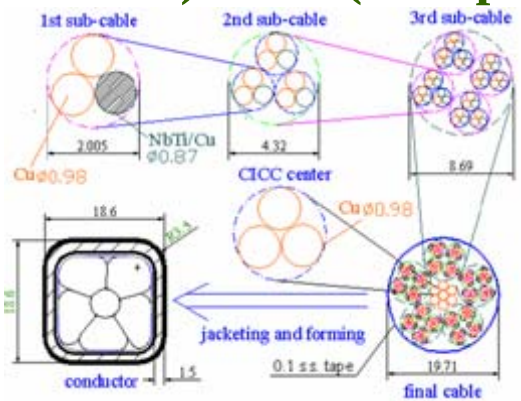
Several types of CICC were designed and analyzed.



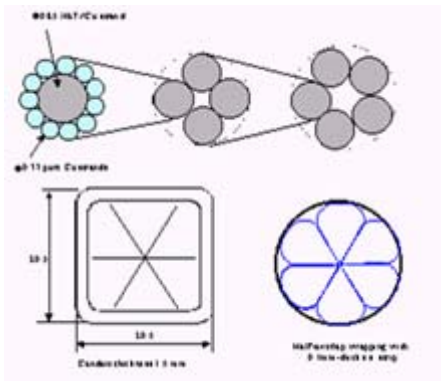
A: (1Cu+2Sc)×3×3×(6+1Spire)



B: (2Cu+2Sc)×3×4×(5+1Cu Cable)



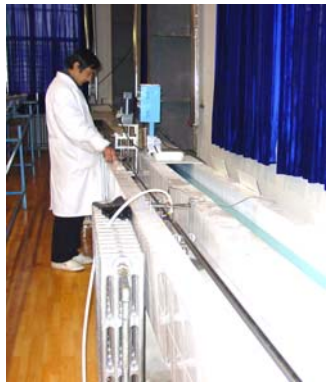
C: (2Cu+1Sc)×3×4×(5+1Cu Cable)



D: (11Cu+1Sc)×4×5×6

A 600 m CICC jacketing line was set up in ASIPP and 32 km CICC have been produced in high quality

Conduit Cleaning



Conduit Surface Check

Conduit Welding

Joint Test

Cable Insert

Conductor Extruding

Conductor Receiving

Conductor Check

Technologies to fabricate PF and TF coils in pre-bending and continuous winding way have been developed.

TF coil winding

TF case machining

TF magnet VPI

14 TF coils fabricated

PF coil winding on site

PF coil VPI on site

12 PF coils fabricated

To test the superconducting performances of coils before installation, a cryogenic test facility system set up in ASIPP.

Cryostat with CLs:

Diameter	3.4 m
Height	6.7 m
Vacuum	1×10^{-5} τ
Current leads	2 pairs
	20-30 kA

Power Supply:
24 kA/0-100V(CW)
100kA/0□800V(5s)

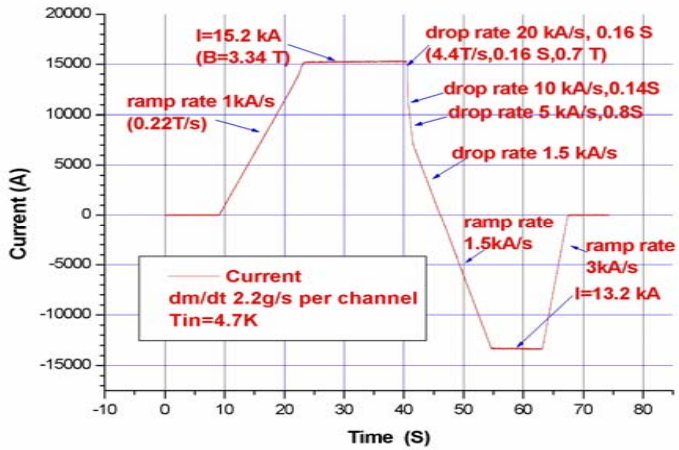
Cryogenic test facility system

Data Collection System

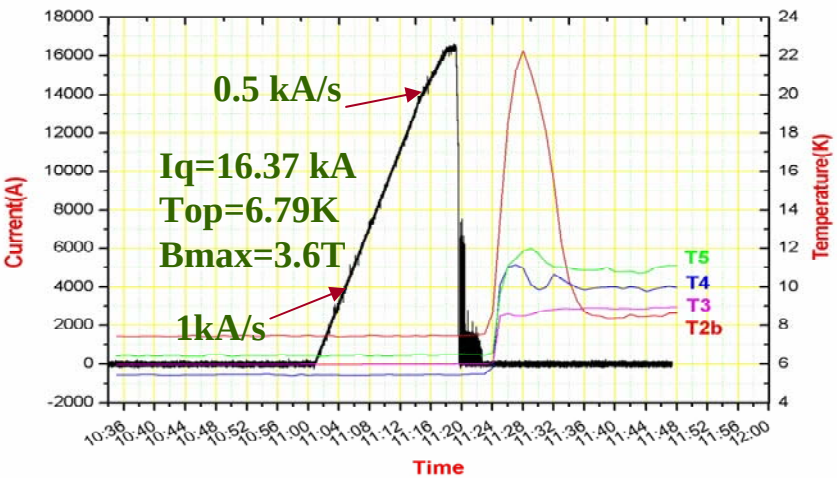
Refrigerator:
500 W/4.5 k

The tests of the CS prototype coil had shown pretty good results in 2003.

CS prototype coil inside the cryostat of the test facility

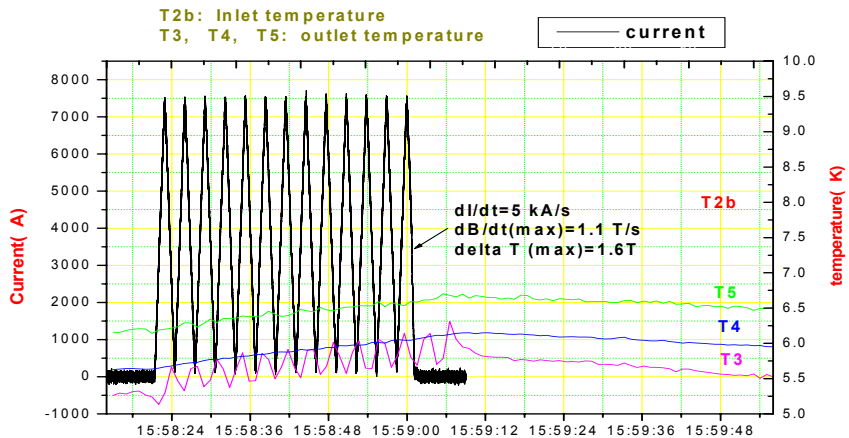


Current charge/discharge



Quench current test

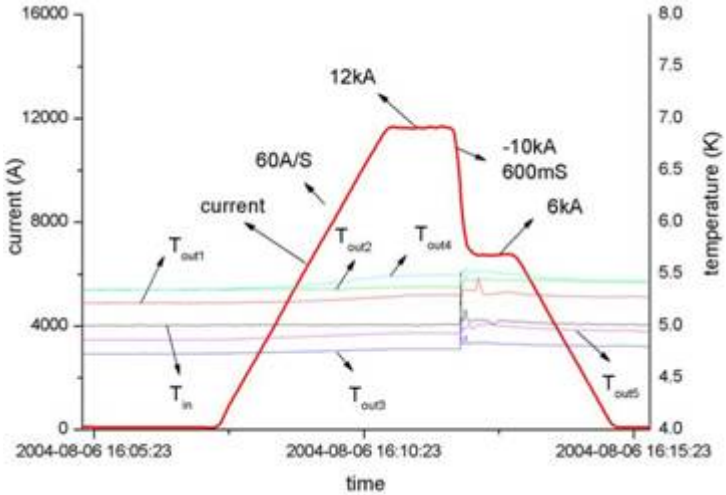
Extrapolated Iq= 54kA (3.8K, 4.5T)



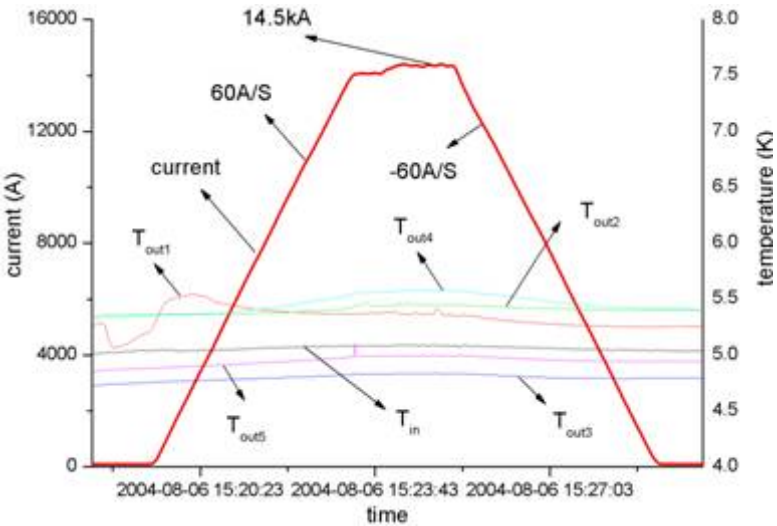
AC losses test

One set of divertor coil was tested successfully.

One set divertor coil inside the cryostat of the test facility



Fast discharge



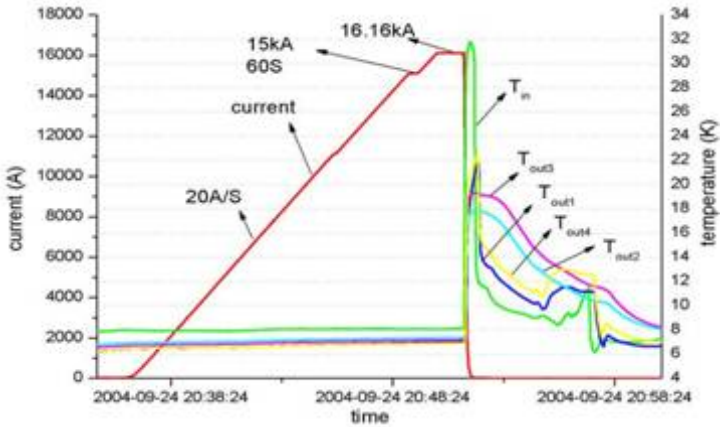
Current charge/discharge

Some Hints:

The results of high flux in several hundreds milliseconds stably suffered by superconducting magnets imply the possibility for realizing the plasma fast control by PF system only, instead of separated control coil system.

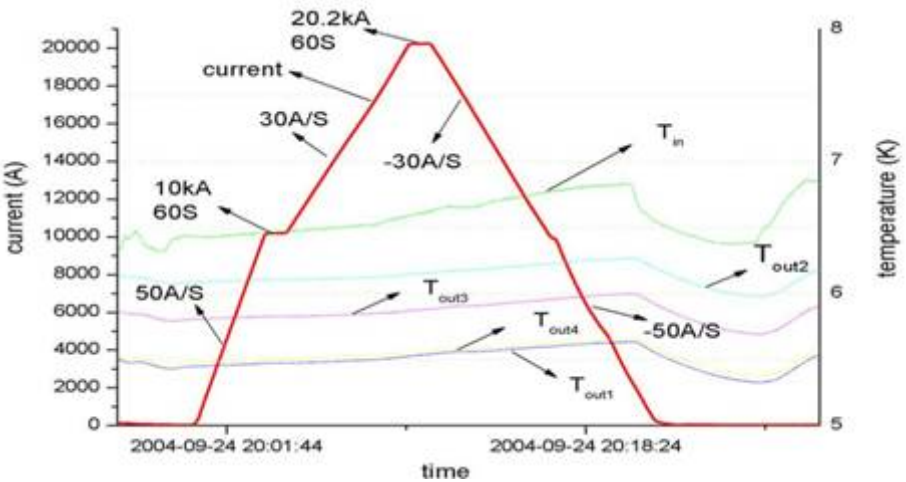
After TF prototype coil test, fourteen TF magnets have been tested successfully and shown similar performances

One TF coil inside the cryostat of the test facility

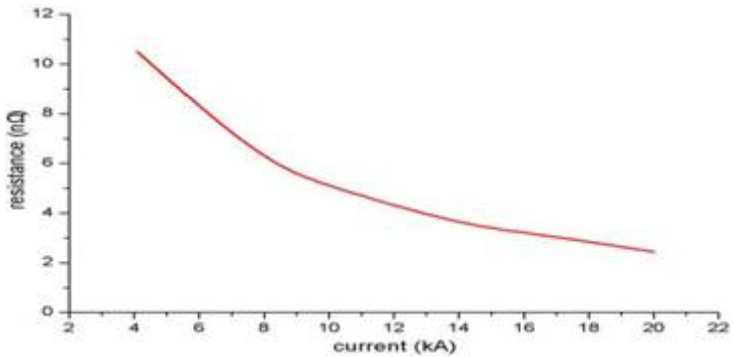


Quench current test

Extrapolated Iq= 58kA (3.8K, 6.72T)



Current charge/discharge



Joint resistance inside TF coil

ASIPP

After successful development on the manufacture technologies, manufactures of the main parts of EAST have been processing very well from 2002. The main parts of the machine have been delivered to ASIPP in succession from 2003.

VV arriving at ASIPP in sections

One TF coil is delivered to ASIPP

TS sections at the assembly site

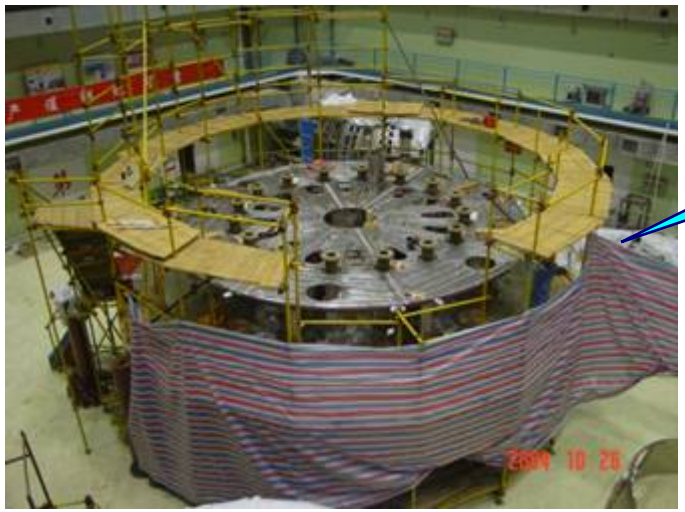
Base of CV arriving at the assembly site

Some of important subsystems of EAST are also integrated and tested by ASIPP

- The ICRH system with a 1.5 MW (30-110 MHz) generator and liquid stab-tuner is ready.
- The pumping and fuelling systems are ready for test.
- An 83 MVA transformer station with a 110 kV transmission line had been set up and operated normally in 2003.
- One set of PF power supply systems had been verified during the prototype CS and TF coil tests and last campaign of the HT-7 operation.
- The buildings, including a new EAST hall and other appurtenant buildings, have been ready for the EAST assembly,
- The integration of the 2 kW/4.5 K cryogenic and refrigerator system will be finished in March of 2005.
- A 2 MW/2.45 GHz LHCD system will be ready in July 2006. The antenna design is now cooperating with Tore-Supra team.

3. Assembly Plan

Assembly has begun from 2003. Pre-assembly of TF, VV and TS has completed. The bases assembly has finished.



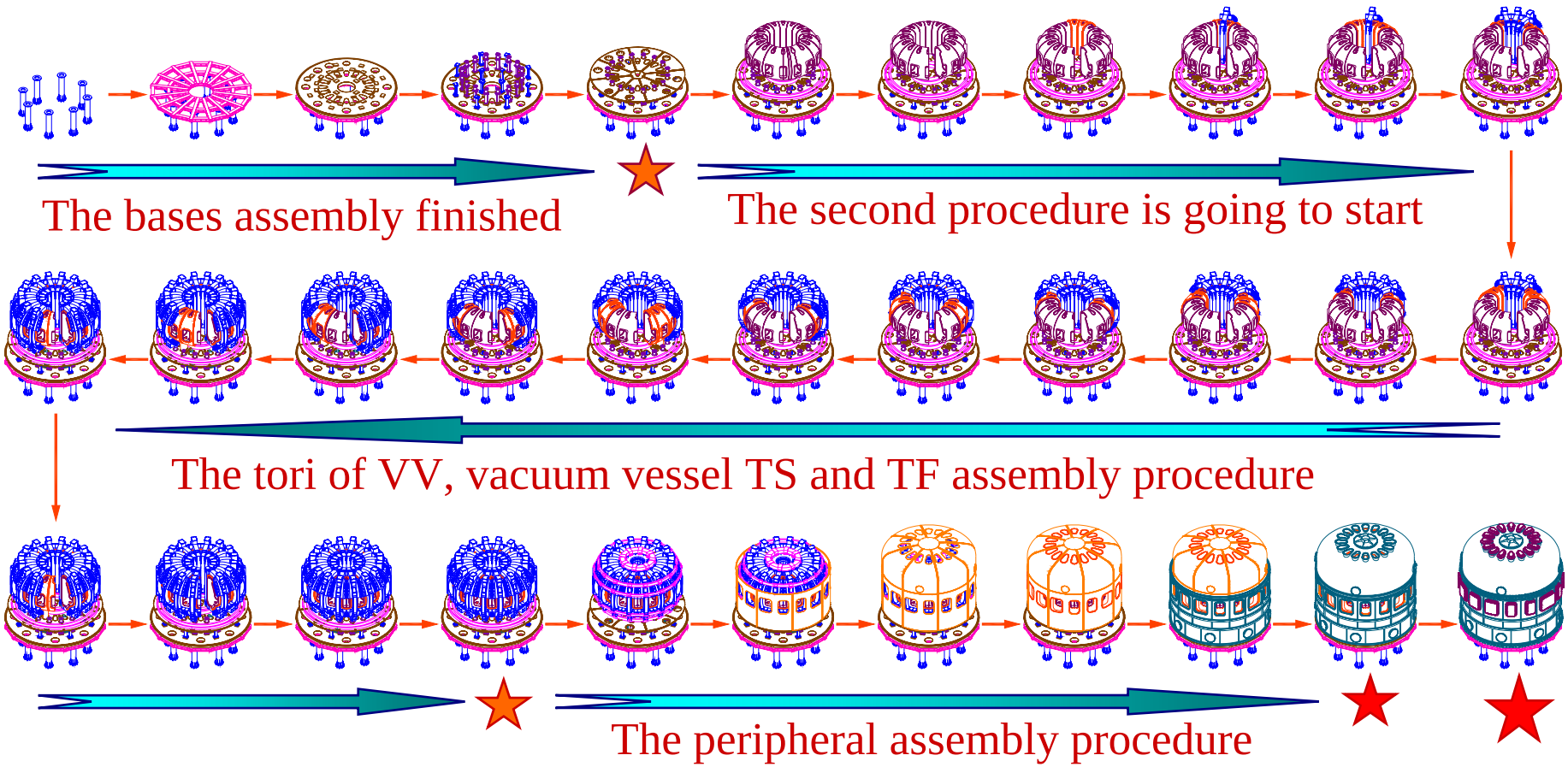
Bases assembly finished

Pre-assembly of TF

Pre-assembly of VV

Pre-assembly of TS

Assembly Procedure



4. Operation Plan in the Future

The operation plan of EAST will be in principle consisted of three phases:

- During the first phase different plasma configurations will be tried mainly by basic ohmic heating combining with total 3.5 MW non-inductive current drive and heating from short to longer discharge.
- In the second phase, additional 8 MW of non-inductive current drive and heating including 4 MW NBI will be put into the machine for different advanced operation modes with divertor configurations under long pulse or even stead state conditions.
- In the third phase, the TF system may be charged up to 4.0 T at the major radio of 1.7 m with update of the cryogenic and refrigerator system. The plasma performances, especially the β, may be increased. Eventually EAST will have more than 23 MW non-inductive current drive and heating power.

5. Summary

- The key R&D program on the engineering and physics of EAST has been successful.
- The significant progresses, especially on the fabrication and test of all TF and PF superconducting magnets, have been achieved during last two years.
- The assembly of the machine has begun. A pre-test procedure during the assembly for ensuring the quality of the superconducting magnet systems and the cooling system will be performed in the early of 2005.
- The first plasma hopefully may be got around end of 2005.
- EAST will open to the fusion research society not only domestically, but also internationally.

Thanks for your attention!