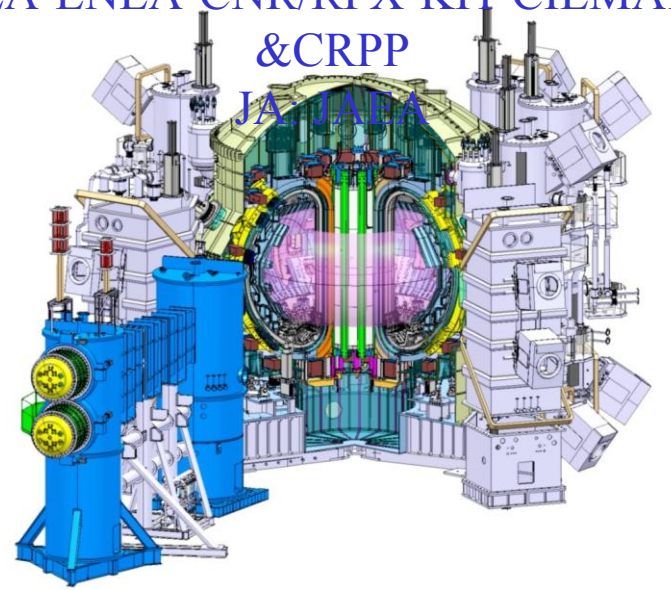
Status of JT-60SA Construction

P. Barabaschi, Y. Kamada, S.Ishida, H. Shirai
For the JT-60SA Integrated Project Team
EU: F4E-CEA-ENEA-CNR/RFX-KIT-CIEMAT-SCKCEN-&CRPP
JA: JAEA

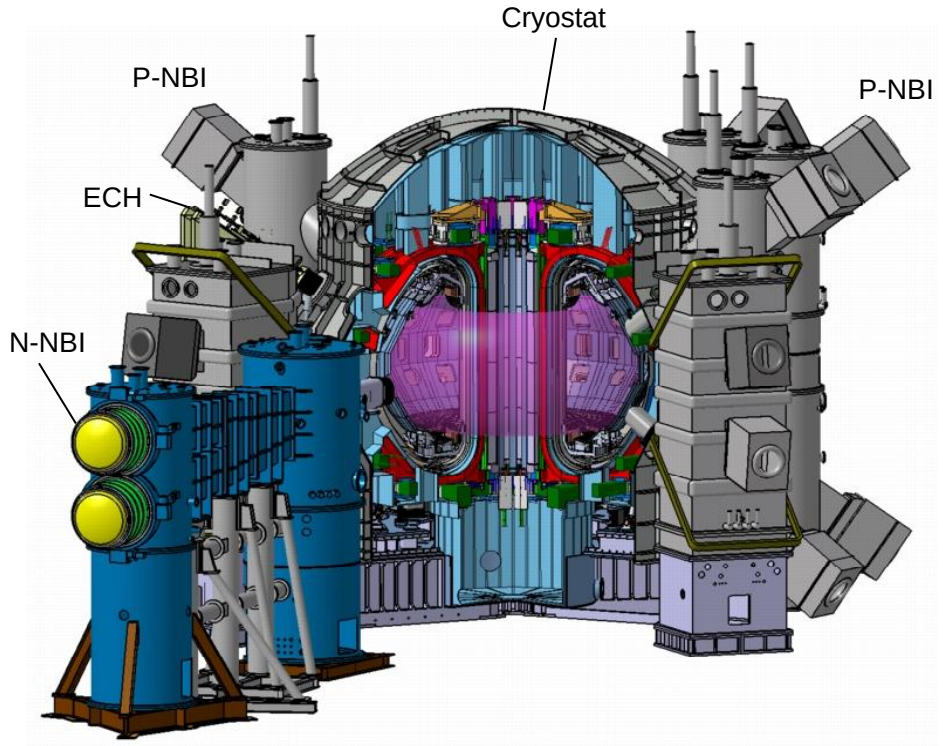


FUSION FOR ENERGY
cea
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CONSORZIO RFX Ricerca Formazione Innovazione
ENEA C.R.FRASCATI- ITALY
KIT Karlsruhe Institute of Technology
SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE
JAEA

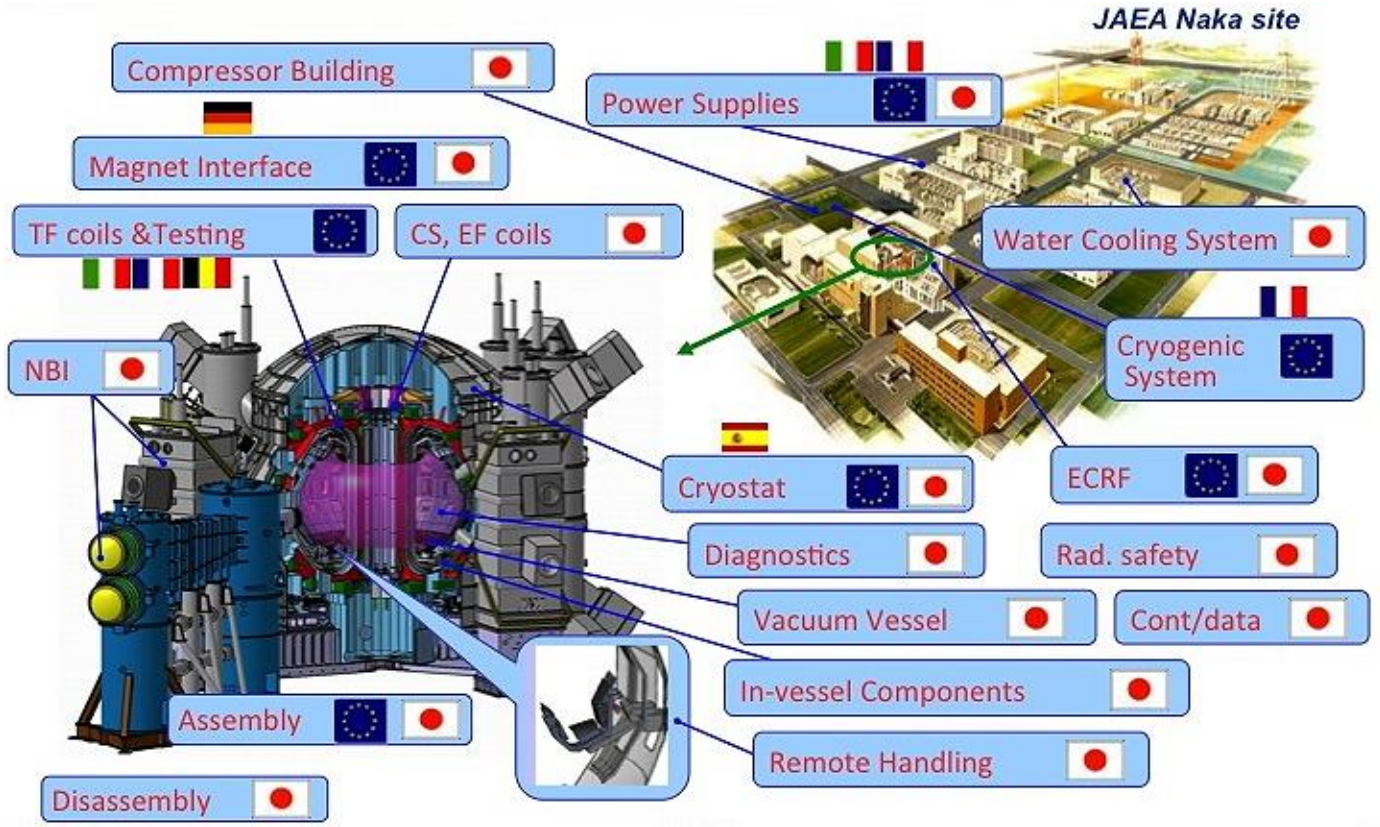
Machine Parameters

Basic machine parameters

Plasma Current	5.5 MA
Toroidal Field, B_t	2.25 T
Major Radius, R_p	2.96
Minor Radius, a	1.18
Elongation, κ_X	1.95
Triangularity, δ_X	0.53
Aspect Ratio, A	2.5
Shape Parameter, S	6.7
Safety Factor, q_{95}	~3
Flattop Duration	100 s
Heating & CD Power	41 MW
N-NBI	10 MW
P-NBI	24 MW
ECRF	7 MW
Divertor wall load	15 MW/m^2



Sharing


JAEA Naka site
Compressor Building
Power Supplies
Magnet Interface
TF coils &Testing
CS, EF coils
Water Cooling System
Cryogenic System
NBI
Cryostat
ECRF
Diagnostics
Rad. safety
Vacuum Vessel
Cont/data
In-vessel Components
Assembly
Remote Handling
Disassembly

Progress since 2010

Design work largely completed

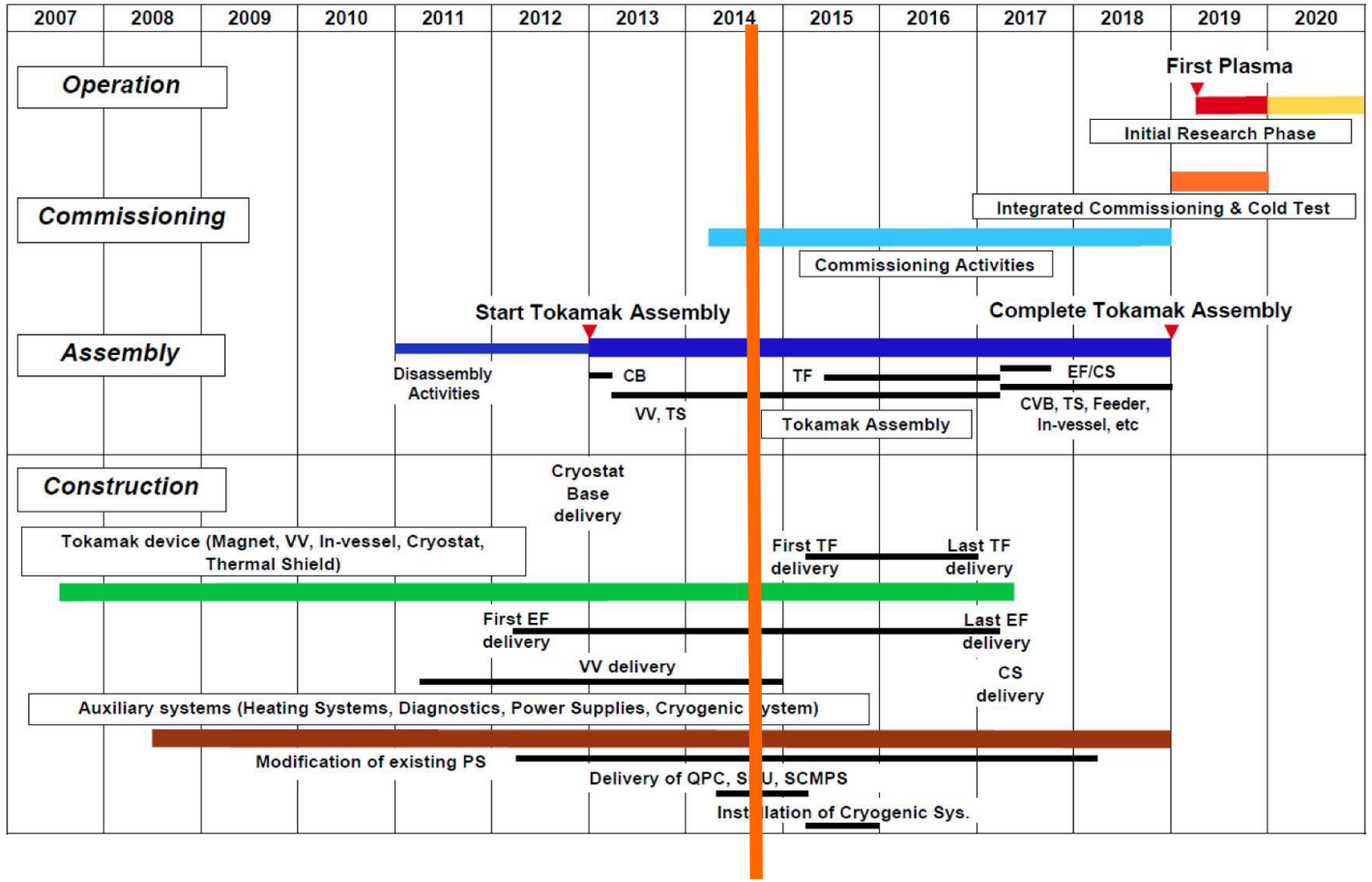
JT-60U disassembly completed

Procurement well underway

Assembly started

Preparing plans for operation

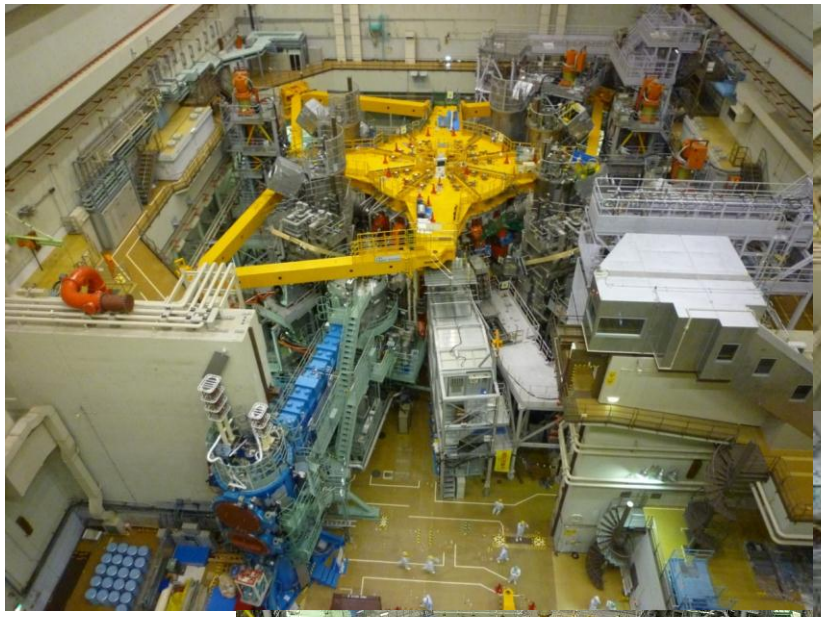
Schedule

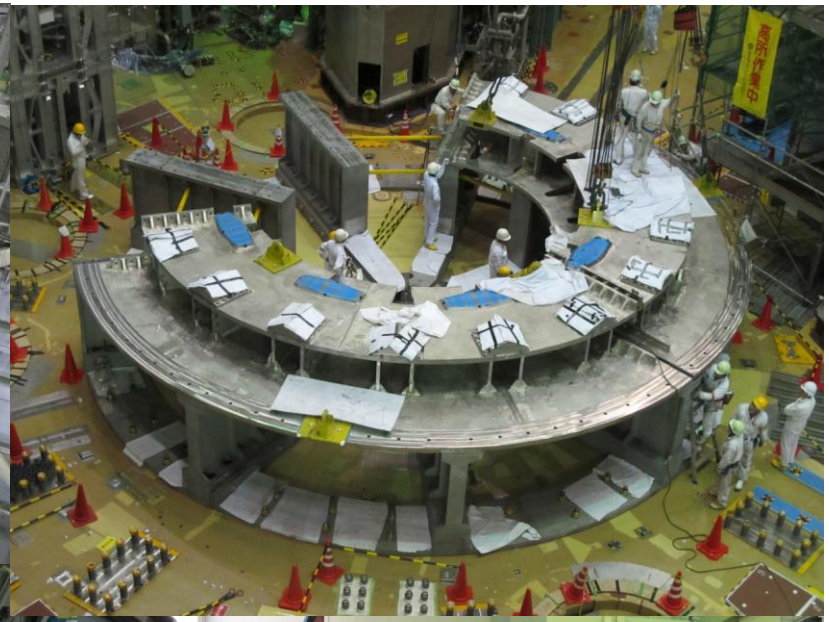

2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Operation
First Plasma
Initial Research Phase
Commissioning
Integrated Commissioning & Cold Test
Commissioning Activities
Start Tokamak Assembly
Complete Tokamak Assembly
Assembly
Disassembly Activities
CB
TF
EF/CS
VV, TS
CVB, TS, Feeder, In-vessel, etc
Tokamak Assembly
Construction
Cryostat Base delivery
Tokamak device (Magnet, VV, In-vessel, Cryostat, Thermal Shield)
First TF delivery
Last TF delivery
First EF delivery
Last EF delivery
VV delivery
CS delivery
Auxiliary systems (Heating Systems, Diagnostics, Power Supplies, Cryogenic System)
Modification of existing PS
Delivery of QPC, SVU, SCMPS
Installation of Cryogenic Sys.

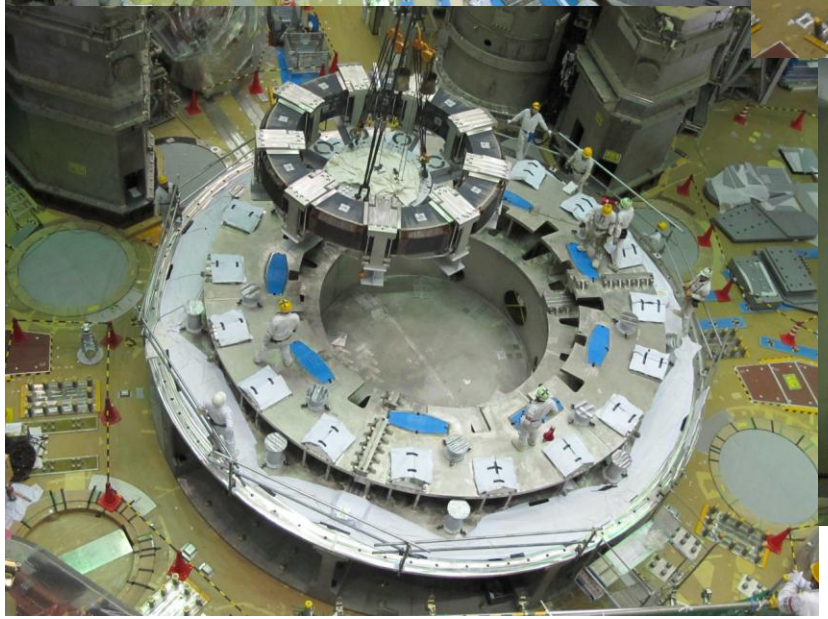
Disassembly

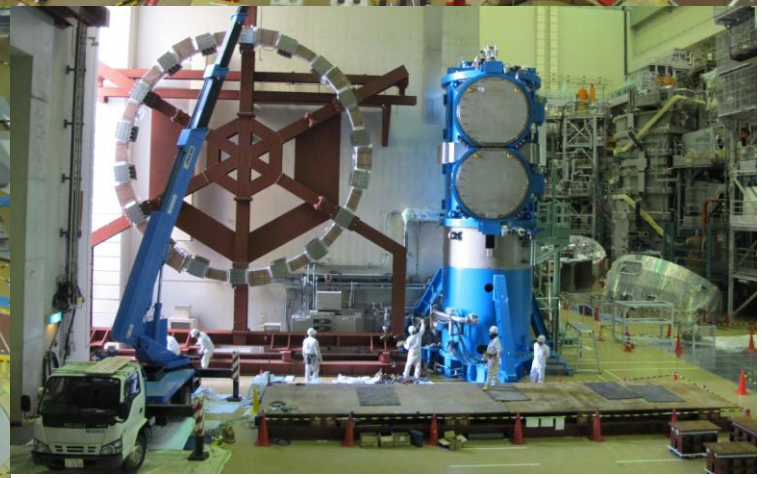
JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

Completed December 2012







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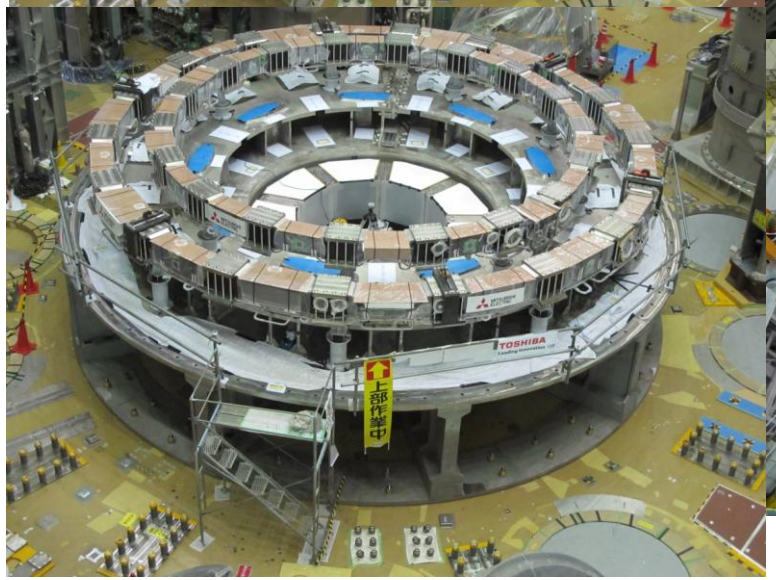
TOSHIBA
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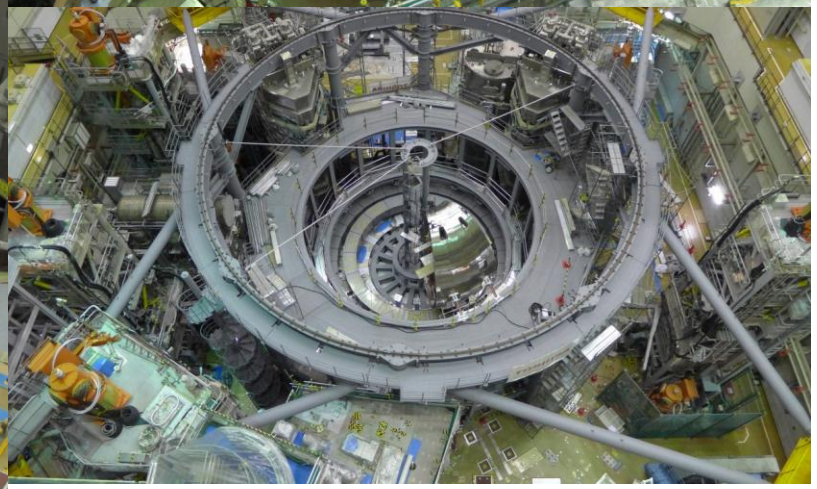
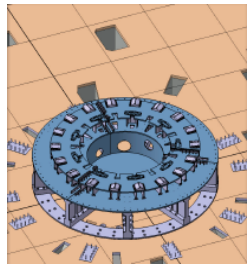
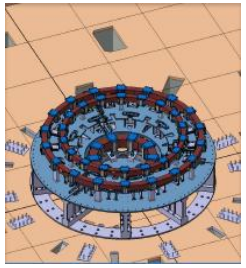


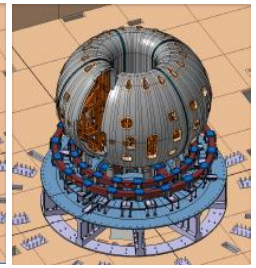
Machine Assembly



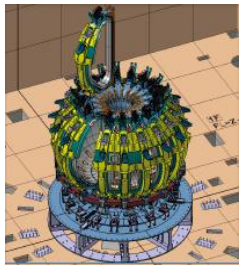
Cryostat Base (260 tons)



Lower Poloidal Field Coils



Vacuum Vessel



Toroidal Field Coils

Upper Poloidal Field Coils and Central Solenoid

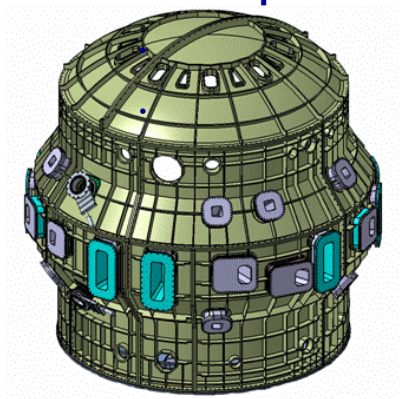
Cryostat Body and Lid

Cryostat

- **Cryostat Base (Idesa-Spain, contracted by CIEMAT), designed in 2008, completed in 2012, delivered in Naka Jan 2013 ->start of assembly**

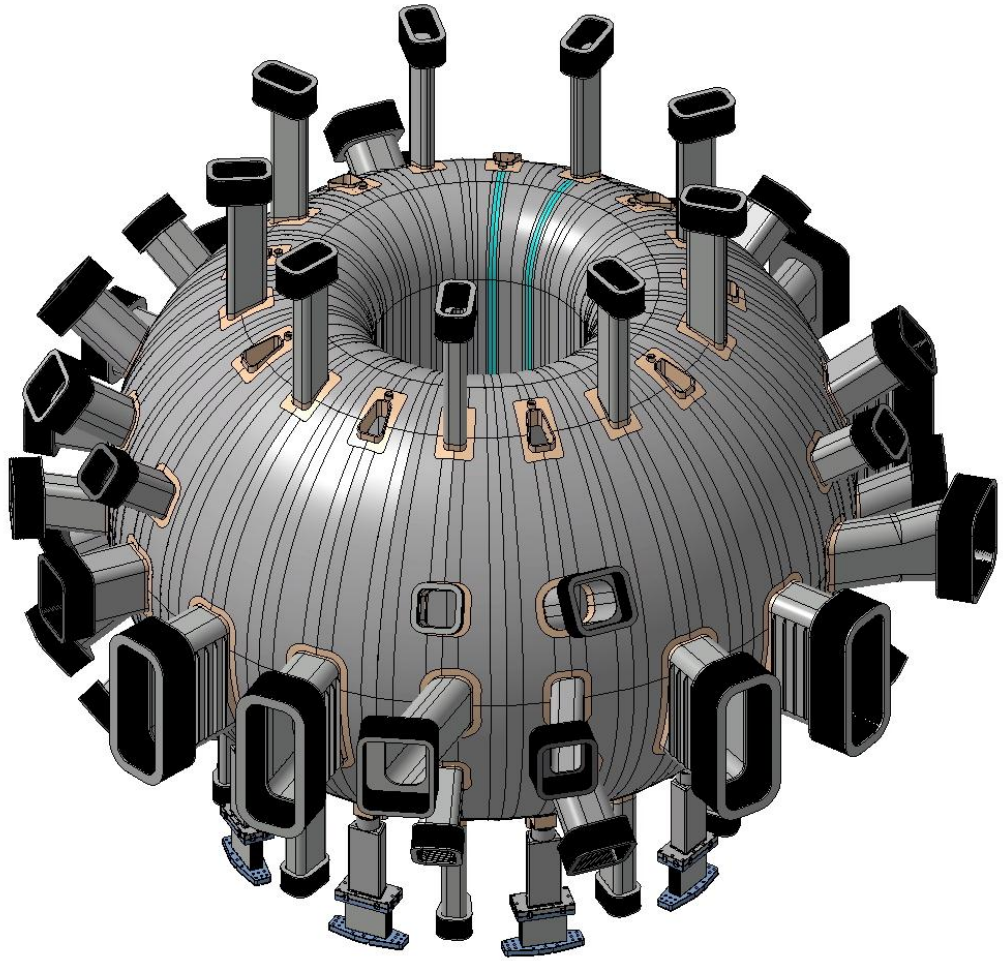
-Cryostat Vessel Body manufacturing started in 2014

-Cryostat Lid (JAEA) will start in 2015



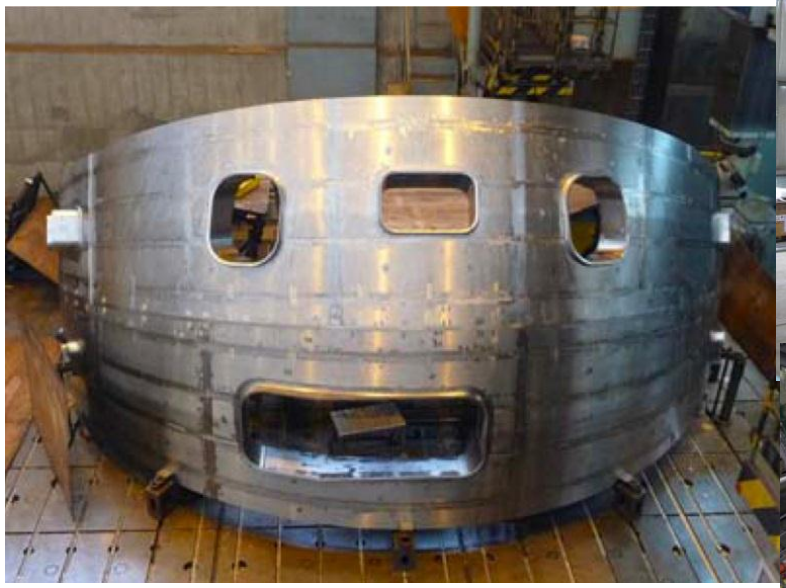
Vacuum Vessel

- **Double Walled**
- **18mm+18mm**
- **Boronised Water interspace (~160mm)**

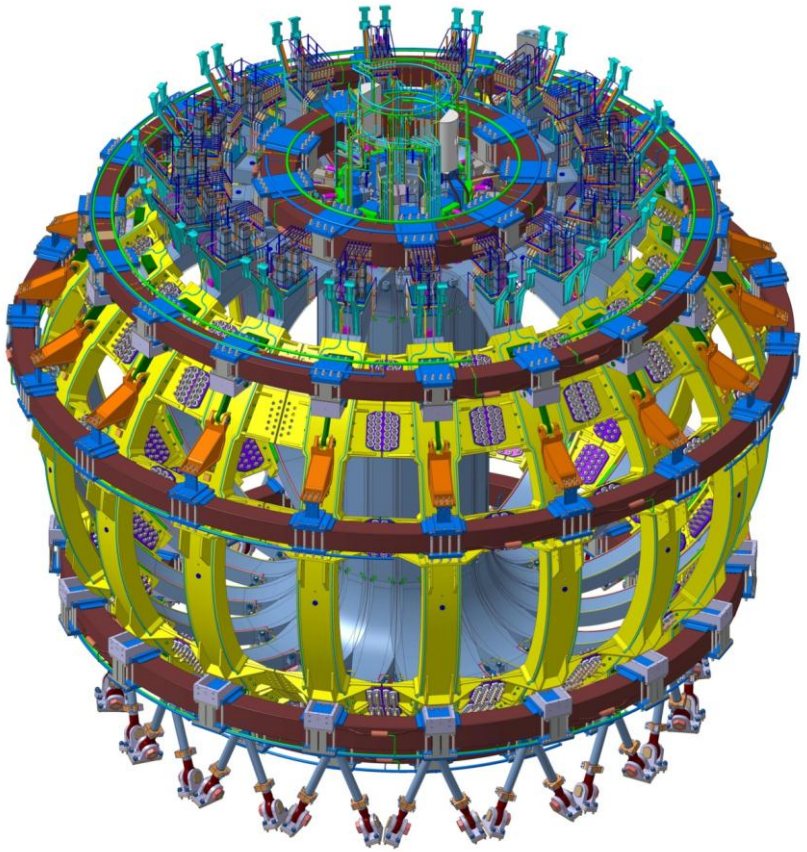


Vacuum Vessel

Vacuum Vessel



Magnets



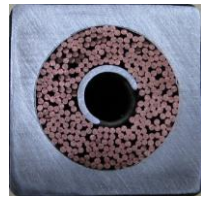
- All SC Magnet
  - Nb_3Sn for CS
  - NbTi for TF, EF
- 18 TF Coils
- 6 EF Coils
- 4 CS independent modules

Conductors

Furukawa Electric
Hitachi Power
ICAS – Italy

Globally >2/3 of conductor produced

TFC conductor



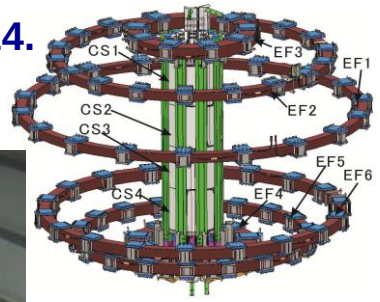
CS conductor

EF-L&H conductor

16

Manufacture - EF Coils

- The manufacturing of EF5 and EF6 completed January 2014.
- Upper coil manufacture (EF1-3) now underway.



Manufacture - EF Coils

Status of Fabrication for CS1

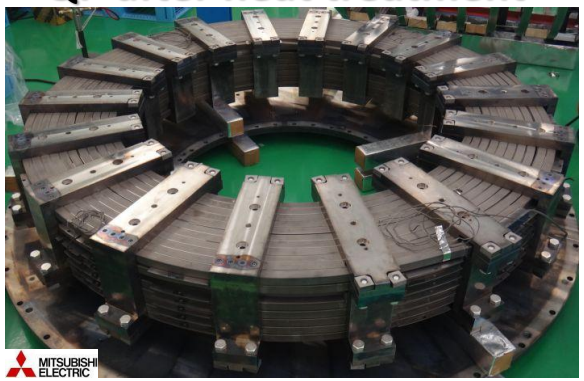
Winding of OP5 for CS1

MITSUBISHI ELECTRIC

Processing of Helium Inlet

Status of Fabrication for CS1

QP after heat treatment

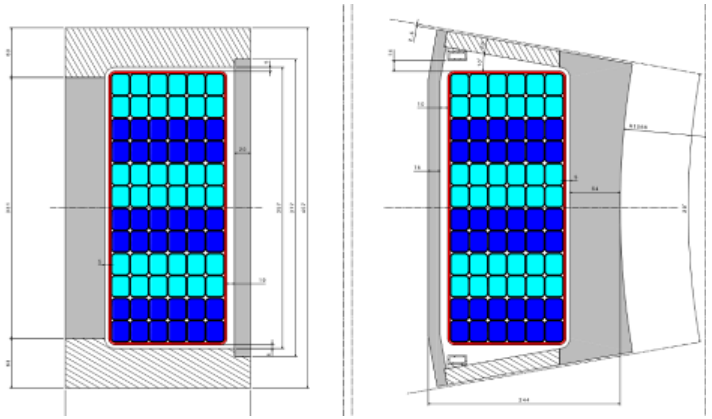


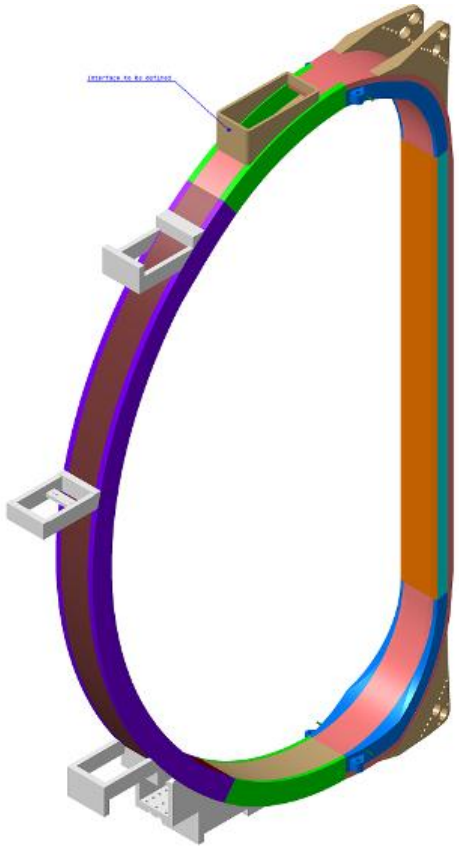
OP2 after heat treatment

OP3 and OP4 after heat treatment

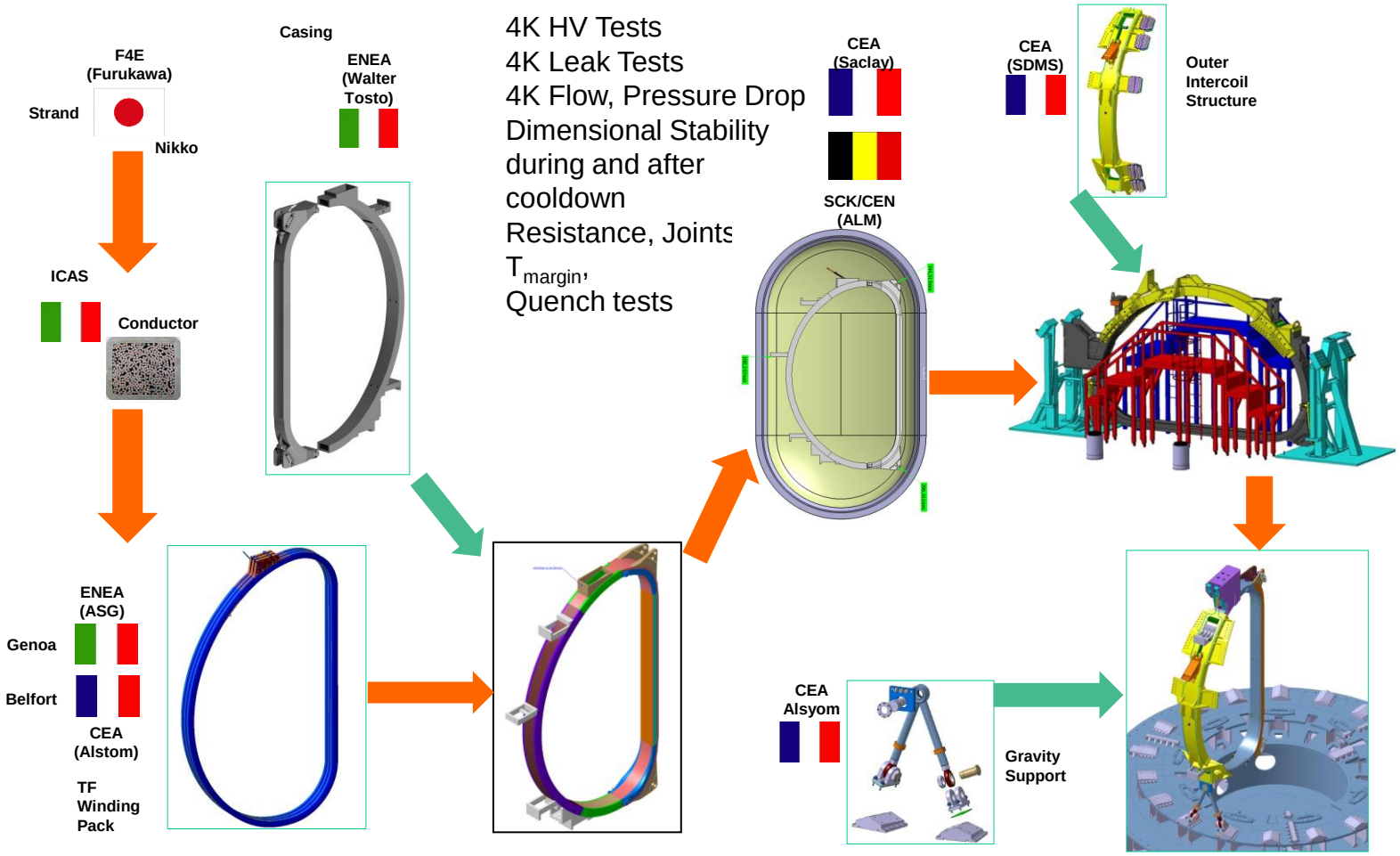
TF Magnet features

- Cable in Conduit Conductor , 72 turns, 25.7kA each
- 6 double pancakes, 6 turns/pancake. Helium inlets in high field side – joints in external low field side
- Windings enclosed in steel casings
- Steel casings supported to ground vertically and toroidally - connected in inboard curved regions by “Inner Intercoil Structure”
- Steel casings guided toroidally by “Outer Intercoil Structure” to support out of plane loads.





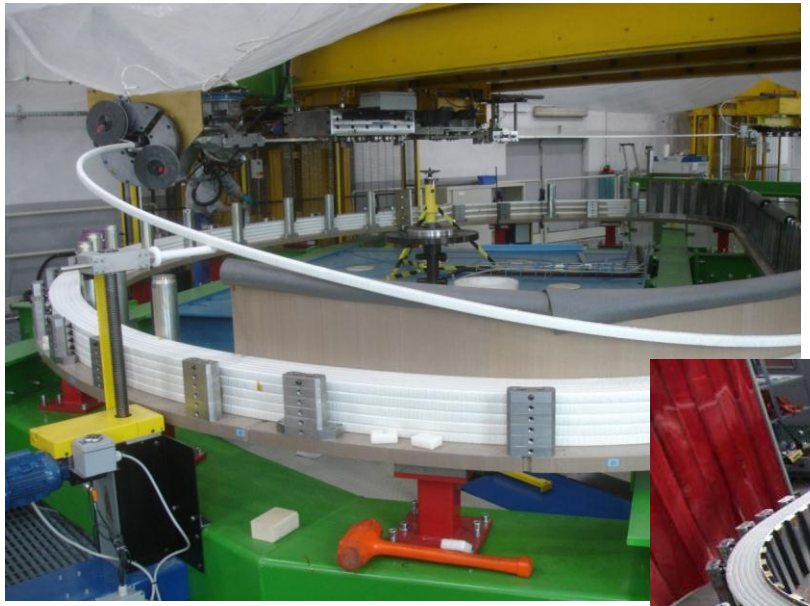
TF Coils Procurement Cycle



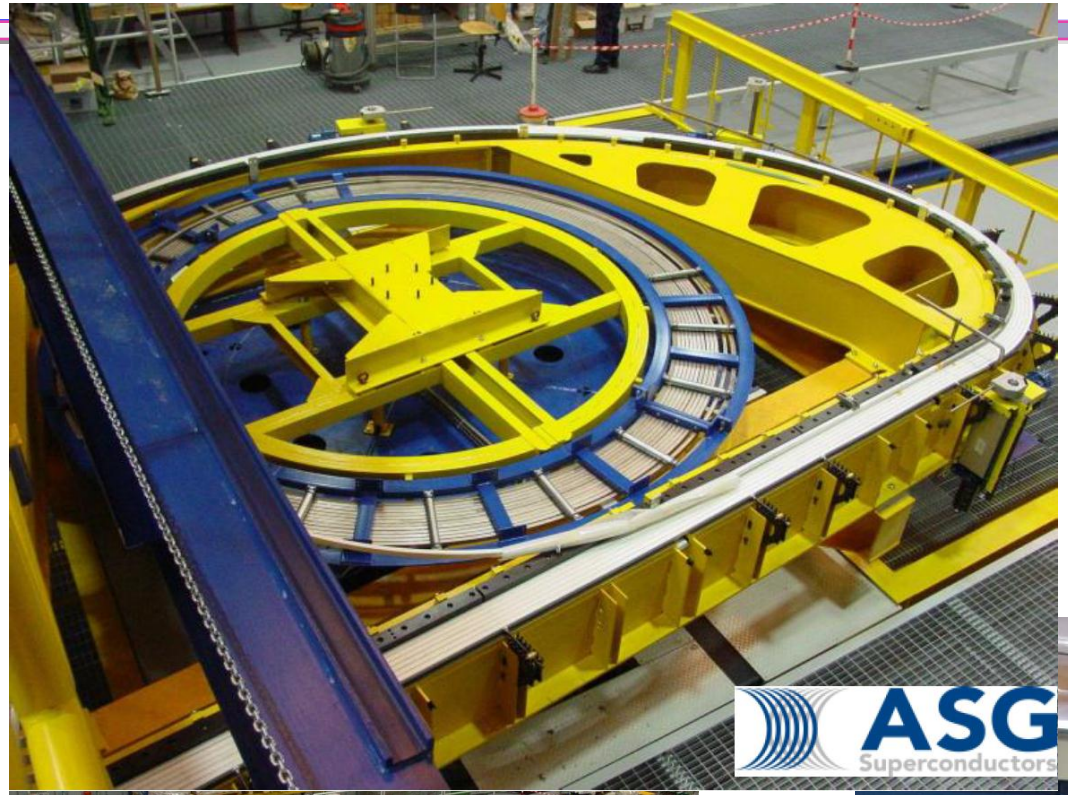
Manufacture – TF

Alstom – WP 9 coils

Manufacture – TF



Manufacture – TF



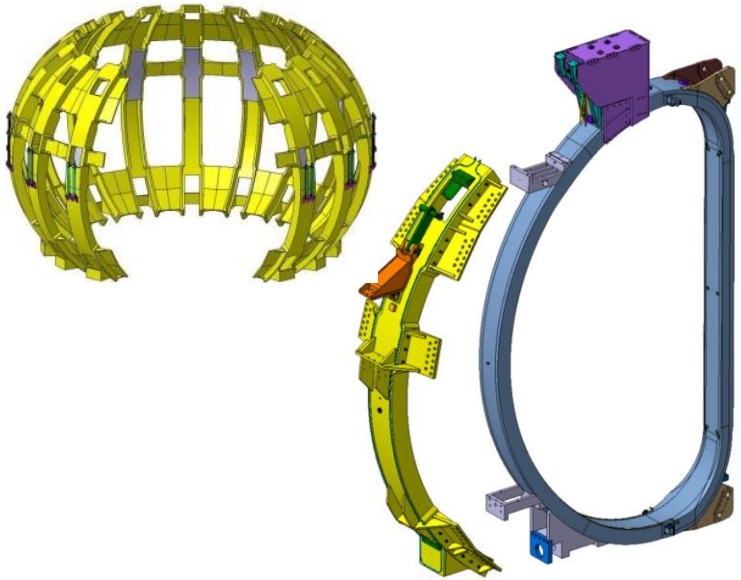
Manufacture – TF

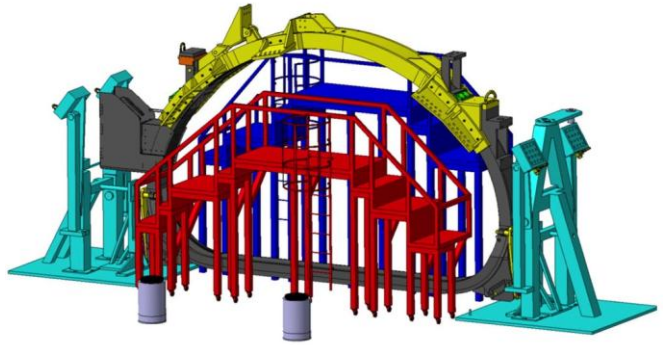
Manufacture – TF

OIS Manufacture, and Pre-Assembly

SDMS
la chaudronnerie blanche®

cea



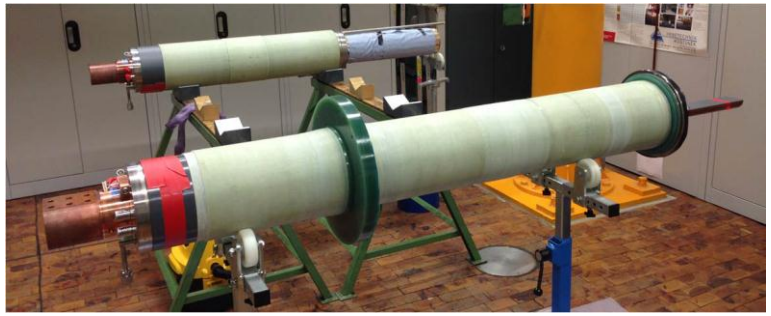


TF Coils – Casings

walter tosto ENEA

Progress – TF Coil Test Facility

HTS current leads



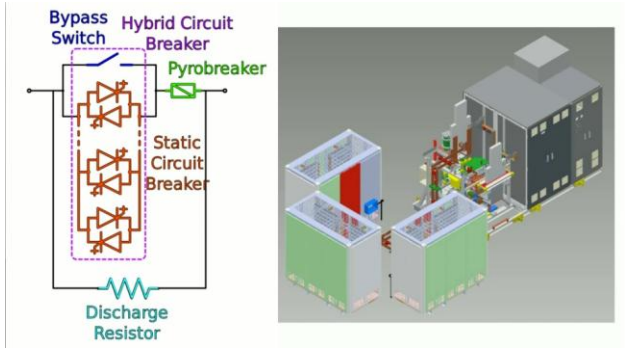
TF HTS CL nr. 3 & 4

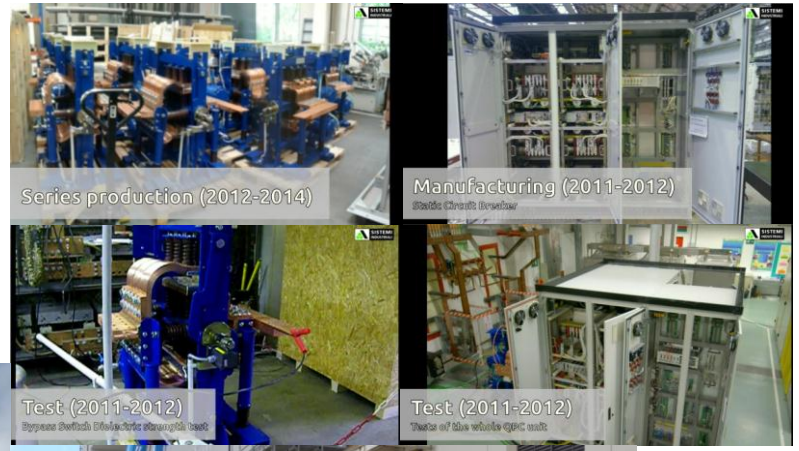
CultKa with JAEA jumper connected to HTS CL nr 1&2

KIT
Karlsruhe Institute of Technology

TF HTS CL nr. 1&2 integrated in CultKa

Magnet Power Supplies - EU





Nidec ASI S.p.A.

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Magnet Power Supplies - EU

SNU: ENEA/OCEM Energy Technology)

- first unit type tested Sept 2014
- acceptance in Naka by Sept 2017

OCEM POWER ELECTRONICS

ENEA

POSEICO POWER ELECTRONICS

SCMPS: ENEA/CEA

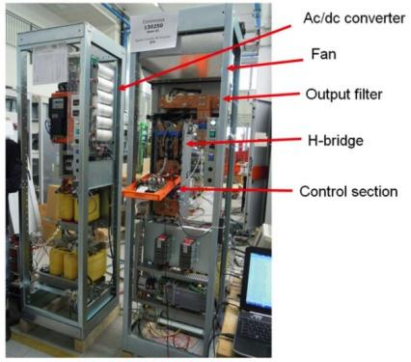
- contracts signed
  - ENEA: CS/EF/FPCC (POSEICO)
  - CEA: TF/EF (JEMA)
- Detailed design being finalised
- Delivery by Dec 2017 and Feb 2016 resp.

cea

Jema

RWM PS: CNR-Consorzio RFX

- Prototype tested in June 2014.
- PA/contract 2014/early 2015.
- Delivery by March 2017

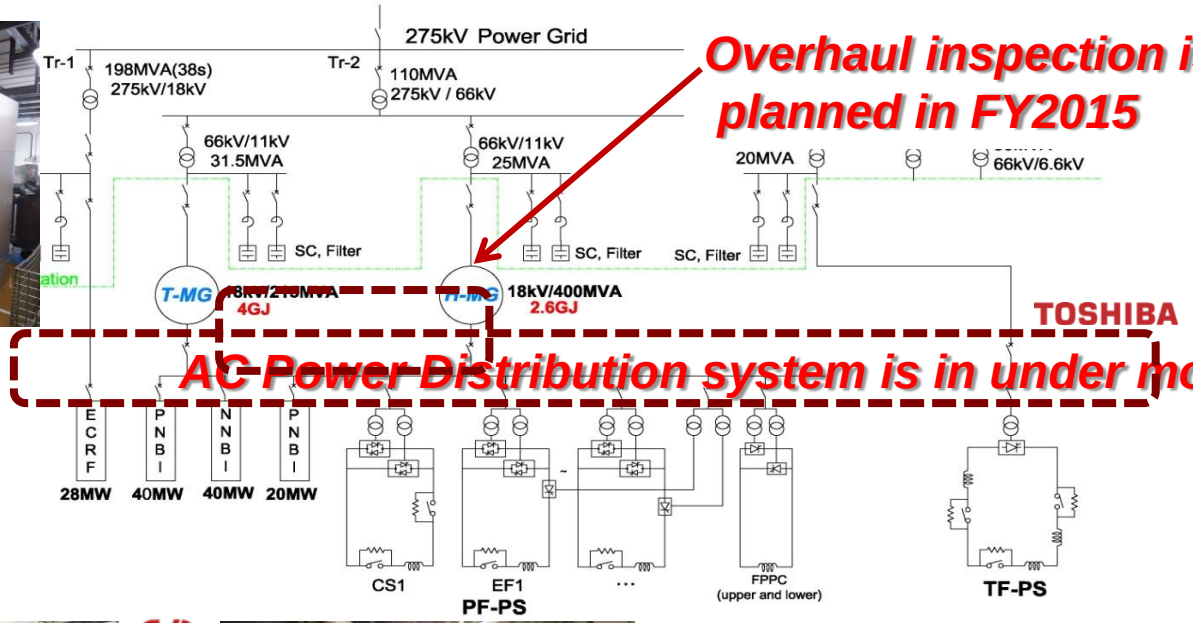


RWM PS Prototype

CONSORZIO RFX
Ricerca Formazione Innovazione

Magnet Power Supplies - JA

UPS of Auxiliary PS



Overhaul inspection is planned in FY2015

TOSHIBA

AC Power Distribution system is in under modification

Water Cooling System for PS

KITASHIBA

SEM

- 2 SNUs (Nidec ASI) will be delivered within FY2014

Magnet Power Supplies - JA

46 cooling towers were installed in Mar. 2014.
12 water pumps replaced.
Pipe laying work for the cooling towers will be completed in Oct. 2014.
The operation of the secondary cooling water supply will start in Apr. 2015 for the heating Motor Generator inspection.

Buildings

Compressor Building
Under construction
⇒will be completed in Mar. 2015

29th Sep. 2014

Foundation construction and preparatory work was completed

JT-60 Transformer Yard

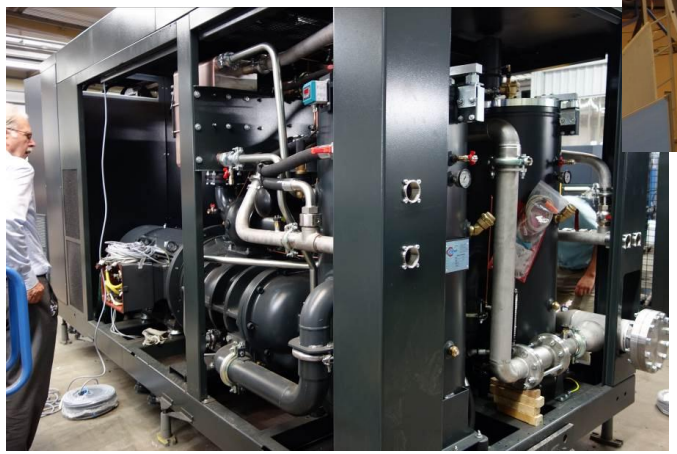
JT-60 Rectifier Room

Dump Resistor Area for TF-QPC

Cryoplant

RCB and ACB
in AL-AT workshop

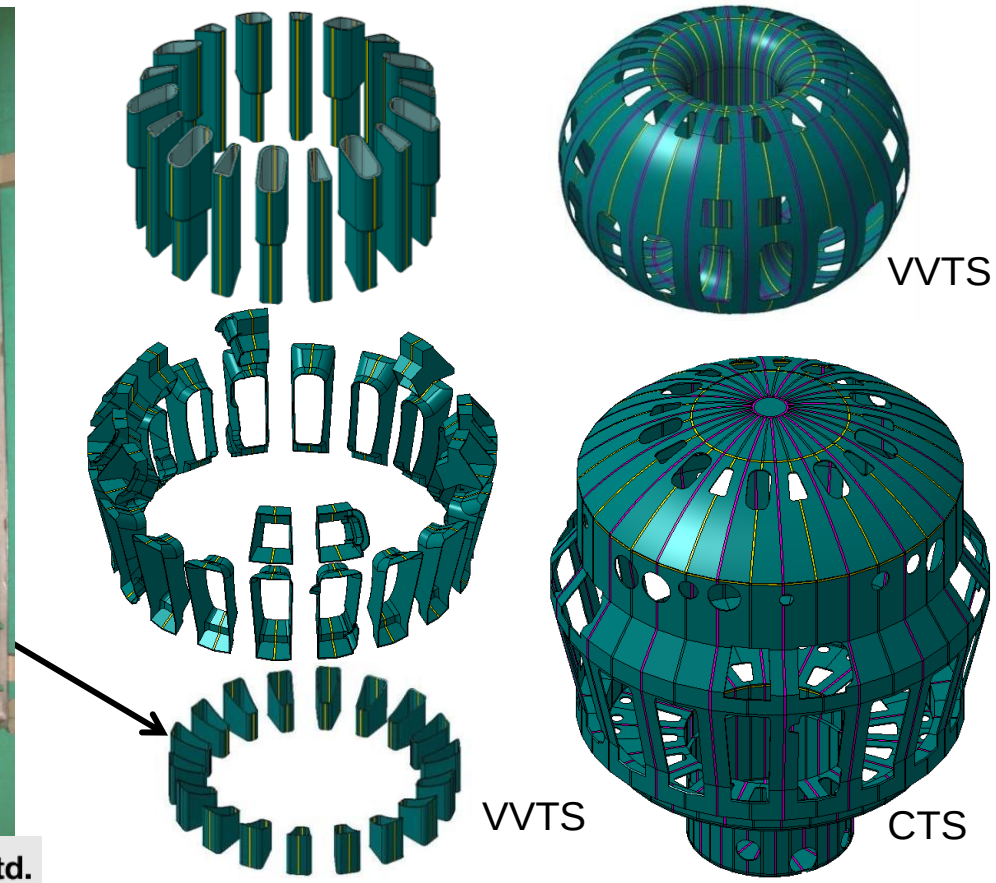
RCB



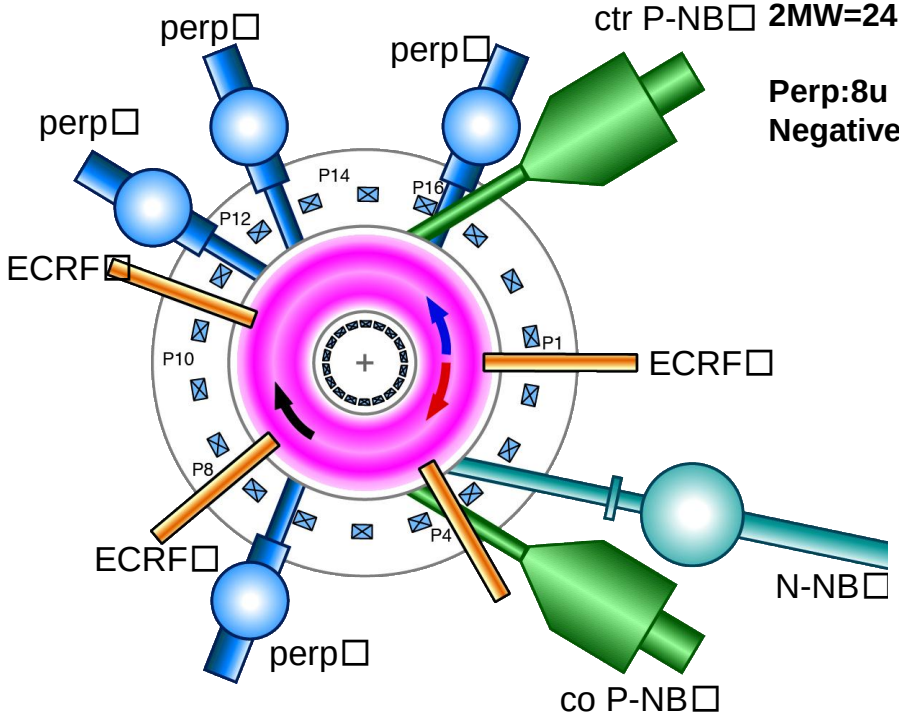
Kaeser compressor
leak and pressure test

Thermal Shield

Hitachi Power Solutions Co., Ltd.

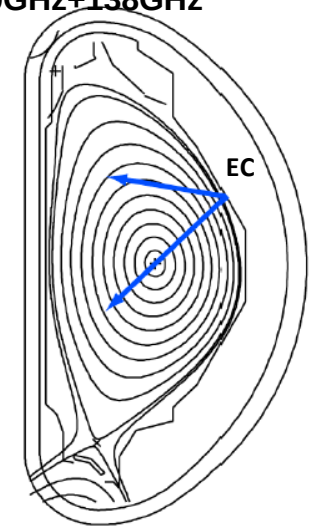


Heating Systems



NB: 34MW×100s
Positive-ion-source NB (85keV)
12units ×
2MW=24MW,
CO:2u, CTR:2u,
Perp:8u
Negative-ion-source NB,500keV, 10MW, Off-axis

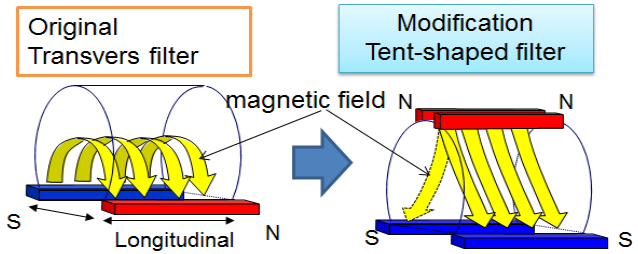
ECRF: 7MW×100s,
110GHz+138GHz

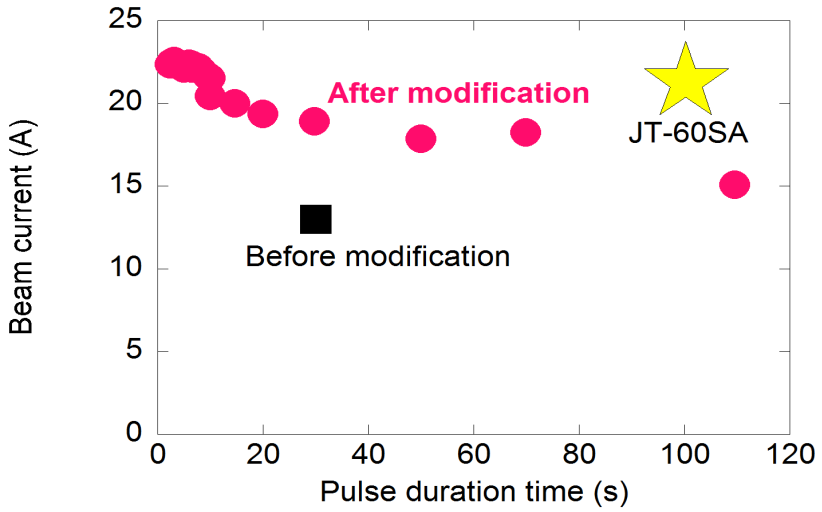


Development of negative ion source

To realize 22A, 100 s negative ion beams, the JT-60 negative ion source has been modified.

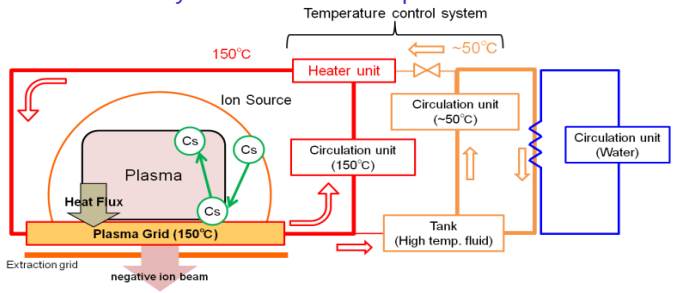
Improve Magnetic structure





Control the plasma grid (PG) temperature

Chiller system for the PG temp.



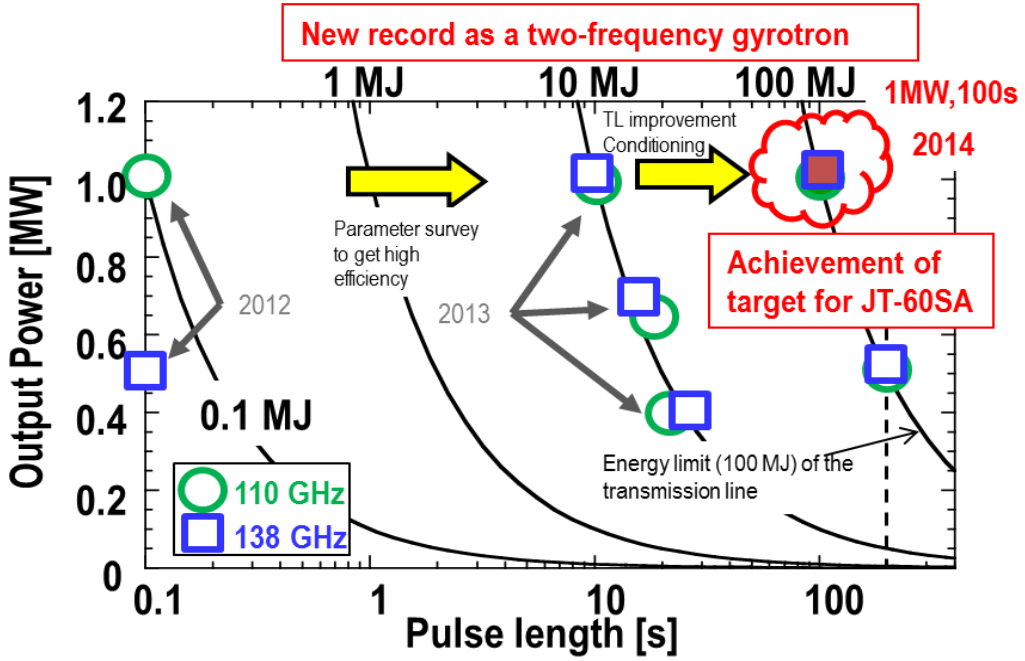
Long pulse production in JT-60 negative ion source

- The pulse duration time has been extended from 30 s at 13A to 100 s at 15A.

- Higher beam current is expected to be increased by a sufficient conditioning of the ion source.

Development of ECRF system

The first **two-frequency gyrotron** (110 & 138GHz) has reached the development target of **1MW x 100s at both frequencies**.



Higher power achieved by 110GHz gyrotron:**1.4MW x 9s**
Longer pulse at the higher power will be tested with the **2-frequency gyrotron.**

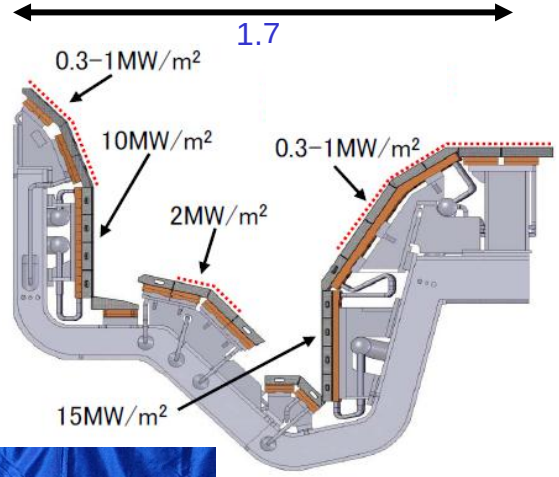
Divertor Cassette Manufacturing

Design Requirements

- Remove max exhaust power for 100 sec.
- Remote handling compatible.

Development

- Vertical divertor with CFC monoblock targets.
- All 36 divertor cassettes were
- Plasma facing components with

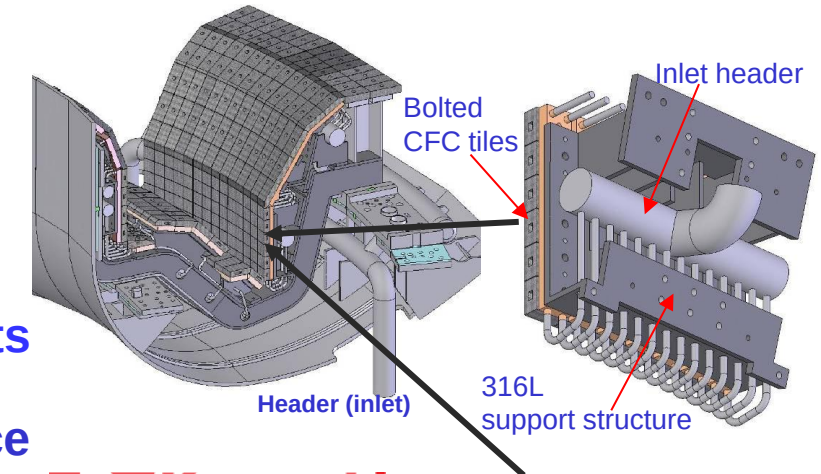


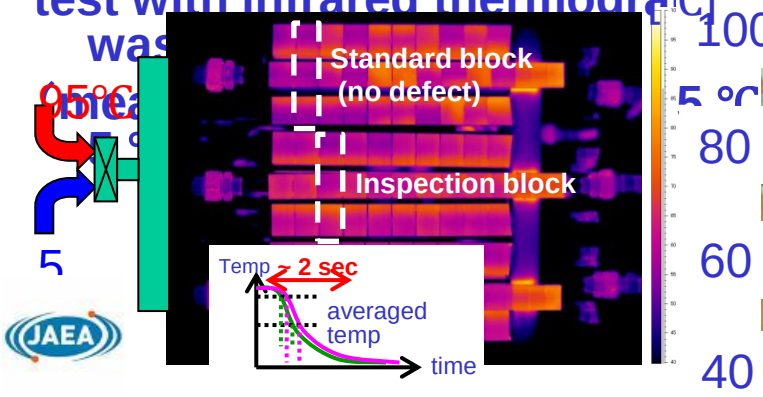
Manufacture of CFC monoblock targets

CFC monoblock targets for outer divertor will be fabricated by Kawasaki Heavy Industry.

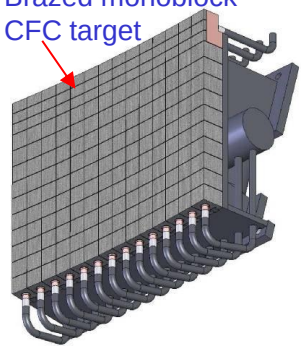
- Heat load: 10~15 MW/m²
- Active cooling with M10 screw tubes of CuCrZr.
- Brazed CFC monoblocks with screw tubes.

All 180 CFC monoblock targets were completed in 2013. Acceptance inspection test with infrared thermography was





Kawasaki



JT-60SA Research Plan

- **"JT-60SA Research Plan" summarizes "Research items and Strategy for JT-60SA" to solve critical issues in ITER and DEMO.**
- **Points of the JT-60SA RP**
  - **Prepare plan**
  - **Encourages collaborative studies on JT-60SA**
  - **Optimize hardware: heating, fueling, pumping, diagnostics, etc.**
  - **Grow year by year toward fruitful experiments.**

Chapter 2:Research Strategy

Chapter 3: Operation Regime Development

Chapter 4: MHD Stability and Control

Chapter 5: Transport and Confinement

Chapter 6: High Energy Particle Behavior

Chapter 7: Pedestal and Edge Physics

Chapter 8: Divertor, SOL and PMI

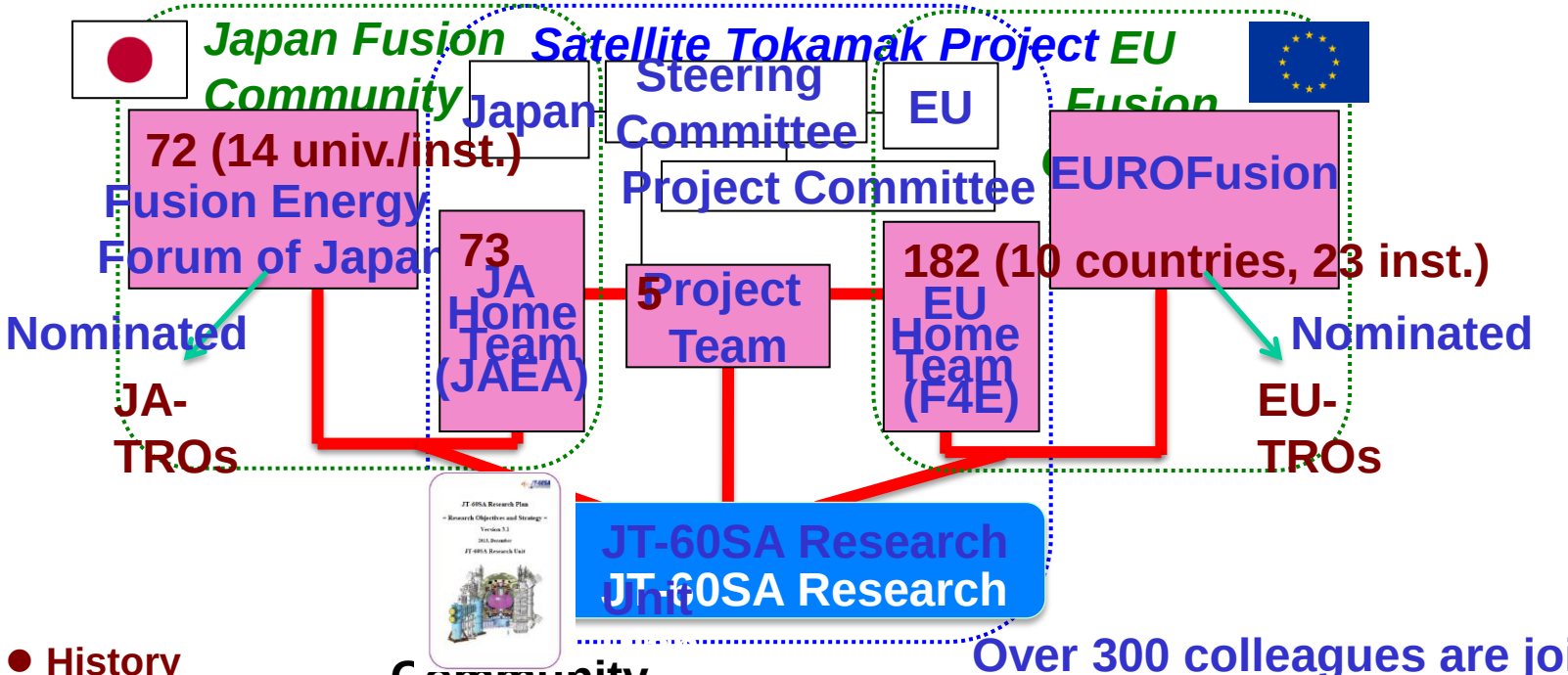
Chapter 9: Fusion Engineering

Chapter 10: Theoretical models and

Technical Responsible Officers (TROs) lead the discussion in their research fields.

Steady Expansion of SARP Activity

- Communities



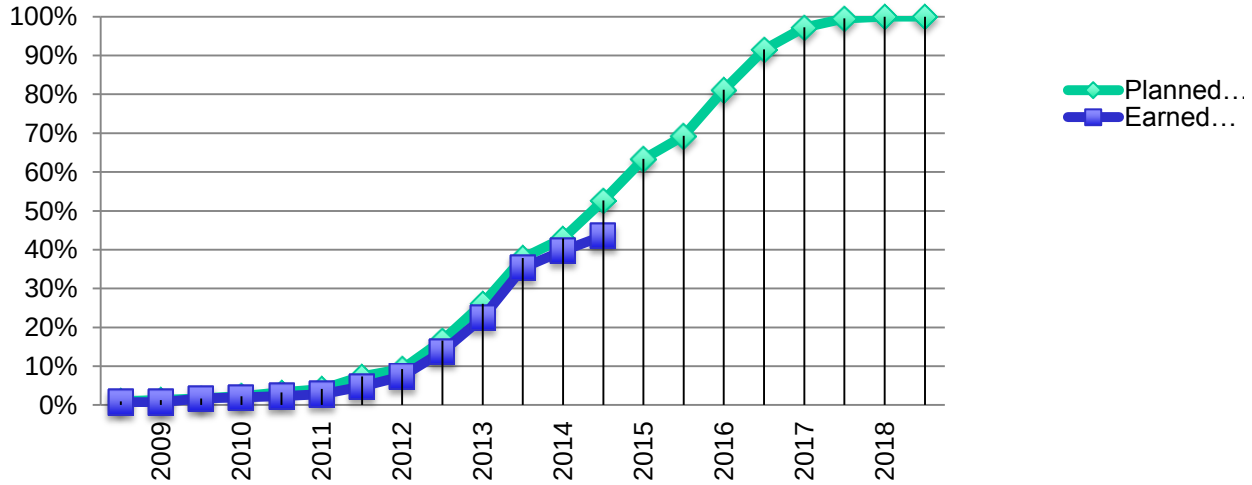
- History

JA Home Team (v.1): 2009 May → Community (v.2): 2010, Jan (v.2.1): 2011, Feb. → JA&EU (v.3): 2011, Dec. → revised (v.3.1): 2013 → continued

Over 300 colleagues are joining

Conclusions

- Design mostly completed
- Almost all procurement arrangements signed. Manufacturing in full swing. Key components being completed and delivered.
- About 50% the creditworthy deliverables have been accepted.
- Machine assembly underway.
- JT-60SA research plan jointly elaborated between EU and JA.



Thanks to:


JT-60SA建設に貢献する企業・機関
Organizations Contributing to JT-60SA Construction
JAEA
FUSION FOR ENERGY
HITACHI
TOSHIBA
MITSUBISHI ELECTRIC
Changes for the Better
VACUUM VESSEL
cea
ENEA
Ciemat
MTC
HITACHI
FURUKAWA ELECTRIC
CONSORZIO RFX
KIT
IBIDEN
POSEICO
Nidec
SISTEMI INDUSTRIALI
MILAN - ITALY
KOBELCO
OKAZAKI
mtt
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WALTER TOSTO
NE
Ateliers de la Meuse
ALLOY
NAT
ALSTOM
Jema
AIR LIQUIDE
Hitachi Chemical
IKC
RALSYOM
SDMS
la chaudronnerie blanche
Fuji Electric
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OCEM
POWER ELECTRONICS
A.SILVAMATOS
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