Italian National Agency for New Technologies, Energy and Sustainable Economic Development

DTT project overview

Villa Mondragone, Monte Porzio Catone (Rome), Italy – 14/12/2018

Aldo Pizzuto - ENEA - Director fo Department for Fusion and Technology for Nuclear Safety and Security

Why DTT?

JET (in operation since 1983): designed to study plasma behaviour in conditions and dimensions approaching those required in a fusion reactor (including D-T operation)

ITER (under construction): reactors-scale international experiment designed to deliver ten times more power than it consumes (burning plasma with Q ~ 10)

DTT: a facility conceived to develop and test *integrated,* controllable power *exhaust solutions* for DEMO

DEMO (predesign activities): expected to be the first fusion plant to provide electricity to the grid

The DTT added value

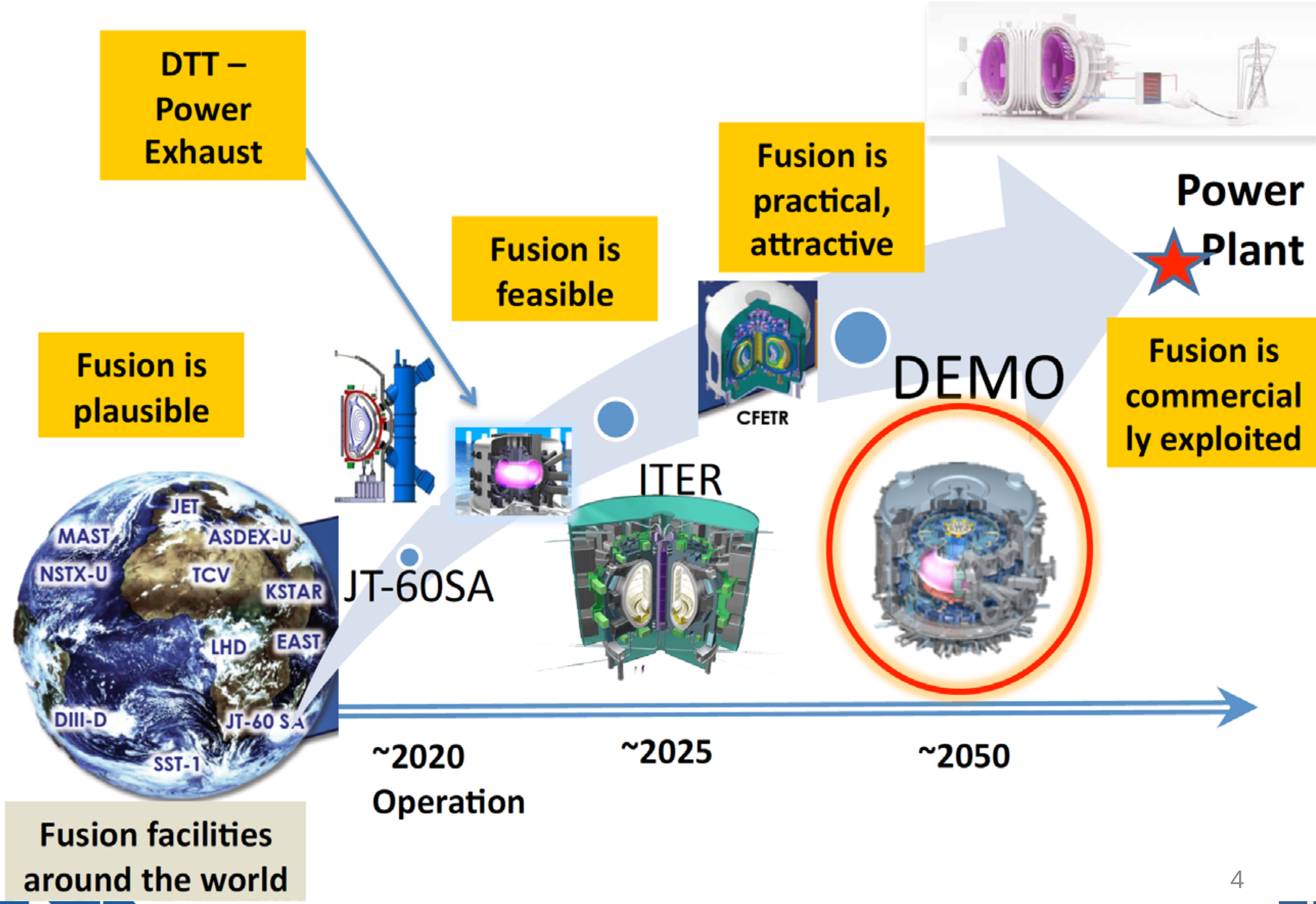
DTT is a new device, where the modern technologies can be adopted and further developed; the presently operating Tokamaks were designed about 40 years ago

It is reasonable affirm that by 2025 most of the plasma experiments built in the ‘80 are shutdown and the experimental plasma physics activities are carried out on a few (modern) machines

DTT construction will keep industry linked to fusion field

DTT would be the ideal training device to grow the new generations needed for feeding ITER and, subsequently DEMO, with skilled people

Titolo della slide



The Divertor Tokamak test facility

DTT has most of the features of a next generation tokamaks


Contributors

http://fsn-fusphy.frascati.enea.it/DTT

July 2015

and

Fusion Engineering and Design, Special Issue: DTT

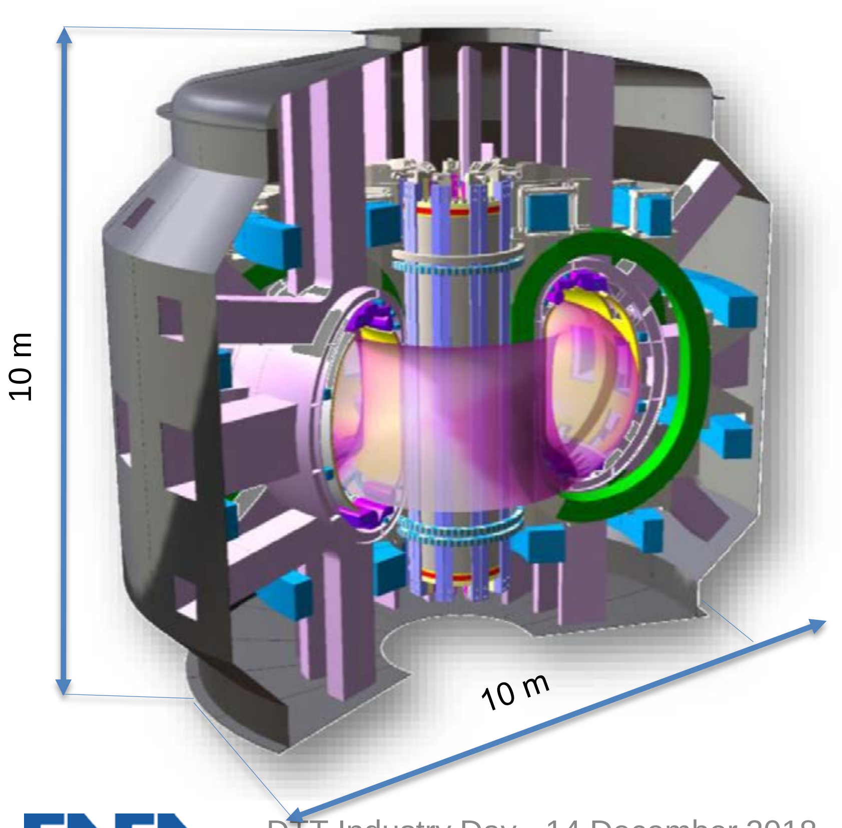
https://www.sciencedirect.com/science/journal/09203796/122

http://www.dtt-project.enea.it

Soon green book

DTT main parameters

DTT



Main Parameters

R (m)	2.10
a (m)	0.65
Ip (MA)	5.5
BT (T)	6.0
Vpl (m^3)	33.0
Padd (MW)	45.0

Procurement and services

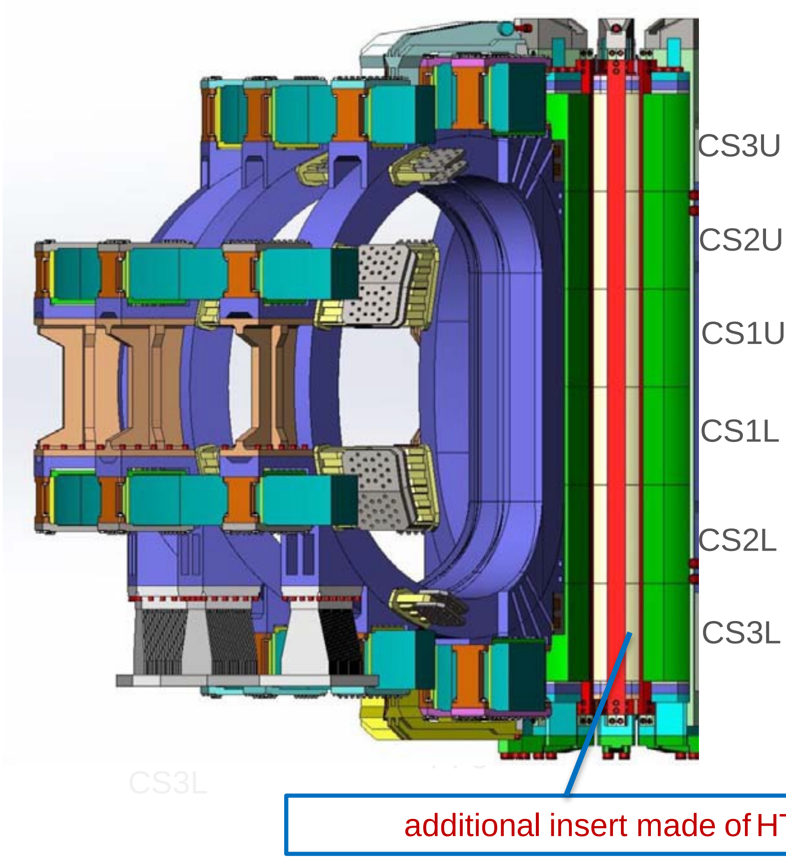
DTT main procurements:

1. Superconducting Magnets:
   - Strands: Ni_3Sn and NiTi
   - Cables
   - Magnets (coils+casings)
   - External structure
2. Vessel/In-Vessel
   - Vacuum Chamber
   - First Wall
   - Divertor
3. Power Supplies:
   - CS, PF, TF & protection systems
   - Additional heating
   - Auxiliaries
   - Distribution systems

4. Radiofrequency:
   - Ion Cyclotron: 4 MW at 90 MHz
   - Electron Cyclotron: 14 MW at 170 GHz
   - Neutral Beam Injector 7 MW
5. Cryocooler: 10 kW at 4.6 K
6. Control
7. Remote maintenance
   - In vessel
   - ex vessel
8. Buildings
9. Assembly

DTT Magnets

DTT – Magnet System

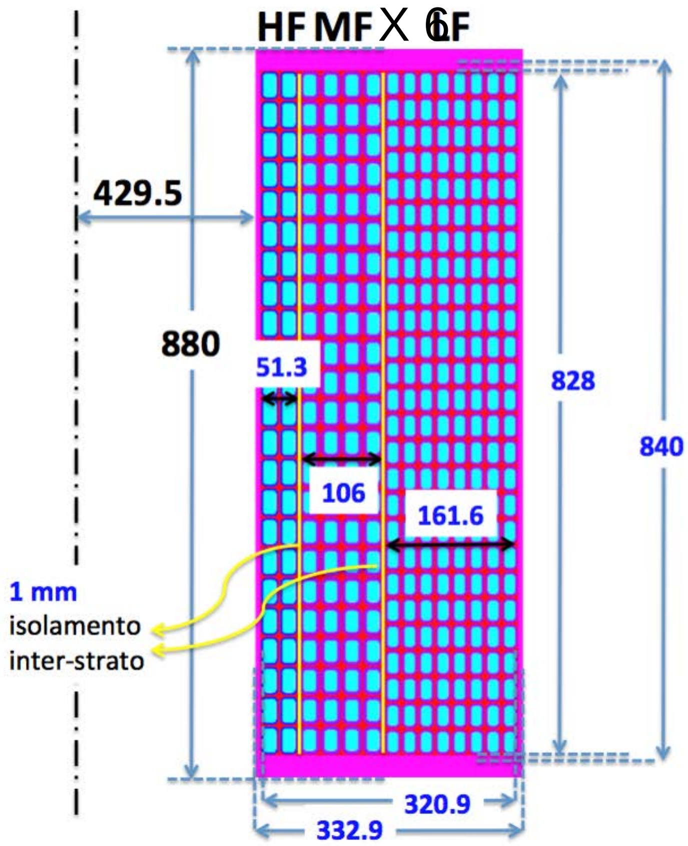


Main Features

18 Toroidal Field coils
Nb_3Sn
6 Central Solenoid module coils
Nb_3Sn
6 Poloidal Field coils
2 Nb_3Sn
4 NbTi

DTT Magnets

DTT – CS solenoid



HF:
2 x 22 = 44 turns

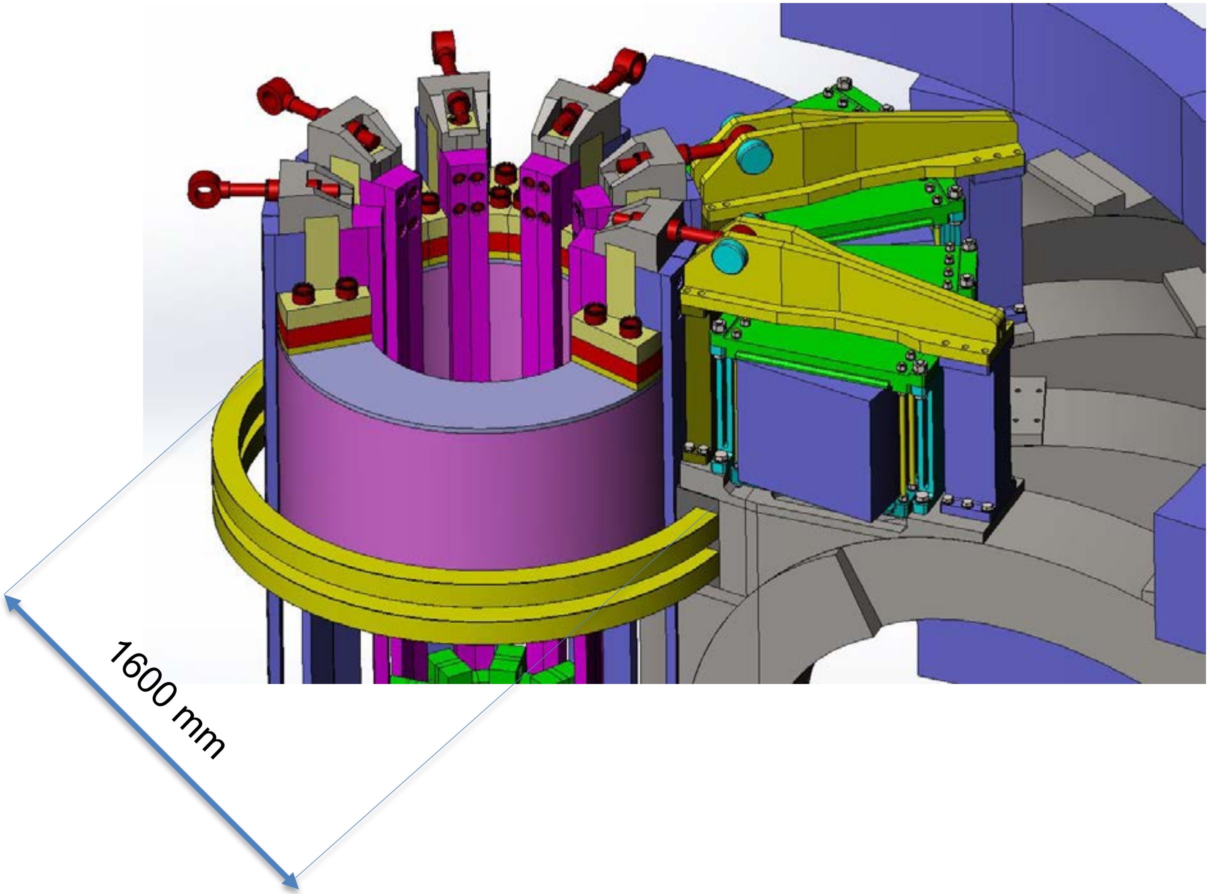
MF:
4 x 22 = 88 turns

LF:
8 x 26 = 208 turns

I_op: 28.0 kA

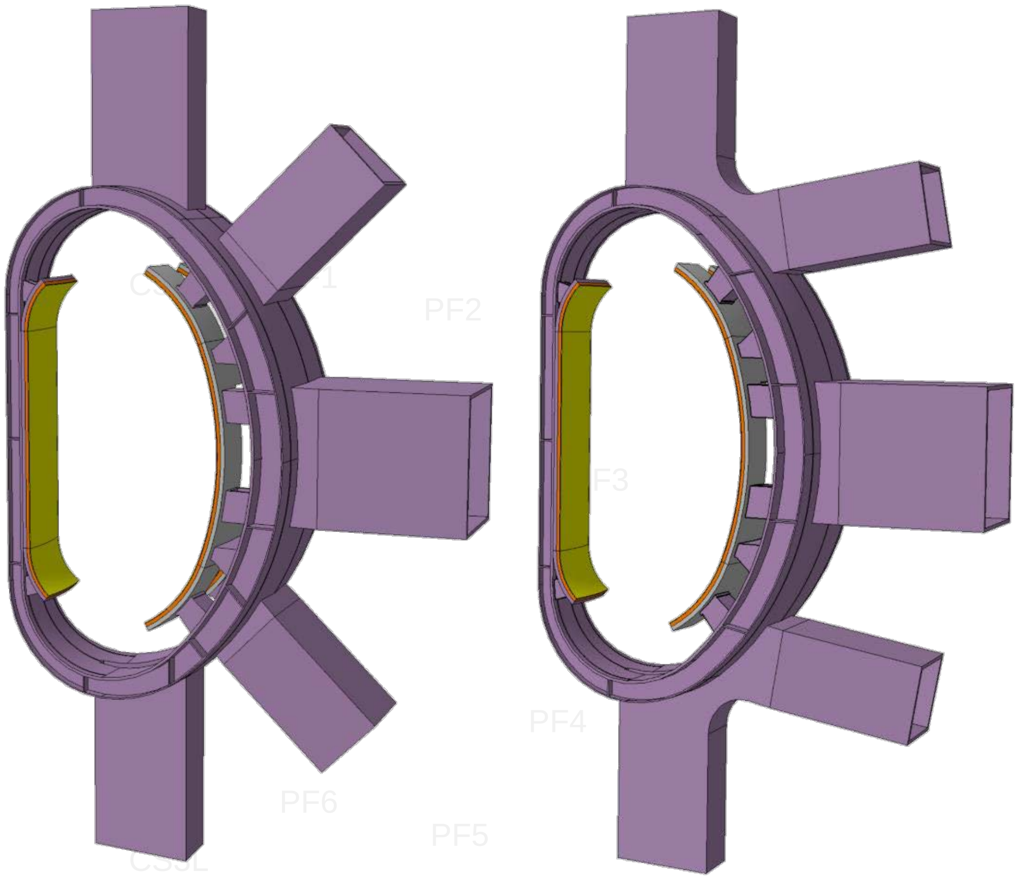
Precompression rings

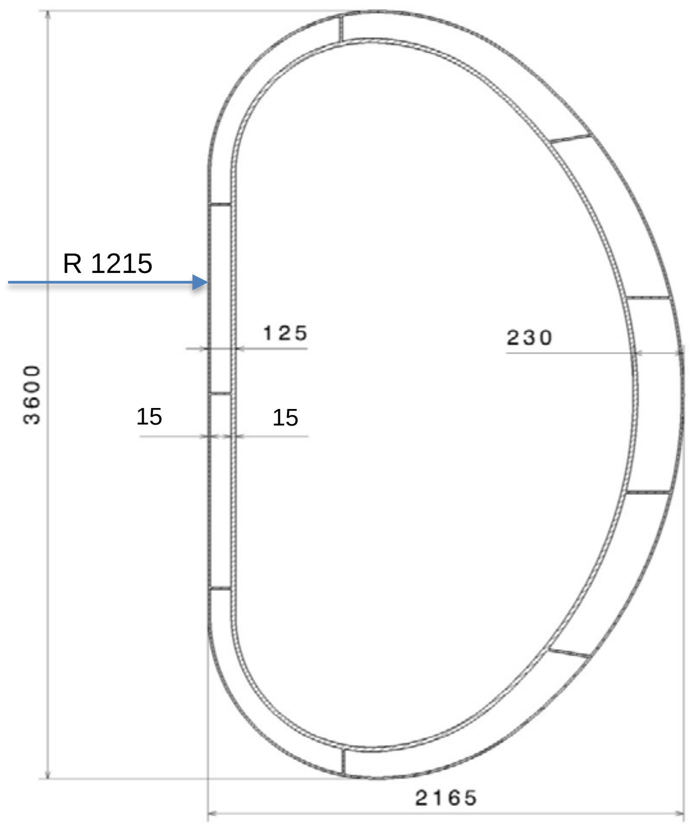
Two couple rings made of glass-epoxy vacuum impregnated



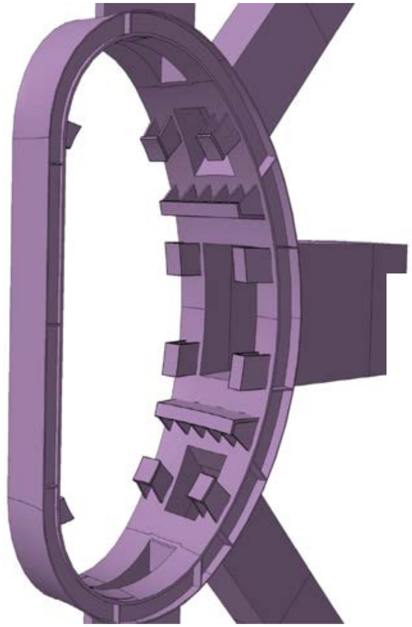
DTT Vacuum Vessel

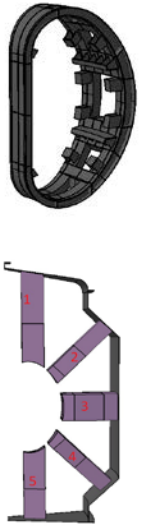
18 sectors – double wall structure – AISI 316 LN – 5 ports/sector – 2 NBI eq. port inclined 30°

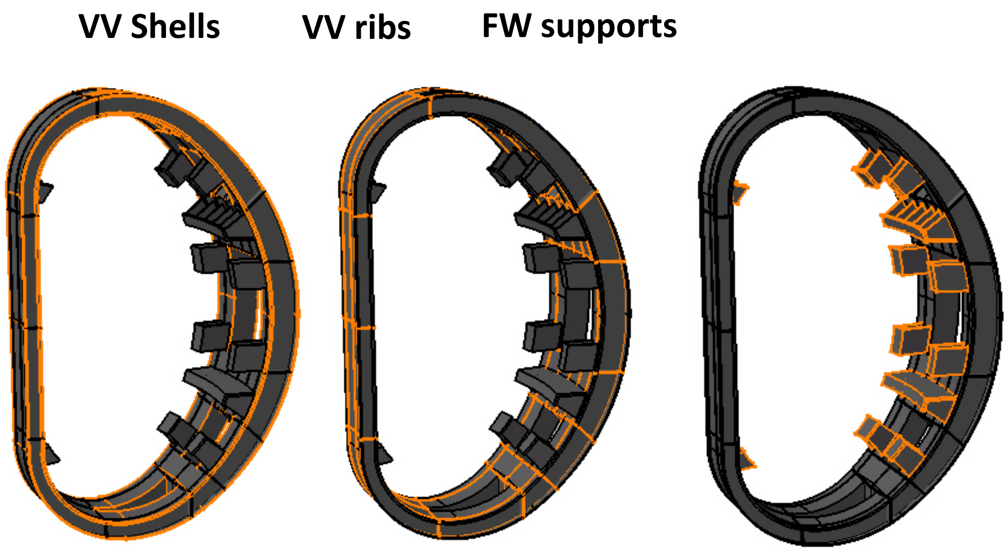


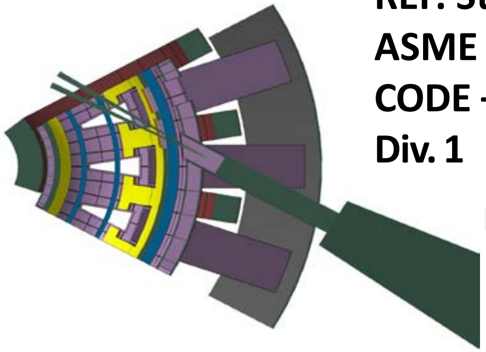


DTT Vacuum Vessel





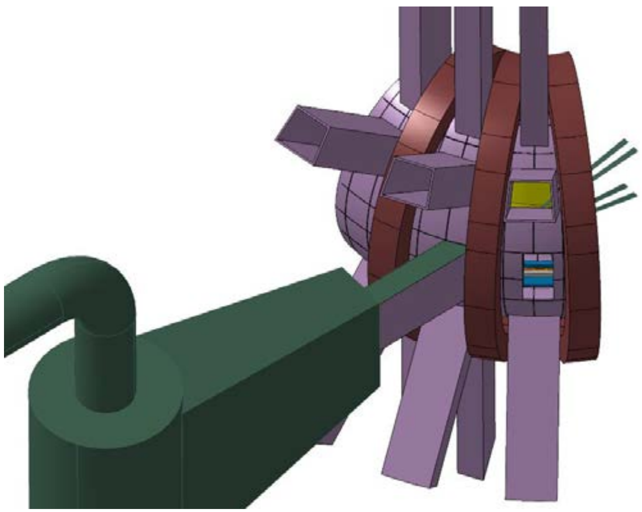


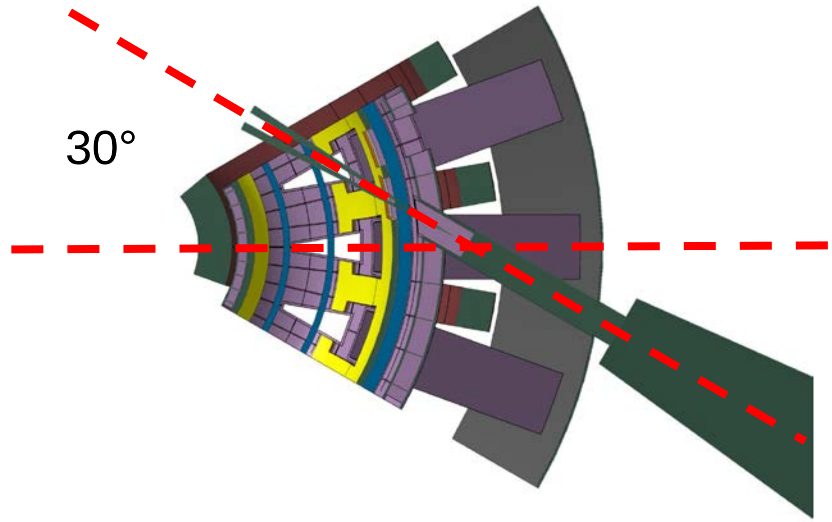


REF. Standard:
ASME BOILER AND PRESSURE VESSEL CODE – Section VIII
Div. 1

DTT Vacuum Vessel

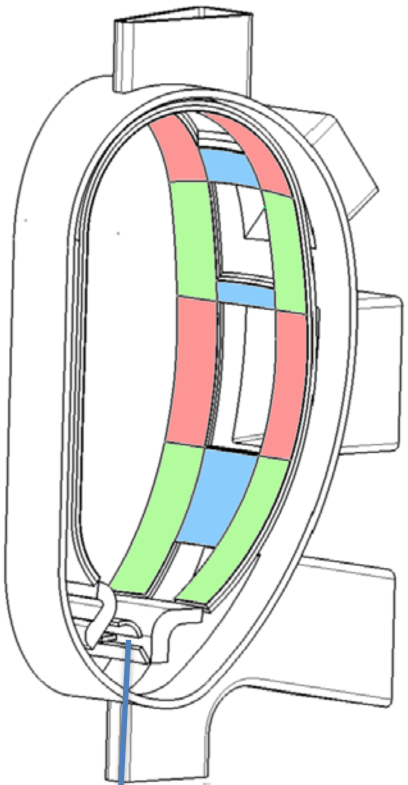
Two modules (three sectors) will be modified to accommodate two co-tangential NNBI.



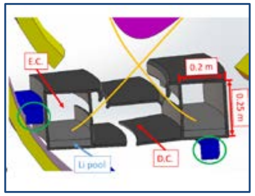


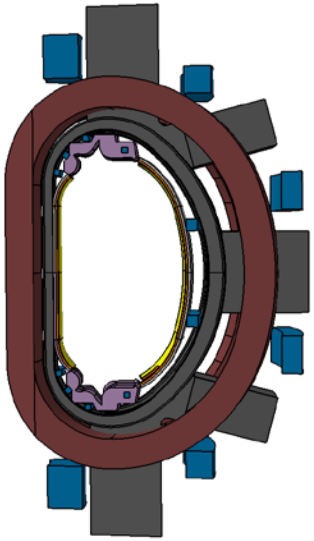
The beams are injected at 40° relative to the magnetic axis

DTT Divertor & First Wall

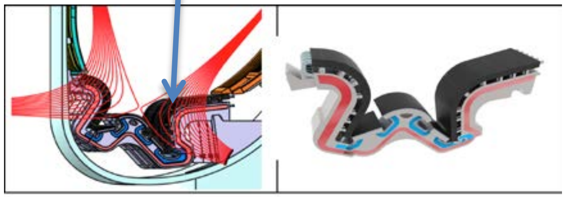


Full scale full W ITER divertor inner vertical target plasma facing units

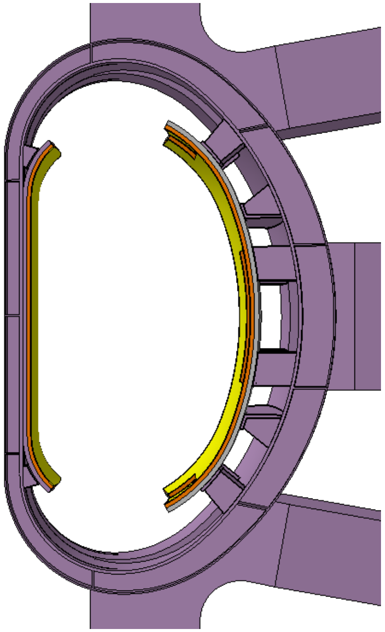




Possible provisional divertor



DTT Divertor & First Wall



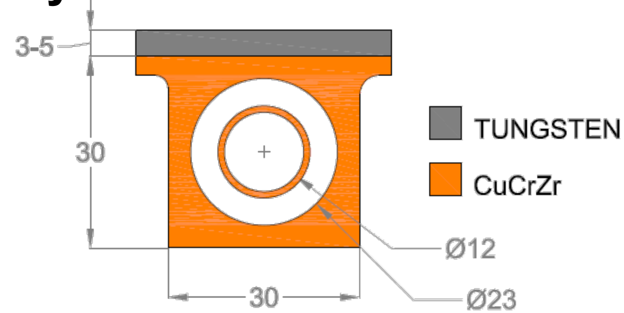
First wall

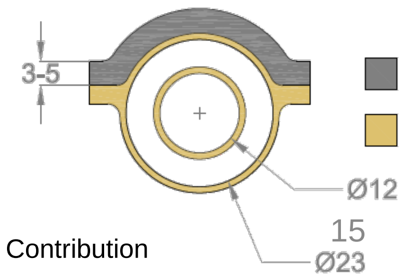
Two coaxial concepts under study:

- square cross-section with CuCrZr as structural material
- circular cross-section without copper

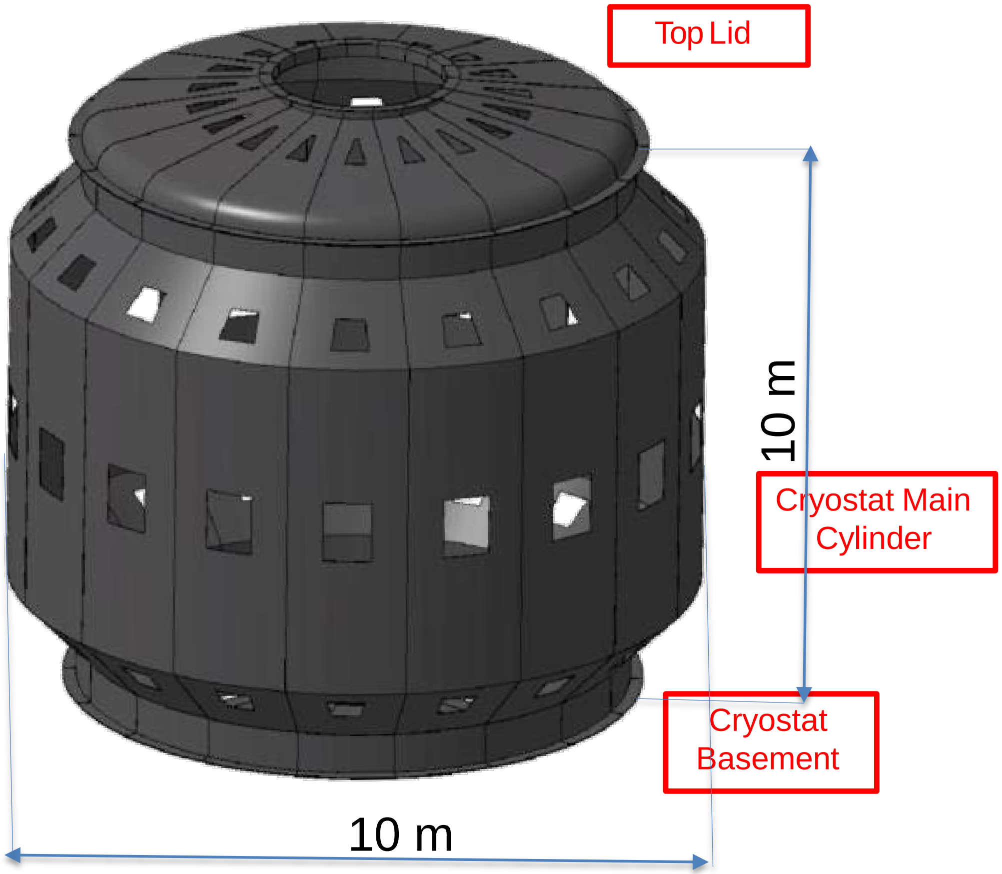
In both cases:

≈3 mm Tungsten plasma spray with Functional Gradient Material interlayer



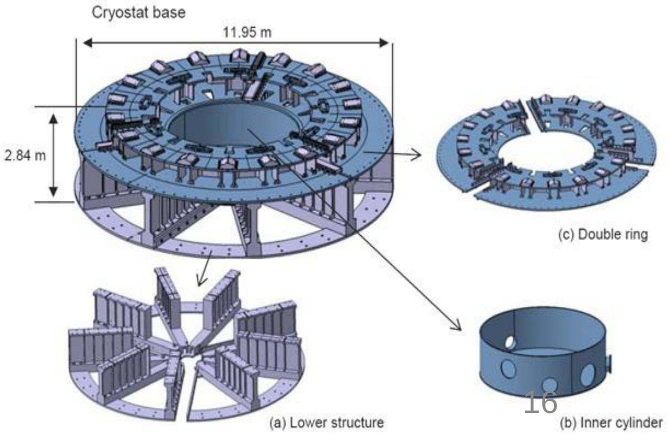


DTT Cryostat



operational pressure: **10^{-3} Pa**

The reference material is assumed to be **AISI 304 L (Co<0.05 wt%)**



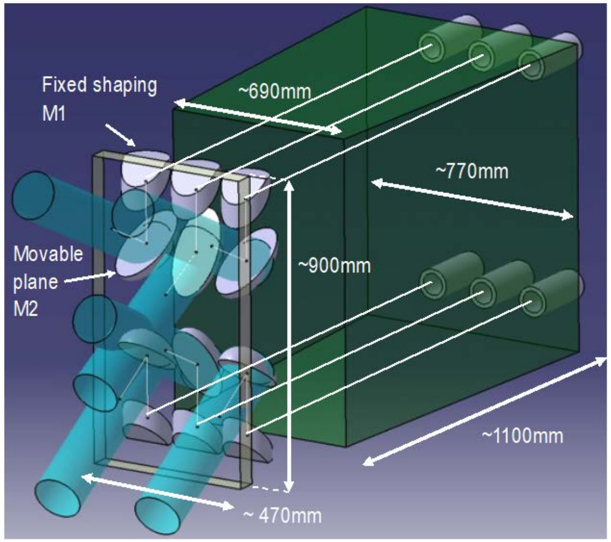
Additional heating: ECRH

ECRH: **16 gyrotrons**

Scheme:
4 Solid State HVPS
8 Gyrotrons (**1MW/170GHz**/100s) *(ITER like)*
1 Multi-Beam **Quasi Optical** TL *90% efficiency*

Front Steering Antennas:
6 Lines in 1 Equatorial Port

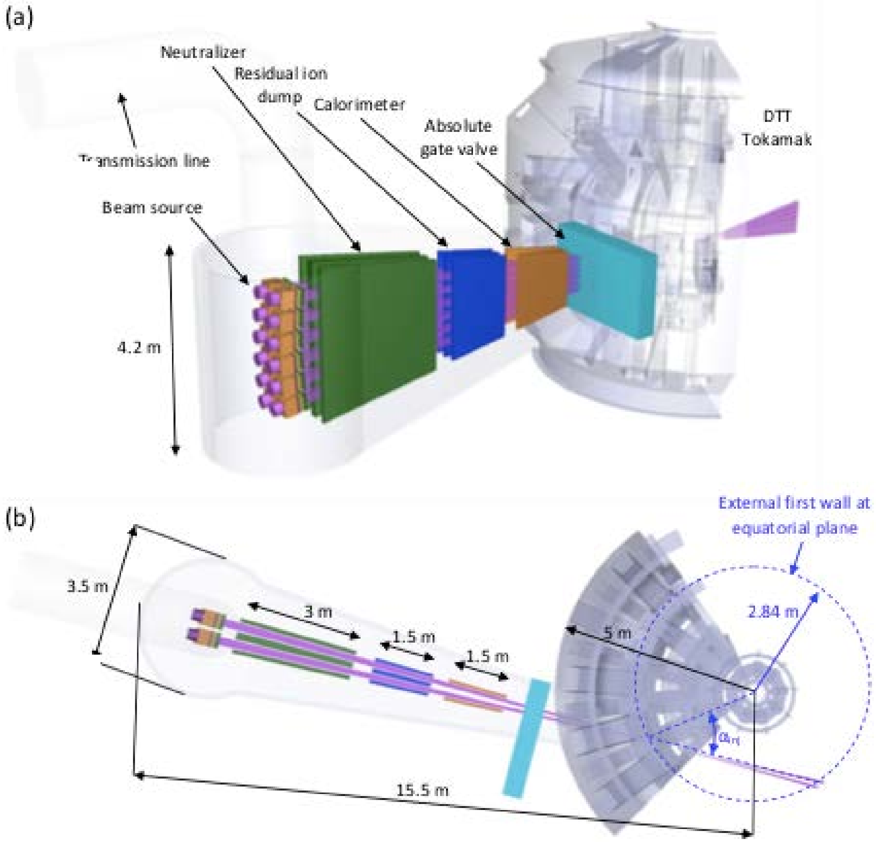
2 Lines in 1 Upper Port



Additional heating: NNBI

Coupled power to plasma 7.5 MW

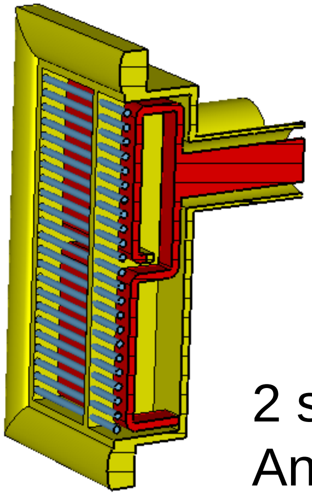
Beam energy: **350 - 450 keV**



Additional heating: ICRH

ICRH: Main features
60-90 MHz frequency range,
3 MW at plasma,
4 MW at generators.

System architecture
1 HVPS,
2 diacrode-based transmitters,
coaxial (9 in.) transmission lines,
2 **antennas**: power density ~2.2 MW/m^2.



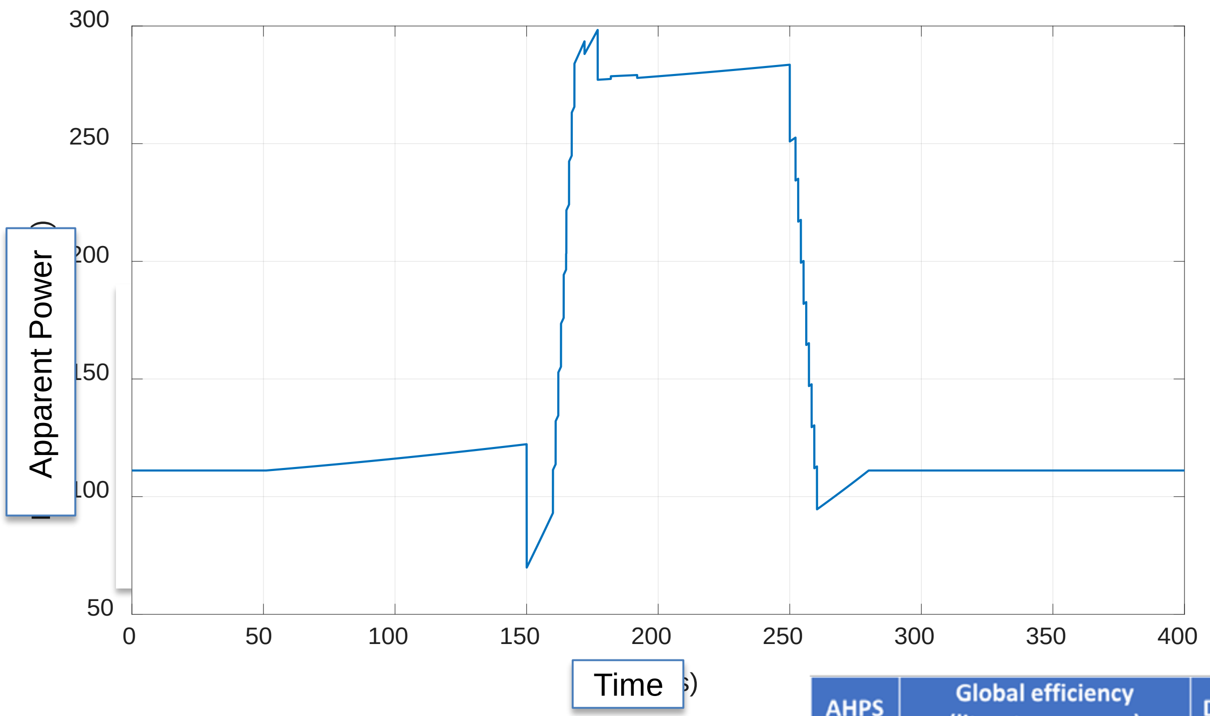
2 straps
Antenna Cut

Remote Handling

The expected neutron rate in DTT amounts to 1.3×10^{17} ns^{-1} for the H-mode extreme scenario ***making remote handling mandatory*** *in the long range.*

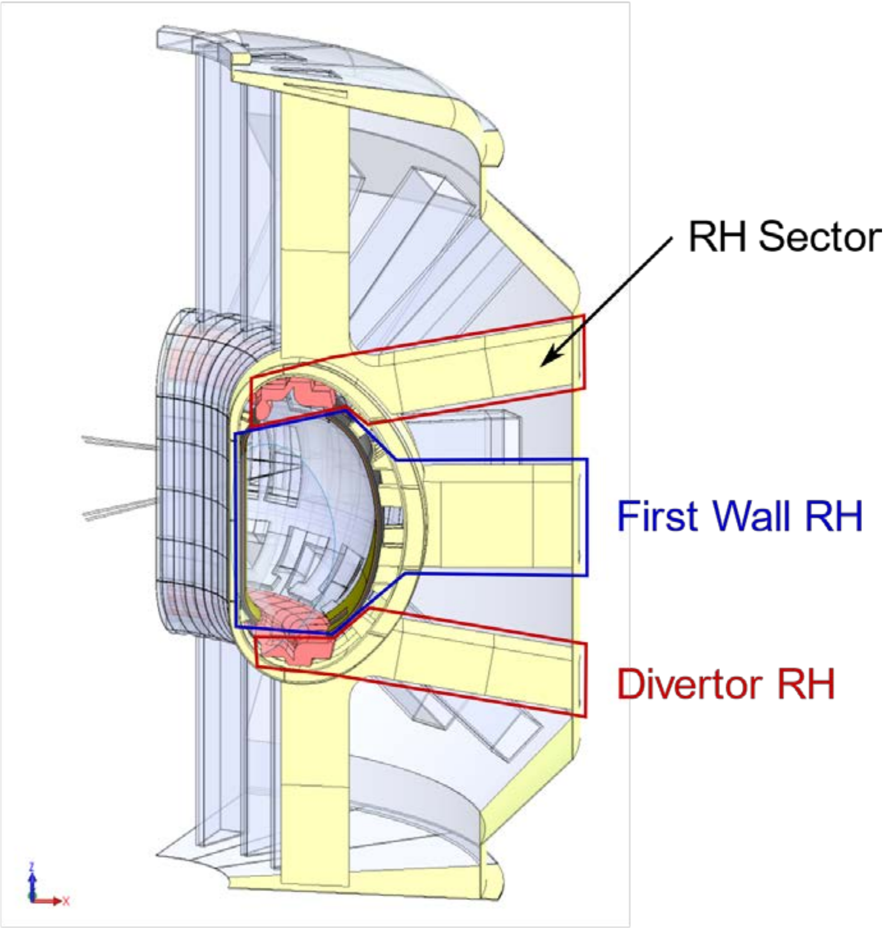
However our assumption is that the remote handling will operate also during the machine assembling phase. This will allow to test and commission the remote handling during a phase when it is not at all necessary.

Power Supply

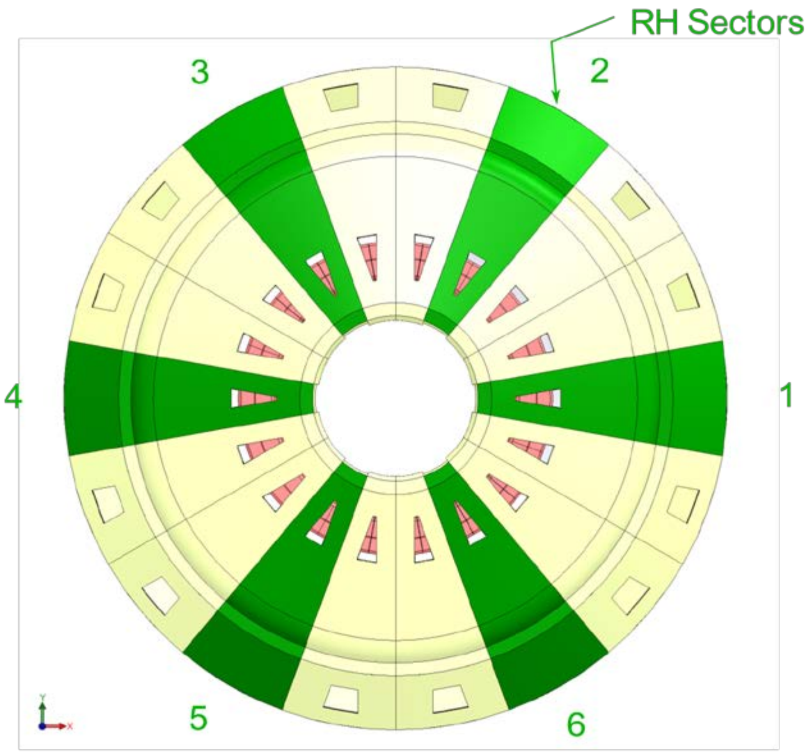


AHPS	Global efficiency (literature survey)	DTT full power	DTT 1st day
EC	η=0.2-0.3 [27] η=0.25 with cosϕ=0.8 [28] η=0.25 [29] η=0.3 with cosϕ=0.9 [11] η=0.4 [30] η=0.25-0.5 [31] η=0.6 @77 GHz, η=<0.9 @154 GHz [32]	20-30 MW (to plasma)	14.5 MW (16 single-freuency gyrotrons)
IC	η=0.3-0.55 [26] η=0.4-0.5 [27] η=0.6 with cosϕ=0.7 [11]	5-10 MW	3 MW (2 antennas)
N-NBI	η=0.2-0.3 [27] η=0.25 with cosϕ=0.6 [7, 28] η=0.4 [30, 33]	7-15 MW	7.5 MW (1 injector)
Total	0.3?	45 MW	25 MW
Electrical power		150 MW	75 MW

RH strategy



- 6 lower/upper ports for Divertor
- 2 equatorial for FW

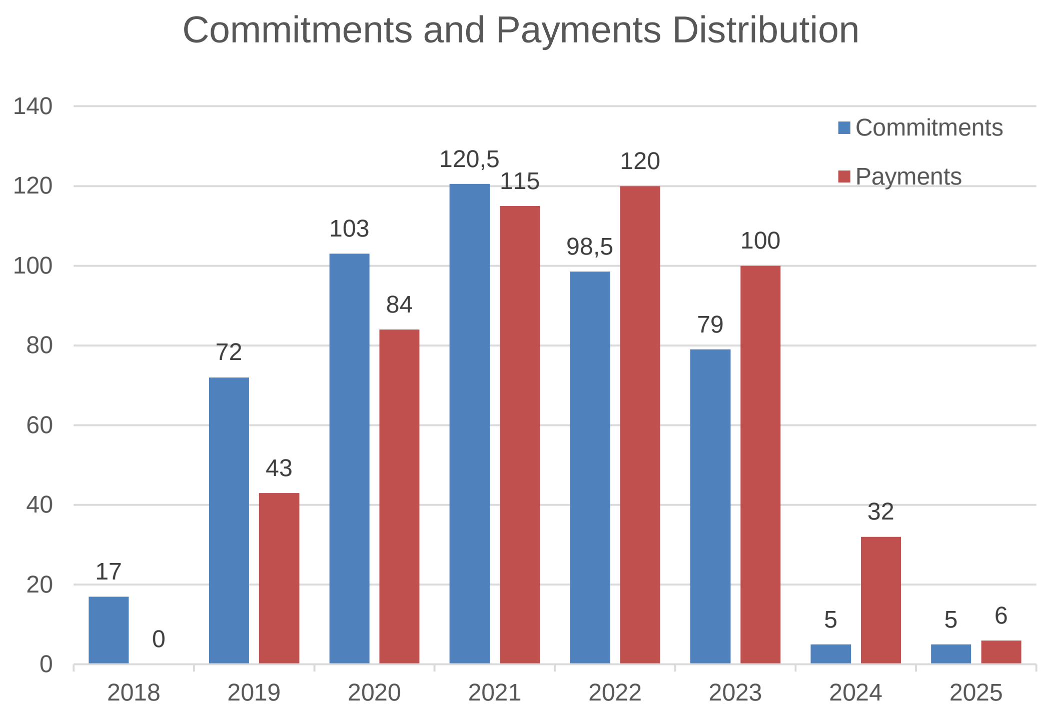


Investments

The total investment is around 450 million euros + contingency

The total duration of the commitment is 6,5 years + 6 months for commissioning

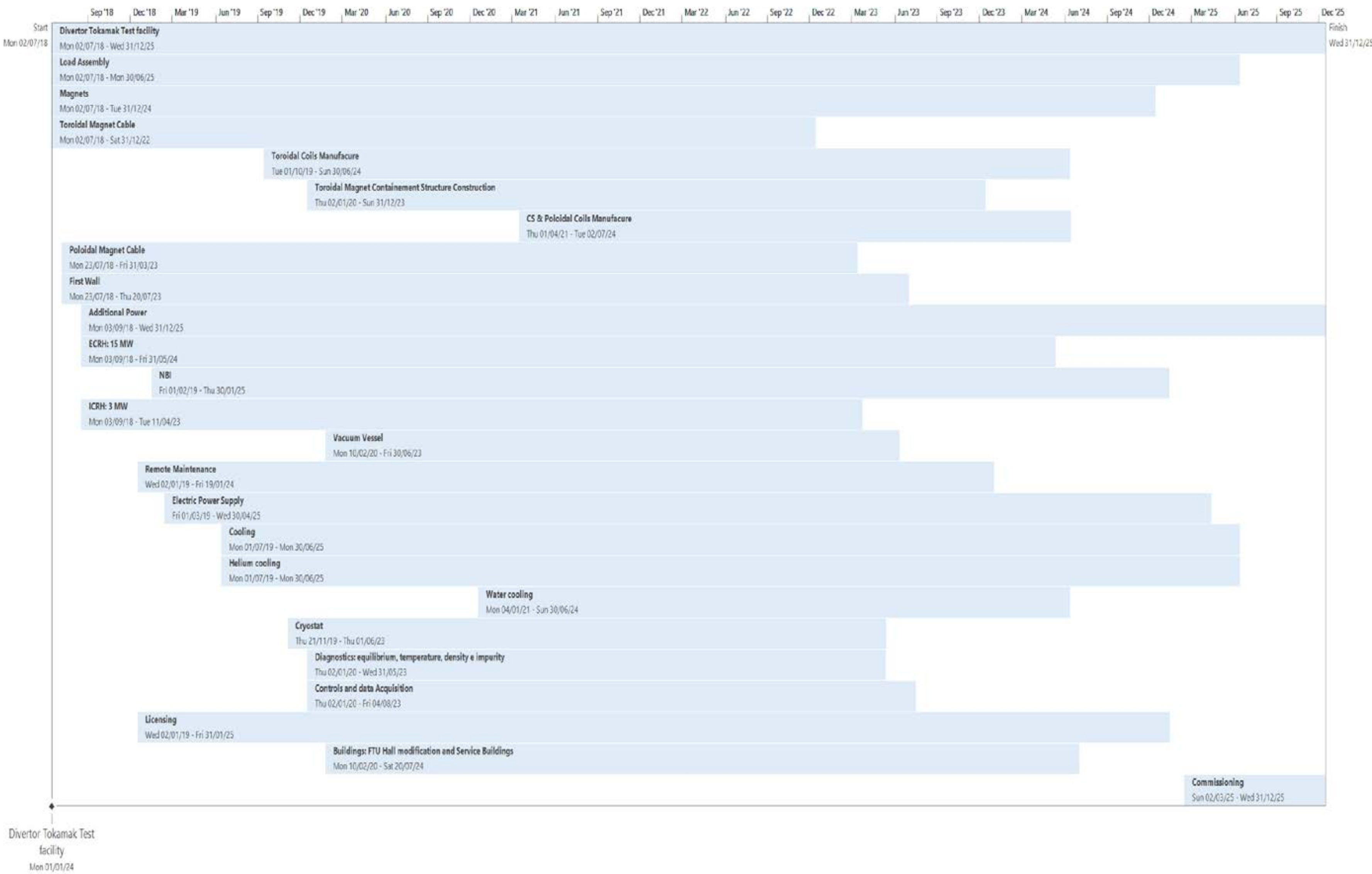
The volume of the tender per year is the following:



Costs

Items	Costs (M€)
Components and Parts (Magnets ~60%; Vessel-InVessel+Cryostat~40%)	210
Magnet power supplies (w/o substation)	60
Additional heating (25 MW)	102
Remote Handling and cooling system	37
Diagnostics & control	11
Infrastructures and Assembly	25
Contingency	25
Services	30
TOTAL	500

Time schedule of the main components



Types of companies and services

The vast majority of the procurement will be oriented to the SME's

In a few cases the value of the contract is quite high so the bidders must have sufficient financial capacity

Services are expected to be required during the assembly and operation phase.

Type of contracts

For a timely realisation the call must be based on suitable specs based on well assessed design and proven technology

Framework contracts and open procurements are deemed too risky for a timely construction within budget

The call will be typically based on negotiated procedures based on a pre-qualifying Call for interest.

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