Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

SEZIONE di PALERMO

ORDINE DEGLI INGEGNERI
DELLA PROVINCIA DI PALERMO

Il progetto italiano Divertor Tokamak Test facility (DTT) nell'ambito della Roadmap Europea per la Fusione Nucleare

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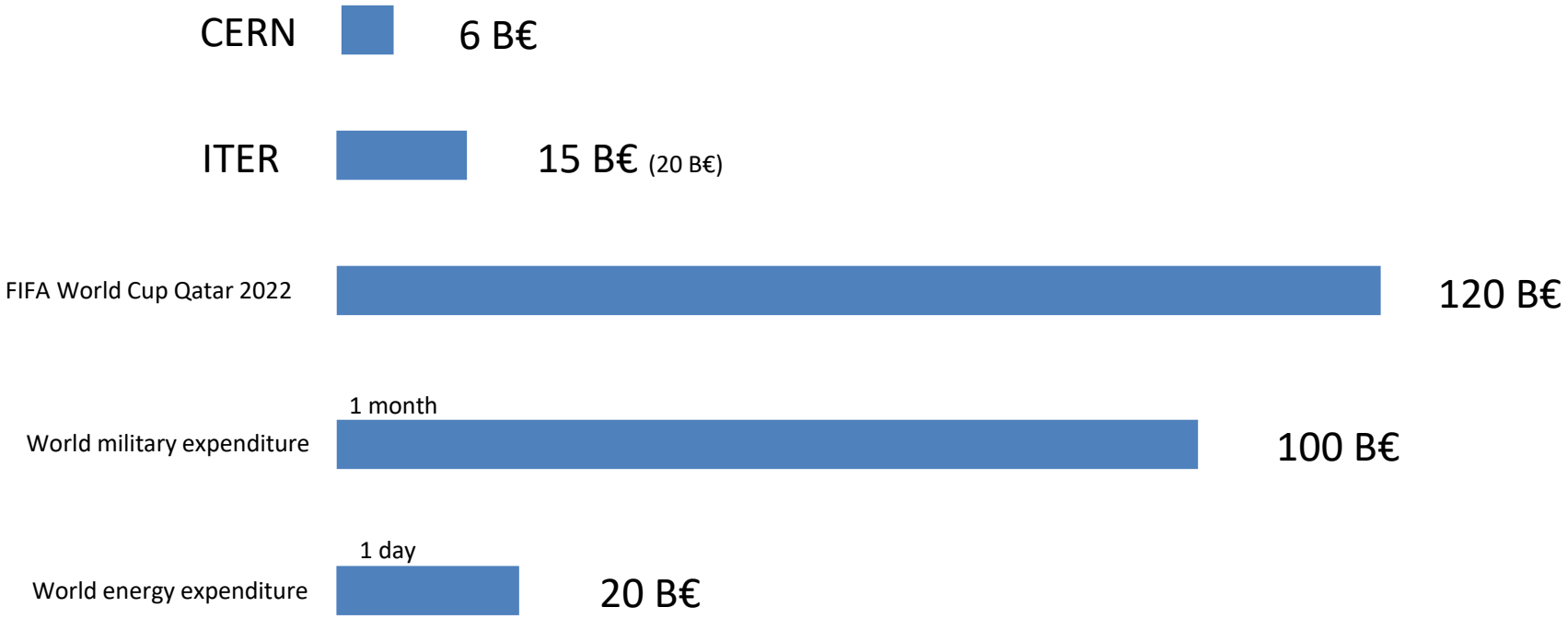
Seminario "Nucleare: Presente e Futuro"

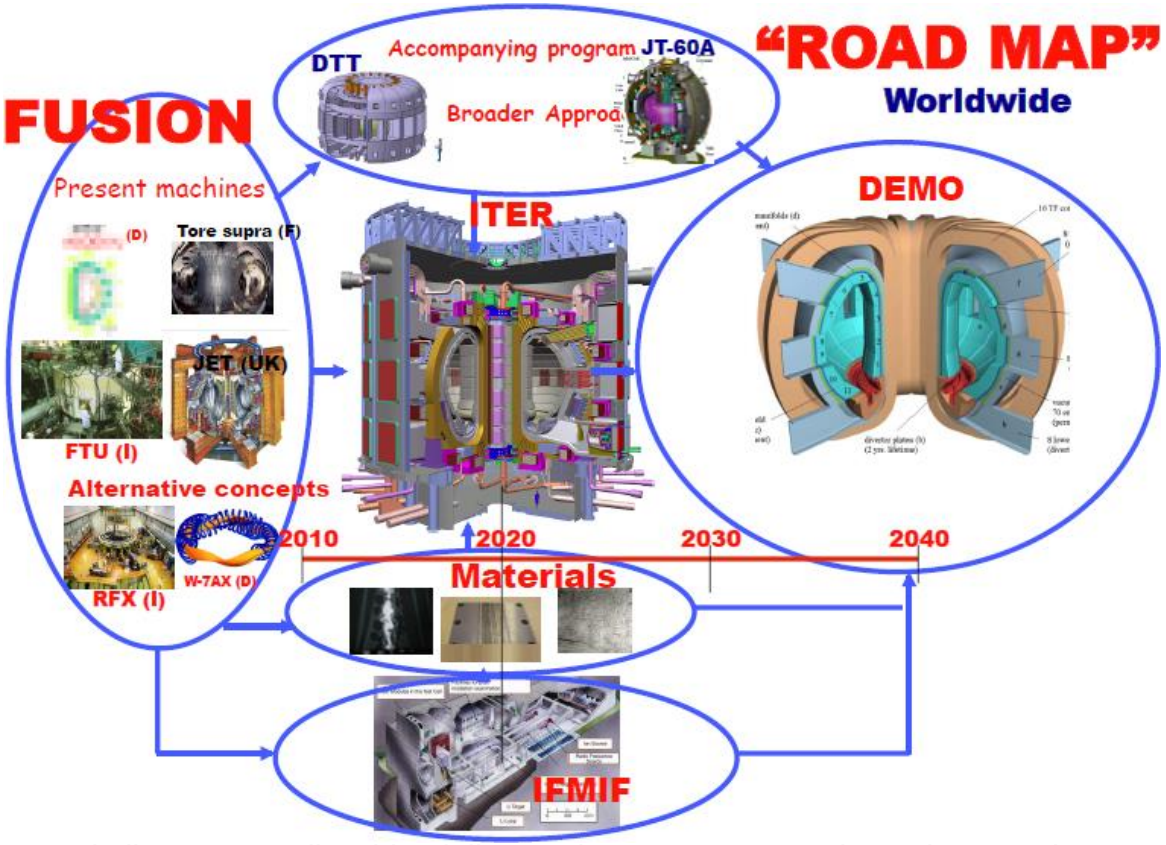
Palermo,15 Dicembre 2022

Nuclear fusion is less know than other topics

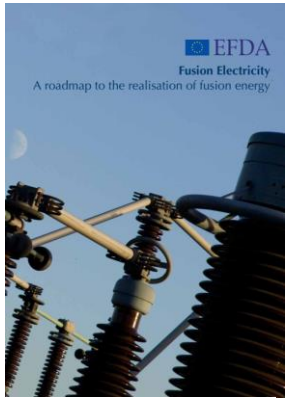


Sources: Sole 24 Ore, Stockholm International Peace Research Institute Yearbook 2014 “Armaments, Disarmament and International Security”

The (EU) Nuclear Fusion Roadmap



Why (a) DTT?



EFDA roadmap 2013:

A solution for the heat exhaust in the fusion power plant is needed.

[…] in parallel to the programme in support of the baseline strategy, an aggressive programme on alternative solutions for the divertor is necessary […] a dedicated test on specifically upgraded existing facilities or on a dedicated Divertor Tokamak Test (DTT) facility will be necessary.

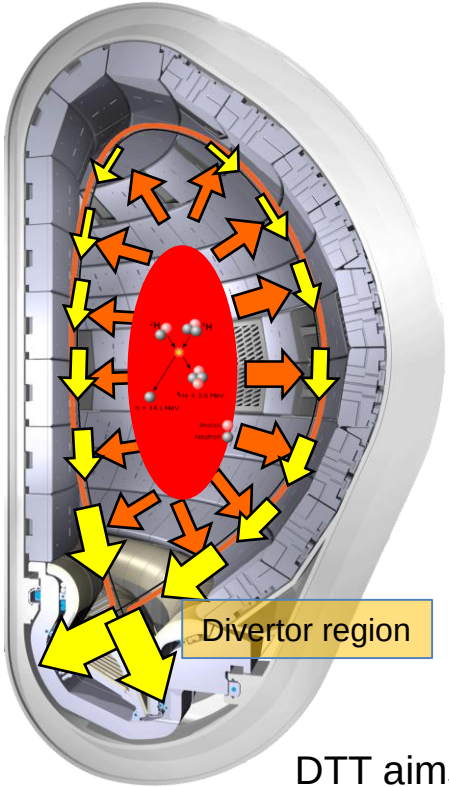
Eurofusion roadmap 2018:

[..] the extrapolation from proof-of-principle devices to DEMO based on modelling alone is considered too large. [..] a divertor optimised for the concept will be implemented in the Italian Divertor Test Tokamak (I-DTT) facility as a joint European collaboration.

EUROfusion

https://www.euro-fusion.org/fileadmin/user_upload/EUROfusion/Documents/Roadmap.pdf

Power exhaust



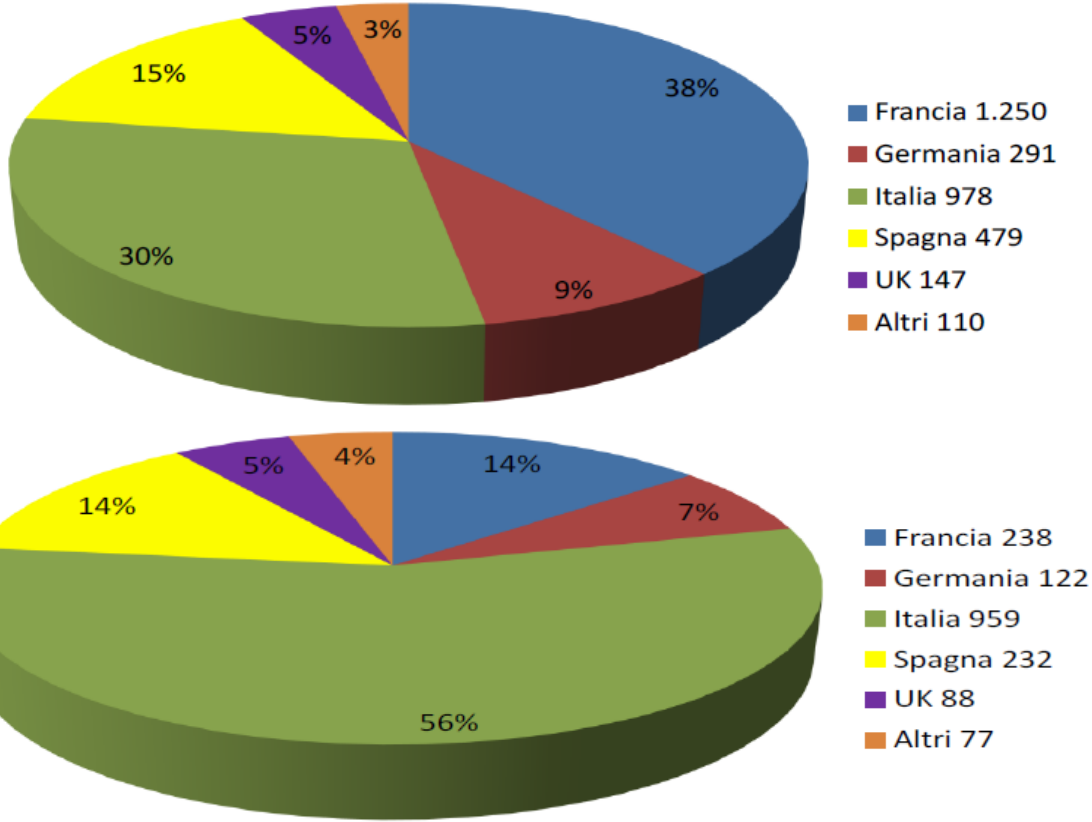
Power exhaust for the DEMO and the first nuclear fusion power plant problem shall solved by:

- Plasma facing components technology
  - Max heat flux presently limited to 10-20 MW/m^2
- Plasma scenario shape
- Impurity seeding to increase radiation
- Liquid metals

DTT aims at providing a **unique flexible integrated environment, relevant to DEMO**

Italian contribution to ITER (old data)

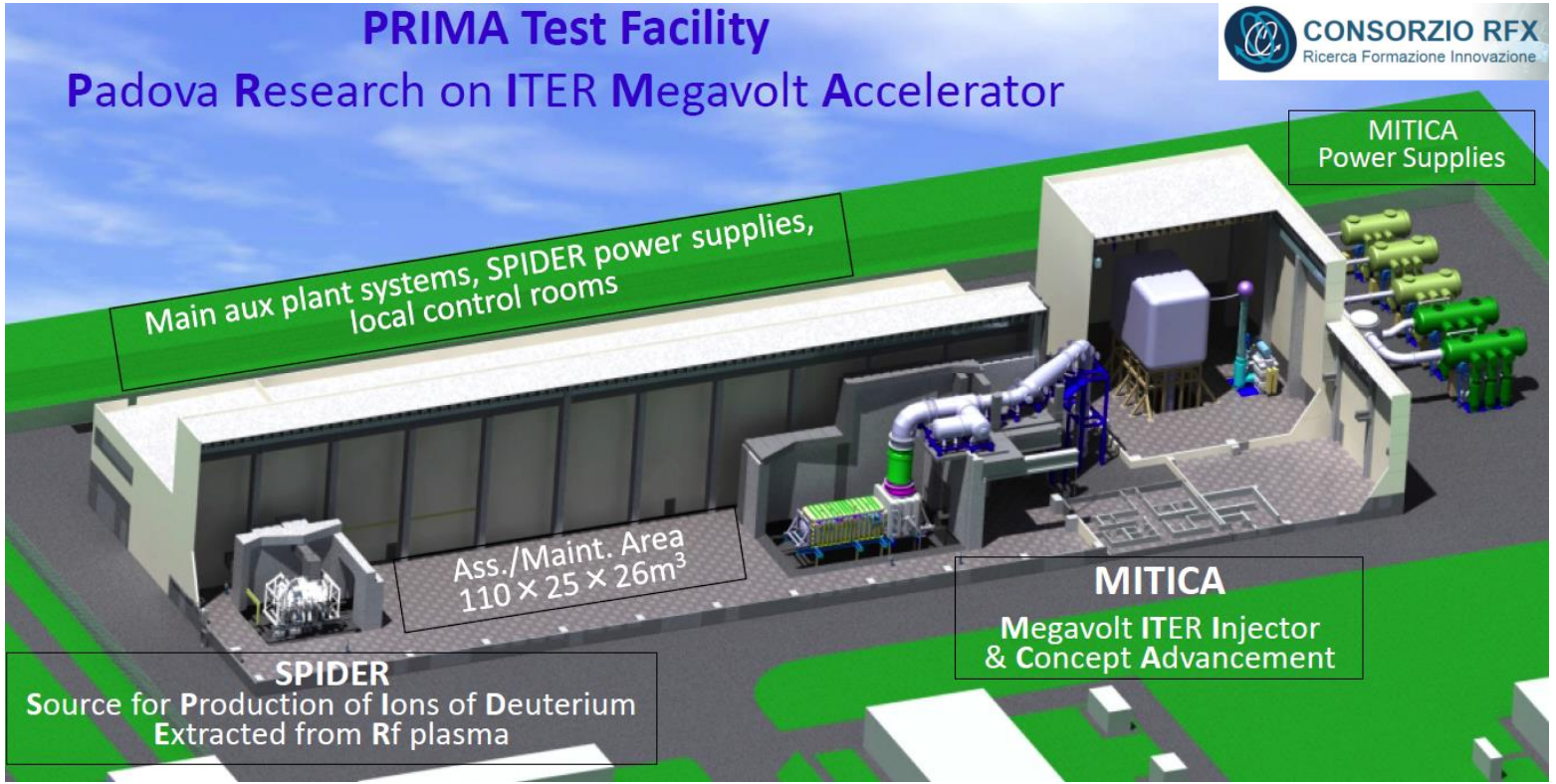
Source: P. Acunzo, Italian ILO
http://www.ilonetwork.it/



All the contracts
(2008-2014)
3255 B€
(half of final budget)

Technology
contracts
(no buildings)
1716 B€
and increasing…

In Padua: 1 MV power supply for ITER



The DTT Consortium (Scarl)

Shareholders	%
ENEA	70%
ENI	25%
INFN	1%
CNR	0.5%
Consorzio CREATE	0.75%
Consorzio RFX	0.75%
Politecnico Torino	0.5%
Uni Tuscia	0.5%
Uni Milano Bicocca	0.5%
Uni Roma Tor Vergata	0.5%

Budget: ≈700 M€

PNRR

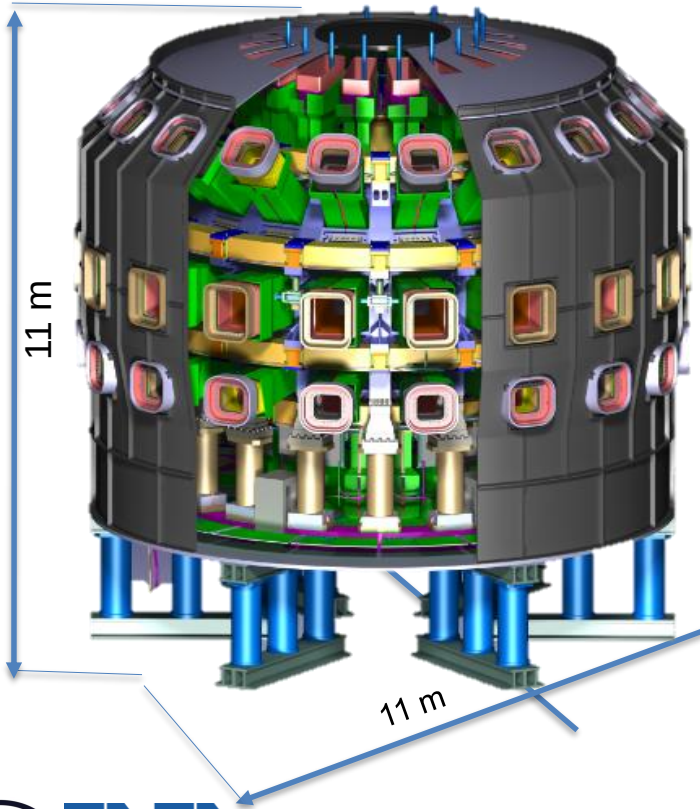
International Technical Scientific Committee: “The lack of personnel is one of the main issues of the project”

EUROfusion support in WPDIV-IDTT ≈60 M€

Scientific program

- 82 proposals for membership of the drafting group rfrom 15 European laboratories (non Italian participation 54%)
- First version of the plan expected in June 2023 in time for the EUROfusion facility review

DTT parameters

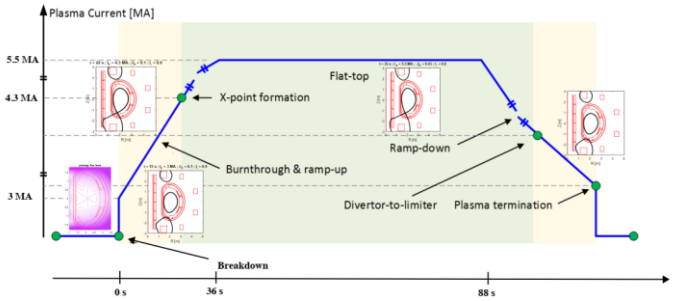


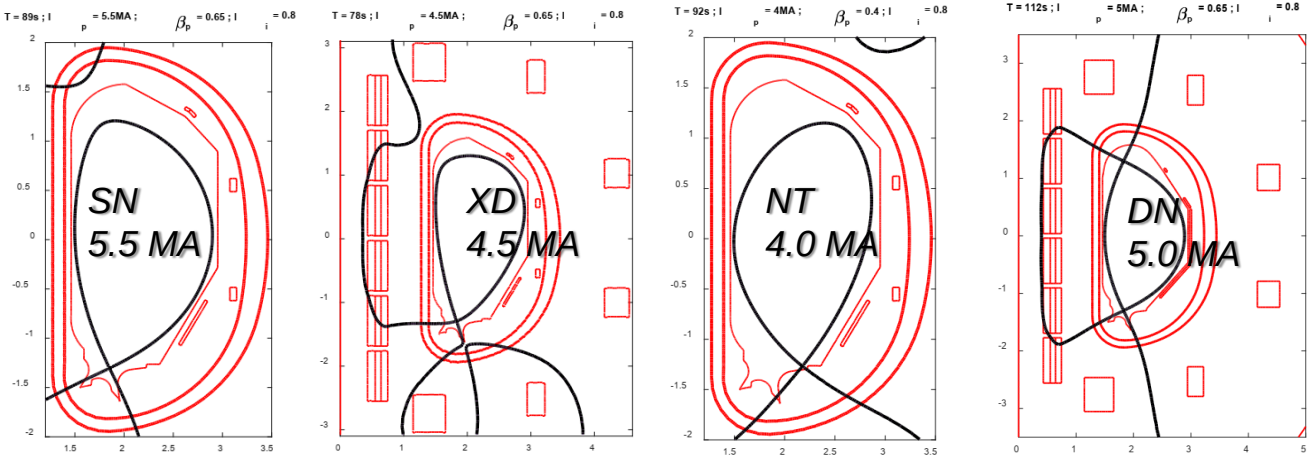
	DTT	ITER	DEMO
R (m)	**2.19**	6.2	9.1
a (m)	**0.7**	2	2.93
A	**3.1**	3.1	3.1
I_p (MA)	**5.5**	15	19.6
B (T)	**6**	5.3	5.7
Heating P (MW)	**45**	50	50
P_{sep} /R (MW/m)	**15**	14	17
λ_q(mm)	**0.7**	0.9	1.0
Pulse length (s)	**100**	400	7600

DTT flexibility as primary design requirement

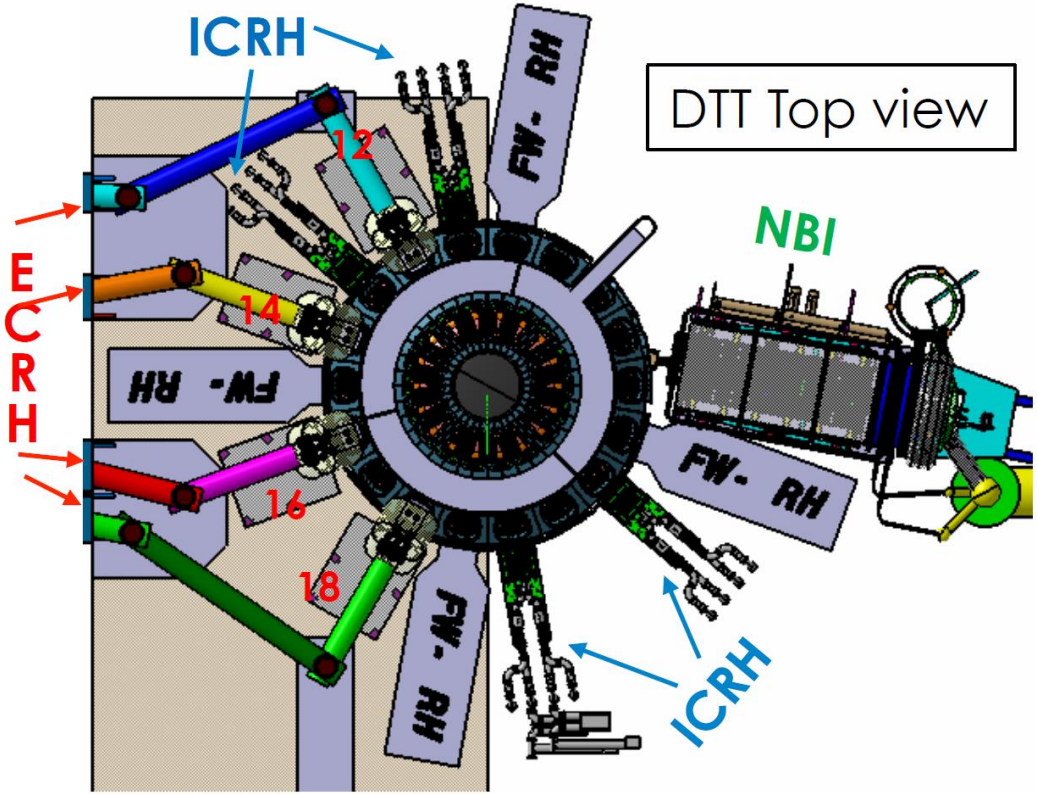
The design of the different systems of DTT has been carried for

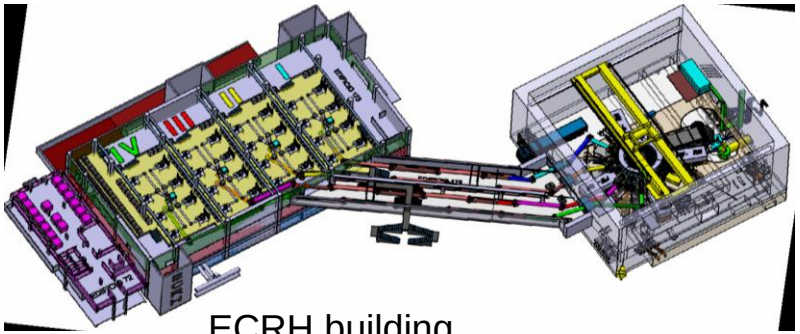
the **largest possible flexibility**





Meaning of additional 45 MW

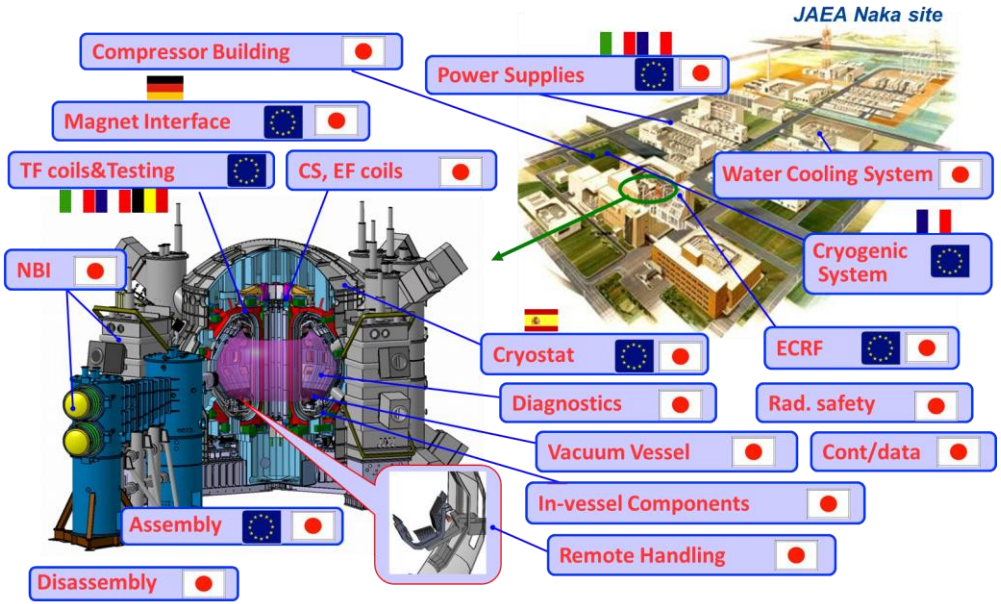




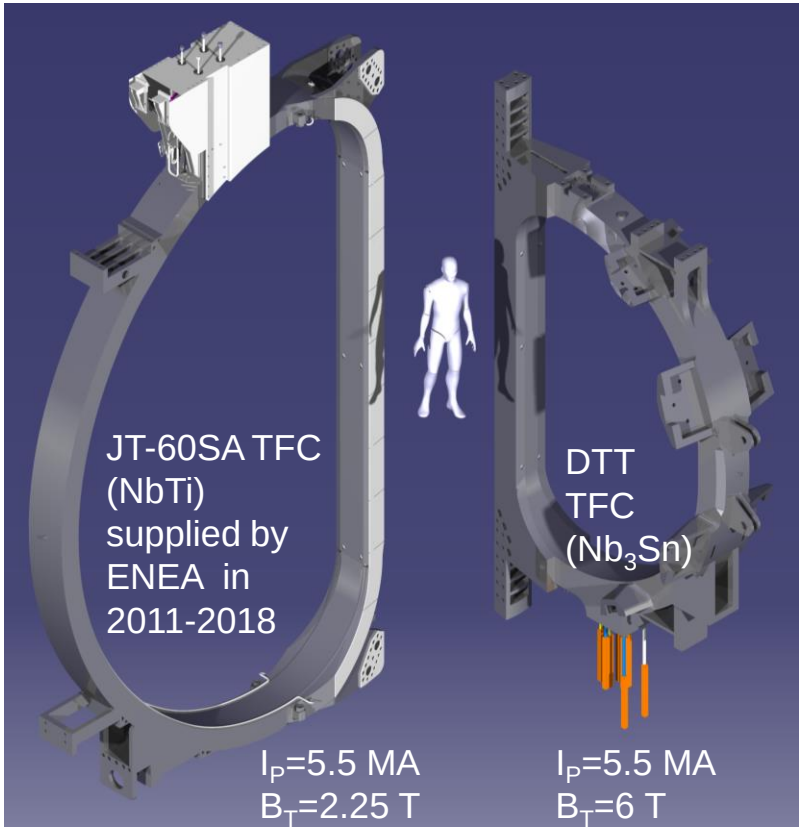
ECRH building

- ECRH: 170 GHz
- ICRH: 60-90 MHz
- N-NBI: 500 keV

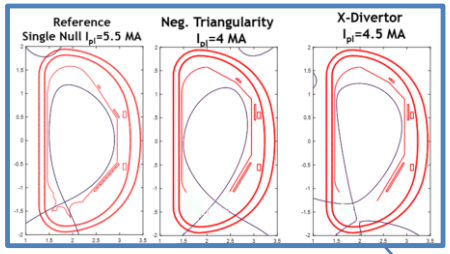
DTT vs. JT-60SA



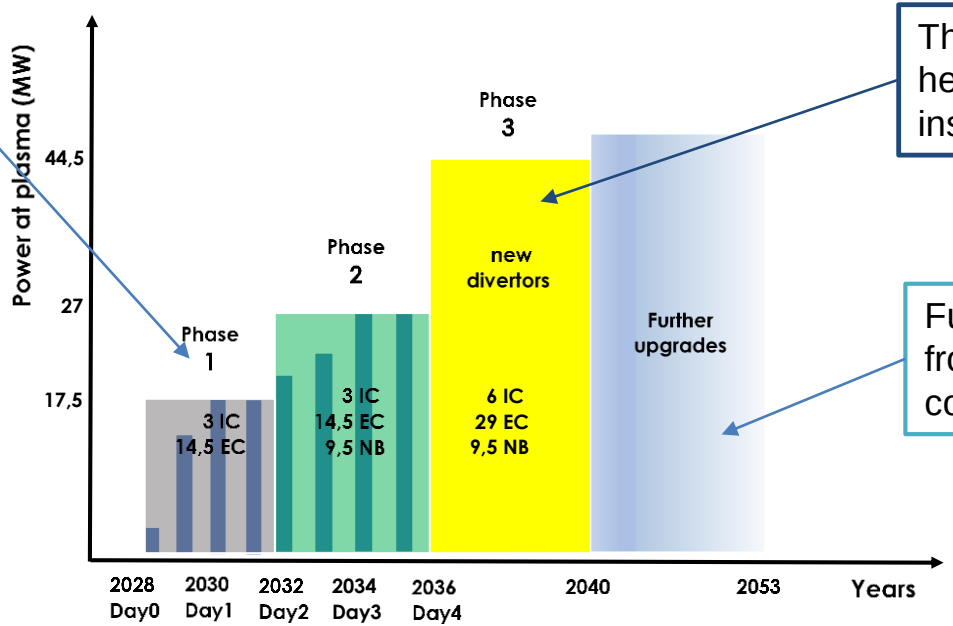
JT-60SA: sharing of contribution



DTT experimental program



In the first phase all the possible plasma scenarios will be tested to identify the most promising following divertors

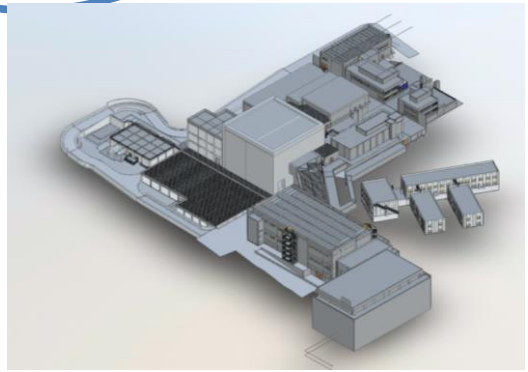


The amount of additional heating power to be installed in three steps

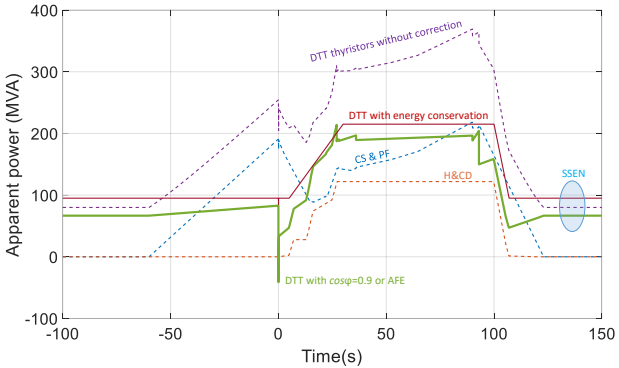
Further upgrades coming from the fusion community

Where: Frascati research center

- About 150.000 m^3 of new buildings
- Refurbishment of more than 10000 m^2 of existing buildings
- “Conferenza dei servizi” for the new buildings successfully completed in November 2021
- TERNA 150-kV line Roma Est – Frascati
- Licensing granted in March 2022 Cat.A ionizing radiation source



Large(st) energy storage installation



- Total Energy Storage for 12 PSs: 600 MW, 3600 MJ, 960 kWh
- Moreover, ENEA has SMESs and flywheels
- Comparison:
  - Korea: 25 MW supercap in several facilities
  - Endesa STORE, Canary Islands, Spain supercap: 4 MW, 20 MJ
  - Terna, Sicilia + Sardegna supercap: 1+1 MW, 1+1 MJ
  - Terna has some battery systems in order of 10 MW
  - DTT could be an “electrostatic lake” (Italy has 4 hydro-storage lakes at 1 GW)

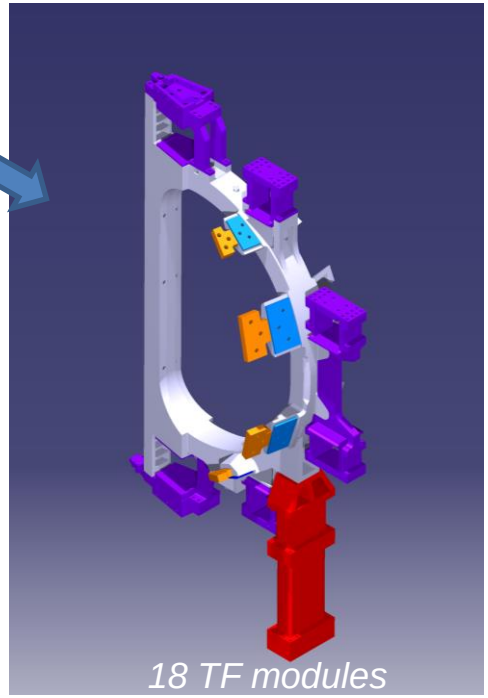
TF coil magnet system: supply chain

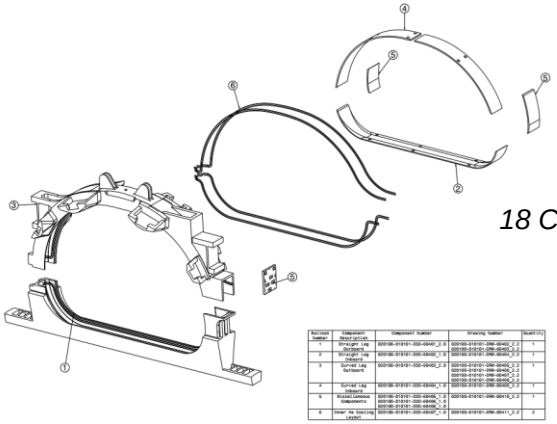
55 tons Nb_3Sn strands

31 tons Cr coated Cu strands

ICAS

20,4 km of conductors



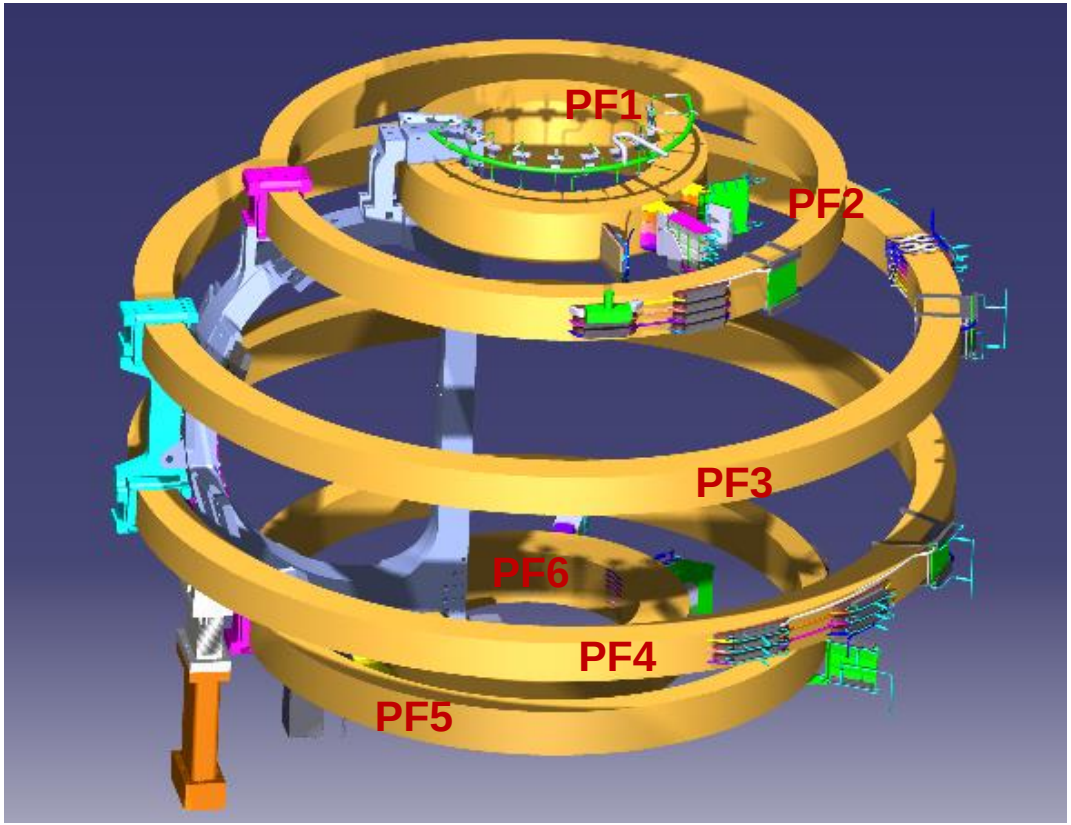


18 Casing components (~360 tons of 316LN material delivered)

SIMIC Spa

ASG SUPERCONDUCTORS

PF system

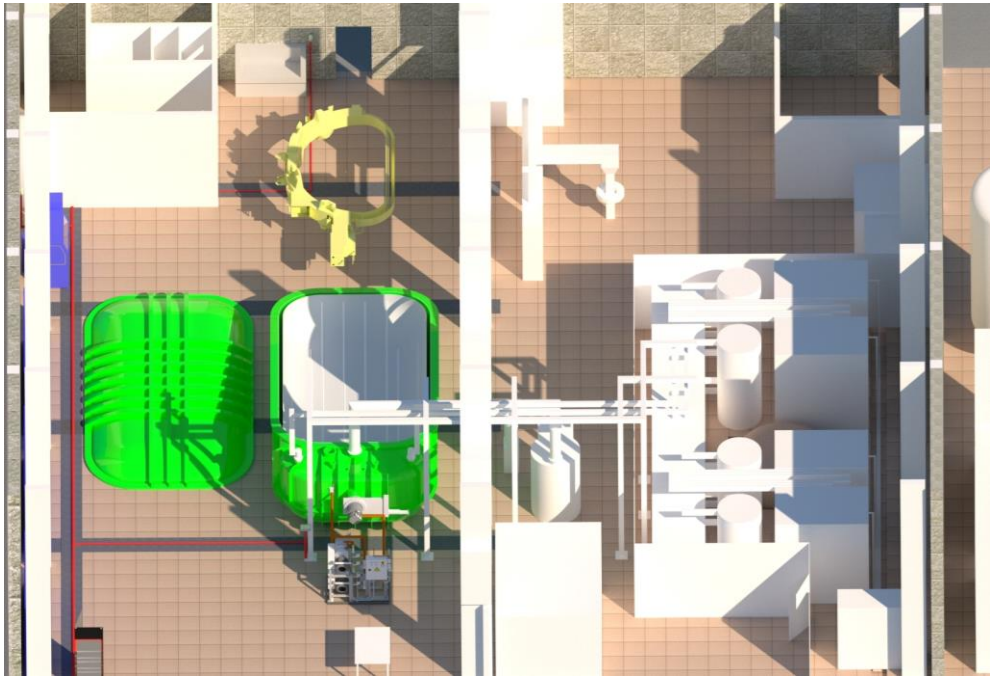


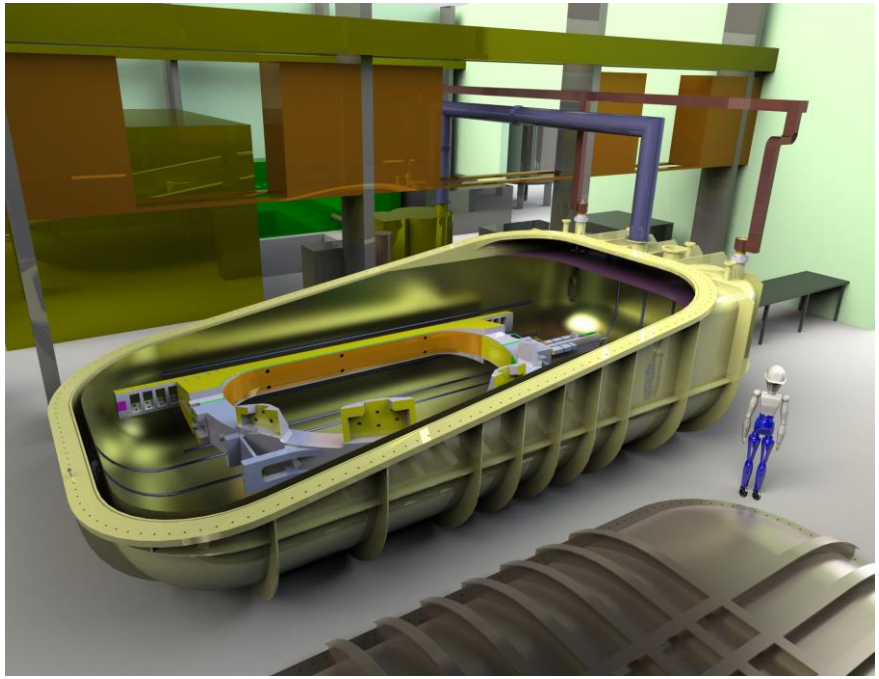
PF1/6 – Nb_3Sn (Luvata):
- Bmax = 9,1 T
- I=10,2 MAt (Nt=360)
- M=15 ton
- D = 3,3 m

PF2/5 – NbTi (Furukawa):
- Bmax = 4,2 T
- I=4,3 MAt (Nt=160)
- M=16 ton

PF3/4 – NbTi (Furukawa):
- Bmax = 5,3 T
- I=5,6 MAt (Nt=196)
- M=28 ton

Coil Cold Test Facility (CTF)

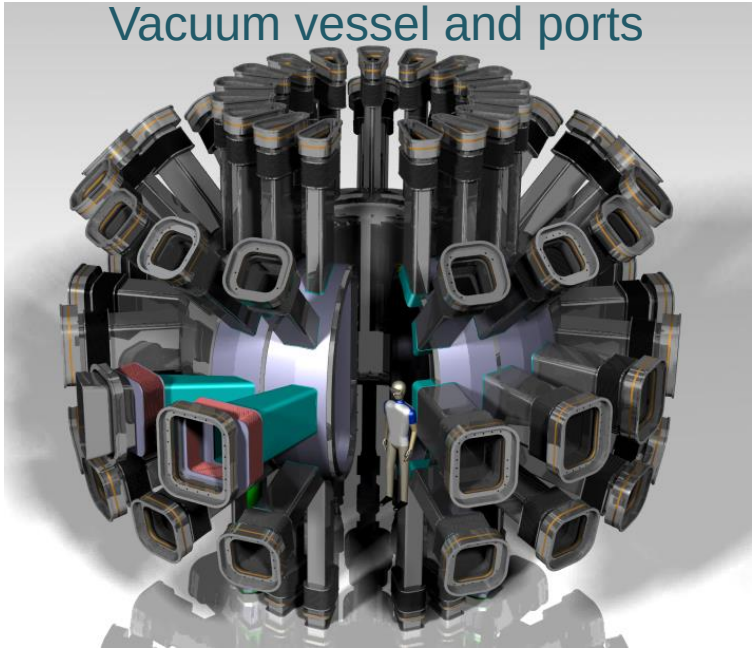




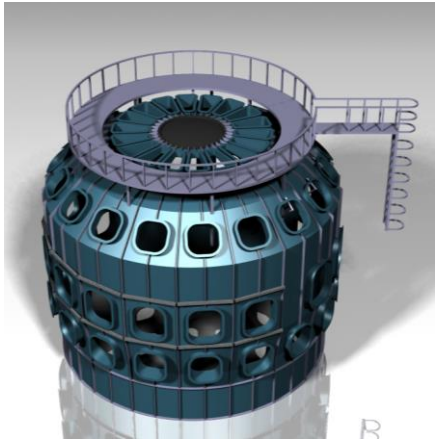
In Frascati, ready in ≈1 year

Mechanical procurements

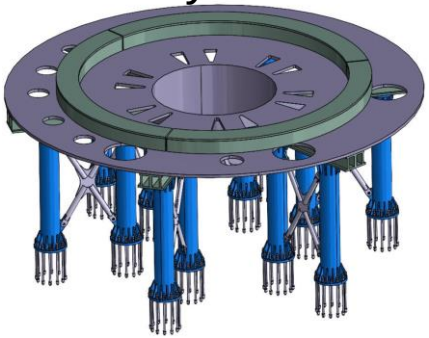
Vacuum vessel and ports



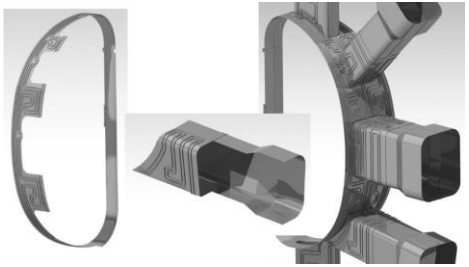
- JT-60SA like double wall 316 lN
- 37 ton (main vessel only, 175 ton all)
- ≈26 M€



Cryostat



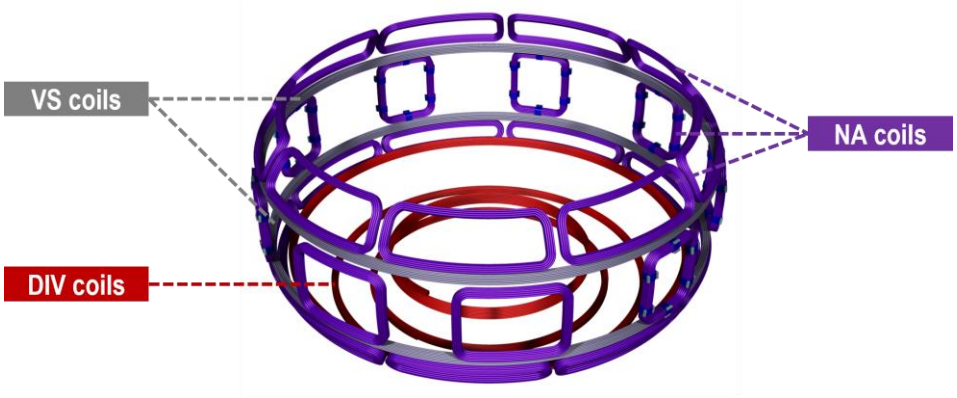
Thermal shield



Vessel Auxiliaries:

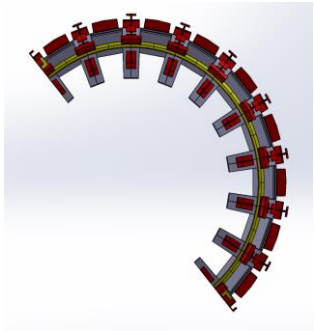
- Pumping
- Fueling
- Cleaning & conditioning

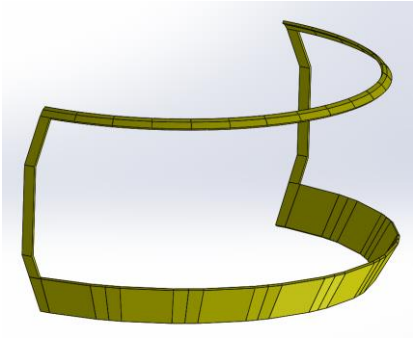
In-Vessel components



In-vessel coils:

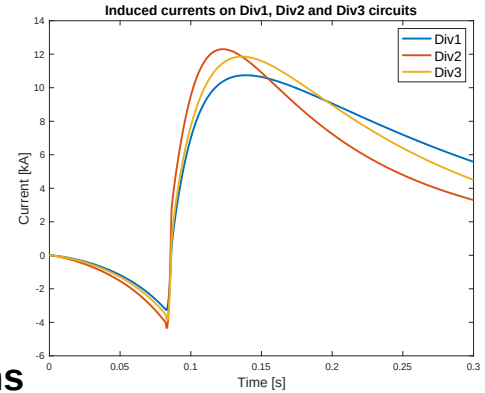
- In DTT, there are 3 types of in-vessel coils:
  1. Vertical Stabilization (VS) coils
  2. Divertor (DIV) coils
  3. Not-Axialsymmetric (NA) coils (saddle)





Stabilization plate:

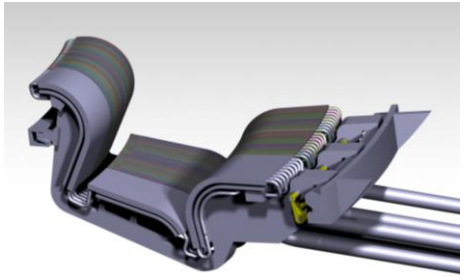
- ASDEX-U like

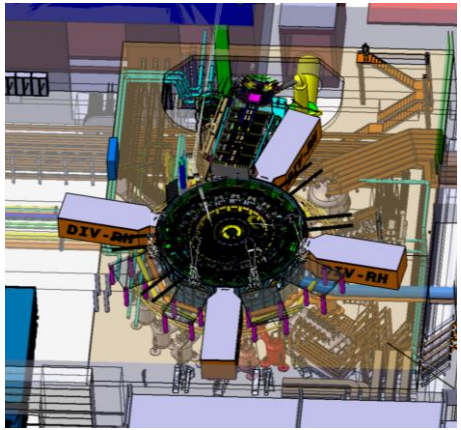


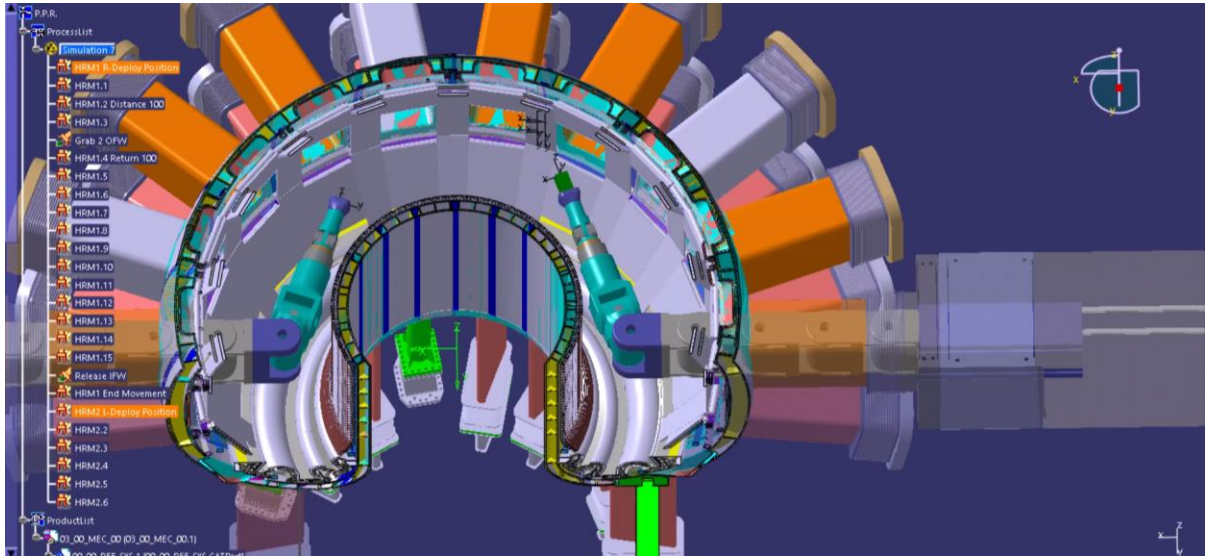
Fault (disruption) problems

Divertor system (and Remote Handling)

Conceptual design jointly with EUROfusion in WPDIV-IDTT



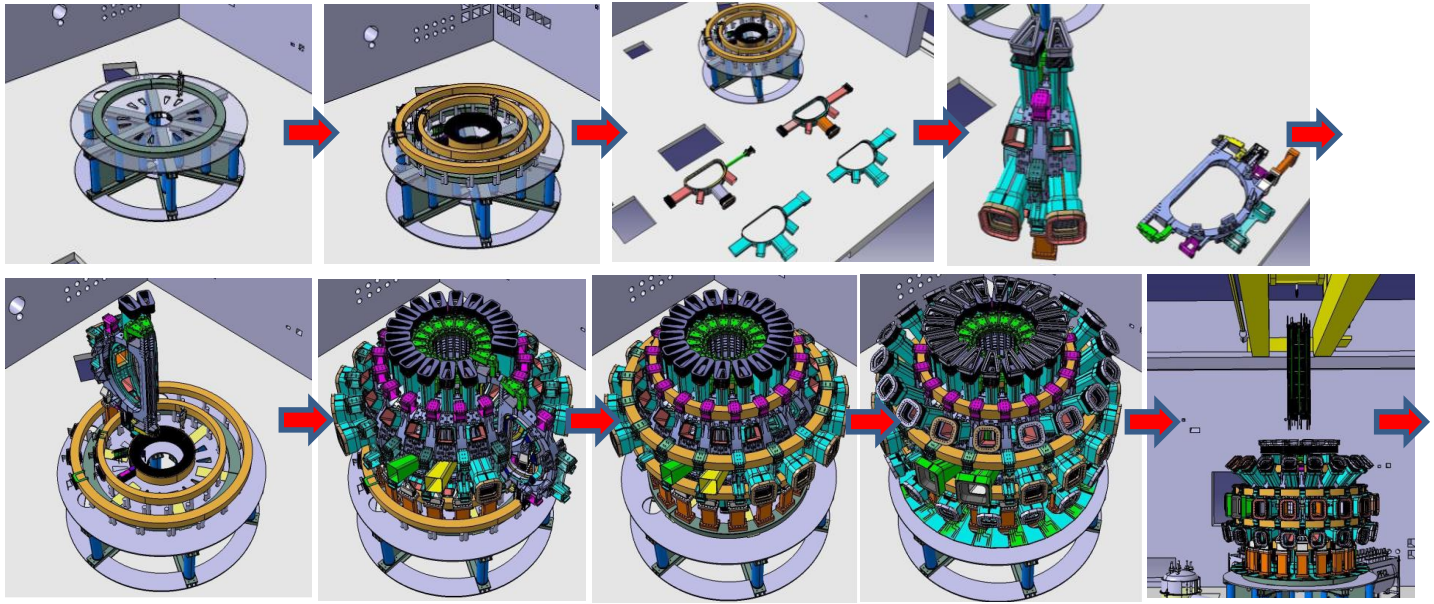




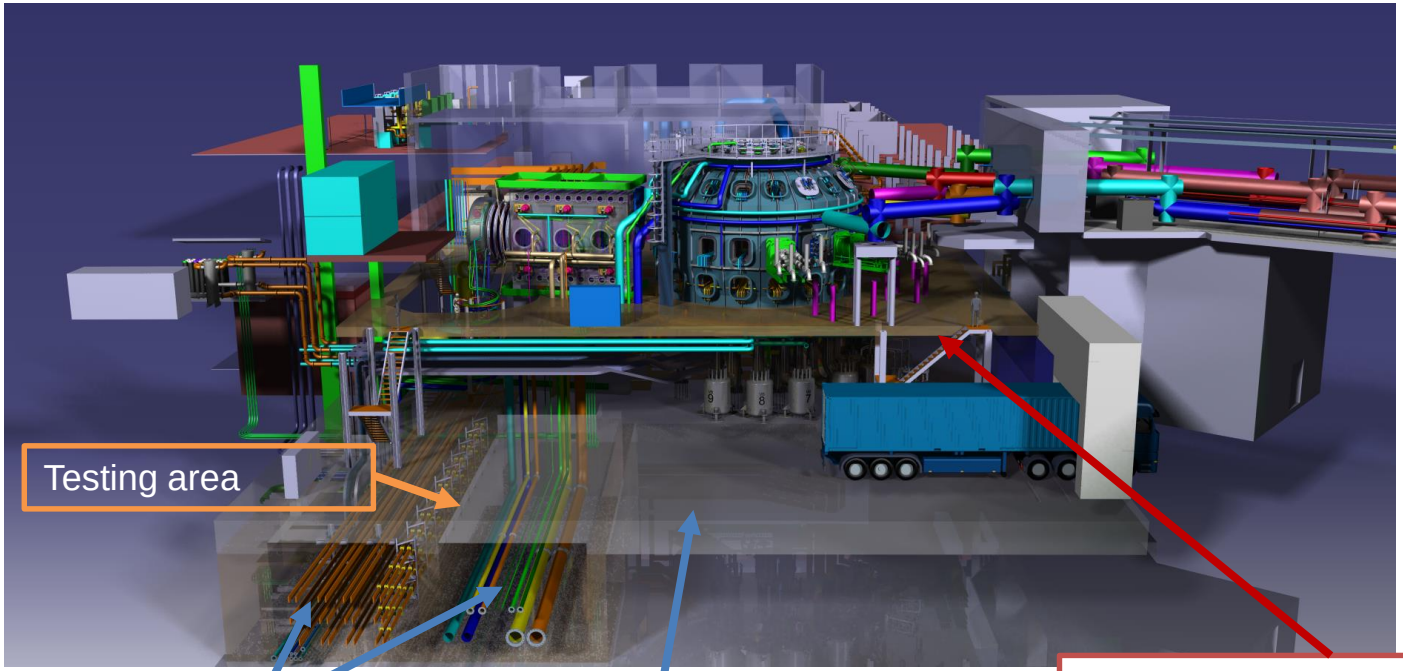
- >20 MW/m^2 steady state
- <400 kg (max allowed weight)
- W monoblocks (ITER-like technology)
- Hot Radial Pressing (HRP)
- Compatibility with SN – XD – NT

- **Procurement strategy**:
- R&D on small mock-up,
- Prototype for manufacturing qualification
- Assembly in vessel

Integration and Assembly procedure



Final Torus Hall



Thank you for your attention!

For more info:

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https://www.dtt-project.it