FUSION FOR ENERGY | Bringing the power of the sun to earth

Fusion for Energy & ITER Powering the Future of Energy in Europe

Benjamin Perier

Head of Market Analysis

F4E @Dutch Fusion Day

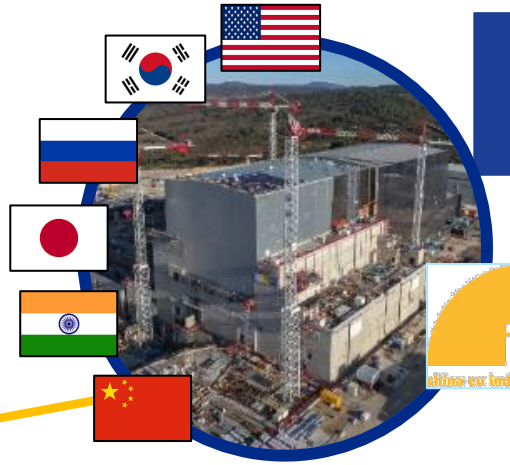
3 May 2024

Four projects on the EU public Fusion Roadmap

FUSION FOR ENERGY

Broader Approach
Three projects with Japan
IFERC\|IFMIF-EVEDA\|JT60SA

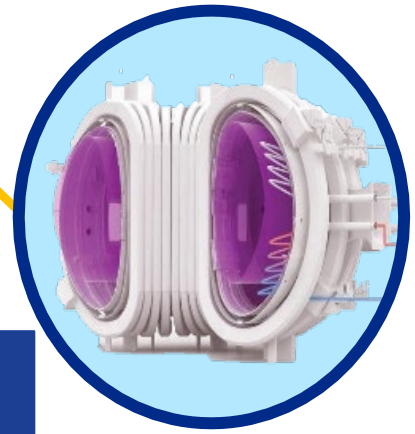
JT60SA, largest tokamak until ITER – starting operations in December 2023



ITER
F4E is responsible of Europe's contribution to ITER as the EU "Domestic Agency"

Short Term → **Medium Term** → **Medium Term+**

IFMIF-DONES
Early phase of design & construction of Demo Orientated NEutron Source



DEMO
Early design studies by EuroFusion DEMOnstration Fusion Reactor
F4E to lead future construction

Fusion for Energy (F4E) key contributor to ITER and the development of EU fusion

- F4E is EU Joint Undertaking based in Barcelona Offices also in Cadarache & Garching (Munich)
- **Staff: ~465 highly competent team of engineers, project managers, supply chain, IP and legal officers**
- **Budget: €5.6 billion 2021-2027**
- F4E Director: Marc Lachaise (since 16 May 2023)
- Main role is to provide the European contribution to ITER as its European “Domestic Agency”, but also involved in other projects to develop fusion
- F4E is a multinational and multicultural organization, keen on the implementation of Diversity & Inclusion and wellbeing policies

Why Fusion? Clean, abundant and safe energy

Abundant

Unlimited fuel, widely available

Stable

Sustainable

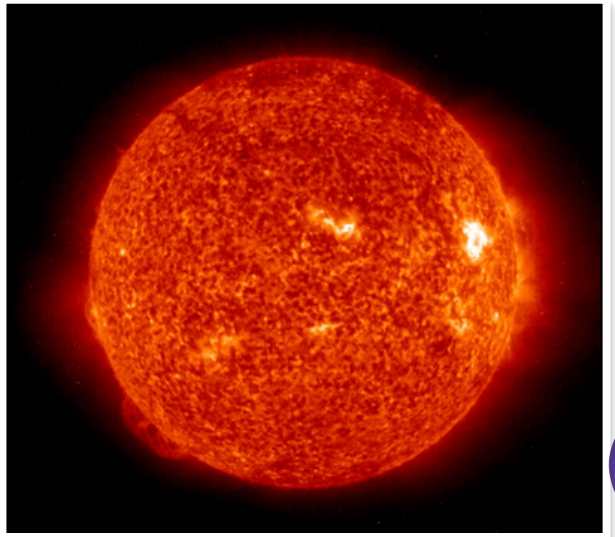
No CO_2 emissions

Safe

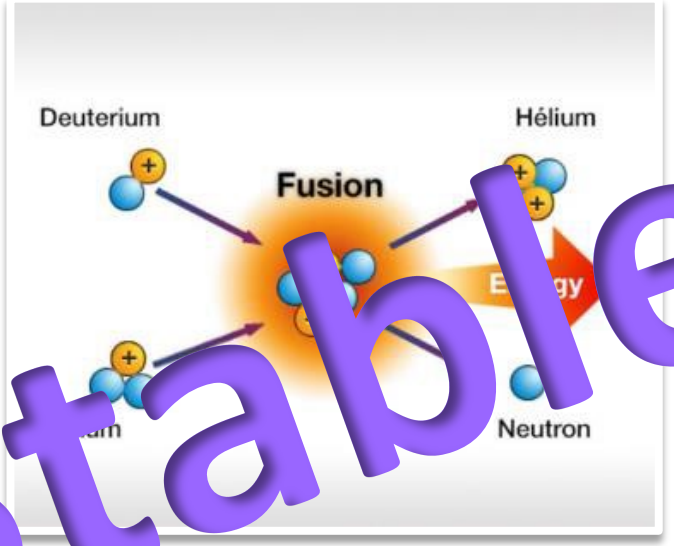
No long-term radioactive waste

Fusion reactors cannot get out of control

Harnessing fusion is a major scientific & technological endeavour

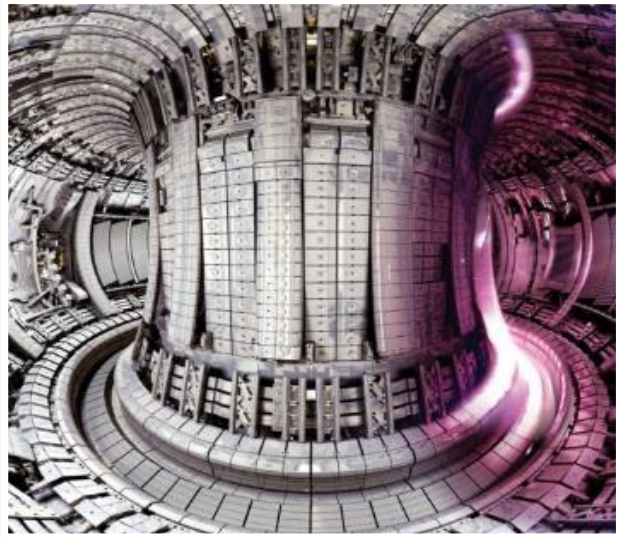


Fusion is process that powers the sun & other stars



Stable

When light atoms fuse at very high temperatures, they release enormous amounts of energy



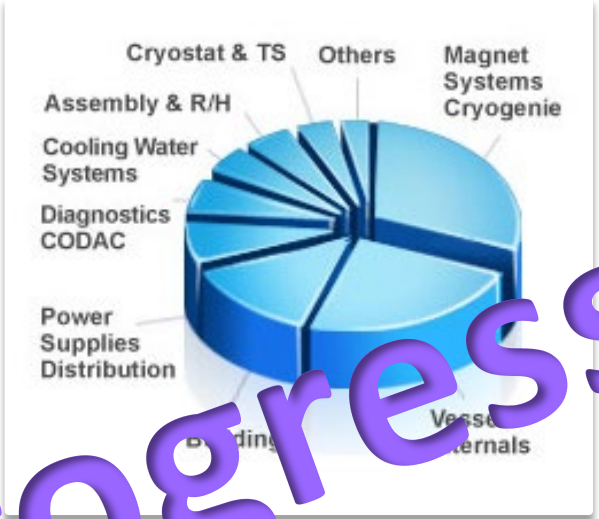
Fusion needs to confine plasma at temperatures of 100-150 million °C

The European Union contributes 45% of ITER

FUSION FOR ENERGY

ITER is an international project with the participation of US, China, Japan, Russia, Korea and India, each with own Domestic Agency

The **7 Domestic Agencies** and Central Team develop and deliver different ITER components



Europe is the **main contributor** and provides about half of the components

F4E works with **EU industry, SMEs and research centers** to design and manufacture components

Progressing

ITER Project – State of Play

ITER Project – State of Play

FUSION FOR ENERGY

PROJECT PROGRESS

Tritium building completed (December 2023)

PROJECT PROGRESS

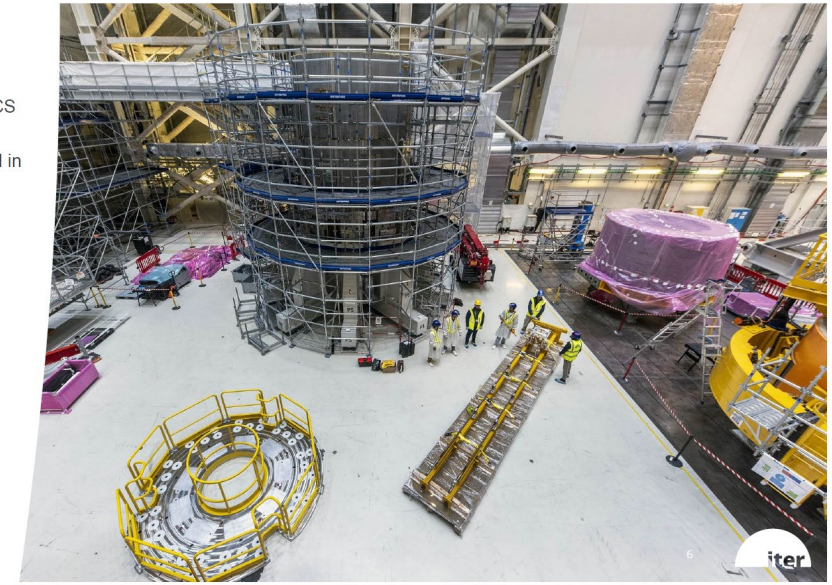
Last TF coil delivered (December 2023)

IO-DA celebration to take place on 15 April.

PROJECT PROGRESS

In process of stacking 3 CS modules (29 Feb 2024)

Fourth CS module arrived in December



EU VV MANUFACTURING

First European vacuum vessel sector passed its leak test (February 2024)

ITER Project – State of Play

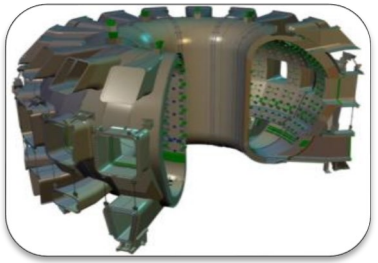
Last PF Coil (PF3) manufactured by Europe has been completed and moved into storage.

The milestone marks the end of a ten-year adventure—from building and equipping the facility, to qualifying the first double pancakes, and finally to the successful fabrication of coils PF2, PF3, PF4 and PF5

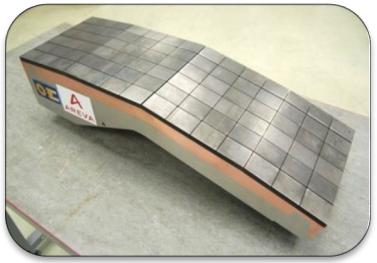
F4E contributes to ITER with a wide range of cutting edge technologies

Site & Buildings

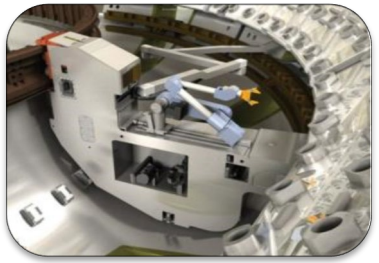
Superconducting Magnets



Vacuum Vessel

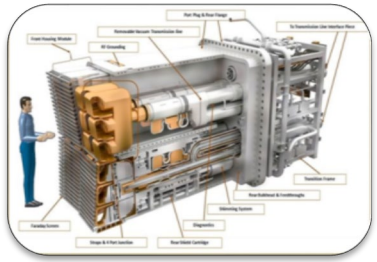


Wall Protection



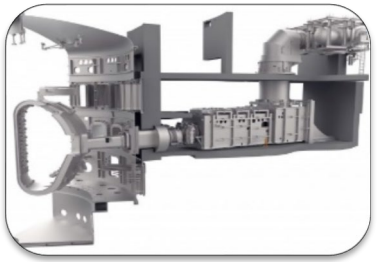
Robotic Remote Handling

Cryoplant & Fuel Systems



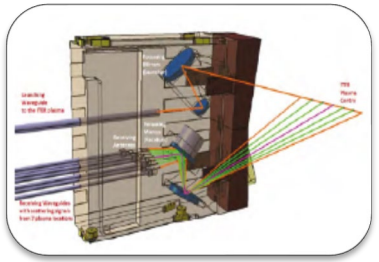
Radio (Ion) Cyclotron Heating

Radio (Electron) Cyclotron Heating

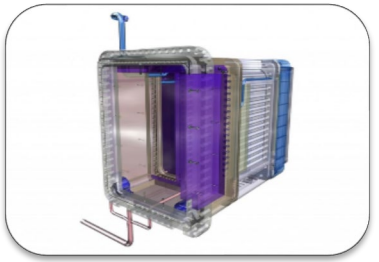


Neutral Beam Injectors

Neutral Beam Heating



Measurement Systems



Fuel Breeding Modules (TBM)

ITER Project – State of Play

The ITER project has been steadily advancing, but faces a critical moment:

- **Some design & quality issues** found - Action Plan to address them is underway
- **Questions by the French Nuclear Safety Authority** related to the machine assembly
- In September 2022 Dr Pietro Barabaschi was appointed as the Director General (DG) of the ITER Organization with strong reform mandate
- ITER DG will propose **a revised timeline, accompanying milestones and financial estimates for the project in 2024**

Goals of the New Baseline *(courtesy iter)*

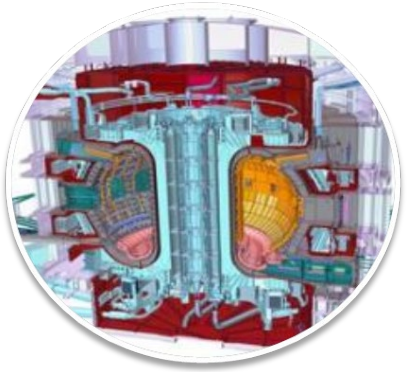
- Start of Nucl. Operations asap, w.o increased technical risk or change in project goals
- Enforce LL from project successes, and address root causes of setbacks
- Restore regulator confidence in ITER
- Take advantage of the delayed assembly sequence to install key components (divertor)
- Take advantage of the completed cryogenics plant to test TF and PF Coils in full parameters (4K)
- Allow fastest Cryostat Closure (2.5 years vs. 11)
- Account for (and leverage) the parallel surge in private sector fusion initiatives, inspired in part by ITER's manufacturing success.

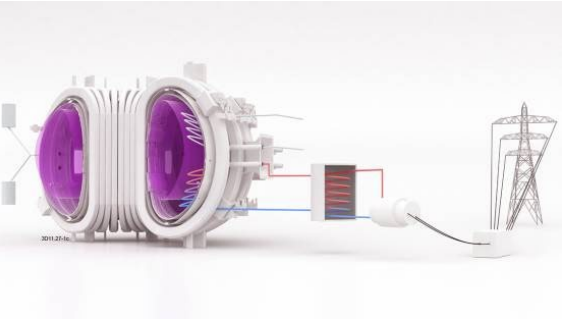
Industry is our fuel… and one of our delivery

Contract
ITER / F4E

FUSION FOR ENERGY | MARKET INTELLIGENCE PLATFORM

Contract
F4E / Industry



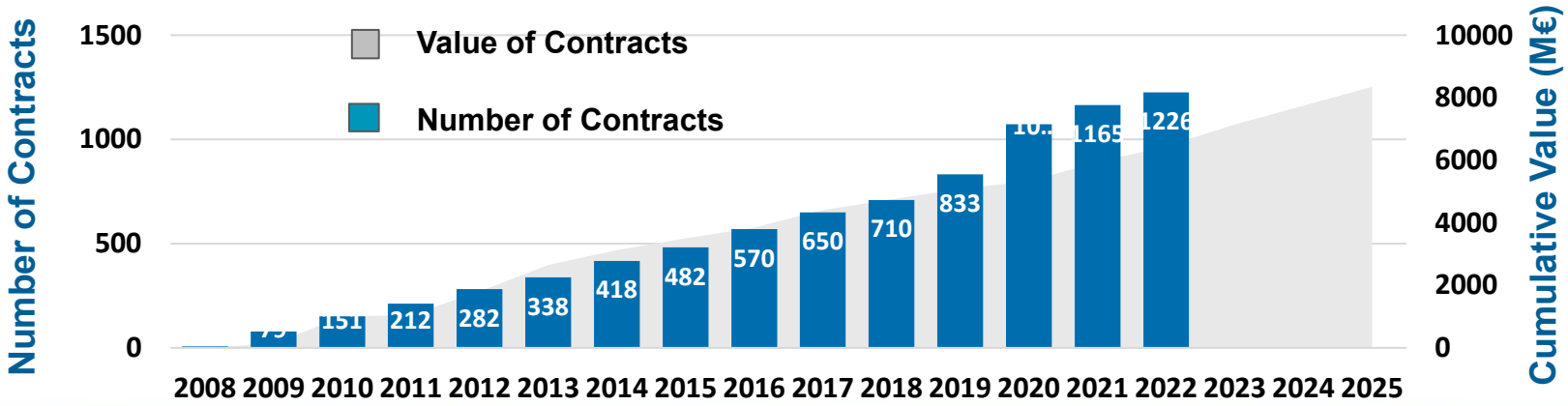


F4E
SUPPLY CHAIN
Fusion industry
Market Intelligence Group

Contracts placed with industry & research labs in Europe

- 1300+ contracts placed
- € 6,7 billion value
- 700+ industrial companies
- 2100+ subcontractors.
- 75 laboratories

F4E Supply Chain example
F4E Supply Chain example 2
F4E TechnoTransfer Marketplace



Fusion benefits European economy

Value of contracts signed since 2007 is more than € 6 billion, involving more than 700 companies and research centres

High-Tech Jobs

Approx. 34,000 job years created 2008-2017

(83,000 more by 2030)

Industrial expertise

Over 700 companies, over 2100 subcontractors in 24 countries

Economic growth

Investment in fusion brings a net economic benefit of 5-6%

Innovation

400+ new technologies, tools and processes

20+ spin-offs, start-ups, joint-ventures

Competitiveness

Companies are expanding into new markets from ITER work

Fusion benefits European economy

Competitiveness

Companies are expanding into new markets from ITER work

400+ new technologies, tools and processes, and around 40 spin-offs, start-ups, and JV

Flexible IP policy fostering the use of technologies by industry.

Specific F4E Technology Transfer Programme to identify the business potential of technologies developed and facilitate their commercial use. F4E offer free technology brokerage services to industry to help them find a partner and innovate.

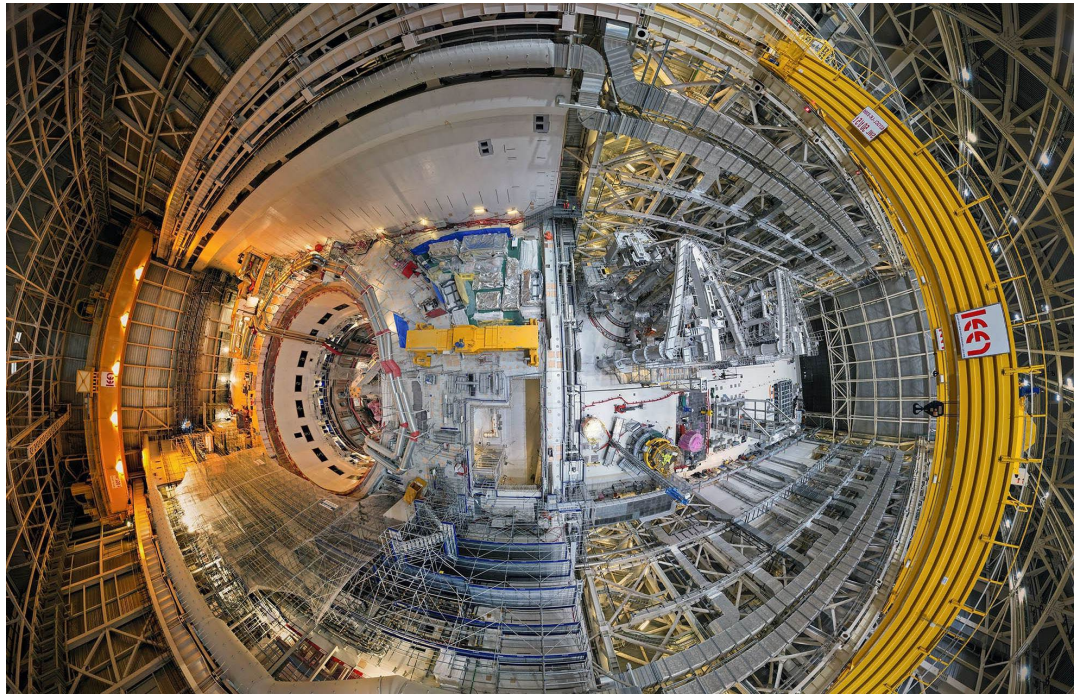
Fusion Technology Transfer Marketplace showcasing 37 technologies ready to be marketed benefitting the companies that have developed them(now joint with EUROfusion).

We provide an annual **"Technology Transfer award"** (10k€) to projects that have succeeded or plan to use their fusion technologies in a non-fusion environment.

Annual **Demonstrator call** (50k€) to offer financial support to integrate fusion solutions in non-fusion applications latest one was published 18 April 2024.

Public Fusion vs. Private Fusion *(courtesy iter)*

- Same goal - *bringing fusion to reality, for a clean energy future (for an EU leadership?)*
- Different preferred methods - *diversity of approaches and concepts is good!*
- Different estimates of the timeline to make fusion energy happen - *we all would like to go faster* ☺
  see also case study from N.J. Lopes Cardozo..
- Agree on some remaining technological hurdles to be overcome - *better materials resilient to extreme conditions, efficient tritium breeding, effective heat removal*



- Way forward - *Break down our silos of info, understand who is doing what, share experience and LL, and bring fusion to reality in the shortest horizon possible?*

Public vs. Private

PUBLIC-PRIVATE WORKSHOP

27-29 May 2024, @ ITER site

Private fusion presentations:
What innovations and breakthroughs have you achieved?
What are the remaining hurdles to bring your fusion approach to reality?
How can ITER help?

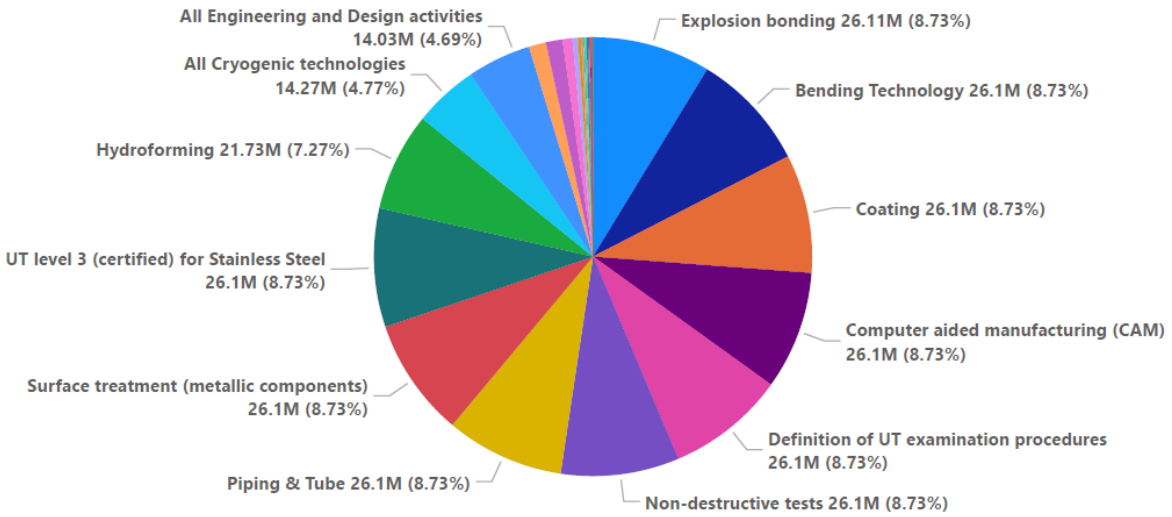
Poster sessions with discussion
ITER site tours: general and specialized
ITER experts open doors for discussion

ITER Goal: to establish priorities and formulate plans for how to engage with private sector fusion companies going forward

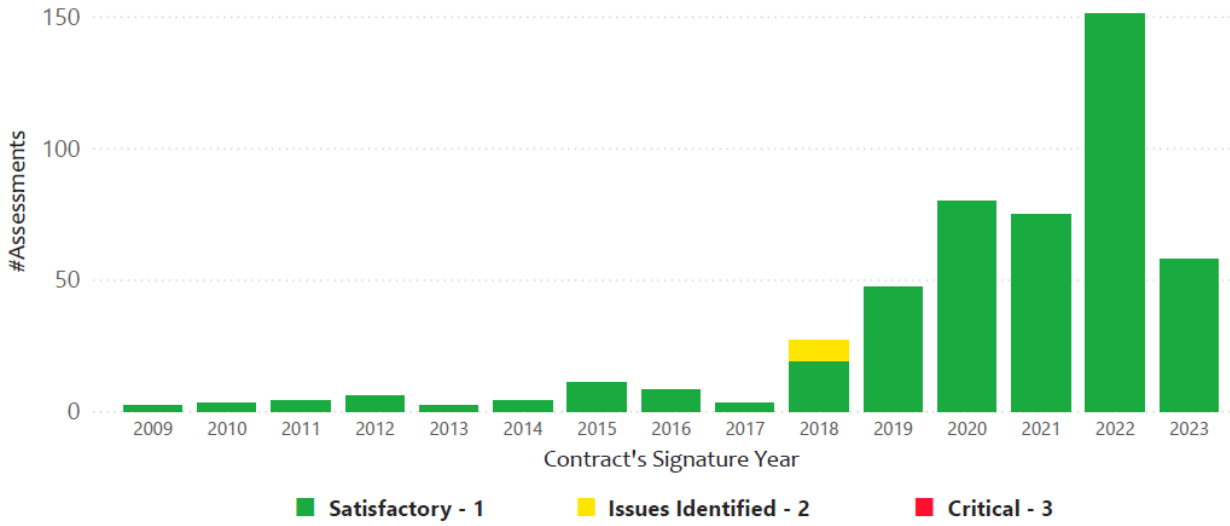
Main Technologies Netherlands

Total Committment
101.88M

The total Contract Value is assigned to all the technologies labeling companies participating in the contract, including sub-contractors

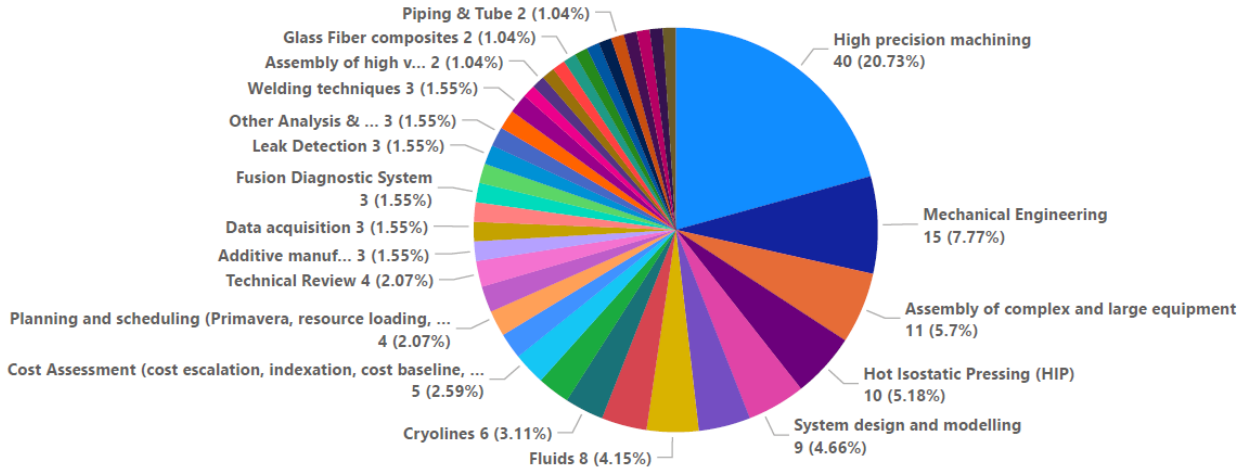


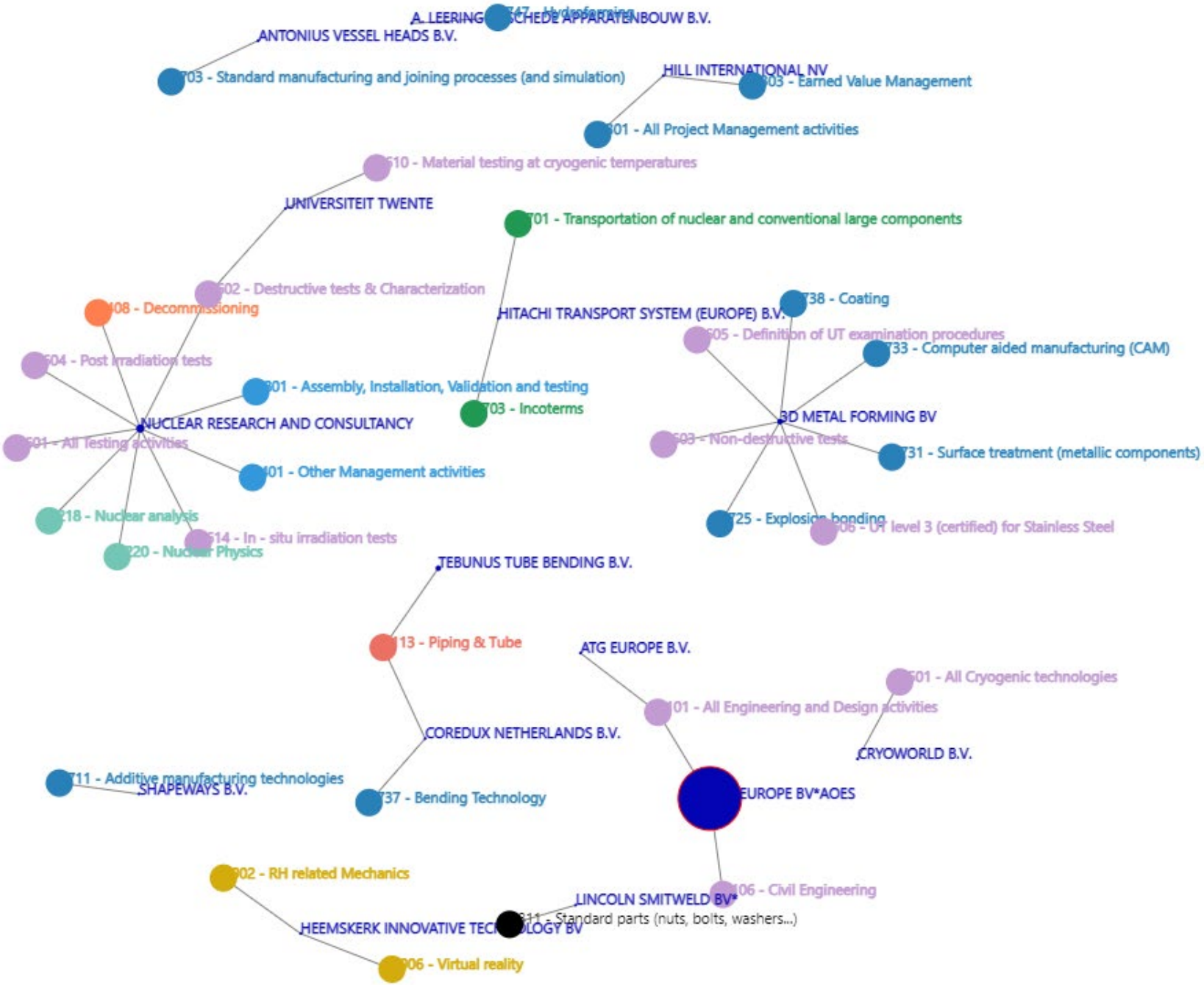
Contractors' Assessment: Netherlands



Main Technologies by Participation to Pre-Procurement Activities

Netherlands





NL Supply Chain mapping

ITER Upcoming opportunities

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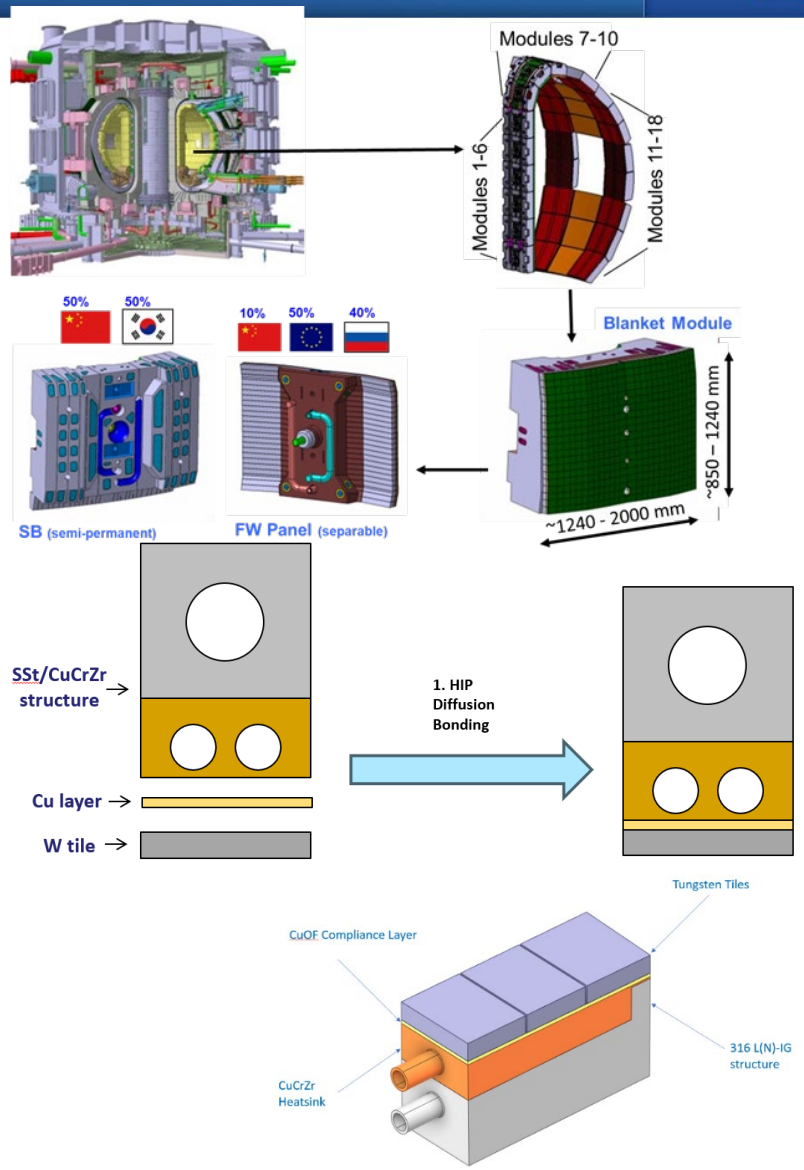
Tungsten Tiles

- W tiles supply, machining, Joining, and assembly.
- About 600 m^2=> 200-500 k pcs.
- Market Survey ongoing. See F4E Industry Portal.
- CFT in Q3 2024.
- Contract signature: Q3 2025.



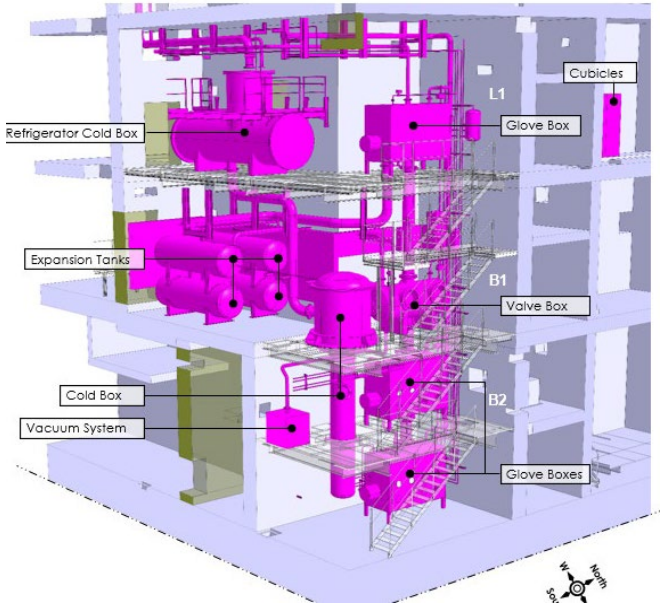
ITER Cryoplant & Fuel cycle

Tritium => Stainless Steel components

•Isotope Separation System

Cryogenic distillation of >650 thermal shield panels

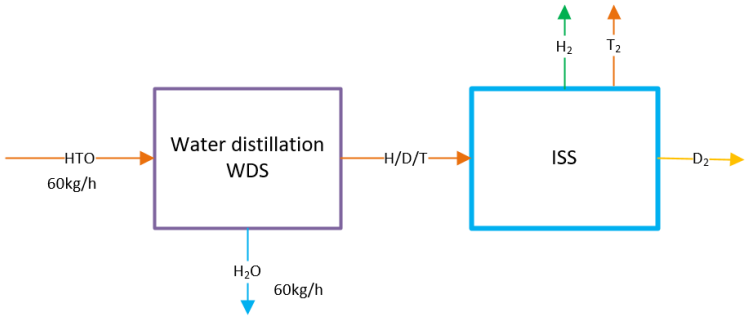
- Cold boxes, Gas Handling System, Tanks, Valve Box, helium refrigerator components, Glove box, Heat exchanger, Metal Bellows pumps, cryogenic lines, etc…



•Water Detritiation System

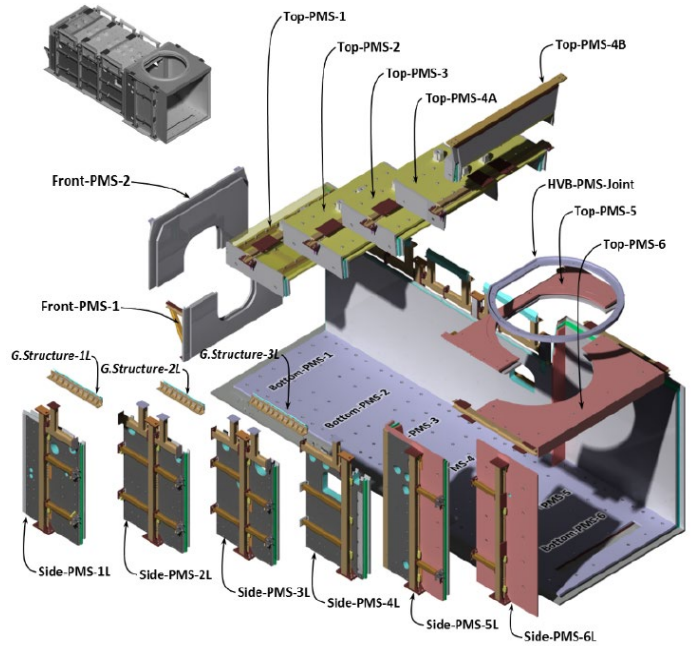
Water Distillation columns, or Combined Electrolysis Catalytic Exchange solutions.

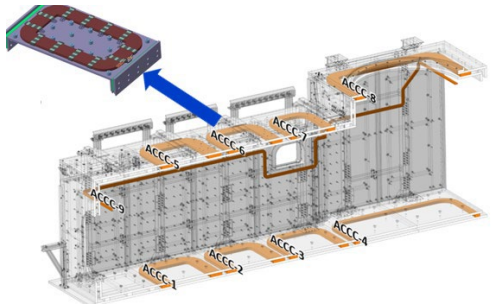
Ask F4E for Technical Description. Market Surveys ongoing.



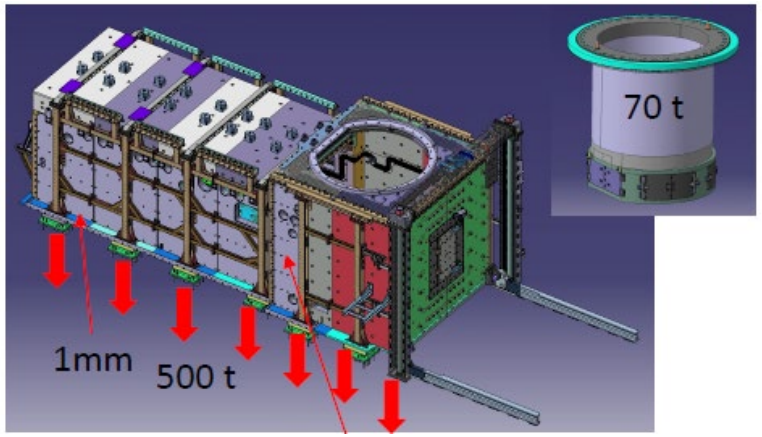
- **Neutral Beam Magnetic Shielding** (NBMS) 2 units
  - Active Compensation Correction Coils (ACCC): 2 x 8 units.
  - Passive Shielding with plates (see next slide)
  - Skills: Machining and precise Assembly (1mm gaps/0.1 mm tolerances) of heavy components (500t) nuclear classified (RCC-MR) + coil design and manufacturing).
  - Market Survey ongoing

=> Target CFT: Q3 2024. Market Survey online.



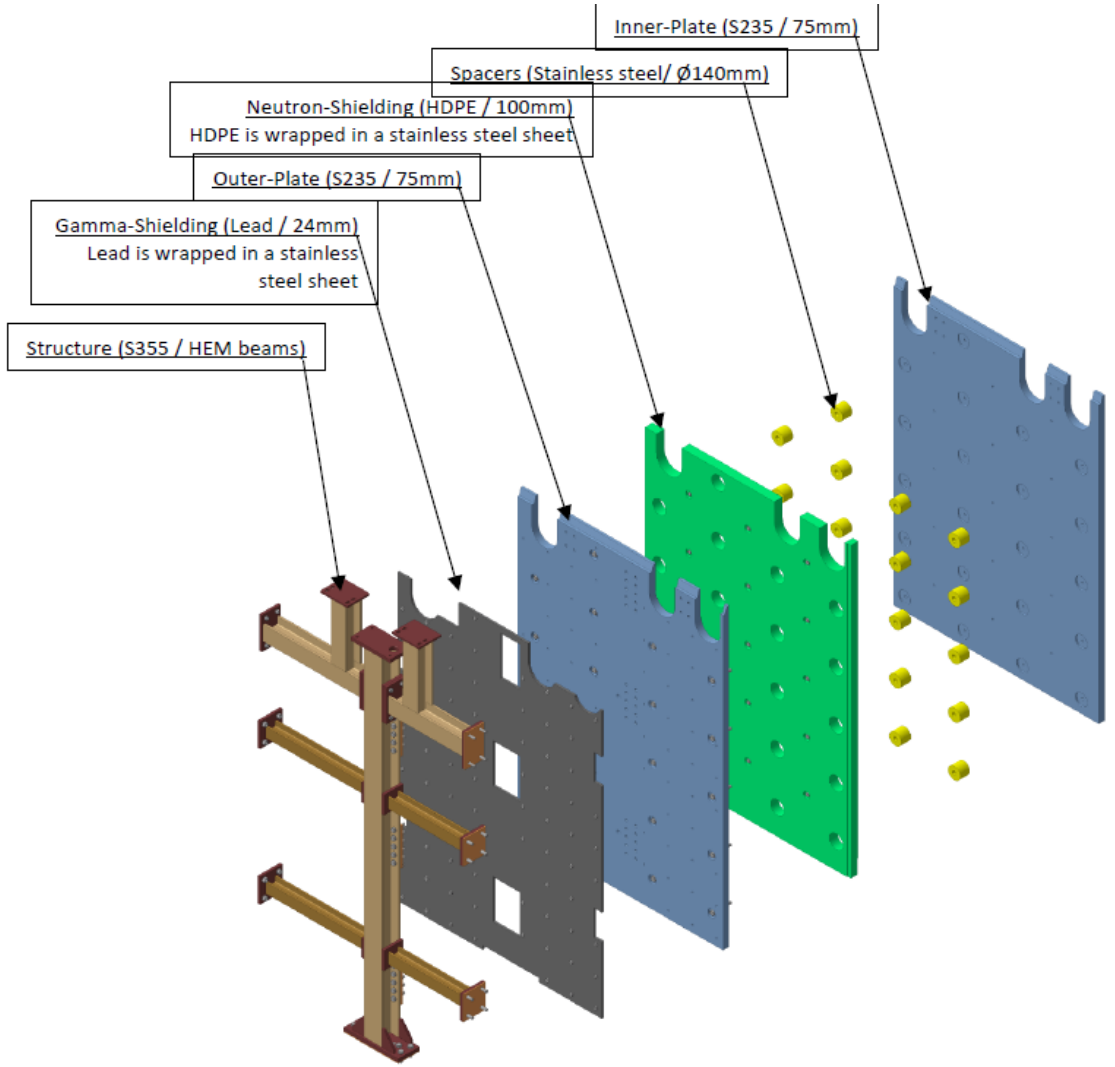


Active Compensation Correction Coils (ACCC)

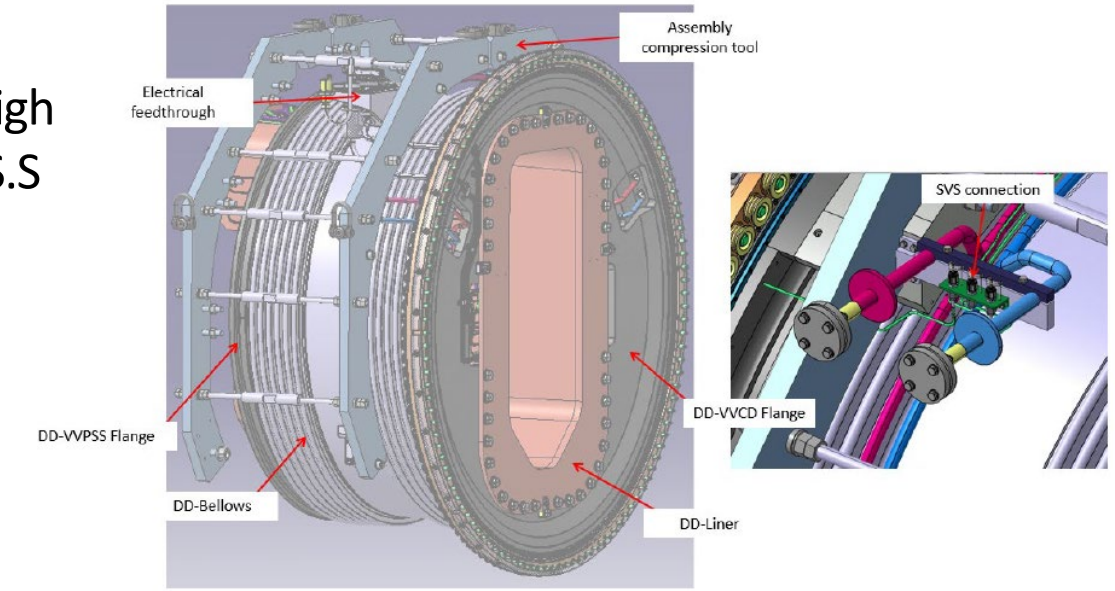


FUSION FOR ENERGY

- **NBMS- FOCUS on Materials**
  - **Steel S235** plates (EN 10025-2) (2 x 400 tons): 1 or 2 additional sample(s) still welcome nowadays for characterization.
  - **LEAD** plates
  - **HDPE** plates
  - **Inconel** or special **316L Stainless Steel** BOLTS (High content in molybdenum)

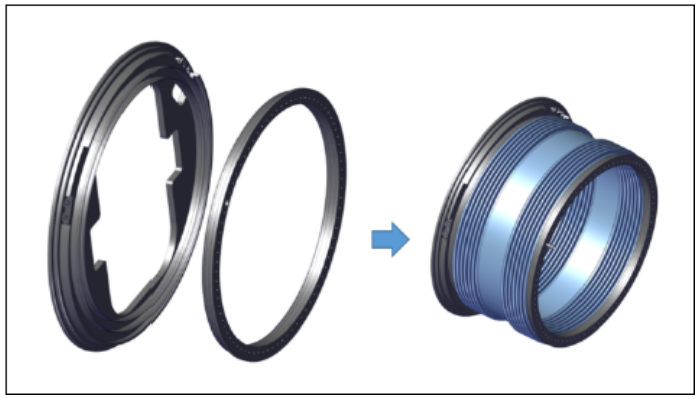


- Drift Duct. (2 units)
  - Skills: Nuclear component manufacturing, High Vacuum, Stainless Steel welding, Brazing of S.S pipes over the CuCrZr plates, NDTs, EBW of CuCrZr.
  - S. Steel SIC-1 Bellows and flanges.



L1.4 m x W3.2 x H3 m -Weight ~ 5.7 t

=> LAUNCHED



View of the flanges

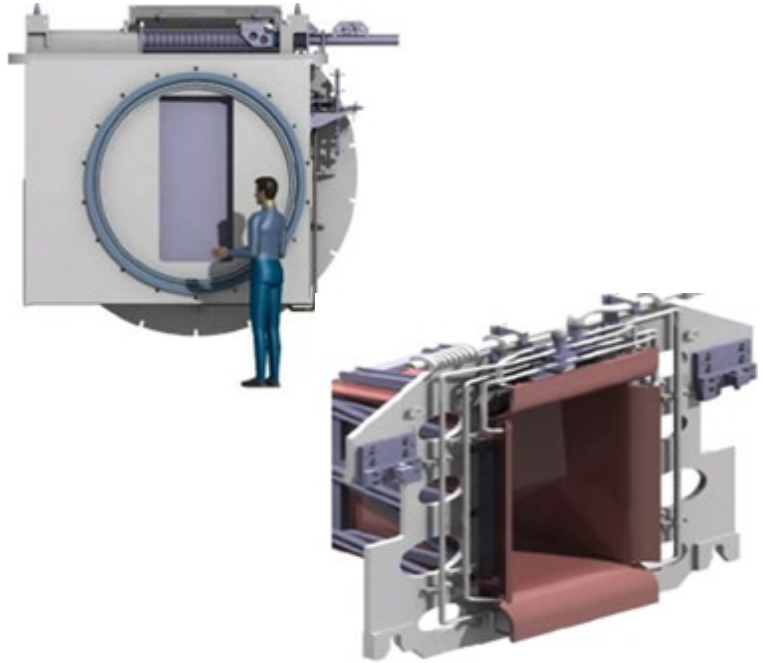
ITER Heating and Current Drive

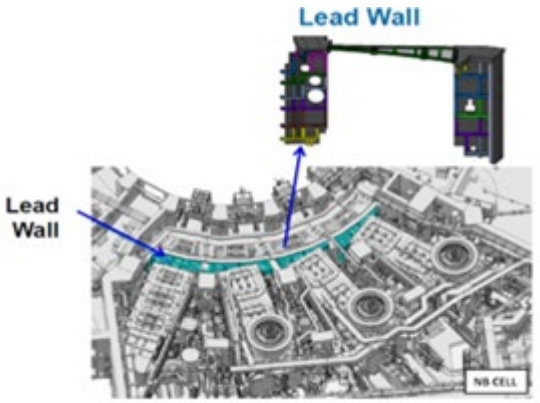
Longer-term (up from 2026):

- **2 Fast Shutters** (extension of the primary vacuum barrier, Nuclear Safety Relevant)

- **2 Exit Scrapers** (High Vacuum, non-safety relevant): Stainless Steel support + Deep drilled water cooled Panels in CuCrZr, Electron Beam Welding (vacuum tight) of CuCrZr.

- **2 Lead Walls** (Gamma protection): Panels of lead and Steel structure.





ITER Diagnostics

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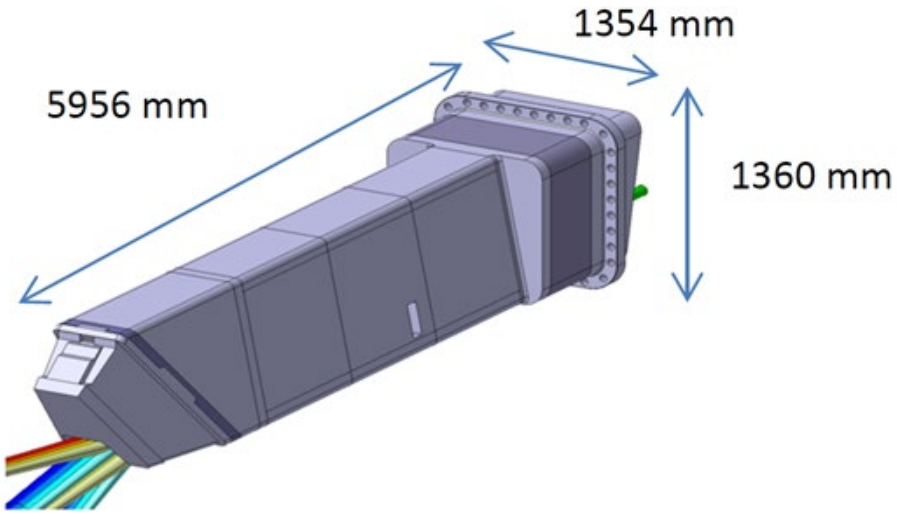
- 6 Diag **PORTS Manufacturing and Assembly**.
- Target => CFT: Q3 2024.
- **316L(N)-IG) Austenitic stainless steel** "X2CrNiMo17-12-2 controlled nitrogen" with a concentration of Cobalt, Niobium and Tantalum not exceeding 0.05%, 0.01% and 0.01% weight respectively
- **Polybore** HE 430, as neutron shielding blankets for ISS (TBC).
- **B_4C pellets:** sintered B_4C pellets used to fill the DSMs B_4C Shielding Chambers, as neutron shielding (about 15 tons).
- **Commercial Off-The-Shelf (COTS) items:** bogie wheels, fasteners, flexible metal seals, piping fittings, connectors, etc.
- **Glass To Metal Process** with 99% purity N_2 atmosphere.
- **Feedthroughs** etc. + **TESTING FACILTY**



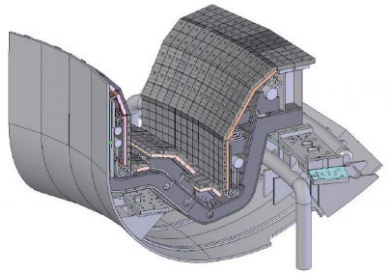
Upper Port Plug general dimensions

Technical Support

- **CAD Design, Dimensional Variation Analysis, General Mechanical and Plant Design** Support: (including scope OMF-1058) LAUNCHED
- **Qualification testing:** Target CFT: Q1 2024.
- **Seismic, Dynamic and Structural** Analyses of ITER Buildings and Mechanical Components Support. (renewal of OMF-1023) Target CFT: Q1 2024.
- **Nuclear Analysis Support** (renewal of OMF-0882): CFT: Q1 2024.
- **Destructive and ND Testing of Material and Mock-ups:** (renewal of OMF-1082). Target CFT: Q2 2024.
- **I&C** Integration Services (renewal of OMF-0989). Target CFT Q2 2024.

Broader Approach

•**OPE-1405: Integration and testing of Actively Cooled Divertors of JT-60SA**, estimated contract value: C D, Annex B under preparation, planned launch Q1/Q2 2024 (Competitive with Negotiation).



Source: JT60SA.org

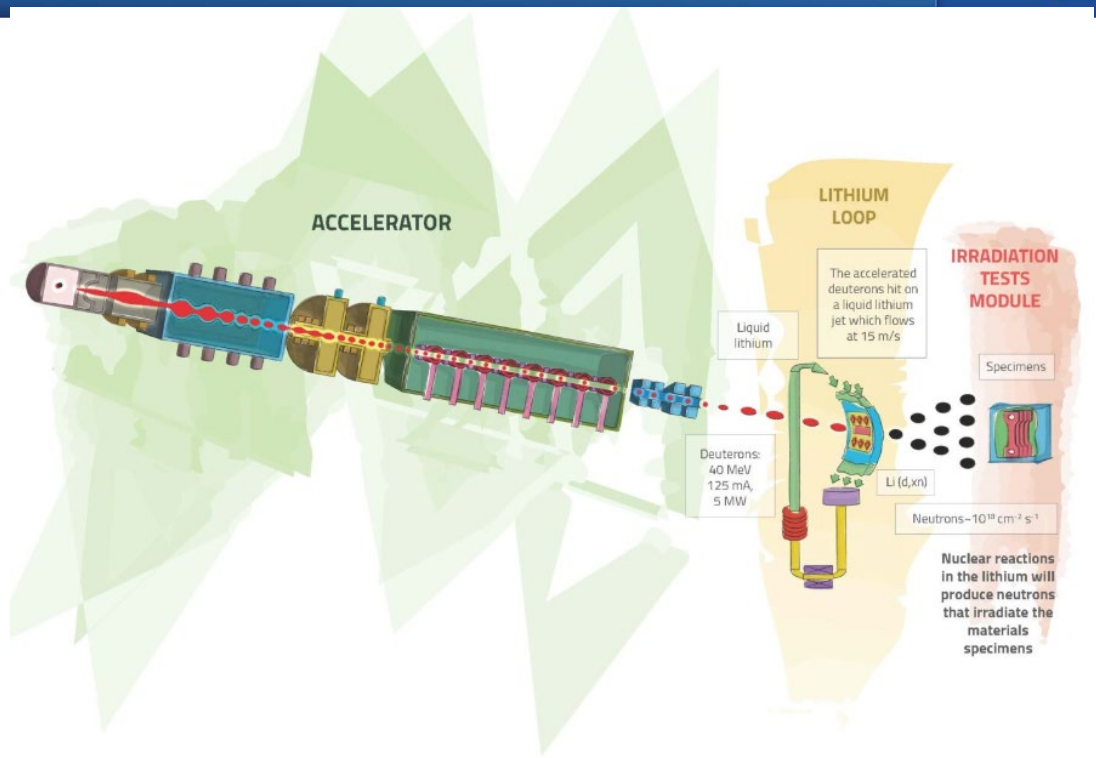
•**OPE-1407: LIPAc Injector Upgrade,** estimated contract value A, Q1/Q2 2024 (Competitive with Negotiation).

Source: IFMIF-DONES.es

•**OPE-1XXX: JT60SA Pellet Injectors (re-issue):** Pre-information notice will be done with overview of technical scope and commercial way forward + dissemination to target companies and ILO network**.** Value A, planned Q1 2024.

DONES (Granada, Spain)

DONES Program: see https://ifmif-dones.es/es/ (Irradiation facility for the development of fusion-like neutron effects database).

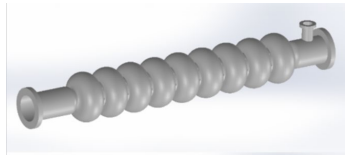


- **Superconducting Radio Frequency Power Coupler.**

- **Design and Supply of a superconductive Cavity.**

IFMIF-DONES – Functioning Scheme

Source: CERN



Source: Wikipedia

The ITER Project – A Global Effort

F4E and EU Industry – A Symbiotic Relationship

•Importance of EU industry in advancing fusion technology

•How F4E collaborates with EU industry for research and development

Slide 10: What F4E Needs from EU Industry

•Overview of the support and collaboration needed from EU industry

•Examples of areas where industry expertise and innovation are crucial

Slide 11: Benefits for EU Industry

•Opportunities for EU industry in the fusion energy sector

•Potential economic and technological benefits

Slide 12: Conclusion

•Recap of F4E's role in advancing fusion energy in Europe

•Call to action for collaboration between F4E, ITER, and EU industry

Slide 13: Q&A

•Open floor for questions and discussions

Slide 14: Thank You

•Express gratitude for the audience's attention

•Provide contact information for further inquiries

Feel free to adapt this plan to better suit your presentation style and audience!

Thank you

https://industryportal.f4e.europa.eu/

https://techtransfer.f4e.europa.eu/