



**FUSION
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ENERGY**

Big Science
Business
Forum
2022

Heating and Current Drive procurement status and opportunities for mechanical and electromechanical components

.....
Francesco Paolucci
.....

5 October 2022



Bringing
the power
of the sun
to earth

Overview of the Neutral Beam and Electron Cyclotron heating systems

- Heating and Current Drive system
- H&CD – Overall status

Status of the NB system development

- Neutral Beam test facility
- MITICA – Status of core components
- Our industrial partners so far

Business opportunities

- Magnetic Shielding
- Drift Duct
- Absolute Valve (AV) & Fast Shutter (FS)
- Long term – Other components
- Summary
- Other business opportunities for EC
- Other business opportunities for NB



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Heating and Current Drive system (1/2)

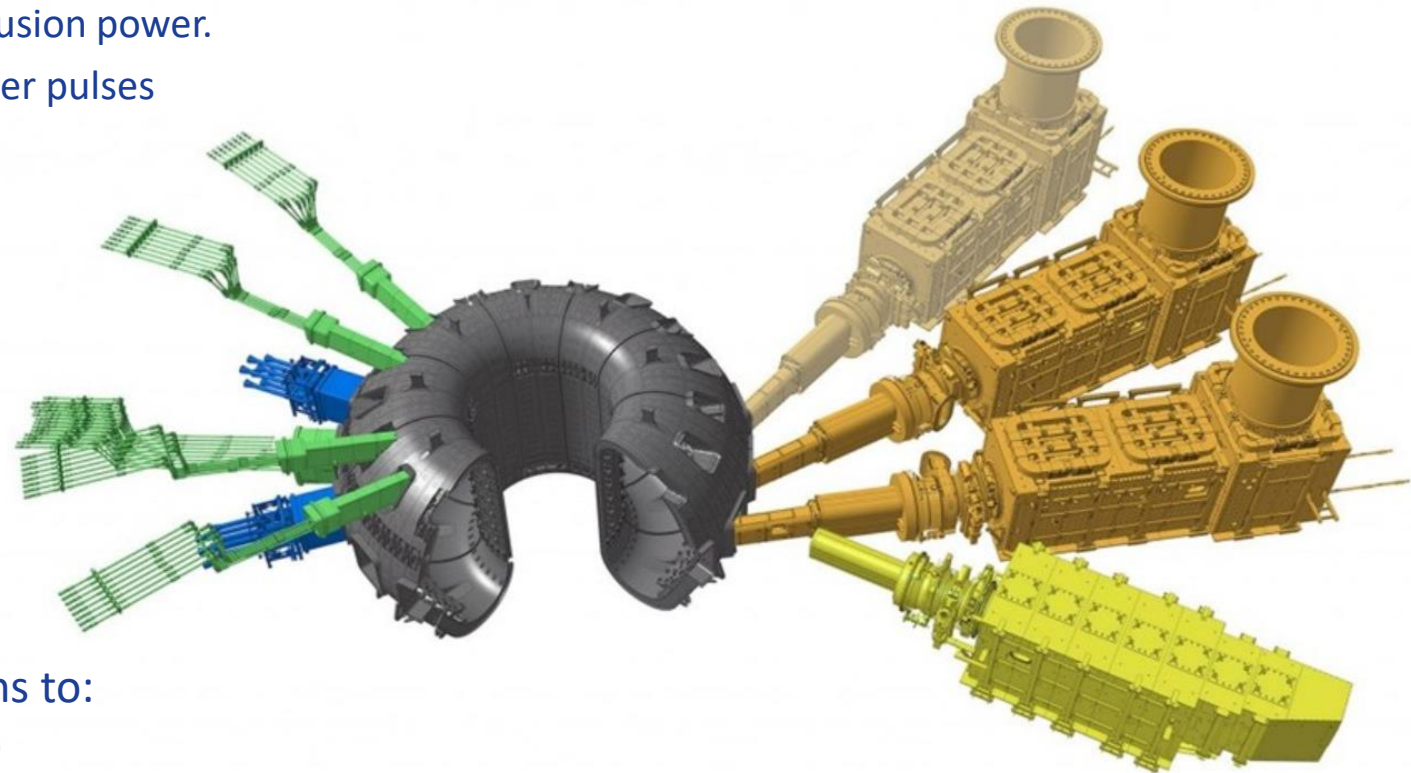


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The Heating Systems in ITER have the following main functions:

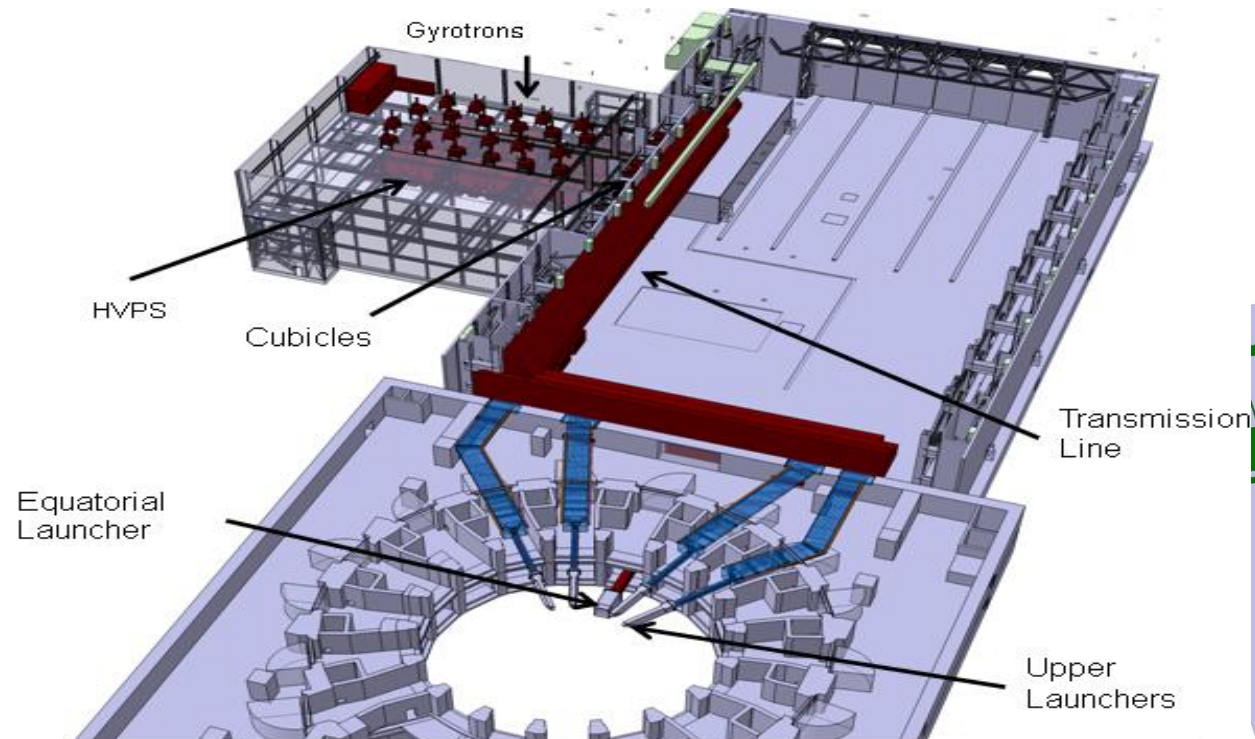
- to **heat up** the plasma to temperatures (typ. 150 million degrees C) where fusion reactions can occur at a rate viable for the production of substantial fusion power.
- To “**drive**” the plasma current and allow to sustain longer pulses
- To **control** some plasma instabilities



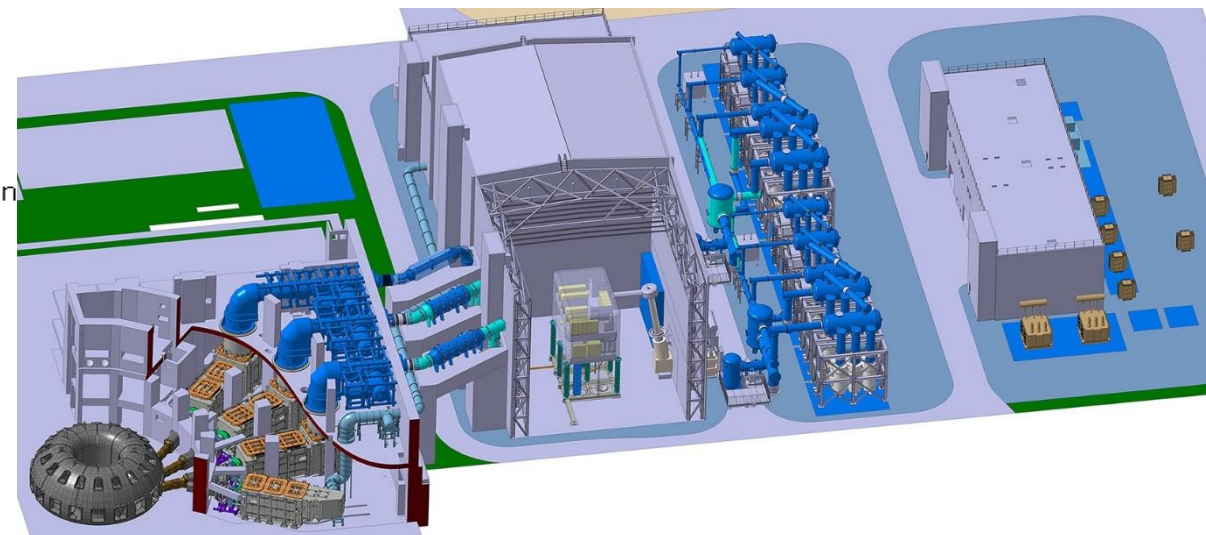
The **European contribution** includes contributions to:

- The Neutral Beam Injectors (1MV 2x16.5MW)
- The Electron Cyclotron system (170GHz, 20MW)

Electron Cyclotron



Neutral Beam





Electron Cyclotron

- Power supplies => Contracts already ongoing
- Sources (gyrotrons) => Contracts already ongoing
- Launchers => Contracts ongoing for main scope
Procurement for vacuum insulation valve ongoing

Neutral Beam Injectors

- Power supplies => Contracts already ongoing (First set Neutral Beam Test Facility + 2 sets for ITER)
- Mechanical components => Contract ongoing for first set of some components (NBTF)
procurement of few components for ITER ongoing (Vessel, Assembly tools)
many others procurements coming starting 2023



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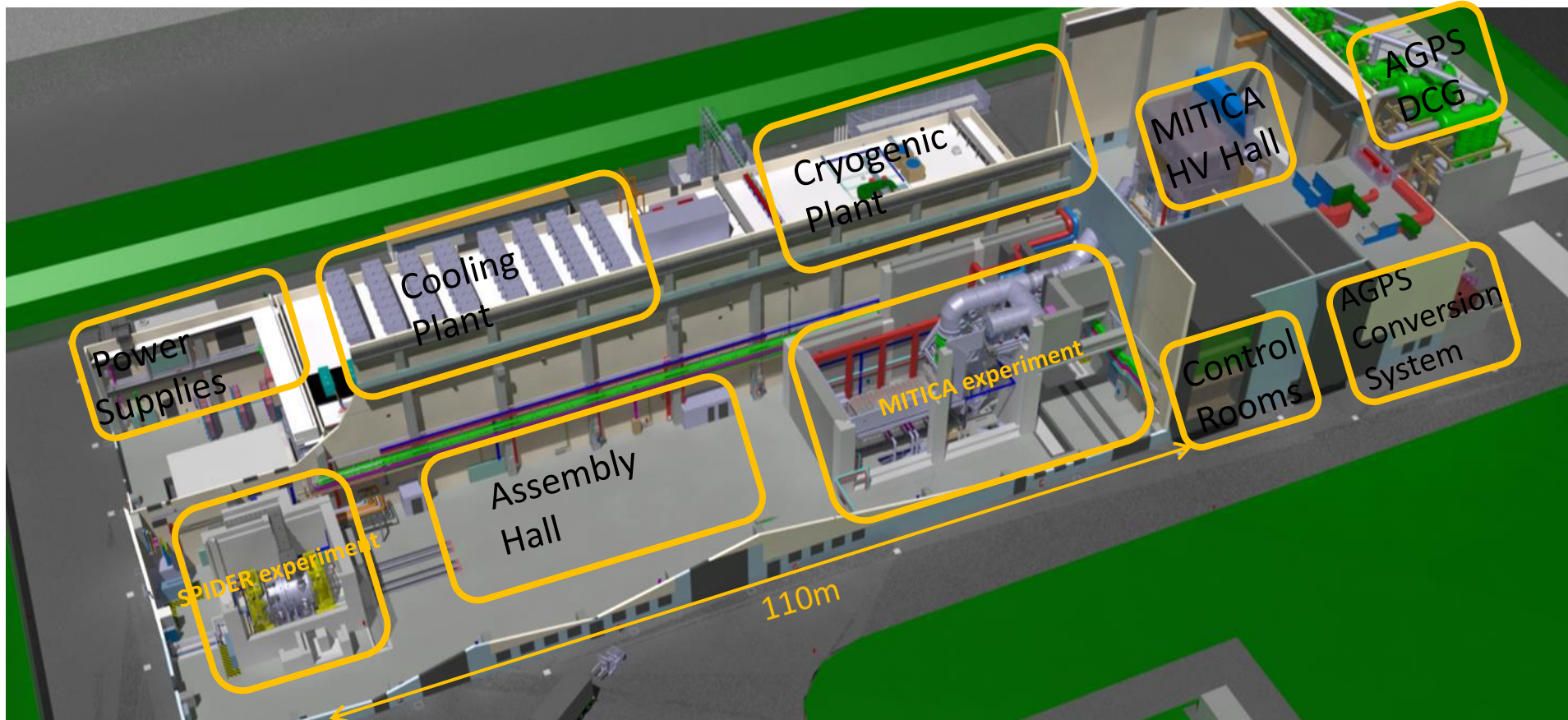
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The Neutral Beam Test Facility



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MITICA

Delivered:

- Power Supplies
- Vessel
- Auxiliaries

In construction:

- Beam Source
- Beam Line Component
- Cryopump

SPIDER

- Delivered

Components procured for a value close to 100ME

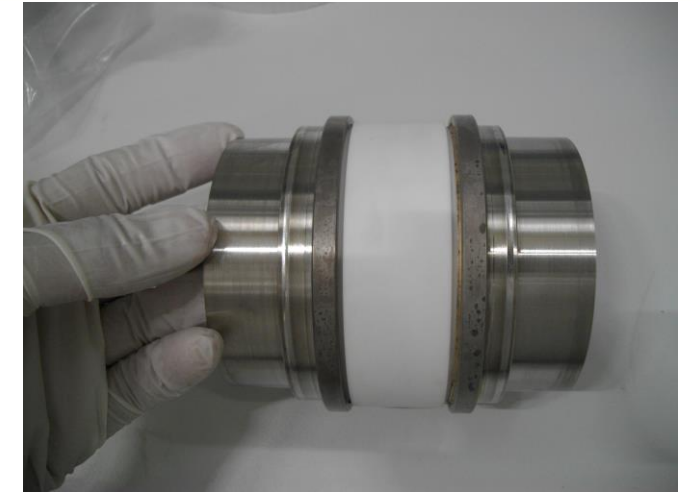
MITICA - Status of core components – BS (1/2)



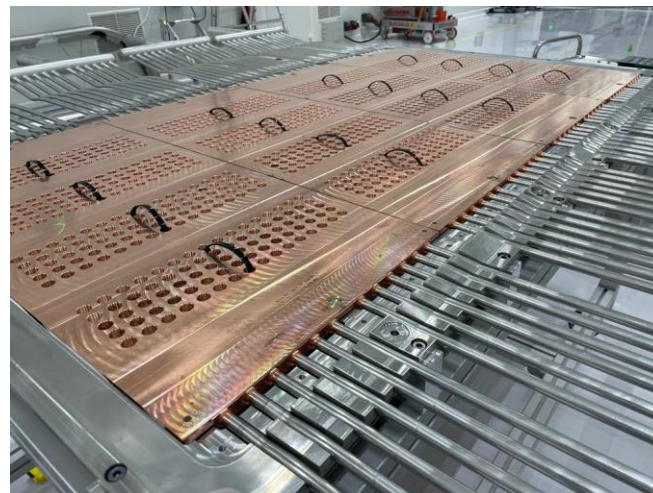
Alignment over the 1280 apertures of the accelerator stages with few tenths of mm precisions



Assembly of one accelerator stage and its post insulators



A 80mm diameter ceramic break for the main cooling line of the BS

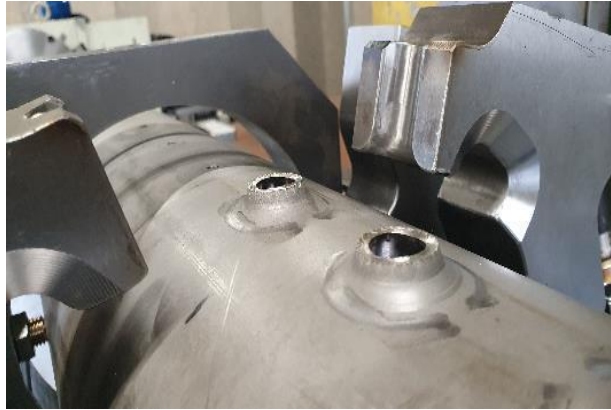


Assembly of on grid composed by four segments



Heterogeneous joint between SS conveyor and exploded bonded Cu-Mo substrate

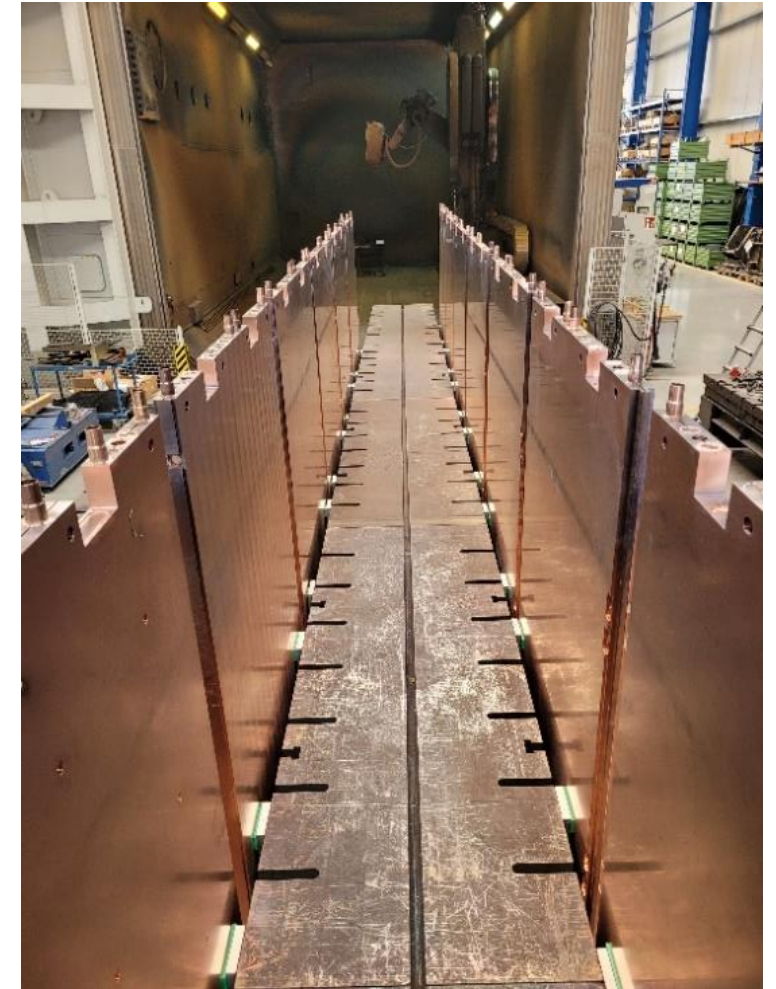
MITICA - Status of core components – BLC (2/2)



Cold extrusion completed for the Calorimeter manifolds



Deep drilling of Neutralizer panels completed
Dimensional measurement of Calorimeter swirl tubes on-going



Electron Beam Welding of Neutralizer panels completed



Insertion of twisted tapes completed for Residual Ion Dump

Our industrial partners so far



THALES



SIEMENS



De Pretto Industrie

AMPEGON

HSP Hochspannungsgeräte GmbH

HSP

N:ER
INGEGNERIA



pro beam



IDOM





Overview of the Neutral Beam and Electron Cyclotron heating systems

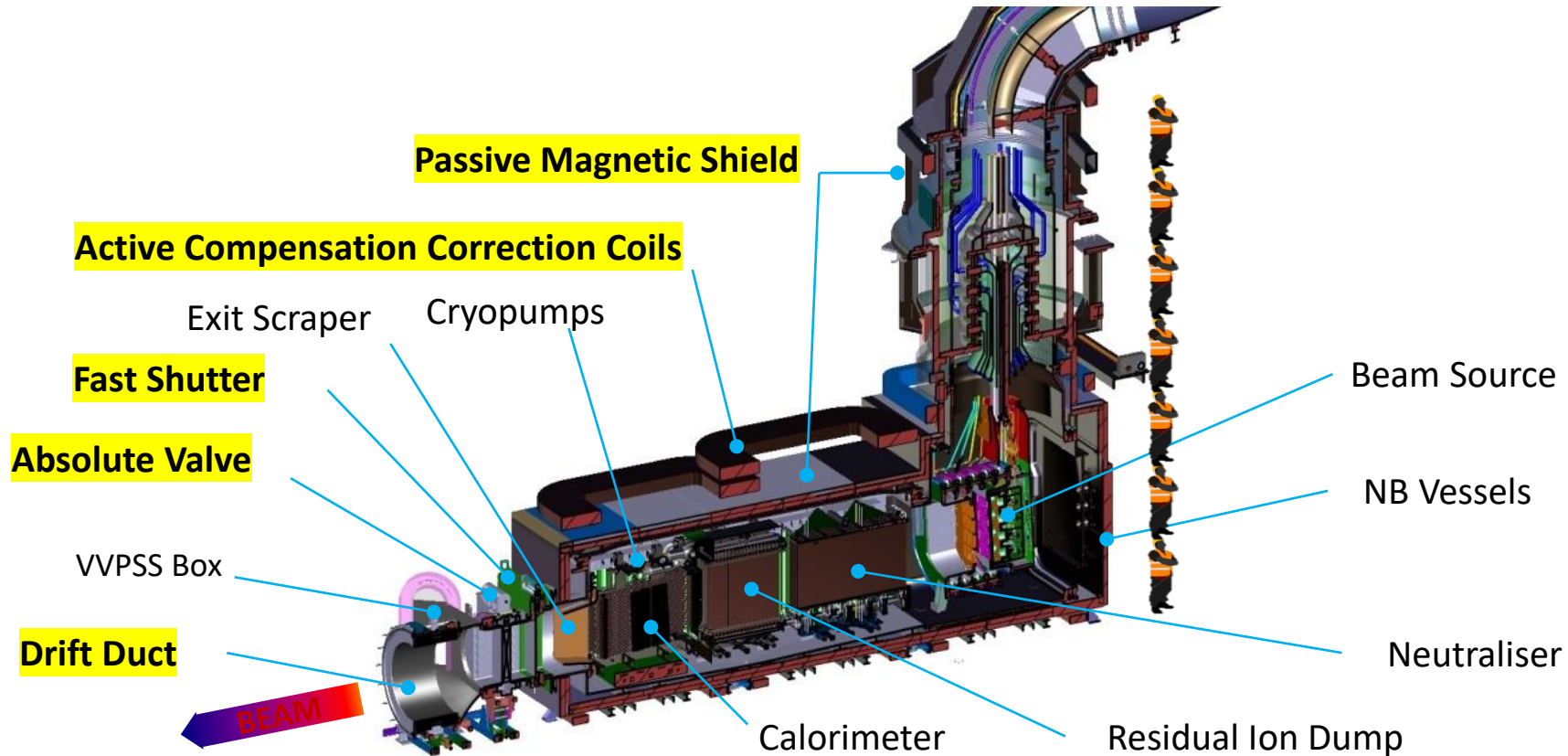
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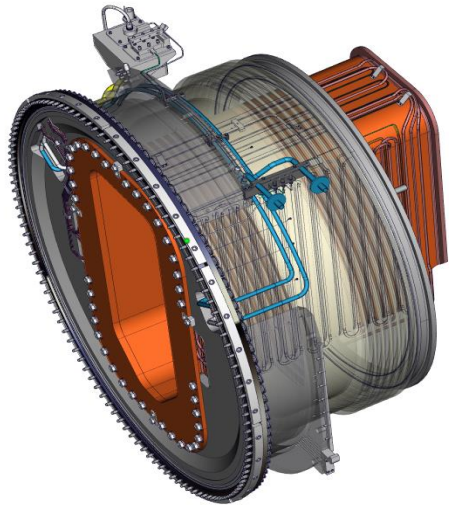
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Drift-Duct (DD) = DD Liner + DD Bellows



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

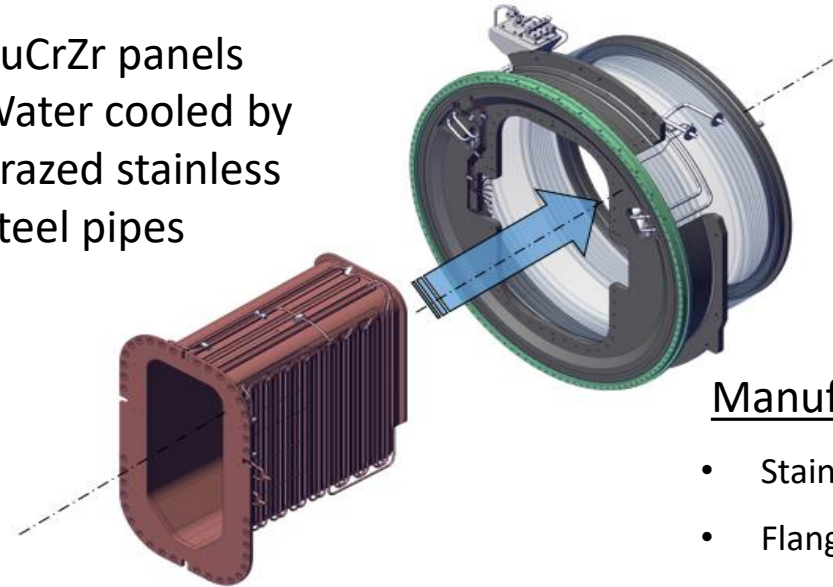
Scope: 2 drift duct units

Manufacturing design, Manufacturing, Factory Acceptance tests

Key skills

- ✓ Manufacturing of nuclear components
- ✓ Experience with **Nuclear code**
- ✓ High vacuum
- ✓ Welding of Stainless-Steel
- ✓ Non Destruction Testing of Austenitic Stainless Steel welds
- ✓ Brazing
- ✓ EBW of CuCrZr

CuCrZr panels
Water cooled by
brazed stainless
Steel pipes



SS double bellow

Manufacturing codes of main components

- Stainless Steel Double Bellows (SIC 1) → EN14917
- Flanges (SIC 1) → RCC-MR Class 2
- DD Liner (Non SIC) → Requirements defined in the technical specification

Status:

Pre-procurement activities

Market survey on-going:

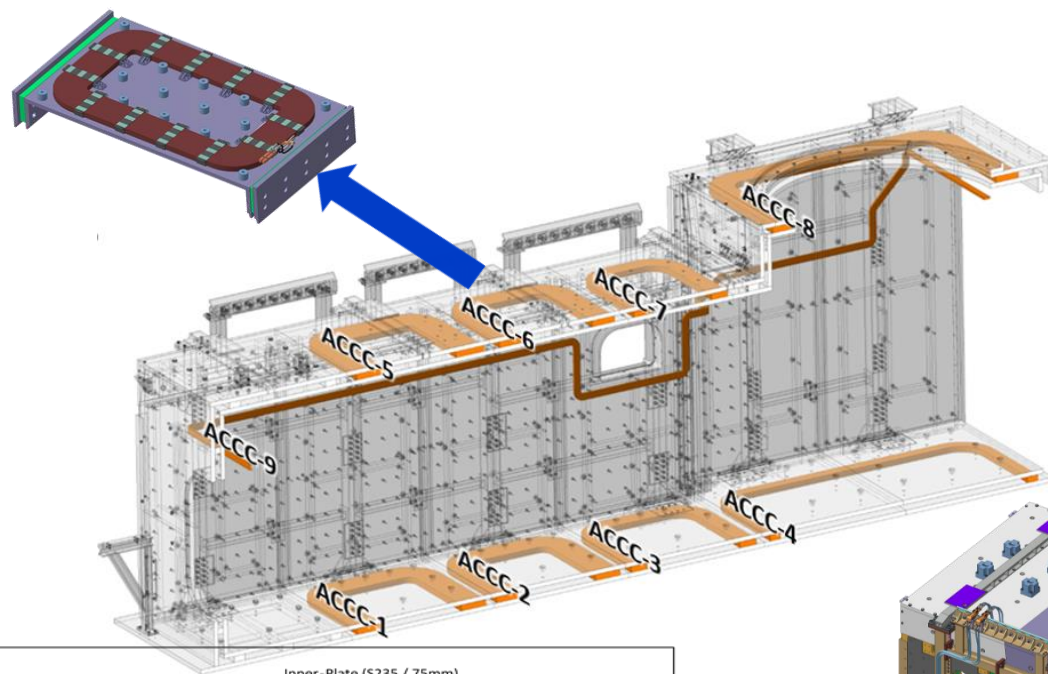
https://ec.europa.eu/eusurvey/runner/ITER_Drift_Duct_II

Date of call for tender: Q2 – 2023

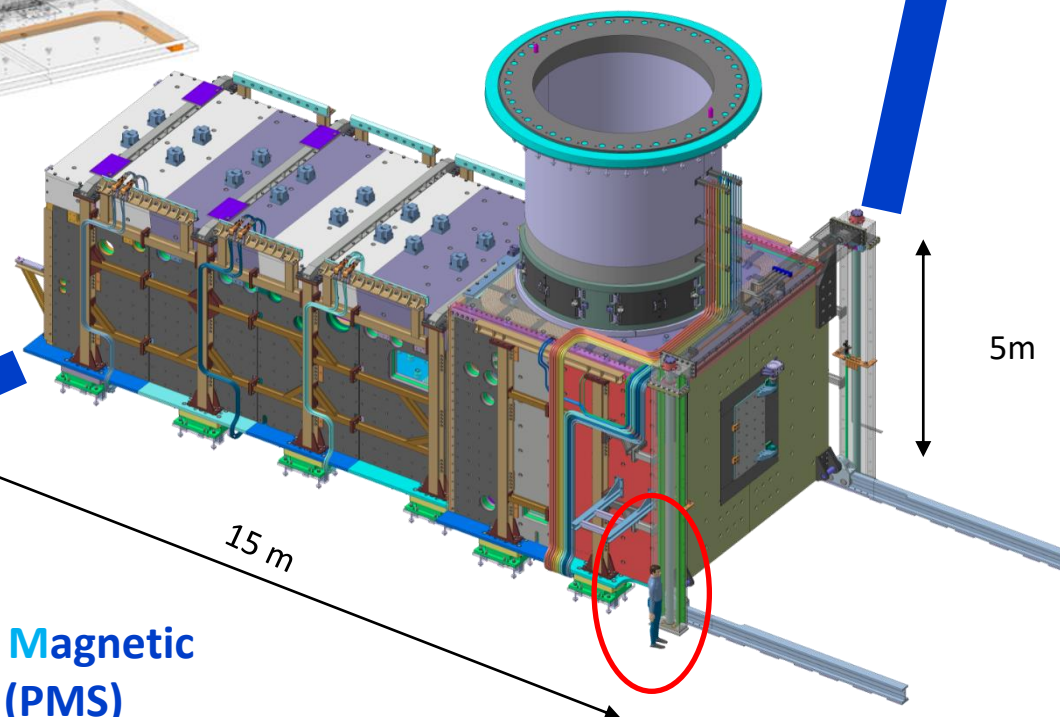
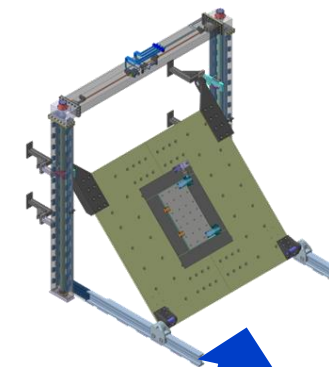
Magnetic Shielding - PMS & ACCC (1/3)



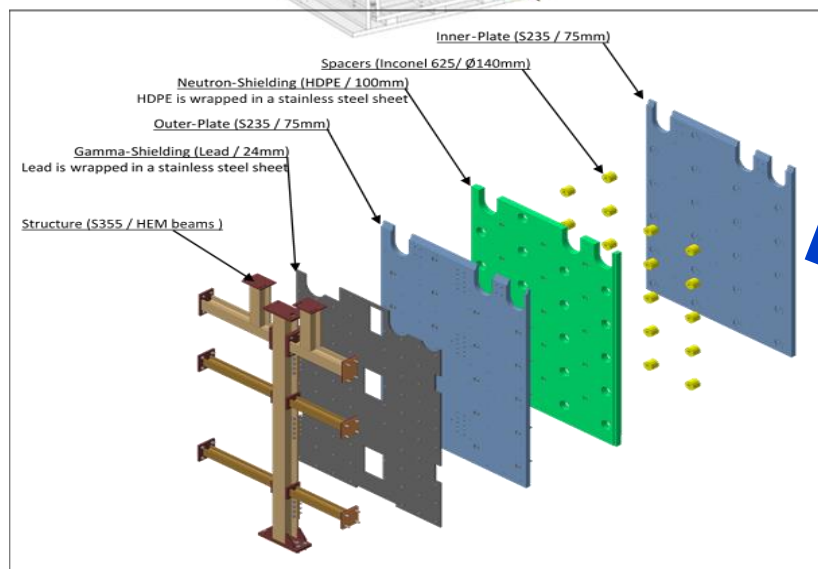
Q3 2023



Active Compensation Correction Coils (ACCC)



Passive Magnetic Shields (PMS)



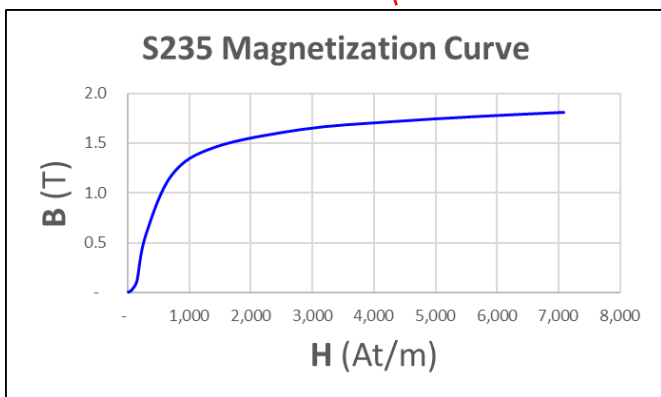
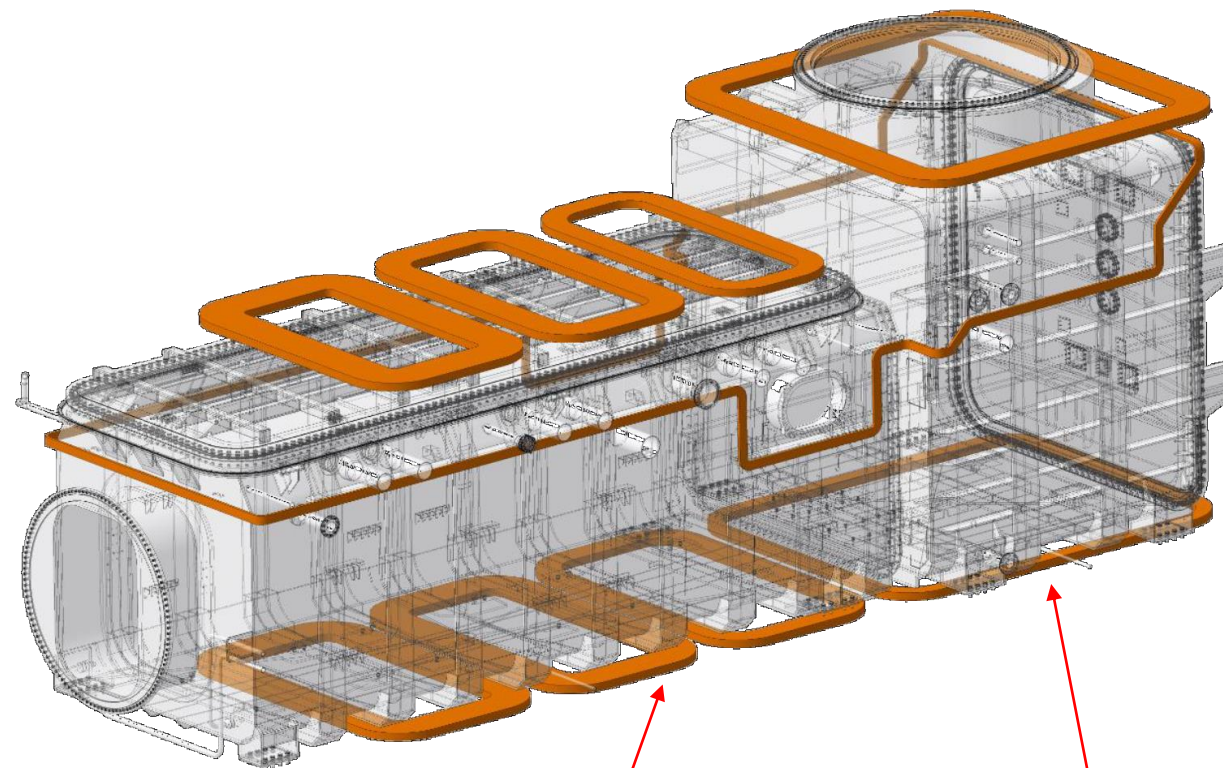
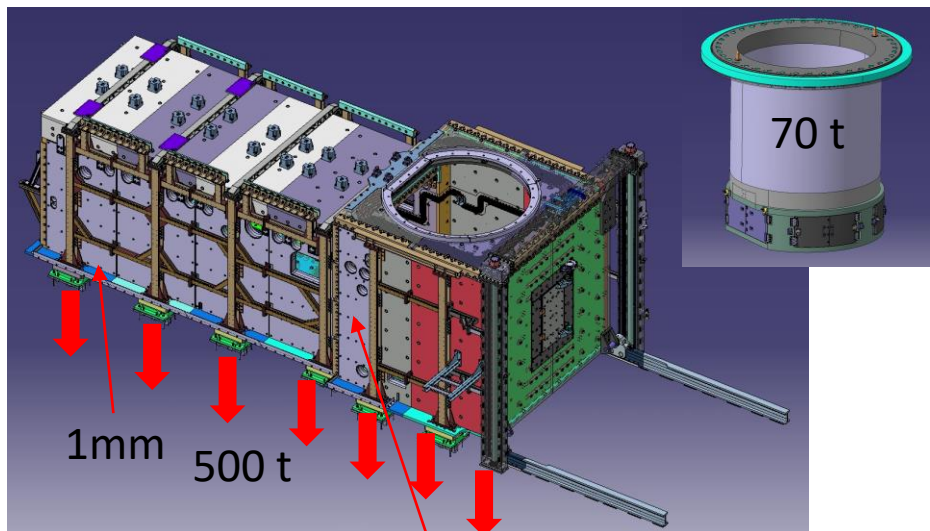
Magnetic Shielding (2/3)



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Magnetic req=> Strict tolerances (checked at FAT)



External dimensions (m)	4x2.5
N. turns /pancake	92
N. pancakes	4
Conductor section (mm)	20x20
Conductor length (m)	890
Conductor mass (kg)	3155

External dimensions (m)	4x4
N. turns /pancake	16
N. pancakes	4
Conductor section (mm)	20x20
Conductor length (m)	1046
Conductor mass (kg)	3730

Requirements on magnetic performance of plates
=>Measurement campaign ongoing (looking for samples)

Copper, epoxy impregnated, passively cooled (Dimensions vary)



Key characteristics:

- Carbon steel construction, sandwich structure with 75mm panels (400 tons)
- Magnetic requirements => Max 1mm construction gap, magnetic properties of steel
- Nuclear safety components (support function) => **RCC-MR construction code, control of impurities**
- 8 copper coils embedded in the structure + 1 internal

Scope of the procurement:

2 PMS and ACCC units, including:

- ✓ Manufacturing design
- ✓ Manufacturing and full assembly at factory

Key skills:

- ✓ Construction and precise assembly of heavy components
- ✓ Coil design and manufacturing
- ✓ Manufacturing of **nuclear components**

Status and pre-procurement activities:

- ✓ Market Survey for ACCC (old design): [News - NEUTRAL BEAM: Early information on Active... \(europa.eu\)](#)
- ✓ Market Survey for steel material (closed) : [News - NEUTRAL BEAM: Steel Plates Market Survey \(europa.eu\)](#)
- ✓ Market survey for the complete scope: **Q4 2022**
- ✓ Date of call for tender: **Q3 2023**

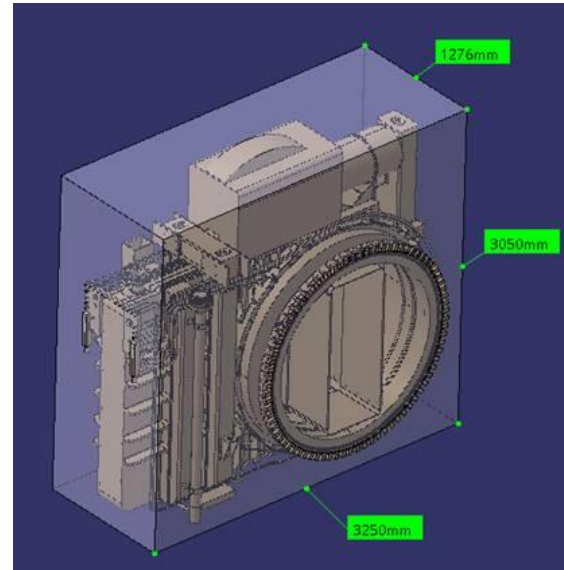
Absolute Valve (AV) – Fast Shutter (FS)



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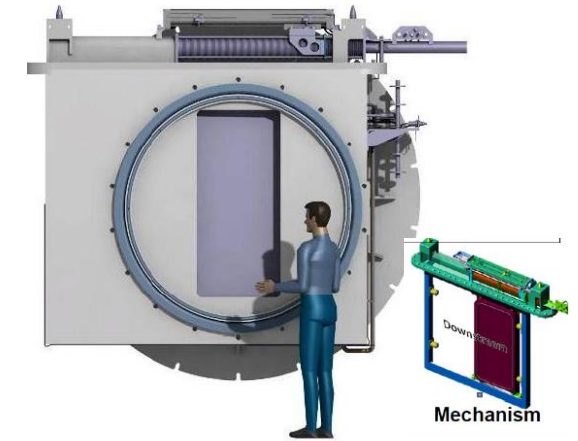
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Absolute Valve



Length ~ 3.2 m
Width ~ 1.2 m
Height ~ 3 m
Weight ~ 8.5 t

Fast Shutter



Scope: 2 Absolute Valves / 2 Fast Shutters

Description:

Isolation valves positioned between NB vessel and VV

- AV: absolute sealing (10^{-8} Pam³/s)
- FS: fast actuation (<10s), lower sealing (10^{-2} Pam³/s)

Key skills

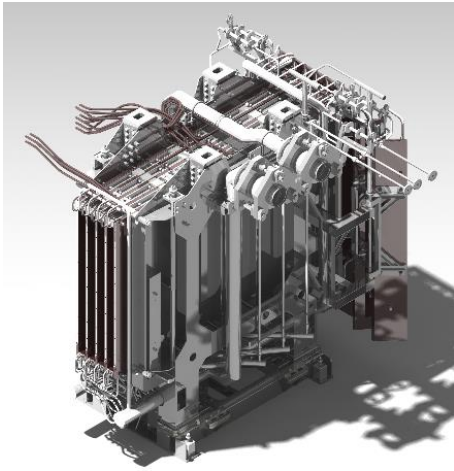
- ✓ Vacuum tightness (non-SIC) of the Valve when closed using a metallic seal (metal to metal) of large diameter > 1.5m
- ✓ Manufacturing of nuclear components (SIC-1) for the casing using a Nuclear Code
- ✓ Welding of Stainless-Steel
- ✓ Non Destructive Testing of Austenitic Stainless Steel welds

Status and pre-procurement activities:

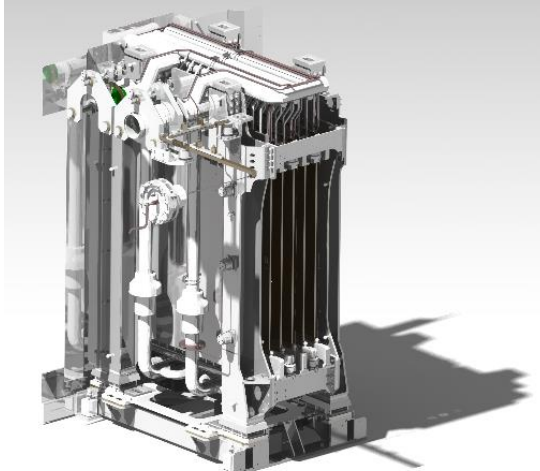
Market survey (closed): [News - NEUTRAL BEAM: international Market Survey... \(europa.eu\)](#)

Date of call for tender: **Mid-2023**

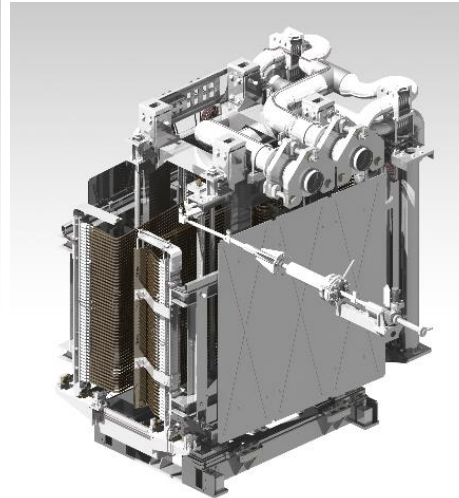
Beam Line Components



Neutraliser

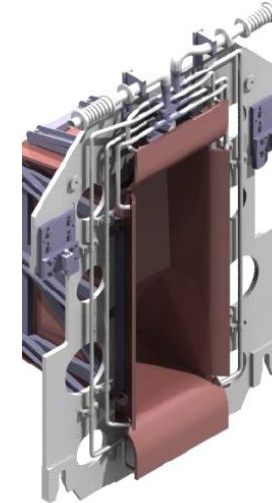


Residual Ion Dump



Calorimeter

Exit Scraper

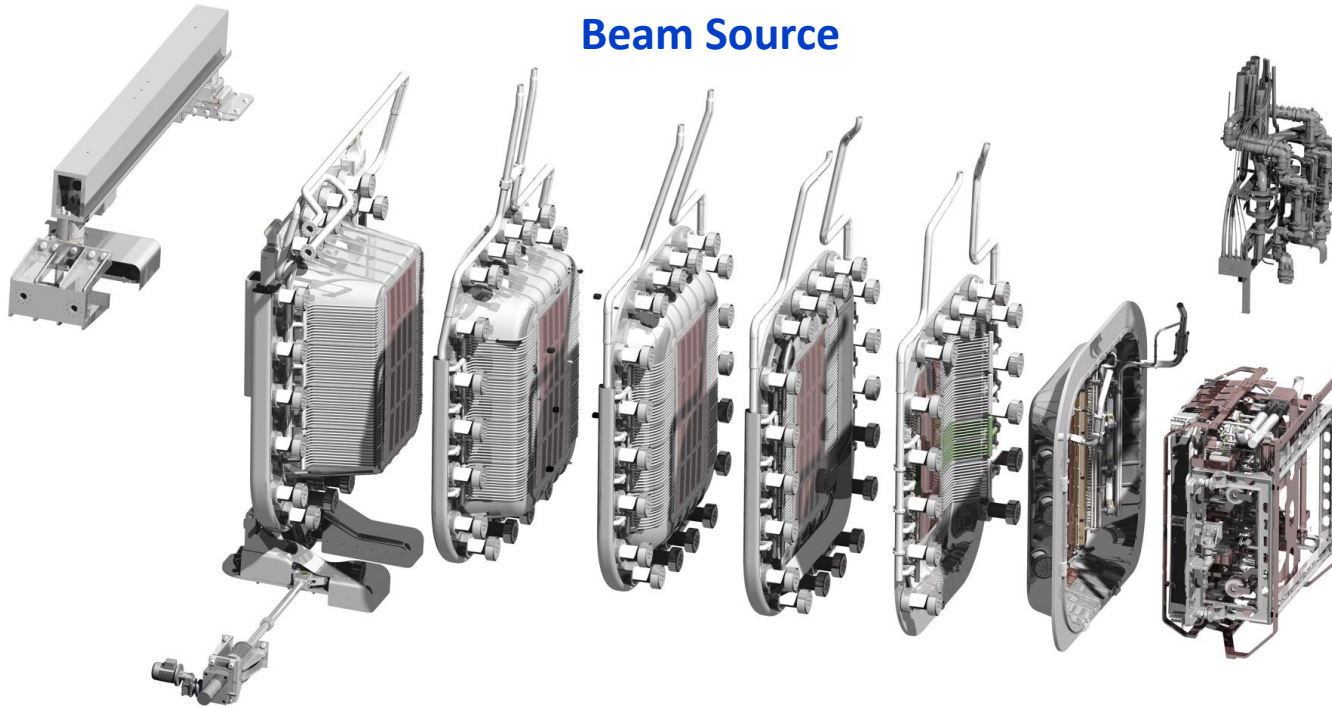


- ❖ High vacuum – non safety relevant – approx. 5t each
- ❖ Stainless Steel Support
- ❖ Deep Drilled Panels in CuCrZr
- ❖ Heterogenous joints
- ❖ Ceramic insulators

Pre-procurement activities

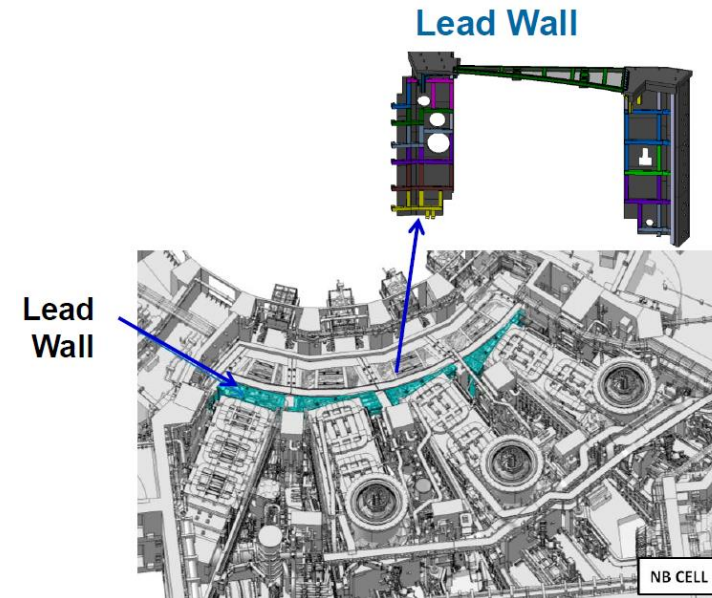
✓ Market Surveys 2024

Beam Source



- ❖ High vacuum – non safety relevant – approx. 15 ton
- ❖ High precision mechanics ion huge components
- ❖ Cu electrodeposited grids
- ❖ Mo coating: thin (PVD) and thick (explosion bonding)
- ❖ Heterogenous joints (Cu-SS)
- ❖ Ceramic insulators and hydraulic breaks

Lead Wall



- ❖ Gamma protection
- ❖ Panels of Lead and steel structure

Pre-procurement activities

- ✓ Market Surveys 2024

Opportunities - Summary



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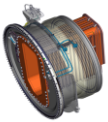
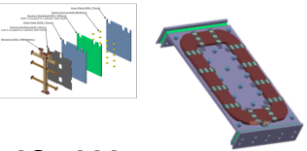


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2022

2023

2024

After 2024

 <p>Drift Duct</p>	<p>Market Survey F4E Industry Portal</p>	<p>Call for Tender Official Journal and F4E Industry Portal</p>	<p>Contract signature</p>	
 <p>PMS&ACCC</p>	<p>Market Survey F4E Industry Portal</p>	<p>Call for Tender Official Journal and F4E Industry Portal</p>	<p>Contract signature</p>	
 <p>Absolute Valve – Fast Shutter</p>	<p>Market Survey F4E Industry Portal</p>	<p>Call for Tender Official Journal and F4E Industry Portal</p>	<p>Contract signature</p>	
 <p>OtherComponents</p>			<p>Market Survey F4E Industry Portal</p>	<p>Call for Tender Official Journal and F4E Industry Portal</p>

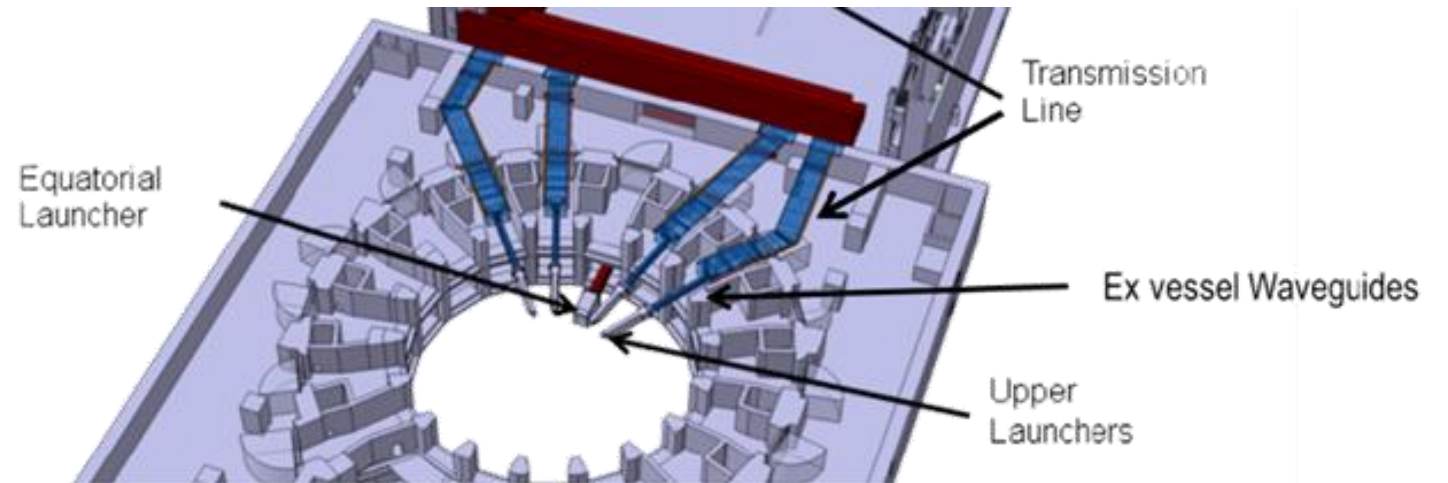
Electron Cyclotron Upper Launcher & Ex-Vessel Waveguides

**Subcontracting of F4E-OMF-1120
(IDOM+ALSYMEX)**

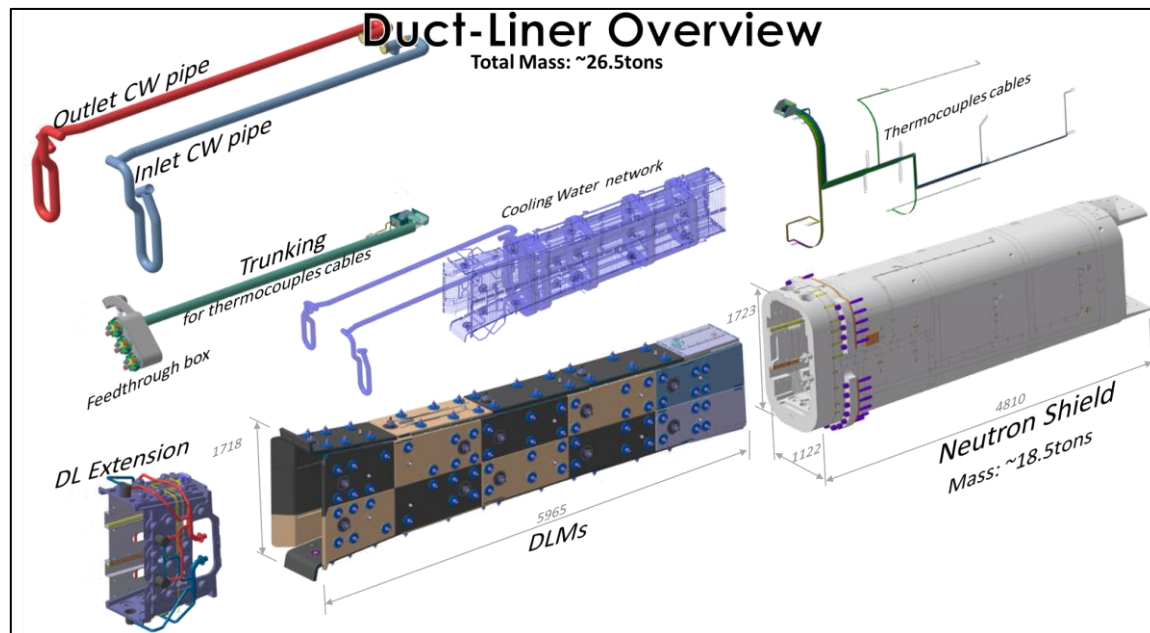
Short term (2022-2023)

Procurement of raw materials

Manufacturing of small prototypes
and testing activities



Duct Liner



Call Q3 2023

Actively cooled vacuum component

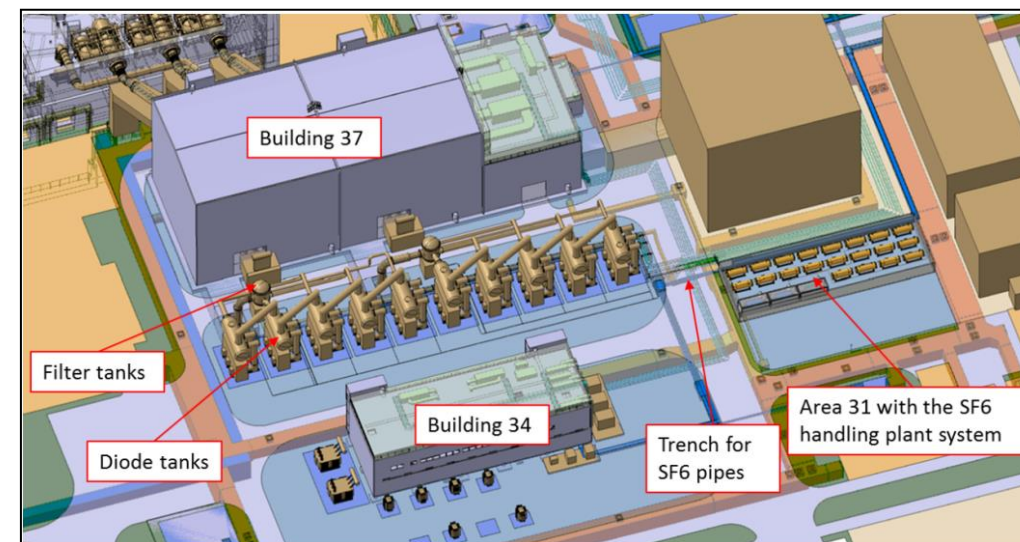
Manufacturing design + manufacturing

Mass 26.5 ton

Materials: mainly 316L(N)-IG, few panel CuCrZr.

Feedthrough box is SIC

SF6 Handling Plant



Call Q2 2023

Design, manufacturing, installation & commissioning

100 SF6 tons

Key parts: Liquid SF6 storage tanks, handling units, distribution pipes and monitoring systems

Including some HC/PIC components.



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