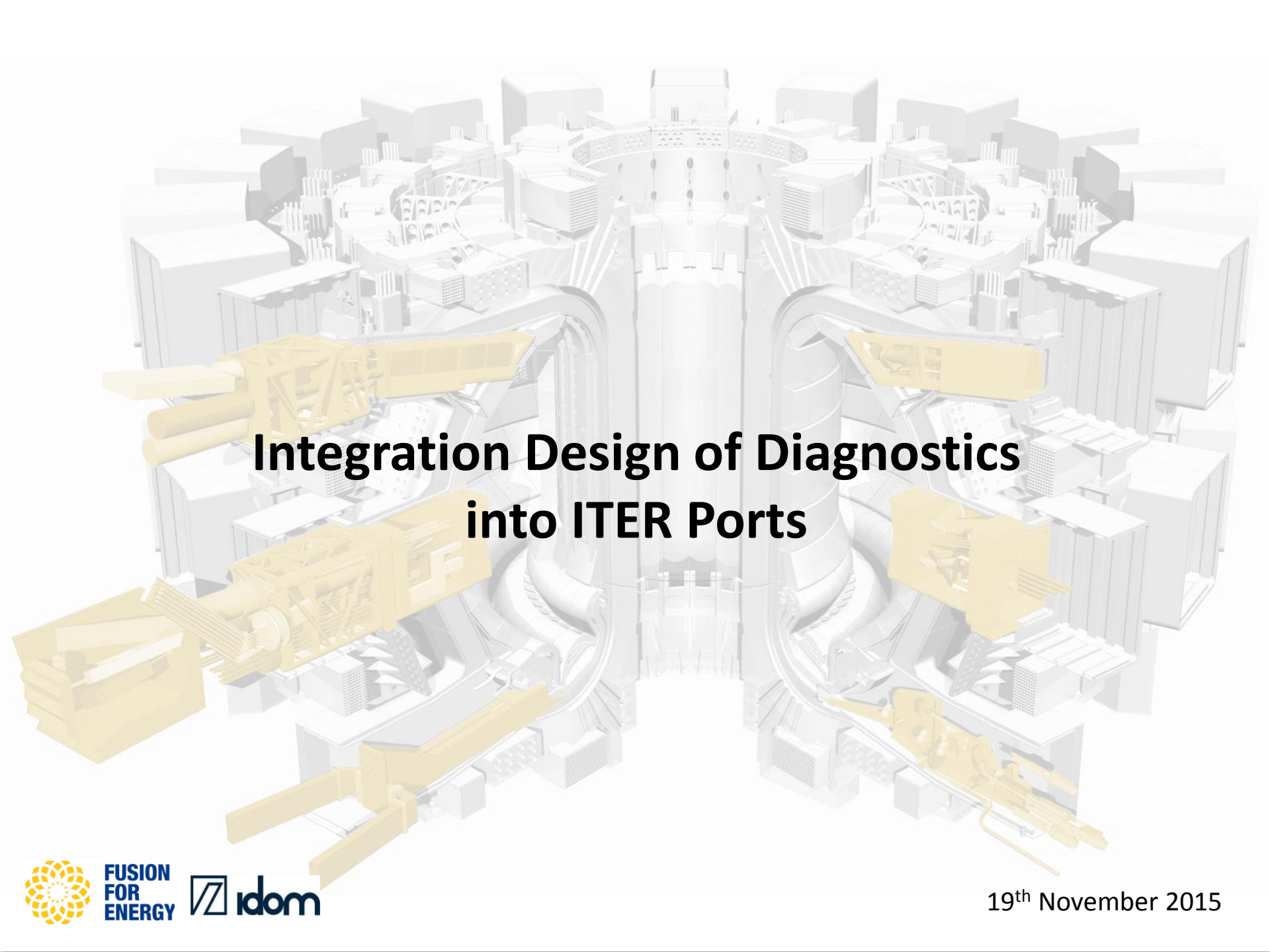


Integration Design of Diagnostics into ITER Ports

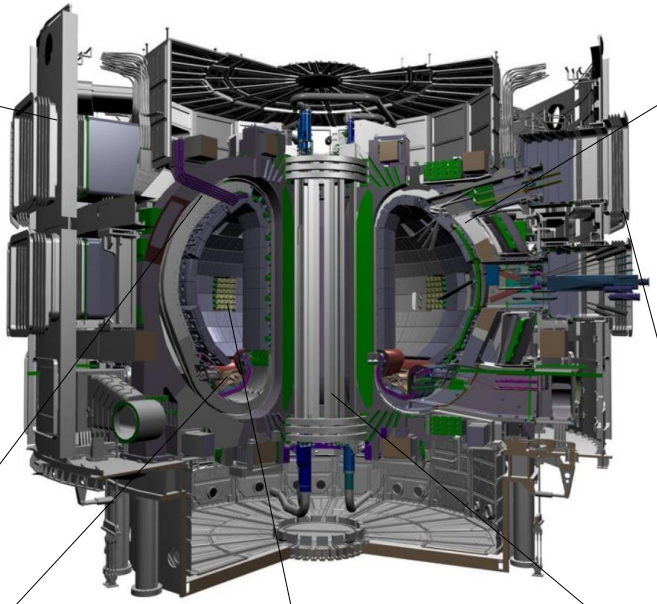
FUSION FOR ENERGY

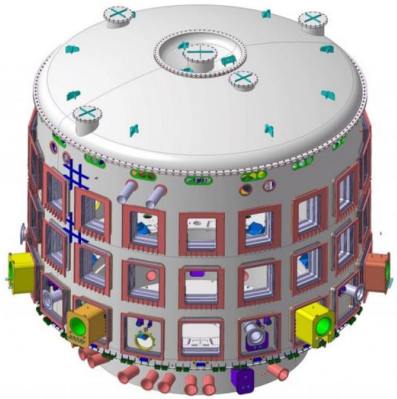
idom

19th November 2015

ITER

ITER TOKAMAK





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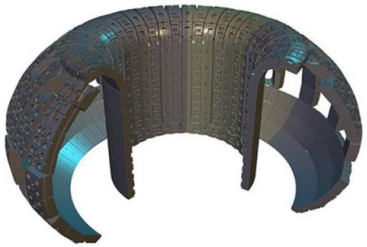

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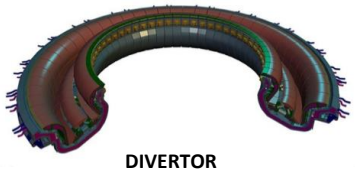
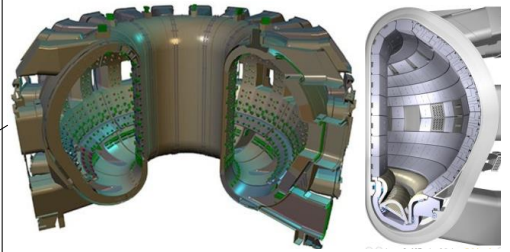
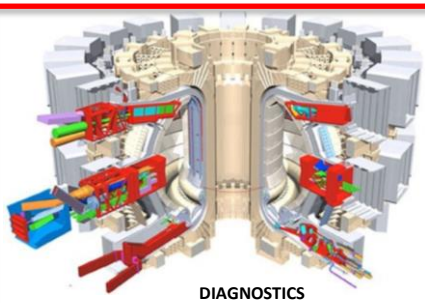


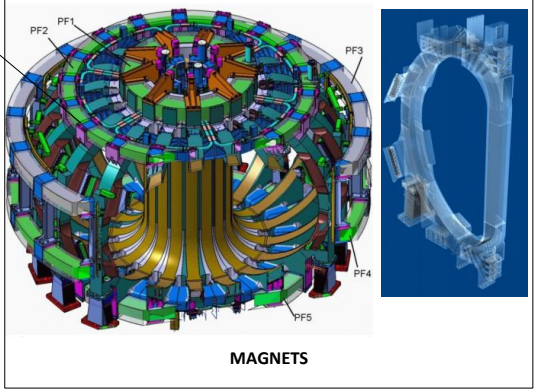
DIVERTOR



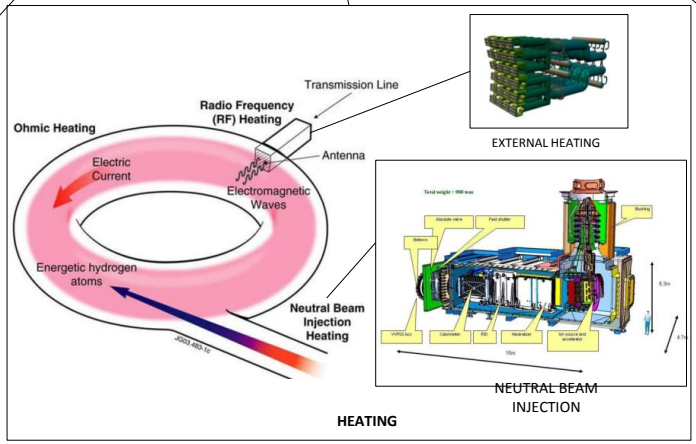
VACUUM VESSEL



DIAGNOSTICS



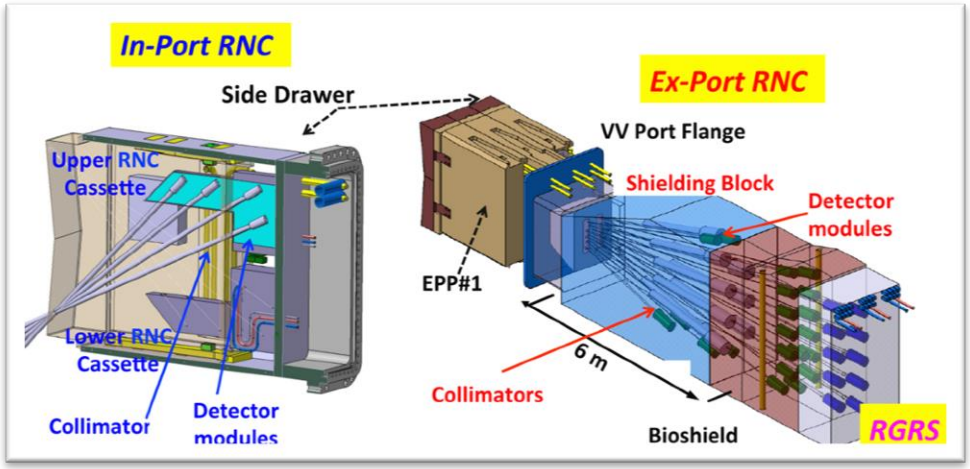
MAGNETS

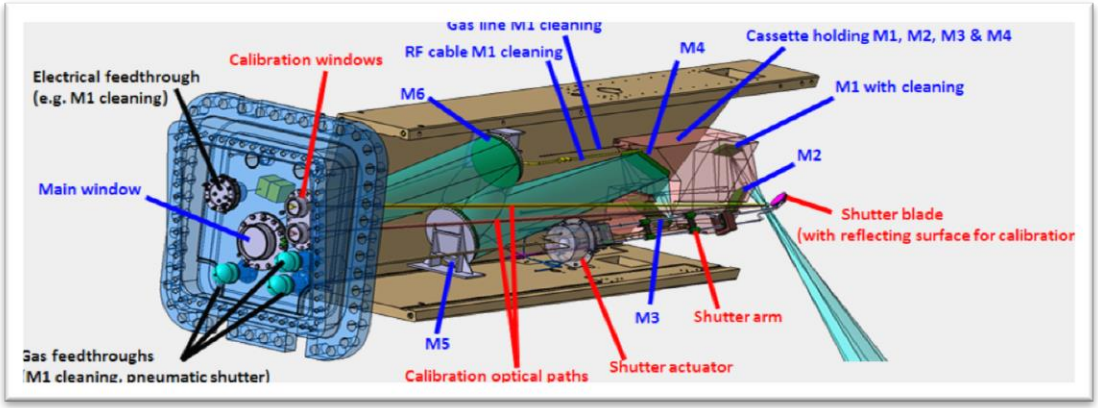


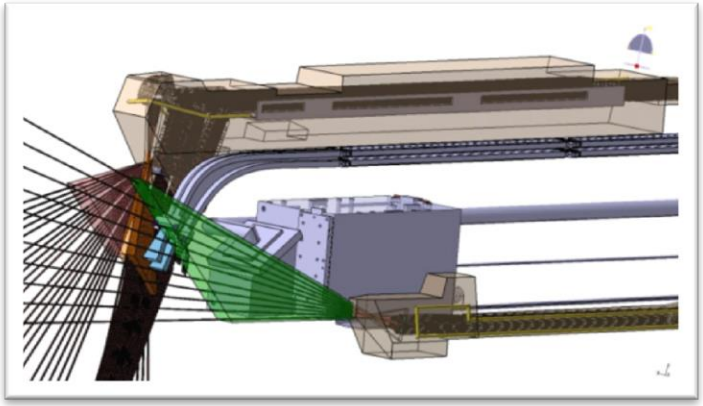
ITER: DIAGNOSTICS

In ITER there are around 50 diagnostics :

- ✓ Magnetics (A)
- ✓ Neutronics (B)
- ✓ Óptics(C)
- ✓ Bolométrics (D)
- ✓ Spectroscopics and NPA (E)
- ✓ Microwave (F)
- ✓ Plasma Facing Operational (G)



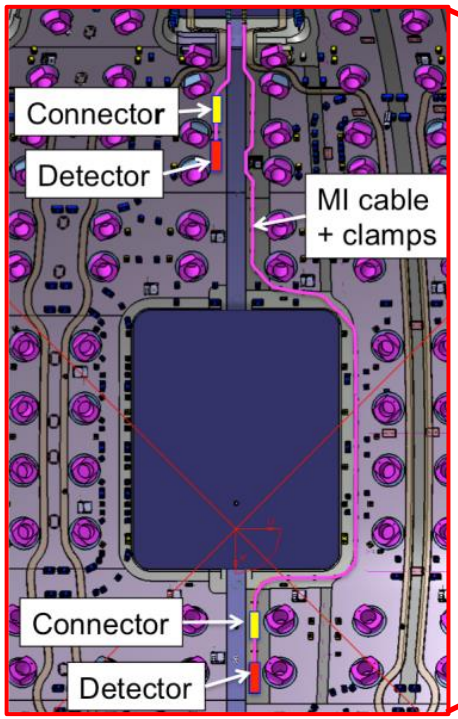


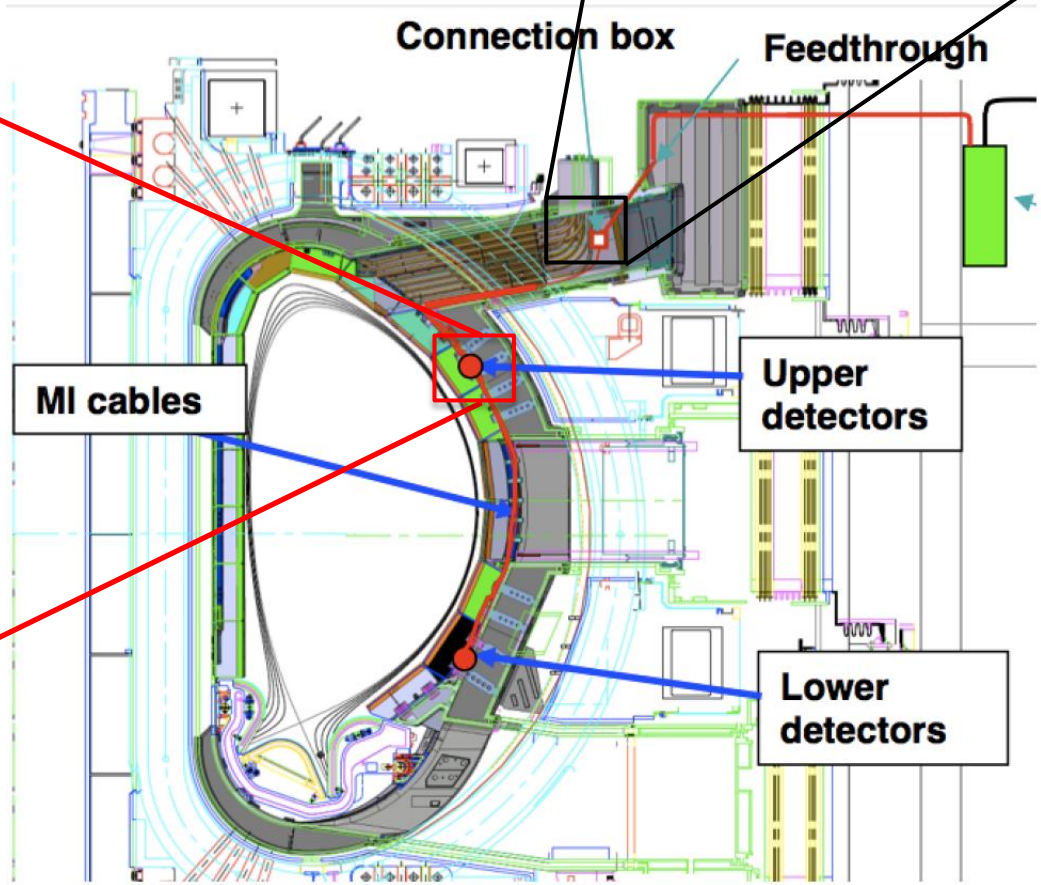


ITER: DIAGNOSTICS

Diferent architecture configurations:

- ✓ Some of them installed in the vacuum vessel

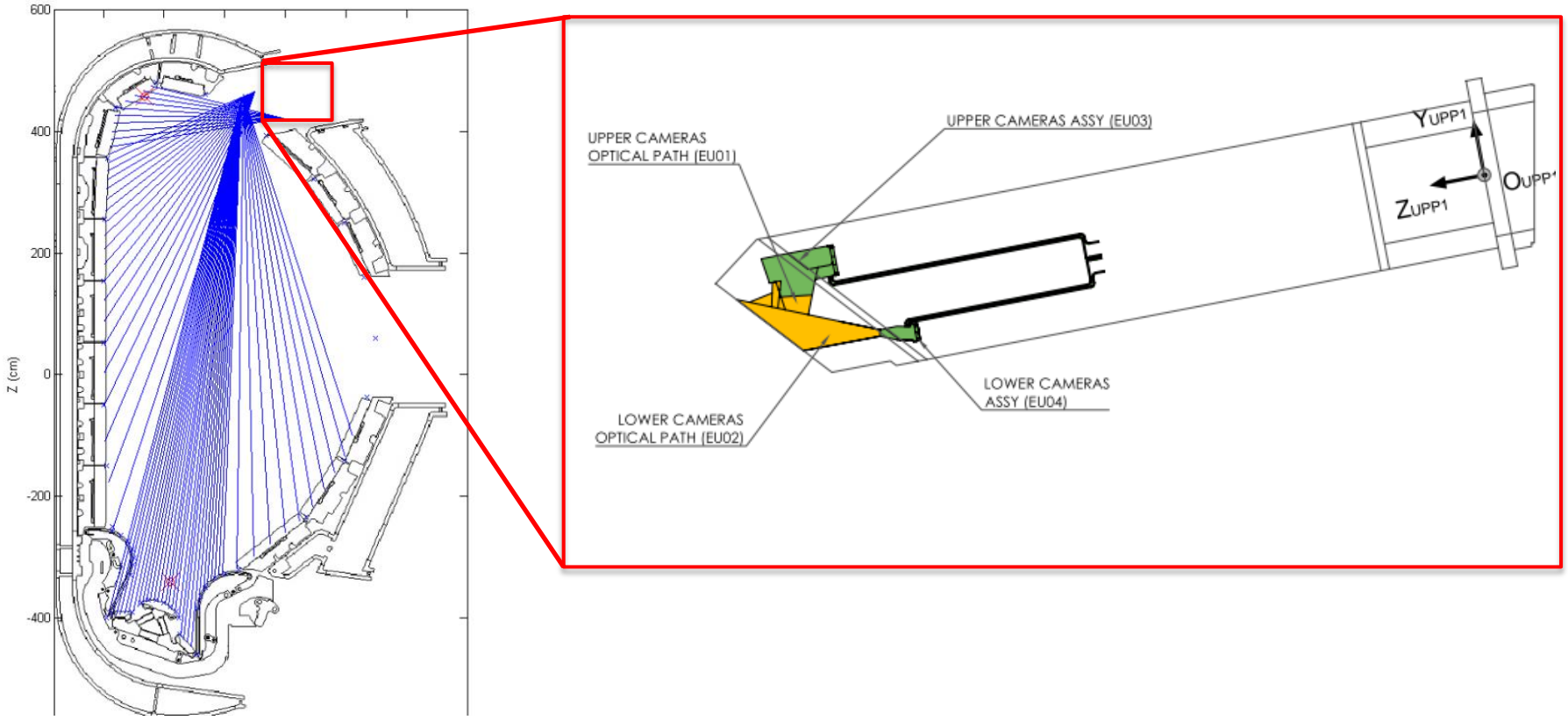




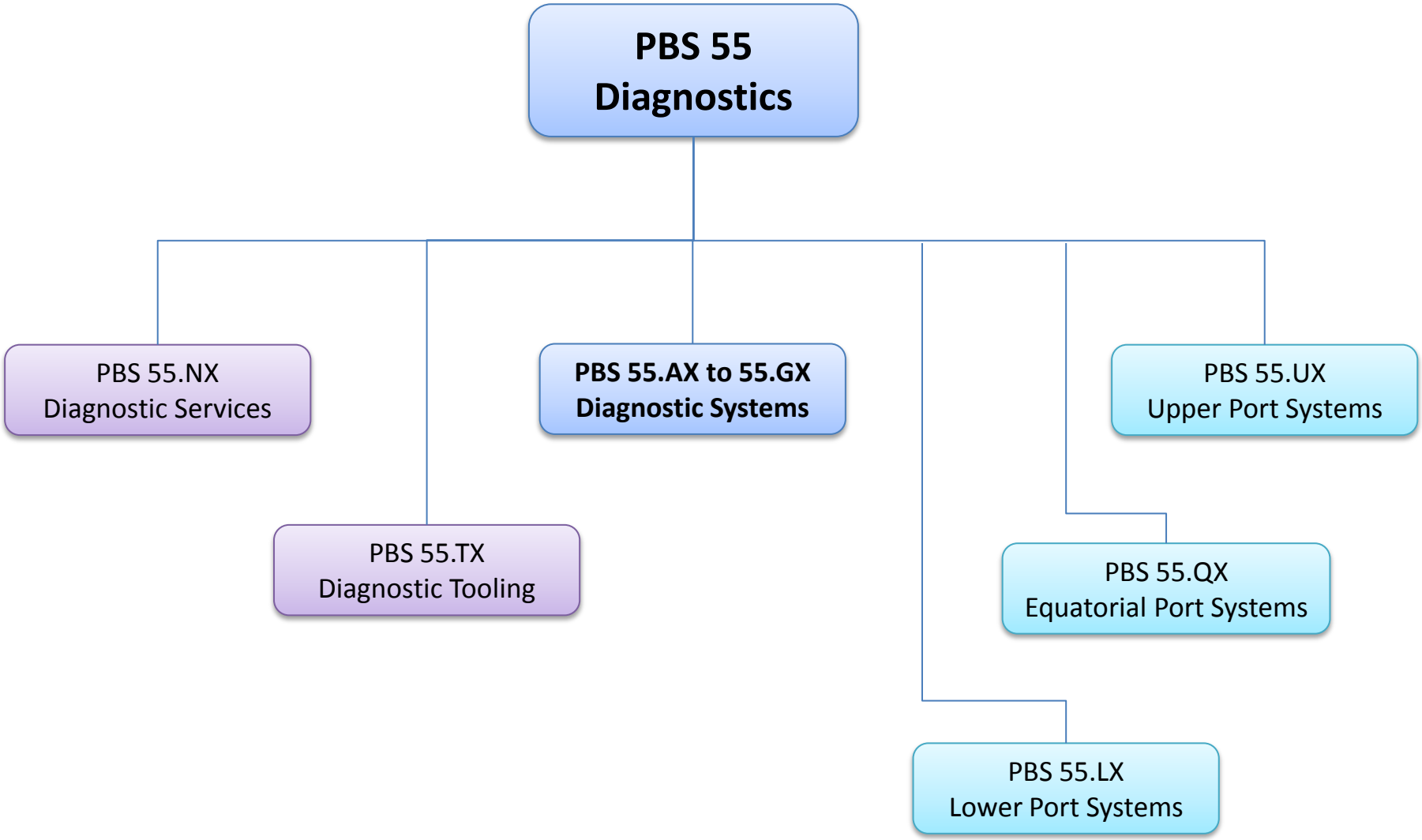
ITER: DIAGNOSTICS

Different Architecture Configurations

✓ Other installed in the Port Plugs



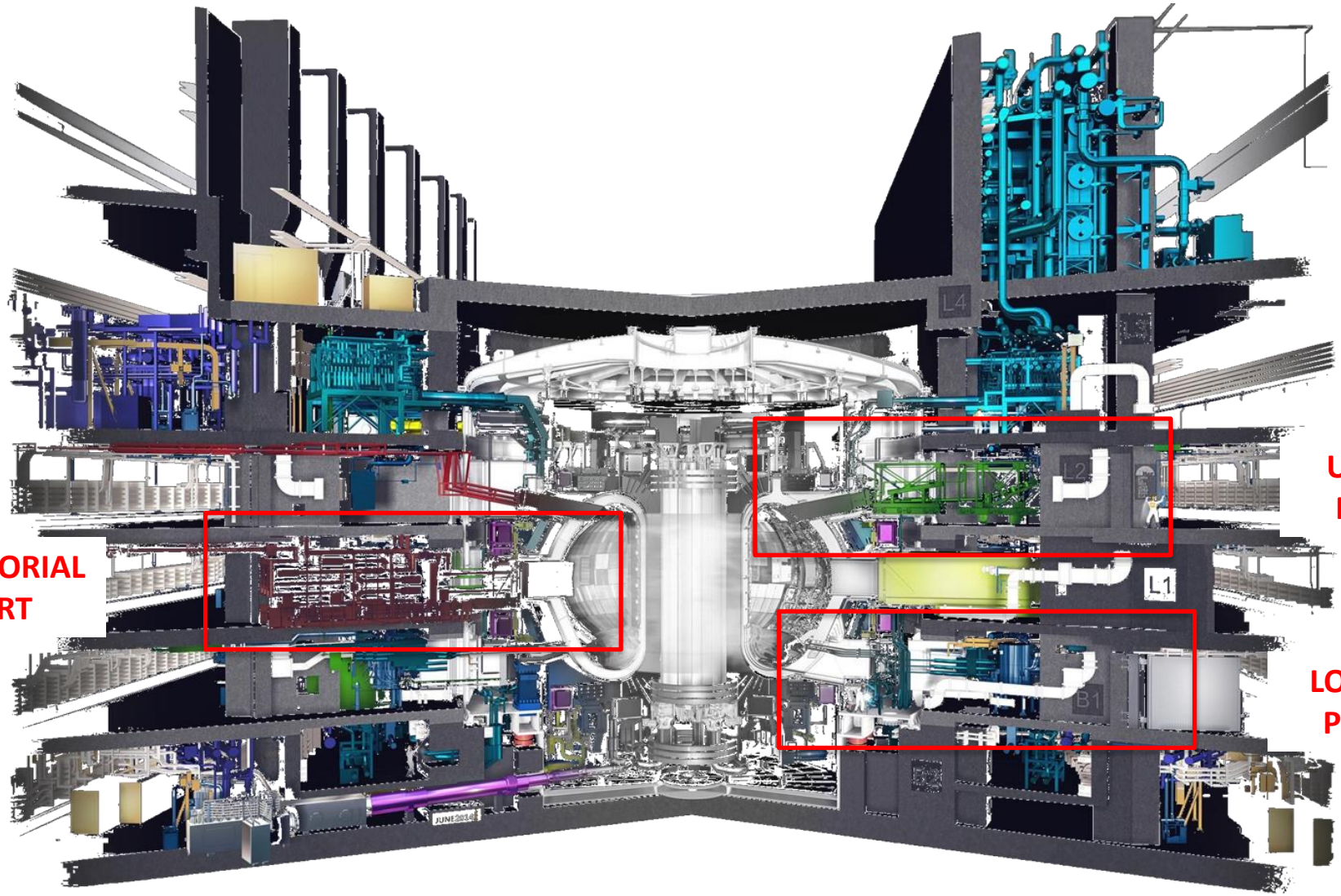
ITER: DIAGNOSTICS



DIAGNOSTIC PORTS

ITER: DIAGNOSTIC PORTS

ITER: DIAGNOSTIC PORTS



EQUATORIAL PORT

UPPER PORT

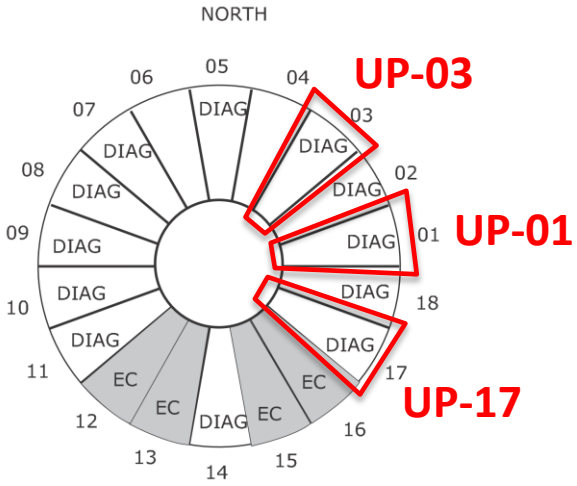
LOWER PORT

Images from www.iter.org

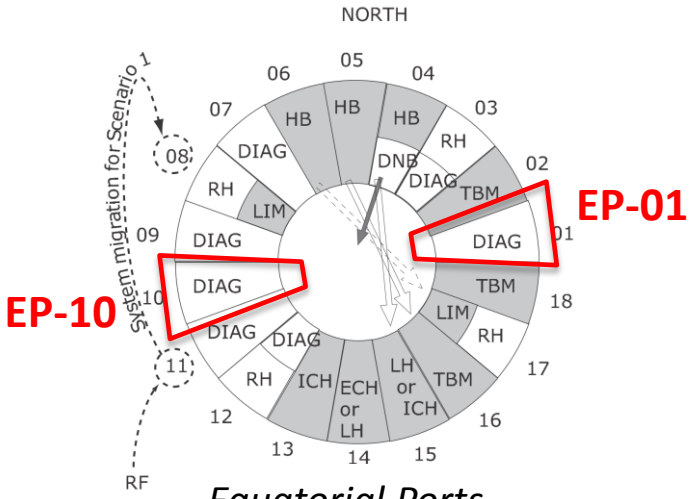
ITER: DIAGNOSTIC PORTS

In the threel levels of the Tokamak, there are 18 ports per level

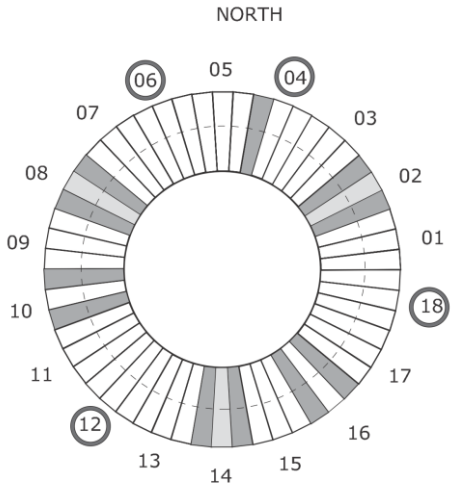
- ✓ Upper Level: 12 Diagnostic Ports
- ✓ Equatorial Level: 9 Diagnostic Ports
- ✓ Divertor Level: 9 Diagnostic Ports



Upper Ports



Equatorial Ports

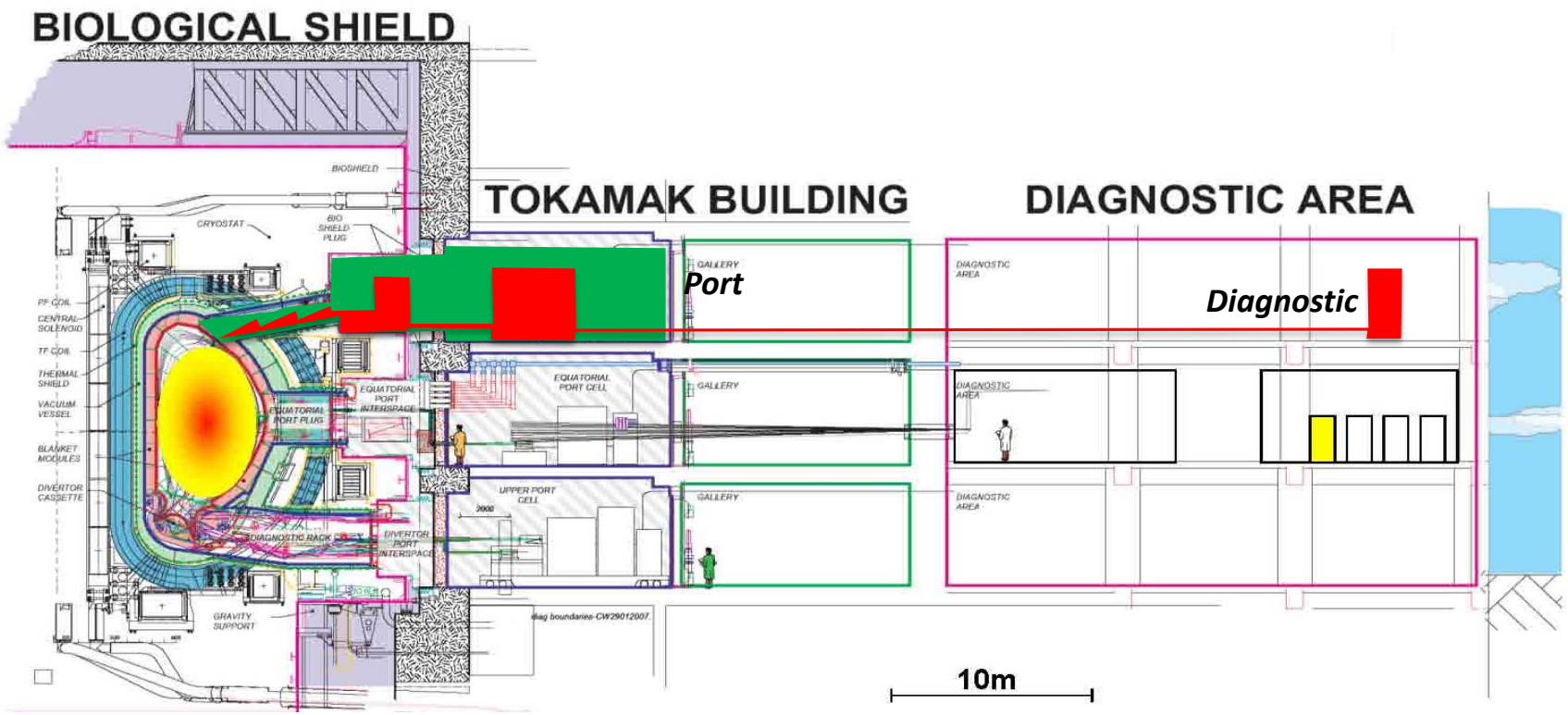


Lower Ports

EU Ports

ITER: DIAGNOSTIC PORTS

ITER: DIAGNOSTIC PORTS



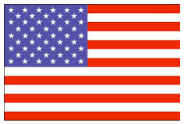
ITER: DIAGNOSTIC PORTS

At the EU Ports (UP01, UP03, UP17, EP01, EP10) there are 17 different diagnostics

- ✓ 3 diagnostics in eachUpper Port (x3)
- ✓ 8 diagnostics in EP01
- ✓ 5 diagnostics in EP10

8 diagn. EU-DA

2 diagn. CN-DA



2 diagn. US-DA

1 diagn. RF-DA

4 diagn. JA-DA

Port	PBS	DIAGNOSTICS	DA
1	55.D1	Bolometers	EU
	55.E4	Divertor Impurity Monitor (Div. Vis/UV)	JA
	55.E3	Plasma position reflectometry (PPR)	EU
3	18.GC	Glow discharge system	CN
	55.B3	Microfission Chambers	JA
	55.E1	CXRS Based On DNB (Core)	EU
17	55.D1	Bolometers	EU
	55.F9	Reflectometer (Main Plasma, HFS)	RF
	55.GA	Vis/IR Cameras (Upper)	US

Port	DSM	PBS	DIAGNOSTICS	Resp.
1	1	55.E4	Divertor Impurity Monitor	JA
		55.EB	MSE Based On Heating Beam	US
		55.G3	Pressure Gauges	EU
	2	55.B1	Radial Neutron Camera (ExPort)	EU
		55.B7	Radial Gamma Ray Spectrometers	EU
		55.BB	BB: High Resolution Neutron Spectrometer	EU
		55.D1	Bolometers	EU
	3	55.B1	Radial Neutron Camera (In-Port)	EU
		55.B4	Neutron Flux Monitors	CN
		55.D1	Bolometers	EU
10	1	55.C2	Edge Thomson Scattering	JA
	2	55.C6	Polarimeter Poloidal	JA
	3	55.C1	Core Thomson Scattering	EU
		55.F3	Plasma position reflectometry	EU
		55.G3	Pressure Gauges	EU

EU PORT INTEGRATION

EU PORT INTEGRATION

IDOM has a Framework Contract with F4E for the engineering phase (up to build-to print phase) :

- ✓ First Phase (Mid 2014-2015)
  1. Preparatory works on Project Management
  2. Diagnostics Integration – First Loop
  3. Preliminary Design of two EU Ports
  4. First End-to-end analysis of two EU Ports.

- ✓ Second Phase (2016)
  1. Second Design Loop
  2. Interface Definition with Tenants – second loop
  3. Early prototyping - Electrical Feedthroughs Feedthroughs (SIC-1)

- ✓ Next Phases …

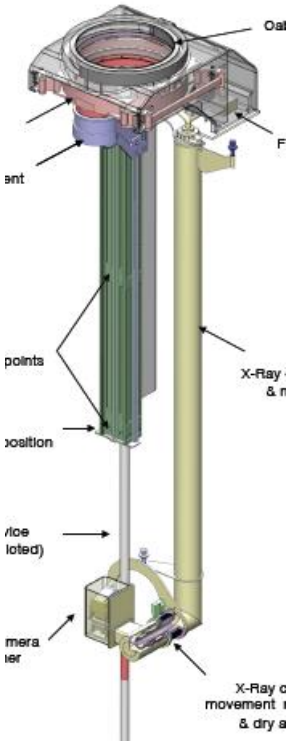
EU PORT INTEGRATION

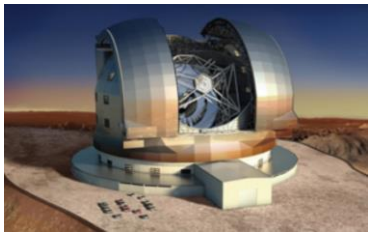
IDOM was founded in 1957, more than 2000 employees and 37 offices in 20 countries.

Big experience in nuclear projects, scientific installations, instrumentation and machining, and systems engineering.

30 people working in the project, a common pull-out of resources for the integration and design of the five EU ports. :

- ✓ System Engineering
- ✓ Design and CAD
- ✓ Analysis
- ✓ Project Management
- ✓ Quality Assurance & Control
- ✓ Different Experts (nuclear, vacuum, manufacturing, tests, etc)

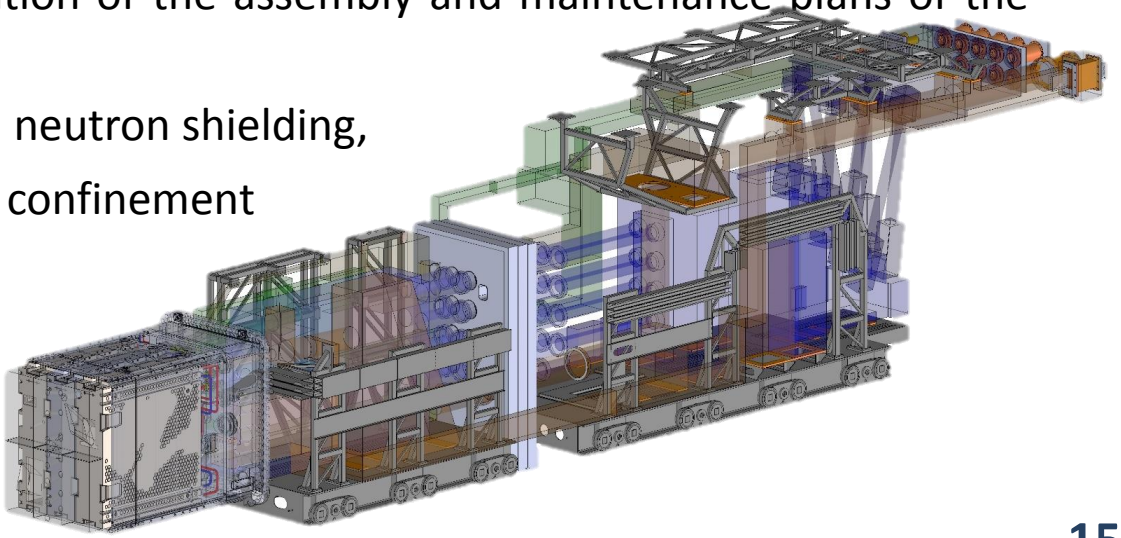




EU PORT INTEGRATION

European Integrator duties: **Integration Design of ITER Ports**

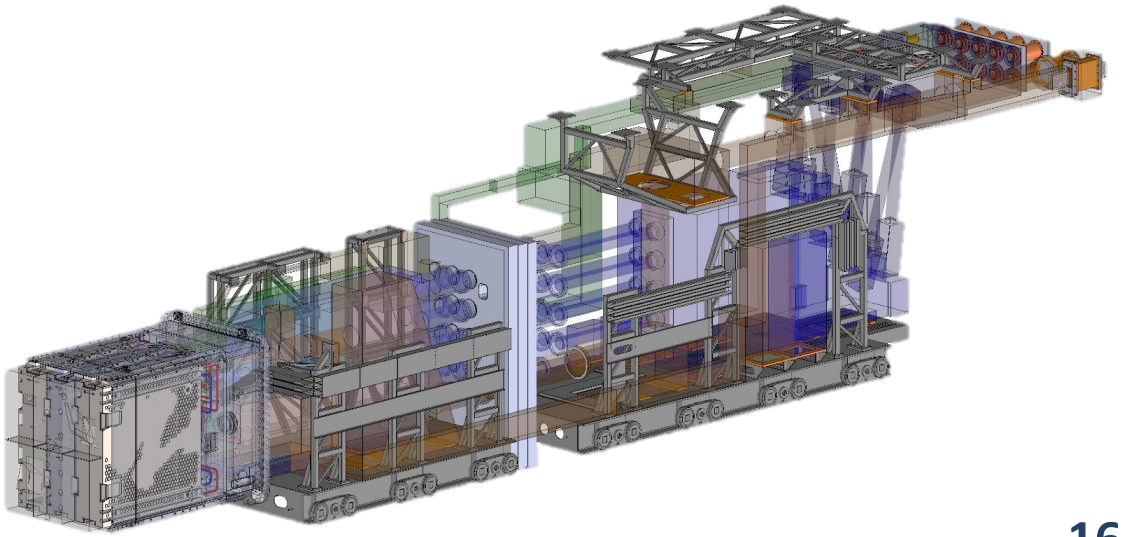
- ✓ House diagnostics
- ✓ Provide services (cooling water, gas, vacuum (SVS), electrical connection)
- ✓ Ensure diagnostics funcionability and maintenability
- ✓ Lead the interface definition
- ✓ Lead Port System Assembly and Maintenance plans:
  - Plan Port Assembly and Maintenance Plans
  - Guarantee the integration of the assembly and maintenance plans of the diagnostics
- ✓ Contribute to confinement: neutron shielding, vacuum confinement, thermal confinement



EU PORT INTEGRATION

Challengues of EU Port Ingrator

- ✓ Large number of diagnostics in a reduced space.
- ✓ Limited services
- ✓ Extreme environment: direct view of the plasma, electromagnetic disruptions, seismic loads, high temperatures
- ✓ Manage the Port System global assembly and maintenance plan
- ✓ Be capable of involving all Tenants in the integration works
- ✓ Design of components in nuclear environment: SIC-1 and ESPN



EU PORT INTEGRATION

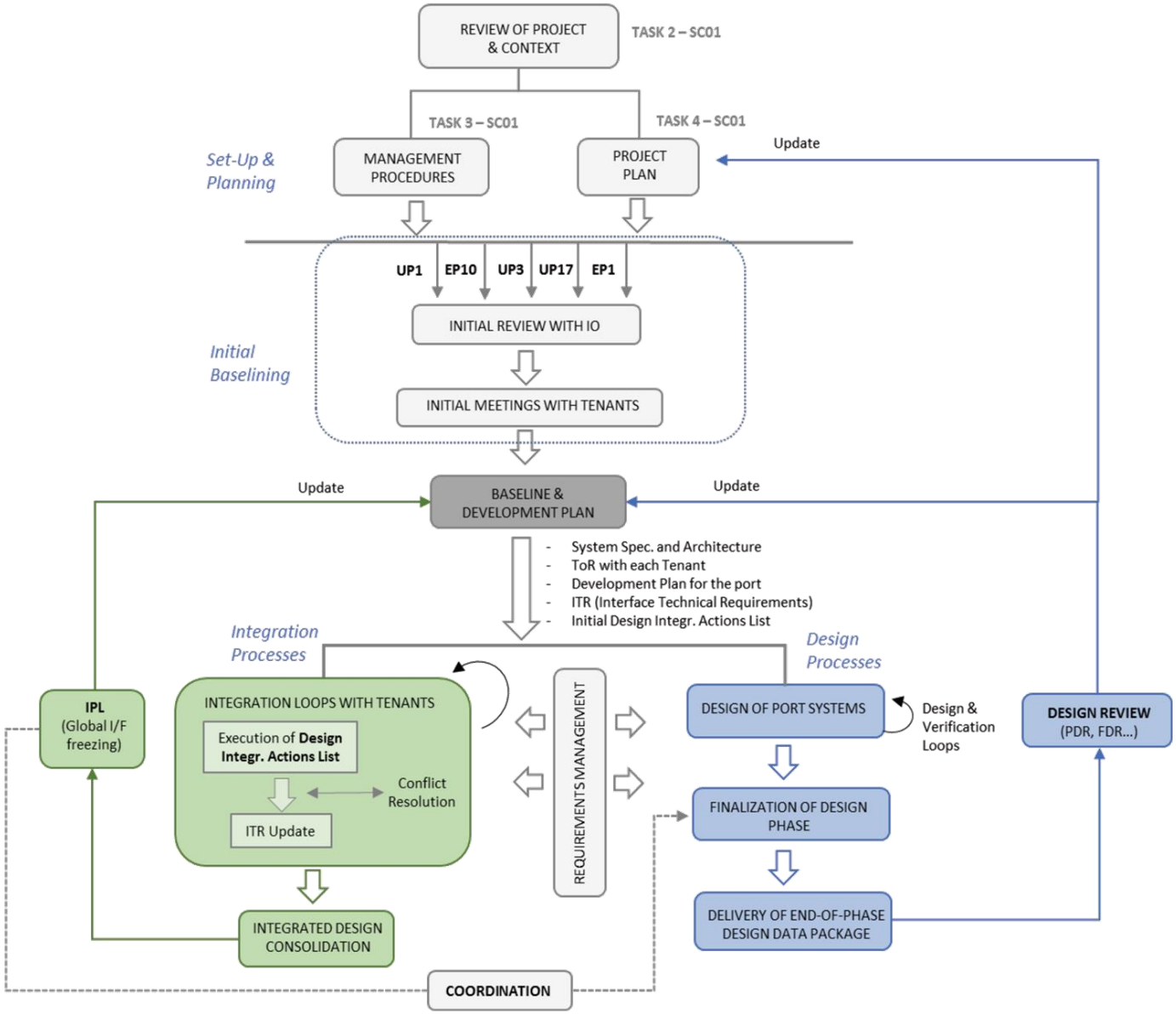
1. Project Management

PROJECT MANAGEMENT

F4E & IDOM working as a whole – IO in the loop

1. Identification of stakeholders
2. Identification of applicable documents
3. Review of applicable documents
   - CAD models
   - Applicable documents
   - History of designs and state-of-the-art technologies
4. Integration design strategy definition
   - Interface Management
   - Requirements Management
   - Communication and Documental Control
   - Engineering Analyses methodology

PROJECT MANAGEMENT



EU PORT INTEGRATION

2. Integration of diagnostics

INTEGRATION OF DIAGNOSTICS

Integration Strategy:

1. Initial study of each diagnostic
2. F4E – IO review meetings
3. Initial meetings with tenants
4. First Issue of Internal Interfaces Document (ITR)
5. Review of the ITR with the tenant.
6. Integration Action List
7. Progress meetings with Tenants

INTEGRATION OF DIAGNOSTICS

Diagnostics Status:

- ✓ Different laboratories and DAs
- ✓ Different cultures in design and management
- ✓ At different stages of the designs
- ✓ With different resources

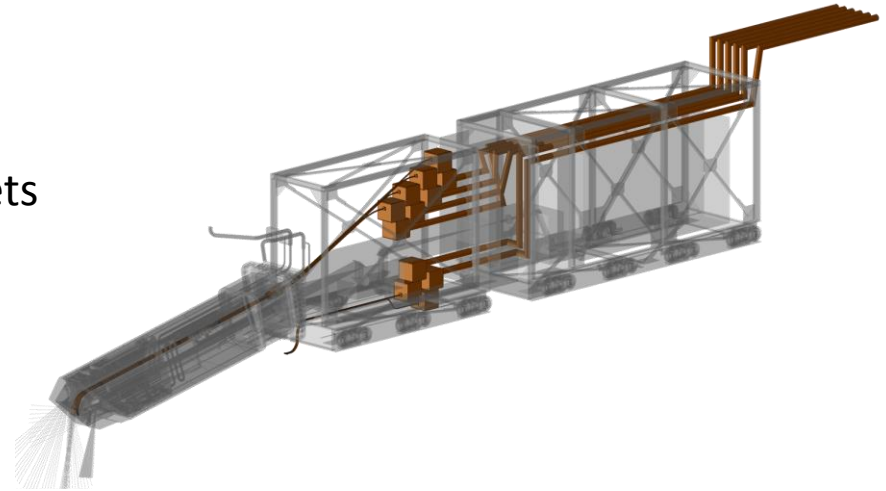
INTEGRATION OF DIAGNOSTICS

SISTEMA PUERTO = Puerto + Diagnosticos + Servicios

Some key issues of the integration

- ✓ The integrator leads the integration in the Port
  - The integrator manages the port resources.
  - Leads the internal interfaces definition
  - Is the interlocutor with the other ITER-PBS in the Port System

- ✓ Is key to minimize (ideally remove) la interdependence of diagnostics:
  - Allowable volume in the port
  - Different stages of the design
  - Weight, neutronic, services, etc. budgets



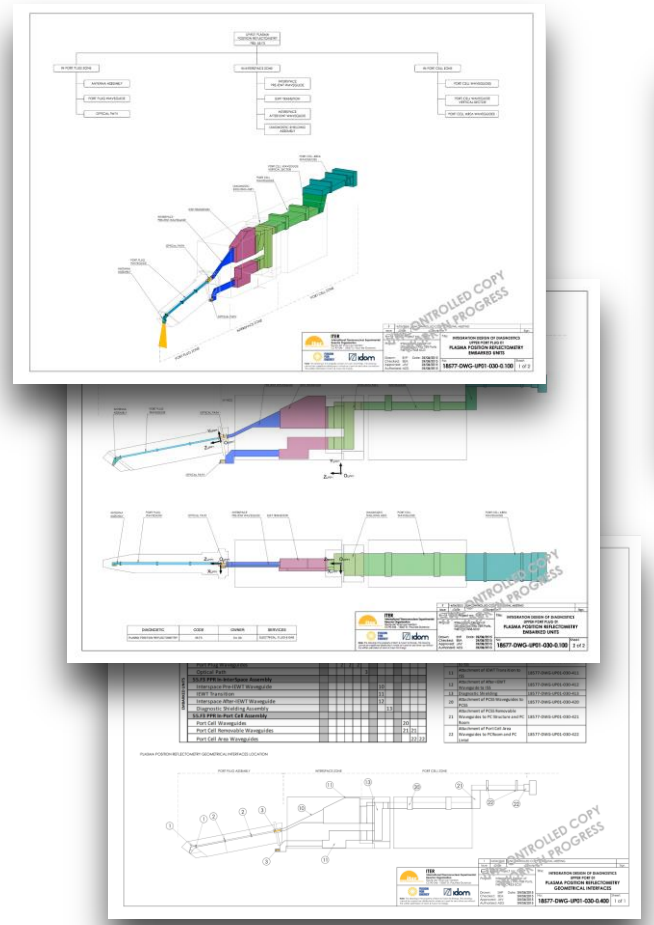
INTEGRATION OF DIAGNOSTICS

Integration Design of Diagnostics Into ITER Ports

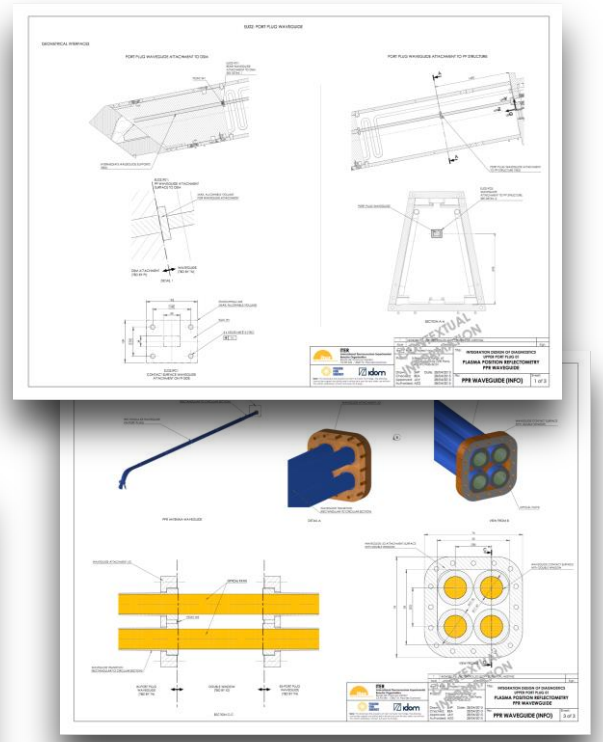
F4E-OFC-433-SC01

INTERFACE TECHNICAL REQUIREMENTS ITR EP#10 PORT AND F3 PPR [DX.XX]

ITR main document
(Interface Technical Requirements)

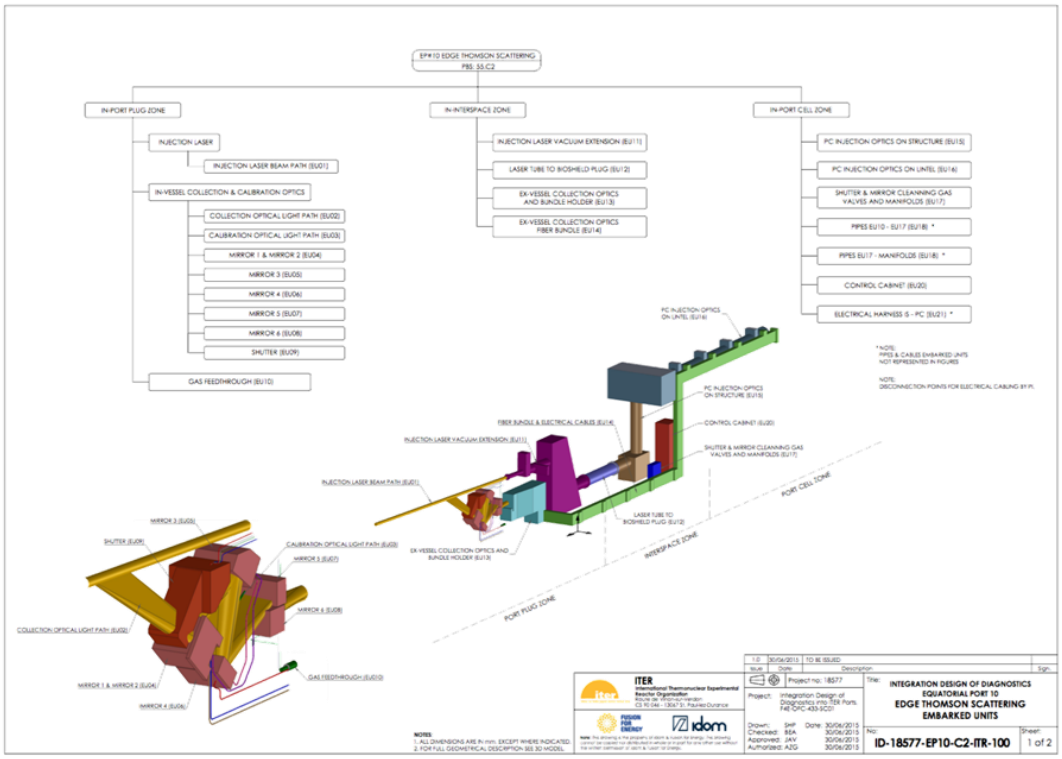


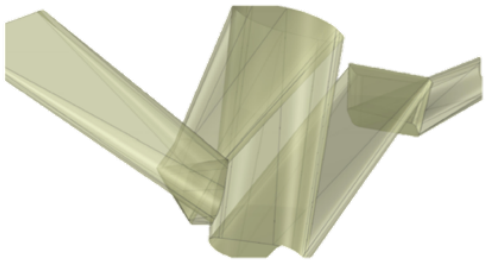
ITR applicable drawings

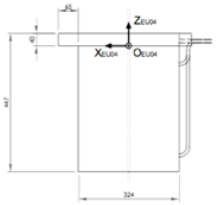


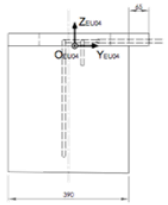
ITR contextual drawings

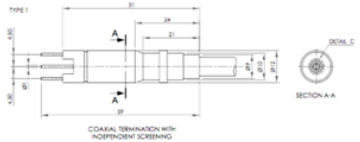
INTEGRATION OF DIAGNOSTICS

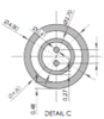


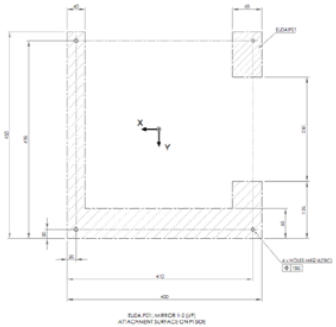


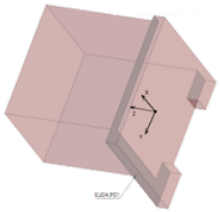


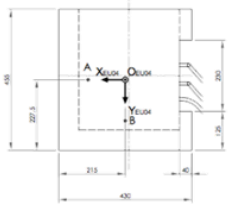


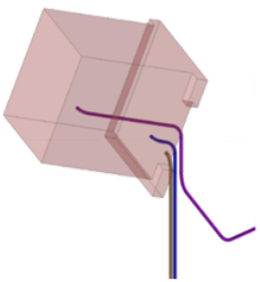




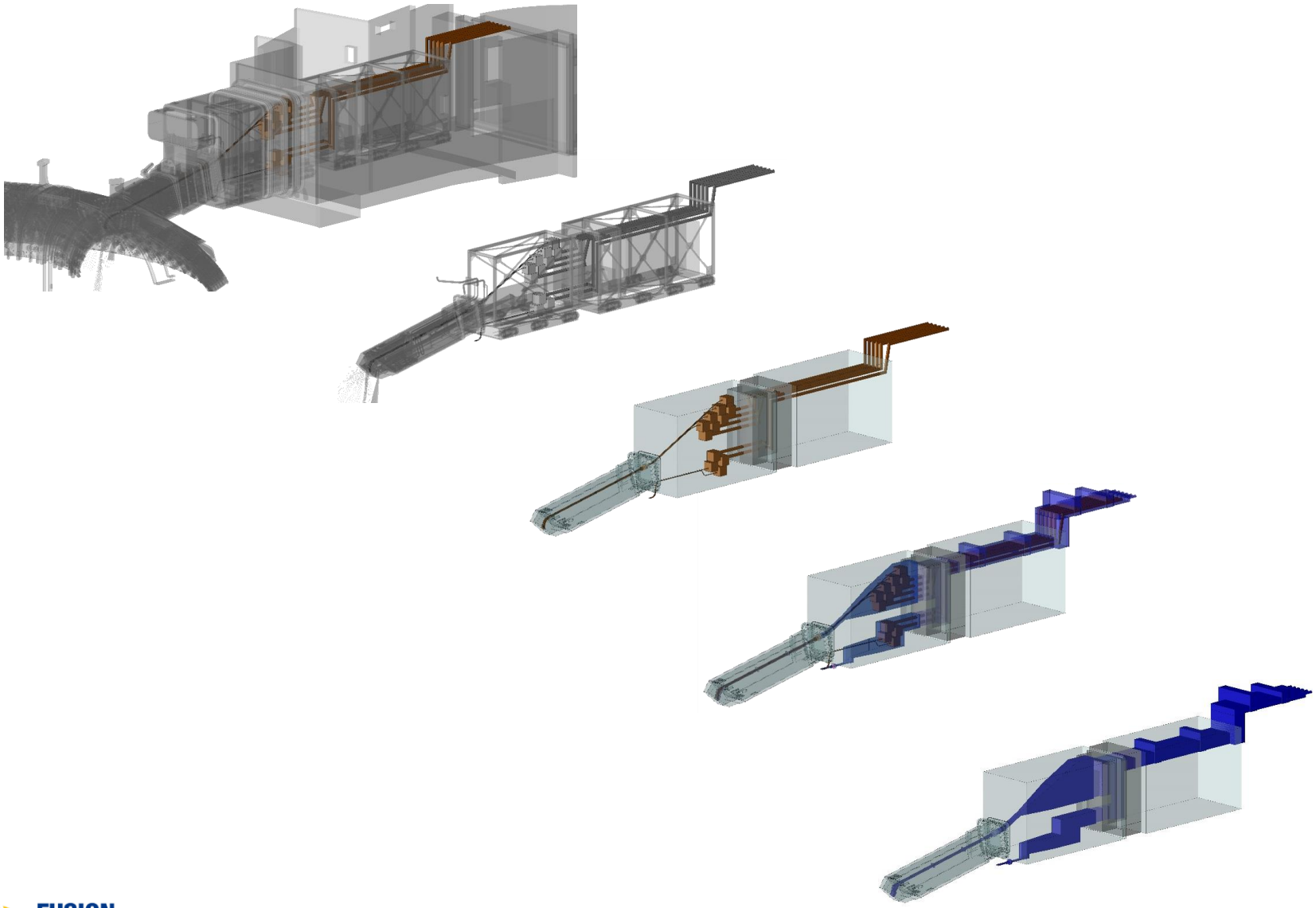








INTEGRACIÓN DE DIAGNÓSTICOS



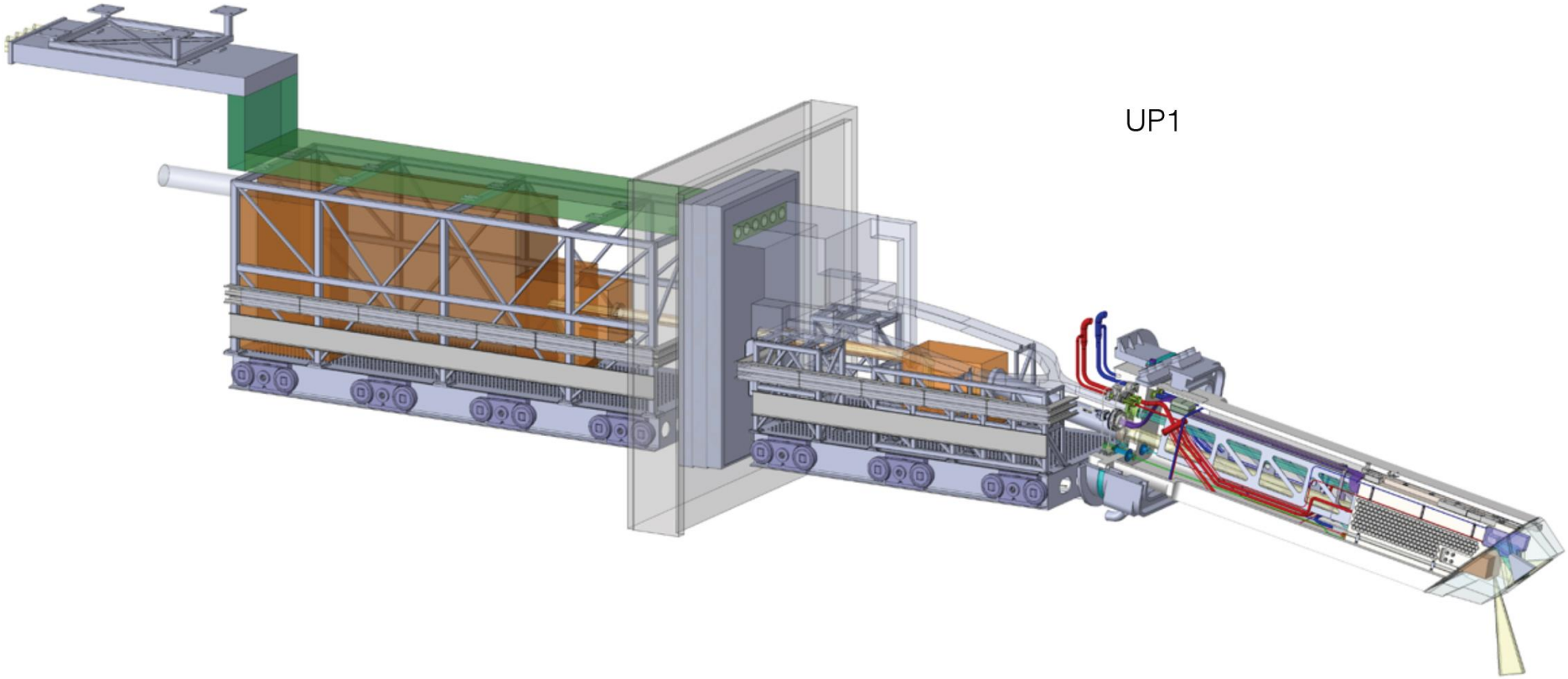
EU PORT INTEGRATION

3. Preliminary Design of UP01 and EP10

PORT DESIGN

PORT DESIGN

Preliminary Design based on ITER proposal for a generic port plug, particularized at this stage of the project considering diagnostic needs, maintenance, RH, etc.



PORT DESIGN

Identification of oomponents and critic issues:

DSM architecture and manufacturability

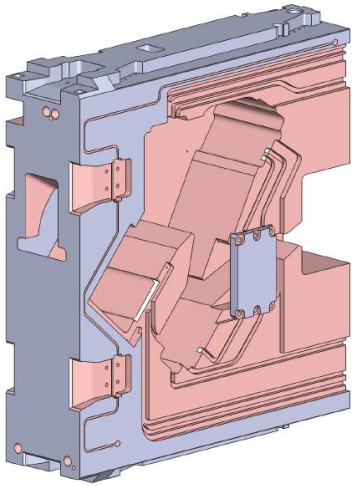
- ✓ Great variety of diagnostics:
  - Different needs
  - Sometimes with opposite requirements
  - Balance of: neutronic shielding, weight, cooling water needs.
- ✓ Definition of a common architecture and design guidelines for all EU-DSMs
- ✓ Survey and selection of potential manufacturing suppliers

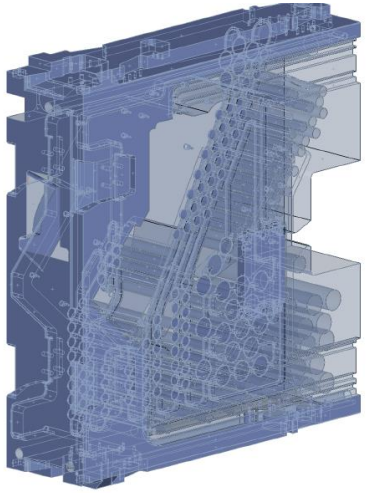
Feedthroughs (in particular, electrical feedthroughs):

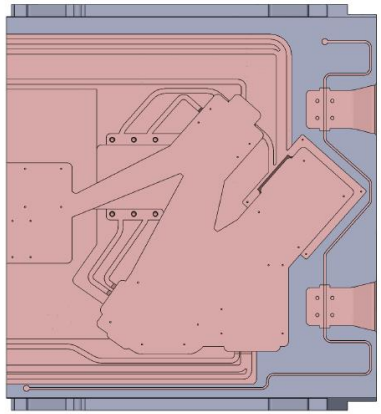
- ✓ Critic SIC-1 components, which require special manufacturing processes
- ✓ Initial electrical feedthrough design and definition of a development plan (early prototyping in 2016 for manufacturing tests)

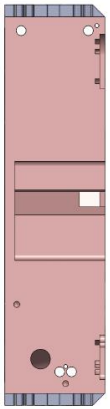
DISEÑO DE PUERTOS

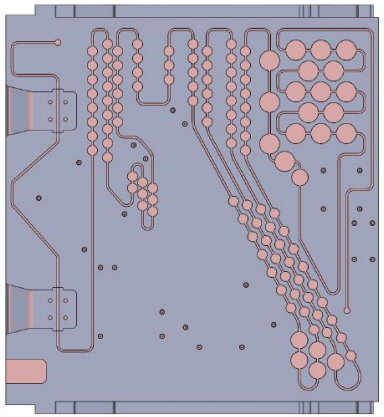
Diseño del DSM – Diagnostic Shielding Module





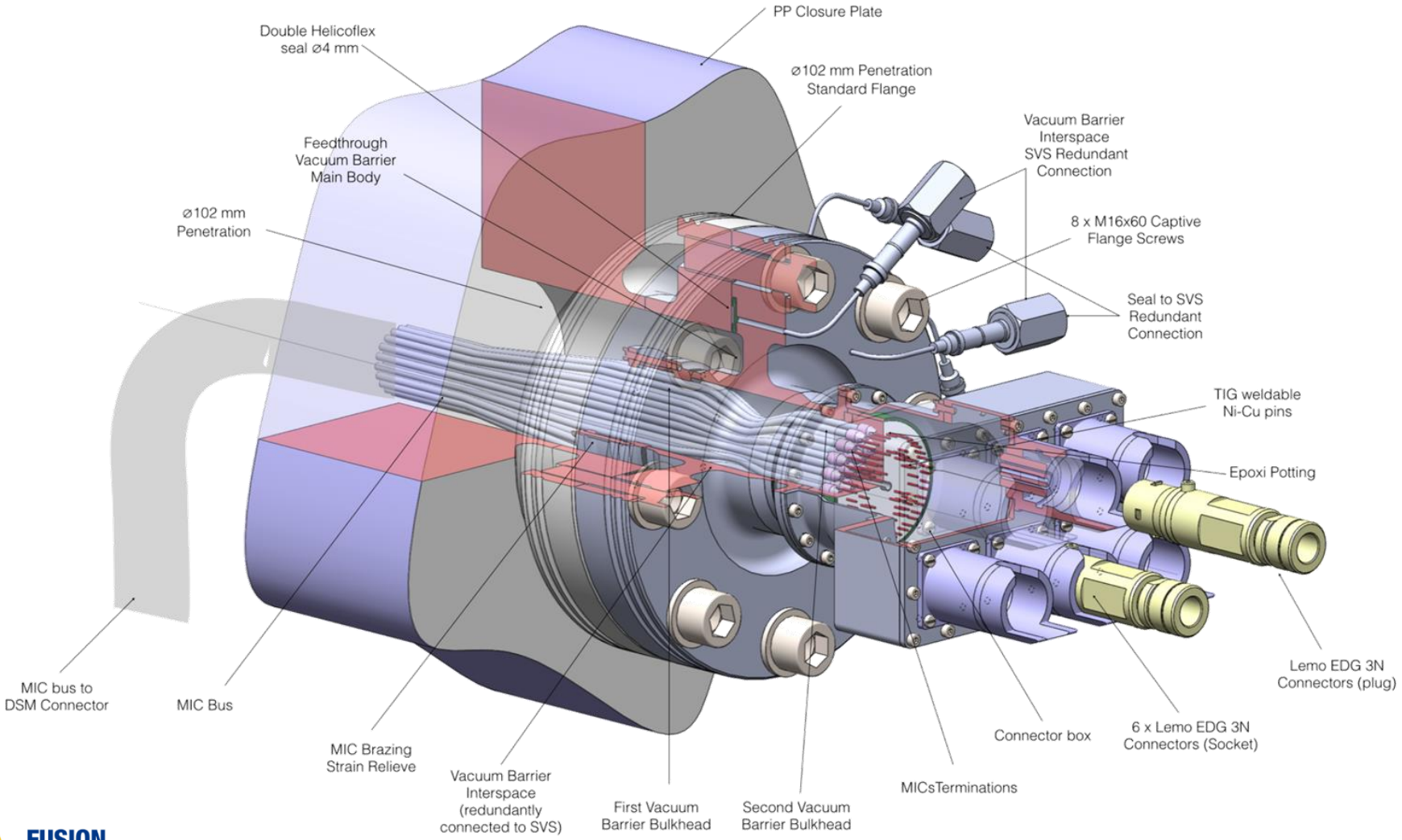






DISEÑO DE PUERTOS

Diseño de Feedthroughs Eléctricos



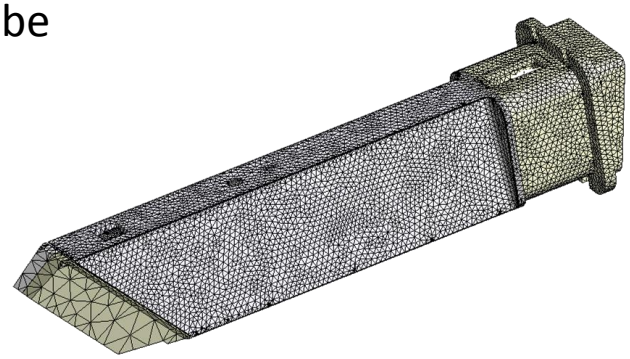
EU PORT INTEGRATION

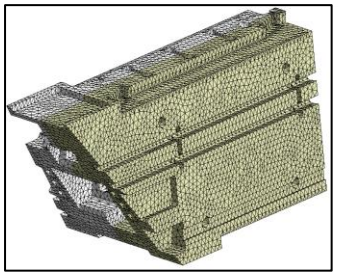
4. End-to-end analyses of UP01 and EP10

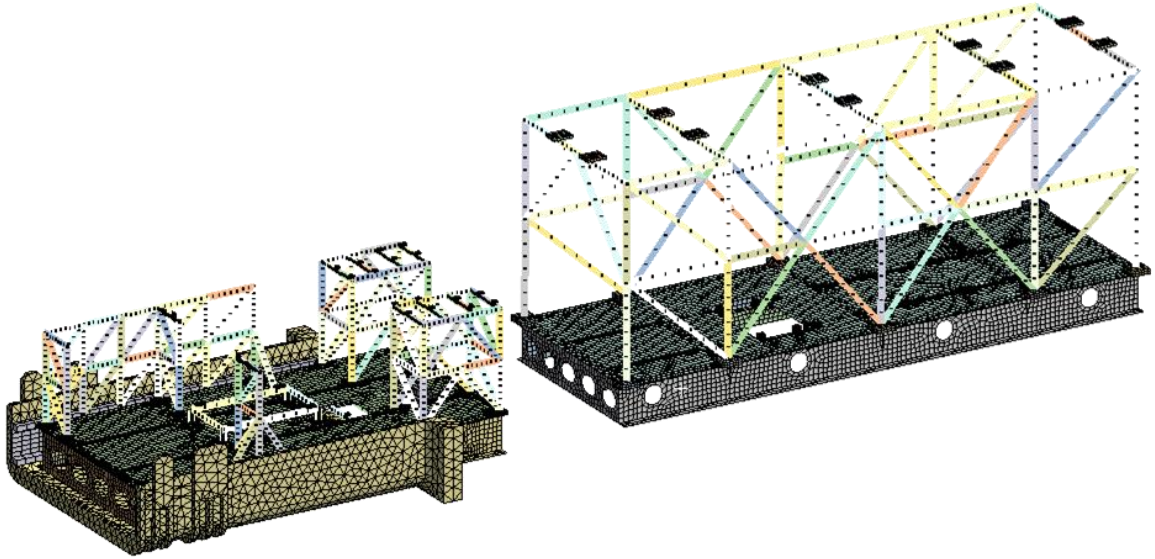
END-TO-END ANALYSES

Identify which of the functional requirements can be verified by means of engineering analyses

- ✓ Structural Analyses
- ✓ Thermohydraulic Analyses
- ✓ Electromagnetic Analyses
- ✓ Neutronic Analyses







PUERTOS EUROPEOS

Priority: stabish the flow diagram for the analysis process

 # 3 Mechanical Support and fixation of DFW-DSMs to GPP structure ensuring adequate load transfer, avoiding overconstraints and minimizing vibr

 # 4 Limited deflections of port plug assembly to avoid collision with vessel walls

 # 5 Structural support of diagnostics (DSMs, ISS, PCSS) with limitation of displacements/vibrations when required for diagnostic functionality

 # 6 Limited relative displacements between PP and IS/PC (especially, for diagnostic vacuum extensions)

 # 8 Integrity against plastic collapse (PP, ISS, PCSS)

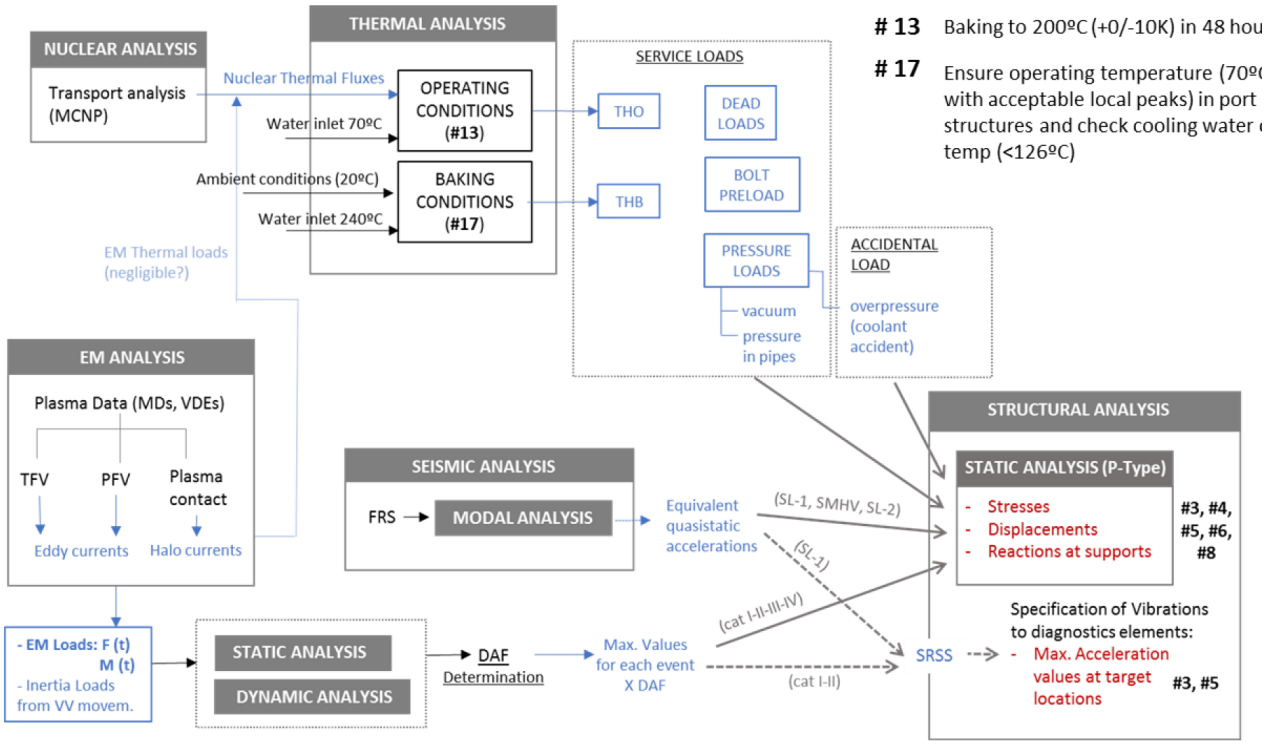


Fig. 3-1 Analysis flow diagram for P-Type damage

CLOSING WORDS

- ✓ This is a challenging project from many perspectives (technical, managerial, institutional)
- ✓ The project scheme set-up by F4E-IDOM puts together the required experience, resources and tools to bring this project to a successful end.
- ✓ During this first year:
  - Fast set-up with important achievements in terms of system engineering / interfaces definition for diagnostics, initial port integration system designs for UP1 and EP10, and technology development for DSMs and feedthroughs.
  - Based on a very positive and fruitful collaboration with IO and Tenants

Integration Design of Diagnostics into ITER Ports

Thanks for your attention

FUSION FOR ENERGY idom

19 de Noviembre de 2015