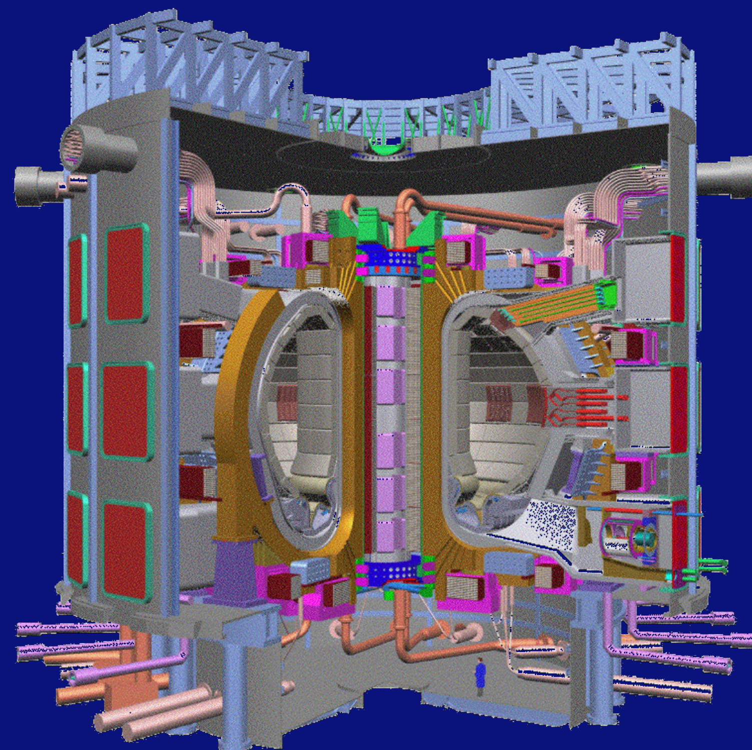
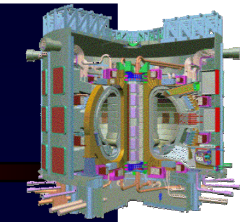


Status of ITER project

P Barabaschi
ITER Team

SOFE – Knoxville 26th September 2005

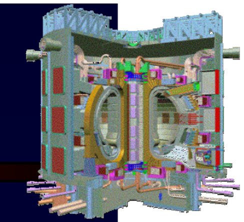
Outline



- Site Selection
- Negotiations Status
- Design Activities
  - General
  - Site Specific
- Licensing Preparation
- Codes and Standards / QA
- Conclusions

The ITER Construction Site

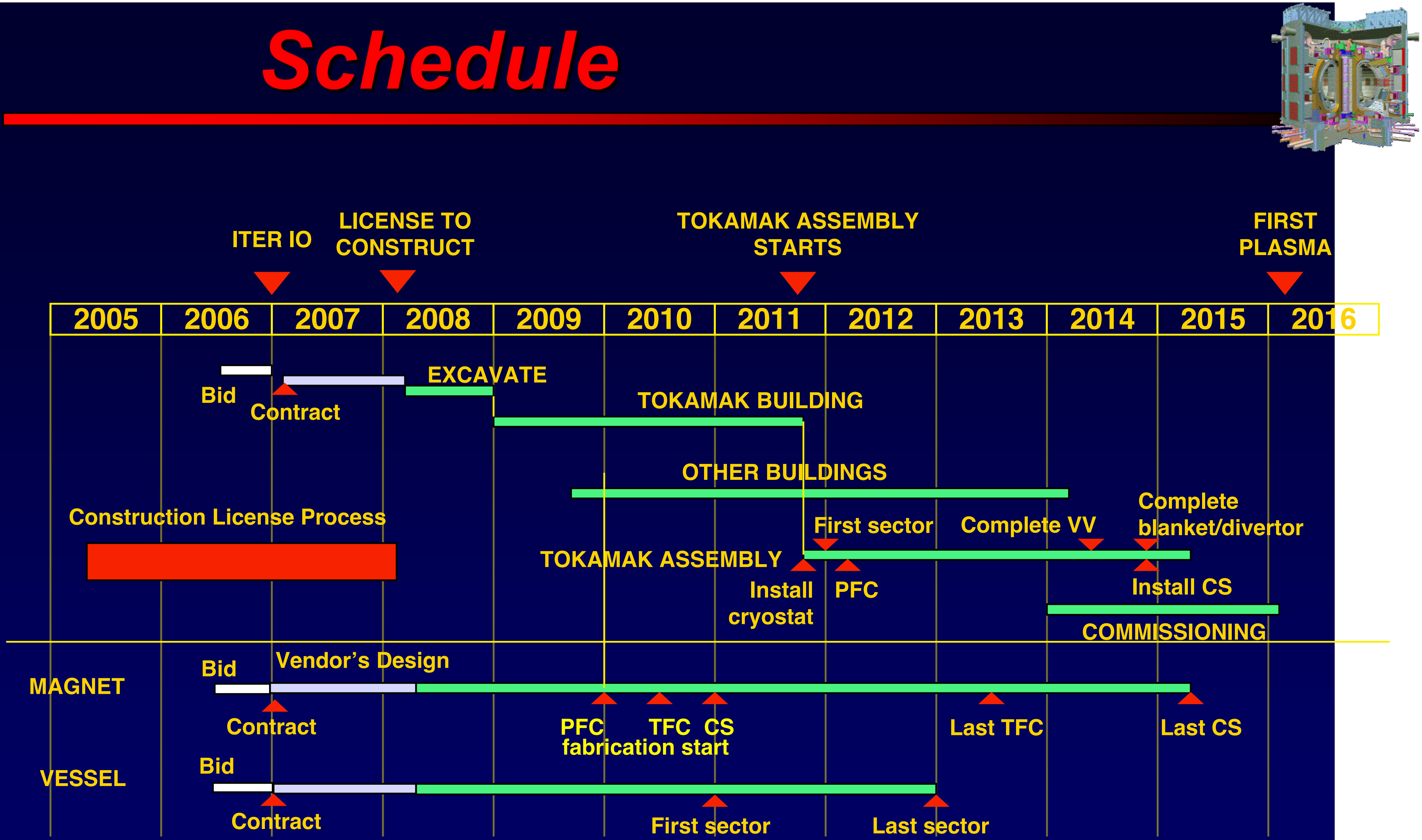
Negotiation Status



- ITER Parties are now in the process of finalising the Joint Implementation Agreement and its main instruments.
  - Main Agreement Text
  - Staffing regulations
  - Procurement and cost sharing
  - Intellectual Property Rights
  - Principles of Operation Programme
  - Resource Management
  - Principles on management, procurement

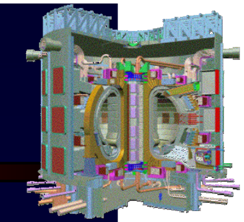
- September: NSSG11/N Meeting
- October: NSSG12/N Meeting,
- November: High level “P” Meeting, DG selected
- December: NSSG13/N Meeting , Finalisation of Drafts
- Spring 2006: Ministerial Meeting to “initial” Agreement
- Jun-Jul 2006: Agreement Formal Signature
- End 2006: Agreement enters into force

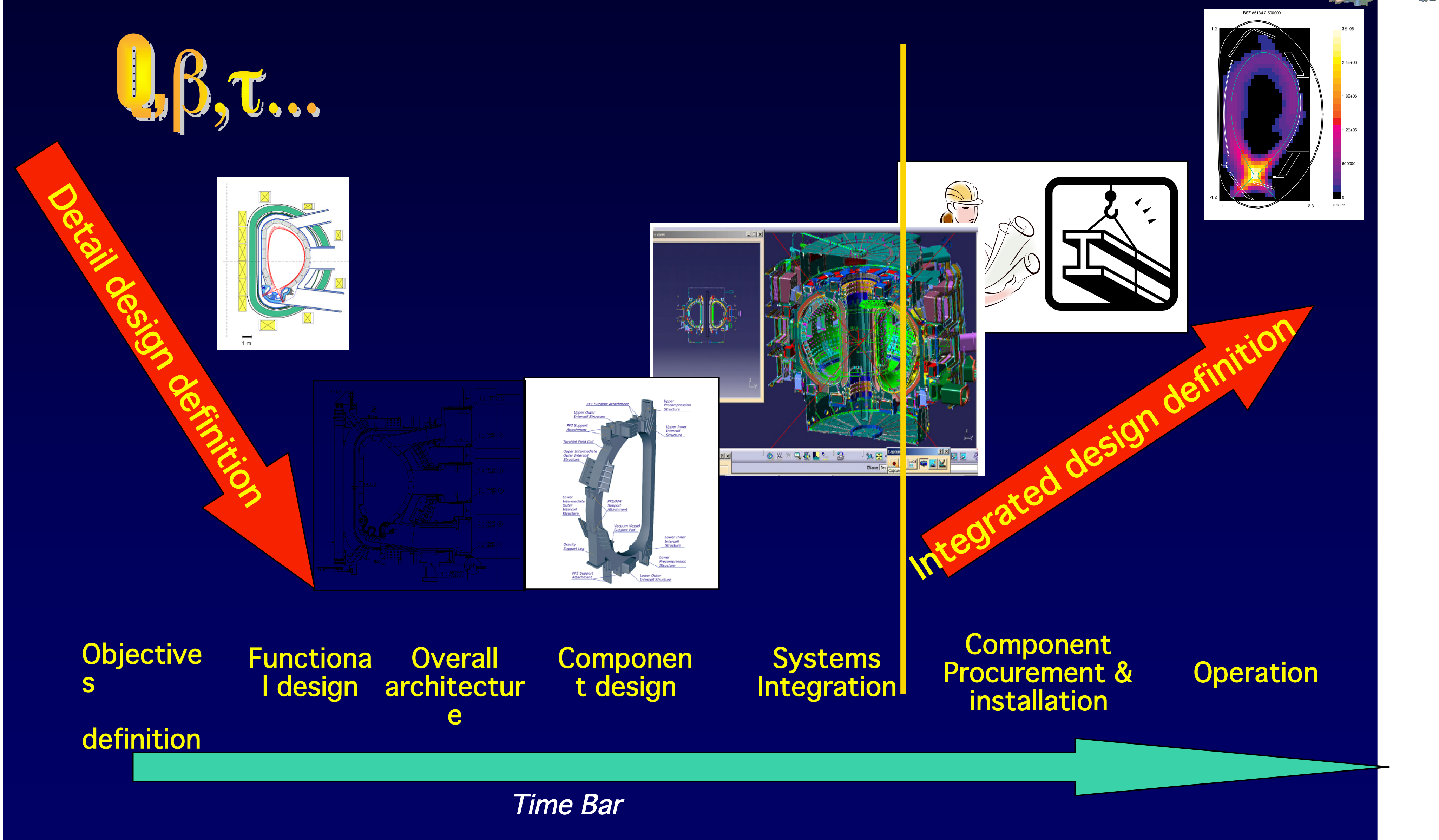
Schedule



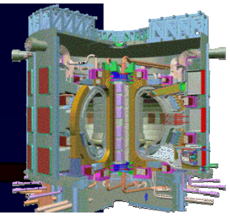
ITER IO
LICENSE TO CONSTRUCT
TOKAMAK ASSEMBLY STARTS
FIRST PLASMA
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Bid
Contract
EXCAVATE
TOKAMAK BUILDING
OTHER BUILDINGS
Construction License Process
First sector
Complete VV
Complete blanket/divertor
TOKAMAK ASSEMBLY
Install cryostat
PFC
Install CS
COMMISSIONING
MAGNET
Bid
Vendor's Design
Contract
PFC
TFC
CS
fabrication start
Last TFC
Last CS
VESSEL
Bid
Contract
First sector
Last sector

Technical Work Status



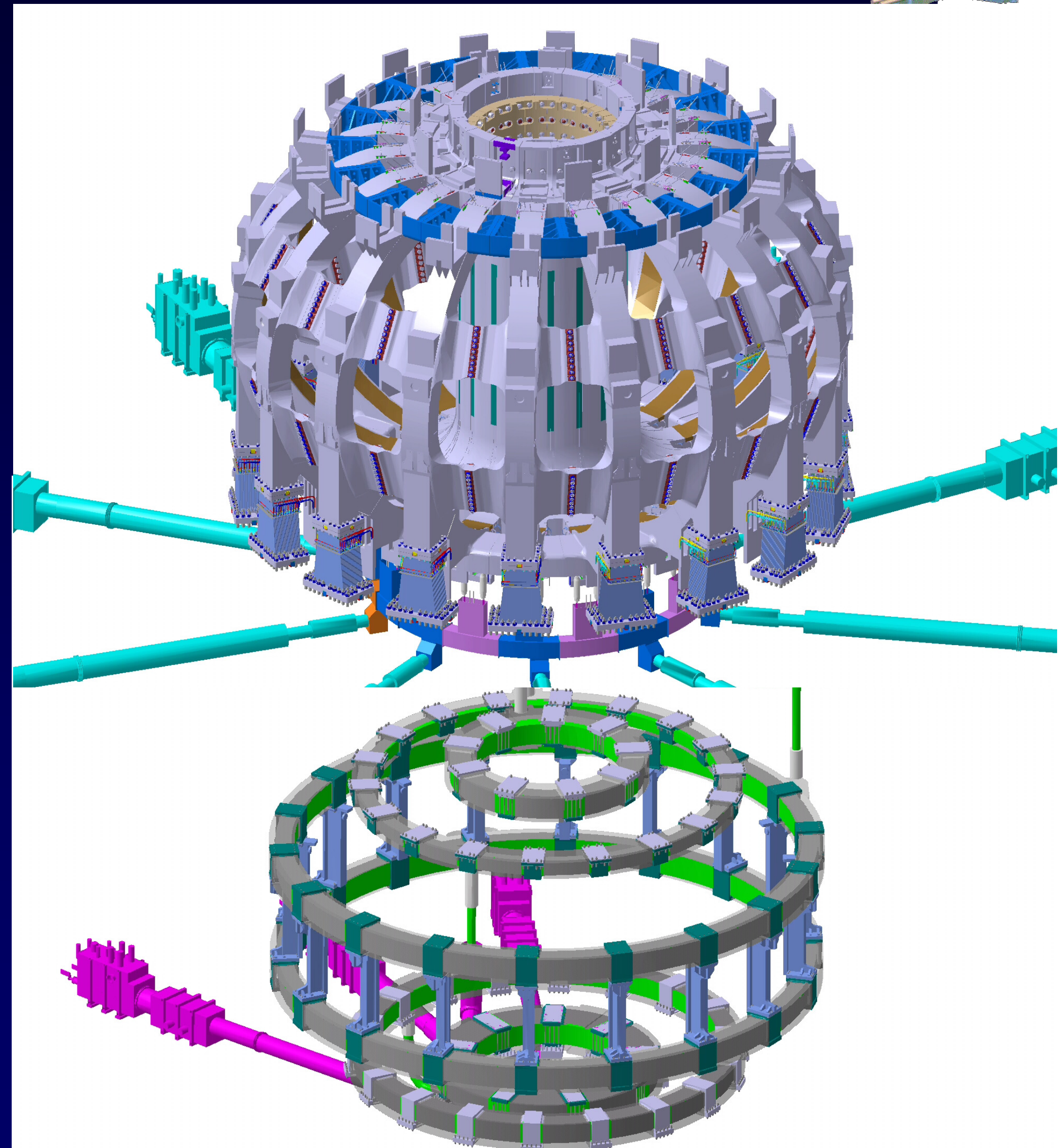


Status of the Design: Machine core



Magnets

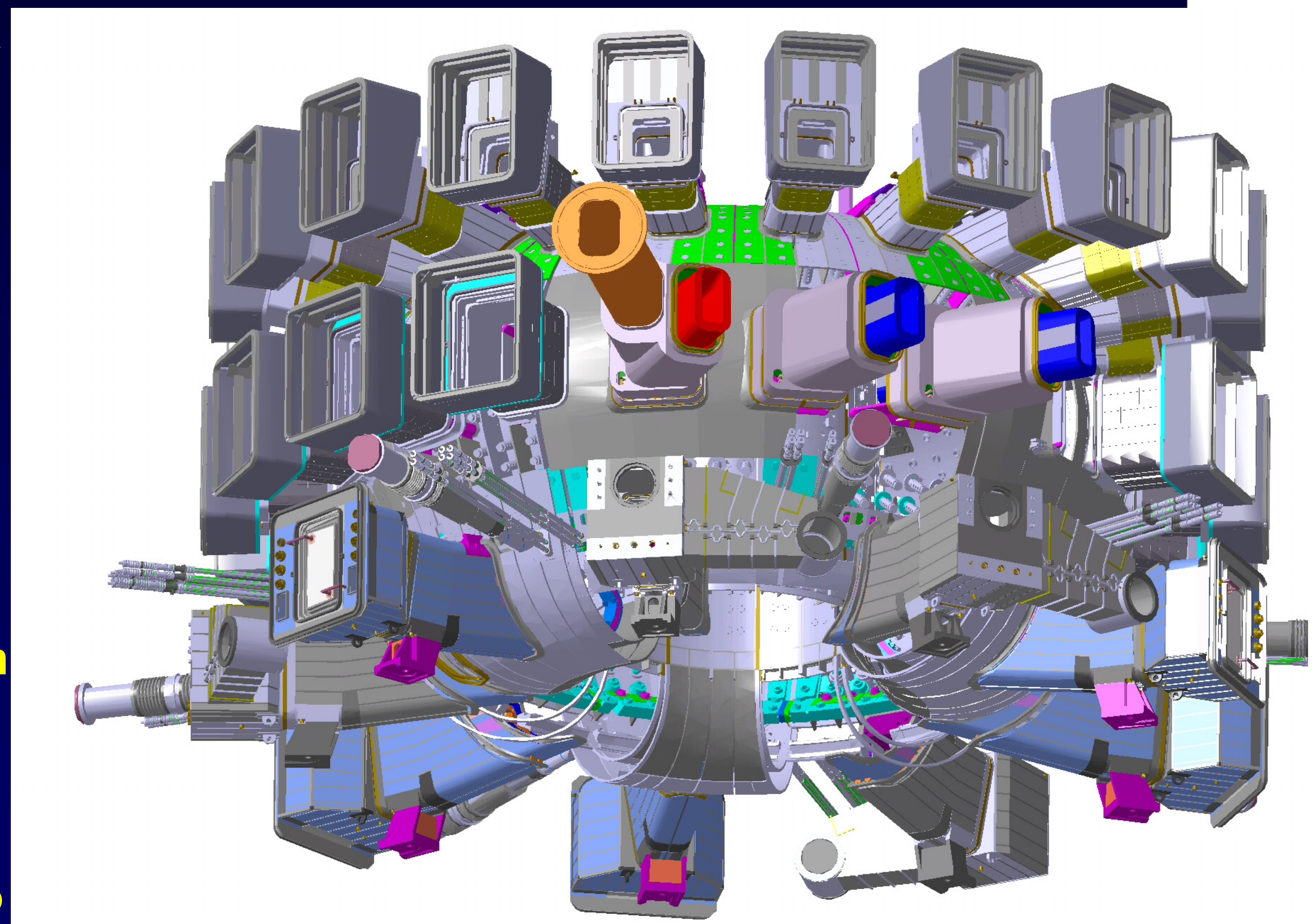
- Geometry and overall as in FDR 2001
- Detailed design of the coil case manufacturing, intercoil structures
- Review of the construction plan and manufacturing and assembly equipment to be launched



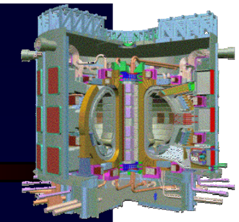
Status of the Design: Machine core

Vacuum Vessel

- Geometry and overall design is stable since a few years
- Detailed design of the standard sector largely completed
- Detailed design of the NB VV sector in progress
- Detailed design of the in-wall shielding, port structure, triangular supports , VV supports is in progress
- Review of the construction plan and manufacturing and assembly equipment to be launched

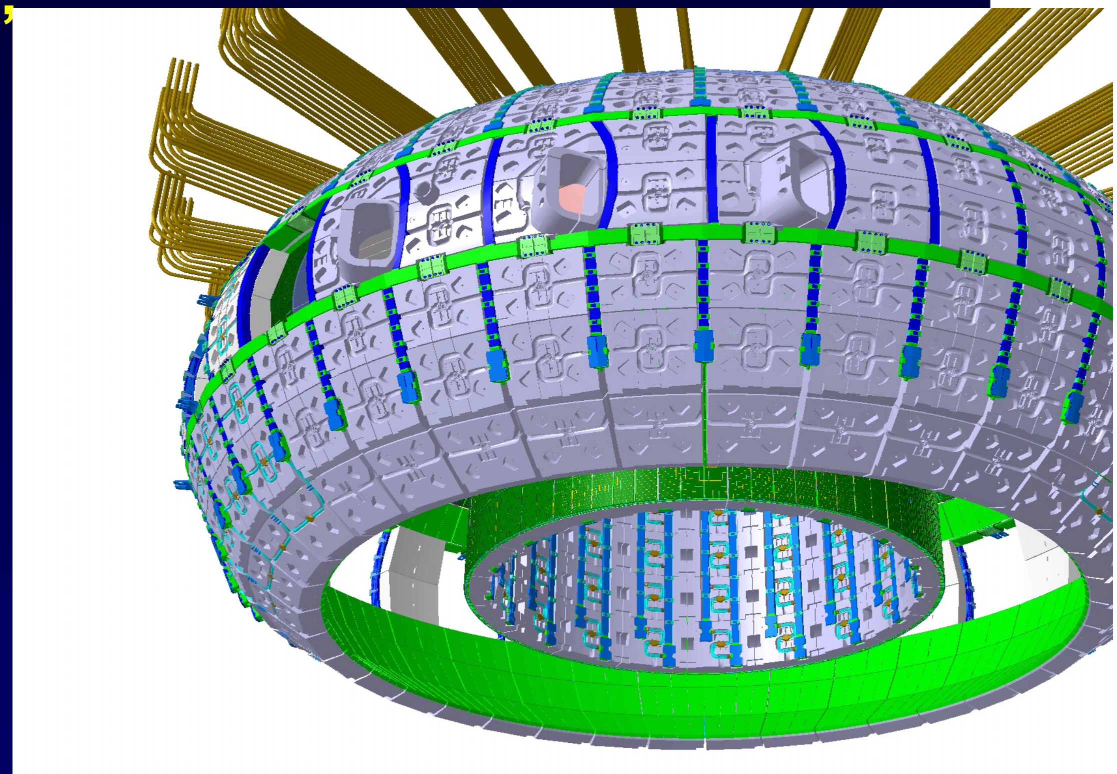


Status of the Design: Machine core



Blanket

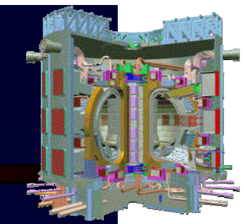
- Detailed design of the standards module completed, but additional work required for the modules in the NB sectors, in the lower region and near diagnostics and heating ports
- Port plugs design and handling being reviewed



Divertor

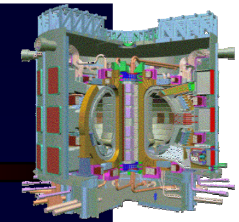
- Standard cassette detail design well advanced,
- Demonstration of the new attachment system underway

Status of the Design: Machine core



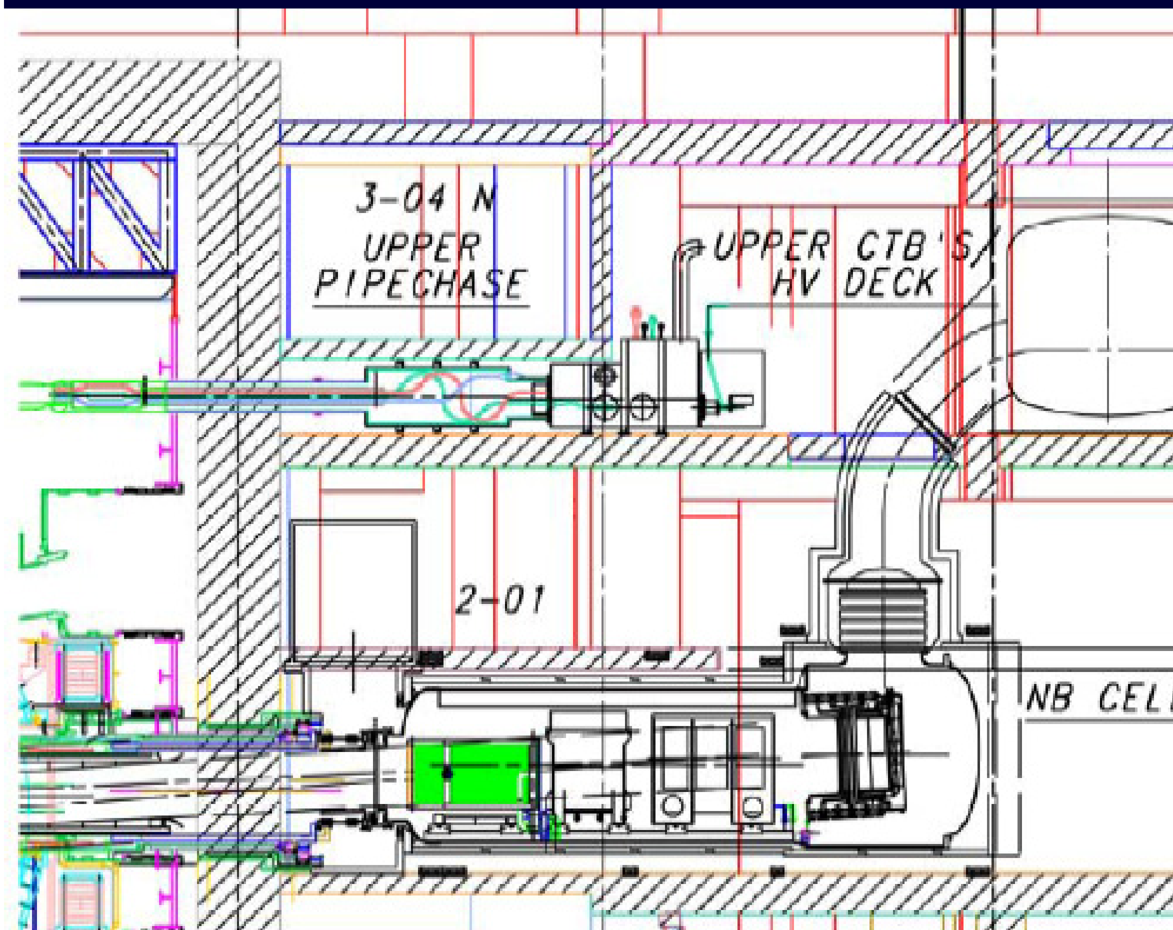
- **Cryostat:**
  - Detail design of the cryostat penetrations and supports in on going
- **Thermal shield:**
  - Design developed but limited resources to resolve some specific issues,
- **Diagnostics**
  - Many Integration issues still pending
- **Auxiliary heating systems**
  - The manufacturing design of none of them is fully completed

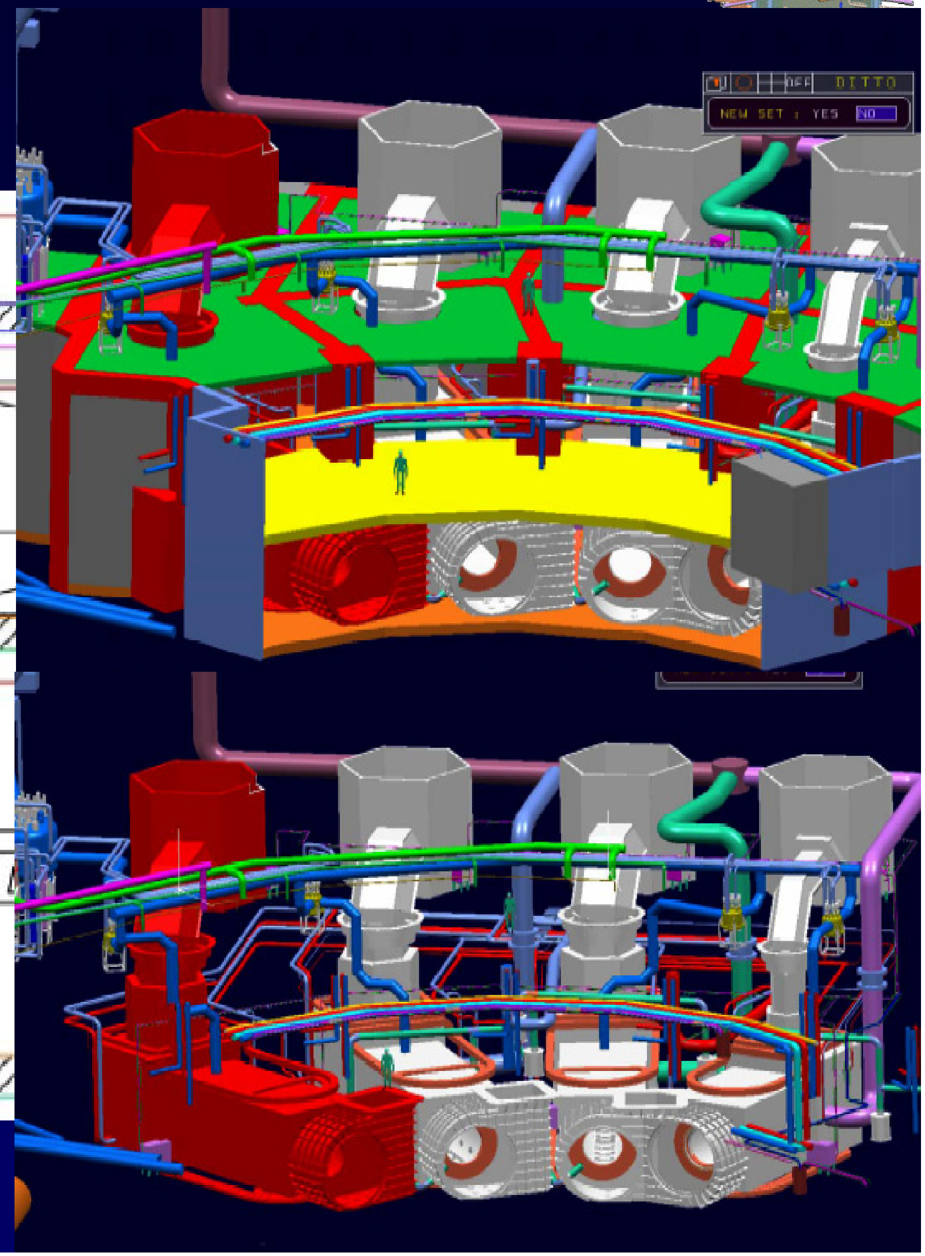
Integration Subjects "in work"



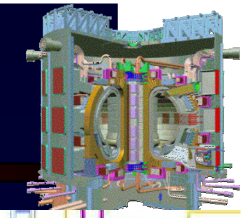
- **Port Plugs review.** ***Weight, shielding, gap clearance, handling and refurbishment facilities.***
- **Wall material, dust and tritium retention.** ***Suggestions for cleaning and higher temperature baking*.**
- **Pursue possibility of *ELM control*.**
- **Divertor gas seals?** ***(limit recycling to plasma and plasma density control issues),***
- **Divertor dome** ***(is it needed?),***
- **NBI Cell and NB maintenance – use of *NB cell as "Hot" cell*. Access to Diagnostic plugs above NB beam-lines.**
- **Outboard First Wall shape – <u>Limiter *(retractable)*</u> and ICRF antenna position. Considerations of start-up and ELM heat load distribution,**

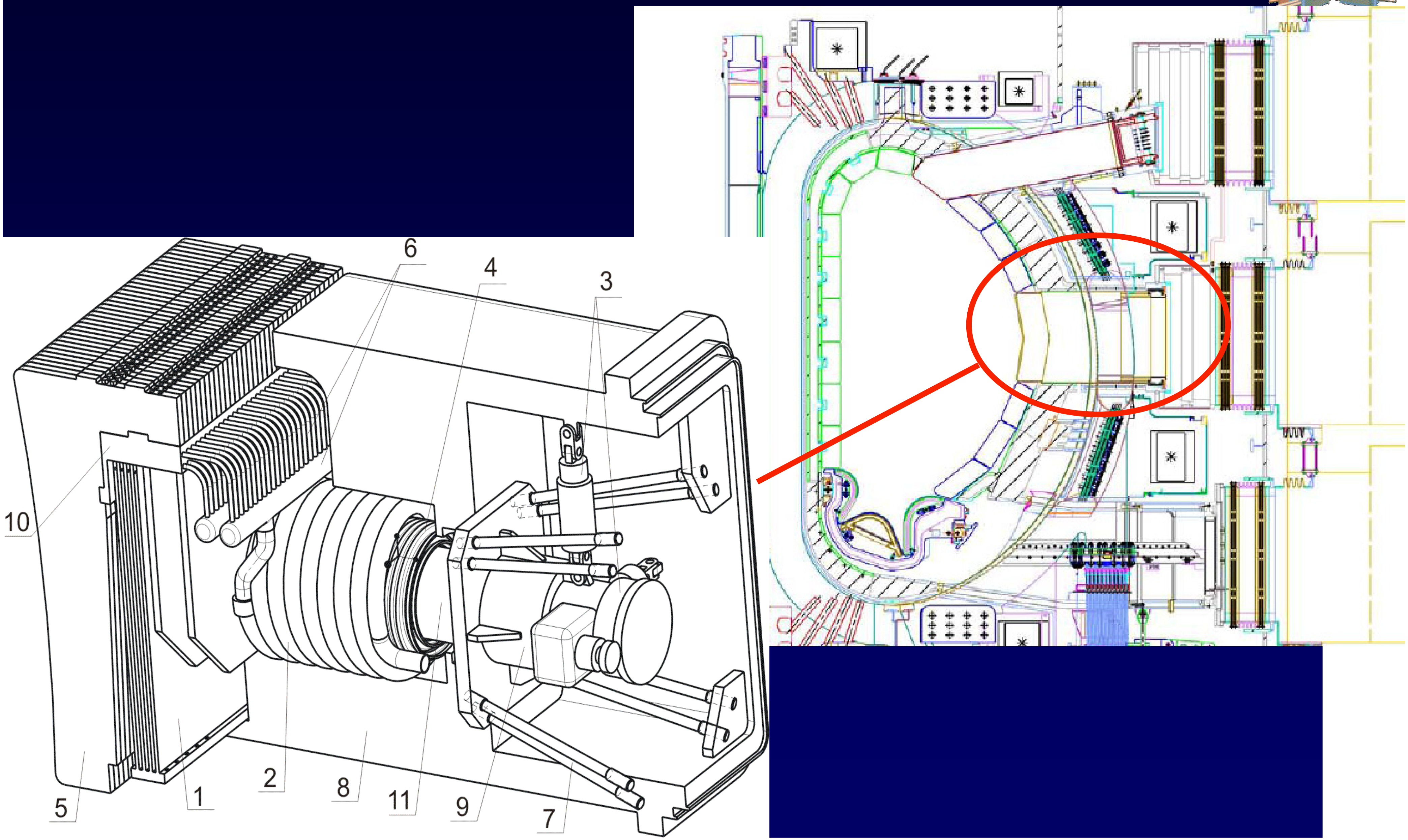
NB and diagnostic access



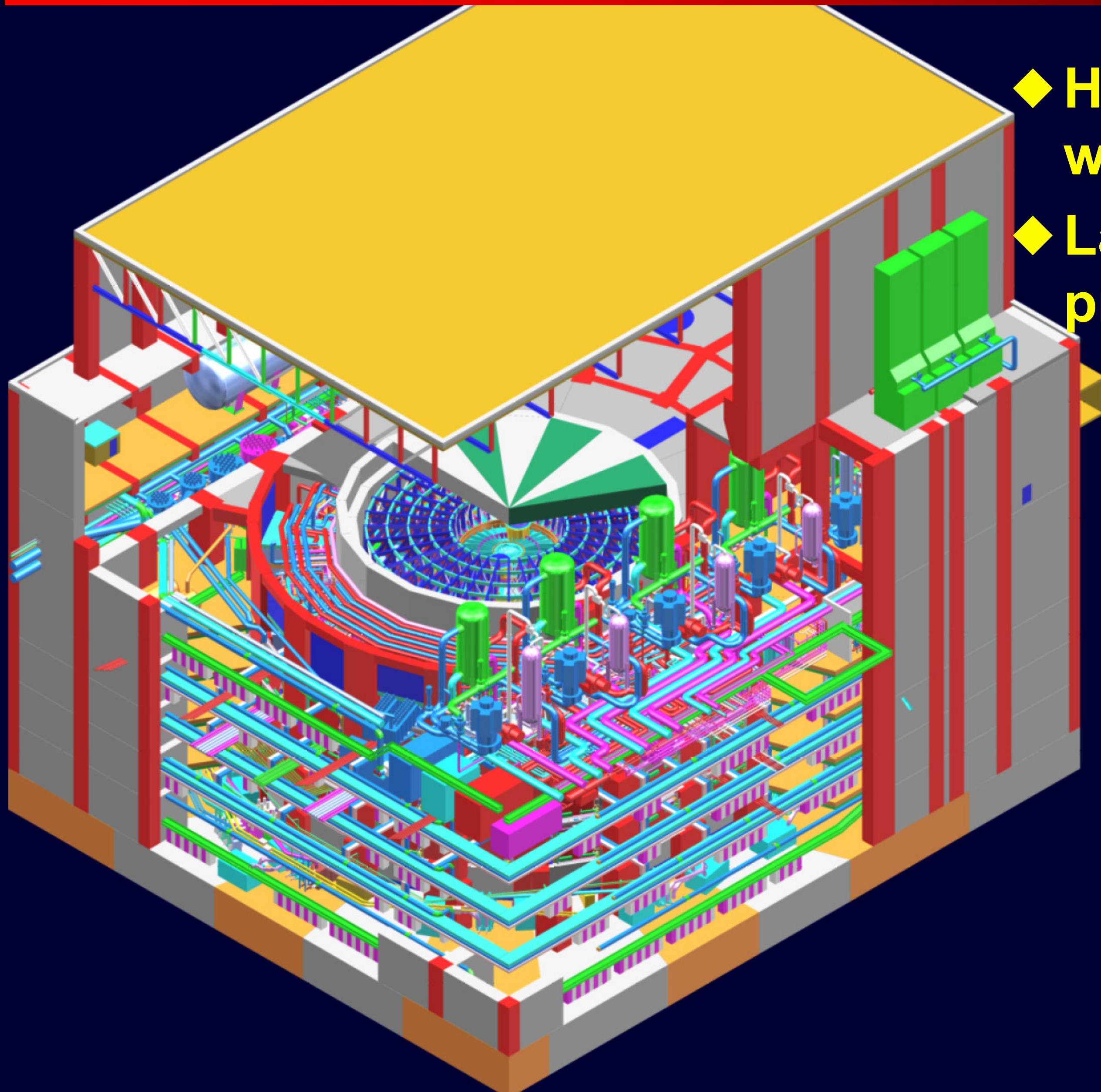


Retractable Limiter



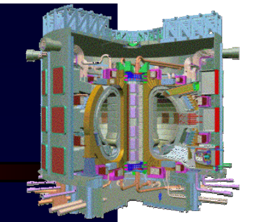


Status of the Design: Tokamak Complex



- Highly integrated building with tight spaces
- Layout of Systems and processes underway:
  - Assembly of large components
  - Remote maintenance
  - HVAC
  - Heating systems
  - Power distribution
  - Cooling Distribution
  - Fuelling
  - Pumping
  - Cable trays

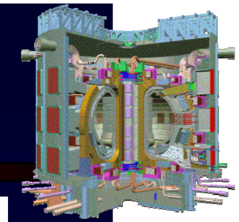
Proc. Specs. For tokamak complex



- The preparation of technical procurement specifications for tokamak complex is in progress (was based on the generic site layout)

- Table of contents for the specifications based on “standard” format.
  - General requirements, Technical requirements, Others,
  - General arrangements and layout,
  - Detailed layout of piping, cabling and supports,
  - Room definition (tokamak, tritium),.
  - Room-by-room database,
  - Efforts for bills of materials, equipment lists and specifications,
  - Engineering schedule, configuration control for integrated project database, etc.

Room by Room layout description



Space allocation

Design

Table 1 - Status of the system integration in the tokamak building
Levels 11-B1, 11-1, 11-2 (under Garching DIU responsibility)

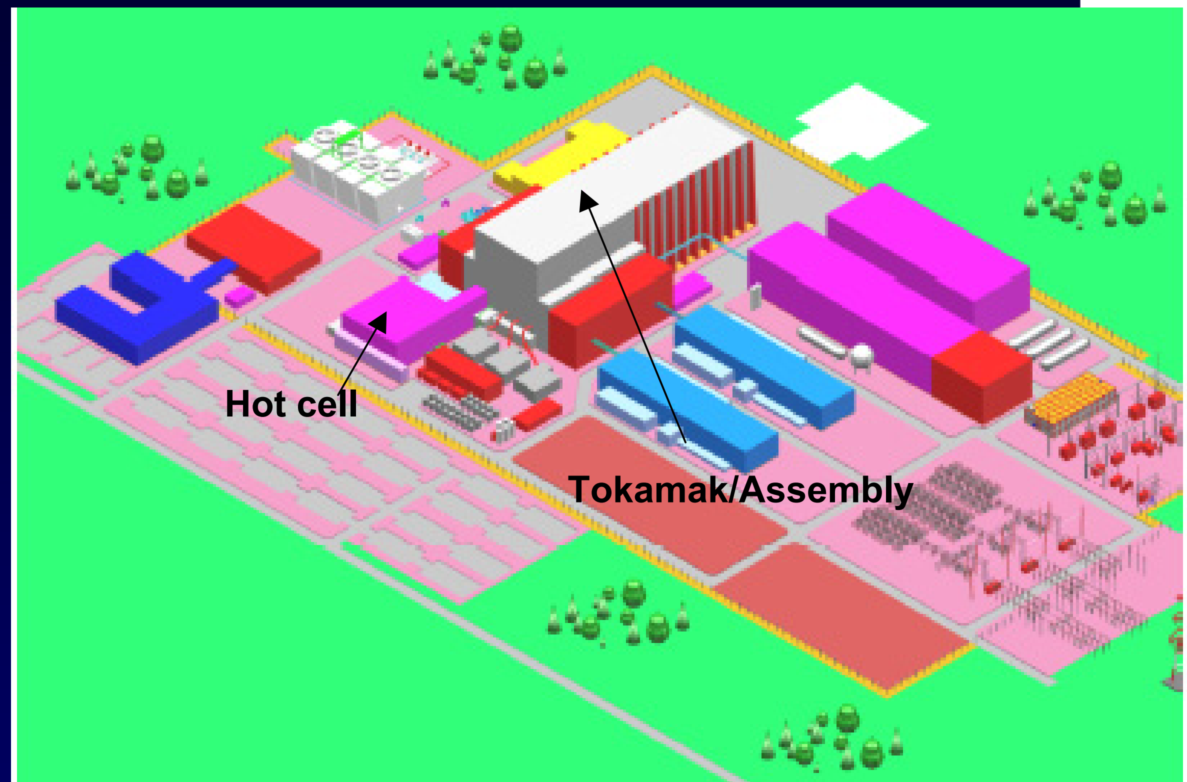
System	Weight factor	Lower level Port cell	Lower level Gallery	Equatorial level Port cell	Equatorial level Gallery	NBI vault	Upper level Port cell	Upper level Gallery	Vertical shaft
Ring Manifolds		50%	NA	30%	30%	0%	30%	NA	NA
Space allocation	0.5	80%		40%	40%		40%		
Detailed design	0.5	20%		20%	20%		20%		
Note									
TCWS		40%	NA	45%	NA	40%	45%	NA	70%
Space allocation	0.5	60%		70%		40%	70%		80%
d design (support,penetrat.)	0.5	20%		20%		40%	20%		60%
Note		guard pipe ?		guard pipe ?		NB duct Liner cooling	guard pipe?		
Diagnostics		31%	52%	55%	52%	10%	55%	52%	NA
Space allocation	0.7	40%	70%	70%	70%	10%	70%	70%	
design (including services)	0.3	10%	10%	20%	10%	10%	20%	10%	
Note									
Additional heating (RF-NBI)		NA	NA	28%	46%	66%	32%	46%	NA
Space allocation	0.6			40%	70%	70%	40%	70%	
design (including services)	0.4			10%	10%	60%	20%	10%	
Note				1) ICH design			ECH Design		
Vacuum Pumping and cryolines		68%	NA	31%	NA	61%	31%	NA	NA
Space allocation	0.7	80%		40%		70%	40%		
design (including services)	0.3	40%		10%		40%	10%		
Note				Guard-service vac.			Guard-service vac.		
Test Breeder Blanket		NA	NA	10%	NA	NA	NA	NA	10%
Space allocation	0.5			10%					10%
Detailed design (including services)	0.5			10%					10%
Note									
Fuelling (GIS-PIS)		68%	NA	NA	62%	52%	34%	NA	NA
Space allocation	0.7	80%			80%	70%	40%		
Detailed design (including services)	0.3	40%			20%	10%	20%		
Note							VV Penetration		
In-vessel viewing, cleaning-Inspection (IVV-GDC-AIA)		56%	NA	NA	NA	NA	38%	NA	NA
Space allocation	0.6	80%					50%		
Detailed design (including services)	0.4	20%					20%		
Note									
Ventilation (HVAC,VDS,Coolers)		35%	62%	35%	62%	35%	35%	62%	48%
Space allocation	0.7	50%	80%	50%	80%	50%	50%	80%	60%
Detailed design (including services)	0.3	0%	20%	0%	20%	0%	0%	20%	20%
Note									
Cabling (SSEPN-CODAC)		16%	44%	16%	44%	16%	16%	44%	NA
Space allocation	0.8	20%	50%	20%	50%	20%	20%	50%	
Detailed design (support,penetrat.)	0.2	0%	20%	0%	20%	0%	0%	20%	
Note									
He purge line		NA	NA	NA	NA	NA	7%	7%	7%
Space allocation	0.7						10%	10%	10%
Detailed design (including services)	0.3						0%	0%	0%
Note							Routing not decided		
RH tools (casks, services)		35%	50%	35%	50%	25%	35%	50%	NA
Space allocation	0.5	50%	80%	50%	80%	30%	50%	80%	
design (including services)	0.5	20%	20%	20%	20%	20%	20%	20%	
Note									
Assembly Operation (equipment-schedules)		38%	41%	41%	41%	14%	44%	41%	0%
Space allocation	0.7	50%	50%	50%	50%	20%	50%	50%	0%
Detailed design	0.3	10%	20%	20%	20%	0%	30%	20%	0%
Note									

Table 2 - Status of the system integration in the tokamak building
Levels 11-B2, 11-3, 11-4 (under Naka responsibility)

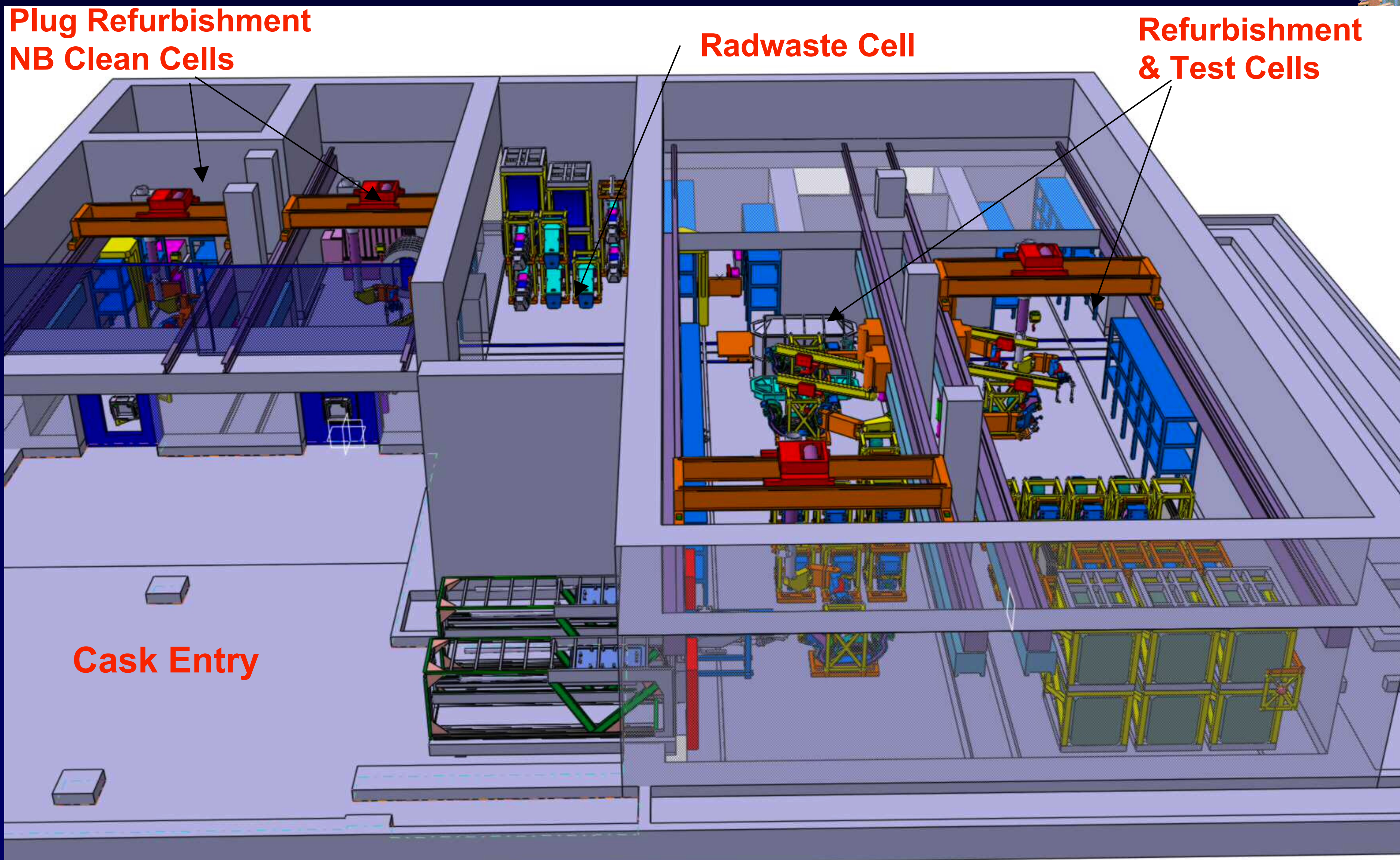
System	Weight factor	Level 11-B2 Magnet area	Level 11-B2 Lower pipe chase	Level 11-B2 Drain Tank room	Level 11-B2 Magnet area	Level 11-B2 Upper pipe chase	Level 11-B2 TCWS Vault	Level 11-B2 CVCS	Level 11-B2 Coldbox room	Level 11-4 VVPSS	Level 11-4 Crane Hall	Roof
Magnet Systems (Incl.Busbars)		40%		NA	40%				40%			40%
Space allocation	0.5	60%			60%				60%			60%
Detailed design	0.5	20%			20%				20%			20%
Note												
Ring Manifolds		50%		NA	30%				30%	0%	30%	NA
Space allocation	0.5	80%			40%				40%		40%	
Detailed design	0.5	20%			20%				20%		20%	
Note												
TCWS		NA	60%	70%	NA	60%	70%		NA	90%	?	70%
Space allocation	0.5		80%	100%		80%	100%	?		100%	?	80%
Detailed design (support,penetrat.)	0.5		40%	40%		40%	40%	?		80%	?	60%
Note												
Diagnostics		?	?	?	55%				52%	?	?	NA
Space allocation	0.7	?			70%				70%	?	?	
Detailed design (including services)	0.3	?			20%				10%	?	?	
Note												
Vacuum Pumping and cryolines		61%		NA	31%				35%	61%	31%	NA
Space allocation	0.7	70%			40%				50%	70%	40%	
Detailed design (including services)	0.3	40%			10%				10%	40%	10%	
Note					Guard-service vac.						Guard-service vac.	
Test Breeder Blanket		NA		NA	NA		10%		NA	NA	NA	10%
Space allocation	0.5						10%					10%
Detailed design (including services)	0.5						10%					10%
Note												
Ventilation (HVAC,VDS,Coolers)		35%		62%	35%	35%	21%	21%	21%	35%	35%	48%
Space allocation	0.7	50%		80%	50%	50%	30%	30%	30%	50%	50%	60%
services)	0.3	0%		20%	0%	0%	0%	0%	0%	0%	0%	20%
Note												
Cabling distribution panels and transformer(SSEPN-CODAC)		40%	40%	20%	40%	40%	40%	40%	40%	40%	16%	40%
	0.8	50%	50%	20%	50%	50%	50%	50%	50%	50%	20%	50%
(support,penetrat.)	0.2	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%
Note												
RH tools (casks, services)		35%	15%	50%	35%	15%	15%	15%	50%	25%	35%	NA
Space allocation	0.5	50%	30%	80%	50%	30%	30%	30%	80%	30%	50%	
led design (including services)	0.5	20%	0%	20%	20%	0%	0%	0%	20%	20%	20%	
Note												
Assembly Operation (equipment-schedules)		38%		41%	41%	21%	21%	21%	14%	44%	41%	41%
Space allocation	0.7	50%	50%	50%	50%	30%	30%	30%	20%	50%	50%	50%
Detailed design	0.3	10%	20%	20%	30%	0%	0%	0%	0%	30%	20%	20%
Note												

Hot Cell Building

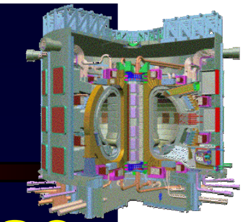
- Consists of a rectangular reinforced concrete structure
- Provides a shielded and controlled area equipped for the refurbishment and testing of in-vessel components, including space for their temporary storage and/or preparation for disposal as radwaste
- Accommodates also the systems and services required to support its operations: cranes, RH tools, RH tools’ repair and storage, active dust filtration system, ventilation and atmosphere clean-up system
- Provides space for RH equipment testing facility, control rooms and cask storage



Hot Cell Building



From Generic to Specific



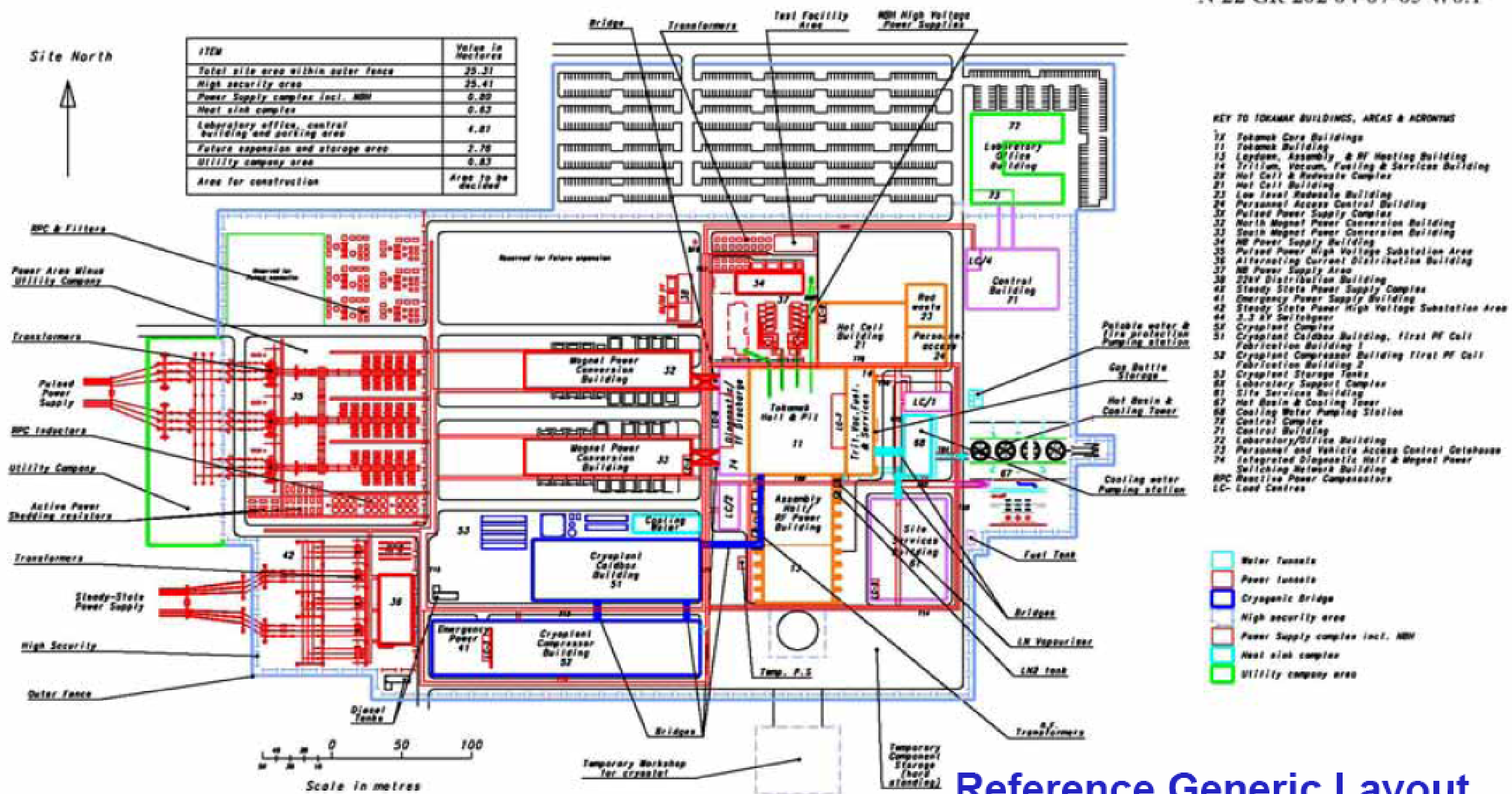
- Site Selection allows IT to concentrate and finalise design for the Site Conditions:
- Site layout
  - General
  - Seismic Isolation Design
  - Hot Cell design
  - Tunnels
- Safety strategy and impact on machine design
  - Finalise safety design
  - Finalise safety analyses
  - Safety Classification
  - Quality Classification
  - Codes and Standards

The generic layout

West: Electrical power supply, switchyards, and cryoplant

North: Personnel-related and waste management functions

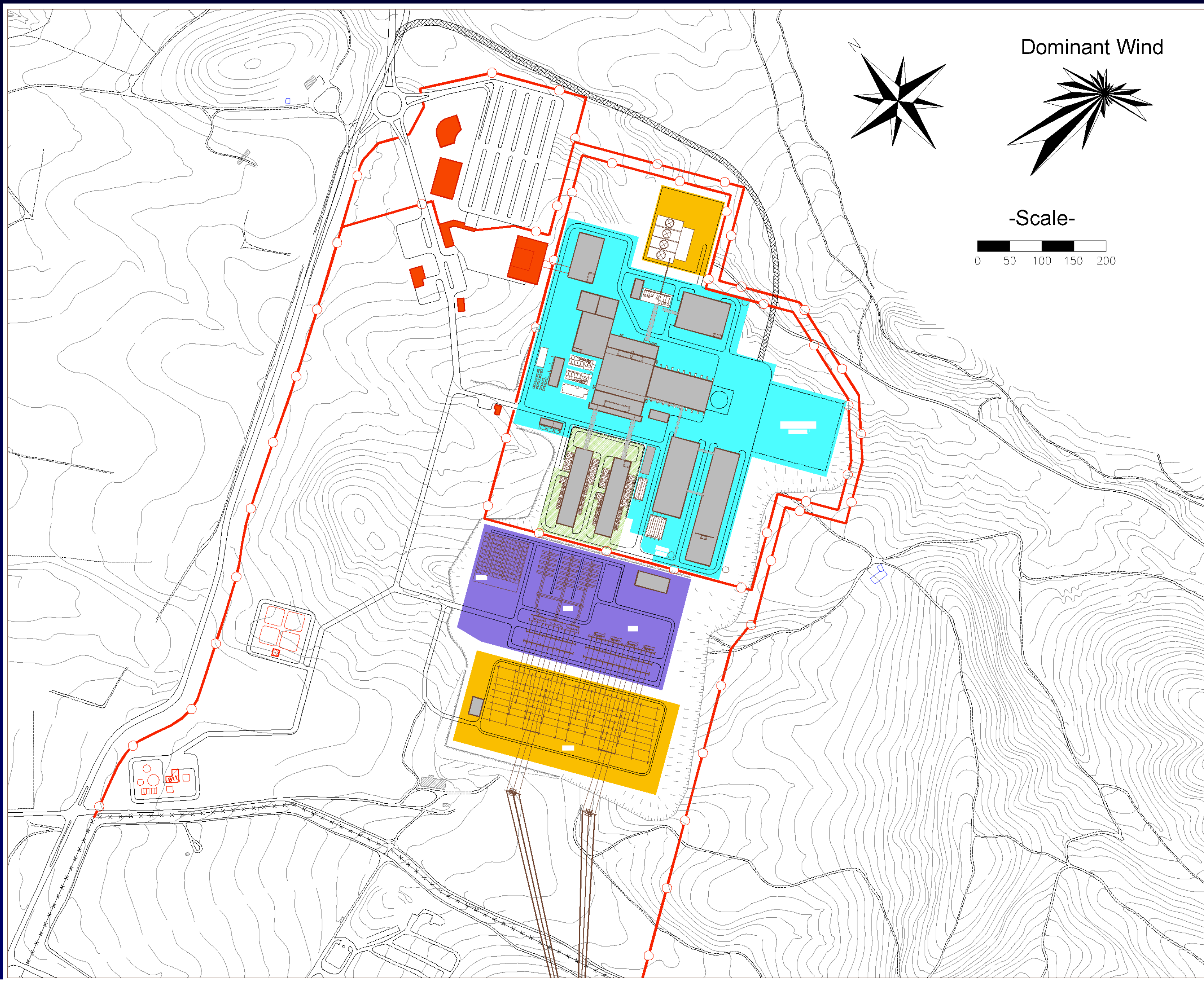
N 22 GR 202 04-07-05 W0.1



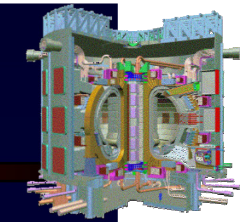
South: Access of main components for assembly and RF heating systems

East: Primary cooling systems and non-electrical site services

Cadarache Layout



Outline



- Site Selection
- Negotiations Status
- Design Activities
  - General
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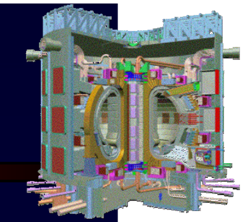
- Conclusions

Regulatory Framework



Normal risk

Special risk (with nuclear inventory)

ICPE facilities (that could induce hazard to the environment)

INB facilities (Nuclear labs, plants, reactors…)

As far as Tritium is concerned :

370 TBq

ITER # 10^6 TBq

450g of tritium # 150,000TBq
20 to 500 mSv to population

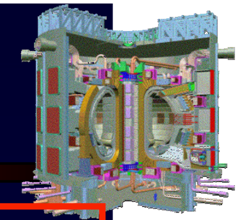
ITER will be a INB facility

due to the tritium inventory and other radionuclide content

ICPE: Installation Classée pour la Protection de l'Environnement

INB: Installation Nucléaire de Base

Regulatory Framework



Regulatory framework Order from 1963/QA 1984

ICPE facilities

Nuclear facilities (INB)

Labs and fuel plants

Nuclear power plants

Only limited nuclear reaction and impact for worst accident

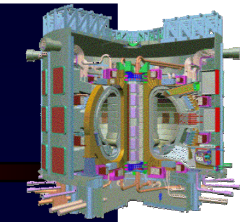
Inventory and geometry may induce long uncontrolled nuclear reaction

ITER will be a INB facility classified as a « Labs and fuel plants » according to the set of design advice rules to use (RFS : règles fondamentales de sûreté) DGSNR 4 July 2002

The framework requested that organization is set in place in the design phase of the project: CEA acts as the representative of the future operator

127 INB under operation in France, among them # 50NPP, same roadmap for ITER

Steps in Licensing



The progressive safety review consists of three steps before starting operation

done — **1 Safety Options** → as a new type of facility

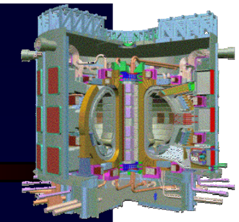
2 Preliminary Safety review → prior to construction — underway

3 Temporary Safety file → on which operation will be possible — Before start-up

The general roadmap for safety analysis has been presented to the Safety Authority on 13 October 2000

Each step consists of the review by the **panel of experts** (GP) under the management of the **Safety Authority** (DGSNR), on the basis on an analysis performed by the **support team** (IRSN)

Steps in Licensing



Two main ***aspects*** for the licensing

- ***Safety*** reviews
  of the Preliminary Safety Report
- Public ***enquiry***

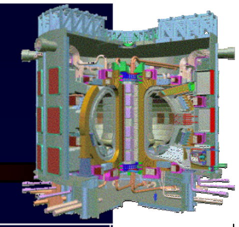
Decrees to construct and operate

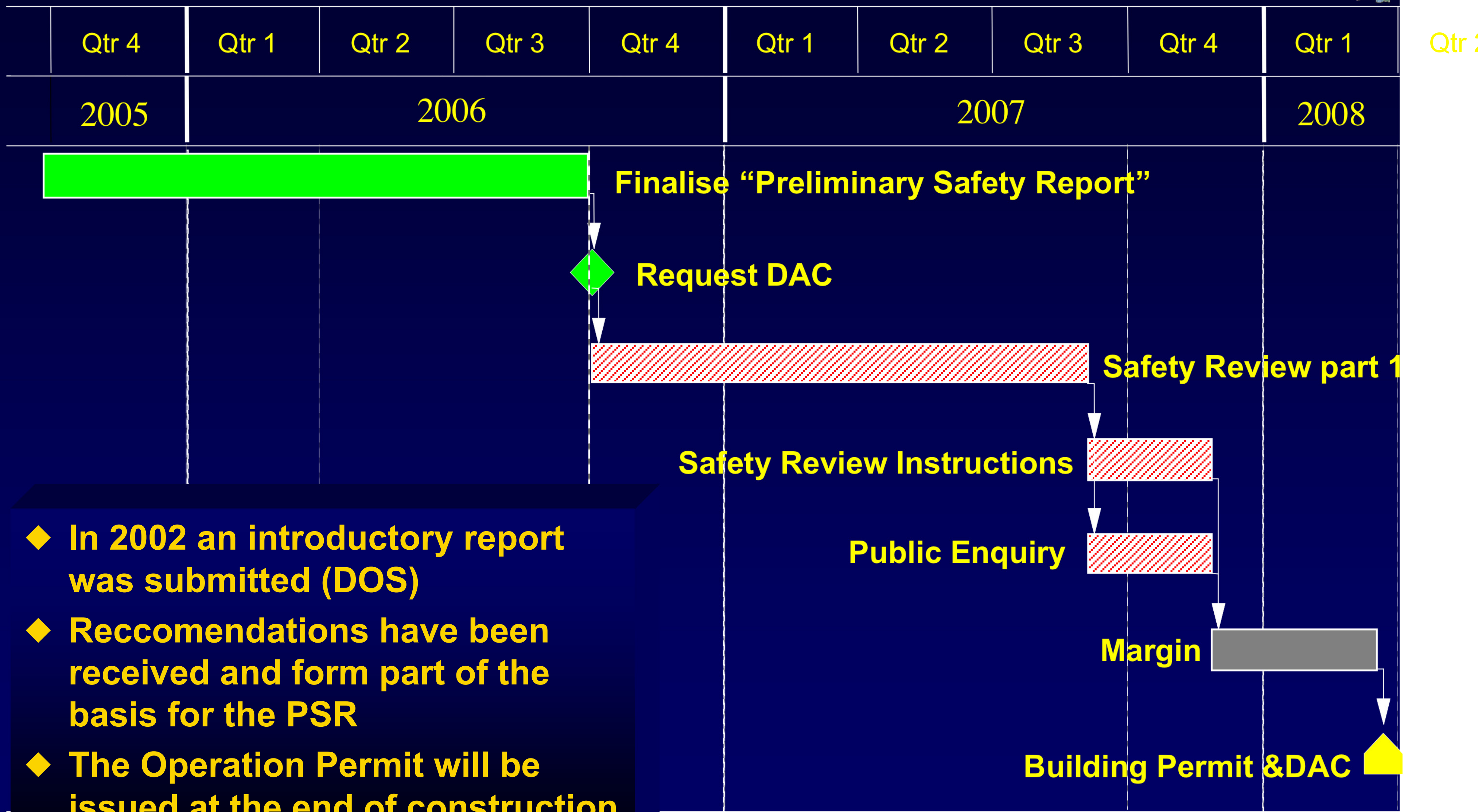
DAC and AARPE

DAC: Décret d'Autorisation de Création

AARPE: Arrêté d'Autorisation de Rejets dans l'environnement et de Prélèvement d'Eau

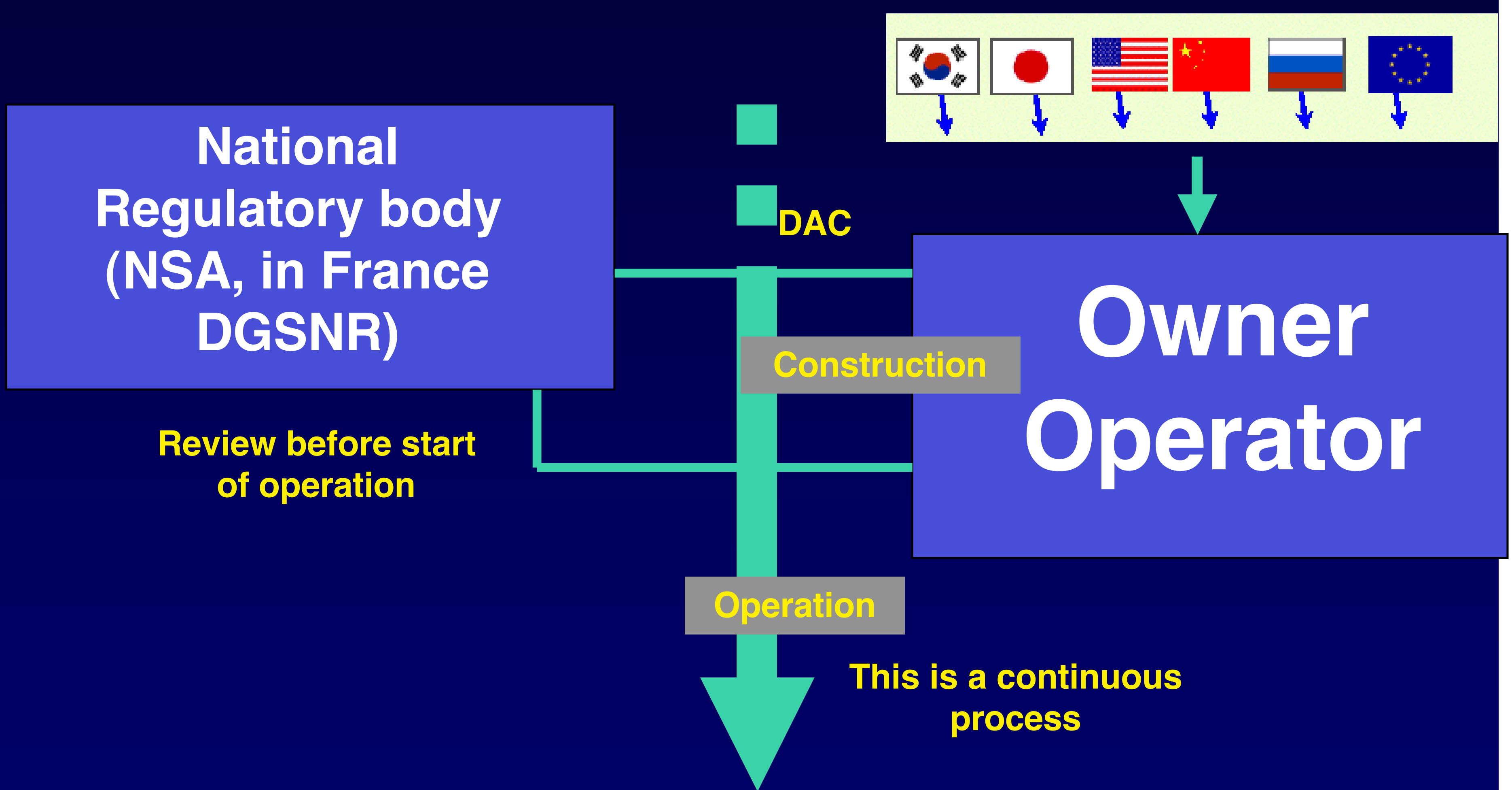
Construction License Schedule



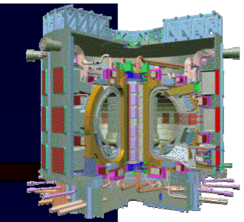


- In 2002 an introductory report was submitted (DOS)
- Reccomendations have been received and form part of the basis for the PSR
- The Operation Permit will be issued at the end of construction

QA: Who is Operator?



Duties of the Operator



ITER is a "Nuclear Facility" according to its radio-isotope inventory

- ITER-org will be responsible under the French law
- Organisation of the ITER "owner" must fulfil the French requirements for such a nuclear facility
  - Sufficient means and skill of teams
  - Management of design, procurements, construction, operation of all aspects in relation with safety

- One legal text on Nuclear Facility Creation (order of December 1963) and releases (order of May 1995)
- One legal text on Quality for nuclear facility (order of August 1984) → close to IAEA 50-C/SG-Q (previously 50-C-QA)

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These text explains the quality requirements for design procurements, realization and operation of the facility

Duties of the Operator

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- On
  Dec
- On
  198

CHAPTER II - Overall liability of the operator

Article 4

Being responsible for the safety of the installation, the operator shall thereby be responsible implementation of the provisions of the present Order concerning quality-related activities.

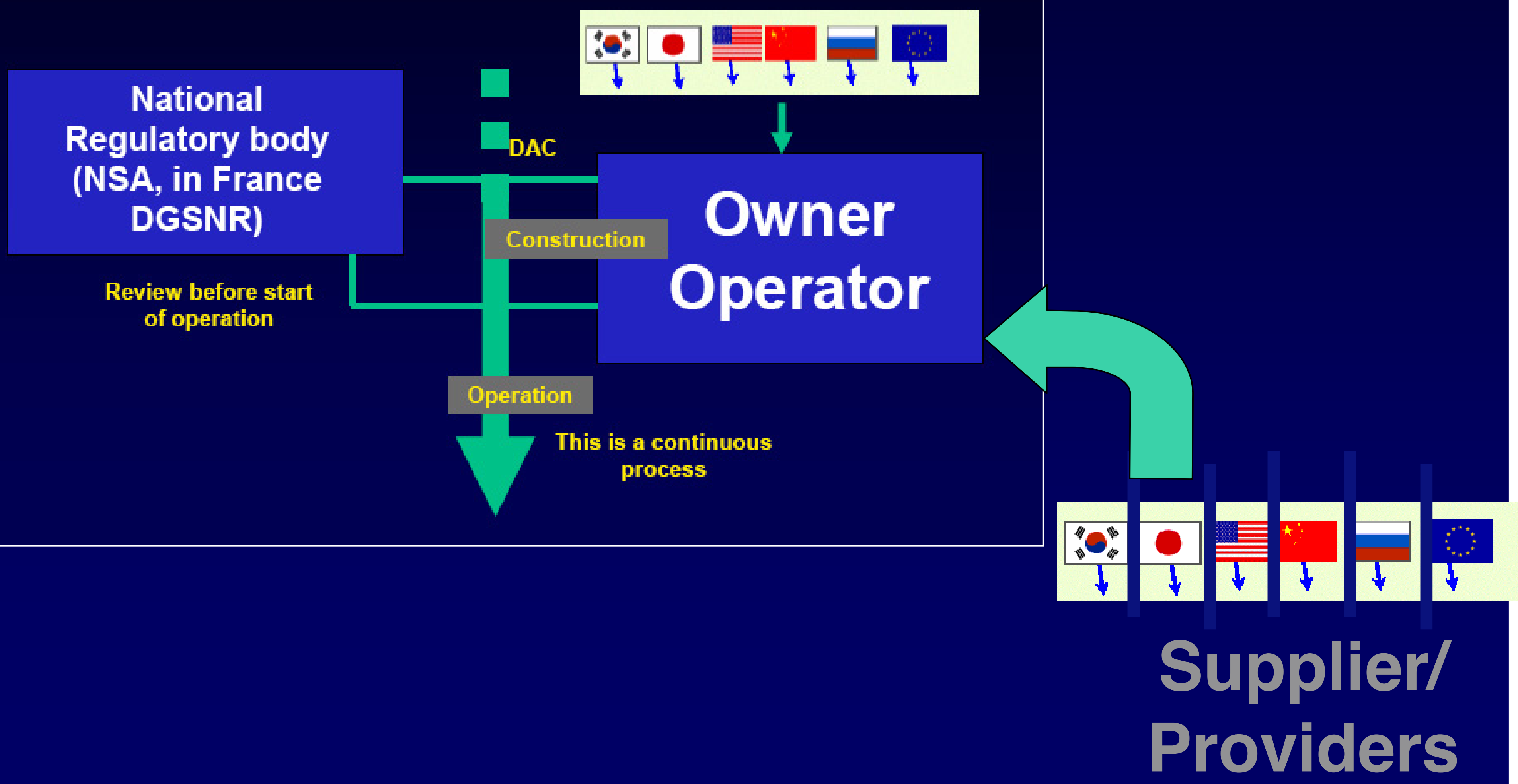
As regards quality related activities carried out by service companies, the operator shall ensure that relevant contracts fully inform the said service companies of all provisions enabling implementatio the present Order.

The operator organises or has organised by all service companies supervision such as to ens compliance of the latter with the provisions thus notified. He shall notably ensure that the good services provided are duly inspected with a view to checking their conformity to the stated requireme

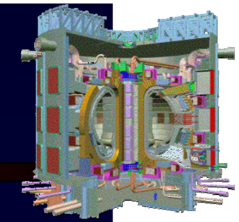
This requirements lead to the necessity of clear **survey** of all safety related **procurements** by the ITER organization as future **operator** of the facility

Parties (DAs) as providers

Who?



Skilled and Sufficient Human Resources



Duties of the Operator

ITER is a "Nuclear Facility" according to its radio-isotope inventory

- **ITER-org will be responsible under the French law**
- **Organisation of the ITER "owner" must fulfil the French requirements for such a nuclear facility**
  - → **Sufficient means and skill of teams**
  - → **Management of design, procurements, constructio… operation of all aspects in relation with safety**
- **One legal text on Nuclear Facility Creation (or… r of December 1963) and releases (order of May 19…5)**
- **One legal text on Quality for nuclear facility (… r of August 1984) → close to IAEA 50-C/SG-Q (previously 5…-C-QA)**

Skilled staff and appropriate human resources

Article 7

The human and technical resources together with the organisational provisions implemented for the performance of a quality related activity must be adapted to this activity and enable compliance with the defined requirements.

In particular, only adequately skilled staff may be assigned to quality related tasks. Appraisal of the competence of such staff shall notably be based on their training and experience.

One legal text on Quality for nuclear facility (order of August 1984)

L'ARRETE QUALITE

SYNTHESE

ART. 1 : 1 – Operator must put in place a graded quality management system according to safety importance of components and activities

2 – Text applies for safety relevant activities

ART. 3 : 3 - Operator and contractors

4 - Operator is responsible for safety and responsible of application by contractors of adequate QA system

ART. 5 : 5 – QA manual + application report of QA

ART. 6 : 6 – Safety requirements are defined and checked

7 - Skilled, qualified, authorized workers, team size in agreement to safety objectives

ART. 8 : 8 – Independent check of safety relevant activity

ART. 9 : 9 – High level QA survey

10, 11 – Keep records, paper work is stored correctly

12, 13 - Safety relevant deviations are studied, corrected, recorded and declared

14 - Safety relevant studies are concerned by QA

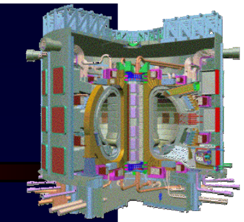
ART. 15 : 15 - QA presented when Creation Permit is asked

ART. 16 : LES ACTIVITES R ET D ET D'ENSEIGNEMENT MENEES DAN[S] UNE INB NE SONT CONCERNEES QUE PAR L'ARTICLE 1 DON[T] IL SERA RENDU COMPTE DE L'APPLICATION A L'AUTORIT[E] DE SURETE.

ART. 17 : C'EST LE MINISTRE QUI ACCORDE LES DEROGATIONS ET L[A] SOUPLESSE DES

ART. 19 : 19 - NSA in charge of application

Summary of QA reqs for INBs



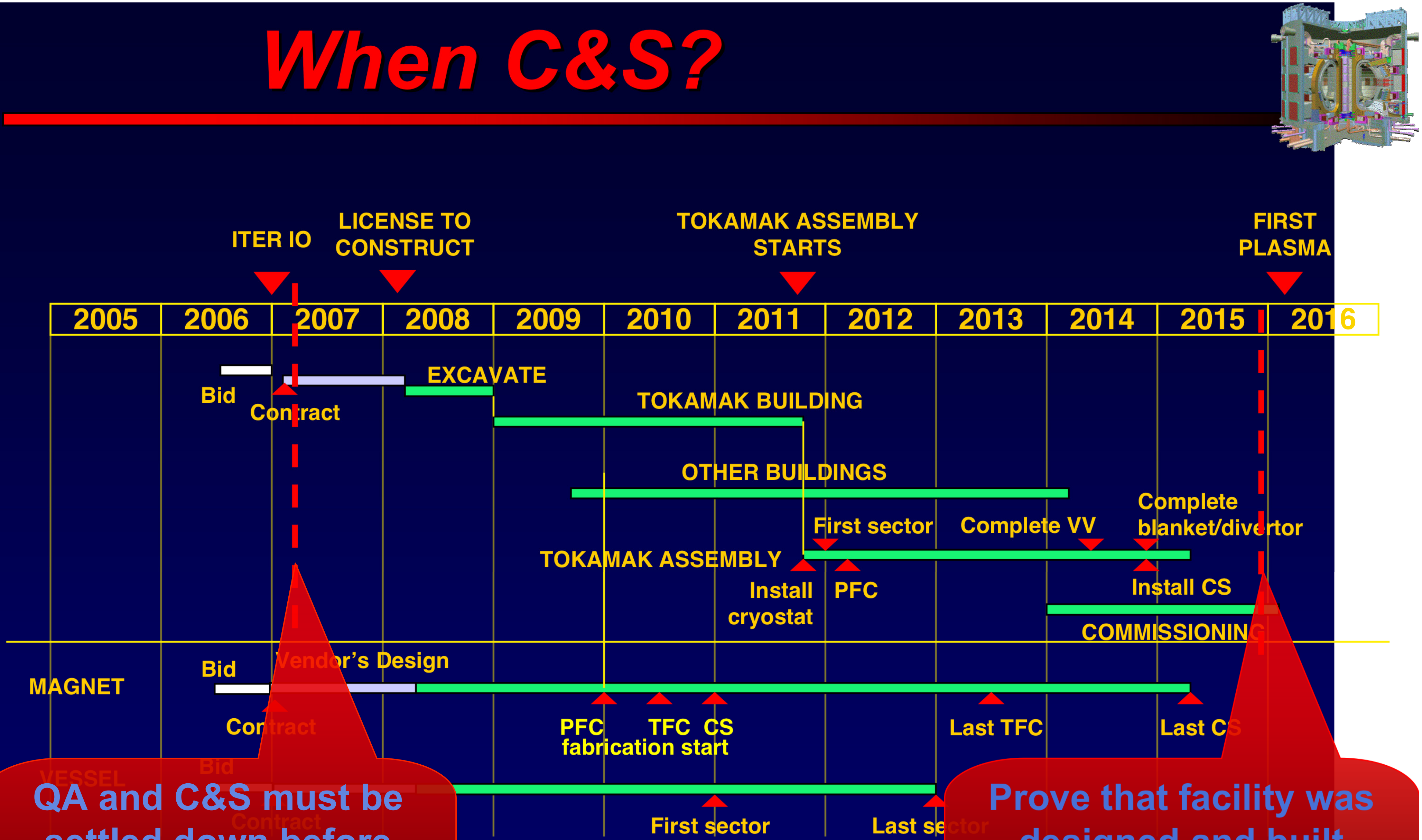
Quality of conception, construction

= IAEA 50-C/SG-Q (previously 50-C-QA, and to be DS338/339)

AND:

- <u>Independent check</u> of all activities in relation with safety (statement Nber 8 or § 309)
- Quality management by <u>high level survey</u> team (statement Nber 9 or § 402/404)
- <u>Requirements specified to contractors and sub-contractors – the Operator is responsible to check compliance</u> (Nber 4)
- <u>Technical survey by sampling</u> (Nber 9 add to § 400)

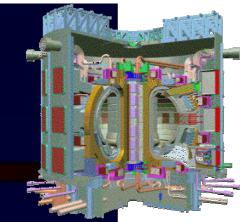
When C&S?



QA and C&S must be settled down before first procurements

Prove that facility was designed and built according to quality requirements and C&S

„Nuclear“ C&S for ITER?



Unnecessary

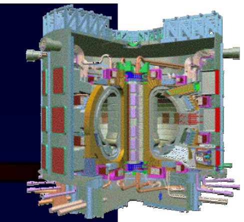
- „Extreme“ CAT-IV ($P=10^{-6}$ to 10^{-4}) Events can be tolerated by limited releases:
- ITER accidental limit= 10mSv (IAEA No Evacuation=50mSv)
- In Cadarache 1gr HTO = 50μSv
  - Failure of VV ->acceptable consequences
  - Failure of Cryostat ->acceptable consequences
  - Failure of Magnet ->acceptable consequences
  - Simultaneus failure of VV and Cryostat is BDB but still no evacuation

Impractical

- Design loads on VV, although considered with much conservativism, still not 100% sure (i.e. VDEs)
- Costly

Still...high quality necessary to ensure machine availability

C&S in VV and Cryostat



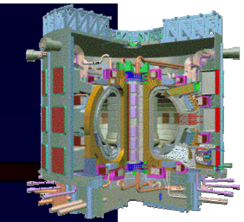
VV approach:

- Use rigorous approach (also Cat IV events) of RCC-MR nuclear standard to enforce high degree of quality and rely on nuclear material data
- Modify to prepare for future devices
- Afterall, assume in safety analysis large breach of component in CAT IV.
- High emphasis to be given to <u>Port Plugs and Windows</u>

Cryostat approach:

- Use ASME VIII type of standard but considering also CAT IV events to show reliability.
- As in VV, assume in safety analysis large breach of component in CAT IV.

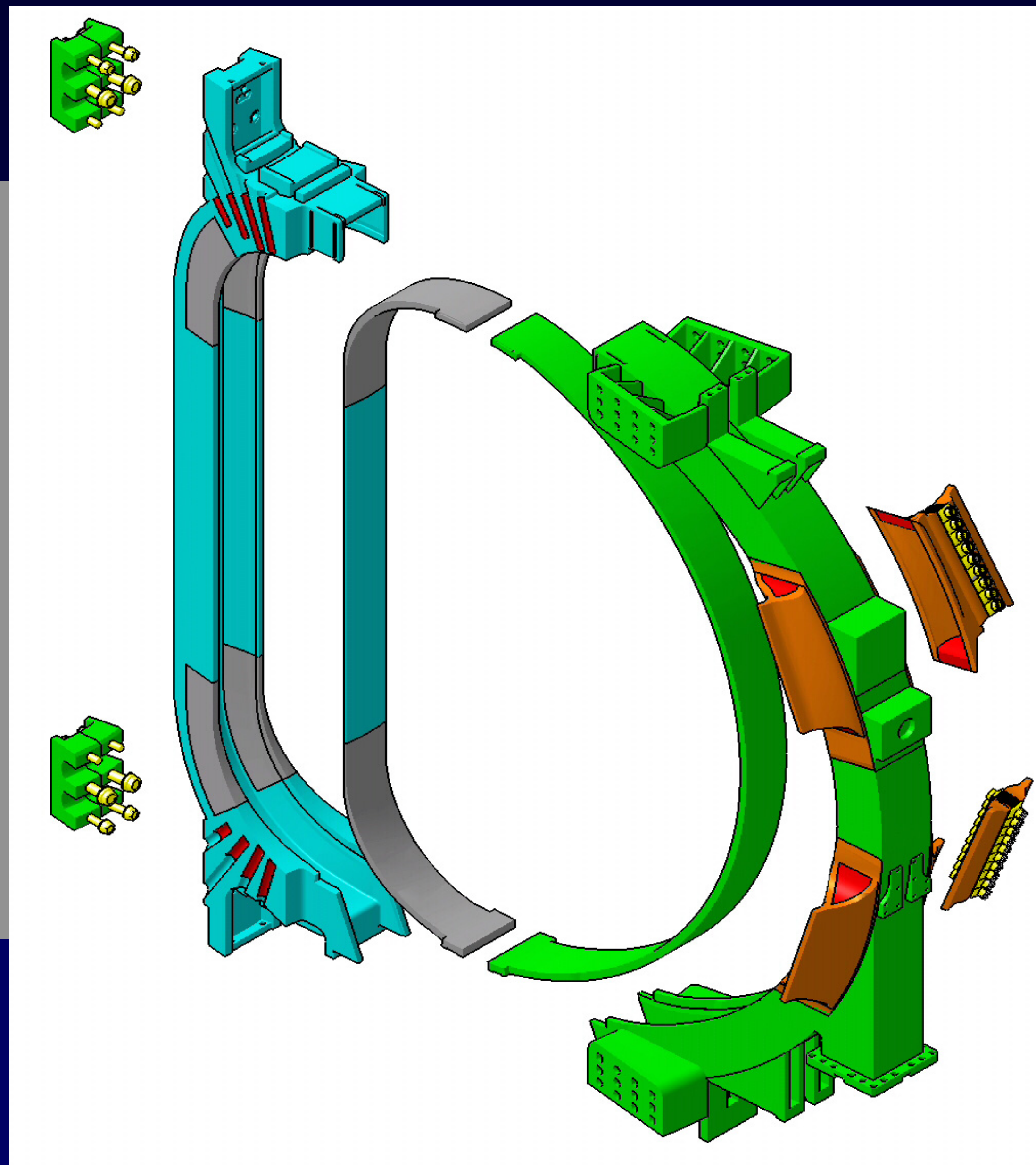
C&S in Magnet



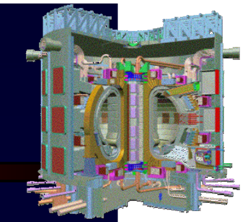
- No existing recognised standard for structural integrity!
- In EDA design „design manual“ developed
- Peculiarities:
  - Non-metallic bonding
  - Cryogenic material with high absolute and cyclic σ
  - No ISI (!)
- Approach
  - Assume flaws to be present above SoA detection
  - Evaluate crack growth in machine lifetime
  - Verify that resulting crack is non-crytical
- Manage residual risk by assuming failure as CAT IV event and ensure no unacceptable releases.

TF allowable defect size

Allowable Defect Size Level	Color
1	Red
2	Orange
3	Grey
4	Cyan
5	Green

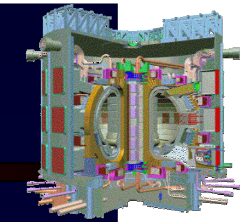


to conclude...



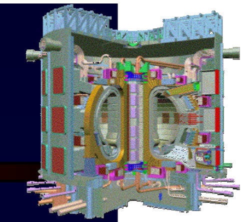
- Important „Critical paths“:
  - DG nomination (imminent)
  - Final design reviews before TS (in 2006)
  - Procurement specifications for VV, Magnet, Tokamak Buildings
  - Licensing process
  - QA programmes in ITER Org and DAs
  - Staffing
- ITER will be the first magnetic fusion facility to undergo nuclear licensing. The experience will have significant reflexes on how fusion will develope
- 2006 will be the year of project renewal & buildup
- 2007 will be the year of the key committments
- 2008 will be the year of the first concrete pour

Process of the safety review



1. Document internally approved and sent by appropriate organization to NSA → t0
2. NSA will ask IRSN to study the file
3. IRSN (+NSA) will invite for the review kick-off meeting t0+1month
4. Instruction in close contact with operator (intermediate meetings)
5. IRSN (+ NSA + Experts) will call for the panel of experts review (GP: Groupe Permanent) and organize a last informal exchange with the operator (this latter will submit his commitments (t1-1 month)
6. GP: The Safety review → t1=t0 + 9 to 12 months
7. GP will forward his advice to NSA
8. NSA will send final advice to operator → t0 + 12 to 15 months
   and write to the Prefect

Process of the Public Enquiries



1. Document internally approved and sent by appropriate organization to NSA, Prefect… → t0
2. NSA will give its approval on files after internal review
3. NSA will ask the Prefect to launch the Enquiries → t0 + 6 months
4. Enquiries
5. Prefect will give its advice following the report of the team in charge of supervision of the enquiries
6. After advice of the NSA (see slide on Safety review) sent to the Prefect, he will sign the Building Permit → t0 + 12 months
7. Creation Decree will be issued after CIINB final wording review on the text
8. Releases and Water Intake Authorization will be issued later, after advice of local CDH commission