Safety Characteristics of ITER
First Fusion Machine Undergoing Full Nuclear License

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china eu india japan korea russia usa

ITER

The ITER tokamak* is an experimental nuclear fusion reactor

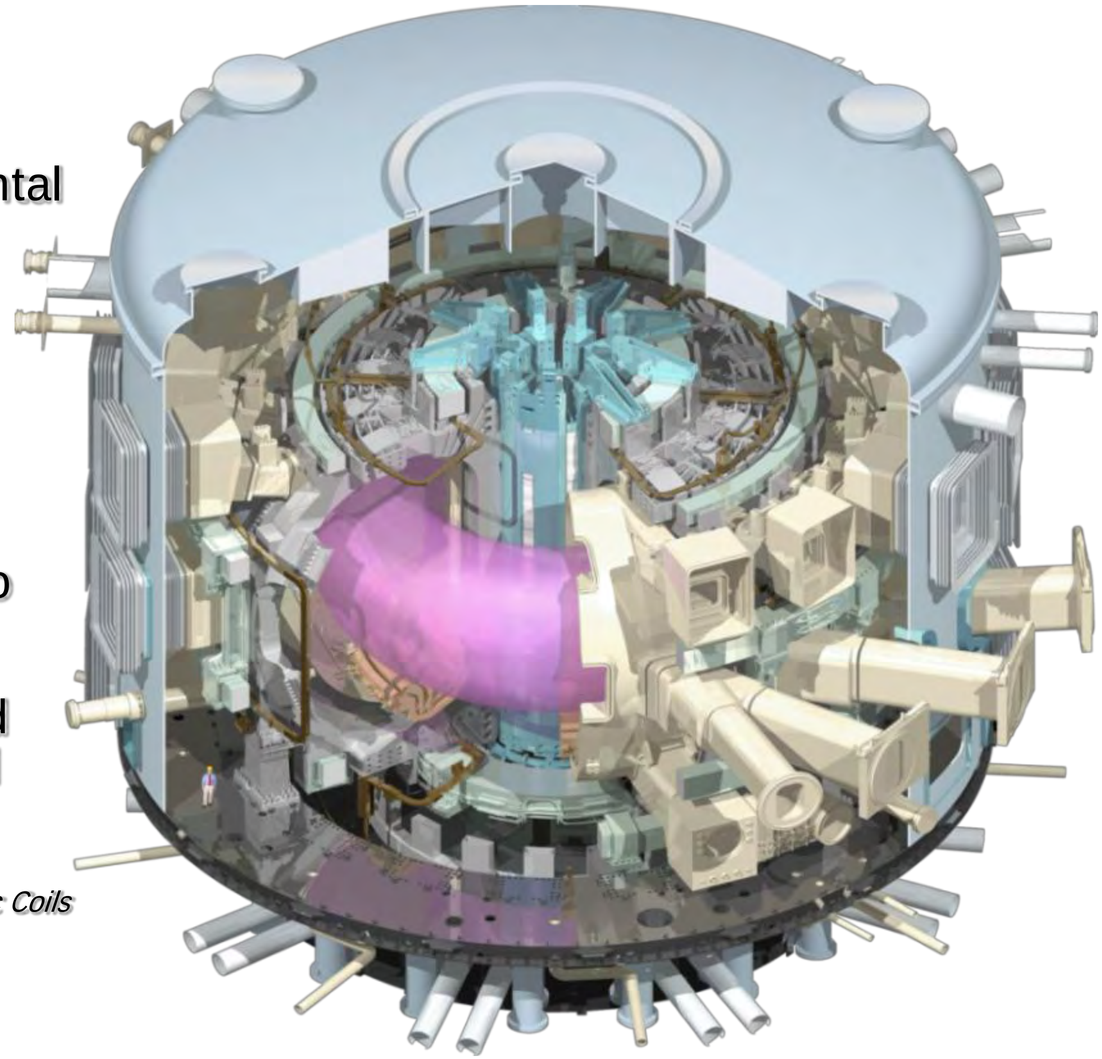
ITER will generate 10 times more energy than it receives.

Input 50 MW – Output 500 MW

It is a necessary step on the way to commercial nuclear fusion energy.

Will demonstrate the availability and integration of technologies essential for a nuclear fusion reactor

** Toroidal Chamber, Magnetic Coils*



Outline

- Introduction
  - Fission, Fusion, Plasmas
- Fukushima Accident and Fusion
- ITER safety features
  - General safety objectives
  - Risks
- ITER Accidental analysis
  - Radiological consequences
- Nuclear licensing process
- ITER Status
- Summary

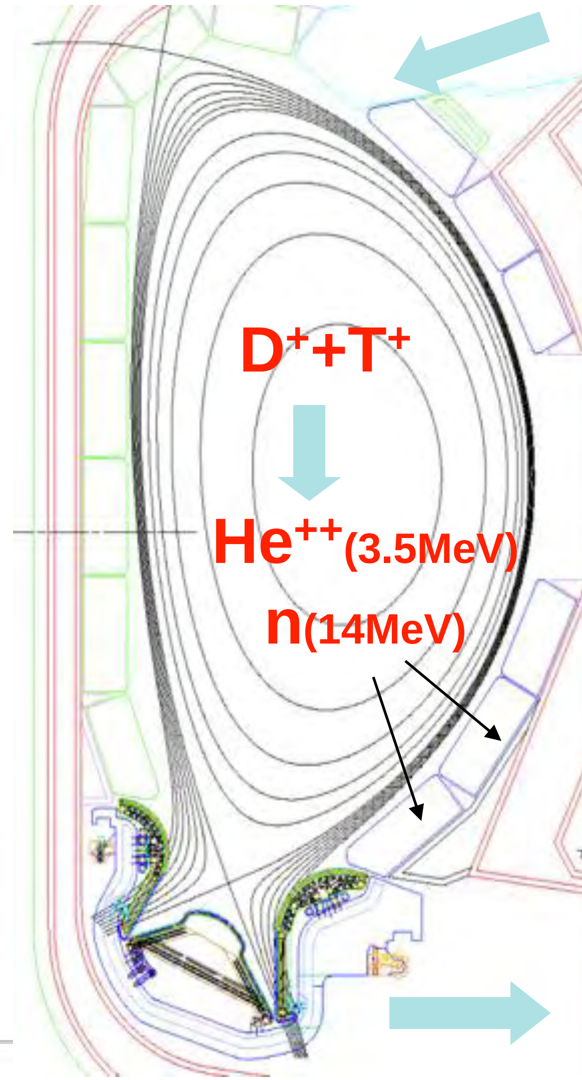
Fusion in ITER Plasma

Donut Shape Plasma

V:	**830m³**
R/a:	**6.2m/2m**
Vertical elongation:	**1.85**
Triangularity:	**0.45**

Density:	**$10^{20} m^{-3}$**
PeakTemperature:	**17keV**
Fusion Power:	**500MW**

Plasma Current :	**15MA**
Toroidal field:	**5.3T**



D_2,T_2 Fuel

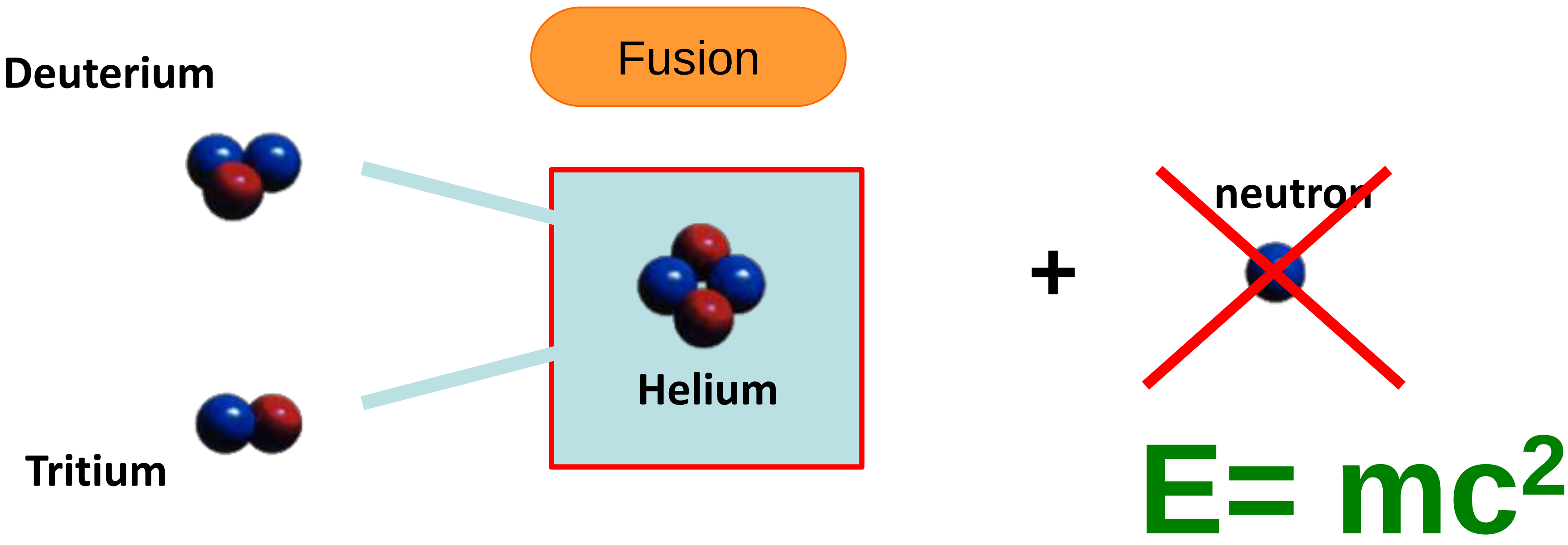
Blanket: neutron absorber

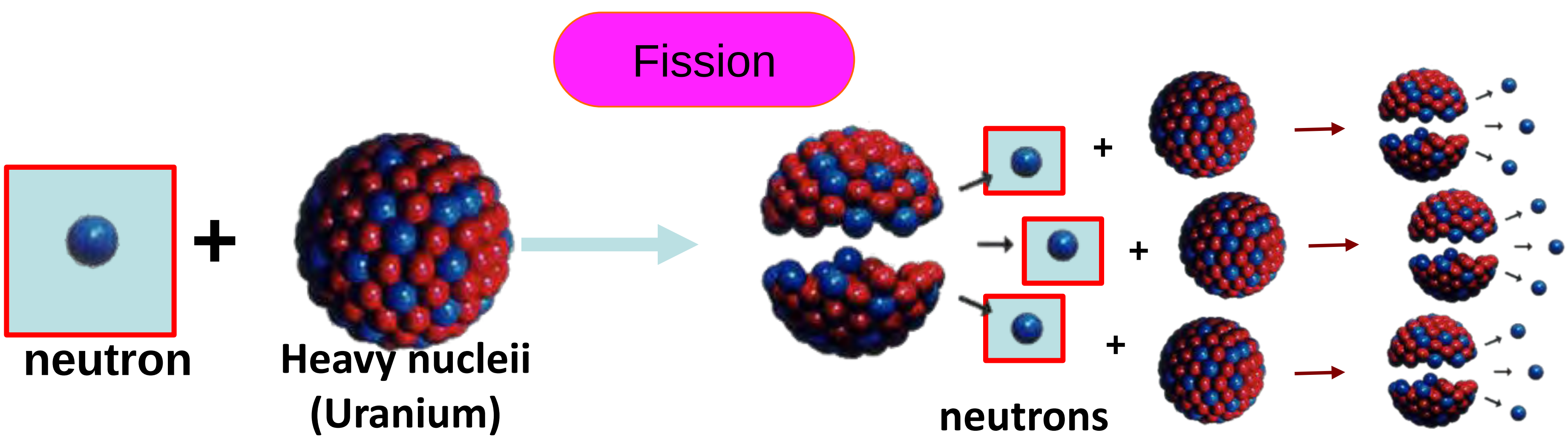
Power Plant
Li-->T
High temperature

Divertor: particle and heat exhaust

He, D_2,T_2, impurities

Physics


Fusion
Deuterium
Tritium
Helium
+
neutron
E= mc²


Fission
neutron
+
Heavy nuclei
(Uranium)
+
+
+
neutrons

Maxwell's equations
Electromagnetic Physics

Temperature ↑ / Density ↓

Plasma

Gas

Liquid

Solid

Confinement quality and Q

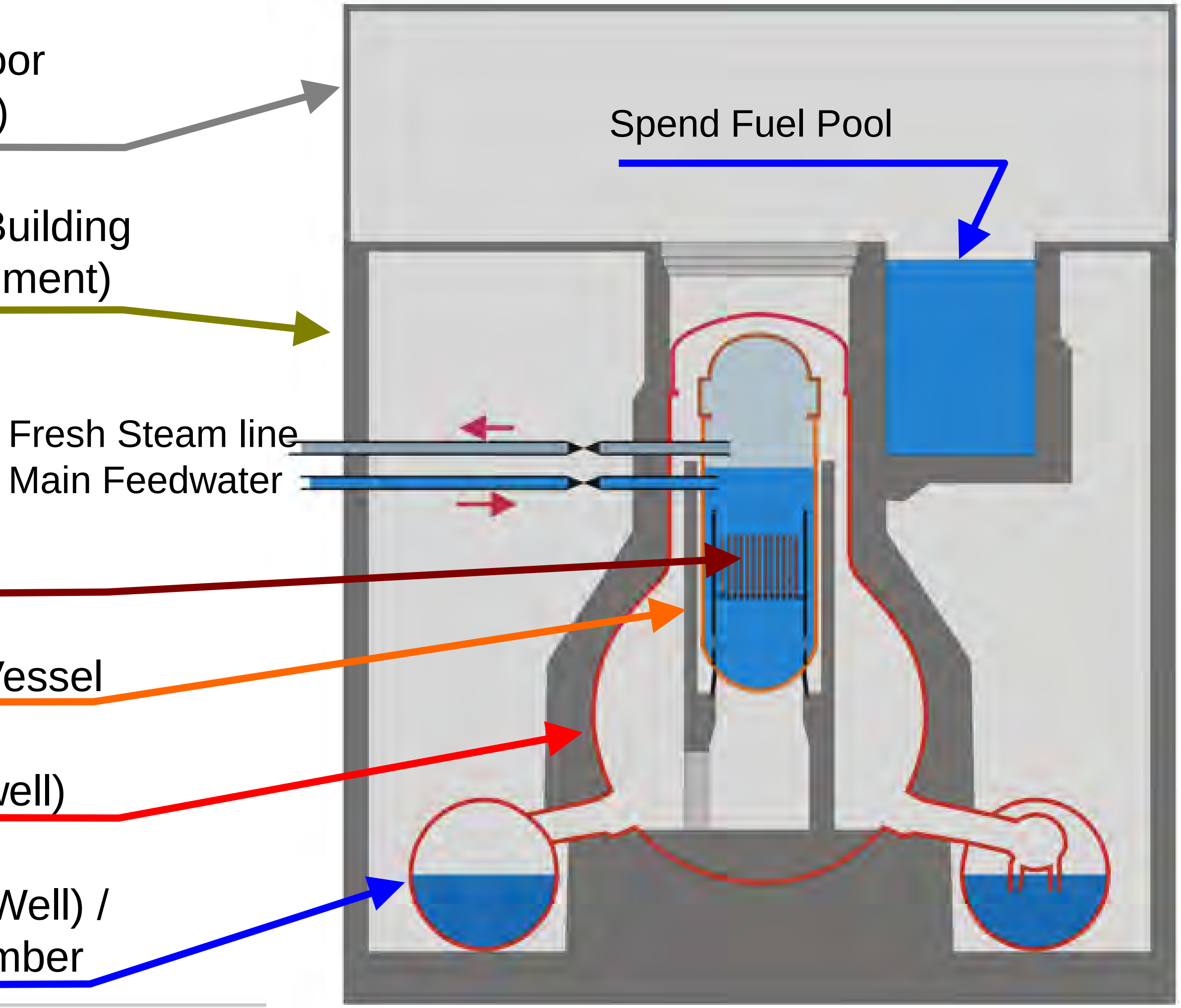
- Temperature (T_i): $1\text{-}2 \times 10^8$ °C (10-20 keV)
  (~10 × temperature of sun's core)
- Density (n_i): 1×10^{20} m^{-3} (~10^{-6} of atmospheric particle density)
- Energy confinement time (τ_E): few seconds
  (plasma pulse duration ~1000 seconds)

- **Fusion power amplification:** $$Q = \frac{\text{Fusion power}}{\text{Input power}} \sim n_i T_i \tau_E$$

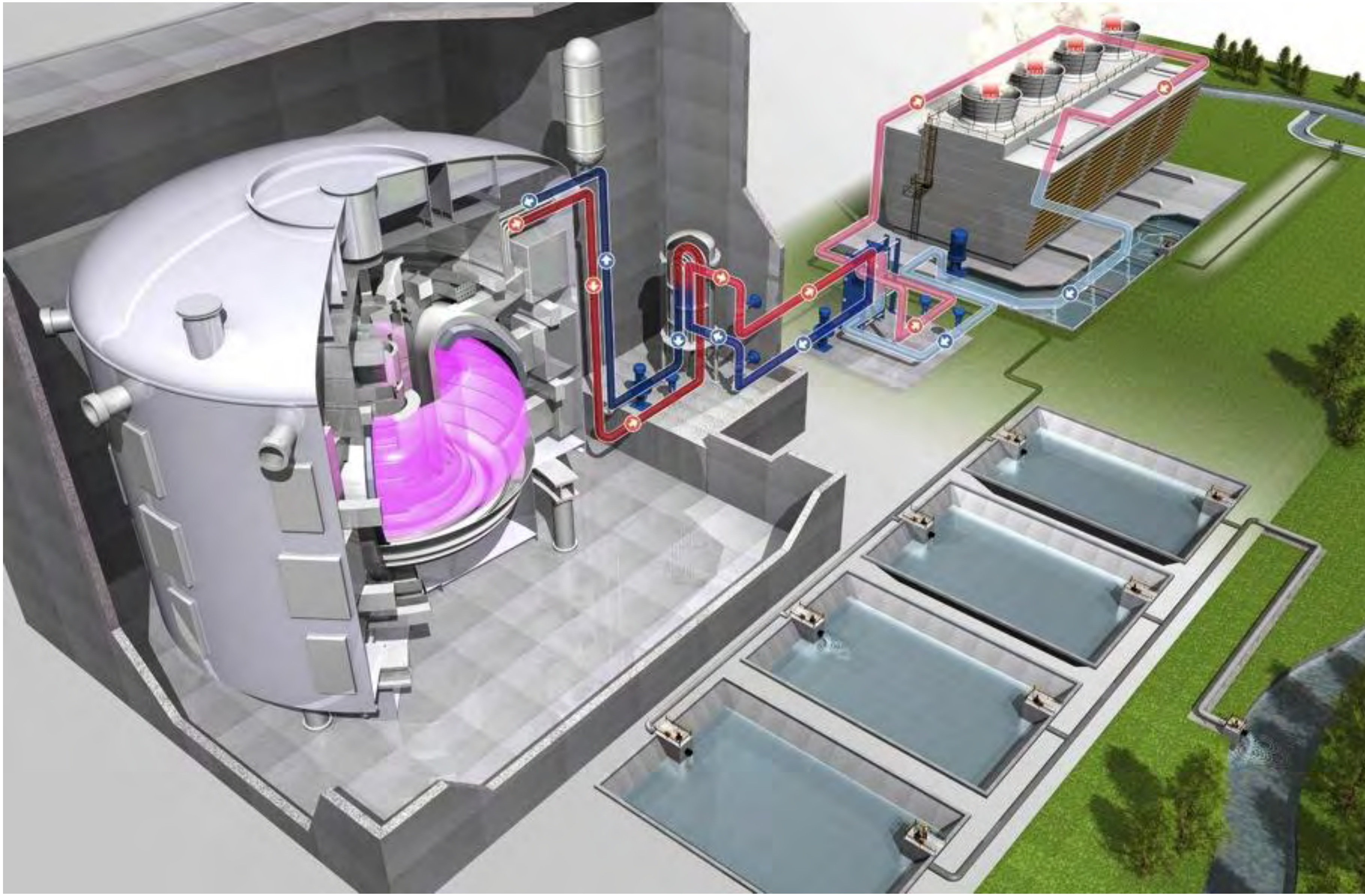
"Scientific breakeven"	**Q = 1**	**(JET)**
"Self-heated plasma"	**Q ~ 10**	**(ITER)**
"Power Plant"	**Q ≥ 30**	**(DEMO)**

The Fukushima Daiichi acccident
Plant Design

- Reactor Service Floor (Steel Construction)
- Concrete Reactor Building (secondary Containment)
- Reactor Core
- Reactor Pressure Vessel
- Containment (Dry well)
- Containment (Wet Well) / Condensation Chamber

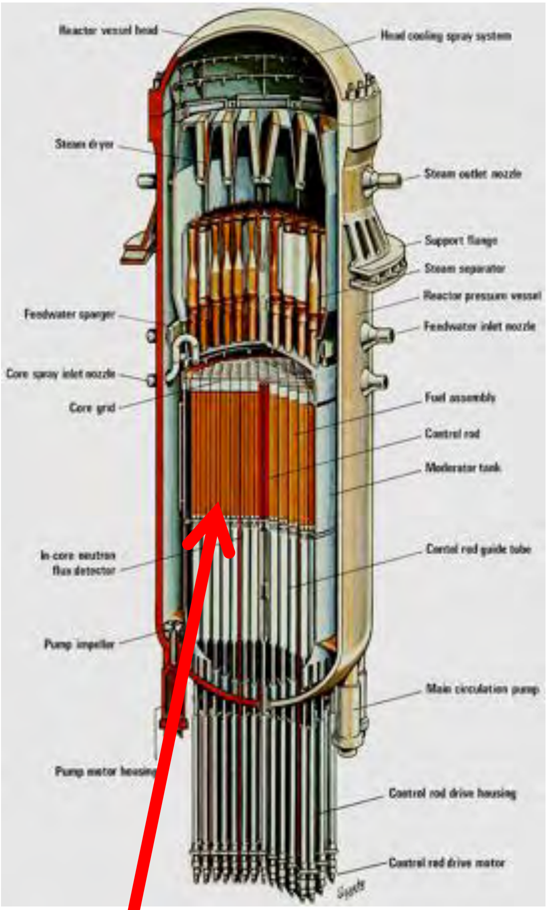


Schematic of ITER in-vessel component cooling system



Fuel

Fission
Reactor Vessel

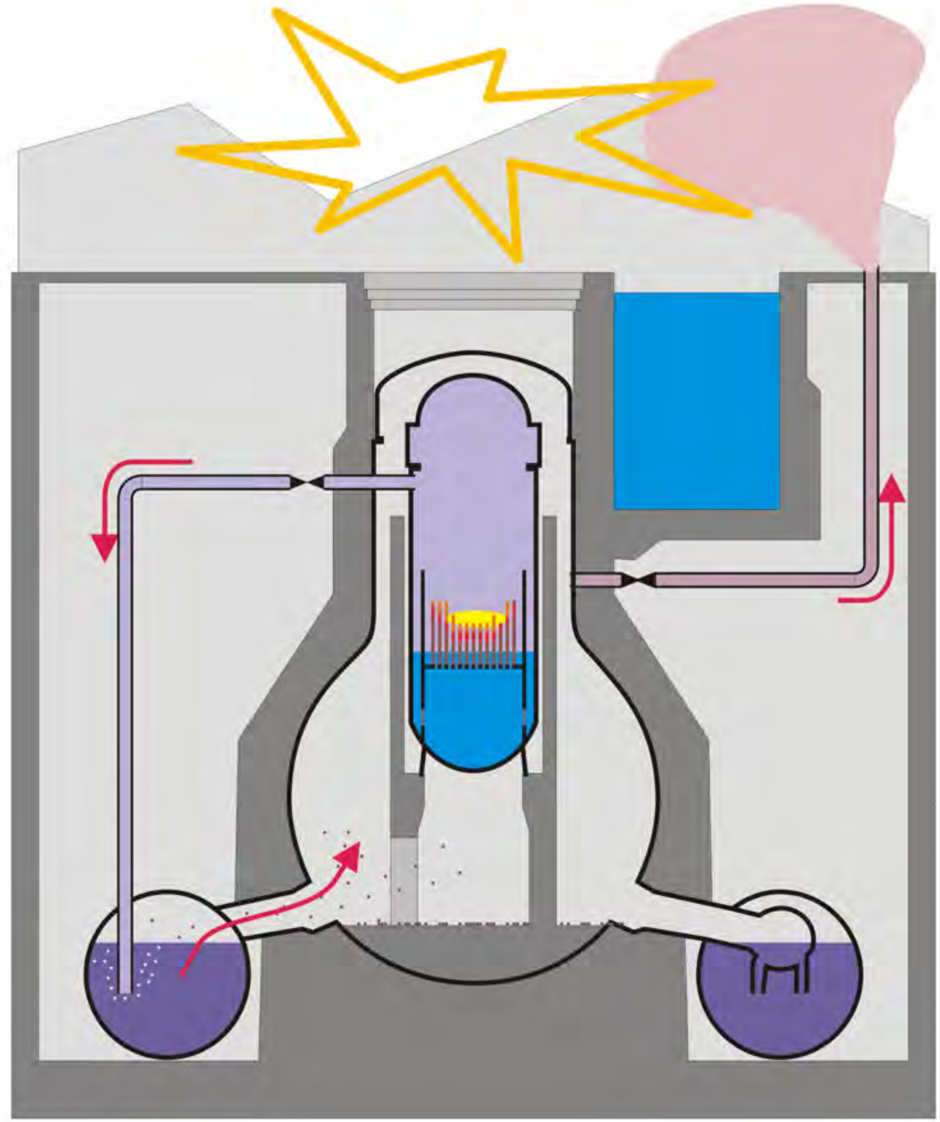


Fusion
Vacuum Vessel

≈ Tons of solid Uranium isotopes

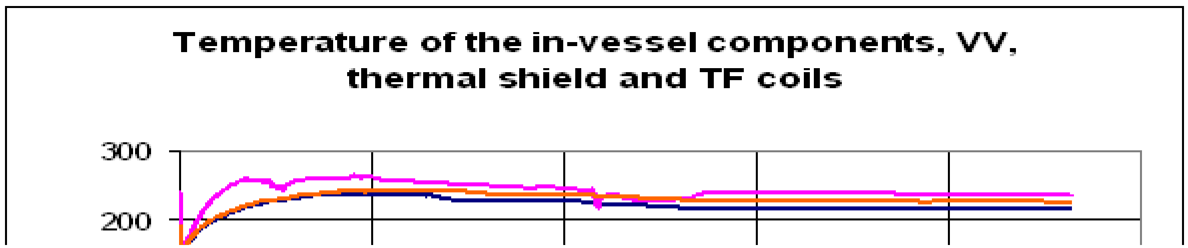
grams of gas Hydrogen isotopes

- Unit 1 und 3
  - Hydrogen burn inside the reactor service floor
  - Destruction of the steel-frame roof
  - Reinforced concrete reactor building seems undamaged
  - Spectacular but minor safety relevant



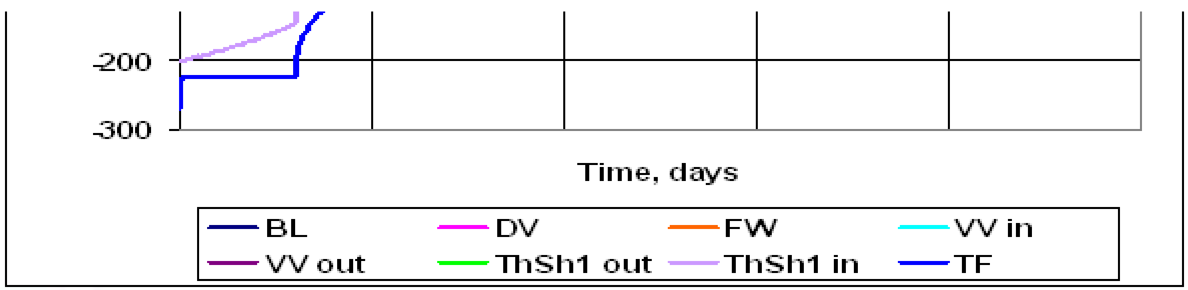
Can anything like that happen in ITER (Fusion) ?

- NO chain reaction to be stopped.
- NO fuel to melt:
    - Vacuum Vessel essentially empty
- Low after heat
    - NO from fuel.
    - Only in structures
    - Very large structures
    - Large cryogenic exchange surfaces



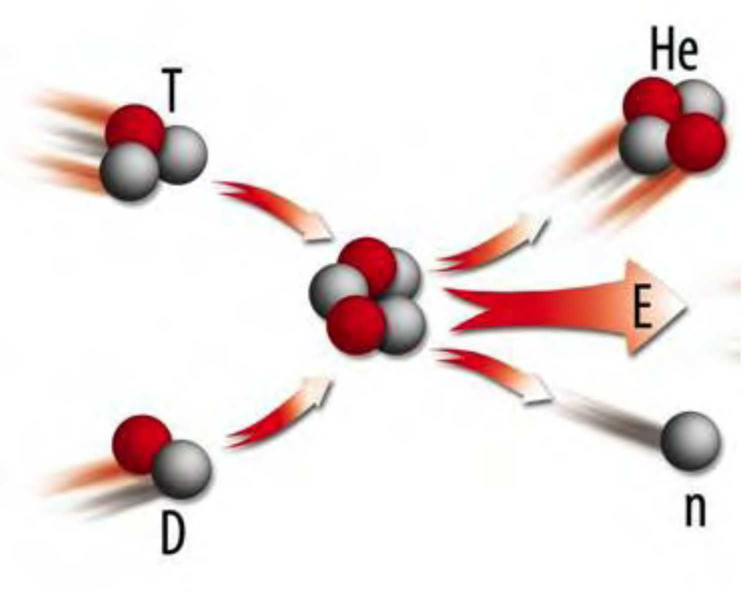
CATEGORICALLY NO!!

COOLING IS NOT SAFETY FUNCTION



Is ITER a nuclear installation?

- The nuclear classification of ITER is due to:



- **Tritium inventory**

  4 Kg **(nuclear fuel for ITER)**

- **Radioactive waste**

  Very low (52%), low (39%) and medium activity/long life (9%)

  ≥ 30.000 Tons

  (operation+dismantling)

The radioactive inventory classifies ITER in France as a

BASIC NUCLEAR INSTALLATION

ITER has two safety functions:

- ➔ Confinement radioactive materials
- ➔ Limitation of radiation exposure

- There is no safety function associated to:
  - **Control of the fusion reactions.**
  - **Power dissipation (cooling systems)**

ITER General Safety Objectives

Normal Operation comprising events and plant conditions planned and required for ITER operation, including some faults or conditions which occur as result of ITER experimental nature

Incidents, or deviations from normal operation, comprising event sequences or plant conditions not planned but likely to occur one or more times during the life of the plant

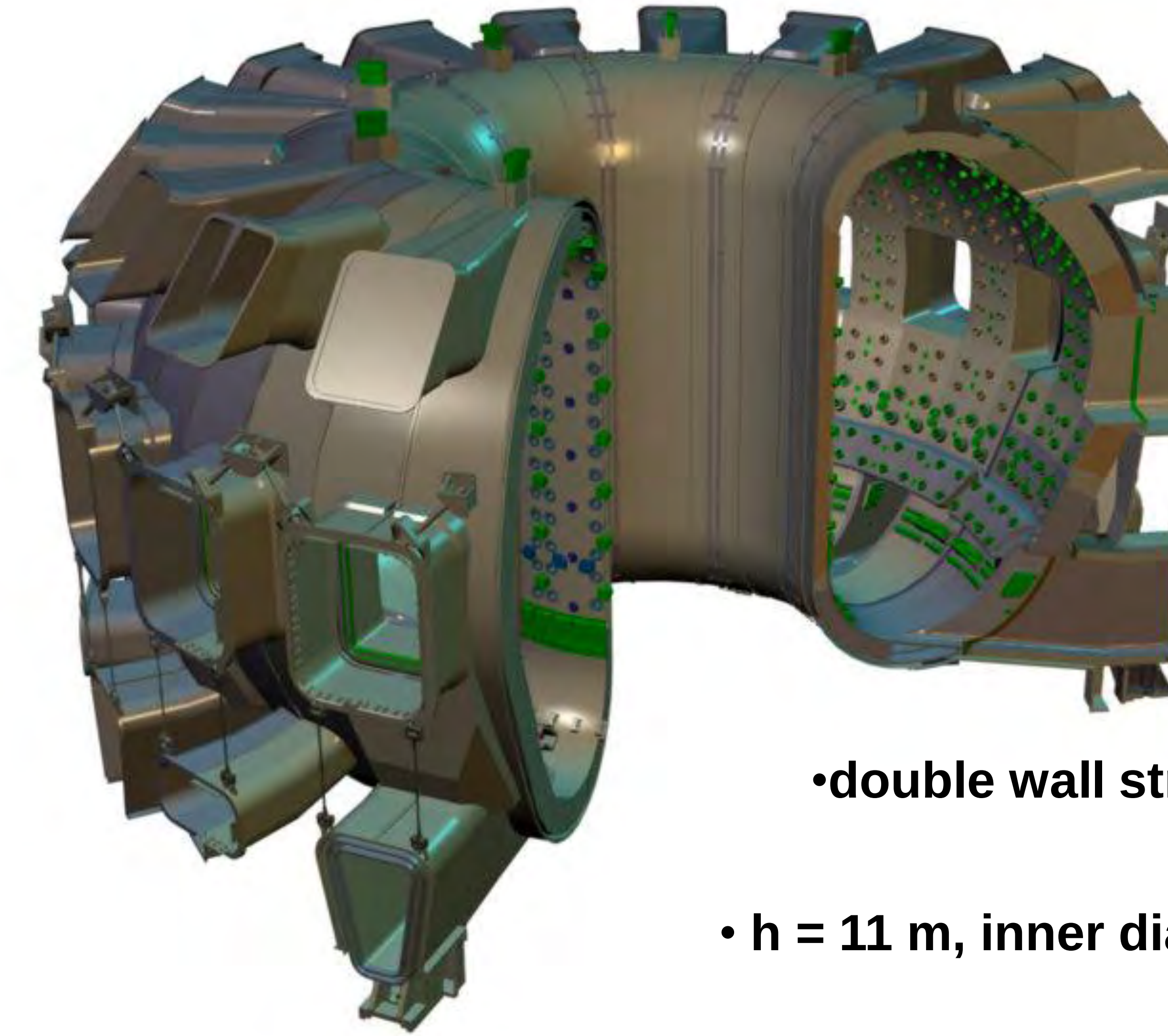
Accidents, comprising postulated event sequences or conditions not likely to occur during the life of the plant

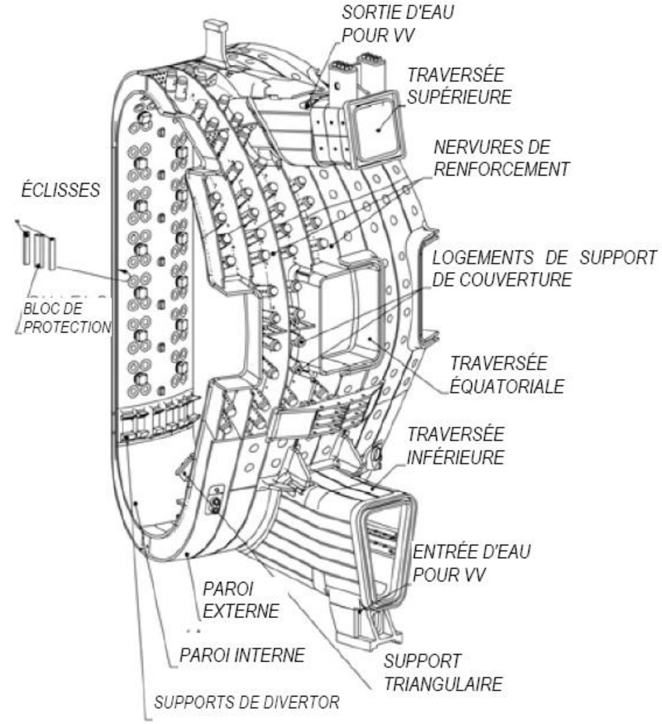
Normal situations	As low as reasonably achievable, and in any ca... Maxin... Avera...	Releases less than the limits authorised for the installation
Incidental situations	As lo... case...	
Accidental situations	Take into account the constraints related to the management of the accident and post-accident situation	No immediate or deferred counter-measures (confinement, evacuation) **< 10 mSv** No restriction of consumption of animal or vegetable products
Situations beyond design basis		
Hypothetical accidents	No cliff-edge effect; possible counter-measures limited in time and space	

Confinement of radioactive inventory

- Confinement is the most important safety function
  - Basic targets of confinement
  - Prevent spreading of radioactive material in normal operation
    - Keep radiological consequences in off-normal conditions within levels below the safety objectives
  - Confinement function is achieved by a coherent set of physical barriers and / or auxiliary techniques
    - First confinement system designed to prevent releases of radioactive materials into the accessible working areas
    - Second confinement system prevents releases to general public and the environment

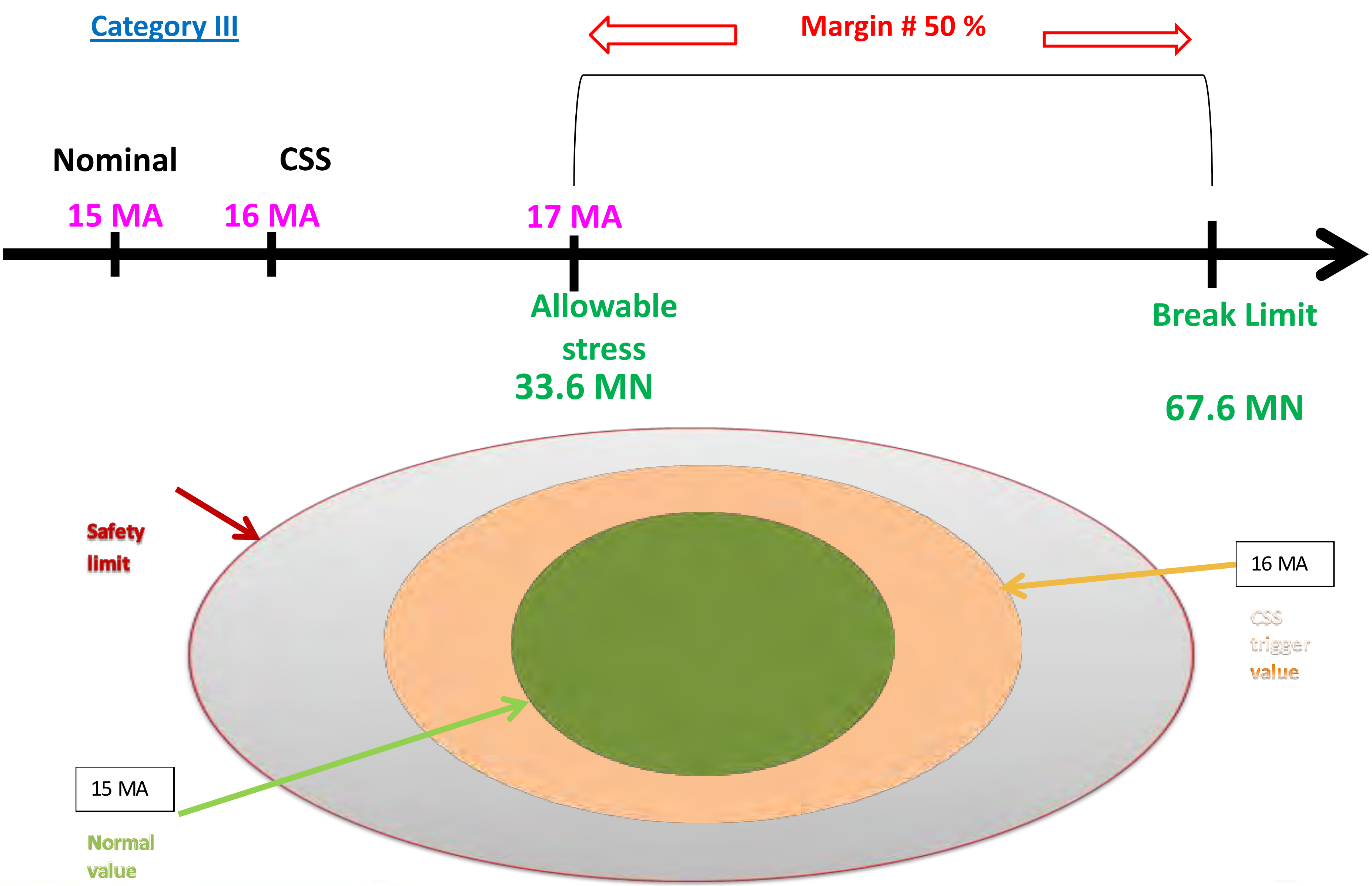
Vacuum Vessel and associated components





- **double wall structure**
- **h = 11 m, inner diameter 6 m**
- **mass 5000 tonnes**

PLASMA AND SAFETY ITER – DESIGN OF VV V.S ELECTROMAGNETIC LOADS



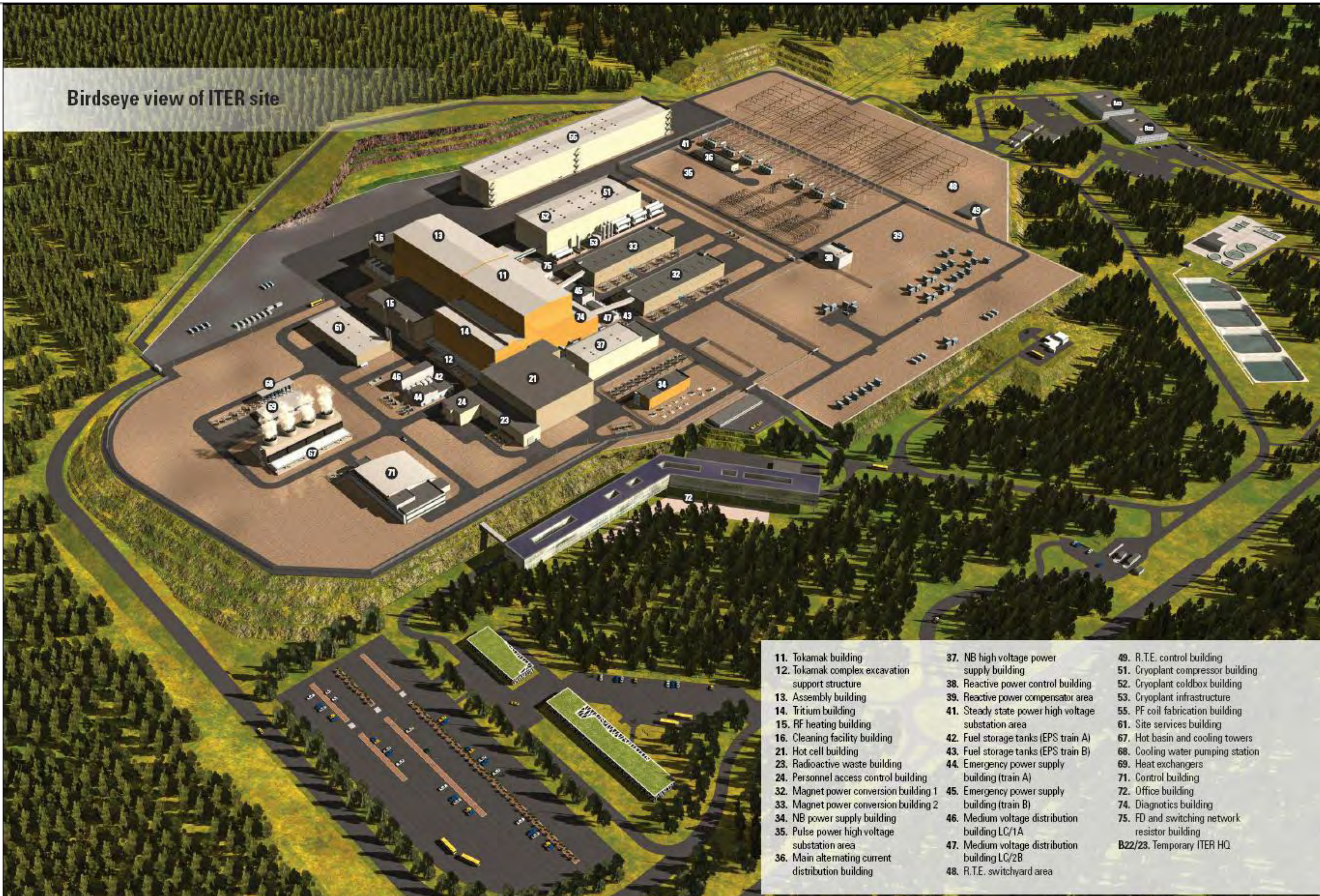
Safety Analysis

Internal Risks

- **Internal fire,**
- **Internal explosion,**
- Thermal deviations
- **Plasma transients,**
- Internal inundation,
- Missile effects,
- Whipping pipe,
- Mechanical risks,
- risques chimiques
- Magnetic and electromagnetic perturbations

External Risks

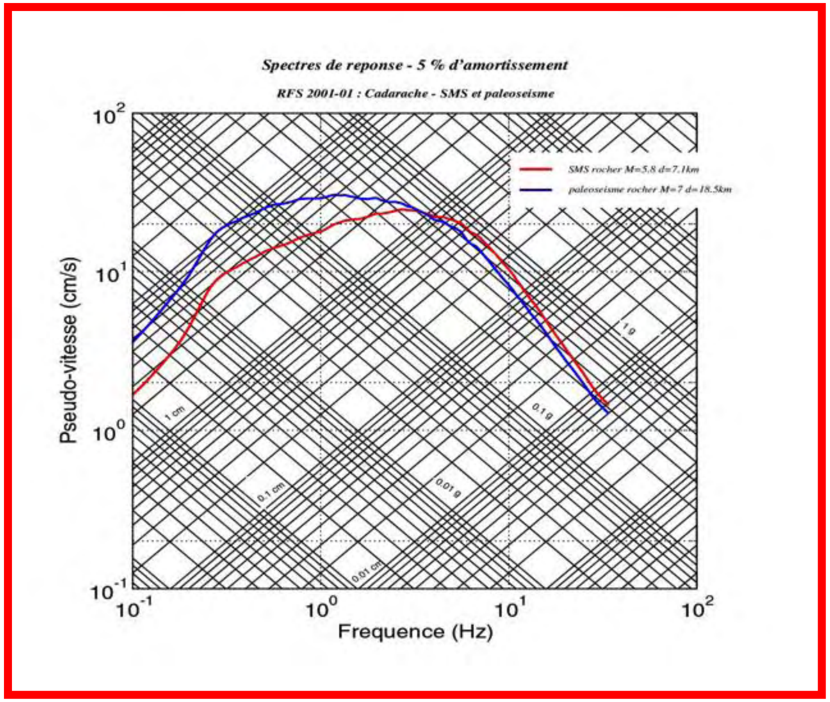
- **Seismic,**
- **Extreme climatic conditions, like hot weather, extreme cold, rain, snow, wind and lightening,**
- **External inundation,**
- **External fire ,**
- **Plane crash,**
- **Accidents associated to the industrial environment and transport routes, mainly external explosions,**
- **Accidents in a nearby installation at the site of CEA Cadarache.**


Birdseye view of ITER site
11. Tokamak building
12. Tokamak complex excavation support structure
13. Assembly building
14. Tritium building
15. RF heating building
16. Cleaning facility building
21. Hot cell building
23. Radioactive waste building
24. Personnel access control building
32. Magnet power conversion building 1
33. Magnet power conversion building 2
34. NB power supply building
35. Pulse power high voltage substation area
36. Main alternating current distribution building
37. NB high voltage power supply building
38. Reactive power control building
39. Reactive power compensator area
41. Steady state power high voltage substation area
42. Fuel storage tanks (EPS train A)
43. Fuel storage tanks (EPS train B)
44. Emergency power supply building (train A)
45. Emergency power supply building (train B)
46. Medium voltage distribution building LC/1A
47. Medium voltage distribution building LC/2B
48. R.T.E. switchyard area
49. R.T.E. control building
51. Cryoplant compressor building
52. Cryoplant coldbox building
53. Cryoplant infrastructure
55. PF coil fabrication building
61. Site services building
67. Hot basin and cooling towers
68. Cooling water pumping station
69. Heat exchangers
71. Control building
72. Office building
74. Diagnostics building
75. FD and switching network resistor building
B22/23. Temporary ITER HQ

Taking into account the full characteristics of the site

- Meteorological conditions : similar to those of Cadarache
- Hydrological Parameters : works designed for a hundred-year flood with margin
- Hydrogeological Parameters
  Many studies on piezometric aquifers (Cretaceous Miocene / Pliocene) year flood level centennial with confidence interval 95%: 305 m NGF, platform level: 315 m NGF => no risk of external inundation,
- Geological Parameters : Many studies on the characterization of the site (Cretaceous and Miocene), no specific tectonic detected
- Seismic parameters : consideration of the SMS to the rock (5.3) and a low frequencies paleoseismic plus margin (7)
- Point zero chemical and radiological : no anomalies detected

What are the effects of an earthquake on ITER?



Seismic parameters:

- SMS to the rock (5.3)
- low frequencies paleoseismic plus margin (7)

Seismic design and application:

- nuclear building design
- ~500 seismic pads
- tokamak complex mainly reinforced concrete
- safety equipment qualification
- automatic shutdown of plasma
- combustible gases removed from VV within several minutes
- plant systems are isolated
- majority of inventory is placed in safe storage; remainder is confined and isolated within the process
- residual heat is removed via natural convection

What are the effects of an external inundation on ITER?

Hydrological Design :

- works designed for a hundred-year flood with margin

Hydrogeological Parameters :

- 100 year flood level with confidence interval 95%: 305 m NGF
- platform level: 315 m NGF
- site drainage exceeds the exceptional storm rainfall by 20%

Tsunami consideration :

- because of the inland location, distance from major bodies of water, and elevation above see level tsunamis are not a concern for ITER

Therefore there is no credible risk of external inundation

What are the effects of an earthquake followed by flooding?

Basic assumption of unlikely event:
- seismic event followed by
- failure of Serre-Ponçon Dam

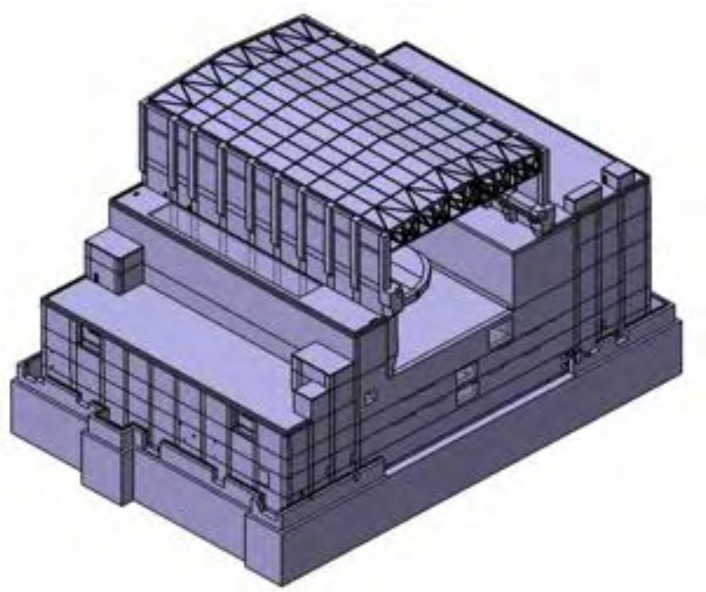
Response to seismic event
- safe state
- plasma shut down
- inventory placed in safe storage
- plant systems isolated
- inventory placed in safe storage
- all within minutes of initiating event
- residual heat removal by natural convection

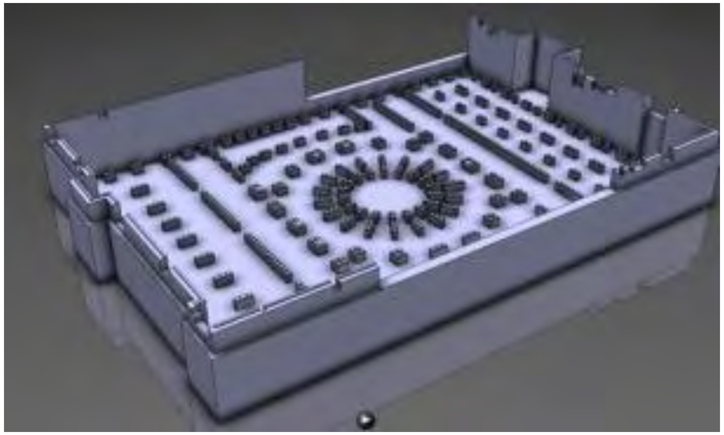
Centenial flood of Durance - failure of the Serre-Ponçon dam
- maximum flood level: 265 meter above sea level
- first raft of nuclear buildings: 298 m ASL
- exceptional rain flood level: 305 m ASL
- nuclear building constructed on a second raft at 315 m ASL

Earthquake followed by exceptional flooding is neither probable nor problematic.

Tokamak Complex

- **Main characteristics**
  - **Tokamak Complex includes Tokamak, Tritium and Diagnostics buildings. These buildings form a monolithic structure.**
  - **All buildings are reinforced concrete structures except the structure that supports the metal roof of the hall handling Tokamak Building is composed of a metal frame**
  - **Joint type bracing walls and columns / beams**





  - **Complex stands on ≈ 500 seismic isolators**

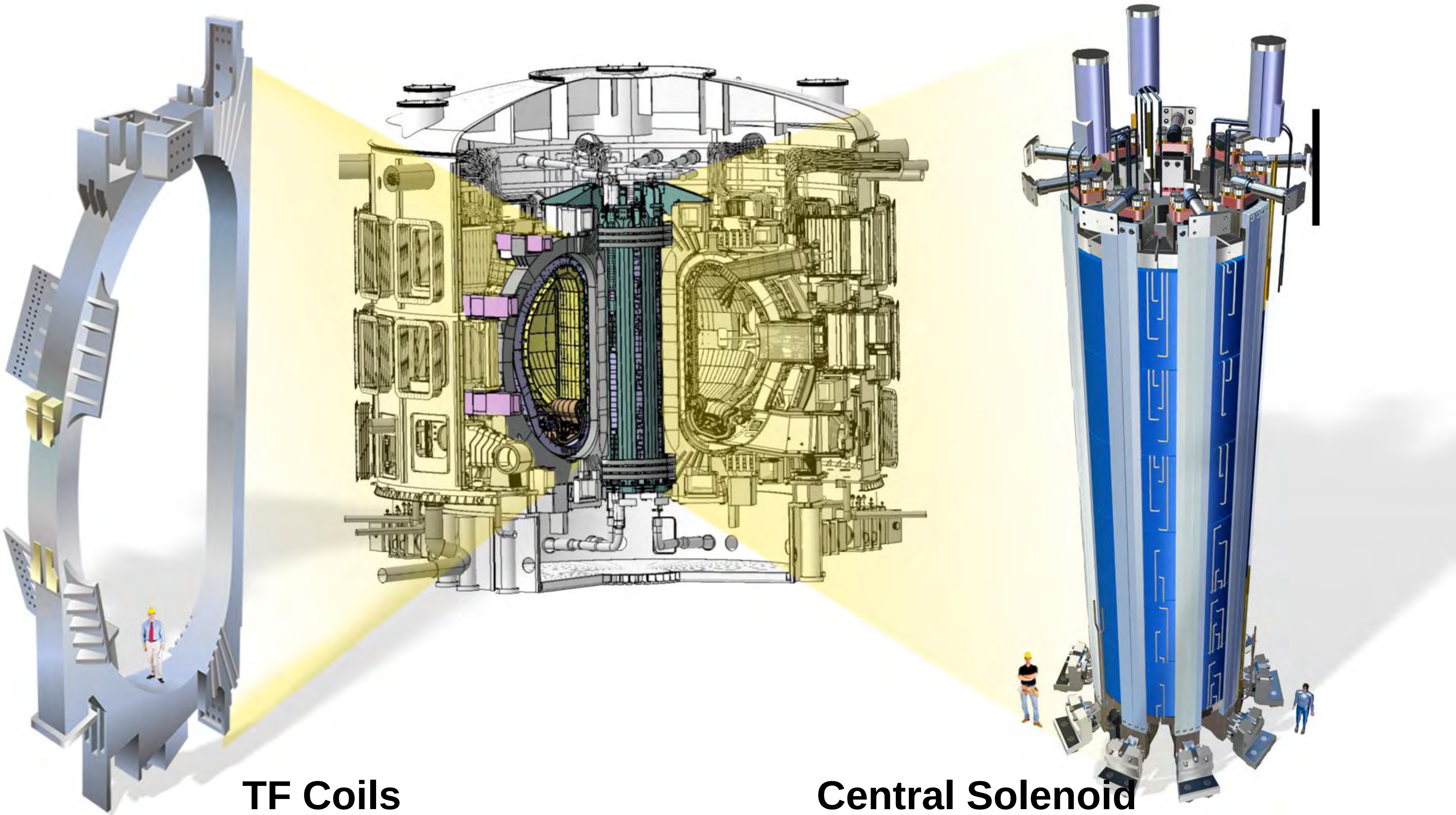
Design Basis Accidents

V1	In-vessel FW pipe leakage
X6	Heat exchanger leakage
X1	Loss of divertor heat sink
X2	Pump trip in divertor HTS
T1	Tritium process line leakage
L1	Loss of off-site power for 32 hours
	blackout for 1 h in Hot cell
V2	Multiple FW pipe break
	Multiple FW pipe break + 10 DV pipes break
V3	Loss of vacuum through one VV/cryostat penetration line (500 MW)
	Loss of vacuum through one VV/cryostat penetration line (700 MW)
X3	Pump seizure in divertor
X7	Heat exchanger tube rupture
X4	Large VV coolant pipe break (ACP mass is reduced 100 times: it is lower than in FW/BLK loop by factor 100)
	baking

X5	Large DV ex-vessel coolant pipe break
	baking (controlled releases means through the stack and releases shall be multiplied by filtering factor)
X8	Coolant pipe break inside Port Cell (normal operation)
	baking, valves close
E1	Stuck divertor cassette and failure of cask
T2	Failure of transport hydride bed
T3	Isotope separation system failure
T4	Failure of fueling line
T5	Leak of tritiated water from WDS
M1	Toroidal field coil short
M2	Arc near confinement barrier
C1	Cryostat air ingress
C2	Cryostat water ingress
C3	Cryostat helium ingress
H1	Loss of confinement in hot cell

Magnets Safety

Magnets - Unprecedented Size and Performance



TF Coils
11.8 Tesla, 41 GJ
400 MN centering force

Central Solenoid
13 Tesla, 7 GJ
20 kV, 1.2 T/s

WHAT COULD BE THE SAFETY ISSUES AND DESIGN IMPLICATIONS ?

- Is there an impact on the 1 st confinement barrier credited in ITER safety analysis?

  the first confinement is the vacuum vessel and contains 1 ton of activated dusts and 1 kg of tritium

- **Is there an impact on the last confinement barrier credited in ITER safety analysis through the anchorage of the coils to the civil work?**

  On **major part of t**he last confinement barrier is the basemate where anchorage ensured the support of the magnets systems, the VV and the cryostat

IS THERE AN IMPACT ON THE FIRST CONFINEMENT BARRIER?

✓ A postulated event (DBA) is a full terminal short of a **TF coil** (TF coil short):

two ground faults in the coil busbar circuit : one on side of the TF coil, while undergoing a fast discharge, plus the failure of the monitoring systems to detect these faults.

- Substantial local plastic deformation can be expected to occur in the TF case (in the shorted coil and the adjacent coils) and intercoil structures.

- There may be a loss of cryostat vacuum due to thermal shield damage.

➔ However, gross structural failure is not predicted. There is no impact of magnets on the vacuum vessel and no radiological consequences are predicted

IS THERE AN IMPACT ON THE FIRST CONFINEMENT BARRIER?

- ✓ **Another postulated event is an arc inside a PF/CS coil (Arc near confinement barrier).**
  - **The arc develops as a result of a failure (or inability) to discharge the coil when a quench occurs.**
  - **The quench will propagate slowly and local conductor melting followed by the development of arcs, is likely.**
  - **The melted material produced by the coil internal arcs may not be contained by the thin coil casing and would probably be spread over components in the cryostat in the vicinity of the shorted coil. It is possible that external arc energy associated with the shorted coil short is sufficient to melt the conductor of the superconducting busbars**

➔cause local melting around the cryostat feed-throughs.

➔However, no radiological consequences are predicted.

- ✓ FUKUSHIMA event pushes us to check for this non plausible accident what could the remaining safety margin

- ✓ A BDBA scenario is postulated and it is not derived from any identified mechanism by which a magnet failure could initiate

Damage to vacuum vessel and cryostat resulting in large holes

large holes, 1 m^2 created simultaneously in VV and cryostat

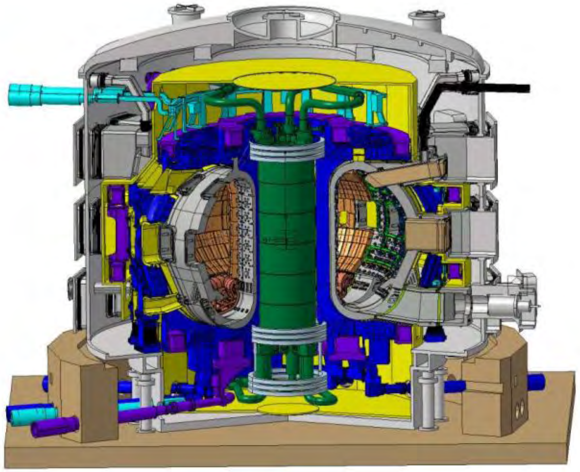
➔ Radiological consequences very limited (0.14 mSv, 2.5 km)
➔ No countermeasure for the public

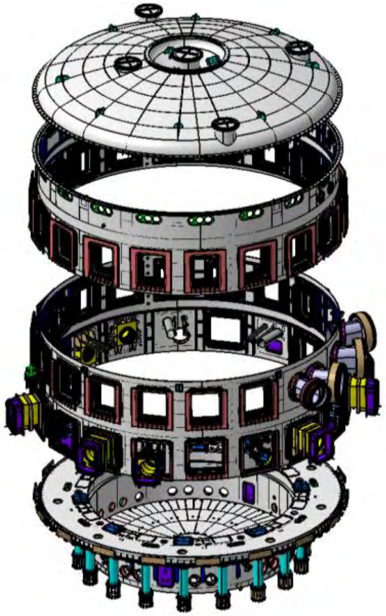
Minimizing the potential for damage

- The potential for a magnet fault to lead to damage to confinement has been minimized by their design.
- Magnet systems incorporate multiple monitoring and protection systems in the design.
- Two of these detection and protection systems are designated Safety Important Class (SIC) as they provide the following safety functions:
  - **TF coil quench detection**
  - **Fast discharge of TF coil stored energy**

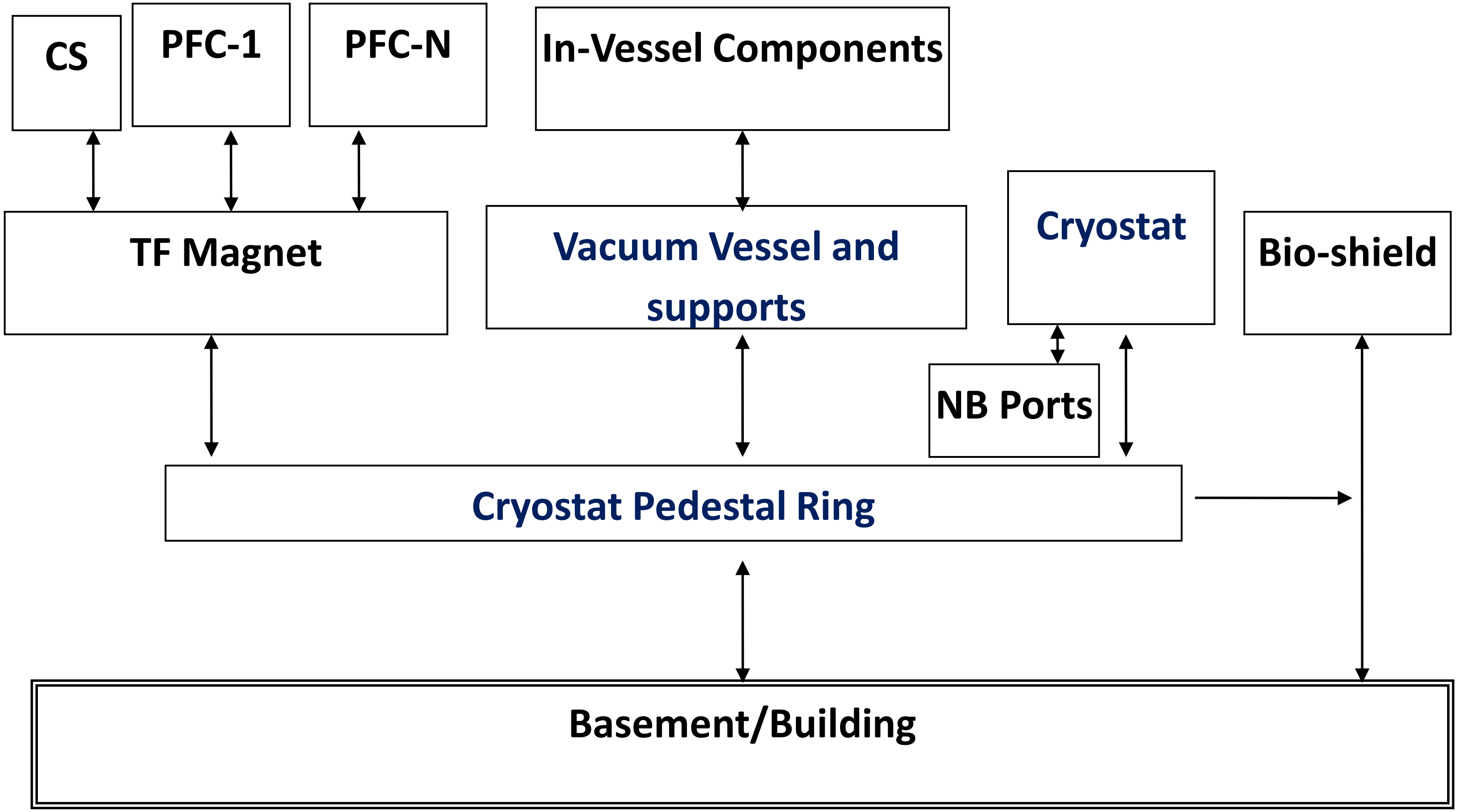
IS THERE AN IMPACT ON THE LAST CONFINEMENT BARRIER CREDITED IN ITER SAFETY ANALYSIS THROUGH THE ANCHORAGE OF THE COILS TO THE CIVIL WORK?

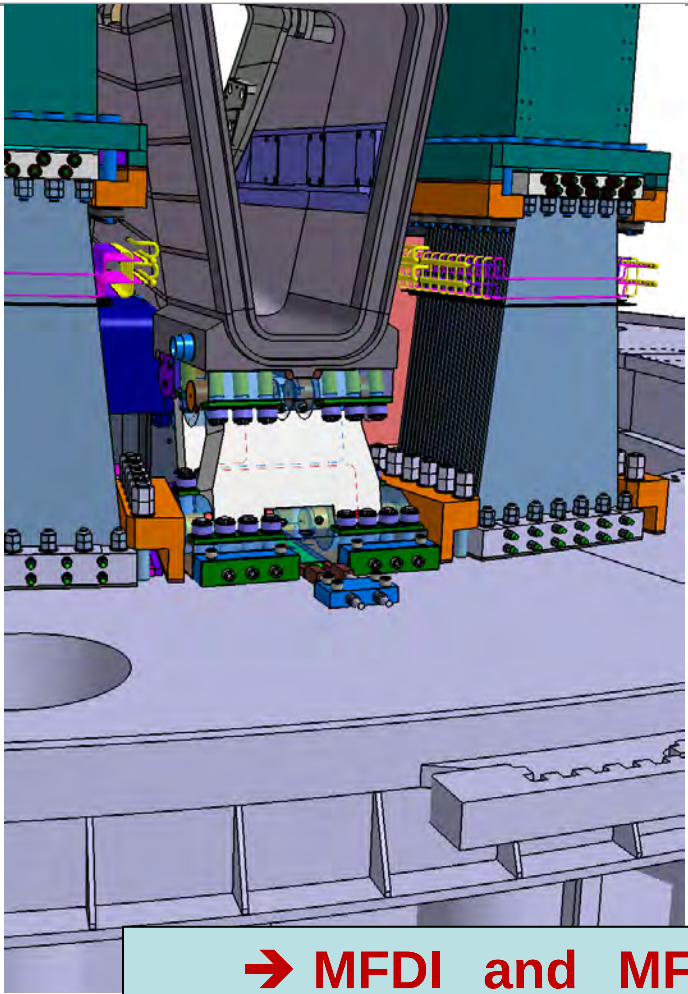
- The two main tokamak components (VV and magnetic coils) rest on the cryostat pedestal ring. The pedestal ring is supported by the building basemat.
- The magnets gravity support system consists of columns made up of flexible compression plates resting on the pedestal ring and resisting vertical and toroidal movements.
- Each PF coils are connected directly to the TF magnet assembly.
- The VV thermal shield is attached to the TF coil system.
- The in-vessel systems (blanket modules, divertor) are directly supported by the vessel.
- The cryostat is supported by the basemat.
- The tokamak building is supported by the basemat.





The support hierarchy is schematically shown





- A fast discharge of the PF and CS coils (MFDI) is defined as a category I event
- A fast discharge of all coils (MFDII) is defined as a category II event

Load Case	Load Combination	Combination Category
1	DL + SL1 + VDE_{TM}	Category III
2	DL + SMHV + Cr ICE II	Category III
3	DL + SMHV + Cr ICE III	Category III
4	DL + SL2 + Cr ICE II	Category IV
5	DL + SL2 + Cr ICE III	Category IV
6	DL + VDE_{WC}	Category IV
7	DL + VDE_{WC-D}	Category IV
8	DL + Cr ICE II	Category II

Table 1 – Load Cases

➔ **MFDI and MFDII are not designing loads for the anchorage on basemat**

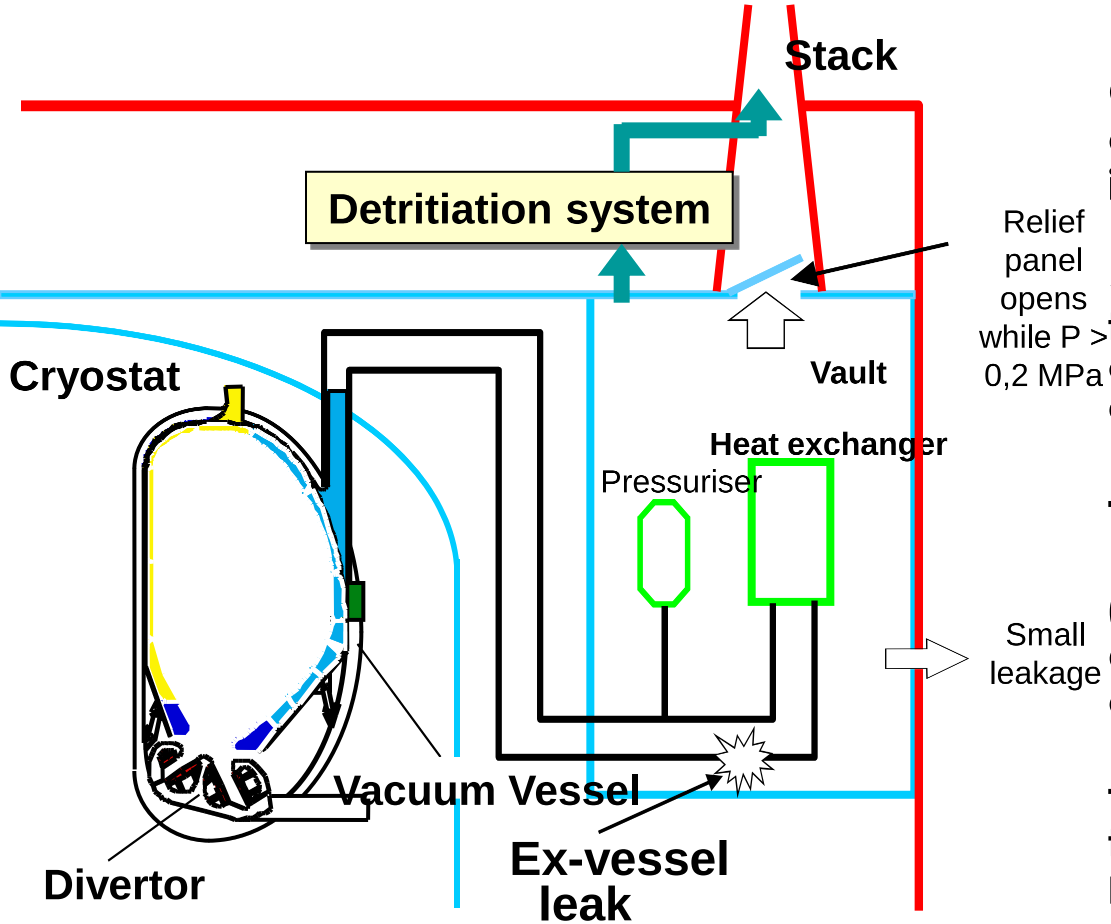
➔ **No impact on civil work**

CONCLUSIONS

- The coils are not SIC (not credited in safety analysis)
- The Instrumentation of the coils is SIC (TF quench detection)
- The fast discharge units are SIC
- TF coils : gross structural failure is not predicted. There is no impact of magnets on the vacuum vessel and no radiological consequences are predicted
- PF/CS coils : cause local melting around the cryostat feed-throughs. However, no radiological consequences are predicted
- MFDI and MFDII are not designing loads for the anchorage on basemate, no impact on civil work

Accident study

Design basis accident generating the most significant doses to the closest people



Guillotine rupture of the largest pipe of the divertor cooling system during its phase of drying

✓ **Releases come from the pressurization of the chamber containing a portion of the cooling loops and from the opening the discharge valve for a few seconds**

The accident "envelope" leads to 18 µSv to the most nearby person (Chateau de Cadarache), taking into account inhalation and ingestion of contaminated.

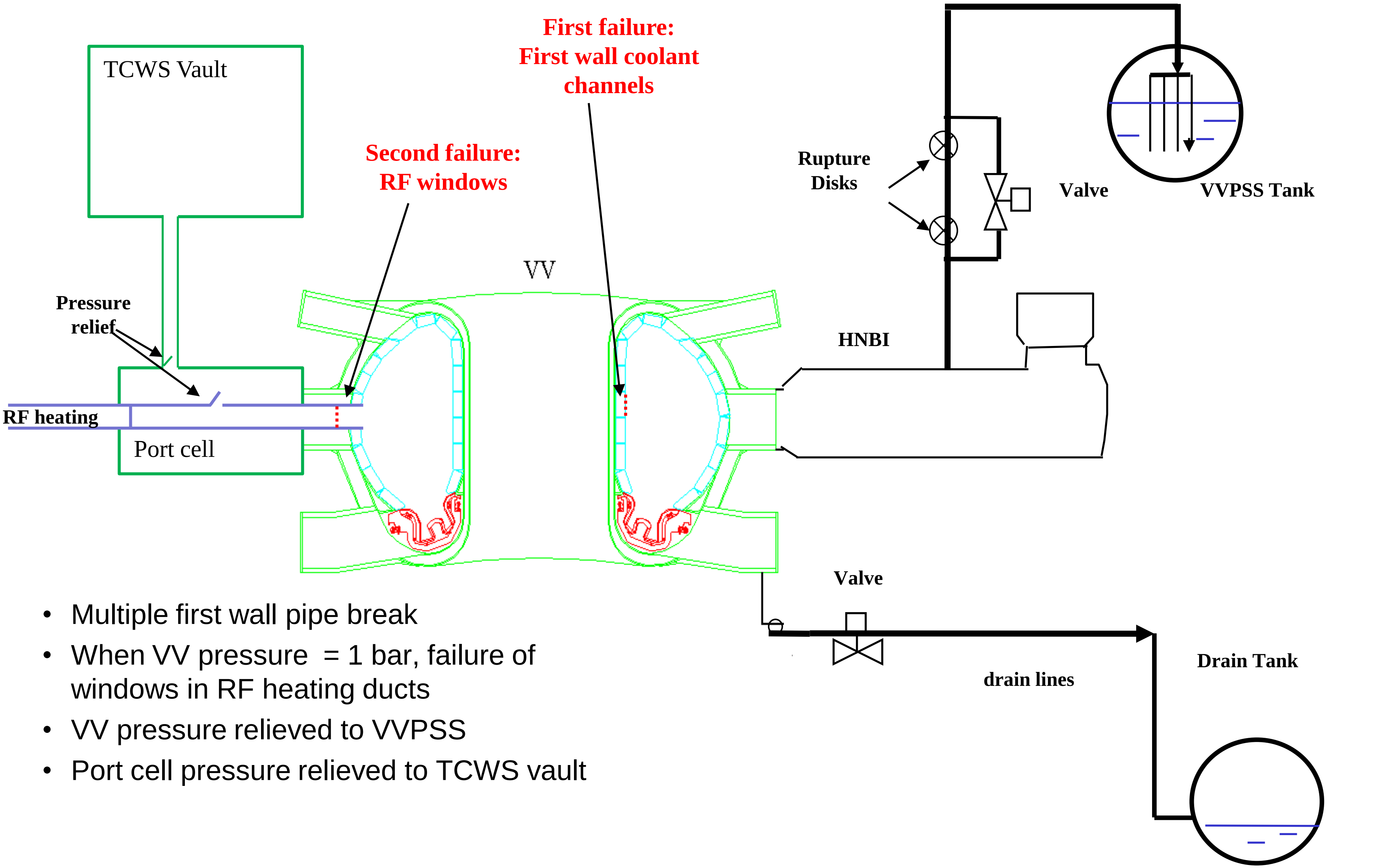
The dose is mainly due to the discharge through the chimney of activated corrosion products (over 90% of dose)

Beyond Design Basis Accidents

Loss of vacuum through one vacuum vessel penetration line plus 2 hours blackout and in-vessel FW coolant leak
Multiple failure of first wall cooling loops inside vacuum vessel together with failure of both windows in an RF heating line ("wet bypass")
Multiple failure of the first wall cooling loops inside vacuum vessel together with a failure of Fusion Power Termination System
FW Ex-Vessel Loss of Coolant with Failure of Fusion Power Termination System
Hydrogen and dust explosion in the vacuum vessel

Damage to VV and cryostat resulting in large holes of 1 m^2
Large VV ex-vessel coolant pipe break plus loss of flow in all intact PHTS loops
Cryostat water and helium ingress (2600 kg of He)
Confinement Failures in the Tritium Plant
Fire in the T-plant
Hydrogen Deflagration and Detonation in the Tritium Plant
Fire in the waste processing area plus propagation to buffer storage room in the hot cell

"Wet By-pass Scenario"



- Multiple first wall pipe break
- When VV pressure = 1 bar, failure of windows in RF heating ducts
- VV pressure relieved to VVPSS
- Port cell pressure relieved to TCWS vault

SAFETY ISSUES

- ANNUAL DOSE IN NORMAL CONDITIONS < 10 μSv at 200 m
  Long term < 3μSv

- MAXIMUM DOSE IN DESIGN BASIS ACCIDENT < 100 μSv at 200 m
  Long term < 17.6 μSv

- DUST EXPLOSION IN VACUUM VESSEL 332 μSv at 200 m
  BEYOND DESIGN ACCIDENT Long term < 200 μSv

- OTHER BEYOND BASIS ACCIDENTS ALSO SHOW LOW IMPACT AND NO "CLIFF EDGE" EFFECT:
  - ✓ Fire in tritium plant following failure of fire protection provisions: Maximum public dose 1.1 mSv (short term, 200m).
    Long term: 200 μSv
  - ✓ Worst event ("wet bypass"): max dose 4 mSv (short term, 200m),
    Long term: 130 μSv

Licensing milestones

- March 2010 — Submission of DAC files
- 14 December 2010 — Acceptance (MSNR)
- January 2011 — Transmission to Environmental Authority
- 13 January 2011 — Submission to CLI Working Group Public Enquiry files
- 23 March 2011 — Advice from Environmental Authority
- 23 May 2011 — Prefectoral Order for Public Enquiry
- 15 June – 4 Aug 2011 — Public Enquiry; Advice from CLI-July 2011
- 9 September 2011 — Advice from Enquiry Commission
- 30 November 2011 — Examination of RPrS by "Groupe Permanent"
- 2012 — CLI advice; Draft Technical Prescriptions by ASN; Authorisation for INB Creation Decree

Definition of the stress test

- The “stress test” is a targeted reassessment of the safety margins of nuclear facilities in the light of the events which occurred at Fukushima: extreme natural events challenging the facility safety functions and leading to severe accident.
- The reassessment consists
  - In an evaluation of the resistance of the nuclear facility when facing a set of extreme situations
  - In a verification of the preventive and mitigation measures chosen following a defense-in-depth logic (noting any potential weak point and cliff-edge effect): initiating events, consequential loss of safety functions, severe accident management
- In these extreme situations, sequential loss of the lines of defense is assumed, in a deterministic approach, irrespective of the probability of this loss

Definition of the stress test

- The objective is
  - To evaluate the robustness of the defense-in-depth approach,
  - To evaluate the adequacy of current accident management measures,
  - To identify the safety improvements, both technical and organizational (such as procedures, human resources, emergency response organization or use of external resources)
  - To describe the conditions for sub-contracting (the nuclear operator has to keep the complete control and responsibility of the facility safety)

Technical Scope

- Initiating events conceivable at the facility site:
  - Earthquake,
  - Flooding,
  - Other extreme natural events.
- Consequential loss of safety functions:
  - Loss of electrical power (including station black out),
  - Loss of the ultimate heat sink,
  - Combination of both.
- Severe accident management issues
  - *Means to protect from and to manage loss of core cooling function,*
  - *Means to protect from and to manage loss of cooling function in spent fuel storage pool,*
  - Means to protect from and to manage loss of containment integrity.

ITER is successfully making the transition from Design to Construction

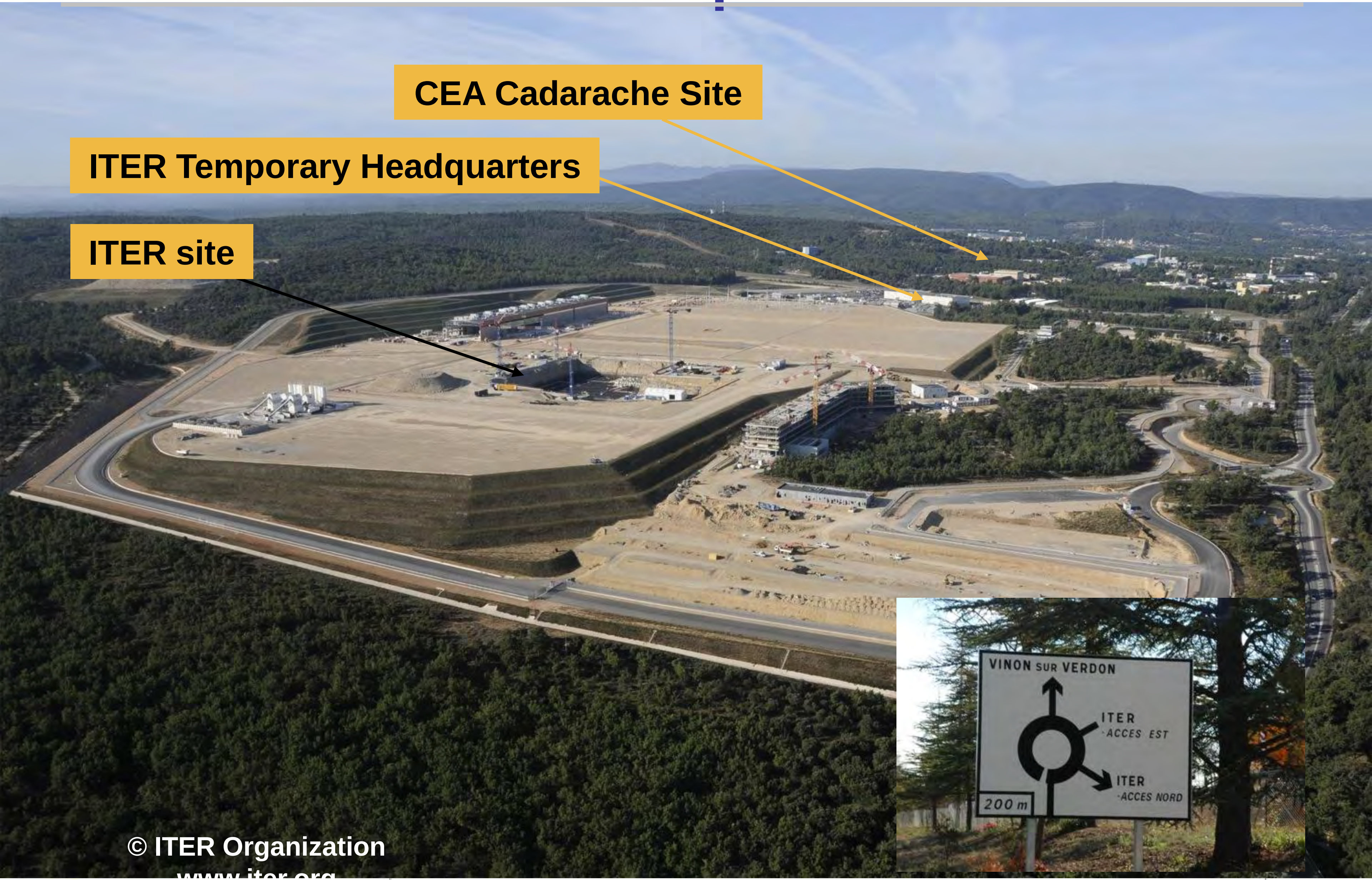
- **Going from developing requirements to detailed designs**
- **Going from R&D to large-scale prototypes**
- **Going from prototypes to large-scale manufacturing**
- **Beginning construction**

Status of the Project

As of May, 72 PAs signed out of 126
76.81 % of value achieved (2250.04 kIUA)

As of now,72 PAs signed with a total value of 2250.041313 kIUA out of a total In-Kind project value of 2929.32591 kIUA; representing 76.81 % of value achieved. The current forecast based on SMP data indicates that over 20 PA are scheduled to be signed in 2012

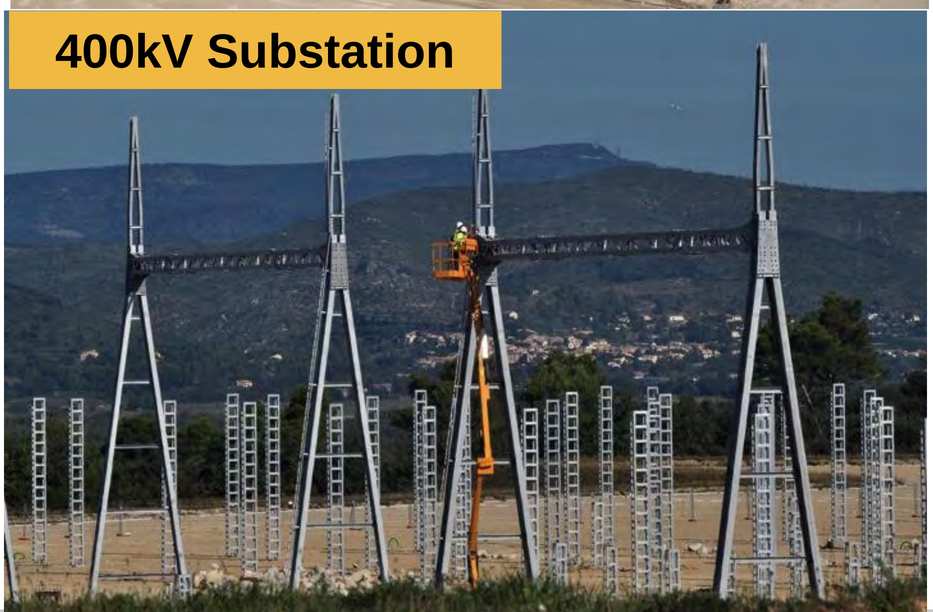
ITER Site in September 2011



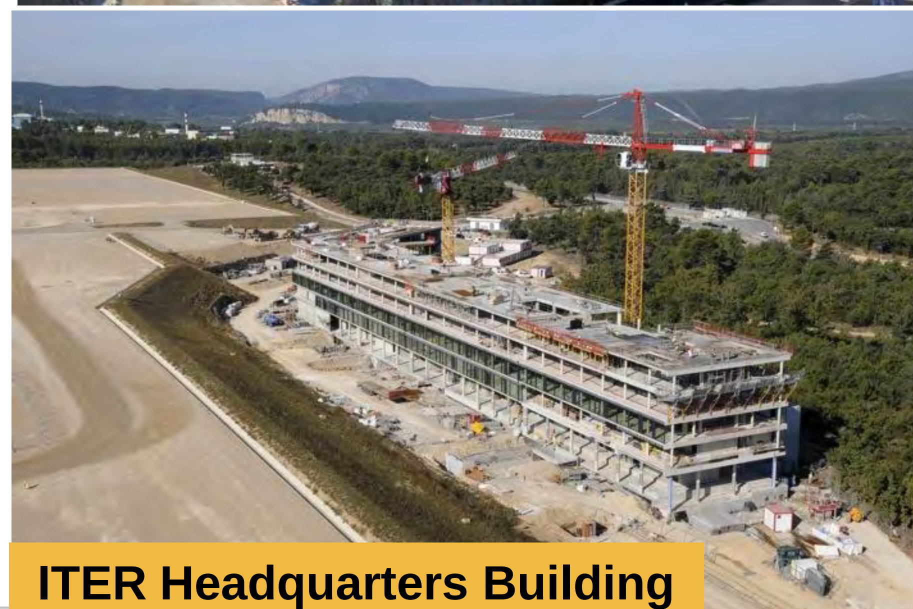
Construction Status at Cadarache

Tokamak Complex Construction

PF Coil Winding Building

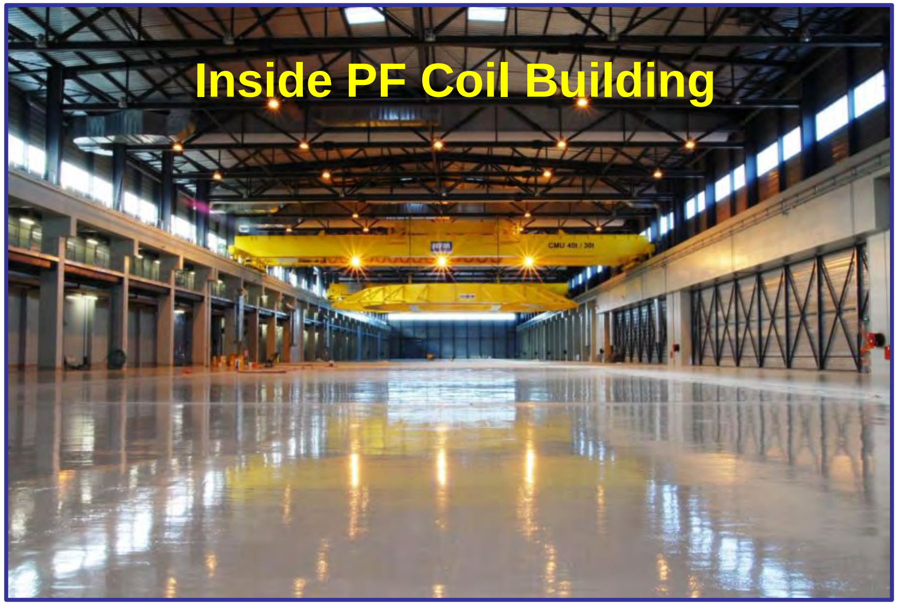


400kV Substation



ITER Headquarters Building

Site Construction Progresses (1)



Site Construction Progresses (2)

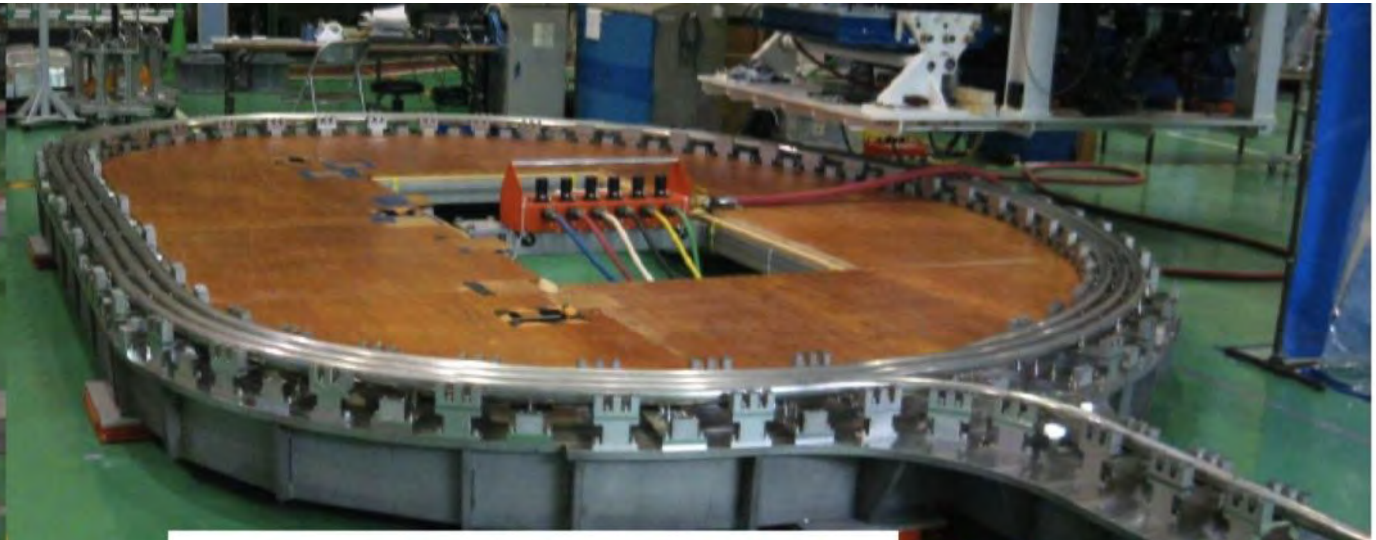
Construction site

ITER conexion to the 400 kV line – Tavel / Tore Supra.

Site **Progress Highlight**

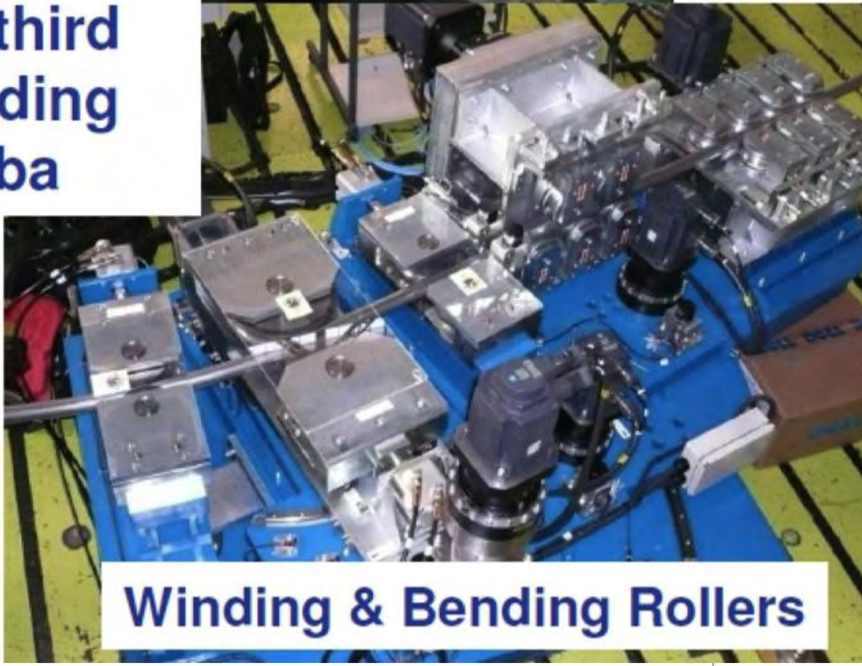
On Wednesday, 18 April, ITER Director-General Osamu Motojima and F4E Head of the Site Laurent Schmieder pressed the switch. The 493rd and last seismic pad was installed in the Tokamak Seismic Pit

Progress on TF Coils - Japan



Completed one third scale 3-turn winding trials at Toshiba

Winding Support Jig



Winding & Bending Rollers

Photos: JAEA and Contractor Toshiba

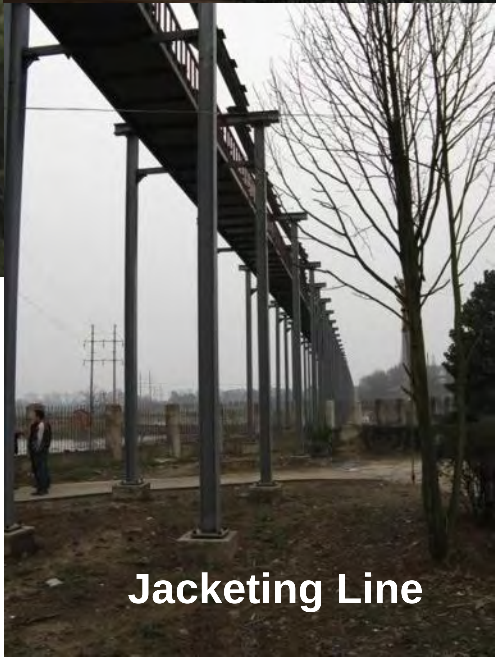
Progress on TF Coils - EU

Radial plate mock-up at CNIM
(Forged segments jointed by EB welding)

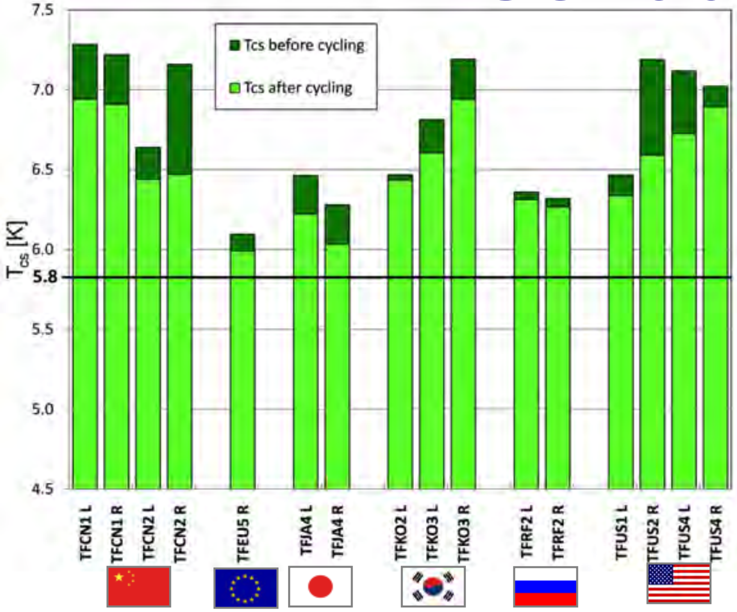
Radial plate welding mock-up at SIMIC
(Powder hipped segments joined by narrow gap TIG welding)

Photos: F4E & Contractors SIMIC, CNIM and Le Creneau

TF & PF conductor activity underway in Hefei, China

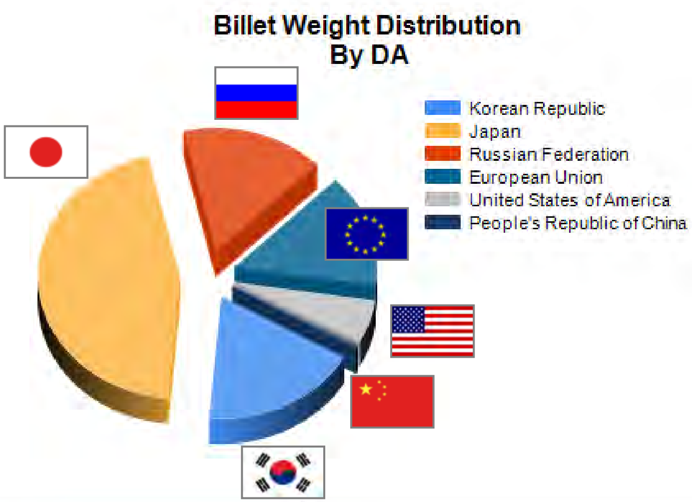


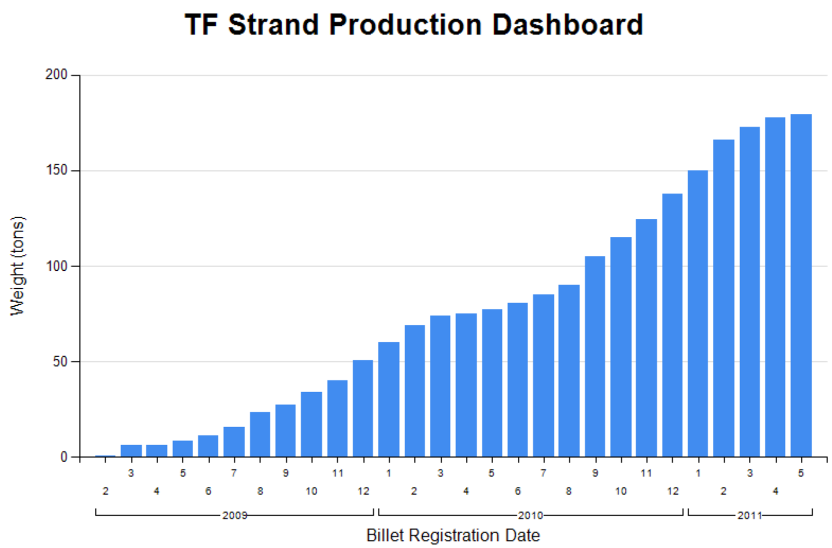
TF Conductor Production



TF Qualification Sample Summary

- Over 40% of required 450t of Nb_3Sn strand has been produced around the world
- Stepping up to 100 tons/year, an increase of two orders of magnitude from previous Nb_3Sn worldwide production rate





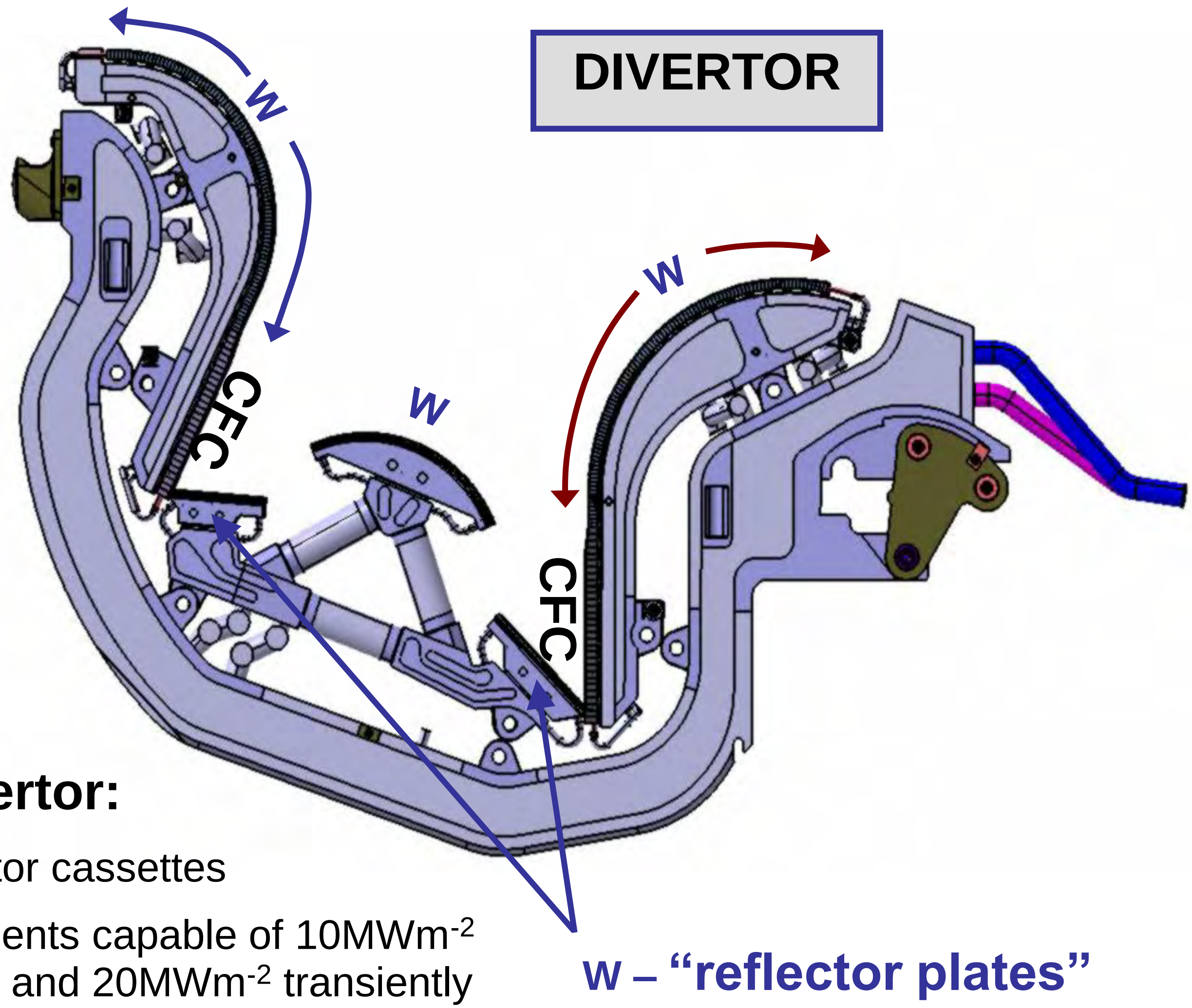
TF Strand Production Summary

In-Vessel Components - Divertor

In the current ITER baseline:

CFC at the strike points, W on the baffles through the H and D phases

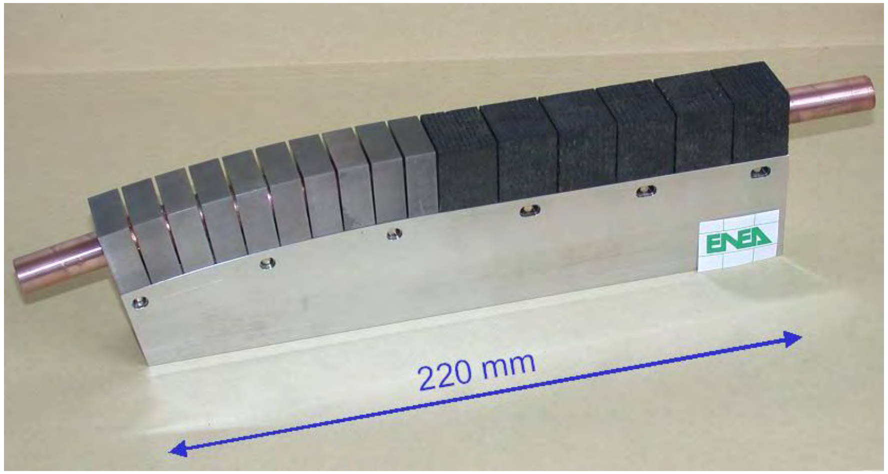
All-W from the start of DT operations



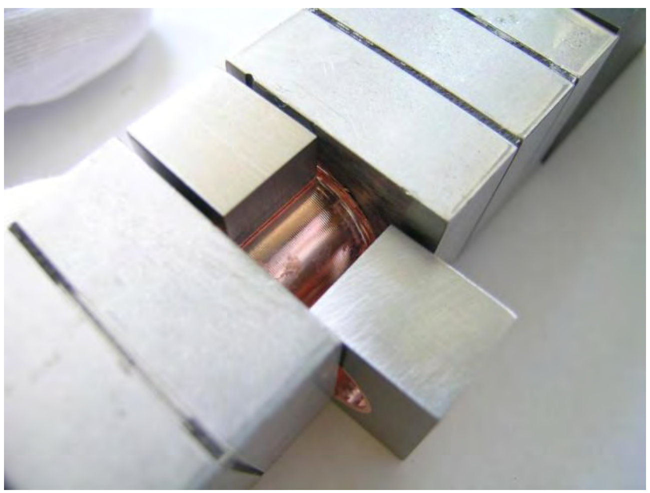
Divertor:

- 54 Divertor cassettes
- High heat flux components capable of $10MWm^{-2}$ in stationary operation and $20MWm^{-2}$ transiently

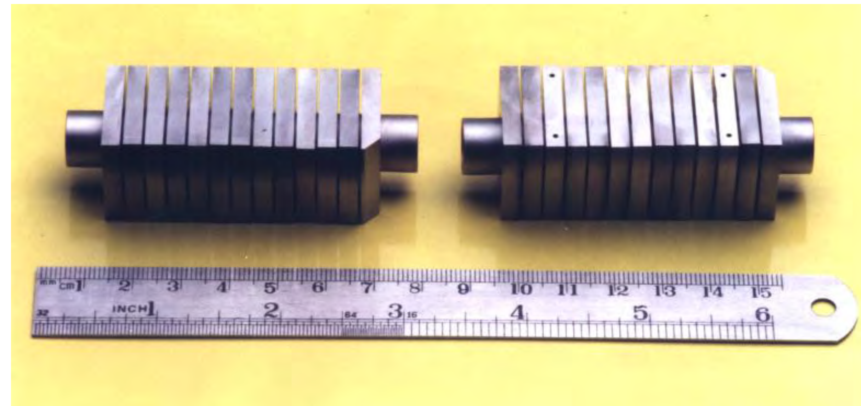
Status of W Technology R&D in EU



2000 cycles at 15 MW/m^2 on W



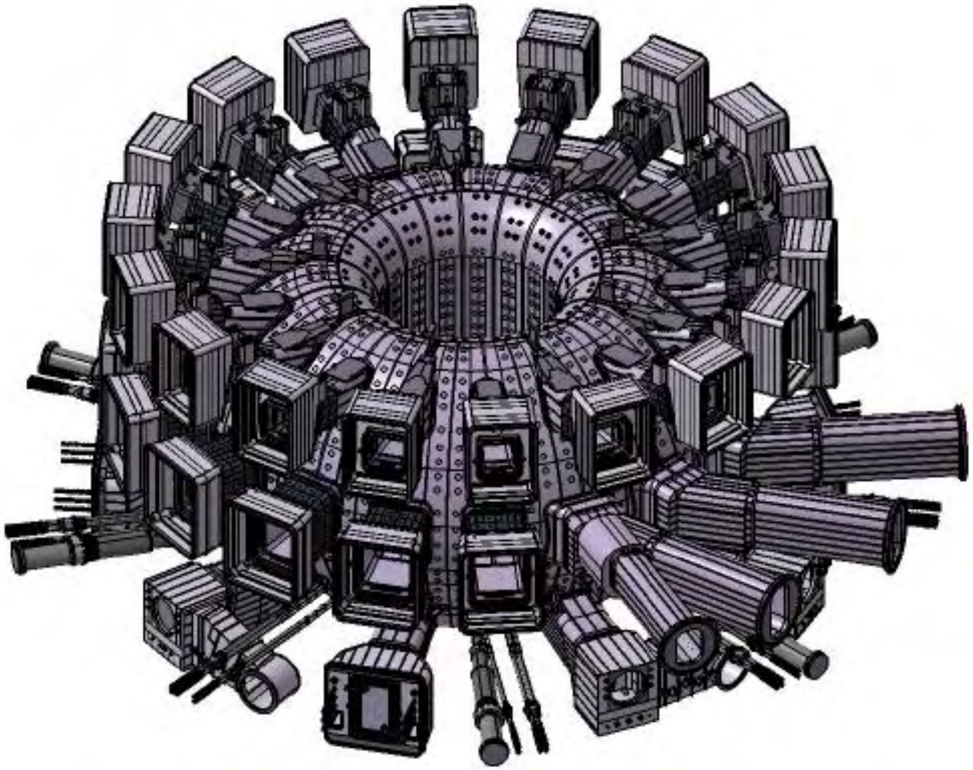
Most of all the W repaired monoblocks behaved like not-repaired ones

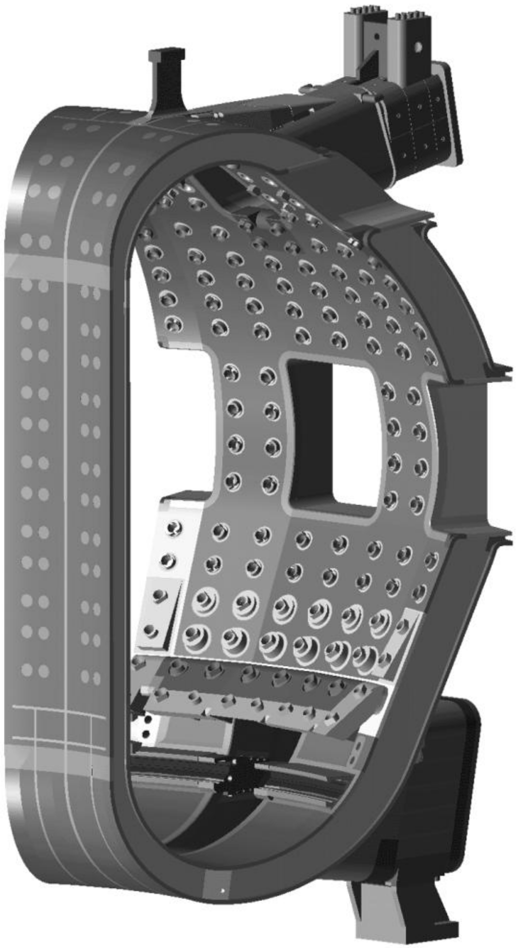


Unirradiated
- 1000 cycles x 20 MW/m^2 – no failure

200°C, 0.1 and 0.5 dpa in tungsten
- Successfully tested up to 18 MW/m^2

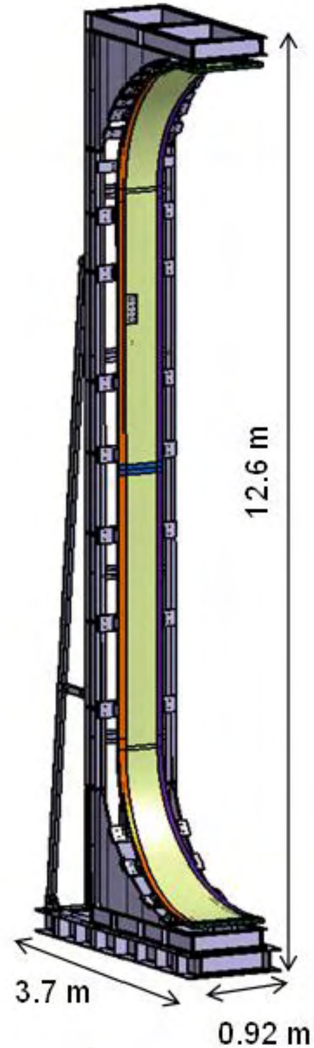
Vacuum Vessel





- **Vacuum Vessel is a double-walled stainless steel structure**
  - 19.4m outer diameter, 11.3m height, 5300 tonnes
    - provides primary tritium confinement barrier

Inboard segment of a VV sector

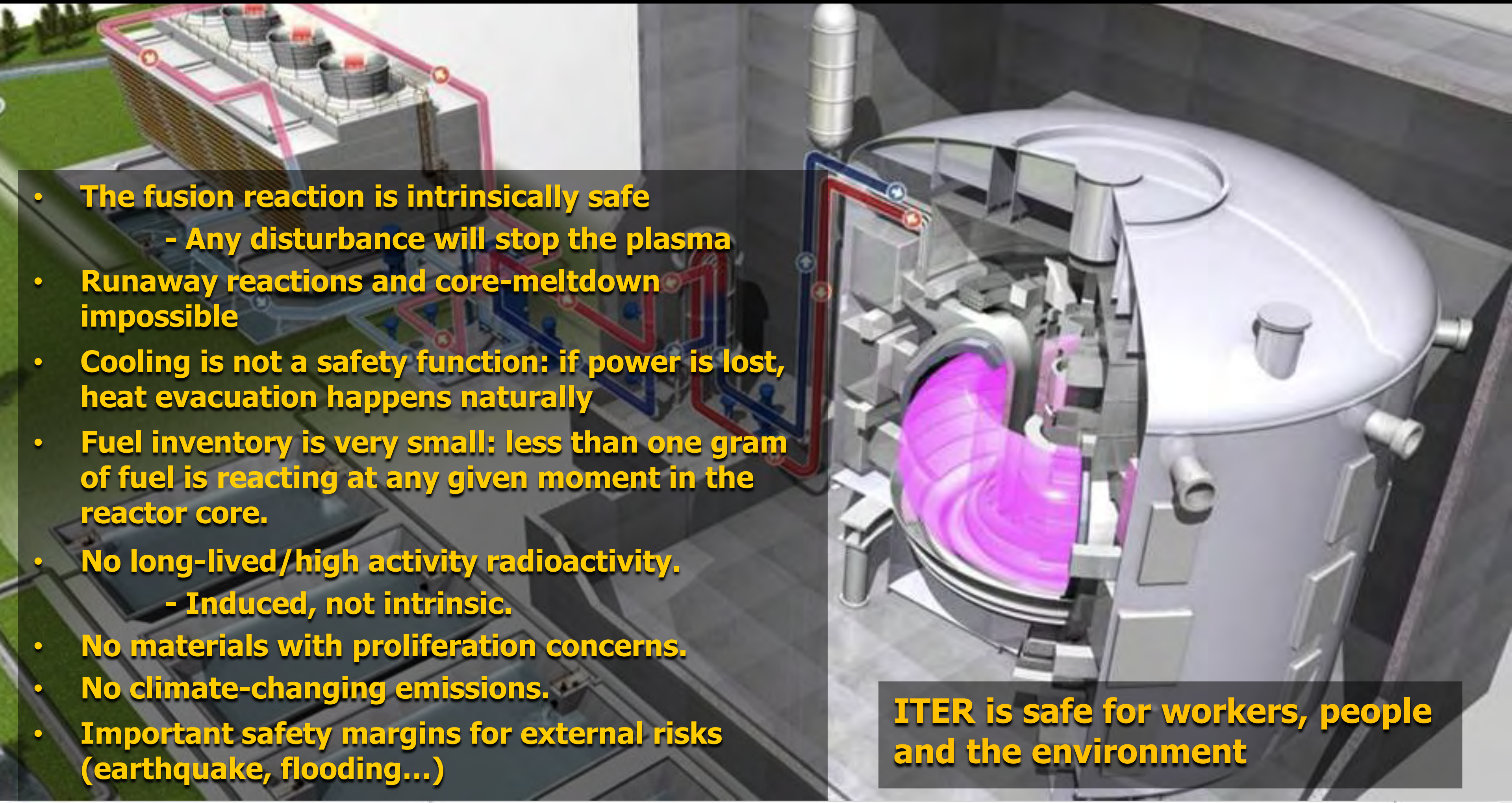


- **Korean Domestic Agency is verifying the manufacturing design and fabrication methods**

Photos: KO DA

How safe is ITER?

A Fukushima-like accident is impossible in ITER



- **The fusion reaction is intrinsically safe**
  - Any disturbance will stop the plasma
- **Runaway reactions and core-meltdown impossible**
- **Cooling is not a safety function: if power is lost, heat evacuation happens naturally**
- **Fuel inventory is very small: less than one gram of fuel is reacting at any given moment in the reactor core.**
- **No long-lived/high activity radioactivity.**
  - Induced, not intrinsic.
- **No materials with proliferation concerns.**
- **No climate-changing emissions.**
- **Important safety margins for external risks (earthquake, flooding…)**

ITER is safe for workers, people and the environment

Thank you for your attention