La Fusione a confinamento magnetico

The ITER Project

Rossella Rotella, ITER Organization - Tritium Breeding Blankets Project Leader

iter

china eu india japan korea russia usa

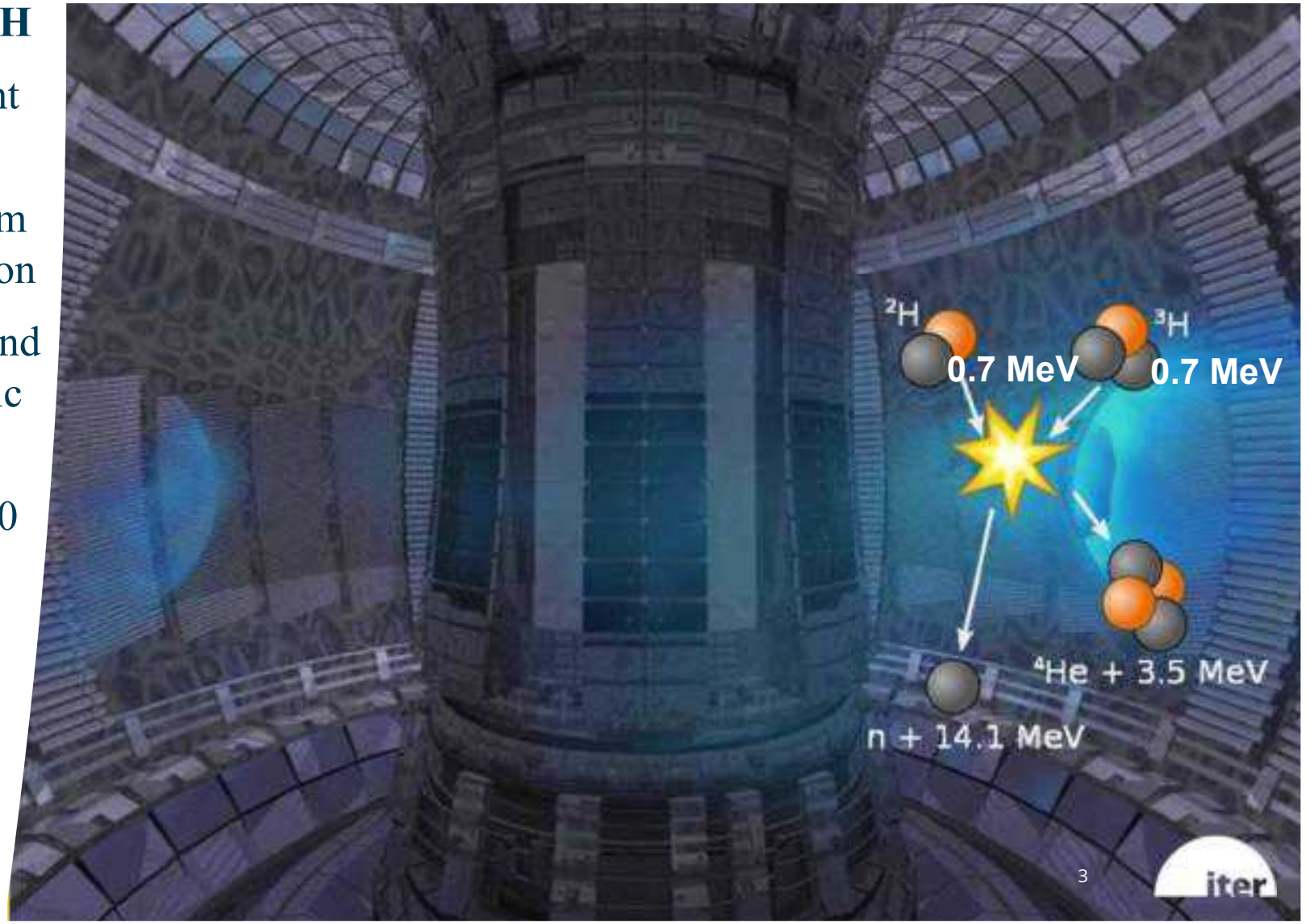
FUSION IN THE UNIVERSE

- Solar power
- Source of light, heat, and life on earth
- Produced by gravitational force

FUSION ON EARTH

Magnetic confinement fusion

- Deuterium + tritium => helium + neutron
- Precisely shaped and controlled magnetic field
- Temperature: ~ 150 million C
- A burning plasma



HOW DOES IT WORK?

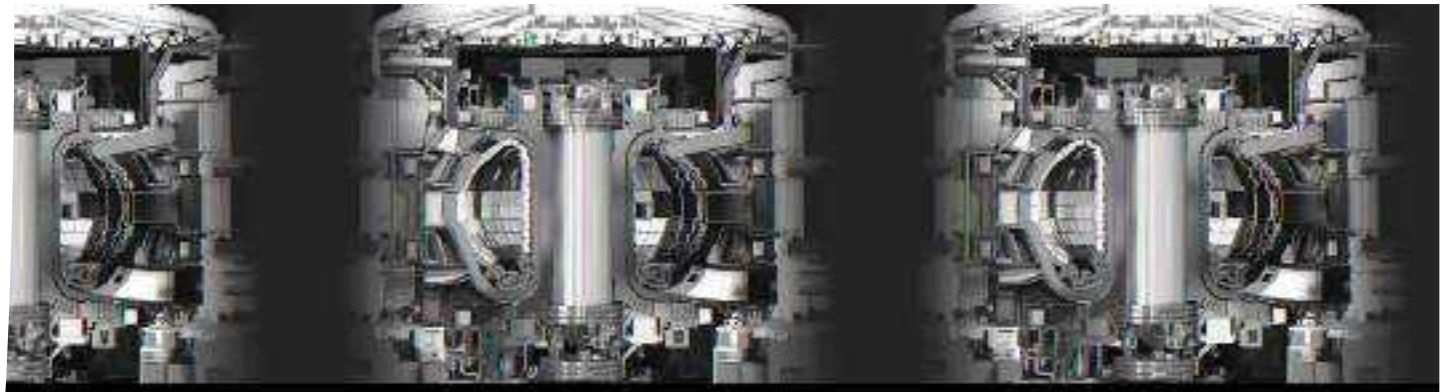
Inject DT gas

Inject electric current to convert the gas to plasma

Inject electromagnetic waves

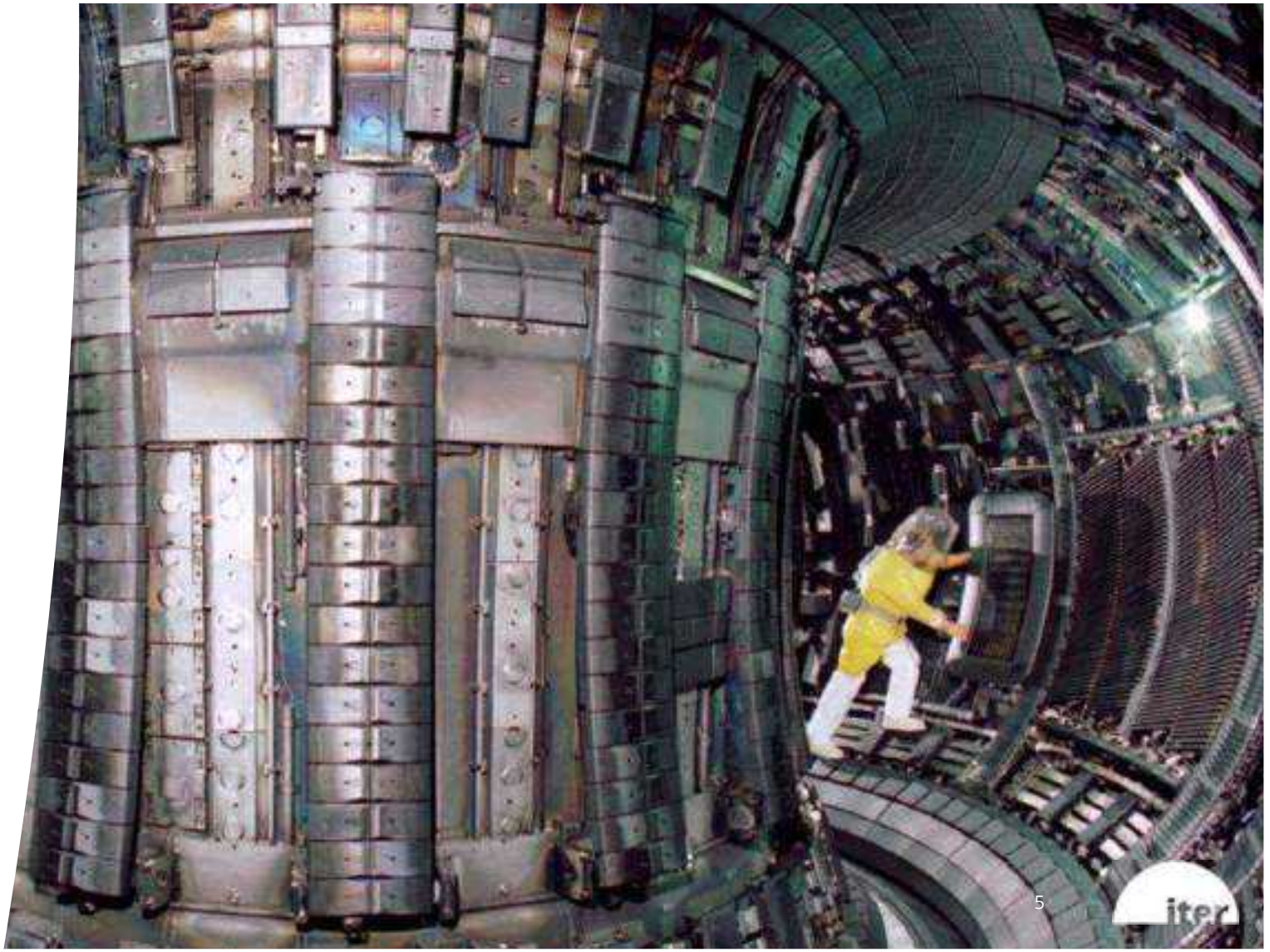
Inject high-energy neutral particles

Combine these techniques to reach 150-million degrees



60 YEARS OF PROGRESS

JET (Joint European Torus), Culham, United Kingdom.



SIZE MATTERS

Ratio of output power over input heating power depends on:

- Magnetic field
- Plasma density
- Plasma volume

ITER, from the idea to the reality

November 1985

November 2006

August 2010

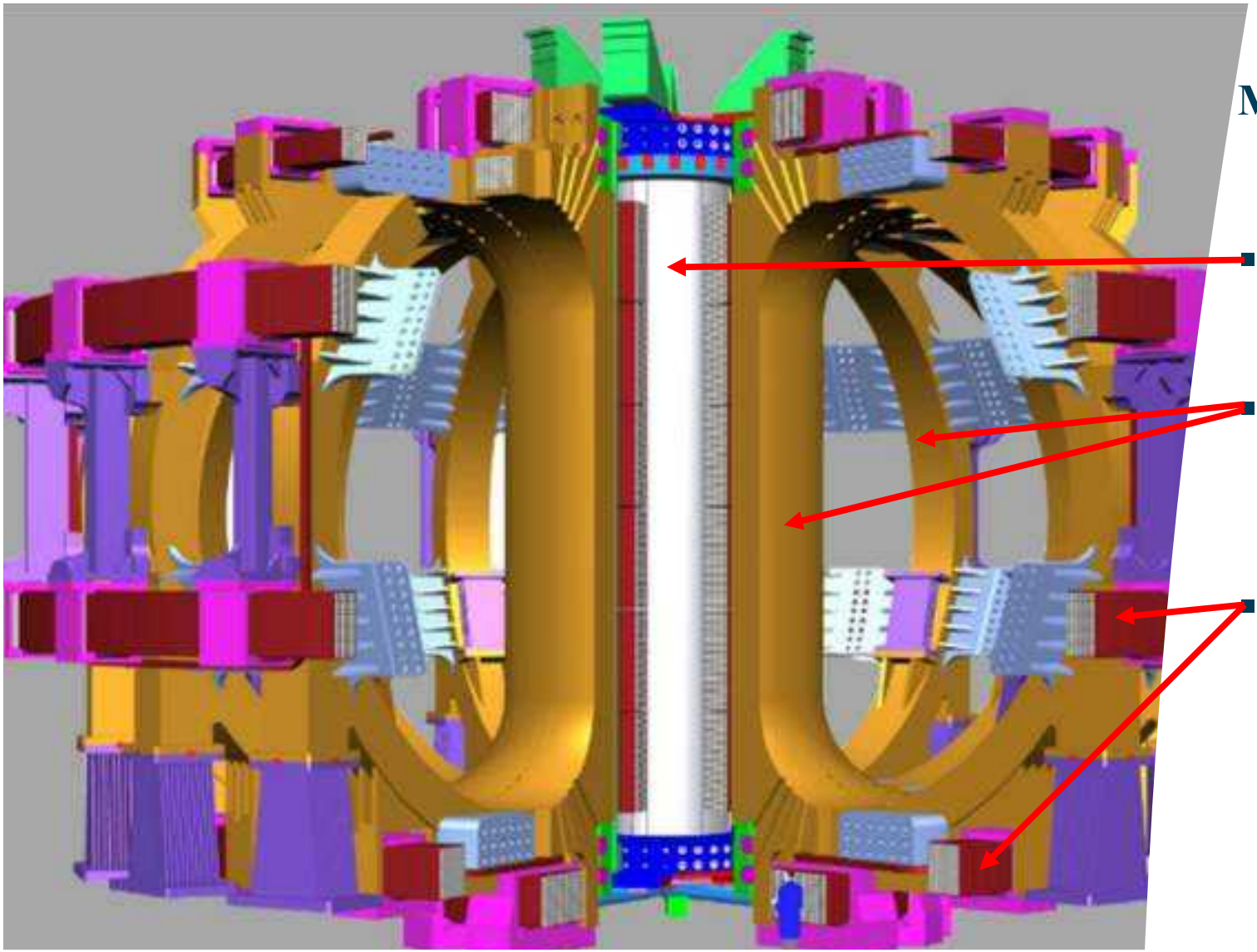
Today

GENERATIONAL CHALLENGES

- International collaboration
- Members contribute largely in-kind
- Europe as Host

INTEGRATED PROJECT

- Europe, as host, contributes ~ 45%
- Non-EU members contribute ~ 9% each

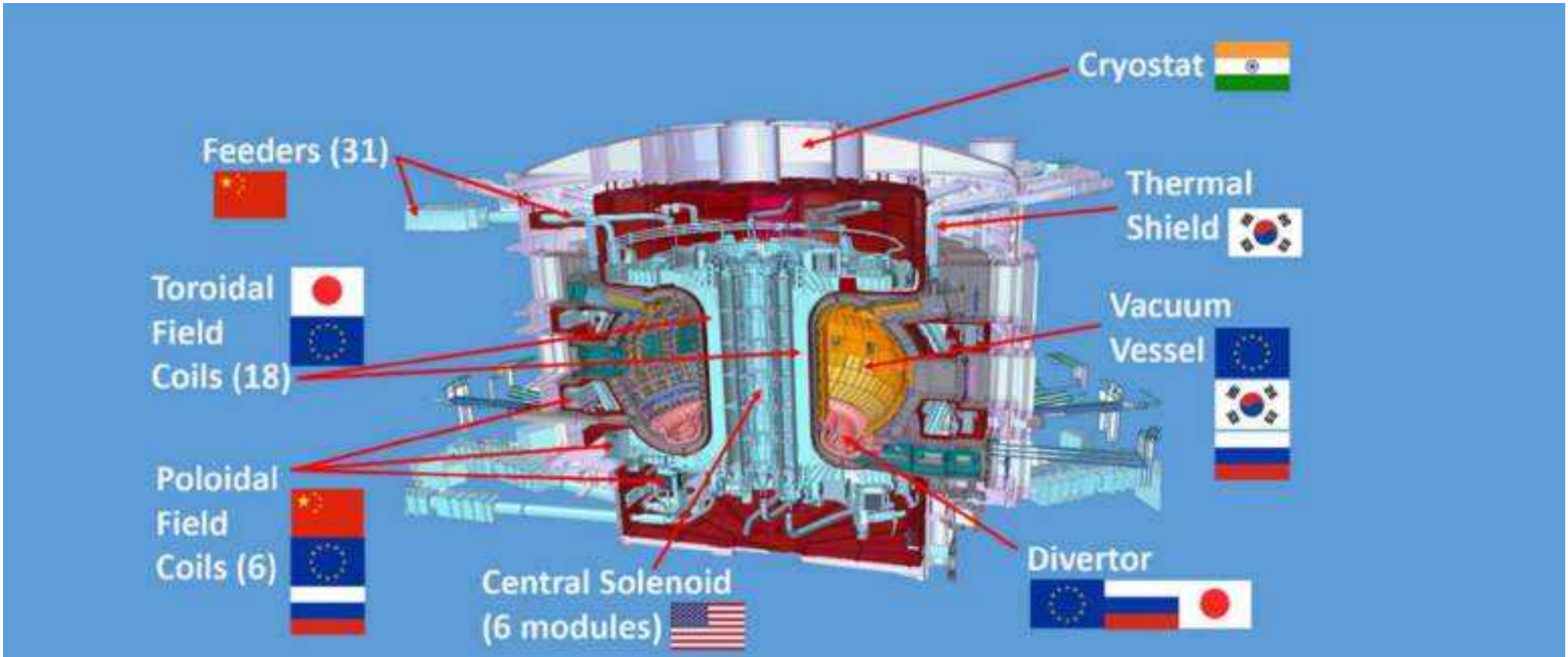


MAGNETIC CHAMBER

1 central solenoid

18 toroidal field magnets

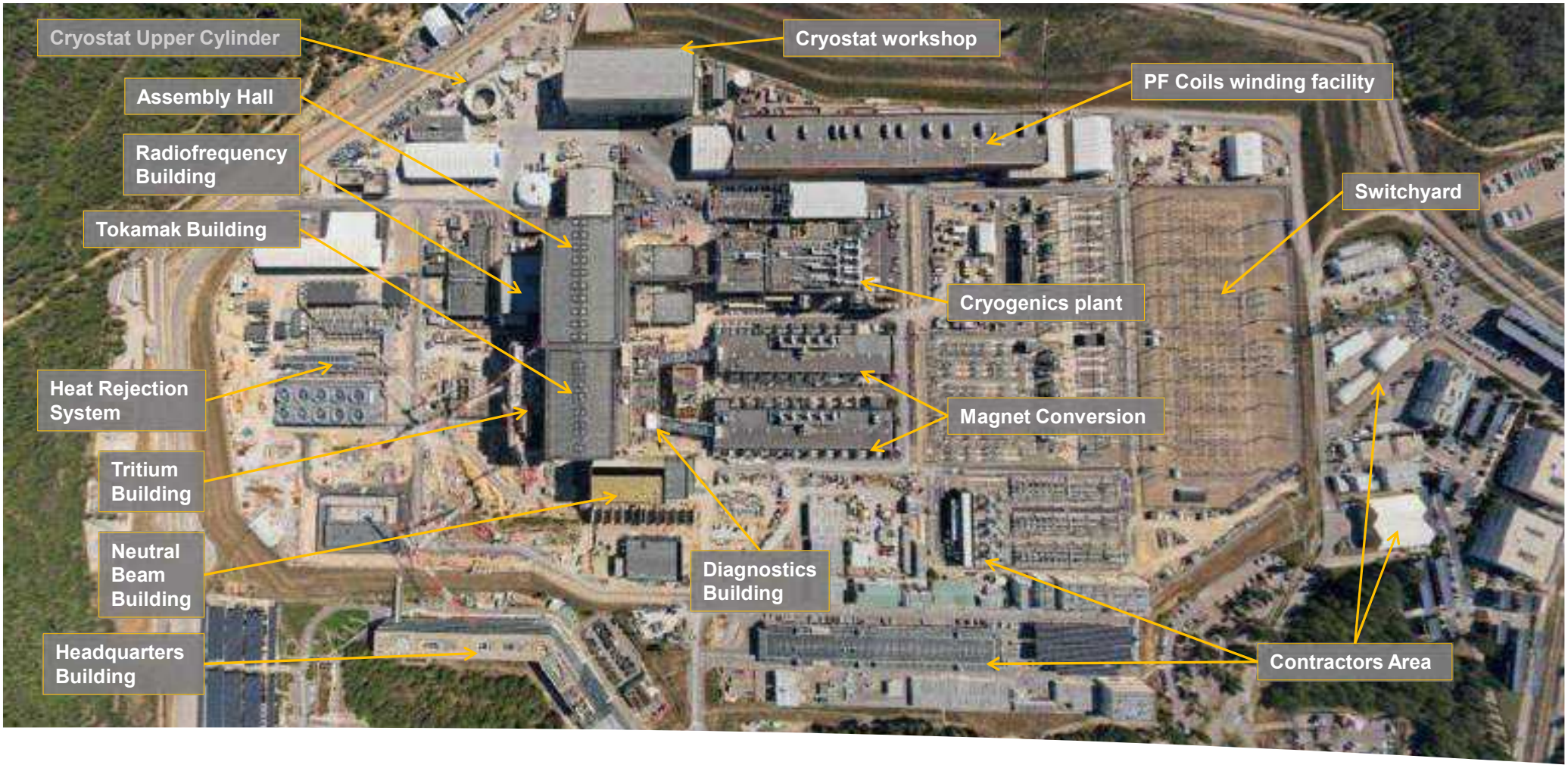
6 poloidal field magnets



WHO MANUFACTURES WHAT?

The ITER Tokamak is comprised of more than 1 million components.

THE ITER WORKSITE


Cryostat Upper Cylinder
Cryostat workshop
Assembly Hall
PF Coils winding facility
Radiofrequency Building
Switchyard
Tokamak Building
Cryogenics plant
Heat Rejection System
Magnet Conversion
Tritium Building
Neutral Beam Building
Diagnostics Building
Headquarters Building
Contractors Area

SOME TECHNOLOGICAL CHALLENGES

- Materials resistant to extreme conditions
- Heat exhaust management in the divertor region
- Remote handling for maintenance
- Tritium fuel cycle and breeding tritium at scale
- Heat removal for electricity generation

MAGNET MANUFACTURING AND DELIVERY

Poloidal field coils delivered

Toroidal field coils (18 + 1 spare) delivered

CENTRAL SOLENOID

Four central solenoid modules delivered and stacked.

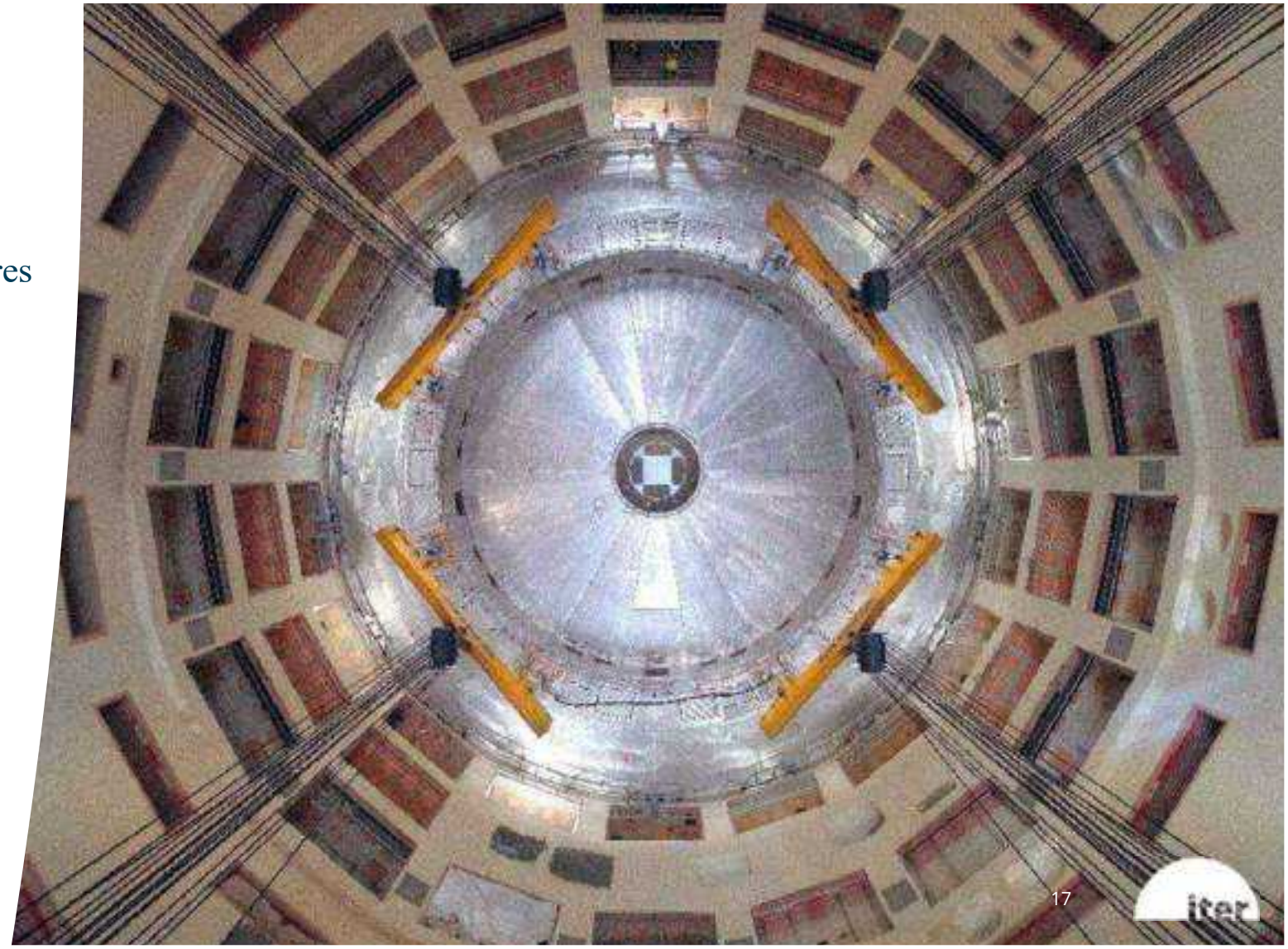
All seven modules planned to be delivered by Fall 2025.

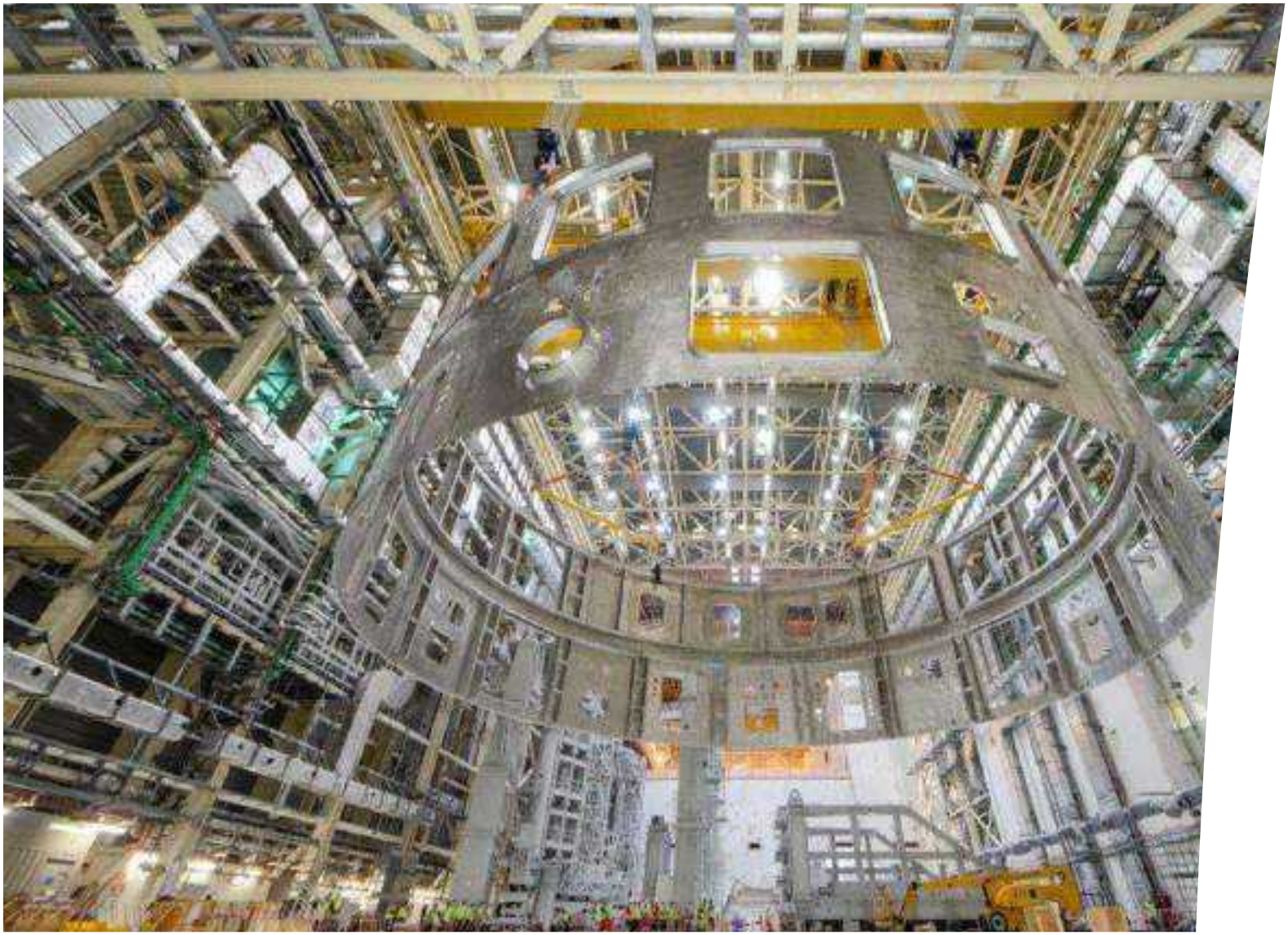
ASSEMBLING THE MACHINE

Cryostat Base installation (1350 t), traversing the assembly hall.

ASSEMBLING THE MACHINE

The cryostat base, 30 metres in diameter, positioned



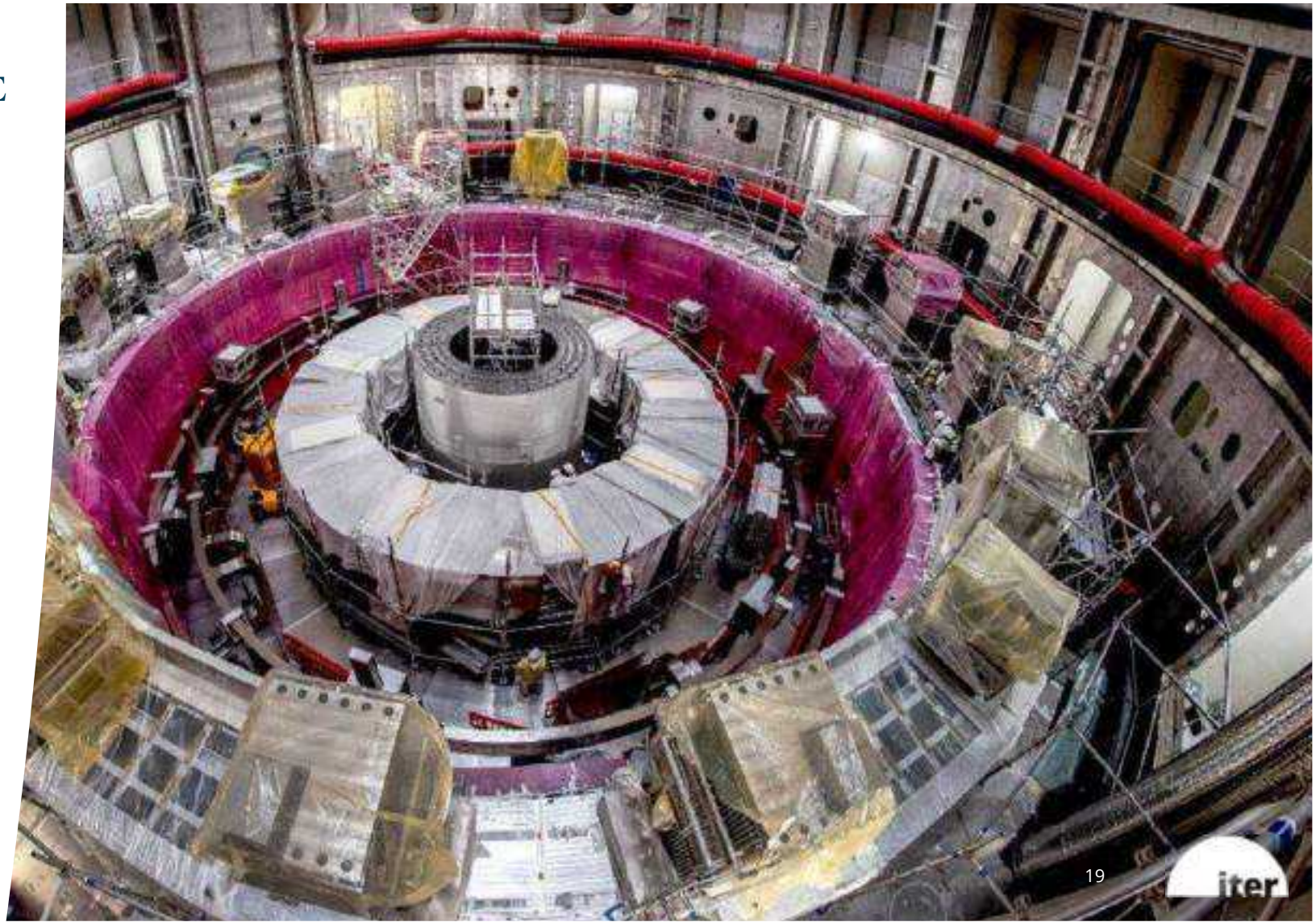


ASSEMBLING THE MACHINE

Cryostat lower cylinder installation

ASSEMBLING THE MACHINE

Poloidal field coil #6 installation



ASSEMBLING THE MACHINE

Poloidal field coil #5 installation

VACUUM VESSEL

Europe delivered its first vacuum vessel sector, and the second is in shipment.

Korea delivered its fourth (and final) sector in November 2024.

EU sector arrival at ITER, 25 Oct 2024

Korean sector arrival at ITER, 8 Nov 2024

VACUUM VESSEL

10 April 2025

VACUUM VESSEL

10 April 2025

VACUUM VESSEL

10 April 2025

PLANT SUPPORT SYSTEMS

The steady-state electrical network

The pulsed-power supply network

PLANT SUPPORT SYSTEMS

Heat Rejection System capable of removing ~1.2 gigawatts of heat

PLANT SUPPORT SYSTEMS

The cryogenics plant equipment installation is complete and in commissioning phase.

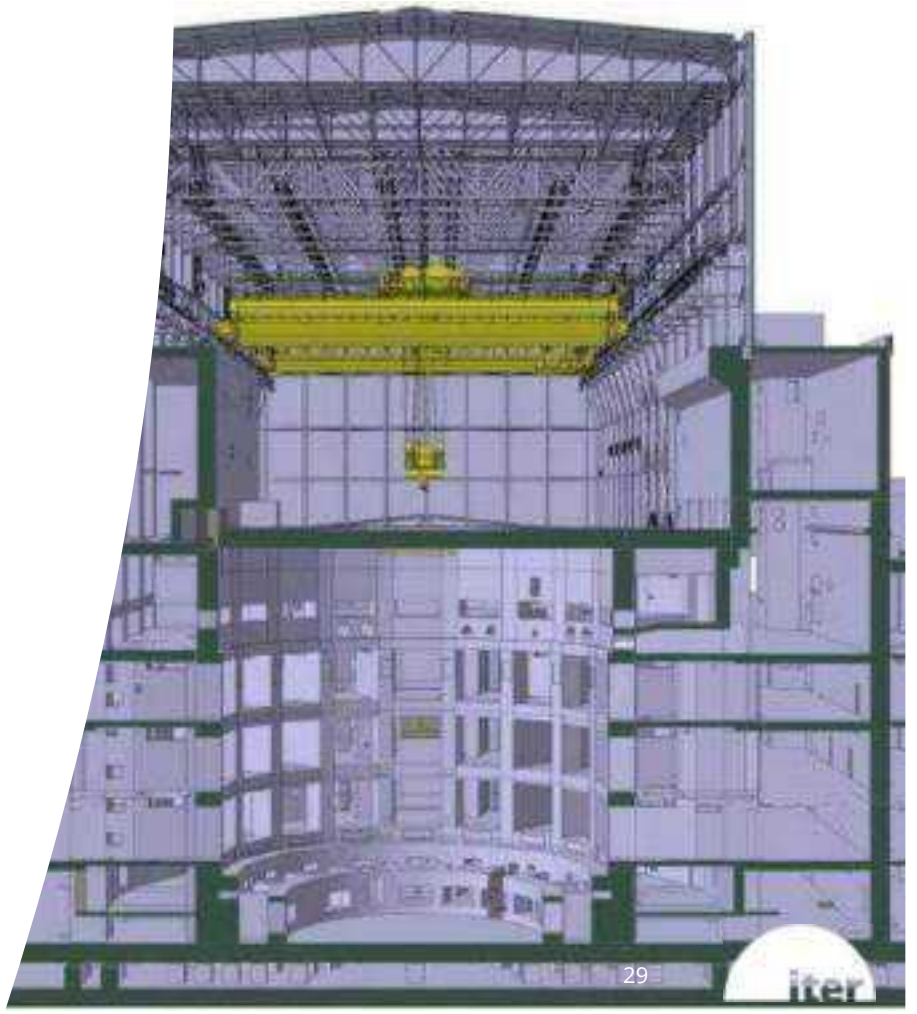
PLANT SUPPORT SYSTEMS

Control Building construction is moving to operation

PROJECT BASELINE

Deliver substantive research as rapidly as possible

- Start of Research Operations in **2034**
- Start of DT-1 Operation in **2039**



GLOBAL FUSION R&D: A SHARED GOAL

90+ PUBLIC & PRIVATE PROJECTS

National Ignition Facility, USA:
Inertial confinement

Wendelstein 7-X, Germany:
Stellarator

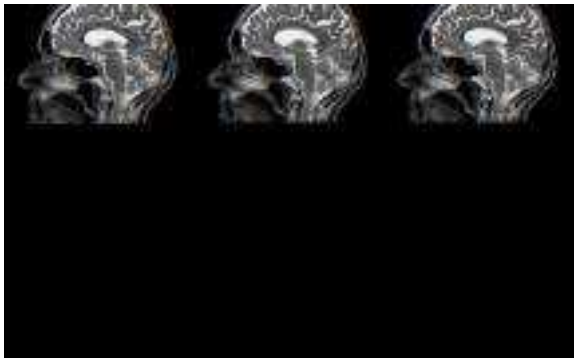
Commonwealth Fusion, SPARC, USA:
Smaller tokamak

Tokamak Energy, UK:
Spherical tokamak

INNOVATION AND SPIN-OFFS FROM ITER

ADVANCING MEDICINE, MANUFACTURING, AND MORE

Superconductor magnet advances → *Enhanced mapping of the human brain*



Complex aluminum structures → *Enhanced electric train bodies*

Explosive forming → *High-strength components such as aircraft*

High-precision diagnostics → *Enhancements for geothermal energy, laser welding, cancer treatment, etc.*

Preparing to power the future