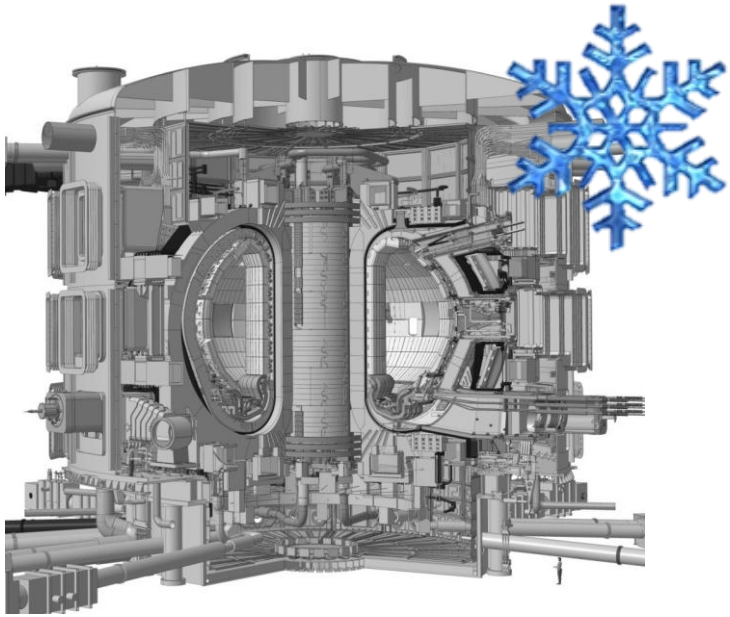


A Brief Introduction to Helium Liquefaction At ITER

ITER Organization
PLANT ENGINEERING DIVISION
CRYOGENIC SECTION
LHe PLANTS TRO: Eric FAUVE

OUTLINE

1. What is Helium?
2. Why and where is Helium used at ITER?
3. The ITER Helium Cryogenic System

1. WHAT ARE HELIUM PROPERTIES?

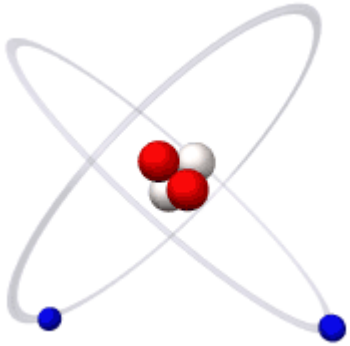
A. What are its properties?

B. Where does it come from?

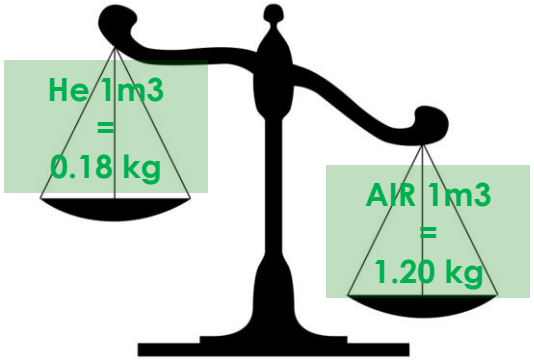
C. What are its applications?

A. WHAT ARE HELIUM PROPERTIES?

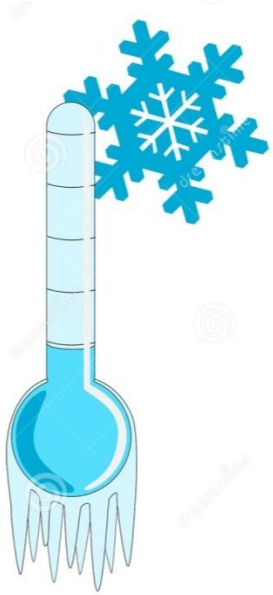
- **SMALL:** Smallest molecule (He… H2)
- **LIGHT:** 7 Times lighter than air
- **COLD:** Boil at -269 degC
- **HEAT:** High Heat Transfer
- **INERT:** No Chemical Reaction with He



2 Protons 2 Neutrons
Smallest Molecule



7 Times lighter than AIR
1m3 lifts 1kg

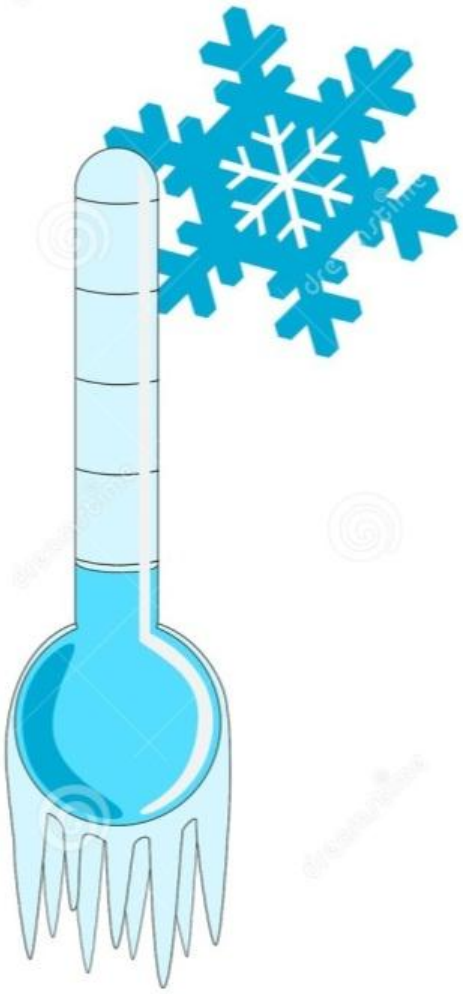


Coldest Fluid
Boiling at -269 degC

A. WHAT ARE HELIUM PROPERTIES?

BOILING POINTS

- **Water: 100°C**
- Methane: - 164°C
- Oxygen: - 183°C
- **Nitrogen: - 196°C**
- Hydrogen: - 253°C
- **Helium: - 269°C**
- Zero: - 273°C



1. WHAT ARE HELIUM PROPERTIES?

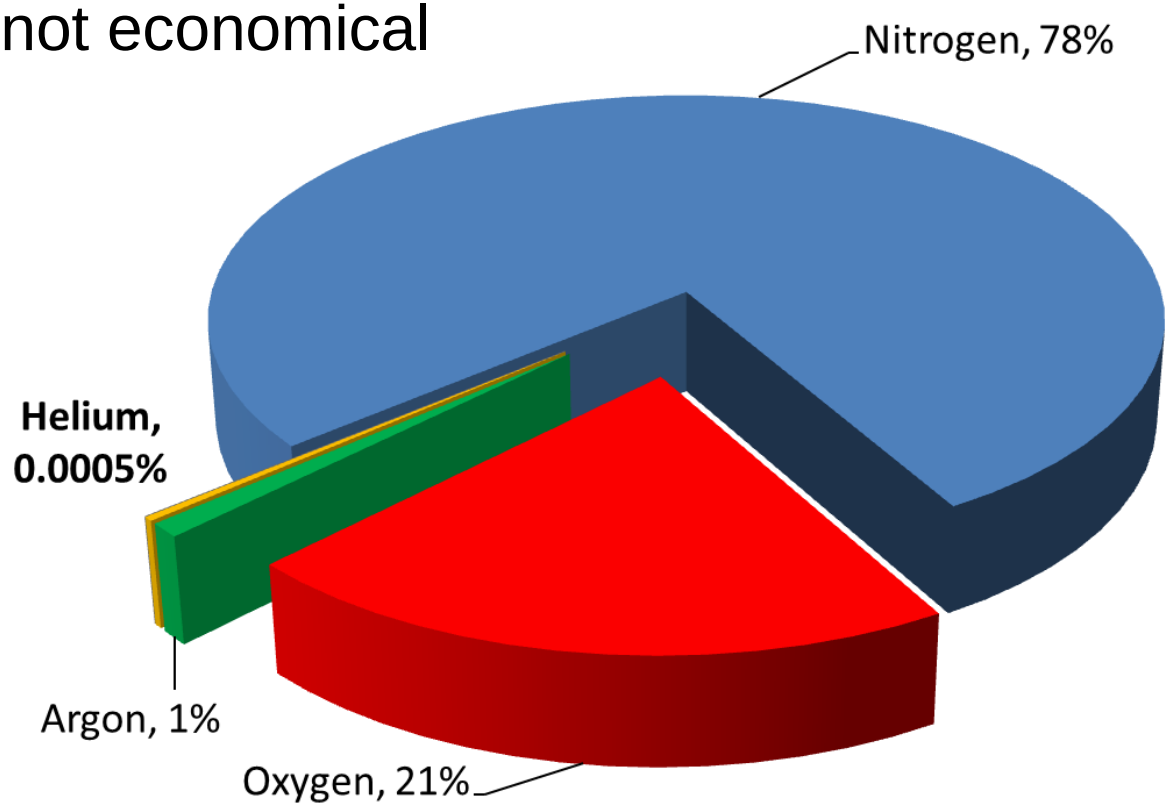
A. What are its properties?

B. Where does it come from?

C. What are its applications?

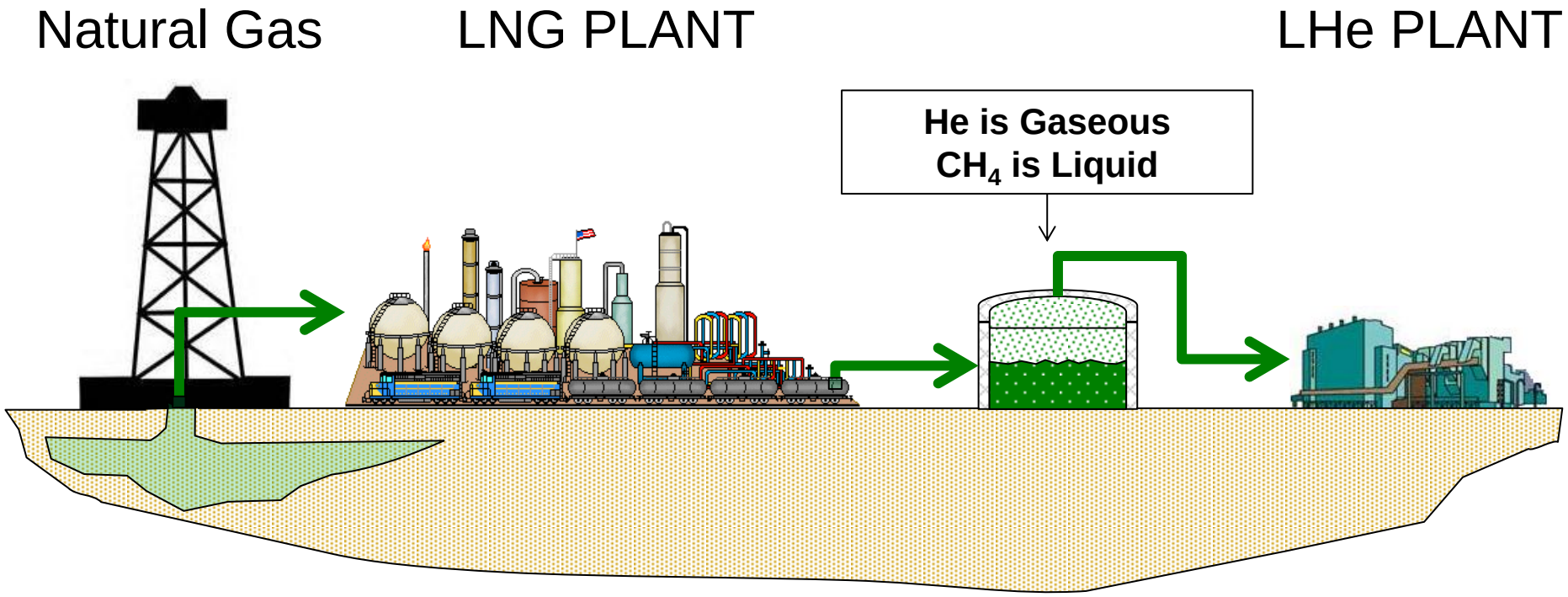
B. WHERE DOES IT COME FROM?

- Present in Air
- But not in very small quantities: 5 ppmv
- Extraction from Air is not economical



B. WHERE DOES IT COME FROM?

- In Natural Gas < 1%
- Natural Gas Boil at – 160ºC



B. WHERE DOES IT COME FROM?

- Liquefied at production site
- Individual Containers (40m^3)
- Transported as “standard” Container

B. WHERE DOES IT COME FROM?

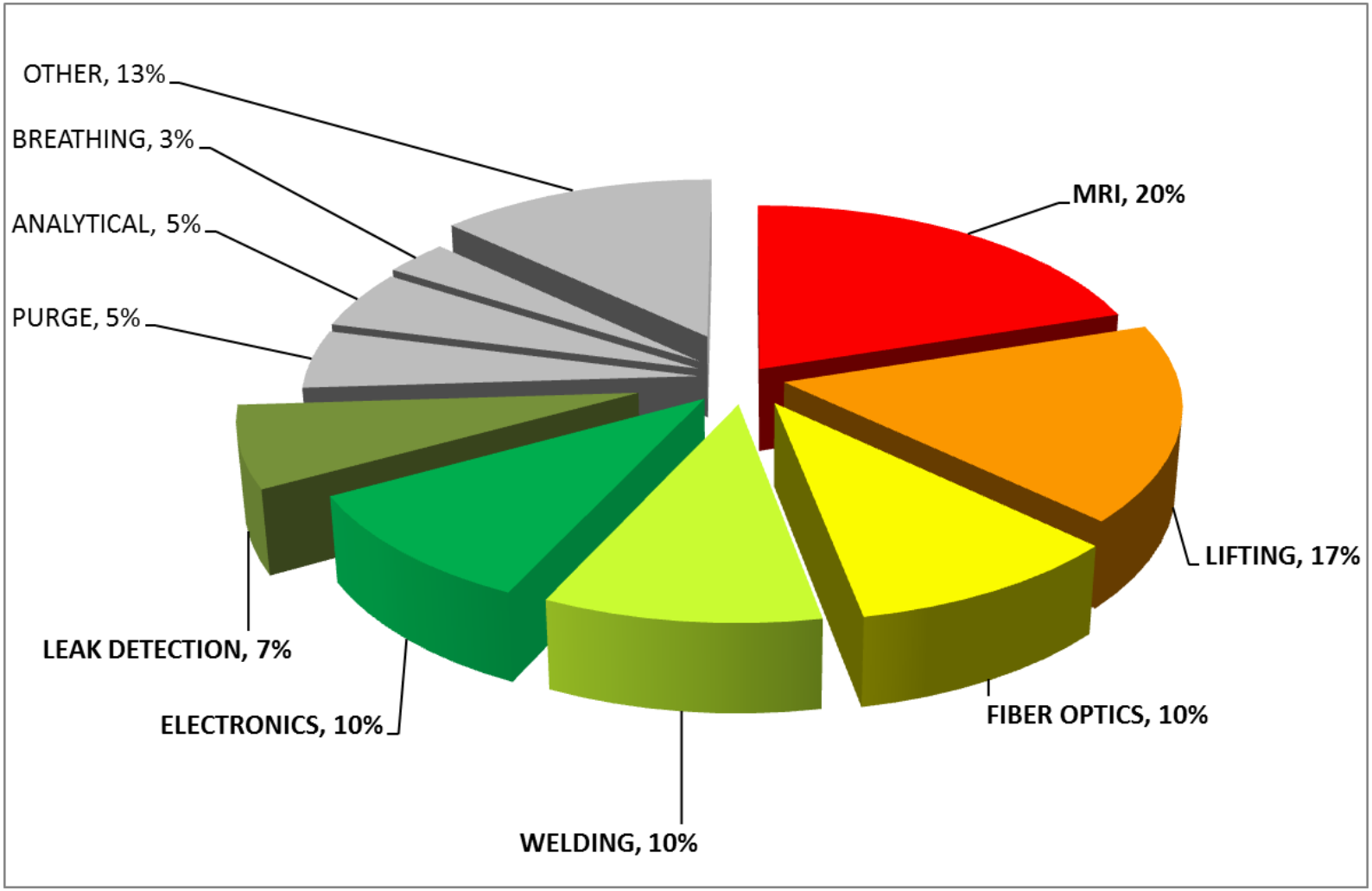
1. WHAT ARE HELIUM PROPERTIES?

A. What are its properties?

B. Where does it come from?

C. What are its applications?

C. WHAT ARE ITS APPLICATIONS?



C. WHAT ARE ITS APPLICATIONS?

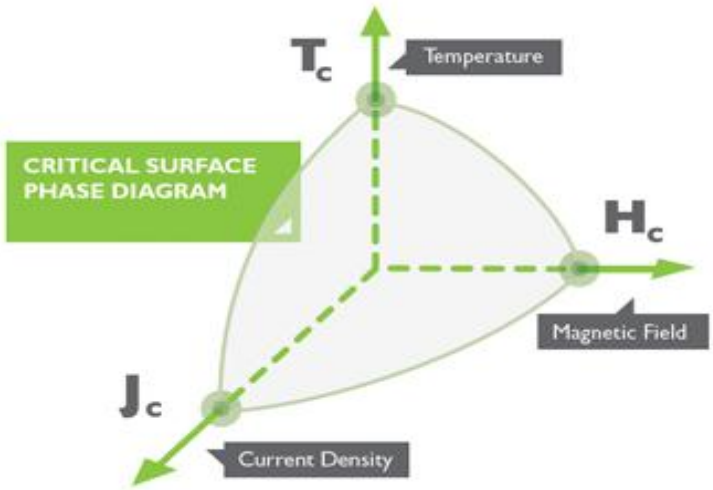
- SPACE
  Inert Gas
  Cold

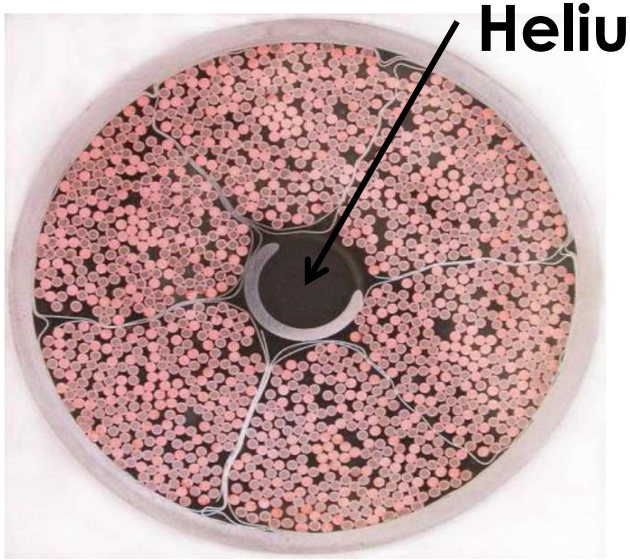
- SCIENCE
  Cold

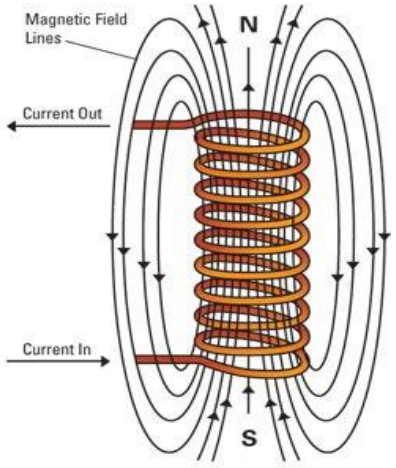
C. WHAT ARE ITS APPLICATIONS?

SUPERCONDUCTIVITY:

- Zero Electrical Resistivity at Low Temperature
- High Current Density
- **High Magnetic Fields** (RMI, Accelerators, Tokamak)







100,000 kilometres of niobium-tin (Nb3Sn) superconducting strands

2. WHY AND WHERE IS HELIUM USED AT ITER?

A. The Superconducting Magnets

B. The Thermal Shield

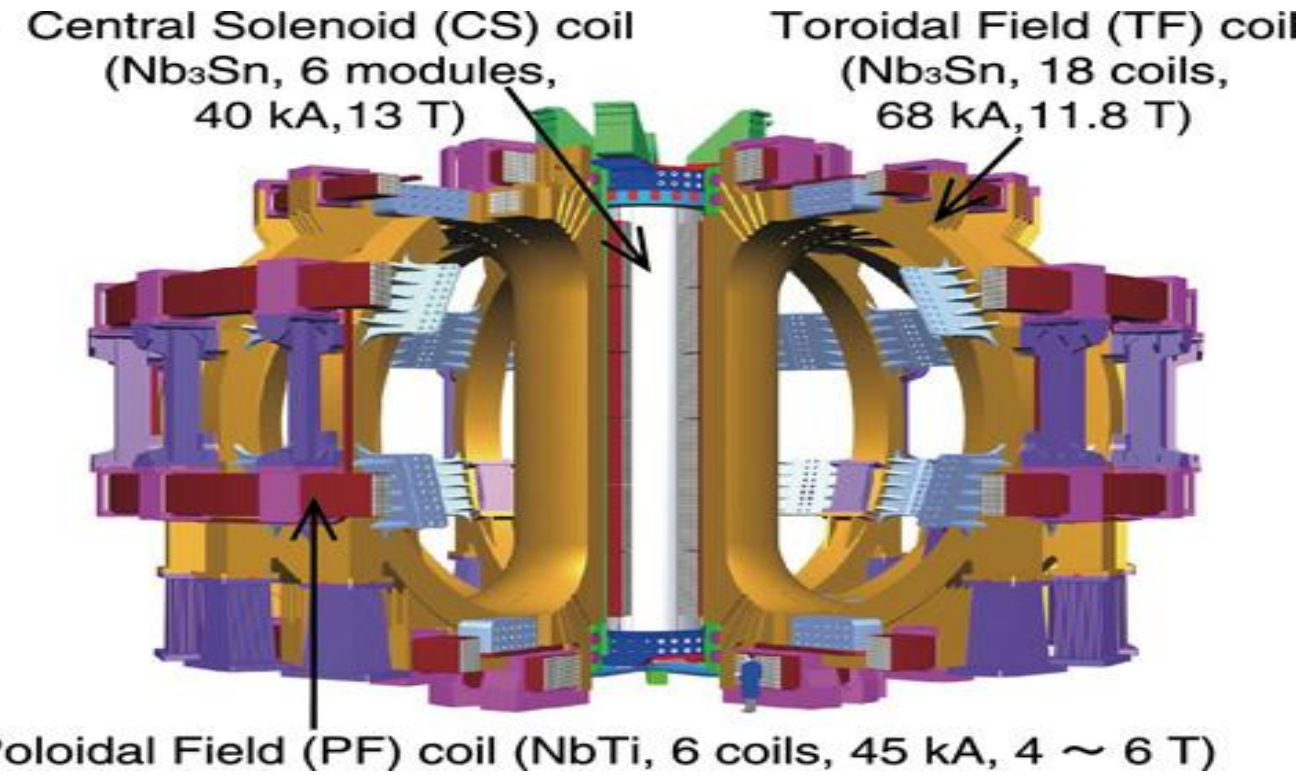
C. The Vacuum System

2. WHERE IS HELIUM USED AT ITER?

A. THE MAGNETS:

Superconductors to be kept at about 5K

18 TF Coils x 360tons…

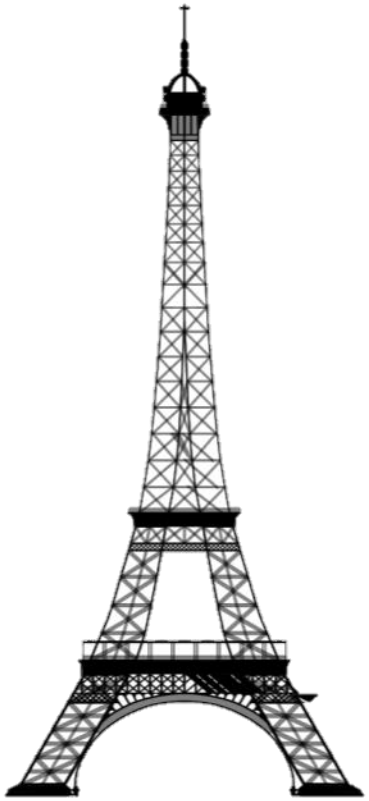


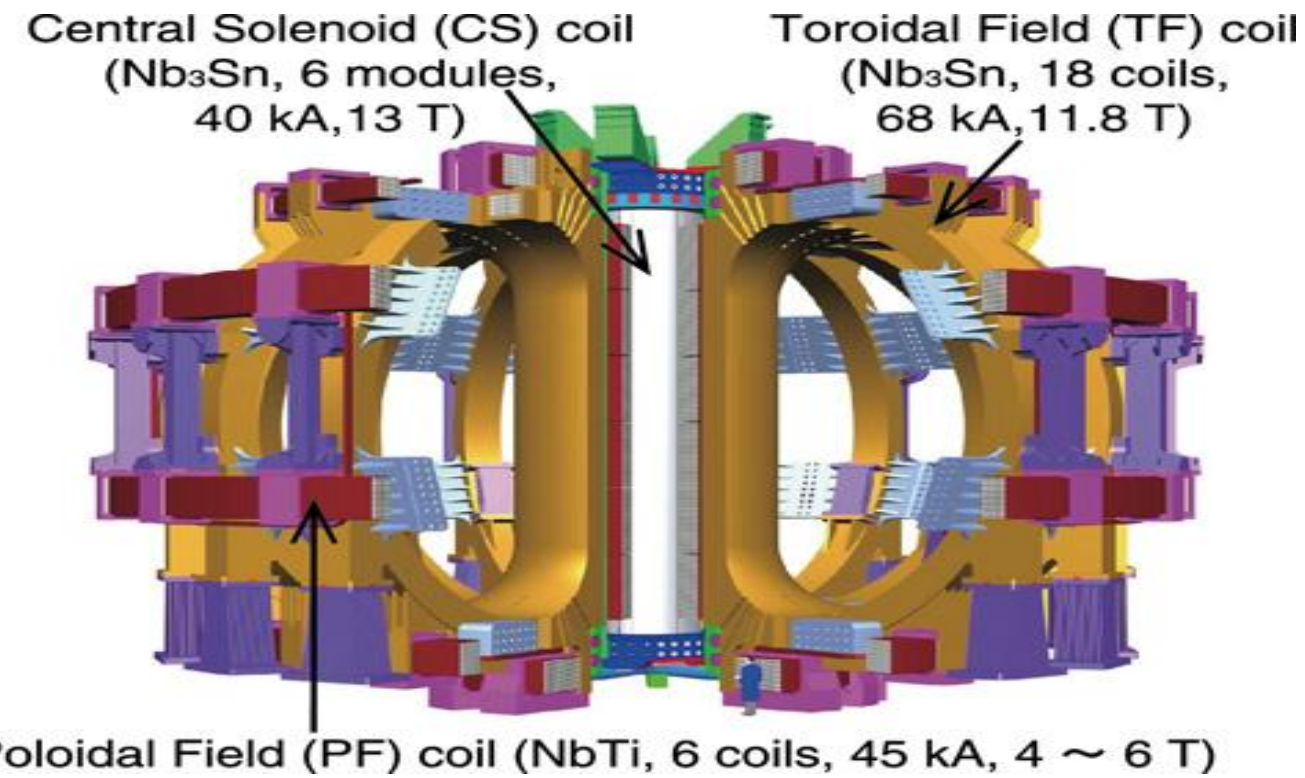
2. WHERE IS HELIUM USED AT ITER?

A. THE MAGNETS:

Superconductors to be kept at about 5K

Total Cold Max: 10,000 Tons





2. WHY AND WHERE IS HELIUM USED AT ITER?

A. The Superconducting Magnets

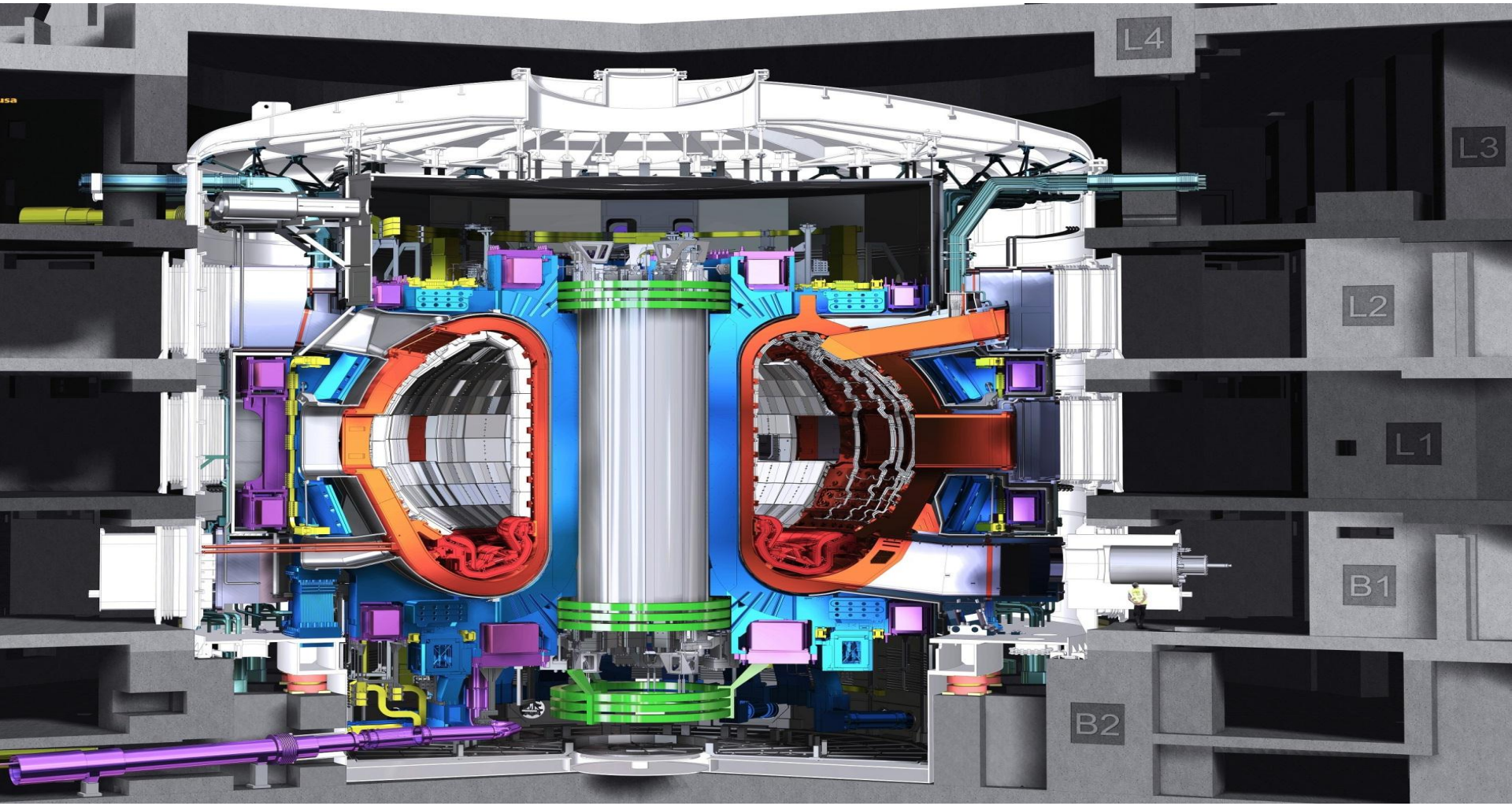
B. The Thermal Shield

C. The Vacuum System

2. WHERE IS HELIUM USED AT ITER?

B. THE THERMAL SHIELDS:

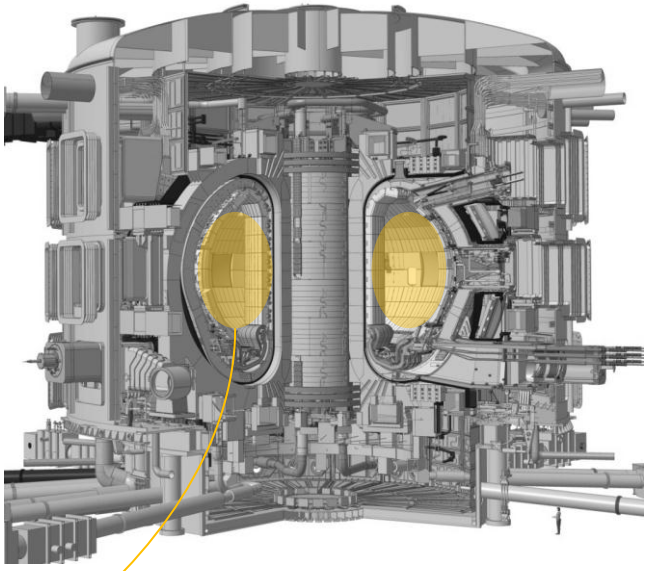
– **80K:** THE THERMAL SHIELDS

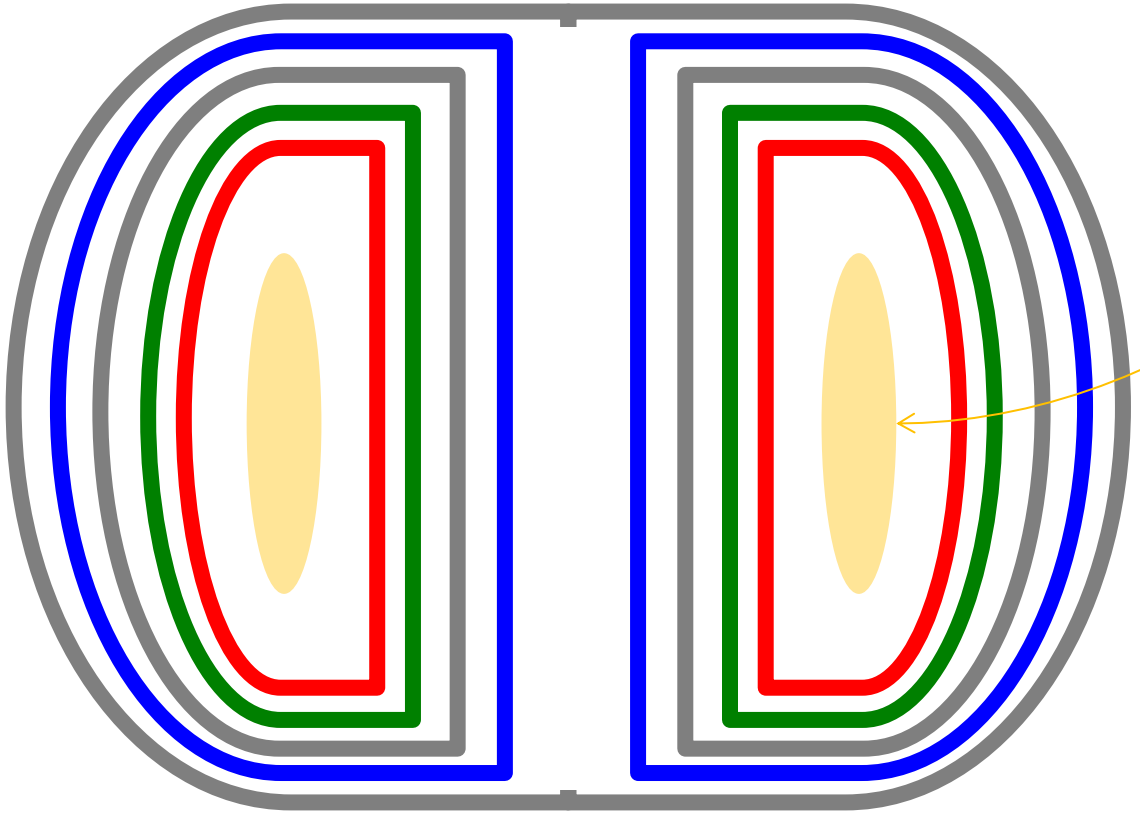


2. WHERE IS HELIUM USED AT ITER?

B. THE THERMAL SHIELDS:

- **80K:** THE THERMAL SHIELDS



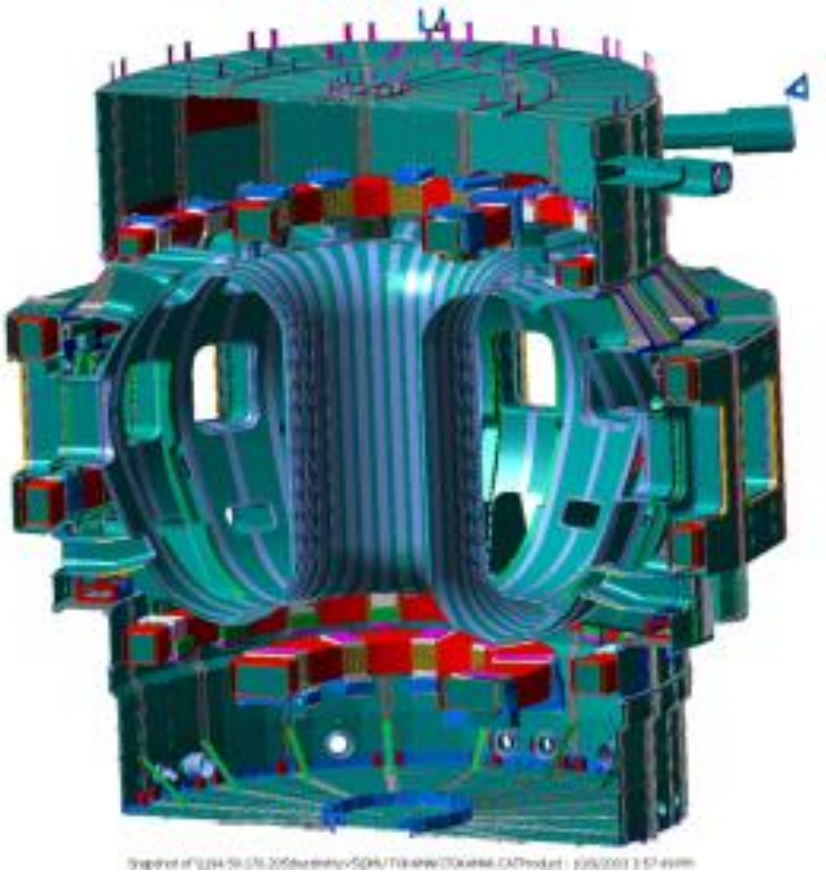


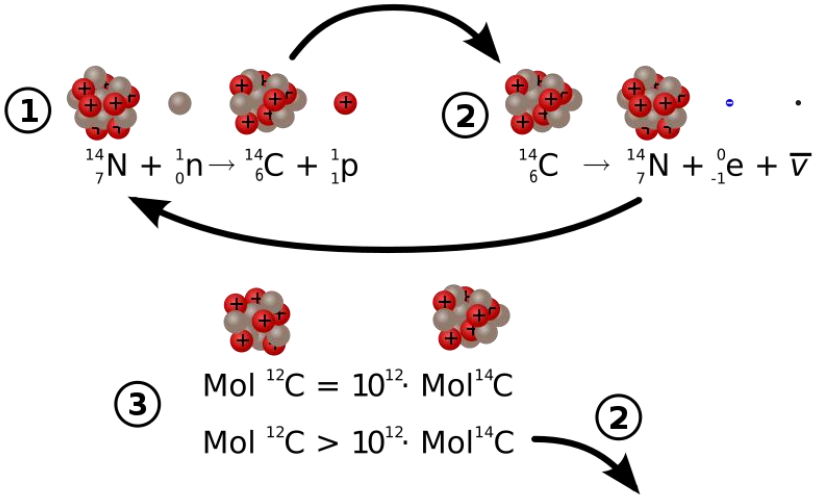
Plasma:	150 000 000 K
Blanket:	1 000 K
Water:	370 K
Thermal Shield:	80 K
Magnets:	4 K

2. WHERE IS HELIUM USED AT ITER?

B. THE THERMAL SHIELDS:

Nitrogen cannot be used within the Tokamak.





2. WHY AND WHERE IS HELIUM USED AT ITER?

A. The Superconducting Magnets

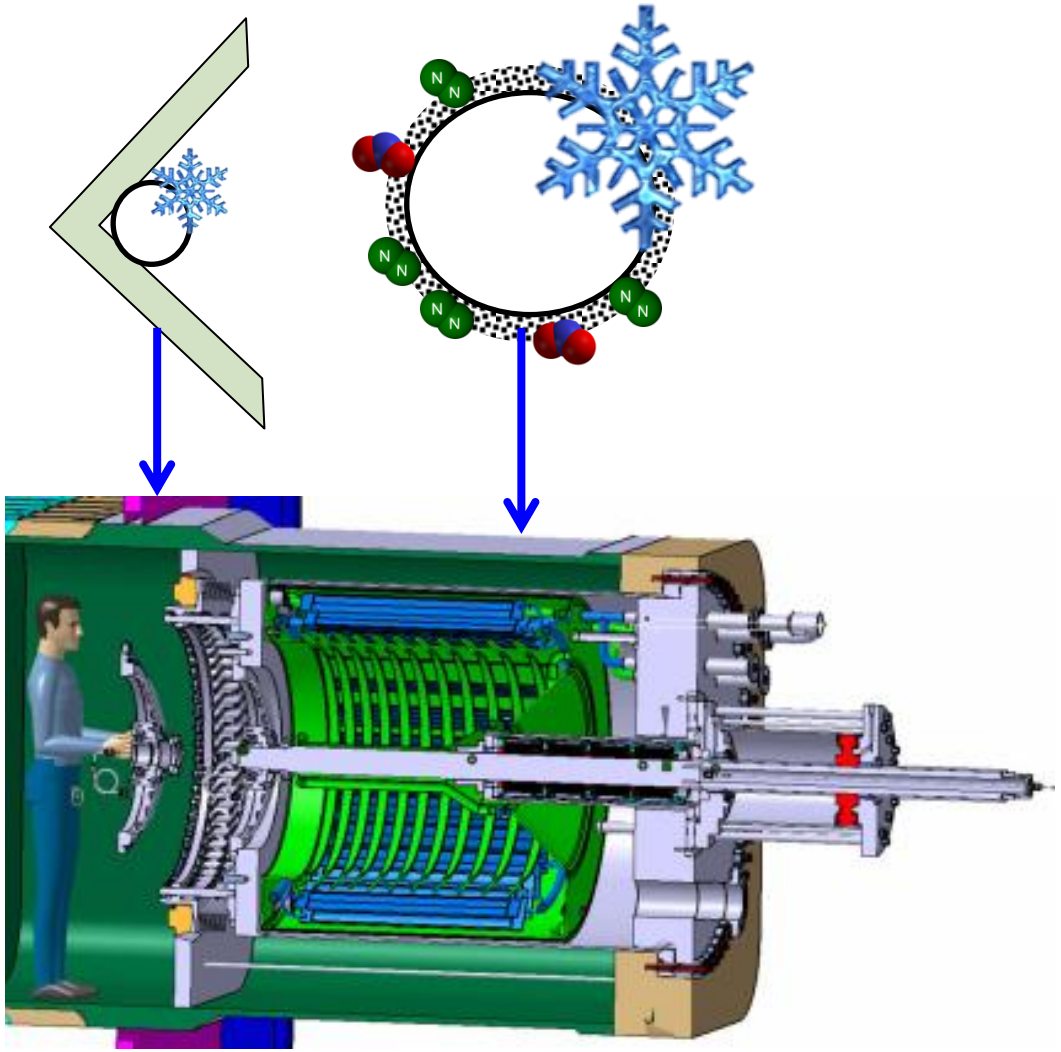
B. The Thermal Shield

C. The Vacuum System

2. WHERE IS HELIUM USED AT ITER?

C. CRYO-PUMPS

- Thermal Shields
- Cold Traps



3. The Cryogenic System

A. Overview

B. The Cryoplant

C. The Distribution System

D. Project Progress…

A. The Cryogenic System: Overview

300K to 80K: LN2 PLANTS

80K to 4K: LHe Plants

80K: Ghe Loops

4K: LHe Distribution

80K: GHe Distribution

Magnets: PF

Magnets: CS

Magnets: TF

Magnets: C. Leads

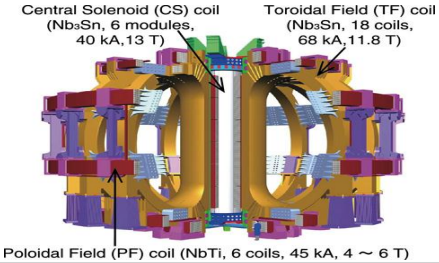
Cryo Pumps

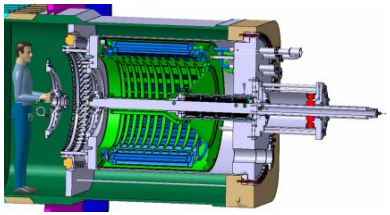
Thermal Shields

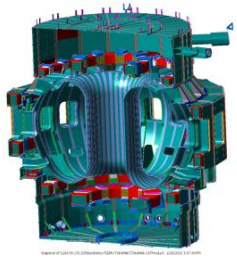
Cryoplants

Cryo-Distribution

Cryo-Lines







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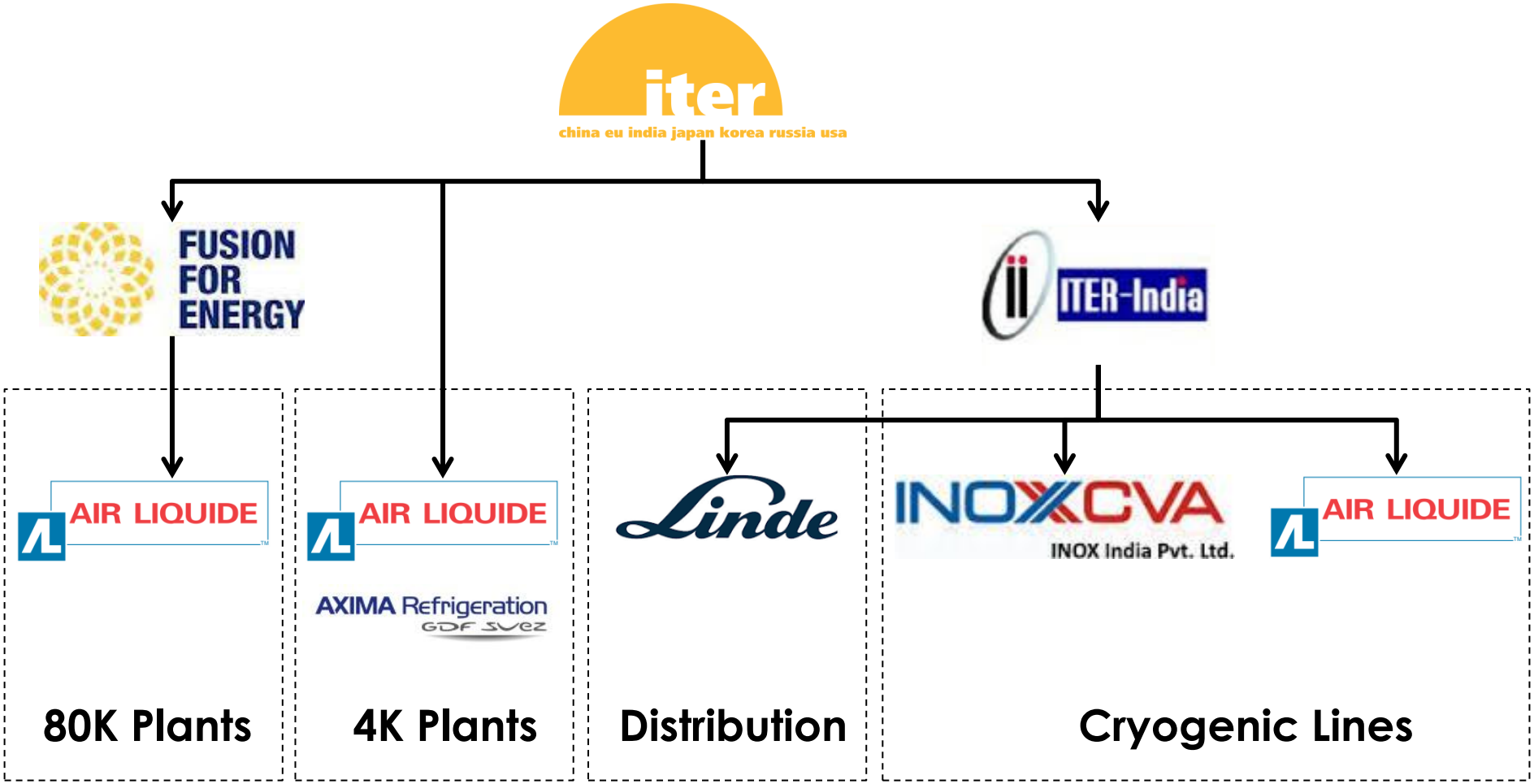
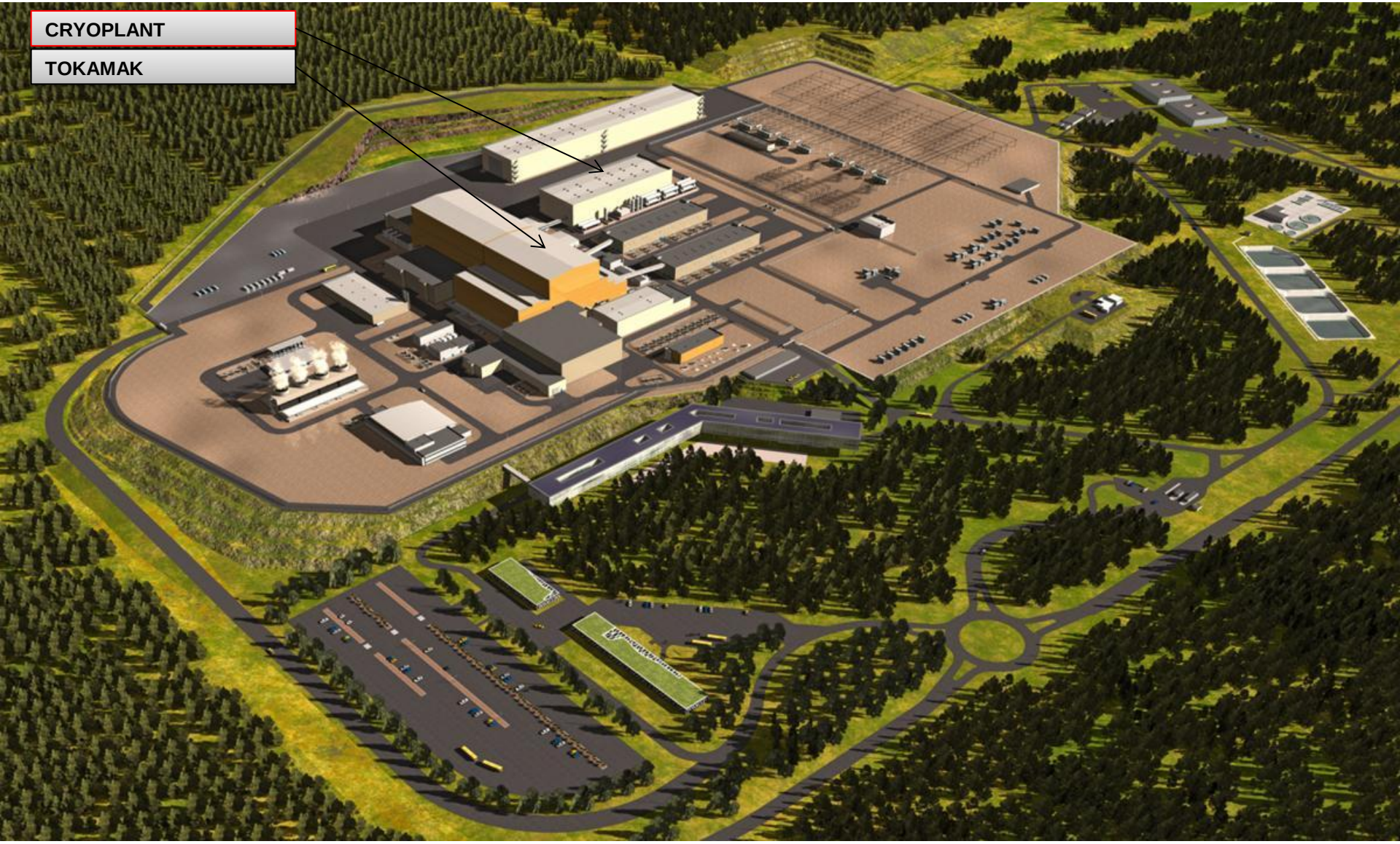
A. The Cryogenic System: Overview

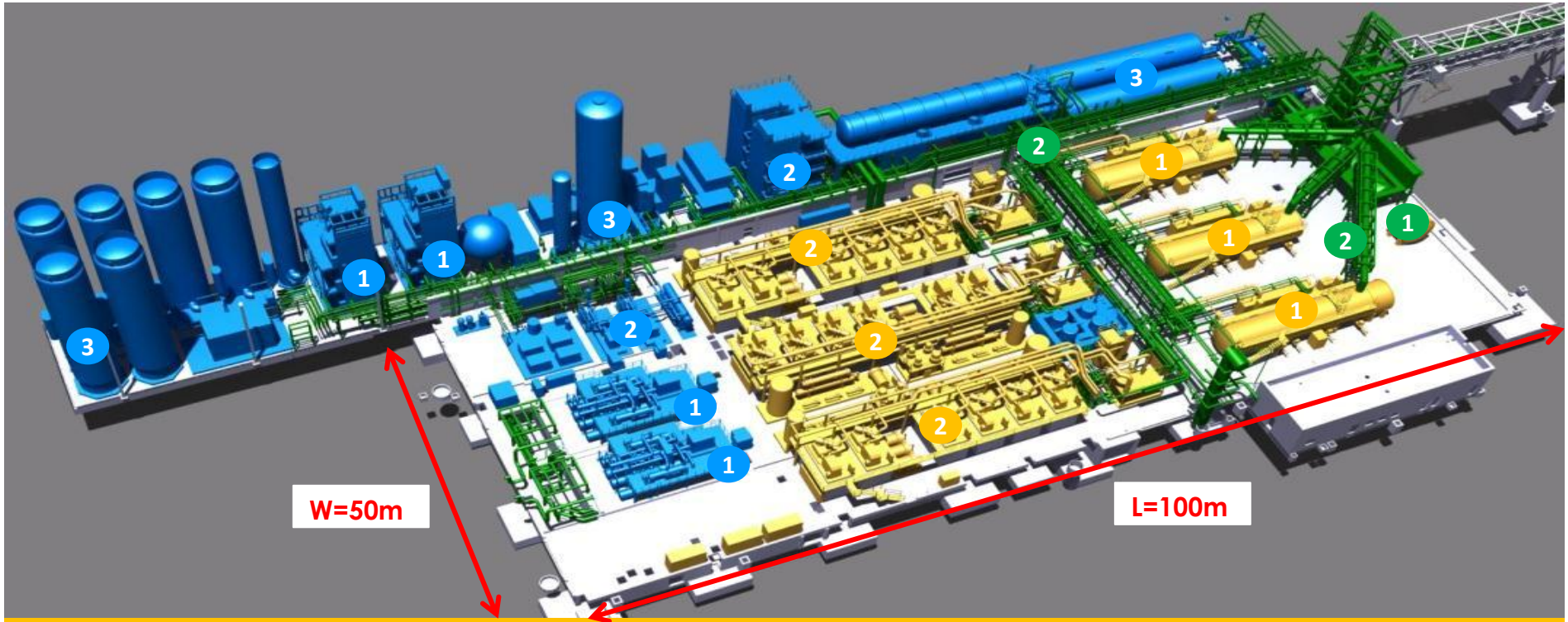


3. The CRYOGENIC SYSTEM



3. The CRYOGENIC SYSTEM

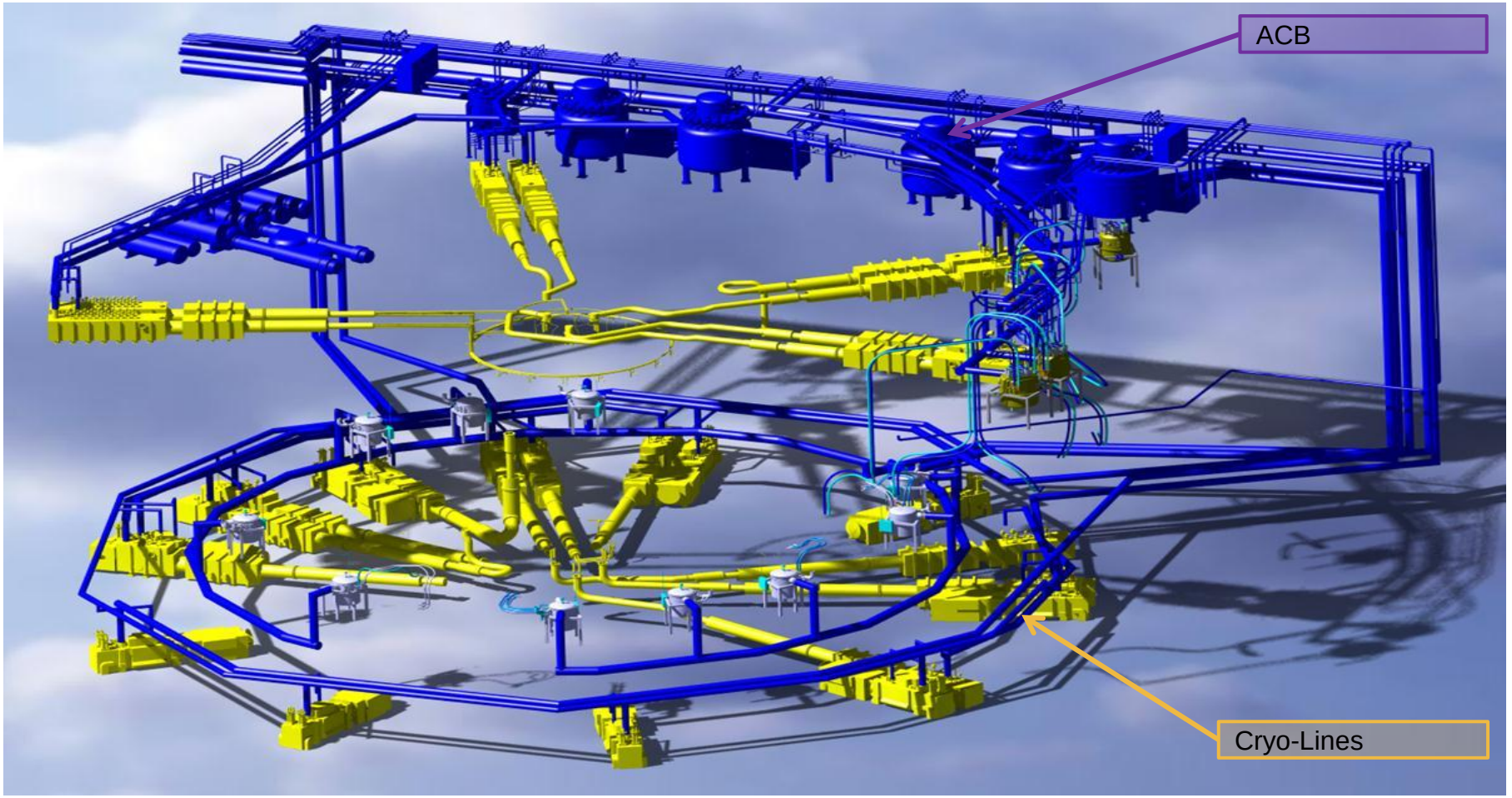
B. The Cryoplant:



ITER ORGANIZATION:	1. LHe PLANTS Cold Boxes 2. LHe PLANTS Compressors
EUROPE:	1. LN2 PLANTS 2. 80K LOOPS 3. STORAGES 4. N2 GENERATOR
INDIA:	1. CTCB 2. Process Lines

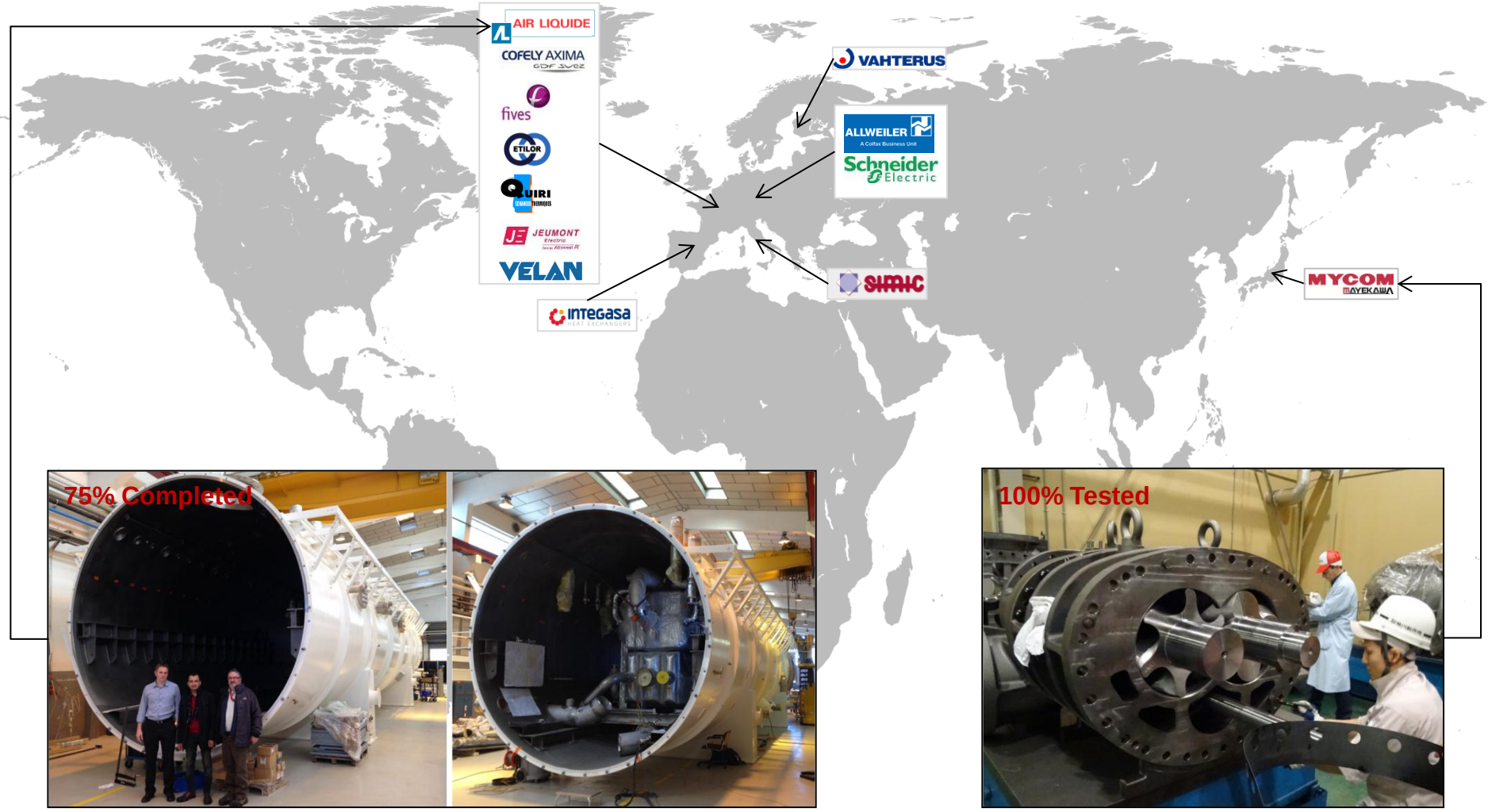
C. The Distribution System:

- CRYO-DISTRIBUTION: B11 (TOKAMAK Building)
- **5km of Cryogenic Lines…**

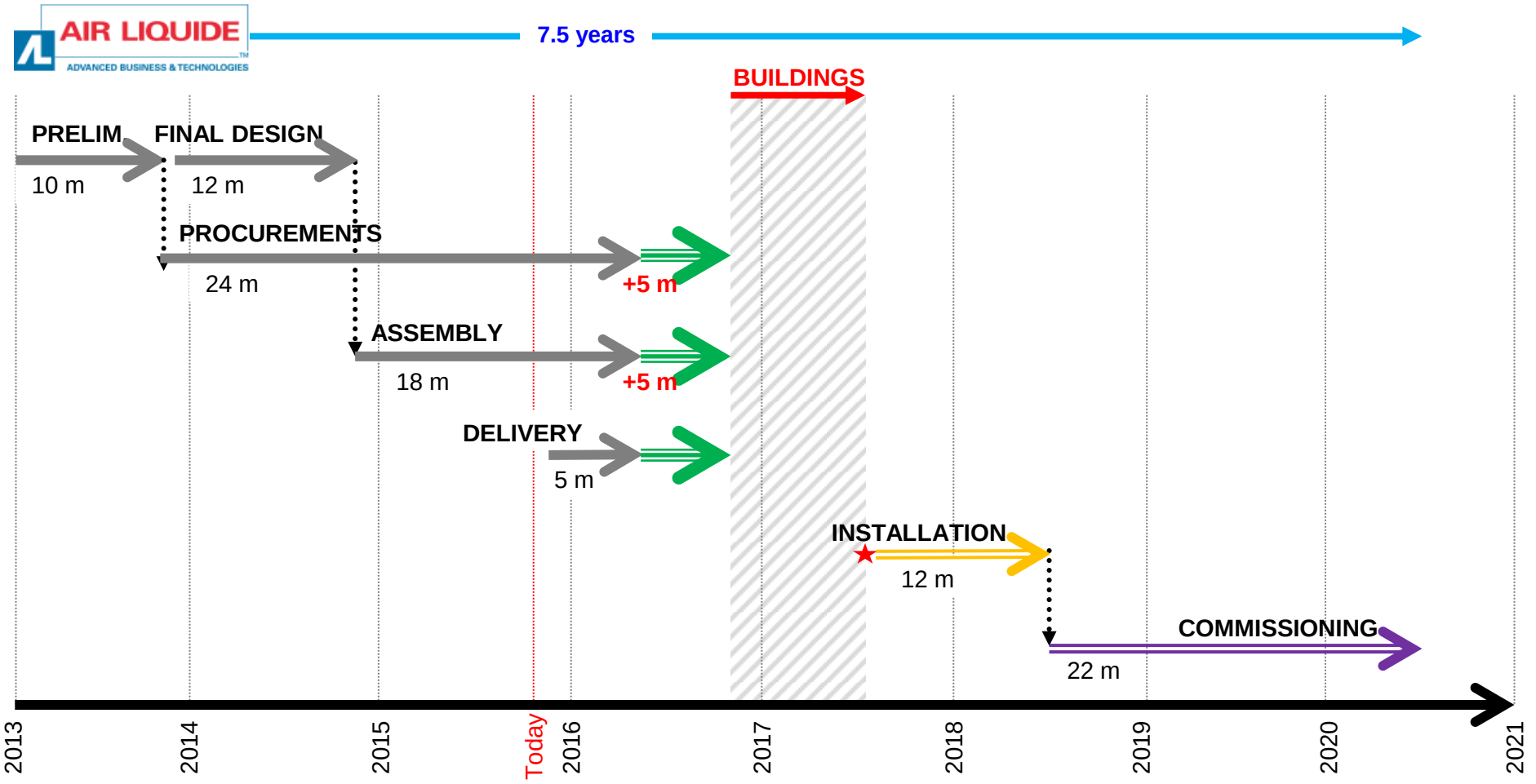


3. The CRYOGENIC SYSTEM

D. Project Progress: LHe Plants…



D. Project Progress: LHe Plants…



QUESTIONS?