ENERGY FROM FUSION: CONTAINING PLASMA TO 100 MILLION DEGREES CELSIUS IN THE TOKAMAK

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CONTEXTUALIZATION

- Fossil fuels have been used as energy resource. Its massive use has caused consequences such as melting of glaciers, droughts and disappearance of flora and fauna.

- Nuclear fission has been a complementary energy resource but it has disdadvantages too.

- Renewable energies have been developed in recent years but they cannot be a primary energy resource.

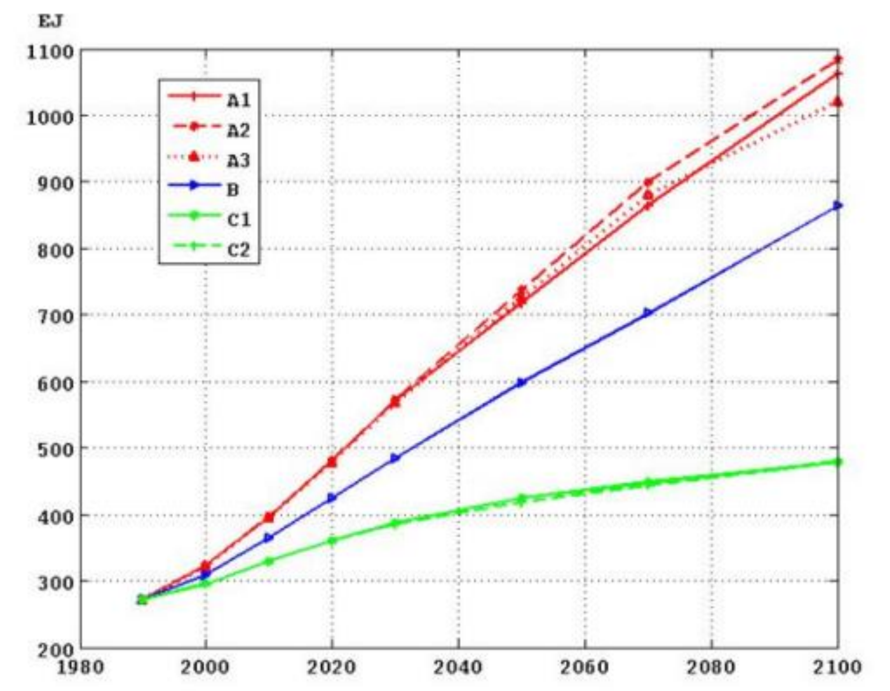
National Academy of Engineering challenge: Provide energy from fusion.

MAP OF THE PRESENTATION

- Energy in the world: types of energy resources with their past, present and future use
- Fusion and its obstacle
- The two proposals
- Tokamak
- Parts of the machine
  - Magnets
  - Vacuum vessel
  - Blanket
  - Divertor
  - Cryostats

ENERGY IN THE WORLD: TYPES OF ENERGY RESOURCES IN RELATION TO THEIR PAST, PRESENT AND FUTURE USE

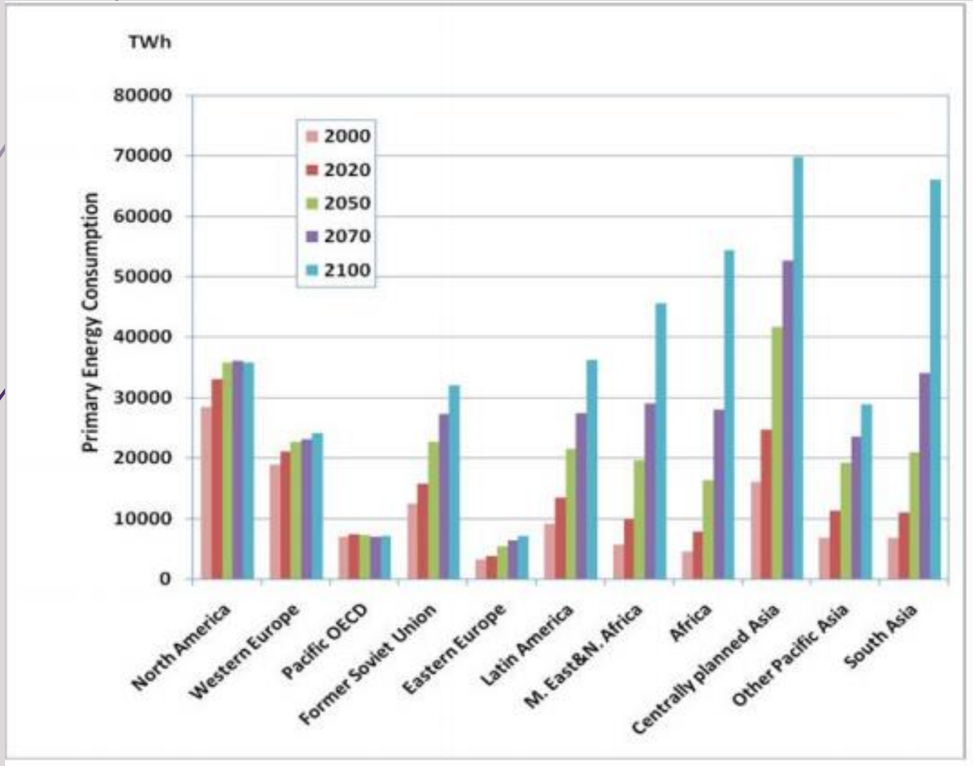
Study carried out by the International Institute for Applied Systems Analysis (IIASA) with the help of the World Energy Council (WEC)



World Final Energy Consumption until the year 2100 in the IIASA–WEC Study “Global Energy Perspectives”.

- The study goes from 1850 to 2100.
- Three cases are defined.
  - Case “A” ⟶ important and significative advance of technologies.
  - Case “B” ⟶ more realistic scenario.
  - Case “C” ⟶ ecological considerations.

ENERGY IN THE WORLD: TYPES OF ENERGY RESOURCES IN RELATION TO THEIR PAST, PRESENT AND FUTURE USE



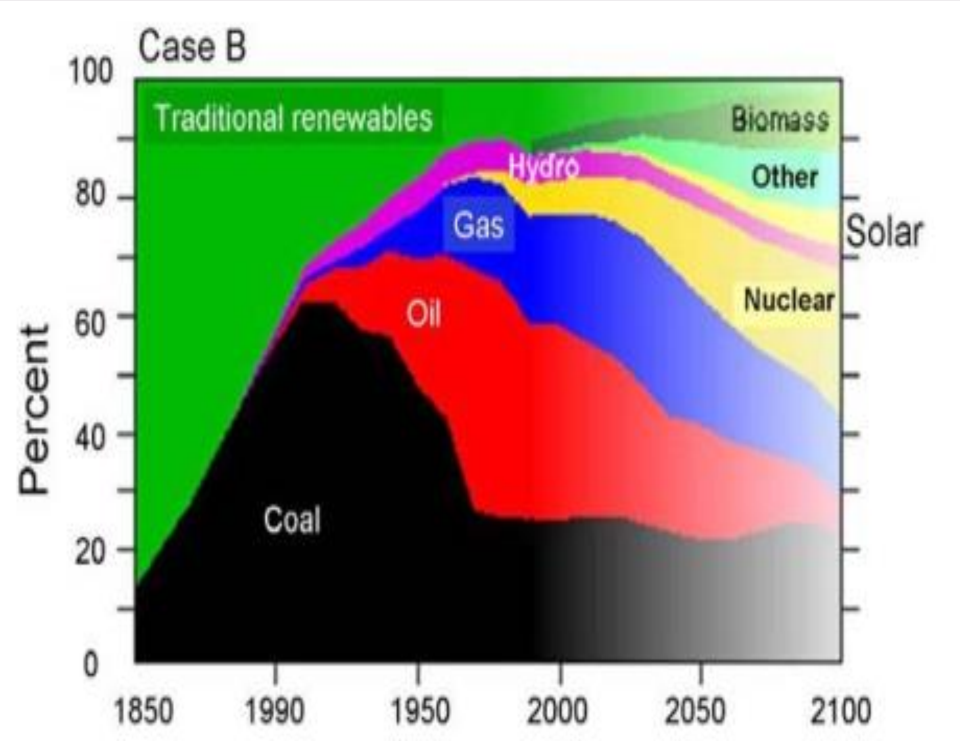
Region-wise primary energy consumption in IIASA–WEC scenario B.

- ❑ Regions with currently advanced technologies for energy will not improve consumption through the years.
- ❑ Regions will present an economic growth and more energy consumption in the future.

ENERGY IN THE WORLD: TYPES OF ENERGY RESOURCES IN RELATION TO THEIR PAST, PRESENT AND FUTURE USE

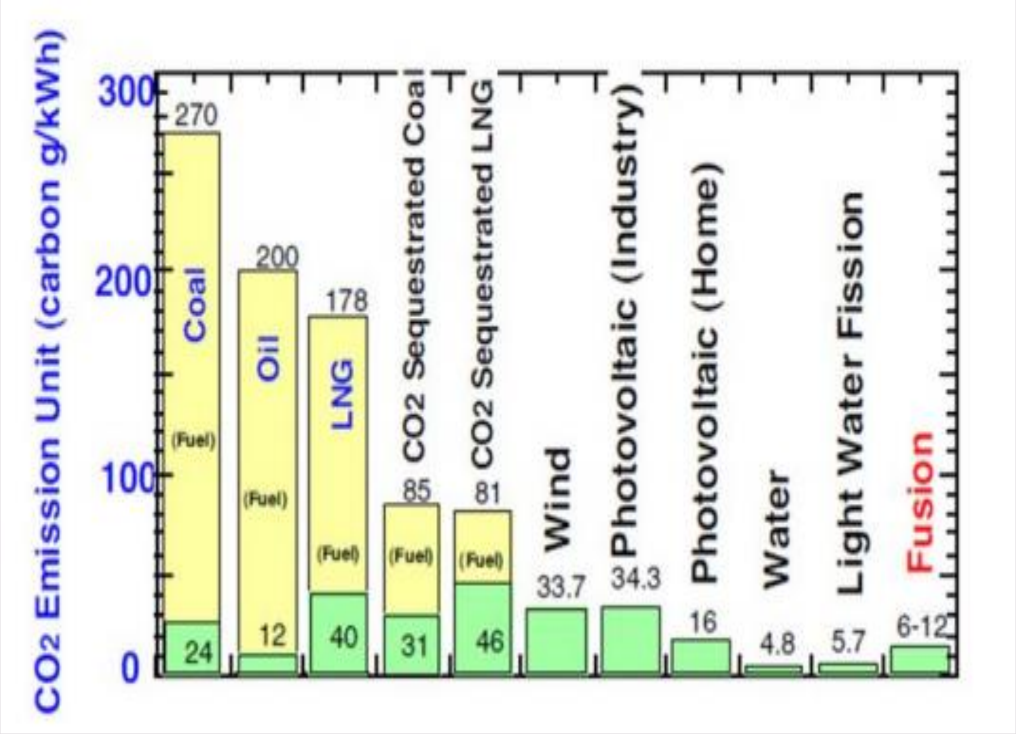
- Nuclear energy will replace gas and oil in the future.

- Coal will continue to be used due to its higher quantity compared to other fossil fuels.



Evolution of primary energy shares, historical development from 1850 to 1990 and projections till 2100, for Case B.

ENERGY IN THE WORLD: TYPES OF ENERGY RESOURCES IN RELATION TO THEIR PAST, PRESENT AND FUTURE USE



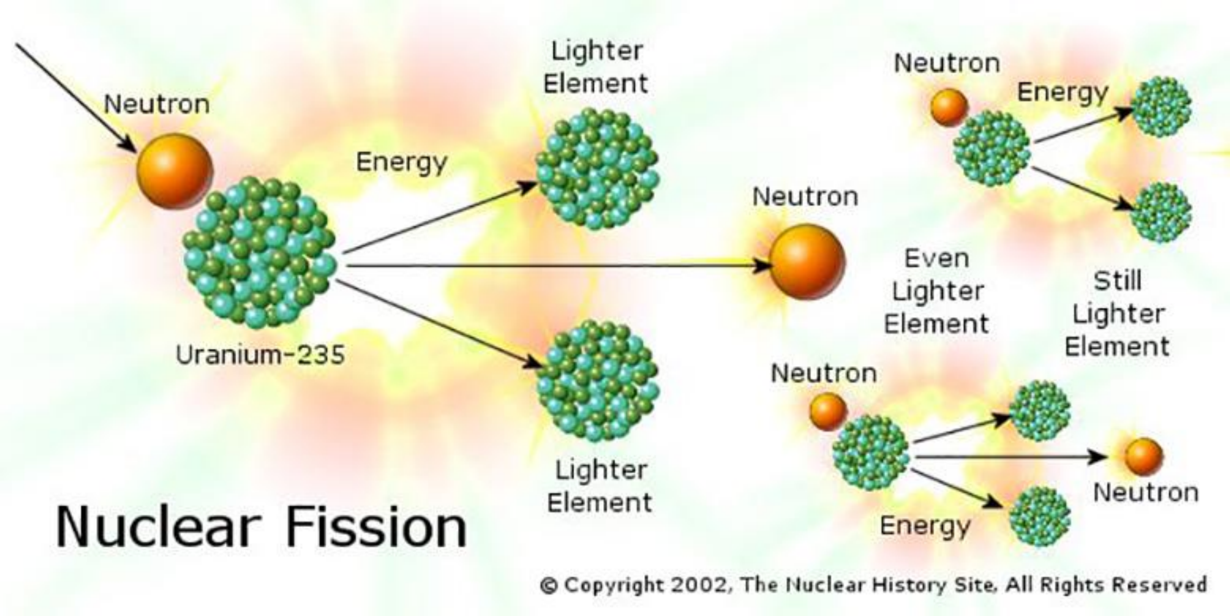
CO2 emission level of power reactors based on various fuel resources in their entire life cycle, showing fusion reactors as the third lowest CO2 emitter after hydro and fission reactors.

- Fusion and fission produce 45 times less CO2 than coal reactors.
- It is crucial to develop and invest in nuclear energy.

FUSION AND ITS OBSTACLE

Two forms of nuclear energy:

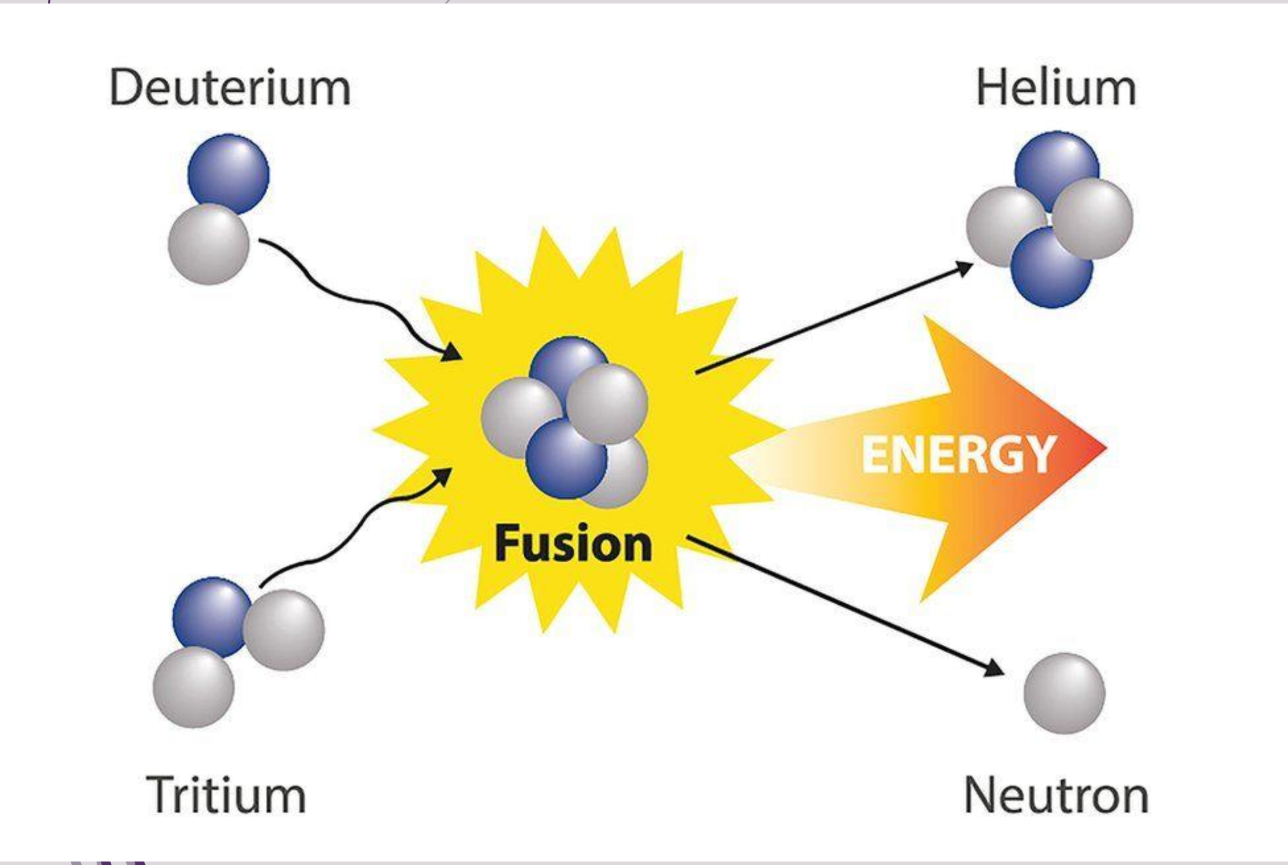
- ❑ Fission
- ❑ Fusion



Nuclear fission has two major issues:

- ❑ Security
- ❑ Radioactive waste

FUSION AND ITS OBSTACLE



Fusion presents some advantages to consider exploiting:

- Fuel is plentiful.
- Fusion fuel is readily accesible.
- There are limited radioactive waste problems.
- The fusion reaction is inherently safe.
- There are no dangers of proliferation.

FUSION AND ITS OBSTACLE

Energy radiated by the sun and stars:

- ❑ Albert Einstein´s equation.
- ❑ Francis Aston´s precise measurements of atomic masses.
- ❑ Artur Eddington´s proposal.
- ❑ Quantum mechanics.

The major obstacle to “bring the energy of the Sun to Earth” is that the plasma must be at a temperature of 100 million C°.

THE TWO PROPOSALS

Possible options to control the thermonuclear fusion problem:

- Inertial confinement fusion: to obtain a dense hydrogen fuel capsule.

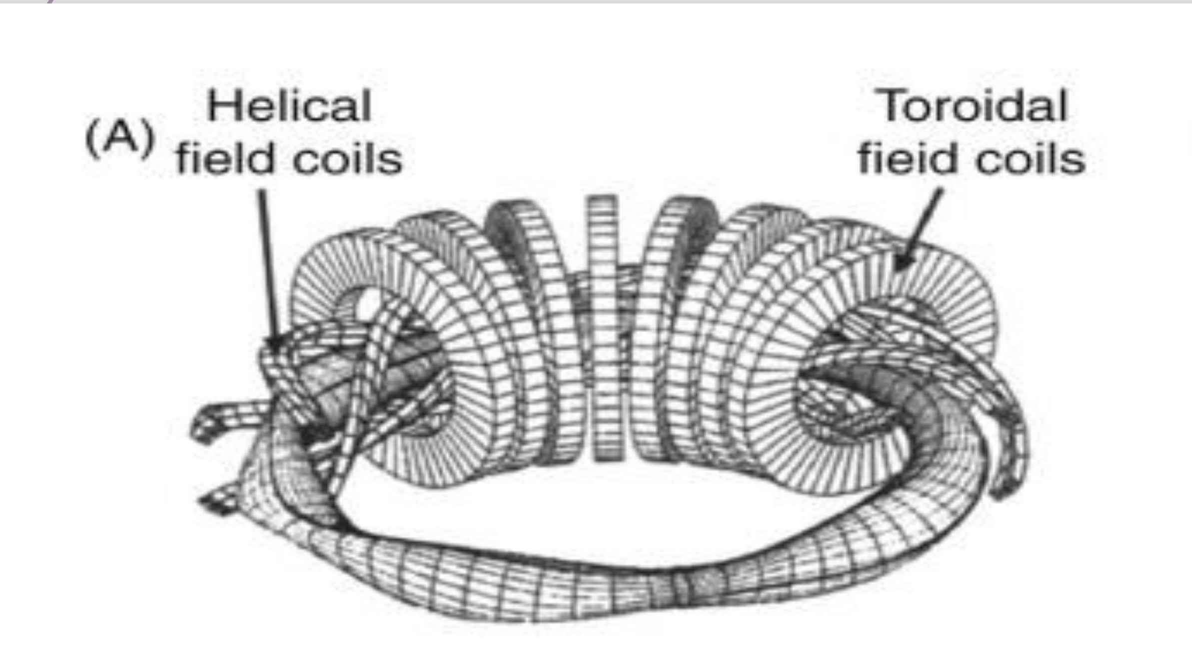
- Magnetic confinement: to isolate a relatively rarefied quasi-stationary plasma using an external magnetic field.

In this type there are two designs:

- Tokamak
- Stellarator

THE TWO PROPOSALS

A stellarator is very closely related to the tokamak, but the difference is how the confining magnetic field is achieved.



Comparation of the field coils of a stellarator and a tokamak.

There are two main disadvantages in the stellarator compared to the tokamak:

- The design of the field coils are too complicated.
- The infrastructure for a stellarator with equal plasma volume as a tokamak is larger.

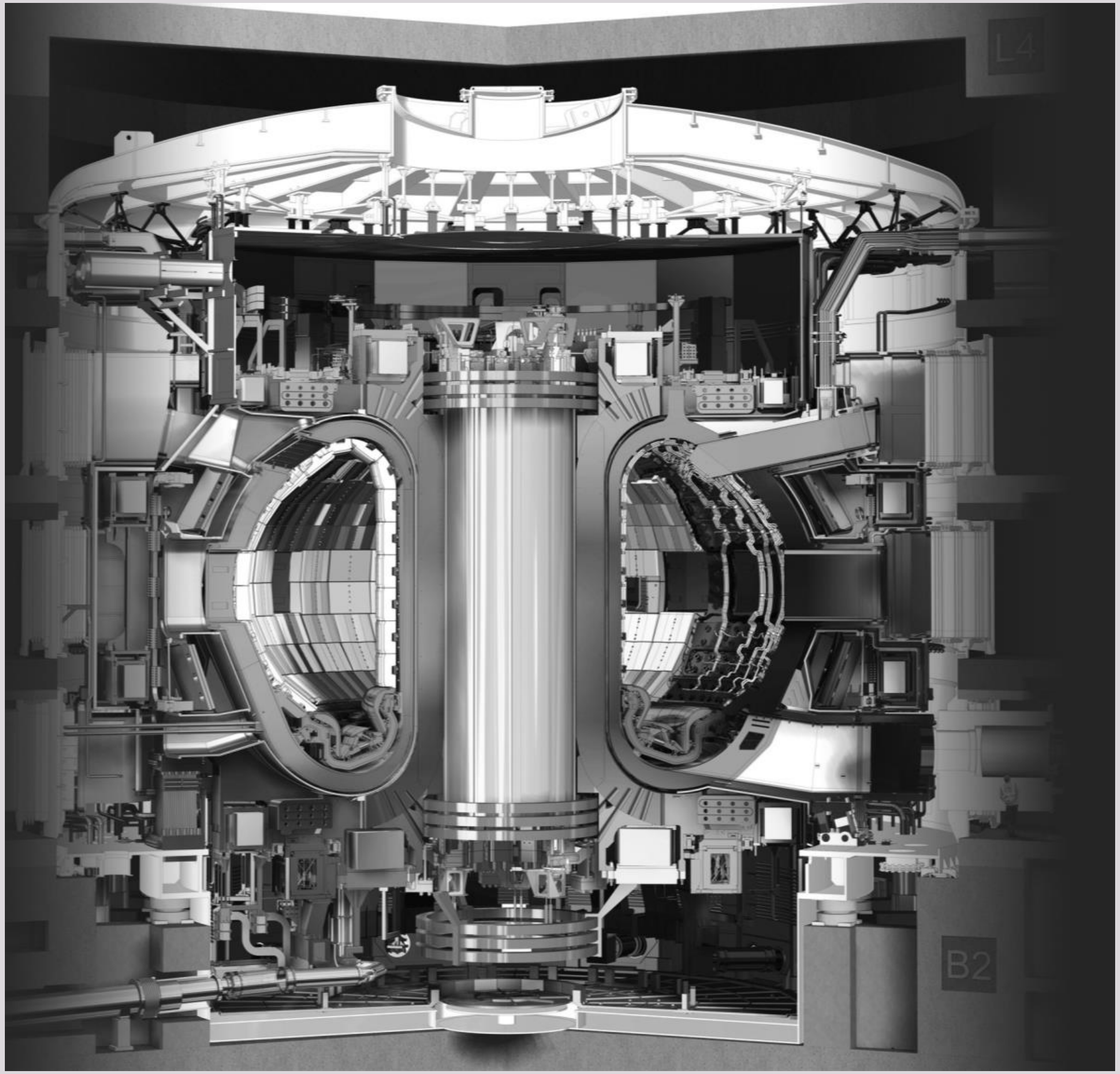
The design of tokamak is more practical.

TOKAMAK

- Its more important component is the vacuum chamber.

- Inside this component, gaseous hydrogen fuel becomes a plasma that provides the environment for the fusion.

- The massive magnetic coils placed around the vessel shape and control the hot plasma.



TOKAMAK

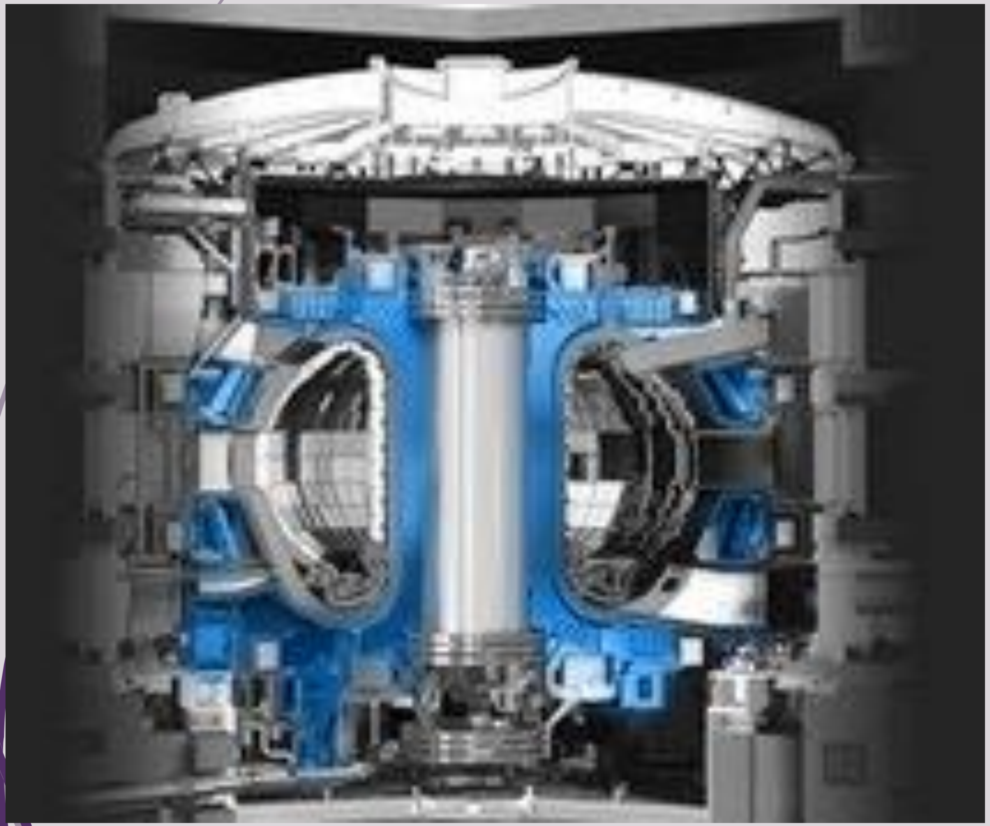
The process in Tokamak consists in:

- Evacuating the air and impurities from the vacuum chamber.
- Charging up of the magnets.
- Introducing of gaseous fuel.
- Breaking down the gas electrically to form the plasma.
- Heating with an auxiliary method to overcome fusion temperatures.
- Receiving the energy from fusion.

PARTS OF THE MACHINE

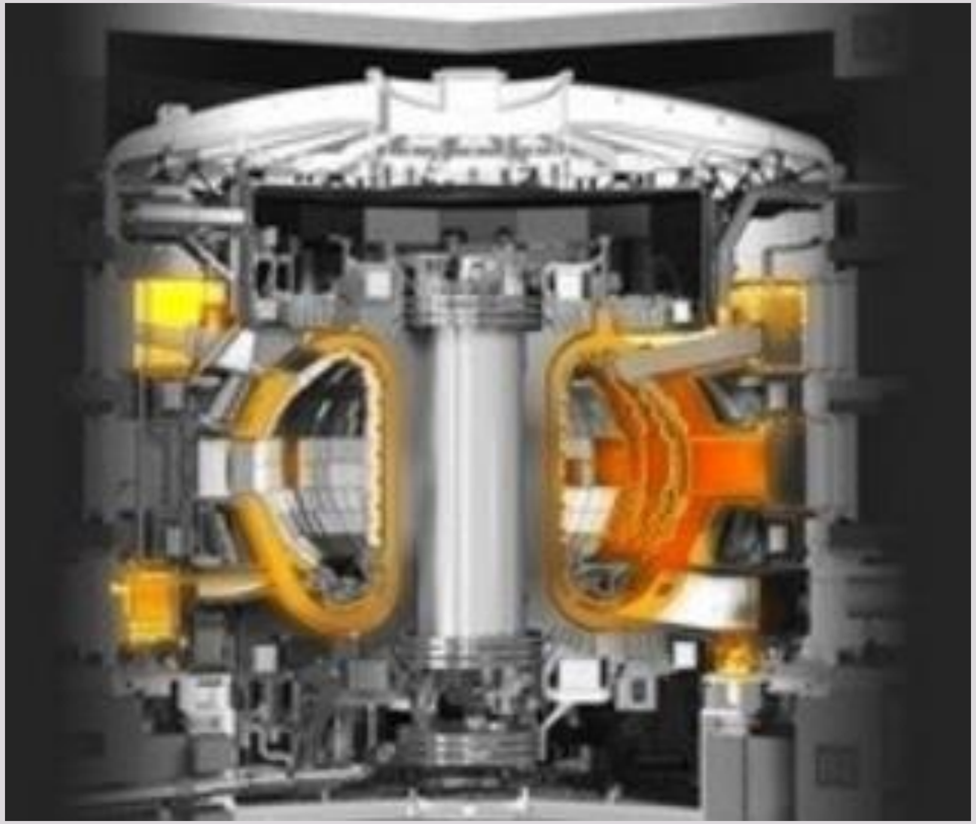
Brief explanation of the parts from the International Thermonuclear Experimental Reactor (ITER)

MAGNETS



Magnets from ITER´s tokamak

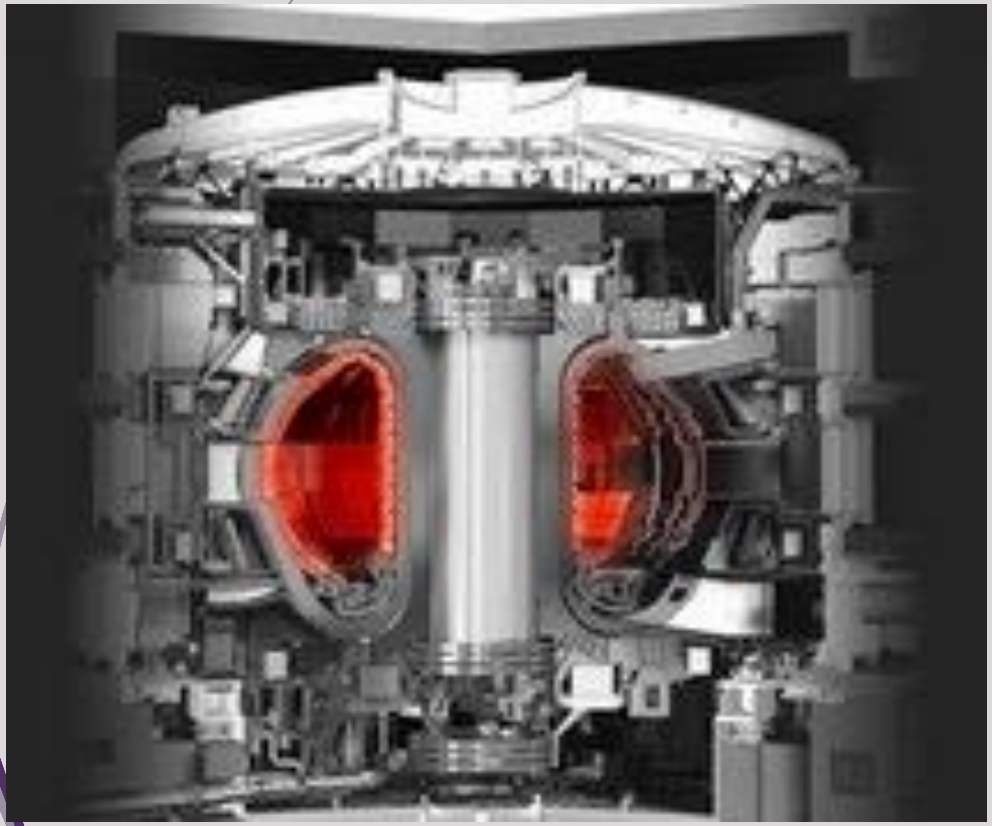
VACUUM VESSEL



Vacuum vessel from ITER´s tokamak.

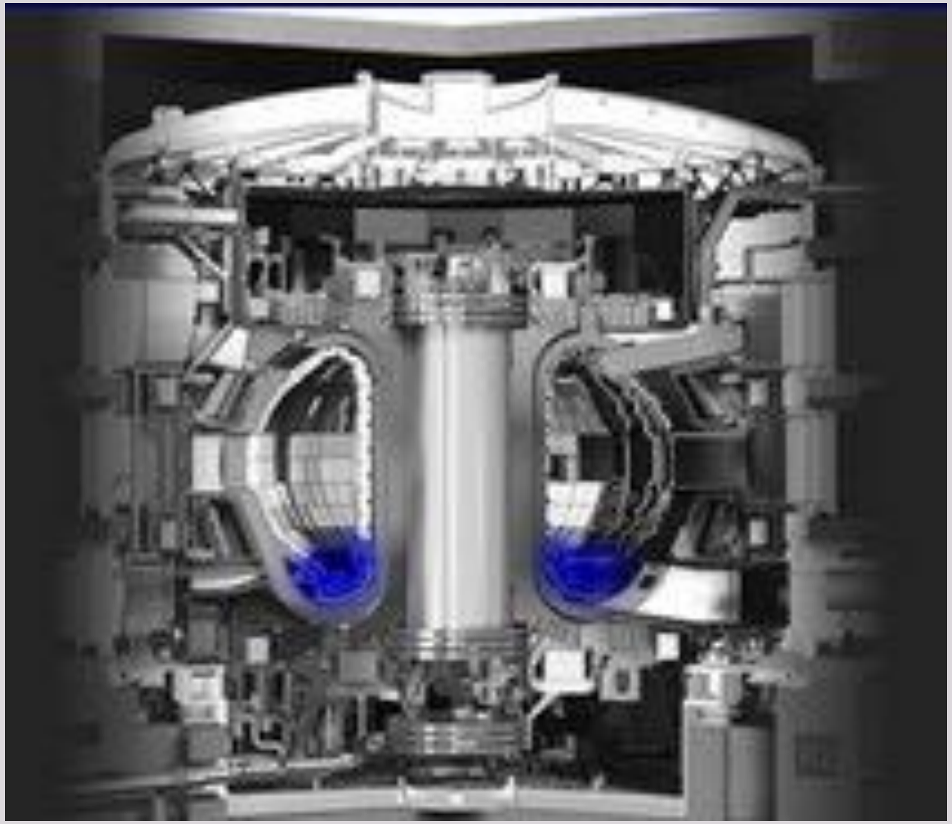
PARTS OF THE MACHINE

BLANKET



Blanket from ITER´s tokamak.

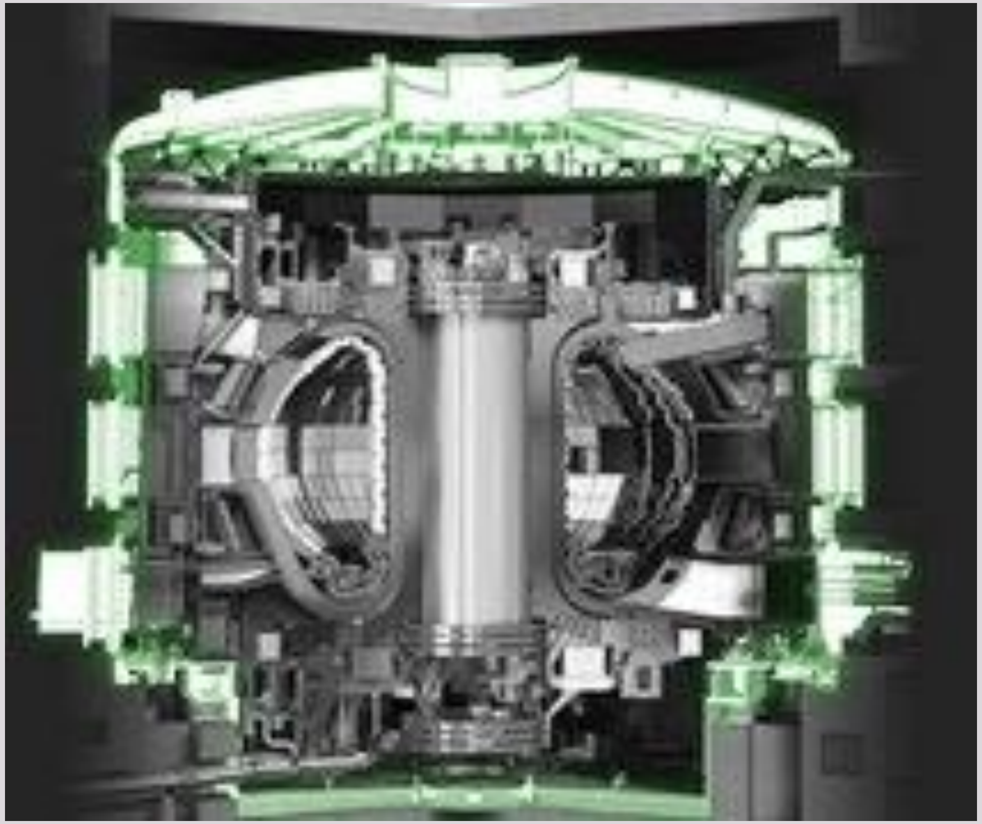
DIVERTOR



Divertor from ITER´s tokamak.

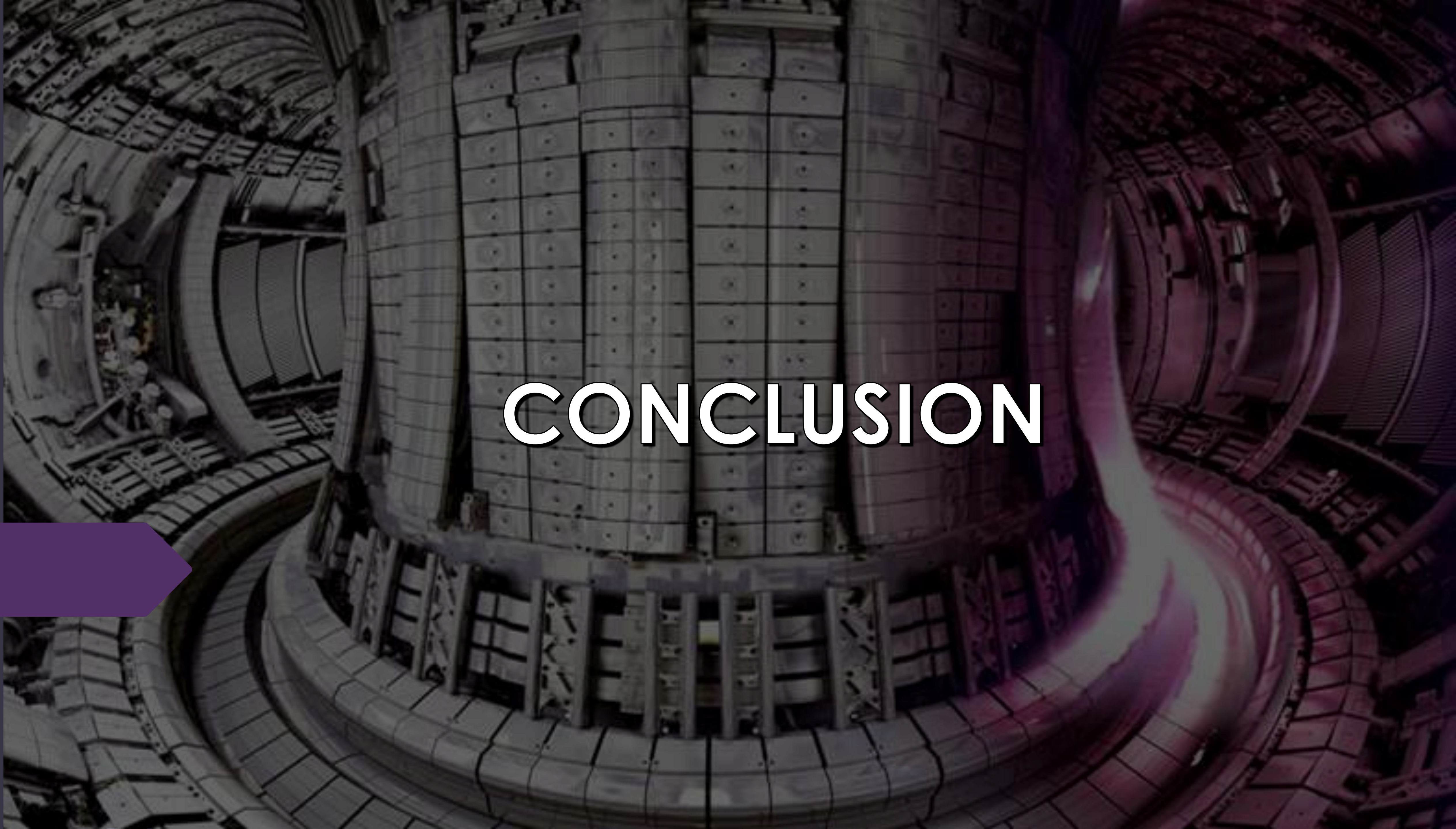
PARTS OF THE MACHINE

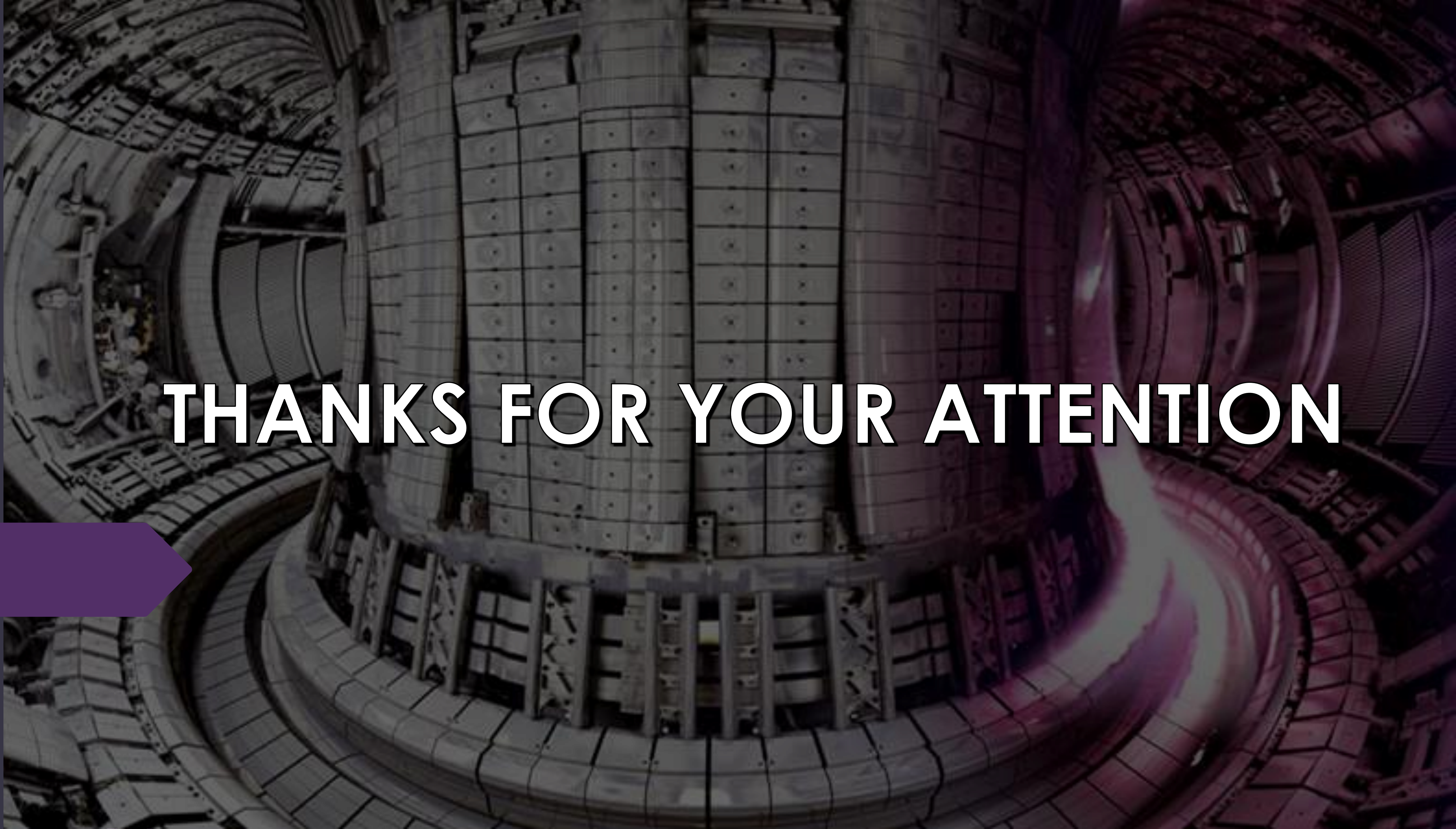
CRYOSTAT



Cryostat from ITER´s tokamak.

CONCLUSION




THANKS FOR YOUR ATTENTION

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