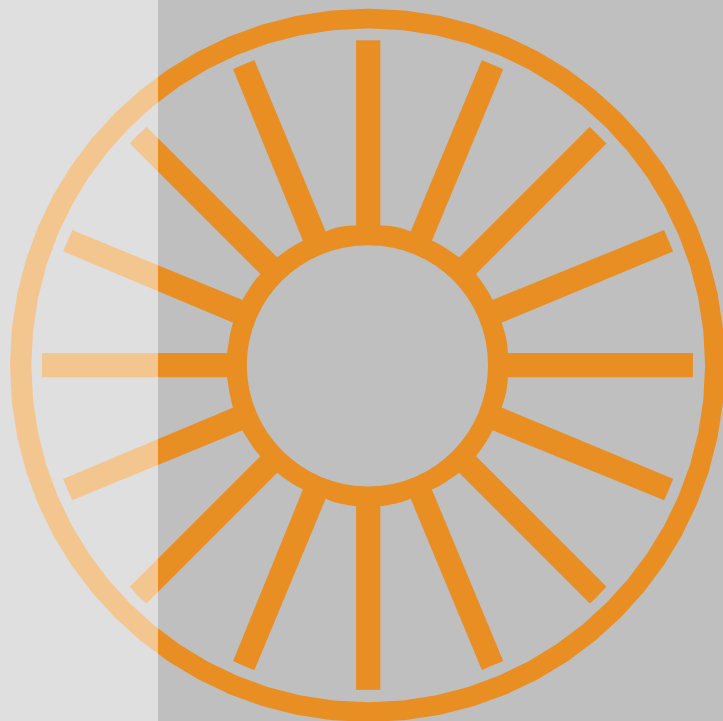


WHAT IS A TOKAMAK?



EXPLANATION

Tokamak is a Russian acronym meaning donut-shaped vessel surrounded with magnets.

The tokamak is the most advanced device towards the production of electricity from fusion energy.

It consists of

- Tokamak itself
- Heating systems
- Measurement systems

**ТОРОИДАЛЬНАЯ
КАМЕРА С
МАГНИТНЫМИ
КАТУШКАМИ**

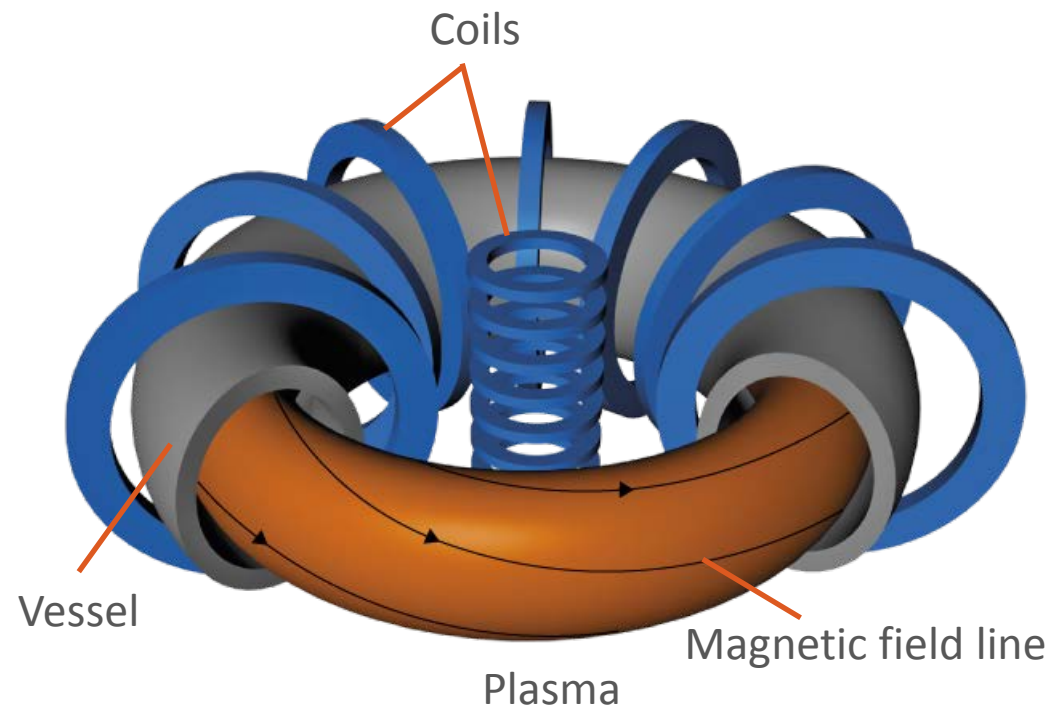
BASICS OF A TOKAMAK

It consists of

Metallic vessel to contain the plasma

Magnetic field coils to

- guide the plasma particles
- generate a current in the plasma
- shape the plasma



TOKAMAKS IN FIGURES

Size:

- Radius 0.5 – 6 m
- Volume 0.01 – 100 m³

Magnetic field 1 – 8 T

~100 thousand times the earth magnetic field

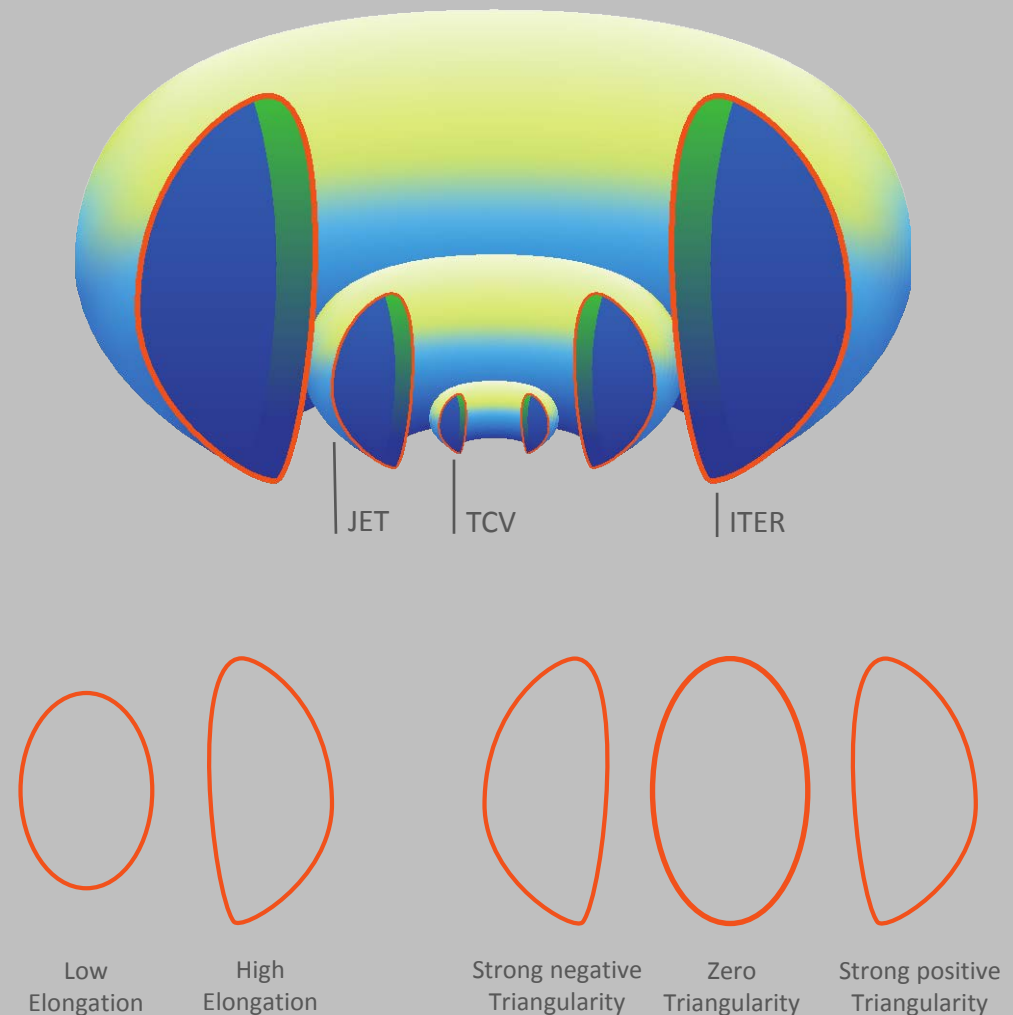
Plasma current 0.1 – 8 MA

~100 thousand times the current in a domestic plug

Plasma shape – shape of cross section

- Plasma Elongation
- Plasma Triangularity

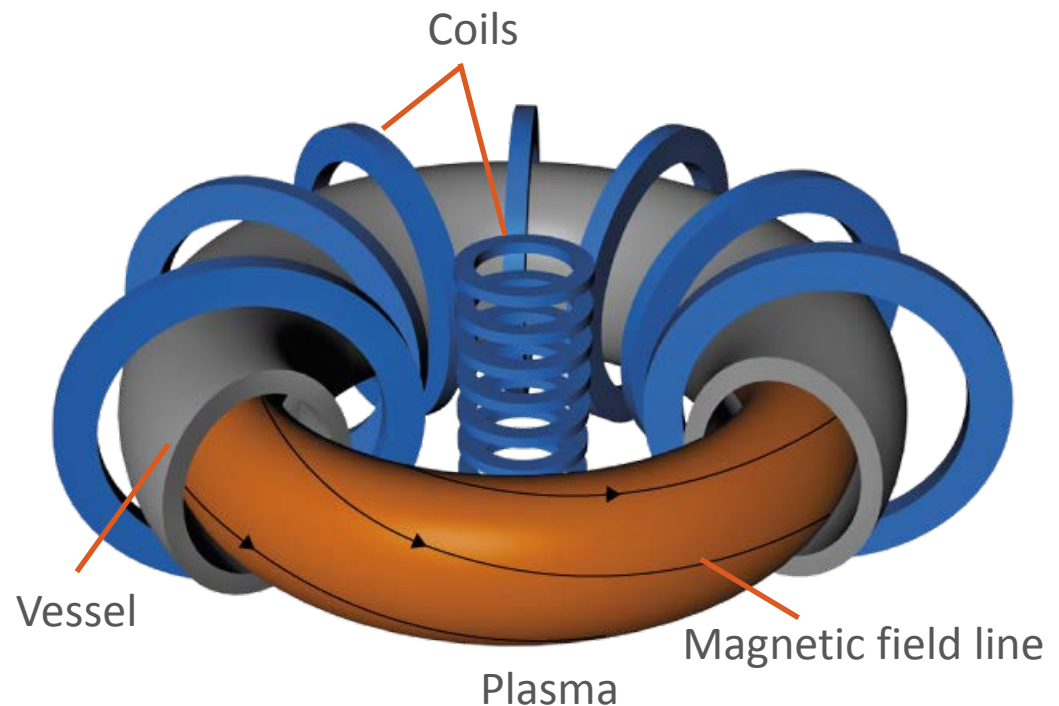
Changing the plasma shape changes the plasma properties especially the confinement



MAGNETIC CONFINEMENT

The combination of the magnetic fields naturally forms a cage-like structure, consisting of a series of nested rings.

Since particles of the plasma follow the magnetic field lines, they remain confined in the vicinity of the surface of a ring.



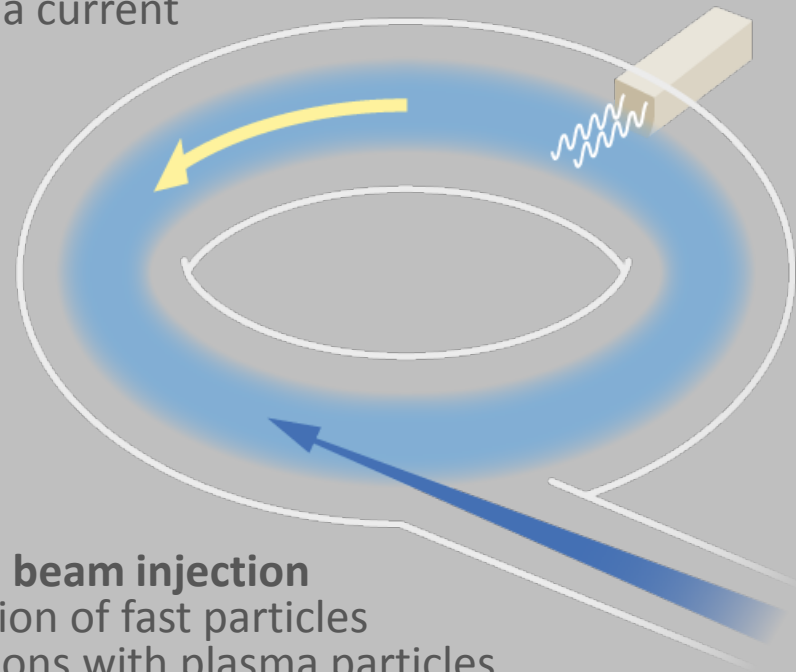
PLASMA HEATING SYSTEMS

Ohmic heating

- Produced by the plasma current

Wave heating

- Injection of high frequency waves (like in a microwave oven but 100-10'000 times more power)
- Wave – plasma resonance
- Energy transferred to plasma



Neutral beam injection

- Injection of fast particles
- Collisions with plasma particles
- Energy transferred to plasma

PLASMA DIAGNOSTICS MEASUREMENT SYSTEMS

It is not possible to insert a thermometer into the plasma ... then

- all systems must be based on
- natural emission of the plasma (light, particles)
 - interaction with laser light (or particle beams)

- to measure the
- plasma density
 - plasma temperature
 - plasma emission

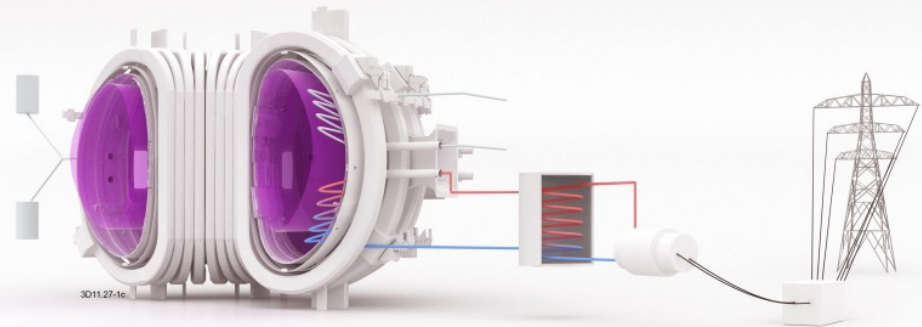
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PLASMA DIAGNOSTICS

Now: several systems to diagnose the plasma, for scientific exploitation

Later: fewer systems in a commercial reactor, for control only



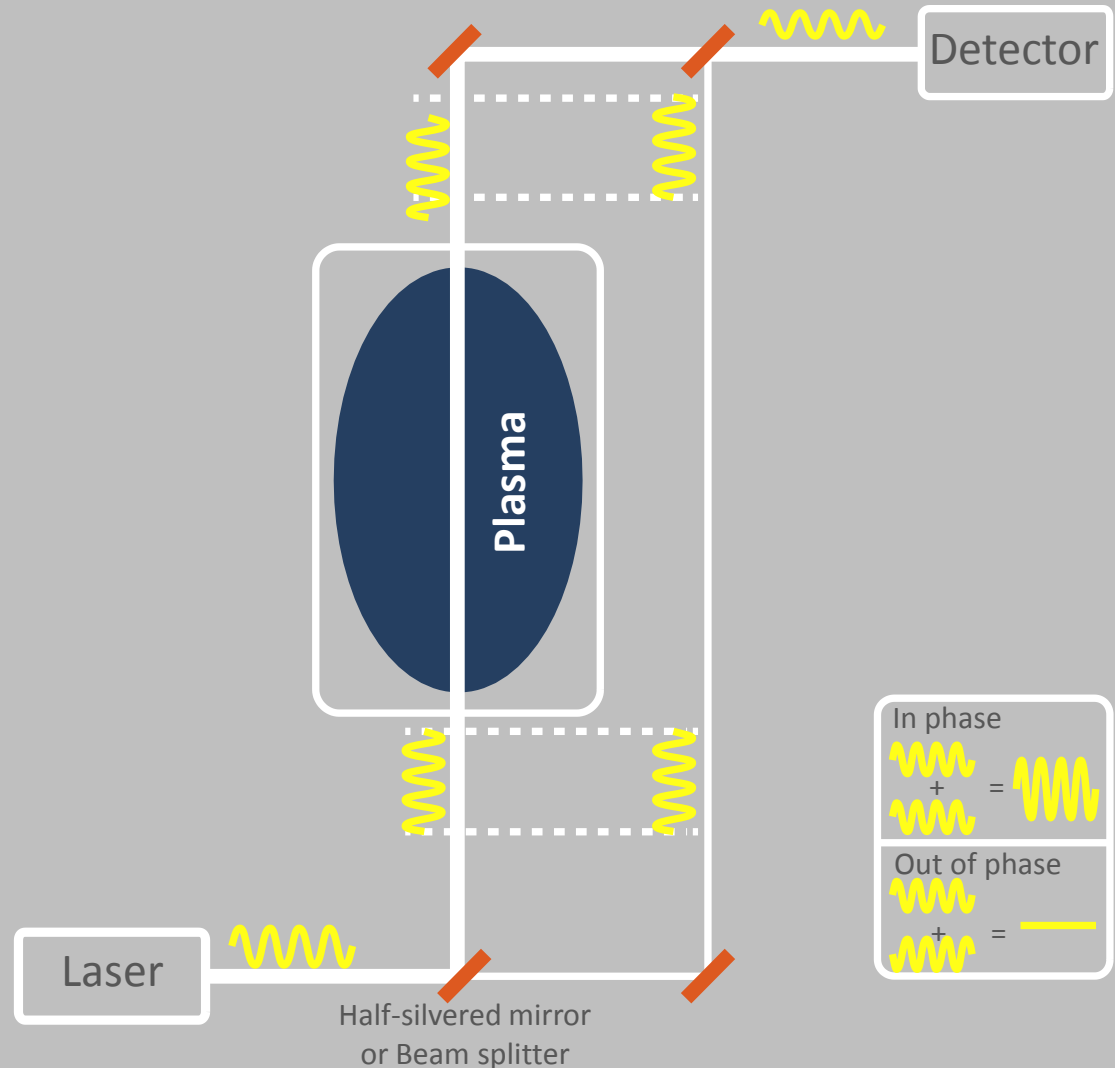
PLASMA DENSITY

Interferometry

- One laser beam
- Split into two beams
 - One through the plasma
 - One outside the tokamak
- Recombine the beams
- Interferometry fringes

When the plasma density increases, it delays the beam crossing the plasma and then induces interferences when it is recombined with the other beam.

Counting the interferences gives the plasma density.



THOMSON SCATTERING

Laser light is scattered by the electrons in the plasma.

Due to Doppler effect, the frequency of the scattered light is shifted.

Collected light shows a continuous spectrum around the laser frequency.

The width of the spectrum increases with electron temperature.

