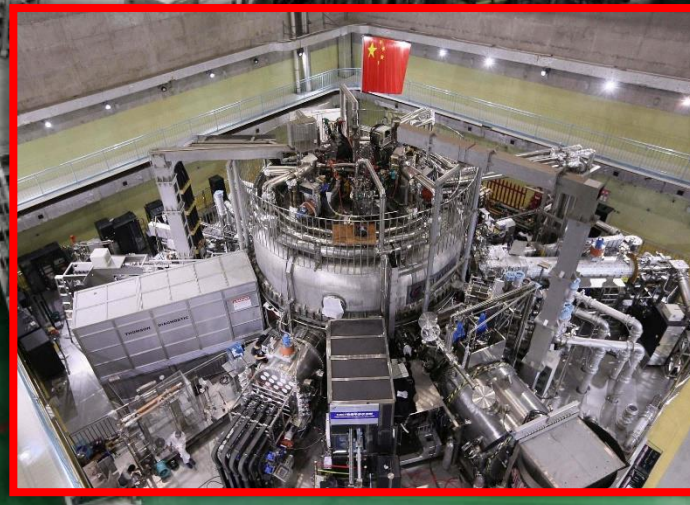
FUTURE OF NUCLEAR POWER: DECISIVE BUT UNKNOWN



Jan Mlynář
FJFI ČVUT

For the US visiting students

23rd January 2023

THE MOST REACTIVE FUSION

Can we find inspiration in the Sun?

1. Much more reactive fuel is required.

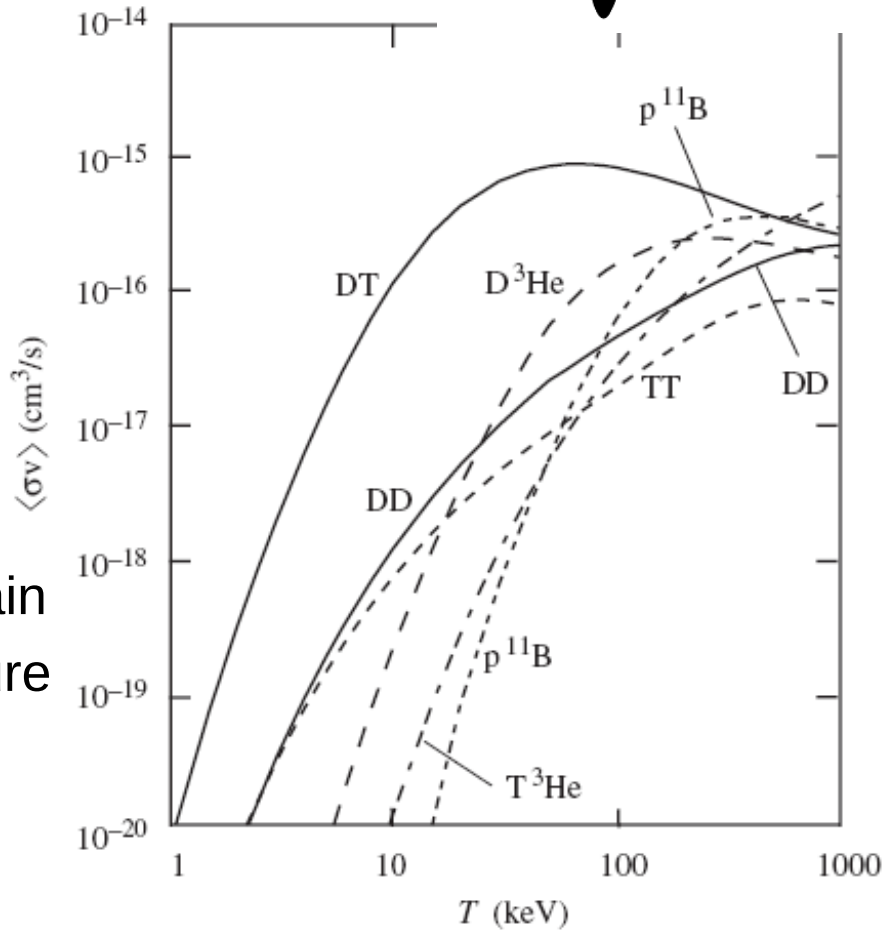
$$D + T \rightarrow \alpha + n + 17.6\ MeV$$

OK however….

Neutrons carry away 4/5 of power

tritium is unstable → challenging to maintain

→ not available in nature

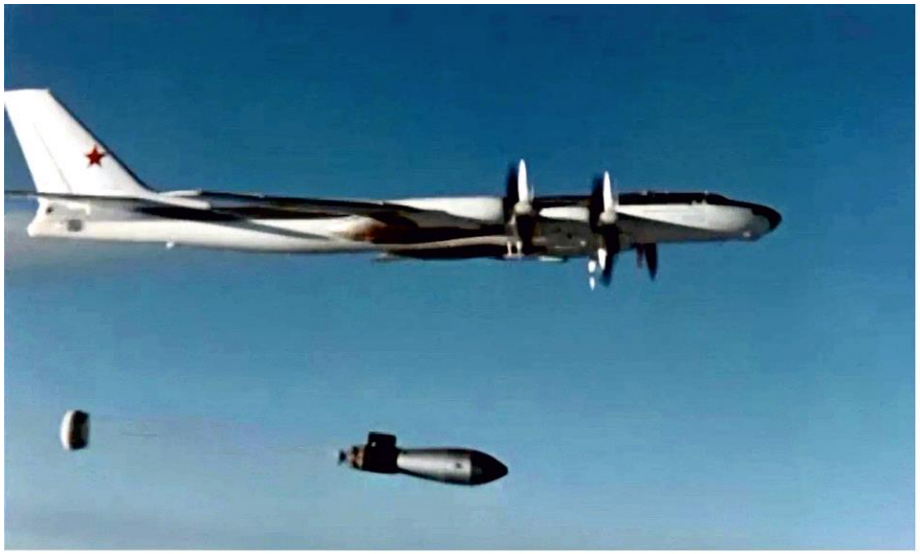


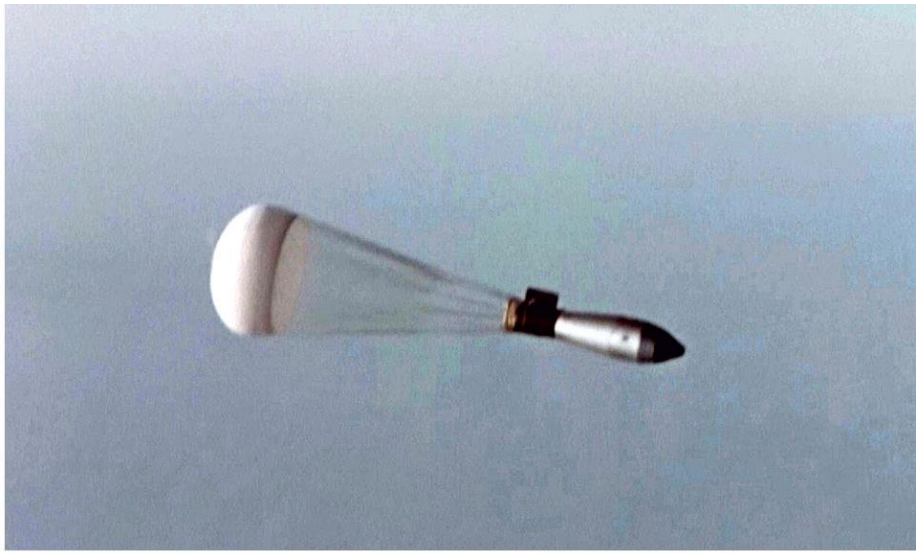
$$n + {}^{6}Li \rightarrow \alpha + T + 4.8\ MeV$$

2. We need a much more efficient plasma confinement as compared to the natural - gravitational one.

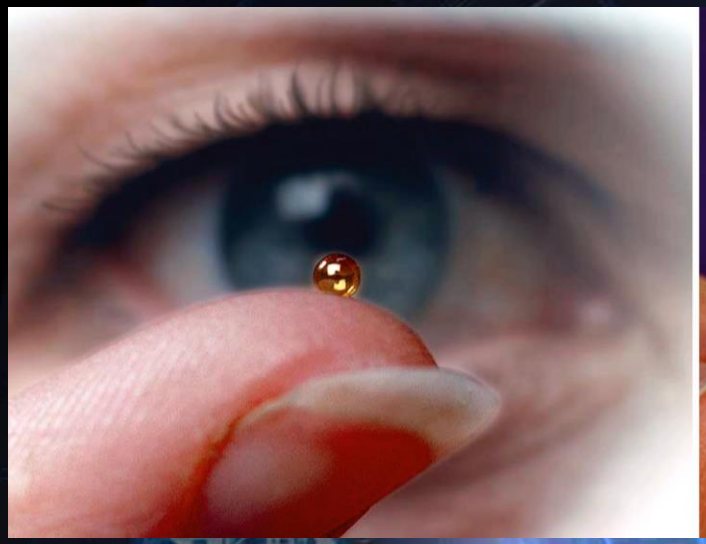
Hydrogen bomb (record Mtons TNT)

1952 -1961

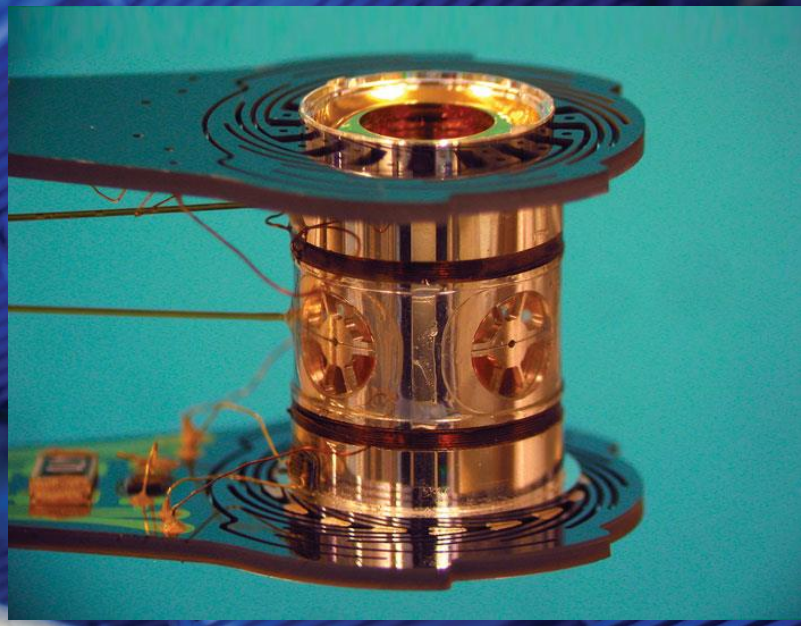




NATIONAL IGNITION FACILITY, LLNL



INERTIAL CONFINEMENT FUSION (ICF)

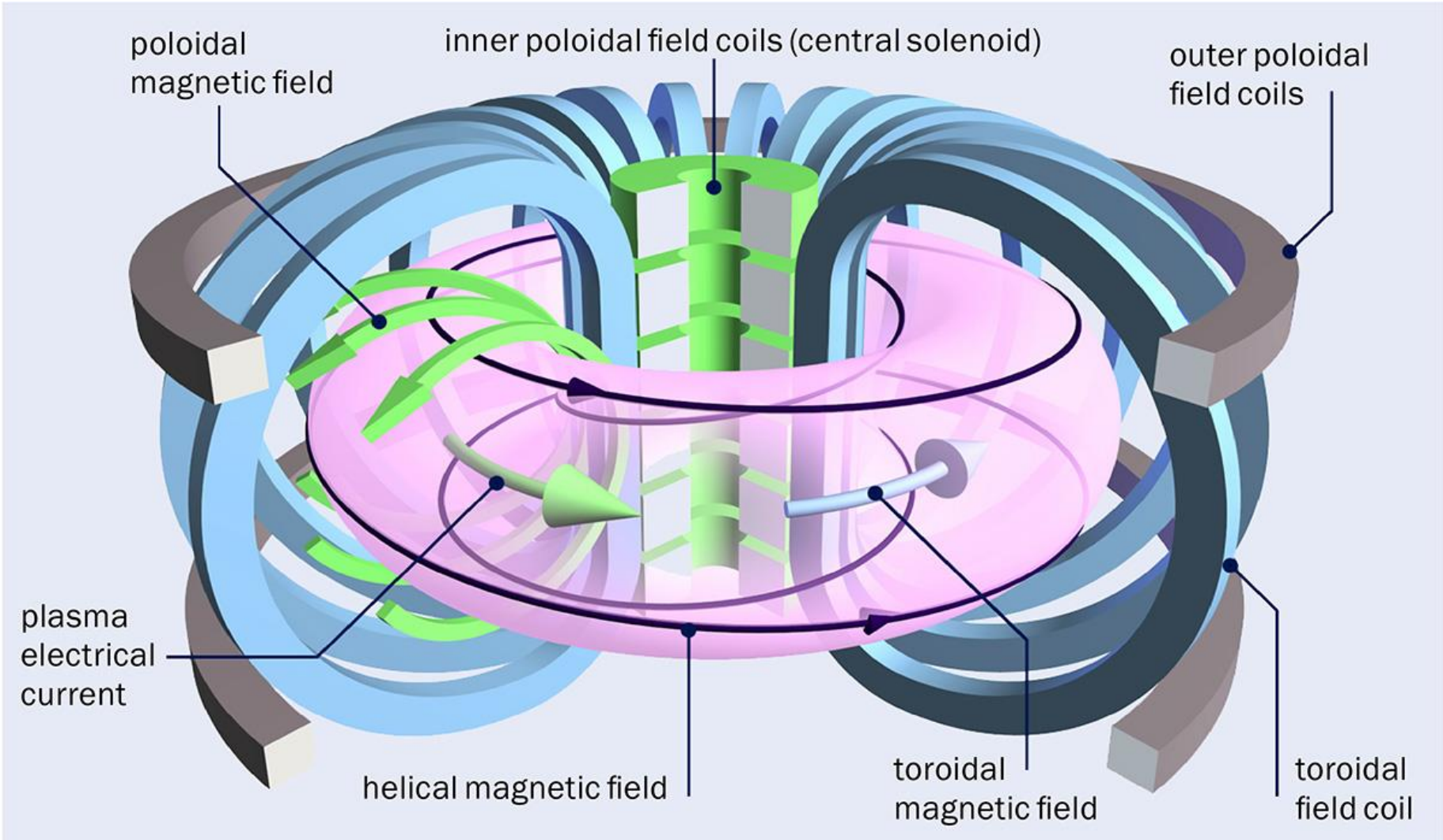


PART OF THE MISSION:
STOCKPILE STEWARDSHIP

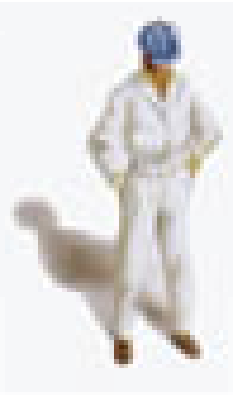
NIF LLNL 2022 world record

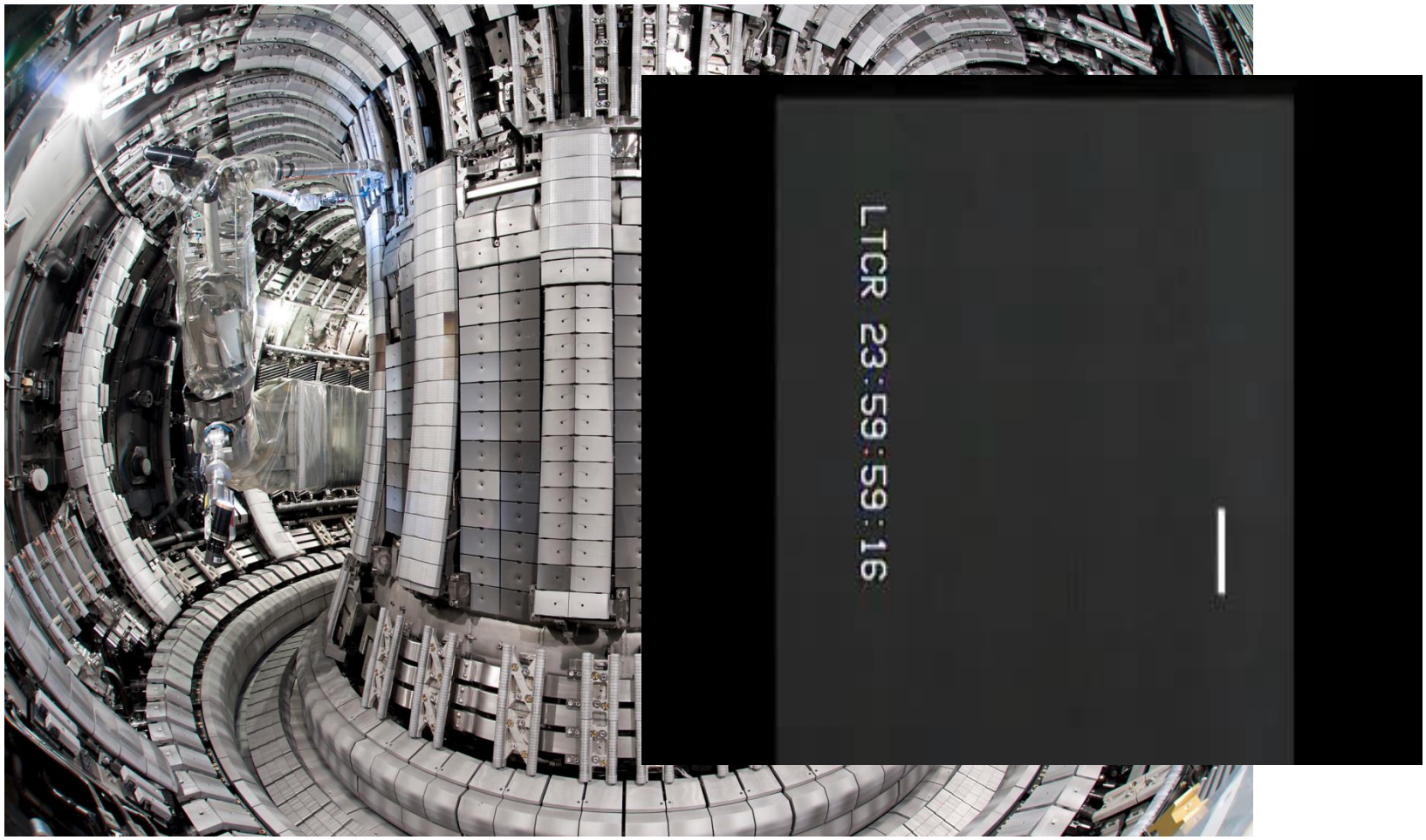
- 5th December 2022
- Laser energy of 2.05 MJ impacted the inner side of the hohlraum, the pellet explosion released 3.15 MJ fusion energy
- Energy of X rays from the hohlraum deposited in the pellet is estimated at 250kJ
- → Q >12 - very good. Mission accomplished
  In ICF, this is now defined as “ignition”
  while in MCF, stars „ignition“ means fusion goes on even if external heating is off

MAGNETIC CONFINEMENT FUSION (MCF)

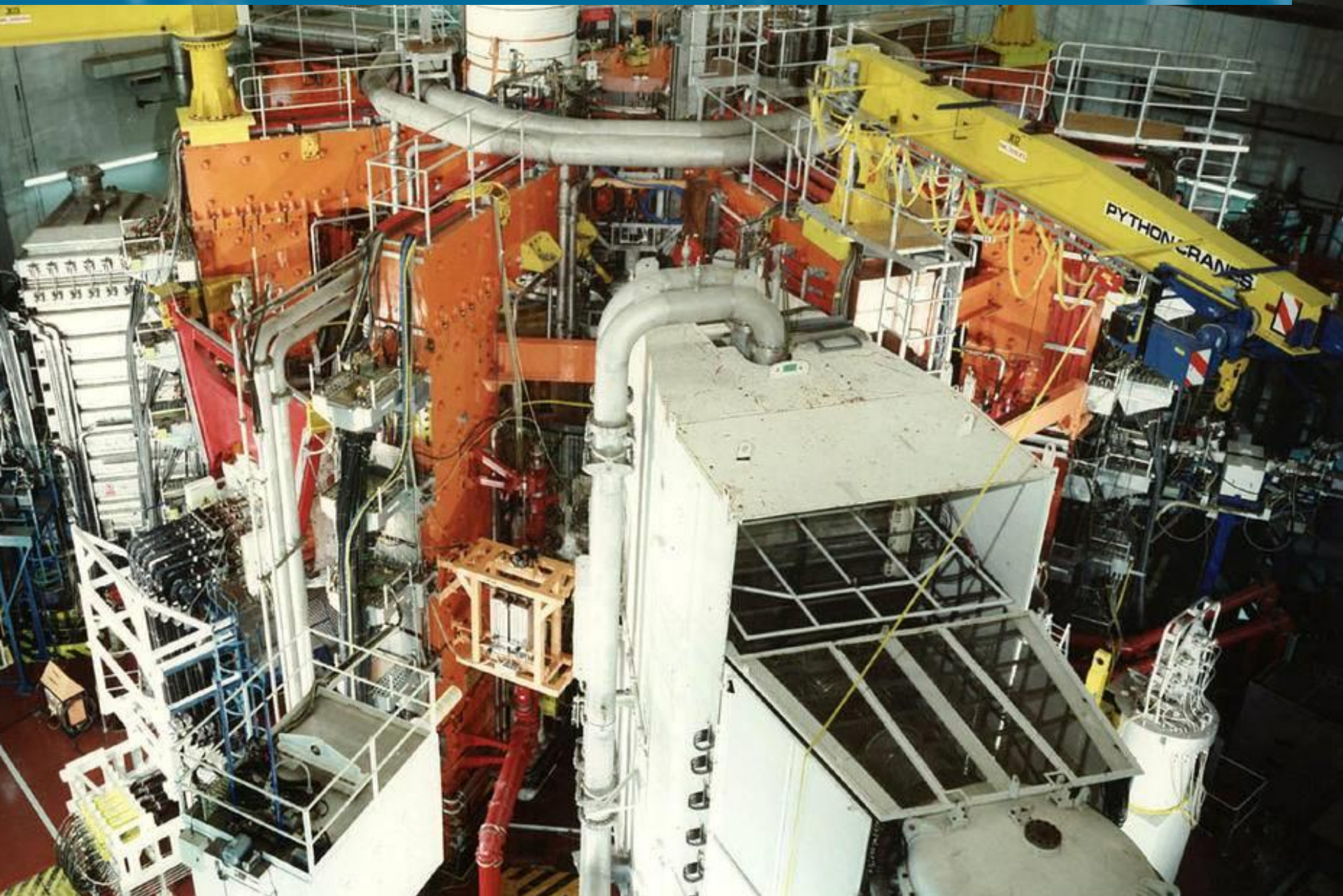


JOINT EUROPEAN TORUS (JET)

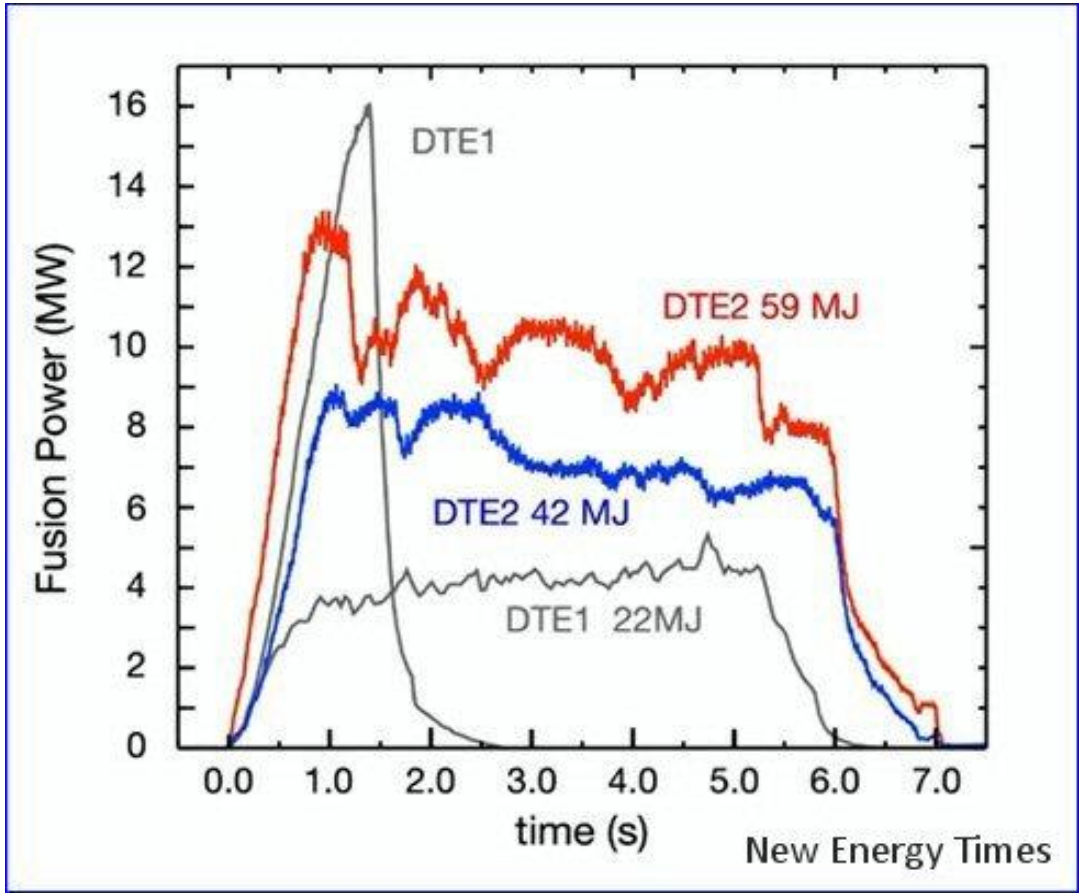


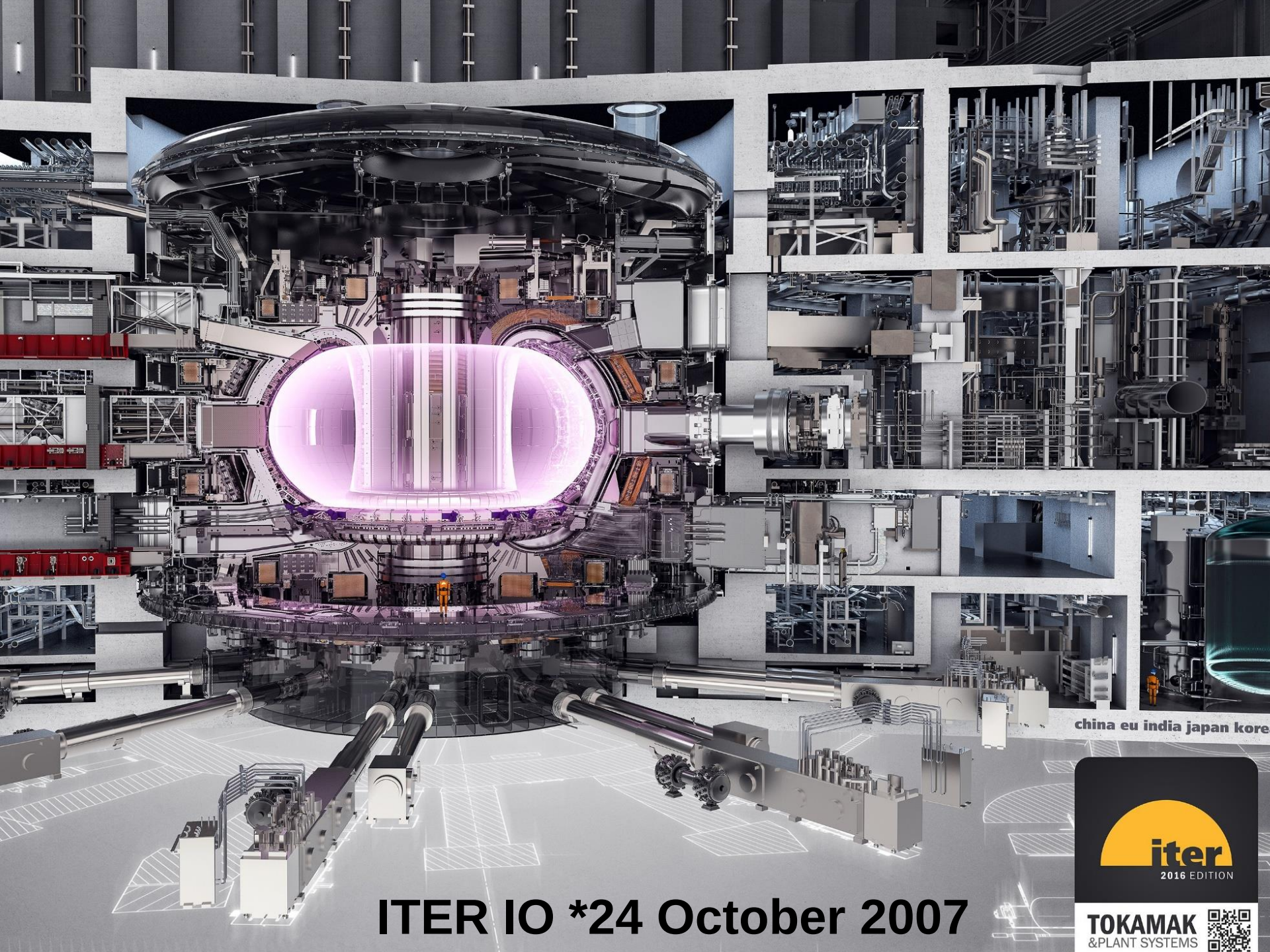


JOINT EUROPEAN TORUS (JET)



JET RECORDS


Fusion Power (MW)
16
14
12
10
8
6
4
2
0
DTE1
DTE2 59 MJ
DTE2 42 MJ
DTE1 22MJ
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
time (s)
New Energy Times



ITER IO *24 October 2007

Suggested points for discusssion

Some differences between current status of ICF and MCF.

- Fuel cycle
- Discuss in particular the fact that MCF research community works on resolving all technology challenges now (materials, remote maintenance, tritium breeding etc.

Key differences between fusion and fission as a power source.

1. Fission has been harnessed for many decades
2. Fusion generates four times more energy per kilogram of fuel than fission used in nuclear power plants, and nearly four million times more energy than burning oil or coal.
3. Fuel cycle more secure in fusion, proliferation issues much more serious in fission.
4. Fusion generates approx 20x more neutrons per kilogram of fuel than fission and they are much much more energetic - yet unknown consequences for reactor materials

FUSION AND FISSION DISTINCTIONS

The second starting point of our discussion.

- Fuel cycle
- Discuss in particular the neutron fluence is different in nature
- Second, compare the prolifferation issues
- Third, the fuel cycle.