

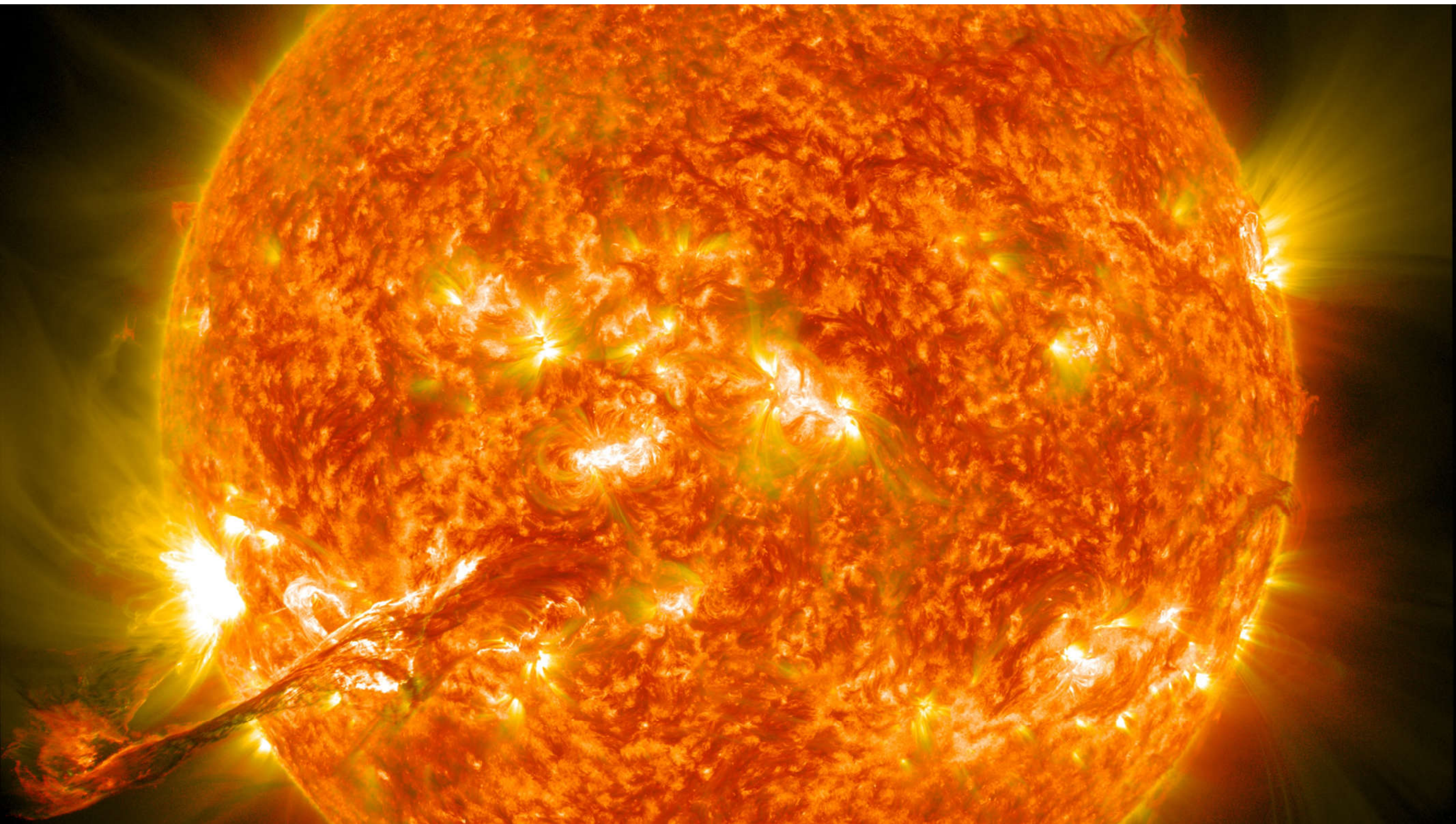
Fuzija - možen vir energije za prihodnost

Igor Lengar

Institut Jožef Stefan



Fakulteta za energetiko, Univerza v Mariboru

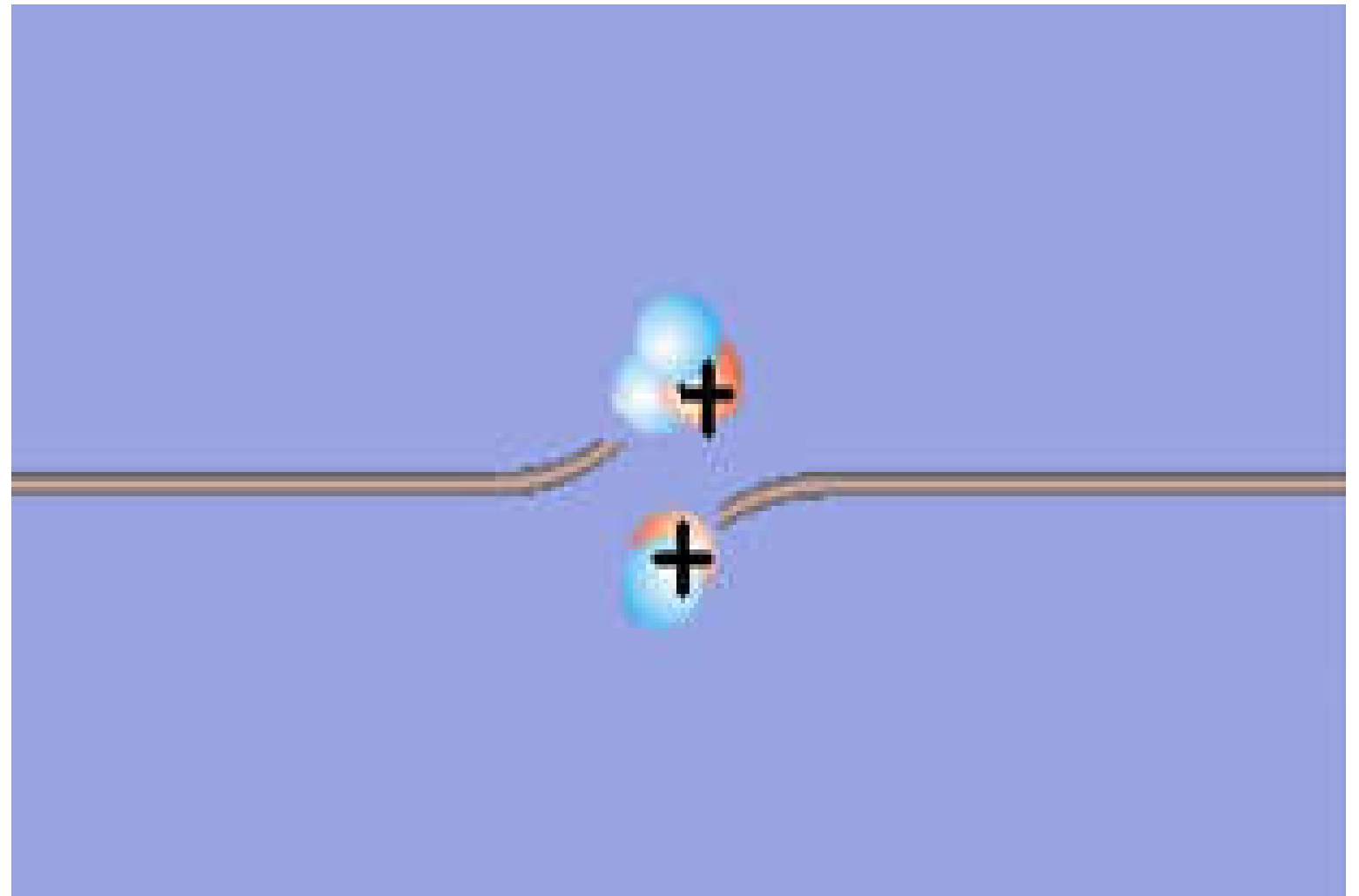


Reakcija devterij - tritij

Izotopi vodika

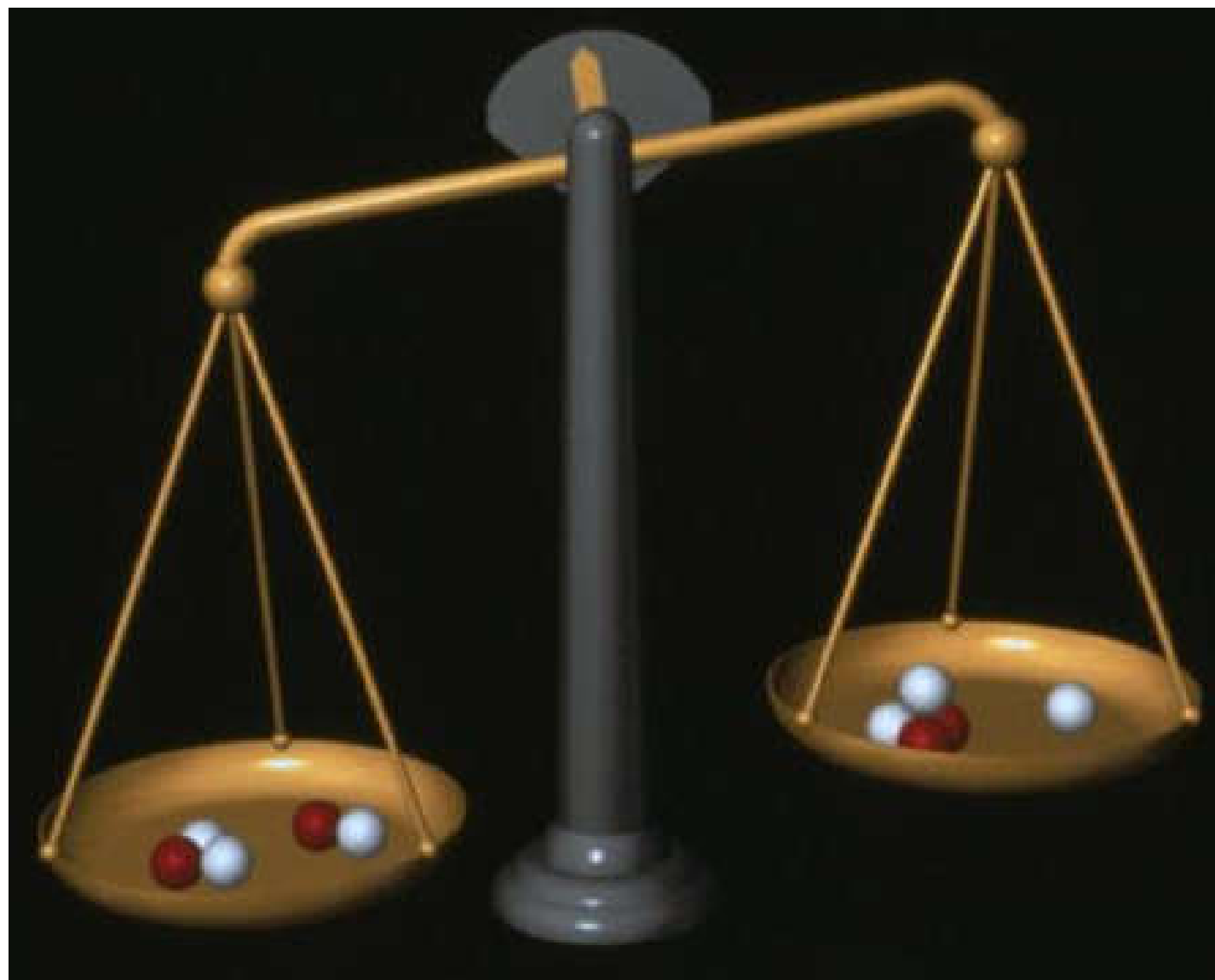


Na Zemlji poteka
fuzijska reakcija med
dvema izotopoma
vodika: devterijem in
tritijem



Za fuzijo potrebujemo več kot 100 milijonov stopinj celzija

Od kod energija

$$E = mc^2$$


Fuzijsko gorivo

1 liter morske vode

360 litrov nafte

5 g litijeve rude



+



=



33 mg devterija

50 mg tritija

Gorivo za fuzijo je poceni in razširjeno po celem svetu, zaloge zadoščajo za tisočletja.

Majhna poraba goriva pri fuziji

termo elektrarna



**50 000 vagonov
premoga letno**

- ni toplogrednih plinov
- ni močno radioaktivnih odpadkov

jedrska elektrarna



**1 tovornjak
urana letno**

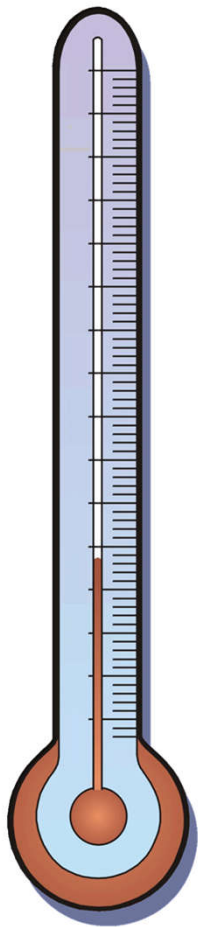
- V fuzijski elektrarni bi v vsakem trenutku gorel le en gram mešanice devterij- tritij

fuzijska elektrarna



**1 kombi devterija
in litija letno**

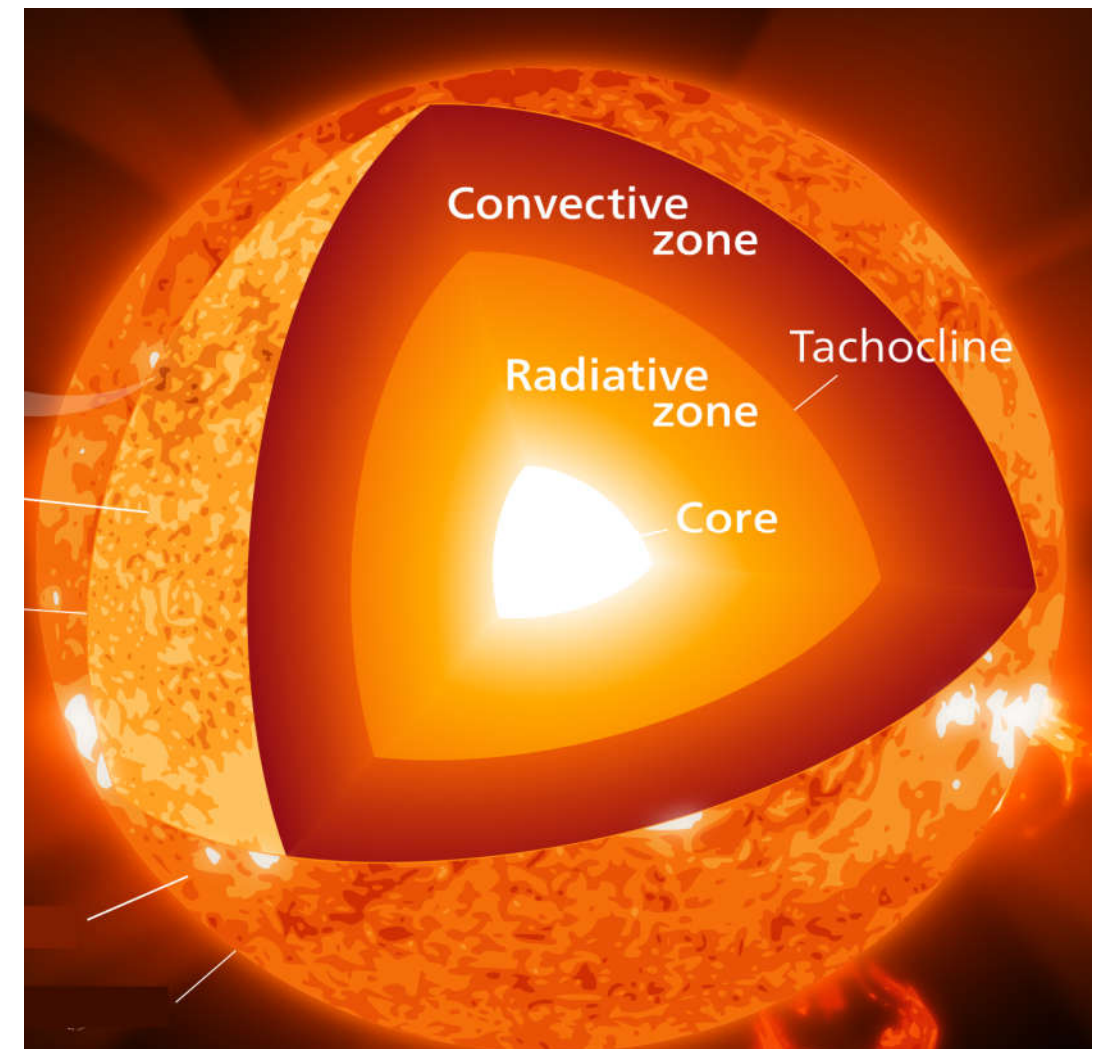
Fuzija je zahtevna



Temperatura:
nad 100 milijonov
stopinj celzija

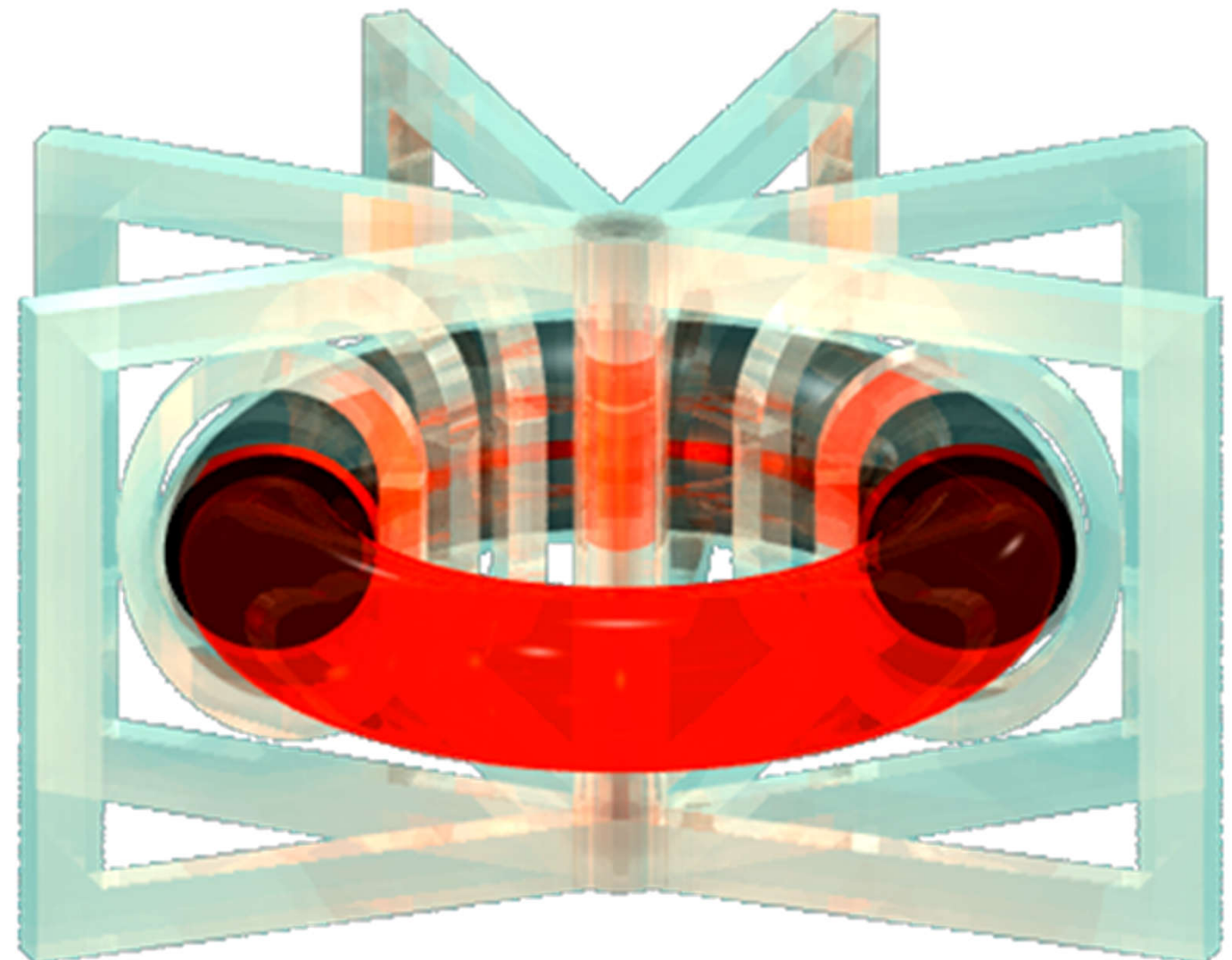
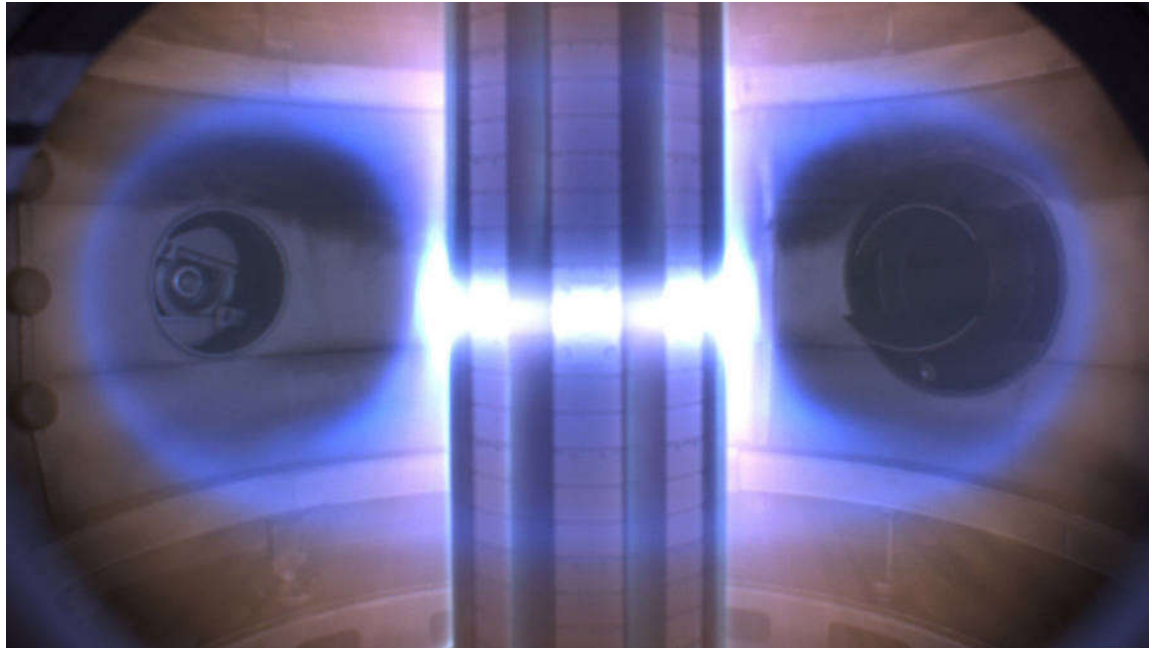


Za plazmo
zelo visoka
gostota snovi

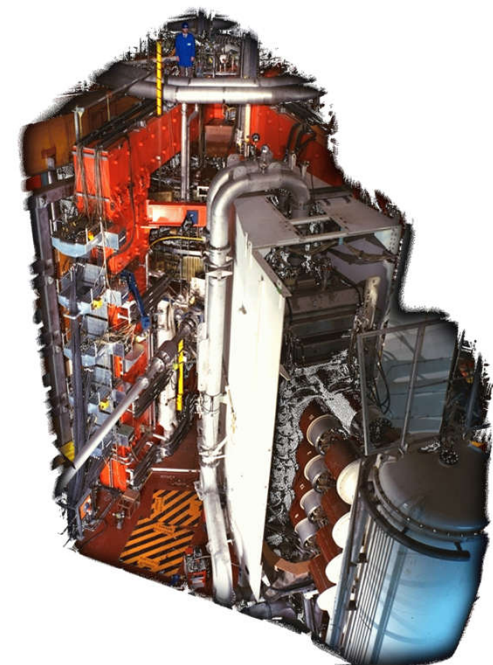
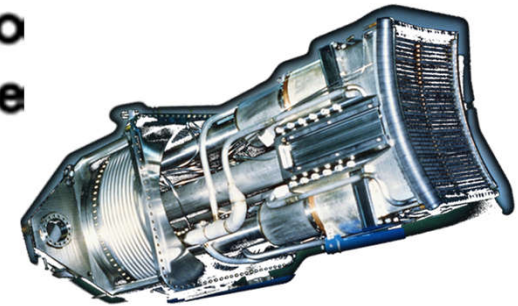
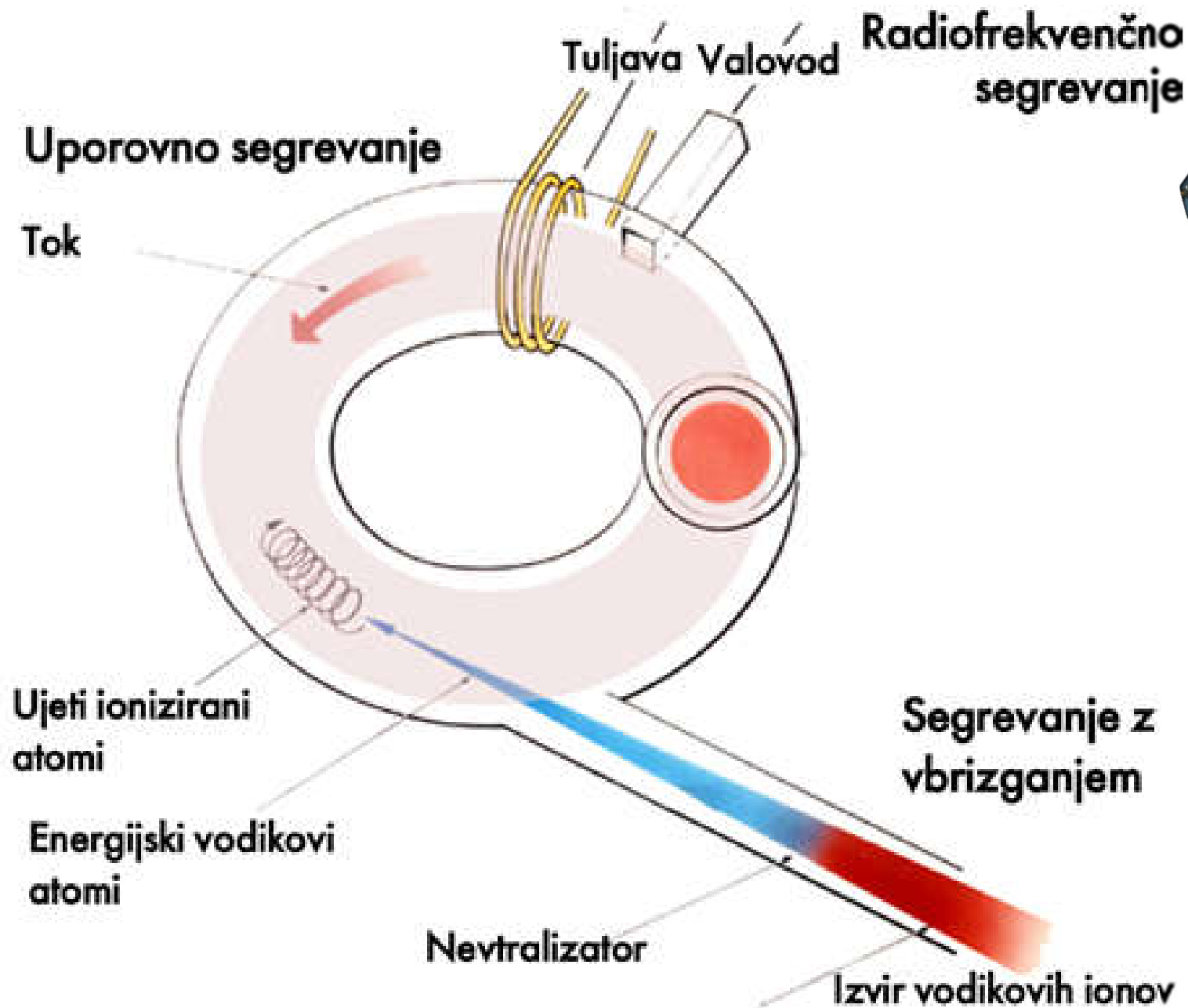
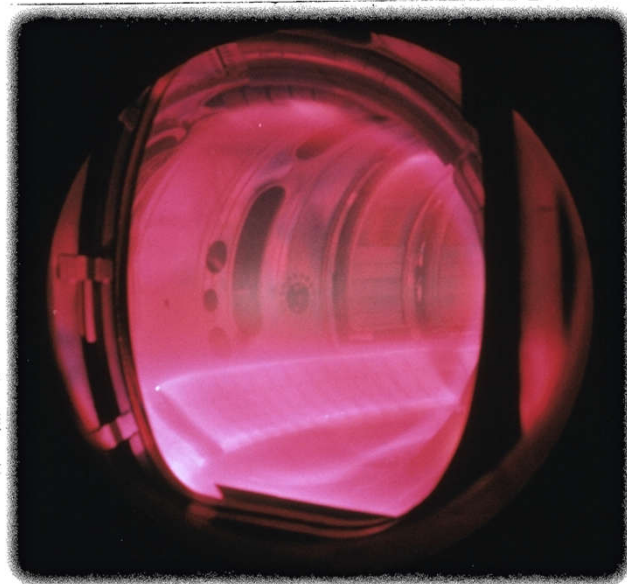


V soncu so pogoji za fuzijo zagotovljeni
le v sredici, to je centralnem 1% volumna

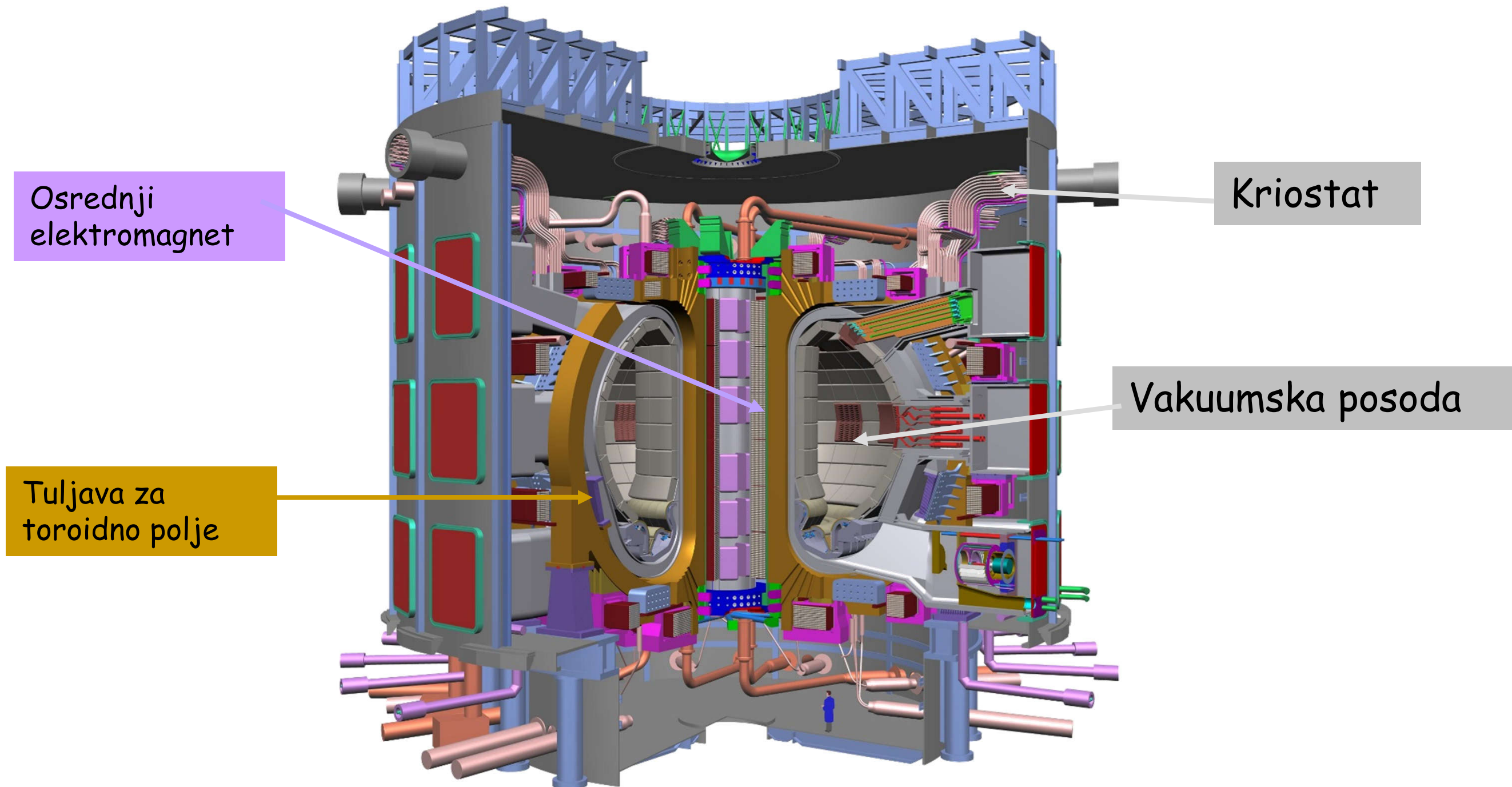
Fuzijski reaktor - tokamak



Segrevanje plazme

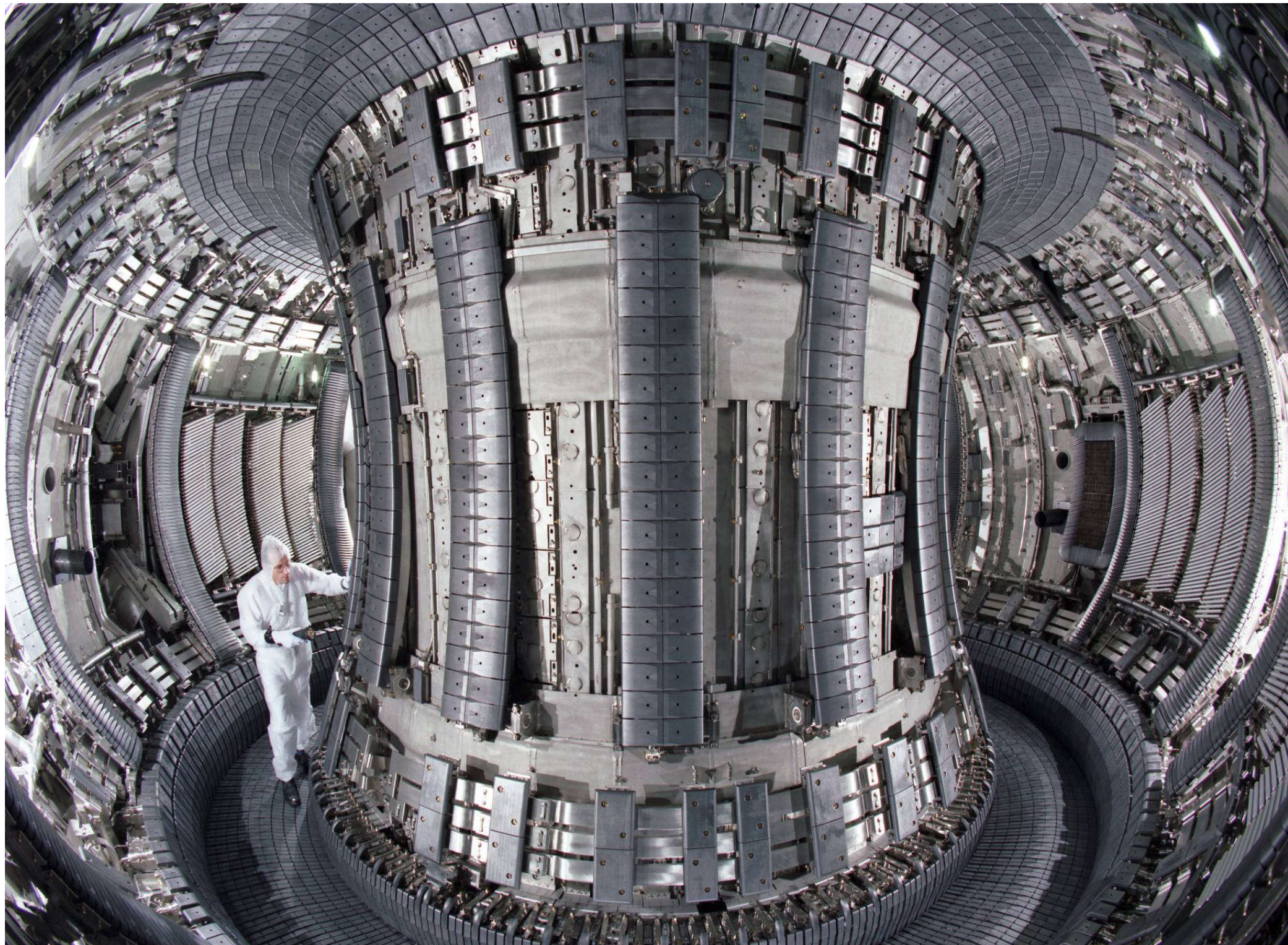


Fuzijski reaktor - tokamak

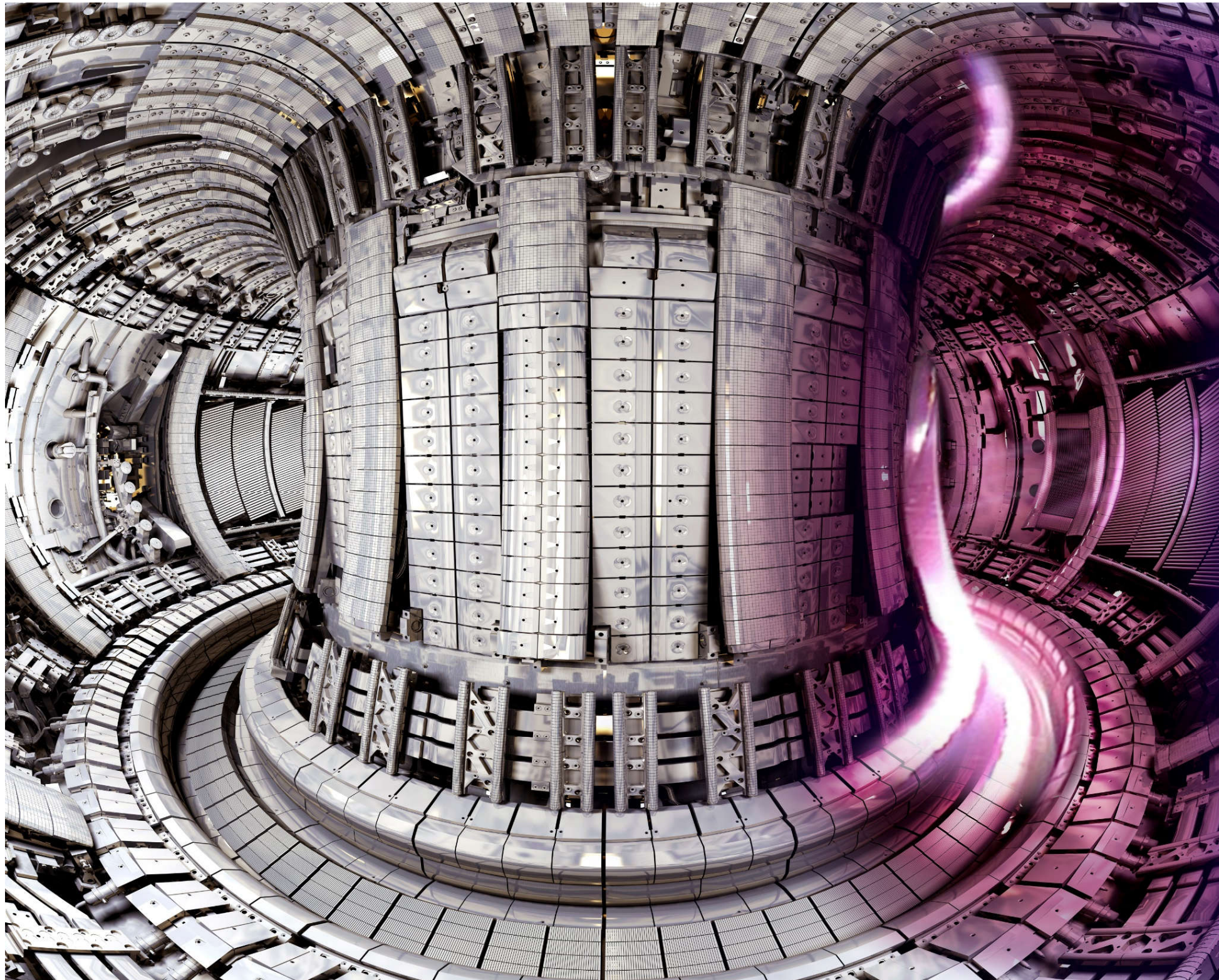


Superprevodni magneti so hlajeni na temperaturo 4 K (- 269 °C)

Joint European Torus – JET

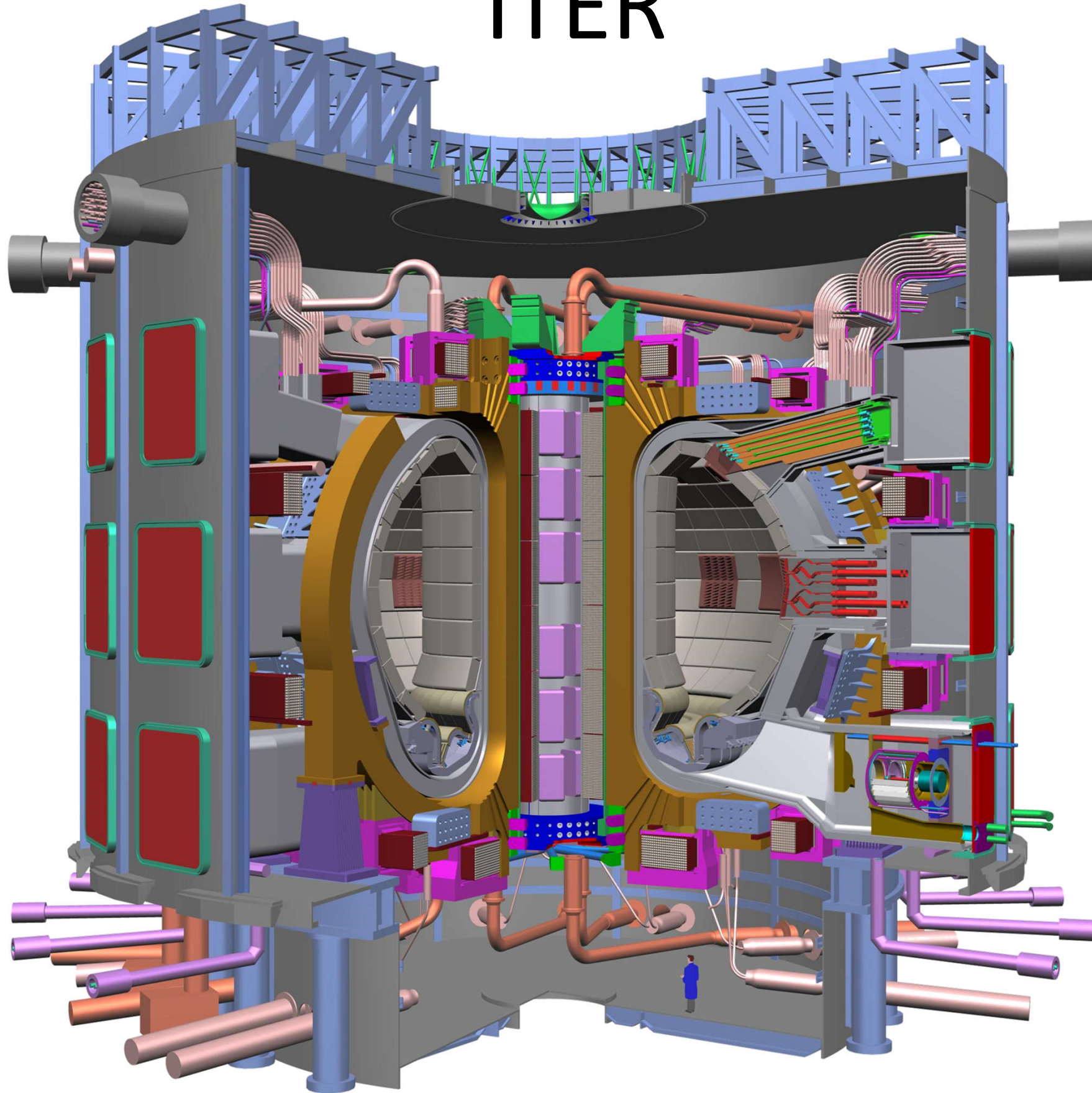
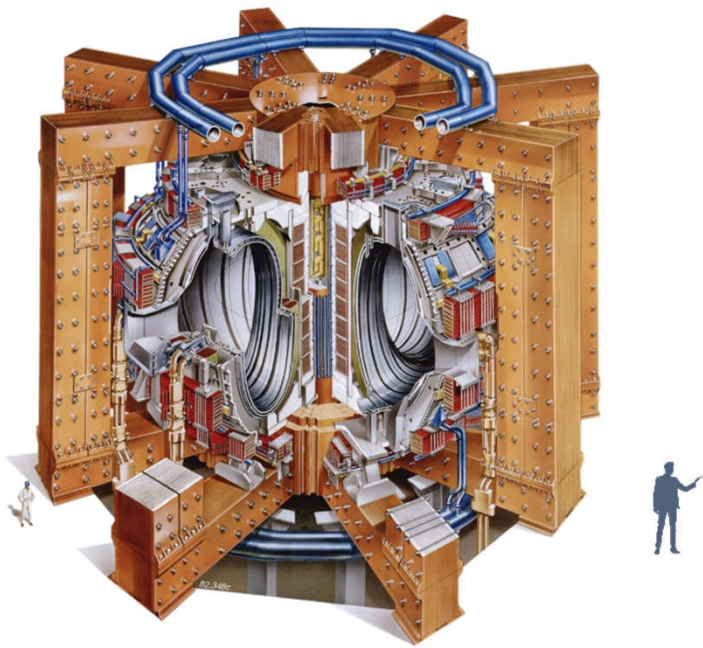


Joint European Torus – JET



ITER

JET – Joint European Torus

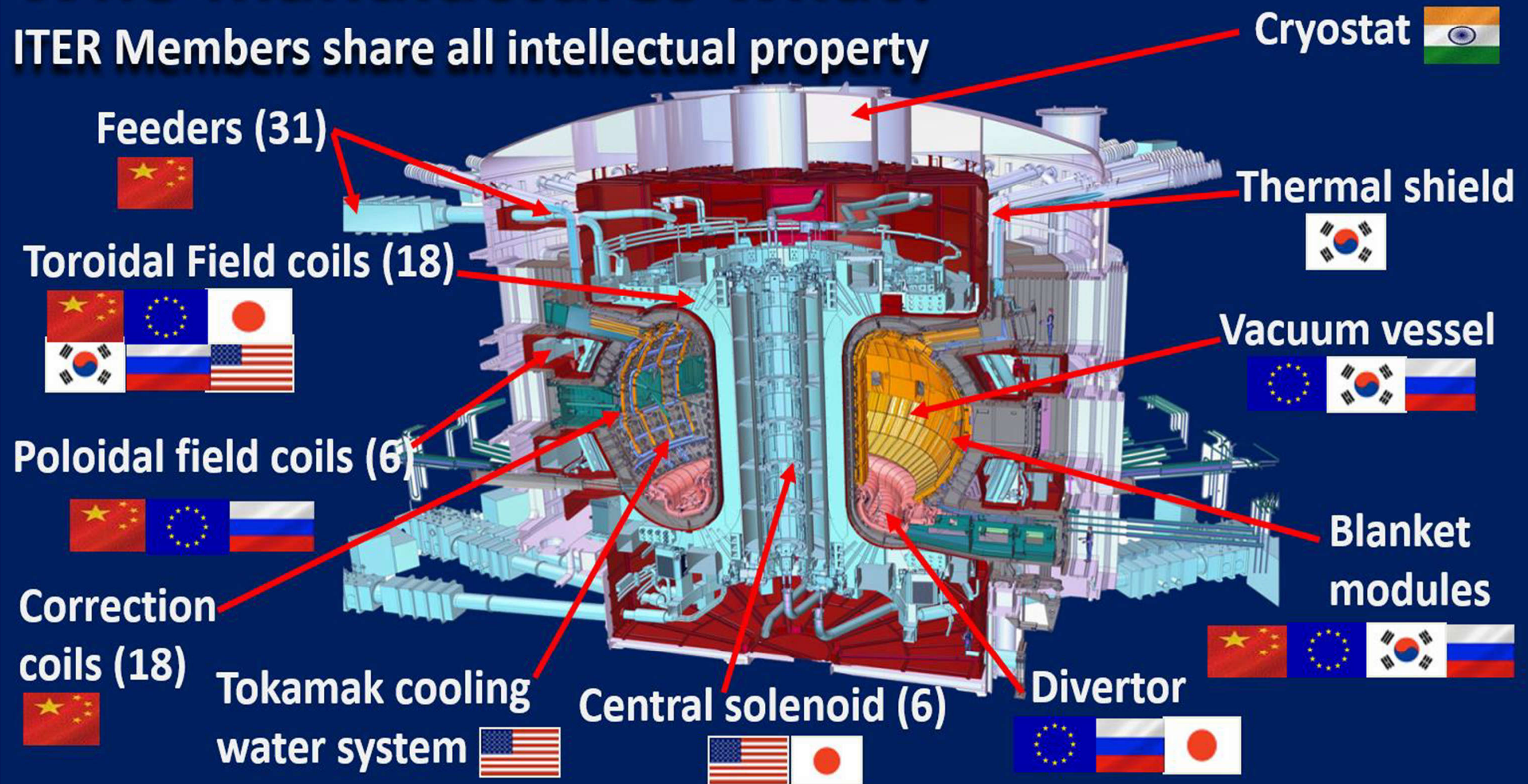


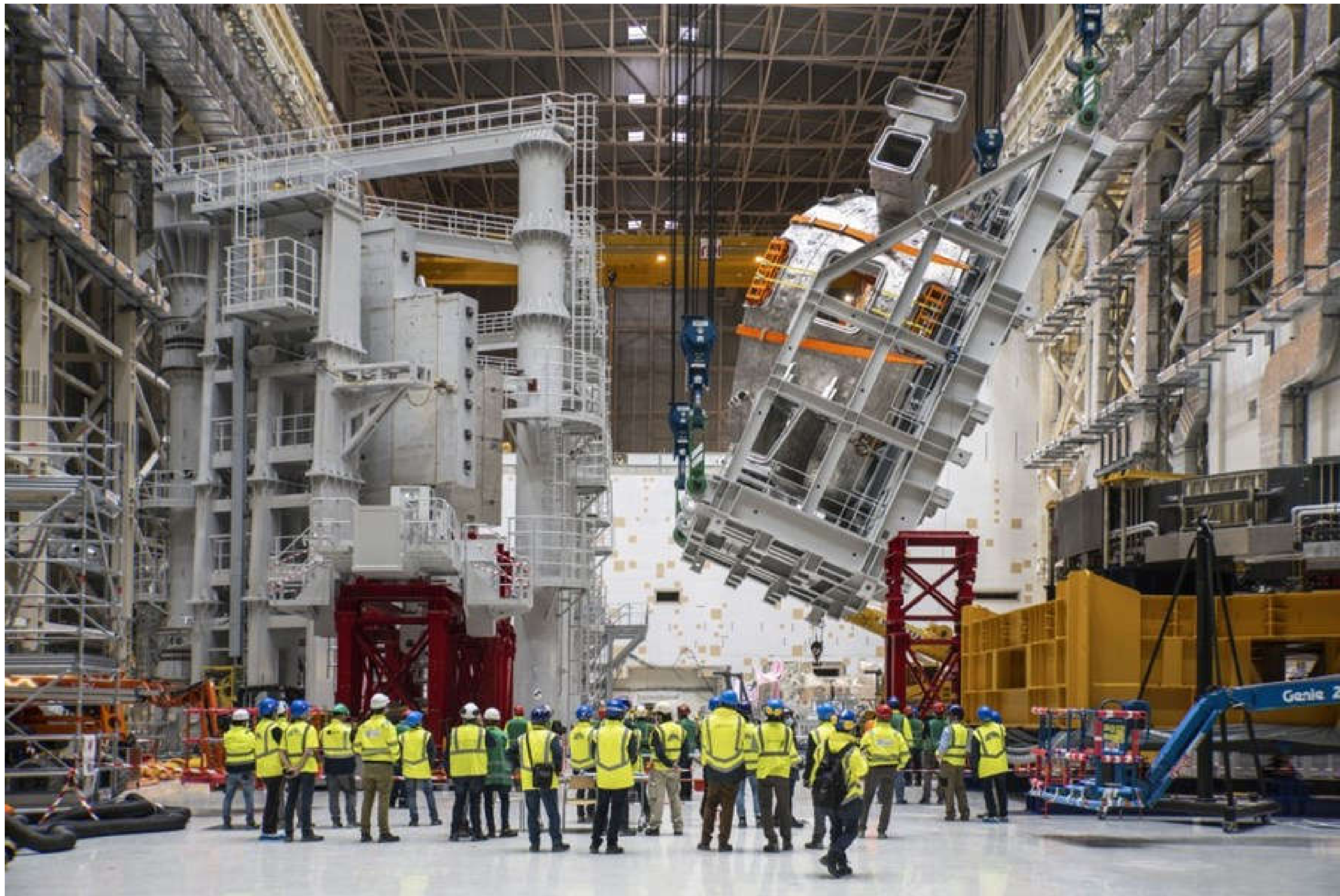
ITER



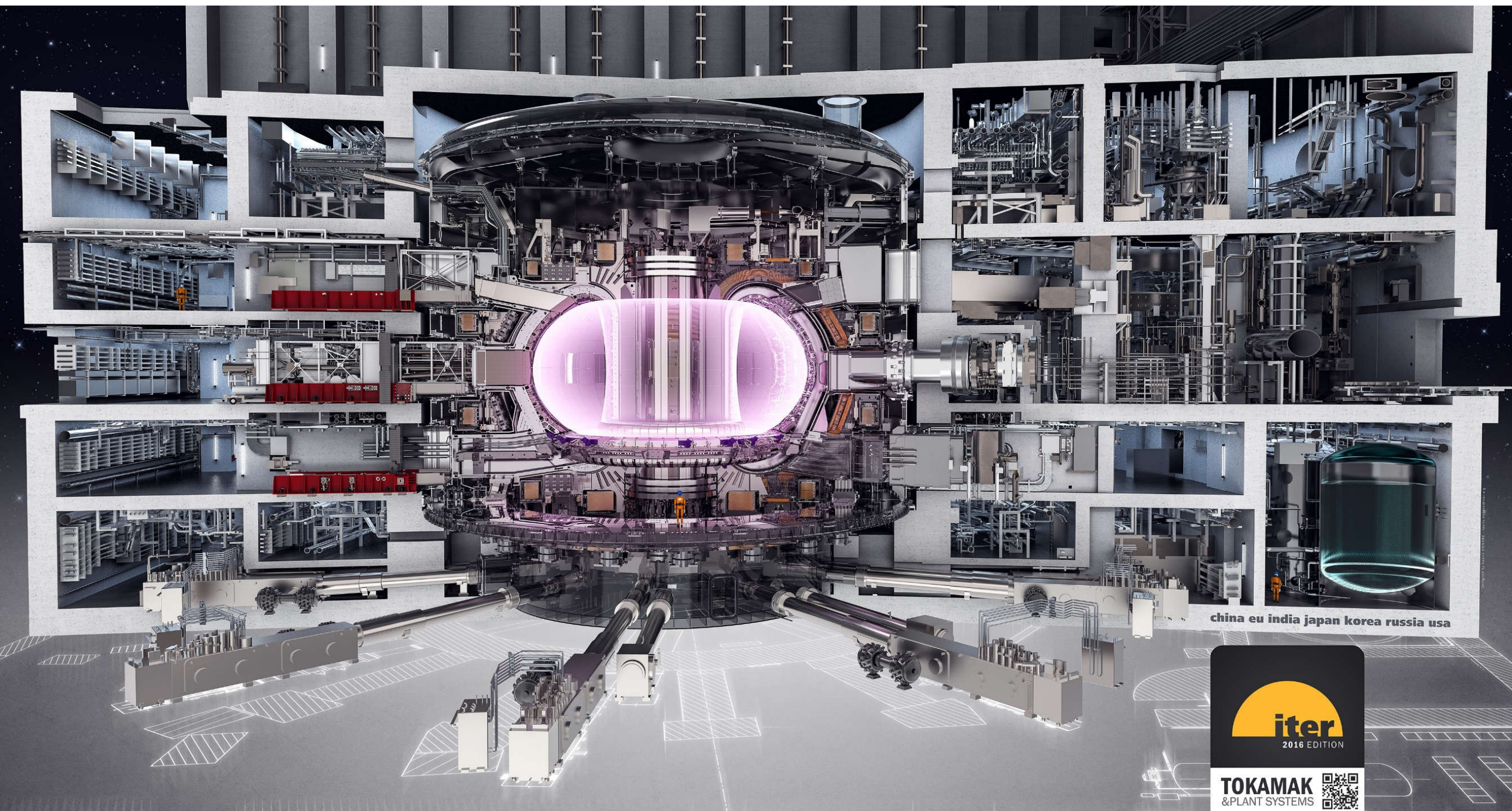
Who manufactures what?

ITER Members share all intellectual property

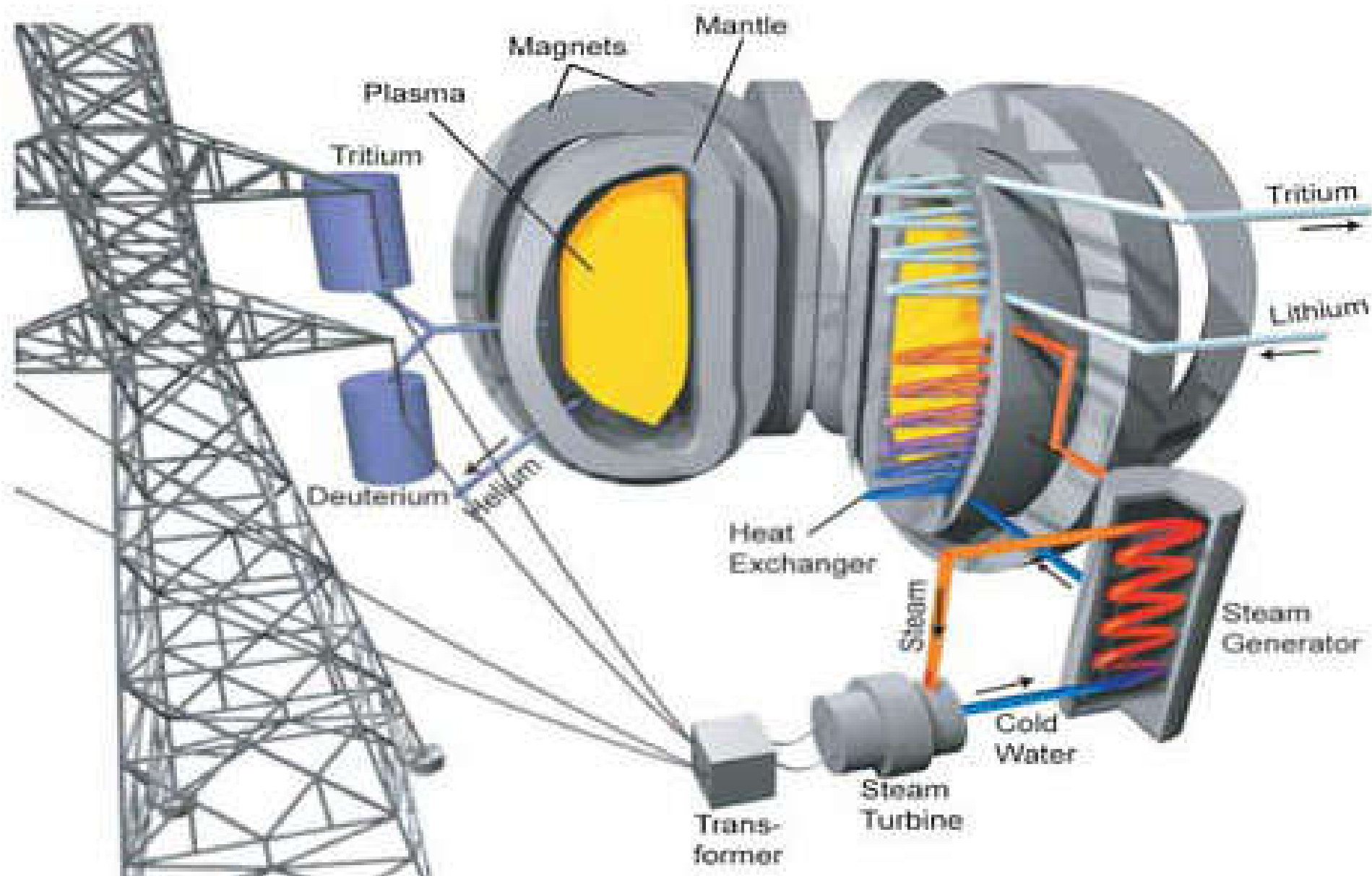




ITER

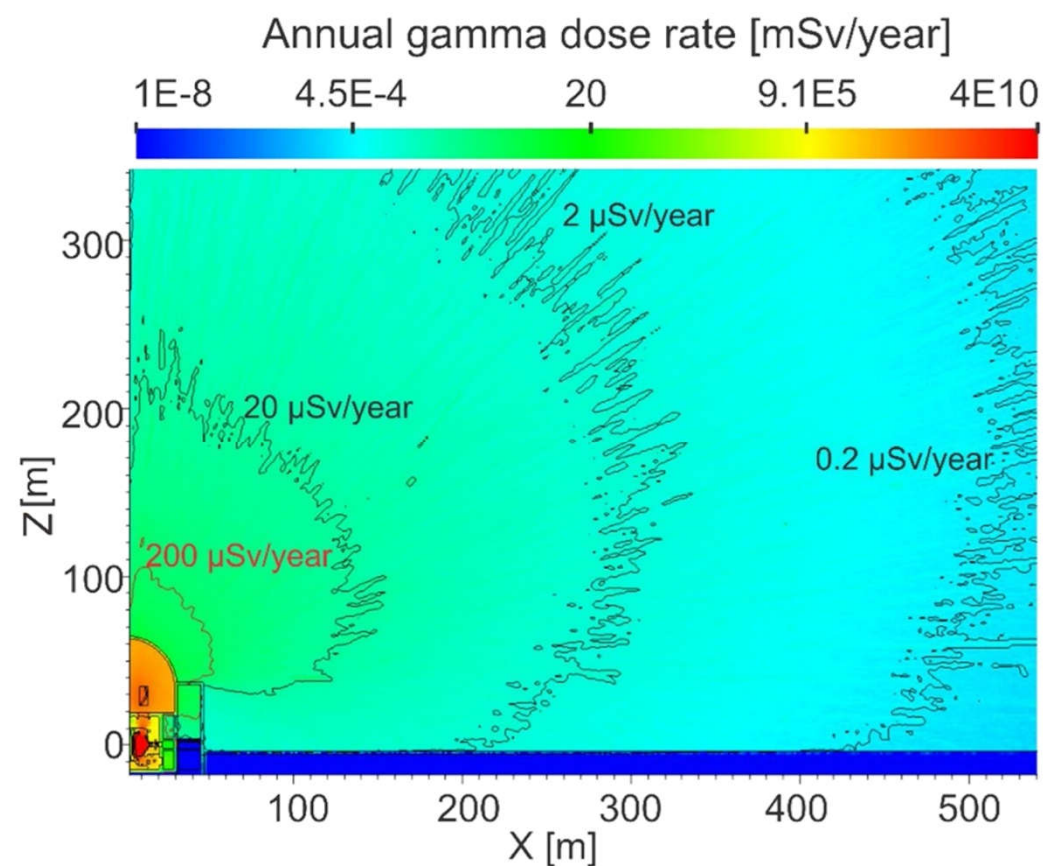
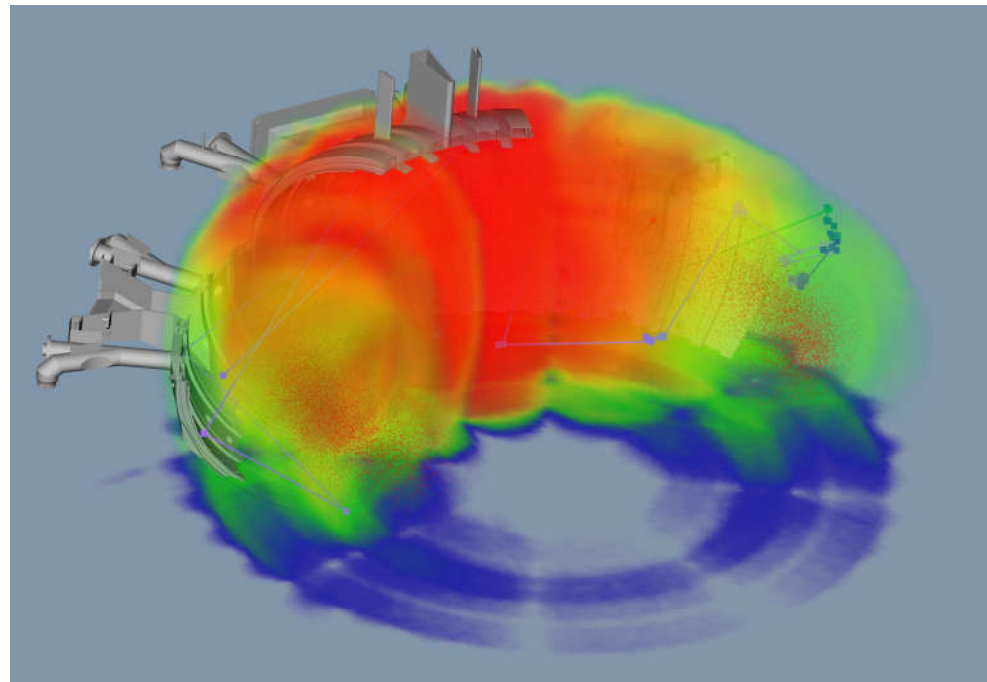


Fuzijska elektrarna



Načrtovana fuzijska elektrarna po letu 2050, DEMO
Na podlagi izkušenj, pridobljenih s projektom ITER

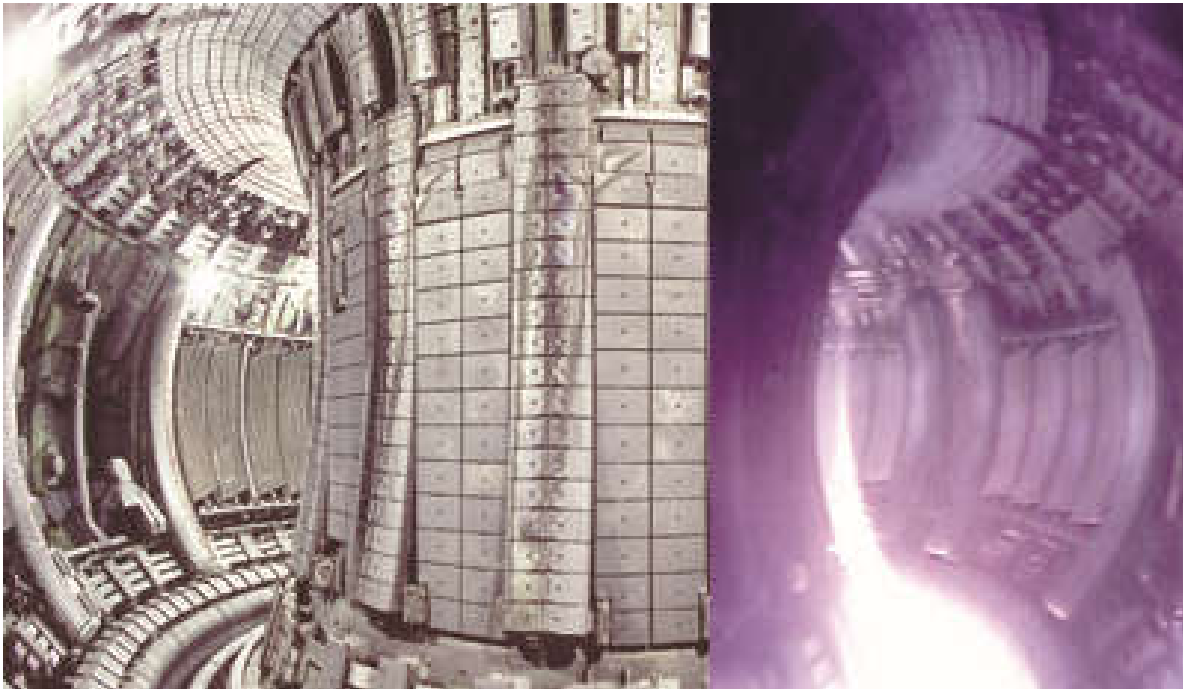
Sodelovanje slovenskih znanstvenikov



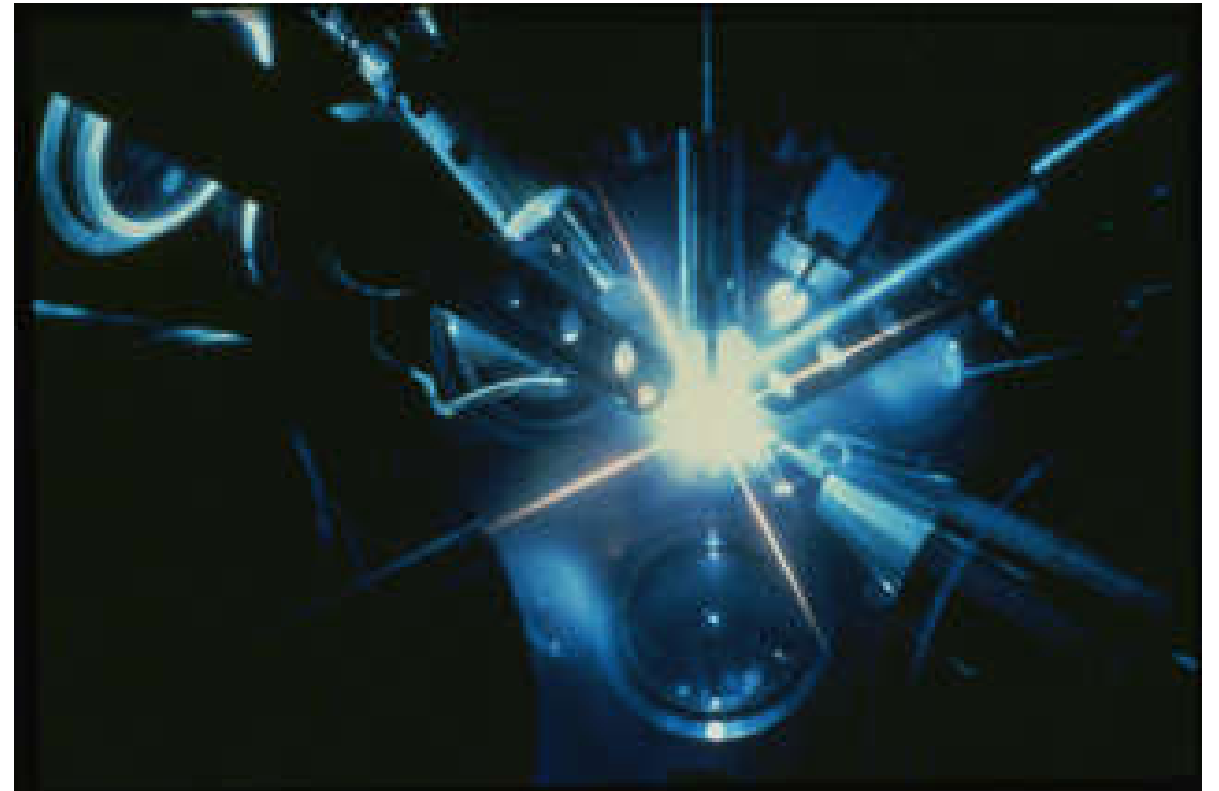
Dodatni slidei

Vrste fuzije

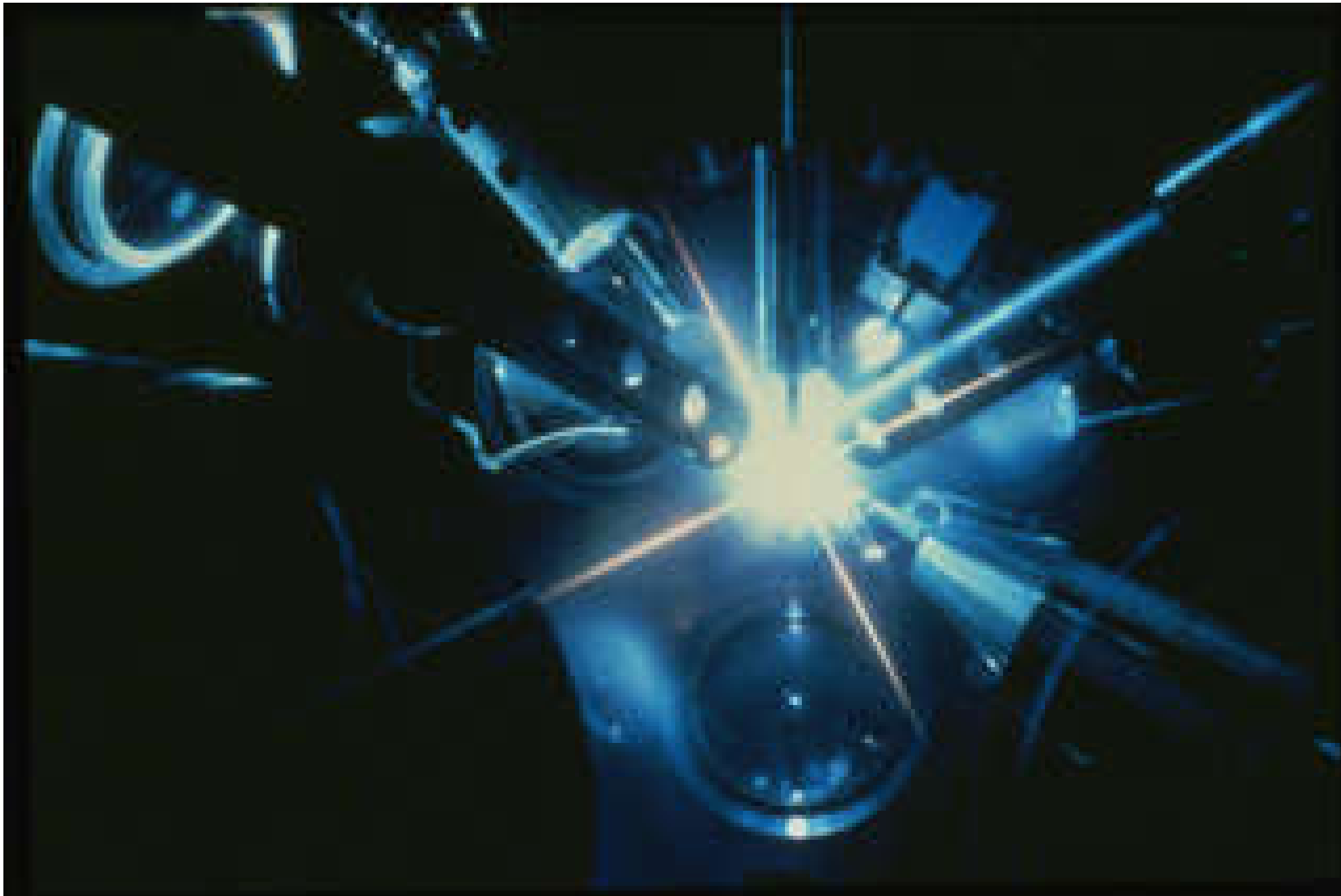
Fuzija z magnetnim zadrževanjem



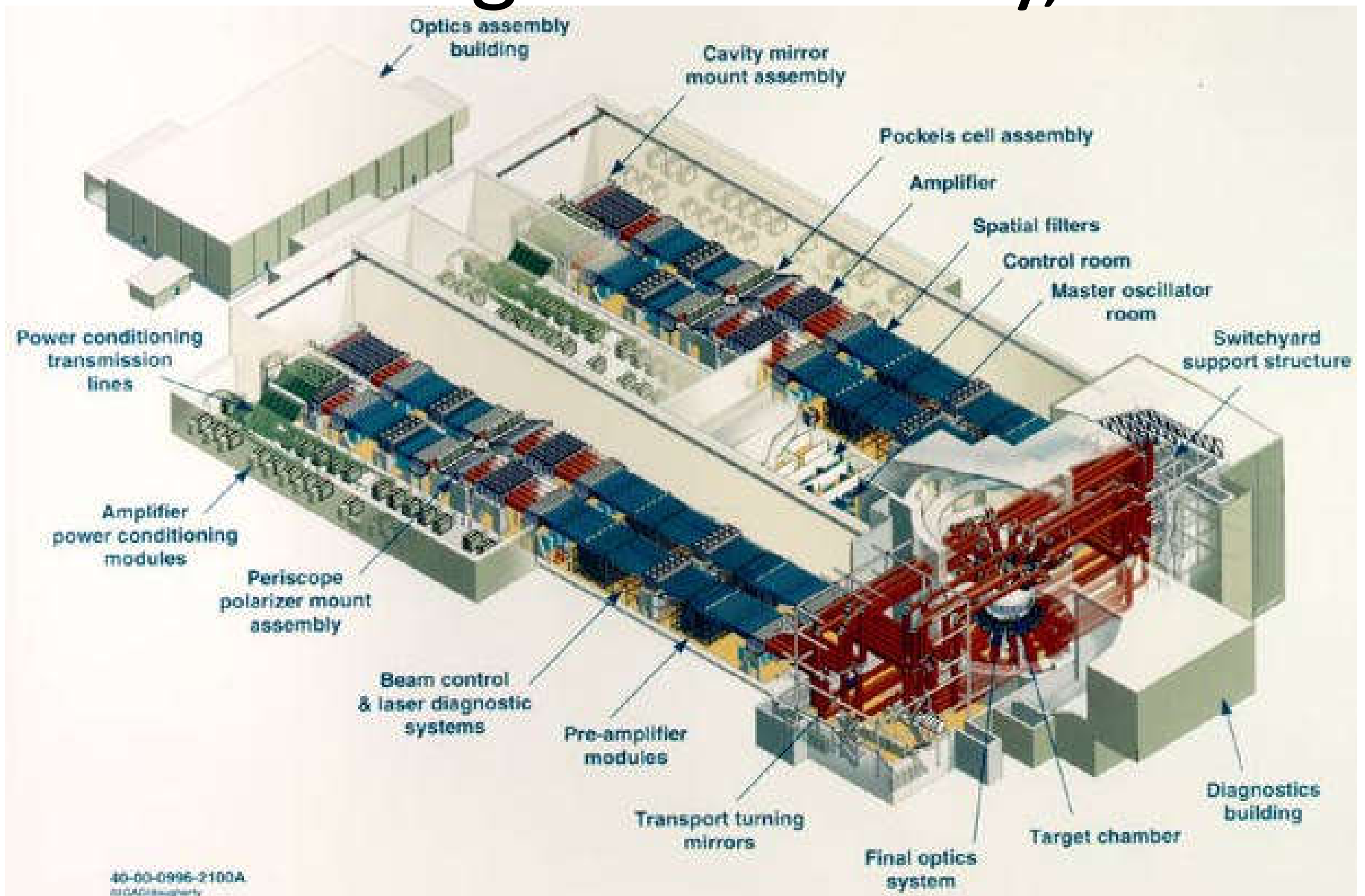
Fuzija z Laserji



Laserji – National Ignition Facility



National Ignition Facility, ZDA

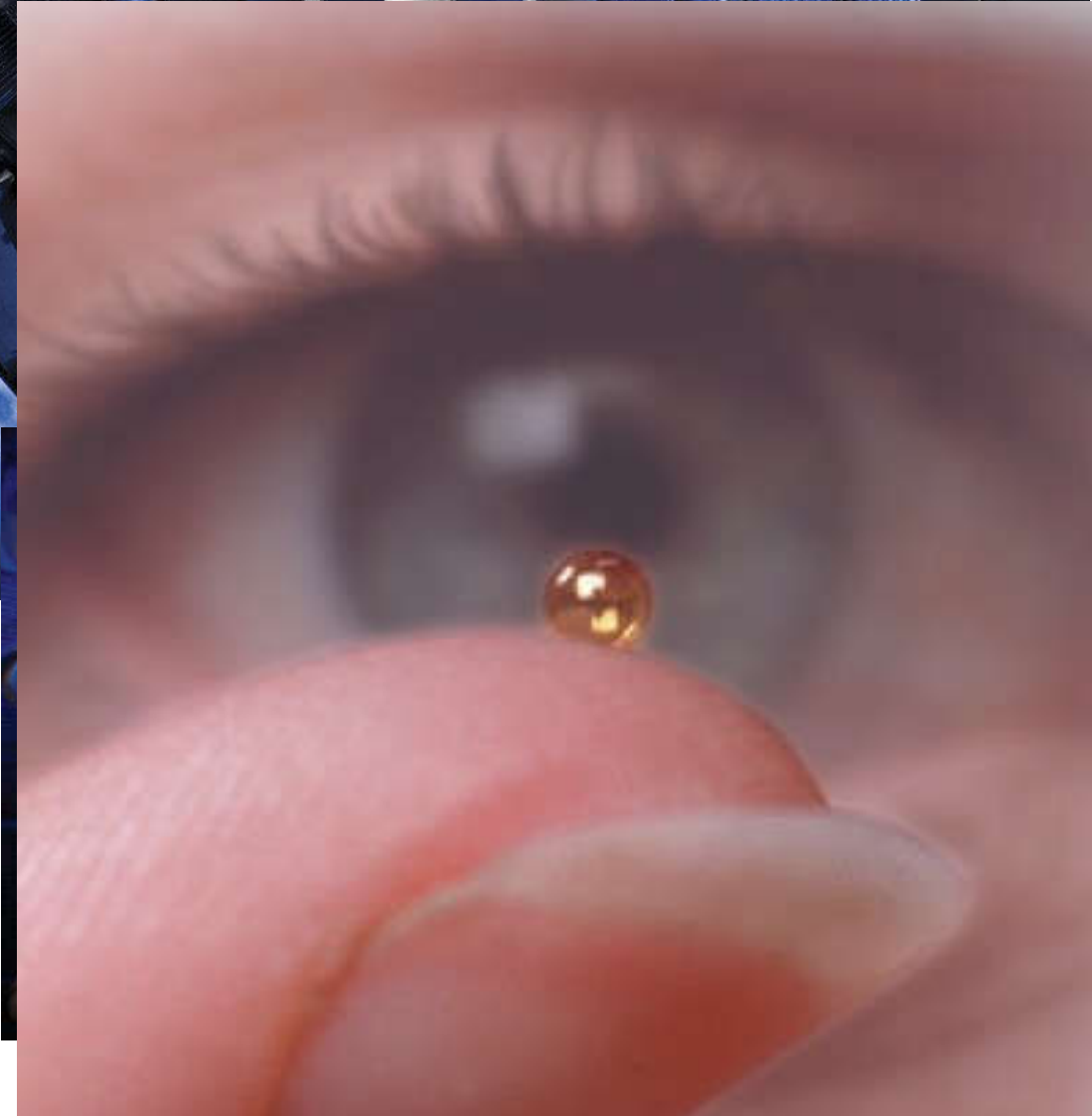
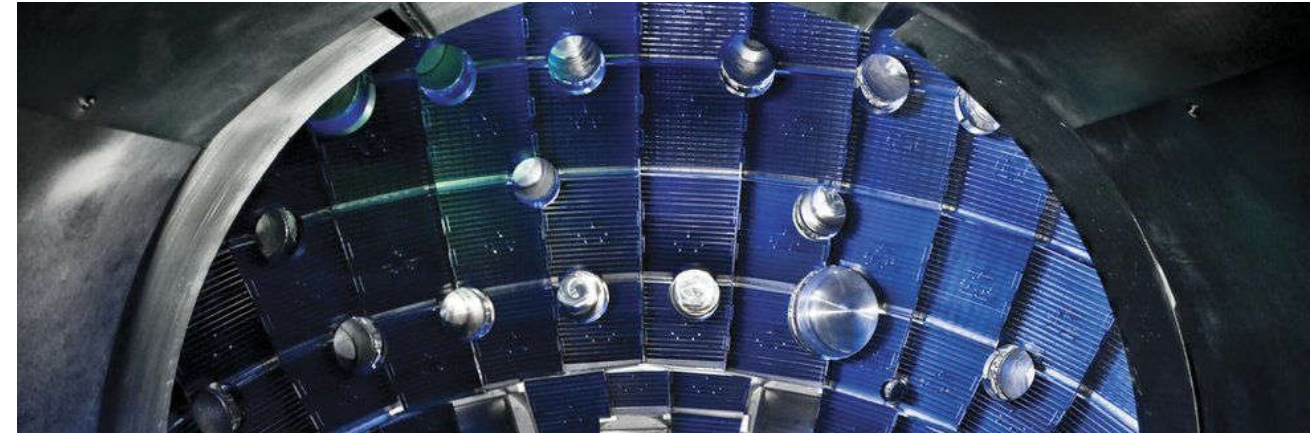


National Ignition Facility

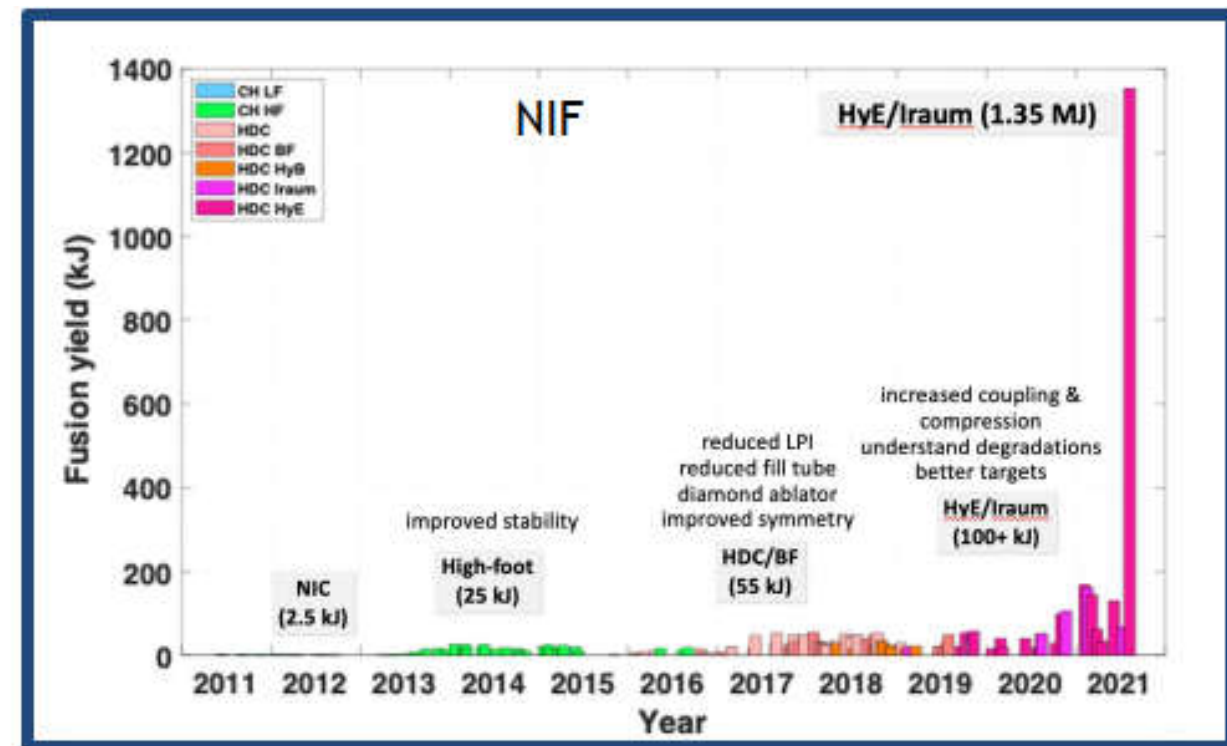
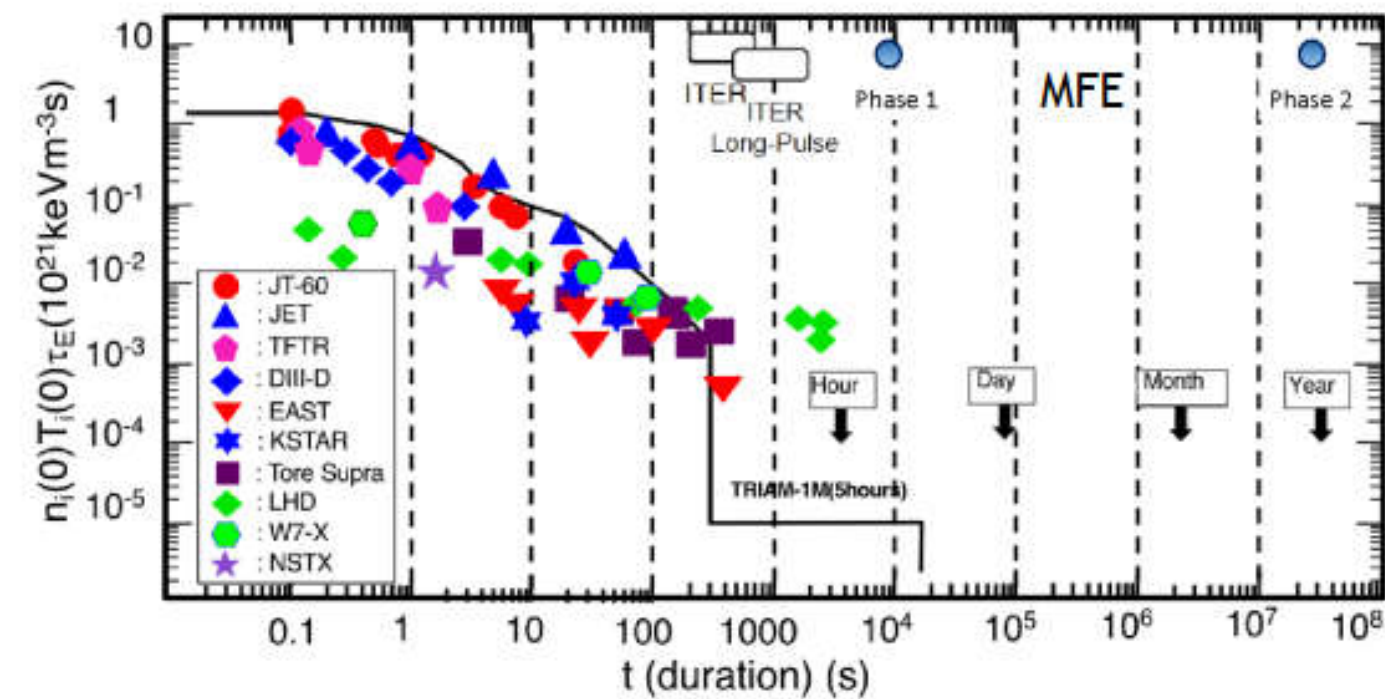
192 laserskih sistemov, energija
črpanja laserjev 422 MJ

1.8 MJ energija laserskih žarkov

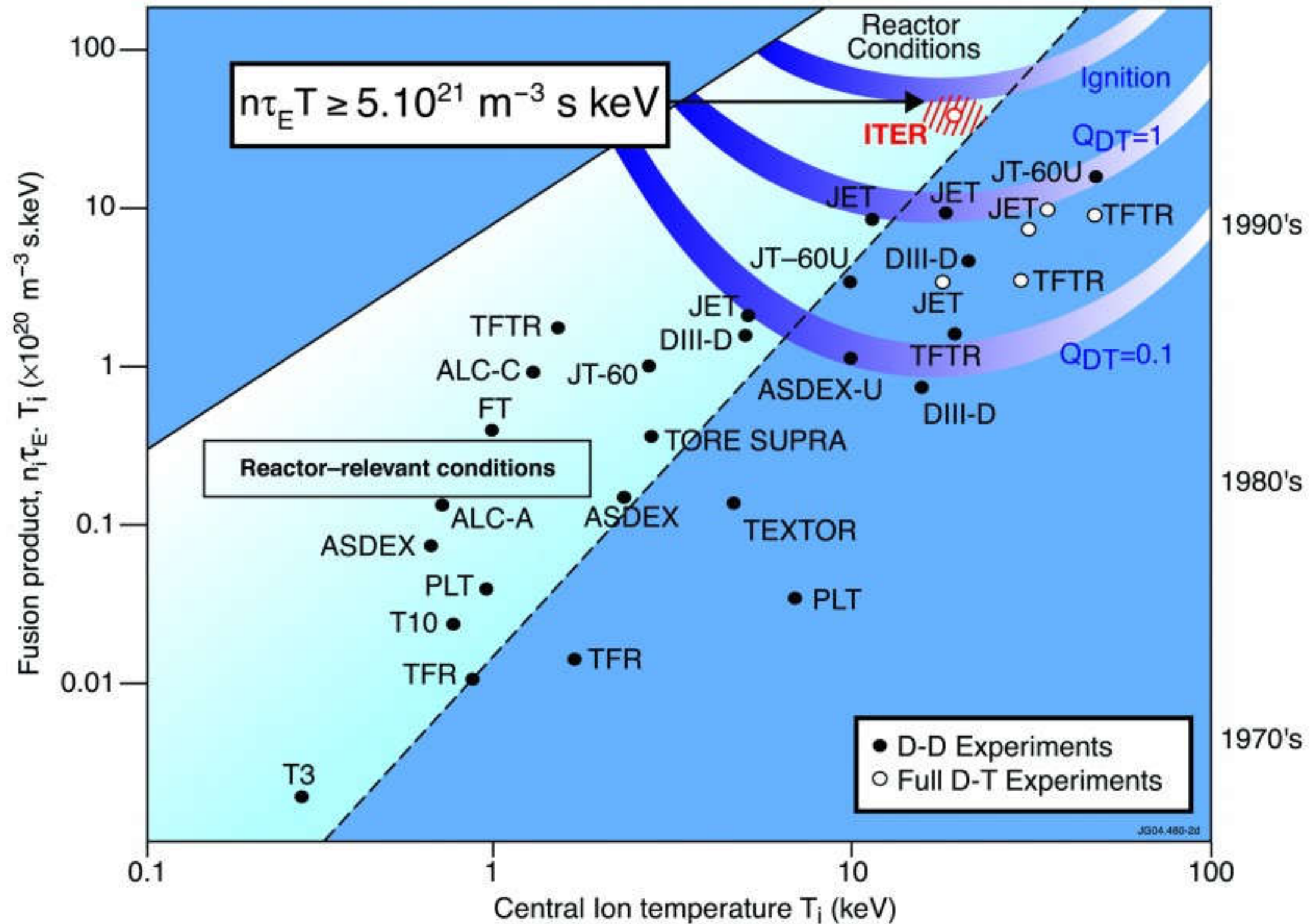
Rekordni pulz, sproščena fuzijska
energija 1.3 MJ (2021)



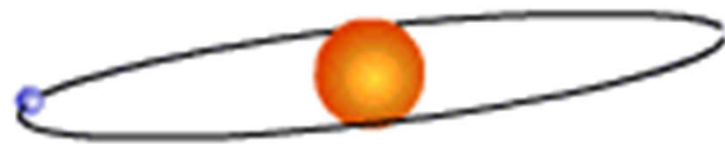
Title



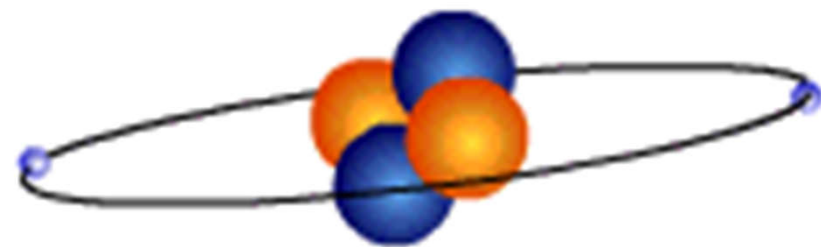
Fuzija - napredek



Atomi in izotopi

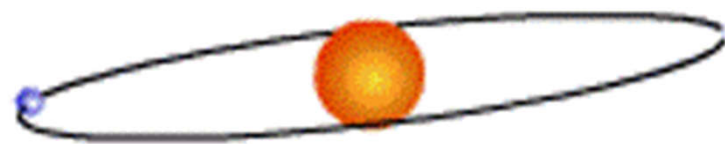


atom vodika

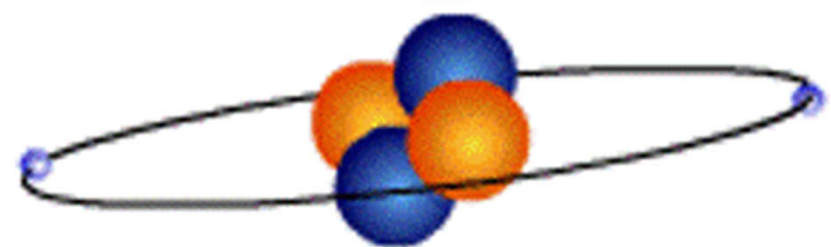


atom helija

Atomi in izotopi

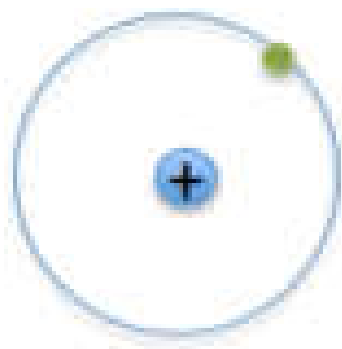


atom vodika

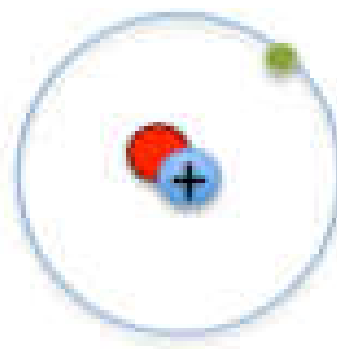


atom helija

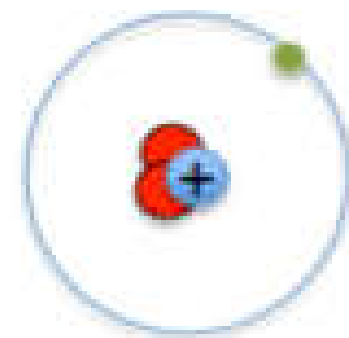
Trije izotopi vodika



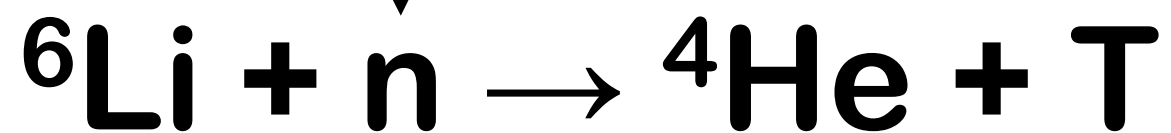
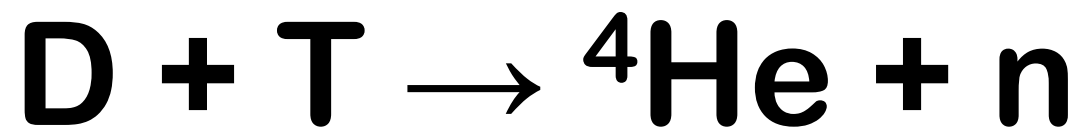
vodik



devterij

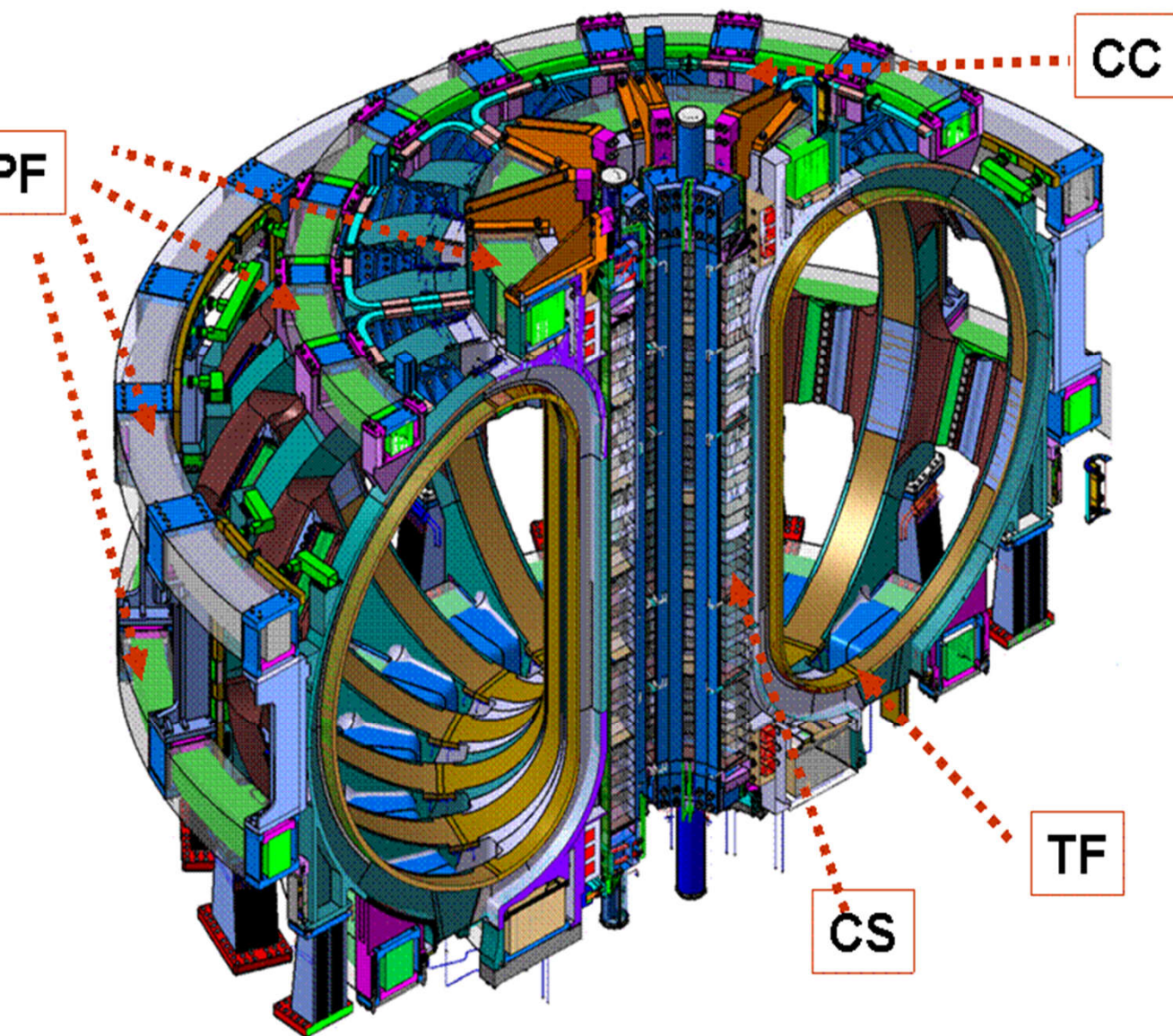


tritij



Devterij se v naravi nahaja v vodi (v 1000 l vode je 20 g D)
potrebujemo še 30 g T
(Tritij pridobivamo iz litija, ki je kovina in se nahaja v naravi)

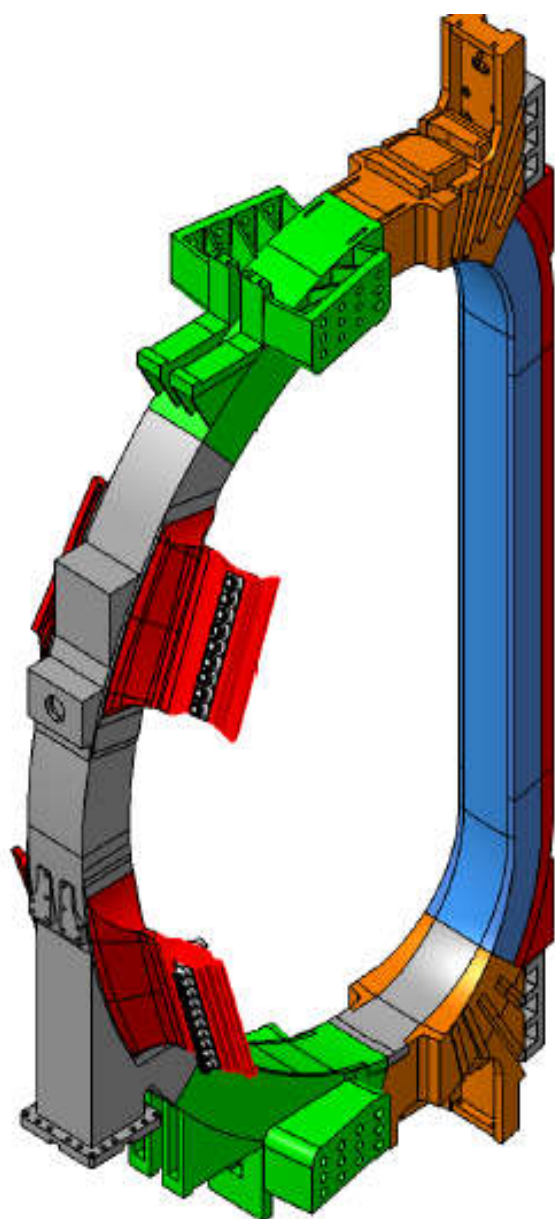
Gorivo za fuzijo je poceni in razširjeno po celem svetu, zaloge zadoščajo za tisočletja.



**Energija v
superprevodnih
magnetih:
~51 GJ**



USS Nimitz
(največja letalonosilka):
~100000 t pri ~ 115 km/h oz. 64 vozlov

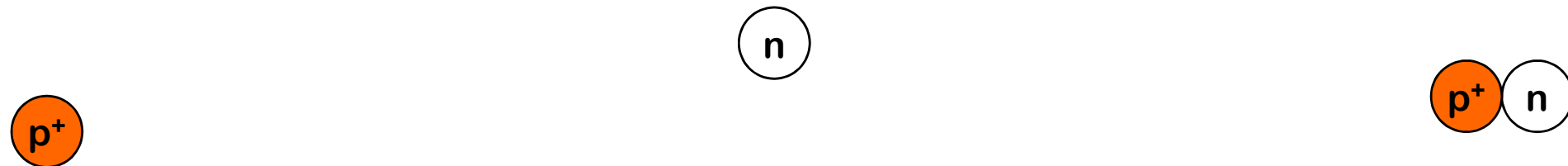


Masa ene tuljave:
 ~360 t
 16 m x 9 m

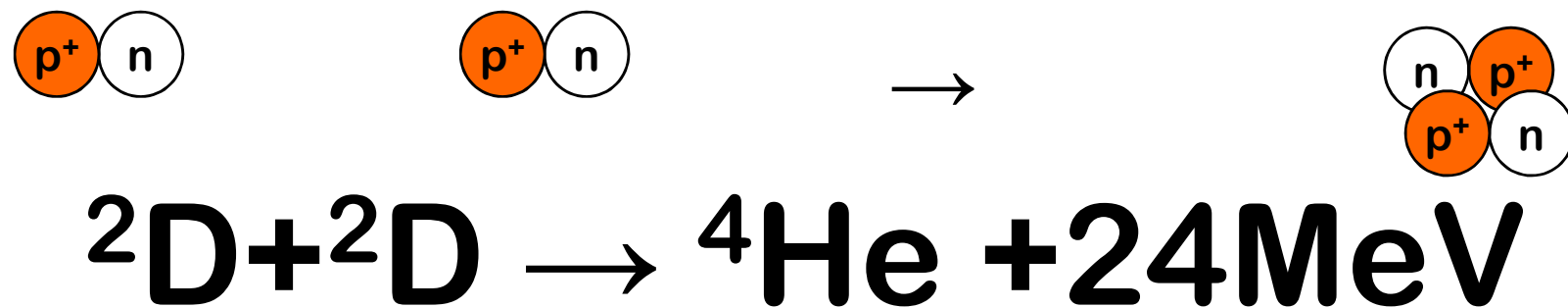


Boeing 747-300
 (največja vzletna masa)
 ~377 t

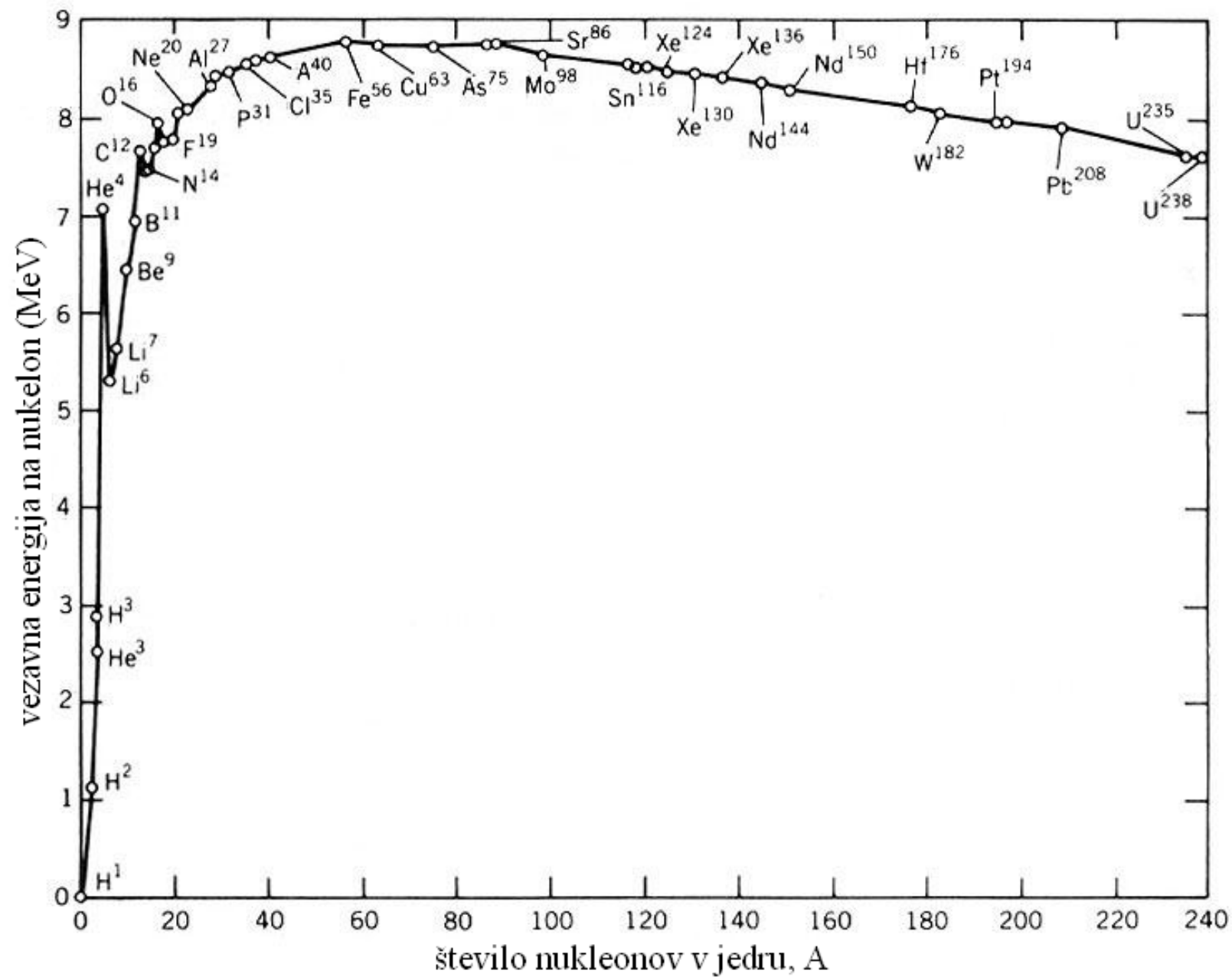
Vezavna energija



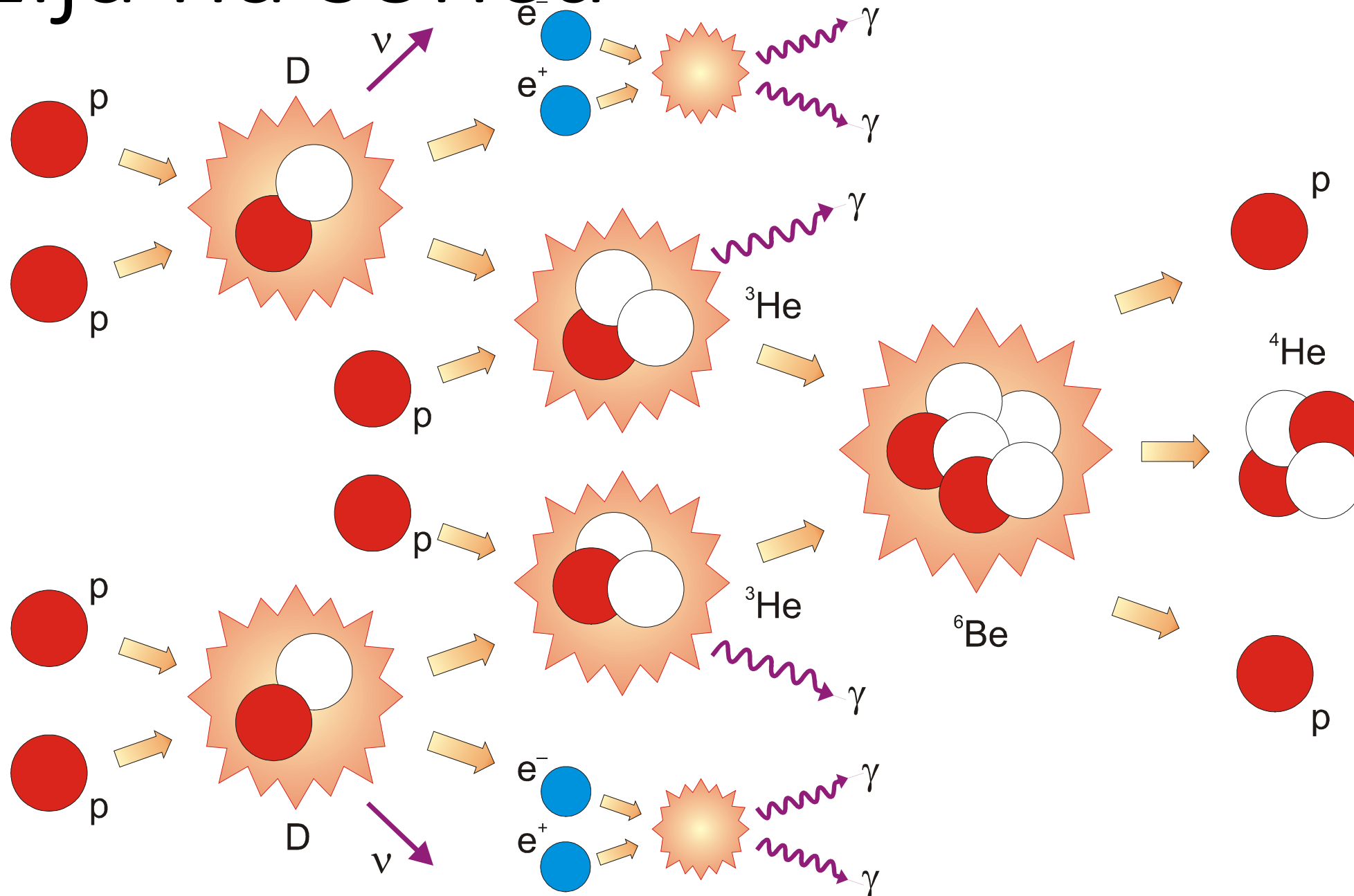
Vezavna energija devterona 2.2 MeV



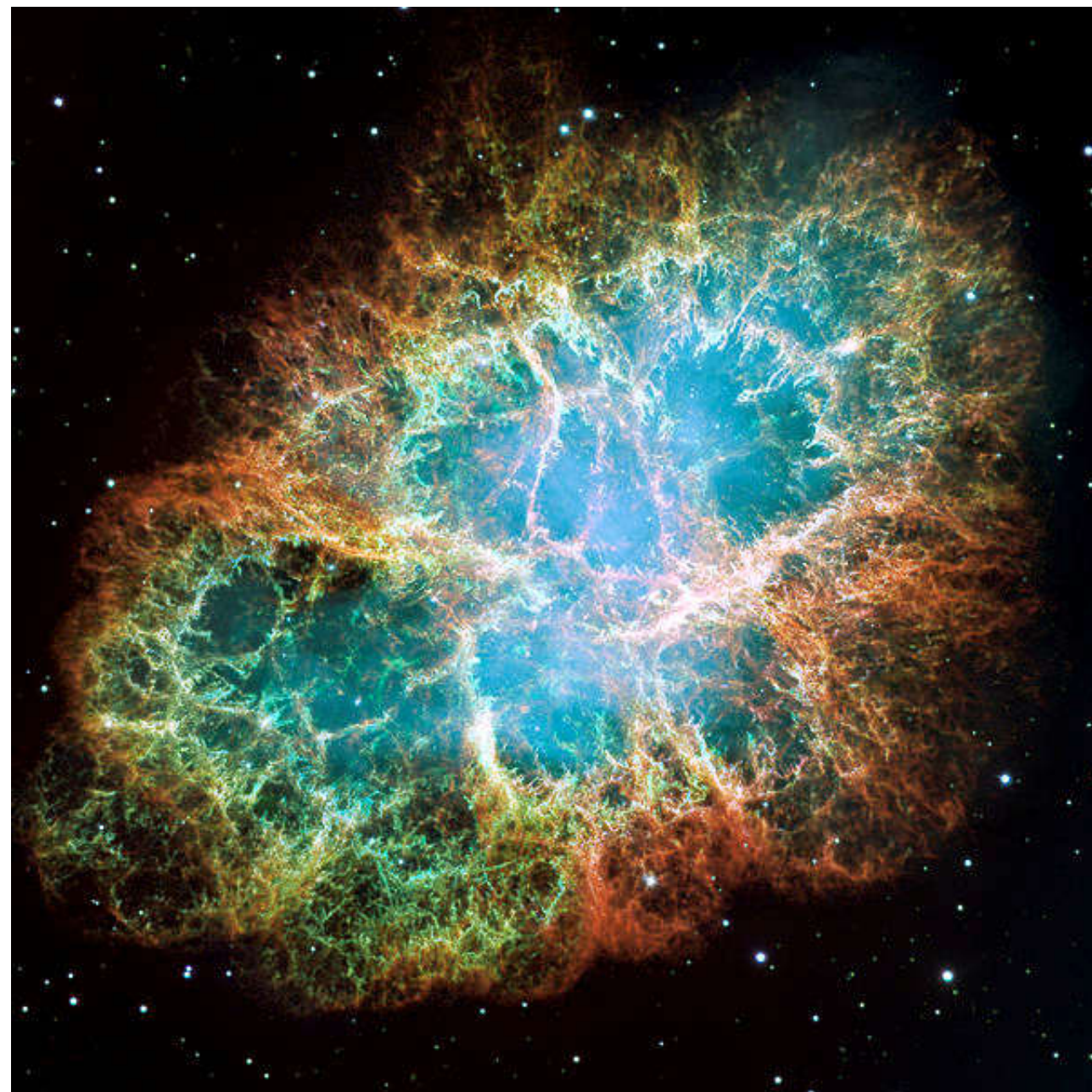
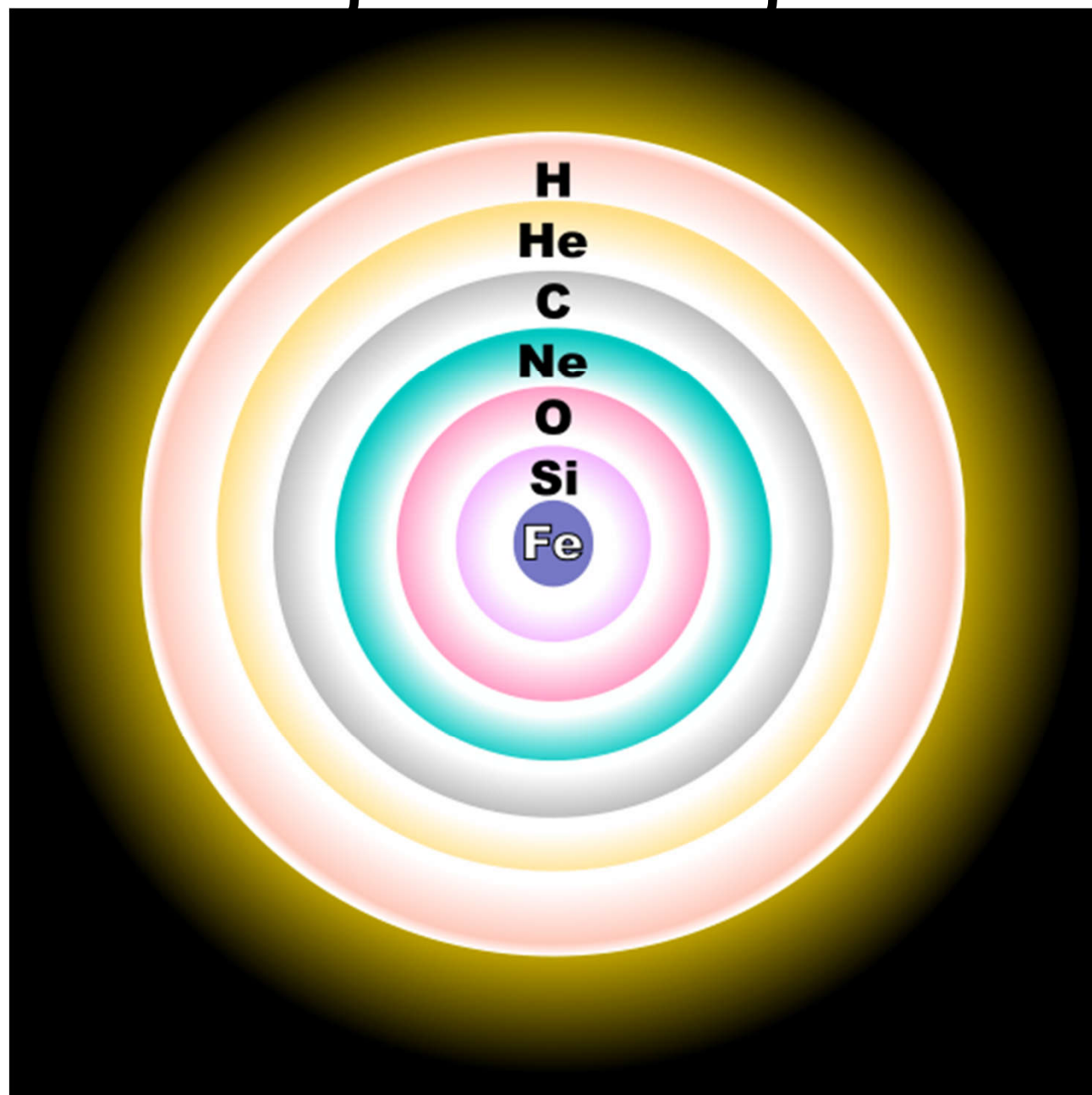
Vezavna energija jedra



Fuzija na soncu



Fuzija v težjih zvezdah



Viri energije za elektrarne

