Fusion devices as neutron sources for FFH (Fusion Fission Hybrid Reactors):Analysis of tokamak parameters , readiness level and design of concept validation experiments

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Main message

1.Plasma parameters of FFH neutron sources based on tokamaks can be obtained from a new derivation of the scaling laws for fusion reactors. The basic properties of tokamak neutron source useful for FFH and the TRL are then reviewed

2.The study of the FFH reactor based on the tokamak neutron sources are derived from point 1. A FFH model composed by a Tokamak source surrounded by a subcritical fission blanket and by a litium blanket, is carried out showing one of the main property: tritium production

3.The proof of principle of the FFH can be demonstrated using a DD or DT neutron source at low power and a fission reactor operated in sbbcritical mode. The scheme of validation of the FFH can be extrapolated from that already developed for the pre-TRADE experiments using the TRIGA fision reactor.

Tokamak neutron source plasma parameters

The scaling parameter linking equivalent fusion plasmas is:

SFR =scaling parameter for fusion reactors = $R\,B^{4/3}\,A^{-1}\,Q^{1/3}$

Q	2
R	1,5
A=R/a	2,5
B	8,5
Y (neutr/s)	7,60E+19
Pfus (MW)	200
a	0,6

Technology Readiness Level of tokamak fusion reactor subsystems

The technology readiness level of the various subsystems of a tokamak can be determined and

TRL≈4 can be given to the plasma heating systems and superconductor magnets ,

while only to the electron cyclotron resonance heating can be given TRL≈6 .

Validation of FFH reactor scheme

From the point of view of the validation of the concept, the coupling of a fusion device to a multiplying fission medium (FFH) can be seen as one very specific case of the coupling of an intense high energy neutron source to a fission system.

In the recent past the case of Accelerator Driven Systems (ADS) was considered, in particular in the frame of waste management strategies. In order to validate the concept, an experimental validation strategy was set up and several relatively large experiments were realized in a European frame.

Validation scheme

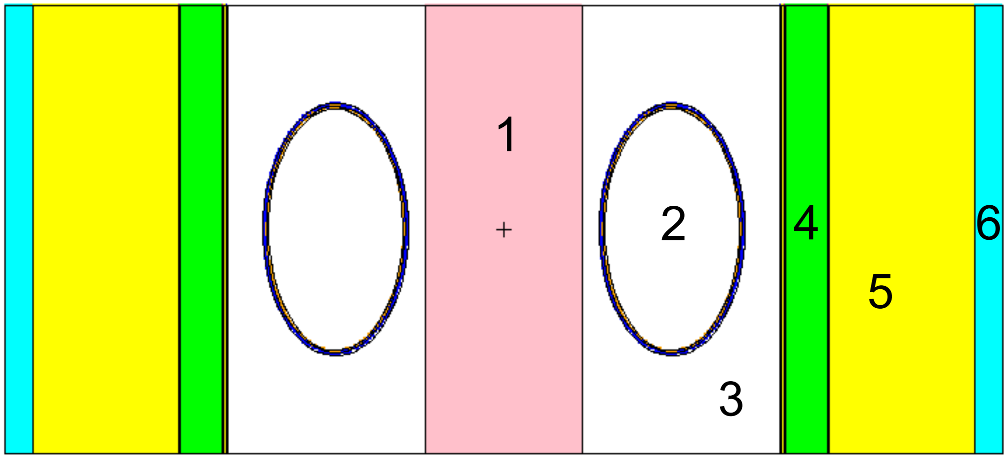
The same strategy of “validation by components” can be applied to FFH concept: apart from the realization of a fusion source , the validation concerns the subcritical region (with a “standard” fuel),

the eventual presence of buffer regions between the fusion source and the fission blanket, the presence of specific shielding zones.

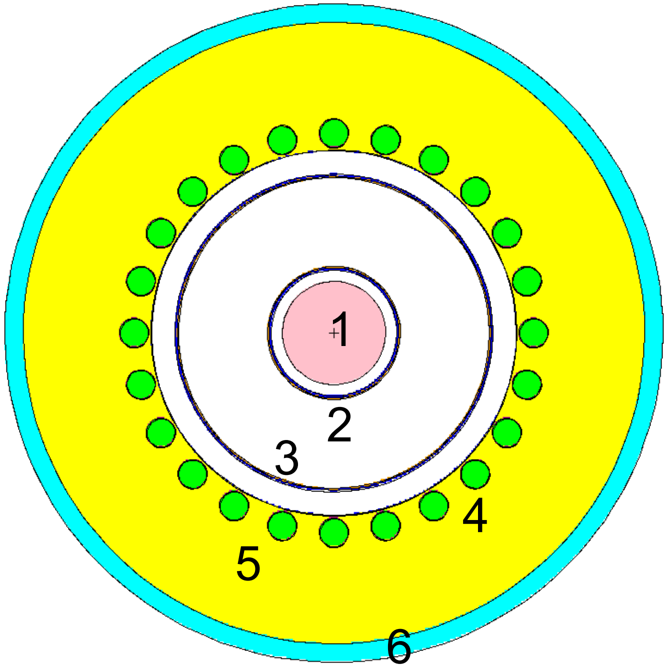
The experimental program should be devoted to

- the study of the sub criticality,
- of the power distributions, and
- of some significant transmutation rates of key isotopes.
- The experimental validation of the FFH concept will be carried out using a DT neutron source injecting 14MeV neutrons in the subcritical core of TRIGA RC-1 reactor.

MCNP model for FFH conceptual design:
tritium production evaluation in fusion blanket

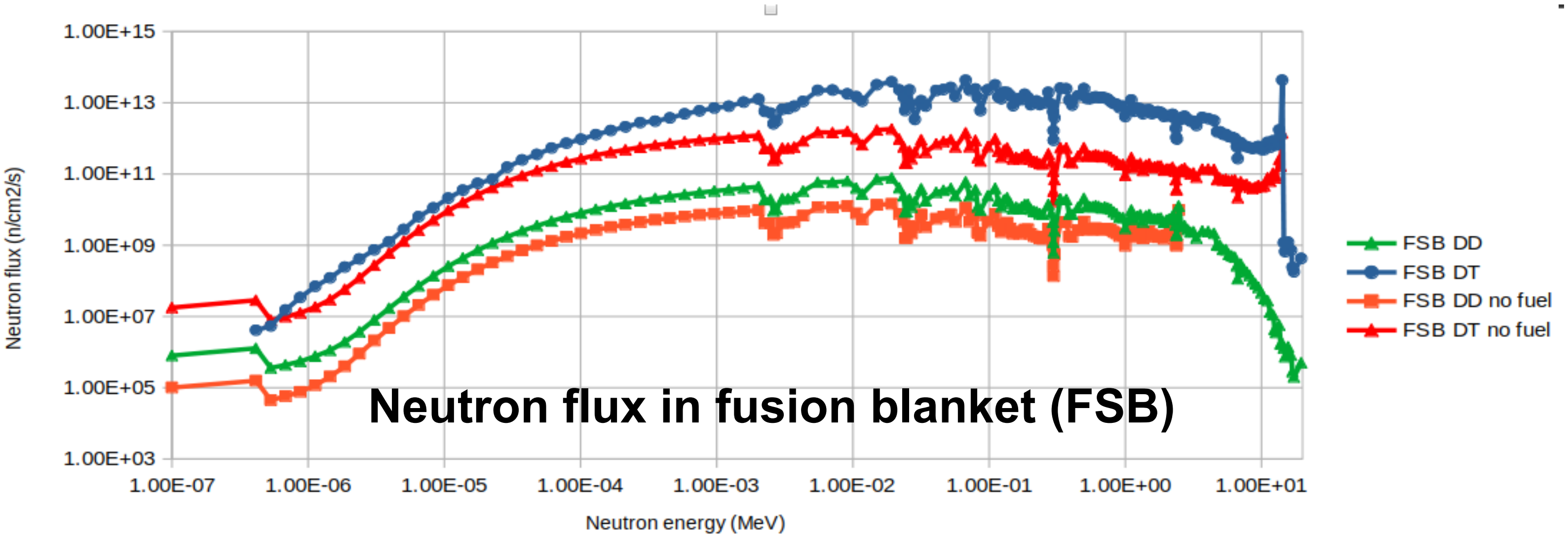


FFH's Model layout
1. Central solenoid
2. Plasma chamber
3. Torus first wall
4. Fuel
5. Fusion blanket
6. Reflector



Main Design parameters	
Fuel	Fresh MOX (Natural U + 5 at% 239Pu oxides, density 7.91 g/cm3) , 24 fuel rods (Height=400 cm, Radius=19 cm)
Coolant	Helium
Fusion breeder	γ lithium aluminate
Neutron yield (n/s)	7.60E+19 (DT) 7.60E+17 (DD)

MCNP model for FFH conceptual design:
neutronic parameters (k_{eff} = 0.96)



Neutron flux in fusion blanket (FSB)

The tritium yielding rate estimation, calculated according to the following relation

$$\frac{dR}{dt} = \int \Phi(E)\sigma(E)dE,$$

$\frac{dR}{dt}$ =Tritium yield;

$\Phi(E)$ = Neutron spectrum;

$\sigma(E)$ = ^{6}Li(n,α)T cross- section;

shows a factor 4.33 and 5.66 gains for tritium production in DD and DT mode, respectively, using the fuel rods.