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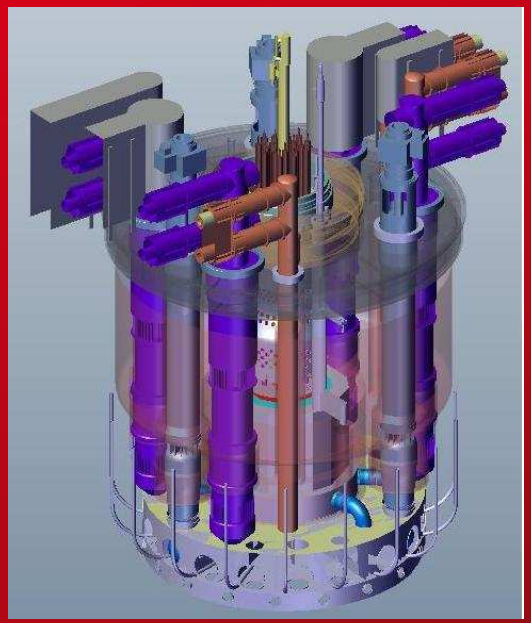

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ESNII

European Sustainable Nuclear Industrial Initiative

SFR R&D Needs:

Topic 1: Core and Fuel

BRUSSELS, MARCH 18th, 2015

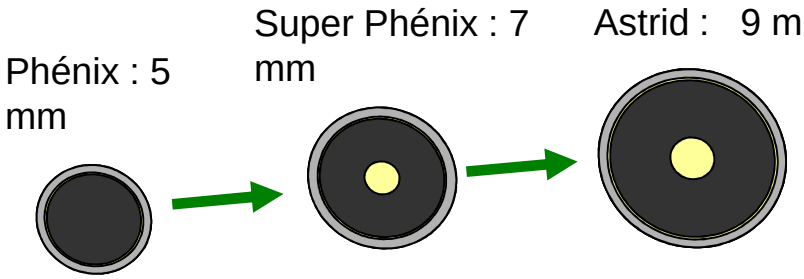
Main priorities for ASTRID Topic 1

1. **Validation of the simulation tools for the core :**
   - **Neutronics**
   - **Fuel behavior**
   - **Core mechanics**
   - **Thermal-hydraulics**
   - **Severe accidents**

2. **Measurement techniques :**
   - **Irradiated fuels**
   - **Irradiated materials**

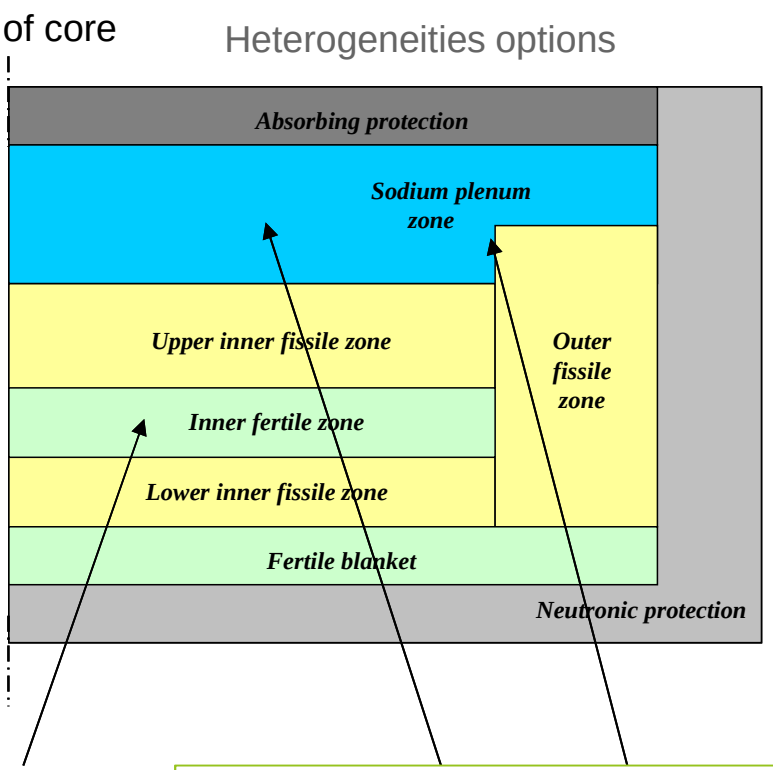
3. **Irradiation (analytical type) in MTR and post-irradiation examination**
   - **Fuel (U, Pu)O_2**
   - **Innovative absorbent materials**
   - **Protection materials**

Core design options for ASTRID



Larger pin :
- Increase of the fuel fraction
- Low reactivity loss during cycle
- ↘ of the Na fraction ⇒ lower Na voiding effect

➔Improvement on control rod withdrawal



CFV Core
(Coeur Faible Vidange): Sodium void worth strongly reduced
➔ Na void effect < 0

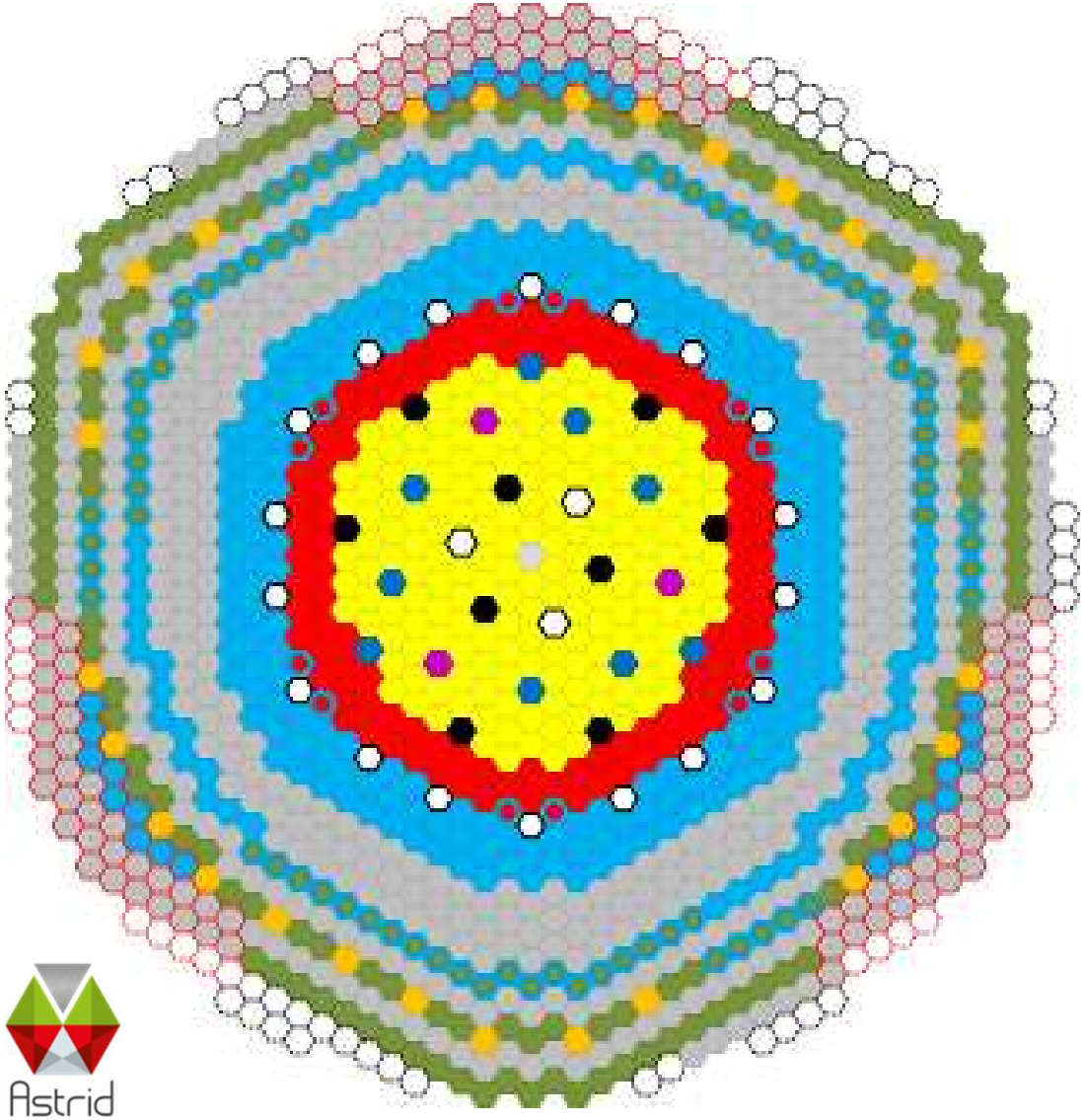
(Patent CEA EDF AREVA)

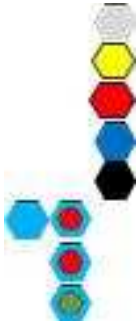
Internal fertile zone :
(heterogeneous fuel subassemblies) + asymmetric core geometry + reduced core height

➔ Increase of neutron leakages

Sodium plenum :
Neutron reflector in normal conditions
➔ Reduction of neutron reflection capability if Na temperature increases
➔ Increase of neutron leakage when Na boiling

The core CFV





1 Dummy S/A
180 Inner core fuel S/As
108 Outer core fuel S/As
9 RBC S/As
9 RBD S/As
344 MgO S/As
12 positions for fuel S/As
72 positions for internal storage

550 B_4C S/As
3 DCS-P-H S/As
21 DCS-M-TT S/As
144 Internal storage
28 Debugging positions
74 available positions
positions without sodium flow

Simulation tools for the core

- **Neutronics to design the core, to check the linear power criteria, the safety criteria, to determine the feedback coefficients …**
- **Fuel behavior to design the fuel element and the fuel sub-assemblies**
- **Core mechanics to design fuel sub-assemblies, to check the RAMSES criteria, to assess the core compactness**
- **Thermal-hydraulics to design the core ie. to optimize the flow distribution, to check the clad temperature criteria, to determine the hex-can temperature**
- **Severe accidents to simulate the core degradation scenarios, primary and secondary phases and corium relocation phenomena**

➔ Needs concern the validation of the tools :
- Benchmarks
- Comparison with reference tools
- Comparison with experimental measurements

Fuels and Materials

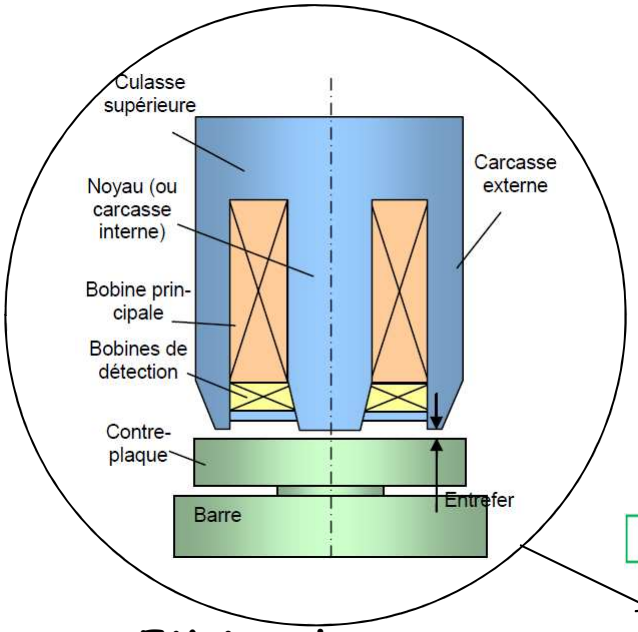
- Development of measurements **techniques** to obtain some measures on the properties of materials already irradiated “Trésor Phénix”:
  - Irradiated spent fuel: thermal and mechanical properties,
  - Irradiated B_4C : thermal properties and release/retention (helium, tritium).

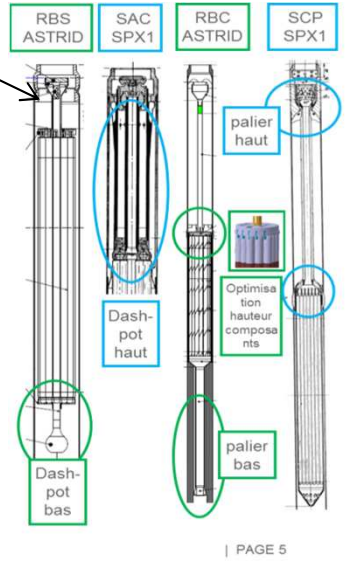
- Separate effect irradiations in MTR followed by post-irradiation examinations, in support of the simulation
  - Representative annular fuel $(U, Pu)O_2$, at the very beginning of irradiation, that could be manufactured in a European laboratory,
    - In support of the validation of the model of gap closure | fracturing, relocation of the fuel at the beginning of irradiation,
    - With reduced pellet-clad gap to support the validation of the simulation of the PCMI (Pellet Clad Mechanical Interaction) phenomenon,
  - Innovative absorbent materials to acquire, in particular, thermal properties at the irradiated state (HfB_2, TiB_2... compared to the B_4C in reference),
  - Shielding materials (boron steel), in order to know its evolution under irradiation, as well as those of its properties,
  - Behavior under irradiation of the constituents of the Electro-Magnet; measurement of magnetic properties on different materials of interest :
    - effect of temperature and Φ*t,
    - measurement on irradiated materials.

Electro-Magnet, key component of the diversified control rod

ASTRID need

- Analytical program on mechanical and **magnetic properties** of EM materials and components (iron, austenitic, …) and their evolution in reactor (effect of ageing, low irradiation, magnetic field)
  - Out of Pile test
  - Sample irradiation in MTR
  - Out of Pile test on irradiated materials
- Realization of a prototype, test in a sodium loop then in prototypic conditions (ie in a sodium cooled FR)





EM is a key component of the diversified control rod system = connection between the absorber rod (in core) and the mechanism (upper structure)