Synthesis

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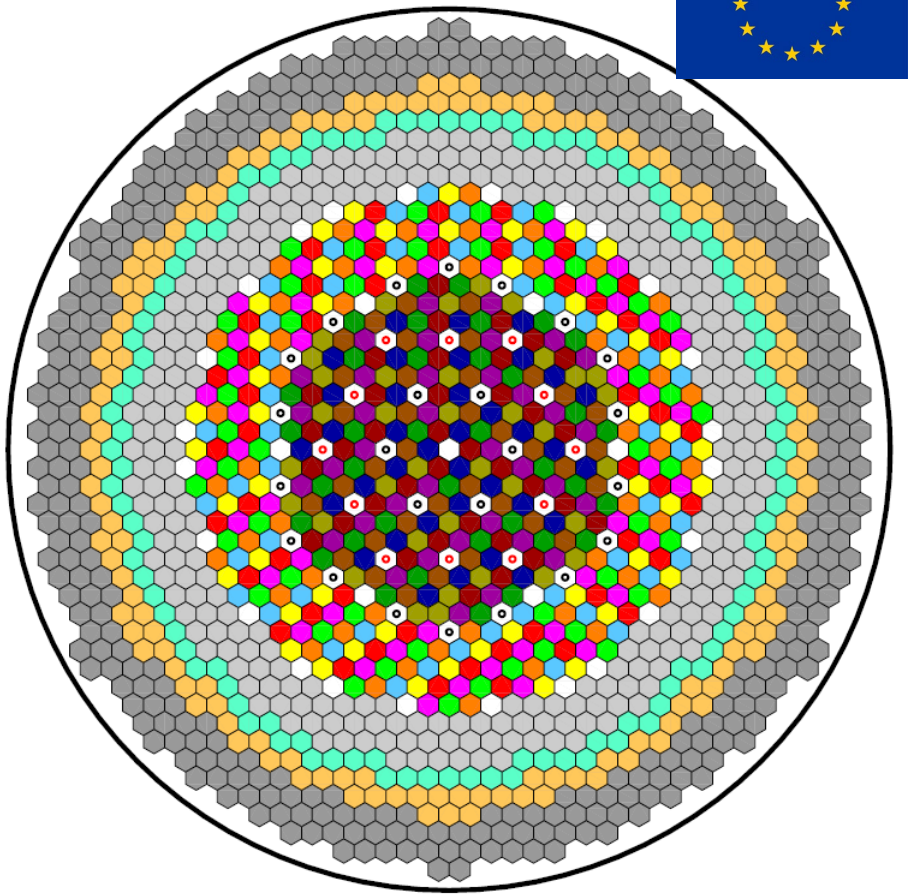
New core design: radial map

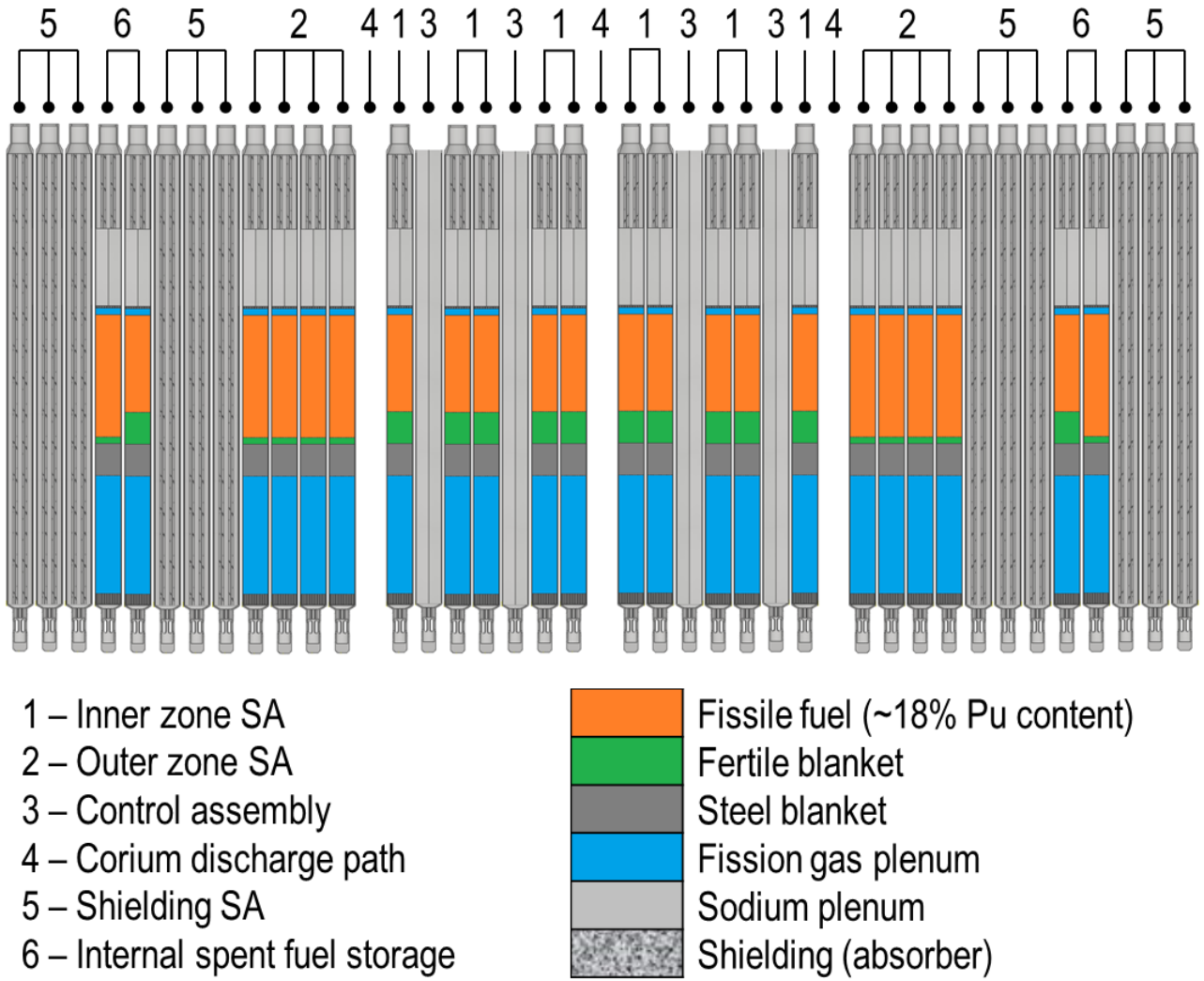
- Perfectly symmetric
- 6 batches = 6-year fuel cycle
- Mixed scheme (no reshuffling)
- Internal storage for 50% of core loading



1 2 3 4 5 6	Inner zone SA	6 batches×36 = 216
1 2 3 4 5 6	Outer zone SA	6 batches×48 = 288
	CSD / DSD	24 / 12
R1 R2 R3	Reflector rings	66 / 96 / 102
S1	Spent inner fuel storage	3 batches×36 = 108
S2	Spent outer fuel storage	3 batches×48 = 144
	Corium discharge path	31

New core design: axial map

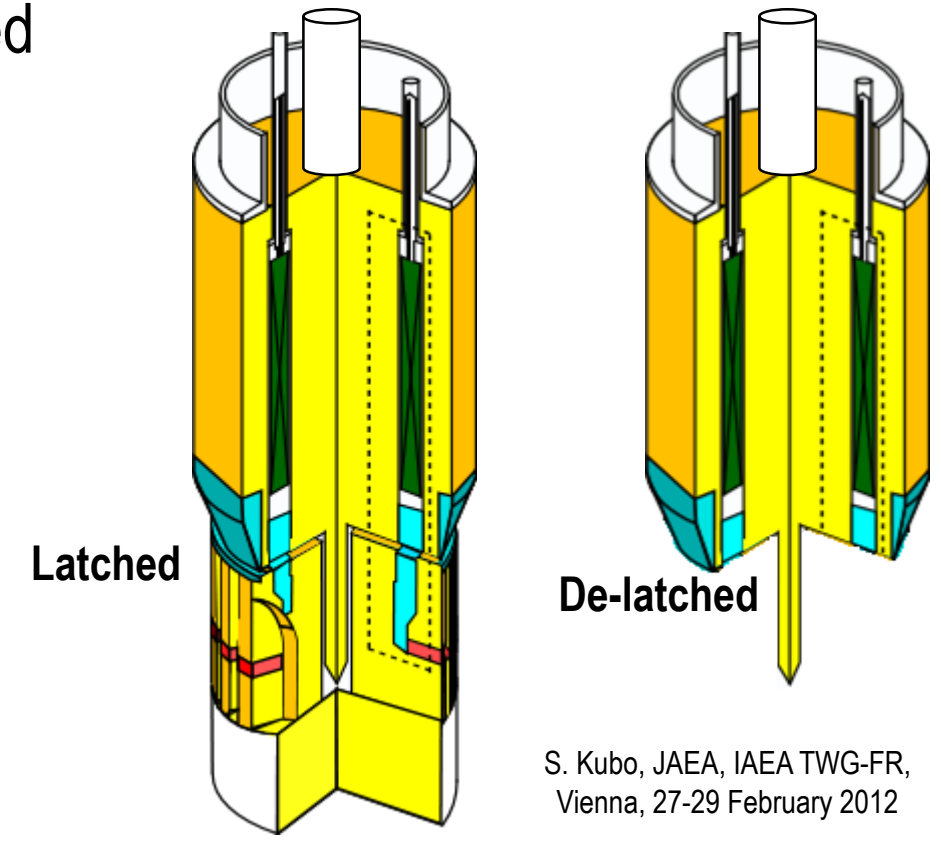
- The same initial plutonium content in the whole core
- The radial power profile is flattened by using different fuel height in inner and outer zones
- Passive protections against power excursion in case of sodium boiling:
  - —Sodium plenum is a layer above fuel which reflects neutrons down, when liquid, and lets them fly up towards neutron absorber when voided



New core design: passive control rods

- The safety control rod drivelines are proposed to be equipped with a Curie point magnetic latch device.
- This device releases the absorber rods downward into the core if either
  - — holding coil current is lost, or
  - — the coolant temperature rises beyond the Curie point of the temperature-sensitive alloy
- Activation is therefore provided both in response to
  - — a scram signal
  - — off-normal core conditions

JAEA SASS concept



S. Kubo, JAEA, IAEA TWG-FR, Vienna, 27-29 February 2012

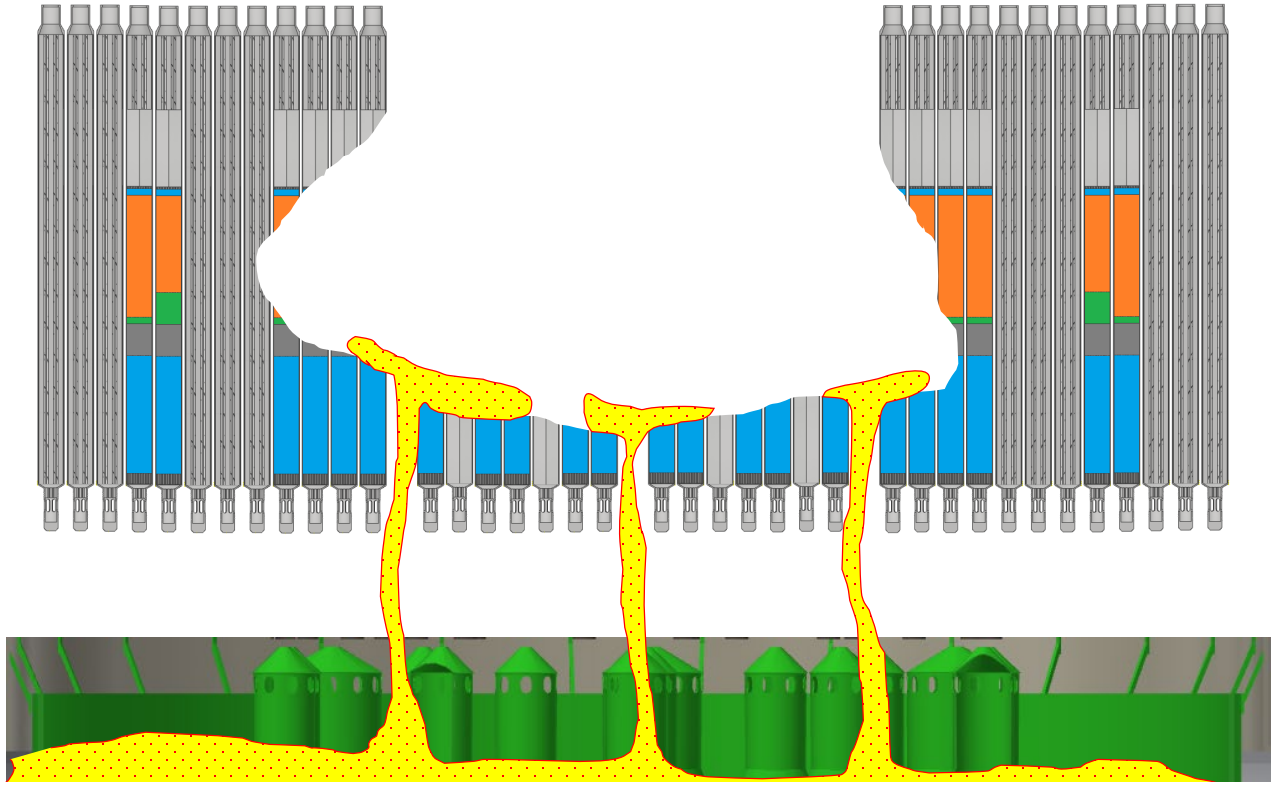
New core design: path for corium

In case of very low probability core meltdown event, the corium discharge channel helps

— To avoid re-criticality

— To promote transfer of the corium to the core catcher

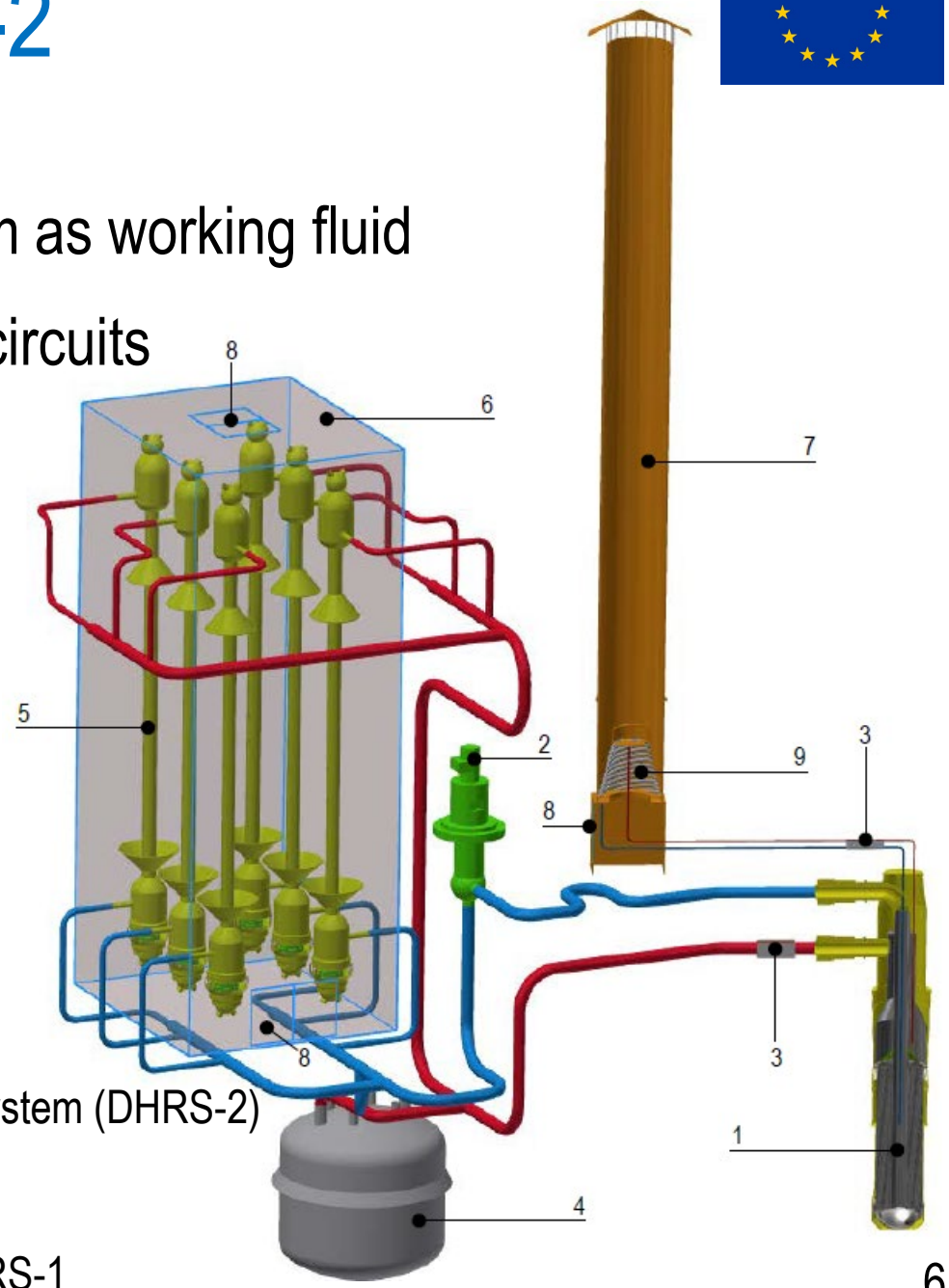
— To efficiently remove decay heat



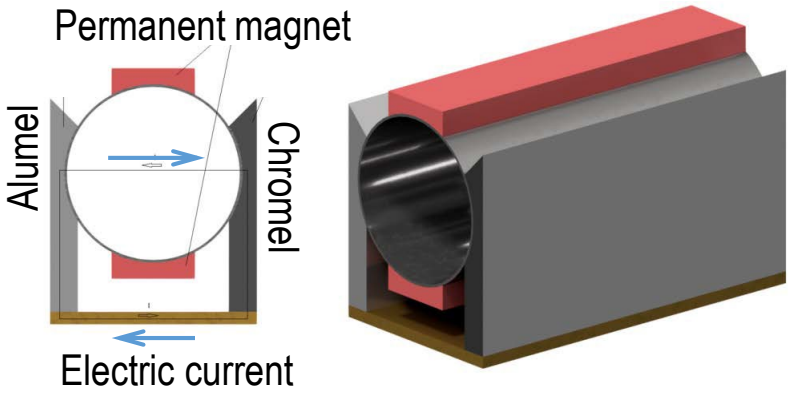
New system design: DHRS-1 and -2

Decay Heat Removal System

- DHRS-1 connected to the IHX and using secondary sodium as working fluid
- Use of passive thermal pumps in secondary and DHRS-1 circuits
- DHRS-2 uses air circulation through the openings in the SG casing and heat removal from the SG surfaces

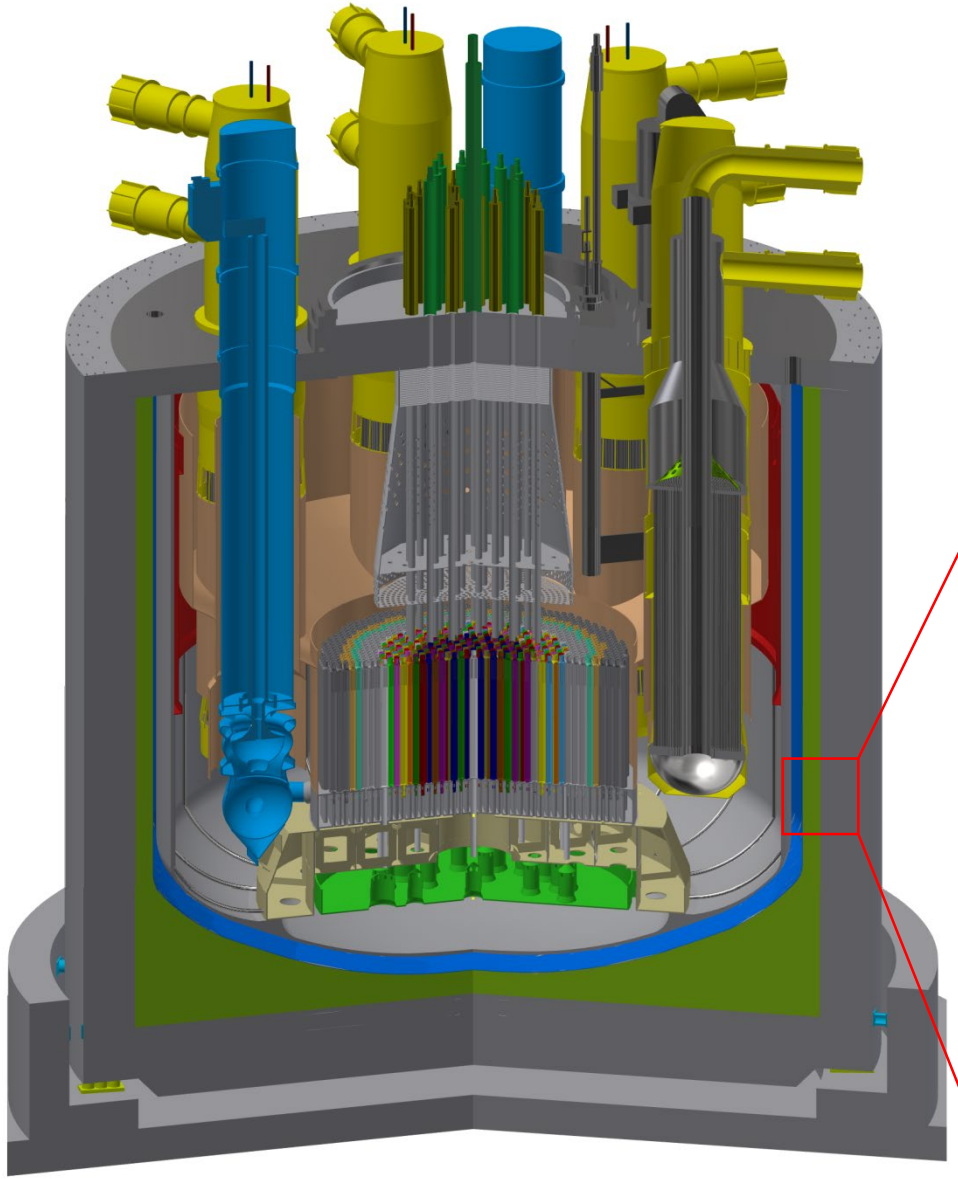


Thermal pump concept

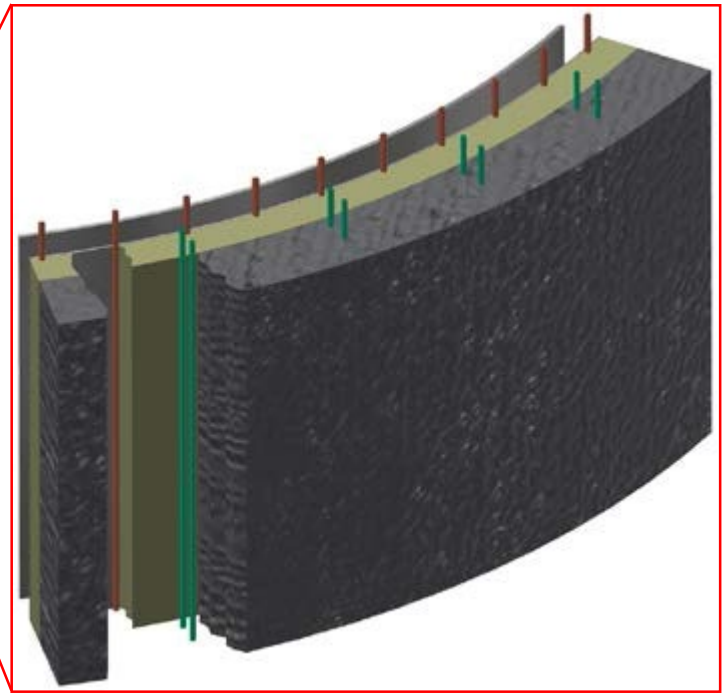


1 – Intermediate heat exchanger
2 – Secondary pump
3 – Thermal pumps
4 – Sodium storage tank
5 – Steam generator
6 – Casing of Decay Heat Removal System (DHRS-2)
7 – Air stack of DHRS-1
8 – Openings for air circulation
9 – Sodium-air heat exchanger of DHRS-1

New system design: pit and DHRS-3



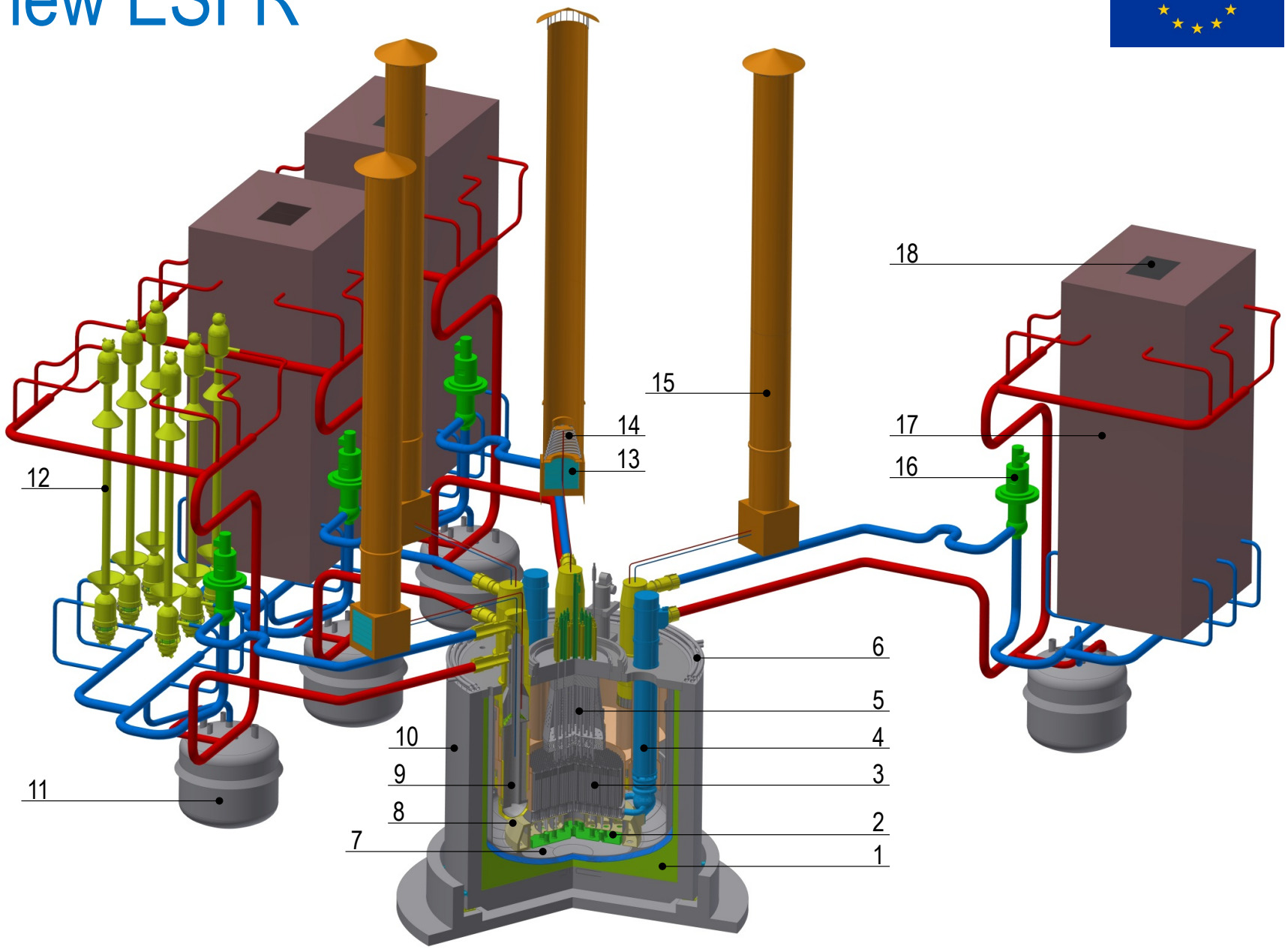
- Elimination of reactor dome and of safety vessel
- Minimization of the reactor vessel-pit gap, still large enough for inspection (shown in blue)
- Insulation (shown in green) with metallic liner on it



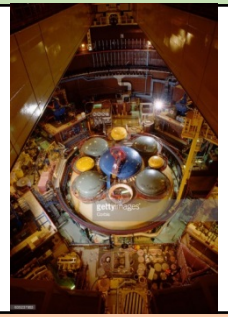
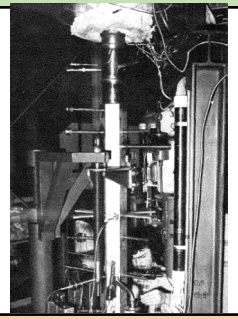
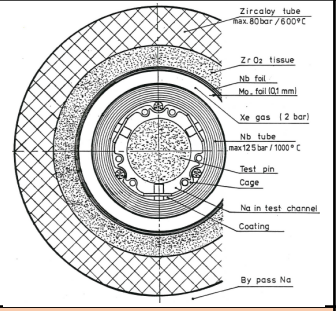
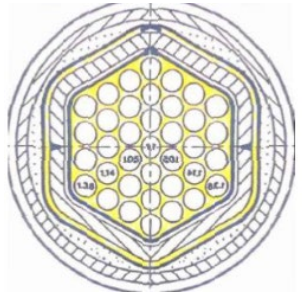
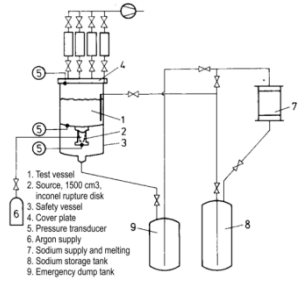
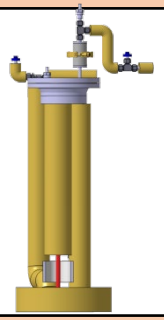
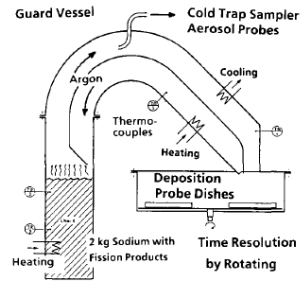
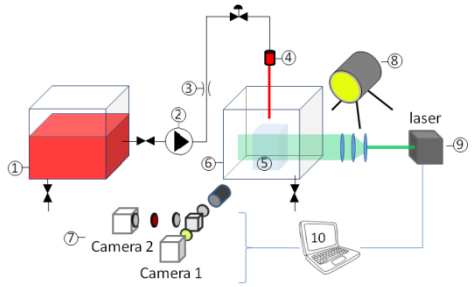
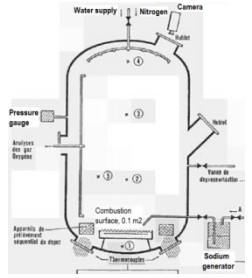
- Two reactor pit concrete cooling systems (oil and water) suitable for decay heat removal (DHRS-3)

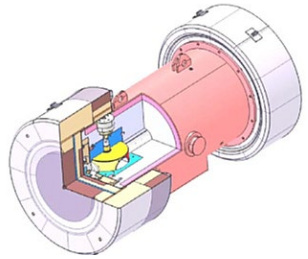
Overall view of new ESFR

1: Insulation with steel liner
2: Core catcher
3: Core
4: Primary pump
5: Above-core structure
6: Pit cooling system (DHRS-3)
7: Main vessel
8: Strongback
9: IHX
10: Reactor pit
11: Secondary sodium tank
12: Steam generator
13: Window for air circulation (DHRS-1)
14: Sodium-air HX (DHRS-1)
15: Air chimney (DHRS-1)
16: Secondary pump
17: Casing of SGs (DHRS-2)
18: Window for air circulation (DHRS-2)



ESFR-SMART: past and ongoing tests

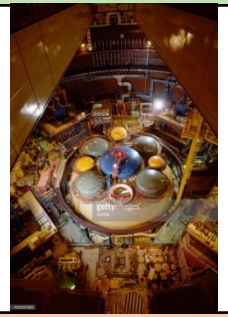
Normal operation	Sodium boiling	Severe accident (SA) management		SA mitigation
Superphenix	KNS-37	CABRI	SCARABEE	FAUST
				
KASOLA	KARIFA	ESFR-LIVE	JIMEC	NALA
				
ECFM	CHUG	HAnSOLO and JEDI		FANAL
				

MOX fuel measurements


ESFR-SMART: past and ongoing tests

Normal operation

Superphenix



The openly available legacy data obtained during the start-up tests at **Superphenix Sodium Fast Reactor** operated in France were used for validation of computer codes for coupled neutronic and thermal-hydraulic calculations

KASOLA

The **new sodium loop** is currently under commissioning at Karlsruhe Institute of Technology. The thermal-hydraulic data will be used for validation of Computational Fluid Dynamics codes.

POSTPONED

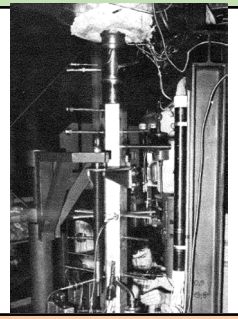
ECFM

The new **Eddy Current Flowmeter** is under development at Helmholtz-Zentrum Dresden Rossendorf to measure sodium flowrate at the fuel subassembly outlet.

ESFR-SMART: past and ongoing tests

Sodium boiling

KNS-37



KARIFA

CHUG

The legacy data obtained at KNS-37 **sodium boiling loop** at Forschungszentrum Karlsruhe are used for validation of computer codes for dynamic thermal-hydraulic calculations of sodium boiling.

A new compact **sodium boiling facility** with pulse laser heating is under development at Karlsruhe Institute of Technology to gain experience with two-phase sodium flow experiments and to provide data for validation of thermal-hydraulic codes.

A new **water-steam facility** was built at Paul Scherrer Institute to study chugging boiling conditions as a first step toward experimental study of the sodium vapour condensation and to provide data for validation of thermal-hydraulic codes.

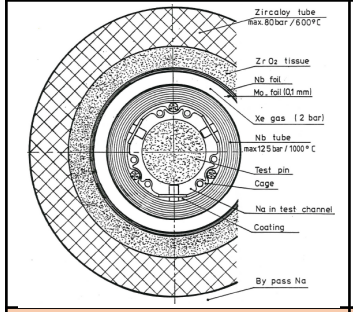
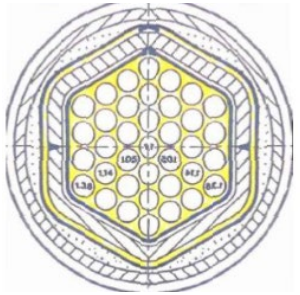
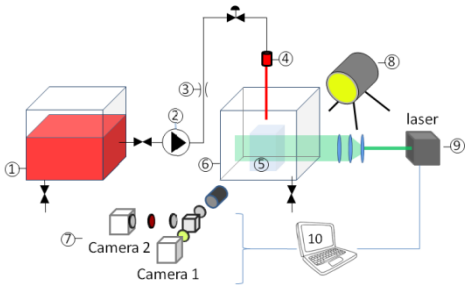
ESFR-SMART: past and ongoing tests

Legacy data on **molten fuel ejection** in the sodium channel obtained at CABRI reactor at Cadarache centre is used for validation of severe accident codes.

The new LIVE facility is designed at Karlsruhe Institute of Technology to study interaction of molten **corium simulant** $NaNO_3$-KNO_3 **with core catcher**.

The new facilities were designed at University of Lorraine to simulate with ice-water jet system interaction of molten **corium jet with core catcher**.

Severe accident (SA) management

CABRI	SCARABEE
	
ESFR-LIVE	**JIMEC**
	
HAnSOLO and JEDI	
	

Legacy data on **melt propagation** into the bundle obtained at SCARABEE reactor at Cadarache centre is used for validation of severe accident codes.

The new JIMEC facility was designed at Karlsruhe Institute of Technology and two tests conducted to study interaction of molten **corium simulant jet*** with substrate simulating **core catcher** .

*SS304

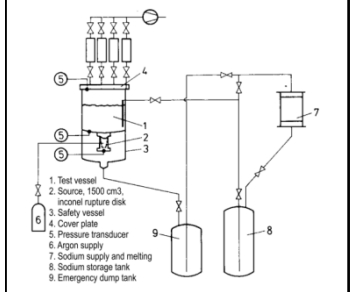
ESFR-SMART: past and ongoing tests

Legacy data obtained at small-scale FAUST and NALA facilities at Forschungszentrum Karlsruhe on hot sodium evaporation rate, release and **behaviour of aerosols** in sodium vapour atmosphere is used for validation of severe accident codes.

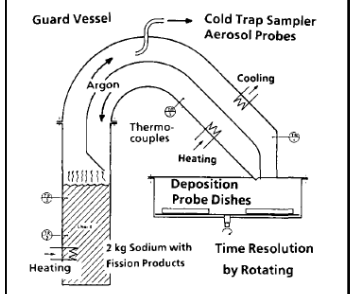
Legacy data on kinetics of aerosols release from sodium **pool fires** conducted at CEA Cadarache centre (France) is used for validation of severe accident codes.

SA mitigation

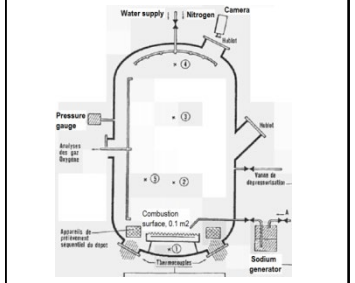
FAUST



NALA



FANAL

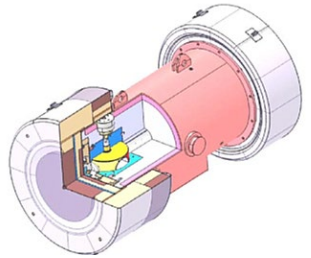


ESFR-SMART: past and ongoing tests

New data on fresh and burned mixed uranium-plutonium oxide **fuel thermal-physical properties** is obtained for the use in computer simulations.

POSTPONED

MOX fuel measurements



Thank you!

Visit us at http://esfr-smart.eu/

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