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SNETP Forum

KIT Contribution to the Multiphysics R&D Activities within the H2020 EU *CAMIVVER* Project

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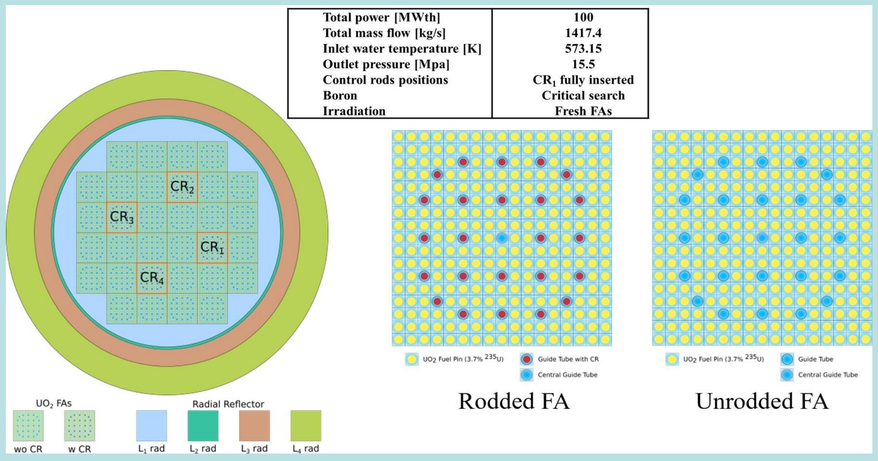
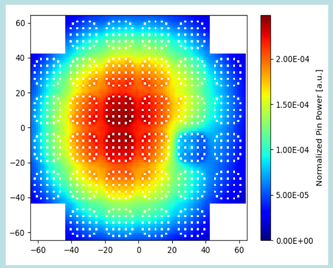
1. Introduction

- Within the framework of the **EU H2020 *CAMIVVER*** project, R&D activities have been performed with the objective to make a step forward towards the industrialization of new advanced coupling schemes for Best Estimate (BE) multiphysics reactor analysis.
- Different numerical solutions for reactivity insertion scenarios occurring on ad-hoc defined PWR and VVER theoretical mini-cores have been produced.

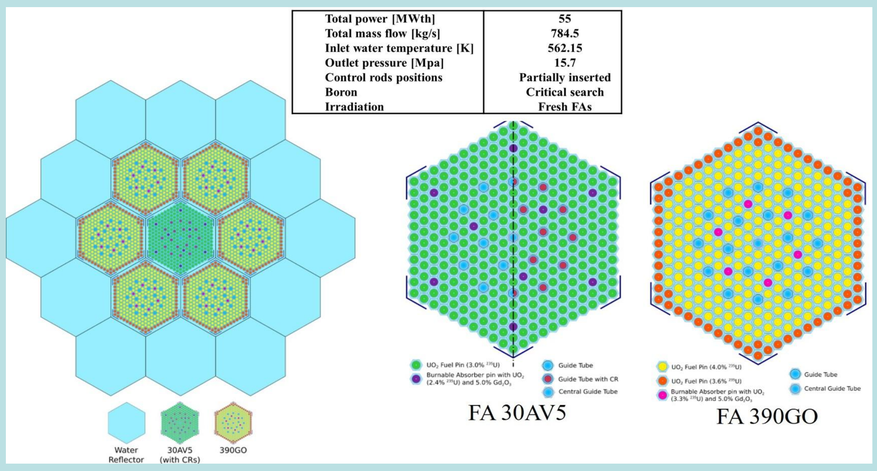
Total power [MWth]	100
Total mass flow [kg/s]	1417.4
Inlet water temperature [K]	573.15
Outlet pressure [Mpa]	15.5
Control rods positions	CR_1 fully inserted
Boron	Critical search
Irradiation	Fresh FAs



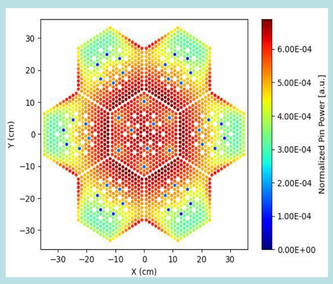
REA Scenario:
CR1 fully extracted in 100 ms
Evolution up to 2 seconds



Total power [MWth]	55
Total mass flow [kg/s]	784.5
Inlet water temperature [K]	562.15
Outlet pressure [Mpa]	15.7
Control rods positions	Partially inserted
Boron	Critical search
Irradiation	Fresh FAs



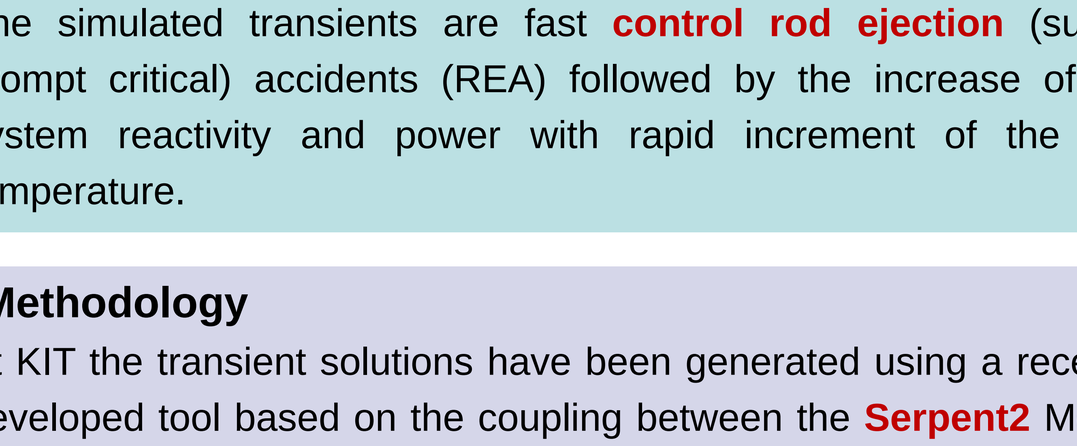
REA Scenarios:
CR fully extracted in 80 ms
Evolution up to 2 seconds



- The simulated transients are fast **control rod ejection** (super-prompt critical) accidents (REA) followed by the increase of the system reactivity and power with rapid increment of the fuel temperature.

2. Methodology

- At KIT the transient solutions have been generated using a recently developed tool based on the coupling between the **Serpent2** Monte Carlo code and the **SCF** thermo-hydraulic code. This **high-fidelity tool** allows performing full core calculations with transient capabilities based on Monte Carlo neutronics at pin level and subchannel-level thermal-hydraulics.



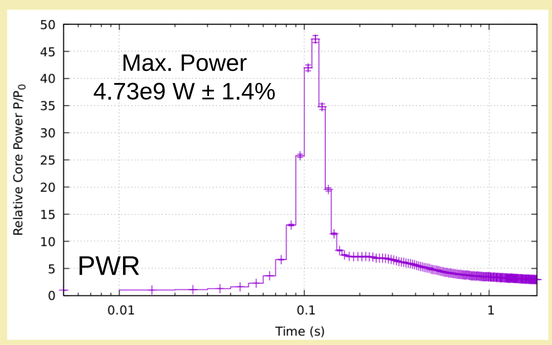
- The Serpent2/SCF results are used for the verification of two different schemes based on the coupling between the APOLLO3® code with its internal 1D thermal-hydraulic solver (THEDI) and on the first version of the newly developed APOLLO3®/CATHARE3 coupling prototype.
- 3D pin-by-pin Serpent2 models were developed making up to 9248 pins and 2184 pins for the PWR and VVER mini-cores.

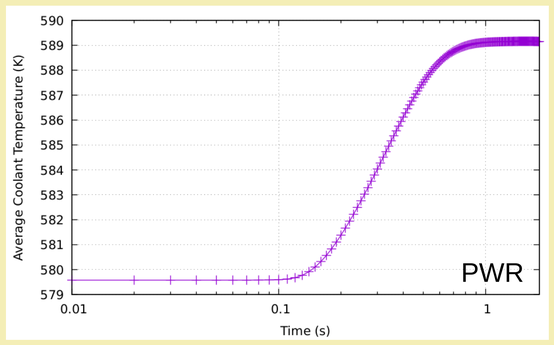
3. Modeling approach

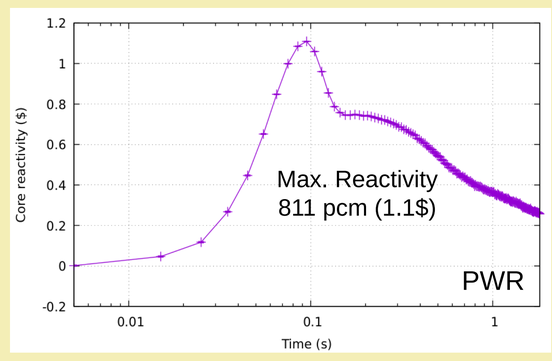
- Δt=10 ms
- 10E+7 source particles
- 10 batches/ 20 MPI = 50k/batch/MPI
- 152 CPUs/node*20 nodes: **3040 CPUs**
- Wall clock time:
  - 2440 m. (PWR) / 1720 m. (VVER)
- Avg. pin power statistical uncertainty < 5%

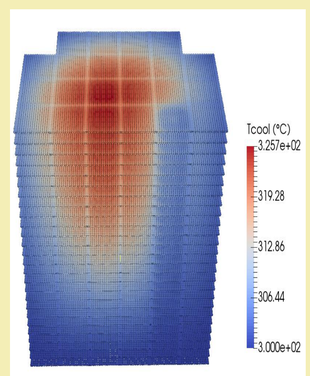
4. Results

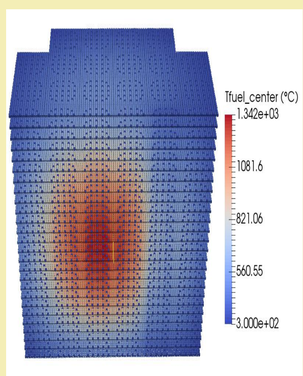
- Good agreement between high-fidelity and APOLLO3®-based solutions. Serpent2/SCF simulations highly sensitive to time discretization











Tools	Serpent2/SCF		APOLLO3®/THEDI		APOLLO3®/CATHARE3	
Minicore	PWR	VVER	PWR	VVER	PWR	VVER
Peak factor (P/P0)	47.3 ± 0.6	15.02 ± 0.2	37.6	14.4	43.1	16.1
Peak time (s)	0.115	0.095	0.122	0.09	0.120	0.10