PAUL SCHERRER INSTITUT

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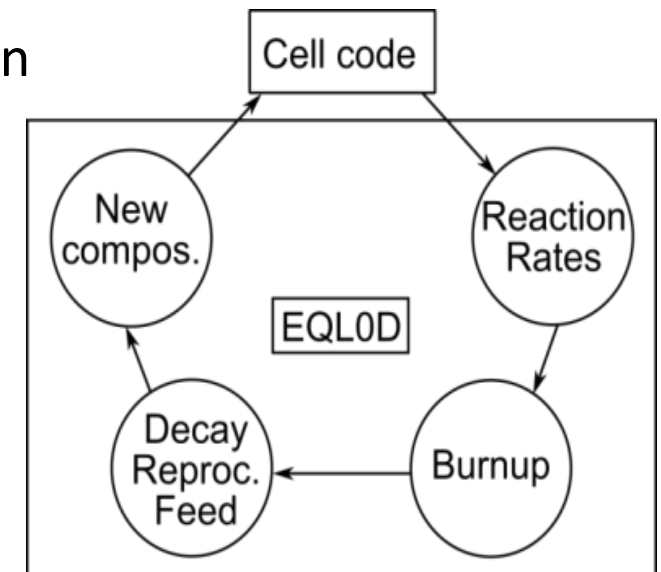
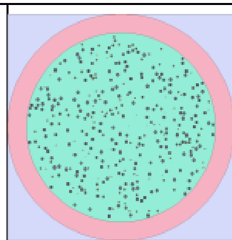
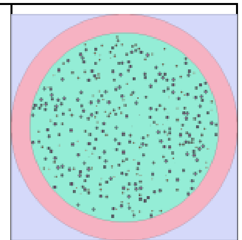
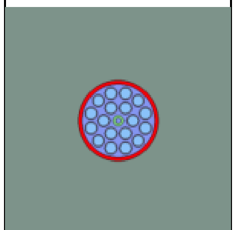
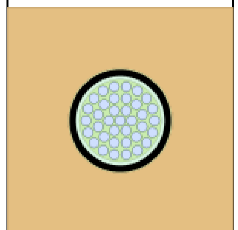
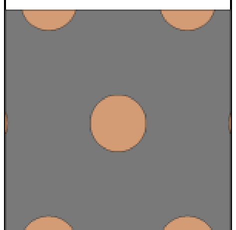
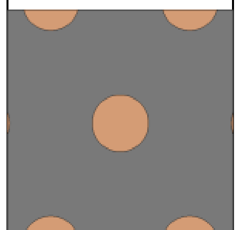
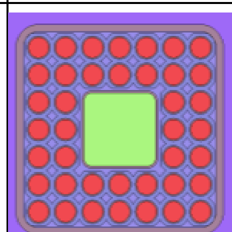
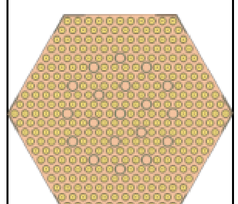
Equilibrium closed cycle:
consequence of self-recycling scenario and inherent core characteristics

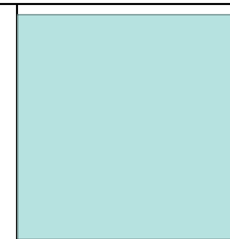
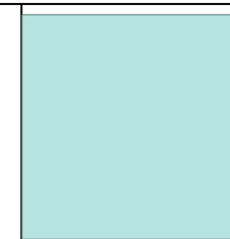
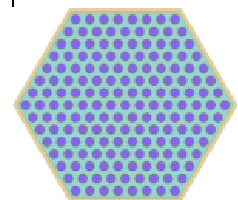
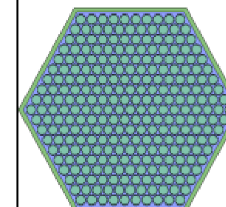
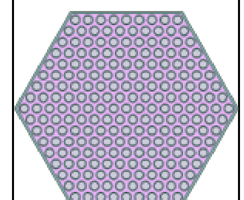
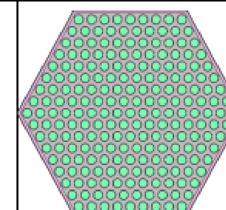
Assumptions for equilibrium cycle simulation

- infinite lattice cell level simulation,
- reactor specific power given by burnup in FIssile MAterial % (FIMA %) and fuel residence time,
- neglecting fission products,
- zero reprocessing losses,
- continuous feed of fertile material (^{232}Th or ^{238}U),
- ENDF/B-VII.0 nuclear data library.
- For D-factors evaluation direct calculation with small amount of given isotope addition was always simulated.
- **EQL0D v2**: MATLAB-SERPENT coupling through reaction rates, cell or core level routine.



16 selected reactors: 8 thermal & 8 fast

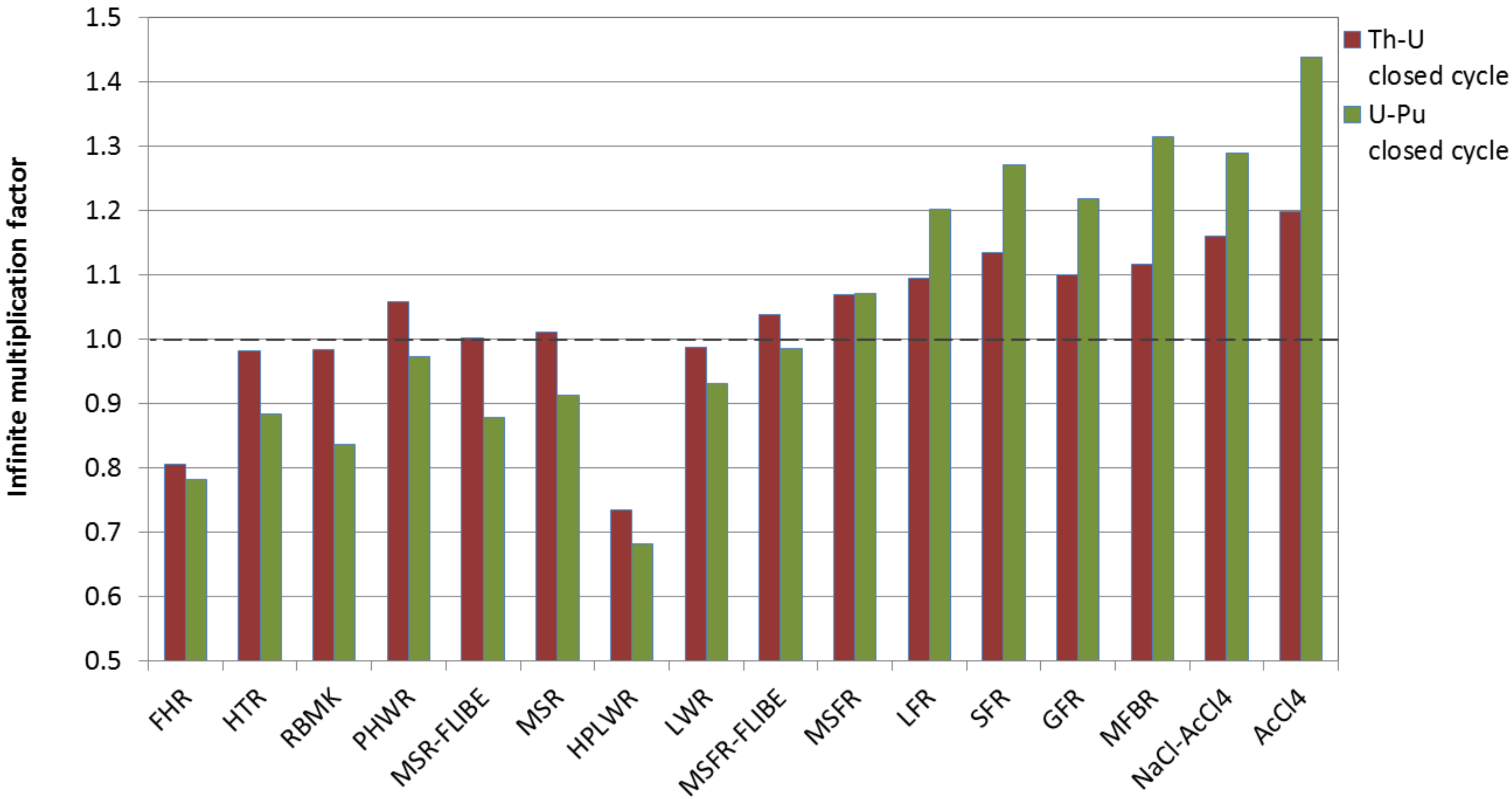
FHR 192.0 W/g_{HM}		HTR 96.8 W/g_{HM}	
RBMK 13.7 W/g_{HM}		PHWR 32.1 W/g_{HM}	
MSR-FLIBE 41.1 W/g_{HM}		MSR 41.1 W/g_{HM}	
HPLWR 25.3 W/g_{HM}		LWR 41.1 W/g_{HM}	

MSFR 41.1 W/g_{HM}		MSFR-FLIBE 41.1 W/g_{HM}	
LFR 54.8 W/g_{HM}		SFR 48.8 W/g_{HM}	
GFR 40.1 W/g_{HM}		MFBR 178.6 W/g_{HM}	
NaCl-AcCl4 salt 54.8 W/g_{HM}		AcCl4 salt 54.8 W/g_{HM}	

- The simplified designs were adopted as is without optimization.
- If the core consists of assemblies with identical geometry but different fuel composition only one assembly was simulated.
- If the geometry differs, all cases have been simulated, but only one selected is presented.

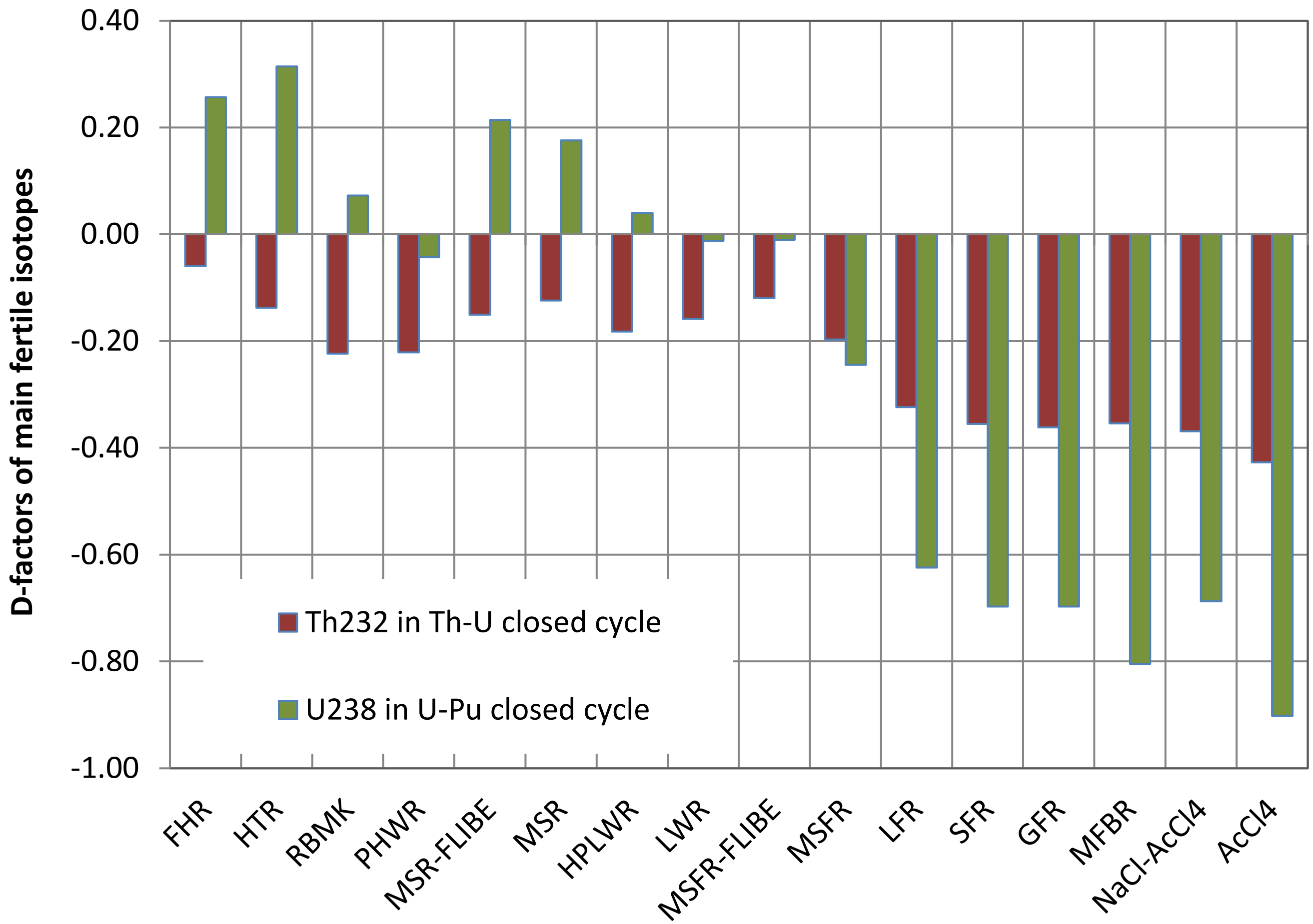
Result 1: equilibrium closed cycle k_{inf}

- Equilibrium closed cycle k_{inf} represents the neutron economy of each lattice.
- It should be strongly above 1 to enable realistic operation in finite geometry and with fission products.



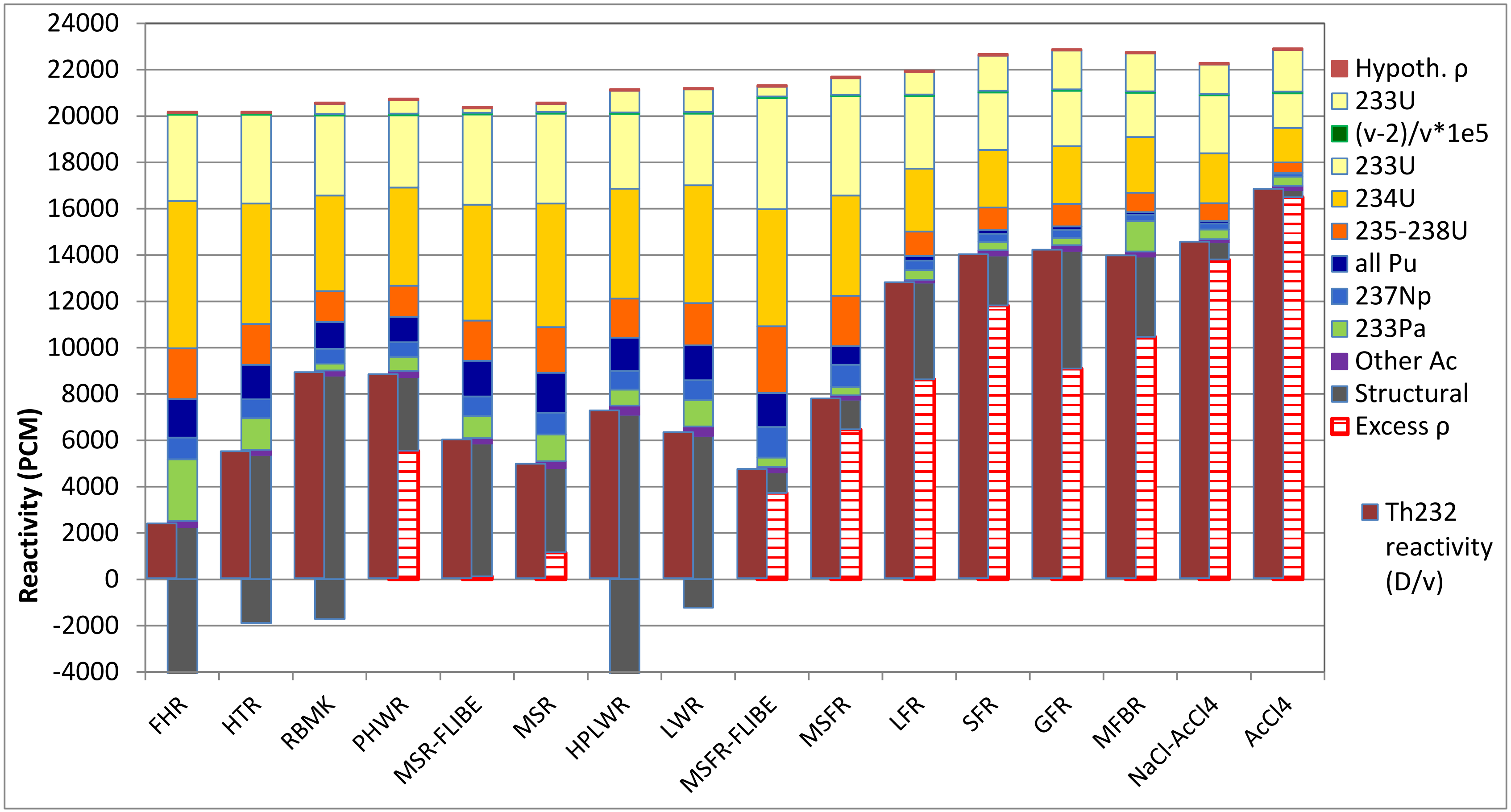
Result 2: static D-Factor for main fertile isotope

- In equilibrium closed cycle the D-factor of fed isotope represents the neutron economy of the whole fuel cycle.
- Since 1 destruction of the feed material = 1 fission, the respective D-factor divided by v-bar represents the reactivity excess reactivity.



Excess reactivity break-down for Th-U cycle

- Hypothetical excess reactivity (with zero parasitic captures in the core) can be divided into the actual capture components
- and it can finally provide the real reactivity excess.
- The ^{232}Th D-factor divided by ν gives the same values.



Summary and conclusions

- 16 selected reactors were compared at equilibrium closed Th-U and U-Pu fuel cycles.
- The reactor designs were adopted as is and not optimized for closed fuel cycle.
- 8 thermal and 8 fast spectra system have been selected.
- The basic criteria for comparison was k_{inf} for the equilibrium closed cycle.
- Neutron consumption D-factors provided additional insight.

- For more detail, please see the attached file or contact Jiri: jiri.krepel@psi.ch