Serpent-DYN3D solution of X2 benchmark: fresh core at HZP

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HZDR
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Outline

- X2 VVER-1000 benchmark
- Models
- Serpent results
- DYN3D results
- Summary

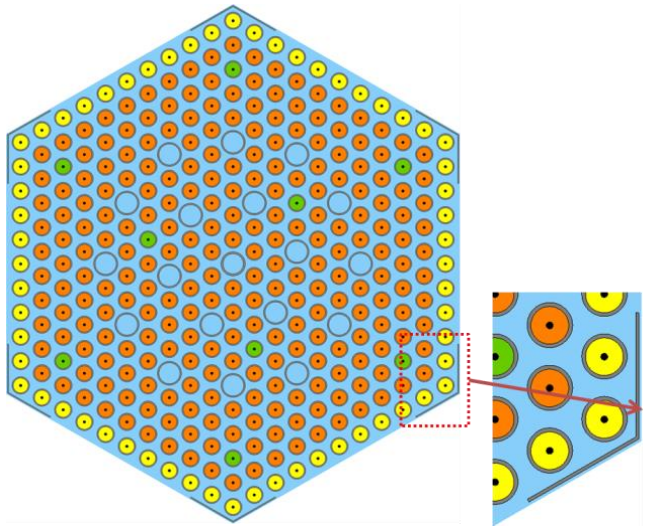
X2 VVER-1000 benchmark

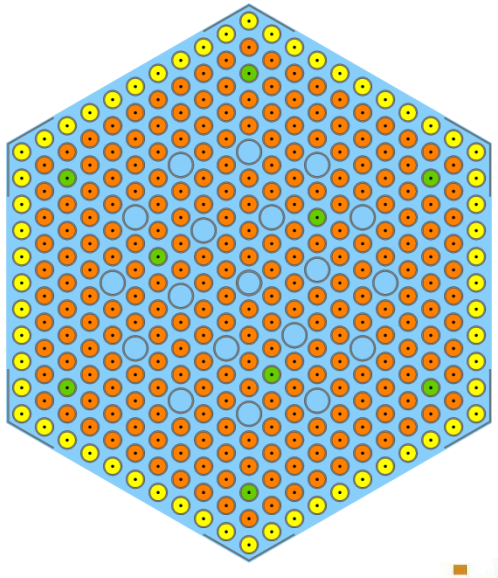
- NPP: Khmelnitsky-2 with VVER-1000 reactor
- Defined by GRS, Munich and SSTC NRS, Kyiv
- As a means for validation of the full core modeling sequences
  - Data libraries, few-group XS preparation, full core modelling, …
- Describes first 4 fuel cycles
  - Materials, geometry, core loading patterns
- Provides plant measurement data:
  - HZP startup experiments
  - Boron letdown curve
  - Reconstructed power distributions

Khmelnitsky-2

VVER-1000 core description

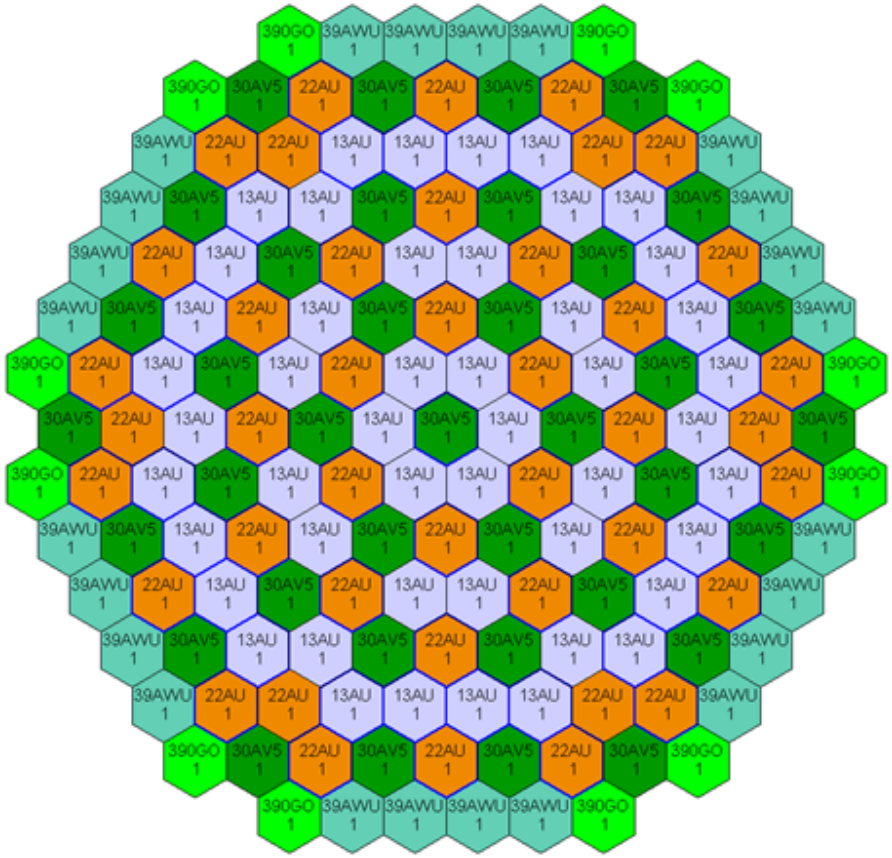
- 312 fuel pins
- 18 guide tubes + 1 instrumentation tube
- 7 fuel assembly of a TWSA type with rigid corners
- 1.3 to 4.4 w/o enrichment
- 6 to 9 UO_2-Gd_2O_3 burnable poison pins in some assemblies





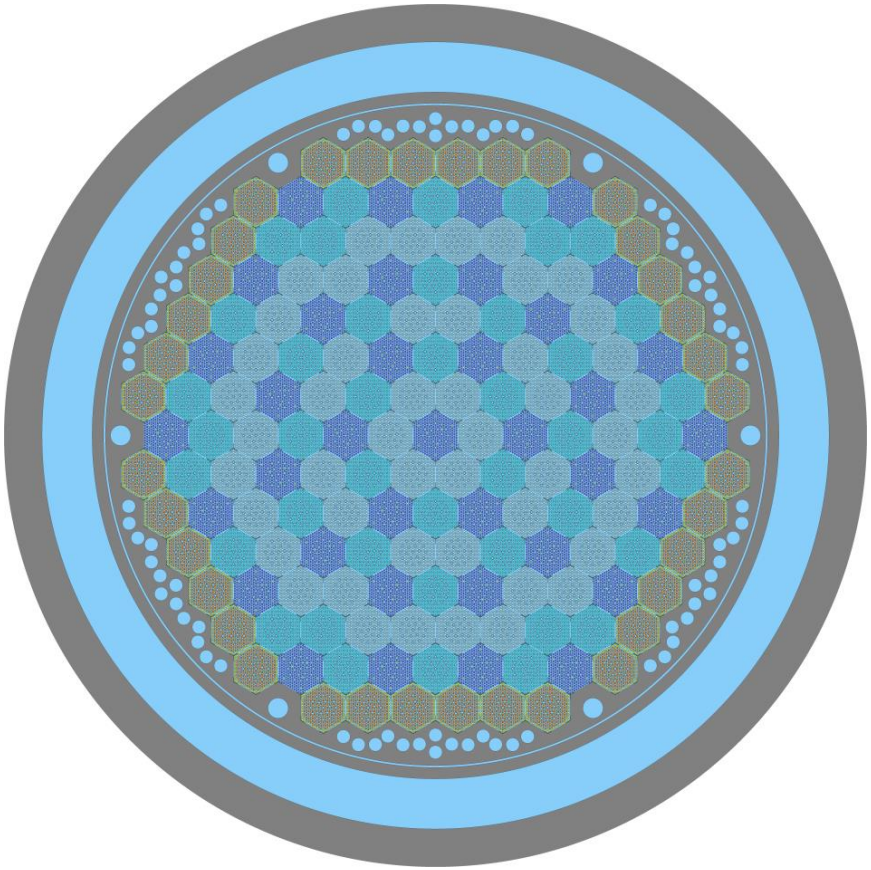
Fuel types and core loading pattern: cycle 1

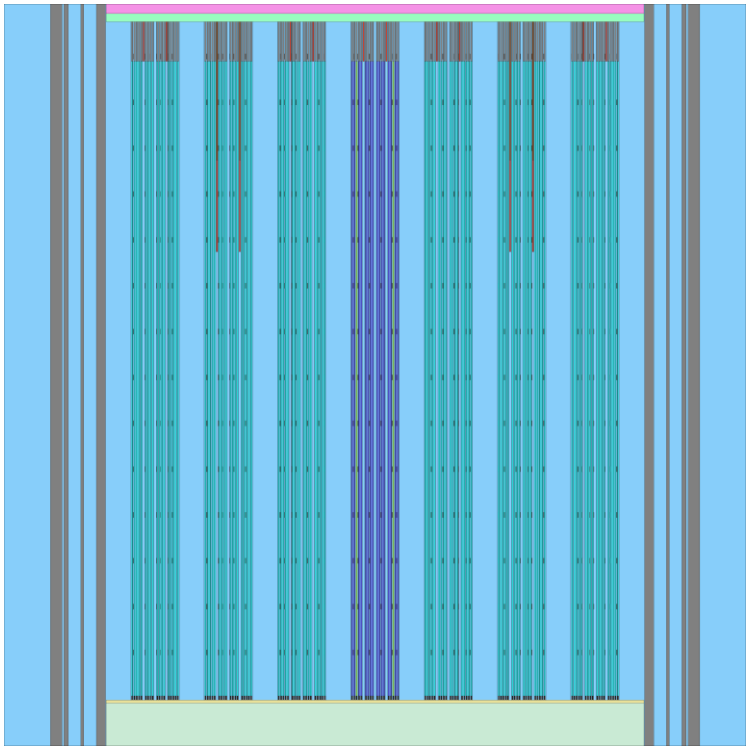
FA type	Average enrichment (w/o)	# of UO_2 pins / Profiled enrichment (w/o)	# of Gd-pins
13AU	1.30	312 / 1.30	--
22AU	2.20	312 / 2.20	--
30AV5	2.99	303 / 3.00	9
39AWU	3.90	243 / 4.00 60 / 3.60	9
390GO	3.90	240 / 4.00 66 / 3.60	6



Serpent core model

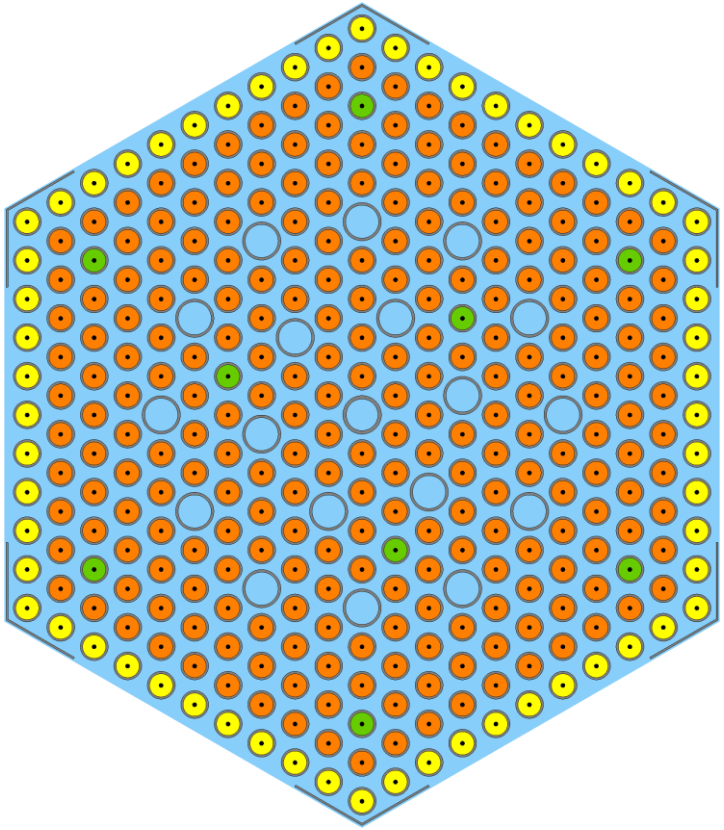
- Detailed representation of the fuel assemblies, control rods, and the radial reflector





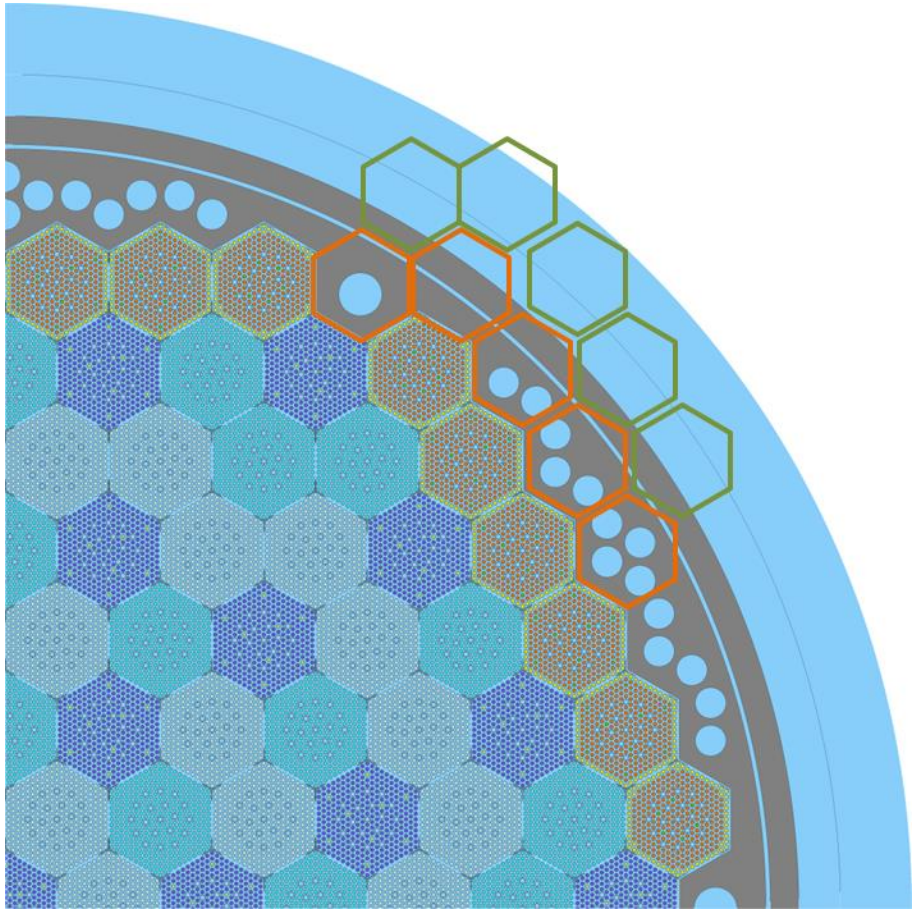
Fuel XS

- Single assembly in periodic BC
- Infinite spectrum XS
- TRC diffusion coefficient
- ADF from DF_SURF_DF



Radial reflector XS

- 30° symmetry, 5 cells in first row and 5 cells in second row
- all XS are calculated in single run ¼ of a core in reflective boundaries
- TRC diffusion coefficient
- DF from DF_SURF_DF
- Side which faces fuel used for all 6 sides
- DF for reflector are corrected by single-assembly fuel ADF



Serpent vs. measurments

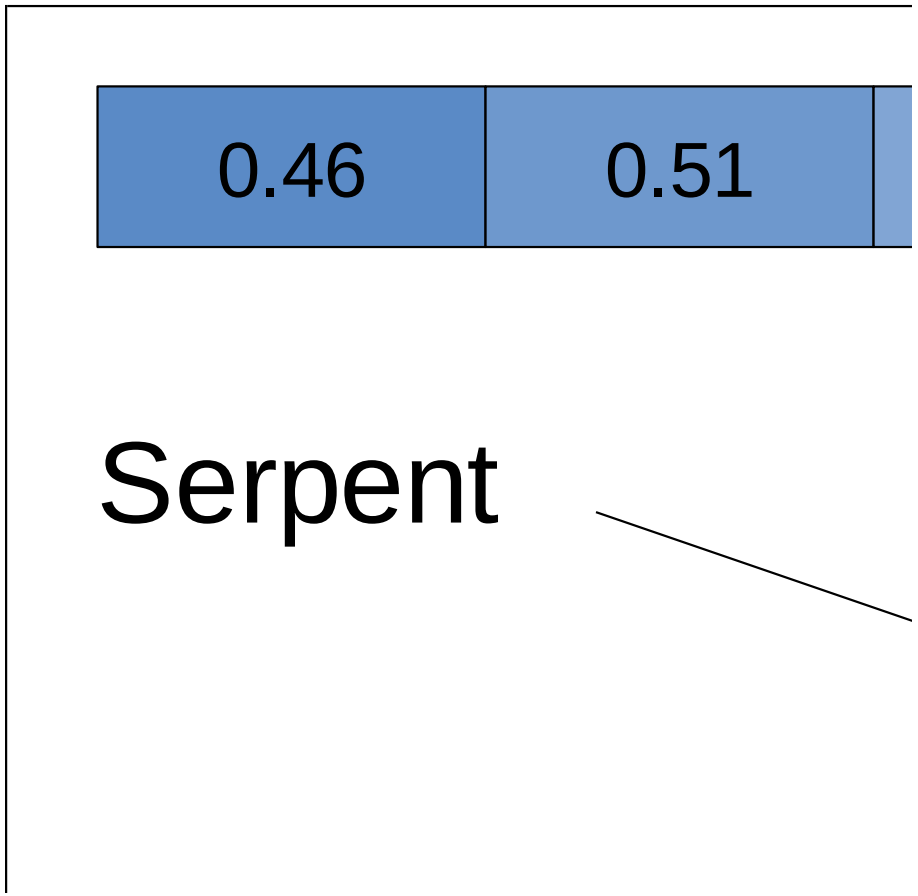
- Fresh core HZP critical state,
- Bank H10 is 24% inserted (6 CR)

Parameter	Measurement	Serpent
Critical boric acid concentration in state 1, g/kg	6.90±0.15	6.97
Temperature reactivity coefficient, pcm/K	-5.39±0.54	-5.81
Full SCRAM worth, %	7.00±0.43	-7.42

Serpent vs. DYN3D

- Δρ = +75 pcm.
- Assembly power deviation
  - Max = 1.3%,
  - RMS = 0.7%

- Note:
  - measured power distribution is not available for HZP
  - Serpent as a reference



Future work

- Solve full power and burnup exercises
- Serpent-DYN3D
- Full core Serpent + TH + burnup ???

Thank you!