Use of TSUNAMI in validation of SCALE 6.1 for the Swedish spent fuel repository Selection of experiments

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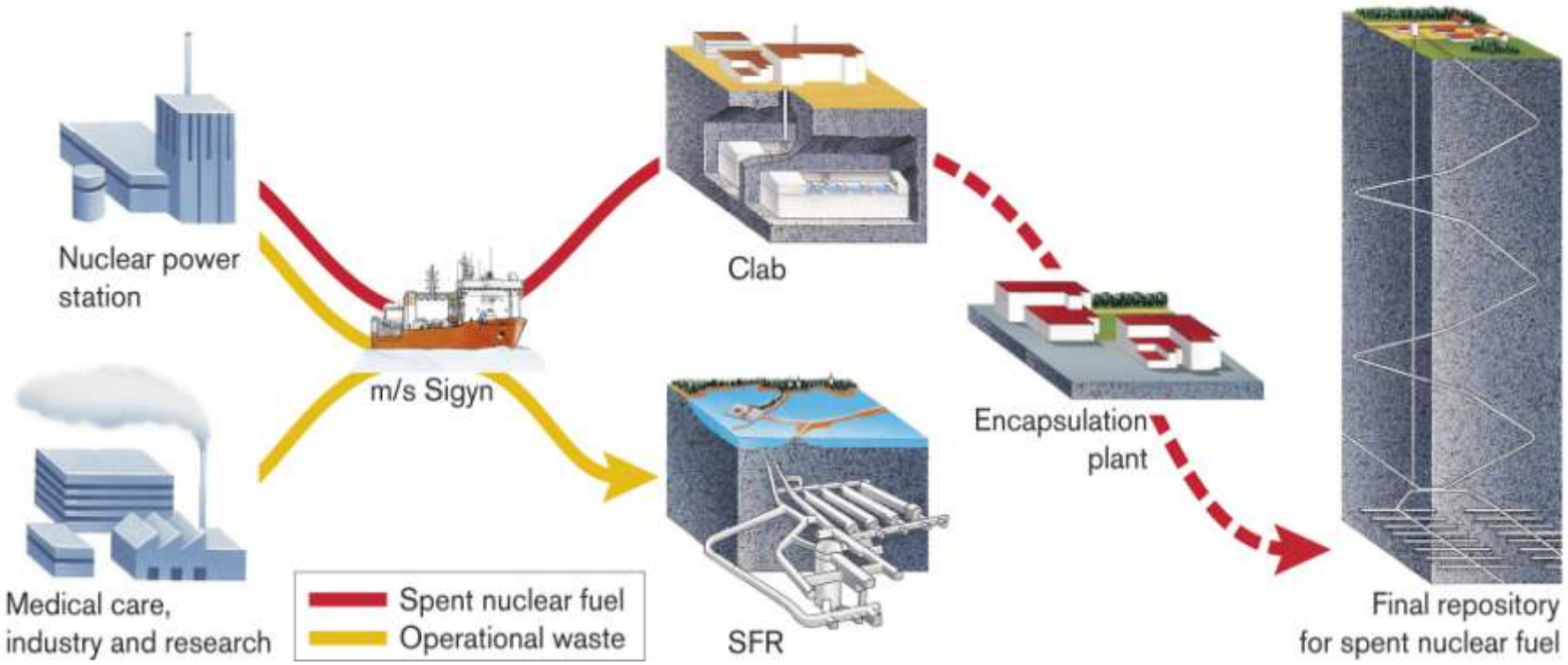


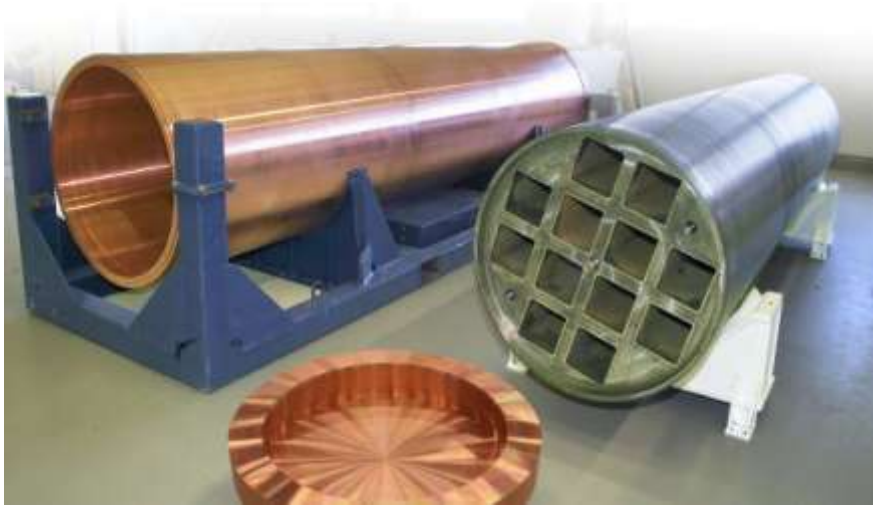
Application for the spent fuel repository

- In March 2011 SKB applied for permit to build a final repository for spent fuel in Forsmark and an encapsulation plant (Clink) in Oskarshamn.
- The application included a criticality safety analysis for Clink and the final repository for spent fuel. The analysis made use of Burn-Up Credit.
- The radiation safety authority (SSM) requested complementary information within many areas in the application. One concerned the validation of the codes and methods used in the SKB application. SSM emphasized that SKB must better motivate the selection of critical experiments used in the validation suite and recommended the use of recently updated standard and guidelines.
- Our current code validation was made years before the application, using ”engineering judgement”.
- SSM was raising the bar.
- To be able to meet the requests of SSM SKB chosed the TSUNAMI tool, within the SCALE 6.1 package, to select appropriate benchmarks.

Scope of validation

- Several different storage canisters
  - Normal BWR
  - Compact BWR and PWR
  - Transfer BWR and PWR
  - Disposal BWR and PWR (Copper)
- Several different fueltypes
  - 15x15 PWR
  - 17x17 PWR
  - 8x8
  - 10x10
  - 4x(5x5)

- Several different nuclear designs
  - Enrichment between 2-5 %
  - Gd-content between 4x1.5% to 14x5.5%.



Initial work

- Generation of sensitivity data files (sdf) for our safety cases.
- Comparing with Tsunami sdf-files developed in-house and provided by ORNL.
- In total 600 experiment whereof 150 from LEU-COMP-THERM.
- ORNL guidelines (ck > 0.8 useful in the determination of bias).

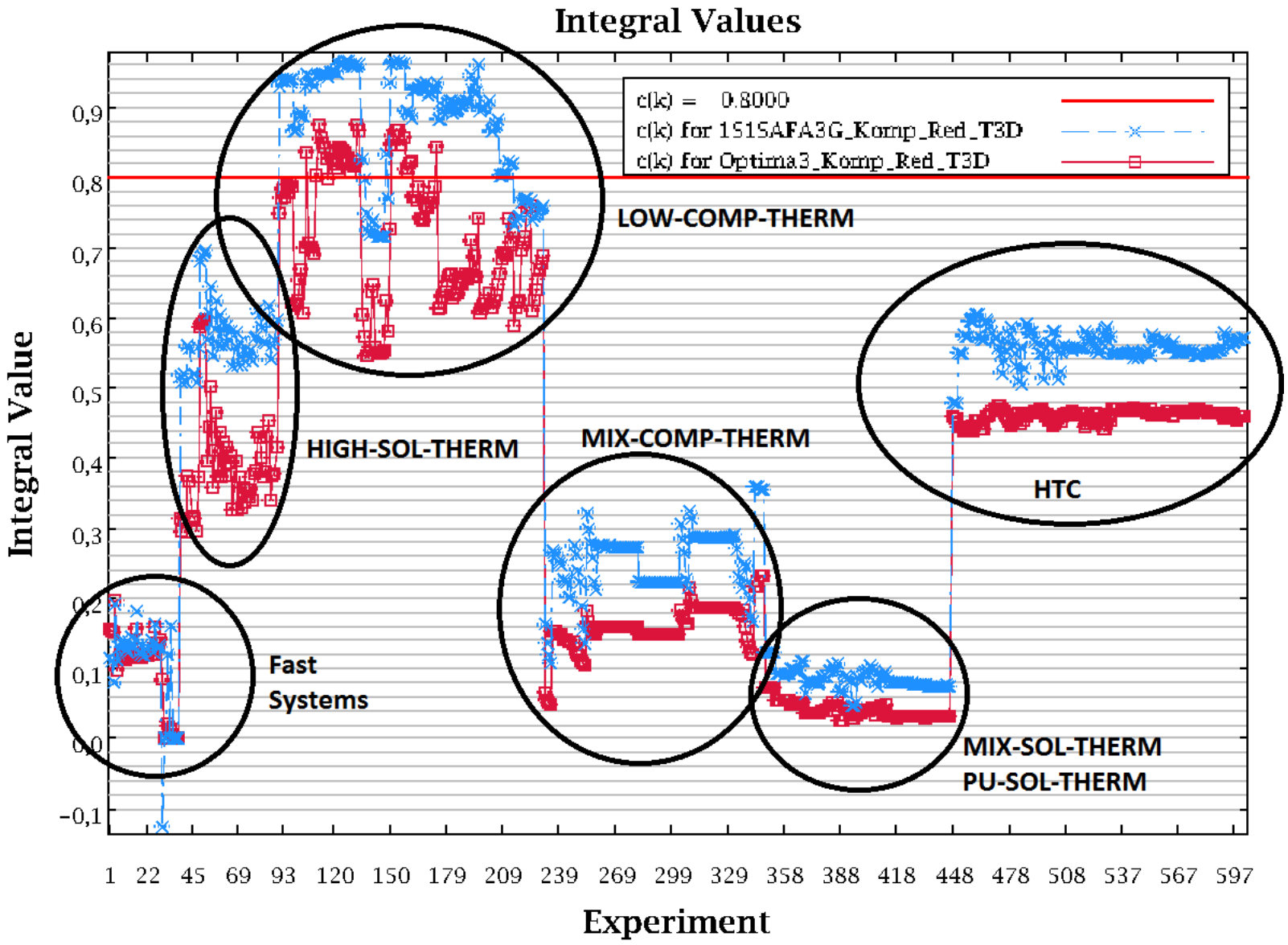
Results

- Very few experiment passed the bar of 0.8 for our BWR applications.
  - PWR compact storage canister: 111 (0.96)
  - BWR compact storage canister: 30 (0.86)
  - PWR disposal copper canister 114 (0.93)
  - BWR disposal copper canister: 5 (0.88)

Range of parameters

Safety Case	Pin pitch	Pellet diameter	EALF	H/U
PWR 15x15 CC	1,43	0,9294	0,272	1,68
PWR 17x17 CC	1,26	0,819	0,276	1,67
BWR 8X8 CC	1,58	1,044	0,246	1,54
BWR 4x(5x5) CC	1,2768	0,848	0,246	1,54
BWR 10x10 CC	1,295	0,888	0,299	1,37
Experiment range	1,075-1,82	0.665-2.6	0,03-2.8	0,66-2,66

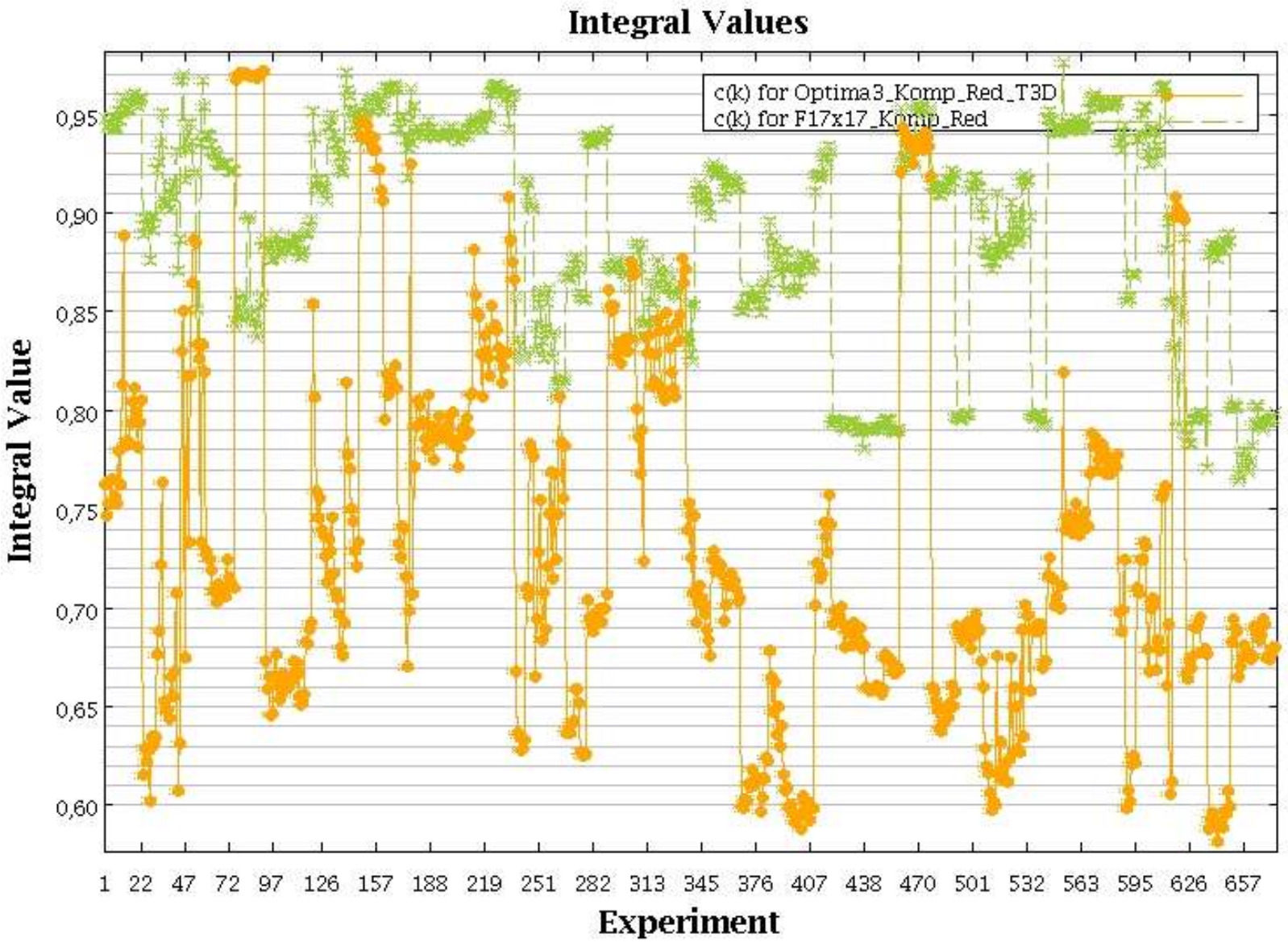
Small differences between BWR and PWR concerning physical parameters.


Integral Values
c(k) = 0.8000
c(k) for 151SAFA3G_Komp_Red_T3D
c(k) for Optima3_Komp_Red_T3D
LOW-COMP-THERM
HIGH-SOL-THERM
MIX-COMP-THERM
HTC
Fast
Systems
MIX-SOL-THERM
PU-SOL-THERM
Integral Value
Experiment
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
−0,1
1 22 45 69 93 120 150 179 209 239 269 299 329 358 388 418 448 478 508 537 567 597

Problem and solution

- Problems
  - No good explanation why BWR gives lower Ck-values.
  - To few acceptable experiment with acceptable Ck.
- We searched the ISCBE handbook to find experiment that look like BWR, built new models and run Tsunami.
- Failure

- OECD NEA (Ian Hill) have generated approximately 2900 sdf files. 677 of them from the LEU-COMP-THERM group.
- We used all these files in a TSUNAMI and finally we found enough of experiment with Ck above 0.8. More than 50 for each application.


Integral Values
c(k) for Optima3_Komp_Red_T3D
c(k) for F17x17_Komp_Red
Integral Value
0,95
0,90
0,85
0,80
0,75
0,70
0,65
0,60
1 22 47 72 97 126 157 188 219 251 282 313 345 376 407 438 470 501 532 563 595 626 657
Experiment

Conclusion and future work

- Tsunami in combination with sensitivity data from (OECD/NEA IRPHE-ICSBE) provides excellent opportunity to scan almost all experiment in the ICSBEP handbook and find the most suitable experiment for your safety case.
- Tsunami gives the possibility to make the choice of experiment on in a structured methodical way and takes away the arbitrariness from the selection process.
- Difficult to choose suitable experiments based on ”engineering judgement”
- Few suitable experiments for the SKB BWR applications. Further work to understand this is needed.
- Dependencies between benchmark**.**

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