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Analysis of simultaneous SBO and LBLOCA considering DEC equipment

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Outline

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- Analyzed SA scenarios
- Krško NPP MELCOR model
- Simulation results
- Conclusions

Krško NPP

2-loop Westinghouse PWR with 1,994 MW_{th} and 696 MW_{el}

Analyzed SA scenarios

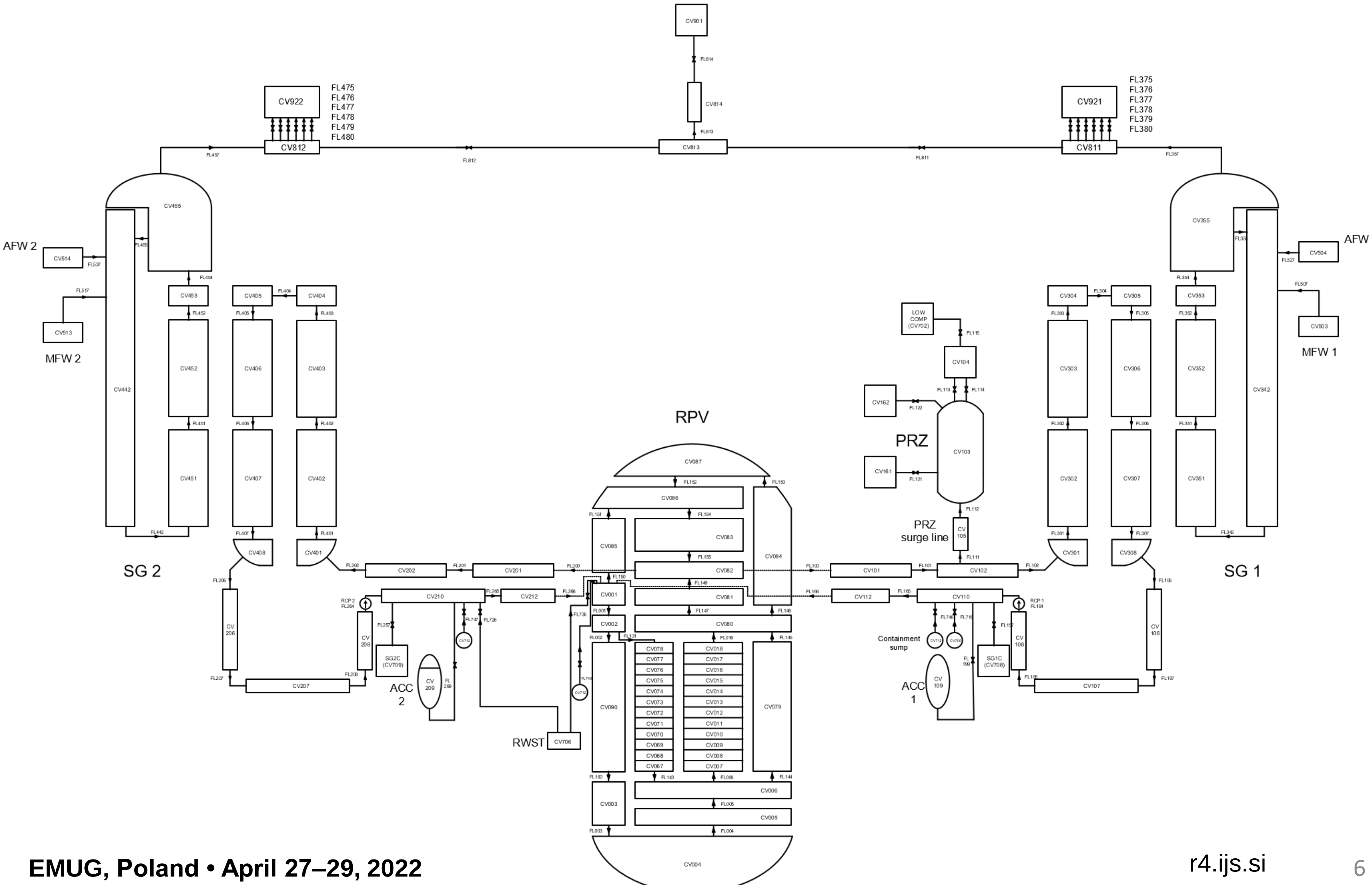
Initiating external event: Strong earthquake resulting in simultaneous SBO and LBLOCA

Analyzed five scenarios:

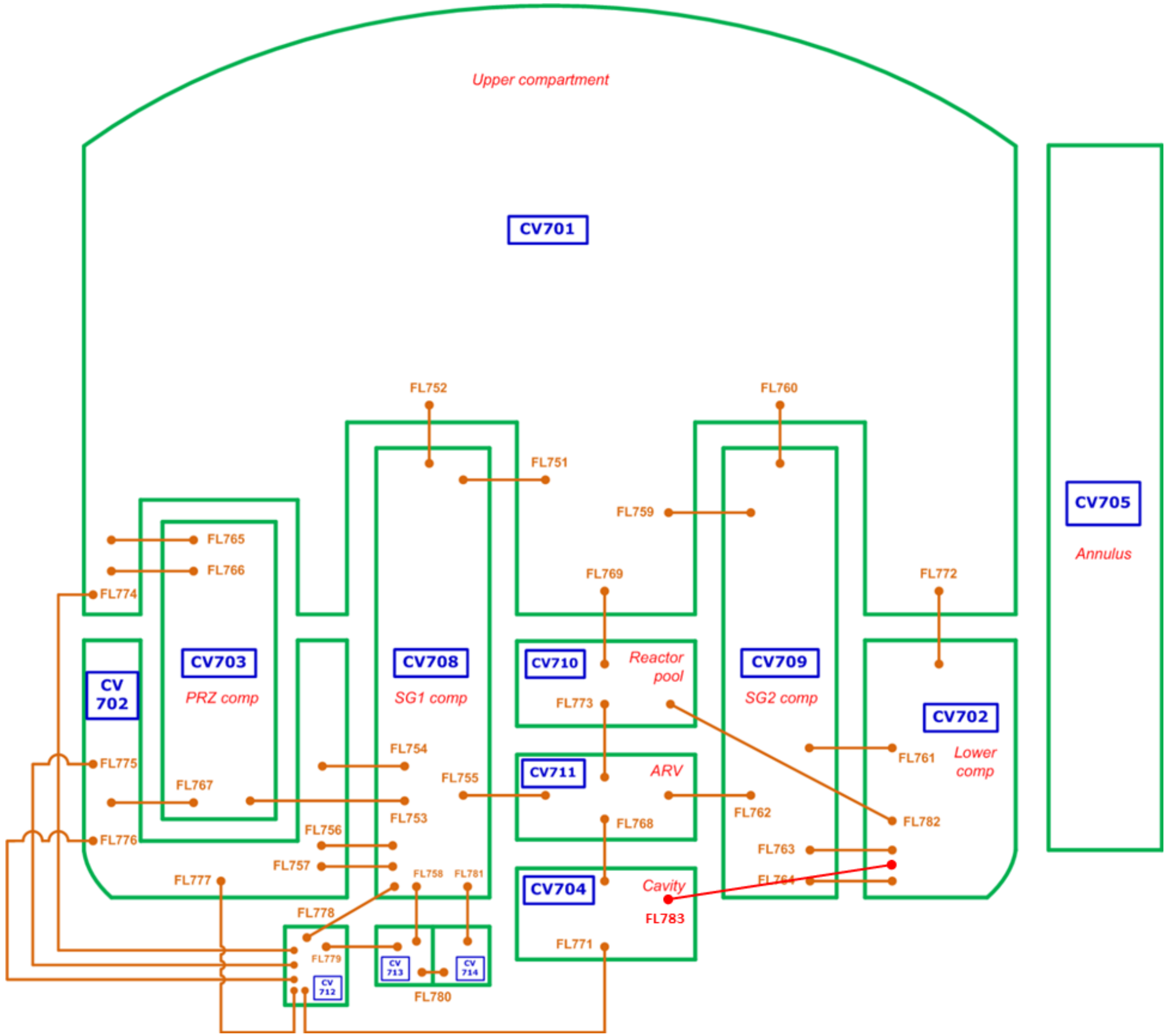
1. No mitigation (noASS)
2. After melt release from RV water injection through cont. sprays (ACI_RV)
3. After melt release from RV water injection simultaneously through cont. sprays and into RCS RV (ACVI_RV)
4. After melt release from RV water injection into RCS RV (AVI_RV)
5. After melt release from RV water injection into RCS RV, without ARHR HEX, with AAF (AVI_RV_noHEX_AAF)

Simulations performed with MELCOR 2.2 revision 15254

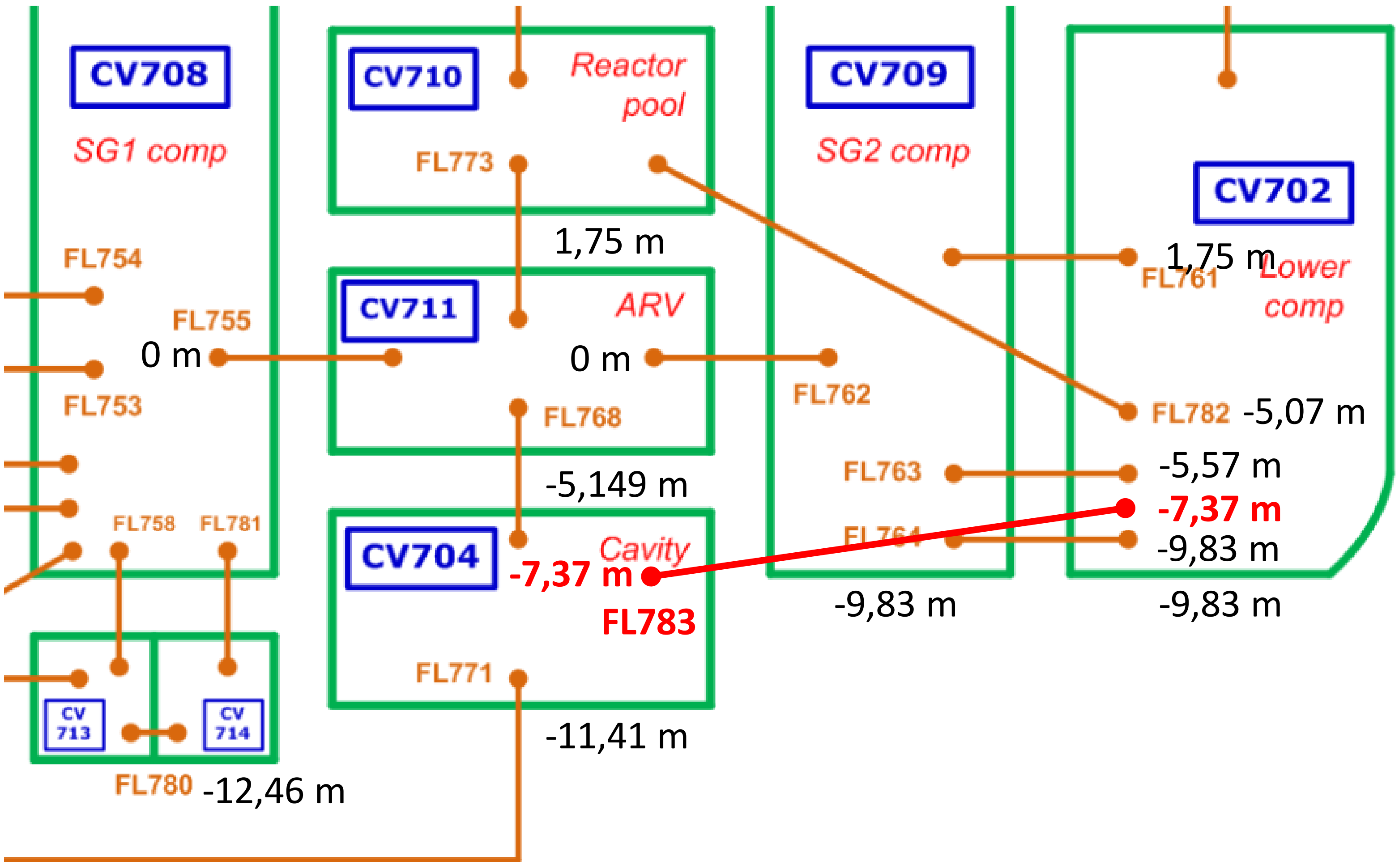
Krško NPP primary and secondary systems nodalization



Krško NPP containment nodalization



Nodalization around reactor cavity



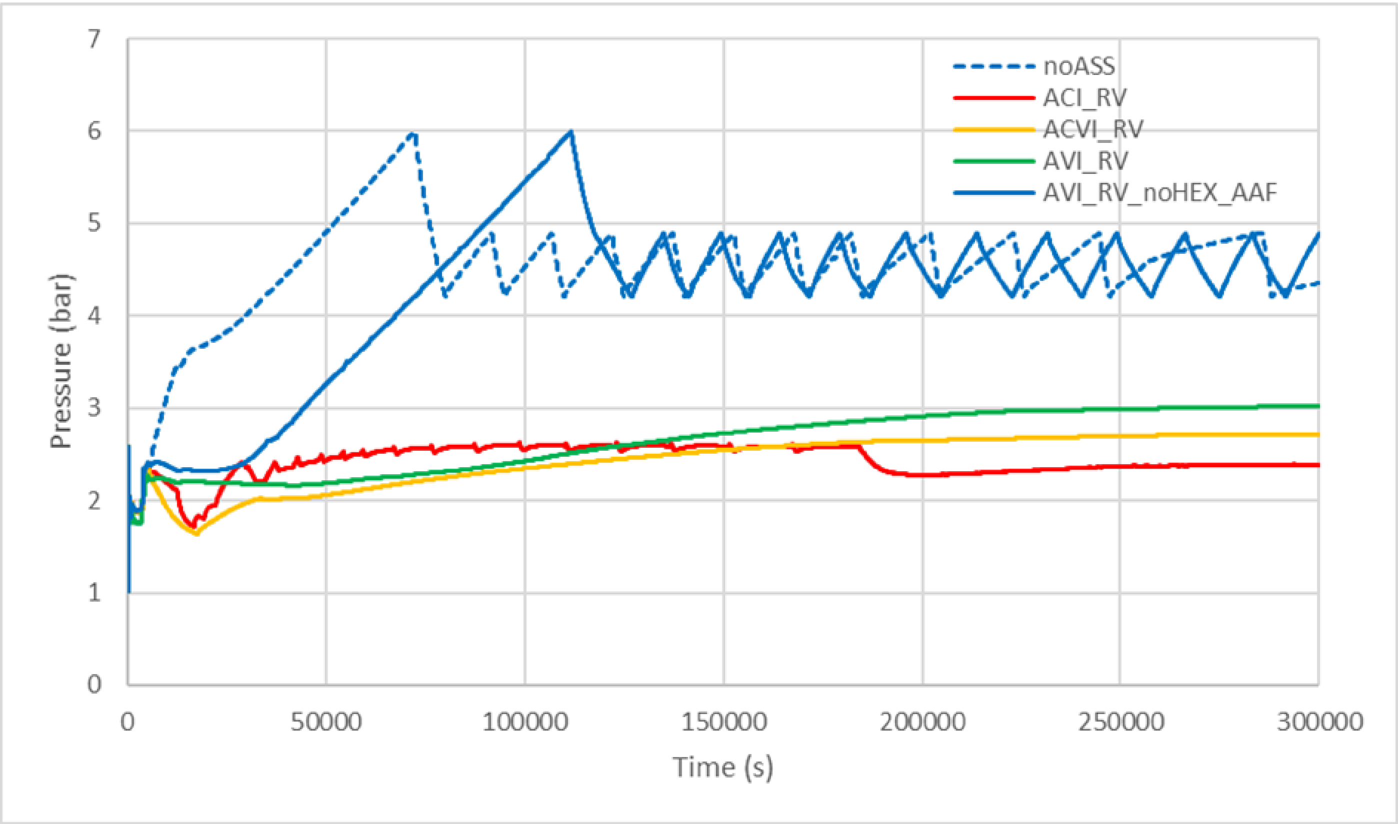
Simulation results

Chronology of main events

Event \ Scenario	Time (s)				
	noASS	ACI_RV	ACVI_RV	AVI_RV	AVI_RV_noHEX_AAF
Accumulators empty	83	82	82	83	81
Gap release	303	305	305	303	302
Core melting	888	927	927	888	874
RV failure	3467	3734	3734	3467	3614
ASS activated	/	5000	5000	5000	5000
PCFVS open	72263	/	/	/	111702
PCFVS open 2nd time	92700	/	/	/	135100

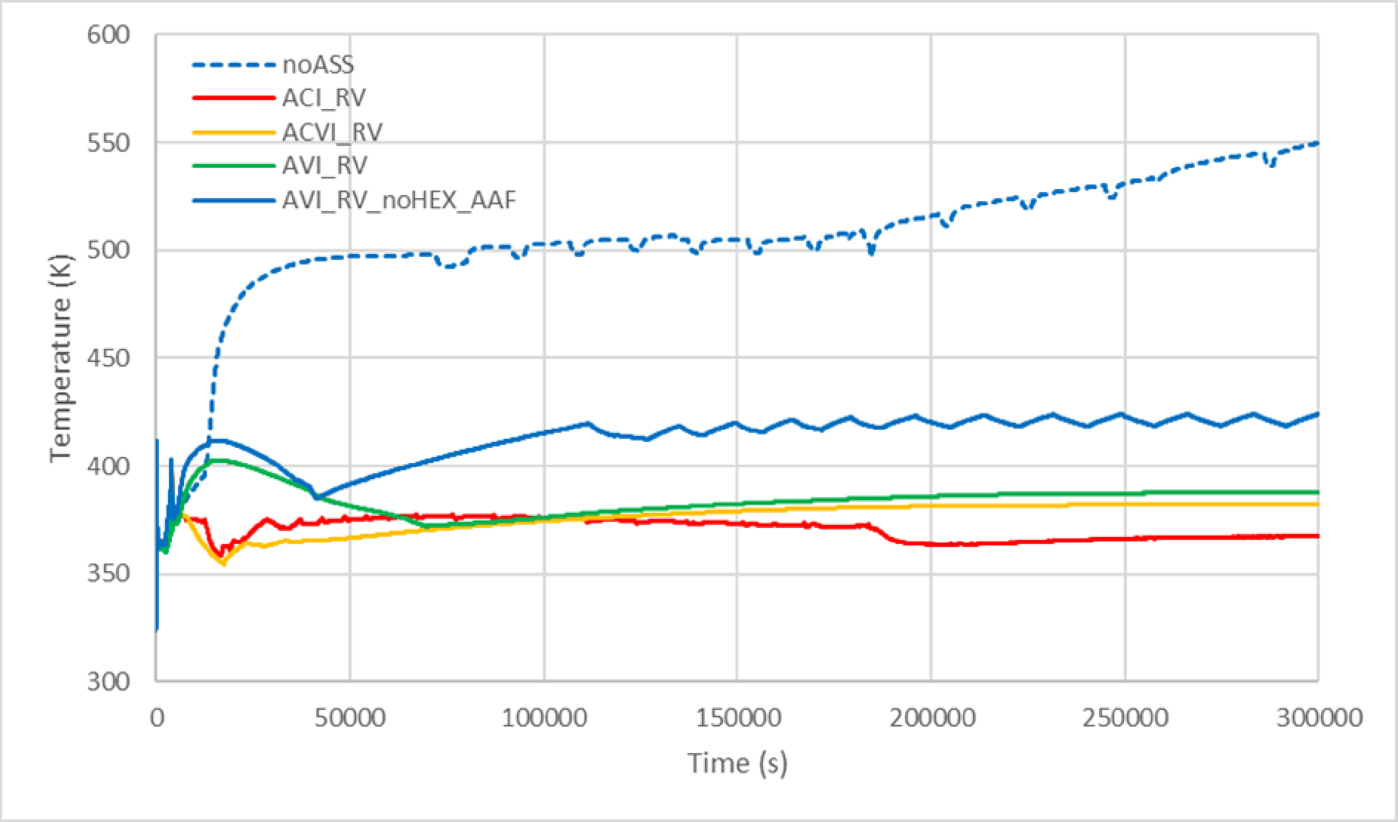
Differences for scenarios in period when they are still identical (first 5000 s) are due to numerical variance

Containment pressure



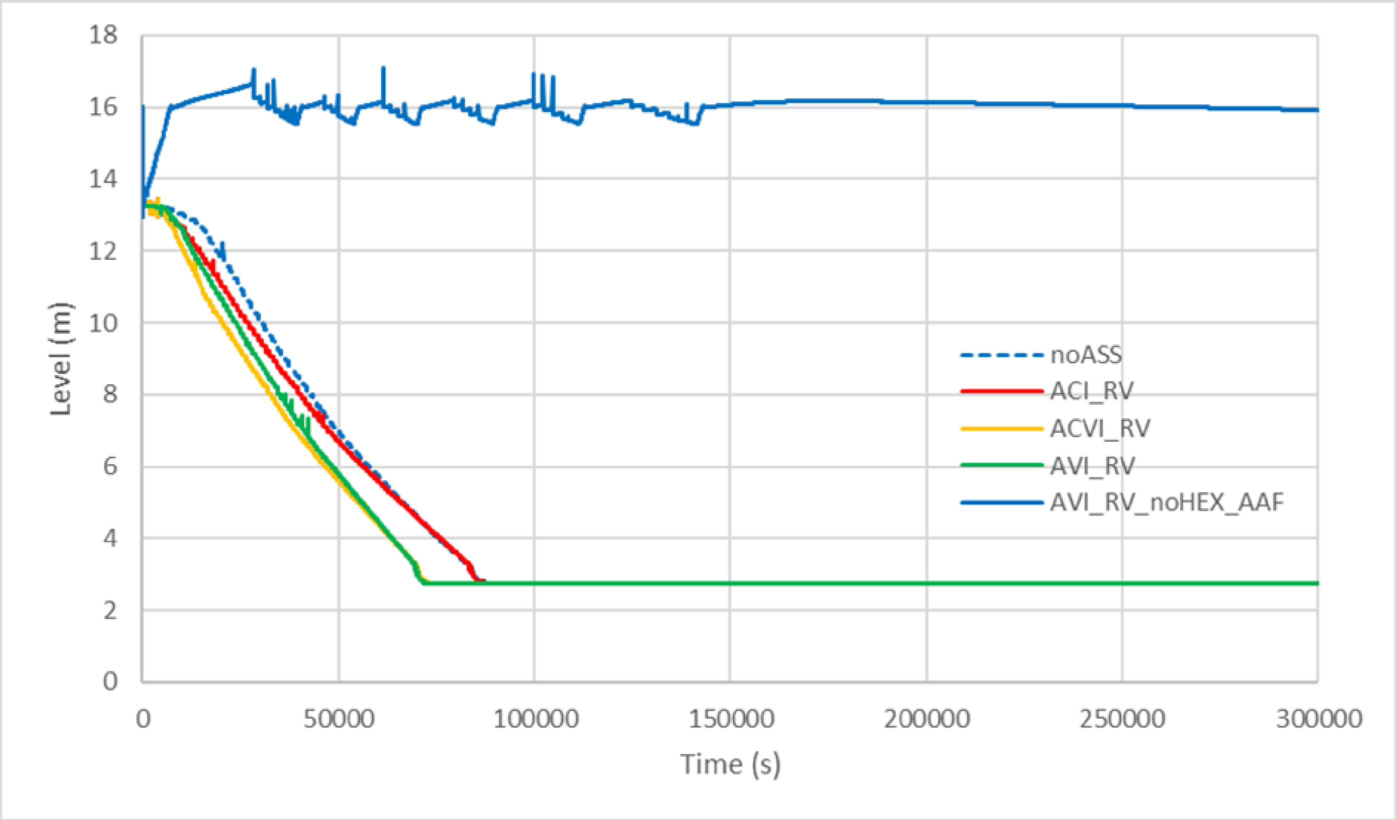
Cooling through steam generators by natural circulation of atmosphere in failed RCS is not sufficient to stabilize severe accident (AVI_RV_noHEX_AAF)

Containment temperature



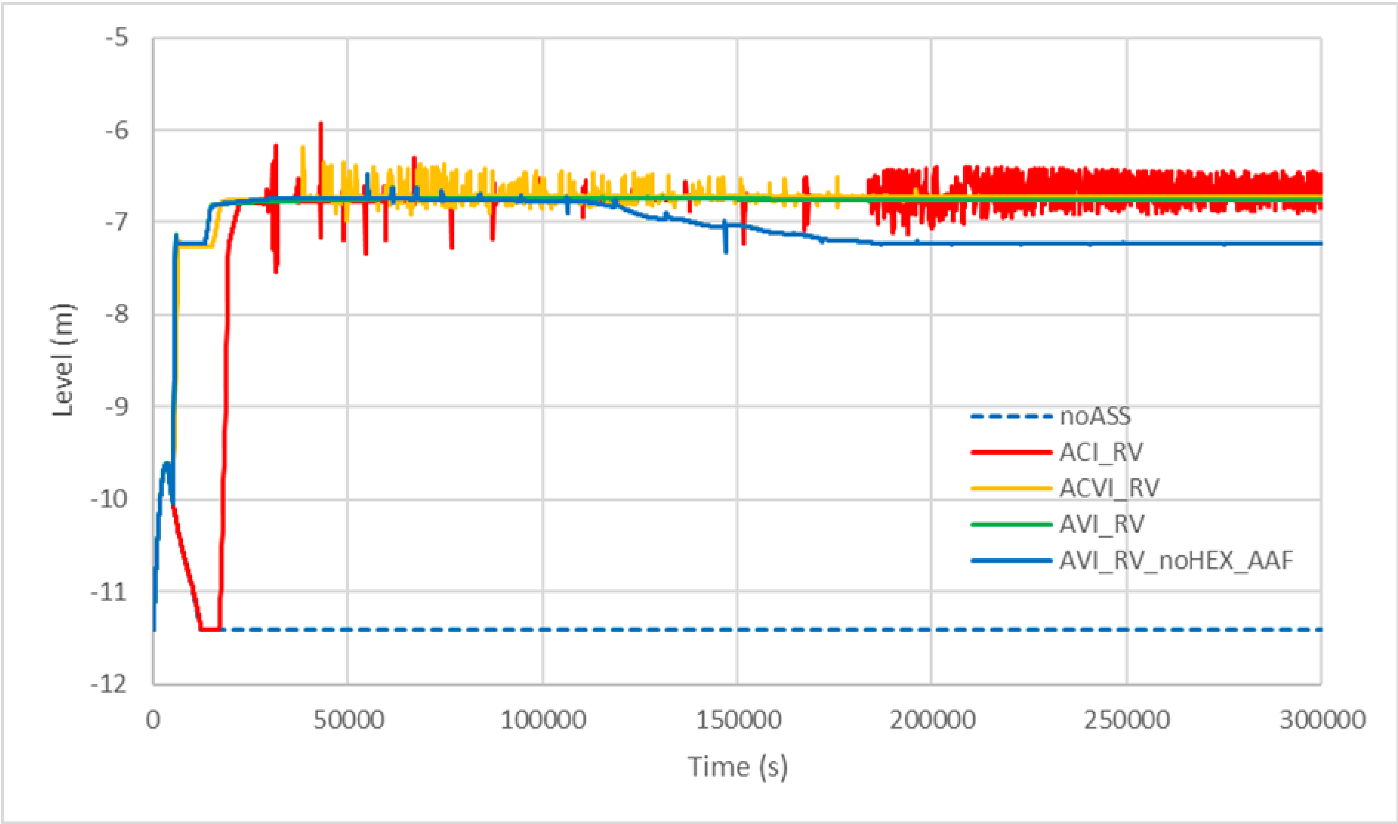
Heat transfer through containment walls not sufficient to extract the entire residual heat from the molten core (noASS)

Water level in steam generator 2



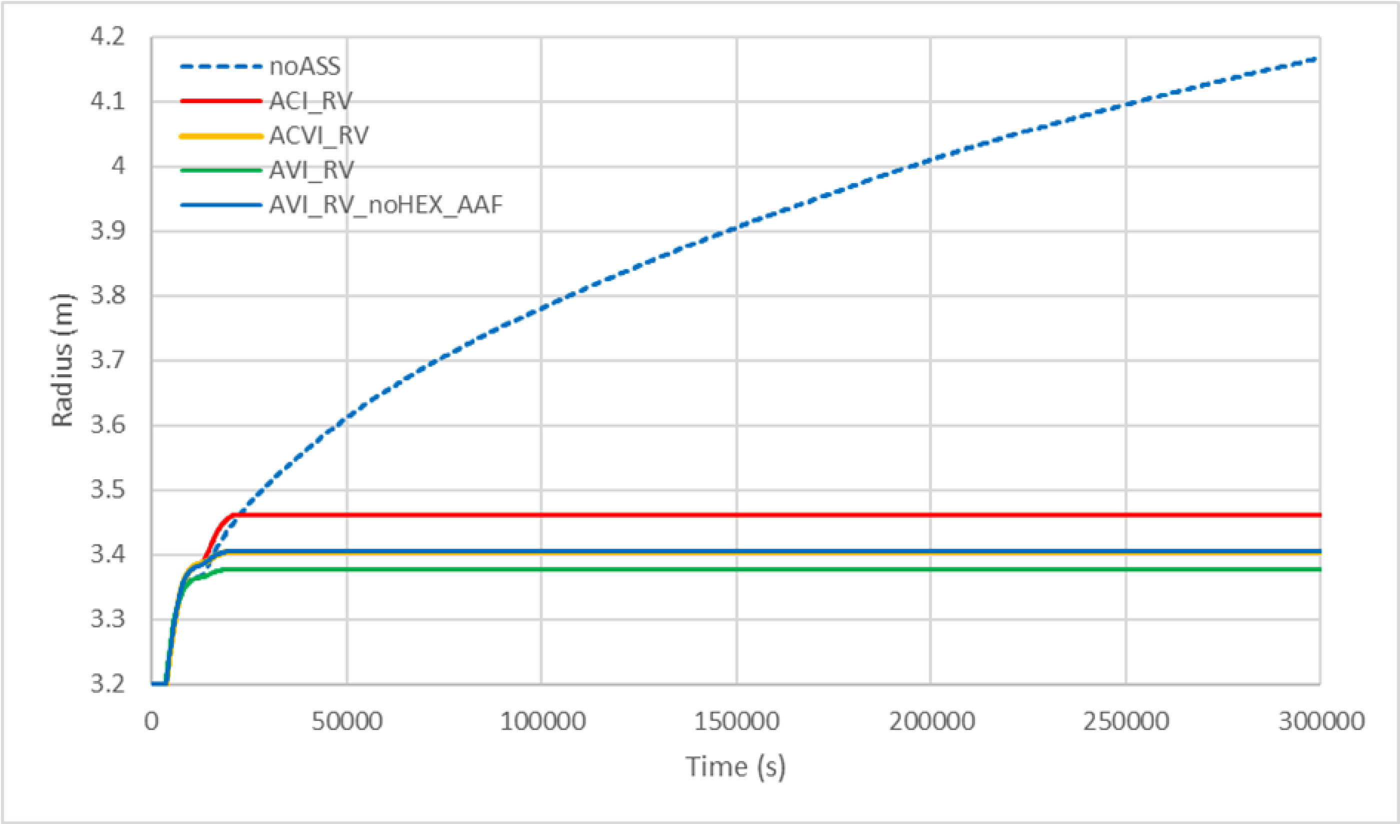
In second loop of RCS with large break natural circulation of atmosphere develops, which transfers heat from containment atmosphere to water in second steam generator

Water level in reactor cavity



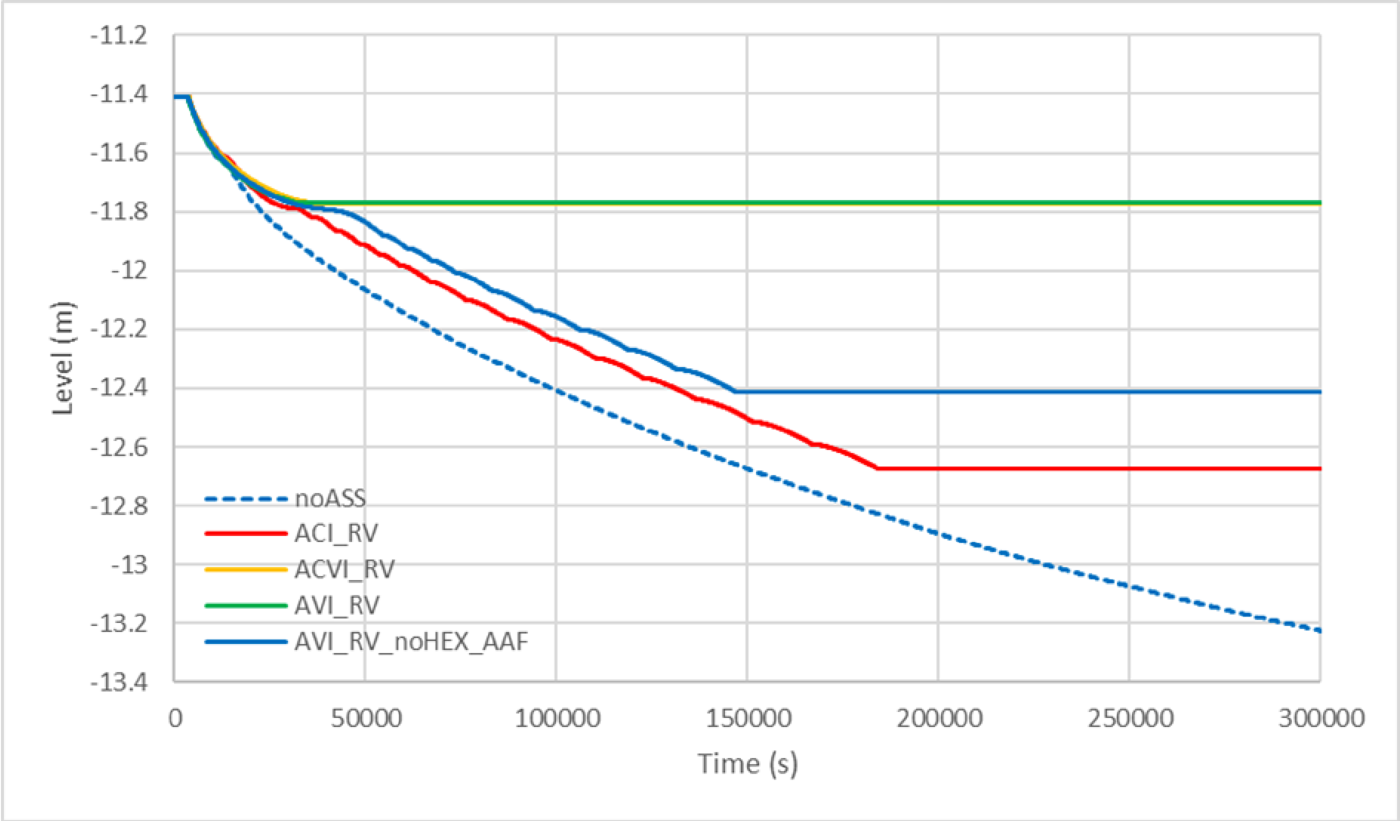
In scenario ACI_RV reactor cavity dries out for more than one hour before it is flooded again

Radius of eroded reactor cavity



In scenario ACI_RV, where the molten core dries out for more than one hour before it is flooded again, the extend of the MCCI is significantly larger

Bottom level of eroded cavity



Small differences in flooding conditions influence characteristics of molten core concrete mixture, which influence the MCCI. Consequently, MCCI is very sensitive on flooding conditions.

Conclusions

- Analysis of unmitigated and mitigated SBO+LBLOCA scenarios performed with MELCOR 2.2
  - Mitigation measures for heat removal from containment solely by DEC alternative safety systems considered
  - Main focus given to MCCI
- MCCI in reactor cavity can be stopped if molten core is flooded soon after it is released from the failed reactor vessel
- Extend of MCCI sensitive on the flooding time
  - In scenarios, where water is injected into RCS RV, molten corium remains flooded all the time
  - In scenario, where water is injected solely through containment sprays, reactor cavity dries out before molten core is flooded again, resulting in much more extensive MCCI
- In loop of RCS system where large break occurs, natural circulation of atmosphere develops
  - Heat transfer by steam generator not enough to remove all residual heat from molten core and to stabilize SA
- In mitigated scenarios with operable ARHR HEX, SA could be stabilized and no releases into environment occurred
  - For mitigation of SA it is important to activate the available safety systems as soon as possible

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