Thermal-hydraulic analysis of the LORELEI test device for the Jules Horowitz Reactor

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October 23th, 2017

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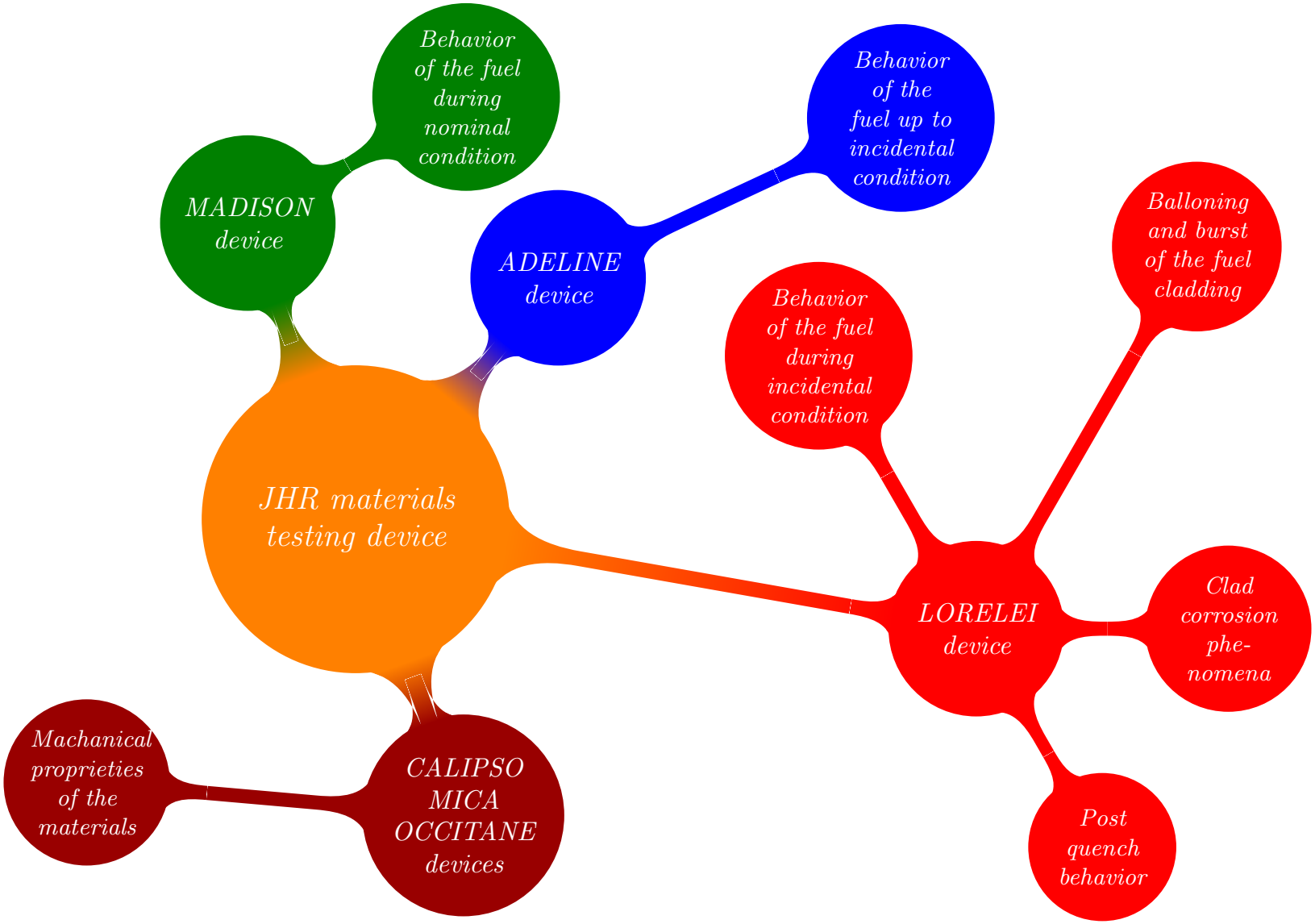
Objective:
The objective of this work has been to model the entire LORELEI device and subsequently, to perform numerical simulations in order to identify the best and appropriate thermal-hydraulic conditions to conduct the the experimental phase which the device undergoes.

Method:
The simulations have been carried on with the code CATHARE2 (Code for Analysis of Thermohydraulics during Accident of Reactor and safety Evaluation). This code takes into account the two-phase flow behavior and it is based on a two-fluid and six-equations model. The code solves three equations for each phase: energy, mass and momentum

JHR materials testing device



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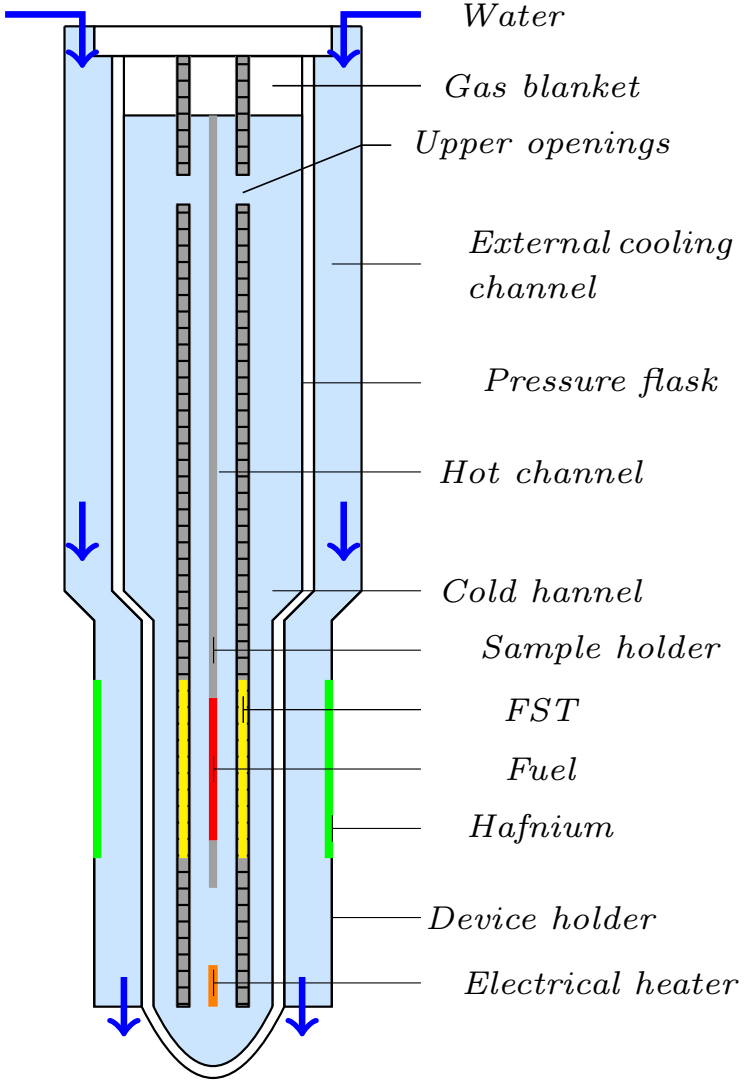
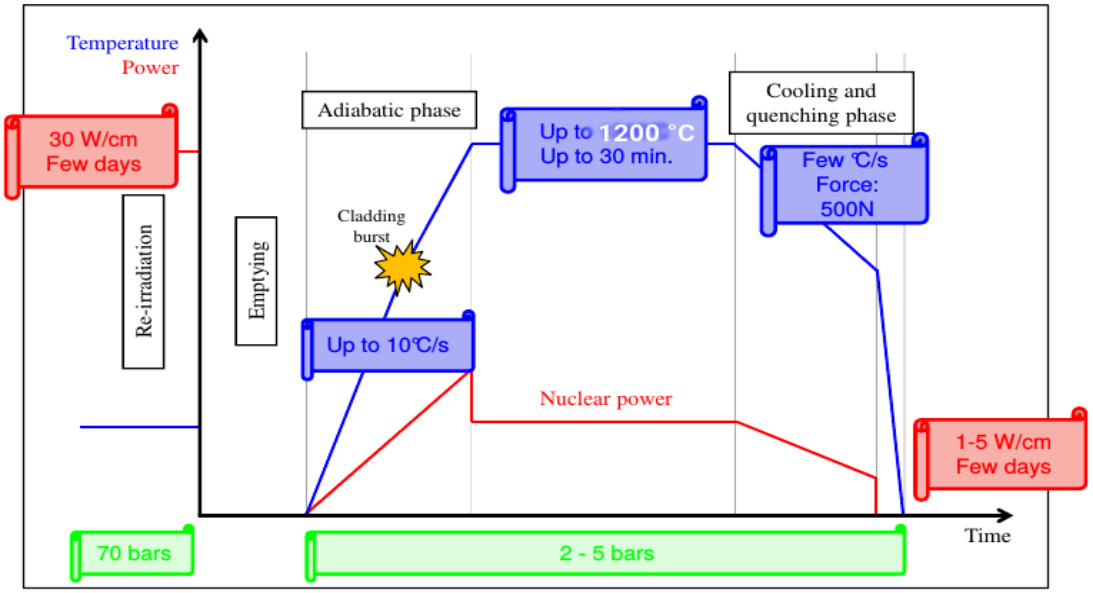
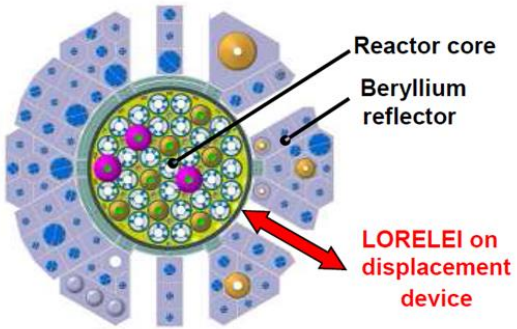
Light-Water One-Rod Equipment for LOCA Experimental Investigation

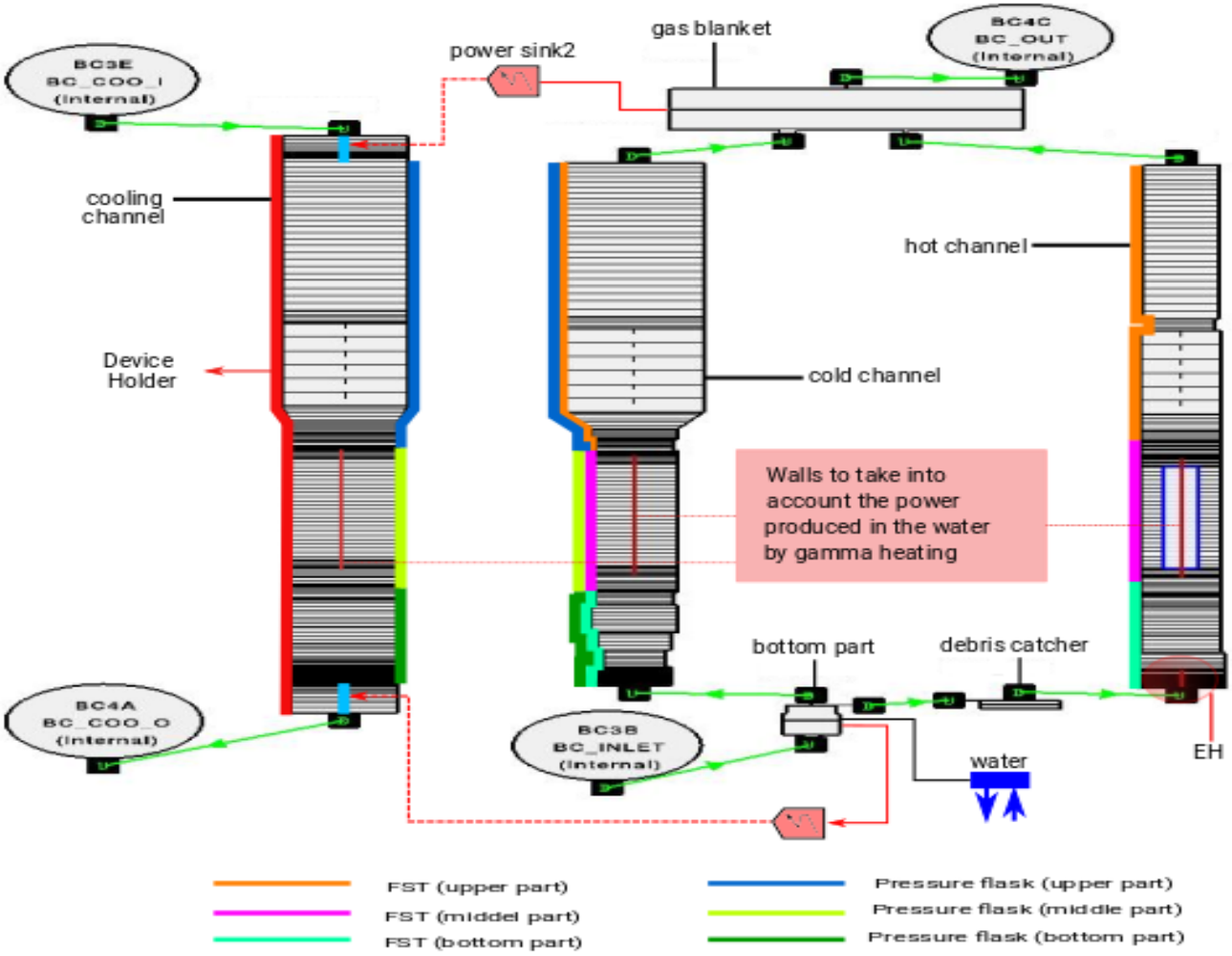


The experimental sequence of LORELEI





Modeling of LORELEI with CATHARE



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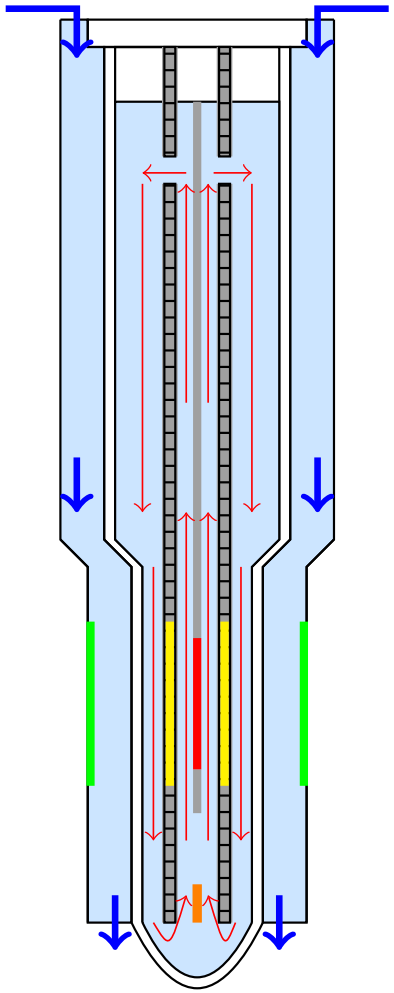
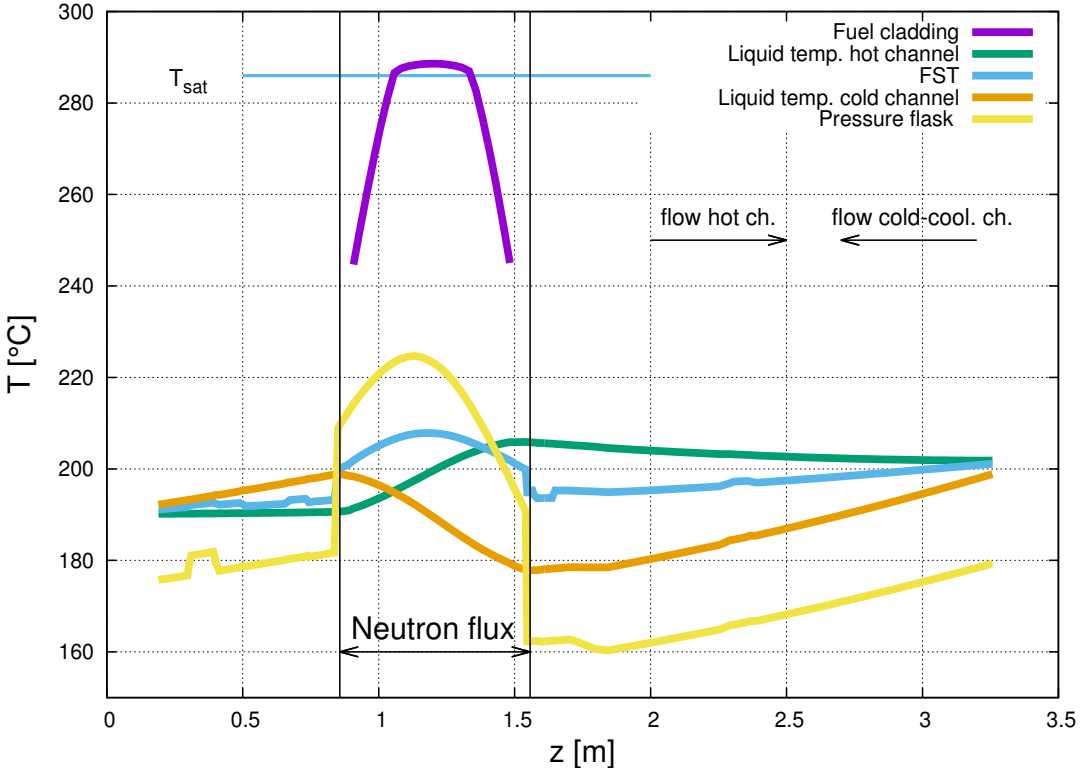
Re-irradiation phase

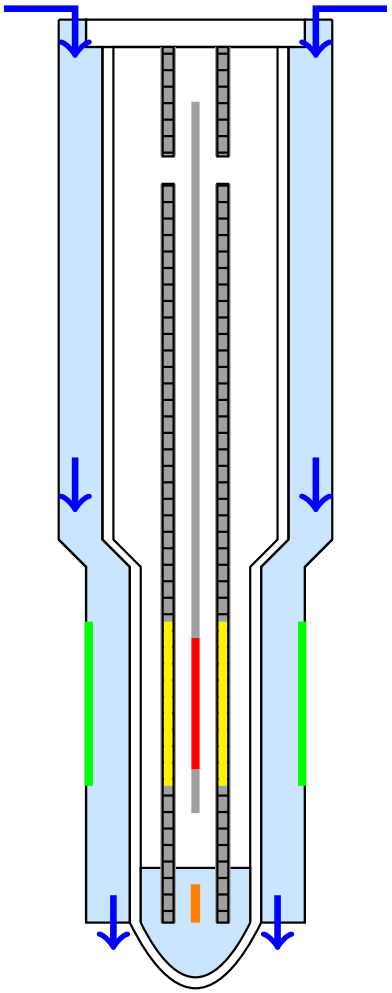


LHGR=40W/cm, P=70bar, x=14.9cm

Map of temperatures



Dry phase



Emptying phase:

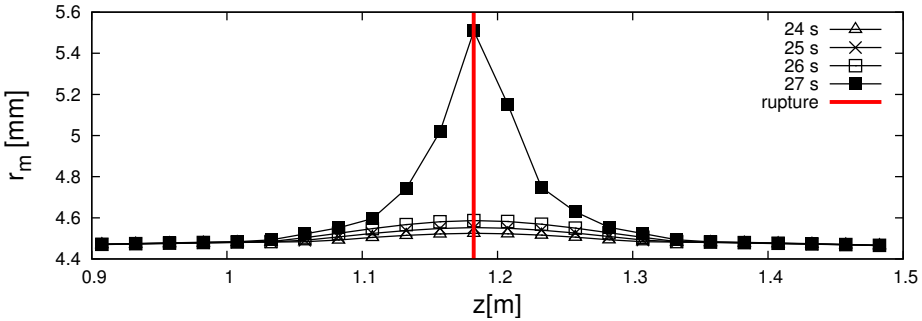
- Gas injection (He), emptying the test device at low pressure $P \approx 3\ bar$
- Nearly 1.2 l of water remains at the bottom of the device in order to produce steam by an electrical heater.

Heat-up:

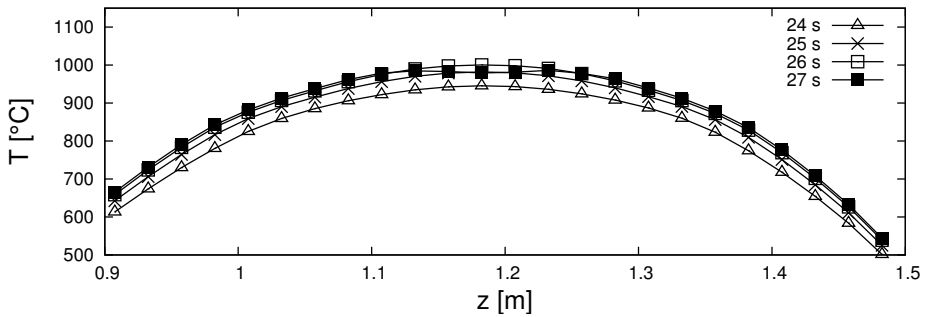
- The heat-up phase at 10 to 20°C/s (if possible) will be monitored by adjusting the distance of the apparatus from the core.
- An ON/OFF type- regulator was implemented to maintain the center of the fuel cladding at 1200 °C (set point value) with a maximum permissible error of ± 50 °C.

Dry phase

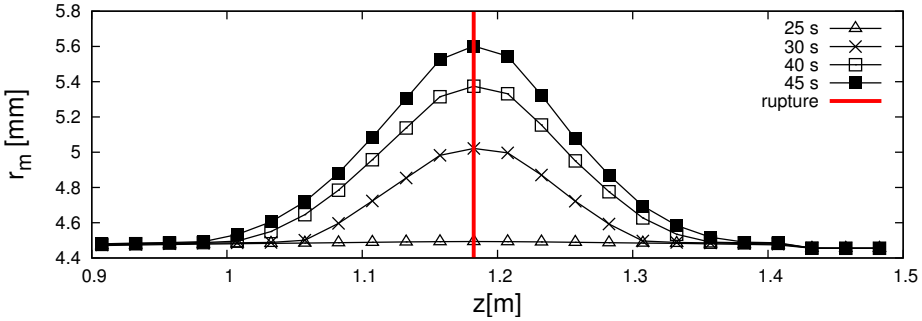
Cladding radius, P_{EH}=1 kW



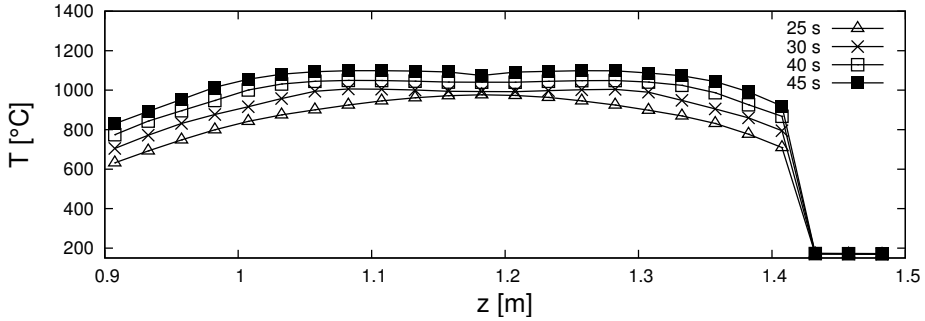
Cladding temperature, P_{EH}=1 kW



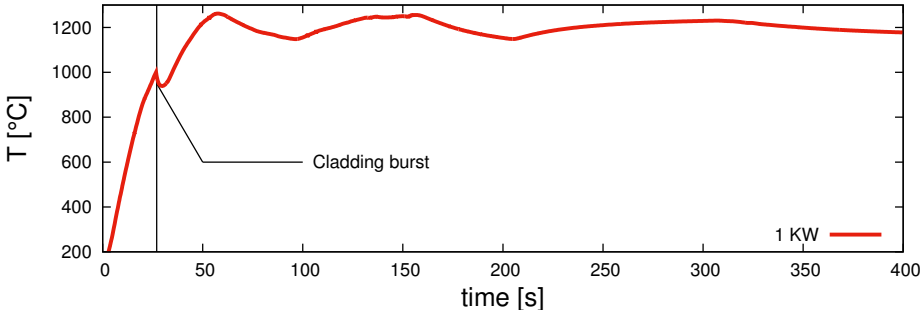
Cladding radius, P_{EH}=2 kW



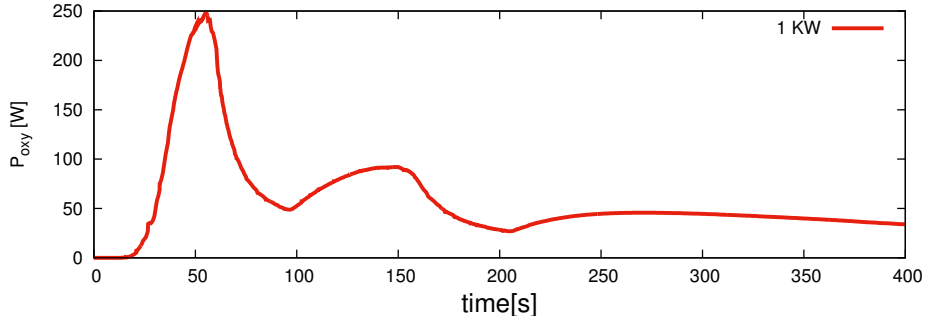
Cladding temperature, P_{EH}=2 kW



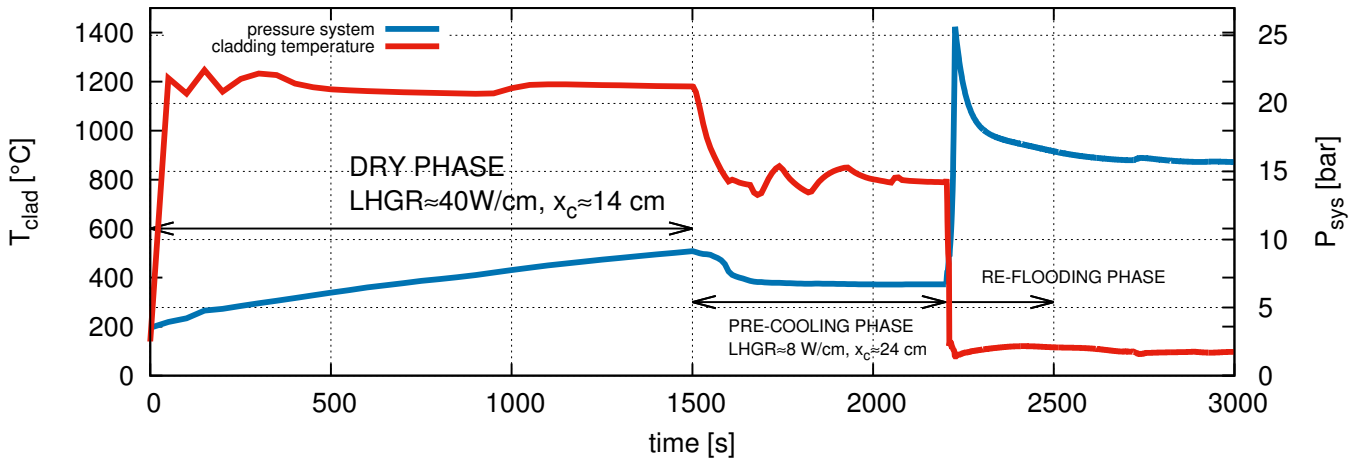
Cladding temperature (central node), P_{EH}=1 kW

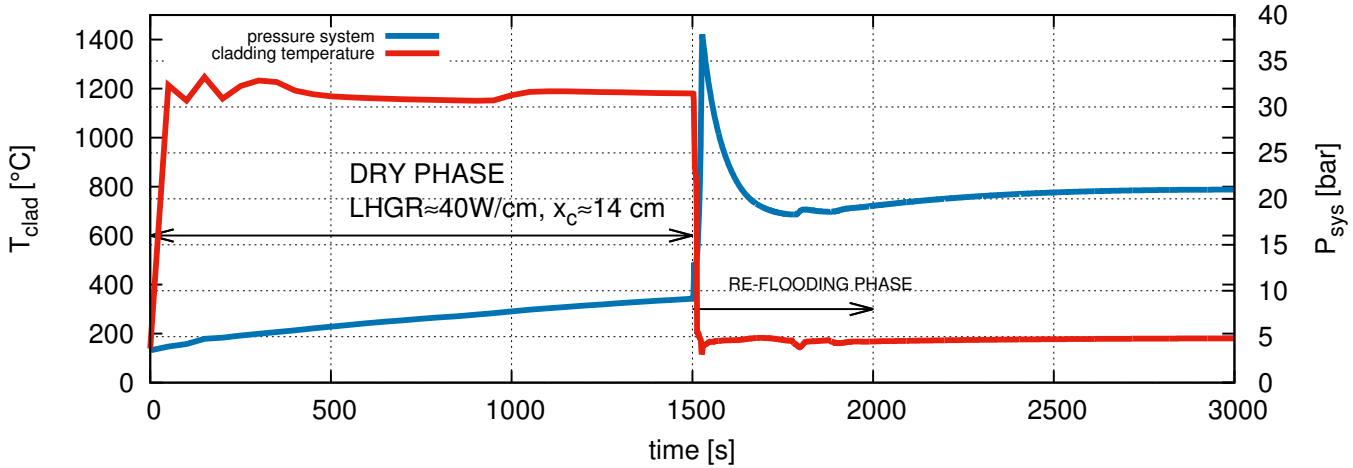


Oxidation power (Cathcart-Pawel), P_{EH}=1 kW



Fuel cladding temperature and pressure evolution





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Some important results achieved

Re-irradiation phase

By means of a proper modeling of the device, it has been possible to study the map of the temperature of the all thermal structures inside the device and the limit of the thermosyphon liquid flow.

Dry phase

It has established the time of activation of the electrical heater and the power to inject inside of it. The results have shown that some problems of condensation along the hot channel, might perturb the fuel cladding temperature profile.

Quenching phase

A preliminary analysis of the Quenching phase has shown the evolution of the fuel cladding temperature and the internal pressure of the system.

Thank you for your attention

Publications:

P Battistoni, D Tarabelli, L Ferry, C Gonnier, S Manservisi, and M Sumini. Thermal- hydraulic analysis of the LORELEI test design by means of CATHARE2 V2.5. *Nuclear Engineering and Design*, 322:397-411, 2017.

P Battistoni, M Sumini, S Manservisi, M Di Giuli, C Gonnier, L Ferry, and D Tarabelli. Preliminary study of the LORELEI test device with the CATHARE2 code. In *24 th International Conference Nuclear Energy for New Europe, NENE, 2015.*