QUENCH-11 test
Quench Phase

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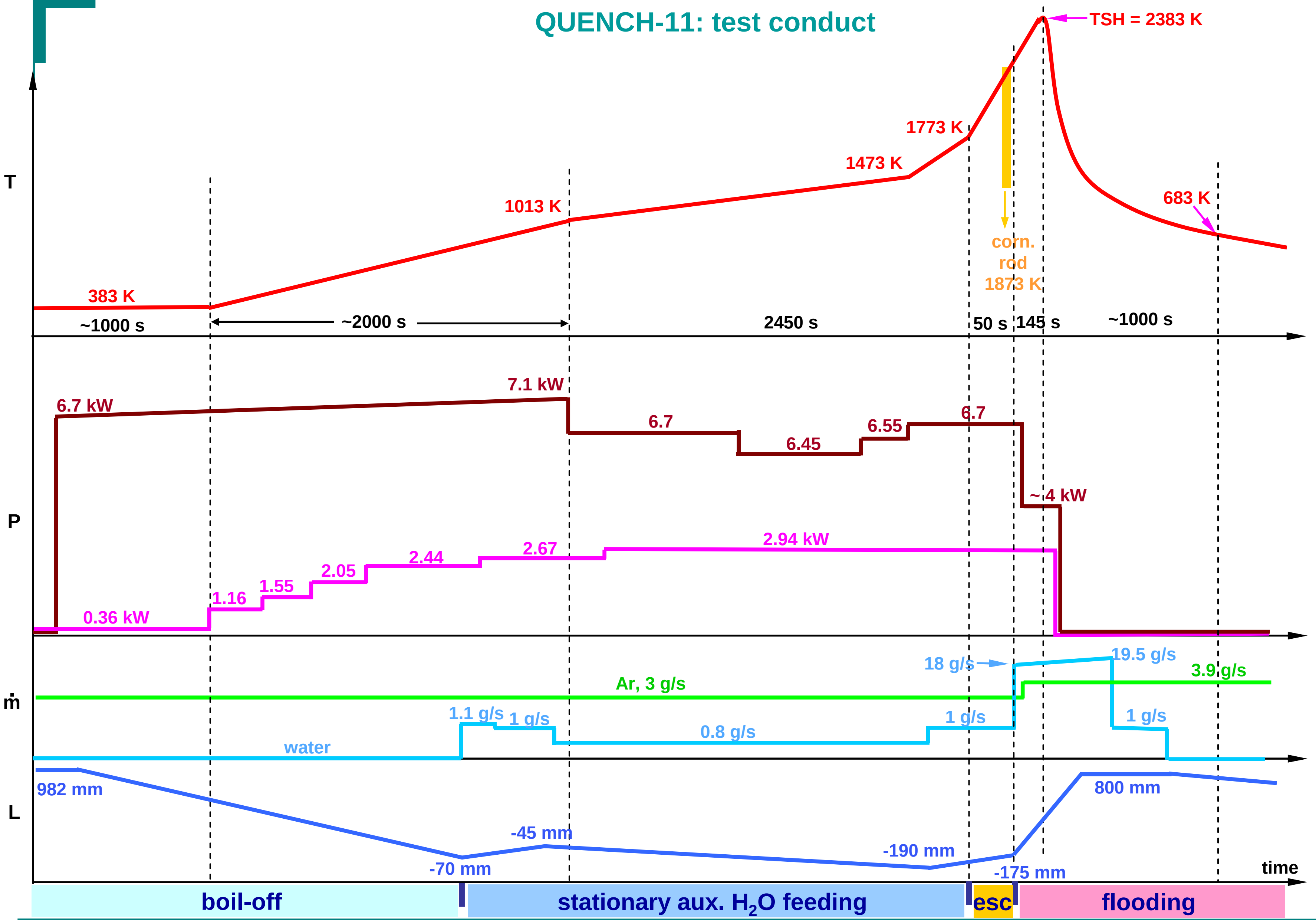
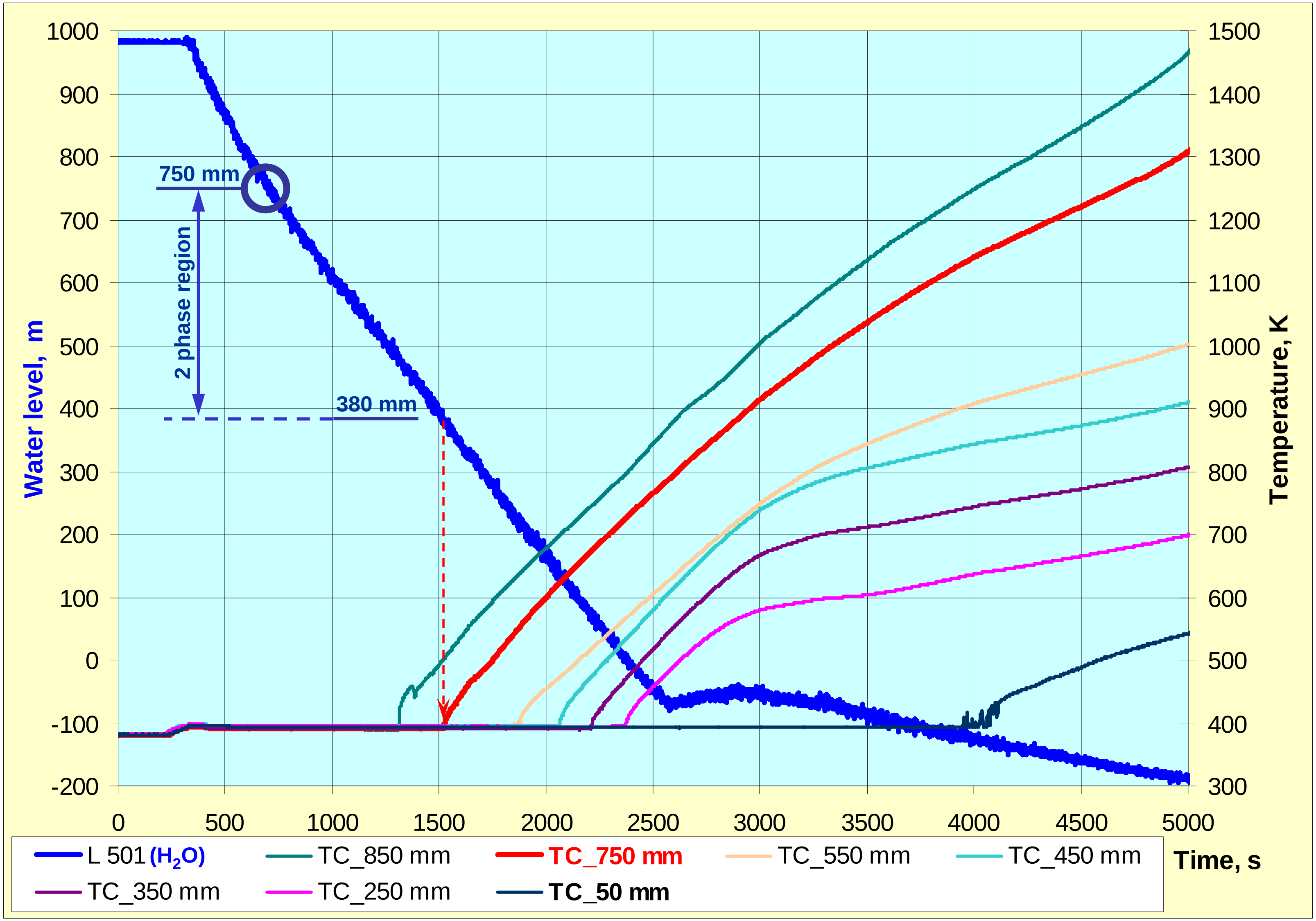
Objectives of the QUENCH-11 test

- **simulation of a depressurised plant sequence in which the core would be essentially dried-out**
- **limited steam flow due to boiling of residual water**
- **simulation of reflood situations with a <u>low mass flow rate</u>**

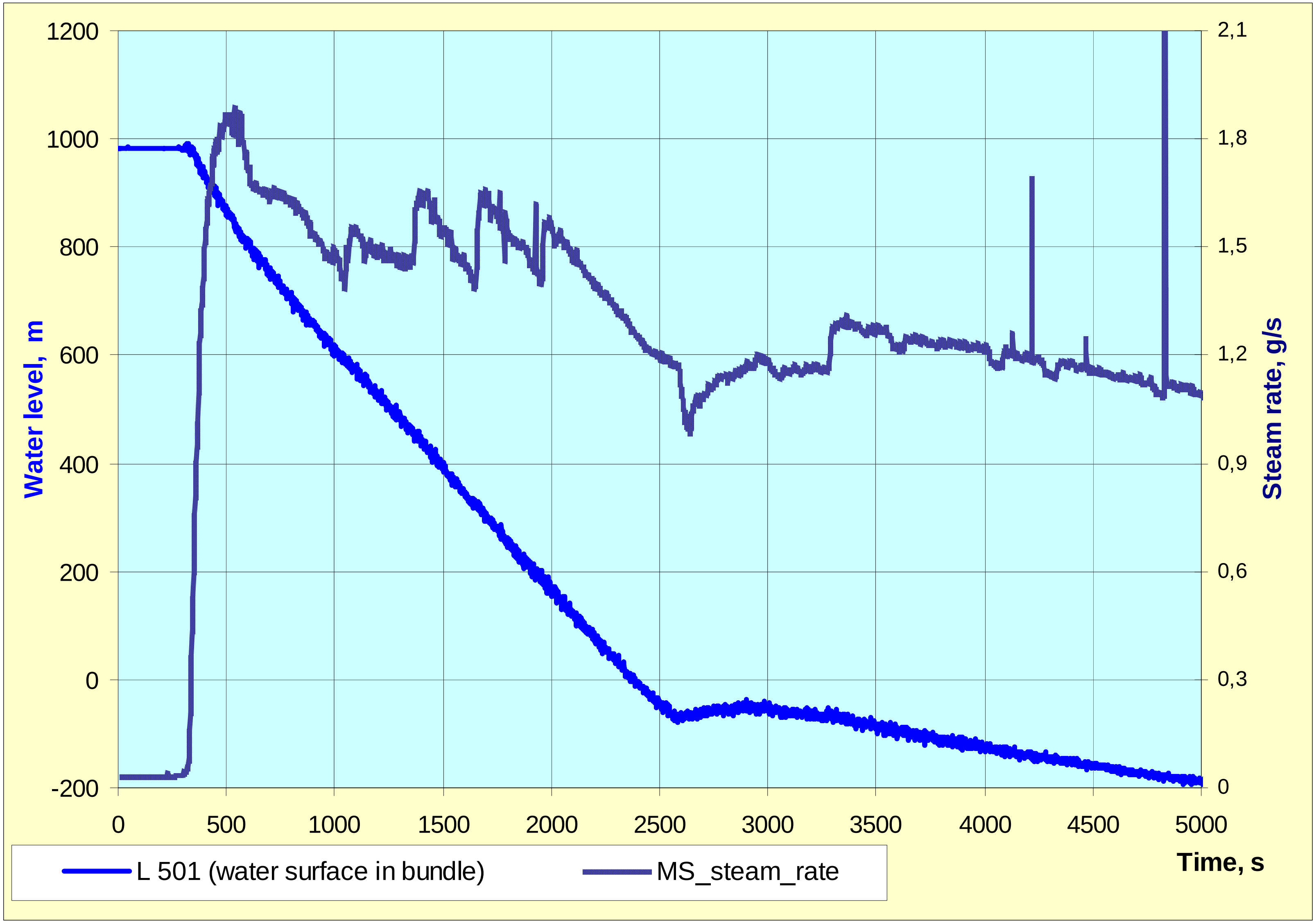
QUENCH-11: test conduct



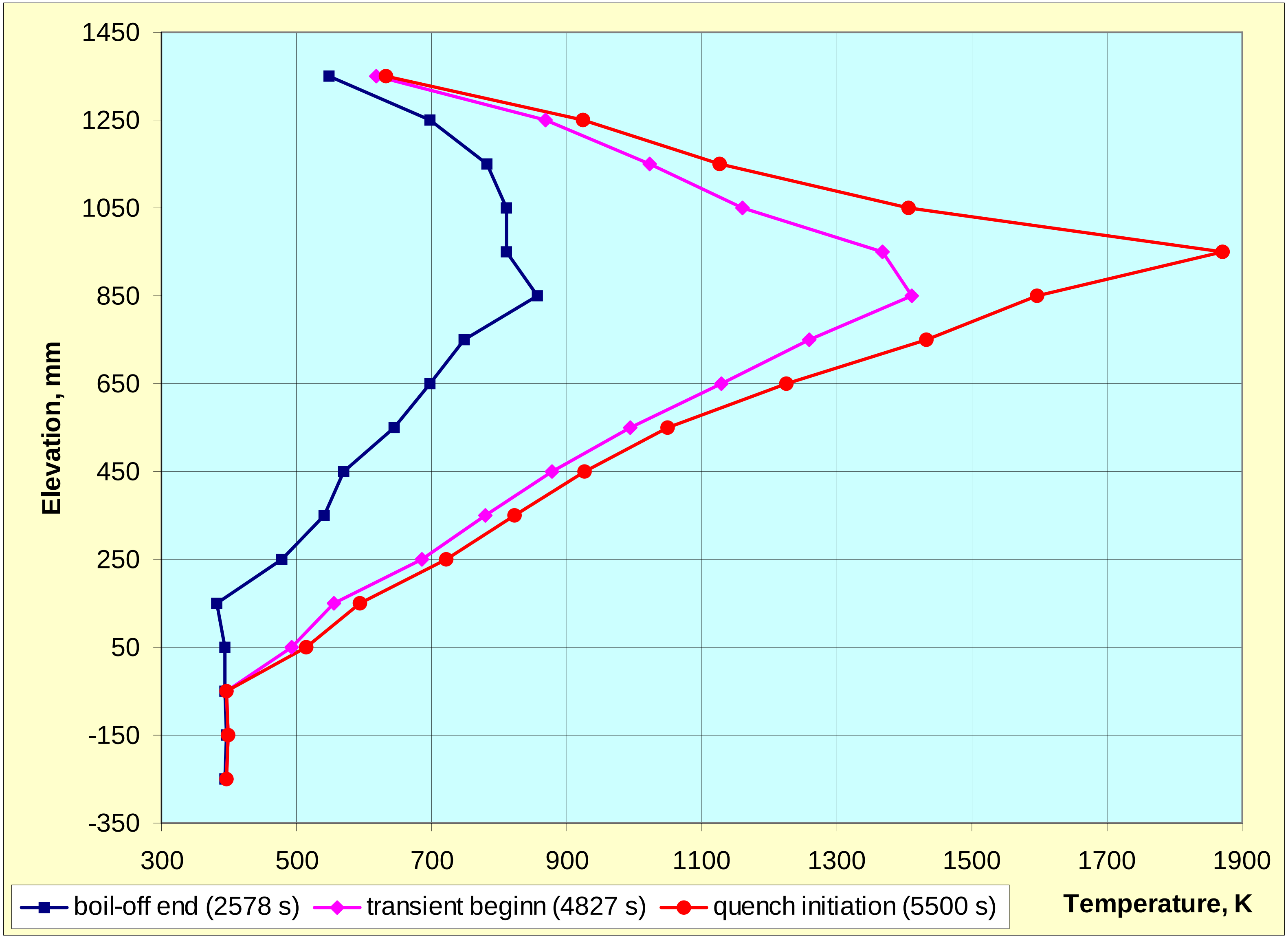
QUENCH-11, boil-off phase: delayed TC reaction on the falling water surface due to two-phase region above the water surface.



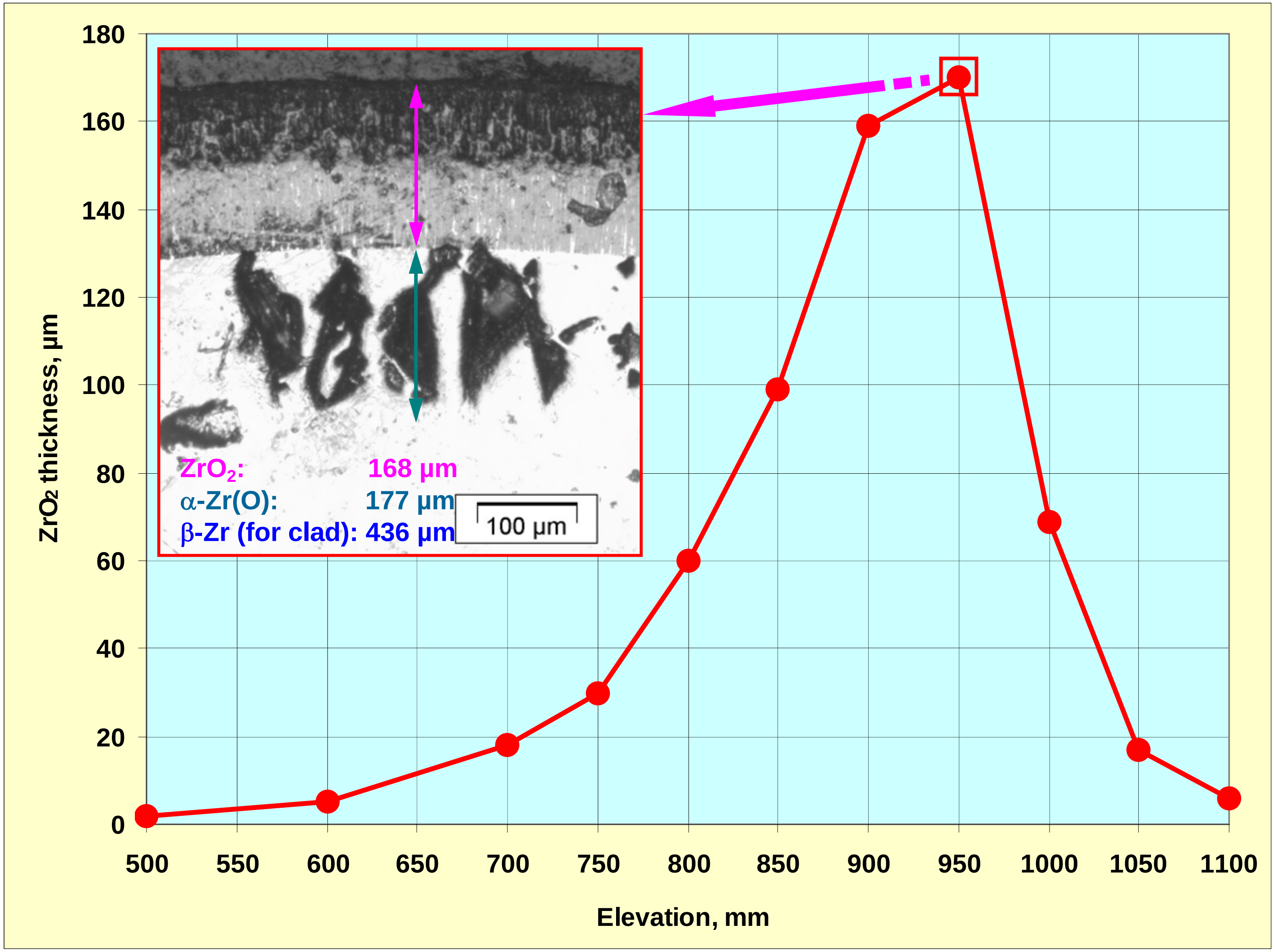
QUENCH-11, boil-off phase: steam generation due to evaporation



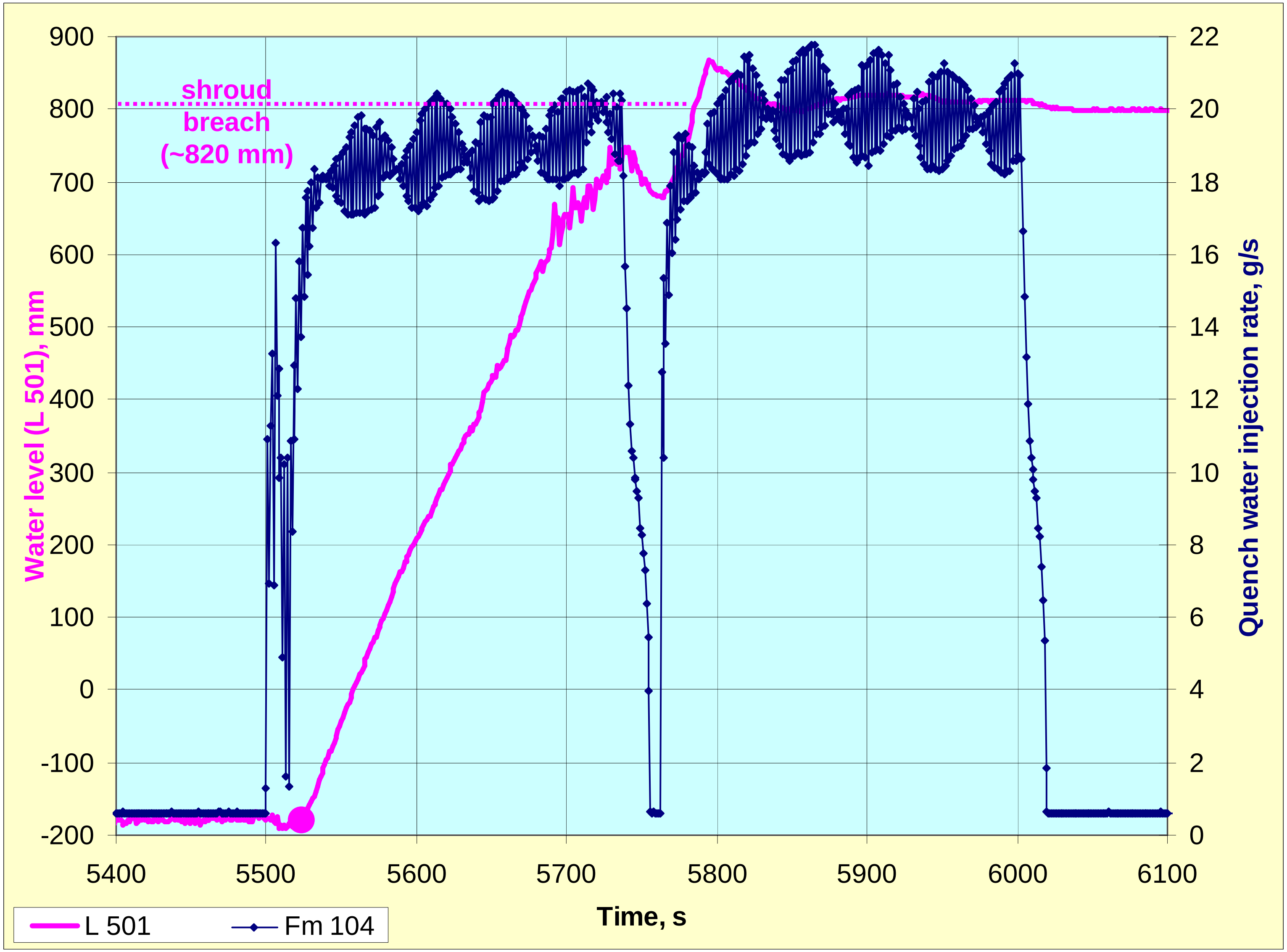
QUENCH-11: axial temperature profiles



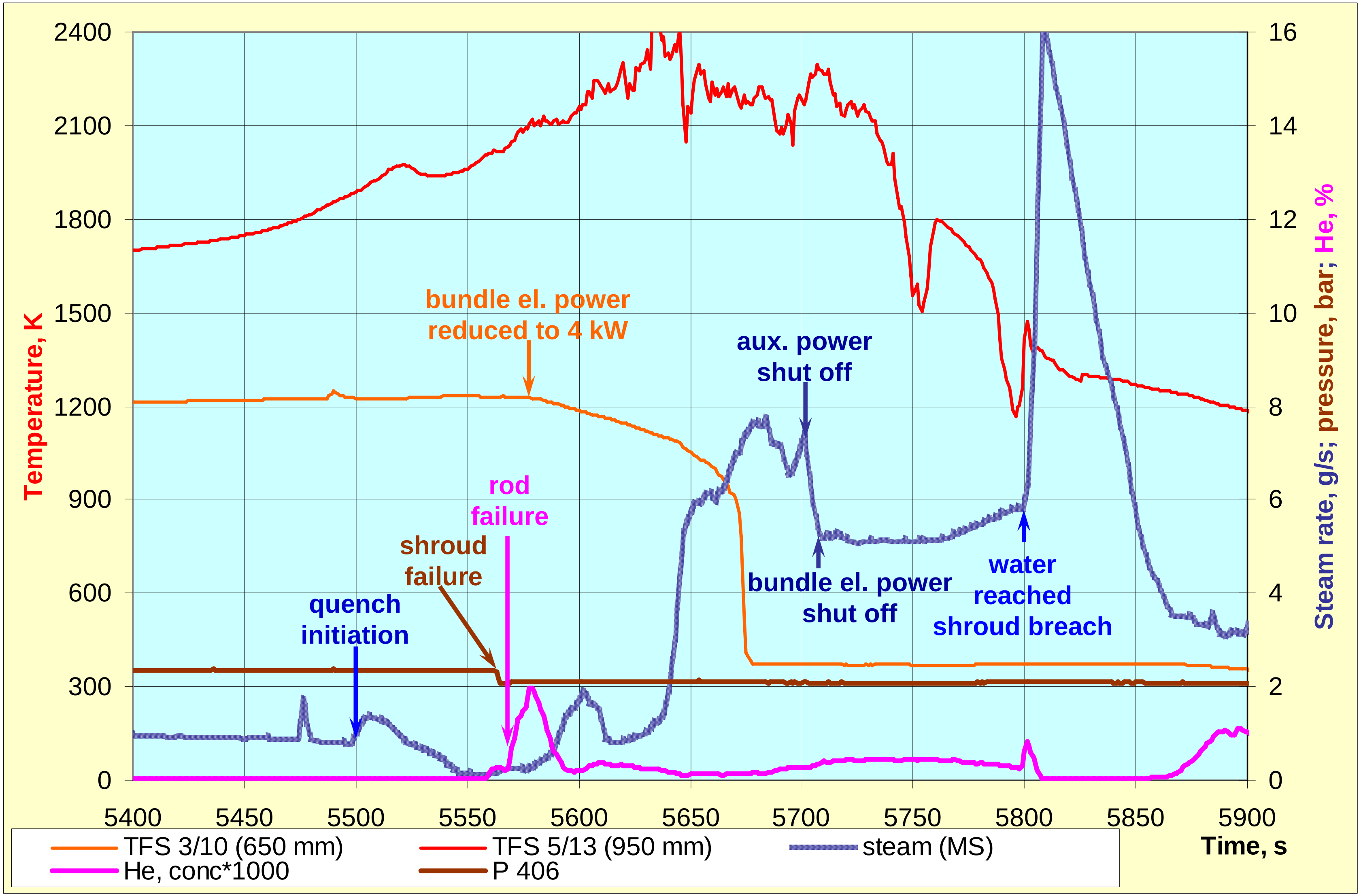
QUENCH-11: appearance of the corner Zry-rod, withdrawn from the bundle prior to the quench phase. Thin, not spalled oxide layer. Thick β-Zry layer.



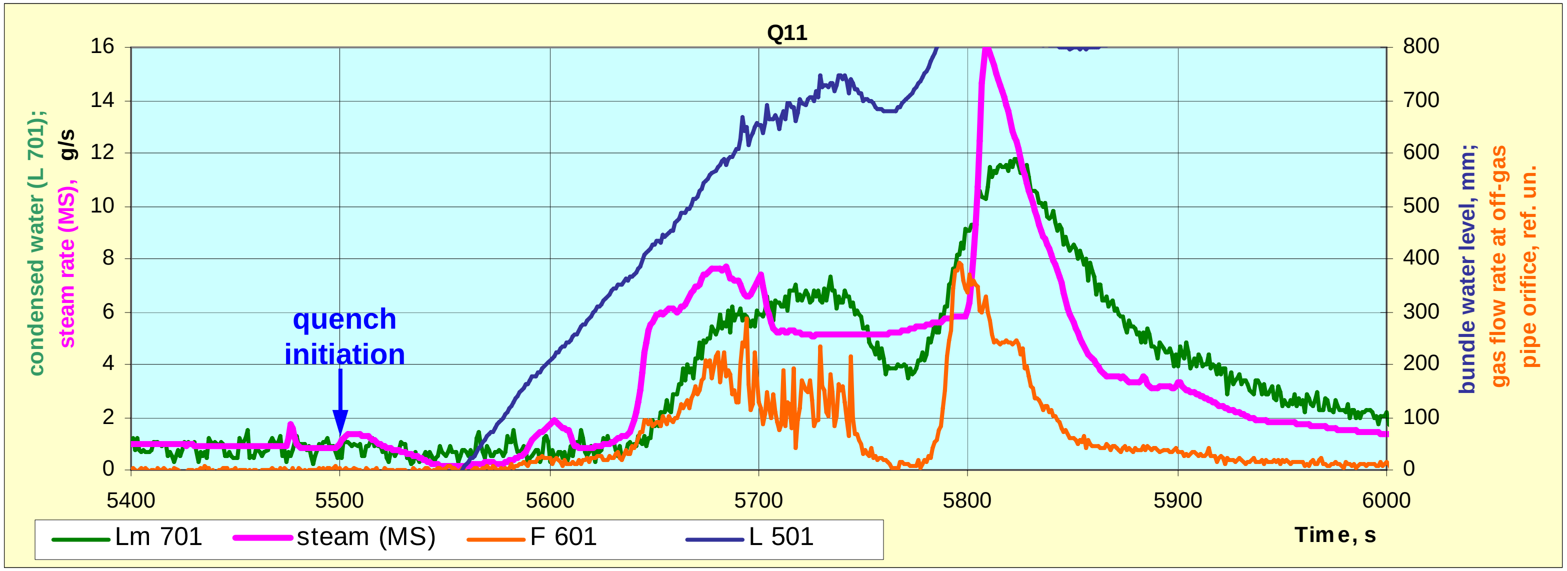
QUENCH-11, quench phase: slow flooding rate (18 – 20 g/s). Water level increase rate: ~4.5 cm/s

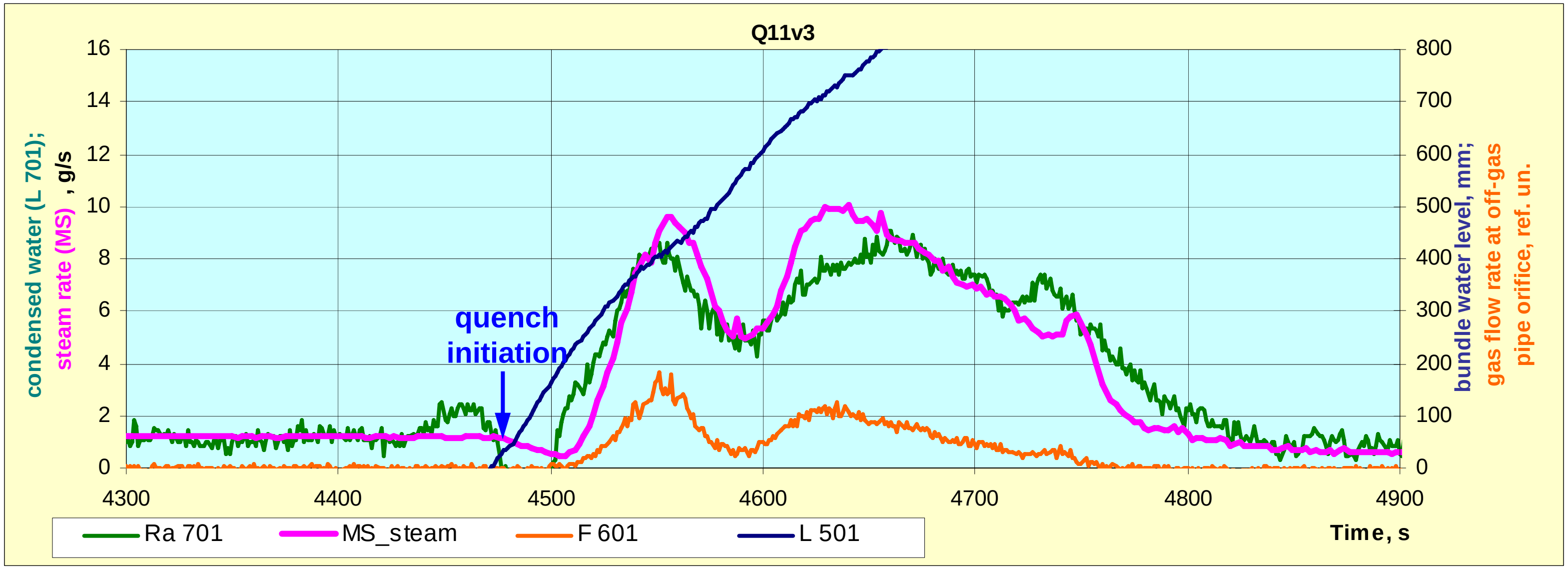


QUENCH-11, quench phase: sequence of events

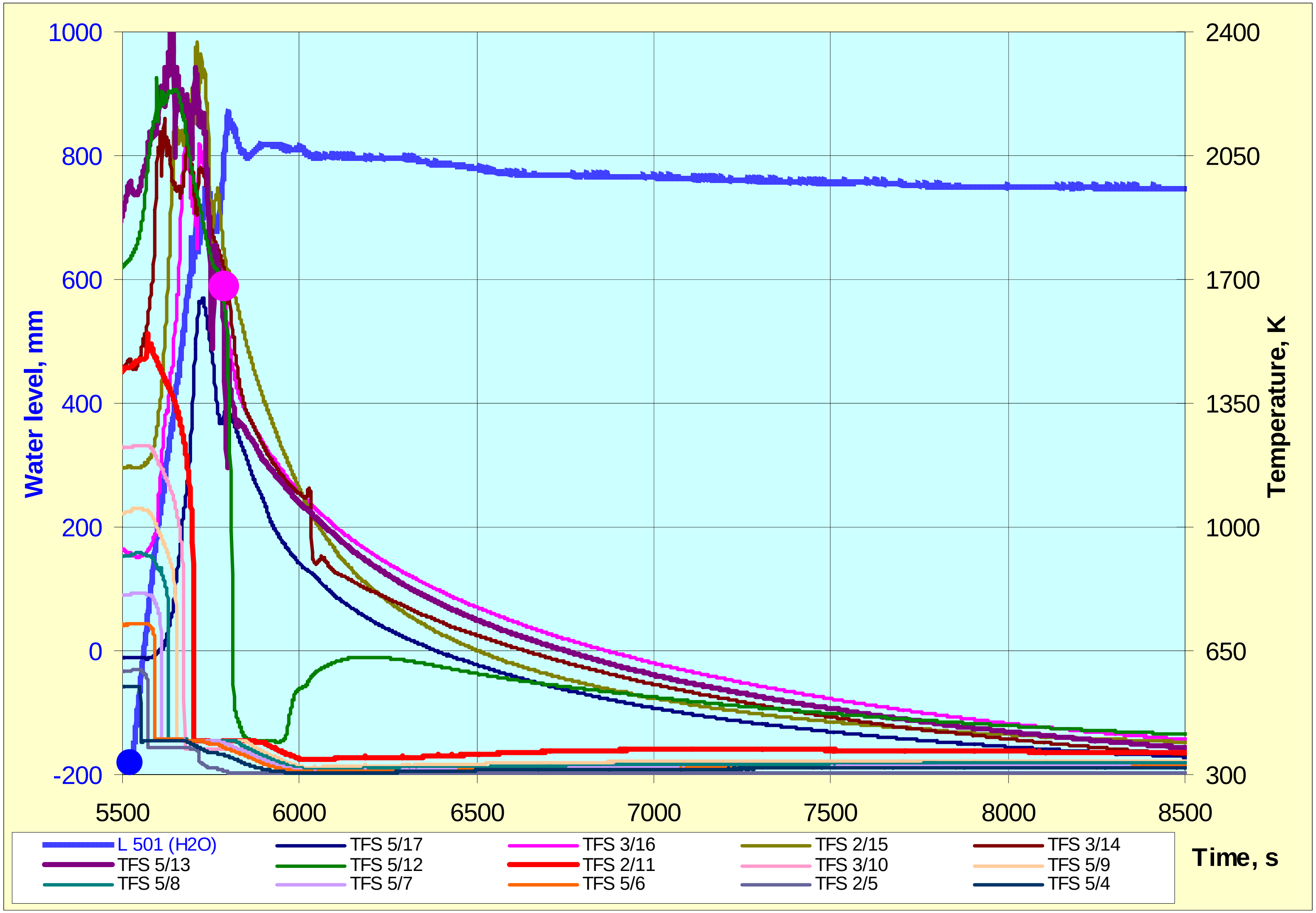


QUENCH-11, quench phase: different detection of steam production. Comparison with pre-test Q11v3.

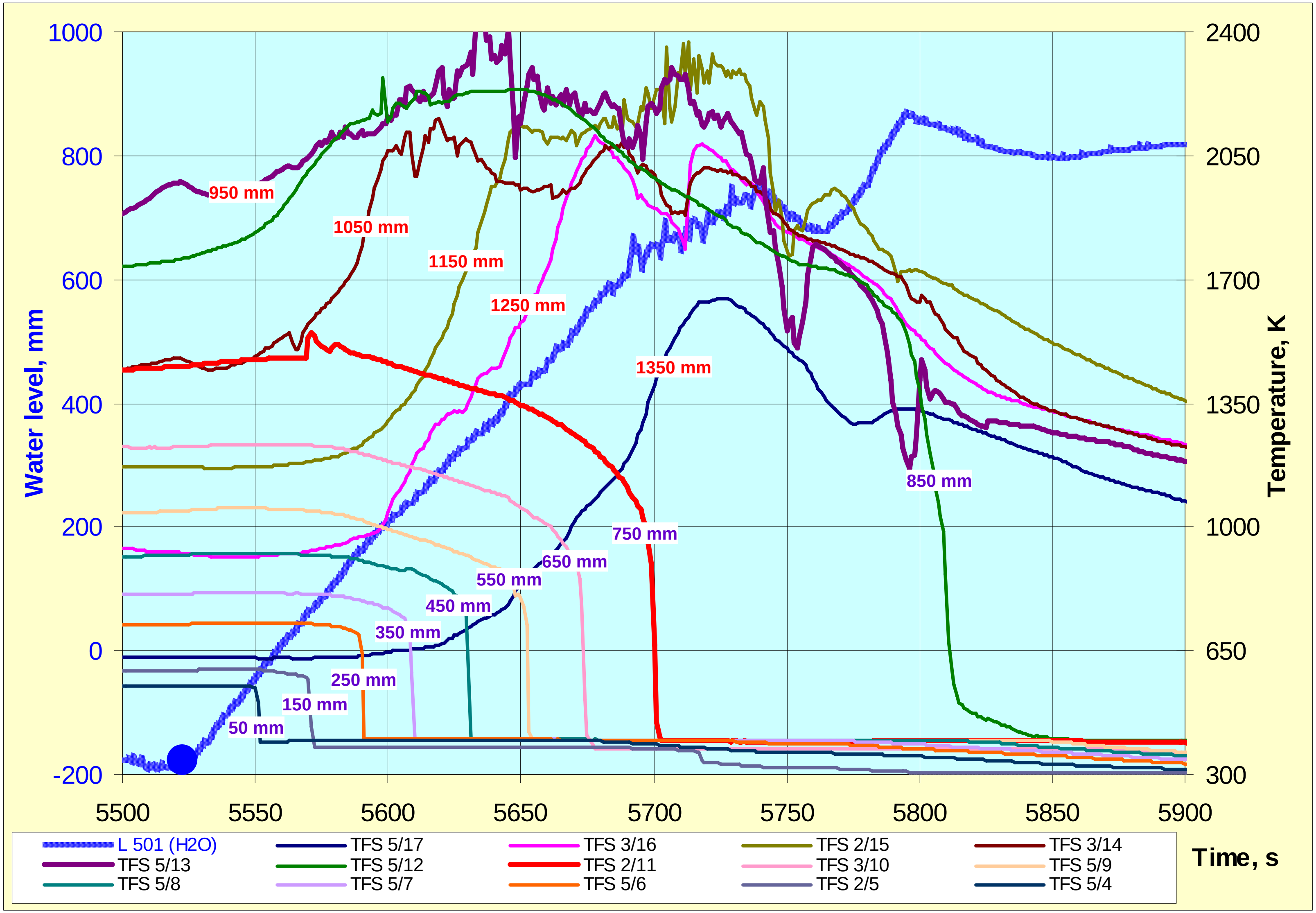




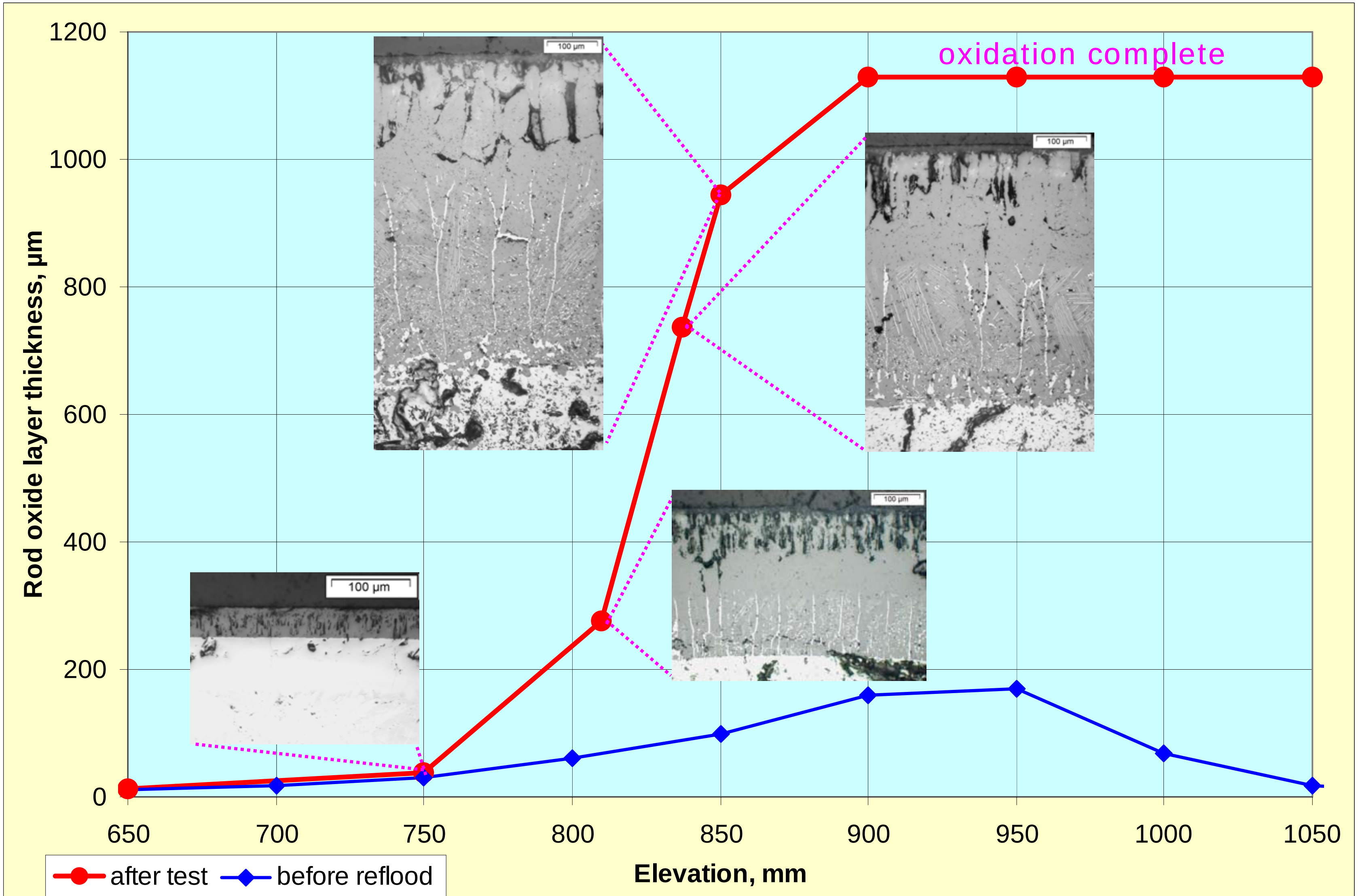
QUENCH-11, cooling phase: water reached the location of shroud breach (~850 mm); bundle elevations 13 – 17 (950 mm – 1350 mm) cooled slowly during 3000 s in decreased steam flow



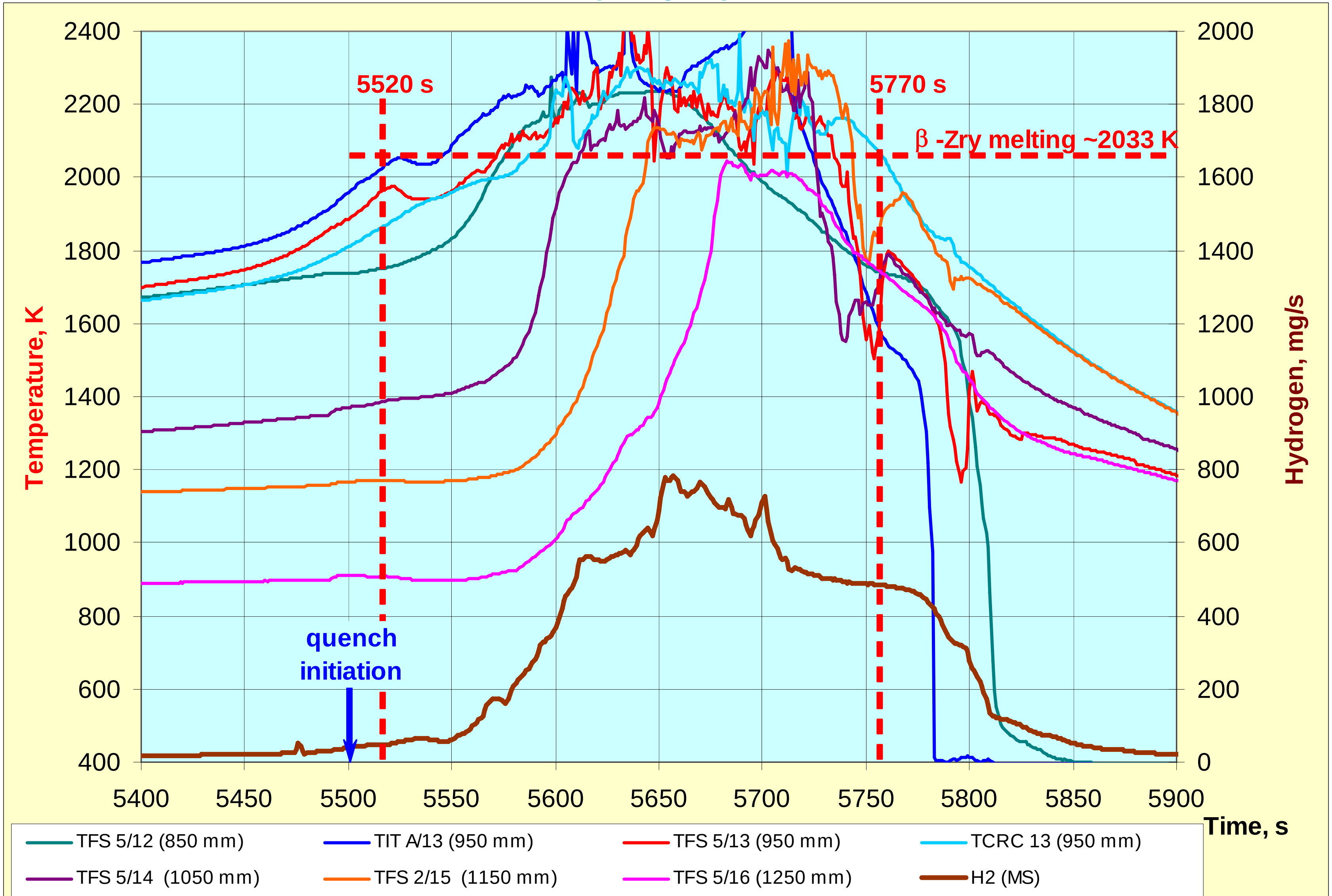
QUENCH-11, phase of slow reflood : accelerated TC reaction on the rising water surface due to two-phase region above the water surface. Escalation at elevations upper 950 mm.



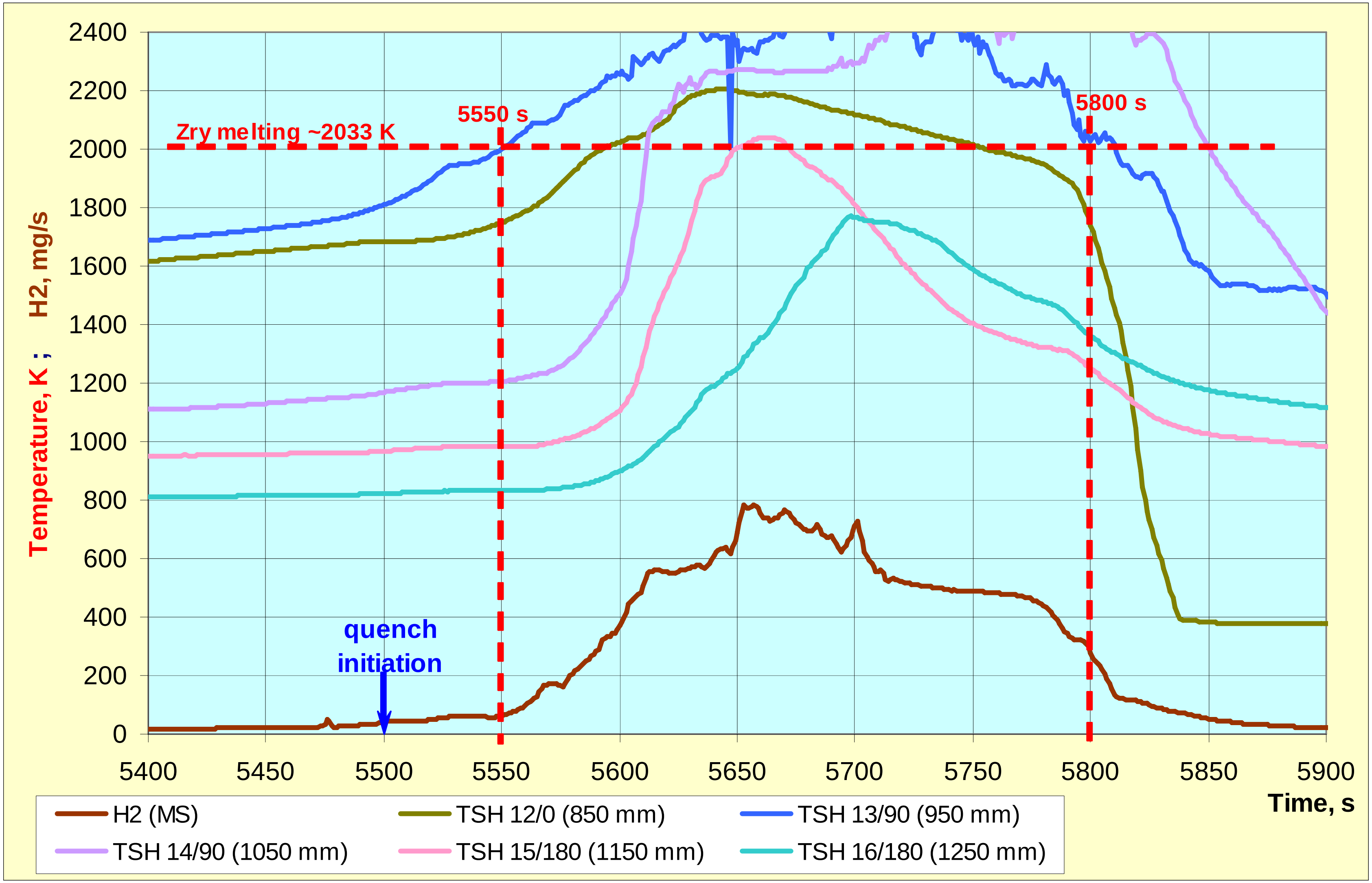
QUENCH-11, pos-test analysis: intensive growth of oxide layer during quench phase



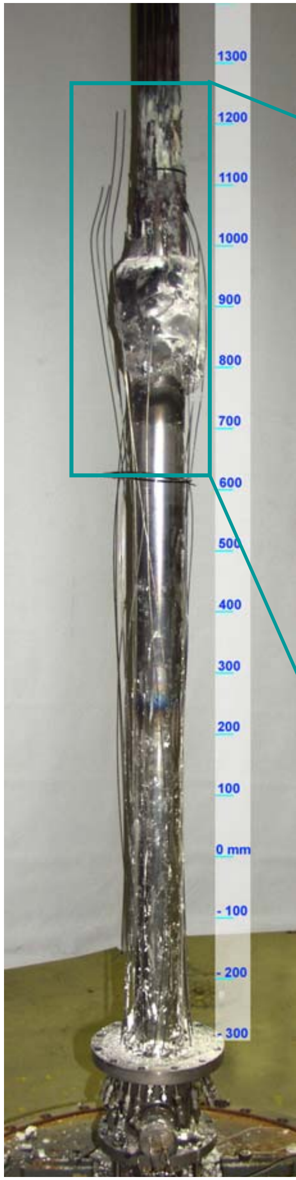
Q11, phase of slow reflood : bundle temperatures escalate above melting point of β-Zry. Intensive hydrogen production.



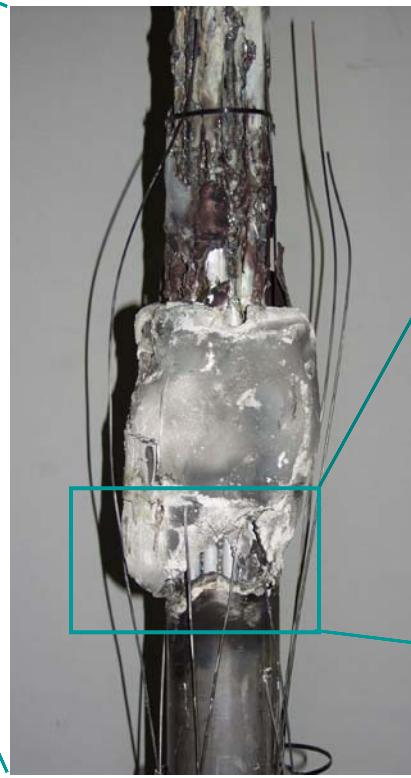
Q11, phase of slow reflood : shroud temperatures escalate above melting point of β-Zry.



Q-11: intensive bundle damage above elevation of 800 mm

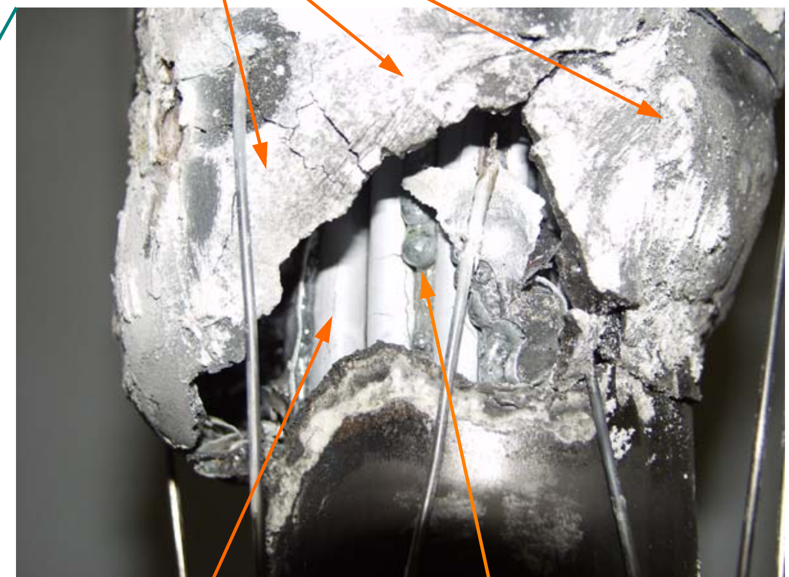


Position: 90°



Position: 270°

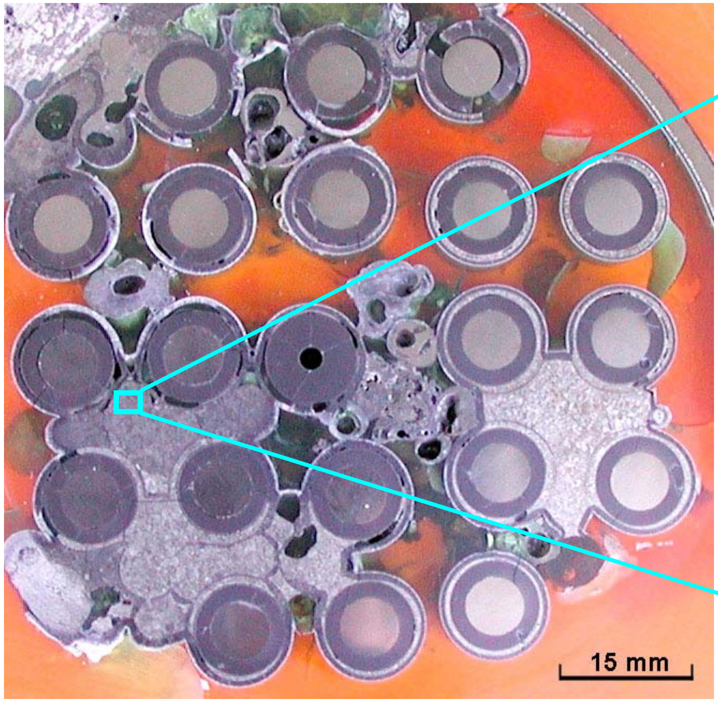
shrunk thermal insulation, interacted with molten shroud



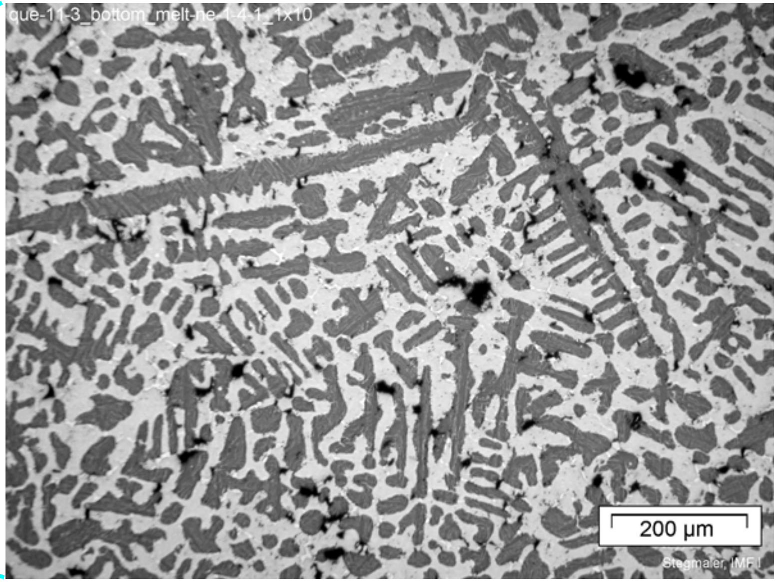
oxidised cladding

melt rivulets between rods

Q-11: melt inside of the bundle at elevation 837 mm

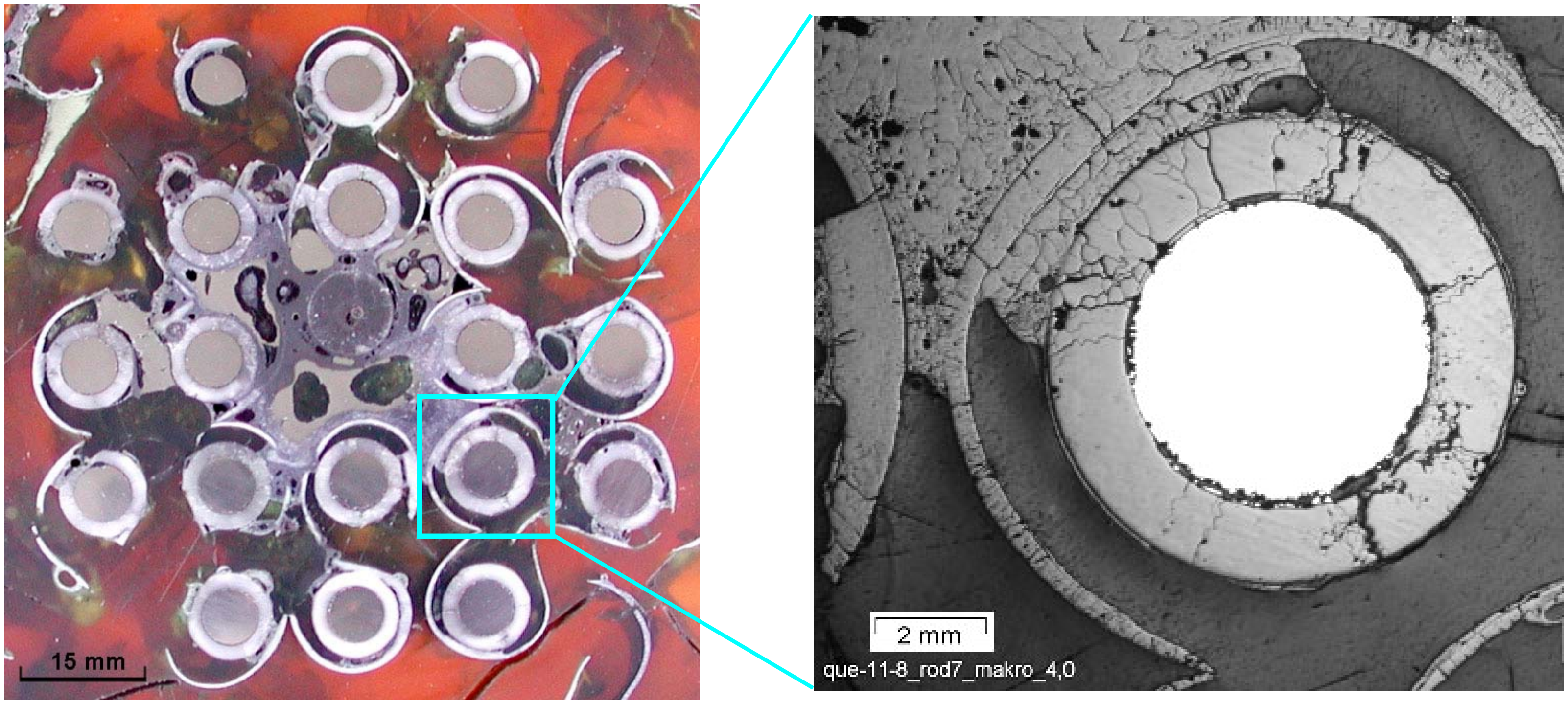


solidified melt between rods



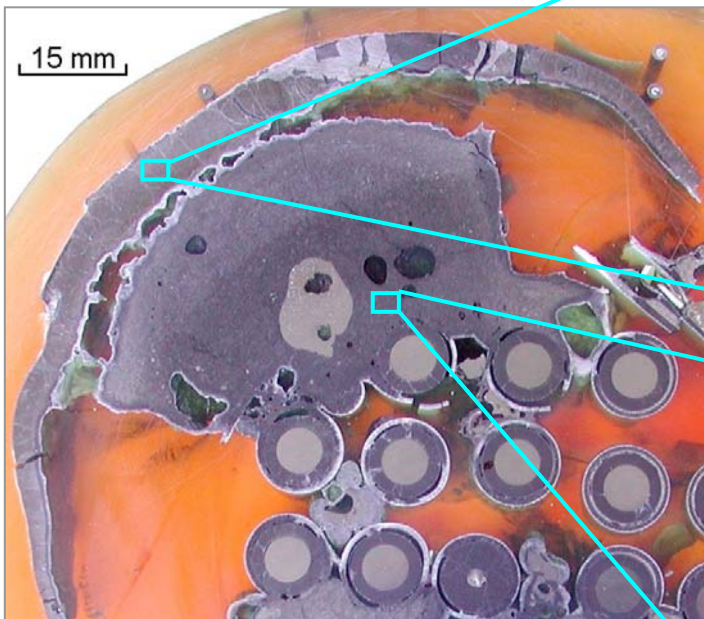
ZrO_2 dendrites: 54 % of area, corresponding relationship Zr:O = 47.4:52.6 (at%), i.e. the oxide precipitates start to develop in the molten melt

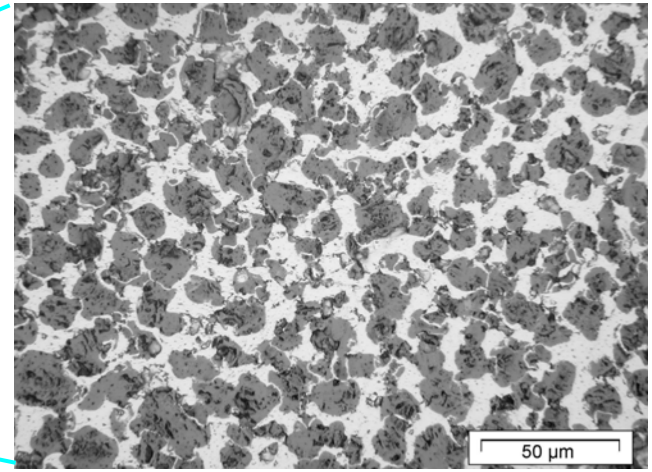
Q-11: melt inside of the bundle at elevation 1000 mm



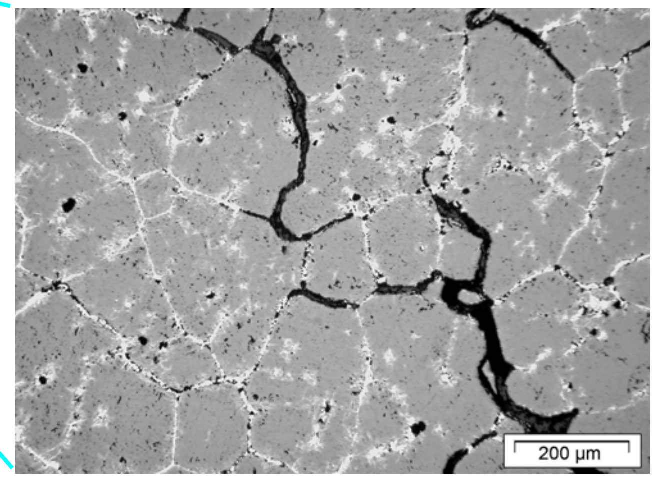
completely oxidised melt

QUENCH-11: shroud melt oxidation, elevation 850 mm





dissolution of fiber insulation by molten shroud



completely oxidised relocated melt

SUMMARY

- The QUENCH-11 test was performed in four stages: 1) Boil-off stage, 2) Stationery auxiliary water feeding at evaporation rate ~1.1 g/s and bundle temperature ramping from 873 K to 1773 K, 3) Temperature escalation to 2000 K, 4) Quench with a low flow rate of 18 g/s.

- The height of the two-phase region above collapsed water level was between 180 mm and 370 mm.

- The maximum oxide layer thickness before reflood was 170 µm (bundle elevation 950 mm).

- The first failure of a fuel rod simulator with simultaneous shroud failure were detected after 1 minute from quench initiation. The shroud failed at an elevation about 800 mm.

- The maximum of temperatures of 2383 K was reached in 2 minutes after quench initiation.

- Intensive melt formation and relocation was observed at elevations above 800 mm.

- The total generation of hydrogen was 141 g. During the reflood was produced 132 g hydrogen.