QUENCH-12 test
First results

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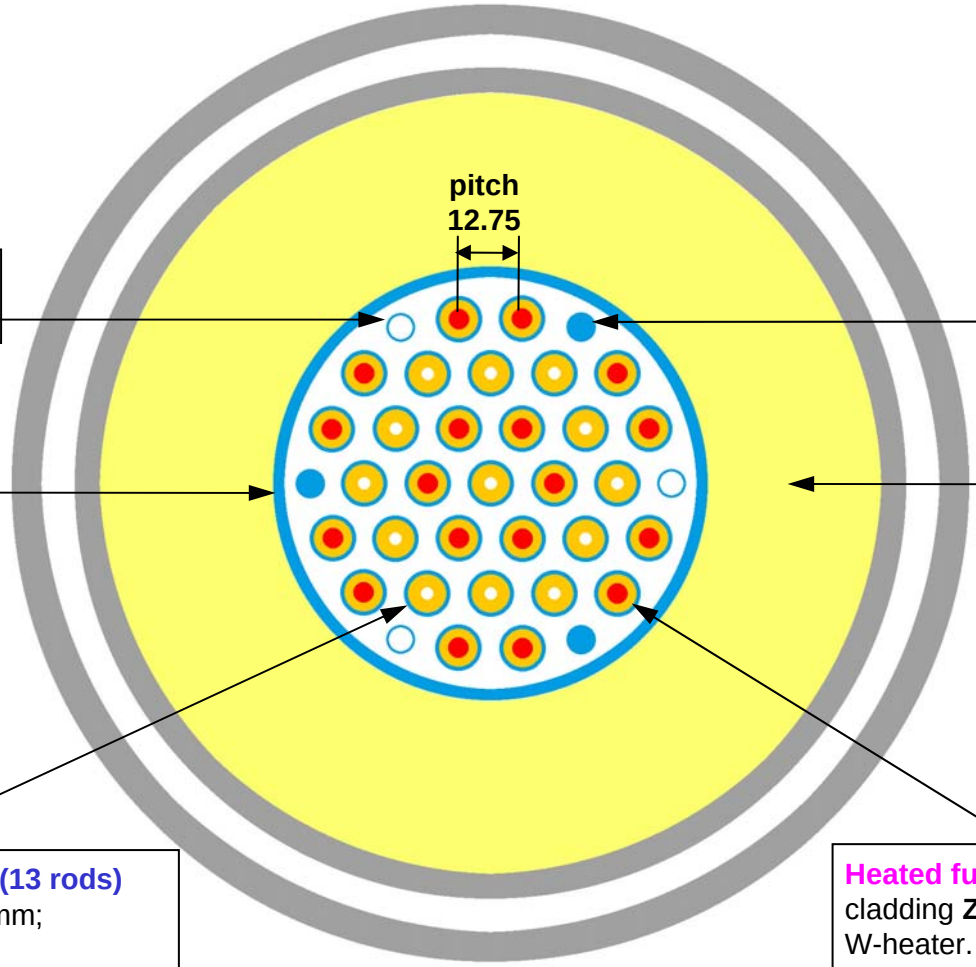
Objectives of the QUENCH-12 test

- **investigation of the effects of VVER materials and bundle geometry on core reflood**
- **comparison with the PWR bundle on the base of repeat of the test QUENCH-06 (ISP-45) scenario**

QUENCH-12: Cross section of the VVER-column.



Instrumented tube.
Zr1%Nb. ø5.75 mm

Removable corner rod.
Zr1%Nb. ø6 mm

Shroud tube **Zr2.5%Nb**
ø 88.0/83.5mm

Thermal insulation:
ZrO_2 fibre;
thickness 37 mm

Unheated fuel rod simulator (13 rods)
cladding **Zr1%Nb**. ø9.13/7.73mm;
central thermocouple;
ZrO_2 pellet. ø7.57/2.5 mm.

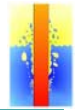
Heated fuel rod simulator (18 rods)
cladding **Zr1%Nb**. ø9.15/7.73 mm;
W-heater. ø4mm;
pellet ZrO_2. ø7.57/4.15mm.

Comparison of geometrical parameters of the QUENCH-12 bundle with the QUENCH-06 bundle:

1) coolant channel area relationship Q12/Q06 = 1.09 ⇒ *the fluid flow rate should be 9% higher for the Q12 bundle than for the Q06 bundle to provide the same flow velocity*

2) metallic surface relationship Q12/Q06 = 1.22 ⇒ *higher chemical energy production for the VVER bundle due to exothermic steam-metal reaction*;

3) bundle material mass relationship Q12/Q06 ~0.97 ⇒ *the electrical power for the VVER bundle should be lower than for the Q06 bundle*.

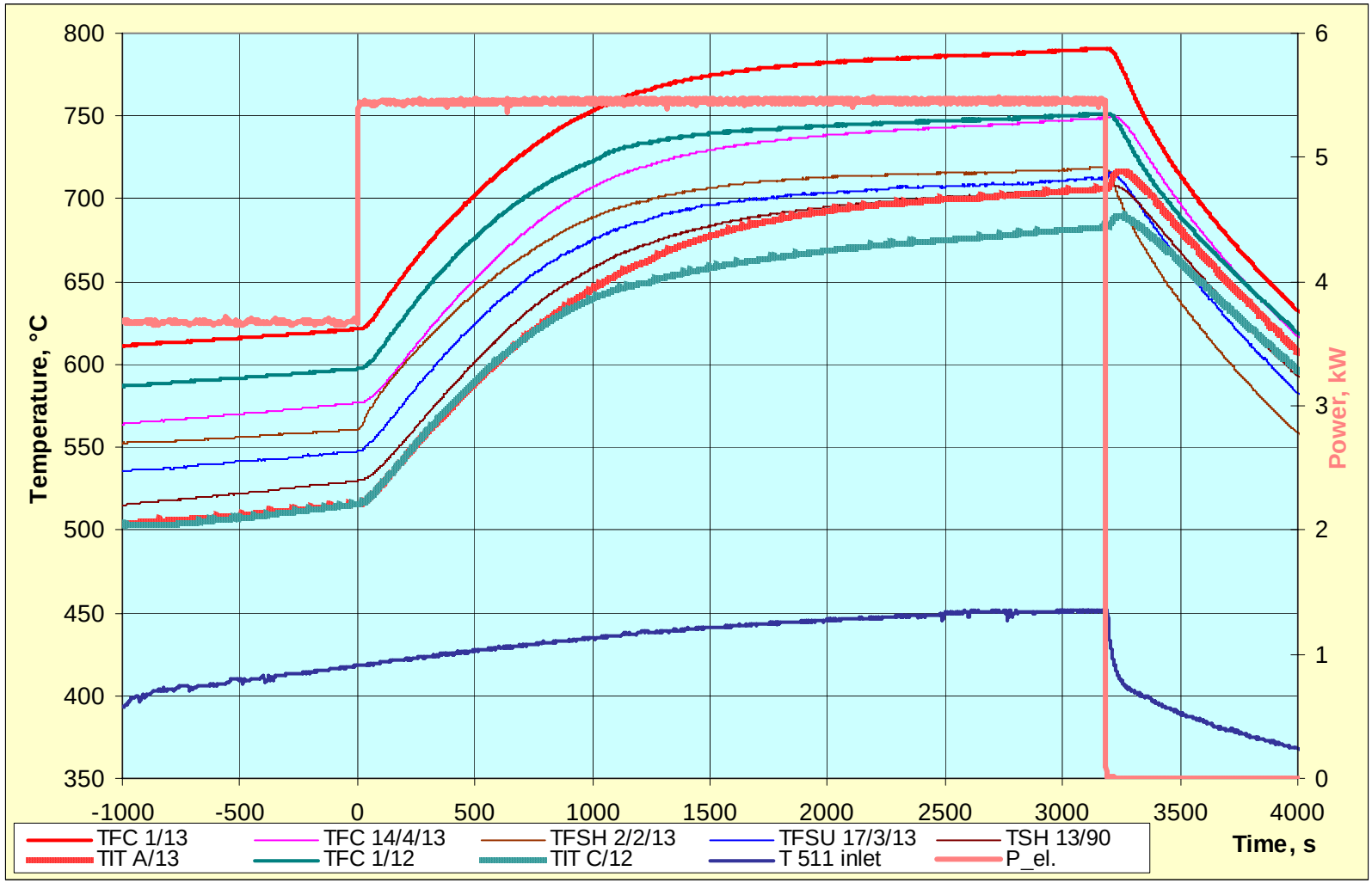


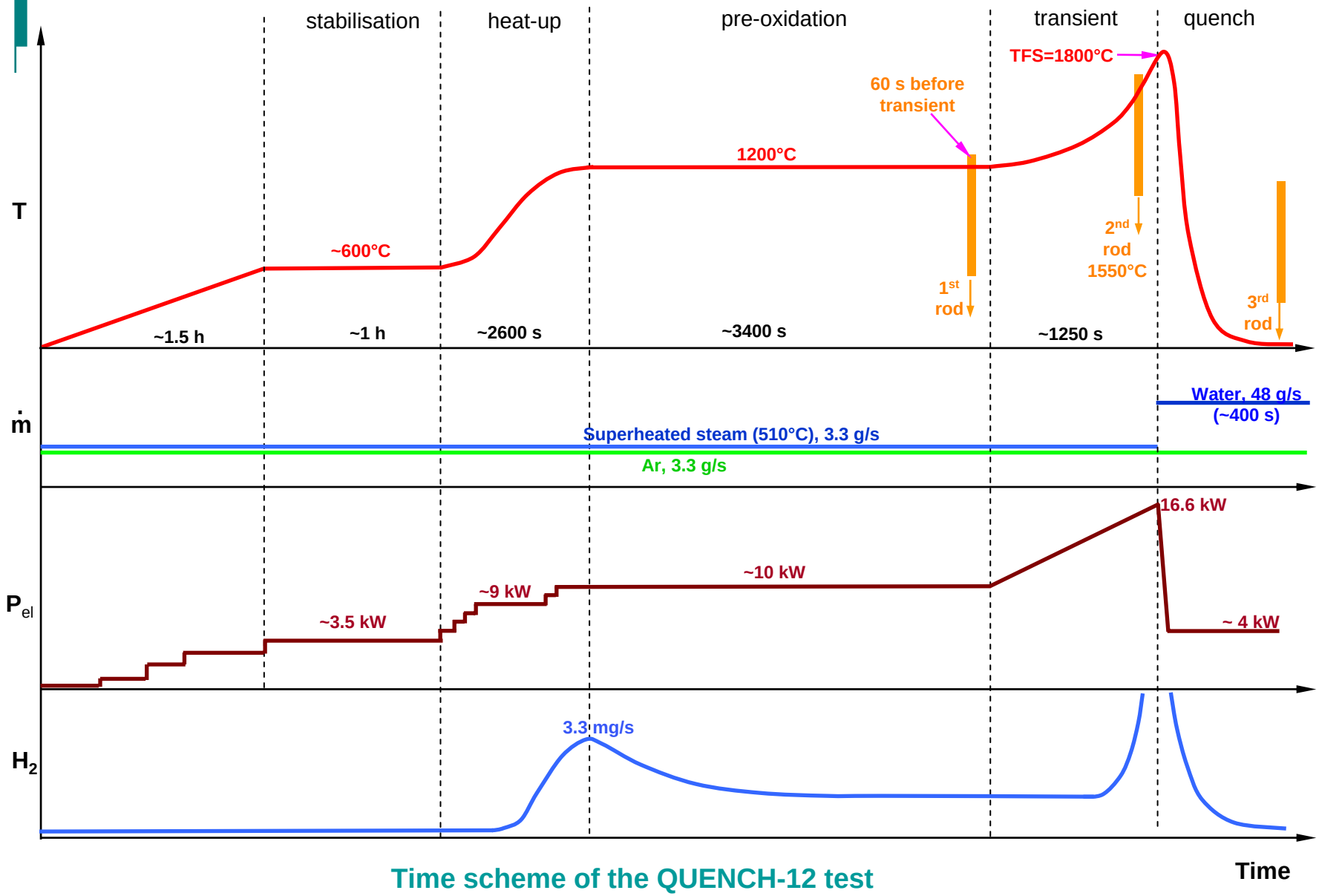
Pretest modelling support:

1. SCDAP/SIM simulations: J. Birchley, T. Haste, *Paul Scherer Institute, Switzerland***.**

2. ICARE/CATHARE simulations: A. Volchek, Yu. Zvonarev, *Kurchatov Institute, Mosccow, with support from IRSN Cadarache***).**

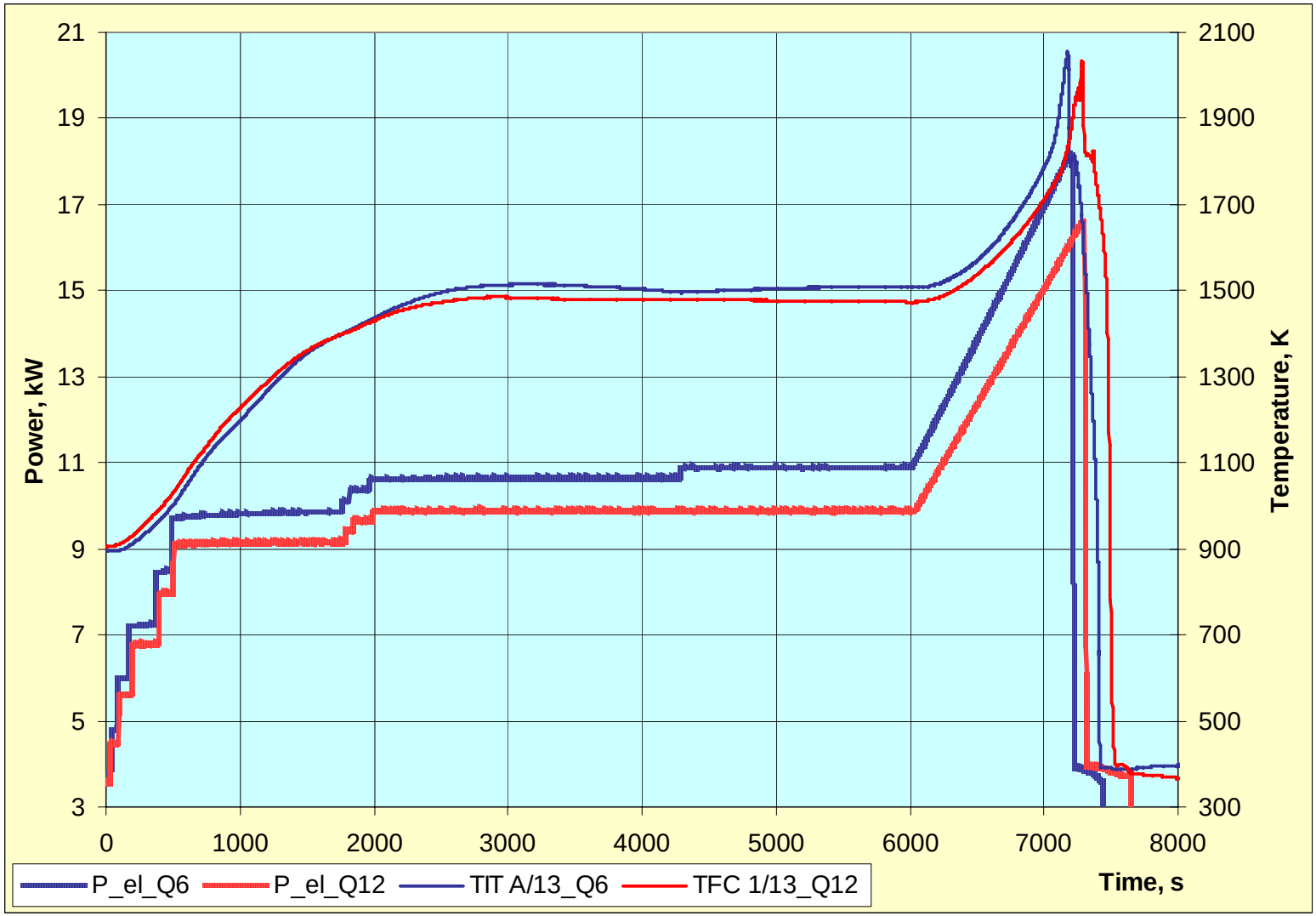
Preliminary test with VVER bundle (without reflood) to supply the tuning parameter for the pretest calculations to QUENCH-12. TC readings for elevations 850 mm and 950 mm: significant radial gradient for low temperatures.



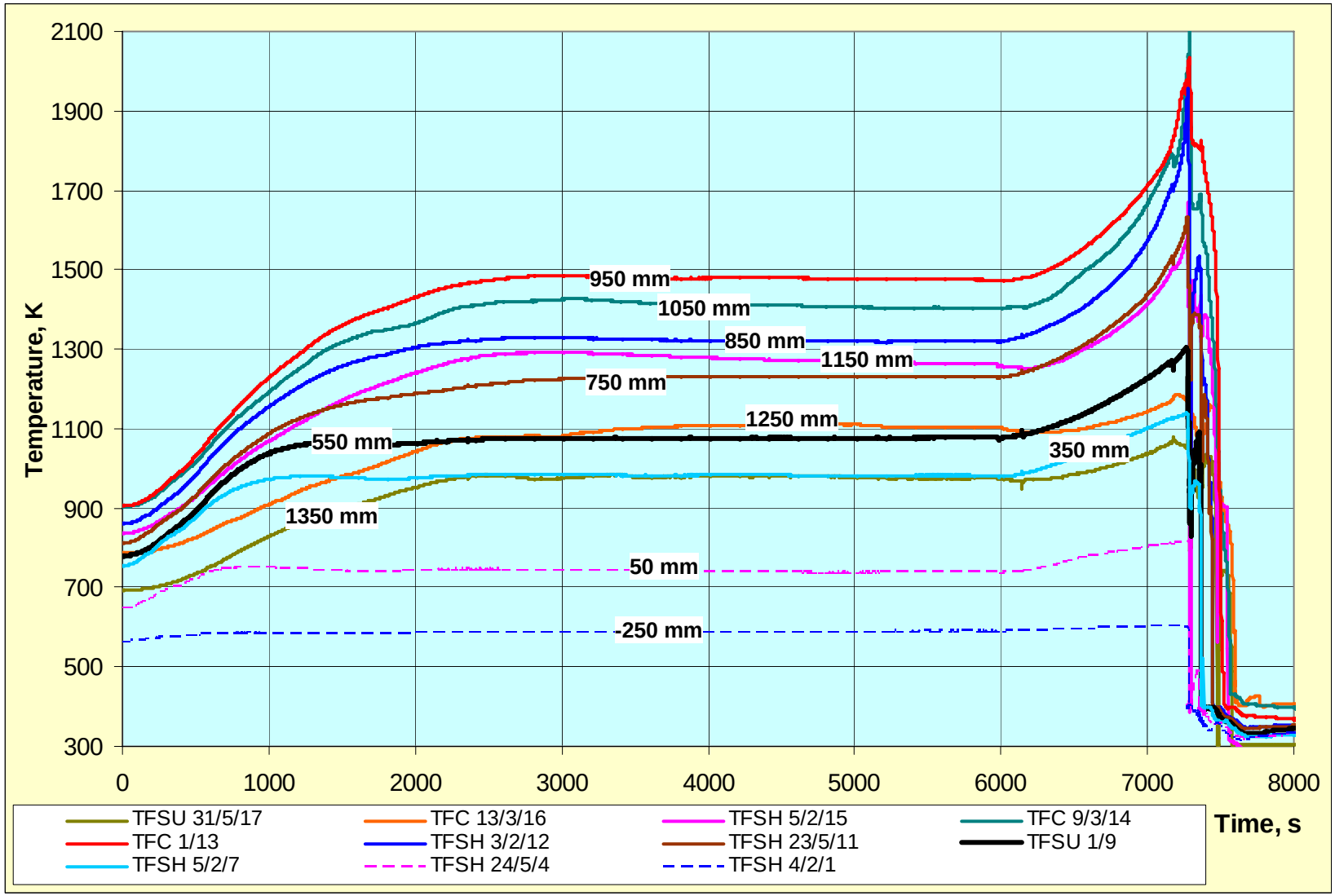


Time scheme of the QUENCH-12 test

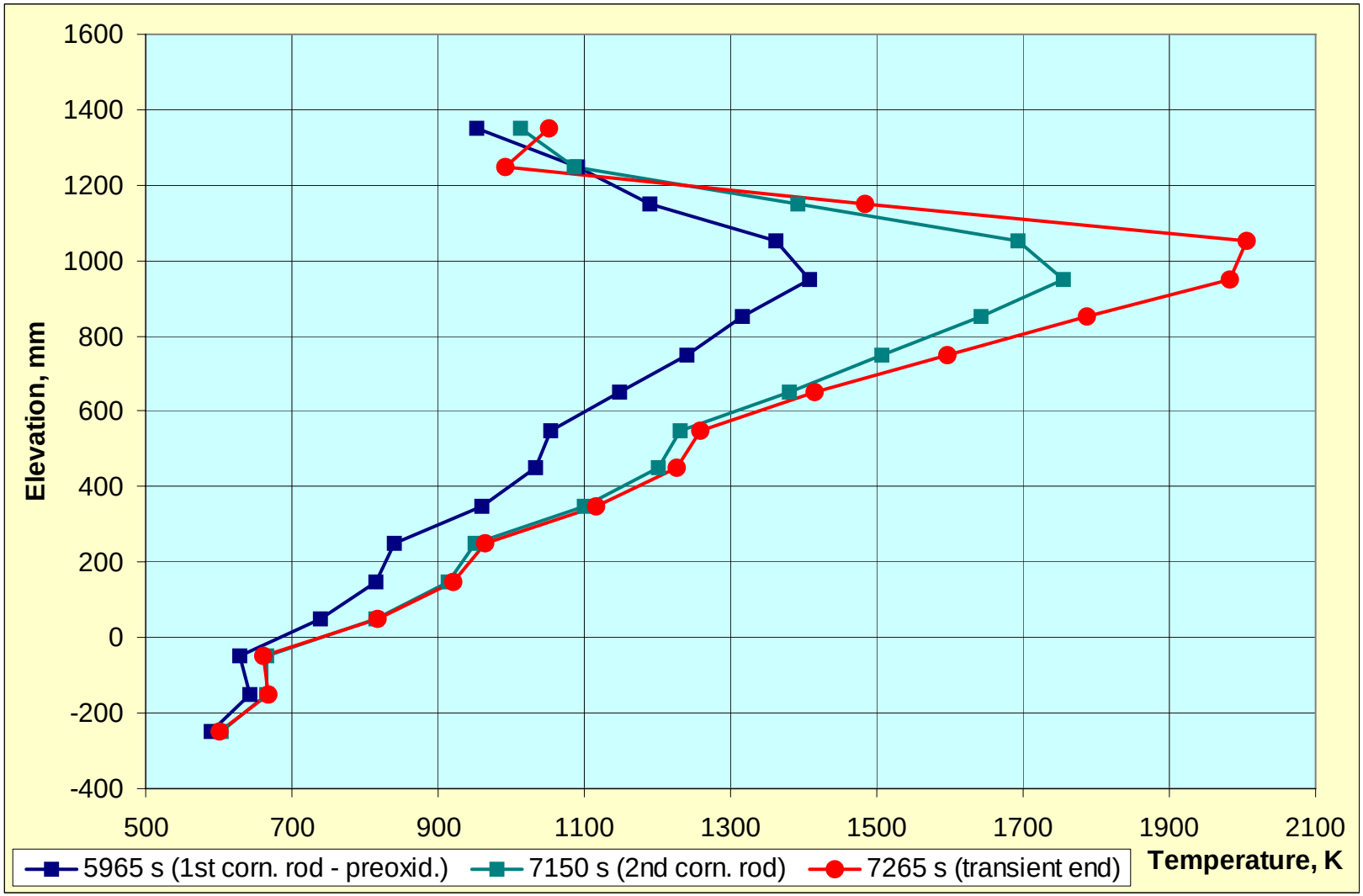
Comparison of temperature and power profiles for QUENCH-12 and QUECH-06.



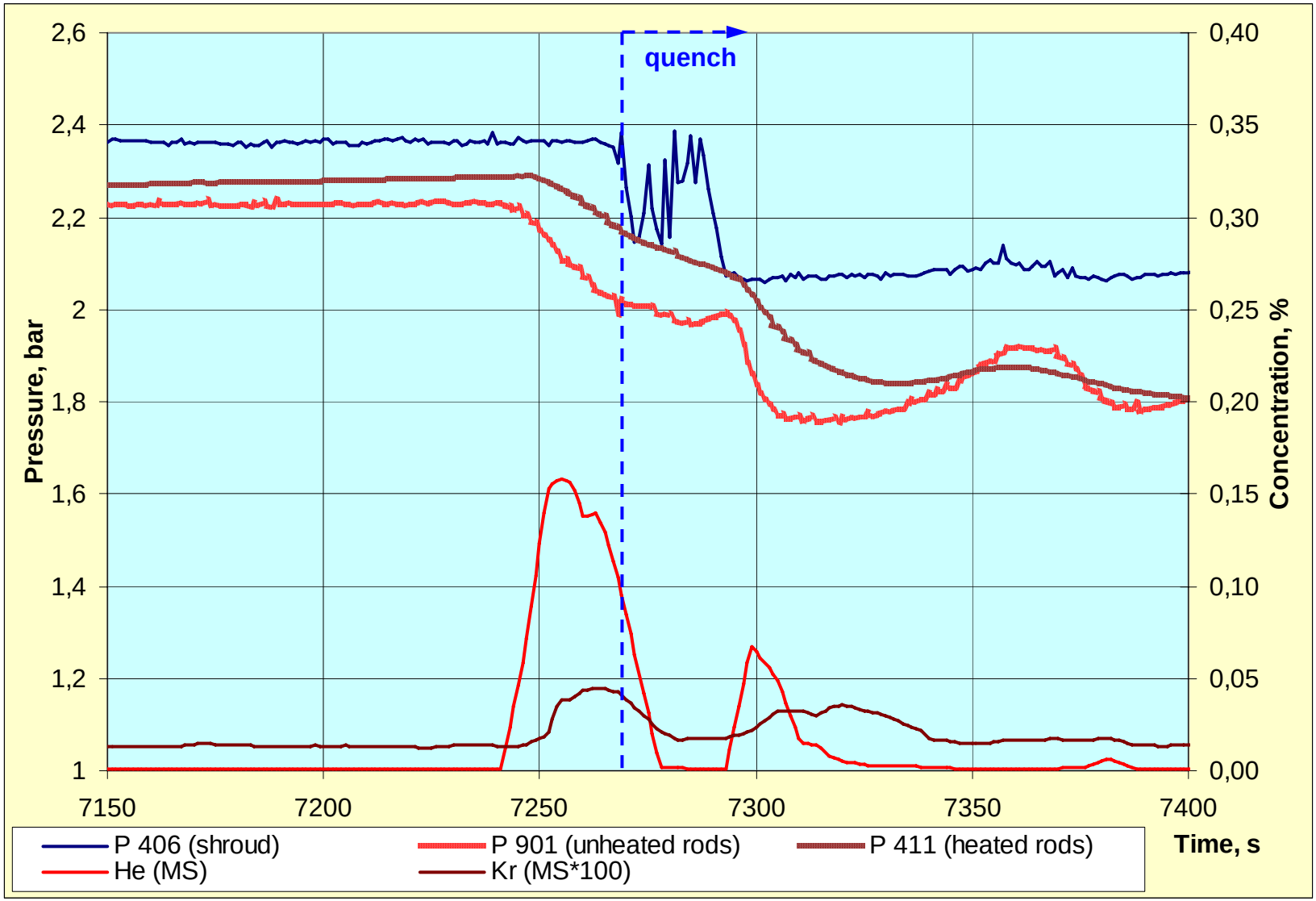
QUENCH-12: selected reading of the bundle thermocouples.



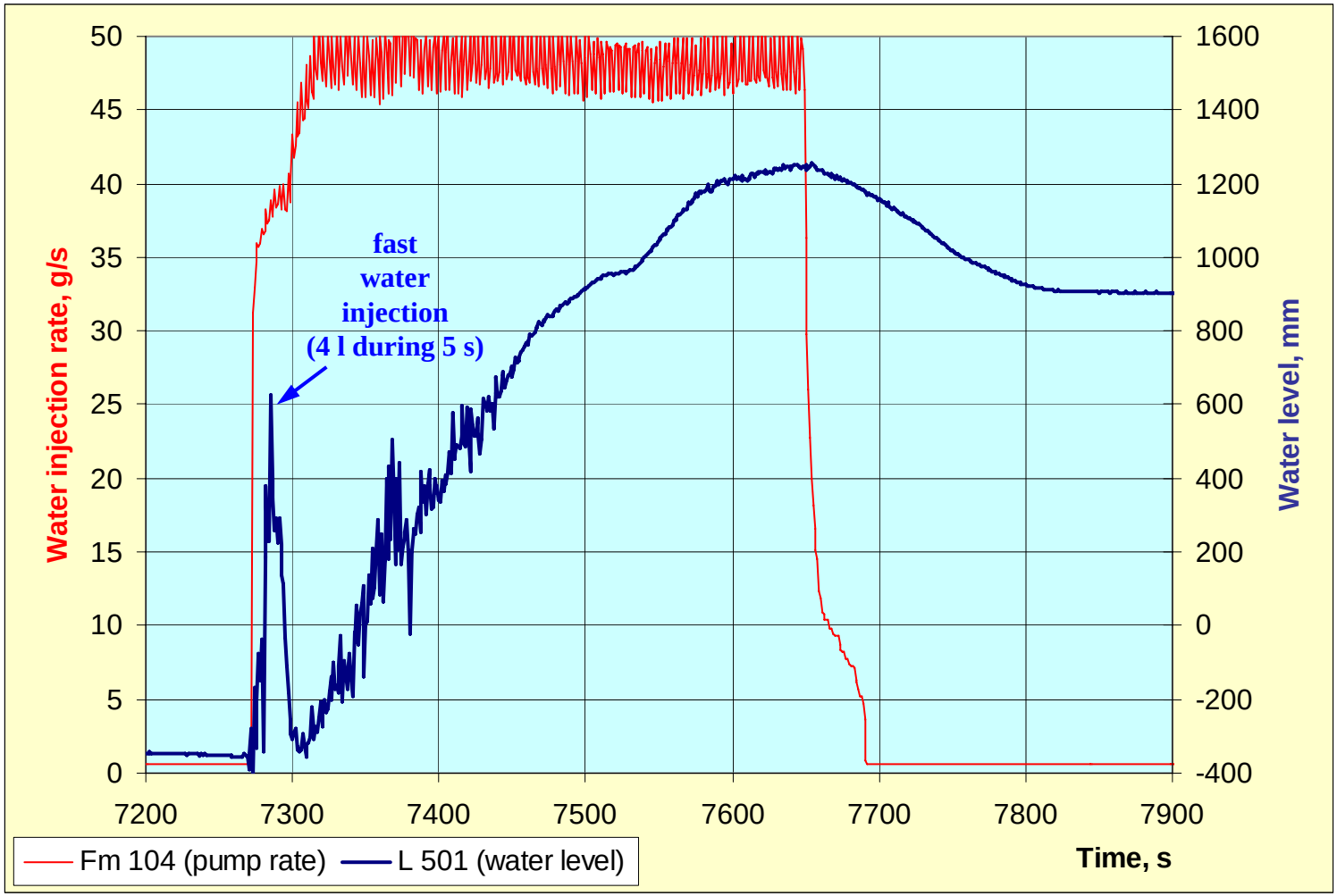
QUENCH-12: axial temperature profiles during pre-oxidation and transient phases



QUENCH-12, before quench phase: failure of unheated rods, heated rods and shroud

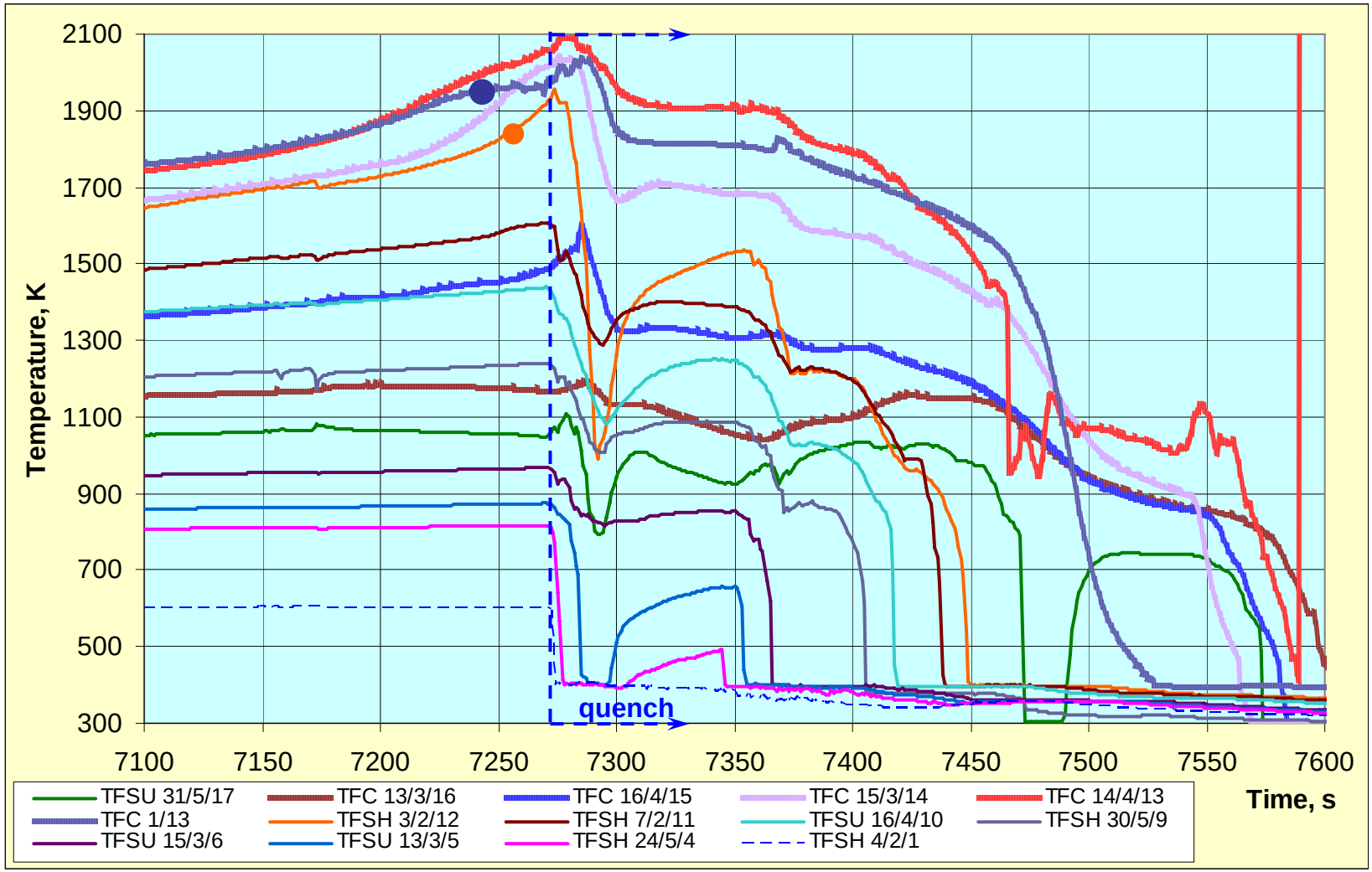


QUENCH-12, quench phase: water injection

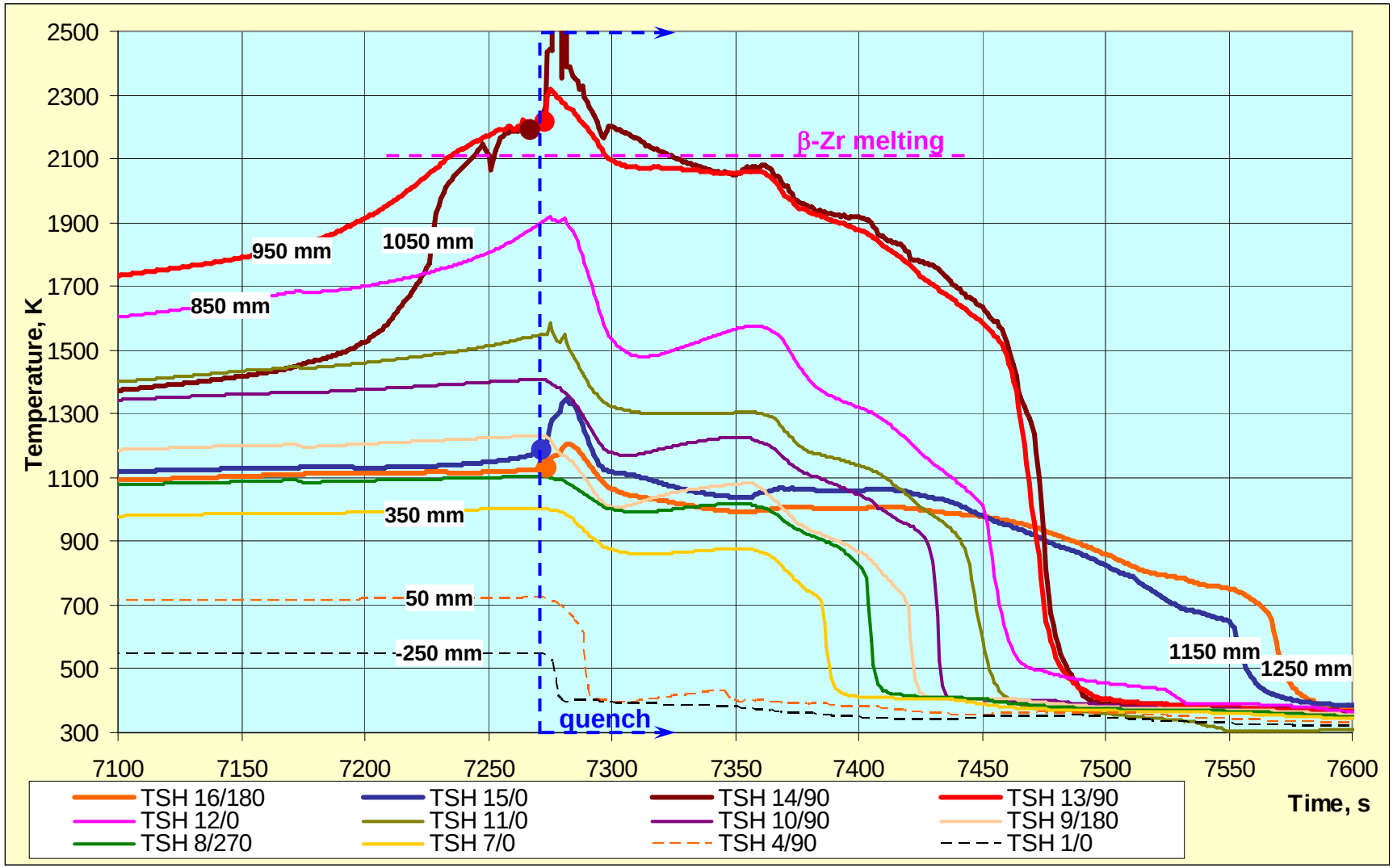


QUENCH-12, quench phase: selected reading of the bundle thermocouples.

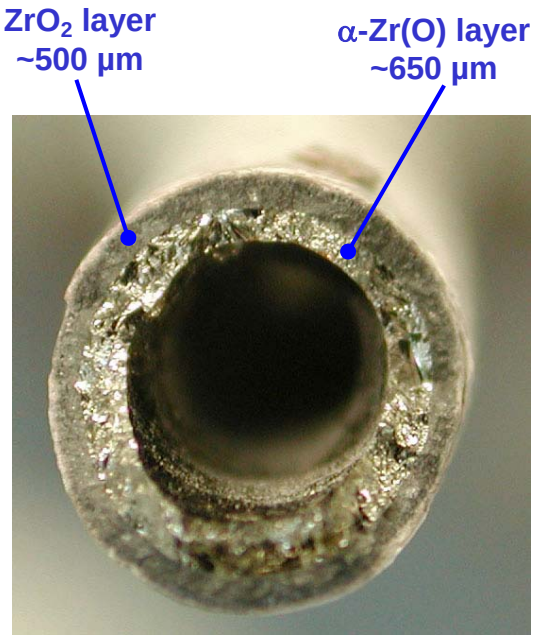
Temporary sharp decrease of the cladding surface temperature as reaction on the fog from the water fast injection system. Pellet internal thermocouples show smooth cooling of the bundle during ~350 s.



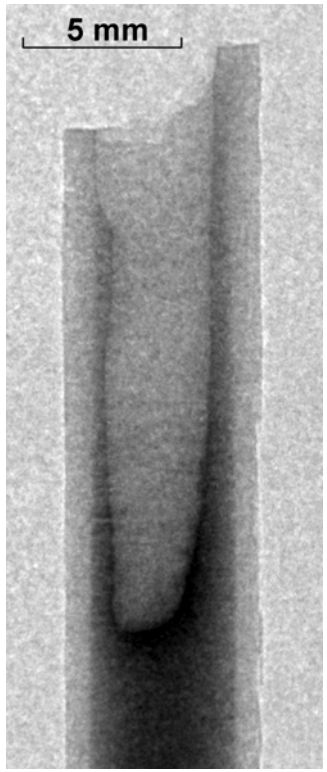
QUENCH-12, quench phase: selected reading of the shroud thermocouples. Short temperature escalation at elevations 950 mm – 1250 mm.



QUENCH-12: melt formation at 850 mm on the position of withdrawn corner rod B.



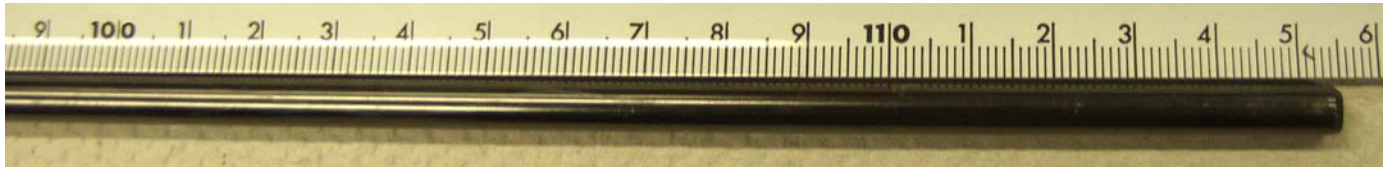
upper part of the rod B:
is the absent central part
the melted β-Zr?



neutronography (M. Große)
shows the deep hole with
irregular diameter

melt formation in bundle at the break
position of the corner rod B (850 mm)

QUENCH-12: withdrawn corner rods



corner rod B after pre-test (800 °C, oxide layer thickness less of 5 µm)

B

F

D

corner rods D, F, B after pre-test: spalling of the outer skin of oxide layer.
D – withdrawn after pre-oxidation,
F – withdrawn before reflood,
B – withdrawn after test.

QUENCH-12: axial sections of different ZrO_2 spalling intensity on withdrawn corner rods

B
after test

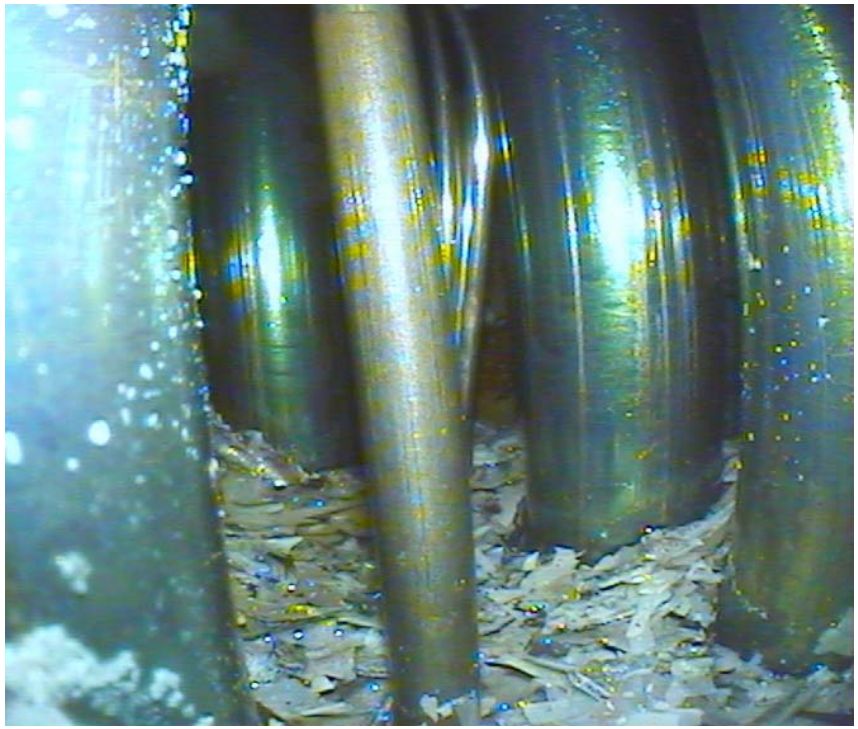
F
before reflood

D
after preoxidation

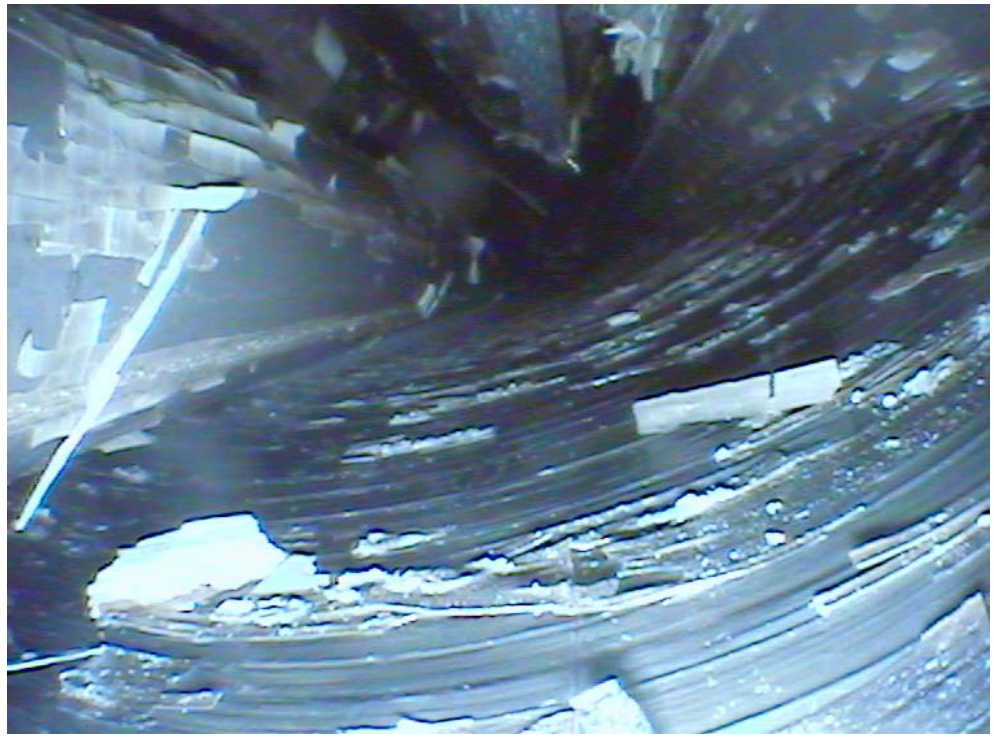
F **D**

F **D**

QUENCH-12, videoscope analysis: intensive oxide scale spalling inside of bundle

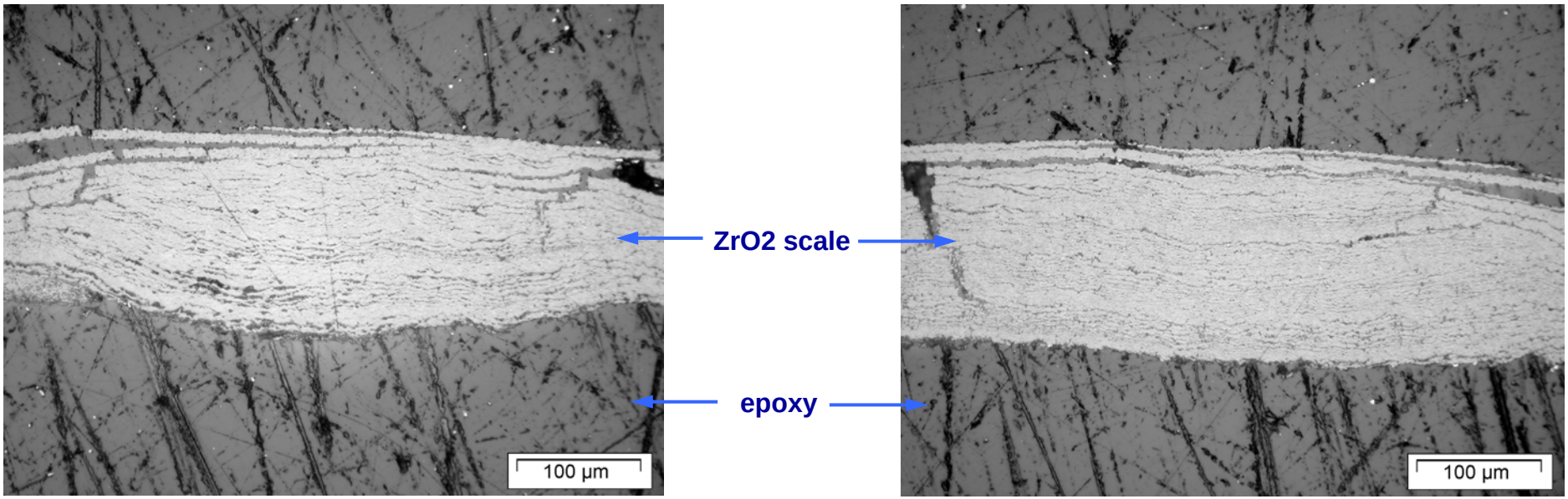


**side view from corner rod B
on the top of the first spacer (-150 mm)**



**camera in position of corner rod D at 650 mm:
spalled oxide scales at shroud and cladding**

QUENCH-12: laminated structure of spalled oxide scales

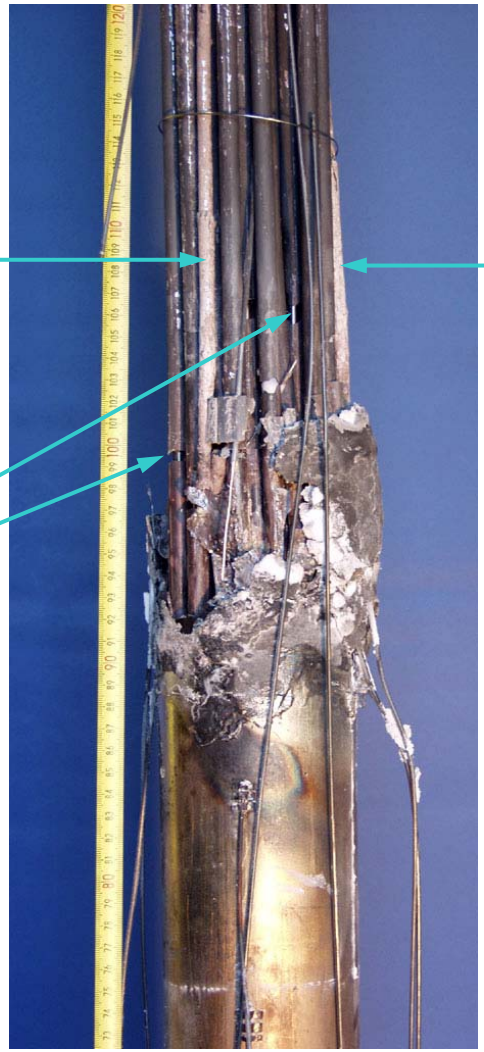


QUENCH-12, videoscope analysis : cladding cracks development

cross crack at 600 mm (rod D)

longitudinal crack at 650 mm (rod F)

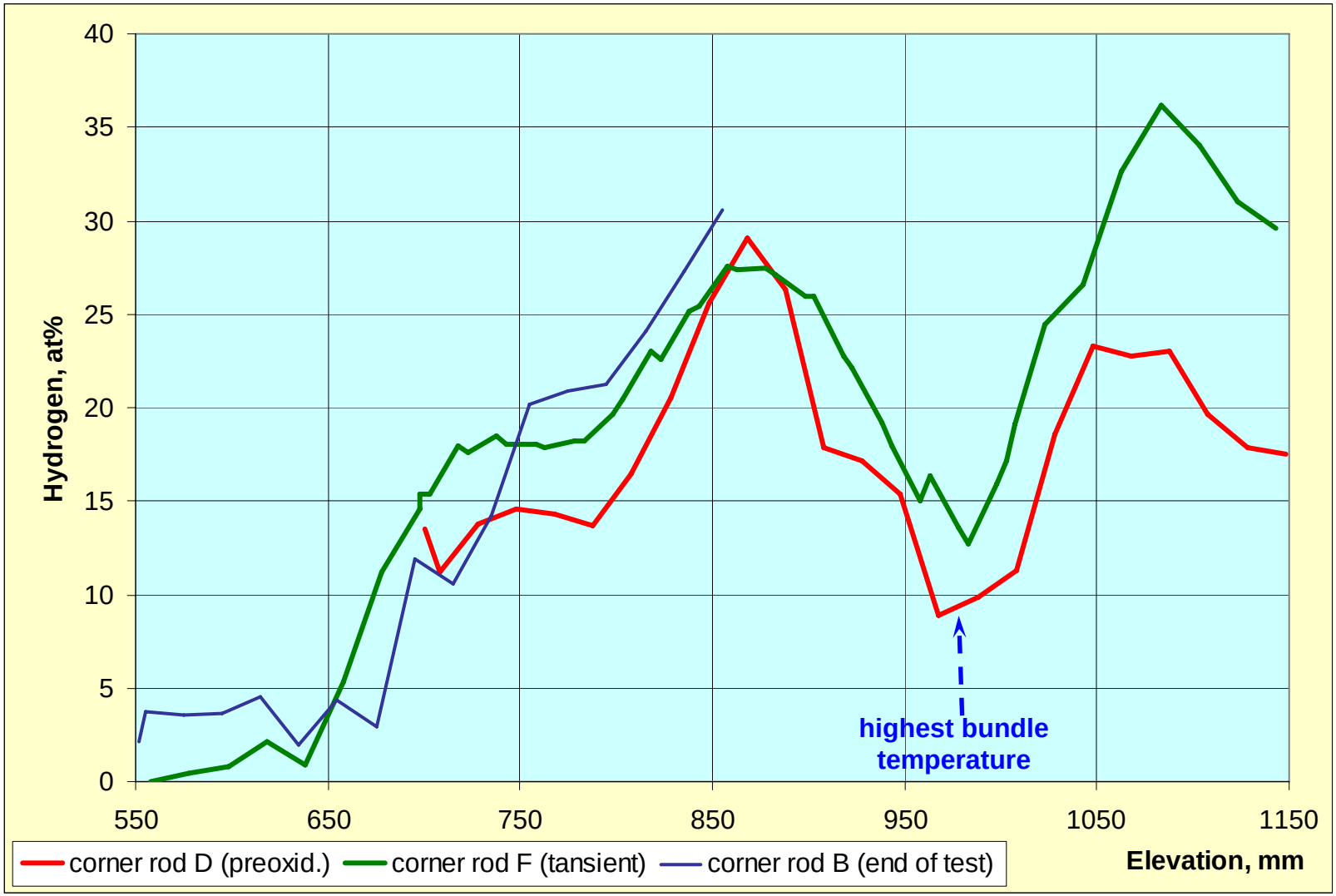
QUENCH-12: bundle posttest view after dismantling of zirconia fiber insulation



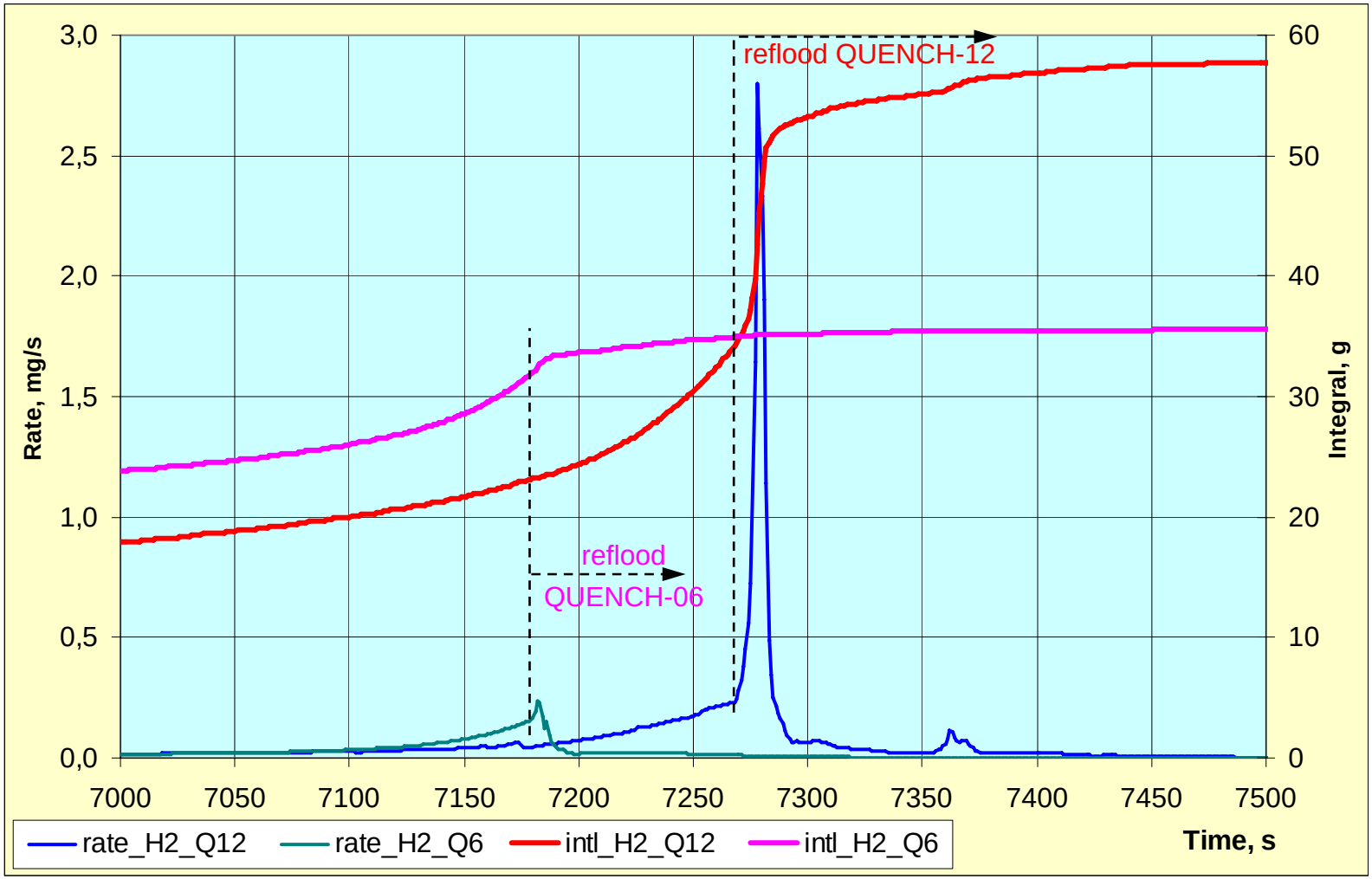
bundle at angle position of 180°

upper part of the shroud braked off
from the bundle during dismounting
(angle position of 180°)

QUENCH-12: hydrogen uptake by corner rods /results of neutronography/

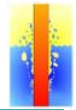


Comparison of hydrogen release during QUENCH-12 and QUECH-06.



QUENCH-06: H_2 production before reflood 32 g, during reflood 4 g

QUENCH-12: H_2 production before reflood 34 g, during reflood 24 g



SUMMARY

- The QUENCH-12 experiment investigated the effects of VVER materials and bundle geometry on core reflood, in comparison with test QUENCH-06 (ISP-45) with Western PWR geometry**.**

- The preliminary test at the maximum temperature 800°C was performed. The corresponding oxidation was negligible: less of 5 µm. The results of this test were used to fine attenuation of the pretest modelling.

- The electrical power changing during the test corresponds completely to calculated values up to reflood phase. The temperature history during preoxidation is very similar to the QUENCH-06 temperature history.

- Two corner rods were withdrawn at the end of preoxidation and transient phases correspondingly. The surface of the rods shows intensive traces of the break-away effect influence. Many oxide scales with thickness about 100 µm were spalled during withdrawn.

- Following reflood initiation, a moderate temperature excursion of ca. 50 K was observed, over a longer period than in QUENCH-06**.** The temperatures at elevations between 850 mm and 1050 mm exceeded the melting temperature of β-Zr.

- The total hydrogen production was 58 g (for QUENCH-06: 36 g), during the reflood was released 24 g hydrogen (for QUENCH-06: 4 g).