NIIAR ROSATOM STATE CORPORATION ENTERPRISE

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Current and Prospective Tests in Reactor MIR.M1

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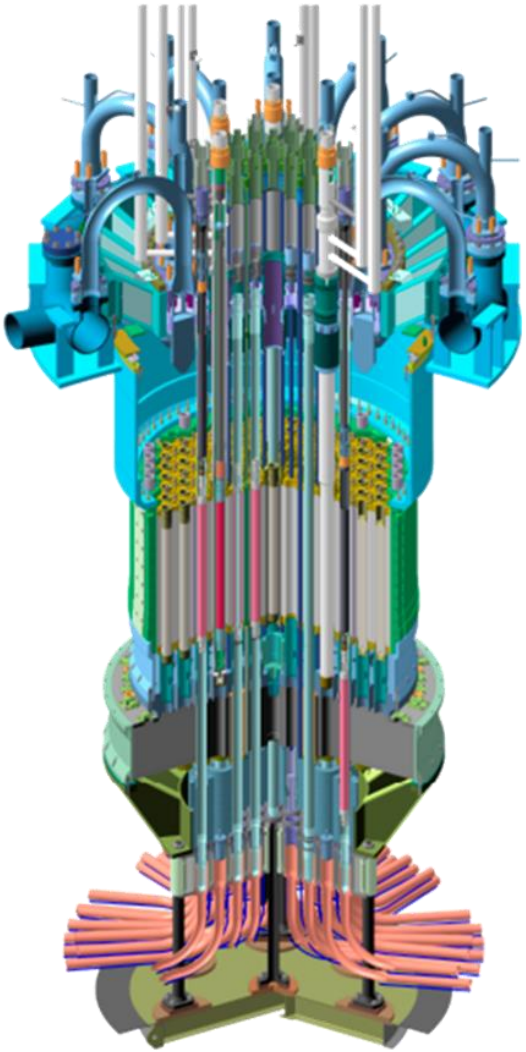
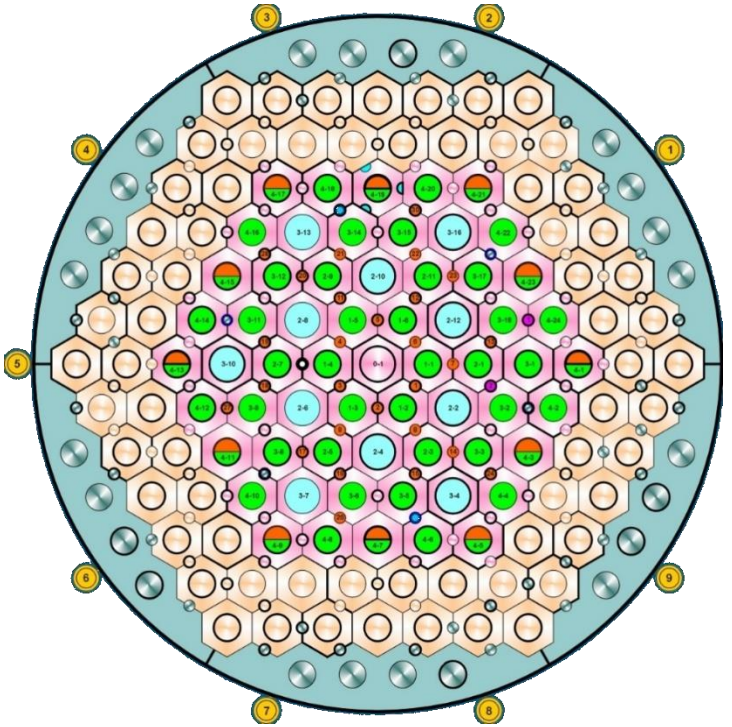
INTRODUCTION

Research Reactor MIR.M1 – *50 years in operation*





№ – operating FA channel

№ – experimental channel

№ – combined operating FA with absorber

№ – control rod channel

INTRODUCTION
General Technical Data of the MIR.M1

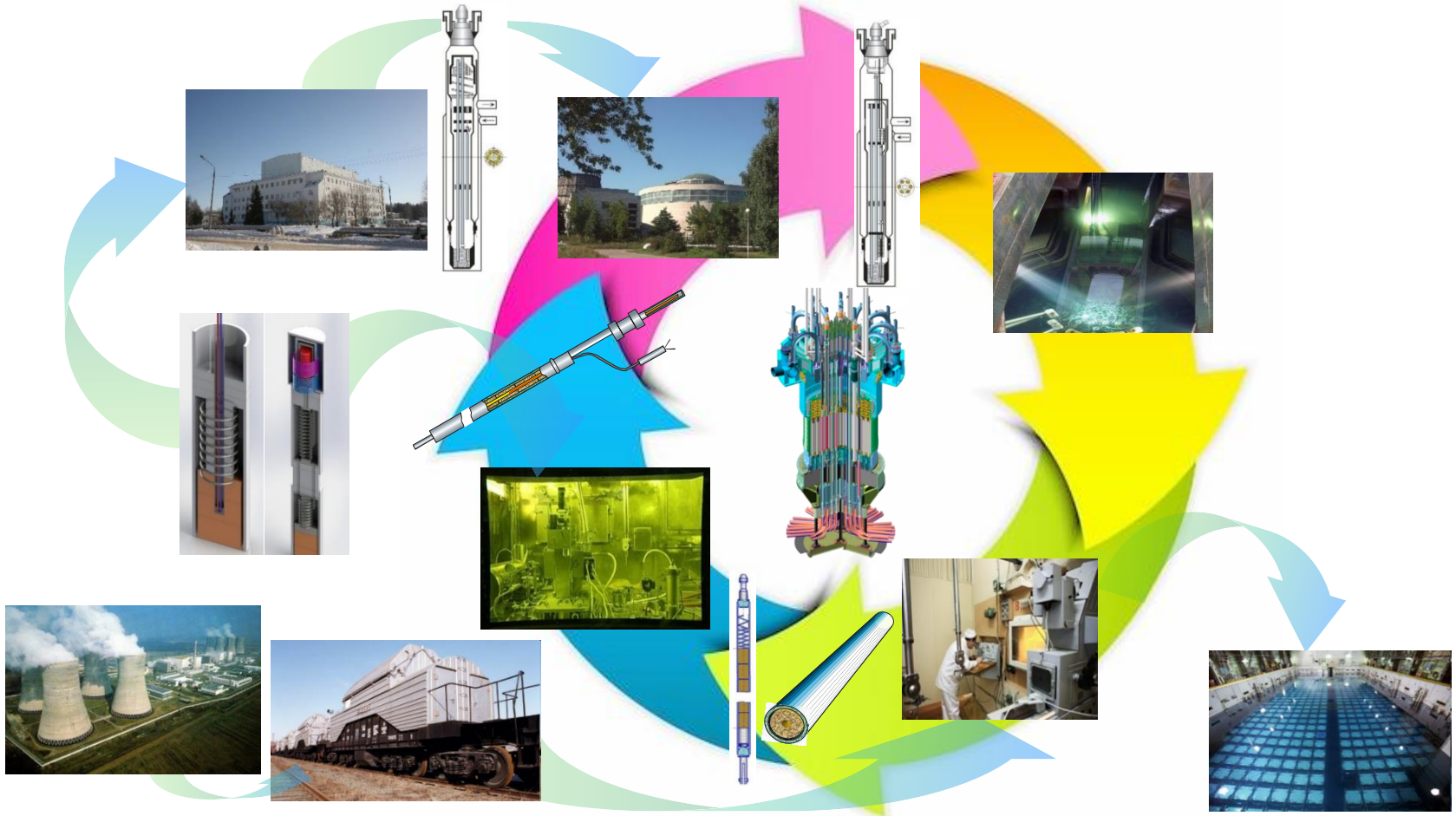
Parameter	Value
Nominal thermal power, MW	100
Maximal thermal neutron flux density in the loop channel, $cm^{-2} \cdot s^{-1}$	$5 \cdot 10^{14}$
Power operation days per year, days	230÷240
Fuel	UO_2 - 90% HEU
Core height, mm	1000
The number of loop channels, pcs.	11
Planned life-time	Till at least 2035

INTRODUCTION
Parameters of MIR.M1 Loops

Parameter	Loops					
	PV-1	PVK-1	PV-2	PVK-2	PVP-2	PG
Coolant	Water	Water, Boiling	Water	Water, Boiling	Water, Boiling, Steam	He, N_2
Number of channels	2	2	2	2	1	1
Channel capacity, kW	1500	1500	1500	1500	2000	160
Coolant temp., ℃	350	350	350	355	550	600
Max pressure, MPa	16,8	16,8	17,8	17,8	20,0	20,0
Max flow rate , t/h	16,0	14,0	16,0	14,0	10,0	-

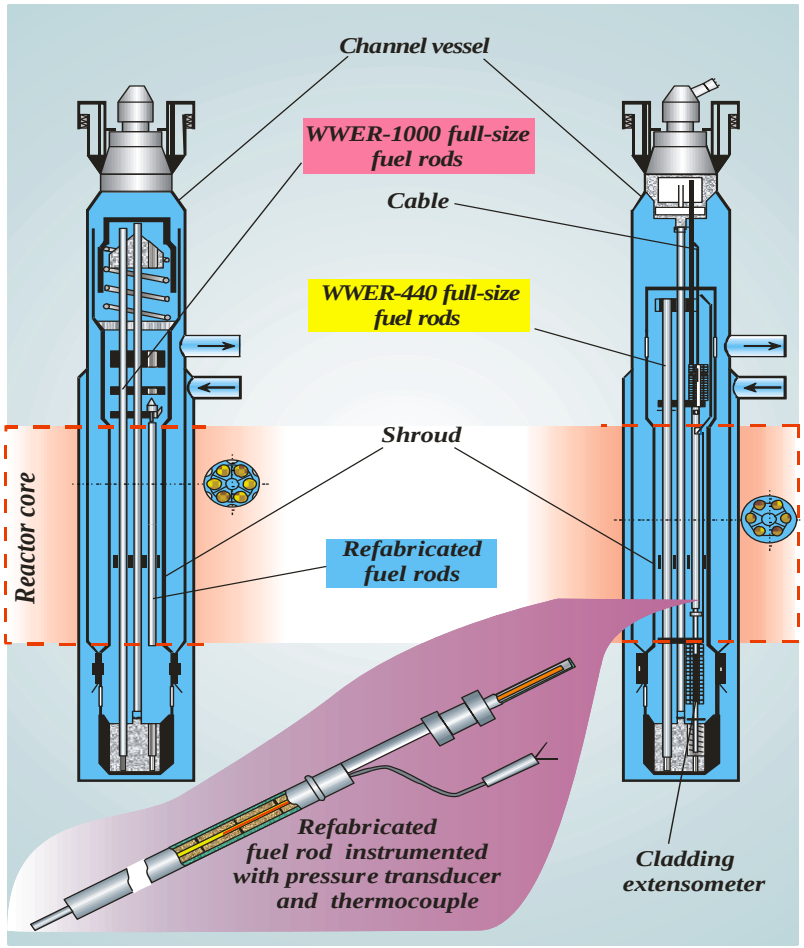
EXPERIMENTAL AND METHODICAL SUPPORT OF TESTS AND EXAMINATIONS

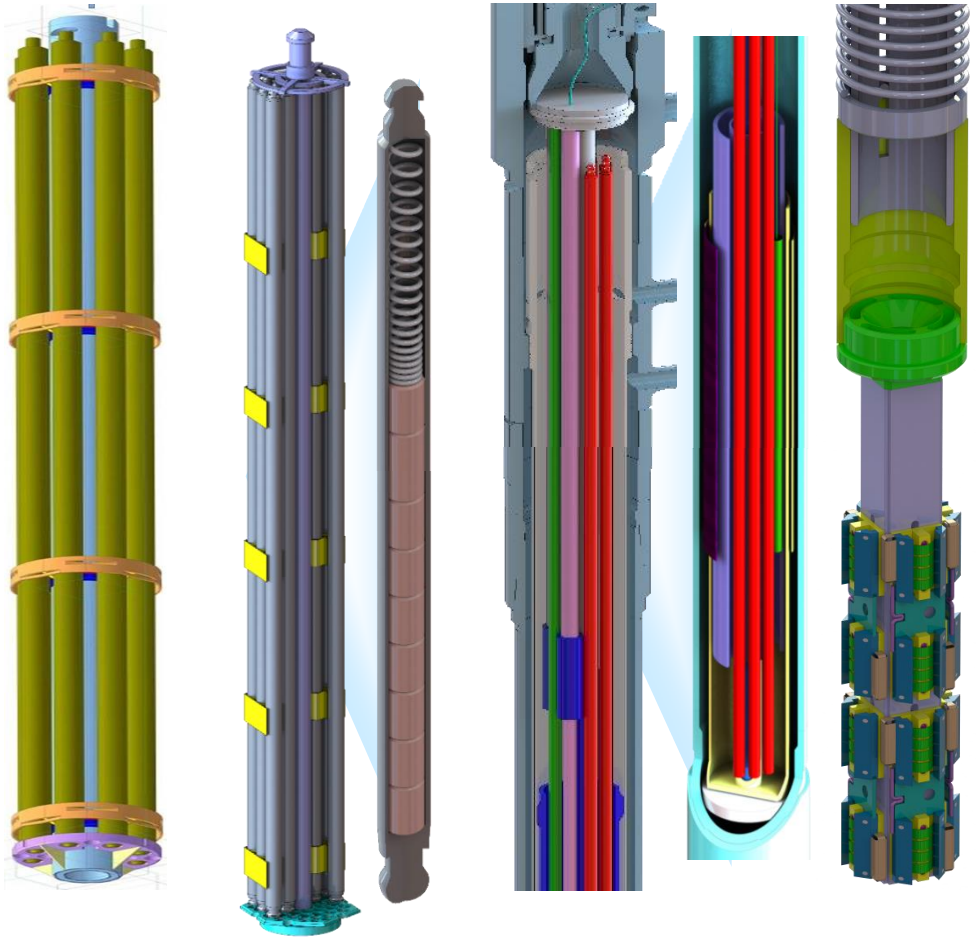
Preparation of experiments with fresh and fuel rods and spent fuel NPP



EXPERIMENTAL AND METHODICAL SUPPORT OF TESTS AND EXAMINATIONS

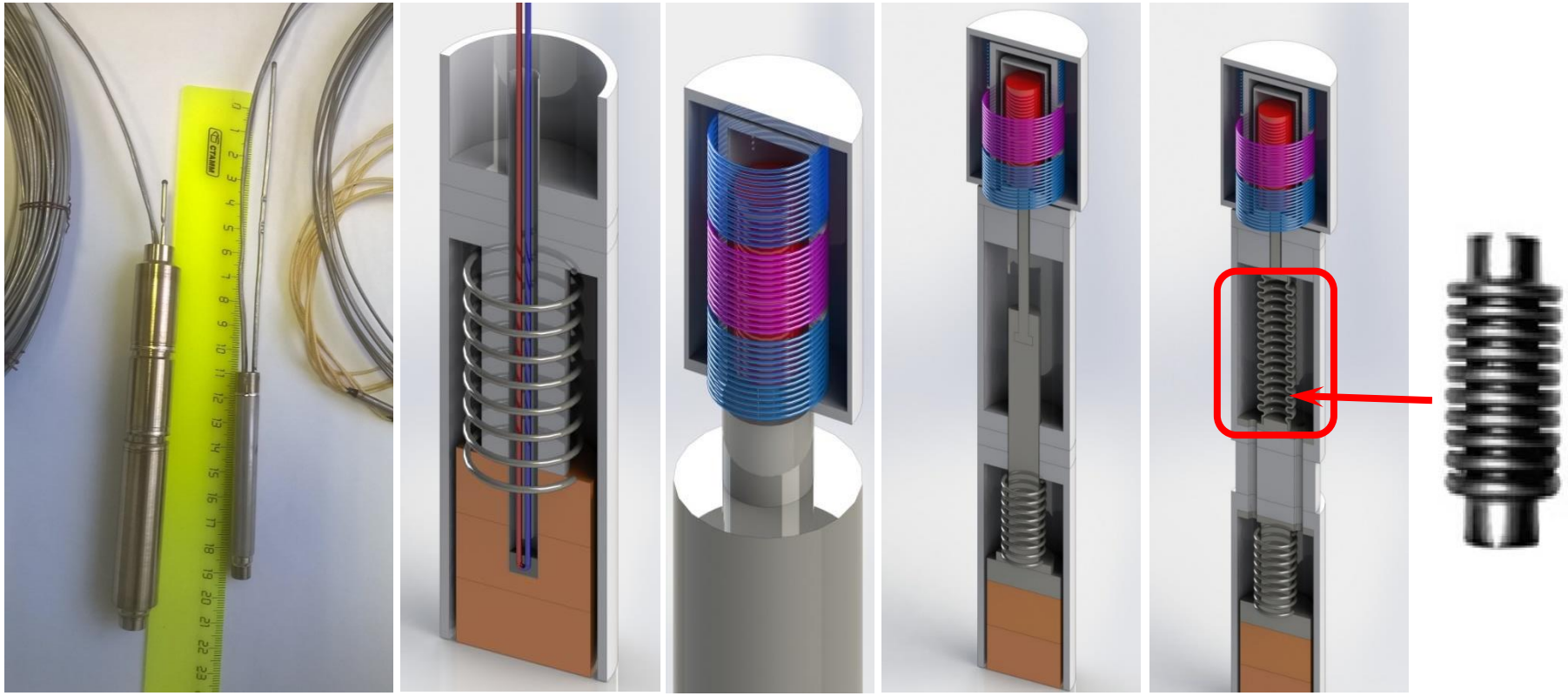
Irradiation rigs to test fuel and structural materials



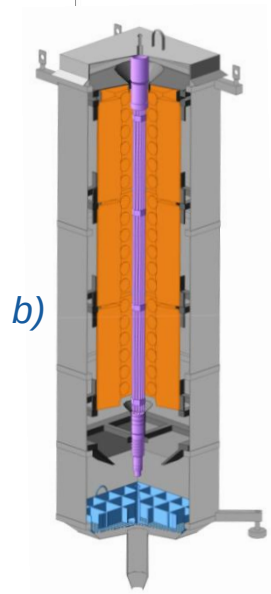


EXPERIMENTAL AND METHODICAL SUPPORT OF TESTS AND EXAMINATIONS

Gauges for in-pile measurements installing installed in fuel rods



EXPERIMENTAL AND METHODICAL SUPPORT OF TESTS AND EXAMINATIONS



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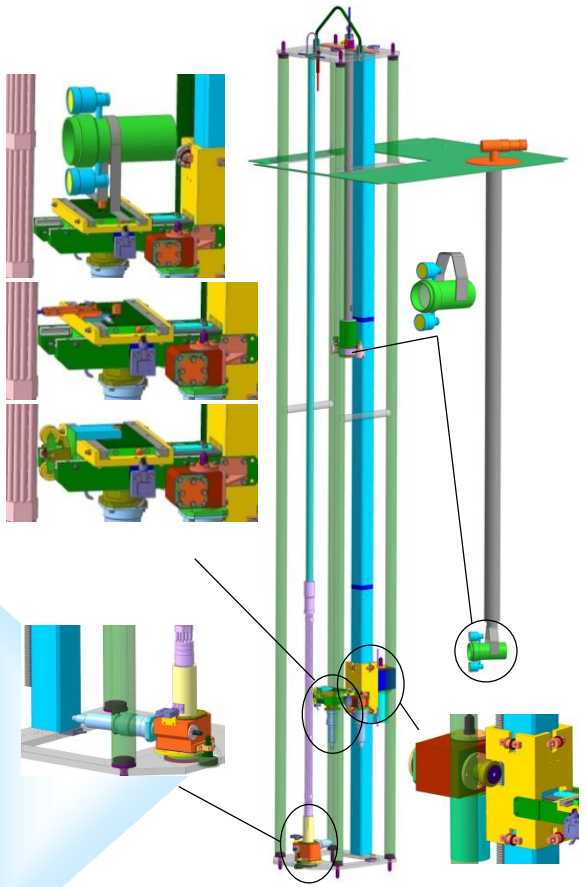
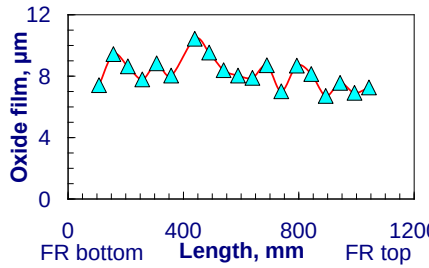
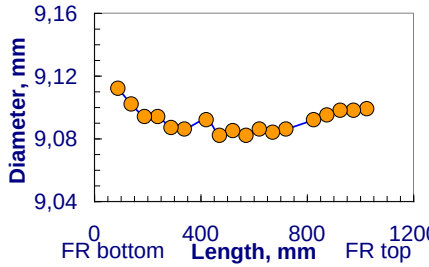


a)

c)



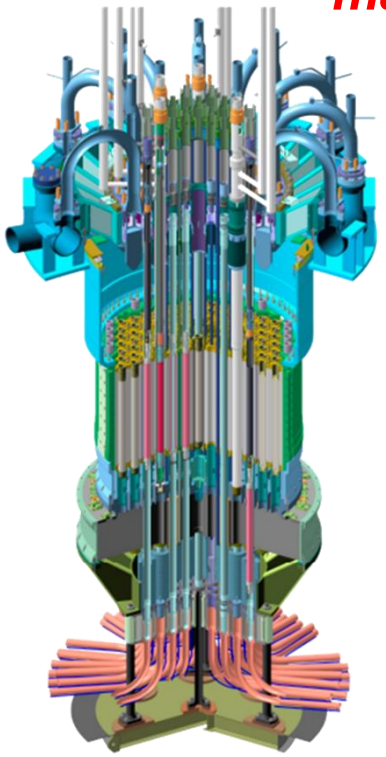


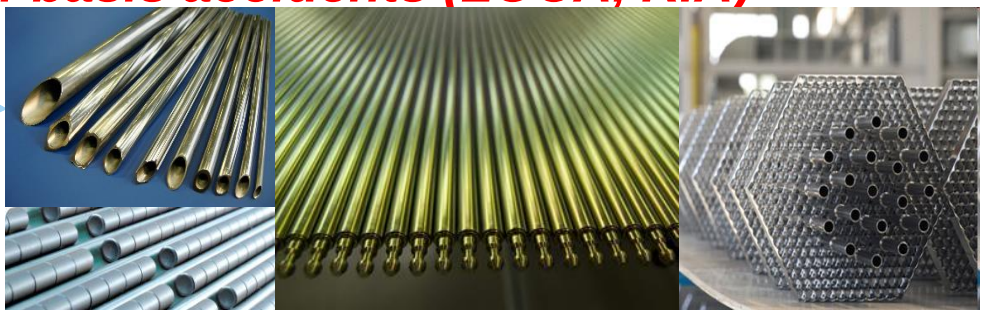
*FR – fuel rod

Design of interim inspection stand (a), design of ultrasonic cleaner (b), photo of interim inspection stand in the MIR.M1 storage pool (c)

KEY TRENDS IN FUEL TESTS

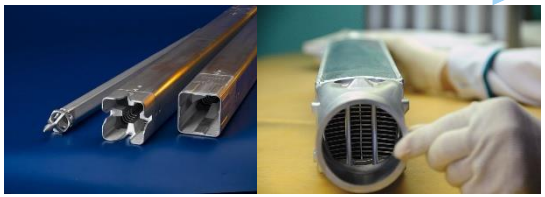
Normal conditions, abnormal conditions (RAMP), maneuvering, design-basis accidents (LOCA, RIA)





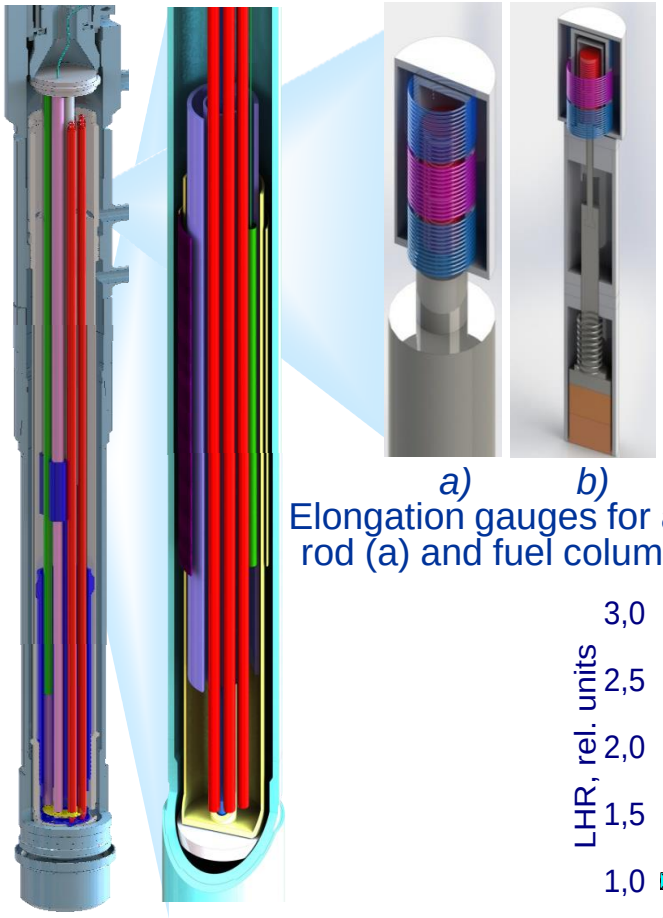
Testing complex of fuel and core components of nuclear reactors of different types

Fission gas release from leaking fuel rods and Gd fuel rods with artificial defects



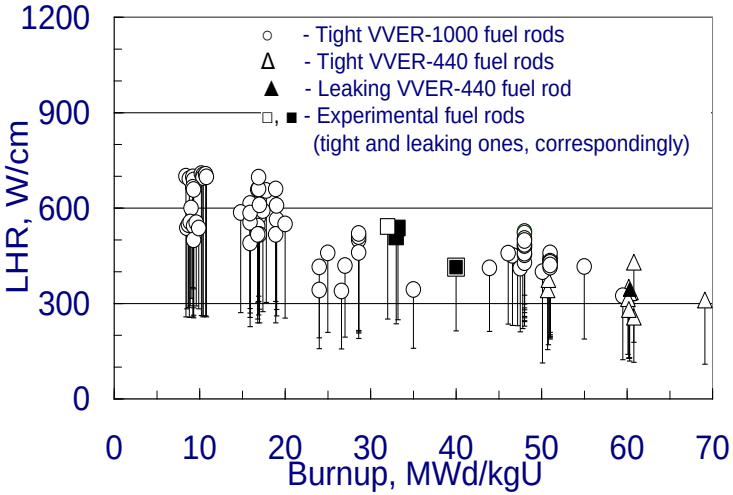
Research reactor fuel

RAMP TESTS



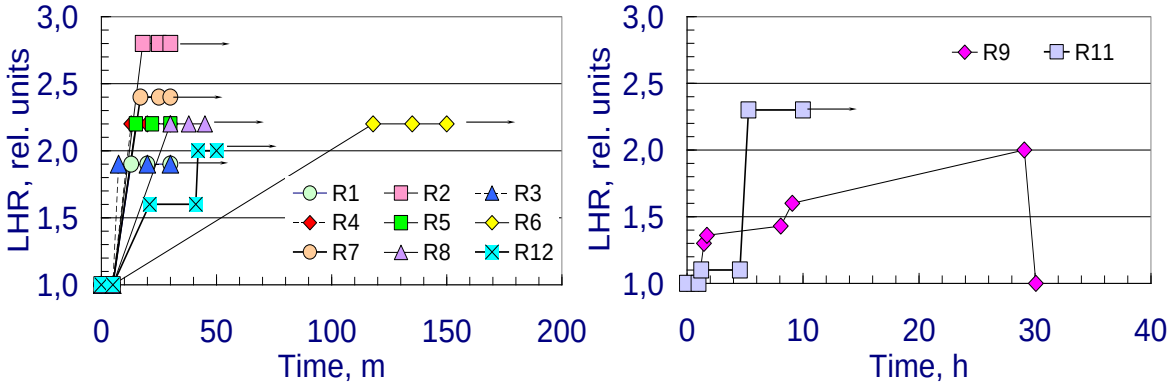
a) *b)*

Elongation gauges for a fuel rod (a) and fuel column (b)



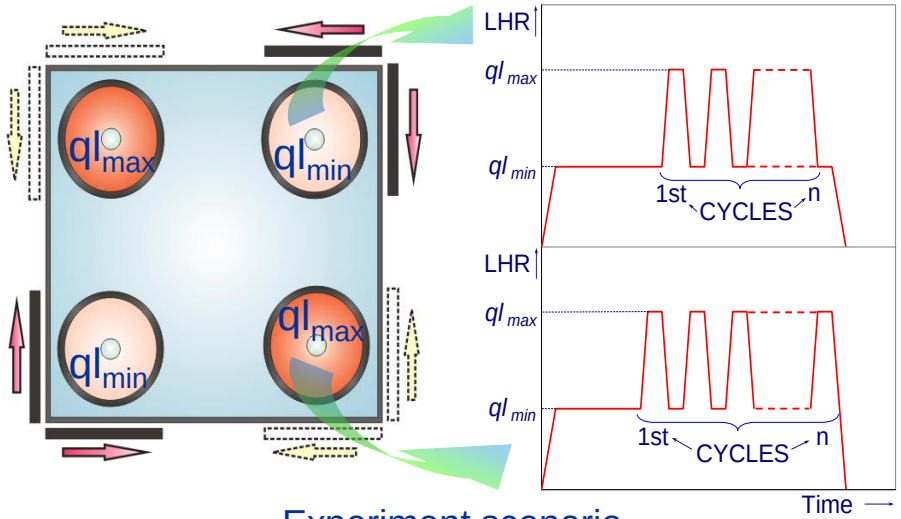
Linear heat rate (LHR) vs of burnup

Irradiation rig to test full-size and refabricated fuel rods under RAMP

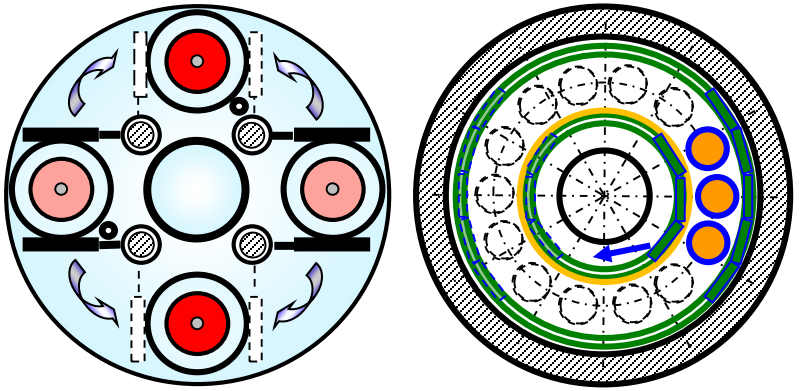


Amplitude of LHR at RAMP tests (R1…R12)

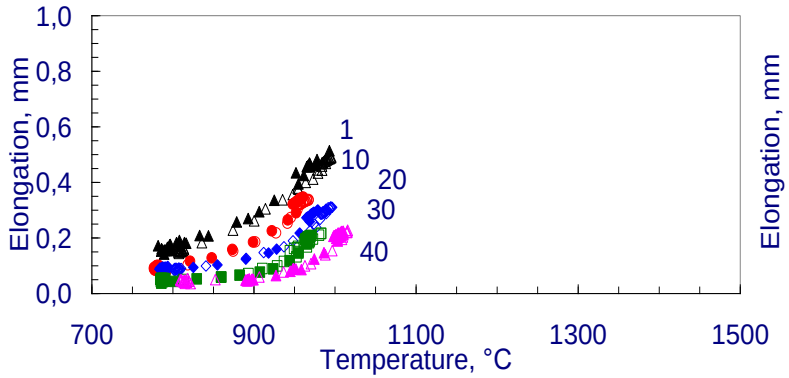
Testing under Power Cycling (Maneuvering)



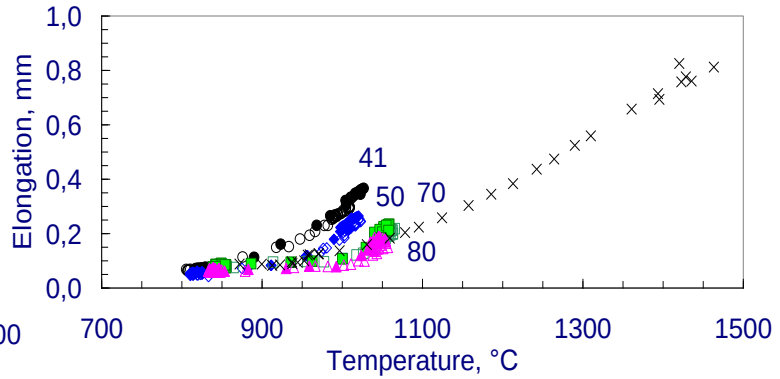
Experiment scenario



Irradiation rig to test fuel rods under multiple power cycling (maneuvering)



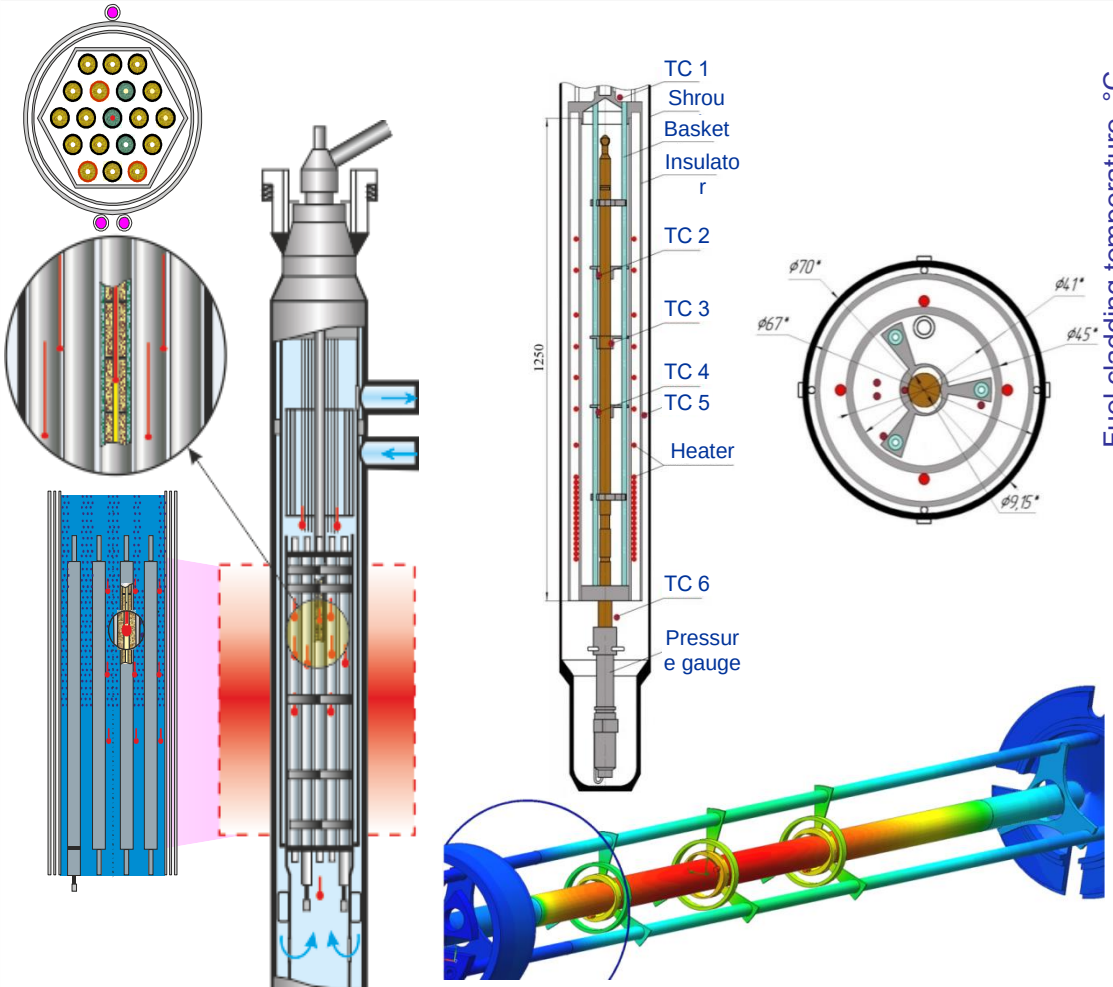
a)



b)

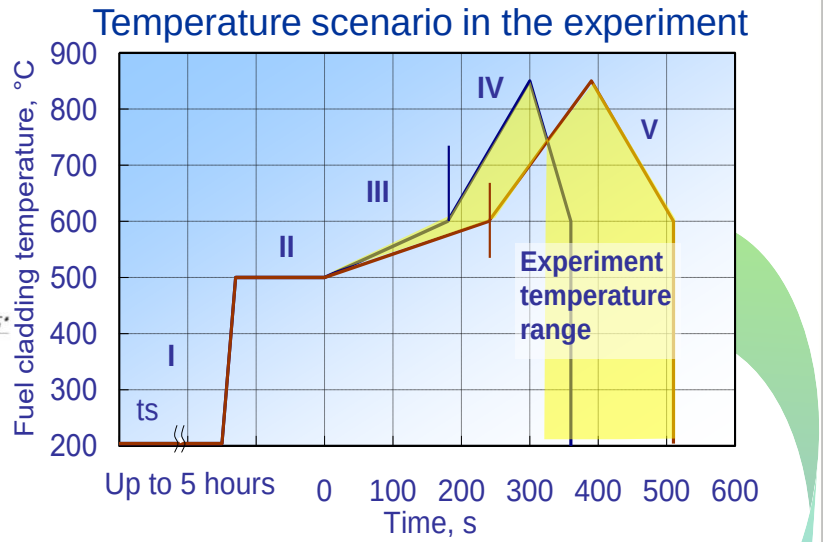
Relation between elongation of the VVER-1000 refabricated fuel rods (50 MWd/kgU) and fuel temperature under power maneuvering: first 40 cycles (a); other 40 cycles, and power ramping (×) after interim storage (b)

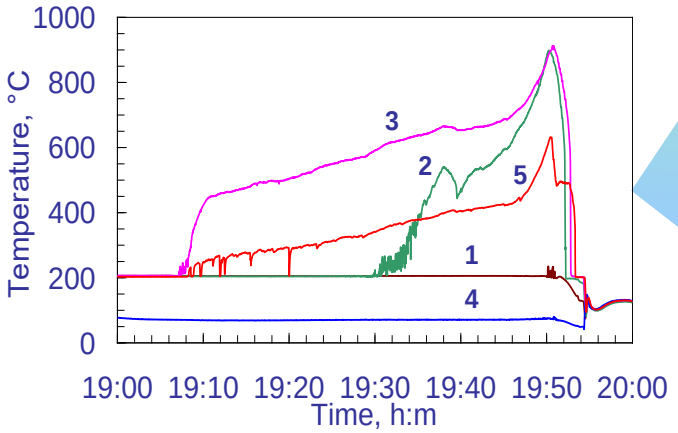
LOCA TESTS



a) b)

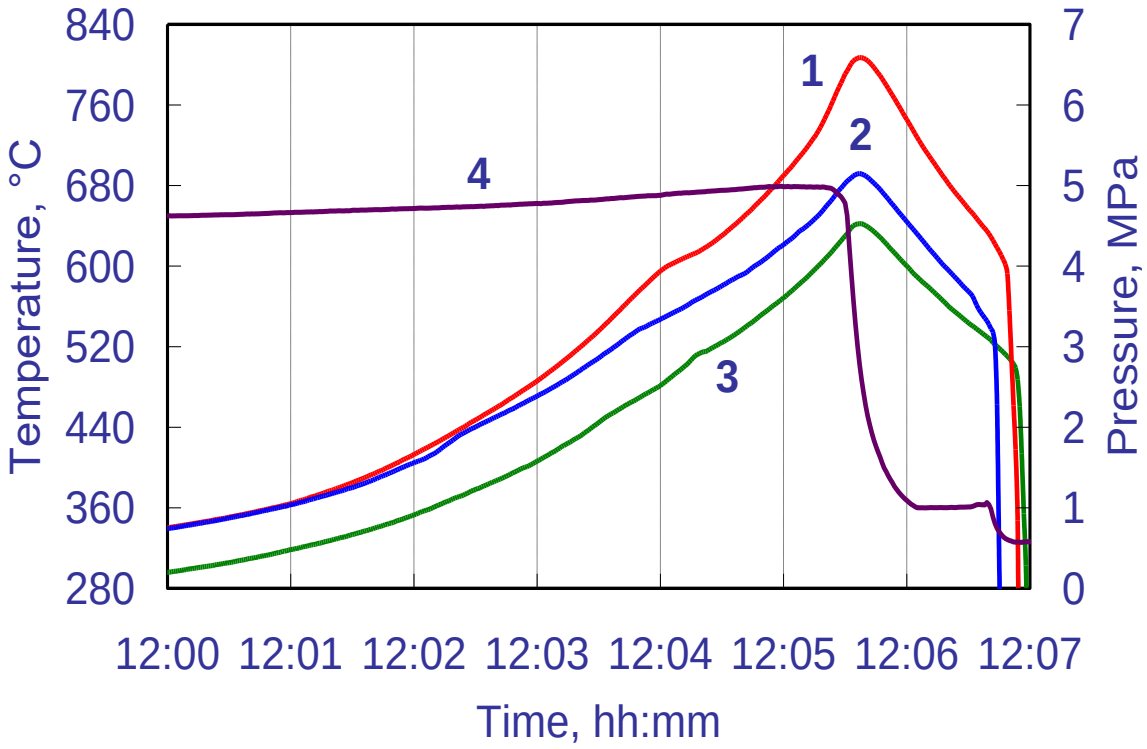
Irradiation rig to test a FA fragment (a) and single fuel rod (b)



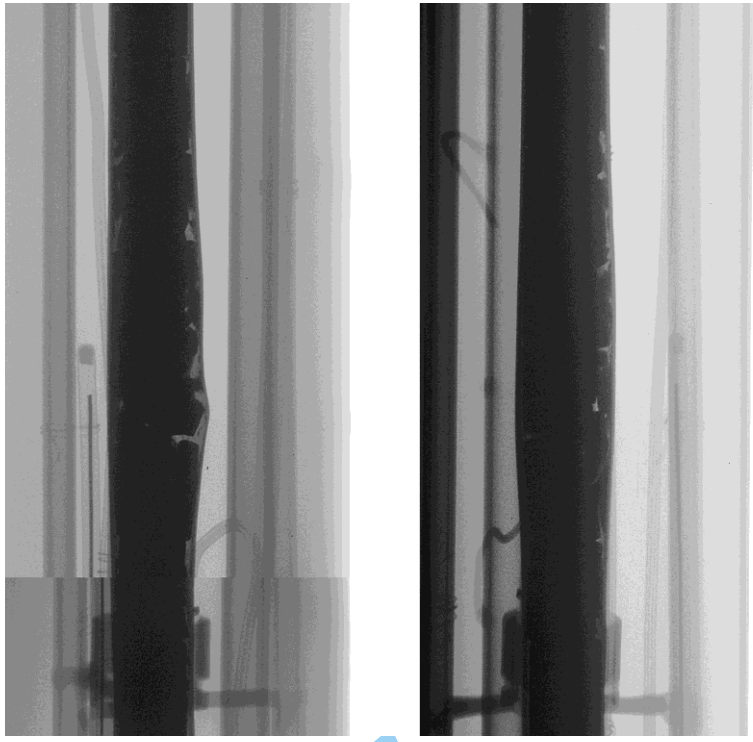


Change in the fuel cladding temperature (thermocouples 1, 2, 3) and coolant (thermocouples 4, 5) in the experiment

LOCA TESTS



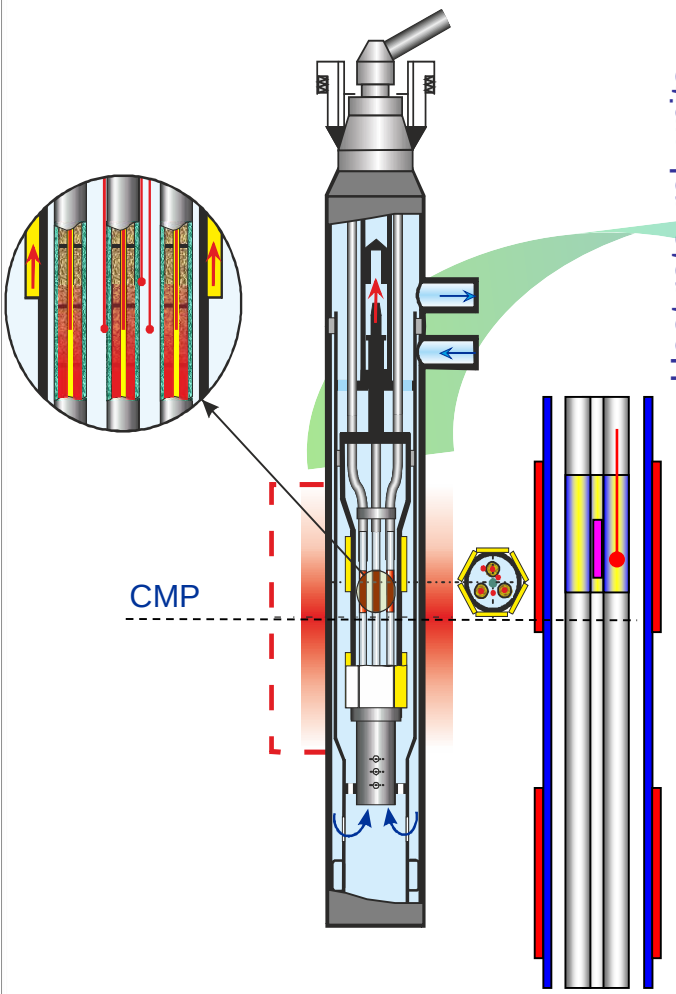
Change in the fuel cladding temperature above the central (1), lower (2) and upper (3) spacer grids at 5…50 mm from the upper grid end. Change in gas pressure (4). MIR-LOCA/50 experiment



Rotation by 90°

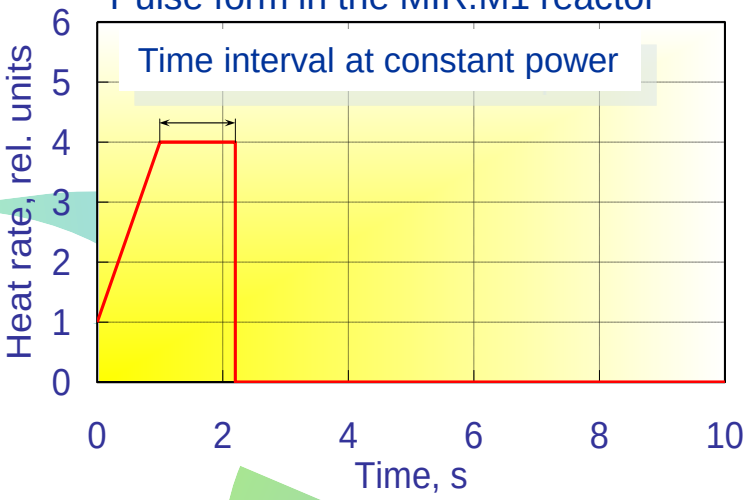
State of the fuel rod after MIR-LOCA/50 experiment (X-ray)

RIA TESTS

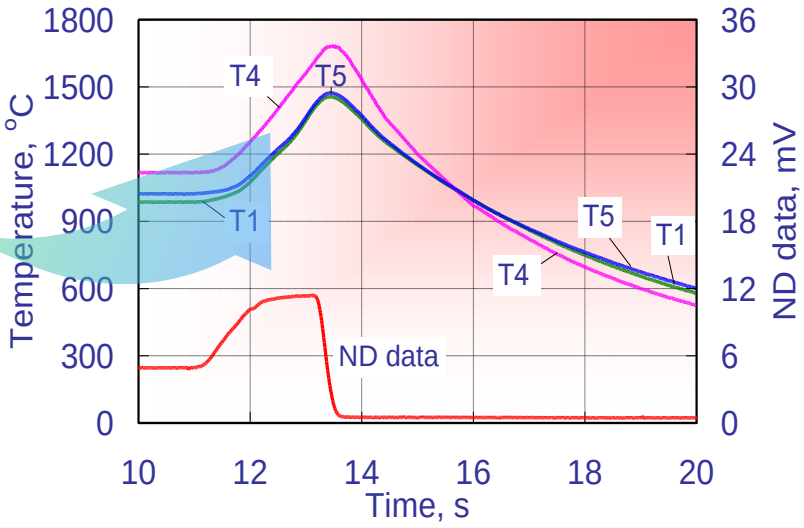


Irradiation rig schematic representation

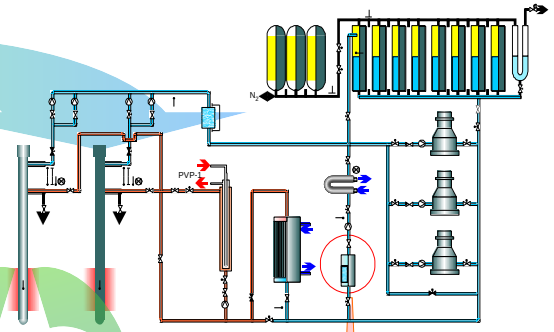
Pulse form in the MIR.M1 reactor



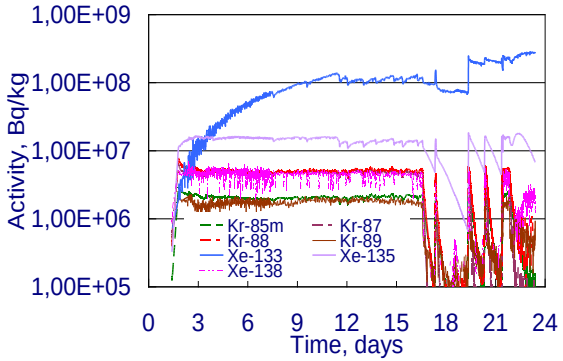
TC data in the fuel column:
T1, T5 – refabricated fuel rods 1,2;
T4 – non-irradiated fuel rod

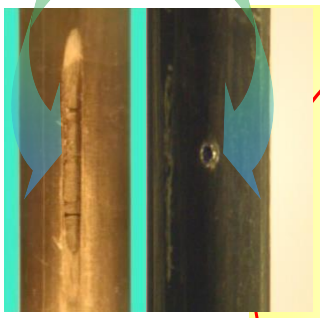


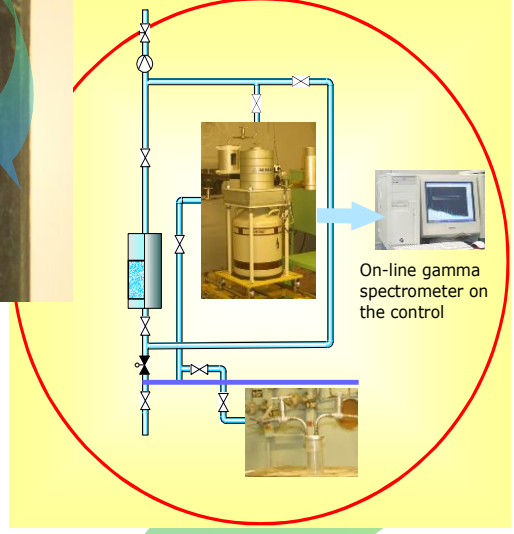
Fission Product Release Investigation of Leaking Fuel Rods

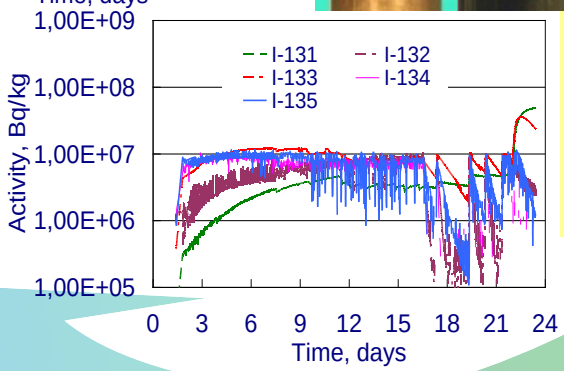


Change in the specific activity of inert radioactive gas in coolant during tests









Change in the specific activity of iodine radionuclides in coolant during tests

Activities to Enhance the MIR.M1 Reactor Safety

After the Fukushima accident, all RIAR's reactors were subject to analysis of consequences from all possible off-site impacts such as earthquake (6 grades), tornado and fire at the adjacent territory.

Key tasks to enhance the MIR.M1 safety:

1. ***Long-term (for more than 24 hours) provision of power for safety-important systems.***
2. ***Anti-seismic system implementation***
3. ***Abgrading the fire protection system .***

Emergency power supply system modernization

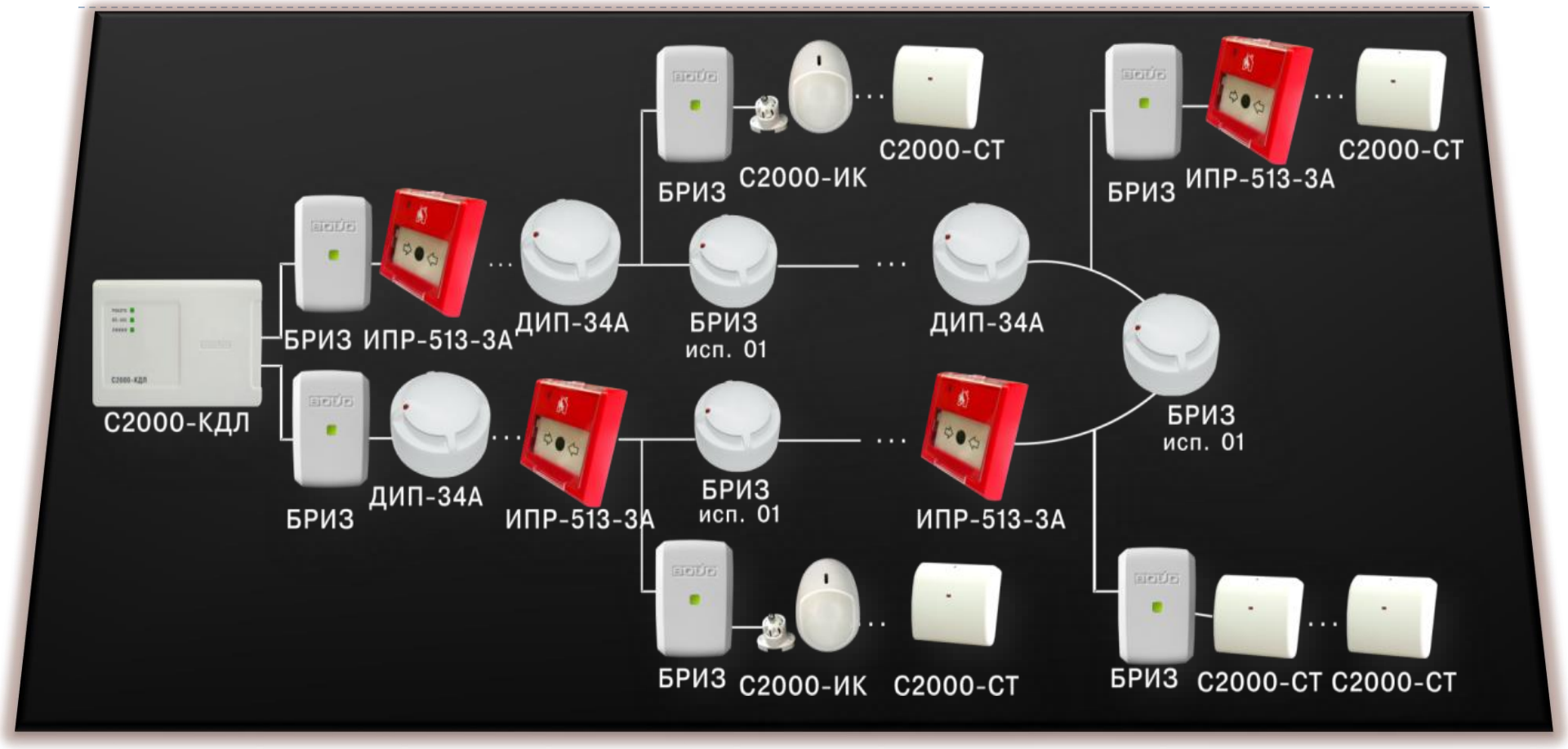
New diesel-based emergency power supply system was put into operation

Anti-seismic system implementation

Seismic sensor CMG-5TD-M.

Anti-seismic system was implemented able to control the reactor building and reactor supporting structure vibrations and output signals to the emergency system in case the set threshold is exceeded.

Abrading the fire protection system



New automatic fire detection and alarm system

Abrading the fire protection system

1. Nominal pump output, ls	10,0
2. Nominal pump pressure, m	60,0
3. Nominal rotation frequency, rot/min	3400
4. Nominal pumping head, m	1,5
5. Max pumping head, m	5,0

Installation of additional mobile water pumps

CONCLUSIONS

Activities to further enlarge the MIR.M1's experimental capabilities and develop promising areas of research:

- improvement of the techniques to control parameters and perform in-reactor measurements of fuel rods characteristics;
- reactor tests in justification of the improved and new types of VVER and PWR fuels under different designed conditions;
- use of a gas-cooled loop to examine core components and FA dummies of high-temperature gas-cooled reactors;
- reactor tests to improve and justify fuels of SMR;
- permanently upgrading of the MIR.M1 reactor and its equipment and extension of its lifetime, including replacement of Be blocks.

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Thank you for your attention!

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