MODELLING AND **CRITICAL CALCULATIONS** OF **IBR-2M** REACTOR

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INTRODUCTION

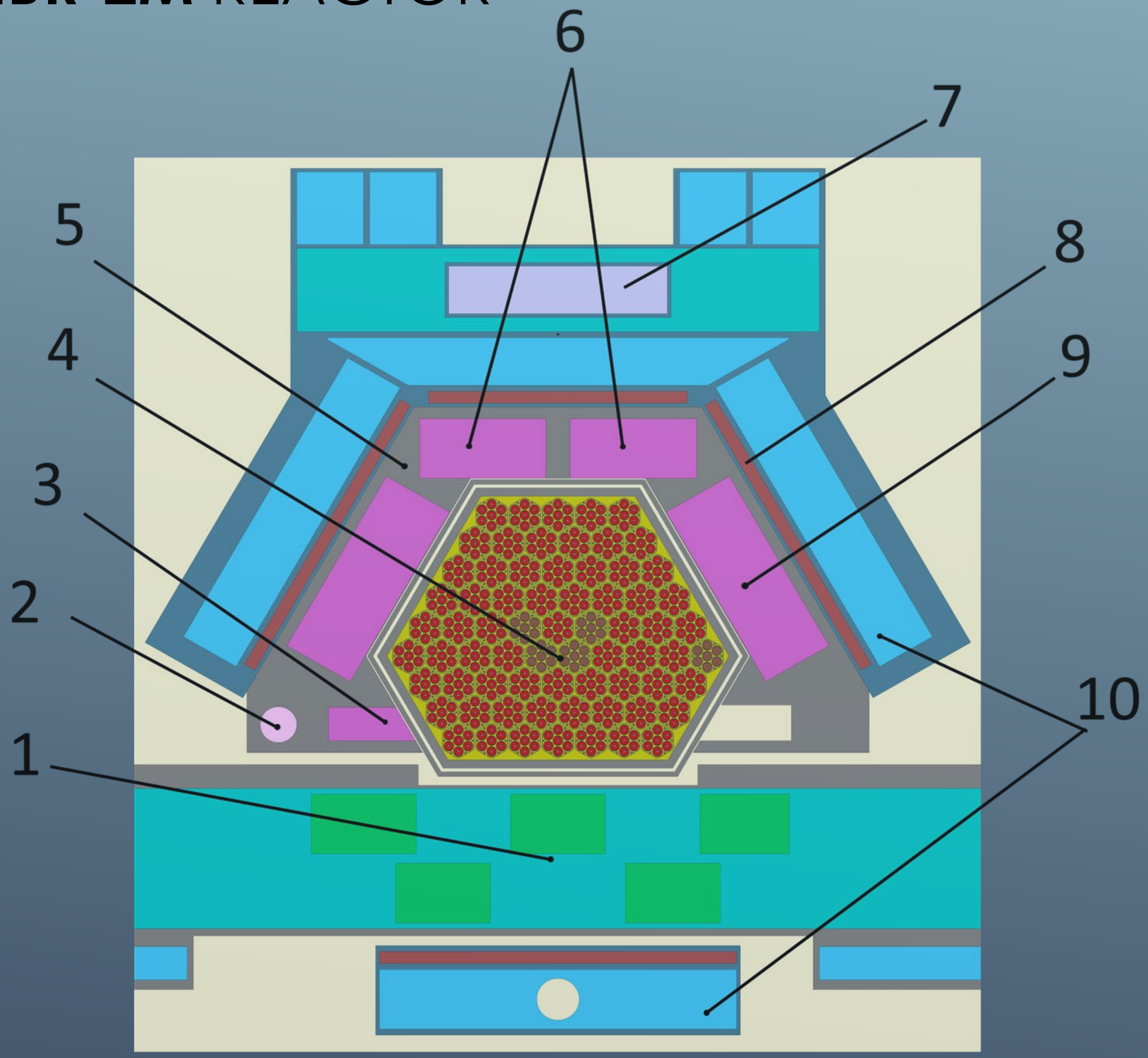
The IBR-2M reactor has been operating in Dubna since 2011 and is a unique facility. This pulsed reactor provides JINR and many other scientific communities with a neutron source for studying condensed matter.

The service life of the IBR-2M is limited, so it is necessary to develop a replacement today. To do this, it is necessary to fully understand all the processes inside the reactor and describe them in the dynamics program in order to take into account all the positive and negative factors of pulsed reactors in the future project.

Our group, led by one of the IBR-2 developers, E.P. Shabalin, is developing the dynamics program.

This report will present a small part of the work related to modeling the IBR-2M reactor, calculating its characteristics, energy release distribution and reactivity inside the core

IBR-2M REACTOR

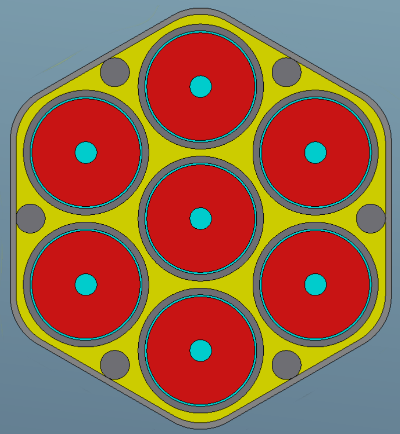


1 – Reactivity modulator PO-3
2 – Automatic regulator (AR)
3 – Manual regulator (RR)
4 – Core
5 – Matrix of stationary reflectors
6 – Emergency protection (AZ-1, AZ-2)
7 – Cold moderator vessel
8 – Boron carbide filters
9 – Compensating reflectors (KO-1, KO-2)
10 – Water moderators

Number of fuel assemblies	69
Number of pins	7
Fuel assembly pitch, mm	27,3
Pins pitch, mm	9,11
FA dia., mm	26,2
Pin dia., mm	8,62
Fuel pellet dia., mm	7,4
Core height, mm	444

Model description

STRUCTURE OF FUEL PINS AND FUEL ASSEMBLIES

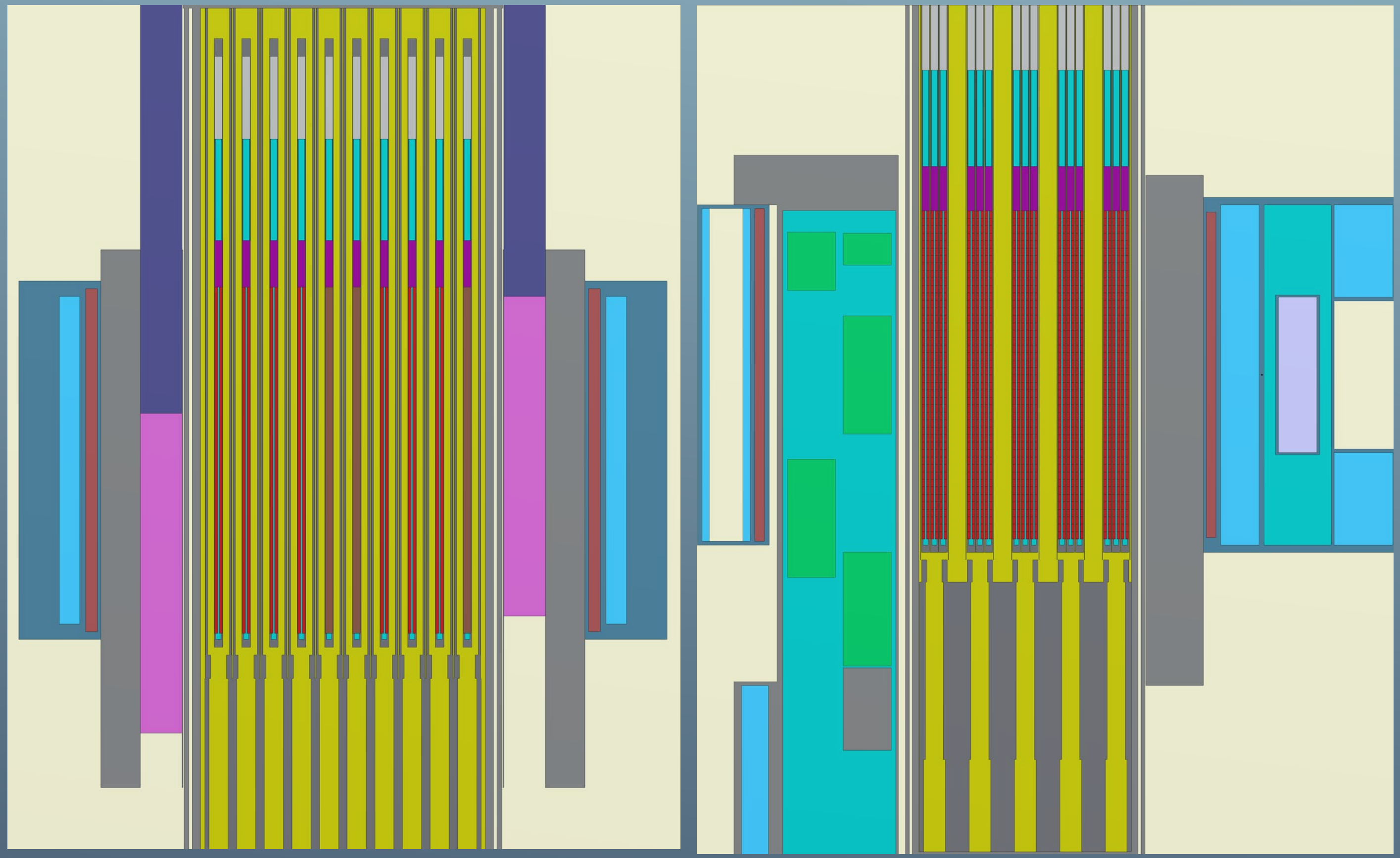


IBR-2 FA

1 – Plug
2 – Fuel pellets
3 – Axial reflector
4 – Plenum (void volume)
5 – Spring

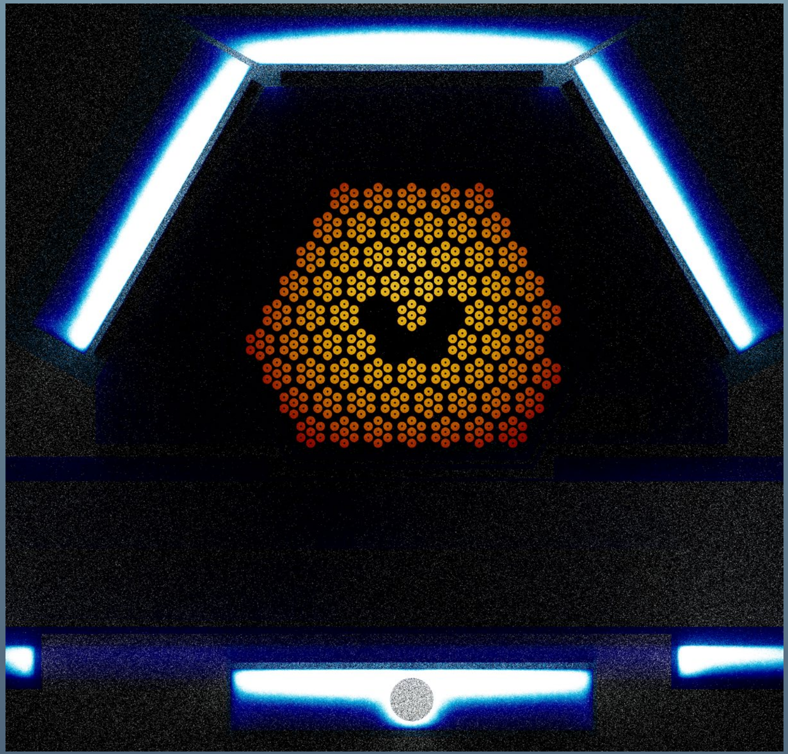
*FA – fuel assembly

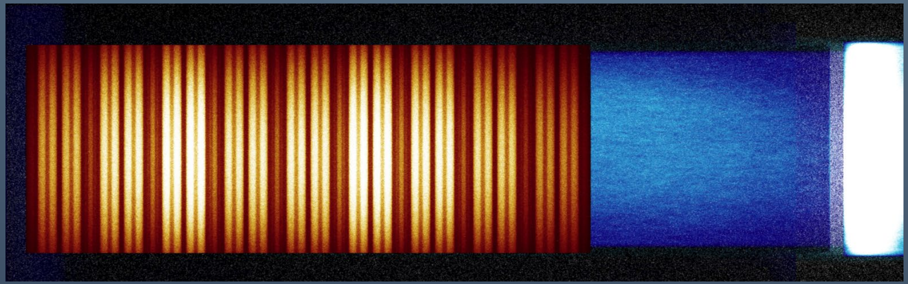
CONTROL BODIES POSITION



Control and protection bodies	KO-1	KO-2	RR	AR	AZ-1 AZ-2
Axial position, mm	286	MAX	190	100	MAX
Max position, mm	410	410	370	290	380

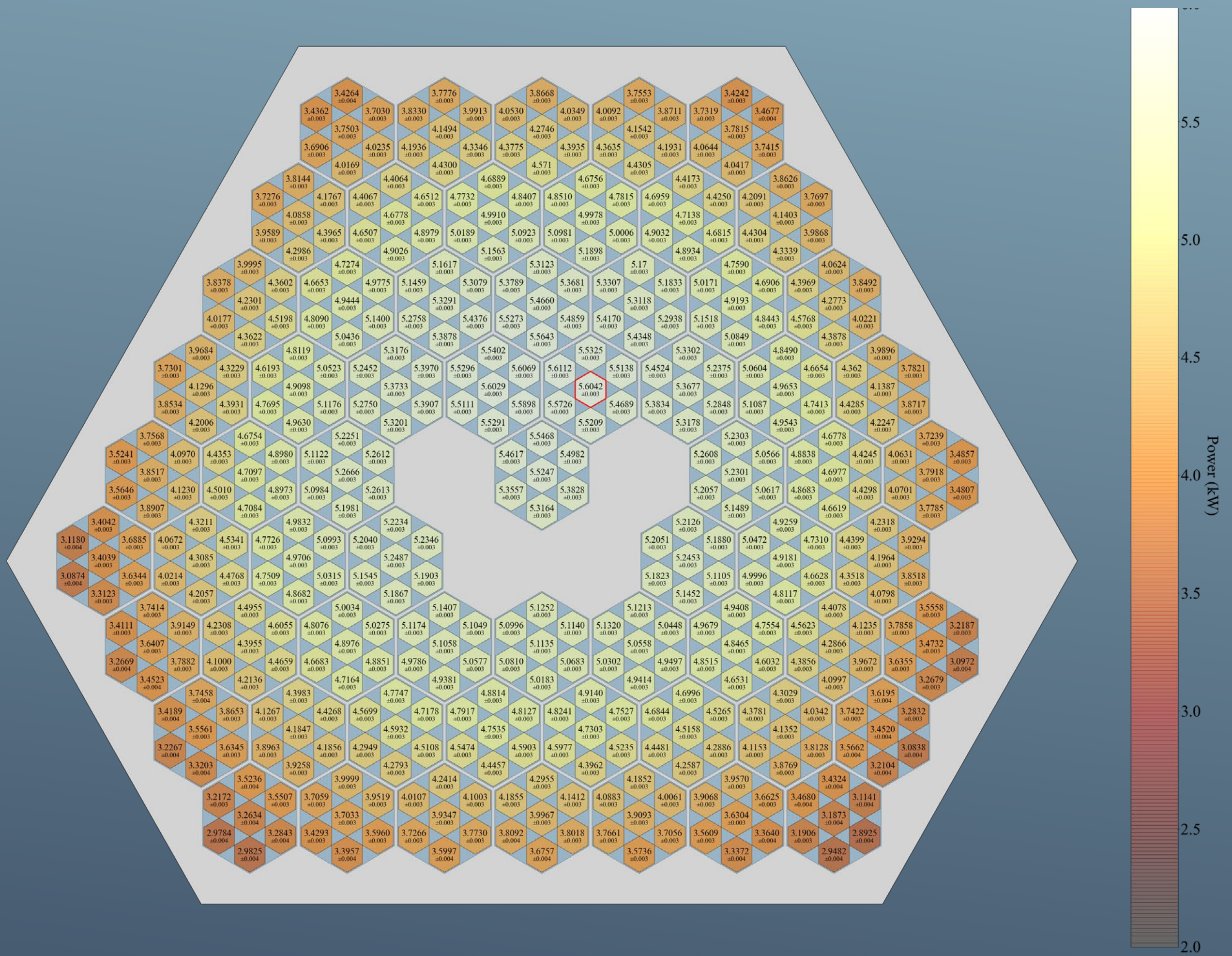
CRITICAL MONTE CARLO CALCULATIONS OF IBR-2M MODEL



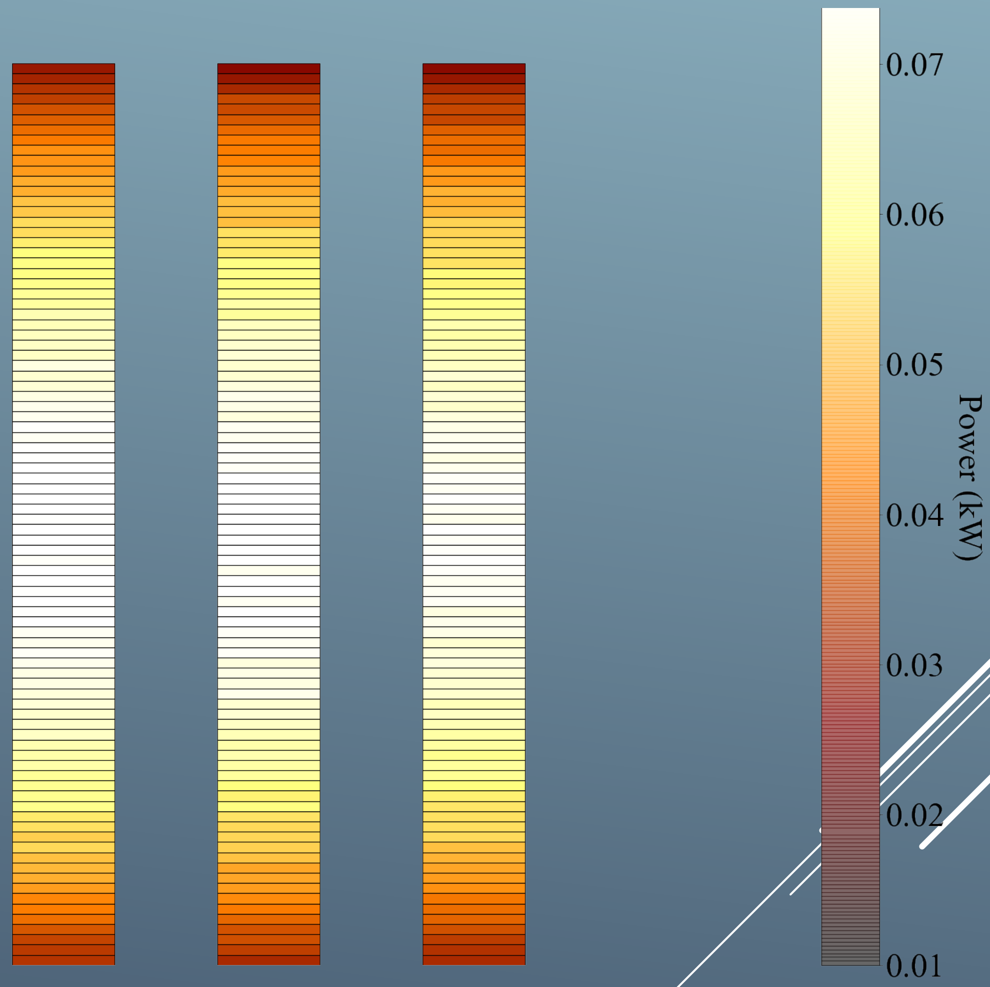


	JEFF-32	ENDFB-7u	Experiment
k_{eff}	1,00219 ± $2 \cdot 10^{-5}$	1,00321±$2 \cdot 10^{-5}$	-
β_{eff}	$2{,}155 \cdot 10^{-3}$	2,159	$2{,}167 \cdot 10^{-3}$
Neutron generation time, ns	60	63	65
Average neutron energy, MeV	1,3	1,3	-
Efficiency of modulator PO-3, % k_{eff}	2,88± 0,042	2,95± 0,04	3±0,05
Max FA power, kW	39,3	39,4	38,5
Flux density at water moderator, $n \cdot cm^{-3}$	$3{,}12 \cdot 10^{13}$	$3{,}2 \cdot 10^{13}$	$\sim 10^{13}$
Efficiency of control bodies, % k_{eff}			
KO-1	2,09± 0,015	2,14± 0,015	2,01
KO-2	2,2± 0,015	2,25± 0,015	2,18
AZ-1	1,06± 0,012	1,15± 0,012	1,04
AZ-2	1.11± 0,012	1,18± 0,012	1,05
RR	0,29± 0,01	0,32± 0,01	0,27
AR	0,026± 0,005	0,021± 0,005	0,018

CORE POWER DISTRIBUTION

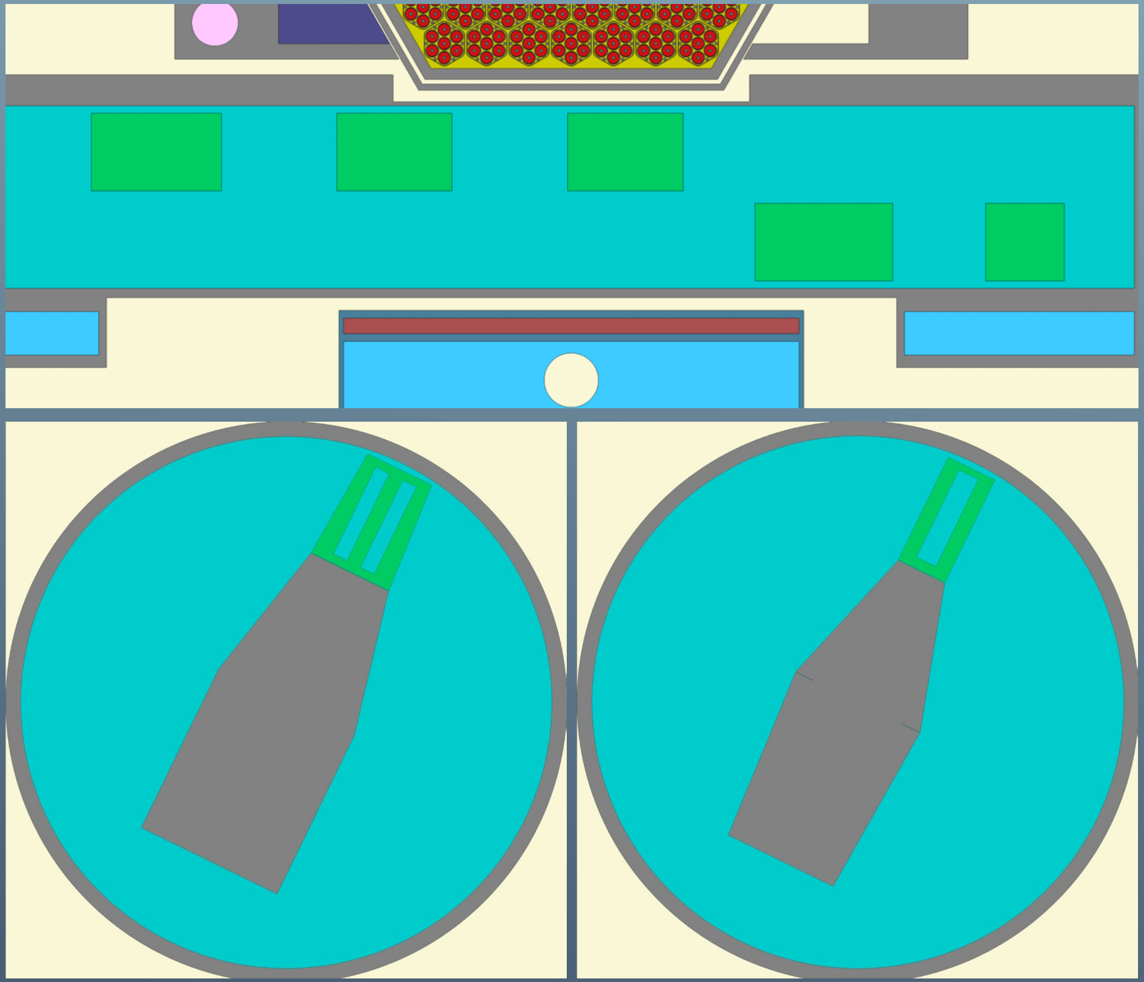


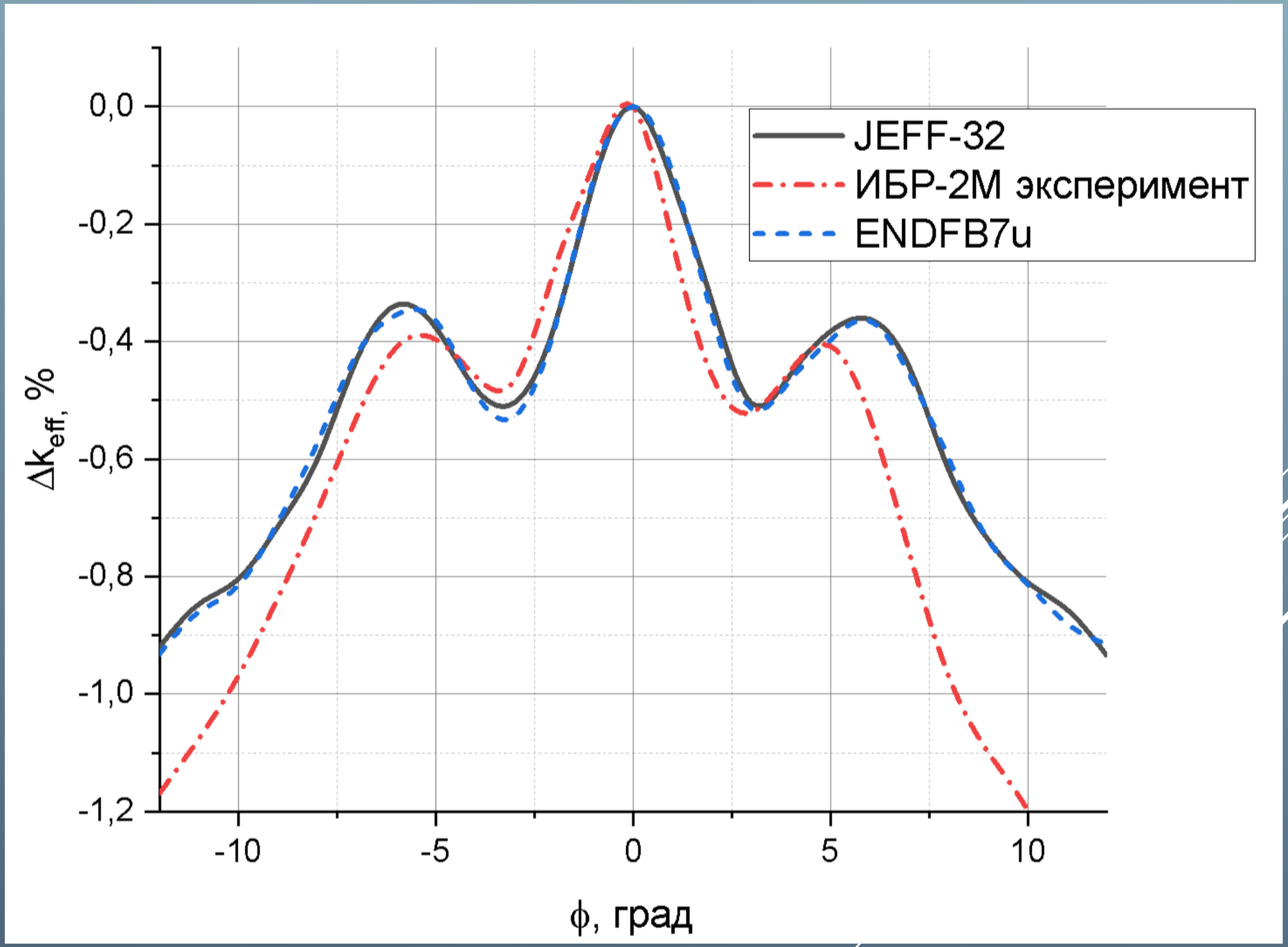
RADIAL distr.



AXIAL distr.

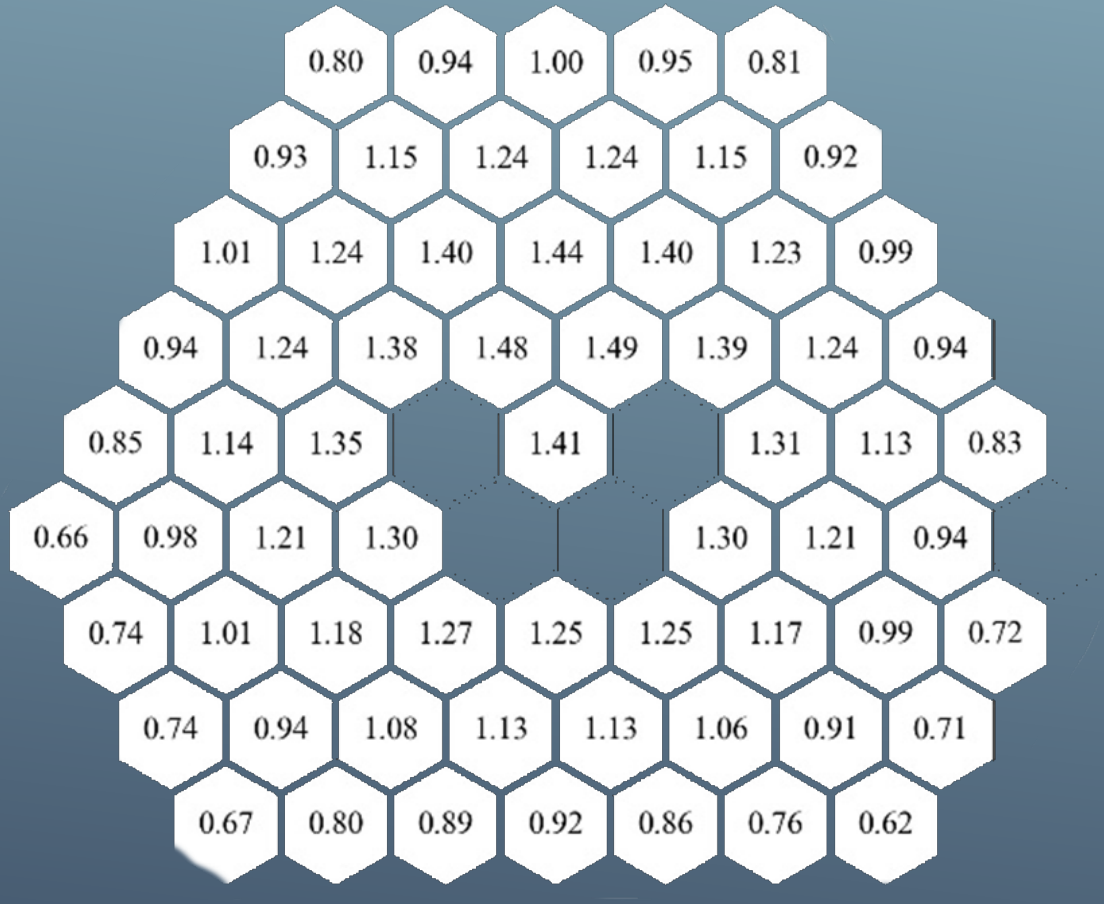
PO-3 MOTION REACTIVITY FUNCTION



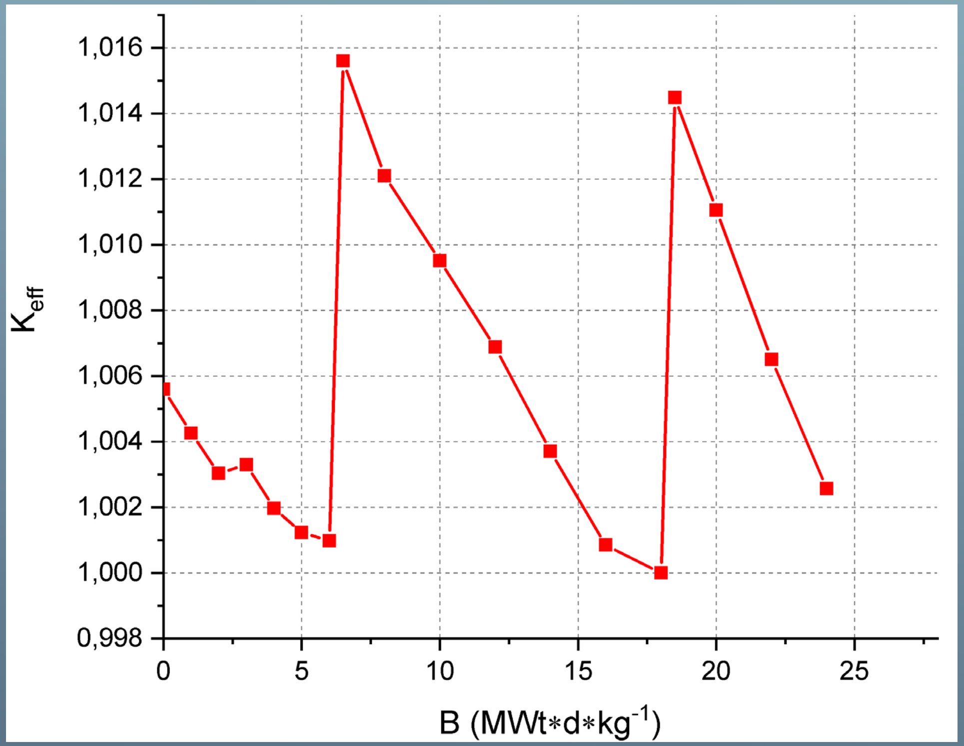


24 critical calculations were performed, in each of which the blades of the movable reflector were shifted by 1 and 0.5 degrees relative to the initial position.

EFFICIENCY OF THE FUEL ASSEMBLIES

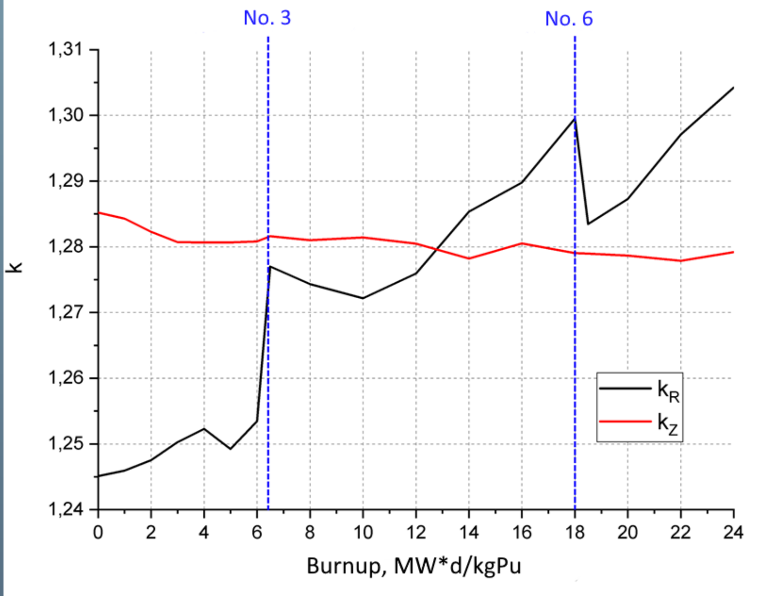


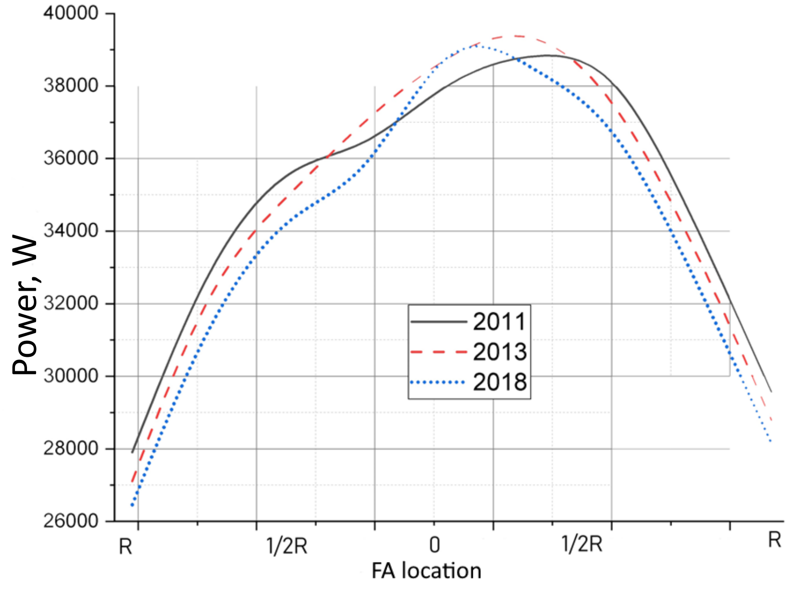
FA EXTRACTION REACTIVITY IN % FROM KEFF



KEFF DYNAMICS FROM BURNUP

BURNUP CALCULATIONS

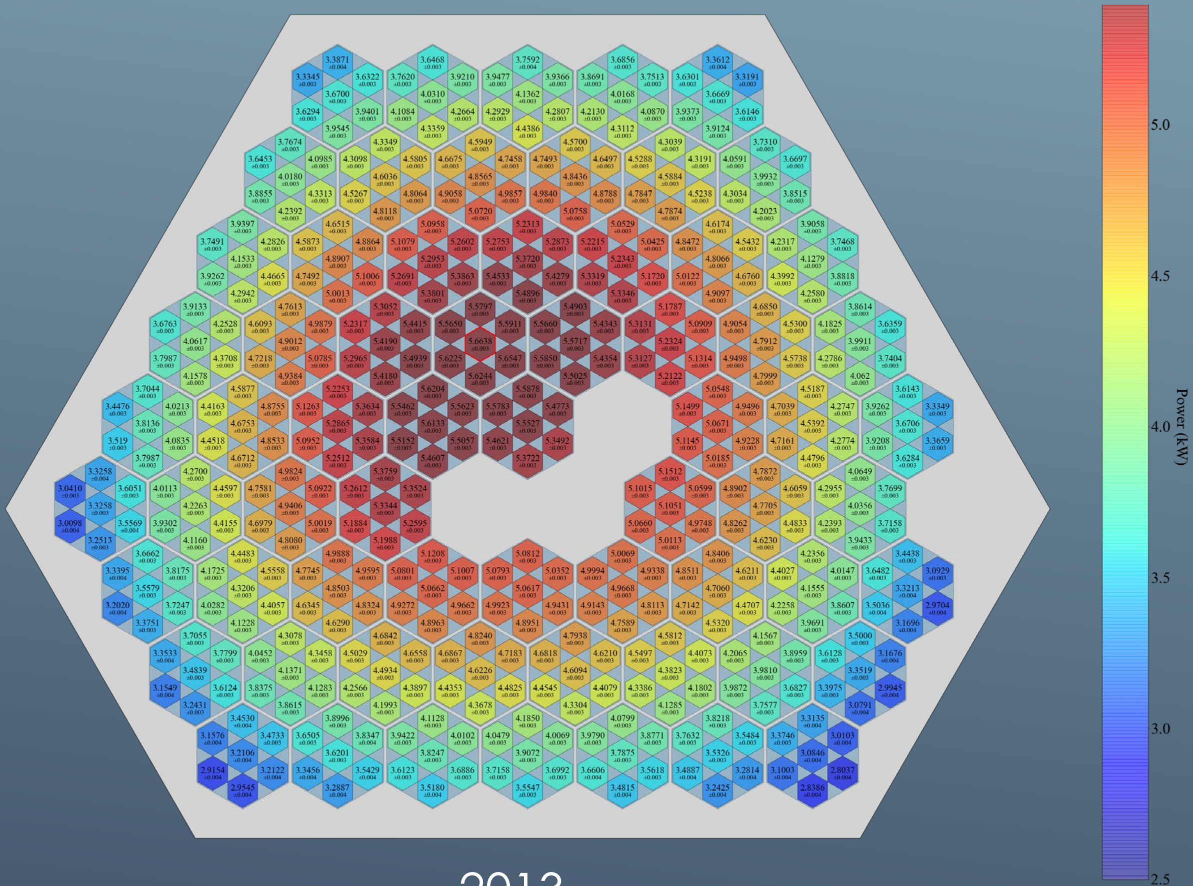




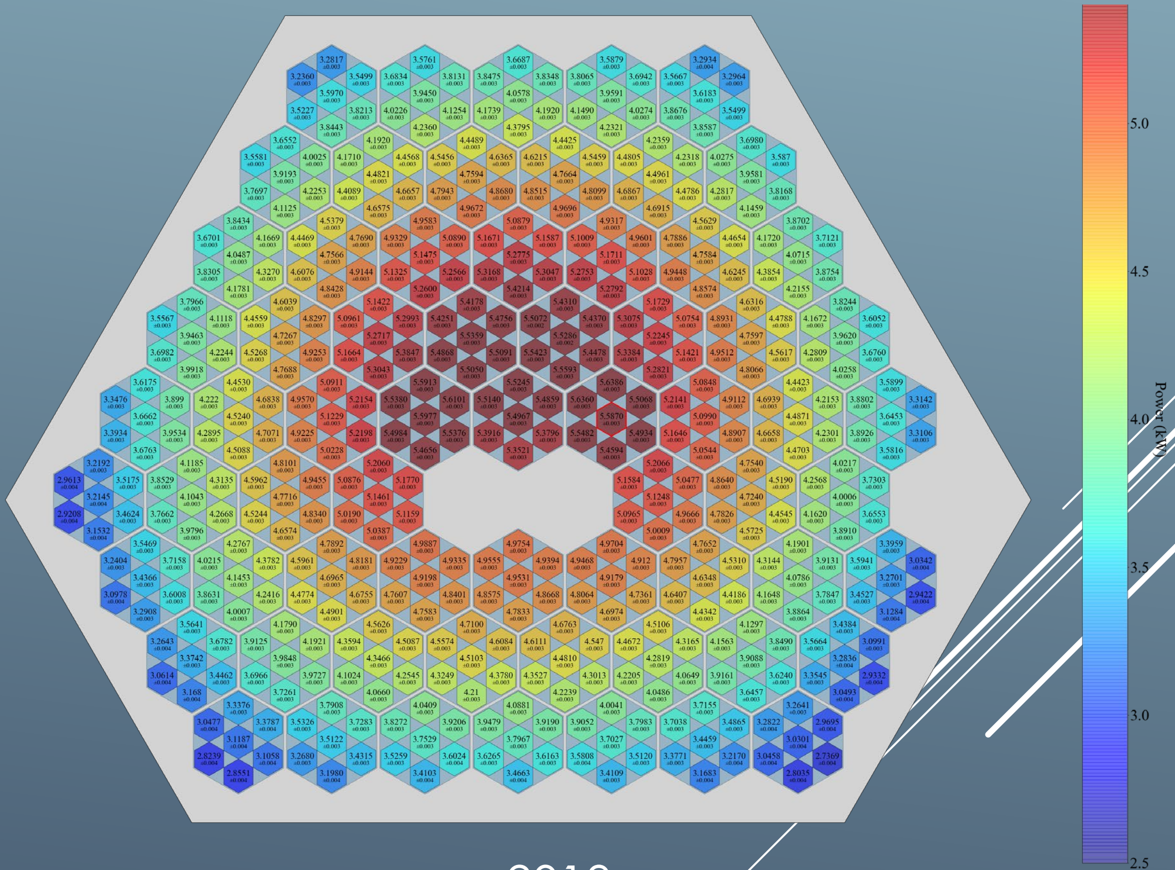
DYNAMICS OF THE CORE ENERGY RELEASE DISTRIBUTION DURING BURNUP

Step-by-step calculations with simulated fuel loading and radial energy release distributions for each stage

DISTRIBUTION OF ENERGY RELEASE DURING FUEL RELOADING



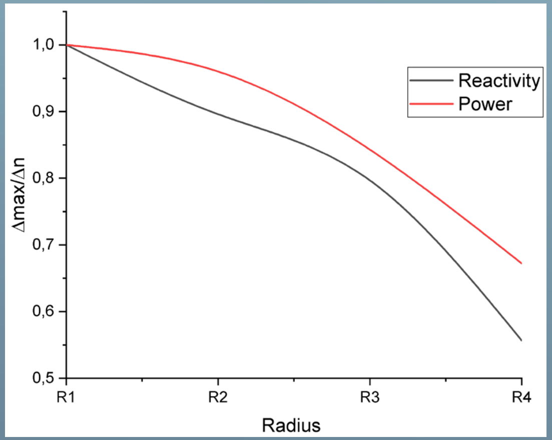
2013

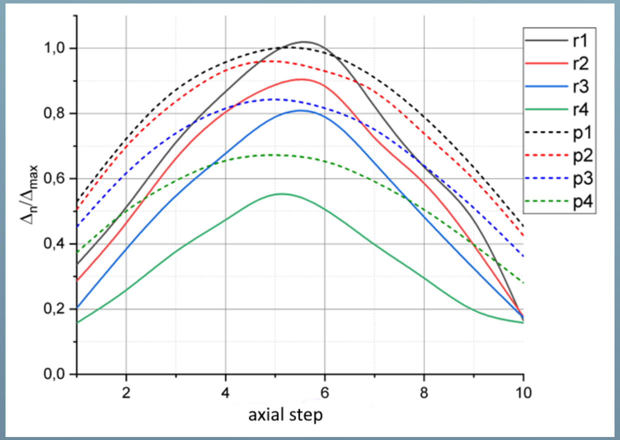


2018

*Reload date

FUNCTIONS OF CORE REACTIVITY DISTRIBUTION





RADIAL AND AXIAL DISTRIBUTION OF ENERGY RELEASE AND REACTIVITY

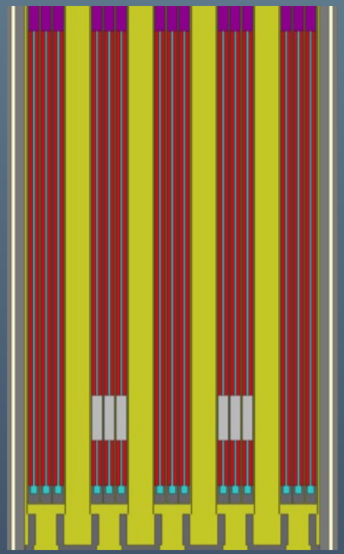
$$L(N, z) \approx A_N \cos^2(0.00524[z - 211]),$$

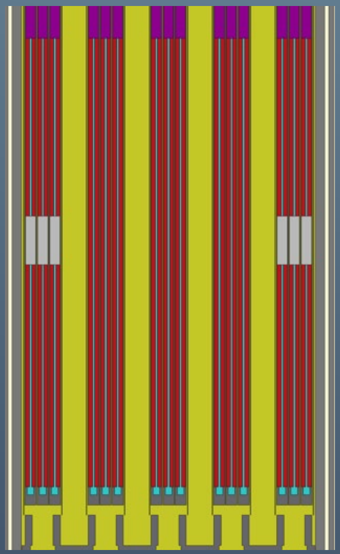
$$A_1 = 3.29 \cdot 10^{-4}\ 1/cm^3,$$

$$A_2 = 2.75 \cdot 10^{-4}\ 1/cm^3,$$

$$A_3 = 2.33 \cdot 10^{-4}\ 1/cm^3,$$

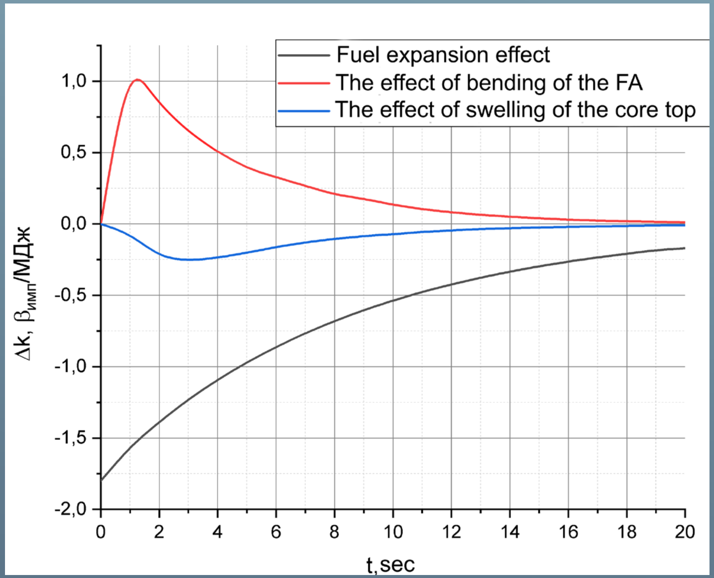
$$A_4 = 1.73 \cdot 10^{-4}\ 1/cm^3.$$



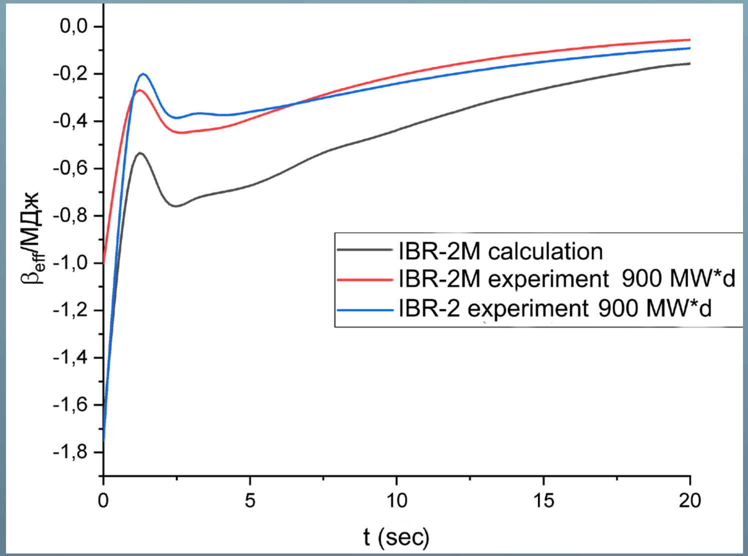


Reactivity distribution functions were obtained for the volume of the active zone, thanks to which we were able to improve the accuracy of calculating the power effects of reactivity

POWER EFFECT OF REACTANCE AND IMPULSE RESPONSE OF FEEDBACK



DISCRETIZATION OF POWER EFFECTS



IMPULSE RESPONSE

Three power reactivity effects were calculated, which determine the type of the impulse response function

The summary graph of the 3 functions and the experimental curves are shown in the graph on the right.

CONCLUSION AND FUTURE STEPS

- A comprehensive 3D model was developed using the SERPENT software package.
- The model demonstrates good agreement with experimental data.
- Distributions of power release and reactivity in the reactor core were determined.
- Data on the dynamics of reactor parameters during fuel burnup and refueling were obtained.
- The three main components of the power feedback were identified, and the feedback's impulse response was calculated.

- It is necessary to develop a fuel burnout model based on experimental data to calculate the impulse response taking into account the fuel campaign
- Theoretical justification and explanation of the positive effect of reactivity
- Construction of a model of the dynamics of pulsed reactors that is consistent with experiments
- Development of a new generation pulse reactor taking into account the obtained results

THANK YOU FOR YOUR **ATTENTION!**