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State Atomic Energy Corporation “Rosatom”

Current Status and Future Trends in the Development of Russian Research Reactors

N. Arkhangelskiy
State Atomic Energy Corporation “Rosatom”,
I.Tretiyakov
Joint-Stock Company "N.A. Dollezhal Research and Development Institute of Power Engineering"

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Introduction

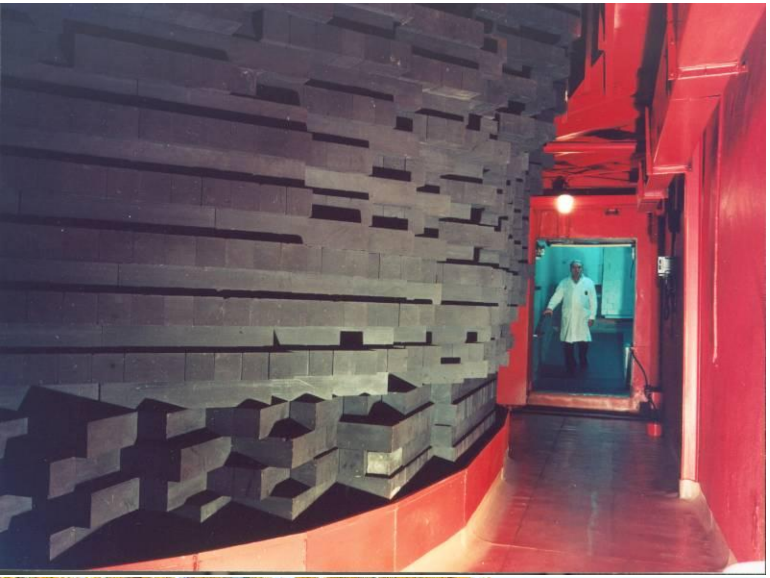
- The development and the construction of research reactors in Russia was very intensive in previous years
- Later these processes were not so intensive owing several reasons: scientific, economic etc.
- Now the utilization of reactors for different purposes is more intensive in comparison with recent years

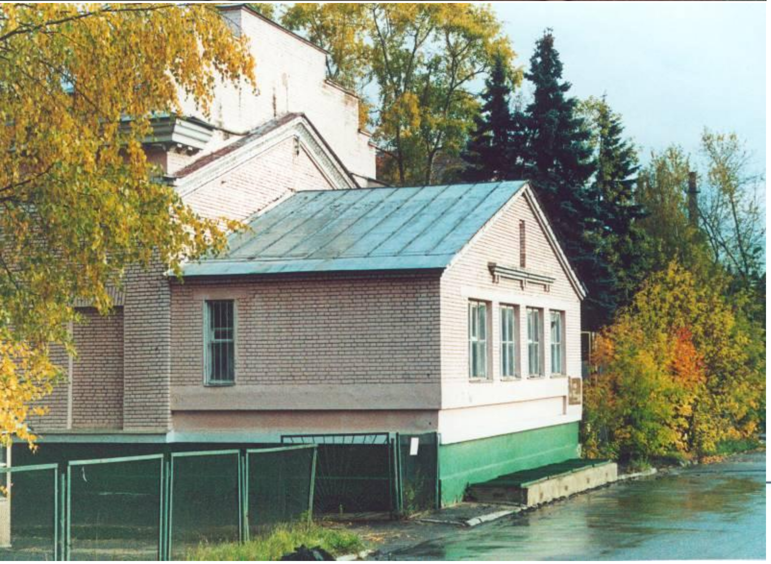
And thereafter!

The development of research reactors in Russia has a new pulse

- Several research reactors were commissioned and the design of new reactors was begin

First Russian Research Reactor F-1





First Russian research reactor F-1 reached the criticality 25 of December, 1946.

65 years ago!

And till now the reactor is in operation in National Research Center “Kurchatov Institute”!

Current Status

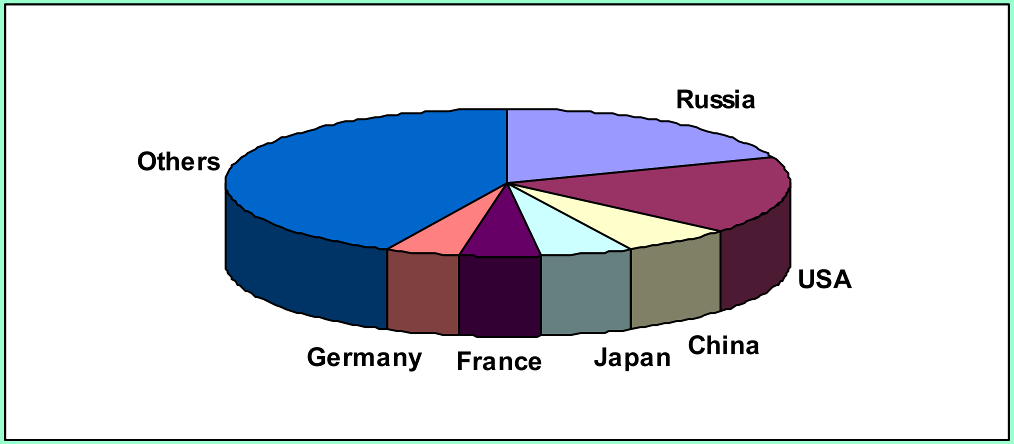
Operating Russian Research Reactors

(power much than 1 MW)

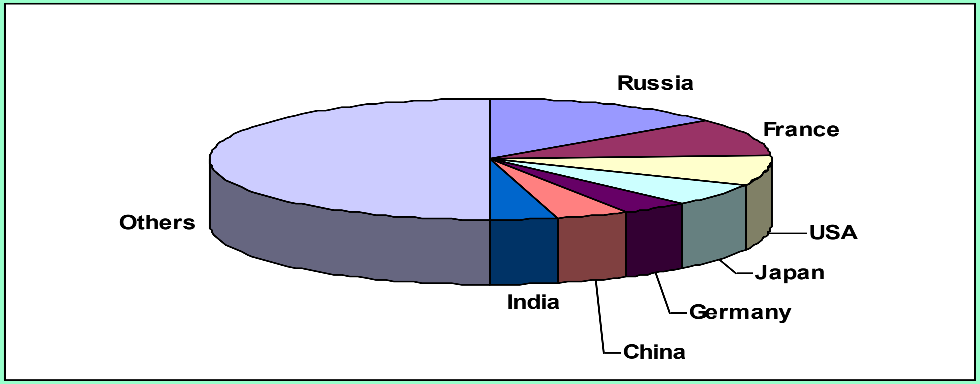
Name	Power, MW	Operating Organization	Maximum Thermal Neutron Flux, n/(sm²*s)
State Atomic Energy Corporation "Rosatom"			
SM-3	100	RIAR	$5*10^{15}$
MIR.M1	100		$5*10^{14}$
BOR-60	60		$3.7*10^{15}$ (fast)
RBT-6	6		$1.0*10^{14}$
RBT-10/2	10		$1.0*10^{14}$
IVV-2M	15	IRM	$4*10^{14}$
WWR-TS	15	NIFHI	$1.3*10^{14}$
Outside "Rosatom"			
IR-8	8	RRC «Kurchatov Institute»	$2.3*10^{14}$
IRT-MEPhI	2,5	MEPhI	$5*10^{13}$
IRT-T	6	TPU	$1.1*10^{14}$
WWR-M	18	PNPI (RRC «Kurchatov Institute»)	$4*10^{14}$
IBR-2M	2	JINR	$1*10^{16}$ (in pulse)
Under Construction or Reconstruction			
PIK	100	PNPI	$5*10^{15}$
IRV-M2	4	RISI	$8*10^{13}$

Russia at the World Research Reactors Map

- About 241 research reactors are in operation around the world
- 47 of them are in Russia



- 50 operating research reactors with power much than 10 MW around the world; 7 of them are in Russia



Current Status

- From the first years the fleet of Russian Research Reactors developed in several important directions:
  - Serial Reactors
  - High Flux Reactors for:
    - material testing
    - radioisotope production
    - fundamental research
  - Pulse Type Reactors
  - Fast Reactors
  - and at last Critical Assemblies or “Zero-Power” Reactors
- All of these directions represents research reactors that continue to operate but nevertheless new reactors were commissioned or under development

Serial Reactors

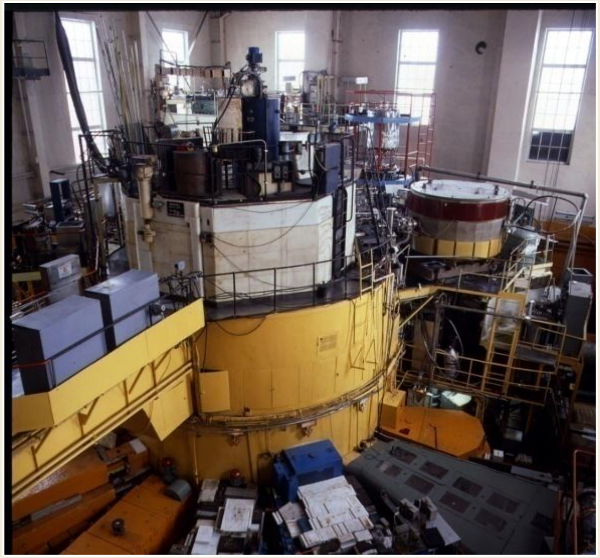
The most widespread type of the reactors of Russian design

Two main modifications of serial reactors were developed and constructed

- IRT
- WWR

Pool type reactors

Universal utilization: fundamental research, material testing, radioisotope production



Serial Reactors

- Many Serial Research Reactors were constructed in Russia and in Foreign Countries
- Many of them are in operation till now
- The design of these reactors was so good that many modifications and refurbishments could be realized
- Now there are new proposals on the development of new generation of research reactors on the base of the design and the operation experience of serial reactors

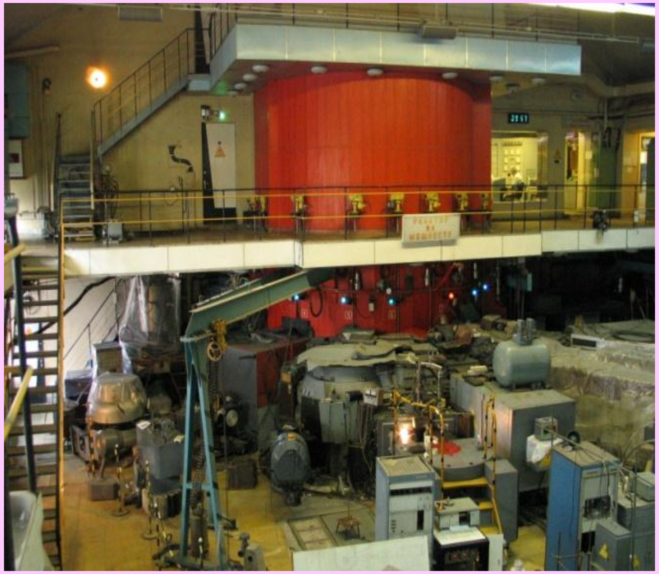
High Flux Reactors

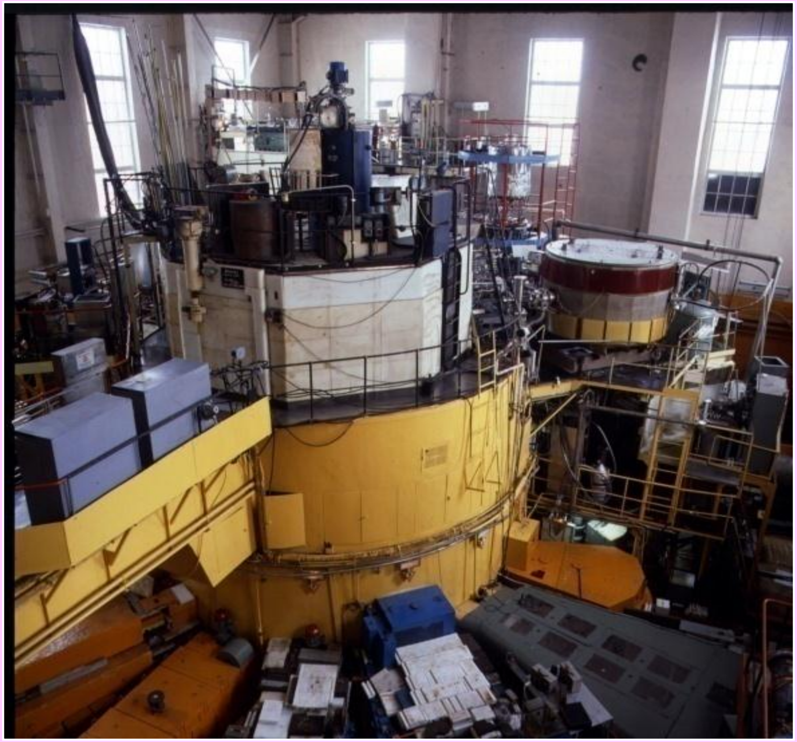
Fundamental research

IR-8 & WWR-M reactors that have the high thermal neutron flux 2.3-4*10^{14} n/(sm^2*s)

These reactors were developed on the base of serial reactors but owing to many modifications the neutron flux in theme is much higer than in serial reactors

Very effective utilization: Fundamental research, Cold neutron source





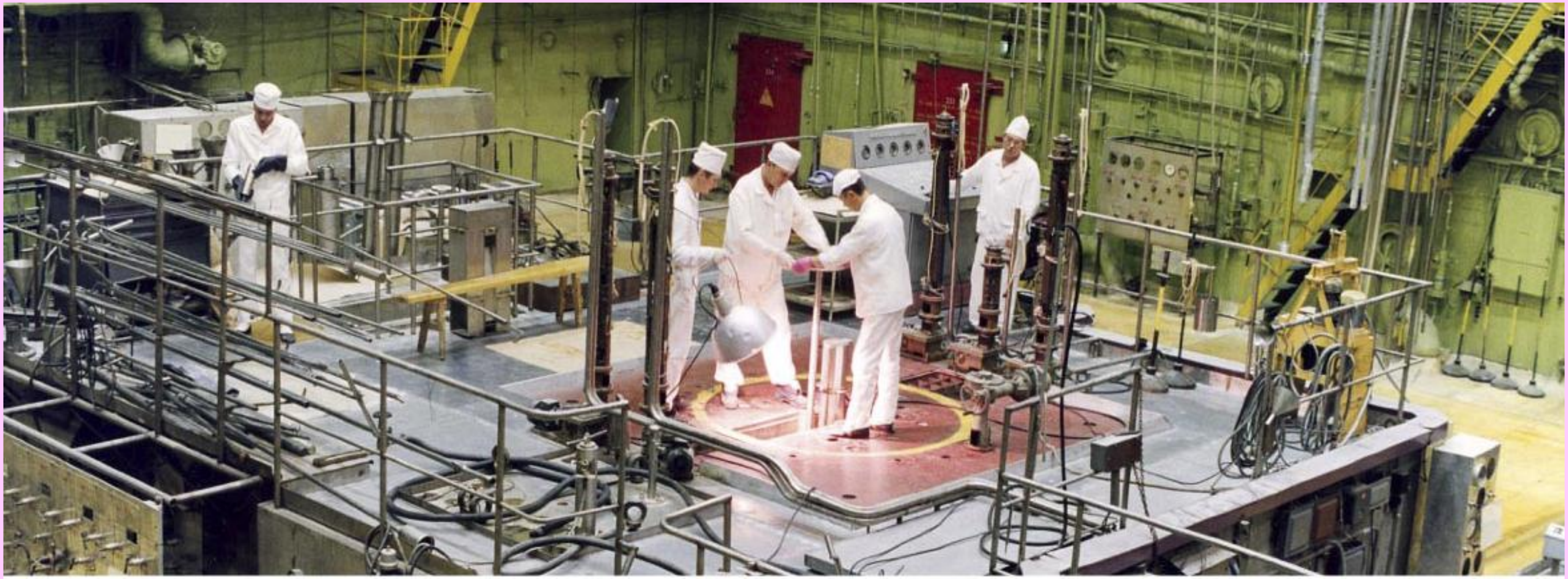
High Flux Reactors

Radioisotope Production

SM-3 reactor that has the higher thermal neuron flux in the world - $5*10^{15}$ n/(sm^2*s)

Tank type reactor

Utilization: Trans uranium isotopes production and material testing

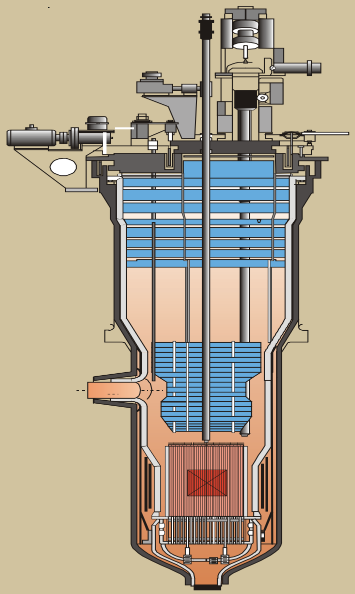


PETELIN A.L., et al., "Use of Multifunctional Research Reactor Complex at SSC RIAR"

High Flux Reactors
Material Testing

- MIR.M1 reactor that has the thermal neuron flux $5*10^{14}$ n/(sm^2*s)
- Channels in the pool
- Utilization: material testing

Fast Reactors

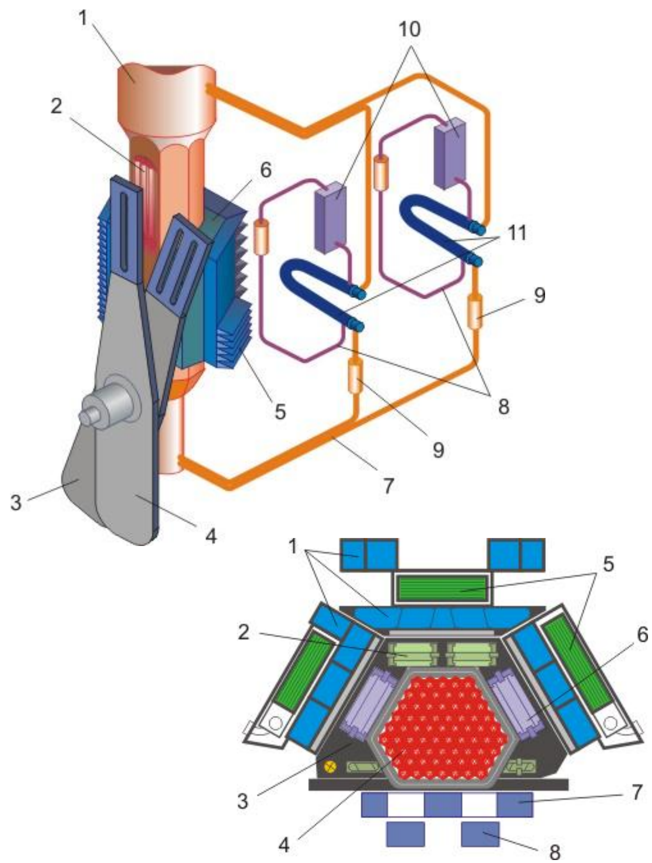


- Several fast research reactors were developed and constructed in Russia – BR-1, BR-2, BR-10, BOR-60
- Now only the BOR-60 reactor is in operation and it has the fast neutron flux $3.7*10^{15}$ $n/(sm^2*s)$
- Utilization: material testing and radioisotope production

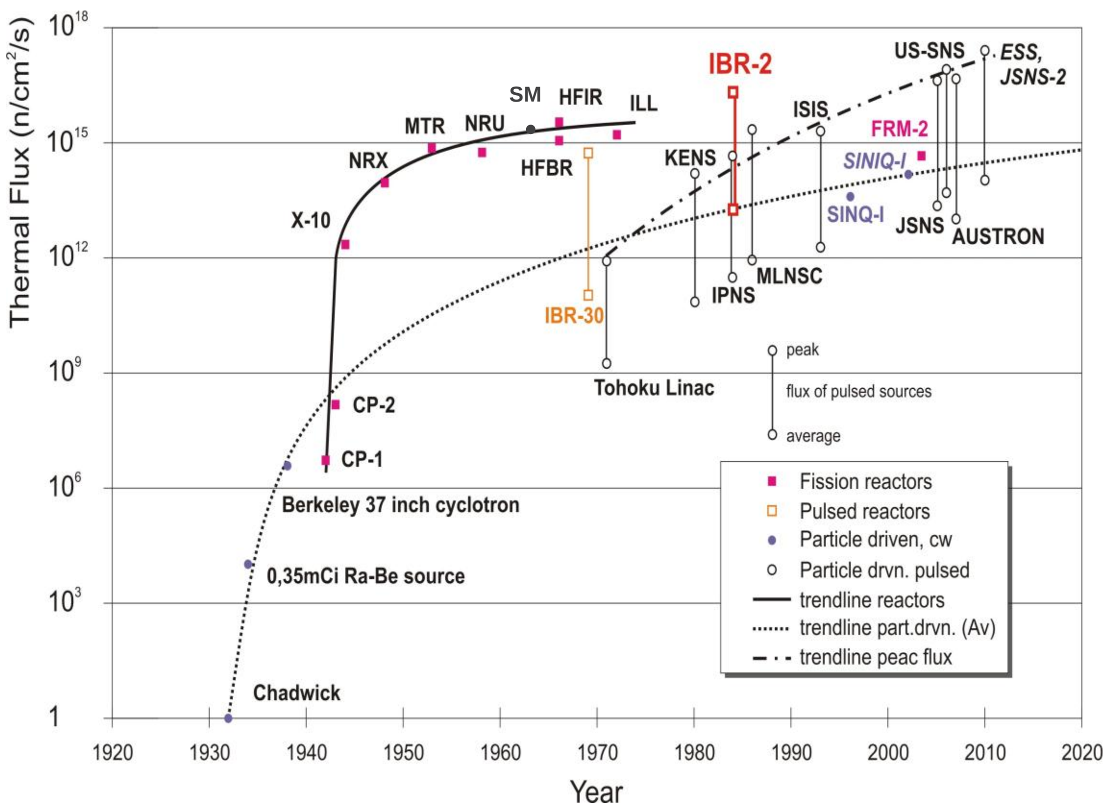
Recent Achievements

Pulse Reactor – Modernization of IBR-2

The reactor that have unique design and unique capabilities for fundamental research



View and cross-section of the modernized IBR-2 reactor



Thermal neutron flux available at various neutron sources

Recent Achievements
Pulse Reactors - Modernization of IBR-2

- **In the end of 2010 all work planned in a frame of the modernization was done and start-up of the reactor in accordance with the elaborated programs has been begun**
- **After the modernization of the IBR-2 the thermal neutron flux will be higher by a factor of 1.5**
- **After 2010 the IBR-2M will retain leading positions for 20–25 years among neutron sources in the world**

VINOGRADOV A.V., et al., "Start-Up of the IBR-2 Fast Pulsed Reactor after Modernization",

Recent Achievements – Very High Flux Reactor PIK

The main parameters:

thermal power 100 MW,

thermal-neutron flux

in reflector - $1.3x10^{15}$ n/(cm^2*s),

in 10 cm-dia. central channel - $5x10^{15}$ n/(cm^2*s),

number of horizontal beam-tubes – 10,

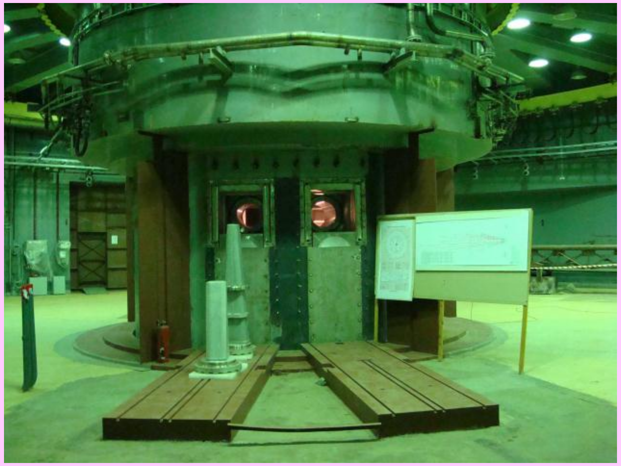
number of inclined beam channels - 6,

num … radiation - 6.

Very High Flux Reactor PIK

First fuel assembly to be loaded into the reactor

The criticality of the reactor was reached in the begin of 2011;
Now the reactor is in the preparation to the physical start-up



Reactor hall

Control room

Recorder "sees" the neutrons!!!

Development of New Reactors

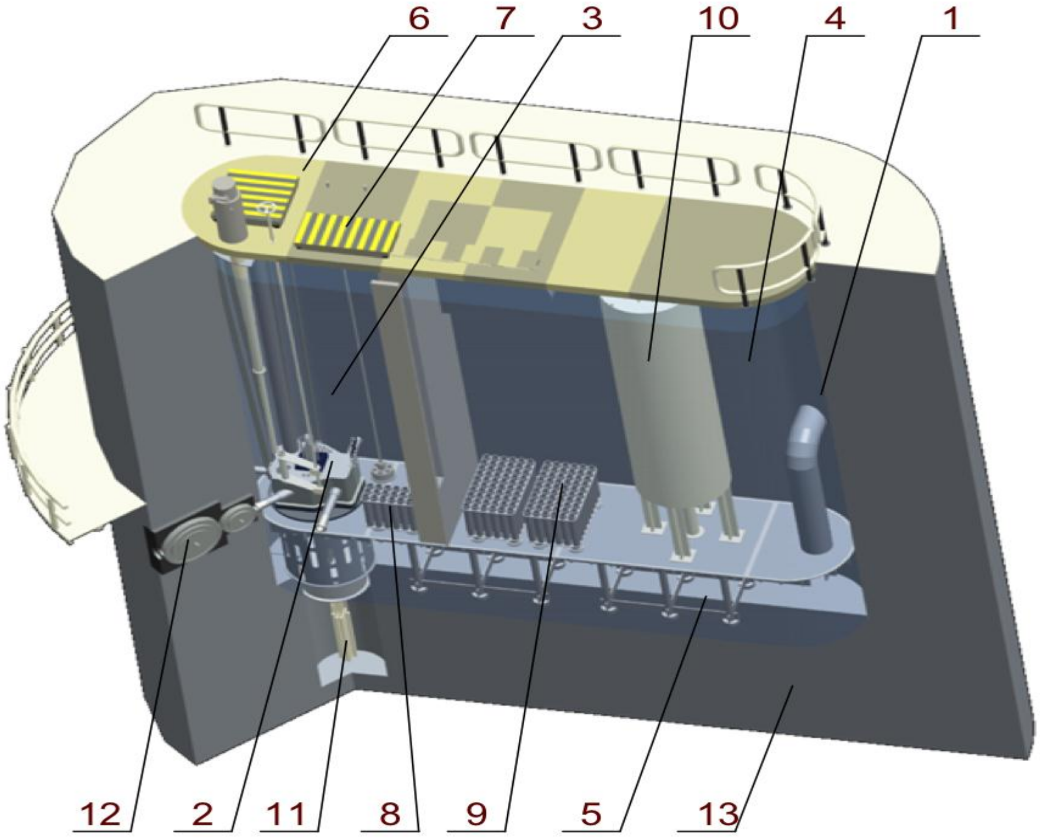
- The development of new research reactors in Russia now has a new pulse
- This activity concentrated on two directions:
  - New generation of small and medium power reactors
  - High flux fast reactor - MBIR

Development of New Reactors
Small and Medium Power Reactors

- These reactors shall cover all requirements of countries that have an intention to develop nuclear science and technology or upgrade the old nuclear facilities
- It will a reactors with LEU-fuel, high level of safety and have a big spectrum of experimental capabilities
- Several modifications of the reactor a with different power level: 1, 10 and 20 MW with different experimental capabilities that cover all requirements of potential customers were developed
- The projects of these reactors accumulate the broad Russian experience in the field of the development and operation of serial research

The Research Reactors of New Generation (one of the modifications)

10 MW Multi-Purpose Research Reactor



1 - tank;
2 - core and reflector;
3 - reactor pool;
4 - fuel storage pool;
5 - delay tank;
6 - covering;
7 - rolling shield;
8 - intermediate storage;
9 - spent FA storage;
10 – tank of emergency core cooling system (ECCS);
11 - CSS drive units;
12 - HEC gate;
13 – biological shield

OSIPOVICH S.V., et al., "The Research Reactors of New Generation with LEU Fuel"

Multipurpose Fast Research Reactor (MBIR) Conception

•MBIR is to be constructed instead of operating fast research reactor – BOR-60

•MBIR is to be designed according to priority of research and experimental tasks that require very high level of fast neutron flux

•MBIR provides fast neutron flux more than $5*10^{15}$ n/(sm^2·s)

•MBIR experimental opportunities must correspond to programmers and tasks of innovative power reactor designs especially reactors of Generation IV

•MBIR draft involves independent loop facilities with various types of coolants

•To increase the operating efficiency of MBIR it is necessary to set the isotope production, applied research and usage of thermal energy for district heating and electricity production

Multipurpose Fast Research Reactor (MBIR) Main Tasks

- Radiation tests of advanced engineer materials in conditions of intensive neutron emission with fast flux density more than $5*10^{15}$ n/ (cm^2 ·s)
- Study of advanced types of nuclear fuel for thermal and fast reactors
- Study of operating modes for fuel, absorber materials of core in the innovative reactors of next generation with Na, heavy metal, gas and molten salt coolants
- Study of fuel element performance in transitional, periodic and emergency operational modes
- Reactor tests and studies of closed nuclear fuel cycle, actinides utilization and burnout of long-living fission products
- Radioisotope production
- Application studies with neutron beams

Multipurpose Fast Research Reactor (MBIR) Main Parameters

Characteristics	Value
Thermal power, MW	~150
Designed life, years	50
Maximum neutron flux density, n/(sm^2 ·s)	$\geq 5\times 10^{15}$
Coolant	Na
Fuel	PuO_2+UO_2, (PuN+UN)
Fuel height, mm	500÷600
Continuous running between fuel assembly discharges, days	up to 120
Number of experimental channels in core	3
Number of loop channels	≥3
Loop channels coolant	Na, Pb, Pb-Bi, molten salt, He
Number of vertical experimental channels	5…8
Number of horizontal and tangential channels	6…8

Multipurpose Fast Research Reactor (MBIR)

Experimental devices:

Experimental Loops:
- with loop channel in the reactor core centre, D~130 mm,
F_n***~5·10***^{15} ***n/(cm***^{2}***·s)***
- with 2 loop channels in the reflector, D~130 mm,
F_n***~1,8·10***^{15} ***n/(cm***^{2}***·s)***

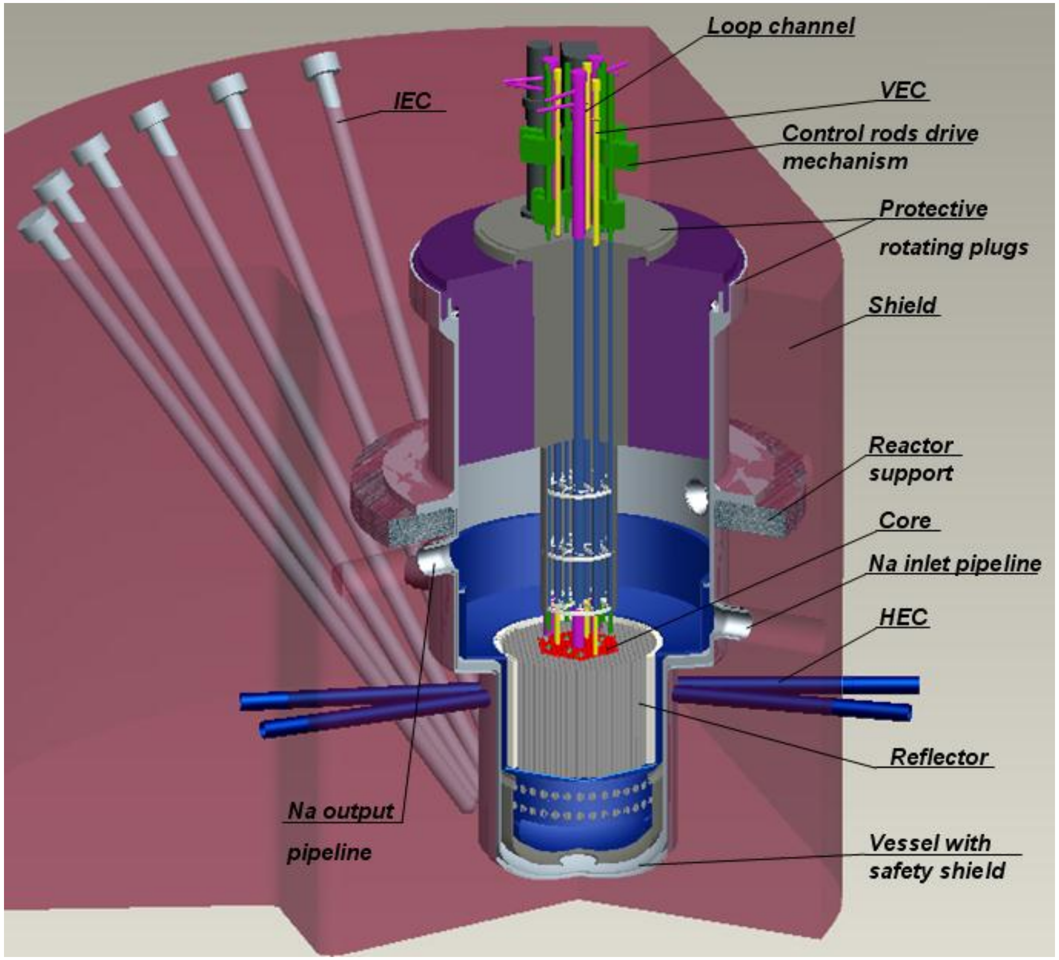
Vertical experimental channels (VEC) :
3 channels in the core., D~60 mm, F_n***~(3,2-5)·10***^{15} ***n/(cm***^{2}***·s)***

Material test assemblies:
Up to 15 assemblies in the core and reflector, D~60mm,
F_n***~up to 5·10***^{15} ***n/(cm***^{2}***·s)***

Horizontal experimental channels (HEC):

Up to 15 channels outside the reactor vessel, D~150-200 mm,
F_n ***~ up to 0,5·10***^{14} ***n/(cm***^{2}***·s)***

Inclined experimental channels (IEC):
Up to 7 channels outside the reactor vessel, D~150-300 mm,
F_n ***~ up to 0,5·10***^{14} ***n/(cm***^{2}***·s)***



Conclusion

- Now the fleet of Russian Research Reactors is big and enough for to provide all requirements of users for fundamental research, material testing and applied tasks
- Russian research reactors developed in different directions such as Serial Reactors, High Flux Reactors, Pulse Type Reactors, Fast Reactors
- In the recent years the activity in the upgrading of operating reactors and development of new reactors increased
- Recent Russian achievements in commissioning of research reactors are physical startup of the two unique reactors: IBR-2 and PIK; these reactors open the broad perspective in fundamental research
- New developed generation of pool type reactors accumulate the broad Russian experience in the field of the development and operation of serial research reactors and can propose a big experimental capabilities for the potential customers
- The development of research reactor with very high level of fast neutron flux – MBIR will give a new perspective of material testing for reactors of Generation IV

Thank you for the attention!