Kazakhstan research reactors

Asset Shaimerdenov, Darkhan Nakipov, Petr Chakrov
Institute of Nuclear Physics, 1 Ibragimov str., 050032, Almaty, Republic of Kazakhstan

Annual Meeting of the Commonwealth of Independent States Research Reactor Coalition (CISRRC) 23-26 June 2016, Almaty, Kazakhstan

Research Reactors
in nuclear research infrastructure of Kazakhstan

Ministry of Energy

- Department of development of nuclear and energy projects
- Committee of Nuclear and Power Supervision and Control

Institute of Nuclear Physics

- WWR-K RR
- Critical assembly

Almaty

National Nuclear Center

- IVG1.M RR
- RA RR
- IGR RR

Kurchatov, East Kazakhstan

Institute of Geophysical Research

Park of Nuclear Technologies

Research Reactors of National Nuclear Centre of the Republic of Kazakhstan (Kurchatov, East Kazakhstan)

Complex of research reactors “Baikal-1”

Complex of research reactor IGR

Complex of Research Reactors “Baikal-1”
IVG.1M Reactor

1975 - power start-up of High-temperature Gas-cooled Reactor IVG.1

IVG.1M research reactor is an upgraded version of IVG.1 reactor used for tests of fuel assemblies (FA) and cores of high temperature gas-cooled reactors.

TECHNICAL PARAMETERS

Thermal power	72 MW
Core effective diameter	548 mm
Core height	800 mm
Uranium-235 content in the core	4.6 kg
Thermal neutron flux density	3.5×10^{14} n/cm$^2\cdot$s
Water rate through the reactor	up to 380 kg/s
Maximum water temperature	95°C

Reactor View from Reloading Machine Side

Reactor Control Room

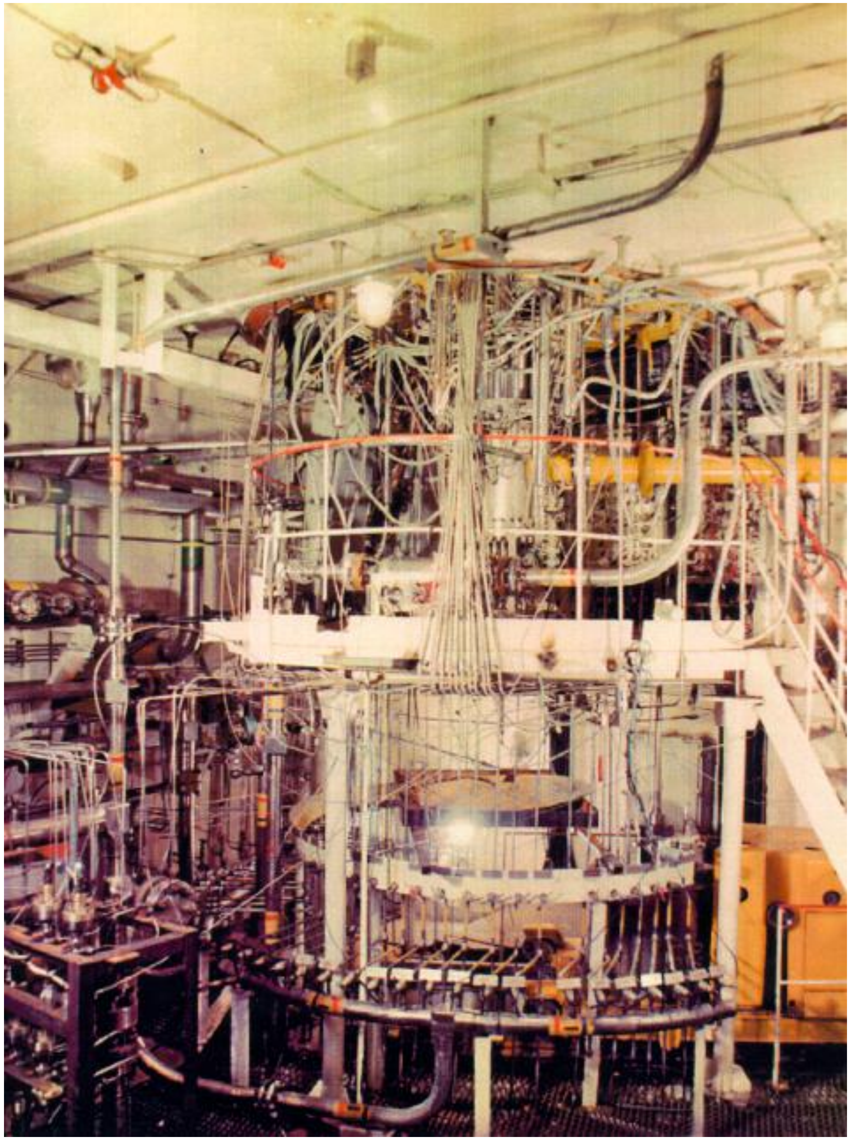
Complex of Research Reactors "Baikal-1"
RA Reactor

RA reactor is the prototype of nuclear jet propulsion reactor.
From 1978 to 1984 at "Baikal-1" CRR the tests of three prototypes of NJP reactor have been curried out.

TECHNICAL PARAMETERS (RA)

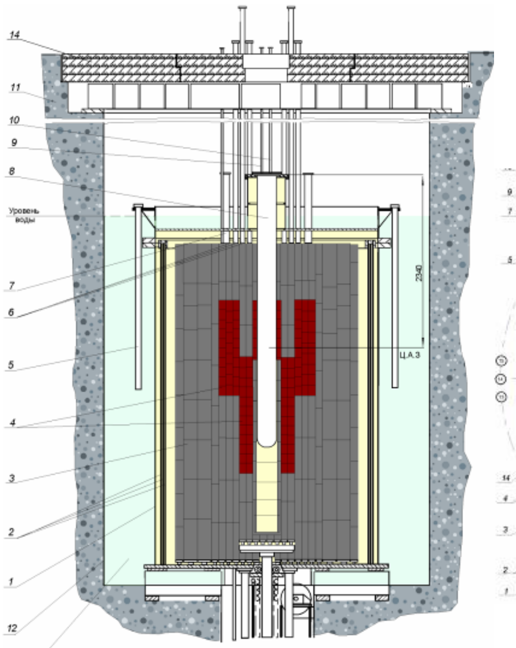
Thermal power	0.5 MW
Core effective diameter	339 mm
Core height	700 mm
Uranium-235 content in the core	8.3 kg
Thermal neutron flux density	2×10^{12} n/cm^2·s
Coolant rate through the reactor	up to 3.3 kg/s
Maximum fuel temperature	2000 K

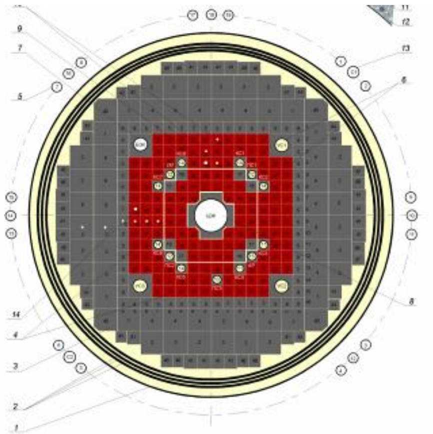
At present the RA reactor at the stage of decommissioning.



RA Reactor

Complex of Research Reactor IGR
IGR Design and Technical Parameters





1961 - IGR power startup

Parameter	Value
Power at the pulse mode (peak), GW	10
Minimum pulse half-width, s	0.12
Max. energy release, GJ	5.2
Max. neutron fluence, thermal/fast, n/cm^2	3.7×10^{16} / 1.1×10^{15}
Max thermal neutron flux, n/cm^{2}s	7×10^{16}

Most Significant Research Programs

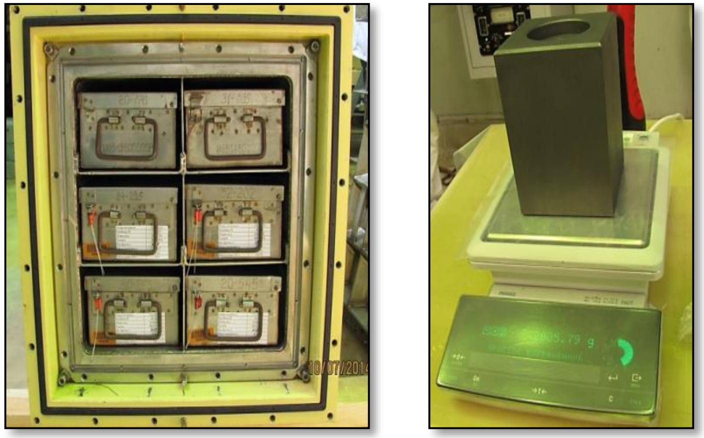
- Creation of the nuclear rocket engine
- Studying of influence of radiation on the electronic equipment and elements of automatics of space and air flying devices
- Determination of the work thresholds of the fuel pins and fuel assemblies with the wide types of fuel (transport reactors, power reactors, research reactors)
- Investigations of the nuclear fuel and structural materials behavior in the accidental conditions (up to the melting of fuel pins and fuel assemblies)

Conversion of research reactors IVG.1M and IGR

With the goal of IVG.1M and IGR reactors' fuel changing from 90% enrichment to 19.75 % following actions is carrying-out in cooperation with DOE, ANL, Battelle Energy Alliance (USA) and "LUCH" (Russia) :

- Feasibility study of the IVG.1M and IGR reactors conversion;
- Life tests of pilot samples of water-cooled technological channels of IVG.1M with low-enriched fuel;
- The tests of experimental samples of IGR reactor fuel (graphite impregnated by low-enriched uranium) for stability against maximum thermal and neutron loads.

Accepting of pilot samples of water-cooled technological channels of IVG.1M



Accepting of the experimental graphite blocks of IGR reactor impregnated by low-enriched uranium

Research Nuclear Facilities
of the Institute of Nuclear Physics
(Almaty)

Critical facility

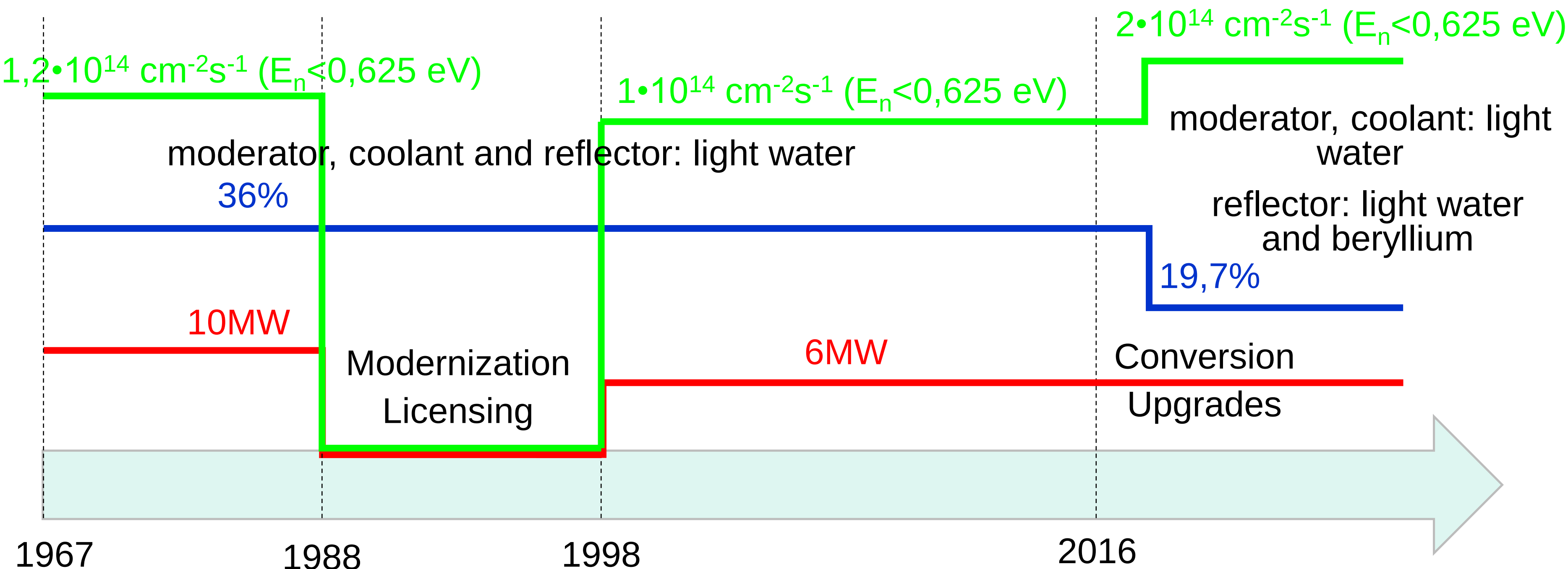
- Maximum thermal power: **100 W**
- Side reflector: **desalted water** and/or **beryllium**. Top/bottom reflector: **water**
- Moderator: **desalted water**
- Temperature of moderator is defined by temperature of a room where critical assembly is allocated
- Fuel composition: $\mathbf{UO_2+Al}$;
- Enrichment in U-235: **19.7 %** (since 2012)
- Two types of the VVR-KN fuel assemblies (FA) are used. FA-1 and FA-2 include, respectively, eight and five fuel elements.
- Maximum value of the thermal neutron flux density in experimental channels of the core is $\mathbf{10^9\ cm^{-2}\ s^{-1}}$.
- Diameters of experimental channels: **65, 96 and 140 mm**.

Utilization:
1. Studies on substantiation of safety for water-water research reactor cores.
2. Treating various reactor techniques.
3. Modeling of the experiments to be carried out at the WWR-K reactor, in order to identify relevant safe conditions.

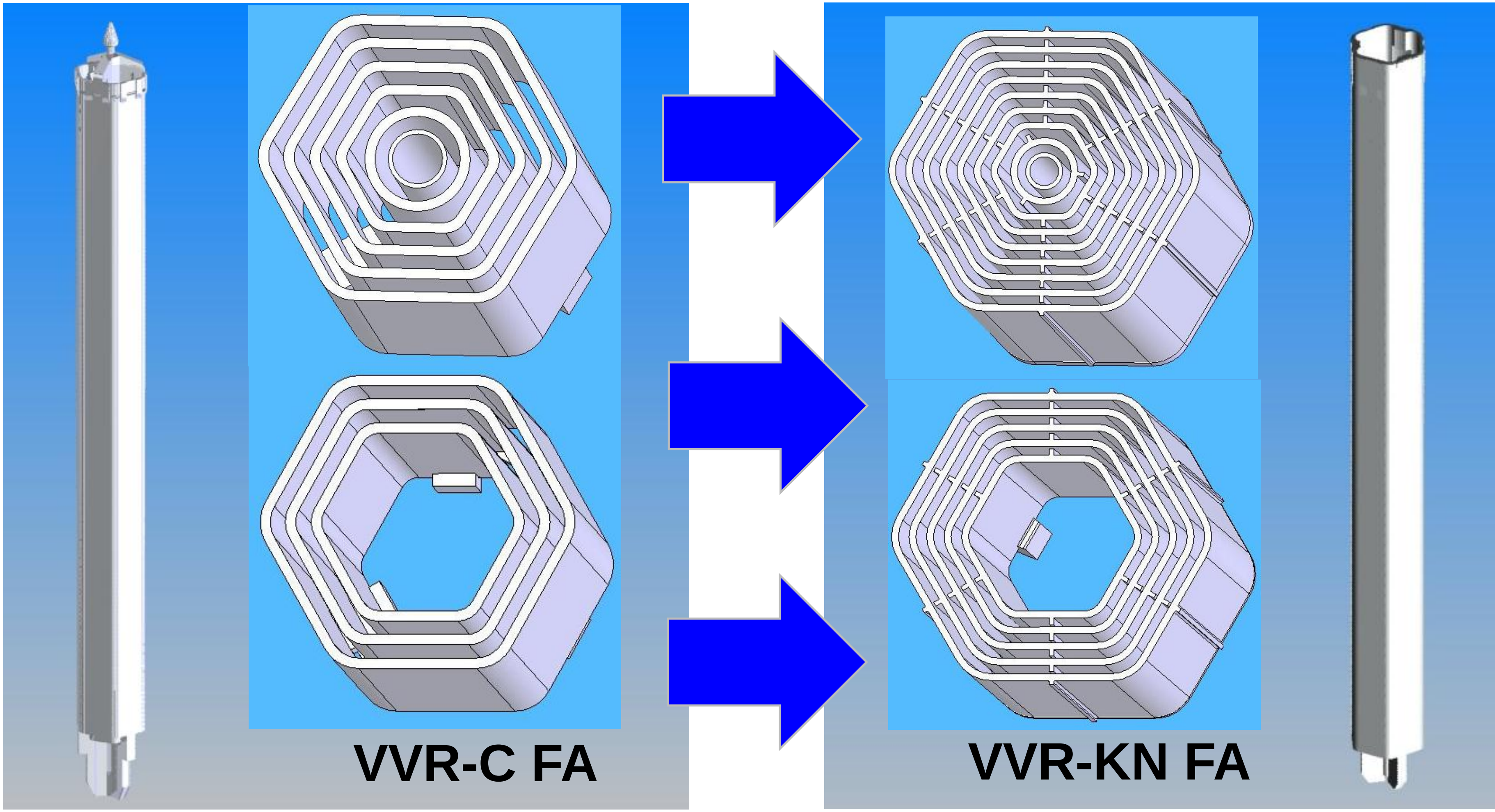
WWR-K Research Reactor

Utilizations:

- **RI production;**
- **Fuel/material testing;**
- **Neutron activation analysis;**
- **Scientific research;**
- **Gemstone coloration (R&D);**
- **Transmutation doping of silicon (R&D)**



Conversion of WWR-K Research Reactor from HEU to LEU fuel (1)

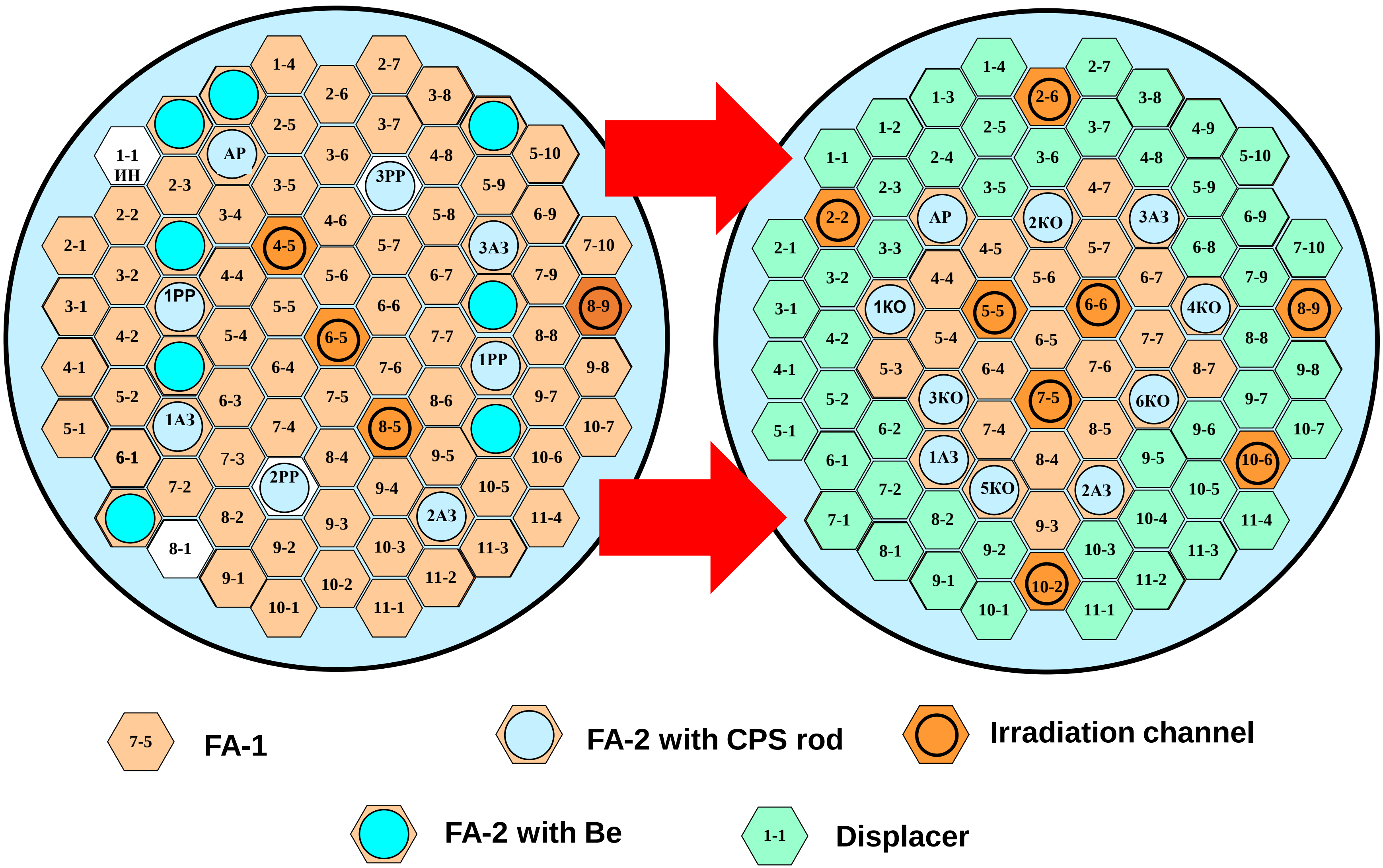


New LEU VVR-KN fuel assembly versus regular HEU VVR-C fuel assembly

VVR-C	Parameters	VVR-KN
36	Enrichment in U-235, %	19.7
UO_2-Al	Fuel composition	UO_2-Al
~1.3	Uranium density, g·cm^{-3}	2.8
111 86	Amount of U-235, g in FA-1 in FA-2	245 198
5 3	Number of fuel elements in FA-1 in FA-2	8 5
2.3	Thickness of fuel element, mm	1.6
0.9	Thickness of fuel meat, mm	0.7
0.7	Thickness of fuel element clad, mm	0.45

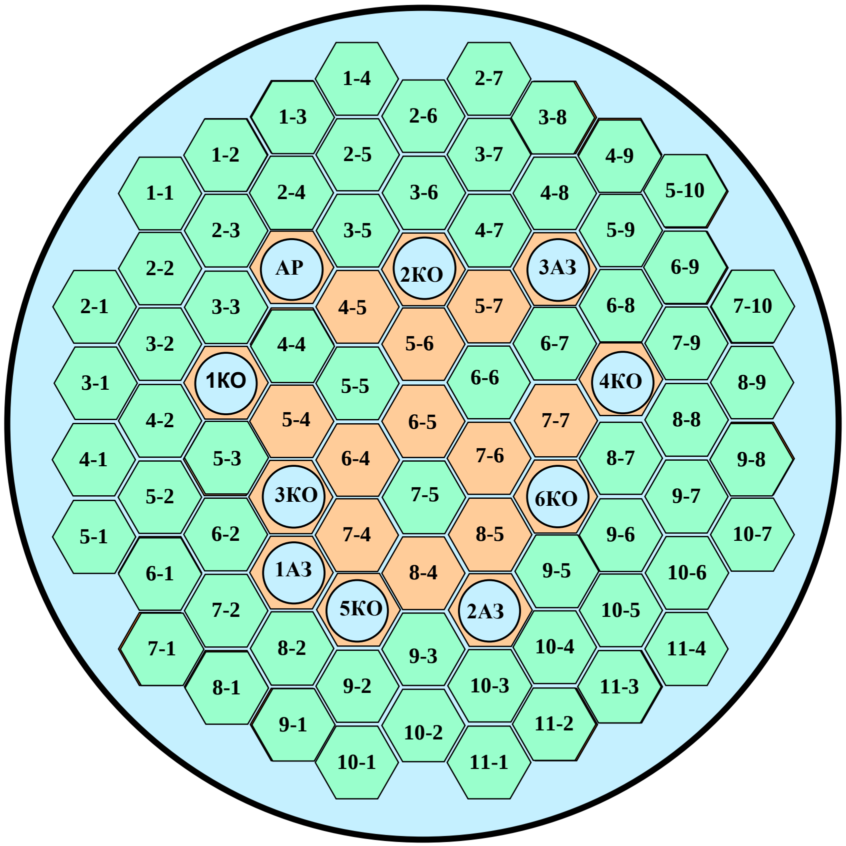
Conversion of WWR-K Research Reactor from HEU to LEU fuel (2)

71 FA-1 VVR-C and 6 FA-2 VVR-C | **17 FA-1 VVR-KN and 10 FA-2 VVR-KN**

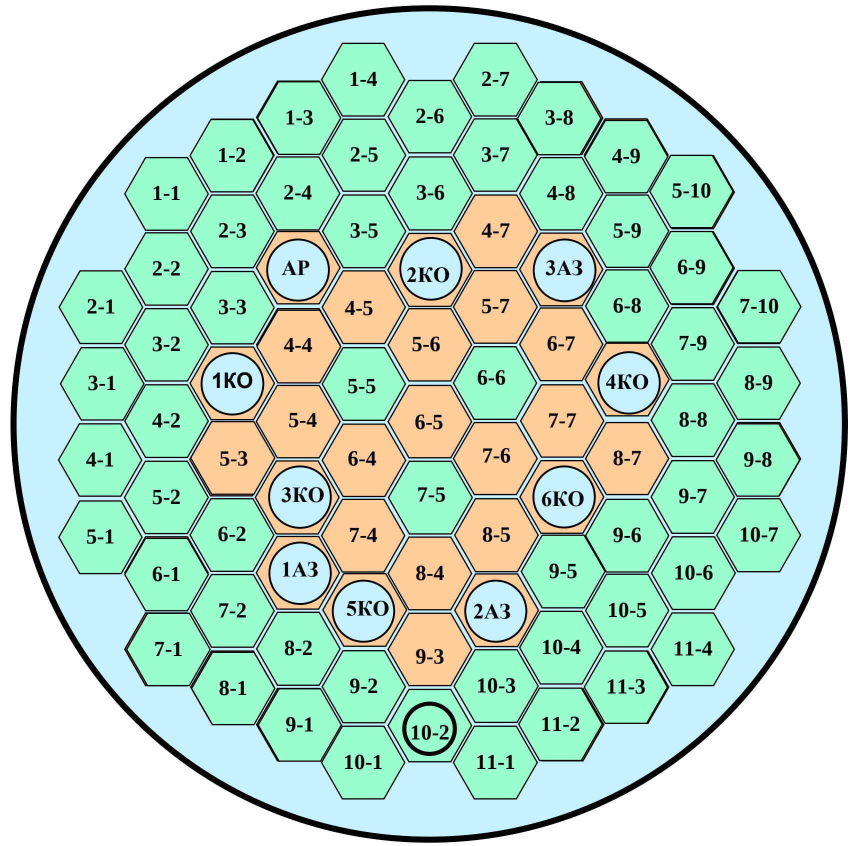


WWR-K Research Reactor physical startup with LEU fuel

March-April 2016 → Physical startup with LEU fuel



Critical load map
21 FAs



Work load map
27 FAs

Safety ensuring during physical startup of WWR-K RR with LEU fuel

- Reaching critical mass was carried out according Nuclear safety requirements NSR-03-75:
  - Loading FA was carried out by portions.
  - To read reverse count curves with calculation of the extrapolated value of critical load.
  - Upon reaching K_{eff}~0.98 (У~50), the CPS system effectiveness was assessed in TOU unit.
  - Fuel assemblies loading process after multiplication ~50 included the use of few dipped compensation rods during loading of the next fuels assembly for safety purposes.

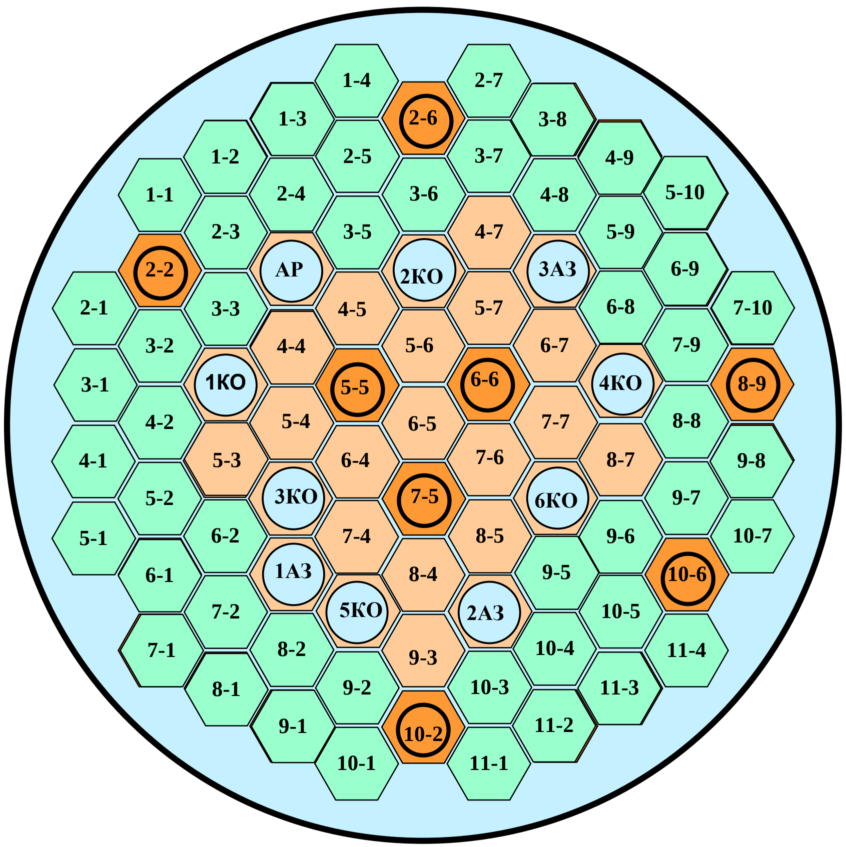
- Created intermediate core for determination rods effectiveness

- In all core cells were installed displacers, eliminating the possibility of loading of fuel assemblies into another cell

- On the critical assembly was carried out experiments on modeling physical startup of WWR-K RR with LEU fuel

WWR-K Research Reactor power startup with LEU fuel

May-June 2016 → Power startup with LEU fuel



Work load map
27 FAs

Reactivity margin: ~ 10β_{ef};

Subcriticality: 3,6β_{ef};

Max thermal neutron flux density: $2 \cdot 10^{14}$ $cm^{-2}s^{-1}$;

Max fast neutron flux density: $7 \cdot 10^{13}$ $cm^{-2}s^{-1}$;

Operation cycle: 21 days;

Density temperature coefficient of reactivity: negative 0.0016 %Δk/k/°C;

Reactivity loss related U-235 burnup: 0,10% Δк/к /day;

Stationary poisoning: 3,7 % Δк/к

Safety ensuring during power startup of WWR-K RR with LEU fuel

- ❑ **Power lifting was carried out step by step;**
- ❑ **Delay at each step of at least one hour;**
- ❑ **Check all technological system at each step;**
- ❑ **Check of radiation condition at each step;**
- ❑ **Subcritical core is much greater than 1 %Δk/k;**
- ❑ **CPS rods positive reactivity insertion speed does not exceed 0,07 β_{ef}/s and provide safety of technological process.**

Goals and expectations from participation in the CIS Research Reactor Coalition

Goals:

- ✓ Exchange of experience;
- ✓ Promote WWR-K research reactor experimental possibilities for international cooperation;
- ✓ Access to RRs from Member States without a RR;

Expectations:

- ✓ Enhancing RR utilization;
- ✓ Harmonize of safety requirements;
- ✓ Technical support for enhancing RR utilization and modernization/refurbishment (ageing of RR) from Coalition members and IAEA;

Назарыңызға рахмет!

Спасибо за внимание!

Thank you for your attention!

Շնորհակալություն ուշադրության համար!

Diqqətinizə görə təşəkkür edirik!

Дзякуй за ўвагу!

Конул бурганын учун рахмат!

Ташаккур ба диққататон!

Дякуємо за увагу!

E'tiboringiz uchun rahmat!