5. NEUTRON SOURCES

5.1. THE IBR-2 REACTOR

On the 27th of March, 1995 the IBR-2 reactor began regular operations with the new PO-2R movable reflector (MR), which is the third in a series of movable reflectors at IBR-2 since the reactor startup. The structure of the new movable reflector repeats the structure of the previous one but has a more developed system for reactor state diagnostics and parameter control. The movable reactor enables the pulsed mode of reactor operation with reactivity modulation frequencies of 5 and 25 Hz. The rotation speed of the main movable reflector (MMR) rotor is 1500 rot/min and of the auxiliary movable reflector (AMR) rotor—300 rot/min.

The data on the MR operation time for 1995 are given in Table 1 (the same inclusive of the on-site test operation time - in Table 2.) No MR operation failures were registered in the reported period.

The radiation fluence at the center of the PO-2R blade is $7.64 \cdot 10^{20}$ n/cm^2 (for $E_n > 0.1$ MeV).

In 1995, reactor operations for physical experiments on 12 extracted neutron beams were conducted. As of December 1, 1995 seven measuring cycles had been performed. The reactor operation is detailed in Table 1, the evidence of steady reactor operation and a low number of emergency shutdowns.

For comparison, data on the specific frequency of emergency shutdowns per year are given below:

1991 - 2.3/cycle

1992 - 3.2/cycle

1993 - 3.7/cycle

1994 - 1.7/cycle

1995 - 2/cycle

On August 16, a leakage of sodium occurred as a result of a depressurization of the air heat transfer (AHT) coil pipe in loop *A* of Contour II. As soon as the leakage was detected, sodium from loop *A* of Contour II was drained into the drain tank of loop *A* of Contour II. Helium density and color defectoscopy tests of the AHT were conducted, revealing micro-cracks in two AHT coil pipes.

In September-October 1995, the malfunctioning AHT units Contour II were fixed. Repairs and necessary tests were conducted by specialists of NIKIMT (Scientific Research and Designing Institute of Assembly Technologies). Following the repair work and sodium refill, the technical reliability of the equipment and pipes of loop *A* of Contour II were conducted together with representatives of GOSATOMNADZOR (Atomic Inspection Committee of Russia).

In 1995, work to estimate the residual resources of the reactor jacket, TVELs (fuel elements), and the fuel system of the core was completed. The decision was made to continue operation of the reactor control and safety system (RCSS) until December 31, 1996 allowing the possibility of a further extension of its operation period.

Table 1

IBR-2 reactor operation characteristics for 1995 (7 cycles)

Cycle №	Start and completion dates of cycles	Operation time for physical experiments, $T_{ph.e.}$	MR operation time, T_{MR}	Number of emergency, N_{ES}	Causes of emergency shutdowns (malfunction classification according to RD-04-10-94)				Number of operating beams
					Voltage drops (MR8)	Equipment breakdowns (MR7)	Electronic equipment breakdowns (MR7)	Personnel malfunctioning (MR5)	
1	27.03—08.04	206	274	6	2		4		12
2	17.04—28.04	247	261	2		1		1	12
3	15.05—26.05	265	271	1			1		12
4	05.06—15.06	217	245	2			2		12
5	26.06—07.07	264	274	0					12
6	17.07—28.07	265	276	0					12
7	20.11—01.12	220	273	3			3		12
Total:		1684	1874	14	2	1	10	1	

Table 2

The state of the reactor (as of Dec. 1, 1995)

№	Parameter (from the start of reactor operations)	Value
1	Total operation time for physical experiments, hrs.	28440
2	Total generated energy, MW/hrs.	53723
3	PO-2R total operation time, hrs. (inclusive of operation time during tests)	2116
4	Maximum fluence on the reactor jacket in the center of the active core: (10^{22} n/cm^2) for $E_n > 0.8$ MeV for $E_n > 0.1$ MeV	 0.97 2.24
5	Maximum fuel burning, (%)	4.48
6	Total number of emergency shutdowns	337

The above calculations shows that operation with the reactor jacket and active core at rated parameters will be possible through the year 2001 and then, in the period from 2002 to 2004, the reactor jacket, fuel load, stationary reflectors, RCSS mechanisms, and water moderators, will have to be replaced.

The concept of IBR-2 modernization in the period from 1995 to 2005 was elaborated. The main directions of IBR-2 development and upgrading are:

- improve the main parameters of the reactor
- increase the reliability and safety of reactor
- modernize the main equipment of the reactor.

The main stages of the modernization project are:

- design and manufacture of new main equipment 1996—1998
- assembly and tests of the equipment 1999—2001
- replacement of the equipment and fuel reloading,
- physical startup, power startup 2002—2004
- IBR-2 startup for physical experiments 2005

The following proposals for changes in the reactor structure are planned to be realized:

- manufacture a compact active core (without the central channel) with 67 fuel cassettes instead of 78 cassettes (Fig. 1). This will increase the average thermal neutron flux in a number of beams at the same IBR-2 mean power of 2 MW (see Table 3).
- Use of pellet TVELs in all fuel cassettes to ensure deeper burning of the fuel (8.2% instead of 6.5%).
- Use a lower rotation speed for the heterogenic type movable reflector for reactivity.

Table 3

Ratio of thermal neutron fluxes on a sample in the 10 m flight path for the new and old configurations of the IBR-2 active core

Beam No.	1	2	3	4	5	6	7	8	9	10
Gain factor	0.57	1.41	1.46	0.93	0.93	0.93	1.79	1.72	0.65	1.48

In 1995, work to create a cryogenic moderator (CM) for the IBR-2 continued. In the first half of the year, technical drawings for the CM were completed, contracts with NIKIET and other organizations for manufacturing the CM were concluded, and investigations of the strain and stress fields for the standard CM configuration, as well as of the metrological equipment for the CM, were conducted. Unfortunately, the work tempo was reduced by delays in financing.

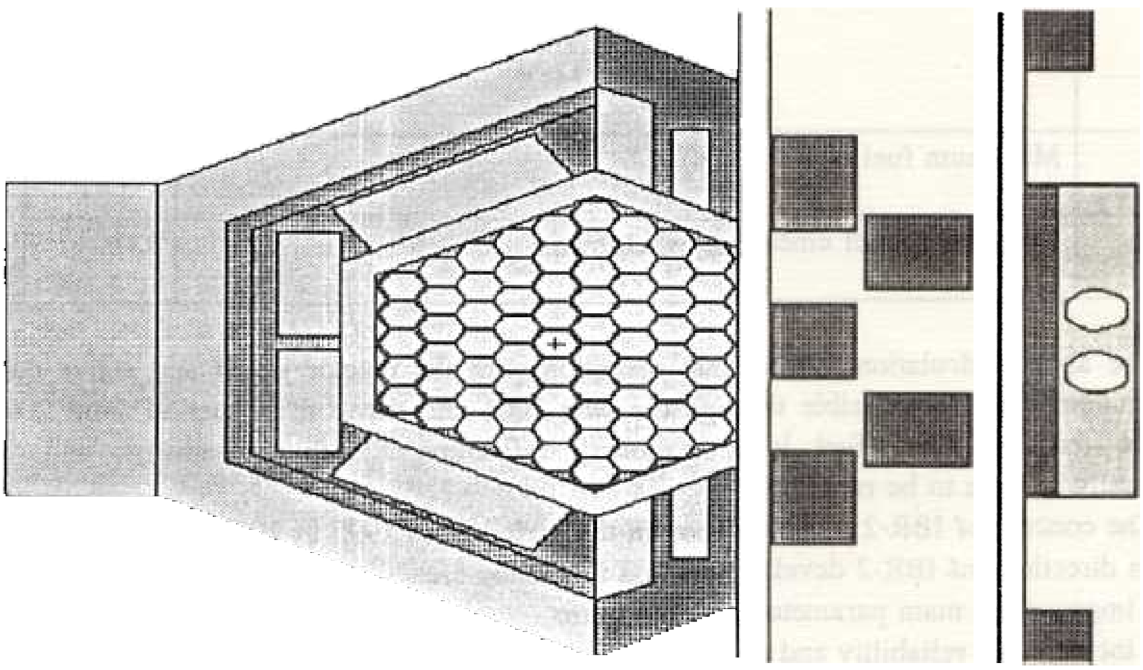

Fig. The calculated scheme of the IBR-2 reactor (69 cassettes).

5.2. THE IBR-30 BOOSTER

In 1995, the LUE-40+IBR-30 complex operated for 1980 hours. Seven neutron beams and the IBR-30 reactor were used to realize the scientific program on neutron nuclear physics, and to test IREN units and systems as well as to conduct irradiation experiments in the framework of the ATLAS project. After completion of the tests at IBR-30, the new design electron-neutron converter was installed, thus making it possible to lower the temperature of the converter considerably.

5.3. THE IREN PROJECT

Following the recommendations of the 77th session of the JINR Scientific Council, the JINR Directorate adopted the detailed work schedule for the IREN project for 1995. The financing schedule for the work on the project carried out by the JINR laboratories was established by special order. Because of the budget deficit and irregular receipt of dues from JINR member-states, the work was not financed according to the adopted schedule. As a result, the IREN completion date was shifted to the end of 1998.

Nevertheless, in 1995, under the agreement with INP SB RAS, Novosibirsk, we managed to start working on the creation of the acceleration sections, the buncher and a system to double the HF power. RMIR (St. Petersburg) completed the work on the redesign of the M-250 "OLIVIN" modulators into M-350's for the 5045-type clystrons which have been accepted as standard for the IREN accelerator. The first set of equipment for the OLIVIN stations has been shipped from Yerevan to Dubna. In FLNP, assembly of the stand for the M-350 modulator was begun in Building 118. In cooperation with the ISTOK industrial enterprise (Fryazino), MEPI (Moscow) completed the construction of elements for the HF feeder. Cold tests of the feeder are being carried out. In LNP, JINR, the design and modelling of the magnetic focusing system of the accelerator were completed. The LNP-LHE-LPP collaboration together with INP, SB RAS elaborated the technical specifications for the electron source and a number of units for the HF power supply were constructed. In collaboration with GSPI (Moscow), specifications for the general design of the electron accelerator (in Building 43) were worked out. NIKIET (Moscow), in cooperation with JINR, completed the specifications for the multiplying target with improved characteristics of the neutron pulse. The MAYAK industrial enterprise in Chelyabinsk-65 started manufacture of the fuel elements (TVELs) based on metal plutonium. According to the project of VNIINM (Moscow), the manufacture of the TVEL components—special thin-walled tubes of stainless steel and tantalum, and other construction elements—was started. At the LUE-40+IBR-30 complex, a number of variants of a radically new electron converter designed for IREN were successfully tested. The results permit us to begin constructing the regular converter for IREN. NIKIMT (Obninsk) prepared the specifications for dismantling IBR-30.