3. THE IBR-2 SPECTROMETERS COMPLEX AND COMPUTATION INFRASTRUCTURE

Organization of investigations and instrument developments. In the year 2000, as in the few previous years, under theme 1031 neutron scattering investigations in condensed matter physics were mainly conducted at the reactor IBR-2. In addition to IBR-2, members of the FLNP Division of Neutron Investigations of Condensed Matter working under the auspices of theme 1031 carried out experiments with the electrostatic generator EG-5 and X-ray diffractometers in FLNP and in some other neutron laboratories in Europe under the terms of the accepted proposals.

During the reported year IBR-2 operated for eight working sessions. The experimental time of the reactor spectrometers was distributed following experts recommendations taking into account the submitted proposals and the existing long-term agreements. The 2000 list of spectrometers operating in the user mode included ten instruments: HRFD, DN-2, DN-12, SKAT, YuMO, SPN, REFLEX-P, KDSOG, NERA, and DIN.

The most important result of the year is the startup of the first stage of the new neutron Fourier diffractometer FSD for investigations of internal stresses in materials and engineering products. By the spring 2000 all basic units of FSD, including the biological shielding, mirror neutron guide, fast Fourier chopper, beam control systems, sample table, and the goniometer devices, had been installed and tested on channel 11 of the IBR-2 reactor. The first high resolution FSD measurements were carried out with a +90° element of the detector MultiCon in the May cycle of the reactor, and by the October 2000 the first –90° element of the detector MultiCon and a lithium glass-based detector in the back-scattering position were installed in FSD. In all the detectors the rated resolution of *d*-spacing is reached (**Fig.1**) (see Experimental Reports).

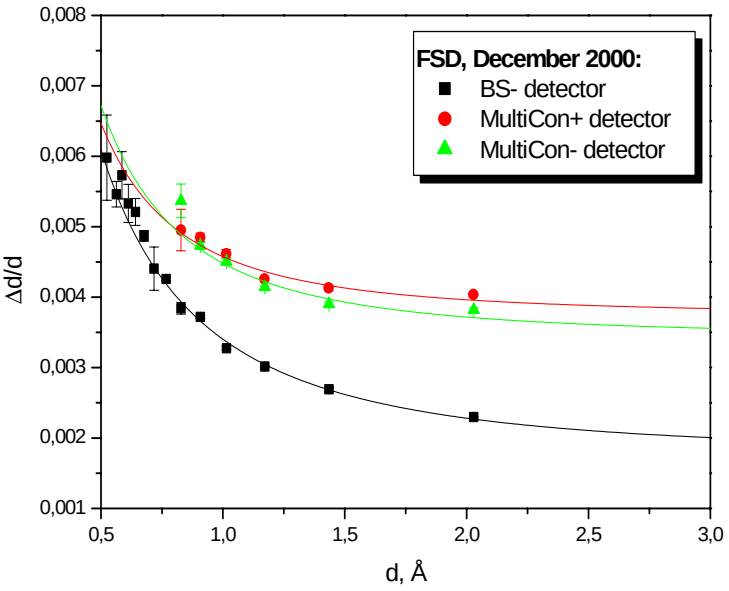

Fig. 1. *The FSD resolution function with the detectors BS^- and $MultiCon^{\pm}$ determined in the diffraction from the powder α-Fe at V_{max}=6000 rot/min.*

At SKAT, a second set of collimators with an angular dispersion of 45' was used for the first time in October-2000. The predicted intensity gain was obtained as well as the predicted worsening of the *d*-spacing resolution. It is proved that collimators with an angular dispersion of 45' are applicable for many kinds of samples, except polyphase rock samples with low-symmetrical constituents like phyllosilicates and feldspars.

The first tests at temperatures up to 600°C were performed with a high-pressure chamber. In the chamber, temperature stabilization close to this limit is possible though negative effects (generation of cracks) are observed in some cases. They are related to internal stresses due to weak

thermal conductivity of geological materials. Reducing the temperature gradient during heating seems to solve the problem. Furthermore, the ultrasonic system of the chamber has been changed to allow ultrasonic measurements even at high temperatures.

In the small-angle scattering spectrometer YuMO a second detector is installed and tested extending essentially the transfer momentum interval over which the neutron scattering spectrum is measured simultaneously (**Fig.2**).

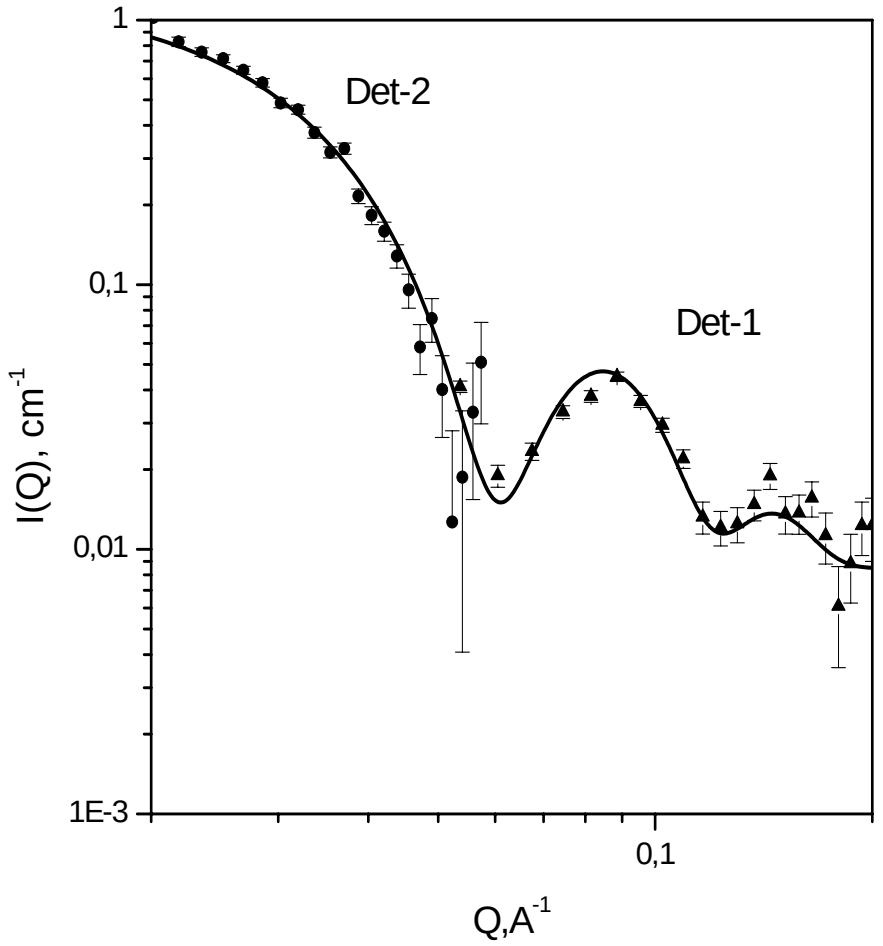

Fig.2. *Small-angle neutron scattering on a diluted solution of apofferitin, the protein consisting of a spherical shell with a known size (Rout=62E and Rin=41E), as a function of the scattering vector Q. The experimental points are measured with two detectors at 11.95m and 5.27m from the sample position. The calculated curve is also shown.*

In the REFLEX-P spectrometer the new low-background detector on the basis of a ZnS screen was approbated and started operation for the physical experiment. An ~50 times reduction of the background helped carry out unique experiments of the registration of surface phonons and magnons in thin films on the level of sensitivity $2 \cdot 10^{-7}$ of the basic elastic scattering process.

In the frame of the modernization project of the polarized neutron spectrometer SPN a supermirror neutron polarizer was built and tested. Compared to the existing standard polarizer it has a considerably larger wavelength interval (~2.6 times) over which the polarization efficiency exceeds 95%. The new polarizer will increase essentially the polarization efficiency of measurements at larger wavelengths (10 times for the wavelengths 3÷7 Å) and will also raise the luminosity of the spectrometer.

On the spectrometer REFLEX-P experiments to study the effect of the «neutron gun», a special deepening (canyon) in the neutron moderator on the side of the spectrometer, were performed. They show, as it has been expected that the neutron flux from the depth of the canyon is noticeably larger than from the flat surface. The integral spectrum gain is 3.5, but in some intervals of the spectrum it is up to a factor of 5.5. The effect can be successfully applied to increase the luminosity of spectrometers that require small areas (~10 mm) of the radiating surface of the moderator (see Experimental Reports).

A transition to VME control electronics completed at some of the IBR-2 spectrometers (HEFD, DN-2, DN-12, YuMO), which is a step towards a higher level of experiment automation.

Work within the theme was focused on three main directions:

- development of the FLNP information and computing infrastructure
- creation and putting into operation of the VME data acquisition and control systems
- development of the IBR-2 spectrometer complex

Local area network and computing infrastructure. At present the realization of the first stage of the project «Measurement and Computational Complex (MCC)» allows us to create a modern basic network and a computing infrastructure of FLNP with characteristics and possibilities on the level of leading European centers. It comprises a high performance four-processor file-server Enterprise 3000 (only two processors are presently available), a cluster of 17 Workstations SUN20 and ULTRA5/10 with a common disk space of 60Gbyte, X-terminals, ~200 personal computers, network printers and a radial-structure local computing network with the commutation equipment enabling the data transfer rate up to 100Mbit/s via fibre-optic communication lines and twisted pairs. Access to the centralized computing resources of JINR is provided via the Orange Ridge ATM/Ehernet switching node at a rate of 155Mbit/s.

In the year 2000, the following work aimed at further development of the information and computer infrastructure of the IBR-2 complex was carried out:

- Data traffic in the FLNP local network was optimized and the data transfer rate increased significantly (Internet).
- Two segments of the network were changed over to twisted pairs (central segment in building 119 and Nuclear Physics Department segment).
- The number of X-terminals and the disk space of the SUN-cluster were increased.

Data acquisition and control systems. In the first stage of the project the architecture and electronic modules of unified VME data acquisition and control systems for the IBR-2 spectrometers were developed. At present, unified VME systems for data acquisition, spectrometers equipment, including step motors, goniometers, refrigerators, furnaces, etc., for control of the experiment as a whole are installed on the main IBR-2 spectrometers.

The spectrometer electronics is installed in VME crates and it includes purchased standard blocks (processor E17 with a memory module, hard and floppy disk subsystems, input/output register, ADC/DAC block, network interface) and blocks developed in FLNP specifically for neutron time-of-flight experiments. The digital systems for registering and accumulating of data represent a unified set of identical (from the viewpoint of hardware) blocks for all the IBR-2 spectrometers. The systems carry on distinction in parameters, functional capabilities, encoding, correction and preliminary data processing specific for each spectrometer on the level of microprograms, electronic tables, *etc.* These blocks are the interface block intended to receive data from PSDs; block for encoding the point detector number; block for encoding the neutron time of flight; processor block and **a** histogram memory.

The instrument and sample environment control systems consist of the following unified subsystems:

- Control systems for executive mechanisms (step motors, etc.);
- Regulation systems based on the Euroterm, LTC or DRC regulators;
- Analog parameter acquisition systems;
- Systems for control of logical parameters.

All the instruments are equipped with the FLNP standard Sonix control software which runs on VME-side in the OS-9 environment. The Sonix has a modular structure. The current set of available Sonix programs consists of the following modules or tasks: Join - script interpreter, Tofa - DAQ control, Unipa - neutron beam and some sample environment parameters supervision, Motor -

goniometer and other stepper-motor driven setup control, Temp - heater/refrigerator control, Graph – visualization protocol of the temperature etc, Vsp - one-dimensional spectra visualization (both on-line and off-line)

To satisfy needs of particular instrument these tasks are very much configurable. Thus exactly the same version of modules are used for all instruments. The OpenG2 program based on PV-WAVE package are adapted to visualize spectra for all of these instruments both for one- and multi-dimensional detectors. This program provides visualization, preliminary data processing, and some analysis of data, measured on IBR-2 reactor.

In 2000 the VME data acquisition and control systems on the YuMO, DN-2, FSD and DN-12 spectrometers were put into test operation. Positive results were achieved on the all spectrometers, however, at the YuMO and DN-2 spectrometers some problem involving data accumulation from PSD arose. In course of the first autumn cycles several non-trivial errors in electronics were found, which revealed them selves only when working with high count rates on the beam. During these cycles the errors were corrected and we hope that they were last ones.

The new generation detector electronics for gas linear and PSD detectors as well as for point detectors has been constructed and installed on the YuMO, DN-2, SPN and DN-12 spectrometers.

At JINR FLNP in collaboration with HMI, Berlin, the development of the main DAQ board for MSGC detector was completed as far as possible with simulation and routing programs as well as the CPLD programming and the development and debagging software. A prototype of the board is ready. FLNP is presently continuing the adjustment and testing of the DAQ board by means of a software event generator. HMI is preparing the testing of the DAQ hardware and software with the MSGC detector prototype in 2000/2001.

The reliable operation with all temperature devices, close cycle refrigerators, cryostats and other sample environment devices has been provided.

The work on improvement of existing VME systems on the spectrometers HRKD, NERA-PR, SCAT and EPSYLON was continued.

- Development of new detector system based on ZnS scintillator will start.