3. THE IBR-2 SPECTROMETERS COMPLEX AND COMPUTATION INFRASTRUCTURE

Work on the theme went in keeping with the FLNP projects ICC, FSD, YuMo, Texture, PNS, Detectors, BMBITF – ECS, etc. in the following main directions:

1. Development of the information-computation infrastructure.
2. Creation of data acquisition and spectrometer control systems.
3. Development of the IBR-2 spectrometer complex:
    - automation of spectrometers and development of "sample environment" systems;
    - creation of neutron detectors;
    - creation of neutron-optical systems;
    - Routine operation of spectrometers.

Local area network. Work to build a local area network (LAN) started over 10 years ago. Initially, it consisted of several segments linked together via repeaters and switches. Since 1996 the network has continuously been modernized. The chief directions of the modernization are a transition from cables to twisted pairs, installing of 2nd-level commutators in the LAN segments, and a transition to the technology Fast Ethernet.

At present, the local area network of FLNP contains about 500 different devices and the number of them continues to grow. A gradual transition of users to Fast Ethernet has raised load on the channels connecting the buildings of the Laboratory. To the LAN FLNP there are switched computing systems controlled with a variety of operational systems. The LAN users communicate employing virtually all the existing time protocols. Among users there exist a small number of relatively independent working groups, each operating a computation system for a particular instrument. At the same time, all LAN users have access to general resources of the FLNP central computation complex, including subsystems for data storage, e-mail, WWW, etc.

A historically established star-like communication structure and the absence of intellectual control devices do not make it possible to distribute flows between users in an optimal way. In addition, the experiments conducted with FLNP facilities are being transformed to a distributed model of data acquisition and processing, which also increases load on LAN. A remote-control policy that has been increasingly used at large physical facilities calls for much stricter observation of such LAN parameters as packets transportation time and percent of losses.

Chief current problems:

- Absence of free IP-addresses
- A large wide broadcast traffic (~30% of the total LAN traffic) is not filtered with commutators and is processed in each network unit
- A poorly tuned or virus-infected working station may hamper, even paralyze, the operation of the entire segment
- Localization and fixing of malfunctions in the network units are difficult.

For the solution of the enumerated problems there has been elaborated a project for the modernization of basic segments and key elements of LAN in 2001. Designing the network of the next generation the following requirements were investigated.

- *Failure immunity* – the topology of the network allows it to retain the operation ability at breaking down of separate elements and switch automatically reserve paths of by-passes for data traffic.
- *Controllability* – operative control of network configuration, possibility of changing the logic structure of the network without changing its physical topology.
- *Service quality control* – guaranteed transmission widths for particular subscribers and network applications, guaranteed delay to response, predictable percentage of packets losses, operative

analysis of traffic aimed at optimization of data flows and service quality, network transmission capability over 100 Mbit/s and over 1Mpacket/s (1st stage), and up to 1 Gb/s (2nd stage).

- *Protection ability* – all the switched units are protected from internal and external attacks.
- *Module structure* – enables easier extension of the network and makes it possible to apply new network technologies.

The existing physical topology of channels linking the FLNP buildings (8 buildings over an area of 1 km in radius) and difficulties in laying new communications between the buildings, in reactor buildings and experimental halls have also been considered.

In the reported year, for the realization of the 1st stage of the project a transition to Fast Ethernet 100 Mbitit standard was executed in two segments of the network (bldg. 42a – NICM Division and bldg. 42 – PN Division). In bldg. 42a, the commutator Catalist 2924XL (CISCO) is installed and put into operation, which increased the reliability and rate of data transmission in the NICM segment. A contract for purchasing of the 3rd level router (CISCO router 8510) is signed and preparative work to install it is fulfilled. The router will be put into operation at the beginning of 2002.

To modernize the network, a two-level scheme is chosen. The entire FLNP network is divided into distributed virtual subnetworks (VLANs) each being a 2nd level domain with an imposed IB subnetwork. This will make it possible to reduce to minimum the size of the broadcast domain and decrease the volume of parasitic traffic. It should be noted that the applied technology makes it possible to form groups of user devices irrespective of their geographical position. The formation of VLAN is executed by the commutators Ethernet / Fast Ethernet providing the access layer of the network. The core layer is a 3rd level commutator of the type ISO. The core accomplishes the routing of packets over the FLNP subsystems and provides access to a basic network of JINR. The existing optical **highways** are used to connect the central and user commutators.

Thus organized network will make it possible to increase a real transmission ability of the network by 50-60% without changing its physical interfaces. In-built mechanisms of control and analysis of traffic will allow operative debugging and determination of reasons for network slow operation. Rich possibilities of quality control provided by 3rd level commutators guarantee reliable data delivery and ensure a guaranteed transmission width for most important network applications. Further extending of the network without changing its logic structure appears possible – commutation on the 3rd level allows increasing of the number of routable IP and IPX networks, application of the address translation technology to improve protection from external attacks, and a more effective use of the address space.

Data acquisition systems. In the reported year, detector systems in a number of spectrometers were modernized. In particular, low-noise electronic blocks for the detectors NEW and YuMO were developed, manufactured and tested, the 32-channel detector of SPN was debugged, detector electronics in KDSOG was completely renewed, a linear PSD with a resistive wire was introduced into DN-2.

To the EPSILON spectrometer a unified VME-system for data acquisition is introduced. In addition to a standard set of functions, its electronics executes neutron time of flight correction (time focusing).

For the MSGC detector (IHM Berlin), a second TDS/DSP data acquisition block with a PCI interface is produced and is tested with a programmable generator of events. A single block of its type processes events from two conjugate planes of the detector situated on two sides of the neutron converter. The block consists of four 8-channel transformers of the type F1 (Acam), different types of FIFO memory, programmable logic matrices, a histogram memory of 256 Mbit, a TMS320C6701 high performance signal processor, and a PCI interface. For every event the coordinates X,Y are measured (by signals from both ends of the delay line) as well as the time of flight (TOF) and pulse height (PH). In DSP on-line calibration and transformation of the X/Y/TOF/PH data into two-dimensional spectra (e.g., 2θ/TOF) are performed. These data are accumulated in the histogram memory and at the end of the measurement, are sent to PC for further processing. At present in FLNP it is used to develop and debug software products.

A multi-processor module (four DSP TMS320C51) for the computation of the correlation function and histogramming of the data from the ZnS-scintillation detector of the FSD facility has been tuned.

Work continued to develop and install on the spectrometers a unique SONIX programs complex for data acquisition. In particular:

- SONIX packet is installed on the spectrometer SPN and EPSILON
- MAX program for on-line viewing and express analysis of data is developed (installed on DN-2, SPN, and EPSILON)
- New SONIX version with automated restart of measurements in the event of malfunctions in the system or network is prepared and tested on the SKAT spectrometer (at present, it is being transferred to the other spectrometers)
- Network VME controller with a data transmission rate of up to 100 MBIT/s is tested (it will be installed on the YuMo facility).
- New version 2.15 of the ISP network packet for OS-9 is tested and has demonstrated a high stability of operation.

Based on the packet Open G2 there are being developed programs for the reduction of the data from the point detectors of the YuMO spectrometer taking into account automatically the geometric parameters of the facility.

A large volume of work to support and upgrade the FLNP web-server was carried out.

Work started to master mezzanine technologies with the aim of their application in data acquisition systems.

Development and routine operation of the IBR-2 spectrometers complex. *Development of sample environment systems*. The development of sample environment systems continued:

- New executive mechanisms adapted to the existing step-motor-based control systems were incorporated into the spectrometer schemes
- Certification of the existing devices, including furnaces, refrigerator heads, etc., continued with the aim of creation of a data base on the temperature control and regulation devices in the spectrometers HRFD, FSD, PNS, YuMO, DN2 and the X-ray diffractometer DRON.
- Research into the connecting of two control elements: the heater and the refridgerator, to one Eurotherm regulator of the type 902S or 906S, was carried out. The results are used on the DRON diffractometer. The precision of the control system is +/- 0.03 degrees.
- A second channel for control of the temperature of the annealing furnace in the sample preparation room is completed and put into operation.
- Work to develop a RGD-1245-refrigerator-based cryostat CHF for up to 4.2 K was carried out and at present, the manufacturing of CHF is being completed.

Creation of neutron detectors. The methodological investigations conducted in the Frank Laboratory of Neutron Physics in 1998-2000 have allowed the development of new-type wide-aperture detectors for high-resolution diffractometers. At present, two experimental prototypes of the detectors built on the basis of a ZnS(Ag)/LiF scintillation screen and spectrum-shifting fiber are in test operation on the fourier spectrometer for internal stress analysis (FSD). The detectors are used to investigate internal stresses in specimens of the reactor jacket on request of the RF Atomic Energy Ministry.

In the nearest years, the new detectors raising dramatically the efficiency of investigations with time-of-flight diffractometers are to be installed on the FSD diffractometer and the DN-12 spectrometer for the investigation of microsamples at high pressures.

So far, the necessary modeling of the facility has been done and a three-dimensional model of the FSD detector has been developed. Manufacturing of the detector blocks started.

Work to create a «clean room» and a gas test-rig for assembling gas detectors continued.

Creation of neutron-optic systems. In the reported year work to create a technology for manufacturing of basic elements of neutron guides started – to manufacture glass sections with a metallic thin-film coating on the basis of the glass FLOATGLASS:

- Equipment for cutting glass based on a milling machine with diamond cutters is put into operation; a test lot of four glass plates is made;
- Test supply of 19 mm Planilux float-glass of Saint-Gobain make is purchased
- Thermovacuum spray-coating facility with the following parameters is put into test operation:
  - Vacuum chamber volume - 1 m^3,
  - Number and size of simultaneously spray-coated glasses – 2 pieces each measuring 750x300 mm^2,
  - Vacuum in the spray-coating mode – $9x10^{-6}$ mm Hg,
  - Heaters – 2 ∅ 3 mm tungsten rods by 1000 mm long,
  - Maximum temperature of the heater - 2000 C,
  - Temperature of heating the substrate – 215 C,
  - Chamber jacket's cooling – water,
  - Sprayed material –Ni, NiCr in the form of a ∅ 0.3-0.5 mm wire,
  - Consumption power in the spray-coating mode – 2 kW.
- Test spray-coating of natural Ni on a float glass measuring 210x80 mm as conducted.

Modernization of spectrometers. The main spectrometer development effort focused on SPN, YuMO, FSD, and DN-12.

Modernization of the spectrometer of polarized neutrons (SPN)

The program for the modernisation of SPN in 1999-2002 involves the following stages:

- Dismantling of outdated equipment, manufacturing and installment of the new head part and a reflectometric shoulder in SPN-2.
- Creation and integration of the new wide-aperture polarization.
- Creation and integration of the new system for data acquisition, storage and control in VME standard.
- Automation of the experiments and extension of the magnetic field and temperature ranges of sample environment systems.

Main results in 2001:

- The dismantling is accomplished and the new head part is installed.
- The adjustment table for the polarization analyzer is made.
- The system for control of the executive mechanisms is modernized to increase the number of control devices to 32.
- Specifications for a polarizer in the small-angle mode of the spectrometer are developed.
- Automatically controlled diaphragms, a shutter and polarizers for separate measuring regimes, a wide-aperture spin-flipper and some step-motor-based elements for control of the physical experiment are integrated into the scheme of the spectrometer.

Modernization of the small angle spectrometer (YuMO)

The first successful experiments in the long-time regime using the final version of VME electronics were carried out.

Work to automate the control systems of the executive mechanisms continued:

- System for control of an УР-7-motor-based device for pressure building on the sample was developed.
- Design work to create a ДШИ-200-step-motor-based-device to introduce standard scatterers into the beam was carried out and four devices were integrated into the executive mechanism systems.
- Systems for control of the executive mechanisms were modernized to increase the number of control devices to 32.
- Work to design devices for the displacement and adjustment of the PSD detector began.

Neutron fourier diffractometer (FSD) for internal stress analysis

Main results in 2001:

Work to design and manufacture a 90-degree detector continued:

- Experimental prototypes of the detector on the basis of ZnS(Ag)/Li^6F scintillation screens with an optimized optical trap were created and tested.
- .A computer model and a technical project of the wide-aperture 90-degree scintillation (ZnS) detector ASTRA was developed.
- Manufacturing and assembling of the first section (8 counters) of the detector ASTRA are under way.

The first version of the table for samples with a three-axis goniometer and a turning ring was manufactured. The equipment and software for sample positioning were debugged.

Neutron spectrum intensities at sample position are calculated for three moderator-neutron guide geometries and a report is prepared.

Neutron spectrometer for investigation of microsamples at high pressure (DN-12)

In 2001 the following work to modernize the spectrometer was performed:

- A section for the loading of high-pressure cells was created.
- A torroid-type high-pressure cell was developed, manufactured and calibrated.

Cracow-Dubna inverted geometry spectrometer (KDSOG-M)

The spectrometer KDSOG-M was built on channel 10 of the IBR-2 reactor in 1982 to investigate the atomic and magnetic structure of condensed matter by inelastic neutron scattering.

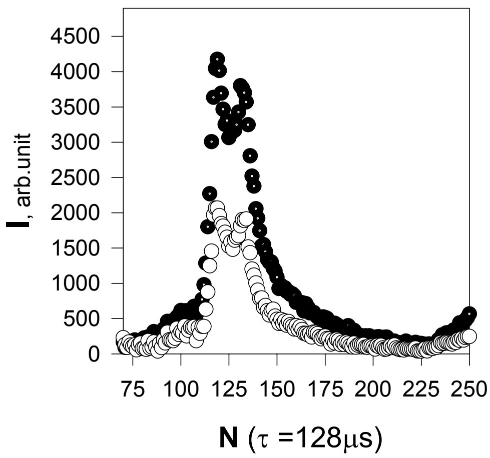

Fig.1. *The time-of-flight IINS spectra of vanadium measured in a time of 10 hours in equal experimental conditions: ● – new detectors, ◦- old detectors*

In 2001 the detector system was modernized. Preamplifiers, a high-voltage-power-supply block, NIM-TTL transformers, and mechanical elements of the detector and of 60 helium counters were manufactured. The equipment of the modernized detector was assembled and adjusted with the spectrometer.

IINS measurements of vanadium showed that the luminosity of the spectrometer increased about 2 times due to only increasing of the efficiency of registration of the scattered neutrons **(Fig.1).** The sensitivity of the spectrometer (signal/background ration) increased significantly, which is important for measurements of small or weakly scattering samples.

In the reported year the spectrometers equipment was prepared for operation and serviced during a total of 8 cycles of the IBR-2 reactor.