6. MEASUREMENT AND COMPUTATION COMPLEX

Research within the theme was carried out in full accordance with the project "Development of the FLNP Information and Computation Complex".

In 1996, the main efforts of the department's specialists and financial resources were directed toward developing the FLNP local computing network (LCN). The network equipment and software necessary to switch over to data-transfer rates of up to 100 Mbit/s in the main LCN segments, and primarily in the segment of the IBR-2 experimental setups, were purchased. A number of X-terminals were bought, in addition to those already available. This will make it possible to significantly increase the efficiency of the servers and workstations of the SUN-cluster.

Main work to design, construct, and put into operation the VME measuring systems at the NERA-PR, HRFD, and NSVR spectrometers has been performed. At the majority of the spectrometers, standard equipment for regulating the temperature of the samples under study was put into service. Development of the detector and unified electronics of the data acquisition and accumulation systems in VME standard for the position-sensitive detectors (PSD) at the YuMO and DN-2 spectrometers has been completed. At present, the equipment is being constructed and adjusted. Financial difficulties, however, have seriously reduced the pace of executing work. Since September 1996, there have been no funds to manufacture multilayer printed circuit boards, to pay the concluded contracts, and for current expenses. This has automatically resulted in corresponding delays in the introduction of new developments.

Nevertheless, in 1996, we ensured the steady running of the experiment automation systems at IBR-2 and IBR-30, and made significant progress in all directions in the creation of new measuring and control systems for the spectrometers and in the development of the information and computation infrastructure of the Laboratory.

Detector electronics. In 1996, a large amount of work to create electronic blocks for PSDs, helium neutron counters, and semiconductor detectors was performed:

- A stand for studying gas PSDs with high-resistance wires was designed and constructed on the basis of a personal computer. It consists of two spectrometric tracks, two ADCs, and a KK-009 CAMAC crate-controller. The software that makes it possible to accumulate amplitude spectra from each ADC and spectra of the sum of two signals (also in the chosen window), as well as to calculate the position codes and accumulate position spectra with several values for the maximum number of channels, was developed for the stand. Work for studying the characteristics of the annular PSD at the YuMO spectrometer was carried out with this stand, and the starting data to design electronics were obtained. At present, the design of the charge-sensitive preamplifier and spectrometric amplifier has been completed and, at the moment, sixteen blocks of this kind are being constructed for eight wires of the detector. A mechanical construction for mounting the preamplifiers onto the case of the annular PSD was designed. But because of still unclarified problems with the detector, we failed to obtain satisfactory amplitude spectra and the required angular resolution for all wires of the detector. For lack of financing, the contract for the manufacture of a set of eight two-channel ADCs has not been fulfilled.
- The prototype of the two-channel time-to-digital converter (TDC) using hybrid microcircuits ("charge-to-time converter") was constructed for the two-dimensional PSD of the DN-2 spectrometer, which is based on a multi-wire proportional chamber with a cathode

delay line readout. The TDC digitizes the time intervals between the formed anode signal and the cathode signal from the end of the delay line and, in this way, determines neutron coordinates. This TDC is constructed in the form of a double two-channel device with ranges of: 500 ns with a scale for 512 channels to determine the x coordinate of the neutron and 250 ns with a scale for 256 channels to determine the y coordinate. In 1996, using this equipment, physical measurements with the two-dimensional chamber were conducted on beam 6 of the IBR-2 reactor. The following results were obtained:

- integral nonlinearity of both TDCs < 0.2%;
- intrinsic resolution over the whole range is 1 channel, i.e., 0.5 mm over the volume of the chamber;
- conversion time for the x coordinate ≈ 5 μs, and for the y coordinate ≈ 2.5 μs.

At present, the standard block of the TDC-2 with the indicated parameters has been constructed and tested. The TDC-2 block has two data outputs: one to the connector on the front panel, and one in parallel to the CAMAC bus.

♦ The engineering specifications were prepared for the manufacture of the one-channel TDC-1 for four ranges of measurement: 50 ns, 100 ns, 512 ns and 1000 ns, for time measurements with the spectrometers of the Scientific Department of Nuclear Physics.

For the X-ray PSD, the analog processor block from the industrial device RKD-1 was adapted to CAMAC construction and adjusted. The AK-1024 ADC was also constructed and adjusted. The interface to connect it to the VME crate is presently being designed.

♦ The detector equipment of the NERA-PR spectrometer, which includes 50 channels of electronics for picking up signals from the helium neutron counters, and the NIM-TTL converter blocks with a light diode display, have been put into operation. Each channel contains a charge-sensitive preamplifier, an amplifier with active signal shaping, a comparator, and a NIM driver.

♦ Thirty similar detectors equipped with electronics have been adjusted for the SKAT setup.

♦ The prototype of the 8-channel preamplifier for the 128-component detector system of the DN-12 spectrometer has been designed, constructed, and tested. The characteristics of the detector were measured with a neutron source. Using the results of the measurement, the detector electronics for DN-12 were constructed and tested on the stand with a neutron source.

♦ Work to modernize the detector electronics of the ROMASHKA setup has been performed.

♦ Ten preamplifiers for the *Si*-detectors of the setup with polarized nuclei have been designed and are being constructed.

♦ Work to adjust the electronics of the anti-Compton spectrometer is in progress. The electronics for the 16-channel neutron detector of the UGRA setup are being designed and constructed.

♦ The prototypes of new ADCs (two types) with 1024 and 4096 channels have been constructed. The main characteristics have been measured and the engineering specifications for production samples are being drawn up.

Data acquisition and accumulation systems. The architecture of the unified systems in VME standard for acquiring and accumulating data from the IBR-2 spectrometers has been developed. These systems are based on a limited but functionally complete set of identical (from the viewpoint of hardware) blocks used for registering and accumulating data, which realize distinctions in parameters and in the correction and preliminary data processing procedures, that are specific to each spectrometer. This is accomplished by means of microprograms, electronic tables, etc.

For any spectrometer, the data acquisition and accumulation system has four basic blocks.

Interface block: intended to receive data from PSDs, add the neutron time-of-flight code to the position code, synchronize read/write processes, and provide intermediate data storage in the FIFO memory and further data transfer to the processor block, etc.

Block for encoding the point detector number: writes the detector number by parallel position codes into the intermediate FIFO memory, followed by determination of the binary code of the detector using the priority encoder.

Processor block: calculates position codes (using ADC codes from both ends of the high-resistance wires of the annular detectors), corrects for the geometric location of the detectors, forms addresses for the histogram memory, executes control over VETO signals, and counts the number of pulses from monitor detectors, etc. This block is based on the high performance TMS320C40 signal processor with a large address space (32 bits), floating-point arithmetic (execution time is 40 ns), six communication ports with a data-transfer rate of 20 Mbytes/s, two internal buffers with dual-port access, two independent buses to connect the external memory, and so on. The processor block includes two buffers with a capacity of 1 Mbyte which store all of the data from the spectrometer detectors from one cycle of the reactor. Thus, for example, the data in the current reactor cycle are written to buffer 1, while the data from the previous cycle are copied from buffer 2 to the DSP internal memory for computations and for transferring the processed data to the histogram memory. In this case, the processor is not involved in data input/output; these operations are executed via communication ports and built-in DMA co-processors. In the processor block, the function of encoding the neutron time-of-flight (the number of channels to 64 K and the number of time scales to 4; the channel width is entered in table form and can be chosen for any scale from 50 ns to 128 μs, graduated in 50 ns) is realized.

Histogram memory: has a two-port configuration to provide access for both the processor block and the VME bus. The storage capacity can be increased from 2 Mbytes (which is sufficient for the majority of spectrometers) to 64 Mbytes (this volume is necessary for DN-2) by building in additional memory chips or by using several blocks. Both the address space and memory depth (up to 32 bits) can be enhanced. The memory has an embedded program-adjustable table for page addressing. The memory access time is not more than 500 ns, the modes of operation are: +1 to the content of the memory cell or +1 to the current address.

The following work has been carried out at the IBR-2 spectrometers:

- In the reported year, at the NSVR spectrometer, the VME-standard data acquisition system was in successful operation. Work to develop this system, specifically in the framework of the EPSILON and SKAT projects, has been performed.
- The equipment and software for the data acquisition and accumulation system in VME standard has been put into service at the NERA-PR spectrometer.
- At the HRFD spectrometer, the equipping of the VME-system has been completed. The subsystem for registering low-resolution spectra (including the TCC-6 time-to-code converter, histogram memory with a capacity of 2 Mbyte, block for encoding the detector number with 16 inputs, software, etc.), has been fully adjusted. Four DSPTMS320C51-based

RTOF-analyzers were constructed and adjusted, and tests for accumulating high-resolution spectra were conducted. In the near future, the system will be put into operation.

♦ Equipment in VME standard has been designed and constructed for the SAX X-ray diffractometer. In October 1996, the system was turned over to the programmers to adjust the software. The multi-parameter measuring system for the ionization chamber with two grids, used in experiments at IBR-30, was adjusted and put into operation.

Sample environment control systems. The control equipment of the step motors for goniometers, neutron scanners, shutters, devices for changing samples, etc., is an important part of the above-mentioned VME-systems at the NSVR, NERA-PR and HRFD spectrometers. This equipment is based on the developed unified power amplifier blocks and standard input/output registers.

The system for acquiring analog parameters for different types of sensors has been developed and tested.

The prototype of the block for controlling the neutron choppers, which is based on the K1816 BE31 microprocessor controller, was constructed. The microprograms for the controller and the service software for the PC of the operating personnel were written. At present, tests on the beam are nearing completion and the preparations for the manufacturing of these blocks for all choppers are being made.

The Euroterm standard temperature regulators were put into operation at the YuMO, SPN, DIN-2, and DN-2 spectrometers. The low-level software to connect the Euroterm regulators to the PCs and VME-based equipment was designed. At a number of spectrometers, these temperature regulators have been mounted and are ready for operation. The delays are caused by the acute shortage of programmers.

The system for correlation analysis of the power pulses of the IBR-2 reactor and for measuring the vibrations of the movable reflector has been completed. Work to create a system for monitoring the power pulses of the reactor and the condition of the shutters has been performed. The operation of this system is being tested.

Software for data accumulation and control systems of the spectrometers. The PC software for a number of spectrometers has been upgraded.

The low-level software was designed for the VME system at the NERA-PR spectrometer. It comprises modules for the motor control equipment, for exercising control over the data accumulation system, the parameters of the spectrometer and the devices for controlling and maintaining a constant temperature at the samples (Euroterm-902/906, LTC-60). These programs make it possible to control the experiment in interactive and automatic modes. The automatic mode is realized by creating a command file and executing it by the standard interpreter of the OS-9 – Shell operating system.

At the HRFD spectrometer, the low-level software for the equipment for accumulating low-resolution spectra and equipment for controlling the motors of the mechanical units of the diffractometer was designed for the VME-based system.

The software of the NSVR spectrometer has been considerably developed and upgraded.

The prototype of the unified control system for the spectrometers was developed for the VME-based systems under the OS-9 real-time operating system. This makes it possible to configure the control software of a specific spectrometer from the set of control and interface modules realized according to certain rules. The program manager plays a key role in this software. It provides the connection between the interface and control modules by means of the

Sockets mechanism using TCP/IP protocol, synchronizes access to the control modules, controls the state of the elements of the spectrometer, and checks the access to them for correctness. It also controls the user's rights to operate the system, manages the system configuration (inclusion or exclusion of spectrometer devices from the working configuration), and provides information on the state of the system as a whole and specific devices or subsystems.

The developed technique for programming the control modules allows one to use the same modules for the control systems of different spectrometers without making any changes, but only adjusting them to the specific configuration and parameters of the devices and subsystems. The new modules design does not require that the modules written previously be changed. The software as designed enables one to use the modules in both interactive and automatic modes. For this purpose, we use standard solutions accepted by the UNIX and OS-9 operating systems that make the realized solutions compatible with other platforms and operating systems, since the software is available in all modern operating systems.

The interface program modules are realized on the SUN SPARCStation 2 (20) and make it possible to control the system in interactive mode. They also can be used as commands to design the interpreted program for measurements in automatic mode. In the future, this new software will allow us to realize a graphic user interface on SUN SPARCStation. The TCL/TK package is to be used for this purpose.

Development of the SUN-cluster and network infrastructure. In the reported year, work to install, support, and service the hardware and software of PCs and workstations was carried out. In particular, the system software was reinstalled or corrected on more than 80 PCs. Disks where defects were detected were excluded from the SUN-cluster configuration and new disks with larger capacities were included by correcting the system configuration on the SUN stations accordingly.

Six X-terminals were adjusted and integrated into the SUN-cluster. A number of them were not only integrated into the local network, but were also put into service as the console terminals of VME-systems. The system programs of the SUN-cluster were modernized or corrected to provide better protection of the system against unsanctioned access, as well as new versions of a number of program products (MAKE, GHOSTSCRIPT, EMACS, TCK/TK, PEARL, etc.) were installed. The software for the network printers was upgraded on the basis of the experience gained during a year of service. The software supporting the terminal mode and the mode of IP connection via the PPP protocol was designed to obtain remote access to the SUN-cluster machines via modems.

New commercial software packages (PV-WAVE v.6.04, POWERVIEW, XILINX) were installed on the SUN-cluster machines and software support of the above-mentioned products is being provided. For the PV-WAVE package, freely distributed additional libraries were installed. These libraries make it possible to save images created by PV-WAVE as files in the standard graphic formats (specifically, GIF), which can be used to create files in the HTML format for the Web.

On the basis of the PV-WAVE package, software to access, visualize, and treat neutron spectra accumulated at different spectrometers of the IBR-2 reactor was developed. In particular, software to import neutron spectra was designed for 14 spectrometers. In addition, a general data format for neutron spectra was developed, which also includes the parameters saved along with the spectra by the different data acquisition programs running at these spectrometers. The parameters are divided into two groups: the so-called spectrum parameters (used directly in the treatment of spectra) and the comments to the spectra (an extendible set of text parameters). Also among the component parts of this format are the spectrum statistic errors and the current accumulation of X-coordinates, which can assume the values of time-of-flight channels, wavelengths, transfer momenta, etc. While importing spectra from any of the 14 spectrometers into the PV-WAVE package medium, the data structure is formed in accordance with the developed data format, which is transparent to treatment procedures and can be saved on disk (and read out later) when exporting data in the general format. The proposed data format can be considered as an intermediate between the formats available at the IBR-2 spectrometers and the HADES (NEXAS) international neutron data format under discussion at the present time. The developed set of 24 procedures for treating spectra includes arithmetic and special operations, specifically, the conversion of spectra to different coordinate systems. Each operation is accompanied by a recalculation of the statistical errors for the resulting spectrum.

The designed software is available to any user of the FLNP SUN-cluster via the graphic user interface of PV-WAVE Point&Click 2.20 and the command interface of PV-WAVE Advantage 5.5 and 6.0. Short illustrated userguides for the packages of the PV-WAVE family and the developed software are available on the Web at:

http:/nfdfn.jinr.ru/flnph/pv/pv_info.html.

The information system on the activity of the Laboratory, as well as the means of presenting information materials on Web, were also further developed.

The channels of the IBR-30 reactor (IREN) and the spectrometers of the Scientific Department of Nuclear Physics were connected to the Ethernet network. The project to change the FLNP "backbone" network over to the Fast Ethernet standard with data-transfer rates of up to 100 Mbit/s was worked out. Based on the purchased network commutators CISCO 5000 and CISCO 2800, as well as the network adapters (10/100 Mbit/s) for SUN-type machines, work to switch over the "backbone" and servers to the Fast Ethernet standard has begun. The completion of the first stage of this work will significantly improve the intra-laboratory traffic and decrease the response time of computers of the Laboratory SUN-cluster.

It should also be noted that traffic to LCTA and on to the outside world will remain as before because the project to switch the JINR "backbone" over to the ATM standard was not financed in 1996.