

# DATA ACQUISITION AND HANDLING IN THE VEPP-4 CONTROL SYSTEM

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## Abstract

The Control System for the VEPP-4 facility [1] was designed more than fifteen years ago and based on the home-developed CAMAC-embedded minicomputers Odrenok [2]. Four years ago, all computers were connected via Ethernet network [3]. This step allowed us to integrate PC into the VEPP-4 Control System.

This paper reviews a new opportunity for the data acquisition and handling in PC computers. The data acquisition system allowed us to study carefully different features of the VEPP-4M collider [4].

The data visualization tools use standard software and the CERN ROOT framework.

## 1 INTRODUCTION

Currently the VEPP-4 Control System includes 14 Odrenok computers. Each Odrenok is responsible for the control of individual parts of the VEPP-4 complex or for the part of diagnostics (vacuum and temperature, beam diagnostics, etc) [2].

Odrenok is a 24-bit computer with 768 kbytes of available RAM and without its own hard disk. Ten processes can be loaded simultaneously in each Odrenok. The Main Clock Timing Reference for most of the programs is 1 Hz. There are about 1000 measuring points on the VEPP-4 Control System, therefore we need about 10 kbytes of memory per second for data saving. It is impossible to save such a large amount of data in the case of Odrenok computers.

Two years ago, PCs under Linux were implemented in VEPP-4 Control System as operator consoles in the main Control Room. Since that time, a number of new programs for the Control System were designed in PCs [5]. New measuring electronics for beam diagnostics were connected directly to these operator PCs: beam profile monitors for VEPP-4M and VEPP-3 [6], VEPP-4M beam length monitor, magnetic field measurements for the main elements of the VEPP-4M.

PCs in the Control System have allowed us also to develop a permanent data accumulation system for following data analysis. This system provides data acquisition from Odrenok computers: set of currents in magnetic elements of the VEPP-4M collider and measured values, temperature of all the devices on the VEPP-4 facility, vacuum, etc.

The data acquisition system allowed us to carefully control the energy of particles in the VEPP-4M collider

during  $J/\Psi$  and  $\Psi'$ -mesons mass measurement experiments during the 2001/2002 season [7].

## 2 DATA ACQUISITION SCHEME

### 2.1 General Description

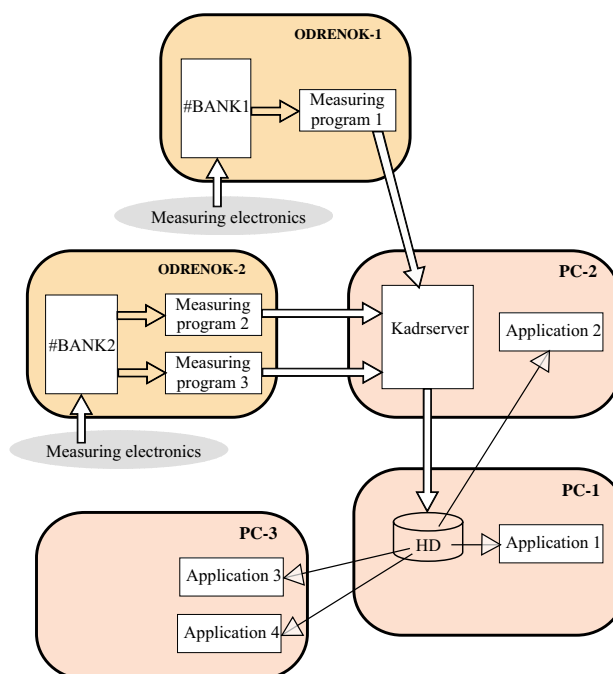


Figure 1: Data acquisition scheme.

Almost all measuring electronics in the VEPP-4 Control System are connected to Odrenok computers. Therefore special software was designed to transfer data from Odrenoks to PCs.

In Odrenok all required data is read automatically by the special resident measuring programs. The interaction with electronics in each Odrenok is made via the singular program, usually named #BANK. The measuring programs send data to the special server in PC named *kadrserver* via Ethernet. Home-developed low-level transfer protocol requires that the data size in one data transfer does not exceed the size of Ethernet package (1.5 kbytes).

*Kadrserver* runs as the daemon process and is automatically started at rebooting of Linux. For this purpose the specified script in */etc/init.d* is placed.

*Kadrserver* receives packages from Odrenoks and puts data to specified files in a specified directory on the hard disk of the PC. This directory mounted to all PCs of the Control System, so applications running in PCs can read data from the files.

Data in each file is refreshed when *kadrserver* receives the packets from Odrenoks. So applications must save necessary data in their own files for long-term statistics.

## 2.2 Data Package Processing

Since the power of Odrenok computer is low (.5 Mips) the data transfer from Odrenok to PC are in Odrenok coding (24-bit words, 6-bit "bytes" or symbols).

Format of data packages, processed by *kadrserver* is shown in Fig.2:

ODRENOK 6-bit "bytes"		Contents	
1-80		low-level home-developed protocol header	
81-100	81-92	high-level data header	filename, in which data should be recorded
	93-96		<b>A00D</b> where <b>A</b> = 1 - the case to write the data in a line (space after each data unit) <b>A</b> = 2 - the case to write the data in a column (LF after each data unit) <b>D</b> = 1 - add the data to the file <b>D</b> = 2 - rewrite the file
	97-100		number of Odrenok words in the data package (without header)
101-... less then 1900		the data divided into blocks	

Figure 2: Data Packet Structure.

*Kadrserver* produces a text file in which data is written as text strings (or single string) or columns.

ODRENOK 6-bit "bytes"		Contents	
1-4		data block header	<b>ABCC</b> where <b>A</b> = 1 - symbol data = 2 - integer numbers <b>B</b> (valid in the case of string data format) = 0 - write the data block in the same line = 1 - LF before writing the data block <b>CC</b> - number of words in the data block
5 -... less then 1820			the data (24-bit Odrenok words)

Figure 3: The header of the data block.

Data in the package are divided into blocks. *Kadrserver* can process both Odrenok integer numbers and Odrenok symbols. Data type is defined in the header of each block (see Fig.3). Each block can contain only one type of data.

The first lines of the text files include date and time of the last recording.

## 3 DATA HANDLING IN PC

All VEPP-4 Control System data require about 10 kbytes memory per second for saving. Therefore the special programs were developed to record selected data for long-time storage.

Data from Odrenok measuring programs comes as fixed-length blocks with fixed contents. *Kadrserver* handles these blocks and writes data to text files. For reading required parameter, application must know the file name and a data position in the file (number of line and position into the line).

### 3.1 Kadrclient - Universal Data Filter

The universal data filter *kadrclient* provides easy manipulations with different groups of observed values. *Kadrclient* can read one or several data files produced by *kadrserver* and write specified data to a specified text file as a new line. At the beginning of each line written by *kadrclient* date and time of recording is placed.

*Kadrclient* has the following main options:

- -s <source file>,
- -t <target file>,
- -d, display on a screen what is written in the file,
- -m <mesh>, number of value in the source file,
- -f <factor>, conversion factor for dividing of the value,
- -p <pause>, pause in seconds before the next reading of the source file.

Example of the command line for start *kadrclient*:

```
kadrclient -d s names1 -t namet -m 13 -m 17 -p 23 -f 1 -f 21 -s names2 -m 21 -f 1.3
```

In the case of a long command line it is convenient to use prewritten script. Here is the example of the script for the recording of some parameters of the VEPP-3 injector linac:

```
#!/bin/sh  
echo 'Starting linac recording'  
/usr/sbin/kadrclient -s bank-pози -d -t vlin -m 18 |  
-m 19 -m 20 -m 424 -m 425 -m 428 |  
-m 104 -f 420.732 -f 367843. -f 19. |  
-f -100000 -f 100000 -f 100000 -f 126
```

Symbol "\" in this script is needed for concatenation of lines.

*Kadrclient* can write the whole source file. In this case a target file has a name that includes date and time of the record (option -a). Moreover, *kadrclient* can write (add) all data from the source file as a single line to the target file (option -e).

### 3.2 Data Observation

Files made by *kadrclient* are conveniently displayed using interactive plotting program *gnuplot* [8]. *Gnuplot* commands required for different cases are included in the text files, which are loaded via the "load" *gnupot* command. Special developed tcl-scripts provide the observation of the diagrams in real time.

### 3.3 VEPP-4M Main Parameters Observation and Saving

During the experiment of  $J/\Psi$  or  $\Psi'$ -mesons mass measurement, it was very important to observe main parameters of collider VEPP-4M.

For observation of the stored parameters the applications based on the ROOT-package [9] were developed.

The special application named *monit* provides for a periodical saving of the data processed by *kadrserver*. *Monit* converts all specified data from different text files to a single file in ROOT-format during 24 hours. The name of this file includes date of saving.

Another application named *status* provides a graphic visualization of these files. The screen of this program is shown in Fig.4. *Status* provides an easy choice of desirable parameters and graphic output flexibility (stretching/shrinking of horizontal and vertical scales).

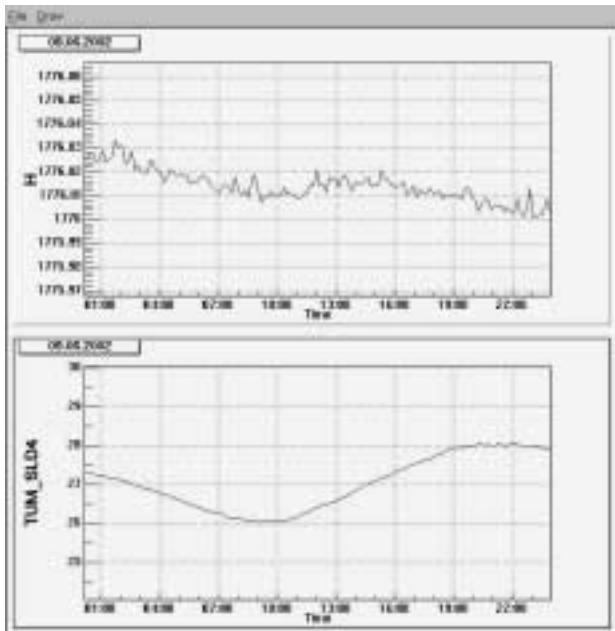


Figure 4: The screen of the VEPP-4M main parameters observation program.

For more detailed long-time analysis, a special script was developed to save all significant VEPP-4M parameters to PostgreSQL tables. The period of saving is 10 minutes.

## 4 GPAPHIC APPLICATIONS IN PC

The data acquisition system allowed us to develop graphic visualization programs in PC. During the last time, two effective applications were developed:

- Beam orbit observation program *lorb*. This program provides orbits graphical output, saving and comparing for both VEPP-3 and VEPP-4M.
- Injector main parameters visualization program *belk*. This program is an applet and can run by a web-browser in any computer in the Control Room.

Display with new application screens is shown in Fig.5.



Figure 5: Display with new applications:

- beam orbit visualization,
- injector parameters visualization.

## 5 REFERENCES

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