MACHINE OPERATIONS AND STATISTICS ON THE VEPP-4 COMPLEX

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Abstract

The VEPP-4 complex provides electron and positron beams for different experiments in parallel.

Due to implementation Linux-based machines in the VEPP-4 Control System the vast statistics are available and are used for the analysis of the stability and reliability of the machines. The improvement of the Control System allowed us to successfully accomplish the precise experiment of measuring of the J/psi- and psi'-meson masses. Now the experiment of tau-lepton mass measurement is being prepared on the VEPP-4 complex in which the analysis of the machine parameters will play a vital part.

The paper reviews an opportunity for data acquisition in the VEPP-4 Control System. Machine operations schedules for different user works are also presented in this paper.

1 INTRODUCTION

The VEPP-4 complex [1] is intended for providing experiments with colliding electron-positron beams, experiments on nuclear physics, experiments with synchrotron radiation.

The VEPP-4 accelerator facility consists of VEPP-4M collider with 365 m circumference (1 - 6 GeV), 2 GeV multi-purpose VEPP-3 storage ring and 350 MeV pulse electron/positron injector. There is pulse transfer line from VEPP-3 to VEPP-4M (see Fig.1).

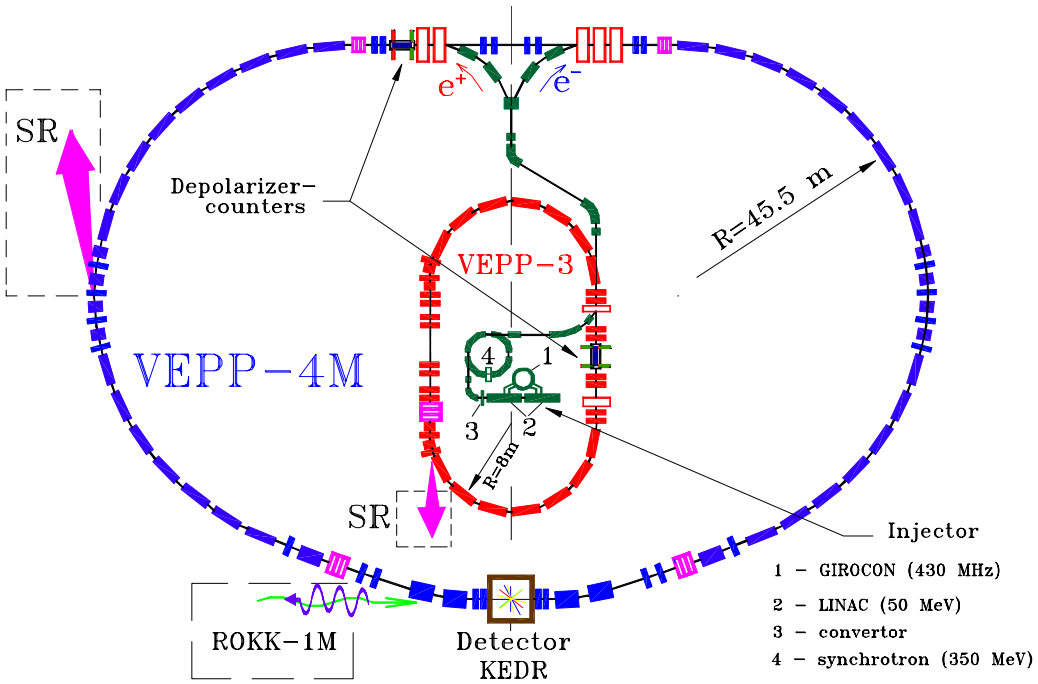

Figure 1: Layout of the VEPP-4 facility.

Both rings, VEPP-3 and VEPP-4, are used for providing experiments. In spite of the fact that VEPP-3 is the booster for VEPP-4, there is a possibility to perform different experiments on VEPP-3 and VEPP-4 simultaneously.

The VEPP-4 Control System [2] was designed more than fifteen years ago and based on the home-developed CAMAC-embedded minicomputers Odrenok. 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).

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Five years ago, all Odrenok computers were connected via Ethernet network. This step allowed us to force an integration of PCs into the VEPP-4 control system.

PCs in the Control System have allowed us to develop data accumulation system for following data analysis. This system provides data acquisition from Odrenok computers: set currents in magnetic elements of the VEPP-4M collider and measured values of the currents, 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/Ψ and Ψ'-mesons mass measurement experiments during the 2001/2002 season [3].

2 VEPP-3 OPERATIONS

2.1 Booster operations

Pulse injector (1 Hz) of VEPP-3 is intended for production of electron and positron beams with particles energy 350 MeV. Injector consists of 50 MeV linac and 350 MeV synchrotron. Linac is RF powered by pulse GIROCON 430 MHz generator.

Positrons are produced after linac from electron beam on tungsten target 3 mm thickness. Number of particles in electron bunch extracted from synchrotron is 10^{10}, number of particles in positron bunch is 2×10^{8}.

Booster operations are (see Fig. 2):

(a) at first the positrons are accumulated during 20 minutes in VEPP-3,

(b) then the positron beam is accelerated and transferred to VEPP-4M.

(c) the polarities of magnetic systems of VEPP-3 and the injector are changed, and within 10 minutes the electron beam is accumulated and accelerated,

(d) after transferring of electron beam the positrons are accumulated again.

The specified current of positron beam is hold in VEPP-3 (e), while the experiments with beams in VEPP-4M are performed. In the case of 2×2 bunches in VEPP-4M the operations (a), (b) (see Fig. 2)are made twice.

2.2 Physical experiments providing

In addition to use as the booster for VEPP-4M collider VEPP-3 storage ring is used for experiments with synchrotron radiation and for experiments with polarized gas internal target. Both types of experiments can be conducted simultaneously. There is an electron beam in VEPP-3 in this case. Synchrotron radiation is produced in three-pole wiggler with energy range from up to 40 keV.

The following operations are executed in this case:

(a) on injection energy (350 MeV) the desirable current is accumulated in one bunch during 2-5 minutes,

(b) the accumulated bunch is accelerated up to energy 2 GeV,

(c) the wiggler for generation of the synchrotron radiation is turned on,

(d) the experiment lasts from 1 till 4-5 hours depending on desire of the users.

During the experiment the orbit stabilization using the position of the spot of the synchrotron radiation bunch is carried out.

(e) after the finish of the experiment the magnetic cycle of the iron of magnetic elements is executed for setting the injection mode of the storage ring.

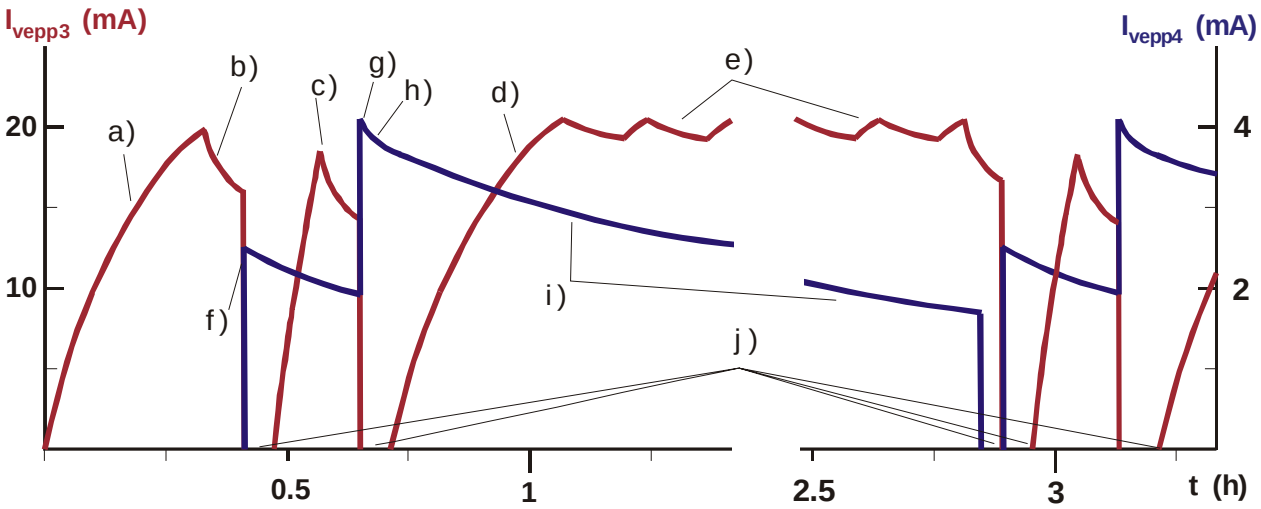

Figure 2: Booster operations of the VEPP-4 facility.

3 VEPP-4M OPERATIONS

4.1 High energy physics experiments providing

VEPP-4M e^+e^- collider [1] was intended for the maximum energy up to 6 GeV to study physics of Υ-meson and two-photon processes [4]. The collider worked in this mode in the first half of the 1980's. Recently the facility efforts are concentrated in J/ψ and τ lepton physics in the low energy range of E=1.5–1.8 GeV [5].

During one experimental cycle the following operations are performed on the VEPP-4M facility (Fig. 2):

f) the injection of the new positron beam from VEPP-3,
g) injection of the new electron beam,
h) acceleration (or deceleration) of injected beams,
i) experiment time,
j) magnetic cycle time.

During regular J/Ψ meson or τ lepton study the collider energy is calibrated with an accuracy of 10^{-4} or better using the method of resonance depolarization [6].

The diagram of the operations in the case of the statistics gathering is shown in Fig.6.

4.2 Nuclear physics and SR experiments providing

There is ROKK-1M installation (see Fig.1) on the VEPP-4 facility which is intended for production of bunches of back-scattered compton γ quanta.

There are several beam lines for extraction of synchrotron radiation beams in the middle of north half-ring. Synchrotron radiation is produced in the bending magnets.

The following operations are performed for providing nuclear experiments and experiments with synchrotron radiation:

(a) injection and accelerating of one or several (up to four) electron beams from VEPP-3,
(b) experimental time from 1 up to 5 hours,
(c) when the beam current in VEPP-4M decreases down to specific level, VEPP-3 injector is turned on and a new beam is accumulated in VEPP-3,
(d) when VEPP-3 is ready to accelerate the new beam VEPP-4 start the magnetic cycle for setting the injection mode. VEPP-3 accelerates the beam in parallel.

4 STATISTICS HANDLING

4.1 Urgency of the problem

For carrying out an experiment on a precision measurement of the tau-lepton mass near its production threshold of 1.8 GeV it is necessary to know the exact energy of colliding particles.

To calibrate the beam energy with high accuracy, rather hard requirements for stability of VEPP-4M parameters have to be applied. For instance, a long-term relative stability of the dipole magnetic field should be better than 5×10^{-6}. Besides, magnetic field imperfections can destroy beam polarization with the characteristic time τ_r. Estimation shows that the spin decay time for VEPP-4M is around τ_r ~ 30 min for the τ lepton threshold energy in the case of vertical close orbit distortion rms value ~ 100 μm. Since depolarization rate depends strongly on the spin resonance tune, magnetic imperfections and magnets misalignment can significantly limit the energy calibration time. These facts make us pay serious attention to the different aspects of the machine stability (power supplies, temperature, geodetic alignment, etc.).

4.2Data acquisition

Almost all measuring electronics in the VEPP-4 Control System is connected to Odrenok computers [2]. Therefore special software was designed to transfer data from Odrenoks to PCs (see Fig.3).

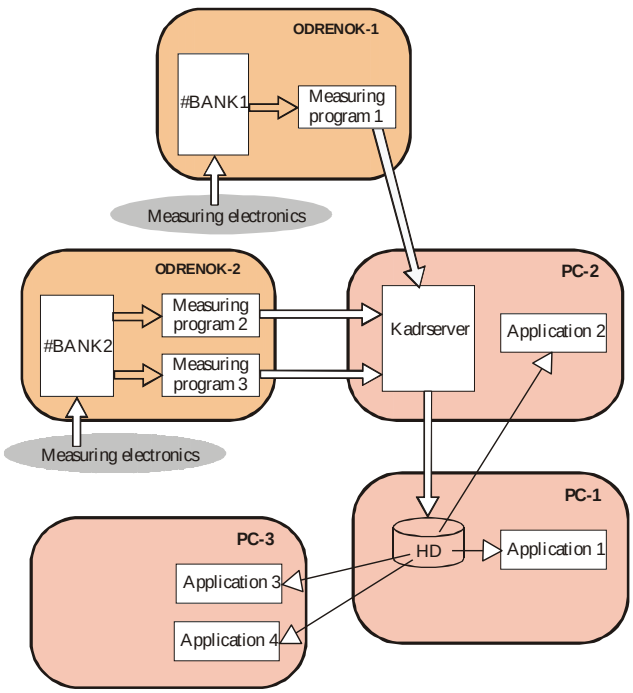

Figure 3: Data acquisition scheme.

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. *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 in PCs must save necessary data in their own files for long-term statistics.

4.3Data storing and analysis

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).

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. Files made by *kadrclient* are conveniently displayed using interactive plotting program *gnuplot* [7]. *Gnuplot* commands required for different cases are included in the text files, which are loaded via the "load" gnupot command. Special scripts provide the observation of the diagrams in real time.

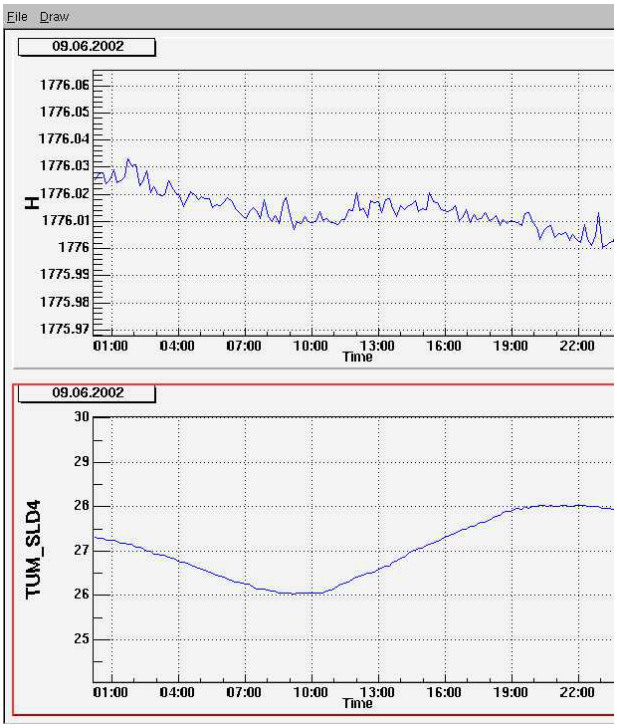

Figure 4: The screen of the VEPP-4M parameters observation program.

During the experiment of J/Ψ or Ψ'-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 [8] 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).

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.

Many parameters of the facility are picked in the block STAP (Status Page) in the Odrenok's fileserver which runs under Linux in PC. Each program running in Odrenok can write data into this block. The file server sends STAP block every second as the single broadcast datagram via Ethernet connecting all VEPP-4 Control System computers. There is *stapserver* program which receives package STAP and writes data to specified file for the other applications. Some main parameters are shown in [9].

5 REFERENCES

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