

# FREE ELECTRON LASER FOR THE SIBERIAN CENTRE FOR PHOTOCHEMICAL RESEARCH: SOFTWARE AND CAPABILITIES OF BEAM POSITION MEASUREMENT SYSTEM<sup>1</sup>

E.N.Dementyev, N.G.Gavrilov, A.S.Medvedko, A.D.Oreshkov, S.S.Serednyakov, E.N.Shubin, N.A.Vinokurov, Budker Institute of Nuclear Physics, Novosibirsk, Russia

*Abstract.*

The system for electron beam position measurement in microtron-recuperator, using the electrostatic pick-up electrodes is described. Option of simultaneous detection of accelerated and decelerated electron beams is considered. The software and its capability of integration to the Epics control system using Epics Channel Access protocol are discussed.

## INTRODUCTION

A high-power FEL, based on the accelerator-recuperator, [1] is under construction now at the Budker Institute of Nuclear Physics. The first phase of the project - the terahertz FEL - was commissioned recently [2].

This article discusses the system, intended for measurement of position of electron beam in the microtron-recuperator beamline, with metal buttons (so-called pick-up electrodes).

## SYSTEM STRUCTURE

The system for measurement of the transverse beam position consists of 28 electrostatic pick-up stations. Each station has four buttons with clear aperture diameter about 80 mm. Signals from plates of all the pick-ups are transmitted by cables outside the shielded hall to the location site of the measurement electronics. At each pick-up station, the beam position is determined via simultaneous measurement of the amplitudes of signals,

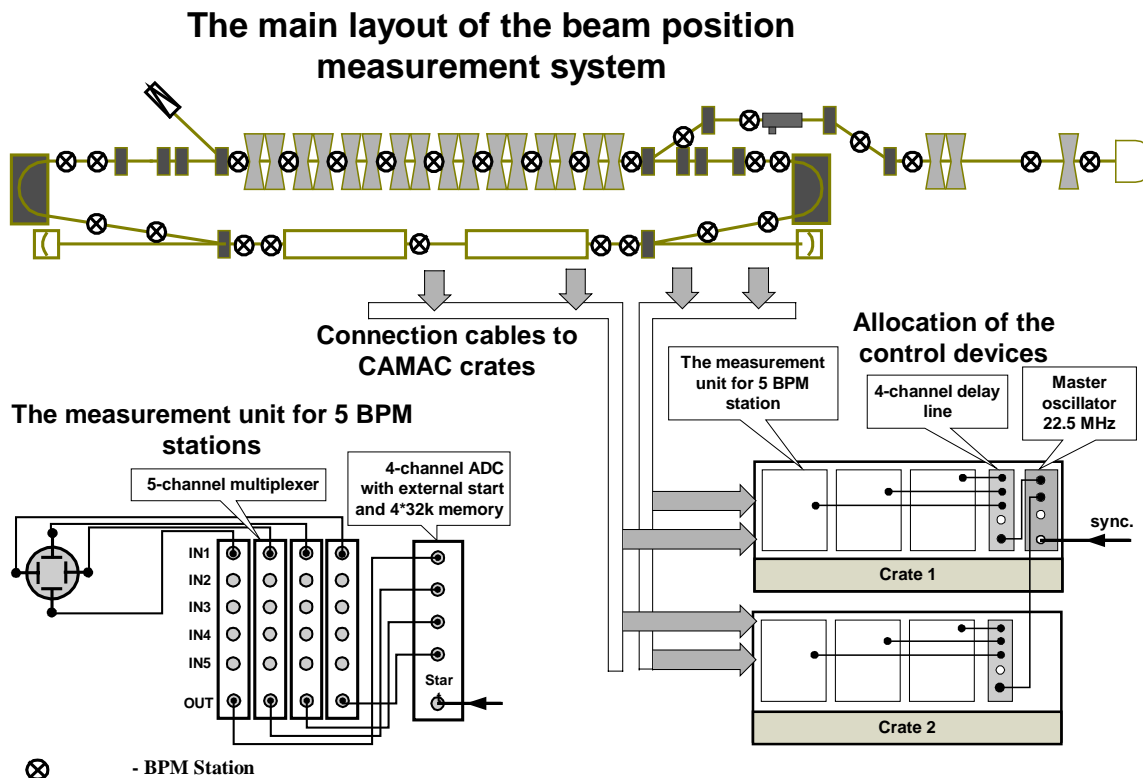


Figure 1. Main scheme of the beam position measurement system.

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induced on the buttons by the beam field. It is done with the use of the linear approximation formula:

$$x = k \frac{U_+ - U_-}{U_+ + U_-},$$

where  $k$  is the factor with dimension of length. It is obtained from electromagnetic measurements (in the case of a circular tube  $k \cong a/4$ , where  $a$  is the tube radius),  $U_+$  and  $U_-$  are the amplitudes of signals from a pair of opposite (left and right) plates. The formula holds true provided the plates' centers lie on the axis  $x$ .

The measuring equipment is described in detail in [3]. The connection diagram of the measuring units and structure of the system are presented in Fig. 1.

The system consists of measurement units, adjustable delay lines, that control them, and a 22.5 MHz generator. Each of the measurement units contains four blocks of 5-channel multiplexers and a 4-channel ADC. So, up to five pick-up stations can be connected to one unit. Six measurement units and two adjustable delay lines, which are located in two CAMAC crates, are used for the 28 pick-up stations (see Fig. 1).

The ADC is clocked by a signal, applied to the "Start" entry, which is passed from timer - device driving the electron gun modulator. This control signal is a sequence of pulses going with any given frequency from 0 to 22.5 MHz. Electron bunches from the gun go with the same frequency. The delay line shifts it by a given value, which makes it possible to adjust the moment of measurement either for the maximum of the beam-generated pulse or for any of its phases. The range of adjustable delays of the delay line is sufficient for compensation of a delay because of the beam flight time and cable length. The adjustable delay line has four channels adjusted independently, which allows one to control independently operation of the four measurement units.

There are simultaneously both the accelerated and decelerated beams in the accelerating straight section. One can perform the measurement of coordinates of one or another beam via choosing a certain delay value.

## SOFTWARE

The software was developed on IBM-PC computer in the operating system Windows 2000. The C++ language was used for code development. Communication with CAMAC crates was performed with the help of the ISP-controller, developed at Budker INP. The controller is made in the PCI standard and allows connection of up to 6 CAMAC crates.

The program has several operating modes:

1. Serial poll of all the pick-up stations to find the transverse coordinates of the beam (the main operating regime).
2. Scanning throughout the delay time value of one of the pick-ups and obtaining of the time dependence of the beam-generated pulse (used mainly to find the delay value for a given pick-up, in order to use it later in regime 1).

3. The mode of measuring of the amplitude stability for the buttons of a given pick-up station.

The first mode is the main operation mode of the program. In this regime, all the pick-up stations are polled subsequently in a specified range of delay time values. Limits of delay times are individual for every pick-up and being determined in mode 2. After running through the whole range, the program finds the maximum of signal from each button, computes the transverse coordinates, and displays it either as the beam trajectory or as the beam positions at every station (see Fig.2).

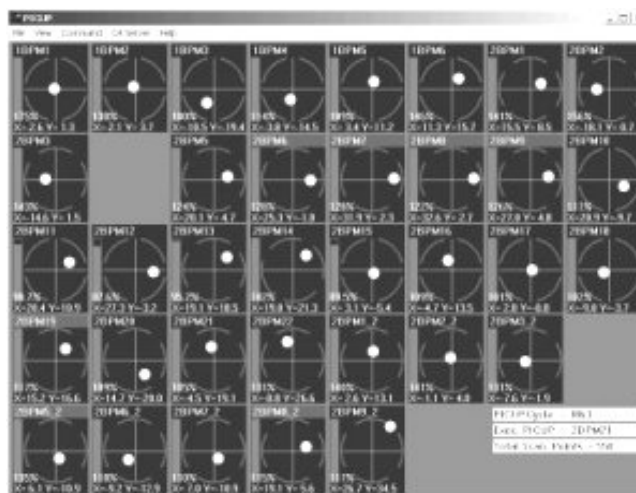


Figure 2. Main window of the program. The mode of serial poll of the pick-up stations.

Totally, 28 pick-up stations are installed on the microtron-recuperator. Nine of them are located in the accelerating straight section, there are simultaneously exists both the accelerated and decelerated beams. Accelerated and decelerated bunches are separated by the period of turn in the accelerator (see Fig. 3). They have different energies and can have different coordinates. In order to watch the "second", decelerated, beam, the program has nine additional "program" pick-up stations (referred to as simply pick-up stations below). Therefore, the whole cycle includes 37 pick-up stations.

An approximate time of polling of a one pick-up with fixed delay is 1 ms. In the normal operating mode, an interval of 5 to 10 steps is set for the delay value for each button. Therefore, for 37 stations the average time of one cycle is 200 to 400 ms, i.e. 2 to 5 cycles per second. Besides, there is the possibility of program disconnection of any station from the common cycle in order to increase the frequency of poll of the rest stations.

The second mode is switched on by the user's command. In so doing, the program stops the serial poll of pickups, comes over to the selected station and starts the cycle of scanning of the delay time. The delay time range is sufficient for coverage of the beam flight over the whole orbit. After completion of the scanning cycle the program either repeats it (if the cyclic mode is on) or continues the interrupted cycle of poll of all stations. The main function of this operation mode is the screen layout

of the time dependence of the pulse from the pick-up buttons of a selected station (see Fig. 3). Using this time dependence user is able to set the maximal and minimal delay values for the subsequent use in the first regime. In addition, one of the values of the set delay is used for the third regime, which is invoked from this window.

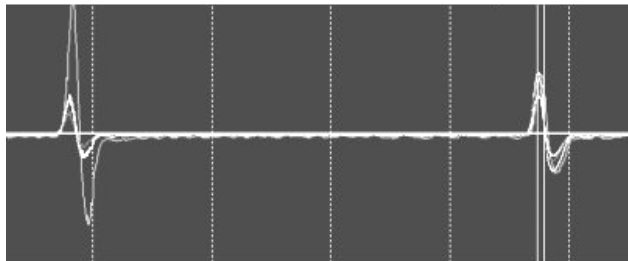


Figure 3. The mode of scanning of a selected pick-up station throughout the delay value.

The third mode is invoked from the second mode window. In so doing, the cycle of serial poll of the pick-ups is also interrupted, the delay time for the selected pick-up station is set and measurement of this station signals in the oscilloscope regime is started. The internal memory of the ADC is used in this case.

The ADC has a memory of 32 K of 12-digit words for each channel and can perform measurements with frequency as high as 50 MHz. That allows one to measure the amplitude of pulse from the pick-up buttons with the frequency of bunch repetition in the beam-line. The user can set the number of measurements for one plot. In the cyclic regime, the user sees on the screen the real-time plot of the measured signal. The dialogue window of this regime is shown in Figure 4.

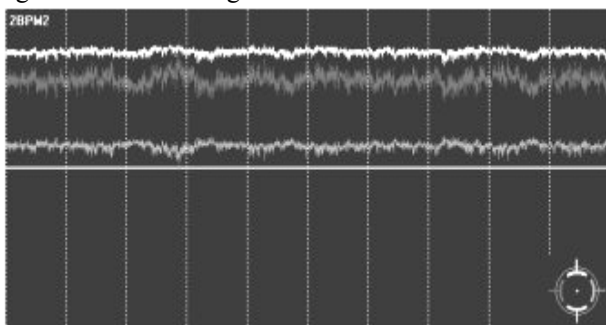


Figure 4. Mode of observation of the signal from the selected pick-up station.

The program provides the option of connection to the integrated control system, using the Channel Access protocol from EPICS. Channel Access is a high-level protocol, which works on the base of TCP/IP. The server is a set of variables (Process Variables) that characterize the status of the system. In this case, they are the values of the transverse coordinates ( $x, y$ ) for all the program pick-up stations. That makes it possible to inform any computer in the local network on the beam position, for visual observation or for use in different control programs (for instance, automatic orbit correction).

## CONCLUSION

The first stage of the free electron laser has been commissioned recently, and is in operation now. During the operation, the system for beam position measurement demonstrated high reliability. The features of the measuring equipment allow one to observe simultaneously the accelerated and decelerated beams in the accelerator-recuperator beam-line. Existence of the Epics Channel Access server in the program allows one to perform remote observation of the system from any of the computers in the local network.

## REFERENCES

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