

# USE OF A THREE-LAYER CONTROL SYSTEM FOR NON-DESTRUCTIVE BEAM PROBE MONITOR

D.Yu.Bolkhovityanov\*, D.A.Malyutin, A.A.Starostenko  
The Budker Institute of Nuclear Physics, Novosibirsk, Russia

## Abstract

The non-destructive beam probe is based on the scanning of a thin electron beam within the energy range 20–100 kV in the electromagnetic field of an intensive relativistic bunch. A CCD-camera is used to view the beam “image”. Initially the facility was controlled by a standalone application. This was dictated mainly by specifics of a CCD-camera and digital oscilloscopes, which are required for tuning. Now, when CCD-camera and digital oscilloscopes are fully supported by a CX networked control system (based on the 3-layer model), the standalone application was replaced by a CX-based set of programs. This enables remote operation, with several applications running in parallel. Additionally, this architecture allows use of scripting facilities to automate various routine tasks, which previously had to be done by hand.

## NON-DESTRUCTIVE BEAM PROBE

### Theory

A thin probe electron beam moves along X-axis that is orthogonal to the direction of the relativistic bunch motion (Z-axis), with the offset parameter  $\rho$  (see Fig. 1).

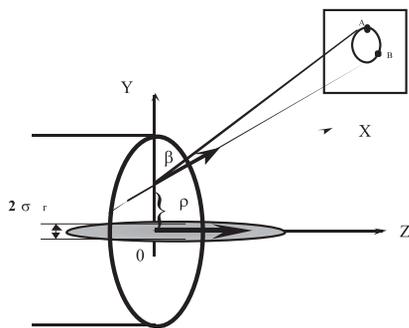


Figure 1: Principle of operation of non-destructive beam probe.

The results of scanning are monitored on the screen parallel to the Y-Z plane and positioned at the distance L from Z-axis. Let the center of the relativistic bunch be located at the origin at time  $t = 0$  whereas the probe beam has the uniform density along X and the diameter  $d \ll \rho$ . Here we assume that  $\sigma_r$  is the transverse sigma of the round

Gaussian relativistic bunch. At the time  $t = 0$  every  $x$ -coordinate is assigned to the certain probe beam particle. Then the total deflecting angles in Y and Z directions for every particle of the probe beam under the influence of the relativistic bunch can be calculated [1].

Due to use of electron beam this device is also named “electron beam probe” (EBP). And as its main application is charge distribution measurement, it is often called “charge distribution monitor” (CDM).

### Use

Currently there are 5 CDMs used in BINP — at VEPP-5 linac, damping ring, at VEPP-4, and 2 test setups. In 2008 one device will be supplied to SNS ORNL (for transverse beam profile measurement), and one to KEK.

## HARDWARE

The following hardware is used:

- 660×500px 10bit/px CCD-camera with Ethernet interface (custom protocol over UDP) — in-house BINP design, based on Sony ICX096BL and Altera EP1K30. It is the main diagnostic device.
- ADC200 2-channel waveform recorders (digital oscilloscopes) are used for setup and tuning.
- CAMAC and/or CAN-bus DACs and timing/synchronization devices.

While the list of hardware is short, it is diverse and vary between instances.

## INITIAL APPROACH TO AUTOMATION

Initially, when works with CDMs began in late 1990s, a standalone “do-it-all” application was used to control the facility. In the first place, it is a traditional approach to automation of small-scale facilities. And, second, VEPP-5 control system — CX [2] — was too young at that time and had no support for CCD and other required hardware.

This application combined GUI with CCD interaction and CAMAC control via a “dumb” serial controller (see Fig. 2). Plus, it supported a dedicated network protocol for remote access and control.

Thus, this application was huge, complex and error-prone upon any modifications.

## NEED FOR CHANGE

It became too costly to support in fact another one control system. Being a niche one, it lagged in features behind

\* bolkhov@inp.nsk.su

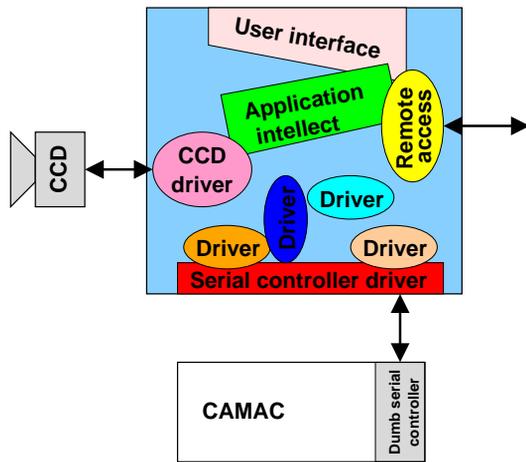


Figure 2: Structure of old control application.

CX. As different CDMs use different control hardware, several slightly different incarnations of the same program had to be maintained, which is a daunting job.

CX now does support “large” channels, up to 4Mb, both fixed-size (such as CCD picture) and variable-size (good for digital oscilloscopes, allowing to change measurement-length at run-time dynamically). And CX user interface is now plugin-based [3]. So, an obvious decision was to switch non-destructive beam probe control system to CX.

## THE CHANGE

CX was already used in a similar project [4], which employed almost the same hardware, including the same CCD. It proved to be highly successful, with only short-coming that CCD-camera had to be supported locally, by the GUI application itself. Now this problem is fixed.

CX now includes drivers for all hardware used in CDMs. So, the main concern was a GUI. Display plug-ins for CCD-camera and for digital oscilloscopes had to be created.

Communication with CX-server and routine interaction with a user are provided by standard CX libraries. Even the flexibility required to work with different sets of hardware is provided by CX, via mechanism of “descriptions” (screens), stored separately [3]. So, besides providing display plugins, the application program has to do only simple specific tasks, such as local processing and saving of obtained data (see Fig. 3).

## RESULTS

Thus, the non-destructive beam probe control software was rewritten from scratch, now based on CX (see Fig. 3). As before, it is a single application — “the experiment control center”, giving the user a full control of the experiment (see Fig. 4).

As could be easily predicted, the results are solely positive:

Control System Evolution

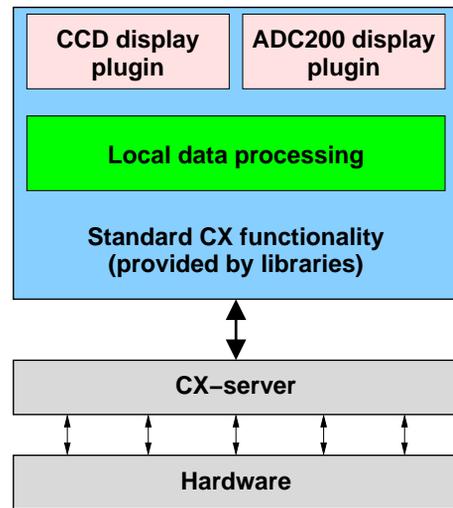


Figure 3: Structure of CX-based control application.

- New version of the program is much smaller and simpler (of course, this was partly conditioned by experience obtained with 1st version).
- Consequently, modifications, requested by users, are performed much more quickly and easily.
- As the hardware is handled by CX and the control application doesn't even care about exact hardware types/standards, all CDM instances are served by a single application — there's no more need to support several variants.
- As CX is a distributed networking system, various long and boring operations, such as tests of micro-channel plate degradation (which require long runs with sequential changes of some parameters), can be easily automated with shell-scripting.
- Of course, several instances of the same application can be run from different places simultaneously.
- Being a native CX application, the program can show (and allow to control) related parameters from other VEPP-5 subsystems, such as vacuum, magnetic system, etc.

## CONCLUSION

This work gave us one more proof that *all* automation, even for small-scale facilities, should apply 3-layer model instead of a standalone “do-it-all” program. This model (taking into account that most infrastructure is already present) makes automation a much easier task and gives a high degree of flexibility.

Charge distribution monitors were the last VEPP-5 subsystem to use “standalone application” approach. Now, VEPP-5 control system had completely switched to distributed 3-layer standard model.

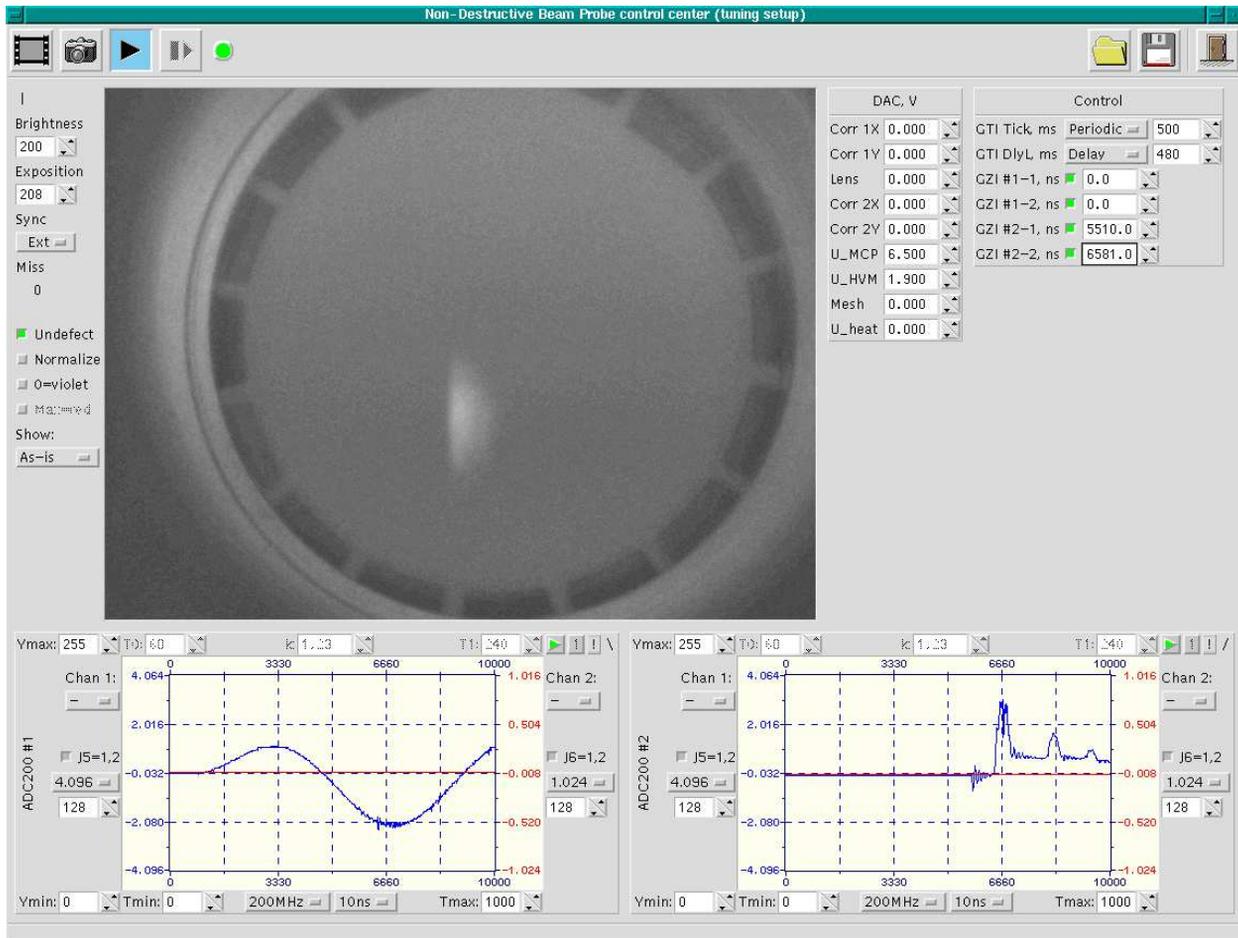


Figure 4: Screenshot of CDM control application (test bench). Main part of the window is occupied by image from CCD-camera. At the bottom are data and controls of ADC200 waveform recorders (these can also be presented as one wide graph with 4 curves, depending on user's preference). The top-right side is allocated to CDM controls and vary between instances, depending on hardware used.

## REFERENCES

- [1] P.V.Logatchov et al, "Non-destructive Single Pass Monitor of Longitudinal Charge Distribution", Proc. HEACC 2001 (Tsukuba, Japan, 2001)  
<http://conference.kek.jp/heacc2001/pdf/p2new04.pdf>
- [2] D.Bolkhovityanov, "VEPP-5 Injection Complex Control System Software", 2007, Ph.D. thesis (in russian)  
[http://www.inp.nsk.su/~bolkhov/publs/bolkhov\\_phd\\_final.pdf](http://www.inp.nsk.su/~bolkhov/publs/bolkhov_phd_final.pdf)
- [3] D.Bolkhovityanov, "UI-oriented Approach for Building Modular Control Programs in VEPP-5 Control System", Proc. PCaPAC-2006 (Newport News, VA USA, October 2006)  
[http://www.inp.nsk.su/~bolkhov/publs/pcapac2006\\_pUI\\_paper.pdf](http://www.inp.nsk.su/~bolkhov/publs/pcapac2006_pUI_paper.pdf)  
[http://www.inp.nsk.su/~bolkhov/publs/pcapac2006\\_pUI\\_poster.pdf](http://www.inp.nsk.su/~bolkhov/publs/pcapac2006_pUI_poster.pdf)
- [4] D.Bolkhovityanov, N.Lebedev, A.Starostenko, A.Tsyganov, "Design and Development of a Control System for Intense Source of Radioactive Ions prototype", Proc.

Control System Evolution

ICALEPCS'2005 (Geneva, Switzerland, October 2005)

[http://elise.epfl.ch/pdf/P1\\_091.pdf](http://elise.epfl.ch/pdf/P1_091.pdf)

<http://icalepcs2005.web.cern.ch/>

[Icalepcs2005/Presentations/Posters/P01\\_091.pdf](http://icalepcs2005/Presentations/Posters/P01_091.pdf)