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INCREASING QUALITY OF EXPERIMENT INTERPRETATION IN REAL-TIME*

A. M. Koshkarev†, T. A. Bykov, Ia. A. Kolesnikov, A. N. Makarov, E. O. Sokolova, S. Yu. Taskaev
Budker Institute of Nuclear Physics, 630090 Novosibirsk, Russia
Novosibirsk State University, Novosibirsk, Russia

Abstract

An Epithermal neutron source based on an electrostatic tandem accelerator of a new type – Vacuum Insulation Tandem Accelerator, and a lithium neutron generating target has been proposed and developed at the Budker Institute of Nuclear Physics [1] for the Boron Neutron Capture Therapy [2] – the promising method for treatment of tumours and for other applications. This paper proposes and implements a flexible and customizable method for the operational data processing, allowing an operator and physicists to obtain and analyze the information during the experiment without the need of post-processing data. The application of it accelerates the process of obtaining informative data during the experimental research and automates the analysis process. Also it was proposed and implemented a process of automatic distributed journaling of the results of the experiment. As a result of the implementation of the proposed tools the productivity of the analysis of experimental data and the detailing of the experimental journal was increased the developed and implemented system of real-time data processing has shown its effectiveness and has become an integral part of the control system, data collection and data storage of the epithermal neutron source.

INTRODUCTION

One of the most important and time consuming parts of researcher's everyday life is the post-processing of experimental data. Sometimes it takes more than 3 hours, but in some experiments physicists need results in real time. For example: visualization of diagnostics, such as beam position by thermocouples or calculation of average beam currents only when the energy is in the nominal range.

SYSTEM ARCHITECTURE

The developed and implemented accelerator control system consists of many units, such as measurement controllers, server, database, operator's software, software for TVs and physicist-analytics software.

Architecture on Fig. 1. allows collecting data from all units of the accelerator on the server and transfer measurements to clients, that can proceed their own real-time analytics.

Main idea of this architecture is to process data on distributed way on client PC. In this case server only collects data, stores it in database and sends to clients. Also, server checks some low-speed interlocks and calculates some composite diagnostics, like proton fluence or power on the stripping target inside the accelerator.

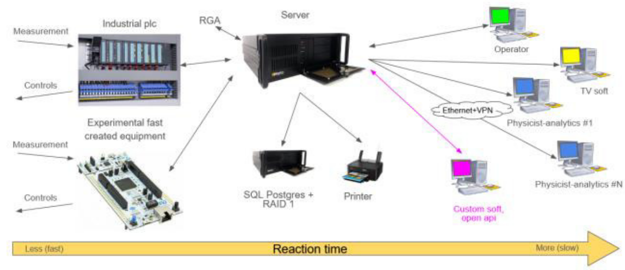

Figure 1: System architecture.

Physicist-Analytics Software

This is a software for physicist-analytics, that allows to proceed a real time analysis, like building a dependence of gamma radiation divided by beam current on the energy (Fig. 2), that was used in the experiment with reactions in lithium targets [3, 4]. Also, this system was used in different experiments [5, 6].

Basic functions are listed below:

1. Plotting the dependences of any measurement channel on another.
2. Time averaging of any channel with displaying "Box plot" on the graph (Fig. 2).
3. Averaging of any channel only by a given condition (example: average if the current is in the selected range).
4. Distribution of the logging status of the experiment with personal notes and an automatic printing at the end of the experiment.
5. Creation of an own channel on the basis of other channels data, for example *(a+b)*c* with all above functions.
6. The program can work from anywhere (via VPN), which can be useful in the case of the new wave of COVID-19.

If this functionality is not enough – programmer can create his own soft, that will process some complex operations and get data with system API.

TV Software

This software is designed to display data on three 50" TVs. During a collaboration experiment with other labs (sometimes international), all physicists who do not have access to the system can see the instantaneous value of the measurements and observe the graph of values.

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† email address: koshi8bit@mail.ru

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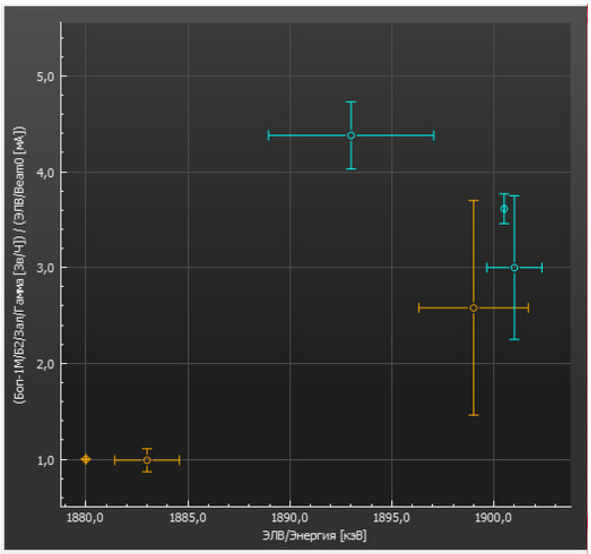

Figure 2: Gamma/Beam current VS Energy with standard deviation

This software allows not only the display of graphs and numerical values, but it is also capable of displaying various visualizations of the beam position, such as the passage of the beam through the chilled apertures (Fig. 3) or the position of the proton beam on the target by thermocouples with different visualization: simple temperature gradient (Fig. 4) and colormap (Fig. 5).

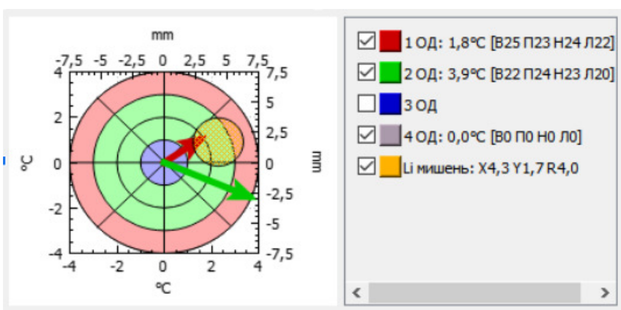

Figure 3: Beam passage through the chilled apertures

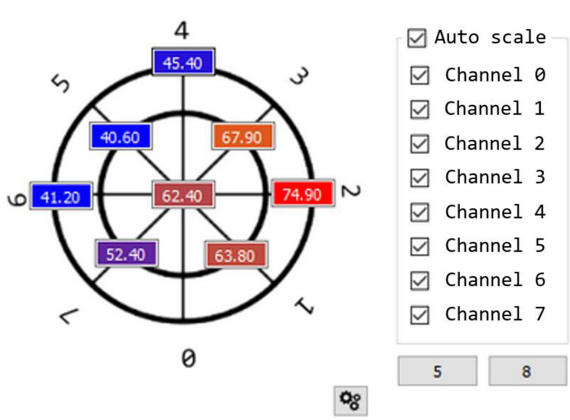

Figure 4: Beam position by temperature (simple gradient)

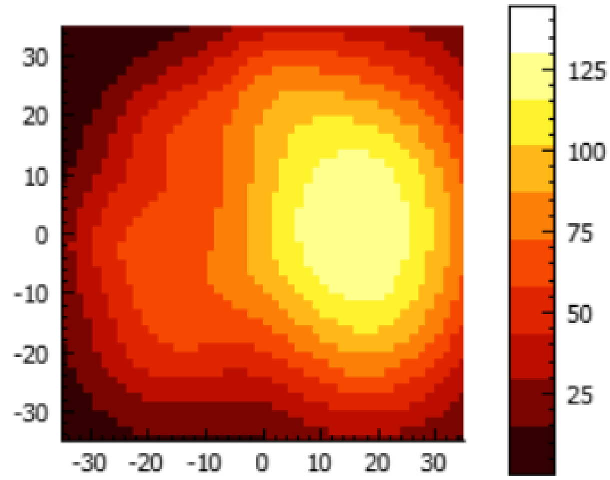

Figure 5: Beam position by temperature (colormap)

Also, in a separate window all participants of the experiment can study the last events recorded in the electronic journal.

Journal

The system includes the possibility of distributed logging from the physicist-analytics software. All logs are stored in the software database and can be printed as a paper anytime and add it in a folder for papers. In the process of filing in a paper journal it is possible to print your own photos or graphs plotted in Excel or other third-party software.

In this way user can easily find the complete information about the experiment in the same folder. This system is in operation since 10 February, 2020 and the thickness of the experimental journal is already 30mm.

CONCLUSION

The developed and tested control system is running on the accelerator and allows to perform some analytics in real time. This can save human efforts, because physicist do not need to extract csv or xlsx files from operator panel and to recall the time of the experiment, it is available during the experiment. Also, journal system allows to find all important data with personal notes very quickly.

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