The Sonix+ current state and perspective directions of its developments

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## History, concept and module composition

The Sonix + software package is the main software for control of instruments on the IBR-2 reactor. It was created in the early 1990s for a high-resolution neutron spectrometer (beam 6a IBR-2). Later, the complex was transferred to other devices, including those located outside the FLNP.
Since then, the complex has been installed on more than 20 devices, including 14 in FLNP and 7 in other centers.
The Sonix + was created simultaneously with the popular Tango and Epics systems. A similar problem generates a similar solution, so the fundamental ideas in these approaches are more or less the same:
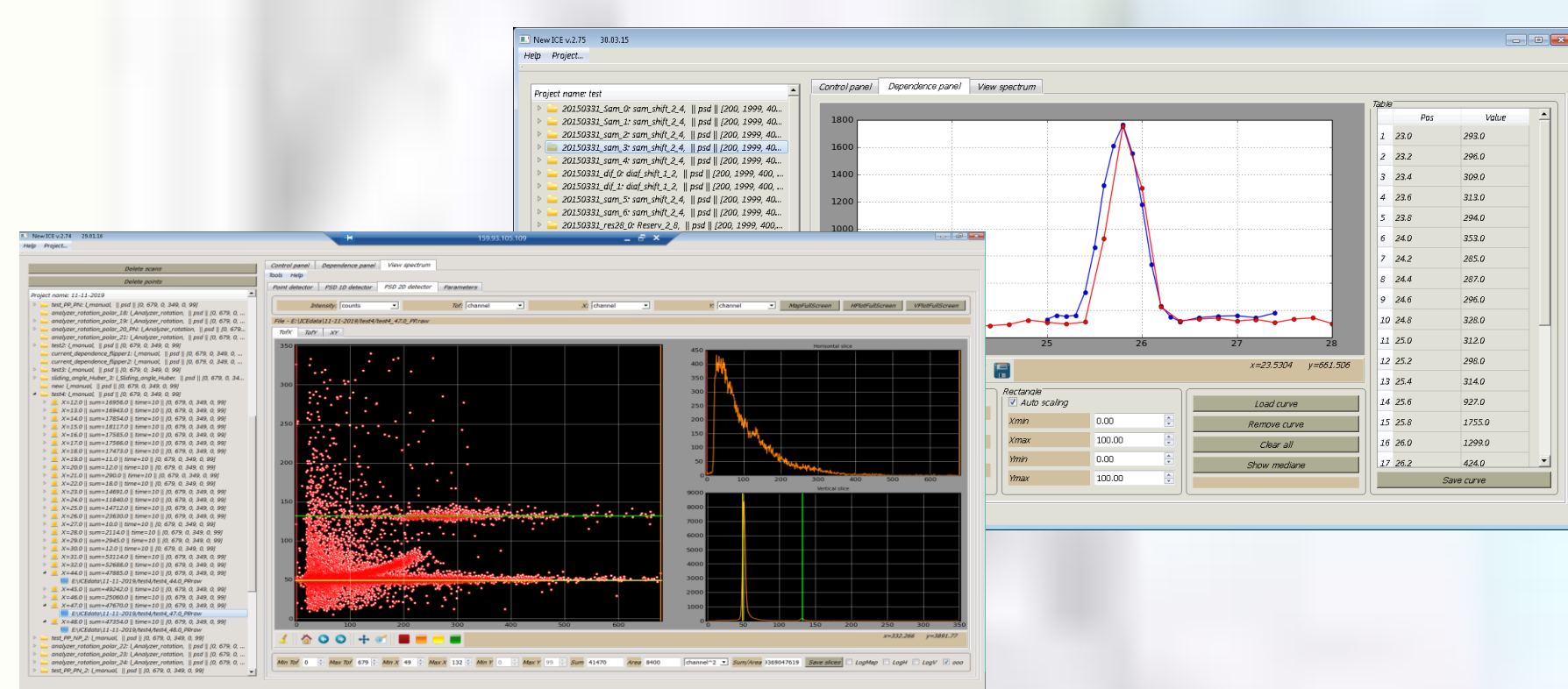There are some significant differences:
 - single control computer is enough to control the instrument. There are some additional tools for servicing rare exceptions.
- the universal approach to the graphical user interface has been proposed and successfully implemented.
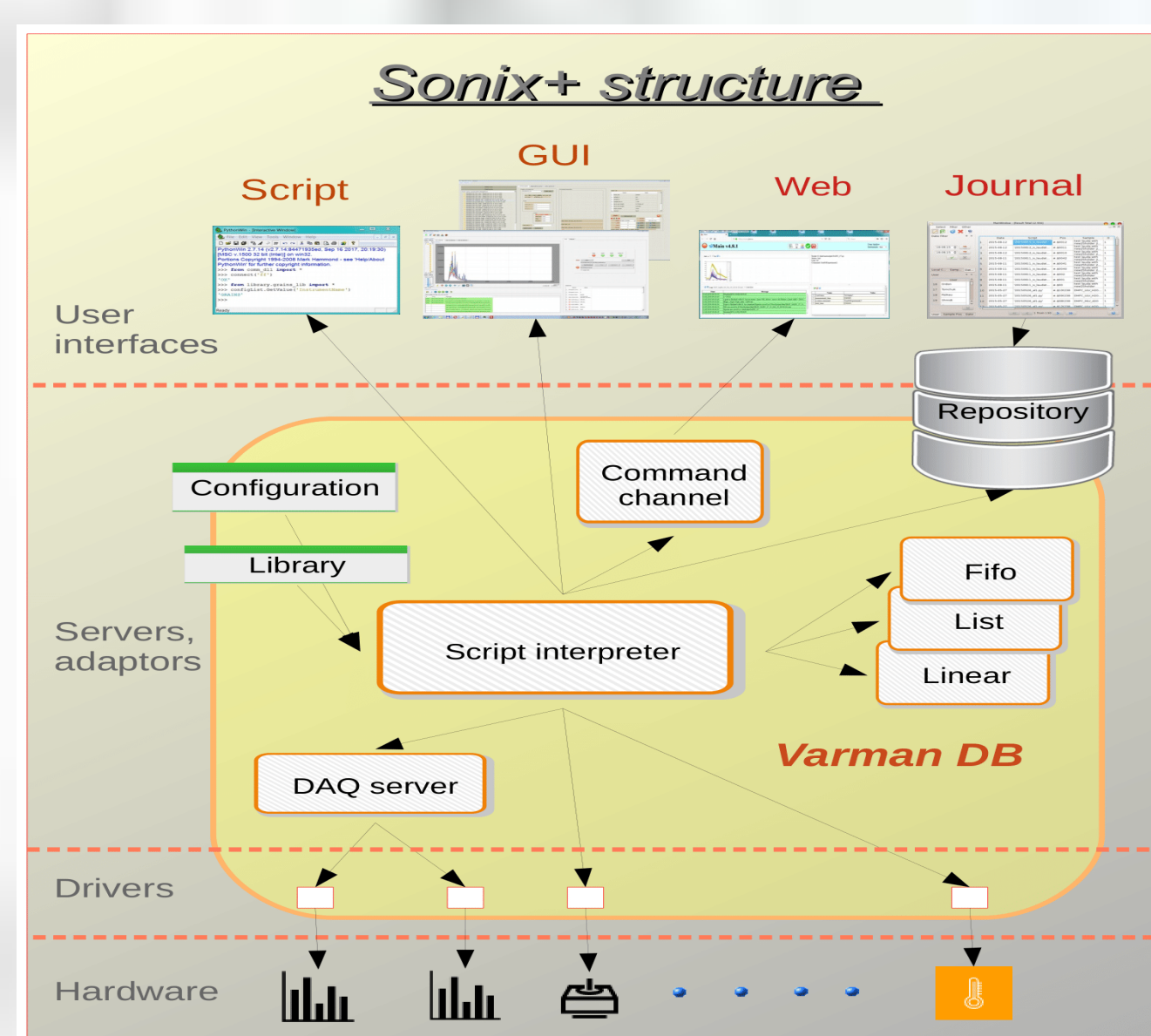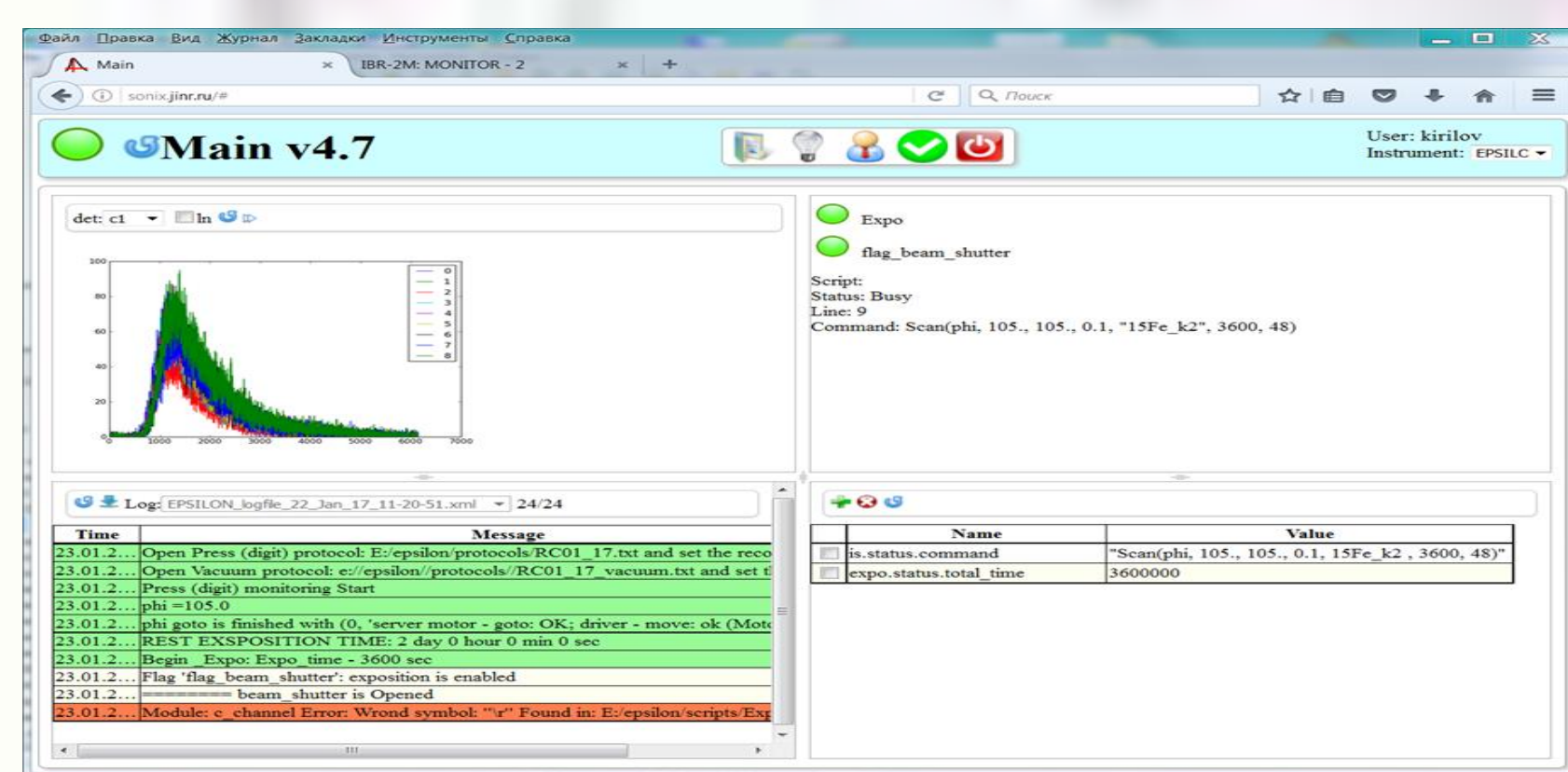

Overall Sonix+ structure
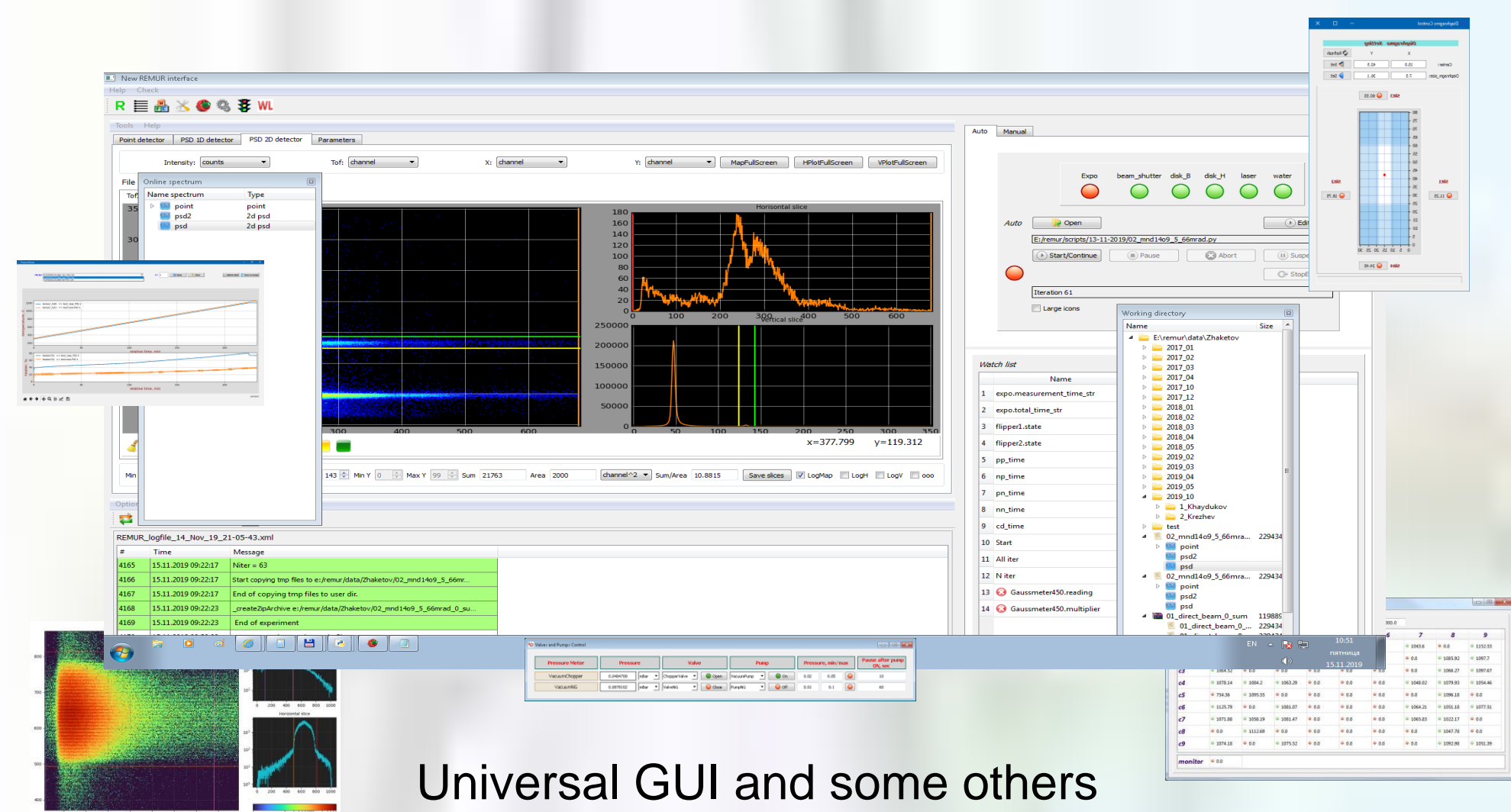
Universal GUI and some others

ICE – tuning program for reflectometers

WebSonix user interface

Recent changes to Sonix+

Code refactoring
Code refactoring is the process of restructuring a program without changing its external behavior, i.e. functionality for the user.

Goal - excluding time-consuming mathematical operations (such as matrices summing, building spectral distributions, etc.) from the main experiment script and perform them in background processes.
Result - simplifying instrument operations libraries, improve its reliability, less time for its development and modification.

Implementation - replacing the previous control mechanism in the device operations library with a new one based on Python decorators and context managers.
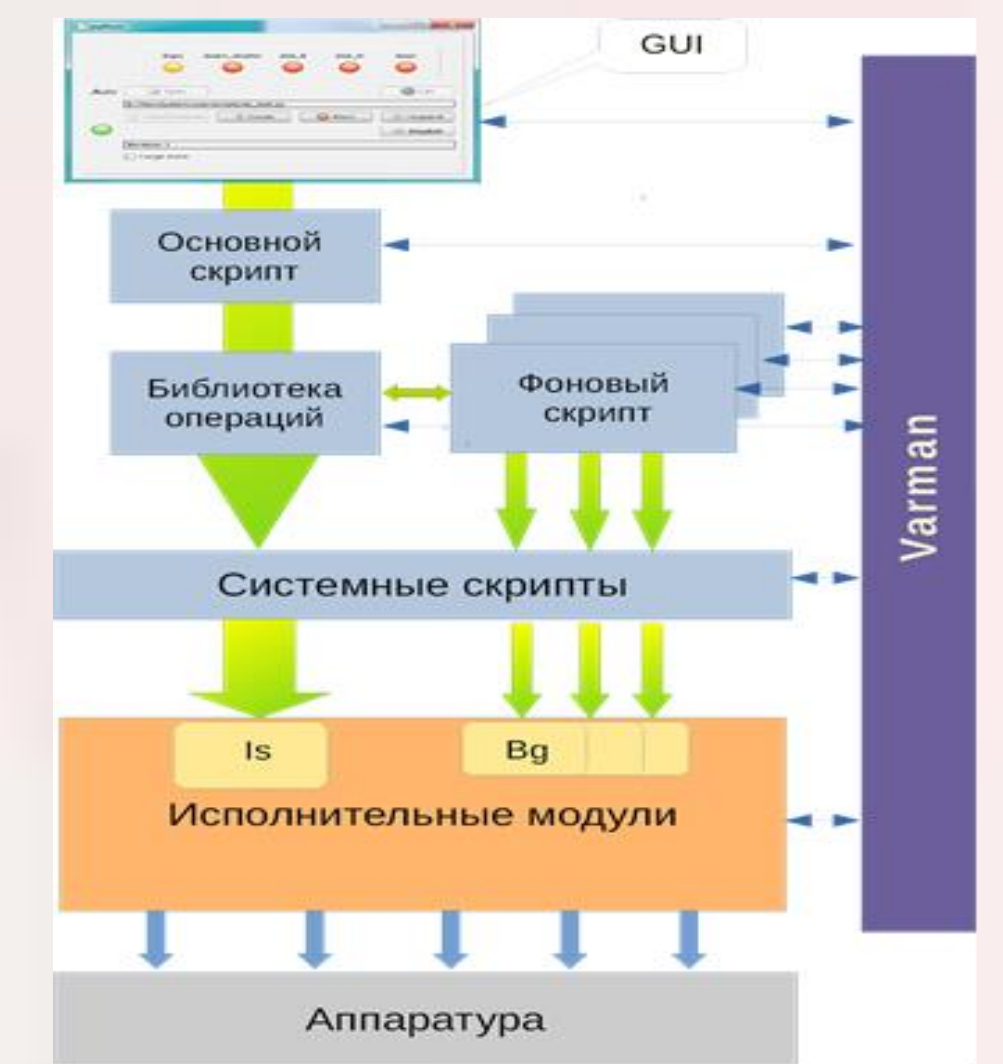
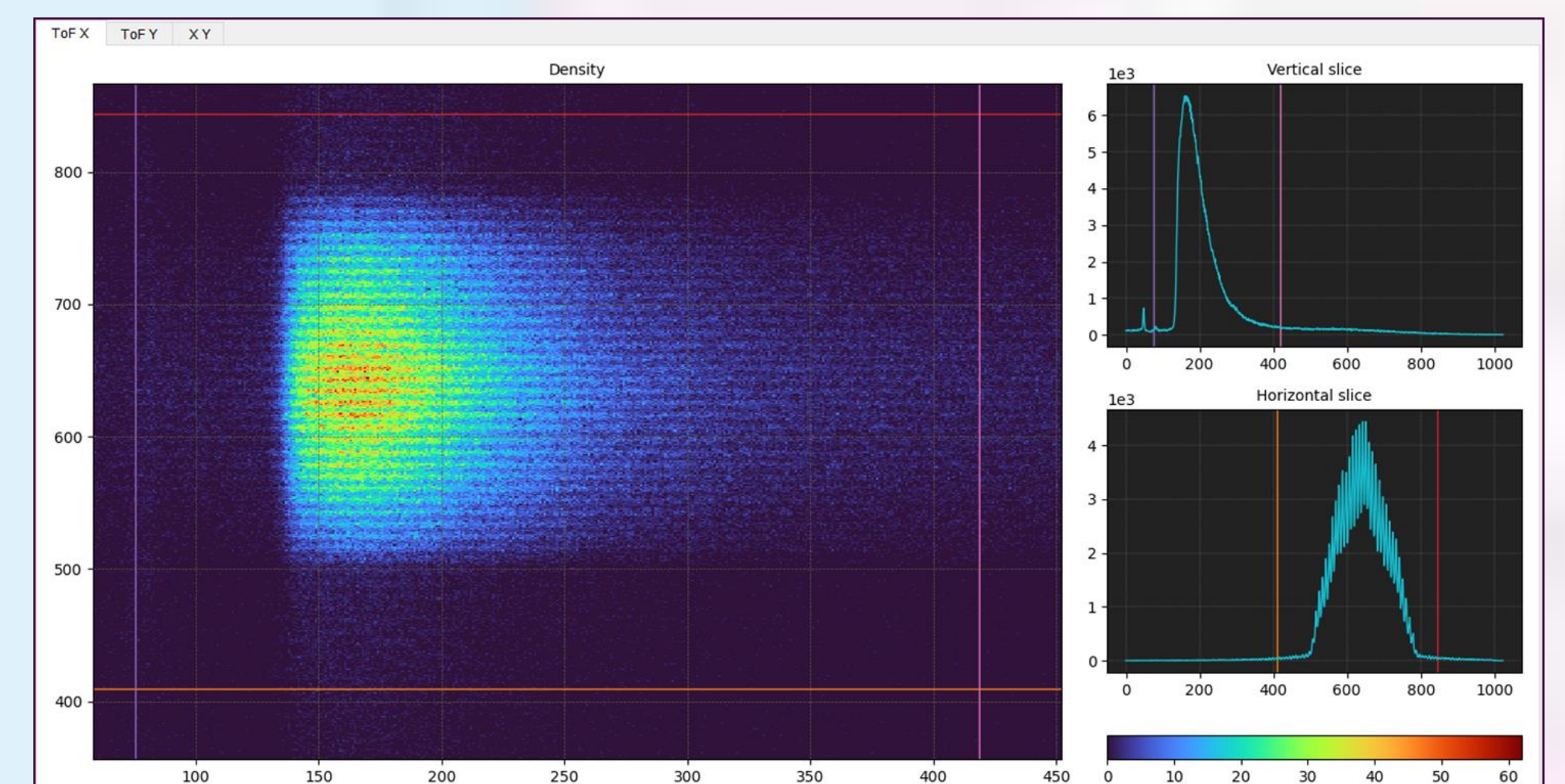Measurement cotrol diagram with additional background devics after refactoring.
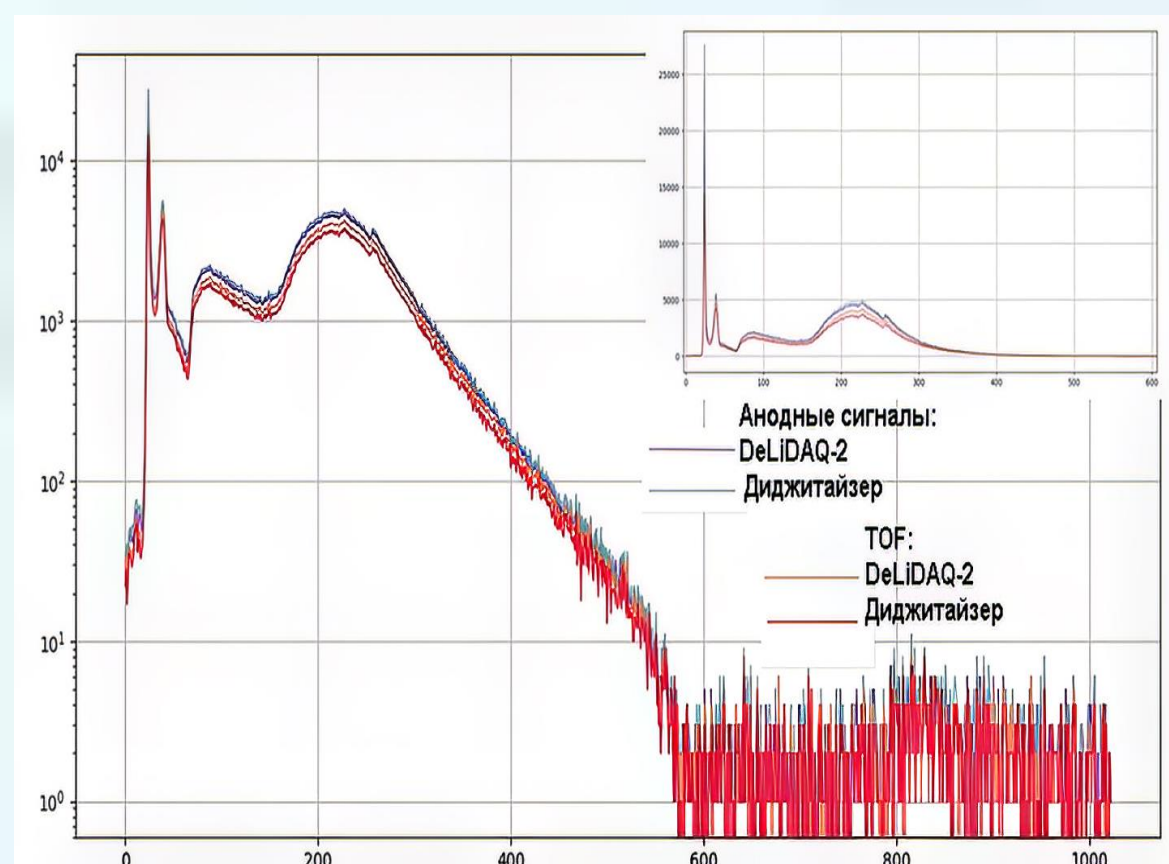
Graphs of anode signals and TOF in logarithmic and linear (top right) scales of Si/SiO2 sample for DeLiDAQ-2 and digitizer after histogramming by software.

Customize to work with event-mode data
The use of DAQ DeLiDAQ-2 controllers and CAEN digitizer N6730 with the absence of hardware histogramming on the IBR-2 instruments required adapting the complex to work with data in the form of a list of events (so-called "event-mode" or "list-mode" data) and transferring a number of DAQ servicing modules to 64-bit address space. To do this:
- DAQ modules have been adapted;
- data formats for event mode data and histograms have been changed;
- data converters and GUIs for manual conversion event-mode data to histogram have been prepared;
- SpectraViewer visualization program has been also adapted.

New SpectraViewer
The SpectraViewer is completely redesigned to optimize its code and improve its performance. It is also transferred to 64-bit address space to work with event-mode data.

Direct beam graphs at the Grains instrument (channel 10), plotted by SpectraViewer in 64-bit mode with resolution ToF = 1024, X = 1024, Y = 1024. The histogram size is ~ 4GB.

Websonix: Features and Real Requirements
The system is designed to remote supervising the experiment with a web browser. It consists of a website on one of the central FLNP servers and the corresponding software on the control computers.
To reduce a response time in the new version, the previous protocol for communication with sequential processing of requests has been replaced.
The new protocol is implemented using the PyChannel Messaging Service.

Central data repository
The Repository is designed for backup storage of measurement data(24 disks combined into a RAID6 array, total volume - 55 TB. At the moment 6 devices are connected to the repository and about 23 TB are filled.
 Operation of the Repository has shown the need to:
  - simplify user's registration;
  - exclude the possibility of overwriting data at the Repository;
  - ensure that data is stored correctly regardless of control computer and network transmission errors;
  - providing ability to autorun user's processing programs for the stored data.
To do this, the additional software layer based on PyChannel service has been included between control computers and Repository.
Besides, a new repository GUI, similar to the Journal GUI, has been developed.
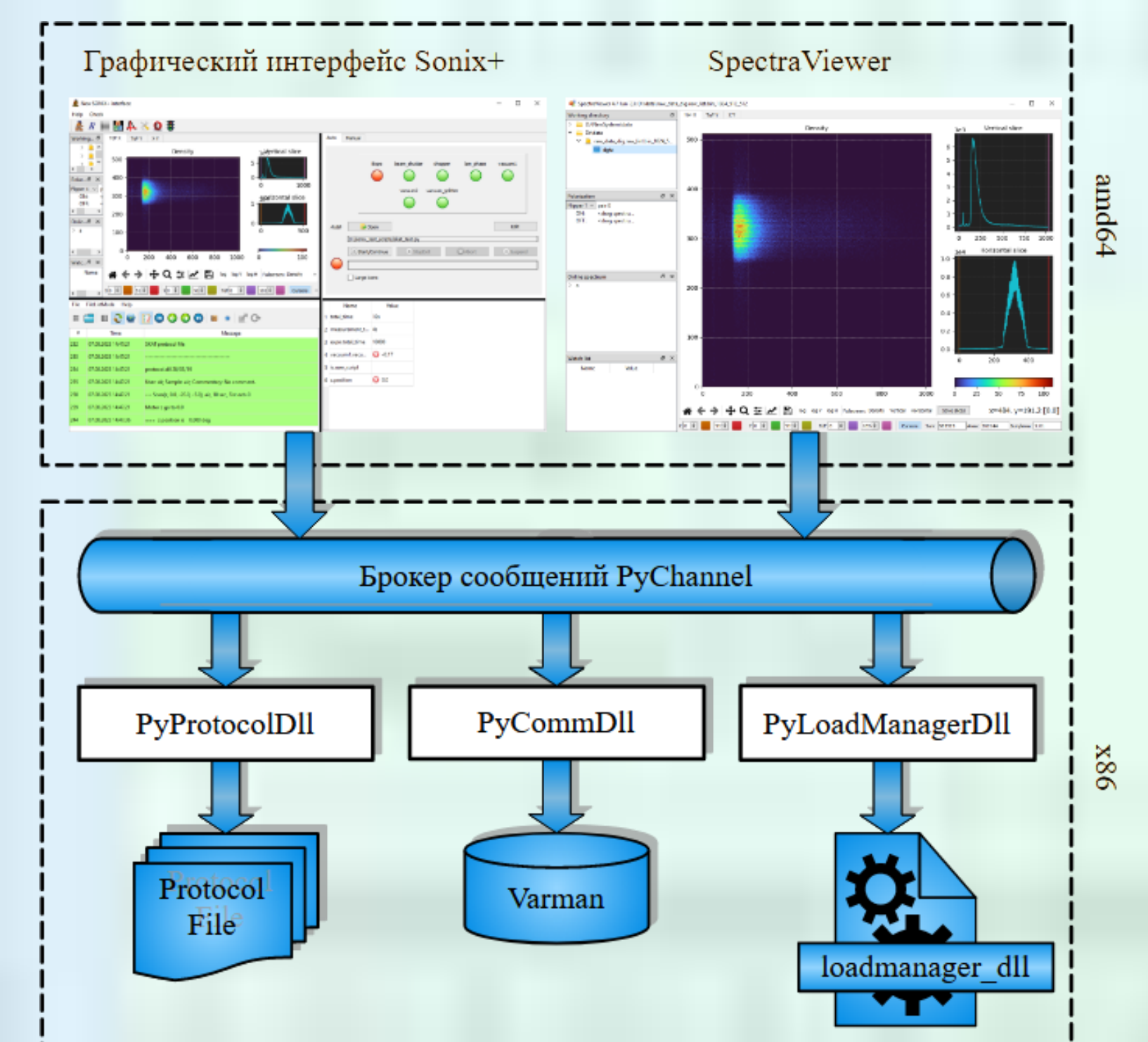
Connection diagram for 64-bit GUI to 32-bit Sonix+ control modules via PyChannel.

PyChannel Messaging Service
The PyChannel messaging service is designed to communicate between the control computer and external server. It has been adapted for communication of 32-bit Sonix+ kernel modules with a 64-bit GUI.

Conclusion
The refactored version of the complex was successfully tested in October 2021 on the NERA device, similar versions were prepared for all other IBR-2 devices. It has been prepared for all instruments.
The initial version of event-mode data processing was implemented and tested with the data of real measurements. This solution meets current needs, but will be improved, if users will formulate new requirements.
The Repositiry software refinement and its integration with the Journal system will also be continued.

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