Data Acquisition and Control Software for Scanning EXAFS Beamline AT Indus-2

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Abstract:

A new X-ray absorption fine structure (EXAFS) data acquisition and data analysis program is developed using LabVIEW. It runs under window operating system and offers several unique features. It has a user friendly graphical user environment and is capable of saving data in variety of formats. The availability of online data presentation is particularly useful for data examination during the EXAFS experiments as well as analysing quality of the sample. Transmission and Fluorescence mode are implemented to characterize variety of samples.

Keywords:

LabVIEW, EXAFS, Beamline, DAQ,

Fig1: Schematic of EXAFS beamline at Indus-2 BL-09

I. Introduction

As the user community is growing rapidly, it is difficult to get beamtime on Indus-2 facility (operational at 2.5Gev @150mA). Every researcher seeks to use his time as efficient as possible. Software is aimed to satisfy the requirement of the user community. An accurate data collection method is provided for all basic EXAFS experiments to help user to decide whether more refinement in data is required or not. A data acquisition program is developed using LabVIEW[1] software of National Instruments which works on all Microsoft windows. Scanning EXAFS beamline[2] at BL-09 port of Indus-2 is planned for thin film, some dilute and some concentrated samples using fluorescence and transmission mode. Graphical routines and numerical procedures that comprise the basic modules of the software are described below.

II. Objective

The main objective of this software development is to integrate different instruments and software working for controlling the set of instruments from a single Personal Computer (PC) located at beamline control room. The basic components of the beamline are as shown in the figure 1. The Double crystal Monochromator which is controlled by its own software developed in EPICS (Linux).The three ionization chambers (IC) are controlled and its data is fetched using serial communication RS-232. The vortex silicon drift detector is having its own software for data presentation and control. It can be handled by using its dynamic link library (DLL) by other software.
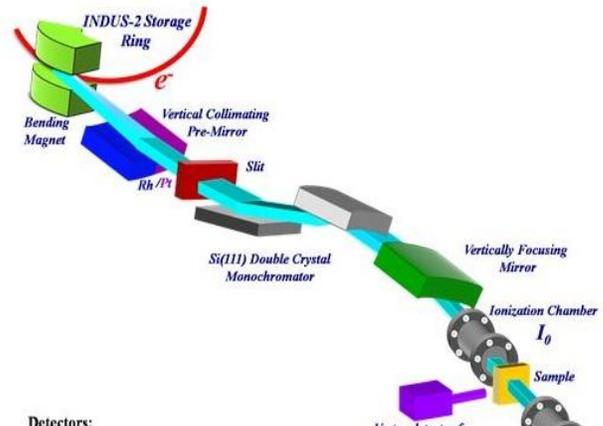
To control and acquire data from these devices graphical user interface software is written using LabVIEW (version 8.6). It gives an attractive and user friendly interface to control. Different tools of LabVIEW are used to control these devices and an appropriate code is developed for performing transmission and fluorescence based experiment.

III. Development of graphical user interface:

The control of double crystal Monochromator (DCM) is controlled and monitored by a program developed in EPICS software through LabVIEW. It is done by using an open source code developed by BESSY SRS Facility called "CA Lab". CA Lab[3] is used to access different EPICS variables and status of the monochromator. The interface needs LabVIEW and any EPICS IOC shell over network. CA Lab architecture is as shown in the figure 2. An additional Ethernet card is installed and configured for the same network. For the customized hardware such as three ionization chambers[4] and vortex silicon drift detector[5], VISA and call library function of LabVIEW are used. VISA is capable of controlling VXI, GPIB, or Serial instruments and makes the appropriate driver calls depending on the type of instrument being used. The Call Library Function Node supports a large number of data types and calling conventions. We have used this node to call

functions in most standard and custom-made DLLs. Schematic diagram of the interfacing is as shown in figure 3.
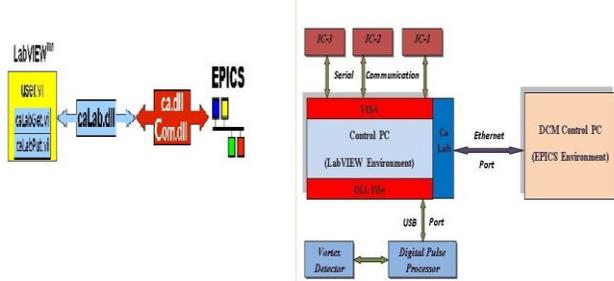

Fig.2: CA lab architecture   Fig3: Schematic of the Interfacing

IV. Software

Sample analysis software for EXAFS beamline has tabular structure. It has five tabs: First tab (Initialization) does the initialization of the three ionization chambers and establishes a connection for DCM. If the initialization of any of the ionization chambers electronics fails or if the connection is not established, the software stops giving user the appropriate message. If the initialization is proper, it moves to another tab called as Configuration tab. Here it allows the user to set the ionization chamber parameters such as bias voltage, sets measurement range and so on and asks the user for the appropriate experiments he would like to perform. User can select either Transmission mode or Fluorescence mode for the sample analysis. If transmission mode is selected the transmission window appears as shown in the figure 4 or else it waits for the user feedback.

V.Transmission Mode

In the transmission mode[6] window user can select energy span for the DCM with its step size movement, an appropriate array is generated. If the signal to noise ratio varies drastically, the data should be weighted so the noisy ones have less weight. This can be accomplished either by performing the repeated scan or averaging the data over a period. One of the data refinement method is selected either by entering the appropriate value in number of scans or scan speed in the desired window. Measurement of the intensity is done with three gas ionization chambers. The experimental arrangement is such that the incident beam (I_0) is only partially sampled by the first ion chamber, while the transmitted beam (I_1) is blocked and absorbed completely.

IJE *Fig4: Transmission mode of sample analysis*

The reference sample is kept after I_2 detector such that beam path looks as shown below. The reference spectrum is measured simultaneously with sample.
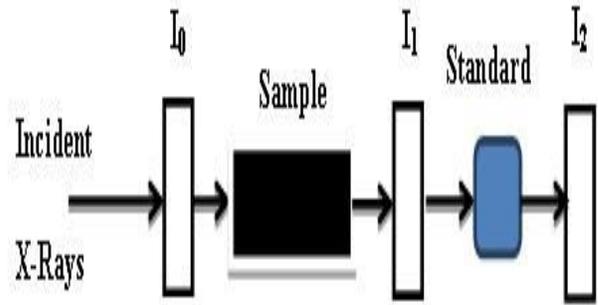

Fig3: Block Schematic of the Interfacing

Absorption spectra are obtained by dividing I_0 by I_1 and taking a logarithm according to equation 1

$$I_0/I_1 = exp(-\mu x).\text{------}   (1)$$

Once started the software checks if the DCM is at the specified starting energy and moves the DCM to the corresponding energy in the desired steps. The software samples the ready status from the DCM (which indicates the DCM is positioned at a particular energy) and the current from all the ionization chambers is readout at each step. If more than one scan is selected, the software averages the data over the specified period and displays the average result. The online data presentation of Ion current and the attenuation constant provides an instant feedback to the user reflecting the quality of the sample under probe. The data is stored in either Excel or DAT file format after completing the experiment. All the important parameters such as DCM energy, synchrotron beam current, current of all the ionization chambers and attenuation coefficient (μ) are stored for further processing.

VI. Fluorescence Mode

In fluorescence mode[7] one measures the incident flux I_0 and the fluorescence X-rays I_f that are emitted following the x-ray absorption event. The fluorescence detector is placed at 90° to the incident beam in the horizontal plane, with the sample at an angle (usually 45°) with respect to the beam. Selecting this mode, the vortex silicon drift detector is initialised. The detector parameters such as pre-set time, peaking time, spectrum size and other detector parameters can be set. Software acquires the spectra (as shown in figure 5) for the selected pre-set time and prompts user to select the region of interest of his choice. Software allows selecting maximum 30 regions of interest (ROI) and stores in its buffer and proceeds for fluorescence measurement. The fluorescence measurement screen appears as shown in figure 6.   At every energy scan it acquires the spectra and measures the total counts in the selected ROI and the ionization current.
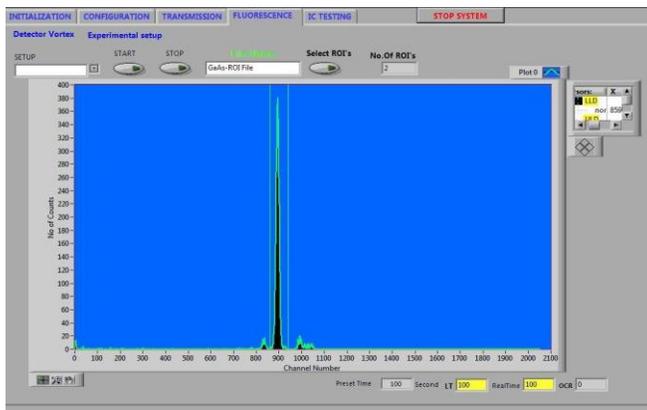
Fig5: Spectra acquired by Vortex detector

In fluorescence no logarithm is taken: the detector signal (selected ROI) is simply divided by I_0. This mathematical calculation is done by using mathematical tools of LabVIEW. Measured data is normalized and average for the specified period defined by the user. The data is stored either in Excel or DAT file format after completing the experiment.
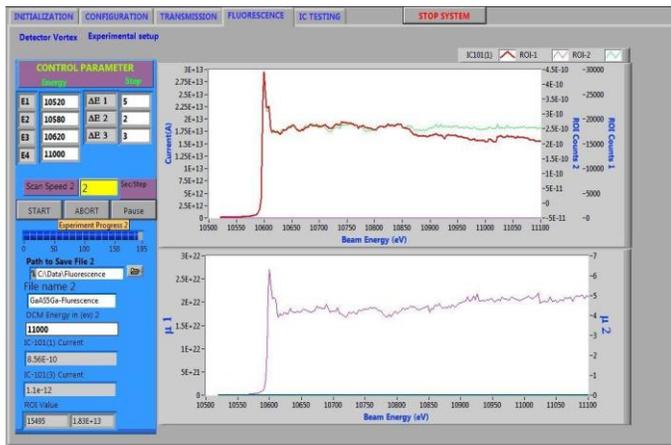

Fig 6: Fluorescence mode of sample analysis

It is often required to monitor the ionization chamber current for aligning the beamline components prior to starting an actual EXAFS measurement. To facilitate the same, a separate tab has been provided in which the user inputs the DCM energy and the currents from the three ionization chambers are acquired continuously and plotted in the form of running graph with time. Beamline components such as slits are then aligned to monitor the effect on the ionization chamber current unless the optimum results at the given DCM energy are obtained.

VII. Conclusion

The most important feature of this software is its graphical user interface where all functions and procedures can be selected using mouse or keyboard. The software is user friendly and the online data plotting gives the judgment of the experiment in the correct direction. The existing GUI can be extended to incorporate different detectors as and when required within minimum modification in the existing code. Additional data saving option can be easily incorporated in the software.

References

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