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Design of 3B3 beamline control system

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Abstract Both structure and design of the control system in BSRF-3B3 beamline, are discussed and the subsystems are described. The LabVIEW software has advantages on data collecting and real time inspecting. In the process of data collecting, some methods are taken to solve the problems that may be met.

Key words Beamline control system, Electronic interpolation, LabVIEW, Real time inspecting, Flexure hinge

CLC numbers TP13, TP31

1 Introduction

BSRF-3B3 Beamline is a middle-energy (1.5~6 keV), monochromatic, focusable X-ray beamline constructed in the Beijing Synchrotron Radiation Facility (BSRF) of the Beijing Electron Positron Collider (BEPC) in order to develop the work of demarcation of detectors for laser diagnosis and middle-energy X ray spectroscopy. Fig.1 is the optical layout of the 3B3 Beamline.

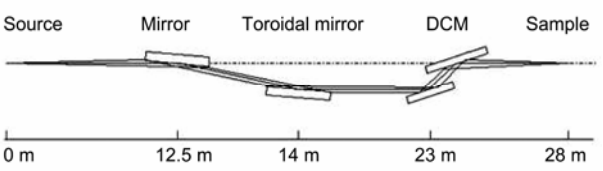

Fig.1 Optical layout of 3B3 Beamline.

2 Design of control system

The 3B3 Beamline control system (see Fig.2) consists of pre-mirror control, slit control, DCM (double-crystal monochromator) control, bending-mirror control, and BPM control. The main function of the control system is to adjust the position and direction of the beamline. Programs of the beamline control system work on the Windows 2000 operating system.

The DCM control system has close communication with experimental users. The pre-mirror and slit should be adjusted to get the beamline arrival at the monochromator in prophase of beamline adjustment.

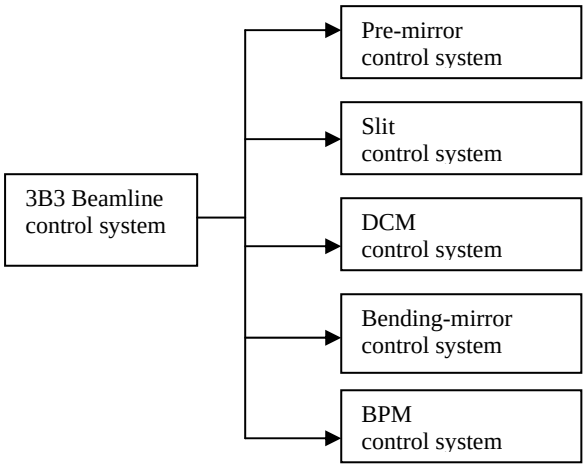

Fig.2 Control system of 3B3 Beamline.

Then the monochromator should be adjusted to get the monochromatic beam. Experimental users need beams with different wavelengths in their research. When the pre-mirror and slit have been adjusted to the corresponding position, the control system will realize

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the movement and adjustment of the crystal to meet the requirement of the experiment. As each mechanic equipment in the beamline has its own function, different softwares are developed to control them.

Original Equipment Manufacturer (OEM) is taken as the control platform of several subsystems of the beamline control system, for OEM has enlargeable slots and can meet the requirement of communication with multi-serial ports. The control object of the pre-mirror is simpler than other control systems because it needs less time to operate [1]; the pre-mirror can also be adjusted manually.

2.1 Design of slit control system

The adjustable gap in the slit is driven by step motors, which are controlled by OEM. The electronic interpolation of step motor and anti-jamming make the gap adjustment stable and reliable. The slit control system (see Fig.3) consists of AT89C55 SCM, NVSRAM with function of non-electricity protection, generator of electronic interpolation, output drive circuit, keyboard scanning circuit, LED display, and communication channel [2]. The system uses SCM to realize the control function of electronic interpolation.

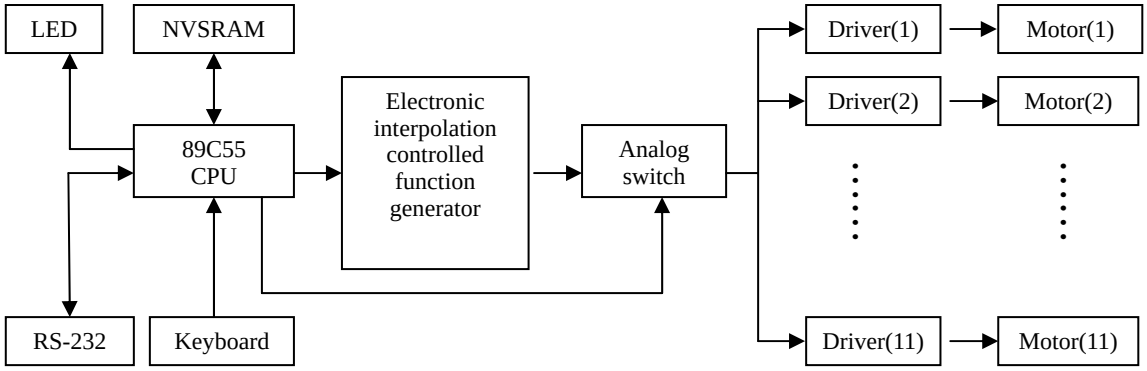

Fig.3 Slit control system.

2.2 Design of DCM control system

When an X-ray beam is incident on the crystal surface and the wavelength of the X-ray beam fits the Bragg condition, it will be reflected by the crystal. The reflected X-ray beam has different wavelengths λ through changing the incident angle θ:

$$\lambda = 2d\sin\theta$$

where d is space between the crystal layers.

The X-ray beam reflected by the first crystal will be reflected again by the second crystal, then the emergence beam will be parallel to the incident beam.

The structure of the DCM control system is shown as Fig.4.

After OEM sends instructions to SC800 step motor controller, the controller can operate the step motor under the instructions to move the crystal. The actual movement of the crystal can be inspected by the detector.

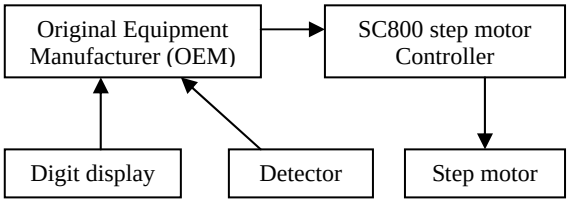

Fig.4 Control system of the DCM.

The control program of DCM is written by LabVIEW [3]. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a software product of National Instruments (NI). It is an integrative environment of graphic software, which has the speediest development, most powerful functions, and the broadest application. A control system with strong function of data collection is easy to work out by LabVIEW. The applications of DCM control system include two parts: one is debugging, and the other is user's operation. The initialization of DCM control program and prophase adjustment is to move the energy point and scan the energy. Users can, in fact, operate several actions of energy point movement.

The LabVIEW software includes three kinds of graphic controls: Waveform Chart, Waveform Graph, and XY Waveform. Waveform Chart can display experimental data dynamically but the displayed graph is just a part of the graph at run-time while Waveform Graph can display full graph when an operation has been done. In the process of energy scan, Waveform Chart is used.

LabVIEW has powerful functions to save and load data. Data can be saved into txt files or excel files expediently. In the process of DCM energy scanning that involves long duration of operation and a great deal of data, time will be wasted if the operation is interrupted in the process of saving data after one full scan. To avoid the loss of data, data are saved in the process of data scan. So the useful data can be saved in time and the work efficiency can be improved.

3 Test result and some discussions

Through the adjustment of pre-mirror, slit, and DCM, luminous flux of the beamline experiment hutch always stays above 10^9 phs·s^{-1}·(100 mA)$^{-1}$, which meets the requirement of users when the energy of incident beam changes from 2.0 keV to 6.0 keV[4]. Fig.5 shows the luminous flux distribution at the Endstation.

The bandwidth of the facula is 1.00 mm in the horizontal direction as shown in Fig.6 and 0.5 mm in the vertical direction as shown in Fig.7 and it meets the design requirements.

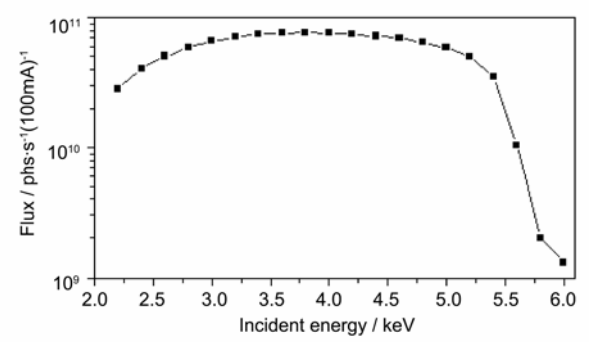

Fig.5 Luminous flux at Endstation.

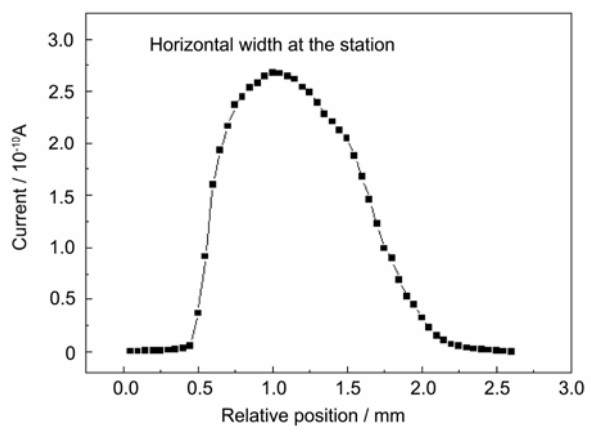

Fig.6 Current in horizontal direction.

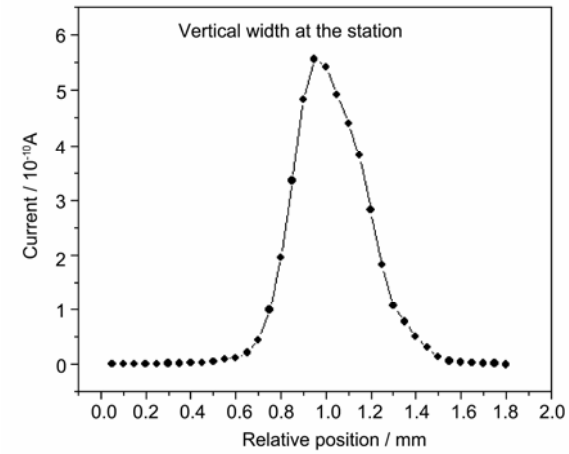

Fig.7 Current in vertical direction.

In LabVIEW program, loop structure is adopted. The time precision in the scan of several points is few ms. As in Fig.8, in the test of absorption spectrum of NaCl-XANES, the step of scan is 0.2 eV and the differentiation is 940.

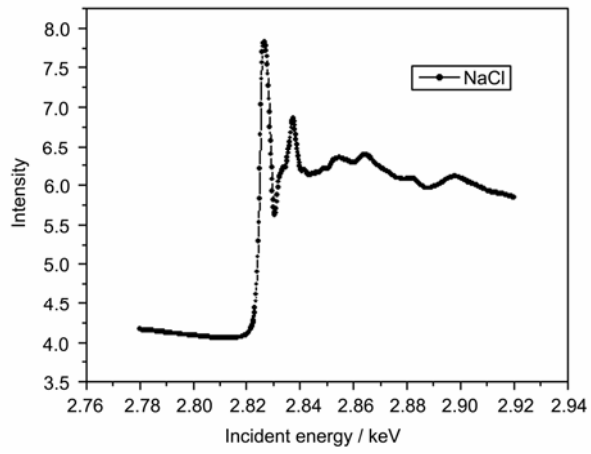

Fig.8 Absorption spectrum of NaCl-XANES.

$$\mathrm{Cl}-K:2822.4\,\mathrm{eV}$$

$$\frac{E}{\Delta E}=\frac{2822.4}{3}=940$$

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