Transverse Profile Measurement System at SRRC

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Abstract

Transverse profile measurement system have been implemented at SRRC. The measurement system include optics, image acquisition, image analysis, compressed image transportation and visualization tools at workstations. The optics has been optimized to reduce measure error due to diffraction as well as depth of field effects. Narrow band filter and neutral density filter are used to reduce chromatic aberration and extend dynamic range of the CCD camera. The beam profile that are took by high resolution CCD camera are captured by frame grabber and process by personnel computer. The diagnostics station play as a profile information server. Processed information as well as image can be send via computer network to any clients which are implemented at workstations for various applications.

Figure 1. Hardware configuration

1. INTRODUCTION

Synchrotron radiation diagnostic station has been setup to characterize properties of electron beam. The photons emitted by electron bunches are collected by unit conjugate optics, high resolution CCD camera at image plane are used to observe beam image. One PC/486 incorporated with frame grabber digitize image and extract beam parameters. The PC/486 system was configured as beam profile server, any clients can access beam profile parameters through network of control system. In order to provide a friendly user interface, prototype graphical user interface based on IDL package running under X-window environment was also developed. Beam profile server can provide beam profile related information such as beam size, beam center, ...etc. Since image data transfer need to sacrifice large amount of network resource, the issue about network traffic is also discussed.

2. HARDWARE STRUCTURE

The hardware structure of the beam profile measurement system are shown as Figure 1 [1,2]. The synchrotron radiation light come from 3o bending magnet port are deflected by a copper mirror, most energetic part of synchrotron radiation are absorbed by the mirror. The visible light pass through the quartz vacuum window and collect by a singlet. The optics is a single lens system with unit conjugate ratio optics to reduce spherical aberration. Slit are used to define horizontal aperture to compromise the effect of depth of field and diffraction due to finite aperture. One neutral density filter wheel with changeable step density are used to extend the dynamic range of CCD camera. An interference filter with 10 nanometers in bandwidth and 500 nanometers center wavelength are used to reduce chromatic abberation effect of the optical components. Beam image is observed by PULNiX TM-7 high resolution
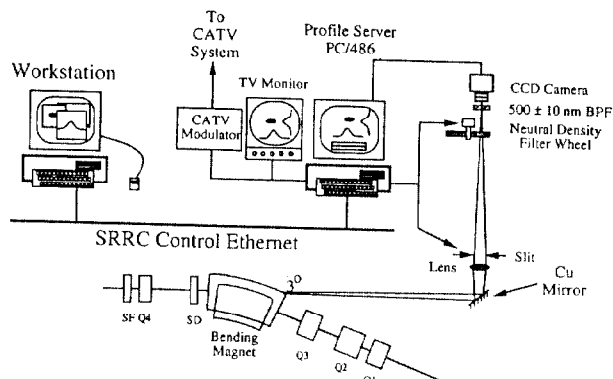
CCD camera with 8.4 x 9.8 μm pixel size.

The beam profile server is PC/486 based system which in charge of network communication and data processing. Frame grabber and network interface card are the major components of the beam profile server. The frame grabber memory subsystem consists of a dual port frame memory, and a frame memory controller, a phase locked loop circuit is used to synchronize the digitization clock with incoming video signals, the pixel clock is also generated for digitized and displaying image. Any of the four 256*8 bits output look up tables (LUT) can be selected for pixel transformation prior to display on a video monitor.

3. SOFTWARE STRUCTURE

The user interface is a standard graphical user interface which are developed based X-window/MOTIF running on the VAXstation. The software at beam profile server are running under the MS-DOS environment. Communication between the workstation and the profile server is based on a client/server model by using TCP/IP protocol. The major roles of beam profile server are image acquisition and analysis. High level user interface software are also developed at workstation.

The software in the beam profile server include frame grabber parameters setting, network service, define region of interest, extract beam profile, calculate beam center, variance, correlation factor and beam size. Emittance is calculated by using measured beam size. Beam profile server also established database of long-term information for users. Beam profile information display on TV monitor at diagnostic station and control room. One channel of the machine status broadcasting CATV systems are used to distribute beam profile information around SRRC.

The program at profile server can be calculated beam tilt, filtering as well as enhance beam image. The light intensity are regulated by neutral density filter based on the reading of CCD camera to avoid saturation of the image detector. IDL was chosen to develop users interface at workstation. All of the jobs are done via point-and-click operation.

4. NETWORK TRAFFIC ISSUE

The control network of SRRC is based on ethernet [3,4]. Process computer send data upload request 10 times per second to VMEcarte based intelligent local controllers, then the local controller broadcast control information via network. All of the console workstation update their data after received broadcast message simultaneously. The transaction is less than 20 percent (about 150 kb/sec) of the full network bandwidth. In principle, network operation of the control system are operated in a synchronous manner, hence, the deterministic performance was achieved despite of undeterministic nature of the ethernet which are using CSMA/CD protocol. Transfer uncompressed image data via network will increase about 10 percent traffic during transfer period. The network traffic are monitoring by Sniffer™ network analyzer. Since request of the profile information are occur rarely during to its on demand basis, hence there are not any degradation happen of the control network.

Reduce network traffic is a favor in anyway, two methods were used to reduce data flow. Most of the CCD area are not exposured by synchrotron radiation, only small interesting area of the CCD chip are send through control network. The image data also compressed by the MPEG standard. Network traffic decrease from 10 percent to 3 percent network bandwidth for compressed image transportation.

5. PROFILE ANALYSIS

To reduce analysis processing time, the image acquisition software define the interesting area according to beam position and beam brightness automatically. Analysis program estimate geometrical center of the beam image firstly, then extract small horizontal and vertical area for analysis base on this center. Beam profile parameters are estimated by fitting. Beam tilt angle is also calculated. The integrated beam profile in x and y axis are fitted by combination a Gaussian and a baseline as following equation

$$f(x) = A\, e^{-(x-x_{fit})^2/2\,\sigma_{fit}^2} + B\,x + C$$

where x is spatial coordinate of horizontal or vertical axis, x_{fit} is the fitting parameters of the beam center, σ_{fit} is the fitted beam size. A is the amplitude of the Gaussian. The
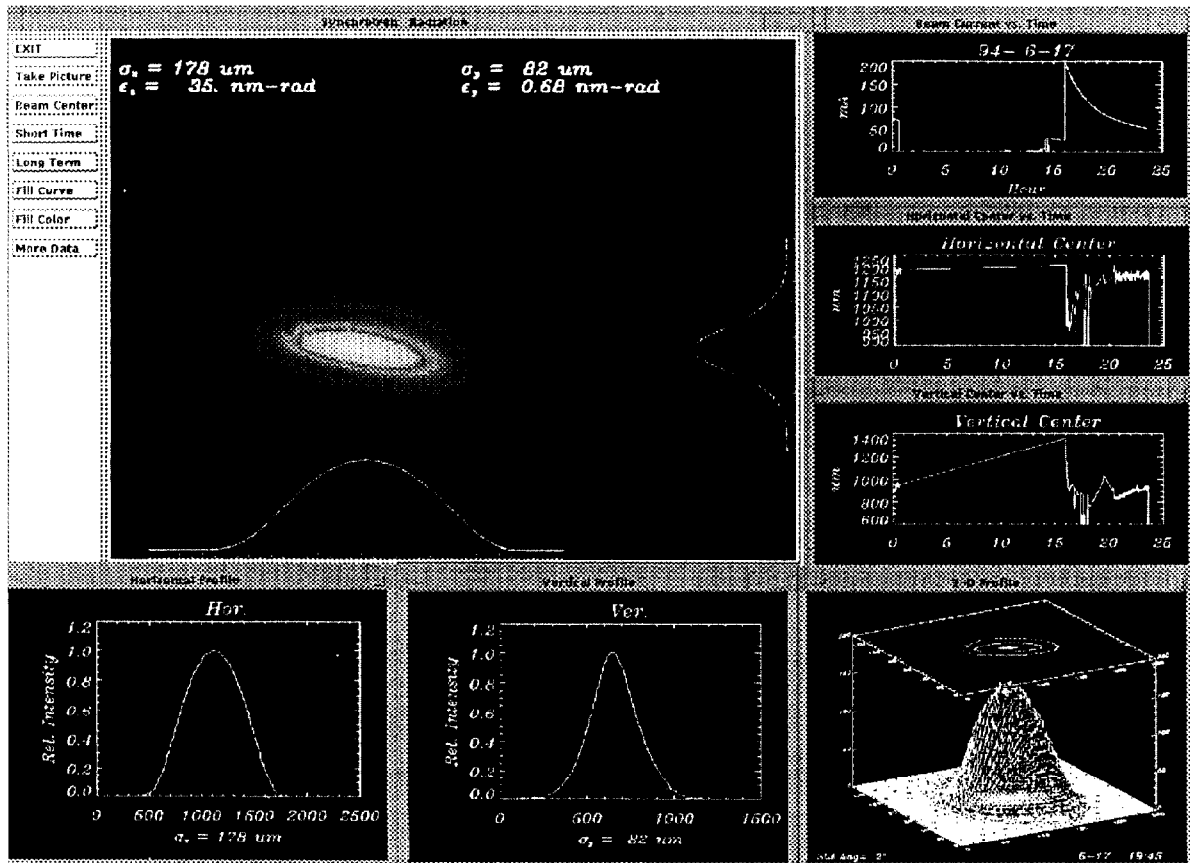

Figure 2. Typical user interface display

background are subtracted by baseline (Bx + C). The real beam size sbeam are obtained by simple deconvolution

$$\sigma_{beam} = (\sigma_{fit}^2 - \sigma_d^2 - \sigma_{diff}^2)^{1/2}$$

where σ_{diff} is the diffraction contribution to the measured beam profile width due to aperture define slit. σ_d is beam width broadening due to the depth of field effect. Fitting is by using Marquardt method, the main convergence condition is determined by quantity of χ^2.

6. USER INTERFACE

The GUI of client are developed based upon IDL under X11/Motif environments. IDL provide a complete computing environments for the interactive analysis and visualization of the beam profile information. The GUI software create control buttons and display windows. Beam profile features such as beam size, beam center, beam image, ...etc can be accessed through network interface. Various GUI buttons allowed user to request different services of the beam profile server.

Typical display page on the workstation are shown as Figure 2. The control button allowed user to get profile image, analysis profile, ...etc. Users can select suitable look up table for pseudo color display to provide clearly and comfortable image. Beam image, horizontal and vertical profile, 3 dimensional plot and analysis results are displayed on the screen simultaneous. The beam current and beam center change with time are also shown on the screen. The beam center versus time history is helpful for user to analyze the short-term variation of beam position.

7. CONCLUSIONS

Synchrotron radiation diagnostic system was setup. The system include optics, associate electronics as well as computer hardware and software. The system has been aided beam properties characterization. There are slightly beam intensity dependent deformation occur at copper mirror, improvement is under way. The shortage of the analysis software are still in improve. Various methods are used to reduce network loading, it seem network traffic not a severe problem at present stage.

8. ACKNOWLEDGEMENTS

9. REFERENCE

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