# Evaluation of a prototype Imaging Plate reader which utilizes line-shaped laser beam and CCD.

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## 1. Introduction

The Bio-Crystallography (MIR-OAS) beamline is constructed at BL41XU for routine structure analyses on macromolecular crystallography [1]. For the routine analysis by the MIR-OAS phasing [2], an automatic diffractometer is indispensable including a two-dimensional X-ray detector which should be on-line controlled and be read out at high frequency. In this beamline, the large-format imaging plate of 400 x 500 mm dimensions (IP, Fuji Film Company) will be used as the X-ray detector. Several kinds of automatic IP diffractometers have already been developed for macromolecular crystallography (RIGAKU, MAC Science and MAR Research Companies). However, all of them utilizes the smaller IPs than the 400 x 500 mm dimensions and requires a relatively long readout time. Because of the lifetime (0.7 microsecond) limitation of photostimulated luminescence (PSL) emitted from IPs, the long readout time is unavoidable when the two-dimensional image is read out by the point-by-point manner with a point-focused laser beam. In order to develop a much faster reader for the large-format IPs, we designed a new readout mechanism [3]. Our basic idea is to use a line-shaped laser beam (19 mm long) for the two-dimensional scanning, instead of the point focused beam, and to measure the PSL intensities with CCD, instead of the photomultiplier tube. Since the PSL photons are stored on the CCD for the order of millisecond on our mechanism, the lifetime limitation of PSL can be ignored. In order to demonstrate the basic idea, we have fabricated a prototype reader, and here is reported the results of evaluations in spatial resolution, dynamic range and readout time.

## 2. Experimental and results.

*2-1. Prototype reader.*

This device is composed of two parts : one is for IP reading, and another is for exchanging IPs between the positions of X-ray exposure and IP readout. The IP reading part consists of the laser optics providing the line-shaped laser beam, the lens system focusing the line-shaped PSL on the CCD tip and the CCD camera system (430 kHz readout) measuring the PSL intensity. The pixel data was transferred to a personal computer (PC) with the direct memory access (DMA) technique through the CCD-controller. Then, the full image are transferred from the PC to a data processing workstation (IRIS WS) by Ether-net protocol. The CCD camera, CCD controller and CCD control software on the PC are the products of Princeton Instruments inc. The IP size on the prototype reader is 125 x 125 mm. The readout pixel size was set to be 50 mm on the IP. The Cu Ka-radiation from a rotating anode X-ray generator (RIGAKU Company) and Blue-IP (BAS-UR : Fuji film Company) were used in this experiment.

*2-2. Spatial resolution.*

The spatial resolution was measured as following. An X-ray line of 50 mm width was exposed on the IP at the X-ray exposure position. The image was read out by the CCD at the readout position. After the readout of X-ray line image by the CCD, the full

width at half maximum of the image was calculated by the least-squares fitting to the Lorentz function. The spatial resolutions were 170 mm and 110 mm in vertical and horizontal directions, respectively.

*2-3. Dynamic range.*

The dynamic range of the prototype reader was tested by exposing X-rays of different intensities at different positions on the IP. The observed PSL intensities were averaged in an uniformly exposed area and plotted on a straight-line as shown in Fig. 1.

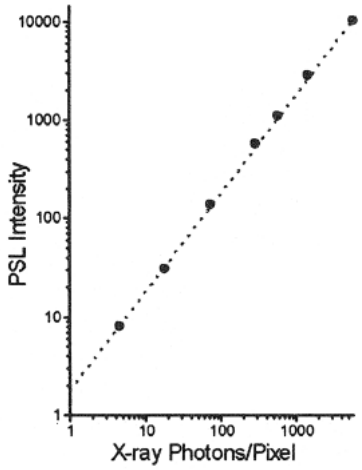


Fig. 1 The dynamic range.

*2-4. Readout time.*

The readout scheme of the prototype reader includes six steps as listed on Table 1. A total of 5 min and 21 sec was required for the IP readout.

Table. 1 Readout time

| stage | Time |
|---|---|
| IP exchange | 1’05” |
| IP readout | 1’40” |
| DMA transfer to PC | 0’29” |
| saving pixel data to PC Disk | 0’55” |
| Ether-net transfer to IRIS WS | 0’50” |
| image drawing on IRIS CRT | 0’22” |
| Total | 5’21” |

## 3. Discussions.

We have already started to fabricate an actual reader of the large-format IP, which will be installed in the experimental station of BL41XU.

The readout pixel size of the actual reader will be set to 150 $\mu$m and 100 $\mu$m in vertical and horizontal directions, respectively, based on the results of the spatial resolution for the prototype reader.

The dynamic range of the prototype reader is in the fourth order of the magnitude. This is mainly caused by the dynamic range of the CCD itself. Contrary, the IP has the dynamic range over fifth order of the magnitude or more. We will utilize optical filters in the actual reader for decreasing laser power and for expanding apparently the dynamic range.

The prototype reader needs 5 min and 21 sec for the readout of the 125 x 125 mm IP with the 50 $\mu$m pixel size (the image data size is 16 Mbytes). However, only 21 sec is spent for the net readout of the CCD, which is calculated from the readout frequency. The almost part (about 5 min) is spent mainly for the transfer of the 16 Mbytes image data and the IP exchange. In the actual reader at BL41XU, the readout time must be shortened by eliminating the wasteful transfer and saving of the image data. The actual reader will carry out the image processing just on the memory of IRIS workstation.

## References

[1] N. Kamiya et al., *Rev. Sci. Instrum* **66** (2), 1703. (1995).

[2] N. Kamiya *et al., Annual Report 1994*, 61 (1995).

[3] N. Kamiya *et. al., Annual Report 1994*, 173 (1995).