Performance of a Proportional Scintillation X-ray Imaging Chamber (II)

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1. Introduction

When combined with ultra-brilliant x-ray beamlines of the third-generation synchrotron radiation facilities, it has been long questioned whether the gaseous detectors based upon the electron multiplication process could not be subject to the space charge abundantly generated in their detection volumes. One of the approaches towards the space charge problem is to operate a gaseous detector in the region of proportional scintillation. Since only the photon amplification process can effectively proceed in this mode but not the electron multiplication because of the much lower electric field applied, operating a gaseous detector in this mode could result in drastically reducing the space charge down to the primary ionization level. The position information on incoming x-ray photons can be optically read out from a proportional scintillation detector as an induced luminous pattern with a highly sensitive video camera in this scheme. Having constructed a prototype of the proportional scintillation imaging chamber for x-ray imaging, we investigated its performance in various aspects in 1994, succeeded in demonstrating its appreciable imaging capability as well as an excellent space-charge resistivity [1-3].

There was, however, a systematic image distortion observed, being attributed to an electric field irregularity happened in the spherical drift chamber. In order to confirm this hypothetical explanation and to eliminate the problematic image distortion, we substituted the spherical drift chamber previously installed with a simple drift chamber April 1995. As described below in detail, the image quality has been significantly improved in the new detector configuration, confirming our understanding upon the origin of the image distortion.

2. Experimental

The newly configured prototype has a parallel drift chamber with an x-ray absorption depth and the applied electric field of 21 mm and 1 kV/cm, respectively, instead of the spherical drift chamber used in the previous works [1-3]. The rest of the prototype such as the parallel plate avalanche counter, the optical window, the image-intensifier-associated CCD camera system, and the gas handling system are, however, essentially the same as before. Having installed the modified prototype in the BL-14C at Photon Factory of KEK, we observed the diffraction patterns of the several well-known powder samples like cholesterol or b-cyclodextrn. The typical diffraction pattern of cholesterol powder observed with integrating 255 video frames and the x-ray intensity profile determined along the horizontal direction are displayed in Fig.1 and Fig. 2, respectively.

2. Results and Discussion

As can be seen from these figures, the cholesterol diffraction pattern has been two-dimensionally imaged with the modified prototype without any significant spatial distortion, clearly confirming that the distortion observed in the previous work was due to the electric field irregularity originated in the spherical drift chamber previously used. The substitution of the spherical drift chamber with the parallel drift chamber should have, however, introduced the radial error caused by the variation of the x-ray absorption depth in the parallel drift chamber, *i.e.*, the parallax error, in the observed images. Since the spherical structure of electric potential in the x-ray absorption region is essential to eliminate the parallax error, the argument given above leads us to redesigning and re constructing the spherical drift chamber part with a higher precision [4]. Once the re-fabrication is done, one could locate this detector on any beamlines, applying it for various types of diffractometry, especially, for those experiments in which an extreme robustness is required on area detectors.

References

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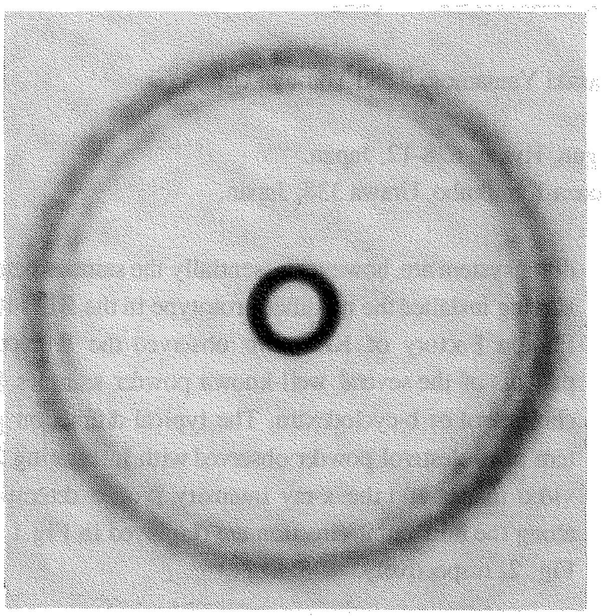

Fig. 1. Observed diffraction pattern of Cholesterol powder

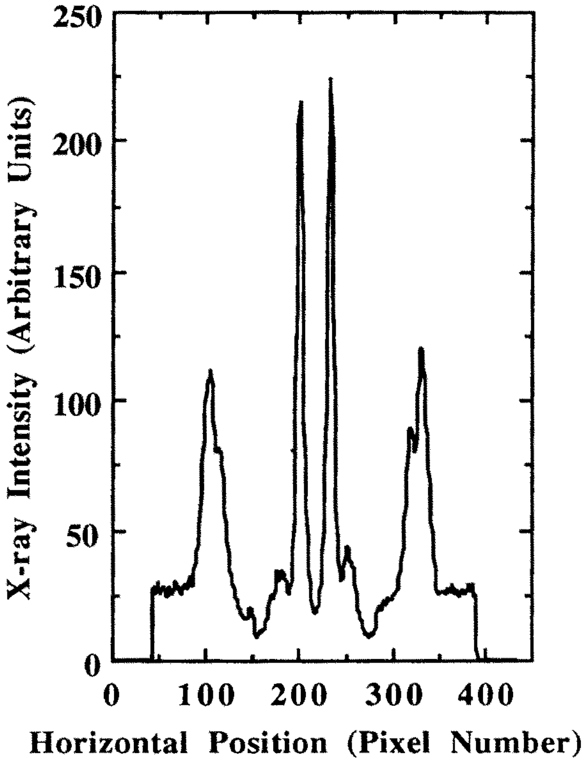

Fig. 2. Horizontal x-ray intensity profile determined