DIGITAL IMAGE RECORDING SYSTEM FOR HYDROGEN STREAMER DETECTOR

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The procedure of data taking with subsequent data processing based on film readout is a longstanding problem in experiments employing the chamber techniques, a streamer chamber not excepted. In the normal sequence of steps for getting the physics from the film, i.e. scanning, measurements, event reconstruction, and kinematical fitting, the two former take too much time, when a few hundreds of thousands of pictures have to be dealt with. It seems that the use of charged-coupled devices (CCD) instead of film should allow the expenditure of time on data processing to be considerably reduced. As was shown in [1,2], a system of CCD cameras and associated aquisition electronics successfully operated to register streamers in a He-Ne mixture in a heavy ion experiment with a streamer chamber.

We have performed the initial work on using an image recording system based on a CCD device matrix in Laser Hydrogen Streamer Detector, the device intended for the studies of the low-energy hadron-proton scattering [3]. The volume of the streamer chamber is filled with hydrogen and illuminated by the laser flash of a pulsed nitrogen laser, $\lambda = 337$ nm. Thus, the CCD camera records the light scattered by a streamer rather than the light emitted by it. The self-luminousity of streamers in hydrogen is too weak to be readily registered.

Digital recording camera includes the CCD chip, optics and hardware unit which controls the CCD and provides intermediate data storage and preliminary data processing. The ISD011A CCD-chip consists of a matrix of 512×512 square pixels, 16 μm$\times$16 μm each. The total sensitive area of matrix is 8.2 mm$\times$8.2 mm. This model belongs to the family of virtual phase CCDs [4] that have the advantages of high quantum efficiency, low dark current and simplification of antiblooming process. The quantum yield of these CCDs is enhanced in the ultraviolet region ($\sim$ 20% in the near ultraviolet), so the registration of nitrogen laser light is not a matter of difficulty. Low level of the dark currents allowed us to operate the CCD at room temperature. In order to eliminate an adverse effect of dark currents and background light on the image quality, pixels are being cleared continuously in the lapse between laser flashes.

The hardware unit is implemented on the base of 40 MHz microprocessor and includes also the external memory, videoamplifier, 8-bit analog-to-digital convertor, interface controller and set of drivers. On the stage of the preliminary data processing it is possible to perform images filtering, compensation of dark signal, aperture correction of images and some other procedures.

Digital recording camera is connected through the remote CAMAC crate controller to a computer. Transfer speed through parallel bus and interface is 400 Kb/s. Total reading, processing and transfer time is about 3 seconds.

To test the operation of the hydrogen streamer chamber with digital image recording system we have taken some number of pictures of electron tracks. Taking pictures with digital recording camera brought about the necessity for a developed software to provide

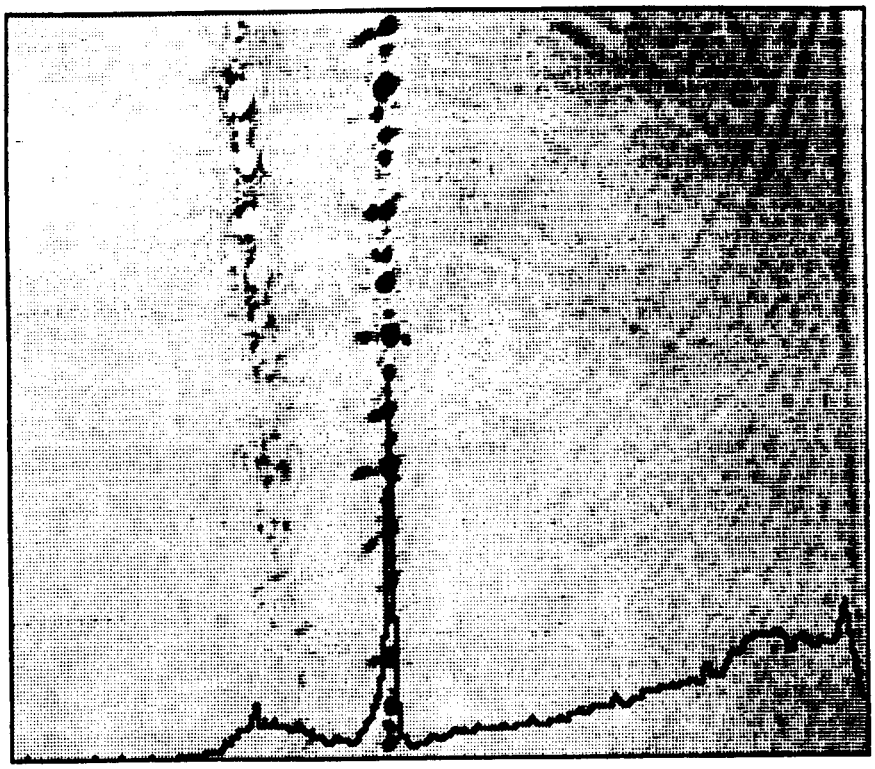

Fig.1. Pixel light intensity hystogrammed on the axis perpendicular to the direction of the track

manually free data processing with automated search for a track in digitized image of event. The examples of the track recognition are demonstrated with the simplest case of one straight-line track in Fig.1,2. To eliminate constant background one of pictures was chosen as typical and was subtracted from all the others. After subtracting the background the pixels were projected and hystogrammed on the axis rotating in the plane of image. At some angle of rotation the pronounced peak revealed in hystogram (Fig.1). The perpendicular projection demonstrates a number of peaks representing the position of streamers along the track (Fig.2).

Our first experiences on using the CCD device as a digital imager for LHSD gave promising results. However, some points of interest associated with the application of CCDs are still remaining to be carefully examined. In particular, it concerns the problem about accuracies that may be achieved when the CCD is used. The experiments on hadron-proton scattering will ask for a good accuracy of angle measurements: 0.1–0.15° [5]. In principle, this accuracy is achievable in conventional film readout [3]. The further work is planned to answer the question of whether this accuracy is achieved with a digital system.

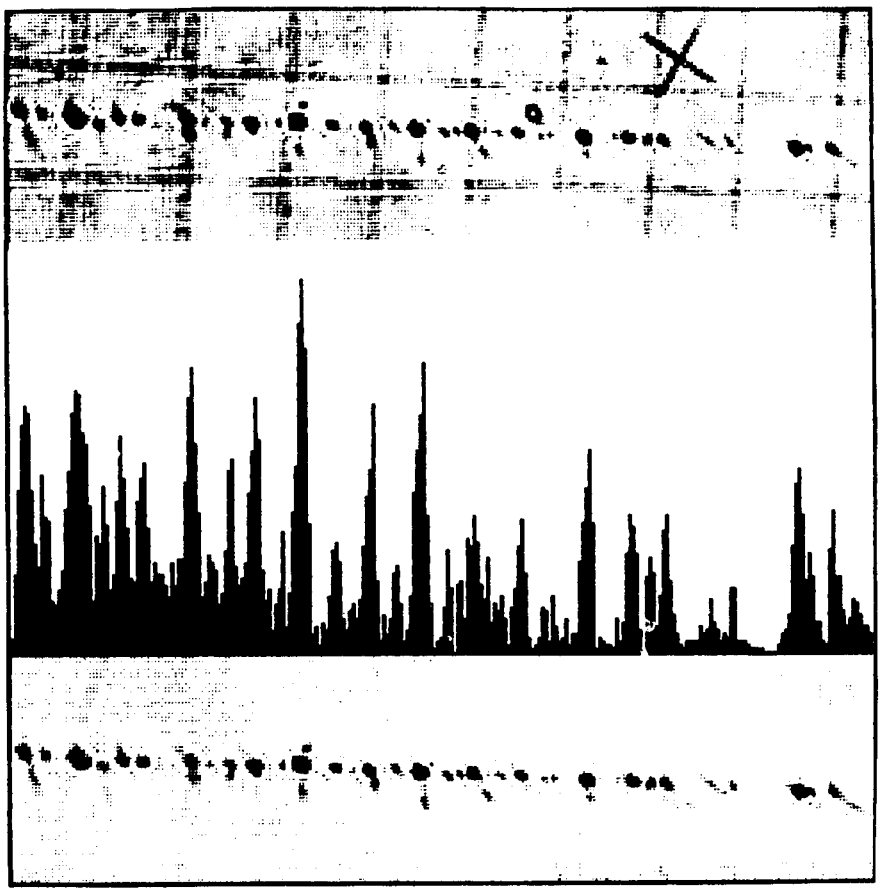

Fig.2. Pixel light intensity hestogrammed on the axis parallel to the direction of the track

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