TV SCANNING APPLIED FOR TWO DIMENSIONAL PHOTON COUNTING IMAGING

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ABSTRACT. A system with an electronomulitplier of two-stage micro-channel plate and a vidicon TV camera is developed for two dimensional photon-counting imaging and is applied for astronomical observations at the Nasmyth focus of the 75cm alt-az telescope of the Sundai Observatory at Kita-Karuizawa (SOK). Some test results are shown here.

1. SYSTEM OF A PHOTON COUNTING IMAGING TV CAMERA

This system consists of an ultra-high sensitivity TV camera called the Hamamatsu C1960-20 VIM (Video Intensified Microscope) camera (figure 1) and of an image processor. This combination enables photon counting imaging additionally to very low light-level imaging. Therefore, the camera has a wide dynamic range (10^0 to 10^9 photons/mm^2.sec). A

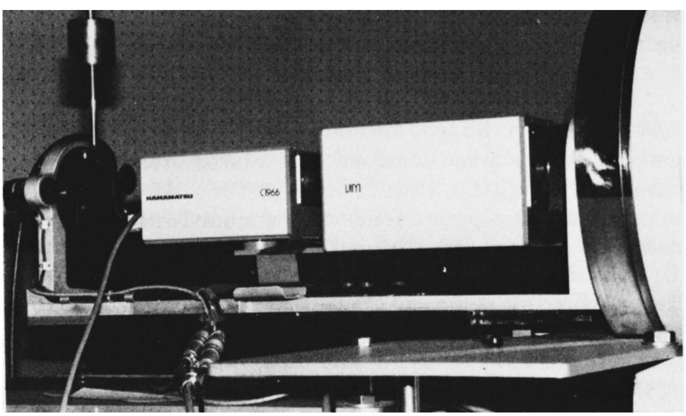

Figure 1. VIM camera fixed at the Nasmyth focus of the 75cm telescope.

J. B. Hearnshaw and P. L. Cottrell (eds.), Instrumentation and Research Programmes for Small Telescopes, 71–74.

vidicon TV camera with low-lag time (5% after 50ms) is optically coupled by a relay lens with two dimensional photon counting tube as shown in figure 2. When an optical image is focused on the photo-

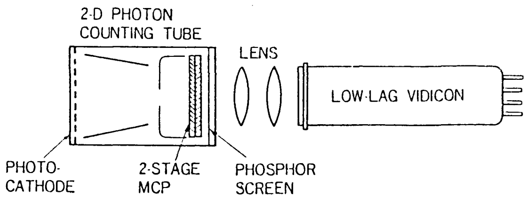

Figure 2. Schematic diagram of Hamamatsu C1960-20 VIM camera

cathode, it emits photoelectrons in accordance with the intensity of the input image. The electron image is focused on the two stage micro-channel plate (MCP) where it is amplified up to the order of 10^6. Pulse height distribution of output signal is given in figure 3. This amplified image produced on the phosphor screen is taken by the coupled video camera. When the intensity of input image becomes extremely low, one video frame of the TV scan gives only a dotted image corresponding

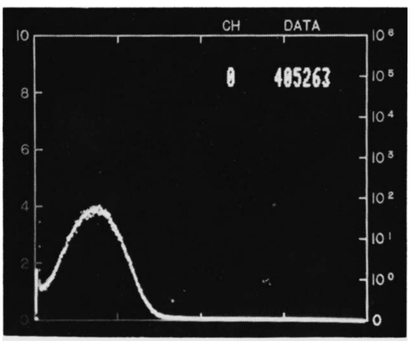

Figure 3. Pulse height distribution of camera.

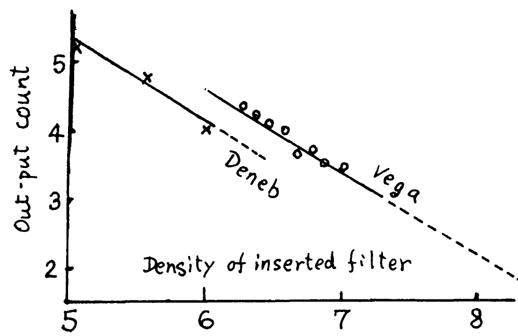

Figure 4. Relation between density and count for Vega (o) and Deneb (x).

to input photons and noise produced at the photocathode. By giving a certain discriminator level to reduce the effect of this noise, the dotted images are digitally processed and accumulated in a video frame memory over a desired number of video frames.

2. ASTRONOMICAL TEST OF THE SYSTEM

The system was fixed at the Nasmyth focus. First, the bright stars, Vega and Deneb with zero and 1.3 magnitude, were observed by adding neutral density filters in front of the detector. A good linear relation between integrated photon number in 15 seconds and total density of inserted filters is shown in figure 4 which suggests that the limiting

https://doi.org/10.1017/S0074180900151058 Published online by Cambridge University Press

magnitude of our system is over 21 magnitude in 15 second exposure because of low dark noise, if skybackground is dark enough. Since a star of 20 magnitude gives 10^3 photons in 15 seconds for a 75 cm telescope, quantum efficiency is about 0.1. Many objects such as the comet Halley, the Crab Nebula, M51 galaxy, and so on were observed and we obtained fine images and found this system has a wide range of applications in astronomical observations.

Table I. Tentative specification of the system

Spectral response	300 - 820 nm
Useful photocathode size	10^2 mm^2
Resolution	360 TV lines
Dark count at 25°C	2 cps
Dynamic range	10^0 - 10^9 photons/mm^2 sec
Geometric distortion	7 %

DISCUSSION

Hiltner: Has Mr. Miyaki measured the photoelectron collection efficiency of the first multiplier stage - the micro-channel plate?

Isobe: Although Mr. Miyaki may have some idea of the photoelectron collection efficiency, I have never measured it. However, quantum efficiency of the whole system was measured as 0.1 from stellar observations, which is a combined efficiency of phosphor, micro-channel plate and photocathode. Therefore, the efficiency asked by Dr. Hiltner may not be worse.

Latham: Rich Cromwell has demonstrated that for most image intensifiers, roughly half of the photoelectrons released from the cathode never make flashes of light at the output phosphor, and that therefore the true DQE is degraded seriously from the d.c. sensitivity measured for the cathode. For MCP intensifiers the counting efficiency was worse than average, typically 0.3 to 0.4 for the tubes measured by Cromwell. Only for some Varo intensifiers was a high counting efficiency found, typically 0.8 to 0.9. Magnetic intensifiers made by ITT, RCA and EMI have efficiencies of 0.5 or 0.6. When comparing photon counters with other detectors, such as CCDs, one must multiply the d.c. cathode sensitivities quoted by the manufacturers by the counting efficiency, a serious degradation.

Hiltner: ITT report a collection efficiency of 60% for their proximity focussed image tube with a micro-channel multiplier.