THE DDO PHOTON-COUNTING SPECTROMETER: A WELL-DRESSED SHECTOGRAPH

S. W. Mochnacki, S. Chew, W. Kunowski, F. Hawker, K. Kamper, D. Blyth, L. Zerafa and A. Platzer

David Dunlap Observatory, University of Toronto, Box 360, Richmond Hill, Ontario L4C 4Y6, Canada

ABSTRACT. We have built a Shectman-type photon-counting spectrometer based on the Latham-Geary "Z-Machine" design. The system is innovative in that the entire system rides on the telescope and communicates to the outside world via standard serial lines. Microprocessor architecture, memory controllers and new interconnect and packaging technologies have been employed. The system is portable and can be easily connected to almost any computer. It is suitable for calibrated spectrophotometry on a smaller telescope as well as for conventional spectroscopy.

1. INTRODUCTION

In the ten years since the prototype was developed (Shectman and Hiltner 1976), a number of "Shectographs" have been built and put to use on medium to large telescopes. The articles of Latham (1982), Allen <u>et al</u>. (1983) and Shectman (1983) describe the evolution of the design, at first using longer one-dimensional Reticon arrays and later using a two-dimensional CCD as the sensor element. At the DDO, we needed a system for one-dimensional Cassegrain spectroscopy on our 1.9 metre telescope, with sky subtraction. We chose tha CfA design (Latham 1982) for the degree of refinement of its electronics and because Drs. Latham and Geary of CfA were relatively nearby and very willing to help us.

2. SPECIFICATIONS

Our particular requirements were: (a) to detect spectra at a resolution of 25 microns or better, over a detector length of 25 mm or more, of stars as faint as 15th magnitude; (b) to measure radial velocities to a precision of ± 1 km s^{-1} at a reciprocal dispersion of 16 A mm^{-1}; and (c) to simultaneously detect the object and the sky through equivalent apertures or slits. These requirements could be met by a "Shectograph" system with the following specifications:

Image Tubes	2 x VARO 8605 40 mm "First Generation" diodes + 1 x VARO 3603 25 mm "Second Generation" MCP tube.
Quantum Efficiency	8% at 4000 A, 14% at 5000 A, 4.5% at 8000 A.

J. B. Hearnshaw and P. L. Cottrell (eds.), Instrumentation and Research Programmes for Small Telescopes, 461–462.

Usable Range	3800 - 8600 A (quantum efficiency > 1%).
Operating Temp.	-35°C, thermoelectric cooling.
Sensor Element	2 x Reticon RL1024-SF, each diode 25μmx2.5mm
Clock Frequency	0.5 MHz, Reticons read out in parallel.
Digitization	8 bit A/D, with frame subtraction.
Event Detection	1/4 diode event centring. Adjustable discrimination.
System Resolution	4 pixels (1 diode,25 microns), design goal 3 pixels.
Output Format	2 x 4096 pixels (A and B sides).
Coincidence Error	1% at 0.5 events sec^{-1} $pixel^{-1}$.
Max. Count Rates	2 events sec^{-1} per pixel, <u>or</u> 4000 events sec^{-1} per side.

3. DESIGN DETAILS

We have followed closely the well-proven design of Latham and Geary, with innovations in certain areas. We have packaged the entire photon counting electronics system into a single box which rides on the telescope. The on-board 6809-based microcomputer is commanded via a serial line using a standard terminal, and the data is sent to a host computer via another serial line. Analogue components are mounted on custom-made printed circuit boards, but the digital components are mounted and interconnected on BICC-Vero Eurocards using Speedwire technology. The cards are connected with DIN pin connectors and daisy-chained wire-wrap. These new interconnect schemes require care to achieve good contact and not break the wires. Nearly all cards are spared. We have aimed for modularity, compactness and reliability.

The intensifier head is potted in RTV and contained in a rather bulky housing thermoelectrically cooled to -35°C. The Reticons are also cooled, a necessary refinement given the large dark current of the S series chips. All optical couplings are custom fibre optic boules.

A digital encoding scheme for data transmission has been devised: the part of a number in the range 0-63 is represented using an ASCII code between 32 and 95; higher order segments (e.g. 64-2047, 2048-65536 etc.) use ASCII codes 96-127. An ASCII character in the range 32-95 therefore signals the least significant portion of a new number in the data stream. In practice, only about 70% as many bytes of data need be sent this way than if pure binary 16-bit data were sent.

This system can be used in the manner of the KPNO Intensified Reticon Scanner, which is used on a fairly large spectrograph with apertures on a 1-metre telescope and gives calibrated fluxes.

REFERENCES

Allen, R.G., Cromwell, R.H., Liebert, J.W., Macklin, H. and Stockman, H.S. 1983, in <u>Instrumentation in Astronomy V</u>, ed. D. Crawford, Proc. SPIE <u>445</u>, 168.

Latham, D.W. 1982, in <u>Instrumentation for Large Telescopes</u>, IAU Coll. No. 67, ed. C. Humphries, p.259.

Shectman, S. 1983, in <u>Instrumentation in Astronomy V</u>, ed. D. Crawford, Proc. SPIE <u>445</u>, 128.

Shectman, S. and Hiltner, W.A. 1976, Pub. A. S. P., <u>88</u>, 960.

https://doi.org/10.1017/S0074180900151939 Published online by Cambridge University Press