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THE ELMER DETECTION SUBSYSTEM

R. Kohley,[1] J. M. Martín-Fleitas,[1] L. Cavaller-Marqués,[1] M. Suárez-Valles,[1] P. L. Hammersley,[1] R. Vilela,[1] and F. Beigbeder[2]

ELMER is a multi-purpose instrument for the GTC designed for both, imaging and spectroscopy in the visible range. The detection subsystem consists of a single E2V Technologies CCD44-82 detector mounted in a LN_2 cooled CCD camera and a SDSU-II CCD controller with parallel interface. The design including the low-noise fan-out electronics has been kept flexible to allow alternatively the use of MIT/LL CCID-20 detectors. We present the design of the CCD camera and first test results.

Introduction

ELMER is one of the GTC 10-m telescope's Day-1 scientific instruments. It has been designed and fabricated as a back-up instrument for imaging and low resolution spectroscopy in the visible wavelength range to alleviate the threat of late instrument arrivals. Although suffering heavy constraints on budget and manpower, the instrument will be finished within about 4 years and is currently awaiting its integration and commissioning phases. The instrument operates in the 365 nm to 1000 nm wavelength range using a single E2V Technologies CCD44-82 detector, a 2Kx4K, 15 μm pixel, red-enhanced CCD. Due to a flexible design of the cryostat and the electronics including the in-cryostat fan-out board (see more details in Kohley R., et. al., these proceedings) also the MIT/LL CCID-20 could be used in ELMER without sacrificing any of the observing modes. The maximum field-of-view in imaging mode is 4.2′ diameter located in the upper half of the detector. The plate scale is $0.''195$/pixel. Resolutions in spectroscopy mode range from 50 to 2500 with the spectra aligned to the rows of the detector. These configurations together with the detector's frame-transfer structure allow a multitude of observing modes among which are charge shuffling in imaging and spectroscopy modes, high duty cycle fast photometry and fast spectroscopy (long slit and multi-object).

[1]GTC Project, Instituto de Astrofísica de Canarias, La Laguna, Spain.

[2]Observatoire Midi-Pyrénées, Tarbes, France.

Fig. 1. ELMER CCD camera: LN2 bath cryostat with CCD head and engineering flat window mounted (middle part), SDSU-II CCD controller (left), and Lakeshore 331 temperature controller and Pfeiffer TPG 261 vacuum gauge controller (right).

CCD camera design

The CCD camera design comprises the CCD, the necessary components for operating the detector (cooling system, fan-out electronics and CCD controller), for exposure timing (shutter) and for housekeeping functions (temperature control and pressure monitoring). Figure 1 shows an assembly of the different components of the CCD camera system except the shutter. The design has been guided by the constraints of low risk and low budget, employing as many proven, commercial products as possible. Nevertheless, it was necessary to carry out own developments like the CCD head design and the fan-out electronics, both successfully finished on time.

0.1. *Detector*

The detector is an E2V Technologies (former Marconi Applied Technologies, former EEV) CCD44-82 detector. The detector has 2Kx4K, 15 μm pixel and is built on 40 μm high-resistivity silicon for improved red response and reduced fringing. QE is high with 38% at 400 nm, 87% at 650 nm and 56% at 900 nm. Read-out noise is very low with below 2 e^- at 20 kpixels/s. The detector has an internal frame-transfer structure, which permits operating the lower

2Kx2K half of the detector independently from the upper half. The serial register has two amplifiers at each end to allow reading out the left and the right half of the detector simultaneously. Although the CCD is non-AIMO, dark current is expected to be very low, in the order of 0.03 e^-/pixel/h.

0.2. *Fan-Out*

Since the delivered E2V CCD44-82 detectors had the internal protection circuitry disconnected due to a glow problem, our board has been designed to provide ESD and overvoltage protection to the CCD, as well as clock waveshaping and bias filtering, and x4 pre-amplification of the video signals. The cabling between the fan-out, mounted inside the cryostat close to the detector, and the controller is about 2 m.

0.3. *Controller*

The controller is the standard instrumentation controller for the GTC, a SDSU-II controller. Although the basic controller is the same, several variants exist for the different instruments and CCD testing purposes. For ELMER the chosen configuration is with Utility and Parallel Timing board. A low noise bias board, developed at the PO, has been added to provide the power supply for the fan-out. Standard read-out frequencies will be 50, 200 and 500 kpixels/s. Electronics noise including the fan-out (input grounded) has been measured to be below 0.5 e^- for the lowest speed. Francis Beigbeder (LAOMP) is providing the DSP codes for all ELMER observing modes.

0.4. *Cryostat*

The ELMER cryostat is a standard LN_2 bath dewar with 6.5 liters filling volume based on an ESO design. The dewar can be filled to 90% and operated in every direction within a half-sphere. This together with a very clean vacuum of about $4{\cdot}10^{-6}$ mbar (over 10 months) results in a LN_2 hold time of more than 2 days operating the detector at about -100°C. To monitor the cryostat pressure from ambient to UHV, a Pfeiffer FullRange Gauge is permanently mounted to one of the two KF-40 ports of the dewar. To improve the vacuum, two cryogenic pumps have been added, one filled with Zeolite and the other with activated charcoal. Detector temperature stabilization is carried out by a Lakeshore model 331 temperature controller and a pair of PT-100 temperature sensor and heater resistors on the CCD mount. The CCD head (see Figure 2) with the CCD mount as well as the in-cryostat fan-out boards have been designed at

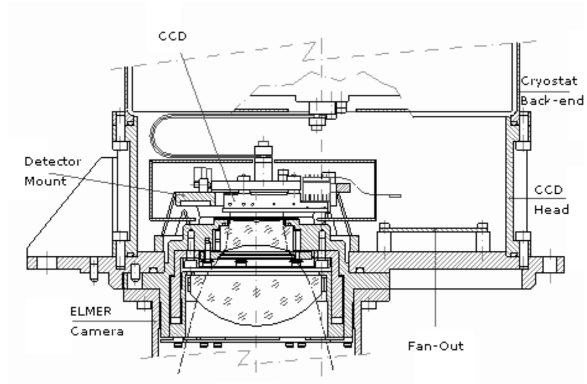

Fig. 2. CAD drawing of the CCD head.

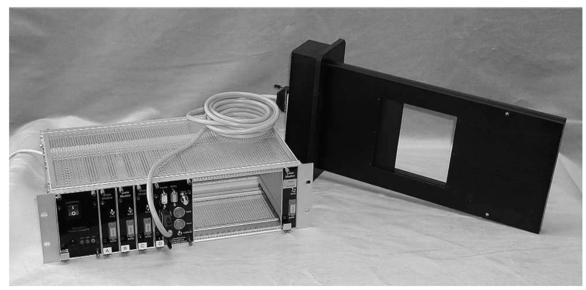

Fig. 3. Shutter and shutter controller

the PO and fabricated at the IAC workshops. To be able to mount the CCID-20, a molybdenum subpackage with the CCD44-82 mounting interface has been ordered from GL Scientific (Honolulu, US).

0.5. *Shutter*

For accurate exposure timing a bi-directional slit-type shutter is placed near the instrument's pupil position. The full aperture is 150 mm x 150 mm allowing exposure times down to 10 ms and a repetition rate of up to 2.5 Hz. Exposure time error is below 300 μs and exposure inhomogeneity is below 1 ms over the full FOV. The shutter has its own controller to operate the stepper motors of the slit blades. Exposure timing signals come directly from the CCD controller. Some observing modes do not need the mechanical shutter, but use masks and electronic on-chip shuttering instead.

0.6. *Readout modes*

Apart from the standard observing modes like full frame imaging and spectroscopy, ELMER provides several high-duty modes including frame-transfer imaging, continuous fast photometry and spectroscopy. The continuous modes can be carried out because of the independent operation of the

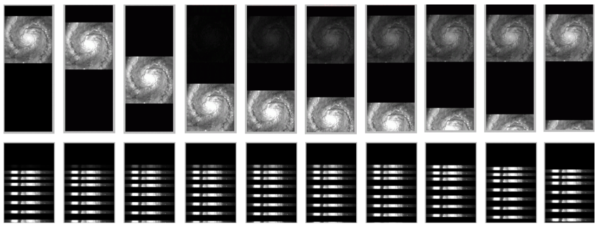

Fig. 4. Examples of readout sequences for frame transfer imaging mode (upper row) and fast aperture photometry (lower row).

lower half of the detector. Since the FOV of ELMER lays in the upper half, charge can be shifted rapidly into the lower half and read out while the upper half is exposed again. Figure 4 shows two examples. The CCD44-82 as the CCID-20 are 3-phase devices, which allow also charge shuffling, the transport of charge in both directions within the detector (up and down).

Conclusions

The ELMER detection subsystem has been built from state-of-the-art components, mostly commercially available. Own developments, where needed (fan-out, CCD head), were successfully carried out and integrated into the whole system. Results from test carried out so far on the different parts promise that the system will perform to specifications. The CCD camera has just recently seen "first light" with an engineering grade CCD44-82, and final tests and commissioning are planned for this summer.

REFERENCES

Kohley R., et. al. 2005, RevMexAA Ser. Conf., 24

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