The New Direct CCD Imaging Camera at the NTT

SUSI2 gets the first FIERA CCD controller and a mosaic of two 2k × 4k, 15 μm pixel, thinned, anti-reflection coated EEV chips

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SUSI2: A Summary View

In 1995, the ESO Instrumentation Division got the green light for a two-step upgrade of the instrumentation at the NTT, in preparation to the key role that this telescope will have to complement and enhance the scientific output of the VLT Observatory. The first and major step was the infrared imager-spectrometer SOFI whose first observations in the sky are described in this Messenger issue. The second part of the upgrade concerned the direct CCD imager SUSI at the same telescope focus. In December 1995, ESO reached an agreement with the Osservatorio di Roma which provided approximately 40% of the instrument budget and supported the effort with 1 FTE, mainly in the CCD technical area and in the commission of the instrument at the telescope, in exchange for guaranteed observing time. The financial support of Rome permitted the project to proceed with an accelerated schedule without limitations from the ESO yearly budget.

The new CCD imager had the requirement of a substantially larger field (at least a factor of 4 improvement in area with respect to the SUSI 2.3 × 2.3 arcmin) and of a CCD camera of enhanced performance, both in terms of speed of readout and of QE in the UV-blue region. The larger field is needed to make studies of gravitational shearing over angular scales which are statistically significant and for survey work which can identify targets (e.g. high redshift galaxy candidates) for spectroscopy with the FORS instrument at the VLT in an efficient way. The higher QE in the UV-blue will make feasible very deep observations in these bands in affordable integration times. The measurements at the shortest wavelengths are essential to derive the overall spectral energy distribution of both galaxies and stars which is the key to understand their physical properties.

The opto-mechanical design was constrained by the need to fit in the 50-cm space between the adapter/rotator and the SOFI vessel (see Fig. 2 in the SOFI article in this issue). In the adopted configuration, a 45° mirror, which can be inserted in the optical beam, feeds, through the filter wheel, a mosaic of two new EEV 44-82, 2k × 4k, 15 μm pixel, thinned, anti-reflection coated chips. The resulting field is 5.5 × 5.5 arcmin with a pixel scale of 0.08 arcsec. The CCDs are driven by the new ESO-developed controller FIERA (for a description see 1998, Proceedings of the ESO Workshop on Optical Detectors, J.W. Beletic & P. Amico eds, Kluwer Academic Publ., p. 103). Other novel features of the instrument are a 8 cm × 8 cm sliding curtain shutter which permits exposures down to 0.3 seconds without vignetting and a special cryostat designed to operate on a rotating Nasmyth adapter.

SUSI2's opto-mechanical layout includes a second, off-axis, red optimised CCD channel which can be used in parallel to the first one. The implementation of this option in the year 1999 is under study.

SUSI2 has become operative at the telescope in a little more than two years

Figure 1: This colour picture of the galaxy NGC 2613 (estimated distance 19.8 Mpc) prepared by F. Pedichini (Rome Observatory) is the combination of 9 SUSI2 exposures in the I, V and B bands for a total of 12 minutes integration. North at the top, East to the left. The CCD mosaic gap of 8 arcsec aligned in the N-S direction has been filled in this combined image by the averaging of 3 dithered exposures in each band.

since the formal go-ahead of the project. This has been made possible by the extraordinary efforts of the project team at a time in which our resources go with first priority to the VLT and the successful development of the new format chips by EEV. With a field of view which is very similar to the one of SOFI, the instrument appears ideally suited to multi-colour studies which will complement and support the programmes carried out with the ISAAC and FORS instruments at the VLT. The instrument total cost was 750 kDM and 4 FTEs (ESO) +1 (Roma).

The First Test Results in the Lab and at the NTT

SUSI2 was first integrated at the telescope with an engineering CCD system in December 1997. The science grade CCDs arrived at ESO in December 1997 and January 1998. The average QEs for the two chips have been measured as: 350/76, 450/90, 550/82, 650/ 74, 750/58, 850/35 where the first number is the wavelength in nm and the second is the % QE. The other properties were in agreement or very close to the original specifications: CTE $>$ 0.999999, linearity within $\pm$ 0.2% over pixel full well of 145000 e^-.

Although severely affected by the bizarre "El Niño" weather of this year in Chile, the commission period just concluded at the end of February could be used to optimise the operation parameters of the CCD system at the telescope, to verify the operability of the instrument in the NTT environment and to measure the basic astronomical parameters of the instrument, such as scale, throughput, colour term and image quality.

FIERA at the NTT is presently reading the two chips in parallel, at 200000 pixels/port, second with a read-out noise of 4.6 e^-/pixel. This is limited by the speed of the Ethernet link between FIERA and the instrument WS: there are plans to upgrade this by the beginning of 1999 with the installation of an ATM connection as it is foreseen for the VLT instruments.

The total time from the end of an integration to the display of the image on the RTD monitor is 56 and 16 seconds for the full format 4k $\times$ 4k and the binned 2k $\times$ 2k format respectively. When compared with the readout times of other 2k $\times$ 2k chips in other La Silla instruments (EMMI, EFOSC2) the gain for equivalent sizes is more than 1 min per exposure, or between 1 and 2 hours in a typical night. The amount of data collected in a clear night (between 3 and 12 Gbytes, depending on the format used and the length of the typical exposure) required an upgrading of the disk memory at the telescope and will call for an upgrading of most of the data reduction facilities operating in the community.

The instrument throughput benefits from the higher QE of the CCDs and the higher efficiency of M4 and the cryostat window. The gain in speed of SUSI2 with respect to SUSI is larger than a factor of 5 in the UV and a factor of $\sim$ 1.5 in the B, V and R bands. The measured count rates for a star of 15 mag in the different bands are reported together with other relevant information on the instrument in the SUSI2 page of the NTT web site. The counts are in good agreement (better than 10%) with the values predicted by the instrument simulator available at the ESO web site for the purpose of proposal preparation. The image quality over the field of view could not be tested extensively due to lack of nights with very good seeing. The first data which have been analysed (see Fig. 2), point to an homogeneous image quality over the whole SUSI2 field down to at least 0.5 arcsec FWHM.

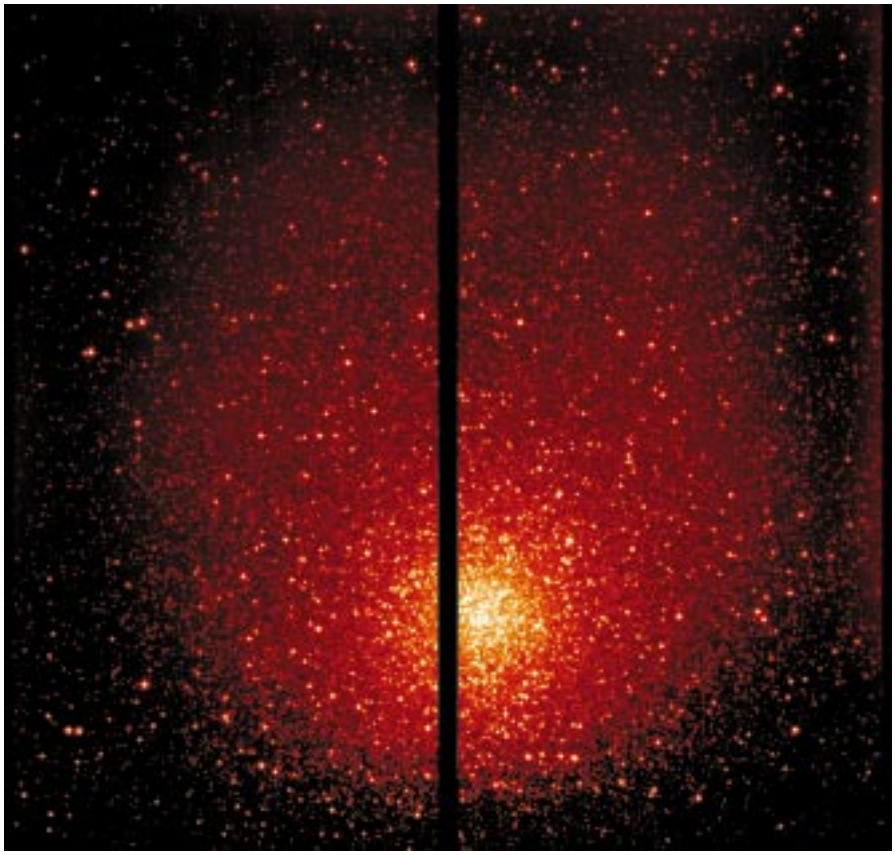

Figure 2: A 30 seconds, flat-fielded, unguided I band exposure of the globular cluster NGC 5286 which illustrates the format of the data from SUSI2. In the unbinned mode, in the x direction there is the prescan region, 2048 active pixels of the first CCD, 46 of overscan, 50 of prescan, 2048 active pixels of the second CCD and the overscan region. In the y direction there are 4096 pixels. The active CCD field corresponds to 5.5′ $\times$ 5.5′. This image was obtained in 2 $\times$ 2 binned format (0.161 arcsec/pixel). The number of overscan and prescan pixels (96) in the central region is chosen to match the physical gap between the two chips, which correspond to 8 arcsec approximately. The image quality measurement over the field gives an average FWHM of the gaussian fits of the stellar images of 0.48 arcsec. The ellipticity is less than 10%, homogeneous over the field and with a constant orientation.

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