CHIP CHARACTERISTICS
FOR
LORAL 2048 edge buttable J. Geary
ESO #34

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1 General Description

ESO S/N	: #34 (in cryostat-tank No.:2223)
Chip type	: LORAL 2048 edge buttable, left CCD, frontside illuminated, UV-coated (LORAL)
Chip format	: 2048x2048, 16 pre–scan pixels in horizontal direction (A-ampl.)
Pixel size	: 15 x 15 μm^2
Serial No.	: W17–4(12.92)

The CCD chip is the best of four UV-coated LORAL 2048 buttable CCDs that ESO has received up to now. This LORAL CCD-chip is coated from LORAL to enhance the UV response and is foreseen for the red arm of EMMI at the NTT.

The complete cryostat assembly without flange is delivered. The detector assembly is adjusted and should **not** be opened. The CCD plane is parallel to the CCD-flange plane and adjusted in a way, that the CCD surface deviates maximal only ± 27 micron from the ideal plane. The central region of 1800x1800 pixels deviates maximal ± 18 micron from the ideal plane.

The delivered pre-assembly # 34 should be used.

Necessary software for the VME Camera system is delivered in parallel by Olaf Iwert.

The cryostat 2223 in addition with the given Detector assembly gives the following operating temperatures with a good vacuum after 48 hours of pumping and with no mechanical short cuts of shields with the housing or the detector assembly:

Without regulation the Monitor temperature reaches approx. 150 K

The recommended operation Monitor (CCD) temperature is **165 K (=Monitor at the ESO temperature controller)**. To reach this, the Control temperature has to be set at the ESO temperature controller to 160 K. With a higher regulated temperature the cold-time is much shorter, because of the heating.

Once cold (Control = 160 K, Monitor = 165 K), the hold-time at this temperature with one new filling is approx. 24^{+0}_{-4} hours.

This CCD has been tested with the ESO VME CCD Camera system.

Attention: *The unpacking and final assembly of the Detector Assembly into the Cryostat 1382/2 has to be done in Chile according to the procedure mentioned in the Maintenance Manual: [3]: CCD Cryostat for the VME-based Control Camera.*. This procedure is given again in the following:

Please read carefully the corresponding chapter (page 24, page 17) of the manual and especially **the following important instructions.**

2 Instructions for the cryostat final assembly

- Do all in the following described work in a clean-air bench and optionally with the help of a **low** pressure anti-static air gun.

- The packing material has to be removed from the shipped pre-assembly # 34. Some screws are sticked on the shield II.

- Remove the Cover Plate (320-38) from the shipped Detector Assembly and protect the detector, which now is open and unprotected, with a small plate, that can be glued with scotch tape onto the Cold-stop front surface.

- Do not open the Detector Assembly itself. The CCD is adjusted in x,y and z in Garching. Every opening of the Detector Assembly would damage this adjustment.

- The Detector Assembly now is **carefully** installed into the pre-assembly (after taking out from its shipping parts):

  For this procedure first fix the Thermal Links(320-17) with Scotch tape to give space for the incoming Detector Assembly.

  The Thrust V-Bearing (130-19) of the Detector Assembly (and there is only one) comes over the glass V-pin (140-11) of the pre-assembly. The Detector Assembly is gently introduced vertical with its “collet for centerdisc”(320-29) into the glass center pin (140-12 or 140-11) of the pre-assembly. **Do not break the glass pins during the introducing**.

- Then the three tension springs (320-14) including one with the analog ground connection are attached and gently screwed (the screws are delivered) at the Centering disc(320-02) of the Detector Assembly.

- The Scotch tape has to be removed and the three Thermal Links(320-17) are screwed with the three M3x8 countersink "Allen" screws without washers and with a special delivered ball headed Allen key with a size of 2 mm (which was delivered in 1989 with the CCD-cryostat # 18 and # 19) to the Detector Assembly. Do not remove the special tape from the Detector Assembly at the three Thermal Link connection points.

  Do only use this special ball-key for these screws.

  Do not apply to much force with this process, not to break the glass pins.

  The Thermal Links have to be placed gently into a low position during the beginning of screwing.

- The two electrical flat cables (330-13, 330-14) have to be pressed into the connectors at the large green printed circuit in the pre-assembly. Note the dark-red point at the socket and at the connector of the small thermal connection (330-14), which gives the right position.

- The separately delivered Radiation Shield III (320-25) is screwed (only one position is possible) onto its spacers with the delivered three M3x5 countersink screws.

- **Now all the following parts and seal surfaces has to be cleaned and dust-inspected very carefully, not to have a leak after the assembly procedure.**

- The O-ring surface (groove) of the housing is cleaned, the delivered O-ring cleaned, inspected and inserted in its groove, then the taped protection of the Detector at the Cold-stop removed and the detector very very carefully cleaned from dust with **gentle** anti-static press-air.

- After this the (in La Silla available) EMMI-flange (with the right Detector window) is introduced at the right position. This means, that the **oval** hole for the parallel pin (217) in the EMMI-flange is placed at the parallel pin **opposite** to the connector side of the housing. The EMMI-flange is screwed with the eight delivered big screws.

- Now a check of the electrical isolation between the detector assembly and the outer housing case is necessary. Therefore a measurement between pin F of the video connector and the outer housing metal has to be done. If there is an electrical connection the cryostat has to be opened again and the problem solved.

- Only in the case of an EMMI Cryostat the EMMI field-lens is introduced (do not forget the O-ring) and screwed. Before it is probably necessary to treat the O-ring with vacuum grease, if the O-ring groove of the delivered EMMI-flange is not perfect!

- The vacuum valve and gauge are ready installed.

- If closed completely the cryostat has to be pumped at least for **48 hours**.

- **Then a leak test with helium and a mass spectrometer or a special helium leak tester has to be done.**

  If there is a leak, no varnish has to applied, because this is a very bad "quick and dirty"-method, that does not work over a long time properly.

  Instead the leakage producing part (O-ring, bad inspected or cleaned surface etc.) has to be inspected, cleaned, probably replaced and again carefully installed.

- The pressure at room temperature in the cryostat after 48 hours of pumping is around 2 times 10^{-5} mbar. The pressure at the cold temperature several hours after liquid nitrogen filling in the cryostat is around 2 times 10^{-6} mbar. If the pressures are much higher, there is a leak in the cryostat (e.g. at the field-lens O-ring, at the EMMI-flange O-ring or at the vacuum valve respectively the vacuum gauge O-rings).

  Also if the temperature does not reach the expected value there is a leak or a undesired touching of the radiation shields to other parts.

  In all these cases the problem has to be solved <u>before</u> installation of the cryostat to the instrument.

  The cooling down takes approx. 6 hours, if the vacuum in the cryostat is good.

3 Interconnection

Same cables required as for all the VME systems usual.

Before connecting cables with the CCD-dewar be sure, that there is **no** remaining conductive foam in the connector sleeves at the cryostat ! This would produce a short-cut and could damage the chip.

4 System Setup

This chip can only be used with the ESO-VME CCD camera system.

All measurements have been done in the 2 by 2 binned mode or without binning.

The clock-pattern jg2020a and the A-amplifier are used. (The B-amplifier is available with jg2020b.)

Normal parameters are SUBPATT 3 and GAIN 2.

The preamplifier current is controlled by a 20 kOhm resistor.

All tests were performed at 160 K, if not otherwise stated. The optimal operation temperature is 155-170 K.

The cryostat should has a hold time of approx. 24 hours at this temperature on condition that the vacuum is good (2E-6 mbar) and the liquid nitrogen filling is done at this temperature of 155-170 K.

5 Voltage Setup

See table 1 on page 5 for all voltage values. Please note that especially the values VDD1/2, RLO1/2 and RHI1/2 have a rather high influence on the gain. They should be adjusted as accurate as possible.

VLO1	-8.00	VHI1	+5.00	VLO2	-5.00	VHI2	+5.00
HLO1	-5.00	HHI1	+5.00	HLO2	-5.00	HHI2	+5.00
RLO1	0.00	RHI1	+4.70	RLO2	-4.00	RHI2	+7.00
VDD1	+22.60	VDR1	+13.40	VDD2	+22.75	VDR2	+12.50
VGS1	0.00	VSS1	0.00	VGS2	0.00	VSS2	0.00

Table 1: Telemetry values

6 Noise and Gain

The conversion factor is 1.47 ± 0.03 e$^-$/ADU with the A-amplifier.

With the B-amplifier we got a value of 1.35 ± 0.04 e$^-$/ADU.

This and all other tests have been done with the ESO-LAB-VME CCD camera system.

The system gain was set to GAIN 2, SUBPATT 3.

The readout-noise is approx. 6.6 ± 0.5 e$^-$ RMS for the A- and B-amplifier,

The noise and gain was measured using the HP-desktop procedure "MEASURE CONFACT" at different illumination levels.

It can be also measured using the IHAP batch 'CONFOR' at illumination levels around 8 000 counts (16 bit ADC).

7 Quantum Efficiency

The RQE was measured using an automatic mode, of the test-bench computer. The values listed below might be no more accurate than ±2% (relative), because the measurement of the CCD conversion gain in e$^-$/ADU is the biggest uncertainty. We have assumed the worst case for the quantum efficiency.

The peak value for RQE of CCD was around 49% at 700 NM.

The UV response could be improved after the UV coating treatment of LORAL (evaporation of a material) and seems to be quite stable. The RQE value in the UV was around 18%.

THE UV-CHIP COATING IS SENSITIVE, THEREFORE DO NOT EXPOSE THE

CCD SENSITIVITY CALIBRATION: 4 Feb 1993 18:08:35

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Detector ID            : L_W17_4
Calibrated against     : _SDC1_NP_1
Detector area (cm2)    : 2.25E-06
e-/[ADU]               : 1.47
System gain            :      2     Subpattern          :    3
Misc.Comments          : L-COATED,A-AMPLIFIER

CCD System values      :            Scanned CCD area
-----------------      :            ----------------
Hor. act. Pixels       :   2100     First pixel         :   810
Tot. vert. Lines       :   2070     Last pixel          :   910
Hor.  Binning          :      1     First line          :   990
Vert. Binning          :      1     Last line           :  1090
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Lambda [nm]	Time [sec]	Dens [log]	Temp [K]	Counts [ADU]	RQE [%]	Sensitivity [A/(W/cm2)]	Photon flux [Phot/cm2]	Irradiance [W/cm2]
320	300	0.0	158.5	500	18.90	+1.104E-07	+5.760E+06	+3.553E-12
340	300	0.0	158.5	2084	18.43	+1.140E-07	+2.463E+07	+1.434E-11
360	300	8.6	158.5	1996	18.19	+1.190E-07	+2.389E+07	+1.316E-11
380	60	8.6	158.5	1544	18.06	+1.248E-07	+9.308E+07	+4.852E-11
400	40	0.0	158.5	1746	19.03	+1.378E-07	+1.498E+08	+7.453E-11
450	10	0.0	158.5	1433	18.37	+1.498E-07	+5.095E+08	+2.252E-10
500	10	.3	158.5	2307	32.06	+2.908E-07	+4.701E+08	+1.867E-10
550	10	.3	158.4	6566	39.62	+3.956E-07	+1.083E+09	+3.906E-10
600	10	.9	158.4	2512	45.67	+4.963E-07	+3.594E+08	+1.191E-10
650	10	.9	158.4	2894	48.08	+5.611E-07	+3.933E+08	+1.214E-10
700	10	.9	158.4	3704	49.02	+6.220E-07	+4.936E+08	+1.401E-10
750	10	.9	158.4	2544	46.59	+6.329E-07	+3.567E+08	+9.459E-11
800	10	.6	158.4	4927	42.49	+6.160E-07	+7.577E+08	+1.883E-10
850	10	.6	158.4	4986	32.35	+4.993E-07	+1.007E+09	+2.351E-10
900	10	0.0	158.4	7151	20.16	+3.289E-07	+2.318E+09	+5.117E-10
950	10	0.0	158.4	3396	9.95	+1.712E-07	+2.229E+09	+4.668E-10
1000	20	0.0	158.4	3033	3.20	+5.789E-08	+3.097E+09	+6.164E-10

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Table 2: RQE measurement protocol for the CCD chip at a temperature of 158.5 K

COATED CCD TO LONGER AMBIENT LIGHT AND DO NOT KEEP IT IN VACUUM AT ROOM TEMPERATURE FOR A LONG TIME. DO NOT TOUCH THE SURFACE, NOT EVEN WITH A BRUSH.

Figure 1 on page 10 shows a plot of the obtained values.

8 Charge Transfer Efficiency

The CTE was measured using Flat Field exposures in the 2x2 binned mode with its overscan regions and gives:

Horizontal CTE = 0.9999985 and Vertical CTE = 0.9999792

9 Dark Current

The dark current was measured with a 1 hour dark exposure at a temperature of 161 K after more than 12 hours in the dark wiping the CCD every minute.

The mean dark current rate is $2 \pm 1\ e^{-}/pixel/hour$ at 161 K.

The "zero-level" (in the unbinned mode) is 333.2 ±4.7 ADU.

10 Linearity

Linearity was measured taking 100 exposures of 50 sec duration at different light levels at 700 NM from approx. 18 photons/pixel up to $3.7 \cdot 10^{5}$ photons/pixel. **There is a maximum deviation of ±1 % from the average value within 3.5 decades.**
and ±3 % within 4.5 decades.
This measurement is limited in the low light region from shot-noise and in the high light region from the precision of the current measurement device (measuring the photo-current of the reference diode).

11 Full well capacity

The full well capacity was measured with flat field images of high intensity.

Upper limit of linearity: 187 000 ± 5 000 e^{-}/pixel
Full well capacity : 216 000 ± 5 000 e^{-}/pixel

12 Cosmic Ray Events

The Cosmic Ray Event rate was measured using our standard method (IHAP Batch: COSRAY) to count *events* independently of their actual size.

The cosmic ray event rate is $1.30 \pm 0.1\ events/min/cm^{2}$**.**

13 Blemishes

On a 5 sec high light level flat field exposure (FF/5s/700NM/D=0.0) we have noticed:

2 defect double lines, where the right line is at the same level brighter as the left line is darker:

Location 1: X=1884..1885 and Y $\geq$ 418 with a higher and lower value of 20%

Location 2: X=803..804 and Y $\geq$ 1941 with a higher and lower value of 50%

and 2 very weak dark line defects at X = 489, Y $\geq$ 1122 and X = 1153, y $\geq$ 1073.

On a 10 sec low light level exposure (FF/10s/700NM/D=2.5) we have noticed in addition to the above mentioned second double line several traps as for front illuminated CCDs usual: All bigger traps, consuming more than 150 e^- in the central 1800 x 1800 pixel of the CCD are given:

Location of traps Number	Pixel coordinate	Line coordinate	lost electrons
1	144	1865	300
2	147	1865	250
3	169	1853	1000
4	174	1757	350
5	176	1867	250
6	202	1798	2000
7	204	1738	300
8	214	1720	250
9	225	220	200
10	252	1748	3000
11	254	1161	250
12	258	1136	200
13	260	1737	300
14	314	1339	1400
15	328	1846	3100
16	334	1844	1300
17	345	1848	200
18	581	865	1250
19	592	1510	1700
20	634	1319	2300
21	673	1410	1200
22	810	1383	3100
23	884	1657	400
24	1082	462	350
25	1191	777	350
26	1213	1694	3300
27	1220..2	259	4000
28	1257	1108	200
29	1472	1462	200
30	1862	1882	200

On a 2 Hour dark exposure no blemishes are visible except of the cosmics

See figure 2 on page 11 for more detail about the traps at low light level exposures.

14 Uniformity

The homogeneity was measured using a standard method of sampling the whole sensitive area and using the RMS value of it. Values of deviations from homogeneity are given in table 3.

Flat-field exposure at a wavelength in [NM]	RMS Deviation from mean value in [%]
340	5
400	3.0
550	1.8
700	1.5
1000	2.4

Table 3: Uniformity of the CCD

There are no fringes due to the UV-coating.

15 Remanence

The Remanence behavior is similar to the other Ford 2k CCDs where the Remanence was measured with 10 minutes dark exposures taken just after each bright light exposure.

No Remanence was noted after a light level of 1/10 Full well capacity, a very weak Remanence of 0.7 e^- was noted after an exposure equivalent to Full well capacity and a Remanence of about 9 e^- was noted after an exposure equivalent to 10 times Full well capacity.

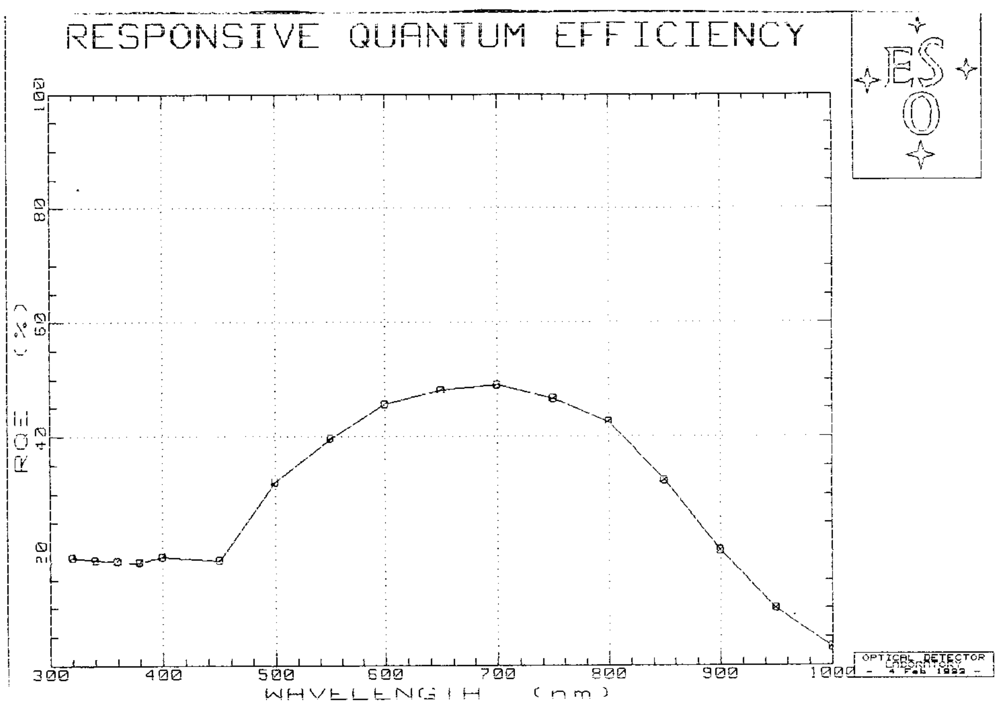

Figure 1: Plot of RQE values of the CCD chip

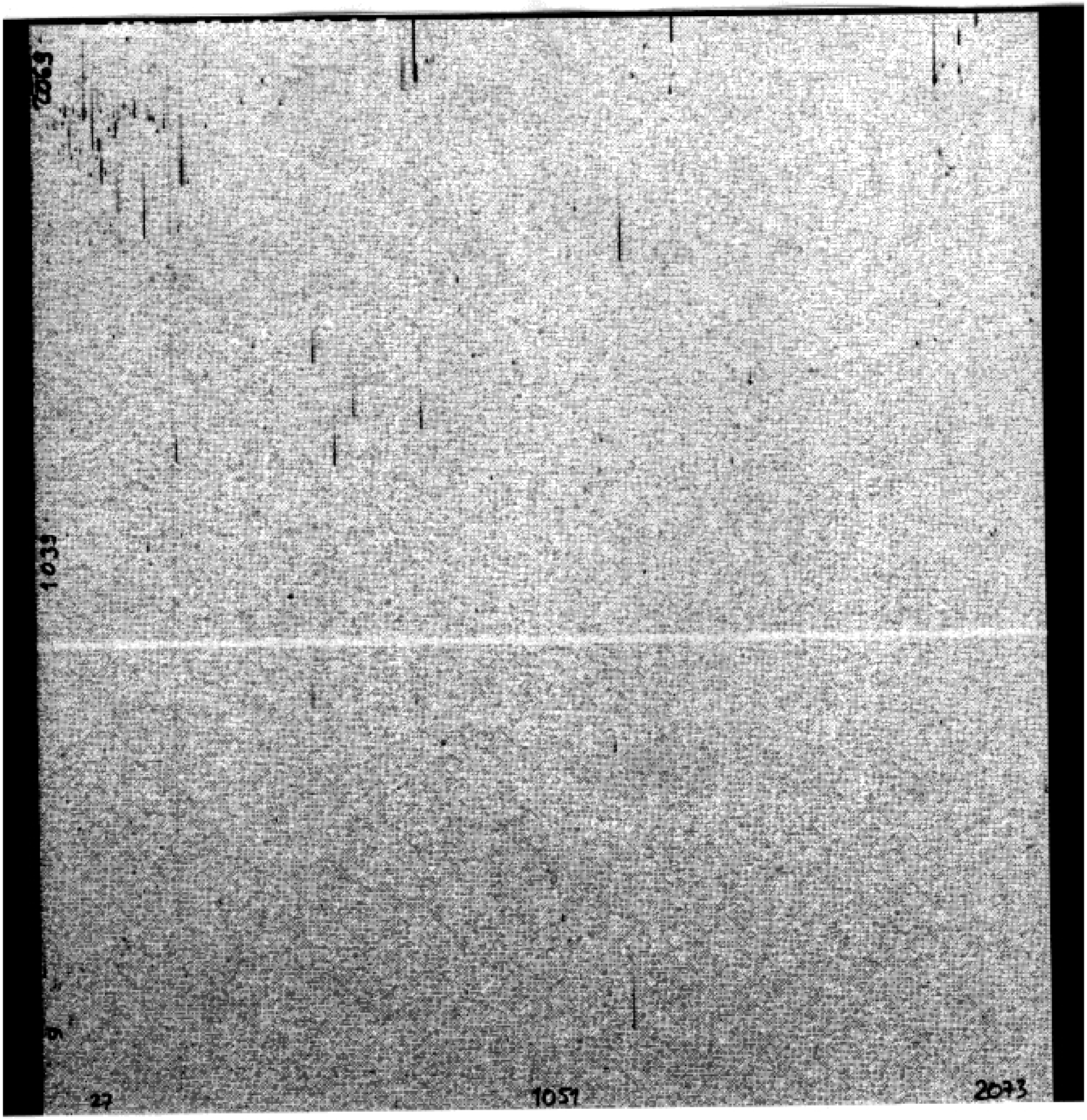

Figure 2: Map of traps seen on a low light level exposure (100 e^- per pixel)

References

[1] Miller. FORTH Compiler Manual.

[2] Roland Reiß. Universal Introduction into the VME based CCD Control Camera, published in Sarajewo

[3] S. Deiries, M. Cullum: ESO Maintenance Manual No.5 July 89, CCD Cryostat for new VME-based Control Camera.