CHIP CHARACTERISTICS FOR Loral/Lesser ml2k3ebBI W2-1

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1 General Description

Chip type	: Loral/Lesser ml2k3ebBI Grade Poor, thinned, AR coated, MPP
Chip characteristics:	AR coating: PPtF, 500 Å HfO_2,
	: O_2 soaking required
Chip format	: 2048x2048, 0 pre-scan pixels in horizontal direction
Pixel size	: 15 x 15μm^2
Serial No.	: W2-1

The cryostat electronic board has special clock shaping capacitors for this CCD (C65-67: 180nF).

2 Flatness of the chip

TBD

3 System Setup

This chip has been tested with the ESO-VME CCD camera system.

The clock-pattern ml2k3bab2 with MPP–mode have been used for the tests.

Parameters are set to SUBPATT 3 and GAIN 2, if not otherwise mentioned.

All tests were performed between 160 K and 180 K, if not otherwise mentioned.

4 Voltage Setup

See table 1 on page 2 for all voltage values.

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VLO1 :  -8.02 VHI1 :  2.51 VLO2 :  -5.00 VHI2 :  7.03
HLO1 :  -5.03 HHI1 :  7.02 HLO2 :  -5.02 HHI2 :  7.01
RLO1 :  0.00 RHI1 :  10.02 RLO2 :  0.00 RHI2 :  10.03
VDD1 :  23.34 VDR1 :  14.18 VDD2 :  23.34 VDR2 :  15.72
VGS1 :  0.08 VSS1 :  0.00 VGS2 :  1.56 VSS2 :  0.00
```

Table 1: Telemetry values

5 Noise and Gain

Amplifier 1:

The conversion factor is (at GAIN = 2)

1.163 ±0.007 **e$^-$/ADU.** at subpatt 3

The readout-noise is

6.0 ±0.1 **e$^-$ RMS** at subpatt 3

Amplifier 2:

The conversion factor is (at GAIN = 2)

3.039 ±0.147 **e$^-$/ADU.** at subpatt 2

1.639±0.019 **e$^-$/ADU.** at subpatt 3

1.589 ±0.019 **e$^-$/ADU.** at subpatt 3 and 2x2 binning

0.848 ±0.025 **e$^-$/ADU.** at subpatt 4

The readout-noise is

6.3 ±0.4 **e$^-$ RMS** at subpatt 2

5.9±0.1 **e$^-$ RMS** at subpatt 3

6.3 ±0.3 **e$^-$ RMS** at subpatt 3 and 2x2 binning

5.6 ± 0.2 $\mathbf{e^-}$ **RMS** at subpatt 4

The noise and gain was measured using the HP-desktop procedure "MEASURE CONFACT" at different illumination levels. This procedure takes two equal dark– and two equal flat-field exposures calculating noise and gain independent from the light level with the variance of the difference of the two flat-fields.

6 Pick-up Noise

At slow-mode pick-up noise could not be seen at short dark exposures.

7 Quantum Efficiency

```
CCD SENSITIVITY CALIBRATION:                        12 Apr 1996   20:13:25
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Detector ID         : ml2kW21      Detector            : Loral/Lesser
Calibrated against  : _SDC2_NP_2   Type                : ml2k3ebBI
Detector area (cm2) : 2.25E-06     ESO CCD No.         :    2287
e-/[ADU]            :  1.74        Used Output(s)      :     1
System gain         :     2        Subpattern          :     3
Misc.Comments       : ml2k3bab2L1-_W2-1

CCD System values   :          Scanned CCD area
-----------------   :          ----------------
Hor. act. Pixels    :  2060        First pixel         :    20
Tot. vert. Lines    :  2060        Last pixel          :  2030
Hor.  Binning       :     1        First line          :    20
Vert. Binning       :     1        Last line           :  2030
```

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	163.6	577	47.41	9.65	+2.769E-07	+3.131E+06	+1.931E-12
340	300	0.0	163.6	2314	55.01	8.77	+3.402E-07	+1.083E+07	+6.307E-12
360	300	8.6	163.7	2531	63.70	9.98	+4.165E-07	+1.023E+07	+5.635E-12
380	60	8.6	163.6	2442	77.03	12.09	+5.323E-07	+4.080E+07	+2.127E-11
400	20	0.0	163.6	1992	92.04	14.94	+6.664E-07	+8.358E+07	+4.158E-11
450	10	0.0	163.6	4110	91.22	11.73	+7.435E-07	+3.480E+08	+1.538E-10
500	10	.3	163.6	4094	90.66	11.66	+8.222E-07	+3.488E+08	+1.385E-10
550	10	.6	163.6	4773	91.00	10.59	+9.086E-07	+4.050E+08	+1.461E-10
600	10	.9	163.6	3436	93.07	13.00	+1.011E-06	+2.851E+08	+9.450E-11
650	10	.9	163.6	3640	86.64	11.77	+1.011E-06	+3.244E+08	+1.001E-10
700	10	.9	163.6	4680	84.99	9.98	+1.078E-06	+4.253E+08	+1.207E-10
750	10	.9	163.6	2984	75.99	11.14	+1.032E-06	+3.033E+08	+8.042E-11
800	10	.6	163.6	5643	66.56	6.94	+9.649E-07	+6.547E+08	+1.627E-10
850	10	.6	163.6	5153	50.92	5.60	+7.859E-07	+7.815E+08	+1.824E-10
900	10	.4	163.6	5345	35.69	3.84	+5.823E-07	+1.157E+09	+2.554E-10
950	10	0.0	163.6	6365	21.11	2.06	+3.632E-07	+2.328E+09	+4.875E-10
1000	10	0.0	163.7	3472	8.46	1.16	+1.531E-07	+3.170E+09	+6.311E-10
1040	10	0.0	163.6	3458	2.81	.40	+5.319E-08	+9.489E+09	+1.809E-09
1080	10	0.0	163.7	1701	1.11	.19	+2.186E-08	+1.182E+10	+2.164E-09
1100	10	0.0	163.6	2597	1.35	.21	+2.700E-08	+1.481E+10	+2.675E-09

```
Calibration_error=    1.50%  Conversion_factor_error=   1.15%
_ML2KW21_23 stored on /users/ms/cali:HFS at 13 Apr 1996 05:13:49
```

Table: RQE measurement protocols for the CCD chip

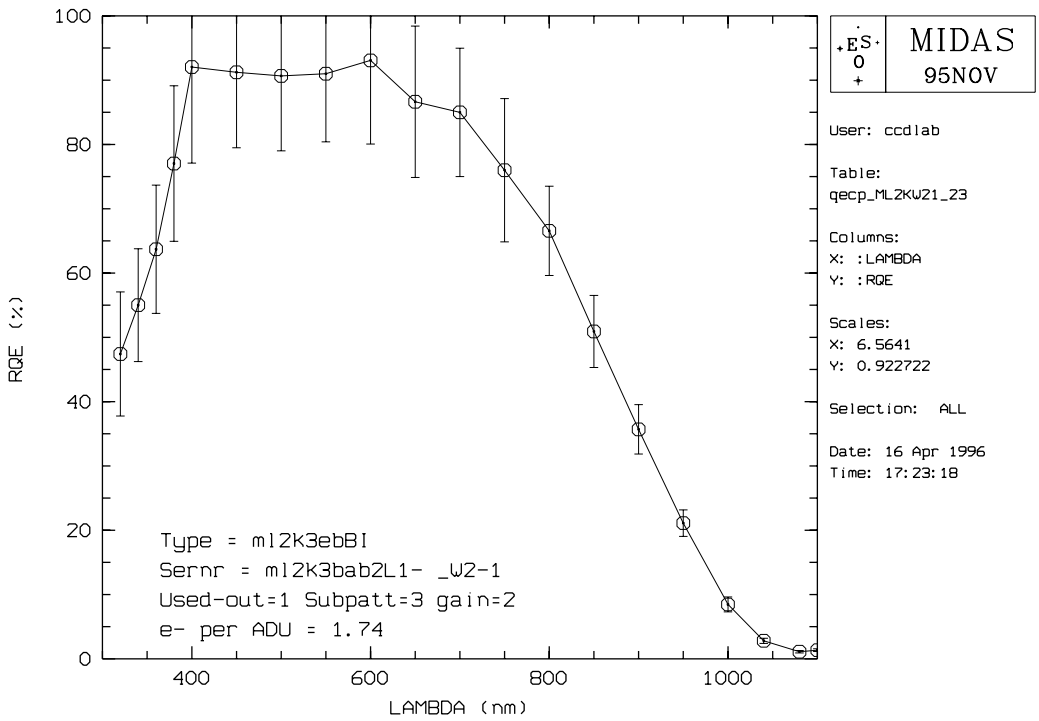

Figure 1: Plot of RQE values of the CCD (complete surface) at 163 K

The RQE was measured in an automatic mode using the test-bench computer. The quantum-efficiency values and their errors are listed below. The given error is the geometrical sum of the error of test-bench calibration (approximate 1.5%), the error of the CCD conversion factor measurement (approximate 1.15%) and of the variation of the quantum-efficiency over the whole chip surface (dependent from the light wavelength). The variation of quantum efficiency over the chip can be seen in detail in the homogeneity measurement in section 14 on page 10. To achieve the stated Quantum efficiency, the CCD was stored at ambient air for some weeks and then pumped four days and simply cooled down to 163 K.
The peak value for RQE of CCD was approx. 93% at 600nm.

Figure 1 on page 5 shows the plot of QE for the CCD.

8 Charge Transfer Efficiency

The CTE was measured using Flat Field exposures and its over-scan regions and gives:

Amplifier 2:

Serial CTE = 0.999938

Other values could not be measured with the EPER method, because the last active pixels are partially covered by wax due to the thinning process.

9 Dark Current

The dark current was measured with a 20 minutes dark exposures with MPP–mode after more than 5 hours in the dark wiping the CCD every minute.

The mean dark current rate is approx. 5.7 ± 1.17 $e^-/pixel/hour$ at 163 K.

10 Linearity

Linearity was measured taking exposures of the same exposure-time at different light levels and at a wavelength of 700 nm.

Amplifier 1:

There is a maximum deviation of less than ±1.1% from the average value within 2.28 decades from 870 to 164600 e^- per pixel.

Amplifier 2:

There is a maximum deviation of less than ±1.1% from the average value within 1.95 decades from 530 to 47000 e^- per pixel.

See figure 2 on page 6 for details.

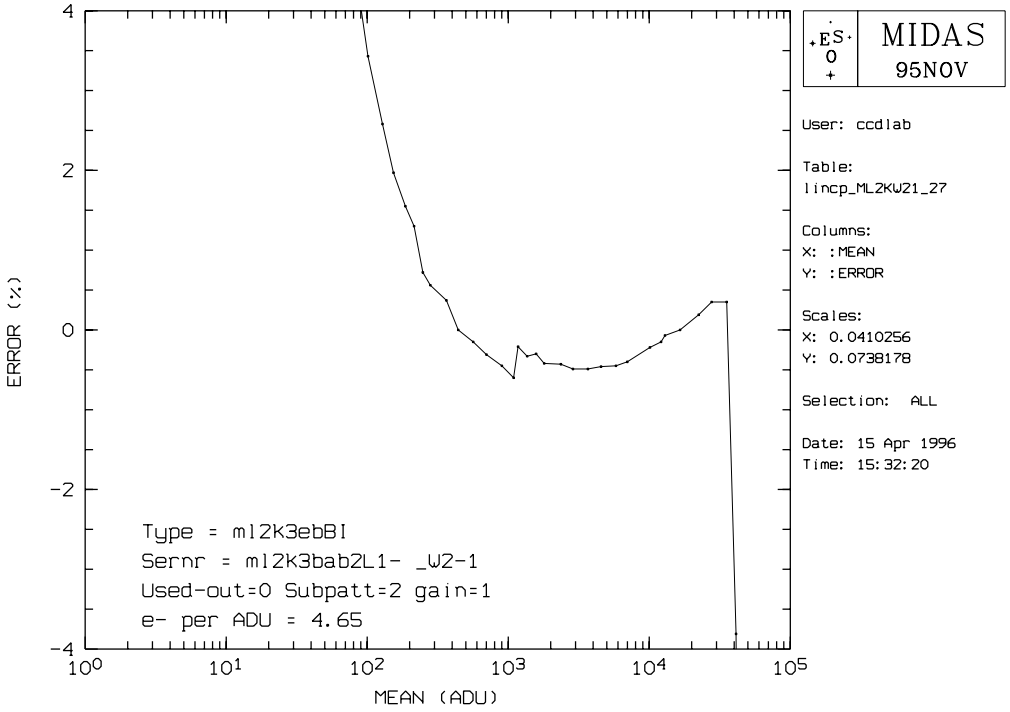

Figure 2: Linearity Measurement with amplifier 1

In view of the other problems with this CCD, the linearity was not optimized with the

voltage setup.

There is a big problem with linearity at this CCD.

11 Full well capacity

The full well capacity was measured with flat-field exposures of high intensities in MPP–mode. The limit of linearity is reached, if at higher intensities the deviation from linearity starts to get larger than the given maximum deviation in the section 10 on page 6.

Amplifier 1:

Upper limit of linearity: 118 000 e^-/pixel
Saturation-value: 183 000 e^-/pixel

Amplifier 2:

Upper limit of linearity: 137 000 e^-/pixel
Saturation-value: 183 000 e^-/pixel

Horizontal voltage has to be adjusted to prevent charge smearing at high illumination values.

12 Cosmic Ray Events

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

The cosmic ray event rate is $1.74 + 0.2 - 0.2$ $events/min/cm^2$**.**

13 Blemishes

With the Amplifier 1 we found 636375 defective pixels. This was measured using three weak light images with a level of approximate 275 e^- per pixel (see page 9) and an automatic MIDAS-procedure to identify and catalogue the defects.

This test is very sensitive: A column defect is any defect which is longer than 10 pixels and a defect is any pixel which is lower than 50 % or higher than 200 % of the mean level of a weak light flat field exposure.

```
Number of hot defects:
Hot spots: 3; Hot cluster: 141; Hot columns: 1

Number of dark defects:
Dark pixel: 321; Dark cluster: 133; Dark columns: 103; Traps: 454

Number of all defects: 1156
```

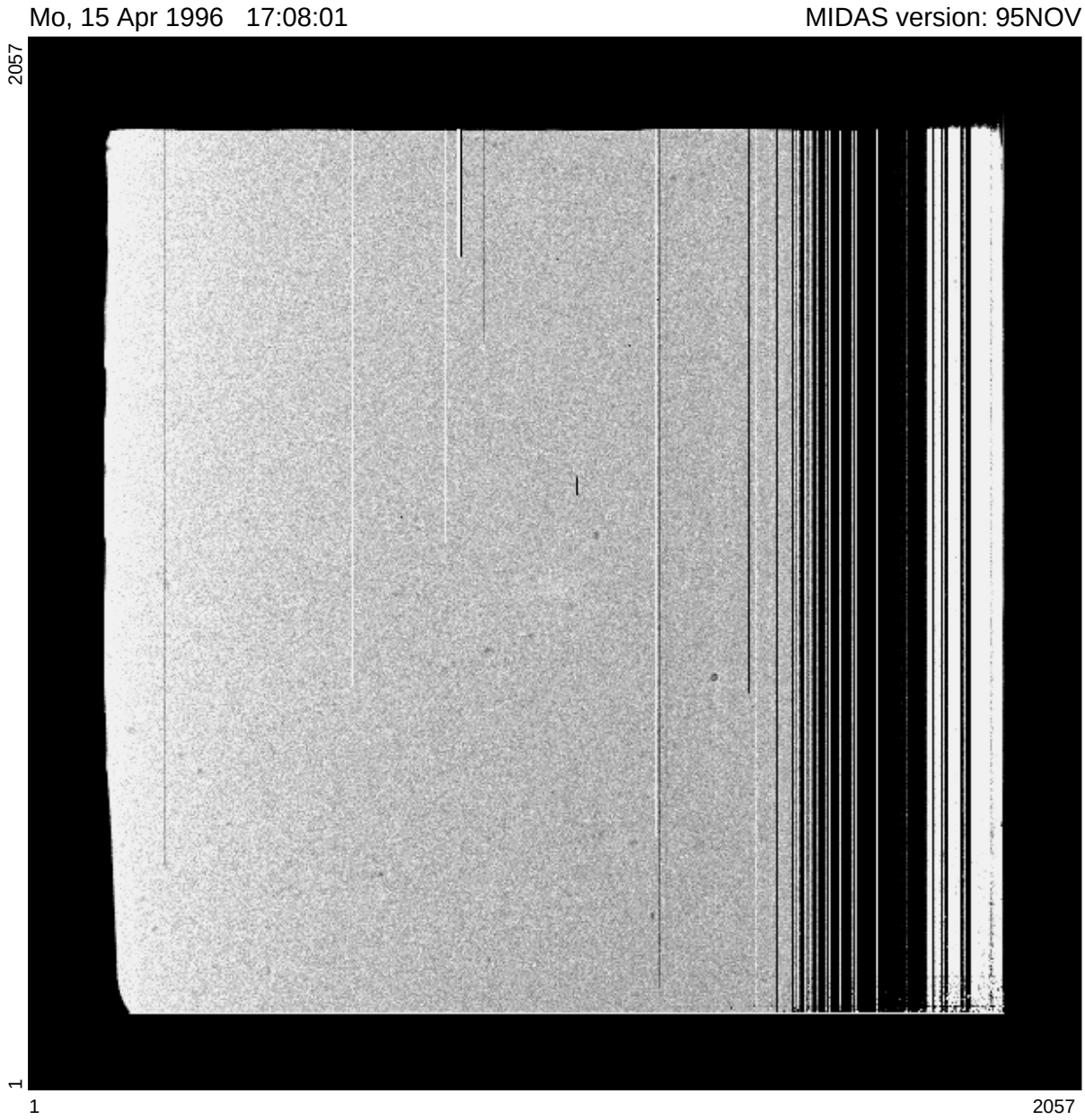

Figure 3: Weak Flat field (700nm,2.5): approx. 275 e^- per pixel with amplifier 1.

With the Amplifier 2 we found 630572 defective pixels.

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Number of hot defects:
Hot spots: 5; Hot cluster: 163; Hot columns: 2

Number of dark defects:
Dark pixel: 197; Dark cluster: 188; Dark columns: 103; Traps: 373

Number of all defects: 1031
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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 2 on page 10.

Flat-field exposure at a wavelength in [nm]	Maximal RMS Deviation from mean value in [%]
320	20.27
340	15.83
360	15.55
380	15.59
400	16.12
450	12.72
500	12.72
550	11.49
600	13.83
650	13.45
700	11.59
750	14.54
800	10.25
850	10.84
900	10.58
950	9.56
1000	13.64
1040	14.15
1080	16.58
1100	15.17

Table 2: Uniformity of the CCD

15 Remanence

Exposure Type	Exposure Time in [sec]	Illumination in [photons/pixel]	CCD Saturation	Remanence in [e^- per pixel]
FF white	1(Dens=1)	67000	0.26	—–
DK	600	—	—	0
FF white	1	589000	2.26	—–
DK	600	—	—	32
DK	600	—	—	6
DK	600	—	—	2
FF white	10	5896000	22.55	—–
DK	600	—	—	48
DK	600	—	—	11
DK	600	—	—	5

Table 3: Remanence of the CCD at 163 K

The Remanence test was made after 10 hours in the dark and periodical wiping at at temperature of 163 K. After a high level flat field with white light which give oversaturation on the CCD, several ten minutes dark exposures have been taken. The mean level in the centre of these dark exposures was compared with the mean level of a ten minute dark before these saturations and the remanence in e^- per pixel has been calculated. The results can be seen in table 3 on page 11.

The remanence is much stronger as with other CCDs of the same type.

References

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

[2] J. Janesick, JPL: Private communication