# CHIP CHARACTERISTICS
# FOR
# Loral/Lesser ml2k3ebBI W_16-1

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## 1 General Description

| | |
|---|---|
| Chip type | : Loral/Lesser ml2k3ebBI Grade Setup, thinned, AR coated, MPP |
| Chip characteristics | : AR Coating: 500 Å $HfO_2$ + 900 Å $MgF_2$, UV–flooding required |
| Chip format | : 2048x2048, 0 pre-scan pixels in horizontal direction |
| Pixel size | : 15 x 15$\mu m^2$ |
| Serial No. | : W_16-1 |

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 ml2k3bab without 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.

```
VLO1 :  -8.01 VHI1 :  2.50 VLO2 :  -5.00 VHI2 :  5.00
HLO1 :  -5.02 HHI1 :  5.04 HLO2 :  -5.01 HHI2 :  5.02
RLO1 :  0.002 RHI1 :  10.04 RLO2 :  0.00 RHI2 :  10.04
VDD1 :  21.49 VDR1 :  12.56 VDD2 :  21.48 VDR2 :  13.17
VGS1 :  1.00 VSS1 :  0.00 VGS2 :  1.01 VSS2 :  0.01
```

Table 1: Telemetry values

# 5 Noise and Gain

## Amplifier 1:

**The conversion factor** is (at GAIN = 2)

$3.650 \pm 0.2$ **e$^-$/ADU.** at subpatt 2

$1.887 \pm 0.06$ **e$^-$/ADU.** at subpatt 3

$1.974 \pm 0.12$ **e$^-$/ADU.** at subpatt 3 and 2x2 binning

$0.908 \pm 0.03$ **e$^-$/ADU.** at subpatt 4

**The readout-noise** is

$55.7 \pm 2.9$ **e$^-$ RMS** at subpatt 2

$52.6 \pm 3.3$ **e$^-$ RMS** at subpatt 3

$61.4 \pm 7.4$ **e$^-$ RMS** at subpatt 3 and 2x2 binning

$46.6 \pm 3.1$ **e$^-$ RMS** at subpatt 4

## Amplifier 2:

**The conversion factor** is (at GAIN = 2)

$1.597 \pm 0.067$ **e$^-$/ADU.** at subpatt 3

$0.860 \pm 0.01$ **e$^-$/ADU.** at subpatt 4

**The readout-noise** is

$7.5 \pm 2.4$ $\mathbf{e^-}$ **RMS** at subpatt 3

$5.9 \pm 0.1$ $\mathbf{e^-}$ **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 Oct 1995   18:39:33
============================

Detector ID         : ml2k161      Detector            : Loral/Lesser
Calibrated against  : _SDC2_NP_2   Type                : ml2k3b=LESS2K3b
Detector area (cm2) : 2.25E-06     ESO CCD No.         :    2230
e-/[ADU]            :  1.31        Used Output(s)      :     1
System gain         :     2        Subpattern          :     3
Misc.Comments       : ml2k3babmppW_16-1

CCD System values   :          Scanned CCD area
-----------------   :          ----------------
Hor. act. Pixels    :  2060        First pixel         :    20
Tot. vert. Lines    :  2060        Last pixel          :  2029
Hor.  Binning       :     1        First line          :    20
Vert. Binning       :     1        Last line           :  2029

Lambda Time  Dens  Temp Counts  RQE  +/-    Sensitivity Photon flux  Irradiance
  [nm] [sec] [log]  [K]  [ADU]  [%]   [%]   [A/(W/cm2)]  [Phot/cm2]   [W/cm2]
*******************************************************************************
   320   300  0.0  167.1   794 57.12  7.96   +3.336E-07  +2.705E+06  +1.668E-12
   340   300  0.0  167.1  3457 69.81  7.39   +4.317E-07  +9.630E+06  +5.609E-12
   360   300  8.6  167.1  3528 75.01  8.04   +4.905E-07  +9.144E+06  +5.038E-12
   380    60  8.6  167.1  2882 75.38  7.97   +5.209E-07  +3.717E+07  +1.938E-11
   400    20  0.0  167.2  2074 81.21  8.58   +5.880E-07  +7.447E+07  +3.705E-11
   450    10  0.0  167.2  3845 71.42  7.20   +5.821E-07  +3.140E+08  +1.388E-10
   500    10   .3  167.2  3936 72.32  7.09   +6.559E-07  +3.175E+08  +1.261E-10
   550    10   .6  167.2  4830 76.02  7.26   +7.591E-07  +3.706E+08  +1.337E-10
   600    10   .9  167.2  3697 81.50  7.65   +8.857E-07  +2.646E+08  +8.771E-11
   650    10   .9  167.3  4175 80.62  7.30   +9.410E-07  +3.021E+08  +9.323E-11
   700    10   .9  167.3  5640 82.63  7.30   +1.049E-06  +3.982E+08  +1.130E-10
   750    10   .9  167.3  3701 77.02  6.62   +1.046E-06  +2.803E+08  +7.433E-11
   800    10   .6  167.3  7343 69.02  5.79   +1.001E-06  +6.206E+08  +1.542E-10
   850    10   .8  167.4  5247 53.03  4.43   +8.185E-07  +5.771E+08  +1.347E-10
   900    10   .5  167.4  5457 37.09  3.08   +6.052E-07  +8.581E+08  +1.895E-10
   950    10  0.0  167.4  8128 21.96  1.84   +3.777E-07  +2.159E+09  +4.522E-10
  1000    10  0.0  167.5  4649  9.10   .78   +1.647E-07  +2.979E+09  +5.930E-10
  1040    10  0.0  167.5  4761  3.11   .28   +5.887E-08  +8.917E+09  +1.700E-09
  1080    10  0.0  167.5  2302  1.24   .12   +2.441E-08  +1.083E+10  +1.982E-09
  1100    10  0.0  167.5  3487  1.45   .13   +2.897E-08  +1.400E+10  +2.529E-09
Calibration_error=    1.50%  Conversion_factor_error=   4.81%
_ML2K161_15 stored on /users/ms/cali:HFS at 13 Oct 1995 01:12:42
```

Table: RQE measurement protocols for the CCD chip

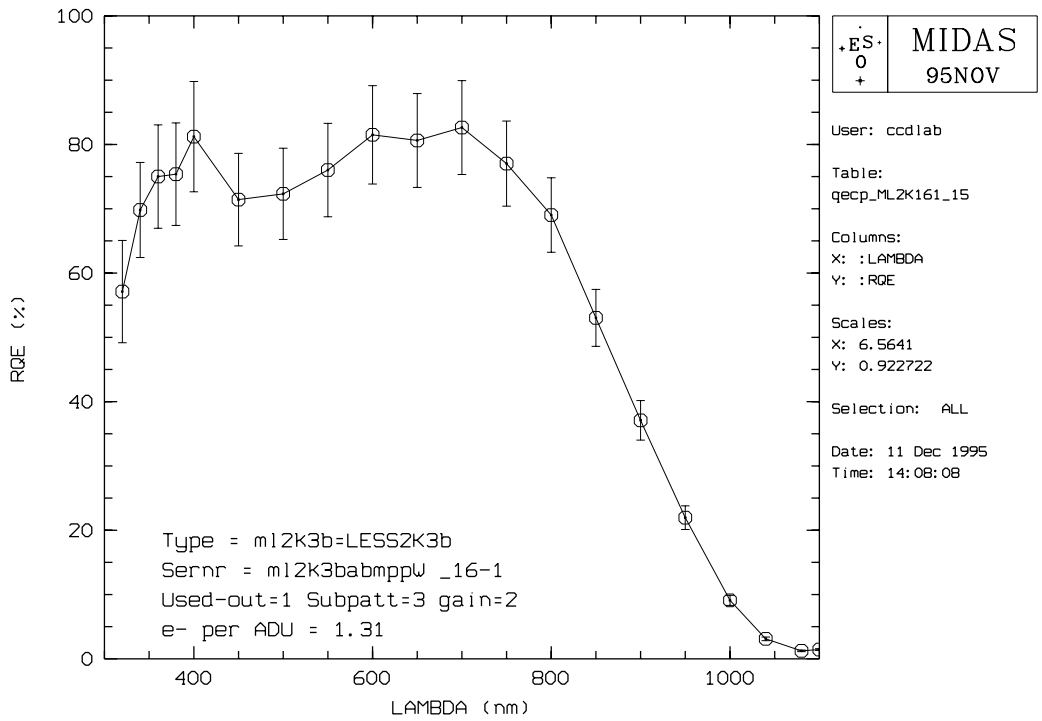



Figure 1: Plot of RQE values of the CCD (complete surface) at 168 K

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 4.8%) 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 9.

The peak value for RQE of CCD was approx. 81 % at 600 nm.

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

## 8 Charge Transfer Efficiency

CTE measurements could not be done with the EPER method because of the wax regions at the edge of the CCD.

## 9 Dark Current

The dark current was measured with a 20 minutes dark exposures without MPP–mode after more than 5 hours in the dark wiping the CCD every minute.

**The mean dark current rate** is approx. $2.2 \pm 0.8$ $e^-/pixel/hour$ at 168 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 $\pm 0.3\%$ from the average value within 3.1 decades from 52 to 66990 $e^-$ per pixel.

## Amplifier 2:

There is a maximum deviation of less than $\pm 0.8\%$ from the average value within 3.1 decades from 21 to 27340 $e^-$ per pixel.

See figure 2 on page 6 for details.

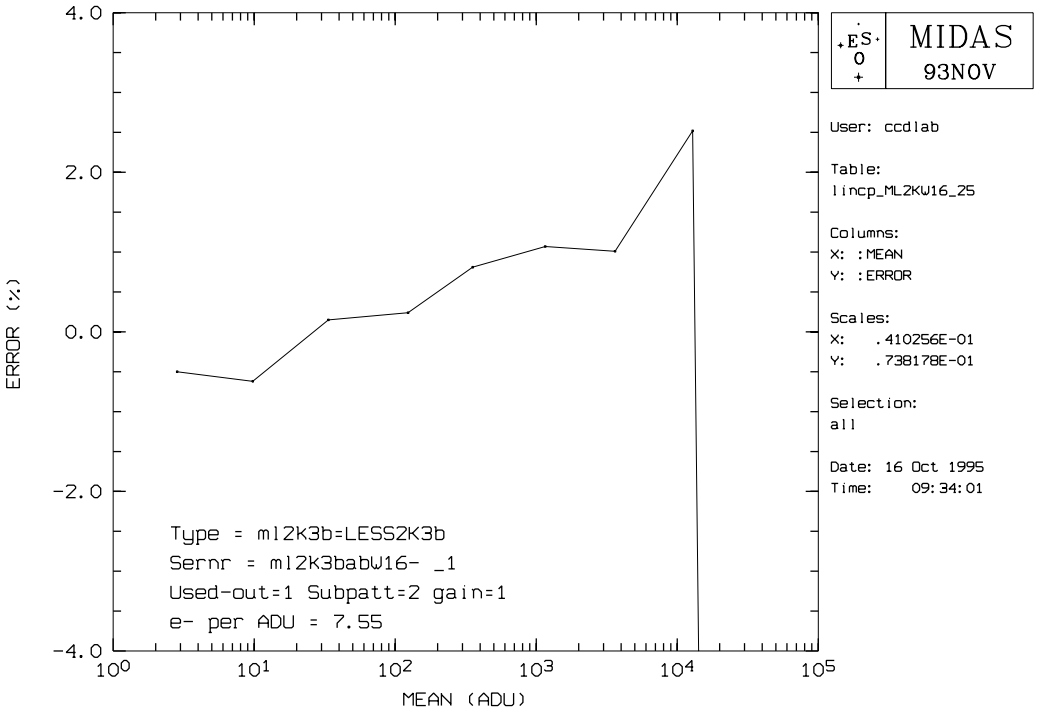



Figure 2: Linearity Measurement with amplifier 2

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

## 11 Full well capacity

The full well capacity was measured with flat-field exposures of high intensities. 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: 70 000 $e^-$/pixel because of "smearing".**
**Saturation-value: 179 000 $e^-$/pixel**

Amplifier 2:

**Upper limit of linearity: 120 000 $e^-$/pixel**
**Saturation-value: 203 000 $e^-$/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** $1.34 + 0.2 - 0.2$ $events/min/cm^2$**.**

## 13 Blemishes

With the Amplifier 1 we found 34211 defective pixels. This was measured using three weak light images with a level of 298 $e^-$ per pixel (see page 8) and an automatic MIDAS-procedure to identify and catalogue the defects.

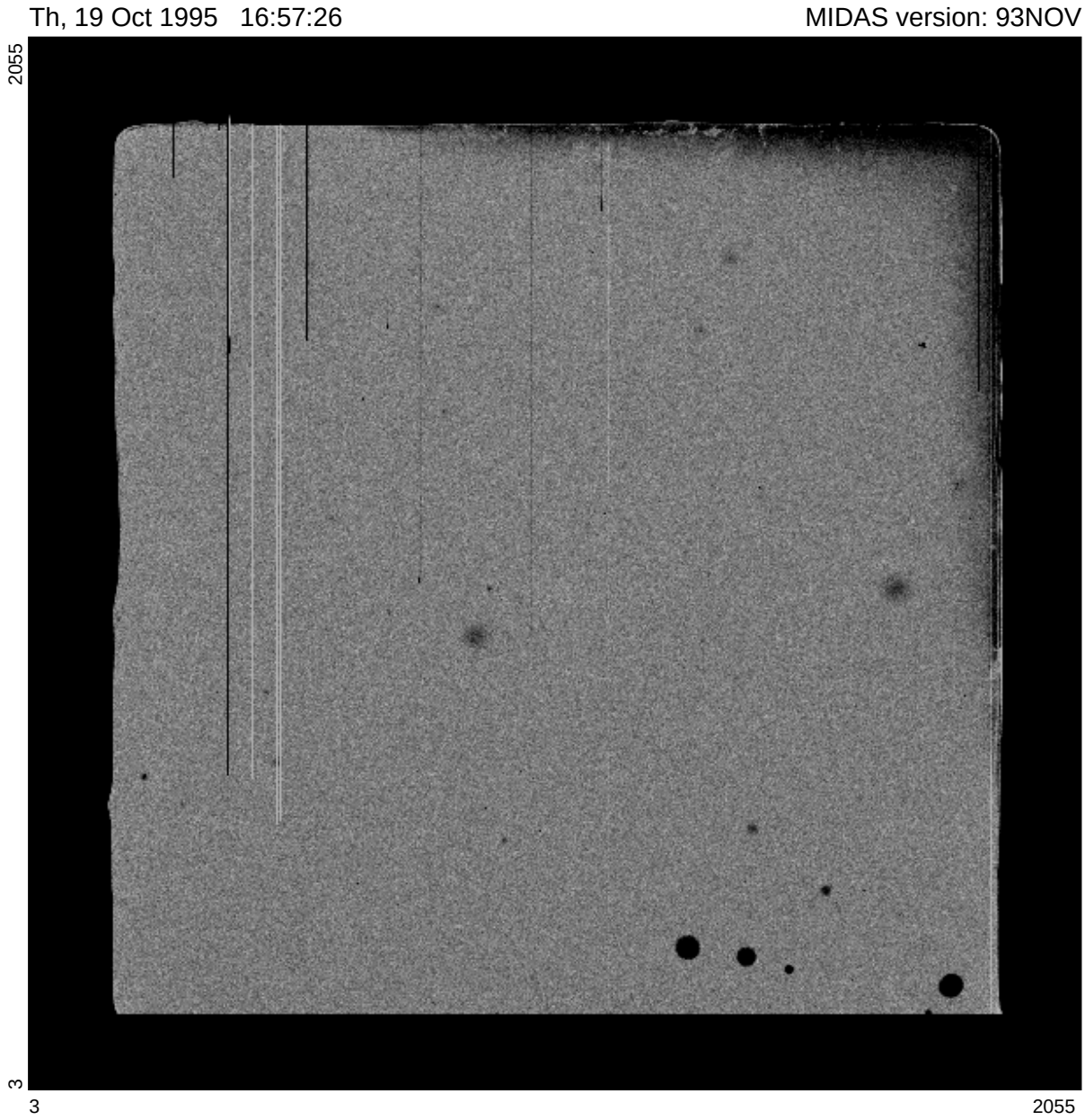
This test is very sensitive: A column defect is any defect which is longer than 10 pixels and a defect is any pixel which is lower than 50 % or higher than 200 % of the mean level of a weak light flat field exposure.

At this CCD a frame of 20 pixels width was excluded during this measurement because of the wax regions at the edges.

```
Number of hot defects:
Hot spots: 0; Hot cluster: 4; Hot columns: 5

Number of dark defects:
Dark pixel: 33; Dark cluster: 543; Dark columns: 101; Traps: 90

Number of all defects: 776
```




Frame : weakmean
Identifier : average frame
ITT-table : ramp.itt
Coordinates : 3, 3 : 2055, 2055
Pixels : 1, 1 : 600, 600
Cut values : 385.64, 446.54
User : ccdlab

Figure 3: Weak Flat field (700nm,2.5): approx. 298 $e^-$ per pixel with amplifier 2.

With the Amplifier 2 we found 36624 defective pixels.

```
Number of hot defects:
Hot spots: 0; Hot cluster: 191; Hot columns: 2

Number of dark defects:
Dark pixel: 7; Dark cluster: 297; Dark columns: 159; Traps: 16

Number of all defects: 672
```

## 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 9.

| Flat-field exposure at a wavelength in [nm] | Maximal RMS Deviation from mean value in [%] |
|---:|---:|
| 320 | 12.99 |
| 340 | 9.31 |
| 360 | 9.46 |
| 380 | 9.29 |
| 400 | 9.29 |
| 450 | 8.73 |
| 500 | 8.41 |
| 550 | 8.10 |
| 600 | 7.92 |
| 650 | 7.51 |
| 700 | 7.26 |
| 750 | 6.96 |
| 800 | 6.71 |
| 850 | 6.66 |
| 900 | 6.61 |
| 950 | 6.71 |
| 1000 | 6.95 |
| 1040 | 7.51 |
| 1080 | 7.94 |
| 1100 | 7.15 |

Table 2: Uniformity of the CCD

## 15 Remanence

The Remanence test was made after 10 hours in the dark and periodical wiping at at temperature of 168 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

| Exposure Type | Exposure Time in [sec] | Illumination in [photons/pixel] | CCD Saturation | Remanence in [$e^-$ per pixel] |
|---|---|---|---|---|
| FF white | 1(Dens=1) | 72000 | 0.24 | —– |
| DK | 600 | — | — | 0 |
| FF white | 1 | 635000 | 2.16 | —– |
| DK | 600 | — | — | 0 |
| DK | 600 | — | — | 0 |
| DK | 600 | — | — | 0 |
| FF white | 10 | 6352000 | 21.6 | —– |
| DK | 600 | — | — | 0 |
| DK | 600 | — | — | 0 |
| DK | 600 | — | — | 0 |

Table 3: Remanence of the CCD at 168 K

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 10. There is **no** significant remanence with this CCD.

## 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