CHIP CHARACTERISTICS
FOR
FORD AEROSPACE FA 2048 L
ESO #30

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1 General Description

ESO S/N	: #30 (in cryostat-tank No.:1387/2)
Chip type	: FORD AEROSPACE FA 2048 L, frontside illuminated, UV-coated (EEV)
Chip format	: 2048x2048, 16 pre–scan pixels in horizontal direction
Pixel size	: 15 x 15 μm^2
Serial No.	: (I) 1-17 0,1

The CCD chip described in this report is the second best of the nine FORD CCDs that ESO has received up to now. This FORD AEROSPACE CCD-chip is coated from EEV to enhance the UV response and is foreseen for the CES instrument at the 3.6m telescope.

Only the Detector Assembly is delivered. This 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 ± 31 micron from the ideal plane.

It should be installed into the Cryostat 1387/2. In this cryostat the Thomson 1k CCD # 18 is installed. To adapt this cryostat to Ford 2k CCDs a small modification is necessary, which is described in section 2 on page 2 in the item: Modification of the Cryostat 1387/2 to adapt it to a Ford 2k CCD.

Into the VME CCD Camera System additional memory boards have to be introduced and some minor modifications (jumpers) have to be carried out (see special Manual from Roland Reiß for this).

The cryostat 1387/2 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. 145 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. 25^{+0}_{-4} hours.

The 16 pre–scan pixels thermally 'isolate' the amplifier from the image section; they contain no intensity information, but reflect the system offset value applied to all pixels. During test period it is recommended to read out this section. During observations the pre–scan area can easily be truncated by defining a readout window in the '*CCD Frame and Binning*' table of the CCD program. Numbering of the image in IHAP starts then with i.e 17 and ends with 2066. It is however possible to suppress these pre–scan pixels already in the CCD system so the first active pixel would have number 1, but this could lead to confusion if sometimes the first active pixel is at X1 and sometimes at X17.

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 works in a clean-air bench and optionally with the help of a **low** pressure anti-static air gun.
- Look for the right parts. The cryostat 1387/2 from the observatory has to be opened, to have a pre-assembly. The Detector assembly #30 has to be introduced after a modification of the cryostat 1387/2:
- Modification of Cryostat 1387/2, to adapt it to a Ford 2k CCDs:

  The radiation shield II (320-05) has to be removed. The spacers (320-20) on it have to be adjusted new in height with suitable washers in a way, that the level of the top of the (really) mounted Radiation shield III (320-25) is adjusted.

The level of this Radiation shield III should be 26.25 ± 0.2 mm over the level of the seal ring surface of the Housing (320-01) for Ford 2K CCDs. This is normally 0.75 mm more as compared with Thomson 1k CCD Cryostats. So you have to add or you have to exchange washers between the spacers (320-20) and the Radiation shield II (320-05). Please check the result by measuring the difference of the two mentioned levels.

- 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 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 delivered EMMI-flange 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 delivered 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 is installed as usual with taking care not to have dust or scratches at the seal surfaces. Note, that the screws intended to fix the valve and the gauge need sometimes **three** washers because of too short windings in the cryostat.
- 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 at 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, because of the missing implementation of the window-read-out mode in Garching.

The clock-pattern FORDa or FORD and the A-amplifier are used.

Normal parameters are SUBPATT 3 and GAIN 2.

The preamplifier current is controlled by a 20 kOhm resistor.

All tests were performed at 173 K, if not otherwise stated. The optimal operation temperature is 160-175 K.

The cryostat should has a hold time of approx. 26 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 160-175 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	+2.00	VLO2	-8.00	VHI2	+2.00
HLO1	-5.00	HHI1	+5.00	HLO2	-5.00	HHI2	+5.00
RLO1	-1.00	RHI1	+7.00	RLO2	-1.00	RHI2	+7.00
VDD1	+23.90	VDR1	+12.00	VDD2	+23.90	VDR2	+12.00
VGS1	+4.00	VSS1	0.00	VGS2	+4.00	VSS2	0.00

Table 1: Telemetry values

6 Noise and Gain

The conversion factor is 2.58 ± 0.2 **e$^-$/ADU.**

This and all other tests have been done with the ESO-LAB-VME CCD camera system, that has in the moment a defect on the ADC-board. Therefore all results depending from the gain and noise measurements are not reliable.

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

The readout-noise is approx. 7.4 ± 1.0 **e**$^{-}$ **RMS.**

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 ±5% (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 45.5 % at 700 NM.

The UV response could be improved after the UV coating treatment of EEV (evaporation of a material) and seems to be quite stable. There is a relative loss of efficiency in the UV after 4 months of storage at room temperature and atmospheric pressure of less than 5%. The RQE value in the UV was around 16%.

THE UV-CHIP COATING IS SENSITIVE, THEREFORE DO NOT EXPOSE THE COATED CCD TO LONGER AMBIENT LIGHT AND DO NOT KEEP IT IN VACUUM AT ROOM TEMPERATURE FOR A LONG TIME.

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 = 0.999977 and Vertical CTE = 0.999968

9 Dark Current

The dark current was measured with a 1 hour dark exposure at a temperature of 183 K after more than 5 hours in the dark wiping the CCD every minute.

The mean dark current rate is 4.5 ± 0.5 $e^{-}/pixel/hour$ at 183 K.

The "zero-level" is 225.9 ±2.7 ADU.

```
CCD SENSITIVITY CALIBRATION:                                19 Mar 1992   17:30:44
==========================

Detector ID          : F_1_17_1_1
Calibrated against   : _SDC1_NP_1
Detector area (cm2)  : 2.25E-06
e-/[ADU]             : 5.15
System gain          :    1    Subpattern          :      3
Misc.Comments        :   COATED,A-AMPLIFIER

CCD System values    :         Scanned CCD area
-----------------    :         ----------------
Hor. act. Pixels     :  1024   First pixel         :    463
Tot. vert. Lines     :  1024   Last pixel          :    552
Hor.  Binning        :     2   First line          :    468
Vert. Binning        :     2   Last line           :    537
```

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	172.6	394	16.48	+3.849E-07	+4.561E+06	+2.813E-12
340	300	0.0	172.8	1727	15.86	+3.924E-07	+2.076E+07	+1.209E-11
360	300	8.6	173.0	1700	15.68	+4.100E-07	+2.068E+07	+1.139E-11
380	60	8.6	172.9	1392	15.93	+4.404E-07	+8.330E+07	+4.342E-11
400	40	0.0	172.9	1584	16.69	+4.835E-07	+1.357E+08	+6.753E-11
450	10	0.0	172.9	1277	15.95	+5.201E-07	+4.582E+08	+2.025E-10
500	10	.3	172.9	1825	23.63	+8.572E-07	+4.420E+08	+1.756E-10
550	10	.3	173.0	6258	34.12	+1.363E-06	+1.049E+09	+3.786E-10
600	10	.9	173.0	2250	36.10	+1.569E-06	+3.567E+08	+1.182E-10
650	10	.9	173.0	2865	40.75	+1.903E-06	+4.023E+08	+1.242E-10
700	10	.9	173.1	4044	45.53	+2.311E-06	+5.083E+08	+1.443E-10
750	10	.9	173.0	2649	38.64	+2.100E-06	+3.923E+08	+1.040E-10
800	10	.6	173.0	4188	29.16	+1.691E-06	+8.218E+08	+2.042E-10
850	10	.3	172.9	7739	18.95	+1.170E-06	+2.337E+09	+5.455E-10
900	10	0.0	173.0	4894	11.00	+7.181E-07	+2.545E+09	+5.619E-10
950	10	0.0	173.0	2486	5.77	+3.971E-07	+2.465E+09	+5.161E-10
1000	20	0.0	173.0	2398	1.99	+1.444E-07	+3.439E+09	+6.846E-10

```
File _F_1_17__4 stored on :,800,0,4 at 20 Mar 1992 08:24:31
```

Table 2: RQE measurement protocol for the CCD chip at a temperature of 173 K

10 Linearity

Linearity was measured taking 100 and 8 sec exposures at different light levels at 700 NM from approx. 22 photons/4pixels up to $9 \cdot 10^5$ photons/4pixels. **There is a maximum deviation of ±5 % from the average value within 4.8 decades.**

11 Full well capacity

The full well capacity was measured with flat field images of high intensity and with spot light sources of high intensities.

Upper limit of linearity: 102 000 e^-/pixel
Full well capacity : 121 000 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 1.35 ± 0.1 $events/min/cm^2$**.**

13 Blemishes

On a 10 sec high light level flat field exposure (FF/10s/700NM/D=0.8) we have noticed:

1 Hot spot at X=614 and Y=1218 with a 30% higher level.

4 Traps at X=90 Y=1370 swallowing 45000 electrons, X=150 Y1940, X=394 Y=1554 swallowing 25000 electrons and X=674 Y1342, all four with zero levels.

2 Double line defects (one line brighter and the neighbor darker) at X=462..466, $Y \geq 1682$ with a deviation of $\pm$ 5% from the mean level respectively

and at X=384..390, $Y \geq 1982$ with a deviation of $\pm$ 8% from the mean level respectively.

6 weak line defects

On a 10 sec low light level exposure (FF/10s/700NM/D=2.8) we have noticed in addition to the above mentioned blemishes the following defects:

1 warm spot with a warm line at X=314, $Y \geq 150$ with values of 210% respectively 20% over the mean level

1 warm line at X=150 3% over the mean level

1 cold line at X=494 15% below the mean level

1 double line defect at X=70..74 and $Y \geq 1194$ with a deviation of $\pm$ 5%

1 additional big trap at X=1370 Y= 1730 that swallows 52000 electrons

6 minor traps containing approx. 7000 electrons and approx. 20 small traps containing approx. 1000 electrons

On a 1 Hour dark exposure additional to the above mentioned blemishes the following defects are visible:

4 Hot spots at X=314, Y=150 and X=394, Y=1742 and X=1370, Y=1734 and X=1898, Y=1638 with very high levels

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

The A amplifier was used because of the less blemishes

The best and cleanest region of the chip is located at X 614...2048 and Y 0...1635

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	2.0
400	1.5
550	1.0
700	1.75
950	2.15

Table 3: Uniformity of the CCD

There are no fringes due to the UV-coating.

15 Remanence / Blooming

A Blooming test procedure was performed with a spot light focused on the CCD surface simulating a starlike source. A visible Blooming effect of ± 180 pixels in the Y-coordinates appeared for an equivalent light level of approximately 25 times Full Well capacity.

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 spot exposure. A Remanence of about 6 e^- was noted on the brightest pixel after an exposure equivalent to 25 times Full well capacity.

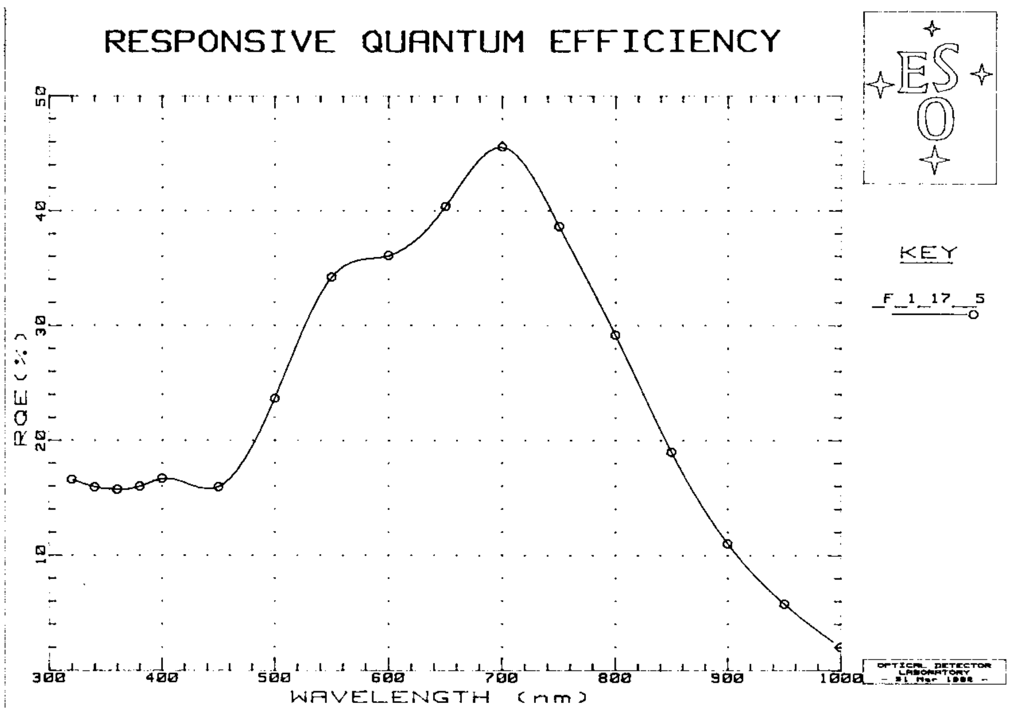

Figure 1: Plot of RQE values of the CCD chip

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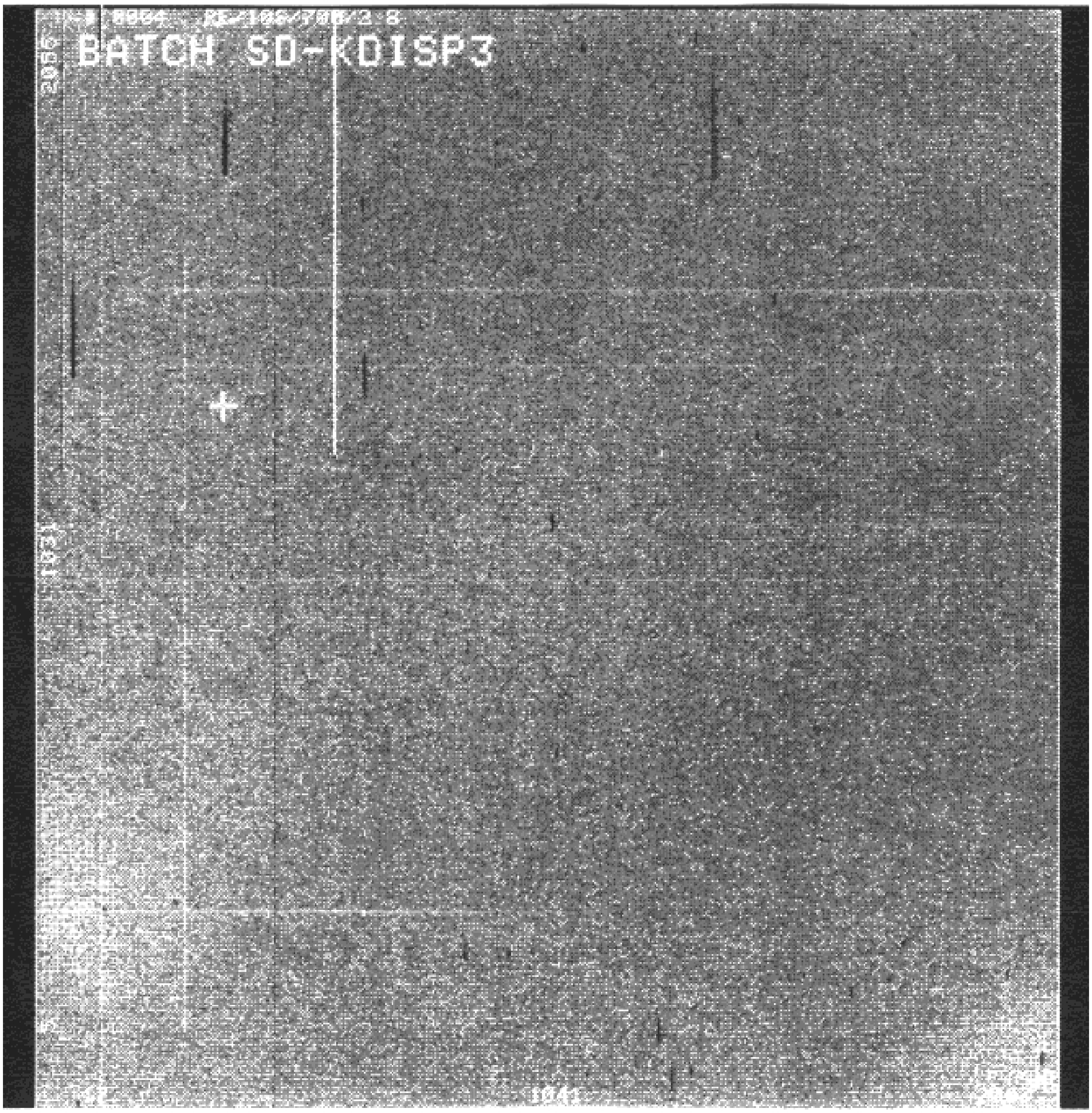

Figure 2: Map of traps seen on a low light level exposure

References

[1] Miller. FORTH Compiler Manual.

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

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