European Southern Observatory

OPTICAL DETECTOR TEAM

VERY LARGE TELESCOPE

NASMYTH ADAPTIVE OPTICS SYSTEM

WFS - CCD detector system : Performance and test report

VLT-TRE-ESO-11650-2592

Issue 1.4

Date 08/11/01

Prepared	Reinhold Dorn, C.Cavadore		04 July 2001
Approved	Norbert Hubin		04 July 2001
Released	Sandro D'odorico		09 July 2001

TABLE OF CONTENTS

Changes record:

Release	Date	By	Changes made
1.1	19/06/2001	C.Cavadore	In hand, to issue 1.2
1.2	27/06/2001	Ph. Feautrier	Accordingly to Ph. Feautrier e-mail posted to naos-ccd list, date 23 Apr 2001
1.3	04/07/2001	C.Cavadore	Final changes
1.4	26/11/2001	C.Cavadore	Clarification of the readout video paths, drawing of preamps versus CCD head and electrical interface.

1. Scope

The purpose of this document is to a provide report on the performance of the final CCD detector system for NAOS. This report will be part of the acceptance of the final CCD detector system. The camera acceptance plan document was taken as a basis to ensure all issues are covered.

2. Applicable and reference documents

2.1 Applicable documents

[1] NAOS Contract: Statement of Work VLT-SOW-ESO-11650-0864

[2] NAOS Contract: Technical Specifications VLT-SPE-ESO-11650-0877

[3] User's Requirements VLT-SPE-NAO-11650-9100

[4] NAOS-Low Noise Fast Read-out CCD Camera Interface Control Document
VLT-ICD-NAO-11650-13640 Issue 3.0

2.2 Reference documents

[5] CCD prototype camera Test Report VLT-TRE-NAO-11650-1-160000-0004 Issue 1.3

[6] CCD Camera flexures Test Report VLT-TRE-NAO-11650-1-160000-0003 Issue 3.0

[7] Technical operating manual of the NAOS CFC (Visible Wave Front Sensor)
VLT-MAN-ESO-11650-1837 Issue 1

[8] Interface CCD-HEAD drawing VLT-IDW-ESO-11650-1612000-0001 (1), issue 6, 14/3/00, Cochard
(Modified by LAOG for interface CCD head acceptance)

[9] Interface of the CCD head for the visible Wave-front sensor of NAOS,
VLT-ICD-ESO-11650-0- 161100-0001, Issue 1, JL Lizon, 6/4/99

[10] Design Report FIERA Visible Detector System R. Gerdes Draft 0.0 9-March-1999

[11] NAOS CCD Detector System Detector design and performance report R. Dorn Draft 0.1 10-8-99
[12] Final CCD Camera Test Report VLT-TRE-NAO-11650-1-160000-0006 Issue 3.0

3. Mechanical interfaces and specifications

3.1. Interfaces specifications: reference plans

The mechanical interfaces between the CCD head and the lenslet holder are described in ref. [8] and [9].

3.1.1. Adapter structure and DFE Power Supply

Dimensions and weight described in ref. [4] Table 3 p9/42

3.1.2. Adapter structure and Detector Head Electronics

Dimensions and weight described in ref. [4] Table 3 p9/42

3.1.3 Cryostat Temperature controller and AD Main Rack

Dimensions and weight described in ref. [4] Table 3 p9/42 and in section 3.2.2 p 9/42

3.1.4 Preamplifiers

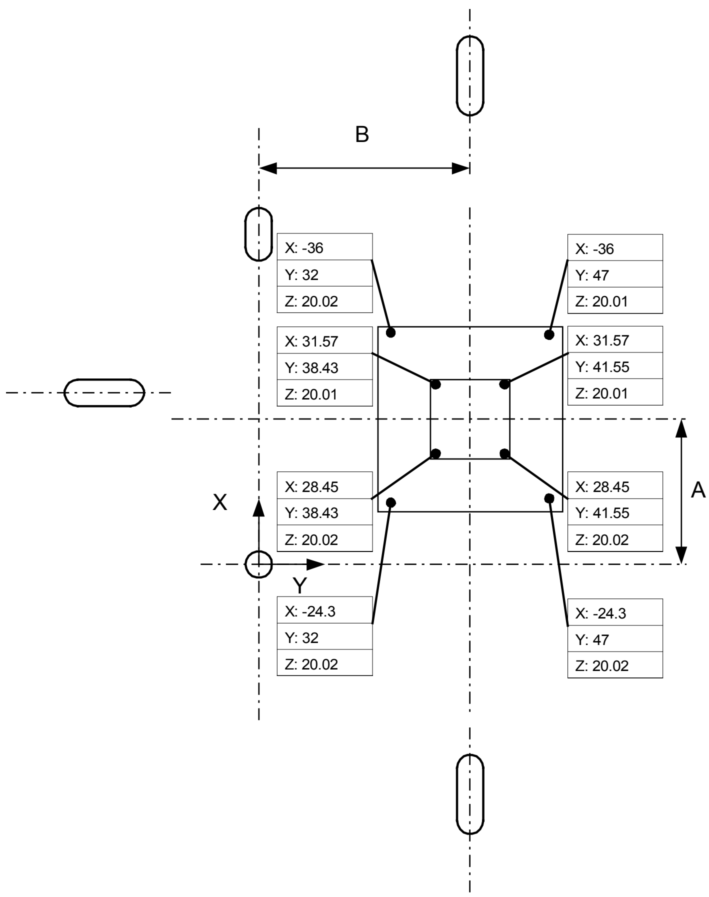
The new preamplifier dimensions are half the size of the dimensions described in ref. [4] section 3.2.2. Reinhold Dorn has sent the drawings to the NAOS consortium.

3.1.5 Chip specifications alignment

a) Position of the chip relative to the lenslet holder

For this measurement the head is leveled such that the reference plane defined by the kinetic interface is parallel to the X and Y axis of the measuring machine.

- X 0 is on the reference point
- Y 0 is on the reference point, the groove is on Y 0
- Z 0 is on the reference plane (flat)



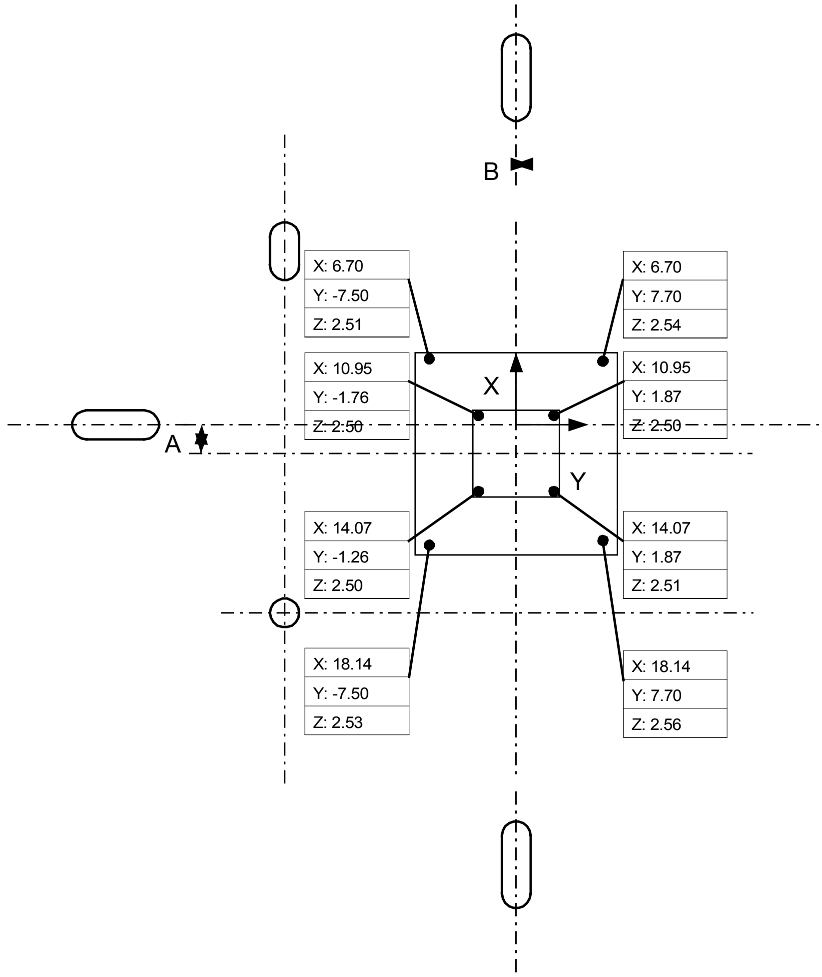
The Z positions has been measured at the edge of the sensitive surface and in order to increase the accuracy again at the physical edge of the chip.

	Specification	Measured
A	30 ± 0.01	30.01
B	40 ± 0.01	39.99
Z	20 ± 0.05	20
Tilt around Y		5.7 arc min
Tilt around X		2.29 arc min
Rotation		<10 arc min

b) Position of the chip relative to the interface flange

For this measurement the head is leveled such that the interface flange is parallel to the X and Y axis of the measuring machine.

- X 0 is on the reference point of the interface flange
- Y 0 is on the reference groove of the interface flange
- Z 0 is on the reference plane of the interface flange



The Z positions has been measured at the edge of the sensitive surface and in order to increase the accuracy again at the physical edge of the chip.

	Specification	Measured
A	12 ± 0.5	12.42
B	0 ± 0.5	0.305
Z (Cold plate / window flange interface)	22 - 0.01	22.02
Tilt around Y	22 arc min	5.7 arc min
Tilt around X	22 arc min	6.9 arc min
Rotation		<10 arc min

4. Detector performance

The following section describes the various performances and functionalities of the NAOS CCD detector system.

4.1 Functionalities and image setup

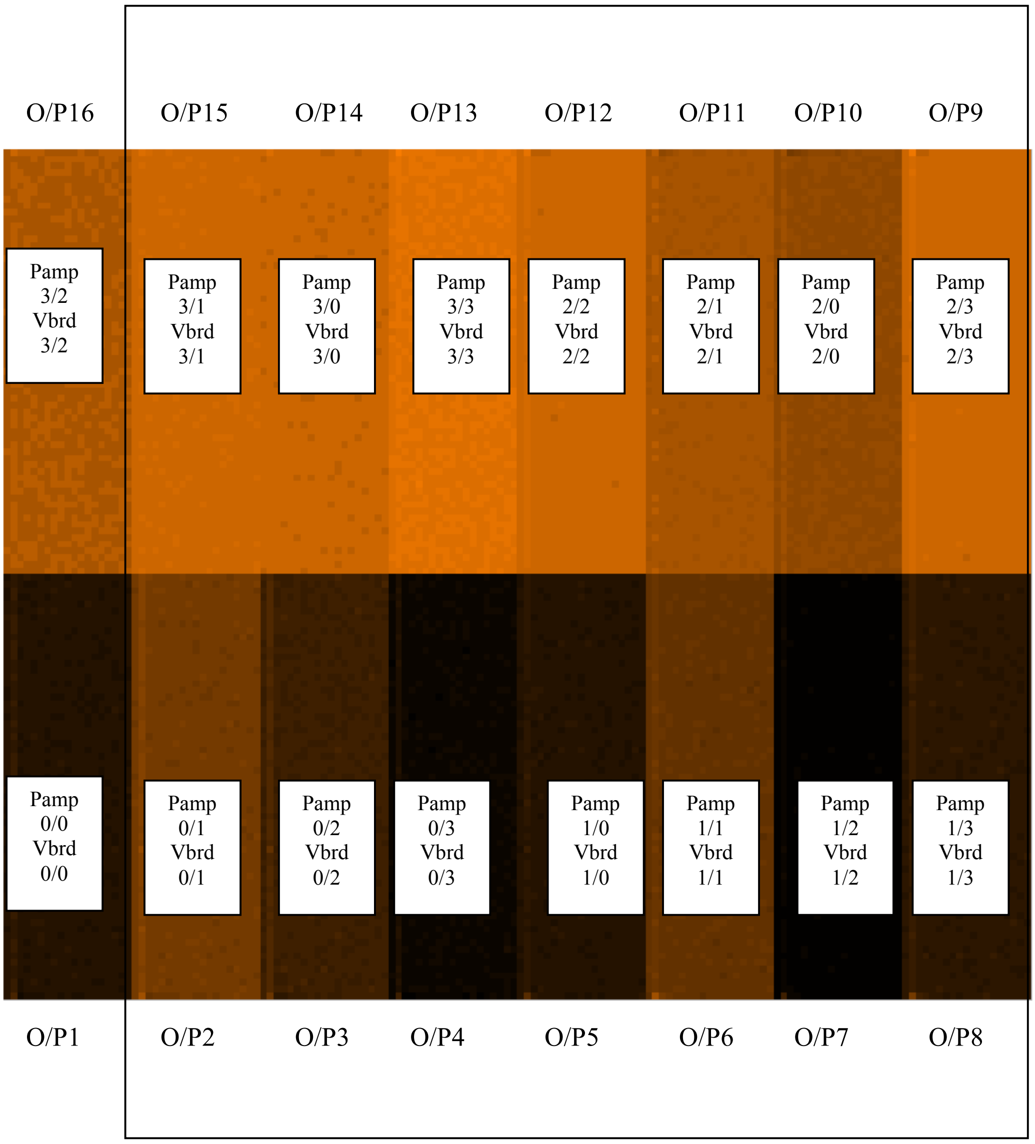


Figure 1 - NAOS CCD port allocation and corresponding preamp and videoboard channels.

This numbering has historical reasons and was therefore kept for the final system to be consistent with the different phases in the development of the NAOS detector system.

4.1.1 Fiera detector head electronics hardware setup

- Videoboard 0 to 3

Videobrd 0 to 3	**Channel 0**	**Channel 1**	**Channel 2**	**Channel 3**
Gain0	2.0 e^-/ADU	2.0 e^-/ADU	2.0 e^-/ADU	2.0 e^-/ADU
Gain1	0.3 e^-/ADU	0.3 e^-/ADU	0.3 e^-/ADU	0.3 e^-/ADU
Resistors (gain0)	R 43= 270Ω	R 47 = 270Ω	R 51 = 270Ω	R 55= 270Ω
Resistors (gain1)	R 42 = 68Ω	R 46 = 68Ω	R 50 = 68Ω	R 54 = 68Ω
Filter 0	C21= 22pF (τ = 33 ns)	C25= 22pF (τ = 33 ns)	C29= 22pF (τ = 33 ns)	C33= 22pF (τ = 33 ns)
Filter 1	C22= 220pF (τ = 500ns)	C26= 220pF (τ = 500ns)	C30= 220pF (τ = 500ns)	C34= 220pF (τ = 500ns)-
Filter 2	C23= 1nF (τ = 1500ns)	C27= 1nF (τ = 1500ns)	C31= 1nF (τ = 1500ns)	C35= 1nF (τ = 1500ns)
Filter 3	C24=C374=1nF (τ = 3000ns)	C28 = C375=1nF (τ = 3000ns)	C32 = C376=1nF (τ = 3000ns)	C36 = C377=1nF (τ = 3000ns)
Offset setting	0 to 10 Volts	0 to 10 Volts	0 to 10 Volts	0 to 10 Volts

Table 1 - Fiera detector head electronics hardware setup

- 1 Clock board, default , no modifications, 10 Ω output resister of the reset, 50 Ω for all other phases
- 1 Communication board, default (no modifications)
- 1 Bias board, **specific to NAOS bridges installed between output 1-2 and 3-4, to get more current**
- Power supplies, default (+15 V; -15 V; +30 V; +24 V; +5 V)
- 1 DSP board (40 MHz), default (no modifications)
- 1 Benner board, **special** and fully populated for AO functionality
- 1 Sparc computer, default (no modifications)
- 4 preamplifiers with gain setting: The preamplifier got special mechanical housing.

For each board :

R10, R24, R38, R52 = 300 Ω and R11, R25, R39, R53 = 120 Ω.
R12, R13, R26, R27, R40, R41, R54, R55 have been removed.

Warning : Preamp 2 channel 3 (O/P9) and Preamp 1 channel 3 (O/P8) has different constant current sources of 3.6mA, other are 2.4mA. C22, C37, C52 and C67 have been removed (cap filter a the input of the first OPA620).

CCD output	Preamp assignment	Preamp input	Preamp Channel	Constant Current in preamp box	Video Board assignment	Video Board Channel	Notes
O/P1	0	A1	0	2.4mA J508	0	0	Not used by RTC
O/P2	0	A2	1	2.4mA J508	0	1	
O/P3	0	A3	2	2.4mA J508	0	2	
O/P4	0	A4	3	2.4mA J508	0	3	
O/P5	1	B1	0	2.4mA J508	1	0	
O/P6	1	B2	1	2.4mA J508	1	1	
O/P7	1	B3	2	2.4mA J508	1	2	

O/P8	1	B4	3	3.6mA J510	1	3	Uses U309
O/P9	2	A4	3	3.6mA J510	2	3	Uses U309
O/P10	2	A1	0	2.4mA J508	2	0	
O/P11	2	A2	1	2.4mA J508	2	1	
O/P12	2	A3	2	2.4mA J508	2	2	
OP/13	3	B4	3	2.4mA J508	3	3	
OP/14	3	B1	0	2.4mA J508	3	0	
OP/15	3	B2	1	2.4mA J508	3	1	
OP/16	3	B3	2	2.4mA J508	3	2	Not used by RTC

4.1.2 Readout functionalities and description of available modes

The following tables explains the readout functionalities for the NAOS modes which feature:

1. Normal read out full 1x1
2. Binning 2x2
3. Binning 4x4
4. Windowing down to 6x6 pixels

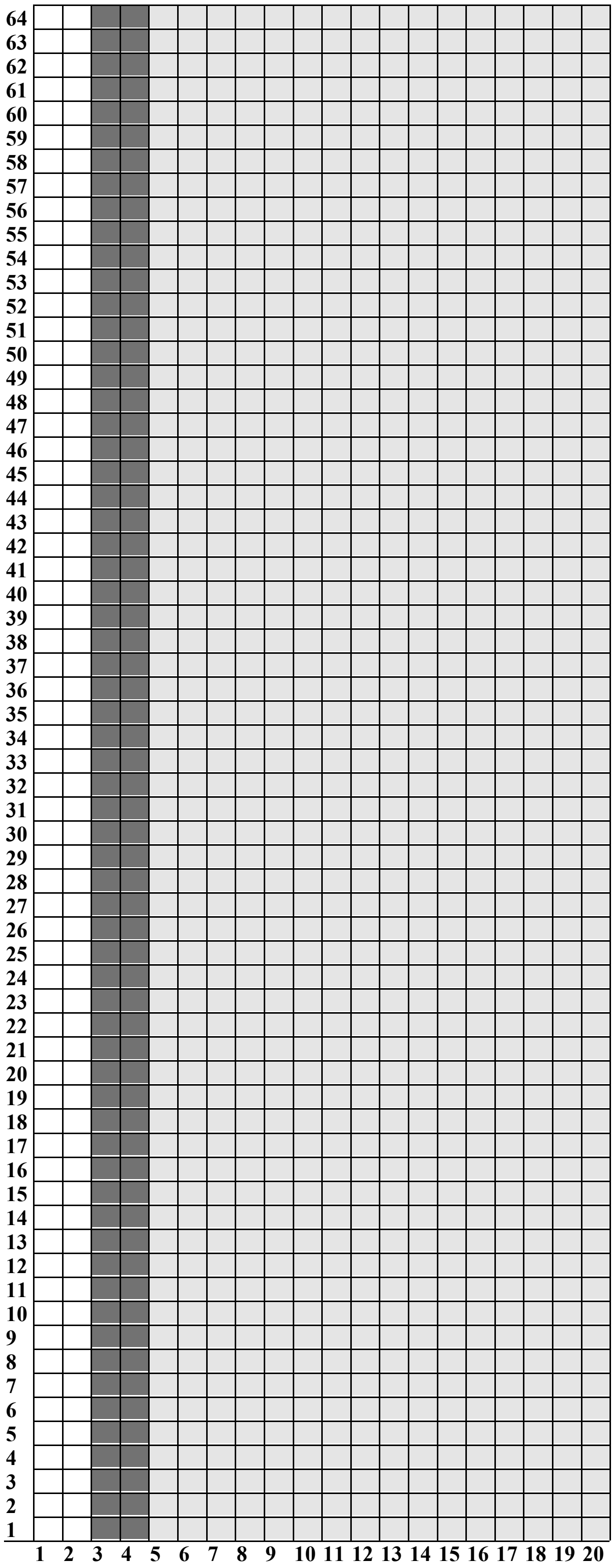
The tables provide the number and location of

- pipeline pixels (visible in image)
- prescan pixels (visible in image)
- image pixels (useful pixel in image)
- skipped pixels (not visible in image)

per port for all readout modes available.

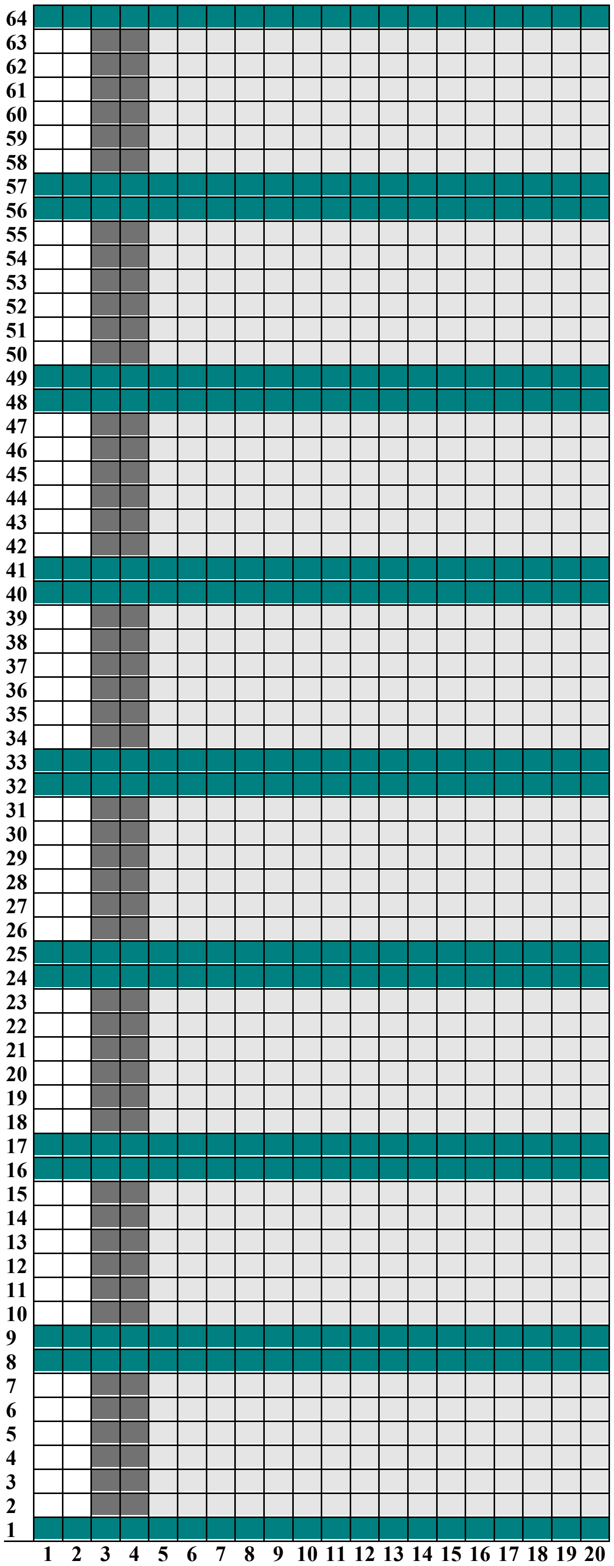
Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
1, 2, 3, 9, 10	2	2	20	64	20 x 64	140 x 128

	Pipeline pixels	(visible in image)
	Prescan pixels	(visible in image)
	Image pixels	(useful pixel in image)
	Skipped pixels	(not visible in image)



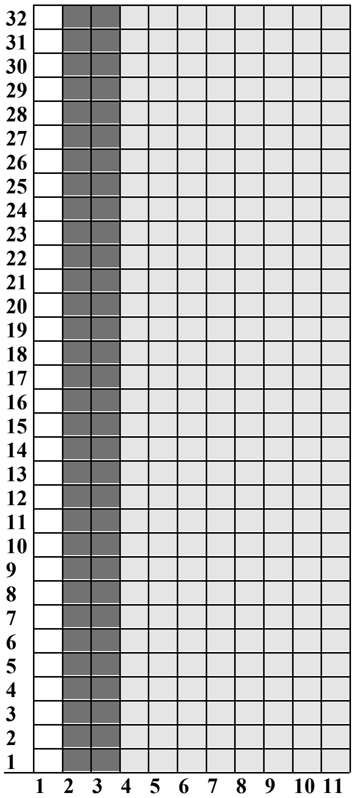
Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
4	2	2	20	48	140	96

	Pipeline pixels	(visible in image)
	Prescan pixels	(visible in image)
	Image pixels	(useful pixel in image)
	Skipped pixels	(not visible in image)



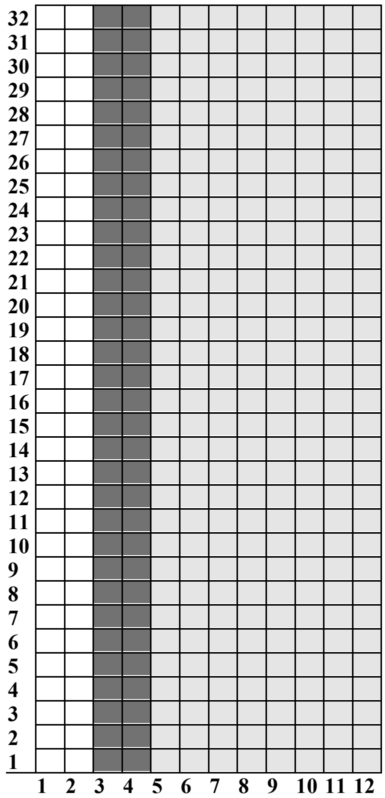
Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
5	1	2	11	32	11 x 32	77 x 64

	Pipeline pixels (visible in image)
	Prescan pixels (visible in image)
	Image pixels (useful pixel in image)
	Skipped pixels (not visible in image)



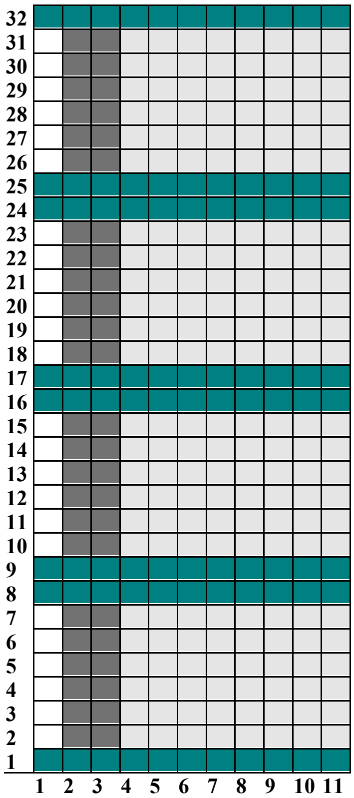
Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
6	2	2	12	32	12 x 32	84 x 64

	Pipeline pixels (visible in image)
	Prescan pixels (visible in image)
	Image pixels (useful pixel in image)
	Skipped pixels (not visible in image)



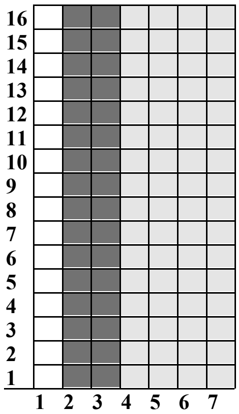
Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
7	1	2	11	24	11 x 24	77 x 48

	Pipeline pixels	(visible in image)
	Prescan pixels	(visible in image)
	Image pixels	(useful pixel in image)
	Skipped pixels	(not visible in image)



Mode	Pipeline pixel per port	Prescan pixel per port	Pixel in x per port	Pixel in y per port	Image size per port	Image size (14 ports)
8	1	2	7	16	7 x 16	49 x 32

	Pipeline pixels (visible in image)
	Prescan pixels (visible in image)
	Image pixels (useful pixel in image)
	Skipped pixels (not visible in image)



ROAM files

There are 10 ROAM files generated to distinguish between the three different kind of pixels:

1. pipeline pixel
2. prescan pixel
3. image pixel

The modes are in the $INS_ROOT of the NAOS configuration and named as following:

for mode 1: mode_1.mdf
for mode 2: mode_2.mdf
for mode 3: mode_3.mdf
for mode 4: mode_4.mdf
for mode 5: mode_5.mdf
for mode 6: mode_6.mdf
for mode 7: mode_7.mdf
for mode 8: mode_8.mdf
for mode 9: mode_9.mdf
for mode 10: mode_10.mdf

4.1.3 Conversion factors

- High gain (H) in the NAOS setup gives a conversion factor of ~0.3 e-/ADU (remotely selectable)
- Low gain (L) in the NAOS setup gives a conversion factor of ~2 e-/ADU (remotely selectable)

The exact values for all modes are given in section 4.2 together with the noise performance of the system.

4.1.4 Integration time (or Gap)

The integration time is programmable independently from the pixel frequency. Adding no gap will allow the maximum frame rate per mode as given in table 2.

4.1.5 Analog to digital converters

- FIERA uses 16 bits per port.
- 14 outputs are used; outputs 1 and 16 are not used for NAOS.

4.1.6 Readout modes and frame rates

Since we agreed to leave the gap as a free parameter the following table summarizes the setup for the readout modes for the NAOS CCD system. The table also states the maximum frame rates and image size.

The "Frame rate final" of this table are estimated value of the frame rate, they have not been measured at Garching.
Measured Frame Rate values are in Ref. [12], measured with the NAOS Real Time Computer during the integration and tests in Bellevue.

The image size of this table contains different type of pixels (see paragraph 4.1.2):

- pipeline pixels
- prescan pixels
- image pixels

Mode	Binning	Window	Gain	Pixel Rate	Sub-apertures	Image size (x,y)	Frame rate goal	Frame rate final
unit	-	-	-	kps	-	pixels	f/s	f/s
1	1x1	no	H	280	7,14	140 x 128	230	215
2	1x1	no	H	635	7,14	140 x 128	500	431
3	1x1	no	L	635	7,14	140 x 128	500	431
4	1x1	6x6	H	280	7,14	140 x 96	290	277
5	2x2	no	H	50	7, 14	77 x 64	120	138
6	2x2	no	H	280	14	84 x 64	500	653
7	2x2	6x6	H	50	7	77 x 48	250	184
8	4x4	no	H	50	7	49 x 32	500	400
9	1x1	no	H	715	7,14	140 x 128	-	500
10	1x1	no	L	715	7,14	140 x 128	-	500

Table 2 - Readout modes and frame rates

4.2 Detector performance

4.2.1 Noise measurement method

The readout-noise and gain (conversion factor in e^-/ADU) was measured using the method explained below. The procedure takes two equal dark and two equal flat-field exposures all of the same exposure time calculating noise and gain independent from the light level. The conversion factor is calculated with the light level of the flat-fields and the variance values of the differences between the two flat-fields and the difference between the two dark exposures. This is then average over 50 dark and 50 flat-field exposures, i.e 25 measurements.

$$Mean = \frac{\sum_{i=1}^{n} pixelvalue_i}{n} \tag{1}$$

pixelvalue in ADU.

$$Variance = \frac{\sum_{i=1}^{n} (Mean - pixelvalue_i)^2}{n-1} \tag{2}$$

$$Standard\ Deviation = \sigma = \sqrt{Variance} \tag{3}$$

$$Conversion\ Factor = K = \frac{number\ of\ e^-}{pixelvalue} \left[\frac{e^-}{ADU}\right] \tag{4}$$

$$K = \frac{Mean(signal)}{Variance(signal)}$$

$$K = \frac{\frac{Mean(FF1) + Mean(FF2)}{2} - \frac{Mean(DK1) + Mean(DK2)}{2}}{\frac{Variance(FF1 - FF2) - Variance(DK1 - DK2)}{2}}$$

$$K = \frac{Mean(FF1) + Mean(FF2) - Mean(DK1) - Mean(DK2)}{Variance(FF1 - FF2) - Variance(DK1 - DK2)} \tag{5}$$

FF1, *FF2*, *DK1* and *DK2* are the equal flat-fields and dark exposures of the same duration.

As the final result of the *Conversion Factor* we take:

$$K_r \pm K_{err} = Mean(K_i) \pm \frac{\sigma(K_i)}{\sqrt{n}} \tag{6}$$

The readoutnoise of the CCD is given by

$$Readoutnoise = R = K_r \cdot \sqrt{\frac{Variance(DK1 - DK2)}{2}} \tag{7}$$

With different measurements this gives:

$$R_r = Mean\ (R_i) \pm \frac{\sigma(R_i)}{\sqrt{n}} \qquad (8)$$

This noise computation method makes the following assumption : the pixel response is ergodic (spatially and in time), with no correlated noise between the pixels. If this assumption is true, then we have the same result by calculating the spatial noise of the difference of 2 dark image (spatial noise of (DK1-DK2)) and the temporal noise of each pixel (the temporal noises of all the pixels are averaged).
The "ergodic" hypothesis is not always true, this explains some differences between noise values measured by ESO and noise values measured by the NAOS consortium (temporal variance method on cubes of 50-100 consecutive images) for some readout modes. In addition, the measured noise by the NAOS consortium with the temporal variance method did not change between the CCD camera acceptance in Garching and the camera integration on the NAOS adapter.
For more details, see Ref. [12].

PLEASE NOTE:

Low noise results are only archived with proper grounding and well-connected cables. Noise is dependent on the cable length and capacitance of connections. Since you will receive a new set of cables after the delivery of the final system you will need to calibrate the noise again, especially when the system is mounted at its final location. The results should not differ much. The ODT will give advice on the grounding of the FIERA system at the adapter rotator if the noise will vary to the figure given below.

4.2.2 Noise results

The following 10 tables summarize the latest measurements done at the ESO CCD testbench in May 2000 for all modes. For the 50 kps modes we were able to archive noise level < 3 electrons/port and for the 280 kps modes we meet the goal of 4 electrons/port.

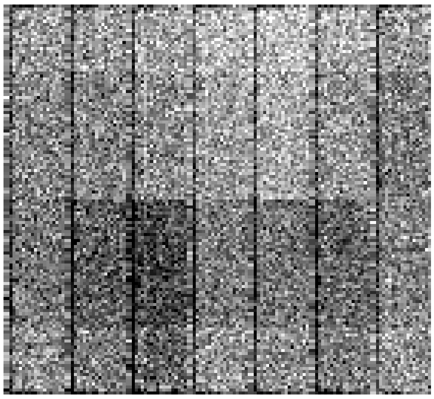
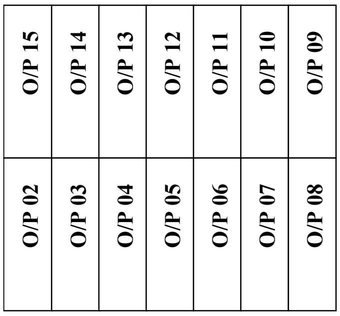
To be able to read the detector with 500 frames/second, we had to increase the pixel frequency to 715 kps per port. At this pixel frequency it was not possible to keep all channels under 6 electrons as foreseen for a 500-frames/sec mode. Nevertheless we were able to keep the noise between 6 and 7.2 electrons at high gain (see noise tables).

For each readout mode a sample of a corresponding image, as seen on the real time display, is shown on the right side of the noise tables.

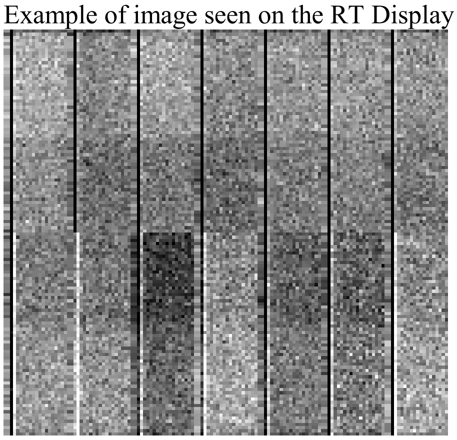
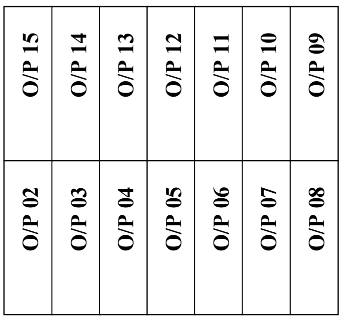
The white and dark lines you can see on some of the images are related to the speed and binning factor of the mode. These are electronic settling effects and occur only on the first two prescan pixels of the serial register. Since these pixels are not used in the NAOS application, it is not an issue.

Readoutnoise is in units of electrons rms and the uncertainty in the noise measurement also given in electrons rms. The conversion factors are given in units of electrons/ADU.

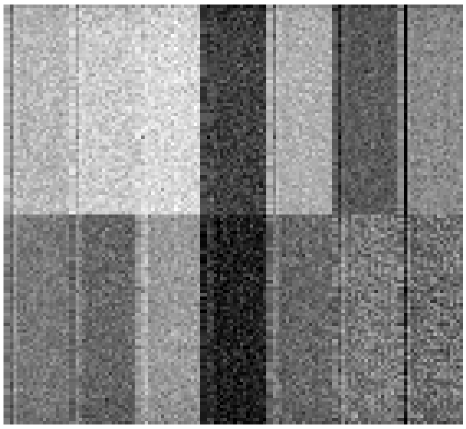
MODE 1 – 280 kps – no binning – high gain

Readout port 0/P2: Convert factor=0.347 ±0.0056 RMS Noise=3.86 ±0.14 Readout port 0/P3: Convert factor=0.336 ±0.0048 RMS Noise=3.83 ±0.14 Readout port 0/P4: Convert factor=0.343 ±0.0053 RMS Noise=3.92 ±0.14 Readout port 0/P5: Convert factor=0.362 ±0.0058 RMS Noise=3.99 ±0.14 Readout port 0/P6: Convert factor=0.356 ±0.0057 RMS Noise=3.82 ±0.13 Readout port 0/P7: Convert factor=0.360 ±0.0056 RMS Noise=3.89 ±0.13 Readout port 0/P8: Convert factor=0.360 ±0.0054 RMS Noise=3.87 ±0.13	readout port 0/P15: Convert factor=0.332 ±0.0052 RMS Noise=3.78 ±0.14 readout port 0/P14: Convert factor=0.339 ±0.0054 RMS Noise=3.80 ±0.13 readout port 0/P13: Convert factor=0.339 ±0.0054 RMS Noise=3.85 ±0.14 readout port 0/P12: Convert factor=0.352 ±0.0054 RMS Noise=3.73 ±0.13 readout port 0/P11: Convert factor=0.353 ±0.0053 RMS Noise=3.77 ±0.13 readout port 0/P9: Convert factor=0.350 ±0.0052 RMS Noise=3.81 ±0.13 readout port 0/P8: Convert factor=0.357 ±0.0057 RMS Noise=3.89 ±0.13	Example of image seen on the RT Display  Note: Image not to scale 

MODE 2 – 635 kps – no binning – high gain

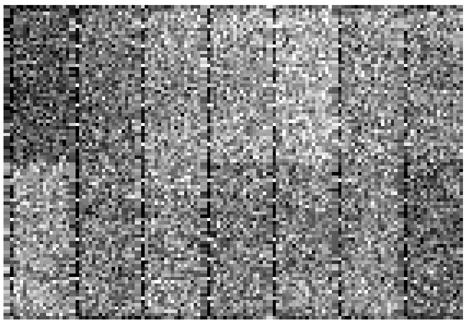
Readout port 0/P2: Convert factor=0.32 ±0.0051 RMS Noise=5.36 ±0.19 Readout port 0/P3: Convert factor=0.320 ±0.0051 RMS Noise=5.84 ±0.21 Readout port 0/P4: Convert factor=0.32 ±0.0050 RMS Noise=5.68 ±0.20 Readout port 0/P5: Convert factor=0.34 ±0.0053 RMS Noise=6.59 ±0.23 Readout port 0/P6: Convert factor=0.33 ±0.0048 RMS Noise=5.69 ±0.21 Readout port 0/P7: Convert factor=0.33 ±0.0052 RMS Noise=6.13 ±0.26 Readout port 0/P8: Convert factor=0.34 ±0.0052 RMS Noise=6.19 ±0.24	readout port 0/P15: Convert factor=0.32 ±0.0049 RMS Noise=5.34 ±0.19 readout port 0/P14: Convert factor=0.33 ±0.0051 RMS Noise=5.46 ±0.19 readout port 0/P13: Convert factor=0.33 ±0.0052 RMS Noise=5.51 ±0.19 readout port 0/P12: Convert factor=0.33 ±0.0052 RMS Noise=5.70 ±0.20 readout port 0/P11: Convert factor=0.33 ±0.0051 RMS Noise=5.26 ±0.18 readout port 0/P9: Convert factor=0.33 ±0.0053 RMS Noise=5.43 ±0.19 readout port 0/P8: Convert factor=0.33 ±0.0050 RMS Noise=5.56 ±0.19	Example of image seen on the RT Display  Note: Image not to scale 

MODE 3 – 635 kps – no binning – low gain

Readout port 0/P2: Convert factor=2.025 ±0.0357 RMS Noise=5.84 ±0.32 Readout port 0/P3: Convert factor=1.988 ±0.0317 RMS Noise=6.55 ±0.34 Readout port 0/P4: Convert factor=2.024 ±0.0348 RMS Noise=6.59 ±0.36 Readout port 0/P5: Convert factor=2.089 ±0.0337 RMS Noise=7.19 ±0.47 Readout port 0/P6: Convert factor=2.073 ±0.0315 RMS Noise=7.31 ±0.42 Readout port 0/P7: Convert factor=2.157 ±0.0391 RMS Noise=7.42 ±0.58 Readout port 0/P8: Convert factor=2.118 ±0.0350 RMS Noise=7.90 ±0.65	readout port 0/P15: Convert factor=2.04 ±0.033 RMS Noise=6.06 ±0.33 readout port 0/P14: Convert factor=2.04 ±0.032 RMS Noise=6.59 ±0.37 readout port 0/P13: Convert factor=2.10 ±0.034 RMS Noise=7.10 ±0.42 readout port 0/P12: Convert factor=2.06 ±0.034 RMS Noise=6.91 ±0.3944 readout port 0/P11: Convert factor=2.03 ±0.036 RMS Noise=5.70 ±0.31 readout port 0/P9: Convert factor=2.08 ±0.034 RMS Noise=6.27 ±0.36 readout port 0/P8: Convert factor=2.09 ±0.034 RMS Noise=6.01 ±0.35	Example of image seen on the RT Display  Note: Image not to scale

O/P 15	**O/P 14**	**O/P 13**	**O/P 12**	**O/P 11**	**O/P 10**	**O/P 09**
O/P 02	**O/P 03**	**O/P 04**	**O/P 05**	**O/P 06**	**O/P 07**	**O/P 08**

MODE 4 – 280 kps – no binning – high gain – window 6x6

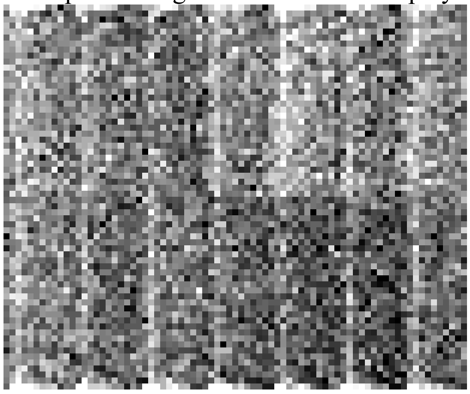
Readout port 0/P2: Convert factor=0.34 ±0.0056 RMS Noise=3.87 ±0.136 Readout port 0/P3: Convert factor=0.33 ±0.0048 RMS Noise=3.83 ±0.136 Readout port 0/P4: Convert factor=0.34 ±0.0053 RMS Noise=3.92 ±0.138 Readout port 0/P5: Convert factor=0.36 ±0.0058 RMS Noise=3.98 ±0.136 Readout port 0/P6: Convert factor=0.35 ±0.0057 RMS Noise=3.82 ±0.132 Readout port 0/P7: Convert factor=0.36 ±0.0056 RMS Noise=3.89 ±0.133 Readout port 0/P8: Convert factor=0.36 ±0.0054 RMS Noise=3.87 ±0.133	readout port 0/P15: Convert factor=0.33 ±0.0052 RMS Noise=3.78 ±0.135 readout port 0/P14: Convert factor=0.34 ±0.0054 RMS Noise=3.80 ±0.135 readout port 0/P13: Convert factor=0.34 ±0.0054 RMS Noise=3.84 ±0.136 readout port 0/P12: Convert factor=0.35 ±0.0054 RMS Noise=3.73 ±0.130 readout port 0/P11: Convert factor=0.35 ±0.0053 RMS Noise=3.77 ±0.131 readout port 0/P9: Convert factor=0.35 ±0.0052 RMS Noise=3.81 ±0.133 readout port 0/P8: Convert factor=0.36 ±0.0057 RMS Noise=3.89 ±0.134	Example of image seen on the RT Display  Note: Image not to scale

O/P 15	**O/P 14**	**O/P 13**	**O/P 12**	**O/P 11**	**O/P 10**	**O/P 09**
O/P 02	**O/P 03**	**O/P 04**	**O/P 05**	**O/P 06**	**O/P 07**	**O/P 08**

MODE 5 – 50 kps – 2x2 binning – high gain

readout port 0/P2: Convert factor=0.32 ±0.0097 RMS Noise=2.71 ±0.15	readout port 0/P15: Convert factor=0.340 ±0.010 RMS Noise=2.85 ±0.15
readout port 0/P3: Convert factor=0.333 ±0.011 RMS Noise=2.80 ±0.15	readout port 0/P14: Convert factor=0.349 ±0.010 RMS Noise=2.90 ±0.15
readout port 0/P4: Convert factor=0.337 ±0.010 RMS Noise=2.81 ±0.15	readout port 0/P13: Convert factor=0.339 ±0.010 RMS Noise=2.76 ±0.14
readout port 0/P5: Convert factor=0.355 ±0.012 RMS Noise=2.83 ±0.14	readout port 0/P12: Convert factor=0.341 ±0.011 RMS Noise=2.77 ±0.15
readout port 0/P6: Convert factor=0.351 ±0.011 RMS Noise=2.84 ±0.15	readout port 0/P11: Convert factor=0.332 ±0.010 RMS Noise=2.70 ±0.14
readout port 0/P7: Convert factor=0.356 ±0.012 RMS Noise=2.87 ±0.15	readout port 0/P9: Convert factor=0.344 ±0.010 RMS Noise=2.92 ±0.17
readout port 0/P8: Convert factor=0.357 ±0.012 RMS Noise=2.80 ±0.14	readout port 0/P8: Convert factor=0.341 ±0.012 RMS Noise=2.72 ±0.14

Example of image seen on the RT Display



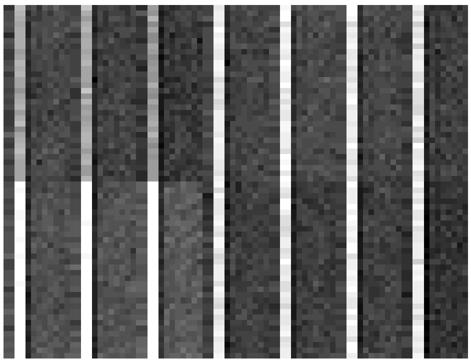
Note: Image not to scale

O/P 15	O/P 14	O/P 13	O/P 12	O/P 11	O/P 10	O/P 09
O/P 02	O/P 03	O/P 04	O/P 05	O/P 06	O/P 07	O/P 08

MODE 6 – 280 kps – 2x2 binning – high gain

readout port 0/P2: Convert factor=0.37 ±0.012 RMS Noise=3.93 ±0.20	readout port 0/P15: Convert factor=0.352 ±0.011 RMS Noise=4.05 ±0.21
readout port 0/P3: Convert factor=0.37 ±0.013 RMS Noise=3.98 ±0.20	readout port 0/P14: Convert factor=0.372 ±0.012 RMS Noise=4.11 ±0.21
readout port 0/P4: Convert factor=0.37 ±0.010 RMS Noise=3.98 ±0.20	readout port 0/P13: Convert factor=0.363 ±0.011 RMS Noise=4.12 ±0.21
readout port 0/P5: Convert factor=0.38 ±0.011 RMS Noise=3.93 ±0.20	readout port 0/P12: Convert factor=0.375 ±0.011 RMS Noise=4.00 ±0.20
readout port 0/P6: Convert factor=0.38 ±0.013 RMS Noise=3.95 ±0.20	readout port 0/P11: Convert factor=0.372 ±0.011 RMS Noise=3.95 ±0.20
readout port 0/P7: Convert factor=0.39 ±0.012 RMS Noise=4.04 ±0.20	readout port 0/P9: Convert factor=0.379 ±0.013 RMS Noise=4.10 ±0.20
readout port 0/P8: Convert factor=0.38 ±0.011 RMS Noise=3.93 ±0.20	readout port 0/P8: Convert factor=0.379 ±0.012 RMS Noise=4.12 ±0.21

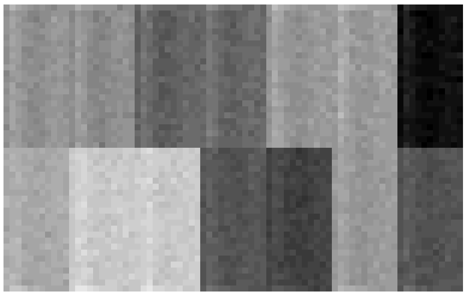
Example of image seen on the RT Display



Note: Image not to scale

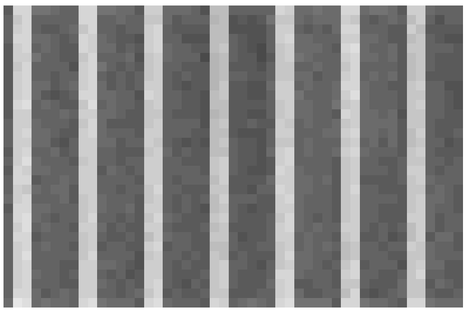
O/P 15	O/P 14	O/P 13	O/P 12	O/P 11	O/P 10	O/P 09
O/P 02	O/P 03	O/P 04	O/P 05	O/P 06	O/P 07	O/P 08

MODE 7 – 50 kps – 2x2 binning – high gain – window 6x6

readout port 0/P2: Convert factor=0.32 ±0.009 RMS Noise=2.71 ±0.15 readout port 0/P3: Convert factor=0.33 ±0.011 RMS Noise=2.80 ±0.15 readout port 0/P4: Convert factor=0.33 ±0.010 RMS Noise=2.81 ±0.15 readout port 0/P5: Convert factor=0.35 ±0.012 RMS Noise=2.83 ±0.15 readout port 0/P6: Convert factor=0.35 ±0.0116 RMS Noise=2.84 ±0.15 readout port 0/P7: Convert factor=0.36 ±0.0124 RMS Noise=2.87 ±0.15 readout port 0/P8: Convert factor=0.36 ±0.0120 RMS Noise=2.80 ±0.14	readout port 0/P15: Convert factor=0.34 ±0.010 RMS Noise=2.85 ±0.15 readout port 0/P14: Convert factor=0.34 ±0.010 RMS Noise=2.90 ±0.15 readout port 0/P13: Convert factor=0.33 ±0.010 RMS Noise=2.76 ±0.14 readout port 0/P12: Convert factor=0.34 ±0.011 RMS Noise=2.77 ±0.15 readout port 0/P11: Convert factor=0.332 ±0.0105 RMS Noise=2.70 ±0.14 readout port 0/P9: Convert factor=0.344 ±0.0103 RMS Noise=2.92 ±0.17 readout port 0/P8: Convert factor=0.341 ±0.0120 RMS Noise=2.72 ±0.14	Example of image seen on the RT Display  Note: Image not to scale

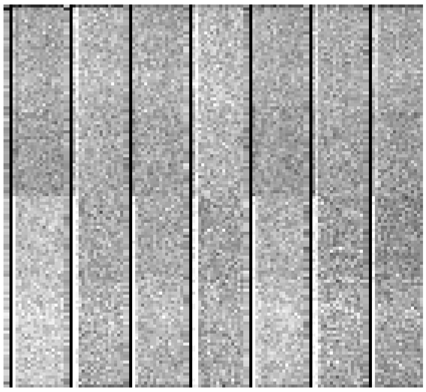
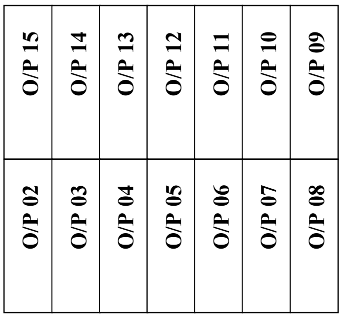
O/P 15	O/P 14	O/P 13	O/P 12	O/P 11	O/P 10	O/P 09
O/P 02	O/P 03	O/P 04	O/P 05	O/P 06	O/P 07	O/P 08

MODE 8 – 50 kps – 4x4 binning – high gain –

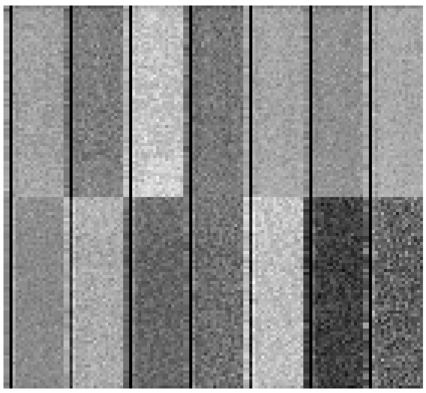
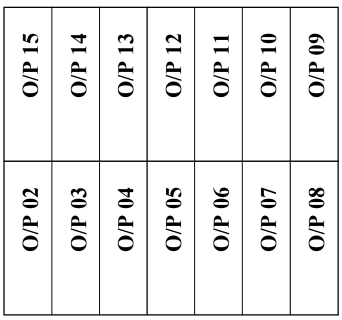
readout port 0/P2: Convert factor=0.33 ±0.014 RMS Noise=2.93 ±0.21 readout port 0/P3: Convert factor=0.31 ±0.012 RMS Noise=2.81 ±0.21 readout port 0/P4: Convert factor=0.33 ±0.013 RMS Noise=2.92 ±0.21 readout port 0/P5: Convert factor=0.35 ±0.014 RMS Noise=2.99 ±0.21 readout port 0/P6: Convert factor=0.35 ±0.016 RMS Noise=3.08 ±0.22 readout port 0/P7: Convert factor=0.34 ±0.014 RMS Noise=3.04 ±0.22 readout port 0/P8: Convert factor=0.35 ±0.014 RMS Noise=3.01 ±0.21	readout port 0/P15: Convert factor=0.33 ±0.011 RMS Noise=2.95 ±0.21 readout port 0/P14: Convert factor=0.33 ±0.012 RMS Noise=2.87 ±0.21 readout port 0/P13: Convert factor=0.35 ±0.016 RMS Noise=3.09 ±0.22 readout port 0/P12: Convert factor=0.32 ±0.013 RMS Noise=2.79 ±0.20 readout port 0/P11: Convert factor=0.33 ±0.014 RMS Noise=2.91 ±0.21 readout port 0/P9: Convert factor=0.34 ±0.013 RMS Noise=3.06 ±0.25 readout port 0/P8: Convert factor=0.33 ±0.013 RMS Noise=2.86 ±0.21	Example of image seen on the RT Display  Note: Image not to scale

O/P 15	O/P 14	O/P 13	O/P 12	O/P 11	O/P 10	O/P 09
O/P 02	O/P 03	O/P 04	O/P 05	O/P 06	O/P 07	O/P 08

MODE 9 – 715 kps – no binning – high gain

readout port 0/P2: Convert factor=0.33 ±0.0053 RMS Noise=5.79 ±0.20	readout port 0/P15: Convert factor=0.33 ±0.0051 RMS Noise=5.9 ±0.21	Example of image seen on the RT Display  Note: Image not to scale 
readout port 0/P3: Convert factor=0.33 ±0.0053 RMS Noise=6.88 ±0.24	readout port 0/P14: Convert factor=0.33 ±0.0047 RMS Noise=6.06 ±0.21	
readout port 0/P4: Convert factor=0.33 ±0.0049 RMS Noise=6.20 ±0.22	readout port 0/P13: Convert factor=0.34 ±0.0051 RMS Noise=6.18 ±0.21	
readout port 0/P5: Convert factor=0.34 ±0.0053 RMS Noise=6.81 ±0.27	readout port 0/P12: Convert factor=0.34 ±0.0053 RMS Noise=6.92 ±0.24	
readout port 0/P6: Convert factor=0.35 ±0.0055 RMS Noise=6.36 ±0.22	readout port 0/P11: Convert factor=0.34 ±0.0048 RMS Noise=5.78 ±0.20	
readout port 0/P7: Convert factor=0.35 ±0.0057 RMS Noise=6.70 ±0.30	readout port 0/P9: Convert factor=0.33 ±0.0049 RMS Noise=6.06 ±0.21	
readout port 0/P8: Convert factor=0.34 ±0.0052 RMS Noise=7.19 ±0.26	readout port 0/P8: Convert factor=0.34 ±0.0055 RMS Noise=6.10 ±0.21	

MODE 10 – 715 kps – no binning – low gain

readout port 0/P2: Convert factor=2.26 ±0.044 RMS Noise=6.61 ±0.30	readout port 0/P15: Convert factor=2.265 ±0.044 RMS Noise=7.13 ±0.33	Example of image seen on the RT Display  Note: Image not to scale 
readout port 0/P3: Convert factor=2.21 ±0.043 RMS Noise=8.27 ±0.37	readout port 0/P14: Convert factor=2.327 ±0.044 RMS Noise=8.06 ±0.44	
readout port 0/P4: Convert factor=2.220 ±0.041 RMS Noise=8.24 ±0.37	readout port 0/P13: Convert factor=2.223 ±0.039 RMS Noise=8.18 ±0.39	
readout port 0/P5: Convert factor=2.352 ±0.047 RMS Noise=7.77 ±0.58	readout port 0/P12: Convert factor=2.287 ±0.043 RMS Noise=8.28 ±0.44	
readout port 0/P6: Convert factor=2.309 ±0.044 RMS Noise=8.49 ±0.45	readout port 0/P11: Convert factor=2.257 ±0.0433 RMS Noise=6.72 ±0.29	
readout port 0/P7: Convert factor=2.287 ±0.046 RMS Noise=8.66 ±0.50	readout port 0/P9: Convert factor=2.238 ±0.043 RMS Noise=7.27 ±0.33	
readout port 0/P8: Convert factor=2.308 ±0.044 RMS Noise=7.49 ±0.84	readout port 0/P8: Convert factor=2.257 ±0.041 RMS Noise=7.01 ±0.32	

4.2.3 Quantum efficiency (QE)

The specifications are given in the table 5 of reference [4] p.17/42.
We did not measure the QE of the final CCD. Nevertheless we provide you with and average curve of a QE measurements done on 12 EEV CCD-44-82 which have the same anti refecting coating and manufacturing process as the CCD-50 used for NAOS. We assume that the QE will not vary more than 5 % to the actual QE of the NAOS chip.

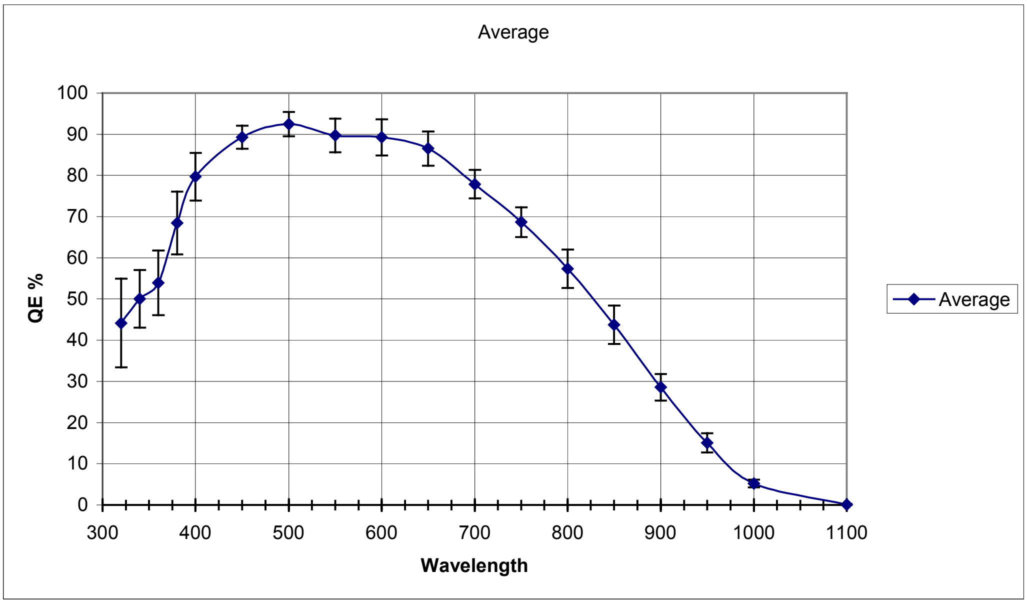


Figure 2 – Expected quantum efficiency of the CCD-50 for the final NAOS system

4.2.4 Dark current

To make the dark current contribution negligible, we recommend that the CCD must be cooled down to -100 °C.

Bin-factor	1 x 1				2 x 2				4 x 4			
	Frame Time / ms											
Temp/ °C	2	5	20	50	2	5	20	50	2	5	20	50
-30	0.26	0.65	2.6	6.4	1.0	2.6	10.3	25.9	4.1	10.3	41.4	103.7
-40		0.22	0.86	2.1	0.35	0.86	3.4	8.6	1.3	3.4	13.8	34.5
-50			0.23	0.5		0.23	0.92	2.3	0.37	0.92	3.7	9.2
-60	negligible (< 0.1 e^-)			0.15			0.23	0.5		0.23	0.92	2.3
-70											0.14	0.35

Table 3 - Noise contribution in electrons from dark current

Table 3 shows the number of electrons resulting from dark current at different readout rates, binning factors, and frame times. We assume a dark current of 1 nA/cm^2 at 20 degree C for the CCD. For a CCD with 3 electrons readout noise, a dark current contribution of 10 %, i.e. 0.3 electrons, can be considered negligible. Using a continuous flow cryostat the performance of the CCD would not be compromised by dark current even for the worst case operating mode. The black line in table3 illustrates the border line for negligible dark current for these CCDs. A CFC cooled with liquid nitrogen will provide us with the possibility to cool down to -110 degree C.

4.2.5 Linearity and full well capacity

Full well capacity

To avoid crosstalk and the effect of undershoot the full well of a single pixel should not be more than ~90.000 electrons.

Linearity

Linearity of the system is dependent on the readout speed of the CCD. We measured the linearity of the fastest readout speed (715 kps and low gain). For slower modes the linearity will be equal or better than the stated value. The measurements were done with a convesion factor of 2 electrons/ADU.

The non linearity (Peak to peak) at 715 kps is: 0.8322 % / -0.7743 %,
(Mean dev.): -0.002073 % / rms dev 0.4553 %

The following plot shows the residual non linearity curve.
(Note that 1 ADU equals to 3.9 electrons for this plot)

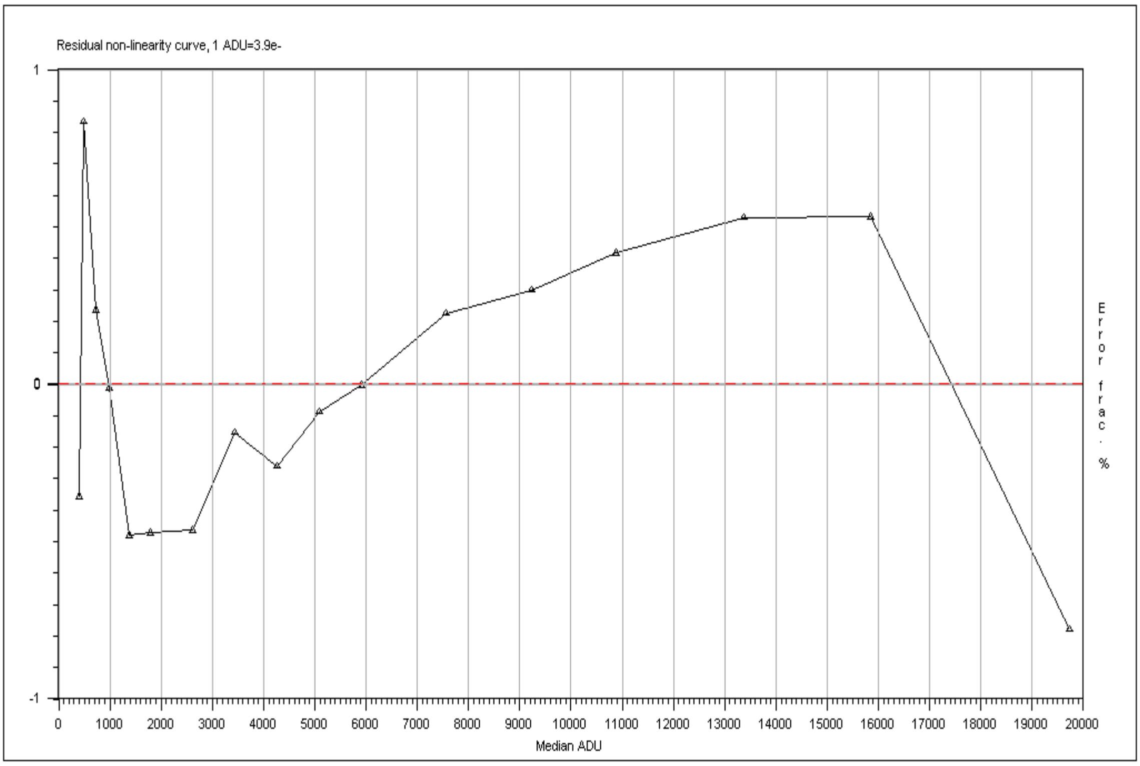


Figure 3 - Non-linearity plot for 715 kps (mode 10, low gain)

4.2.6 Undershoot problem, cross-talk and charge transfer efficiency

The undershoot problem

We enhanced the electronic response of the undershoot effect for the pixel after a bright pixel. We worked on the filter settings and made some improvement. Nevertheless since we have to discharge more, this improvement is trade-off between the "dark pixel " problem and the readout noise for the high-speed modes.

To avoid undershoot problems we recommend not put more than 90.000 electrons on the detector for the 635 kps and 715 kps modes.

Following we will give 2 examples of the response for the 635 kps modes and high and low gain.

The following image was taken at 635 kps with high gain (0.3 electrons/ADU). We did not measure any undershoot. The spot is almost saturated at this gain setting (19.500 electrons).

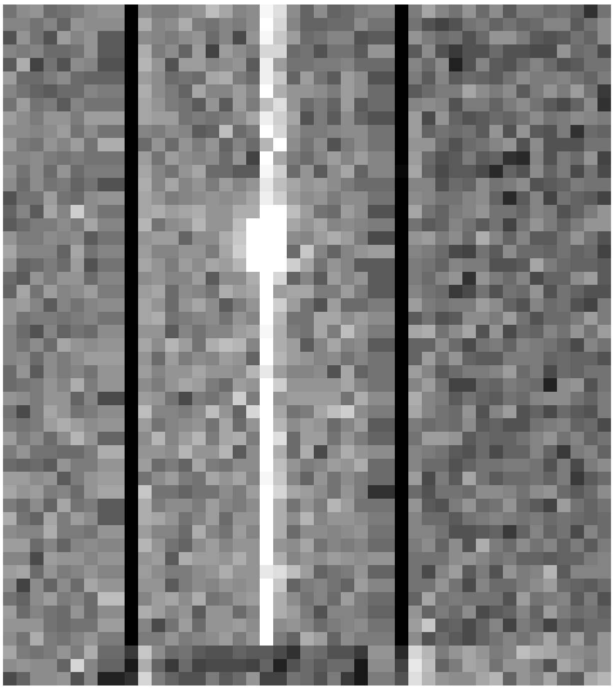


Figure 4- Image at 635 kps at high gain (highest pixel value 19.500 electrons)
- No undershoot is visible.

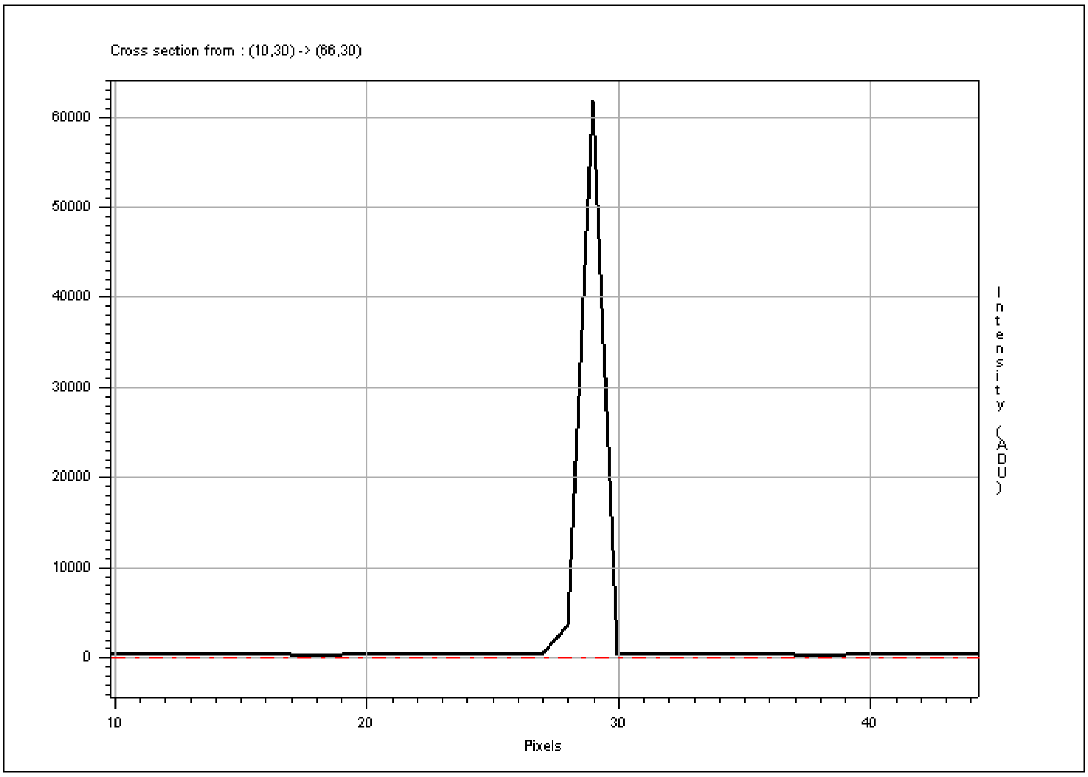


Figure 5 - Cross-section of the image at 635 kps at high gain (highest pixel value 19.500 electrons)
- No undershoot is visible. Horizontal axis : pixel number, vertical axis : pixel response (adu).

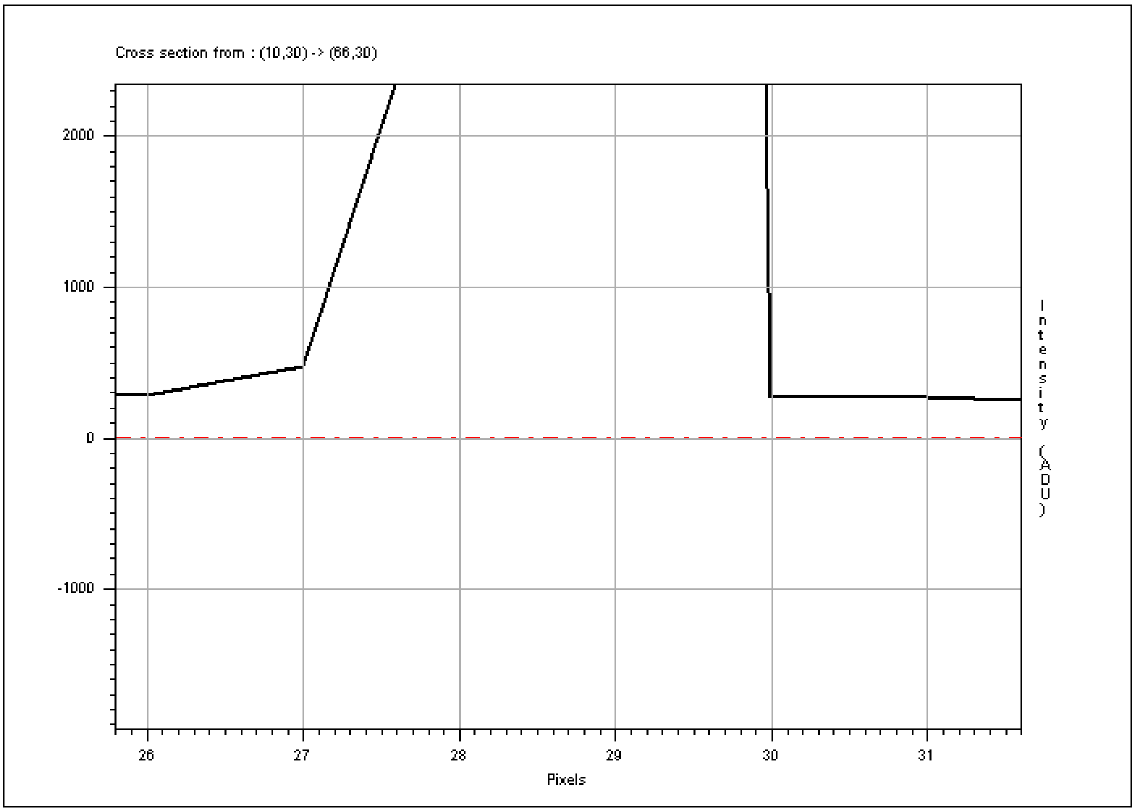


Figure 6 - "Blowup" of the cross-section of the image at 635 kps at high gain
(highest pixel value 19.500 electrons) - No undershoot is visible.
Horizontal axis : pixel number, vertical axis: pixel response (adu).

The following image was taken at 635 kps with low gain (2 electrons/ADU). We did not measure any undershoot. The brightest pixel in the spot has 53.000 ADU this gain setting (highest pixel value at 106.000 electrons)

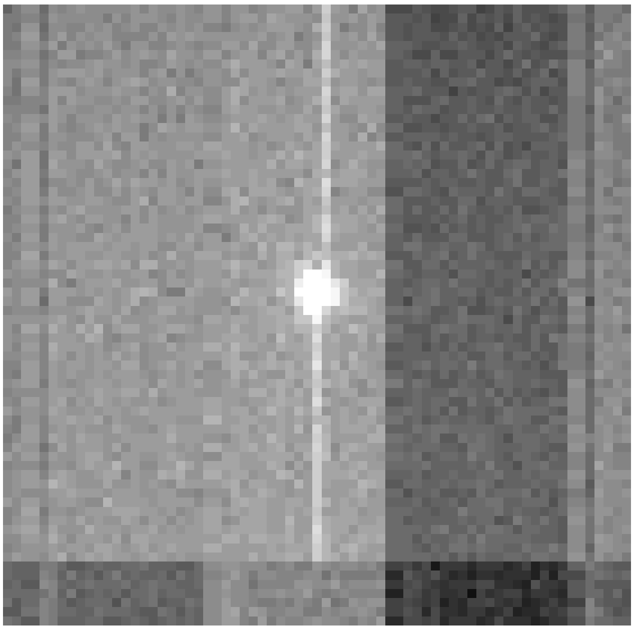


Figure 7 - Image at 635 kps at low gain (highest pixel value 106.000 electrons) - No undershoot is visible.

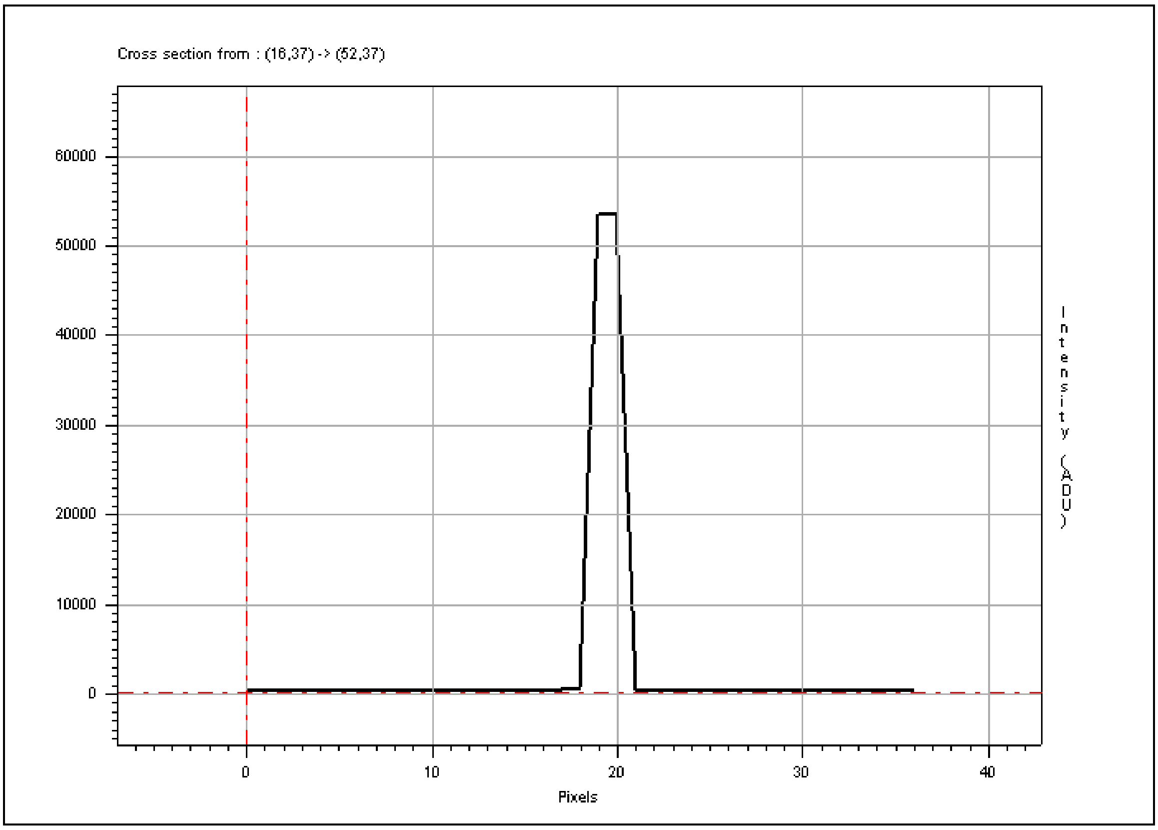


Figure 8 - Cross-section of the image at 635 kps at low gain (highest pixel value 106.000 electrons) - No undershoot is visible. Horizontal axis : pixel number, vertical axis: pixel response (adu).

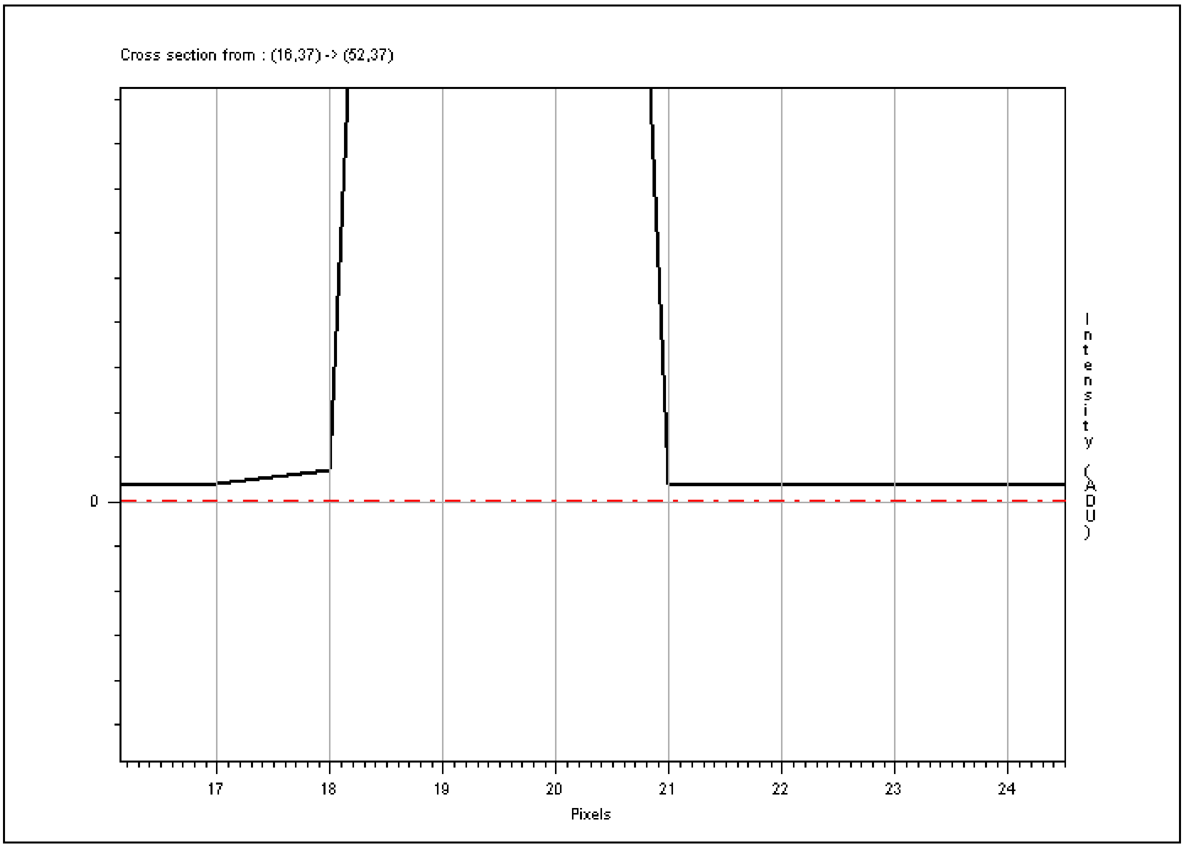


Figure 9 - "Blowup" of the cross-section of the image at 635 kps at low gain (highest pixel value 106.000 electrons) - No undershoot is visible. Horizontal axis : pixel number, vertical axis: pixel response (adu).

Cross-talk

We did not detected any cross-talk between the channels under a levels of 90.000 electrons per pixel. Nevertheless for a highly saturated pixel, over 120.000 electrons, crosstalk is visible. To avoid cross-talk we recommend to keep the light level always under 90.0000 electrons per pixel or less.

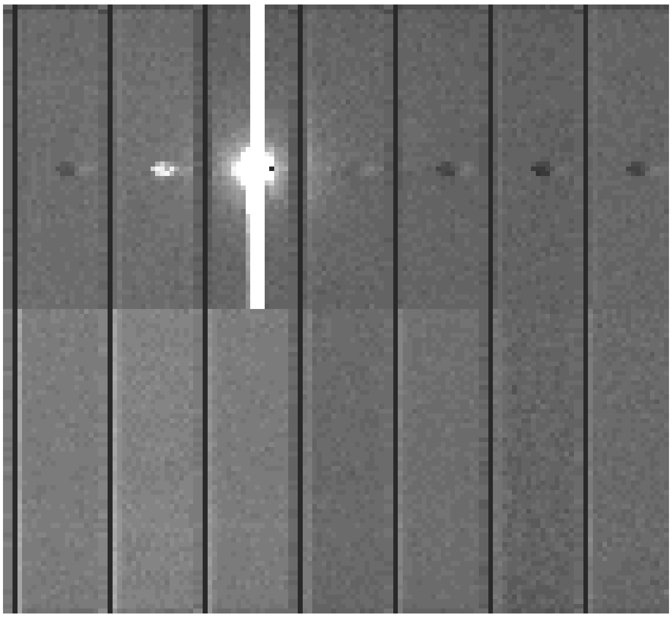


Figure 10 - Highly oversaturated image at low gain, crosstalk is visible.

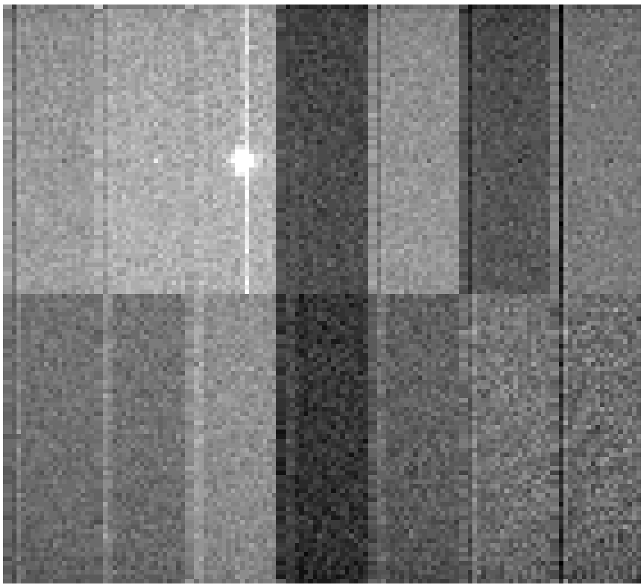


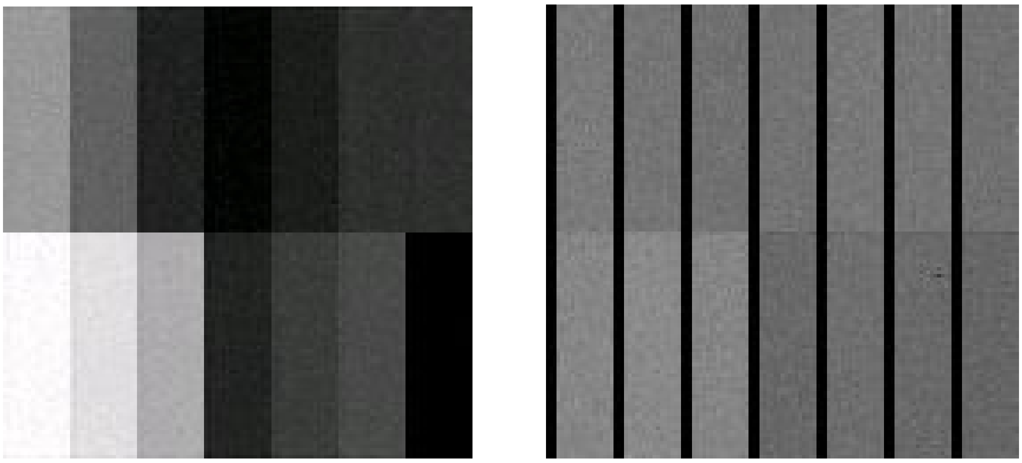
Figure 11 - Image at low gain with 100.000 electrons, crosstalk within the noise.

Charge transfer efficiency

- The CTE for parallel transfer will be not less than 0.99999 (EEV measurement)
- The CTE for serial transfer will be not less than 0.99999 (EEV measurement)

4.2.7 Cosmetic quality of the NAOS CCD

The CCD used for the final system is, except for a single trap seen in output port 0P/7, defect free. This trap is only visible in a flat field image and is slightly less light sensitive by 3 % compared to the other pixels.



dark frame flat field

Figure 12 - Cosmetic quality of the detector

4.2.8 Electronic offset

All offsets are adjusted between 200 and 400 ADU for all channels. Nevertheless the offset level will depend on the grounding applied. We expect a maximum variation of around 50 ADUs. There is not need to readjust the offset levels once the system is mounted at the final structure.

4.2.9 Contamination risks and how to keep the system clean

The final detector system was undergoing a thorough cleaning procedure at the ESO ODT lab. During the final test phase we did not detect any contamination on the CCD.

The cryostat should be always under vacuum if not used and the CCD should be the warmest point in the dewar during warming up phases. If possible the CCD should be heated to 25 C during the warming up phase with the PULPO temperature controller.

If you start integrating the lenslets and other mechanics inside the cryostat the procedures described in the ODT webpages : http://www.eso.org/projects/odt/contamination/clean.html must be followed to ensure a clean system. The pages give detailed information on:

- Good and Bad Materials
- Needed Equipment and Precautions
- Handling Procedures and Working Conditions
- Treatment of Components - Washing and Baking
- List of Contaminants

5. Cryogenics

5.1 Cooling and temperature parameters

CFC cold plate temperature:	-150 °C
CCD carrier temperature:	-120 °C
CCD operating temperature is: (Sensor one and two)	-100 °C
Electronic box shut down temp:	+ 40 °C

The temperature mentioned here are temperature issued from the cryostat design.
Real cold plate and CCD operating temperatures have been measured in Bellevue and are reported in Ref. [12].

5.2 Flexure test

There will be a detailed report from Grenoble (see Ref. [12]) on the results of the flexure tests performed on the 9th and 10th of May 2000 at ESO.

5.3 Lenslet holder integration

The lenslet holder will be integrated in the final camera in Grenoble. The lenslet holder will be cleaned at Grenoble using the recommended ESO cleaning procedures.
The lenslet holder integration and characteristics are fully described in Ref. [12].

6. Electrical interfaces

6.1 Cryostat temperature controller

The interface between the cryostat temperature controller and NAOS is a RS485 link connected with the cable named “VIS-HSK-CRYO” [7]. The interface is fully described in this document.

6.2 FIERA/RTC cable interface

The electrical interface is fully described in the ref. [4].

7. Deliverable

The items preceded by a * are already provided to LAOG with the previous system.

7.1 Cryogenic system

7.1.1 Cryostat

- One continuous flow cryostat. The pumping interface is a Pneurop DN40 flange terminated with a manual valve (in the ref. [4], an electrovalve was connected the cryostat flange, this one will be now placed near the vacuum pump).

- Specific cryostat temperature controller including PULPO (the standard ESO temperature controller can be provided first when delivering the system at LAOG) . The 12 V power supply will be provided by the NAOS consortium

- Full range vacuum Gauge Balzers connected to the cryostat.

7.1.2 LN2 pipes

- LN2 pipes from tank to the Visible and the IR Cryostats including the rotating feed-through and connectors including valves .

7.1.3 Pumping system

- *One vacuum pump Alcatel Drytel Micro terminated DN40
- *One DN40KF vacuum electrovalves

7.2 Detector

7.2.1 Detector electronics

- FIERA Detector Head Electronics (DFE)
- FIERA preamps
- FIERA SPARC LCU
- FIERA DC Power Supply
- All electrical cables defined in the ref. [4],including the link Spark LCU/ RTC, excepted the cable "VIS-HSK-Omega" provided by the NAOS consortium

7.2.2 CCD cryostat head with the EEV chip

7.2.3 Cables

Cables will be provided 2 times. One set for the prototype camera integrated on the adapter, the other set for the final camera. Fiber links (VIS-DFE-DAT and VIS-HSK-PULPO): For each link, 2 fibers will be provided, the longest one goes through the cable twist, the smallest one goes from the rack (PULPO or FIERA DFE) to a connecting box fixed on the adapter. The cable VIS-PWR-Omega is provided by NAOS.

- PULPO Cryostat VIS-CR-PULPO, 6.1 m
- FIERA DFE Fiera PT100, 3.7 m
- Vac Gauge VIS-CR-VAC, 6.1 m
- RS232 Sparc (fiber) VIS-HSK-PULPO, 20 m + 1.4 m
- FIERA DC (power) VIS-PWR-Pulpo, 3.2 m
- Temp control Cryostat VIS-CR-OMEGA, 6.1 m
- Nitrogen valve VIS-CR-N2V, 6.1 m
- 12 V PS VIS-PWR-Omega provided NAOS
- FIERA DFE cryostat clocks VIS-DET-clocks, 1.6 m
- FIERA DFE cryostat bias VIS-DET-bias, 1.7 m
- FIERA DFE video preamp VIS-DET-video, 1.7 m
- FIERA DFE preamp control VIS-PA-ctrl, 1.7 m
- Preamp 1 cryostat video 1 Not named ,20 cm

- Preamp 2 cryostat video 2 Not named, 20 cm
- SPARC SPARC cable twist VIS-DFE-DAT, 20 m + 3.4 m

7.3 Documentation

7.3.1 FIERA User's Manual

7.3.2 FIERA Maintenance Manual

7.3.3 Cryostat Operating and User's Manual

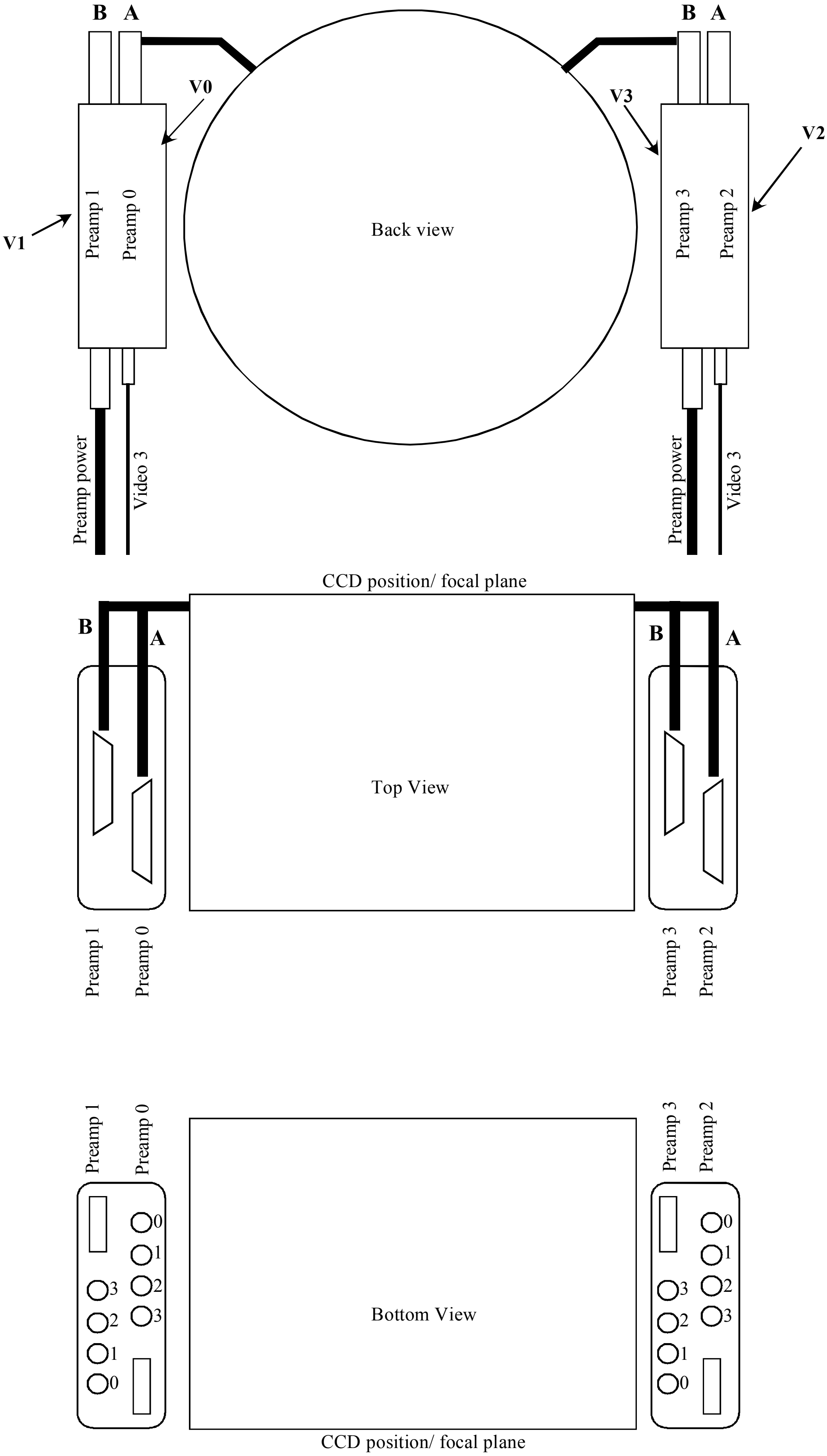
9. Spares

A full CCD detector system will be delivered as a spare (date to be defined with the ESO ODT). Therefore the first CCD system will be reused and upgraded.

9. NAOS specific cable documentation

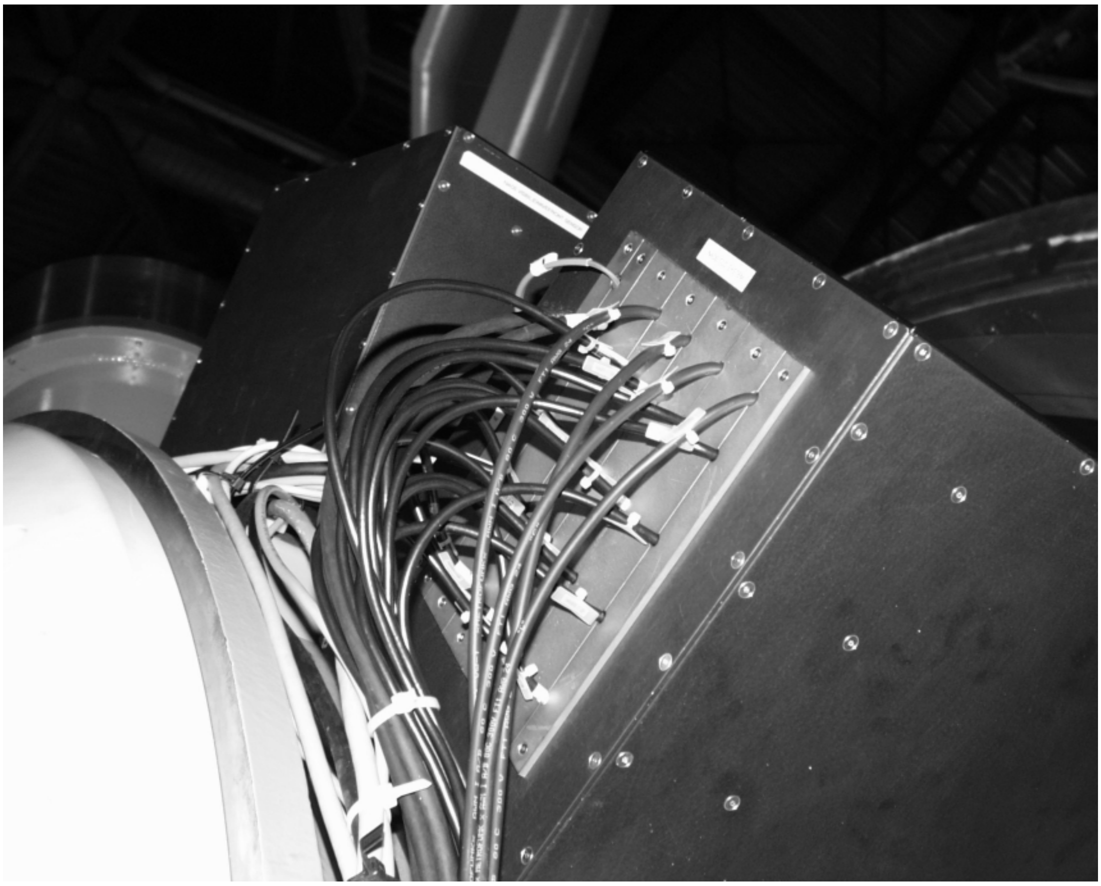
All cables used for the NAOS system are standard FIERA system cables. Cables specific to the NAOS system are documented below:

1. CCD clockcable
2. CCD video cable
3. CCD bias cable.
4. CCD cryostat PCB : video connector and bias connectors
5. CCD cryostat PCB : CCD Ziff socket
6. CCD cryostat PCB : Channel 8 and 9 loads



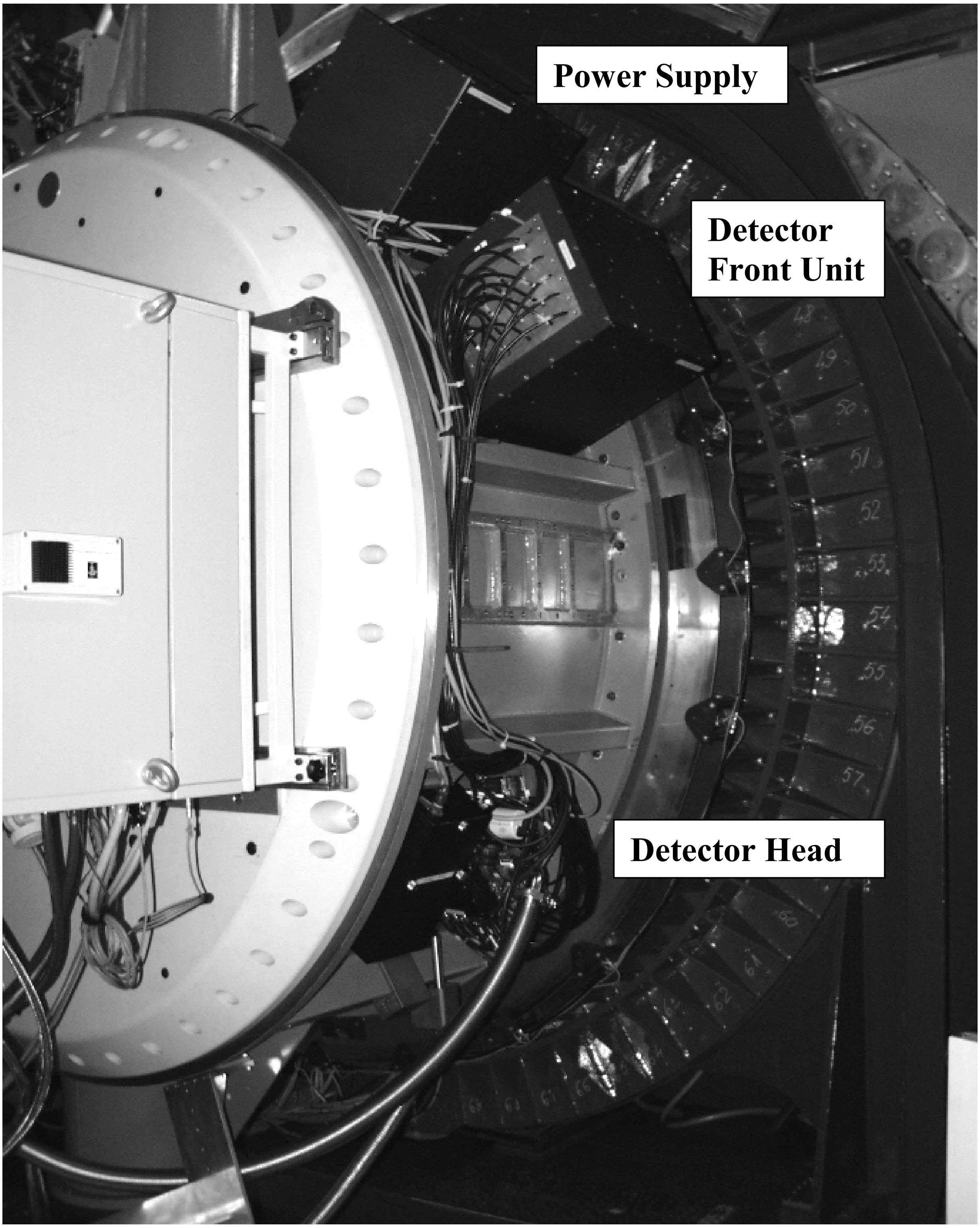
Preamp location and mechanical/electrical interface

10. Pictures



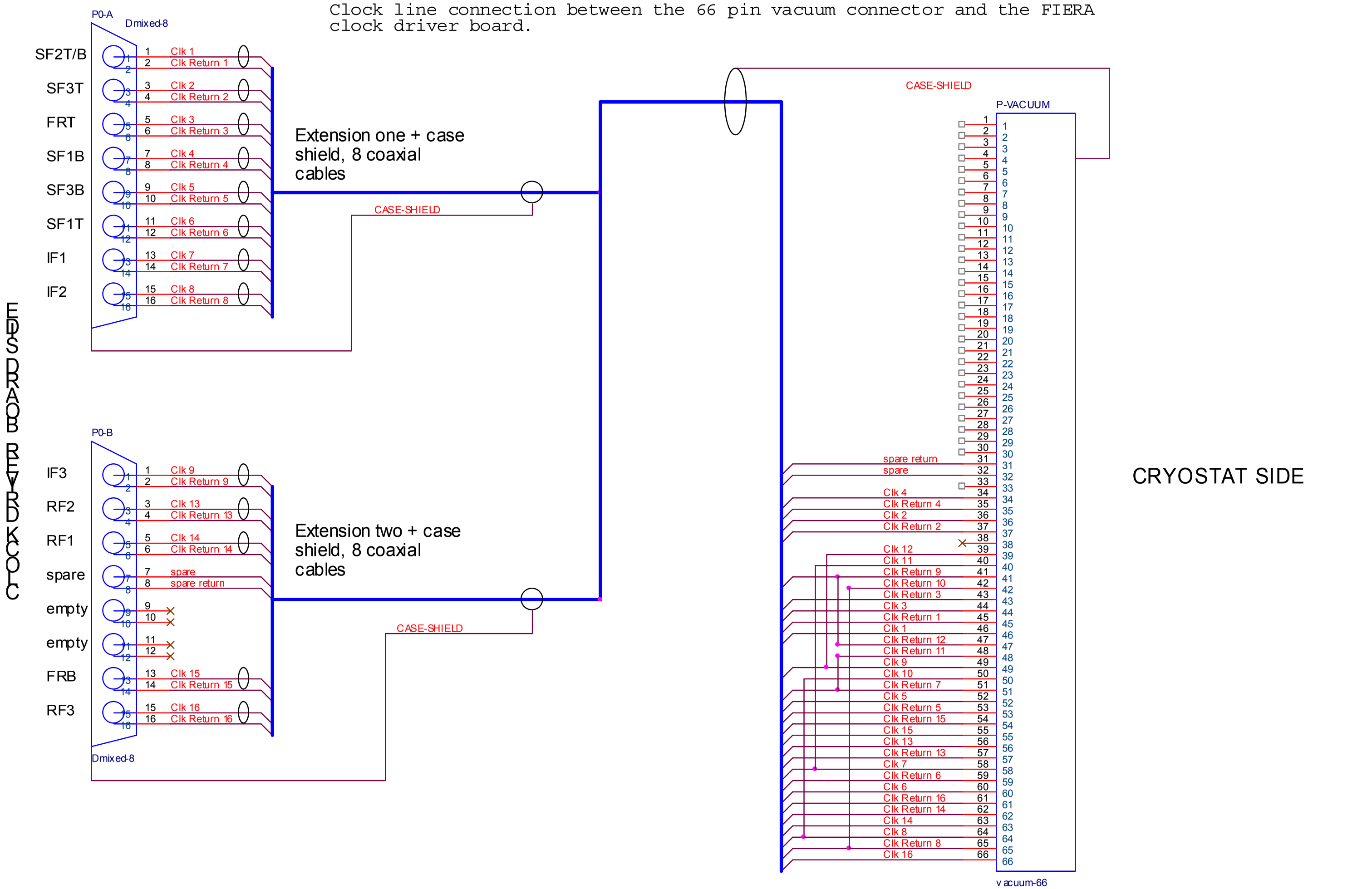
Fiera Detector Front unit Boxes attached to NAOS

Detector head attached to NAOS



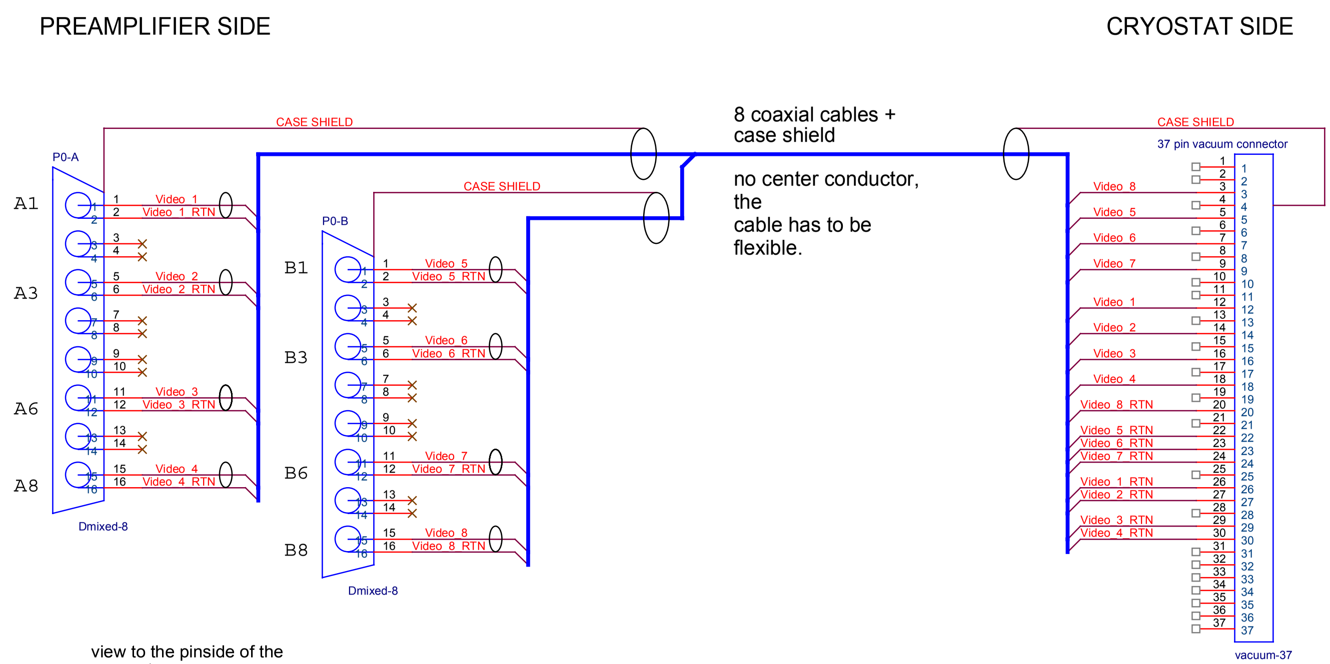
FIERA system with NAOS

Clock line connection between the 66 pin vacuum connector and the FIERA clock driver board.



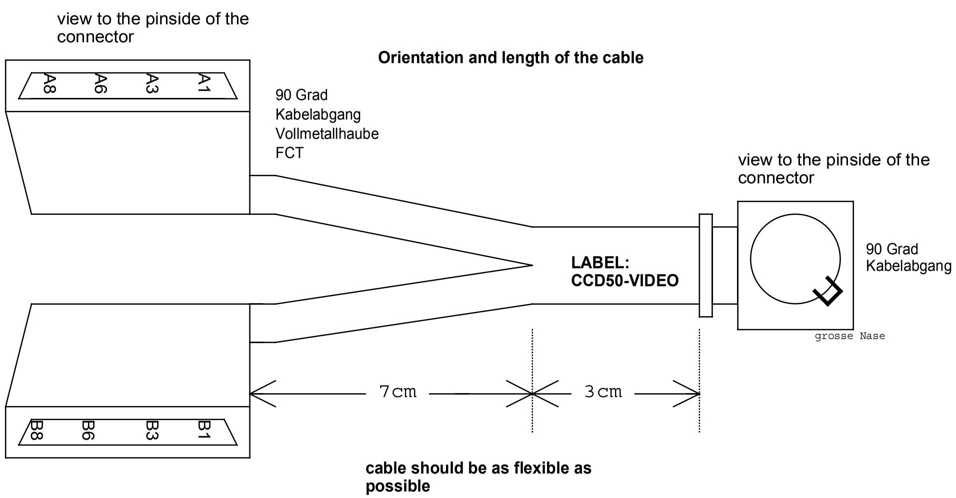
NOTE: All clock lines are 50 ohm coaxial cables. The central insolation of the coaxial cables are of Teflon type. The housing of the three connectors are connected to the case shield.

NAOS	EUROPEAN SOUTHERN OBSERVATORY			
CLOCK-EEV-CCD50	INTERFACE CRYOSTAT / CLOCK BOARD			
Rolf Gerdes	Size B	CAGE Code	DWG NO ESO-INS-ODT-CRYCLK-0597000	Rev V0
Thursday, December 24, 1998	Scale		Sheet 1 of 1	



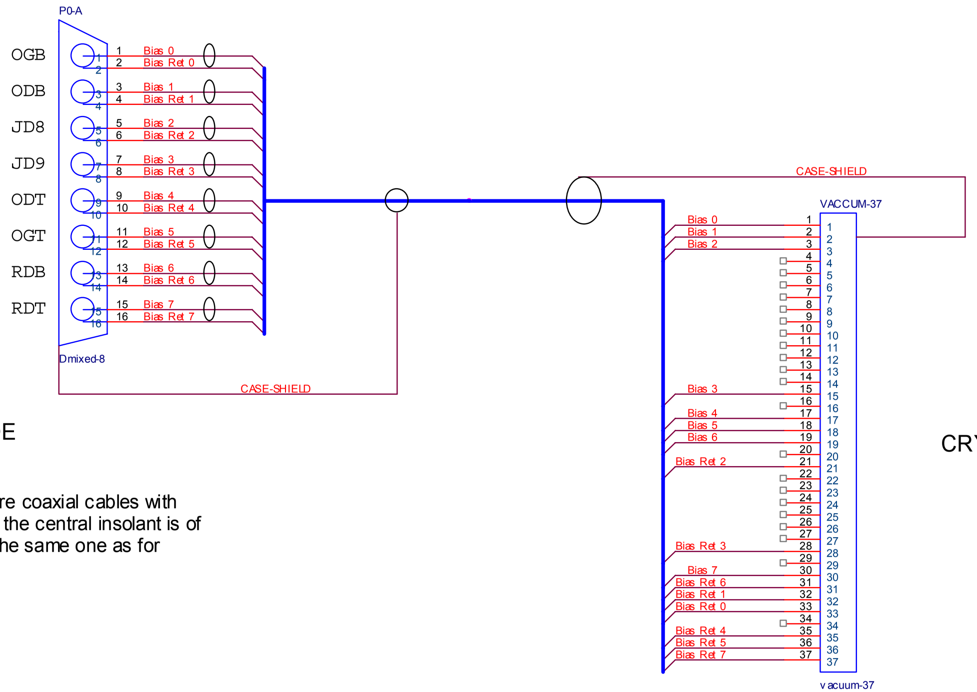
NOTE: The central wire of the coaxial cable should be connected to the video signal. The shield of the coaxial cable is to be connected to each video signals corresponding video return signal.

NOTE: Each video signal is fed to the preamplifier via a coaxial cable.Teflon insolated coaxial cables should be used, the central insolant should also be of Teflon.



CCD VIDEO NAOS	EUROPEAN SOUTHERN OBSERVATORY				
	INTERFACE CRYOSTAT / PREAMPLIFIER				
Rolf Gerdes	Size B	CAGE Code	DWG NO ESO-INS-ODT-CRYPAMP-		Rev V1
Thursday, January 14, 1999	Scale		Sheet 1 of 1		

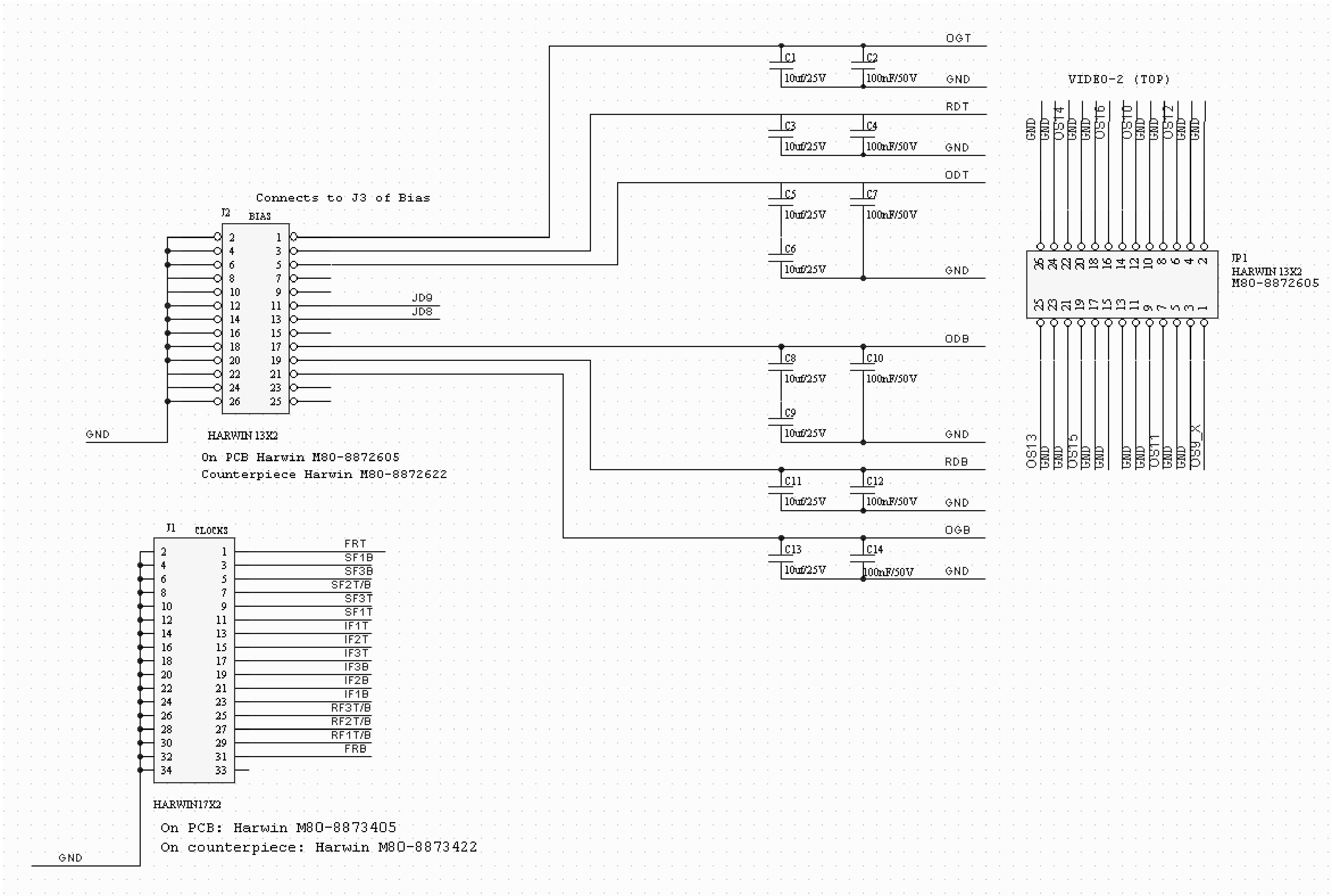
BIAS BOARD SIDE



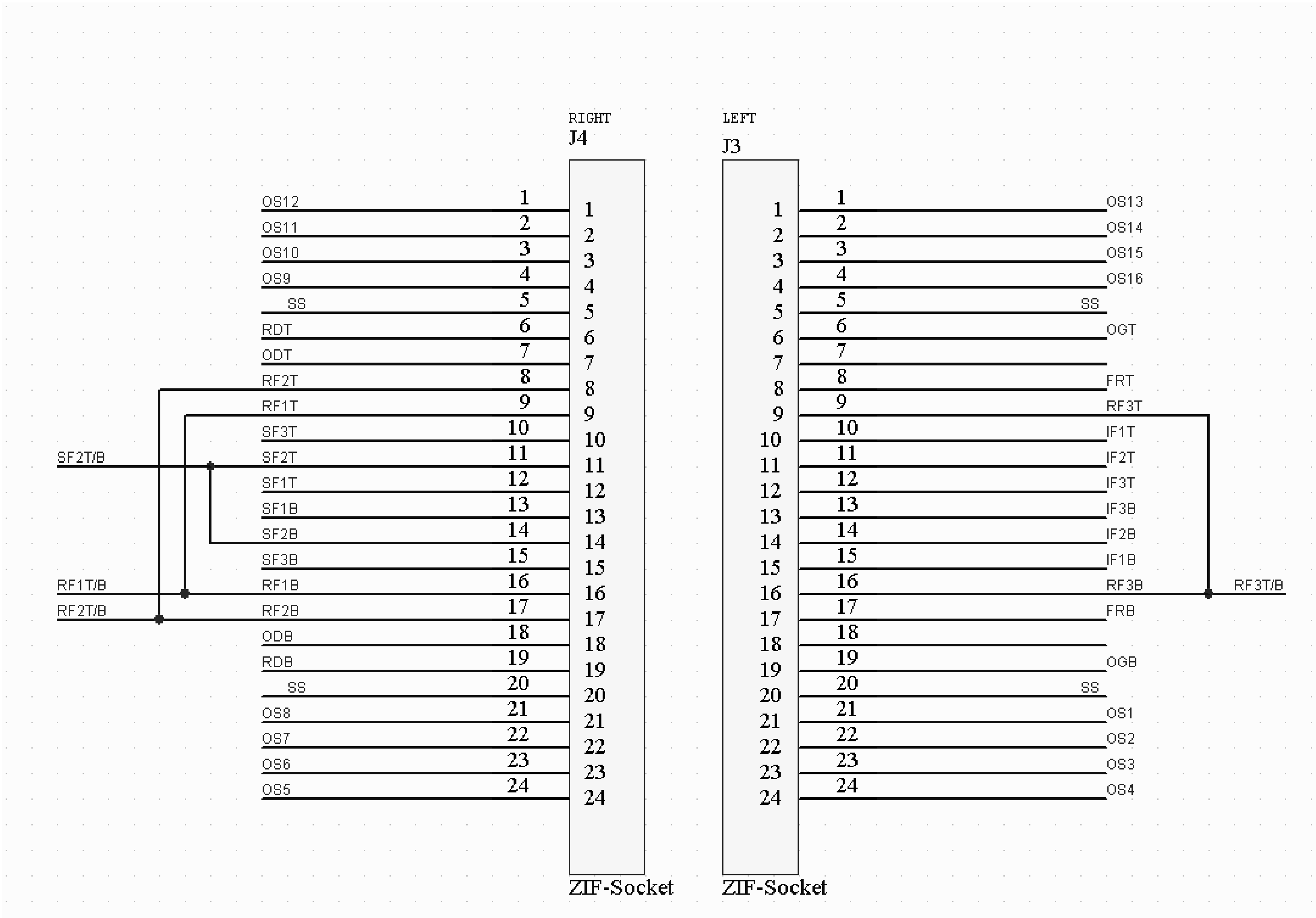
CRYOSTAT SIDE

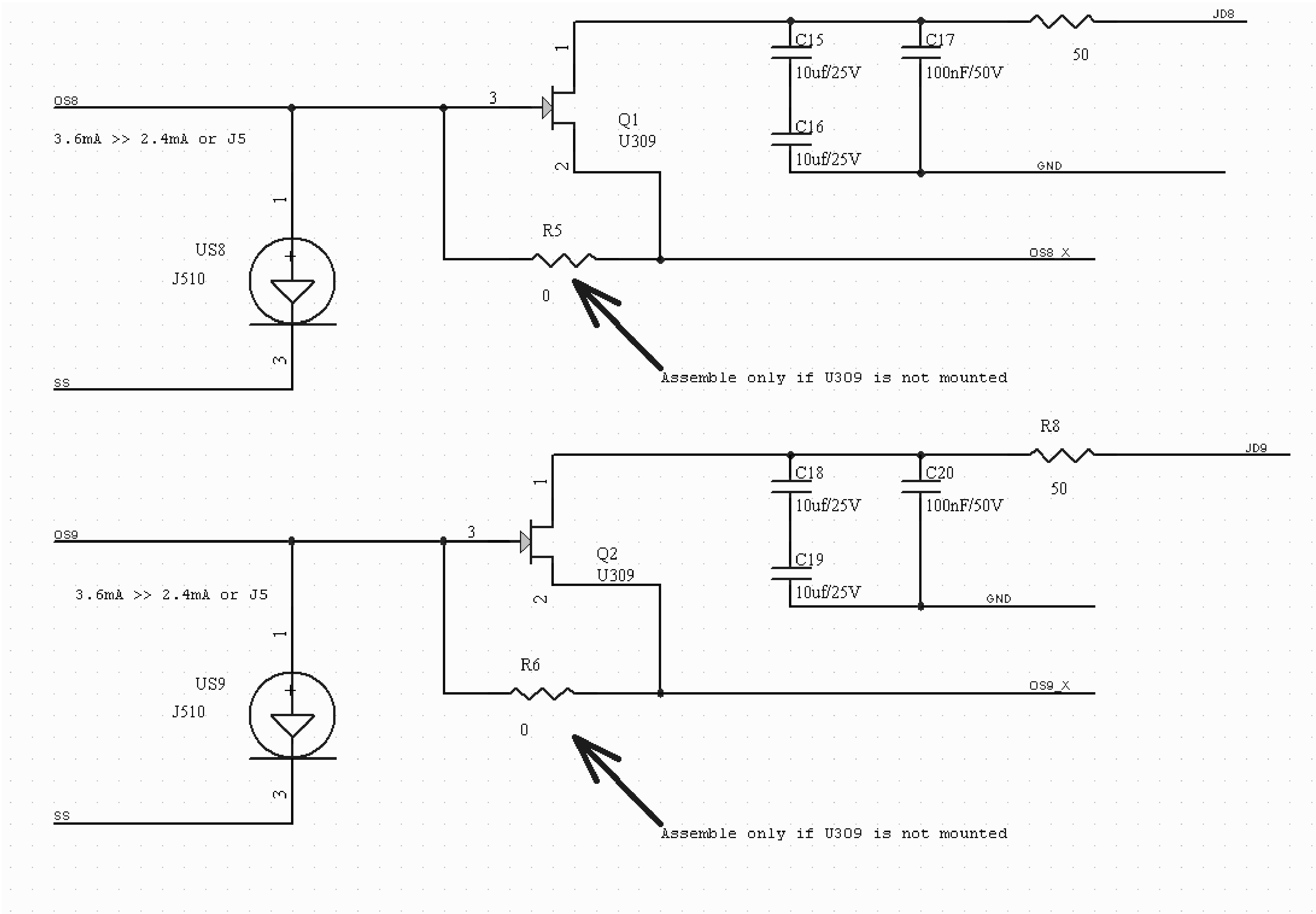
NOTE: All bias lines are coaxial cables with Teflon insolation (also the central insolant is of Teflon). The cable is the same one as for UVES blue.

NAOS-CCD-EEV50	**EUROPEAN SOUTHERN OBSERVATORY**			
	INTERFACE CRYOSTAT / BIAS BOARD			
Rolf Gerdes	Size B	CAGE Code	DWG NO ESO-INS-ODT-CRYBIASCABLE	Rev V0
Thursday, December 24, 1998	Scale		Sheet 1 of 1	



Connects to J3 of Bias
J2
BIAS
HARWIN 13X2
On PCB Harwin M80-8872605
Counterpiece Harwin M80-8872622
JD9
JD8
GND
OGT
RDT
ODT
ODB
RDB
OGB
C1 10uf/25V
C2 100nF/50V
C3 10uf/25V
C4 100nF/50V
C5 10uf/25V
C6 10uf/25V
C7 100nF/50V
C8 10uf/25V
C9 10uf/25V
C10 100nF/50V
C11 10uf/25V
C12 100nF/50V
C13 10uf/25V
C14 100nF/50V
VIDEO-2 (TOP)
JP1
HARWIN 13X2
M80-8872605
OS13
OS15
OS11
OS9_X
OS14
OS16
OS10
OS12
J1
CLOCKS
FRT
SF1B
SF3B
SF2T/B
SF3T
SF1T
IF1T
IF2T
IF3T
IF3B
IF2B
IF1B
RF3T/B
RF2T/B
RF1T/B
FRB
HARWIN17X2
On PCB: Harwin M80-8873405
On counterpiece: Harwin M80-8873422


RIGHT
J4
OS12
OS11
OS10
OS9
SS
RDT
ODT
RF2T
RF1T
SF3T
SF2T
SF1T
SF1B
SF2B
SF3B
RF1B
RF2B
ODB
RDB
SS
OS8
OS7
OS6
OS5
SF2T/B
RF1T/B
RF2T/B
ZIF-Socket
LEFT
J3
OS13
OS14
OS15
OS16
SS
OGT
FRT
RF3T
IF1T
IF2T
IF3T
IF3B
IF2B
IF1B
RF3B
FRB
OGB
SS
OS1
OS2
OS3
OS4
RF3T/B
ZIF-Socket


OS8
3.6mA >> 2.4mA or J5
US8
J510
SS
3
1
2
Q1
U309
R5
0
Assemble only if U309 is not mounted
C15
10uf/25V
C16
10uf/25V
C17
100nF/50V
GND
50
JD8
OS8_X
OS9
3.6mA >> 2.4mA or J5
US9
J510
SS
Q2
U309
R6
0
Assemble only if U309 is not mounted
C18
10uf/25V
C19
10uf/25V
C20
100nF/50V
GND
R8
50
JD9
OS9_X