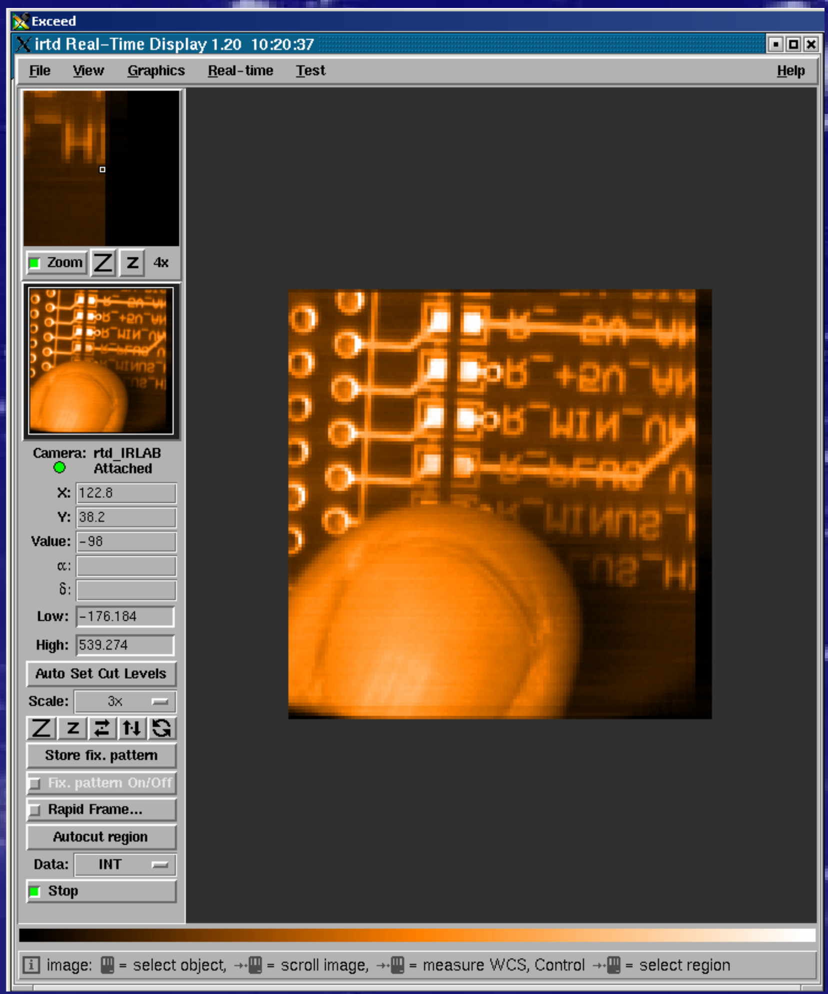
NGC and L3 CCDs



First Light

L3 CCD 60

Screenshot

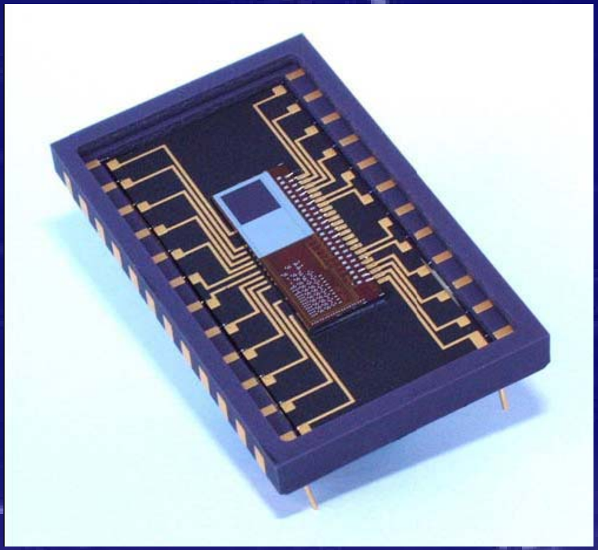
M.Meyer
Dez 05

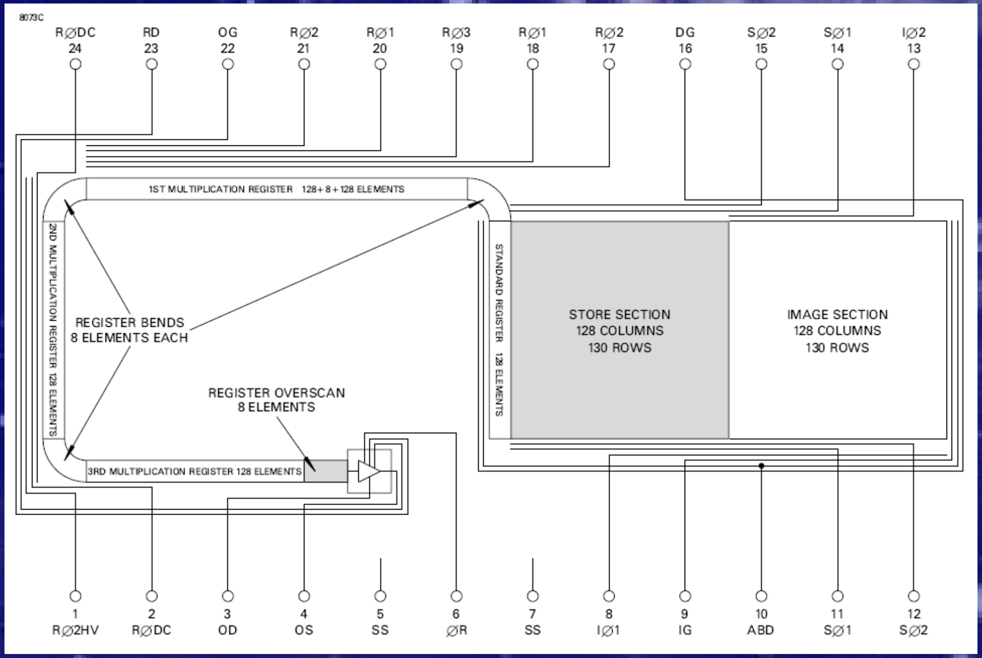
Introduction

The goal of this project was getting in touch with the technology needed to read an electron multiplying CCD sensor, because in adaptive optics an sensor of this type (CCD 220) is foreseen as wave-front sensor.

The sensor was running **uncooled**, so the data may be much worse than with a cooled device.

CCD 60





Active image area	3.072 x 3.072 mm
Image section active pixels	128 (H) x 128 (V)
Image pixel size	24 x 24 µm
Number of output amplifiers	1
Fill factor	100%
Spectral range	400 - 1060 nm

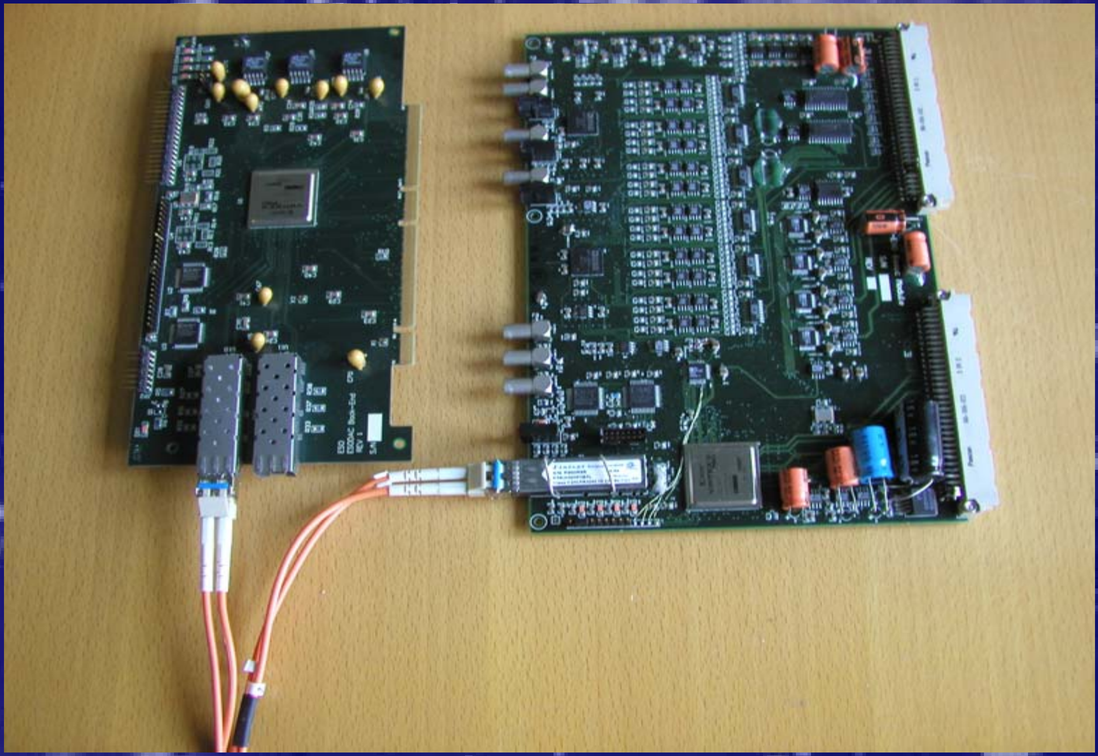
Test Set-up NGC Prototype for L3 Read-out 1

The read-out electronic used is the NGC prototype and an add on board with some components (mainly fast clock drivers and a high voltage resonant circuit).

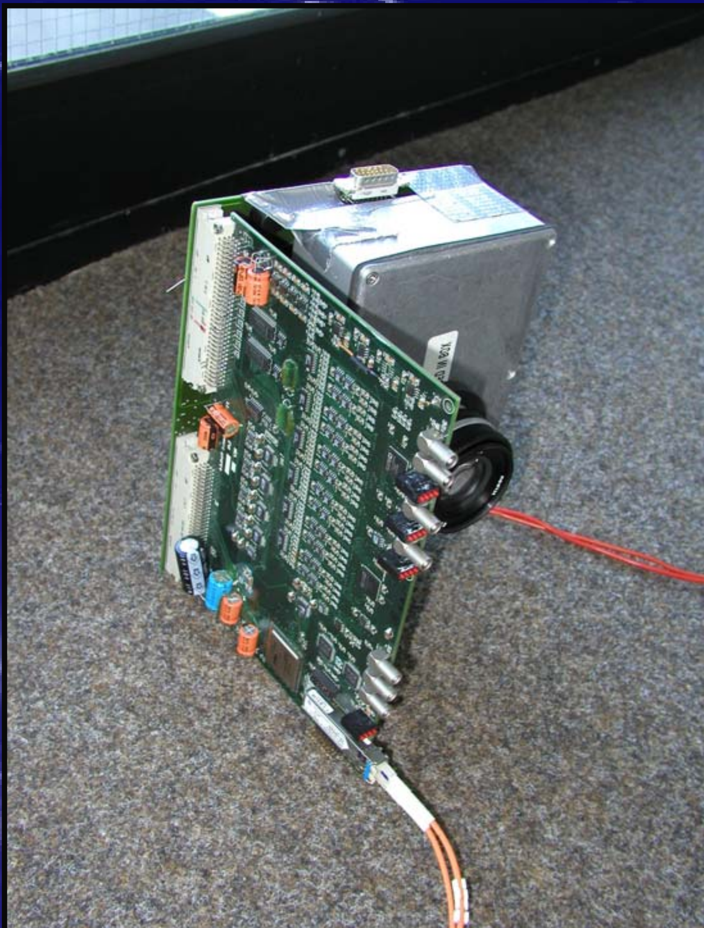
A small housing with a NIKON objective was used as optic set up.

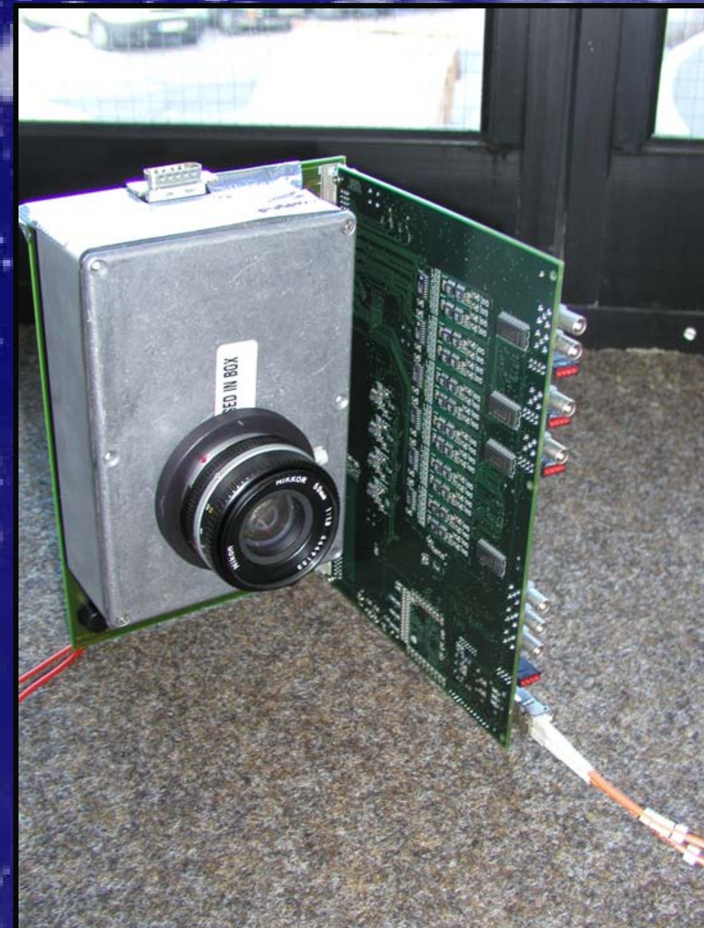
The sensor runs uncooled.

The ADC on NGC Proto has a maximum conversion rate of 1 MS/s, this determined the maximum pixel rate (at a later time it is foreseen to run with a high speed, pipelined ADC (till 40 MS/s) of the add on board - footprint implemented but chip not yet delivered).

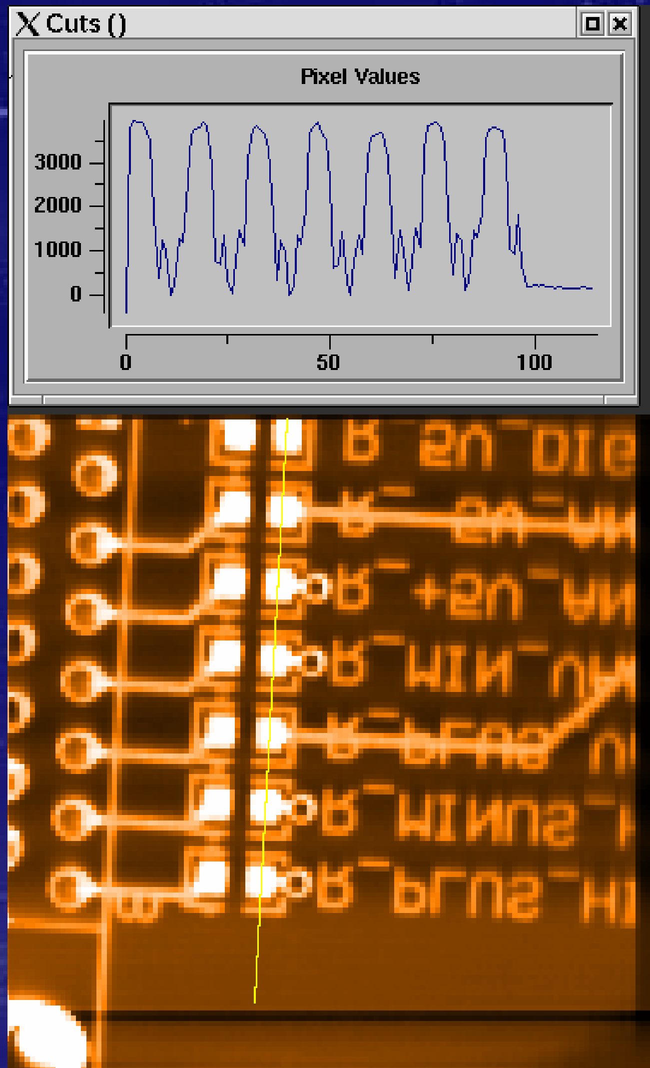


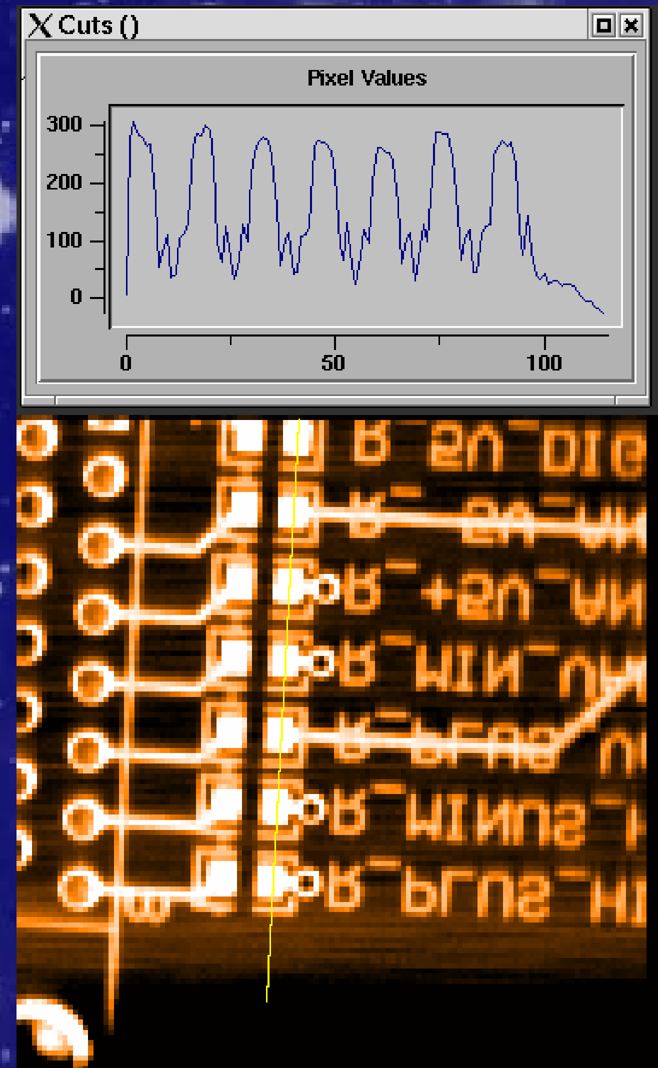
Test Set-up NGC Prototype for L3 Read-out 2



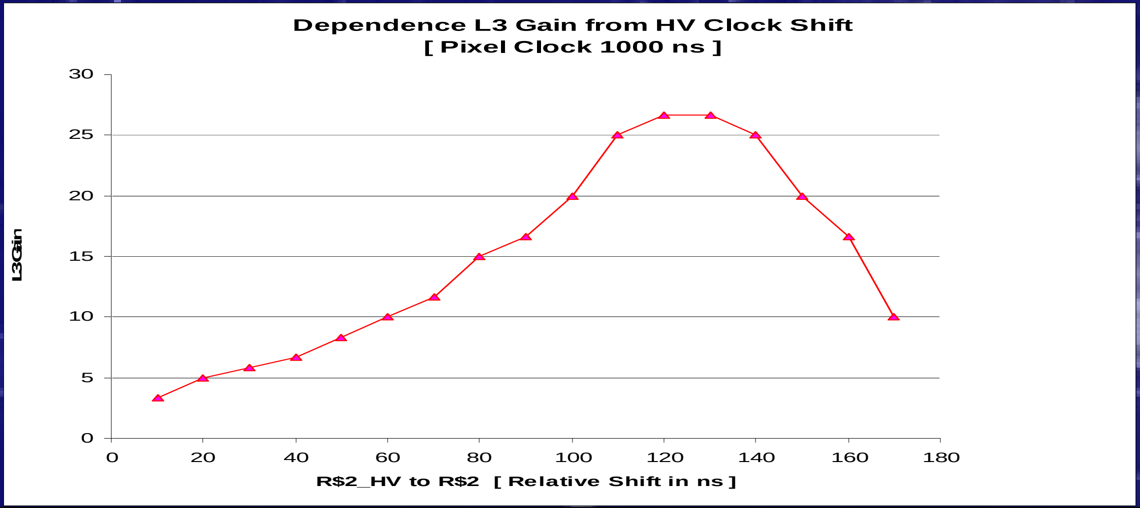


L3 with and without Gain





Multiplication Gain versus Phase Shift



Δ Gain = 1/27 = ~ 0.037 @ assume 10MHz clock and phase noise of 2ns and therefore a gain change of 1 (equal behavior of clock phase to 1MHz)

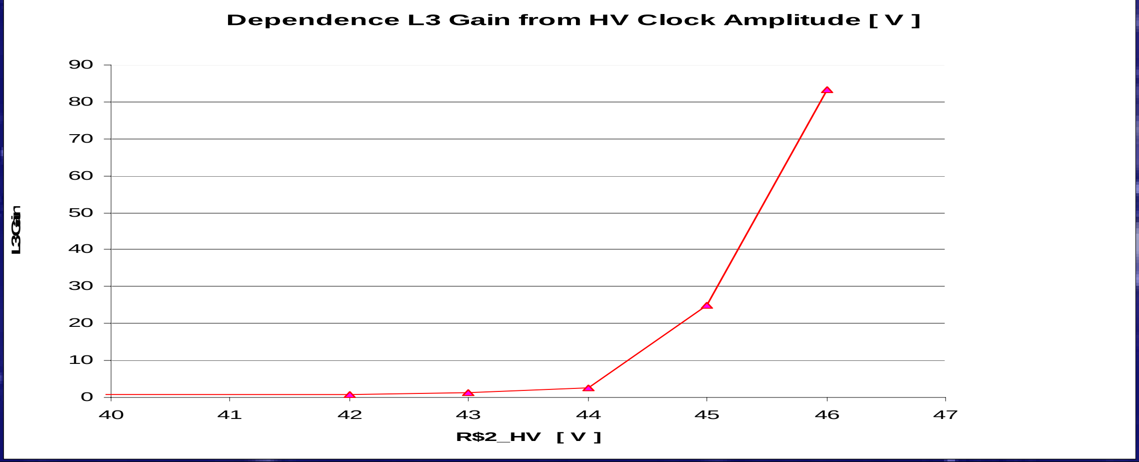
Shot noise = SQRT(N) | N after multiplication
Gain Noise = 0.037 * N

Shot noise = Gain Noise → SQRT(N) = 0.037 * N

Assume operation at gain 100

This means already with 730 electrons after multiplication (or 7 at sensor) the noise caused by gain variation is as big as shot noise.
The error will then always be > 3.7 %!

Multiplication Gain versus R$2_HV Gate Voltage



Δ Gain = 100 for 1Volt at a Gain 100
Δ Gain = 1 for 10mV | 10mV RMS estimated amplitude noise

Shot noise = SQRT(N) | N after multiplication

Gain Noise = 0.01 * N

Estimation of the error caused by gain variation due to R$2HV voltage variation :

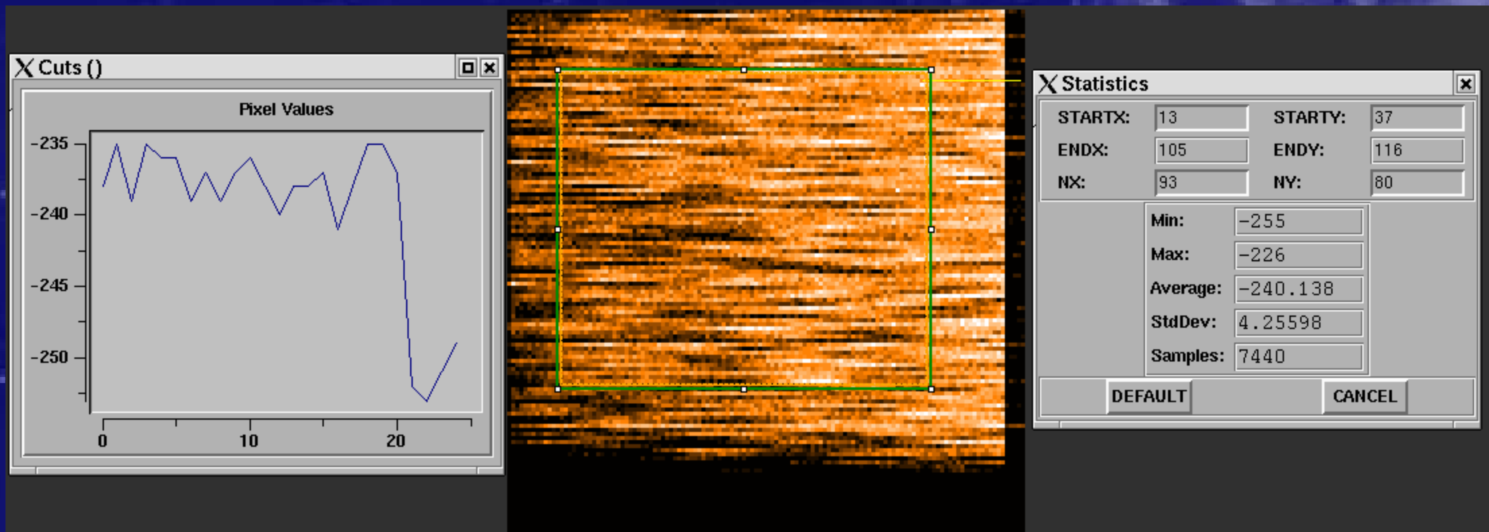
Gain Noise = 0.01 * N
Shot noise = Gain Noise → SQRT(N) = 0.01 * N

This means already with 10000 electrons after multiplication (or 100 at input) the noise caused by gain variation is as big as shot noise.

Then the error will always be > 1%!

For higher multiplication gains also Δ Gain increases exponentially, and so the sensitivity to amplitude noise ! The estimated 10mV are probably not easy to achieve.

Dark exposure



As already mentioned , the device runs uncooled with relatively high dark current.

The picture below shows a dark image (~ 750 e/Frame and Pixel) and the typical smearing in row direction. What causes this effect is unclear , a bad transfer efficiency could cause it. Let's hope with a cooled chip things get better.

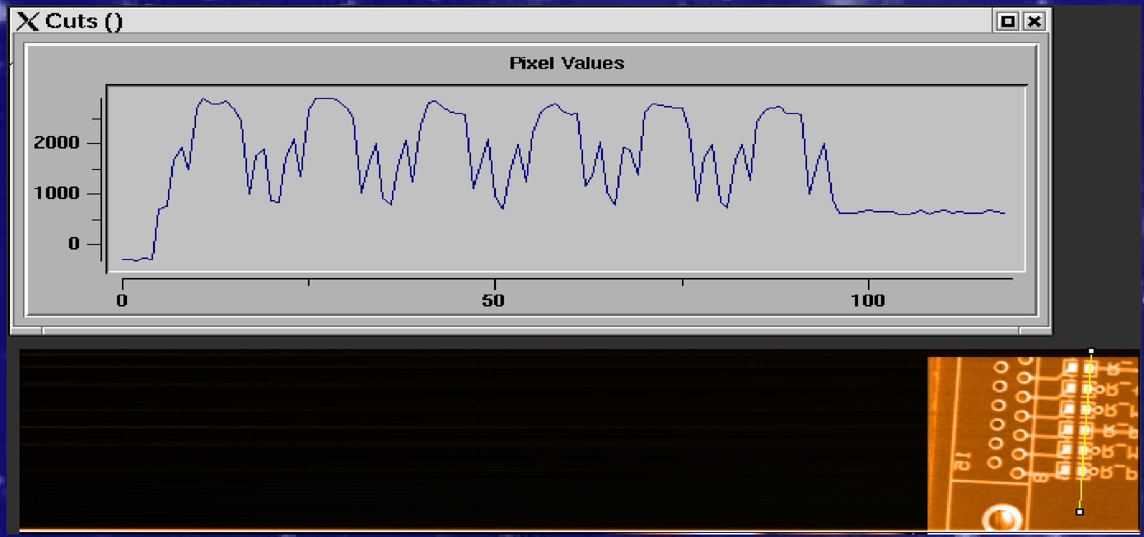
A different Read-out

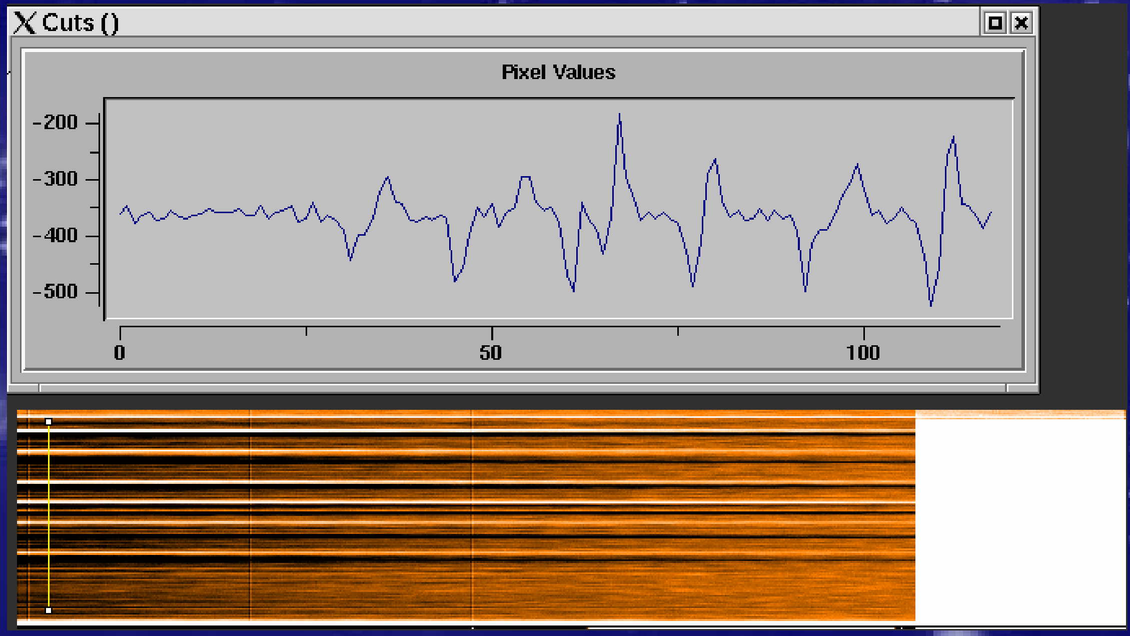
frame transfer image to storage

transfer of one line to horizontal register

read out and digitizing of whole horizontal chain = four times (8 bit register bends + 128 bit multipliers) + 8bit register bends + 128 bit pixel register

2 and 3 129 times to read out complete image



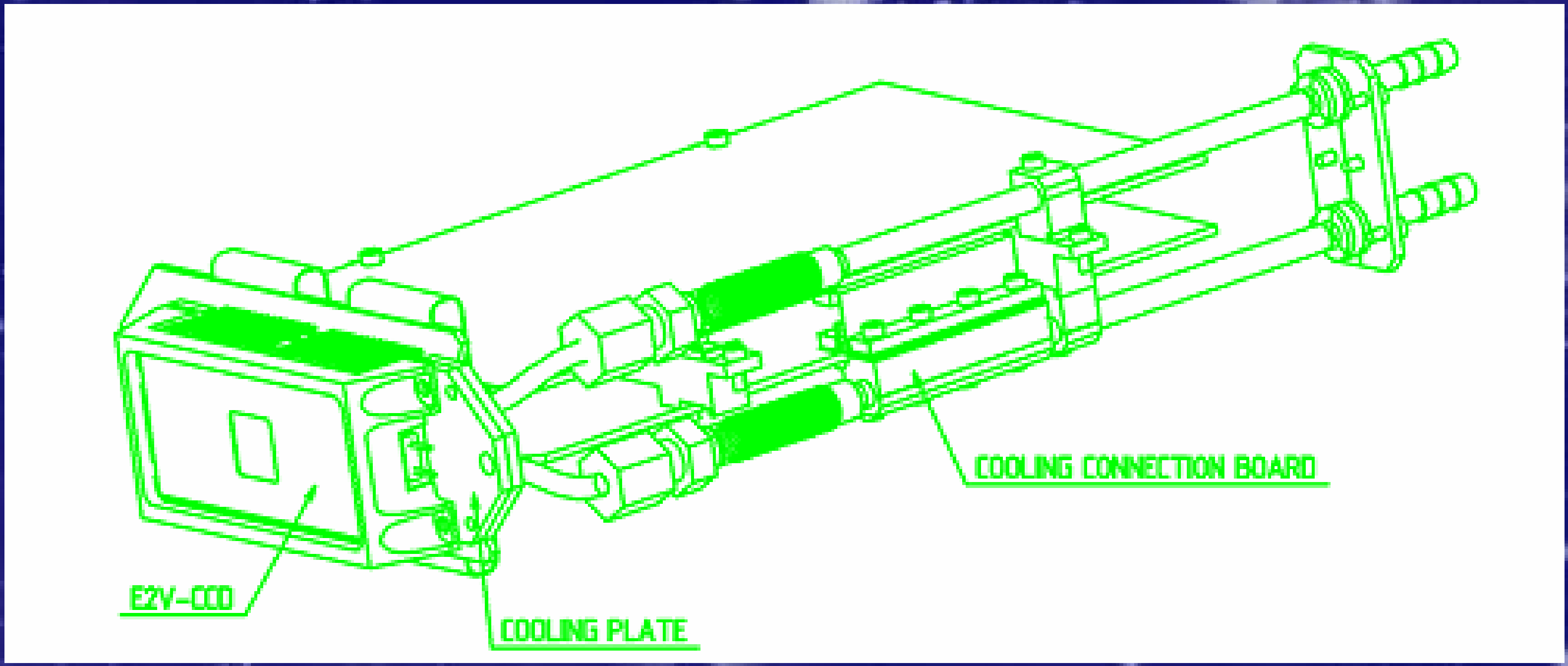


Mechanical Set-up for Wave-front Sensor

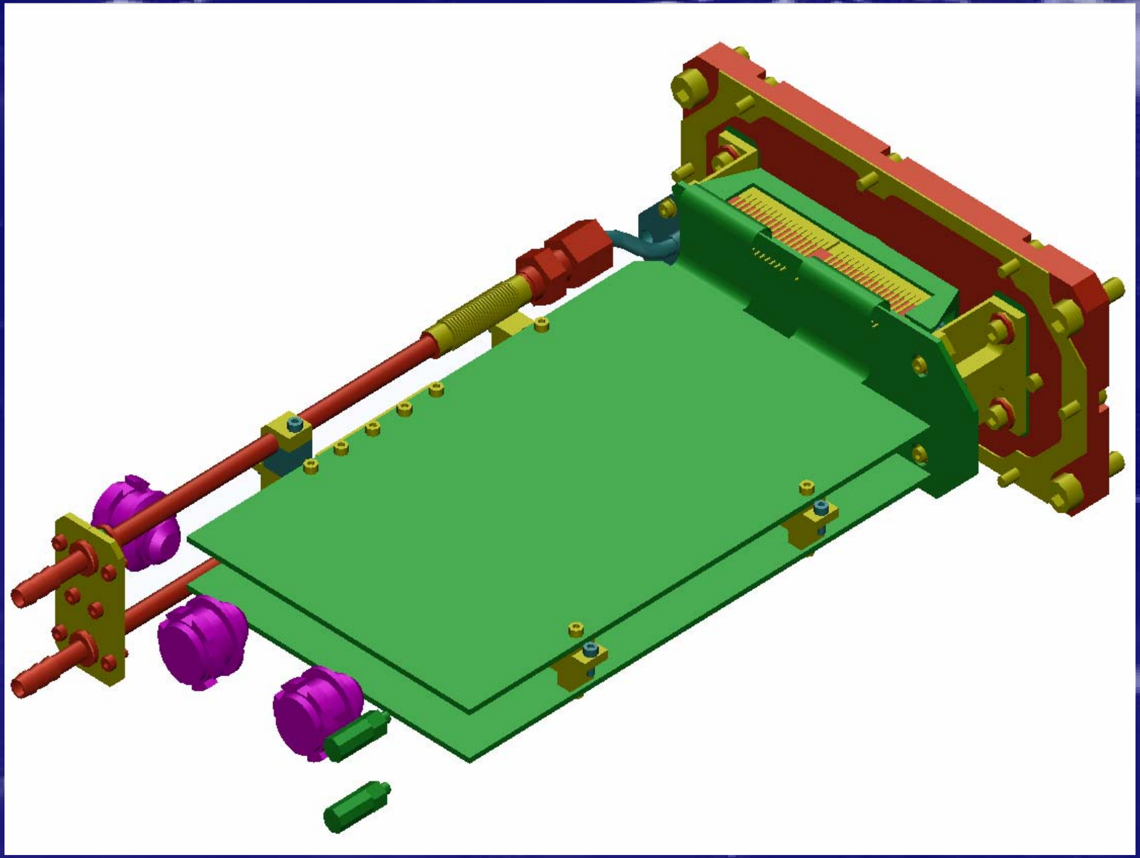
Designer

Ralf Conzelmann

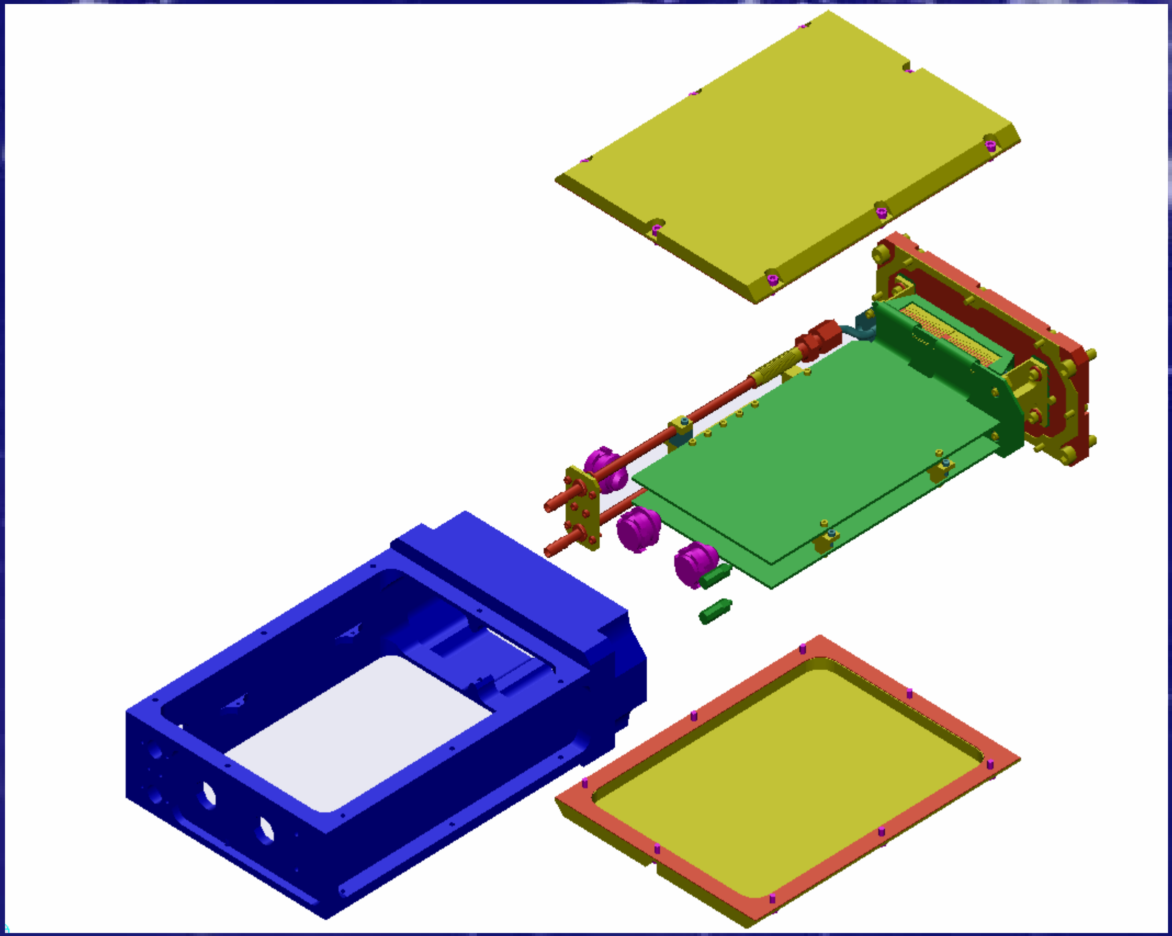
Mechanical Set-up 1



Mechanical Set-up 2



Mechanical Set-up 3



Conclusion

The L3 CCD behaved in the measurements like described the delivered data sheets from E2V.

The sensitivity of the high voltage clock amplitude and phase to the gain of the chip is seen as critical for applications in adaptive optics. Lets hope we will be much better than estimated before.

Critical is also the bad transfer efficiency. There is hope that this will be better at low temperatures.

Thanks especially for the help in preparing the mechanical camera setup to Mr. Kirchbauer from our mechanical workshop and Mr. Eschbaumer from the IR workshop.

Thanks to Joerg Stegmaier for the excellent software support, Gert Finger and Reinhold Dorn for helpful discussions and ideas.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