AiC Report to NOT STC
NOTCam Commissioning, Summer 2001.

Version for distribution to STC

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Contents

1 Introduction

This report describes the operational and technical process of bringing NOTCam to the telescope for its first three observing runs. A considerable quantity of data has been collected but has not yet been analysed sufficiently to allow a full description of the instruments capabilities. However, no "show-stoppers" have been identified and we are confident that NOTCam will shortly be available for use by the NOT community at large.

2 Timeline

Date	Event
2001-05-22	NOTCam is shipped from Copenhagen to La Palma.
2001-06-01	NOTCam arrives at NOT.
2001-06-15	Camera w/o collimator sees first star light.
2001-06-30	NOTCam is mounted on telescope and acquires first light.
2001-06-30 & 2001-07-01	First commissioning run.
2001-08-10 & 11	Second commissioning run.
2001-09-05 to 08	Third commissioning run.

3 Before shipping to La Palma

The new engineering grade detector was installed in Copenhagen in March. A modified detector flange was used (see Figure 1) which should avoid any possibility of repeating the previous engineering device destruction. The instrument was pumped and cooled and used to obtain recognisable images through both cameras, the first such images obtained with this instrument.

An early noise test shows a gain of 2.4 e^-/ADU, full well of $\sim$120ke^-, and readout noise 9-13 e^-/pixel (see Figure 2). Performance at the telescope at the time of writing is similar. Cosmetically, the detector appears very good and can probably be used for initial science observations.

The high resolution camera was shown to be incorrectly assembled by the manufacturer producing the focus point of an infinite object actually within the barrel and was returned to Graseby Specac for repair.

The detector mount assembly was modified to reach the focus of the wide field camera. Some deviations of components from the design are found, with some affecting focus positions, but none critical to proper use of the instrument.

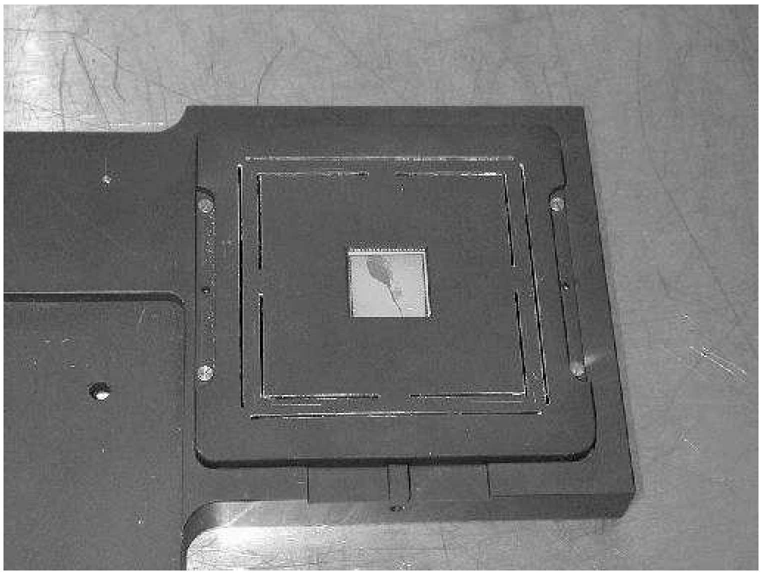

Figure 1: The modified array mount. The flexible cover plate keeps the force on the detector low to avoid any risk of overloading, even during cooldown.

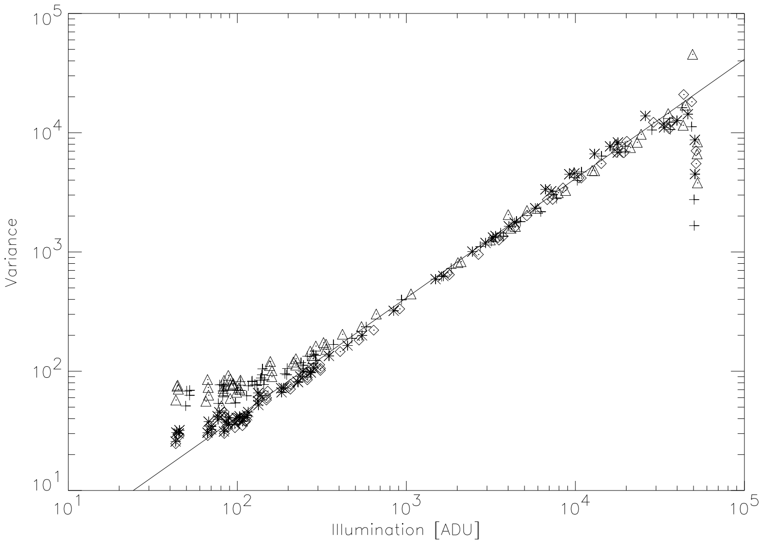

Figure 2: Transfer curve for the engineering grade device measured before NOTCam was shipped to La Palma. On-telescope performance is substantially the same.

4 Preparing the instrument for first light

On arrival on La Palma, the instrument was immediately assembled without the optics or detector installed. The electromechanics were found to operate normally (after a loose screw was removed). The lid was installed and the instrument pumped and found to acheive a reasonable vacuum.

The H filter, pupil imager and wide field camera lens were installed, the dewar closed and pumped again. (More filters could not be installed because all the holders in hand, except 2, are insufficiently thick. New holders were ordered from CUO/IJAF.) Everything was verified to operate normally at room temperature. Cooling was begun with the PTR alone, acheiving a cold table temperature of -7.5C after 7 hours. The instrument was cooled with liquid nitrogen (LN_2). One channel of the video card failed and the card was replaced with the spare. Various software bugs were identified and fixed.

Using a flat mirror placed outside the office window, the collimator-less instrument saw starlight for the first time. A rough idea was obtained of where the wide field camera's focus lies and various other images were collected.

These images were heavily affected by pickup noise and the readout noise was found to be about $100e^-$/pixel (this was later fixed by connecting the mains ground to the array controller zero volts (5V ground), internally to the array controller). The focus mechanism and camera wheel motions timed out on occasion, although the camera wheel could be run reliably by slowing down the stepper motor, although, confusingly, this does not change the motor torque significantly.

Before bringing the instrument back to room temperature, we attached the telescope mount plate to make sure it fit, then rotated the instrument to a looking-down position to verify that the motors still ran in this orientation.

The instrument was returned to room temperature, assisted by forcing dry air through the LN2 reservior. This can increase the temperature of the cold table above that of the detector and raises some concern about cryopumping contaminants onto the optics or detector.

We installed the colimator, broad-band filters, four polaroids at 45°-steps and cold stops with one displaced a few millimeters along the light path to check focus. Crude experiments using a flat mirror and laser showed that the mounted optics are aligned to within a factor of 2 of the specification. The camera wheel timeouts were resolved by proper counterweight balancing. Instrument mounts for the detector controller and motor controller were fabricated.

In preparation for final closure of the instrument before first light, the getter was baked at 150 °C for $\sim$2.5 hours (less than usually preferred). The dewar was closed and pumped, and developed a vacuum better than 10^-2 mbar within 20 hours. We remounted the telescope adaptor plate and moved the instrument to the dome, in the process establishing a a safe procedure for rotating the instrument between horizontal and vertical orientations.

Pumping was continued on the dome floor. A temporary supply of glycol coolant was fed up to the dome floor to extract heat from the Iwatani compressor. Finally, NOTCam was cooled using both the PTR and LN_2. After 20 hours from the start of cooling, it was at:

Cold table temperature	-201 °C
Centre wheel temperature	-197 °C
Detector mount temperature	-189 °C
Dewar pressure	1.95×10^{-5} mBar

The detector was probably cold enough to produce useful images within 24 hours of the start of cooling. Initial cooling consumed 80 – 100l of LN_2.

The subsequent runs of cold table and detector temperatures and dewar pressure are shown in figure 3. With PTR backing, the LN_2 hold time was approximately 5 days. When the LN_2 was exhausted, the PTR maintained a cold table temperature of ~-165 °C (in the looking-up position) but by day ~ 30 this was compromised by the apparent presence of a slow leak and LN_2 was needed in the cold table to maintain cryopumping of N_2 and O_2 by the activated carbon getter. Saturation of the getter was not observed during this period.

The region around day 50 when the detector occasionally appeared cooler than the cold table is the warmup period when warmup time was reduced by forcing dry air through the LN_2 reservior. Under normal operating conditions, the detector is within ~3 °C of the cold table.

As noted above, the high readout noise was reduced by tying motor and detector controller grounds together. Grism wheel timeouts were observed and could be resolved by restarting the UIF, reinitialising the motor controller, or power-cycling the motor controller. Shutter mechanism timeouts were also observed but appeared to resolve without intervention. A number of software features and bugs were identified. Approximate internal focus of the aperture wheel was located at or near one end of the focus travel.

5 First commissioning run 30 June & 1 July 2001

NOTCam was mounted on the telescope without difficulty on 30 June (Figure 4). The PTR was disconnected while NOTCam was mounted on the telescope (pending delivery of appropriate long, high-pressure hoses.) First light was obtained at twilight that evening, the very first stellar image was very nearly in focus and positioned near the center of the array (Figure 5).

During the first two nights' observations, the following were acheived and learned:

- There is no sharp focus of the primary mirror by the pupil imager, but what focus there is lies within the range of the focus mechanism.

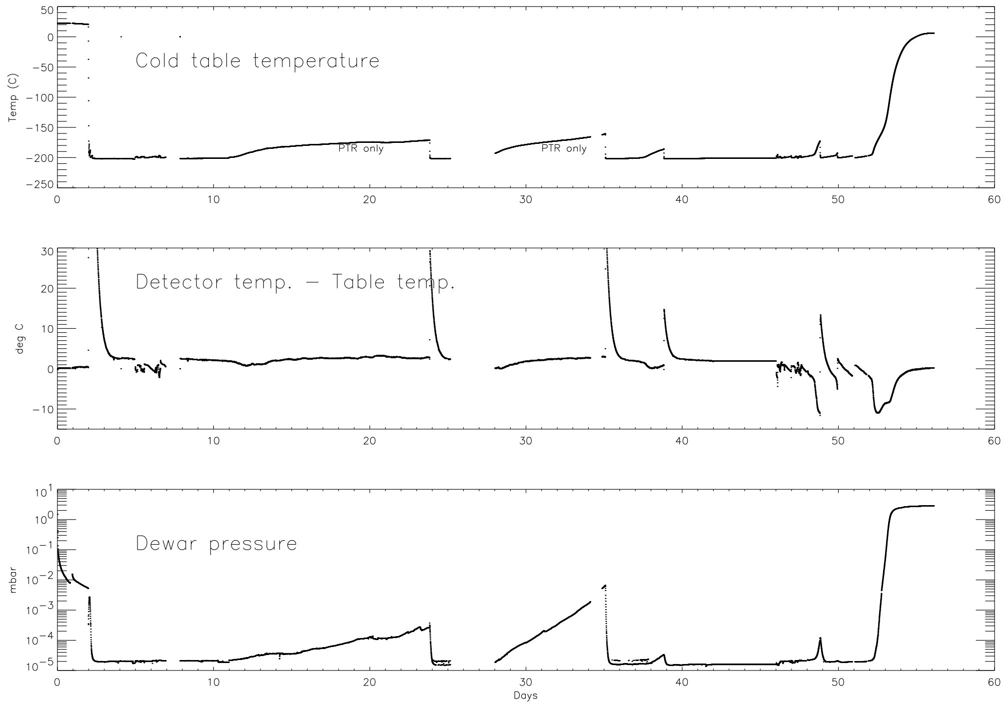

Figure 3: Temperature and pressure profiles of NOTCam from start of dome floor pumping before first light. Top: Cold table temperature; middle: detector temperature minus cold table temperature; bottom: dewar pressure. See text.

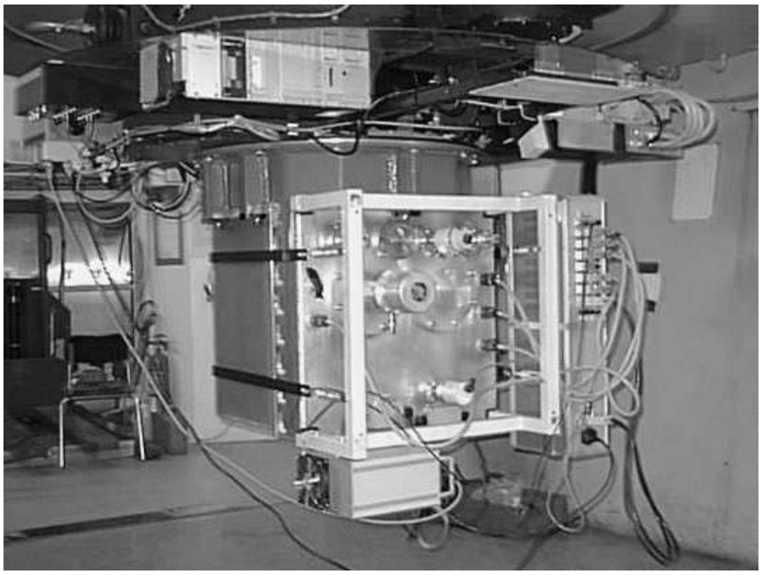

Figure 4: NOTCam mounted on NOT before first light.

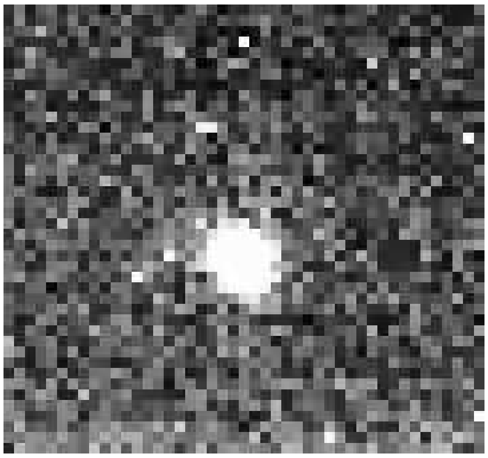

Figure 5: The very first stellar image from NOTCam on NOT – a 40×40 pixel region from the raw image. The near-IR standard AS28-0 (K = 8.37 mag) integrated for 1s through the K-band. In focus and at a seeing of 0.6" FWHM

- The focus of the cold stops in their default position is slightly beyond the range of the focus mechanism, but this can be remedied by means of spacers in the cold stop wheel.
- The error in the lateral positioning of the cold stops is of the same order as their looseness in the wheel fittings. This can be easily fixed but fortuitously, the 15mm cold stop was found to be both correctly sized and placed.
- The focus of the aperture-wheel pinhole appears at the same position for all installed filters to within the possible accuracy of measurement.
- The center of the detector was determined to lie within 20arcsec of the rotator axis.
- Dome & sky flats using lamp on/off and fading twilight sky were acquired.
- Images of multiple photometric standard stars were acquired.
- Any aberrations present were shown to be small, although some distortion is present but has yet to be properly characterised. J & K images of M10 were obtained for this purpose.
- A telescope focus value of 21150 puts instrument focus within the useful range of the focus mechanism and close to that of the pinhole.
- J, H & K of a Serpens star formation were acquired for scientific and demonstration purposes.
- Noise test data were obtained and found to be consistent with previous measurements at CUO.
- Intra- and extra-focal stellar images were obtained for purposes of wave-front analysis, but have not proved useful. Nevertheless, visual inspection implies fairly good alignment and no clear decentering effects.
- Standard stars were observed through polaroids.
- A small number of commissioning-science programmes were executed.

The most consequential problem identified was that the instrument cannot be used with the cold table in a vertical orientation and greater than 30 degrees from the zenith without draining out unacceptable quantities of LN_2. This is because of the two LN_2 fill & vent holes which are placed near neighbouring corners of the instrument. The obvious workaround is to disallow certain combinations of orientation and position on the sky, but this is relatively ungraceful and other options are being explored, possibly involving mutually opposed capiliaries attached to each LN_2 vent or an additional PTR head. For the time being, we are exercising caution and filling the dewar every morning after observations to minimise LN_2 loss during the night.

Numerous other minor hard- and software problems were identified during the run, including the omnipresent (in CUO controllers) "missing-column", but nothing prevented observations.

On removal from the telescope after the commissioning run, a few drops of an oily substance were found on the window mount (outside the dewar). The origin of this is not clear but the incident has not repeated.

6 Second commissioning run, 10 & 11 August 2001

NOTCam was kept cold during the intervening few weeks as an test to explore the feasibility of keeping it cold for long periods and so extend the useful lifetime of the detector. This experiment was compromised by the slow leak discussed above.

During this time, NOT and CUO staff collaborated to correct most software problems and the repaired high resolution camera arrived on La Palma.

On the first night of the second commissioning run, filter wheel 1 became irremediably stuck. At the time, it was believed to be stuck in an open position and observations continued with this assumption. But on later opening, a polaroid was found to be in the light path. The degree to which observations were compromised is not known at this time.

The shutter occasionally entered an indeterminate mode, sometimes appearing to open during an exposure, sometimes partially and sometimes not at all. Later investigations showed that the spring holding the microswitch down was sufficiently strong to push the shutter back a short distance after initialising. The observed consequences of this can fully explain all the observed behaviour.

Observations were obtained of Saturn, WZ Sge (in outburst) and 3C390.3 (commissioning proposal) and photometric and astrometric standard fields.

After the run, NOTCam was brought to room temperature again with the assistance of dry air forced through the LN_2 reservior. The filter wheel jam was found to be caused by a filter holder retainer tab, presumably the one originally held in place by the loose screw found in early tests. Even so, we decided to increase the clearance of the filter wheel and housing by minor modifications to the wheel's hub mounting. The shutter initialization problem was diagnosed and the microswitch spring weakened in an effort to cure the problem. A diagnostic "LED box" was added to the shutter control circuit to permit remote verification of shutter position.

We decided to make the next commissioning run without the PTR cold head and so removed it.

7 Third commissioning run, 5-8 September 2001

We installed the high resolution camera and all remaining filters (using further filter holders received from Copenhagen). Due to a miscommunication, the activated charcoal getter became contaminated and the charcoal had to be replaced by a donation from ING. We have since ordered a considerable supply for ourselves. The dewar was then closed and pumped, transferred to the dome, cooled and mounted on the telescope. This procedure is becoming smoother with practise, but will always require a minimum of two staff members to achieve and ideally three.

During the third commissioning run:

- The shutter lost synchronisation with the controller on at least two occasions, implying the need to further weaken the microswitch spring.
- The HR camera focus was found to be almost within the range of the instrument focus with the same telescope focus as WF camera. A small adjustment may be necessary.
- The guide probe vignetted the field during an image raster scan (this is a known problem with the *teloffset* routines.
- The need for large numbers of twilight flats provides strong pressure to improve the readout time, a problem acknowledged by CUO and being worked on.
- More than half the run was given over to pursuing commissioning time science programmes.
- The focus mechanism timed out several times.
- Best seeing was observed to be 0.3" FWHM in K.
- The volume of data production is now so large that the existing archive system cannot keep up. This was made particularly obvious when half of the last night's data was lost due to a disk crash on the instrument computer.
- To permit optimal use of the instrument, at least two observers are required, possibly 3 in winter.

LN_2 hold time without the PTR installed was found to be approximately 2.25 days. The PTR will be reinstalled for the next run in early October.

8 Pending issues

Of course, there are a number of issues still pending, including:

- The focus mechanism timeouts are still not explained.
- The slow leak whose effects were observed between the first two runs still has to be located.

- The readout time is still very long ($\sim 5sec$) for the HAWAII array and efforts are being made in Copenhagen to reduce this. Likewise, the "zero column" problem being worked on because it is particularly serious for a HAWAII array and dual-readout CCDs. When this problem is solved, the solution will be propogated to other suitable CUO/IJAF detector systems as well.
- A number of bugs and features are still present in NOTCam BIAS and are being systematically hunted down.
- The volume of data produced by NOTCam is huge compared to other NOT instruments, overwhelming our archive system. One night in the last run required 26 CDROMs to be burned, which took until 4am the following night. This problem is being addressed by the purchase of a RAID disk system and an automated juke-box CDROM burner.