Report on a Mintron cooling modification

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February 2005

Note1: This report is preliminary as a few items in the modification are still to be incorporated. Also some further tests have to be performed. When relevant this is indicated in *italics* in this document.

Note 2: All points/remarks I already posted in the Videoastro Yahoogroup regarding this modification have been incorporated in this document.

Summary

This document describes my modification for the cooling of a Mintron 12V-Ex. The main advantage of this modification is the absence of warm pixels in real-time view and images, which normally are present at temperatures above ~+10 °C (~ 50 °F). The cooling below ~ 5 °C (~ 41 °F) is sufficient to remove the warm pixels. Further cooling to lower temperatures does not improve image quality and does not reduce image noise as amplifier glow (amp-glow) is responsible for a prominent background noise. This background noise can be reduced by an amp-off modification but not eliminated. Also cooling to lower temperatures does not eliminate this glow, as it is induced in the CCD itself. The Peltier cooler I use in my modification is able to achieve a temperature difference of about ~20 °C (~ 86 °F) with respect to the ambient air temperature, with the camera operating. During summer time with ambient air temperatures of about 25 °C (~ 77 °F) I expect to reach about +5 °C (41 °F) *to be tested*. The whole body of the Mintron camera is being cooled in this modification.

Introduction

Warm pixels are very annoying in an image and real-time viewing as they as easily misinterpreted as moons, asteroids or stars. Therefore I decided to start building a cooling device for my Mintron (12V-Ex). At that time I had the idea that cooling would also reduce image noise. This showed not to be the case as will become obvious from the test results.

For the modification I had one hard constraint. The camera plus cooling device should not be too long. The camera body without cooling device already strikes my telescope base (fork mount in polar) at declinations above +65 degrees. When the device is too long it will reduce observation possibilities at higher declinations.

Therefore I opted for two possible modifications:

1. a cooling box as short as possible
2. splitting the front part of the Mintron with CCD from the rest of the Mintron body and cooling only that part. This would give a very short building length, plus the advantage of cooling only the CCD-part and not the rest of the camera body and thus reducing heat input and reaching lower temperatures.

This second option however forced me to extend the flat cable connecting the CCD-circuit board and the camera body. However after extensive search on the internet I could not find a longer cable (with 18 wires). Through my contacts I was kindly helped with some extra flat cables and connectors. These connectors needed to be removed from the printed circuit boards and soldered together. This is a laborious and difficult job. For the time being I decided to go on with the easier first option. I now am glad I did as test-results show that deep-cooling of the CCD does not improve anything. So the second option would only be beneficial in a shorter building length. A further advantage of the first option is that the Mintron stays complete and can be sold separately (if necessary in a later stage).

Lessons learned from this modification

From this modification I learned two very important things:

Very good insulation
Good thermal contact

I have made several modifications before I came to this final modification. During all the tests I performed it showed that thermal grease between the cooling and heated parts is indispensable. Without thermal grease at certain contact points the cooling is not effective enough. Also very good insulation of the coldest parts is invaluable for reaching sufficient low temperatures.

Point for attention

As temperature drops at the camera, condensation of water and/or forming of ice is quite likely. Therefore good sealing of all parts is necessary. Cable entrances should be sealed from the outside air as well as the CCD window in front of the camera. *This last part is still under construction*.

Parts for the modification

For the modification I used some parts from an defective car cooling box at 12V. This car cooling box had a heat sink, a Peltier element and an aluminium cooling block attached to it. I did not use the fan from this cooling box. These cool boxes cost about 30 – 40 Euro's new. As the Peltier consumes quite some power I had to buy a 220VAC to 12V power supply.

In order to measure temperatures inside the Mintron and at the cooling block I bought a cheap indoor/outdoor temperature measuring device (costs a few Euro's). An image of this temperature device is shown further in the document. So the parts list is as follows:

Heat sink	size 12,3 x 10 x 3 cm
Cooling block	size 4 (l) x 4 (w) x 3,3 (h) cm

Peltier cooling element
Size : 4 x 4 cm
Type : Melcor Thermoelectric cooler type CP1.4-127-06
Power consumption is 4,7A at 12V

Fan
size 9 x 9 cm
2600 rpm and 32,5 dB(A).
Air displacement 78,8 m^3/h
Power consumption 12V and 0,23A
I have chosen one with the lowest rpm and lowest dB(A) in order to have as low noise levels as possible. 12V or 220 V is of course up to anyone's one choice. Most important is the amount of air displacement. With this rating I reach the temperatures stated further on.

12V power supply 6A

Thermal grease - any brand

Indoor/outdoor temperature sensors – any brand

PVC box or boxes - any which suits.
I have two boxes one 11,5 (l) x 9 (w) x 8 (h) cm and one 6 (l) x 6 (w) x 3,5 (h)

Costs

The costs for this modification are of course strongly dependant on which parts are already available, but in order to give some indication I have listed indicative costs below.

Heat sink + cooling block (from a new cooling box)	~ 40 Euro's
Peltier element	~ 20 – 30 Euro's
Thermal grease	~ 5 Euro's
12 V – 6 A Power supply	~ 40 Euro's
Fan	~ 15 – 20 Euro's
Temperature indoor/outdoor sensors	~ 5 Euro's
PVC boxes	~ 9-15 Euro's
Insulation	~ 5 Euro's
Total costs	~ 100 – 150 Euro's

Cooling box for the Mintron

I used the 11,5 x 9 x 8 cm PVC-box to install the Mintron. As this box was just a little bit too short to accommodate also the BNC signal connector, the 12V power supply connector and the RS-232 remote control connectors I attached (glued) a small PVC box to the big box (see image 1).

Image 1 PVC boxes with the necessary holes for the cooling block, the 1.25” adapter and cable connectors

Heat sink and cooling block

The heat sink, Peltier element and cooling block are shown in image 2.

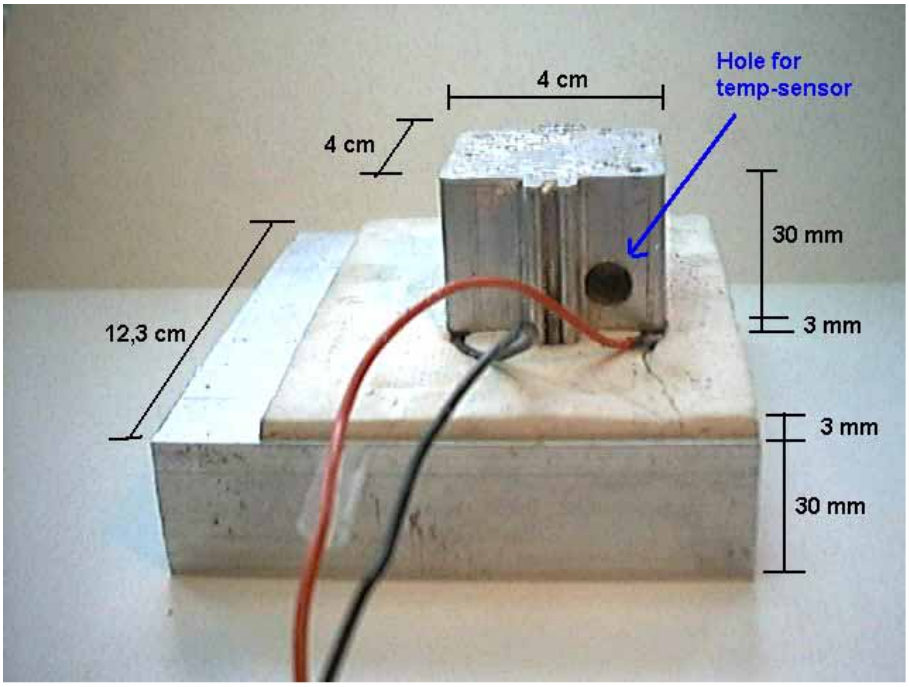

Image 2 Heat sink, Peltier element and cooling block. The Peltier element (not visible, only the wires connected to it) is mounted under the cooling block.

Temperature indoor/outdoor sensor

I needed two sensors, one for measuring the cooling block temperature and one for measuring the temperature inside the Mintron. Therefore I removed one temperature sensor from of the in/outdoor temperature device (see image 3).

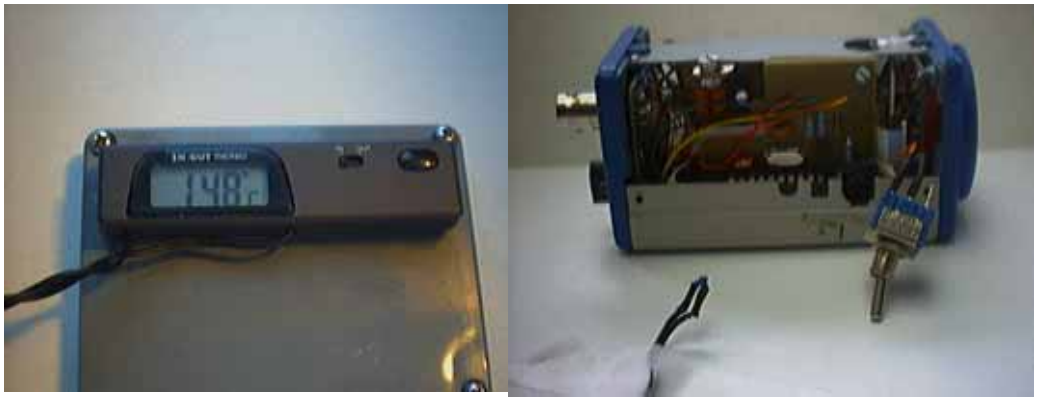

Image 3 Indoor/outdoor temperature sensor device (LEFT - already mounted to the lid of the PVC box). RIGHT: temperature sensor in front of the Mintron, which was removed from the indoor/outdoor temperature device.

In image 4 details of the outdoor temperature sensor are shown which was used for measuring the temperature inside the cooling block.

Image 4 Outdoor temperature sensor with scale in cm's.
LEFT : Front view. RIGHT: Back view

The mounting of the indoor temperature sensor in the Mintron is shown in image 5.

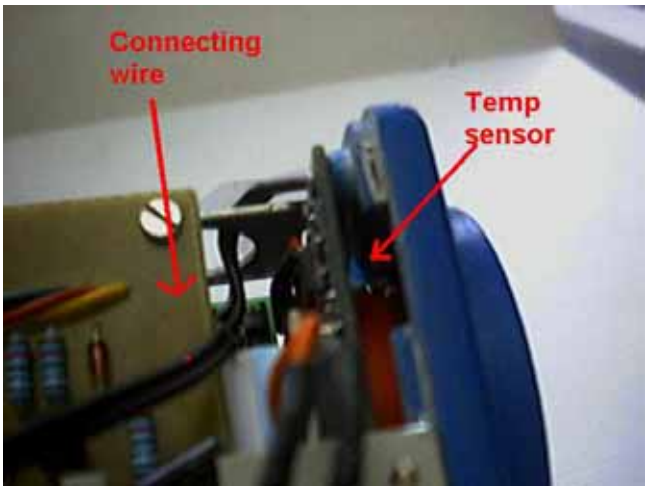

Image 5 Mounting of the temperature sensor between the casing and CCD circuit board. The red cap which is seen below the temperature sensor is another modification on me which is not relevant for thsi project.

Sealing of the CCD window *(to be completed)*

This point of the modification is still under construction.

For the sealing of the CCD window several options are possible. One is that a permanent window (1.25") is screwed and glued to the 1.25" adapter. However then the possibility to change the focal ratio is very limited. I am now thinking of applying a window just behind the brass part in front of the CCD window.

At this moment I have not yet decided which window I will install. I have searched the internet and found one supplier with several windows. It is however difficult to find out if the offered windows are coated for anti reflection.

The following windows are provided by ASTROVID (www.astrovid.com) type : "clear filter" at their search engine:

1. Astrodon Tru-Balance 1.25 Inch Clear Filter with NO IR Blocking
2. Schuler CL Clear filter w/o IR Blocking
3. True Technology – 1.25 Inch Clear Filter
4. Optec Clear Filter Window

Price ranges from $20 to $80. Thickness of the windows varies and no hard evidence if these filters have anti-reflection (AR) coating.

Mounting and assembling the cooling block and the Mintron

In image 6 (left) the principle of mounting the complete unit is shown. Please note that the contact between the cooling block and Mintron is tight and has thermal grease between it.

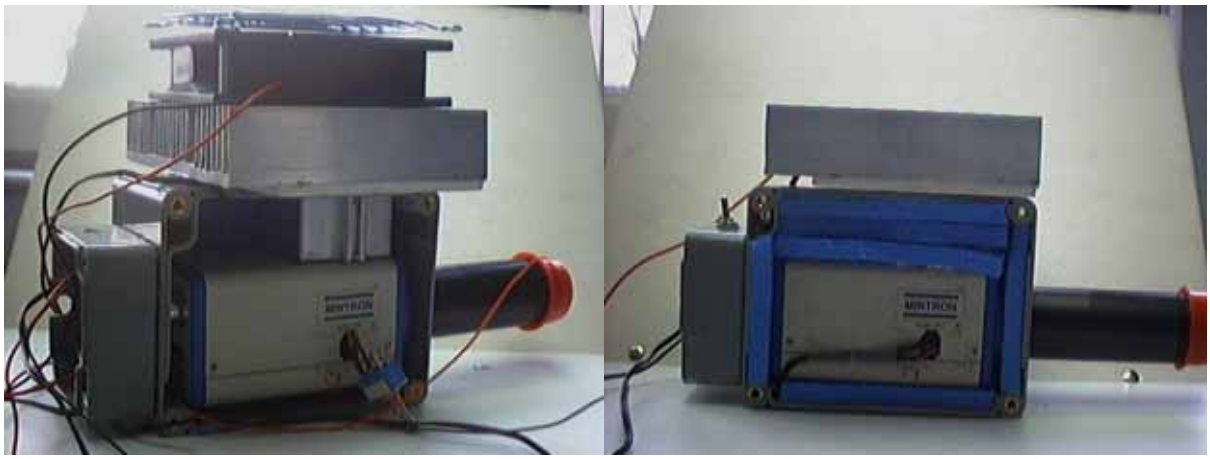

Image 6 Mounting of the cooling unit on top of the Mintron (left). Please note that there is thermal grease between the cooling block and the Mintron. Right: Complete with insulation.

The cooling unit is attached to the box by means of two screws. The fan is attached to the heat sink with long screws ending in the heat sink itself.

The amp-off mod switch has been removed from the Mintron and has been mounted on the small box. From test it shows that the wire extensions induce some pick-up noise in the image. *An improvement for this will be given in the final document.*

A description of my amp-off mod can be found at:
http://www.dd1us.de/astro%20downloads.html (see August 29th 2004) or at
http://homepage.ntlworld.com/c.rogers/mintron/HS%20Report%20on%20amp-off.doc

In image 7 the complete unit is shown.

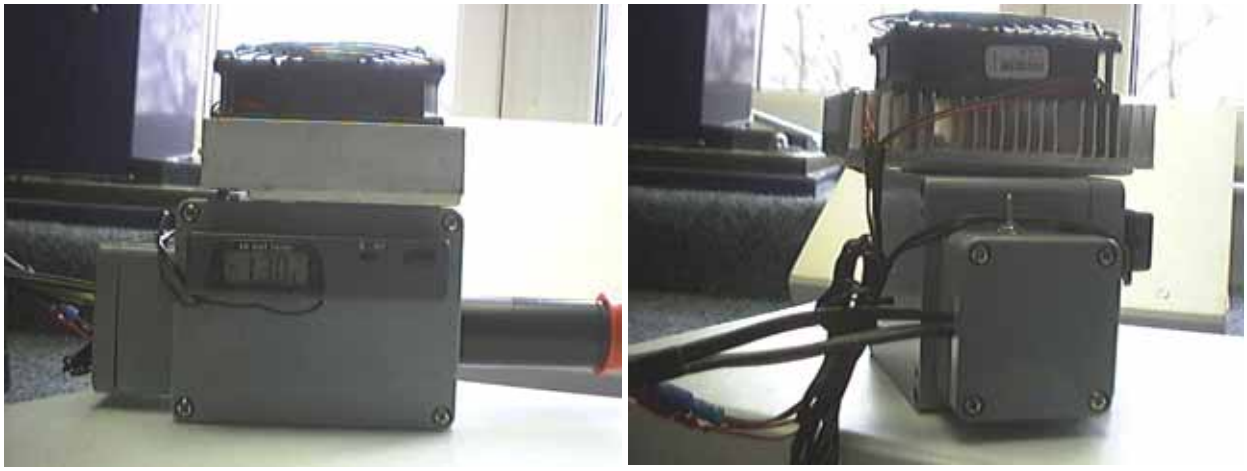

Image 7 The completed unit is shown. LEFT: side view. RIGHT back view.

Please note that the side cover has insulation at the back as well.

Cooling test results (*more to be added)*

In table 1 test results on the cooling are given.

Table 1 Cooling test results with the unit

Temperatures in °C				
Ambient air	Camera off		Camera on	
	Cooling block temp	Camera	Cooling block	Camera
...				
...				
14	-14	-12	-12	-6
...				
...				

Image test results *(more to be added)*

During the preliminary tests I have been taking dark frames during the cooling of the Mintron. In order to minimize statistical variations in the results I have stacked 10 images (each 2,56 seconds) with AstroVideo. The amplifier was off during the imaging. The images were measured (histograms) in AIP4WIN. As the analyzed data could not be exported from this program, I have screen captured the analyzed data.

On the next page the results are presented.

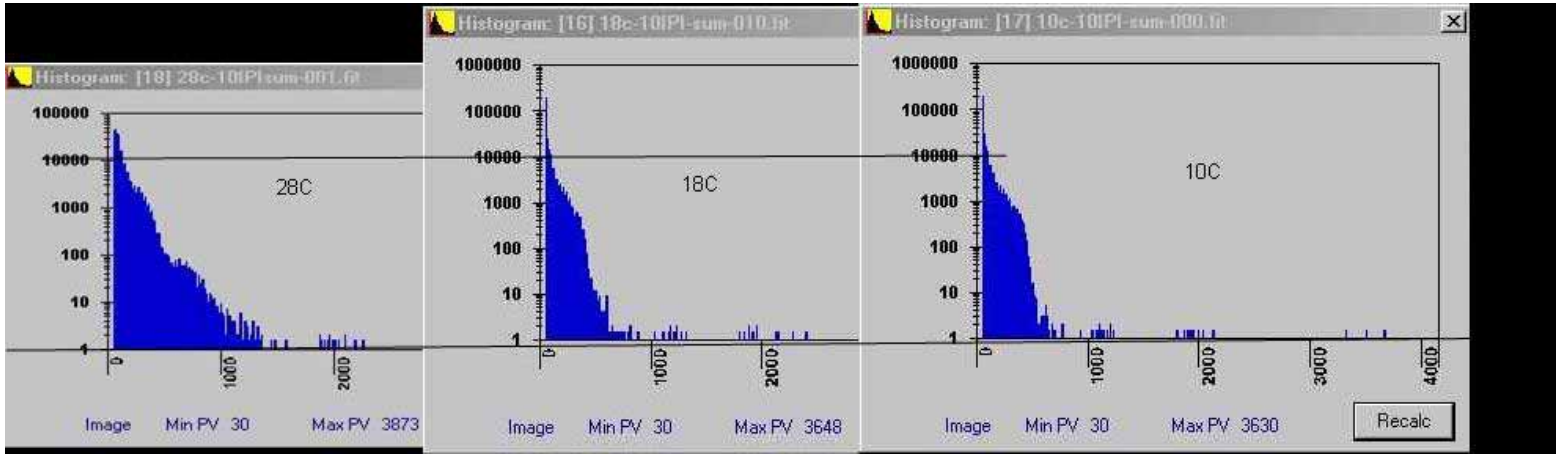

Image 8 Effect of cooling from 28 °C to 10 °C (10 stacked images, amp-off)

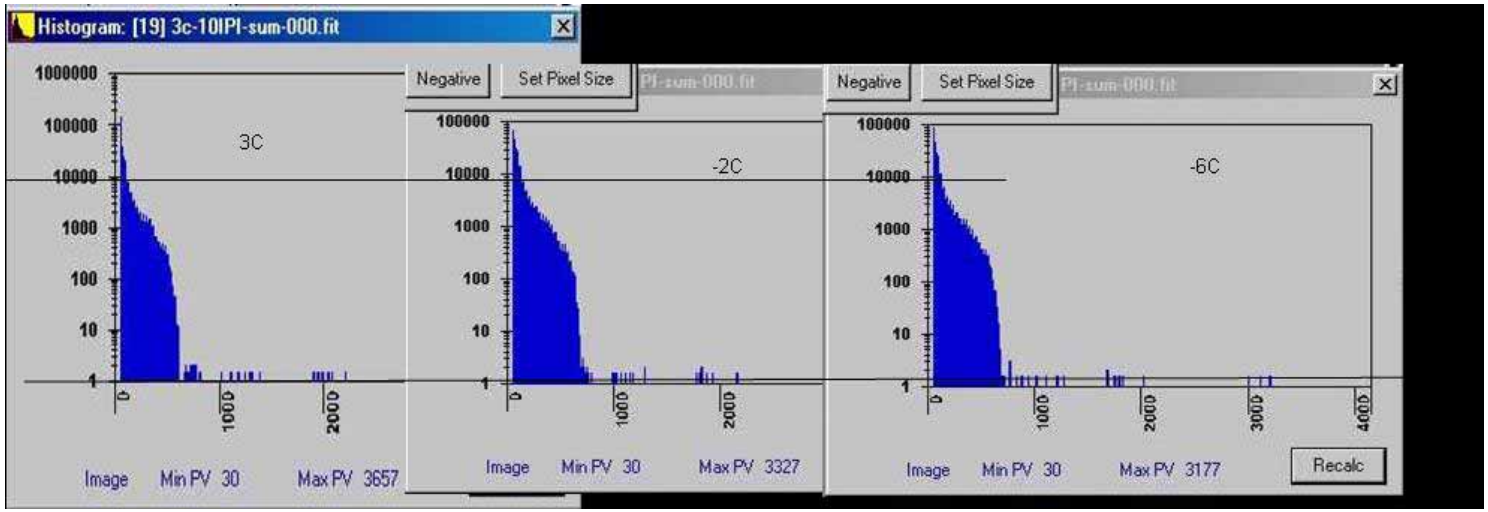

Image 9 Effect of cooling from 3 °C to -6 °C (10 stacked images, amp-off)

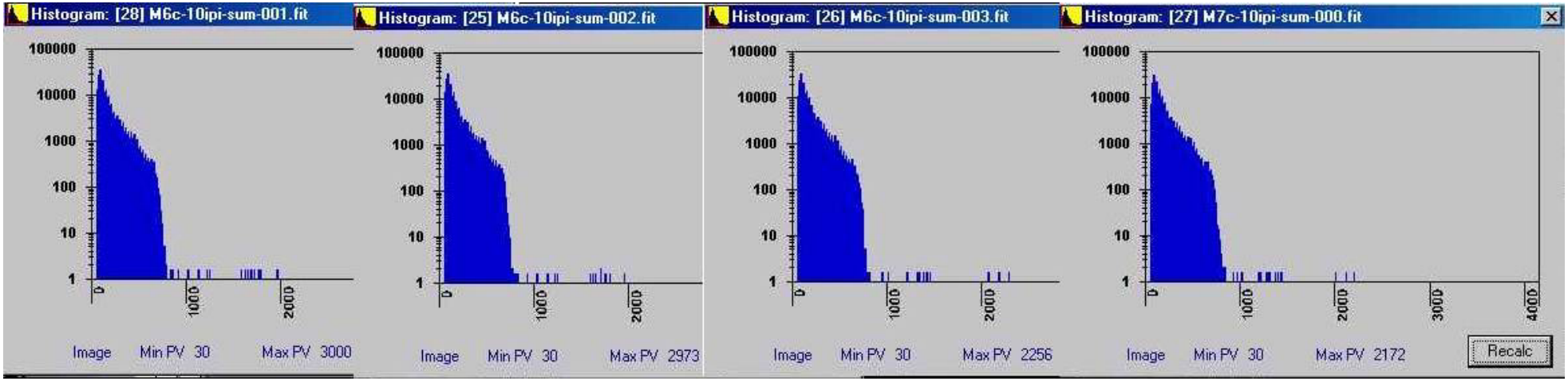

Image 10 Effect of prolonged cooling at -6 °C to -7 °C (10 stacked images, amp-off) for about 1,5 hours.

From these histograms the following can be deduced:
The tailing of the histogram decreases from 28 °C to 3 °C. It looks as if the width of the histogram is smallest at 3 °C. I think this is a pure statistical fluctuation. At 28 °C, 18 °C and 10 °C warm pixels are visible in a decreasing intensity. This in line with the decrease in tailing.

Most striking is that the width of the histogram does not decrease with decreasing temperatures. I have the following reasoning for this effect. As amp-glow can only be reduced and not be eliminated, the CCD still produces “light”. A preliminary conclusion is that further cooling does not further reduce this noise. So when cooling reached the point that warm pixels are not visible anymore, further cooling is not necessary.