FLAMINGOS Camera Dewar Cooldown On Kitt Peak

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1. Introduction

This manual is a guide to cooling down the FLAMINGOS Camera Dewar after it has been at room temperature. In past years, the frequent use of FLAMINGOS on both the 2.1-m and 4-m telescopes allowed us to keep the Camera Dewar cold for the entire observing year (while letting the MOS Dewar warm up between runs), and it was allowed to warm up only over the summer shutdown. It was therefore pumped out and refilled only once per year. The present heavy use of NEWFIRM on the 4-m has resulted in a decreased use of FLAMINGOS; we have therefore been allowing the Camera Dewar to warm up if the time between adjacent observing runs exceeds one month to conserve the use of LN_2 and the labor required for daily filling.

The procedure for filling the Camera Dewar is more complicated than for the MOS Dewar, which simply requires pumping with a Tribodyn pump until the pressure is < 10 mTorr, followed by filling with LN_2 at full throttle until the dewar is full. The Camera Dewar contains both the FLAMINGOS optics and the detector, and both of these can be damaged by rapid temperature changes. Most of the optical elements are crystalline materials, such as BaF_2, CaF_2, or ZnSe, which can crack under stress induced by differential thermal expansion. The detector is a hybrid of a detector (HgCdTe) bump-bonded to a readout of a different material (Si). For both of these, cooling must proceed slowly so that the bulk conductivity of the materials allows them to cool more or less uniformly.

NOTE: The optics and detectors in NEWFIRM are subject to the same damaging stresses when cooling down or warming up. However, since the cold heads on NEWFIRM can remove a limited amount of heat, the mass of the cold bench naturally limits the cooling rate to a few degrees per hour. FLAMINGOS has a much smaller mass than NEWFIRM, and the LN_2 cryogen is capable of removing very large amounts of heat in a short time (boiling 1 liter/min of LN_2 is equivalent to 2.5 kW). *Filling the FLAMINGOS Camera Dewar at an excessive rate will cool the optics and detector sufficiently quickly that damage will occur. There are documented cases of HAWAII-2 detectors being catastrophically damaged by rapid cooling.*

We have determined empirically that the FLAMINGOS detector can be cooled as rapidly as 50 K/hour with no ill effects. This can be accomplished by transferring LN_2 into the Camera Dewar at a slow rate, regulating by slight opening or closing of the valve on the storage dewar while monitoring the detector temperature. The person(s) carrying out the cooldown should be prepared to spend up to 4 hours monitoring the cooldown or be in contact with someone else monitoring the detector temperature remotely:

- The most critical part of the operation is at the beginning, since there will be some initial delay in the detector temperature response, so it is possible to have too high a fill rate and not realize it for several minutes. This is also the most critical region for potential damage, because the temperature coefficients of expansion are larger at higher temperature.

- After an hour or so, when the temperature may be in the 240 K range, it should be possible to find a valve setting which provides a fairly constant ~ 0.8 K/min cooling rate and leave the system unattended if someone else is monitoring the temperature and can contact the responsible person in the event that an adjustment to the valve setting is needed.
- Once the temperature reaches ~ 130 – 140 K, the detector cooling rate naturally slows and it is possible to fill the Camera Dewar completely.
- When the detector temperature reaches 90 – 95 K, it is necessary to turn on the detector controller, initialize the instrument, and take some images to ensure that the detector is working. Allowing the detector to cool to 75 K before turning on the controller can cause the amplifiers to draw a large current. Once the controller is powered up, this operation can be done remotely.

2. Initial Preparation

Before initiating the cooldown, the following preparatory steps should be carried out:

- The Camera Dewar should be evacuated thoroughly with a high vacuum pump such as the Mosaic turbopump. Take care in hooking up the pump line to the vacuum port on the Camera Dewar (Figure 1). This should be done for several hours, preferably overnight.
- After pumping, close the vacuum valve on the Camera Dewar, remove the pump, and roll the FLAMINGOS cart to an area with both AC power and Ethernet.
- One should have a full dewar (either 160 or 240 l) of LN_2 available. Attach the hose to the LN_2 manifold on FLAMINGOS, open the valve to the Camera Dewar, and close the valve to the MOS Dewar.
- Hook the FLAMINGOS Ethernet cable to a working outlet on a hub.
- Check that all of the power switches on the FLAMINGOS racks are OFF (Fig. 1), and plug the AC power into the outlet. Some of the electronics (temperature controller, Perle terminal switcher) should come up because they are always switched on.

3. Monitoring Options

There are three possible ways of monitoring the temperature during the cooldown and turning on the detector once it reaches the 90 – 95 K range. The choice can depend on the amount of time one can spend with the instrument and the availability of others to monitor the cooldown, either at the instrument or remotely.

1. Start up the system (except for the MCE4 detector controller) using a host computer in the telescope control room and monitor the cooldown locally using the LakeShore controller readout (back of flamingos1a rack, lower right; see Fig. 2); when the detector reaches the 90 – 95 K range, turn on the

detector controller and start up the MCE4 daemon on the host computer. **NOTE:** *Even when monitoring the temperature using the LakeShore controller readout, the FLAMINGOS software has to be operating in order for the temperature readout to cycle through the three temperature sensors*.

2. Hook up a local monitor, mouse, and keyboard to the legacy connectors (Fig. 2) and bring up the system (except for the MCE4 detector controller). Monitor the detector temperature using the temperature screens; when the detector reaches the 90 – 95 K range, turn on the detector controller power and start up the MCE4 daemon using the local terminal.
3. Monitor the cooldown locally using the LakeShore controller readout in parallel with another person who has brought up the FLAMINGOS program from a remote location and can monitor the temperature. This will permit the local person to carry out other tasks as long as they are in communication with the remote observer who can request adjustment to the LN_2 flow rate. When the detector reaches the 90 – 95 K range, the local person must turn on the MCE4 detector controller power while the remote person brings up the MCE4 daemon and verifies system operation.

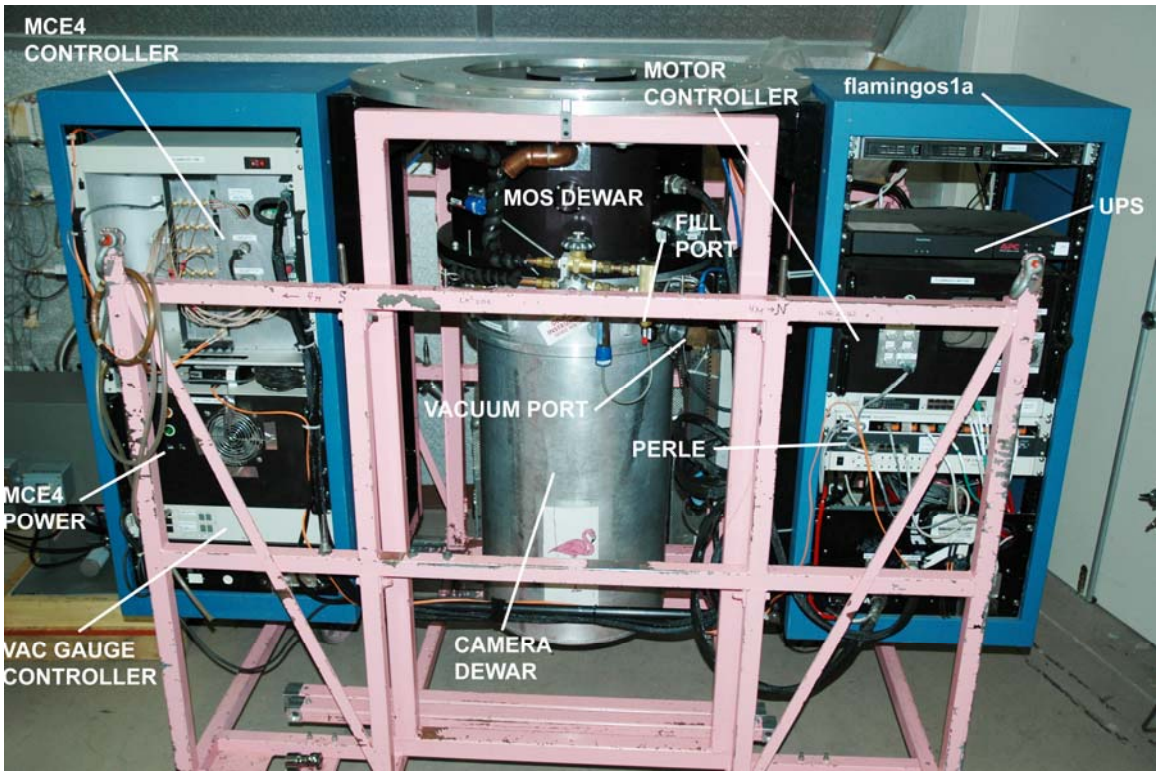

Figure 1: Front view of FLAMINGOS and the two electronics racks, with the components and switches labeled. The MCE4 and motor controller power switches are toggles; the UPS and flamingos1a power switches are push buttons.

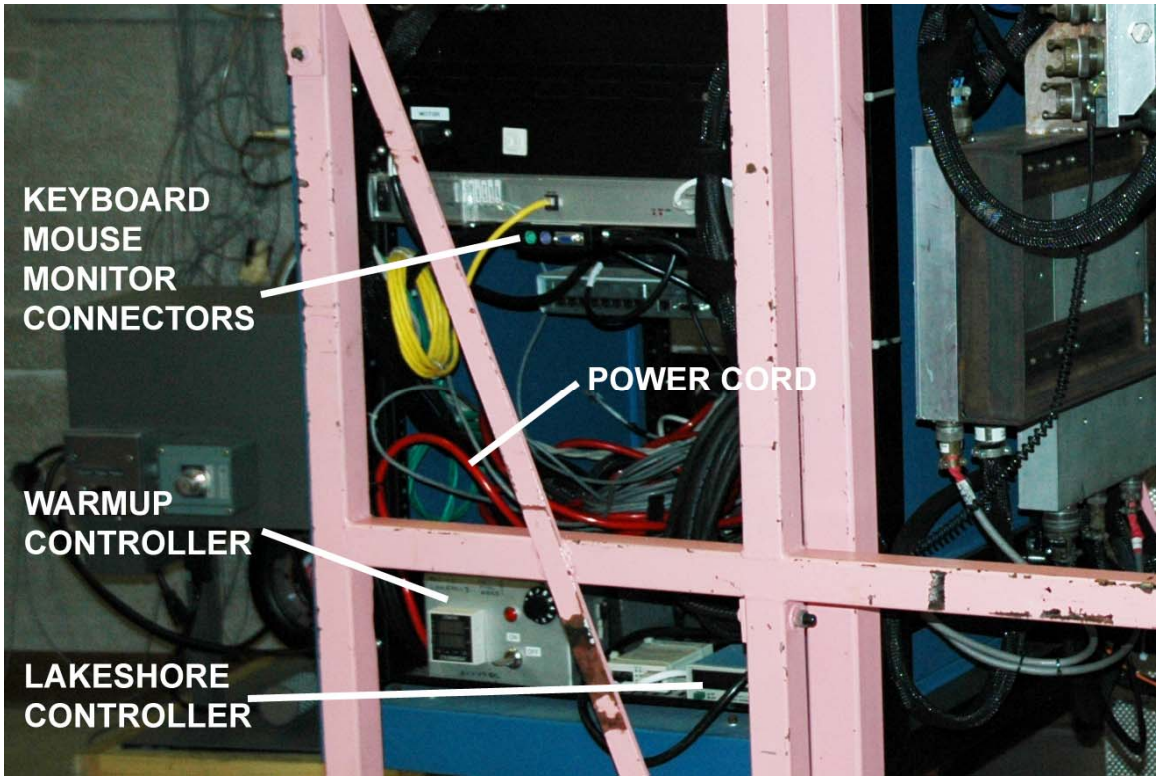

Figure 2: Closeup view of the back of the "flamingos1a" rack, showing the LakeShore temperature controller and the local monitor, keyboard, and mouse connections.

4. Cooling the Camera Dewar

If monitoring and operating the instrument locally (option 2), locate the monitor, monitor power supply, keyboard and mouse, which are normally kept in FLAMINGOS box #6. Plug in the monitor power supply to the monitor and to a source of AC power (there is a power strip near the bottom of the flamingos1a rack). Plug in the monitor, keyboard, and mouse to the local connectors on the back of that rack (Fig. 2). **NOTE:** Even if using this option, the Ethernet cable must be plugged into a hub for the flamingos1a computer to identify itself through DHCP.

- Turn on the UPS power supply on the flamingos1a rack (Fig. 1). This supplies power to the flamingos1a computer and to the Perle terminal server. Wait a minute for the Perle to boot up.
- Check that there are green lights on the Ethernet hubs, verifying the cable is hooked into a live network.
- After the Perle has booted, turn on the flamingos1a computer (Fig. 1). If you are using the local monitor, you should see the boot process proceed on the monitor, culminating in a login screen. Log in using the appropriate username (2mguest or 4mguest depending on the telescope) and standard FLAMINGOS password _____. Alternatively, log in using the MacMini (mayall-2 or second-

2 at the 4-m or 2.1-m telescopes, respectively) in the telescope control room with the command "ssh flmn-4m-1a" or "ssh flmn-2m-1a" at the respective telescope. No password is required. If someone is monitoring remotely, allow flamingos1a to boot (about 3 minutes), then contact them to log into the instrument remotely.

- Ensure that the login screen comes up as "flmn-4m-1a" or "flmn-2m-1a" and not "unknown". Otherwise it will be impossible to bring up the system. If the system comes up as "unknown", try rebooting the flamingos1a computer.
- If using the local monitor, open a window and execute "initflam.pl" to bring up the system. *The MCE4 detector controller power must be OFF*. *The motor controller can be turned on as long as no motors are operated during the cooldown.* When you get to the question about initializing the MCE4 controller, answer "n". If logged into flamingos1a from the MacMini in the control room, execute "initflam.pl" from the prompt in the same way. If someone is monitoring remotely, have them log in and go through the "initflam.pl" routine, again answering "n" to the MCE4 initialization.
- Once the system is up, the TEMP daemon should begin reading out the temperatures at 30 second intervals.
- If the system is being remotely monitored, check the temperature using the LakeShore readout on the back of the flamingos1a rack (Figure 2). The detector temperature is channel 1. The readout cycles through the three channels every 30 seconds.
- One can now begin to cool the dewar. Open the valve on the LN_2 storage dewar about 0.5 turn to give a good shot of cryogen into the camera dewar and cool the lines. After 30 – 60 seconds, close the valve so it is passing enough LN_2 to keep the lines frosted.
- After a few minutes, the temperature readout should begin to drop. Keep an eye on it for several minutes and if the temperature difference every 30 s is 0.4 K or more, close down the valve on the supply dewar. If it drops to 0.2 K, open it slightly. After a while, one should be able to stabilize (more or less) at a cooling rate in the 0.6 – 1.0 K/minute (0.3 – 0.5 K per sample). If the rate exceeds 0.5 K per sample, close the supply valve and wait until the rate drops.
- If the system seems to be cooling at a reasonable rate, one can leave for short (20 – 30 min) intervals to carry out other tasks, provided it is possible to return on short notice if the remote observer sees the cooling rate getting too large.
- After a couple of hours, the temperature should be near 200 K and it will probably be necessary to open the supply valve slightly to keep the cooling rate in the right range.
- After 3.5 – 4 hours, the temperature should be near 130 – 140 K. At this point, one can open the supply valve completely and fill the Camera Dewar until LN_2 drains out of the vent port. The cooling rate will begin to decrease, limited by the internal thermal conductance. At this point, one may leave the system for an hour as it cools to the 90 – 95 K range.
- When the temperature reaches 90 – 95 K, *turn on the MCE4 controller power*. You may wish to turn on the motor controller power as well, if it is not already on.

- If running from the local monitor, make sure the MCE4 daemon window is closed, then run “initflam.pl” again. If the MCE4 window does not report “listening on port 52008”, you may have to close the daemon, run the script “ufstop.pl –clean” (terminate with ctrl-C), then run “initflam.pl” again. This time, answer “y” to the question about initializing MCE4. Once the initialization is completed, move some of the plot windows to desktop 2 to reduce clutter
    - Enter “ds9 &” to bring up a ds9 window; move it to desktop 3.
    - Change directory to /data/4mguest (or /data/2mguest) and make a directory “test”, if it does not already exist.
    - Run “configure.exposure.pl” to change the directory to /data/4mguest/test/ (or /data/2mguest/test/) and an exposure time of 3 s. The rest of the parameters are not important.
    - Run “singleimage.pl” to take an image; it should automatically display to the ds9. The first image will probably be junk (58000 ADU, appearance like a pillow), so take another. One should see a typical FLAMINGOS dark image, but with an elevated (1500 ADU or so) level.
    - If this is the situation, everything is working OK. Disconnect the monitor, keyboard, mouse and store back in box #6. *Leave the instrument, flamingos1a computer, motor controller, and MCE4 detector controller powered up and the Ethernet connected so that it is possible to monitor the instrument remotely.*
    - Top off the LN_2 within four hours, then fill once/day.
- If monitoring the temperature locally using the LakeShore readout, once the temperature reaches the 90 – 95 K range, go to the control room and use mayall-2 or second-2 (4-m or 2.1-m) to run these tests:
    - Open up a terminal on the MacMini and “ssh flmn-4m-1a” or “ssh flmn-2m-1a” to bring up the FLAMINGOS control window. No password is required.
    - Run ‘initflam.pl” from the FLAMINGOS window, this time answering “y” to the question about initializing MCE4.
    - Carry out the same tests outlined above.
- If someone is monitoring remotely, inform them once the MCE4 controller is powered up. They can then run the “initflam.pl” to bring up the MCE4 daemon and take the test exposures. If they report that the system is operating normally, leave everything powered up and begin the routine of topping off and daily filling of the cryogen.