Test on heating of LOU windows by STM-2 straylight source
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**Scope**
A hot black body source is to be used for the evaluation of the straylight from the HIFI LOU windows inside the STM-2 cryostat. Concerns have been raised about the heating of the quartz windows on the cryostat from the thermal infrared from the source and we have undertaken a series of tests to evaluate the problem.

This note describes the test set ups and results from a laboratory test of various configurations in order to determine the optimum configuration for the STM-2 test.

**Equipment**
Radiation source

The source used is an ISOTECH Pegasus-R capable of heating a furnace up to 1200$^{o}$c with an exit aperture of ~20 mm. This source comes with a two channel temperature readout with a calibrated temperature probe. We used the second channel as the measurement device for assessing the thermal impact of the source. Appendix 1 is the specification sheet for this device.

Chopper

In order to obtain a modulated signal a chopper is to employed between the source output and the LOU windows. We use a Scitech Optical Chopper with two blades giving chop frequencies from 0.5 to 5 Hz.

Lens

During these tests we did not have a real LOU window available – instead we used a fused quartz plano-convex lens with diameter 50 mm and centre thickness ~5 mm. The temperature probe was attached to the curved side of the lens using aluminium electrically conductive tape to ensure reasonable thermal contact. In all cases the flat side of the lens was the one illuminated from the source.

LOU Window

A final check has been made using a QM model LOU window provided by Astrium. This consists of a ~5mm thick disk of quartz 40 mm in diameter with a polymer coating on each side to act as an anti reflection coating for the HIFI wavelengths.

Mirrors and Baffles

Plain machined aluminium plates were used both as baffles and as FIR mirrors during the tests. These were only machined (milled) and no attempt to polish them. As a comparison an optical flat was used in one configuration (see below).

FIR Detector

A Golay cell was used to as a relative calibration detector in order to check to FIR output of the source under different configurations. To ensure that only FIR radiation was detected a 100 cm$^{-1}$ filter was fitted to the cell. The detection was via a lock-in amplifier with a DVM to read out the volts. Various “neutral density” filters were used to keep the Golay signal within the range of the lock-in amplifier.

**Test Configurations and results**
Two basic configurations were employed to test the heating of the lens – direct and via different mirror types. The test configurations, purposes and results are listed in this section.

**1. Direct illumination FIR signal check**
In order to check that different configurations gave broadly similar FIR output we first tested the relative signal versus distance from the source. The sketch below shows the test configuration and

the results are given in figure 1. The small jump in the data is where the filtering was changed to keep the signal on scale and represents the esti8mated systematic error in the measurement. Nevertheless we can gain an impression of how far we can move the source before suffering too great a loss in incident flux.

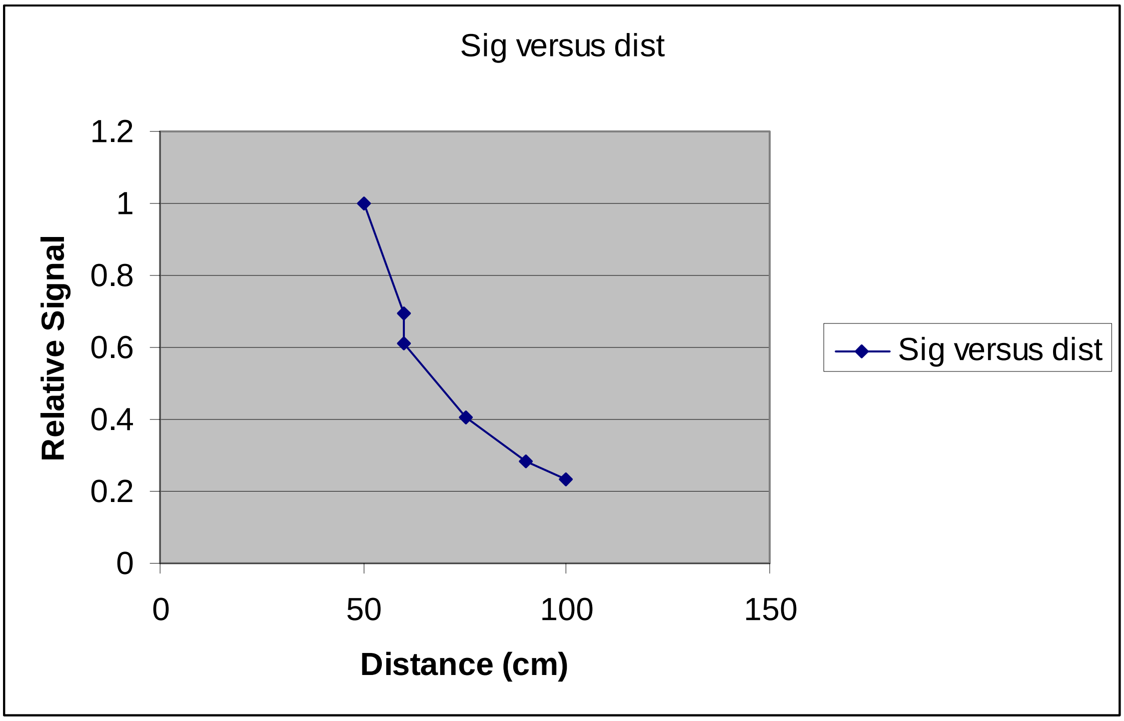
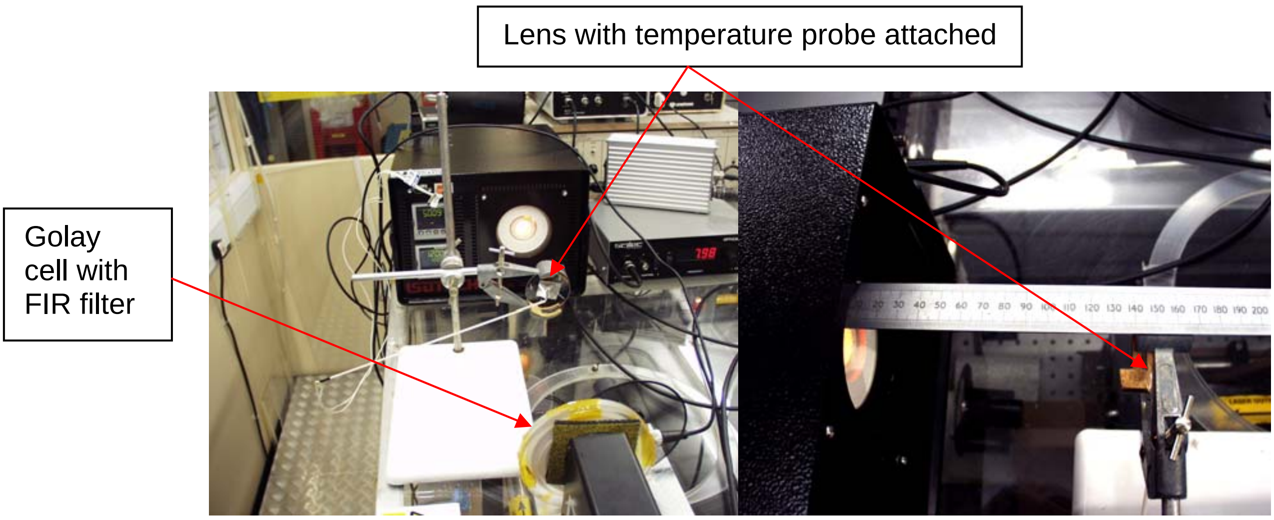



**Figure 1:** Relative signal <100 cm$^{-1}$ versus distance from the source

**2. Direct illumination heating check**

The most basic check on the effect on the LOU windows is just to shine the HBB directly onto the lens set about 15 cm from the source aperture. The configuration used is as shown in figures 2a and 2b. The lens was allowed to stabilise in temperature – this occurred after approximately 30 minutes. The temperature recorded is shown in figure 3 – the lens reached about 50$^o$c.



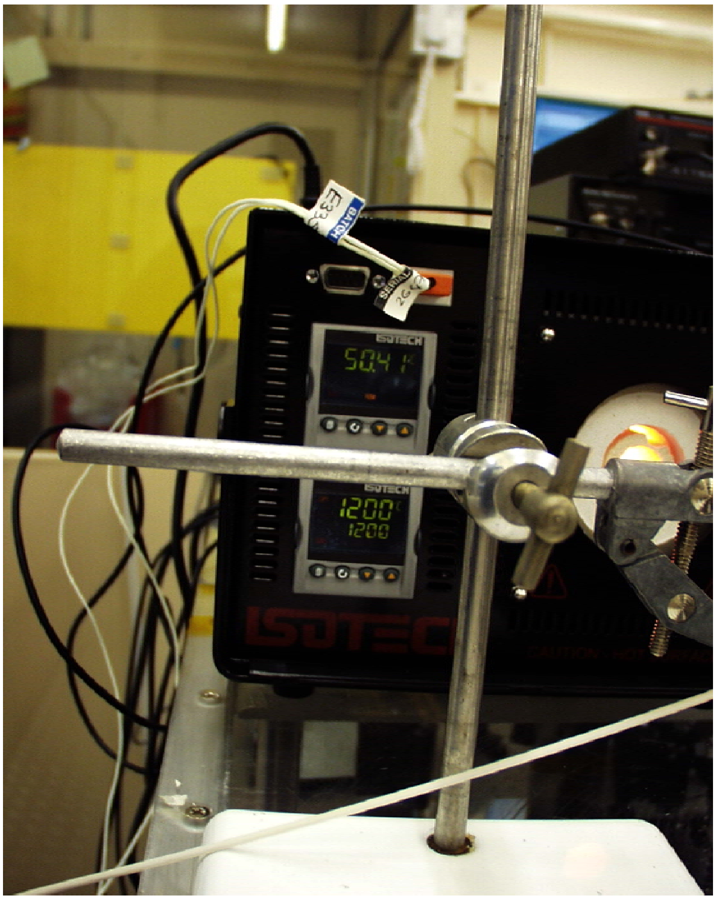



Figure 2a (left) and 2b (right): Configuration used to evaluate the direct heating effect on the quartz lens. In figure 2a we can also see the setup used for checking the FIR output of the HBB – the lens was removed for this test.

**Figure 3:** Temperatures recorded after 30 minutes of direct illumination of lens. The upper one (50.41 $^{o}$c) is the lens probe, the lower (1200 $^{o}$c) is the HBB furnace temperature.

**3. Mirrored illumination FIR output check**

To test a possible method of reducing the thermal infrared flux we checked the effect of different mirror surfaces on the FIR flux reaching the Golay cell. The basic configuration is shown in figure 4 – note the use of an aperture plate in front of the Golay cell to further reduce the incident flux onto the quartz lens. Here a machined surface has been used for the mirror, we also tested an optical flat and a deliberately prepared Lambertian reflector made from shot blasted aluminium. The relative signals are as given in table 1. Intercomparison of this configuration and the direct illumination is difficult but the voltage levels were certainly similar enough for us to conclude that the FIR flux is of the same order of magnitude via the mirror and by direct illumination at the same equivalent distance.

**Table 1:** Evaluation of FIR flux for different mirror types

| **Mirror Type** | **Relative Signal <100 cm$^{-1}$** |
|---|---|
| Optical flat | 1 |
| Machined aluminium | 0.95 |
| Shot blast aluminium | 0.36 |

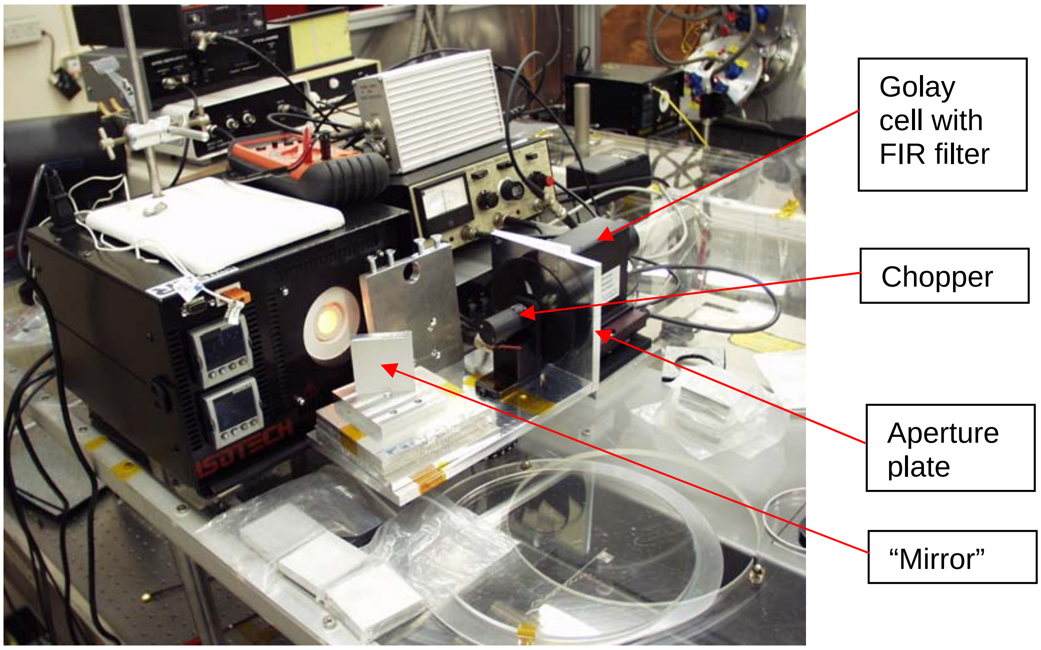



**Figure 4:** Configuration for mirrored FIR flux check.

**4. Mirrored illumination FIR output check**

The final test was to check the heating of the lens with the different mirror surfaces. The configuration used was the same as for the flux test and is shown in figure 5. The equilibrium temperatures reached are as given in table 2. Note that the total distance to the lens from the HBB aperture was around 18-22 cm for these tests rather than 15 cm used for the direct illumination – in practice this makes little difference to the heating as evidenced by the optical flat case. Of the three mirror types the optical flat and machined aluminium showed definite temperature increases. The optical flat case showed an increase similar to direct illumination, the machined surface showed a much lower increase. The shot blasted surface was used after the machined surface case and the lens was cooling (slowly!) back to ambient temperature. No decrease in cooling rate was observed although it is not possible to tell what this means in absolute heating terms.

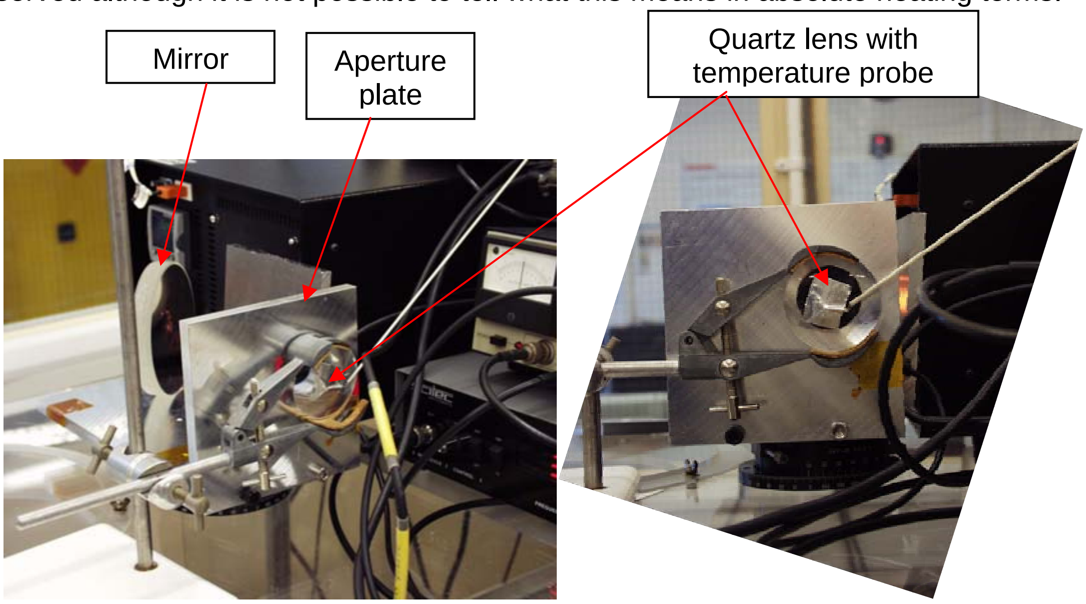


**Figure 5:** Configuration used for mirrored illumination of lens

**Table 2:** Evaluation of lens heating for different mirror types

| Mirror Type | Lens temperature after 30 minutes |
|---|---|
| Optical flat | $48^{o}$ c |
| Machined aluminium | $29^{o}$ c |
| Shot blast aluminium | No increase |

## 5. Final test at Estec using LOU window

In order to confirm the results the source was set up at Estec with an actual LOU window. Figure 6 shows the set up used. No temperature increase greater than 3-4 $^{o}$c above the ambient was observed at any time during the 2 hours of illumination.

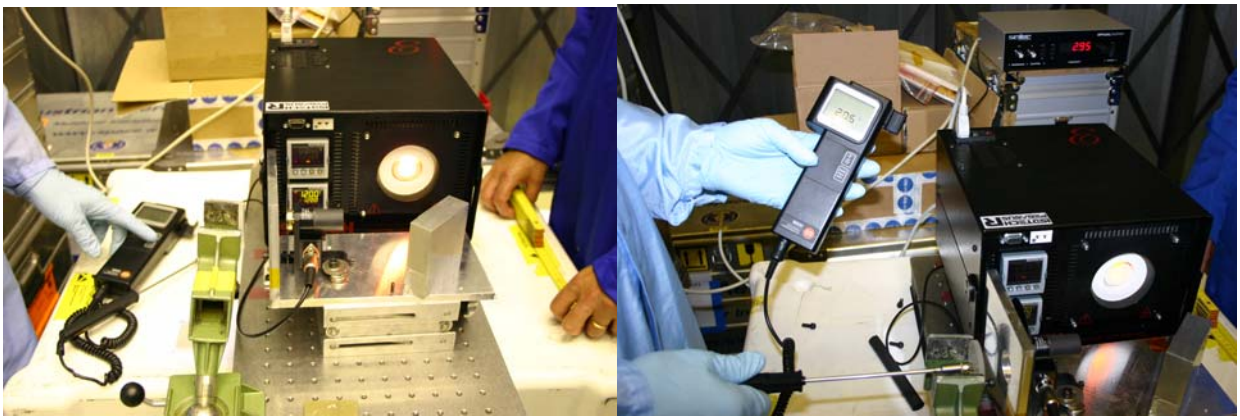


**Figure 6:** Test configuration for test at Estec. The thermometer is a direct contact device here shown measuring the back side of window on axis with the centre of the source after about 30 minutes of illumination.

## 6. Conclusions

We conclude that the safest use of the HBB with respect to heating the LOU windows is to view the source via a machined aluminium surface which reflects reasonably well in the FIR whilst scattering or absorbing the thermal infrared. Combined with the use of a chopper and aluminium aperture plate this configuration restricts the temperature rise of a thermally isolated sample quartz lens to no more than 10 $^{o}$c above the ambient conditions whilst leaving the FIR flux essentially unaffected. We have confirmed that this configuration does not severely heat the LOU windows with a dedicated test on a representative window.