MIPS Campaign D1

MIPS Team

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Abstract

In this campaign, we achieved first light at 24 microns. The resulting stellar image is a textbook reproduction of the TinyTim image model. From the stellar signal, it was possible to correlate the MIPS radiometric model. We found that the instrument throughput is probably somewhat higher than in the prelaunch model, indicating that the matching onto the telescope is better than in our slightly pessimistic estimates. The instrument sensitivity will probably be 10 to 20% better than the prelaunch estimates.

1. First Light

The first light image is shown in Figure 1. The image is unsaturated, but the stretch on the display burns out the central peak and the first bright diffraction ring - the prominent diffraction ring is the *second* one. The image is in very close agreement with the TinyTim model, a subject that will be discussed in more detail in the summary of Campaign E.

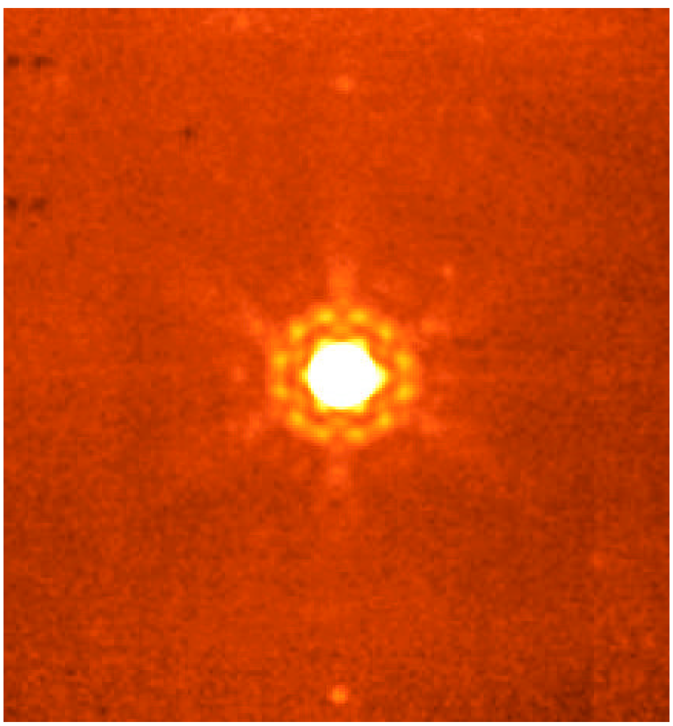

Figure 1. First light image of HD 53501, a K3III star. The image is a manual shift-and-add of 74 individual images, each of nominal 3 seconds integration. The high quality of the coadded image demonstrates good stability of the scan mirror over the 3 second integration time for each image.

2. Operational Aspects of Campaign D1

2.1 Anneal

Start up and shut down were both nominal. Because the helium bath was approaching a plausible final equilibrium temperature, we started accumulating data for an anneal behavior template. A sample of the anneal behavior is shown in Figure 2. The data demonstrate that the anneal is working as expected and that the thermal isolation of the 160µm array is effective.

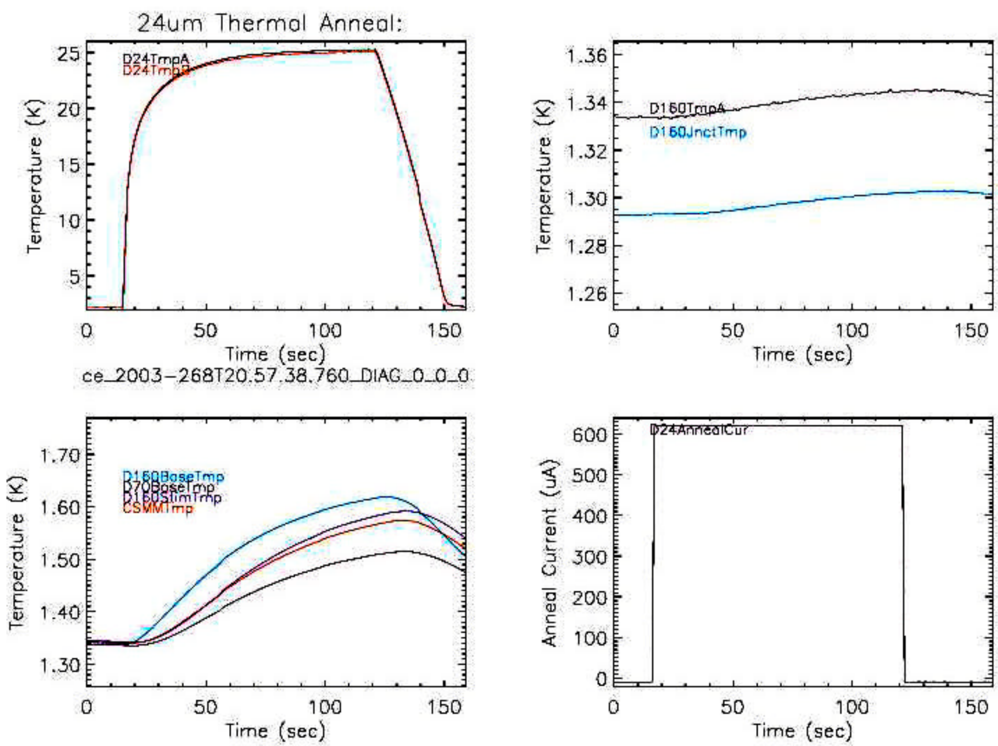

Figure 2. Anneal behavior at 24 mm. The upper left panel shows the array temperature, in response the anneal current shown in the lower right. The temperature rapidly climbs above 20K and reaches 25K during the 100 second anneal, adequate to fully thermalize it. The lower left panel shows the behavior of a number of thermometers connected to structures in the instrument baseplate, and the upper right panel is the temperature at the 160µm array. Despite the 0.2K temperature change on the baseplate, the effect at the 160µm array is < 0.01K.

2.2 Photometry AOR

The photometry AOR worked as expected. Figure 3 shows the first light star data on a small scale, showing the combined action of the scan mirror (vertical) and a spacecraft motion (horizontal) in dithering the image over the array. The first light image (Figure 1) was obtained by manually shifting and adding the images in Figure 3.

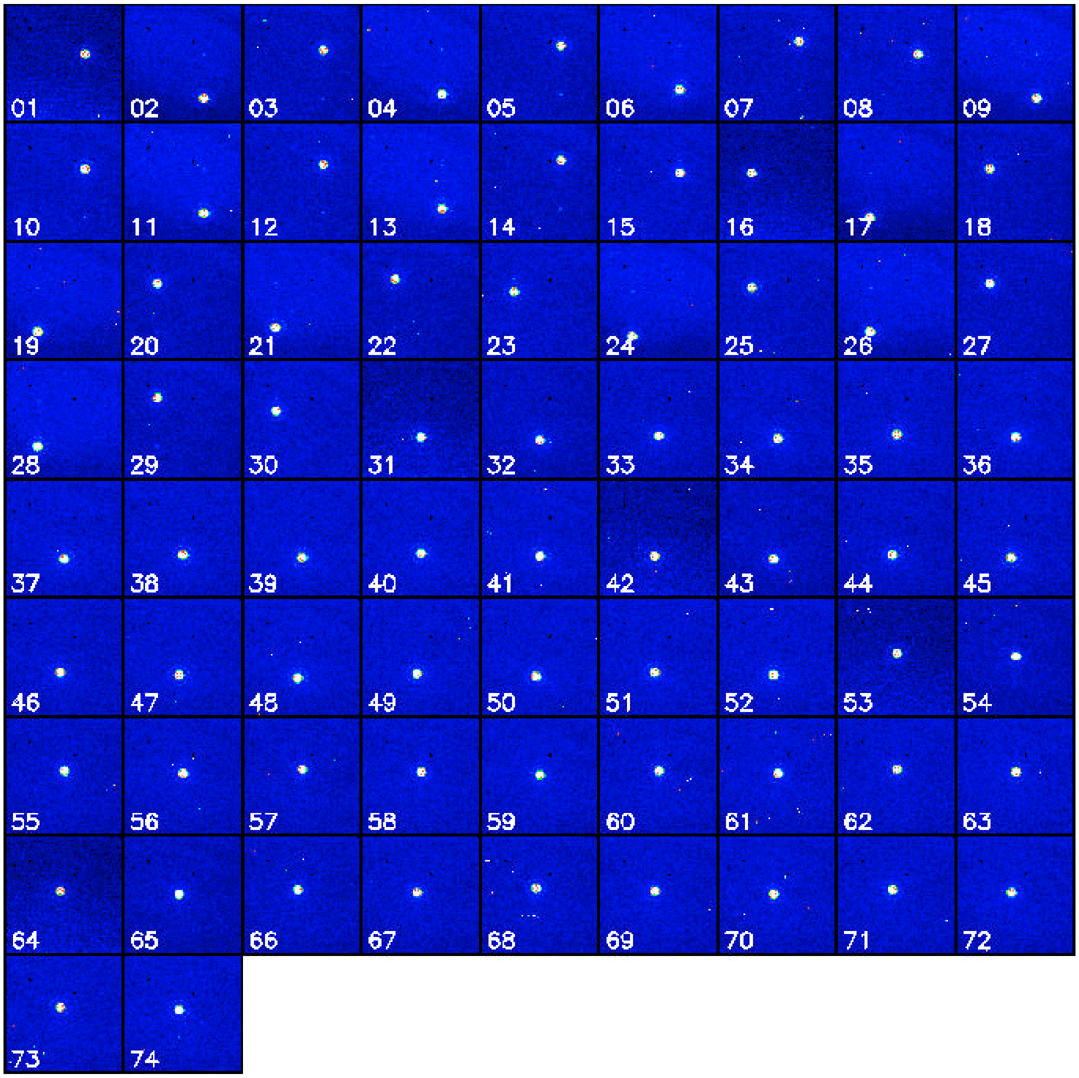

Figure 3. Observation of the first light star demonstrates the operation of the photometry AOR.

3. Other Results

3.1 Stimulators

It was shown that the 24μm stimulators are working, and that the illumination patterns and levels are the same as in the prelaunch data, to within a measurement repeatability of about 2%. Additional data on the stim behavior will be obtained in later compaigns, and when backgrounds and temperatures are more stable.

3.2 Dark Frames

Because the 24μm array was out of saturation on the sky, we could measure the effectiveness of the dark position. We found that it reduces the sky signal by about a factor of 300, so the dark frames will be of high quality.

3.3 Response (Flat Field) Frames

This campaign provided the first opportunity to measure response frames on the sky. The standard deviation of the 24μm response over the entire array is approximately 6%. This statistic does not include correction for distortion in the optics (projected pixel sizes vary slightly over the field as a result of distortion). The deviations may from perfect flatness also include possible variations in the instrument illumination pattern on the array, as well as the intrinsic response variations of the array. Given these effects, the measured uniformity is extremely good.

If we take the ratio of a response frame based on the first DCEs of each pointing, and a second one using the last 8DCEs of each pointing (that is, two response frames of 32DCEs each), then we find that the rms is approximately 0.2%. Thus, the stability of the response frames is good. Another way to estimate the uniformity of response is to do differential photometry of stars observed on different positions on the array. The comparison between the photometry of the first-light star on the combined 74DCEs and the individual 74DCEs yields differences of between 2 and 4% for a few positions on the 24μm array.

3.4 Offset Adjustment

The A/D converter has a range from -32K to +32K. An offsetting amplifier on its input lets us set the "zero" level and we want to place it as close to the appropriate end of the range as possible so we get the maximum dynamic range, but without danger of having the signal go off-range below "zero." We found that all the relevant parameters were behaving as they had on the ground. As a result of this test, we are recommending that the array offset be placed so "zero" is at -30K.

3.5 First Difference Frame

The first difference frames were substituted for some of the traditional integrations for some of the peak signal pixels. There is no detectable effect in the point spread function. We conclude that the difference frame strategy is working, and that the expended dynamic range will be available in a way that may even be transparent to users of MIPS.

3.6 Throughput
We estimated the brightness of the first-light star obtained by extrapolation from shorter wavelength data (it does not have high-accuracy measurements in the mid-infrared except with IRAS). The value agreed well with the IRAS measurement. To be cautious, we have assigned 10% error bars to its flux.

We determined the conversion from DN/s to flux density to be $1.5 \pm 0.15 \times 10^5$ DN/s per Jy at 24μm. The error is based on the uncertainty in the flux density from the star. The resulting instrument throughput is somewhat greater than predicted from the prelaunch MIPS radiometric model, indicating that all the measured instrument parameters are basically correct and that the instrument is matched to the telescope very well.

The indicated adjustments have been made in the radiometric model, as discussed in MER-IOC-001. Once this report has been updated to reflect the results of additional campaigns, it will be the basis for revising estimates of the instrument sensitivity and saturation limits. Based on Campaign D1, it appears likely that the sensitivity will be 10 to 20% better than predicted in the prelaunch model, and that the saturation levels will be similar to slightly higher than in the prelaunch model.

4. Issues
A number of issues were identified as a result of this campaign:

1. The first slope in a series of 24μm exposures is smaller than the rest. The flight SUR fitting routine will be tested and inspected to see if a cause can be identified.

2. There are a number of issues with frame orientation and as a result with the distortion corrections.

3. The initial pointing was off by about 20 arcsec, consistent with the pointing errors found by IRAC and the PCRS. This error will presumably be removed by an update to the spacecraft frame tables.

5. Summary
MIPS first light at 24μm was very successful. A textbook quality diffraction limited image was obtained of the first-light star, and many other instrument functions were verified. A few issues also became apparent, which provide the team with something to do waiting for the next set of campaigns. However, none of them threaten correct operation of this band. We tentatively conclude that it will work closely as advertised prior to launch, and probably at an increase in sensitivity by 10 to 20% over those predictions.