In-flight Performance of the Infrared Array Camera (IRAC) on the Spitzer Space Telescope

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The Infrared Array Camera (IRAC) is one of three focal plane instruments on the Spitzer Space Telescope. IRAC is a four-channel camera that obtains simultaneous images at 3.6, 4.5, 5.8, and 8 μm. Two adjacent 5.2x5.2 arcmin fields of view in the focal plane are viewed by the four channels in pairs (3.6 and 5.8 μm; 4.5 and 8 μm). All four detector arrays in the camera are 256x256 pixels in size, with the 3.6 and 4.5 μm channels using InSb and the 5.8 and 8 μm channels using Si:As IBC detectors.

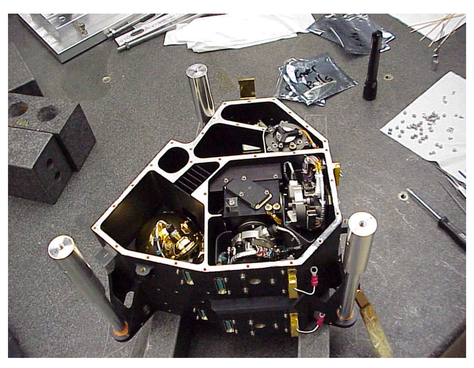
The Spitzer Space Telescope was launched on August 25, 2003, and in the following three months an In-Orbit Checkout (IOC) and Science Verification (SV) was performed. During this period the telescope was focused, and the functional checkout of the instruments and Astronomical Observing Templates (AOTs) was conducted. Since launch, IRAC has been powered on for over 1300 hours and has collected in excess of 100,000 frames of calibration and science data. The nominal operations mission phase began on December 1, and two IRAC campaigns have been completed which included parts of the First-Look Survey, Legacy, and guaranteed time science programs.

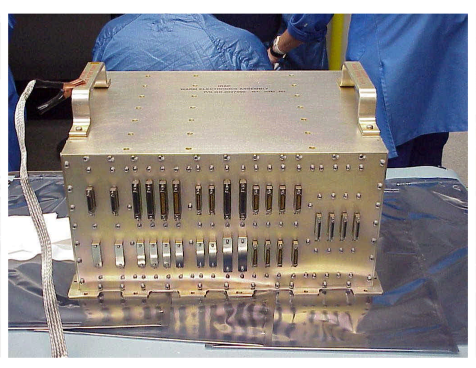
Channel	1	2	3	4
Central wavelength (μm)	3.6	4.5	5.8	8.0
Bandwidth (%)	21	23	26	37
Pixel size (arcsec)	1.22	1.21	1.22	1.22
Field of View (arcmin)	5.2×5.2	5.2×5.2	5.2×5.2	5.2×5.2
Sensitivity: 5s , 200 sec (μJy)	3.2	3.9	26	28
Noise pixels (mean)	7.0	7.2	10.8	13.4
FWHM (mean, arcsec)	1.66	1.72	1.88	1.98
FWHM of centered PSF (arcsec)	1.44	1.43	1.49	1.71
Max. central pixel flux (peak, %)	42	43	29	22

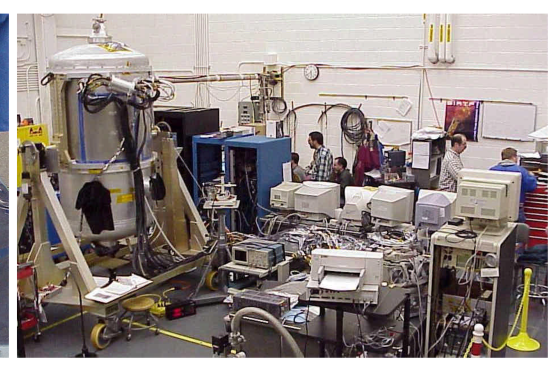
IRAC Performance

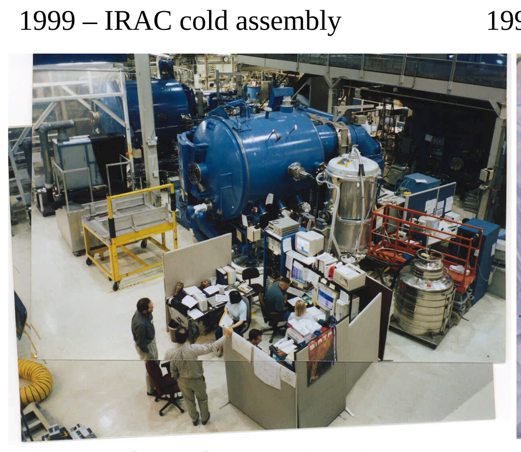
The table at left shows the in-flight performance of the camera. The filter wavelengths and bandpasses are from the ground-based data; the other parameters were measured during the IOC/SV period after focus. IRAC's performance is generally consistent with pre-flight predictions. IRAC exceeds its requirements for sensitivity and image quality in all channels.

For more detailed info on IRAC performance and use, see http://ssc.spitzer.caltech.edu/irac/


1999 – IRAC cold assembly

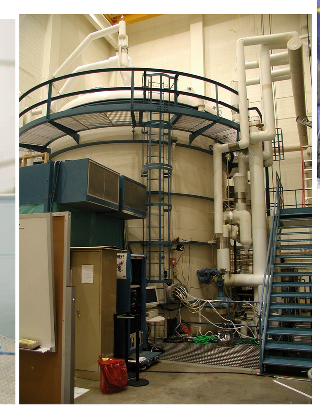

1999 – IRAC Warm Electronics

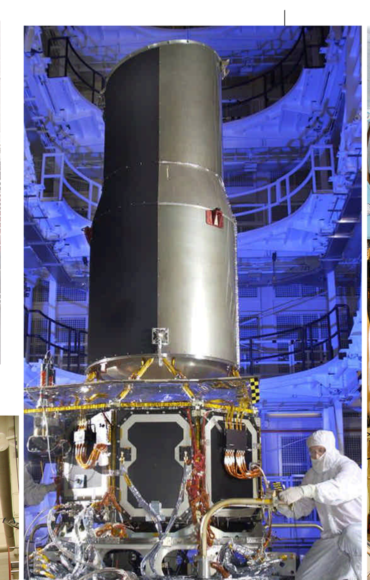

2000 – Integration and Test at GSFC

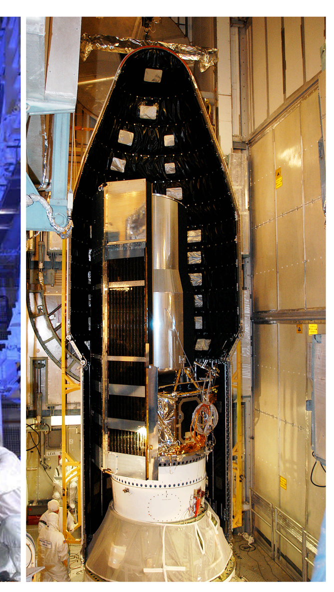

2000 – Thermal Vac at GSFC


2000 – Installation in MIC at Ball


2001 – Telescope on MIC


2001 – Cold test at Ball

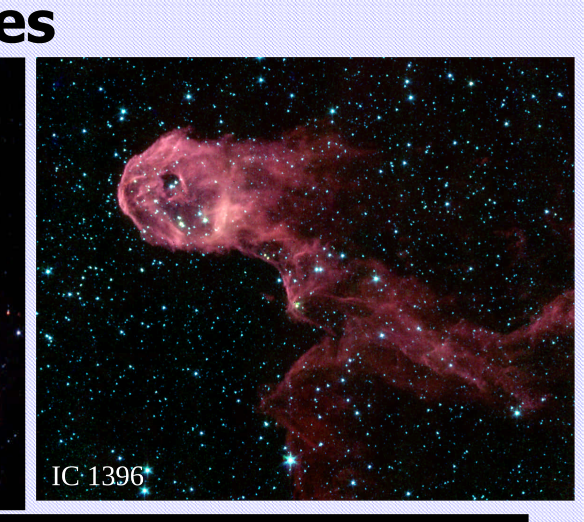

2002 – On S/C at LMMS

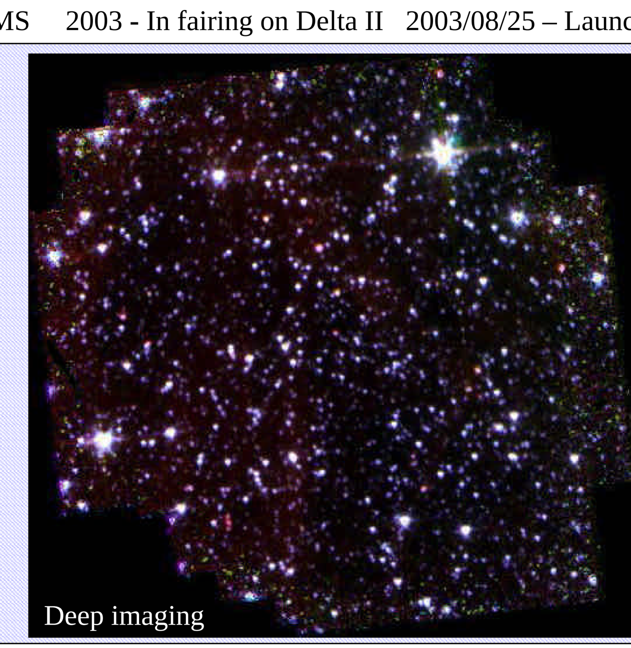

2003 - In fairing on Delta II

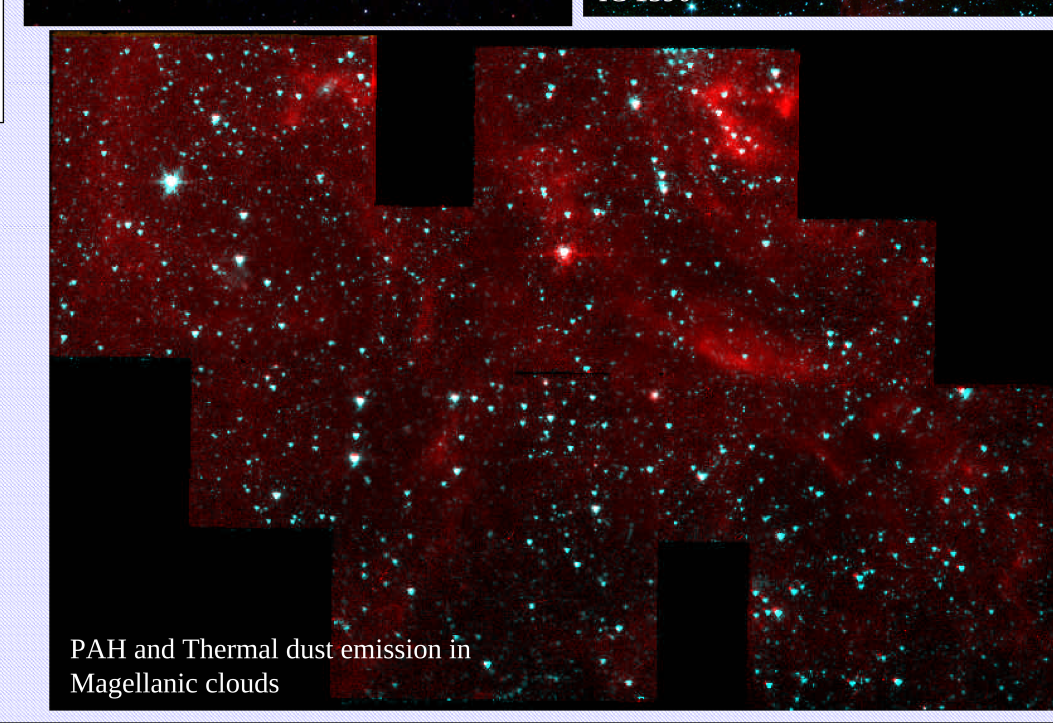

2003/08/25 – Launch!

Post-Launch Images


M81


IC 1396

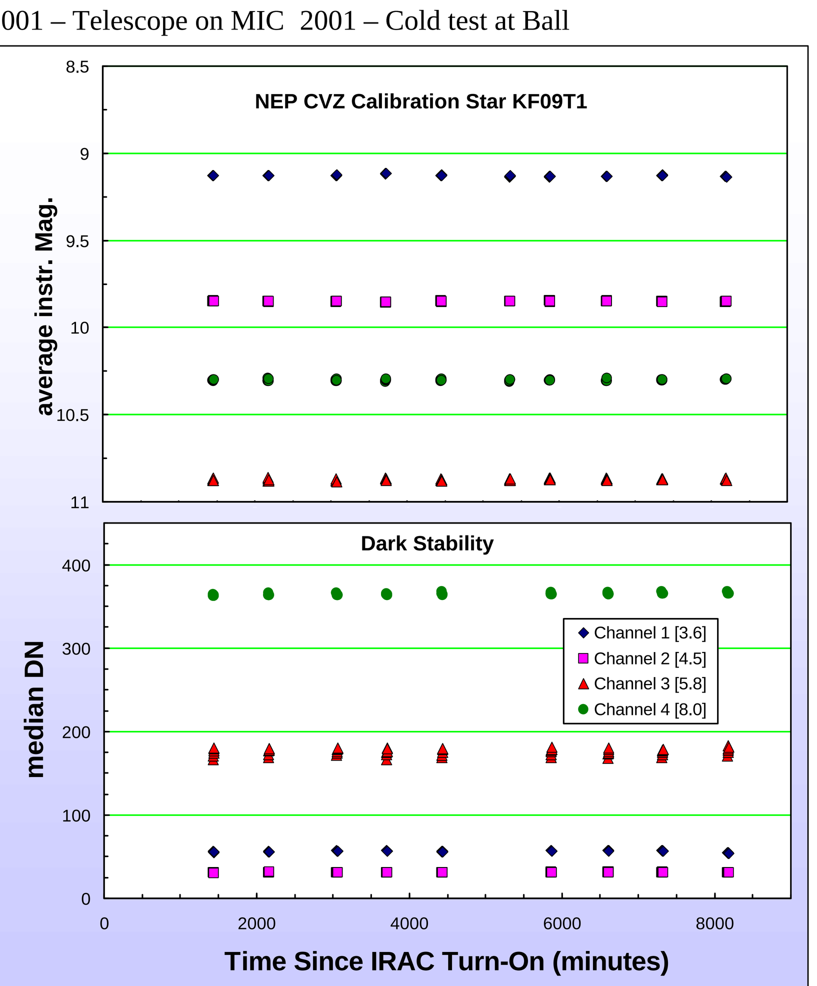

Deep imaging


PAH and Thermal dust emission in Magellanic clouds

Instrument Stability

To monitor the dark stability, a relatively blank field near the NEP was imaged using 12-sec HDR-mode frames and a 5-position dither, with 6 repeats. Each group of dithers was median-filtered to remove sources and the median level measured. To monitor the photometric stability, the calibration star KF09T1 (K0 III, m_K = 8.1) was imaged as five consecutive sets of 2-second frame times using a 5-point dither pattern in all fields. The average instrumental magnitude was calculated for each set of dithers.

The range in the median darks in the 5 day period shown is less than 10% of the median in all four IRAC channels. For the photometric stability, the ensemble average instrumental magnitude is found to have standard deviation of less than 1% and a range of ~2% for all four IRAC channels over the monitoring period.

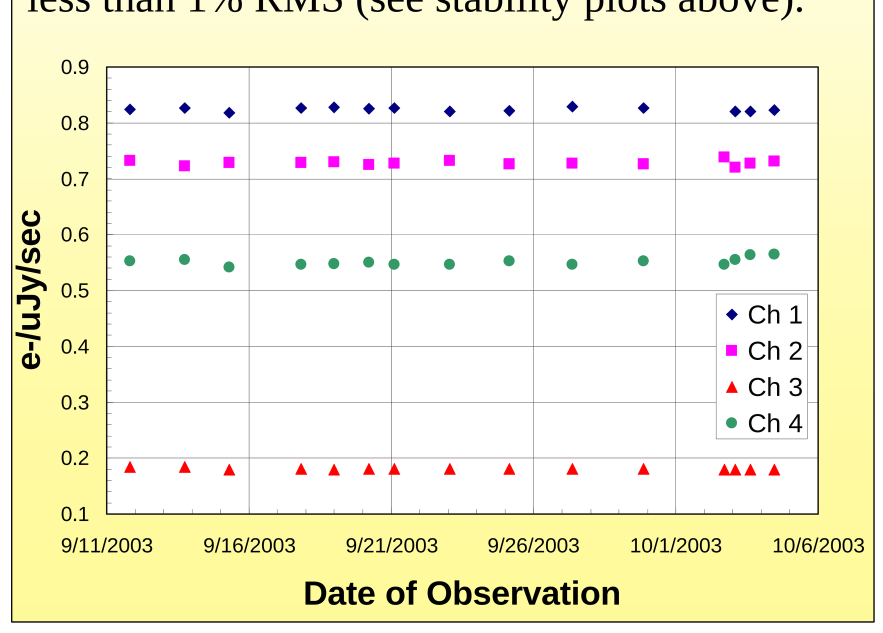


Long-term Residual Images

It was observed in flight during one of our first downlinks during a campaign that after staring at a fixed field for many minutes, the image of that field was visible in Channel 1 as a long-term residual many hours after the downlink, even though the arrays were being reset every 0.2 sec. In addition to downlinks, we also saw long-lived residuals in Channel 4 when an extremely bright object had been observed. We found that the best way to remove these residuals is to do a short thermal anneal of the arrays, where the temperatures are raised into the 20-30K range (from their nominal 15K for InSb and 6K for Si:As) This has the added benefit of stabilizing the drift in array bias currents and dark levels, and reducing the emission from hot pixels. In nominal ops, an anneal will be performed after power-on and after each down-link, which will take place once every ~12 h.

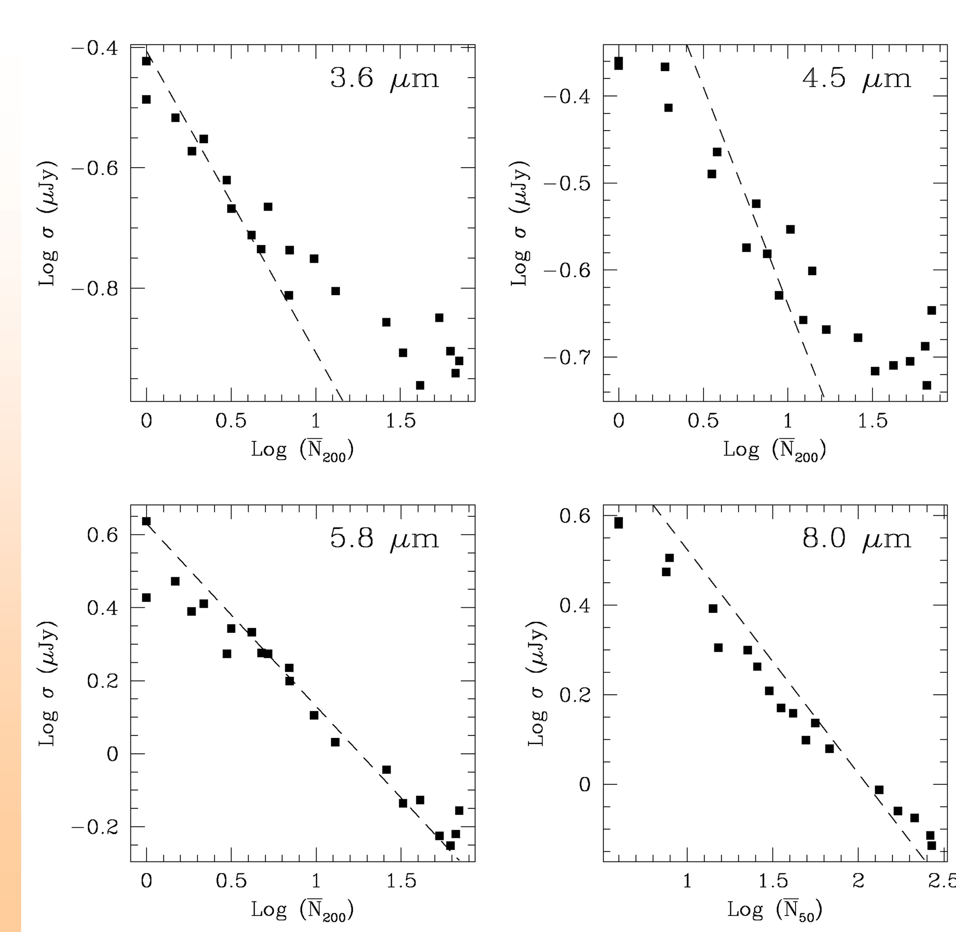
Calibration

Calibration data are taken regularly in each campaign (~10 day period that IRAC is on). Standard stars and dark monitoring frames are taken every 12 hours. A full dark calibration suite and a flat field is obtained every 3 days. The instrument response is stable to ~1% RMS or better from campaign to campaign (see plot below), and within a campaign the changes are less than 1% RMS (see stability plots above).



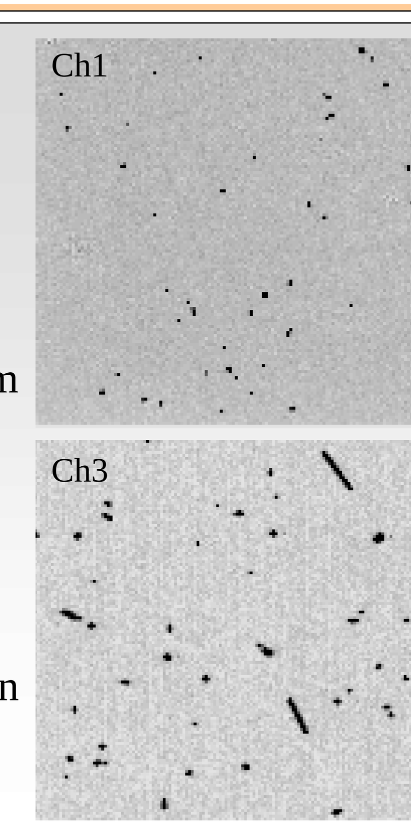
Deep Integrations, Sensitivity, and Confusion

A ~10 hour per field integration was performed in a low background region during IOC to assess the behavior of noise as a function of integration time. The plots at right show the results for each channel. The one sigma noise of the image is plotted against number of coadds. The dashed line represents the predicted behavior, the squares are the results. Channels 3 and 4 show the expected decrease in noise with sqrt(N): channels 1 and 2 reach a noise floor of ~ 0.2 μJy at about $\bar{N}$=10 (corresponds to about 15 dither positions of 200 sec integration time each). The noise floor is due to either source confusion or systematic calibration effects.



Cosmic Rays

Cosmic rays (CRs) affect approximately 2-4 pixels/sec in an IRAC integration. The most common CRs do not affect the pixel performance in subsequent frames, and are confined to a few pixels near the peak. However, other events can cause streaks or other multiple pixel structures in the array, and less common energetic events can cause muxbleed and short-term residuals in subsequent frames. Single CRs should not permanently affect the responsivity of a pixel, but multiple strikes over time and strong solar flare events may lead to an increase in dark current, and perhaps a degradation of responsivity. The images at right show portions of two 100-sec IRAC frames obtained in IOC. The stars have been subtracted to show only the CRs in the images. The CRs in channel 1 are more compact than in channel 3. The channel 3 CRs can appear as streaks or blobs depending on the angle of incidence of the CR as it penetrates the thicker Si:As detectors.



Acknowledgments: This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under NASA contract 1407. Support for this work was provided by NASA.

AAS January 2004: 22.02