The SAGE Data Description: Delivery 2

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Contents

1. Executive Summary

This document describes the second SAGE delivery that includes:

- SAGEcatalogIRAC, the v2.1 IRAC catalogs containing Epoch 1 only (revised) and Epoch 2 only data bandmerged with All-Sky 2MASS and 6X2MASS
- SAGEarchiveIRAC, the v2.1 IRAC archives containing Epoch 1 only (revised) and Epoch 2 only data bandmerged with All-Sky 2MASS and 6X2MASS
- fits images containing information about the time of observation for a given SAGE IRAC source
- SAGEcatalogMIPS24, the Epoch 1 only (revised) and Epoch 2 only MIPS 24 μm catalogs
- MIPS 70 μm and 160 μm full mosaics combining two epochs of data
- MIPS 70 μm and 160 μm weight maps (no. of measurements per pixel)
- MIPS 24 μm Epoch 1 only and Epoch 2 only full mosaics
- MIPS 24 μm $1^{\circ}.1 \times 1^{\circ}.1$ tiles combining two epochs of data

The source lists include over 4 million IRAC and ∼40,000 MIPS 24 μm sources for each epoch from the entire LMC, and were constructed to be highly reliable. This second data delivery from the SAGE project includes the revised Epoch 1 IRAC catalog and archive and the revised Epoch 1 MIPS 24 μm catalog which supersede the previous release, see Appendix A (IRAC) and Appendix C (MIPS) for details on the differences. New with this release are the Epoch 2 IRAC catalog and archive, the Epoch 2 MIPS 24 μm catalog and MIPS 24, 70 and 160 μm images. See Tables 1 and 2 for a summary of the delivered point source lists and images, respectively. This document provides a brief overview of the project and data processing. A guide to contents of the SAGE catalog and archive columns is provided.

2. Overview of the *Spitzer* SAGE Survey of the LMC

The SAGE project is a Cycle 2 legacy program on the *Spitzer* Space Telescope, entitled, “Spitzer Survey of the Large Magellanic Cloud: Surveying the Agents of a Galaxy’s Evolution (SAGE)”, with Margaret Meixner (STScI) as the PI. The project overview and initial results are described in a paper by Meixner et al. (2006). The main characteristics of the survey

Table 1. Point Source Lists for SAGE Epoch 1 and Epoch 2 Delivery

Source List Title	Data Volume	Wavelengths (μm)	Content
SAGEcatalogIRAC	Epoch 1: ∼4.3 million sources Epoch 2: ∼4.2 million sources ∼22.4 GB	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC catalog containing Epoch 1 only and Epoch 2 only sources with 0.6 and 12 second frame photometry bandmerged with 2MASS and 6X2MASS; high reliability emphasized. Faint limits for both epochs are 18, 17, 15, and 14 mag for IRAC 3.6, 4.5, 5.8, and 8.0 microns, respectively.
SAGEarchiveIRAC	Epoch 1: ∼4.5 million sources Epoch 2: ∼4.3 million sources ∼23.1 GB	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC archive containing Epoch 1 only and Epoch 2 only sources with 0.6 and 12 second frame photometry bandmerged with 2MASS and 6X2MASS; includes more sources and more source fluxes (fewer nulled wavelengths), see section 3.2. Faint limits for both epochs are 18.5, 17.5, 15, and 14.5 mag for IRAC 3.6, 4.5, 5.8, and 8.0 microns, respectively.
SAGEcatalogMIPS24	Epoch 1: ∼39,000; sources Epoch 2: ∼37,000 ∼71.8 MB	24	MIPS 24 micron catalog containing Epoch 1 only and Epoch 2 only sources; high reliability emphasized. Faint limit for both epochs is 10 mag at 24 microns.

Table 2. Images for SAGE Epoch 1 and Epoch 2 Delivery

Image	Pixel Size (″)	Surface Brightness Sensitivity (MJy/sr)	Description
SAGE_LMC_MIPS24_E1.fits	2.49	0.02	MIPS 24 μm Epoch 1 full mosaic
SAGE_LMC_MIPS24_E2.fits	2.49	0.02	MIPS 24 μm Epoch 2 full mosaic
SAGE_LMC_tile_MIPS24_TN.fits SAGE_LMC_tile_MIPS24_TN_wt.fits SAGE_LMC_tile_MIPS24_TN_res.fits	2.49	0.014	24 μm $1^\circ.1 \times 1^\circ.1$ tiles combining Epoch 1 and Epoch 2 data (*TN.fits, where TN is a tile number from 1 to 85); a weight map (*TN_wt.fits, # of measurements per pixel), and a point source subtracted image (*TN_res.fits). See Appendix C.3 for details.
SAGE_LMC_MIPS70_E12.fits SAGE_LMC_MIPS70_E12_wt.fits	4.80	0.15	MIPS 70 μm full mosaic combining Epoch 1 and Epoch 2 data (*E12.fits) and a weight map (*E12_wt.fits)
SAGE_LMC_MIPS160_E12.fits SAGE_LMC_MIPS160_E12_wt.fits	15.6	0.30	MIPS 160 μm full mosaic combining Epoch 1 and Epoch 2 data (*E12.fits) and a weight map (*E12_wt.fits)
SAGE_LMC_IRAC*_E1.earliest_obstime.fits SAGE_LMC_IRAC*_E1.latest_obstime.fits SAGE_LMC_IRAC*_E2.earliest_obstime.fits SAGE_LMC_IRAC*_E2.latest_obstime.fits	2.0	···	Fits images that display the earliest and latest observational times for any given area observed by SAGE for each of the 2 SAGE epochs and for each of the 4 IRAC channels (* = 1,2,3,4). Image units are minutes, corresponding to the number of minutes past Julian Date 2453500.5. See Section 3.7 for details.

are listed in Table 3. The LMC was mapped at two different epochs dubbed Epochs 1 and 2 separated by 3 months, because it provides a 90-degree roll angle in the orientation of the detectors, which optimally removes the "striping" artifacts in MIPS and artifacts along columns and rows in the IRAC image data. In addition, these two epochs are useful constraints of source variability expected for evolved stars and some young stellar objects (YSOs). Note, the predicted sensitivities for the complete survey are listed in Table 3 are for the whole survey, whereas the Epoch 1 and Epoch 2 catalogs use only half of the data and thus have less sensitivity (see Meixner et al. 2006 for more details). Not all sources in the SAGE catalog belong to the LMC. Meixner et al. (2006) derived preliminary estimates of 18% and 12% for Milky Way foreground and background galaxy contributions to the SAGE catalog, respectively.

Table 3. Principal Characteristics for SAGE Survey: *Spitzer* program ID 20203

Characteristic	IRAC Value	MIPS Value
Nominal Center Point	RA(J2000): $5^{\rm h}$ $18^{\rm m}$ $48^{\rm s}$ Dec(J2000): -68° 34′ 12″	RA(J2000): $5^{\rm h}$ $18^{\rm m}$ $48^{\rm s}$ Dec(J2000): -68° 34′ 12″
Survey area	7.1° × 7.1°	7.8° × 7.8°
AOR size, grid size	1.1° × 1.1°, 7 × 7	25′ × 4°, 19 × 2
Total time (hrs)	290.65	216.84
λ (μm)	3.6, 4.5, 5.8, and 8.0	24, 70, and 160
Pixel size at λ	1.″2, 1.″2, 1.″2, 1.″2	2.″5, 9.″8, 15.″9
Angular resolution at λ	1.″7, 1.″7, 1.″9, 2.″0	6″, 18″, 40″
Exposure time/pixel at λ (s)	43, 43, 43, 43	60, 30, 6
Predicted point source sensitivity for combined epoch data, 5σ at λ (mJy)	0.0051, 0.0072, 0.041, 0.044	0.5, 30, 275
Predicted point source sensitivity for combined epoch data, 5σ at λ (mag)	19.3, 18.5, 16.1, 15.4	10.4, 3.5, -0.6
Saturation limits (Jy) at λ	1.1, 1.1, 7.4, 4.0	4.1, 23, 3
Saturation limits (mag) at λ	6.0, 5.5, 3.0, 3.0	0.60, -3.7, -3.2
Epoch 1	July 15-26, 2005	July 27 - Aug. 3, 2005
Epoch 2	Oct. 26 - Nov. 2, 2005	Nov. 2-9, 2005

The catalogs and archives in this delivery, shown in Table 1, were produced by the IRAC pipeline (Univ. of Wisconsin) and MIPS pipeline (Univ. of Arizona) and ingested into a SAGE database for review, SAGE Team use and staging area for releases (STScI).

In comparison to the SAGEcatalogIRAC, the SAGEarchiveIRAC has more source fluxes (fewer nulled wavelengths) and some more sources but these additions have more uncertainty associated with them. For the SAGEcatalogIRAC, the S/N must be greater than [6, 6, 6, 10] for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively, for the flux to appear in the corresponding wavelength column. For the SAGEarchiveIRAC, the S/N must be greater than [5,5,5,5] for IRAC bands [3.6], [4.5], [5.8], and [8.0], respectively. For the SAGEcatalogIRAC, sources with neighbors within a 2″ radius are excluded (culled). For the SAGEarchiveIRAC, sources within a 0″.5 are excluded. The difference in criteria for the catalog and archive creation is more complex and described in the next section.

3. IRAC Catalog and Archive

The point source lists presented in this document were extracted from IRAC Epoch 1 and Epoch 2 single frame images processed with the SSC pipeline version S13.2 and later using a modified version of DAOPHOT (Stetson 1987). The Wisconsin IRAC pipeline, which was originally developed to process the GLIMPSE data (Benjamin et al. 2003), is described by the GLIMPSE pipeline documents[1]. This pipeline was modified for the SAGE project to handle the high dynamic range (HDR) data and longer exposure times. The details for the SAGE IRAC processing can be found in Meixner et al. (2006). Here we summarize the criteria for selection of the point sources to be in the catalog (SAGEcatalogIRAC) and the archive (SAGEarchiveIRAC) after the sources are extracted from the images. Then we describe the quality of the resulting SAGEcatalogIRAC and SAGEarchiveIRAC.

3.1. Bandmerging to Produce Sourcelists

The point source lists are merged at two stages using a modified version of the SSC bandmerger[2]. Before the first stage, source detections with S/N less than 3 are culled. During the first stage, or in-band merge, all detections at a single wavelength are combined using position, signal-to-noise (S/N) and flux to match the sources. The 0.6 second flux is included if the signal-to-noise is greater than (5,5,5,7) and the magnitudes are brighter than (12,11,9,9), for the four IRAC bands [3.6],[4.5],[5.8], and [8.0], respectively. This prevents Malmquist bias from affecting the results. The 12 second flux is included if the magnitude is fainter than the saturation limit of (9.5, 9.0, 6.5, 6.5) for the four IRAC bands [3.6], [4.5], [5.8], and [8.0], respectively. When both criteria are met, the 0.6 and 12 second fluxes are combined, weighted by the propagated errors. Fluxes of sources within $1''.6$ in the IRAC frame are combined together or 'lumped' into one flux.

The second stage, or cross-band merge, combines all wavelengths for a given source position using only position as a criterion in order to avoid source color effects. Cross-band lumping is done with a $1''.6$ radius. Position migration can still occur in the bandmerging process which results in a small number of sources that have sources within $1''.6$ of it. In the cross-band merge stage we also merge with a combined All-Sky 2MASS (Skrutskie et al. 2006) and 6X2MASS point source list (Cutri et al. 2004; details on how that combined list was made can be found in Appendix A.4). Note that we only propagate a subset of

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[1]http://www.astro.wisc.edu/glimpse/docs.html

[2]http://ssc.spitzer.caltech.edu/postbcd/bandmerge.html

the 2MASS quality flags and information, and users should refer to the original 2MASS and 6X2MASS catalogs available through IRSA for full information. We include the unique numeric identifier assigned by the 2MASS project "cntr" (TmassCntr in the SAGEcatalogIRAC and SAGEarchiveIRAC) to allow this cross-referencing. All the sources with TmassCntr < 1E+08 come from the 6X2MASS catalog, and the sources with TmassCntr > 1E+08 from the All-Sky 2MASS catalog.

3.2. Catalog and Archive Criteria

The IRAC source lists were produced from photometry on individual BCD frames. The 12 second exposures suffer from cosmic rays. For this reason, a stringent selection criteria was developed to limit false sources. To ensure high reliability of the final point-source SAGEcatalogIRAC by minimizing the number of false sources, we adopt the following selection criteria: Given M detections out of N possible observations (see Appendix B.3), we require that $M/N \gtrsim 0.6$ in one band, and $M/N \gtrsim 0.32$ in an adjacent band, with a $S/N >$ 5, 5, 5, 7 for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively. As an example, a source is typically observed twice at 0.6 second and twice at 12 second for a total of four possible observations in each band. Such a source detected three times in band [3.6] with $S/N > 5$, and twice in band [4.5] with $S/N > 5$ would be included in the catalog and archive. We throw out fluxes in bands with hot or dead pixels within 3 pixels of source center, those in wings of saturated stars, and/or those within 3 pixels of the frame edge in the culling process. Sources are also culled when they are too close to another source because this neighboring source could influence the flux for the source. We use the Archive list to search for near neighbors, and cull from the Archive sources within $0''.5$, and from the Catalog sources within $2''$.

A source may be reliably detected in two bands (usually [3.6] or [4.5]) but have questionable flux in another (usually [5.8] or [8.0]). To ensure high quality fluxes for each source, a flux/magnitude entry for a band in the catalog will be nulled, i.e. removed, for any of the four following reasons. One, the source is brighter than the 0.6 sec. saturation magnitude limits, 6.0, 5.5, 3.0, 3.0, for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively. Two, the source location is flagged as coincident with a bad pixel. Three, the S/N is less than [6, 6, 6, 10] for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively in order to mitigate Malmquist bias. Four, for 12-second only data, if $M < 2$ or M/N is less than 0.6 in order to mitigate faint cosmic ray detections. Note that in HDR mode, data from one epoch (N=4: 2 12 sec observations and 2 0.6 sec observations) having a result with N=2 is not uncommon. Bright sources are only measurable in the 0.6 sec data and faint sources are only measurable in the 12 sec data. Only stars in the intermediate range of brightness will have useful detections in both the 0.6 and 12 sec images. If all fluxes for a source are nulled, the source is removed from the catalog. For the Archive, the nulling criteria are less stringent. The magnitude is nulled if the SN is less than 5 in that band. For photometry with 12 second only data, if $M/N < 0.3$ the magnitude is nulled.

Future catalogs, combining both epochs and based on mosaic photometry (with cosmic rays removed) will have different criteria. Characteristics of the Epoch 1 only and Epoch 2 only source lists are summarized in Table 1.

In the next few sections, we describe some quality checks performed on the SAGEcatalogIRAC and SAGEarchiveIRAC including astrometry, photometric precision, photometric accuracy, comparison of photometry between the two epochs, and completeness.

3.3. Astrometry

The IRAC catalog astrometry is referenced to the All-Sky 2MASS astrometry through cross matching of the IRAC and All-Sky 2MASS frames. The absolute uncertainty in this 2MASS astrometry is typically $0''.3$ (1σ). We determine the astrometric quality of the SAGEcatalogIRAC and SAGEarchiveIRAC by cross checking its positions against the 2MASS/6X2MASS catalogs. Note that sources with 2MASS associates have SAGE positions that are in part derived from the 2MASS position.

In Figure 1, we plot the histogram showing the offsets between the SAGEcatalogIRAC Epoch 1 only and Epoch 2 only positions and the corresponding 2MASS or 6X2MASS positions in 0.05 arcsecond bins. For both Epoch 1 and Epoch 2, the peak of the histogram is within the anticipated precision of $0''.3$. The slight difference between the Epoch 1 and Epoch 2 data may be due to the fact that the data were taken 3 months apart with a 90° difference in the spacecraft position angle, thus the SSC position solution may be slightly different for each epoch. Both epochs were processed in the same way by the IRAC pipeline team.

3.4. Precision and Accuracy of the Photometry

Figures 2 and 3 show the photometric uncertainty due to the extraction for Epoch 1 and Epoch 2, respectively. There is a jump in uncertainties at the brighter magnitudes, e.g. 9.5 at 3.6 microns, shows at the photometry boundary between the 0.6 and 12 second photometry. These brightest magnitudes have larger errors because the exposure time is shorter.

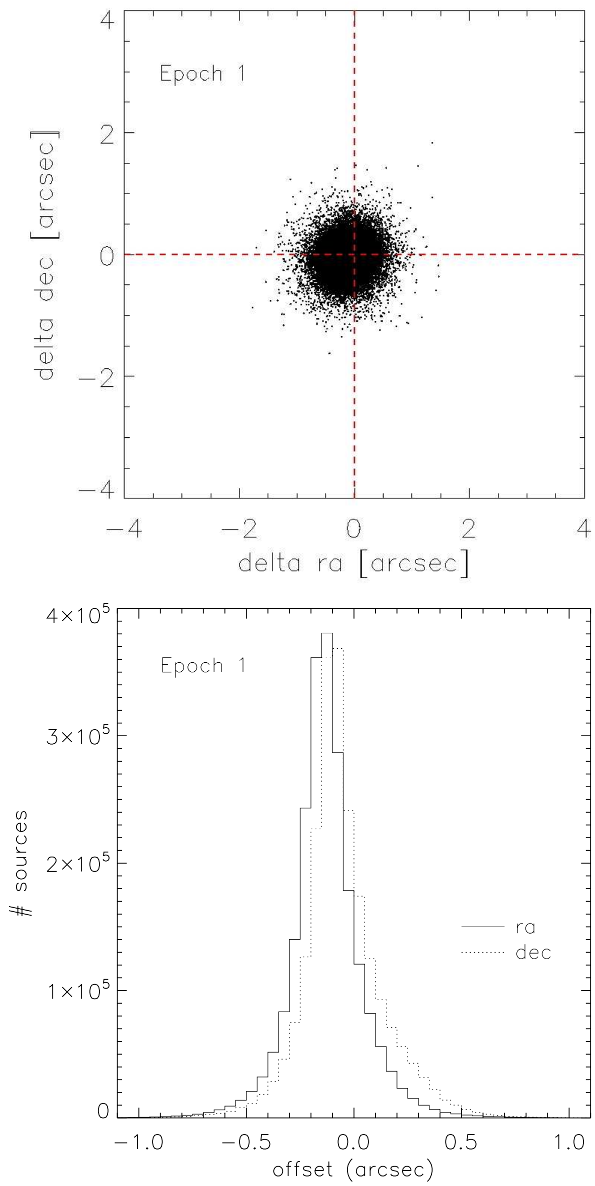

Fig. 1.— The top plots show the scatter plots of the position difference between 100,000 SAGECatalogIRAC Epoch 1 (*left*) and Epoch 2 (*right*) sources and their corresponding 2MASS or 6X2MASS catalog positions. The histograms at the bottom quantify the offsets between these two lists (for all ∼2.2 million sources) and show that the average is within the anticipated precision of $0''.3$.

To assure that our photometric calibration is uniform across the large area observed by SAGE, and between different AORs, epochs, and wavelengths, we extract the photometry

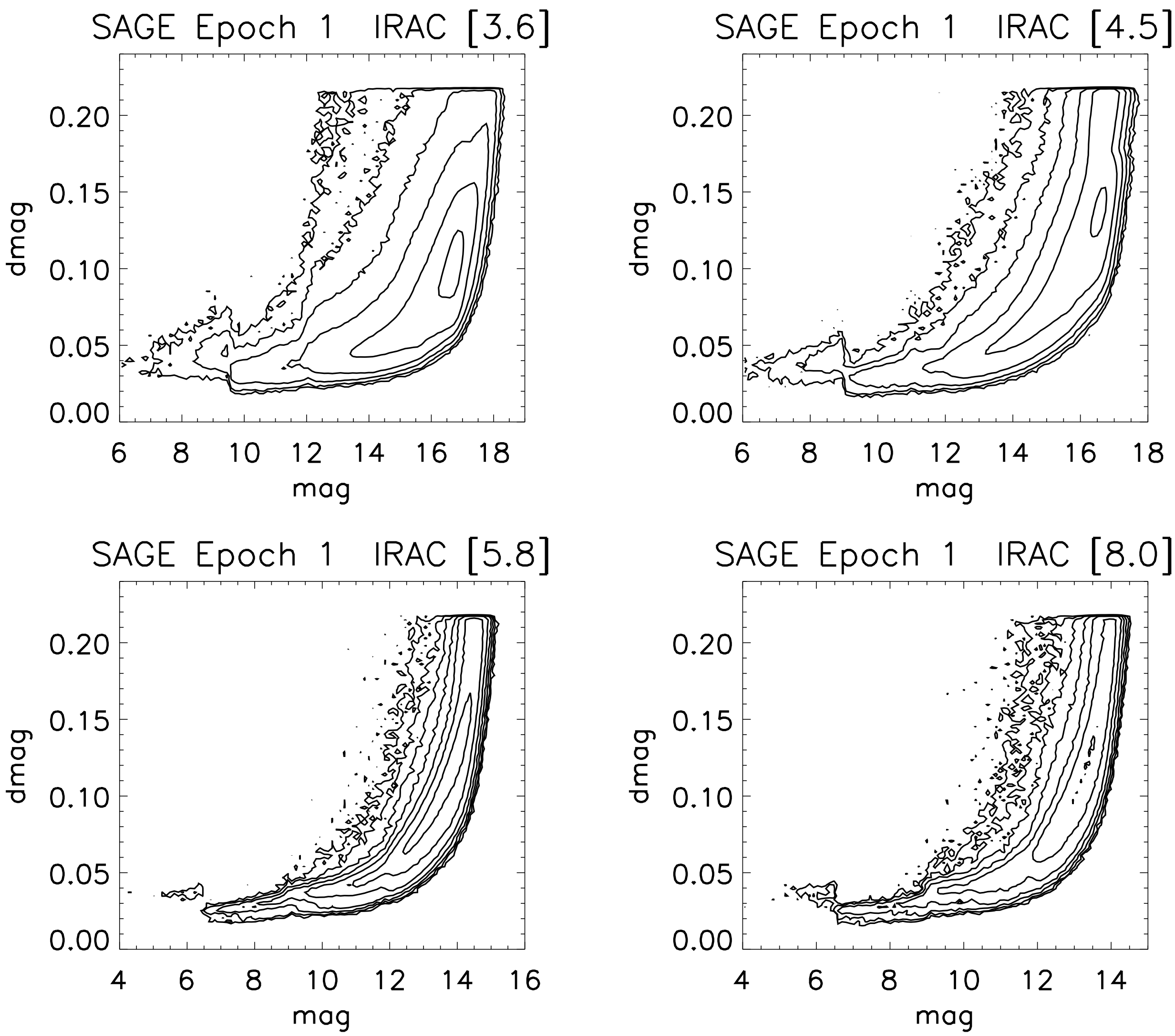

Fig. 2.— Uncertainty in Magnitude vs. magnitude for each IRAC band in Epoch 1 included in the SAGEarchiveIRAC. Contours are used to show the density of the sources. The lack of data above dmag of .22 is caused by the criteria that archive data have signal to noise ratios of 5 or better.

for a network of absolute stellar calibrators custom-built for SAGE. These are A0-A5V or K0-M2III stars selected from SIMBAD and their surface density within the SAGE area is approximately 3 stars per square degree. The techniques used to produce the complete UV to mid-IR absolute spectra are described by Cohen et al. (2003). Any stars showing inconsistency between optical photometry, spectral type and reddening, and photometry were culled to produce the final list of 139 viable calibrators for the Epoch 1 and Epoch 2 data.

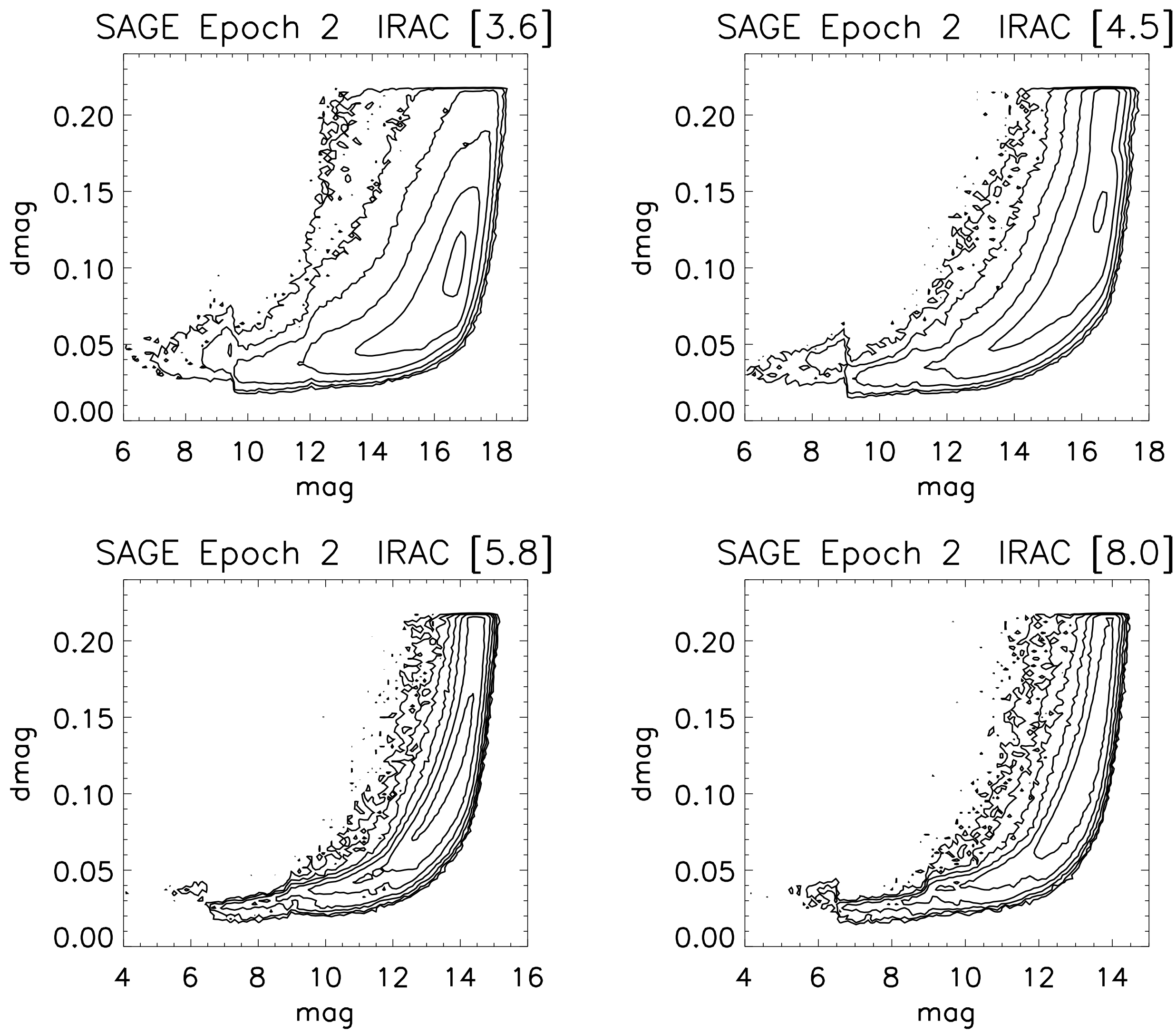

Fig. 3.— Uncertainty in Magnitude vs. magnitude for each IRAC band in Epoch 2 included in the SAGEarchiveIRAC. Contours are used to show the density of the sources. The lack of data above dmag of .22 is caused by the criteria that archive data have signal to noise ratios of 5 or better.

Figures 4 and 5 show the excellent agreement between the SAGE magnitudes and the predicted magnitudes of the calibration stars for the IRAC data. Errors in both the extracted magnitudes and those predicted were added in quadrature to produce the plotted error bars. Magnitude differences are much smaller than the one-sigma errors of our photometry. The ensemble averaged differences and standard deviations in the four IRAC bands between SAGE and predicted magnitudes are -0.011±0.048, 0.019±0.063, 0.008±0.051, 0.008±0.046, respectively for Epoch 1 and 0.003±0.072, 0.020±0.076, 0.007±0.051, 0.010±0.049, respec-

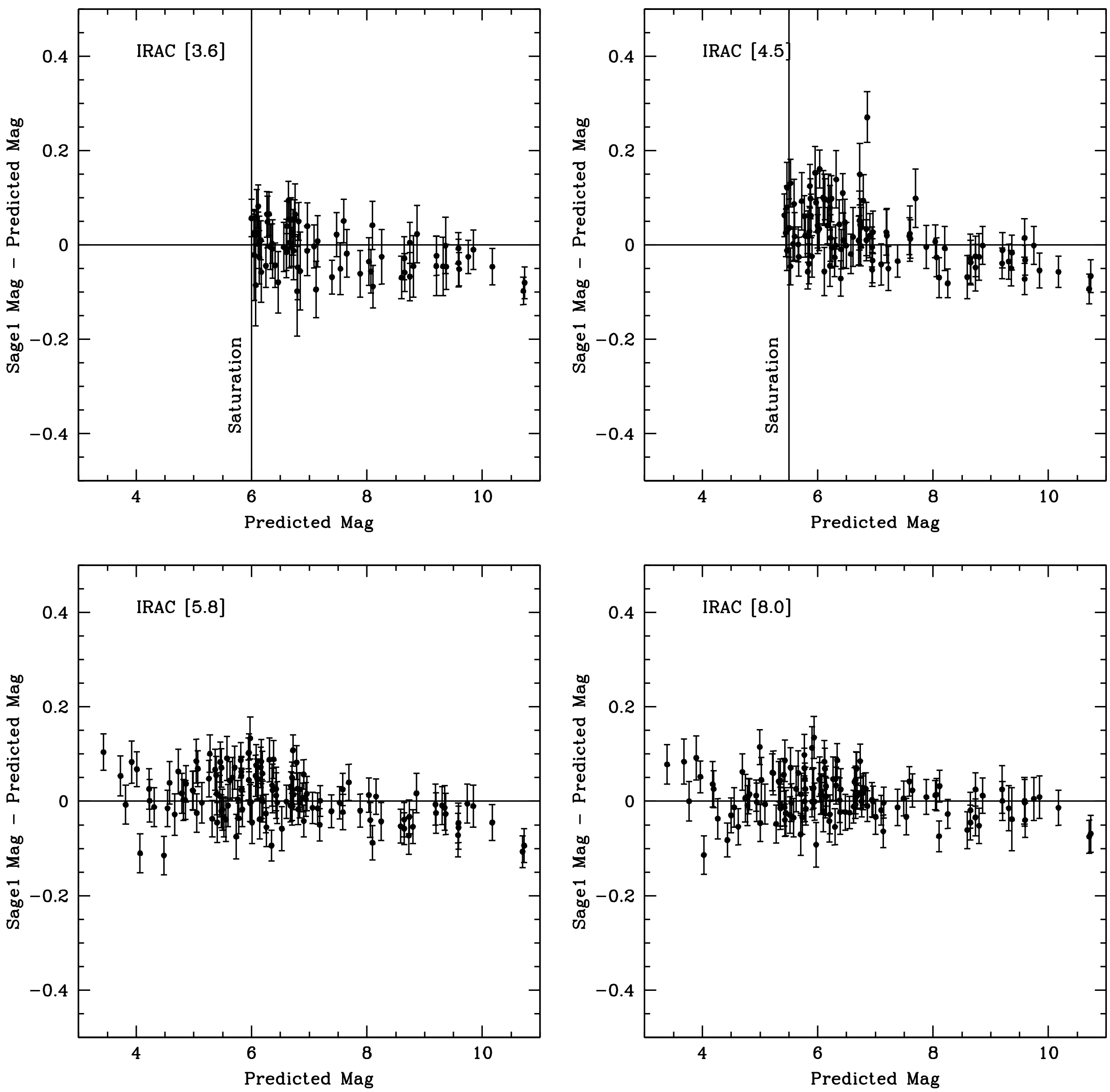

Fig. 4.— Plots demonstrating the quality of the SAGE magnitude measurements in the SAGEarchiveIRAC for Epoch1. For each IRAC band, noted in the top left of the plots, the differences between measured SAGE magnitudes and those predicted for the 139 calibration stars in the SAGE field are plotted. Error bars are the RSS of the errors of both extracted and predicted magnitudes for each star.

tively for Epoch 2. The number of calibrators per channel varies due to saturation and varies per epoch due to slight coverage differences, for Epoch 1 SAGE data, these were 74, 105, 134 and 131 flux calibrators while Epoch 2 had 73, 101, 129, and 128 for IRAC [3.6], [4.5],

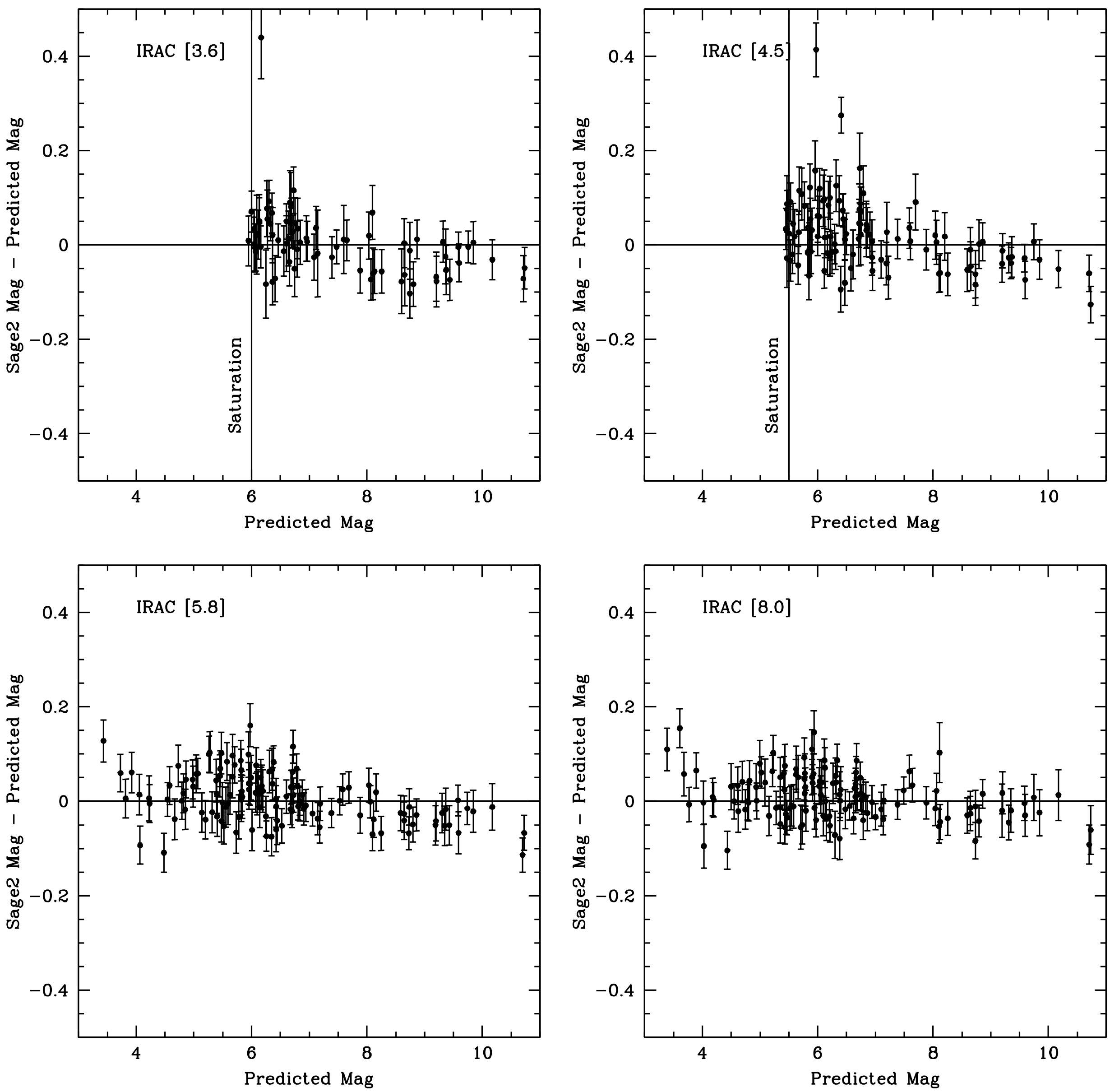

Fig. 5.— Plots demonstrating the quality of the SAGE magnitude measurements in the SAGEarchiveIRAC for Epoch 2. For each IRAC band, noted in the top left of the plots, the differences between measured SAGE magnitudes and those predicted for the 139 calibration stars in the SAGE field are plotted. Error bars are the RSS of the errors of both extracted and predicted magnitudes for each star.

[5.8], and [8.0] respectively.

The basis for calibration is identical for 2MASS (Cohen, Wheaton & Megeath 2003) and

IRAC (Cohen et al. 2003), with absolute zero points (expressed in Jy for zero magnitude) for 2MASS J, H, K_s and the IRAC bands (3.6, 4.5, 5.8, and 8.0 μm) of 1594.0, 1024.0, 666.7, 280.9, 179.7, 115.0, 64.13 Jy, respectively. These zero points are tied to the Midcourse Space eXperiment's absolute calibration which has an accuracy of $\pm$1.1% (Price et al. 2004). The method employed to produce the SAGE network of calibrators is identical to that used to create the suite of standards at the NEP (Cohen et al. 2003) from which the IRAC primary calibrators were selected (Reach et al. 2005).

3.5. Comparison of Photometry between the IRAC Epoch 1 and IRAC Epoch 2

Figure 6 shows a histogram comparing the fluxes of the IRAC sources detected in both epochs of the SAGE survey. The quantity on the X-axis is the absolute value of the ratio of the flux difference to the expected flux difference, $|(f_1 - f_2)/\sqrt{df_1^2 + df_2^2}|$, where f_1 and f_2 are fluxes in the two epochs and df_1 and df_2 are the associated errors. Sources in the IRAC catalog were matched and the fluxes in the 2 epochs compared for each band. The IRAC sources were matched using a search radius of $0''.9$ and only the closest neighbors were considered. The different colored lines in the histogram represent the distributions in the different bands. 78% of Epoch 1 sources and 81% of Epoch 2 sources are detected in both epochs ($\sim$3 million sources). More than 99% of the sources in each band (99.5%,99.5%,99.3%,98.8% in 3.6,.4.5, 5.8 and 8 micron bands, respectively) are within 3σ. The fact that most all of the fluxes for sources found in both Epoch 1 and Epoch 2 agree, confirms the flux measurements in both epochs. A small population of sources are real variable sources such as asymptotic giant branch (AGB) stars, and young stellar objects (YSOs). These variables are discussed in Vijh et al. (2008).

3.6. Completeness

The SAGEcatalogIRAC and SAGEarchiveIRAC has been designed for reliability, not completeness. For this release of the data, we do not run a thorough completeness test of the catalogs. Instead, as a gauge of its completeness, we compare the number counts per magnitude bin of sources between the SAGEarchiveIRAC with source counts based on the cleaner and deeper combined Epoch 1 & 2 mosaicked image for a particular region of the SAGE survey, RA 81°.5 to 84°.0 and Dec -67° to -68° (Figure 7). These plots show that the Epoch 1 lists are mostly complete down to 16.0, 16.0, 13.0 and 10.0 in IRAC bands [3.6],[4.5],[5.8],[8.0] respectively, with the big drop-offs at 16.5, 16.5, 14.0 and 13.5 for bands 1

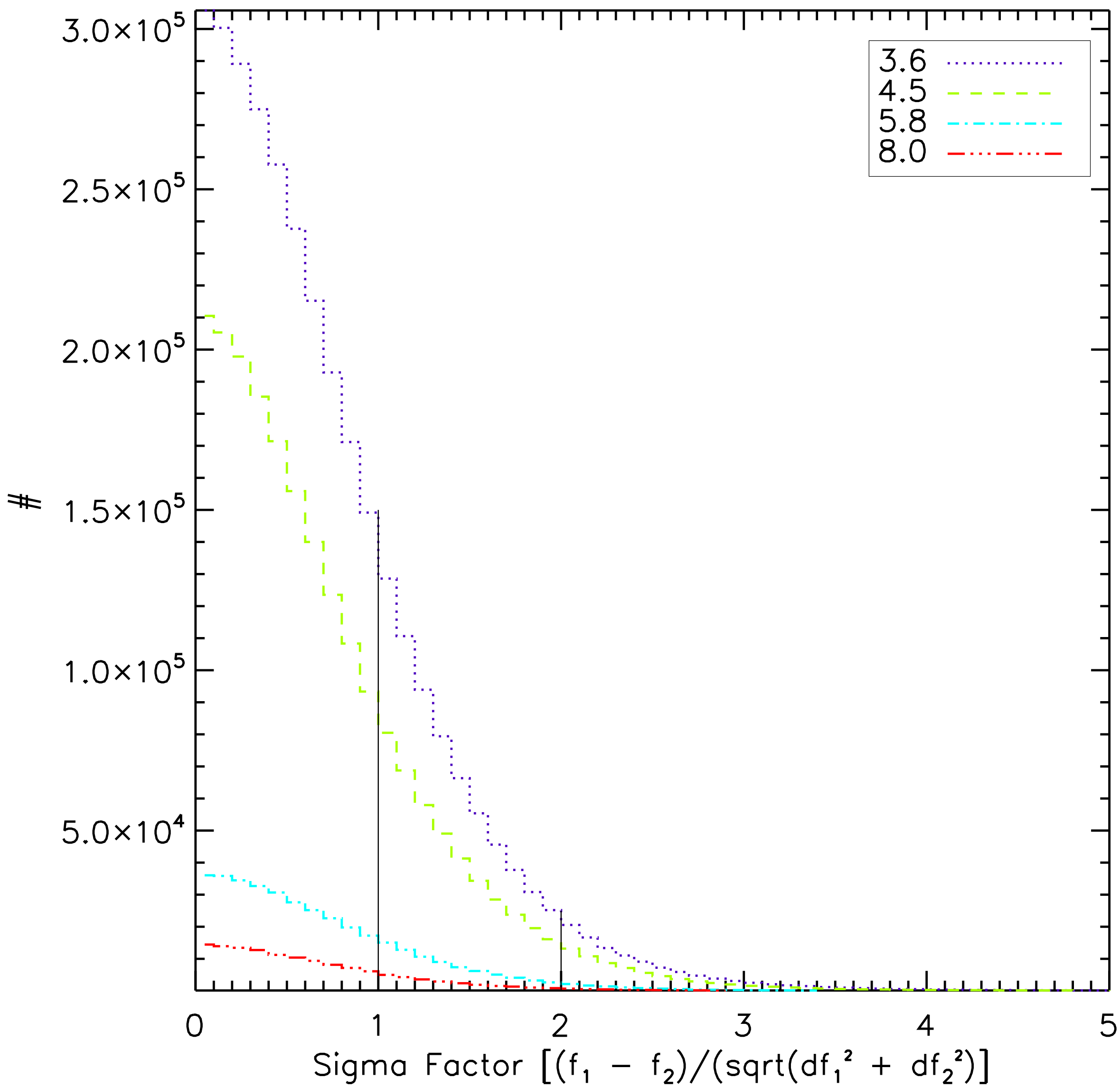

Fig. 6.— The histogram of the absolute value of the ratio of the flux difference to the expected flux difference is plotted for diffferent IRAC bands. IRAC Epoch 1 sources are matched to the closest Epoch 2 sources within 0″.9.

through 4, respectively. Divergence from the 'truth' list (obtained from mosaic photometry) occurs at the fainter magnitudes, due to our stringent source-selection criteria that removes real sources in addition to cosmic rays. Also completeness will be a function of background level which will be more variable for IRAC [5.8] and [8.0].

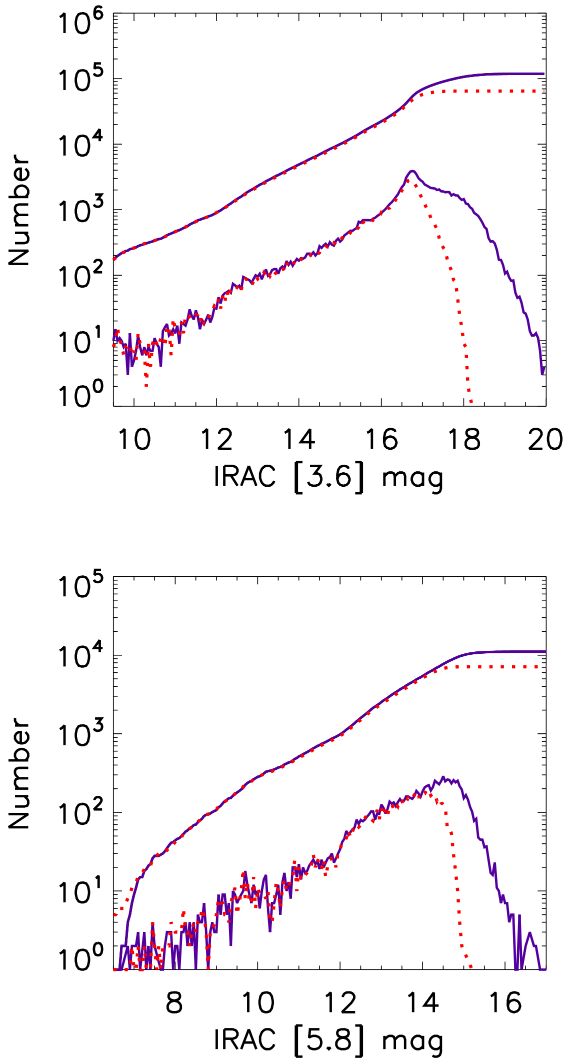

Fig. 7.— Comparison of the Epoch 1 SAGEarchiveIRAC source counts (dotted red lines) with the mosaicked photometry source counts (solid blue lines) in the area RA 81°.5 to 84°.0 and Dec -67° to -68° of the SAGE survey. The upper 2 curves in each panel are the cumulative plots while the lower 2 curves in each panel are the differential number counts. The bright end magnitude is cutoff at the 12 sec saturation limit since the mosaic photometry is done on mosaics of the 12 sec data. Those saturation mags are 9.5, 9.0, 6.5, 6.5 for bands 1 through 4, respectively.

We discover on AOR boundaries an apparent increase in the number of IRAC [4.5] sources (see Figure 8). This is a result of sensitivity and M/N selection effects. For IRAC [4.5] overlap areas were N $\gtrsim$ 3, slightly fainter sources are slightly more reliably extracted, and since IRAC [3.6] is more sensitive, these sources have a greater chance of making the

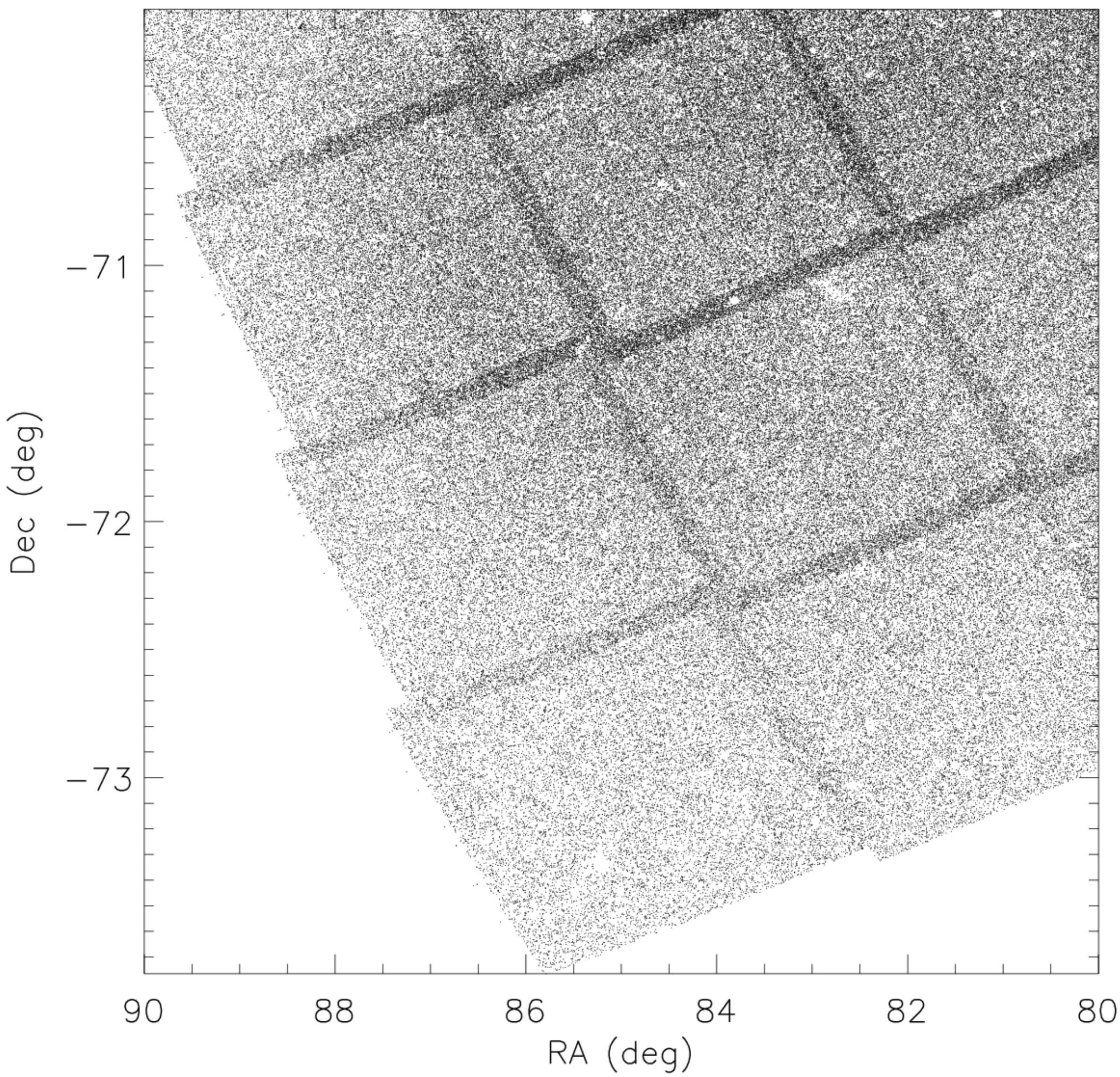

Fig. 8.— Source density image of IRAC band 2 (4.5 μm) sources of magnitudes between 16 and 17 showing some of the enhanced detections in the overlap boundary regions.

Archive, thus producing a slight increase in IRAC [4.5] sources in these overlap regions.

3.7. Time of Observation Information for each IRAC Source

The time of observation for any given SAGE IRAC source is a complex question. SAGE IRAC sources are bandmerged results from multiple imaged frames. IRAC has 4 channels and each channel was intended to observe the SAGE area a minimum of 2 times for each epoch. IRAC channels 1 and 3 do not observe the same area of the sky as channels 2 and 4, thus a SAGE source with entries in all 4 channels will consist of measurements made from several different times. SAGE was also observed in HDR mode resulting in data taken at 0.6 second as well as 12 second exposure times meaning each area of the sky was observed a minimum of 4 times, not 2, and in overlap areas the number can rise to more than 10 unique observations for some limited strips of data. Because of this complication we have provided time-of-observation information in a broad sense. We provide fits images that display the earliest and latest observational times for any given area observed by SAGE for each of the 2 SAGE epochs and for each of the 4 IRAC channels. The fits files are in units of minutes and correspond to the number of minutes after Julian Date 2453500.5. In this fashion, any SAGE source with a given RA and Dec can be cross referenced with these fits files to determine the time period within which those results were taken by epoch and by channel. We also provide an IDL program (get_sage_jd.pro) which shows how to use these timestamp fits files.

4. MIPS 24μm Catalog

The point source lists presented in this document were extracted from MIPS 24 μm Epoch 1 and Epoch 2 images. The Arizona MIPS team pipeline, MIPS Data Analysis Tool v3.06 (DAT; Gordon et al. 2005) and customized post-processing scripts were used to do the processing and mosaicing of the individual images. The details for the SAGE MIPS 24 μm Epoch 1 and Epoch 2 data processing can be found in Meixner et al. (2006). Here we summarize the criteria for selection of the point sources to be in the catalog after the sources are extracted from the images. Then we describe the quality of the resulting SAGEcatalogMIPS24 that includes both Epoch 1 and Epoch 2.

4.1. Catalog Criteria

The MIPS 24 μm source lists were extracted using StarFinder (Diolaiti et al. 2000) on the MIPS 24 μm Epoch 1 and Epoch 2 image AOR mosaics. The extraction was done using a model PSF and setting the acceptable source parameters to be $>2\sigma$ and a correlation >0.80. The source lists for the individual AORs were merged into single epoch source lists averaging the sources which were detected in multiple AORs. This produced two large lists of sources, one for each epoch. The reliability of sources was nonuniform over LMC and extensive tests were carried out to identify criteria which could be used to create a high reliability catalog for each epoch. To be included in each single epoch catalog, each 24 μm source has to meet a number of criteria. The source had to be nearly point like with a correlation value >0.89. This removed approximately 2/3 of the entries in the single epoch source lists. In regions where there is a significant structure in the surrounding region (identified as having a $\sigma > 0.25$ in a 120″ width square box), the source had to have a correlation value >0.91. This requirement removed a small number of sources (∼1500). There are a small number of sources with 24 μm magnitudes between 4 and 8 which have unusually low uncertainties (i.e., high S/N). The origin of these sources is under investigation and seems to be related to edge effects in the AORs. In the meantime, these sources were removed from the catalogs (∼70). Finally, all sources had to have signal-to-noise (S/N) values >5. The S/N used was that estimated from the StarFinder code using the mosaic uncertainty image added in quadrature with an 1% error due to the background subtraction. This removed ∼6000 sources. The final Epoch 1 and Epoch 2 catalogs (both in SAGEcatalogMIPS24) likely have a few remaining unreliable sources, but we estimate this to be at the less than 1% level.

In the next few sections, we describe some quality checks performed on the SAGEcatalogMIPS24 including astrometry, photometric precision, photometric accuracy, comparison of photometry between the two epochs, and completeness.

4.2. Astrometry

The astrometry of the SAGEcatalogMIPS24 Epoch 1 is referenced to the SAGEcatalogIRAC Epoch1 by using a bright 8 μm source list for the astrometric framework of the MIPS 24 μm catalog. The corrections required to register the MIPS 24 μm catalog to the bright 8 μm catalog are ∼1″. This is not unexpected as the nominal pointing accuracy of Spitzer is ∼1″. As the IRAC observations have already been registered to 2MASS sources, this results in the MIPS 24 μm sources being registered to the 2MASS coordinate system as well.

Histograms showing the offsets between the registered MIPS 24 μm and the bright IRAC 8 μm list reveals the average offsets sharply peaked at zero as expected (Figure 9).

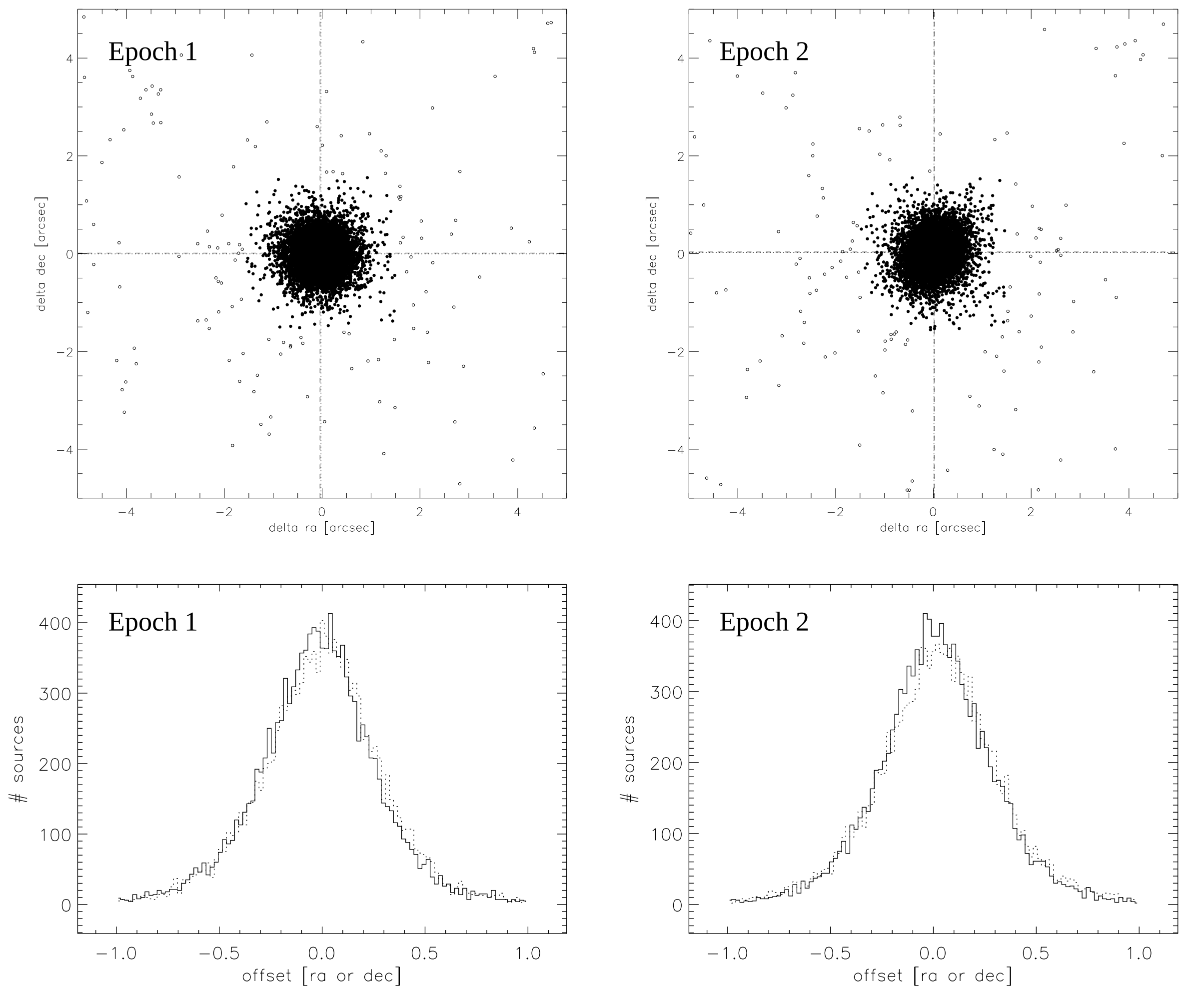

Fig. 9.— The top plots show the scatter plot of the sources matching between the bright IRAC 8 μm and the MIPS 24 μm sources within $5''$. The histograms quantify the offsets between these two lists and show that the average is very near zero for both ra and dec.

4.3. Precision and Accuracy of the Photometry

Figure 10 shows the photometric uncertainties of the MIPS 24 μm catalogs. The behavior of the uncertainties as a function of magnitude is as expected. The scatter in the uncertainties at the same magnitude is due to the large variations in the background (extended) emission across the LMC.

The absolute photometry accuracy of the MIPS 24 μm fluxes is $\sim$2% (Engelbracht et al. 2007). The zero points for the MIPS 24 μm magnitude is 7.17 Jy (Rieke, G. et al., 2008,

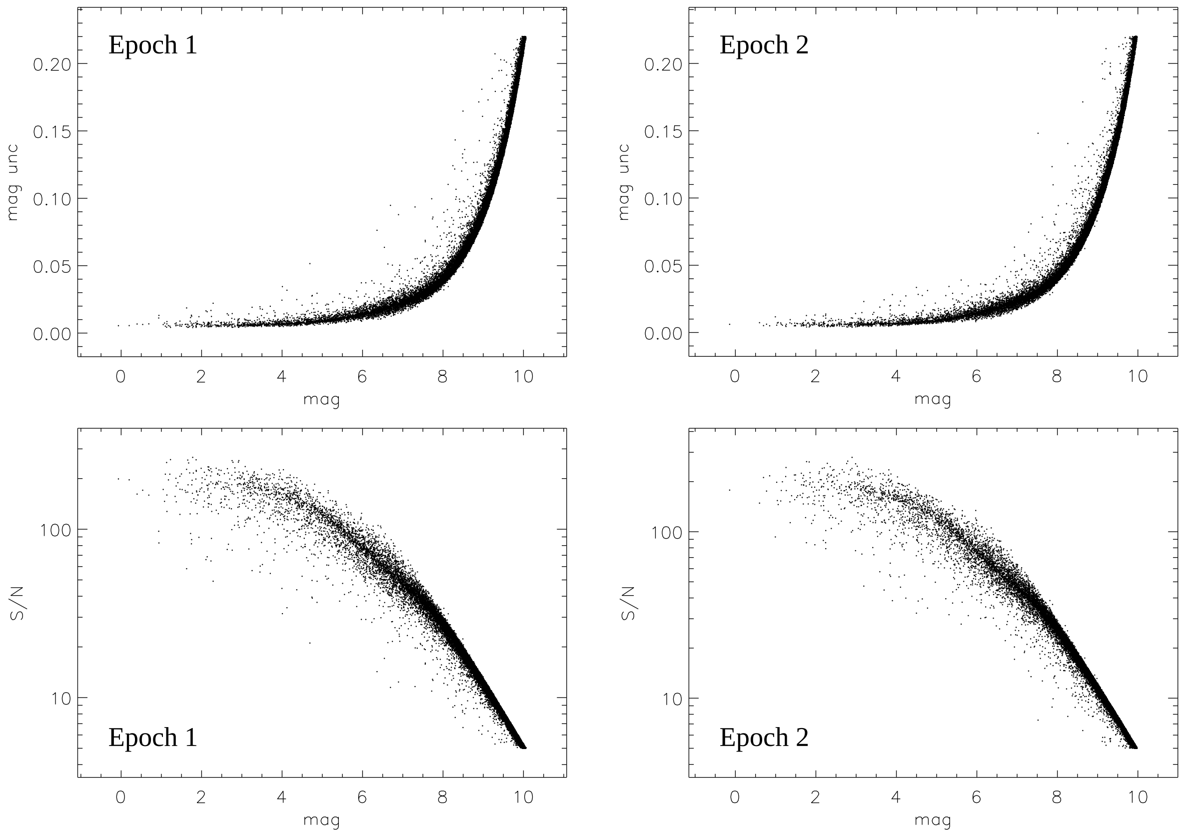

Fig. 10.— The uncertainty in magnitudes is plotted versus magnitude for the MIPS 24 μm catalogs in the upper plots. The lower plots show the S/N versus magnitude for the same catalogs.

submitted). As an independent check on the measured MIPS24 magnitudes, we compared the SAGE magnitudes to the predicted MIPS24 magnitudes of calibration stars in the SAGE fields (Figure 11). This checks that the extraction of point source fluxes from the images has not introduced systematic errors. The average offsets are 0.040 and 0.033 mag for Epoch 1 and Epoch 2, respectively. The expected offset is 0.029 mag due to small differences between the Cohen et al. (2003) and Rieke et al. (2008) photometric systems. The good agreement seen between the measured and expected differences provides confidence that the extraction of the MIPS 24 μm sources provides accurate photometry.

The quoted uncertainties in the fluxes were checked by comparing the flux differences between sources seen in both Epoch 1 and Epoch 2 catalogs with the flux differences expected given the quoted uncertainties. Figure 12 plots the histogram of this comparison along with the best fit Gaussian. The best fit Gaussian has a σ below 1 which means that the quoted

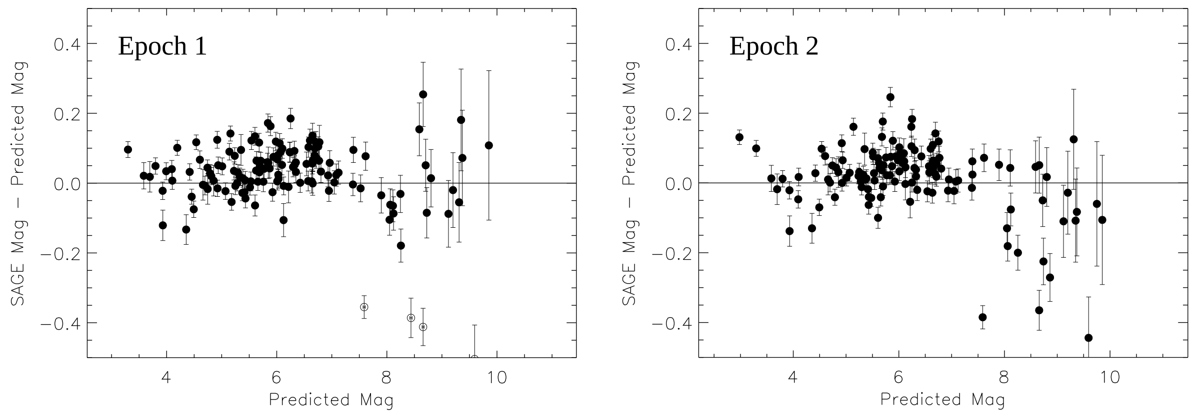

Fig. 11.— The difference between the measured SAGE magnitude and the predicted magnitude for the Cohen et al. (2003) calibration stars in the SAGE catalog is shown. The solid line is at zero. The expected offset is 0.029 mag and the observed is 0.040 and 0.033 for Epochs 1 and Epoch 2, respectively. The predicted magnitudes are based on techniques by Cohen et al. (2003).

uncertainties are overestimated. This overestimation is likely the result of a slightly too large uncertainty assigned to the background subtraction.

4.4. Comparison of Photometry between the MIPS 24 μm Epoch 1 and Epoch 2

Figure 13 shows a histogram comparing the fluxes of the sources detected in both epochs of the MIPS 24 μm catalog. This plot is analogous to Figure 6 for IRAC (see Section 3.5 for description). The MIPS 24 μm sources were matched using a search radius of $1\farcs0$ and the fluxes in the 2 epochs were compared. 65% of Epoch 1 and 68% of Epoch 2 sources are matched. Of the $\sim 25,000$ sources detected in both epochs, 93.6% are within 3σ. A detailed analysis of both MIPS 24 μm and IRAC variable sources can be found in Vijh et al. (2008, in prep.)

4.5. Completeness

We have not conducted full completeness tests for this release of the MIPS 24 μm catalogs. Full completeness tests require extensive false source tests which will likely be completed for the next release. The overall completeness can be estimated by examining the

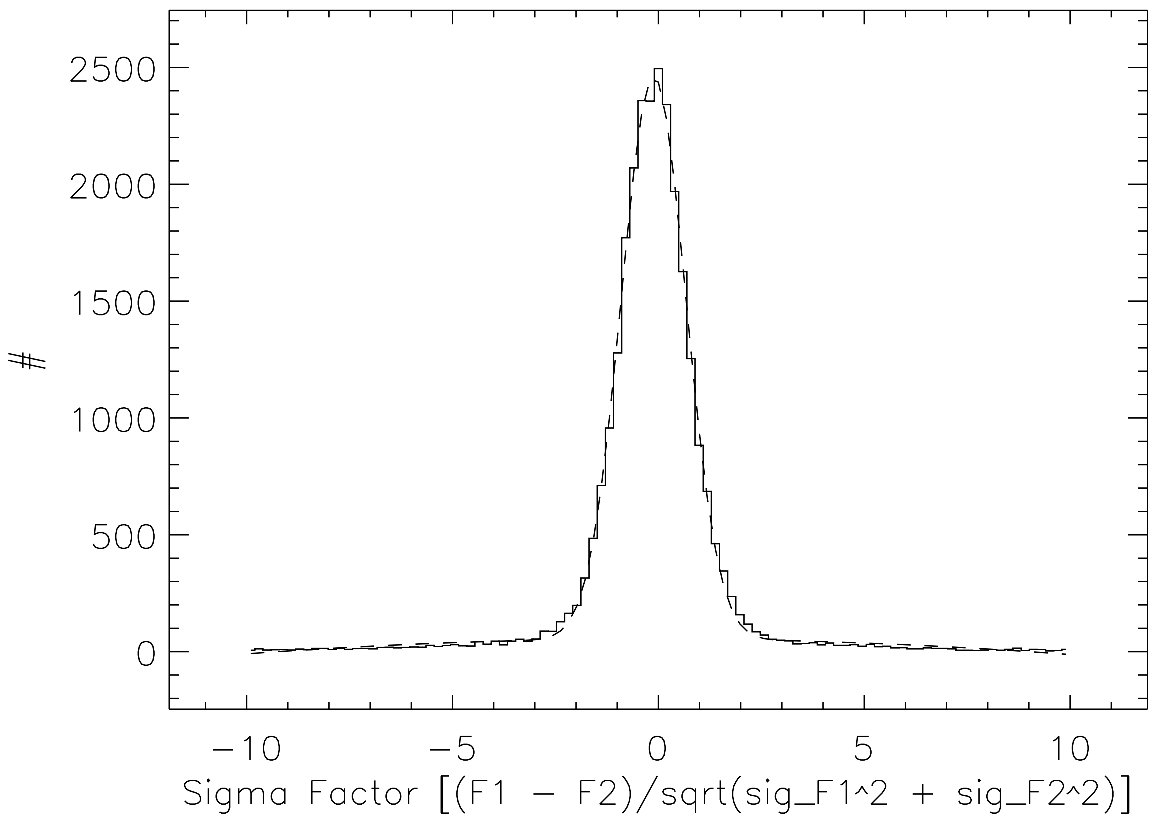

Fig. 12.— The histogram of the ratio of the flux difference to the expected flux difference is plotted for all sources in both MIPS 24 μm catalogs. In addition, the best fit Gaussian is plotted as a dashed line. The best fit Gaussian has $\sigma = 0.78$ and the expected σ is 1 indicating the flux uncertainties in the catalogs are slightly *overestimated*.

flux histogram of the catalog sources. Figure 14 shows the histograms for both MIPS 24 μm catalogs. The full source list and the high reliability catalog histograms are shown. From the catalog histograms it can be seen that the catalogs are complete to a little above 1 mJy. Given the large variations in the extended emission in the LMC, the completeness limit will vary significantly over the LMC. The number quoted above is for the faintest, least crowded regions in the LMC.

A measure of the reliability of a catalog is the histogram of the nearest neighbor distances. Figure 15 shows this histogram for the full source lists and the catalogs for both epochs. The full sources lists clearly include a number of spurious sources given the large peak at $\sim$6″. This peak is not seen in the catalog histograms confirming that they are highly reliable (at least in the context of nearest neighbors). The MIPS 24 μm catalog nearest

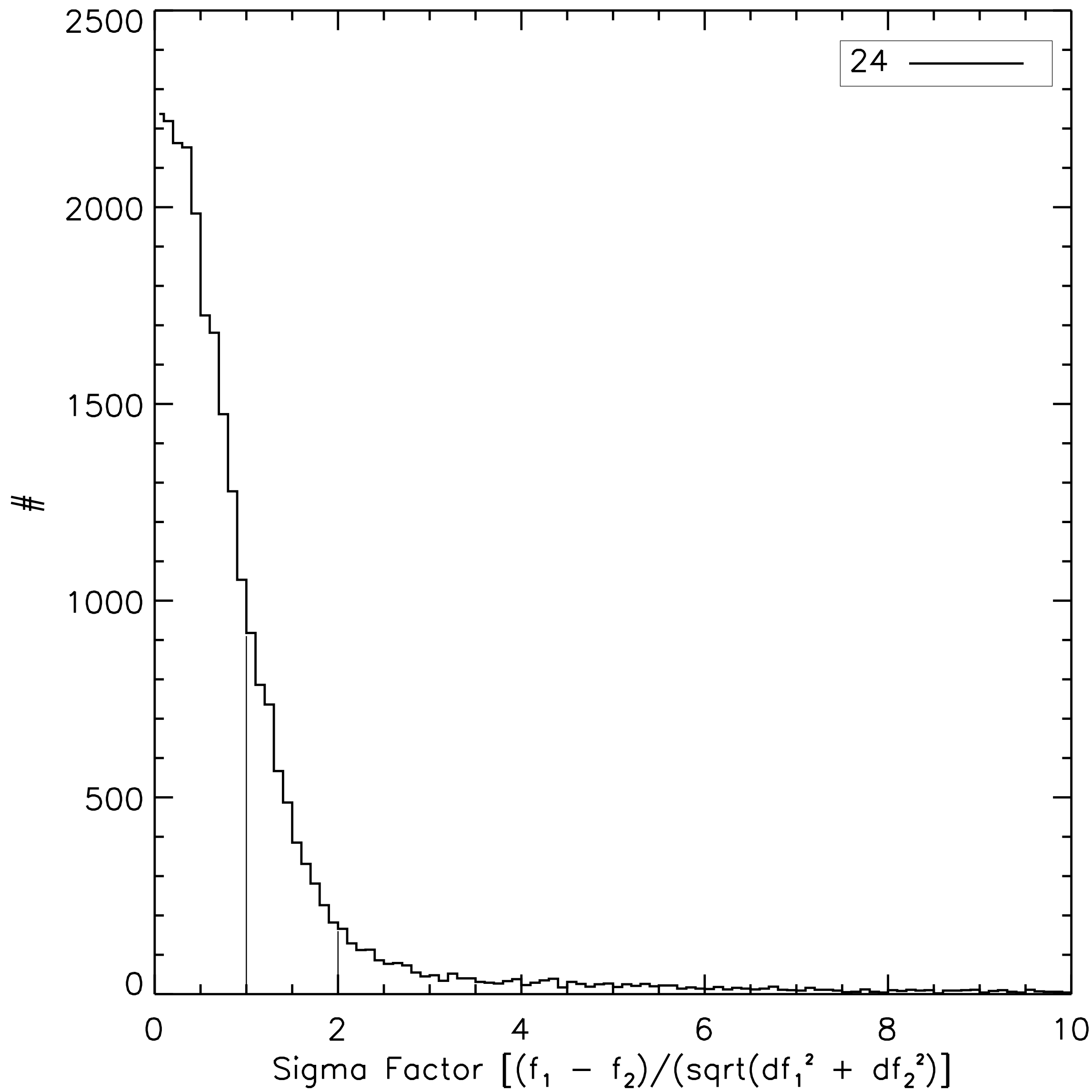

Fig. 13.— The histogram of the absolute value of the ratio of the flux difference to the expected flux difference is plotted for the MIPS 24 μm band. MIPS 24 μm Epoch 1 sources are matched to the closest Epoch 2 sources within $1''.0$.

neighbors are shifted to larger distances, compared to the full list, because there are fewer sources, in particular the spurious sources near $\sim 6''$ are eliminated.

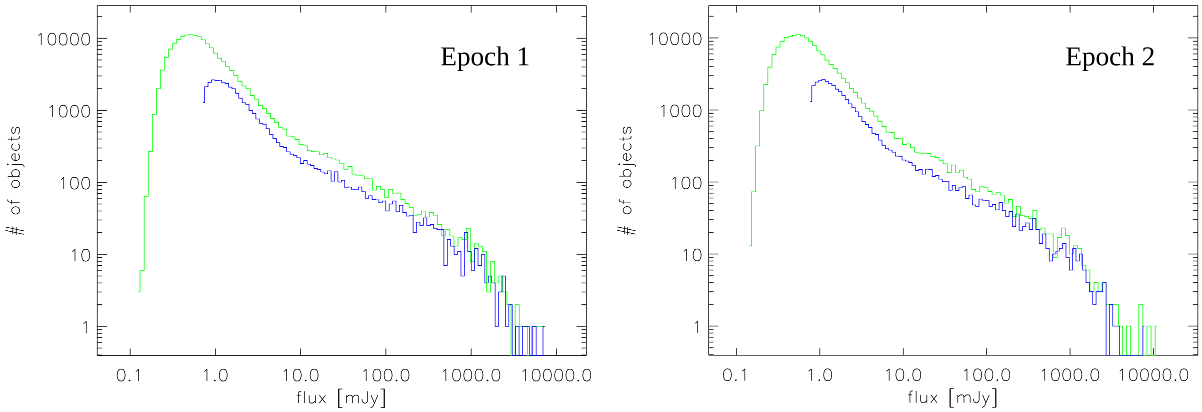

Fig. 14.— The flux histograms for the full source lists (green) as well as the high reliability catalogs (blue) is shown.

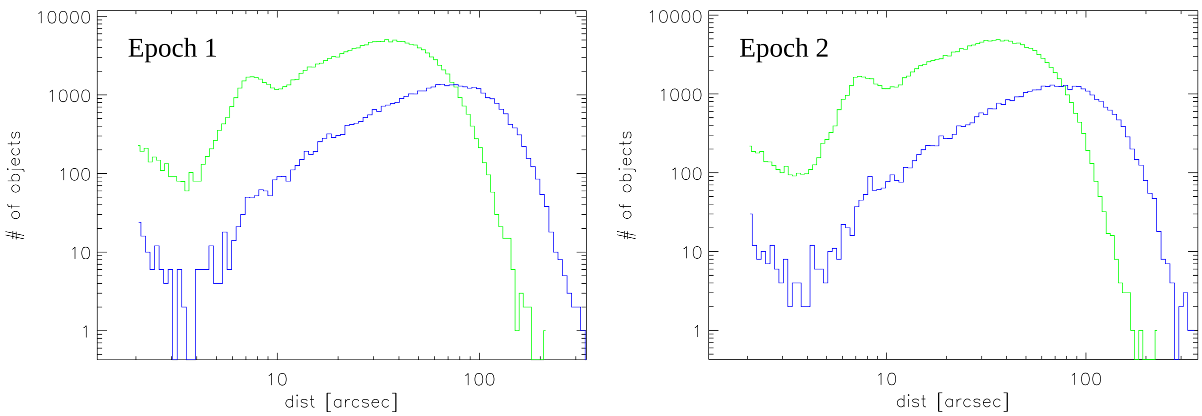

Fig. 15.— The nearest neighbor histogram of the full source lists (green) and catalogs (blue) is plotted.

5. MIPS Images

The MIPS 24, 70, & 160 μm mosaics of the whole LMC were created by combining the ∼200,000 individual images per band into single mosiacs. Given the large number of images, this was especially challenging for the MIPS 24 μm data requiring different steps between the 24 μm and 70/160 μm data.

The delivered LMC images were background subtracted at 24 & 70 μm, but *not* background subtracted at 160 μm.

The processing of the individual AORs was done as described in the previous section.

5.1. MIPS 24 μm Images

The MIPS 24 μm mosaics are delivered in two different flavors. The first is single epoch full mosaics of the LMC. The second is $1^\circ.1 \times 1^\circ.1$ tiles which combine the data for both epochs in a single image. The two different flavors of the mosaics were created using two different methods mainly due to the number of individual images and large size of the final MIPS 24 μm mosaics.

The single epoch mosaics were created using the combination of the MIPS DAT and Montage programs. The individual AOR mosaics were created using the MIPS DAT. The zodiacal dust emission contributes significantly to the 24 μm band. The zodiacal dust emission is time variable and variations were seen during the $\sim$1 week it took to take a single epoch of SAGE MIPS data. The nature of the variations required them to be removed before combining the 38 AORs mosaics into a single image. The zodiacal dust emission was modeled as two planes for each epoch where each plane was fit to the background regions outside of the LMC in each "row" of AORs. The LMC was mapped using two rows of 4^o long scan legs (18 AORs per row). After subtraction of the fitted planes, the resulting single epoch mosaics were created using Montage with only mean offset corrections applied. The final mosaics displayed only small residual mismatches which can be traced to residual instrumental artifacts in the AOR mosaics themselves. Some of these will be corrected in future processing.

The $1^\circ.1 \times 1^\circ.1$ tiles were created combining both epochs of observations. These tiles were created directly from the individual images using the MIPS DAT allowing for smaller mosaic pixels and improved cosmic ray rejection. The individual images were corrected for the time variable zodiacal emission utilizing the planer fits and Montage mean offsets. These tiles overlap each other at the edges. In addition to the image tiles, point source subtracted images were also created by running StarFinder on the tiles with the same parameters used for the full source lists described previously.

5.2. MIPS 70 & 160 μm Images

The MIPS 70 & 160 μm mosaics were created using the MIPS DAT and represent the combination of both epochs of data. The individual epoch mosaics exhibit significant residual instrumental signatures (70 μm) or excessive cosmic rays (160 μm). This was expected as these observations have lower redudancy than the 24 μm data and suffer from larger residual instrumental signatures.

The MIPS 70 μm data were corrected for residual instrumental signatures on a pixel-by-pixel basis using a low order polynomial fit to the data outside of the LMC. This step also effectively removes the background emission measured in the regions outside of the LMC.

The MIPS 160 μm data did not require a correction for residual instrumental signatures. Thus the final full LMC 160 μm image is not background subtracted. The background subtraction at 160 μm is not simple as the dominant background source at this wavelength is the complex Milky Way cirrus which is not well approximated by a plane.

A. APPENDIX A - The differences between the IRAC SAGE v2.1 and v1 processing

A.1. Main improvements in the SSC processing versions S13.2 and later

The December 2006 SAGE-LMC v1 data release used data processed by SSC pipeline version S12.4.0. The v2 data products uses SSC pipeline processing versions S13.2 and later. The S13.2 and later processings have two important improvements. First, the absolute flux calibration has been updated to reflect the results described in the IRAC calibration paper (Reach et al. 2005). Second, 'super-boresight' pointing refinement was implemented, improving the pointing accuracy for bands 3 and 4 as well as removing positional offsets between the IRAC channels. Better positions result in crisper mosaics and more accurate bandmerging of sources. Other improvements in SSC processing S13.2 include new linearity corrections for band 3 and using a 'super-skyflat' for the flat fielding. The dark drift correction, which removes vertical striping (jailbar effect) in the data, was applied to only band 3 in the S13.2 processing but it was later found that the dark drift correction was needed for the other three bands. SSC processing version S14.0 rectified this problem. We applied a jailbar correction (http://ssc.spitzer.caltech.edu/irac/jailbar/) to bands 1, 2 and 4 frames if they were processed by the S13.2 pipeline. See the IRAC pipeline history log at http://ssc.spitzer.caltech.edu/archanaly/plhistory/irac.html for more details about the SSC processing versions.

A.2. Improved banding correction for band 3

An improved banding correction for band 3 was applied using an algorithm fitting each incidence of banding individually. Previously we used an exponential function. The better banding correction for band 3 provides a more uniform background for the source extraction.

A.3. Increase/decrease flux uncertainties

The reliability of the flux uncertainties were studied by comparing the quoted error (dFi) with the RMS of the measurements (Fi_rms). Bands 2 & 4 showed the largest discrepancy. The formal band 2 uncertainties have been decreased 30%, band 3 uncertainties increased 10% and band 4 uncertainties have been increased 35%. Band 1 uncertainties were not changed.

A.4. Bandmerging with 2MASS PSC

- Bandmerged the IRAC data with a combination of the 2MASS All-Sky Point Source Catalog and the 2MASS 6X Deep Point Source Catalog. This should result in more matches with 2MASS in the v2.1 source lists. Previously we used only the 2MASS All-Sky PSC.

- How the 2MASS All-Sky + 6X2MASS were combined

  The 6X2MASS catalog is deeper than the original All-Sky catalog, but contains only direct pipeline extractions from 2MASS imaging, whereas the All-Sky has been supplemented at the bright end with more sophisticated photometry. Thus, the most scientifically robust catalog should use the original All-Sky for bright sources, the 6X2MASS for faint sources, and possibly a combination at intermediate fluxes. In order to maintain maximum tracability back to the 2MASS catalog, we chose to use either the 6X or the All-Sky bandmerged source, and not to mix photometry from the different catalogs in different bands. (The latter would arguably result in a higher quality catalog, but we were reluctant to deviate dramatically from 2MASS published catalogs because of the possibility of confusion about which product was being used by the community).

  We first removed sources within 2″ from the 6X2MASS catalog: the pre- release version which we used contained such near neighbors, which should be removed according to the documentation. We followed the procedure outlined in the 2MASS documentation of choosing the source furthest from its tile boundary. To the best of our knowledge this results in a catalog consistent with the 2MASS documentation.

  For each source we determined the reddest measurement (e.g. for a source with a K_s detection we use the K_s magnitude. For a source with K_s upper limit and H detection we use the H magnitude). We then constructed a list consisting of:

  – any source in the All-Sky with reddest magnitude (redband) <13
  – any source in the 6X with redband >15
  – any source in either the All-Sky or the 6X with 13 < redband < 15 and no source in the other list within 5″
  – any source with a match from the other list within 5″, choosing the source with better photometric quality flag in the reddest band.

- The criteria for including a 2MASS source has changed. In the SAGE v1 processing, a source would match to a 2MASS source only when the 2MASS source had a good K_s band measurement (photometric quality of 'A'). We now include a 2MASS match if the source has a photometric quality flag of A, B, C or D for the K_s band, or a quality flag of A or B in the H band (see Appendix B.4.2 for the definition of the photometric quality flag).

The 2MASS combined catalog contains a large number of sources without K_s detections because 2MASS is more sensitive at shorter wavelengths, and the majority of sources in the Galaxy have the "blue" infrared colors of main-sequence stars. We found that in crowded regions, sources with questionable 2MASS photometry (according to their photometric quality flag) in J and/or H, and no detection in K_s, usually led to incorrect associations with IRAC. In fact, comparison of the SAGE and 2MASS sensitivity limits makes it clear that a source with reasonable astrophysical colors, good IRAC photometry, good J photometry, and only upper limits at K_s, is highly unlikely. Thus we performed a (very conservative) selection on the 2MASS catalog, removing sources with worse than A photometric quality in J, worse than C in H, AND worse than E in K_s.

- The 2MASS photometric quality flag is now included in its Source Quality Flag (see Appendix B.4.2).

A.5. Source List Criteria

- We should no longer be losing sources when N=3 (along AOR overlaps). Previously one of the source list criteria was that $M/N > 0.4$ which is too harsh when N=3. We changed this criteria to $M/N > 0.32$.
- Use K_s as a '1' detection in the source list criteria.
- In the Archive, we no longer null the band's flux if M=1 if the result is from only the 12 sec data.

A.6. Bandmerging fix

There should not be missing sources in the corners of the grid cells at high declinations.

NOTE: The value of the flux calculation method flag has changed.

B. APPENDIX B - IRAC Catalog and Archive Formats

Table 4 describes the columns in the SAGEcatalogIRAC and SAGEarchiveIRAC including the data format and null values. Note that:

- The fields in the Catalog and Archive are the same. Data is delivered in IPAC Table format.
- Where NULL values are not legal, NO is entered in the column. Otherwise, the null value is given.

The selected columns are discussed in detail in the following subsections.

B.1. Designation

The format of the source designations is 'SSTISAGE1A JHHMMSS.SS±DDMMSS.S' and 'SSTISAGE1C JHHMMSS.SS±DDMMSS.S' for the IRACarchiveIRAC and IRACcatalogIRAC, respectively, where

SST = Spitzer Space Telescope
I = IRAC
SAGE = LMC Survey project
1 = Epoch 1; **2** = Epoch 2
C = highly reliable Catalog
A = more complete Archive
J = 2000.0 epoch
HHMMSS.SS = Right ascension (hr, min, sec) of source
±DDMMSS.S = Declination (deg, min, sec) of source

B.2. Close source flag

The Close Source Flag is set when a source in the Archive is within $3''.0$ of the source. It was found that the magnitudes of a source with nearby sources closer than about $2''.0$ are not reliably extracted and bandmerged. A source that has Archive sources within $2''.0$ of the source are culled from the Catalog. A source that has Archive sources within $0''.5$ of the source are culled from the Archive. The Close Source Flag can have values from 0 to 6, where:

Table 4. IRAC Catalog and Archive Formats

Col.	Name	Description	Data	Format	Null
1	globalSourceID	Unique identifier	I*4	i10	NO
2	sourceCatalog	Identifier for source catalog	ASCII	a8	NO
3	epoch	Identifier for the epoch of the observations of the source	ASCII	a16	NO
4	designation	Source name Archive: SSTISAGE1A JHHMMSS.SS±DDMMSS.S Catalog: SSTISAGE1C JHHMMSS.SS±DDMMSS.S	ASCII	a32	NO
5	TmassCntr	cntr from 2MASS Point Source Catalog	I*4	i10	0
6	TmassDesignation	2mass source name	ASCII	a32	null
7	ra	Right Ascension, J2000 (deg)	R*8	f11.6	NO
8	dec	Declination, J2000 (deg)	R*8	f11.6	NO
9	dra	Error in Right Ascension ($''$) dra is in units of arcseconds, so to convert to seconds of time, multiply by cos(dec)/15.	R*8	f4.1	NO
10	ddec	Error in Declination ($''$)	R*8	f4.1	NO
11	closeFlag	Close source flag	I*2	i3	NO
12-25	magi, dmagi	Magnitude from from J,H,K (i=1-3) and each IRAC band (i=4-7) and 1σ error (mag)	R*4	7(f7.3,f7.3)	99.999,99.999
26-39	fi,dfi	Fluxes and 1σ error in each band i, i=1-7 (mJy)	R*4	14(e11.3)	-999.9,-999.9
40-43	rms_fi	rms dev. of individual detections from fi (i=4-7), (mJy)	R*4	4(e11.3)	-999.9
44-47	skyi	Local sky bkg. for band i flux (i=4-7), (MJy/sr)	R*4	4(e11.3)	-999.9
48-54	sni	Signal/Noise for band i flux (i=1-7)	R*4	7(f6.2)	-9.99
55-58	srcdensi	Local source density for band i object (i=4-7), (#/sq')	R*4	4(f5.1)	-9.9
59-62	mi	Number of detections for band i (i=4-7)	I*2	4(i3)	NO
63-66	ni	Possible number of detections for band i (i=4-7)	I*2	4(i3)	NO
67-73	sqfi	Source Quality Flag for band i flux (i=1-7)	I*4	7(i10)	-9
74-77	mflagi	Flux calc method flag for band i flux (i=4-7)	I*2	4(i3)	-9
78	versionNo	Version number assigned by IRAC pipeline team	R*4	f6.2	NO
79	versionDate	Date catalog was produced in the following format, "mon dd yyyy", "Dec 5 2007"	ASCII	a12	NO
80	cx	x of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
81	cy	y of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
82	cz	z of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
83	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

0	no sources in the Archive within $3''.0$ of the source
1	sources in the Archive between $2''.5$ and $3''.0$ of the source
2	sources in the Archive between $2''.0$ and $2''.5$ of the source
3	sources in the Archive between $1''.5$ and $2''.0$ of the source
4	sources in the Archive between $1''.0$ and $1''.5$ of the source
5	sources in the Archive between $0''.5$ and $1''.0$ of the source
6	sources in the Archive within $0''.5$ of the source.

B.3. M and N (number of actual detections, number of possible detections)

M = All detections used in the final flux calculation. Detections can be thrown out by exposure time, or because they have bad SQF flags. Detections are also thrown out at the beginning of bandmerging for sensitivity or saturation reasons. If *any* detections without bad flags went into the final flux, then only those good detections are counted. If all detections had bad flags, then all are counted, and the final source will have some bad quality flags also. Bad for this is 8=hot/dead pixel and 30=edge.

N = All frames containing the position of the combined source in this band (*not* including the edge of the frame, within 3 pixels) for which the exposure time was used in the final flux. As for M, if *any* good detections are used, we only count the good detections, but if they're all bad we count all of them and set flags in the final source. For sources not detected in a band, the position of the final cross-band merged source is used for calculating N. N is all frames which contain this position, not within 3 pixels of the edge.

B.4. Source Quality Flag (SQF)

The Source Quality Flag (SQF) is generated from SSC-provided masks and the SAGE pipeline during point source extraction on individual IRAC frames and bandmerging. Each source quality flag is a binary number allowing combinations of flags (bits) in the same number. Flags are set if an artifact (e.g., a hot or dead pixel) occurs near the core of a source - i.e. within 3 pixels. A non-zero SQF will in most cases decrease the reliability of the source. Some of the bits, such as the DAOPHOT tweaks (see Appendix B.4.1), will not compromise the source's reliability, but has likely increased the uncertainty assigned to the source flux. If just one IRAC detection has the condition requiring a bit to be set in the SQF, then the bit is set even if the other detections did not have this condition. Sources with hot or dead pixels within 3 pixels of source center (bit 8), those in wings of saturated stars (bit 20), and those within 3 pixels of the frame edge (bit 30) were used in the culling to produce the Catalog. Table 5 gives the Source Quality Flag bits and the origin of the flag (SSC or SAGE pipeline). Each of the 7 bands has its own Source Quality Flag. For the cross-band confusion flag and the cross-band merge lumping flag, when the condition is met for one of the bands, the bit is set for all the source's bands.

B.4.1. IRAC Source Quality Flag

Information is gathered from the SSC IRAC bad pixel mask (pmask), SSC bad data mask (dmask) and the SAGE IRAC pipeline for the Source Quality Flag. For more information about the IRAC pmask and dmask, see
http://ssc.spitzer.caltech.edu/irac/products/pmask.html
and
http://ssc.spitzer.caltech.edu/irac/products/bcd_dmask.html

The value of the SQF is $\sum 2^{(bit-1)}$. For example, a source with bits 1 and 4 set will have SQF = $2^0 + 2^3 = 9$. If the SQF is 0, the source has no detected issues. A detailed description of the bits is given below.

bit
1 - poor pixels in dark current
This bit is set when a source is within 3 pixels of a pixel identified in the SSC IRAC pmask as having poor dark current response (bits 7 and 10 in the pmask).
2 - flat field questionable
If a pixel is flagged in the SSC IRAC dmask as flat field applied using questionable value (bit 7) or flat field could not be applied (bit 8), a source within 3 pixels of these pixels will have this bit set.
3 - latent image
This flag comes from the latent image flag (bit 5) from the dmask. The SSC pipeline predicts the positions of possible latent images due to previously observed bright sources.
7 - muxbleed correction applied (bands 1 & 2)
This bit is set if the source was within 3 pixels of a pixel that had a muxbleed correction applied.
8 - hot, dead or otherwise unacceptable pixel
Hot, dead or unacceptable pixels are identified in the IRAC pmask as having an unacceptable response to light (bits 8, 9 and 14 in the IRAC pmask). After inspecting IRAC frames, we have added bit 12 to the pmask to flag additional pixels we found to be bad. Also considered bad pixels are ones flagged as bad or missing in bit 11 and 14 in the IRAC dmask. SQF bit

Table 5. Source Quality Flag bits

SQF bit	Description	Origin
1	poor pixels in dark current	SSC pmask
2	flat field questionable	SSC dmask
3	latent image	SSC dmask
3	persistence (p)	2MASS
4	photometric confusion (c)	2MASS
7	muxbleed correction applied	SAGE
8	hot, dead or otherwise unacceptable pixel	SSC pmask,dmask,SAGE
9	muxbleed corr. applied is $>3\sigma$ above bkg	SAGE
9	electronic stripe (s)	2MASS
10	DAOPHOT tweak positive	SAGE
11	DAOPHOT tweak negative	SAGE
13	confusion in in-band merge	SAGE
14	confusion in cross-band merge (IRAC)	SAGE
14	confusion in cross-band merge (2MASS)	SAGE
15	column pulldown corrected	SAGE
16	banding corrected	SAGE
19	data predicted to saturate	SAGE
20	saturated star wing region	SAGE
20	diffraction spike (d)	2MASS
21	pre-lumping in in-band merge	SAGE
22	post-lumping in cross-band merge (IRAC)	SAGE
22	post-lumping in cross-band merge (2MASS)	SAGE
23	photometric quality flag	2MASS
24	photometric quality flag	2MASS
25	photometric quality flag	2MASS
30	within three pixels of edge of frame	SAGE

8 is set if a source is within 3 pixels of any of these bad pixels. Bands with this bit set are not counted during the source selection process (see Section 3.2)

9 - muxbleed correction $>3\sigma$ above the background (bands 1 & 2)

This bit is set if the source was within 3 pixels of a pixel where there was a muxbleed correction applied which is $>3\sigma$ above the background.

10 - DAOPHOT tweak positive

11 - DAOPHOT tweak negative

Bits 10 and 11 correspond to an iterative photometric step (tweaking). Photometry is initially performed by DAOPHOT/ALLSTAR using PSF fitting. This photometric step produces a list of sources, their positions and brightnesses, as well as a residual image of those sources removed from the input image. By flattening the residual image (smoothing it and then subtracting the smoothed image from the residual image) and then performing small aperture photometry at the location of each of the extracted sources, it is possible to determine if the extracted source was over or under subtracted due to any local complex variable background or the undersampled PSF. SQF bit 10 refers to sources that were initially under-subtracted. From the aperture photometry a positive flux correction was applied to the DAOPHOT/ALLSTAR extraction value (source was brightened via aperture photometry as compared to the initial PSF fitted DAOPHOT/ALLSTAR photometry). SQF bit 11 refers to sources that were initially over-subtracted. Using aperture photometry, a negative flux correction was applied to the DAOPHOT/ALLSTAR extraction value (source was dimmed via aperture photometry as compared to the initial PSF fitted DAOPHOT/ALLSTAR photometry). Sources with both SQF bits 10 and 11 set imply 1) the source was initially under-subtracted, but the aperture photometry over- corrected and thus a second aperture correction was applied or 2) multiple observations in a band consisting of at least one observation with a positive tweak and another observation with a negative tweak.

13 - confusion in in-band merge

14 - confusion in cross-band merge

These bits are set during the bandmerging process. The bandmerger reports, for each source and band, the number of merge candidates it considered in each of the other bands. If the number of candidates is greater than 2, then the bandmerger had to resolve the choice based on examination of the different band-pair combinations and position (and flux in-band) χ^2 differences between candidates. If the number of candidates is greater than 1, the confusion flag is set for all bands.

15 - column pulldown corrected (bands 1 & 2)

This bit is set if the source is within 3 pixels of a column pulldown corrected pixel.

16 - banding corrected (bands 3 & 4)

This bit is set if the source is within 3 pixels of a banding corrected pixel.

19 - data predicted to saturate

This bit is set when a source is within 3 pixels of a pixel identified in the SSC IRAC dmask as being saturated (bit 10 in the dmask). The SAGE IRAC pipeline runs a saturated pixel predicter and sets bit 10 in the dmask. This program finds clusters of high-valued pixels. The cluster size and high pixel value are tuned so that sources above the IRAC saturation limits are flagged as saturated. Before photometry is done on an IRAC frame, these pixels are masked.

20 - saturated star wing region

False sources can be extracted in the wings of saturated sources. This bit is set if the source is within a PSF-shaped region (with a 24-pixel radius) surrounding a saturated source determined from bit 10 in the dmask. Bands with this bit set are not counted during the source selection process (see Section 3.2)

21 - pre-lumping in in-band merge

Sources in the same IRAC frame within a radius of 1.6 arcsec are merged into one source (weighted mean position and flux) before bandmerging. This is potentially a case in which the source is incompletely extracted in the first IRAC frame and a second source extracted on the second IRAC frame. Or it could be a marginally resolvable double source. This bit is set for the band if sources have been lumped for that band.

22 - post-lumping in cross-band merge

This bit is set if the source is a result of sources that were lumped in the cross-band merge step for all bands. Cross-band lumping is done with a 1.6 arcsec radius. For example, say there are two sources within 1.6 arcsec of each other. One source has data in bands 1 and 4 and the other has data in bands 2 and 3. These two sources will be lumped into one source with data in all 4 bands.

30 - within three pixels of edge of frame

Sources within three pixels of the edge of the IRAC frame are flagged since it is likely to be too close to the edge of the frame for accurate photometry to be done. Bands with this bit set are not counted during the source selection process (see Section 3.2)

B.4.2. 2MASS Source Quality Flag

For the 2MASS bands, the following contamination and confusion (cc) flags from the 2MASS All-Sky Point Source Catalog are mapped into bits 3, 4, 9 and 20 of the Source Quality Flag. For more information about the cc flags, see
http://www.ipac.caltech.edu/2mass/release/All-Sky/doc/sec2_2a.html#cc_flag.
Three Source Quality Flag bits (23, 24, 25) provide the 2MASS photometric quality flag information, whose possible values are (from worst to best) X, U, F, E, D, C, B, and A (see http://pegasus.phast.umass.edu/ipac_wget/releases/All-Sky/doc/sec1_6b.html#phqual.)
Users should consult the 2MASS PSC documentation for the complete information about the source, including all of their source quality flags.

bit

3 - "p" persistence

Source may be contaminated by a latent image left by a nearby bright star.

4 - "c" photometric confusion

Source photometry is biased by a nearby star that has contaminated the background estimation.

9 - ”s” electronic stripe

Source measurement may be contaminated by a stripe from a nearby bright star.

14 - confusion in cross-band merge

This bit is set during the bandmerging process. The bandmerger reports, for each source and band, the number of merge candidates it considered in each of the other bands. If the number of candidates is greater than 2, then the bandmerger had to resolve the choice based on examination of the different band-pair combinations and position χ^2 differences between candidates. If the number of candidates is greater than 1, the confusion flag is set for all bands.

20 - ”d” diffraction spike confusion

Source may be contaminated by a diffraction spike from a nearby star.

22 - post-lumping in cross-band merge

This bit is set for all bands (IRAC and 2MASS) if the source is a result of sources that were lumped in the cross-band merge step. Cross-band lumping is done with a 1.6 arcsec radius.

23 - Photometric quality flag

24 - Photometric quality flag

25 - Photometric quality flag

Table 6. 2MASS Source Quality Flag

2MASS ”ph” Flag =>	SQF bits 23, 24, 25	value
X	0, 0, 0	0
U	1, 0, 0	4194304
F	0, 1, 0	8388608
E	1, 1, 0	12582912
D	0, 0, 1	16777216
C	1, 0, 1	20971520
B	0, 1, 1	25165824
A	1, 1, 1	29360128

In Table 6:

X - There is a detection at this location, but no valid brightness estimate can be extracted using any algorithm.

U - Upper limit on magnitude. Source is not detected in this band or it is detected, but not resolved in a consistent fashion with other bands.

F - This category includes sources where a reliable estimate of the photometric error could not be determined.

E - This category includes detections where the goodness-of-fit quality of the profile-fit photometry was very poor, or detections where psf fit photometry did not converge and an aperture magnitude is reported, or detections where the number of frames was too small in relation to the number of frames in which a detection was geometrically possible.

D - Detections in any brightness regime where valid measurements were made with no [jhk]_snr or [jhk]_cmsig requirement.

C - Detections in any brightness regime where valid measurements were made with [jhk]_snr>5 AND [jhk]_cmsig<0.21714.

B - Detections in any brightness regime where valid measurements were made with [jhk]_snr>7 AND [jhk]_cmsig<0.15510.

A - Detections in any brightness regime where valid measurements were made with [jhk]_snr>10 AND [jhk]_cmsig<0.10857.

B.4.3. Key to Bit Values

This section describes how to determine the bit values of a Source Quality Flag.

bt = bit in sqf
value = $\sum 2^{(bt-1)}$

bit values:
bt 1 => 1; 2 => 2; 3 => 4; 4 => 8; 5 => 16; 6 => 32; 7 => 64; 8 => 128 bt 9 => 256; 10 => 512; 11 => 1024; 12 => 2048; 13 => 4096; 14 => 8192; 15 => 16384; bt 16 => 32768; 17 => 65536; 18 => 131072; 19 => 262144; 20 => 524288; bt 21 => 1048576; 22 => 2097152; 23 => 4194304; 24 => 8388608; 25 => 16777216; 30 => 536870912

For example, say the Source Quality Flags are 29360128 for the 2MASS J and H bands and 29360136 for the K_s band. This translates to bits 23, 24 and 25 being set for J & H, which is the photometric quality A flag from the 2MASS PSC. For K_s, bits 4, 23, 24 and 25 are set, meaning the "c" photometric confusion flag was set and the photometric quality flag is A. Say IRAC band 1 has a SQF of 16384. This means bit 15 has been set which means the source is within three pixels of a column pulldown corrected area.

B.5. Flux calculation method flag

The flux calculation method flag (mflag) indicates by bit whether a given exposure time was present, and whether that exposure time was used in the final flux.

Table 7.

ft	present		used	
	bit	(value)	bit	(value)
0.6	1	(1)	2	(2)
1.2	3	(4)	4	(8)
2	5	(16)	6	(32)
12	7	(64)	8	(128)
30	9	(256)	10	(512)
100	11	(1024)	12	(2048)

For example, if 0.6 and 12 sec data were present, but only the 12 sec data were used, then bits 1 and 7 will be set (fluxes present) and bit 8 will be set (12 s used) and the mflag will be $2^0 + 2^6 + 2^7 = 1 + 64 + 128 = 193$ (see Table 7). Note that, in practice, an mflag of 193 is rarely assigned because some detections are thrown out at the beginning of bandmerging because of sensitivity or saturation issues (see Sect 3.1).

For SAGE 12/0.6s HDR mode, the relevant numbers work out to be
3 - short exp data used, long exp data absent
67 - short used, long present but unused
192 - long exp used, short absent
193 - long exp used, short present but unused
195 - both long and short present and used

B.6. An example of a line of text for SAGEcatalogIRAC

Here is an example of a line of text for the Catalog (83 columns)

globalSourceID sourceCatalog epoch designation tmass_cntr tmass_designation ra dec dra ddec closeFlag magJ dmagJ magH dmagH magK dmagK mag3_6 dmag3_6 mag4_5 dmag4_5 mag5_8 dmag5_8 mag8_0 dmag8_0 fluxJ dfluxJ fluxH dfluxH fluxK dfluxK flux3_6 dflux3_6 flux4_5 dflux4_5 flux5_8 dflux5_8 flux8_0 dflux8_0 rms_f3_6 rms_f4_5 rms_f5_8 rms_f8_0 sky3_6 sky4_5 sky5_8 sky8_0 SNJ SNH SNK SN3_6 SN4_5 SN5_8 SN8_0 srcDensity3_6 srcDensity4_5 srcDensity5_8

Table 8. The Example Line from SAGEcatalogIRAC

Parameter	Value	Description
globalSourceID ..	51539756	Unique identifier
sourceCatalog ...	iracc	Identifier for source catalog
epoch	epoch 1	Identifier for epoch of source
designation	SSTISAGE1C J041826.63-693904.4	source name
TmassCntr	119920193	2MASS cntr from 2MASS PSC
TmassDesignation	04182666-6939043	2MASS designation from 2MASS PSC
ra, dec	64.610977, -69.651224	RA and Dec in degrees
dra, ddec	0.3, 0.3	Error in RA and Dec in arcsec
	...	dra is in units of arcseconds,
	...	so to convert to seconds of
	...	time, multiply by cos(dec)/15.
closeFlag	0	Close source flag
mag	11.361, 11.062, 10.93, 10.908, 99.999, 99.999, 99.999	Magnitudes [JHK, Bands 1-4]
dmag	0.025, 0.024, 0.023, 0.044, 99.999, 99.999, 99.999	mag uncertainties [JHK, Bands 1-4]
flux	45.51, 38.5, 28.31, 12.17, -999.9, -999.9, -999.9	Fluxes (mJy) JHK and Bands 1-4
dflux	1.048, 0.8511, 0.5997, 0.4945, -999.9, -999.9, -999.9	Flux uncertainties (mJy) [JHK, Bands 1-4]
rms_f	1.735E-15, -999.9, -999.9, -999.9	rms_flux (mJy) [Bands 1-4]
sky	0.042, -999.9, 1.069 , -999.9	Sky Bkg (MJy/sr) [Bands 1-4]
SN	43.43,45.24,47.21,24.61,-9.99,-9.99,-9.99	Signal to Noise [J,H,K,Bands 1-4]
srcDensity	26.4, -9.9, 2.4, -9.9,	Local Source Density [Bands 1-4]
m	2,0,1,0	Number of detections [Bands 1-4]
n	2,0,1,0	Number of poss detections [Bands 1-4]
sqf	29360128,29360128,29360128,16896,-9,1024,-9	Source Quality Flag [J,H,K,Bands 1-4]
mf	195,-9,192,-9	Flux Calculation Method Flag [Bands 1-4]
versionNo	2.1	Catalog version number assigned by
....	...	IRAC pipeline team
versionDate	Jan 8 2008	Date catalog was produced
	...	in the following format,
	...	"month day year"
cx	0.14909512579792	x of unit vector to this source
cy	0.314148921760202	y of unit vector to this source
cz	-0.937593247853356	z of unit vector to this source
htmID	9328366705324	20-deep HTM ID of this source

srcDensity8_0 m3_6 m4_5 m5_8 m8_0 n3_6 n4_5 n5_8 n8_0 sqfJ sqfH sqfK sqf3_6 sqf4_5 sqf5_8 sqf8_0 mf3_6 mf4_5 mf5_8 mf8_0 versionNo versionDate cx cy cz htmID

51539756 iracc epoch 1 SSTISAGE1C J041826.63-693904.4 119920193 04182666-6939043 64.610977 -69.651224 0.3 0.3 0 11.361 0.025 11.062 0.024 10.93 0.023 10.908 0.044 99.999 99.999 99.999 99.999 99.999 99.999 45.51 1.048 38.5 0.8511 28.31 0.5997 12.17 0.4945 -999.9 -999.9 -999.9 -999.9 -999.9 -999.9 1.735E-15 -999.9 -999.9 -999.9 0.042 -999.9 1.069 -999.9 43.43 45.24 47.21 24.61 -9.99 -9.99 -9.99 26.4 -9.9 2.4 -9.9 2 0 1 0 2 0 1 0 29360128 29360128 29360128 16896 -9 1024 -9 195 -9 192 -9 2.1 Jan 8 2008 0.14909512579792 0.314148921760202 -0.937593247853356 9328366705324

Table 8 shows the same line from SAGEcatalogIRAC with the detailed description of the individual columns (see also Table 4 in Appendix B).

C. APPENDIX - MIPS 24 μm Catalog Formats

C.1. The differences between the 2nd and the 1st delivery of the MIPS 24 μm Point Source Catalog

This second MIPS 24 μm catalog delivery has benefited from extensive reliability testing. The high reliability single epoch catalogs are the result of this testing. In addition, the processing of the individual AORs has improved by a small amount allowing for the removal of some additional 24 μm instrumental artifacts. The first MIPS 24 μm catalog delivery was based on the preliminary extractions of sources.

C.2. An example of a line of text for the MIPS24 Catalog

Here is an example of a line of text for the Catalog (29 columns; see also Table 10)

globalSourceID sourceCatalog epoch designation ra dec dra ddec conf24 mag24 dmag24 flux24 dflux24 sky24 SN24 flag24 correlation24 mmmSkymode24 mmmSigma24 mmmSkew24 mmmNsky24 averageCoverage24 AORNumber24 versionNo versionDate cx cy cz htmID

51643635 mips24c epoch 1 SSTM1SAGE1 J051321.75-692240.3 78.34063 -69.377871 0.02 0.02 0 -0.06707 0.005458 7627 38.34 58.98 198.92 0 0.964 37.63 33.41 0.7805 2122 11.17 14382080 2.1 12/12/2007 0.0711777387999096 0.344935919964786 -0.935923576269654 9315124191905

The detailed description of the individual columns and the data format can be found in Table 9.

Table 9. SAGEcatalogMIPS24 Format

Col.	Name	Description	Data	Format	Null
1	globalSourceID . . .	Unique identification number of each source in the catalog	I*4	i10	NO
2	sourceCatalog	Character string identifier for	ASCII	a8	NO

Continued on Next Page. . .

Table 9 – Continued

Col.	Name	Description	Data	Format	Null
		source catalog			
3	epoch	Character string identifier for the epoch of the observation of the source	ASCII	a16	NO
4	designation	SAGE source designation name	ASCII	a32	NO
5	ra	Right ascension, J2000 (deg)	R*8	f11.6	NO
6	dec	Declination, J2000 (deg)	R*8	f11.6	NO
7	dra	Error in Right Ascension (″)	R*8	f4.1	NO
8	ddec	Error in Declination (″)	R*8	f4.1	NO
9	conf24	Confusion Flag for band 24, currently unused	I*2		-9
10	flux24	24μm flux (mJy)	R*8	e11.3	-999.9
11	dflux24	24μm 1σ error (mJy)	R*8	e11.3	-999.9
12	mag24	24μm magnitude	R*8	f7.3	-999.9
13	dmag24	24μm 1σ error	R*8	f7.3	-999.9
14	sky24	Local Sky Bkg. for band 24 (MJy/sr)	R*4	e11.3	-999.9
15	SN24	Signal/Noise for band 24	R*4	f6.2	-9.99
16	flag24	The flag currently refers to how many times a source was observed by different AORs in a single epoch. Is it was observed more than once, the reported flux is the average of the multiple observations. If flag24 = 0, then it was only measured in 1 AOR. If it is > 1 (it will never be 1), then that is the number.	I*2		-9
17	correlation24	Correlation describes how like the input PSF each point source is	R*8	e11.3	-999.9
18	mmmSkymode24 . .	Scalar giving estimated mode of the sky values. Sky is determined in a 49x49 square	R*8	f11.6	NO

Continued on Next Page...

Table 9 – Continued

Col.	Name	Description	Data	Format	Null
		pixel (1 pixel = $2''.49$) region surrounding the source in the residual image (all sources subtracted).			
19	mmmSigma24	Scalar giving standard deviation of the peak in the sky histogram. If for some reason it is impossible to derive skymode, then SIGMA = -1.	R*8	f11.6	NO
20	mmmSkew24	Scalar giving skewness of the peak in the sky histogram	R*8	f11.6	NO
21	mmmNsky24	number of points used to determine the sky values for mmmSkymode24, mmmSigma24 and mmmSkew24	R*8	f11.6	NO
22	averageCoverage24	The average coverage (no. of independent observations per pixel) in a 49×49 square pixel (1 pixel = $2''.49$) region centered on the source.	R*8	f11.6	NO
23	AORNumber24 ...	Request key for the 1st AOR within which the source appears	I*4	i10	NO
24	versionNo	Version number assigned by MIPS pipeline team	R*4	f6.2	NO
25	versionDate	Date catalog was produced in the following format, ”mon dd yyyy”, ”Dec 5 2007”	ASCII	a12	NO
26	cx	x of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
27	cy	y of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
28	cz	z of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
29	htmID	The Hierchical Triangular	I*4	i20	NO

Continued on Next Page...

Table 9 – Continued

Col.	Name	Description	Data	Format	Null
		Mesh partition computed at index level 20 in which this source lies			

Table 10. The Example Line from SAGEcatalogMIPS24

Parameter	Value
globalSourceID . .	51643635
sourceCatalog	mips24c
epoch	epoch 1
designation	SSTM1SAGE1 J051321.75-692240.3
ra, dec	78.34063, -69.377871
dra, ddec	0.02, 0.02
conf24	0
mag24, dmag24 . . .	-0.06707, 0.005458
flux24, dflux24	7627, 38.34
sky24	58.98
SN24	198.92
flag24	0
correlation24	0.964
mmmSkymode24 .	37.63
mmmSigma24 . . .	33.41
mmmSkew24	0.7805
mmmNsky24	2122
averageCoverage24	11.17
AORNumber24 . . .	14382080
versionNo	2.1
versionDate	12/12/2007
cx	0.0711777387999096
cy	0.344935919964786
cz	-0.935923576269654
htmID	9315124191905

C.3. MIPS 24 μm 1°.1 $\times$ 1°.1 Tiles

SAGE_LMC_tile_MIPS24_TN.fits and SAGE_LMC_tile_MIPS24_TN_wt.fits images were mosaicked to match the size and positions of the IRAC 1°.1 $\times$ 1°.1 tiles. 'TN' in the filenames is the Tile Number and ranges from 1 to 85. Table 11 lists the centers of the tiles and Figure 16 is a graphical representation of the tile positions. Each FITS file is calibrated in units of MJy/sr, and has 2″.49 pixels. Data from both epochs of SAGE observations are included in the tiles. SAGE_LMC_tile_MIPS24_TN.fits files give the images in MJy/sr. SAGE_LMC_tile_MIPS24_TN_wt.fits give the depth of coverage (# of measurements per pixel). A background has been subtracted from these data, using the same fit that was made to the full LMC mosaic. In addition, the small residual background (−0.03 MJy/sr, or about 0.15% of the original background level) measured in the full mosaic has also been subtracted from these tiles.

For each tile, there is also a point-source-subtracted image, found in the SAGE_LMC_tile_MIPS24_TN_res.fits files. Point sources have been subtracted using the same software (StarFinder) used to create the 24 μm catalog. The temperature of the model

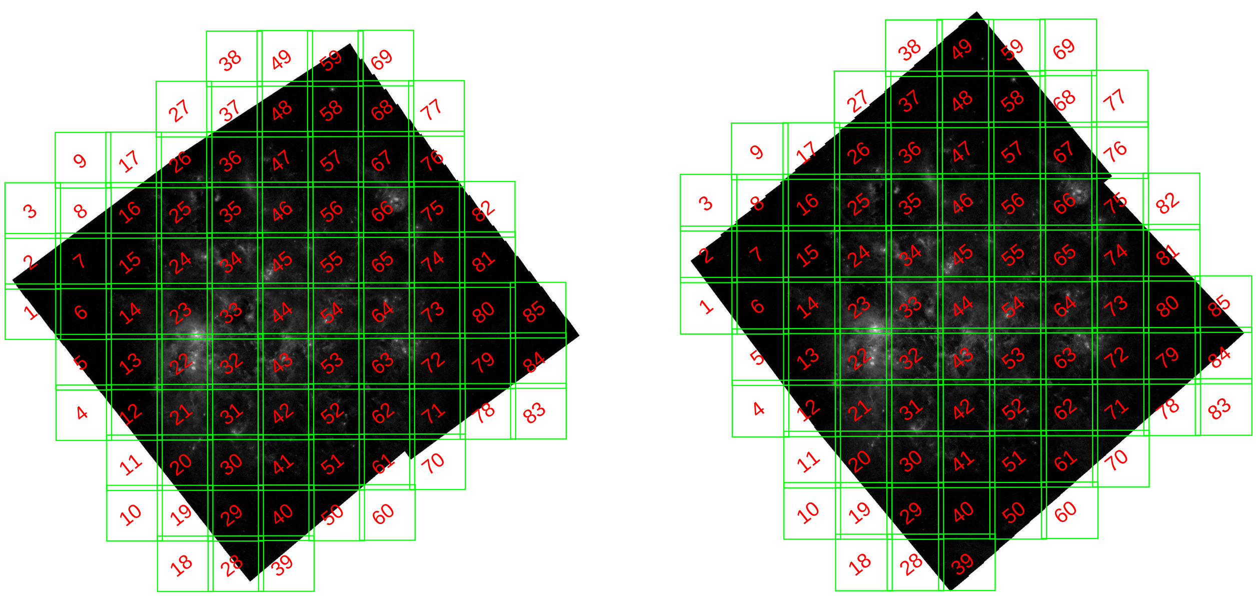

Fig. 16.— Tile positions overlayed on the MIPS 24 μm Epoch 1 (*left*) and Epoch 2 (*right*) mosaics. The tiles contain more data than the full mosaics shown here, e.g. for tile #18, no data appear in the full mosaic but do appear in the tile. The tiles were created using the software developed by the MIPS team, while the full mosaics were made with the Montage program from the AOR mosaics. More data were rejected by either Montage or during the AOR mosaic creation than when the tiles were made.

PSF of 100 K and a 2σ cutoff were used for source identification. No attempt has been made to rotate the PSF to match the orientation of the images (and couldn't be on these products, anyway, since 2 epochs at different roll angles are combined), so there will be residual diffraction spikes where bright sources were present.

Table 11. The Centers of the MIPS 24 μm $1^{\circ}.1 \times 1^{\circ}.1$ Tiles.

TN	RA (deg)	Dec (deg)	TN	RA (deg)	Dec (deg)	TN	RA (deg)	Dec (deg)
1	93.21	-68.15	31	82.72	-70.67	61	73.37	-71.59
2	92.65	-67.18	32	82.58	-69.68	62	73.68	-70.60
3	92.13	-66.20	33	82.45	-68.68	63	73.96	-69.61
4	91.62	-70.31	34	82.33	-67.68	64	74.21	-68.61
5	91.08	-69.33	35	82.23	-66.68	65	74.44	-67.62
6	90.58	-68.35	36	82.13	-65.68	66	74.66	-66.62
7	90.12	-67.36	37	82.03	-64.69	67	74.86	-65.63
8	89.70	-66.38	38	81.95	-63.70	68	75.04	-64.63
9	89.32	-65.40	39	79.70	-73.69	69	75.21	-63.64
10[a]	89.66	-72.44	40	79.70	-72.69	70	70.25	-71.46
11	89.15	-71.46	41	79.70	-71.70	71	70.70	-70.48
12	88.70	-70.48	42	79.70	-70.70	72	71.12	-69.49
13	88.28	-69.49	43	79.70	-69.70	73	71.50	-68.50
14	87.90	-68.50	44	79.70	-68.70	74	71.84	-67.51
15	87.56	-67.51	45	79.70	-67.70	75	72.16	-66.52
16	87.24	-66.52	46	79.70	-66.70	76	72.46	-65.53
17	86.94	-65.53	47	79.70	-65.70	77	72.73	-64.54
18	86.76	-73.57	48	79.70	-64.71	78	67.78	-70.31
19	86.38	-72.58	49	79.70	-63.71	79	68.32	-69.33
20	86.03	-71.59	50	76.35	-72.67	80	68.82	-68.35
21	85.72	-70.60	51	76.52	-71.67	81	69.28	-67.36
22	85.44	-69.61	52	76.68	-70.67	82	69.70	-66.38
23	85.19	-68.61	53	76.82	-69.68	83	64.92	-70.09
24	84.96	-67.62	54	76.95	-68.68	84	65.58	-69.12
25	84.74	-66.62	55	77.07	-67.68	85	66.19	-68.15
26	84.54	-65.63	56	77.17	-66.68	···	···	···
27	84.36	-64.63	57	77.27	-65.68	···	···	···
28	83.24	-73.66	58	77.37	-64.69	···	···	···
29	83.05	-72.67	59	77.45	-63.70	···	···	···
30	82.88	-71.67	60	73.02	-72.58	···	···	···

[a]no coverage, tile not provided

D. Acknowledgements and References

The SAGE survey was proposed by a creative team of scientists listed in the SAGE overview paper. At the core of the SAGE team are three data centers at which the Spitzer data are processed and distributed.

- IRAC pipeline based at the University of Wisconsin: Barbara Whitney (lead/SSI), Marilyn Meade (Univ. of Wisconsin), Brian Babler (Univ. of Wisconsin), Remy Indebetouw (Univ. of Virginia), Joe Hora (Harvard/CfA), Steve Bracker (Univ. of Wisconsin)
- MIPS pipeline based at the University of Arizona: Karl Gordon (Univ. of Arizona/lead; now at STScI), Chad Engelbracht (Univ. of Arizona), Bi-Qing For (Univ. of Texas), Miwa Block (Univ. of Arizona), Karl Misselt (Univ. of Arizona), Steve Bracker (Univ. of Wisconsin)
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REFERENCES

Benjamin, Robert A., Churchwell, E., Babler, Brian L., Bania, T. M., Clemens, Dan P., Cohen, Martin, Dickey, John M., Indebetouw, Rmy, Jackson, James M., Kobulnicky, Henry A., Lazarian, Alex, Marston, A. P., Mathis, John S., Meade, Marilyn R., Seager, Sara, Stolovy, S. R., Watson, C., Whitney, Barbara A., Wolff, Michael J., Wolfire, Mark G. 2003, PASP, 115, 953

Cohen, M., Megeath, T.G., Hammersley, P.L., Martin-Luis, F., & Stauffer, J. 2003, AJ, 125, 2645

Cohen, M., Wheaton, W.A., & Megeath, T.G. 2003, AJ, 126, 1090

Cutri, R. M., 2MASS 2004, AAS, 205, 9103

Diolaiti, E., Bendinelli, O., Bonaccini, D., Close, L., Currie, D., Parmeggiani, G. 2000 A&AS, 147, 335

Engelbracht, C. W., Blaylock, M., Su, K. Y. L., Rho, J., Rieke, G. H., Muzerolle, J., Padgett, D. L., Hines, D. C., Gordon, K. D., Fadda, D., Noriega-Crespo, A., Kelly, D. M., Latter, W. B., Hinz, J. L., Misselt, K. A., Morrison, J. E., Stansberry, J. A., Shupe, D. L., Stolovy, S., Wheaton, Wm. A., Young, E. T., Neugebauer, G., Wachter, S., Prez-Gonzlez, P. G., Frayer, D. T., Marleau, F. R. 2007, PASP, 119, 994, *"Absolute Calibration and Characterization of the Multiband Imaging Photometer for Spitzer. I. The Stellar Calibrator Sample and the 24 μm Calibration"*

Gordon, Karl D., Rieke, George H., Engelbracht, Charles W., Muzerolle, James, Stansberry, John A., Misselt, Karl A., Morrison, Jane E., Cadien, James, Young, Erick T., Dole, Herv, Kelly, Douglas M., Alonso-Herrero, Almudena, Egami, Eiichi, Su, Kate Y. L., Papovich, Casey, Smith, Paul S., Hines, Dean C., Rieke, Marcia J., Blaylock, Myra, Prez-Gonzlez, Pablo G., Le Floc'h, Emeric, Hinz, Joannah L., Latter, William B., Hesselroth, Ted, Frayer, David T., Noriega-Crespo, Alberto, Masci, Frank J., Padgett, Deborah L., Smylie, Matthew P., Haegel, Nancy M. 2005, PASP, 117, 503

Meixner, M.,, Gordon, K., Indebetouw, R., Hora, J.L., Churchwell, E.B., Whitney, B., Blum, R., Reach, W., Bernard, J-P., Meade, M., Babler, B., Engelbracht, C., For, B-Q., Misselt, K., Leitherer, C., Vijh, U., Cohen, M., Boulanger, F., Frogel, J.A., Fukui, Y., Gallagher, J., Gorijian, V., Harris, J., Kelly, D., Kemper, C., Kawamura, A., Kim, S., Latter, W.B., Madden, S., Mizuno, A., Mizuno, N., Mould, J., Nota, A., Oey, S., Olsen, K., Onishi, T., Paladini, R., Panagia, N., Perez-Gonzalez, P., Shibai, H., Shuji, S., Smith, L., Staveley-Smith, L., Tielens, A.G.G.M., Ueta, T., Van Dyk, S., Volk, K., Werner, M., and Zaritsky, D. 2006, AJ, 132, 2268, *"Spitzer Survey of the Large Magellanic Cloud, Surveying the Agents of a Galaxy's Evolution (SAGE) I: Overview and Initial Results"*

Price, S. D., Paxson, C., Engelke, C., & Murdock, T. L. 2004, AJ, 128, 889

Reach, William T., Megeath, S. T., Cohen, Martin, Hora, J., Carey, Sean, Surace, Jason, Willner, S. P., Barmby, P., Wilson, Gillian, Glaccum, William, Lowrance, Patrick, Marengo, Massimo, Fazio, Giovanni G. 2005 PASP, 117, 978

Rieke, G. et al. 2008, submitted (MIPS zero points)

Skrutskie, M. F. Cutri, R. M., Stiening, R., Weinberg, M. D., Schneider, S., Carpenter, J. M., Beichman, C., Capps, R., Chester, T., Elias, J., Huchra, J., Liebert, J., Lonsdale, C., Monet, D. G., Price, S., Seitzer, P., Jarrett, T., Kirkpatrick, J. D., Gizis, J. E., Howard, E., Evans, T., Fowler, J., Fullmer, L., Hurt, R., Light, R., Kopan, E. L., Marsh, K. A., McCallon, H. L., Tam, R., Van Dyk, S., Wheelock, S. 2006, AJ, 131, 1163

Stetson, P. 1987, PASP, 99, 191

Vijh, U., Meixner, M., Srinivasan, S., Whitney, B., Meade, M., Babler, B., Indebetouw, R., Hora, J., & Leitherer, C. 2008, in preparation

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