GLIMPSE Science and Data Requirements
Version 0.5 Preliminary
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1. Overview and Motivation for *GLIMPSE*

The inner workings of our own Galaxy are as mysterious as those of galaxies located millions of light years away, mainly because of our unfavorable location in the mid-plane outskirts of the Milky Way's dusty disk. The structure of the Galactic disk has been determined primarily from the distributions of atomic hydrogen (Westerhout 1957) and carbon monoxide which together contain no more than about 10% of the visible mass of the Galaxy (Scoville & Solomon 1975). The Galaxy is a typical luminous spiral, but its stellar distribution, particularly in the inner quadrants, is poorly known. For example, although there is significant evidence that the Galaxy has a molecular ring (Scoville & Solomon 1975), the number of stars recently formed in this ring, and the resultant appearance of the Galaxy's spiral arms to an outside observer, are unknown.

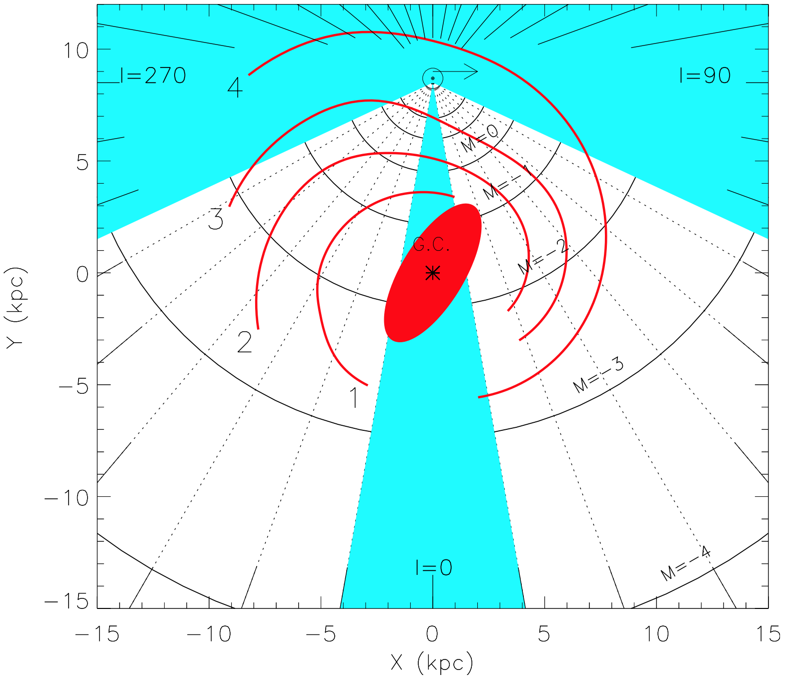

Fig. 1.— The Galactic Plane, with the Sun at the top, and the direction of solar motion noted with an arrow. The area covered by *GLIMPSE* is unshaded. The dotted lines are intervals of 10° in longitude. The solid circles indicate the 5σ detection distance for objects with absolute magnitude $M_{8\mu m} = 2, 1, .. - 4$ assuming no extinction. Young OB stars ($M = -4.35$) and M giants ($M = -4.24$) will be visible throughout the Galaxy. The approximate positions of Galactic spiral arms (Taylor & Cordes 1993) are indicated with bold lines and are numbered: (1) Norma Arm, (2) Scutum-Crux Arm, (3) Sagittarius Arm, and (4) Perseus Arm. The central oval represents the approximate extent of the central bar (Gerhard 2002; Cole & Weinberg 2002) with the Galactic Center marked with an asterix.

The principal impediment to cataloging the stellar content of the inner Galaxy has been dust obscuration of the visible light from stars. What has been needed is a survey with high sensitivity and angular resolution in the middle infrared and longer wavelengths. The recently completed 2MASS (Two Micron All-Sky Survey) survey (Cutri et al. 2001) has been an important step in this process, producing a view of the inner Galaxy at wavelengths as long as 2.2 μm. Yet even at these wavelengths, the extinction due to dust significantly compromises our ability to probe the stellar content of the inner Galaxy and obtain accurate measurements of fundamental Galactic parameters.

GLIMPSE , a Legacy Project using the *Spitzer Space Telescope* (See Gallagher, Irace, & Werner 2002 for a description of the full facility), is a project to map the infrared emission from the inner Galaxy over the two strips $|b| \leq 1°$ and $|l| = 10°$ to $65°$ using the IRAC instrument (see Fazio et al. 1998). Of all the *Spitzer* Legacy programs, this survey will cover the largest area on the sky (some 220 square degrees) and will yield the most panoramic images. With a total observing time of 400 hours, the survey will consist of over 80,000 pointings, each resulting in four simultaneous IRAC images at 3.6 μm, 4.5 μm, 5.8 μm, and 8.0 μm. The *GLIMPSE* team will use these data to produce a highly reliable point source catalog, a somewhat deeper point source archive, a set of mosaicked images, and associated analysis software.

The survey area was chosen to include all of the major known or suspected stellar components of the inner Galaxy (except the central bulge), namely the outer ends of the Galactic bar, the molecular ring at a Galactocentric radius of $\sim 3-5$ kpc, the inner disk, and the inner spiral arms and spiral arm tangencies (See Figure 1). The inner ±10° degrees of the Galaxy are excluded from our survey because of the high background and confusion present there.

The major purpose for *GLIMPSE* is to provide the community with a Legacy dataset complete to a well-defined flux limit suitable for a wide variety of astrophysical investigations. These might encompass population studies of different classes of Galactic objects, including regions of low and high mass star formation, highly evolved AGB and OH/IR stars, stars with circumstellar dust shells, cool stars of all luminosities, photodissociation regions (PDRs), proto-planetary nebulae, planetary nebulae, Wolf-Rayet stars, open clusters, and supernova remnants. Table 1 lists several classes of objects and the number of these objects already known to exist in the *GLIMPSE* survey area. *GLIMPSE* data will also be used to study the infrared dark clouds (Egan et al. 1998) revealed by MSX (Midcourse Space Experiment) and ISO (Infrared Space Observatory) and will extend the catalog of these objects to smaller sizes and fainter limits.

Table 1 Objects in the GLIMPSE Area[a]

Object Type	Number known in GLIMPSE region	Example
MSX point sources	61,321	
IRAS point sources	15,501	
HII regions	1174	M16 (Eagle Nebula), M17, W43,W49,W51
ROSAT point sources	459	
Radio pulsars	264	
Dark clouds	210	Coalsack, Vulpecula Rift, B48, LDN485
Galaxies	157	IRAS 16232-4917, GAL 312.11-0.20
ASCA point sources	144	
Supernova remnants	100	Kes 69, RCW 103, CTB 37A/B, Carina
O/B stars	98	BD-20 5020, BD-15 4930,BD+31 3921
Open clusters	76	NGC 3572, Sco OB2, Sct OB2, Westerlund 1
Planetary nebulae	65	NGC 6537, NGC 6842, IC 4637
Wolf-Rayet stars	50	IC14-17, Vyl-3, W43#1, The 3
Herbig-Haro objects	4	M16-HH1, 1548C27 jet, HGIG33.3+0.2
Globular clusters	1	2MASS-GC01

[a] A listing of the objects in the *GLIMPSE* region with links to various databases and maps showing the positions of these objects can be found at the *GLIMPSE* website: http://www.astro.wisc.edu/glimpse .

We expect that *GLIMPSE* data will be used by the community for investigations that we can not anticipate. Of all the directions in the sky, the inner Galaxy has heretofore been the most inaccessible because of dust obscuration. The *GLIMPSE* program will reveal for the first time a wealth of completely new stars, clusters, and galaxies. It is this element of serendipity that makes *GLIMPSE* a particularly exciting endeavor!

The *GLIMPSE* team will focus on two central science questions:

- *What is the structure of the inner Galaxy?* What is the structure of the disk and molecular ring? What are the number and locations of spiral arms? What is the nature of the central bar as traced by the spatial distribution of stars and infrared-bright star formation regions? In particular, we will address the question of whether the Galaxy is a ringed galaxy by correlating the stellar content with studies of the molecular ring of the Galaxy (Clemens et al. 2000).

- *What are the statistics and physics of star formation?* How does the nature of star formation depend on mass, stage of evolution, and location in the Milky Way? What will an unbiased infrared survey with well over 2000 star formation regions reveal about the earliest evolutionary stages of star formation? How does the infrared emission change during each of the principal stages of star formation?

In this document, we provide a description of the *GLIMPSE* observing plan (§2.1), data processing (§2.2), and data products (§2.3). Next, we give details on the scientific goals and challenges of the *GLIMPSE* survey, including high mass star formation in the inner Galaxy (§3.1.1), Galactic structure (§3.1.2), Legacy science (§3.2), and a description of the data sets that complement *GLIMPSE* (§3.3). The relation between the data requirements and the science goals of *GLIMPSE* is is given in §4, and a summary is given in §5.

2. Project Description

Spitzer and the Infrared Array Camera (IRAC) will be used to image two long strips comprising 220 square degrees at wavelengths centered at 3.6, 4.5, 5.8, and 8.0 μm. The area surveyed by *GLIMPSE* ($|b| \leq 1°, |l| = 10° - 65°$) contains most of the star formation activity in the Galaxy, the outer ends of the central bar, all of the Galactic molecular ring, and four spiral arm tangencies. The principal characteristics of *GLIMPSE* are listed in Table 2. In §5, we discuss the relationship between these characteristics and the principal science goals of the *GLIMPSE* program. The improvements in sensitivity, angular resolution, and areal coverage afforded by *GLIMPSE* over previous infrared surveys of the Galactic plane are shown in Figure 2.

Table 2 Summary of Principal GLIMPSE Characteristics

Charcteristic	Description
Galactic Longitude Limits	$\|l\| = 10° - 65°$
Galactic Latitude Limits	$\|b\| < 1°$
Total Survey Area	220 square degrees
Total Survey Time	400 hours
Total Resolution elements per band	$\sim 2 \times 10^9$
Total Number of IRAC frames per band	~80,000
IRAC frame size	$5.17' \times 5.17'$ (256×256 pixels)
Pixel resolution	$1.2'' \times 1.2''$
Frame time per visit	2 seconds
Number of visits per position	2
Frame overlap[a]	$14.4''$ (12 pixels)
IRAC wavebands	3.6μm, 4.5μm, 5.8μm, 8.0μm
5σ Sensitivity (4 sec.)	0.2, 0.2, 0.6, 0.4 mJy
Estimated reliability limit for GPSC[b]	3.5, 3.0, 2.5, 4.0 mJy
Saturation limits	180, 190, 570, 470 mJy
Photometric accuracy[c]	0.2, 0.2, 0.3, 0.3 mag
Galactic features covered	Outer ends of Galactic bar, molecular ring, four spiral arm tangencies: Norma($l = 333°$), Scutum-Crux($l = 30, 320°$), Sagittarius-Carina($l = 50°$)

[a] Subject to change after observing strategy validation period. [b] Flux level necessary to achieve 99.5% reliability based on simulated data. These values are subject to change after the observing strategy validation period. [c] Minimum photometric accuracy for GLIMPSE PSC and Archive.

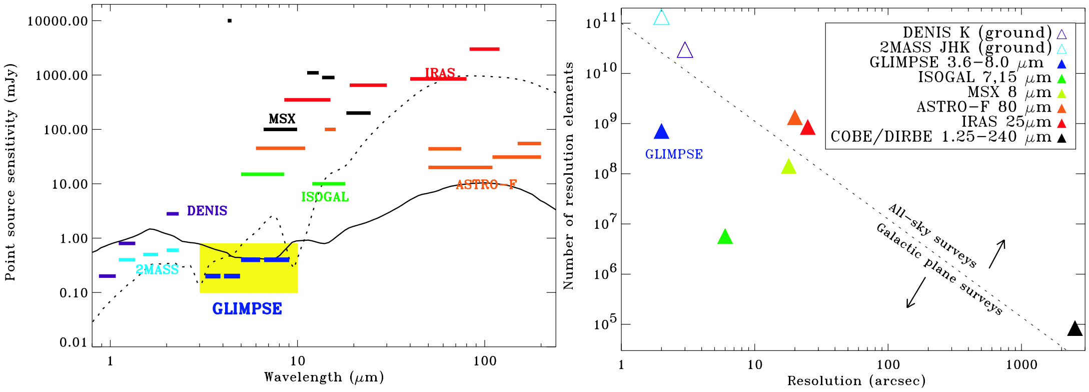

Fig. 2.— [Left panel] A comparison of the *GLIMPSE* sensitivity limit to the sensitivity of other ground and space-based infrared surveys. This shows the good match in sensitivity between *GLIMPSE* and 2MASS. The curves show model spectra of Whitney et al (2003) for a 1 $L_\odot$ T Tauri star at a distance of 0.7 kpc (solid) and a deeply embedded 1 $L_\odot$ protostar at a distance of 0.6 kpc(dotted). [Right panel] The number of resolution elements versus resolution for *GLIMPSE* and other infrared surveys. *GLIMPSE* will have the largest number of resolution elements of any Galactic plane-only survey, and a comparable number of resolution elements to several space-based all-sky infrared surveys.

The *GLIMPSE* team will provide the following products: a high reliability *GLIMPSE* Point Source Catalog (GPSC) containing about 10 million objects, a *GLIMPSE* Point Source Archive (GPSA; 5σ), and a Mosaicked Image Atlas of the entire surveyed area in all four IRAC bands. All these data products will be made available via the SSC (*Spitzer* Science Center). In addition, a set of web-accessed modeling tools will permit users to interpret *Spitzer* and other IR data.

Here we discuss the *GLIMPSE* implementation, data processing plans, and resulting data products. Up-to-date information on the progress of *GLIMPSE* observations (including a graphical survey tracker), data reduction and data releases can be found at the *GLIMPSE* website: www.astro.wisc.edu/glimpse.

2.1. *GLIMPSE* implementation

The orbit, orientation, and viewing limits on *Spitzer* conspire to make mapping the Galactic plane a complex process. Furthermore, the spectacular sensitivity of IRAC/*Spitzer* means that only exceedingly short exposures of the Galactic plane will not be saturated. These issues drive much of the *GLIMPSE* observing implementation.

Survey strategy: During standard *Spitzer* operations, IRAC "campaigns," lasting a week or so, will be scheduled. A fraction of these IRAC campaigns during the first year will be devoted to the *GLIMPSE* program which will observe many IRAC frames tiled together into $\sim 15^\circ \times 2^\circ$ segments of the Galactic plane. Each $\sim$ 30 square degree segment will consist of 35-45 "chained" AORs (Astronomical Observing Requests).[1] Each AOR will cover a narrow rectangular strip $0.3^\circ \times (2-3)^\circ$ spanning $b \cong -1^\circ$ to $b \cong +1^\circ$, but inclined to the Galactic plane. The inclination angle of the AOR to the Galactic plane depends upon the spacecraft roll angle. For *GLIMPSE* observations, the roll angle will lie between 15-50° from Galactic North. Example AOR sky coverage in the direction of the star formation region W51 is shown in Figure 3.

Each IRAC pointing simultaneously images two adjacent $5.17' \times 5.17'$ fields in two bands. An IRAC frame has 256×256 pixels; the 3.6 and 5.8 μm fields coincide on the sky and the 4.5 and 8.0 μm fields coincide on the sky, but the frame edges of the two fields are separated by $1.5'$. The total integration time per position is two seconds. The observations will be stepped by half-frames (128 pixels; $2.58'$) along the long axis of the AOR (which could be the spacecraft X or Y-axis, depending upon the roll angle). Every sky direction in the *GLIMPSE* region will be visited at least twice. The time separation between the two visits will range from 20 seconds (the time between pointings) to 3 hours (the time between AORs). The frame overlap along the short axis of the AOR will be $14.4''$ (12 pixels). A typical AOR will take 1.5 hours to complete, yielding $(3-4) \times (47-70)$ IRAC frames per band. Each $\sim 15^\circ \times 2^\circ$ segment of the Galactic plane will require 35-45 AORs; the entire survey will require 8 segments.

Observing Strategy Validation: Time was scheduled during early *Spitzer* operations to validate our observing strategy (OSV). Due to scheduling constraints, the *GLIMPSE* OSV region, RCW 49 ($l = 283^\circ.4$, $b = -0.^\circ3$), lies outside the *GLIMPSE* survey areas. A 2MASS image of RCW 49 is shown in Figure 4. This region was chosen to sample a range of stellar densities and diffuse background levels characteristic of the inner Galactic plane. Regions of particularly high stellar density and diffuse background are included to assess our strategy in the most challenging cases. The goals of these observations are to:

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[1] "Chained" AORs must be carried out within a certain amount of time of each other. For *GLIMPSE* , the typical maximum separation between AORs is 3 hours.

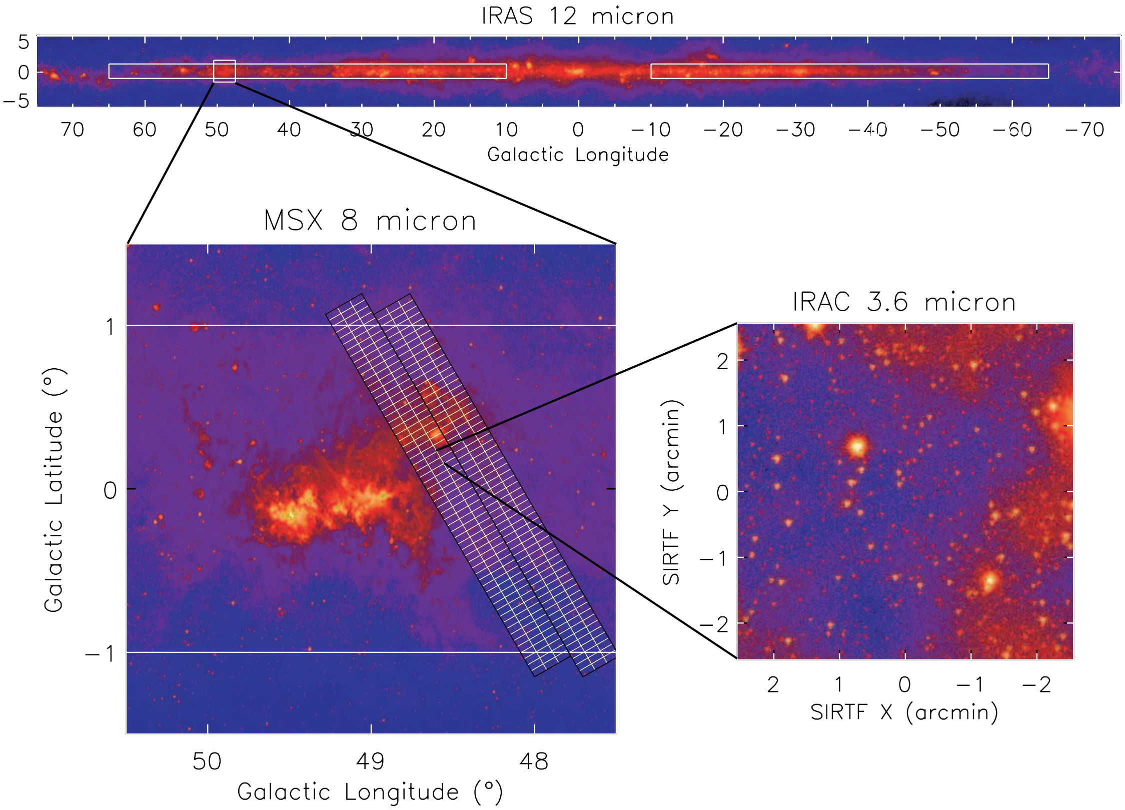
IRAS 12 micron
5
0
−5
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Galactic Longitude
MSX 8 micron
Galactic Latitude (°)
1
0
−1
50
49
48
Galactic Longitude (°)
IRAC 3.6 micron
SIRTF Y (arcmin)
2
1
0
−1
−2
SIRTF X (arcmin)

Fig. 3.— The upper figure shows an IRAS 12 μm image of the Galactic plane with long rectangular boxes indicating the region to be covered by *GLIMPSE* . The subregion on the lower left is an MSX 8μm map (Price et al. 2001) of the star formation region W51. This map shows the location of a set of tiled IRAC frames across the image. The black rectangle represents one Astronomical Observing Request (AOR) consisting of about 180 individual $5' \times 5'$ frames. A 15° segment in longitude will typically require about 40 AORs. The subregion of this plot is a synthetic *GLIMPSE* IRAC 3.6μm frame (1.2″pixel resolution), containing all the 2MASS point sources in this direction, supplemented with additional, fainter sources using the SKY model described in Wainscoat et al. (1992). The diffuse flux is taken from MSX observations.

1. determine the minimum criteria reuired to achieve a reliability $\geq 99.5\%$ for the GPSC;
2. assess if two 2 sec observations are adequate to achieve reliable flux densities and positions of point sources in crowded fields with high background levels;
3. determine if a 12 pixel overlap is adequate to insure that no gaps in the survey occur;
4. provide a basis for assessing reliability and completeness of the survey.

The OSV consisted of a total of 20 AORs. Each AOR provided strips of about $2° \times 0.17°$ which were placed side by side with varying offsets perpendicular to the strip direction and half-frame overlaps in the strip direction. The total area imaged was about $2° \times 0.6°$ and the set of four AORs used to cover this area

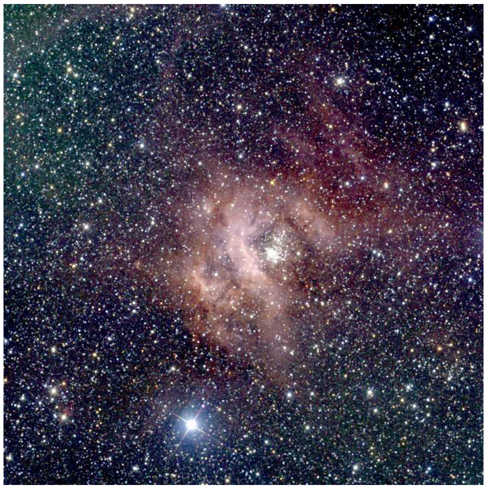

Fig. 4.— A 2MASS JHK color image of the *GLIMPSE* Observing Strategy Validation (OSV) area, the star formation region RCW49 ($l = 283^\circ.4$, $b = -0^\circ.3$). The image is $0.^\circ5 \times 0.^\circ5$. This area was observed by *Spitzer* in late December 2003.

was repeated five times which insured that each point in the area was observed a minimum of 10 times. At the end of the OSV evaluation, the outer longitude limits of the survey may be adjusted so that the total survey time does not exceed 400 hours.

Frame Details: The simulated 3.6μm IRAC frame for the W51 region shown in Figure 3 illustrates both the wealth of detail that *GLIMPSE* will uncover and the significant challenges for processing and analyzing these data. In this region, there are 400-600 2MASS sources per frame, all of which are detectable by *GLIMPSE* . (See Table 3 for the 5σ sensitivities and estimated flux limits for 99.5% reliability.) Examination of 2MASS and MSX data for this region indicates that we should expect 2-4 saturated sources per frame in the 3.6μm band decreasing to an average of one saturated source per frame in the 8.0μm band.

Table 3a GLIMSE/IRAC, 2MASS and MSX Characteristics (Flux Version)

Band	λ (μm)	Bandwidth (μm)	Zero mag[a] (mJy)	5σ Sens. (mJy)	Reliability Lim. (mJy)	Sat. Lim (mJy)
2MASS/J	1.24	0.25	1592	0.4	0.8	25230
2MASS/H	1.66	0.30	1024	0.5	0.9	25720
2MASS/K	2.16	0.32	667	0.6	1.3	26550
GLIMPSE/IRAC 1	3.55	0.66	289	0.2 [b]	3.5[c]	180[d]
GLIMPSE/IRAC 2	4.49	0.88	183	0.2 [b]	3.0[c]	190[d]
GLIMPSE/IRAC 3	5.66	1.32	131	0.6 [b]	2.5[c]	570[d]
GLIMPSE/IRAC 4	7.84	2.40	71	0.4 [b]	4.0[c]	470[d]
MSX/Band A	8.28	3.36	58	30	60	400000

[a] Zero magnitude for J,H,K from 2MASS Explanatory supplement. Zero magnitude from MSX from Cohen, Hammersley, & Egan (2000). IRAC zero magnitudes are interpolated from Table 7.5 in Tokunaga (2000); these may differ by as much as 13% from the final adopted values (M. Cohen, priv communication). [b] 5σ sensitivity for a 4 second integration using IRAC. [c] Flux limits for the Point Source Catalog are based on assuming a reliability of ≥ 0.995 and

is based on simulations. Limits may change after observing strategy validation period. [d] Diffuse source saturation limit for GLIMPSE/IRAC bands in units of MJy/sr can be obtained by multiplying the point source number (in mJy) by $30/\sqrt{N_{pix}}$, where N_{pix} is the number of pixels in the point source PSF. $30/\sqrt{N_{pix}} = 9.2$ for Band 1 and decreases to 7.0 for Band 4.

Table 3b GLIMPSE/IRAC, 2MASS and MSX Characteristics (Magnitude Version)

Band	λ (μm)	5σ Sens. (mag)	Complete Lim. (mag)	Sat. Lim (mag)	$A_\lambda/N(H)^{\rm a}$	$A_\lambda/A_V{}^{\rm a}$	$A_\lambda/A_V{}^{\rm b}$
2MASS/J	1.24	16.5	15.8	4.5	1.482	0.293	0.293
2MASS/H	1.66	15.8	15.1	4.0	0.959	0.190	0.190
2MASS/K	2.16	15.1	14.3	3.5	0.593	0.117	0.117
GLIMPSE/IRAC 1	3.55	15.4	12.3	8.0	0.237	0.047	0.058
GLIMPSE/IRAC 2	4.49	14.9	12.0	7.5	0.153	0.030	0.053
GLIMPSE/IRAC 3	5.66	13.3	11.8	5.9	0.103	0.020	0.053
GLIMPSE/IRAC 4	7.84	13.1	10.6	5.4	0.161	0.032	0.053
MSX/Band A	8.28	8.2	7.5	-2.1	0.022	0.044	0.053

[a] Extinction curve from Li & Draine (2001). $A_\lambda/N(H)$is in units of 10^{-22} cm^2 mag.[b] Extinction curve from Lutz et al 1996.

Timetable and Survey Tracking: For our timetable, we give both the date and the elapsed time since launch date (**L+n** months). The OSV data, to validate the survey strategy for *GLIMPSE* , was acquired in late December 2003 (**L+4**). Data acquisition for the full survey will begin after OSV data are analyzed and the survey strategy is validated, and will continue for about a year. The observability of a section of the Galactic plane as a function of Galactic longitude and time of year is shown in Figure 5.

The first installment of the *GLIMPSE* Point Source Catalog will be delivered to SSC on June 2004(**L+9**); the first installment of the mosaicked data and *GLIMPSE* Point Source Archive will be delivered in Dec 2004 (**L+15**). Updates to each of these data products will be provided at six month intervals after the first release dates. The final version of all *GLIMPSE* data products will be delivered to SSC on December 2005 (**L+27**). Documentation of the *GLIMPSE* survey have been available since launch; updates will be provided with the data releases.

2.2. Data Processing

The SSC will deliver Basic Calibrated Data (BCD) from the *GLIMPSE* IRAC observations to the *GLIMPSE* team. BCD will have gone through the following steps: validation, addition of header keywords, sense of InSb flux flipped, conversion to floating point, correction for dichroic flip, normalization by Fowler number and barrel-shifts, corrections of electronic bandwidth limitations, subtraction of dark/bias frames, correction for multiplexer bleed, correction for first-frame effects, linearization, flattening, detection of radiation hits, subtraction of sky darks, flux calibration, and detection of latents. The positional information will be good to 1.4$''$ and the photometric accuracy should be better than 10% early in the mission. BCD will also contain several ancillary data files, including the raw data, and several mask images that contain information on cosmic rays, linearity corrections, etc. A complete description of the processing that goes into generating the BCD is given in §6.3 of the *Spitzer* Observers' Manual (obtainable from the SSC web site).

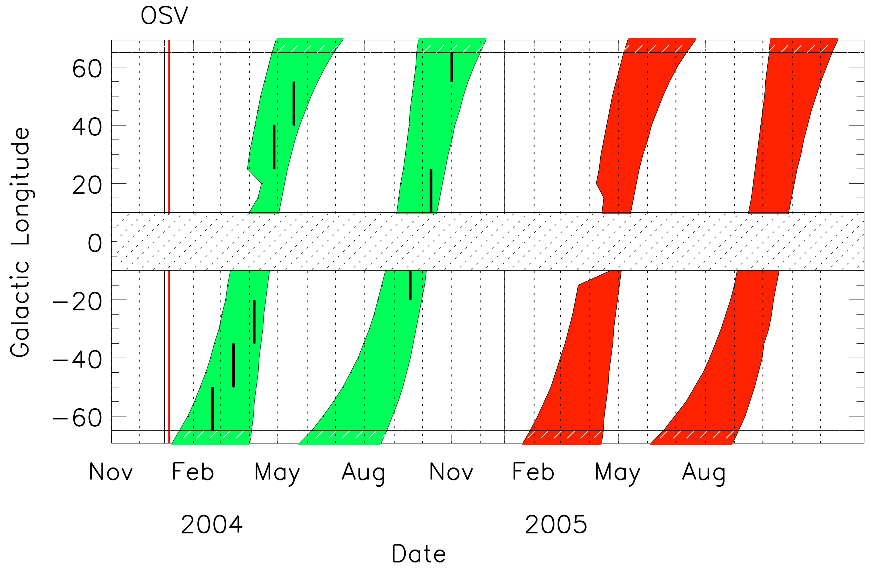

Fig. 5.— Visibility of the Galactic plane to *Spitzer* as a function of date and Galactic longitude. This can be used to judge when a particular part of the *GLIMPSE* region is likely to be observed. The planned *GLIMPSE* campaigns are noted with vertical bars.

The *GLIMPSE* team will further process these data using an automated pipeline (a "Post-BCD" pipeline) to correct for remaining instrumental artifacts, extract and cross identify point sources, and mosaic the images. The resulting *GLIMPSE* Point Source Catalog and Archive and the set of mosaicked images will be released to the astronomical community via the SSC. These released data will be more useful than the original BCD data, since they will benefit from the *GLIMPSE* team's experience in analyzing IRAC data in crowded and confused fields which have bright and positionally varying background emission.

The data reduction will occur at the University of Wisconsin-Madison using a network of LINUX workstations. The *GLIMPSE* pipeline is parallelized and will simultaneously use multiple processors; data flow will be controlled using OPUS pipeline software (Swade & Rose 1999). Locally, the data will be stored using the commercial database system, *Oracle 9i*, Release 2.

We have divided the Post BCD pipeline into a few key levels with clearly defined steps within each. In order, these levels are:

- **Data Verification:** Observed AORs are verified and checked to make sure the AOR was properly executed. The data are checked to verify that all SSC pipeline steps were carried out and checked for simple artifacts such as excessive cosmic ray hits and instrumental and down-link problems. A Quick-Look Validation Tool (QLVT) is used for spot-checks of frames and to inspect frames with flagged problems.[2]

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[2] Quick-Look Validation Tool (QLVT) is a quality assessment tool developed by team member Mark Wolfire, which simul-

- **Basic Processing and Mask Propagation:** The data are corrected for the zodiacal background (Gorjian, Wright, & Chary 2000). Pixels affected by stray light, banding[3], or that are in the wings of saturated sources are flagged and corrected wherever possible. An error mask for these pixels is created.

- **Point Source Extraction**: Flux density and position of point sources are determined using DAOPHOT (Stetson 1987). Positions of the brighter sources are checked against the 2MASS Point Source Catalog. Statistics are computed for the residual images and used to assess the extraction process. Flux calibration is also checked several times during each campaign.

- **Bandmerging:** The point source lists obtained in the eight pointed observations (two passes each in four bands) are merged to produce input for the generation of the *GLIMPSE* Point Source Catalog and *GLIMPSE* Point Source Archive.

- **Mosaicked Image Production:** The data are resampled, registered to a Galactic coordinate system, and IRAC frames are background matched, if necessary. The resulting images are turned into tiles of mosaicked images of $20' \times 20'$. The pixel size for these images is not yet finalized but will be approximately $0.6''$.

- **Point-Source Photometry on the Mosaicked Image:** The mosaicked images are used to perform point-source photometry. The resulting source list is then bandmerged with source list from single-frame data.

- *GLIMPSE* **Point-Source Catalog and Archive Generation:** Sources found in mosaicked and single frames are cross identified. Appropriate quality and reliability filters are applied to generate the *GLIMPSE* point-source products.

2.3. Data Products

There are four principal data products that will result from the *GLIMPSE* program. These are:

1. A *GLIMPSE* Point Source Catalog (GPSC, or the "Catalog"). The flux limit for this catalog will be determined by the requirement that the reliability be $\geq$99.5%. We currently estimate this flux limit to be $\sim$ 3.5 mJy at 3.6μm and $\sim$ 4.0 mJy at 8.0μm. The 8μm channel has a brighter limit due to the increased diffuse background from PAH emission near 7.7 μm and 8.6 μm in the Galactic plane. The Catalog photometric uncertainty will be < 0.2 mag. For each IRAC band, the Catalog will provide fluxes (with errors), positions (with errors), the density of local point sources, the local sky brightness and source density, and flags that provide information on source quality and any anomalies present in the data. The Catalog is expected to contain $\sim 10^7$ objects.

2. A *GLIMPSE* Point Source Archive (GPSA or the "Archive"), consisting of point sources with signal levels $\geq 5\sigma$ above the local background, to approximately a flux limit of 0.2-0.4 mJy. The photometric

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taneously displays four IRAC frames, data masks, and ancillary 2MASS/MSX data. The interface allows a user to insert comments and mark potentially bad pixels.

[3] Banding refers to streaks that pre-launch tests suggest might appear in the rows and columns radiating away from bright sources in the 5.8 and 8.0 μm bands. The severity of this effect will be determined on-orbit.

uncertainty is expected to be $\lesssim 0.2$ mag. The information provided will be the same as for the Catalog. The Archive will contain $\sim 5 \times 10^7$ objects.

3. Mosaicked Images for each band, each of approximately $20' \times 20'$ angular coverage. About 9000 FITS formatted images will be tiled to smoothly cover the entire survey area, using a Galactic coordinate system. The pixel resolution has not been finalized but will be about $0.6''$.
4. The Web Infrared Tool Shed (WITS), a web interface to a collection of model infrared spectra of dusty envelopes and photodissociation regions (PDRs), updated for IRAC and MIPS band passes. WITS currently resides on servers at the Infrared Processing and Analysis Center (IPAC, www.ipac.caltech.edu). The interface contains two "toolboxes": DIRT (Dust InfraRed Toolbox) and PDRT (PhotoDissociation Region Toolbox) which provide databases of circumstellar shell emission models and PDR emission models. Users can input data and retrieve best fit models. DIRT output includes central source and dust shell parameters; PDRT output consists of gas density, temperature, incident UV field and IR line intensities.

3. *GLIMPSE* Scientific Challenges

The *GLIMPSE* project will produce a rich dataset that can be used for numerous and diverse investigations. Here we discuss some of the expected scientific uses of this survey and several complementary datasets. We first discuss the principal science goals of the *GLIMPSE* team: a census of star formation in the inner Galaxy and a study of Galactic structure as determined by the distribution of stars. This is followed by a discussion of community science and complementary data sets.

3.1. *GLIMPSE* Team Science Goals

The *GLIMPSE* survey will uncover for the first time a huge number of stars in the inner Galaxy. As a result, it will be the survey of choice for those interested in the stellar structure of the Galaxy. Moreover, since the preponderance of star formation in the Galaxy is expected to occur in the inner Galaxy, studies using *GLIMPSE* will be able to characterize star formation in a wide range of environments. These are the two principal goals of the *GLIMPSE* science team.

3.1.1. Star Formation in the Inner Galaxy

The *GLIMPSE* team will address several fundamental questions regarding star formation in the inner Galaxy using the *GLIMPSE* data products. These include the following:

At what rate are stars forming in the inner Galaxy? Conservatively, we expect that analysis of *GLIMPSE* data will reveal several thousand star formation regions (SFRs). A search of the SIMBAD database lists over one thousand HII regions in our survey area; MSX 8μm images of the *GLIMPSE* survey area indicate that there are many more to be found (Cohen & Green 2001). Extrapolation from the luminosity functions of OB associations in other galaxies (McKee & Williams 1997) suggest that there should be several thousand SFRs in our survey area. SFRs and other Galactic clusters are about 0.7 pc in diameter (Harris & Harris 2000) and will subtend $\geq 10''$ at 15 kpc. Nearby clusters will spread across arcminutes, and will be partially resolved into individual stars and protostars. CO, HI, and radio continuum surveys (see §3.4) will also allow us to carry out targeted searches for star formation in the inner Galaxy.

What are the spatial and mass distributions of lower mass stars in massive star formation regions? Because of high extinction and the low luminosity of low-mass stars in massive star formation regions, we know very little about the spatial and mass distributions of low mass ($M < 1 - 2M_{\odot}$) stars associated with massive star formation regions. *GLIMPSE* data can be used to delineate both the spatial and mass distribution of lower mass stars in nearby (few kiloparsecs) star formation regions.

How does star formation vary as a function of position in the Galaxy? Since *GLIMPSE* will permit for an unbiased sample of massive star formation in the inner Galaxy, it will allow us to search for variations in star formation properties, i.e., cluster density, initial mass function, gas content, in a wide range of Galactic environments.

How many low mass star formation regions in the inner Galaxy have been hidden until now? SFRs that contain only stars later than spectral type B3 are not easily detected in radio continuum searches but will be detected by *GLIMPSE* . In the nearest SFRs, *GLIMPSE* data could be used for a census of the properties of intermediate mass pre-main sequence stars.

How does the infrared emission of star formation regions change over time? *GLIMPSE* data will provide information on the stellar content of all of the principal stages of massive star formation, summarized recently in Churchwell (2002). Figure 6 demonstrates that these stages are expected to have significantly different IRAC colors.

3.1.2. Galactic Structure

There are three main questions that the *GLIMPSE* team seeks to address using *GLIMPSE* data:

Does the Galaxy have a stellar ring? The Galactic molecular ring contains some 70% of all molecular gas in the Galaxy, and should be the dominant star-forming structure in the Milky Way (Clemens et al. 2001). On this basis, Kennicutt (2001) suggests that our Galaxy should be classified as an SB(r)bc pec. Where in the ring are the stars forming? How do the properties of the gas correlate with star formation? How does the ring's star formation efficiency compare with starburst regions in other galaxies? Comparison of *GLIMPSE* data with the ^{13}CO maps of this region of the Galaxy should yield answers to these important questions.

What are the nature of the spiral arms and disk in the inner Galaxy? Observations have given clues for the gas (HI and CO), but we know little about the stars and SFRs. Are stars formed on the leading or trailing edges of gas arms? How do the stars formed in arms and in interarm regions differ? Drimmell & Spergel (2001) show that K band (stellar light) profiles are consistent with a two-armed logarithmic spiral model, while the 240μm (dust emission) is consistent with a four-armed HII region distribution (Taylor & Cordes 1993). *GLIMPSE* data will allow us to determine the positions of individual star formation regions, account for regions of high obscuration, and determine if the integrated light observed by COBE/DIRBE is dominated by individual objects. *GLIMPSE* data will also allow us to identify different tracer populations (SFRs, OH/IR stars, IR carbon stars, etc) and their spatial distributions. The resulting information will help test models of gas dynamics, star formation and evolution in the inner Galaxy (Englmaier & Gerhard 1999).

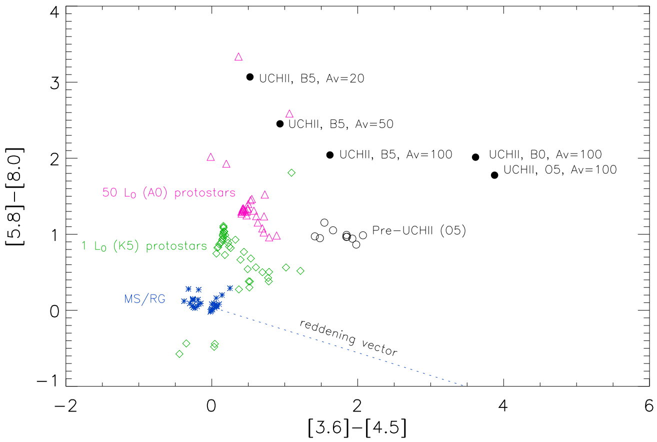

Fig. 6.— IRAC color-color diagrams of model protostars calculated by Whitney et al. (2003) with both axes in magnitudes. Filled circles are UCHII models, with various values of $A(V)$. The open circles are for a model of a UCHII precursor (O star embedded in an infalling envelope and accretion disk). Several viewing inclinations are plotted for this model. Open triangles show different inclination models for intermediate mass protostars (here, A0) from early protostar stage to remnant disk. Open diamonds are similar models for low mass pre-main sequence stars (K5). Only sources that are detectable to a distance of 2 kpc are plotted (i.e., the more pole-on, less reddened sources). The main sequence and giant branch are plotted as asterisks (MS), with the reddening line shown by the dotted line. Reddening is actually "blueing" in the longer wavelength bands, based on the ISM model of Li & Draine (2001) because of the strong silicate absorption features usually observed in these objects. *GLIMPSE* will improve our understanding of the opacity in this wavelength range.

GLIMPSE data will also help constrain values of the scale-lengths for the thin and thick stellar disks. Measuring the ratio of the thin-to-thick disk scale-length will constrain the merger history of the Galaxy (Quinn, Hernquist & Fullager 1993). Measuring the scale-length of the thin disk will establish whether the central mass distribution of the Galaxy is stellar- or dark matter-dominated.

What are the principal properties of the central stellar bar of the Galaxy? COBE/DIRBE data have shown the global distribution of the bar (Freudenreich 1998; Gerhard 2002). 2MASS studies using IR carbon stars have also traced the structure and possibly the age of the Galactic bar (Cole & Weinberg 2002). *GLIMPSE* data will allow us to extend these studies, look for star formation at the ends of the bar, and explore the connection between the bar and inner spiral arms.

3.2. Community Science from *GLIMPSE* Data

The wide variety of objects contained in the *GLIMPSE* survey region is illustrated in Figure 7, which shows the positions of many types of objects overlaid on an 8μm MSX map of a section of the *GLIMPSE* survey region. With the higher sensitivity and angular resolution of *GLIMPSE* , together with the color-select possibilities of seven or more photometric bands (*GLIMPSE* + 2MASS+MSX), data from *GLIMPSE* will allow the astronomical community to evaluate the statistics, spatial distribution, and internal structures of numerous classes of Galactic objects as well as providing new probes of the interstellar medium. These include studies of stellar populations, photo-dissociation regions (PDRs), extinction, as well as serendipitous discoveries.

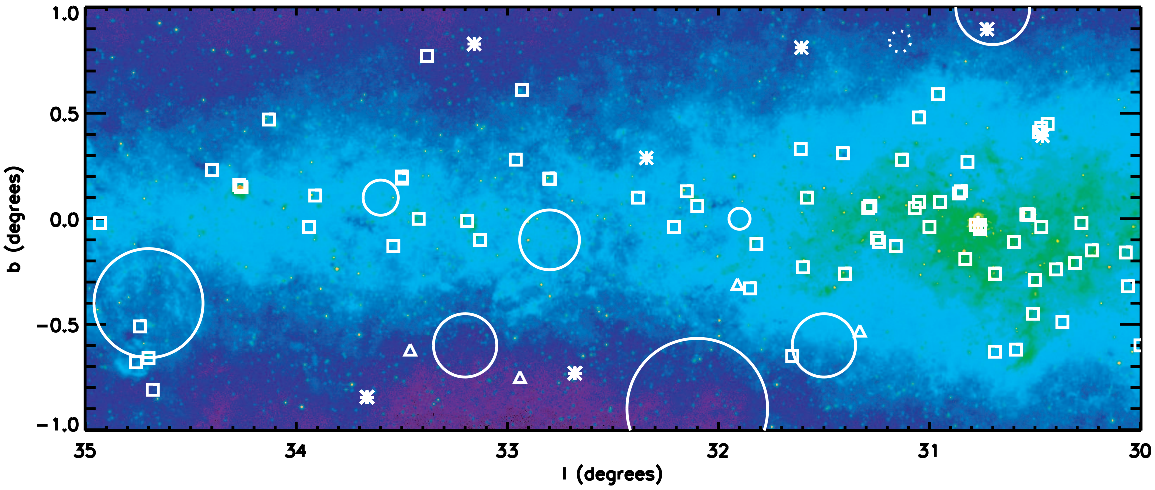

Fig. 7.— MSX 8μm image of a ten square degree piece of the *GLIMPSE* survey region, with the positions of the following classes of objects noted: OB stars (asterisks), HII regions (squares), planetary nebulae (triangles), supernova remnants (solid circles), and open clusters (dotted circles). Most of the diffuse emission in this image is due to polycyclic aromatic hydrocarbons (PAHs). The prominent star formation region at ($l = 30^\circ.8$, $b = 0.^\circ0$) is W43, which is obscured optically ($A_V \approx 30$ mag). The angular resolution of MSX was $18''$ as compared to the $< 2''$ pixel resolution expected from *Spitzer* /IRAC.

Stellar population studies: Using a combination of 2MASS and MSX data towards a sample of previously classified objects in the Large Magellanic Clouds, Egan et al. (2001) showed that the mid-IR 8μm band provides an important "lever arm" that allows color separation of many classes of objects. Planetary nebulae, HII regions, and some classes of C- and O-rich AGB stars have very red mid-IR colors. Other attempts to develop mid-IR and near-IR color selections focus on infrared carbon stars using ($J - K_s$) vs. K_s (Cole & Weinberg 2002), young stellar objects (YSOs) using ISOGAL [7]-[15] vs. [15] (Felli et al 2002), brown dwarfs (Burrows et al. 1997), and carbon stars, OH/IR stars, PN, Herbig AeBe stars, compact HII regions, and massive YSOs using a combination of 2MASS J, H, K, and MSX 8μm (Lumsden et al 2002).

Photo-Dissociation Regions (PDRs): The near/mid IR spectrum of photo-dissociation regions at the surface of molecular clouds is dominated by emission bands at 3.3, 6.2, 7.7, 8.6, and 11.3 μm, probably arising from polycyclic aromatic hydrocarbon (PAH) molecules (Peeters et al. 2002 and references therein). Figure 7 shows that this emission is a striking characteristic of the MSX maps of the Galactic plane. *GLIMPSE* data can be used to characterize the spatial distribution of different charge states of PAH to constrain the chemistry and evolution of PDRs. The IRAC 3.6 μm band is sensitive to the 3.3μm feature from neutral PAHs; the 5.8 and 8.0 μm bands are sensitive to PAH$^+$, while the 4.5μm band contains no PAH features and thereby monitors the continuum (Bakes et al. 2001).

Turbulence and Structure in Star Formation Regions: A comparison of the infrared brightness fluctuations in star formation regions with the spectral line information from CO and HI observations can yield information about the source of ISM turbulence, by using the Velocity Channel Analysis technique of Lazarian & Pogosyan (2000).

Interstellar Extinction: Data from *GLIMPSE* will allow studies of interstellar reddening in dense dusty regions and diffuse environments, using the colors of stars that lie behind dark clouds. This will allow testing near/mid infrared extinction models, two of which are given in Table 3 (Li & Draine 2001; Lutz et al. 1996). Since extensive grain coagulation occurs in the inner regions of dense clouds, the IR extinction law could be quite different between very dense clouds like the MSX dark clouds (Egan et al. 1998) and presently observable regions. *GLIMPSE* data will allow a vital characterization of the variation of extinction properties with environment.

Serendipity: Since the inner Galaxy is the region of the sky with the greatest extinction, it is also the direction in which one is most likely to make serendipitous discoveries. The recent 2MASS discoveries of new globular clusters in the Galactic plane (Hurt et al. 2000) and galaxies in the "Zone of Avoidance" (Jarrett et al. 2000) hint at the possibilities for *GLIMPSE* .

3.3. Complementary Data Sets

The value of the *GLIMPSE* data products will be enhanced by the availability of complementary IR and radio data sets. The basic characteristics of the IR surveys are given in Table 4. Data sets that we anticipate will be the most useful, and that will play important roles in the *GLIMPSE* team science studies, are

1. *2MASS*: This survey (Cutri et al. 2001) provides an ideal companion dataset to *GLIMPSE* , with an excellent match in both sensitivity and angular resolution for many types of objects. Many objects will have *GLIMPSE* +*2MASS* magnitudes in a total of seven near-IR and mid-IR bands! This will permit a wide variety of different possible color selections and SED's from ~ 1 μm to 8 μm. The *GLIMPSE* bands provide crucial mid infrared information.
2. *MSX*: The MSX (Price et al. 2001) survey provides a good match to the *GLIMPSE* /IRAC 8μm band. The MSX dataset will be particularly useful for studies of diffuse emission, since the diffuse emission is calibrated extremely well. It provides a good complement to the *GLIMPSE* data for bright sources, since the saturation limit of *GLIMPSE* is only slightly brighter than the faint detection limit for MSX.
3. *Arecibo/Green Bank Telescope/Australia Telescope Compact Array Surveys of GLIMPSE HII Regions:* This dataset resolves the distance ambiguities to many massive star formation regions. The data include > 100 objects with resolved distance ambiguities which will be published and made available on the *GLIMPSE* web site: www.astro.wisc.edu/glimpse.
4. *Milky Way Galactic Ring Survey (GRS):* A Boston University and Five College Radio Astronomy Observatory collaboration, this is a large-scale ^{13}CO $J = 1 \rightarrow 0$ molecular line survey of the inner Galaxy between latitudes -1° to $+1^\circ$ and longitudes 18° and 52°, with an angular resolution of $22''$ and a velocity resolution of 0.3 km s^{-1} (Simon et al. 2001). It is available through the GRS website: www.bu.edu/grs. GRS will be completed by winter 2003.
5. *The International Galactic Plane Survey:* This survey will map the Milky Way disk in the HI 21-cm line with a resolution of $1'$ and 1 km s^{-1} over the entire *GLIMPSE* survey area. The data cubes will be available at www.ras.ucalgary.ca/IGPS. The Southern Galactic Plane Survey is available at ftp://ftp.astro.umn.edu/pub/users/john/sgps .

Table 4 Summary of Infrared Surveys

Survey	Wavebands (μm)	Resolution ($''$)	Coverage	Sensitivity
GLIMPSE	3.6,4.5,5.8,8.0	≤ 2	$\vert l\vert = 10$-$65°$,$\vert b\vert \leq 1°$	0.2,0.2,0.6,0.4 mJy[a]
2MASS	1.22,1.65,2.16	2	all-sky	0.4,0.5,0.6 mJy
DENIS	0.97,1.22,2.16	1-3	$\delta = +2$ to $-88°$	0.2,0.8,2.8 mJy
MSX	4.1,8.3,12,14,21	18.3	$l = 0$-$360°$,$\vert b\vert \leq 5°$	10000,100,1100,900,200 mJy
ISOGAL	7,15	6	$\vert l\vert \leq 60°$,$\vert b\vert \leq 1°$[b]	15,10 mJy
IRAS	12,24,60,100	25–100	all-sky	350,650,850,3000 mJy
ASTRO-F[c]	8.5,20,62.5,80,155,175	5–44	all-sky	20-100 mJy
COBE/DIRBE[d]	1.25–240	0.7°	all-sky	0.01-1.0 MJy sr^{-1}

[a] Best effort 5σ limit for sources in the GLIMPSE Point-Source Archive; the GLIMPSE Point-Source Catalog will contain only sources at about the 20σ level to insure high reliability. [b] Survey contained only selected fields in this region, totaling 16 square degrees. [c] Launch planned February 2004 [d] DIRBE photometric bands are 1.25, 2.2, 3.5, 4.9, 12, 25, 60, 100, 140, and 240 μm. We report the diffuse flux sensitivity rather than point source sensitivity due to the large beam size.

There are several other surveys that will provide a useful complement to *GLIMPSE* . These include the ISOGAL survey at 7 and 15 μm (Omont et al 2003; Felli et al 2002) which provides complentary data for the inner Galaxy region not covered by the *GLIMPSE* survey, and the planned all-sky ASTRO-F survey at $8.5 - 175$ μm which will provide provide an extension to large galactic latitudes and longitudes, although at lower resolution and sensitivity than *GLIMPSE* (See Table 4). High angular resolution X-ray surveys of the Galactic plane using Chandra (Grindlay et al 2003; http://hea-www.harvard.edu/ChaMPlane) and XMM (Helfand et al 2002) will also provide a useful comparison to *GLIMPSE* data in selected regions of the Galactic plane.

4. GLIMPSE Data Requirements

In order to maximize the survey data needs of both the astronomical community and the GLIMPSE Science Team, the GLIMPSE data should meet reasonable performance expectations falling into the general categories of (1) survey area, (2) Galactic longitude coverage, (3) Galactic latitude coverage, (4) angular resolution, (5) positional accuracy, (6) photometric accuracy, (7) sensitivity, and (8) reliability/completeness. We have established values within each category based on science goals, augmented by models of the distributions and properties of the Galactic objects and features being studied. Here, we list the main requirments and science drivers; the summary of these requirements is given in Table 2.

1. Galactic Longitude Coverage: All GLIMPSE data users will want the largest numbers and best statistics for their objects of interest. This translates into a need to survey the largest area of the Galactic plane as practical or as the allotted time will permit. From the Sun's position, all Galactic directions are not equivalent; Galactic star formation and young objects are predominantly found in the spiral arms within the inner Milky Way. We and others will want to compare conditions and populations of spiral arms with interarm regions. To sample large numbers of objects that are concentrated in spiral arms, Galactic longitude coverage out to ±65° on both sides of the Galactic Center, is required. This corresponds to tangent distances up to ∼7 kpc from the center. This limit includes the tangencies to the spiral arm just inward from the Sun. Thus, the area covered by the survey is dictated by:

- The GLIMPSE survey should encompass the inner Milky Way.
- GLIMPSE should sample Galactic longitudes on both sides of the Galactic Center.
- GLIMPSE should sample Galactic longitudes to ±65° if adequate completeness and reliability can be maintained.

At Galactic longitudes near the Center, confusion is severe and extended structures become so bright that the fraction of saturated pixels in the IRAC images will grow too high to extract useful information from the data. Nevertheless, it is important that GLIMPSE press as closely to the Center as is practical to probe the very active Molecular Ring (centered at roughly a Galactocentric distance of 5 kpc and is virtually gone by a radius of 1.5 kpc) and the outer reaches of the Galactic bar. At the inner tangency, 1.5 kpc corresponds to a Galactic longitude of 10°. GLIMPSE should observe Galactic longitudes to within ±10° of the Galactic Center in order to sample objects and structures characteristic of the Molecular Ring and the central bar of the Galaxy.

2. Galactic Latitude Coverage: GLIMPSE will trace star formation in the inner Galaxy if it fully samples the area of highest projected molecular gas column density. Based on CO surveys of the inner Milky Way (e.g., Sanders et al. 1983), GLIMPSE must survey in Galactic latitude to at least one degree away from the Galactic equator. Substantially less coverage would impact the science goals of the community of Galactic astronomers.

3. Angular Resolution: The IRAC camera will provide a resolution of about $2''$. This will provide several resolution elements across typical stellar clusters at distances of 8.5 kpc and will allow resolution into individual stars within nearby ($d \lesssim 3$kpc) SFRs.

4. Positional accuracy: The GLIMPSE Catalog and Archive will be compared to data sets and images from 2MASS, DENIS, ISO, HST, and other telescopes. The positions of GLIMPSE sources must be established well enough to avoid mismatches with comparison data sets.Therefore, GLIMPSE positions must be accurate to at least $1.5''$, with a goal of $1''$.

5. Number of bands: Many GLIMPSE science goals depend on having object fluxes from more than one IRAC band. For example, only color-color diagrams can separate objects based on differences in their spectral energy distributions. Most, though not all, GLIMPSE Science Team investigations require at least three working IRAC bands. The reliability of our product is greatly increased by merging different bands, so that each object is detected in at least two if not 3 or 4 bands. This multiple wavelength detection ensures an even higher reliability than multiple passes for a single band. Therefore, *GLIMPSE should have at least three working IRAC bands.* However, this is a softer requirement than many others, since high reliability may be achievable by combining 2MASS data with only two IRAC bands, though at a considerable loss in ability to see through dust.

6. Sensitivity: The high sensitivity of IRAC and *Spitzer* mean that toward the Galactic plane, GLIMPSE will be mostly confusion-limited. *GLIMPSE should be sensitive enough to reach the confusion limit in the Galactic plane (~ 0.7 mJy, $m \sim 14$) in Band 1 and ~ 1 mJy, $m \sim 12$ in Band 4. In some regions (near hot embedded stars), the background limit will be reached in Band 4.*

7. Photometric Accuracy: GLIMPSE Catalog sources and mosaic images must contain accurate flux information if colors and magnitudes of the target objects are to be properly interpreted and/or modeled. Our modeling of the effects of various levels of accuracy suggests that a photometric accuracy of ±0.2 mag will likely be attained in Bands 1 and 2, and ±0.3 mag in Bands 3 and 4. This is accurate enough

to allow color separations for many types of objects. Based on the need to separate different object types using color-color and color-magnitude diagrams drawn from IRAC band magnitudes. *GLIMPSE photometry should be accurate to 0.2 mag or better in Bands 1 and 2, and 0.3 mag in Bands 3 and 4.*

8. Completeness/Reliabilty: A survey should not miss or wrongly characterize significant numbers or types of objects. However, the bright, patchy Galactic background of blended stars and extended structures make achieving these goals more difficult for GLIMPSE than for directions far away from the Galactic plane. The main goal of the *GLIMPSE* Point Source Catalog is to achieve $\geq$ 99.5% reliability when each point in the survey are is observed only twice in each of the 4 IRAC bands.

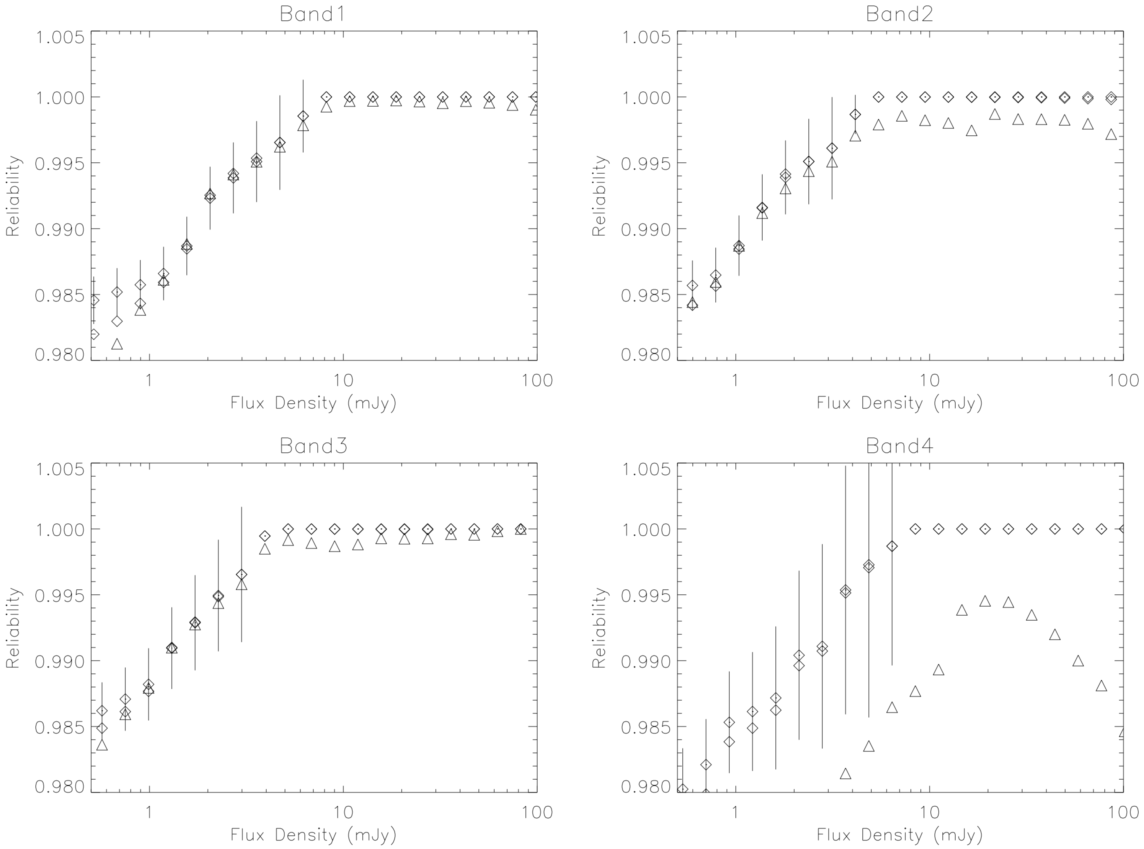

Fig. 8.— The reliability of a GLIMPSE catalog using an external truth table and three different catalog criteria. The catalog criteria are 2+2 (+), 2+1 (◇) and 2+0 (△).

To estimate the completeness and reliability of *GLIMPSE* , we have used the ISDS (IRAC Science Data Software) (Ashby, priv comm.) to create simulated IRAC data for the *GLIMPSE* OSV region. The input data consisted of point sources taken from the 2MASS catalog, with fluxes adjusted to match expected fluxes in IRAC bands. Additional bright sources (not included in the current 2MASS release) and an extrapolation to faint point sources were also added. Diffuse background was taken from MSX data (after point source extraction and smoothing). The ISDS was used to simulate the effects of Poisson noise, pointing error, muxbleed, saturation, and other instrumental effects. Banding was also added to channels 3 and 4 using BRUTUS chamber data (Megeath, priv. comm.)

A “truthlist” was taken from the input data, and then compared with the point source list obtained by processing the data in the *GLIMPSE* pipeline. Several different selection criteria were tried: requiring two detections in a single band only (“2+0”), requiring two detections in a single band and one detection in an adjacent band (“2+1”), and requiring two detections in a single band and two detections in an adjacent band (“2+2”). As shown in Figure 8 we find that the “2+1” results in a $\geq$ 99.5% reliability at flux levels of $\sim$ 3 mJy in all four bands. The completeness is shown in Figure 9. More details concerning completeness and reliability will be published by Watson et al (2004).

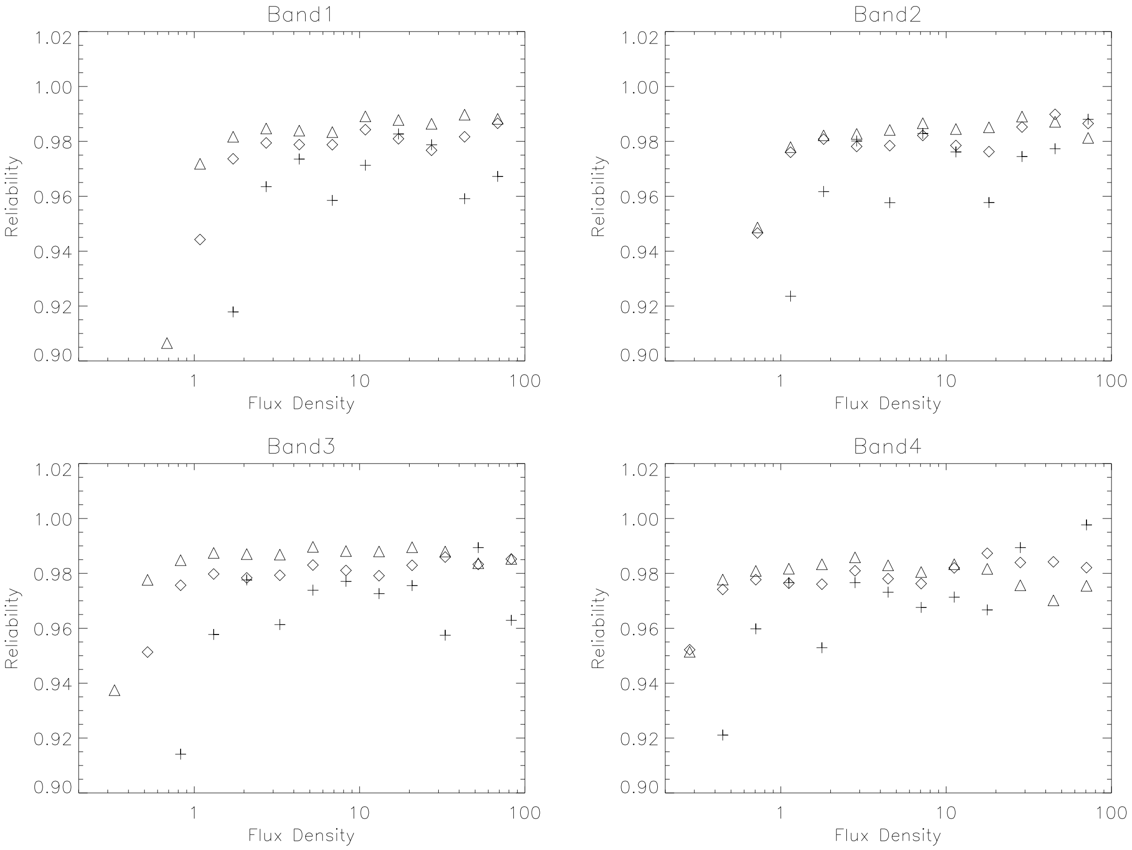

Fig. 9.— The completeness of a GLIMPSE catalog using an external truth table and three different catalog criteria. The catalog criteria are 2+2 (+), 2+1 (◇) and 2+x (△), as described in the text.

5. Summary

The *GLIMPSE* project will permit us to study, for the first time, the stellar content of the inner Galaxy with high angular resolution and a minimum of extinction. The *GLIMPSE* team and others will use these data to study Galactic stellar structure, characterizing the stellar content and star formation in the Galactic bar and inner spiral arms. It may allow us to ascertain whether the Galaxy is a ringed spiral. In addition, the data will be used to study the distribution and statistics of star formation throughout the Galaxy.

The survey will use the IRAC instrument on *Spitzer* to image 220 square degrees in four bands (3.6,4.5,5.8, and 8.0 μm) with a pixel resolution of 1.2$''$. It will cover two strips spanned by $|b| \leq 1^\circ$ and $|l| = 10^\circ$ to 65°, a region covering the outer ends of the Galactic bar, the Molecular ring, and four spiral arm tangencies. The resulting dataset will be the most panoramic produced by *Spitzer* .

The principal data products from the *GLIMPSE* team will be a high-reliability *GLIMPSE* Point Source Catalog (GPSC) with about ten million sources and approximate flux limit of ~ 3.0 mJy (3.6μm band) to ~ 4.0 mJy (8.0 μm band), a *GLIMPSE* Point Source Archive (GPSA) with about 50 million sources and an approximate flux limit of 0.2-0.4 mJy , a set of mosaicked images for each band, and a set of Web based analysis tools. The first release of the GPSC will be nine months after the launch of *Spitzer* , and the first installments of the GPSA and mosaicked images will be fifteen months after launch. These data products and the supporting documentation will be updated at six month intervals and will be complete 27 months after launch.

GLIMPSE data will drive a wide range of scientific investigations including the search for rare, bright Galactic objects, stellar population studies, studies of Galactic structure, high angular resolution studies of diffuse emission in PDRs, and studies of extinction in the near to mid-infrared. The science from *GLIMPSE* data will fuel many future observing programs and scientific investigations. The probability of serendipitous discoveries is high for the *GLIMPSE* survey. We expect that it will lead to the discovery of new stellar clusters and galaxies hidden behind what had previously been an impenetrable wall of dust. We eagerly look forward to providing this resource to the community.

This work has been supported by NASA contract 1224653. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, the NASA/IPAC Infrared Science Archive, which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA, and data products from the Midcourse Space Experiment. Processing of the Midcourse Space Experiment data was funded by the Ballistic Missile Defense Organization with additional support from NASA Office of Space Science.

A. Changes to text since Aug 2003 PASP article

Much of this document was originally published in *Publications of the Astronomical Society of the Pacific* (Benjamin et al 2003). Here we note differences and changes between that article and this document. Any corrections, suggested modifications, or questions should be mailed to Dr. Robert Benjamin (benjamir@uww.edu).

A.1. Major changes

1. Telescope name change: On Dec 18, 2003, SIRTF was renamed the *Spitzer Space Telescope* in honor of Prof. Lyman Spitzer, Jr. a pioneer in the study of the interstellar medium. Preferred usage is to simply refer to the telescope as *Spitzer* (as opposed to the acronym *SST*).
2. *GLIMPSE* Data Requirements: Section 4 added to give *GLIMPSE* data requirements and scientific justification for these requirements.

3. Completeness and Reliability: Figures added summarizing the completeness and reliability study for *GLIMPSE* using simulated data (Watson et al 2004). All of the tables (2, 3a, 3b) and text have been updated to incorporate these new "Reliability Limits" for the *GLIMPSE* point source catalog (called Completeness Limits in the original article). These estimates are based on synthetic data and will be tested by the OSV observations.

4. Sensitivity change in Bands 3 and 4: In-orbit characterization of IRAC indicates a loss of sensitivity in Bands 3 and 4. The 5 σ limits in these band have been adjusted, changing the values in Tables 2, 3a,3b and 4.

5. Expanded description of Observing Sratategy Validation: OSV section in Section 2.1 updated to include information about RCW49 and details of the OSV strategy and goals.

A.2. Minor changes

1. Number of Herbig-Haro objects in *GLIMPSE* area added to Table 1.

2. Minimum required photometric accuracy added to Table 2.

3. Table 3 (GLIMPSE Characteristics) table broken into two tables, one in flux units and one in magnitude units.

4. Timetable in Section 2.1 updated to give actual dates for data release schedule.

5. Visibility of Galactic plane figure (Fig 5) updated to show current plans for *GLIMPSE* observations.

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