SIRTF First Look Survey

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… and thanks to Debbie Padgett, Bill Latter, and Vikki Meadows for overheads

SIRTF Science

Some of the very basics:

- From our comfy perspective at home here on Earth
  - The Universe is generally very cold (“warm” is a relative concept…)
  - The Universe is generally very empty
  - The Universe is dusty (cough; hack!)
  - The Universe is very big – really, really big (and getting bigger)
  - The Universe is very old (and getting older)

- The speed of light is finite (about 300,000 km/s)
  - It takes measurable time for light from distant objects to reach us
  - The farther out we look, the further back in time we see
  - Telescopes are time machines

First Look Survey Overview

- What?
  - First science program executed after In-Orbit Check-out and Science Verification phases
  - 100 hours of Director's Discretionary time
  - Imaging surveys with IRAC and MIPS
  - Extragalactic, Galactic and Solar System
  - Fast data turn-around to the community
  - Carried out by the SIRTF Science Center

First Look Survey Overview

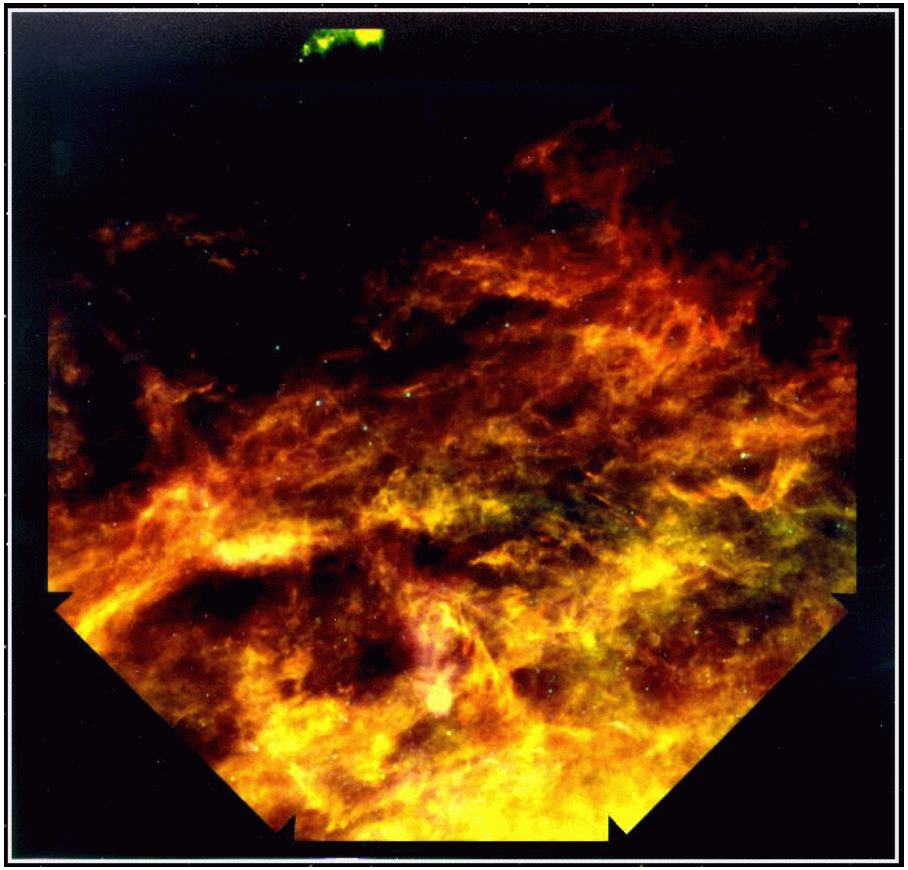
- Why?
  - WIRE (Wide Field Infrared Explorer) mission failed
    - Would have surveyed the sky at 12, 25 microns
  - How do we get the most out of SIRTF?
    → an early survey
- Primary Goals
  - Provide a characteristic "first-look" at the mid-infrared sky at sensitivities that are ~100 times deeper than previous systematic large-area surveys.
  - Rapidly process the data and place it into the public domain in time to impact early SIRTF investigations.

First Look Survey Goals

- Extragalactic Component
  - detect enough extragalactic sources at unexplored sensitivity levels in order to generate a representative sample and reduce uncertainties in the source counts
  - characterize the dominant source populations with MIPS and IRAC, plus ancillary optical, near-infrared, and radio data
  - explore the cirrus foreground at moderately high galactic latitudes, and its effect on point-source detectability

Infrared Cirrus

- IRAS image of the south ecliptic pole
- 12, 60, 100 microns (blue → red)
- Cirrus = interstellar dust grains heated by the ambient stellar radiation field



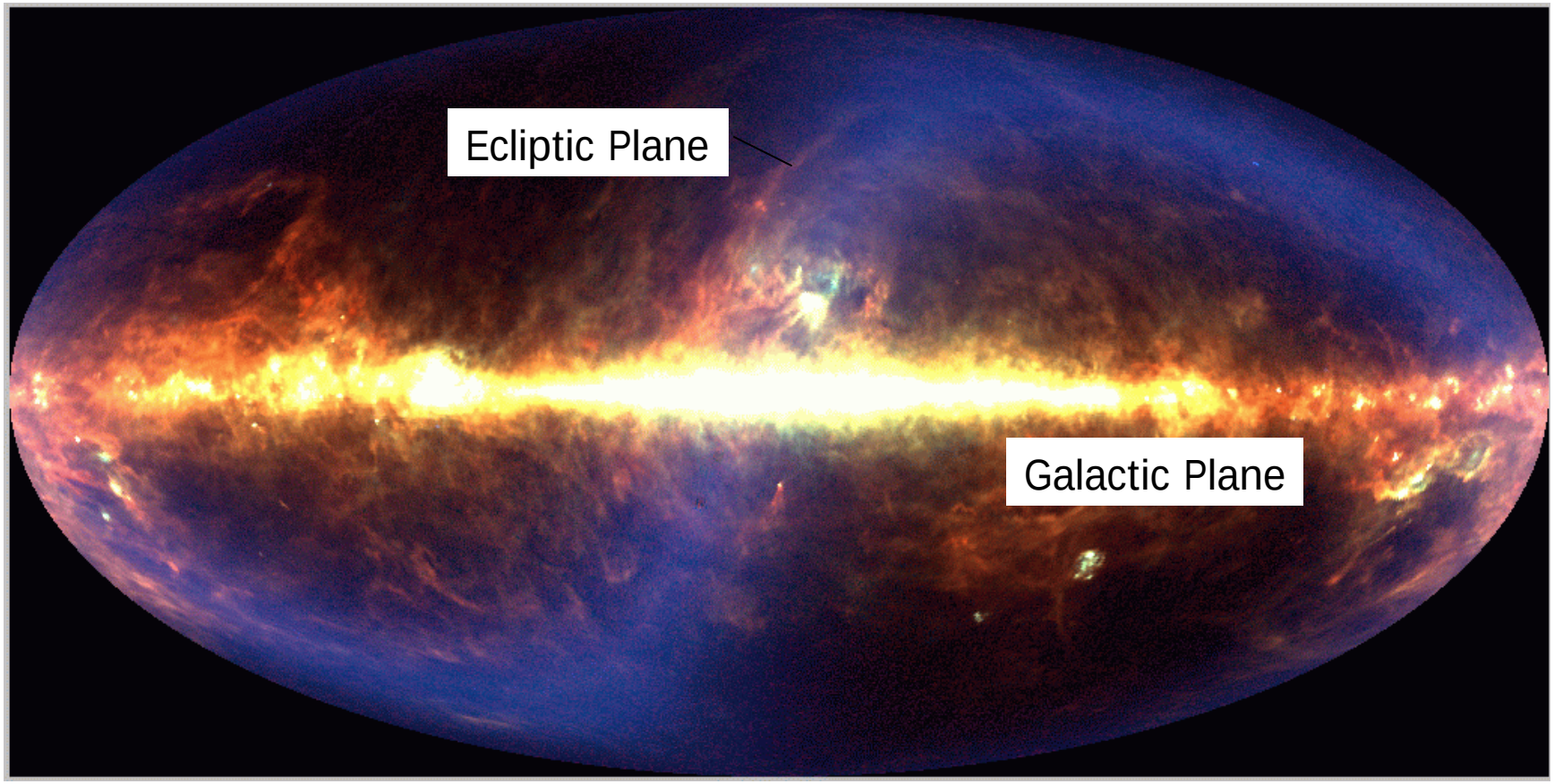
First Look Survey Goals

- Galactic Component
  - characterize the cirrus and background source counts at low galactic latitudes
  - characterize the internal cirrus and background source counts toward a molecular cloud
  - Determine effect of confusion upon extraction of faint point sources

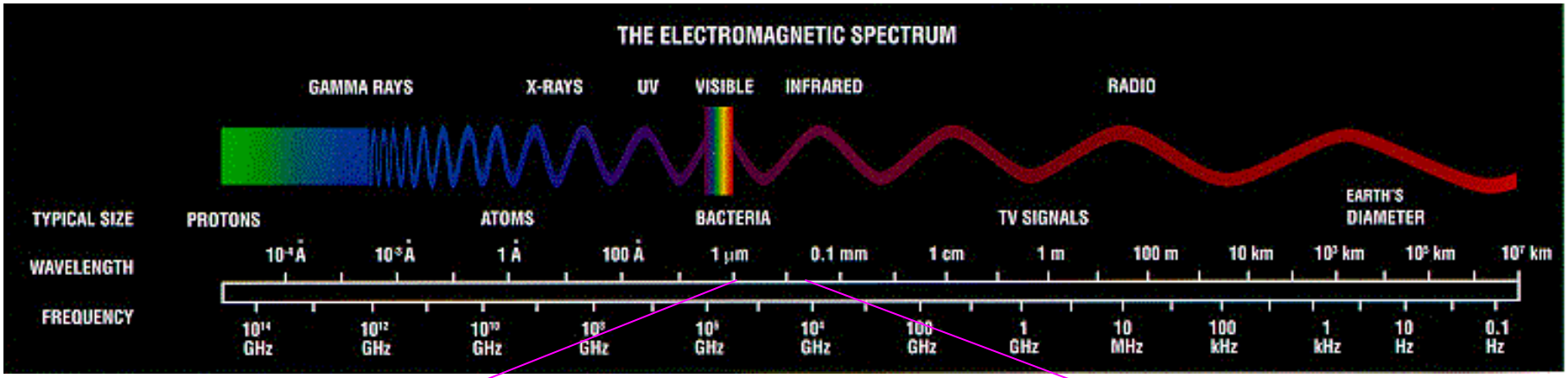
First Look Survey Goals

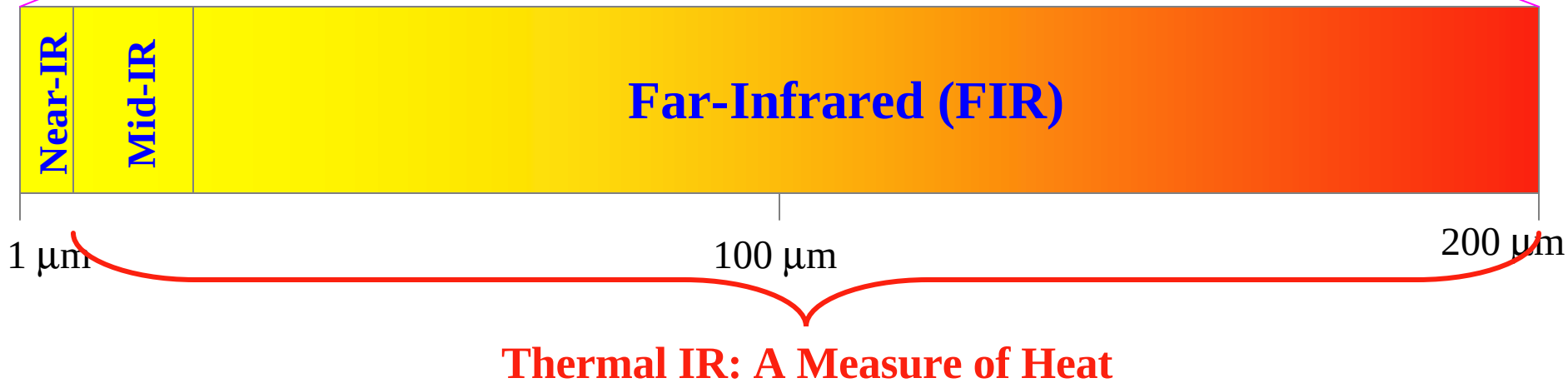
- Solar System Component
  - characterize the ecliptic plane and zodiacal light for solar system observations

All Sky Image – COBE
60-100-240 microns



The Electromagnetic Spectrum (Standard Version)





What will we see?

- **The Universe is Cool**

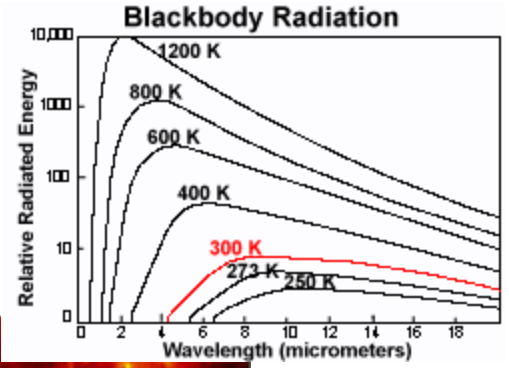
  Unlike stars, most objects in the universe – such as planets and interstellar gas & dust – are too cool to emit visible light but can be detected in the infrared.

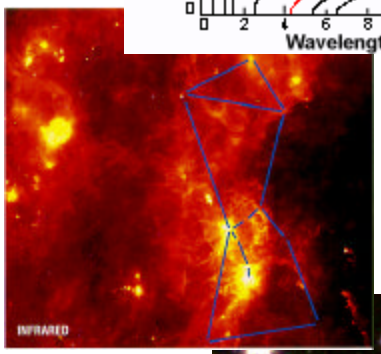
- **The Universe is Dusty**

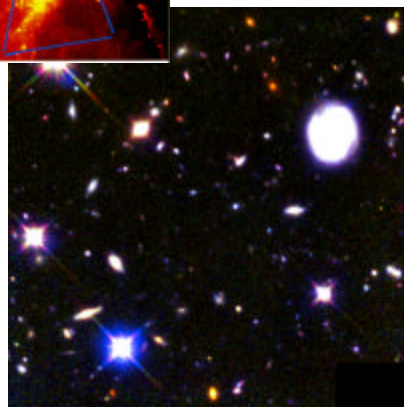
  Cosmic dust grains absorb visible and UV light, warm up, and re-emit lower-energy light in the infrared.

- **The Universe is Expanding**

  The visible-light radiation emitted by distant objects is red-shifted into the infrared region when observed from the Solar System.







The Milky Way

Visible Light

Near-Infrared (COBE)

Far-Infrared (IRAS)

Electromagnetic Spectrum

(Pasadena/Tucson Version)

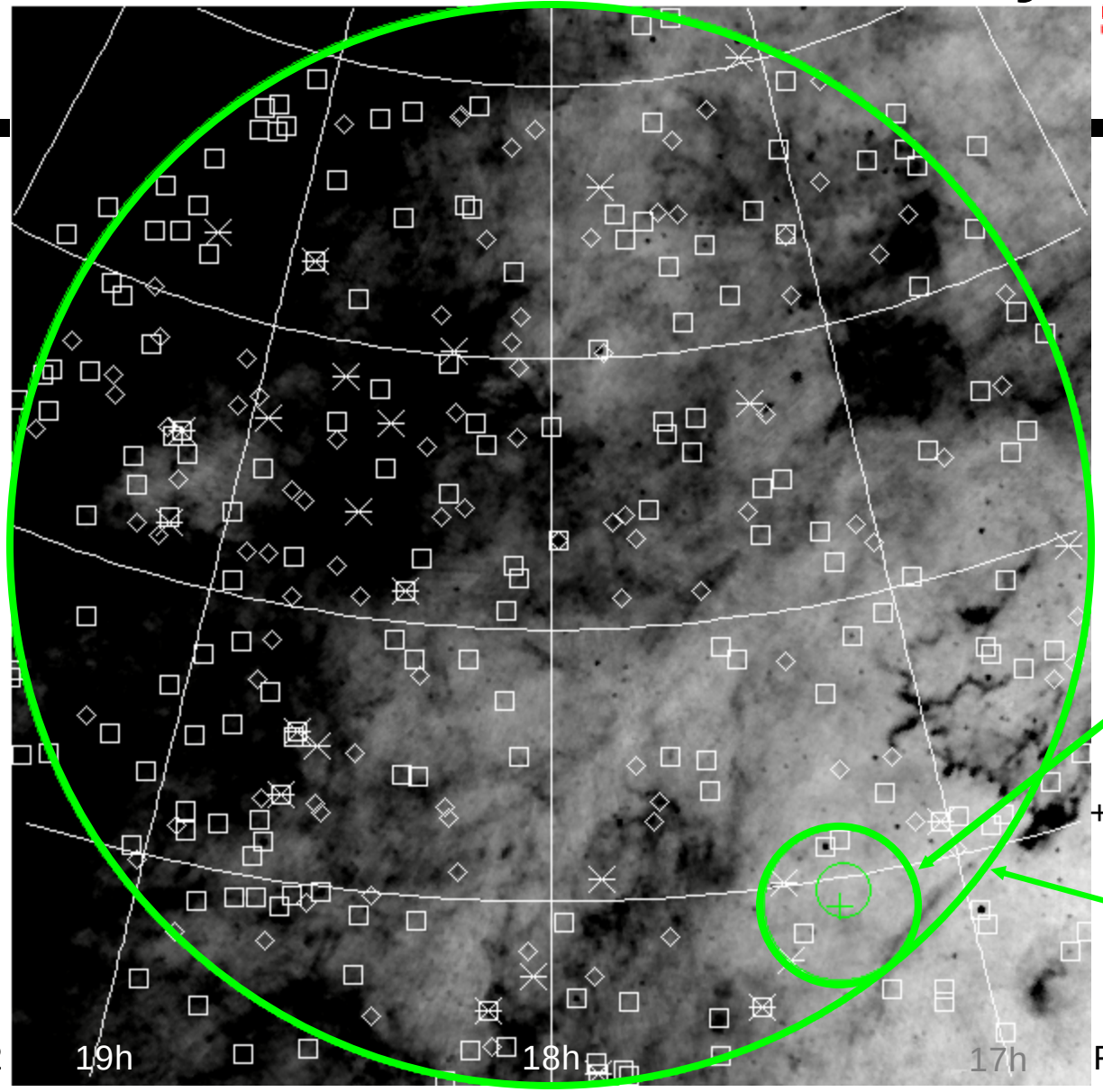
Extragalactic Component

- Main Survey
  - 5 sq degrees in SIRTF Continuous Viewing Zone Centered at 17h18m00s +59d30m00s, 2° x 2.5°
  - Map with MIPS (2x40 sec) and IRAC (5x12 sec)
- Verification Survey
  - Cover a few percent of main survey area with greater redundancy
  - 5-10 times greater redundancy, exposure time
  - 0.75° x 0.3° strip centered at 17h17m00s, +59d45m00s
- Orientation depends on observation date

Ancillary Data

- NOAO: R-band MOSAIC @ Kitt Peak 4m
  - 9 square degrees to R~25.5 (5σ, 2” aperture)
- Sloan Digital Sky Survey:
  - SDSS Early Data Release
  - 5 bands, u’g’i’r’z’
- VLA – radio data (1.4 GHz/20 cm)
  - 5 square degrees to 90 μJy (5σ)
- NOAO: K-band FLAMINGOS @ Kitt Peak 2.1m
  - 1 square degrees to K’~19.5 (5σ, 2” aperture)
- Palomar 200”: optical imaging (g’i’), 1.5 sq. deg.

Location of Main Survey



Legend:

Box = Bright IRAS source

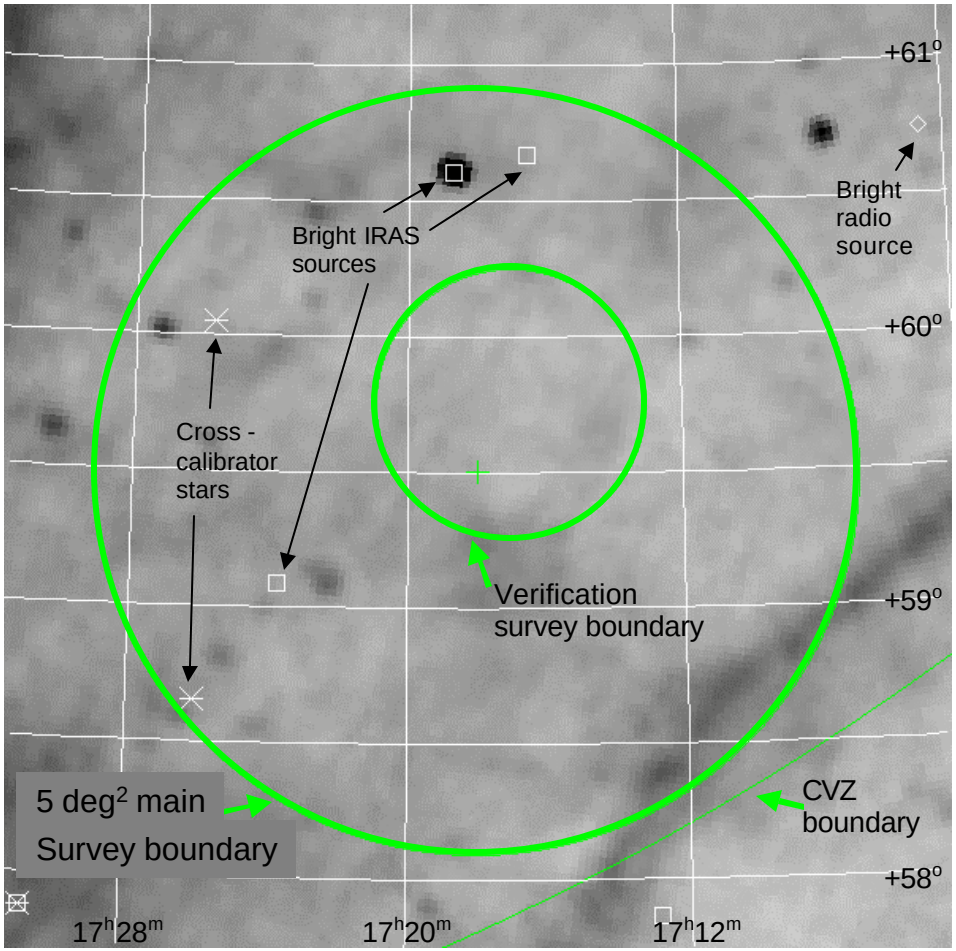
Diamond=Bright radio source

CVZ=continuous viewing zone

May 31, 2002

FLS 16

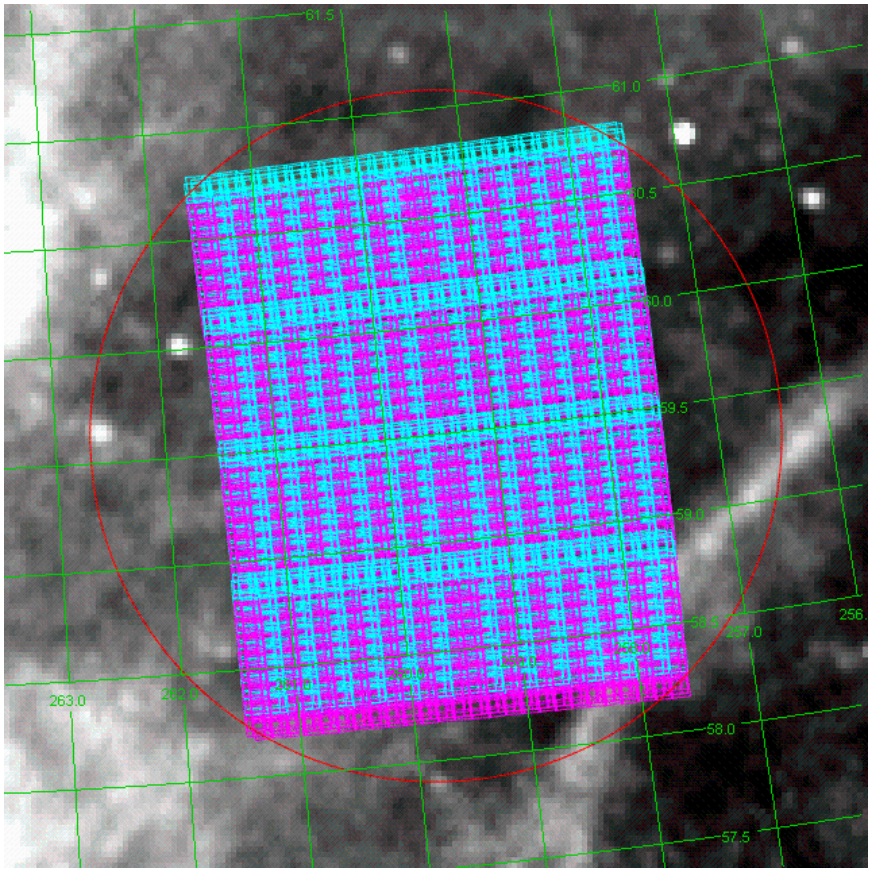
Extragalactic Survey



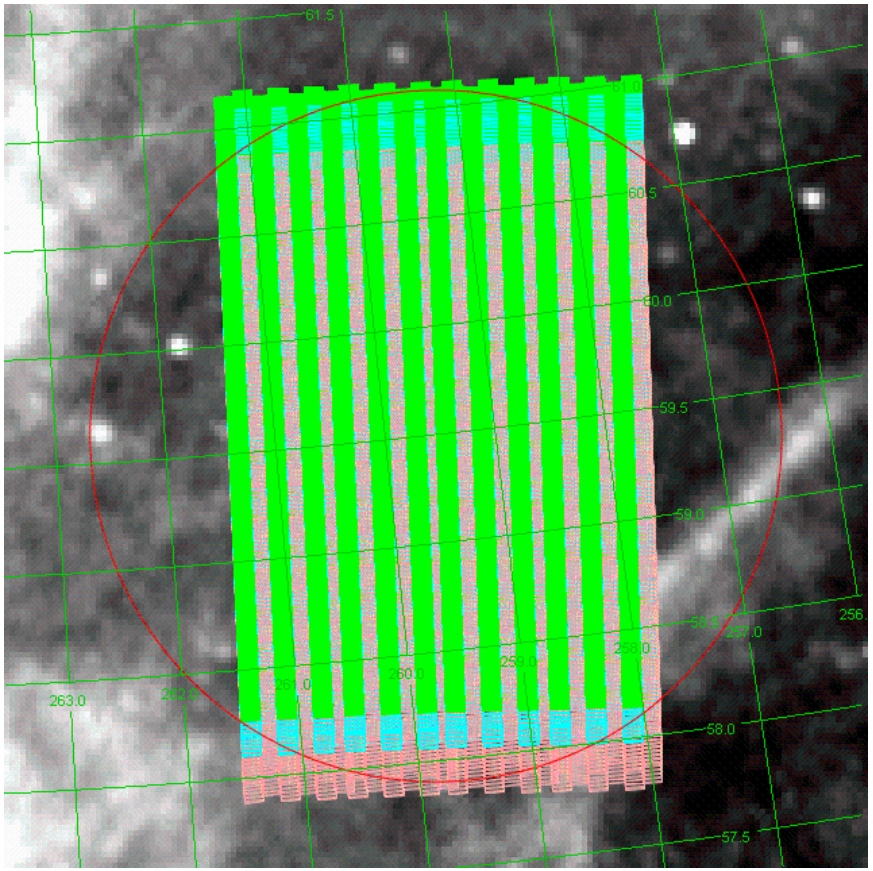
- Large green circle shows boundary of main survey
- Smaller green circle shows boundary of verification survey (20’ wide strip whose orientation depends on date)
- Includes lowest cirrus region in north CVZ

March, 2003

IRAC



MIPS



Ancillary Observations

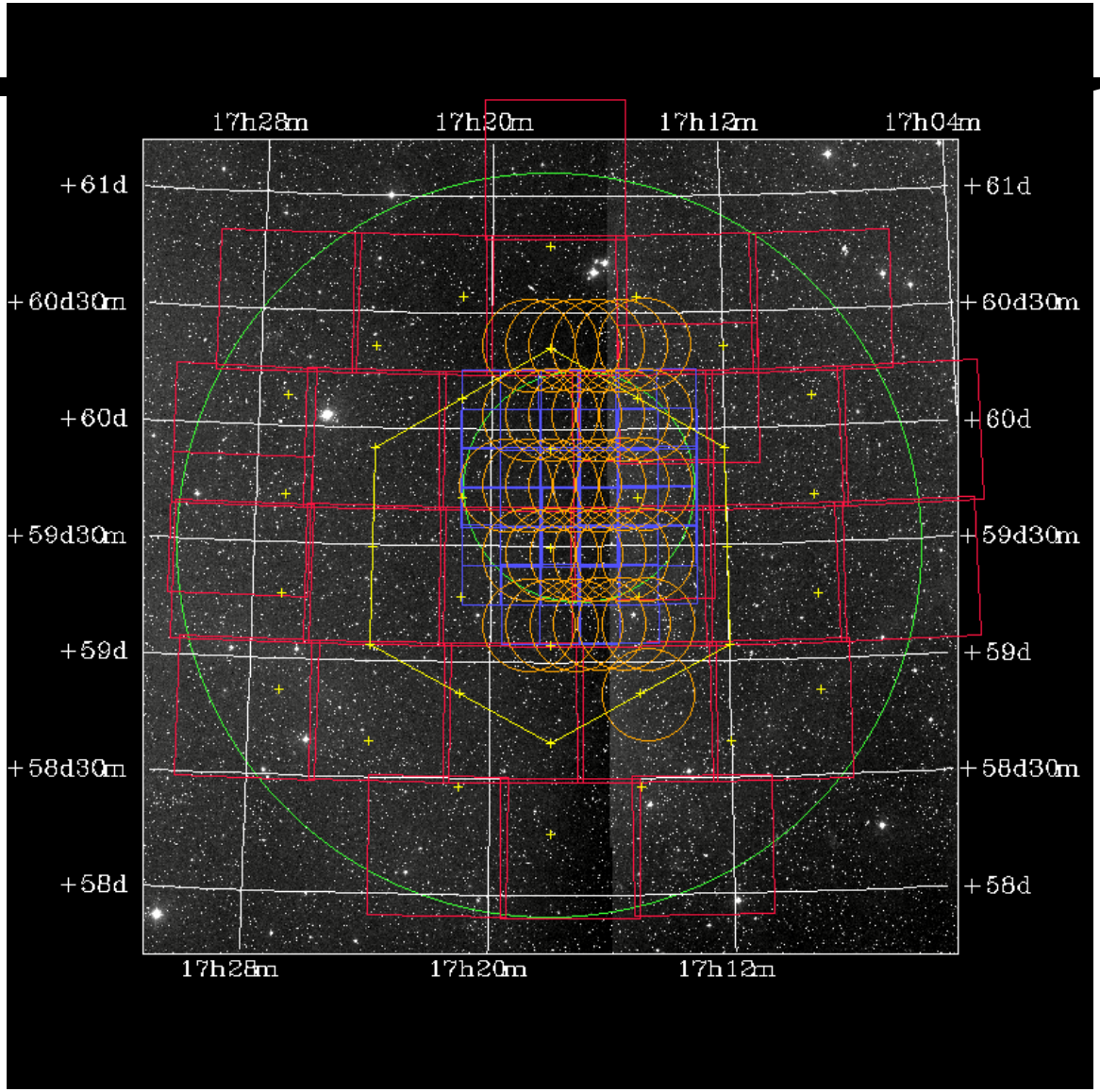
LEGEND:

R – Kitt Peak (red)

VLA 20 cm (yellow)

K’ – Kitt Peak (blue)

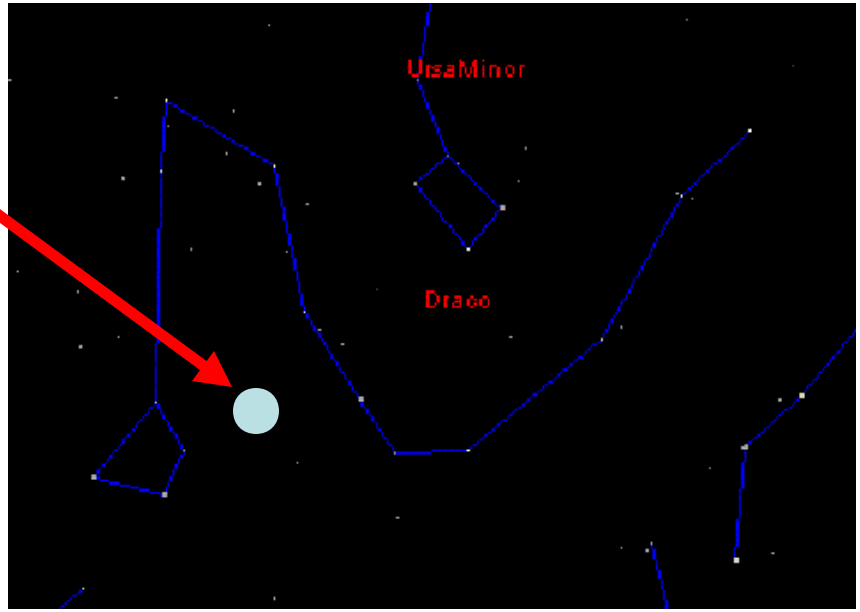
g’i’ – Palomar (orange)



May 31, 2002

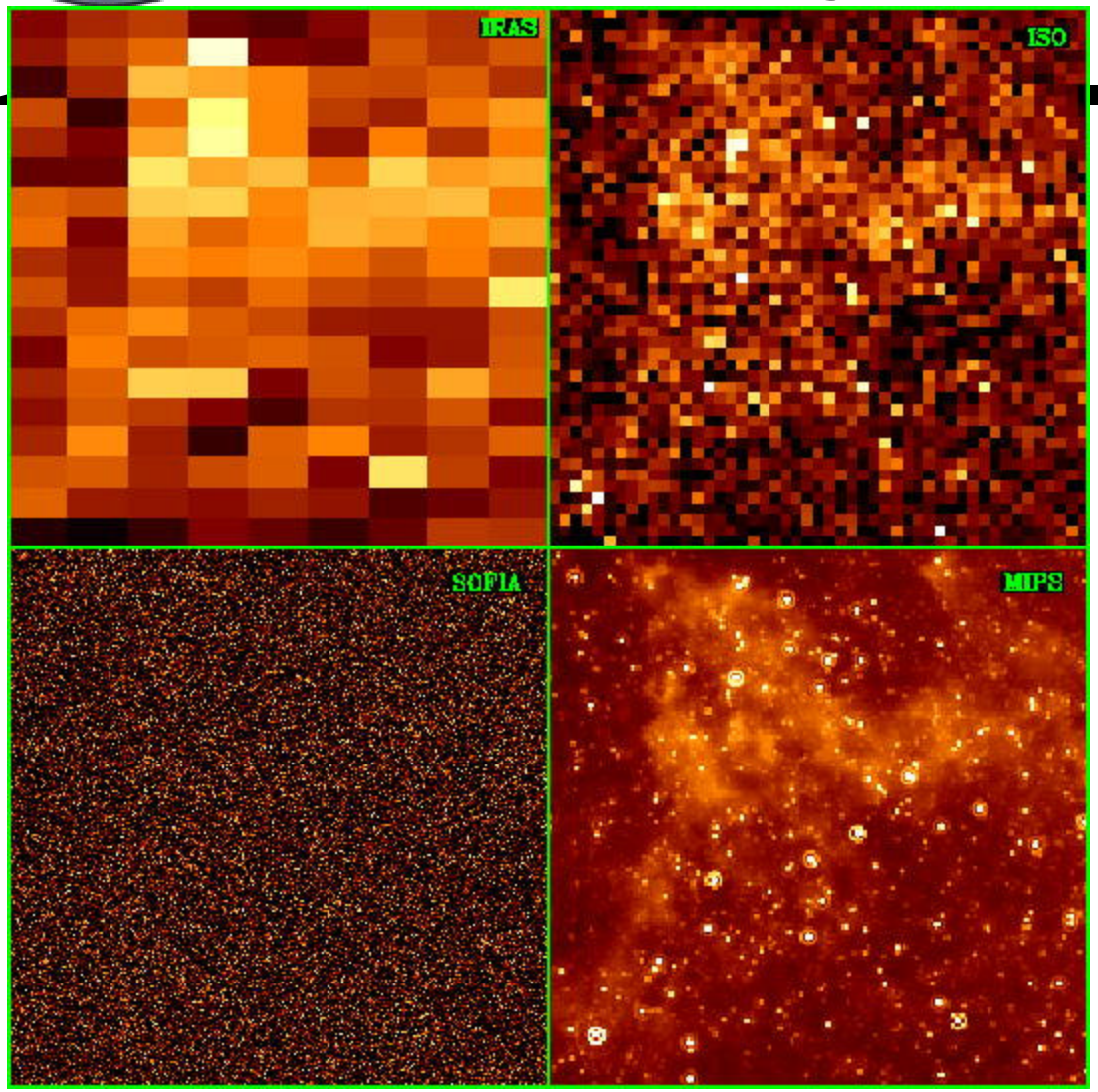
Back-yard Astronomy

SIRTF will be pointing here, in the constellation DRACO



http://www.astro.wisc.edu/~dolan/constellations/java/Draco.html

Discovery Potential

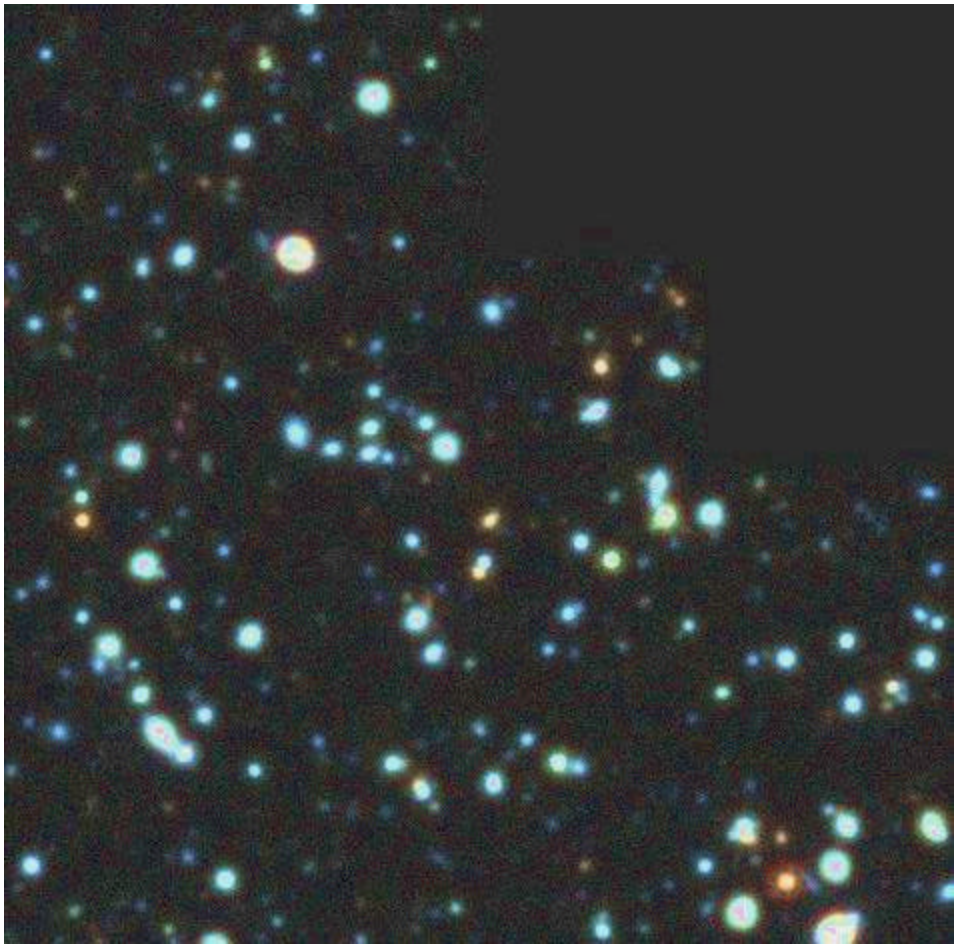


The MIPS 70 micron sky

These are logarithmically scaled versions of comparison images generated for MIPS, SOFIA, ISO, and IRAS. A test field was "observed" with with each instrument for 24 hours, taking into account sensitivity, image scale, and field of view. The IRAS image has very large pixels and is really only capable of detecting the infrared cirrus in this field. The ISO image has better spatial resolution but is limited by the small field-of-view and low sensitivity of the arrays. SOFIA has excellent spatial resolution but a correspondingly small field-of-view and is limited in sensitivity because it uses warm optics.

Courtesy of Chad Engelbracht

Discovery Potential



IRAC Simulation
GOODS Legacy Program

This shows a simulated IRAC observation of the Hubble Deep Field with 100 hours of exposure time in each of the four band passes, 3.6, 4.5, 5.8 and 8.0 microns. Galaxies at redshifts z > 2.5 are recognizable by their red IRAC colors.

From the GOODS web page,
www.stsci.edu/science/goods/simulation.html

Initial Science Drivers

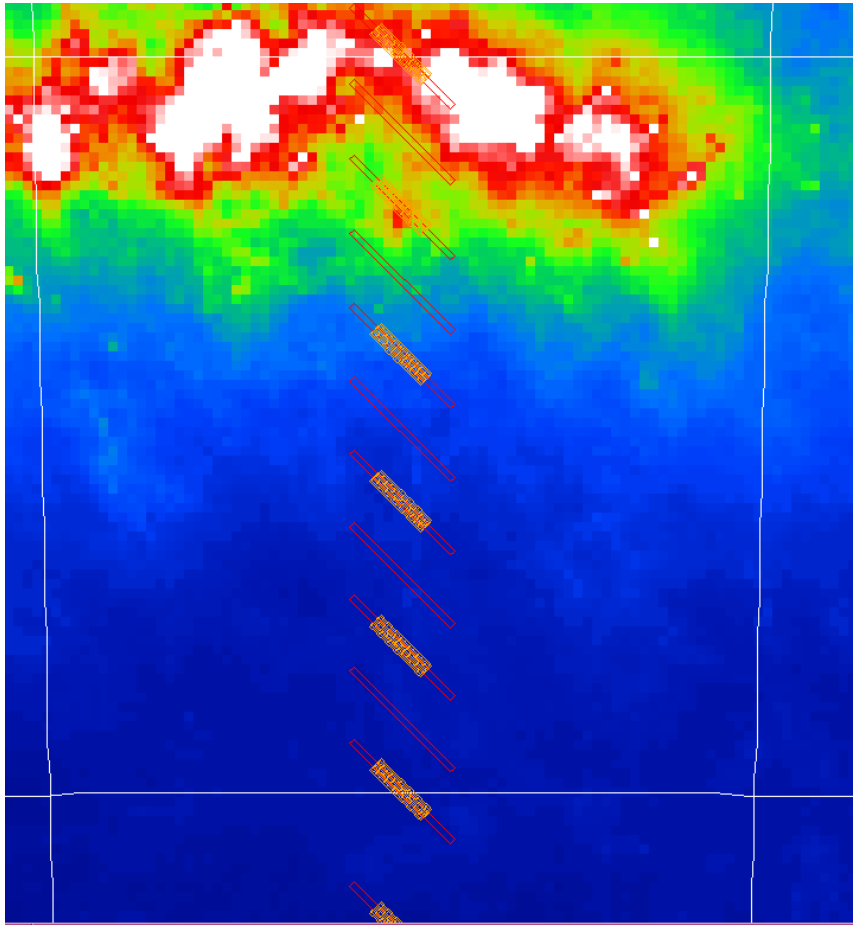
- Census of Galaxies selected in mid-IR
  - characterize dominant populations
- Compare galaxy distance/age determination with/without SIRTF data
- Large survey of ‘extremely red objects’
  - Old galaxies? Active galaxies?
- Surprises … this is a survey

Galactic Component

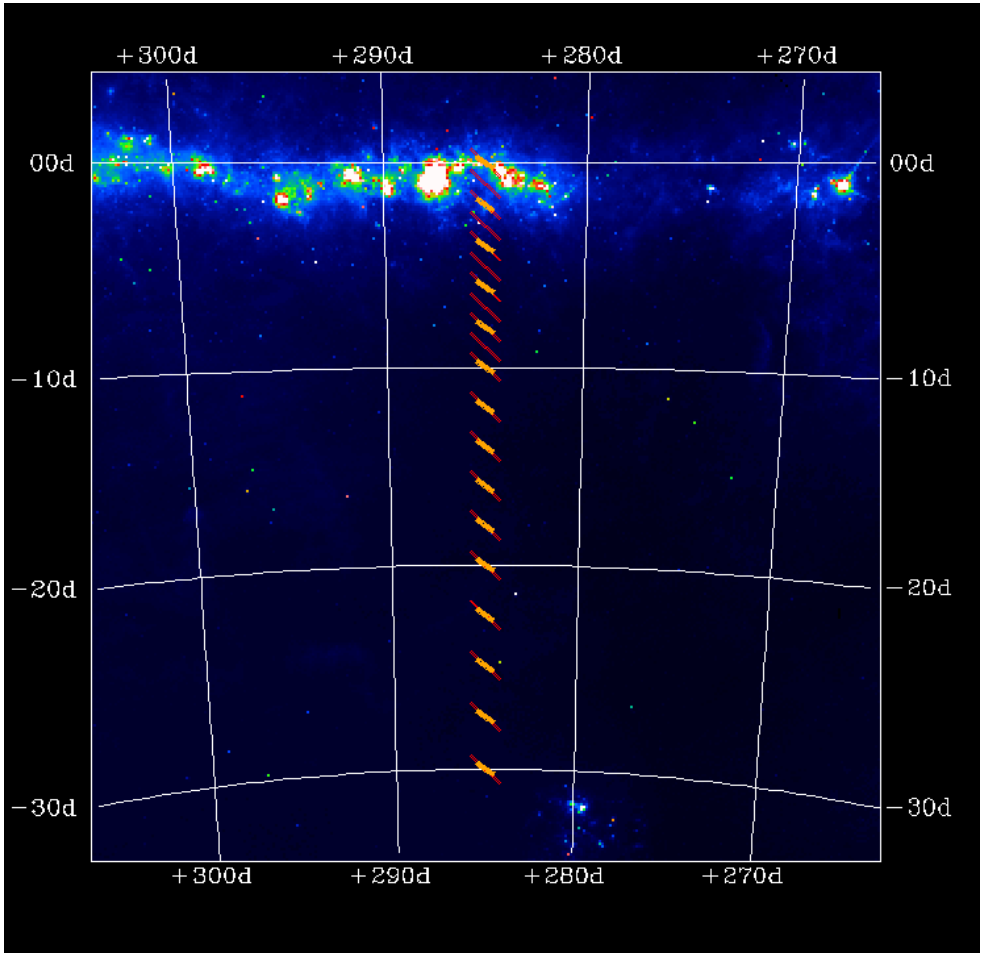
- What are the size scale and amplitude of fluctuations in cirrus when viewed at SIRTF resolution and sensitivity?
- How do these fluctuations depend on cirrus brightness levels?
- What are the mid-IR/far-IR point source confusion levels for SIRTF at varying galactic latitudes?

Galactic Plane Scans

- MIPS scan perpendicular to galactic plane
- Sparse IRAC mapping of region scanned by MIPS
- Two galactic longitudes
  - lon = 285, scan from latitude 0° to -30°
  - lon = 150, scan from latitude 0° to +10°



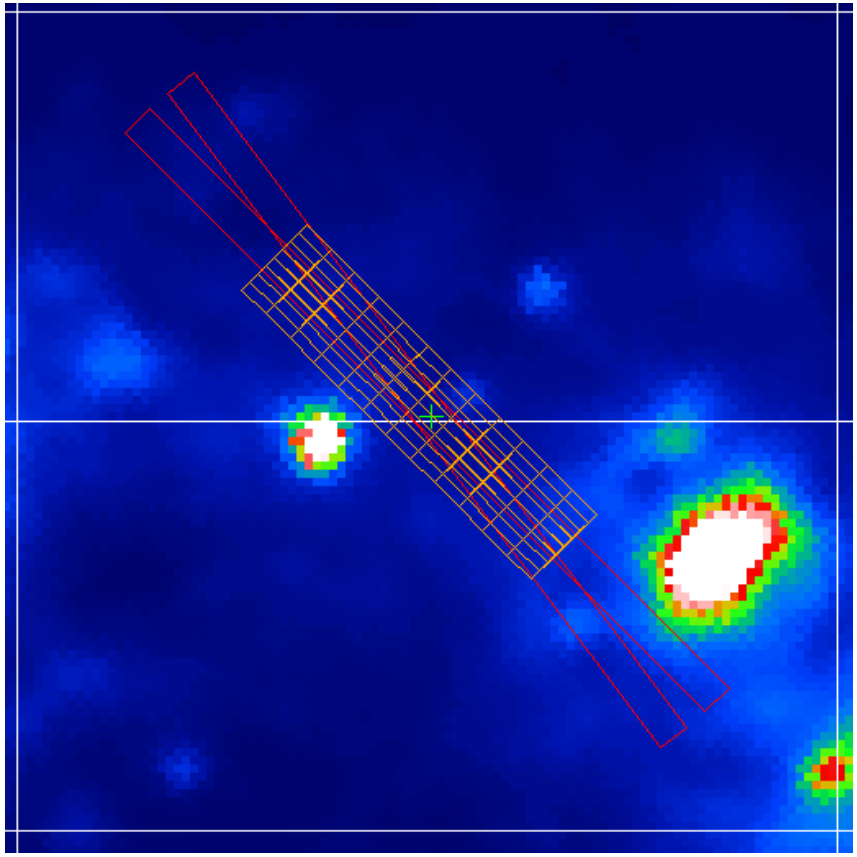
Longitude 285° Scan



25 μm IRAS image

Non-simultaneous MIPS and IRAC Observations

- Red rectangle is MIPS strip; orange grid is IRAC map
- 10 degree rotation of MIPS strip shown
- Array directions rotate between dates of observation by about 1 degree per day near ecliptic pole

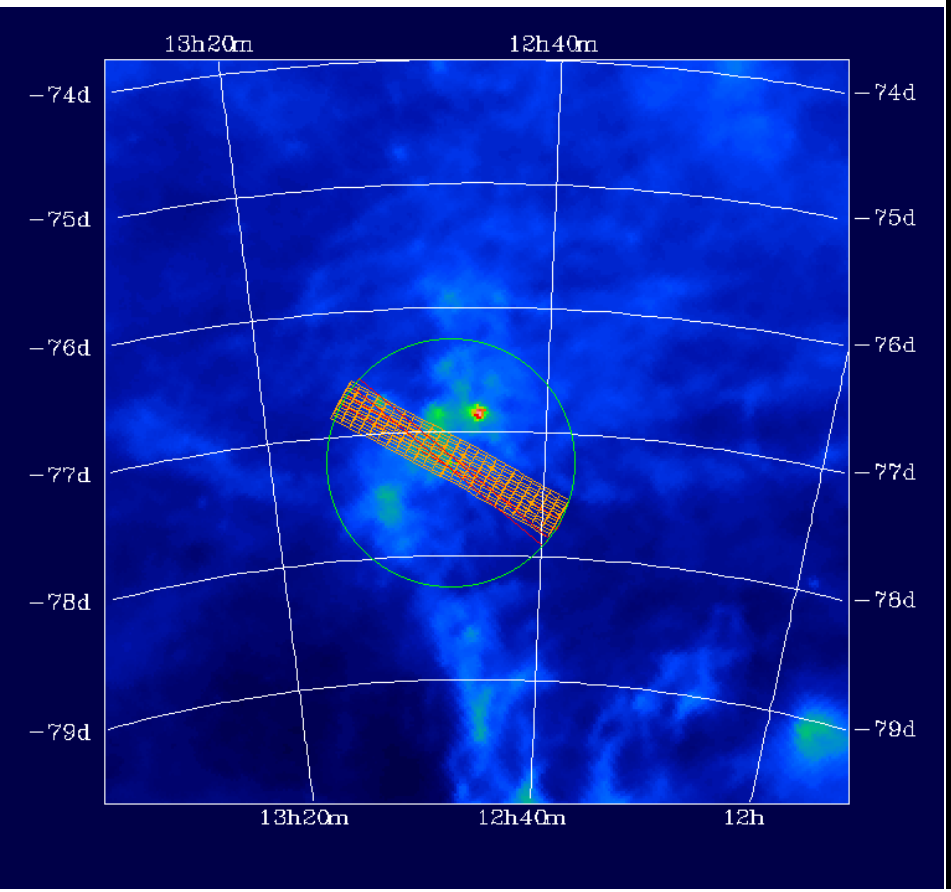


Molecular Cloud Scan

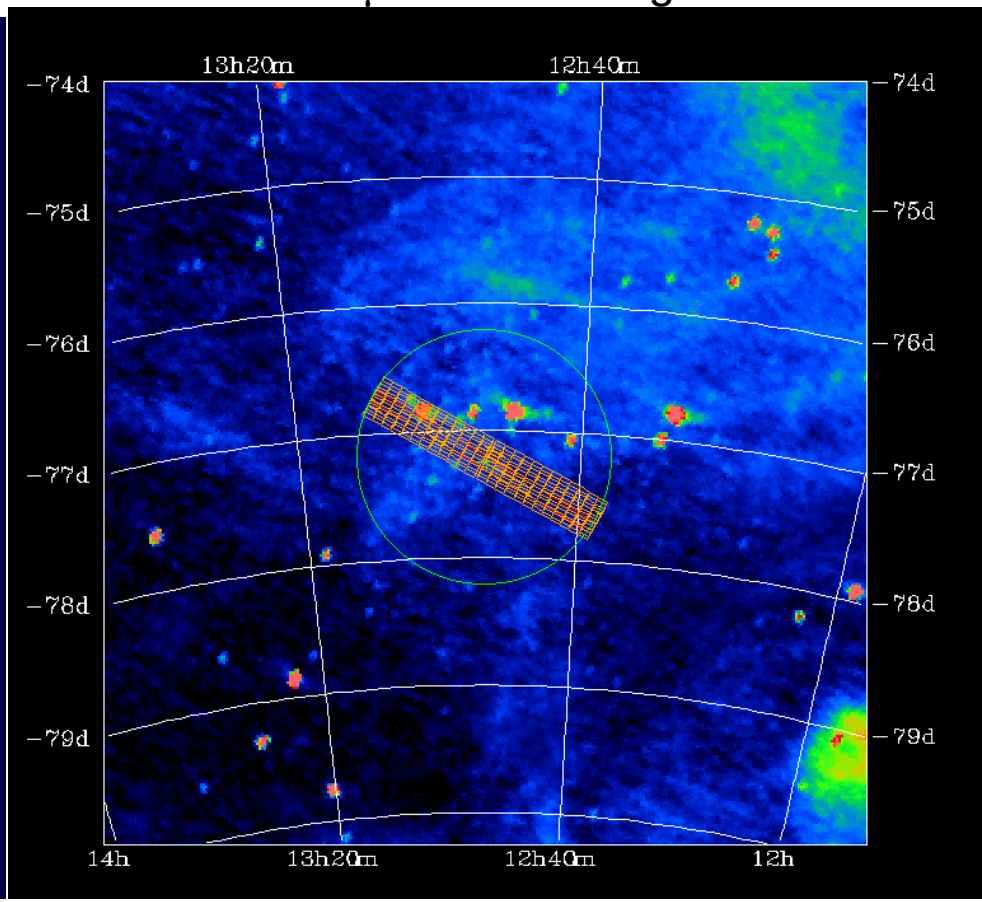
- ~30 young stellar objects known here
- Two degree MIPS scan through Chamaeleon II cloud
- MIPS scan should be half-on and half-off the cloud to check contamination by background stars
- IRAC imaging along strip considerably deeper than for galactic strips

Chamaeleon II Scans

100 μm IRAS image



25 μm IRAS image



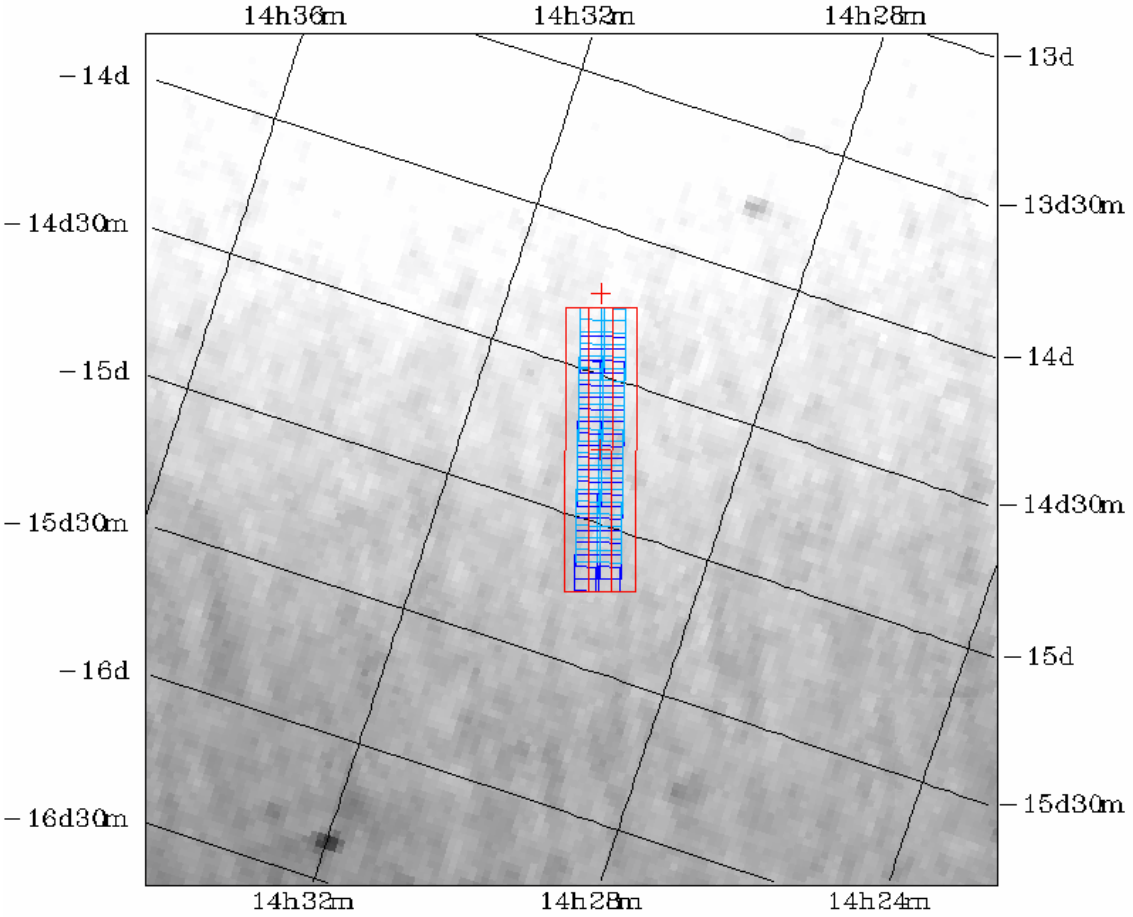
Ecliptic Plane Survey

- Goals: Monitor the moving object population at 8, 24 μm
  - targets Main Belt Asteroids between 2 and 4 astronomical units
  - sensitive to objects with diameters < 1km
  - includes scan strip to help characterize zodiacal light
- Main component consists of two 0.13 sq. deg. fields
  - centered at ecliptic latitudes 0° and 5°
    - two fields for scale height determination
  - between 110-120° solar elongation
    - tunes asteroid motion to 5- 40”/hr (10”/hr median)
  - pointing back towards the Earth
    - increases ground-based “follow-up” season
- Optical follow-up is required to maximize science return
  - thermal properties, diameters, orbits

Ecliptic Plane Survey

- Asteroids – detect with 3 IRAC passes
- One wider-area pass performed consecutively with MIPS
  - wider area compensates for possible loss of moving IRAC sources
- Zodiacal Light -- MIPS fast scan
  - latitude -2° to +8° to map zodiacal light
  - runs through the asteroid fields

Ecliptic Plane Survey



Summary

- First Look Survey: characterize the mid-infrared sky
- ~100 hours
  - 60 extragalactic
  - 26 galactic
  - 14 solar system
- First Look Survey will provide an excellent start to the SIRTF science program

In the constellation DRACO