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SIRTF:
The Last Great Observatory

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Themes of Infrared Astronomy

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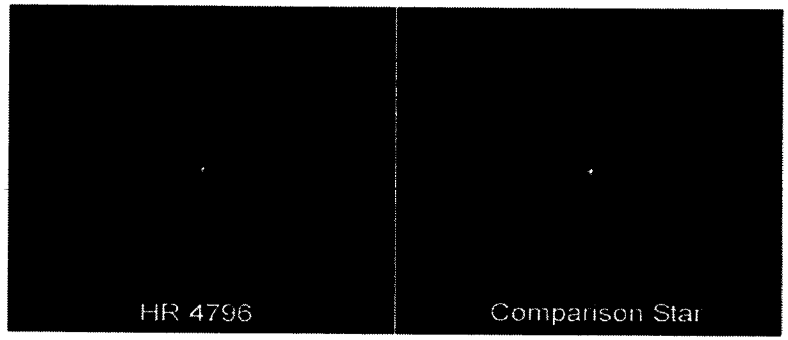
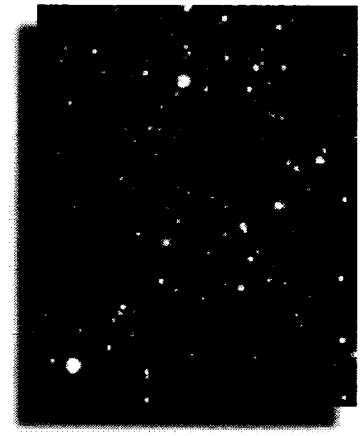
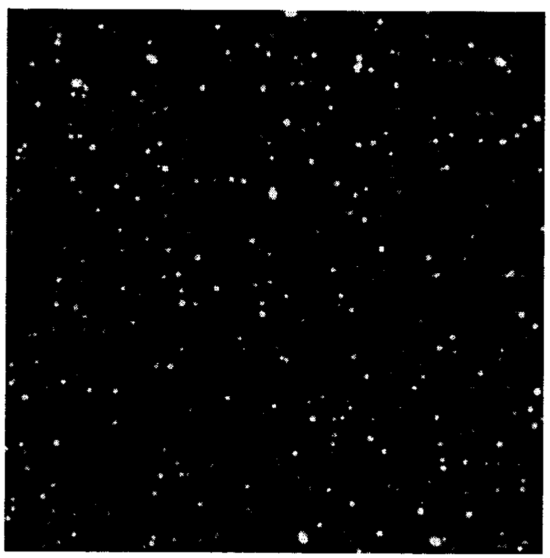
Infrared Observations Probe:



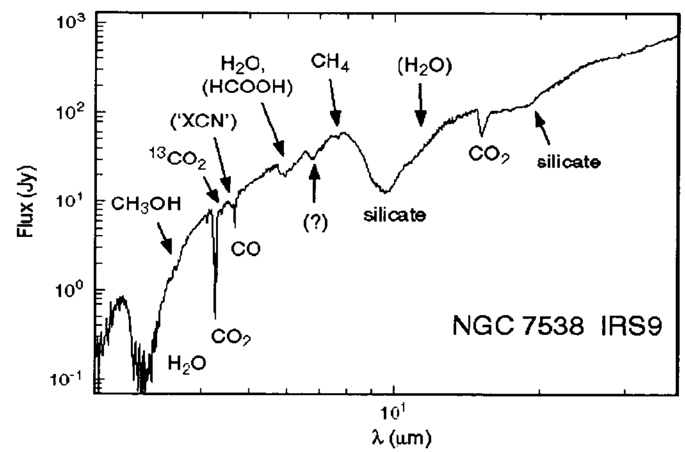
- **The Cold Universe**



- **The Dusty Universe**



- **The Distant Universe**



- **The Chemical Universe**

Advantages of Space

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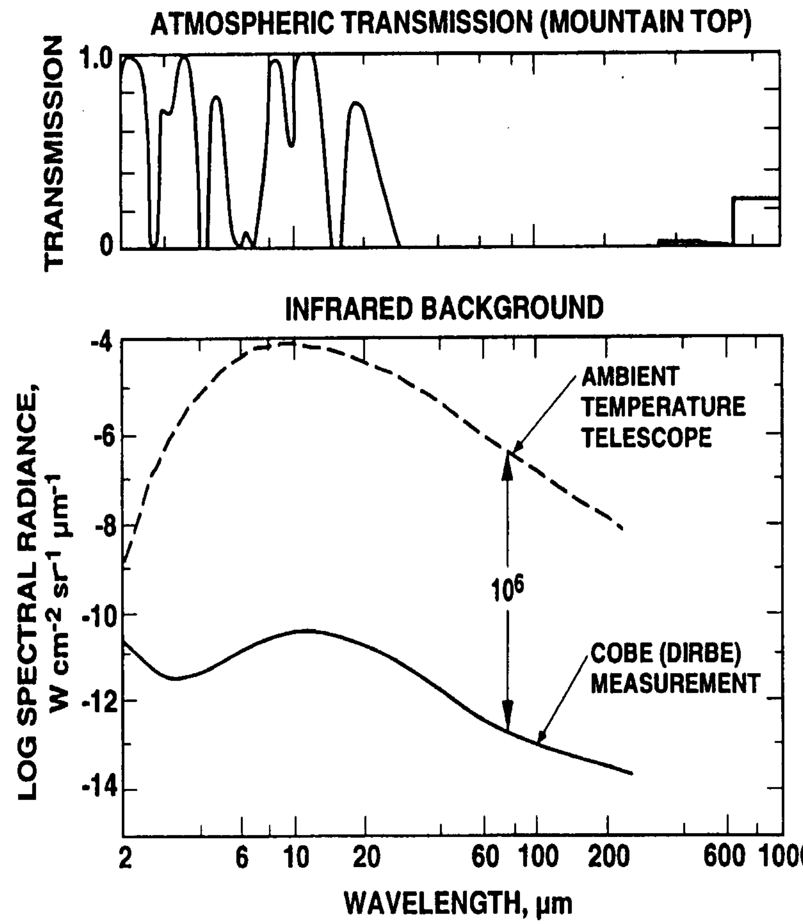
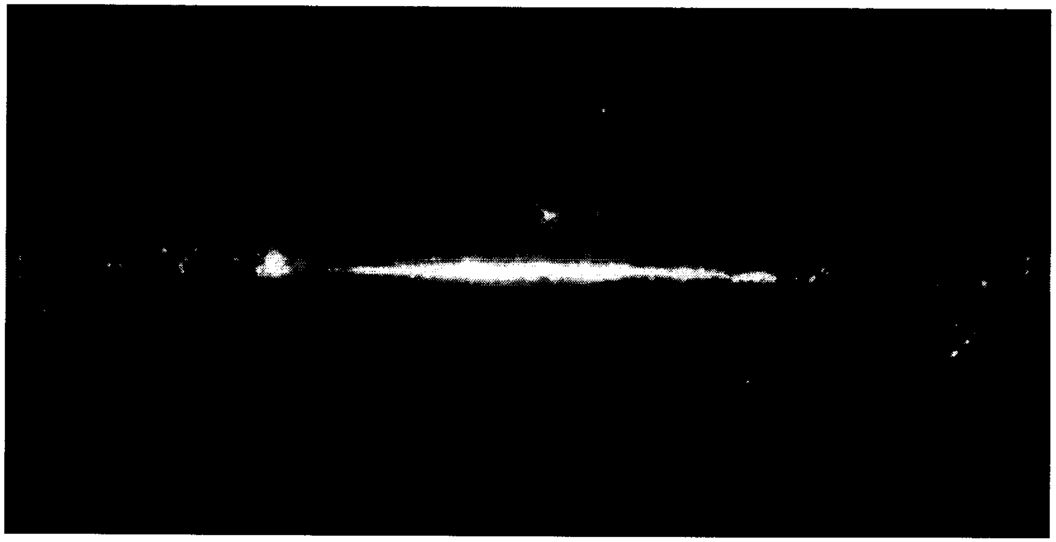
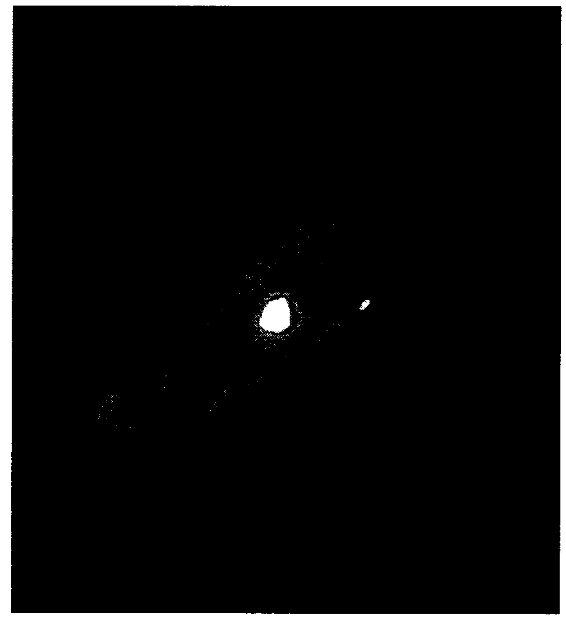
- Elimination of Atmospheric Absorption
    - Virtually entire far-infrared and submillimeter is inaccessible from the ground
- 1,000,000-fold Reduction in Background with a corresponding reduction in integration time
    - Photon noise is proportional to $(\text{background})^{1/2}$
    - Integration time is proportional to noise^2

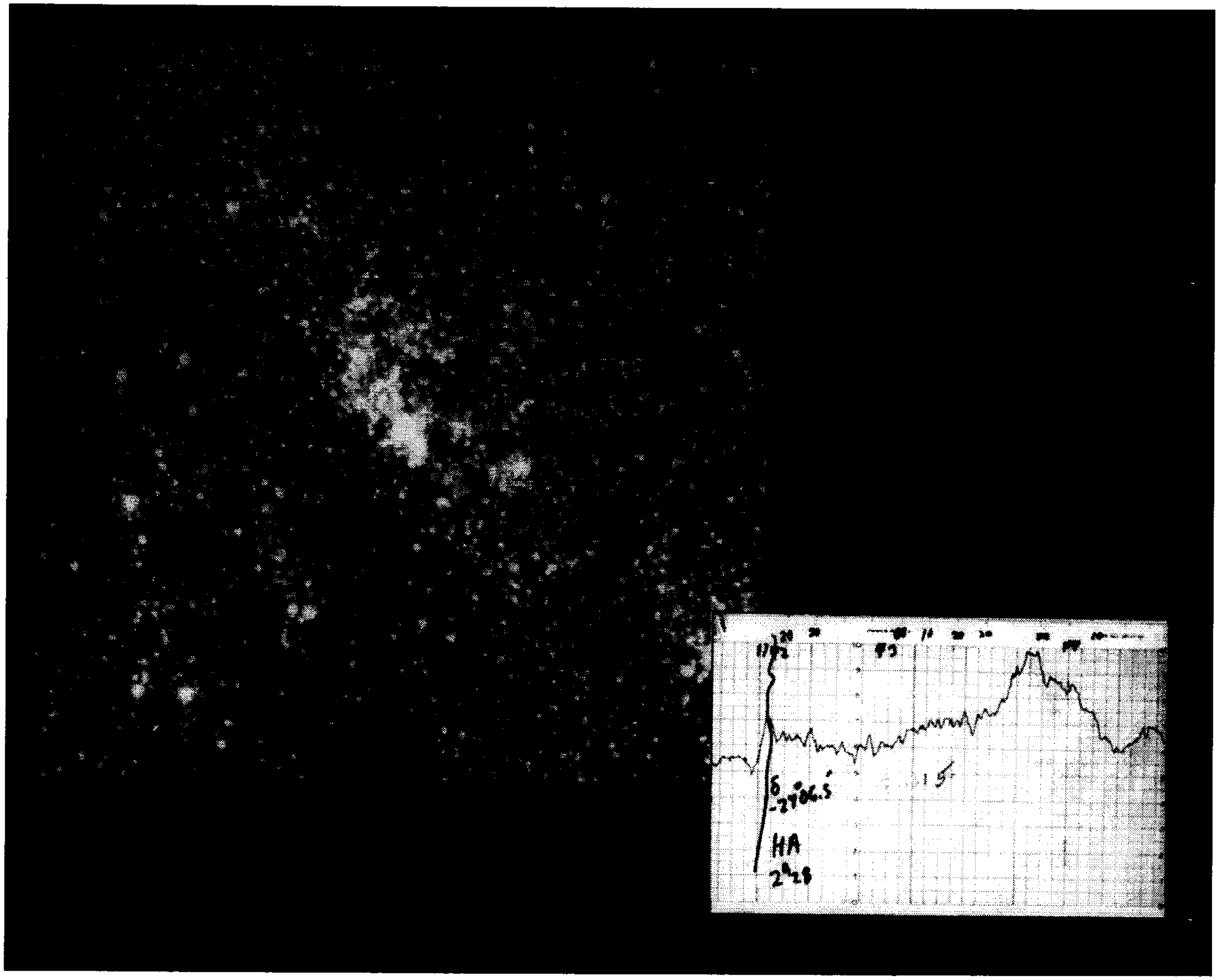


IRAS Legacy





The Infrared Array Revolution



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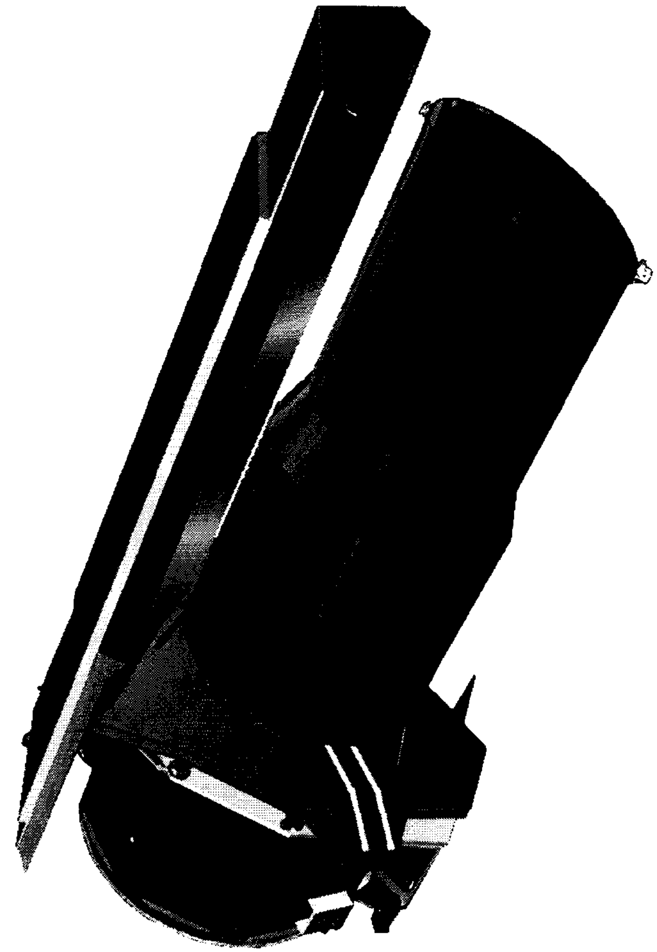
SIRTF Basics

- Background Limited Performance 3 -- 180 μm
- 85 cm f/12 Beryllium Telescope < 5.5K
- 6.5μm Diffraction Limit
- New Generation Detector Arrays
- 2.5 yr Lifetime/5 yr Goal
- Launch in Dec. 2001 (Delta 7920H)
- Solar Orbit



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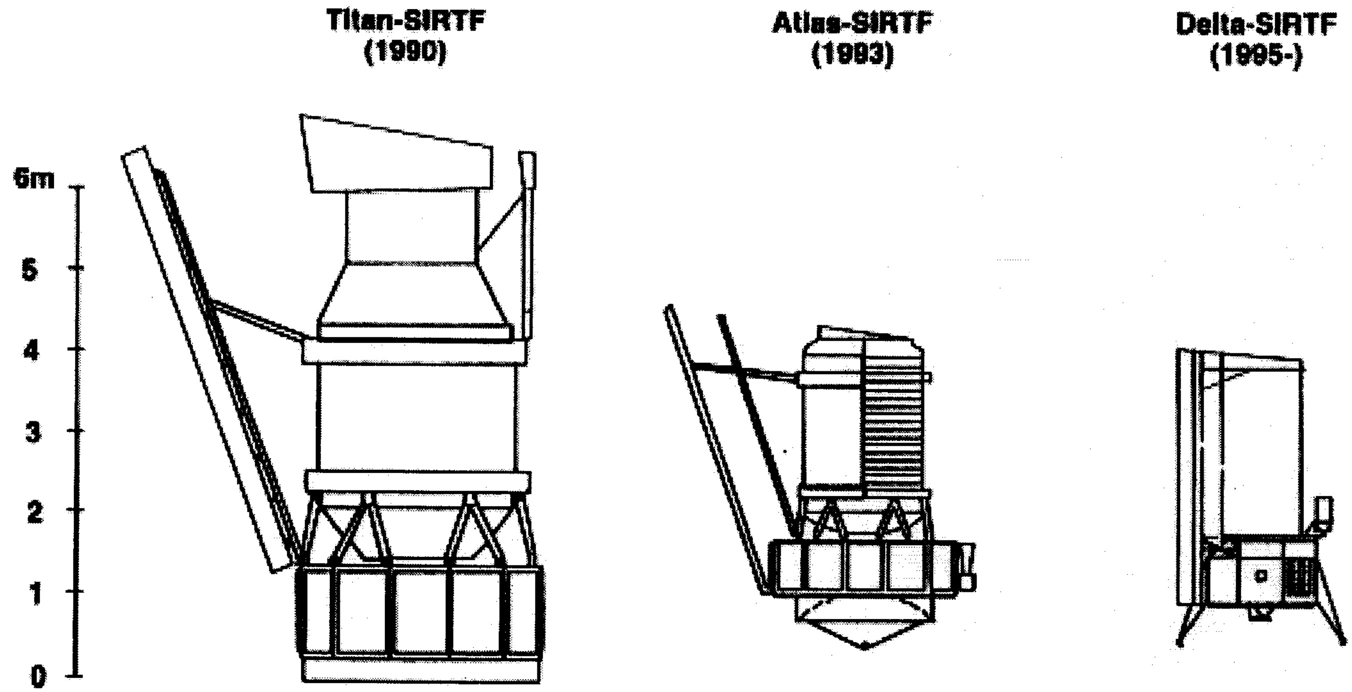
SIRTF History

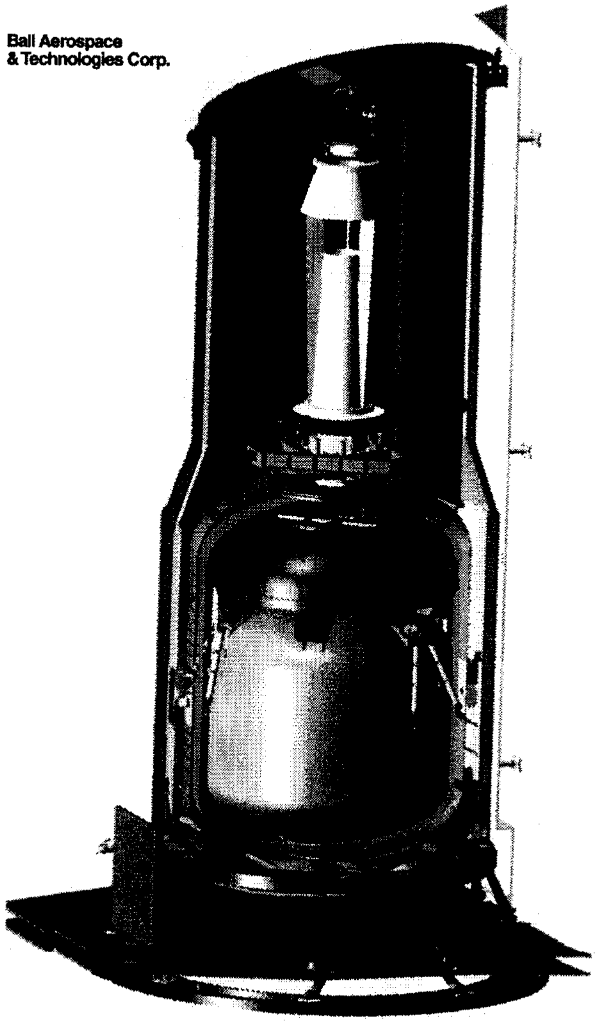


	Titan-SIRTF (1990)	Atlas-SIRTF (1993)	Delta-SIRTF (1995-)
Launch Mass	5700 kg	2500 kg	750 kg
Liquid Helium Volume	3800 liters	920 liters	250 liters
Planned Lifetime	5 year	3 year	2.5 year
Cost	>$2 billion	~$1 billion	$450 million

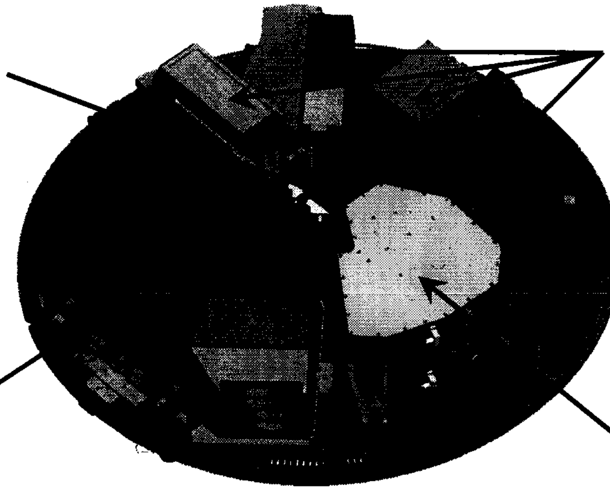
Expectation: 5 years

Observatory Elements

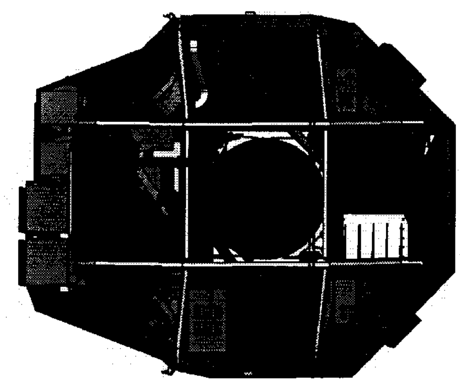
Ball Aerospace & Technologies Corp.



Cryo-Telescope Assembly



LOCKHEED MARTIN



Spacecraft

Defining Scientific Programs for SIRTF

- Protoplanetary and Planetary Debris Disks
- Brown Dwarfs and Super Planets
- Ultraluminous Galaxies and Active Galactic Nuclei
- The Early Universe

The SIRTF mission is driven only by the requirements of these programs. This methodology provided guidance and discipline during the difficult descope episodes.

The resulting system will have very powerful capabilities in many other scientific areas, allowing SIRTF to be an ***observatory for the entire scientific community***

In addition, SIRTF will have great potential for the ***discovery*** *of new phenomena in the Universe, and the mission must exploit this potential*

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SIRTF Science Update

- Progress in each major science area highlights SIRTF's role:
  - 2-MASS has discovered large numbers of Brown Dwarfs
  - Keck and HST imaging reinforces prevalence of Planetary Debris Disks
  - Numerous Kuiper Belt Objects discovered outside Neptune's orbit
  - Radial velocity detections show massive planets common around nearby stars
  - ISO results show spectroscopic discrimination of starbursts and AGN achievable in infrared
  - Hubble and Keck results show Universe full of galaxies at z>3
  - DIRBE [COBE] detects submillimeter background resolvable by SIRTF

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SIRTF Instrumentation Overview

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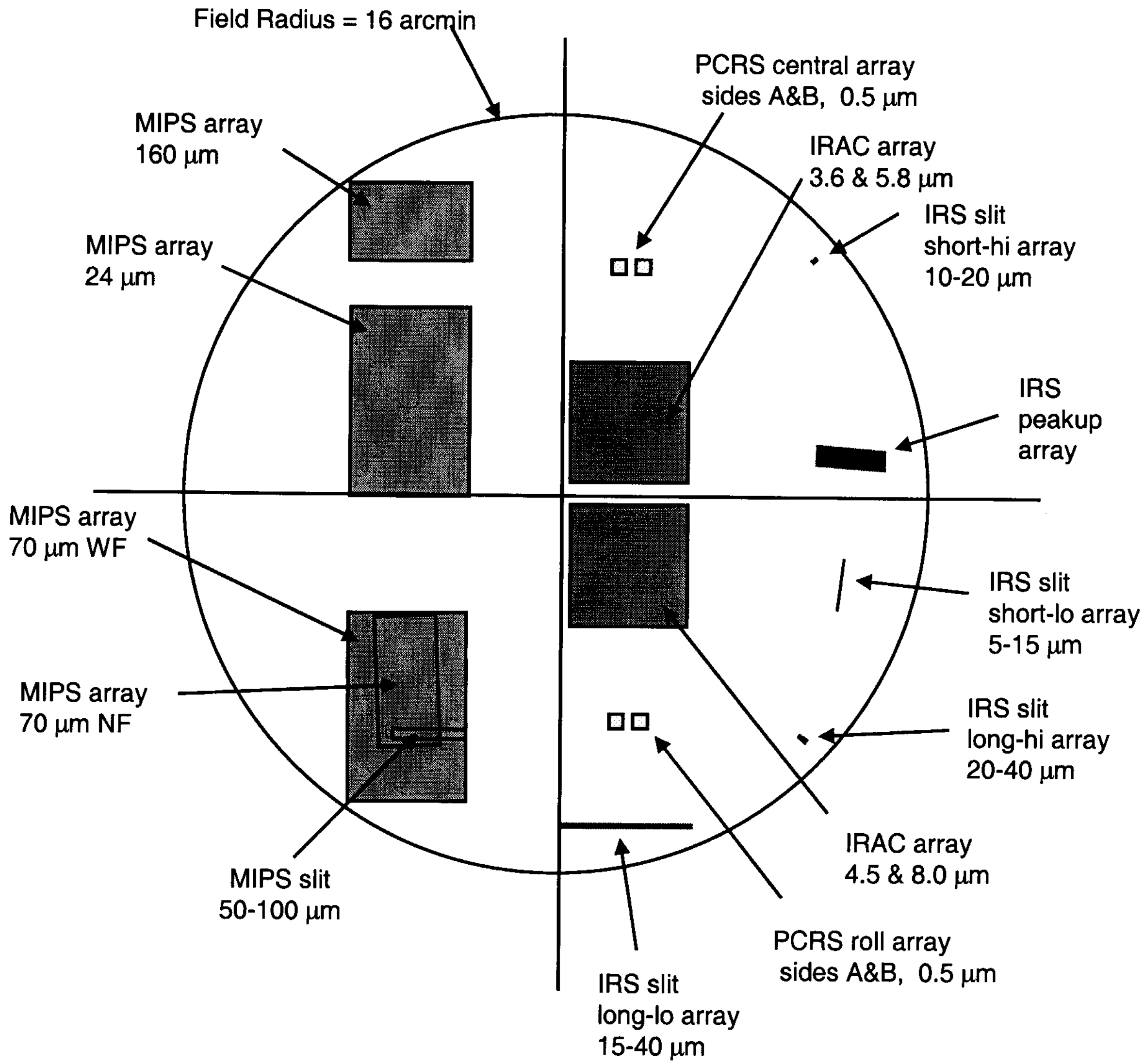
- **Infrared Array Camera, G.G.Fazio, SAO, PI.**
  - Wide-field (5x5 arcmin) imaging
  - Simultaneous viewing at 3.6, 4.5, 5.8, 8μm
  - *InSb and Si:As IBC arrays, 256x256 pixel format*

Infrared Spectrograph, J.R.Houck, Cornell, PI.
  - R=600 echelle spectrographs, 10-20 and 20-40mm
  - R=50 long-slit spectrographs, 5-15um and 15-40μm
  - Imaging/Photometry, 15μm
  - *Si:As and Si:Sb IBC arrays, 128x128 pixel format*

- **Multi-band Imaging Photometer for SIRTF, G.Rieke, Arizona, PI.**
  - Imaging and photometry: 24, 70, 160μm;
  - Optimized for efficient large area surveys and superresolution;
  - R~15 spectrophotometry, 50-100μm
  - *Si:As IBC, 128x128 and Ge:Ga 32x32 format arrays*
  - *Stressed Ge:Ga array, 2x20 format*

SIRTF Focal Plane Apertures



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SIRTF Instrumentation Summary

λ (μm)	Array Type	λ/Δλ	F.O.V.	Pixel Size (arcsec)	Sensitivity (μJy) (5σ in 500 sec, incl. confusion)
IRAC: InfraRed Array Camera					
3.6	InSb	4.9	5.1' x 5.1'	1.2	3
4.5	InSb	4.3	5.1' x 5.1'	1.2	4
5.8	Si:As (IBC)	4.0	5.1' x 5.1'	1.2	10
8.0	Si:As (IBC)	2.7	5.1' x 5.1'	1.2	15
MIPS: Multiband Imaging Photometer for SIRTF					
24	Si:As (IBC)	4	5.1' x 5.1'	2.4	370
70	Ge:Ga	3.5	2.7' x 2.7' / 5.1' x 5.1	4.9 / 9.4	1400
52 - 99	Ge:Ga	14 - 24	18.75" x 4'	9.4	6500
160	Ge:Ga (stressed)	4	0.5' x 5.1'	15	22.5 mJy
IRS: Infrared Spectrograph					
5.3 - 14.5	Si:As (IBC)	60 - 120	3.6" x 55"	1.8	550 μJy
15 (peakup imaging)	Si:As (IBC)	3	1' x 1.2'	1.8	100 μJy
10 - 19.5	Si:As (IBC)	600	4.8" x 11.8"	2.4	3×10^{-18} W/m^2
14 - 40	Si:Sb (IBC)	60 - 120	9.7" x 151"	4.8	1.5 mJy
19 - 37	Si:Sb (IBC)	600	9.7" x 22.4"	4.8	3×10^{-18} W/m^2

Sensitivity numbers are indicative of SIRTF performance. Detailed times estimates should be based on tools available on SSC website: http://sirtf.caltech.edu.

Infrared Array Camera (IRAC)

- **PI** - Giovanni Fazio, Harvard/SAO
- **Contractor** - Goddard Space Flight Center
- **Key Features:**
  - Wide field imaging in four bands centered at 3.6,4.5,5.8, and 8um
    - 5x5 arc min field of view in each band with 1.2 arcsec pixels
    - Two adjacent fields observed simultaneously; each is viewed in two bands [3.6/5.8um, 4.5/8um] by using dichroic beamsplitters
  - Four 256x256 SBRC arrays: two each of InSb and Si:As
  - Cold shutter for determination of dark current and total sky brightness
  - Subarray mode for short integrations to improve dynamic range
  - Internal flood and transmission calibrators

Performance:

Can detect red-shifted starlight from L* galaxy at z=5, providing our first look at the stellar content of the Early Universe at rest wavelengths beyond 1μm

Infrared Spectrograph (IRS)

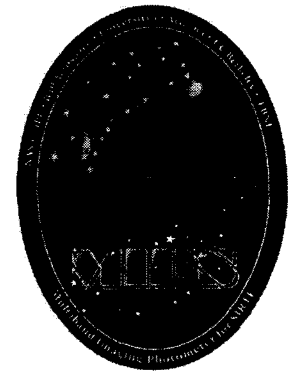
[redacted]

- **PI** - Jim Houck, Cornell University
- **Contractor** - Ball Aerospace
- **Key Features**
  - R=600 spectroscopy, 10-40um; R=50 spectroscopy, 5-40um
  - Uses 128x128 Boeing Si:As and Si:Sb IBC arrays
  - No moving parts
  - Two R=600 modules [10-20,20-40um] operate in echelle mode
  - Two R=50 modules [5-15, 15-40um] operate in long-slit mode
    - Order sorting accomplished by filters on lo-res slits
  - Peak-up imaging at 15um incorporated into short-lo module
    - Allows acquisition of sources with poorly known positions
    - Can be used with any module, or independently for photometry
  - Operates in staring and scanning modes

Performance:

Measures complete spectrum of any IRAS source in just a few minutes

Multiband Imaging Photometer for SIRTF (MIPS)



- **PI:** George Rieke, University of Arizona
- **Contractor:** Ball Aerospace
- **Key Features:**
  - Imaging at 24, 70, and 160um
    - 5x5 arcmin fields of view at 24,70um; 0.5x5 arcmin field of view at 160um
    - Nyquist sampling achievable in all three bands [with 2.5x2.5 field at 70um]
  - Arrays: 128x128 Si:As(24um); 32x32 Ge:Ga(70um); 2x20 GeGa*(160um)
    - Si:As from IRS program at Boeing; Ge:xx built at Arizona, from LBNL material
  - Internal scan mirror allows mapping in all three bands simultaneously
    - efficient surveying without stopping telescope motion
    - scan mirror also allows modulation of signal on Ge:xx arrays
  - Photometric, Total power, and Spectral Energy Distribution [SED] modes
    - SED mode provides resolving power ~20 from ~50-95um

Performance:

Detect ultraluminous infrared galaxy to z>5

Image planetary debris disks with 1% the brightness of that around Vega

SIRTF Performance Expectations

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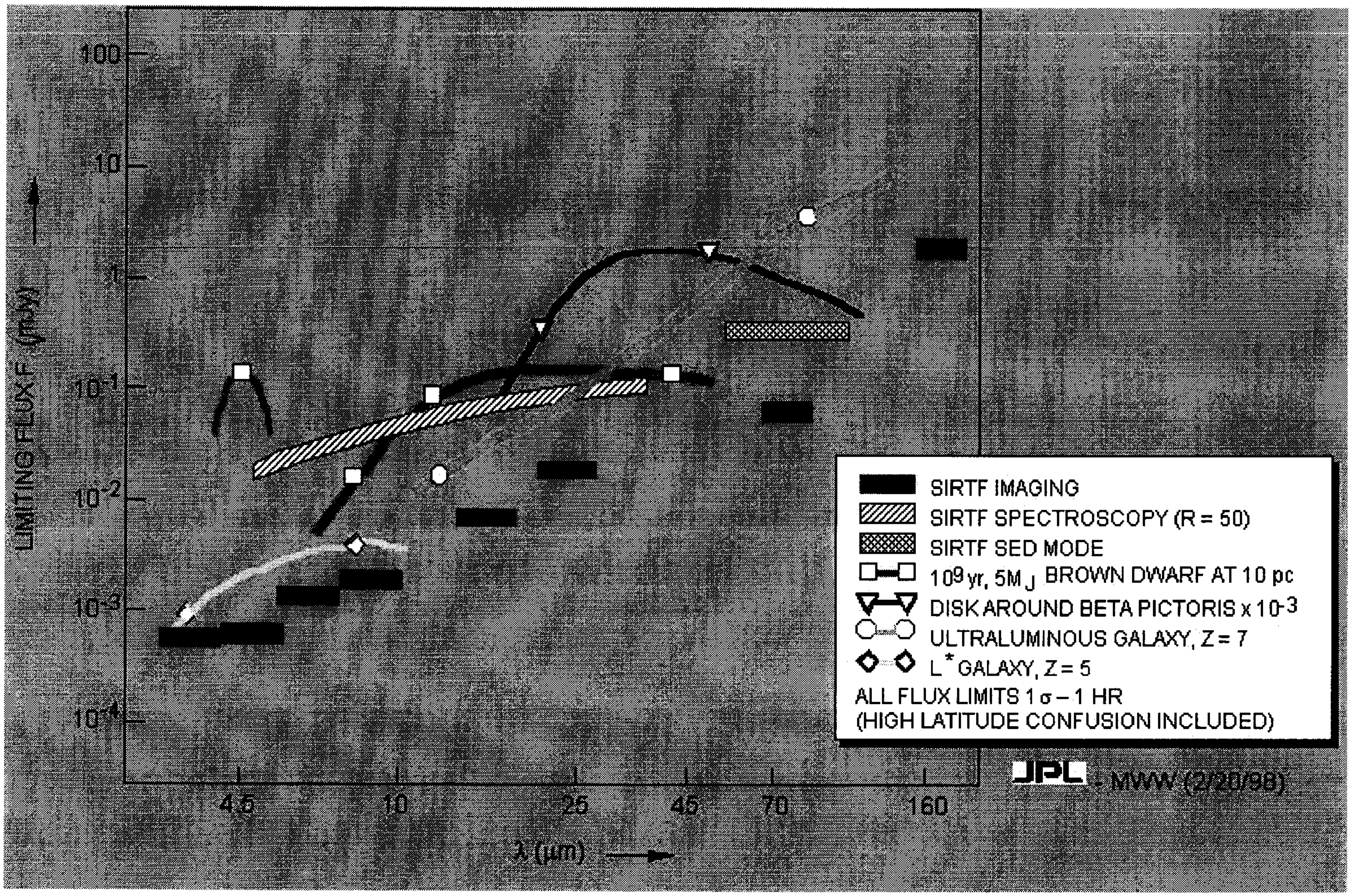

Simulated MIPS 24 and 70 micron Observations of Circumstellar Disks

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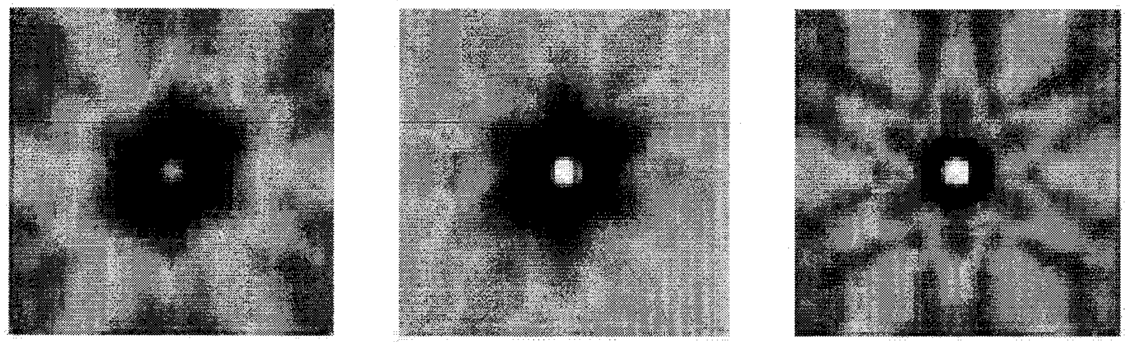
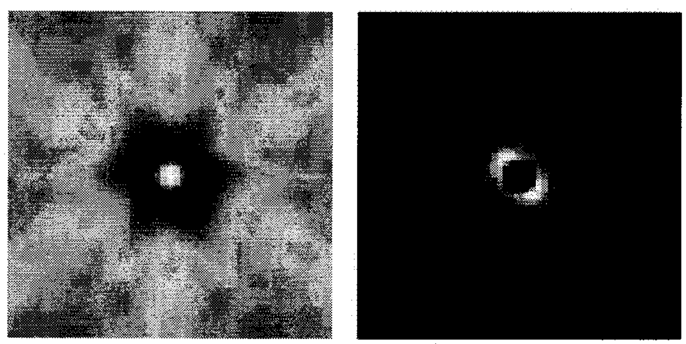
Below are simulated 70 μm observations convolved with a model of the SIRTF Point Spread Function. Left to Right: Vega, 1/10 as much dust as Vega, a point source. All are on a logarithmic brightness scale.





Left are simulated 24 μm observations convolved with a model of the SIRTF PSF on a logarithmic brightness scale. The left image is Vega. On the right is the difference of a Vega-like star with 1/100 times less dust and a point source of the same total flux.

Simulations by Ned Wright (UCLA)

Spectral energy distributions

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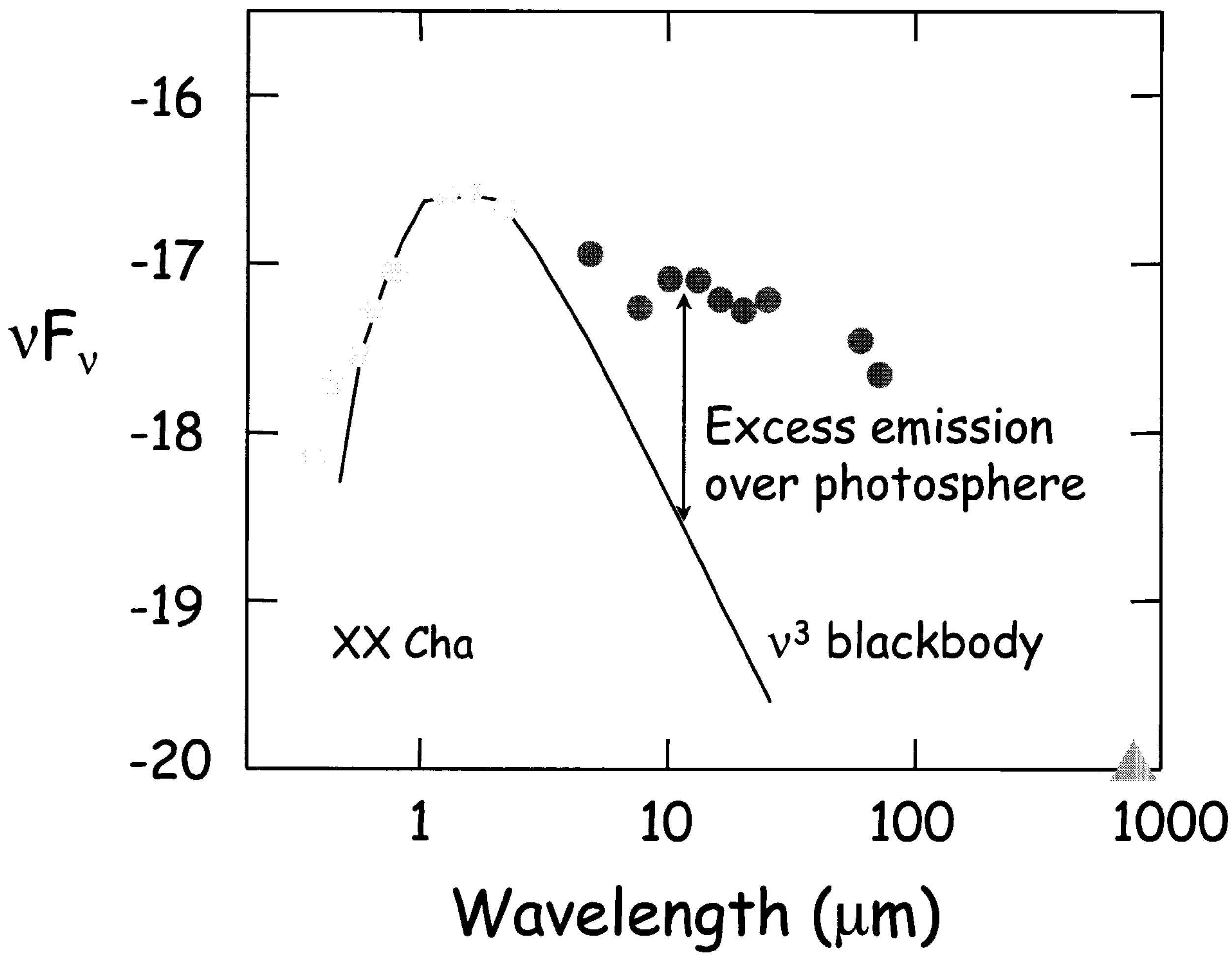
Adams, Lada, & Shu 1988, *Ap. J.*, **326**, 865.

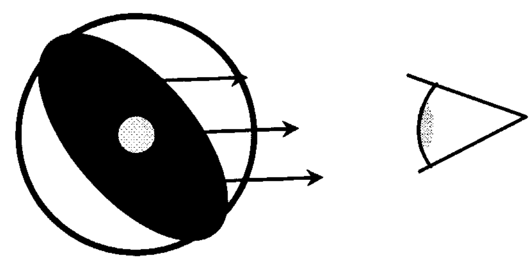


Far IR optical depth:
$\tau \sim 1$ at 100 μm
$\tau \sim 0.01$ at 1 mm

$\therefore$ $\tau \geq 100$ at 1 μm
$\Rightarrow A_V \geq 300$

Observed $A_V \sim 3$

$\therefore$ clear line of sight to star and dust.



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SIRTF Science Timeline

- **Now** - *Legacy Science Release of SPOT - SIRTF Planning and Observation Tool - available on Web*
- **December 2000** - *Legacy Science teams selected and funded*
- **October, 2001** - *Cycle 1 Call for General Observer Proposals*
- **August 25, 2003** - *Launch of SIRTF*
- **February 14, 2003** - *Cycle 1 General Observer Proposals due*
- **May, 2003** - *SIRTF Public Archive open*

**http://sirtf.caltech.edu/*