# Spitzer Space Telescope Calibration Strategy: The Use of Asteroids

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2004 Dec[illegible]

Herschel Calibration Worksh[illegible]

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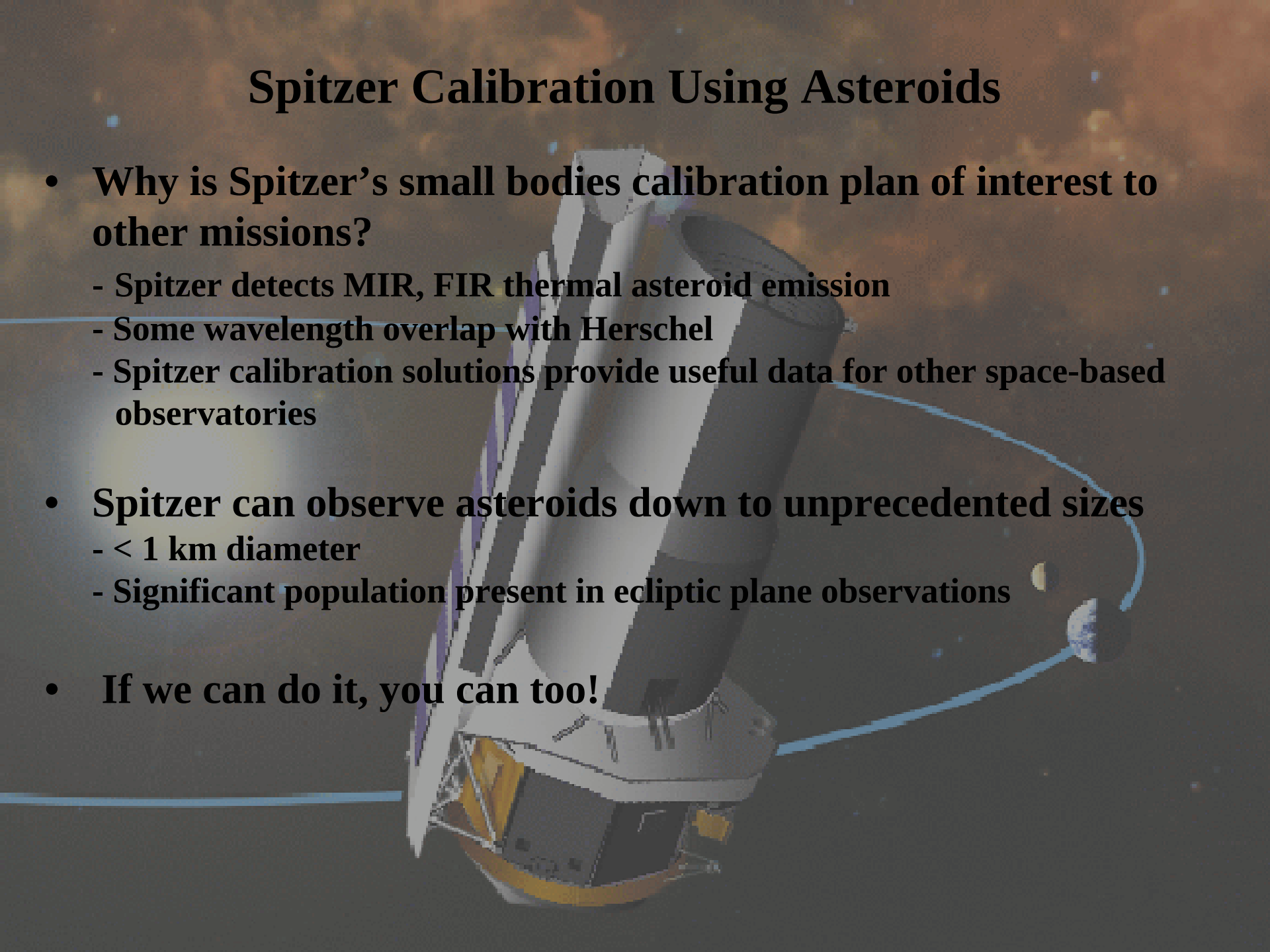
# Spitzer Calibration Using Asteroids

- **Why is Spitzer's small bodies calibration plan of interest to other missions?**
  - **Spitzer detects MIR, FIR thermal asteroid emission**
  - **Some wavelength overlap with Herschel**
  - **Spitzer calibration solutions provide useful data for other space-based observatories**

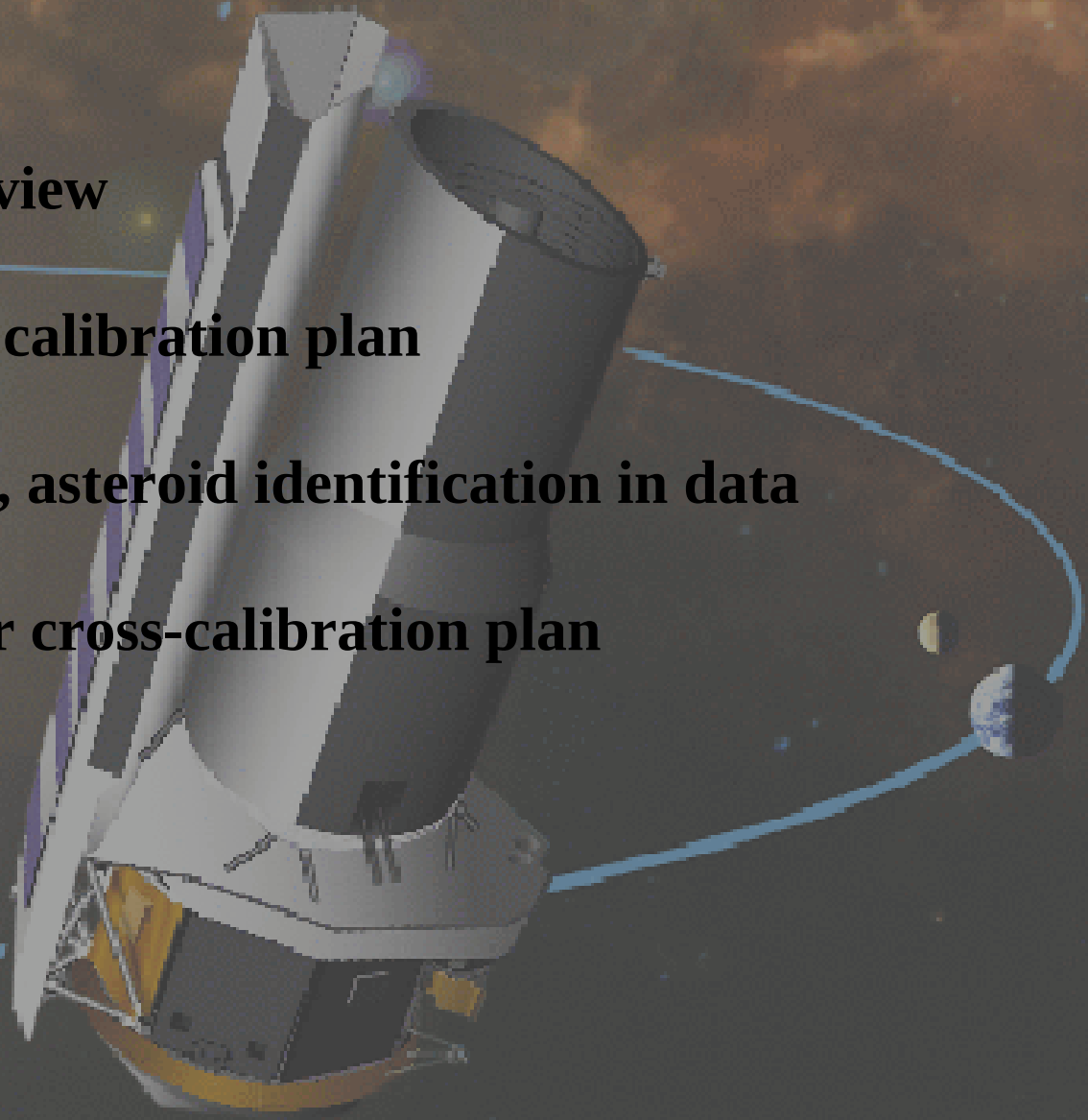
- **Spitzer can observe asteroids down to unprecedented sizes**
  - **< 1 km diameter**
  - **Significant population present in ecliptic plane observations**

- **If we can do it, you can too!**

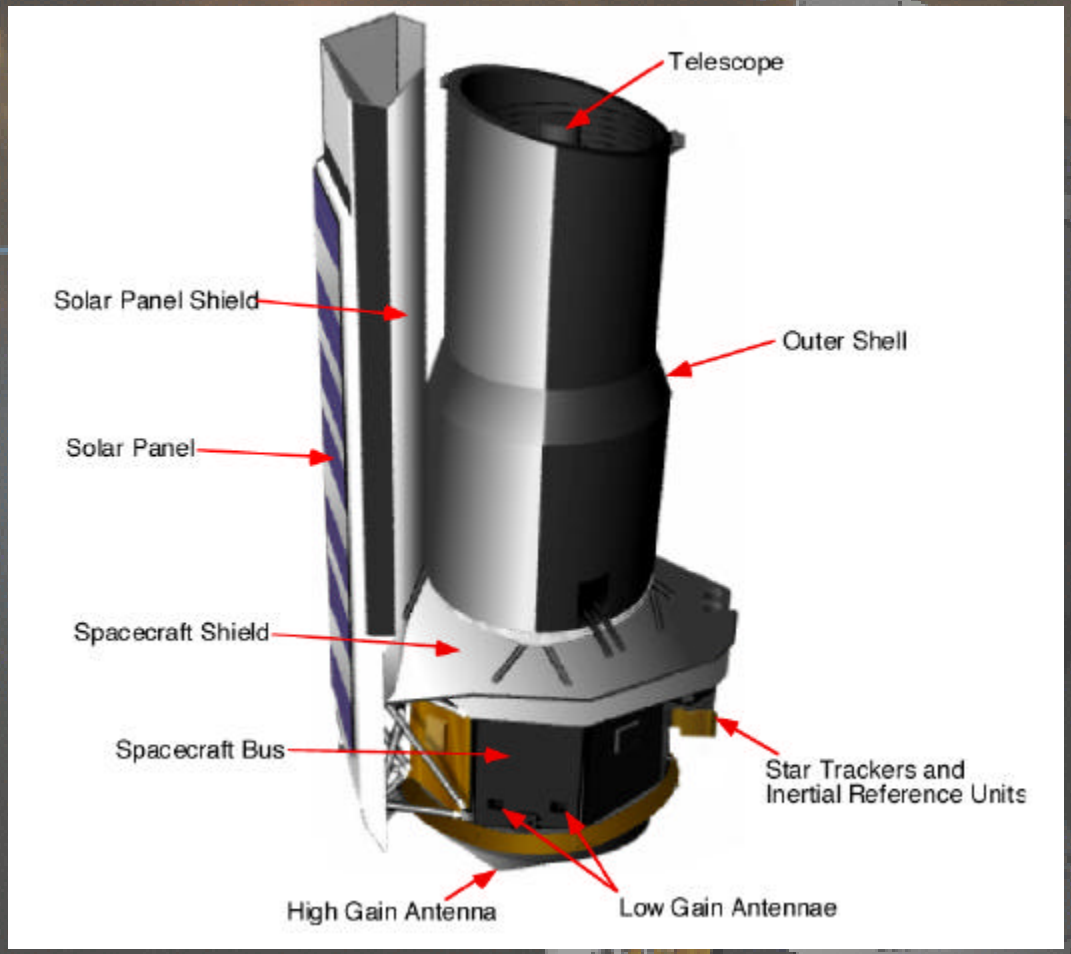


# Spitzer Calibration Using Asteroids

- Spacecraft overview
- Asteroid role in calibration plan
- Target selection, asteroid identification in data
- Herschel/Spitzer cross-calibration plan



# Spacecraft Overview

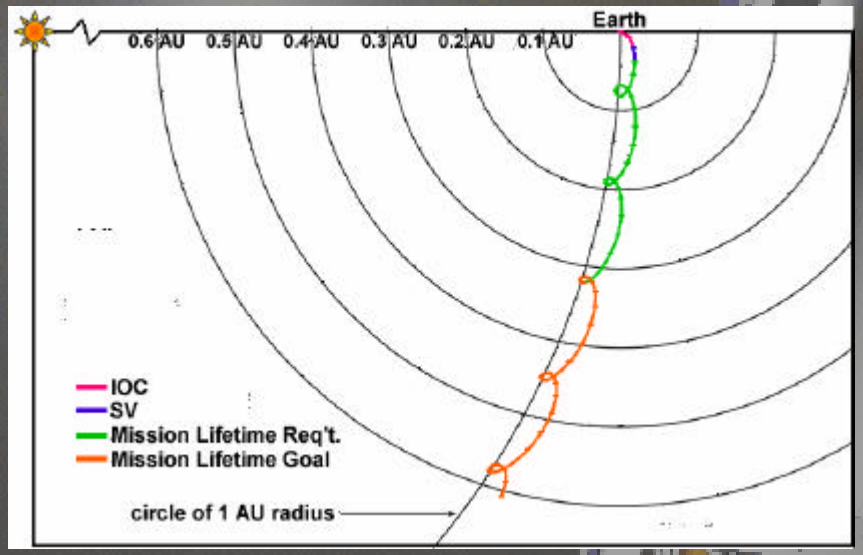


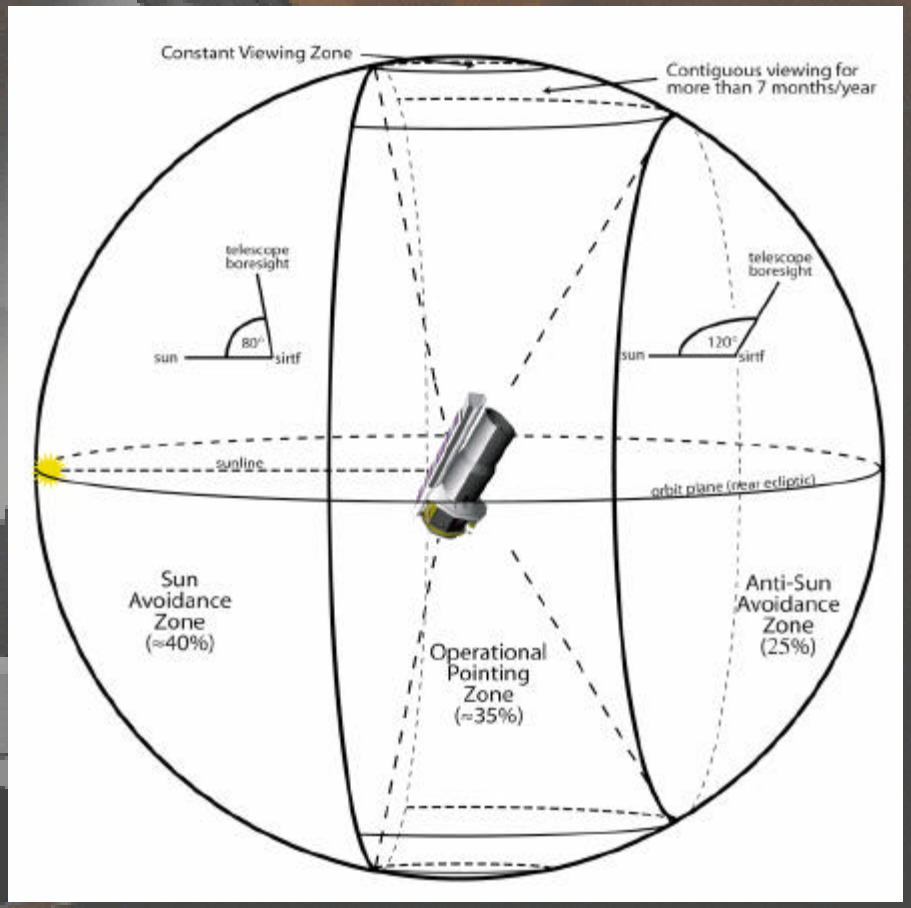

| | |
|---|---|
| Aperture (mirror diameter) | 85 cm |
| Orbit | Solar (Earth-trailing) |
| Cryogenic Lifetime | ~5 years |
| Wavelength Coverage | 3.6–160 μm (imaging)<br>5.2–38 μm (spectroscopy)<br>51–106 μm (SED) |
| Spectroscopic Resolving Power | 64–128, 600 (IRS)<br>15–25 (MIPS SED) |
| Diffraction Limit | 5.5 μm |
| Image Size | 1.5" at 6.5 μm |
| Pointing Stability (1-sigma, 200 s, when using star tracker) | <0.1" |
| As-Commanded Pointing Accuracy (1-sigma radial) | <0.5" |
| Pointing Reconstruction | <1.0" |
| Field-of-View (imaging arrays) | ~ 0.5′ × 5′ at 160 μm<br>~ 1′ × 1′ at 13–26 μm (IRS PUI)<br>~ 5′ × 5′ in other bands |
| Telescope Minimum Temp. | ~5.6 K |
| Maximum Tracking Rate | 1.0 °/sec |

Basic external view of Spitzer. One of Spitzer's unique features is its "warm launch" mission design, which allows its operational lifetime goal (~5 years) to be reached with a small, light cryostat (~360 liters of superfluid helium). The observatory is ~4 m tall and ~2 m in diameter, and has a mass of ~900 kg. Spitzer is operated autonomously for periods of 12–24 hours, interspersed with short periods (30–60 minutes) of ground contact. During routine science operations, Spitzer typically executes a pre-planned week-long schedule of science observations, calibrations, and routine engineering activities, which has been uploaded in advance and stored on board the spacecraft.

# Spacecraft Overview

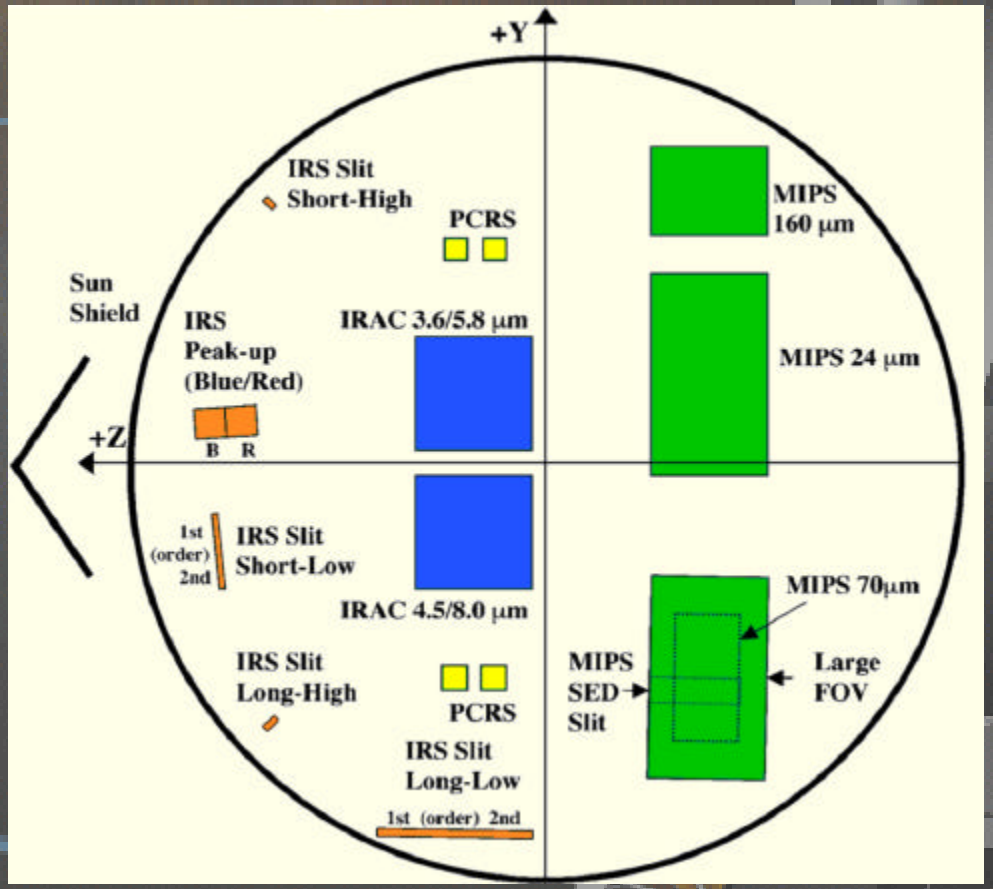
- **Spitzer's Earth-trailing, heliocentric orbit and Operational Pointing Zone (SolElong = 82.5º to 120.0º)**

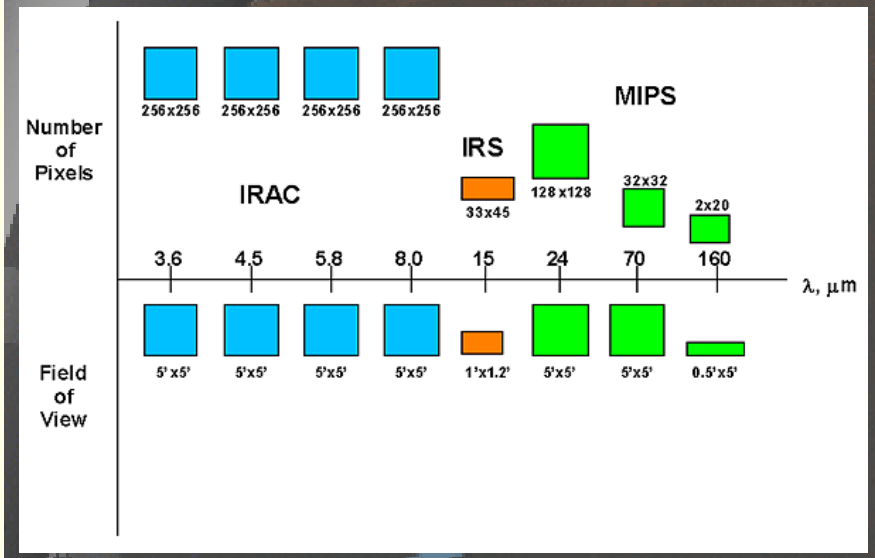


# Spacecraft Overview

## Spitzer Instrument Focal Plane Positions and Wavelength Ranges



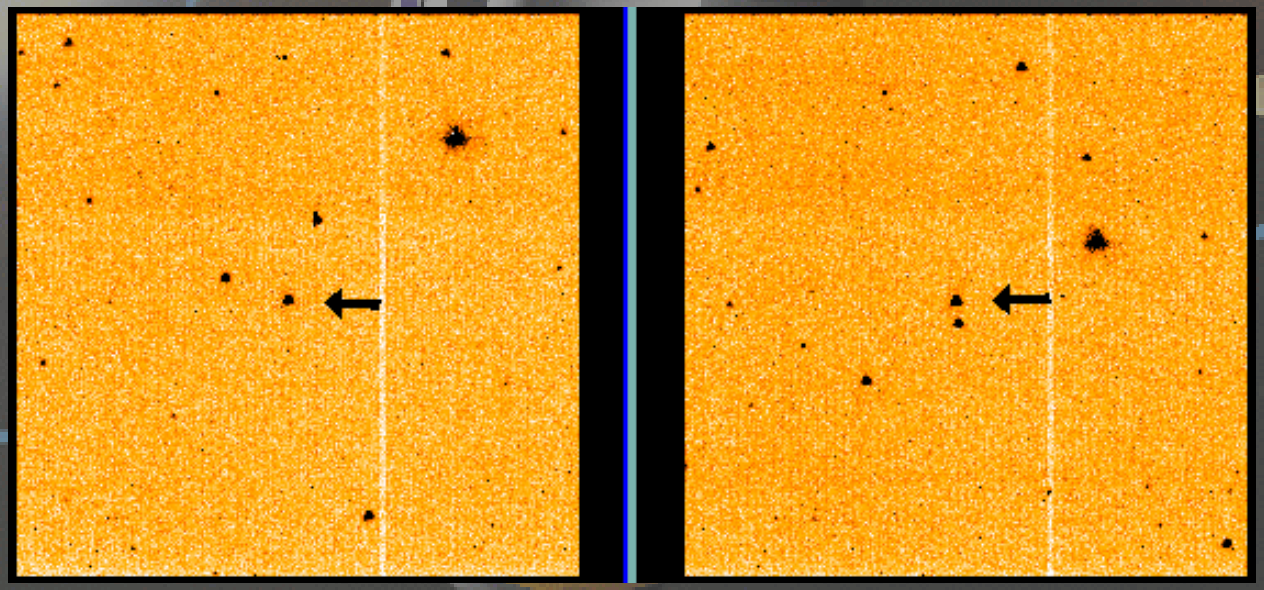
# Moving Target Verification

- **Mission requirement to acquire and track moving sources up to 3600”/hr**
- **Verified during In Orbit Checkout**
- **Asteroid 443 Photographica observed while tracking in full array (5.2’ x 5.2’)**
  - **Both panels provide examples of 2 sec exposures, taken in separate AORs**
  - **Distance from Sun = 2.26 AU**
  - **Distance from Spitzer = 1.78 AU**
  - **Rate ~ 31”/hr; asteroid moved across ~ 1 arcminute of sky in 2 hours**

2003-264:23:08 UT

2003-265:00:06 UT

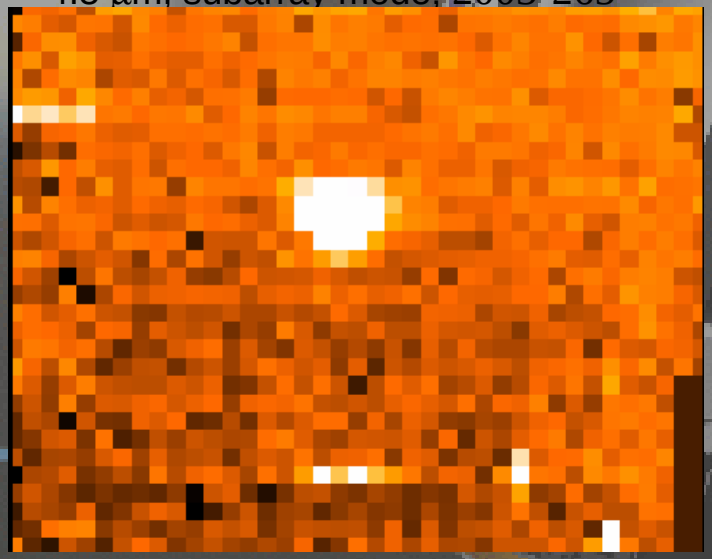
**4.5 mm**



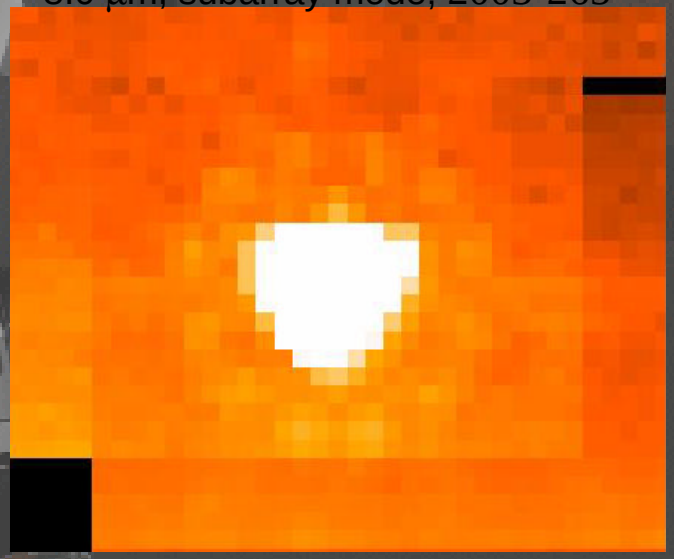
# Moving Target Verification

- **Asteroid 326 Tamara observed at 4.5 and 8.0 mm while tracking in subarray (38”x38”)**
  - **Six sequential exposures of 0.1 sec each; 24 frames combined for each image**
  - **During one AOR, target was repeatedly acquired and tracked in all 4 IRAC bands**
  - **Distance from Sun = 2.26 AU**
  - **Distance from SIRTF = 1.78 AU**
  - **Rate ~ 39”/hr**
- **Peak emission near 20 mm; cross-instrument studies highly desirable**

4.5 μm, subarray mode; 2003-265



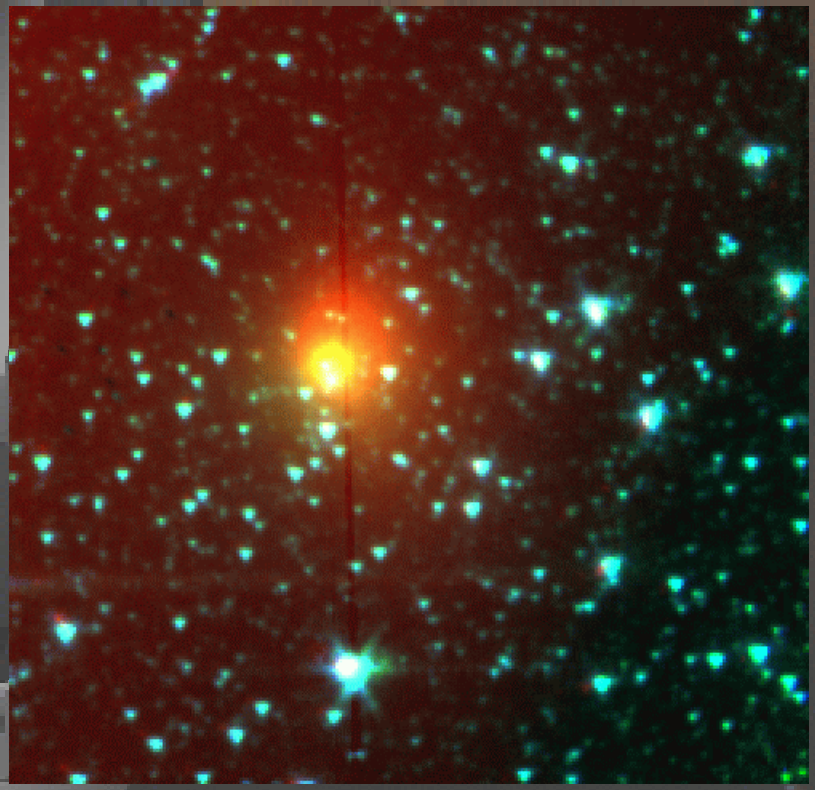
8.0 μm, subarray mode; 2003-265



# Moving Target Verification

- **Comet 65P/Gunn observed at 3.6, 4.5, 8.0 mm while tracking in full array (5.2'x 5.2')**
  - **12 sec exposure**
  - **Distance from Sun = 2.58 AU**
  - **Distance from Spitzer = 2.18 AU**
  - **Rate ~ 32"/hr**
- **Stars appear blue, with white cores**
- **Starlight is brighter at shorter wavelengths**
- **Peak emission near 20 mm, making cross-instrument studies highly desirable**
- **Ground-based telescopes would have difficulty seeing the inner coma**

Combination of IRAC images of Comet 65P/Gunn at 3.6 (blue), 4.5 (green),and 8 (red) μm



# Spectral Leak

## 160μm Images of Red and Blue Sources

HD 131873: K4III, V=2.1, 160um=0.656 Jy
29, 3.1, 0.66 Jy at 24, 70, 160 μm (Rayliegh-Jeans)
Mrk 279: double Seyfert galaxy
<.25, .26, 1.1, 2.3 Jy @ 12, 25, 60, 100 μm (Red as Hell)
160 μm images of both sources, 4 dither positions along array long axis.

Combined 160 and 1.6 μm images. Offset depends on position on the array.


160 μm image only. Dither identical to star, pointing accurate to ~0.1 pixel.

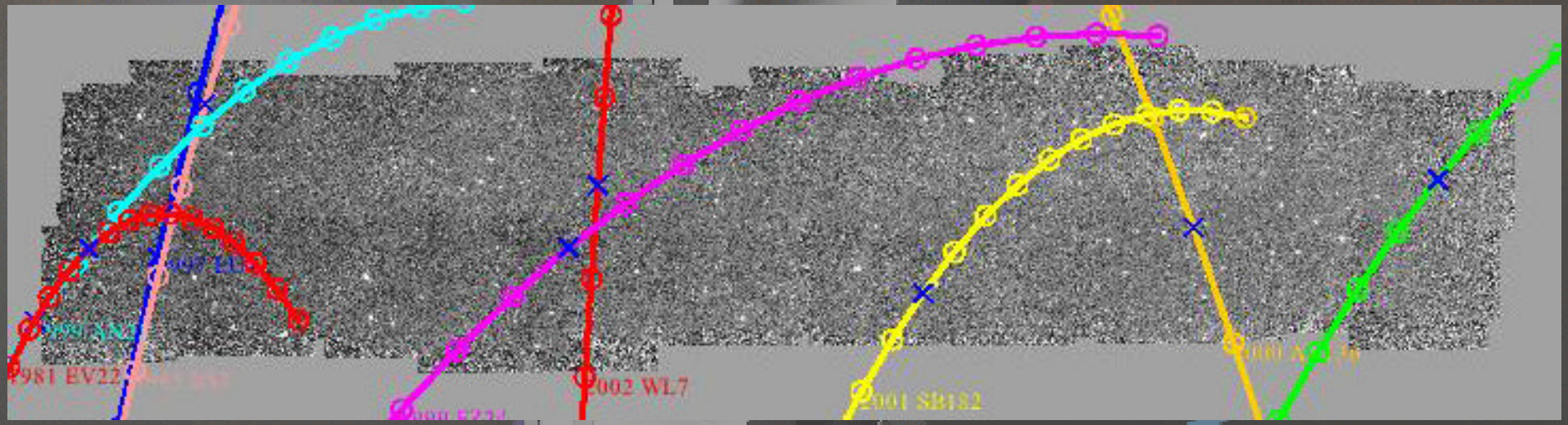
# Target Selection

- **Identified using JPL/Horizons**
  - **Public access software via telnet or www**
  - **Provides ephemeris information for solar system targets**
  - **Observatory can be specified**
- **SSC has list of ~100 asteroids from which calibration objects for all three instruments are identified**
- **Database developed initially to meet IRAC sensitivity and saturation limits**
  - **8 < H < 11, radius up to ~ tens of km**
  - **Additional asteroids, observed from any place within solar system, can be easily included**
- **MIPS provided with 12-20 asteroids in visibility window per campaign**

  **F70 = 0.5 - 18 Jy**
- **Objects selected through 17MC, Jan 2005 calibration**

# Asteroid Identification

- Load mosaic into SPOT
- Overlay asteroid trajectories
  -orbital information good to better than ~20”




- List of known asteroids for any FOV can be obtained using JPL Horizons ISPY software
- Can be used for any ground-based or Spitzer field
  - observation planning or data analysis

# Serendipitous Asteroid Detections

- **IRAC 8㎜ flat field**
- **Should pipeline flag moving sources, both known and unknown?**

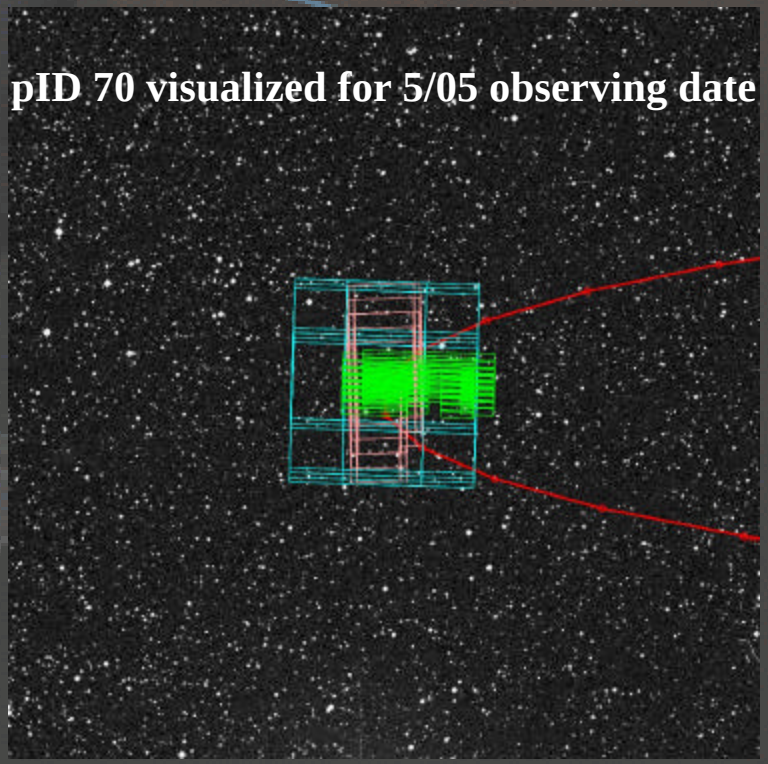
# Useful Spitzer Data

Spitzer Space Telescope Approved Science Programs Issued: 29 October 2004

| Principal Invest. | pid# | Cat. | prog user name | Program Title |
|---|---|---|---|---|
| Cruikshank Dale | 67 | GTO | | IRS and MIPS SED observations of Centaurs and Kuiper Belt Objects |
| **Cruikshank Dale** | **70** | **GTO** | | **Observations of the Pluto/Charon system** |
| Cruikshank Dale | 88 | GTO | | Extinct Comets and Low-Albedo Asteroids |
| Cruikshank Dale | 91 | GTO | | Extinct Comets and Low-Albedo Asteroids-2 |
| Latter William | 1716 | CAL | | CAL MIPS 1716 |

**Program ID 70 - ABSTRACT:**

**–We examine the combined Pluto/Charon system using all SIRTF instruments. The IRS observations generally use the Long Lo module. When used in conjunction with IRAC and MIPS photometry observations, these observations will provide us with composition, albedo, and thermal properties information. Pluto is observed at 8 equally spaced observer sub-longitudes, and follow-up observations 1 and 2 yr after the initial lightcurve measurements are planned.**



# Calibration Issues to Consider

- MIPS Team has list of Herschel calibration asteroids
  - Observed as part of MIPS cal plan when visible and in appropriate flux range
- Coordinated Spitzer/Herschel Calibration Program?
  - GO proposals?
  - DDT?
  - Dedicated cross-calibration program?
  - Spitzer operational through summer 2008-ish
    - Timeline?