



IPAC as Institutional Partner for the Far-IR Surveyor

Sean Carey (IPAC)



IPAC support for the FIR Surveyor STDT



- IPAC is eager to support the STDT and its mission
- IPAC can make substantial and cost-effective contributions to the STDT effort, based on
 - *Work and products from past missions,*
 - *expertise from past and current missions,*
 - *existing communication channels to FIR community*



NASA's Infrared Processing and Analysis Center



IRAS (1983), 12–100 microns



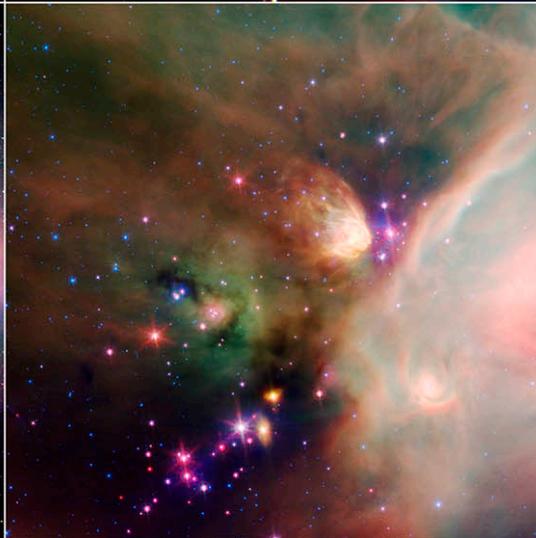
ISO (1995), 7–15 microns



Herschel



2MASS (1997), 1.3–2.2 microns



Spitzer (2003), 3.6–24 microns

WISE





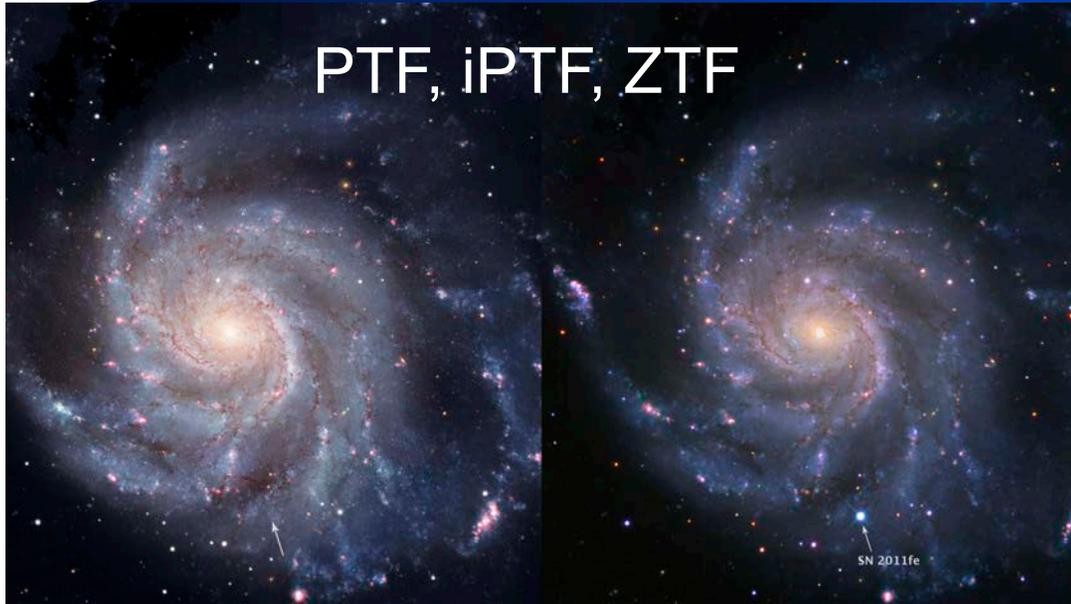
NASA's Infrared Processing and Analysis Center



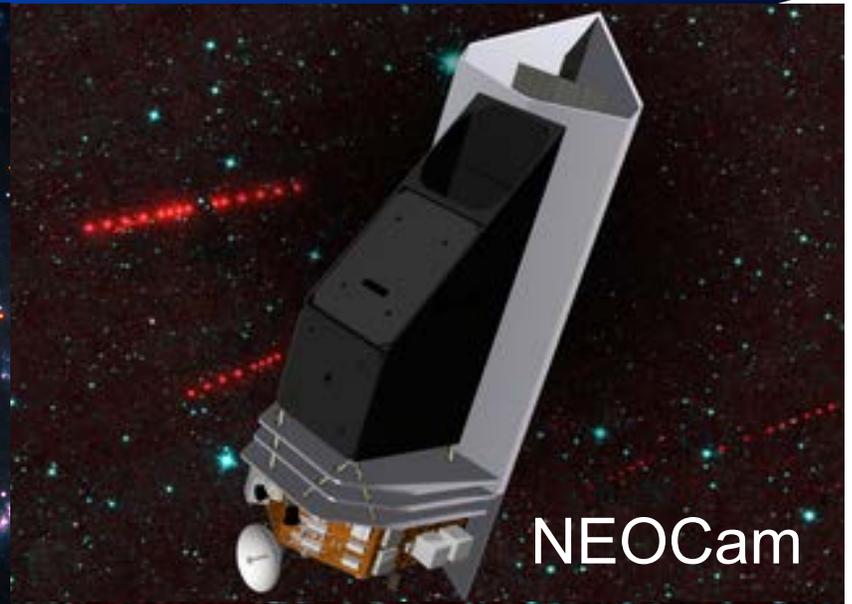
- 30+ year legacy of supporting space-based IR astronomy
- General purpose observatories: ISO, Spitzer and Herschel
- Large surveys: IRAS, 2MASS, MSX, WISE, Planck
- Three main centers: Spitzer Science Center, NASA's Exoplanet Science Institute (NExScI), IPAC Classic
- Three Archives: InfraRed Science Archive (IRSA), NASA's Extragalactic Database (NED) and NASA's Exoplanet Archive
- 100+ dedicated scientists/engineers/programmers
- All stages of astronomical missions supported
 - *Formulation*
 - *Integration, Testing, Operations*
 - *Data Analysis and Pipeline Processing*
 - *User support and documentation*
 - *Archiving*



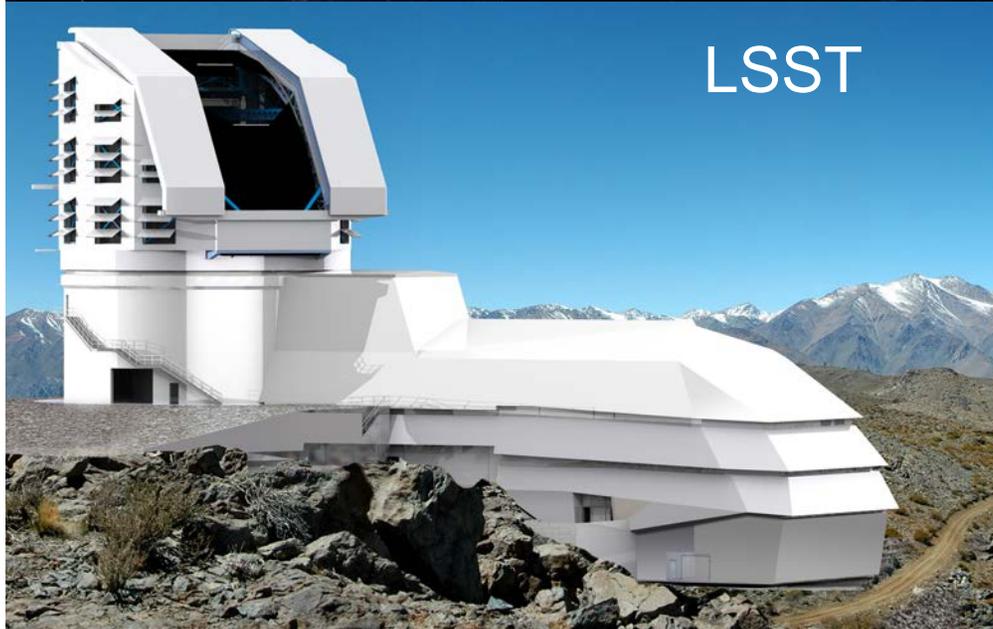
New Initiatives



PTF, iPTF, ZTF



NEOCam



LSST



NEOWISE



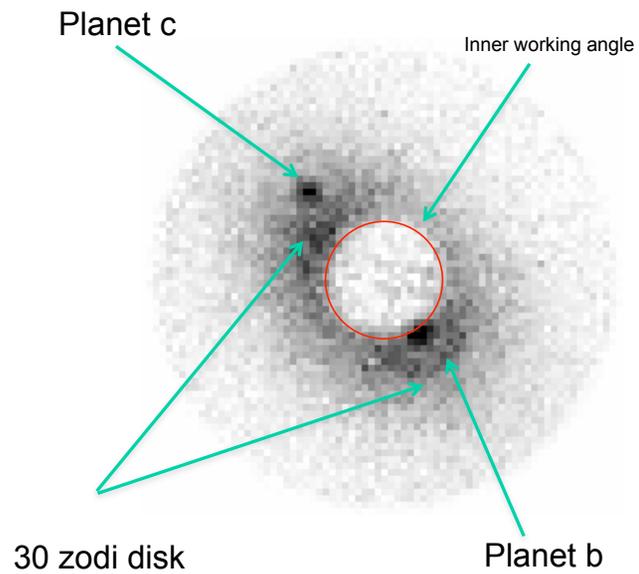
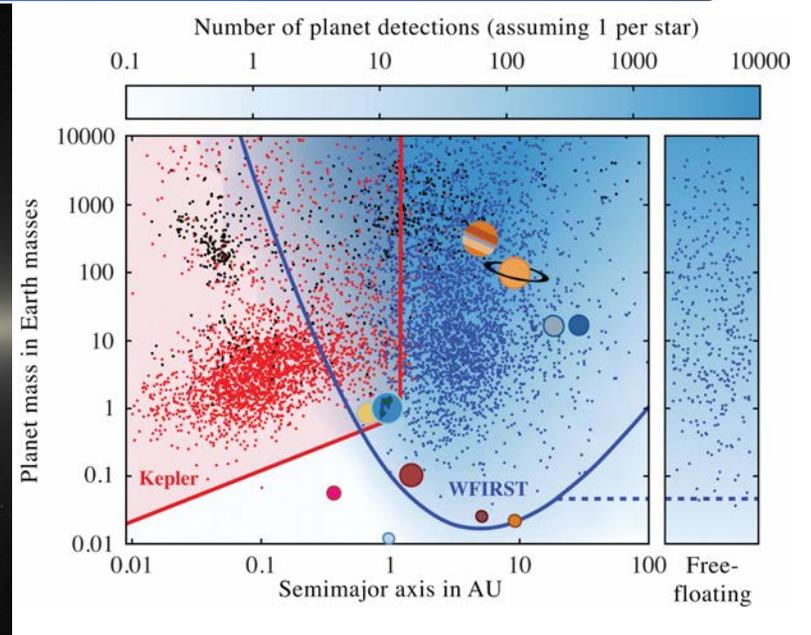
New Initiatives



- Time-domain astronomy
 - *Science pipeline / archive for Palomar Transient Factory and Zwicky Transient Facility*
 - *Science User Tools for LSST*
- “Big Data” astronomy
 - *PTF, ZTF : Petabyte scale pipelines and archives*
 - *Synthesis of Galactic plane surveys: GLIMPSE, MIPS GAL, HiGal*
- Solar system science
 - *Rapid data processing and release*
 - *NEOWISE*
 - *NEOCam (in development)*



WFIRST and Euclid

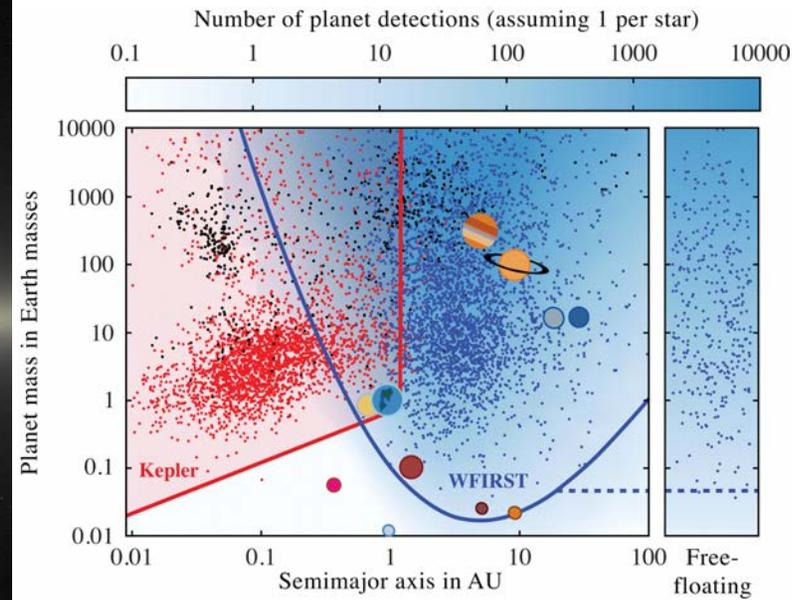




WFIRST and Euclid



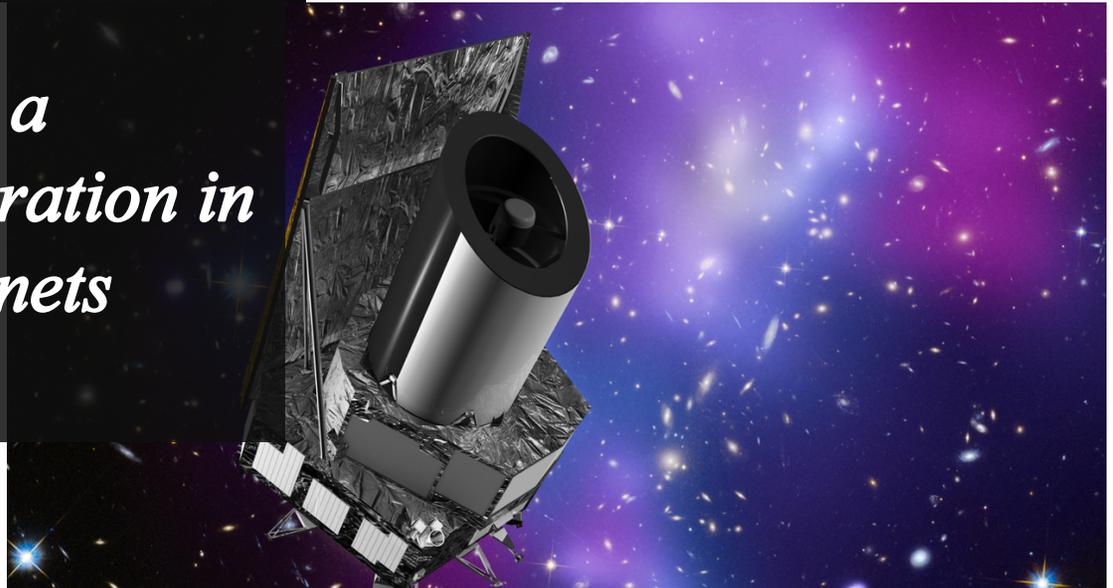
- Science Centers for both WFIRST and Euclid
 - NASA Euclid Science Center following in the tradition of the NASA centers for ISO, Herschel and Planck



- WFIRST effort has a significant concentration in the study of exoplanets

30 zodi disk

Planet b





Potential Science Tool Contributions



- Background estimators (Zodiacal, Milky Way, CIB, CMB) and brightness fluctuation estimators [Adapt/extend existing tools]
- Confusion estimators (from galaxy counts and MW emission, continuum and lines) [Adapt/extend existing tools]
- Time estimators (from analytic approximations of performance) [Adapt/extend existing tools]
- Sky observing/data simulators (higher fidelity than time estimators) [leverage on-going simulation work and knowledge of FIR sky]
- Other tools as requested by STDT



Visualization and Observation Planning Tools



SOFIA Planning Tool (SSpot)

Mouse Control: **Left Mouse Button:** Drag to adjust bias (horizontally) and contrast (vertically); double-click to reset.
Shift-Left Mouse Button: Shift the center of image.

Mouse:

M31 3a

FORCAST_Grism [AOR ID: _6]

Unique AOR Label:

Target: M31 Type: SOFIA Fixed Single
10.684708, 41.268750 Equ J2000 or 0h42m44.3300s, +41d16m07.500s Equ J2000

Exposure Time (sec)
Cycles
Min Contiguous Exp Time (sec)
Observation Order
IR Source Type

Instrument Configuration Slit
SW LW

Chop / Nod

Example Rotation Angle (deg)

Chop/Nod Style

Chop Type
Chop Throw (arcsec)
Chop Angle Coordinate

Chop Angle (deg)

Nod Throw (arcsec)
Nod Angle Coordinate
Nod Angle (deg)

Number	Offset Along Slit(°)	Offset Perp Slit(°)
1	0.0	0.0
2	-20.0	0.0
3	-10.0	0.0
4	10.0	0.0
5	20.0	0.0

Observations Snake 3a

Target: M31 Type: SOFIA Fixed Single

Proposal - <No File>

Net Up

Total AORs: 6 / Active: 6



Visualization and Observation Planning Tools



- Tool kit based off of SPOT used for planning Spitzer observations

- Straightforward point and click interfaces and dialogs

- Extended for Herschel and SOFIA

– *Incorporates bolometer and heterodyne instruments*

- Includes time estimation calculators and visibility servers

- Extensive visualization capabilities in both standalone and web tools

Target: M31 Type: SOFIA Fixed Single
268750 EquJ2000 or 0h42m44.3300s, +41d16m07.500s EquJ2000

Exposure Time (sec) 105.000 Instrument Configuration GRISM_LWC Slit FOR_LS24
LW FOR_G227

Observation Order 1 IR Source Type Extended Source

Dither Pattern None Dither Offset Dither Coordinate Apply
9 point ExpTimePerDither (sec) 21.000
custom Scan Size (arcsec) 0.000

Number	Offset Along Slit(°)	Offset Perp Slit(°)
1	0.0	0.0
2	-20.0	0.0
3	-10.0	0.0
4	10.0	0.0
5	20.0	0.0

Chop / Nod
Example Rotation Angle (deg) 0.000
Chop/Nod Style Nod Match Chop
Chop Angle Coordinate Array
Set Chop Angle Ranges
Chop Angle (deg) 30.000
Nod Throw (arcsec) 60.000
Nod Angle Coordinate Array
Nod Angle (deg) 210.000

Observation Est... Comments... Proposal Info...
Cancel Apply OK

Target: M31 Type: SOFIA Fixed Single
Proposal - <No File> Net Up Total AORs: 6 / Active: 6



Background Estimators and Integration Time Calculators



SSO EX-PET

ssc.spitzer.caltech.edu/warmmission/propkit/pet/expet/index.html

EX-PET: Extragalactic - Performance Estimation Tool

Other tools: Performance Estimation Tool | Magnitude/Flux Density Converter

Overview: An "Extragalactic Performance Estimation Tool" (EX-PET) to estimate the flux density in the Spitzer IRAC + MIPS imaging passbands for various point source SEDs. For user configured Spitzer observing parameters, the PET also returns an estimate of the instrument sensitivity, total integration depth per pixel, and expected S/N.

Input: choose an SED model, set normalization parameters, expected background level, and configure IRAC/MIPS instrument settings. *Note: these are provided as a guideline only. Observers are responsible for verifying the expected source flux densities for their observations.*

Output: summary of SED properties, intrinsic flux, color corrections and observed flux in the Spitzer passbands and a signal-to-noise estimate for the observing parameters chosen.

Help: EX-PET help page.

Input parameters: [Do calculations...] [Reset Form]

SED model: (choose one)

<input type="radio"/> Composite SED	SED type: LINER	Flux density at fiducial wavelength (mJy): 1.0	Fiducial wavelength (microns): 1.0	Redshift: 0.0
<input type="radio"/> Named Object	Object name: Arp 220	Flux density at fiducial wavelength (mJy): 1.0	Fiducial wavelength (microns): 1.0	Redshift: 0.0
<input type="radio"/> Modified Blackbody	Temperature (K): 5000	Flux density at fiducial wavelength (mJy): 1.0	Fiducial wavelength (microns): 1.0	Emissivity index: 0.0
<input checked="" type="radio"/> Blackbody	Temperature (K): 5000	Flux density at fiducial wavelength (mJy): 1.0	Fiducial wavelength (microns): 1.0	
<input type="radio"/> Power Law	Index: -1	Flux density at fiducial wavelength (mJy): 1.0	Fiducial wavelength (microns): 1.0	

Background: Background level: low

IRAC Observing parameters:

<input checked="" type="radio"/> Full Array / HDR / Stellar mode	Frame time: 2	Number of repeats: 1
<input type="radio"/> Subarray	Frame time: 0.02	Number of repeats: 1

MIPS Observing parameters:

Passband:	Pixel scale:	Field Size:	Frame time (sec):	Number of cycles:
<input checked="" type="radio"/> Photometry and Super Resolution	24 microns: Default	Small	3	1
	70 microns: Default	Small	3	1
	160 microns: Default	Small	3	1
<input type="radio"/> Scan Map	Scan rate: Slow		Number of scan passes: 1	

[Do calculations...] [Reset Form]

Output:

INPUT PARAMETERS:	Blackbody: T _{eff} = 5000 K; F _{nu} (1.0 microns) = 1.0 mJy IRAC: Full Array mode; Frame Time = 2 sec; Nrepeat = 1 MIPS: Photometry mode 24 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 70 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 Pixel scale = default: 160 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 Background = Low
Waveband (microns):	IRAC: [3.55 4.49 5.73 7.87] MIPS: [23.68 71.44 155.90]
Source intrinsic flux density in IRAC/MIPS bands (mJy):	IRAC: [0.3 0.207 0.137 0.078] MIPS: [0.00979 0.00112 0.000238]
Color correction in IRAC/MIPS bands:	IRAC: [1.01 1 1.01 1.03] MIPS: [0.999 0.999 1]
Spitzer quoted flux density in IRAC/MIPS bands (mJy):	IRAC: [0.302 0.207 0.138 0.0801] MIPS: [0.00979 0.00112 0.000238]
Sensitivity in IRAC/MIPS bands (micro-Jy, 1-sigma):	IRAC: [32 39 150 92] MIPS: [126 5930 55300]
Exposure time per pixel in IRAC/MIPS bands (s):	IRAC: [2 2 2 2] MIPS: [42 30 6]
S/N in IRAC/MIPS bands:	IRAC: [9.4 5.4 0.81 0.85] MIPS: [0.077 0.00019 0.0000043]

Background Model

You can specify coordinates by selecting a position on the above all-sky map, a MONTECLO generated model of the individual IRAC 100 micron images created by Schlegel et al. (1998, ApJ 500, 523).

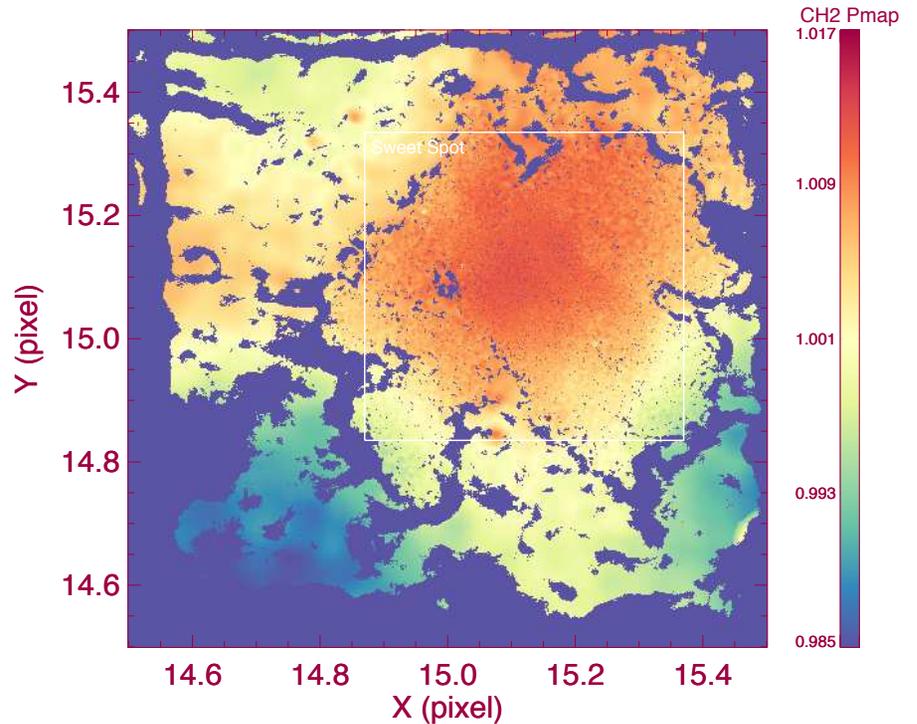
Version 2, July 30, 2014.
This tool gives infrared background estimates for observations from Earth, or from the Earth-Sun L2 Lagrangian region, the future site of the James Webb Space Telescope (JWST) and Euclid.

See this link for Help. This service can also be accessed by an ETC program interface.
SCFEE Version 2 contains new estimates of zodiacal light. See the Help page for a description. Version 1 can be accessed from the bottom Google location or with table column "observer" set to "1" (table option).

Single Location [Upload Table]

Coordinate/Object: 0 0 0 0 gal
Wavelength: 100 (0.5 to 1000.0 microns)
Year: 2010 (see below)
Day: 180 (0 to 366)
Observing Location: Earth-Sun L2 Earth
Note: L2 estimates currently limited to Day 139, 2017 to Day 308, 2021. (Zodiacal model value depends on date and estimated location.)
Version of code: Version 2 Version 1
Coordinate Examples: 19h17m32s 14d58m02s Eqa J2000 1 46.8377 -0.2518 gal 1 M 31 1322.9824 60.1873
Default Coordinate System: Equatorial J2000

[Submit] [Reset] [Service Help]





Background Estimators and Integration Time Calculators



• Sensitivity estimators for imaging and spectroscopy
 • Tools for observing different classes of sources
 • Algorithms and tools for estimating backgrounds in the infrared – Tool developed for JWST easily extensible to far-IR
 • Knowledge base for dealing with high-precision photometry

The screenshot shows the EX-PET web interface with the following sections:

- Overview:** An 'Extragalactic' observing configuration.
- Input parameters:**
 - SED model:** Composite SED, Named Object, Modified Blackbody, Blackbody, Power Law.
 - IRAC Observing parameters:** Full Array HDR, Number of repeats: 1.
 - MIPS Observing parameters:** Photometry and Super Resolution, 24 microns (Field size = small, Frame time = 3 sec, Nrepeat = 1), 70 microns (Field size = small, Frame time = 3 sec, Nrepeat = 1), 160 microns (Field size = small, Frame time = 3 sec, Nrepeat = 1).
 - Scan Map:** Scan rate: Slow, Number of scan passes: 1.
- Output:**

INPUT PARAMETERS:	Blackbody: T _{eff} = 5000 K; F _{nu} (1.0 microns) = 1.0 mJy IRAC: Full Array mode; Frame Time = 2 sec; Nrepeat = 1 MIPS: Photometry mode 24 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 70 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 Pixel scale = default; 160 microns: Field size = small; Frame time = 3 sec; Nrepeat = 1 Background = Low
Waveband (microns):	IRAC: [3.55 4.49 5.73 7.67] MIPS: [23.66 71.44 155.90]
Source intrinsic flux density in IRAC/MIPS bands (mJy):	IRAC: [0.3 0.207 0.137 0.078] MIPS: [0.00979 0.00112 0.000238]
Color correction in IRAC/MIPS bands:	IRAC: [1.01 1 1.01 1.03] MIPS: [0.999 0.999 1]
Spitzer quoted flux density in IRAC/MIPS bands (mJy):	IRAC: [0.302 0.207 0.138 0.0801] MIPS: [0.00979 0.00112 0.000238]
Sensitivity in IRAC/MIPS bands (micro-Jy, 1-sigma):	IRAC: [32 39 150 92] MIPS: [126 5930 55300]
Exposure time per pixel in IRAC/MIPS bands (s):	IRAC: [2 2 2 2] MIPS: [42 30 6]
S/N in IRAC/MIPS bands:	IRAC: [9.4 5.4 0.81 0.85] MIPS: [0.077 0.00019 0.000043]

The background map shows a color-coded intensity distribution with axes labeled X (pixel) and Y (pixel). A color bar on the right indicates intensity values from 0.985 to 1.017.



Archive, Visualization and Data Manipulation



IRSA | DATA SETS | SEARCH | TOOLS | HELP

Pixel Size: 4.8" Eq-J2000: 5h10m30.62s, -69d33m06.0s SAGE_LMC_MIPS70_E1...
Flux: 5.461505 MJy/sr Image Pixel: 4781.5, 3699.5 Lock By Click

Images Catalogs Help Background Monitor

Tiled View

WCS Search Target Match
WCS Match

SAGE_LMC_MIPS70_E12: Large Magellanic Cloud 1/2x

SAGE_LMC_MIPS24_E12: Large Magellanic Cloud .049x



Archive, Visualization and Data Manipulation



- **Firefly: Generalized server-client architecture developed for data delivery, visualization and manipulation**
- **Basis of all IRSA archive interfaces**
- **Baseline for LSST Science User Interface and Tools (SUI/T)**
- **Jupyter notebook / Python interfaces being developed**
- **Existing infrared data archived at IRSA using common interfaces with APIs available**



Collaborative Approach



- Science tool development:
 - *Algorithms scoped and formulated by the STDT, and implemented by IPAC*
 - *IPAC would develop the tools for any architecture or option, based on STDT guidance*
- Science operations tools:
 - *Framework would be scoped and formulated by the STDT, coordinated with the Study Center effort, and implemented by IPAC*
 - *IPAC would develop the tools for any architecture or option, based on STDT guidance, and participate in related trade studies*