# * MIPS CALIBRATION

*Alberto Noriega-Crespo*

*Infrared Processing and Analysis Center*

*California Institute of Technology*

# * Outline

* Brief Intro to MIPS – Refreshing your memory.

  Spitzer launched 8/25/2003. MIPS ended operations 4/1/2009.

* MIPS 24μm calibration.

  It ties together the 70 and 160um asteroids &160um calibration.

* MIPS 70μm calibration.

  Point Sources & Extended Emission.

* MIPS 160μm calibration.

  Point Sources & Extended Emission.

* The "unpublished stuff".

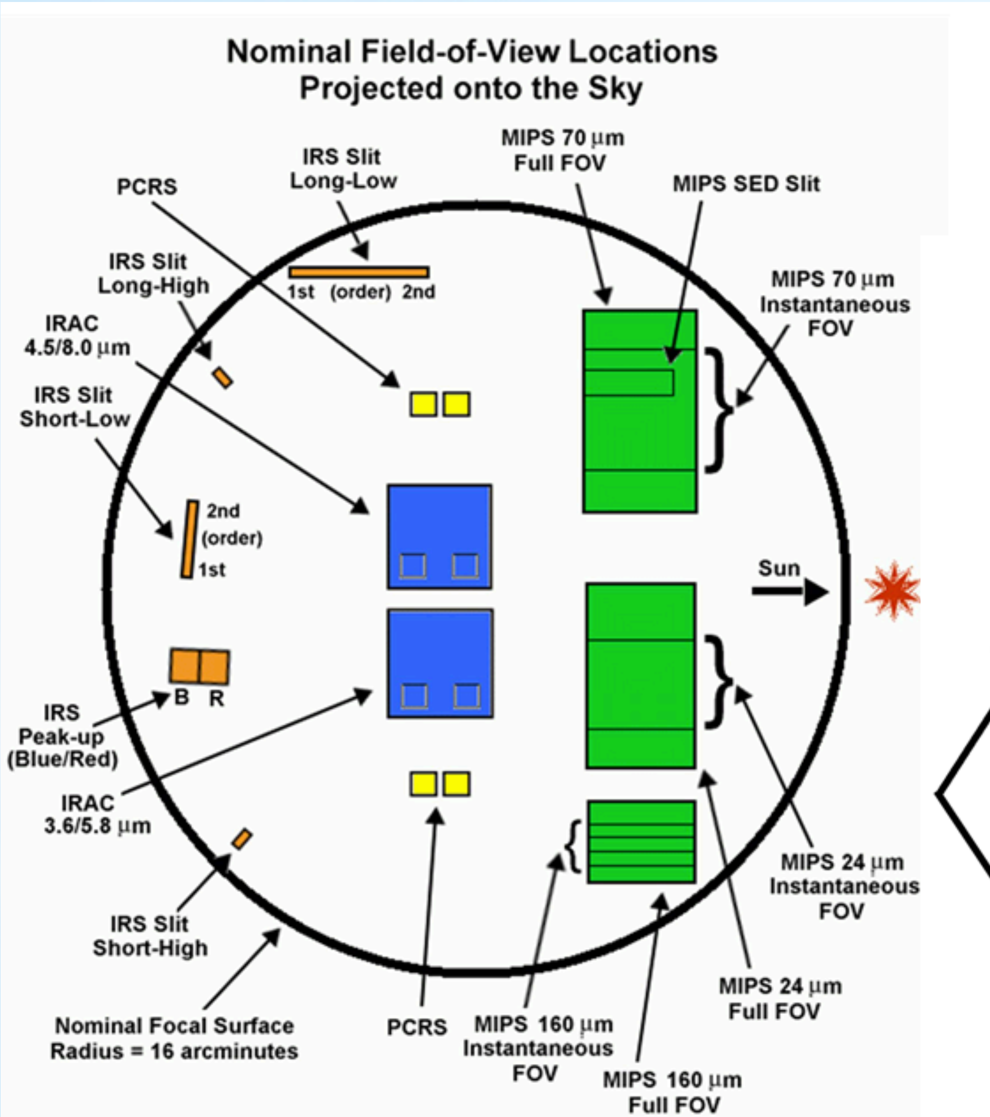
* Post-Operations.

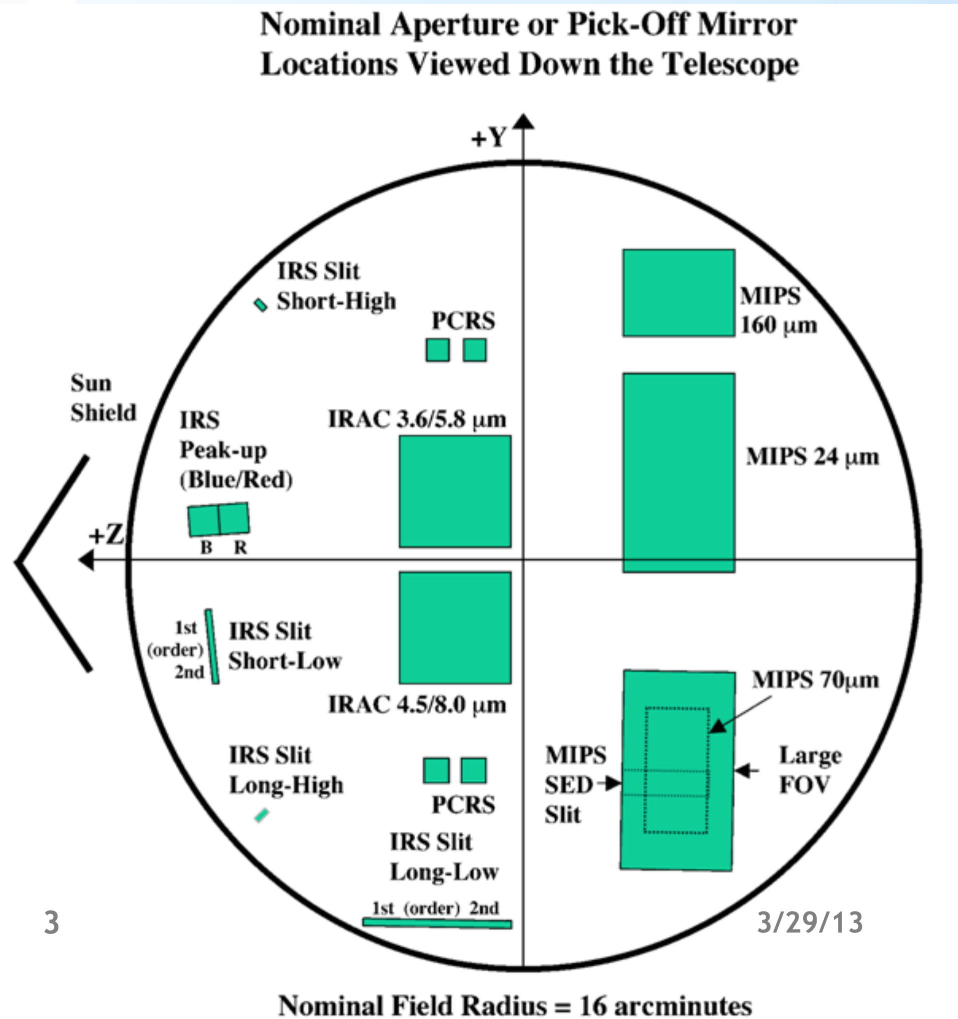
  SSC Enhanced Products.

*(Use what we learned from our research)*

  SAFIRES.

# MIPS I


Nominal Field-of-View Locations
Projected onto the Sky
PCRS
IRS Slit
Long-Low
MIPS 70 μm
Full FOV
MIPS SED Slit
IRS Slit
Long-High
1st (order) 2nd
MIPS 70 μm
Instantaneous
FOV
IRAC
4.5/8.0 μm
IRS Slit
Short-Low
2nd
(order)
1st
Sun
IRS
Peak-up
(Blue/Red)
B R
IRAC
3.6/5.8 μm
IRS Slit
Short-High
MIPS 24 μm
Instantaneous
FOV
Nominal Focal Surface
Radius = 16 arcminutes
PCRS
MIPS 160 μm
Instantaneous
FOV
MIPS 160 μm
Full FOV
MIPS 24 μm
Full FOV


Nominal Aperture or Pick-Off Mirror
Locations Viewed Down the Telescope
+Y
IRS Slit
Short-High
PCRS
MIPS
160 μm
Sun
Shield
IRS
Peak-up
(Blue/Red)
IRAC 3.6/5.8 μm
MIPS 24 μm
+Z
B R
1st
(order)
2nd
IRS Slit
Short-Low
IRAC 4.5/8.0 μm
MIPS 70μm
IRS Slit
Long-High
PCRS
MIPS
SED
Slit
Large
FOV
IRS Slit
Long-Low
1st (order) 2nd
Nominal Field Radius = 16 arcminutes

# MIPS II

1/04.4.
02 → 84.

**Table 8.9 Saturation levels**

| Observing Mode PTGDIFF | Point Source Saturation in 1 sec | Extended Source Saturation in 10 sec |
|---|---|---|
| 24µm | ~~6.4 Jy~~ 5.6 | ~~500 MJy/ster~~ 440 |
| 70µm coarse scale | ~~8 Jy~~ 5.3 | ~~70 MJy/ster~~ ~~46~~ 100 |
| 70µm fine scale | ~~41 Jy~~ 20 | ~~360 MJy/ster~~ ~~290~~ |
| SED (@ 55, 70, 95µm) | 16, 41, 145 ~~24, 64, 220 Jy~~ | ~~430 MJy/ster (@ 60µm)~~ 260 |
| 160µm | 17 Jy 8 | ~~33 MJy/ster~~ ~~14~~ 20 |

**http://ssc.spitzer.caltech.edu/mips/**

**Astronomical Observation Templates:**

**Photometry & Super Resolution**
- Telescope staring mode imaging photometry

**Scan Mapping**
- Freeze frame mapping in all three bands with constant telescope slewing

**Spectral Energy Distribution (SED)**
- Low resolution (R = 15 – 25) spectroscopy over 55 to 95 µm (half power response points)

**Total Power Mode**
- Zero level brightness of very extended emission

**Field of View:**

| | |
|---|---|
| 24 µm | 5.4×5.4 arcminutes |
| 70 µm | 5.25×2.6 or 2.6×1.3 arcminutes |
| 160 µm | 0.53×5.33 arcminutes (effective) |
| SED Slit | 3.8×0.32 arcminutes |

**The MIPS Detector Arrays:**

| | | |
|---|---|---|
| 24 µm | Si:As (IBC)<br>128x128 pixels; 2.55"<br>4.7 µm bandwidth | 6" beam |
| 70 µm | Ge:Ga<br>32x32 pixels; 4.99" or 9.84"<br>19 µm bandwidth<br>SED R = 15 – 25 (9.84" pixels) | 17" beam |
| 160 µm | Stressed Ge:Ga<br>2x20 pixels; 16.0"<br>35 µm bandwidth | 38" beam |

**Basic Sensitivities (low background):**
5 sigma in 500 seconds on source

| | | |
|---|---|---|
| 24 µm | 110 µJy | → 0.114 MJy/ster |
| 70 µm default | 7.2 (3.2 w/ confusion) mJy | 15 mJy |
| 70 µm fine | 14.4 mJy | |
| SED | 82/201/447 mJy @ 60/75/90 µm | |
| 160 µm | ~~29~~ (40 w/ confusion) mJy | 15 mJy |

5–6

PACS point source sensitivity ~3 mJy 5 sigma in hour

**Saturation Limits:**
Point source in 1 second (Jy); Extended source in 10 seconds (MJy/ster)

| Band | Point Source | Extended |
|---|---|---|
| 24 µm | 4.1 | 260 |
| 70 µm (default) | 23 | 101 |
| 70 µm (fine) | 57 | 292 |
| SED @ 60,75,90µm | 250/290/1000 | 1087/1261/4350 |
| 160 µm | 3 | ~~TBD~~ ~20 |

or 200 MJy/sr in 1 sec

Prepared by:
William B. Latter
SSC/MIPS Instrument Support Team Lead

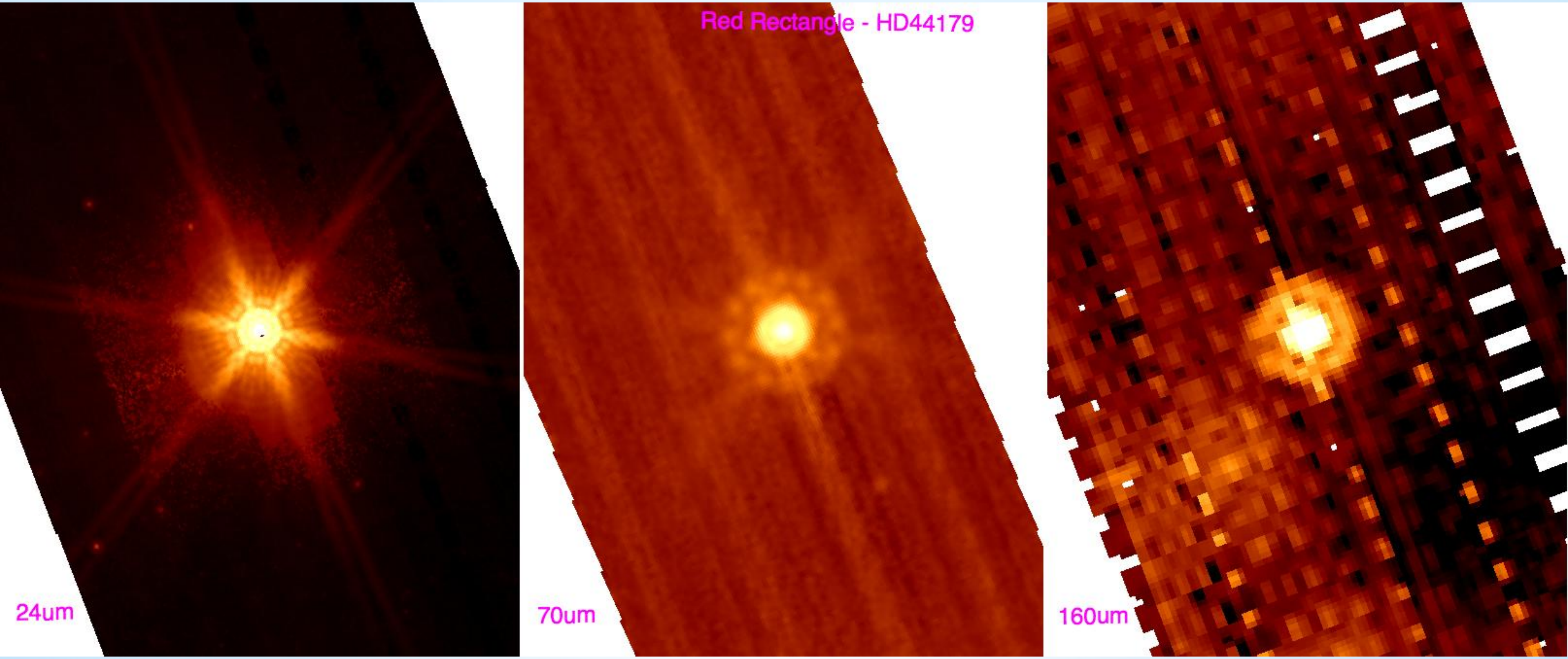
*(v6.1, updated 28 October 04, LMR)*

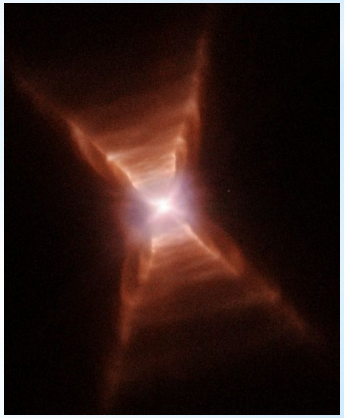
SSC Spitzer Science Center

SPITZER SPACE TELESCOPE

H

# MIPS III

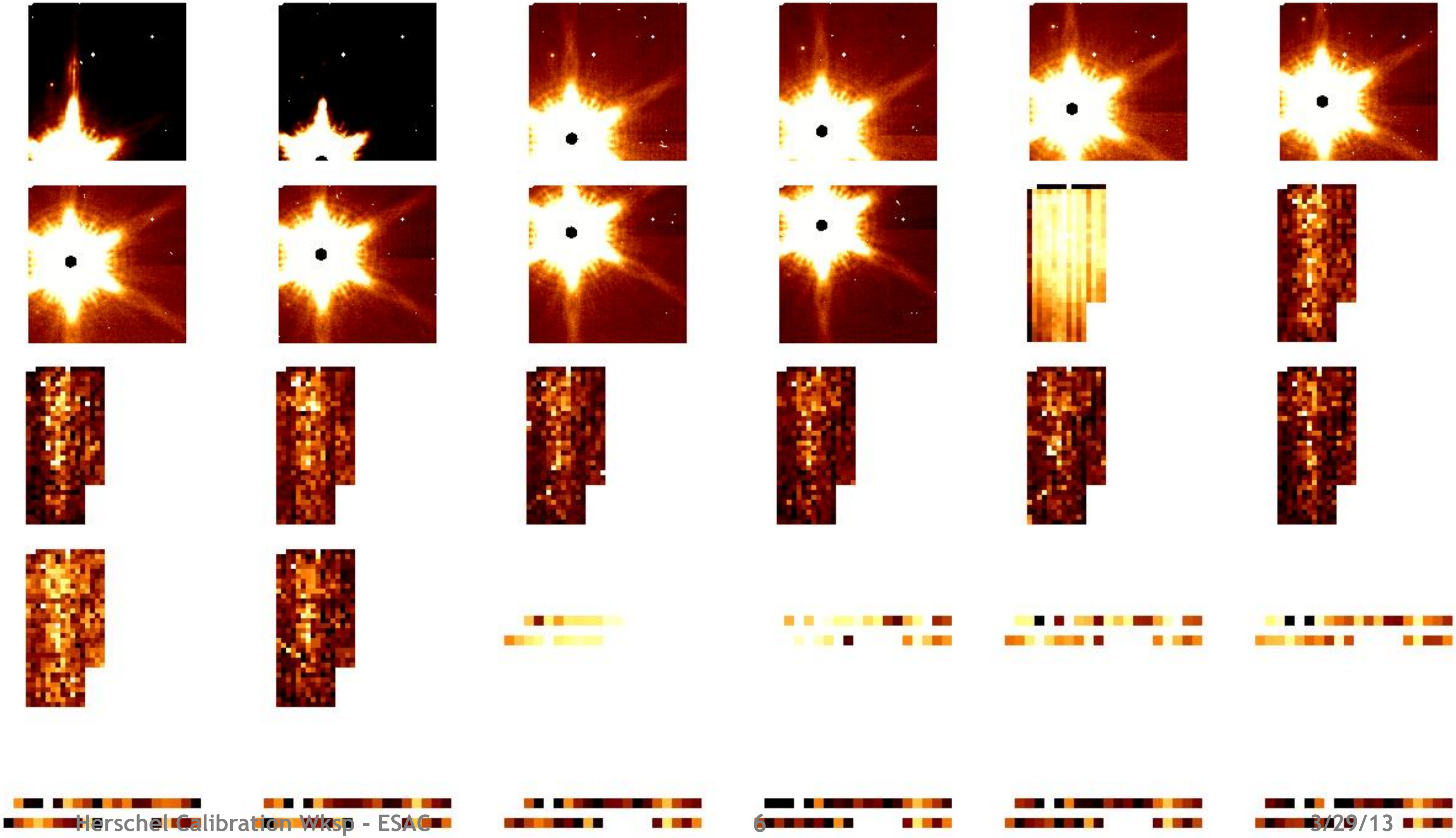


HST

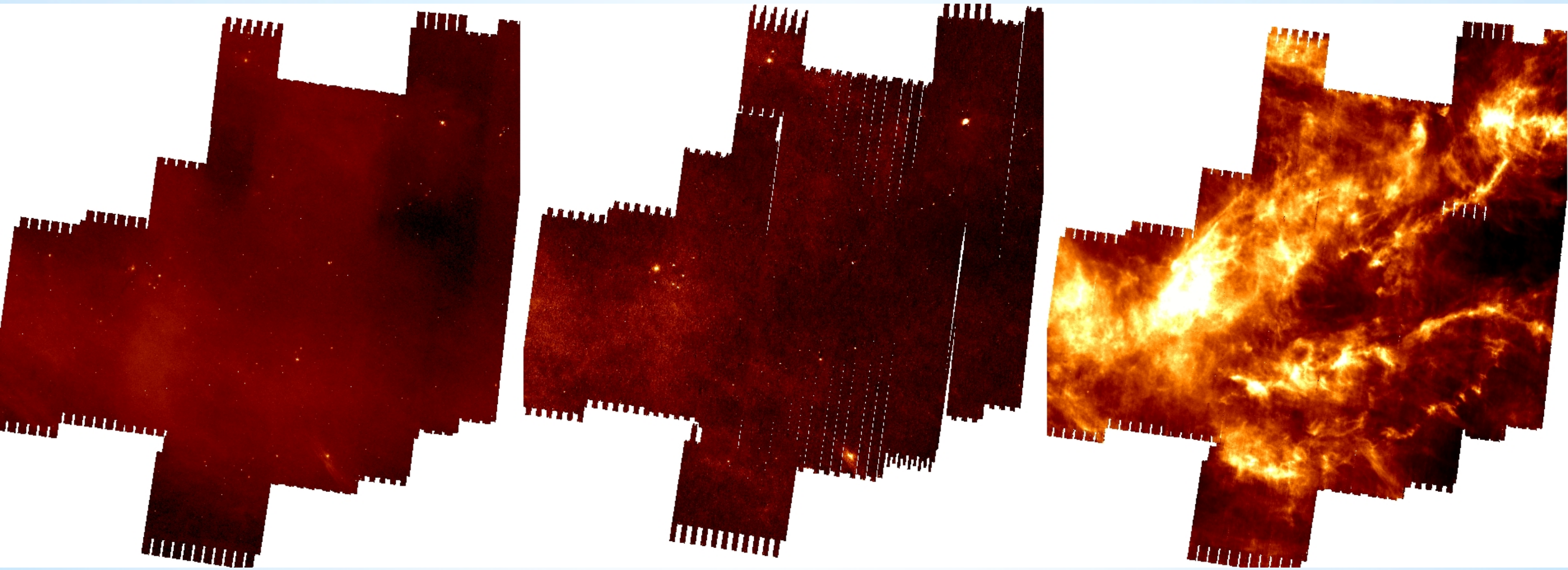
Red Rectangle IRAS Flux Densities
(12, 25, 60, 100μm) = (421.6, 456.1, 173.1, 66.2Jy)

# * MIPS IV



# TMC Legacy MIPS

~48 sq deg



24µm　　　70µm　　　160µm

Flagey, Noriega-Crespo, Boulanger et al 2009

# Calibration Papers

Publications of the Astronomical Society of the Pacific, 119: 994–1018, 2007 September


## Absolute Calibration and Characterization of the Multiband Imaging Photometer for *Spitzer*. I. The Stellar Calibrator Sample and the 24 $\mu$m Calibration

C. W. Engelbracht,[1] M. Blaylock,[1] K. Y. L. Su,[1] J. Rho,[2] G. H. Rieke,[1] J. Muzerolle,[1] D. L. Padgett,[2] D. C. Hines,[3] K. D. Gordon,[1] D. Fadda,[2] A. Noriega-Crespo,[2] D. M. Kelly,[1] W. B. Latter,[4] J. L. Hinz,[1] K. A. Misselt,[1] J. E. Morrison,[1] J. A. Stansberry,[1] D. L. Shupe,[2] S. Stolovy,[2] Wm. A. Wheaton,[2] E. T. Young,[1] G. Neugebauer,[1] S. Wachter,[2] P. G. Pérez-González,[1,5] D. T. Frayer,[2] and F. R. Marleau[2]
*Received 2006 November 15; accepted 2007 July 25; published 2007 September 28*

Publications of the Astronomical Society of the Pacific, 119: 1019–1037, 2007 September


## Absolute Calibration and Characterization of the Multiband Imaging Photometer for *Spitzer*. II. 70 $\mu$m Imaging

Karl D. Gordon,[1] Charles W. Engelbracht,[1] Dario Fadda,[2] John Stansberry,[1] Stefanie Wachter,[2] Dave T. Frayer,[2] George Rieke,[1] Alberto Noriega-Crespo,[2] William B. Latter,[3] Erick Young,[1] Gerry Neugebauer,[1] Zoltan Balog,[1] Jeffrey W. Beeman,[4] Hervé Dole,[5] Eiichi Egami,[1] Eugene E. Haller,[4,6] Dean Hines,[7] Doug Kelly,[1] Francine Marleau,[2] Karl Misselt,[1] Jane Morrison,[1] Pablo Pérez-González,[1,8] Jeonghee Rho,[2] and Wm. A. Wheaton[2]
*Received 2006 November 15; accepted 2007 April 16; published 2007 October 2*

Publications of the Astronomical Society of the Pacific, 119: 1038–1051, 2007 September


## Absolute Calibration and Characterization of the Multiband Imaging Photometer for *Spitzer*. III. An Asteroid-based Calibration of MIPS at 160 $\mu$m

J. A. Stansberry,[1] K. D. Gordon,[1] B. Bhattacharya,[2] C. W. Engelbracht,[1] G. H. Rieke,[1] F. R. Marleau,[2] D. Fadda,[2] D. T. Frayer,[2] A. Noriega-Crespo,[2] S. Wachter,[2] E. T. Young,[1] T. G. Müller,[3] D. M. Kelly,[1] M. Blaylock,[1] D. Henderson,[2] G. Neugebauer,[1] J. W. Beeman,[4] and E. E. Haller[4,5]
*Received 2006 November 15; accepted 2007 July 25; published 2007 September 28*

Publications of the Astronomical Society of the Pacific, 120:328–338, 2008 March


## Absolute Calibration and Characterization of the Multiband Imaging Photometer for *Spitzer*. IV. The Spectral Energy Distribution Mode

Nanyao Lu, [1] Paul S. Smith, [2] Charles W. Engelbracht, [2] Alberto Noriega-Crespo, [1] Jane Morrison, [2] Karl D. Gordon, [2] John Stansberry, [2] Francine R. Marleau, [1] George H. Rieke, [2] Roberta Paladini, [1] Deborah L. Padgett, [1] Joannah Hinz, [2] William B. Latter, [1] Dario Fadda, [1] and Jeonghee Rho[1]
*Received 2007 November 14; accepted 2008 January 22; published 2008 March 13*

Publications of the Astronomical Society of the Pacific, 117:503–525, 2005 May


## Reduction Algorithms for the Multiband Imaging Photometer for *Spitzer*

Karl D. Gordon, George H. Rieke, Charles W. Engelbracht, James Muzerolle, John A. Stansberry, Karl A. Misselt, Jane E. Morrison, James Cadien, Erick T. Young, Hervé Dole, Douglas M. Kelly, Almudena Alonso-Herrero, Eiichi Egami, Kate Y. L. Su, Casey Papovich, Paul S. Smith, Dean C. Hines, Marcia J. Rieke, Myra Blaylock, Pablo G. Pérez-González, Emeric Le Floc'h, and Joannah L. Hinz
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Matthew P. Smylie and Nancy M. Haegel
Department of Physics, Fairfield University, Fairfield, CT 06824
*Received 2003 September 14; accepted 2005 February 2; published 2005 April 28*

The Astronomical Journal, 135:2245–2263, 2008 June
doi:10.1088/0004-6256/135/6/2245


## ABSOLUTE PHYSICAL CALIBRATION IN THE INFRARED

G. H. Rieke[1], M. Blaylock[1,8], L. Decin[2], C. Engelbracht[1], P. Ogle[3], E. Avrett[4], J. Carpenter[5], R. M. Cutri[6], L. Armus[3], K. Gordon[1,9], R. O. Gray[7], J. Hinz[1], K. Su[1], and Christopher N. A. Willmer[1]
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[2] Department of Physics and Astronomy, Institute for Astronomy, K.U.Leuven, Celestijnenlaan 200B, 3001, Leuven, Belgium
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*Received 2008 January 16; accepted 2008 March 14; published 2008 May 13*

The Astronomical Journal, 141:173 (12pp), 2011 May
doi:10.1088/0004-6256/141/5/1


## ABSOLUTE FLUX CALIBRATION OF THE IRAC INSTRUMENT ON THE *SPITZER SPACE TELESCOPE* USING *HUBBLE SPACE TELESCOPE* FLUX STANDARDS

R. C. Bohlin[1], K. D. Gordon[1], G. H. Rieke[2], D. Ardila[3], S. Carey[4], S. Deustua[1], C. Engelbracht[2], H. C. Ferguson[1], K. Flanagan[1], J. Kalirai[1], M. Meixner[1], A. Noriega-Crespo[4], K. Y. L. Su[2], and P.-E. Tremblay[5]
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[3] Caltech, NASA Herschel Science Center, IPAC/MS 100-22, Pasadena, CA 91125, USA
[4] Caltech, Spitzer Science Center, MS 220-6, Pasadena, CA 91125, USA
[5] Université de Montréal, C.P. 6128, Succ. Centre-Ville, Montréal, Québec H3C 3J7, Canada
*Received 2011 February 10; accepted 2011 March 7; published 2011 April 7*

ABSTRACT

The absolute flux calibration of the *James Webb Space Telescope* (*JWST*) will be based on a set of stars observed by the *Hubble* and *Spitzer Space Telescopes*. In order to cross-calibrate the two facilities, several A, G, and white dwarf stars are observed with both *Spitzer* and *Hubble* and are the prototypes for a set of *JWST* calibration standards. The flux calibration constants for the four *Spitzer* IRAC bands 1–4 are derived from these stars and are 2.3%, 1.9%, 2.0%, and 0.5% lower than the official cold-mission IRAC calibration of Reach et al., i.e., in agreement within their estimated errors of ~2%. The causes of these differences lie primarily in the IRAC data reduction and secondarily in the spectral energy distributions of our standard stars. The independent IRAC 8 $\mu$m band-4 fluxes of Rieke et al. are about 1.5% $\pm$ 2% higher than those of Reach et al. and are also in agreement with our 8 $\mu$m result.

*Key words:* stars: atmospheres – stars: fundamental parameters – techniques: spectroscopic

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- MIPS 70um calibration.

  Point Sources & Extended Emission.

- MIPS 160um calibration.

  Point Sources & Extended Emission.

- The “unpublished stuff”.

- Post-Operations.

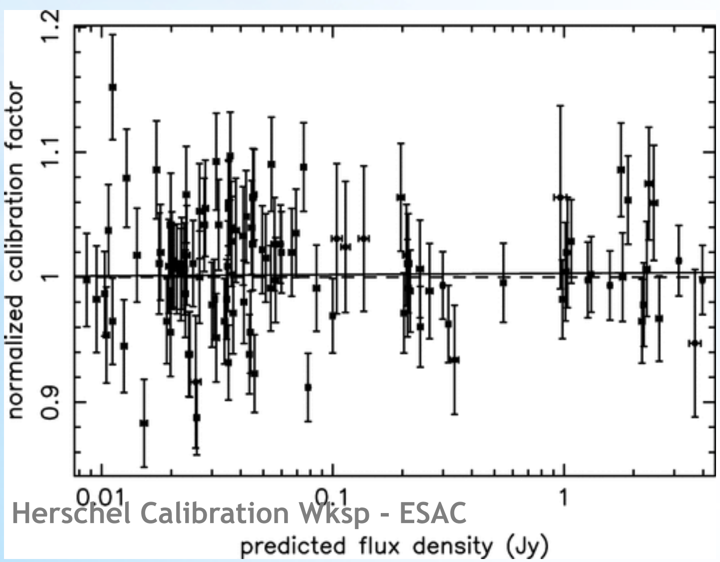
  SSC Enhanced Products.

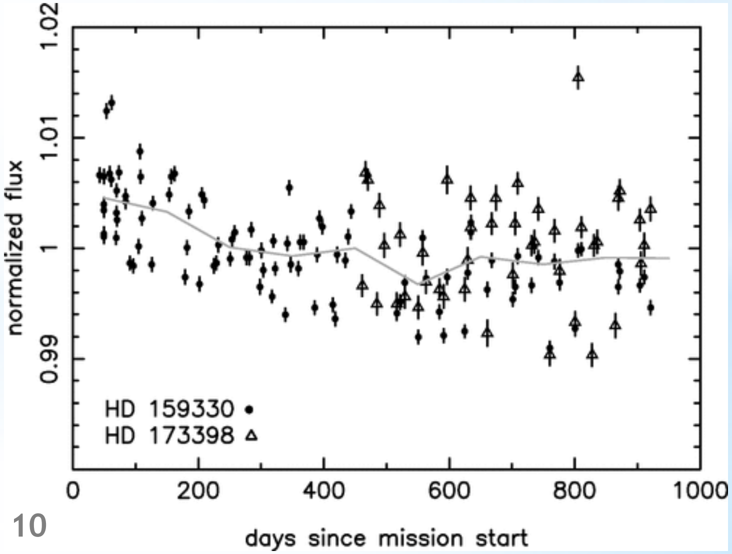
  *(Use what we learned from our research)*

  SAFIRES.

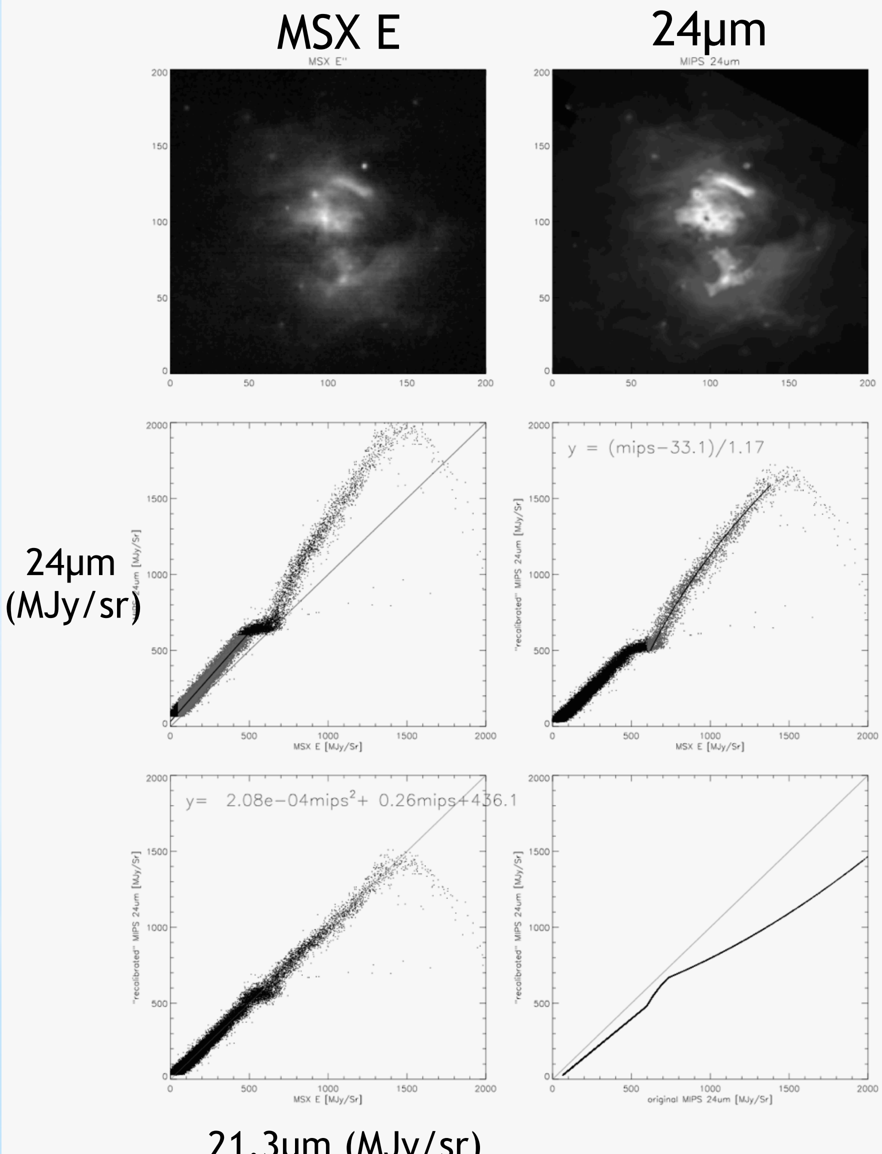
# 24μm

- Original analysis included ~3yr of data (2007 paper).
- Stars are calibrators (hot dwarfs, solar analogs and cool giants).
- From instrumental to physical units (calibration factor): 4.54e-2 MJy/sr per DN/s with a nominal uncertainty of 2%.
- 348 measurements from 141 stars covering a flux density factor of ~465: from 8.6mJy up to 4Jy.
- Repeatability 0.4-0.7% (UofA, SSC)

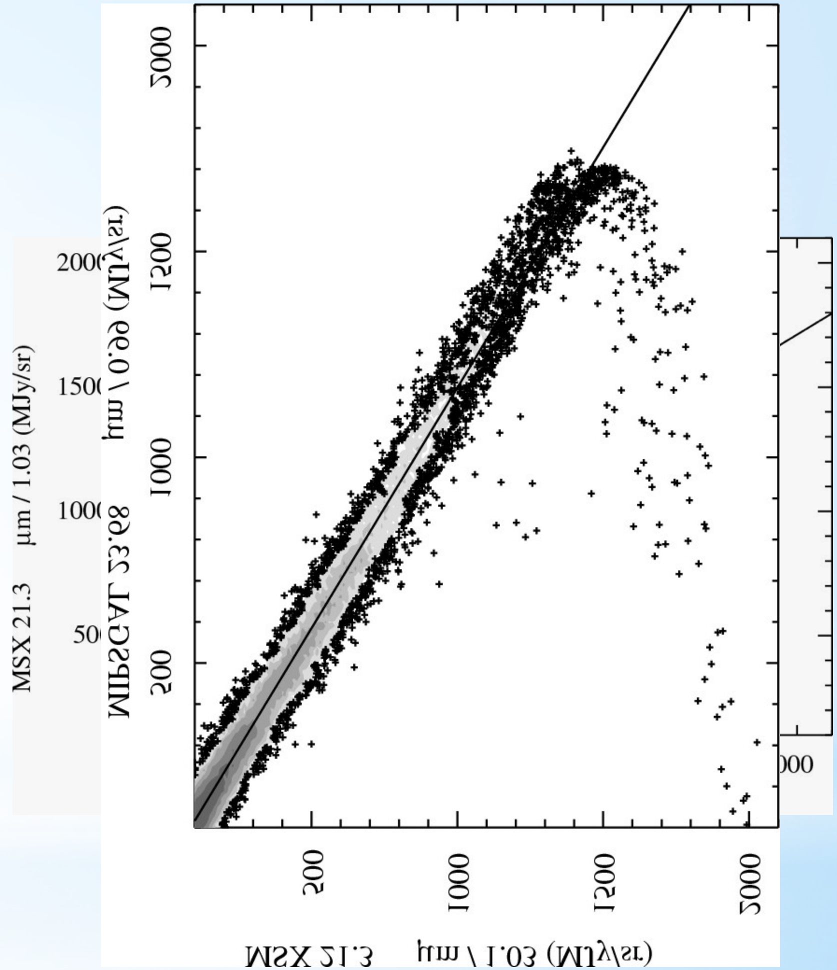


# 24μm II




*Indebetouw (private comm 2006; et al 2007)*




*Carey, Noriega-Crespo et al. 2009*

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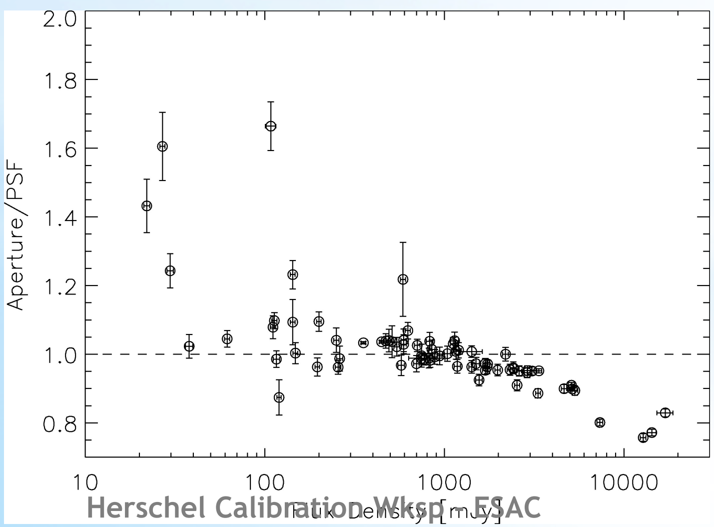
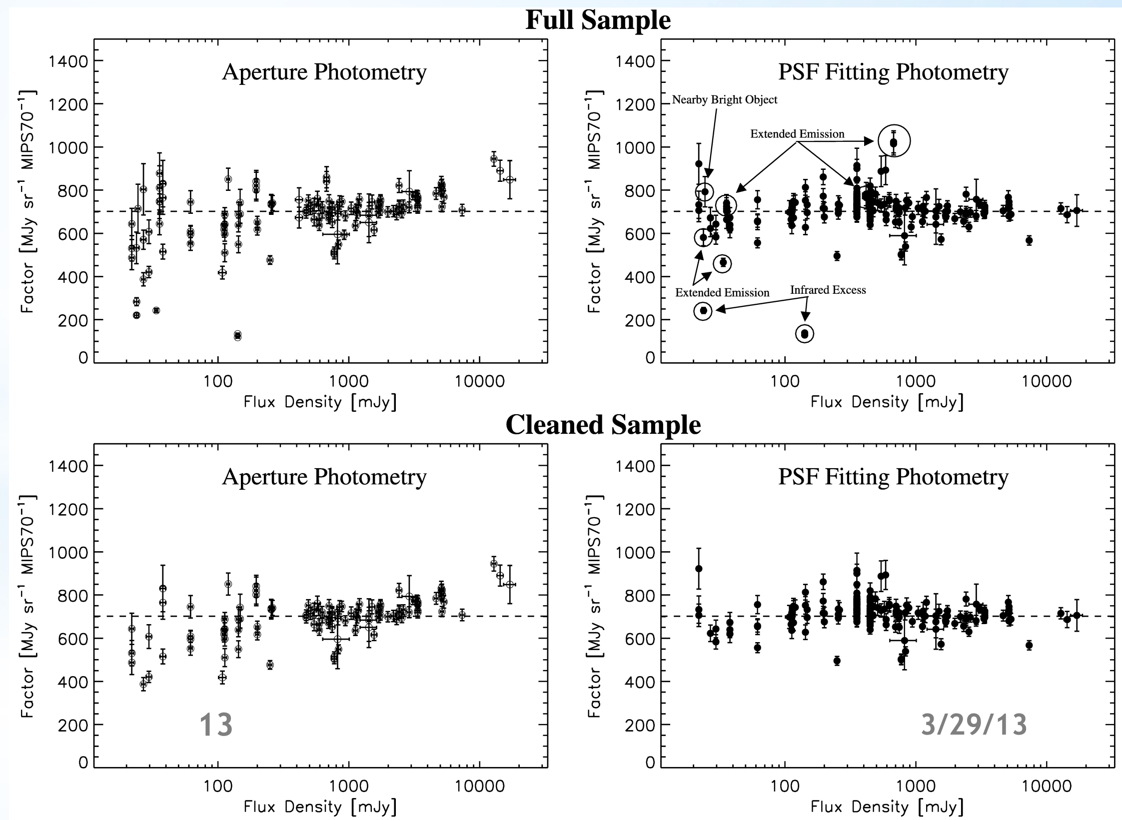
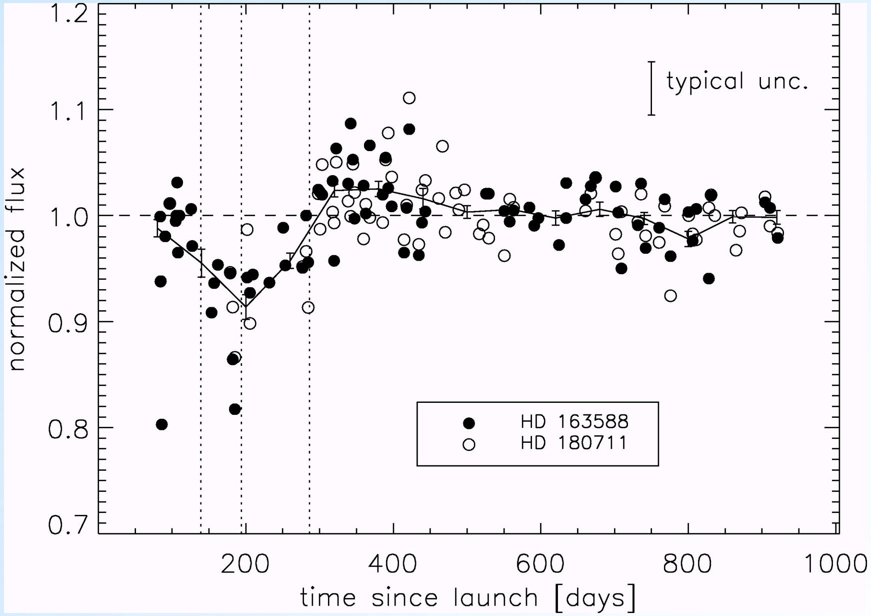
# 70μm Coarse

* Original analysis included ~3yr of data (2007 paper).
* Stars are calibrators (B to M spectral types).
* From instrumental to physical units (calibration factor): 702+/-35MJy/sr per MIPS70μm unit with a nominal uncertainty of 5%.
* 292 measurements from 66 stars covering a flux density factor of ~770: from 22mJy up to 17Jy.
* Repeatability 4.5%.
* PRF fitting for everything.

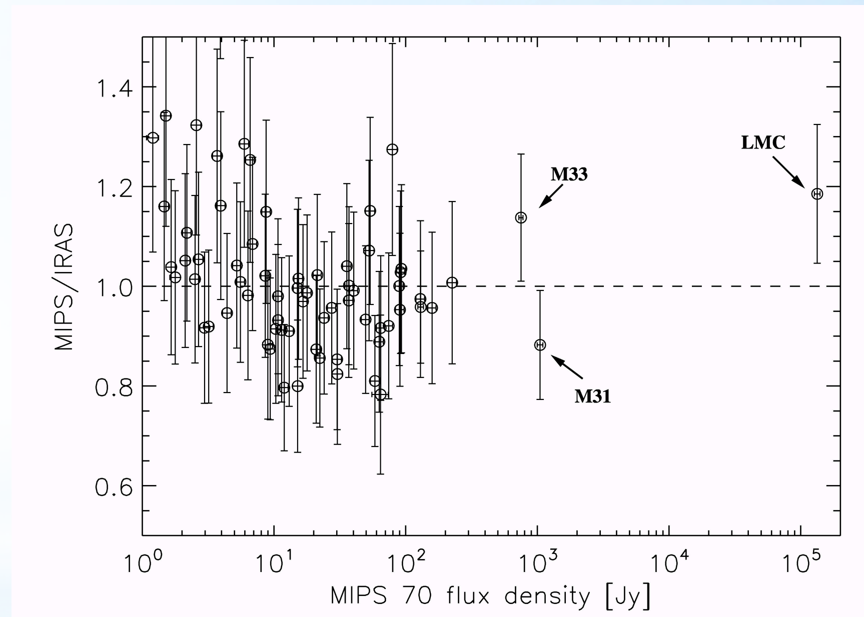


# * 70µm Coarse II




Repeatability




Extended Emission Calibration using SINGS Galaxies

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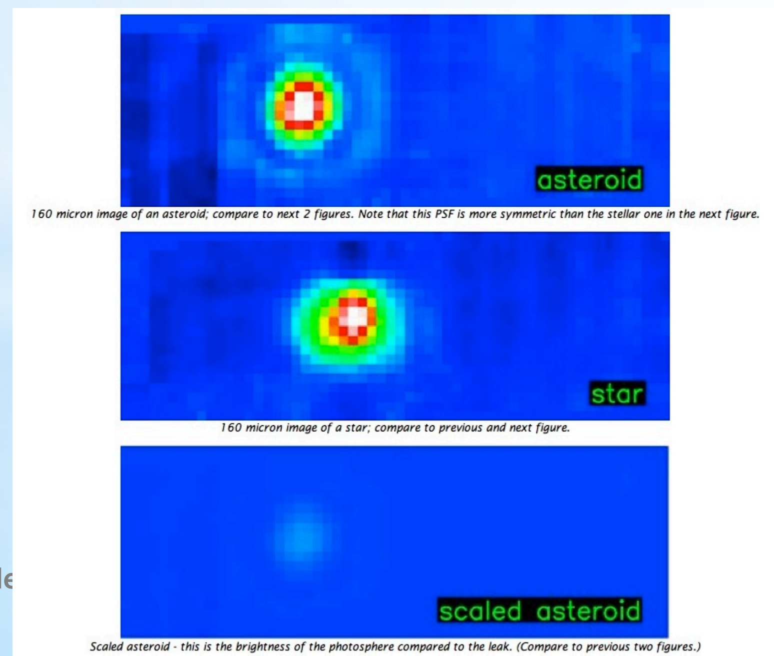
# * 160μm

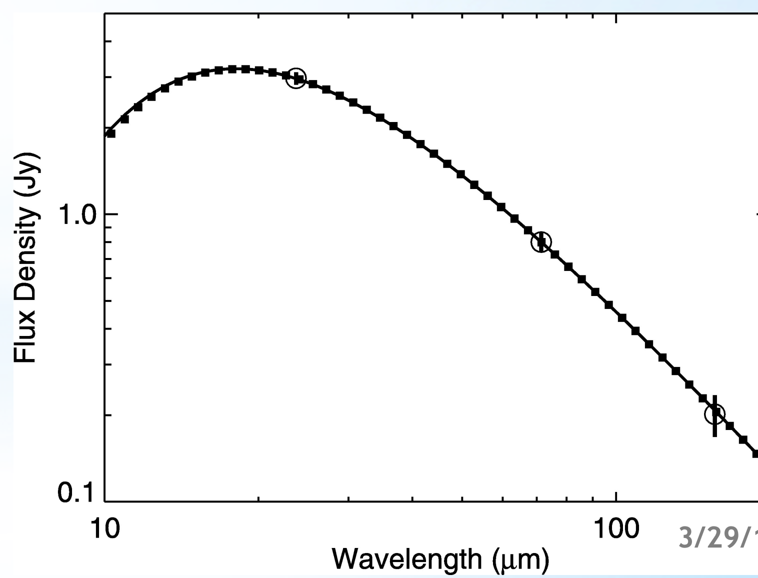
* NIR "Ghost" dominated the emission for sources hotter than 2000K. We could not use stars for calibration.
* Transfer strategy. Observe asteroids and transfer the 24 and 70μm calibration at 160μm to them. Required near simultaneous observations of the same target on the 3 bands.
* Use the "Standard Thermal Model" with 24 and 70μm to predict 160μm

spherical body; surfaces reaches instantaneous thermal equilibrium

non-rotating body or rotating illuminated and viewed pole-on




SED for asteroid 282 Clorinde

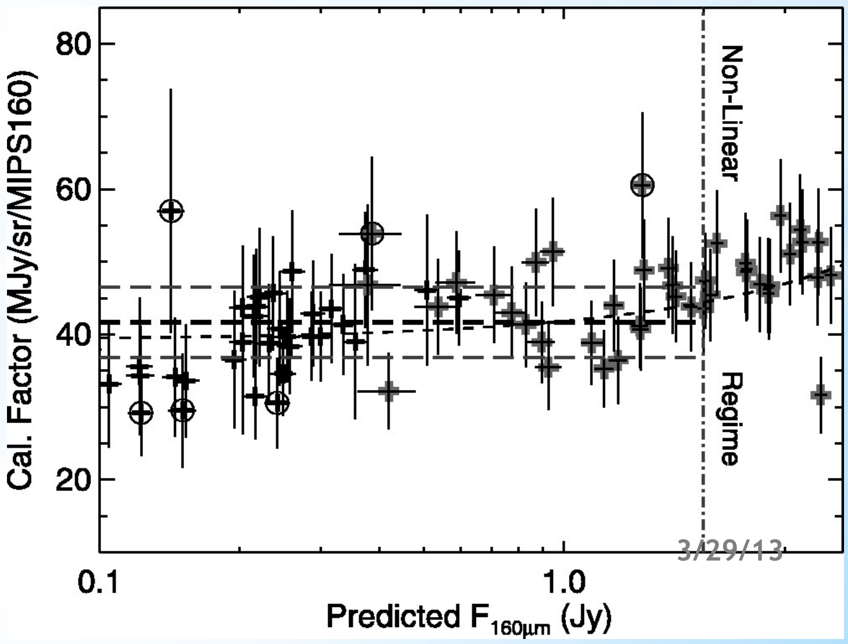


# 160μm II

- 51 asteroids at (24, 70 & 160). Faint Sample.
- 24 w/ 70 & 160μm and 27 at 160μm. Bright Sample.
- Calibration Factor 41.7 MJy/sr per MIPS160μm unit with a 12% uncertainty.
- Sources brighter than ~2Jy are affected by a non-linear behavior that underestimates the flux density.
- At 4 Jy this can be as much as 20%.
- The extended emission check was done w/ Galaxies (M31, M33, M101, NGC3198, etc) and in comparison with ISOPHOT C-160 broad band (170um). The <160μm>/<170μm> = 0.94+/-0.06
- "ISOPHOT and MIPS consistent

with each other".

Short-dash: 2.58+/-0.76 MJy/sr per MIPS160μm per Jy



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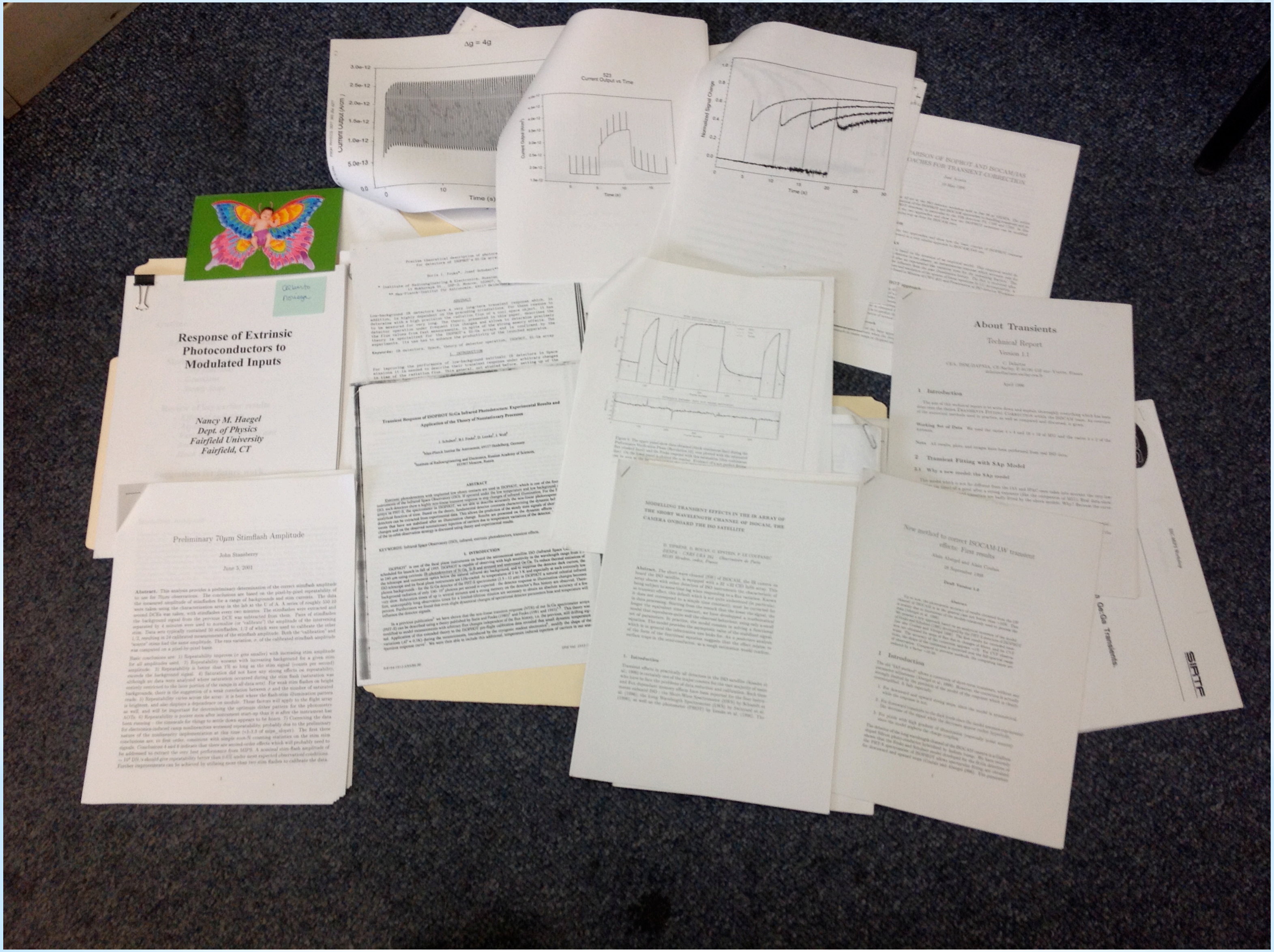
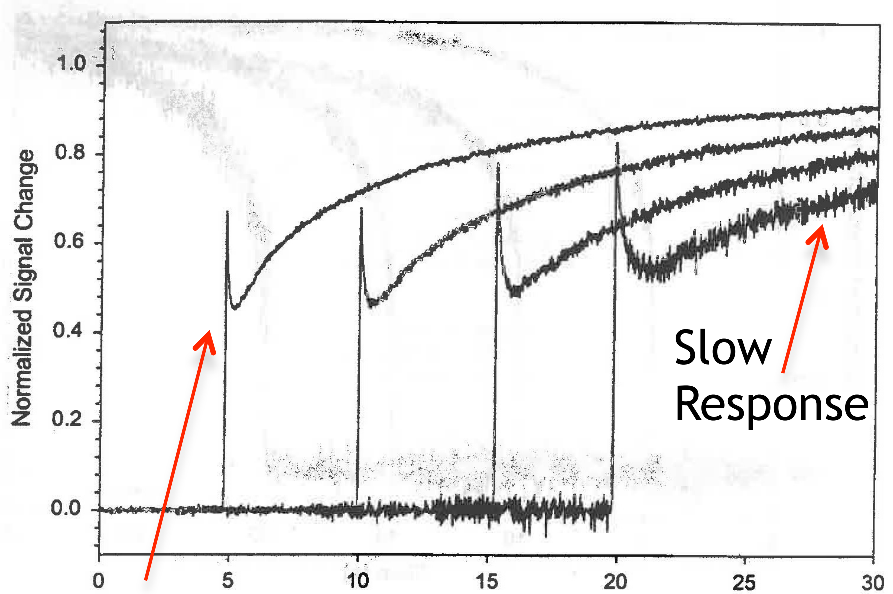
# Ge:Ga Non-Linearity



# *Ge:Ga Non-Lin




MIPS was designed to use the CSMM to take data during the fast response.
The calibration stims ("fix brightness") were used to track slow response effects.

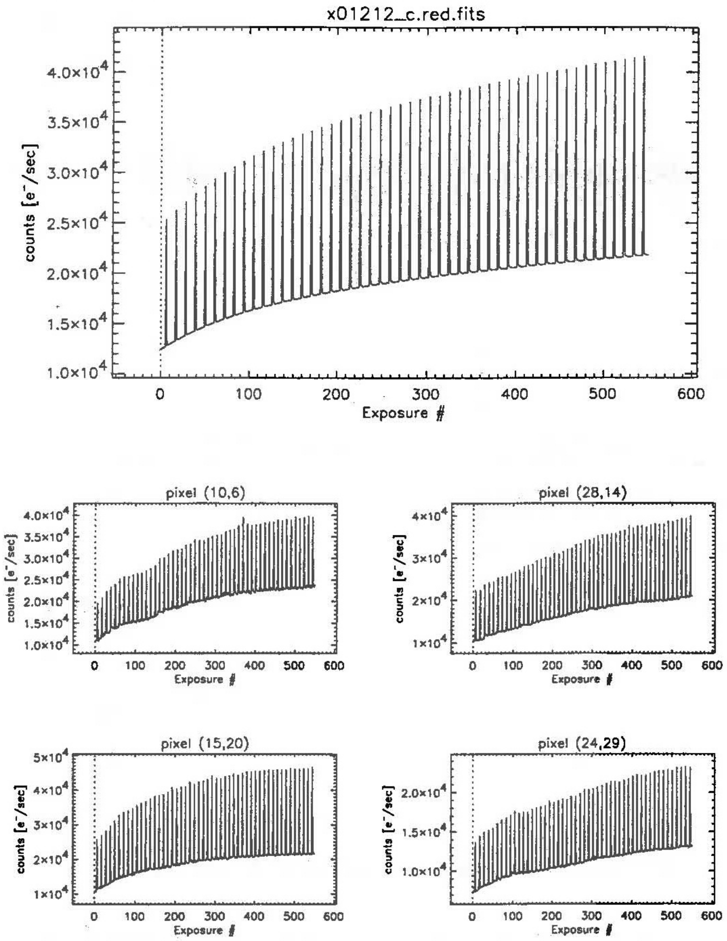
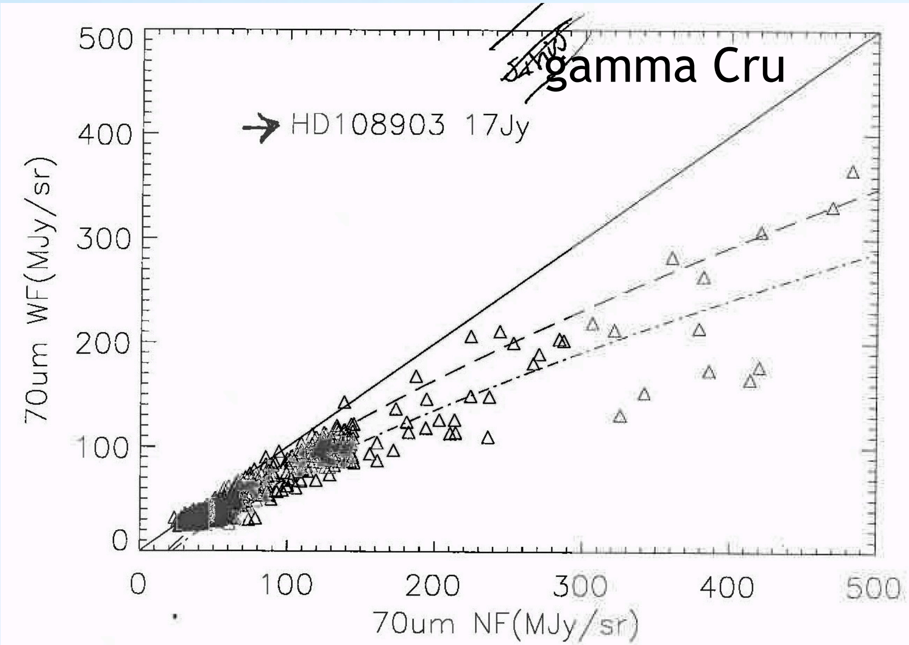
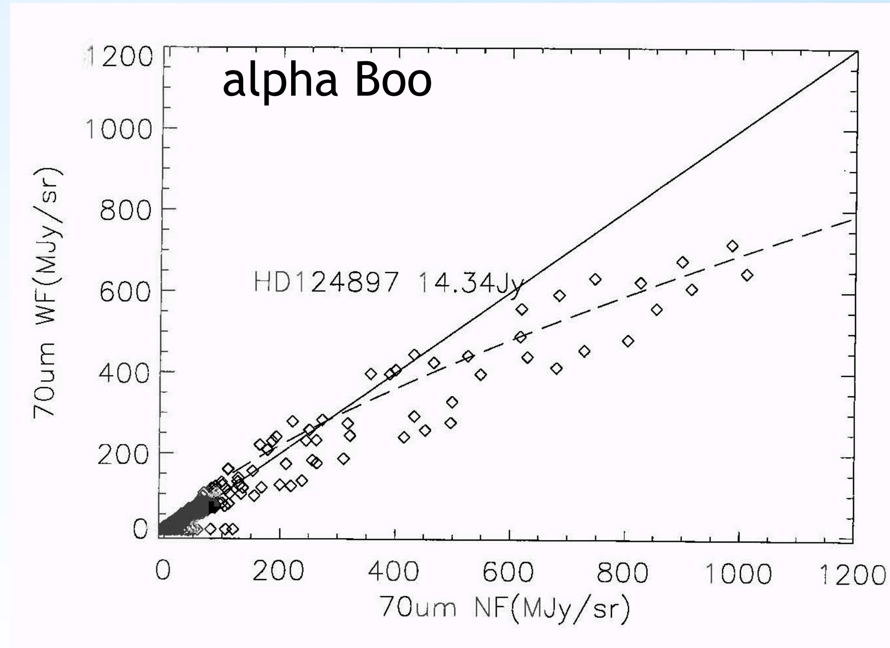



Figure 1: Measured signal (e-/s) on the array *vs.* DCE number. The upper panel shows the average signal, while the 4 sub-panels show the signal for individual pixels. Data from Dec. 12, 2000, experiment c.

# 70μm Non-Lin I




Dale et al. 2007

NGC 7552
~16% corr.
F(70) = 67.6 +/- 11.1 Jy

Finally, a correction for 70 $\mu$m nonlinearity effects is included in this presentation. A preliminary correction of the form

$$f_{\rm true}^{70\,\mu{\rm m}} = 0.581\left(f_{\rm measured}^{70\,\mu{\rm m}}\right)^{1.13}, \qquad (3)$$

derived from data presented by K. D. Gordon et al. (2007, in preparation), is applied to pixel values above a threshold of ~66 MJy sr$^{-1}$. A small fraction of the pixels in a total of 40 SINGS 70 $\mu$m images require such a correction. The median correction to the global 70 $\mu$m flux density for these 40 galaxies is a factor of 1.03, with the three largest corrections being factors of 1.124 (NGC 4826), 1.128 (NGC 1482), and 1.158 (NGC 7552).

# * 70μm Non-Lin II

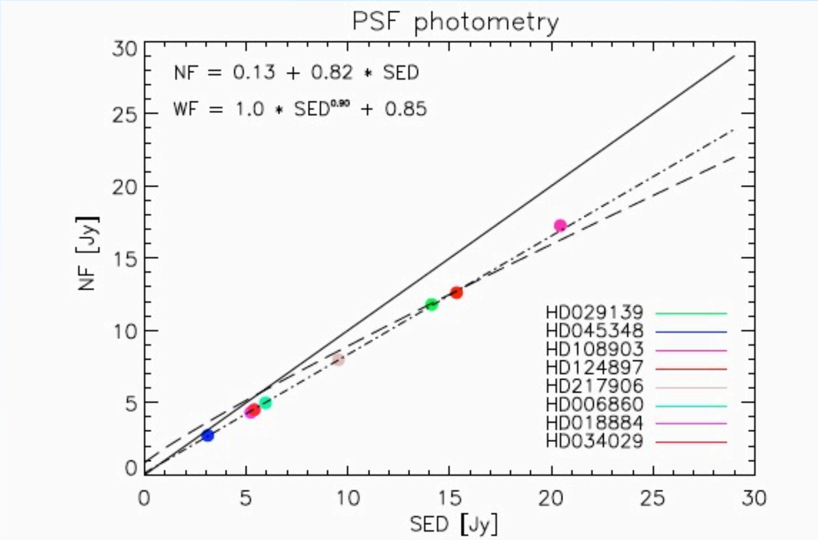
## Characterization of MIPS 70$\mu$m flux non-linearity

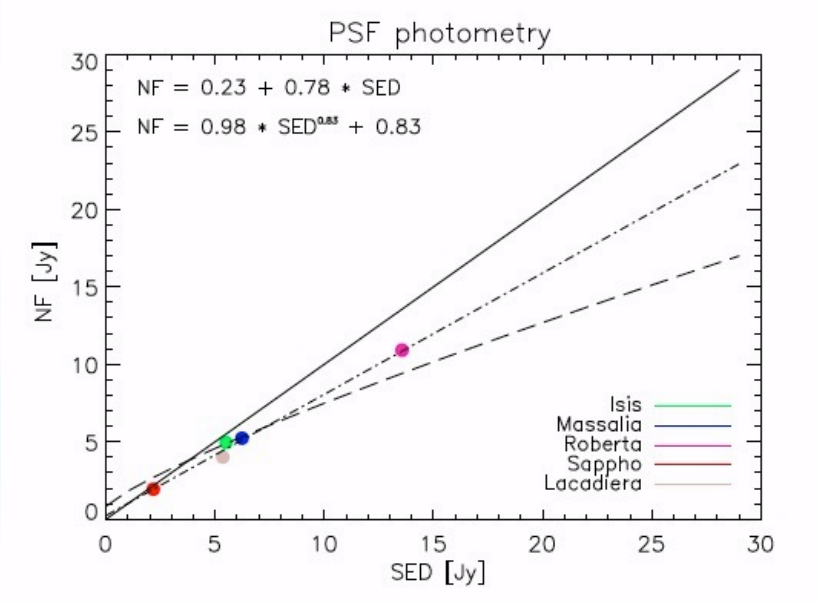
Roberta Paladini & Alberto Noriega-Crespo

April 22, 2009

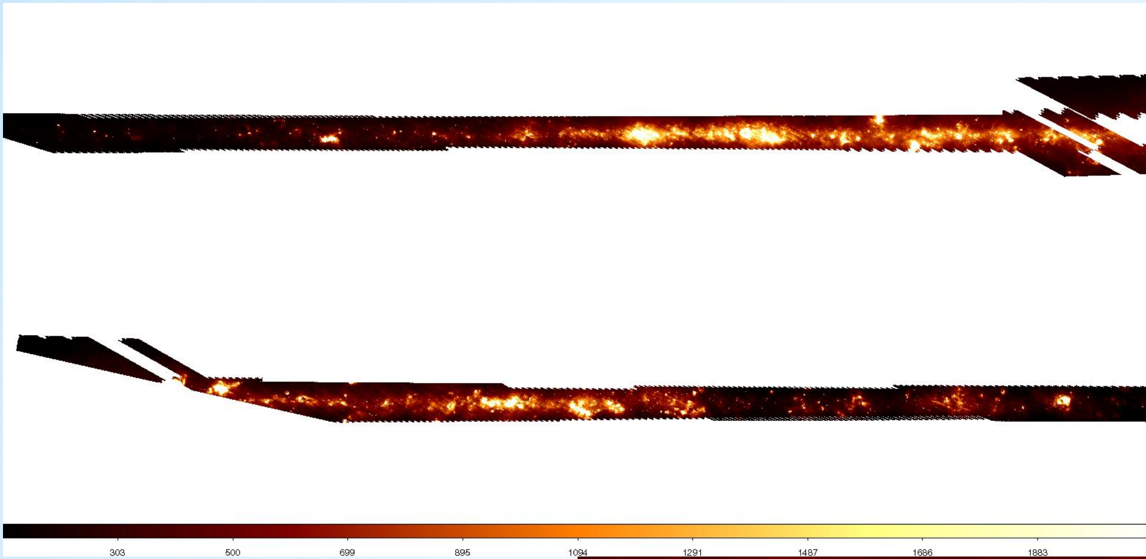
### 1. Summary

This document describes the work undertaken for characterizing the flux non-linearity of the MIPS 70$\mu$m array. The effect, due to the change of rate of incident radiation on the detector, has been described in Gordon et al. (2007) and is typical of Ge:Ga photoconductors. The analysis has made use of MIPS calibration data aquired in Wide Field (WF), Narrow Field (NF) and Spectral Energy Distribution (SED) mode, and has attempted the characterization of this effect in terms of flux density as well as of surface brightness. Indications of a departure from a linear behaviour are present in both cases. The analysis shows that the NF measurements are less severely affected by a non-linear behaviour with respect to WF observations. In particular, the MIPS 70$\mu$m NF data of targets brighter than $\sim$ 2 Jy underestimate the true flux up to 20%, while WF measurements underestimate the true flux up to 50%. A functional form characterizing the non-linear behaviour of the NF and WF measurements is provided. We have also rederived the calibration factor for NF, before and after applying the non-linearity correction described above. For this purpose we make use of a data set of calibration stars which nearly doubles the sample in Gordon et al. (2007). The calibration factor obtained before correcting for non-linearity effects is consistent with Gordon et al. (2007). However, when non-linearity effects are taken into account, we show that the calibration factor is lower by $\sim$ 20%.

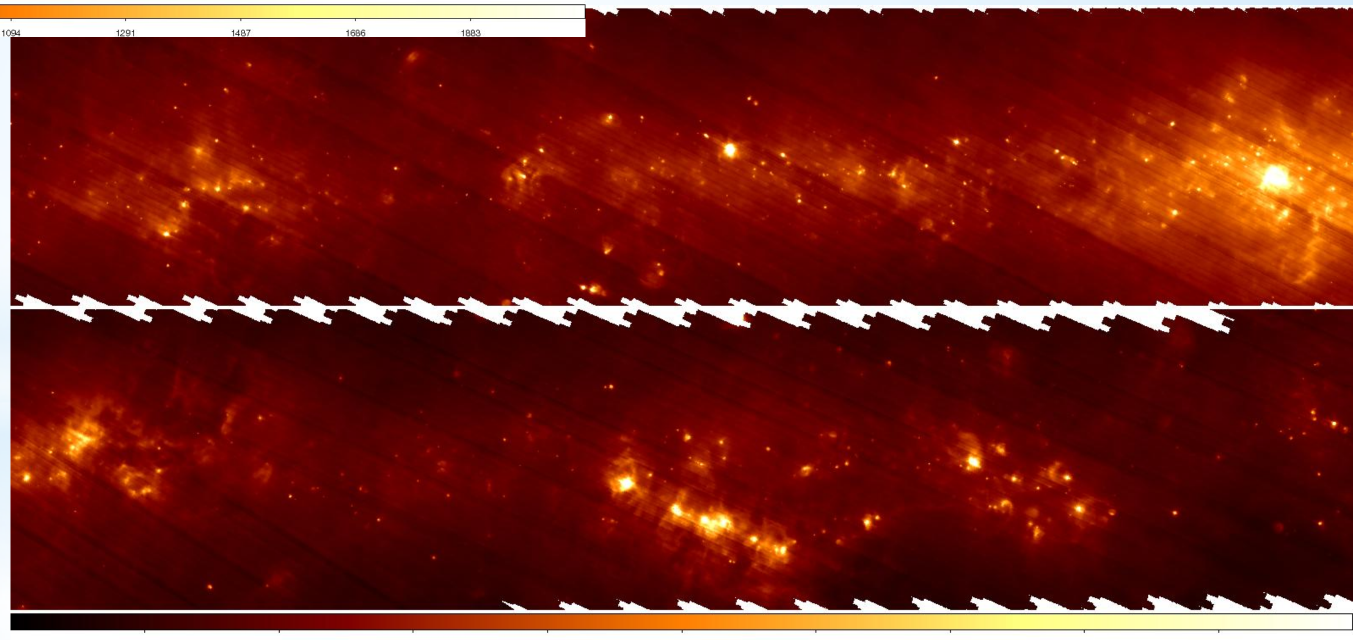


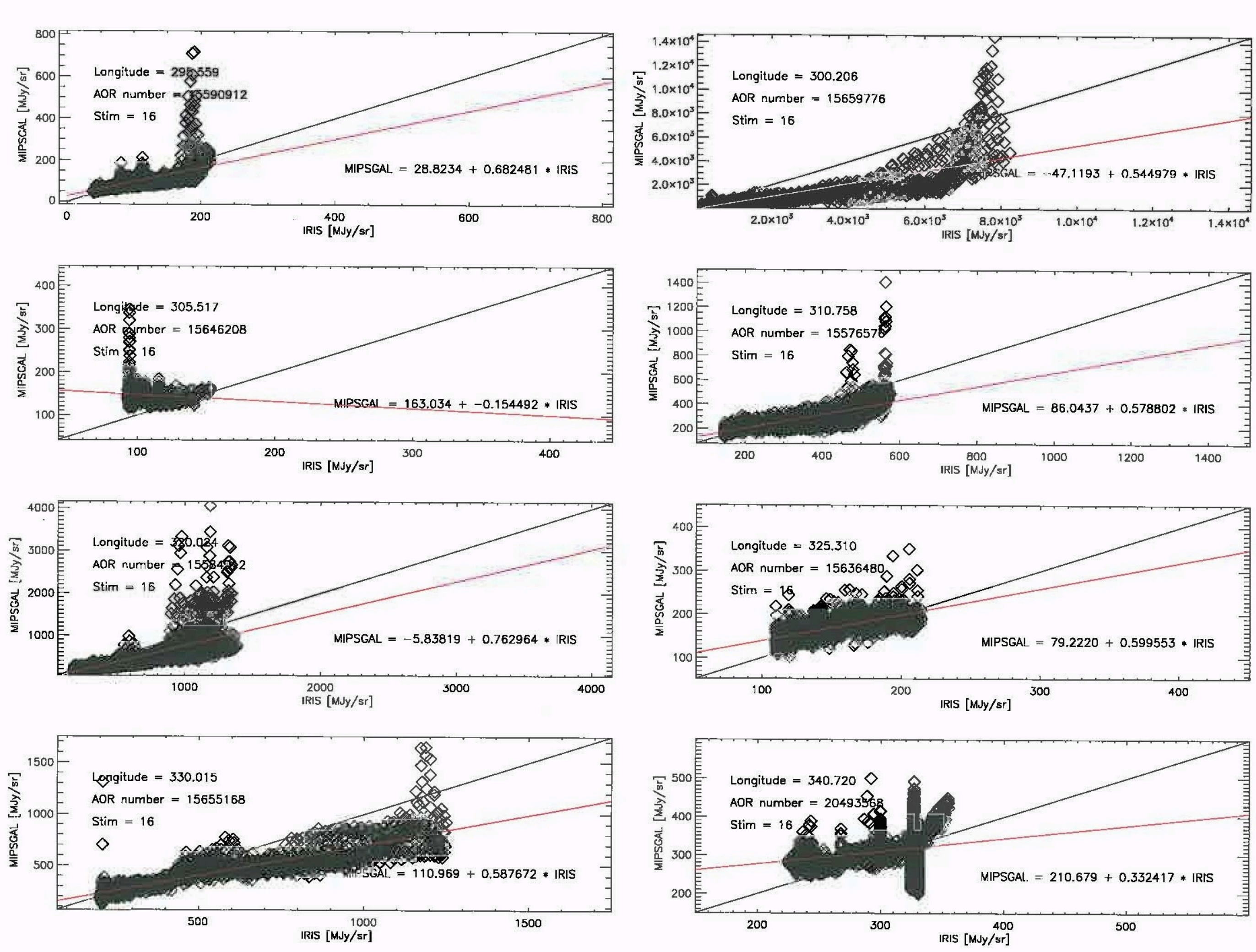
# * 70μm Non-Lin III

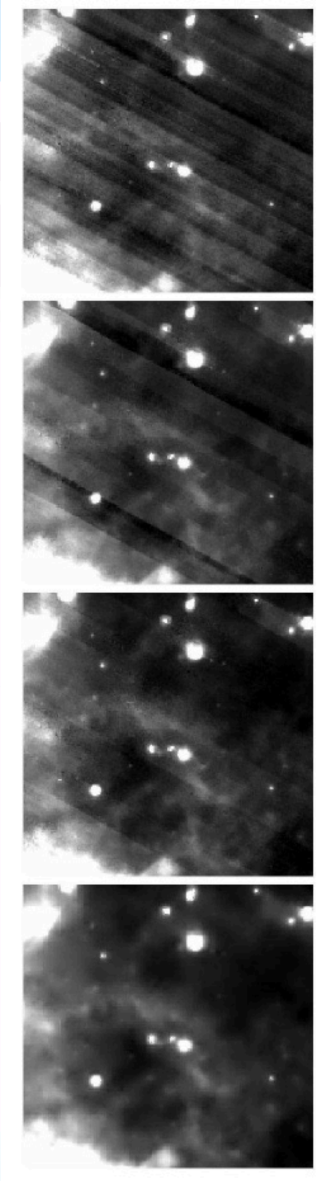



MIPSGAL
(l= +/- 60, b=+/- 1 deg)
70um parallel data



# * 70μm Non-Lin IV



g.

r stim

t 100um

*Crespo,*

*paration.*

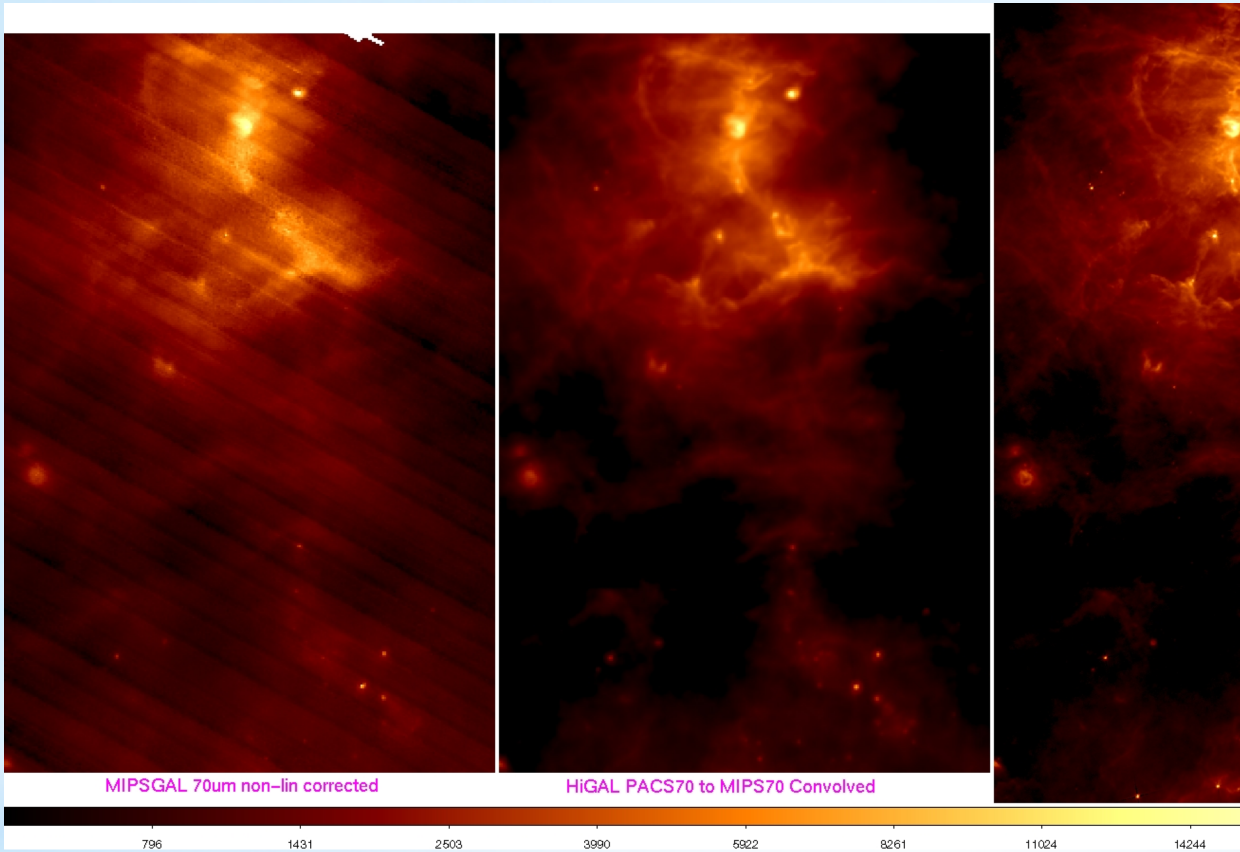
# * MIPS & PACS

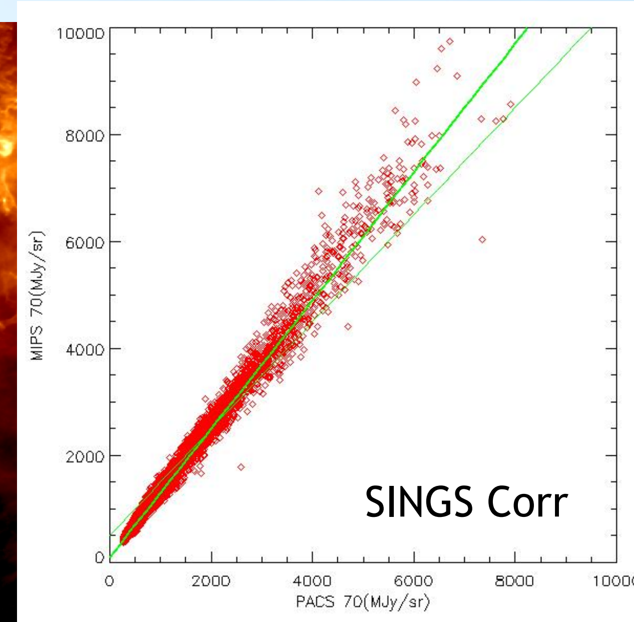
## PACS calibration and performance

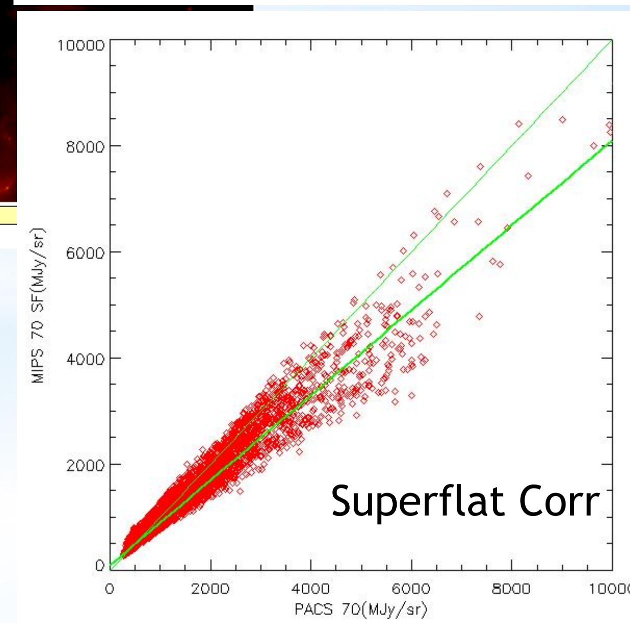
### Photometer calibration in scan maps.

- **Point Spread Function:** PACS Photometer Point Spread function (10 Mb), version 2.0, 4 April 2012. A detailed document of the in-flight observed PSF. The accompanying tarball can be found here (76 Mb).
- Herschel/PACS modelled point spread functions (3.1 Mb) is a related document presenting Zemax modelled point spread functions for both an `ideal' and an 'as built' Herschel telescope model. Tarballs with corresponding broad-band and monochromatic PSFs for these two cases are at http://pacs.ster.kuleuven.ac.be/pubtool/PSF. These are useful in addition to the observed PSFs but cannot replace them, since the models do not capture all effects found in the observed PSFs.
- **Point-source photometry**: PACS uses 5 stars as primary calibrators with fluxes ranging from 0.6 to 15 Jy, plus fainter stars and asteroids as secondary calibrators. The absolute flux scale accuracy in 5% in the 3 filter bands. The flux calibration is described in detail in the technical note "PACS photometer point-source flux calibration (3.1 Mb) (PICC-ME-TN-037), version 1.0, 12 April 2011.
- **Point-source photometry in deep PACS maps/surveys**: The effect of the high-pass filter data reduction technique on the PACS Photometer PSF, point-source photometry and noise has been investigated in depth in this technical note
- PACS Photometer Passbands and Colour Correction Factors for various source SEDs (2.5 Mb), PICC-ME-TN-038, version 1.0, 12 April 2011.
- **Extended emission photometry**: Three technical reports which assess the extended emission (or surface brightness) measured from PACS data and compare that to IRAS and Spitzer/MIPS data:
  - Assessment analysis of the extended emission calibration for the PACS red channel, version 1.0, April 2012: latest results on the comparison of extended emission in the PACS red channel (i.e. 160um) with corresponding data from Spitzer/MIPS 160um.
  - Experiments in photometric measurements of extended sources (3.2 Mb), (report SAp-PACS-MS-0718-11, March 18, 2011). This report compares photometry of large extended galaxies (using large apertures) between PACS, IRAS and MIPS.
  - Surface brightness comparison of PACS blue array with IRAS and Spitzer/MIPS images (1 Mb), (report PICC-NHSC-TN-029, v1.01, 12 April 2011). This report summarises pixel-to-pixel comparisons between extended emission as measured between PACS, IRAS and MIPS.
  - We refer to the paper Common-Resolution Convolution Kernels for Space- and Ground-Based Telescopes, G. Aniano et al. (2011) for kernels and associated routines (IDL) to match spatial resolution between several infrared instruments PSFs (PACS, SPIRE, Spitzer/MIPS, Spitzer/IRAC, WISE) as well as GALEX (UV) and other PSF families (gaussian, bi-gaussian, Moffat).

# * 70µm Non-Lin V



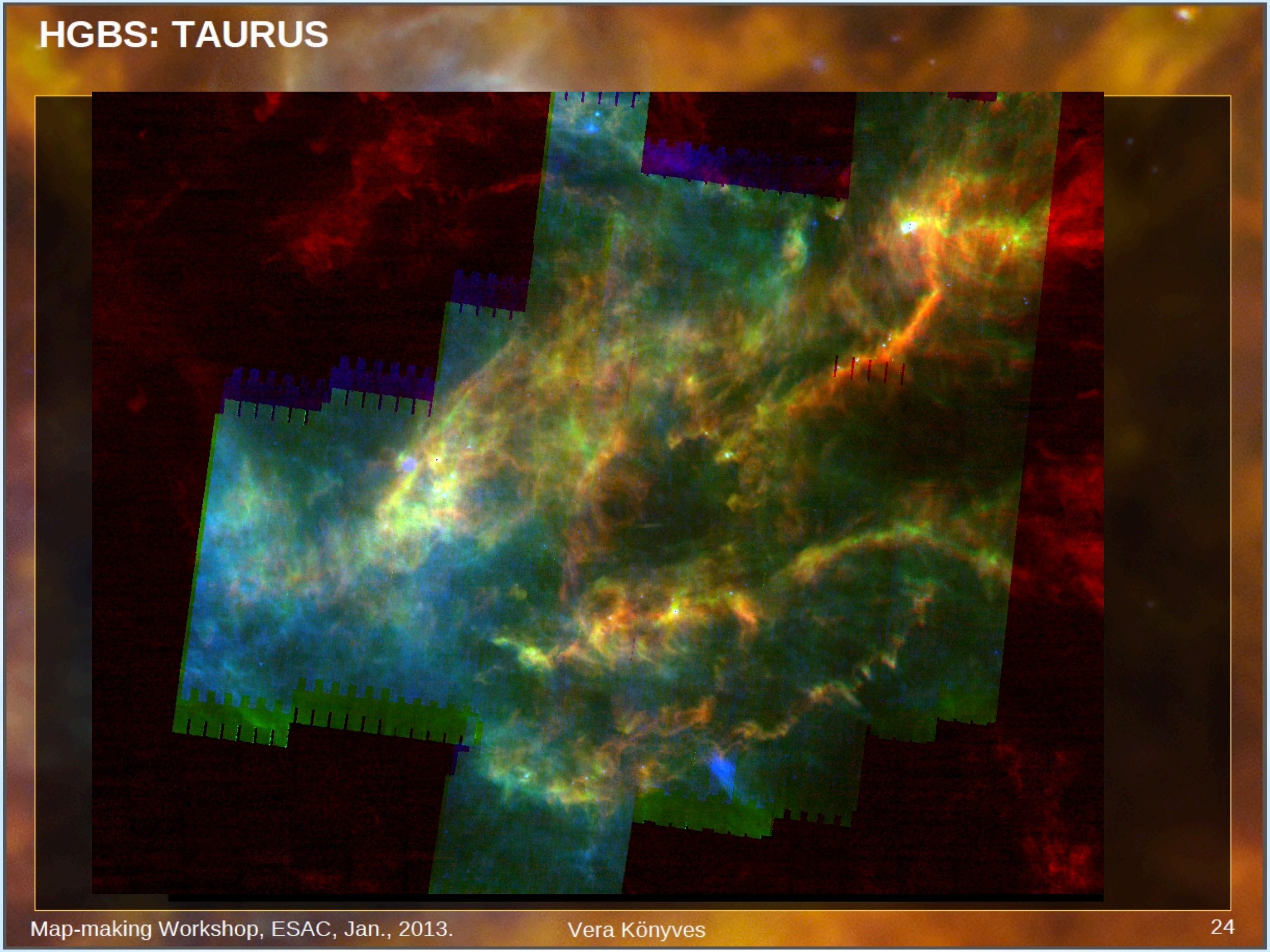




M16 –Eagle Nebula

*Flagey, Boulanger, Noriega-Crespo et al. 2011*

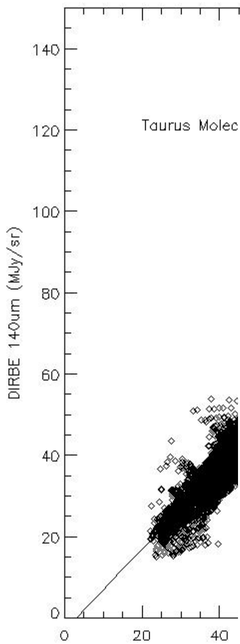
# * 160μm Non-Lin I




24μm
160μm
13CO

# * 160μm Non-Lin II

*Flagey , Noriega-Crespo, Boulanger et al. 2009*




Inversion algorithms for the 160 $\mu m$ imaging photometer for Spitzer

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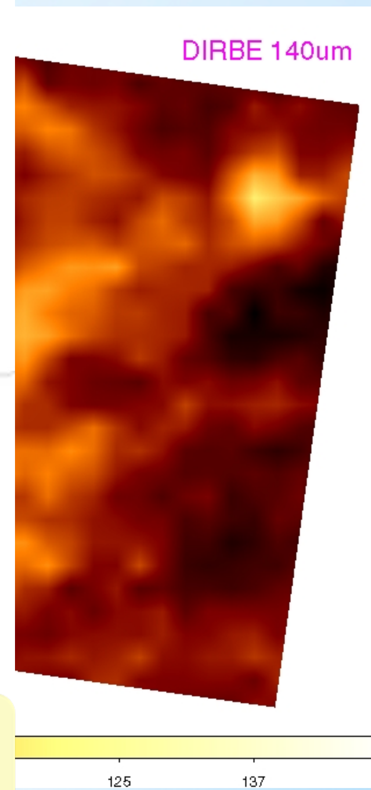
[2] Institut d'Astrophysique Spatiale (IAS) ...

Abstract

The MIPS Spitzer photometer is a powerful instrument to image, with unprecedented angular resolution and sensitivity, diffuse far-IR emission from dust in the Galaxy and nearby galaxies. But maps produced by the Spitzer Science Center pipeline suffer from instrument artifacts. We believe that stripes reflect gain changes across the observation unaccounted in the data reduction. The pipeline uses the stimulator measurements to calibrate gain variations. Residual stripping in the images shows that this is not optimal to process data on very extended emission. This is be particularly true for sources with a far-IR brightness, close to the saturation level, e.g. for Galactic molecular clouds and the central parts of resolved galaxies.

We have developed two algorithms to improve the maps quality. A first algorithm optimizes deglitching and permits to identify gain changes due to glitches. A second algorithm estimates jointly the sky image and the detector gain as a function of time. The sky and gain estimates are the solution of a least square fit to the data which penalizes image structure on short angular scales and gain variations on short time scales. The algorithms have been implemented in our version of the MIPS pipeline code (DAT v2.71). Our data reduction does not rely on the stimulator measurements to calibrate gain changes; We allow the gain to depart from stimulator measurements. and only force the mean gain to be equal to that given by the stimulator measurements. Two parameters control gain variations. A first one brings the algorithm to prefer data fits where the detector gain varies smothly with time. A second one constrains the gain to remain close to the stimulator value. A third parameter constrains the sky image to have a certain smoothness. This last parameter is optimized as a function of spatial redundancy. Good destriping is obtained even for low spatial redundancy to the expense of a slight smoothing of the image. The spatial filtering has been estimated theoretically as a function of the image regularity parameter and checked on simulated images.

We illustrate our data reduction procedure by presenting a 10 deg2 160 micron image of the Taurus molecular cloud. This image has been compared with DIRBE observations. After proper smoothing by the DIRBE beam, we find that the MIPS 160 micron cloud brightness is consistent with interpolation of the 140 and 240 micron DIRBE values. The potential of such an image to study the structure of molecular clouds will be discussed.



# * Outline

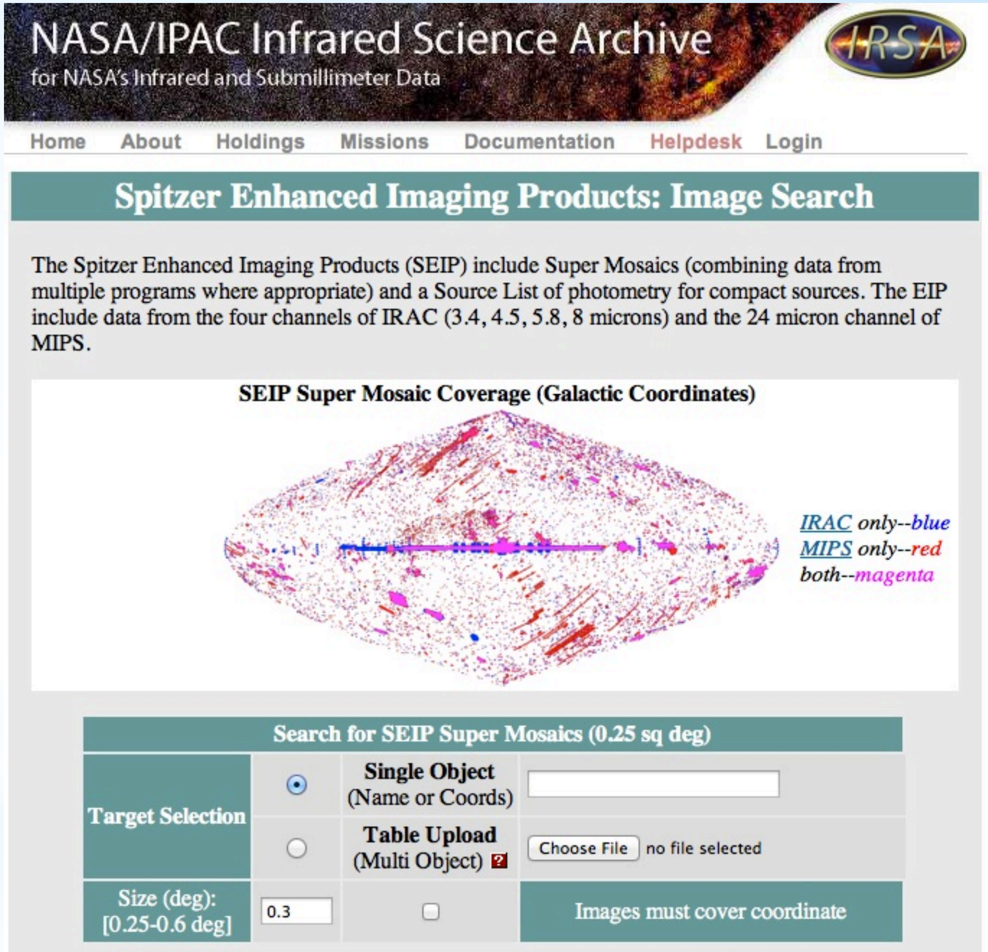
* Brief Intro to MIPS – Refreshing your memory.
  Spitzer launched 8/25/2003. MIPS ended operations 4/1/2009.
* MIPS 24 um calibration.
  It ties together the 70 and 160um asteroids &160um calibration.
* MIPS 70um calibration.
  Point Sources & Extended Emission.
* MIPS 160um calibration.
  Point Sources & Extended Emission.
* The “unpublished stuff”.
* Post-Operations.
  SSC Enhanced Products.

*(Use what we learned from our research)*

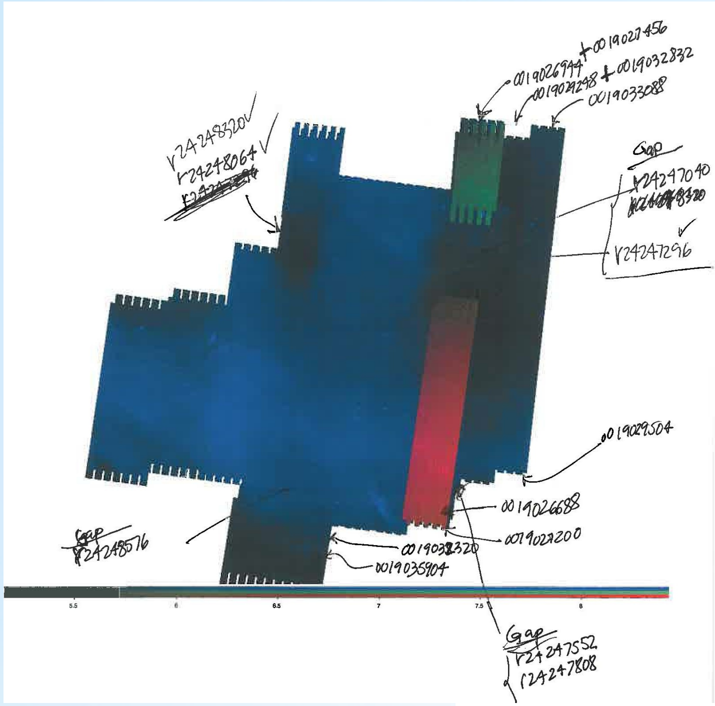
  SAFIRES.

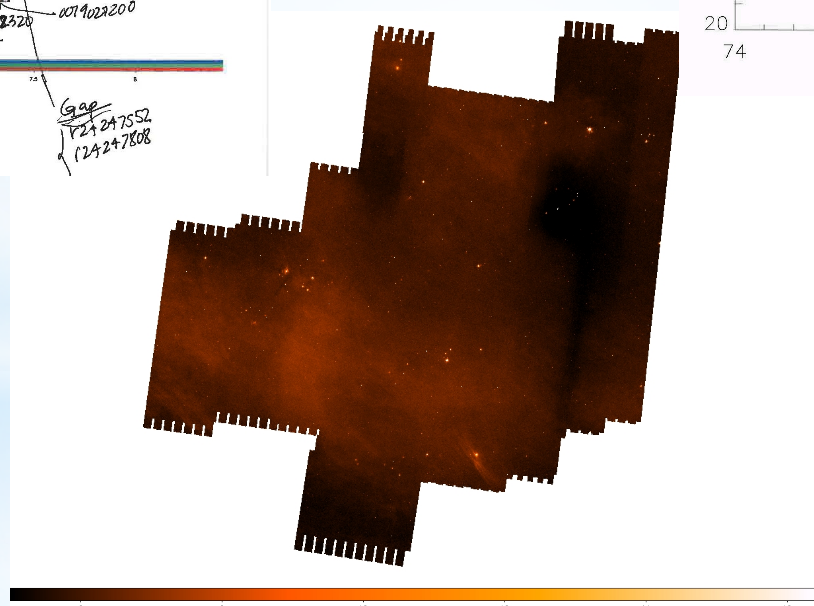
# Post-Ops I

* Spitzer Enhanced Products (24μm)
  - Combination of multiple programs
  - Pointing correction
  - Delta Flat at 24μm
  - Zodiacal light removed per BCD
  - Overlap Correction
  - Highly reliable point source list (S/N > 10)

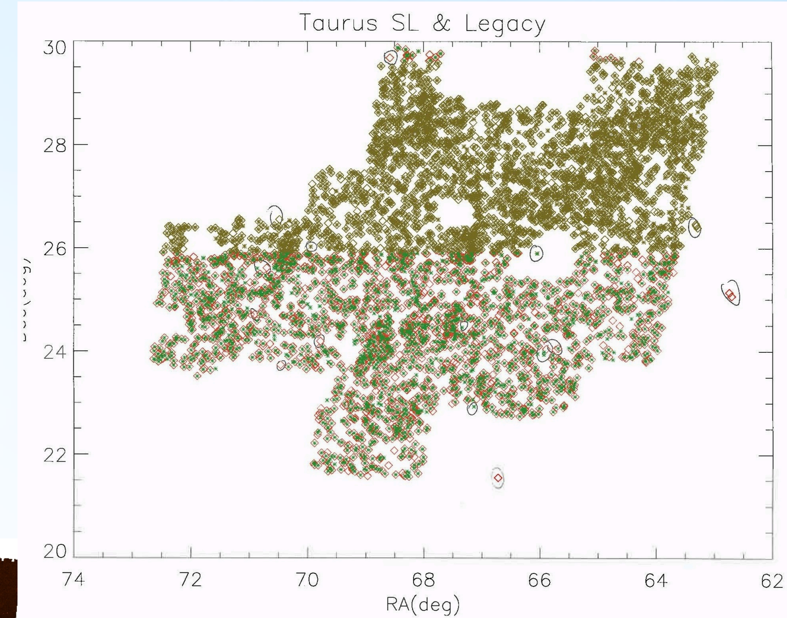


# * Post-Ops II



Dec




RA

SSC Enhanced
24μm Products

# SAFAIRES

FAR-INFRARED PROPERTIES OF TYPE 1 QUASARS

D.J. Hanish[1], H.I. Teplitz [1], P. Capak[1], V. Desai[1], L. Armus [1], C. Brinkworth [1], T. Brooke[1], J. Colbert [1], D. Fadda[1], D. Frayer[2], M. Huynh [3], M. Lacy [4], E. Murphy [5], A. Noriega-Crespo [1], R. Paladini [1], C. Scarlata [6], S. Shenoy [7], and the SAFIRES Team

*Submitted to ApJ 2012 October 5, Accepted 2013 March 4*



ABSTRACT

We use the *Spitzer Space Telescope* Enhanced Imaging Products (SEIP) and the Spitzer Archival Far-InfraRed Extragalactic Survey (SAFIRES) to study the spectral energy distributions of spectroscopically confirmed type 1 quasars selected from the Sloan Digital Sky Survey (SDSS). By combining the Spitzer and SDSS data with the 2-Micron All Sky Survey (2MASS) we are able to construct a statistically robust rest-frame 0.1 – 100 $\mu m$ type 1 quasar template. We find the quasar population is well-described by a single power-law SED at wavelengths less than 20 $\mu m$, in good agreement with previous work. However, at longer wavelengths we find a significant excess in infrared luminosity above an extrapolated power-law, along with significant object-to-object dispersion in the SED. The mean excess reaches a maximum of 0.8 dex at rest-frame wavelengths near 100 $\mu m$.

*Subject headings:* galaxies: active; quasars: general; infrared: galaxies; surveys

NASA ADAP ("Spitzer Archival Far-IR Extragalactic Survey").
GeRT for 70 & 160μm.
Best Techniques.

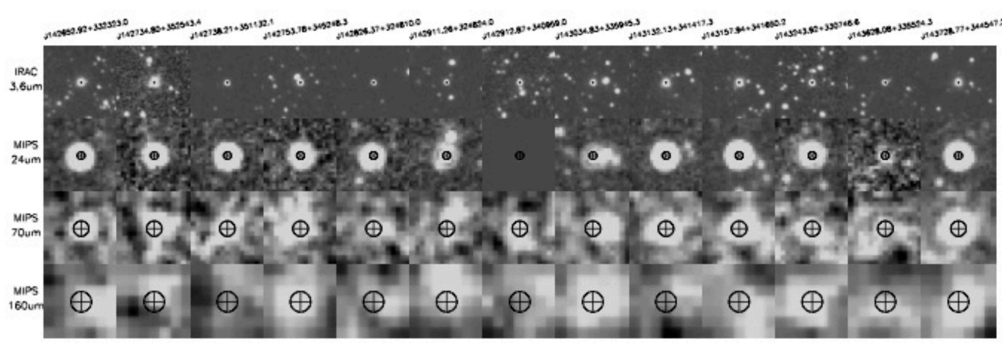
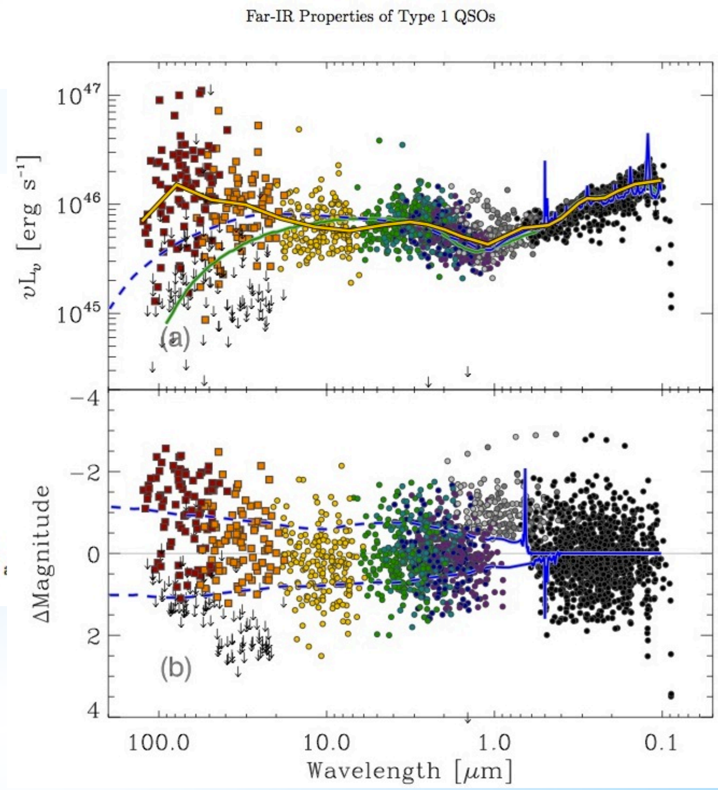



**Figure 2.** Several quasars in the SDWFS field, shown in the IRAC 3.6 $\mu m$, MIPS 24 $\mu m$, MIPS 70 $\mu m$, and MIPS 160 $\mu m$ bands. images are 1 arcminute square, centered on the SDSS position for each quasar. The overlay circles show the position of each quasar, a the maximum correlation distances allowed within each band.



# * Summary

* The MIPS published calibration papers summarized quite accurately the MIPS calibration.
* We (IT & IST) learned a lot more, on particular on 70 & 160μm non-linearity effects, through our own science [Legacy Projects, e.g. SINGS, Taurus & MIPSGAL].
* No final conclusion/agreement on non-lin correction was achieved before the end of the mission. Therefore the SSC 70 & 160μm Heritage Data have not been corrected.
* Several of the corrections we learned (through the best practices from the Legacy teams] have been applied to the data, either in Post-Ops (SSC Enhanced products, 24μm) or thanks to specially funded grants, (NASA ADAP, SAFIRES, 70 & 160μm deep extragalactic fields).

# * Complementary Slides

# * Flux Conversion Factors

### 4.3.2 *Flux Conversion Factors*

The best conversion factors between instrumental units and MJy/sr to use for any given data set are included within the headers of the data themselves; grep on BUNIT and FLUXCONV. The factors are listed in Table 4.10. The MIPS-24 instrumental units are DN/s, but note that the instrumental MIPS-Ge units are dimensionless after the stimflash response calibration. Uncertainties in the conversion values are often limited by our astrophysical understanding of stars in the far infrared, and thus the uncertainties are likely to decrease with time. We include a history of the changes to the conversion factor of the various MIPS observation modes in Table 4.11.

This conversion factor at 24 microns was derived from 3 sec exposures. The difference in the conversion factor for scan mode and 10 and 30 sec exposure should not be more than 2-8% different.

**Table 4.10: Conversion from instrumental units to MJy/sr.**

| Array | Conversion factor | Uncertainty[a] |
|---|---|---|
| 24 | 0.0447 | 4% |
| 70 | 702. | 7% |
| 70 fine scale | 2808. | 15% |
| SED | 20572.7 | 10% |
| 160 | 41.7 | 12% |

**[a] For optimal data reduction and flux density extraction of single sources in photometric mode, the uncertainties can be as small as 2%/5%/10% for 24/70/70fine.**

**Table 4.11: Changes in Conversion Factor with Pipeline.**

| Pipeline Version[a] | 24 µm | 70 µm | 70 µm Fine | 70 µm SED | 160 µm |
|---|---|---|---|---|---|
| S10 | 0.04391 | 634. | --- | --- | 42 |
| S11 | 0.04391 | 634. | 2536. | 27093 | 42 |
| S12 | 0.04391 | 634. | 2536. | 21835 | 42 |
| S13 | 0.04391 | 702. | 2808. | 20572.7 | 44.7 |
| S16 | 0.0447 | 702. | 2808. | 20572.7 | 44.7 |
| S17 | 0.0447 | 702. | 2808. | 20572.7 | 41.7 |

**[a] This history is meant to be suggestive of what changes occurred and when. The process of pipeline updates was complicated, with multiple versions and versions that were replaced before significant data was run through them. The data header will always contain the correct conversion factor used.**

### 4.3.3 *Magnitude Zero Points*

Dr. C. Engelbracht has computed MIPS magnitude zero points using the Kurucz (1993) Vega model, which has then been scaled to the Rieke et al. (2008) 10.6µm zero point of 35.03 ± 0.3 Jy. He has further assumed that Vega is 0 magnitudes in all MIPS bands, and has computed fluxes at 23.68, 71.42, and 155.9 µm. The resultant zero points are in Table 4.12.

**Table 4.12: Magnitude zero points.**

| Wavelength (microns) | Zero point (Jy) | Uncertainty (Jy) |
|---|---|---|
| 23.68 | 7.17 | 0.11 |
| 71.42 | 0.778 | 0.012 |
| 155.9 | 0.159 | 0.020 |

# Ge:Ga Non-Lin II

*7.2.5 Flux non-linearities*

The flux nonlinearities for the MIPS-Ge detectors represent the differences in the flux conversion factor as a function of source flux. Thre pipeline assumes a constant flux conversion factor for all flux ranges. MIPS 70 micron sources show significant (~40%) flux non-linearities over the range from 22 mJy to 17 Jy, although the use of PSF-fitted photometry rather than aperture photometry greatly reduces this effect (see Gordon et al. 2007, PASP, 119, 1019). The overall behavior of the 160 micron stressed Ge:Ga array is linear between 0.1 and 2 Jy (Stansberry et al 2007, PASP, 119, 1038). Continuing up to 4 Jy, 160 micron shows a departure of ~10% from linearity for point sources

## MIPS Instrument Handbook

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*7.2.1 Variations of the slow response*

MIPS-Ge data are calibrated using the stimulator flashes (or "stims") to track the variation of the short-term response of the detectors; see section 4.1.1 for more information.

The stim flashes are designed to track the responsivity drift of the Ge detectors. Since we measure the stim minus background signal, the calibration most accurately tracks the response to a step function, i.e., the fast response. The stim flash calibration does not completely remove long-term transients for the MIPS-Ge detectors. The effects are most noticeable before the bias change for MIPS-70 (e.g., dark horizontal stripes in bottom of Figure 7.20). The effects are not as noticeable for MIPS-160 due to short time constants for the stressed 160 micron detectors. For point source science, this effect can be removed using a temporal median filter (e.g., for scan data).

For point source science, this effect can be removed using a temporal median filter (see section 8.2). The variation of the drift in the slow response affects the ability to accurately measure the true background level. For point sources, the long-term drifts can be treated as an additive effect (i.e., subtracting off a temporal median). The long-term drifts affect the actual response from the background, suggesting a multiplicative correction may be needed for large extended regions. For large extended sources, we recommended that observers take enough off-source data of the surrounding background so that the total extended source flux can be estimated.

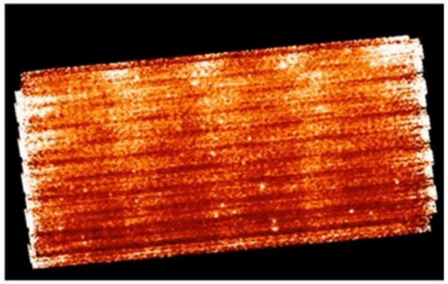

**Figure 7.20: Default mosaic from 4 AORs of unfiltered MIPS-70 BCDs. The dark horizontal (in-scan) stripes are fast/slow response variations, and the bright vertical stripes are stim latents.**

## MIPS Instrument Handbook

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### 7.2 MIPS Ge: 70 and 160 Micron

All traditional photoconductors, such as the MIPS Ge:Ga unstressed and stressed detectors, show multiple time constant response. In addition, they can exhibit spontaneous spiking and non-monotonic response characteristics (the "hook"). For much more discussion, see section 2.3.2. The result is a slow increase in detector response lasting tens of minutes (MIPS 160 μm detectors) to hours (MIPS 70 μm detectors). MIPS takes advantage of the fact that the fast generation-recombination response (fast response) of the detectors is inherently different than the longer term response by using the scan mirror to modulate (chop) the source signal on timescales of a few seconds, keeping measurements mostly confined to the fast response regime. Frequent use of on-board calibration sources (called stimulators, or stims) additionally allows tracking of the long-term drifts in response. However, some artifacts do remain (see Figure 7.19, for examples) and are discussed below along with possible mitigation methods.

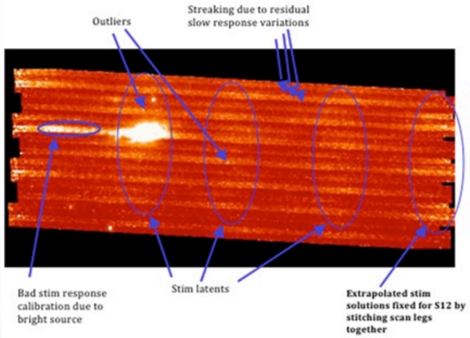
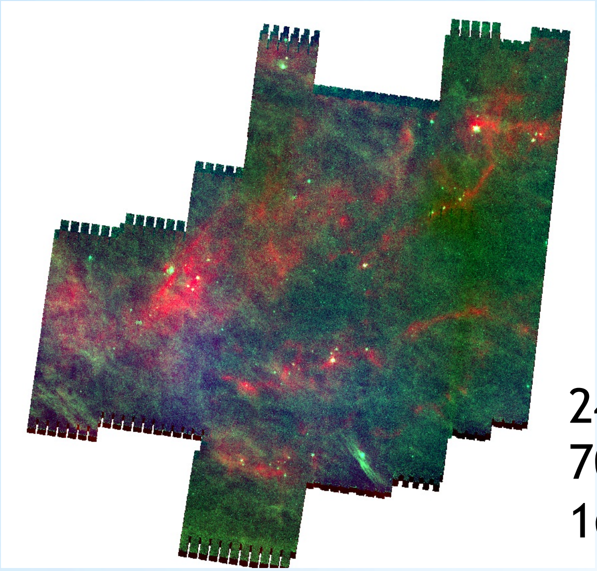



**Figure 7.19: Examples of several of the most common MIPS-70 artifacts; see next several sections for more discussion. Note that these data are pre-bias change data processed under S10. Techniques for improving these data are discussed in section 8.2.8 (These data are NGC 7331, from the SINGS Legacy team).**

# 160µm Non-Lin II



24µm
70µm
160µm