

Project 5: The Spatially-Resolved Dust Properties of Nearby Galaxies

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Outline

- ★ **Scientific goals**
- ★ **Data:** NGC1140, NGC3938 (DustPedia)
- ★ **Method:** MCMC Error propagation
- ★ **Results**

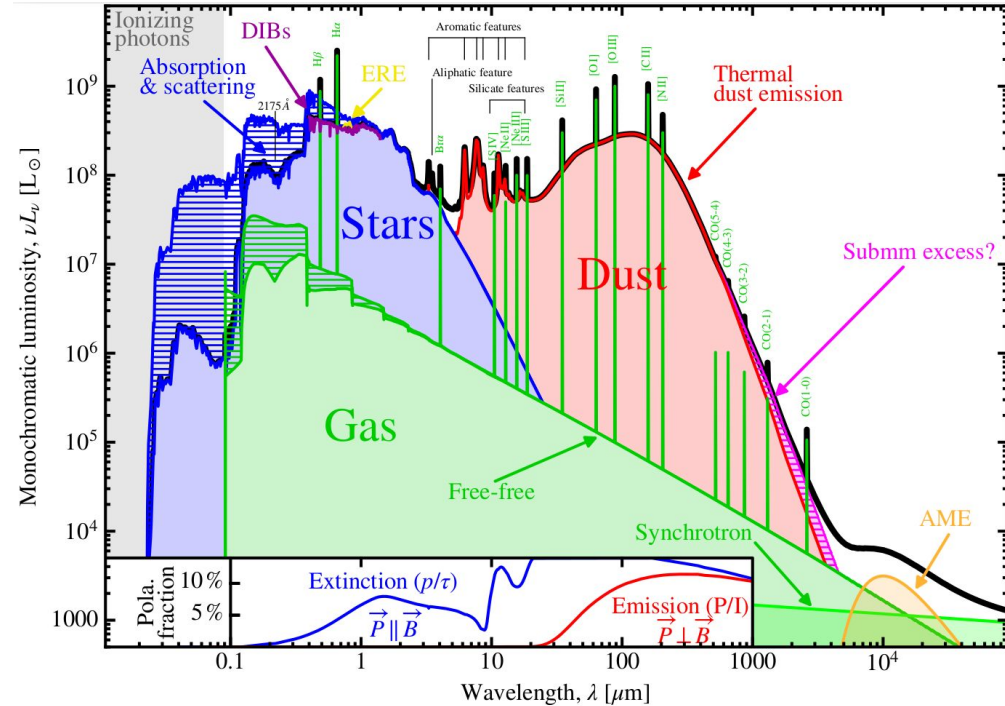


Scientific goals

1. Learn to homogenize multi-wavelength images of galaxies
2. Perform SED modeling in order to infer maps of the dust properties

Useful to:

- ❖ Estimate dust-to-gas mass ratio distributions
- ❖ Have a better understanding of the heating sources
- ❖ Study dust evolution



Data sample: 2 nearby galaxies

NGC3938

- Spiral, unbarred
- Distance: ~15 Mpc
- (Angular) diameter: ~5'



NGC 3938
Adam Block/Mount Lemmon
SkyCenter/University of Arizona

NGC1140

- Irregular, starburst
- Distance: ~19 Mpc
- (Angular) diameter: ~1.7'




NGC 1140
ESA/Hubble

DustPedia

- UV-to-mm photometry
- Images of 800 nearby galaxies with ancillary data

→ Use of IRAC,
SPIRE, MIPS, PACS,
WISE

<http://dustpedia.astro.noa.gr/Data>



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The Archive

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MBB
CIGALE
HerBIE
SKIRT

The Data

The [DustPedia](#) Data archive contains multiwavelength imagery for 875 nearby galaxies (every extended galaxy within 3000 km s⁻¹ that was observed by the [Herschel Space Observatory](#)). The data hosted in the archive are all the available maps for the DustPedia sample coming from the [GALEX](#), [SDSS](#), [DSS](#), [2MASS](#), [WISE](#), [Spitzer](#), [Herschel](#), and [Planck](#) surveys. In the left-hand side of each entry some basic galaxy properties are provided, as well as, photometry cutouts (in [png](#) format) for each galaxy with the exact aperture used for the [photometry](#), per band, and the annuli used to calculate the background.

The user can retrieve all the available maps (and in some cases its associated error map) in the database in [fits](#) format. All maps are in units of Jy pixel⁻¹ except for DSS (left as photographic densities). The user can search with Galaxy Name, Hubble Stage (T), Velocity (in km s⁻¹), Inclination Angle (in degrees), and size (D₂₅ in arcmin). In each search parameter the user can define the range desired but also have the option to define only the lower or the higher limit. A "show all results in a single page" button allows the user to print all results on a single page.

A detailed description of the multiwavelength image reduction and photometry is provided in [Clark et al. \(2018, A&A, 609, 37\)](#).

Homogenizing multiwavelength data

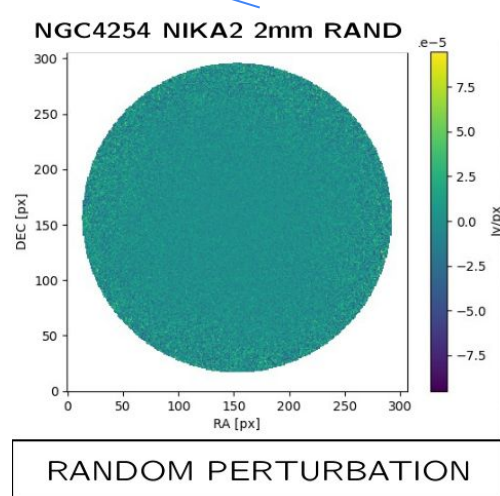
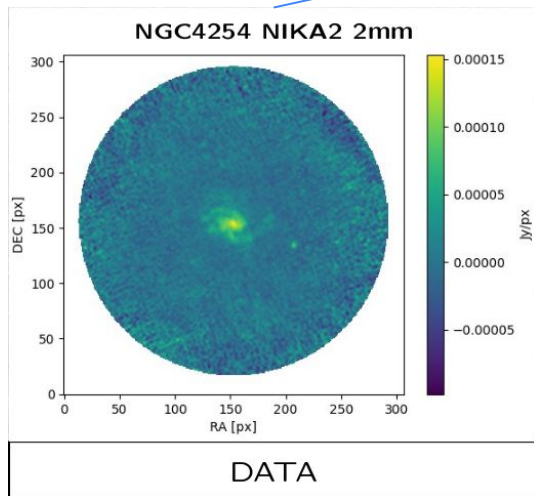
- Different size maps, spatial resolution, pixel size, orientation, units
- HIP pipeline: Homogenization of IMEGIN Photometry (Pantoni et al. in prep.)
 - Foreground large scale emission subtraction
 - Unresolved background sources
 - Mask bright foreground stars
 - Convolution to SPIRE 500 resolution
 - Regridding and reprojecting to same frame

Monte Carlo error propagation

Monte Carlo method (frequentist approach) relies on random perturbations that are added to the data map for a number N of iterations. It accounts for e.g. correlations between pixels.

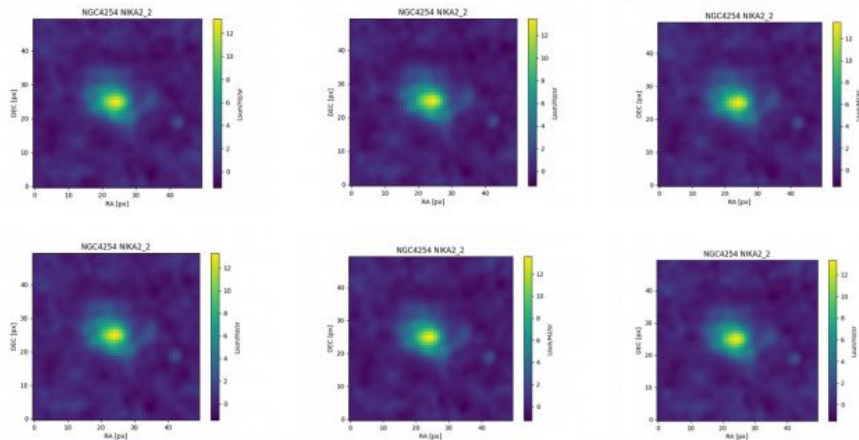
1. The random perturbation is a random normal distribution centered on zero with standard deviation equal to the original uncertainty on the data map.

$$F_{\nu}^{(i)}(x, y, \lambda) = \underline{F_{\nu}(x, y, \lambda)} + \underline{\delta(i, x, y, \lambda)} \times \sigma_{\nu}(x, y, \lambda)$$

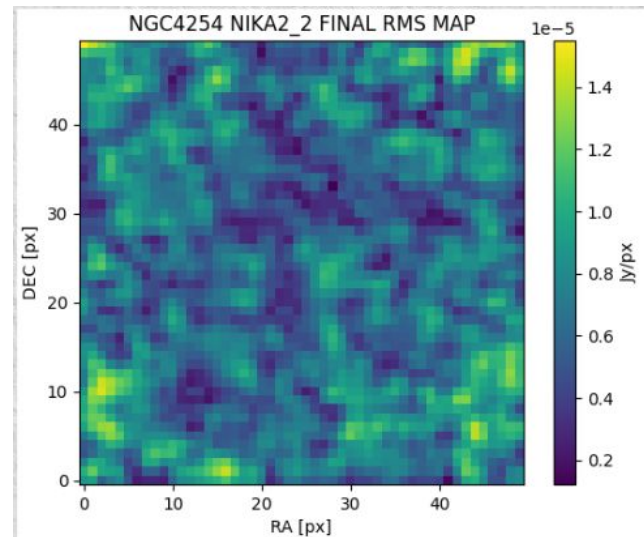
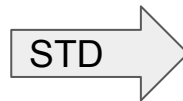


Monte Carlo error propagation

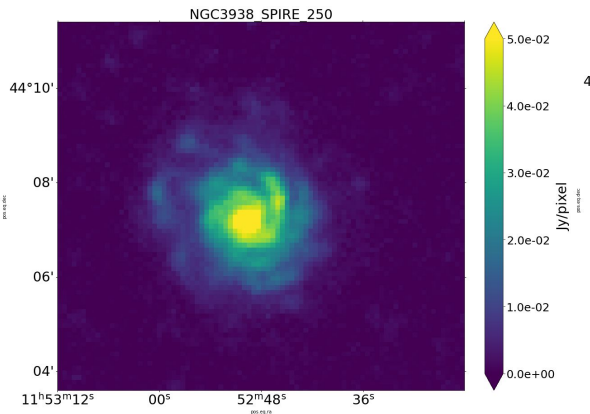
- 3) After N iterations, we have N perturbed data map that have been processed in the same way.
- 4) The px-by-px standard deviation of the N data maps gives the final statistical uncertainty map



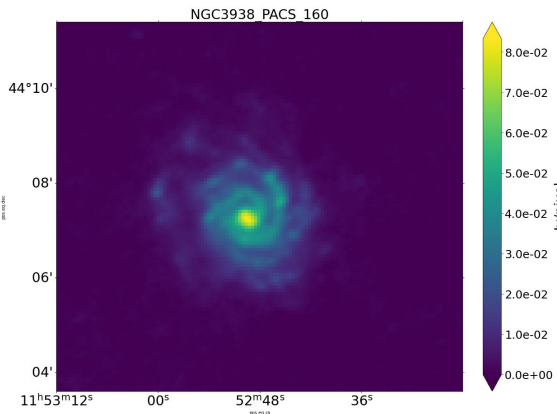
N random realization of the processed data map



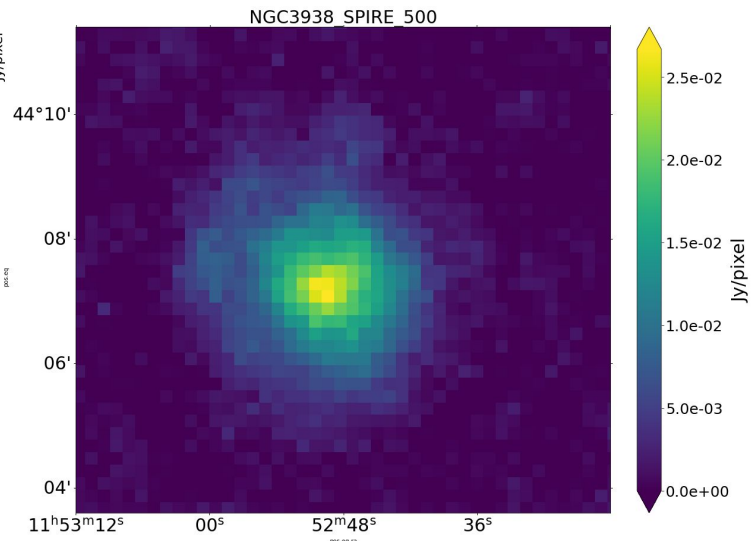
resolution: 18.15"



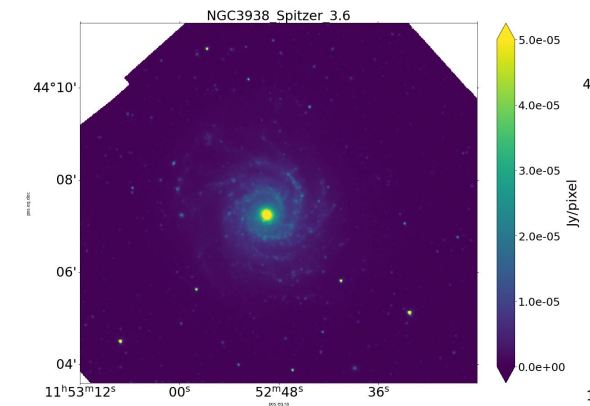
resolution: 11.18"



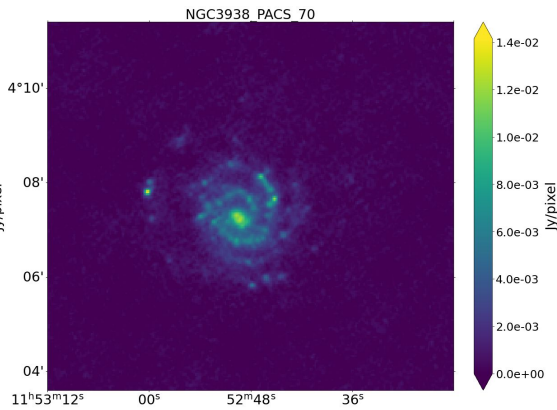
resolution: 36.09"



resolution: 1.90"

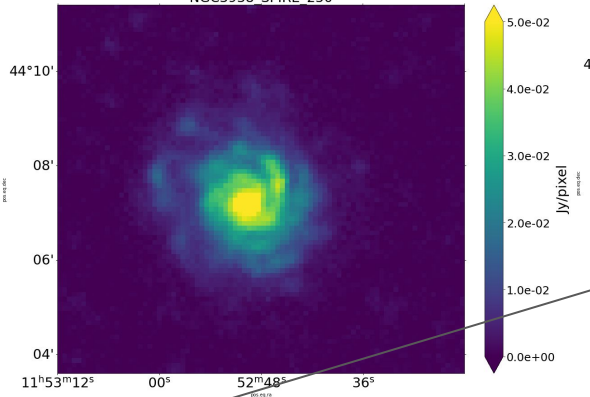


resolution: 5.67"



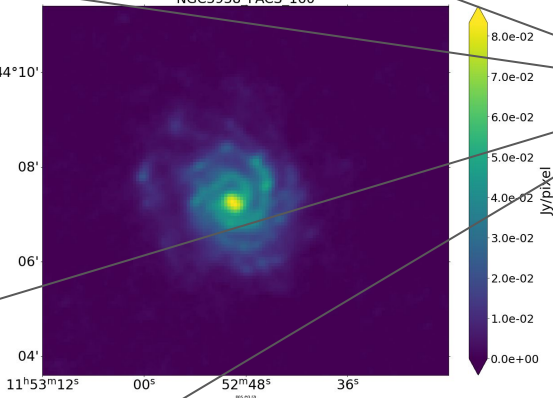
resolution: 18.15"

NGC3938 SPIRE 250



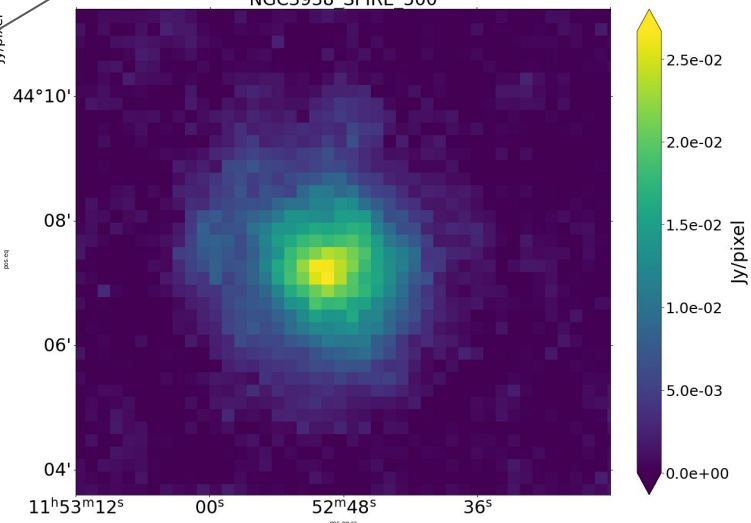
resolution: 11.18"

NGC3938 PACS 160



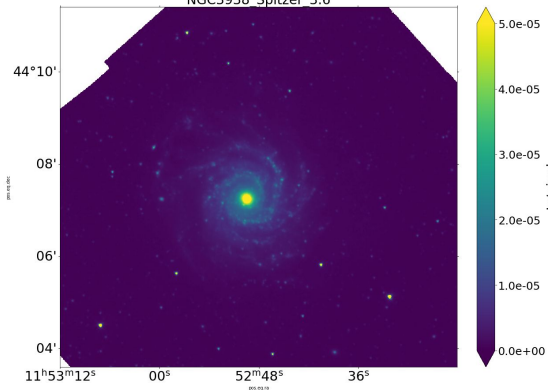
resolution: 36.09"

NGC3938 SPIRE 500



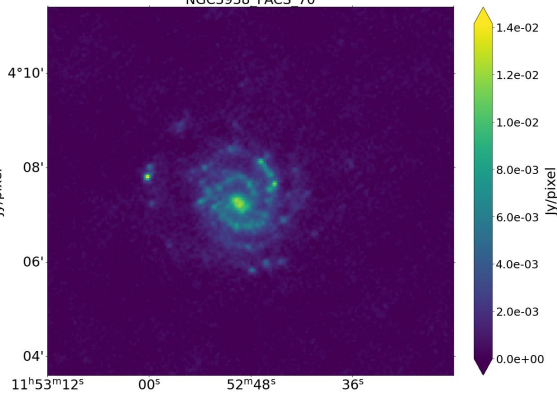
resolution: 1.90"

NGC3938 Spitzer 3.6

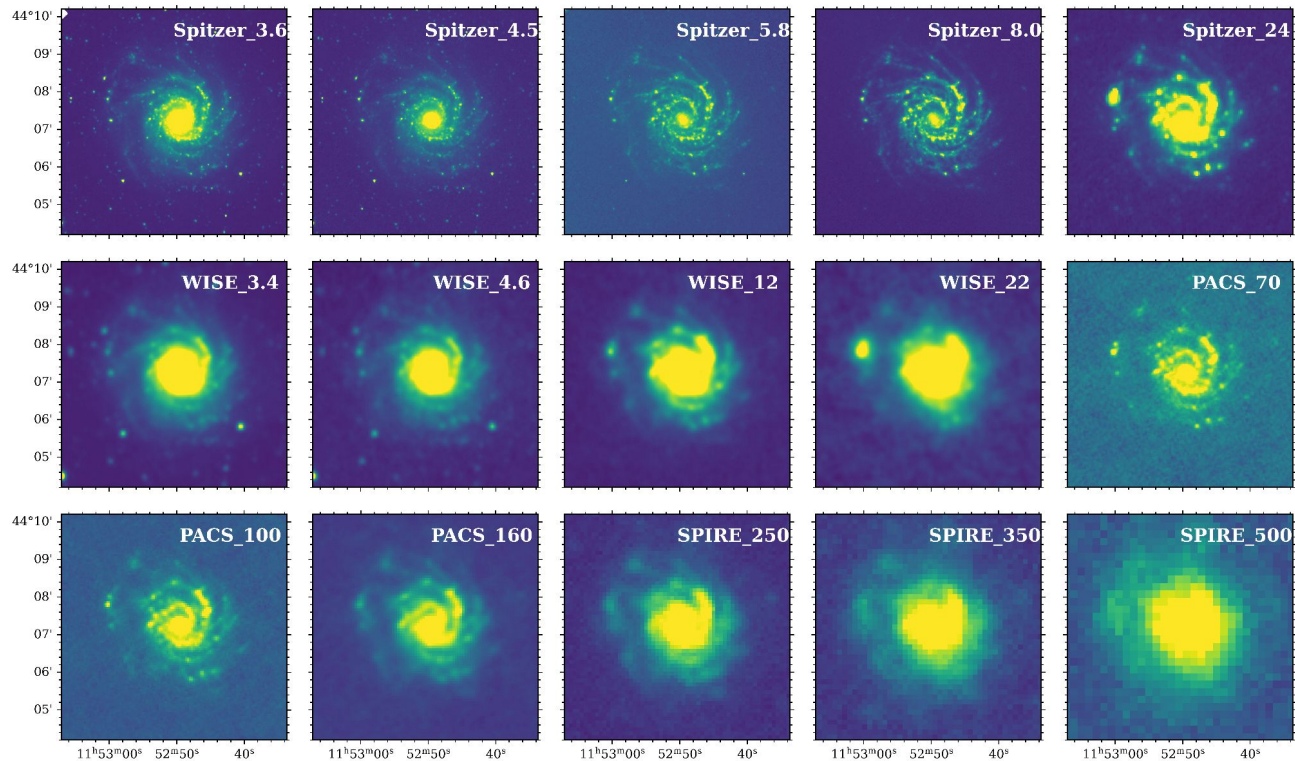


resolution: 5.67"

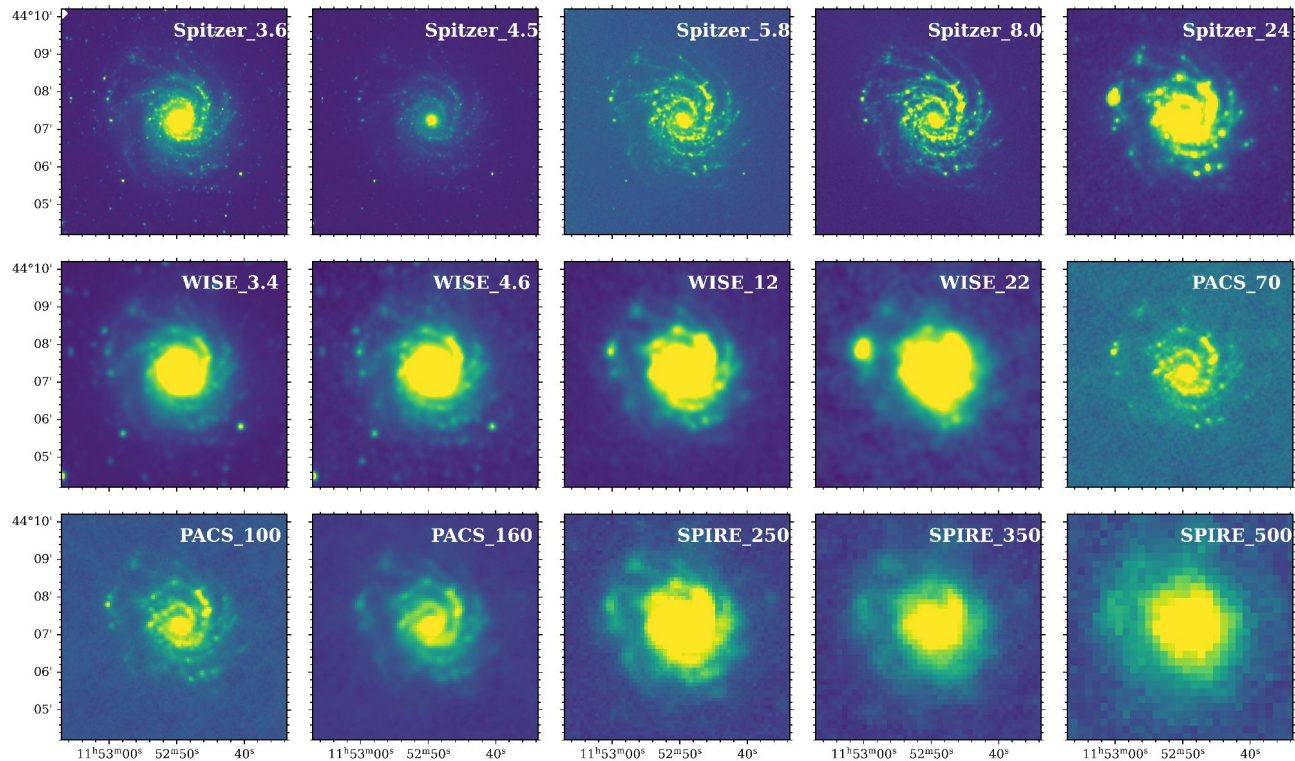
NGC3938 PACS 70



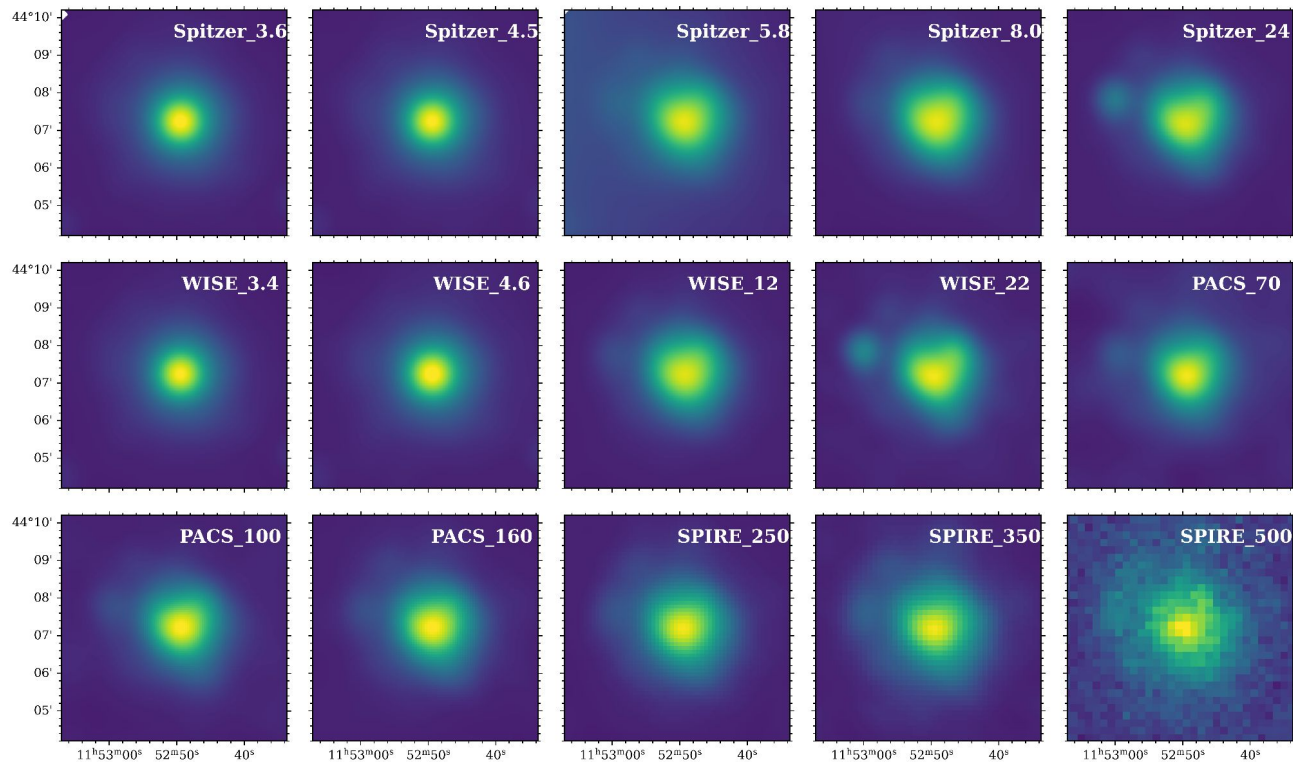
NGC 3938 (before homogenization)



NGC 3938 (cropped / background subtracted)



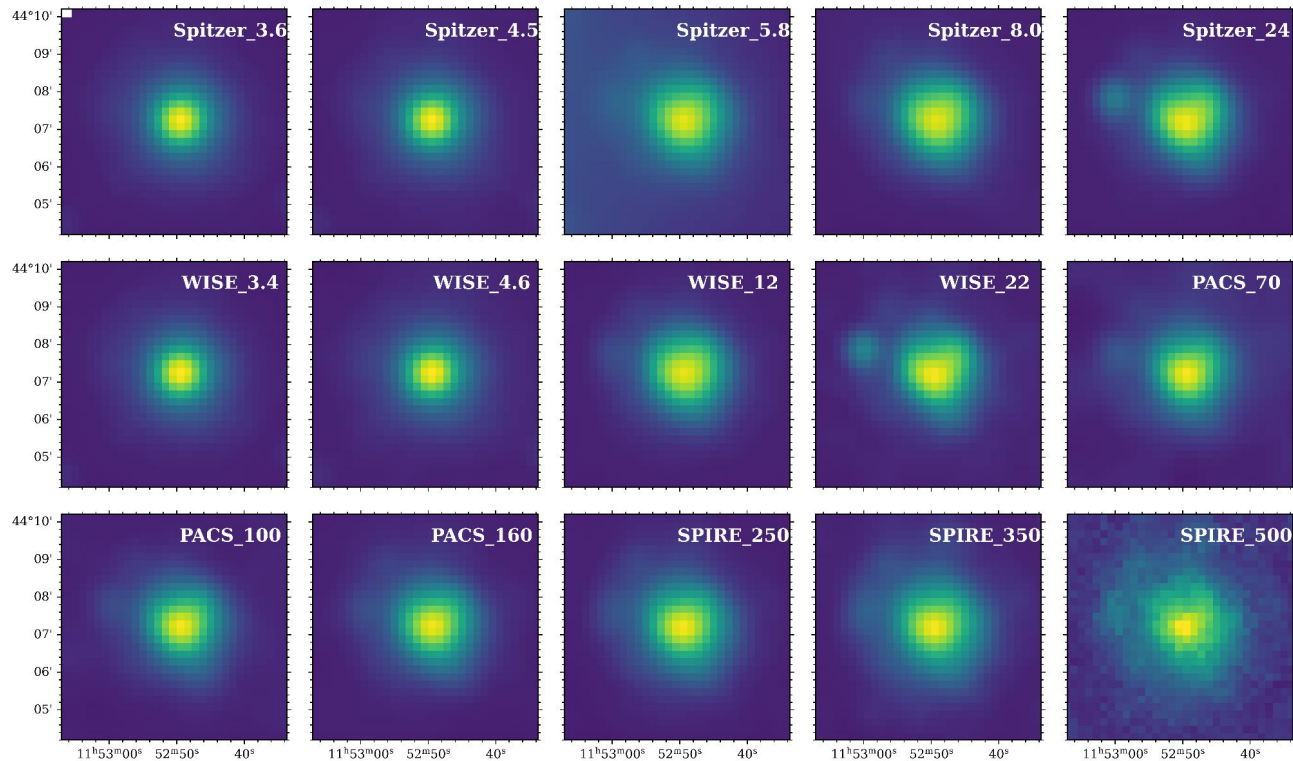
NGC 3938 (convolved)



Pixel size =
original px size

← Convolve all to
SPIRE 500 μ m

NGC 3938 (after homogenization)

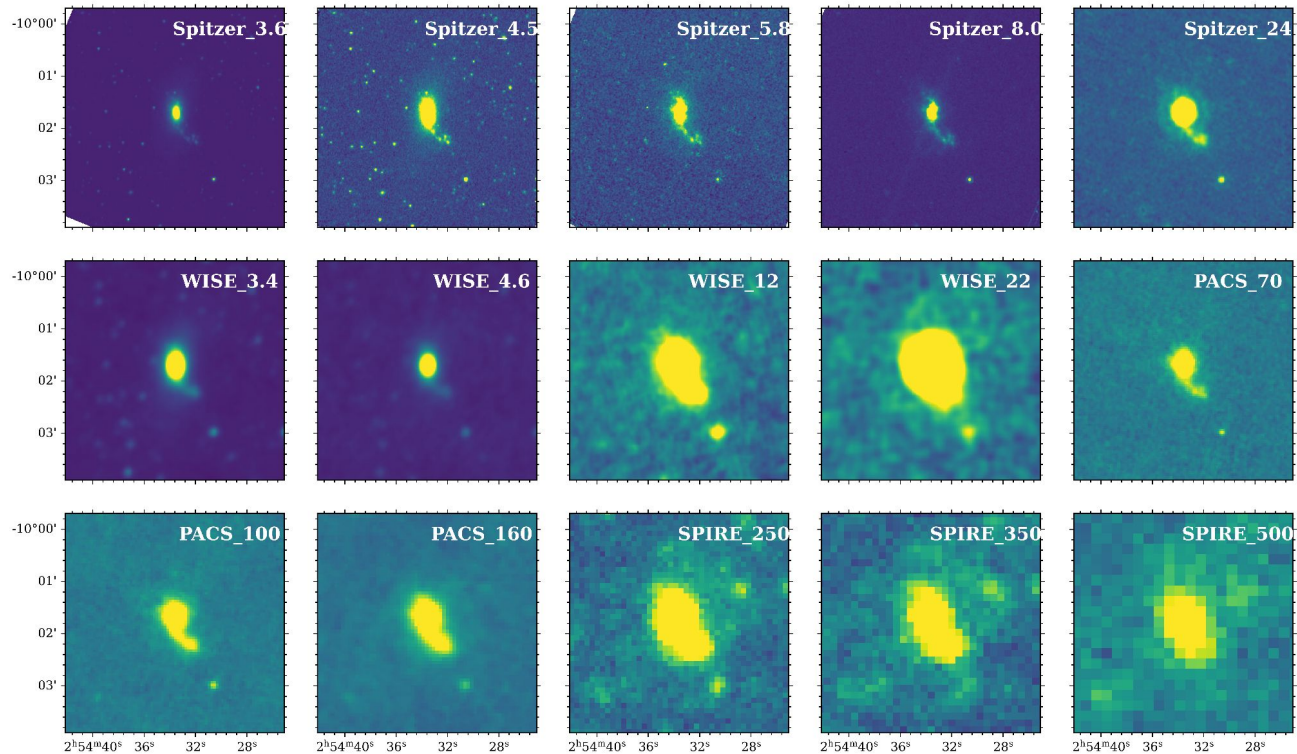


Pixel size =
SPIRE 500 μm
px size

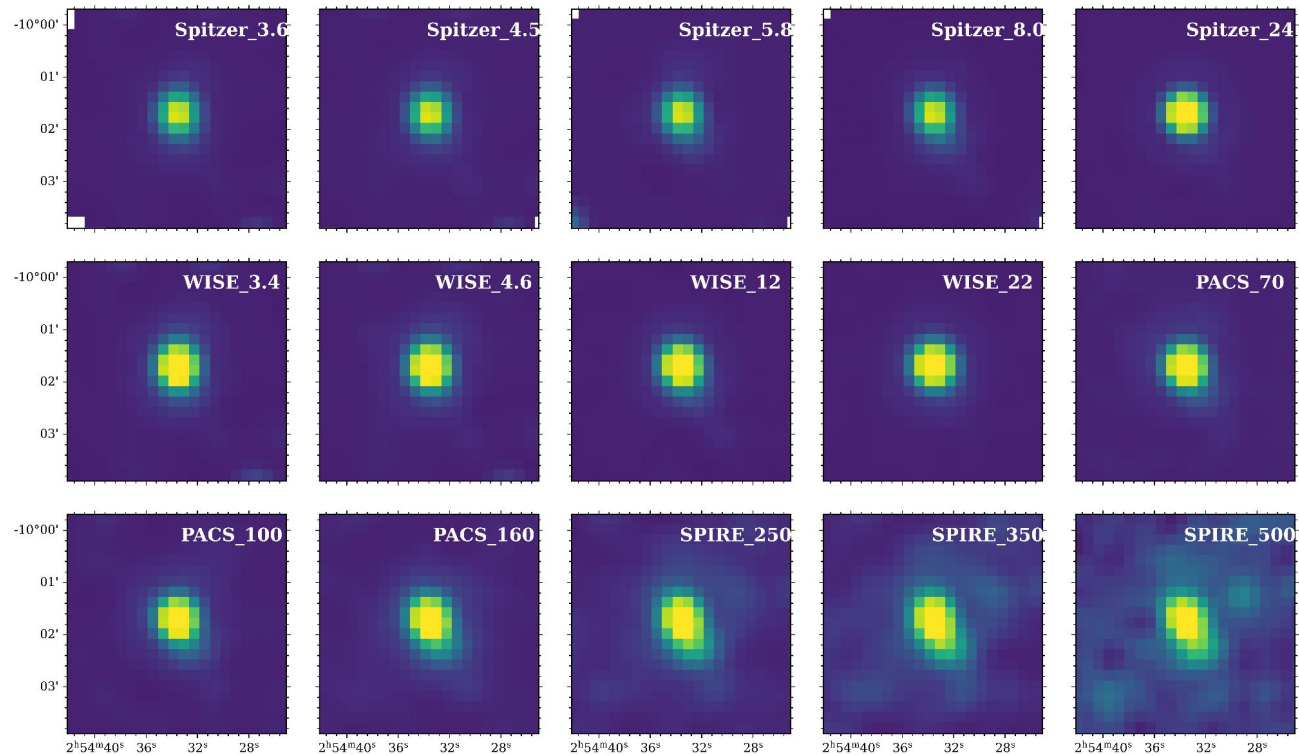
then mask out
pixels with S/N < 3

← Reproject all to
SPIRE 500 μm

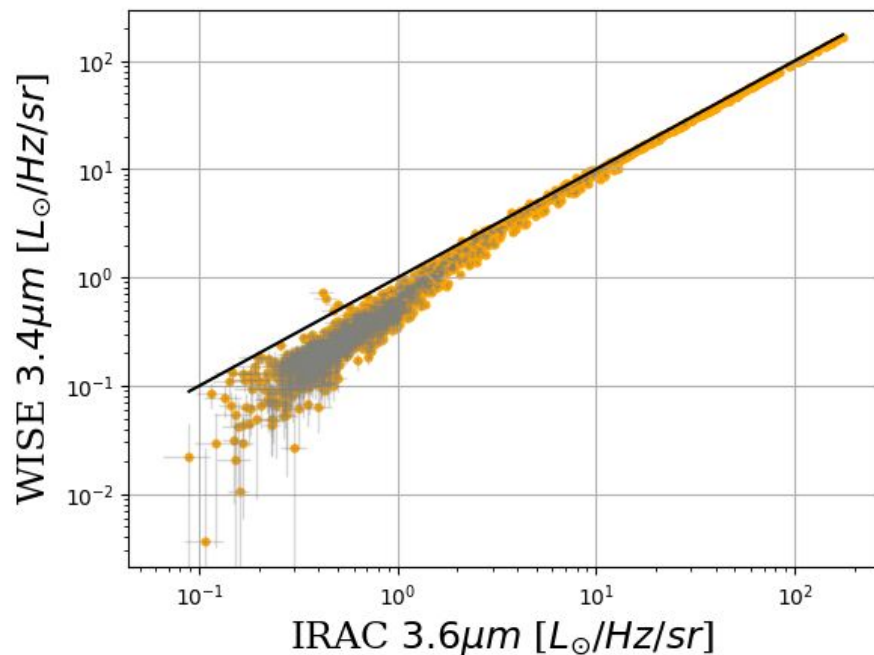
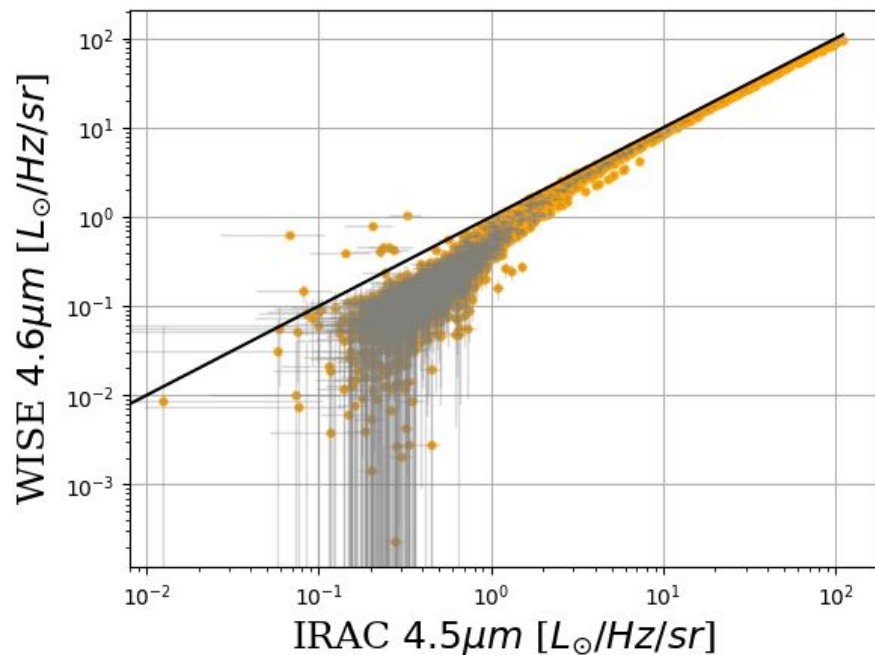
NGC 1140 (**before** homogenization)



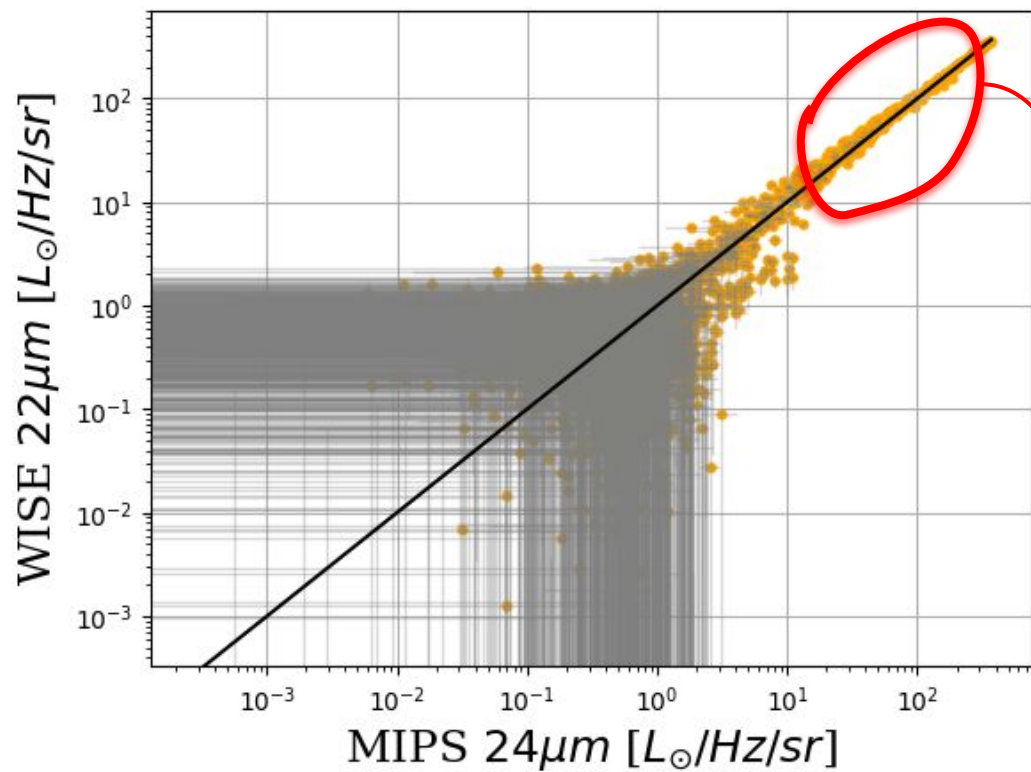
NGC 1140 (after homogenization)



Check flux calibration between overlapping bands



NGC 3938

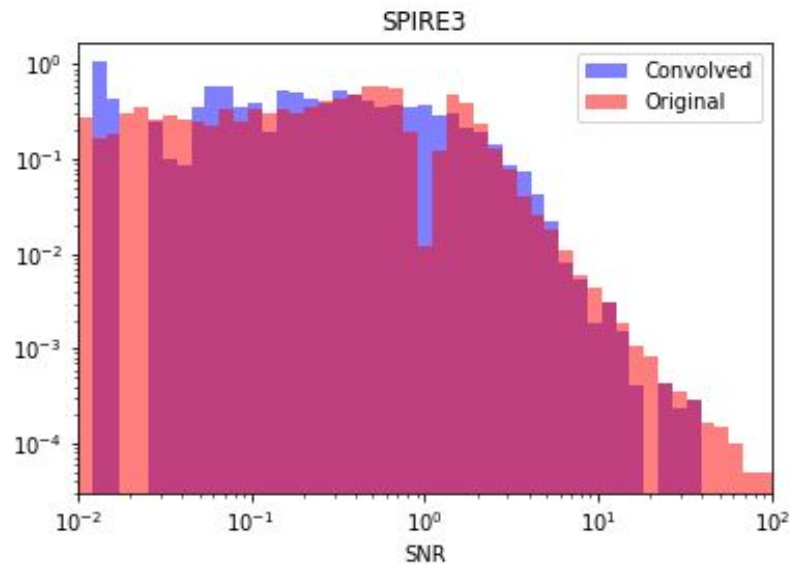
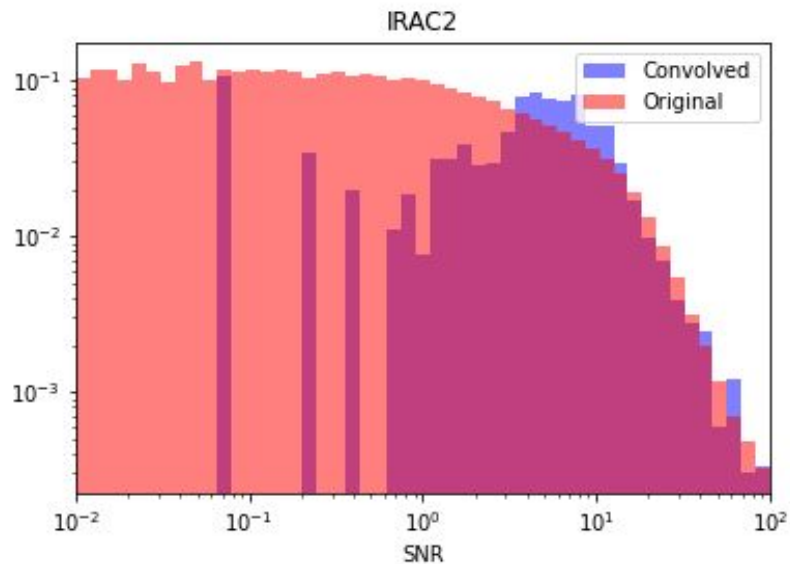


SOURCE



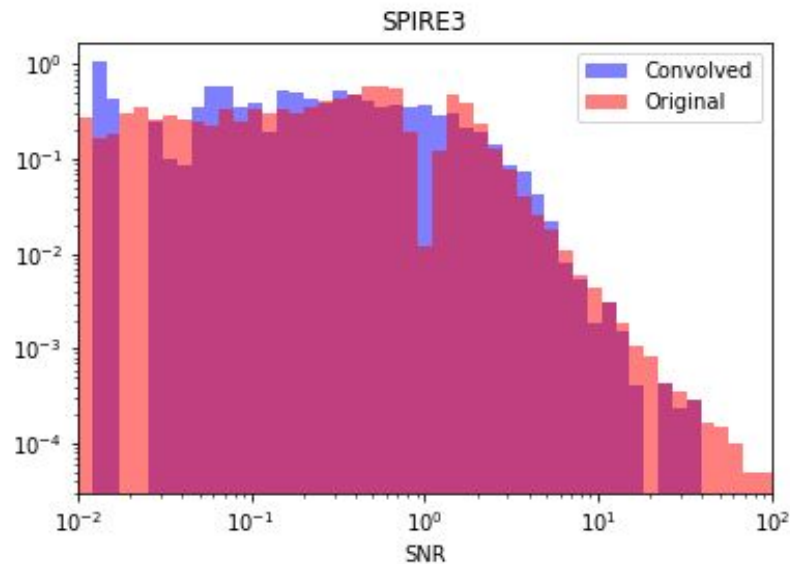
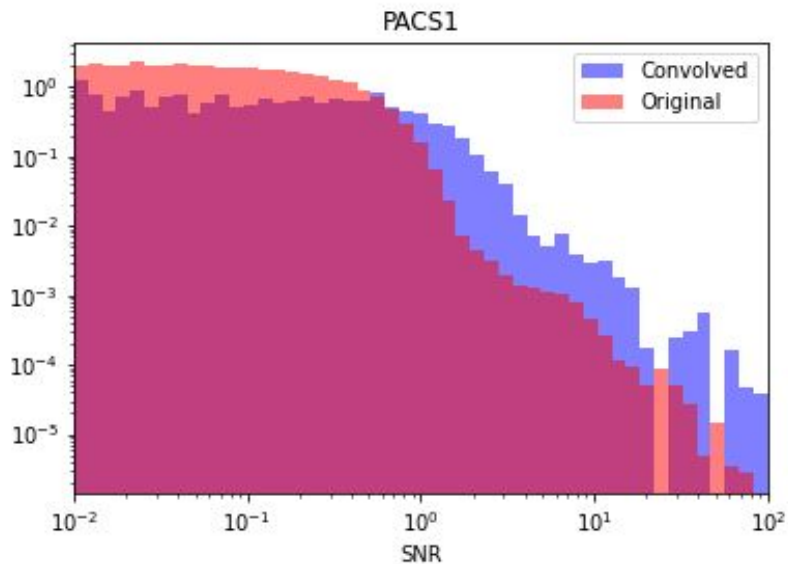
NGC 3938

Signal-Noise comparison



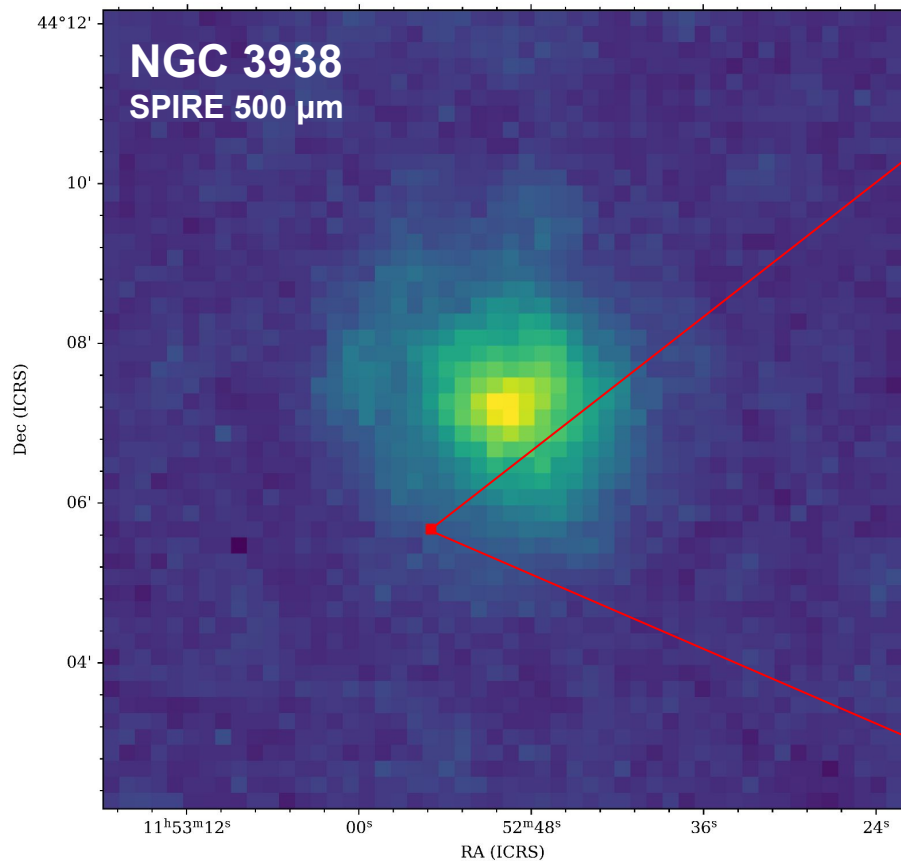
NGC 1140

Signal-Noise comparison

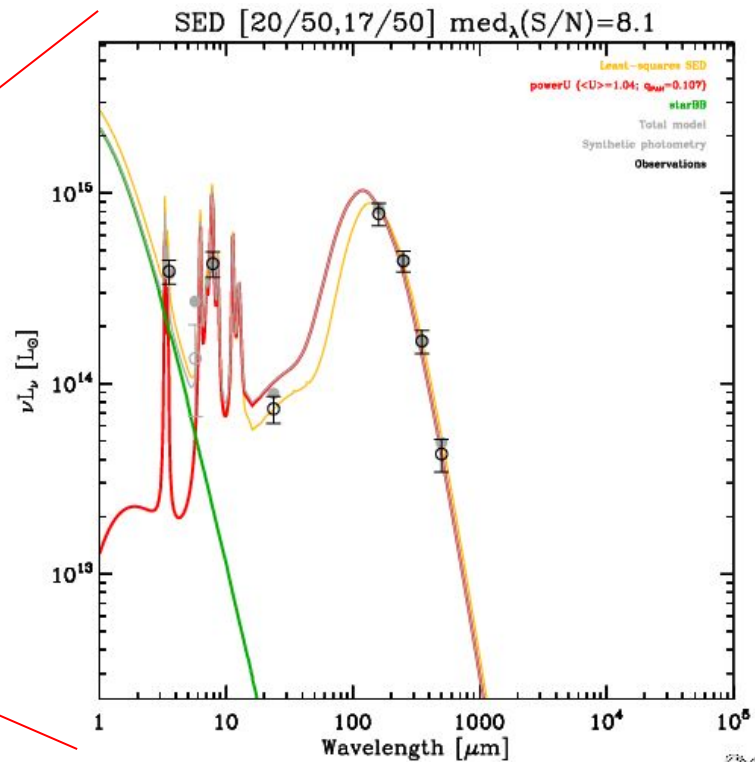


NGC 1140

SED fitting with HerBIE (Galliano 2018)

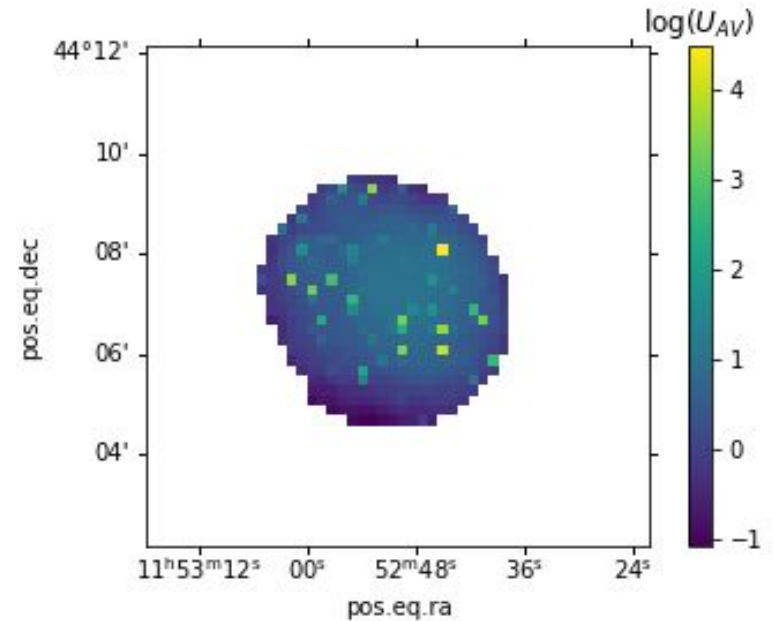


A pixel in the disk



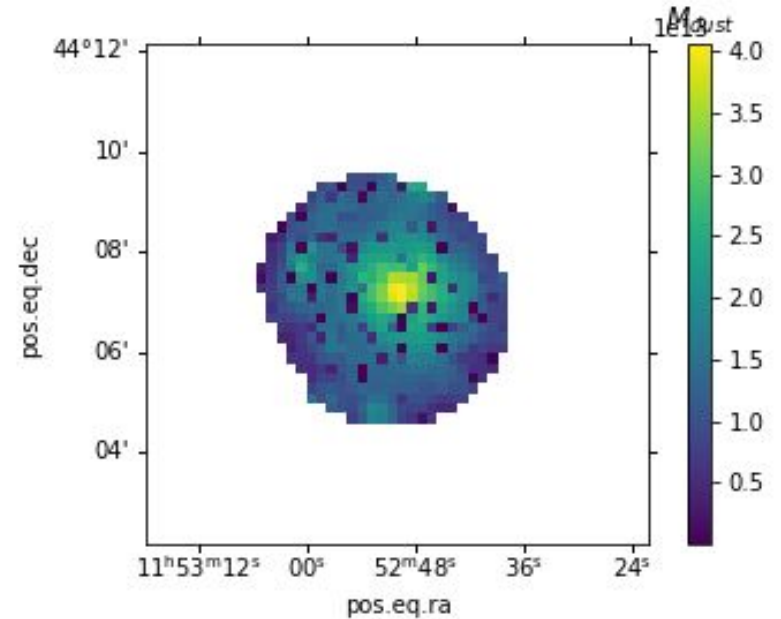
Physical properties

- Radiation field decreases with radius



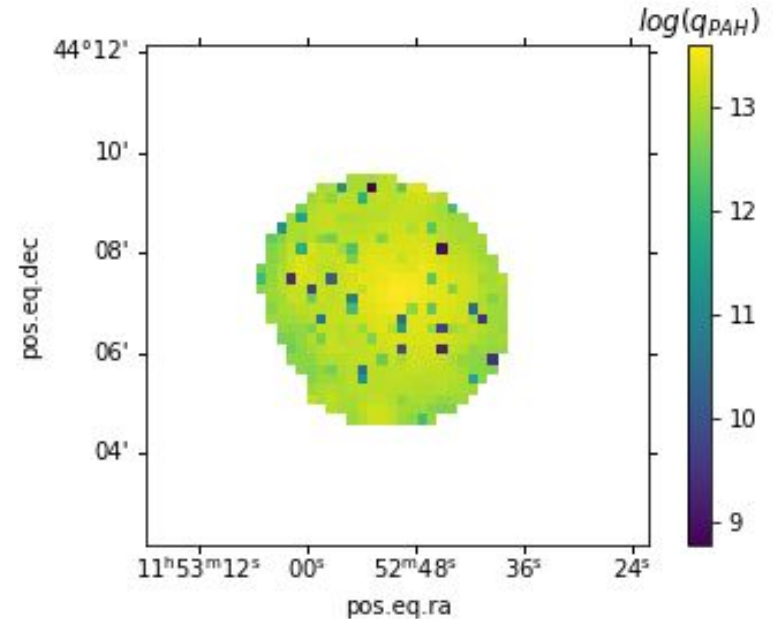
Physical properties

- Radiation field decreases with radius
- Dust mass decreases with radius



Physical properties

- Radiation field decreases with radius
- Dust mass decreases with radius
- PAH fraction varies with dust mass

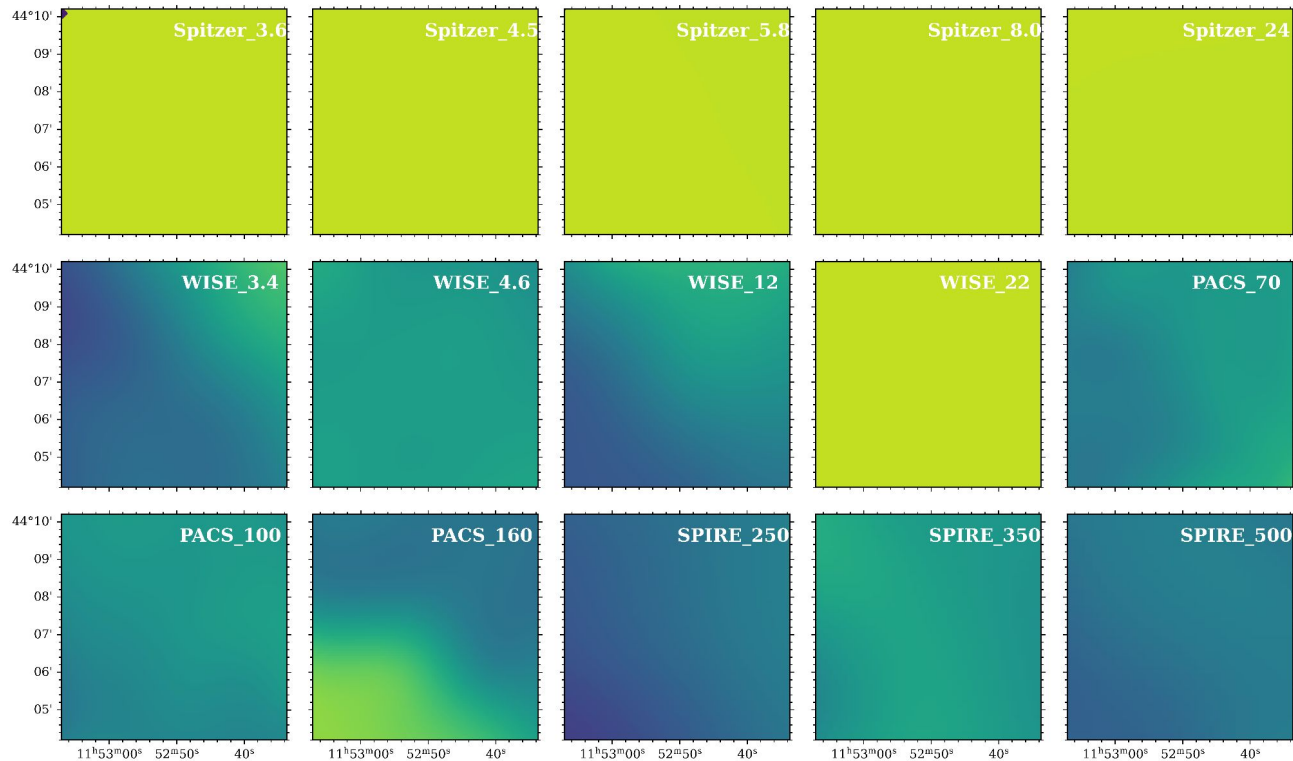


Thank you !

**CRAZY SPACE DUST
WAS CREATED BY**



NGC 3938 (background map)



Mask stars /
galaxy

Interpolate bkg
emission behind
the galaxy