GISM 2023
02/08/23

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

Davide Belfiori · Lucie Correia · Luis Garduno · Niklas Moszczynski · Andrea Romanelli · Martin Shanobe · Suphakorn Suphapolthaworn · Stefan van der Giessen

Supervisors: Frédéric GALLIANO & Lara PANTONI

Outline

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

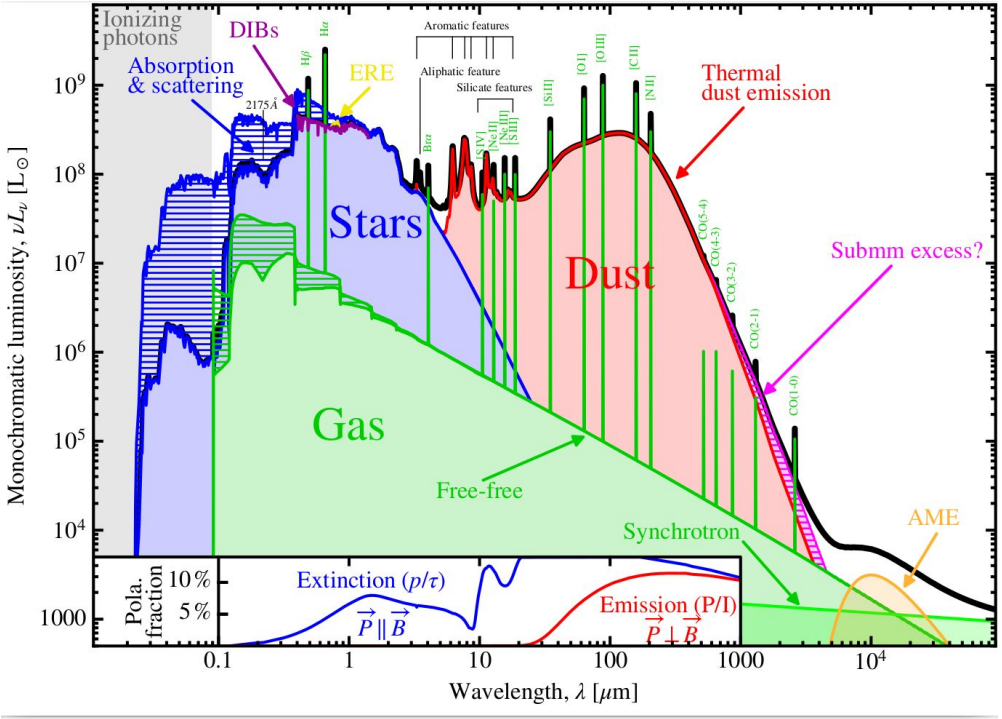
Scientific goals

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’

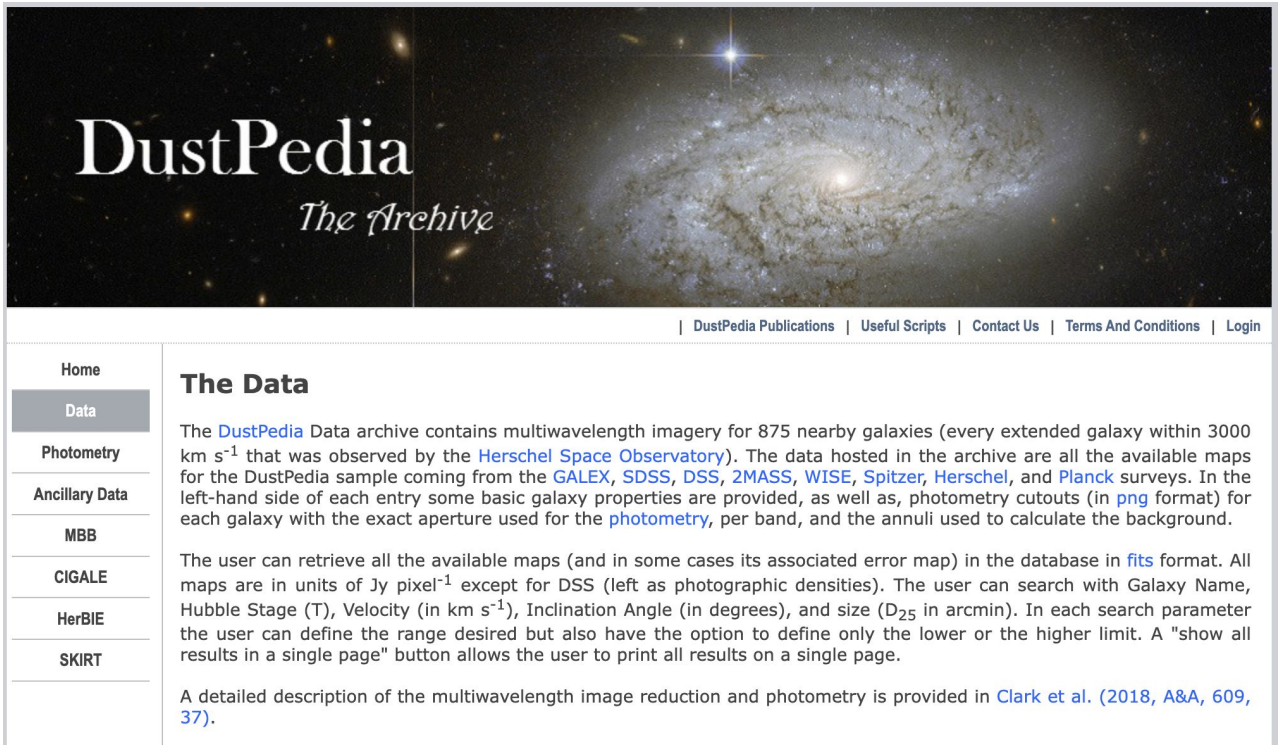
NGC 1140
ESA/Hubble

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



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

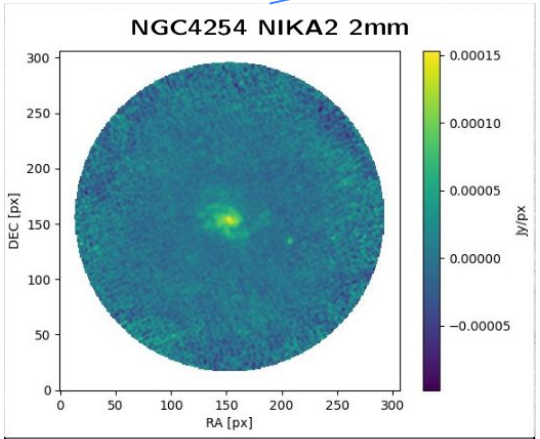
Monte Carlo error propagation

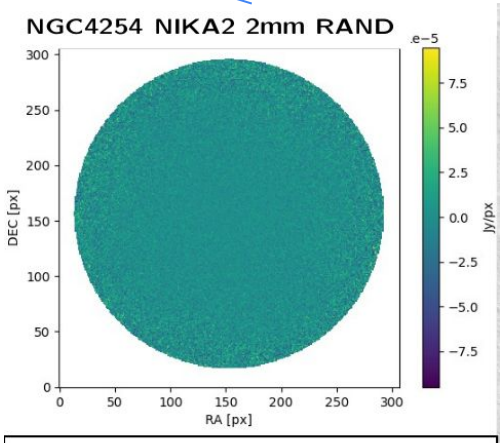
Images from Laura Pantoni

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.

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



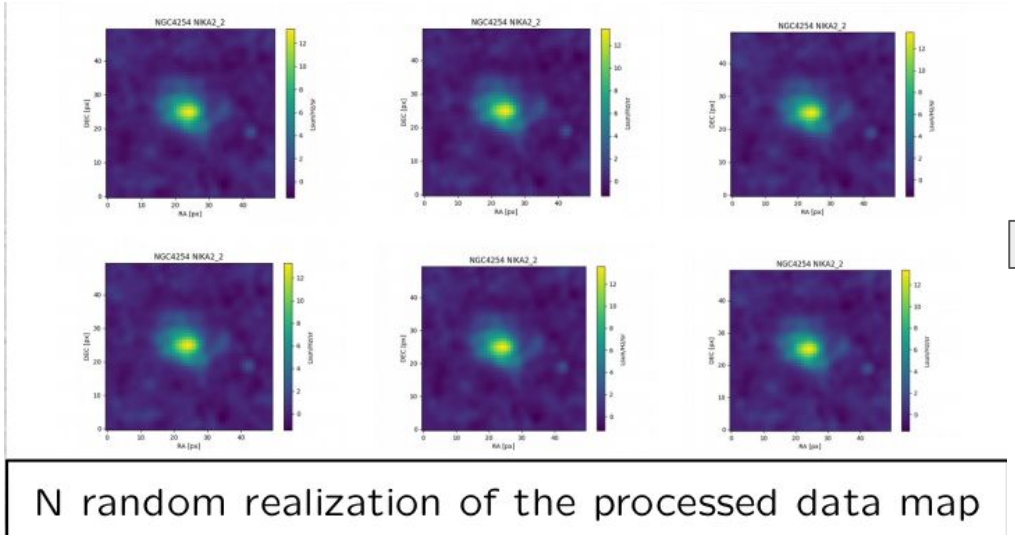


Monte Carlo error propagation

Images from Laura Pantoni

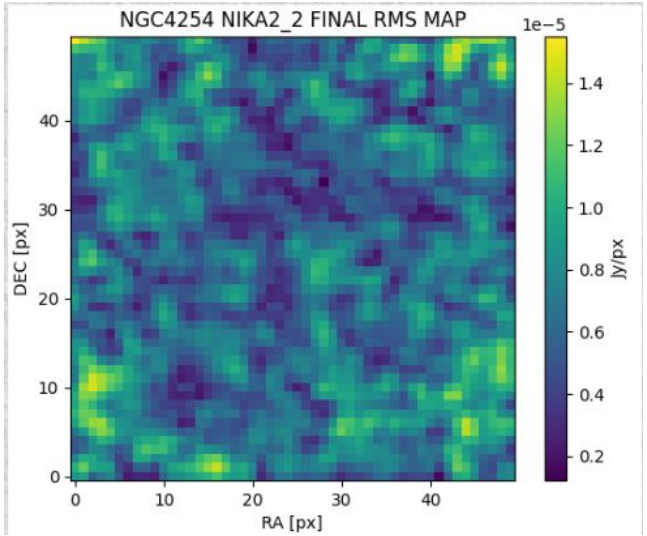
3) After N iterations, we have N perturbed data map that have been processed in the same way.

4) The px-by-px standard deviation of the N data maps gives the final statistical uncertainty map

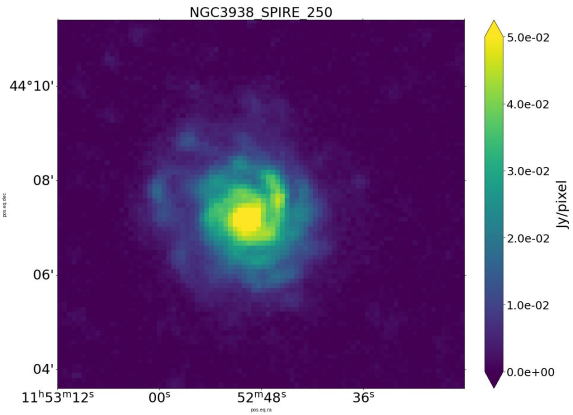


N random realization of the processed data map

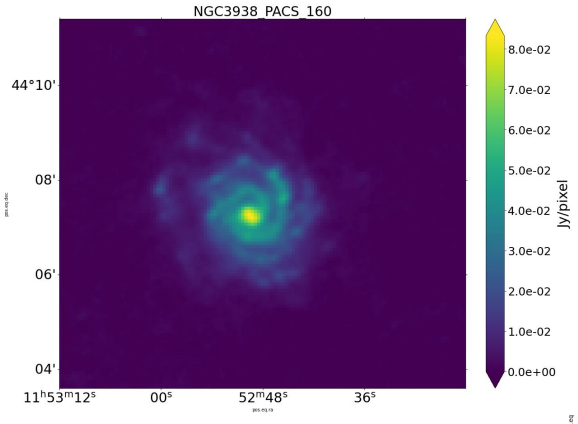
STD



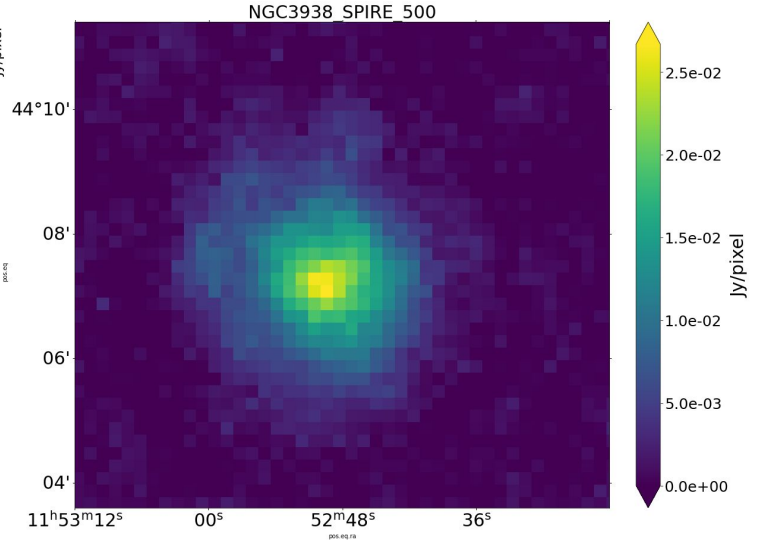
resolution: 18.15″



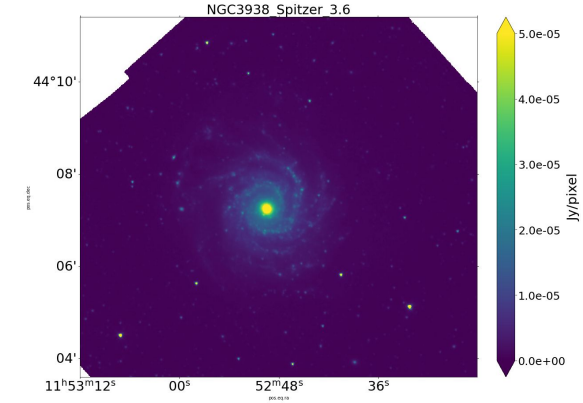
resolution: 11.18″



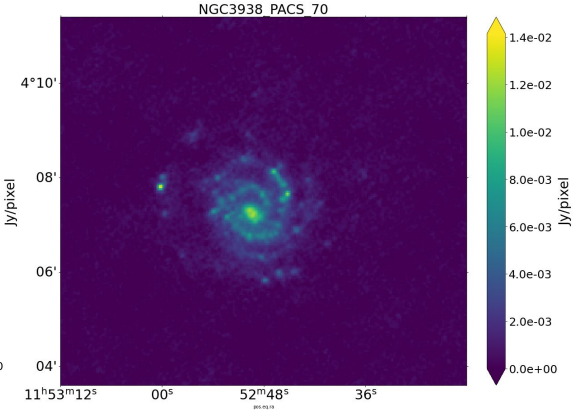
resolution: 36.09″



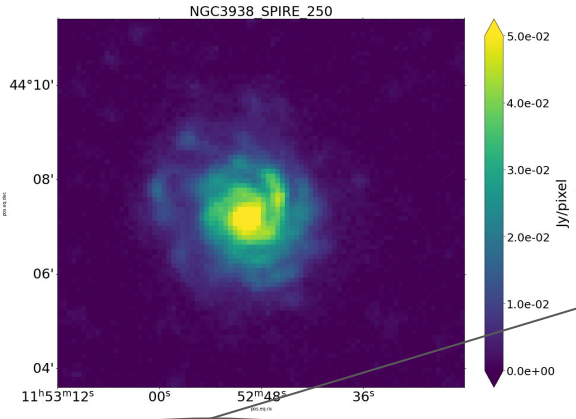
resolution: 1.90″



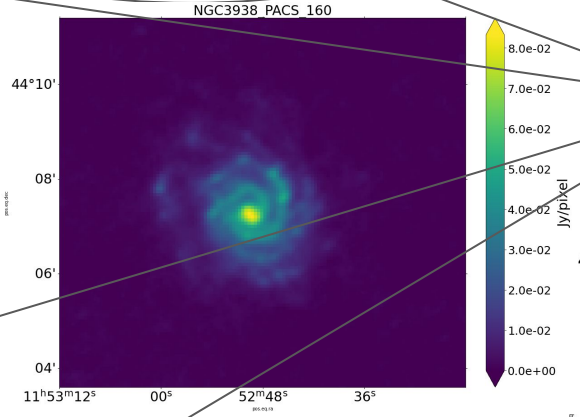
resolution: 5.67″



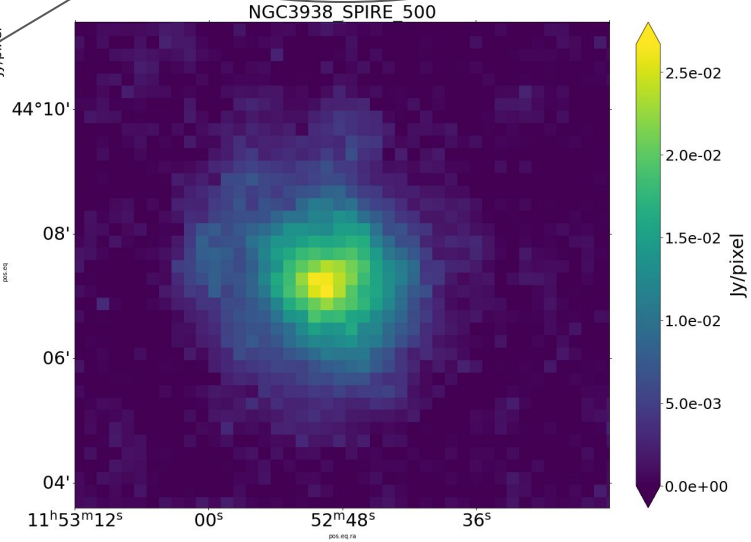
resolution: 18.15″



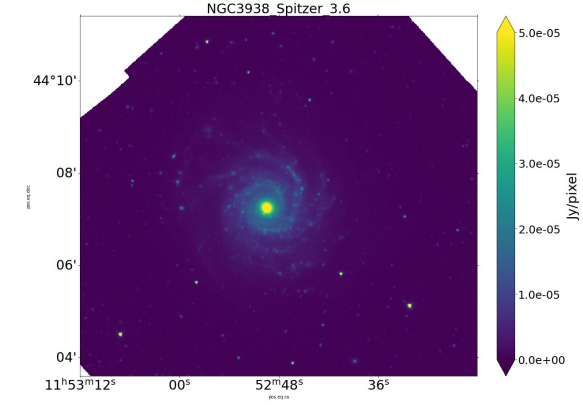
resolution: 11.18″



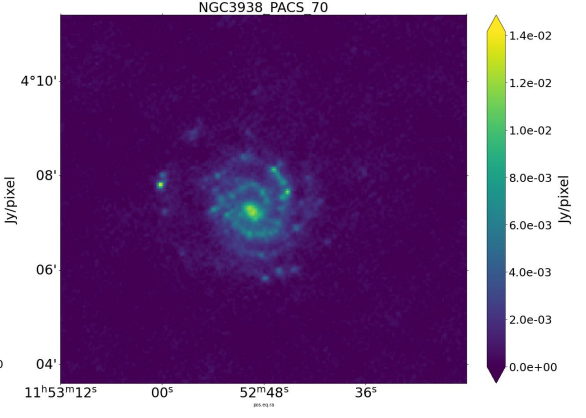
resolution: 36.09″



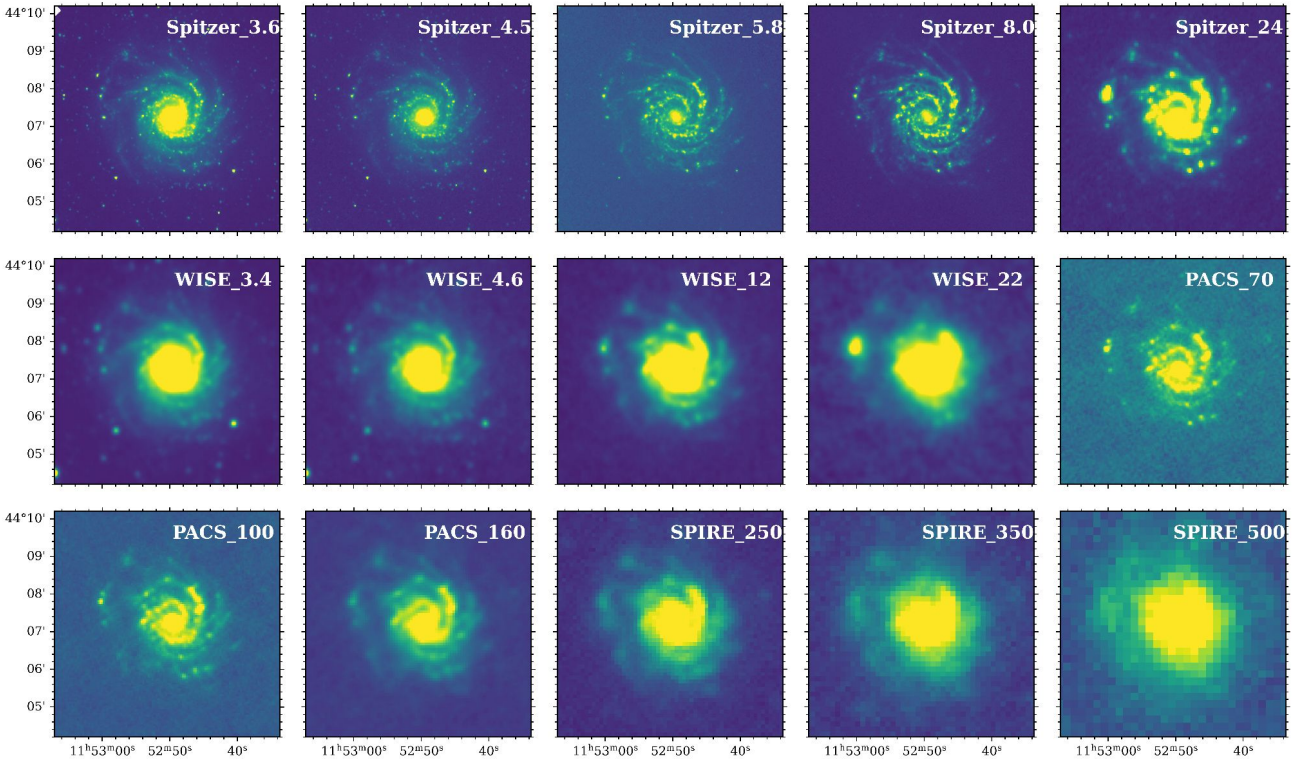
resolution: 1.90″



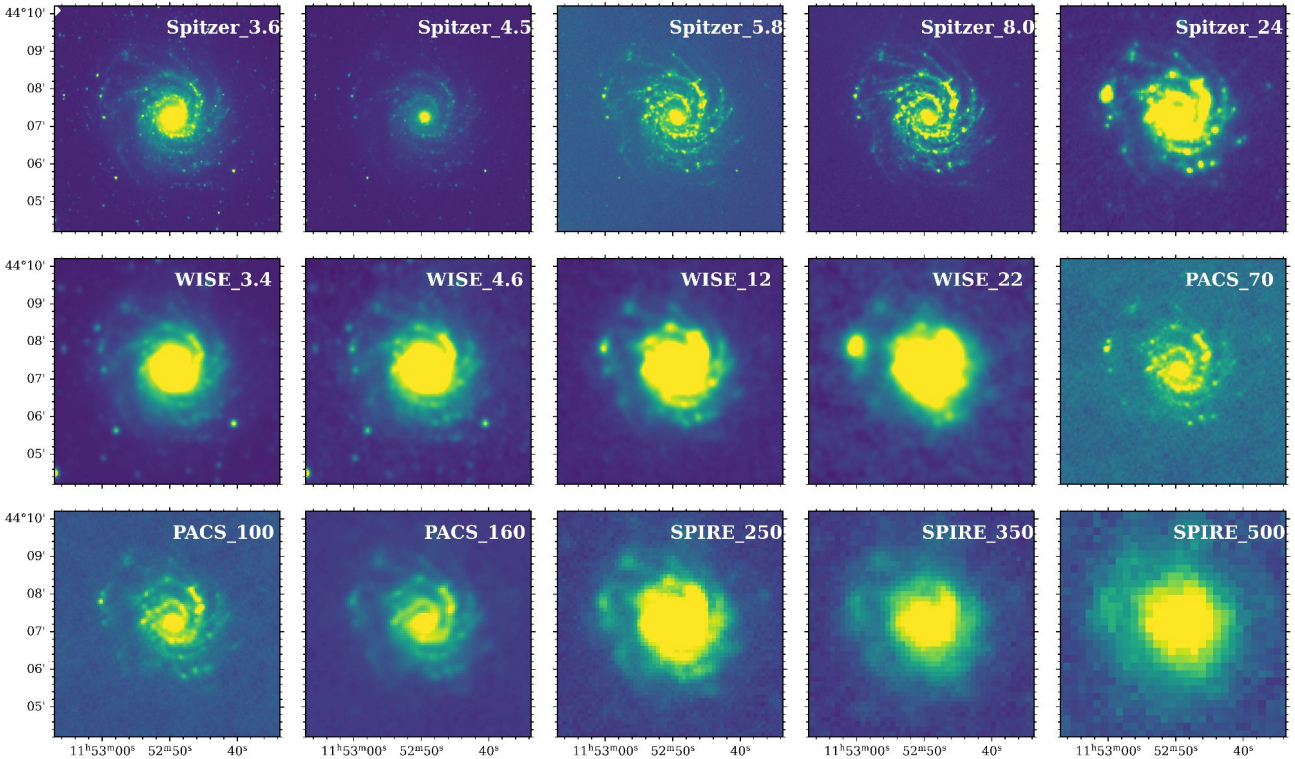
resolution: 5.67″



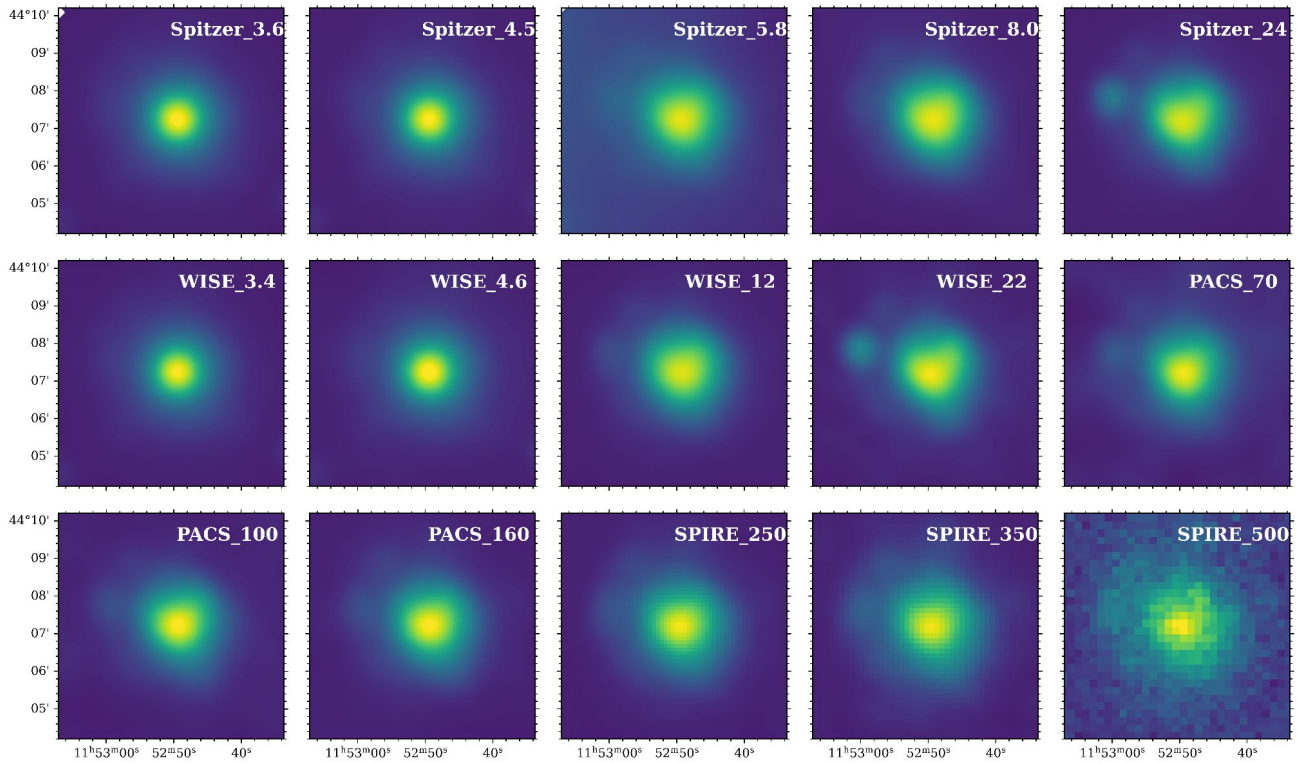
NGC 3938 (**before** homogenization)



NGC 3938 (cropped / background subtracted)



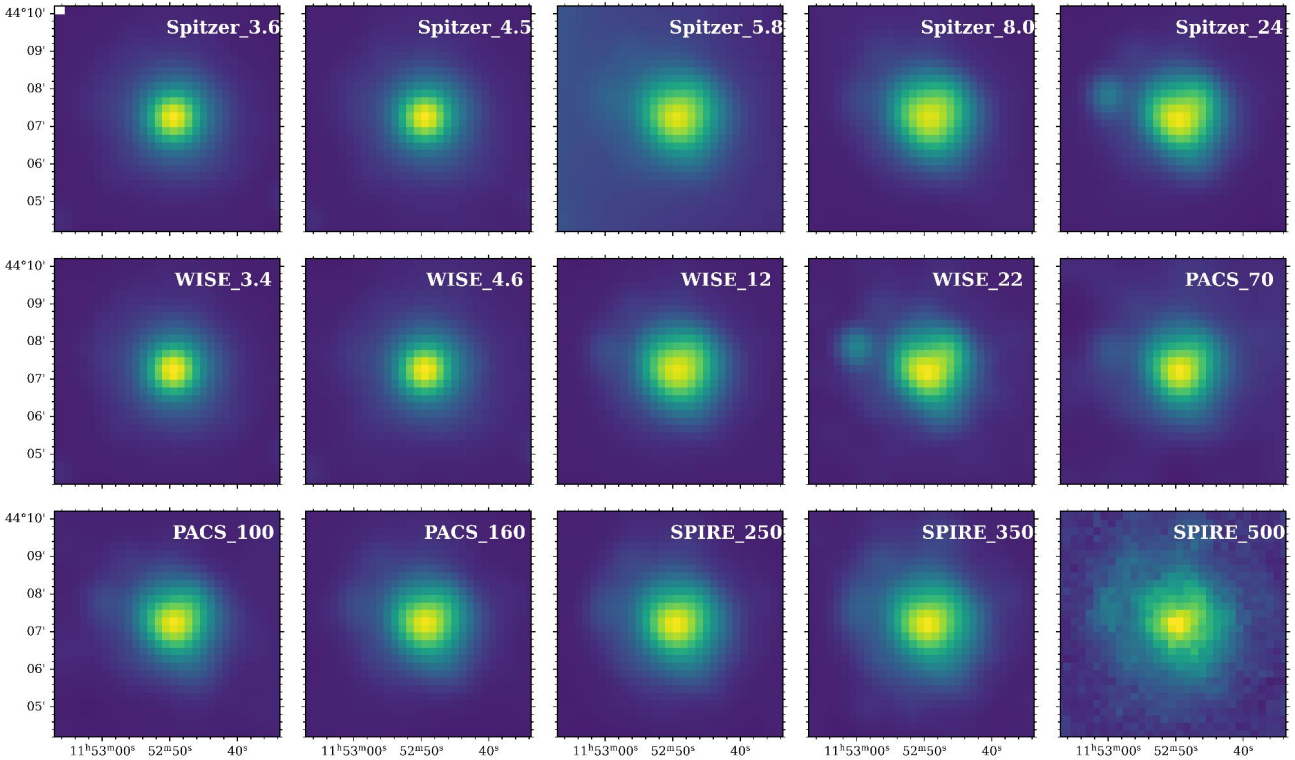
NGC 3938 (convolved)



Pixel size = original px size

Convolve all to SPIRE 500 μm

NGC 3938 (**after** homogenization)

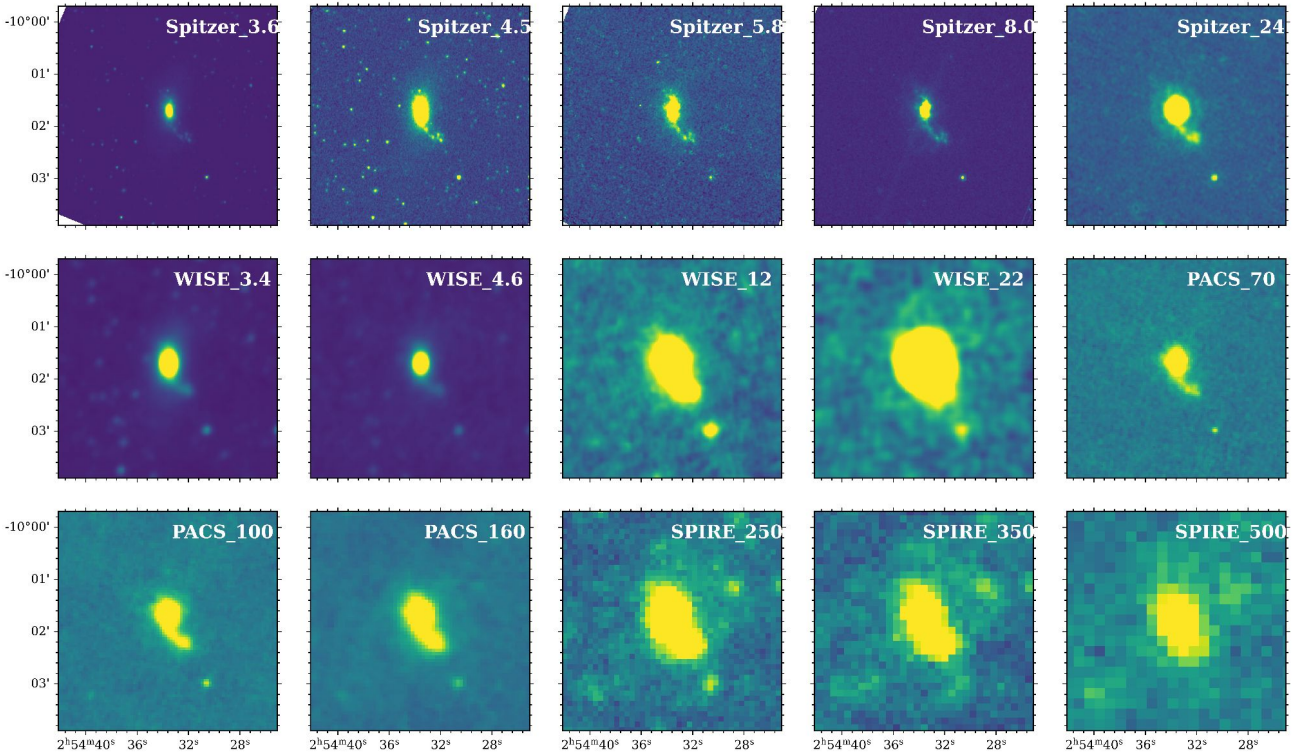


Pixel size = SPIRE 500 μm px size

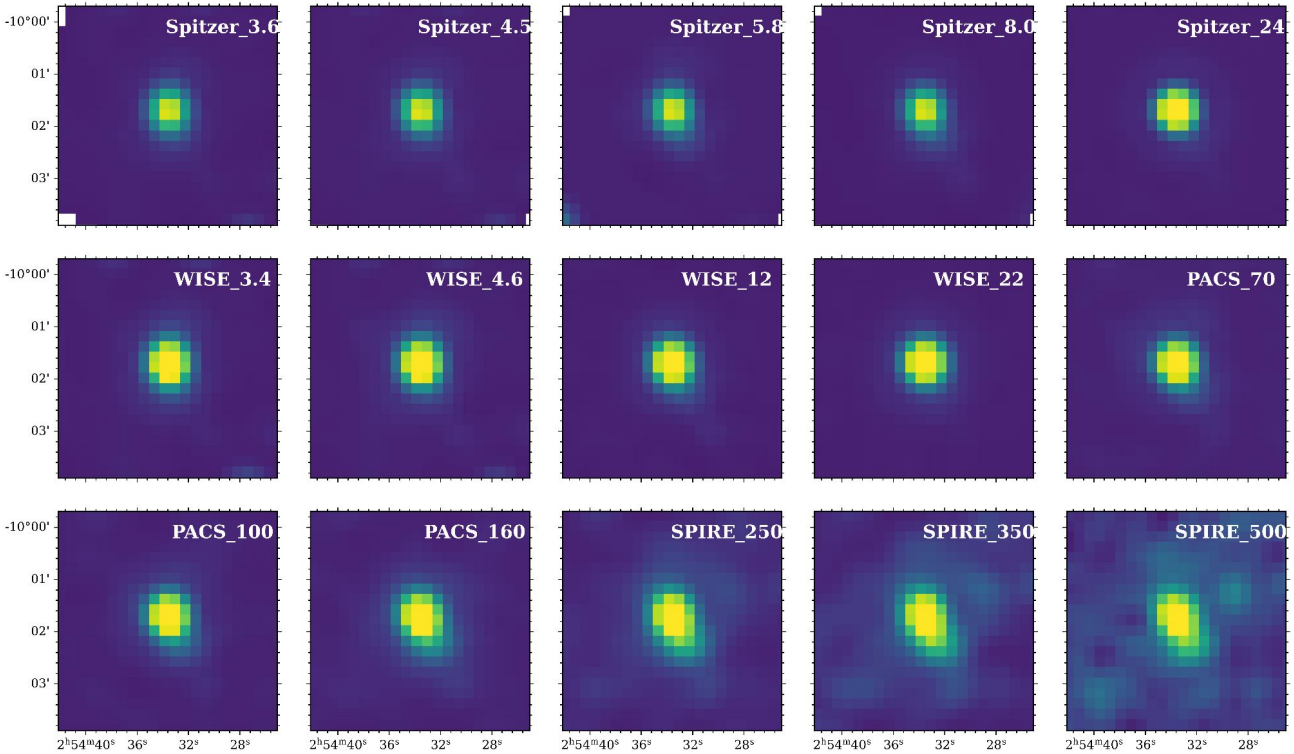
then mask out pixels with S/N < 3

Reproject all to SPIRE 500 μm

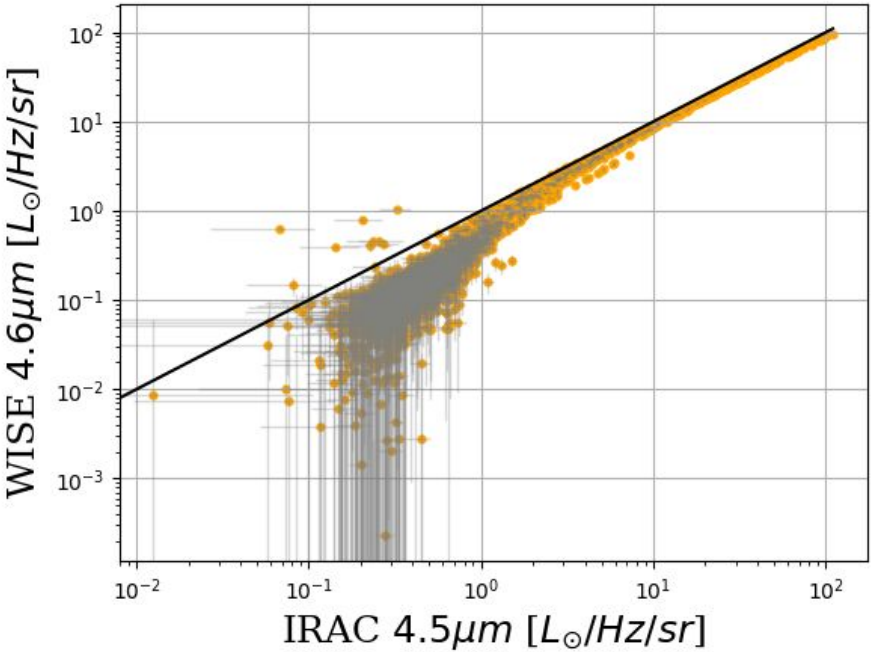
NGC 1140 (**before** homogenization)

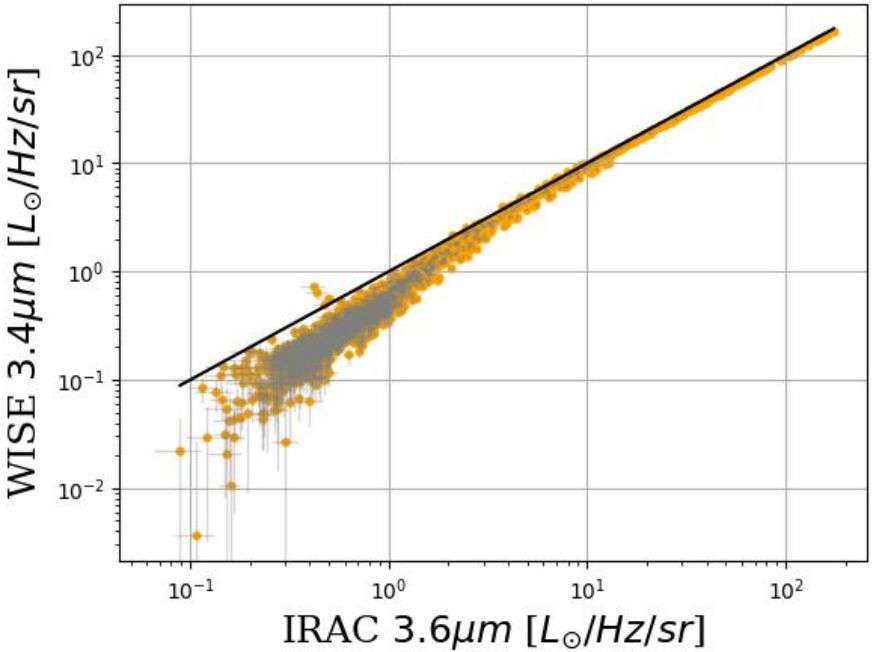


NGC 1140 (**after** homogenization)

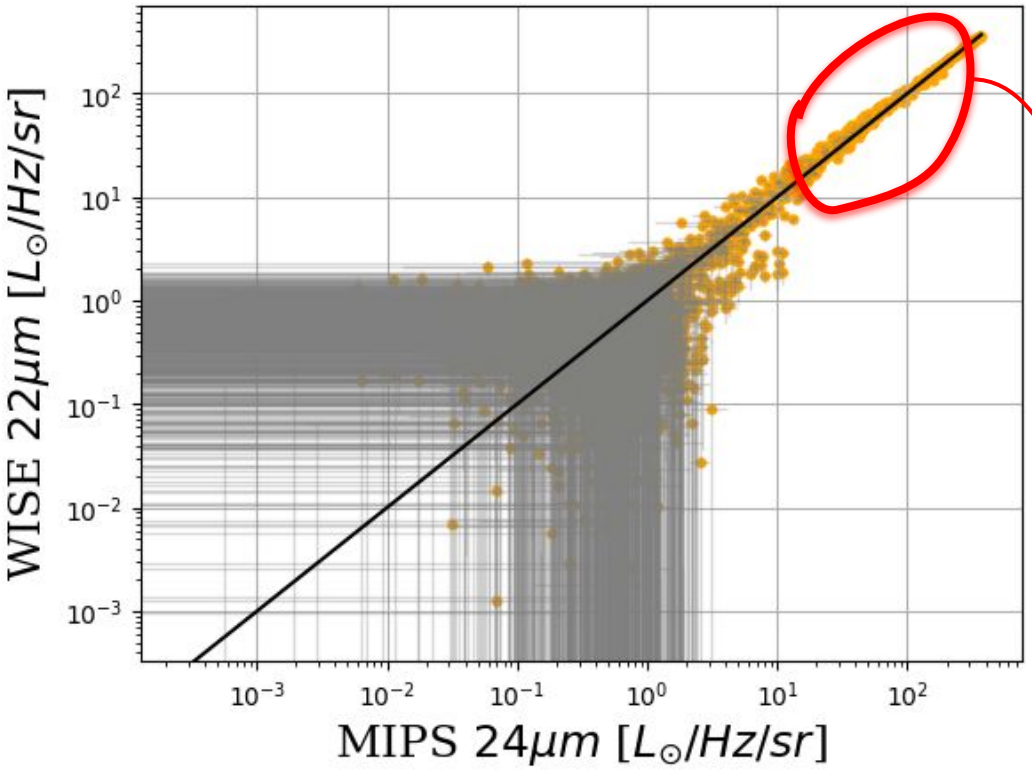


Check flux calibration between overlapping bands





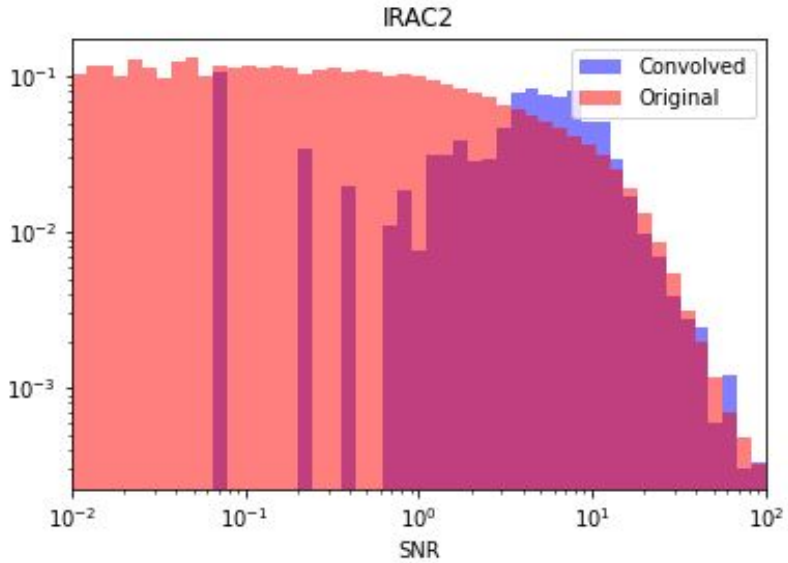
NGC 3938

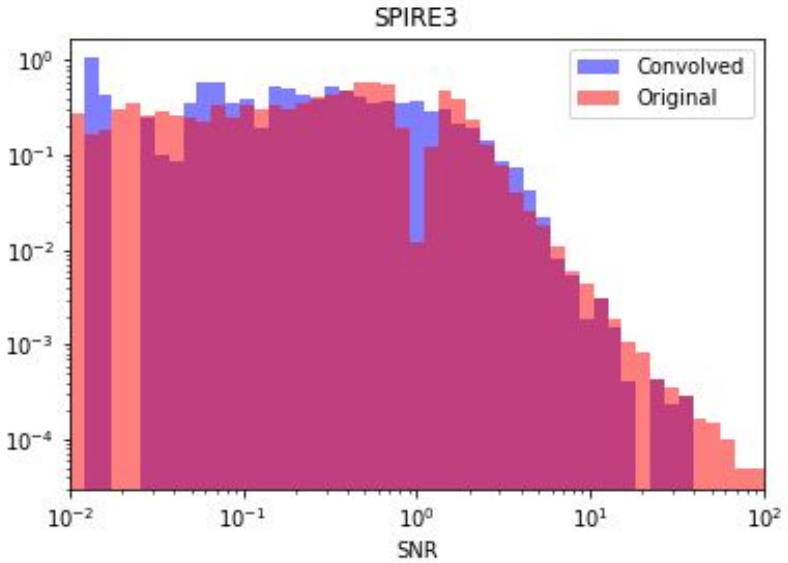


SOURCE

NGC 3938

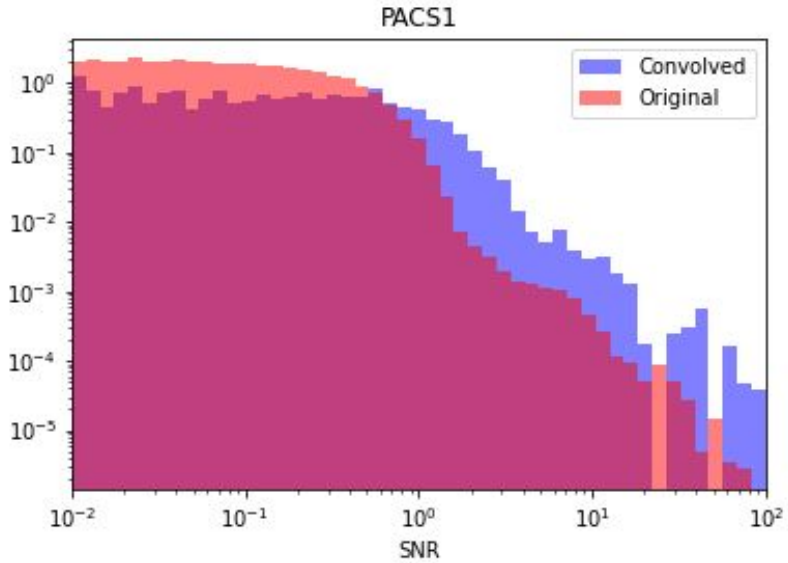
Signal-Noise comparison

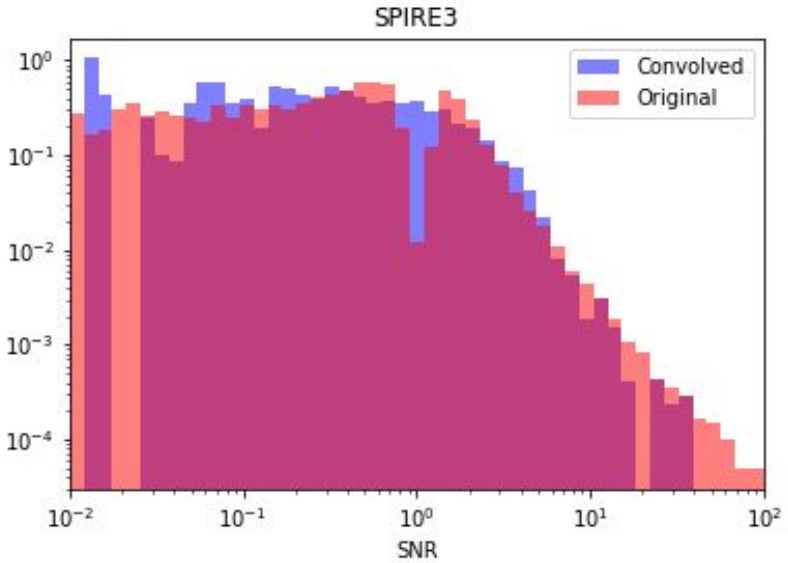




NGC 1140

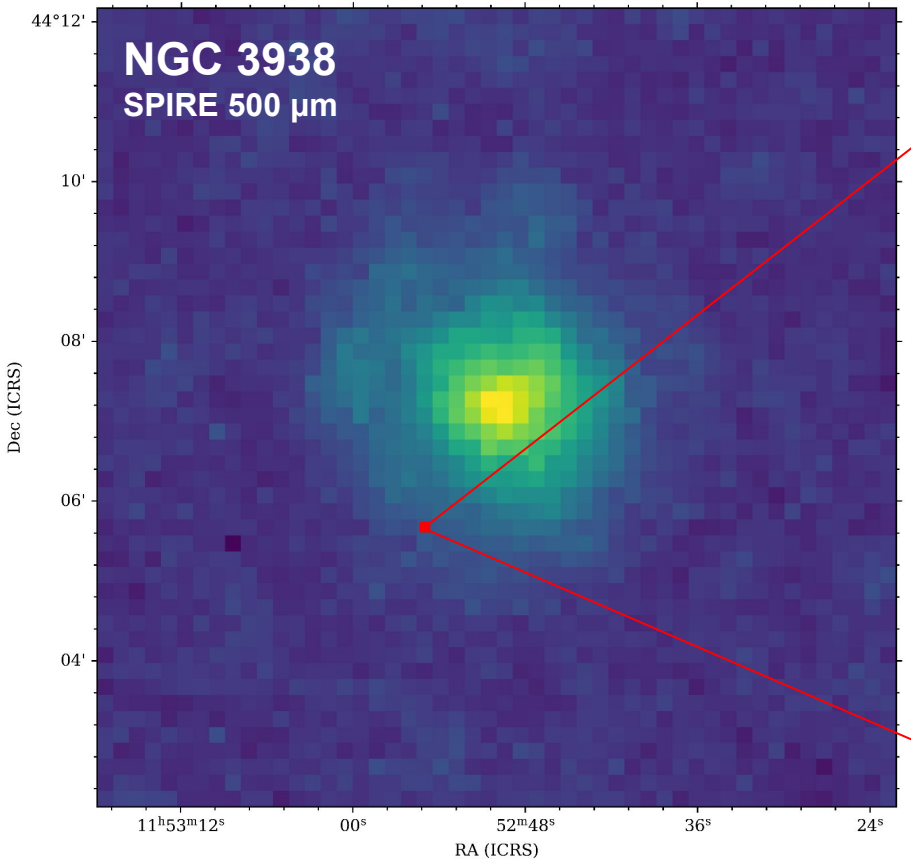
Signal-Noise comparison



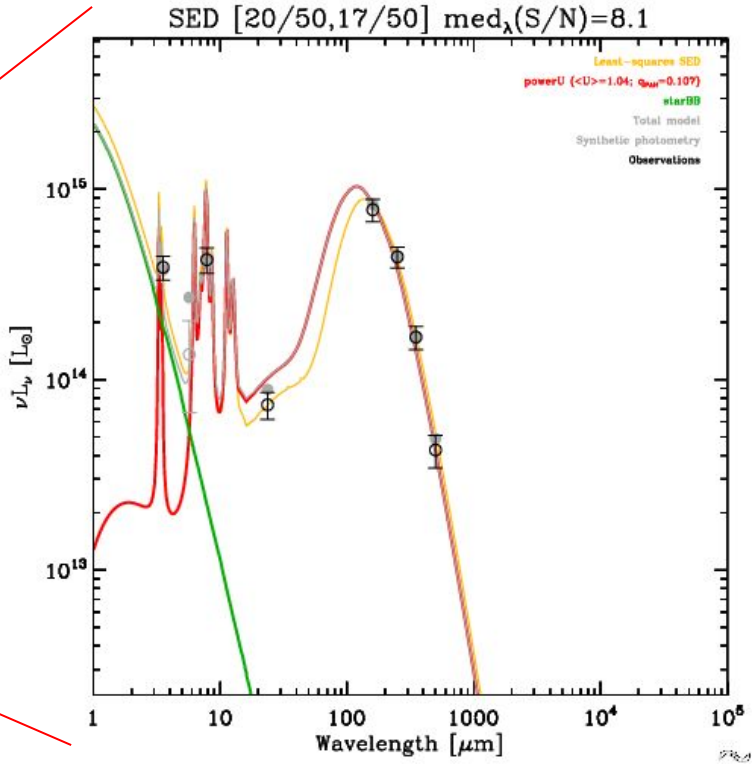


NGC 1140

SED fitting with HerBIE (Galliano 2018)

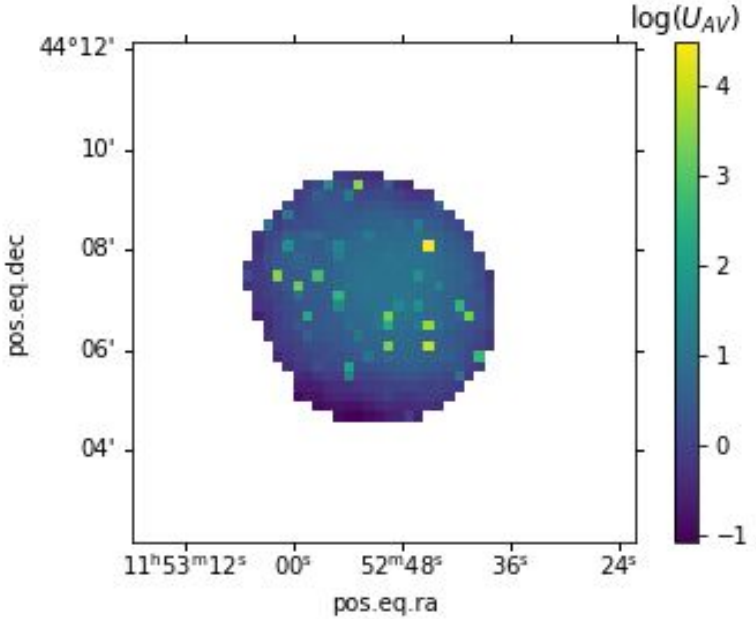


A pixel in the disk



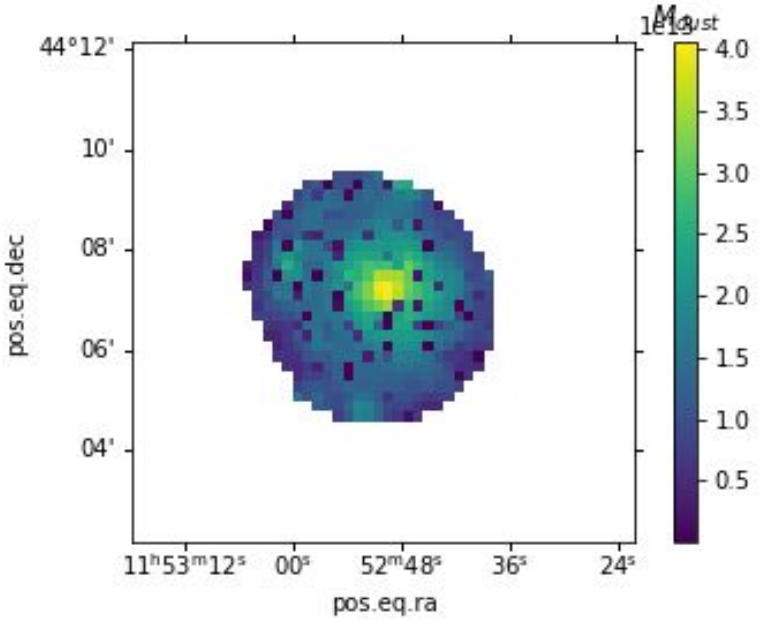
Physical properties

- Radiation field decreases with radius



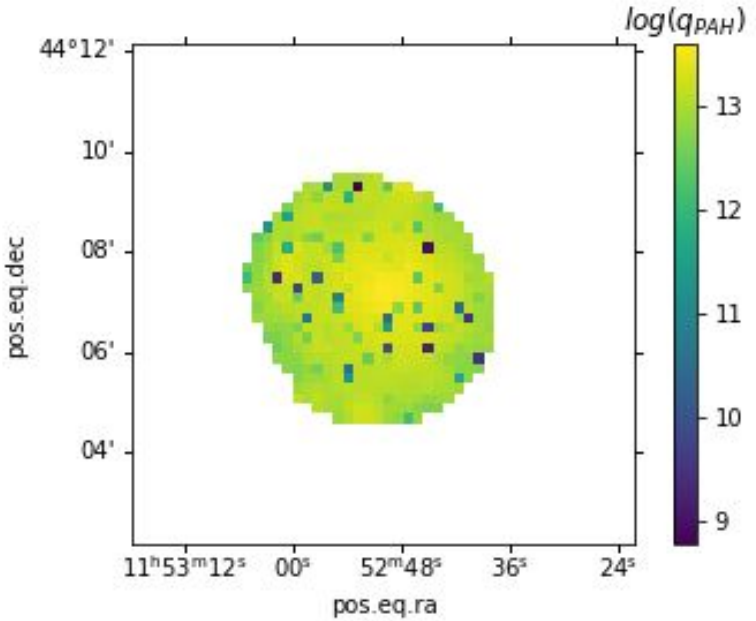
Physical properties

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



Physical properties

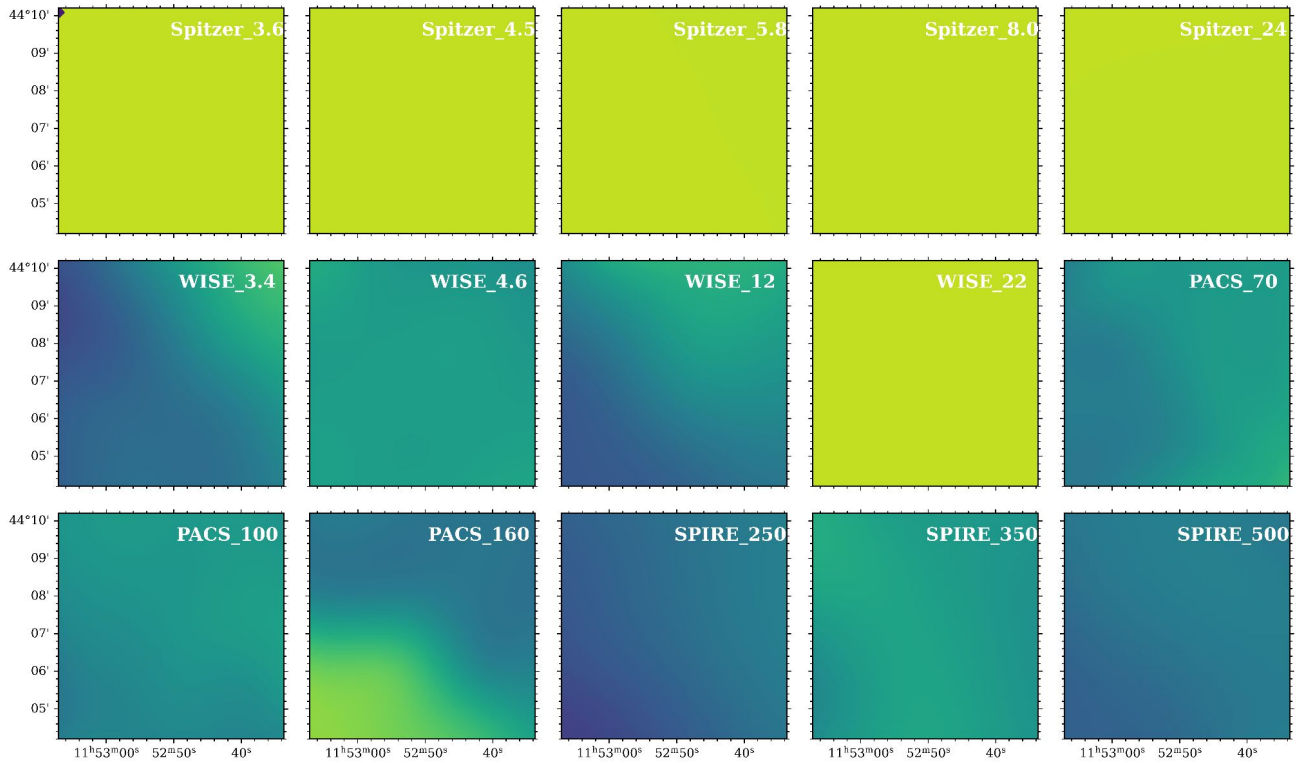
- Radiation field decreases with radius
- Dust mass decreases with radius
- PAH fraction varies with dust mass



Thank you !


CRAZY SPACE DUST
WAS CREATED BY
tiny aliens
HISTORY.COM
imgflip.com

NGC 3938 (background map)



Mask stars / galaxy

Interpolate bkg emission behind the galaxy