ACTIVE GALACTIC NUCLEI: INVESTIGATING THE DUSTY TORUS USING SOFIA

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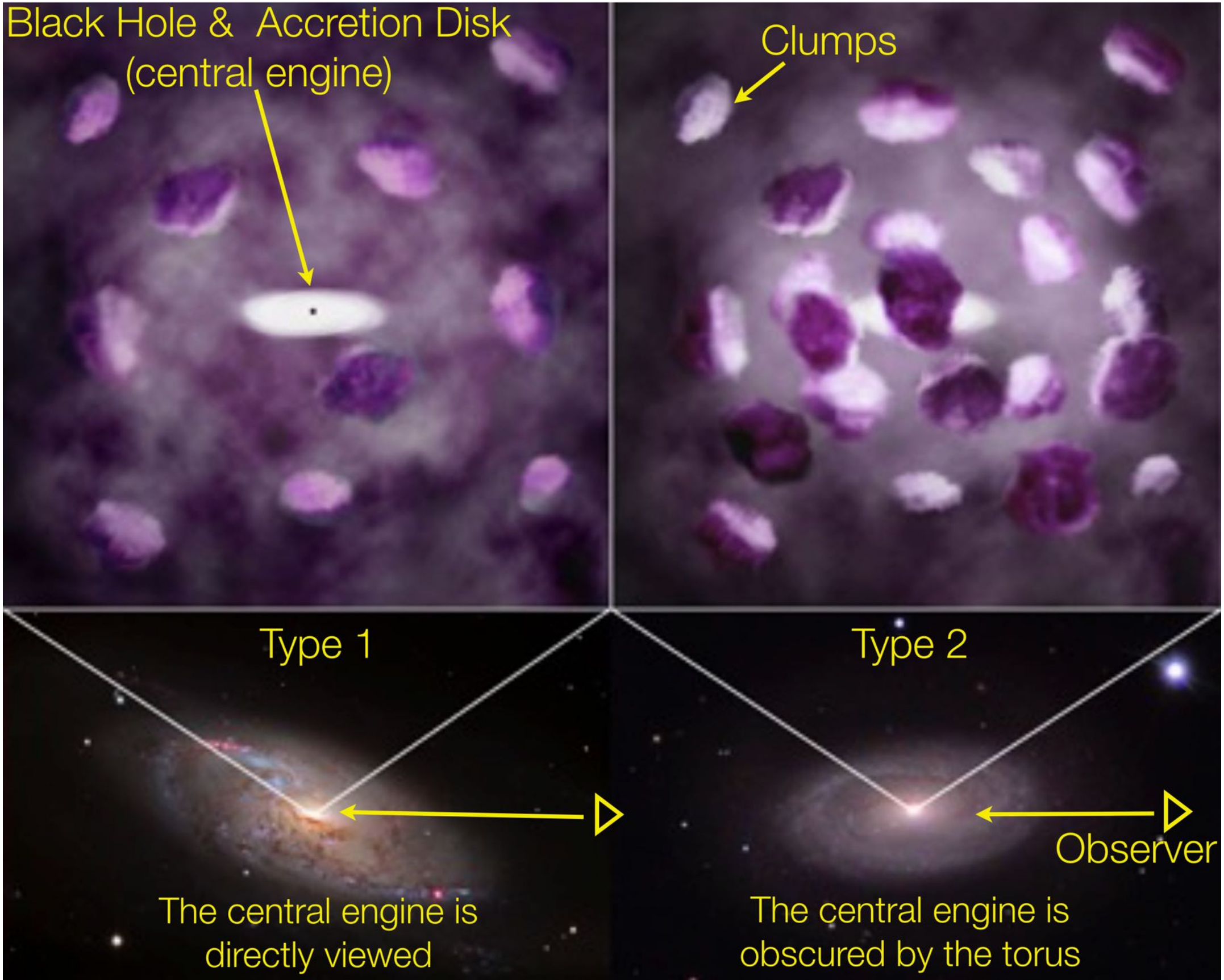
INCLUDING 30–40 μm PHOTOMETRY FROM SOFIA:

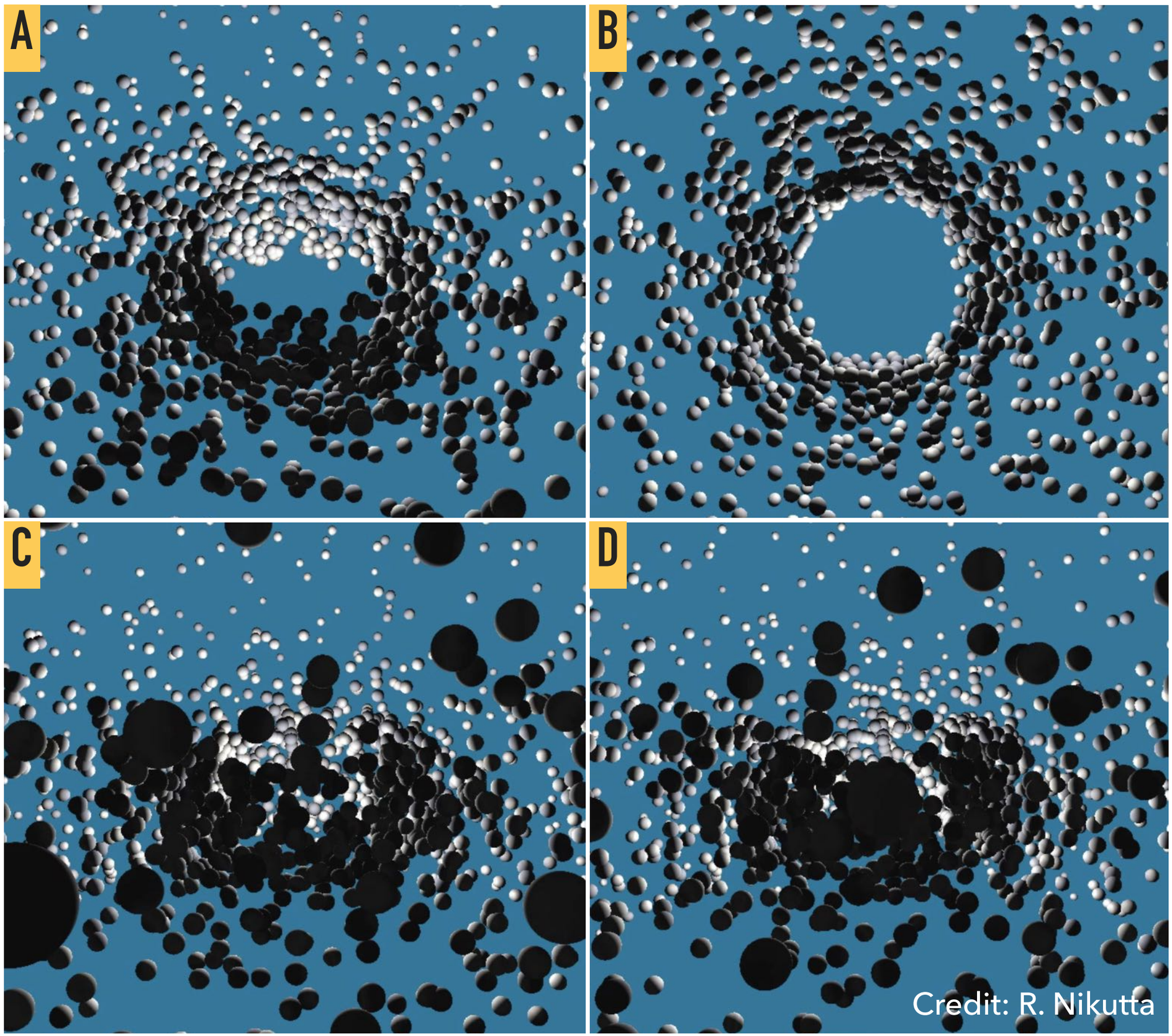
1) THE TURNOVER OF THE TORUS EMISSION DOES NOT OCCUR <31.5 μm
2) EXTENDED EMISSION FROM NARROW-LINE REGION IS DETECTED AT 30–40 μm
3) THE TORUS RADIAL EXTENT IS REDUCED, RANGING FROM 1 pc TO 8.4 pc

Fuller et al. (2016)

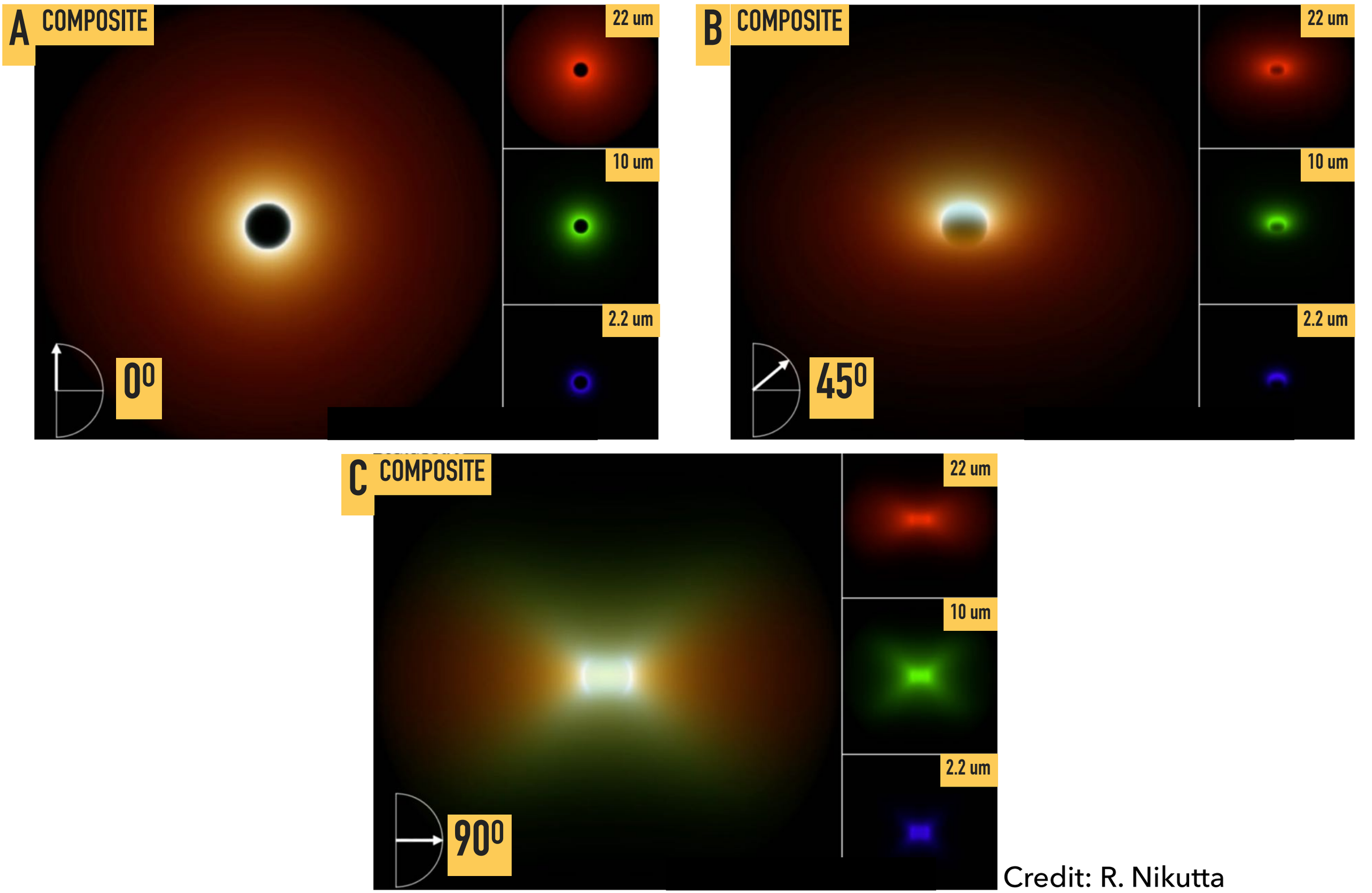
ACTIVE GALACTIC NUCLEI: THE DUSTY TORUS



THE DUSTY TORUS OF AGN: TORUS MORPHOLOGY



THE DUSTY TORUS OF AGN: TORUS EMISSION



Credit: R. Nikutta

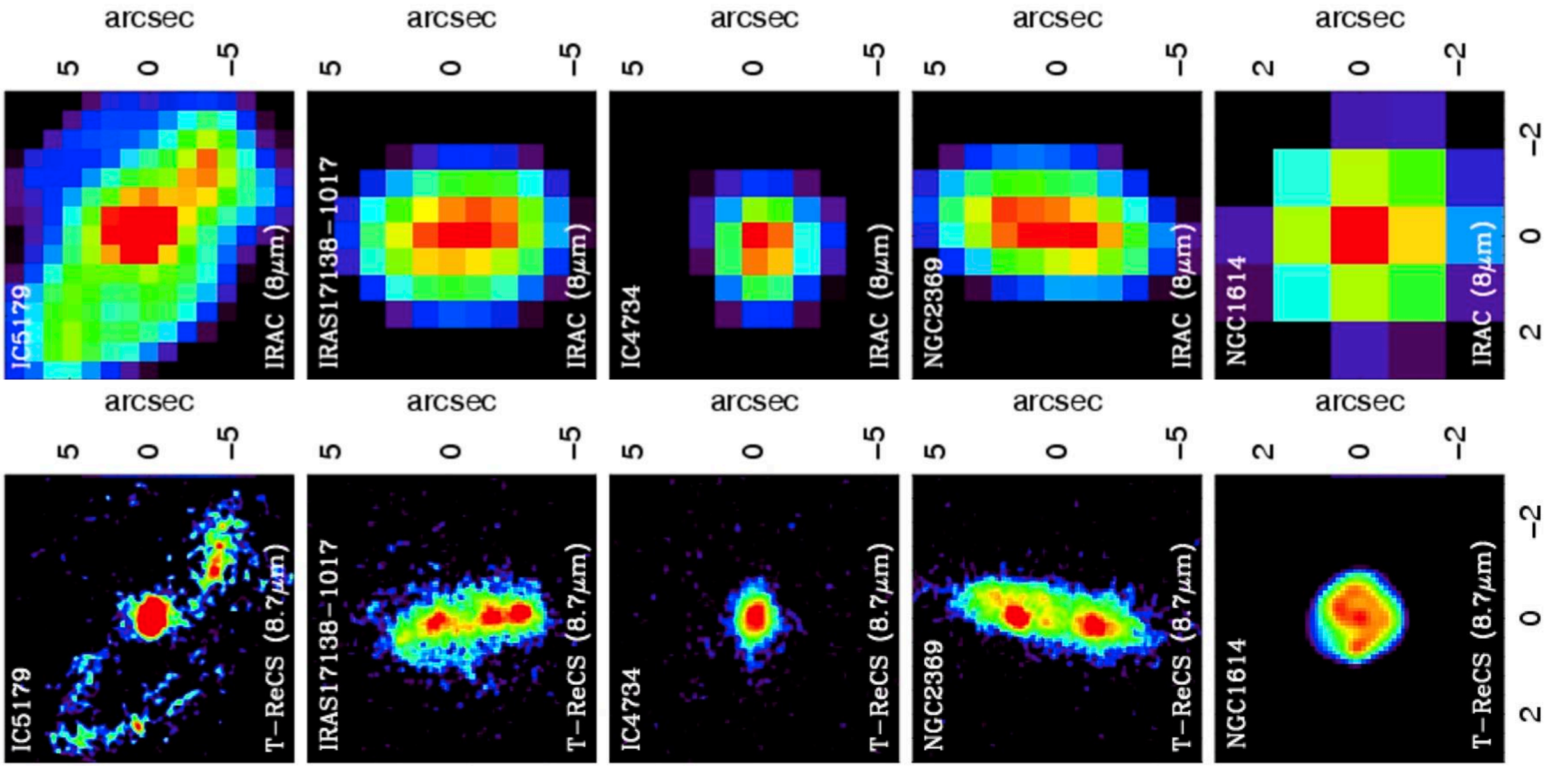
Torus models using CLUMPY (Nenkova et al. 2002, 2008a,b)

CLUMPY TORUS: CHARACTERISTICS

- Optically and geometrically thick, clumpy and dusty torus
- Scales of few parsecs
- We need to isolate the torus from:
  - Host galaxy, diffuse extended dust emission, star formation

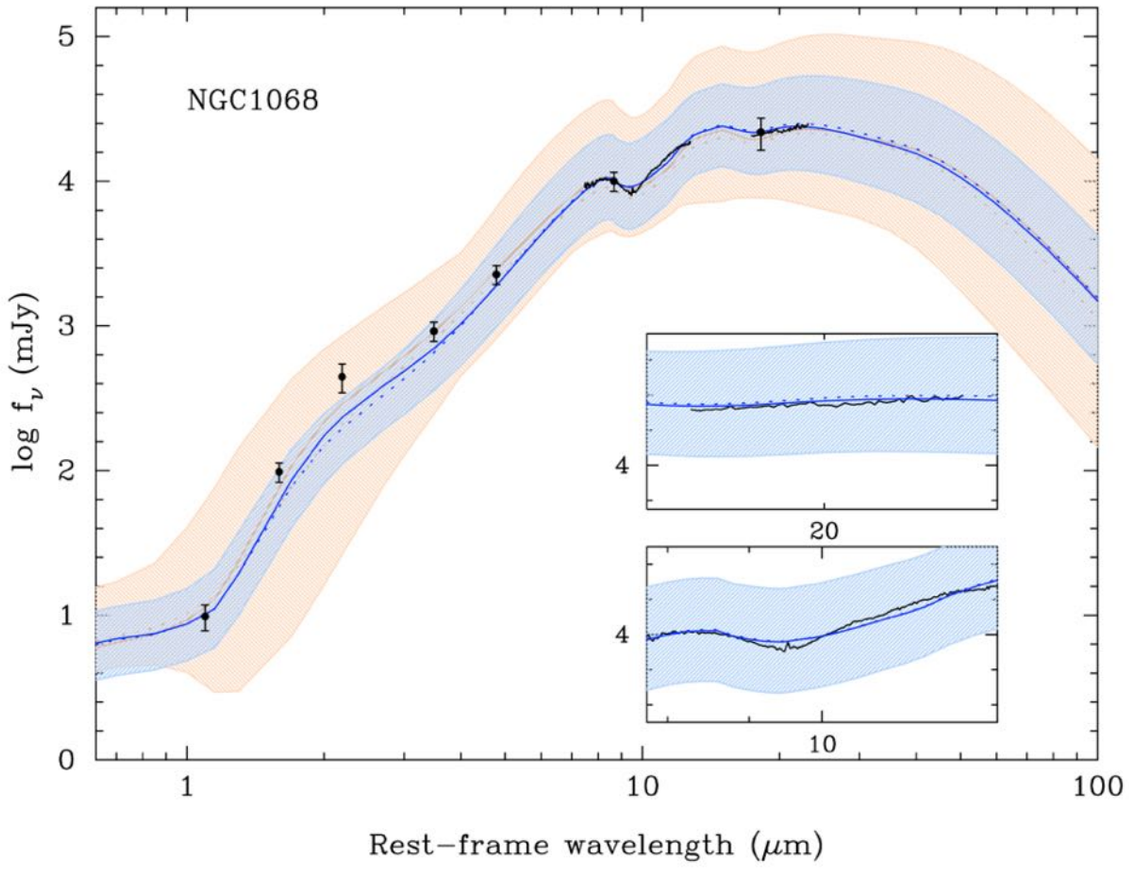
CLUMPY TORUS: THE IMPORTANCE OF HIGH-SPATIAL RESOLUTION

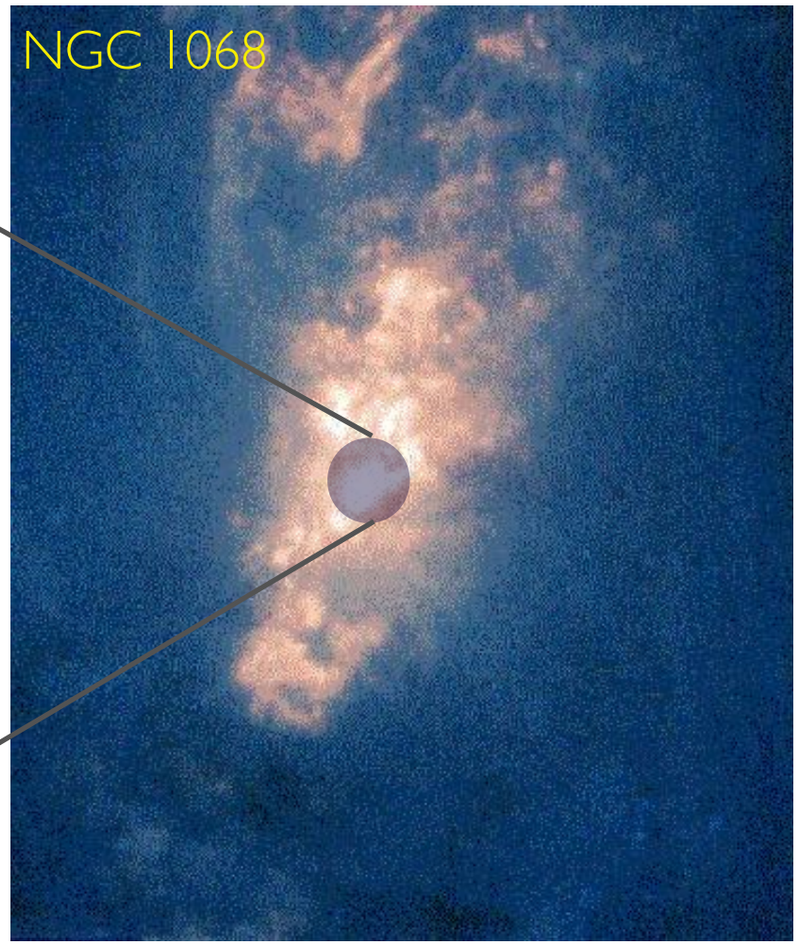
- Optically and geometrically thick, clumpy and dusty torus
- Scales of few parsecs
- We need to isolate the torus from:
  - Host galaxy, diffuse extended dust emission, star formation



CLUMPY TORUS SED: MODELING

- The isolated emission from the nucleus using 10-m class telescopes is well reproduced using clumpy torus models.





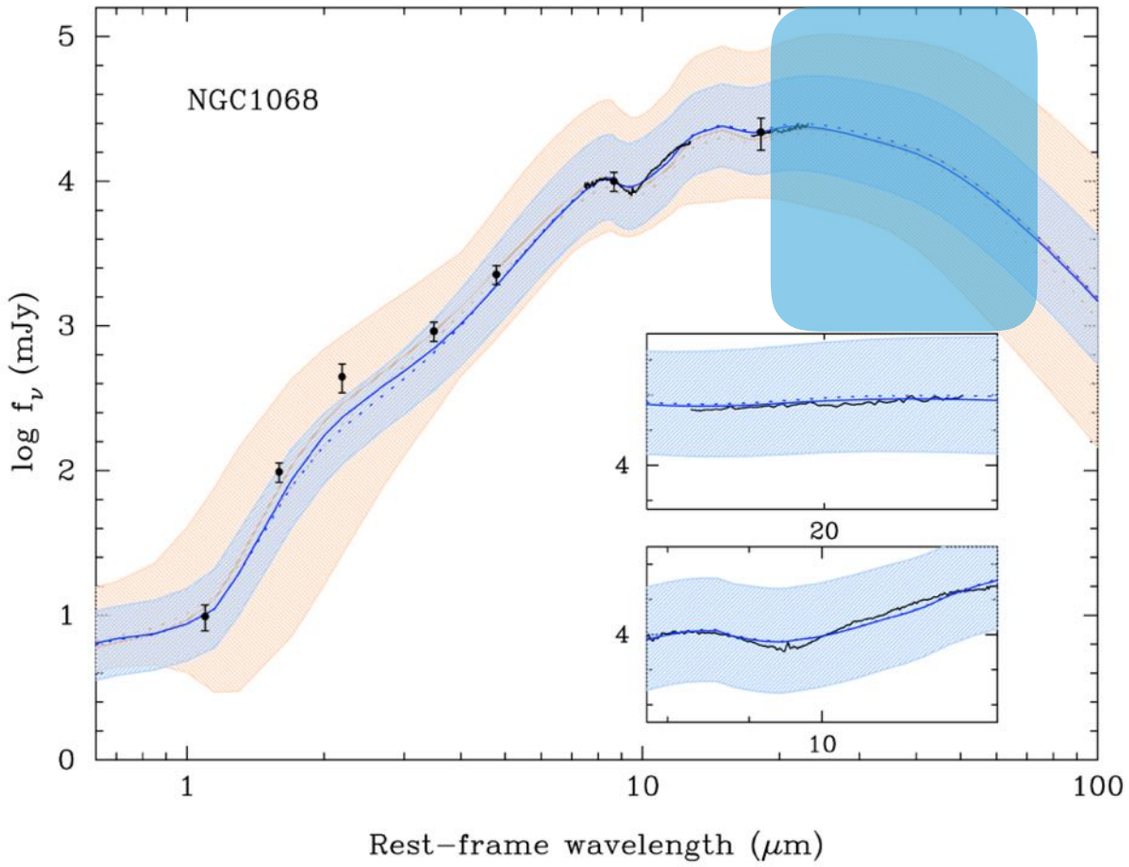
Alonso-Herrero et al. (2011)

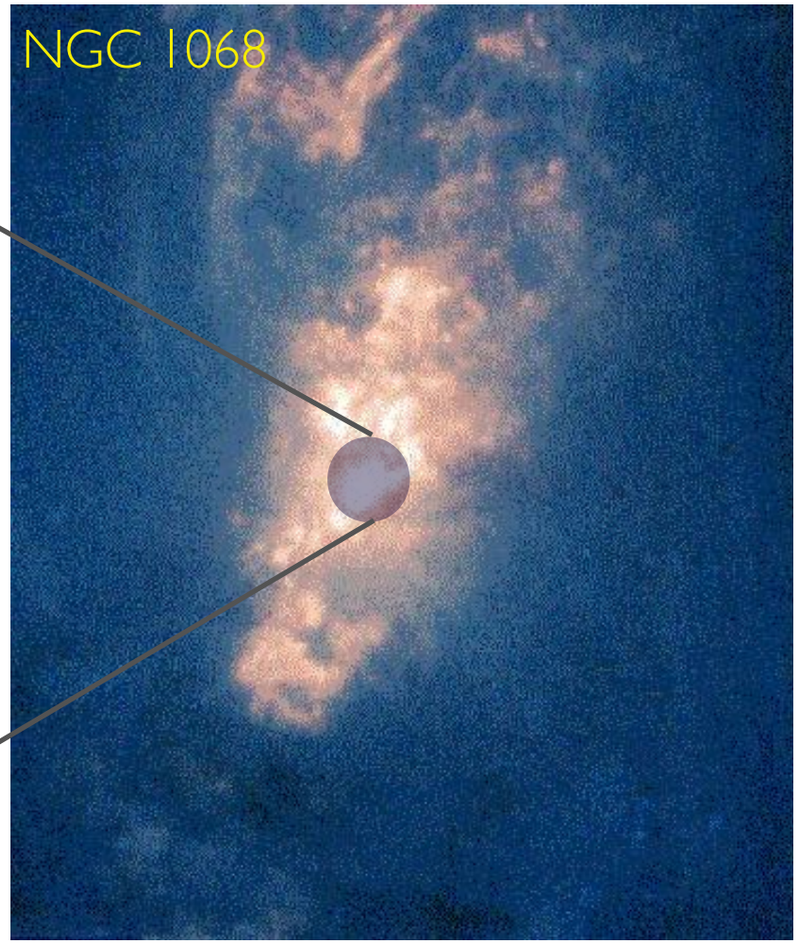
Torus models using `CLUMPY` (Nenkova et al. 2002, 2008a,b)

CLUMPY TORUS SED: LACK OF DATA AT 30-40 μm WITH RESOLUTIONS <10”

- Lack of spatial resolution observations <10” in the 30-40 μm wavelength range.
- This is important because the expected peak emission of the torus is in that wavelength range

- lack of observations with resolutions <10”
- large dispersion of models





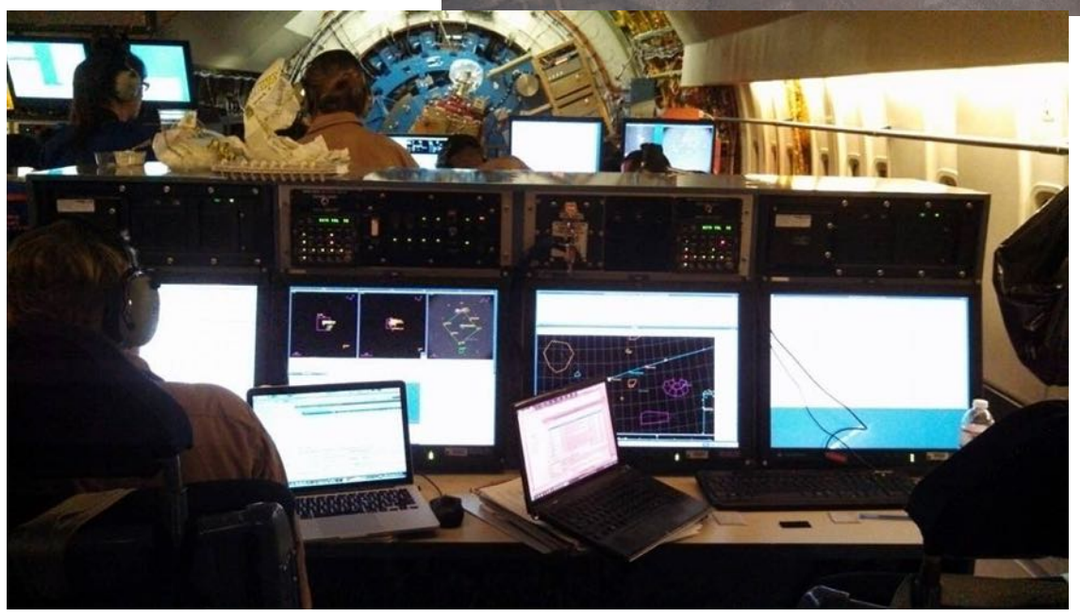
Alonso-Herrero et al. (2011)

Torus models using CLUMPY (Nenkova et al. 2002, 2008a,b)

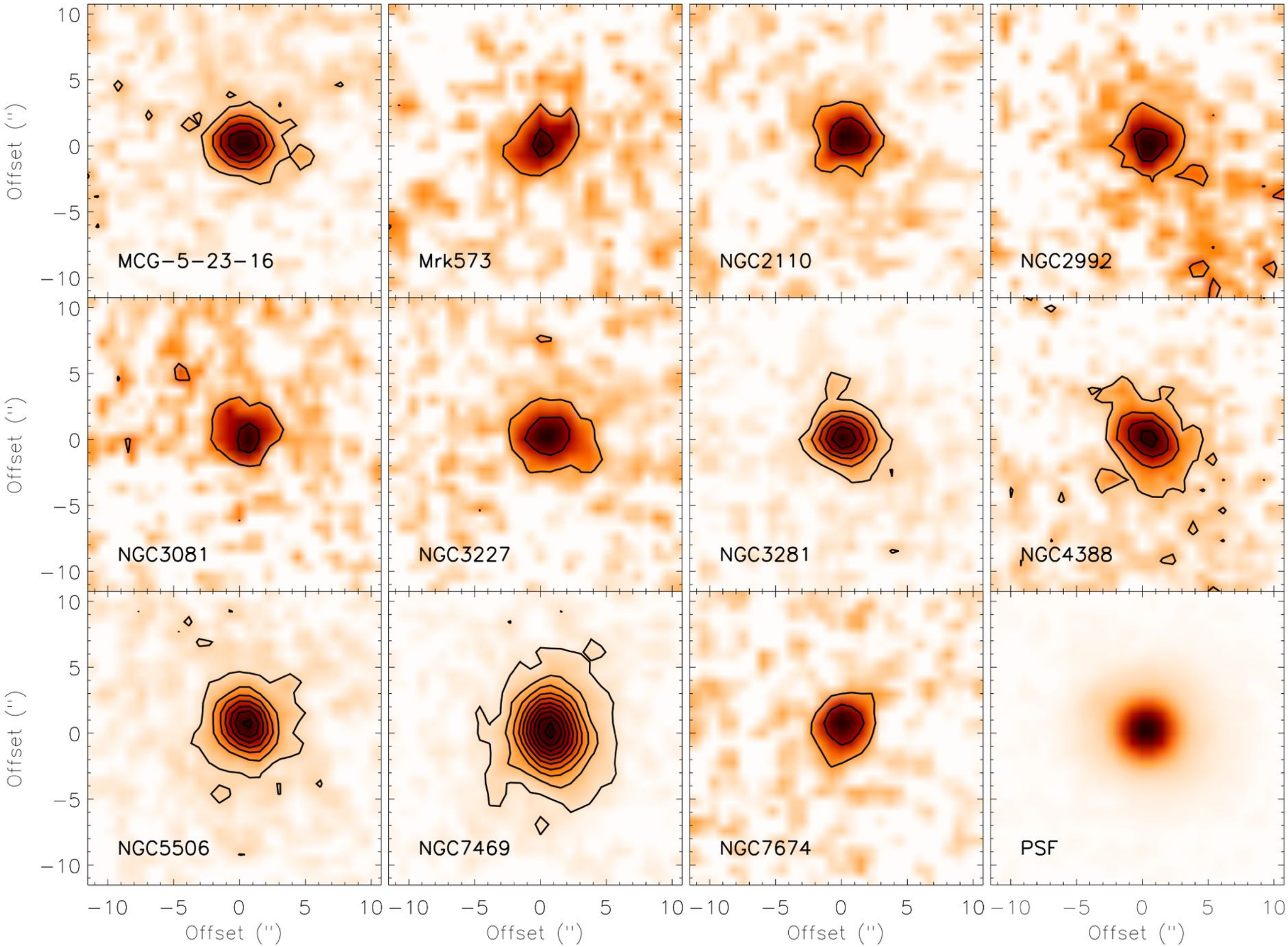
Survey of Seyfert galaxies to characterize the torus emission

SOFIA Cycle 2 and 4 (PI: Lopez-Rodriguez)

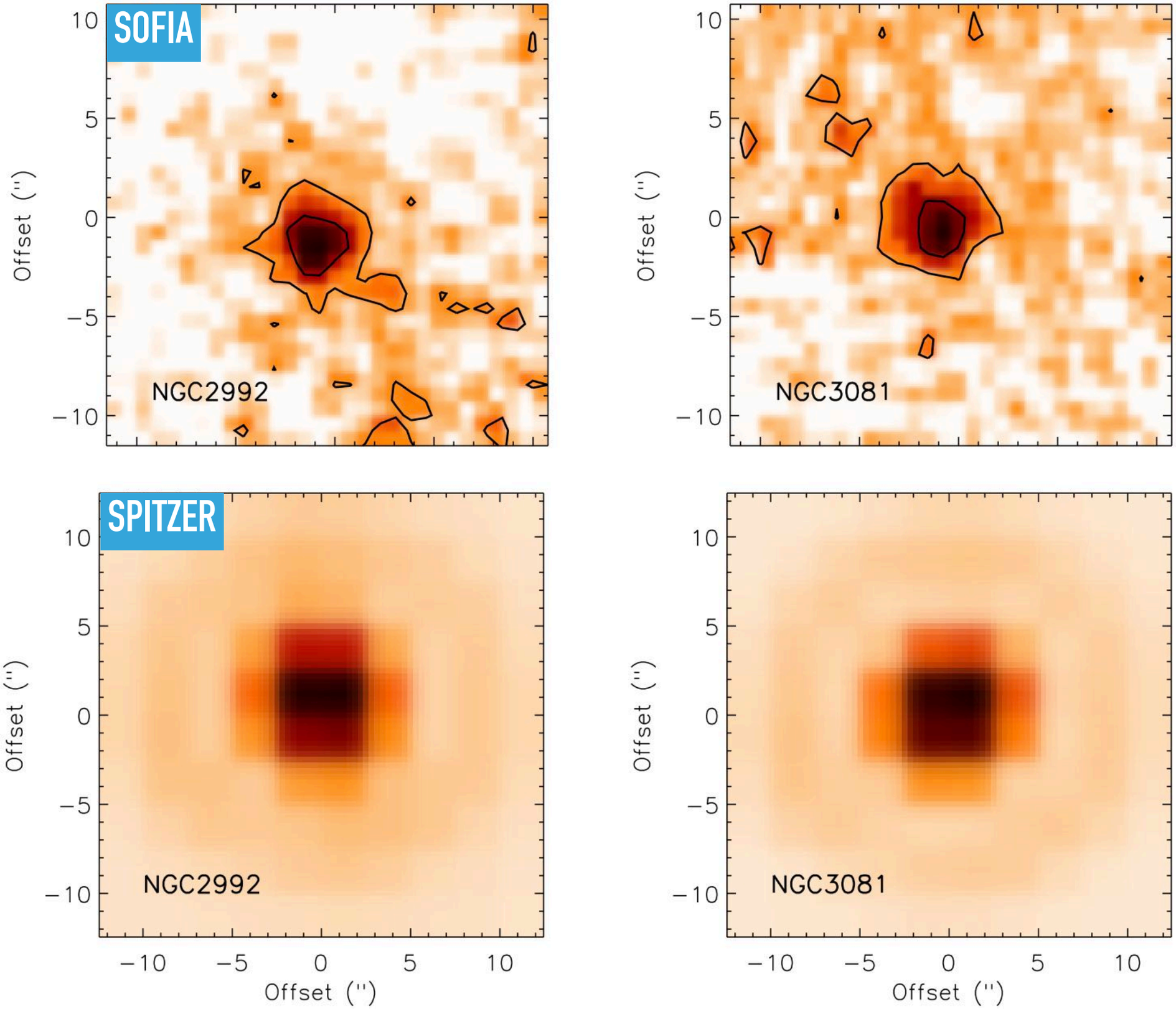
FORCAST presents a unique opportunity to explore AGN, providing the best angular resolution for the current suite of of telescopes in the 30-40 μm



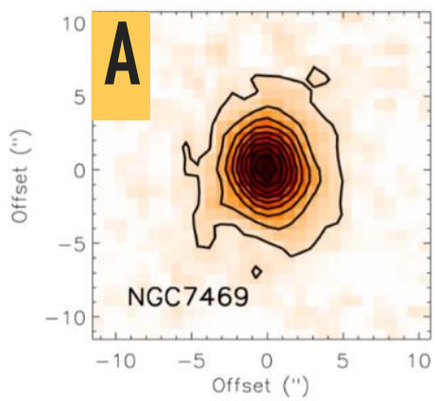
FORCAST 31.5 μm OBSERVATIONS: FULL SAMPLE USING CYCLE 2 DATA

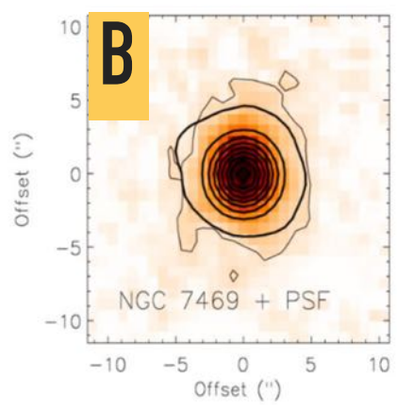


SOFIA vs SPITZER: THE IMPORTANCE OF THE SPATIAL RESOLUTION

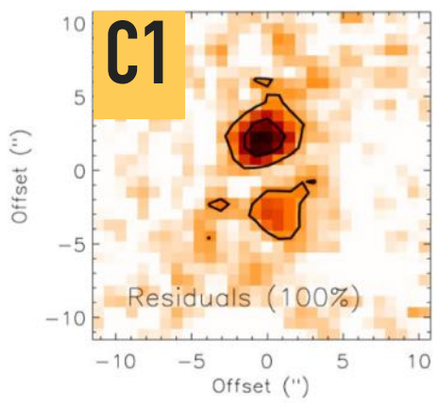


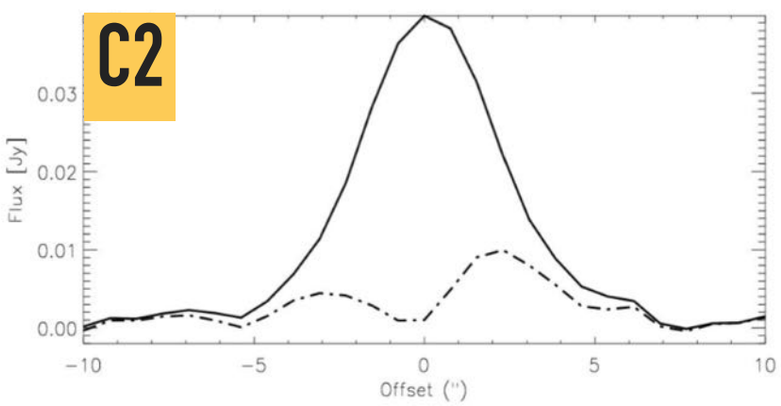
The torus emission was estimated using: PSF-scaling



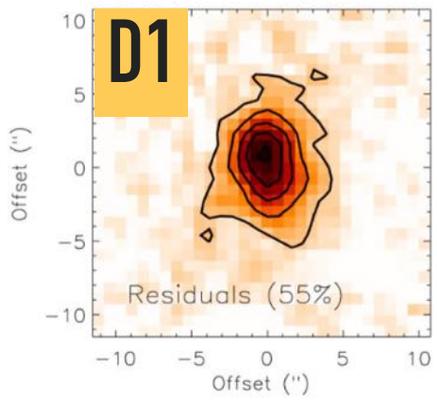


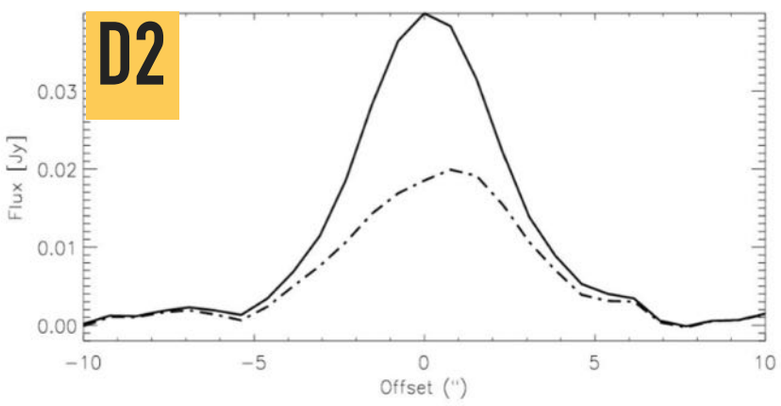
The goal is to extract the point-like source from the core and have a residual that 'emulate' the galaxy emission





Over subtraction of the PSF

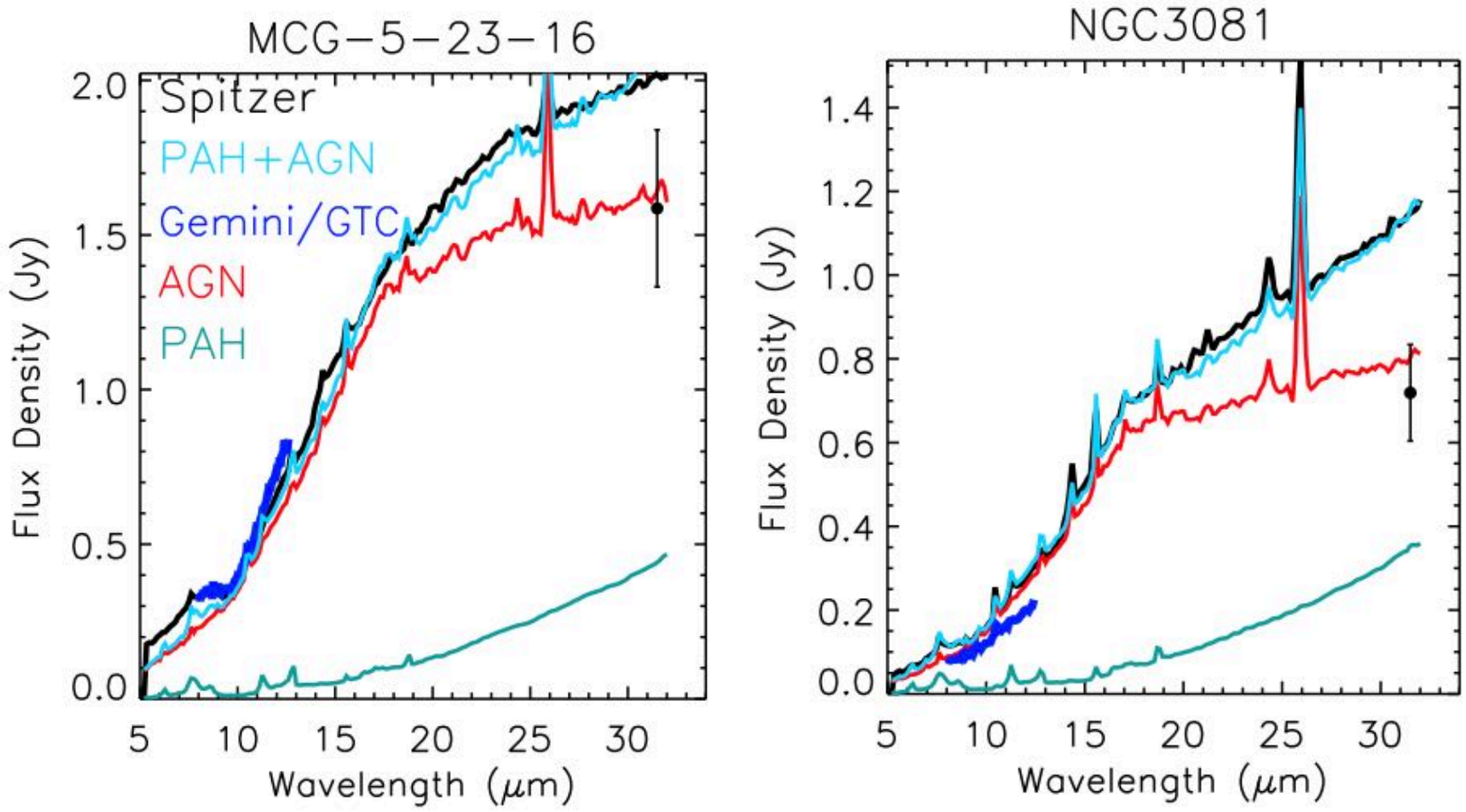




Optimal subtraction of the PSF

The torus emission was estimated using:

Spectral decomposition



The goal is to perform a decomposition of the several emitting components in the core of AGN.

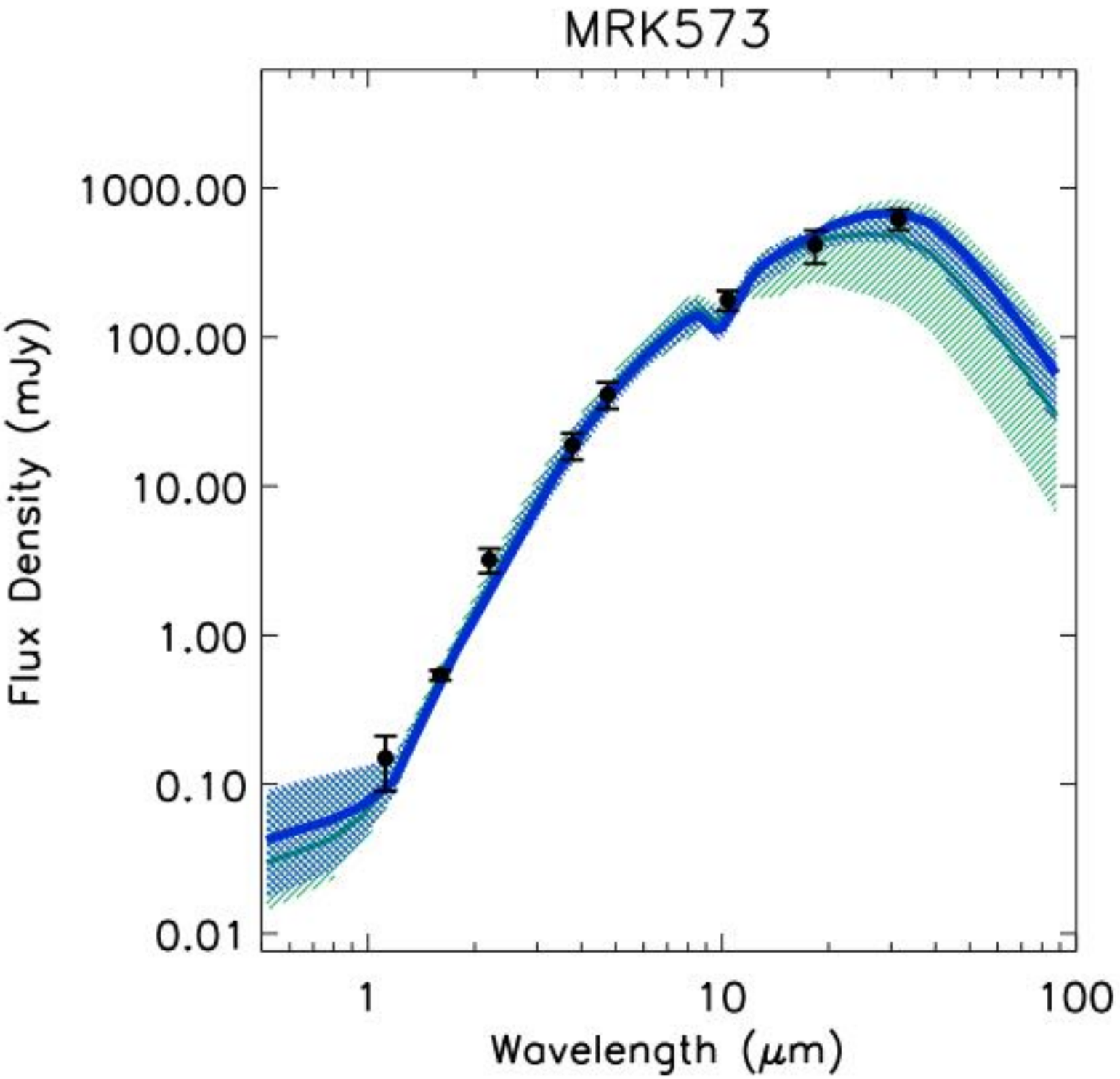
Results:

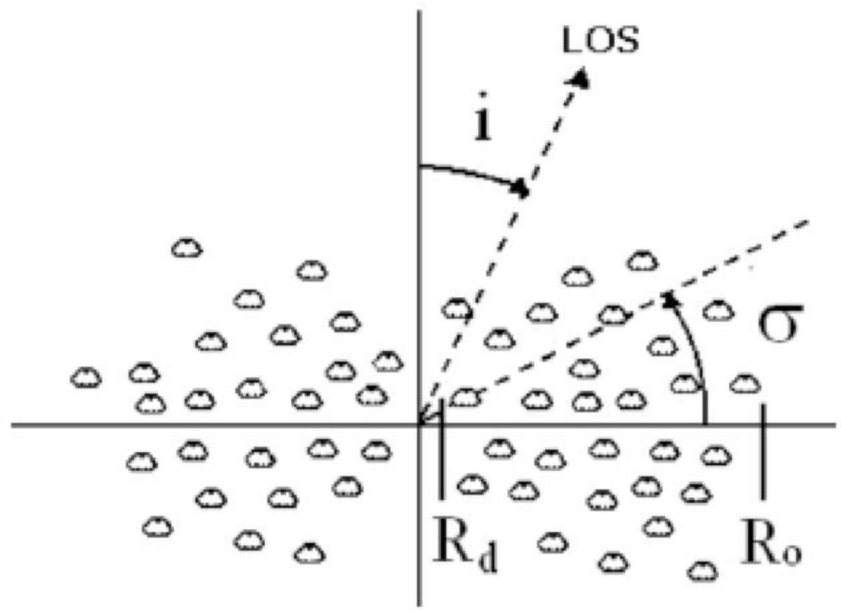
SOFIA/FORCAST photometry using PSF-scaling (black dot) agrees with the AGN component (red) using the spectral decomposition method

The torus emission was estimated using:
1) PSF-scaling
2) Spectral decomposition

both methodologies agree on the subtraction of
a) Extended emission from the NLR and/or host galaxy
b) Star formation regions

CLUMPY TORUS MODEL: SED FITTING WITHOUT AND WITH SOFIA

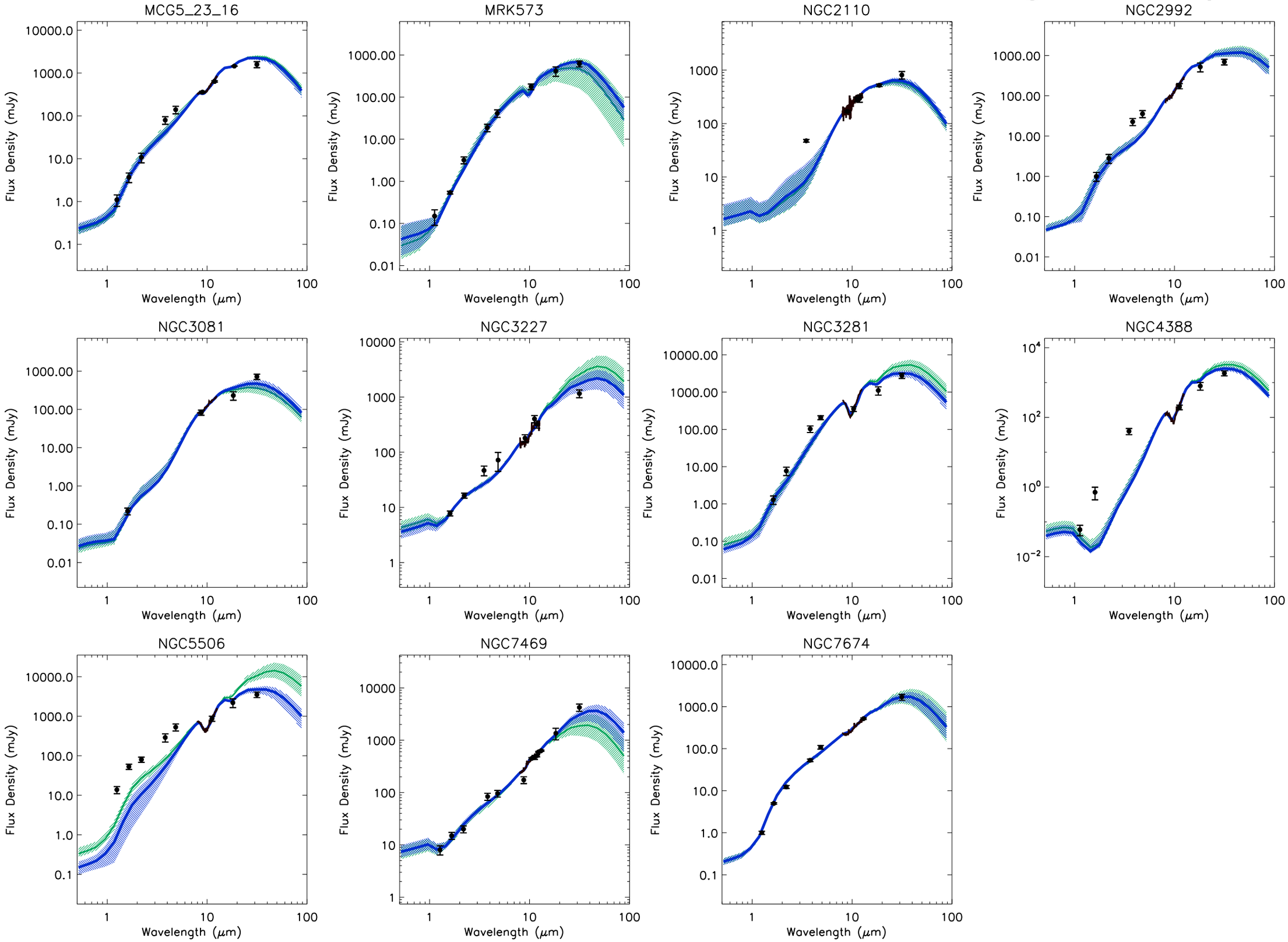




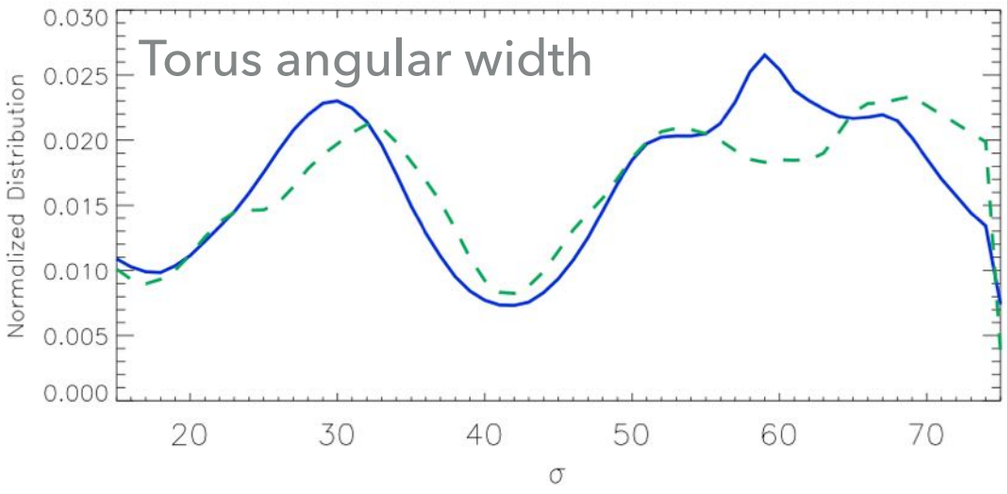
Torus models using CLUMPY (Nenkova et al. 2002, 2008a,b)

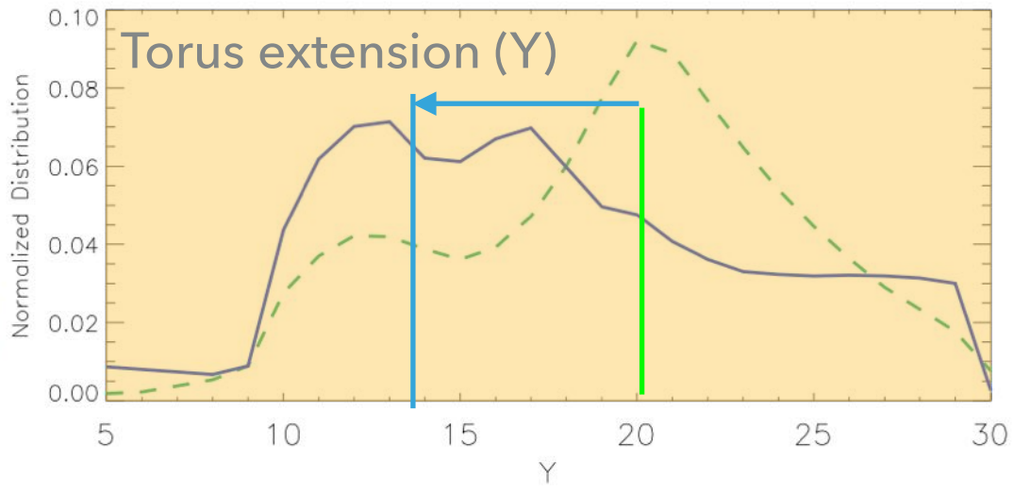
CLUMPY TORUS MODEL: SED FITTING WITHOUT AND WITH SOFIA

The turn-over of the torus emission does not occur at wavelengths <31.5 μm

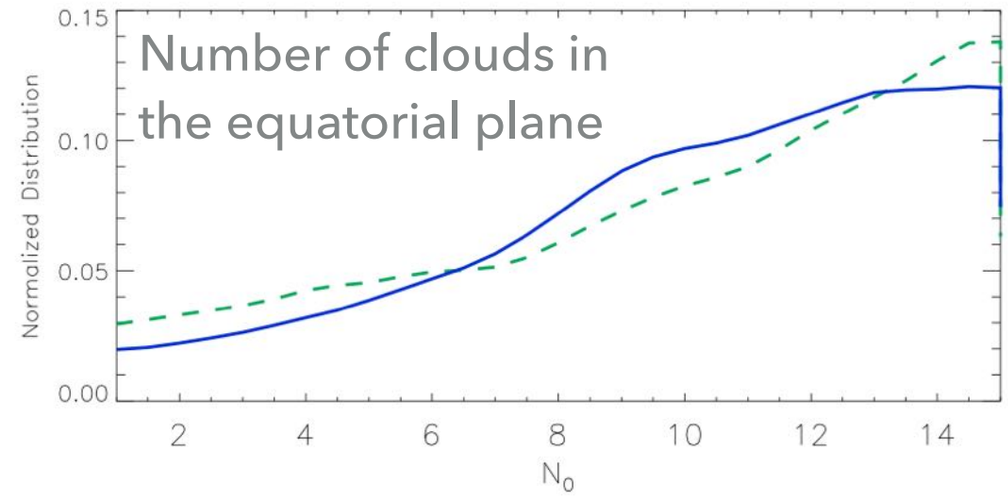


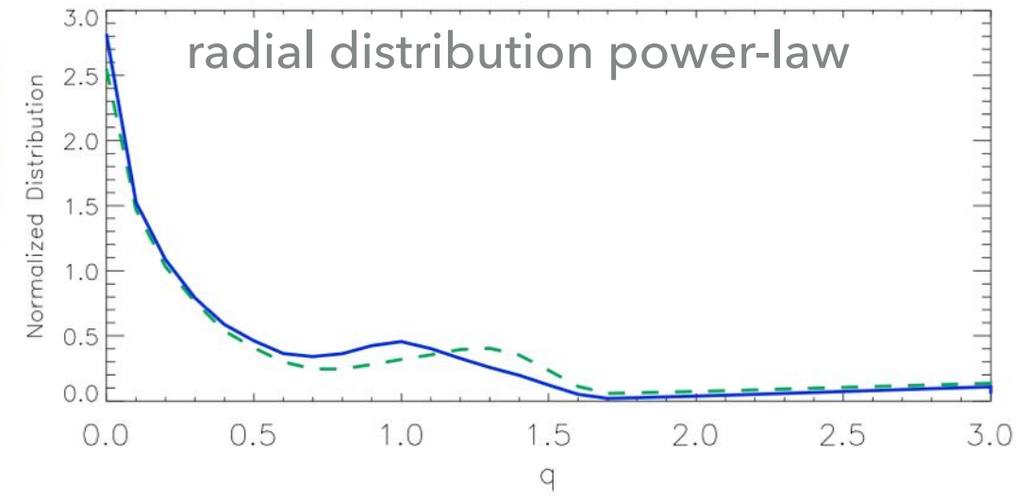
GLOBAL POSTERIOR DISTRIBUTIONS: KLD TEST

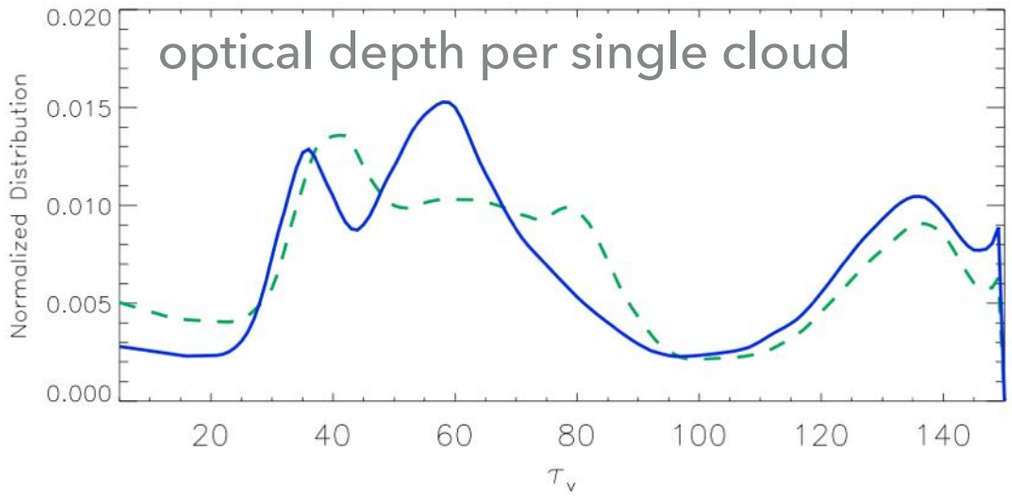


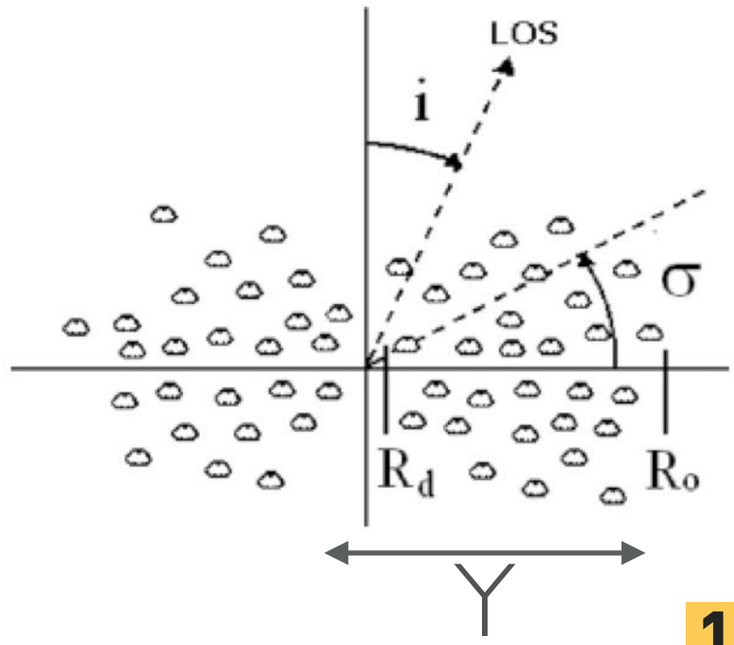


Torus extent is smaller when 31.5 μm data is taken into account.









SOFIA has proven the potential to advance our knowledge on the AGN torus

We found:

1) THE TORUS TURNOVER DOES NOT OCCUR <31.5 μm

2) EXTENDED EMISSION RELATED WITH THE NARROW LINE REGION

3) THE TORUS EXTENT IS SHORTER THAN WE THOUGHT

4) SO FAR, SOFIA IS ABLE TO OBSERVE DISTANCE GALAXIES UP TO 117 Mpc (MORE TO COME!)

Work currently in progress:

1) SOFIA IS STILL OBSERVING MORE AGN AT 31.5 AND 37.0 μm, WHICH WILL IMPROVE THE STATISTIC ANALYSIS

2) DETAILED STUDY OF THE EXTENDED EMISSION, i.e. CHARACTERISTIC TEMPERATURE AND SPATIAL COMPARISON AT OTHER WAVELENGTHS


Thank you