

Resolved Dust Analysis in HRS and HeViCS Galaxies

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ABSTRACT

1 We present a resolved dust analysis of galaxies observed in the Herschel Virgo Cluster Survey (HeViCS) and the Herschel Reference Survey (HRS). For two HeViCS galaxies NGC4501 and NGC 4567/8 we fit dust models on a pixel-by-pixel basis, to create maps of dust temperature, dust mass and gas-to-dust ratio (Smith et al 2010). We find the distribution of dust temperature in both systems ranges from ~19-22 K and peaks away from the centres of the galaxies. The distribution of dust mass in both systems is symmetrical and exhibits a single peak coincident with the galaxy centres. For M99 and M100 we compare distribution and extent of cool dust inside and beyond the optical radius using HRS observations (Pohlen et al 2010). We find the dust extends to at least the optical radius of the galaxy and shows breaks in its radial profiles at similar positions as the stellar distribution. The large number of galaxies observed with sufficient angular sizes to resolve structure allows us for the first time to compare the distribution and properties of dust in galaxies with different morphological type and environment. Our analysis provides important insights into the interplay between dust, gas and star formation in both a cluster and field environment.

2 Herschel Reference Survey (HRS)

The Herschel Reference Survey is a complete sample of 323 selected galaxies chosen based on 3 selection criteria,

1. $15 < \text{Dist} < 25$ Mpc (Volume limited)
2. High galactic Latitude (avoid Cirrus contamination)
3. 2MASS K selected sources
 - $E + S0 \text{ Ktot} < 8.7$ (65 objects)
 - Spirals + Im + BCD (258 objects)

Measurements are taken with the three SPIRE bands and reach a sensitivity of 12, 8, 12 mJy/beam for the 250, 350 and 500 μm band respectively. Details of the survey can be found in Boselli et al (2010). There are ~60 galaxies in the sample outside the HeViCS fields with optical diameters greater than $3'$.

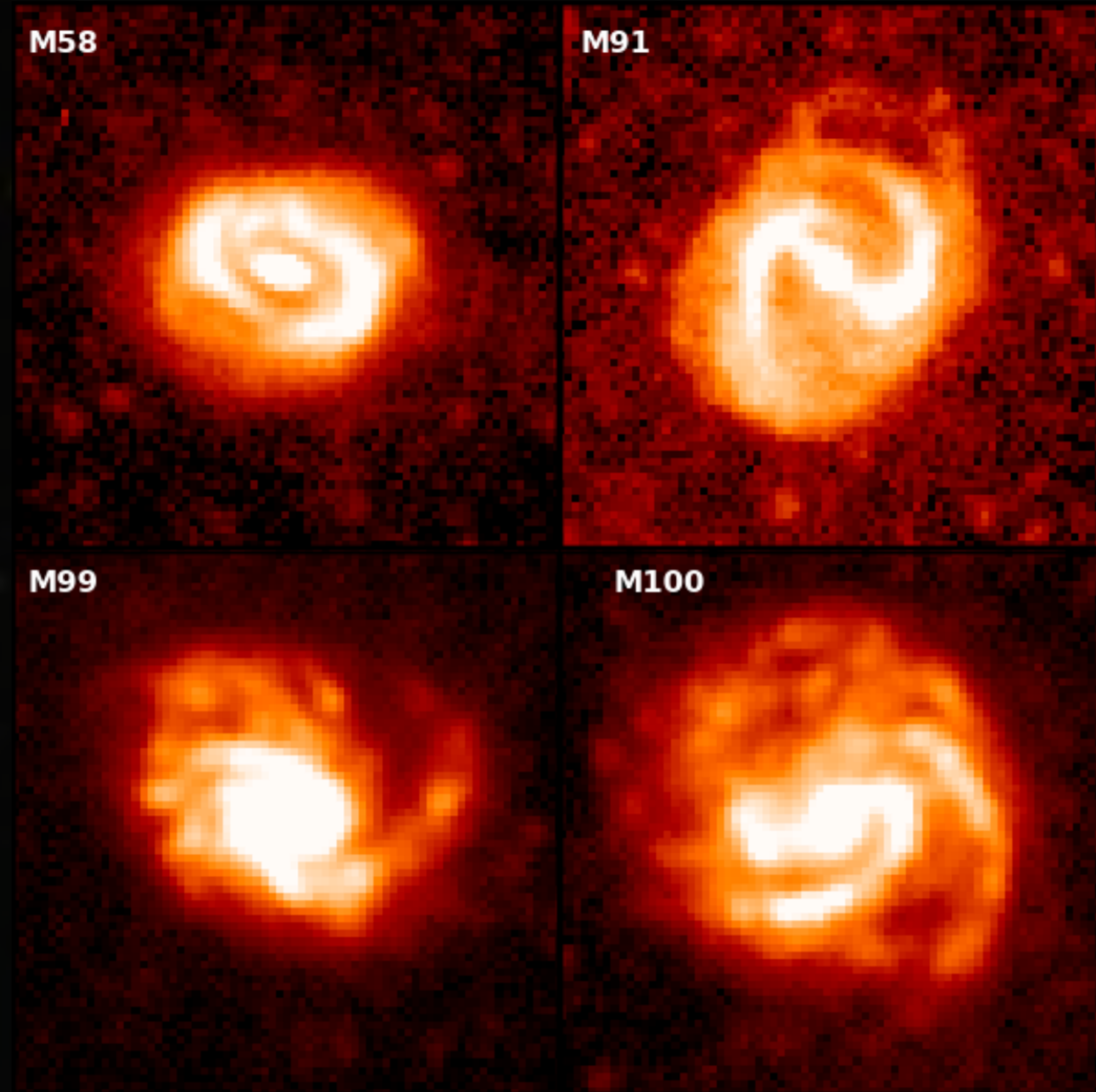


Figure 1
Example of 4 HRS galaxies

3 Herschel Virgo Cluster Survey (HeViCS)

The Herschel Virgo Cluster Survey is a 64 square degree survey of the Virgo Cluster. HeViCS uses PACS - SPIRE parallel mode measuring simultaneously at 100, 160, 250, 350 and 500 μm . The observations are split into four $4^\circ \times 4^\circ$ tiles as shown in Figure 2. Each tile is observed with 8 fast scan, reaching the SPIRE 250 μm confusion limit of 1 MJy/sr. There are ~48 galaxies in the sample with optical diameters greater than $3'$. For more information visit www.hevics.org

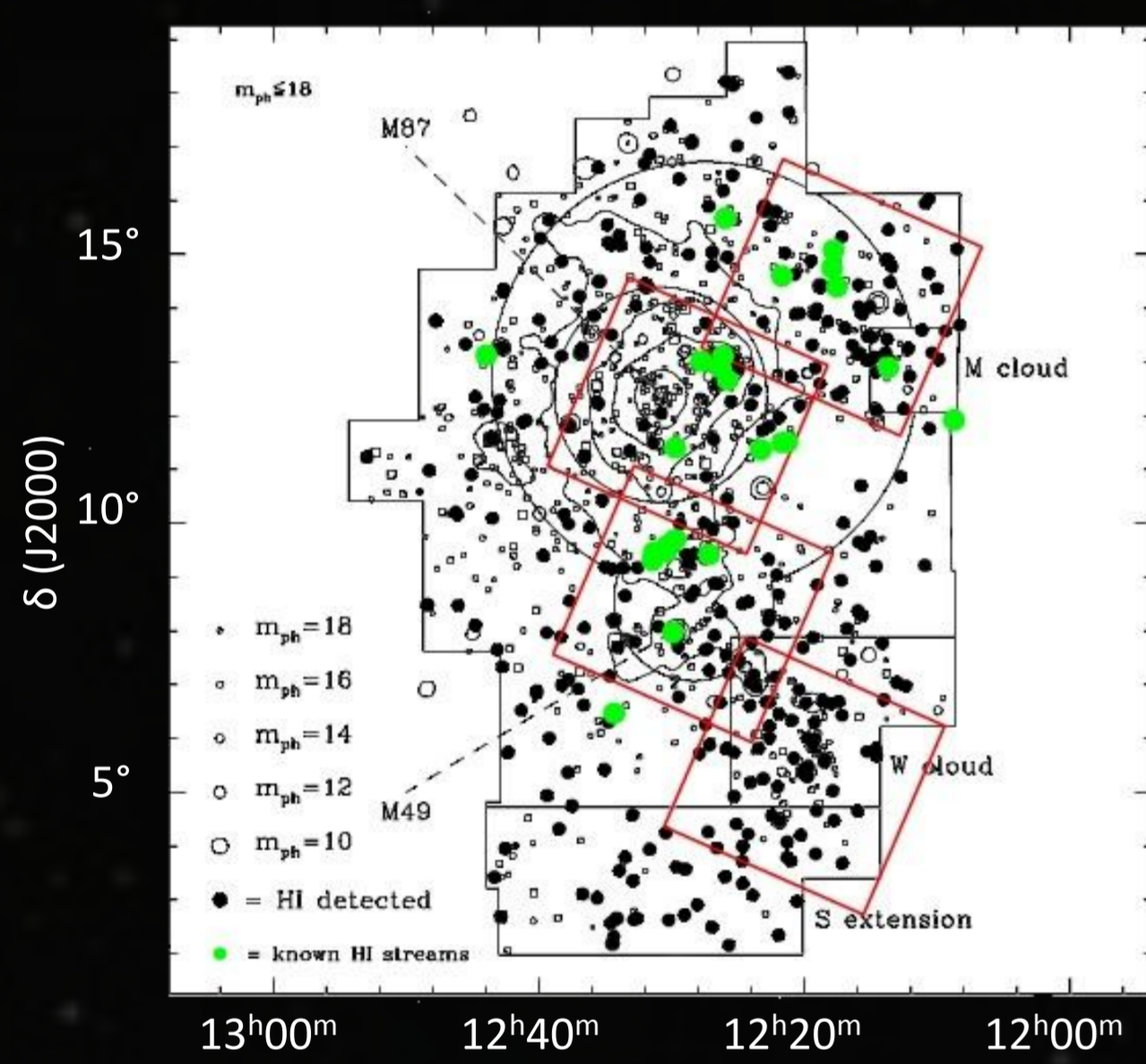


Figure 2
HeViCS Observing Fields

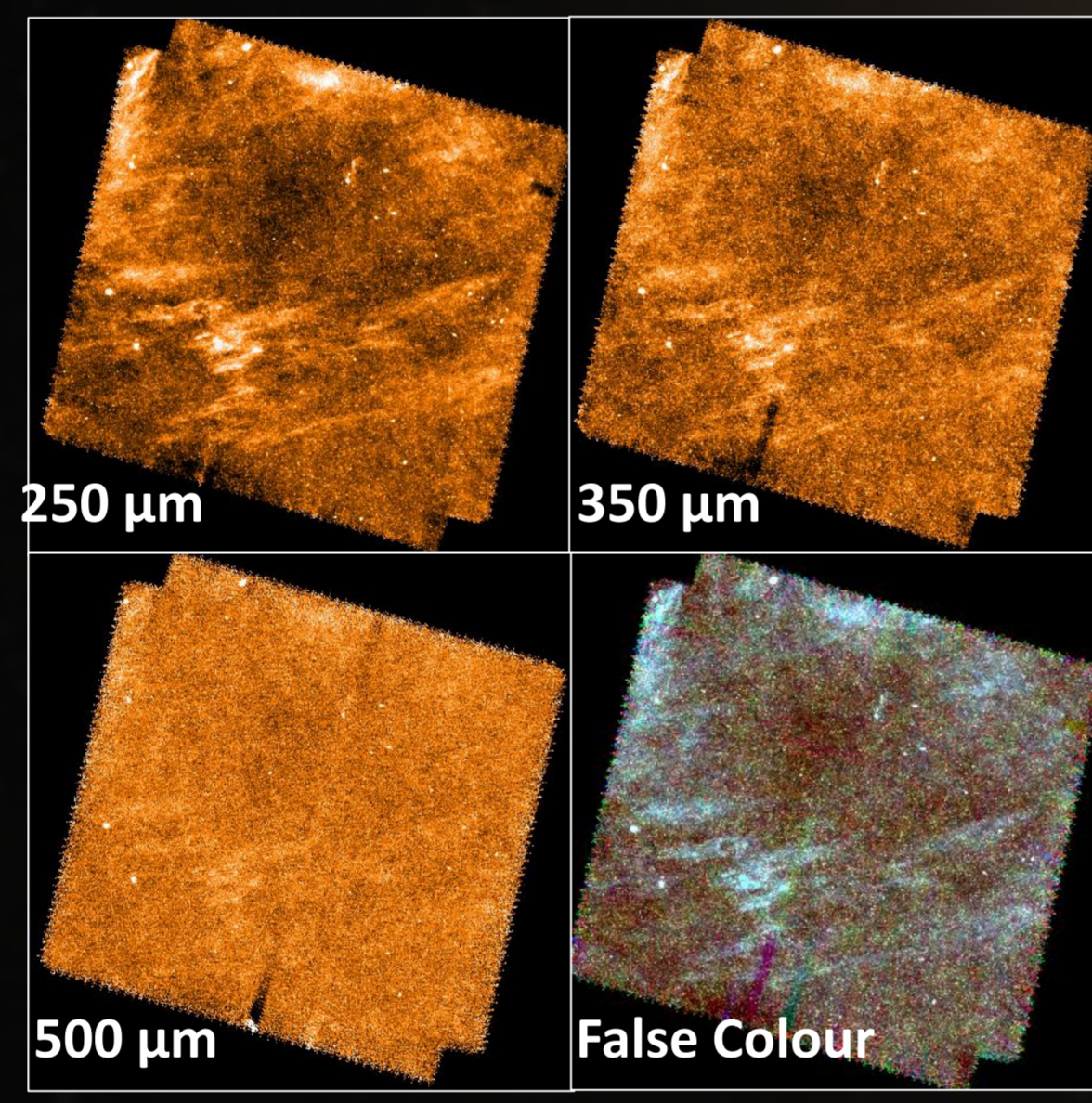


Figure 3
HeViCS SDP Field centred on M87

6 Radial Distribution of Gas and Dust in M99 and M100

A radial profile analysis has been applied to two grand-design spirals (M99 and M100) observed by the HRS galaxies in Pohlen, et al. 2010 (profiles shown in Fig 7). Dust emission is detected in the SPIRE bands to at least the optical radius (R_{25}). For M100 the dust can be found almost to the edge of the HI disk, which is not surprising as it mildly HI deficient. For M99 which is not HI deficient the HI disk is more extended than the submm. For the first time a clear radial break in the dust distribution is observed at $\approx 0.6 \times R_{25}$, which is also visible in the optical. Plotting submm colour profiles we find a decrease in $F(250)/F(350)$ and $F(350)/F(500)$ suggesting the dust temperature is decreases with radius.

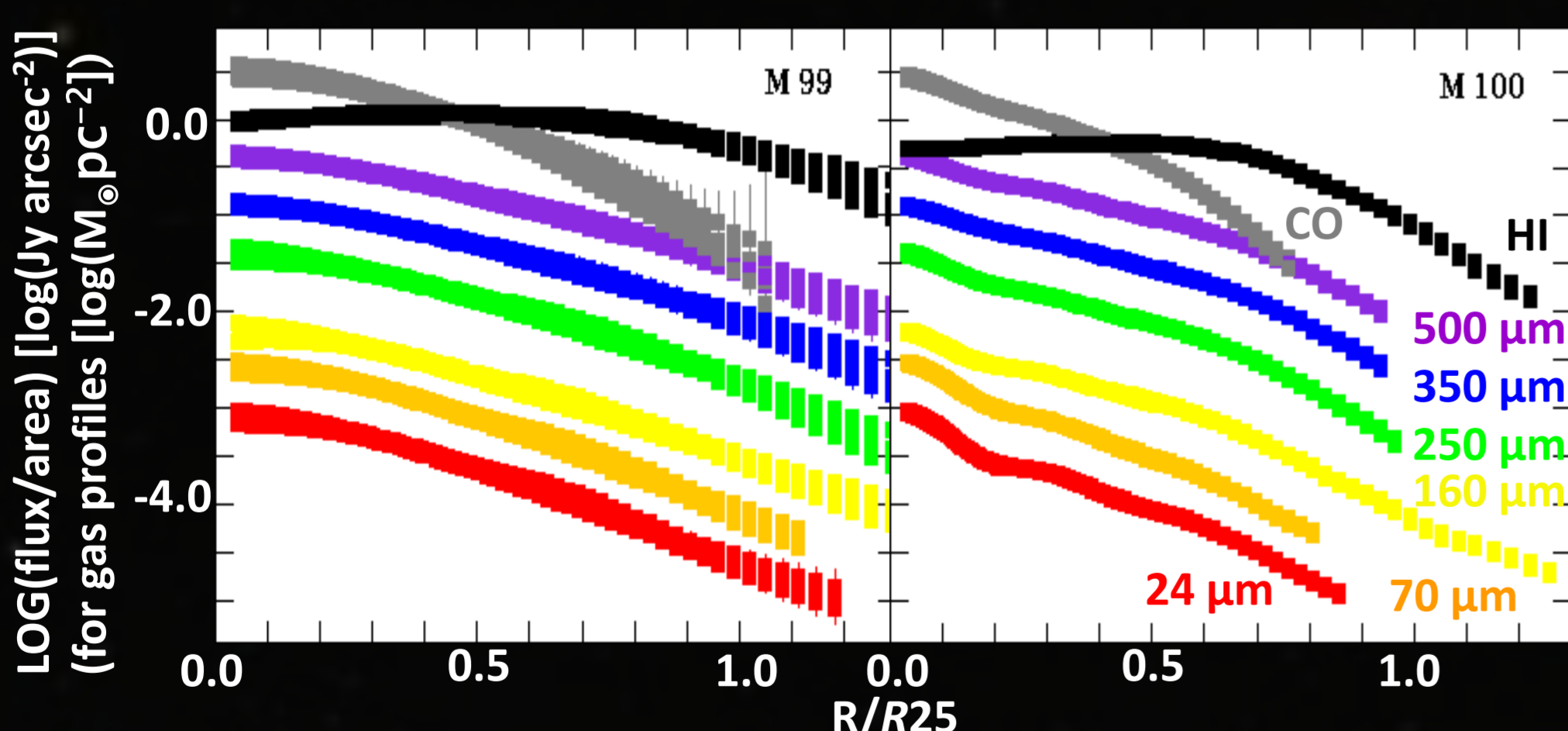


Figure 7
Radial surface brightness profiles for M99 and M100 for MIPS, SPIRE and gas maps. For both cases the results from 4 different ellipse fitting are shown. Offsets of 0.5, 0, 0, 1, 2, 3, -1, -1 (bottom to top) have been applied to separate in plot.

7 Conclusion / Future Work

With the new Herschel data we can investigate the distribution and properties of dust in nearby galaxies. We have found symmetric dust surface distributions, but an asymmetric dust temperature with higher temperatures peaking away from the centre. Once the full HeViCS and HRS observations are complete we will be able to extend the analysis to larger radii with lower dust densities. With ~100 galaxies late type galaxies with optical radii greater than $3'$ to be observed we will be able to begin to tackle questions about the dominant source of dust heating, how the dust interacts with the other phases of the ISM and how morphology influences the dust distribution and temperature. By combining results from HeViCS and the HRS we will be able to study how environment affects the dust distribution and other properties of a galaxy.

4 SED Fitting

We fit SEDs in the 70-500 μm range with a one component modified black-body model, for both global and pixel-by-pixel fluxes. For an accurate resolved analysis all images were convolved to the resolution of the 500 μm and re-gridded to the same pixel scale. A significant excess was found in the 70 μm point, suggesting a warmer component than the ~20 K component which dominates in the 100-500 μm regime is present; we therefore use the 70 μm data as an upper limit. We assume an emissivity index of $\beta = 2$ and $\kappa_0 = 0.192 \text{ m}^2 \text{ kg}^{-1}$ at 350 μm . Figure 4 shows example global and single pixel fits.

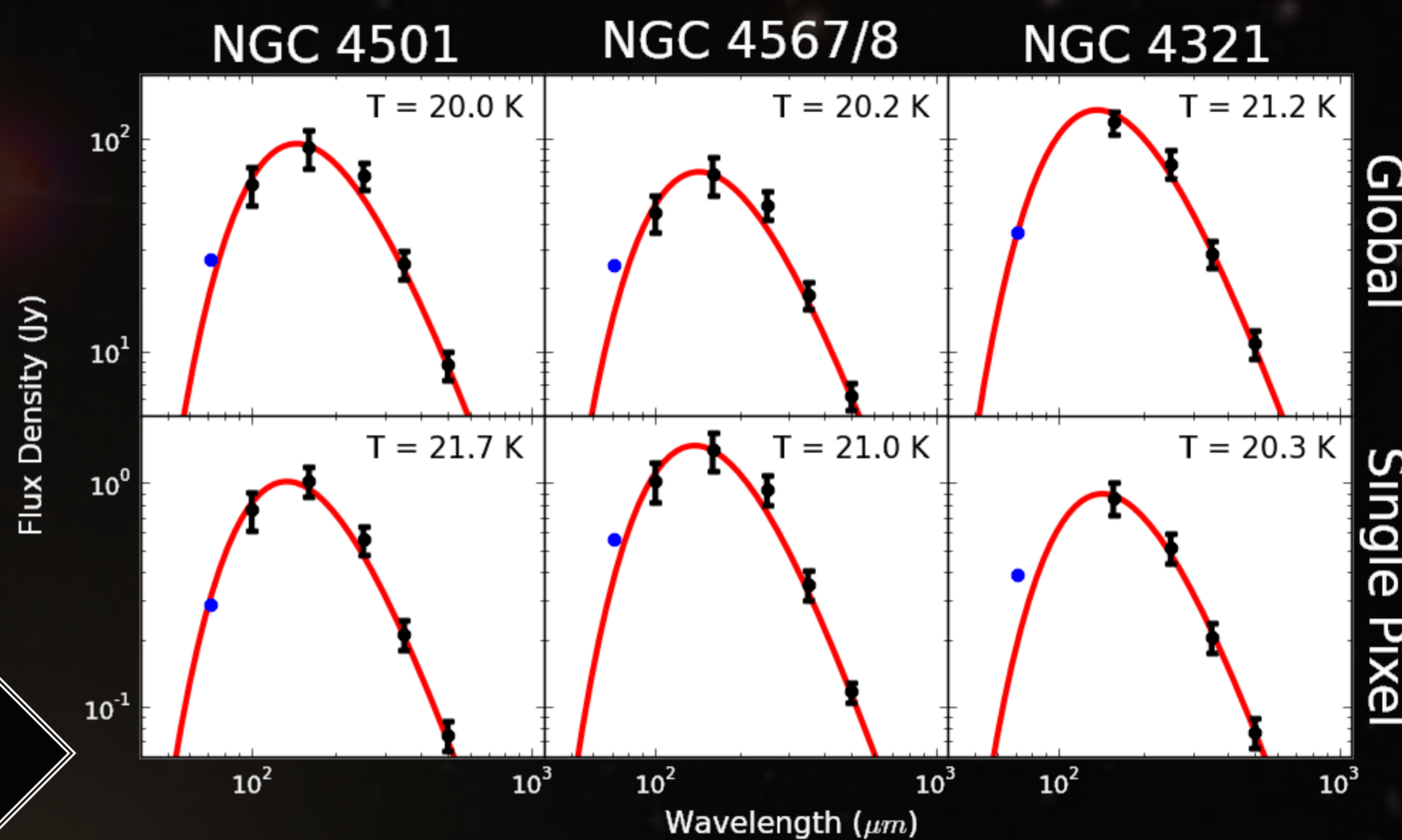


Figure 4
Global and example SED fits. If not shown, uncertainties are smaller than the symbol size. The 70 μm point (blue) is used as an upper limit.

5 Resolved Pixel-by-Pixel Dust Analysis

We applied the analysis outlined in Section 4 to NGC 4501 and NGC 4567/8 which were observed by HeViCS (in regions with a $S/N > 10\sigma$). The far-infrared, gas, dust temperature, dust surface density and gas to dust ratio maps are shown in Figures 5 and 6. In both cases we find a centrally peaked, symmetric distribution of dust mass in the galaxies. However the distribution of the dust temperature does not have the same symmetric distribution and varies across both galaxies, peaking at ~22 K and decreasing to ~19 K towards the outskirts of the galaxies. For NGC 4501 the gas-to-dust ratio is asymmetric, peaking in the south east and varying by a factor ~2 across the galaxy.

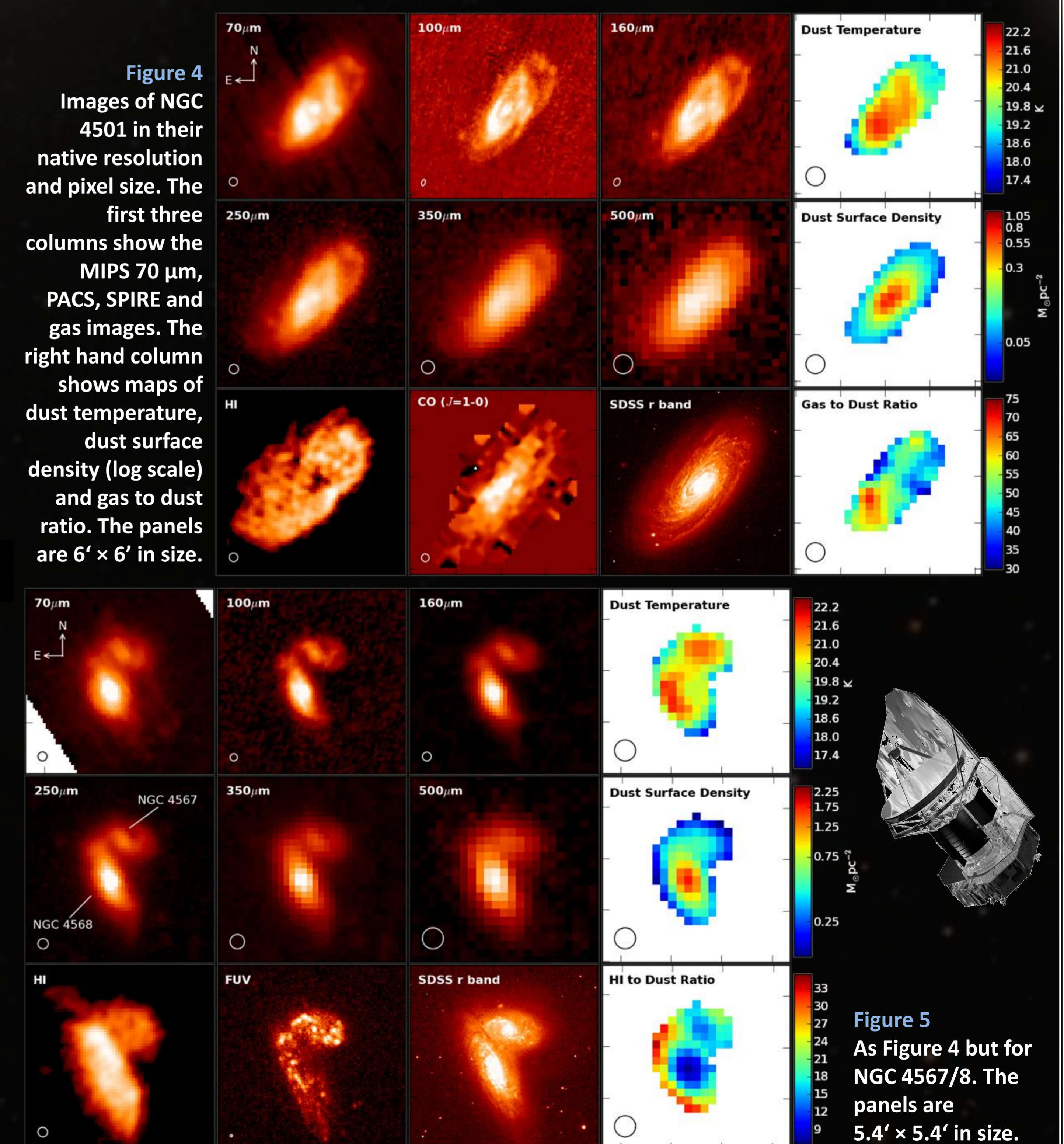


Figure 4
Images of NGC 4501 in their native resolution and pixel size. The first three columns show the MIPS 70 μm , PACS, SPIRE and gas images. The right hand column shows maps of dust temperature, dust surface density (log scale) and gas to dust ratio. The panels are $6' \times 6'$ in size.

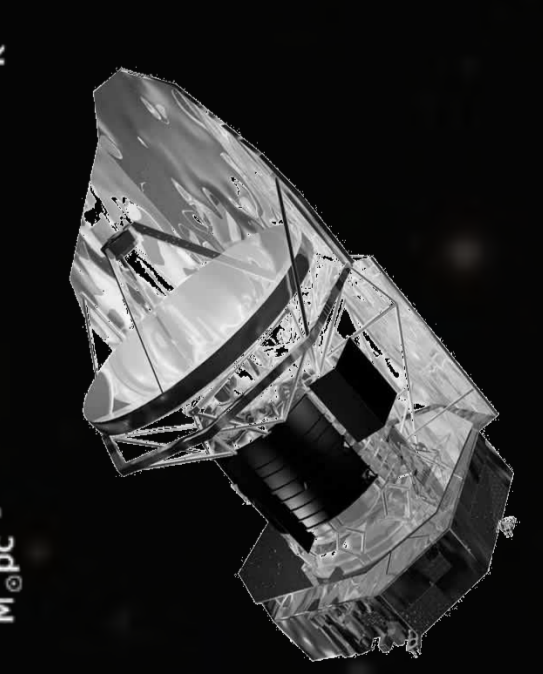


Figure 5
As Figure 4 but for NGC 4567/8. The panels are $5.4' \times 5.4'$ in size.

REFERENCES

- The Herschel Reference Survey, Boselli et al. 2010 PASP, 122, 261B
Radial Distribution of Gas and Dust in M99 and M100, Pohlen et al. 2010 A&A, Herschel Special Issue
The Herschel Virgo Cluster Survey: IV. Resolved Dust Analysis of Spiral Galaxies, Smith et al. 2010 A&A, Herschel Special Issue
[†] Email: Matthew.Smith@astro.cf.ac.uk, Background is a SDSS montage of the M87 region at the centre of the Virgo Cluster.