UNIVERSITY OF CAMBRIDGE

« From Dust to Galaxies » ,
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Resolving the dust properties in Nearby Galaxies with Herschel and LABOCA

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Contents

The KINGFISH programme

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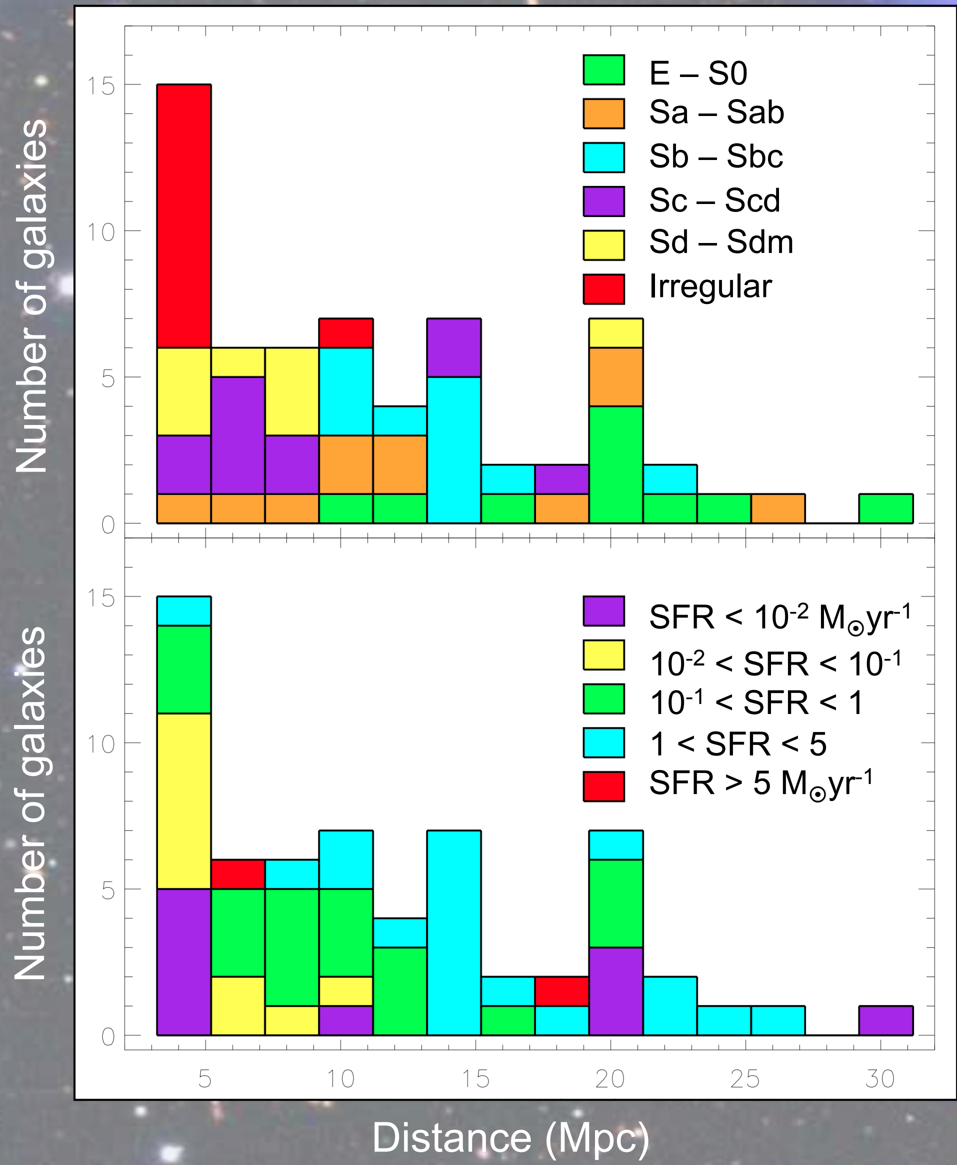
- Key Insights on Nearby Galaxies : a Far-Infrared Survey with Herschel (PI: R. Kennicutt)
- Imaging and spectroscopic survey of 61 nearby galaxies
- Goals:
  - Star formation in the ISM
  - Heating/cooling processes
  - Cold dust and gas
  - Radio / IR correlation
  - Metal abundance (7.5 → 9.5)



1 Kingfish with Herschel

- *Biggest mirror ever sent to space*
- *Photometric and spectroscopic observations*

Angular resolution of the instruments

	PACS			SPIRE		
λ	70 µm	100 µm	160 µm	250 µm	350 µm	500 µm
FWHM	5.2 ’’	7.7 ’’	12 ’’	18 ’’	25 ’’	36 ’’

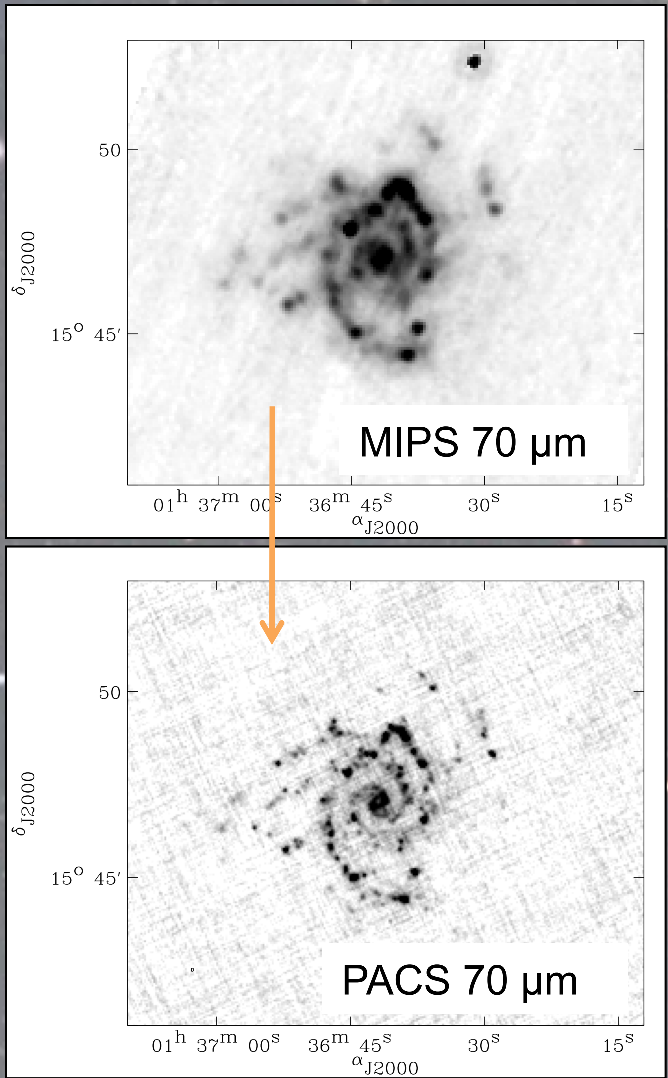
For Kingfish galaxies :

At 3 Mpc	~ 75 pc	~ 110 pc	~ 175 pc	~ 260 pc	~ 360 pc	~ 520 pc
At 31 Mpc	~ 780 pc	~ 1.2 kpc	~ 1.8 kpc	~ 2.7 kpc	~ 3.7 kpc	~ 5.4 kpc

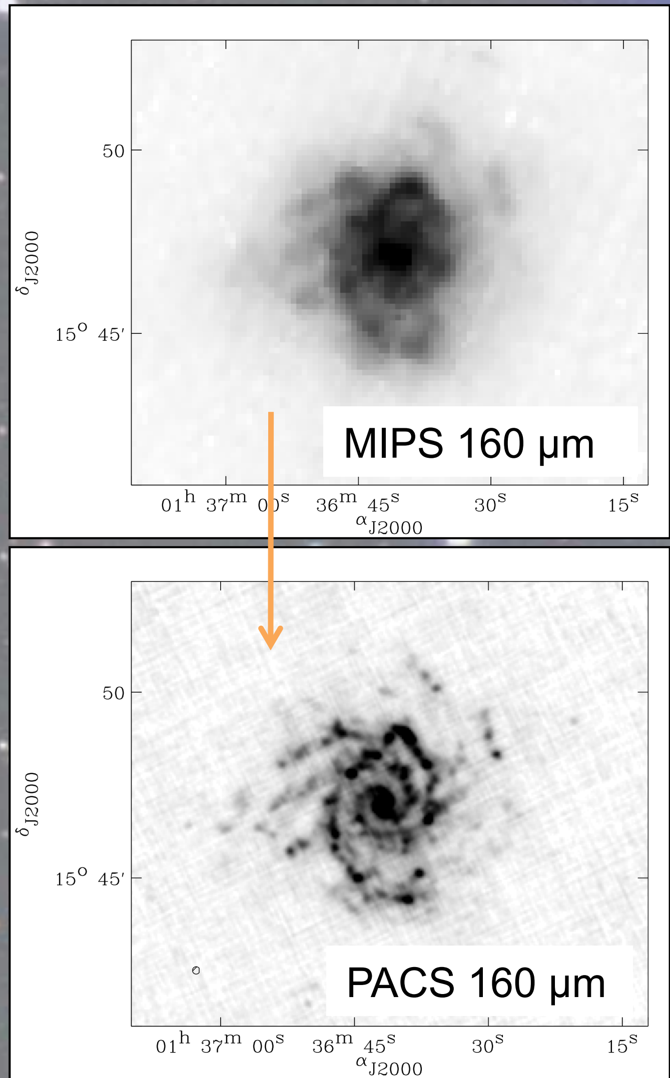
Kingfish with Herschel

- Winning in resolution with PACS

70 μm



160 μm



Kingfish with Herschel

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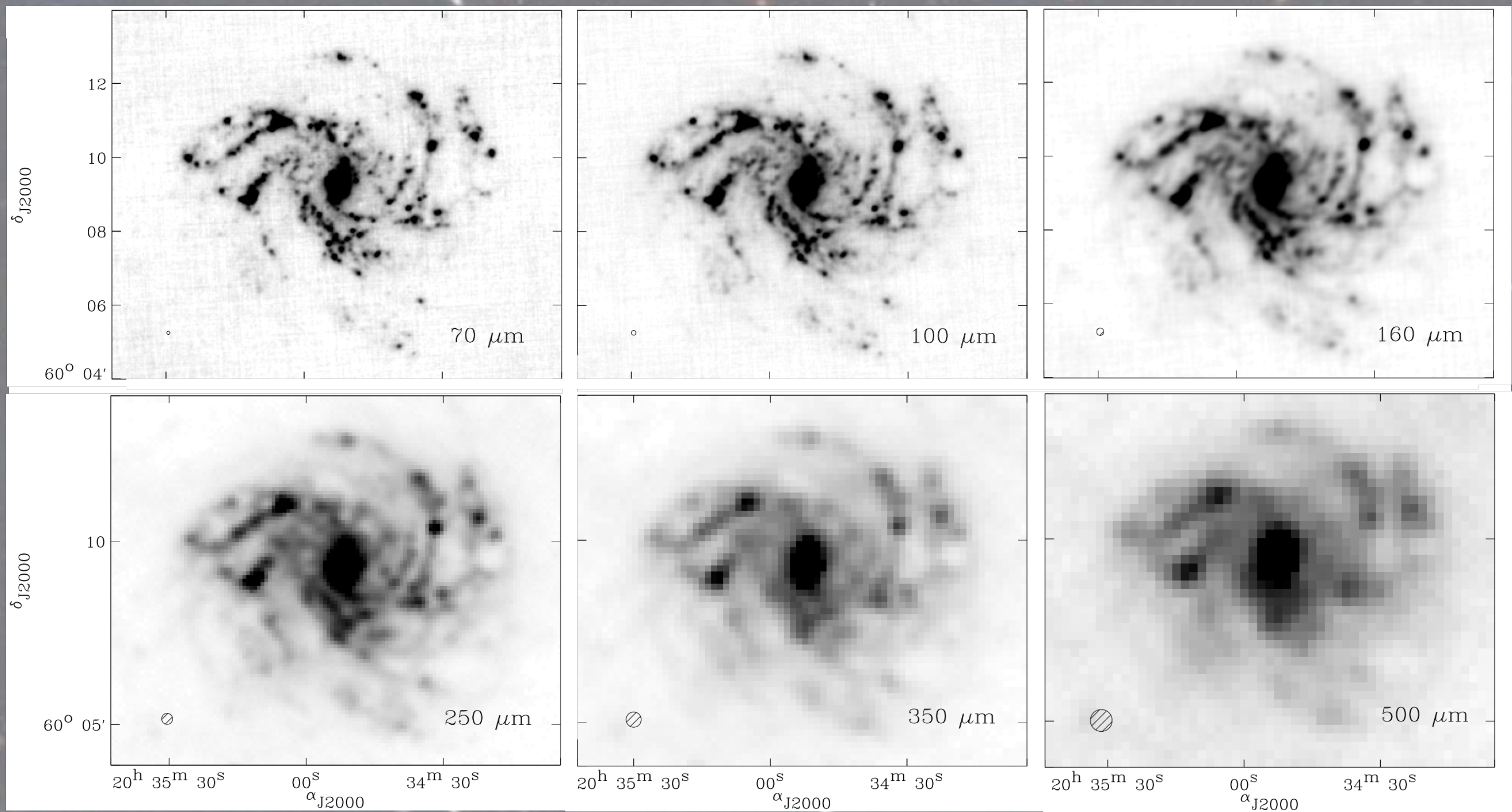
- Probing the cold phases of dust with SPIRE

NGC 6946



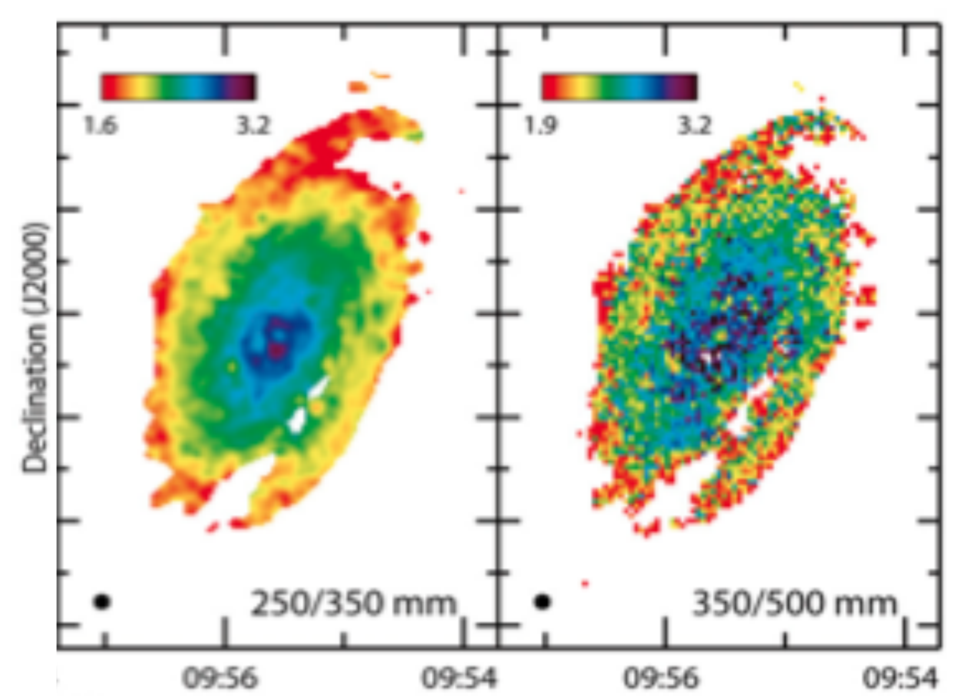
→ Individual SEDs of the star forming regions / diffuse ISM

→ Resolve the properties (dust heating - T - β) of cold dust

Herschel (and Planck) first results

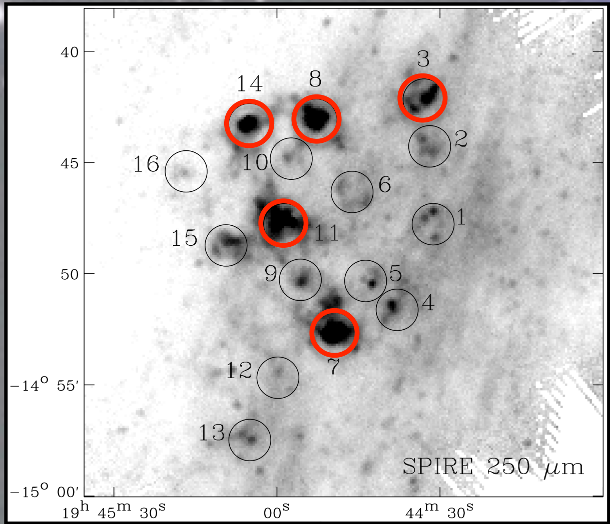
- Dust heating processes

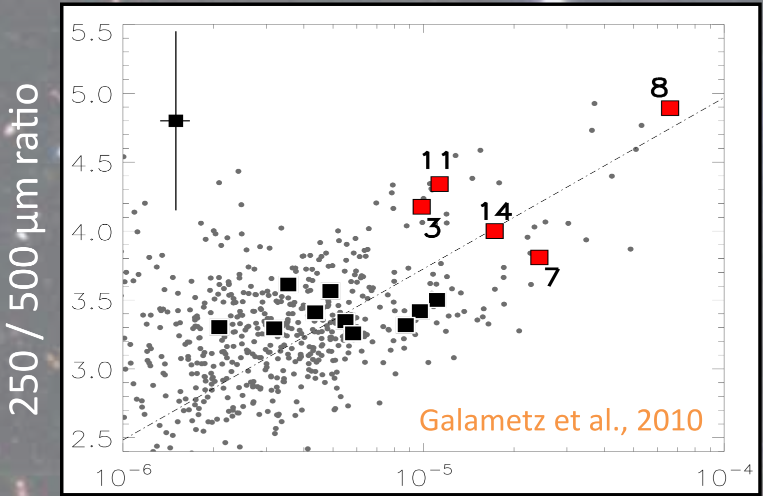
Normal spiral galaxy



Bendo et al., 2010

Low-metallicity galaxy





Galametz et al., 2010

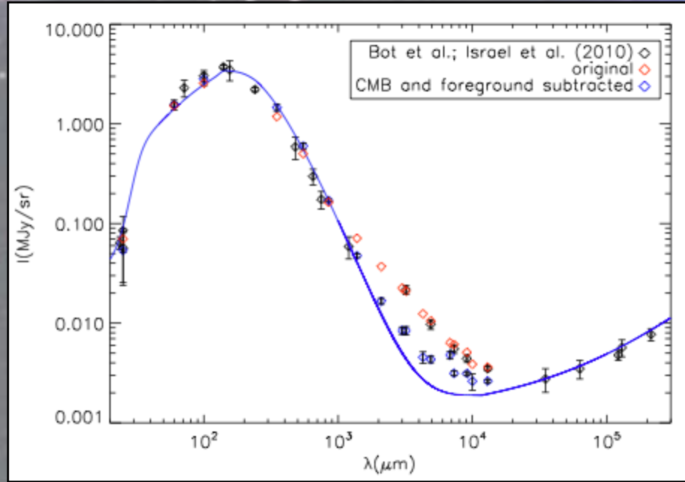
Herschel (and Planck) first results

- Submm dust properties

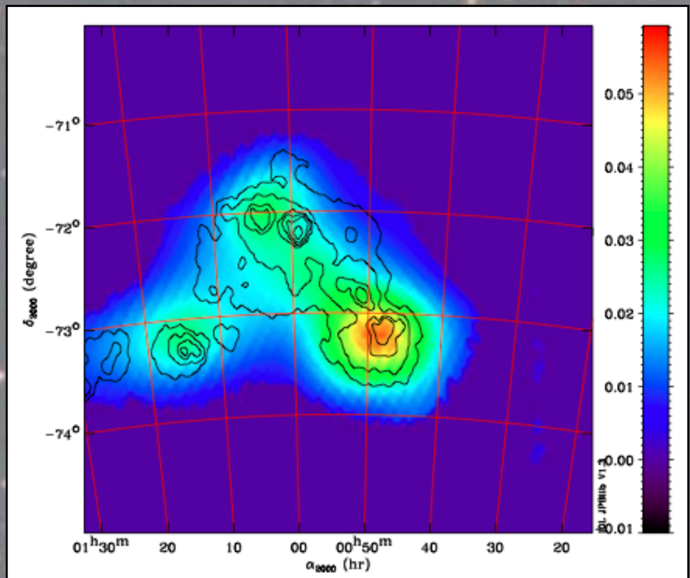
✓ Excess detected in some low-metallicity galaxies
(Gordon et al., 2010, Planck Collaboration 2011)

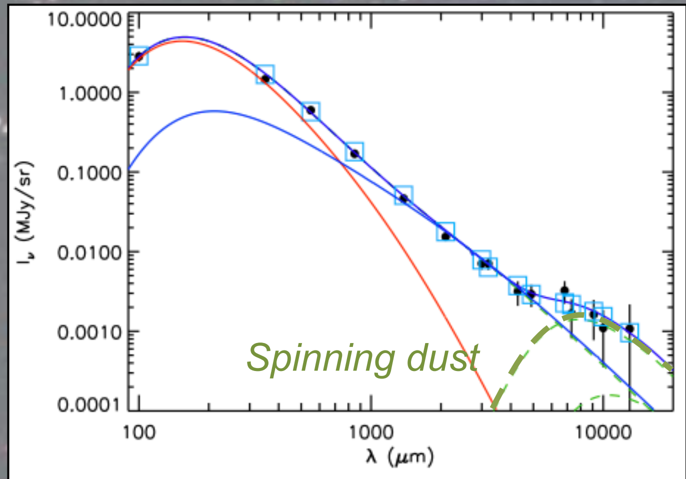
✓ Herschel data require new dust properties to obtain physical D/G.
(Meixner et al., 2010, Galametz et al., 2010)

SMC



Mm Excess at 3 mm in the SMC





Planck Collaboration, 2011

2

Submm excess: possible origins

Another type of dust grains

- Rotating charged dust grain (« spinning dust»)
  (Draine & Lazarian, 1998; Hoang et al., 2010; Bot 2010)
- Very cold dust
  (Galliano et al., 2003, 2005; Galametz et al., 2009, 2011)

Different dust properties

- Anti-correlation between β and the temperature
  (Dupac et al., 2003; Meny et al., 2007)
- Fractal aggregates / coagulation of grains
  (Bazell et al. 1990; Stepnik et al., 2001; Paradis et al., 2009)
- Amorphous carbon grains instead of graphite
  (Serra Diaz-Cano & Jones, 2008; Meixner et al., 2010)

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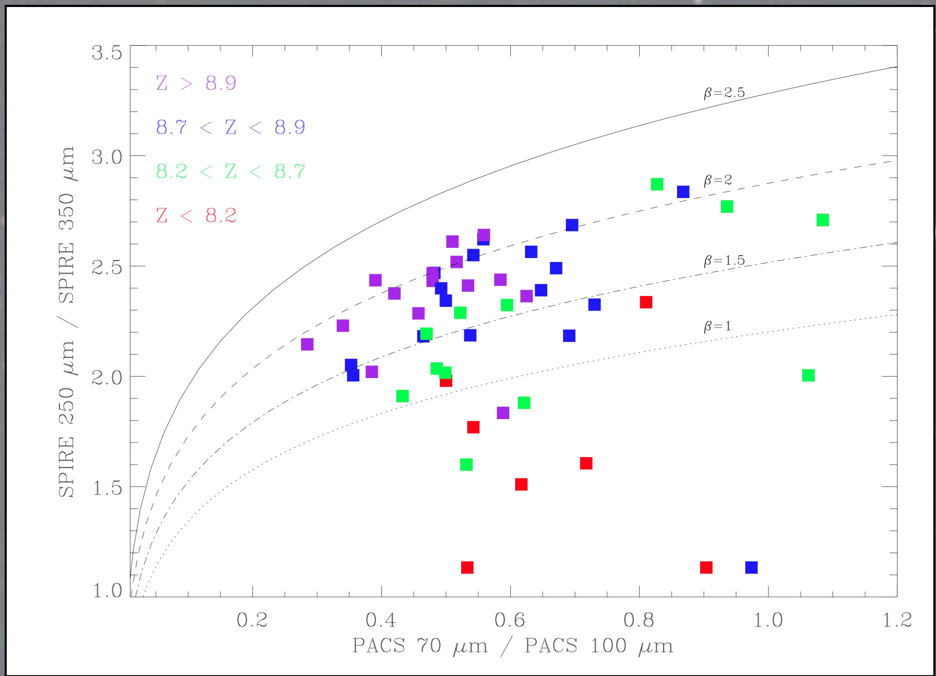
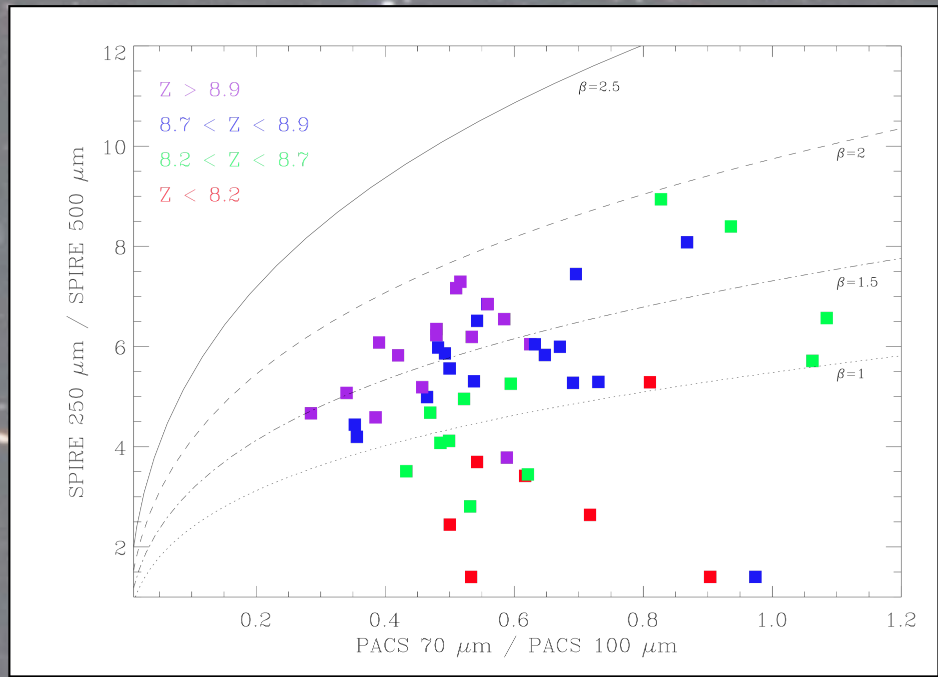
Global photometry and colours

- Positions of the galaxies in a PACS/SPIRE colour-colour diagramme
- Deviations from a single modified-blackbody model
- Strong variations with metallicity





3 Combining Herschel and LABOCA

- 11 KINGFISH galaxies observed with :

SINGS + PACS (70-160 µm) + SPIRE (250-500 µm) + LABOCA (870 µm)

Herschel

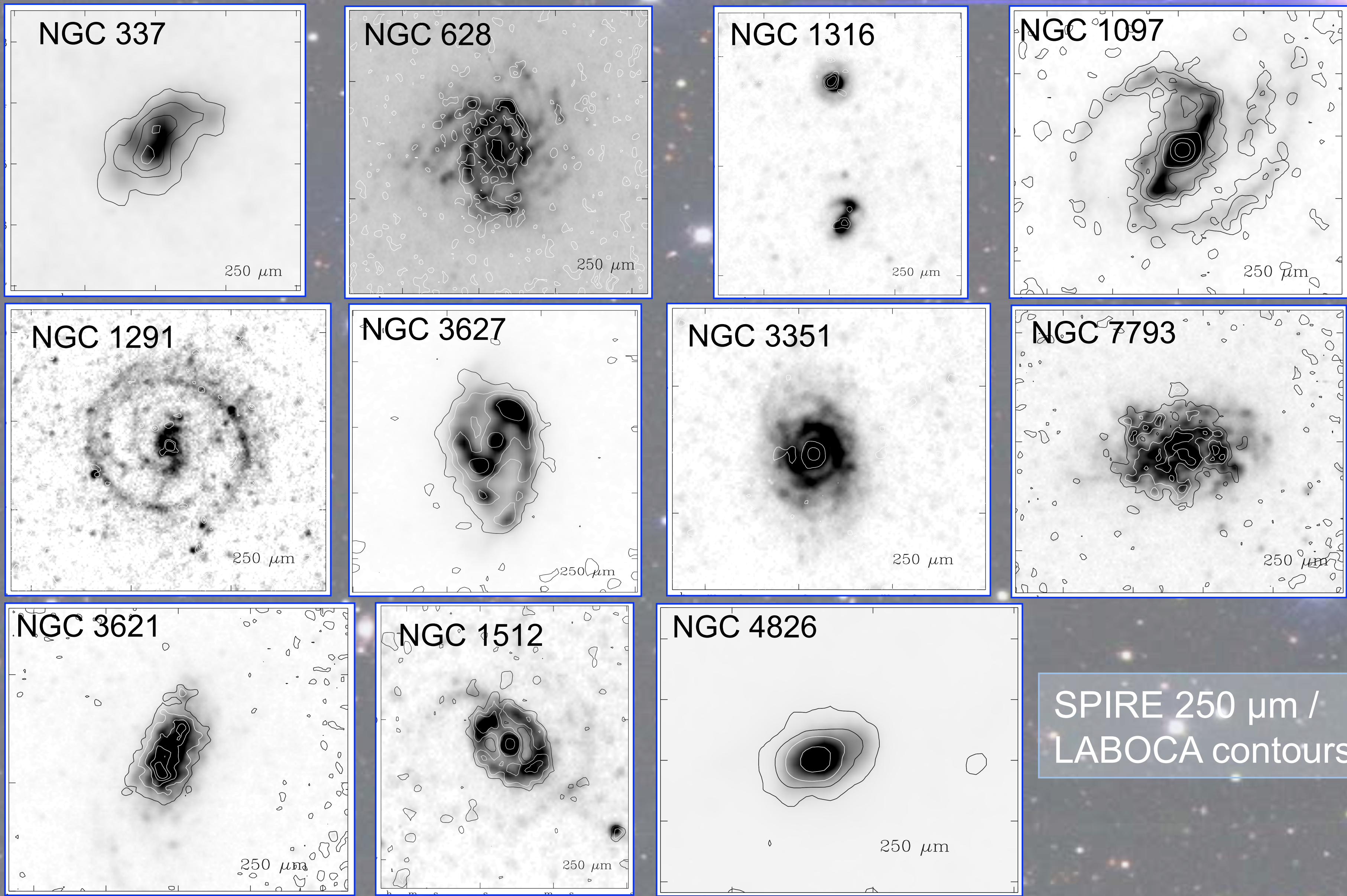
Resolution/sensitivity
SED coverage

+

LABOCA

Resolution of SPIRE 250 (19 ’’)
Coldest phases of dust
Submm Excess Distribution

3 Combining Herschel and LABOCA



SPIRE 250 μm / LABOCA contours

Global dust temperatures

- SED modelling with two modified blackbodies

$$L(\lambda) = \lambda^{-2} B(\lambda, T_w) + \lambda^{-\beta c} B(\lambda, T_c)$$

✓ Different shapes

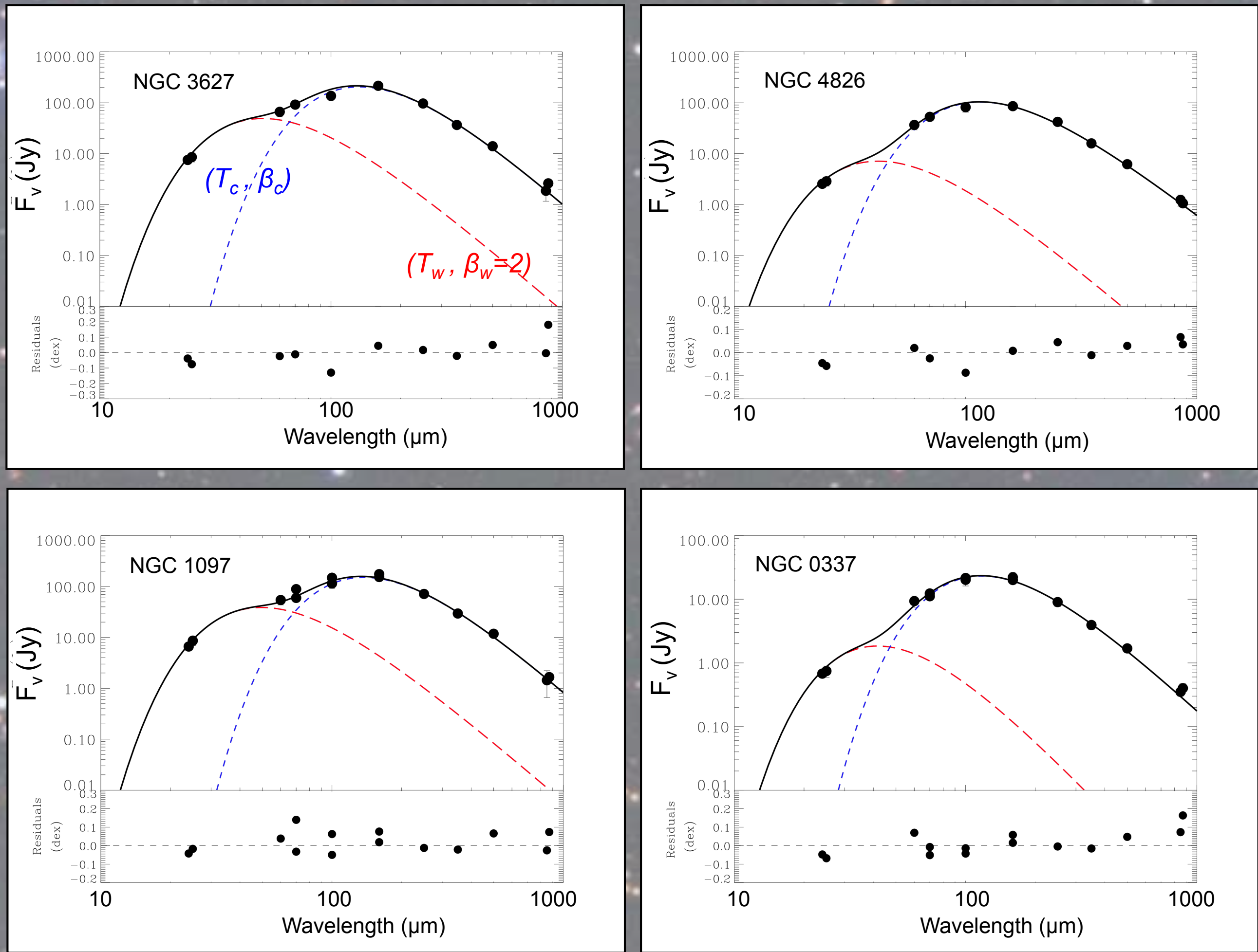
✓ Higher T_{cold} if β_{cold} is free

✓ Mean (β_{cold}) = 1.7

✓ Strong variations in β_{cold} in the sample

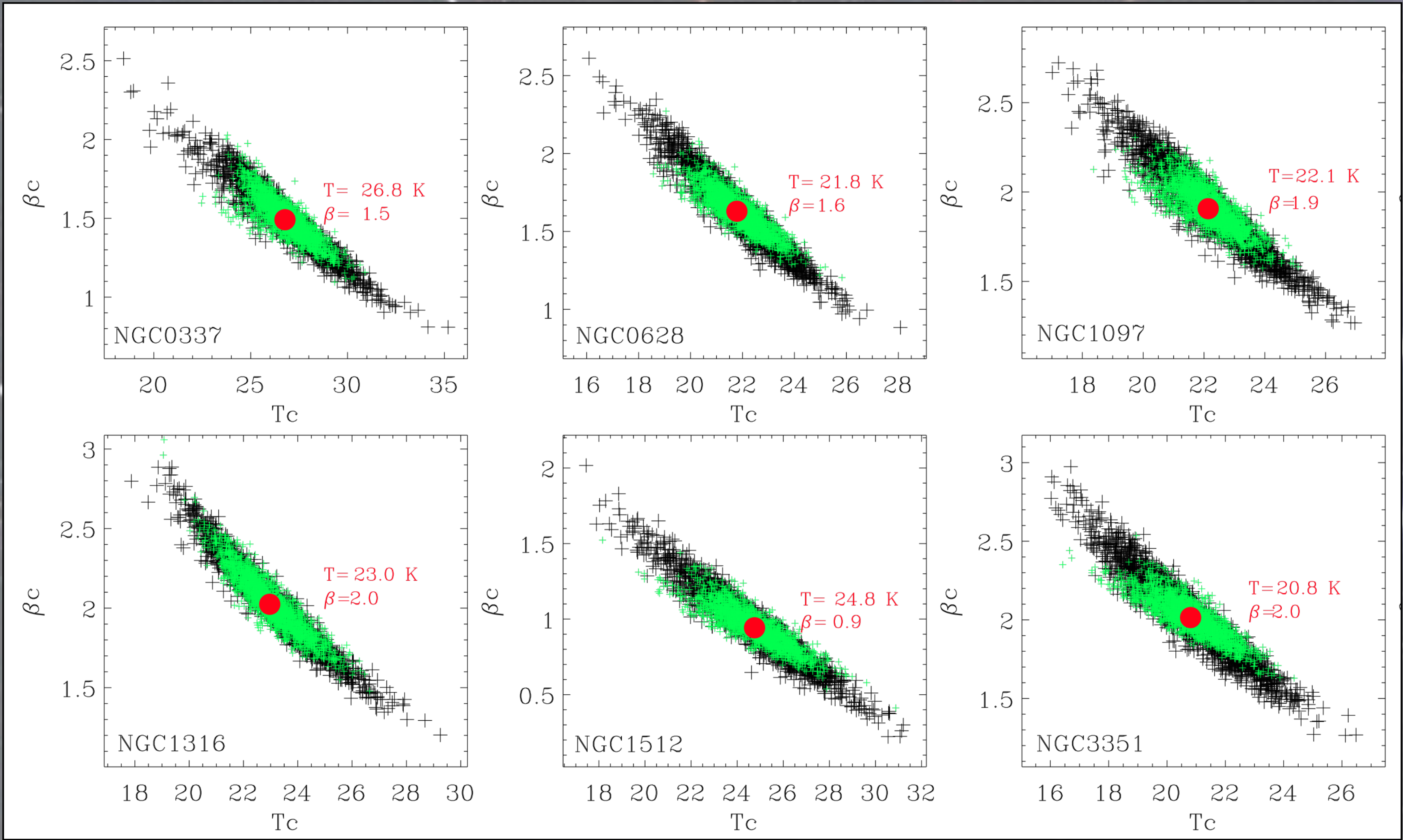
✓ Error estimates

(Monte Carlo method)



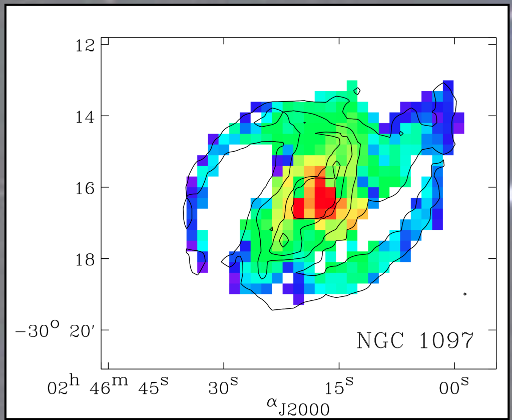
Global dust properties

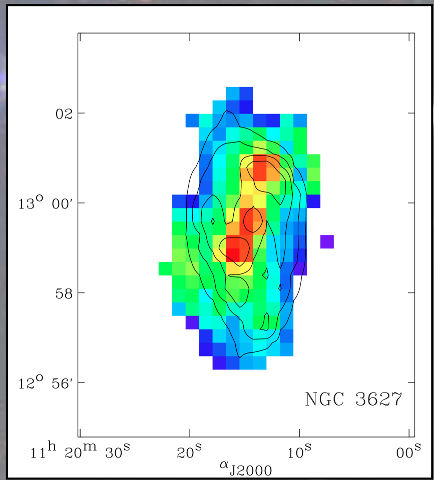
- SED modelling with two modified blackbodies



3 Dust temperature maps

- Pixel-by-pixel SED modelling – β_{cold} fixed to 2



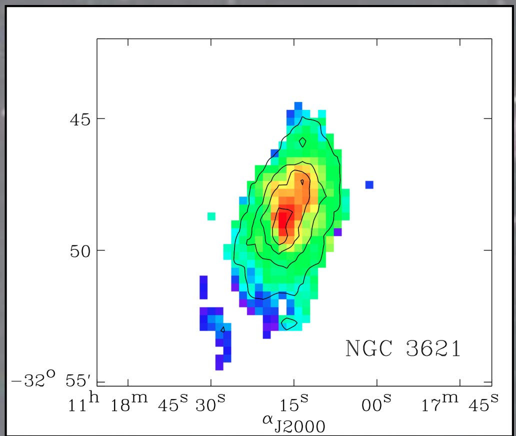


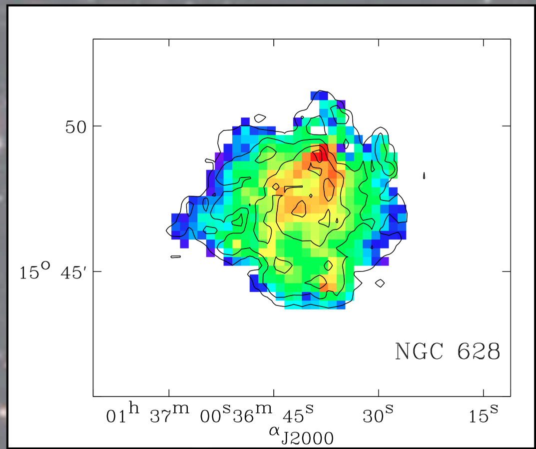
- Convolved to SPIRE 500 resolution
- Projected to a common grid

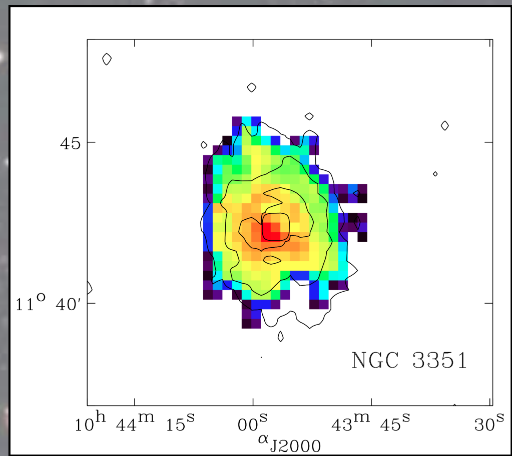
✓ Variation on the dust temperature

✓ Decreases in the outer parts

✓ Shift of the scale if β_c fixed to 1.5







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Residual maps at 870 μm

Can we detect a submm excess locally ?

870 μm not used in the fitting procedure

↓

Extrapolation of the fitting to create 870 μm maps

↓

Comparison with the observed 870 μm emission

↓

Evolution of the excess with the emissivity index

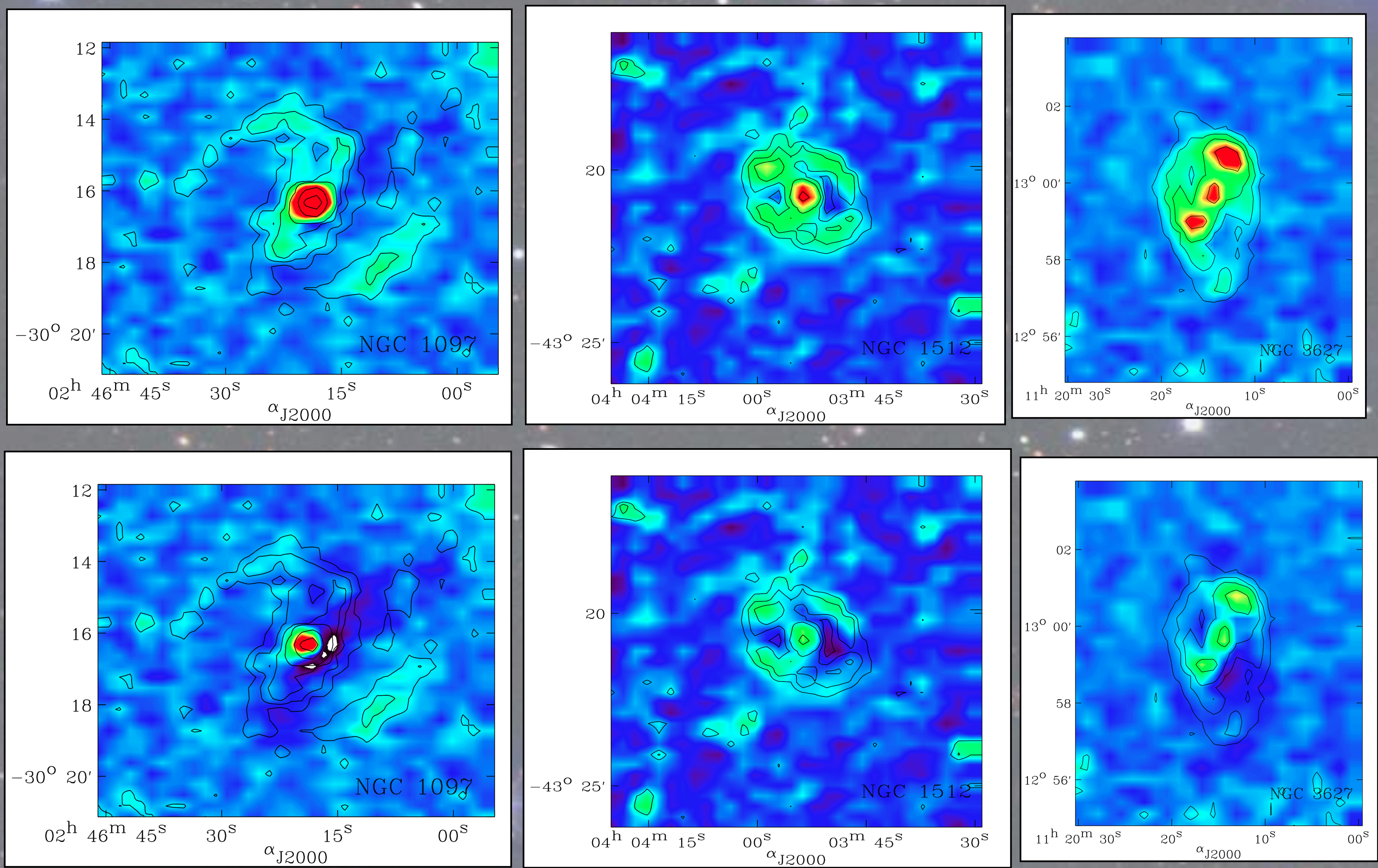
3

Residual maps at 870 μm

NGC 1097 | NGC 1512 | NGC 3627

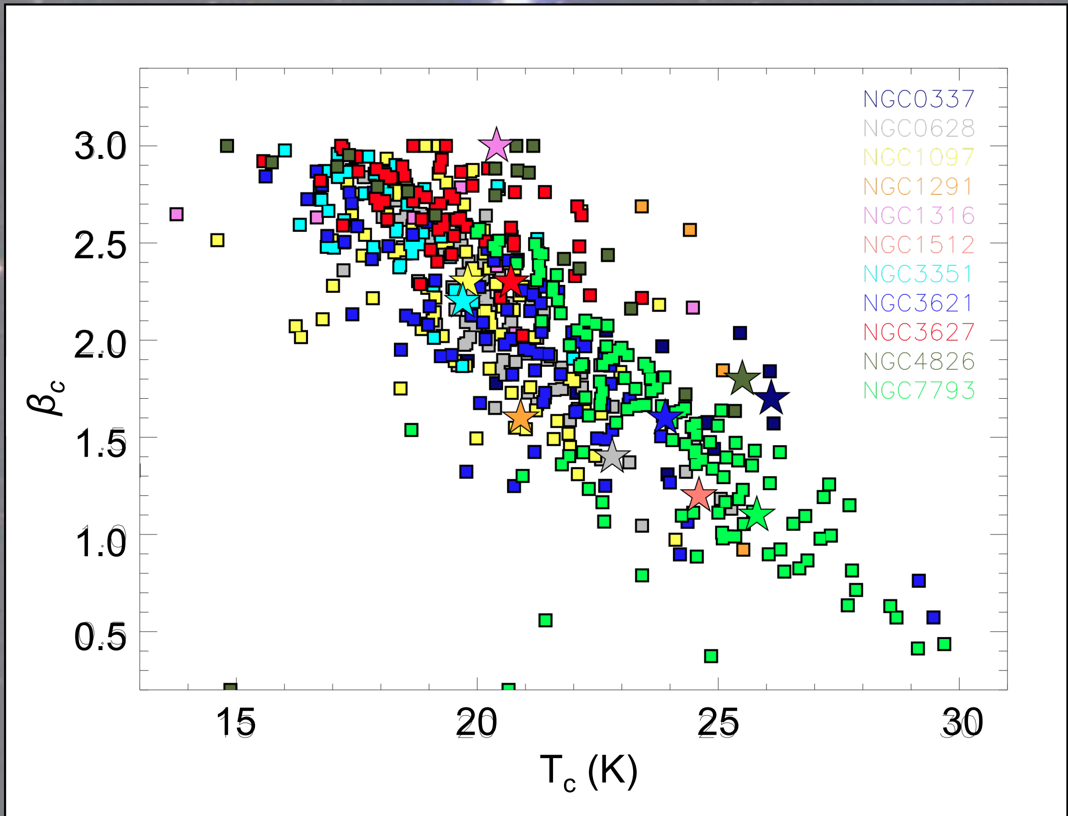
$\beta = 2$

$\beta = 1.5$



3 T – β correlation

- Individual pixels in the T_{cold} – β_{cold} parameter space



✓ Eddington bias ?

→ unlikely

✓ Changes in the emissivity index ?

✓ Mixture of temperatures along the line of sight ?

Further studies to come

Short-term objectives

- Understand the origin of the 870 µm excess
- Use a more complex SED modelling to access to the dust temperature range per ISM mass element (Draine et Li., 2007)
- Access to the dust mass distribution

Longer-term

- Combine the dust information with the gas tracers
- Study the excess at the scale of a star forming region