HERschel Observations of Edge-on Spirals (*HEROES*)

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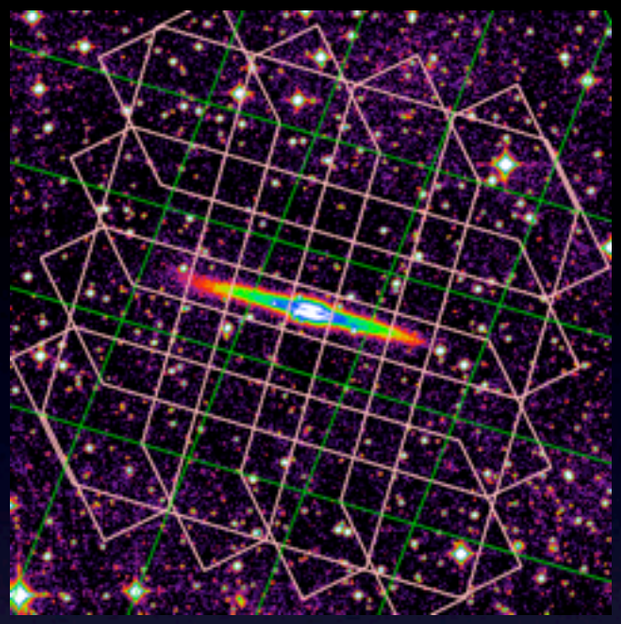
Why study dust in galaxies?

- Dust is an important component of the ISM
  - Grains scatter & absorb UV/optical light
  - Regulate several processes in the ISM
    - Crucial role in star & planet formation
- Amount & distribution give vital clues about these processes
- Observed in extinction (UV/optical) and in emission (IR/submm)

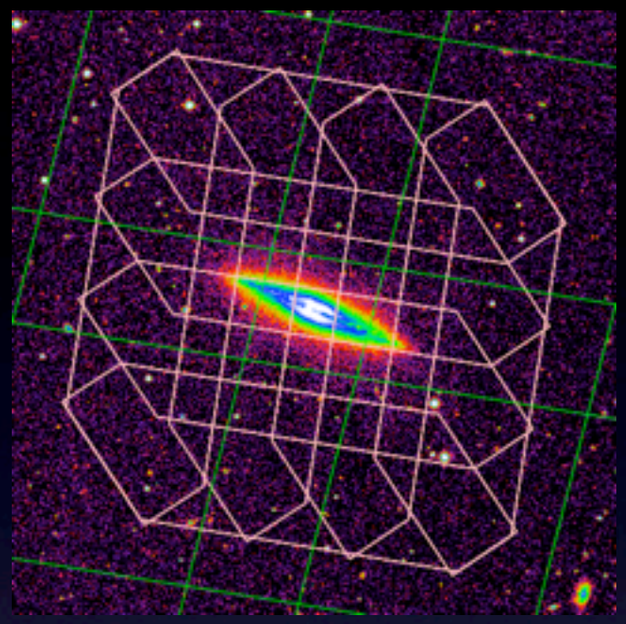
*HER*OES

- Sample of 7 large(-mass) spiral disc galaxies with clear dust lane
- 6h Belgian GT time: UGent & KULeuven
- Excellent perspective to study dust
  - properties & distribution (R & z)
- Sample selection: radiative transfer (RT) models fitted to optical images (Xilouris et al. 1997, 1999 & Bianchi 2007)

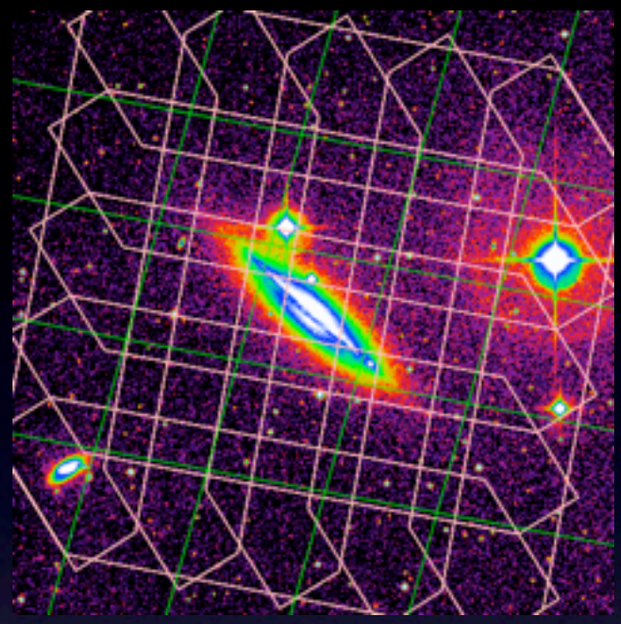
HEROES



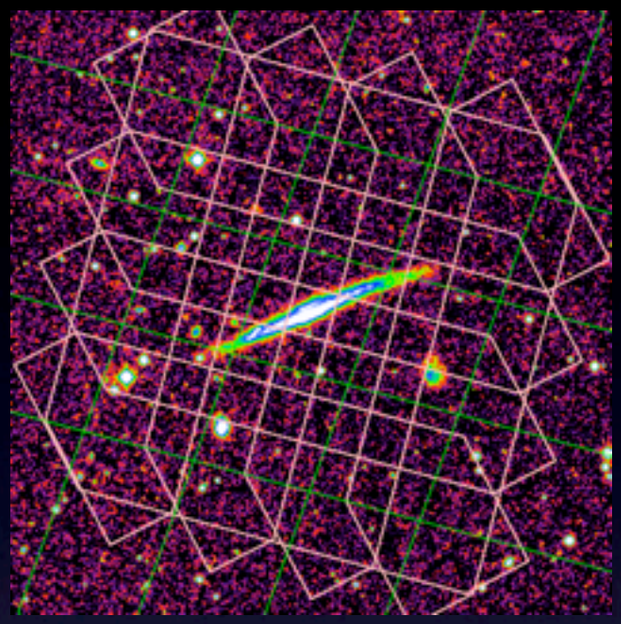
IC2531



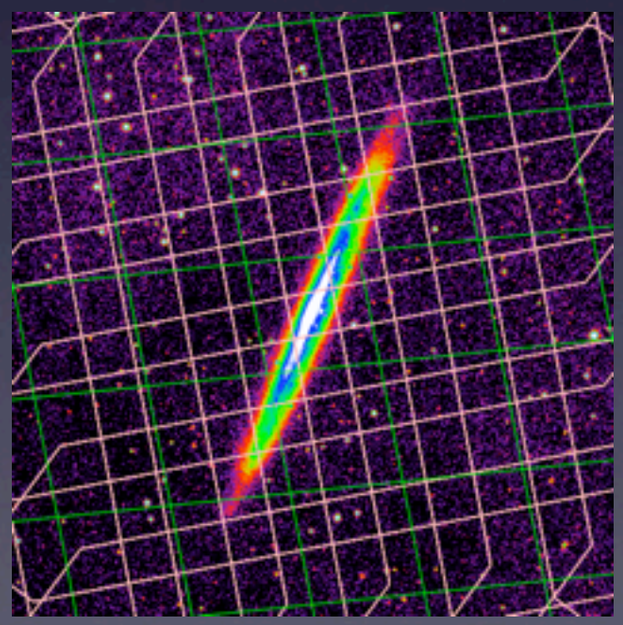
NGC4013



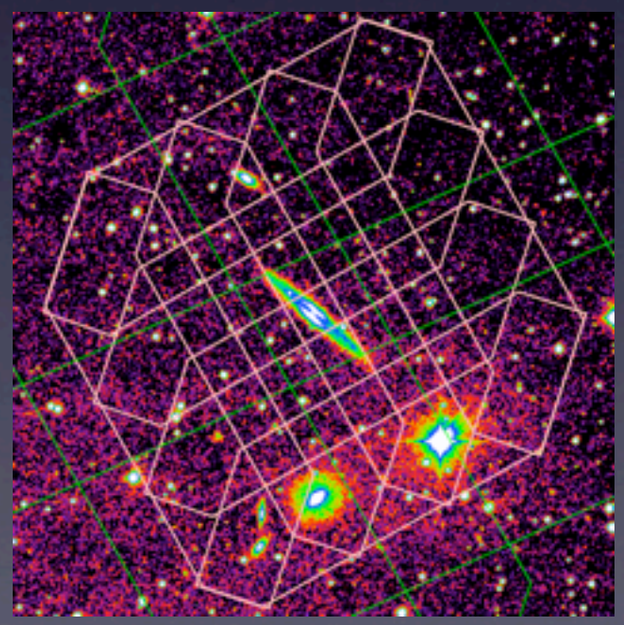
NGC4217



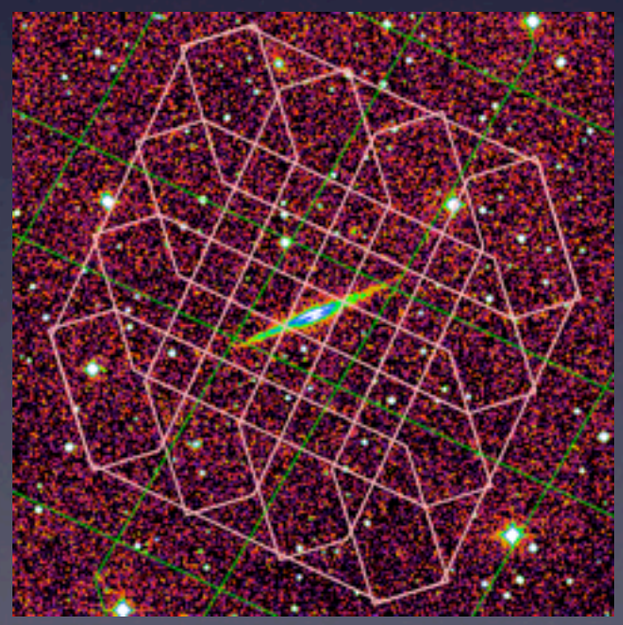
NGC5529



NGC5907

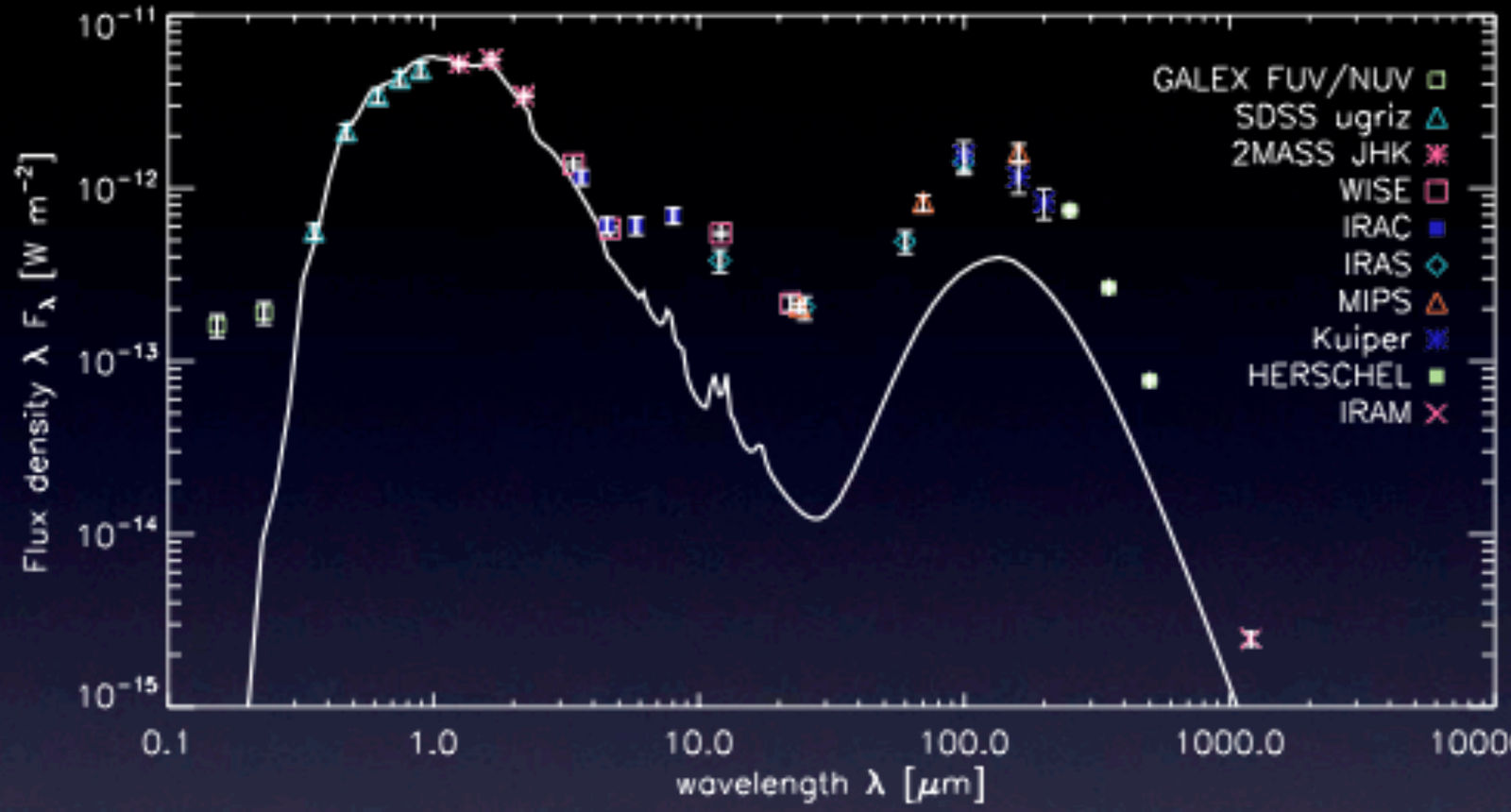


NGC973



UGC4277

Dust energy balance in galaxies



(De Looze et al. 2012)

- Dust energy problem in spiral discs:
  - UV/opt. ext. models: 10% stellar absorbed
  - FIR dust emission: 30% of UV/optical!

Dust energy balance in galaxies

- Possible solutions:
  - Dust FIR emissivity underestimated
  - Dust with low contribution to UV/optical extinction
- See also De Looze et al. (2012) & last year's talk

NGC 5529

V band

0 125 250
MJy sr^{-1}

N
E

10 kpc

PACS 100

0 125 250
MJy sr^{-1}

PACS 160

0 50 100
MJy sr^{-1}

SPIRE 250

0.0 17.5 35
MJy sr^{-1}

SPIRE 350

0 5 10
MJy sr^{-1}

SPIRE 500

arcsec

arcsec

Dust distribution

- Double-exponential model, 3D density:

$$\rho(R,z) = \frac{M_\mathrm{d}}{4\pi\, h_R^2\, h_z} \exp\left(-\frac{R}{h_R} - \frac{|z|}{h_z}\right)$$

- Mass surface density distribution edge-on:

$$\Sigma(x,y) = \frac{M_\mathrm{d}}{2\pi\, h_R\, h_z} \left(\frac{|x|}{h_R}\right) K_1\left(\frac{|x|}{h_R}\right) \exp\left(-\frac{|y|}{h_z}\right)$$

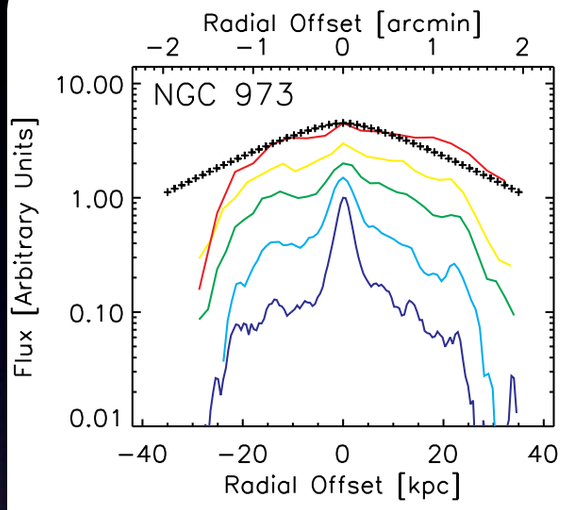
- Normalised horizontal profile for edge-on:

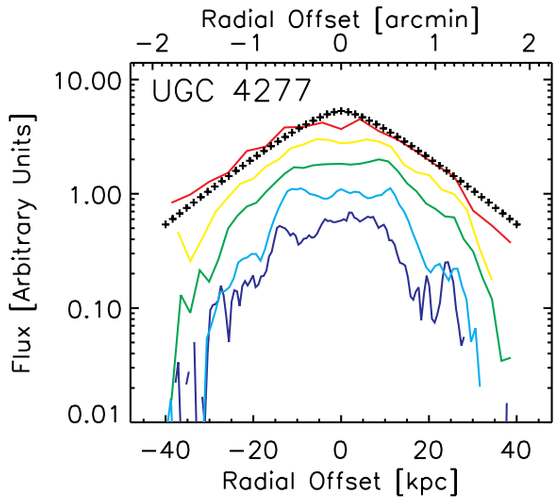
$$\Sigma_\mathrm{hor}(x) = \frac{1}{\pi\, h_R} \left(\frac{|x|}{h_R}\right) K_1\left(\frac{|x|}{h_R}\right)$$

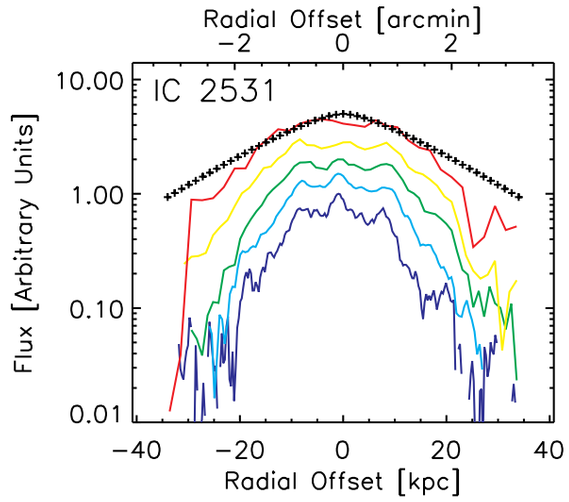
- Normalised vertical profile for edge-on:

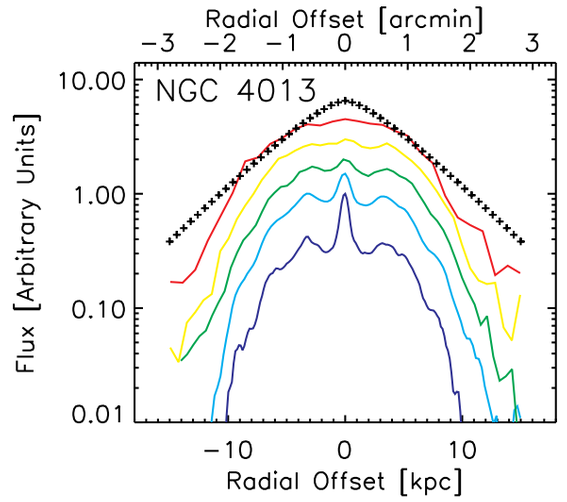
$$\Sigma_\mathrm{ver}(z) = \frac{1}{2h_z} \exp\left(-\frac{|z|}{h_z}\right)$$

Horizontal profiles

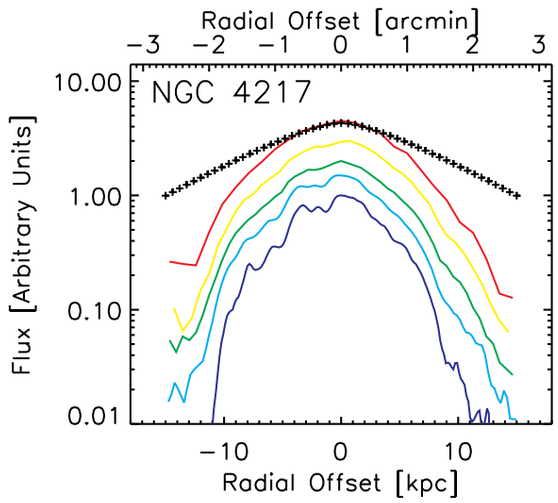


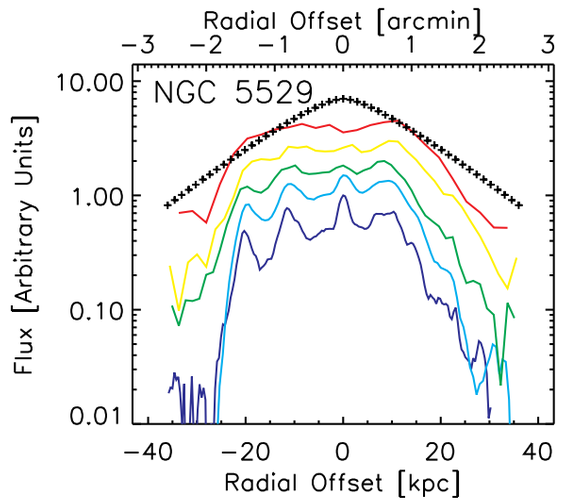


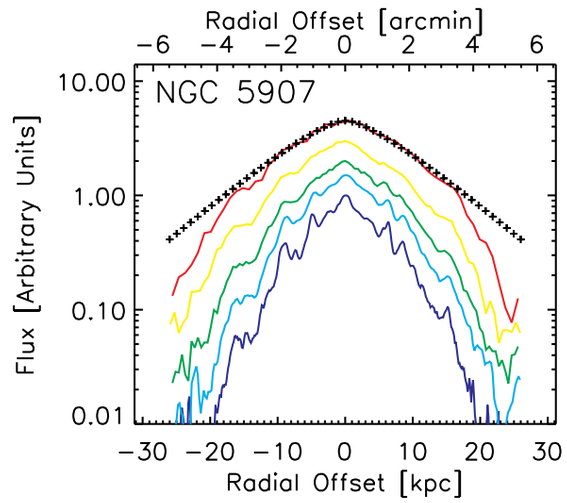




100 μm
160 μm
250 μm
350 μm
500 μm
Exponential model







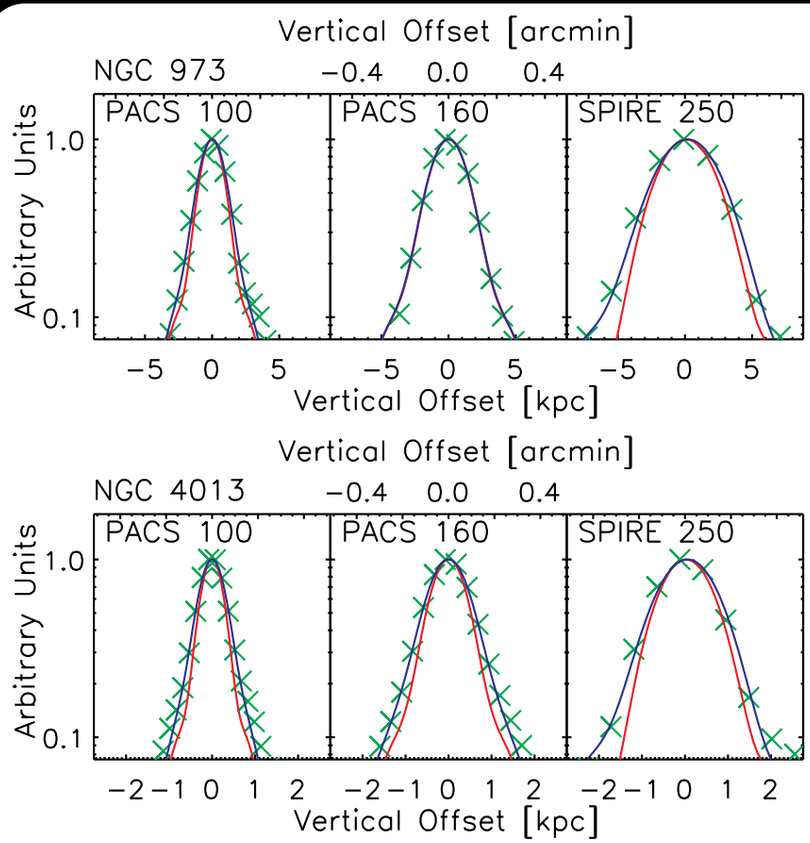
Horizontal profiles

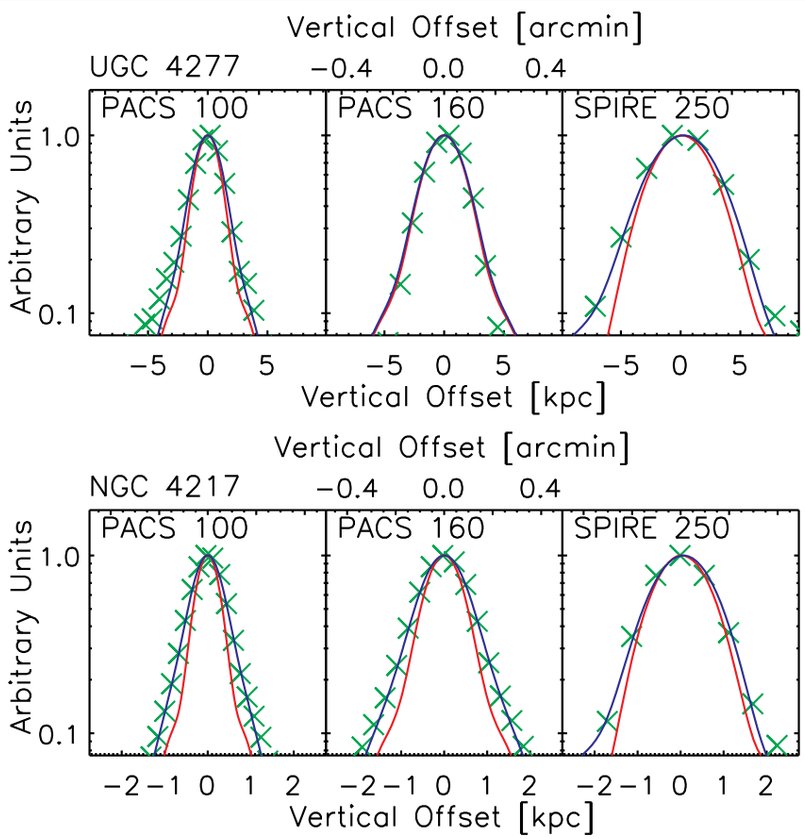
- Model describes observations fairly well (mainly 500 μm; ignoring disc truncation)
- At shorter wavelengths: peaks from morphological structures (spiral arms, rings, star formation regions)
- NGC973 & 4013 (Seyfert 2/LINER): strong central peak at 100 μm, likely due to AGN-like source heating surrounding dust

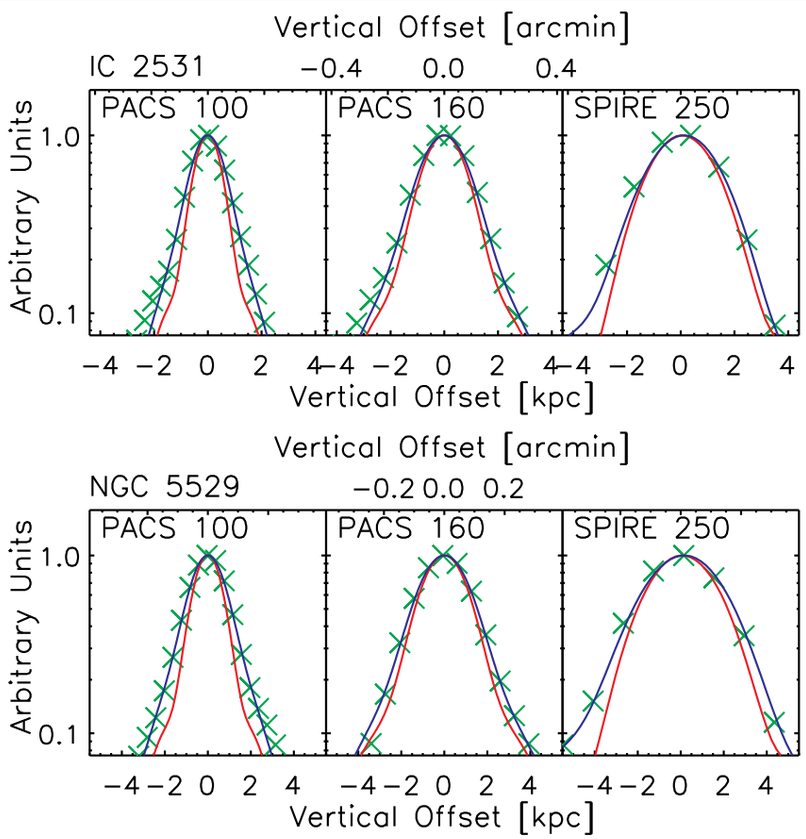
Vertical profiles

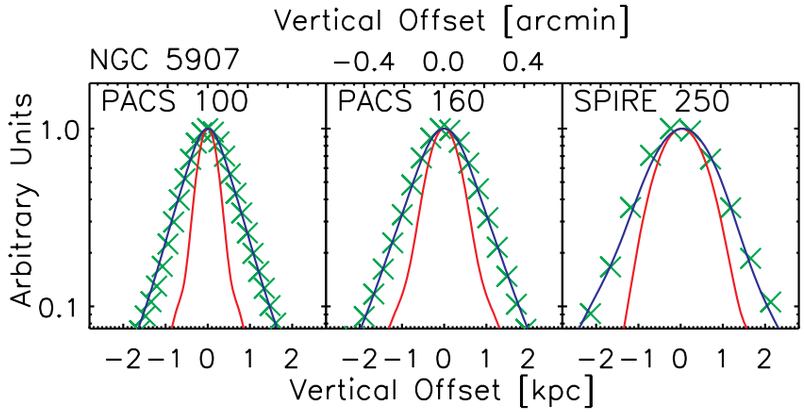
- Resolved vertical profiles indicate extra-planar dust
- High-latitude dust: outflowing material into or infalling matter from circum-/intergalactic medium
- Only possible in edge-on

Vertical profiles









Vertical profiles

- Considered resolved if beam not dominant
- IC2531, UGC4277, NGC973 & 5529 not resolved at 5-sigma level
- NGC4217 & 5907 affected by inclination
- NGC4013 resolved in PACS100 & 160 μm; extra-planar dust also noticed in optical (in extinction)

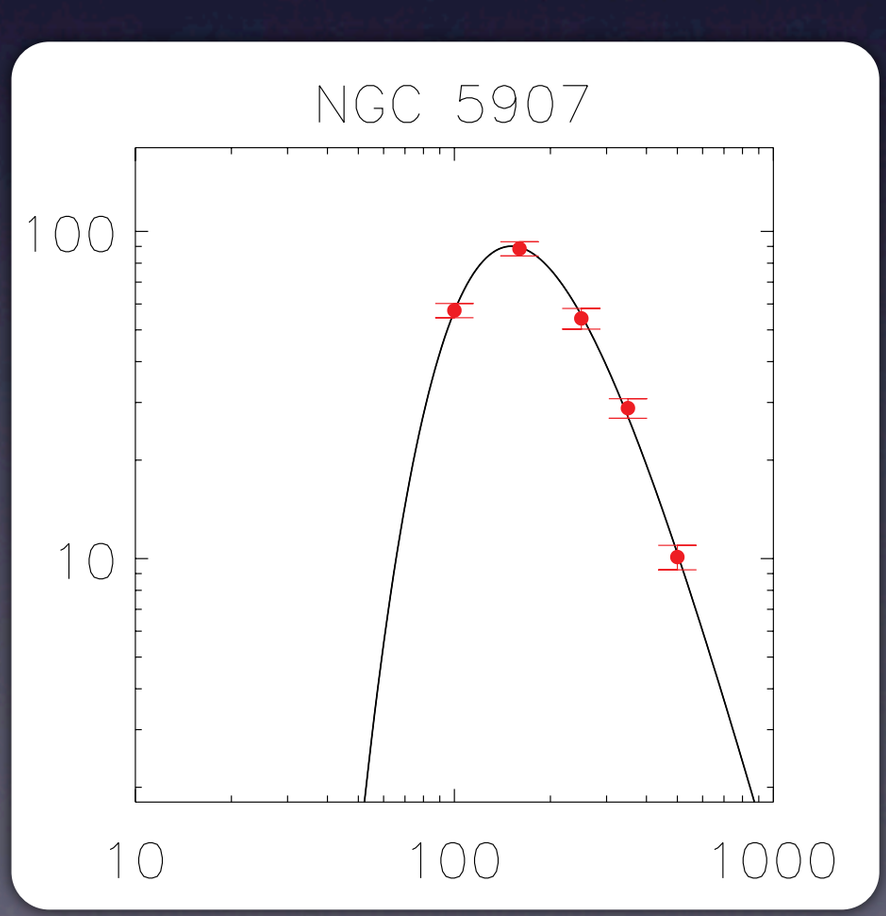
Determining dust mass

- From RT models fitting dust extinction in optical images:

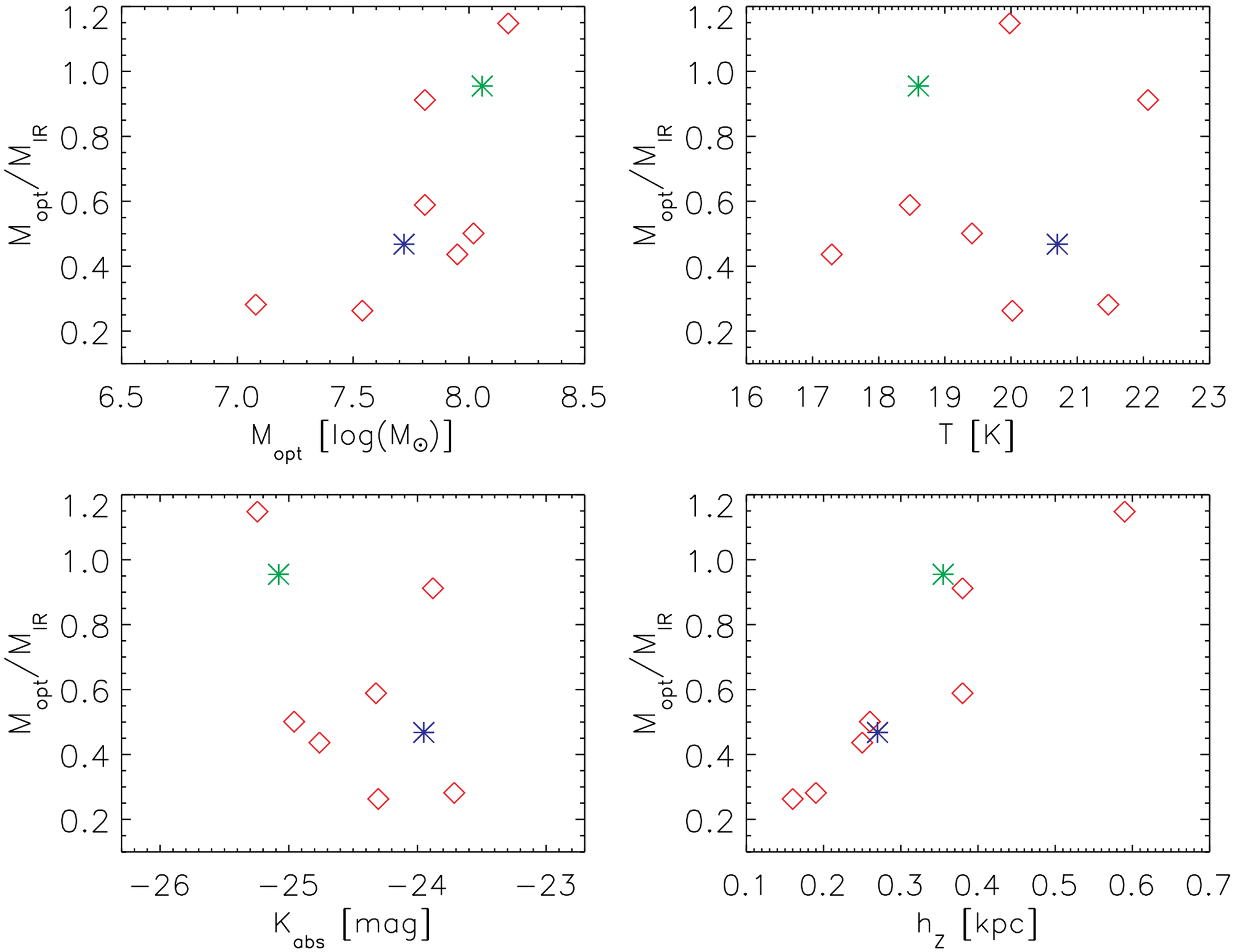
$$M_{\rm d} = \frac{2\pi\,\tau_\lambda^{\rm f}\,h_R^2}{\kappa_\lambda}$$

- From global FIR SED fitting:

$$F_\nu = \frac{M_{\rm d}\,\kappa_\nu\,B_\nu(T_{\rm d})}{D^2} \quad (\kappa_\nu \propto \nu^\beta)$$



Comparing dust masses



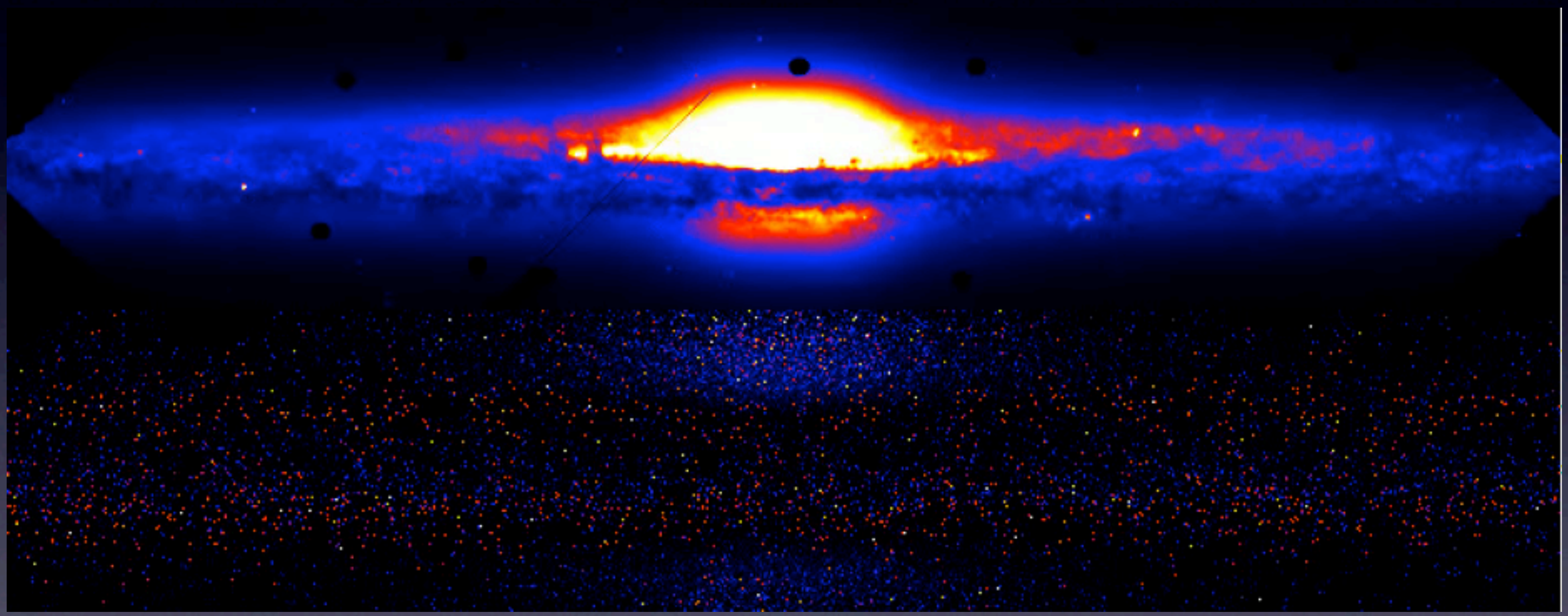
Dust mass comparison

- Mass ratio = measure for dust clumpiness?
- No clear correlation between ratio of 2 dust masses and other properties
- Except for vertical scaleheight from optical extinction
- Thinner dust disc: more clumpy structure?

Ongoing & future research

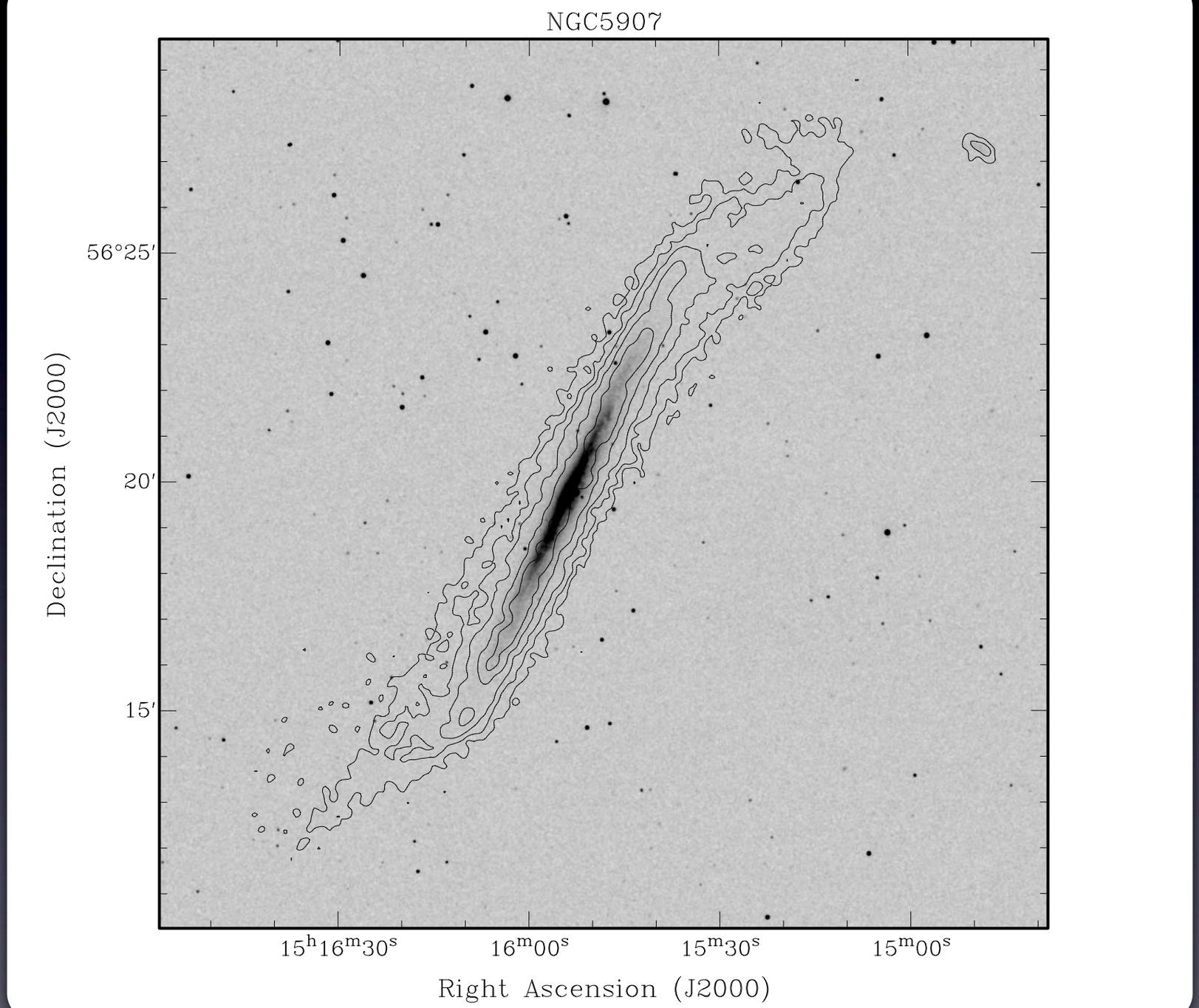
- Pixel-by-pixel SED fitting to study spatial variation of dust properties
- Detailed RT modelling with FitSKIRT, predicting FIR/submm from UV/optical/NIR
- Combining *Herschel* and HI & CO data to study gas-to-dust ratio (spatially resolved)
- Comparing dust-to-total-mass ratio in galaxies with global value in Universe

FitSKIRT



(De Geyter et al. 2013)

Radio observations



(Allaert et al. in prep.)

Questions?