Herschel Expoitation Of Local Galaxy Andromeda (HELGA)

A SPIRE/PACS guaranteed time Programme

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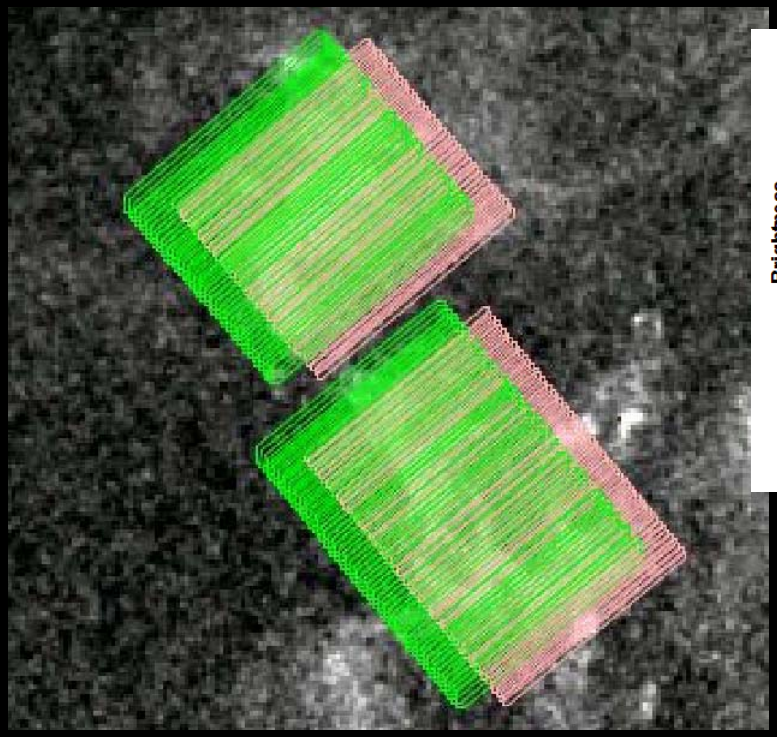
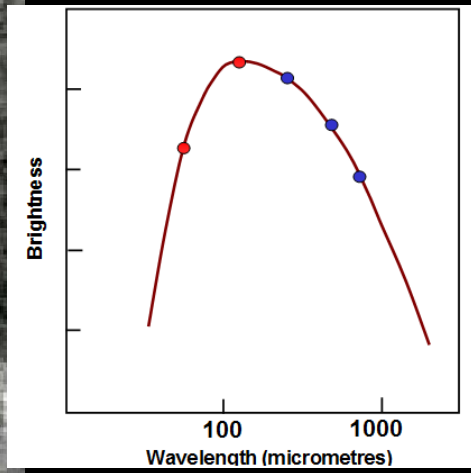
SPIRE SAG2 & The Belgian PACS team

SPIRE-PACS Parallel Mode

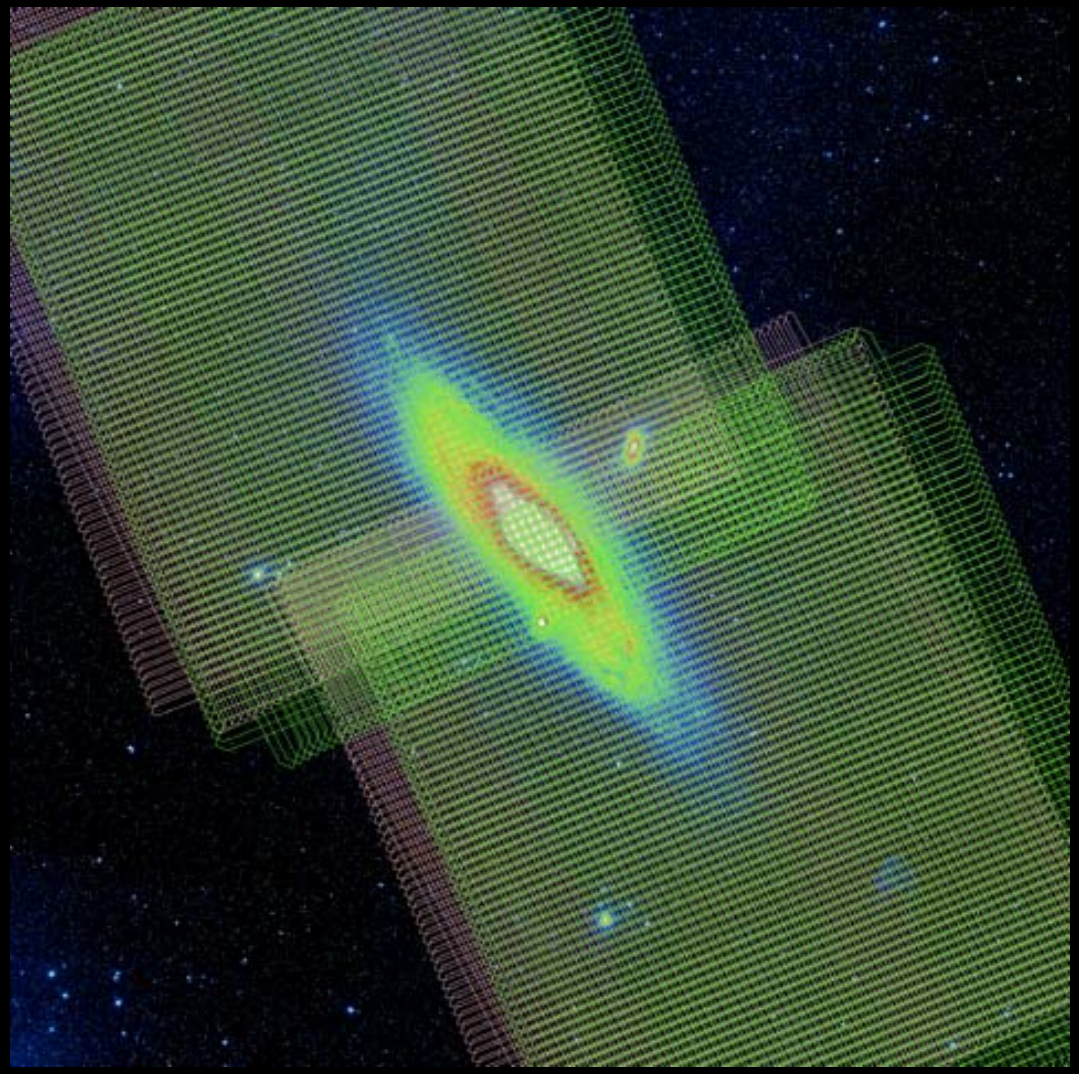
- Scan map with SPIRE and PACS
- Simultaneous 5-band mapping (3 SPIRE and 2 PACS)





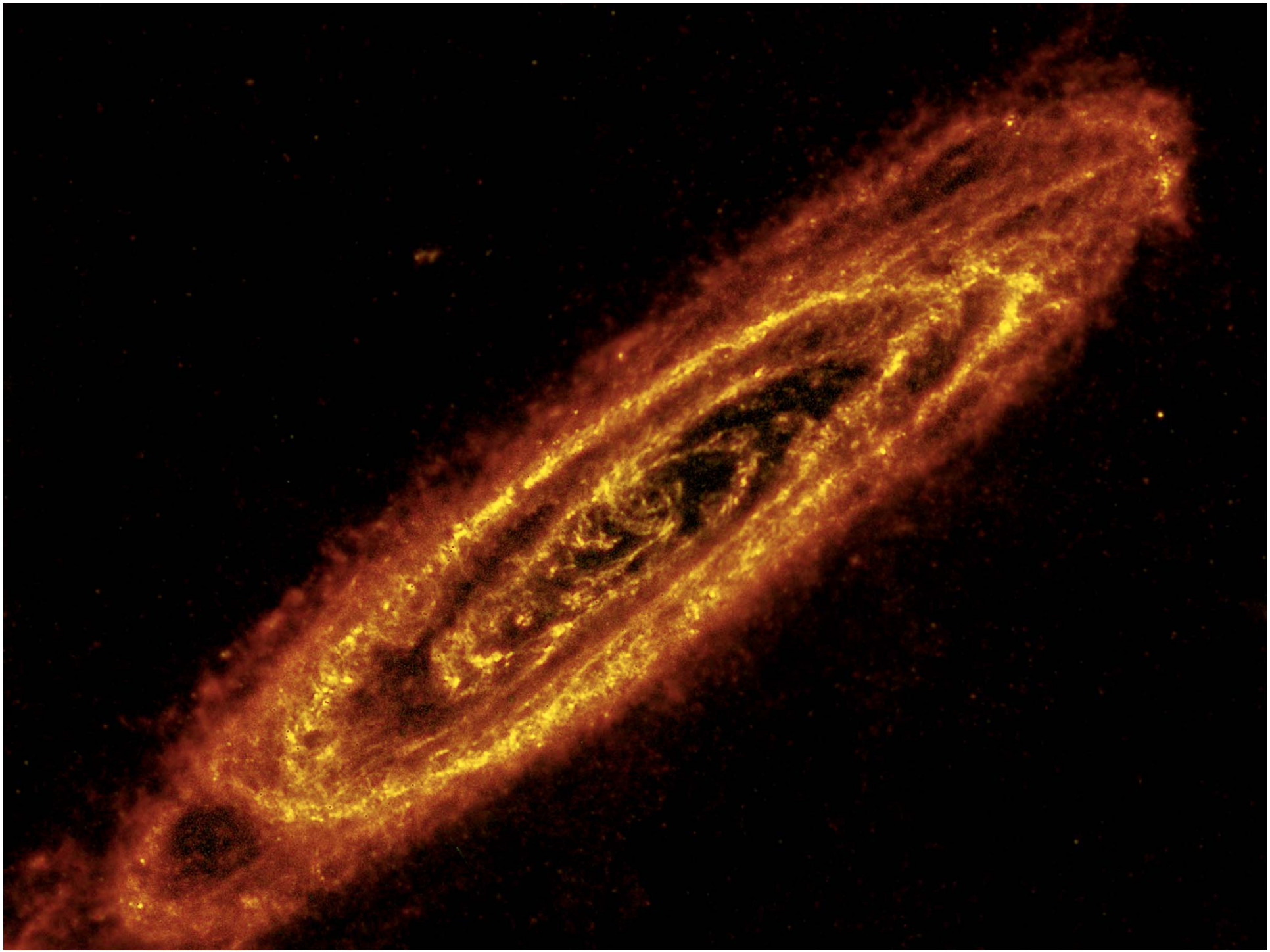
HELGA Observations

- 18.2 Hours
- 4 Scans
- Total 2.5x5.5 deg
- Observed over Xmas &New year
- Complementary XMM obsns made
- Results shown live on BBC TV !!
- Has become iconic Herschel image…

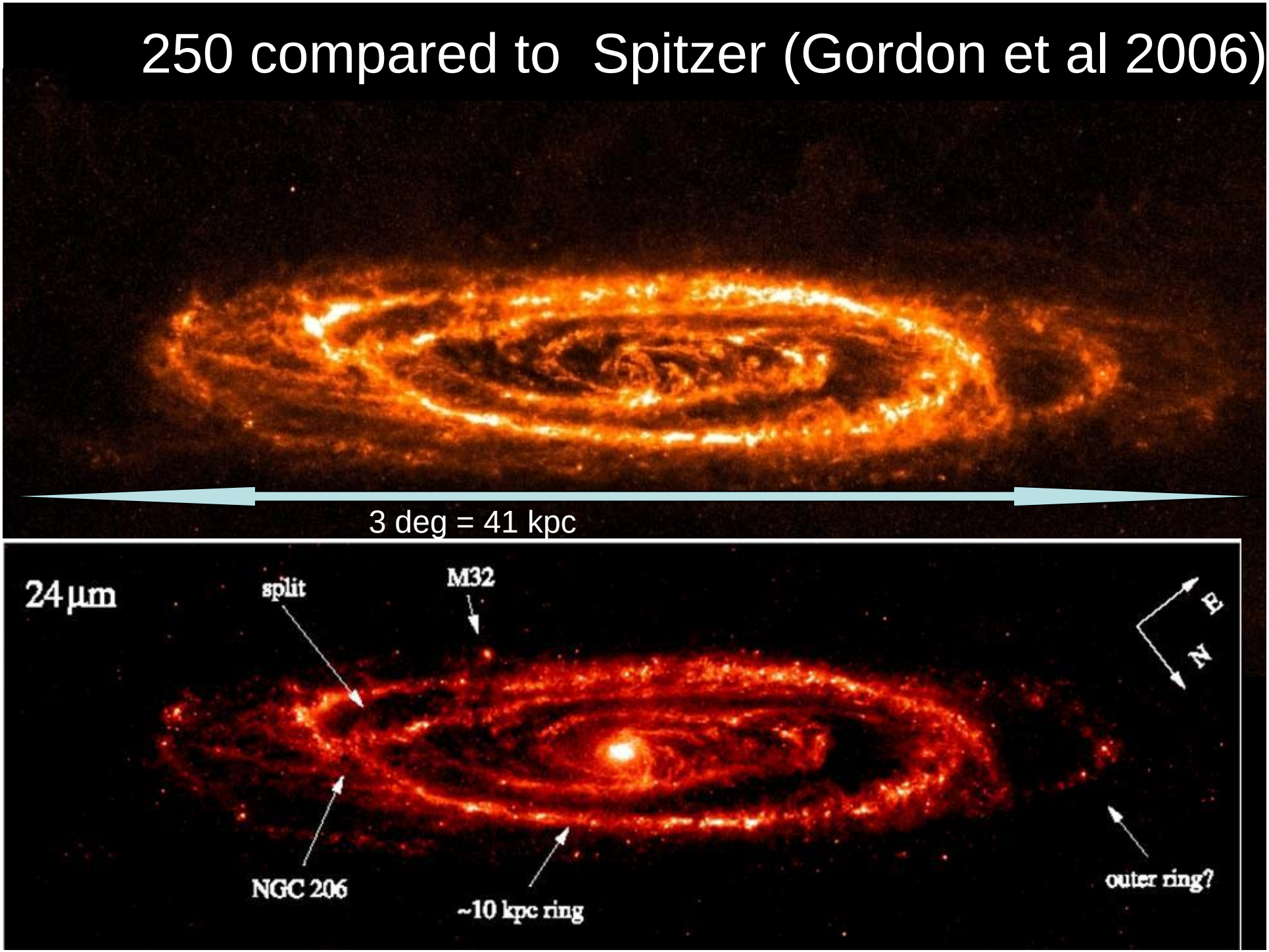


Herschel & XMM in BBC Stargazing Live

- Peak live audience of 4M
- 2.4M downloads of star charts



250 compared to Spitzer (Gordon et al 2006)

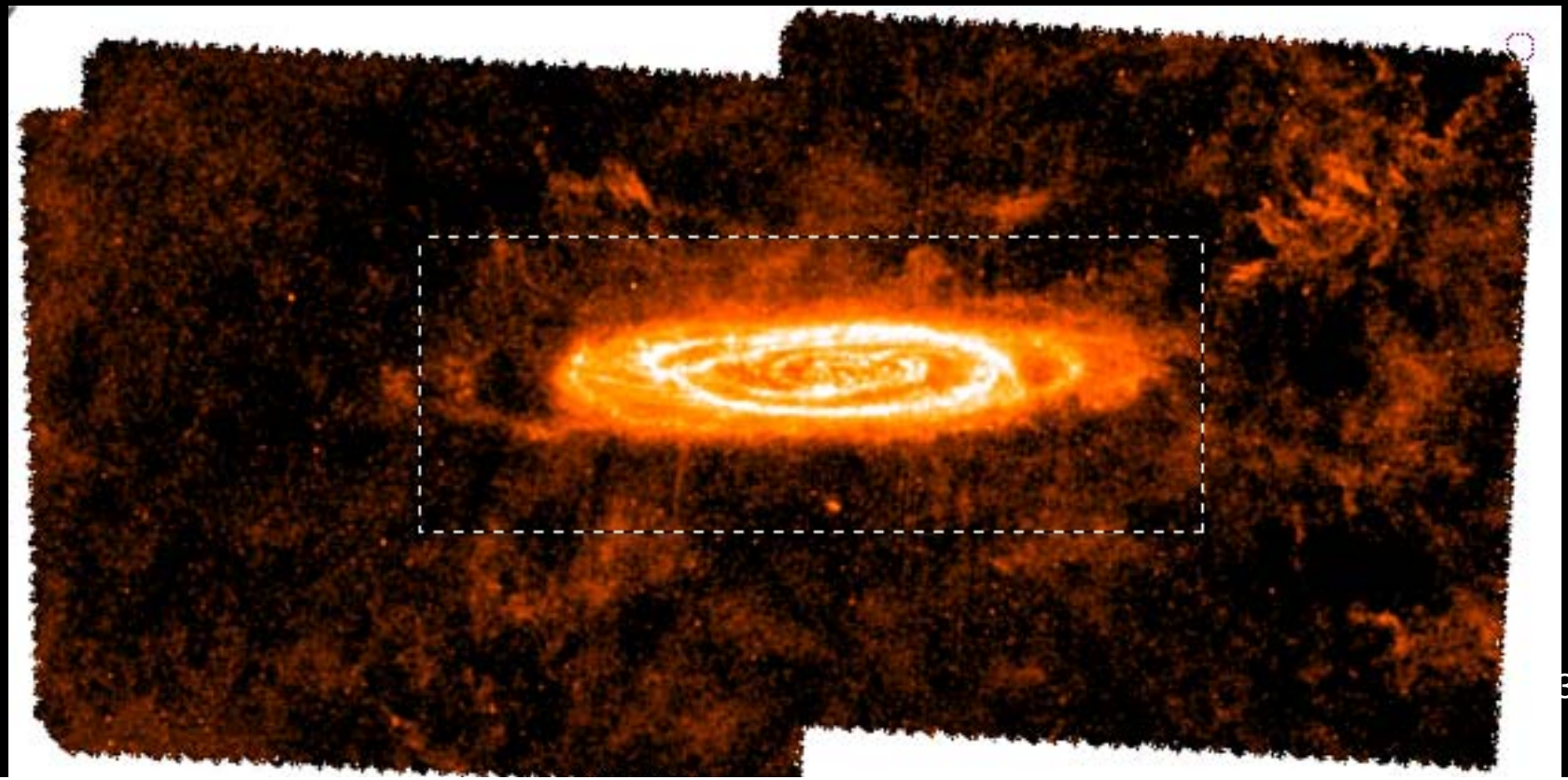


HELGA Science

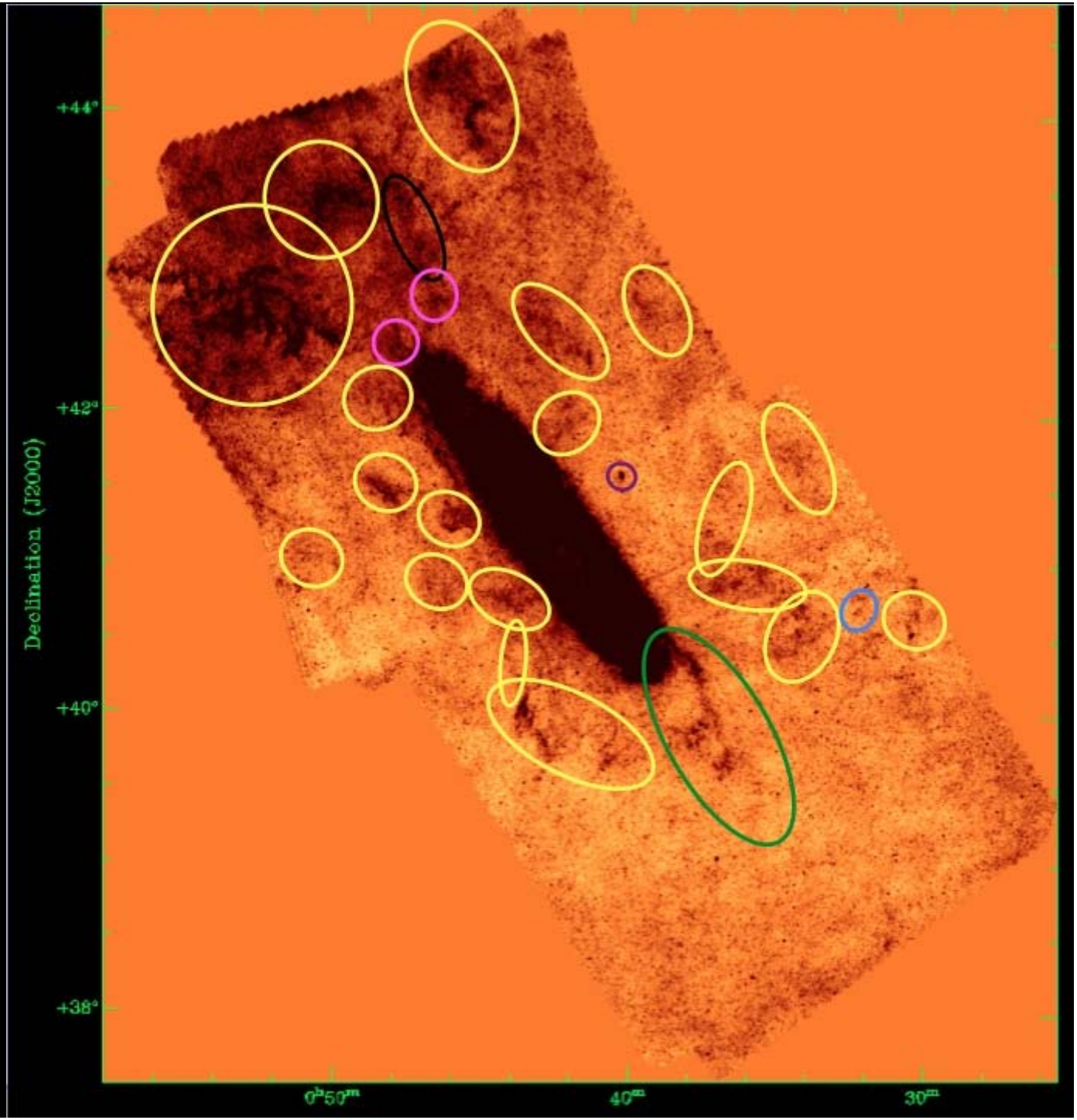
- HELGA is not just for PR
- M31 is the nearest and closest MW-like (?) Giant Spiral galaxy
- We can now study at high(ish) resolution all components – Dust, Molecular gas, Atomic Gas, Ionized gas, Young stars, Old stars etc
- We can study the (K-S) star formation law at a scale (~100pc) intermediate between more distant galaxies and the Milky Way

Cirrus contamination ?

- Full Image shows a lot of structure..(HELGA I Fritz et al 2012)
- Use HI data cubes (Braun et al) to isolate M31 & Galaxy
- Unfortunately M31 rotation velocity ~ systemic velocity so separation difficult on one side the one with most extended emission…

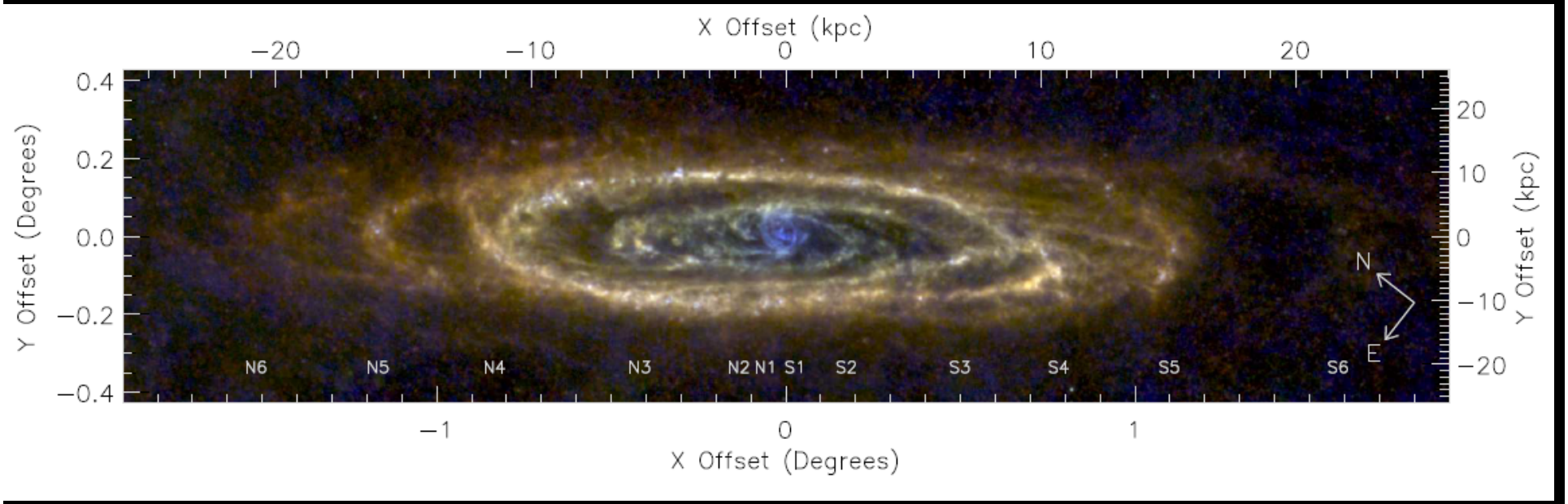


- Yellow areas definitely milky way
- Faint ring in green circle definitely M31
- Pink & black ambiguous
- Purple = NGC205
- Fritz et al 2012 A&A 546,A34

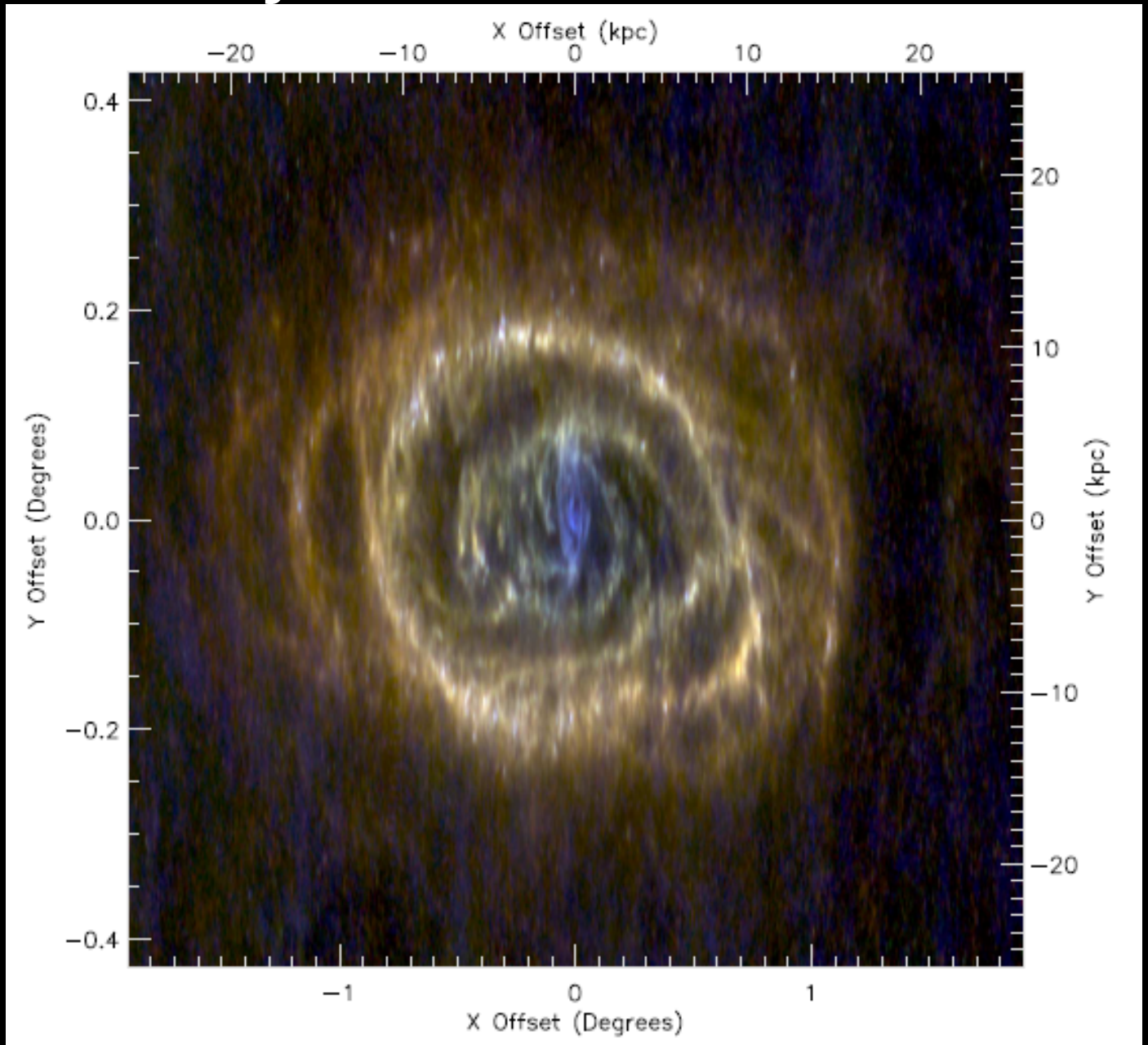


Nov 12th 2014

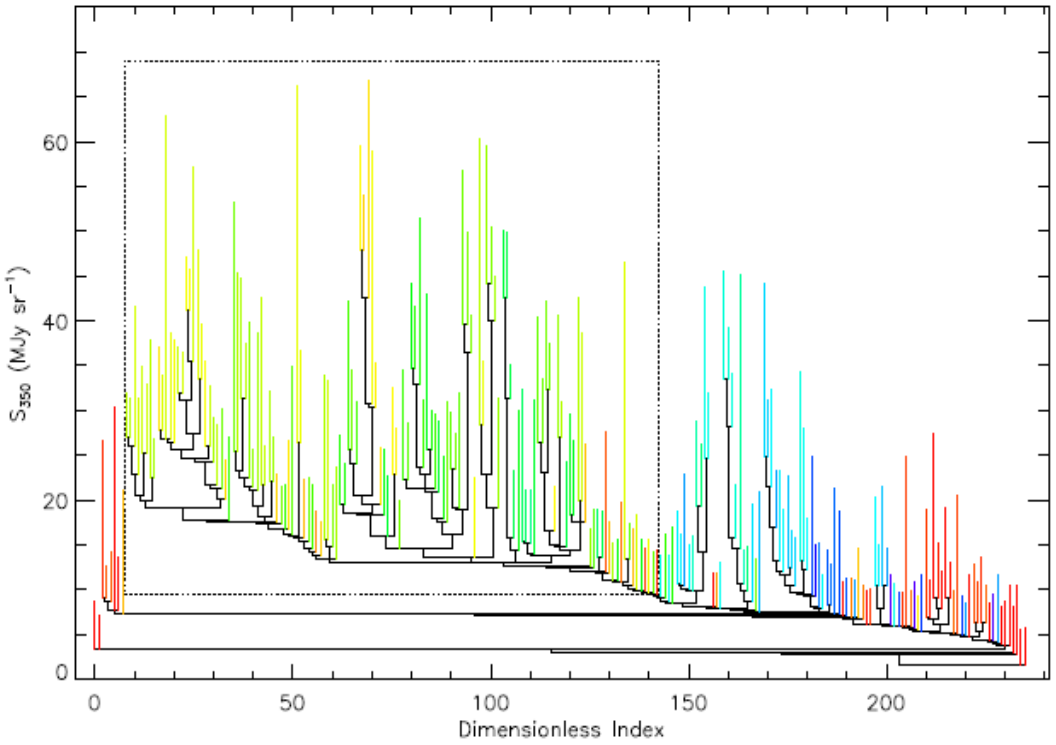
M31 Structure: 3-colour image..

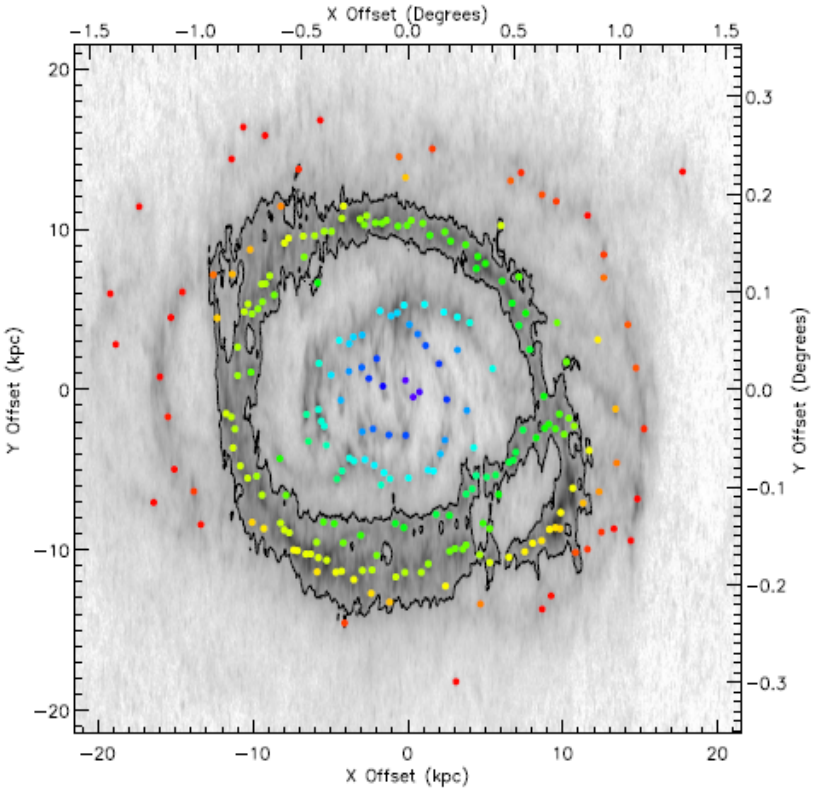


De-Project to Face-on View

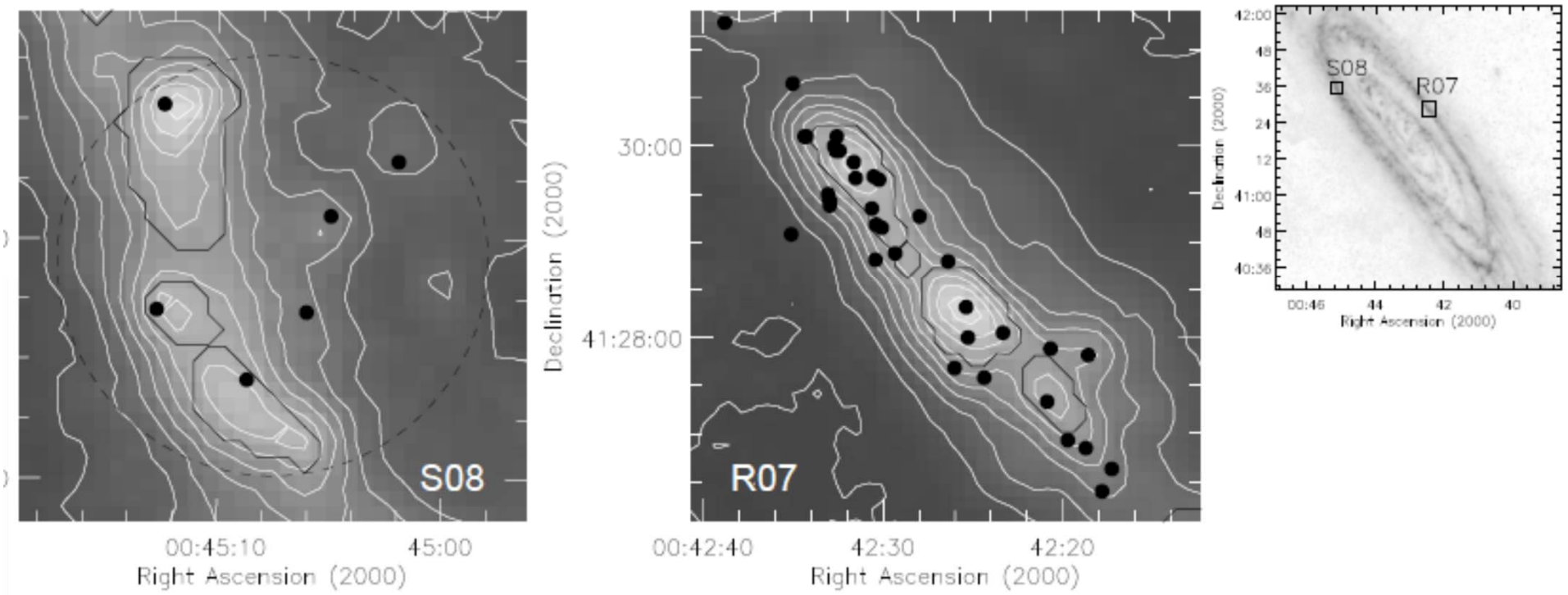


Pick out (236) Molecular Clouds from Extended Structure (Kirk et al HELGA VI)



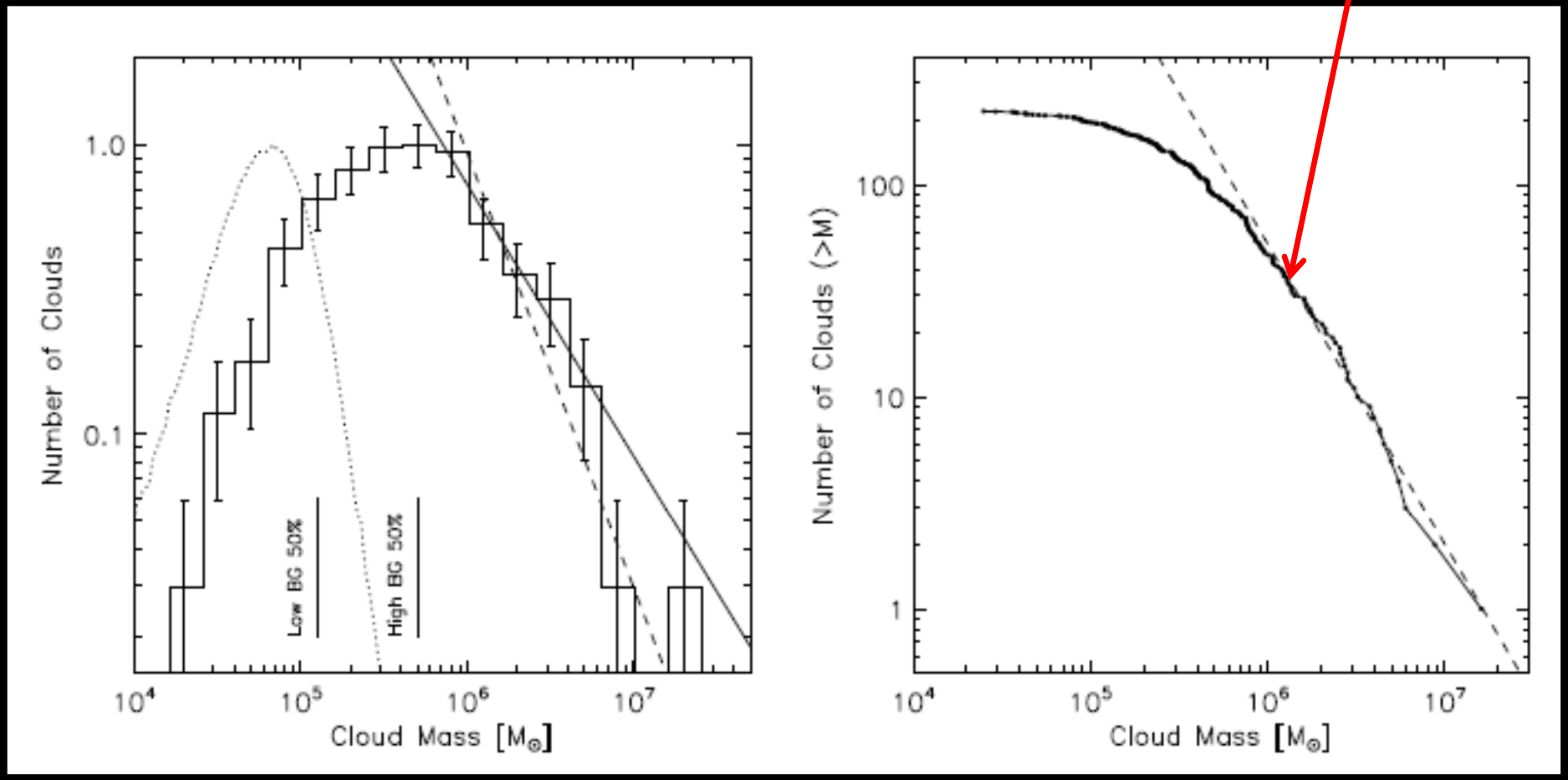


Compare with interferometry of small regions

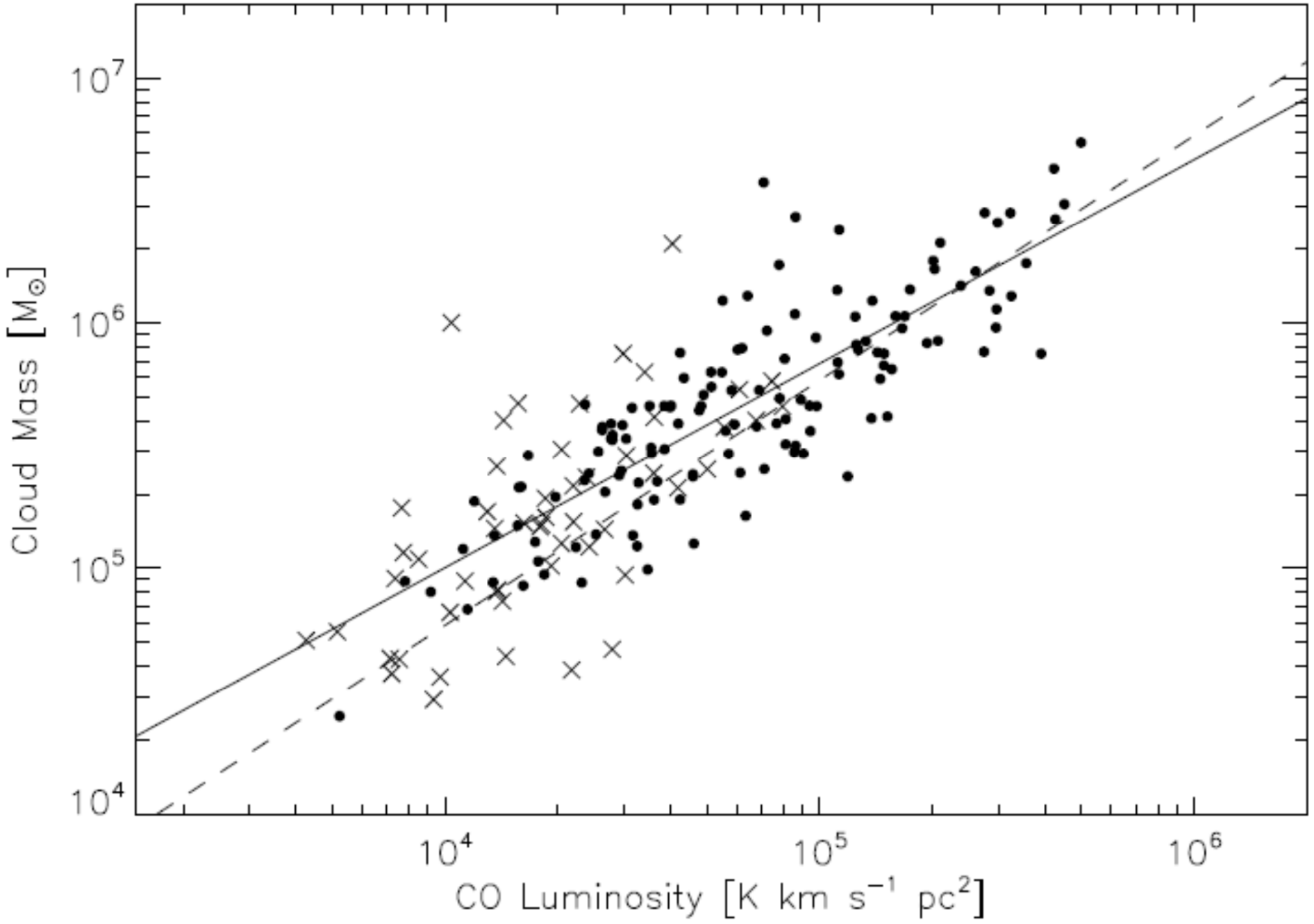


(left) Shetty et al 2008 and (right) Rosolowsky et al 2007 BIMA CO clouds as dots with contours and greyscale of SPIRE 350 um from Kirk et al

Cloud Mass distbⁿ a bit flatter than Milky Way

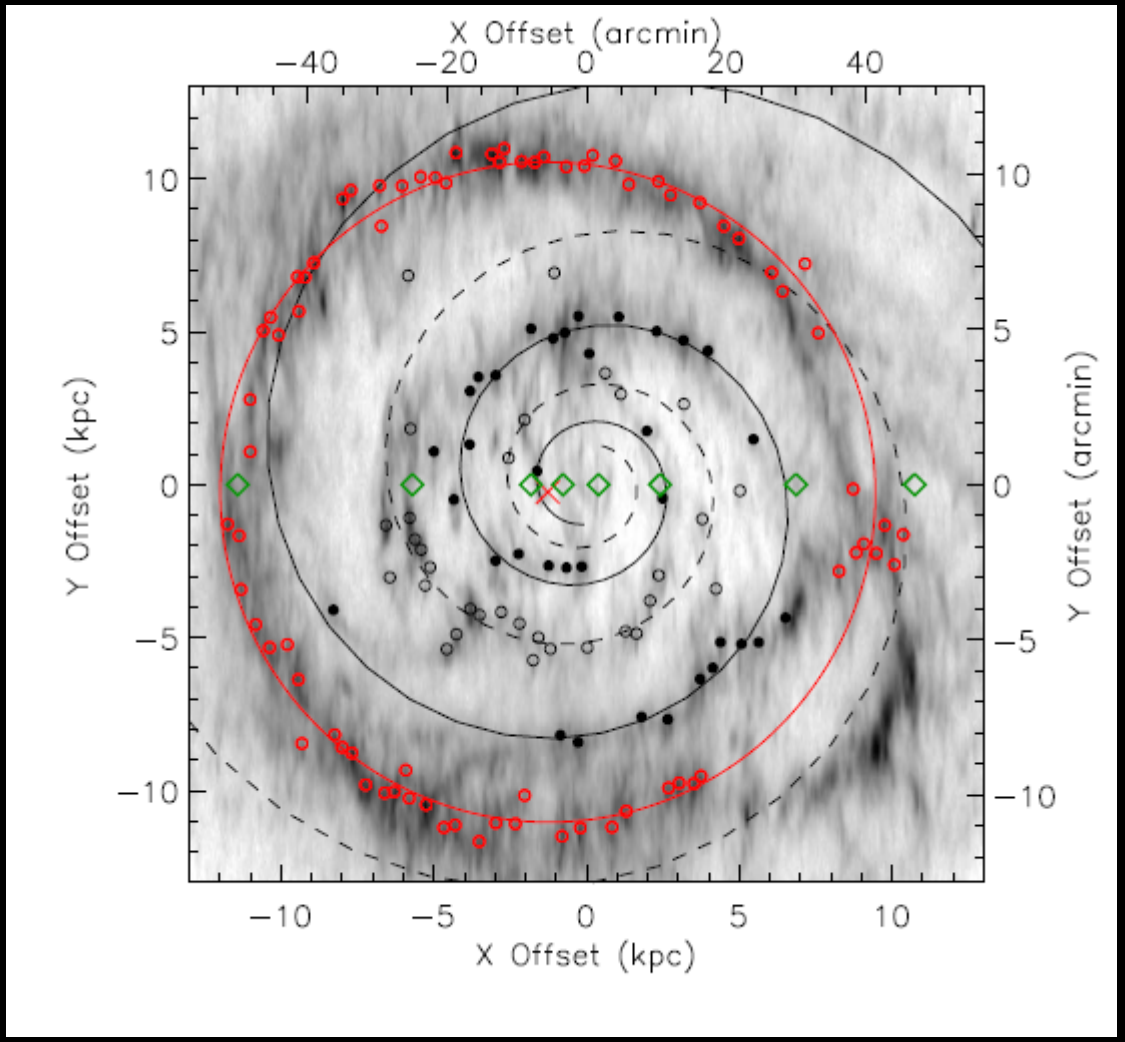


Dust is a good tracer of gas (cf Hildebrand 1983)



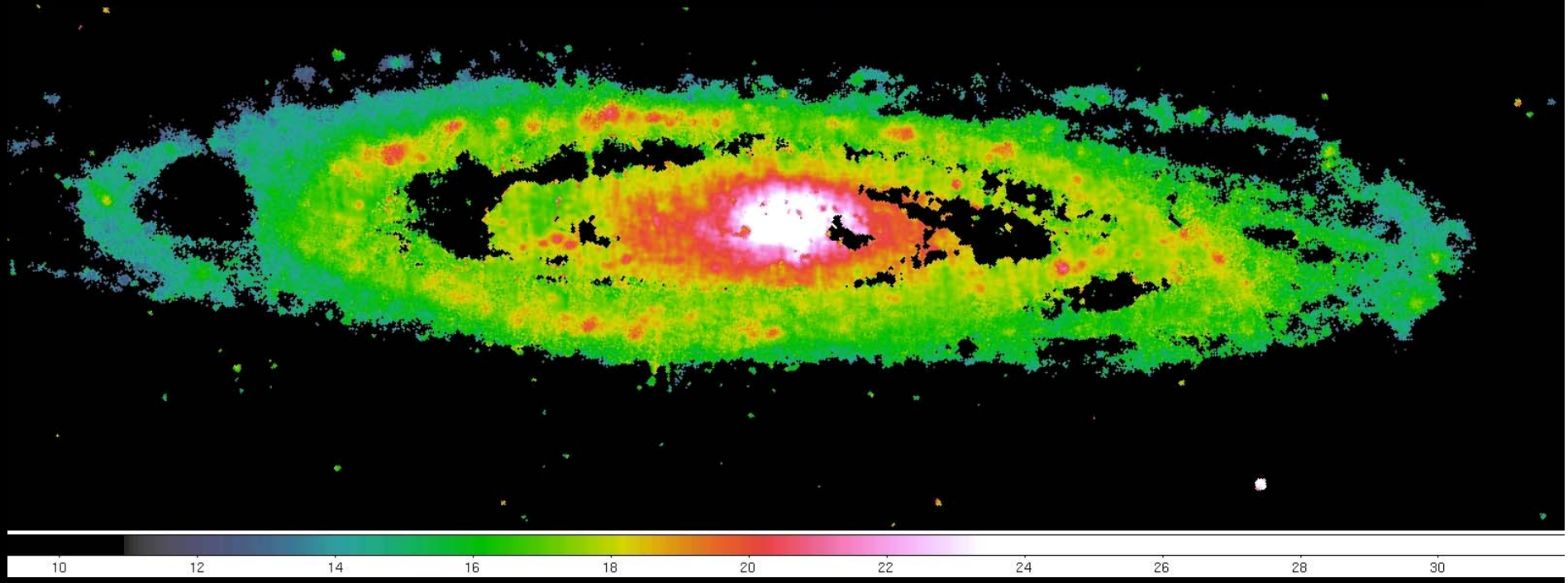
Spiral Structure

- Has been controversial
- We confirm Ring + 2 spiral arms as proposed by Gordon et al 2006



Dust Temperature Map

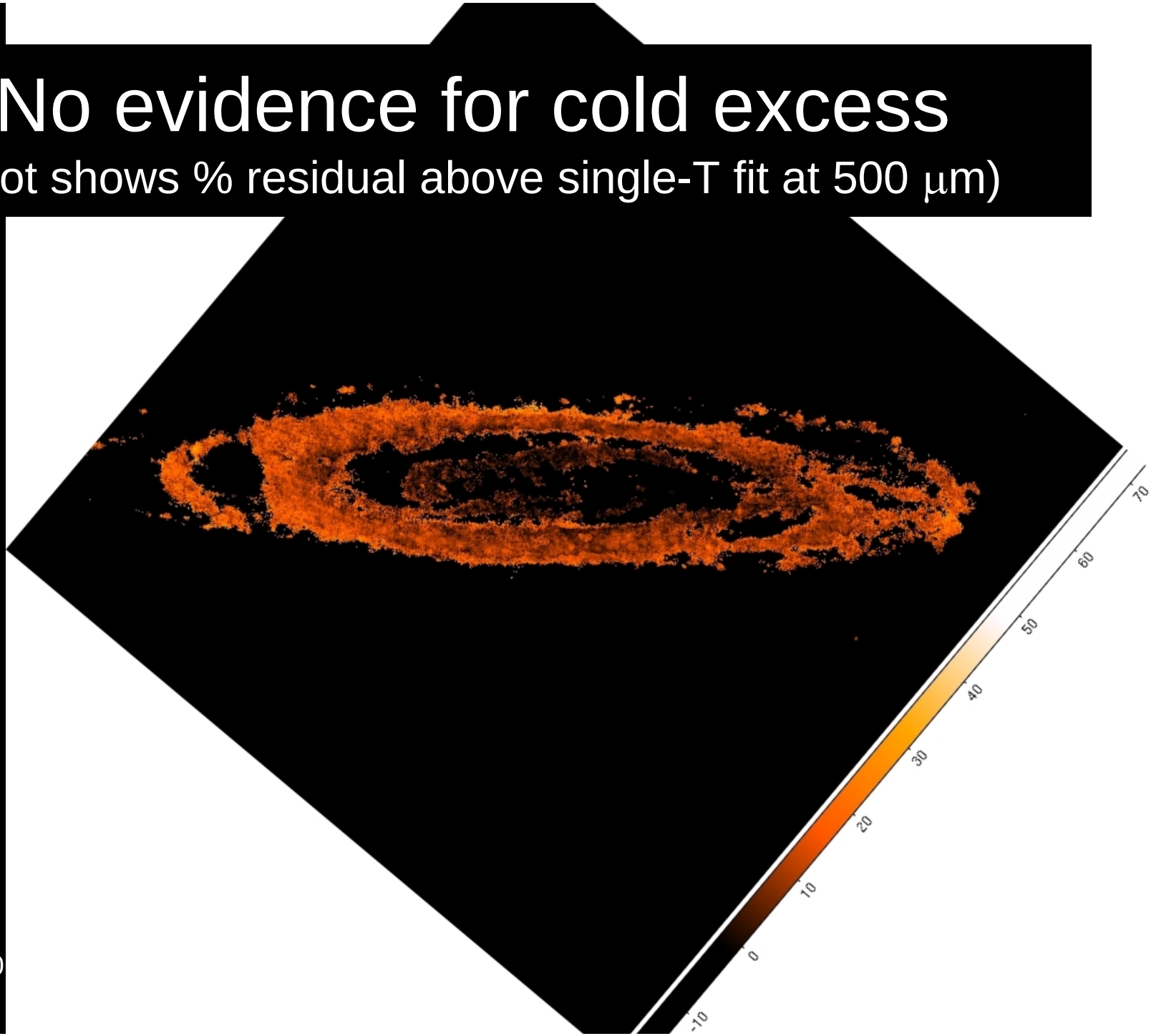
HELGA II Smith et al 2012



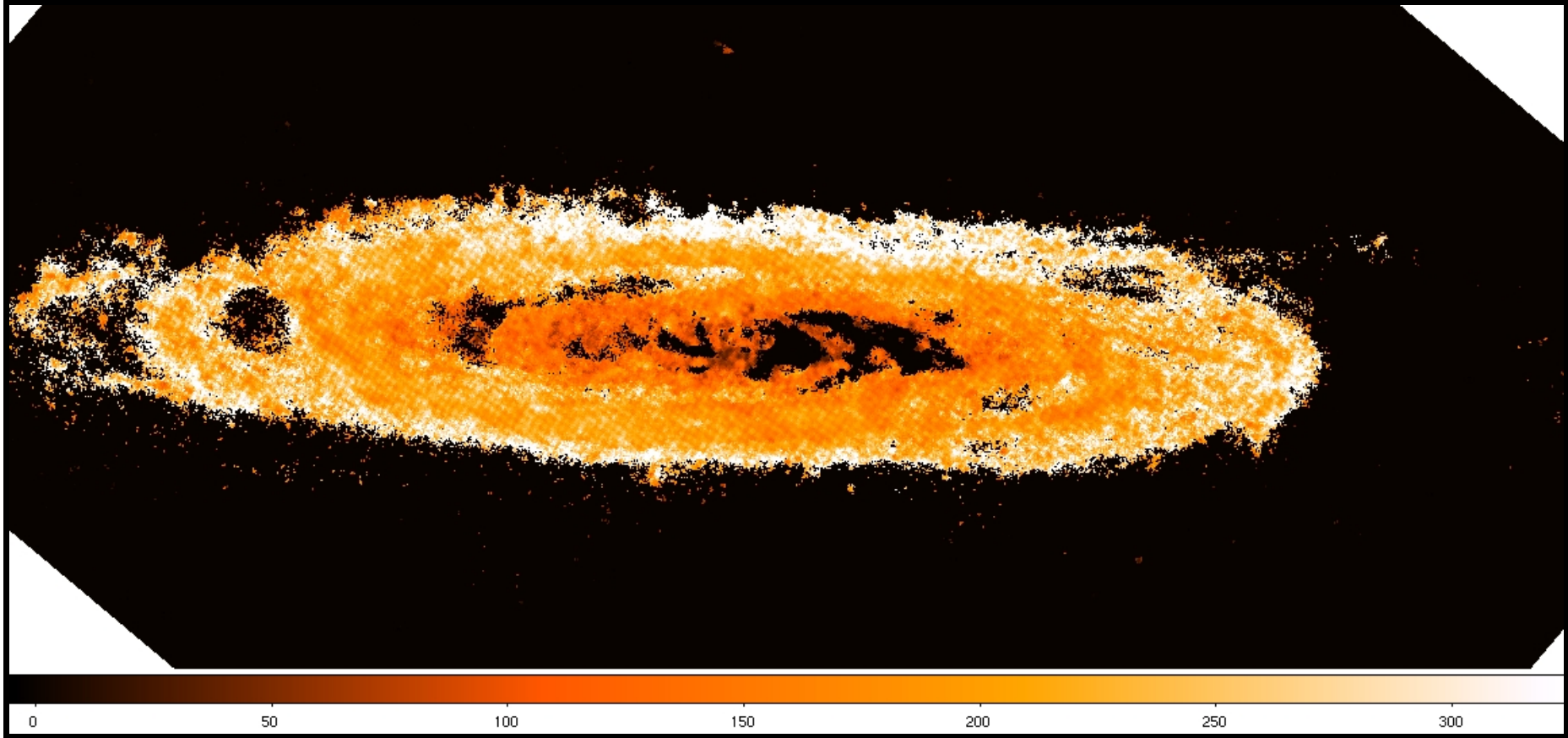
- 500, 350, 350, 160, 100 +70 um upper limit
- 12 “ pixels, must have at least 3 fluxes >5σ
- Temp range 12-32K (for β =2)

No evidence for cold excess

(Plot shows % residual above single-T fit at 500 μm)



Gas to dust ratio I (M. Smith et al 2012)

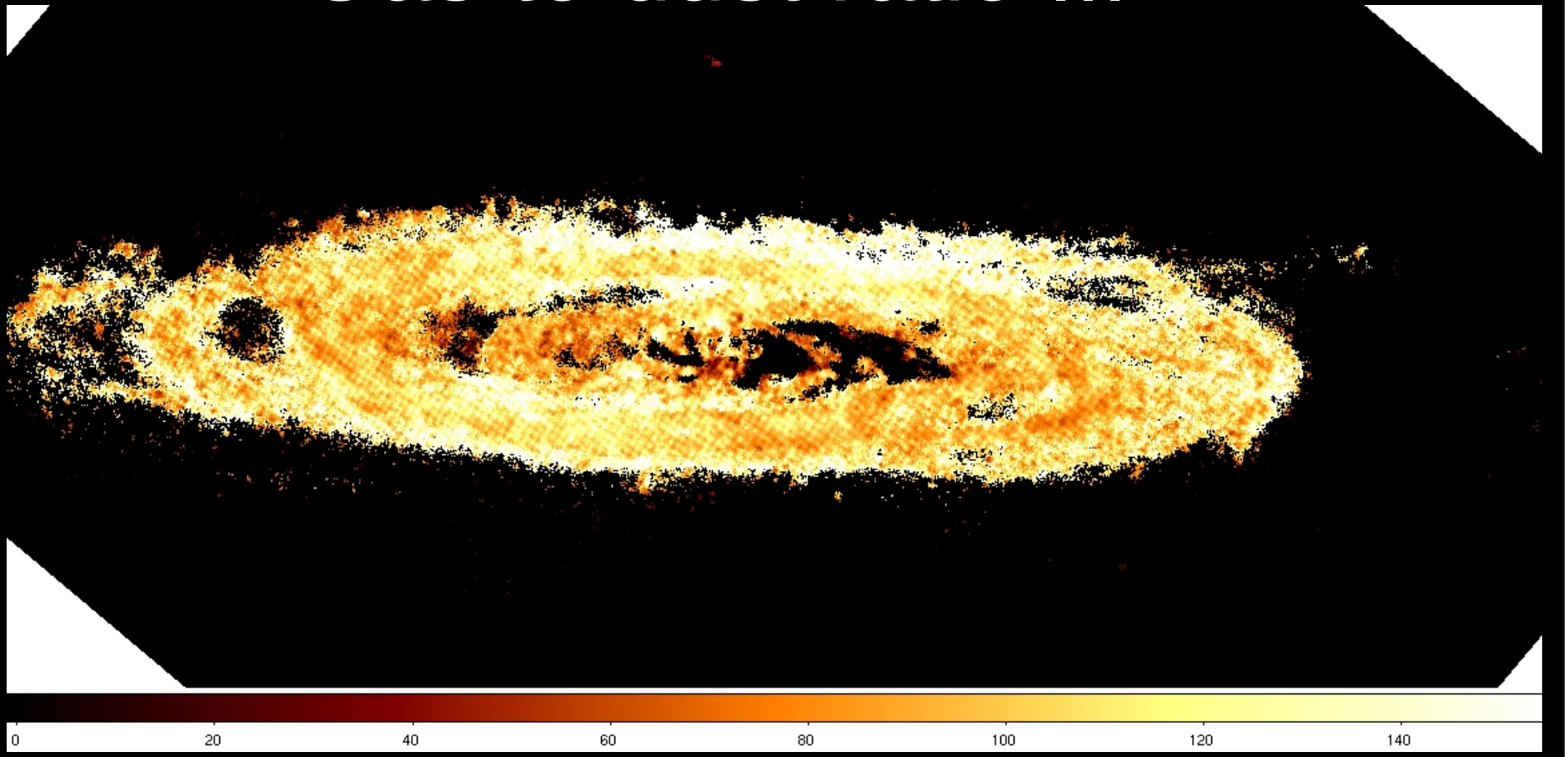


- Take dust mass from HELGA & H_2 from CO map (Neininger et al) with $X=2x10^{20}$
- HI from Braun et al
- Plot gas/dust map

Gas to dust ratio II

- There is a clear radial gradient in previous image g/d ~30-250
- However there is also a known radial metallicity gradient
- HI from Braun et al
- “Correct” dust masses linearly for metallicity gradient and replot

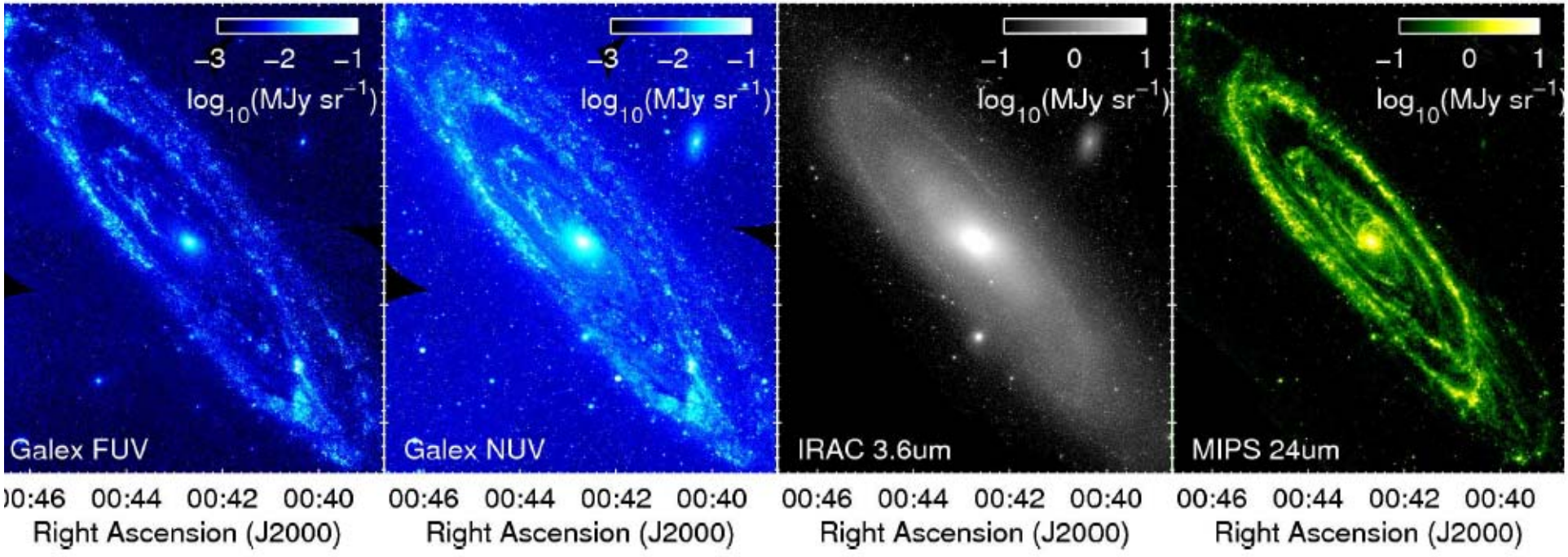
Gas to dust ratio III



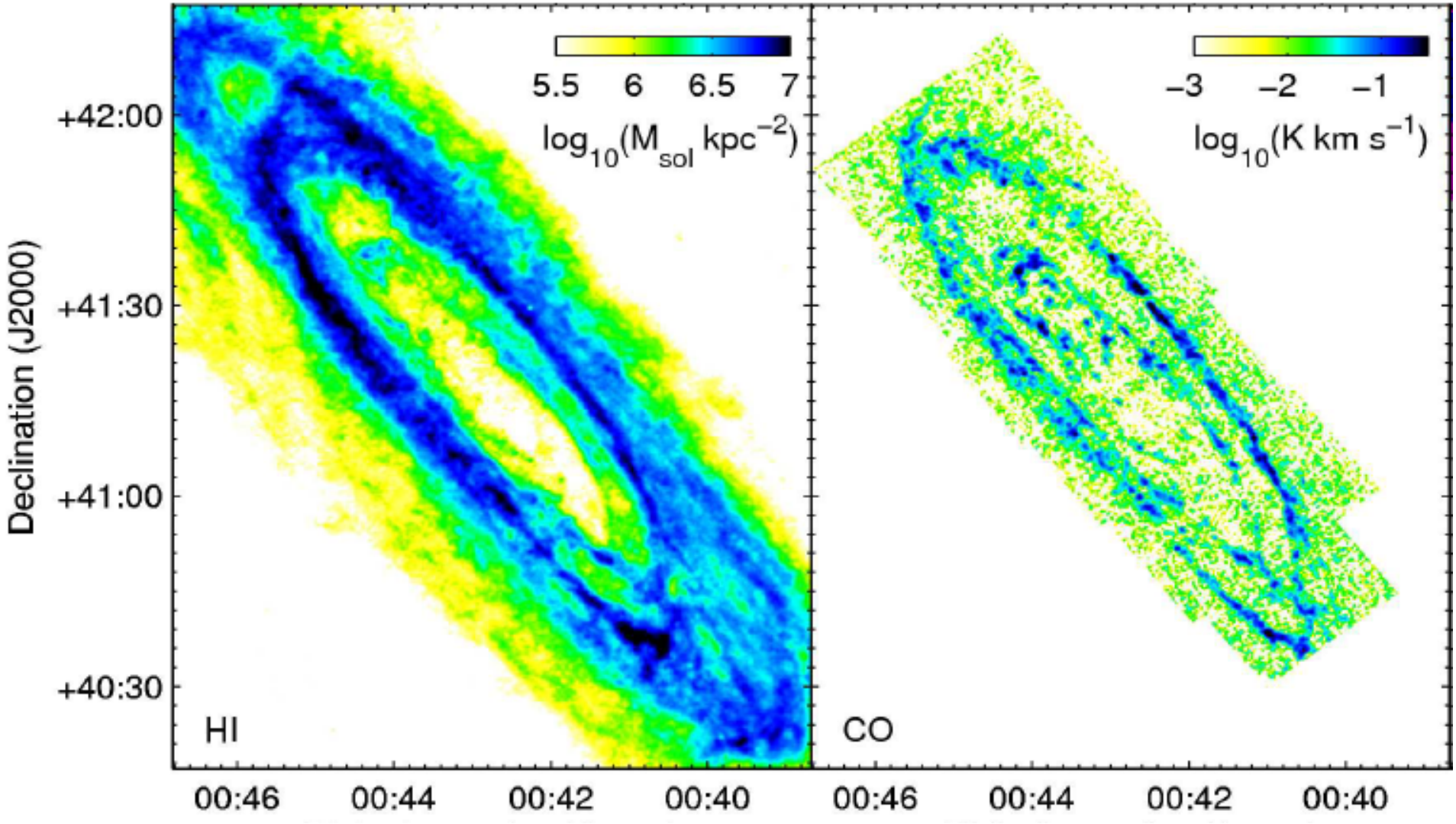
- Range now very narrow around g/d @100

Global SFR in M31: (Ford et al 2013 HELGA III)
M31 is well studied in almost all possible tracers..

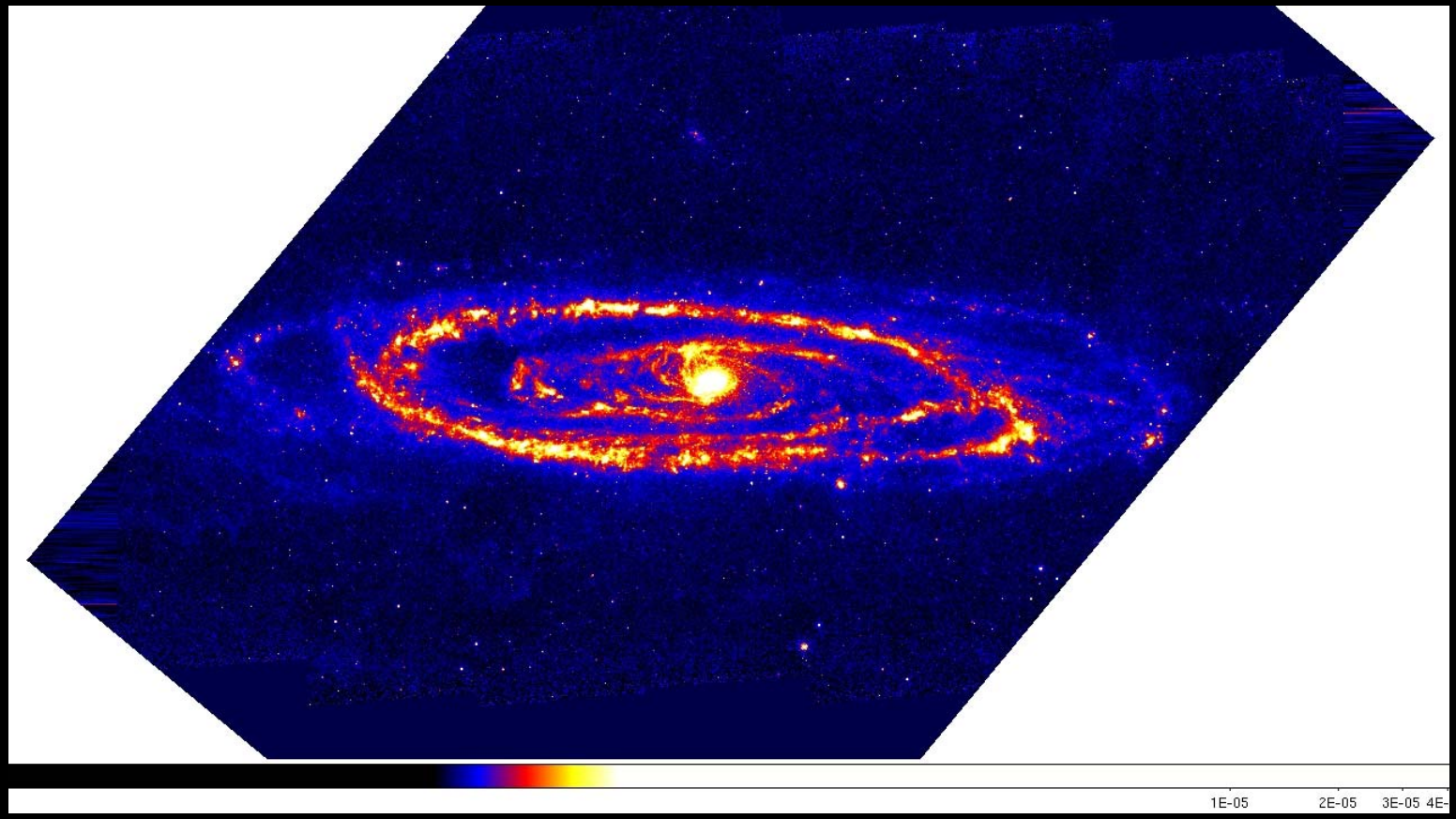
Hot young stars Old stars Hot Dust



Atomic & Molecular gas

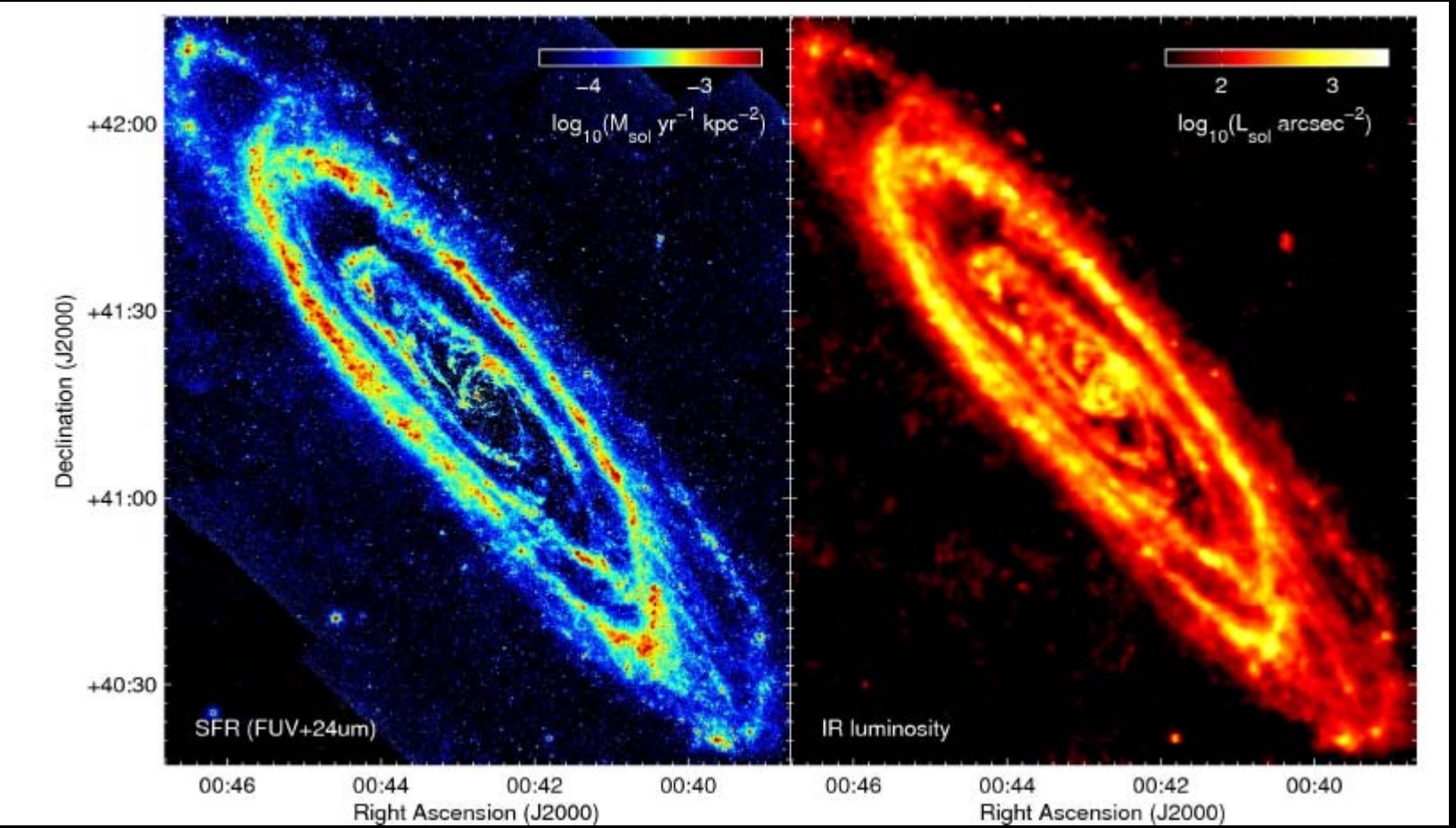


Star-Formation Rate



- SFR in M_{solar} Kpc $^{-2}$ yr $^{-1}$
- Using Leroy et al 2008 prescription from combination of UV and 24 um
- Total SFR <~ 0.3 Msolar per year

Compare (UV+24um) to L_{FIR} SFR

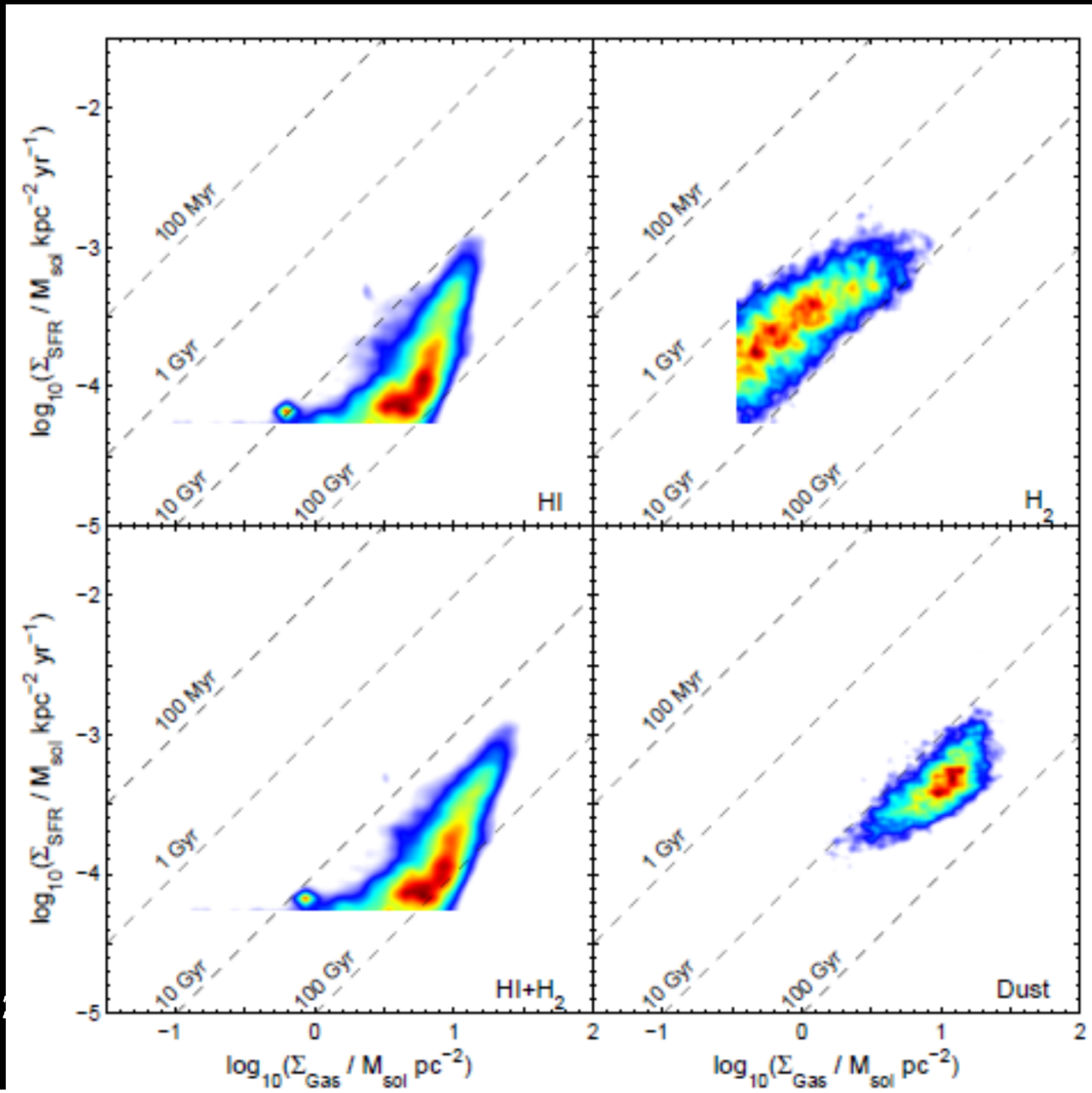


- L_{FIR} always gives x3 higher rate due to heating by ISRF
- Total SFR ~0.3 M_{sun} yr^{-1}, a factor ~10 lower than Milky way

M31 K-S results for different gas tracers

HI

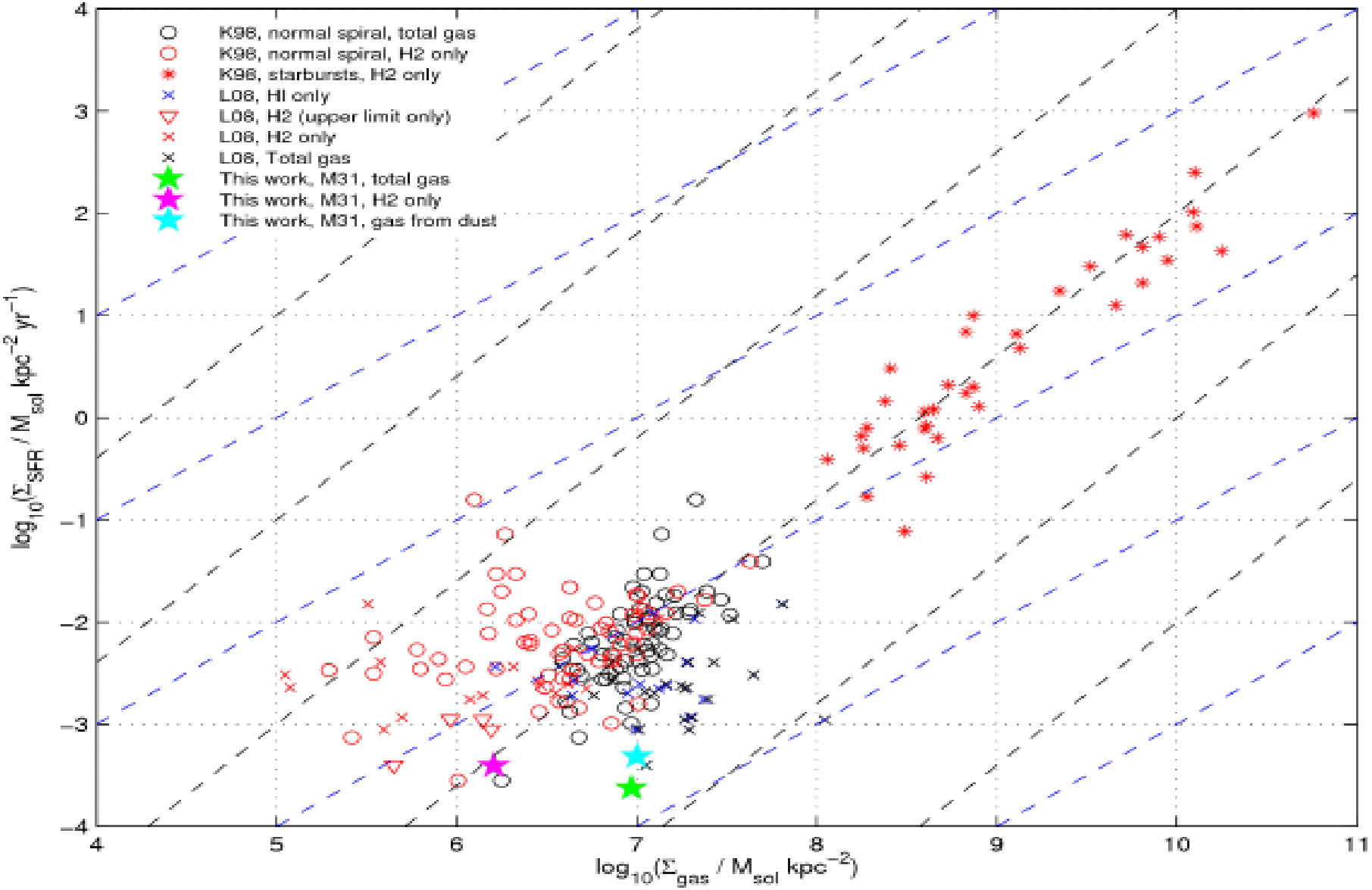
H_2(CO)



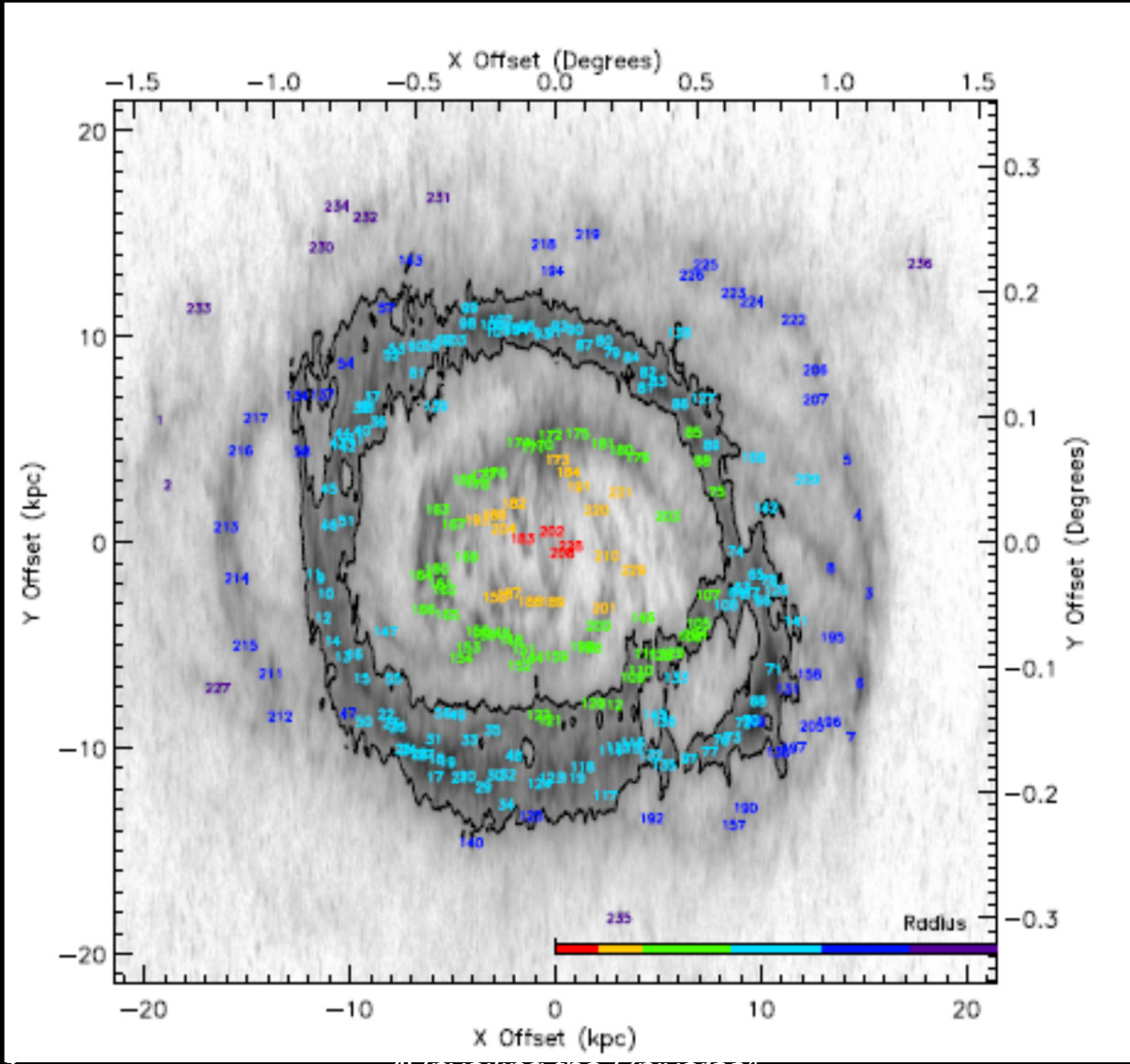
$HI+H_2$

gas(dust)

M31 globally seems to be consistent with being at the very low SFR end of the universal trend..



K-S results for GMCs only



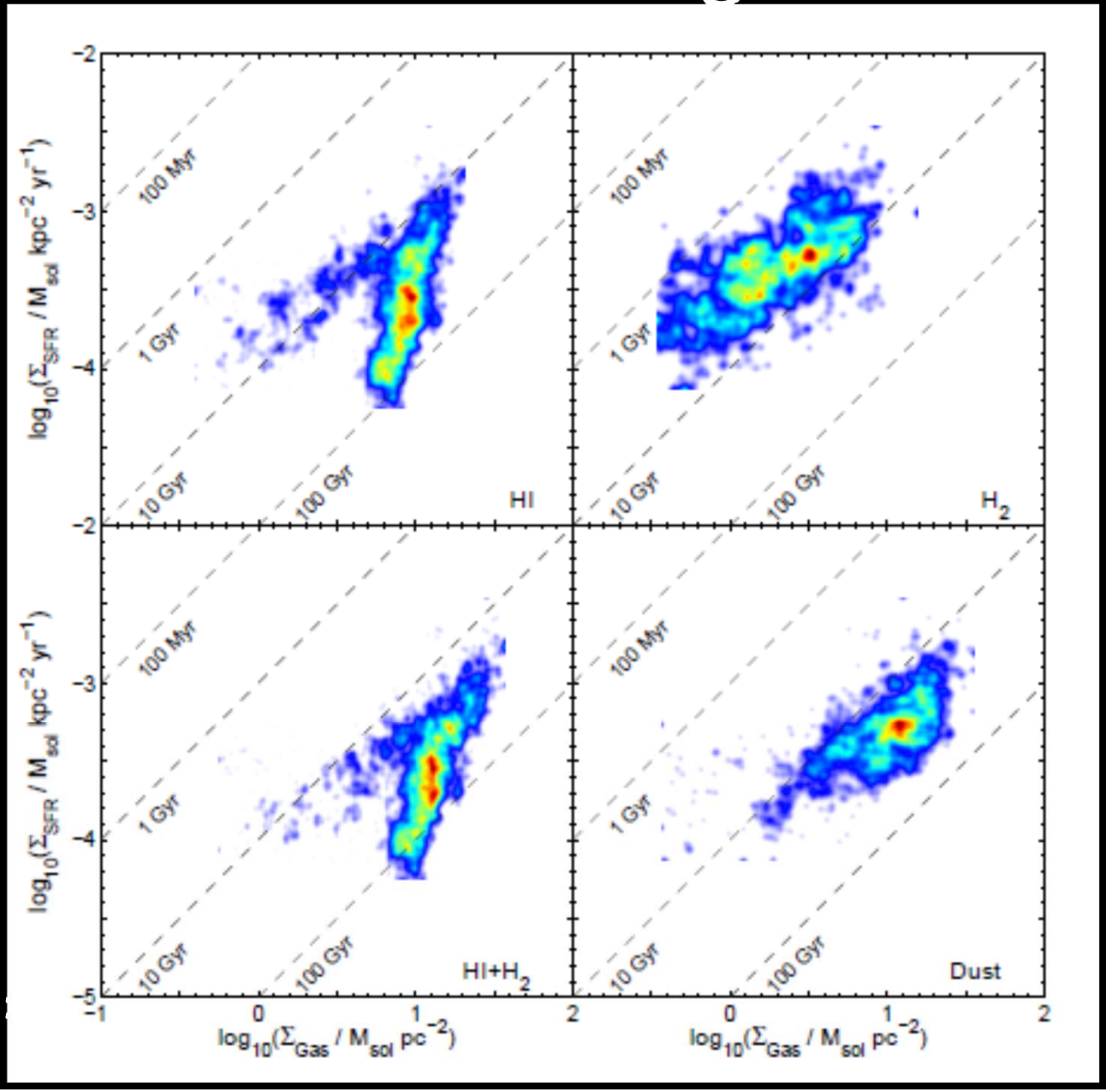
K-S for GMC catalog sources only

HI

H_2(CO)

$HI+H_2$

gas(dust)



Future Work

- Compare M31 results with Herschel Hi-Gal and SCUBA2 Milky Way detailed surveys
- Higher angular resolution follow-up of GMCs
- HST M31 legacy survey (PHAT) will allow counting of individual stars and complete resolution of contributions to the ISFR and heating of the dust
- Conduct similar analyses on other local galaxies (M33, LMC, SMC etc)
- How much of the scatter in K-S plots is due to calibrations of different tracers ? (H2020 network?)
  - SFR (UV, Hα, 24 μm, FIR, CII etc…+IMF, SFH etc)
  - Gas mass (CO X-factor, metallicity, dust…etc.)