



Imaging Andromeda and Nearby Galaxies with SCUBA-2: HASHTAG & DOWSING

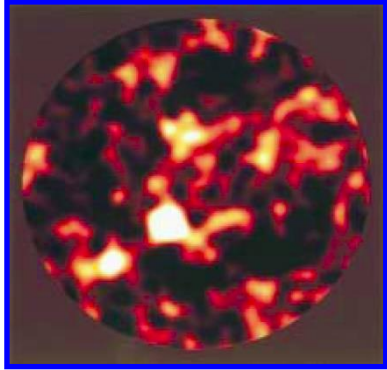


Overview – Continuum Talk

- ▶ 17 minutes too short to talk about all JCMT nearby galaxy science
- ▶ Will talk about some very selected dust topics/problems
- ▶ HASHTAG
 - ▶ CO survey (2 papers) – see Zongnan Li's talk
 - ▶ Overcoming SCUBA-2 challenges
- ▶ DOWSING
- ▶ Advertising a postdoc position soon in Cardiff, and open to new members

Dust as a Tracer

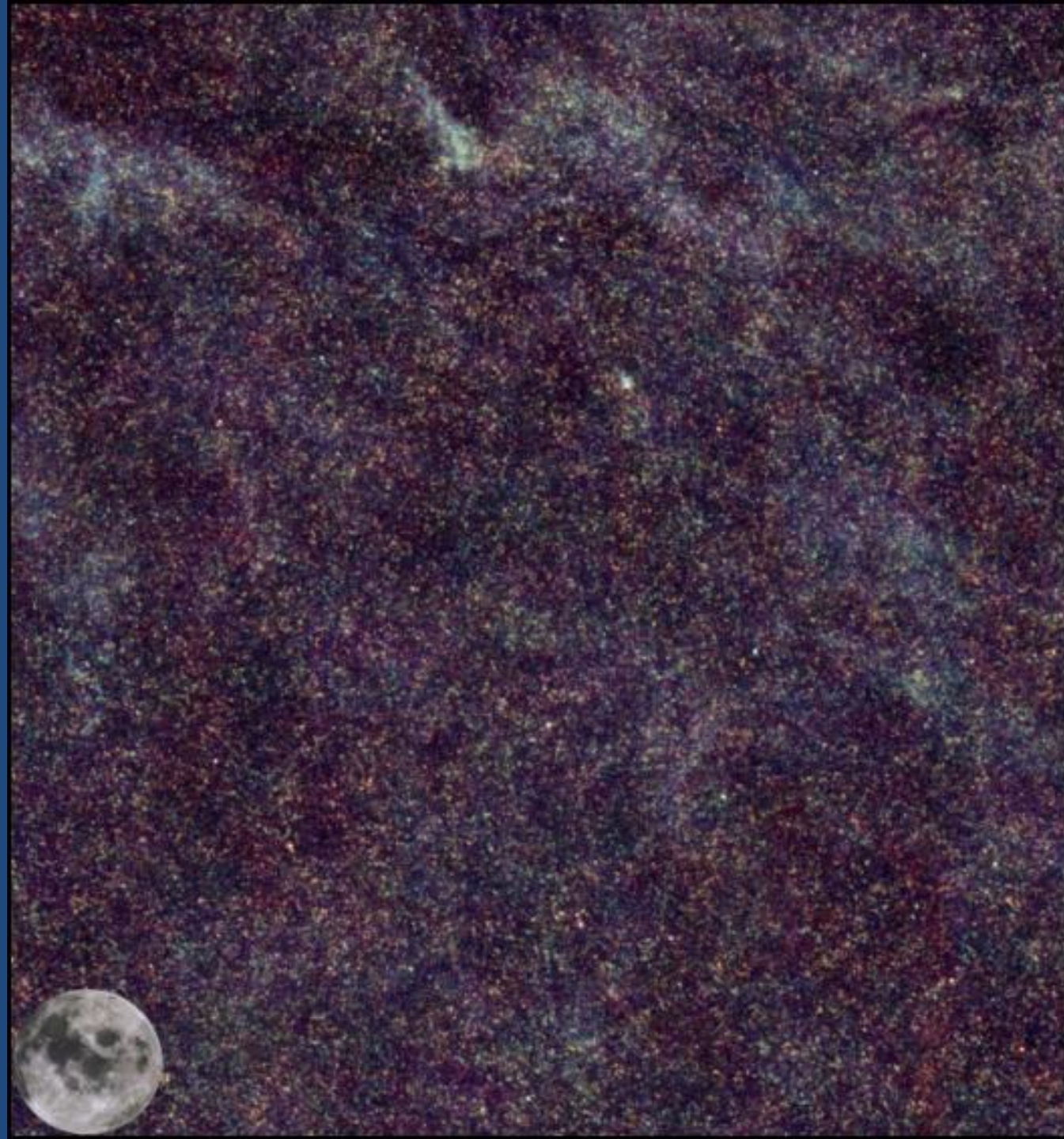
1998 Ground-based
5 galaxies after 20 nights



To scale



- ▶ Gas as a tracer has been suggested since Hilderbrand (1983)
- ▶ Found promising with Herschel e.g., Eales et al. (2010/12), Sandstrom et al. (2014), need to account for the metallicity
- ▶ Becoming more prominent with ALMA continuum measurements of high- z galaxies being efficient (Scoville 2016).
- ▶ For Early-Types ETGs are more easily detected with Herschel than gas tracers (Smith et al. 2012, Amblard et al. 2014)



16 out of
660 sq.
degrees

**All H-ATLAS
now released!**

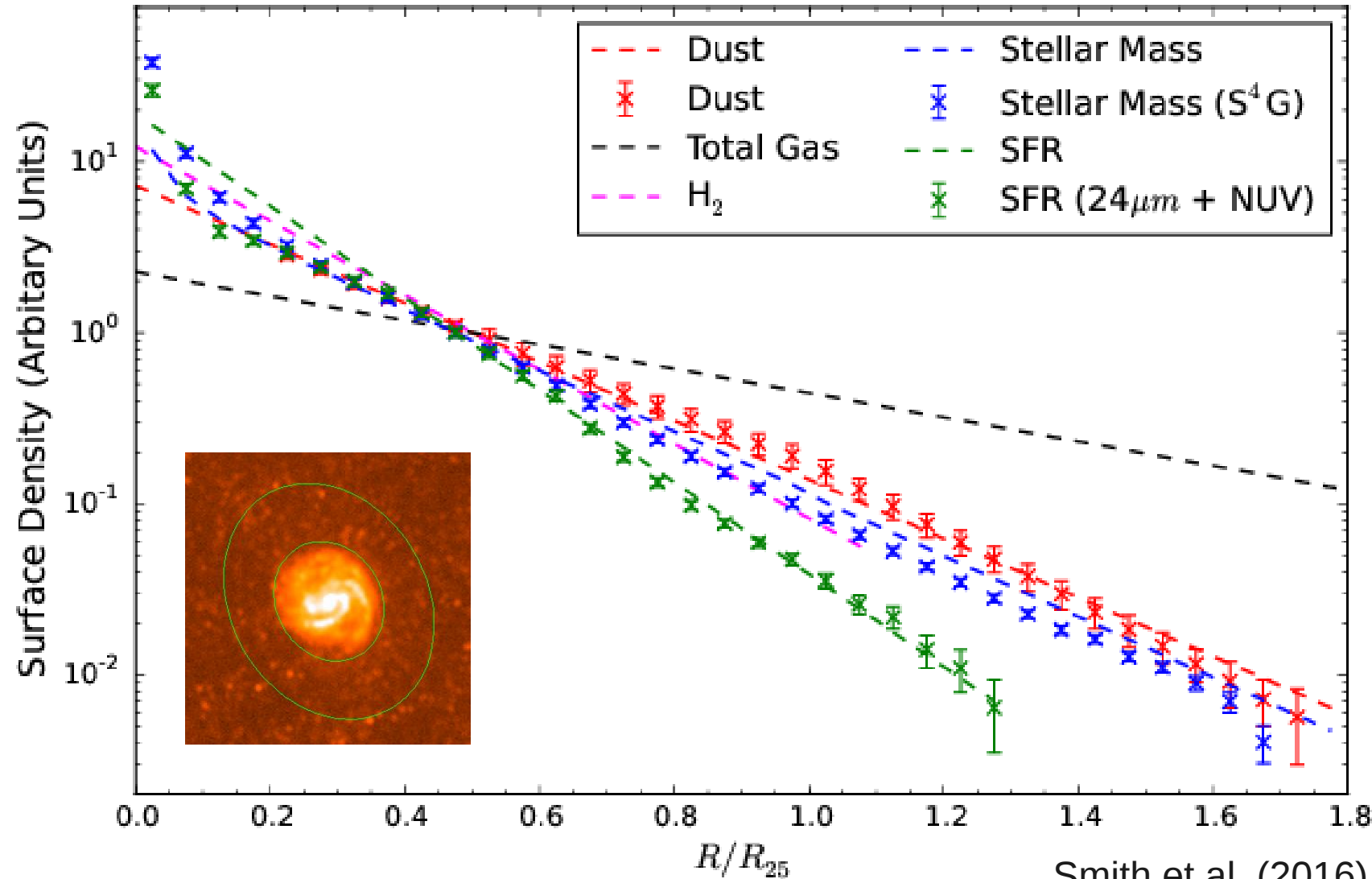
(Smith et al. 2017,
Furlanetto et al. 2017,
Maddox et al. 2018)

Dust Seems Ubiquitous

- ▶ Dust extends all the way into the galaxies outskirts
- ▶ Holwerda (2009) detected dust to $1.5 R_{25}$ via occulting pair
- ▶ Traced in emission with IRAS (Nelson et al. 1998), and Herschel (Smith et al. 2016)
- ▶ Possible (???) explanation of Menard et al. results if assume galaxy clustering



Holwerda
(2009)



Dust Has Its Problems

- ▶ Dust opacities are uncertain
- ▶ Exact size distribution, composition... are uncertain
- ▶ How reliably can we know gas to dust ratio (metallicity, morphology, etc...)
- ▶ To solve these problems – two local potential solutions:
 - Need samples that cover a range of all galaxy properties (e.g. JINGLE survey)
 - High-resolution studies of objects that cover a range of objects

HELGA II: SED Fitting (Smith et al. 2012)

► Processing:

- Convolve and rebin all bands
- 140pc resolution
- Restrict to all 5 fluxes $> 5\sigma$
- Take into account all correlated uncertainties
- 4000 independent pixels

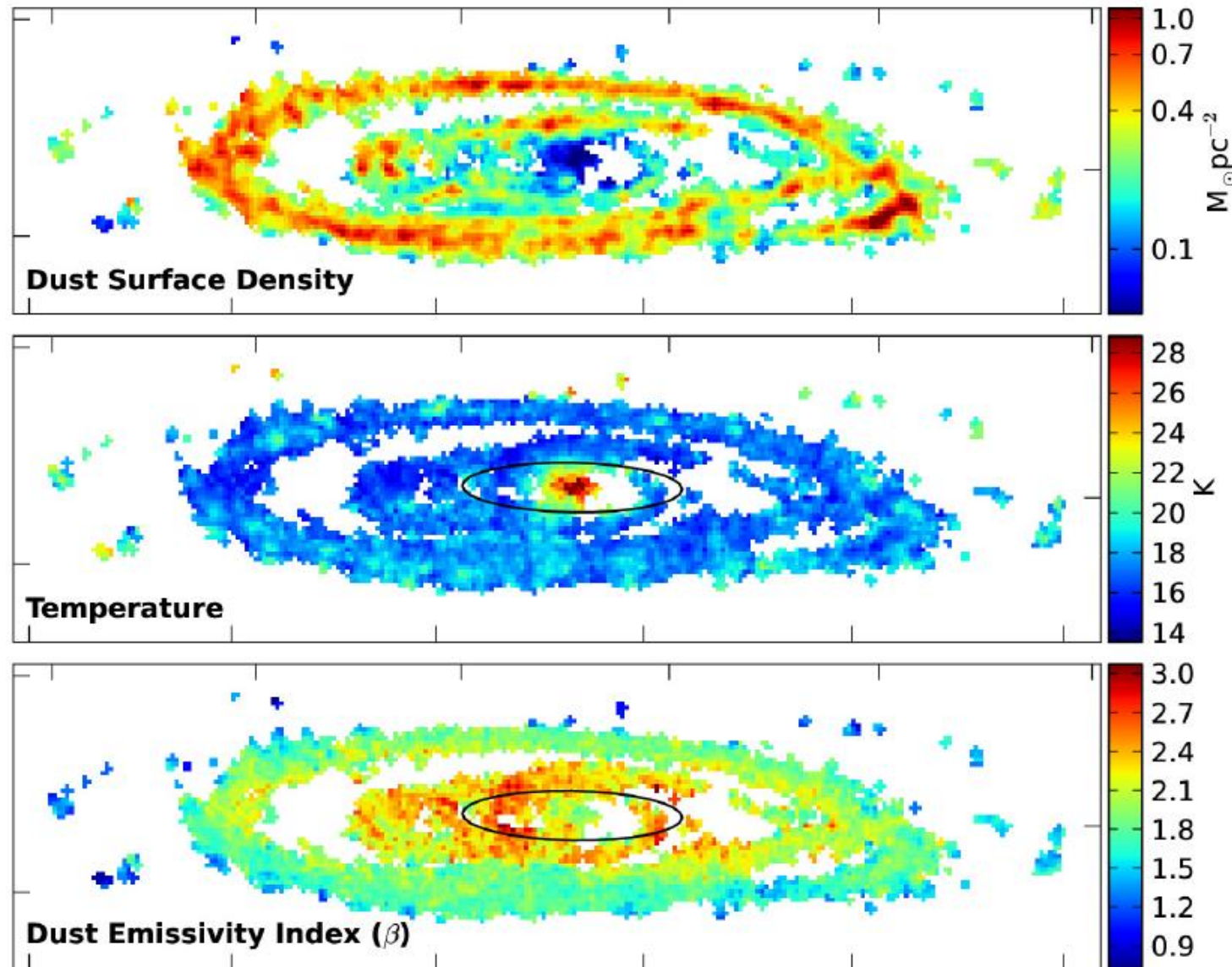
► Fit 1 modified blackbody model

► Find a need for a variable β

► Method is not optimal as information is thrown away

► Both HELGA II (Smith 2012) and Groves (2012) found dust in the centre is heated by the stars in the bulge

► HELGA VII (Viaene 2016), from radiative transfer 91% dust heated from bulge, extending out to the 10kpc ring.

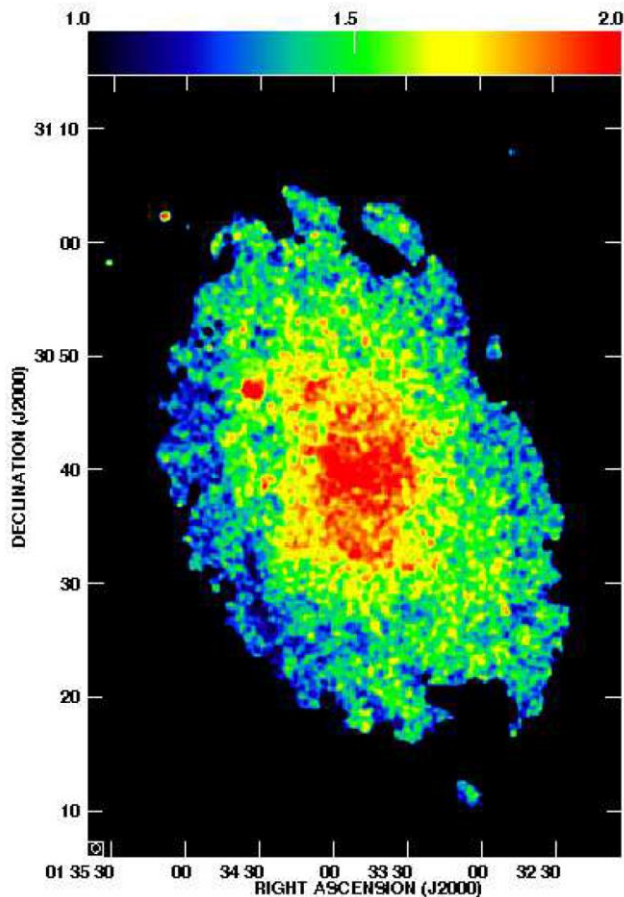


Variations of β in Other Galaxies

- Many studies have seen variations in other objects

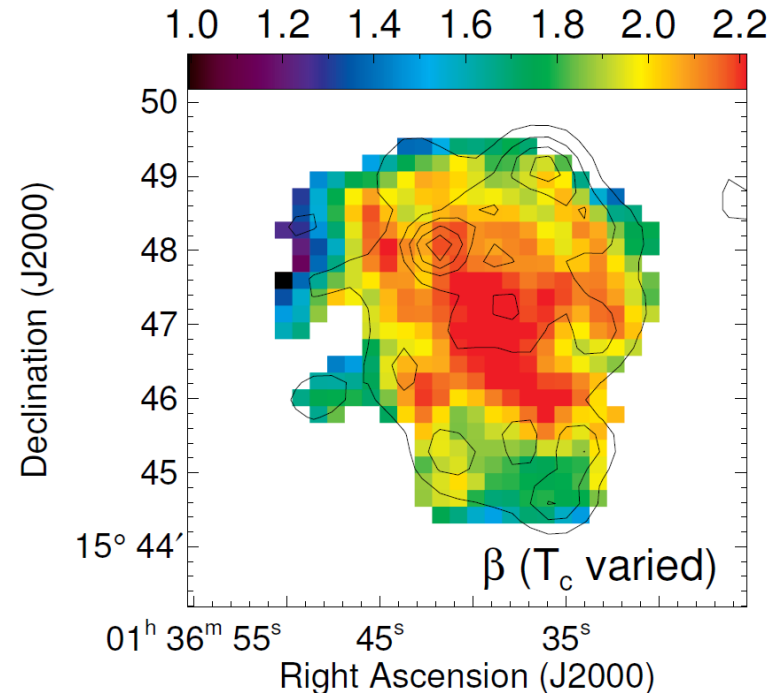
M33

Tabatabaei et al. 2013

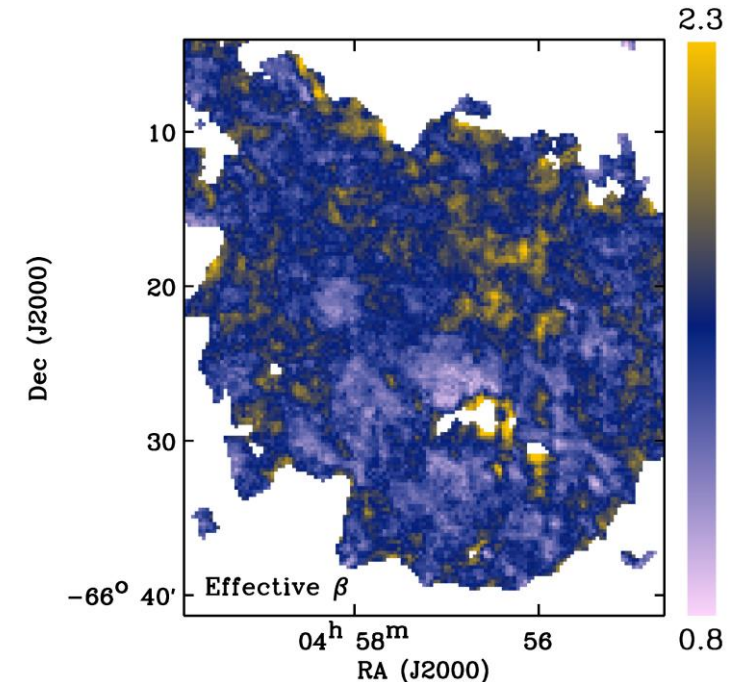


KINGFISH 20 galaxies
(NGC0628)

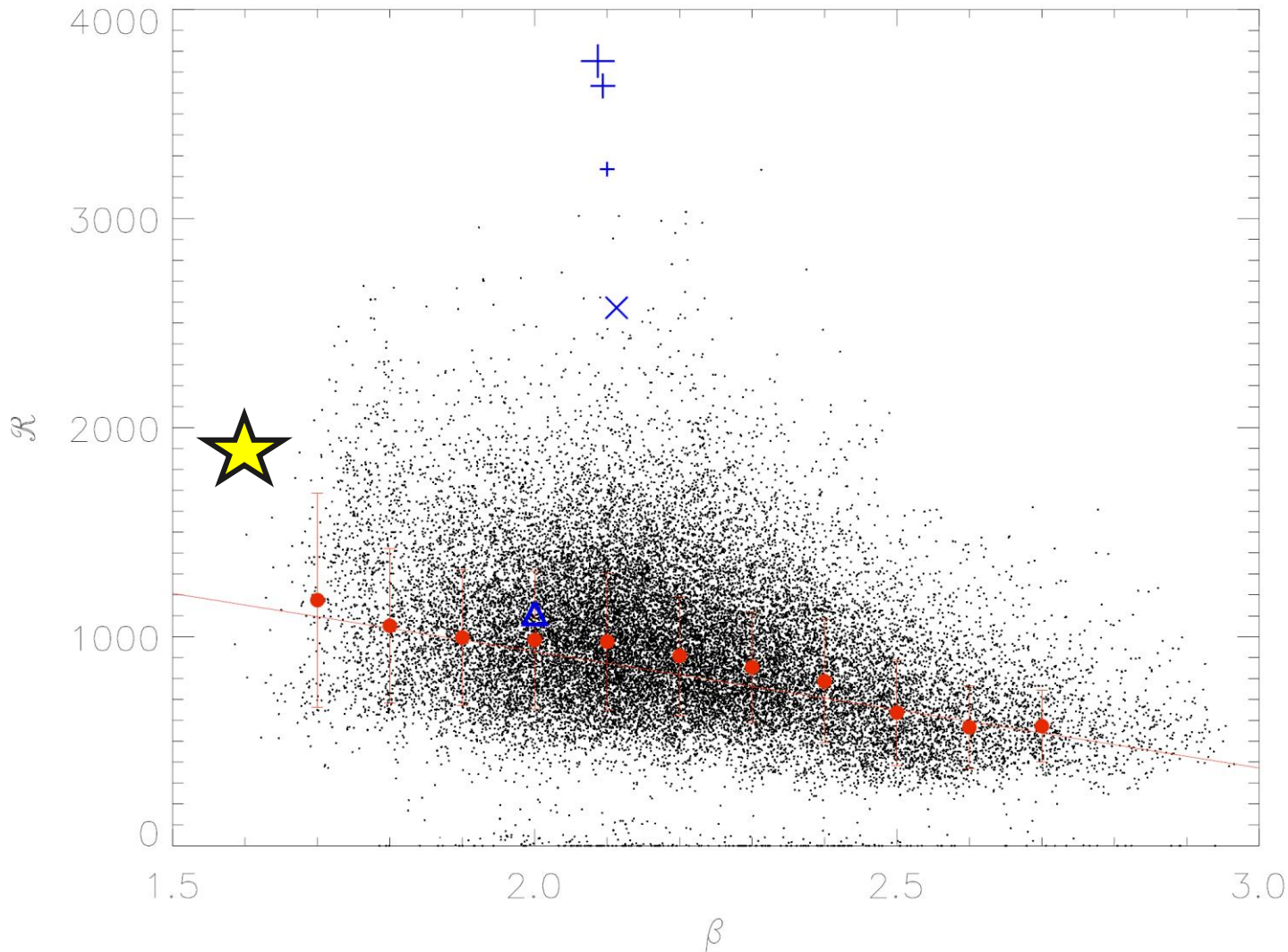
Kirkpatrick et al. 2014



LMC Complex N11
Galametz et al. 2015



Ratio Opacities vs Dust Emissivity Index



- ▶ Recent submitted paper
- ▶ $\mathcal{R}$ is ratio of $1.1\mu\text{m}$ to $300\mu\text{m}$ opacities
- ▶ Dust models do not predict the correct ratio of optical-to-FIR opacity (but these are from 2001/03 - please let me know any newer references)
- ▶ Triangular point is model from Mathis (1990)
- ▶ Anti-correlation between the ratio of opacities and sub-mm β

HARP and SCUBA-2 HI-resolution Terahertz Andromeda Galaxy survey (HASHTAG)

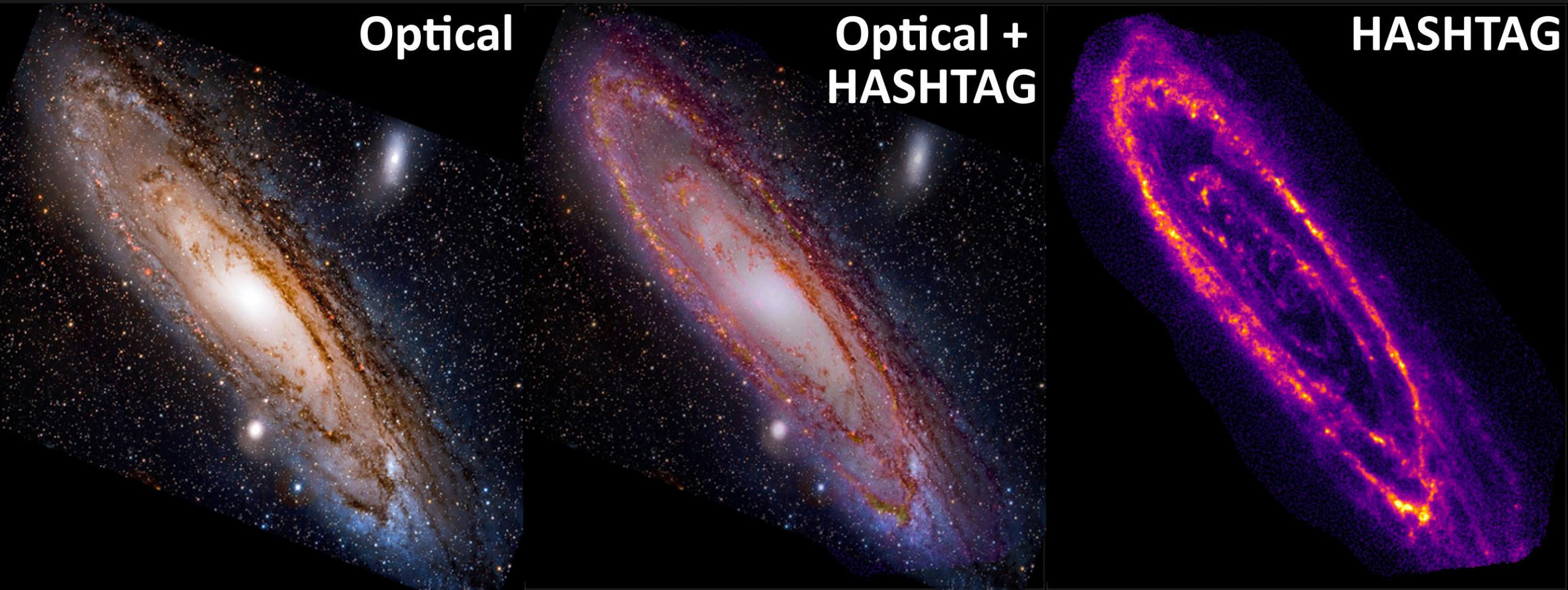


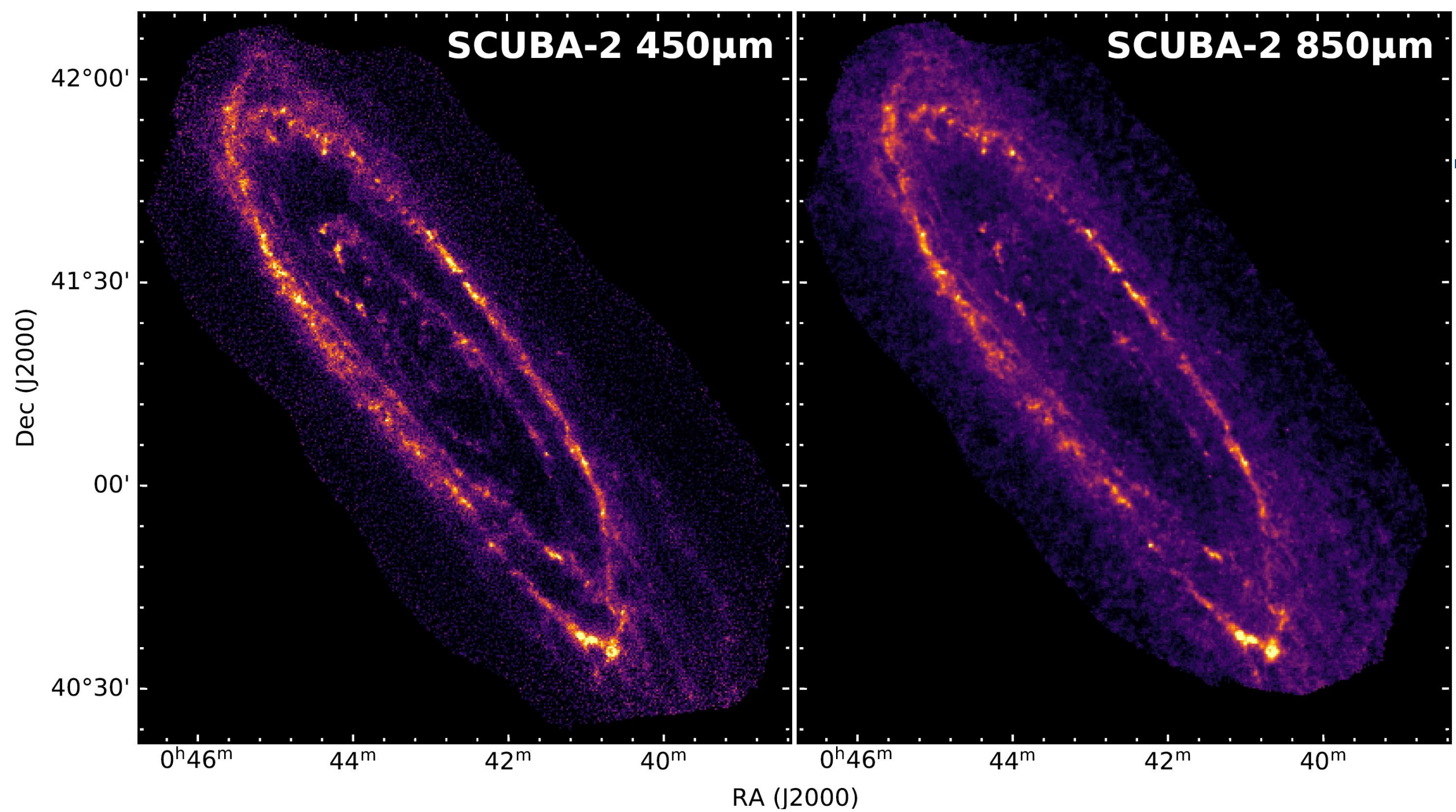
- ▶ Large program with the JCMT (I'm the UK PI) – 275 hr
- ▶ Idea is to get deep SCUBA-2 images for the entirety of Andromeda
- ▶ CO($J=3-2$) is a big contaminant between 10-30%. Proposed 60 square arcminutes to calibrate contamination.
- ▶ 25pc resolution, expecting ~ 2000 clouds with $> 10^3 M_{\odot}$

<https://hashtag.astro.cf.ac.uk/>

HASTAG – Data Release 1 (Smith et al. 2021)

~70% complete

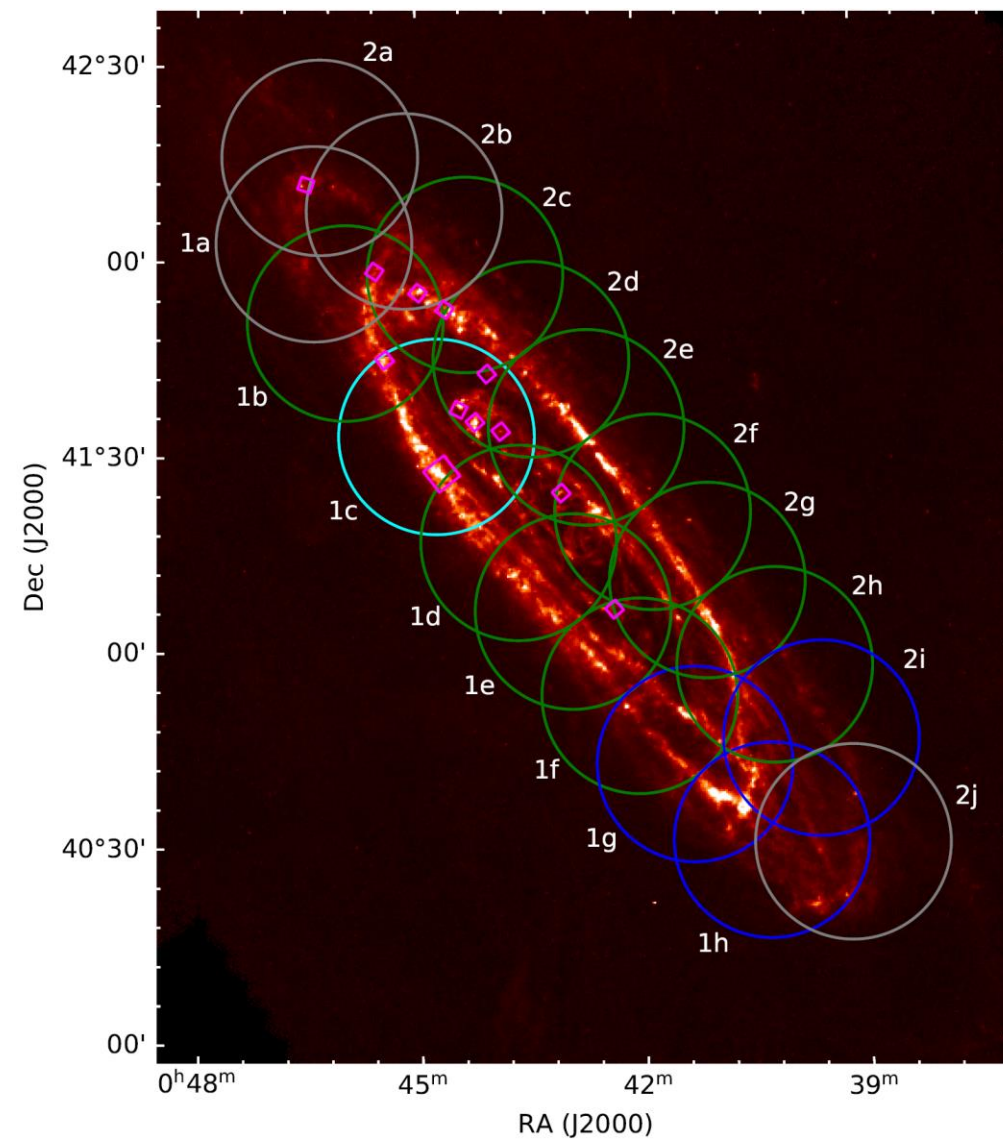






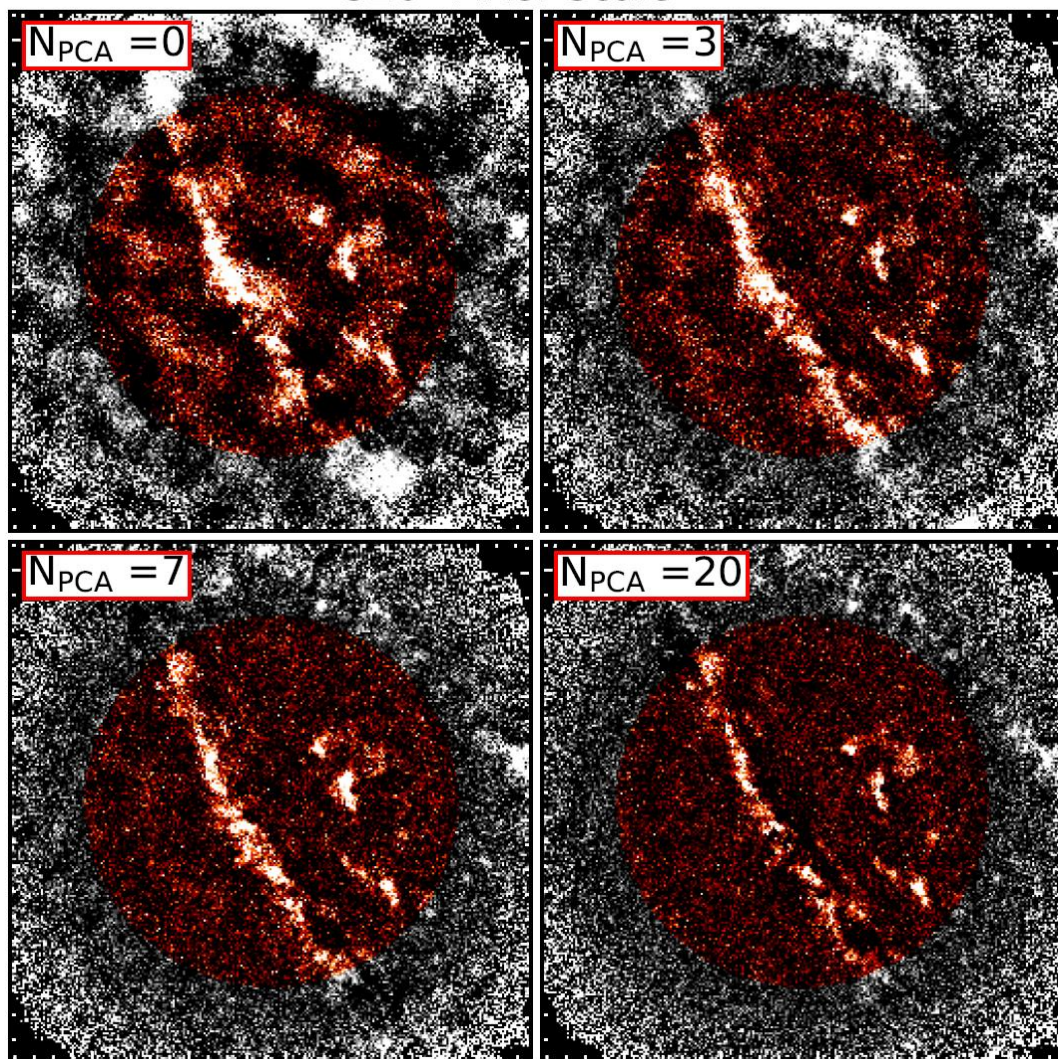
The Challenge

- ▶ Possibly most challenging SCUBA-2 map ever made...
- ▶ Andromeda – big and faint
- ▶ ~2.5 weeks continuous processing on a 750GB RAM, 64 Thread machine
- ▶ New Skyloop
- ▶ First Continuum PCA study
- ▶ How well do we recover real signal?
 - ▶ ~150 simulations – inject known signal into cosmology field
 - ▶ 20 hours per sim!

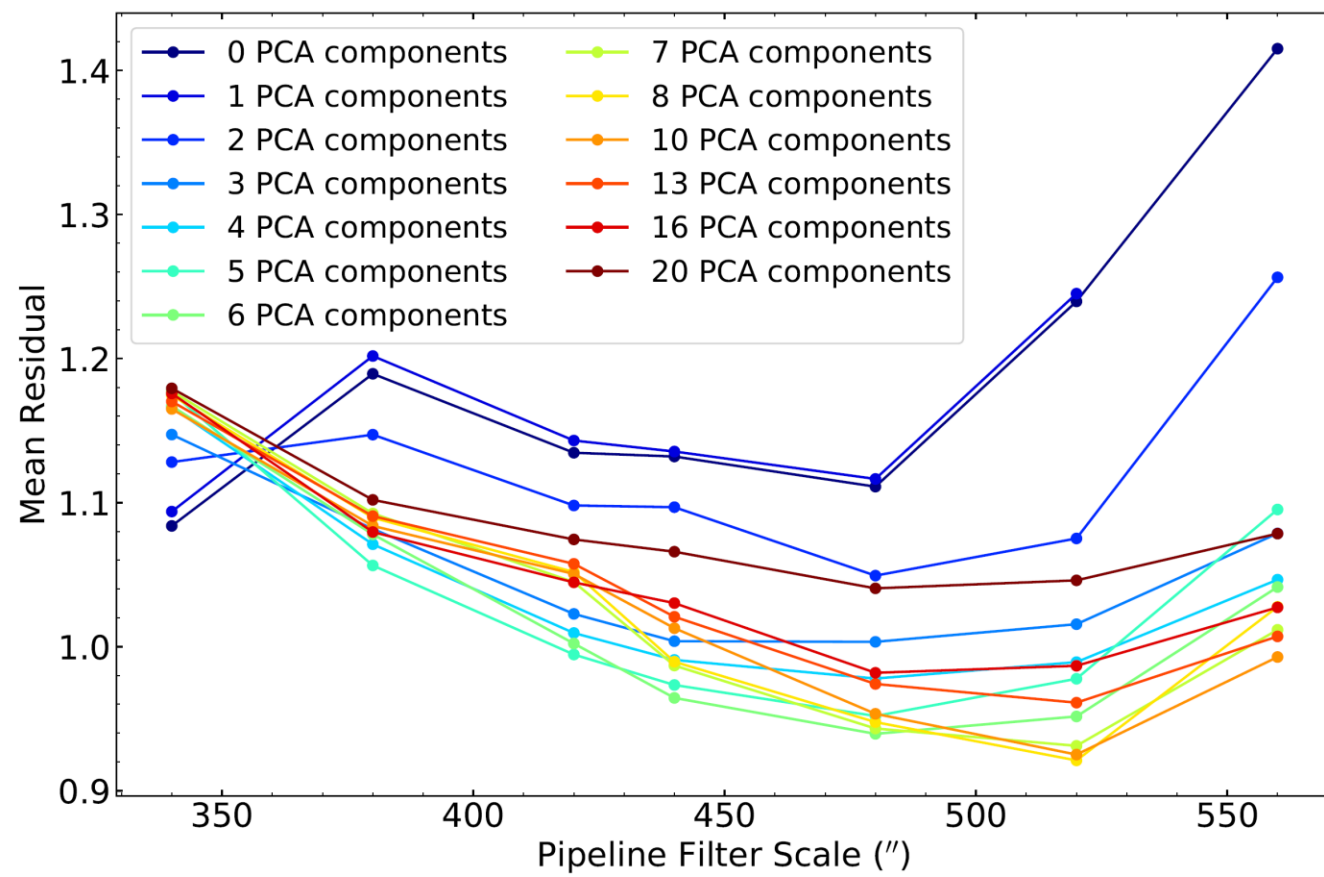


Tuning the Parameters – First use of PCA

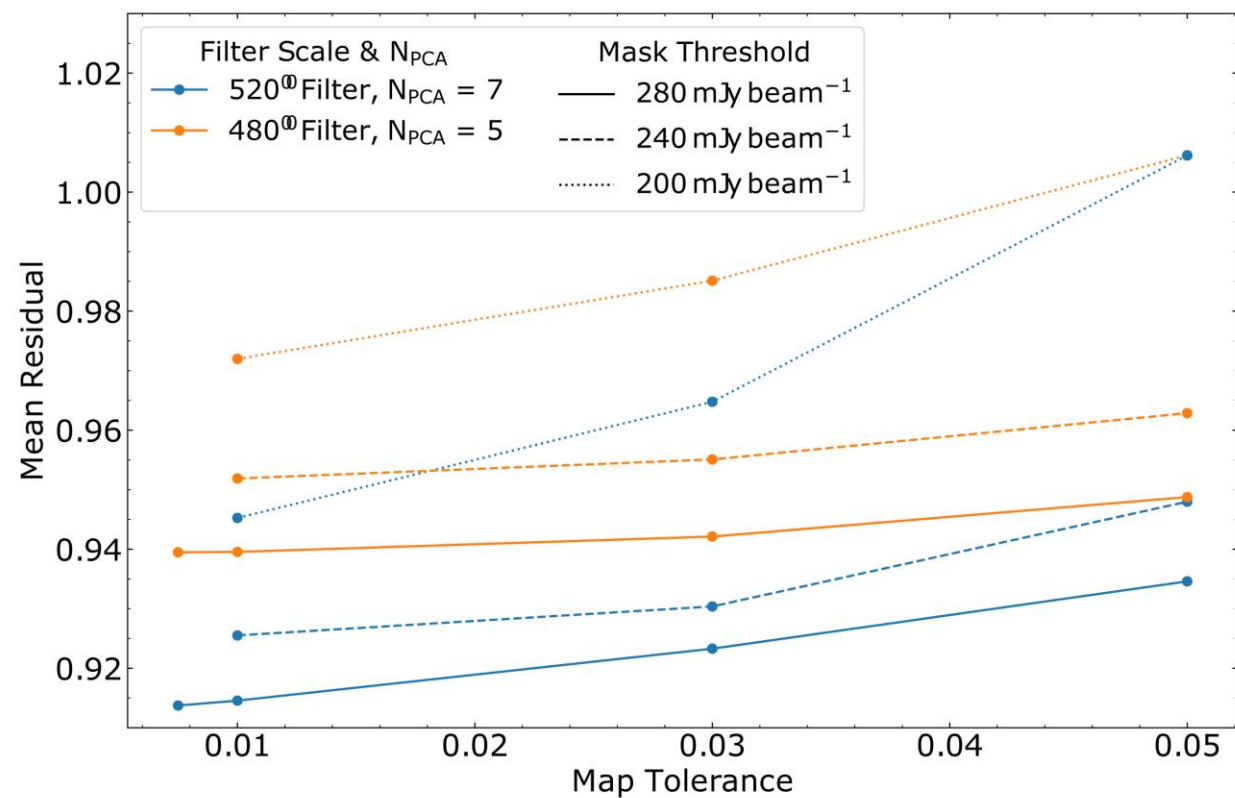
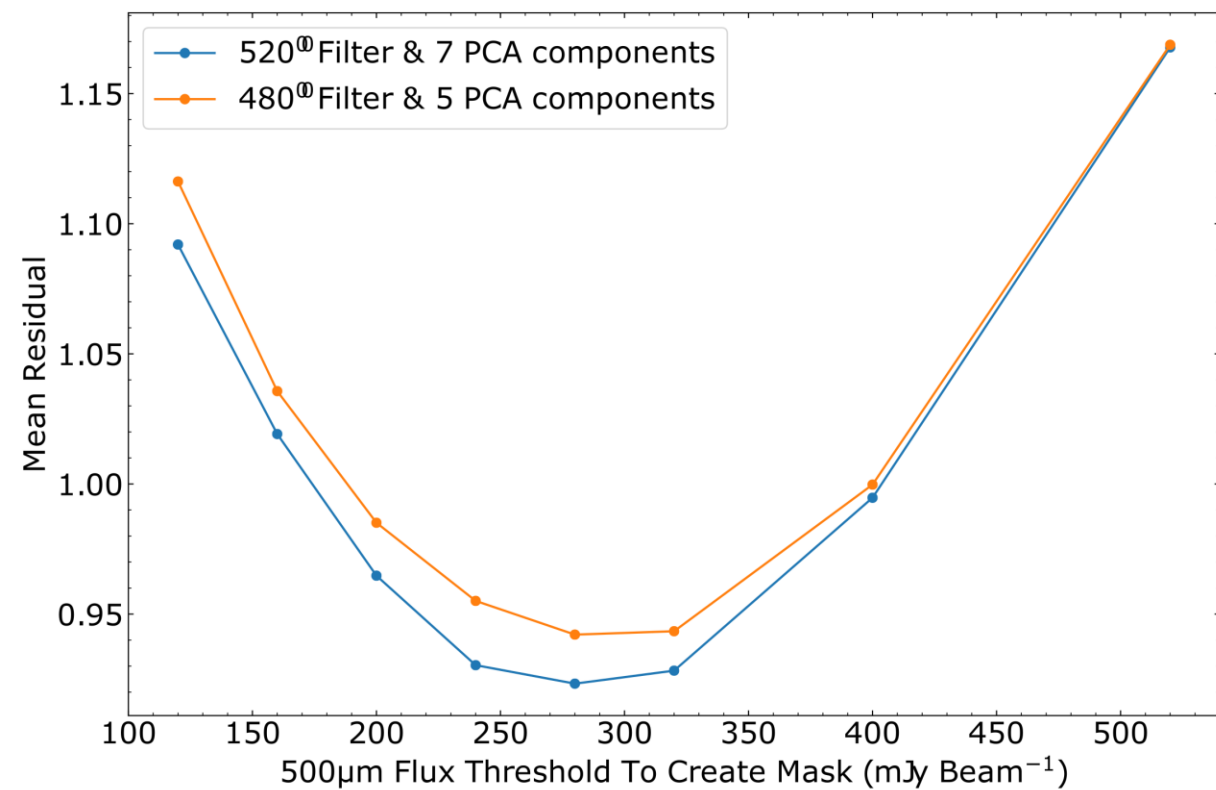
520'' Filter Scale



- First use of PCA for continuum
- Hit on speed

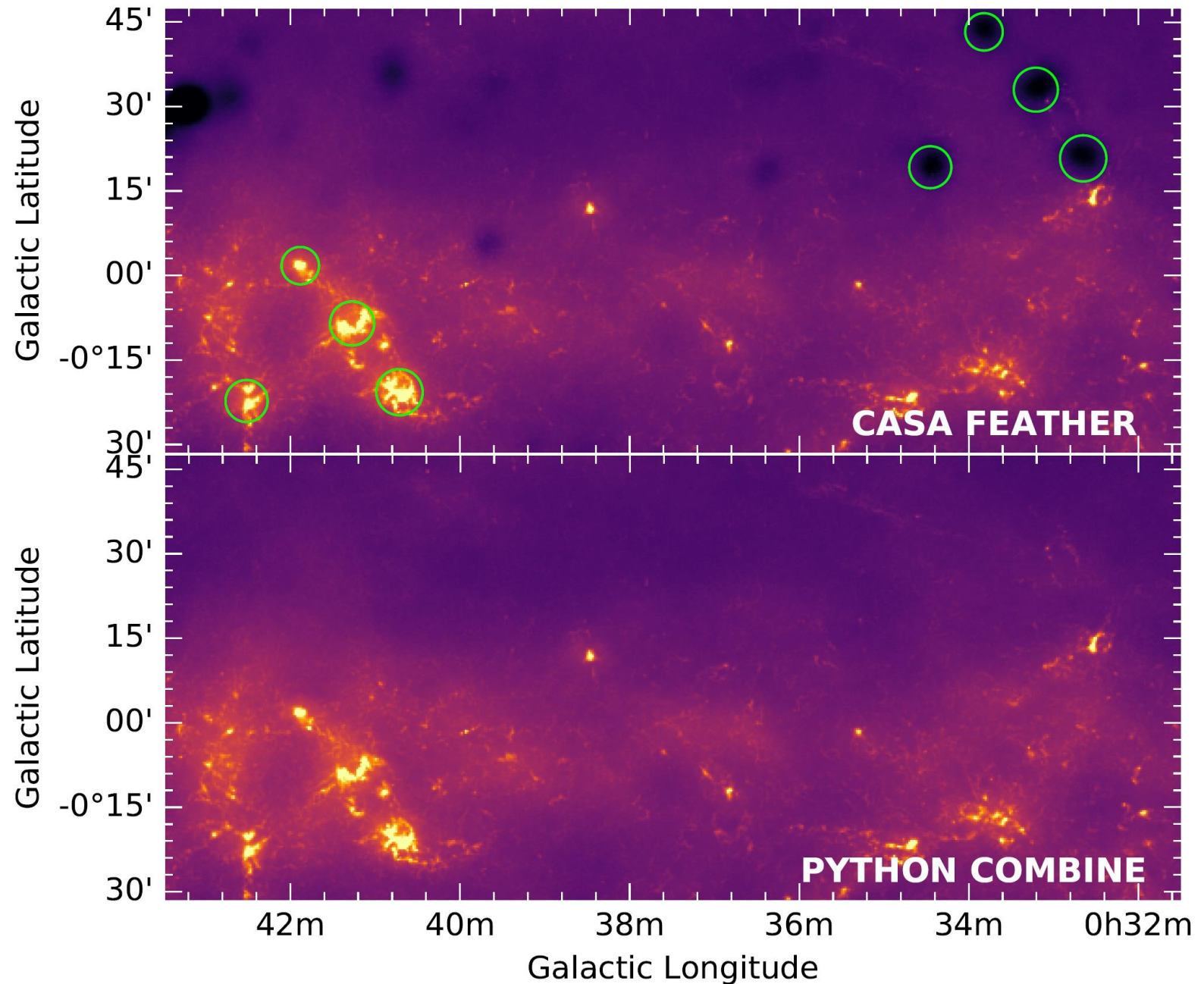


Other Parameters



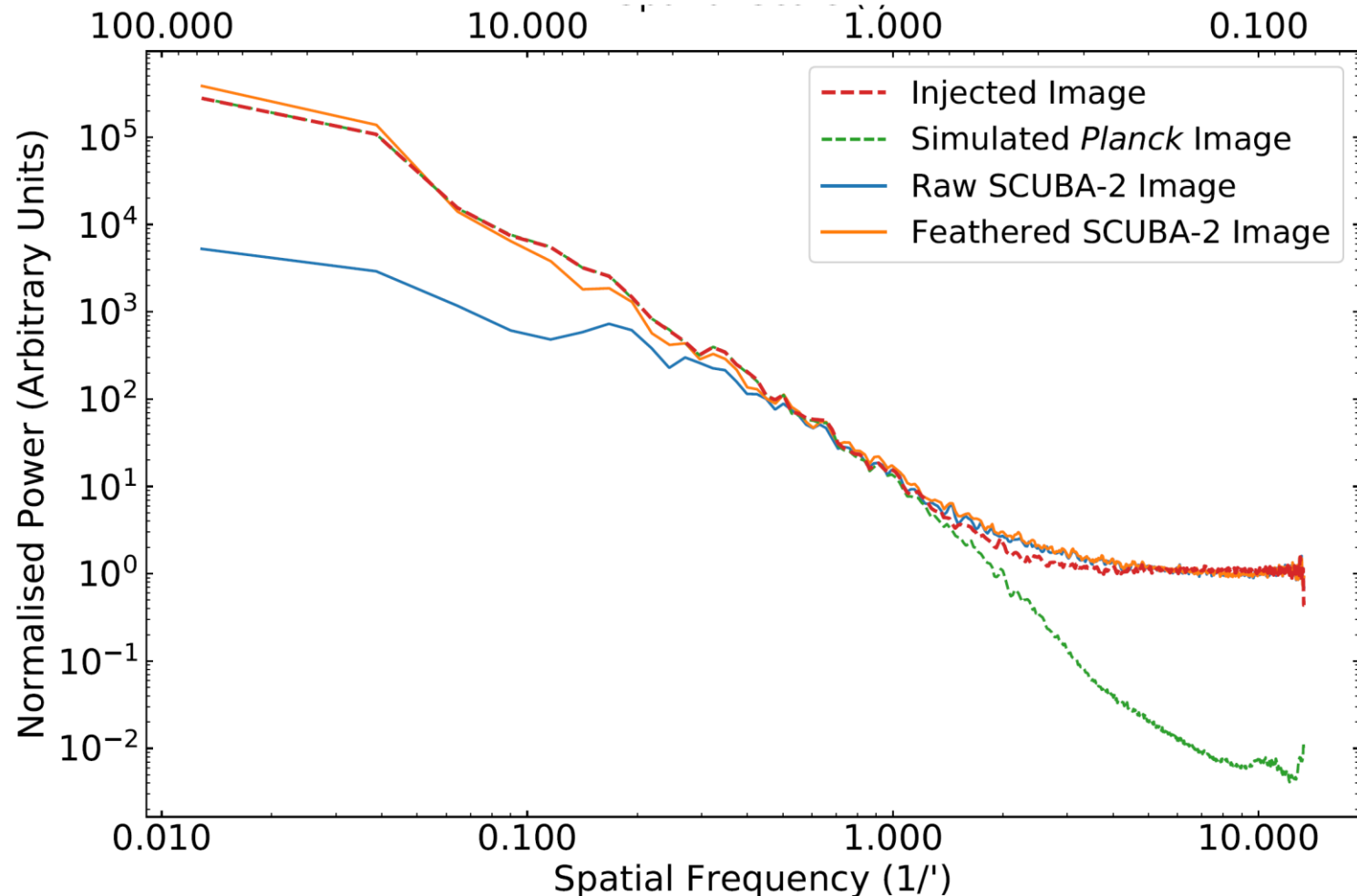
Large Scale Structure

- ▶ At 850 μ m use Planck for scales $>5'$
- ▶ At 450 μ m use Herschel 500 μ m
- ▶ Tasks are being packaged in 'astrolm' python package
- ▶ Package is designed to reduce tasks to one line (great project students!)

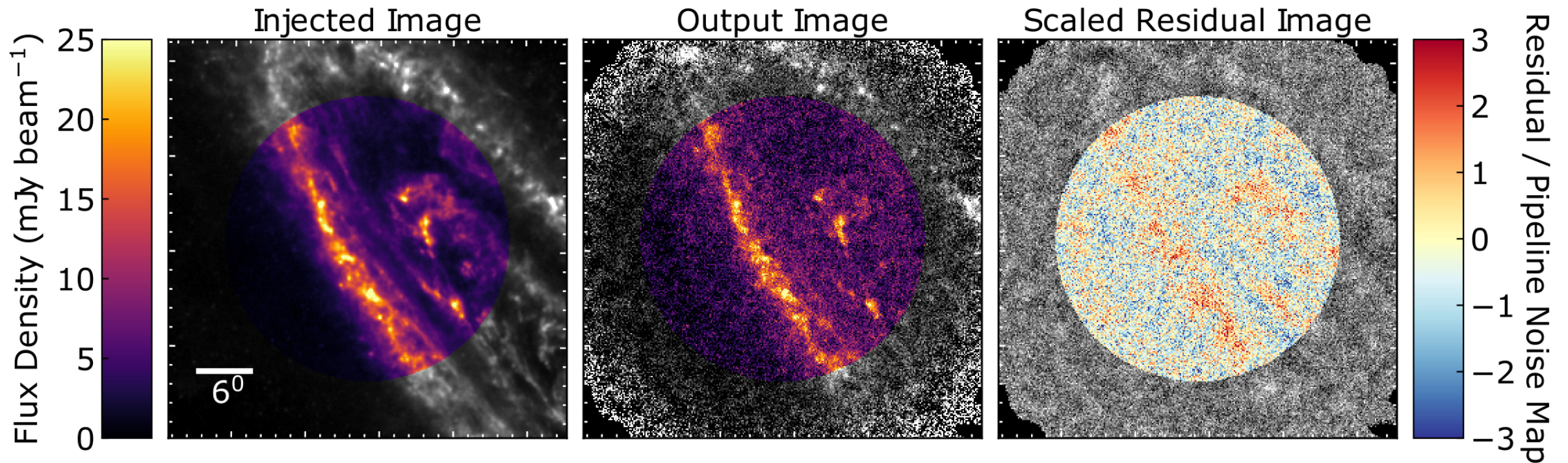


Feather

- In this formulation using the beam as the filter

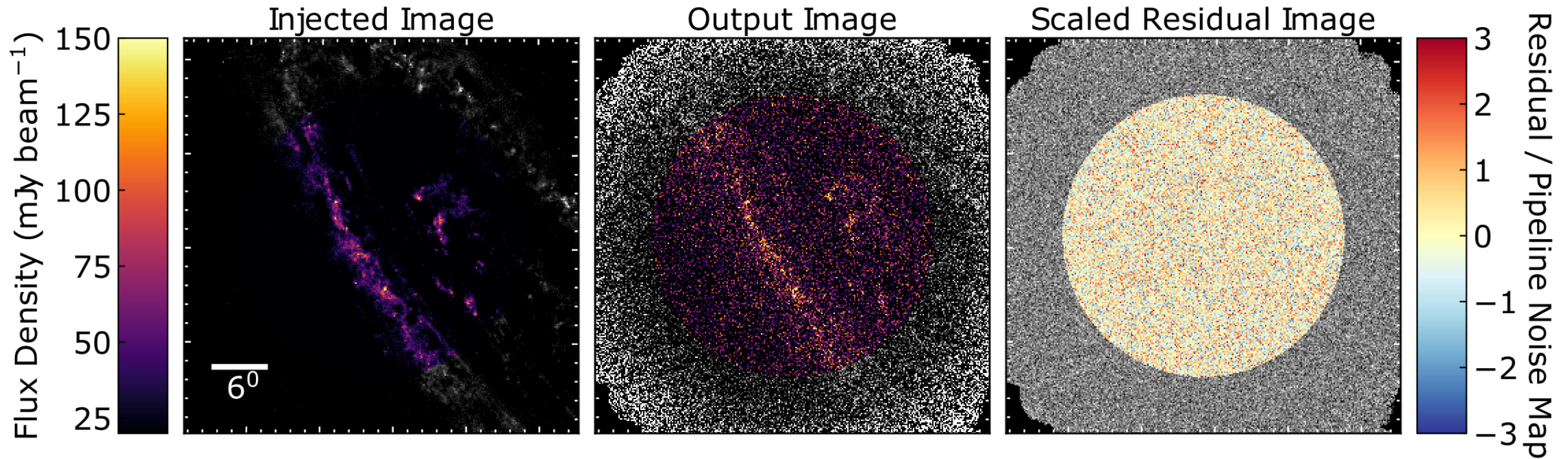


How well do you reconstruct the source?

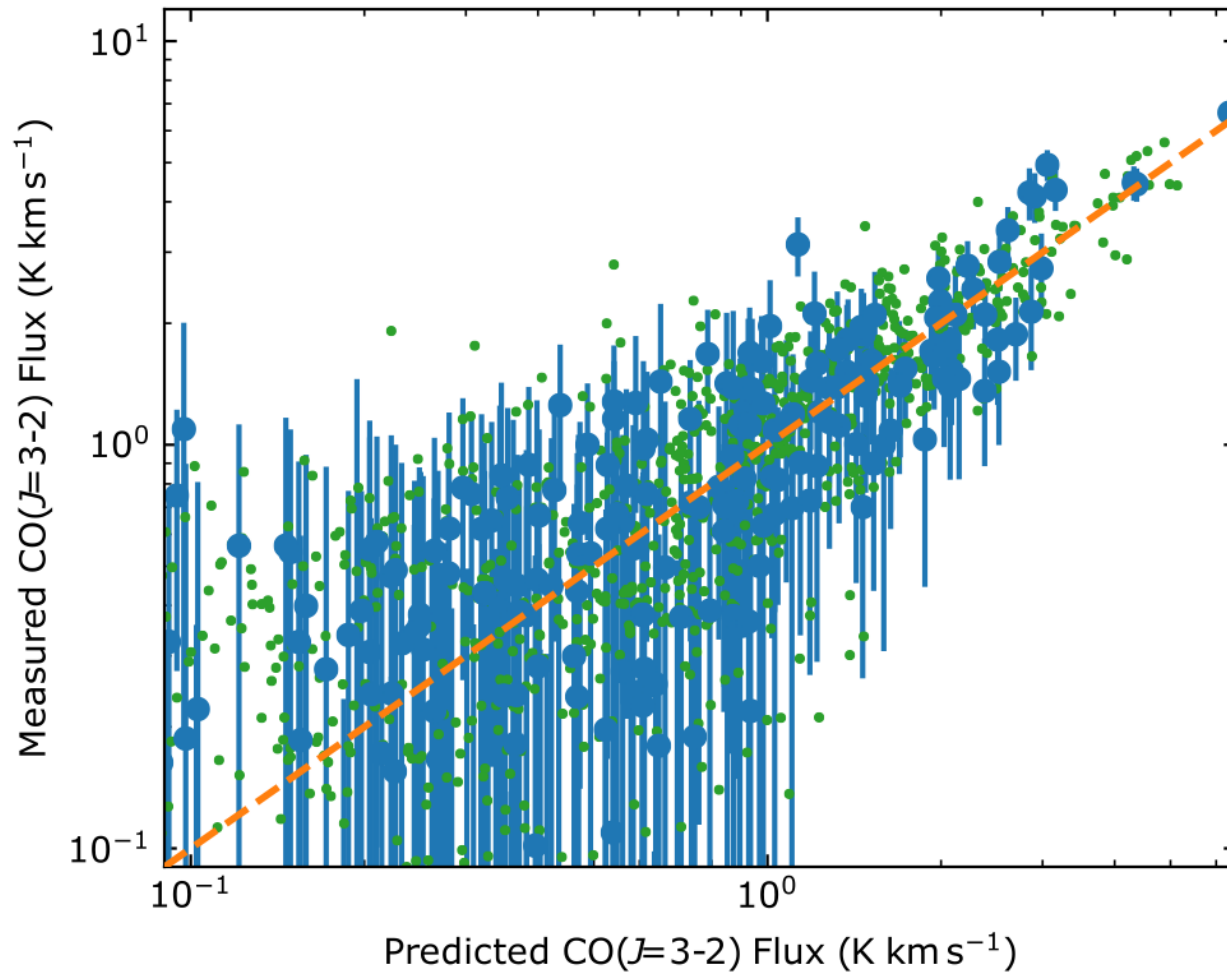


Why I haven't mentioned 450 μ m

- ▶ 450 μ m is far easier due to the resolution overlap with Herschel



CO Contamination



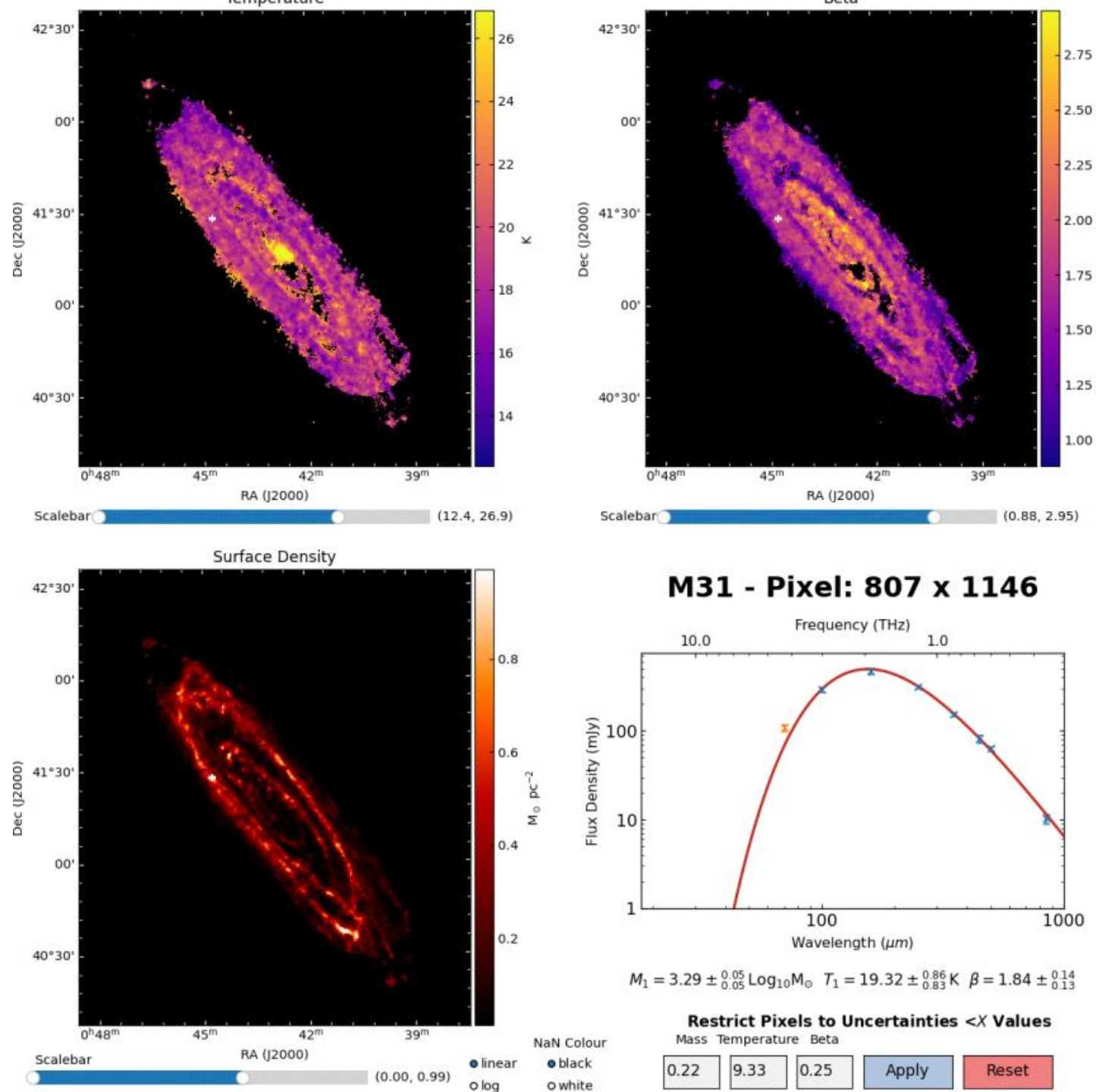
- ▶ Stage 1 – predict CO(3-2) from:
 - CARMA (CO1-0)
 - Dust Surface Density
 - Dust Temperature
 - Dust β
 - MIPS $24\mu\text{m}$
 - SFR Surface-Density
 - WISE W1, W2, W3, W4
- ▶ Training Set (Green), Test (blue)
- ▶ Stage 2 – Use CARMA area to train model rest of the galaxy

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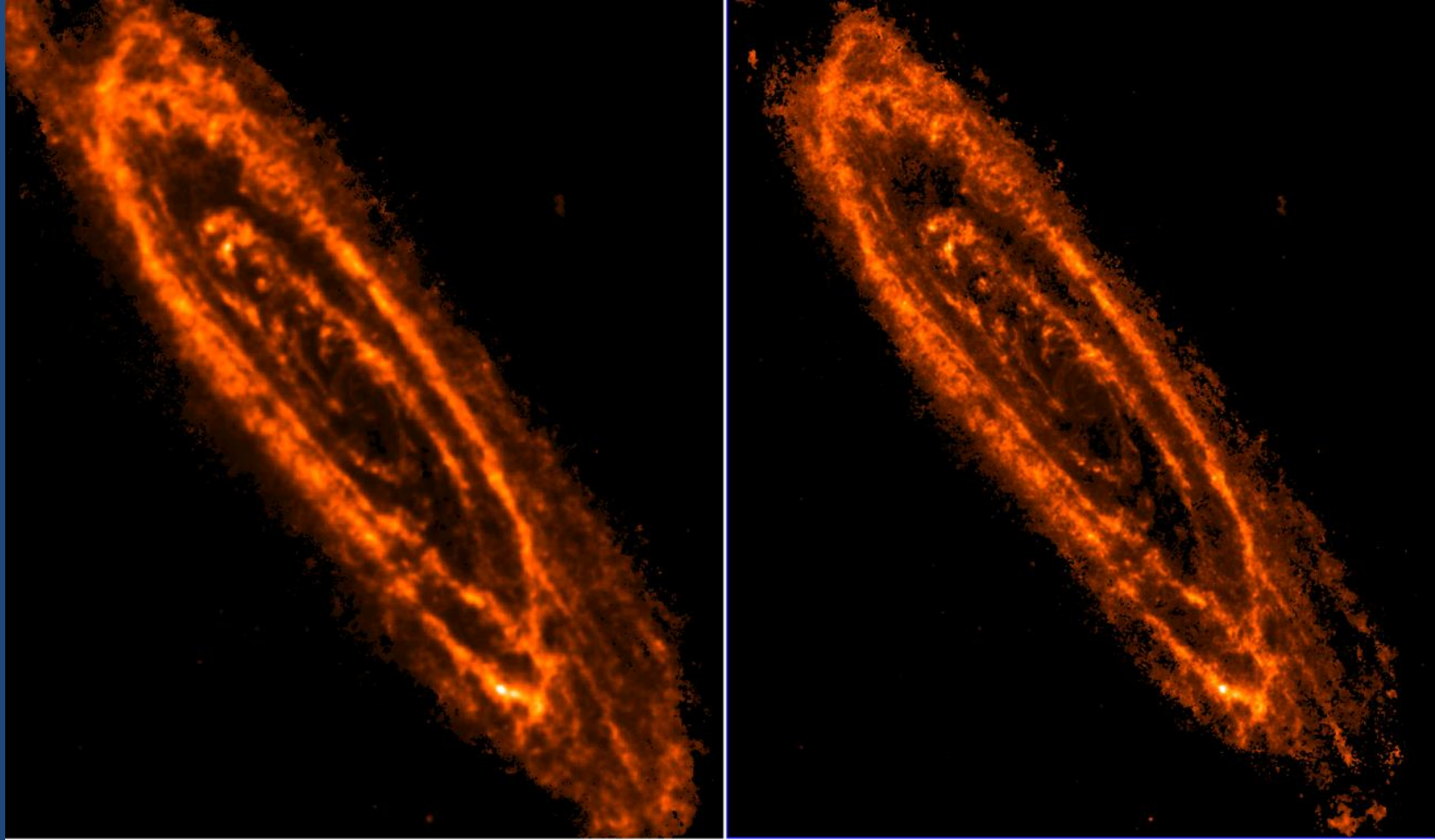
Current Work in Progress

- ▶ SED fitting
- ▶ Another big data challenge!
- ▶ Some interesting structures



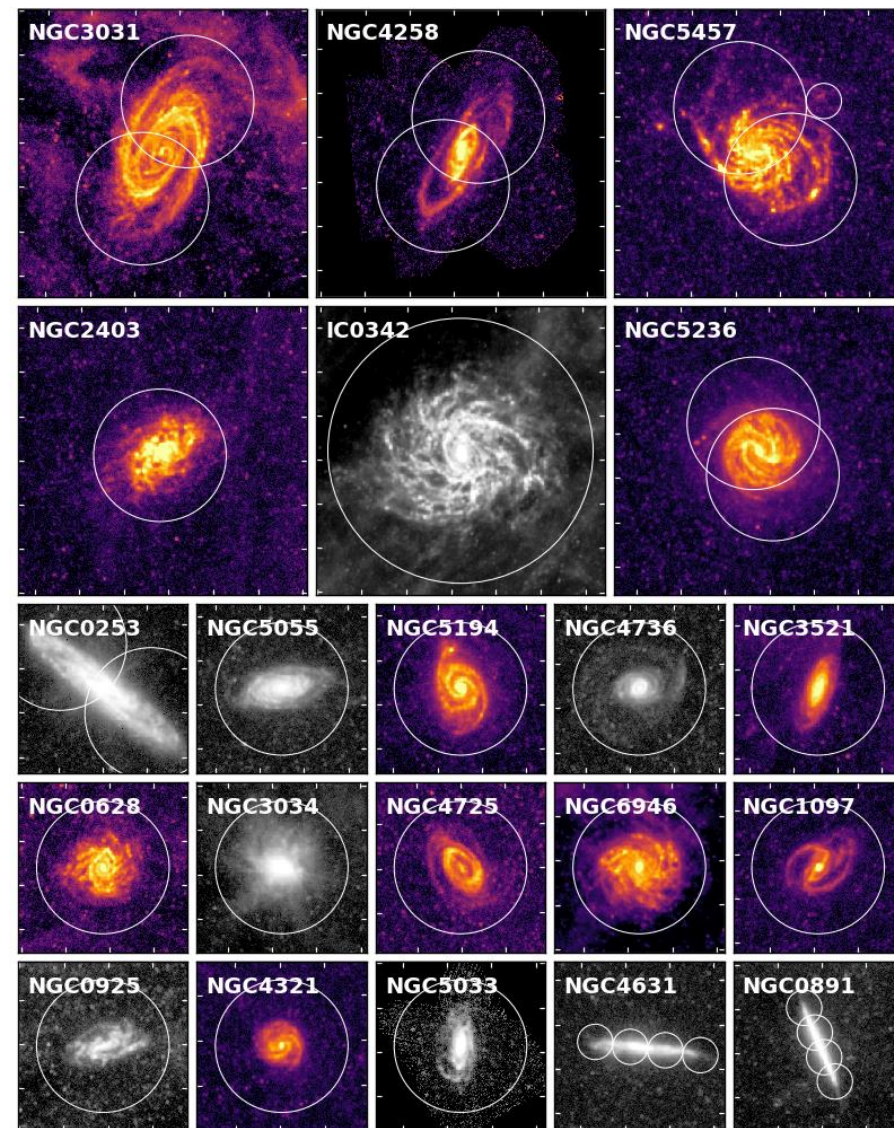
Current Work in Progress

- ▶ Bayesian MCMC SED fitting
- ▶ Another big data challenge!
- ▶ Some interesting structures



Dust Observations With Scuba-2 In Nearby Galaxies (DOWSING)

- ▶ New Large program with the JCMT (I'm the UK PI) – 240 hr
- ▶ Idea is to get deep SCUBA-2 images for sample of nearby (large angular size) galaxies
- ▶ 12 galaxies targeted
- ▶ Combine with PPMAP
- ▶ Help get closer to the interferometric CO observations



SCUBA-2 M51

- ▶ Very quick reduction of M51
- ▶ Made Some mistakes

