Exploring the millimetre emission in nearby galaxies: analysis of the edge-on galaxy NGC0891

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& IMEGIN collaboration
on behalf of the NIKA2 collaboration

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EST. 1837

IMEGIN

(**I**nterpreting the **M**illimeter **E**mission of **G**alaxies with **I**RAM and **N**IKA2)

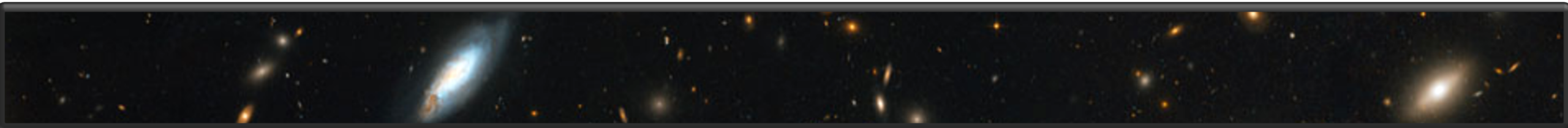
PI: *S. Madden*

A Guaranteed Time Large Program (~200 hours of telescope time) which aims to map 22 nearby galaxies (distance < 30 Mpc) at 1.15 and 2 mm (at a resolution of 11.1" and 17.7", respectively) using the IRAM 30-m telescope and the NIKA2 continuum camera.

At a distance of **D=10 Mpc** the spatial resolutions is **~0.5 kpc** and **~0.8 kpc** at 1.15 and 2mm respectively.

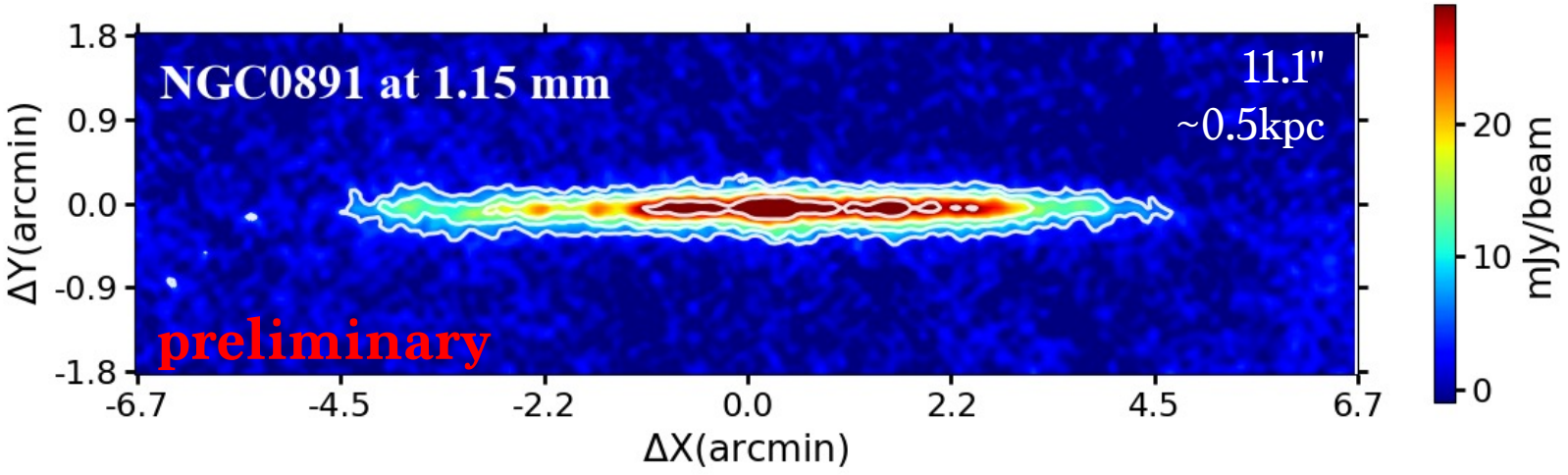
The sources cover two orders of magnitude in star formation rate (0.1 to 10 $M_\odot\,yr^{-1}$) and mass ($8.0x10^8$ to $8.5x10^{10}$ $M_\odot$) and are of various galaxy morphology types ranging from **Sa** to **Irr**.

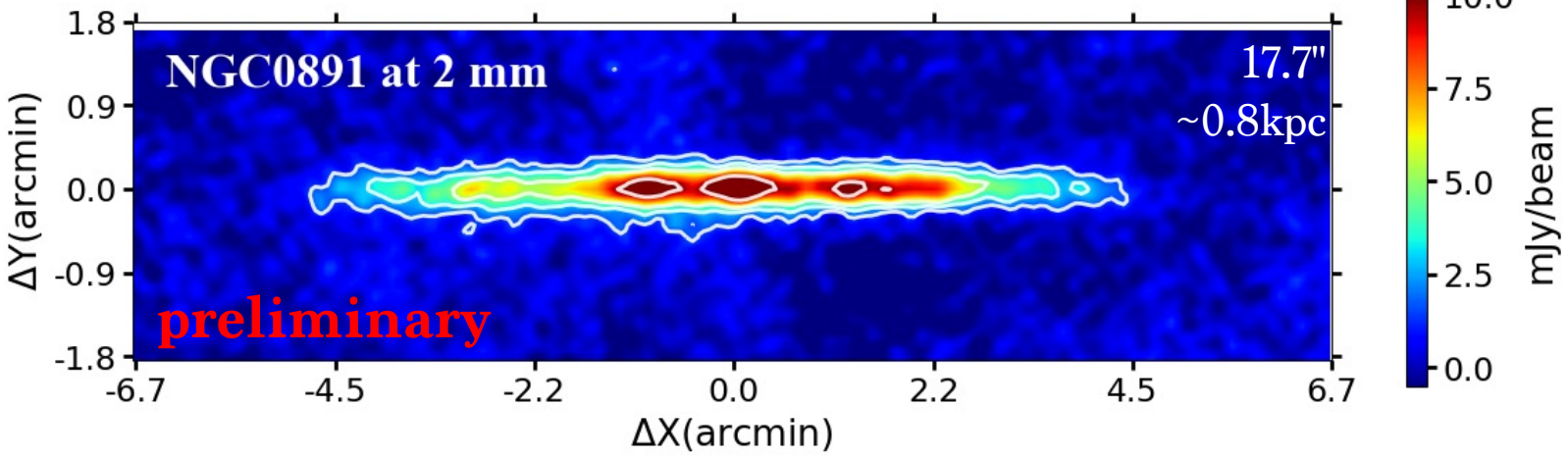
All galaxies have been detected in all **Herschel - PACS** and **SPIRE, WISE** and **Spitzer** bands, with additional **UV, optical,** and **radio** continuum observations. **CO** and **HI** maps are also available.



IMEGIN

NGC0891 observations





NGC0891: IMEGIN pilot study

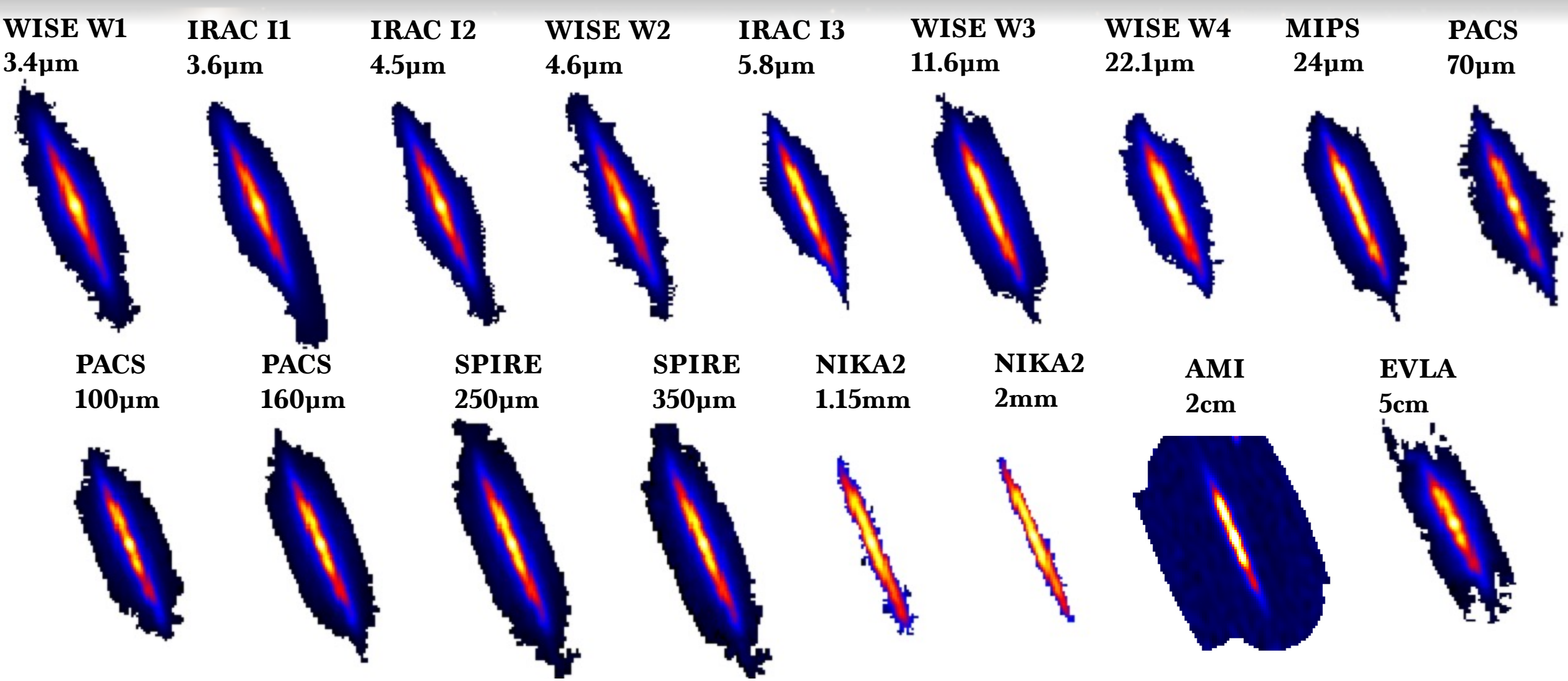
Type: SA(s)b — Position angle: 22.9°
Distance: 9.6Mpc — Inclination: 90° [a]

[a] Bianchi & Xilouris (2011)

Reduction: **PIIC/GILDAS**
Telescope time: **~7 hours**
RMS: 1.0 mJy/beam at 1.15mm
0.32 mJy/beam at 2mm
Peak values: 55.0 mJy/beam at 1.15mm
15.0 mJy/beam at 2mm

SED (Spectral Energy Distribution) fitting

Resolved fitted maps: Spitzer, WISE, Herschel, **IRAM**, AMI, EVLA (λ from 3.5μm to 5cm)



Maps convolved at a matched resolution of 24" (~1.1kpc) and regridded into a common frame and a pixelsize of 8".
CO(2-1) line contamination has been removed from the NIKA2 1.15mm map.
Sources for the archival data: **Dustpedia**, **NED** databases

SED (Spectral Energy Distribution) fitting

HerBIE (HiERarchical Bayesian Inference for dust Emission)

The fitting code takes into account:

- realistic optical properties of the dust grains
- stochastic heating
- mixing of the physical conditions in the interstellar regions
- distribution of starlight intensities
- color correction
- calibration uncertainties

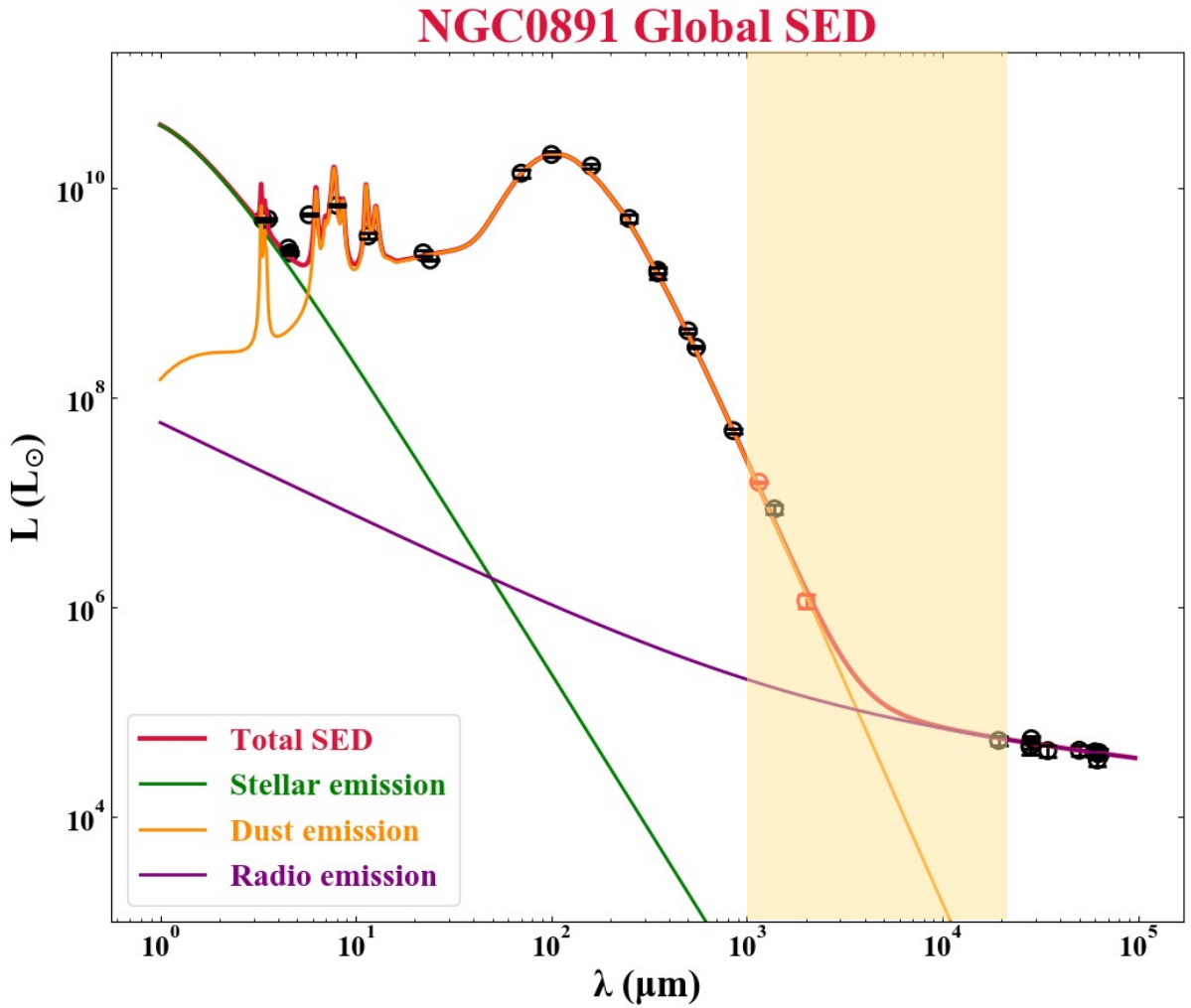
The hierarchical Bayesian approach recovers the true correlations of the parameters suppressing the noise-induced, false correlations.

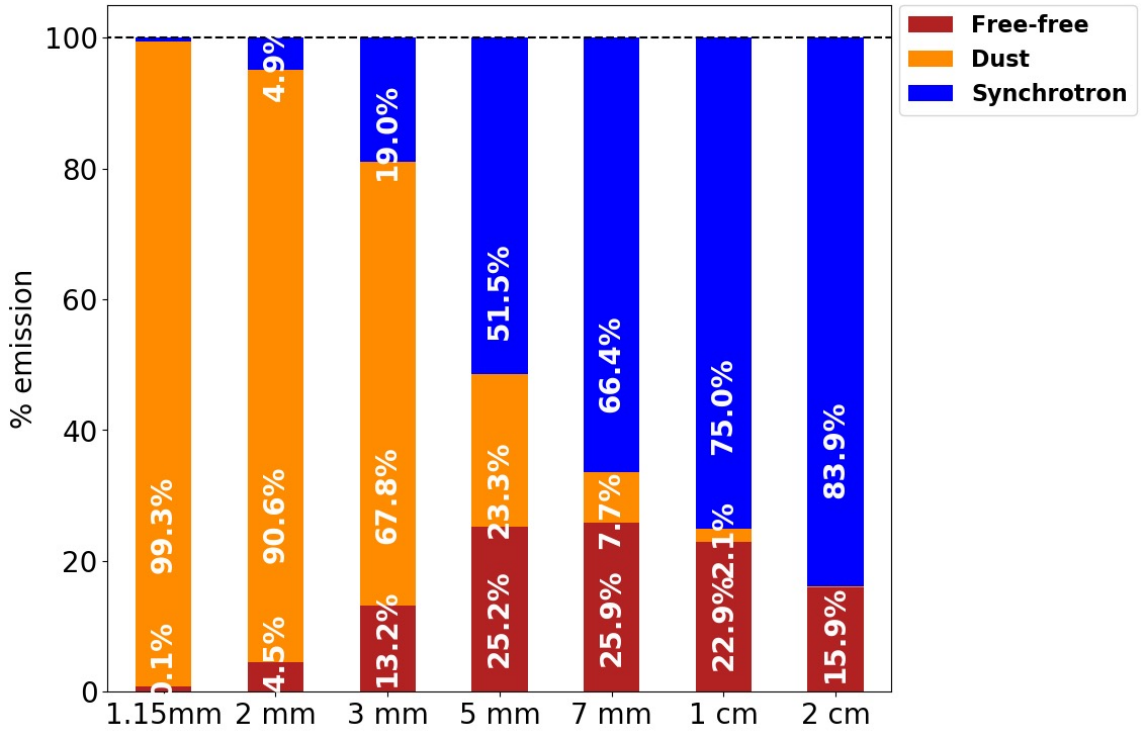
Galliano (2018) and Galliano et al. (2021)

Dust **THEMIS** model: Jones et al. (2013; 2017)

HerBIE

Global SED fitting of NGC0891

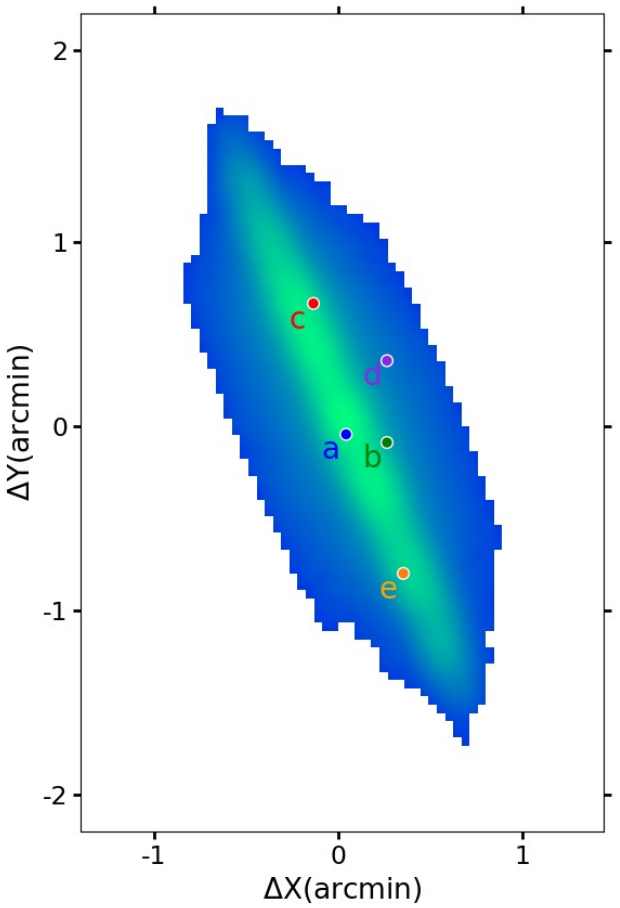


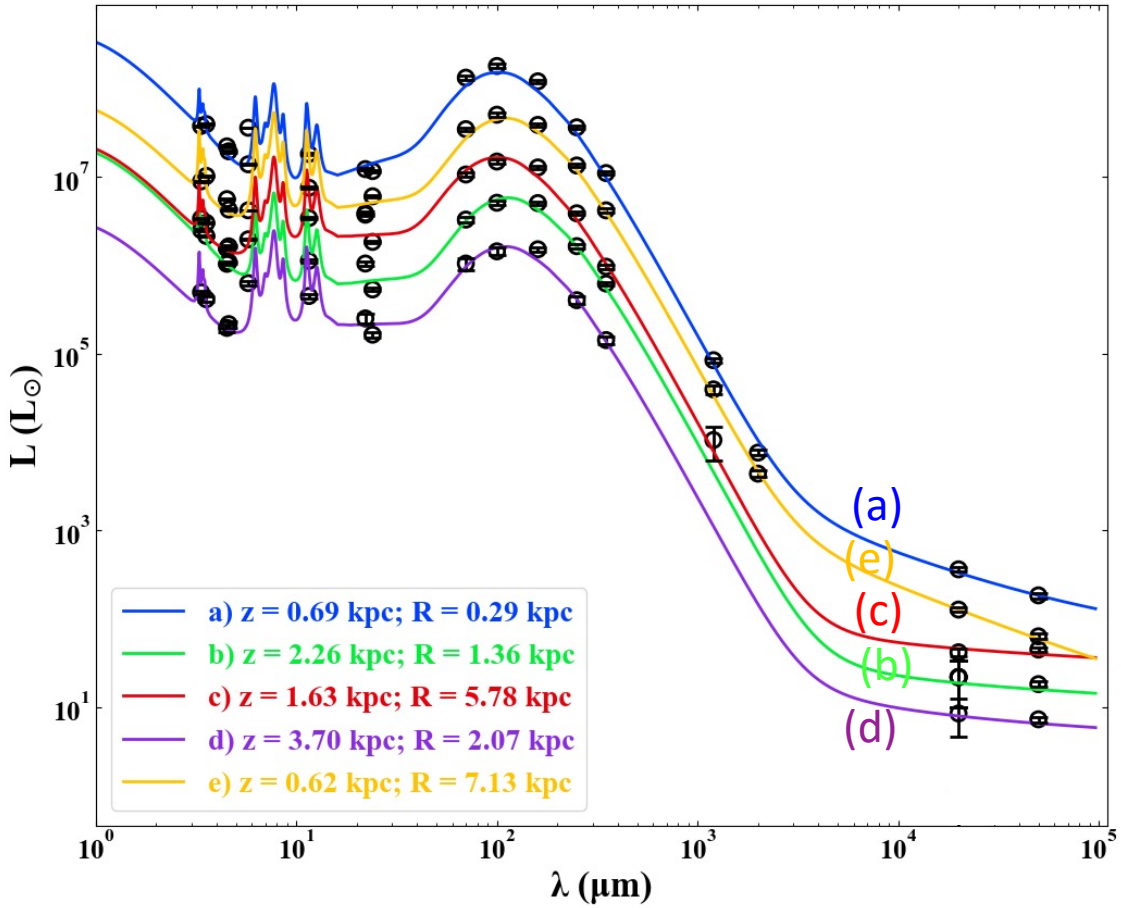


Emission decomposition into the different physical mechanisms from 1.15 mm to 2 cm.

Photometry data from the telescopes:
Spitzer, WISE, Herschel, Planck, JCMT, IRAM, VLA, AMI, MPIfR, OVRO, WSRT, GBT

Maps from the archive: **DustPedia, NED databases**
More photometry data from: Mulcahy et al. (2018)





z: vertical distance from the galactic plane

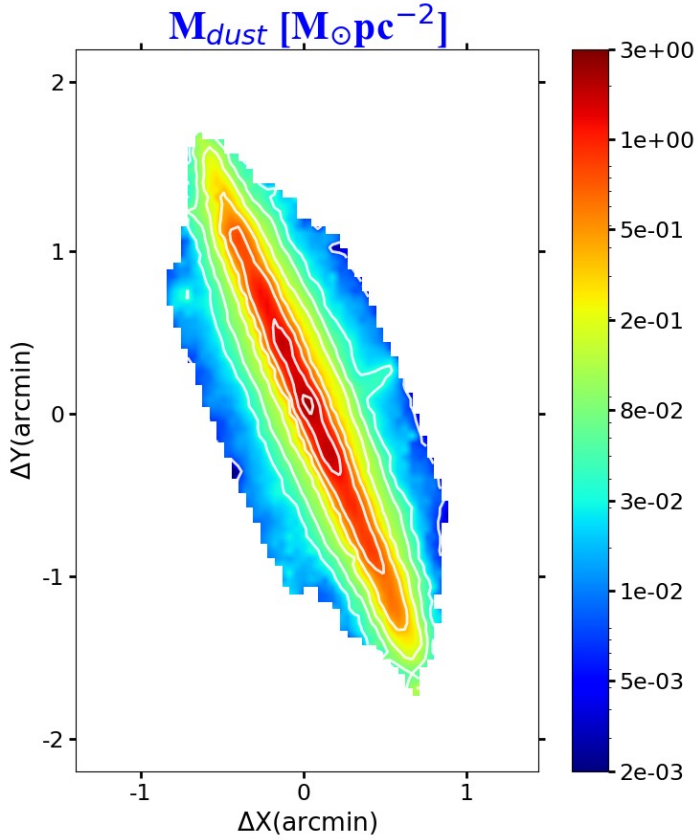
R: radial distance from the center of the galaxy

SED examples in five different positions throughout the galaxy. The pixel scale (8") corresponds to ~0.4 kpc.

HerBIE

Dust emission parameters

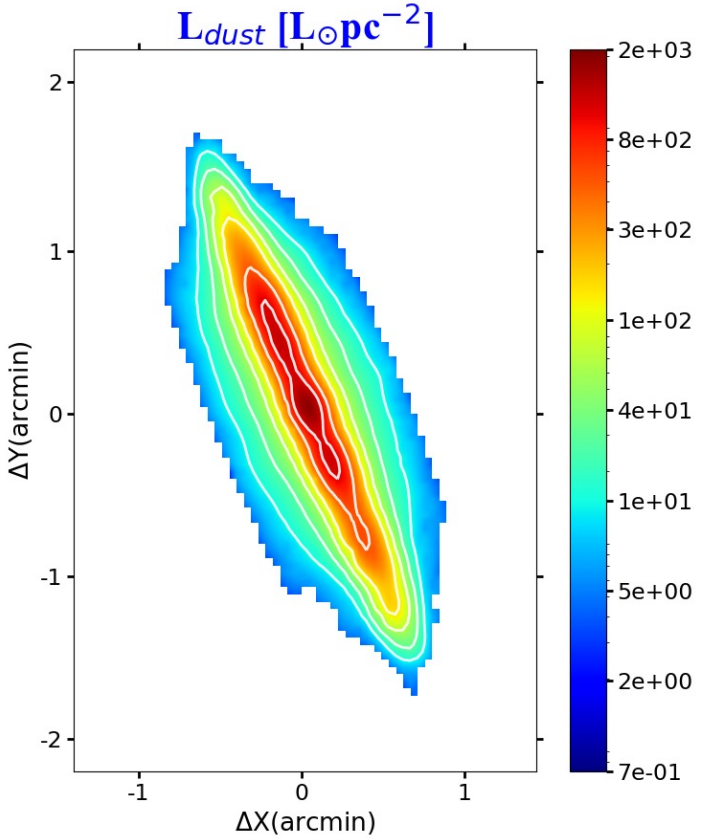
Dust mass



Contours levels:

7e-3, 4e-2, 7e-2, 1e-1, 4e-1, 7e-1, 1, 2 $M_\odot pc^{-2}$

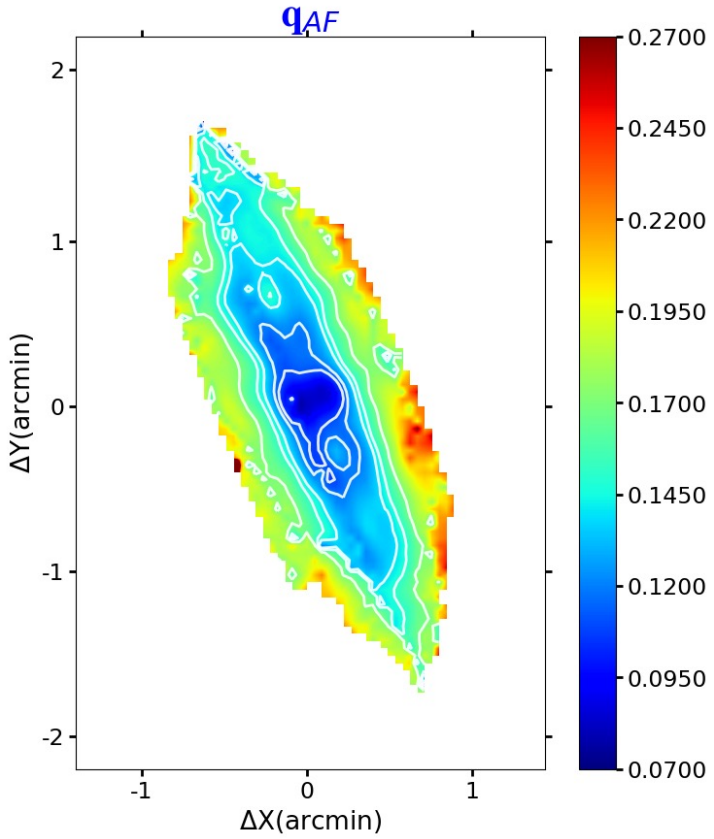
Dust luminosity



Contours levels:

1e1, 3e1, 6e1, 1e2, 5e2, 1e3 $L_\odot\ pc^{-2}$

Mass fraction of aromatic grains



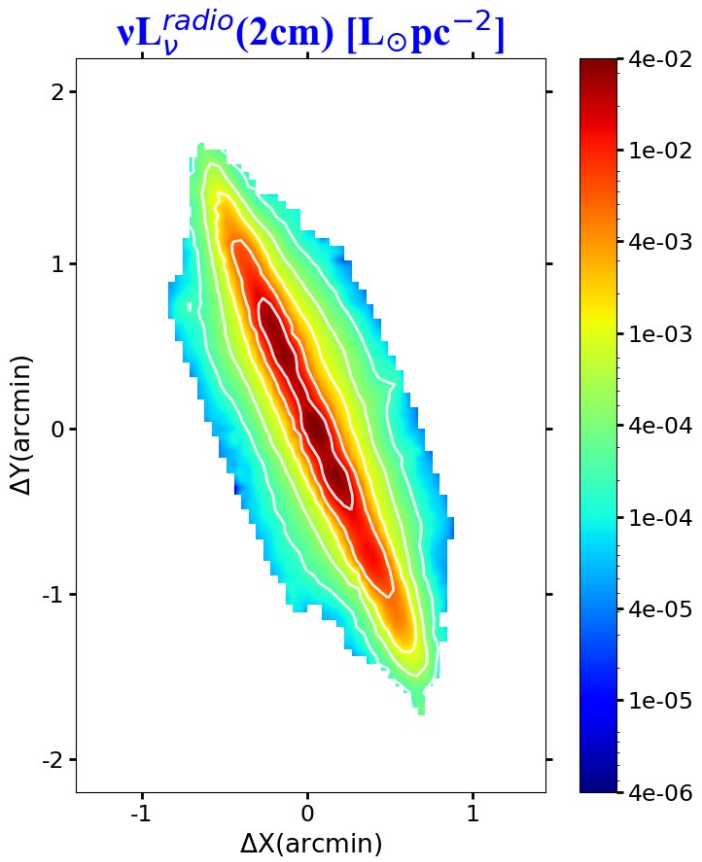
Contours levels:

0.11, 0.12, 0.14, 0.15, 0.17

HerBIE

Radio emission components

Total radio luminosity at 2 cm



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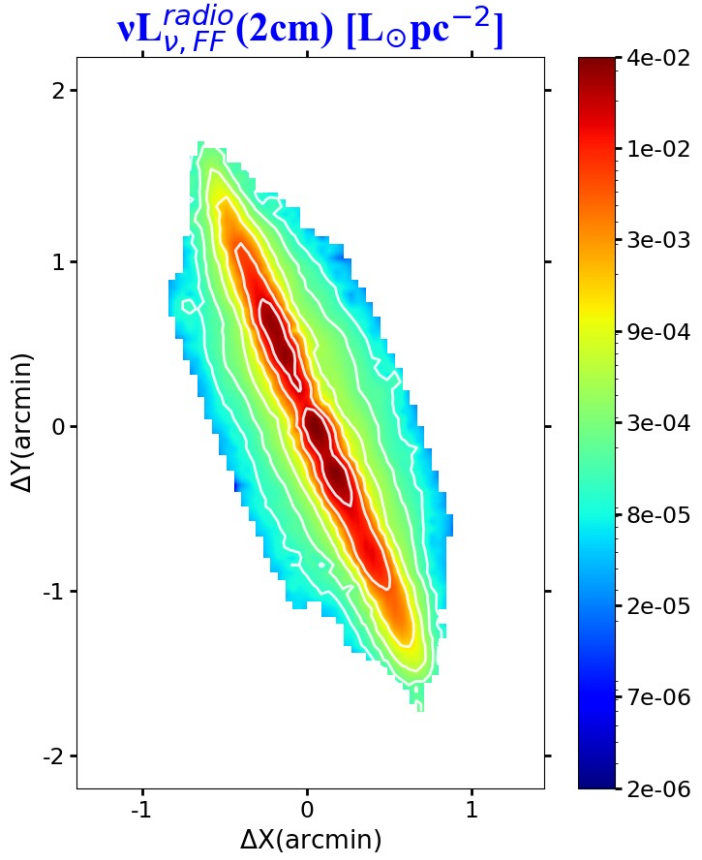
Free-free luminosity at 2 cm



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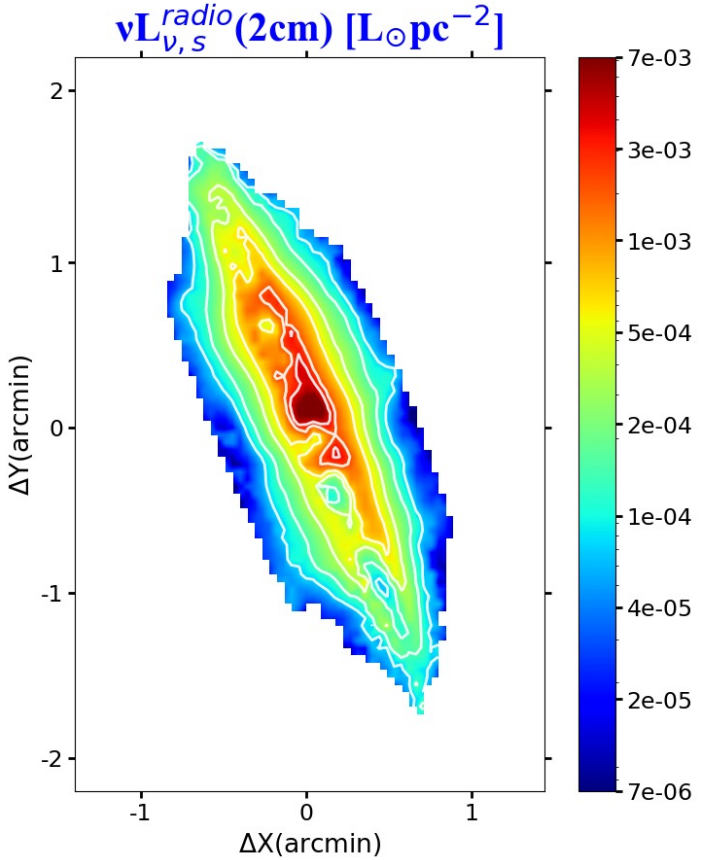
Synchrotron luminosity at 2 cm



Contours levels:

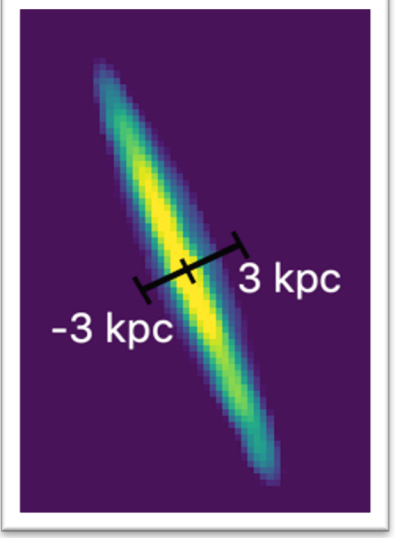
2e-4, 6e-4, 1e-3, 6e-3, 2e-2 $L_\odot\ pc^{-2}$

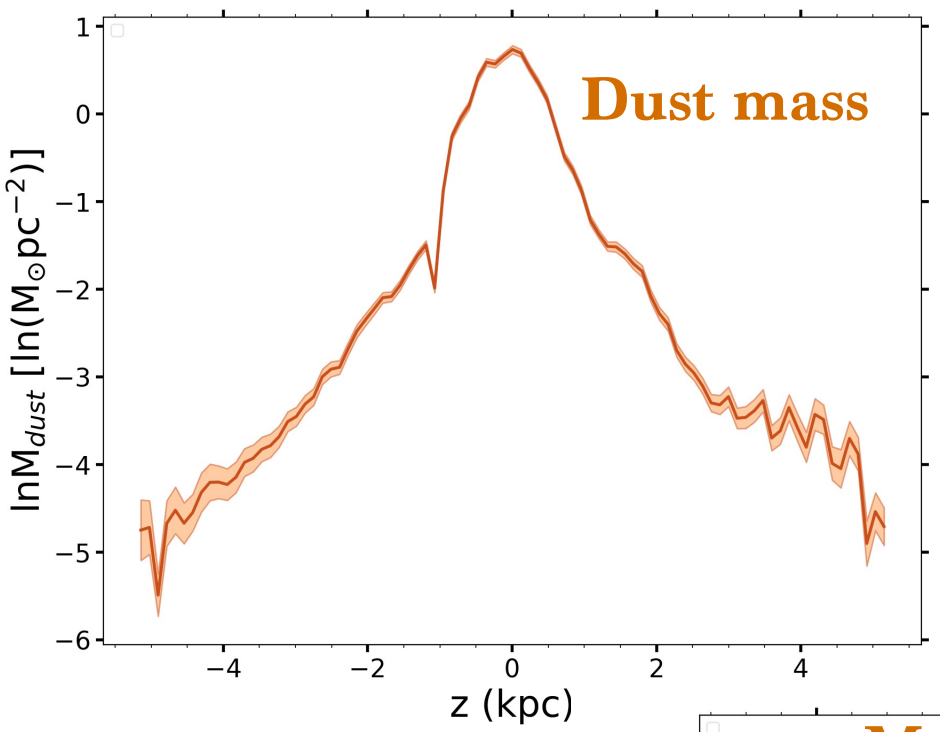
Contours levels:

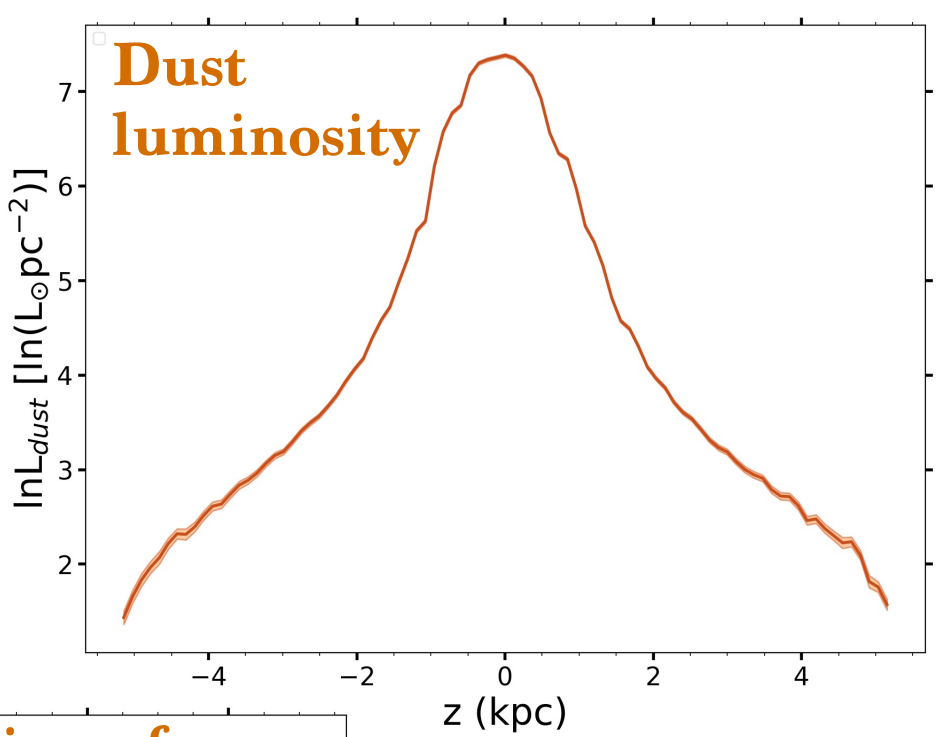
1e-4, 2e-4, 5e-4, 1e-3, 6e-3, 2e-2 $L_\odot\ pc^{-2}$

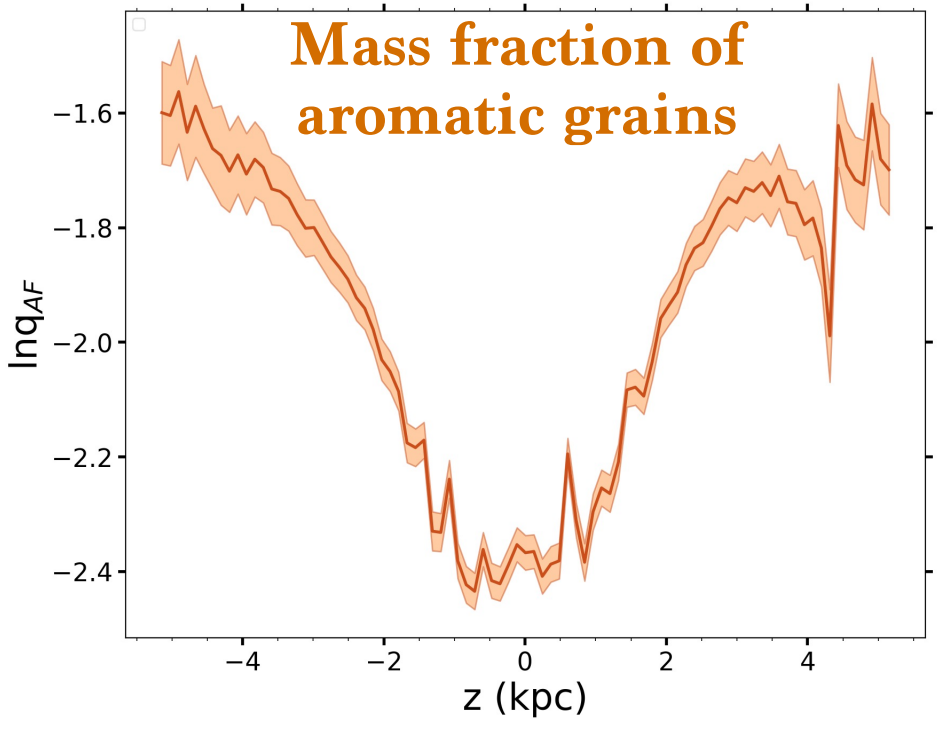
Contours levels:

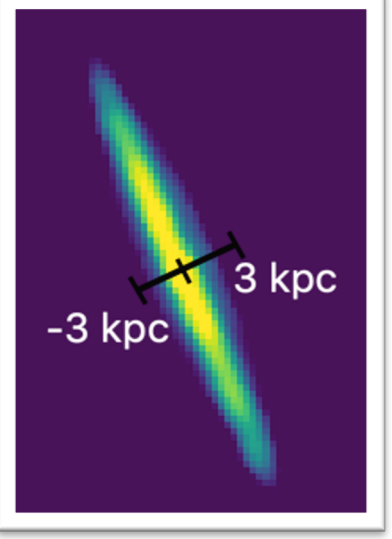
7e-5, 1e-4, 4e-4, 7e-4, 2e-3, 4e-3 $L_\odot\ pc^{-2}$


3 kpc
-3 kpc

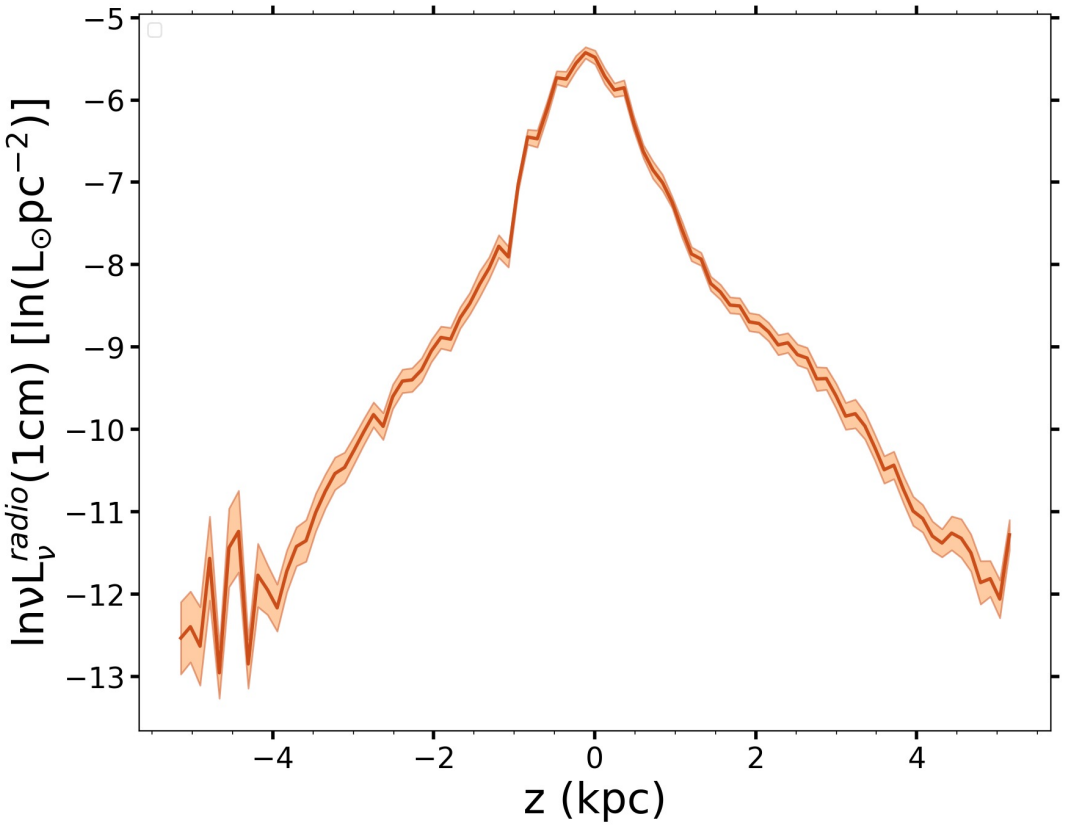

Dust mass
lnM$_{dust}$ [ln(M$_\odot$pc^{-2})]
z (kpc)


Dust luminosity
lnL$_{dust}$ [ln(L$_\odot$pc^{-2})]
z (kpc)

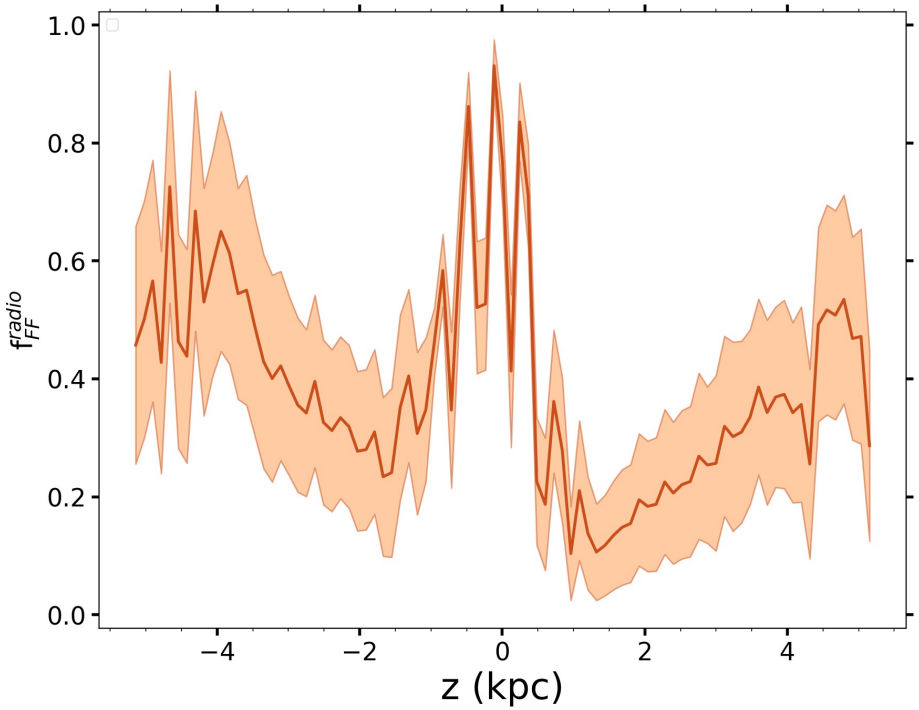

Mass fraction of aromatic grains
lnq$_{AF}$
z (kpc)



Total radio luminosity at 2 cm

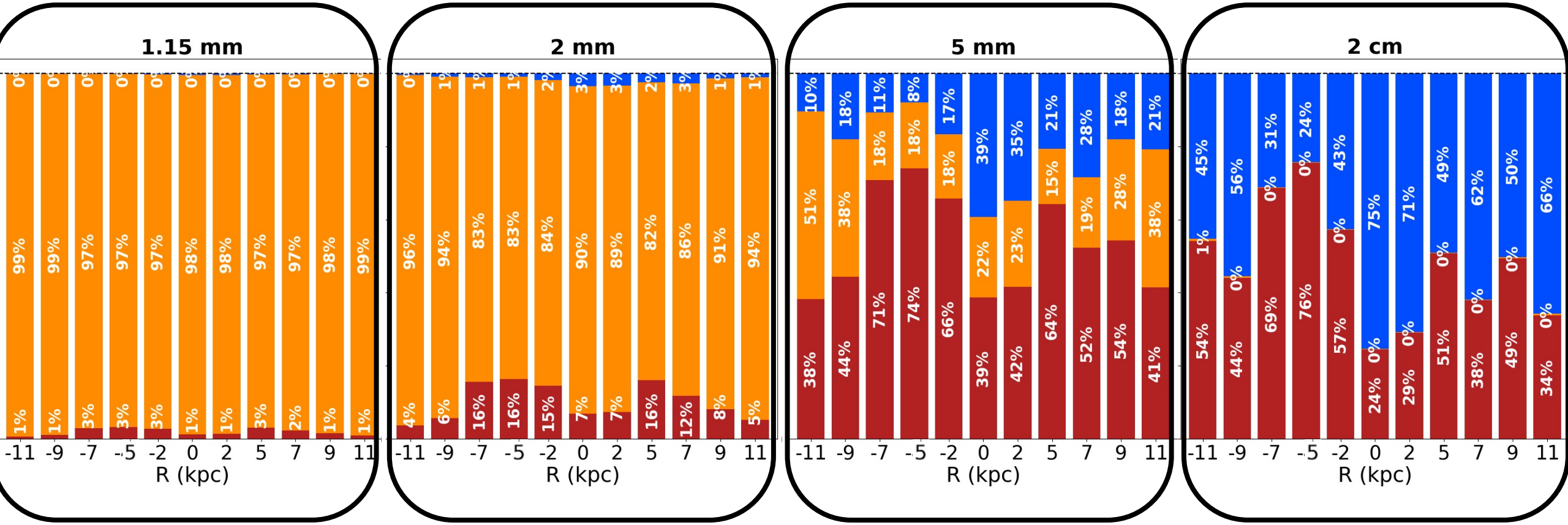


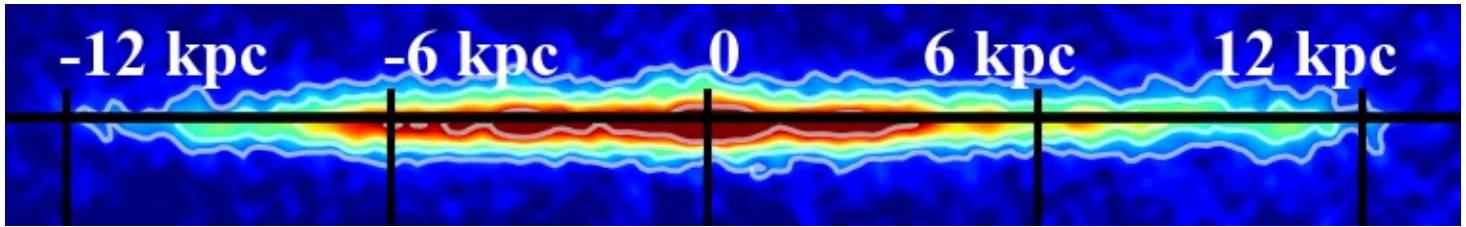
Fraction of free-free emission at 2 cm



synchrotron spectral index: ~0.8
[in agreement with Heesen et al. (2018) for NGC0891]

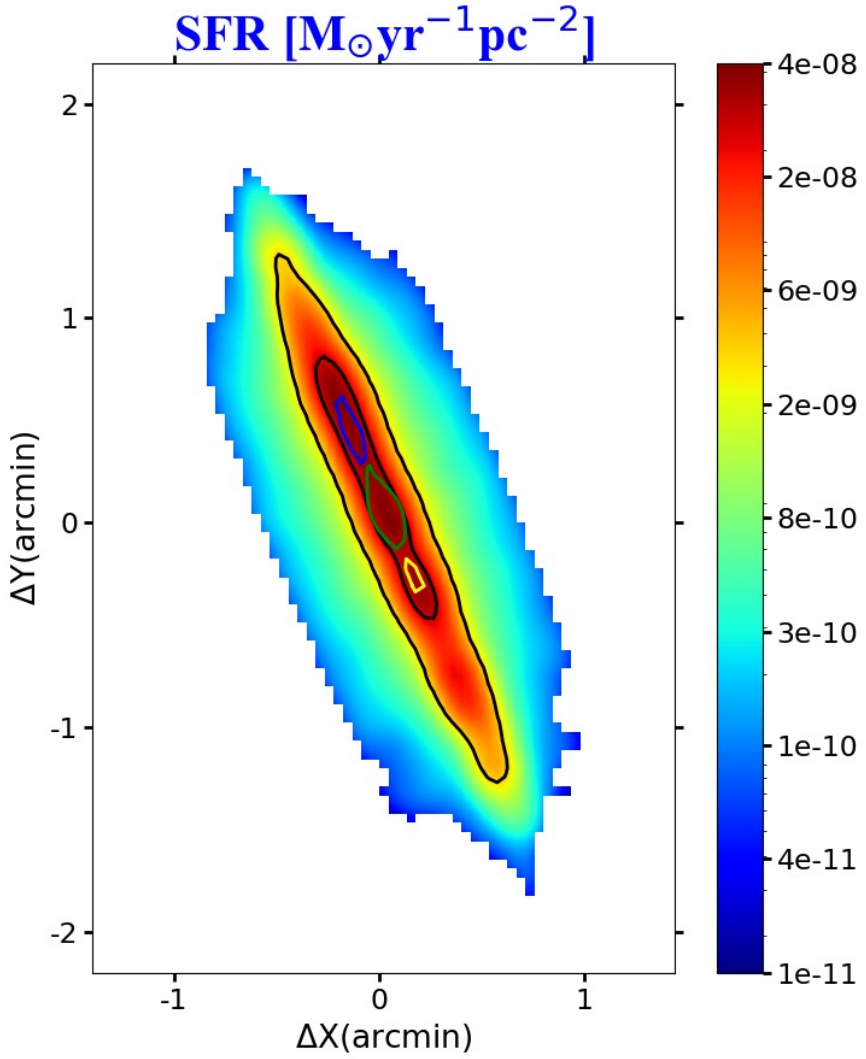
Emission decomposition along the major axis of the galaxy

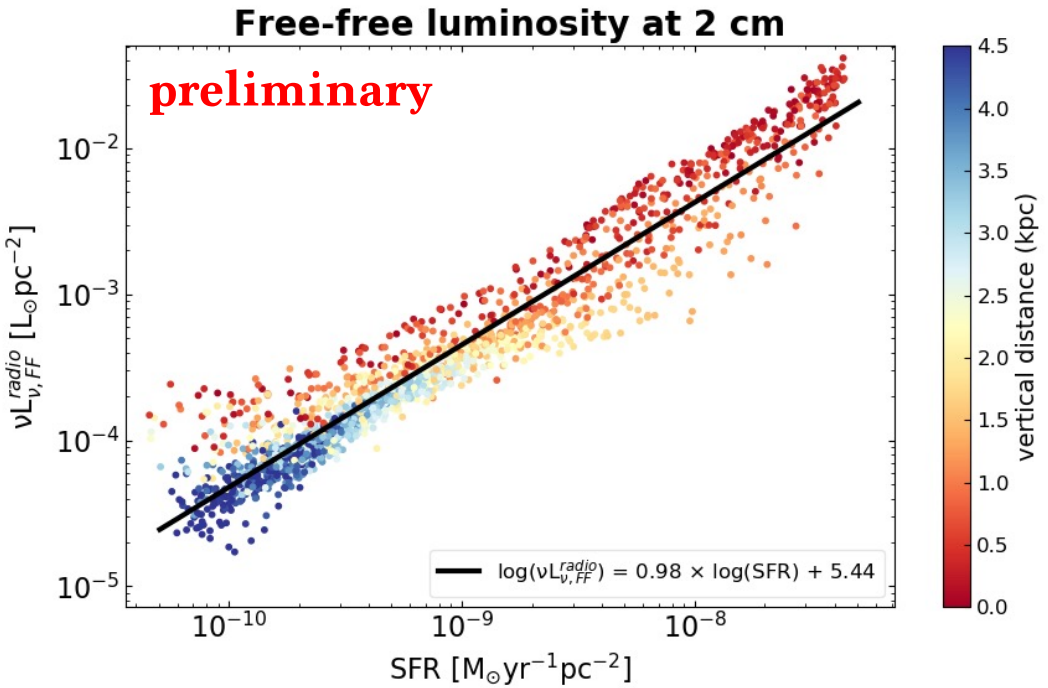




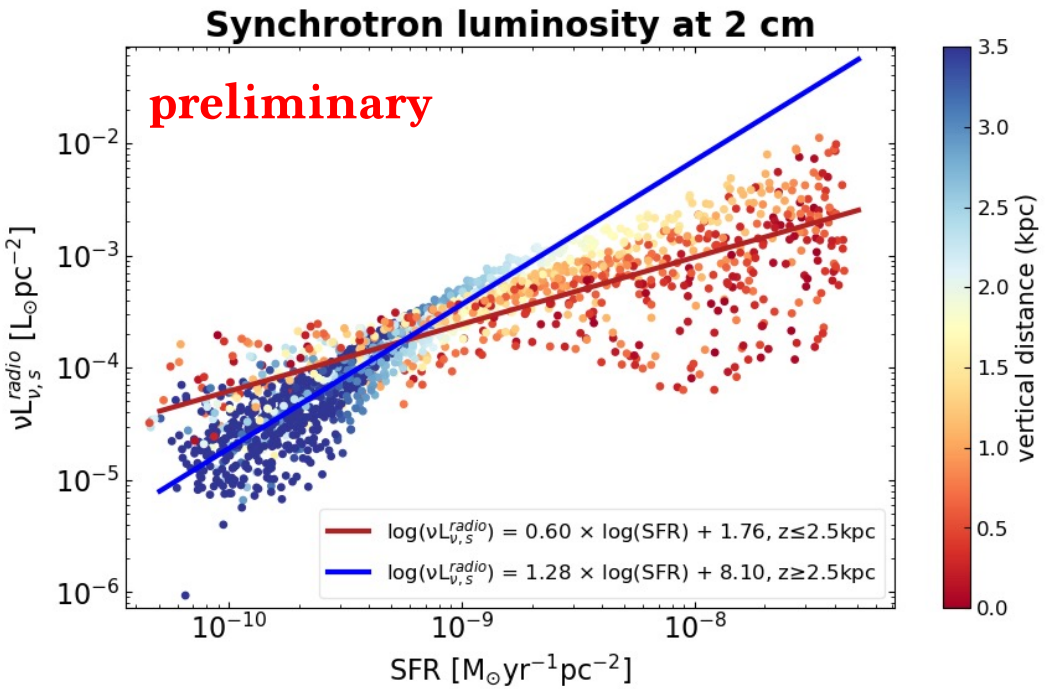
How the star formation activity is related to the radio emission components (at 2 cm) in NGC0891

Star formation activity at NGC0891 (MIPS-24μm tracer)





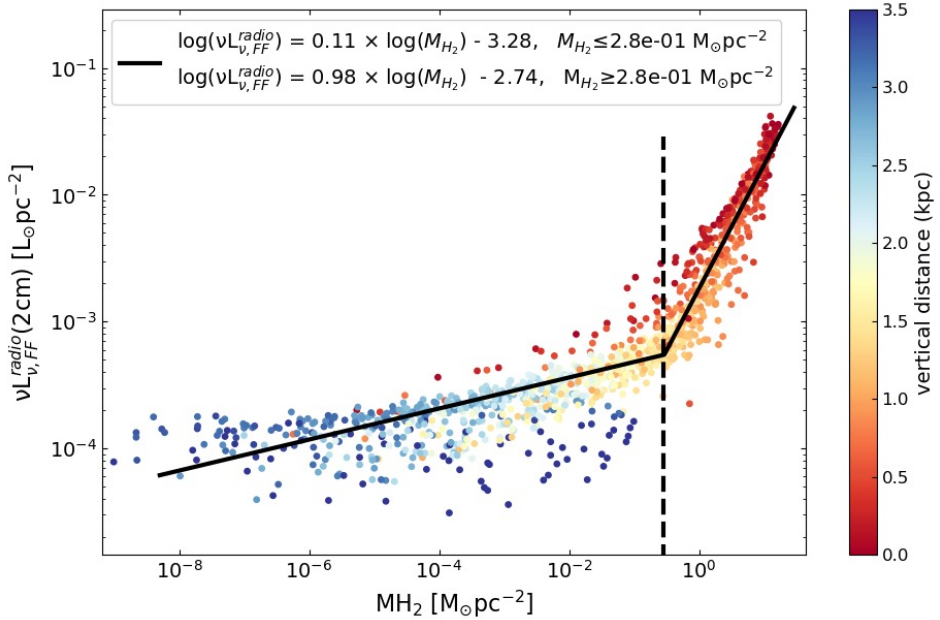
Pearson coefficient: 0.943



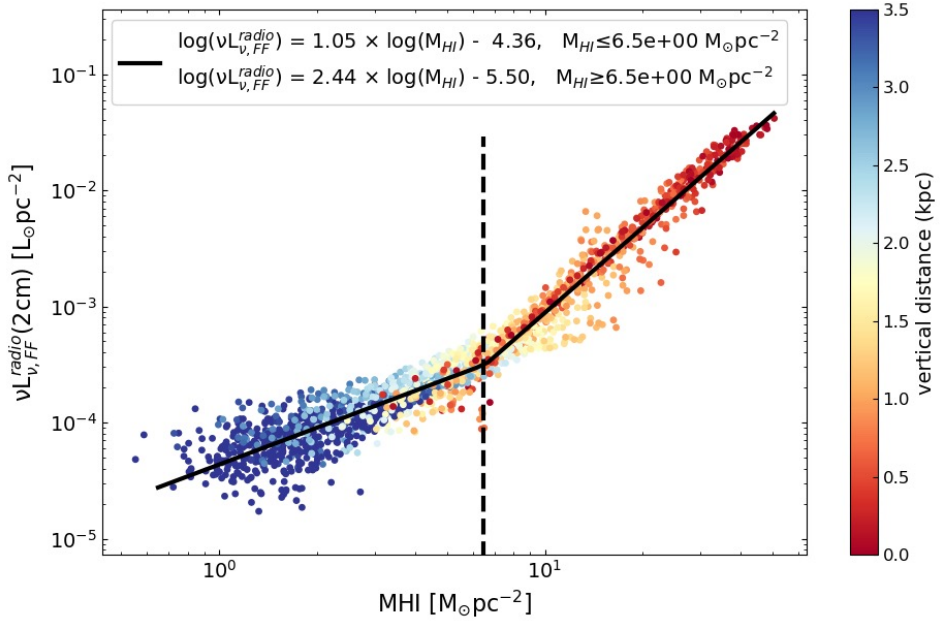
Pearson coefficient: 0.665

Free-free luminosity at 2cm

MH_2

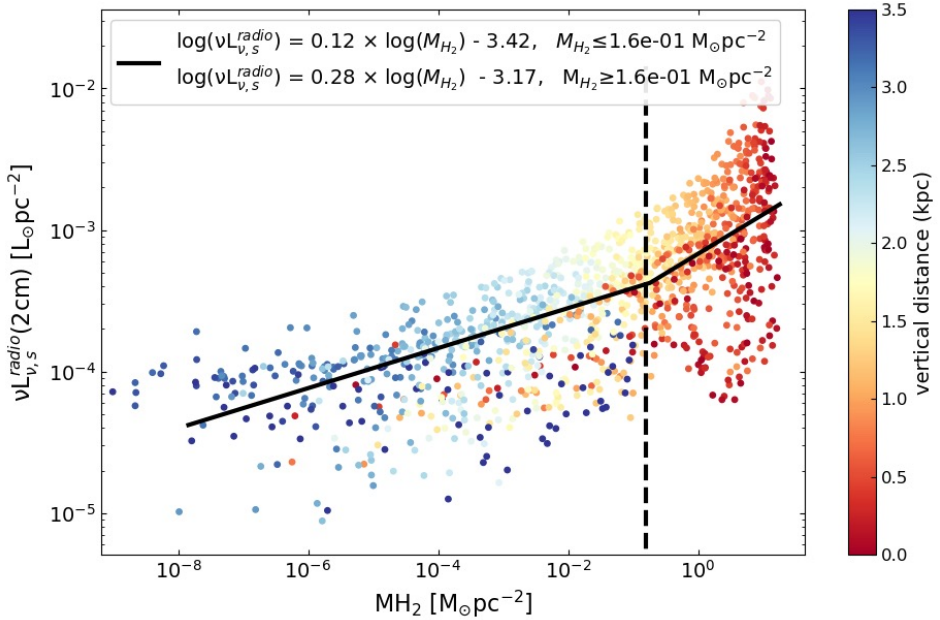


MHI

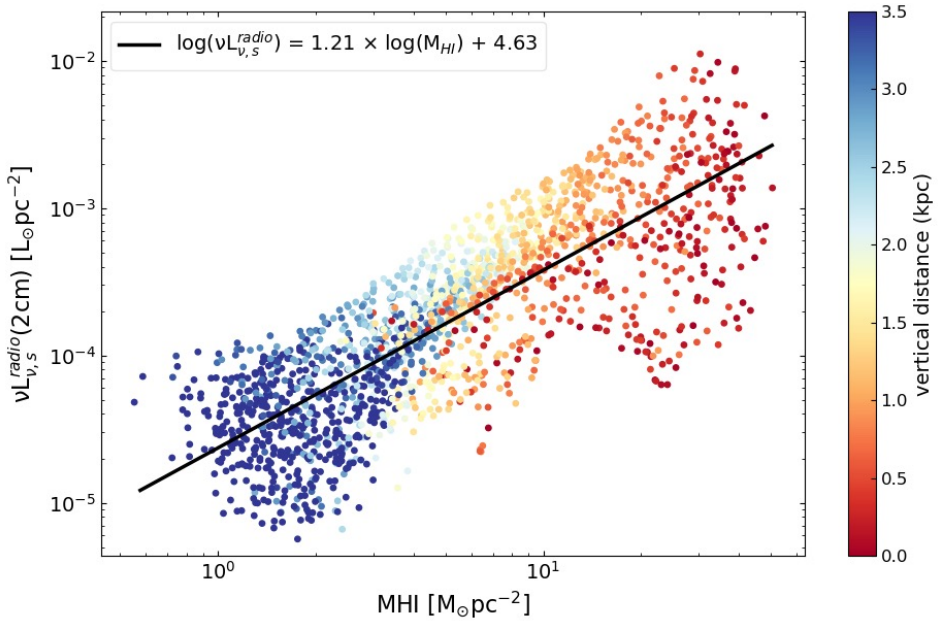


Synchrotron luminosity at 2cm

MH_2



MHI



Conclusions:

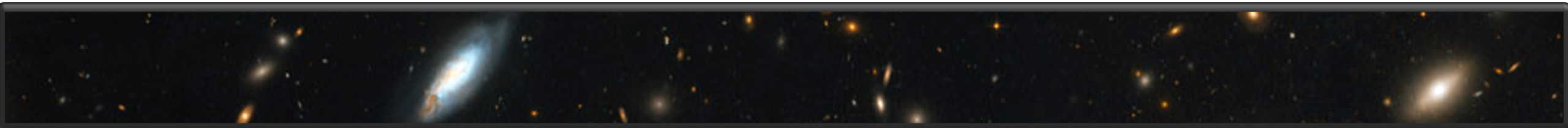
❑We present maps of NGC891, a nearby (9.6 Mpc) edge-on spiral galaxy observed at 1.15 and 2 mm as part of the **IMEGIN** program.

❑We make use of multiwavelength observations (from mid-IR to radio wavelengths) together with the **HerBIE SED fitting code** to decompose the galaxy's SED into the different emission mechanisms (**PAH emission, dust thermal emission, Free-Free, and synchrotron emission**).

❑ **Due to the NIKA2 observations, we are capable of constraining better the emission of the galactic disk within the millimeter regime.** We find that the majority of the emission at 1.15 mm comes from the dust thermal emission while for wavelengths longer than 2 mm (up to 5 cm) the dust emission fraction progressively drops, giving rise to Free-Free, and synchrotron emission.

❑The Free-Free radio luminosity at 1 cm shows, in general, a tight correlation with the SFR (tracing through the 24μm emission) for all the SFR range and for all areas throughout the galaxy. The luminosity originating from the synchrotron emission also correlates well with the SFR but in a different way for areas closer to the galactic plane (below 2 kpc) and for areas away from the plane of the galaxy (above 2 kpc).

❑ This break at ~2 kpc is also evident when comparing the radio emission mechanisms (Free-Free, and synchrotron) with the atomic and the molecular gas masses (MHI and MH2).



Thanks a lot for your attention!