A new analysis of low-frequency radio luminosity as a star-formation tracer in the Lockman Hole region using LOFAR deep observations

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Paper

The LOFAR Two-metre Sky Survey Deep Fields: A new analysis of low-frequency radio luminosity as a star-formation tracer in the Lockman Hole region

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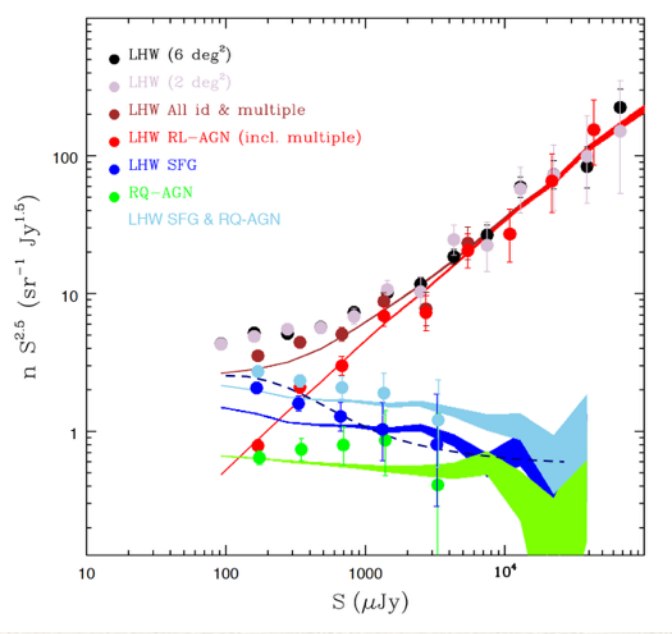
Introduction

- Radio-source counts increasingly dominated by star-forming galaxies at 1.4 GHz flux densities fainter than a few hundred μJy ➜ **growing role for deep radio surveys** in the study of the **star-formation history** of galaxies



Prandoni+,2018

JVLA

LOFAR

MeerKAT

ASKAP

- Huge increase in sensitivity of **JVLA**, **LOFAR**, **MeerKAT** and **ASKAP** ➜ exploiting radio surveys as a probe of galaxy evolution up to **high redshifts**

Introduction

- UV surveys have allowed the investigation of the galaxy luminosity functions up to z~10, BUT miss a lot of dust-obscured star formation and may be contaminated by emission from AGN. FIR and sub-mm surveys measure only starlight reprocessed by dust, which may include the contribution of evolved stars. Large-area FIR and sub-mm surveys currently suffer from resolution limitations, implying severe confusion limits

- **Radio emission: dust–independent and powered by recent star formation** (although may also be contaminated by radio AGN)

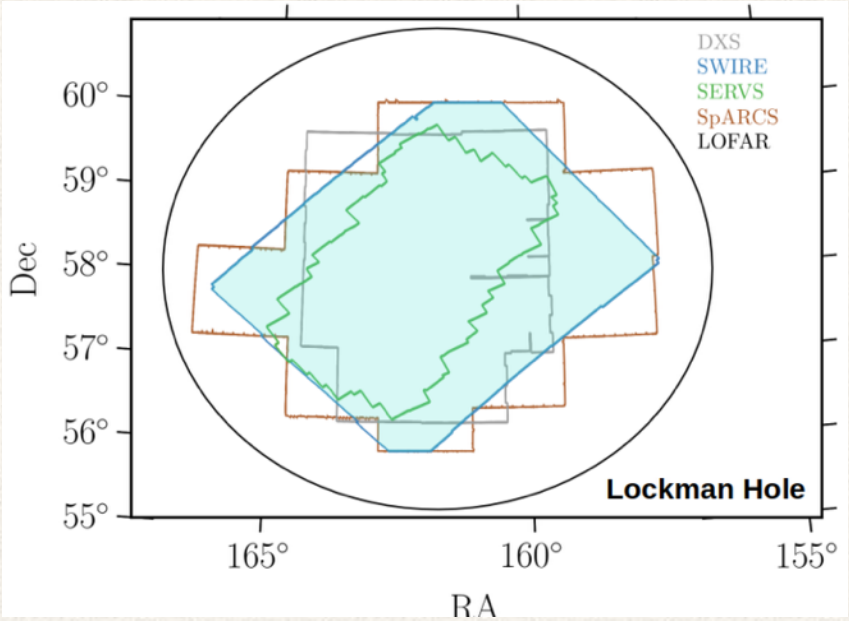
- New radio surveys ➜ **l**arge increases in **sensitivity**, **resolution** and **survey speed**

- **New deep radio surveys in preparation for the deeper and wider continuum extra-galactic surveys that will be carried out by SKA**

Data and classification

- **~112 h** of LOFAR observations (at **~150 MHz**)

- **Deep multi-frequency data** for a large fraction of the field:
  - optical (u, g, r, i and z bands, from SpARCS and RCSLenS);
  - NUV and FUV (from GALEX-DIS);
  - NIR (J and K bands; from UKIDSS);
  - MIR (in the 4 IRAC channels, from SWIRE and SERVS);
  - FIR (MIPS, SPIRE and PACS, from HerMES).

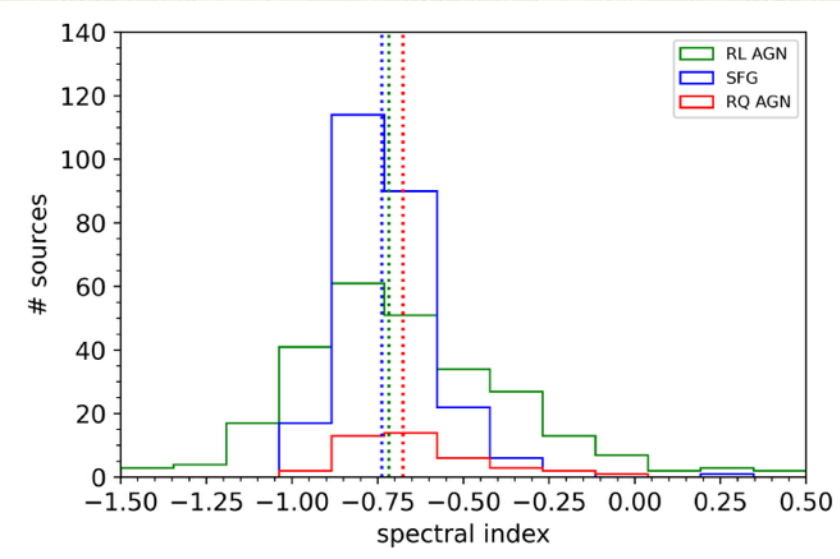


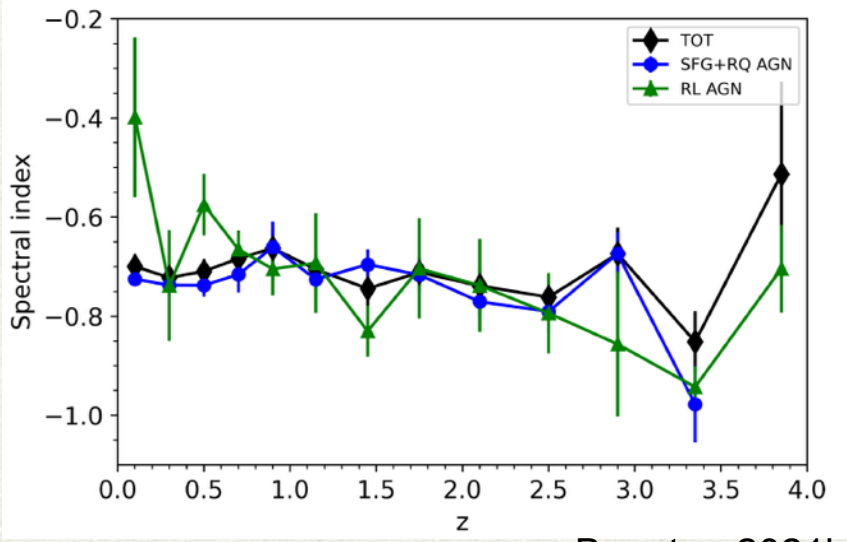
Kondapally+,2021

- The final LH cross-matched catalogue contains **31162** sources: **~98% optically identified**; **~97% spectroscopic or high-quality photometric redshifts**

- **4 different SED fitting methods** used for source **classification** and to estimate **SFR** and **M_***: **MAGPHYS**, **BAGPIPES**, **CIGALE** and **AGNfitter** (Best et al. in prep.)

1.4GHz-150MHz spectral index





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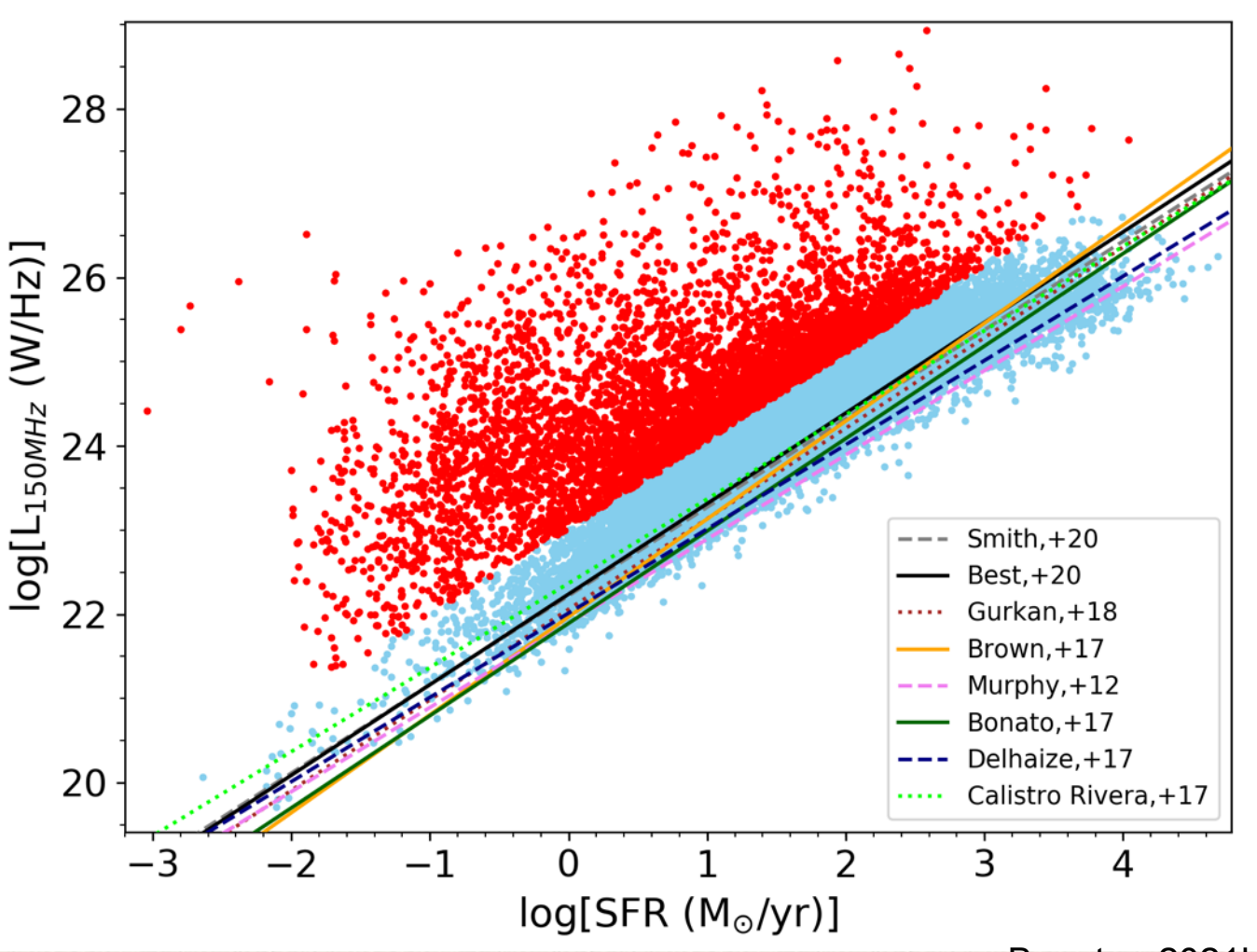
- The conclusion related to the origin of the dominant radio emission (nuclear activity or star formation) **may be different at different frequencies**

- Flattening of the median spectral index of RL AGN at the lowest redshifts and a slight trend towards a steepening of the RL AGN spectral index with increasing z

SFR-L_{radio} relation



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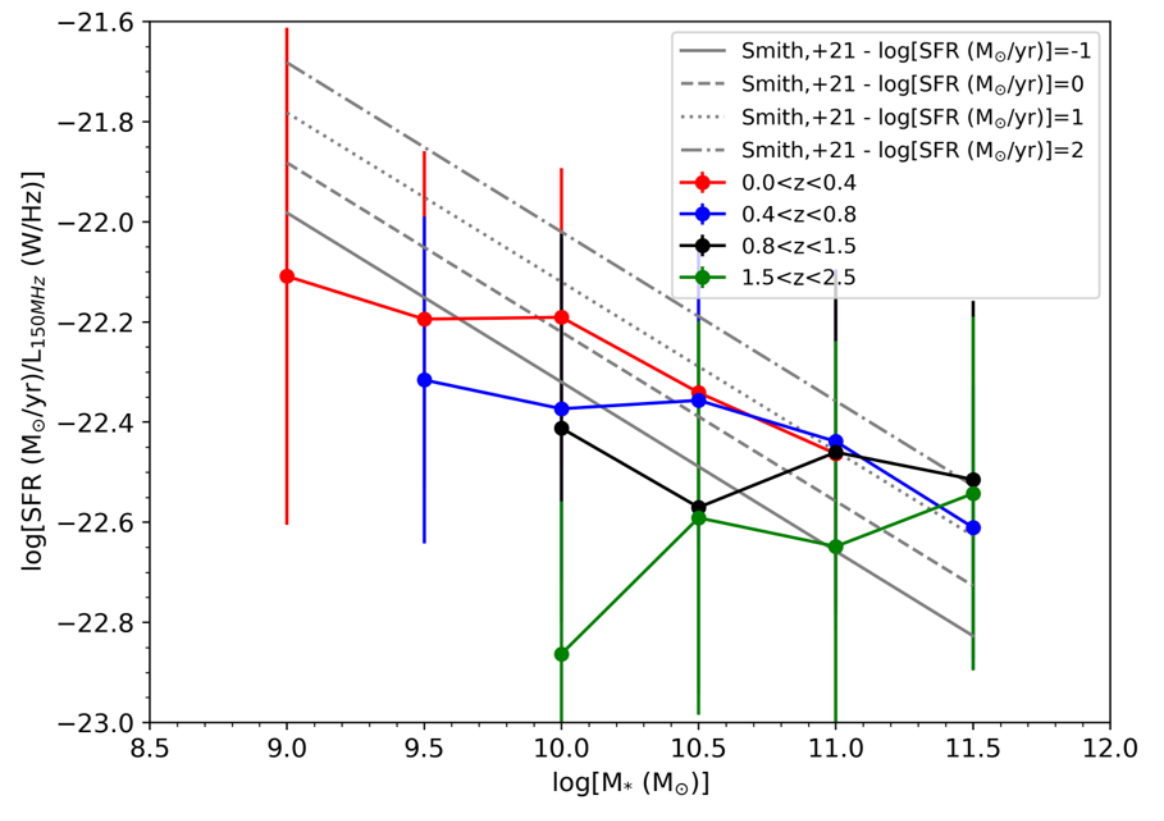
Variations in the ratios reach a factor>2

SFR/L_{radio} vs. M_*



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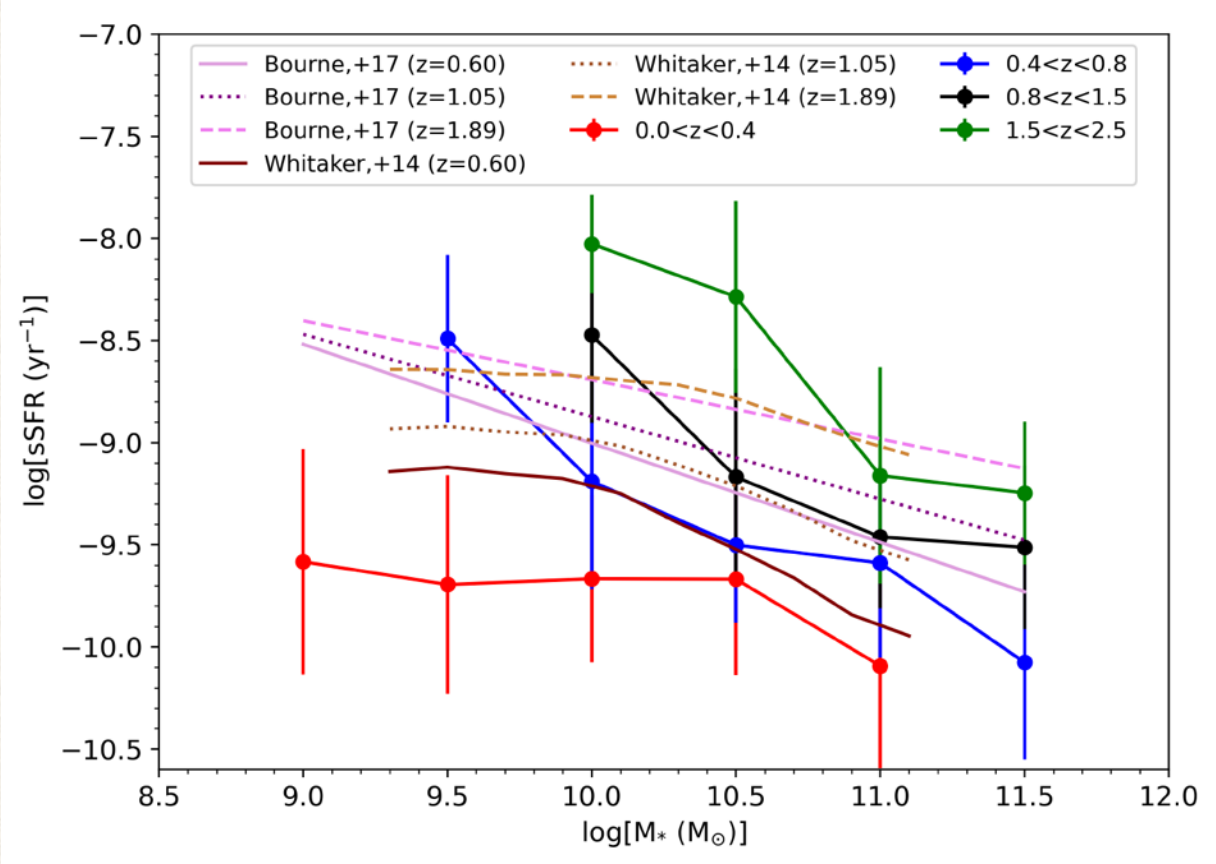
- Trend towards a lower ratio between SFR and radio luminosity for higher stellar mass
- Evolution of the ratio being mostly driven by its increase with stellar mass

➜consistent with Smith et al. (2021) and Delvecchio et al. (2021)

sSFR vs. M_*



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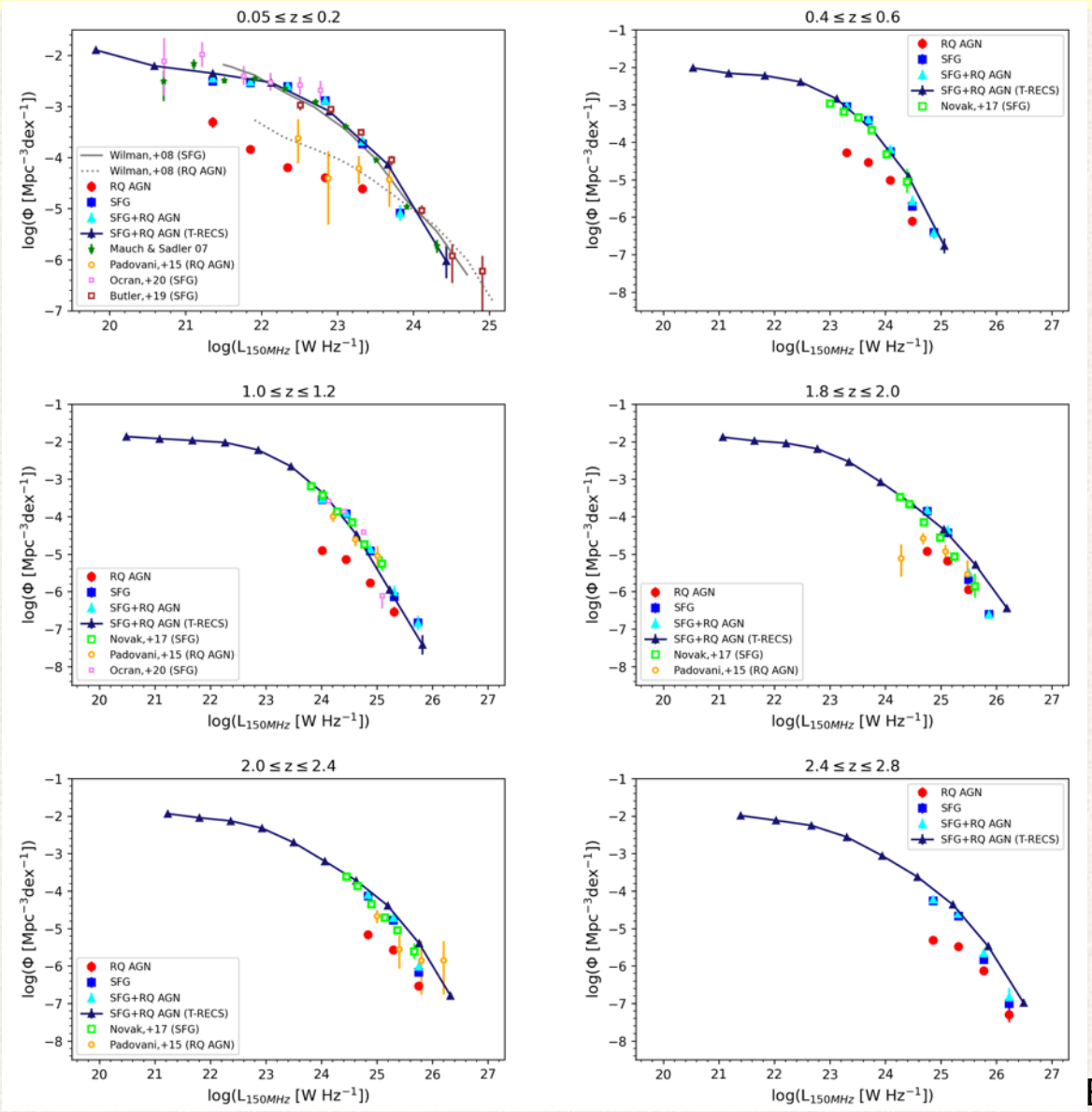
Potential **higher efficiency** of the **radio selection** at detecting **early phases of galaxy evolution**, when the stellar masses were still relatively low

150 MHz LFs



- 15 different redshift bins, up to **z~4**
- Good agreement with the T-RECS simulations and with other theoretical and observed luminosity functions

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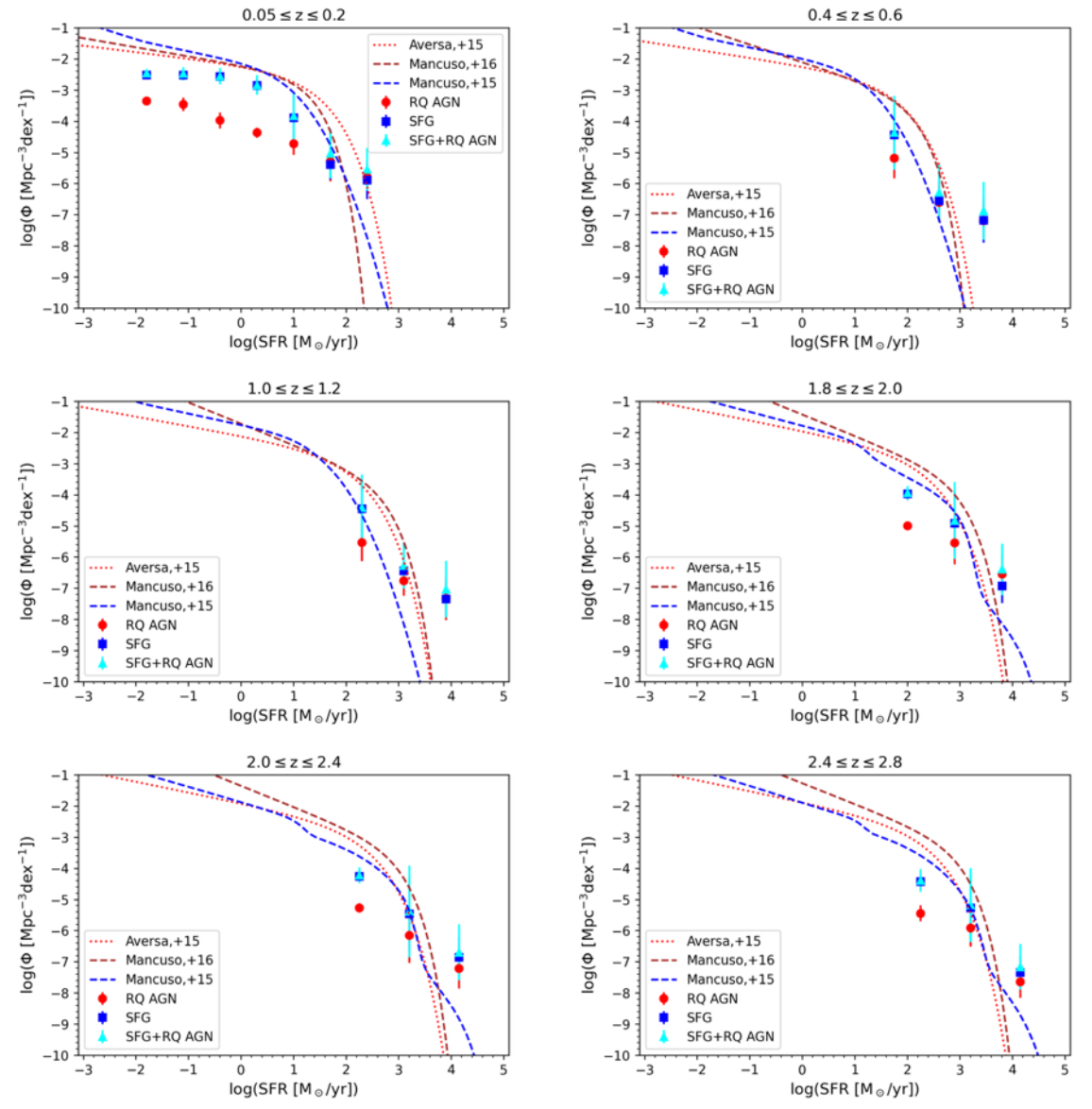
SFR functions



- 13 different redshift bins, up to z~3.2

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Summary

- ☑ We have exploited LOFAR deep observations of the LH field at 150MHz to investigate the relation between the radio luminosity of SFGs and their SFRs, as well as its dependence on stellar mass and redshift.
- ☑ The adopted source classification, SFR and M_* are consensus estimates based on a combination of 4 different spectral energy distribution fitting methods.
- ☑ We note a flattening of the radio spectra of a substantial minority of sources below 1.4 GHz➜such sources have thus a lower 'radio-loudness' level at 150MHz than expected.
- ☑ We find a weak trend towards a lower SFR/L_{150MHz} ratio for higher M_*➜such a trend may account for most of the apparent redshift evolution of the L_{150MHz}/SFR ratio, in line with previous works.
- ☑ We find a weaker evolution with redshift of the specific SFR than found by several (but not all) previous studies.
- ☑ We have derived luminosity functions at 150MHz of both SFGs and RQ AGN at various redshifts. Our results are in very good agreement with the T-RECS simulations and with literature estimates.
- ☑ We have derived explicit estimates of SFR functions of SFGs and RQ AGN at several redshifts.
- ☑ **Better data are necessary for the increasing complexities.**