The low-frequency radio luminosity – star formation rate relation

Gulay Gurkan Uygun,
Martin Hardcastle, Dan Smith and LOFAR & H-ATLAS Collaborations

The broad impact of low-frequency observing, Bologna-Italy 19-23 June 2017

CSIRO ASTRONOMY AND SPACE SCIENCE
www.csiro.au

University of Hertfordshire

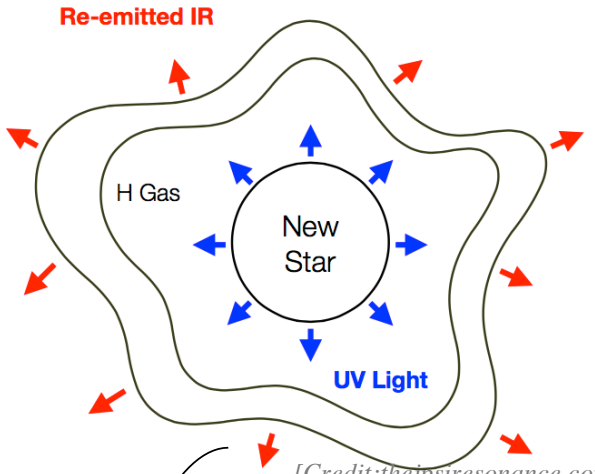
Outline

- Background
- Motivation
- Data and sample
- Results
  - Investigations of the L_{150}-SFR relation
  - The far-IR – radio correlation
  - Nature of objects unclassified by BPT diagrams
- Conclusions

Star formation in normal galaxies (SFGs)

Synchrotron emission
(High energy electrons and positrons accelerated in supernova remnants)

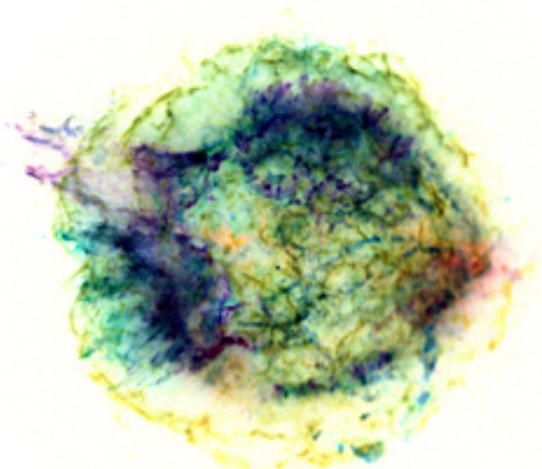
Optical and ultraviolet emission from young stars



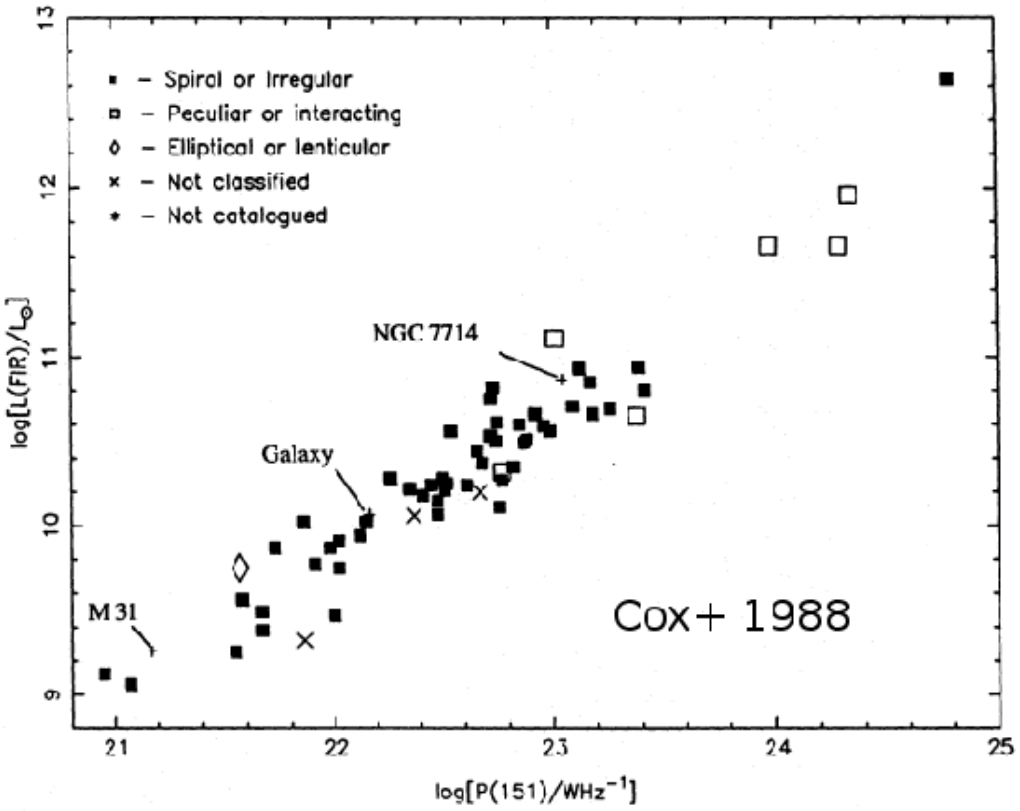
[Credit:thejpsiresonance.com]

Free-free emission from gas ionised by massive stars

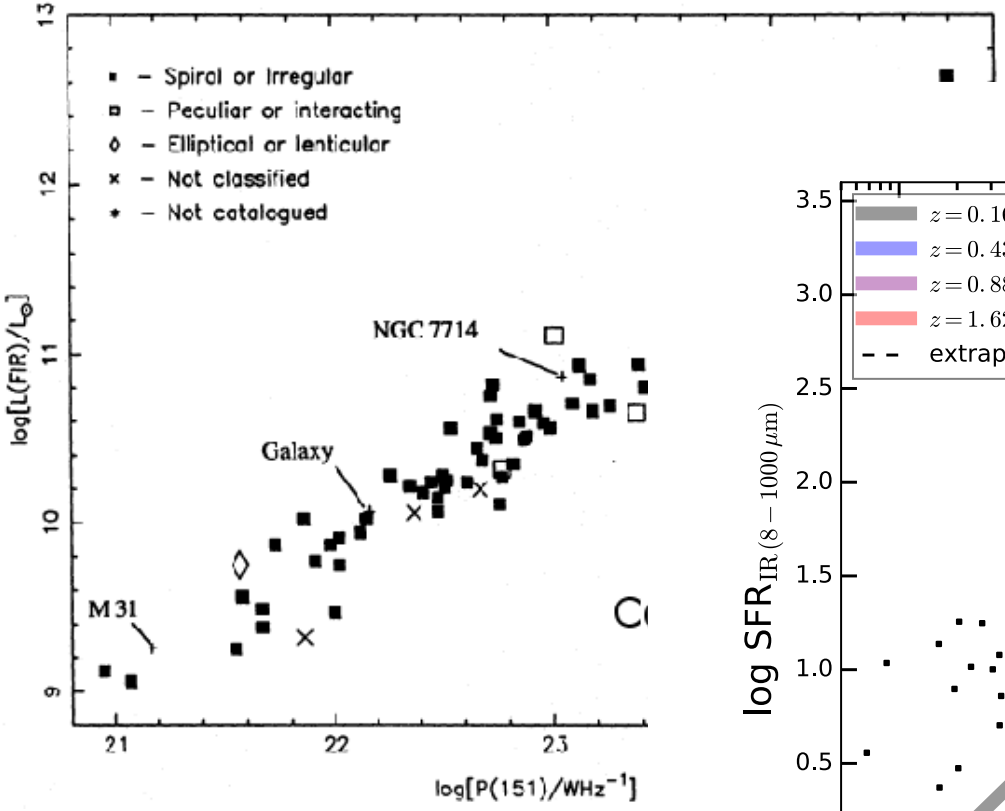
Partially absorbed by dust and re-emitted in the far infrared

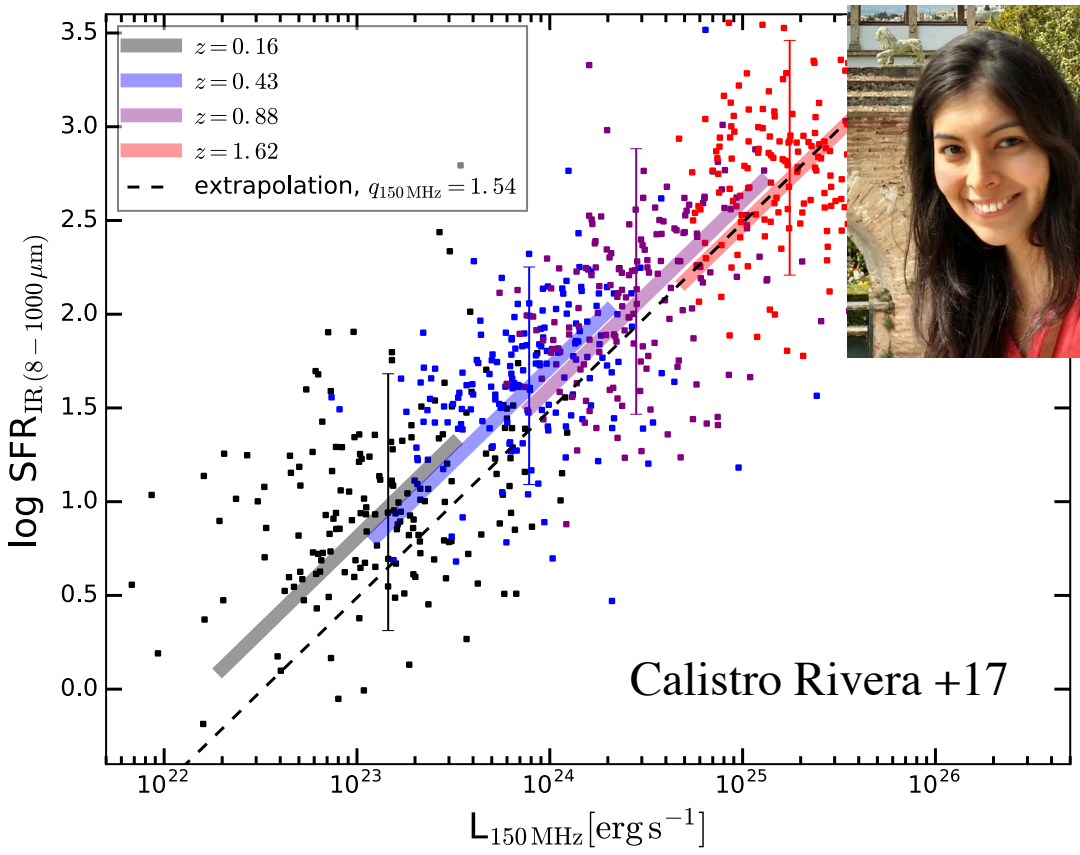

Credit: NASA/CXC/MIT/UMass Amherst

The far-IR – radio correlation



The far-IR – radio correlation



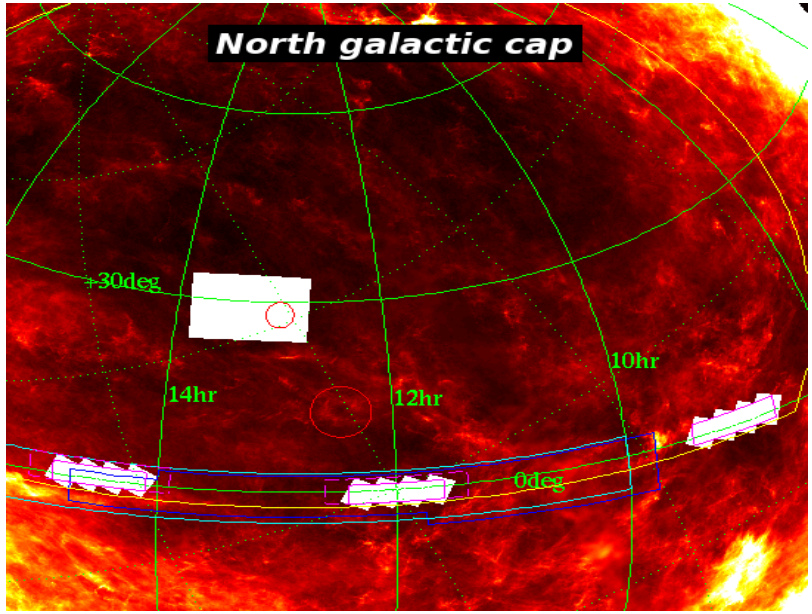


Motivation

- Low-frequency radio as SFR indicator?
- Radio emission from normal galaxies are not affected by dust obscuration.
- At low frequencies the contribution to the radio luminosity from thermal free-free emission becomes increasingly negligible.
- There is no far-IR instrument currently surveying the sky.
- LOFAR ⟶ the northern sky

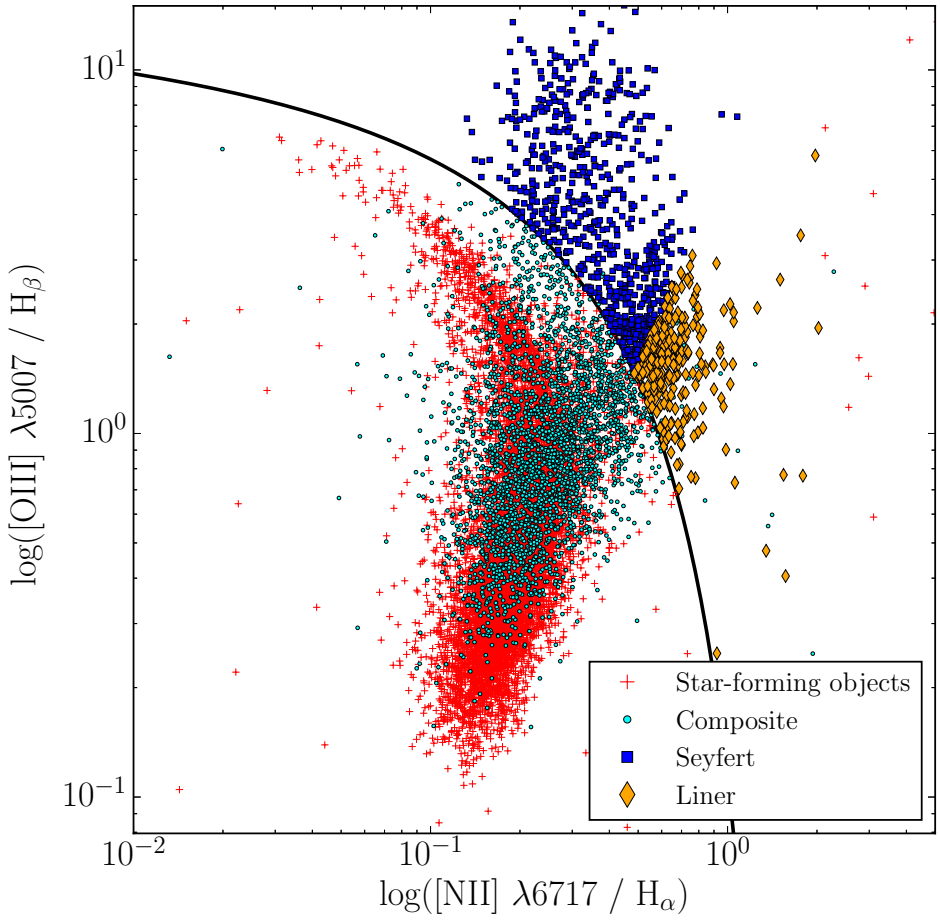
  The Square Kilometer Array (SKA) ⟶ the southern sky.
- The `main sequence' of star formation (the effect of stellar mass)!?

Sample



H-ATLAS North Galactic Pole field
~170 square degrees

MPA-JHU sample
Radio AGN *[Best & Heckman 2012]*



[BPT; Baldwin, Phillips, Terlevich 1981]

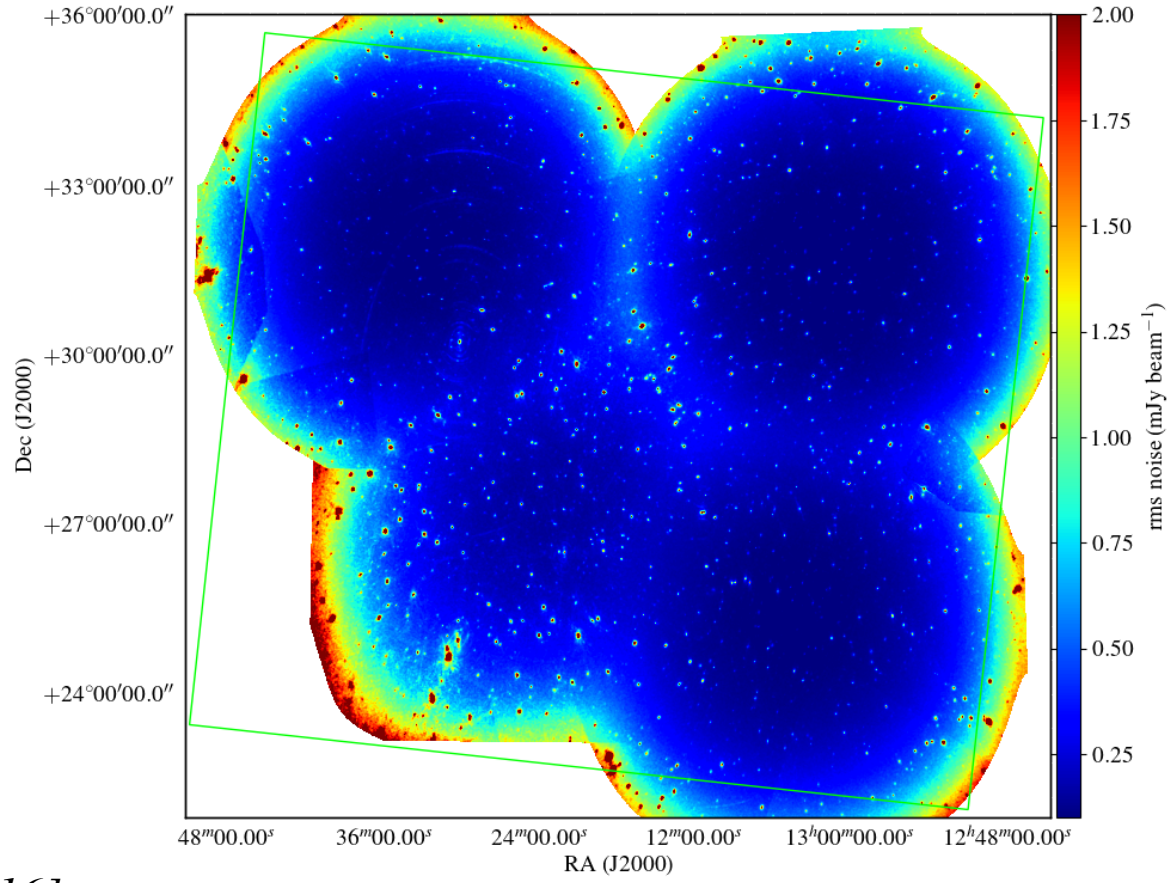
The LOFAR survey of the HATLAS/NGP field

Low-HBA Observations
(110-180 MHz)

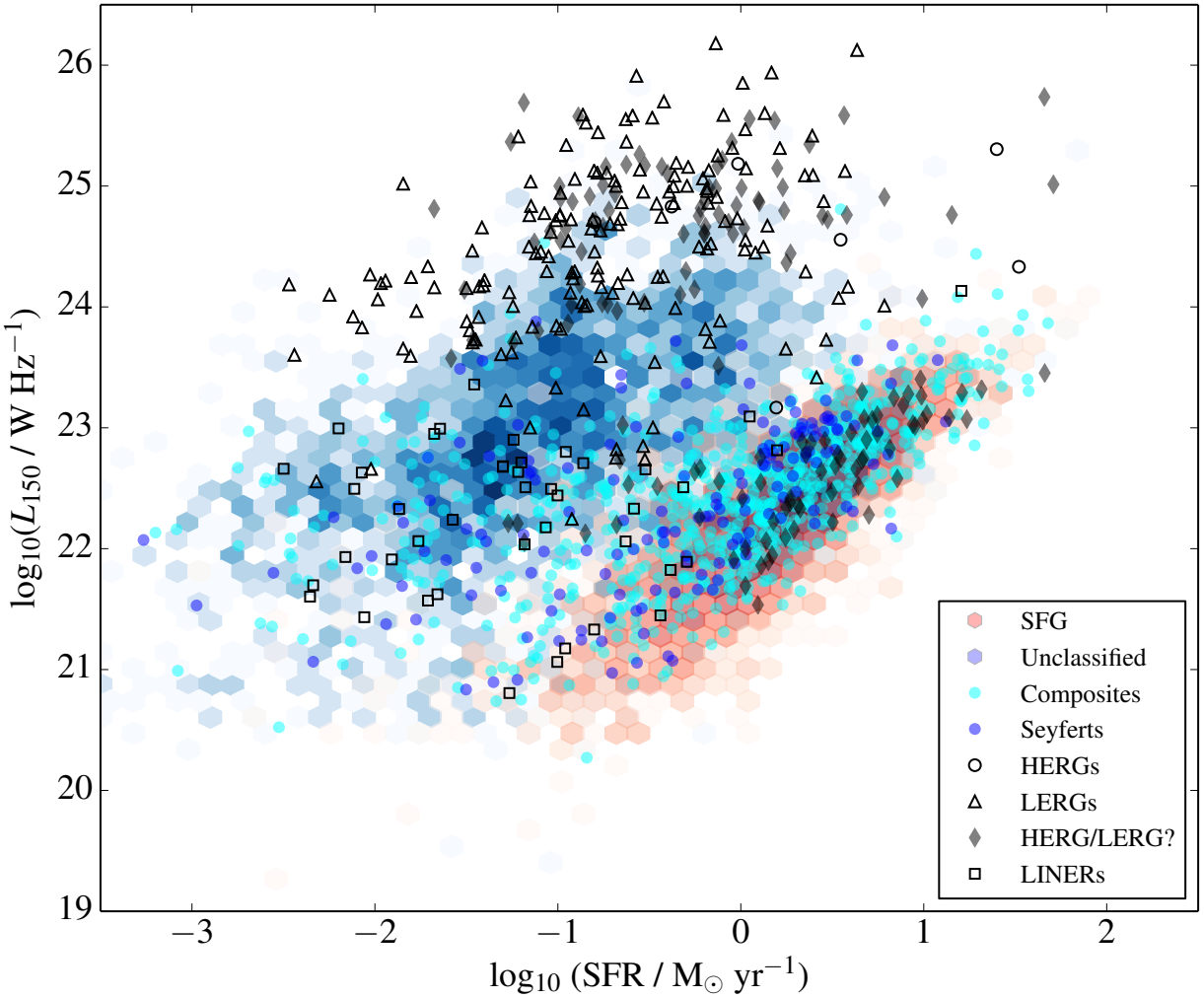
Average frequency is 150 MHz

LOFAR LoTSS pipeline:
DDFacet and KillMS
[Cyril Tasse, Tim Shimwell and Martin Hardcastle]

Final mosaic map:
Resolution ~ 10x8 arcsec
Sensitivity ~100μJy/beam



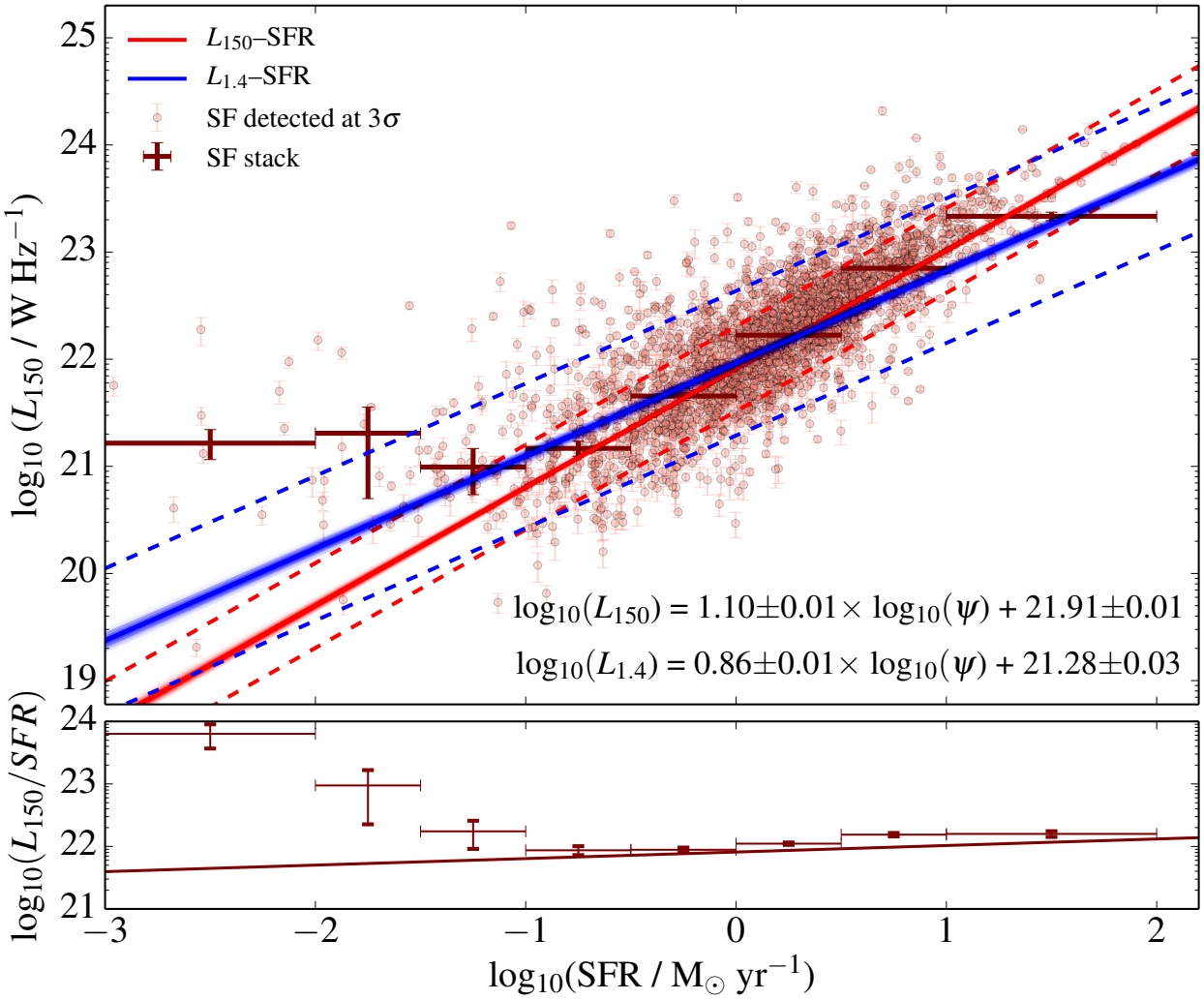
[Hardcastle et al. 2016]



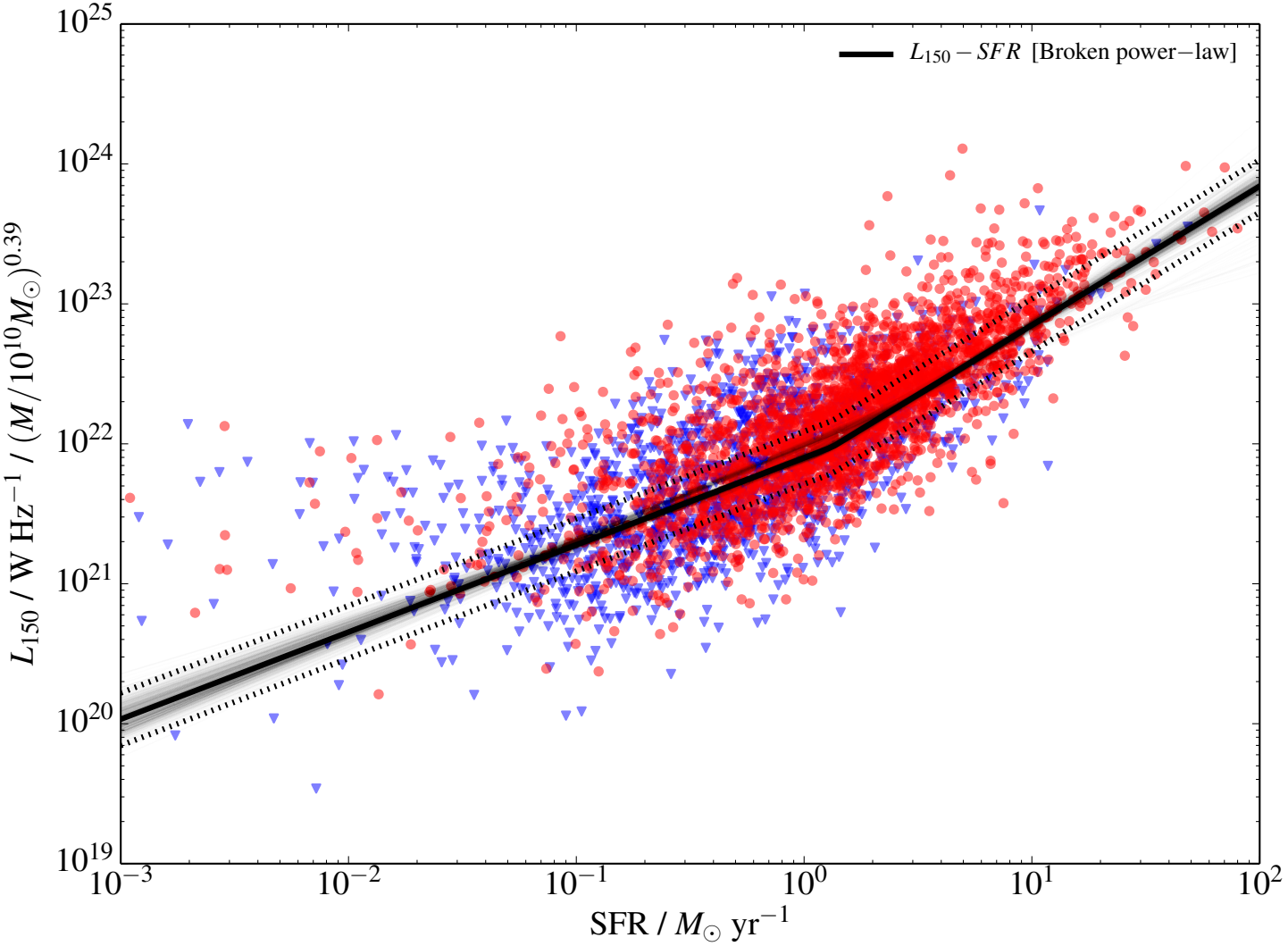
Star formation rates and stellar masses are from MagPhys

[Da Cunha, Charlot & Elbaz 2008]

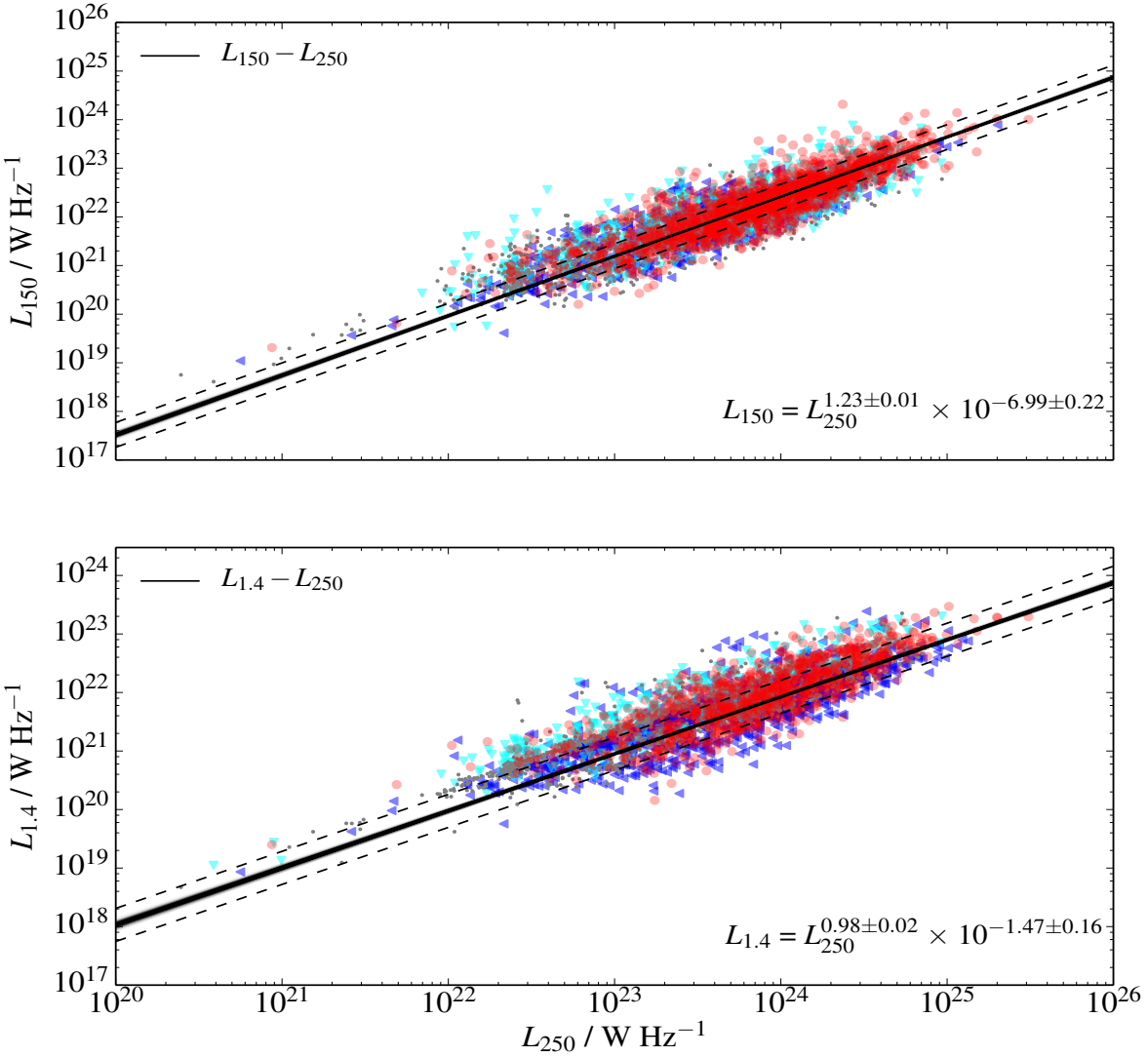
The L_{150} – SFR relation in local SFGs



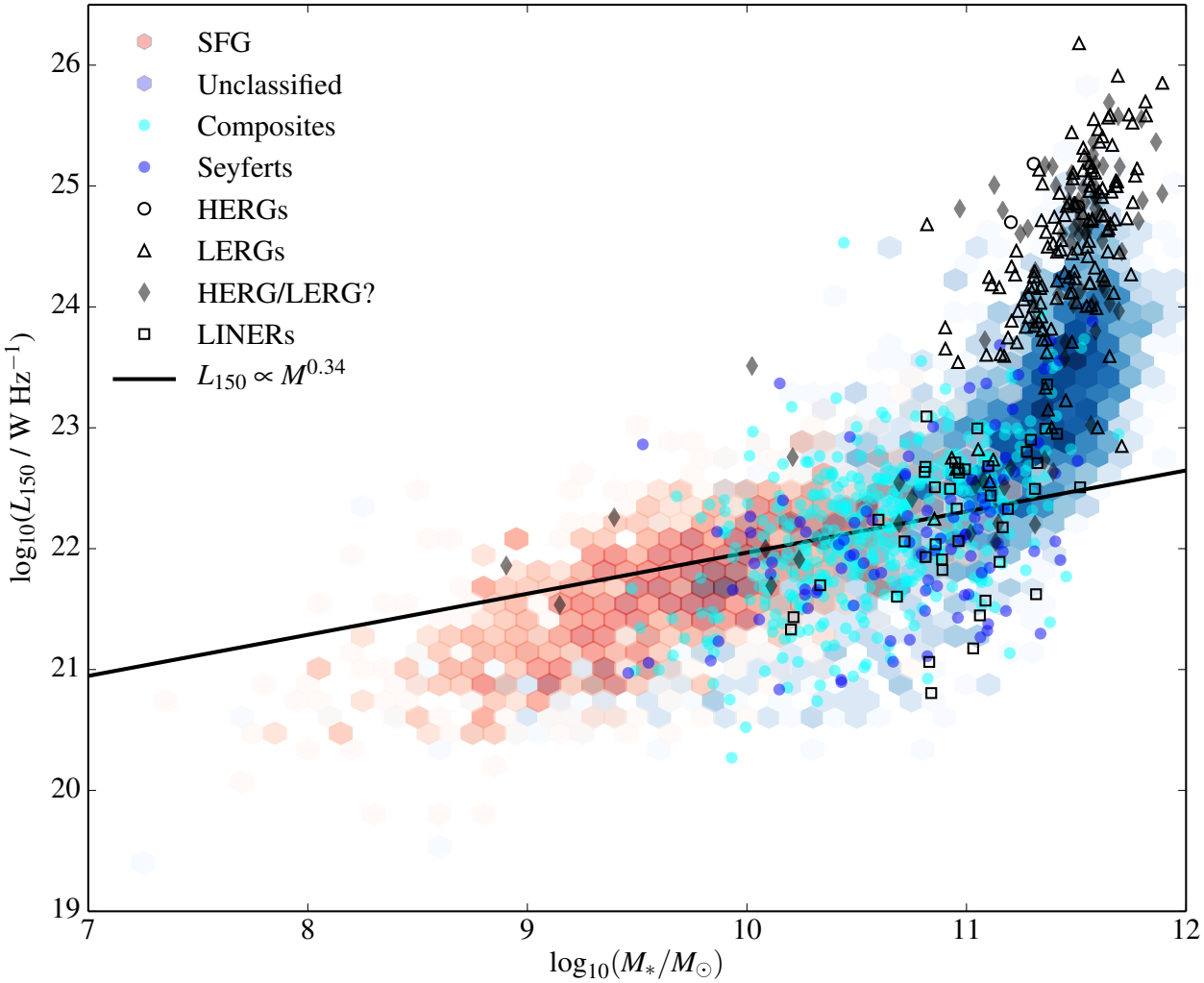
Further investigations of the L_{150} – SFR



The far-IR – radio correlation



Nature of sources unclassified by optical emission lines



What have we learned?

- ✓ A single power-law relationship between radio luminosity and SFR is not a good description of all SFGs in our sample and including stellar mass information is crucial.

- ✓ The slope of the L150 – SFR relation is steeper than that of the L1.4 – SFR relation, probably due to a contribution from thermal radio emission at 1.4 GHz.

- ✓ A tight radio–far-infrared correlation still exists for SFGs at 150 MHz.

- ✓ The combination of the strong mass dependence of non-AGN radio emission from normal galaxies *and* the presence of radio-loud AGN activity at significant levels in many massive galaxies means that a simple inference of star-formation rates from radio luminosity alone is extremely *complicated*.

[Gurkan et al. in prep.]

Thank you

CSIRO Astronomy and Space Science
Gulay Gurkan Uygun
OCE Postdoctoral fellow

t +61 8 64368533
e gulay.gurkanuygun@csiro.au