The Promise of Next-Generation RC Surveys

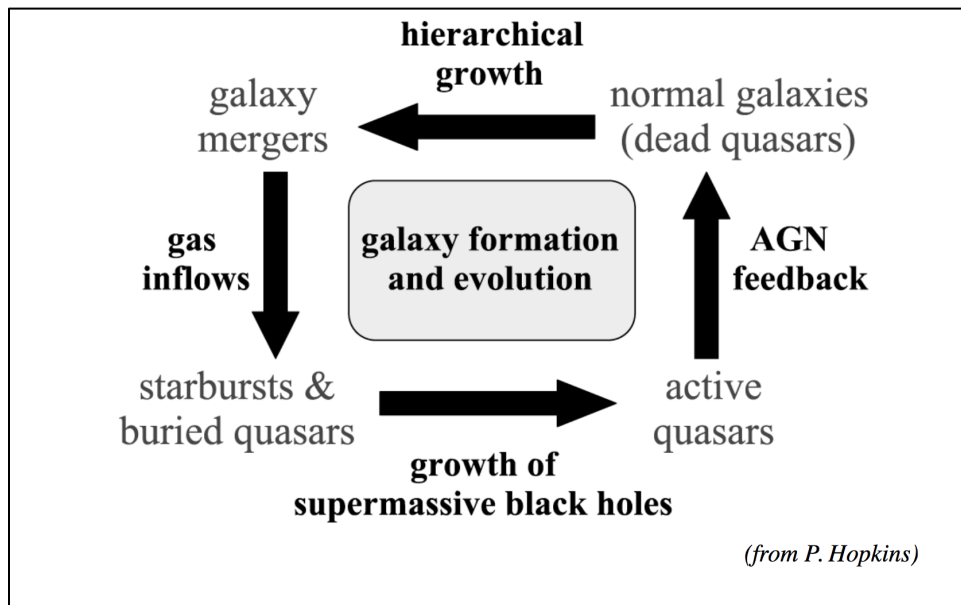## Revealing the Physics & Evolution of Galaxies and AGNs
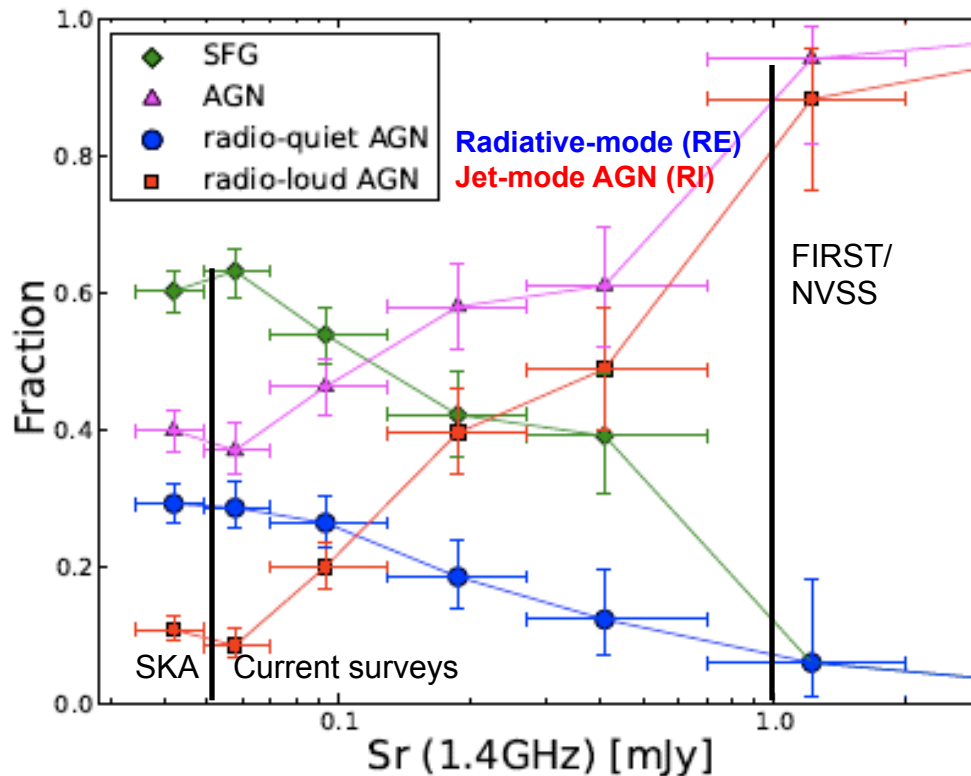
Isabella Prandoni

INAF - IRA

Talk Focus

Galaxies/AGN through next-generation RC surveys:

- demography & evolution – the benefit of **wide-area deep surveys**
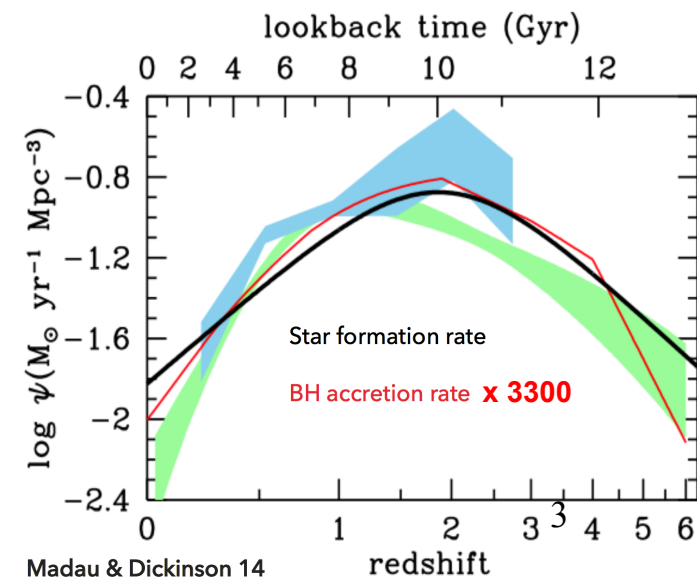- AGN physics and feedback - the **added value of spatial resolution**

(from P. Hopkins)

The promise of next-generation RC surveys

ECDFS S>40 uJy (→ 200 uJy @ 150 MHz)
Adapted from Bonzini+2013

SFG
AGN
radio-quiet AGN
radio-loud AGN

Radiative-mode (RE)
Jet-mode AGN (RI)

FIRST/
NVSS

SKA   Current surveys

Fraction

Sr (1.4GHz) [mJy]

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➤ Complete census of SF, AGN activity, up to high-z and down to RQ regime

➤ Co-evolution of SF AND AGN
➤ Role of AGN feedback [QSO winds & radio jets]
➤ not dust extinction/gas obscuration effects

lookback time (Gyr)

$\log \psi (M_\odot \ yr^{-1} \ Mpc^{-3})$

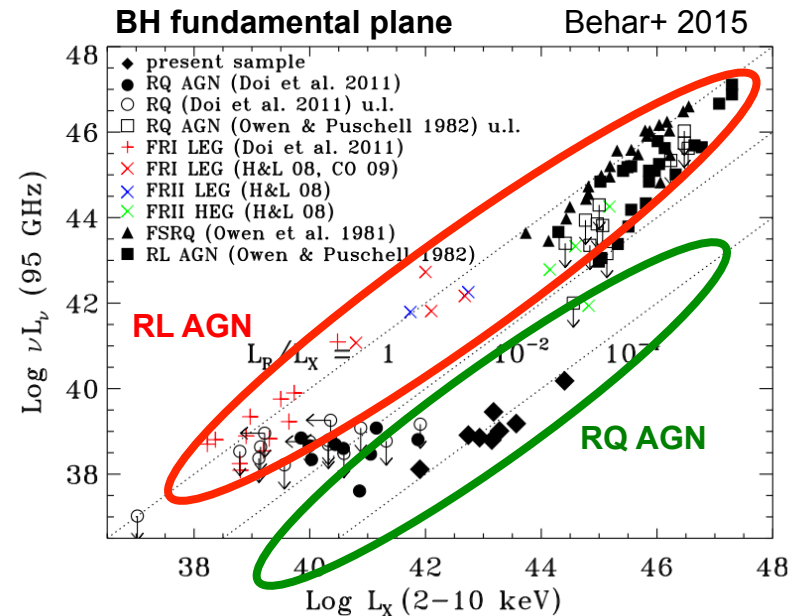Star formation rate

BH accretion rate **x 3300**

redshift

Madau & Dickinson 14

The promise of next-generation radio surveys

ECDFS S>40 uJy ($\rightarrow$ 200 uJy @ 150 MHz)
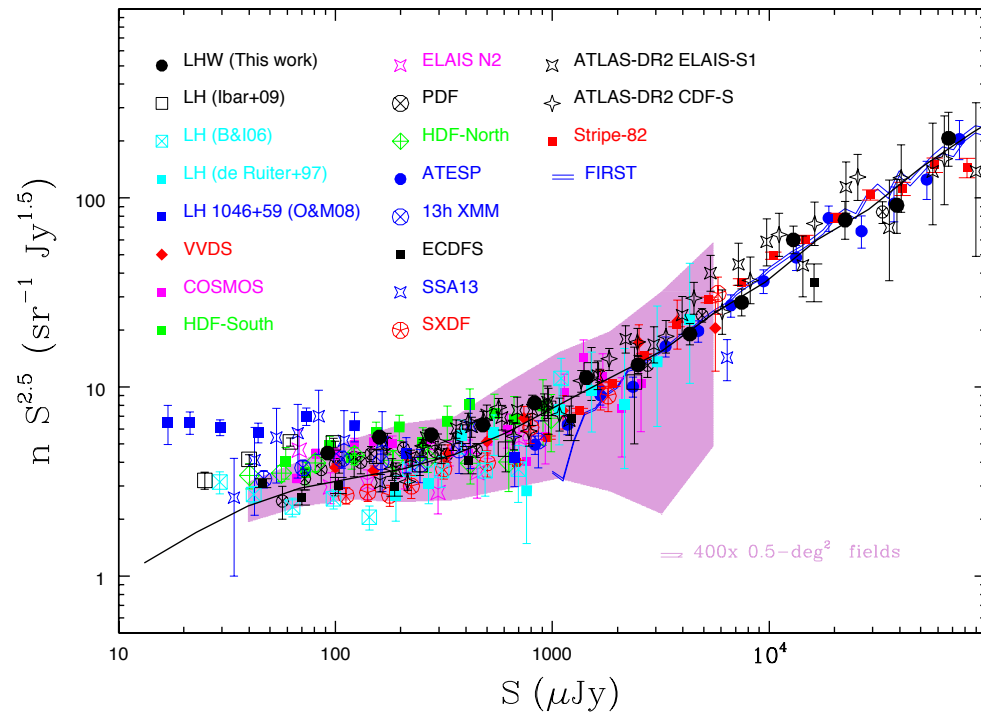Adapted from Bonzini+2013
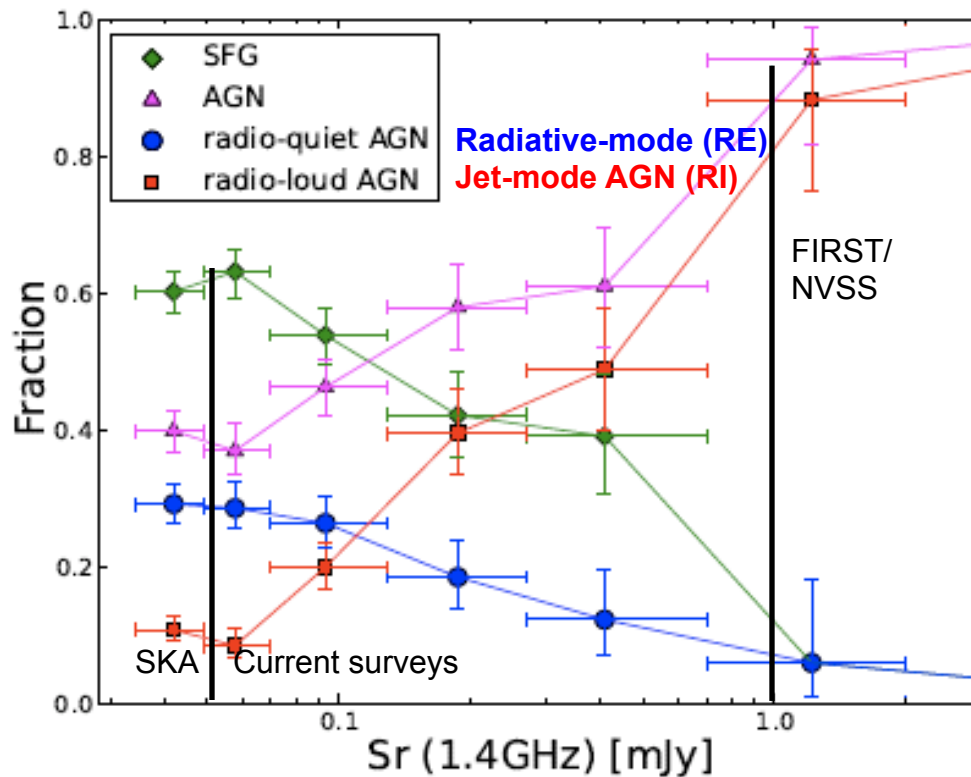
Physics of radio emission
➤ RQ/RL dichotomy;
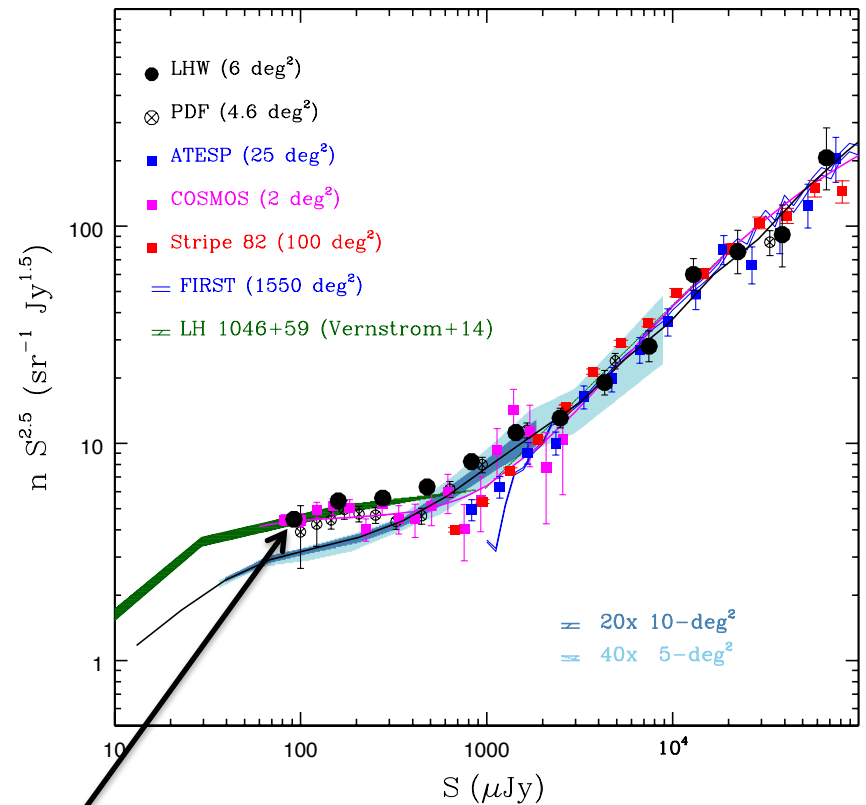➤ Origin of radio emission in RQ AGN
➤ radio duty cycles/feedback physics
➤ origin od radio/IR correlation

BH fundamental plane   Behar+ 2015
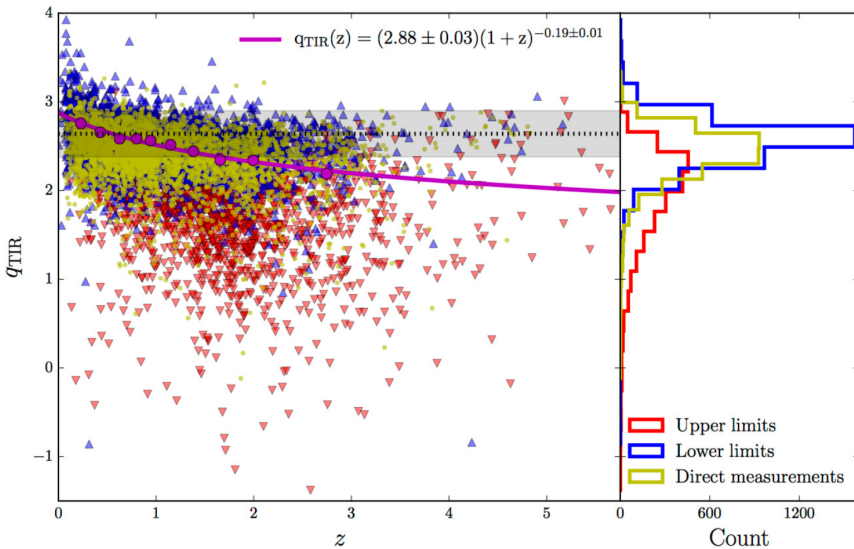
The quest for new evolutionary models

Prandoni+2018

1.4 GHz Large fields point toward an excess wrt S3 models (Wilman+08) at S<400 uJy

The quest for new evolutionary models

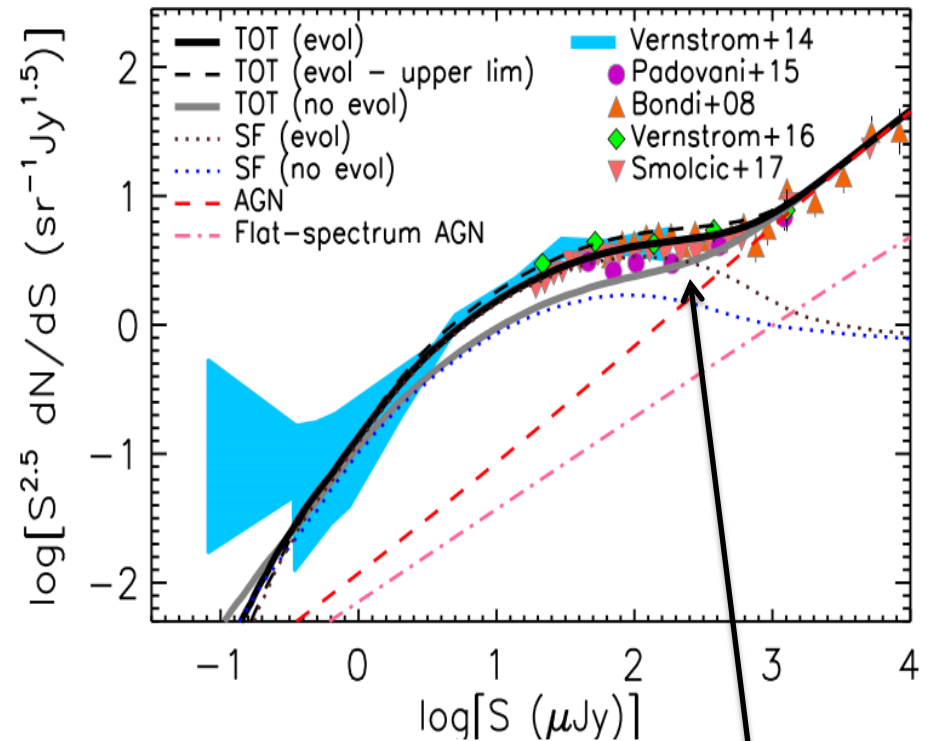*Bonato+ 2017*

Delhaize+ 2017 → $a_{1.4GHz}$ = -0.19±0.01

Implemented in T-RECS (Bonaldi et al. 2018)

SFG(+RQ) RL AGN 2-component modeling:
mild L_{synch}/SFR evolution $q \sim (1+z)^a$; $a < \sim 1.1$

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The quest for new evolutionary models

Smolcic+2017b

Mancuso, Lapi, IP+2017; Prandoni 2018

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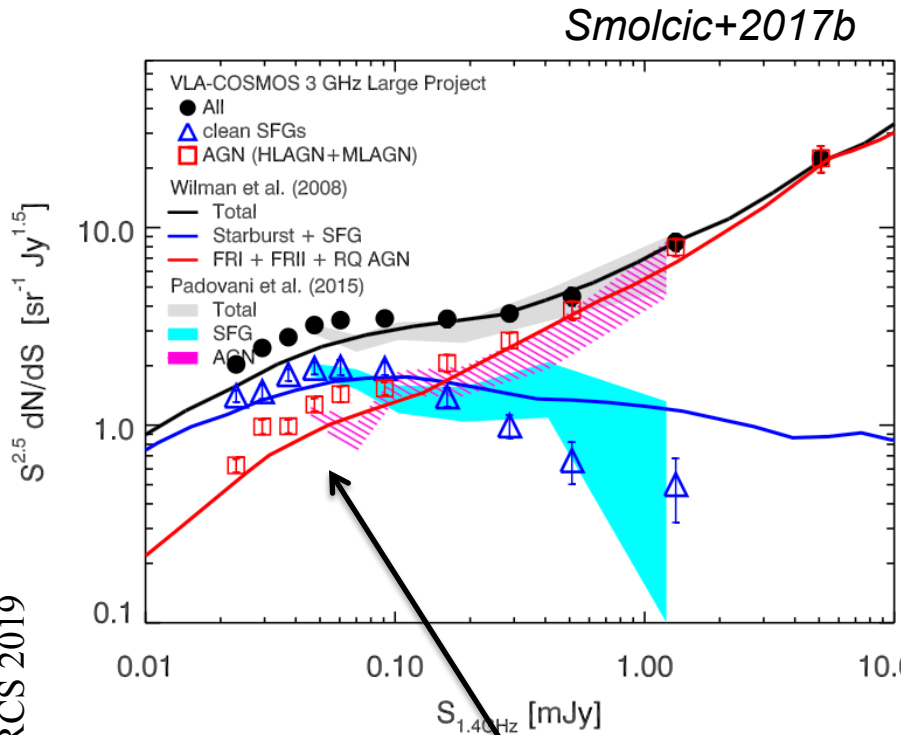
☐ **Radio excess sources**
△ **clean SF**
2 component modeling: more RL AGN and SFG than predicted by the S3-SEX model (Wilman+2008)
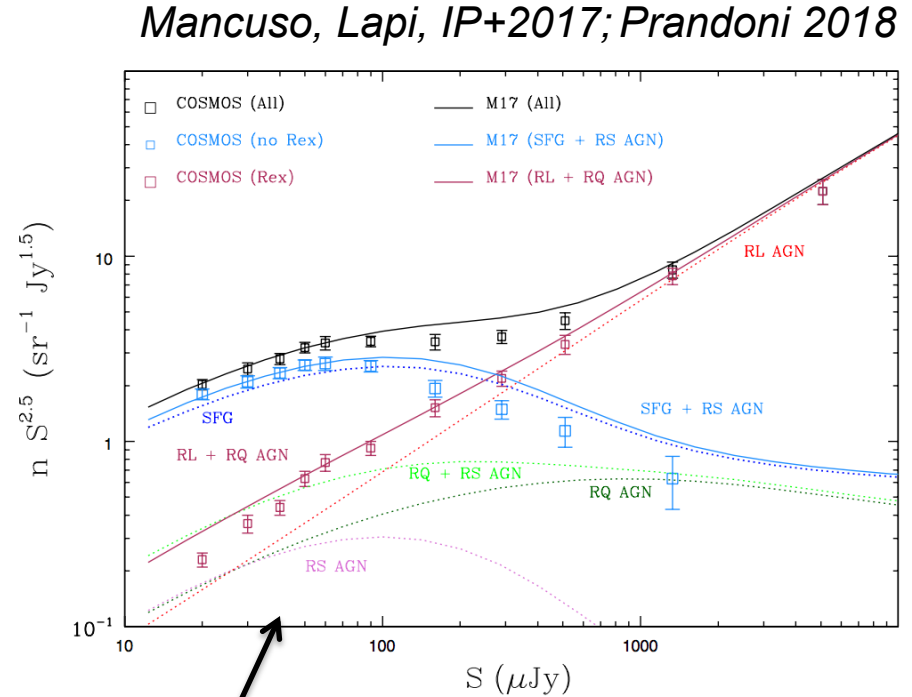
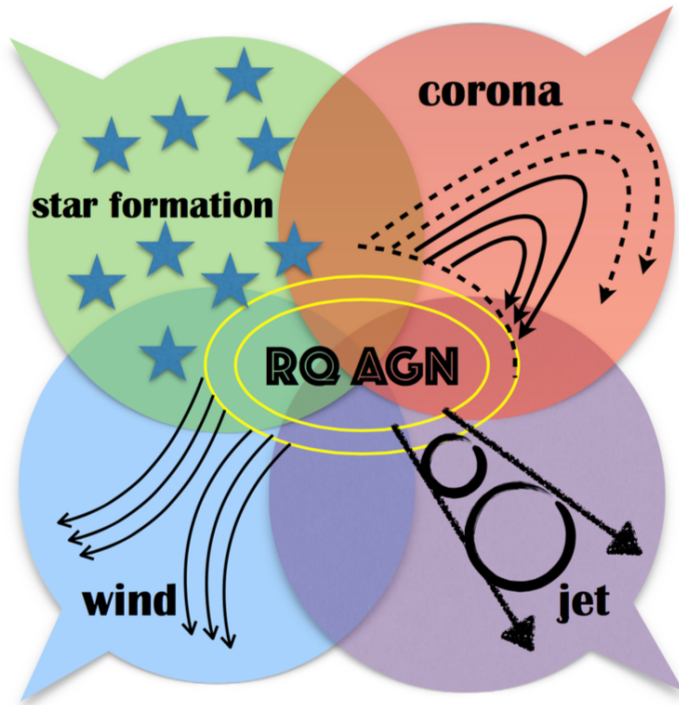**Radio Excess (RL+RQ AGN)**
clean SF (SFG + RS AGN)
→ 2 component modeling
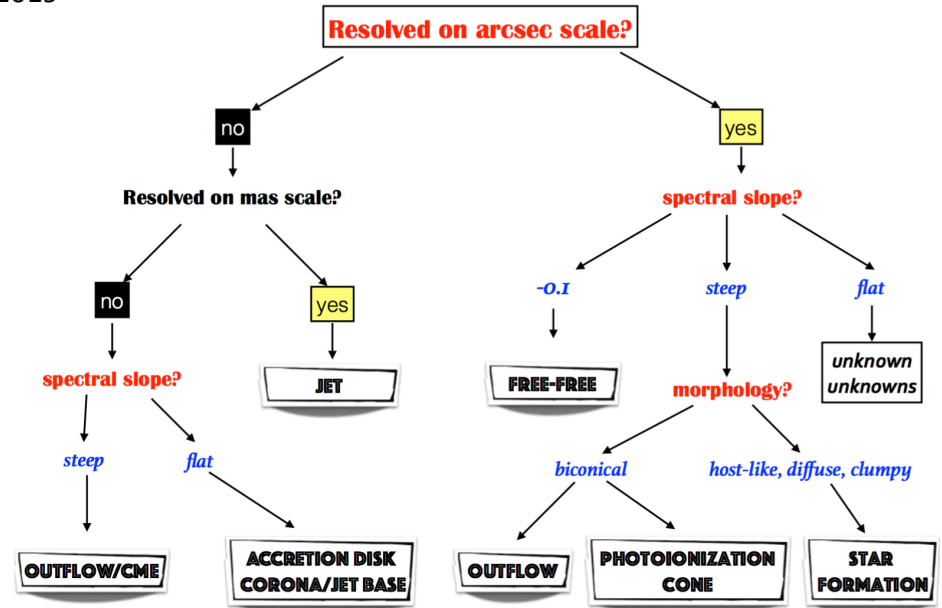
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The Origin of Radio Emission in RQ AGN

Evidence of radio excess in ~30% of RQ AGN (DelVecchio+17) [see also VLBI deep field follow-ups]
➔ SF and AGN related emission likely co-exist on a broad range of relative proportions

Which mechanism is responsible for the AGN emission?

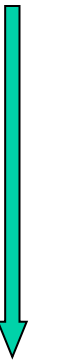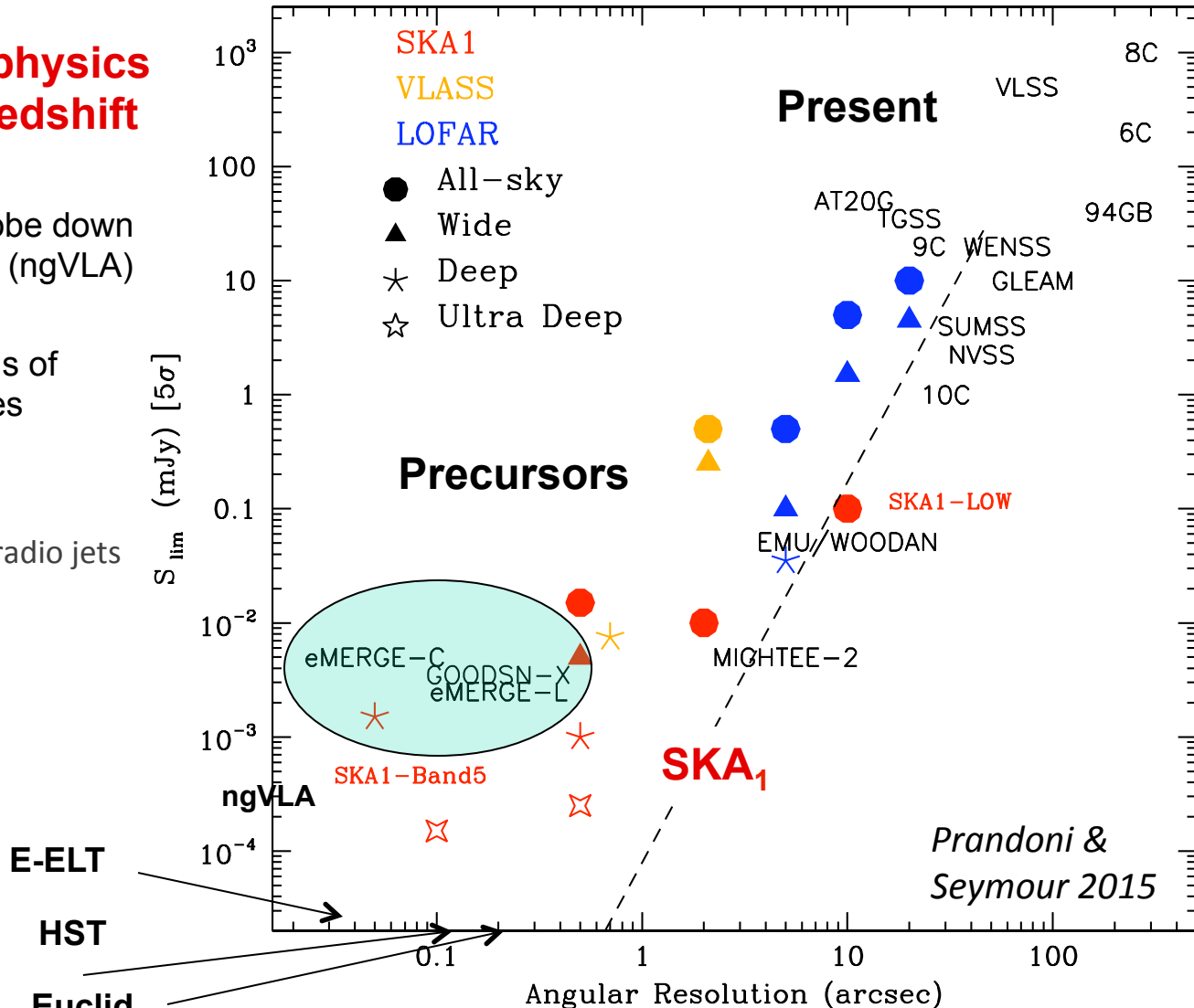Panessa+ 2019

The role of high-resolution RC Surveys

Resolved astrophysics out to high redshift
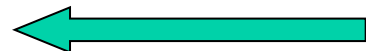
Radio surveys will probe down to mas resolution (ngVLA)

➔ multi-scale census of sources/processes

➔ Physics of RQ AGN:
  • incidence of radio jets
  • SF

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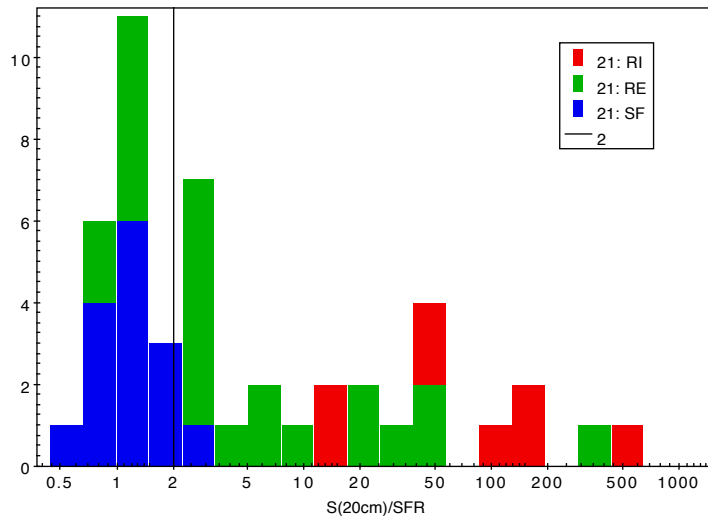
eMERGE: Resolving the radio sky

Correlation between size and Rex (Prandoni+ in prep.) – see also JVLA-COSMOS (Bondi+18)

Spectro-morphological classification

flat   **steep**

z~0.5
5.5 GHz contours
HST I-band image

size

0.8"
5 kpc

0.3"

0.3   spectral index   0.7

GOODS-N: VLA-L/Cband 3 uJy rms; 0.5" res.
Guidetti, Bondi, IP + 17; Morrison+10
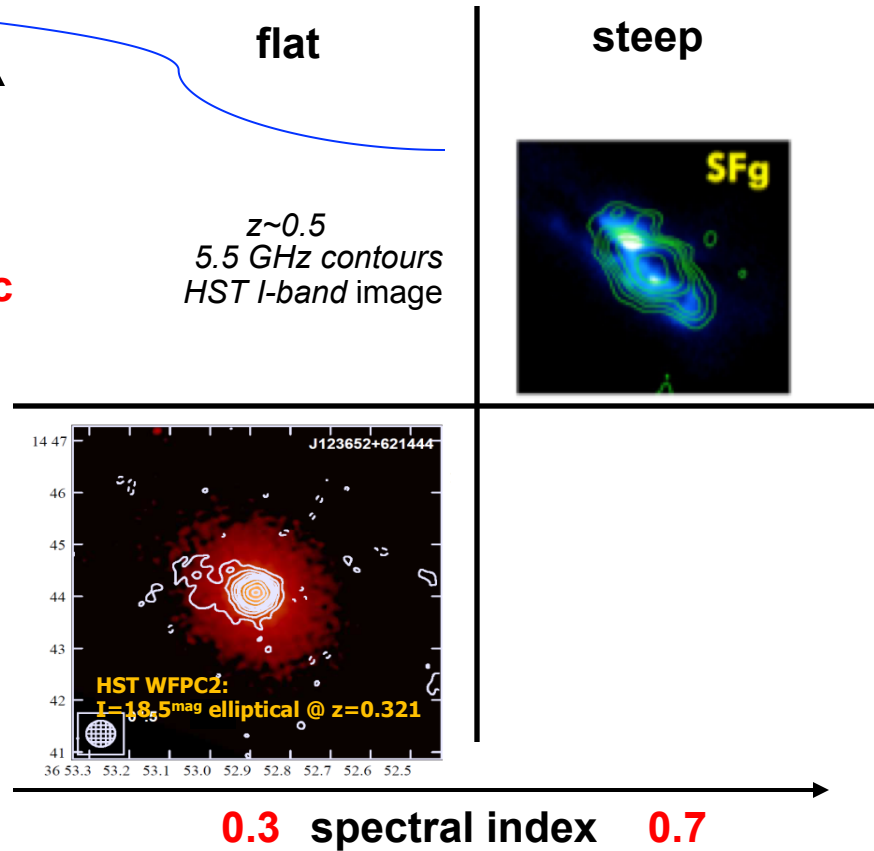
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eMERGE: Resolving the radio sky

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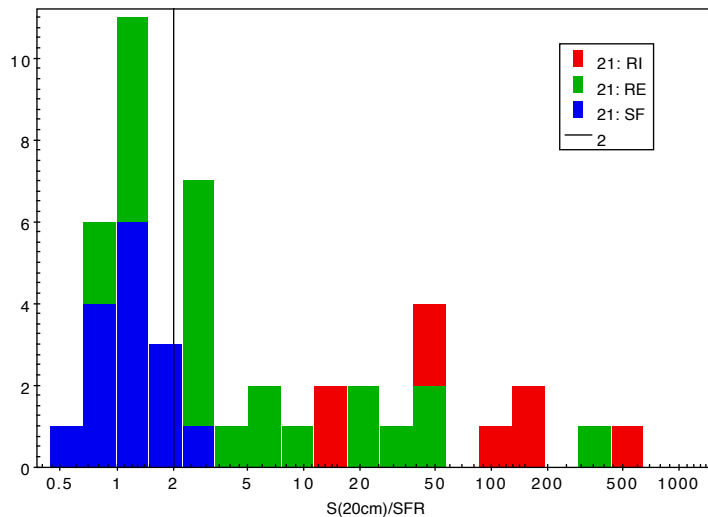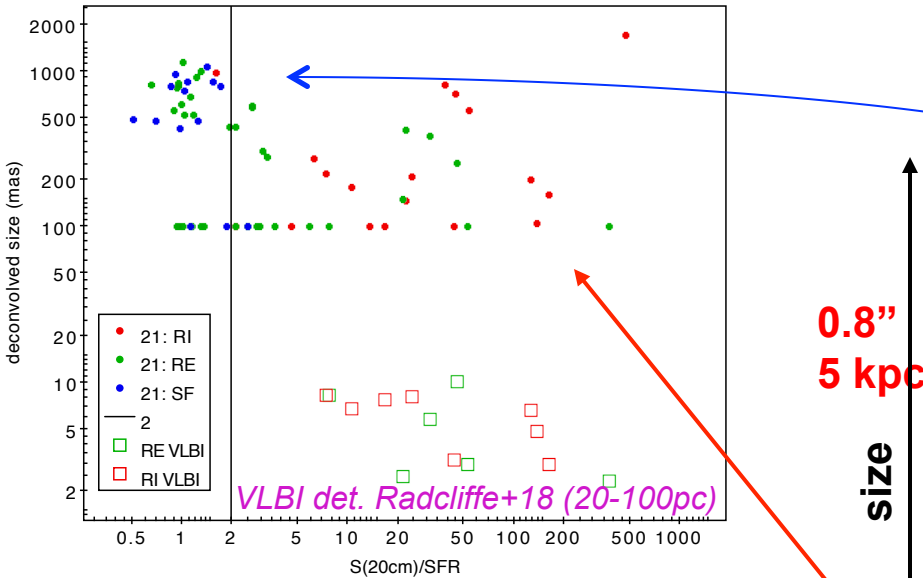**Spectro-morphological classification**

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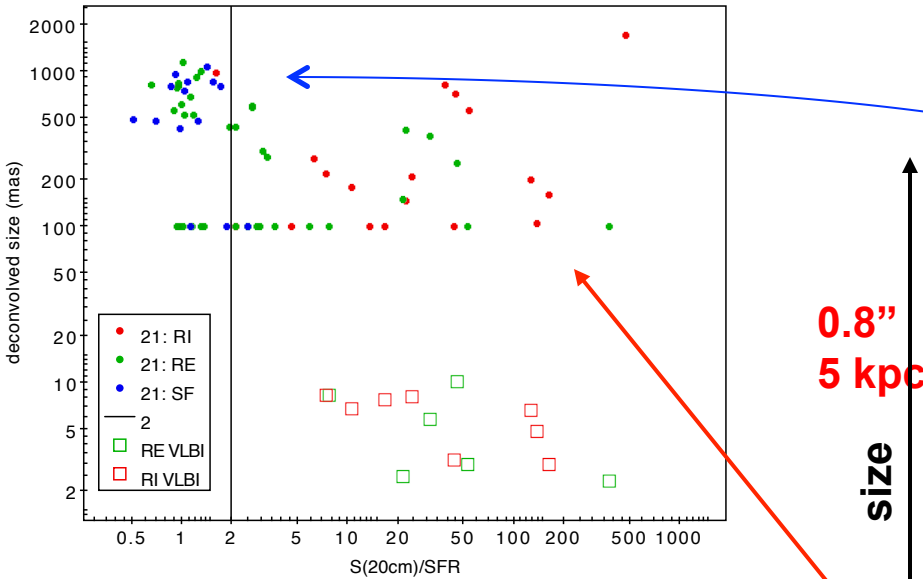
mini-jets/Outflows?
Nuclear SB?

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GOODS-N: VLA-L/Cband 3 uJy rms; 0.5" res.
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Summary

Ongoing surveys are revolutionizing our knowledge of radio source populations
  ... much more expected in next future

Deep RC surveys

→ **valuable dust-extinction/gas-obscuration-free tool** to study thermal and non -thermal emission in galaxies and AGN

• Low-nu surveys can now compete with 1-3 GHz surveys (non thermal emission)
• **multi-frequency surveys → radio SED**

→ **provide unique insights on aspects that arise at radio band**

• RQ/RL AGN dichotomy
• Physics and evolution of SFG Radio-FIR correlation
• low E/old electron populations – radio AGN life cycle

Deep high-res. RC surveys → resolved studies of the high-z Universe

• Composite (AGN+SF) sources at peak of activity z~1-3
• Role of jet-mode AGN feedback vs redshift

Pan-chromatic approach is key -> get comprehensive view of SF/AGN co-evolution

• radio surveys brings in unbiased SFR and HI content information