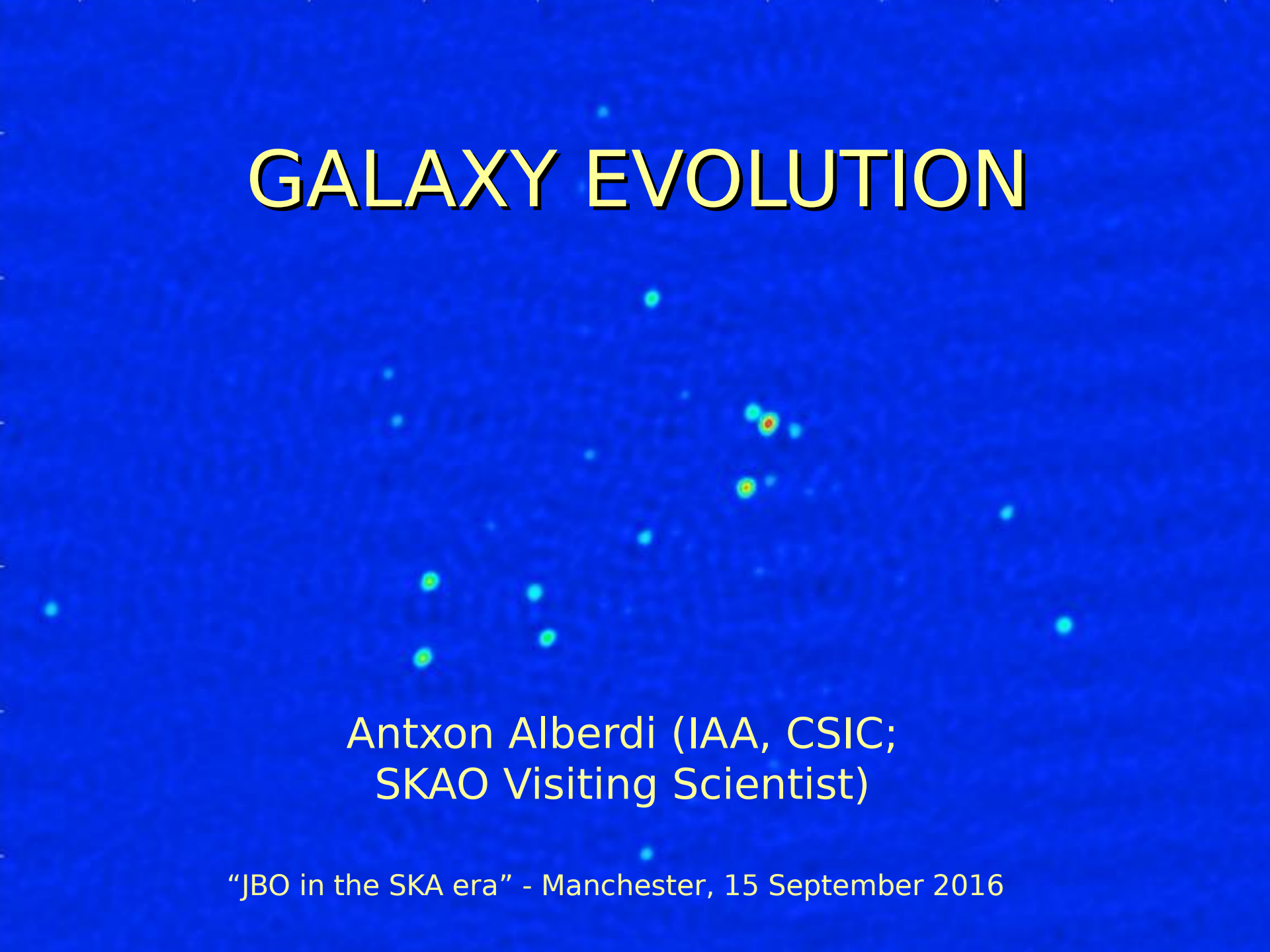
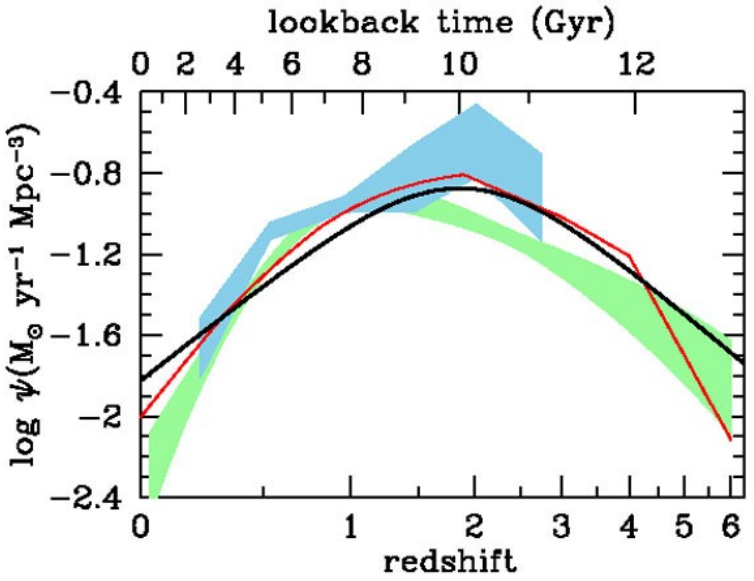
GALAXY EVOLUTION

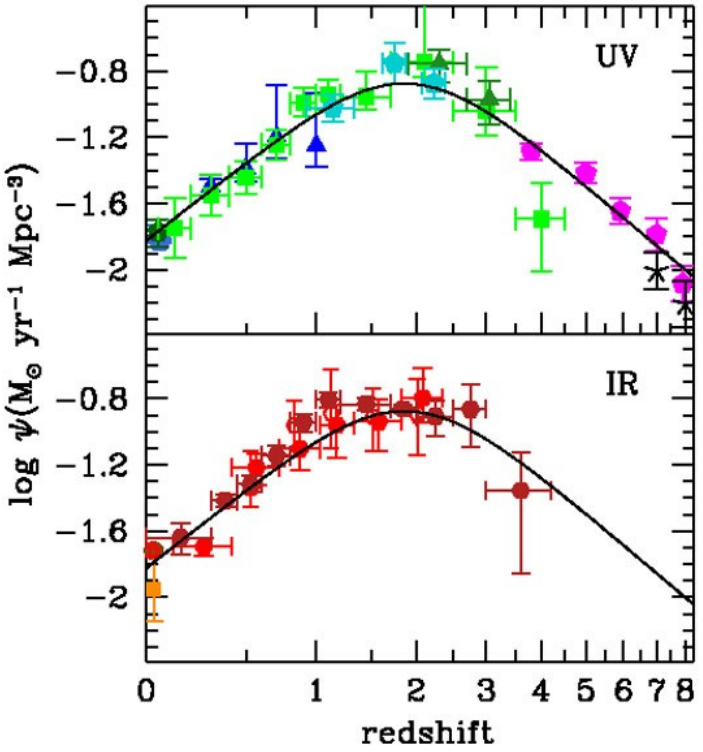


Antxon Alberdi (IAA, CSIC;
SKAO Visiting Scientist)

“JBO in the SKA era” - Manchester, 15 September 2016

Star-formation and black hole accretion history across cosmic time

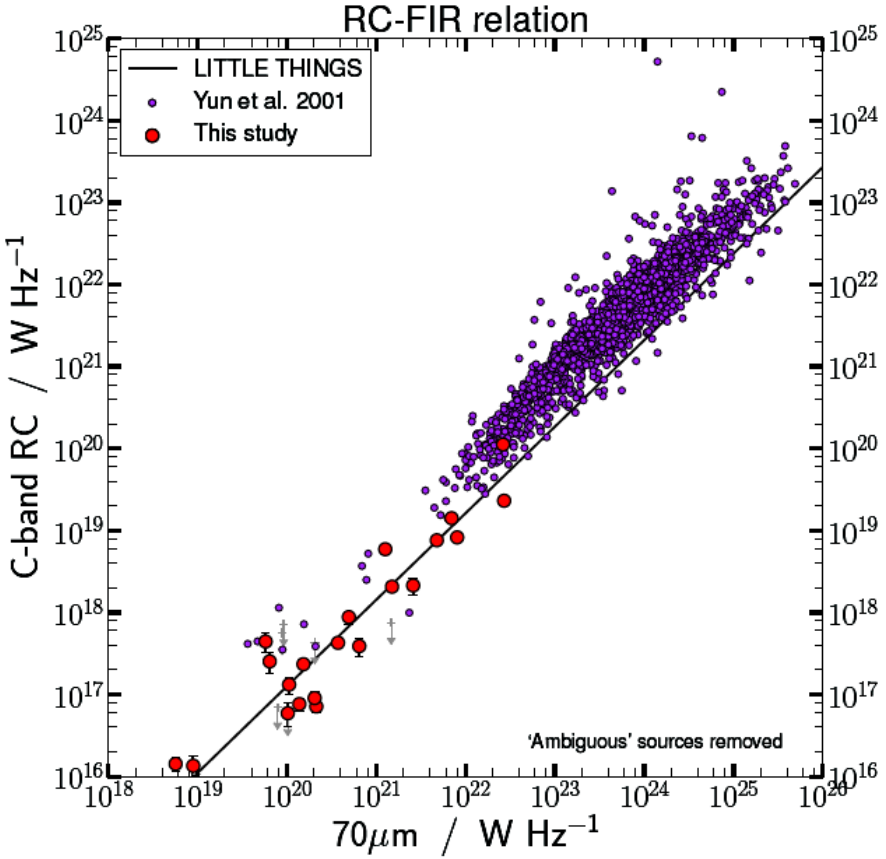


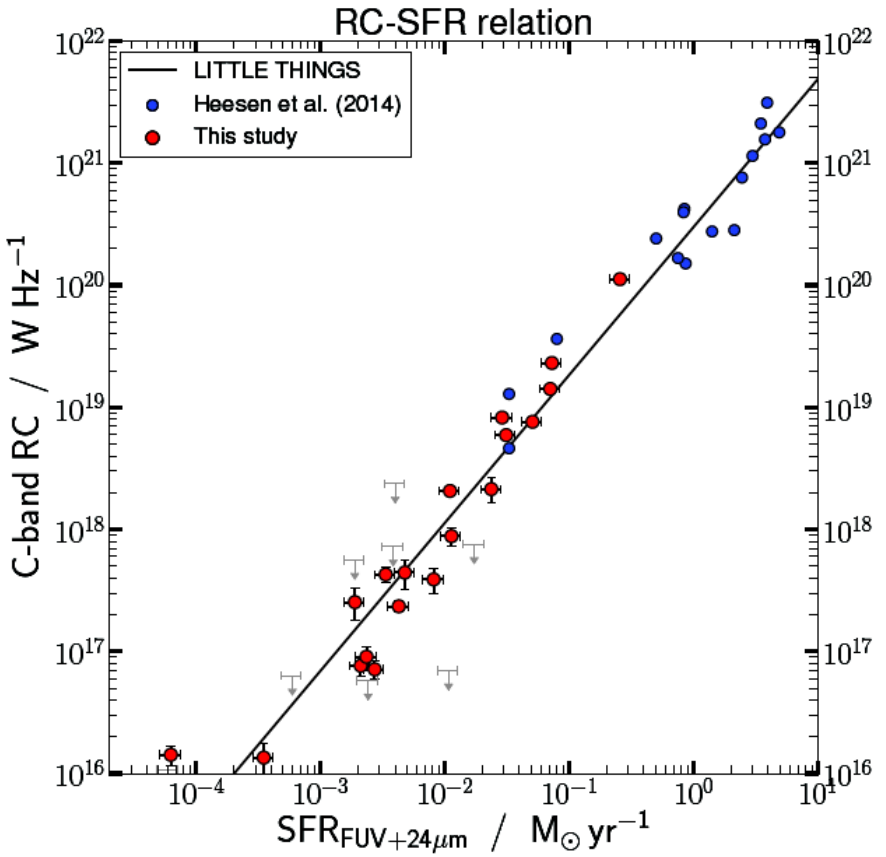


Comparison of the best-fit star formation history (*thick solid curve* Madau & Dickinson 2014) with the massive black hole accretion history from X-rays [*red curve* (Shankar et al. 2009); *light green shading* (Aird et al. 2010)] and infrared (*light blue shading*) (Delvecchio et al. 2014) data.

The co-moving rates of black hole accretion have been scaled up by a factor of 3,300 to facilitate visual comparison to the star-formation history.

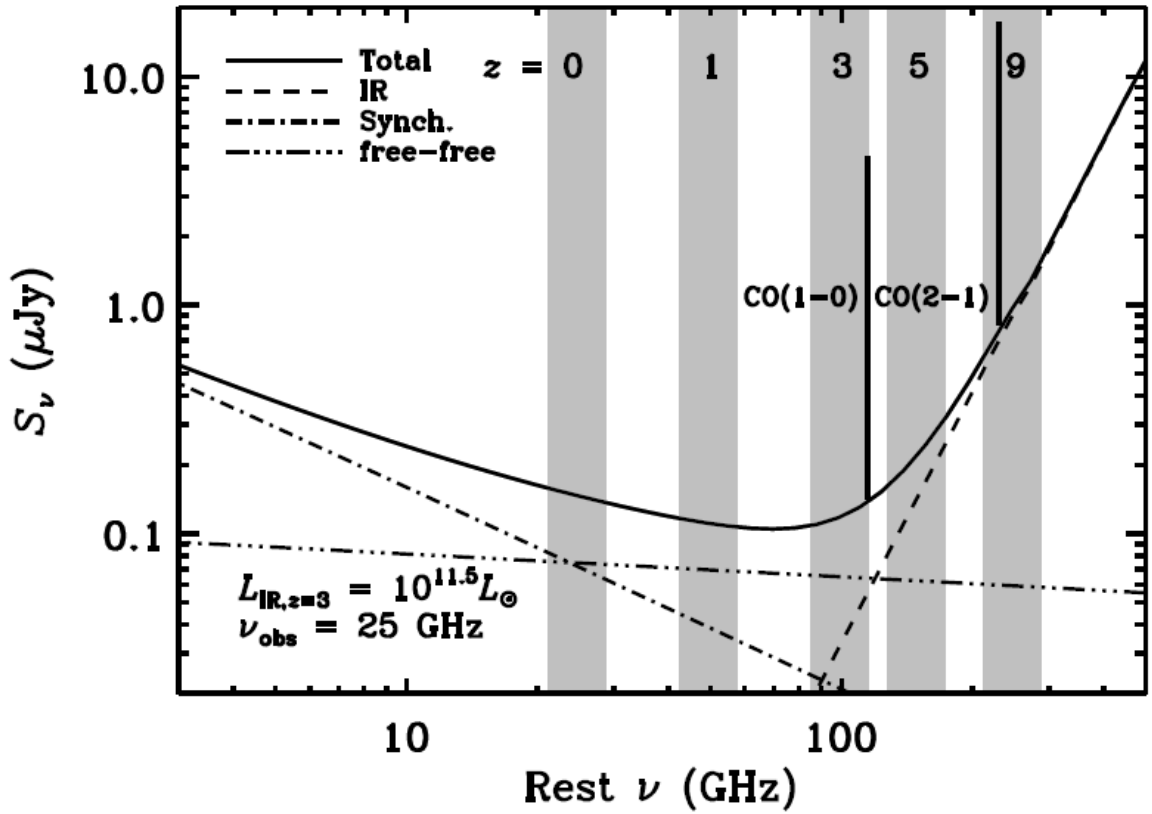
The Star Formation History of the Universe





Radio Continuum offers a unique way of measuring SFR:
non-thermal synchrotron + thermal free-free

The Star Formation History of the Universe: the importance of Band 5

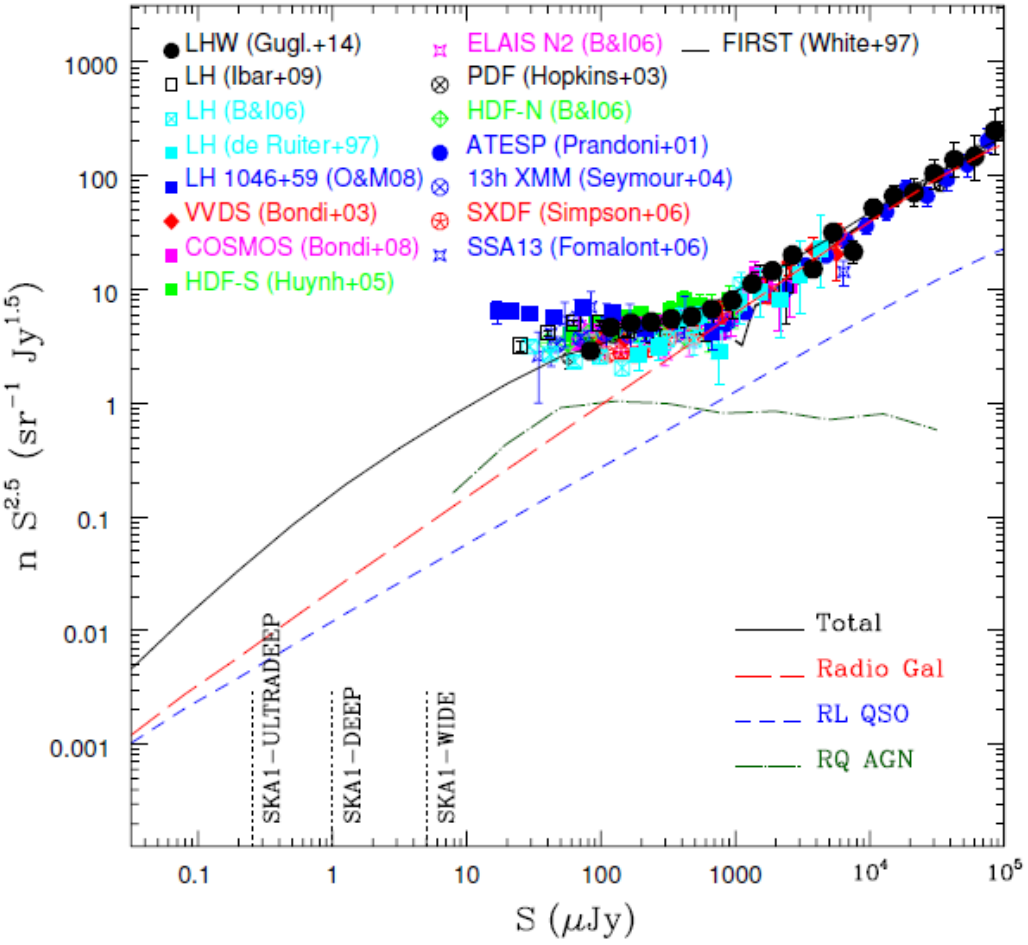


Band 5 is highly sensitive to the number of ionizing photons that are produced

The Star Formation History of the Universe

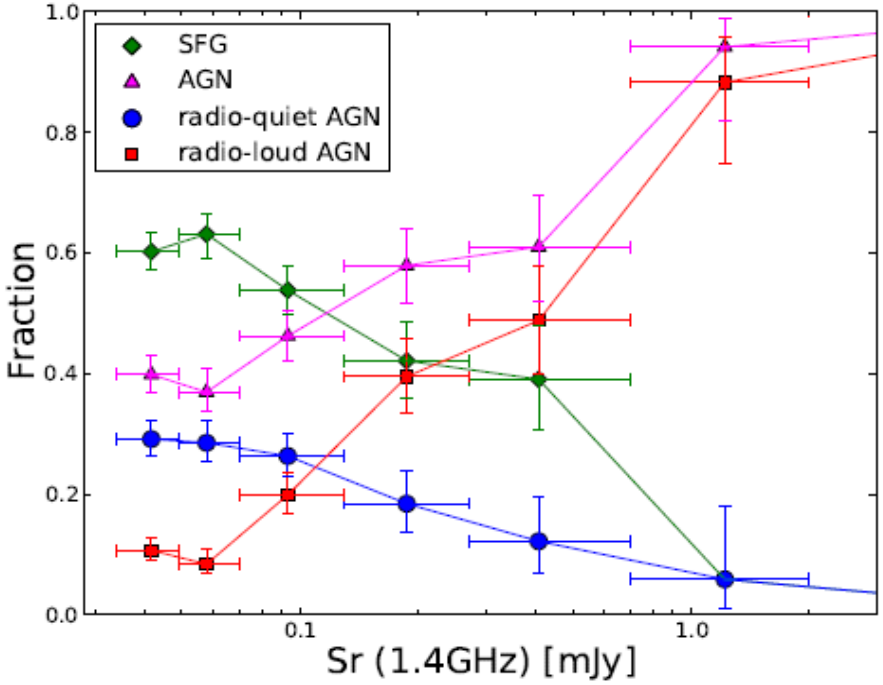
- Double approach: deep **statistical studies** + **detailed studies of smaller samples**, focusing on the role of z, environment, galaxy mass ...
- Key Observations: measure the **evolution of the radio luminosity function** of star-forming galaxies. For that, the radio flux density, redshift and fraction of the flux associated with SF should be known

The role of Black Holes



Radio-Source Counts from radio surveys: they flattened below 1 mJy and are expected to decrease at fainter fluxes

The role of Black Holes



- At levels of **a few mJy**, the **RL population dominates**
- At **micro-Jy** levels, there is an increasing contribution to the **radio population from RQ AGN**
- S**F In the host galaxy of RQ AGN** may be the **dominant** contributor to the RC emission

The interplay between SF and AGN Activity

SMBHs accretion occurs in two different modes:

- **Quasar Mode**: fast, radiatively efficient, related to the accretion Disk→ RQ AGN;
- **Radio Mode:** slow, radiatively inefficient, with powerful radio jets → RL AGN

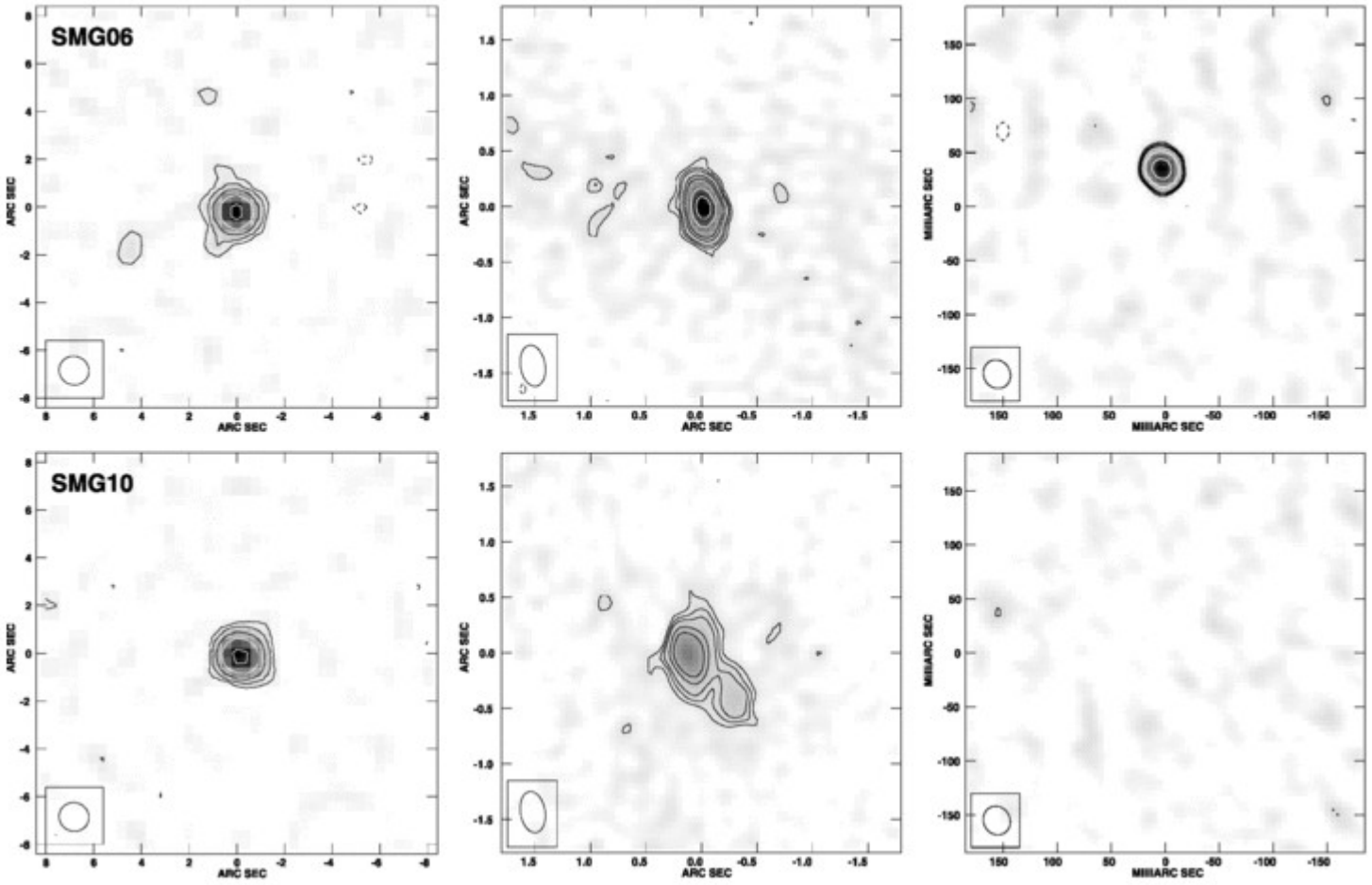
with different “feedback” processes:

- **Quasar Mode:** High velocity winds (dependent on mass and luminosity of the central BH)
- **Radio Mode:** AGN outflows heat the gas halo surrounding a massive galaxy (bubbles/cavities)

The importance of Radio Surveys

- Radio surveys are **sensitive** to emission from **star-forming galaxies**, and emission from both **“quasar” and “radio” mode accretors**
- **Sub-arcsecond resolution**: free of confusion from backgound-sources;
- **Disentangle SF and AGN activity** at any redshift → Multi-freq obsvtns
- **Unaffected** by dust extinction and obscuration

Resolving AGN and SF with Radio Surveys



VLA MERLIN EVN

Talks in the “GALAXY EVOLUTION” Session

12:10 – 12:25: Tom Muxlow (JBCA) - **“e-MERGE – latest results and future”**

12:25 – 12:40: Alasdair Thomson (Durham) - **“Sub-mm starbursts at high-z”**

12:40 – 12:55: Jack Radcliffe (JBCA/Groningen) -

“**Isolating AGN using wide-field VLBI & e-MERLIN observations”**