Herschel & AGN – 10 years after

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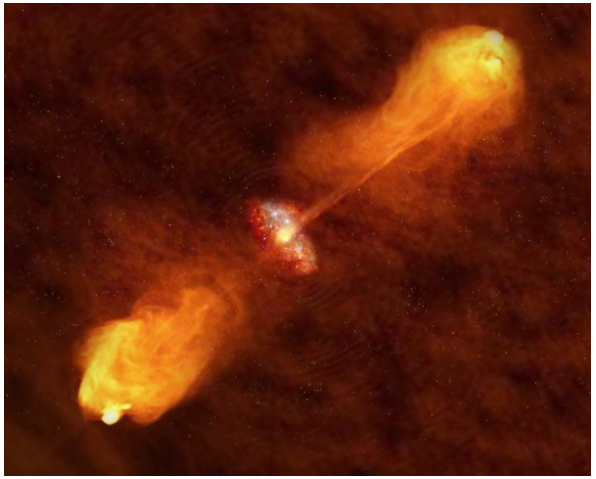
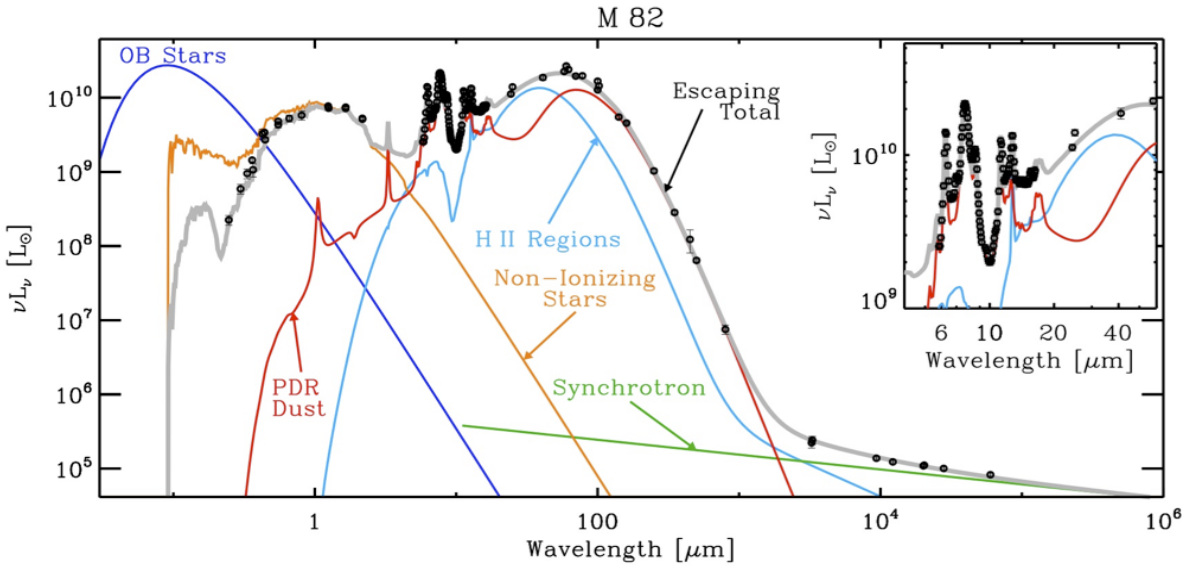
Herschel Mission Scientist 1997-2017

Take-away message:

AGN (i.e., accreting MBHs) are basic (boring/ important/fascinating ...) ingredients of star-forming galaxies, throughout cosmic time.

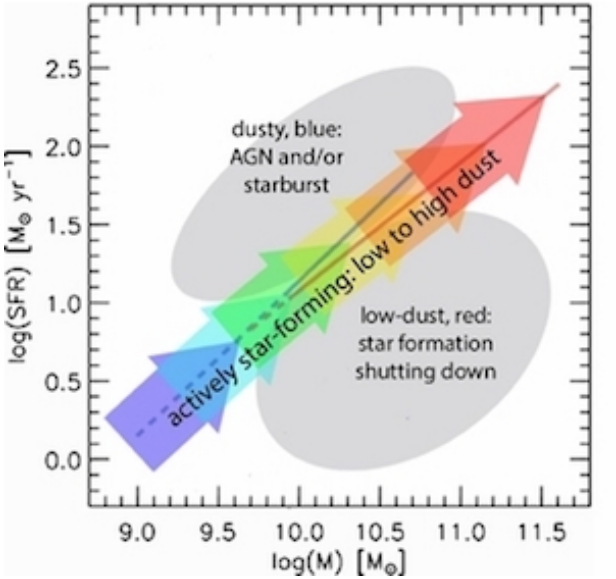


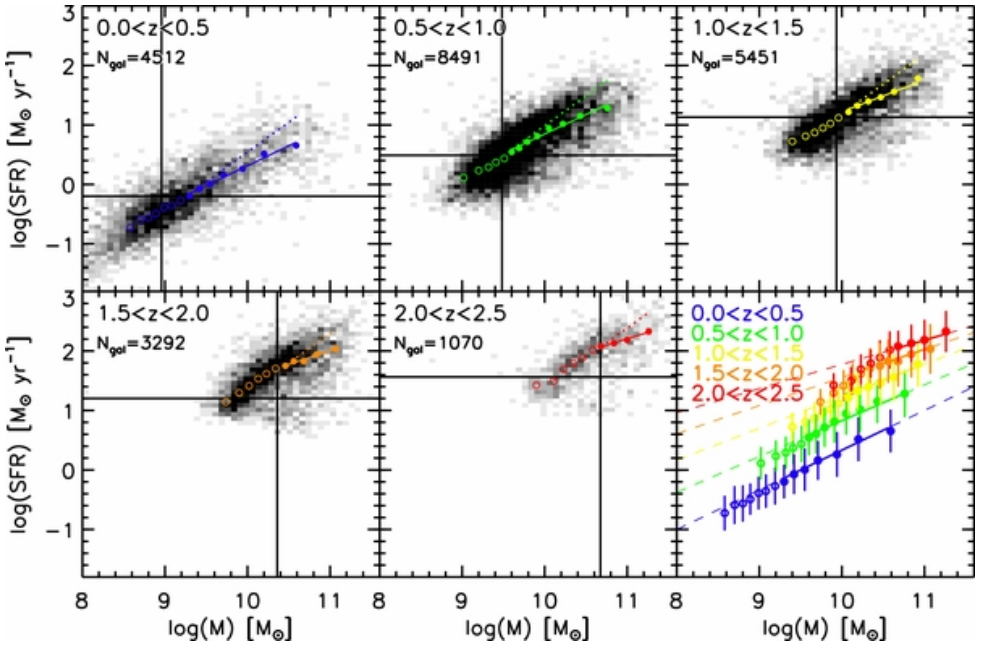
First of all, let us recall Rowan-Robinson (1995): “an AGN is inevitably accompanied by a starburst but the reverse is not true”, and look at the SED of a prototypical starburst galaxy, LIRG M82 (having SFR ~10$M_{\odot}$/yr).



SED from Dustpedia

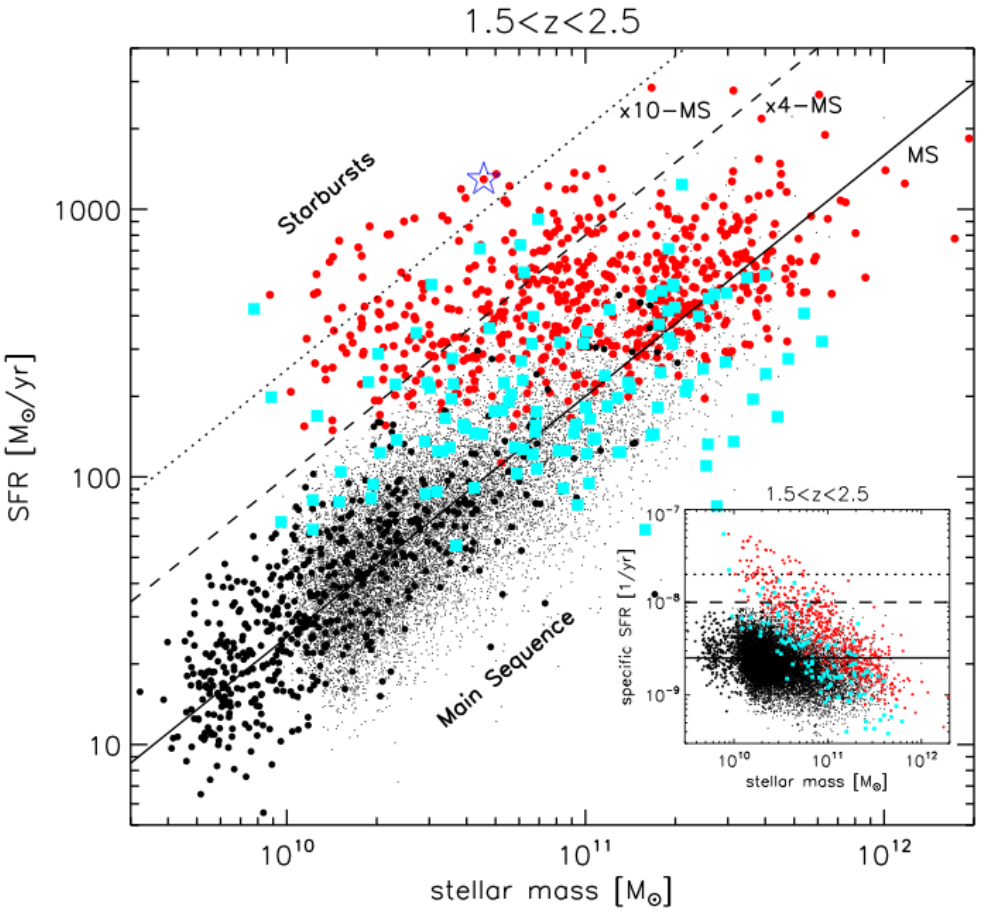
SFR(z) on Main Sequences: $SFR \sim M_*^a (1+z)^b$, with a~0.8 and b~2.5





e.g., Whitaker+12

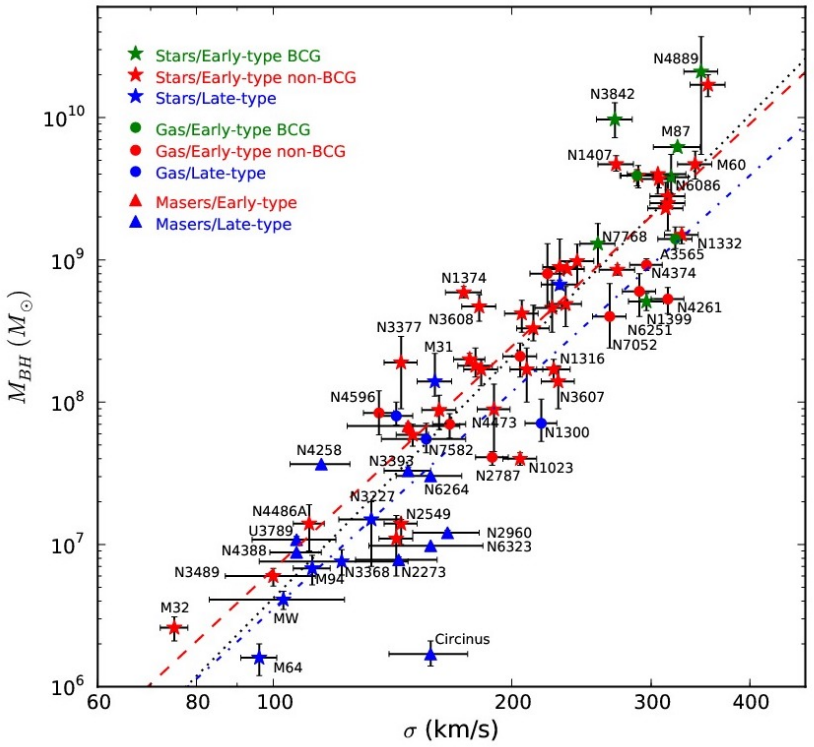
Herschel: 90% of the high redshift star-forming galaxies are on the MS, and "merger-starbursts" represent a small fraction.



Rodighiero+11

But what about AGN hosts?

As central black hole mass scales with host bulge mass, star-formation and black hole growth must somehow go hand-in-hand.

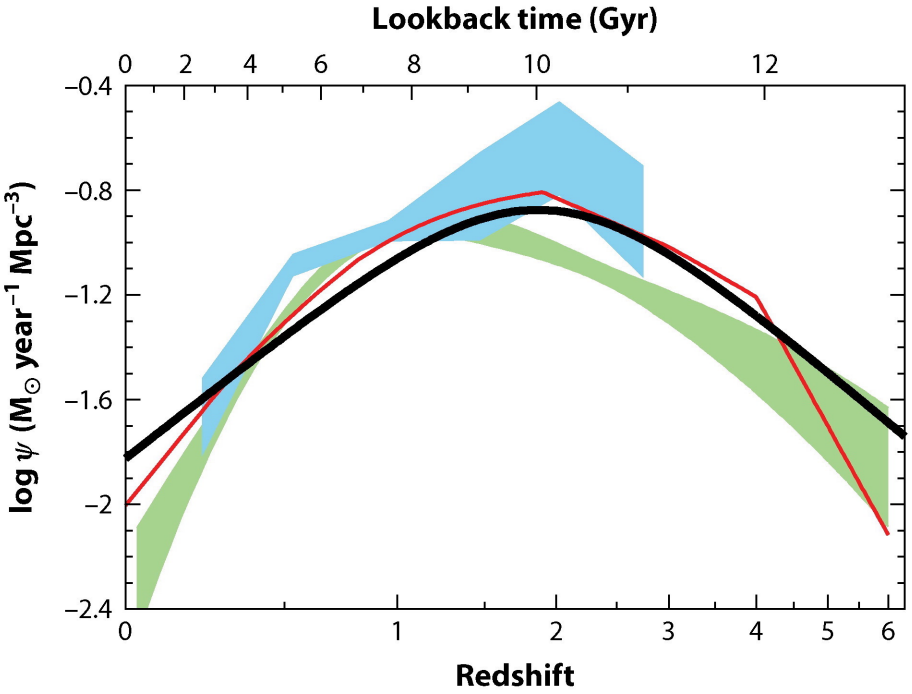


McConnell & Ma 2013

Moreover, MBH accretion over cosmic time, $n_{QSO}(z)$ (colors, scaled up), runs more or less like the cosmic SF history (black line).

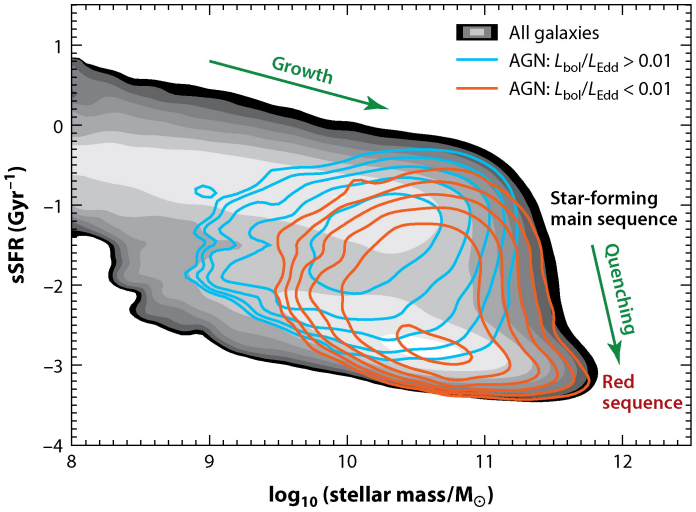
Pre-Herschel JCMT/IRAM mm-photometry indeed detects thermal emission in certain distant AGN =>

NEED THE SENSITIVITY, RESOLUTION, AND WAVELENGTH COVERAGE OF HERSCHEL TO STUDY LARGE SAMPLES



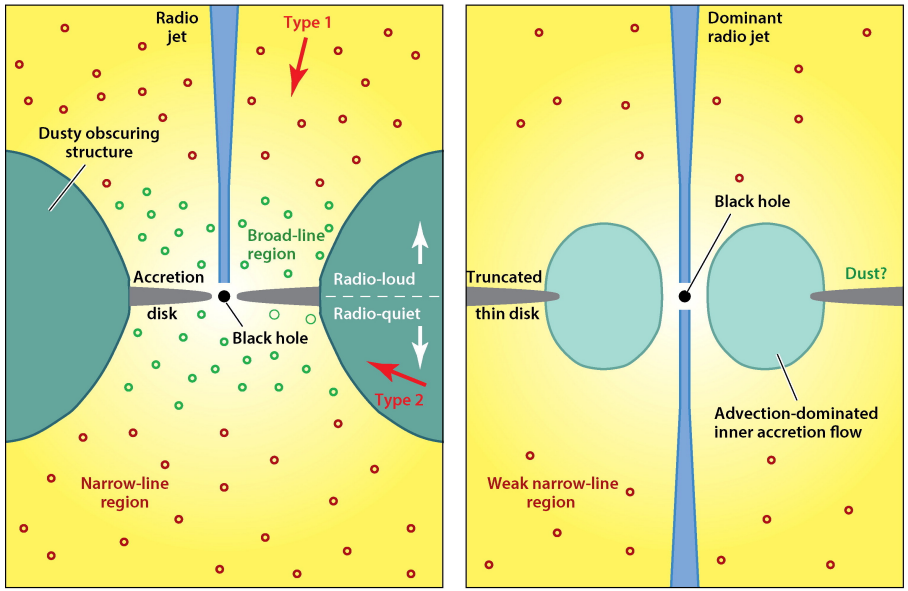
Madau + Dickinson 2014

Key question: are AGN in regular star-forming galaxies?



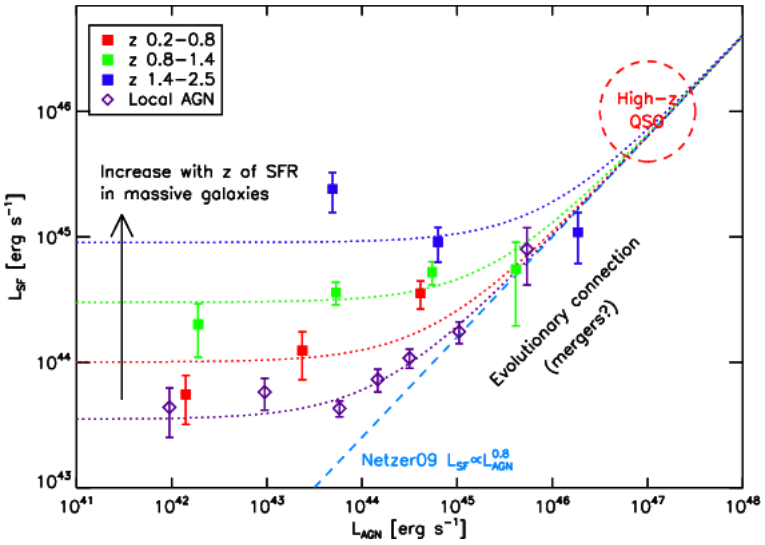
Heckman TM, Best PN. 2014.
Annu. Rev. Astron. Astrophys. 52:589–660

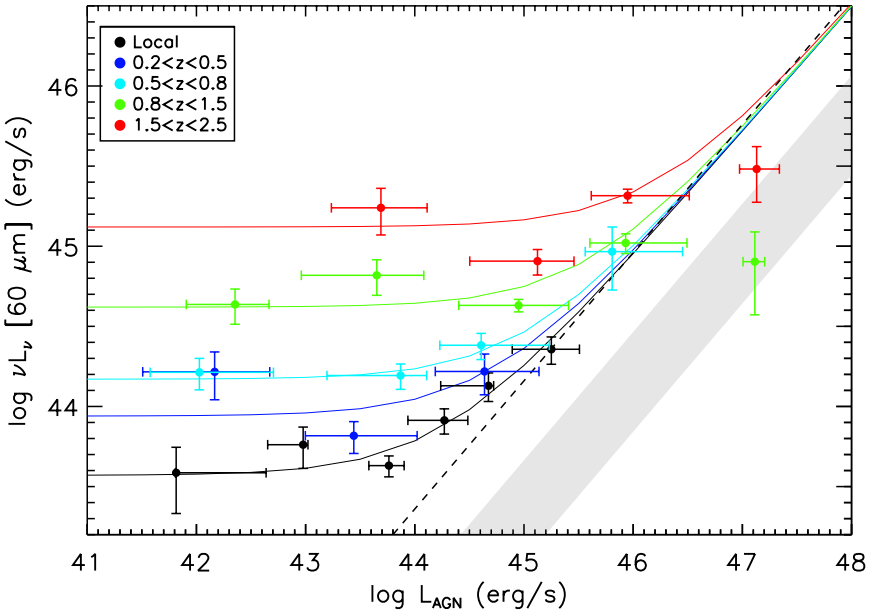
AGN: efficient vs. inefficient accretion



For instance, the Sombrero galaxy and M87 (Virgo A) – ultra-massive, dust-poor galaxies – are inefficient accretors, starving for fuel, while radio-loud quasars, Cygnus A, and radio-quiet QSOs are dusty, efficient accretors, happy consumers. Obscuring tori in the efficient class are key element in unification scenario's.

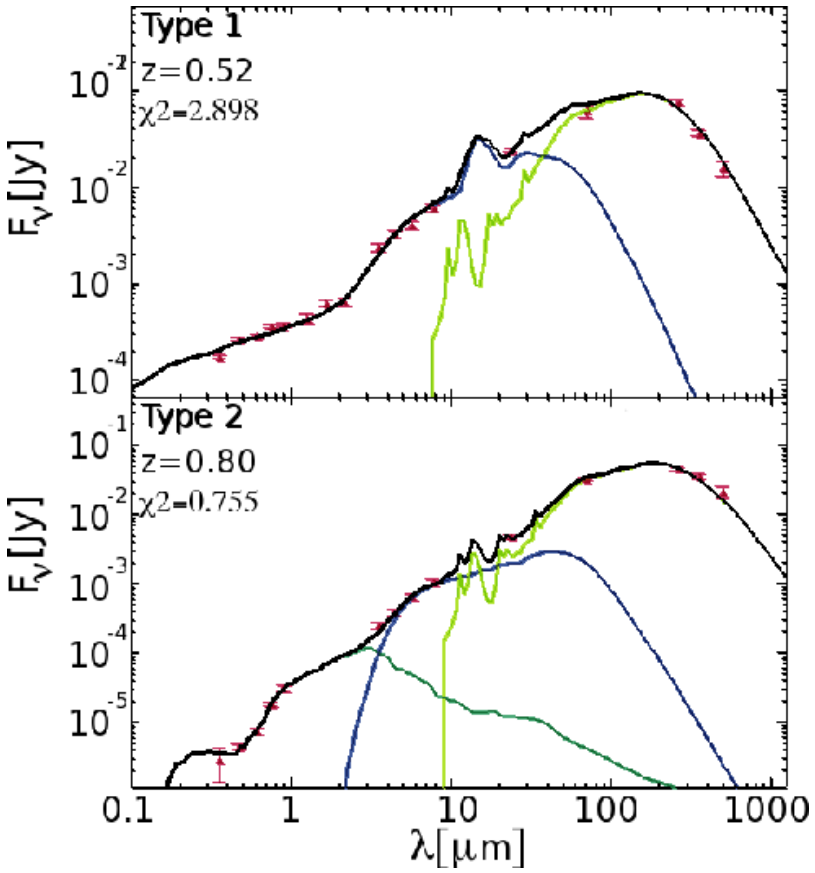
NGC1068 and Mkn231 are famous AGN-starburst symbiotic cases: what about all the others?

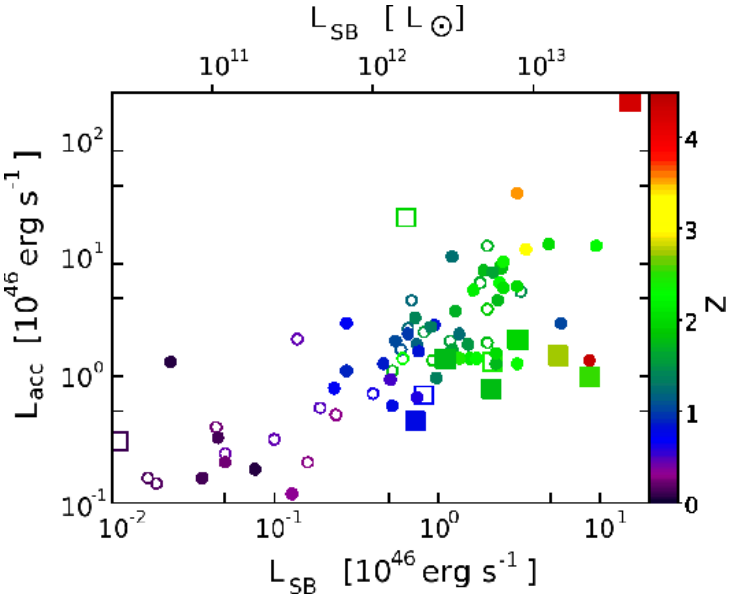




Shao+10 and Rosario+12: X-ray AGN host galaxies provide extra-strength FIR emission.

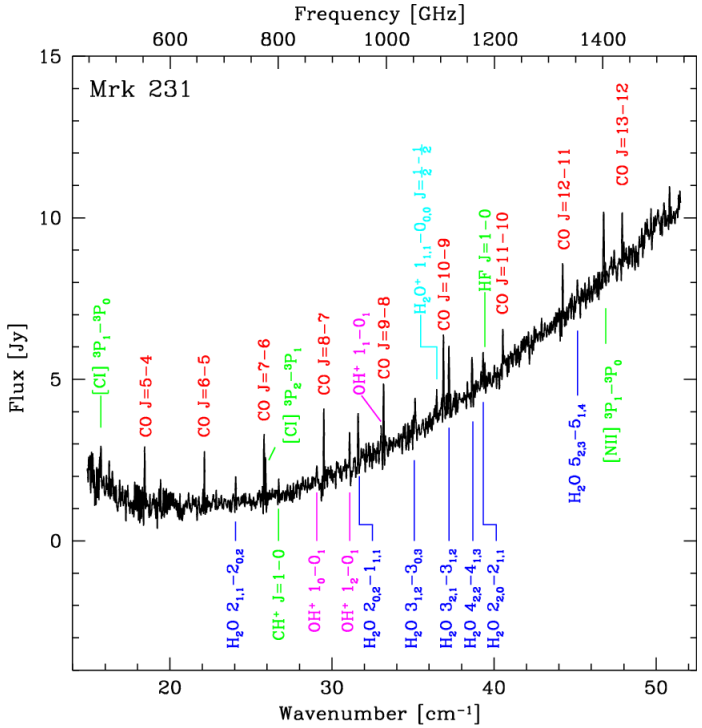
Using SED composition, the Leipski/Meisenheimer team found the same in very high z SDSS QSOs.

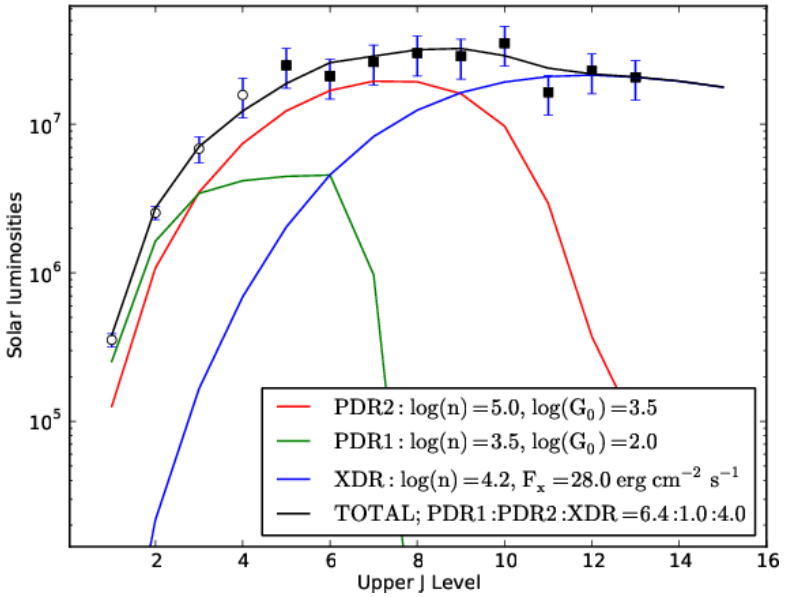




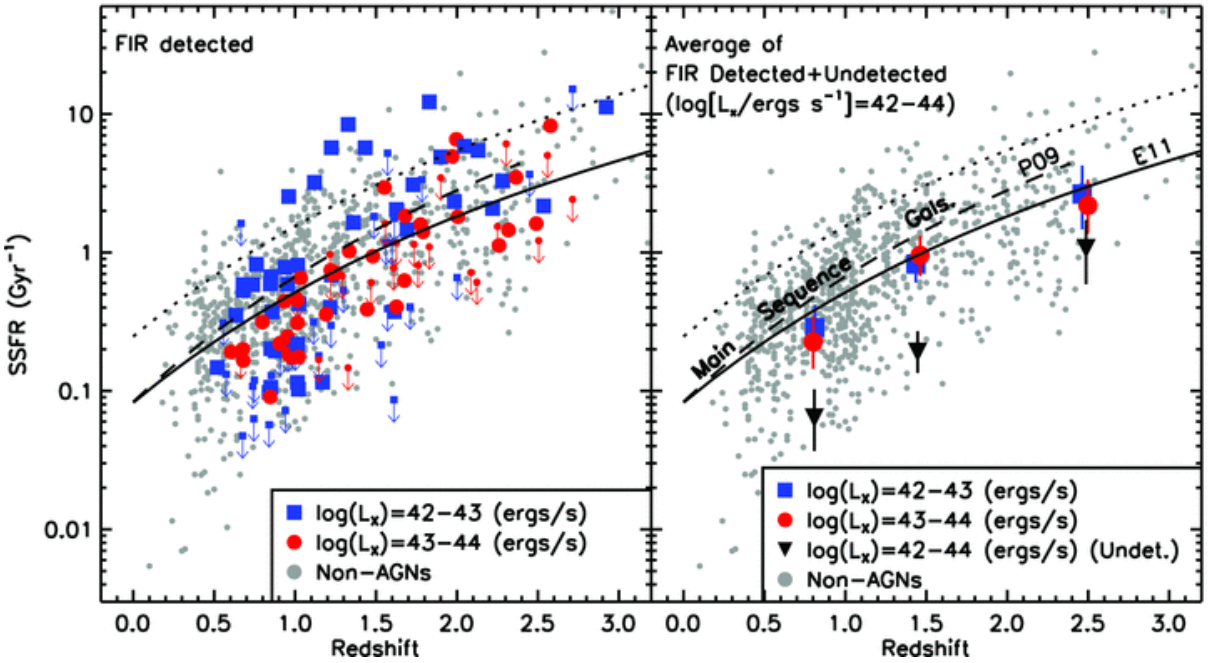
Hatziminaoglou+10, using SED decomposition: flattish MIR-FIR color due to warm AGN torus dust and extra-strength FIR emission in HerMES AGN, of both Type-1 and Type-2

The beauty of spectroscopy: SPIRE FTS line diagnostics (VanderWerf+10), calling for XDRs; plus the wealth of (PACS, SPIRE, HIFI) outflow data

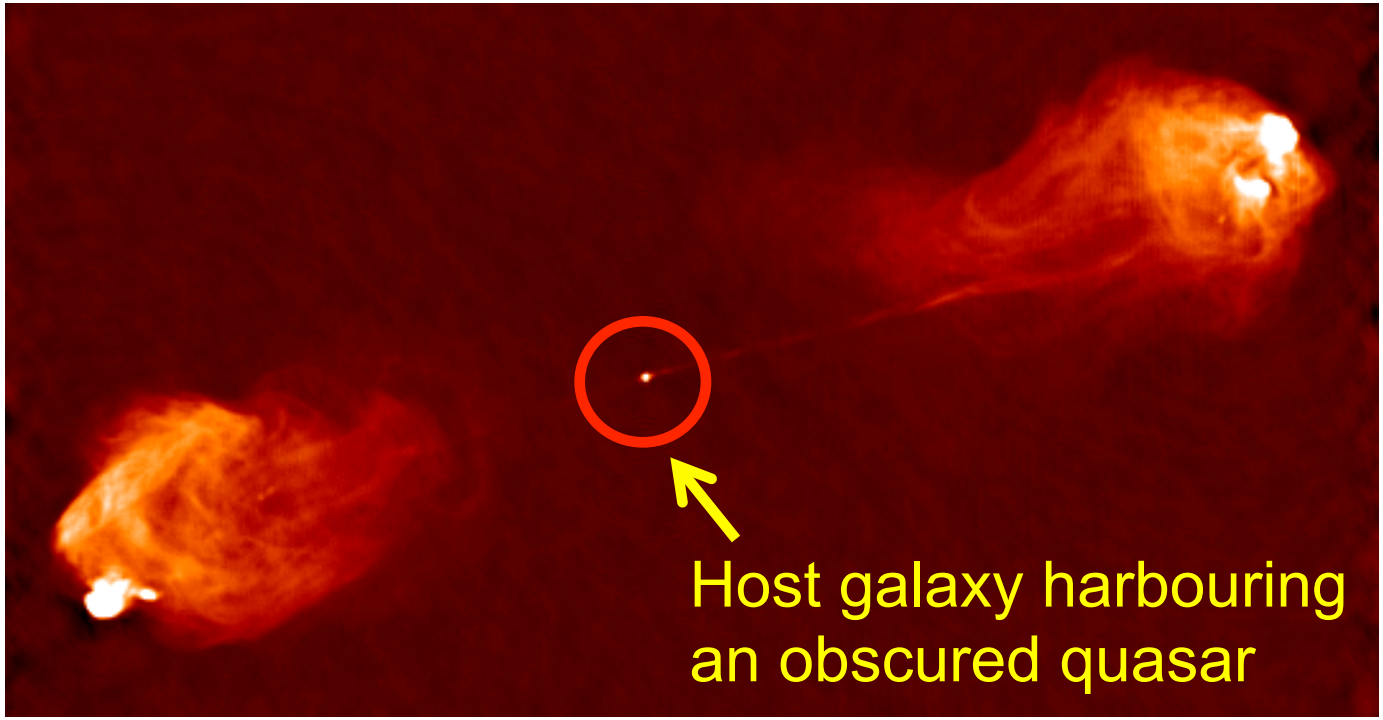




X-ray selected AGN - on MS, with redshift evolution (Mullaney+12, and other studies).

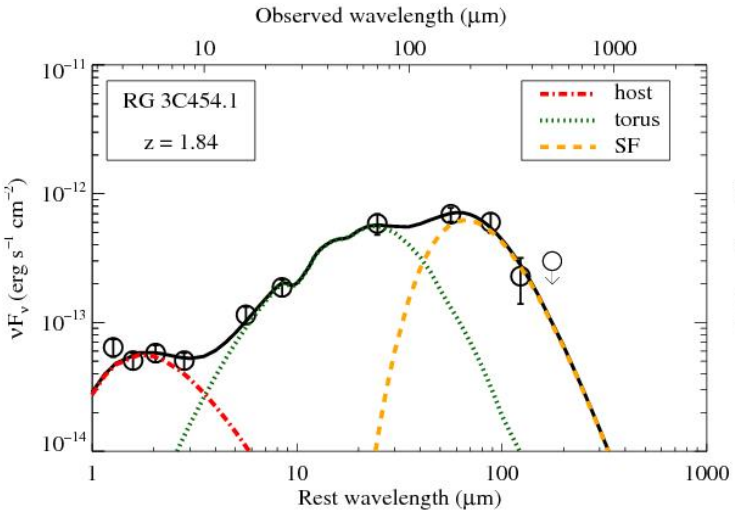


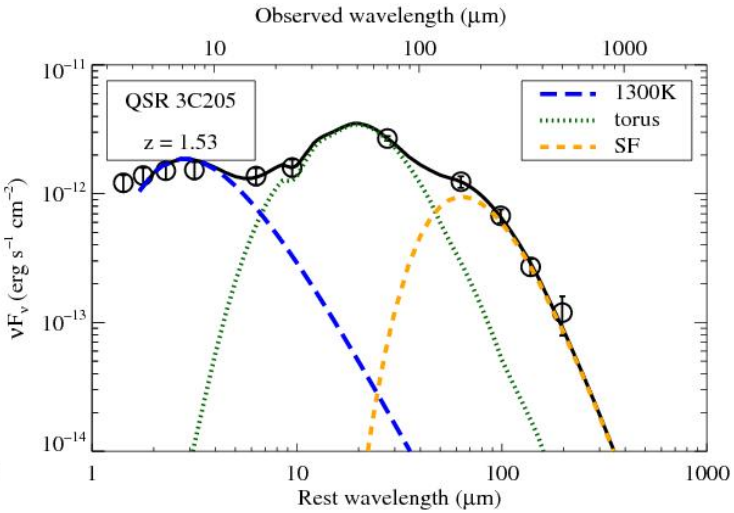
Now the all-sky monsters: ultra-powerful (3C) FR2 radio sources, à la Cygnus A, in very massive hosts – GT and OT studies by the Hergé-, Tadhunter-, and Barthel-teams.



Typical 3C radio galaxy and QSR SEDs, indicative of prodigious (200 – 900 $M_\odot$/yr) starbursts in 1/3 of the sample.

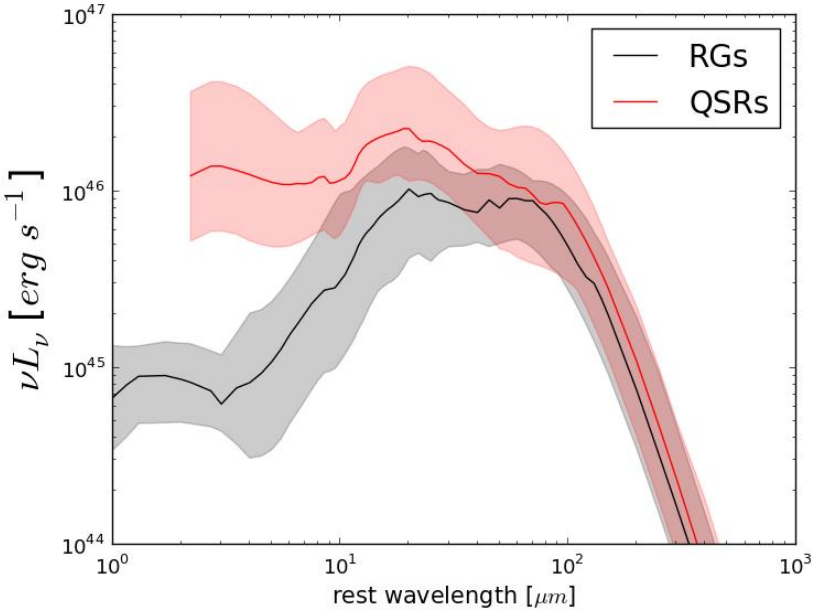
But ⋯ still on the Main Sequence (massive hosts!)





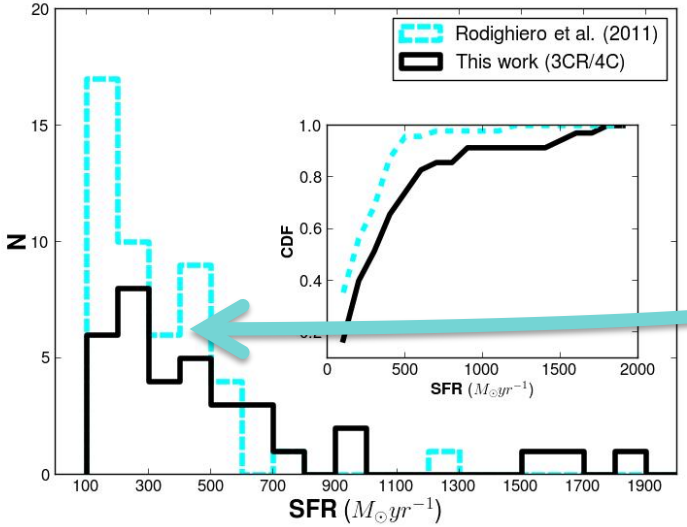
Podigachoski+15

… and the average $z>1$ 3C Herschel SEDs, supporting orientation unification, including the aspect-dependent warm torus emission.

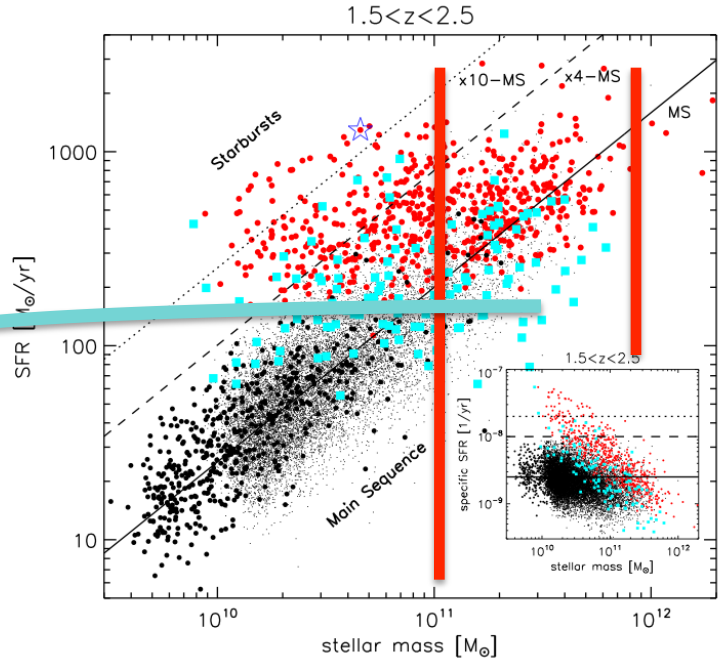


Podigachoski+15

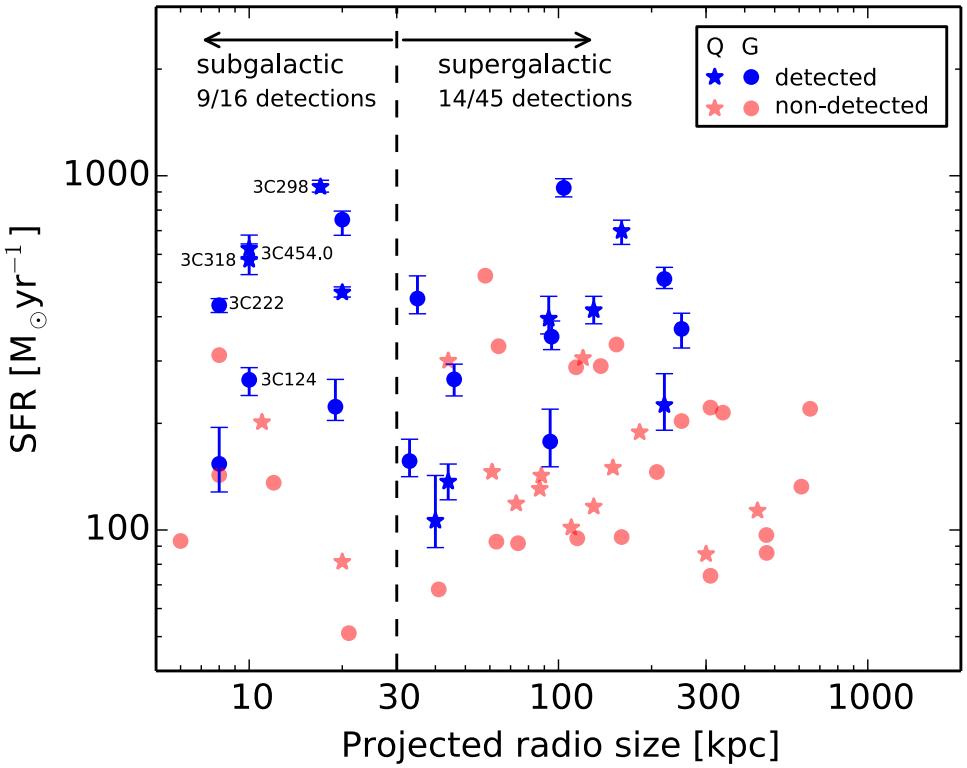
Comparing the N(SFR) distribution of the 3C AGN with non-AGN (in the same host mass range) we see no sign of negative AGN feedback whatsoever. Note also the SFR-distribution of SDSS QSOs (Ma&Yan15, Pitchford+16), going through the ceiling (but watch out!)



Podigachoski+15



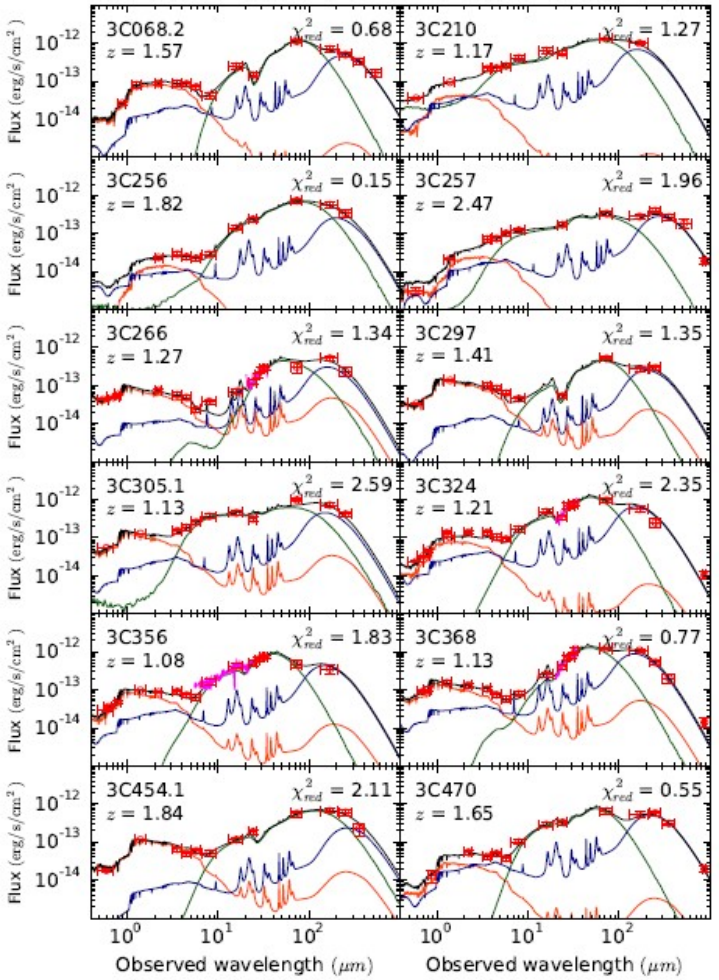
We observe stronger starbursts in smaller (younger) 3C radio sources: jet-induced star-formation, i.e., positive feedback? TBC.



Podigachoski+15

Further quantification of 3C radio galaxy host properties, using the Pégase-3 SED code, in an IAP collaboration (Podigachoski+16).

Other studies of the YSPs (Young Stellar Populations) are done by the Tadhunter-team. More clever work is needed to constrain the timing/impact of the events.



So, yes, AGN live in regular star-forming/bursting galaxies

Take-away image (C.Carreau)

Outstanding (!) issues

1. Quantifying the circumnuclear starbursts, and the related positive/negative feedback: location, size, strength, timing w.r.t. AGN, duration, winds, ..

2. AGN outflows as negative feedback: nature, strength

3. Torus models/observations

1. The starburst issue

a. Hergé-team (f.i. Falkendal+18) and Tadhunter/Morganti teams make progress re timing/duration and feedback

b. Starburst-driven superwinds in distant QSOs are observed as associated absorption in optical-uv, over ~kpc dimensions (à la Mkn231) – Barthel+17

c. Lutz-team (e.g., Lutz+18) has made clever size estimates (~kpc) of the circumnuclear starbursts by deconvolving the PACS images

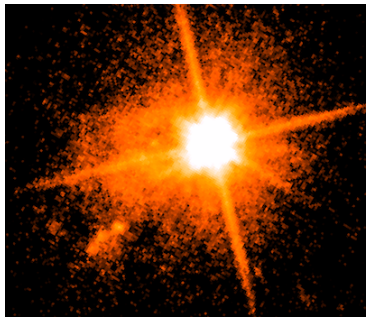
d. ALMA imaging by Barthel-team indeed finds sub-kpc dimensions, and positive feedback (Barthel+18)

Ad b: another take-away image

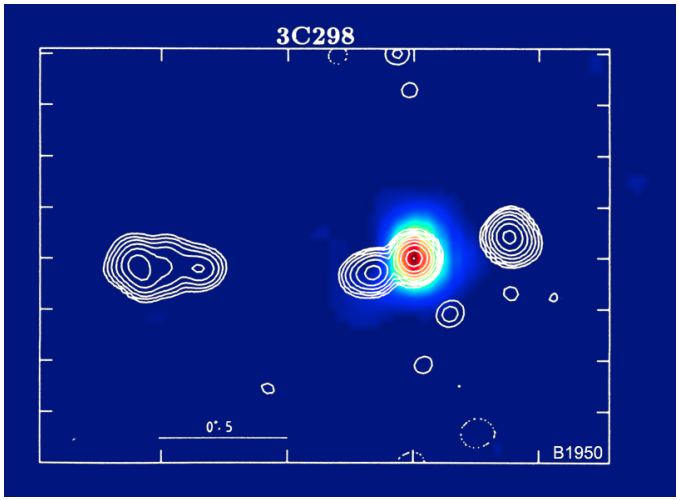
Ad d: 3C298 (SFR=930, strong CIV absorption) imaged by ALMA at 0.15arcsec resolution

- The 1mm emission is ~75% non-thermal and ~25% thermal
- The thermal emission resides in an asymmetric plateau
- Its morphology implies jet-ISM interplay, on the sub-kpc scale

See Barthel+18; similar results in 3C318 and 3C454.0 (June 2019 issue of ESO Messenger).



HST: Chiaberge+17

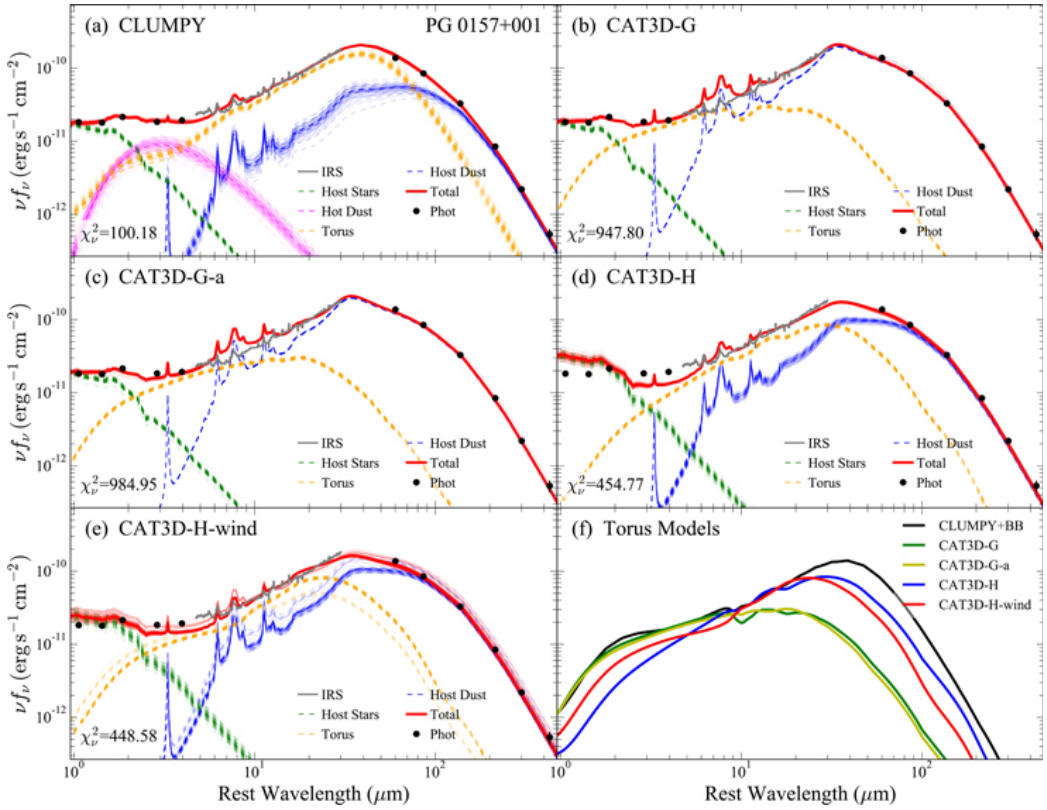


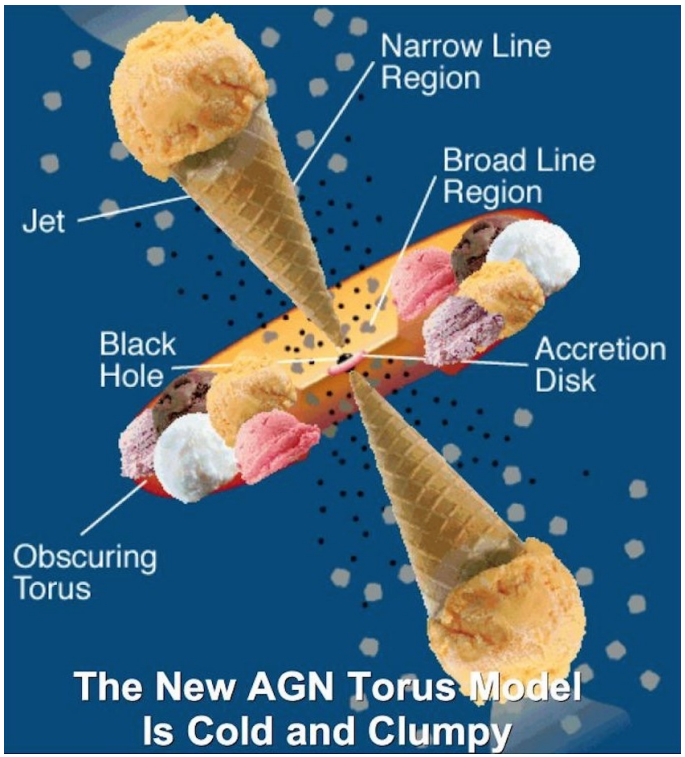
Barthel+18

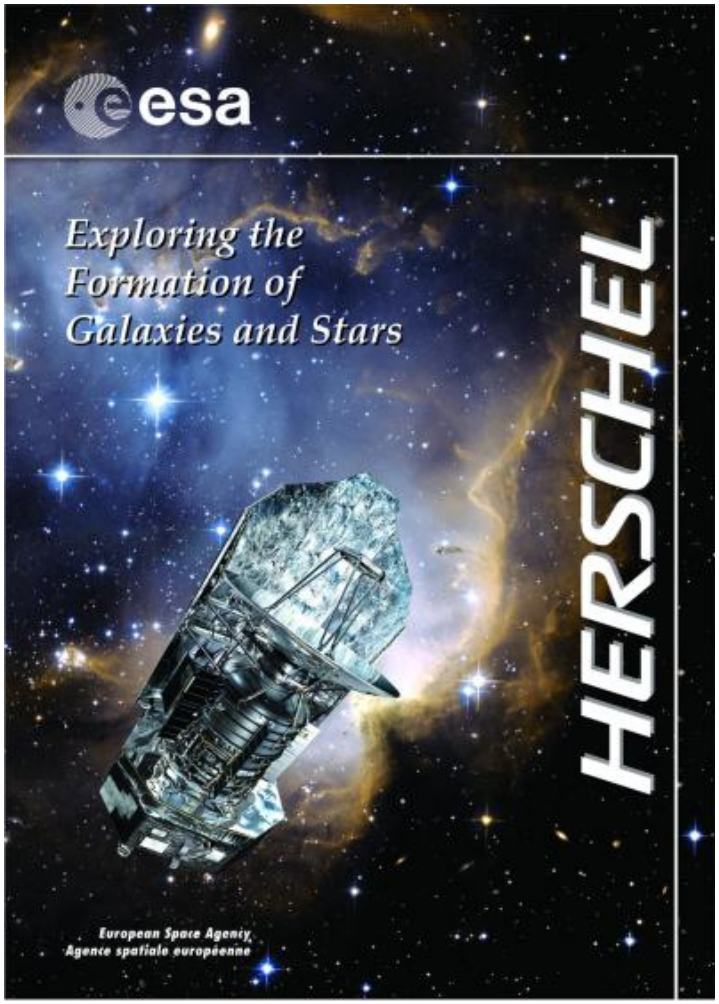
2. The AGN outflow issue

Bottom line: I am still confused as to the magnitude of pure AGN feedback, that is to say, it's global time-integrated importance – please update/convince me. I also have trouble understanding how it would quench star-formation on the kpc scale: radio jets – yes, but accretion disk radiation or winds – no.

3. The torus models: see f.i. Zhuang+18







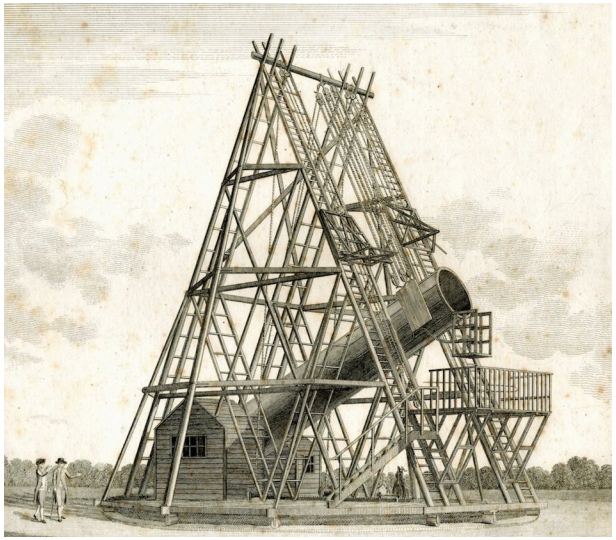
Concerning AGN and their hosts:

Herschel explored

ánd

Herschel delivered

N.B. To my surprise there is still a big Herschel telescope !



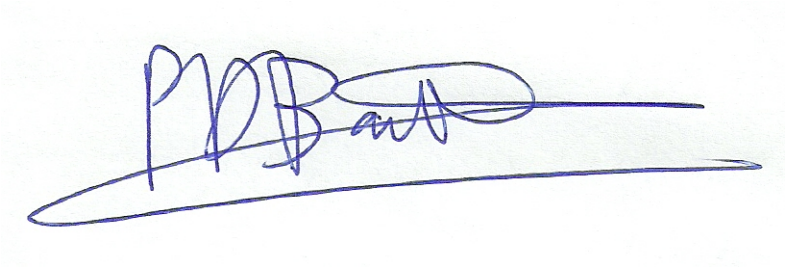
RGO - Greenwich

Finally, quoting Friedrich Wilhelm Herschel:

“They (the stars) are now seen to resemble a luxuriant garden which contains the greatest variety of productions in differing flower beds…”
“… every stage through which the plant passes is brought to our view..”

“There are two kinds of happiness or contentment for which we mortals are adapted: the first we experience in thinking and the second in feeling”

I FEEL PROUD TO HAVE BEEN PART OF IT!!



Herschel Science Team (2009,
a few months before the launch)

n.b. Herschel was #7 in the Time Magazine list of greatest inventions of the year 2009