BAT AGN prefer circumnuclear star formation

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MPE

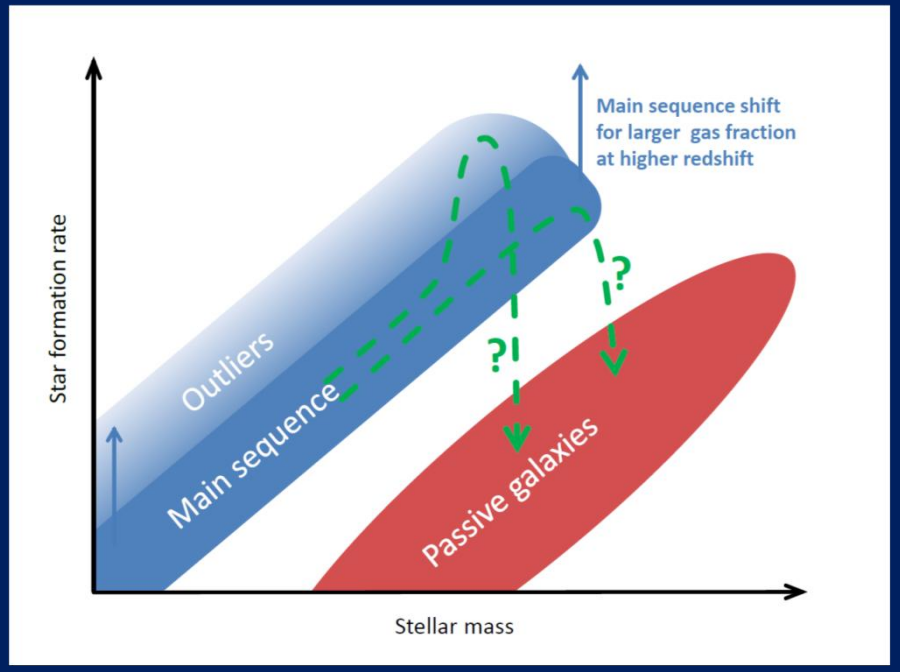
Torus 2018

The many faces of AGN obscuration

Puerto Varas, December 12, 2018

What is the size and structure of star formation (or cold gas) in galaxies as a function of SFR, M*, z, AGN content...?

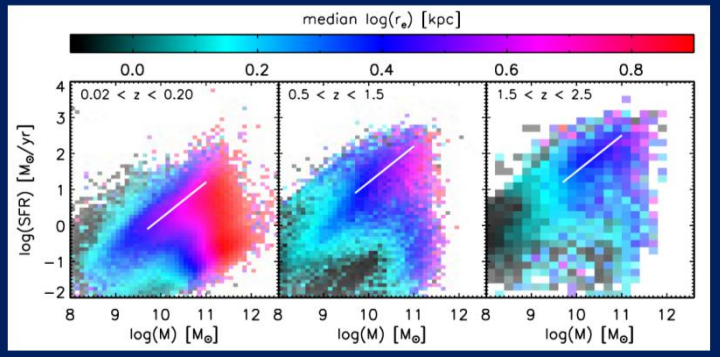
- Inside-out growth of star forming galaxies?
- Compaction in gas rich instable disks?
- Gas inward transport in mergers?
- Relation of star formation to Black Hole accretion?
- ...



Methods

- Rest-UV/optical continuum, Hα

Obscured for massive dusty galaxies and outliers, AGN contamination



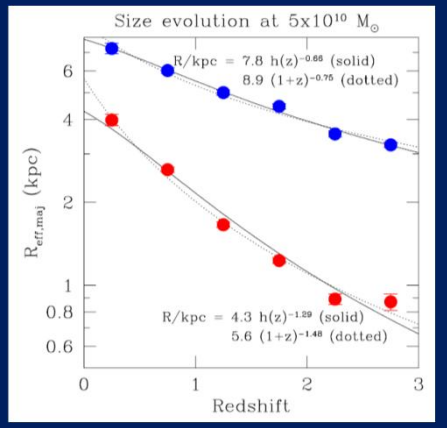
Wuyts+11

More extinction insensitive:

- Mid-IR imaging or long-slit spectra

e.g., Soifer+00,01, Diaz-Santos+10,11

Sample sizes, AGN contamination



van der Wel+14

- Radio interferometry

e.g., Condon+90,91, Barcos-Munoz+17

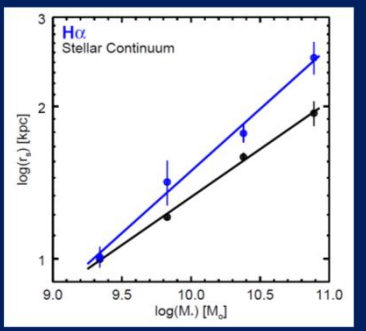
Sample sizes, AGN contamination

- (sub)mm interferometry of dust or CO

e.g., Sakamoto+99

Sample sizes, have to assume star formation law

Nelson+15

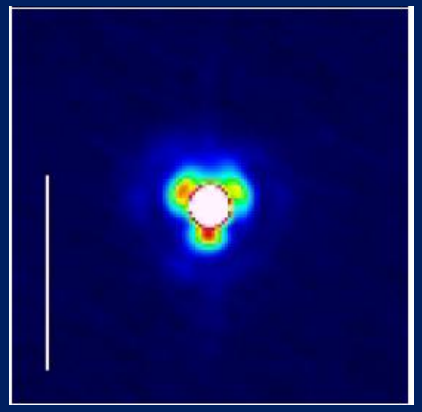


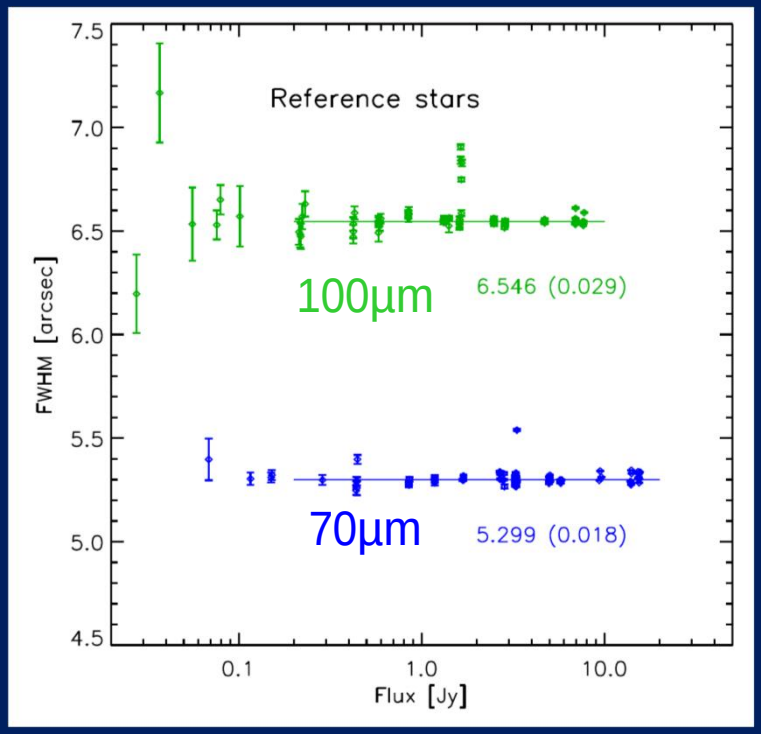
- Far-infrared imaging

No sensitive far-infrared interferometry in the foreseeable future

Herschel FIR sizes for hundreds of galaxies

Ugly but highly stable PSF

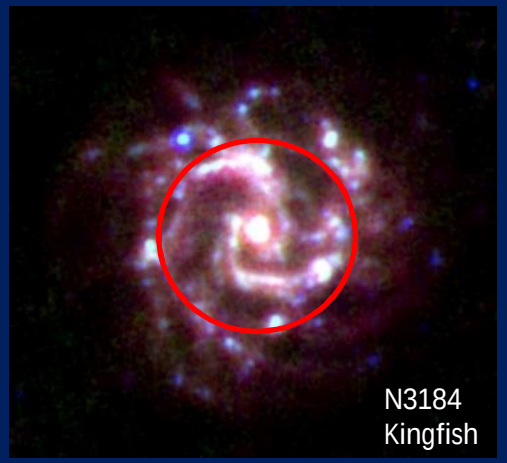




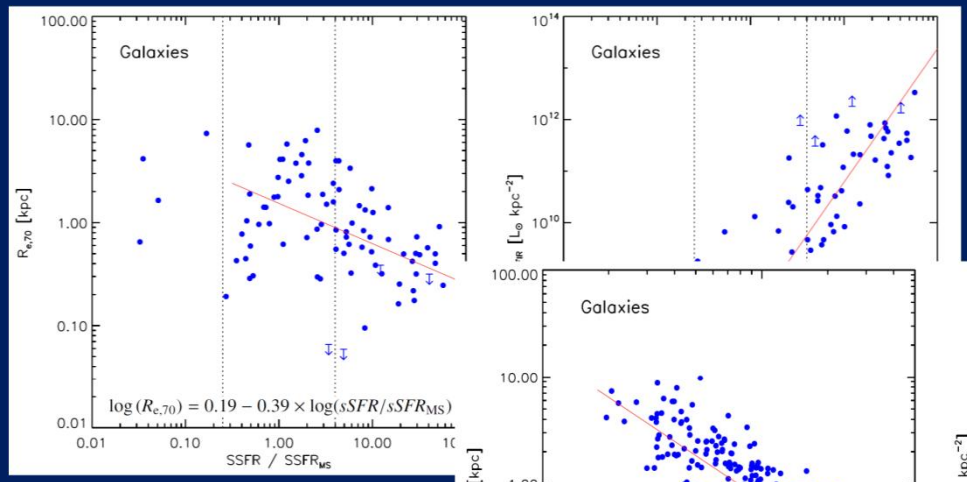
$$FWHM_{Source} = \sqrt{FWHM_{Obs}{}^2 - FWHMPSF(\alpha)^2}$$

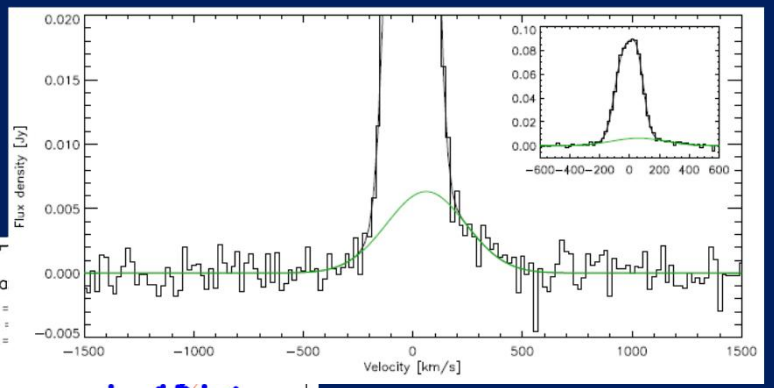
Overall FWHM, not a detailed map, simplifying

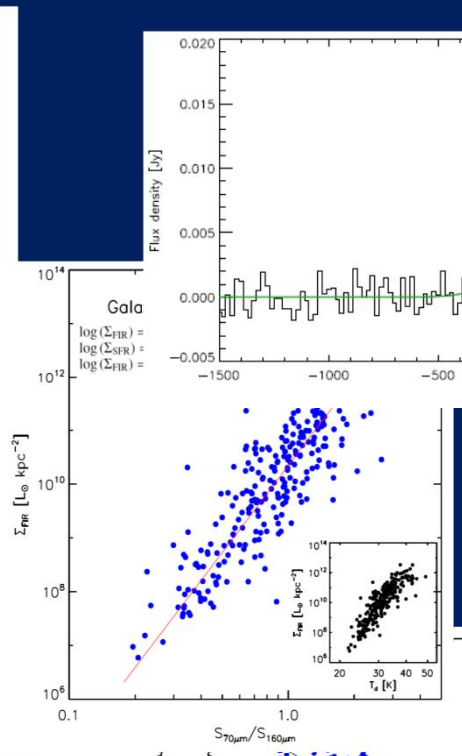
Consistently available for hundreds of targets

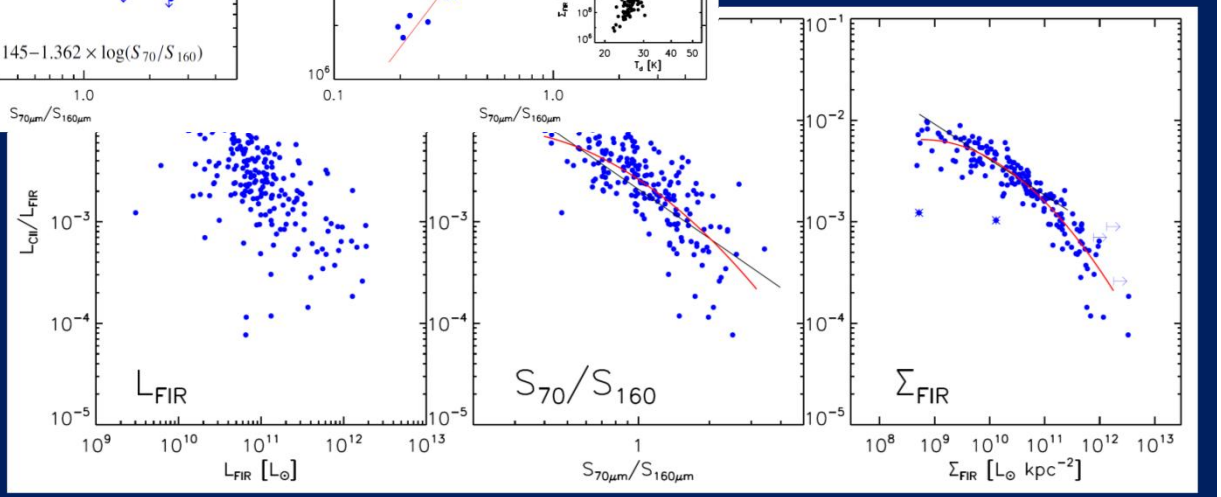


Scaling relations for R_e and Σ_{FIR}, link to [CII] deficit, candidates for molecular outflows…



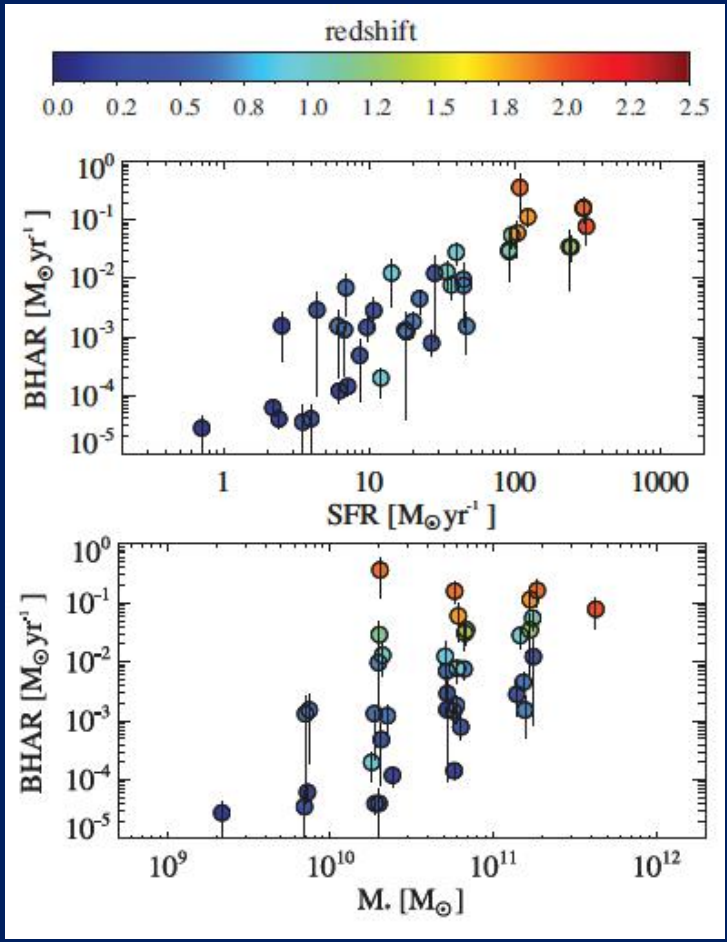




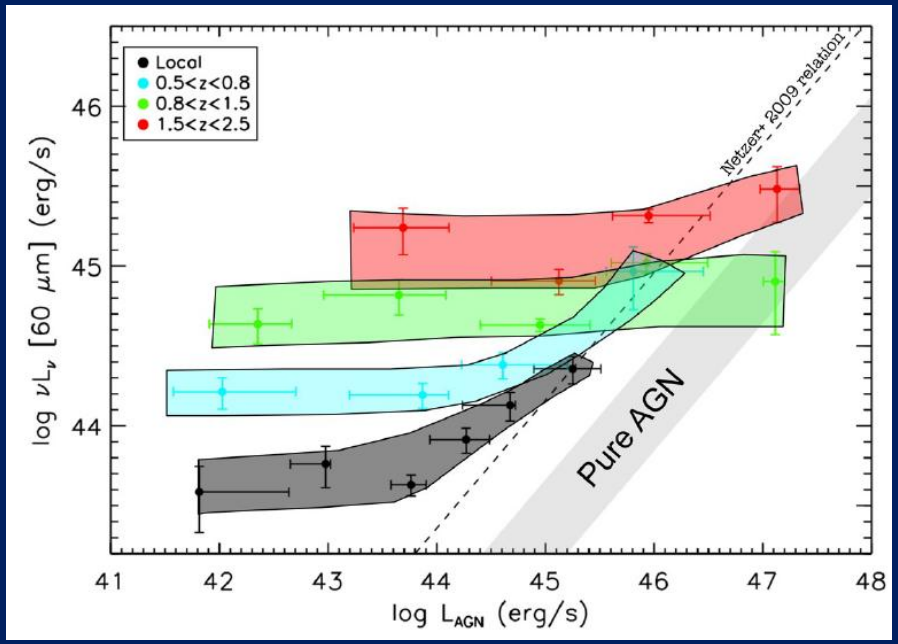


Lutz et al. 2016, 2019 in prep

Herschel: Link of flickering BHAR and SFR – ‘unsynchronized coevolution’



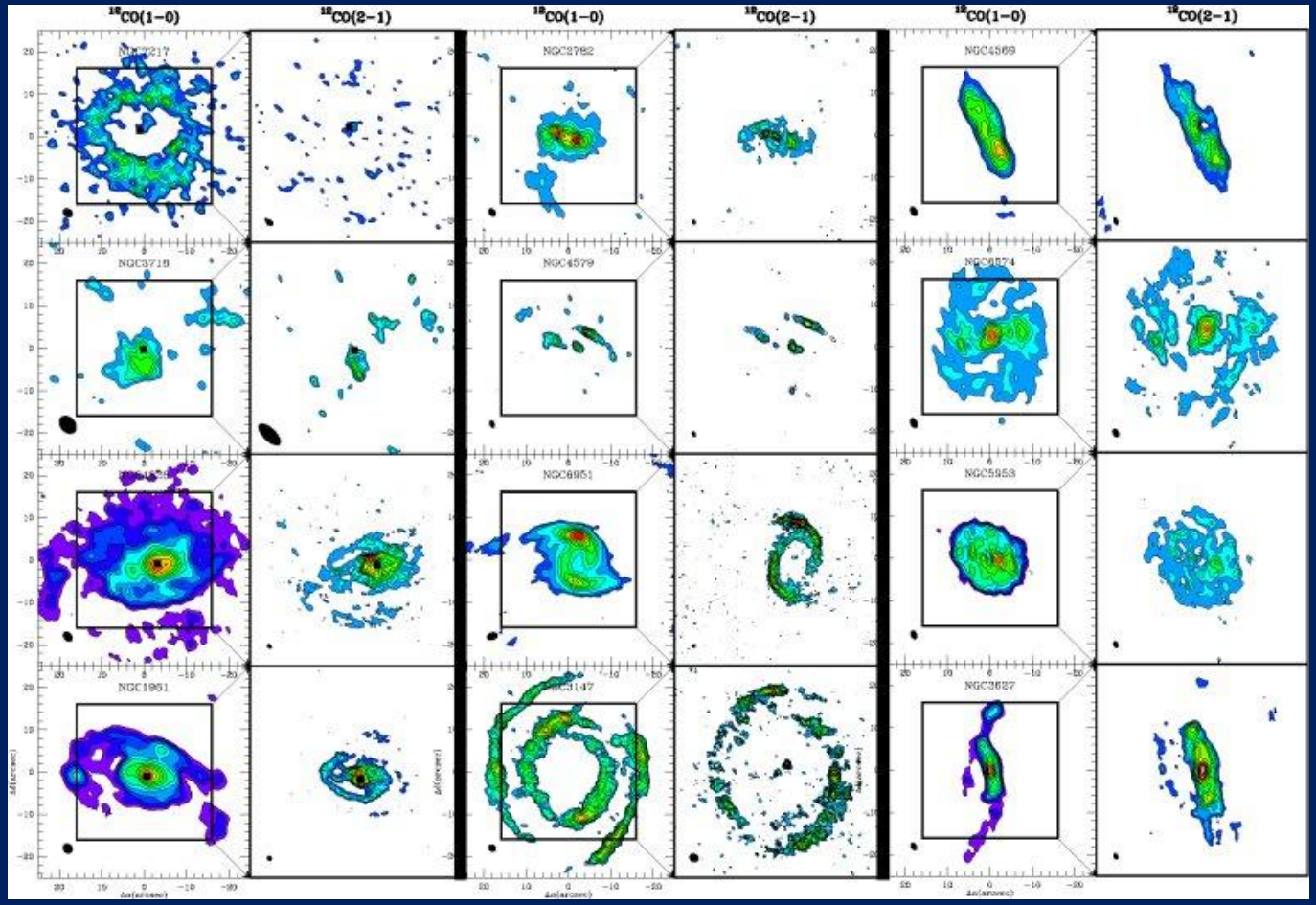
Average BHAR for samples selected in bins of SFR,M*,z (Delvecchio+15)



Average SFR for samples selected in bins of instantaneous BHAR, z (Rosario+12)

Shao+10, Rosario+12,13, Santini+12, Mullaney+12ab, Chen+13, Hickox+14, Stanley+15, Delvecchio+15…

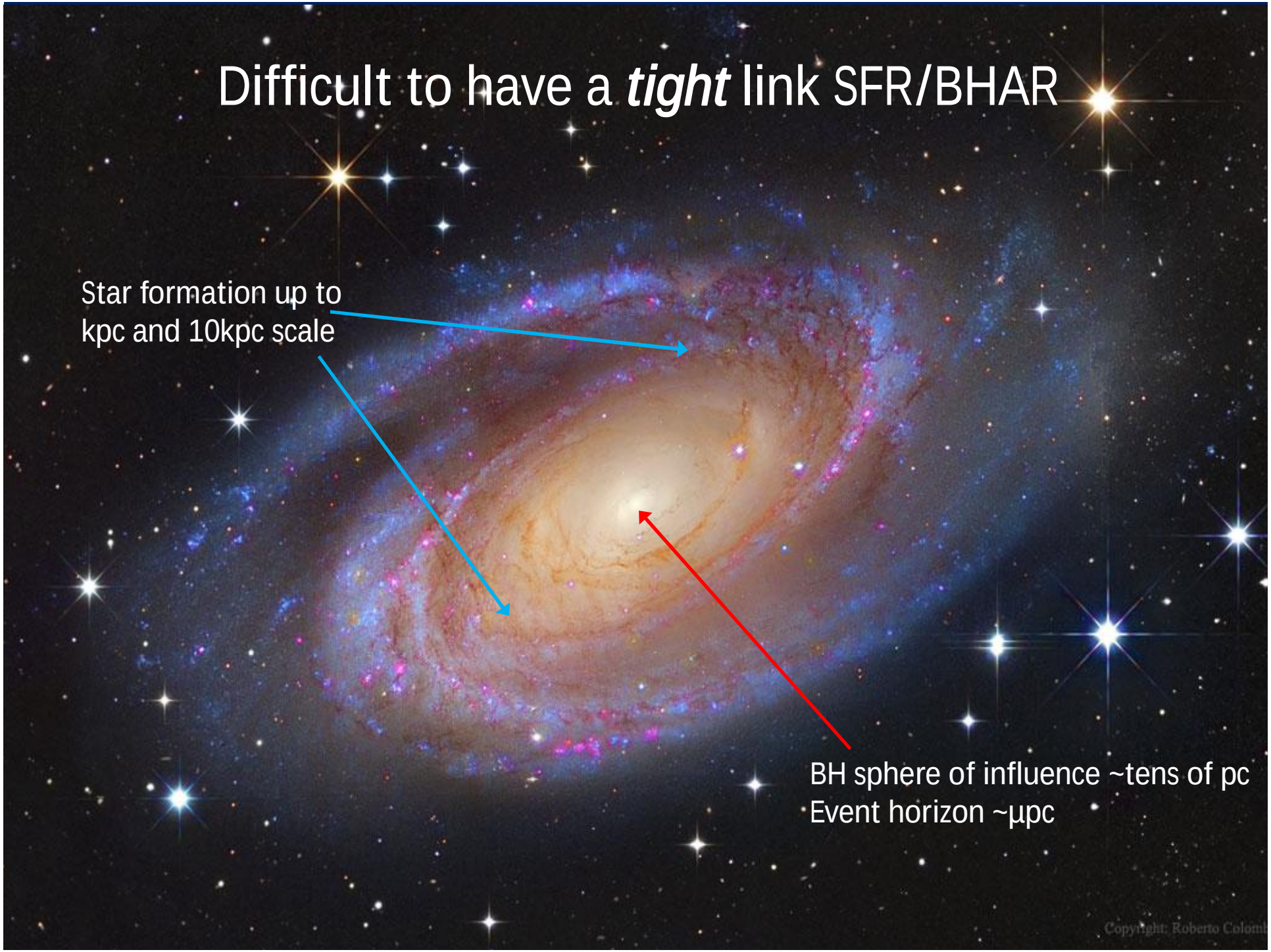
Structural differences favouring AGN, if BHAR and SFR fed from same gas reservoir?



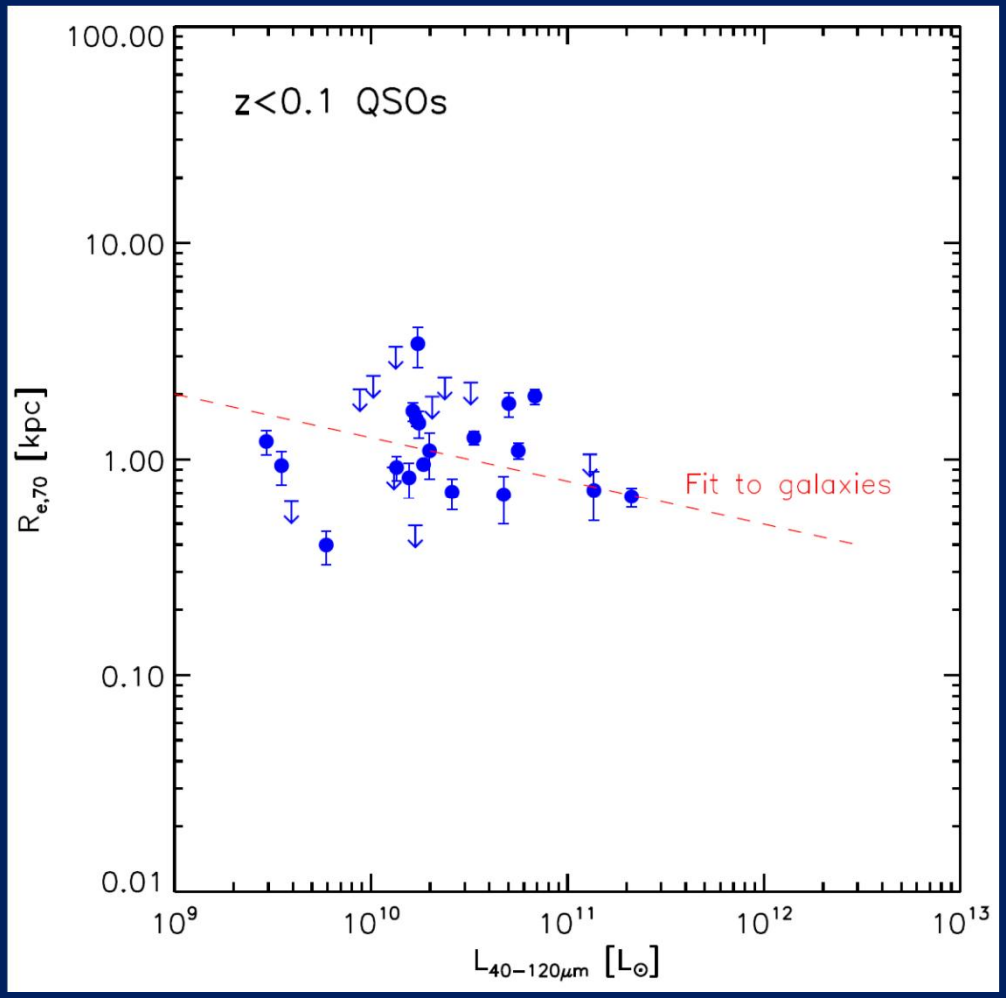
NUGA project
@ IRAM PdB

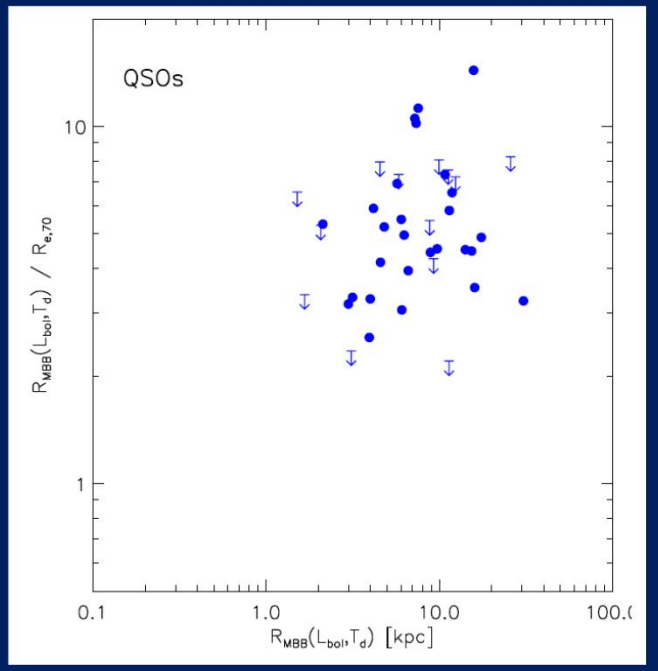
To establish the role of intriguing features, such data would be needed for very large samples of AGN and reference galaxies!

Difficult to have a *tight* link SFR/BHAR



PG QSO hosts agree with galaxy scalings





Optically thin AGN-heated FIR emission would be larger than observed size… FIR from host SF!

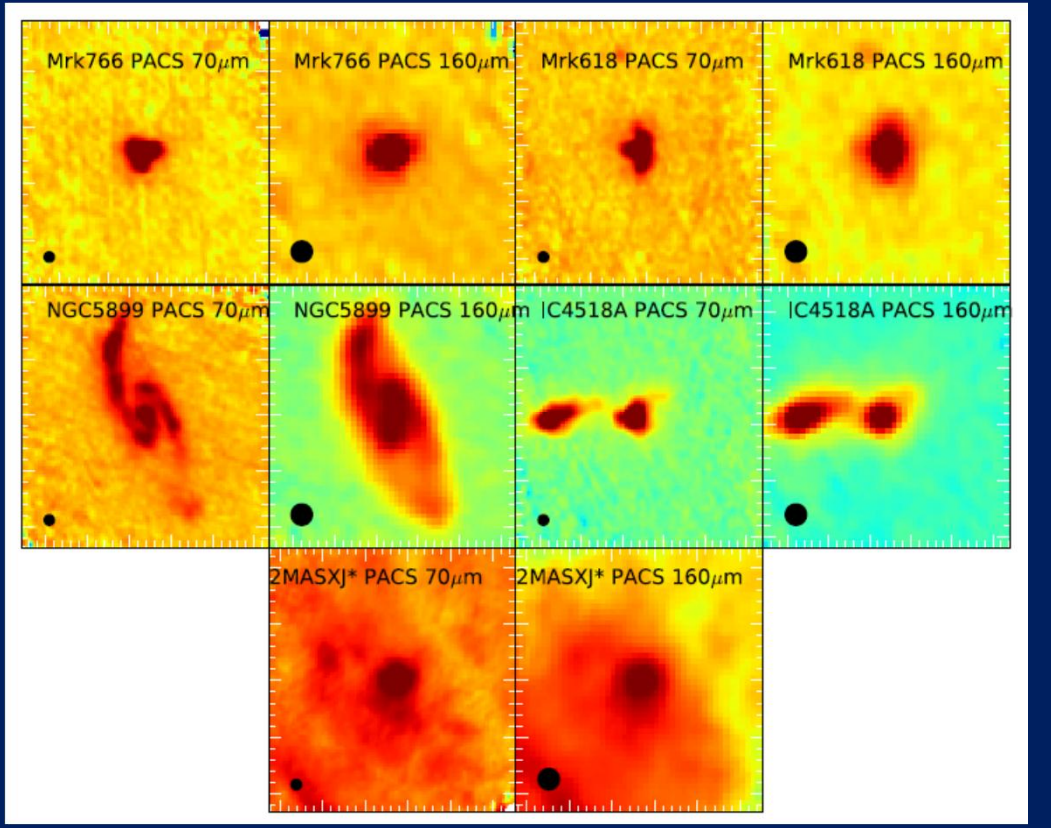
.. But limited by distance, faintness, and sample size – Different AGN sample?

Swift-BAT sample to the rescue

Selected by extremely hard 14-195keV X-ray – will catch all but the most obscured AGN

z<0.05 BAT AGN from 58 month version observed with Herschel PACS & SPIRE photometers:
Mushotzky+14
Melendez+14
Shimizu+15,16,17

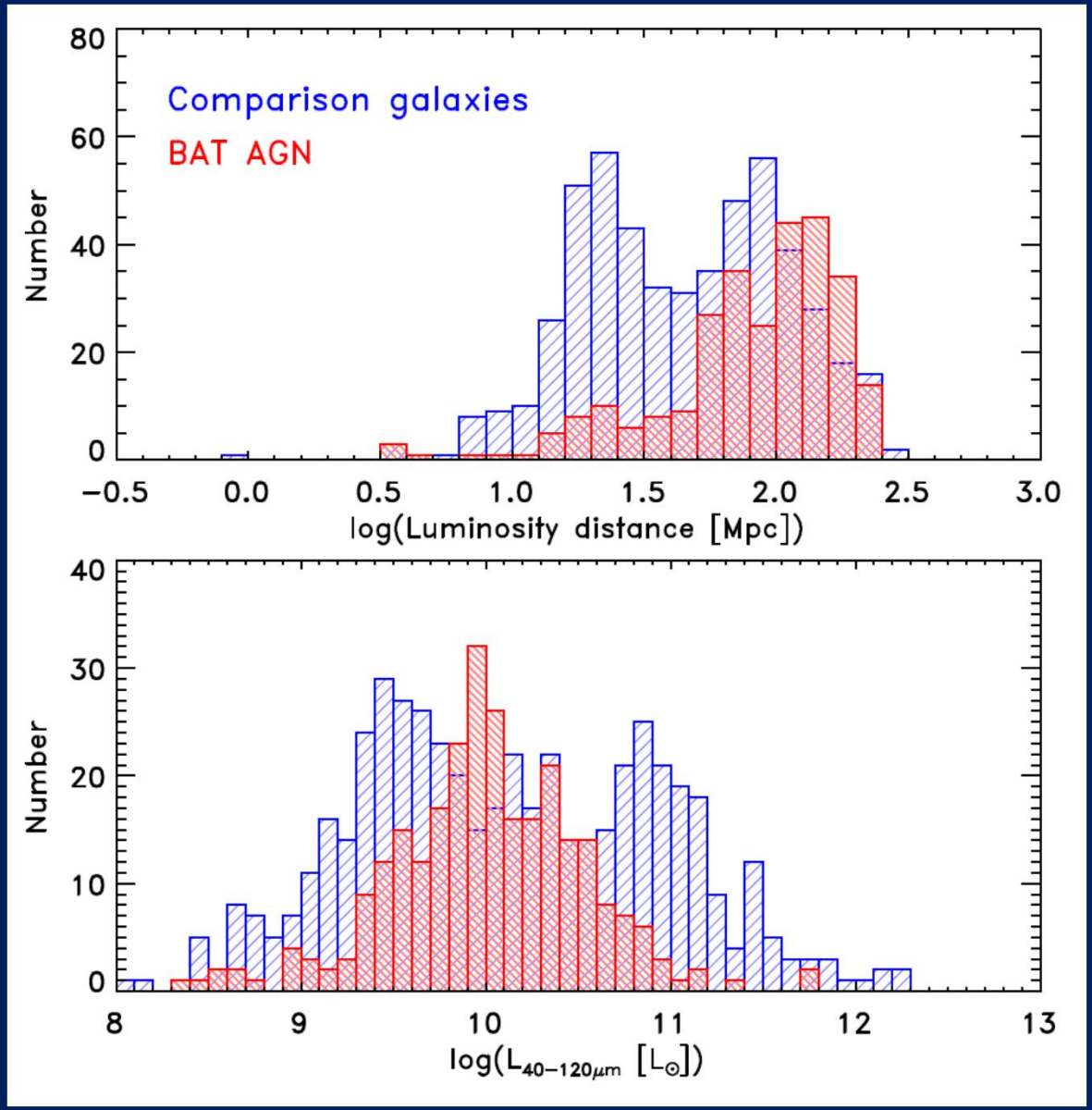
→ Apply the tuned ‘Herschel-PACS size measurement’ machine to BAT sample and as large as possible reference sample



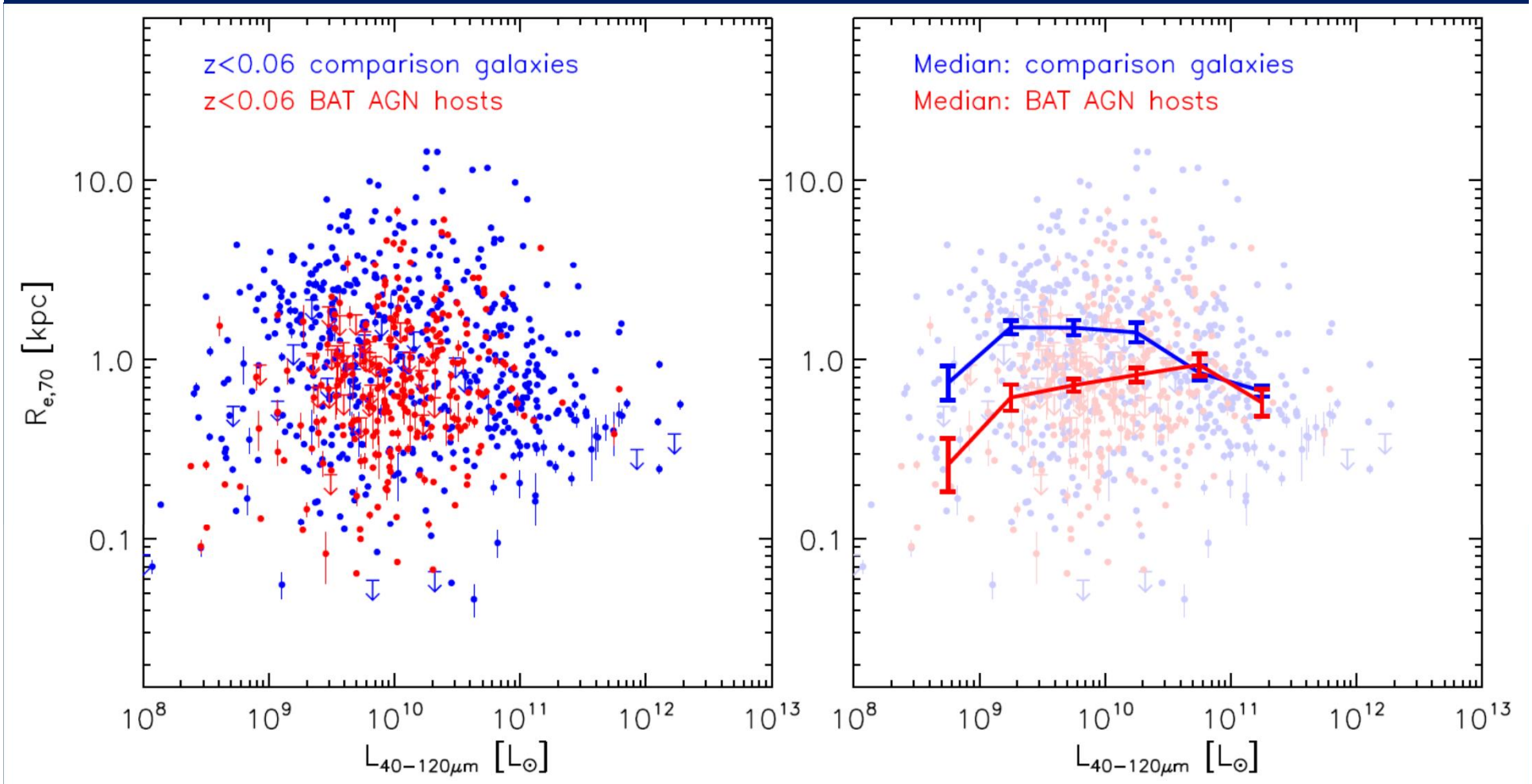
Sample

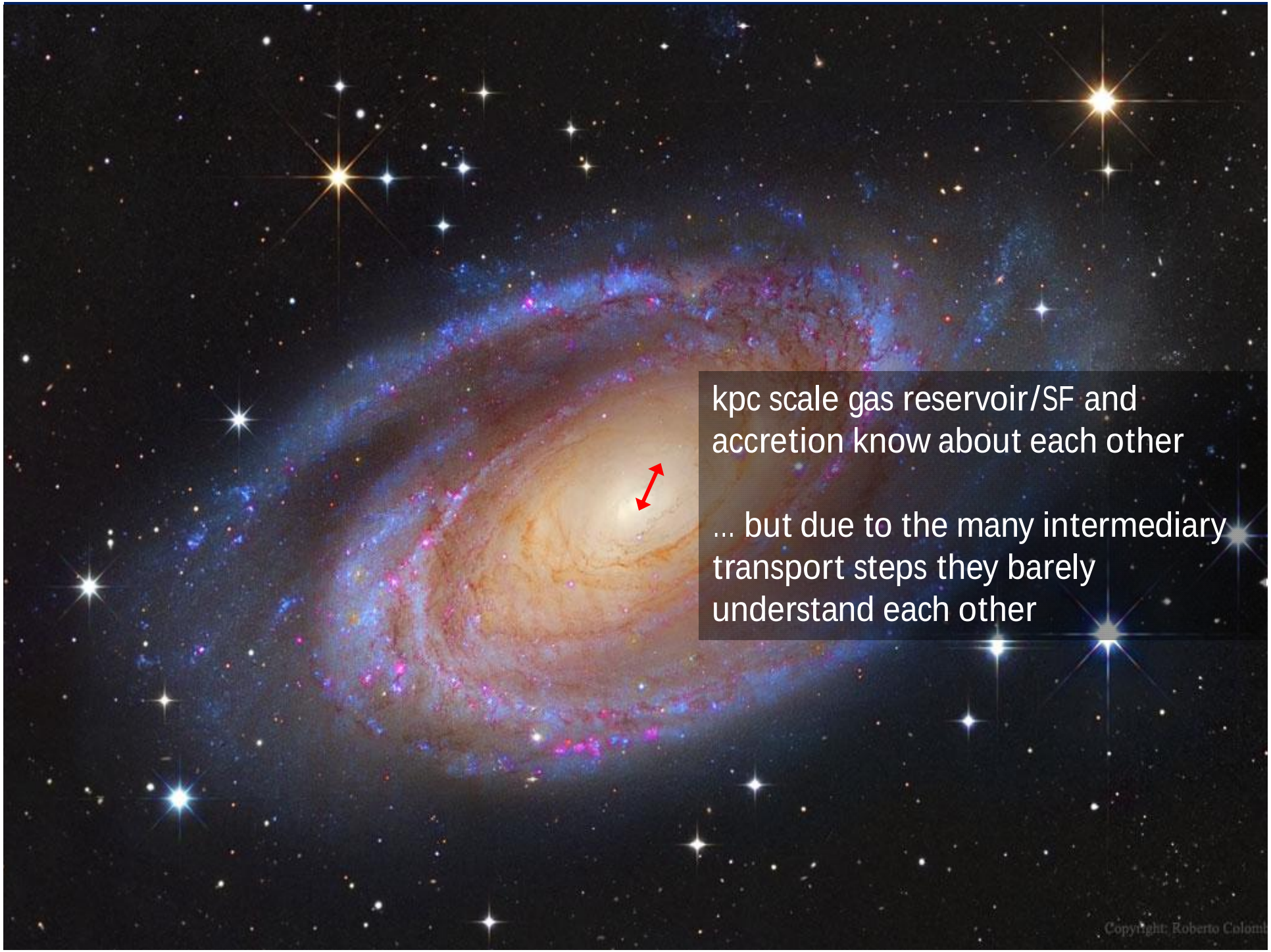
N(Comparison) = 515

N(BAT) = 277
Typical log(Lbol)~44.5

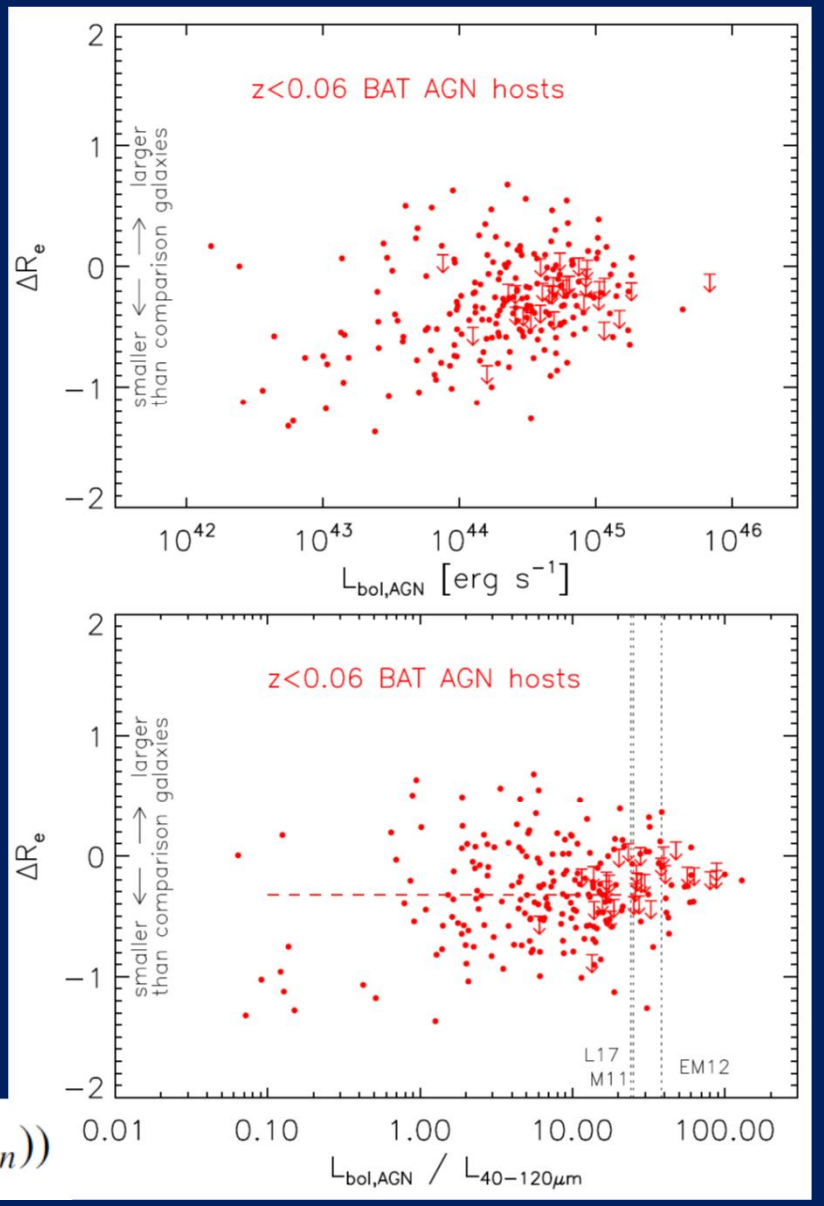


Huge scatter, but modest SFR AGN hosts are on average more compact



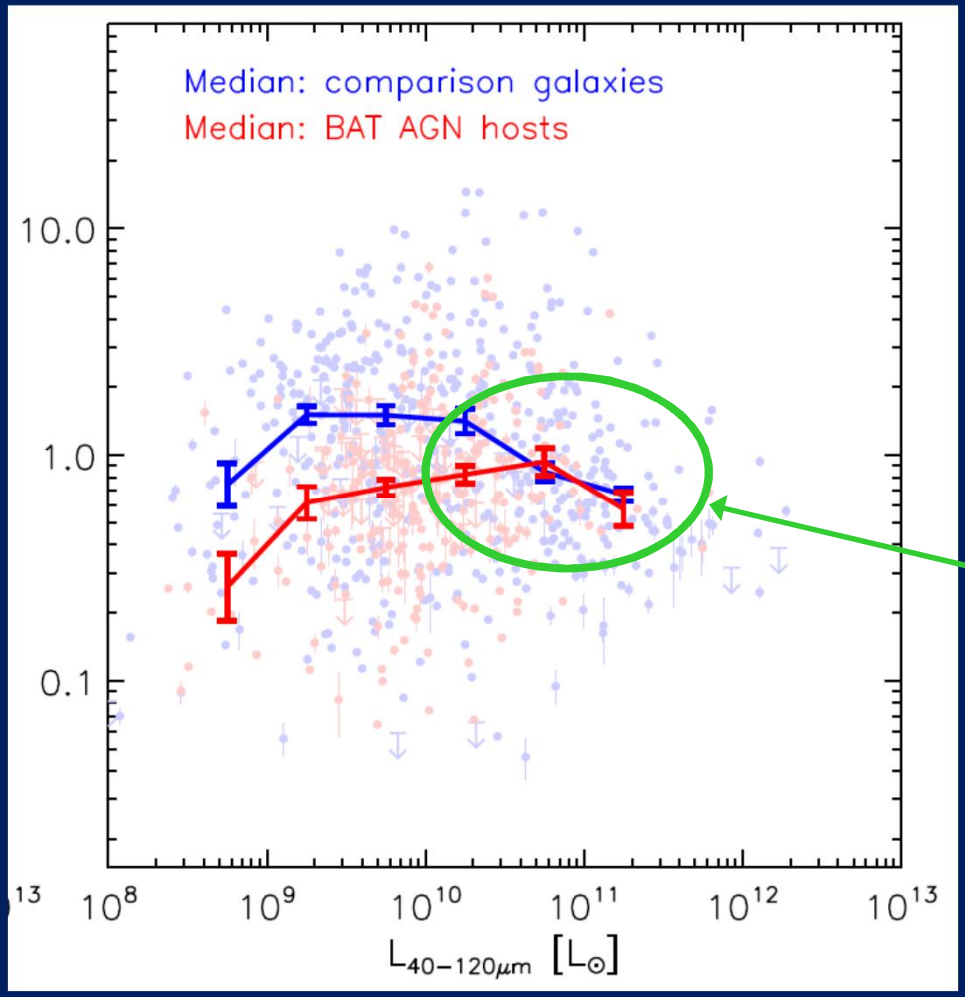

kpc scale gas reservoir/SF and accretion know about each other
... but due to the many intermediary transport steps they barely understand each other

Are we fooled by compact AGN-heated dust?



$$\Delta R_e = log(R_{e,70,AGN}) - log(Median(R_{e,70,Comparison}))$$

Why no size difference at higher SFR?



For limited gas content of local galaxies, high SFR needs compact gas in the first place?

What can we expect from a gas distribution experiment at 10pc 'torus' resolution?

(NIR adaptive optics, Alma)

- Obviously and naively a tighter link, but

- Dynamical times are still large compared to AGN flickering/ accretion variations
- Any non-AGN reference sample is contaminated by yesterday's and tomorrow's AGN, with ~same structural properties

- Hopefully not "it's all very complex"

Thank you!

- Characteristic size and surface brightness of FIR emission (star formation) in several hundred local AGN and normal or IR-luminous galaxies
- At same SFR, local AGN prefer more compact circumnuclear star formation (but note large scatter!)
- Accretion and SF feed from galaxy's gas reservoir, with more efficient AGN feeding if reservoir is more concentrated – some link is left over the many orders of magnitude inward transport

Lutz+16 A&A 591, A136, Lutz+18 A&A 609, A9, work in progress