# Star Formation in AGN hosts in GOODS-N

**L. Shao[1], D. Lutz[1], R. Nordon[1], R. Maiolino[2], D.M. Alexander[3], B. Altieri[4], P. Andreani[5,6], H. Aussel[7], F.E. Bauer[8], S. Berta[1], A. Bongiovanni[9,10], W.N. Brandt[11], M. Brusa[1], A. Cava[9,10], J. Cepa[9,10], A. Cimatti[12], E. Daddi[7], H. Dominguez-Sanchez[12], D. Elbaz[7], N.M. Förster-Schreiber[1], N. Geis[1], R. Genzel[1], A. Grazian[2], C. Gruppioni[12], G. Magdis[7], B. Magnelli[1], V. Mainieri[5], A.M. Pérez Garcia[9,10], A. Poglitsch[1], P. Popesso[1], F. Pozzi[12], L. Riguccini[7], G. Rodighiero[13], E. Rovilos[1], A. Saintonge[1], M. Salvato[14], M. Sanchez Portal[4], P. Santini[2], E. Sturm[1], L.J. Tacconi[1], I. Valtchanov[4], M. Wetzstein[1], E. Wieprecht[1]**

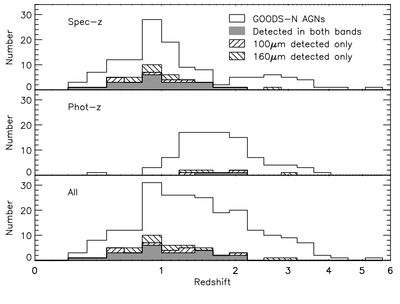
1. Max-Planck-Institut für extraterrestrische Physik, Postfach 1312, 85741 Garching, Germany, E-mail: shao@mpe.mpg.de
2. INAF - Osservatorio Astronomico di Roma, via di Frascati 33, 00040 Monte Porzio Catone, Italy
3. Department of Physics, Durham University, South Road, Durham, DH1 3LE, UK
4. European Space Astronomy Centre, Villafranca del Castillo, Spain
5. European Southern Observatory, Karl-Schwarzschild-Straße 2, 85748 Garching, Germany
6. INAF - Osservatorio Astronomico di Trieste, via Tiepolo 11, 34143 Trieste, Italy
7. IRFU/Service d'Astrophysique, Bât.709, CEA-Saclay, 91191, Gif-sur-Yvette Cedex, France
8. Pontificia Universidad Católica de Chile, Departamento de Astronomía y Astrofísica, Casilla 306, Santiago 22, Chile
9. Instituto de Astrofísica de Canarias, 38205 La Laguna, Spain
10. Departamento de Astrofísica, Universidad de La Laguna, Spain
11. Department of Astronomy and Astrophysics, 525 Davey Lab, Pennsylvania State University, University Park, PA 16802, USA
12. Istituto Nazionale di Astronomia, Osservatorio Astronomico di Bologna, Via Ranzani 1, I-40127 Bologna, Italy)
13. Dipartimento di Astronomia, Universitá di Padova, 35122, Padova, Italy
14. Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching, Germany

## Motivation

Measuring star formation in AGN hosts is one of the keys to study AGN evolution. At z~1, *Herschel*/PACS provides direct measurement to the far-infrared SED peak, which is a good proxy of star formation rate. *Herschel* also has high sensitivity to detect much lower star formation rates than previous FIR/submm telescopes.

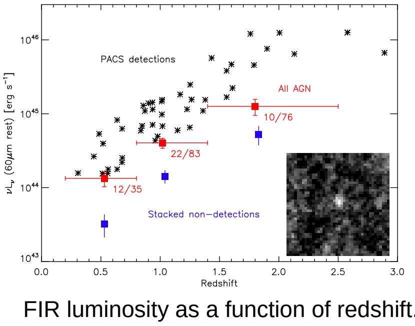
## Data

We select 224 AGN from 2Ms Chandra X-ray catalog, with a combination of criteria to distinguish X-ray AGN from star formation dominated objects (Bauer et al. 2004). We use both spectroscopic (Barger et al. 2008) and photometric redshifts.



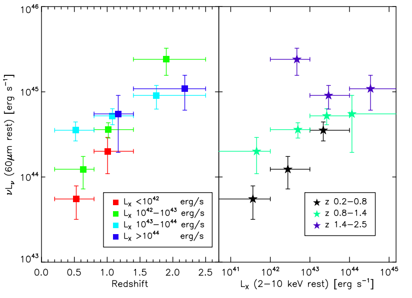

## Results

**The rest frame 60μm luminosity is calculated** from the detection wavelength closer to rest 60μm or log-linearly interpolating from both bands at 0.67<z<1.67. For undetected sources, we use stacked 100μm and 160μm fluxes to derive the mean rest $\nu L_\nu$(60μm), adopting median z of the particular sample in small redshift bins.

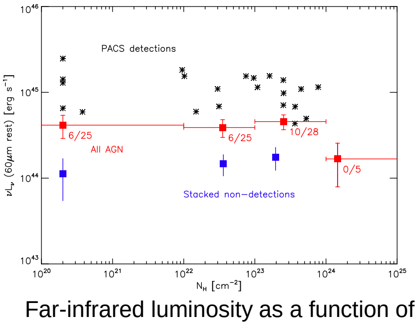



FIR luminosity as a function of redshift. The red symbols are the average of the detections and nondetections. The errors are from bootstrap. Bottom-right is an example of stacked image.

The detection number is large enough to allow us to split the sample into smaller bins, both in z and $L_X$.

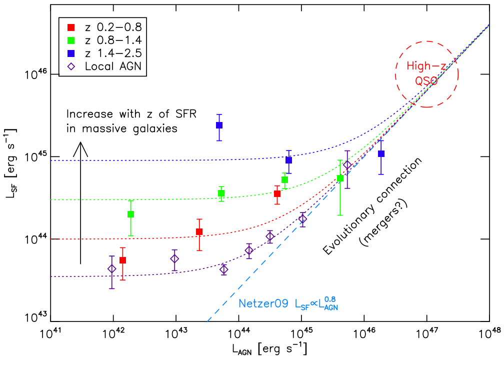



This figure shows **our effort to break the redshift/luminosity degeneracy.** Left: FIR luminosity as a function of redshift, for different bins in intrinsic rest frame 2-10keV luminosity. Right: FIR luminosity as a function of intrinsic X-ray luminosity, for different redshift bins.




Far-infrared luminosity as a function of X-ray obscuring column. Sample for redshifts 0.8<z<1.4. Low obscuring column objects have been placed at $2{\times}10^{20}$cm$^{-2}$. **There is no significant trend of $L_{IR}$ with column density.**

## AGN/host relation: two modes of co-evolution




Left figure shows star forming (=far-infrared) luminosity as a function of AGN bolometric luminosity (converted from $L_X$, see eq. 5 of Maiolino et al. 2007) for GOODS-N AGN and a local (z<0.3) reference sample of extremely hard X-ray selected *Swift*/BAT AGN.

The dotted lines indicate schematically how the observations are explained by **two modes of AGN/host co-evolution.**

The dashed line in the left figure is the relation implied by Netzer et al. (2009) with their local bright Seyferts sample. It extends to higher luminosities where the high redshift QSOs reside. There seems to be **an evolutionary mechanism, likely merging, to make host star formation tightly coupled with AGN activity**, i.e. this diagonal trend 'evolution connection'.

However, at lower AGN luminosities, the data points deviate from the log-linear correlation. We propose the 'flatten' part reflects **a secular evolution without close coupling of AGN luminosity and galaxy-integrated host star formation**. The hosts star formation of moderate luminous AGN are similar to that for the general galaxy population at the same redshift, which corresponds to the increase of secular star formation rate from local Universe to z~2.