from Herschel to SAFARI

Photometric surveys strategy:

	Field	Flux	time	
SW: 34-60 μm	GOODS (10'X15')	0.02 mJy	26 hours	OK
	COSMOS (~2 deg^2)	0.02 mJy	(>1000 hours)	?
MW: 60-110 μm	GOODS (10'X15')	0.4 mJy	2 minutes	OK
	COSMOS (~2 deg^2)	0.4 mJy	2 hours	OK
LW : 110-210 μm	wide and shallow fields	~3-5 mJy		OK

Based on Gruppioni+10 model

from Herschel to SAFARI

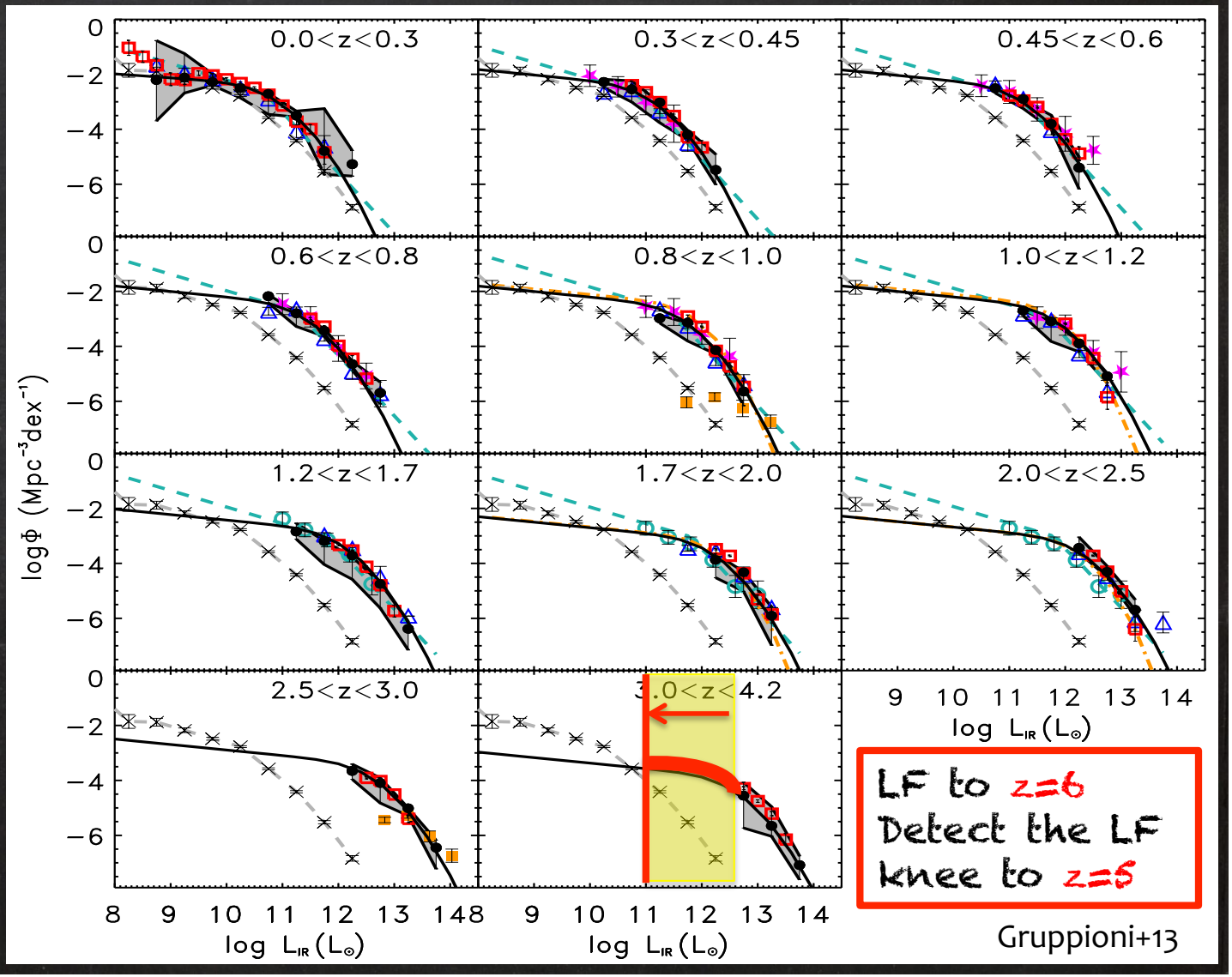
Extend the IR LF to fainter luminosities by ~2 orders of magnitude

LW (34-60) Band

L~10^{11} (LIRGs) @ z~4

PEP @ z=1-2

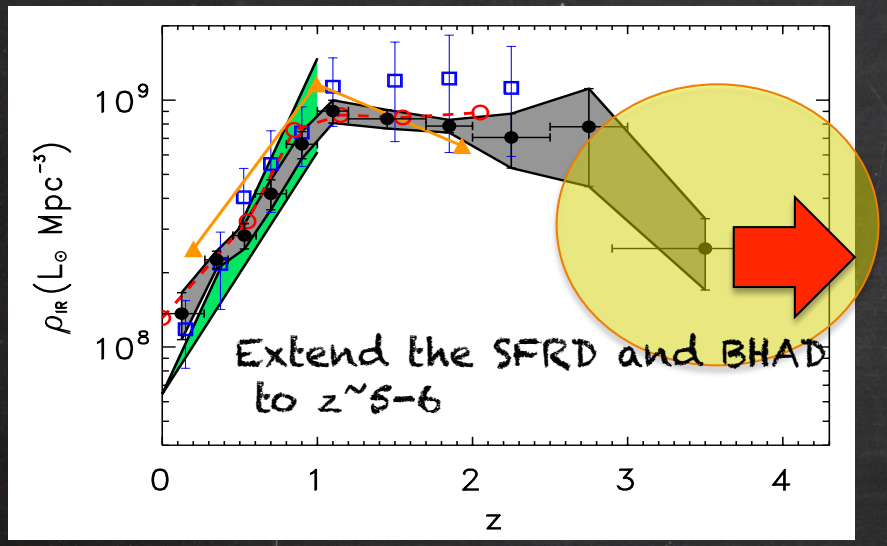
L~10^{12} (ULIRGs) @z~6



from Herschel to SAFARI

1) Go to higher-z's (>3-4)

2) Disentangle AGN/starburst up to z~4

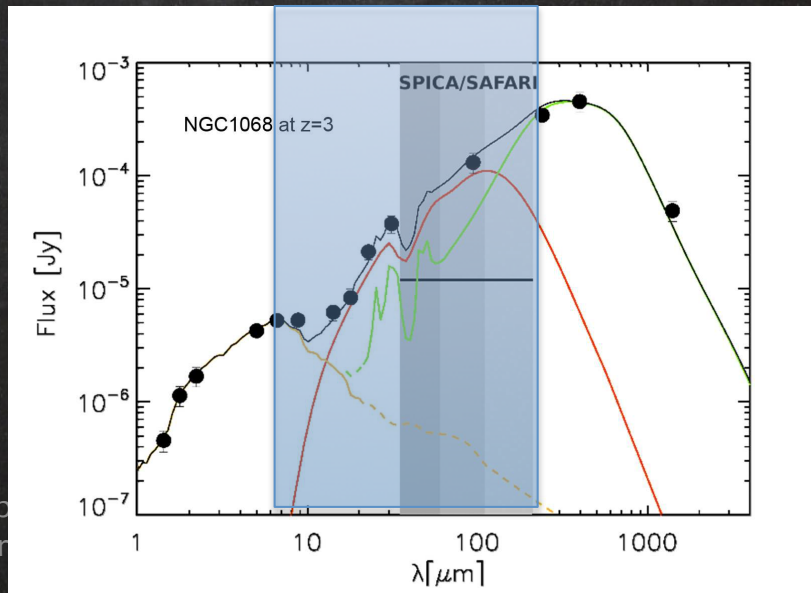


SPICA (MCS + SAFARI) Multi-Band

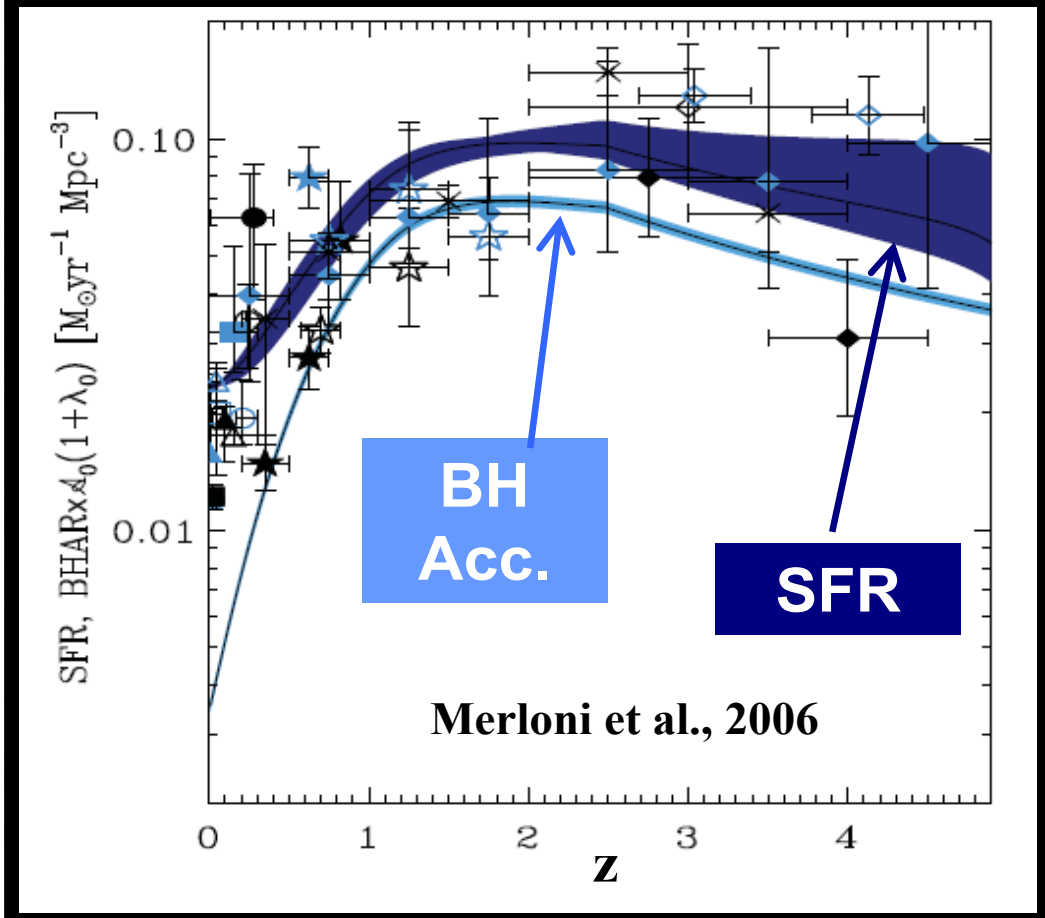
Detailed broad-band SED analysis to z~4-5

BUT :

SAFARI spectroscopy up to z~3



Co-eval Growth of Black Holes and Host galaxies



- Dust-enshrouded AGN accretion phase undergone by all galaxies?
- Need to compare evolution of BH mass function with galaxy mass and luminosity functions in large samples
- Must include heavily obscured AGN
- Both peak at z = 2 – 3, when most SF was in LIRGs – current data very limited
- Key AGN signature: high-excitation fine structure lines
  e.g., [NeV] 14.3 μm
  [OIV] 26 μm
- Line widths indicative of BH mass

Comparing different wavelengths for separating AGN and SF

No single criteria distinguish AGN & SF ➔ limits and potentialities of different techniques

– UV/Optical/NIR observations ➔ galaxy morphology and spectra,
BUT they seriously suffer from dust obscuration

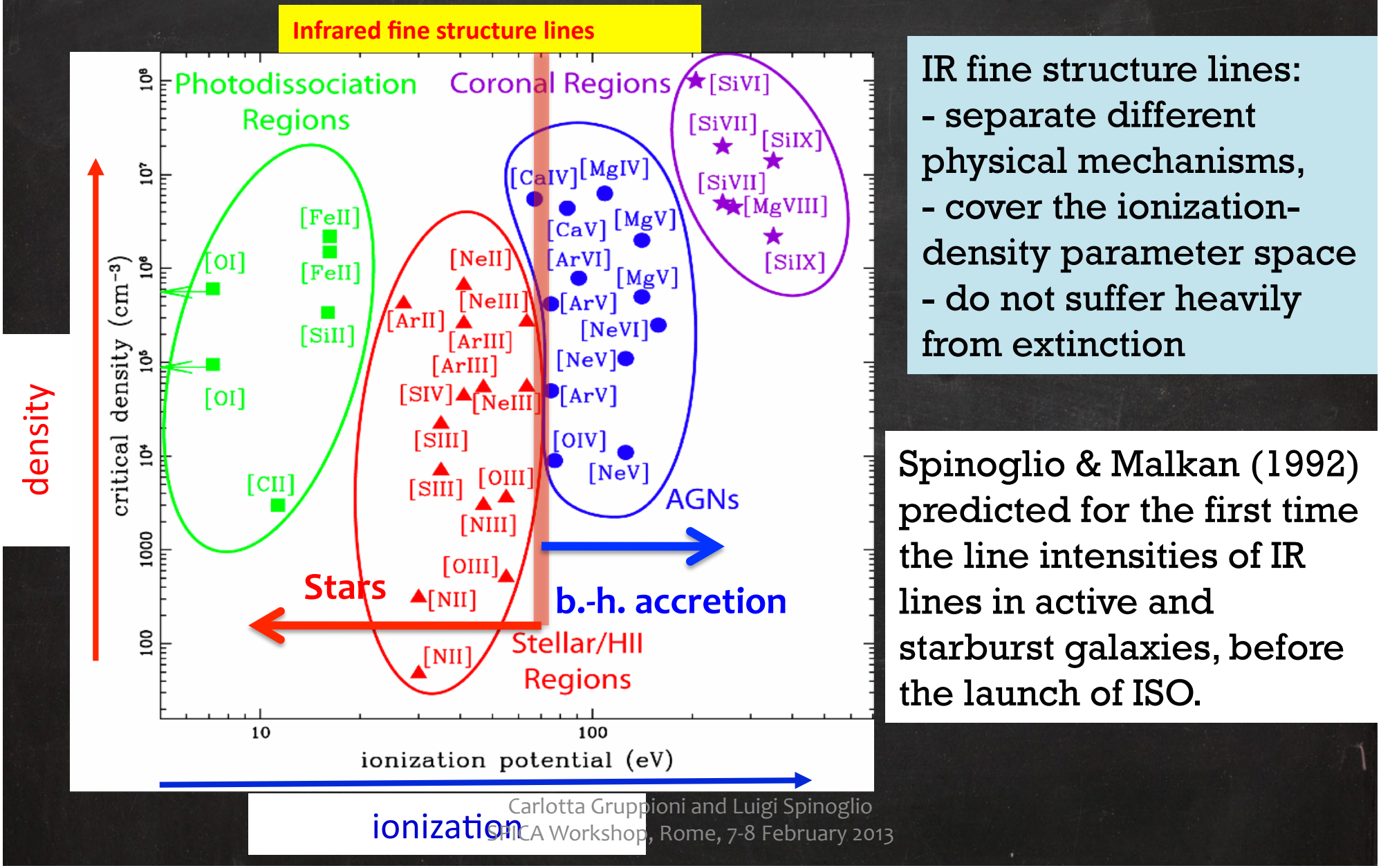
– X-ray observations ➔ good tracers of AGN,
BUT only weak X-ray emission can be detected from star formation
BUT heavily-obscured AGN (Compton-thick) completely lost.

– Radio observations (EVLA, SKA) ➔ can detect AGN and SF to large z and can see through gas and dust, ➔measure morphology and spectral SED, detect polarization and variability, BUT not always redshifts can be measured. (at its highest frequencies SKA will measure redshifted molecular lines in the ISM of galaxies).

– mm/submm observations (e.g. ALMA, CCAT) ➔ spectra from SF (redshifted CO, CII, etc.), BUT need to find AGN tracers. One candidate is CO: SLED different from PDR (SF) and XDR (AGNs).

Rest-frame MIR/FIR imaging spectroscopy ➔ complete view of galaxy evolution and the role of BH and SF because it can (provided that large field of view and high sensitivity can be reached)
➔ trace simultaneously both SF and AGN,
➔ measure redshifts
➔ see through large amounts of dust.
➔ the most promising technique.

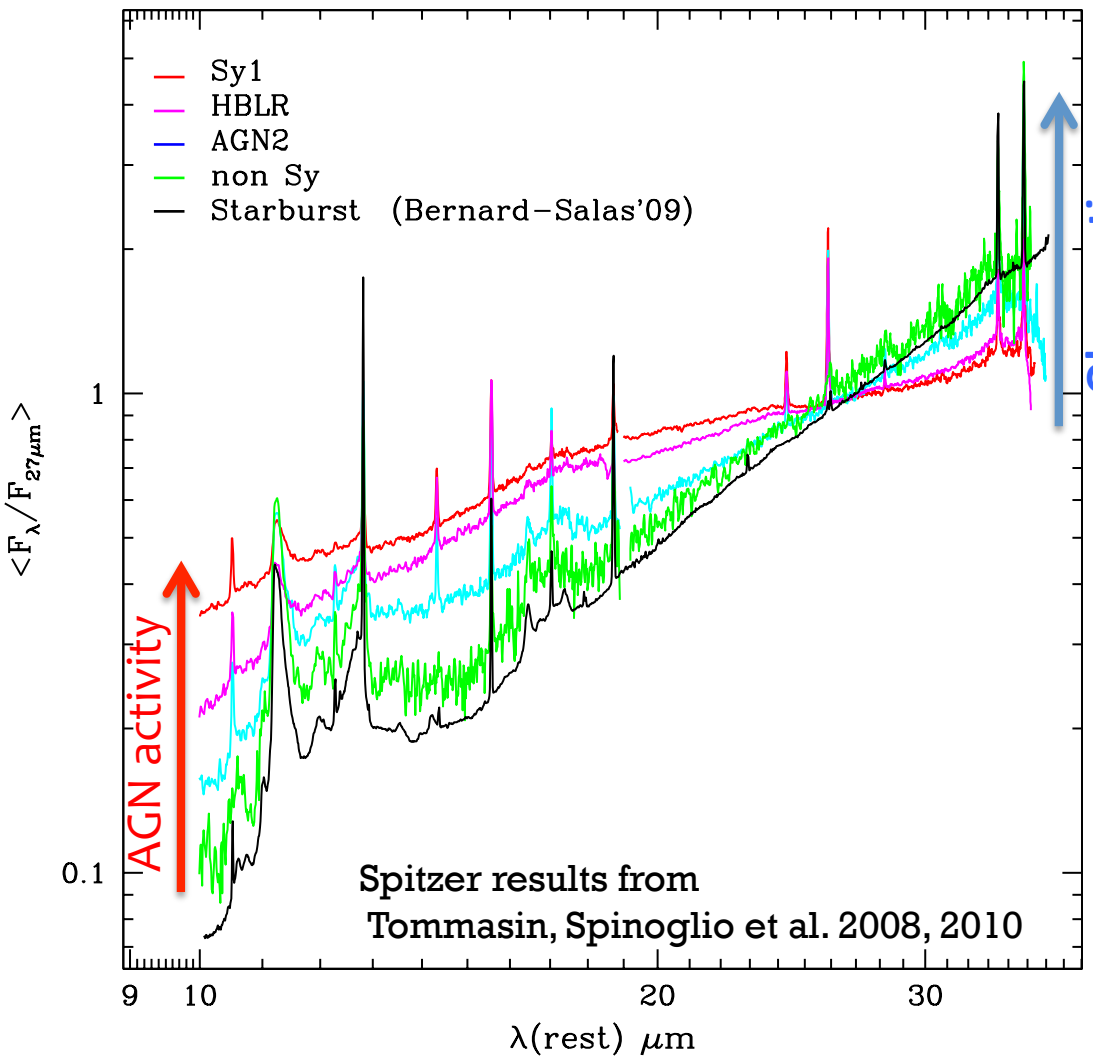
Why infrared spectroscopy is the best tool to isolate star formation and accretion?

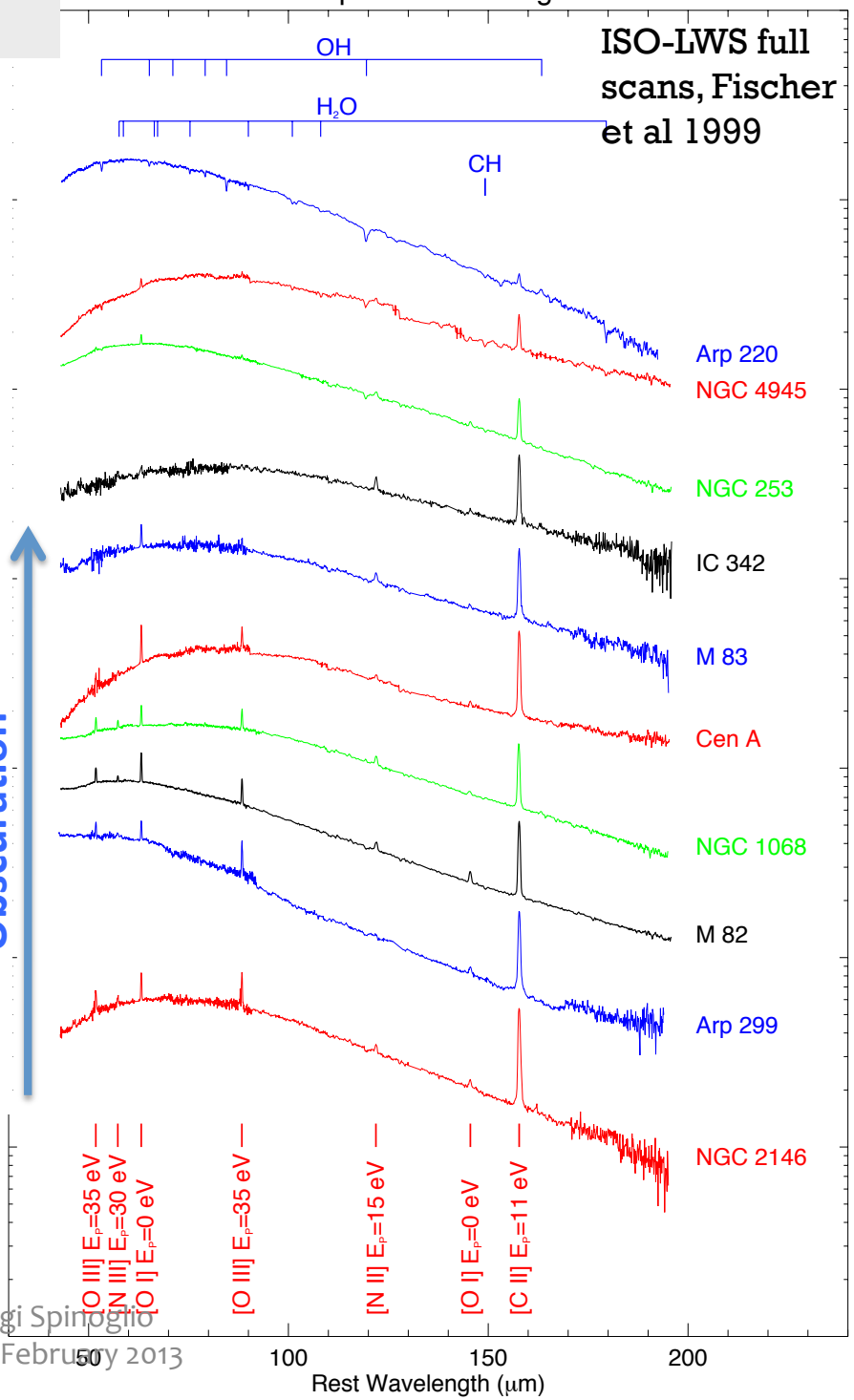


IR fine structure lines:
- separate different physical mechanisms,
- cover the ionization-density parameter space
- do not suffer heavily from extinction

Spinoglio & Malkan (1992) predicted for the first time the line intensities of IR lines in active and starburst galaxies, before the launch of ISO.

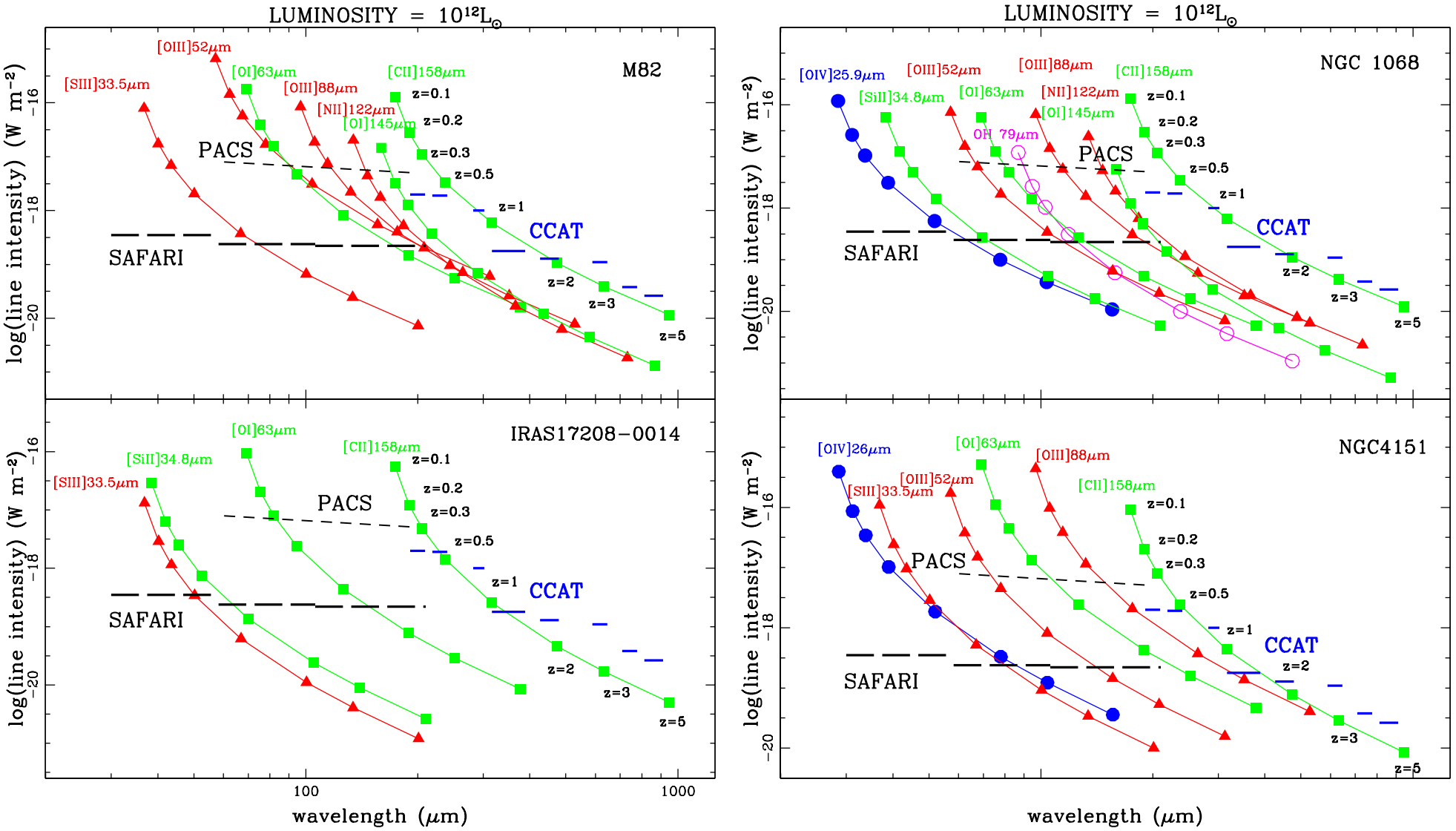
MIR & FIR spectroscopy complementary



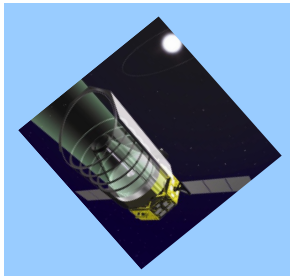


Links between **OBSCURATION**, **ACCRETION ACTIVITY** and **STAR FORMATION** in galaxies must be determined to understand **GALAXY EVOLUTION**

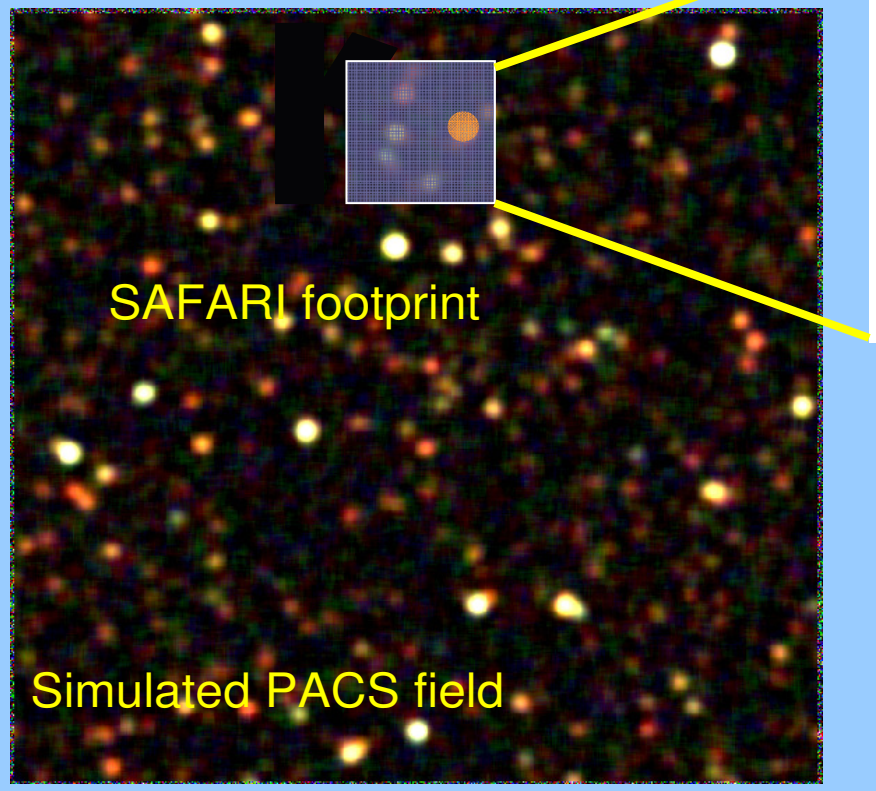
Four local templates: at what redshift can SPICA-SAFARI & CCAT detect their lines ?



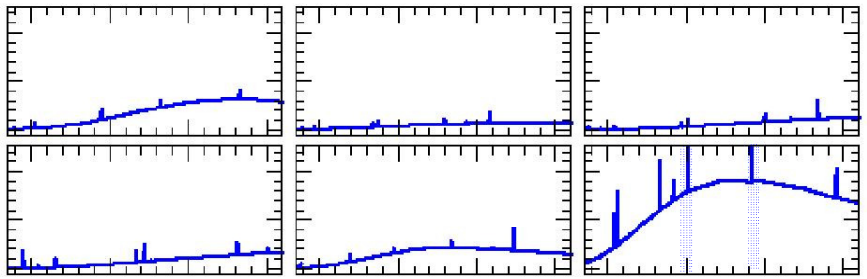
Sensitivities are given as 5σ, 1 hour



Understanding the formation and evolution of galaxies (3D surveys)



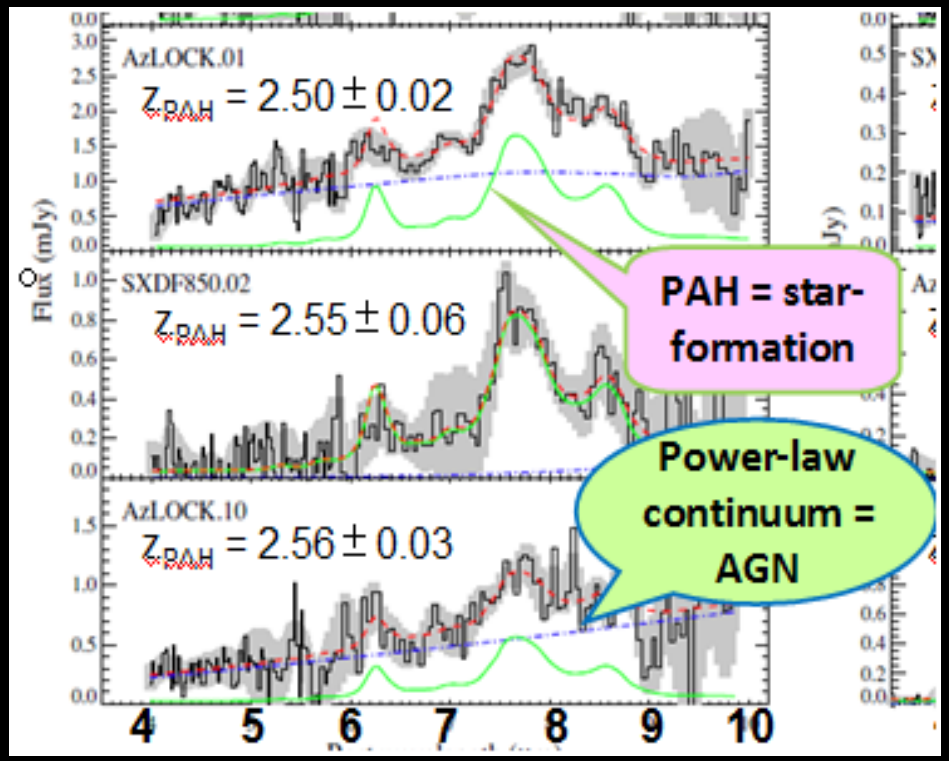
11 ‘

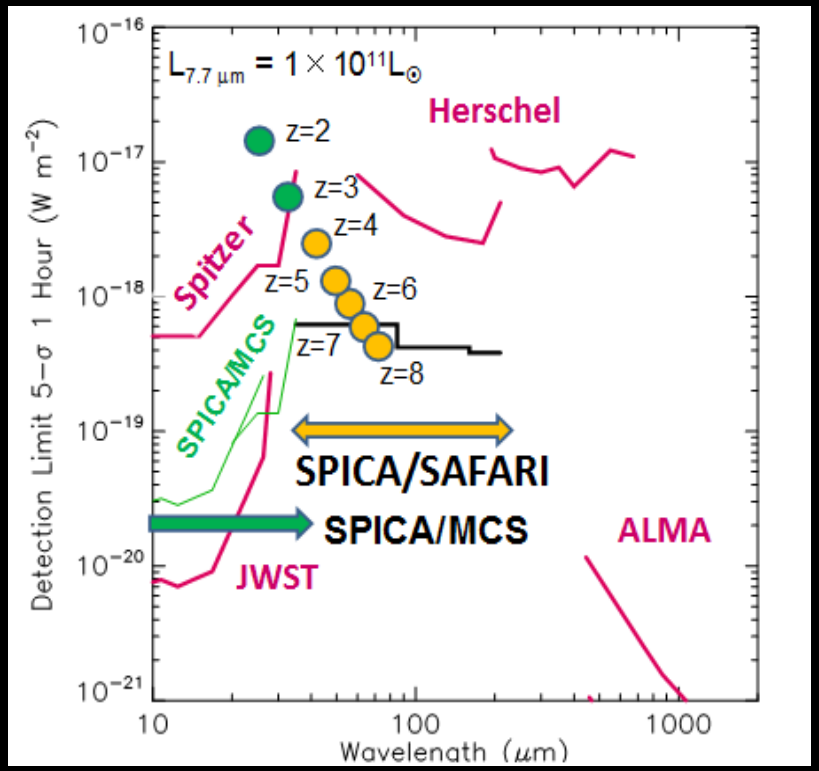


- Enormous multiplexing advantage:
  - Sensitivity
  - Bandwidth
  - Field of view
- Multiple sources + multiple lines

7-10 spectra per FOV !!!

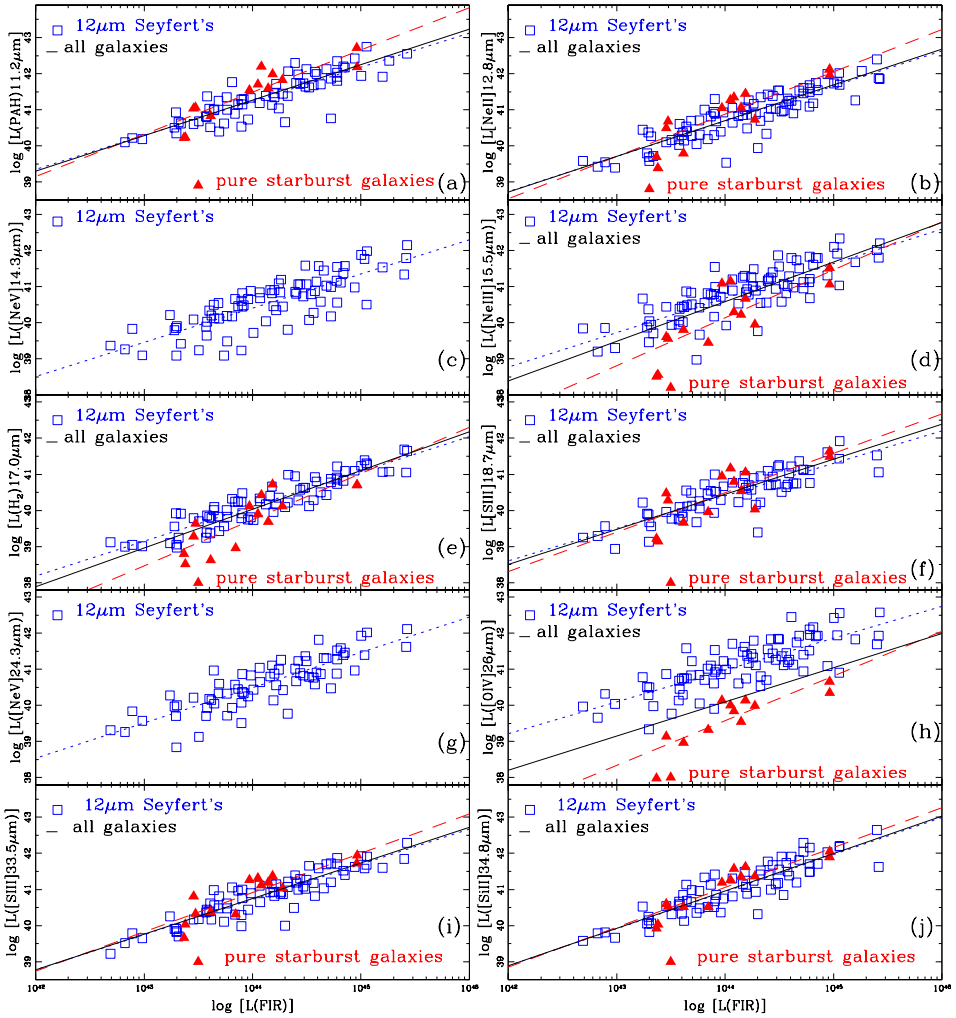
Redshifted PAH Emission

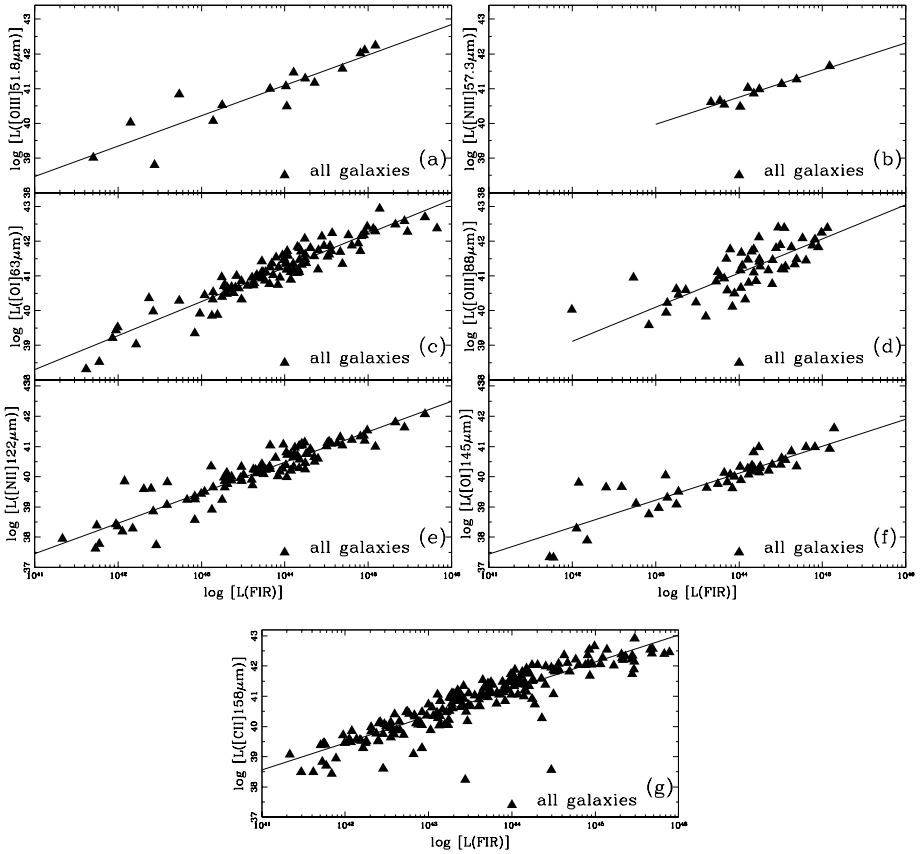




- Unbiased, spectroscopic survey of dusty extreme starburst population
- Evolution of luminosity function and AGN contribution
- Transition phase from starbursts to quasars

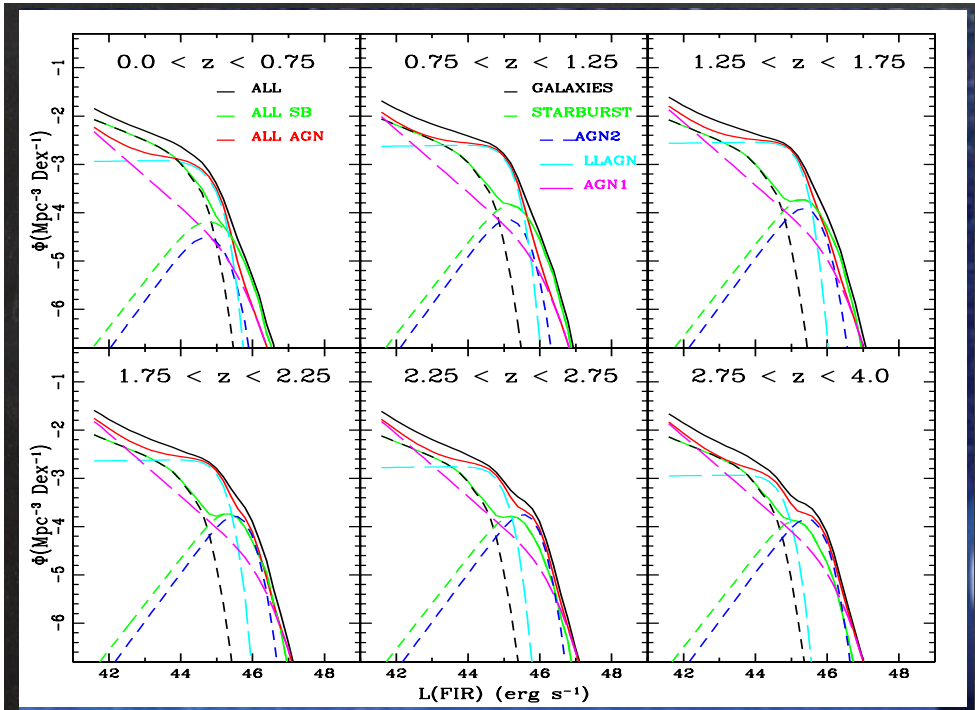
FIND CORRELATIONS BETWEEN LINE AND CONTINUUM LUMINOSITY IN THE LOCAL UNIVERSE



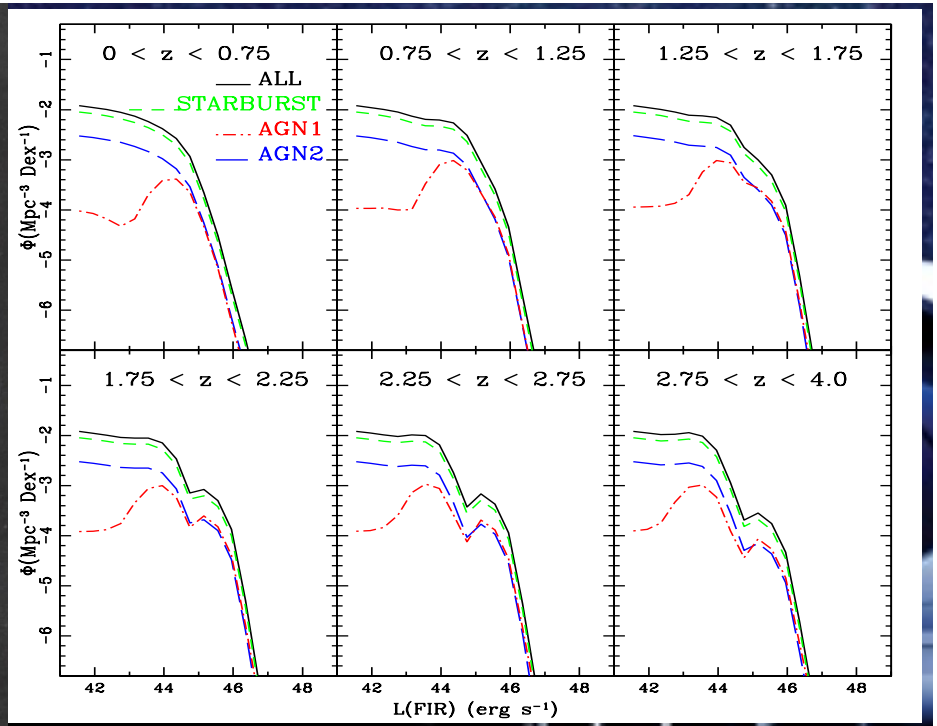


Least-squares fit to data

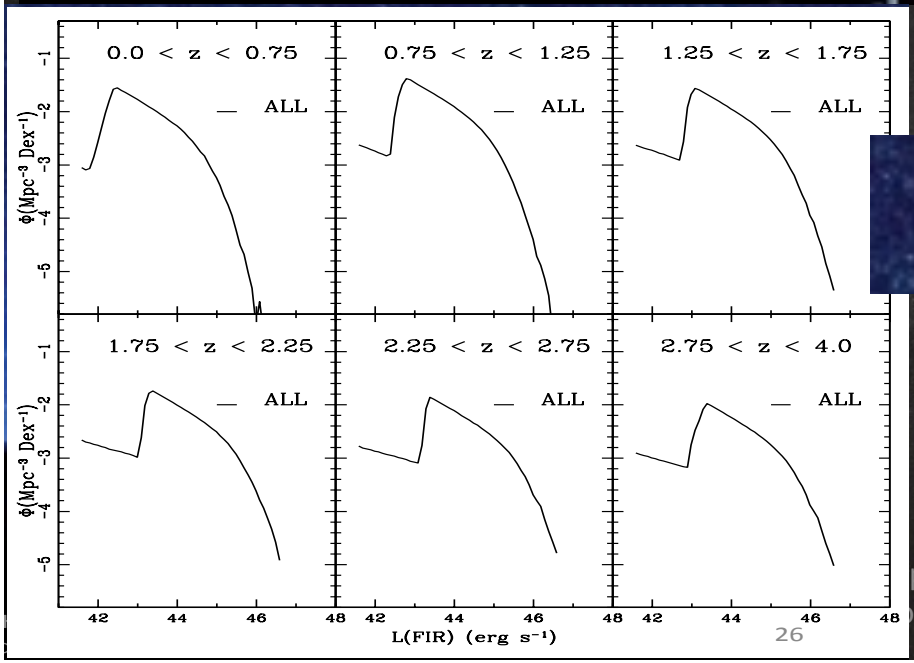
Spinoglio et al. 2012



Gruppioni et al (2011) model



Franceschini et al (2010) model

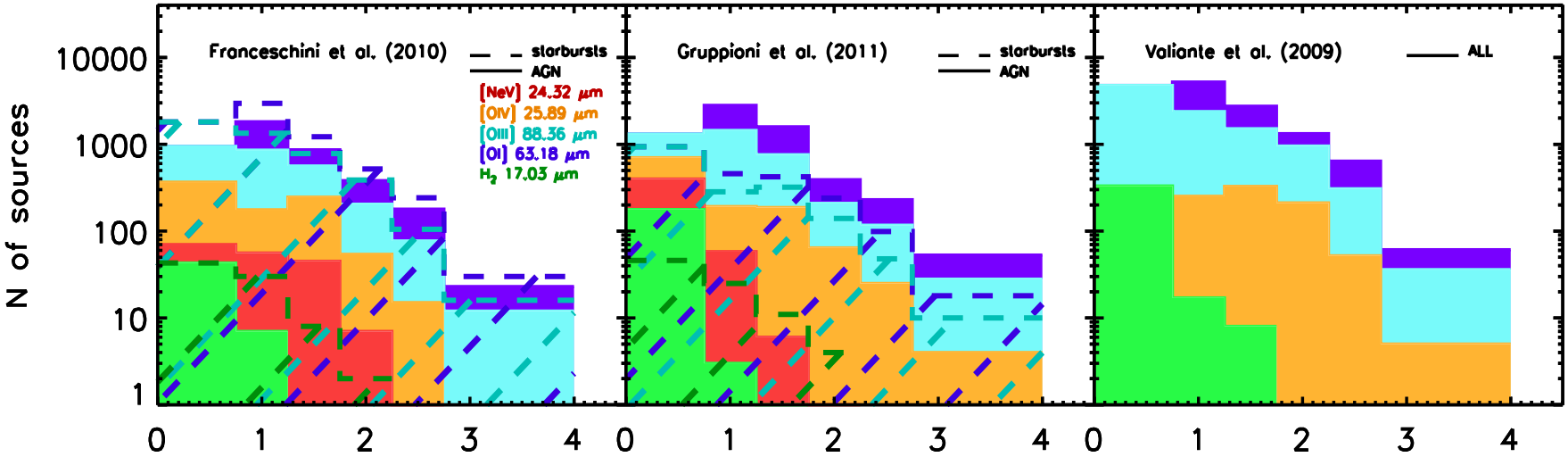


Valiante et al (2009) model

Spinoglio et al. 2012

➔ The total number of detectable objects agrees to within a factor of 2–3 for most lines and z ranges,

➔ ~ thousand galaxies will be simultaneously detected in 4 lines at 5σ over a half square degree. The bright lines (e.g., [O I] and [O III]) and PAH features will be detected in thousands of galaxies at z>1. Hundreds of z>1 AGN will be detected in the [O IV] line, and several tens of z>1 sources will be detected in [Ne V] and H_2.



Number of objects detected per spectral line in 1 hour integration/FoV 0.5 deg2 survey with SAFARI.

Spinoglio et al. 2012