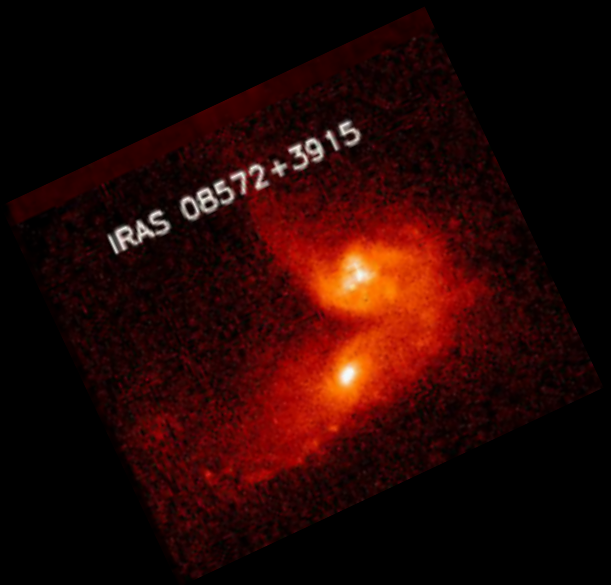
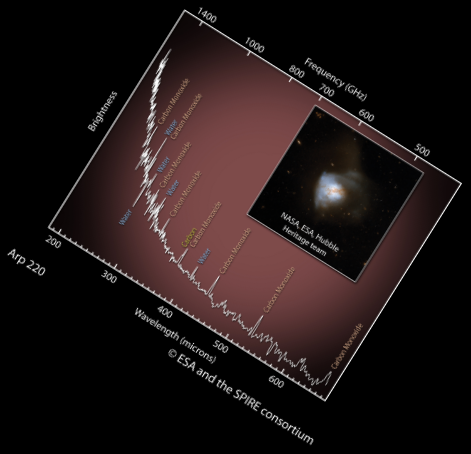
A Herschel Survey of FIR lines in ULIRGs near and far: Their nature and Evolution

Dimitra Rigopoulou
Oxford/RAL

G. Magdis, R. Hopwood, N. Thatte, A. Alonso-Herrero and the HerMES team



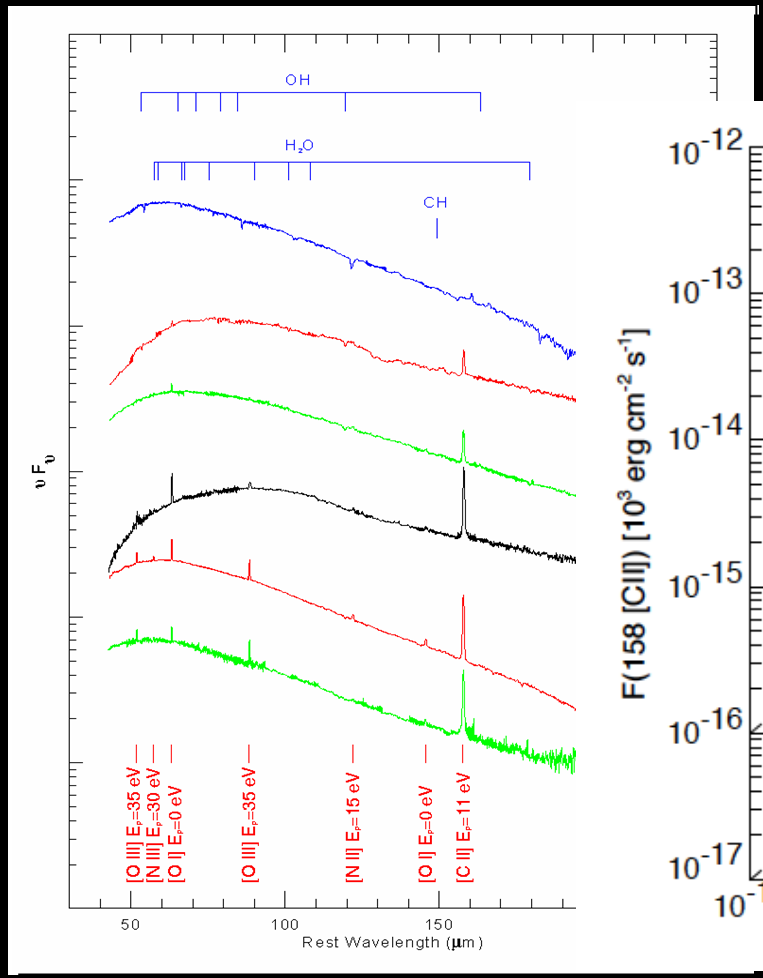


Local ULIRGs

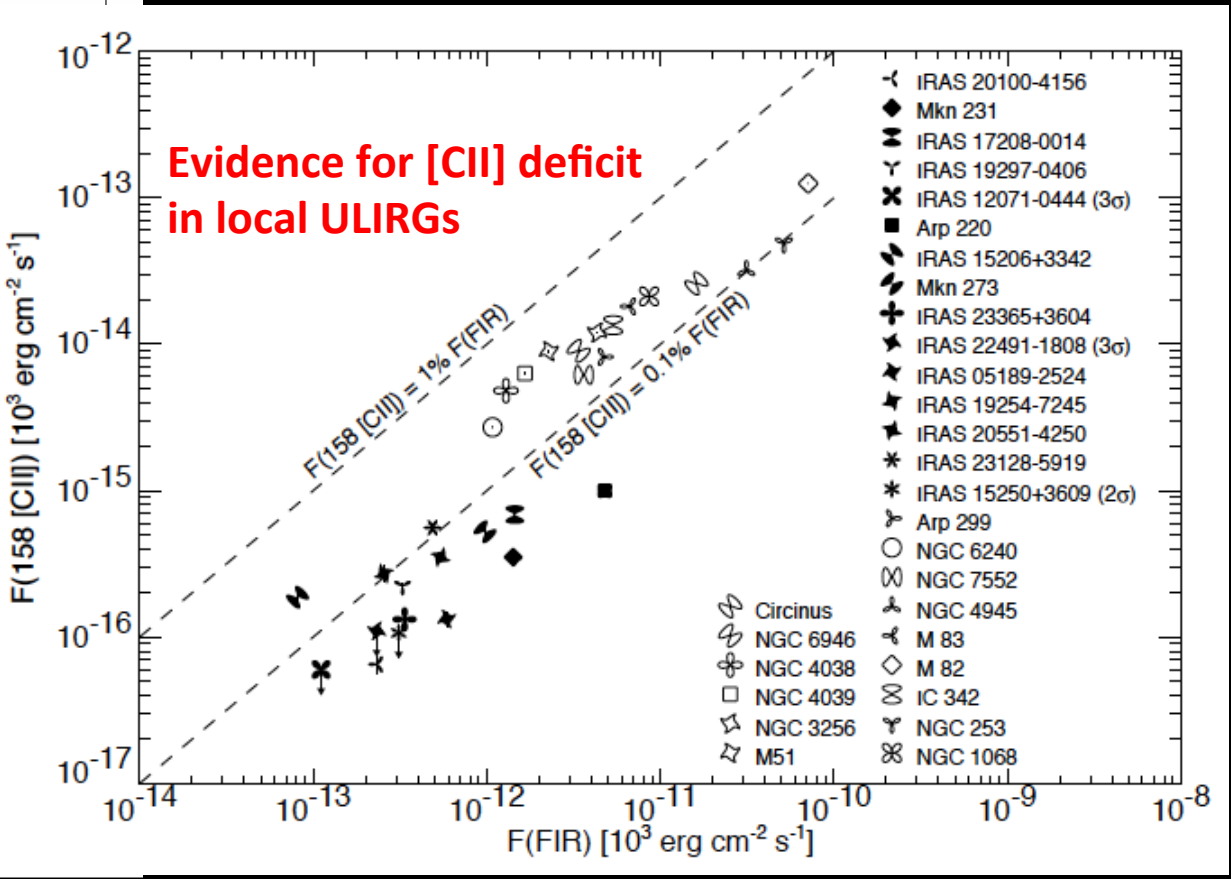
- Extremely rare
- Nearly always mergers
- Powered predominantly by star formation
- Half contain a detectable AGN
- Templates for high redshift ULIRGs

The facts:

ISO first hinted that local ULIRGs are [CII] deficient



Fischer et al. 1999



Malhotra et al, Brauher & Helou, Luhman et al.

The facts….

Herschel confirms that local ULIRGs are [CII] -deficient

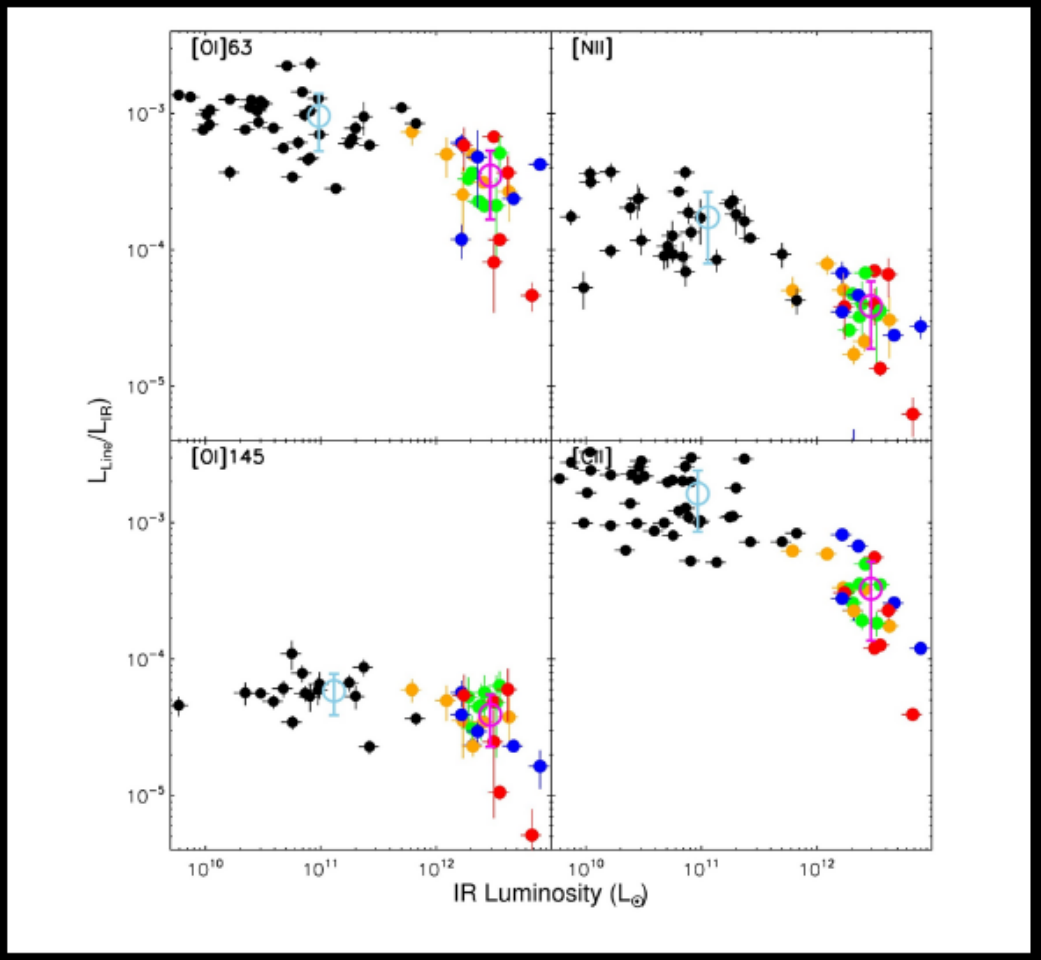
The HERUS survey (250 hours)
S_{60} > 1.7 Jy

- PACS spectroscopy of fine structure lines: [OII]52,[NIII]57, [OI]63,[NII]122,[OI]145,[CII]158

- SPIRE FTS spectroscopy

- SPIRE photometry of the full far-IR SED

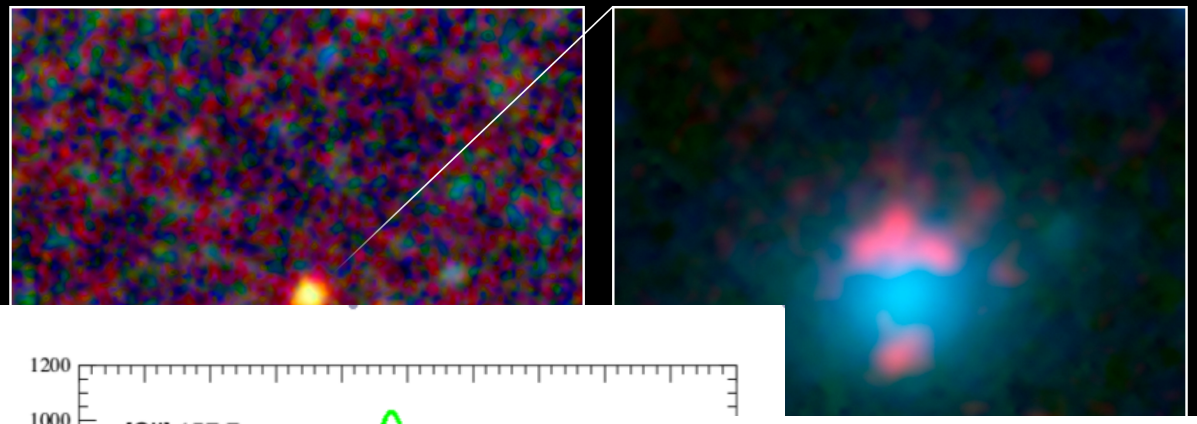
PI: D. Farrah,
co-PIs : H. Spoon, D. Rigopoulou



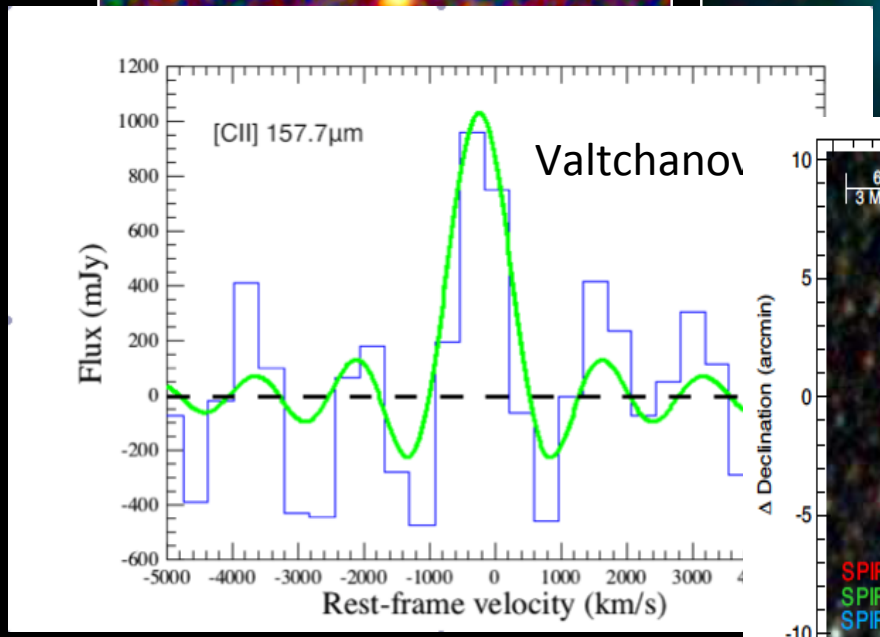
Farrah et al. 2013

But then came the HERSCHEL lenses but also other evidence from ground-based facilities….

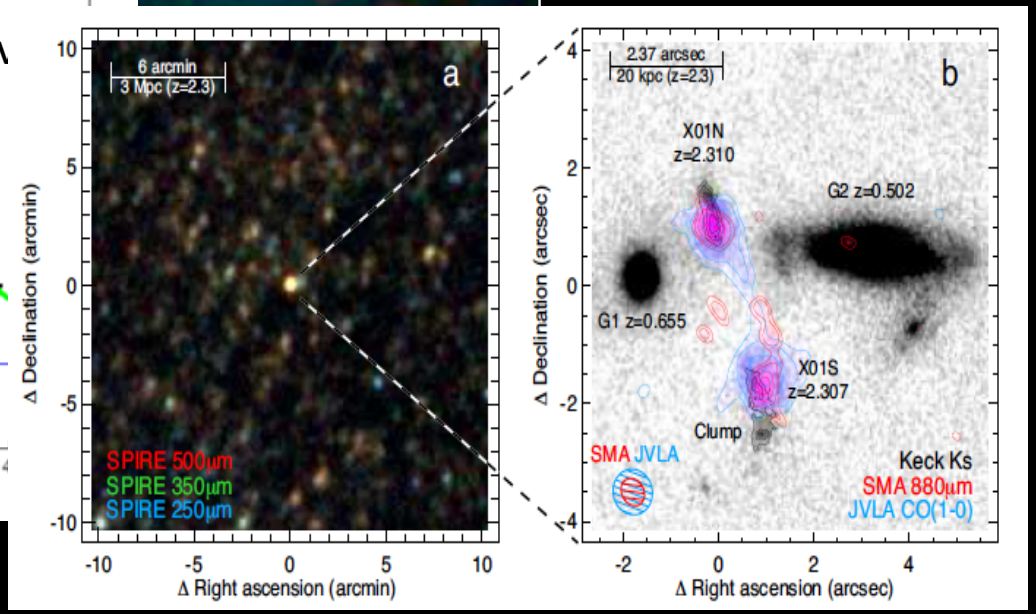
SDP 81



Negrello et al. 2010



Valtchanov



Fu et al. 2013, Nature

The questions:

- ✔ Why are local ULIRGs [CII] deficient and high-z luminous infrared galaxies not?
- ✔ When does a change in the ISM properties occur?
- ? Does metallicity play a role?

The HERSCHEL-FTS Survey of intermediate redshift ULIRGs

Sample : 23 objects
Selection criteria:

- S_{250} >150 mJy (appropriate for SPIRE-FTS spectroscopy)
- 0.23<z<0.8 ([CI],[CII],[OI] in the FTS bands)

Target selection: X-match of HerMES 250 micron catalogues with 24 micron priors

Targets have excellent ancillary multi-λ data available

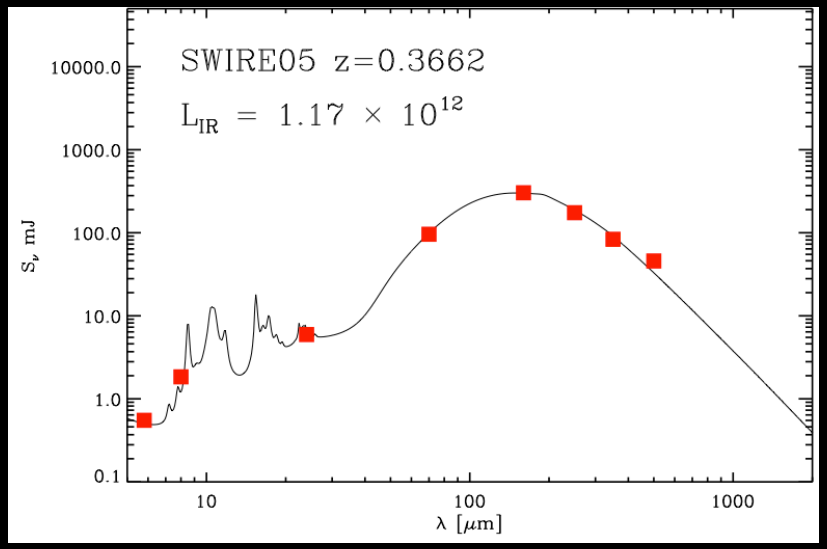
By construction the sample is dominated by ULIRGs

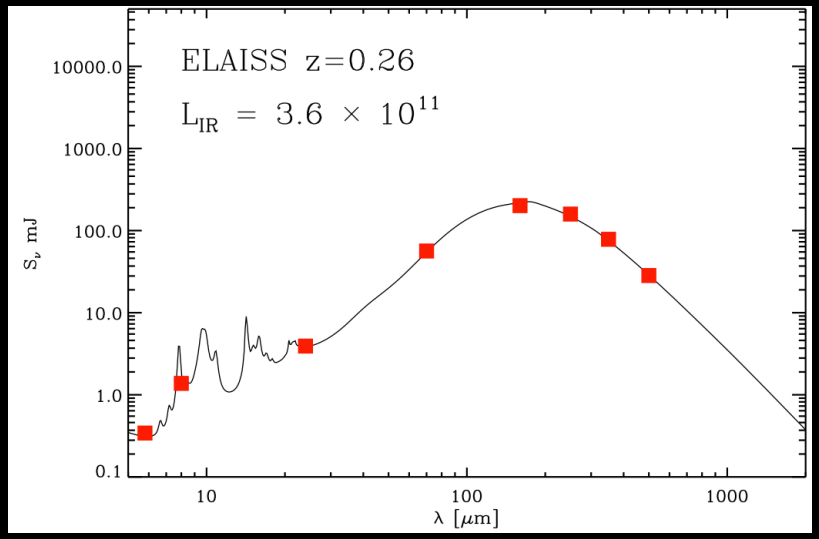
4hours/target (x100 reps) SPIRE-FTS

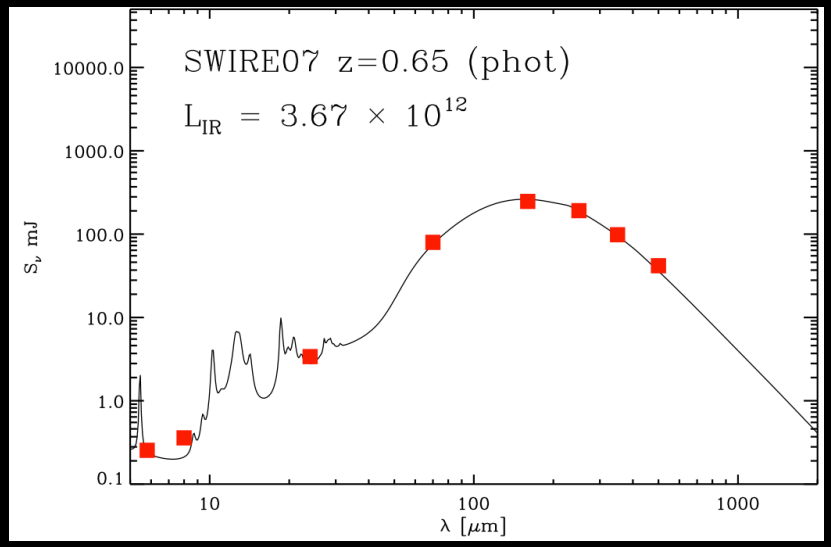
89 hours of FTS time
Program completed

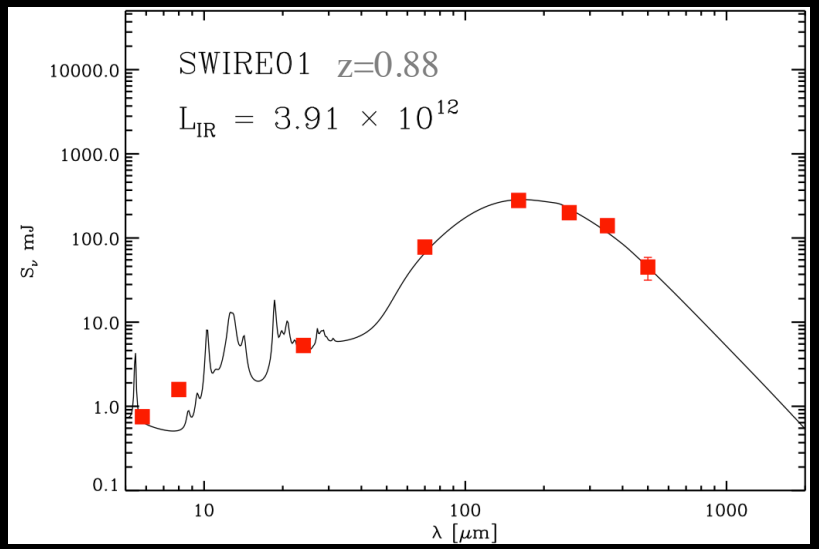
Data Analysis ,session A: P20

Spectral Energy Distributions of intermediate redshift ULIRGs



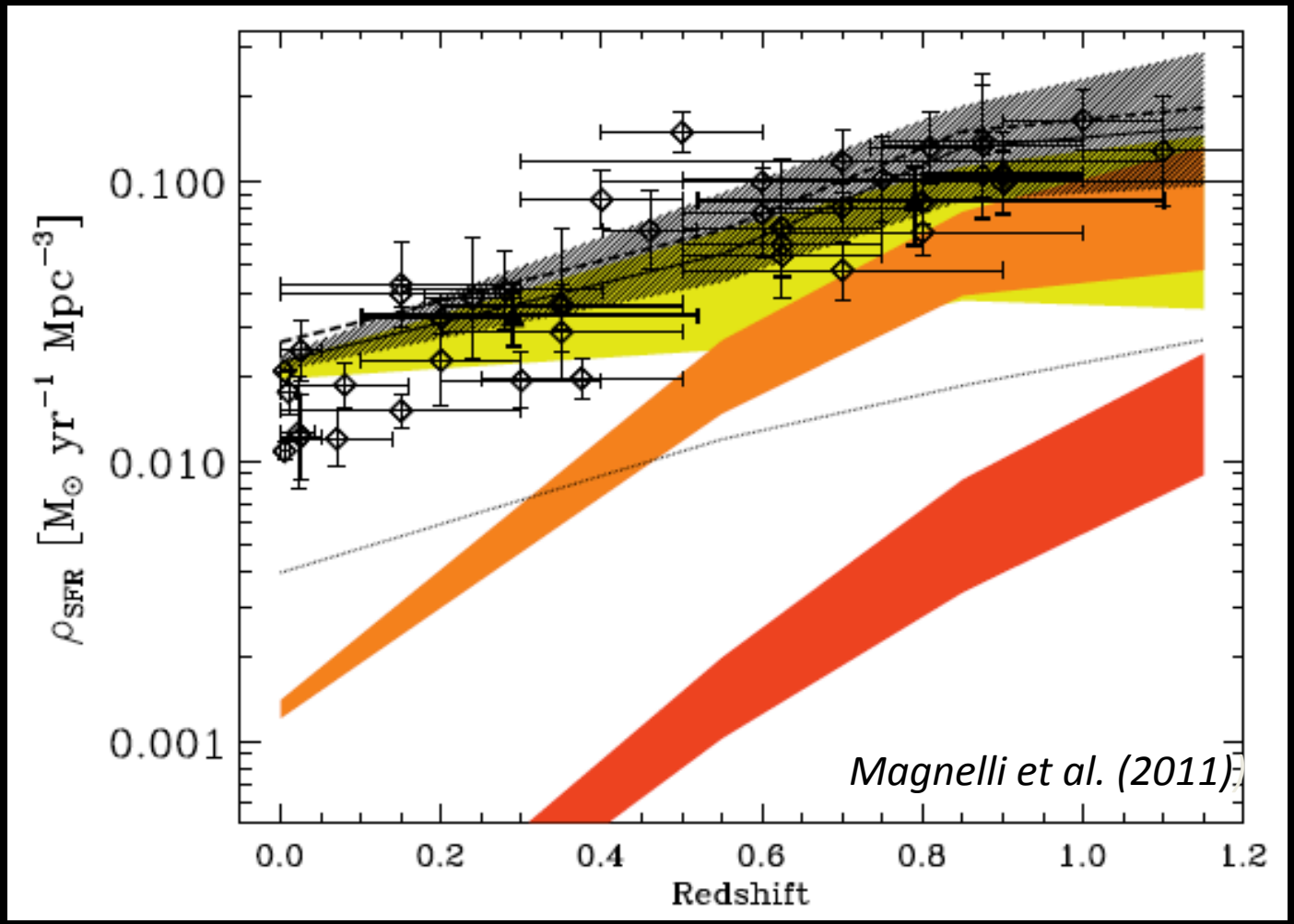




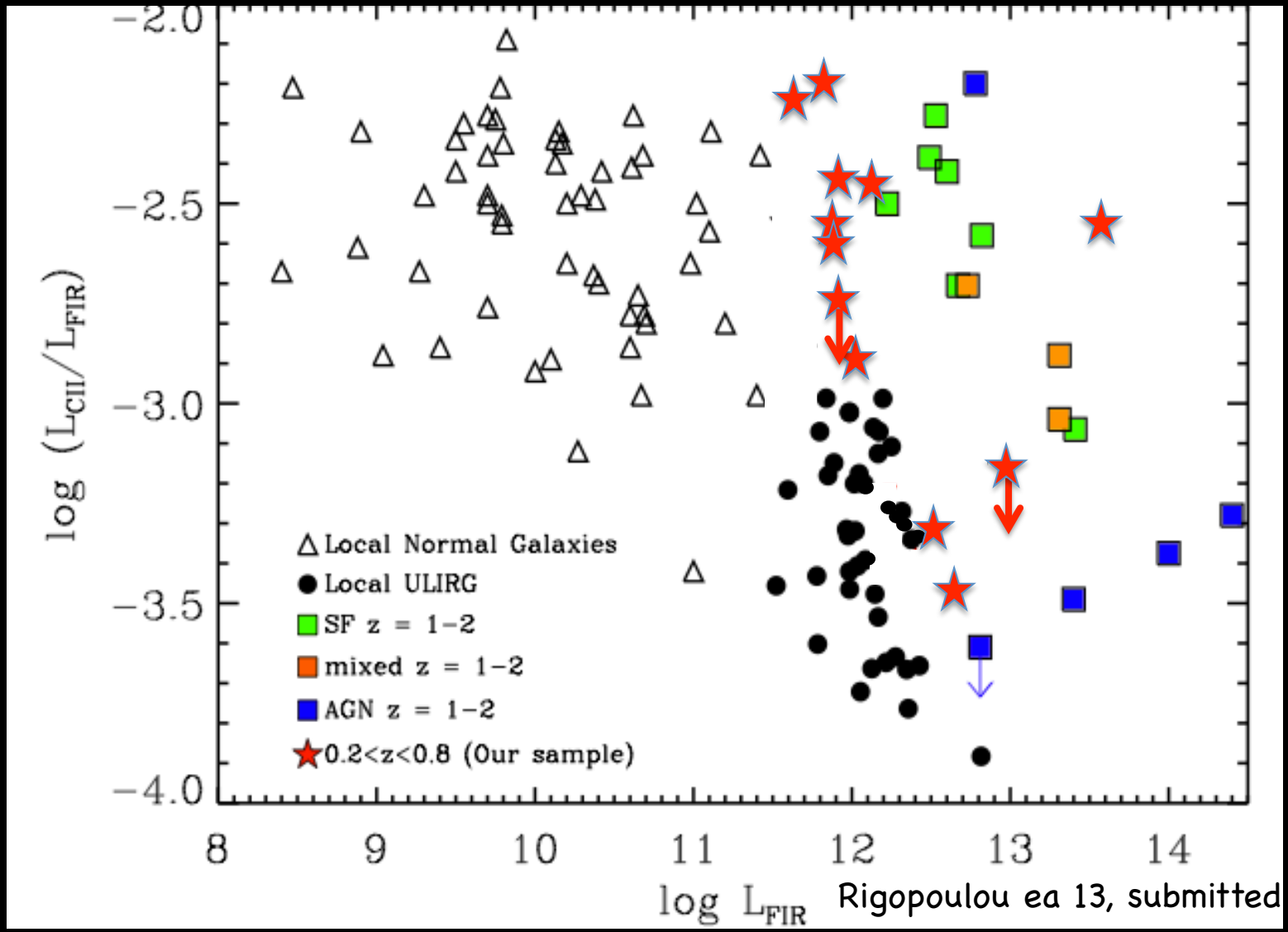


Magdis et al., in prep

Incidentally, our FTS sample probes an interesting phase in galaxy evolution…



The $L_{[CII]}/L_{FIR}$ plot



Rigopoulou ea 13, submitted

Malhotra et al., Stacey et al, Hailey-Dunsheath, Farrah et al. Diaz-Santos et al

What can we say about the properties of the ISM*?

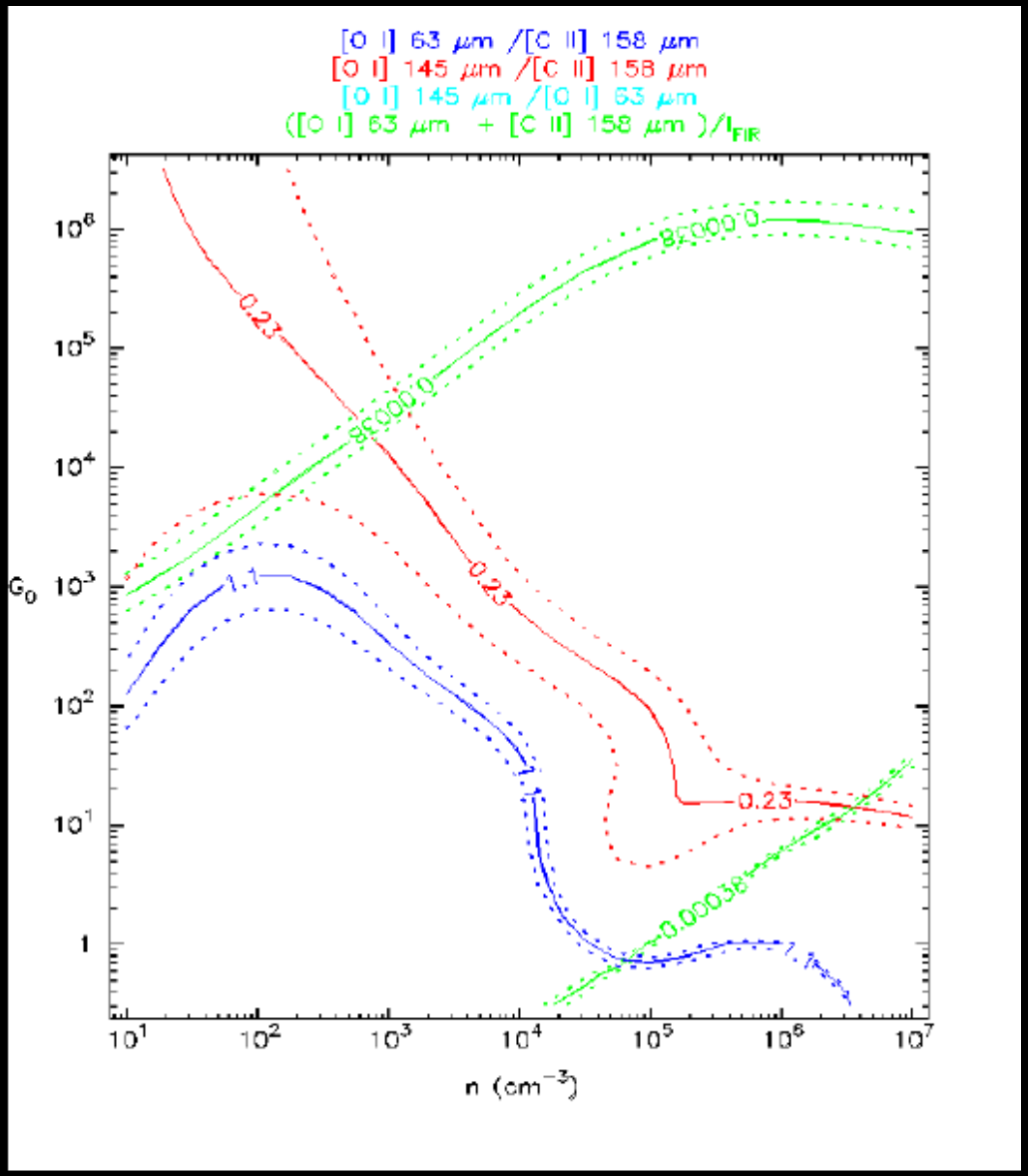
* by ISM I mean PDRs

Gas Conditions in local ULIRGs

Use multiple line ratios as inputs to simple PDR models to constrain gas conditions

PDRToolBox
http://dustem.astro.umd.edu/pdrt/

But HII regions in ULIRGs are likely dusty

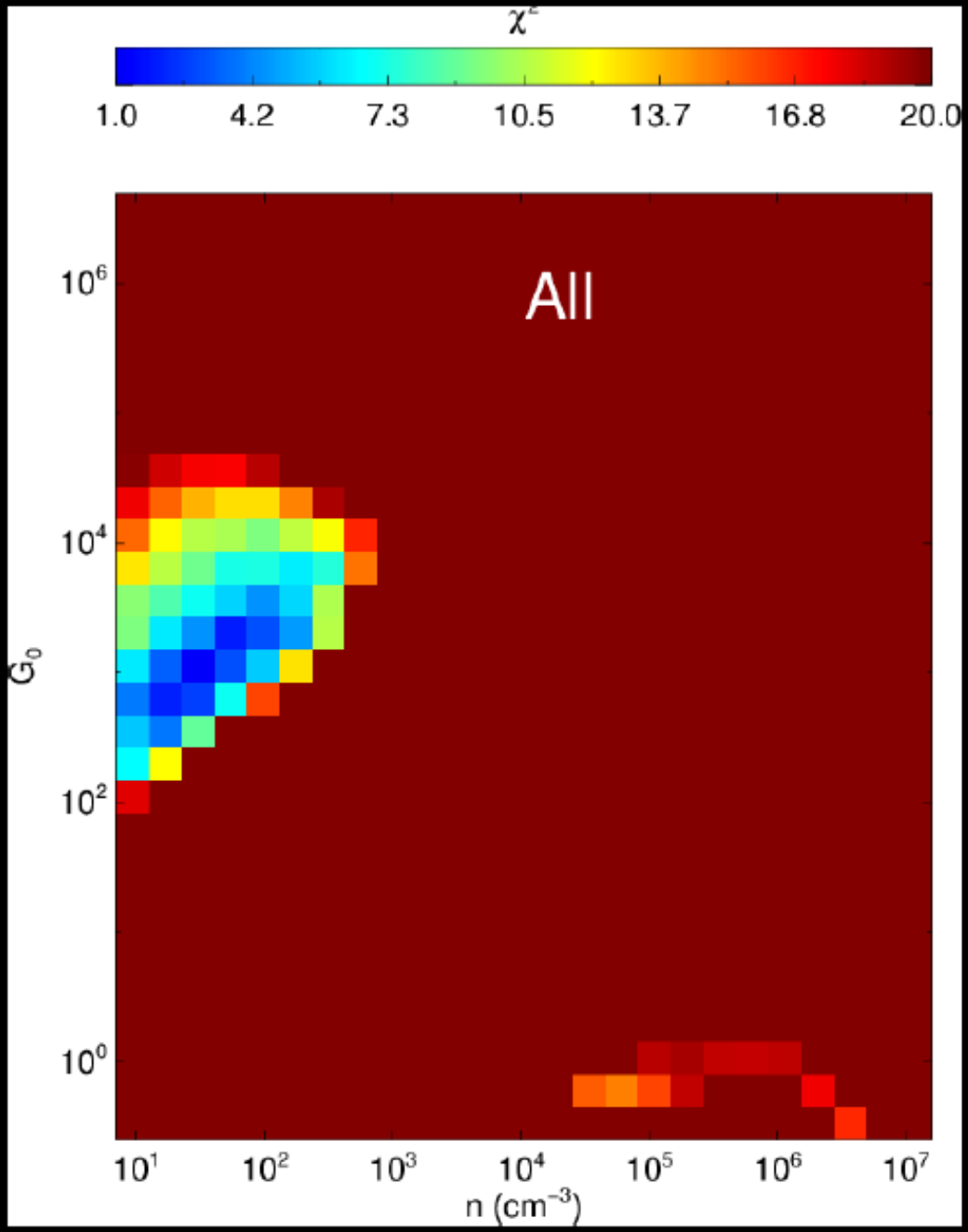


Gas conditions in local ULIRGs

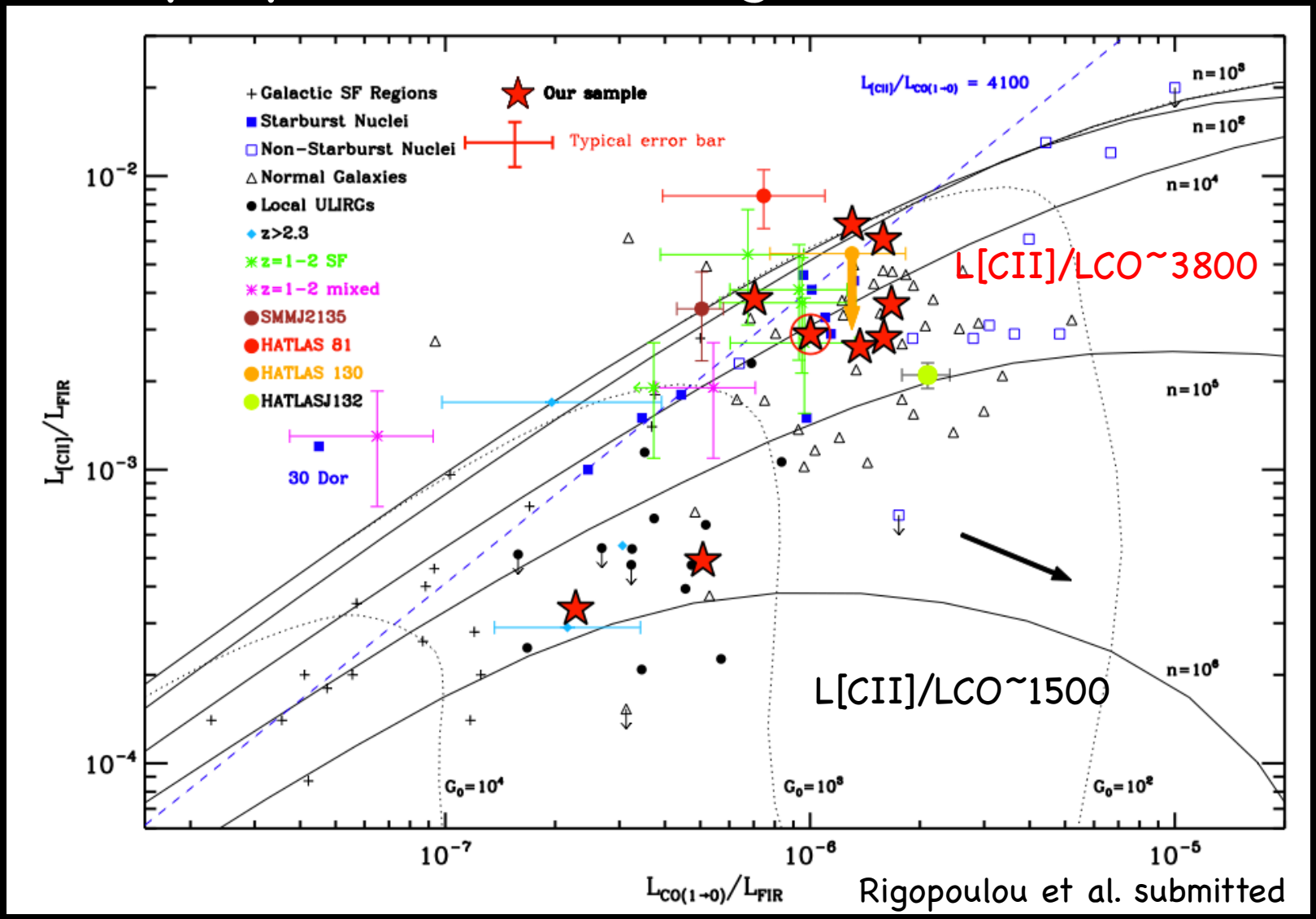
UV radiation flux
250 – 6400 ergs cm^{-2} s^{-1}
Electron density
10 – 500 cm^{-3}

Lower electron density and harsher than lower luminosity starbursts?

Farrah et al. 2013



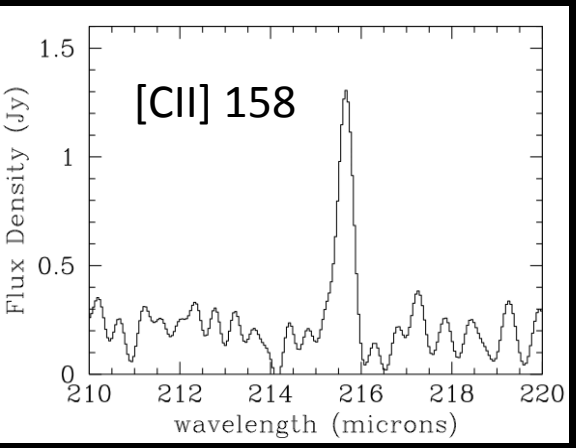
The properties of the gas…

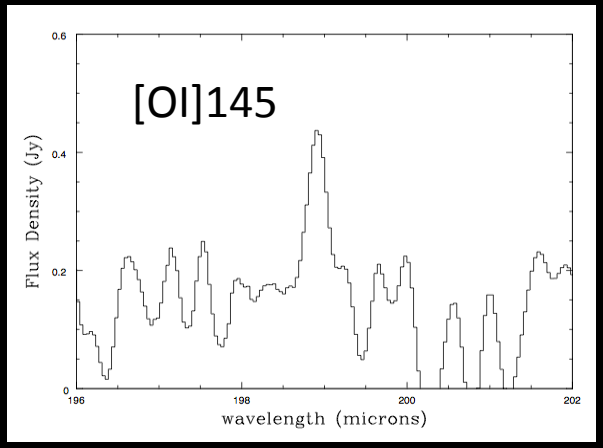


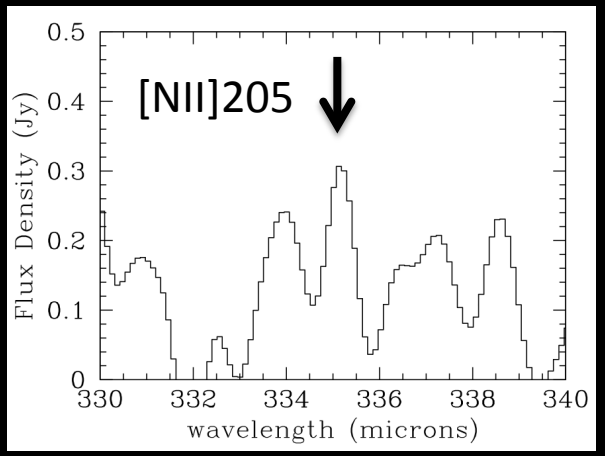
Malhotra et al., Stacey et al., Ivison et al., Valtchanov et al., George et al.

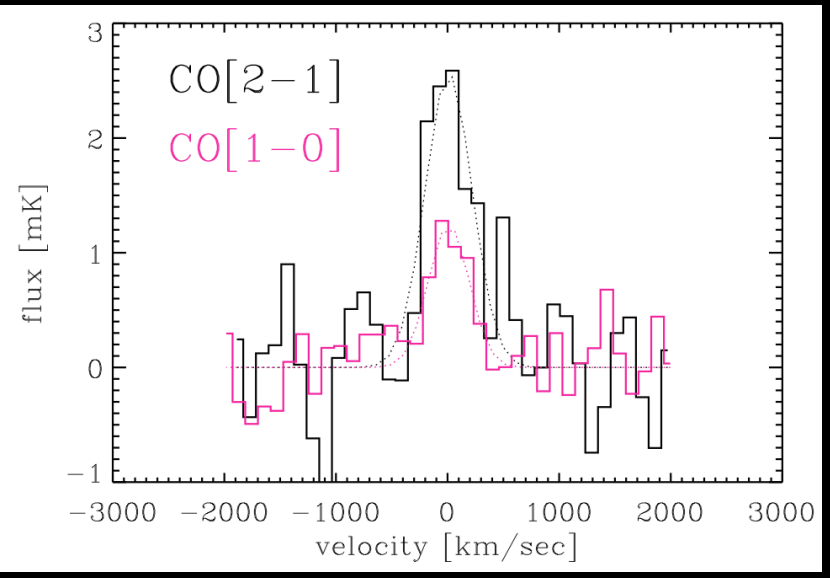
… so it seems that 0.2<z<0.8 ULIRGs have different ISM properties when compared to local ULIRGs…

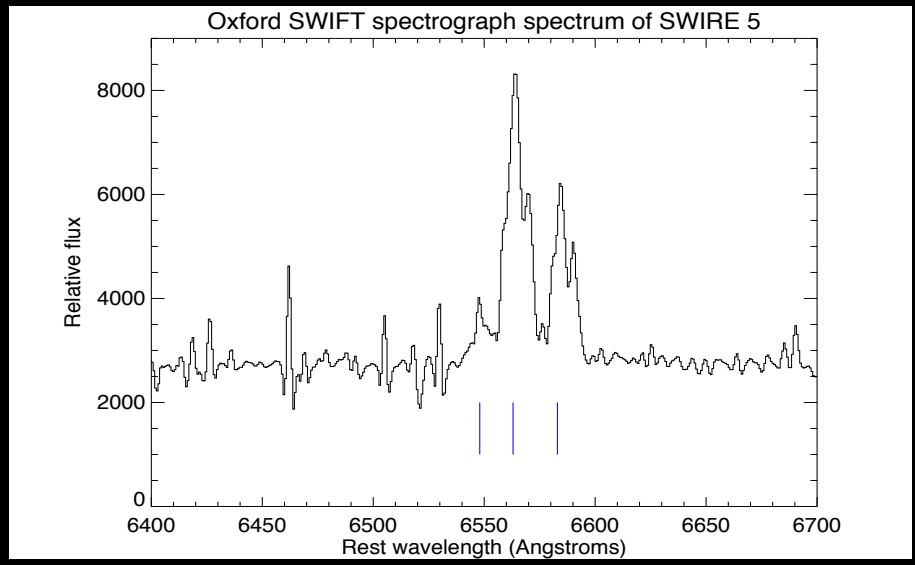
A case study : SWIRE5







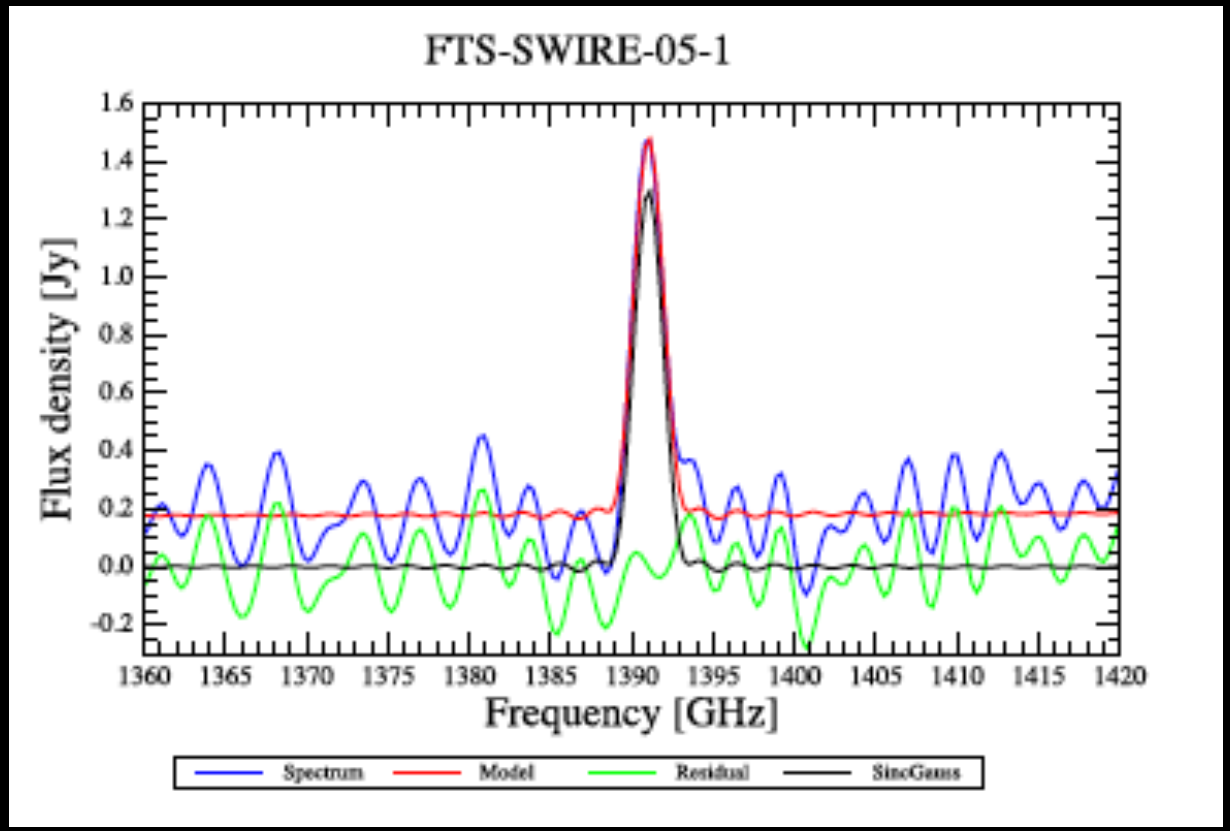




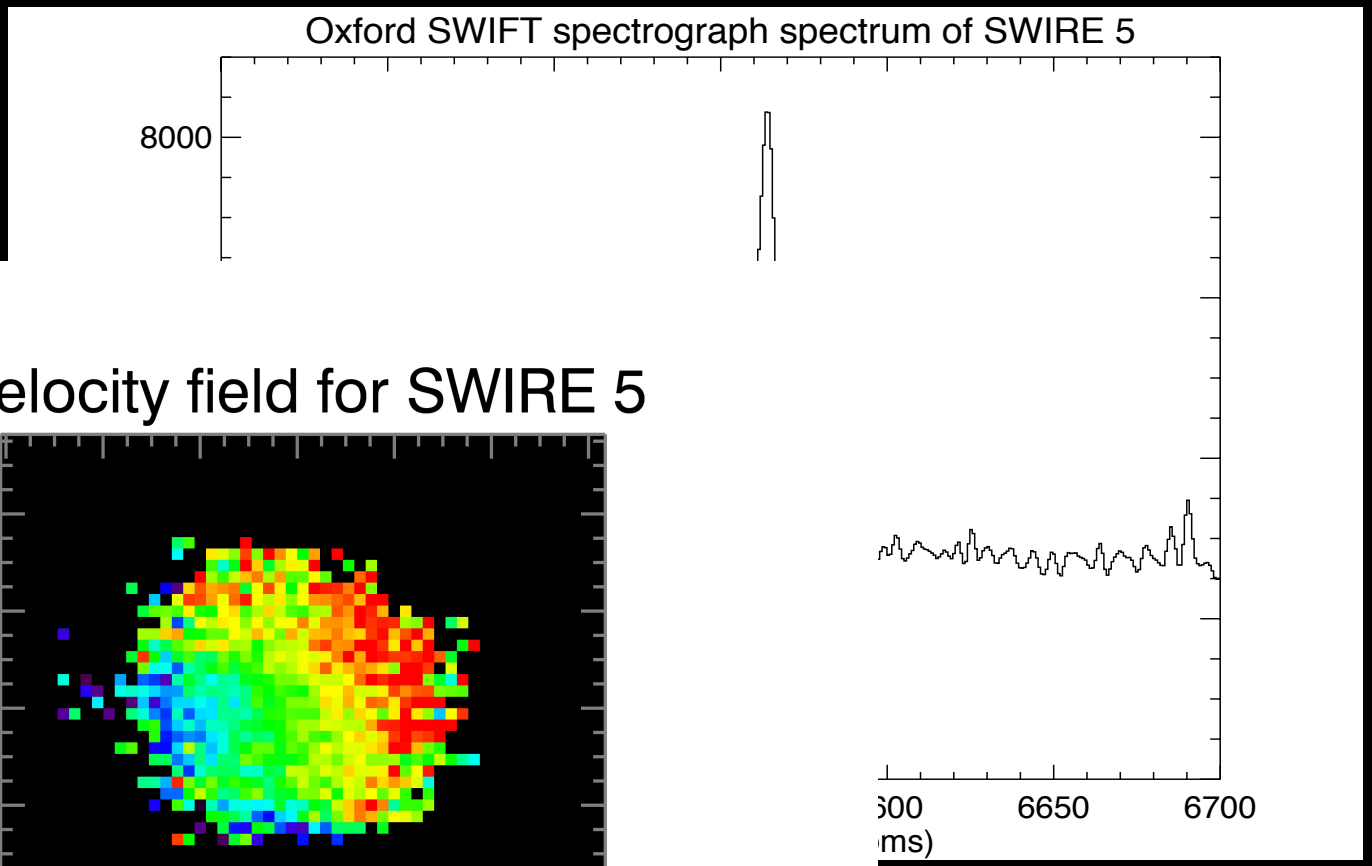
IRAM 30m

Oxford-SWIFT IFU @ Palomar

A signature of `extended' [CII] emission



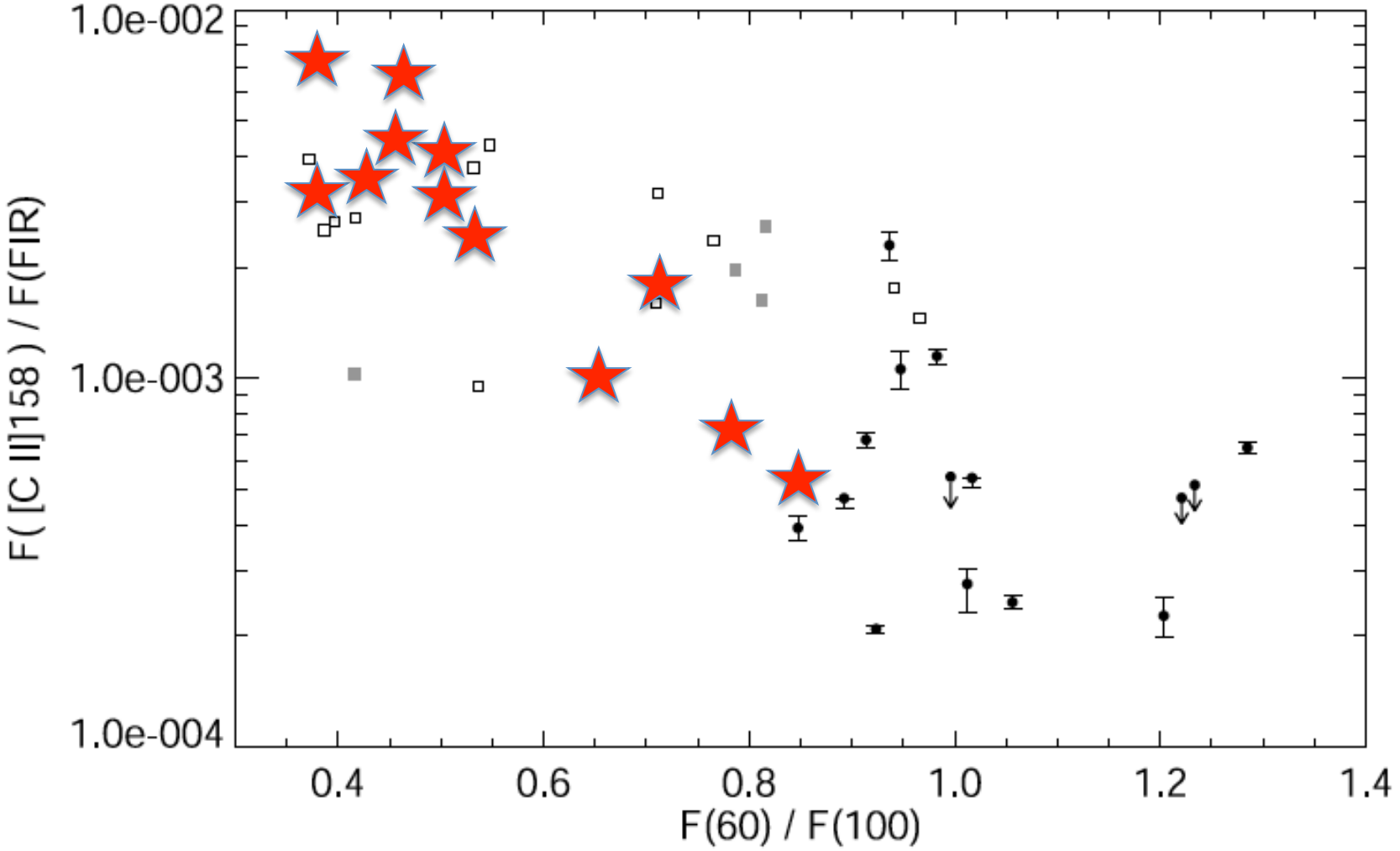
Take a closer look at the Ha spatially resolved emission



Houghton et al. in prep

end-to-end velocity: 250 km/sec

Are the intermediate-z ULIRGs colder?



Luhman et al. 2003

Our conclusions….

Intermediate redshift ULIRGs are not [CII] deficient

Intermediate redshift ULIRGs are not mergers

Rapid evolution in the properties of ISM (PDRs) takes place in the last 5 billion years

With thanks to

The Herschel Instrument Teams
The HSC
The Project Scientist
The SOC of the meeting