SPICA and ALMA: going into the physics of galaxy/AGN

Pozzi Francesca

Dipartimento di Fisica e Astronomia

Bologna University

Collaborators:

C. Gruppioni, C. Vignali, L. Vallini, L. Spinoglio, E. Hatziminaoglou, M. Talia

Outline

1) IR lines: Statistical study on the local Seyfert galaxies sample using *Herschel+ Spitzer data*

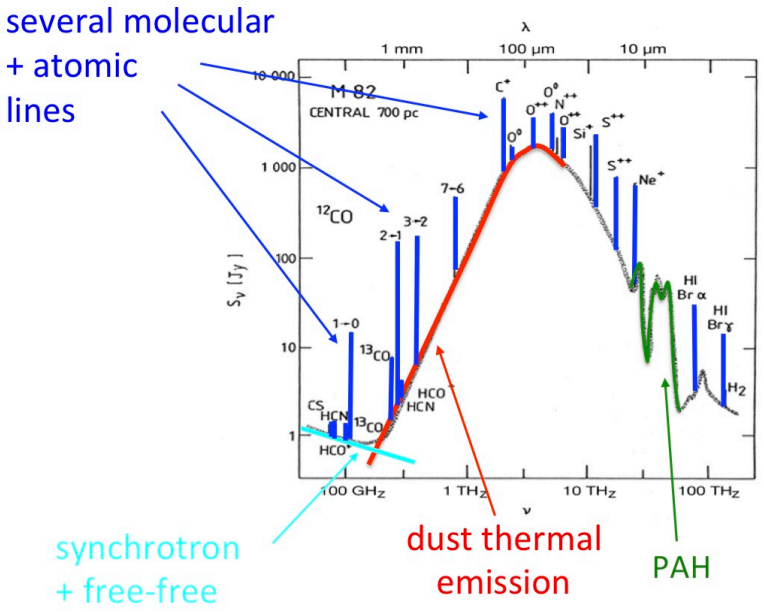
2) On the physics of a selected Compton-thick source using *ALMA+ Herschel*

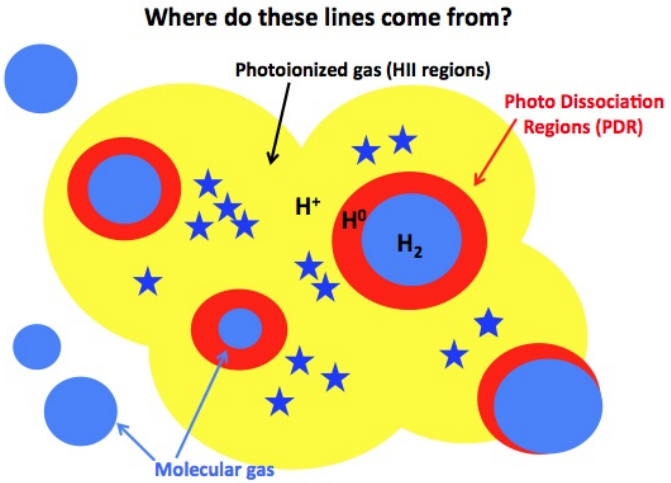
3) Extension to high-z using *ALMA & SPICA*

The FIR-mm spectral region:

1) Plenty of strong atomic and molecular lines
2) Tracing all phases of the ISM in galaxies
3) Essentially unaffected by dust extinction

FIR-mm spectrum of a star forming galaxy





Critical parameters regulating the physics:

➔ Radiation field strength (G_0)
➔ Gas density (n)

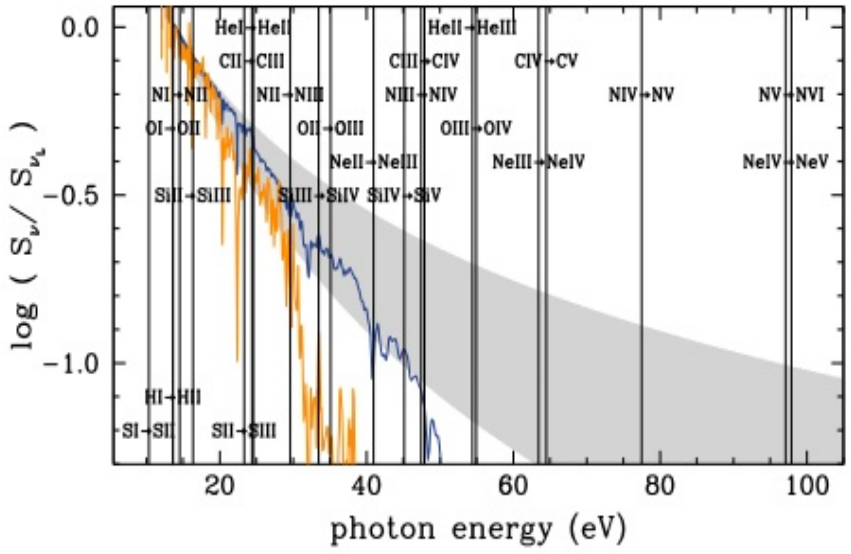
Courtesy of Maiolino

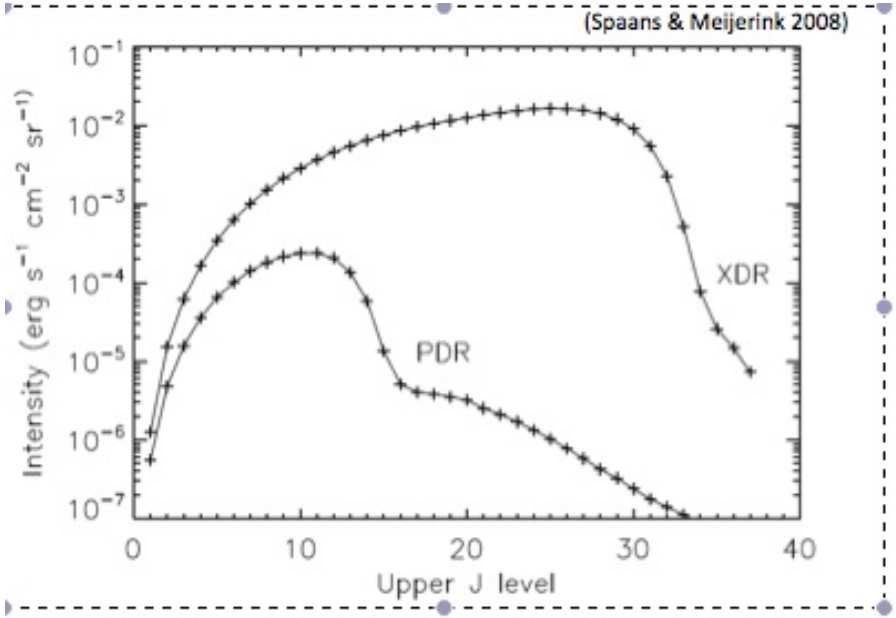
Active Galactic Nuclei: What's their effect?

X-ray photons (more energetic) penetrate deep into the cloud → creating X-ray Dominated Regions (XDR).

X-ray photons:
Excite lines with high potential
(i.e. NeV)

X-ray photons
excite high-J CO lines





Feltre et al. 2015

12-micron Seyfert sample

~100 local 12 μm Seyfert galaxies (Rush et al. 1993)

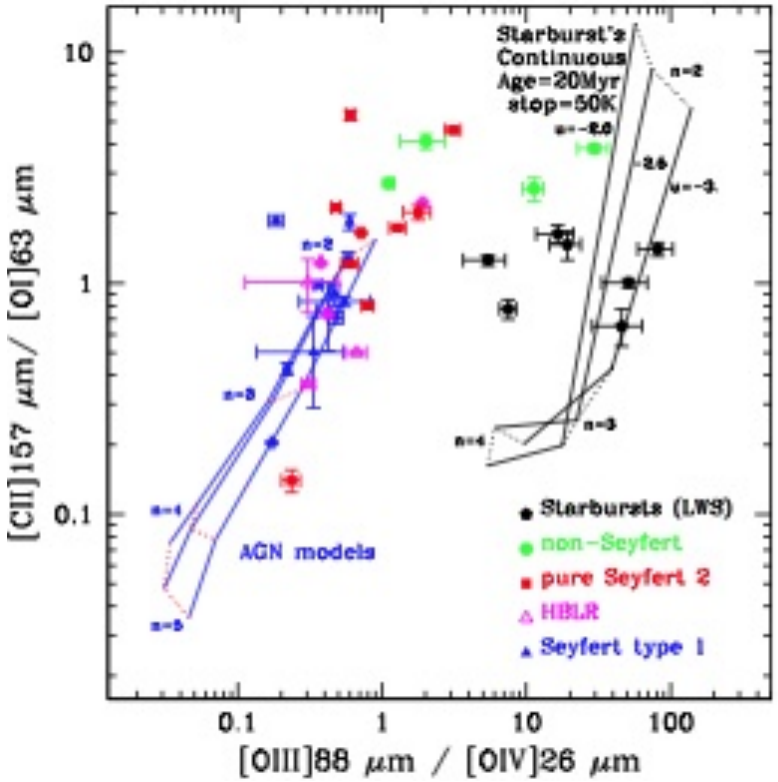
Perfect sample: * local: good quality data

* multi-band: data from X-ray to the sub-mm,

(*both photometric and spectroscopic)*

Study of the line ratios in order to separate Starburst/AGN

(Spinoglio et al. 2015)



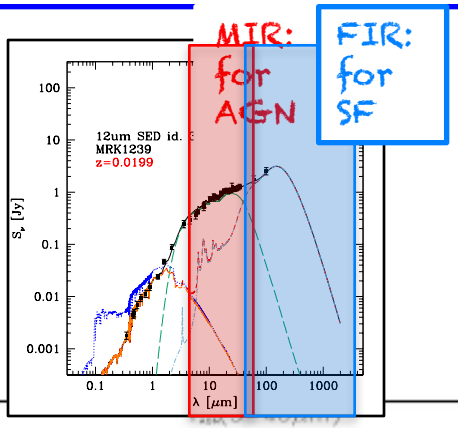
→the line ratio of [OIII]88 μm/ [OIV]26 μm can reliably discriminate the two emission regions, while the far-IR line ratio of [CII]157 μ m/ [OI]63 μ m is only able to mildly separate the two regimes.

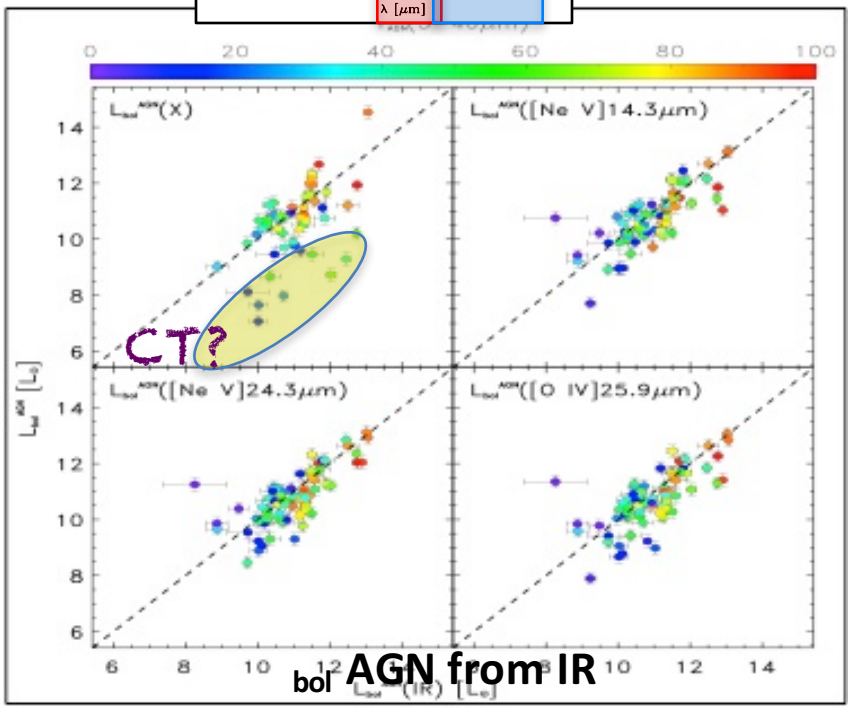
12-micron Seyfert sample

Study and comparison of the different AGN proxies (Gruppioni et al. 2016)

AGN proxies:

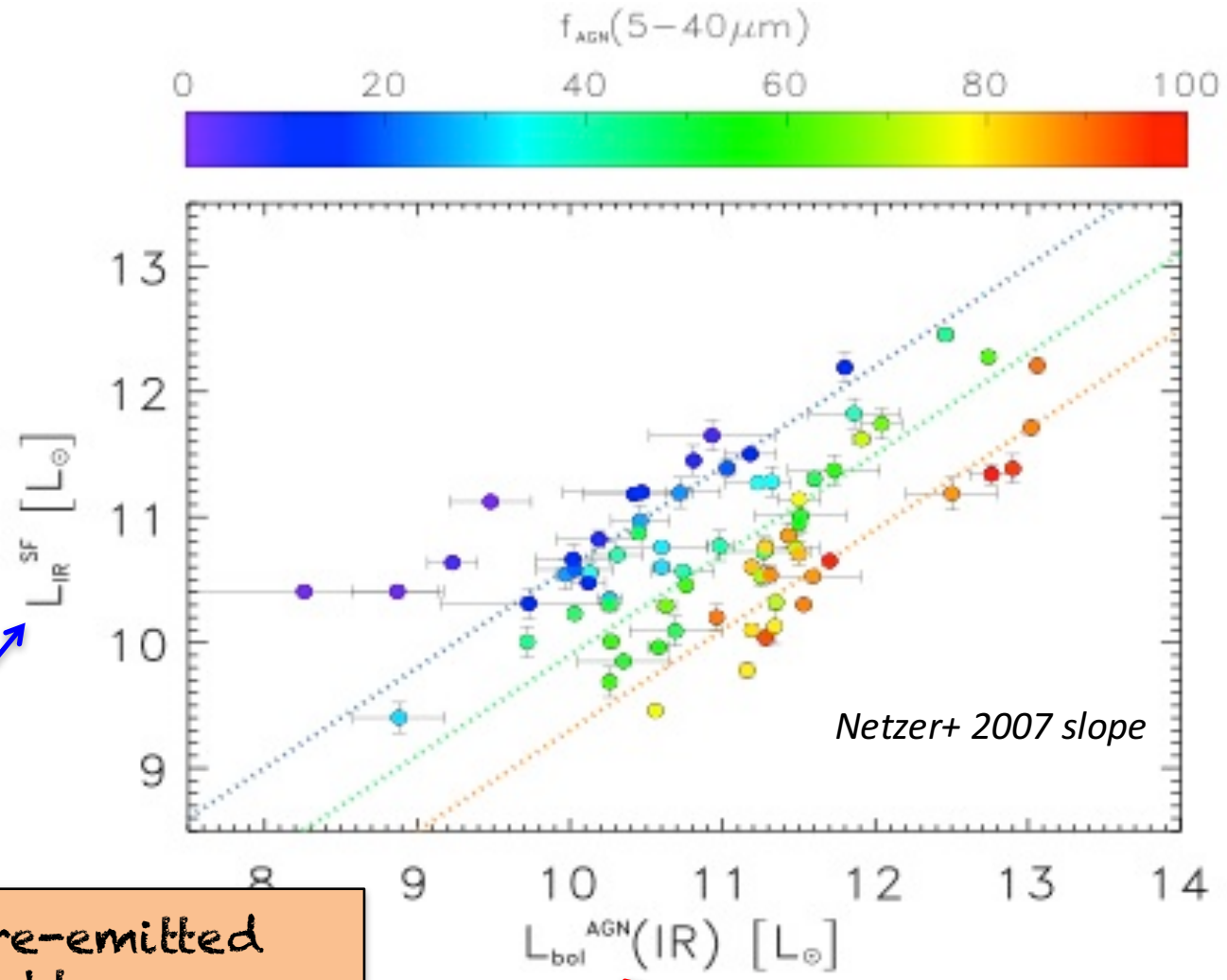
- Torus from SED-fitting decomposition
- X-ray luminosity
- high-excitation lines(i.e. [NeV] and[OIV]





➔ Bolometric AGN luminosities Derived from the different proxies (taking into account the different bolometric correction) agree.

L_{bol}^{AGN} from IR



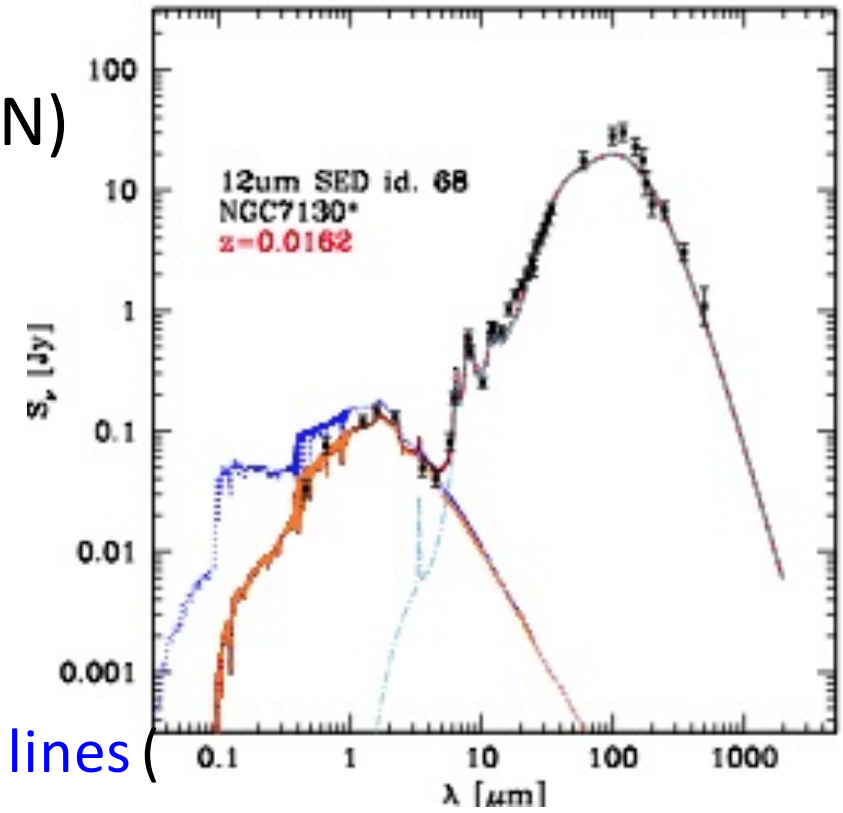
L_{IR} from re-emitted stellar light (L_{IR}[8-1000μm] is a proxy)

L_{bol} from AGN torus model

- An intriguing source: NGC7130

No evidence of torus (i.e. AGN) from SED-decomposition

but….

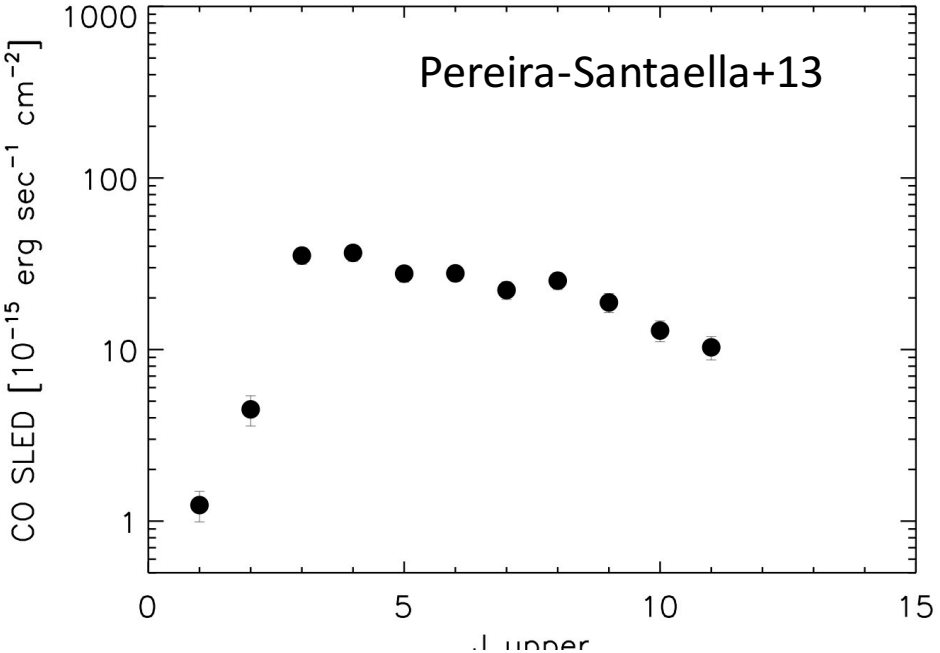


1) Strong high-ionization potential lines (

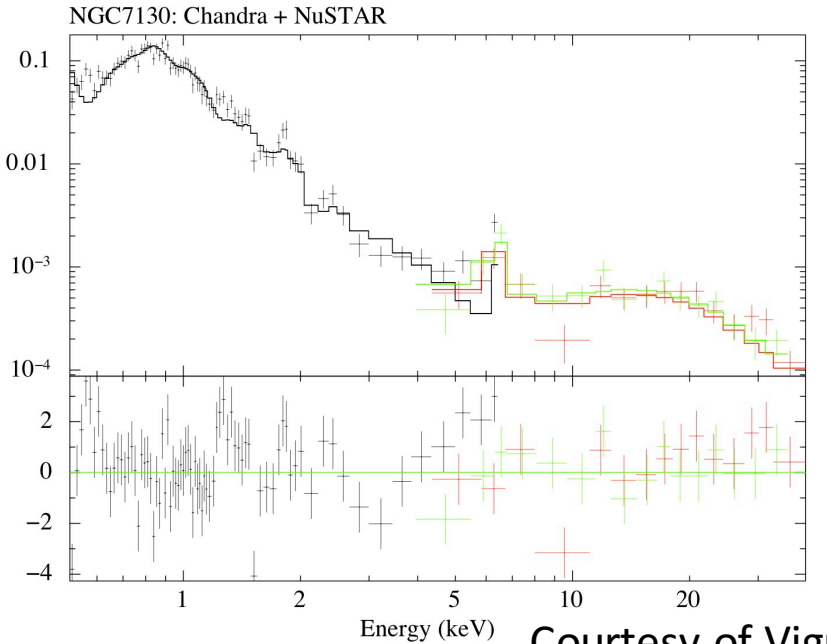
OIV [25.6um]→ 54.9 eV
NeV [14.3um]→ **97 eV**

➔ requires a hard ionizing spectrum

2) CO-SLED:
Almost flat up to J_{up}~12



3) X-ray spectra (using NuSTAR data)
➔ *Compton thick source*
$L_{2\text{-}10keV}$ ~ 2 x10^{42} erg sec^{-1}
NH ~ 10^{24} cm^{-2}

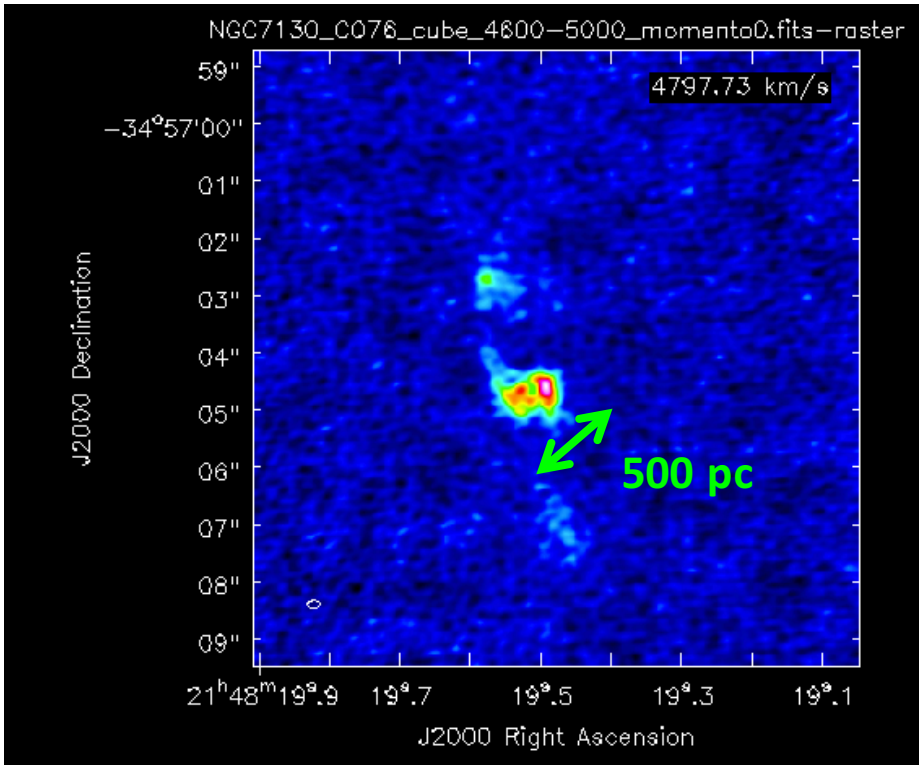


Courtesy of Vignali

Necessary to understanding the physics

ALMA data from archive, PI: Lu

Band 9, CO(6-5)



Spatial information from ALMA

Modelling lines with photodissociation code (i.e. CLOUDY)

Physics of the ISM

Cloudy Modelling: Method

INPUTS

1. Starburst99 spectrum
2. AGN spectrum
3. gas density
4. distance from the source

OUTPUTS

A. **line luminosities**
B. emitted continuum
C. gas and grain temperature

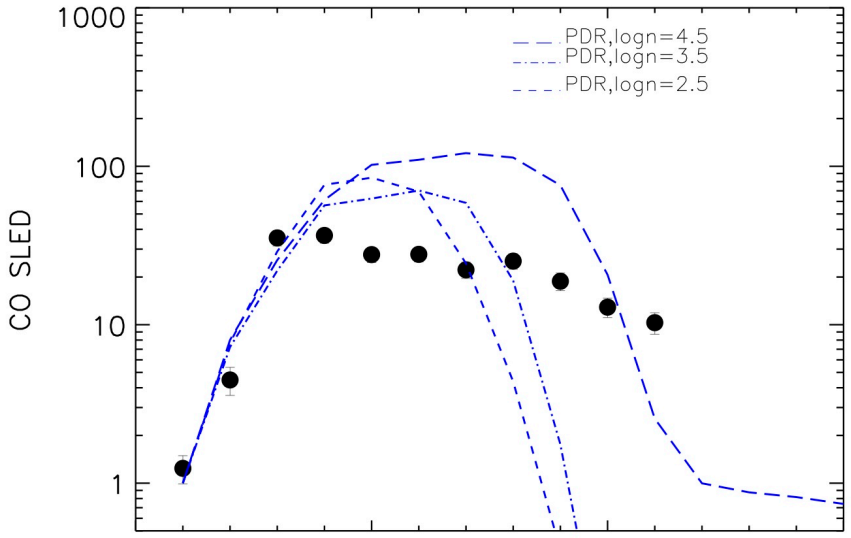
OBSERVATIONAL CONSTRAINTS:

Star-formation	20 $M_{\odot}$/yr
AGN X-ray luminosity:	2 x10^{42} erg sec^{-1}
Dimension C0(6-5) emission	500 pc

GRID

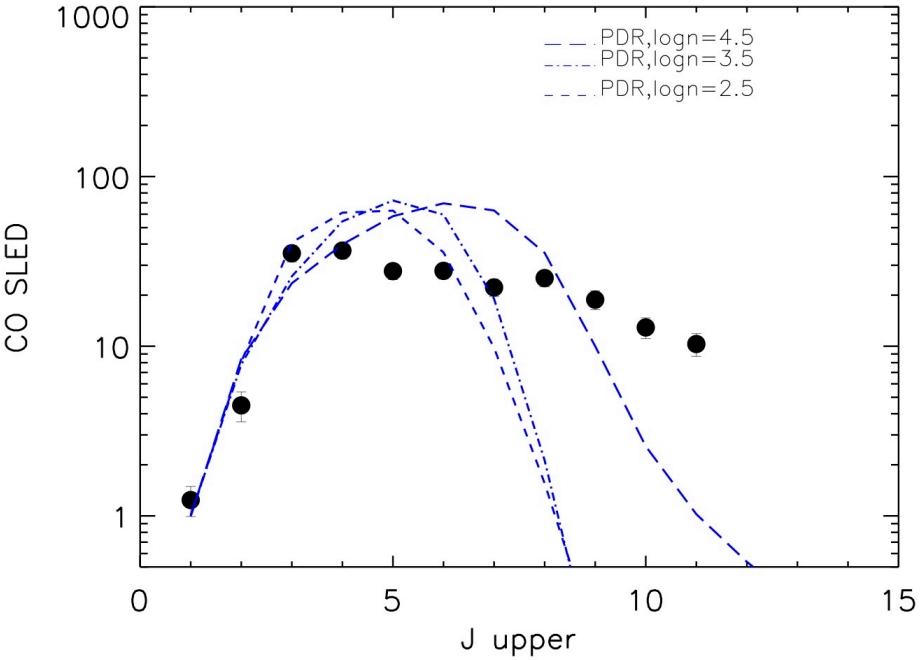
	log Density [cm^{-3}]	Region [pc]
PDR	2.5/3.5/4.5	125/250/500
XDR	3.5/4.5/5.5	125/250/500

Only PDR



R=125 pc

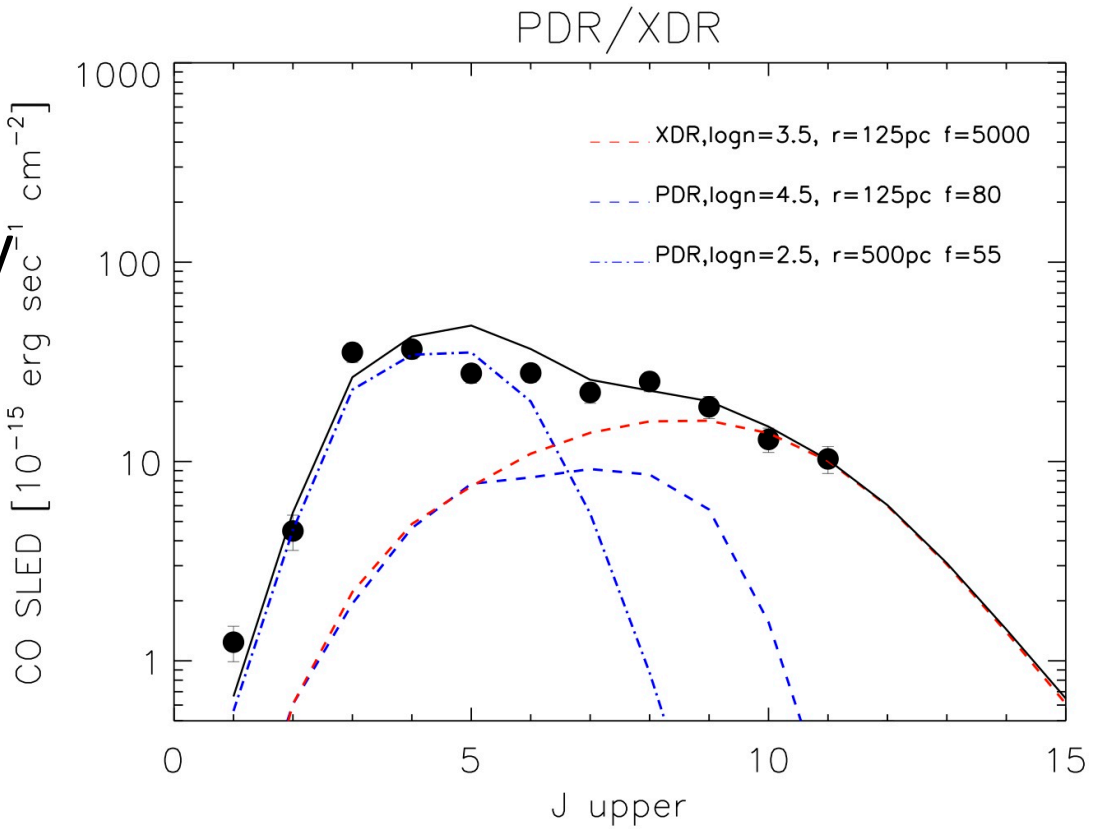
Impossible to recover J_{up} shape



R=500 pc

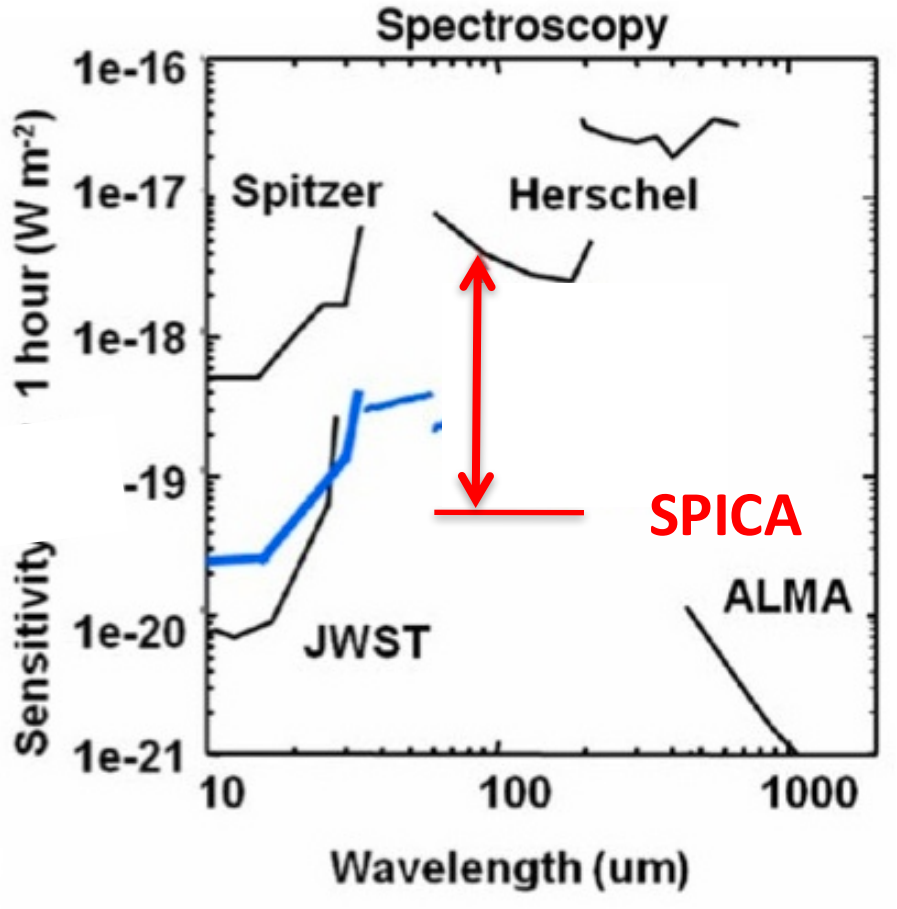
CO SLED reproduced

Parameters from cloudy using real data (SFR, AGN luminosity, dimension)



Pozzi et al. in preparation

Synergies ALMA/SPICA



SPICA/ALMA→ Physics of galaxies/AGN

- SPICA will extent the local Universe explored by Herschel in terms of mid/far IR lines at the peak of SFR/accretion, z~2-3

  - ***Fine structure lines***: SMI/SAFARI (10-230 μm)
    OIV [25.9 μm] → **0.4 < z < 4 [at least]**
    (**JWST/MIRI** 5-27 μm up to z ~0.2)

  - ***CO lines*** @ z=2 J_{up}>= 40

- ALMA will spatially resolve the region emitting the lines (i.e. CO) giving constraints to the modelinig