L & M band spectroscopy of

UltraLuminous InfraRed Galaxies

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UltraLuminous InfraRed Galaxies

ULIRG	Milky Way
$L_{IR} \geq 10^{12} L_{sun}$	$L_{IR} \sim 10^{10} L_{sun}$

⇓

ULIRGs are the brightest sources in the Local Universe

Local counterparts of high redshift sources:

- they dominate submillimetric background
- story of star formation

Mirabel & Sanders, ARA&A, 1996
Barger et al., Nature, 1998

They host obscured Active Galactic Nuclei (AGN):

- contribution of AGNs to the total luminosity of the Universe
- study of local population of AGNs

Comastri et al., A&A, 1995
Gilli, Risaliti, Salvati, A&A, 1999

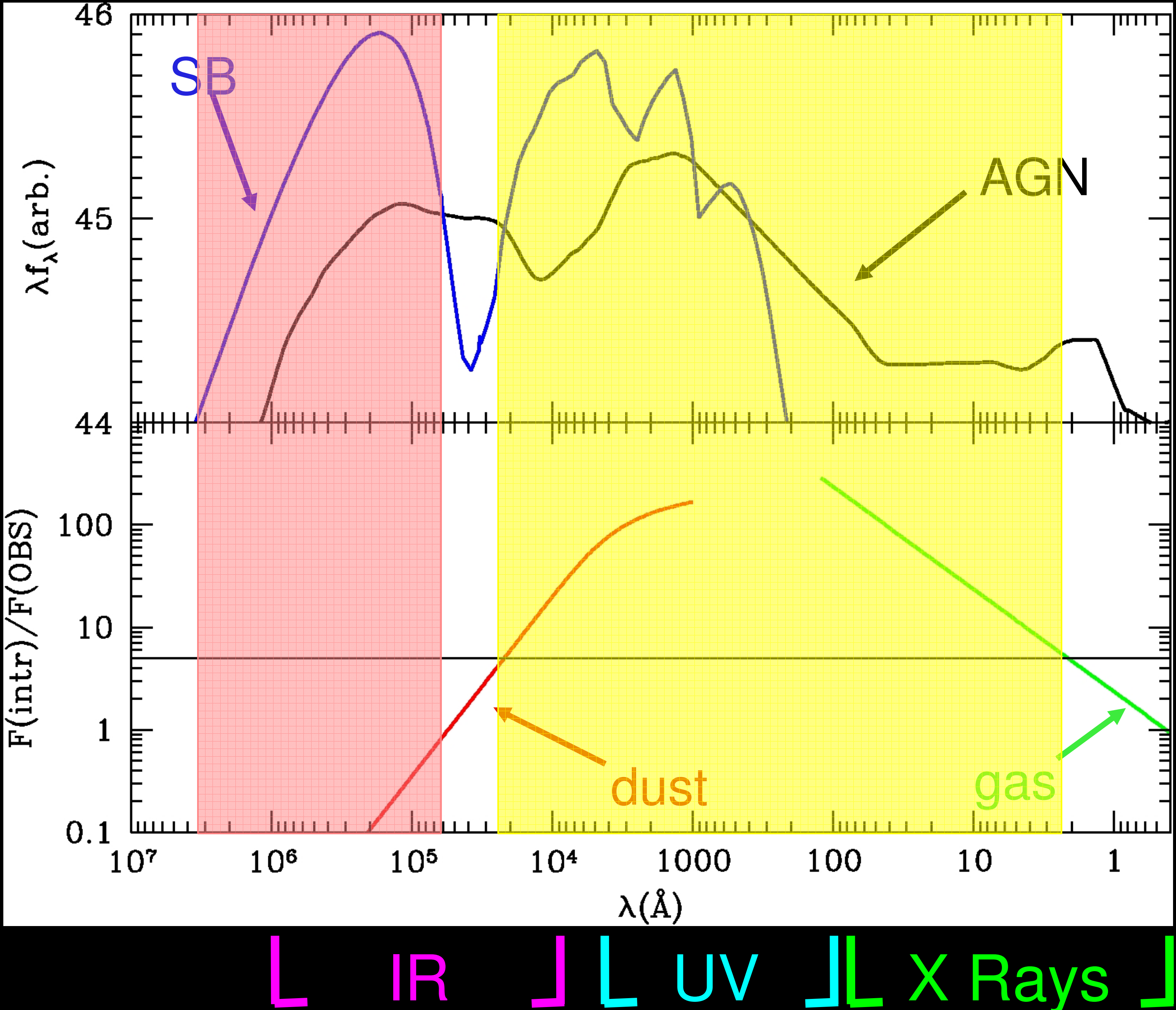
Hot dust reprocesses UV-X photons coming from the central engine: Starburst (SB) and an Active Galactic Nucleus (AGN) if present...

Dominant source?

Outline

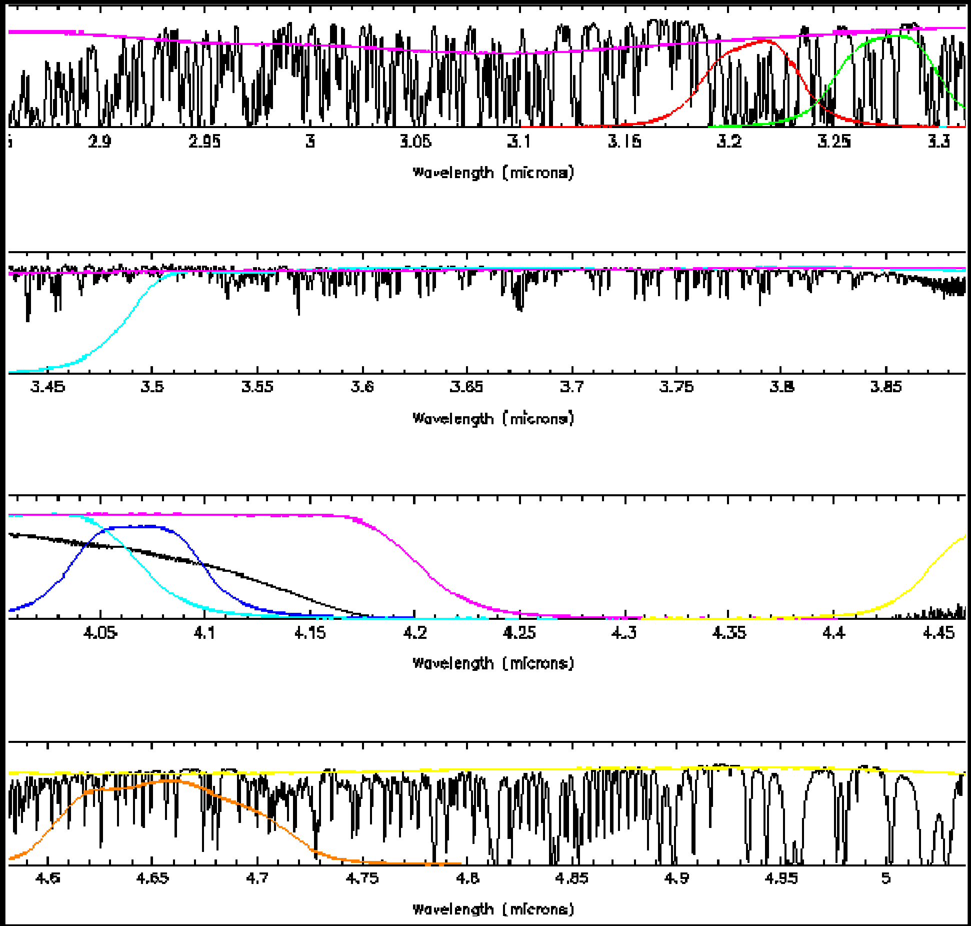
- **What we know about ULIRGs:**
  - How to disentangle AGN and SB
- **Our project about ULIRGs:**
  - Sample of galaxies
  - Observations
- **Results:**
  - Analysis of sources
  - Diagnostic diagrams
  - Analytical model
- **Conclusions and outlook**

Disentangling AGN and SB



Observative problems

High atmospherical variability



Background emission

band	J	H	K	L	M	typical ULIRG
mag/ arcsec^2	16.5	14.4	13.0	3.9	1.2	~11 (L-band)

Our project

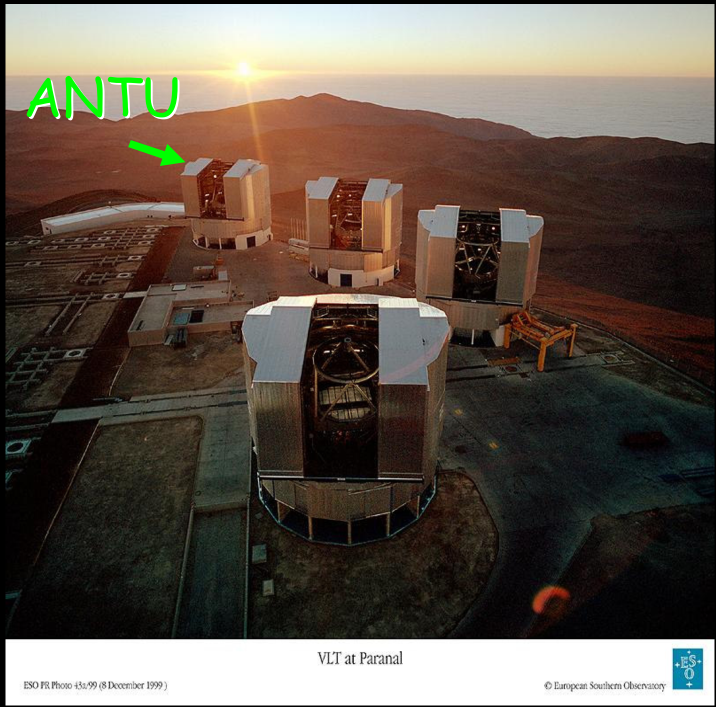
Sample: 5 local brighter ULIRGs, containing an AGN

$10^{11.8} < L_{IR} < 10^{12.2} L_{sun}$, $f_{60} > 5.4Jy$

source (IRAS)	z	f_{60} (Jy)	$\log L_{IR}$ ($L_\odot$)	spectral class
05189-2524	0.0426	13.94	12.07	Sy2
16504+0220	0.0245	22.7	11.78	LINER
19254-7245	0.0617	5.5	12.02	Sy2
20551-4250	0.0428	12.8	11.98	H_{II}
23060+0505	0.173	1.2	12.41	Sy2

Genzel et al, AJ, 1998

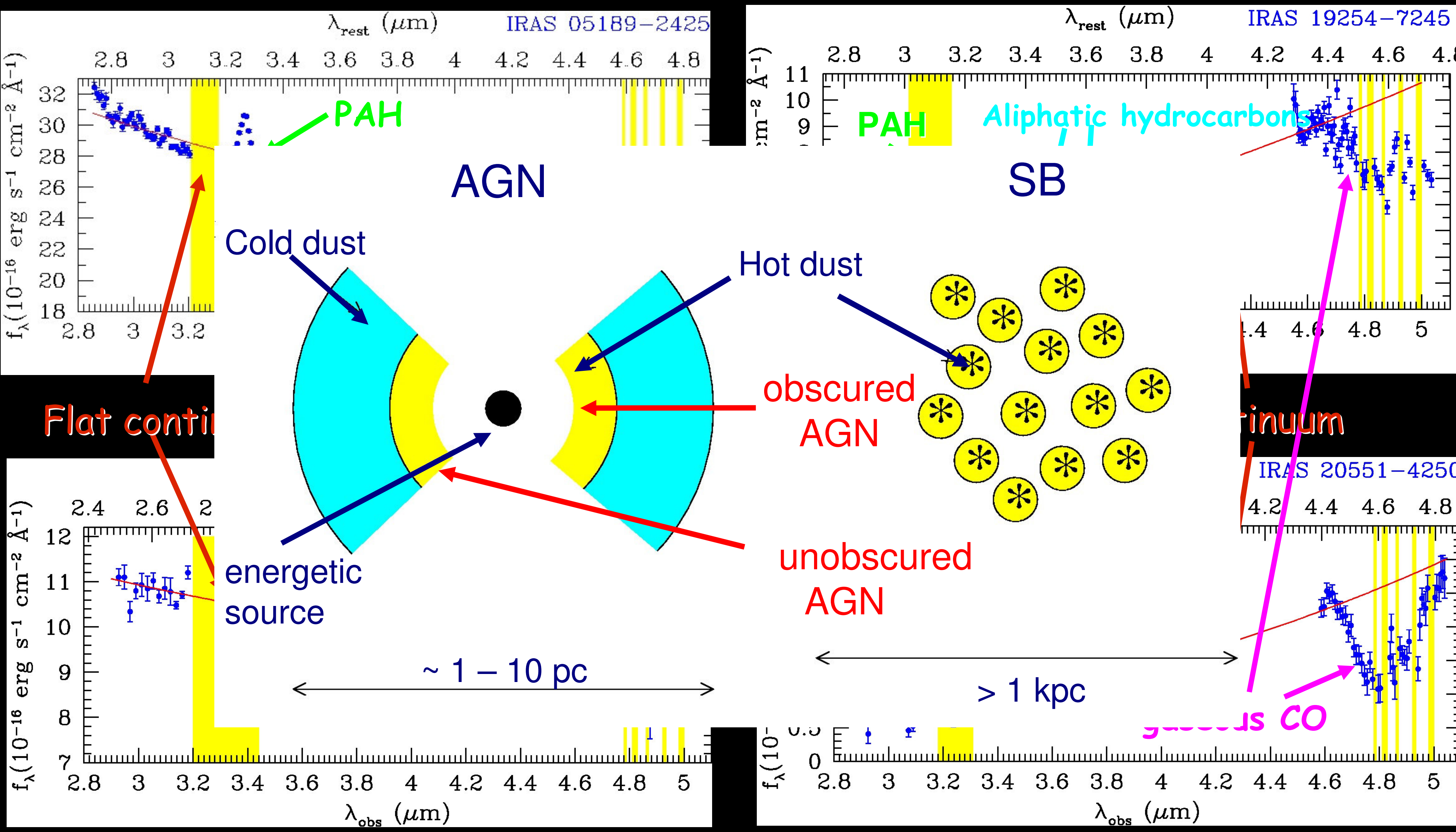
ISAAC @ VLT
Low resolution observing mode



Goals:

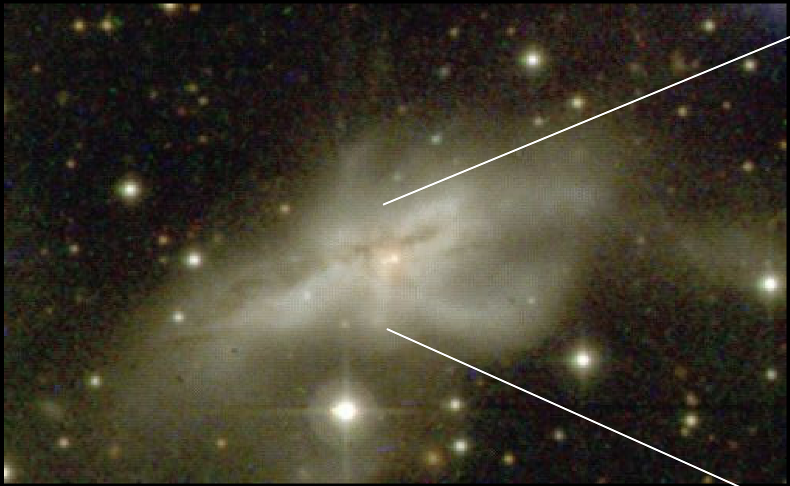
- extending this study to the M-band,
- verifying the presence of AGN and study of physical parameters,
- representative sample for possible cases.

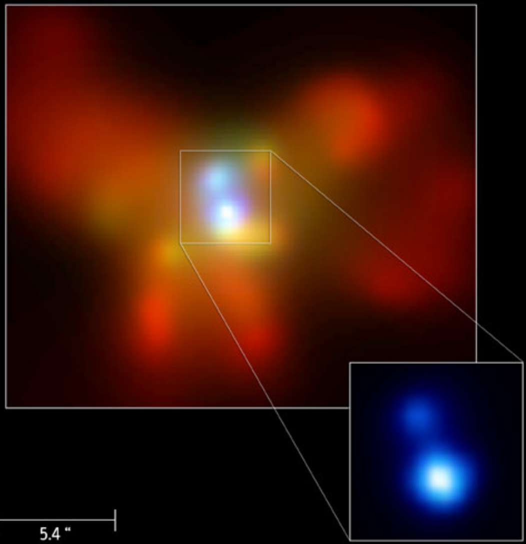
Physical analysis of sources



Imanishi & Dudley, ApJ, 2000
Imanishi & Maloney,ApJ, 2003
Sani, Risaliti et al. 2006 to be published

NGC 6240



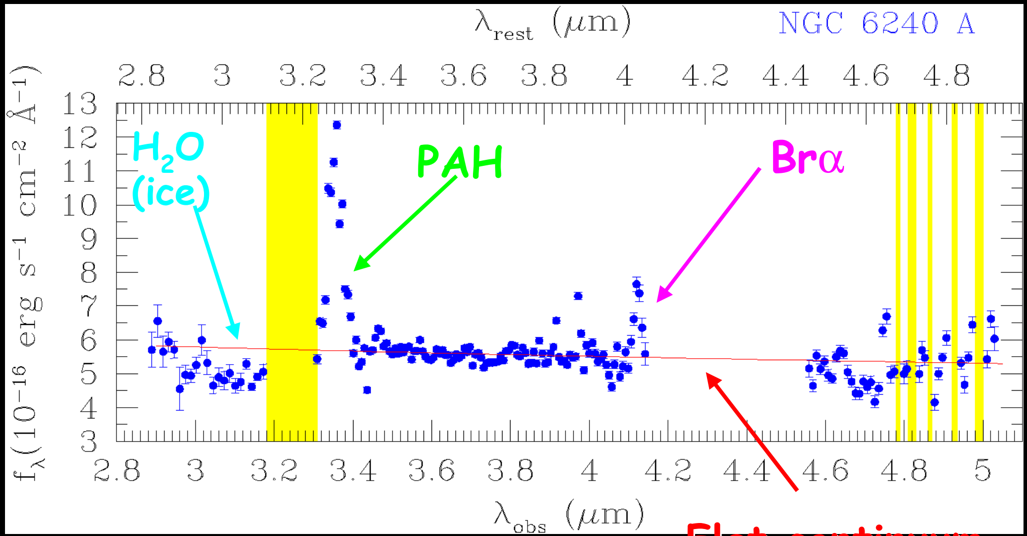


X Rays:

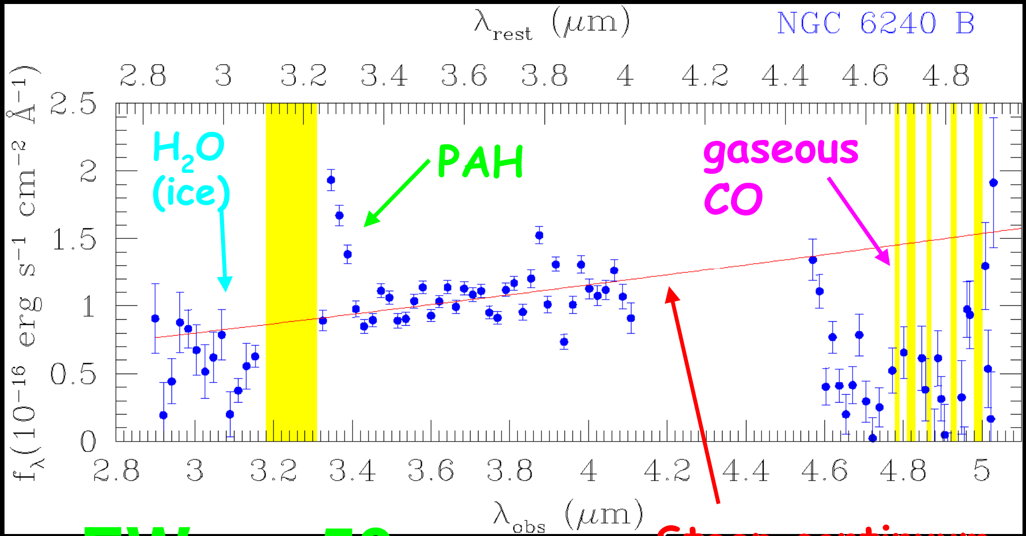
double AGN

observed

Komossa et al., ApJ, 2003



Flat continuum



Steep continuum

$EW_{3.3}$~50 nm

$v_{Br\alpha} \simeq 1800$ km/s

$EW_{3.3}$ ~ 50 nm

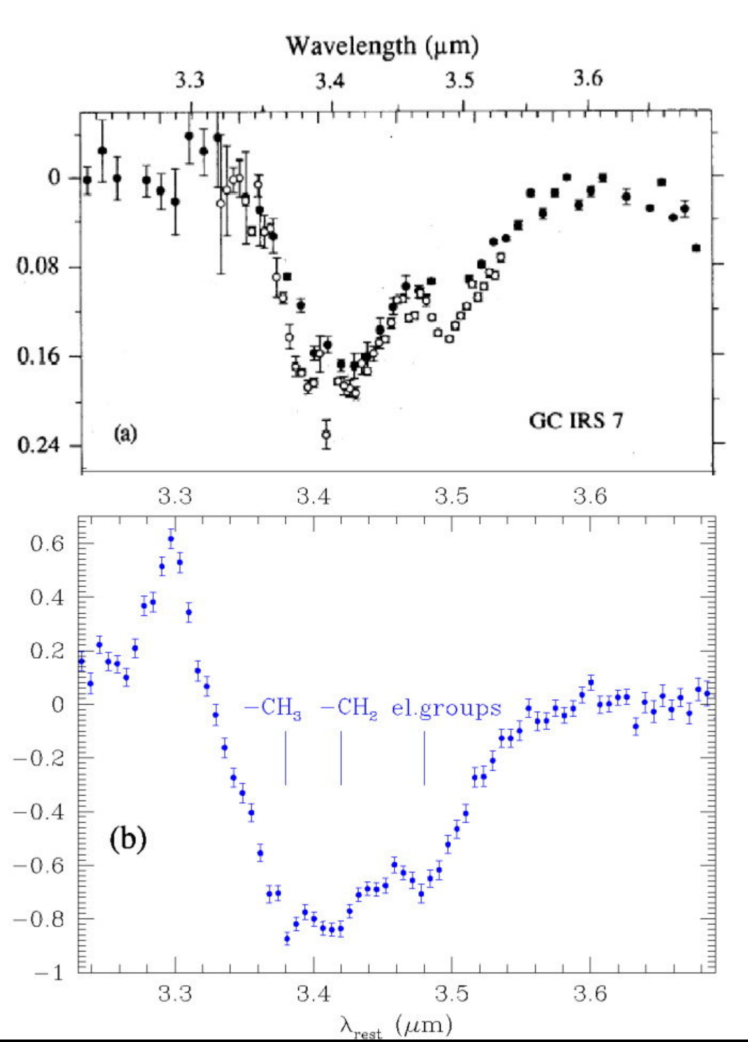
τ_{CO} ~ 2

Γ~1.3

Lutz et al. AJ 2000

L-band absorptions chemistry

IRAS 19254-7245



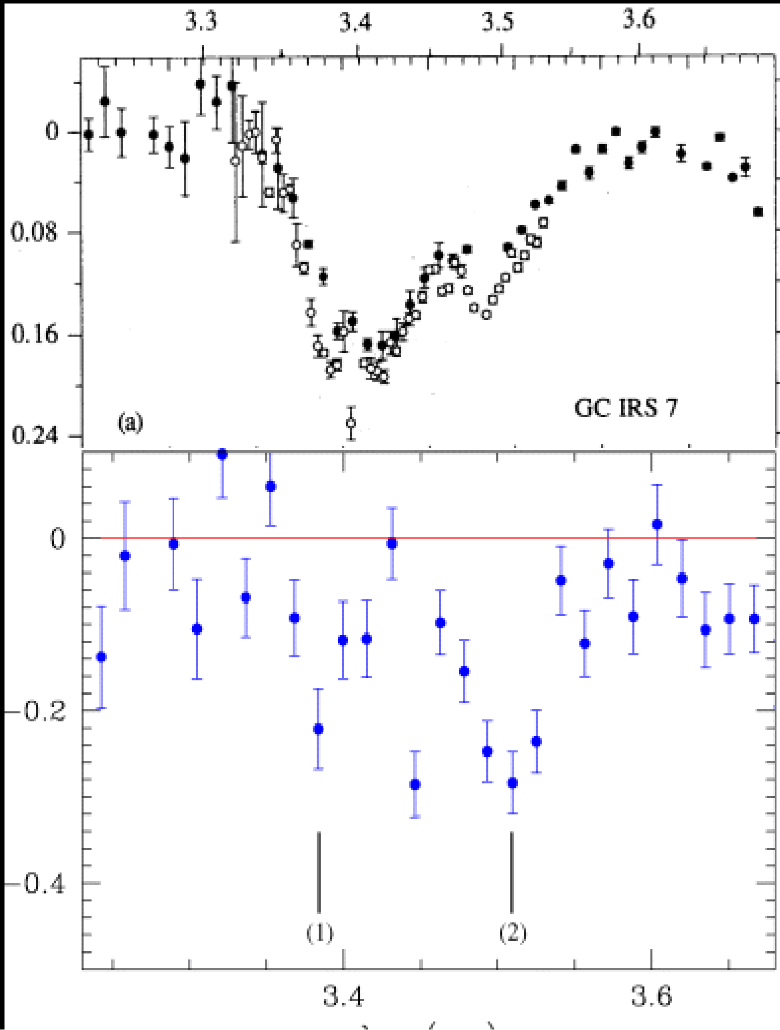
$CH_3 - (CH_2)_n - CH_3$

⇓

$-CH_3 / -CH_2 \sim 2-2.5$

Sandord et al., ApJ, 1991
Pendleton et al., ApJ, 1994
Risaliti et al., AJL, 2003
Risaliti, Maiolino, Marconi, Sani et al., MNRAS, 2006

IRAS 20551-4250



~ 3.5 μm peak

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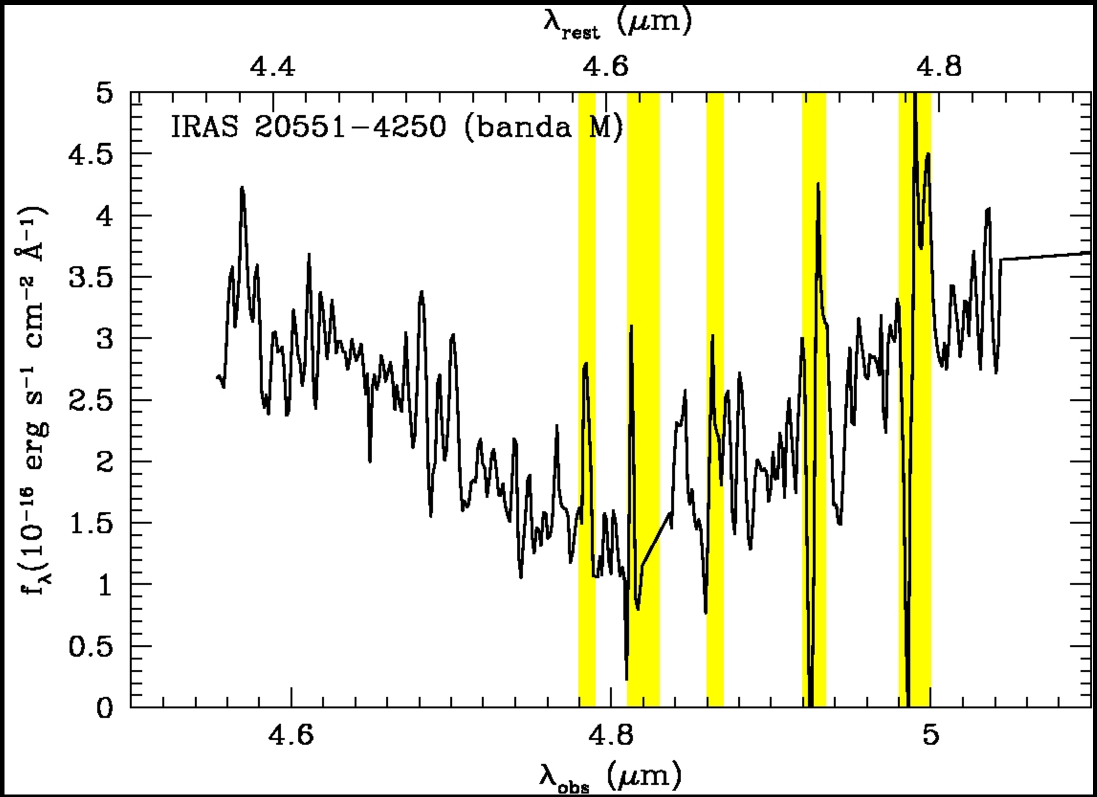
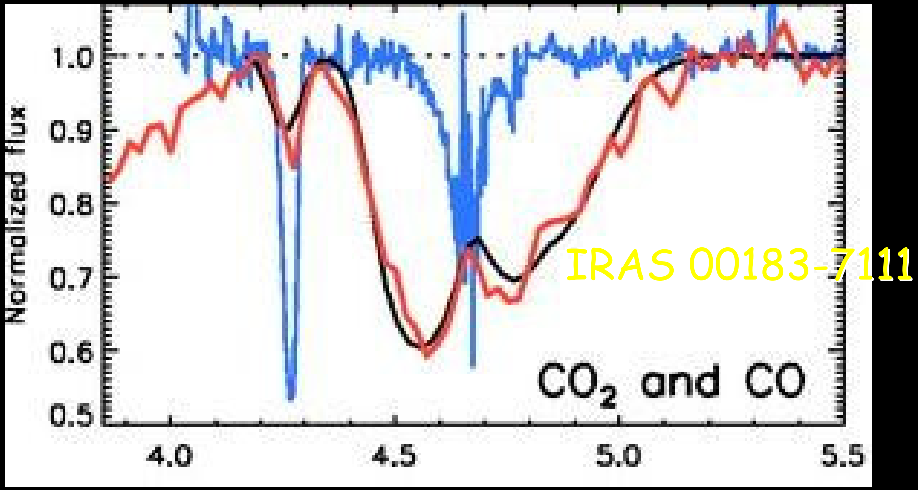
$-NO_2$, $-OH$ overabundant

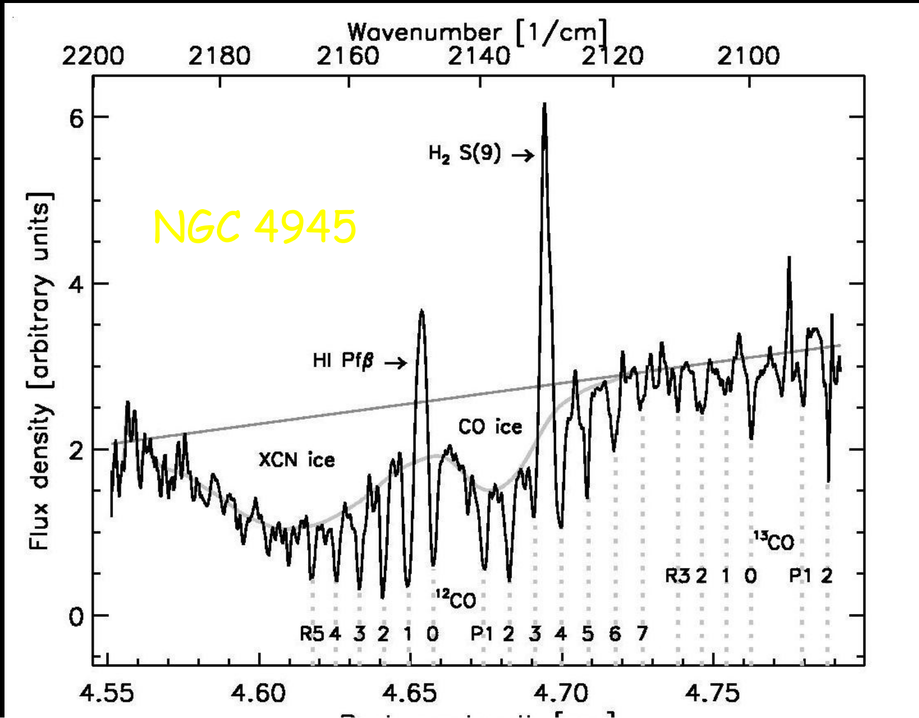
M-band absorptions chemistry





Spoon et al, *A&A*, 2004

Spoon et al, *A&A*, 2003



Gaseous CO absorption

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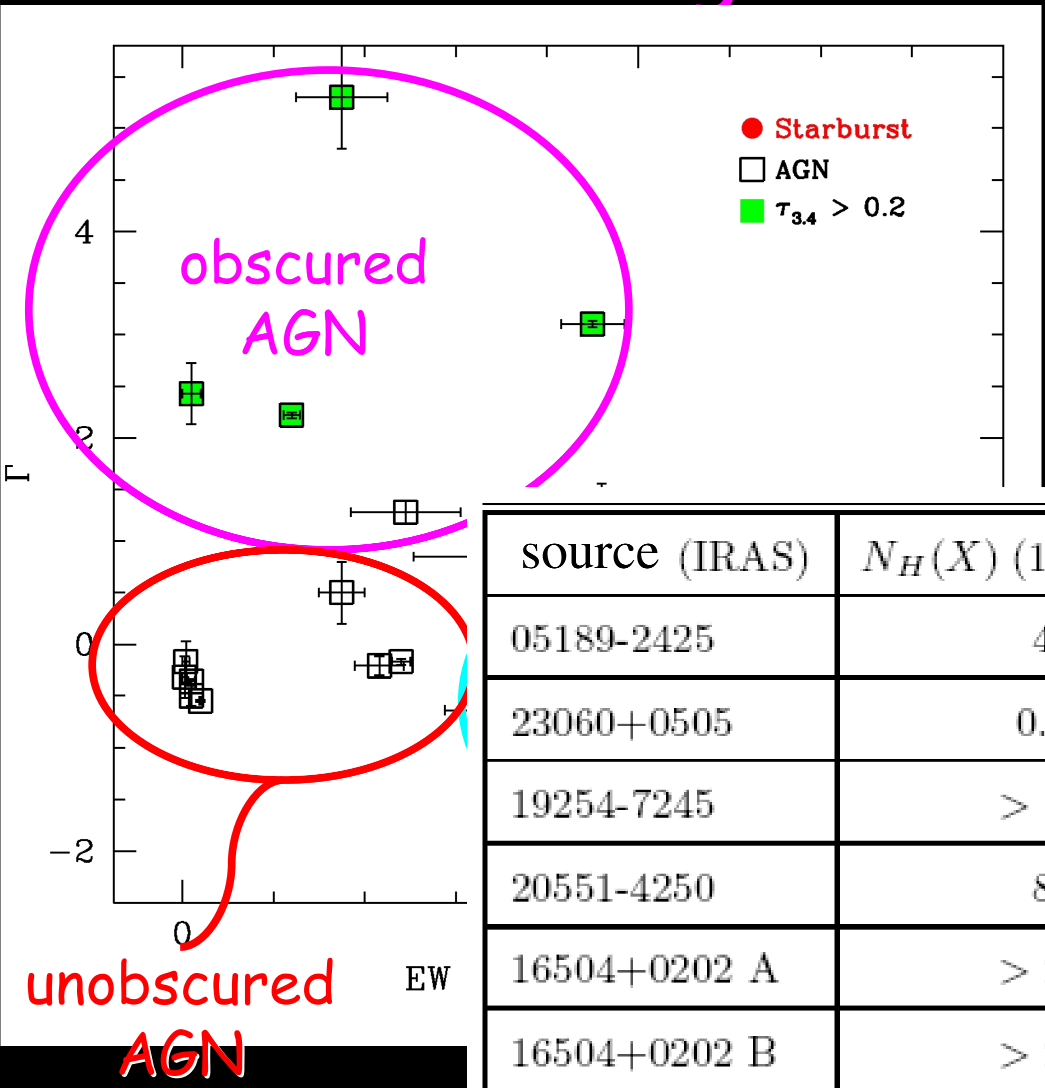
3.4 ⇔ 4.6 self consistency

Sani, Risaliti et al, 2006 to be published

Diagnostics and model



⇒ The 3 classes of sources are completly separated

$$EW_{3.3}=EW_{PAH}\frac{1-\alpha}{\alpha e^{-\tau_L}+(1-\alpha)}$$

$$\Gamma_{obs}=\Gamma+\frac{1.75\,\alpha\,\tau_L\,e^{-\tau}}{\alpha e^{-\tau_L}+(1-\alpha)}$$

source (IRAS)	$N_H(X)$ $(10^{23}cm^{-2})$	$A_L(X)$	$\tau_{3.4}$	$A_L(\tau_{3.4})$	$A_L(obs)$
05189-2425	4	9	< 0.02	< 0.2	0
23060+0505	0.8	2	< 0.03	< 0.3	0
19254-7245	> 10	20	0.59	7	2.2
20551-4250	8	17	0.23	3	> 4
16504+0202 A	> 20	20	< 0.03	< 0.3	2.2
16504+0202 B	> 20	20	< 0.05	< 0.5	0.54

[illegible]	[illegible]	[illegible]	[illegible]
16504+0202 A	0.5	0.7	0.02
16504+0202 B	2	0.9	0.08

$$f_\lambda=\alpha f_\lambda(AGN)e^{-\tau(\lambda)}+(1-\alpha)f_\lambda(SB)$$

Risaliti, Maiolino, Marconi, Sani et al., MNRAS, 2006

Conclusions and outlook

Analysis of 5 ULIRGs:

- complete analysis of spectral parameters
- detection of a double AGN in NGC 6240
- detailed chemical analysis of the absorber

Extended sample:

- realization of diagnostic diagrams
- efficient disentanglement of AGN and SB
- accurate calibration of diagnostics

⇨ extendibility

- Observation of weak ULIRGs ($m_L \sim 14$)
- Observations in medium resolution
  ⇨ investigation of chemical features
- Observations with adaptive optics
  ⇨ higher spatial resolution