Seyfert Galaxies in the Local Universe: Analysis of SPITZER Spectra of a Complete Sample.

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From the observational evidence that the main energy-generating mechanisms in galaxies are black hole accretion and star formation and that Starbursts and AGN's may be linked in an evolutionary sequence, we present mid-infrared spectroscopy of a complete sample of Seyfert Galaxies in the Local Universe with the aim to derive the bi-variate AGN and Star Formation luminosity functions in the Local Universe.

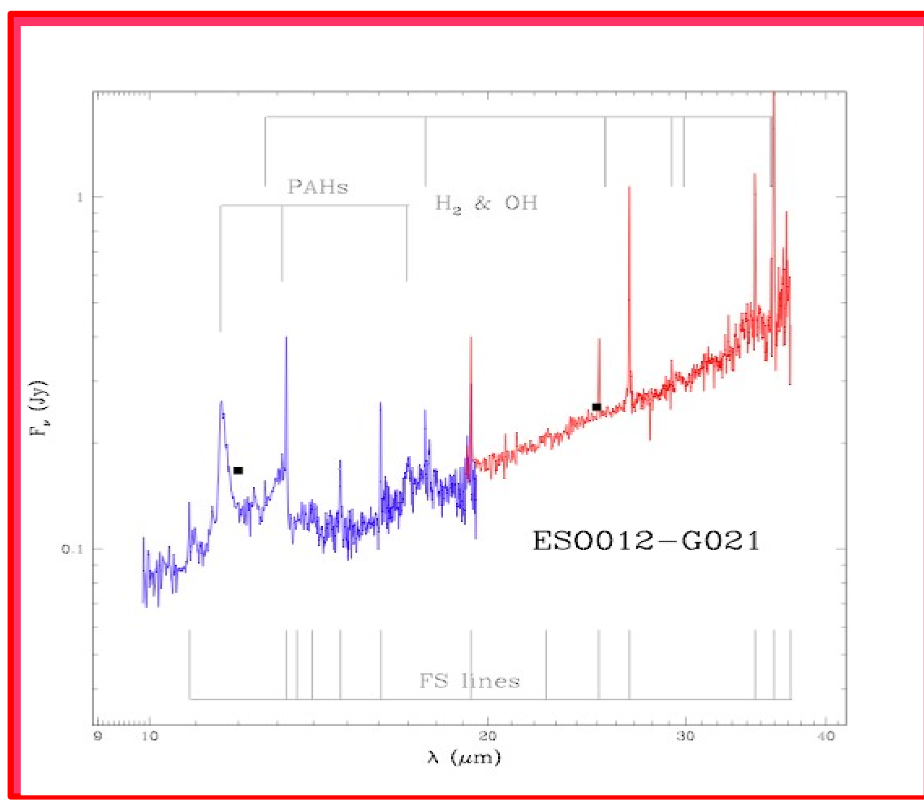
Mid-infrared spectra can provide a census of the dominance of the two processes at zero redshift and it will be the basis for any future comparison with the history of the energy production mechanisms along galaxy evolution as derived from future cosmological surveys.

Because most of the local active galaxies contain both an AGN and a starburst component, often obscured by dust, infrared spectroscopy has to be used to separate the two emission processes. Many spectroscopic indicators such as the ratios of high to low ionization lines, eg [NeV]/[NeII], [NeV]/[SiII], [OIV]/[NeII] are directly linked to the AGN dominance, while others are indicators of the Star Formation dominance, e.g. the PAH 11.25µm, the molecular hydrogen rotational lines and some nebular lines (e.g. from [NeII] and [SIII]) equivalent widths.

Available Data on the 12MGS

About an half (60 objects) of the active galaxies of the 12MGS have been observed by **Spitzer IRS at high resolution**, in a GT program by G. Fazio and the CfA team in collaboration with us. The data reduction and analysis methods have been reported in Tommasin et al, 2008. The other half of the sample is in the Spitzer public archive and its reduction and analysis are in progress.

Some results from Tommasin et al, 2008 are presented hereafter.

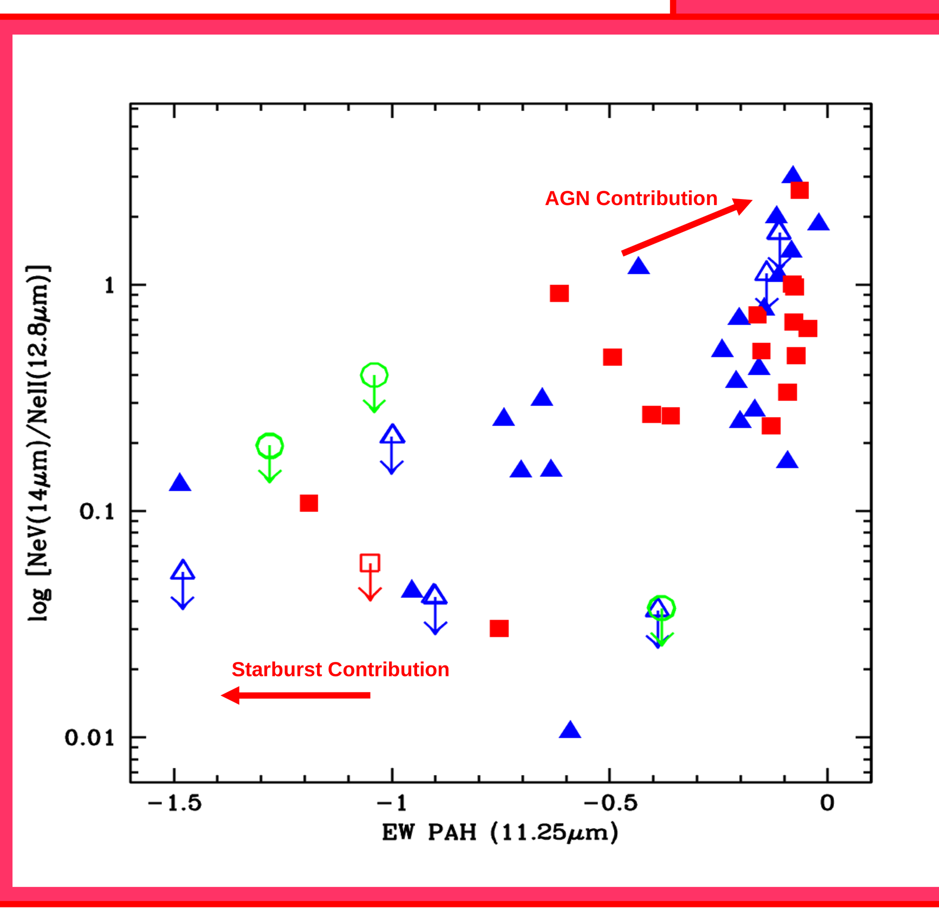


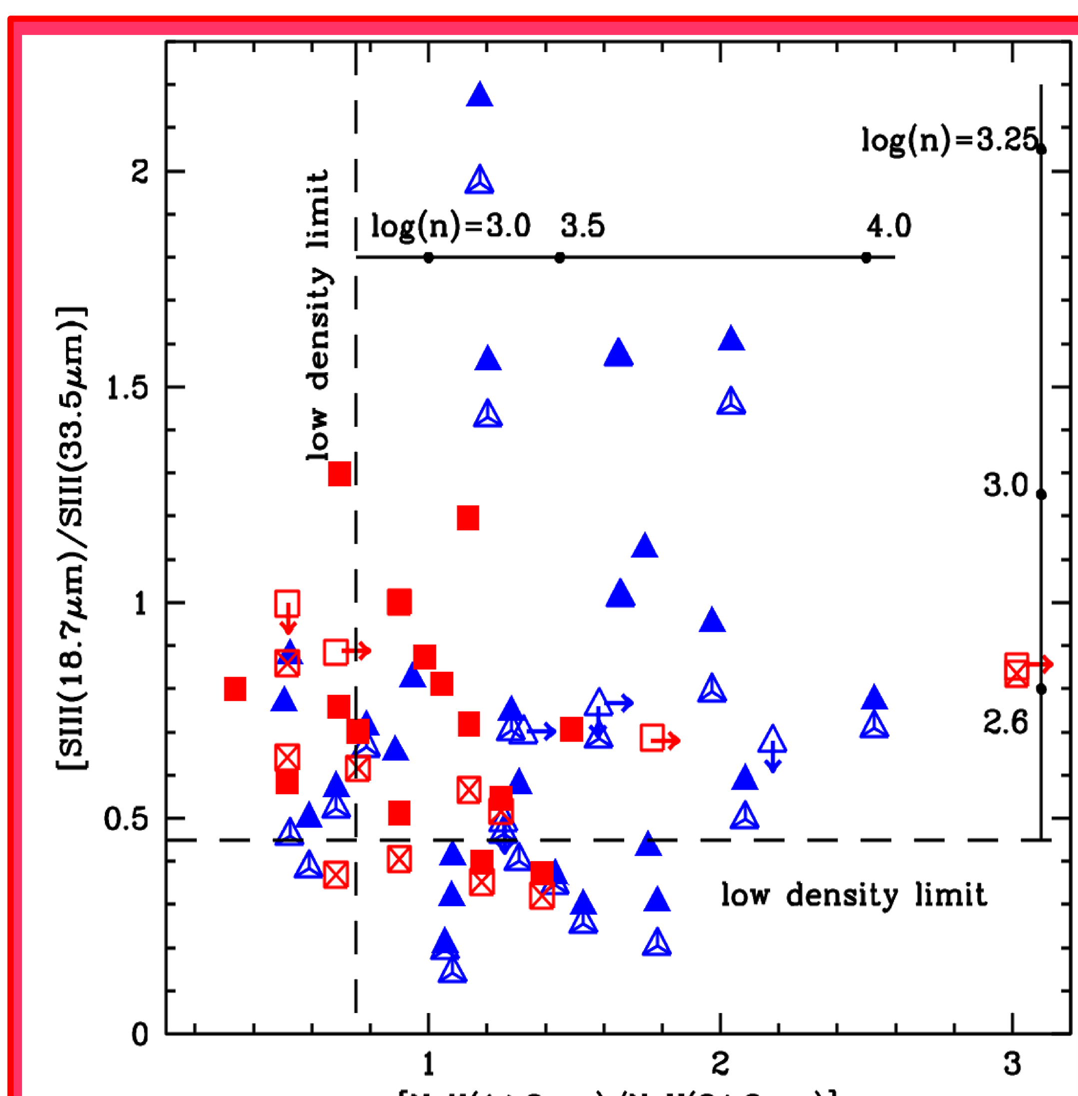
High resolution IRS Spitzer spectrum. PAH features at 11.25µm and 12.50µm can be seen, as well as the highly ionized OIV at 25.89µm from the AGN and NeII at 12.81µm, SIII at 18.71µm and at 33.48µm from the lowly ionized HII regions.

Blue spectrum tail concerns IRS SH Spectrographand red tail LH Spectrograph.

Red Square: Seyfert type I, Blue Triangle: Seyfert type II, Green Circle: Normal Galaxy. Full Figure: Detection, Empty Figure with Arrow: Upper/Lower Limit.

The ratio of lines of the same element at different ionizing potential gives the galaxy radiation field. NeV 14.32µm and NeIII 15.56µm are AGN tracers. Polyciclyc Aromatic Hydrocarbons Equivalent Width is inversely proportional to the AGN activity . The plot shows for each of the galaxy types the trend to blank the emission of the PAH at 11.25µm, increasing the AGN contribution.





The ratio between ions of the same element is an index of the gas density.

From models Dudik et al (2007) estimate the low density limit for neon and sulfur ratios.

Following this approach about the 40% of the sample is lying below those low limits:

- Object below the low density limit are obscured?

Possible torus evidence?

Electron density n at the theoretical emission regions Temperature (T = 10^4K) is done.

Need of a well defined statistical sample.

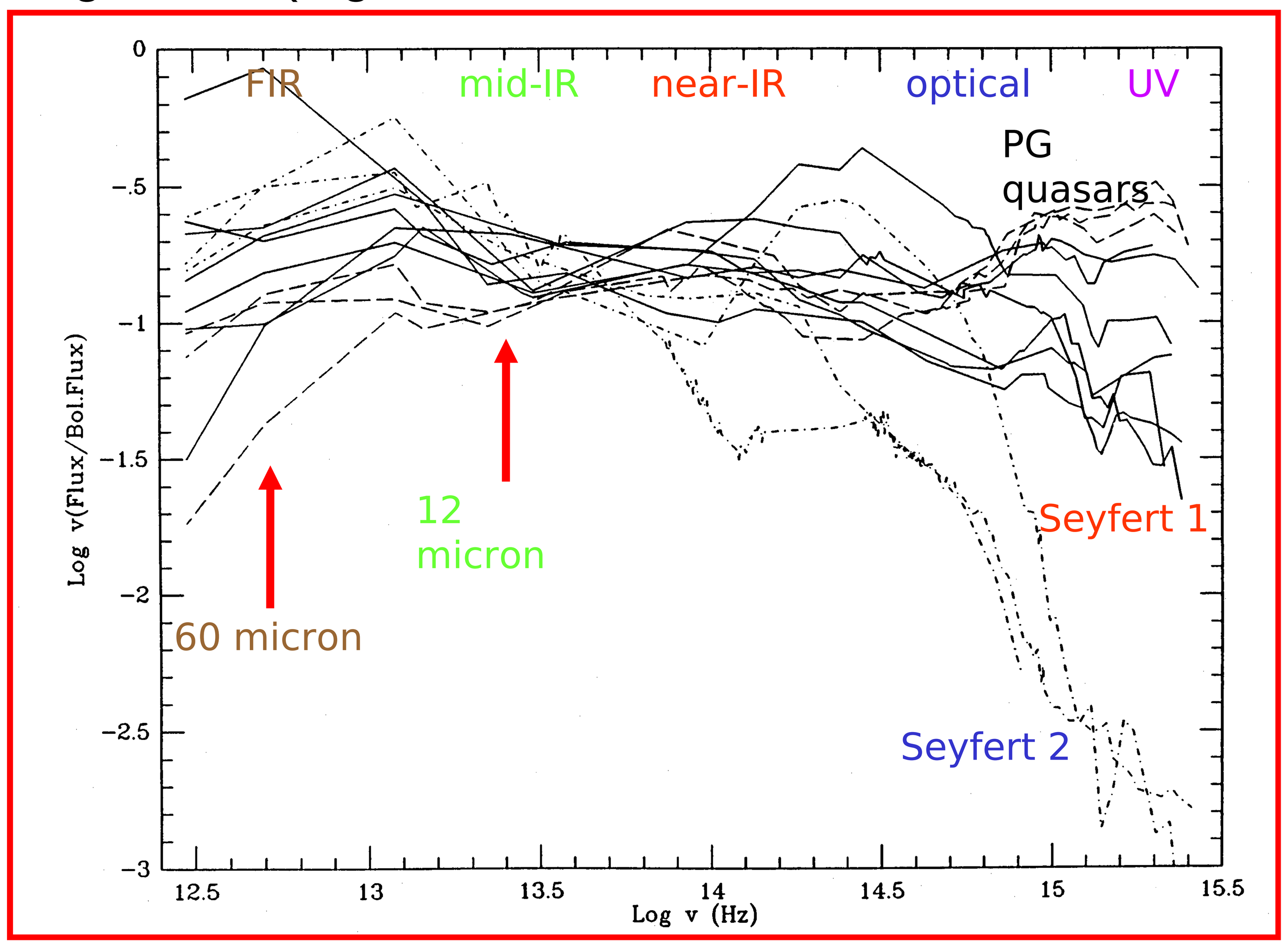
Selecting at 12 micron

Dust absorbs the continuum at short wavelengths and re-emit it in the FIR. There is a spectral interval (7-12µm) at which the absorption of the original continuum is balanced by the thermal emission.

The 12µm sample is an IRAS-selected all-sky survey flux-limited to 0.22Jy at 12µm relatively unbiased sample of active and star forming galaxies from the local Universe (hereafter 12MGS; Spinoglio & Malkan 1989; Rush, Malkan & Spinoglio 1993)

It is less subject to contamination by high star-formation rate objects than other infrared samples defined at longer wavelengths (Hunt & Malkan 1999).

It is generally used to give the zero point to infrared cosmological studies of galaxies (e.g. Matute et al 2002, Perez-Gonzalez et al 2005)



F12µm≈1/5 $F_{bolometric}$ for all types of AGN

- 12 µm COMPLETE SAMPLES IN BOLOMETRIC FLUX

Spectral energy distributions of 13 AGN normalized to the bolometric fluxes (computed from 0.1-100µm. [Spinoglio & Malkan, 1989]

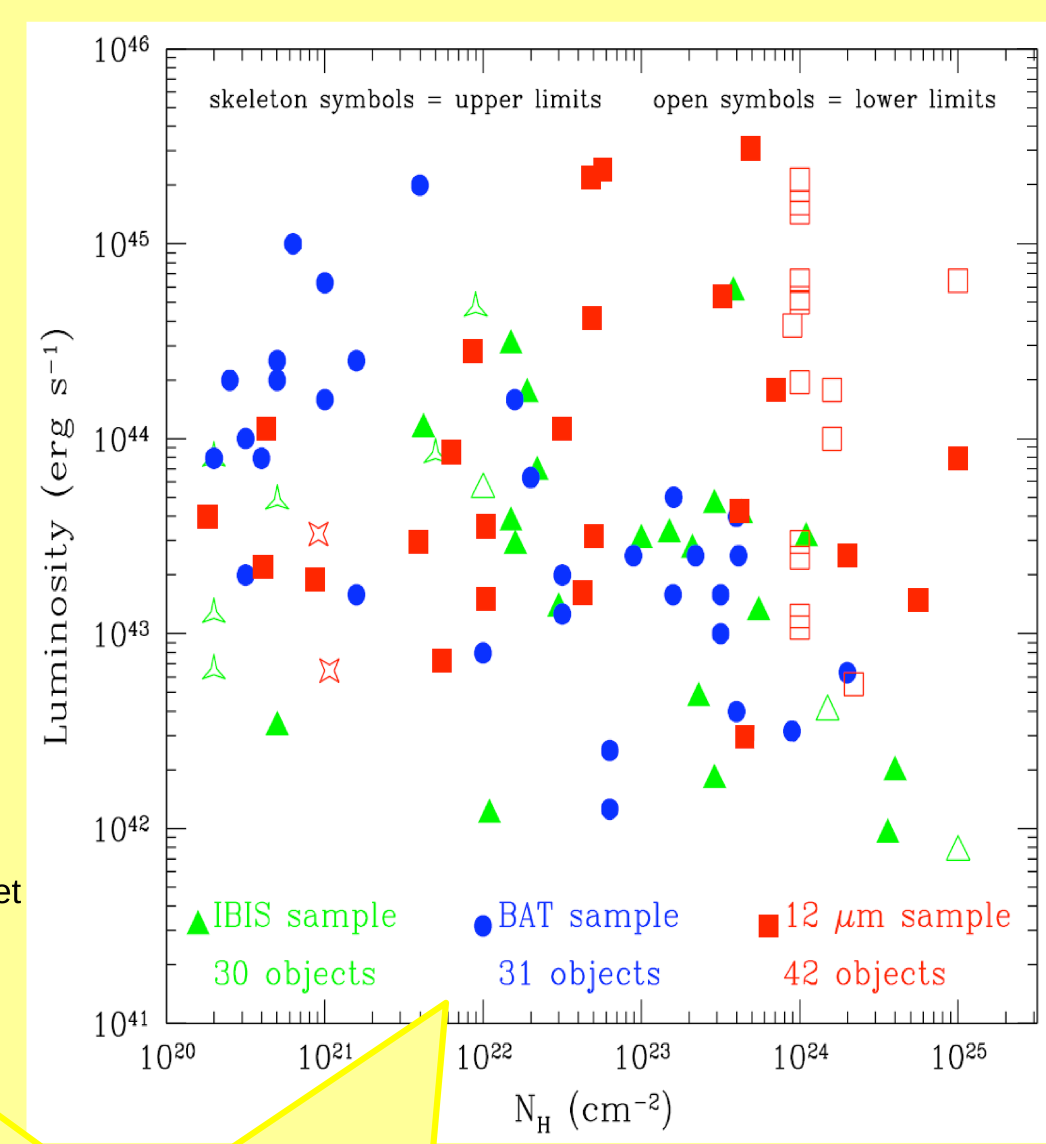
Optical and X Counterpart

A large fraction of the 12MGS Seyferts are obscured at soft X-rays, but detectable at hard X-rays. These are defined Compton-thick objects, having very high absorption hydrogen column density (N_H>10^{24}cm^{-2}) (e.g. Guainazzi 2006, astroph/0610935).

Similarly optical and shorter wavelengths are extincted from the dust present in the nucleus and reradiated in the infrared.

12MGS Seyferts cover a wide range of hydrogen column density, from 10^{20}cm^{-2} (of Compton-thin's) to >10^{24}cm^{-2} (of Compton-thick's). C-thins are mainly visible at hard X rays with IBIS-BAT data, on the contrary the C-thicks are predominantly IR selected objects.

NH data are avaible from Bassani+ (2006), Markwart+ (2005) and Shu (Shu et al. 2007 ApJ, 167



Is it because of the existence of a gas toroidal Structure around the nucleus? And what about the geometrical distribution of this obscuring matter? Are there relations between absorbing gas and obscuring matter? What kind of proportion can we find between N_H and IR fine structure line or continuum emission? And between optical and IR lines?

These arguments and more will be treated in the following of this work.