Spitzer spectroscopy of AGN

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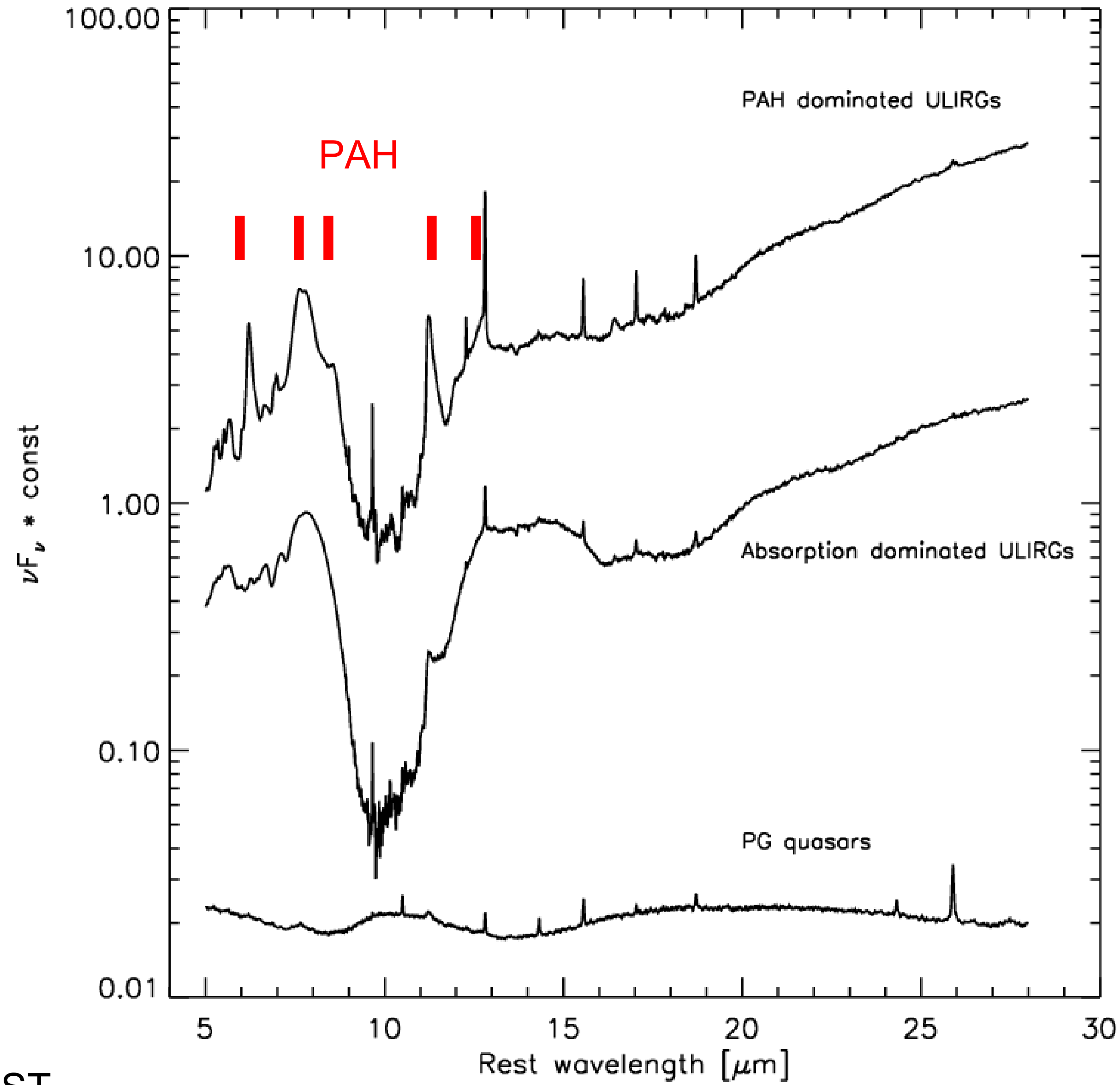
MPE

Mario Schweitzer, Eckhard Sturm, Hagai Netzer, Sylvain Veilleux, QUEST team…

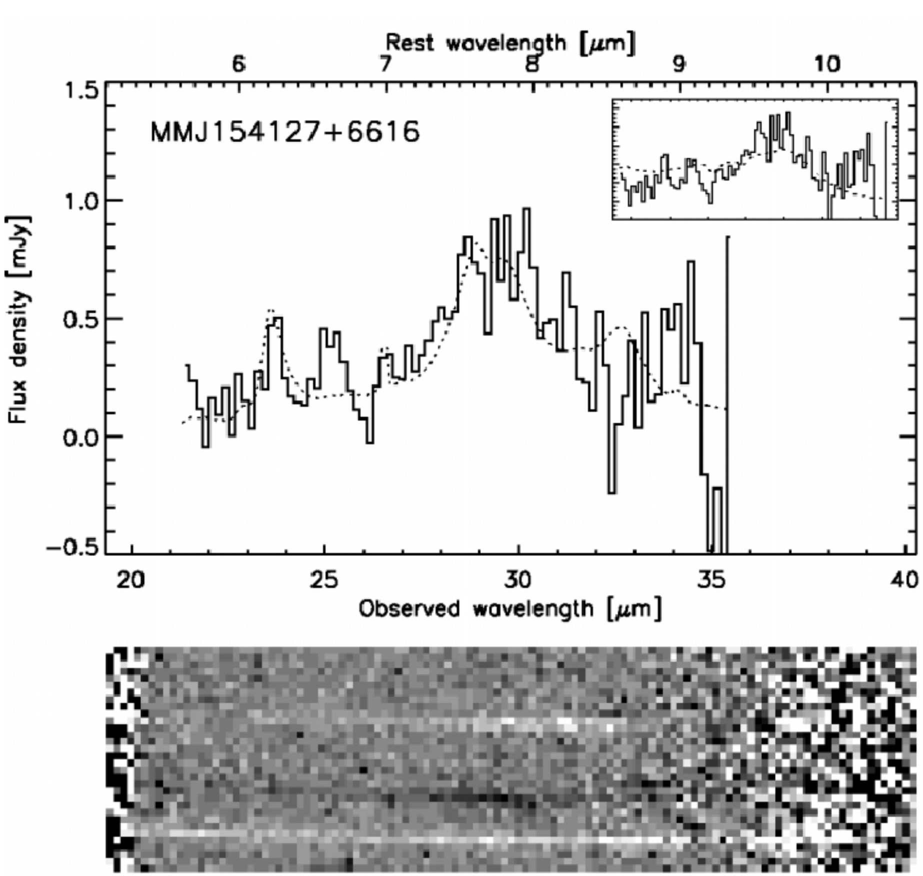
Tel Aviv, February 20, 2006

A new quality of mid-infrared spectroscopy

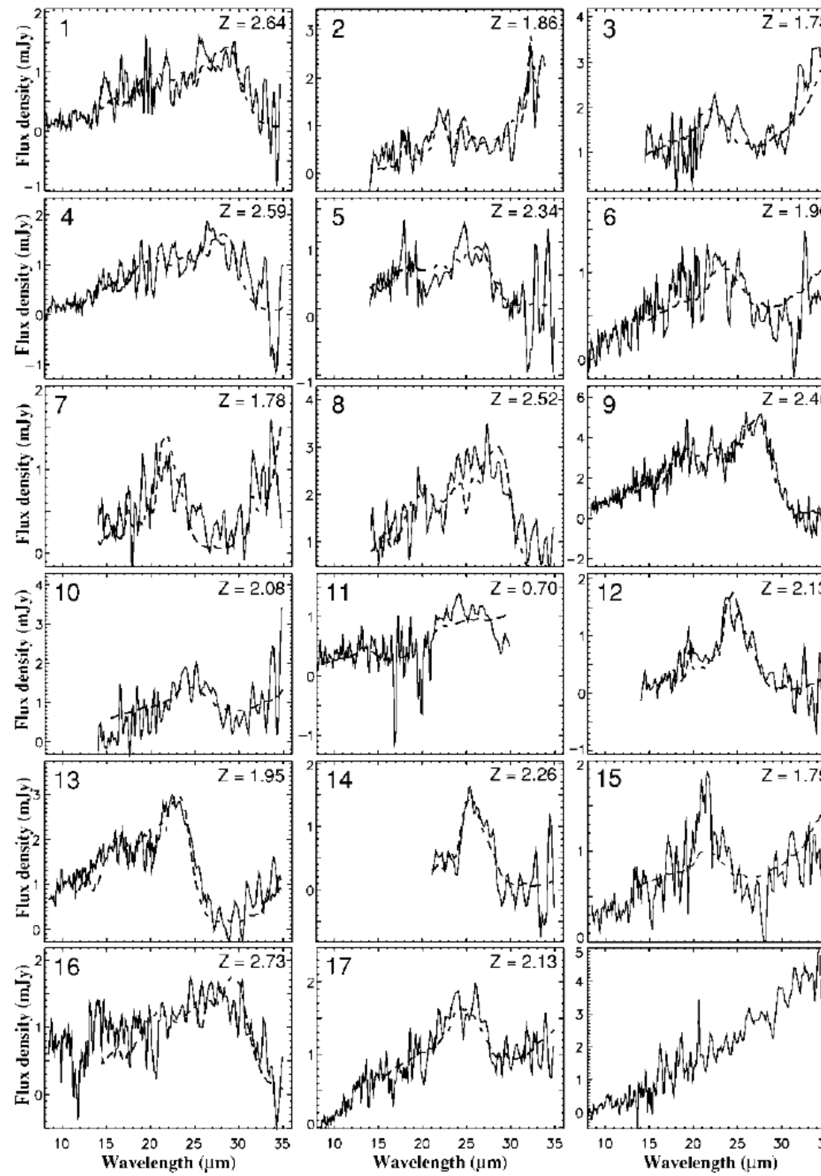


Spitzer QUEST

Opening the era of high-z infrared spectroscopy

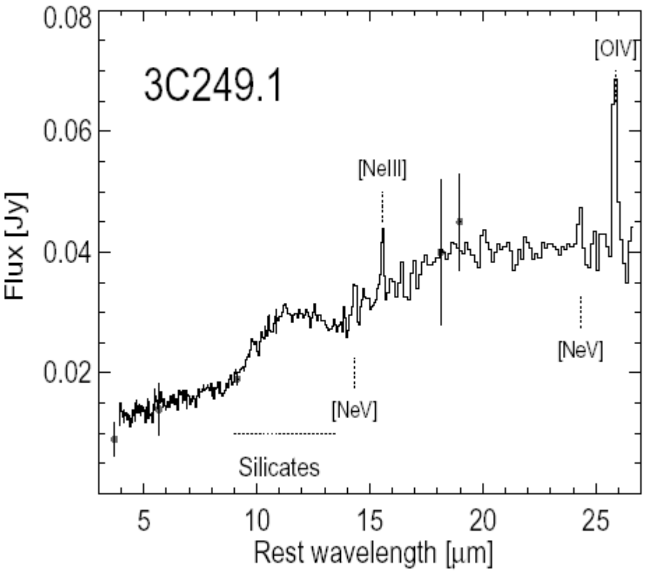


Lutz et al. 2005

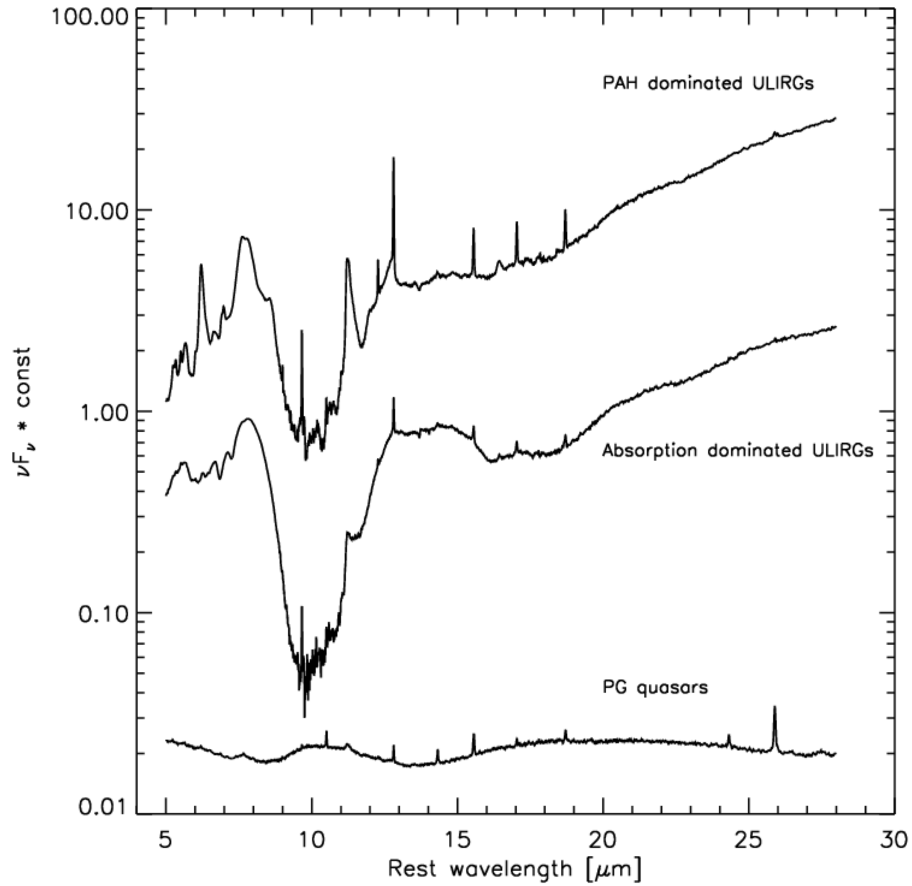


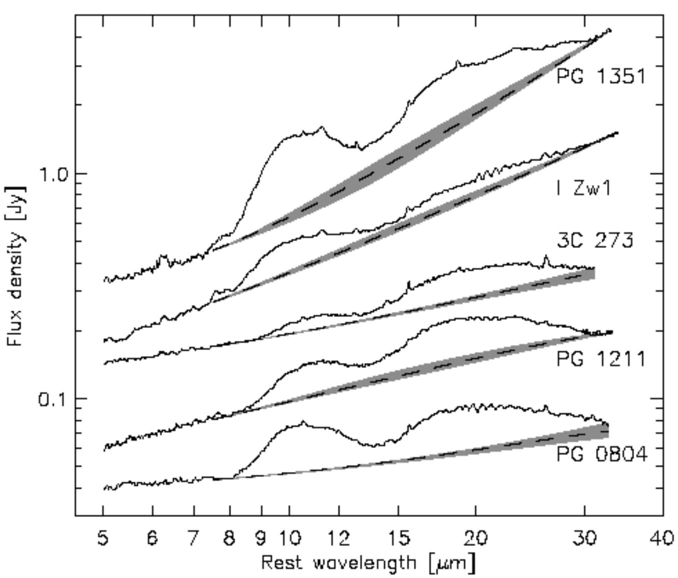
Houck et al. 2005

The first surprise: silicate emission in quasars



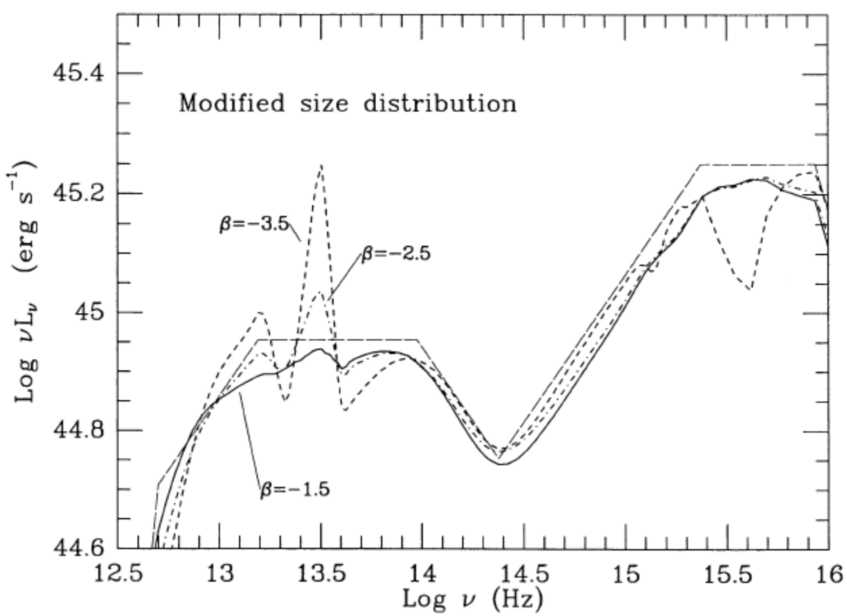
Siebenmorgen et al. 2005, Hao et al. 2005



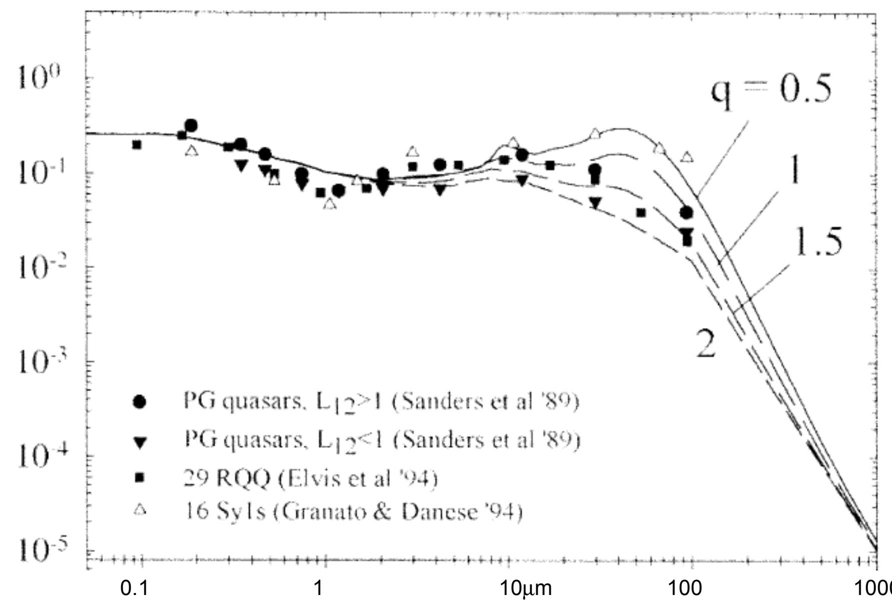


Predicted by unified models, but never observed before….

Suggested modifications to explain absence of silicate emission in type 1 AGN:
- changes of grain size distribution (Laor & Draine 1993, Maiolino et al. 2001)
- Special geometries, e.g. tapered disks (Efstathiou & Rowan-Robinson 1995)
- Clumpy tori (Nenkova et al. 2002)



Opt. thin dust, different size distributions (Laor & Draine 93)

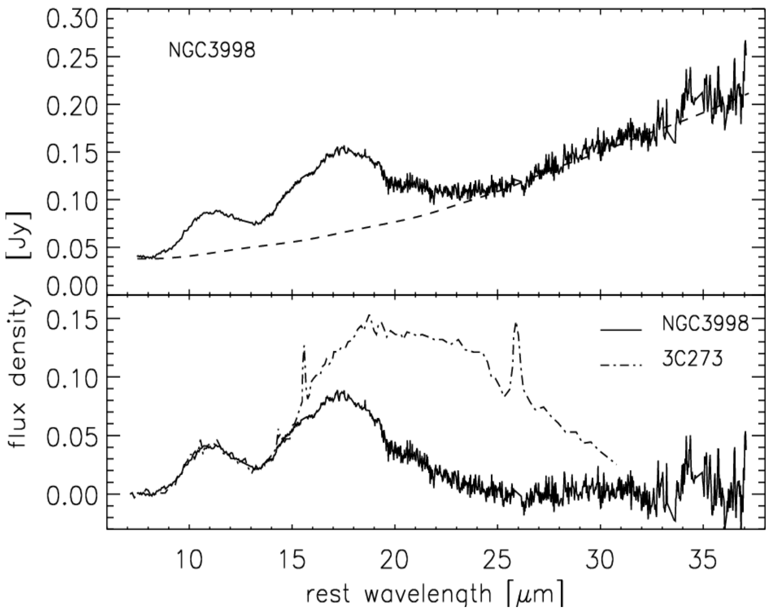


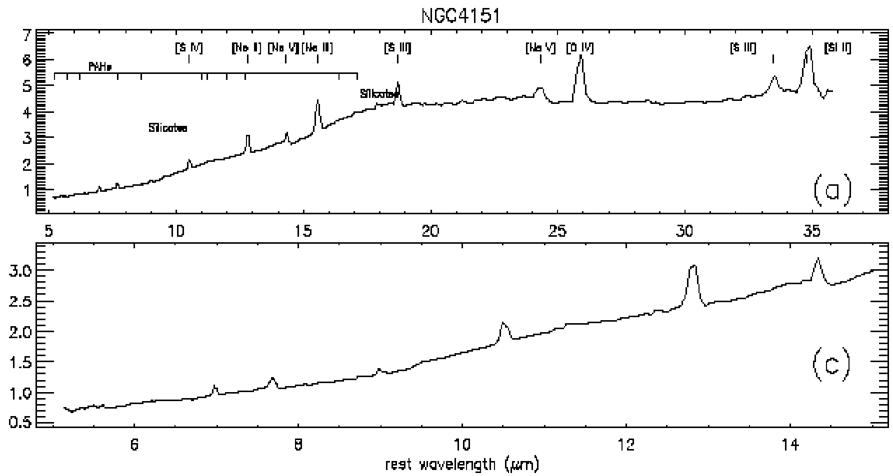
Type 1 SED for different radial distributions of clumps (Nenkova et al. 02)

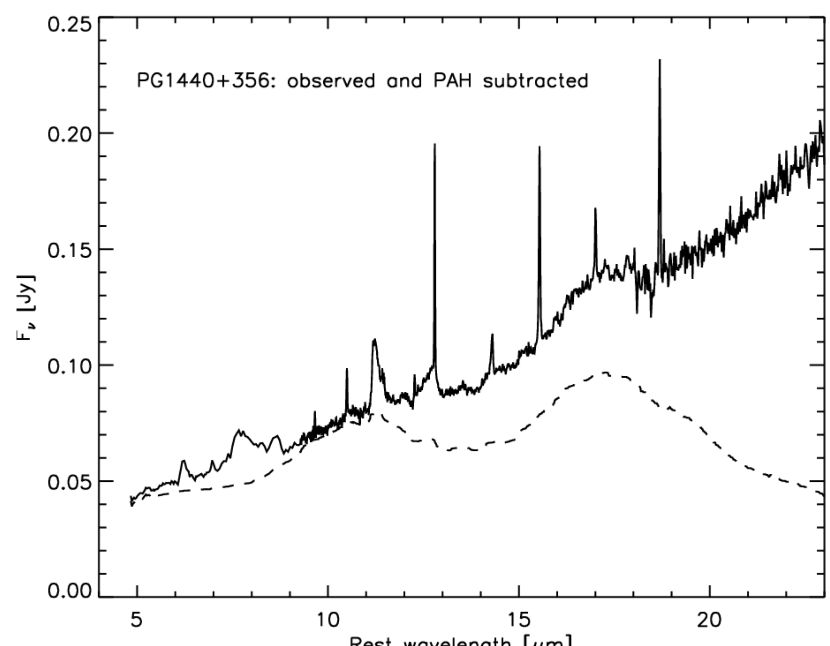
…observed also at lower luminosity

NGC 3998 (Liner 1.9) Sturm et al. 2005

NGC 4151 Weedman et al. 2005







Finding silicate around weaker AGN more difficult (PAH contamination….)

Is this the ‘unified’ silicate emission?

• Sizeable population of Type 1 AGN with silicate emission

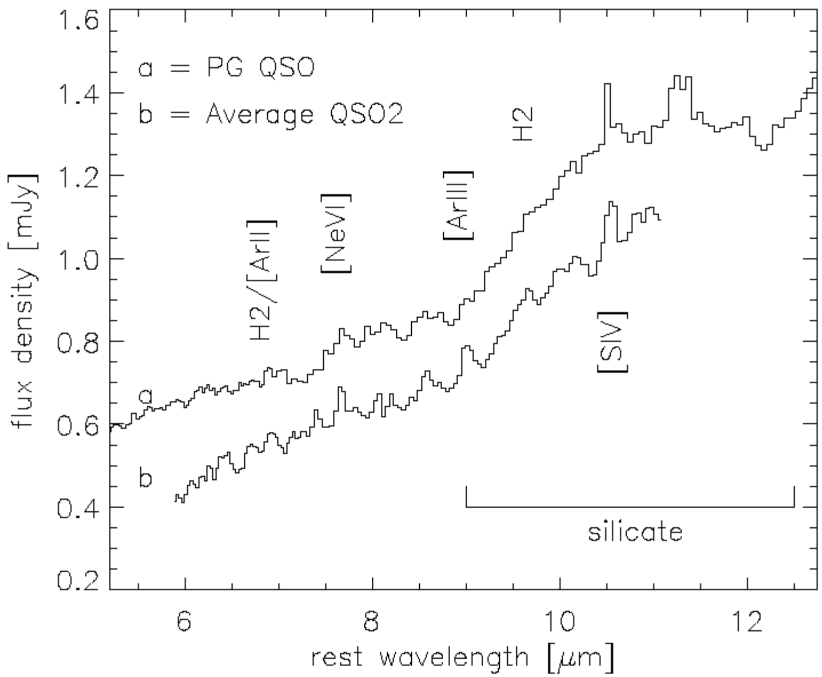
• Incidence as a function of luminosity and other factors still under investigation

• Demonstrates presence of a significant component of optically thin silicate dust

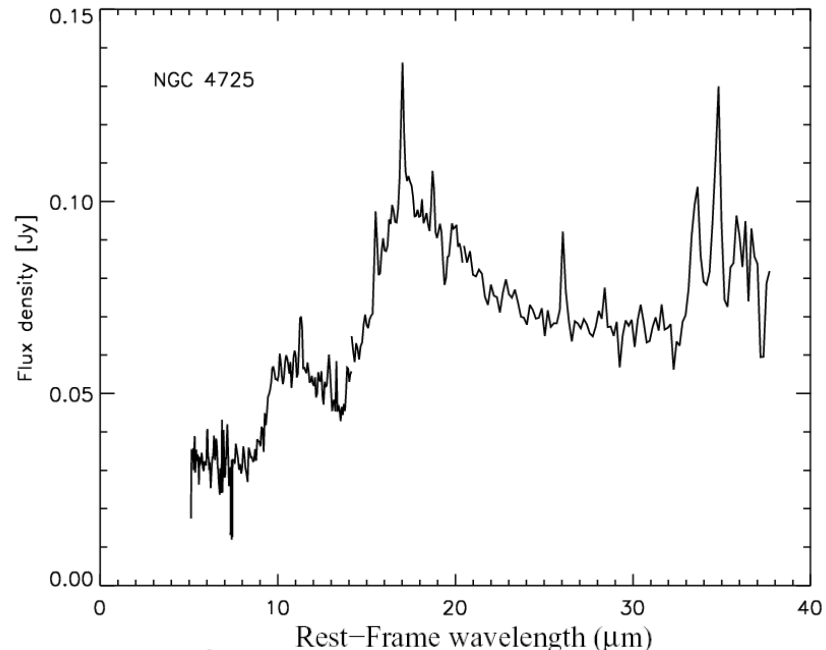
• **Cold** Temperatures ~140K-220K (from feature ratio and ISM silicate emissivity profile). Too cold for inner side of torus near sublimation but ok for dust further out, e.g. in the NLR?

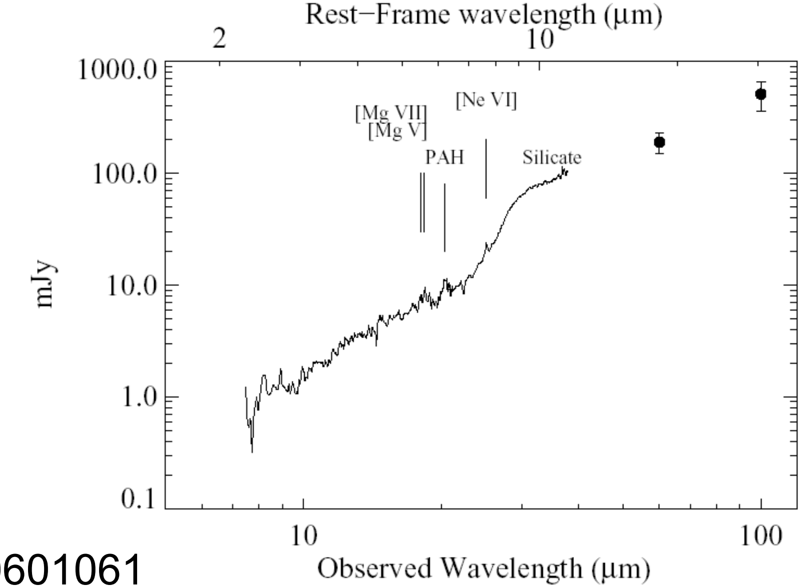
Silicate emission in Type 2 objects!

NGC 4725: Type 2 AGN from Ho sample
(SINGS data, Kennicutt et al.)



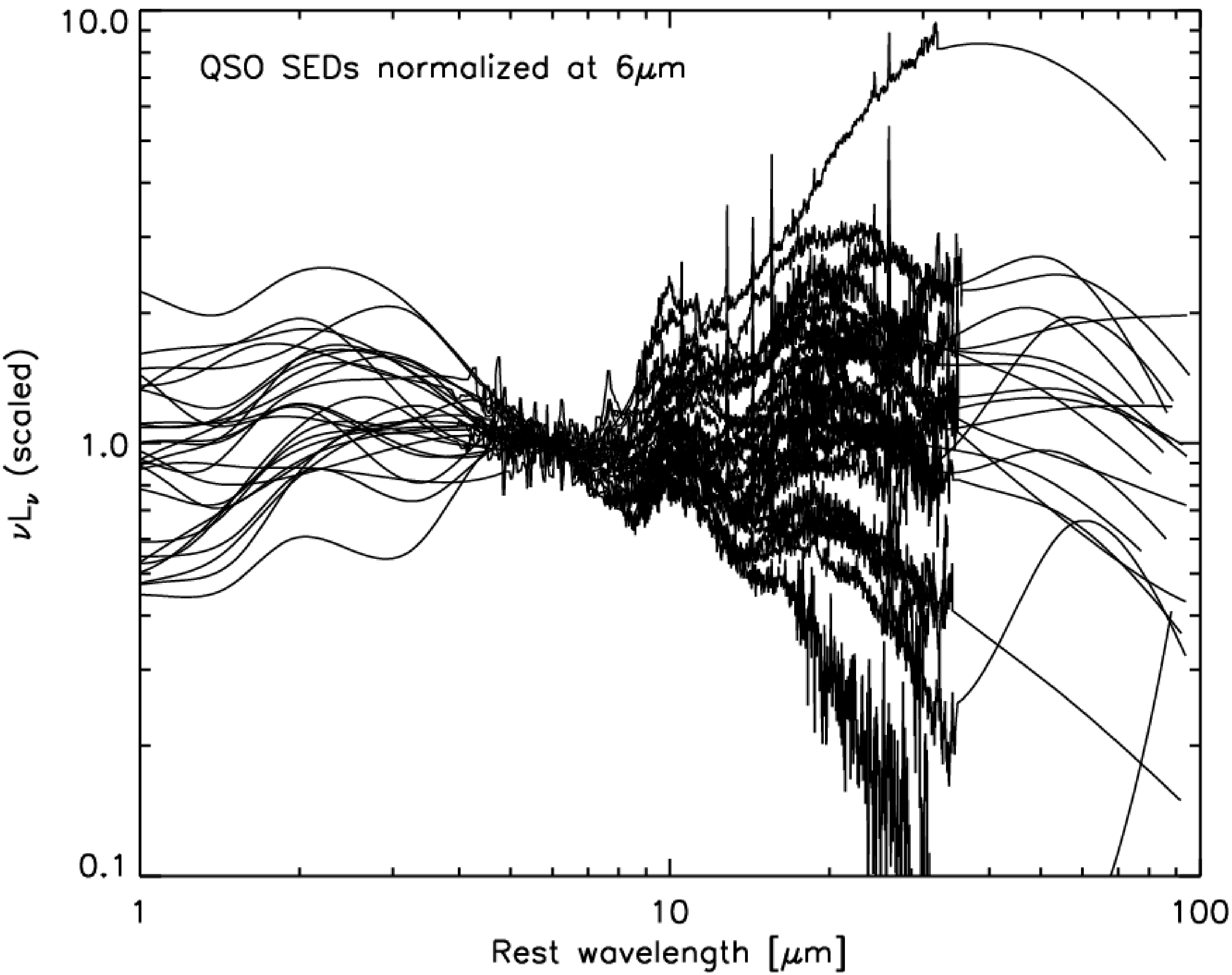
QSO2s: Sturm et al. 2006 astro-ph/0601204



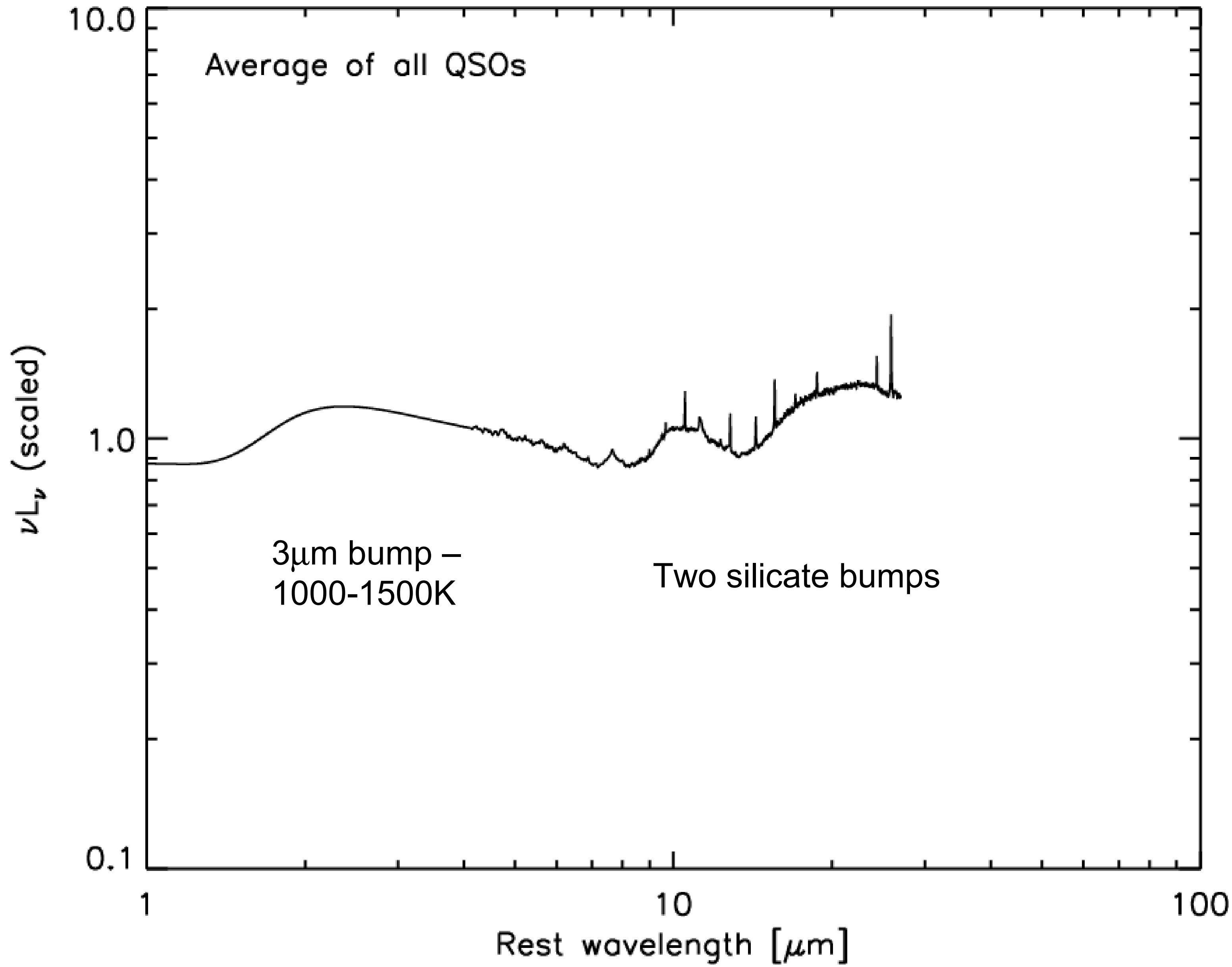


IRASF10214+4724: Teplitz et al. 2006 astro-ph/0601061

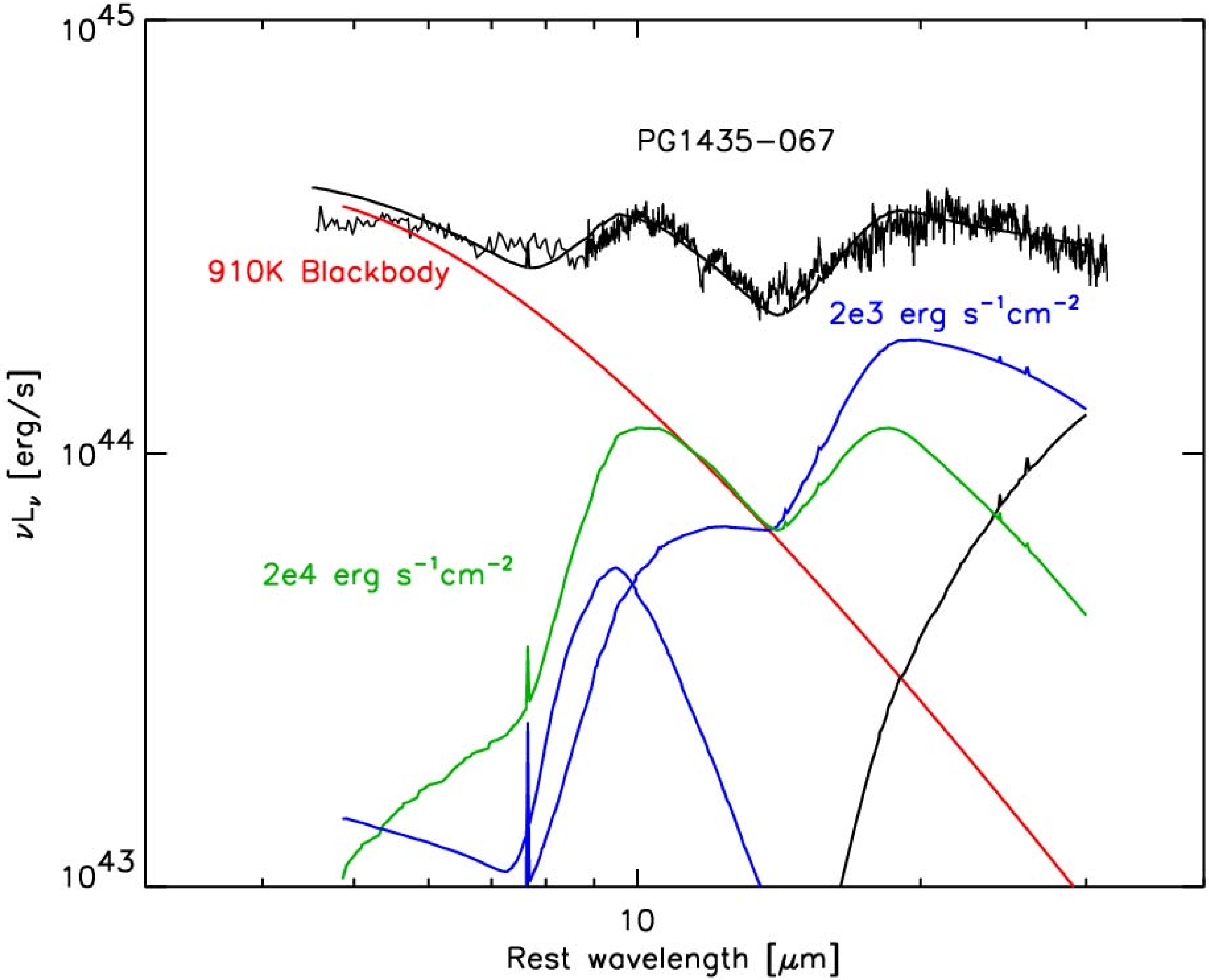
1-100μm QSO SEDs



Average QSO SED: three mid-infrared bumps

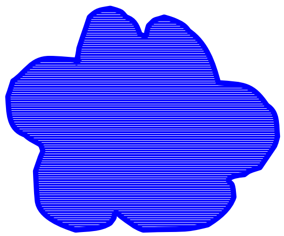


Conditions in the silicate emitting region



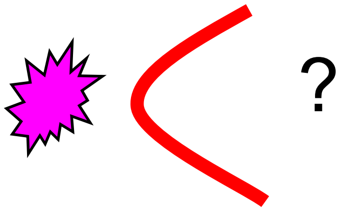
Illuminated cloud models: Brent Groves (MPA)

The most simple cartoon…



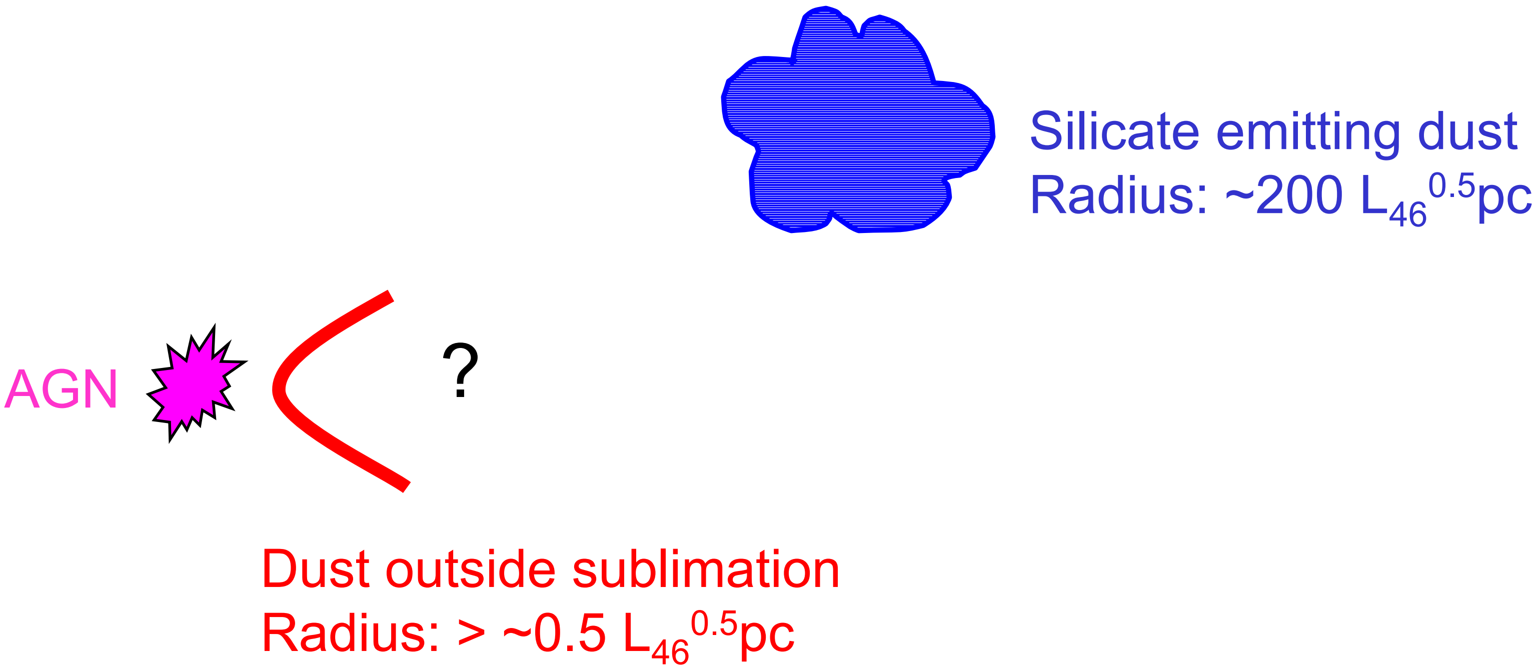
Silicate emitting dust
Radius: ~200 $L_{46}^{0.5}$pc

AGN



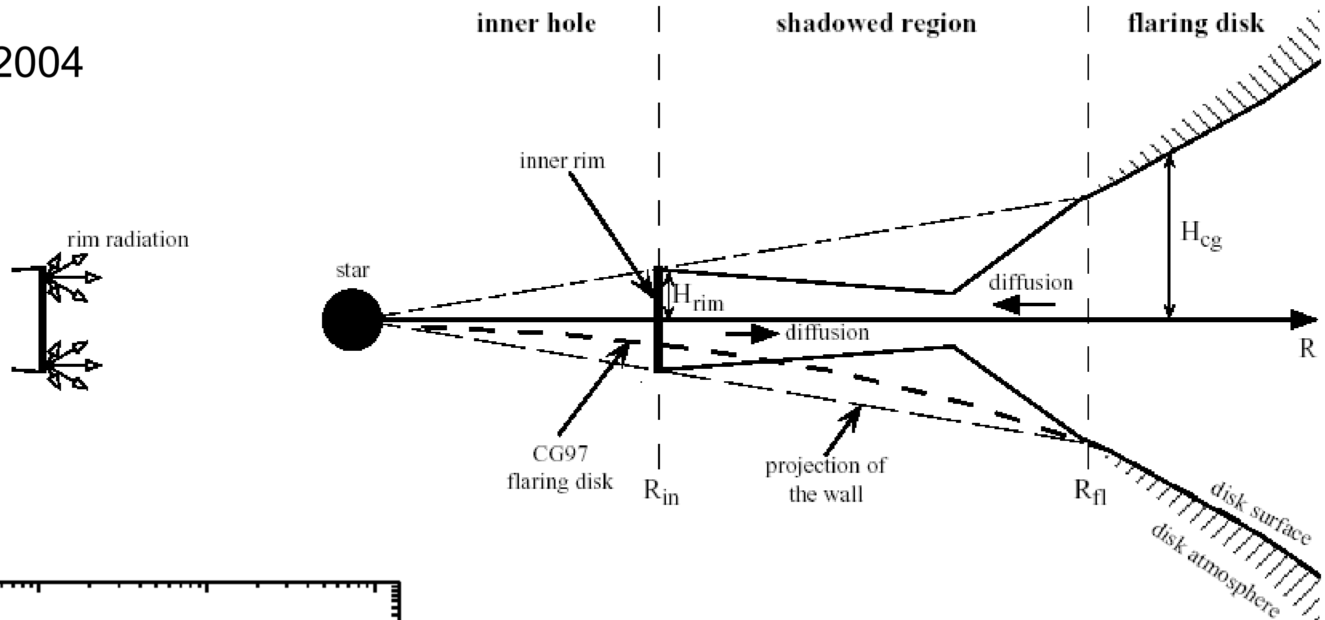
Dust outside sublimation
Radius: > ~0.5 $L_{46}^{0.5}$pc

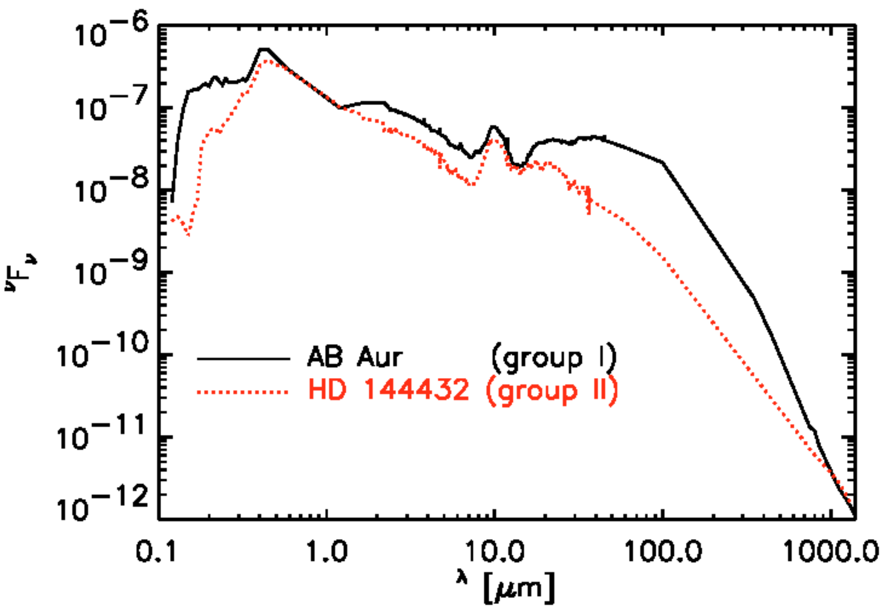
Another most simple cartoon…



Similar Galactic SEDs: flared, passive irradiated protostellar disks

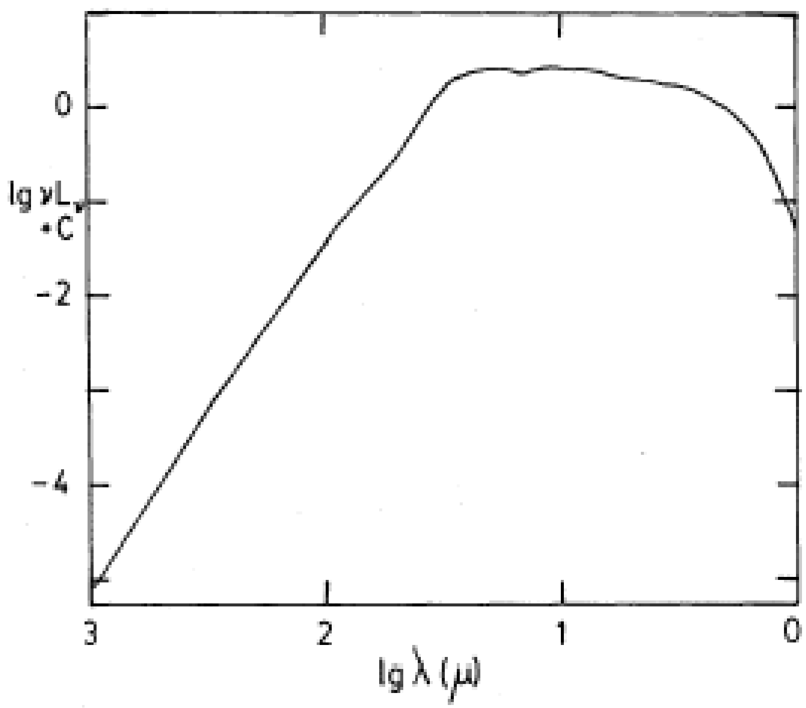
Dullemond et al. 2001, 2004

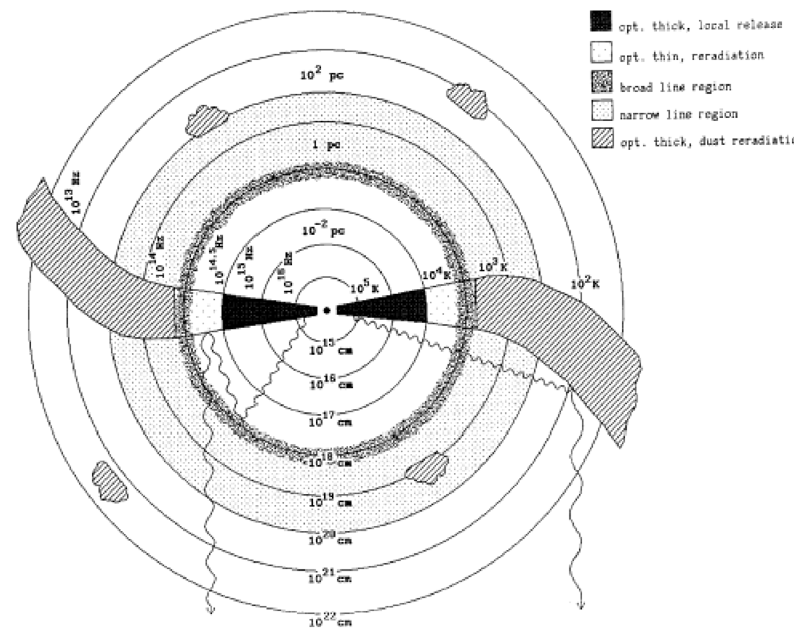




… but of course cannot be scaled simply!

The origin of QSO far-infrared emission



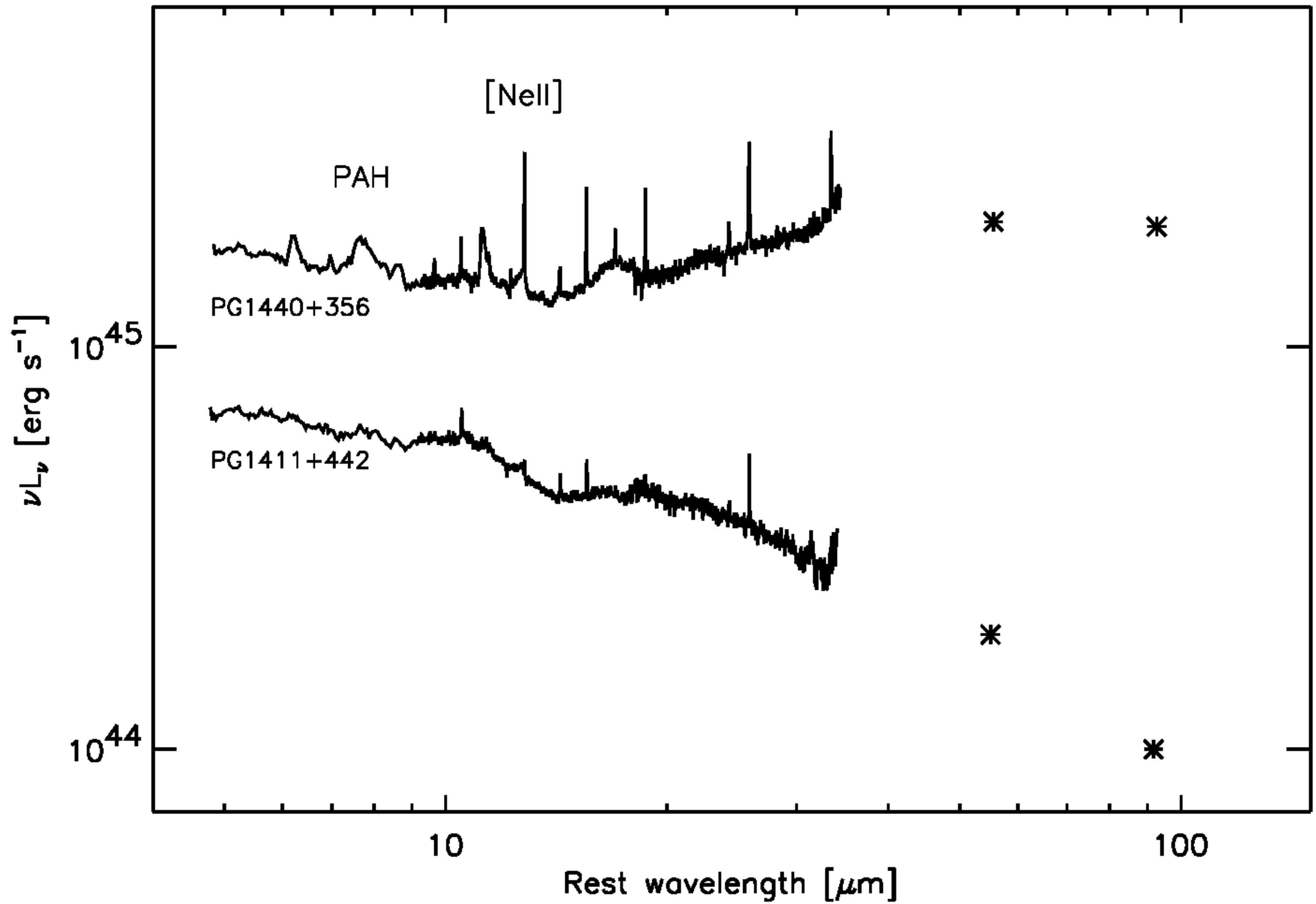


Rowan-Robinson (1995) pure AGN SED – strong far-infrared then must be star formation

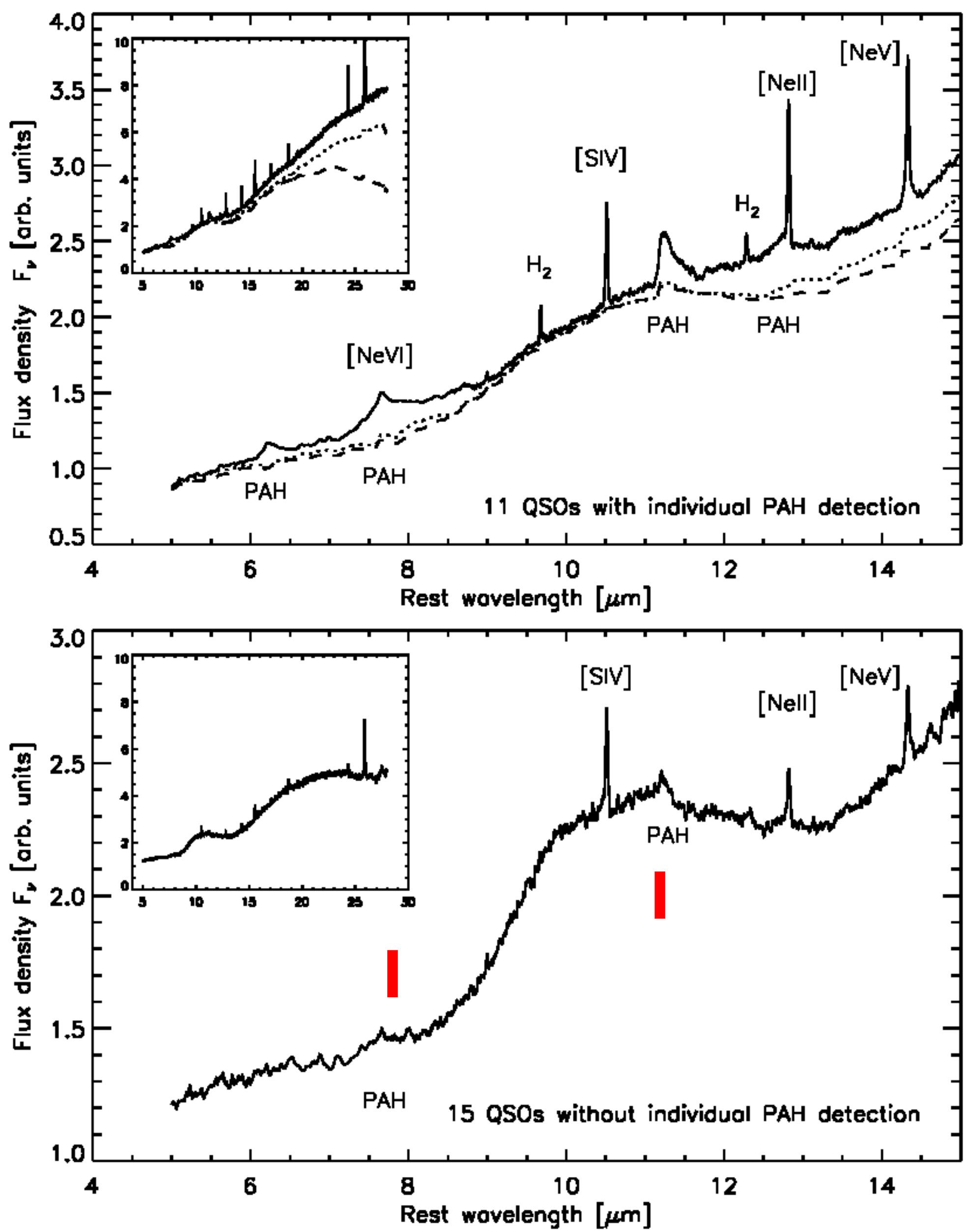
Sanders et al. 1989: warped disk could provide enough cold but AGN-heated dust

Ho 2005: [OII] 3727 study
- SF inhibited by QSO?

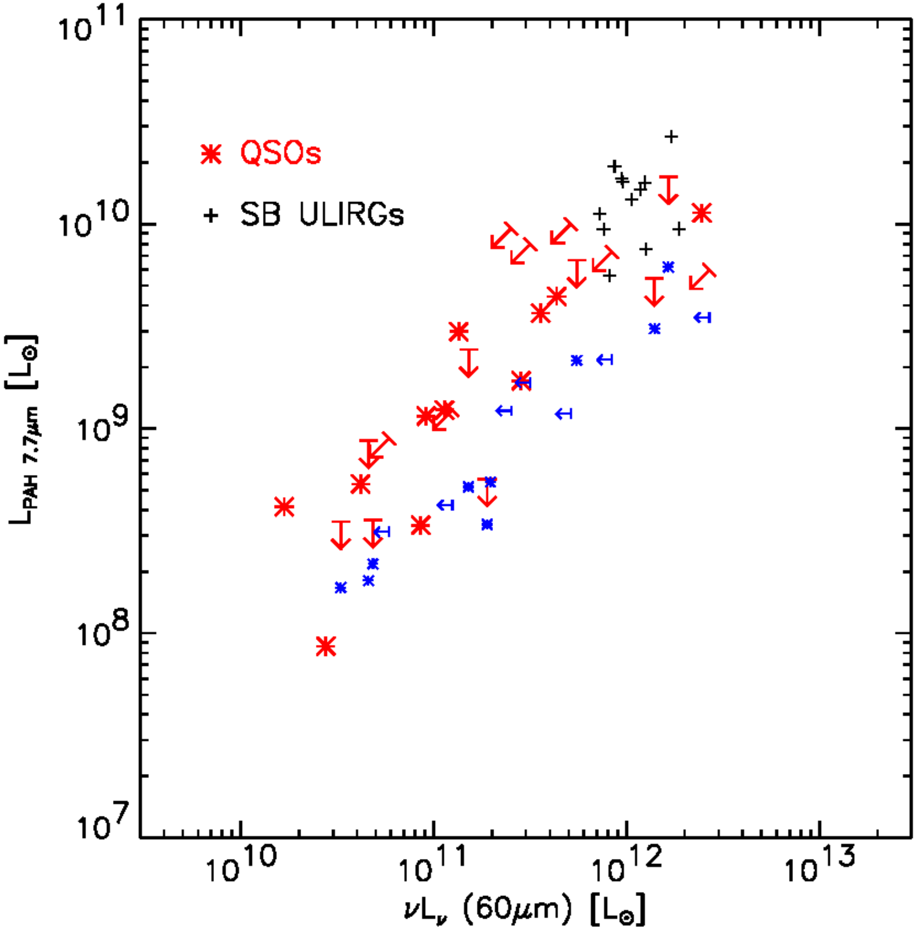
QSOs with strong/weak PAH and [NeII]

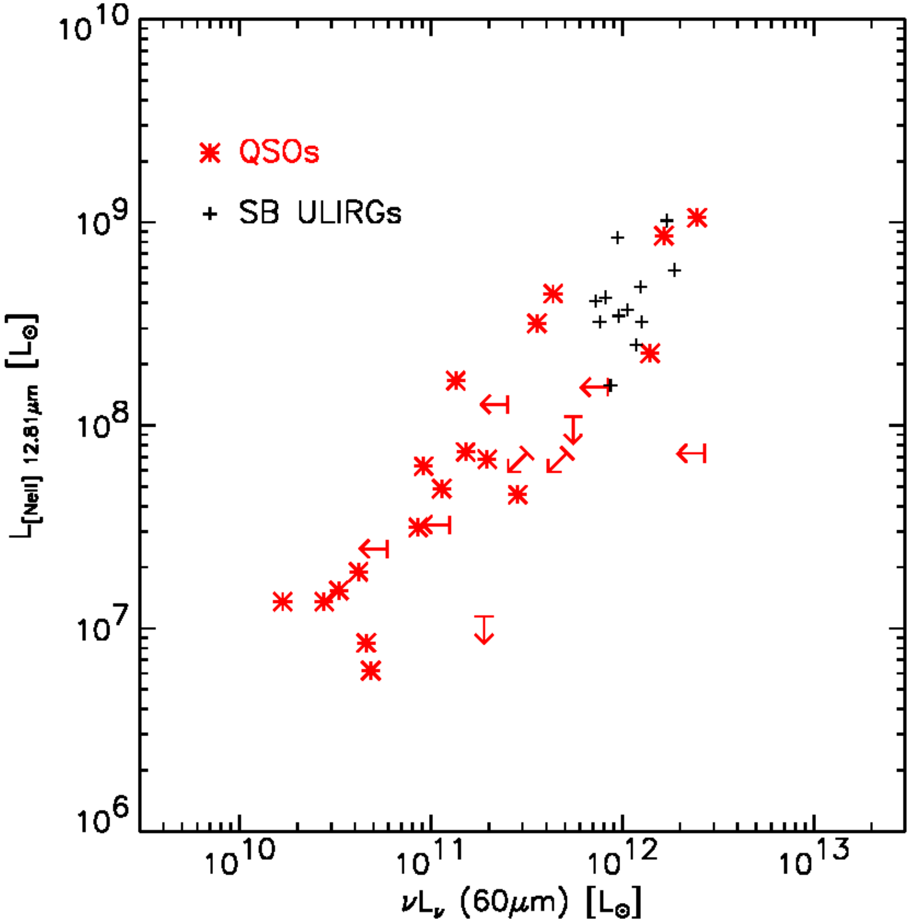


Average spectra: PAH is widespread



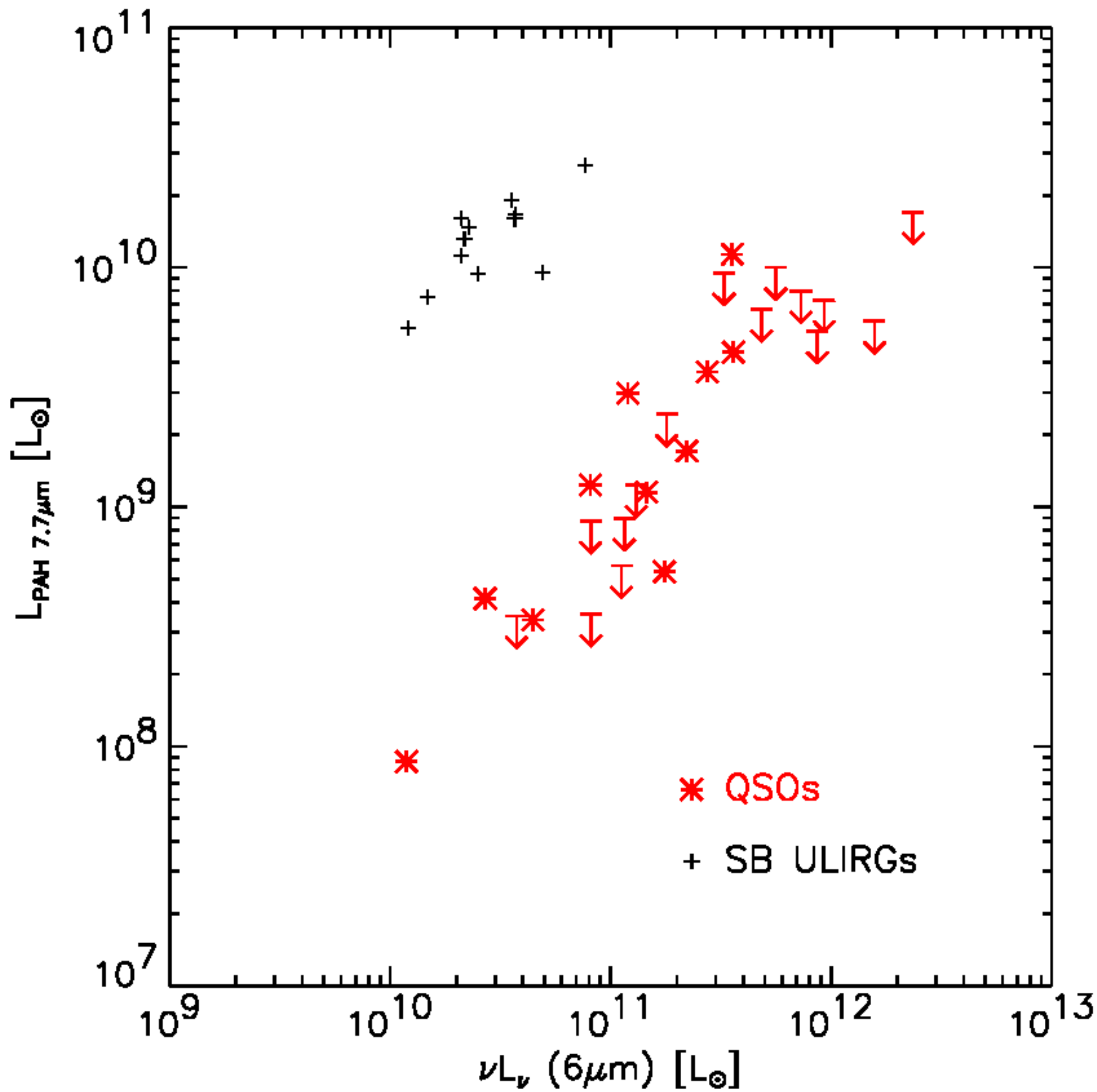
Star formation tracers and far-infrared emission





Ratios in QSOs
= Ratios in starbursting ULIRGs

Starburst-AGN connection



Conclusions

- Silicate emission widespread in Type 1 AGN, and also detected in some Type 2 objects – not a straightforward unification effect…
- 3μm and silicate bumps in SED: matter near sublimation radius, and at few 100pc – detailed geometry?
- Far-infrared emission in QSOs arises mostly from star formation
- Star formation activity and AGN luminosity correlate up to high luminosity

If Tel Aviv gets too hot…

…re-visit the cool places