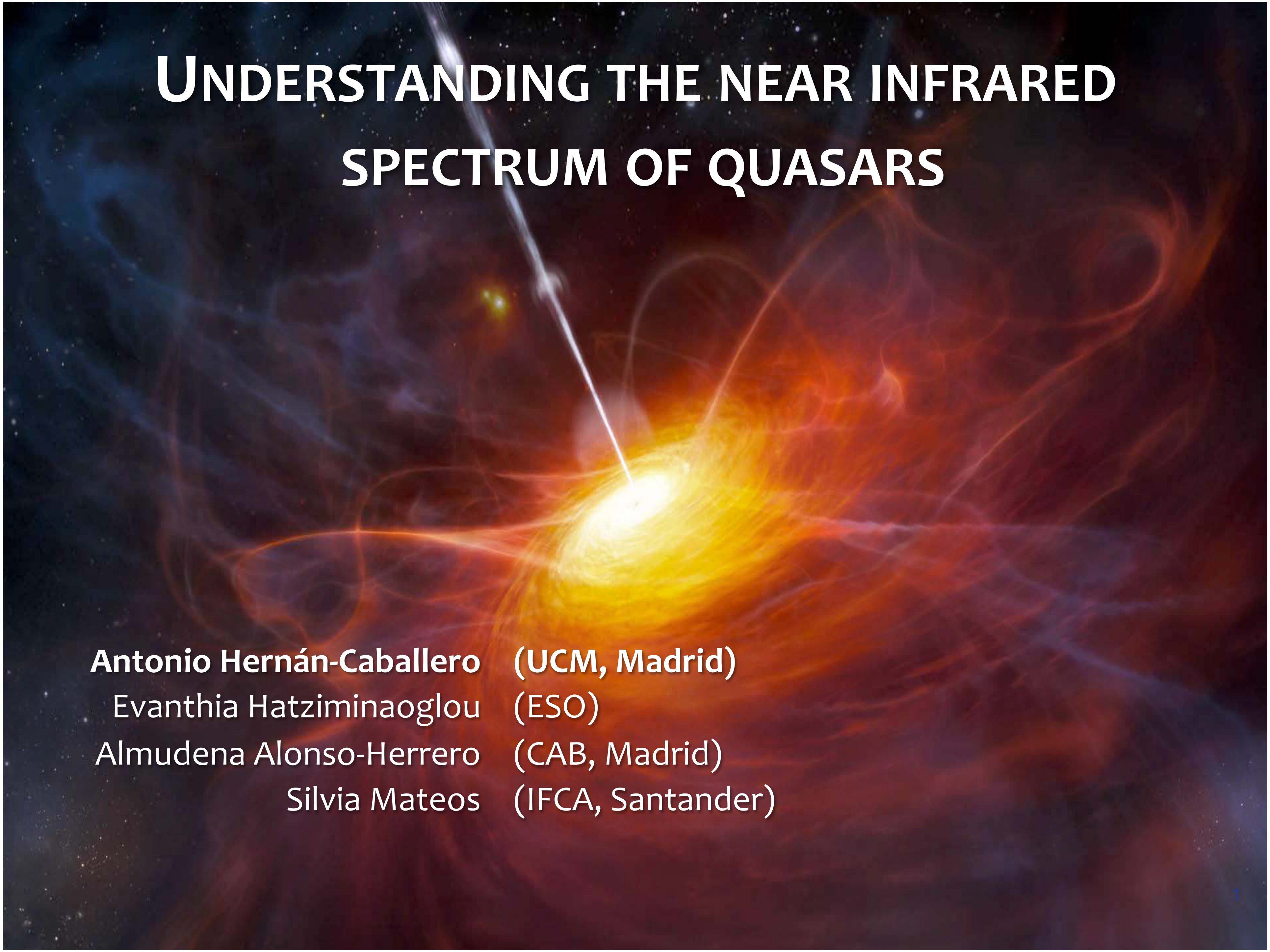

UNDERSTANDING THE NEAR INFRARED SPECTRUM OF QUASARS

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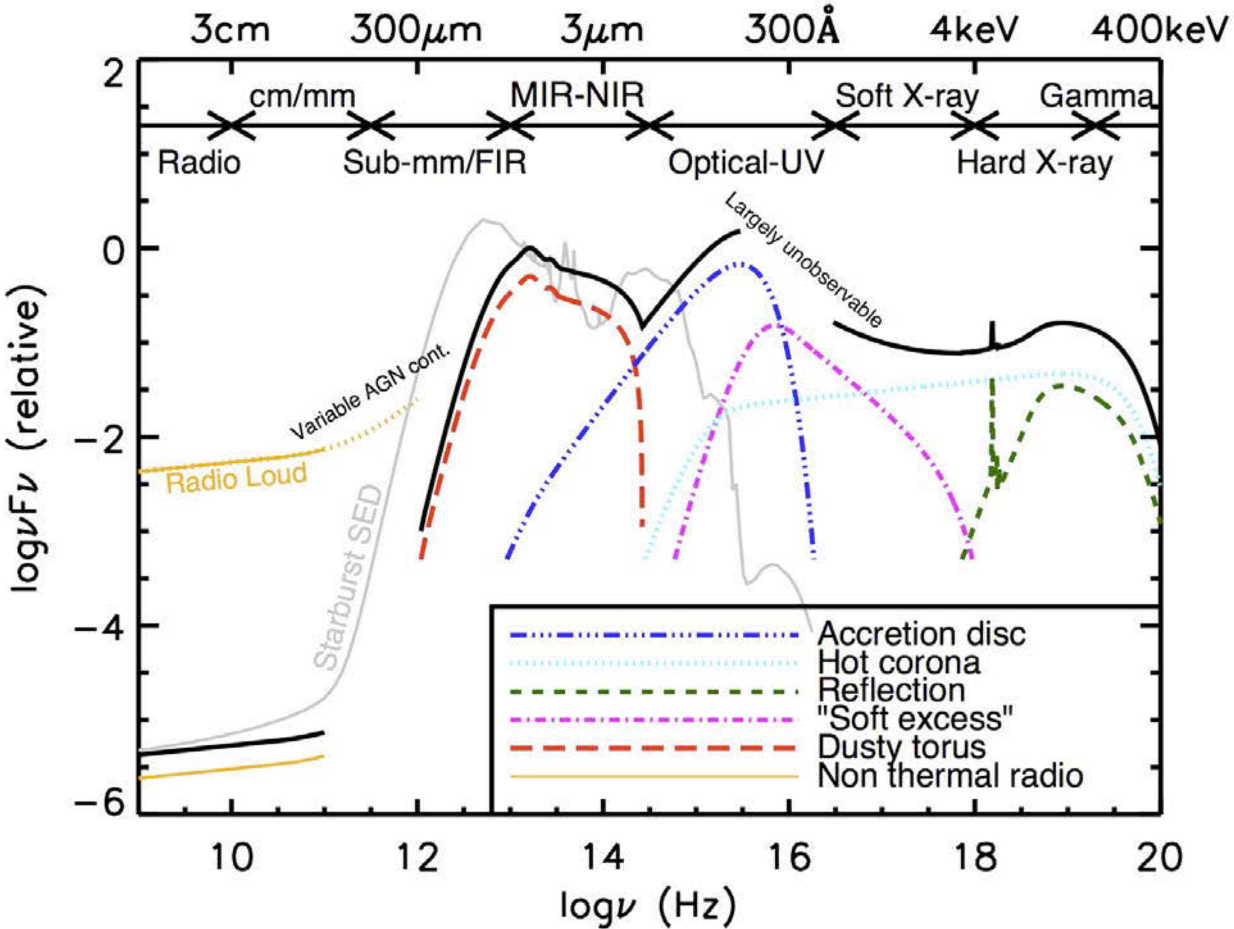
Spectral components of quasar emission



C. Harrison PhD Thesis (2014)

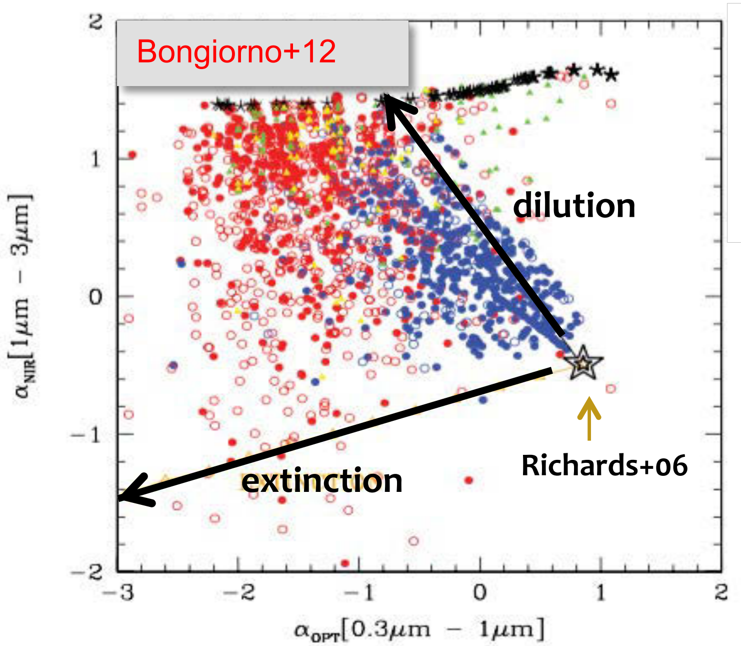
Near-IR range (1-3μm) important for understanding quasars:

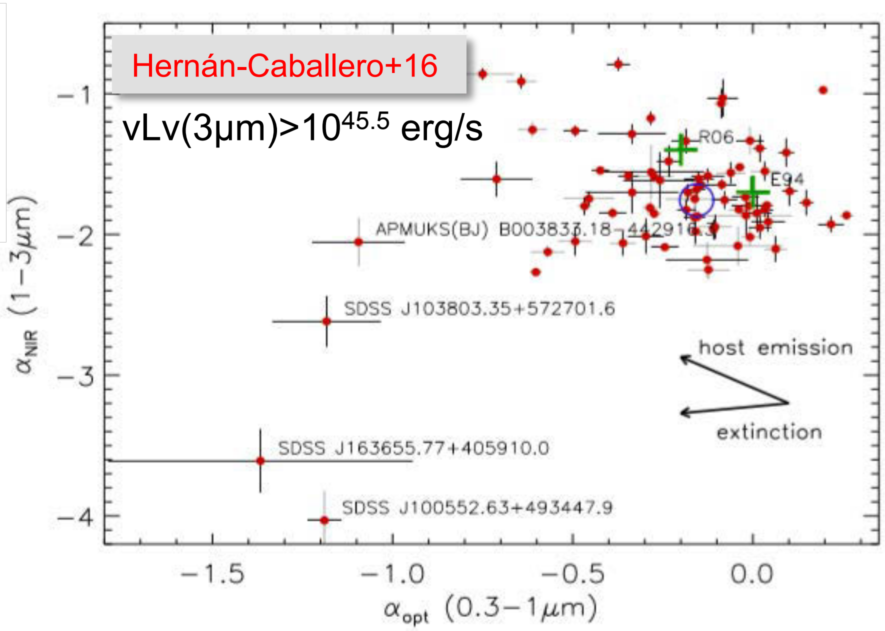
- accretion disk
- dusty torus

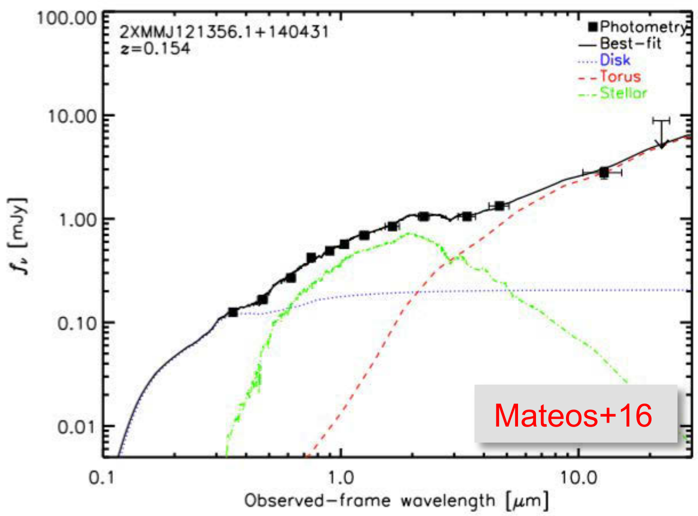
Models for the disk and dust emission at NIR wavelengths are uncertain

Components of NIR emission spatially unresolved

Variation in the slope of the NIR emission







Causes for variation in NIR spectral index:

- extinction
- stellar emission in host galaxy
- intrinsic

Luminous (νLν(3μm)>$10^{45.5}$) type 1 quasars:

- foreground extinction negligible at >1μm
- peak stellar contribution < 10%

→ **intrinsic variation in NIR spectrum**

¿diferences in dust spectrum?

¿or differences in dust/disk luminosity ratio?

Objective

To perform a careful **subtraction** of the **disk emission**
in a sample that is **free** from **stellar** contamination
to reveal the actual **shape** of the **dust emission**
and its **dependence** with other **AGN properties**

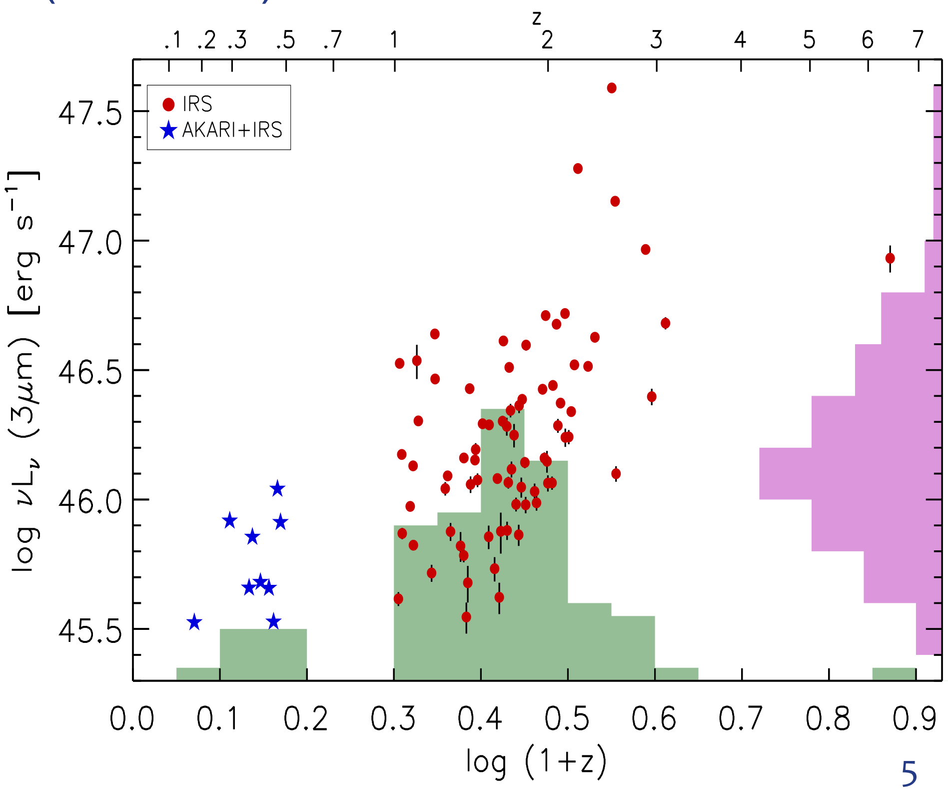
Luminous quasar sample

Sample selection criteria

* Spitzer/IRS spectrum in CASSIS v7 (Lebouteiller et al. 2011)
* Optical spectroscopic redshift
* Type 1 AGN classification
* Full spectroscopic coverage in 2.5-5μm (restframe)
* νL_ν (3μm) > $10^{45.5}$ erg/s

76 z>1 quasars with Spitzer/IRS

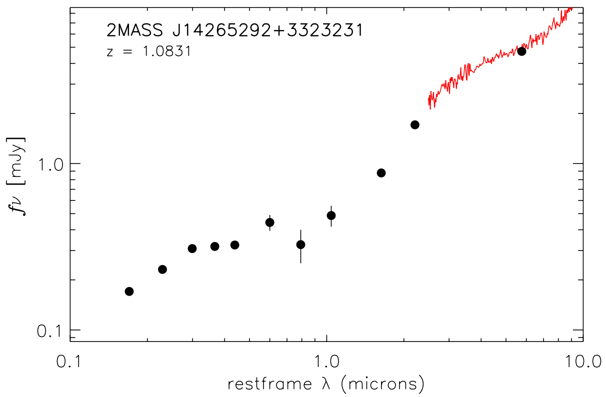
9 z<0.2 quasars AKARI + Spitzer/IRS

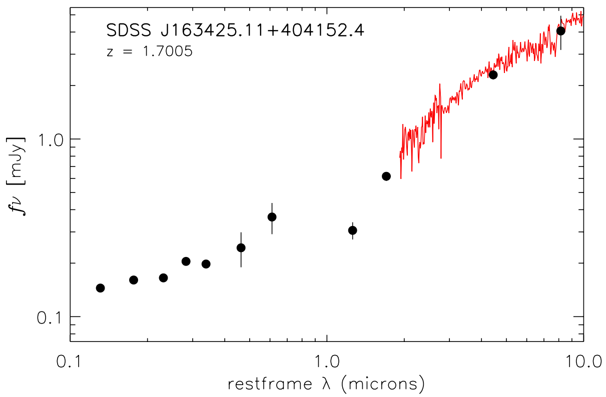


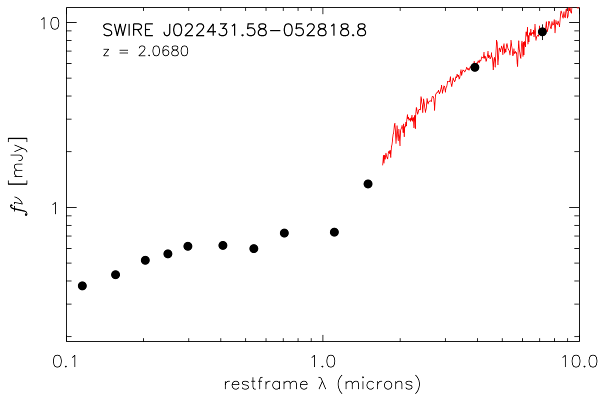
Broadband data

- **Optical:** SDSS DR12 *ugriz* (71) + NED
- **Near-IR:** UKIDSS *YJHK* (24), VHS *JHKs* (14), 2MASS *JHK* (38) + NED
- **Mid-IR:** WISE 3.4, 4.6, 12, 22μm (85)

85% of sources with 7-8 points in restframe UV-optical (0.1-1μm)







Fitting the accretion disk

UV-optical = broken power-law + emission lines
→ too many free parameters

Fit 0.15-0.85μm SED with empirical quasar template
SED variation reproduced with extinction
→ only 2 free parameters!

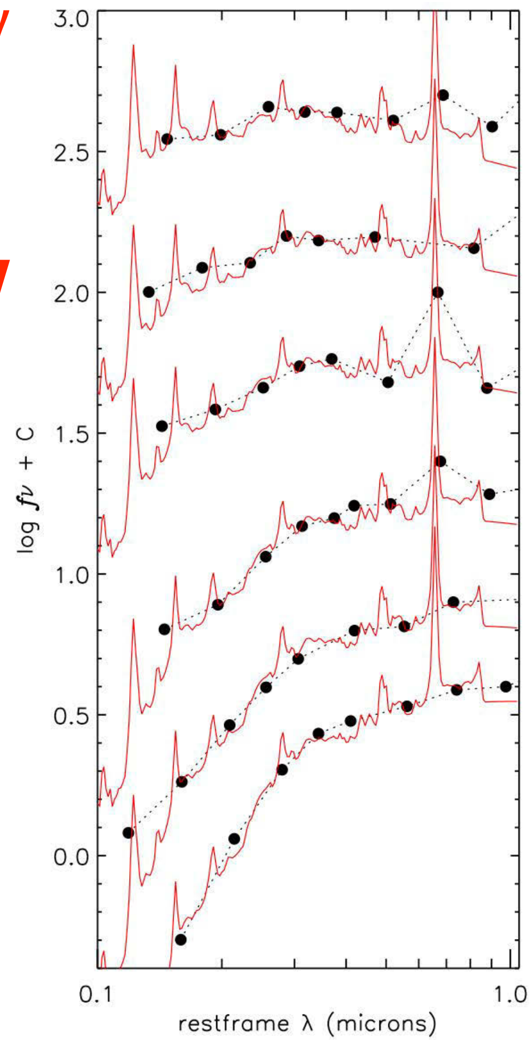
template: composite of 74 luminous (L_{bol}>$10^{46.2}$ erg/s) quasars at 1.5<z<3.5 (**Shen 2016**)

extinction law: **SMC bar**

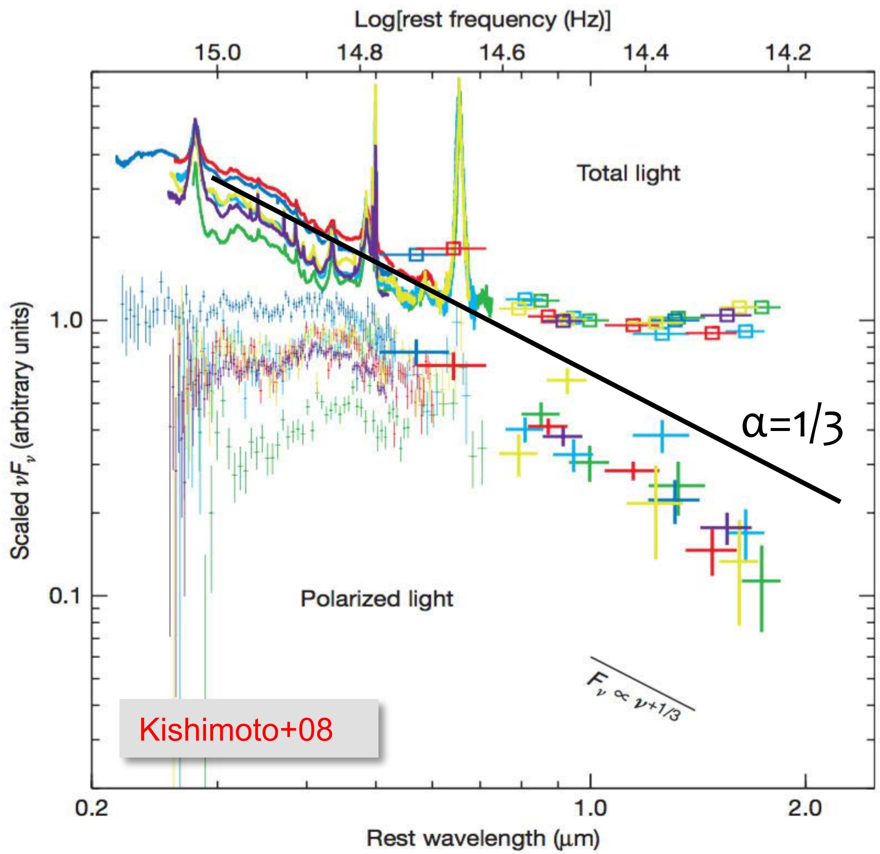
Results:
very good fits!
-0.1<Av<0.9 [90% with Av<0.4]
<Av>=0.05

Av obtained is relative to that in the quasar template

A_V

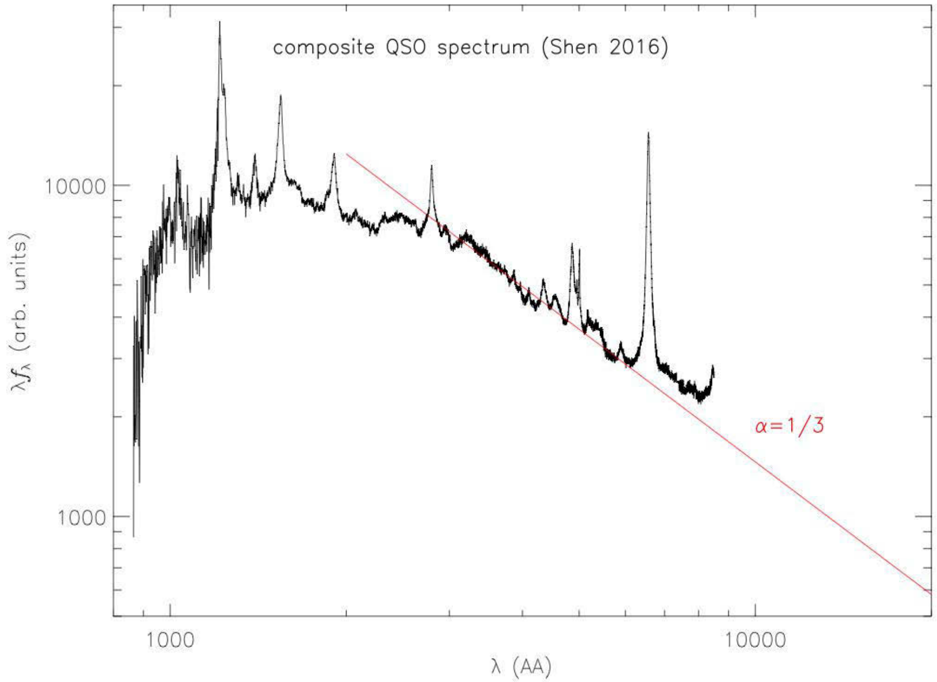


NIR emission from the disk (I)



Prediction for locally heated optically thick disk: $\mathbf{f}_\nu \propto \nu^{1/3}$ (Sakura & Sunyaev 74)

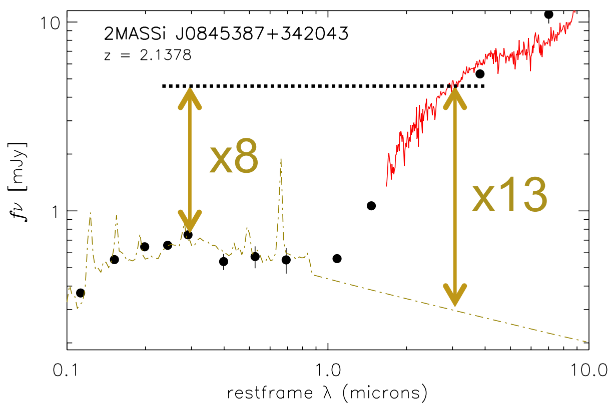
→ *confirmed by polarized light observations*



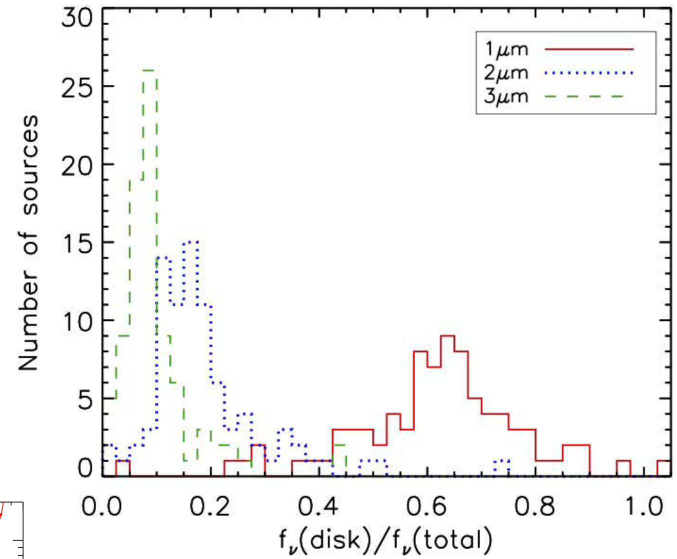
We extend the Shen composite with α =1/3 power-law scaled to match 0.3-0.6μm spectrum

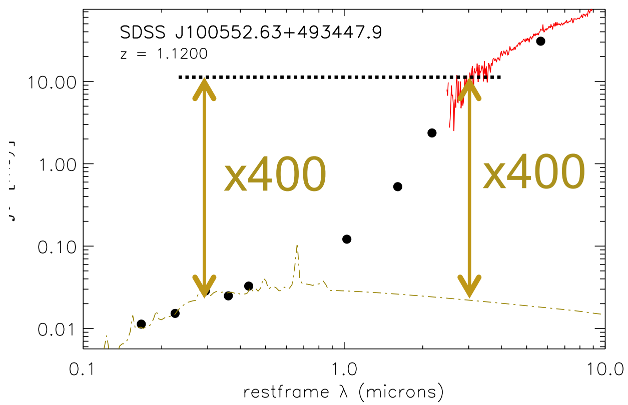
NIR emission from the disk (II)

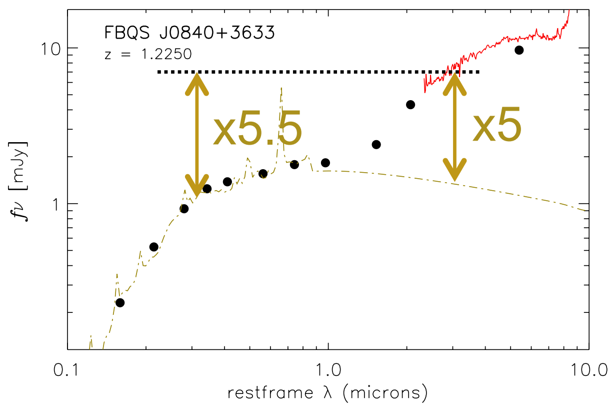
- Large source-to-source variation in disk contribution to NIR emission
- Variation due to differences in dust/disk luminosity ratio



Disk emission small but NOT negligible even at 3μm





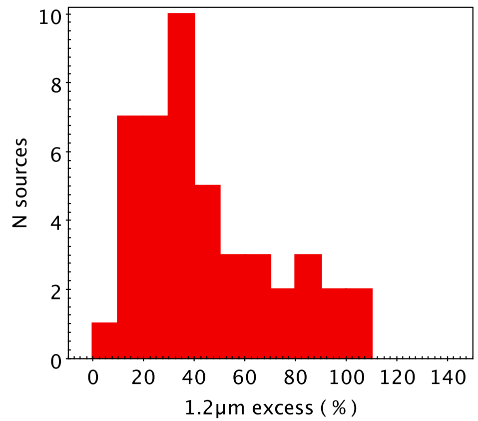


disk contribution decreases **steeply** with wavelength:
~63% at 1μm
~17% at 2μm
~8% at 3μm

NIR emission from the dust

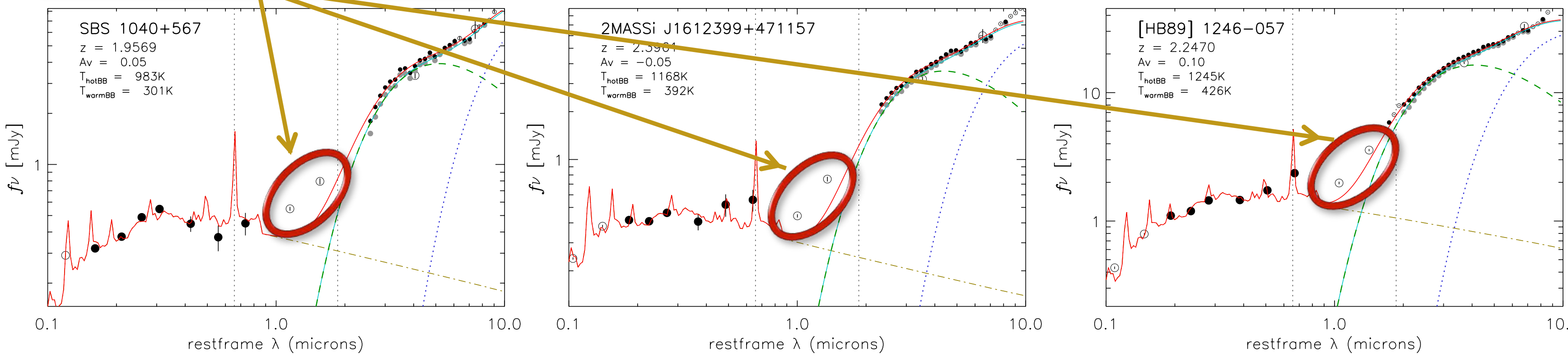
- Remove disk component (power-law extrapolation)
- Fit restframe 1.7-8.4μm with 2 blackbodies:

  T_{warm} = 150-800 K & T_{hot} = 800-2000 K



NIR excess = 40% (median)
of total flux @1.2μm →

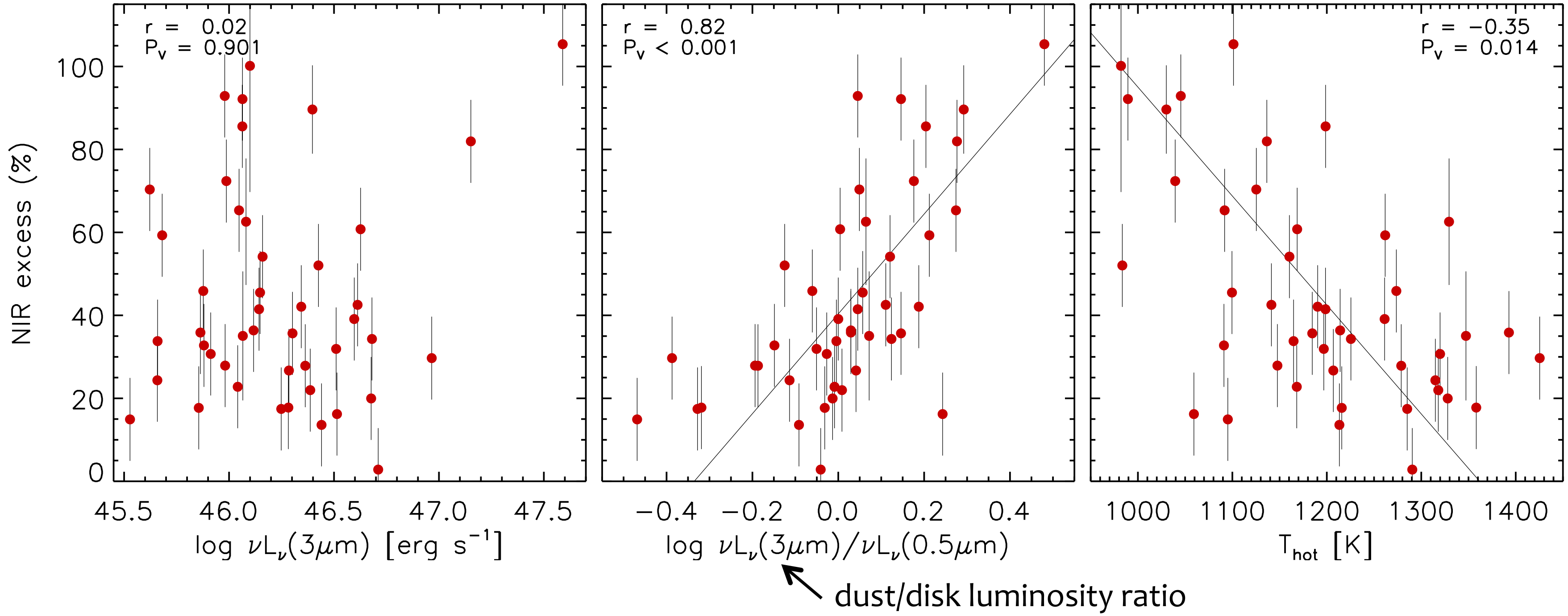
Good fits overall,
but systematic excess
at 1-1.5μm
over disk+dust model



Origin of the NIR excess

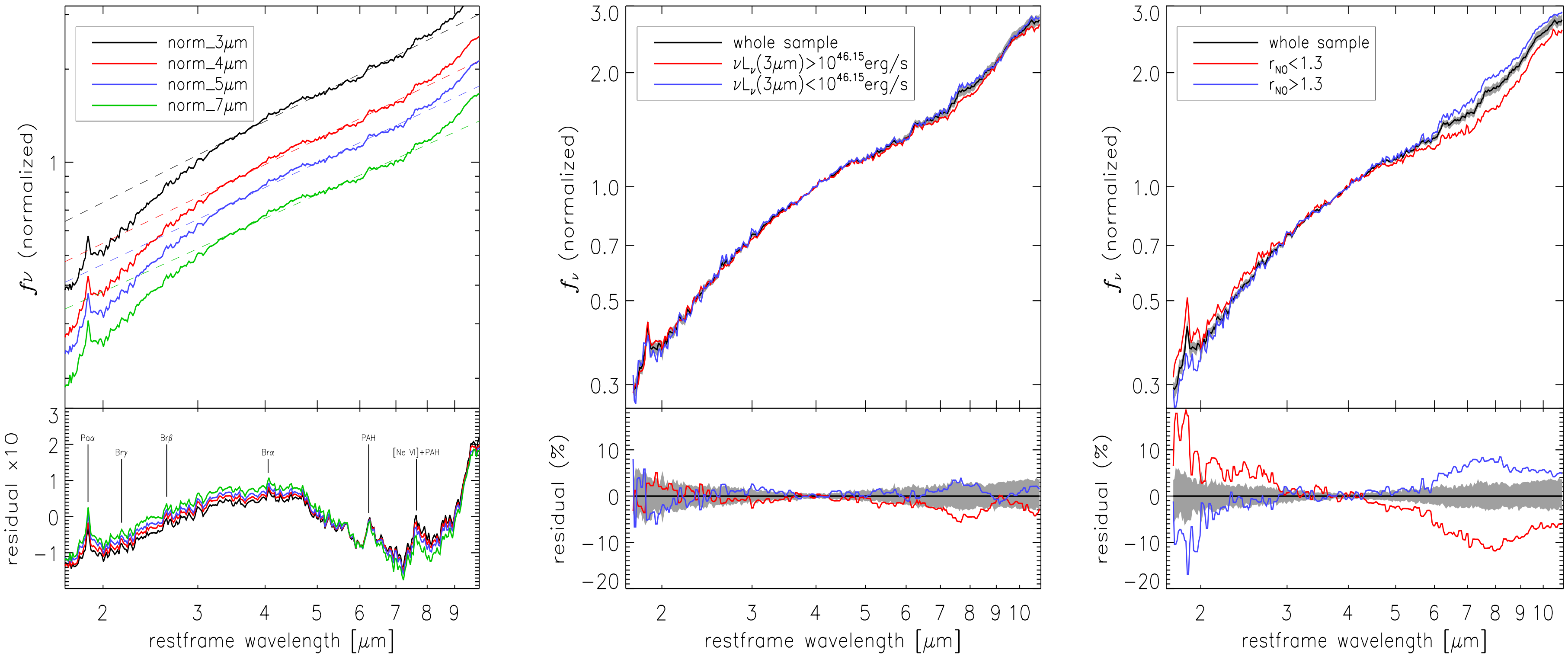
Hypothesis tested:

0) problems in photometry (calibration, apertures…) → no redshift dependence
1) stellar emission in the host → no correlation with AGN luminosity
2) extra emission from the disk → no anti-correlation with NIR/optical ratio
3) **extra emission from the dust → correlation with NIR/optical ratio**



Composite spectra

High S/N composite spectrum shows hydrogen lines, PAH features
No dependence of spectral shape with AGN luminosity
Weak dependence with dust/disk ratio → variation in covering factor
(see S. Mateos' talk)

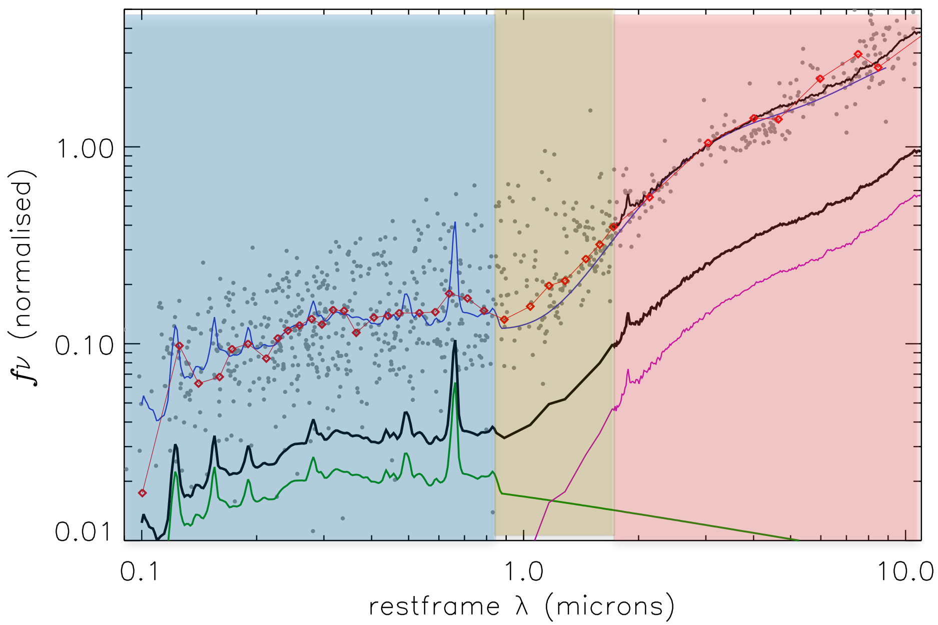


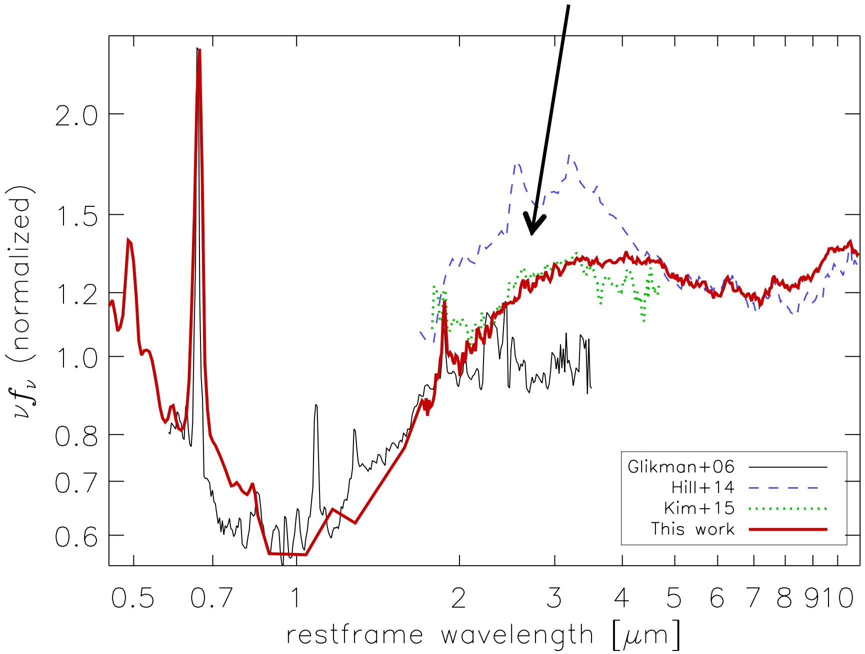
Quasar template

λ<0.85μm: median disk model (Shen template+Av)
0.85<λ<1.7μm: median broadband SED
λ>1.7μm: AKARI+IRS quasars composite

separate templates for disk and dust components

our template is the only one with full spectroscopic coverage of 3μm bump





Conclusions

* Variation in NIR spectral index caused by dust-to-disk luminosity ratio
* Single quasar template + Av reproduces variation in UV-optical SED
* α=1/3 disk + 2 blackbody dust provides good fit to 1.7-8.4μm spectrum
* NIR excess (1-1.5μm) caused by extra hot dust not included in model
* Hydrogen recombination lines and PAH bands detected in composite
* No luminosity dependence in NIR-MIR composite spectrum
* High dust-to-disk ratio → redder 1.7-10μm spectra
* We provide first quasar composite with full coverage of 3μm bump

Further info:

Hernán-Caballero et al. 2016, MNRAS submitted (**astro-ph/1605.04867**)