Hot-Dust Poor Type 1 AGNs in the COSMOS Survey

Hao et al. 2010, ApJL submitted

Heng Hao, M. Elvis, F. Civano
(Harvard Smithsonian Center for Astrophysics)

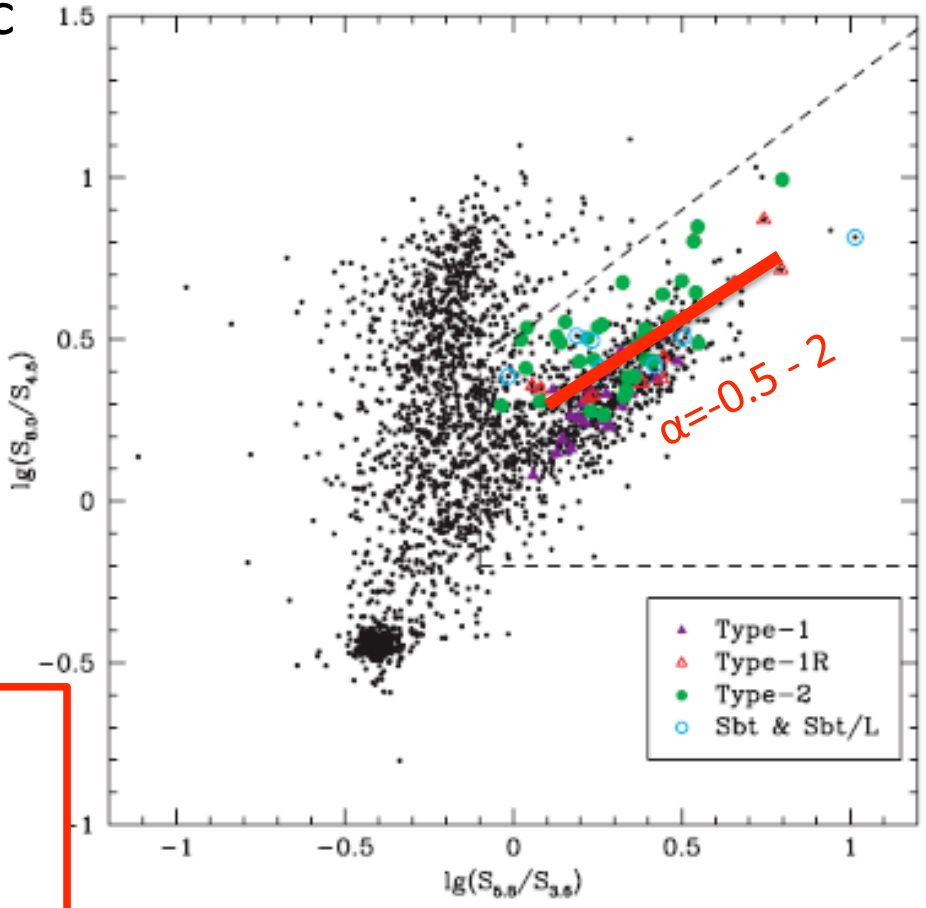
G. Lanzuisi, M. Brusa, M. Salvato, A. Comastri, E. Lusso
and COSMOS Team

Hot Dust Universal in AGN

- Hot dust emission is characteristic of AGN
  - not seen in starbursts
- Infrared slope selects AGNs, especially obscured ones ,

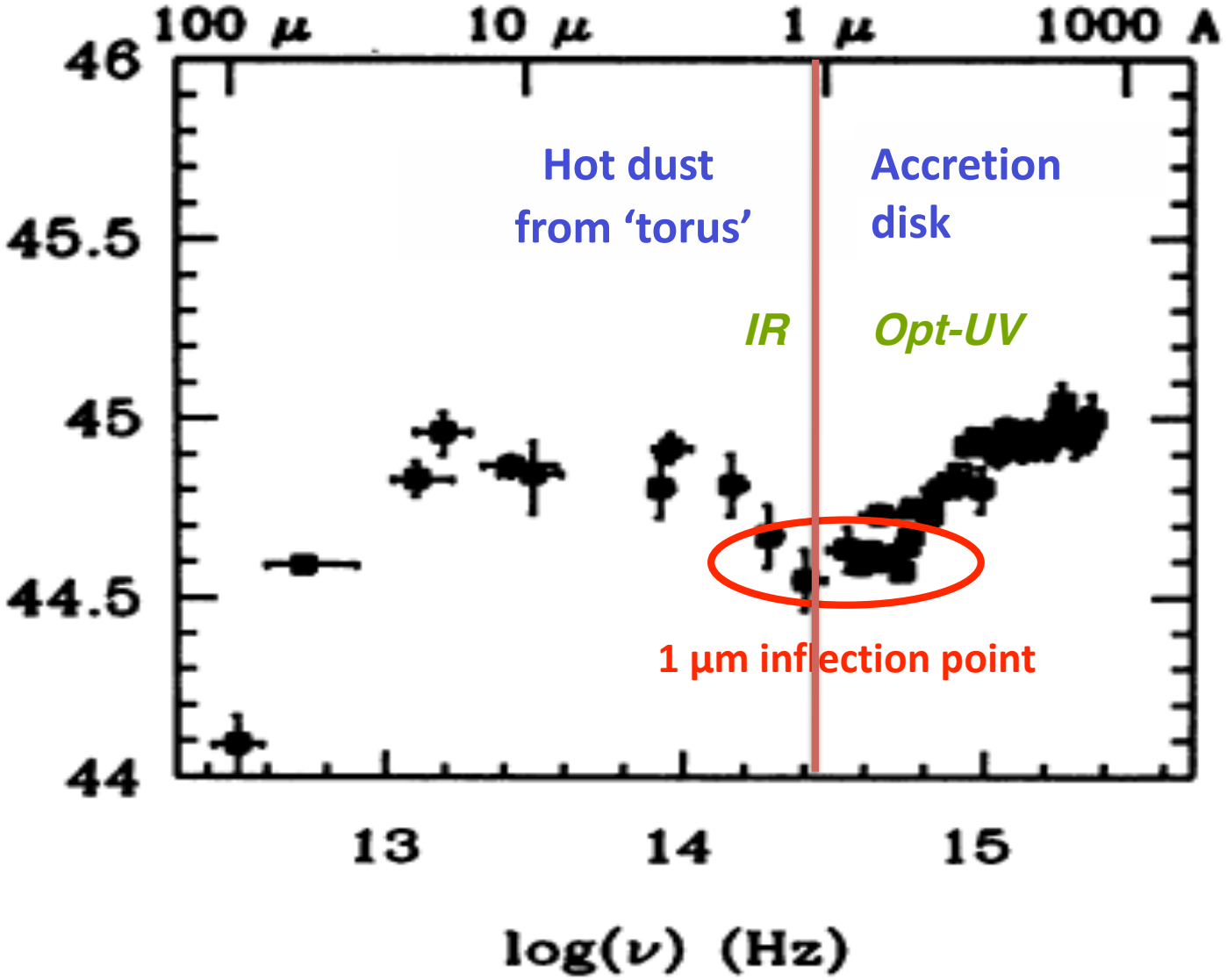
  $vf_v = v^{\alpha}$; α=-0.5 to +2

(Miley+ 1985….Lacy+ 2004, Stern+ 2005, Lacy+ 2007, Donley+ 2008)



Maximum dust temperature
1400K - 1900K (eg. Laor & Drain 1993)
Inner radius of dust sublimation
0.01 - 0.1pc (10~100 light days)
(Suganuma+ 2006)

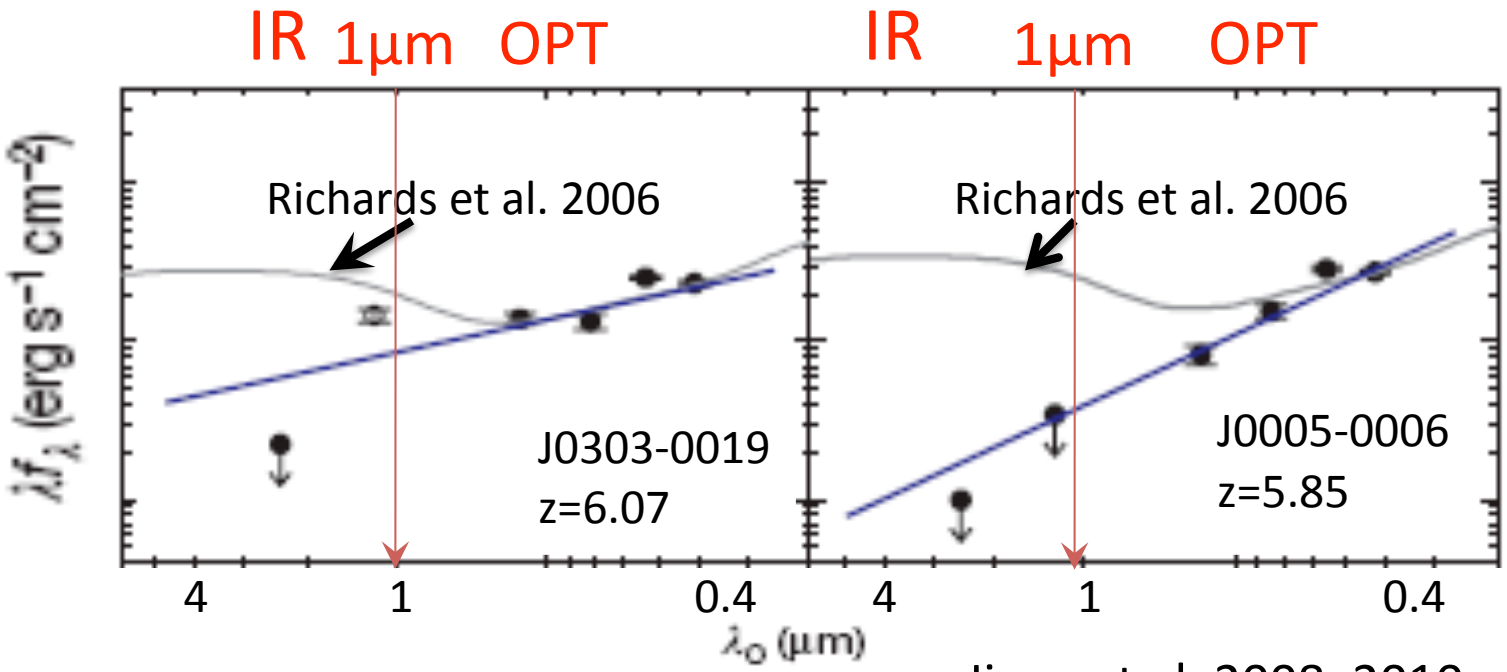
Example Quasar UV-IR SED



Elvis et al. 1994

No Dust in z~6 Quasars

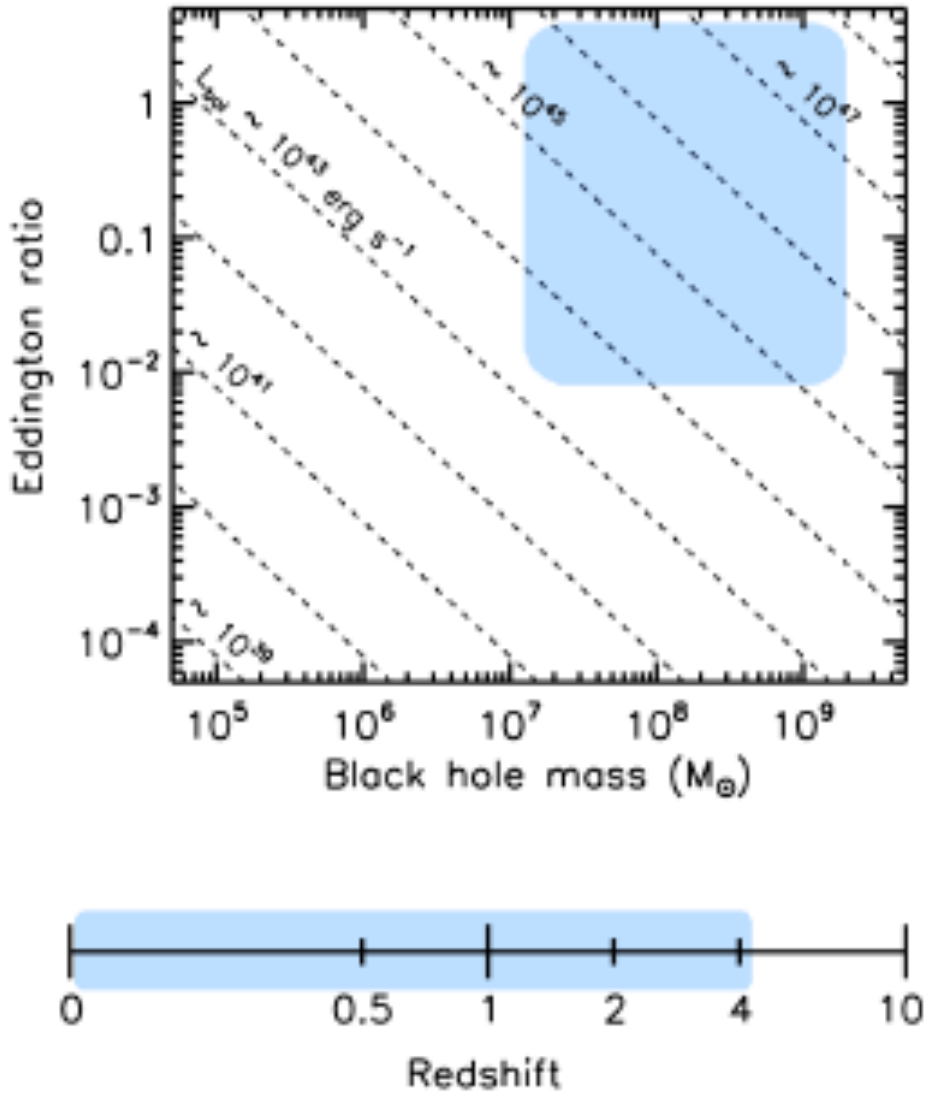
- 2/21 of 5.8<z<6.4 SDSS quasars are 'dust-Free'
  - Spitzer IRAC, IRS (15.6μm), MIPS 24
- Not enough time to form 'Torus' (0.93 Gyr)?



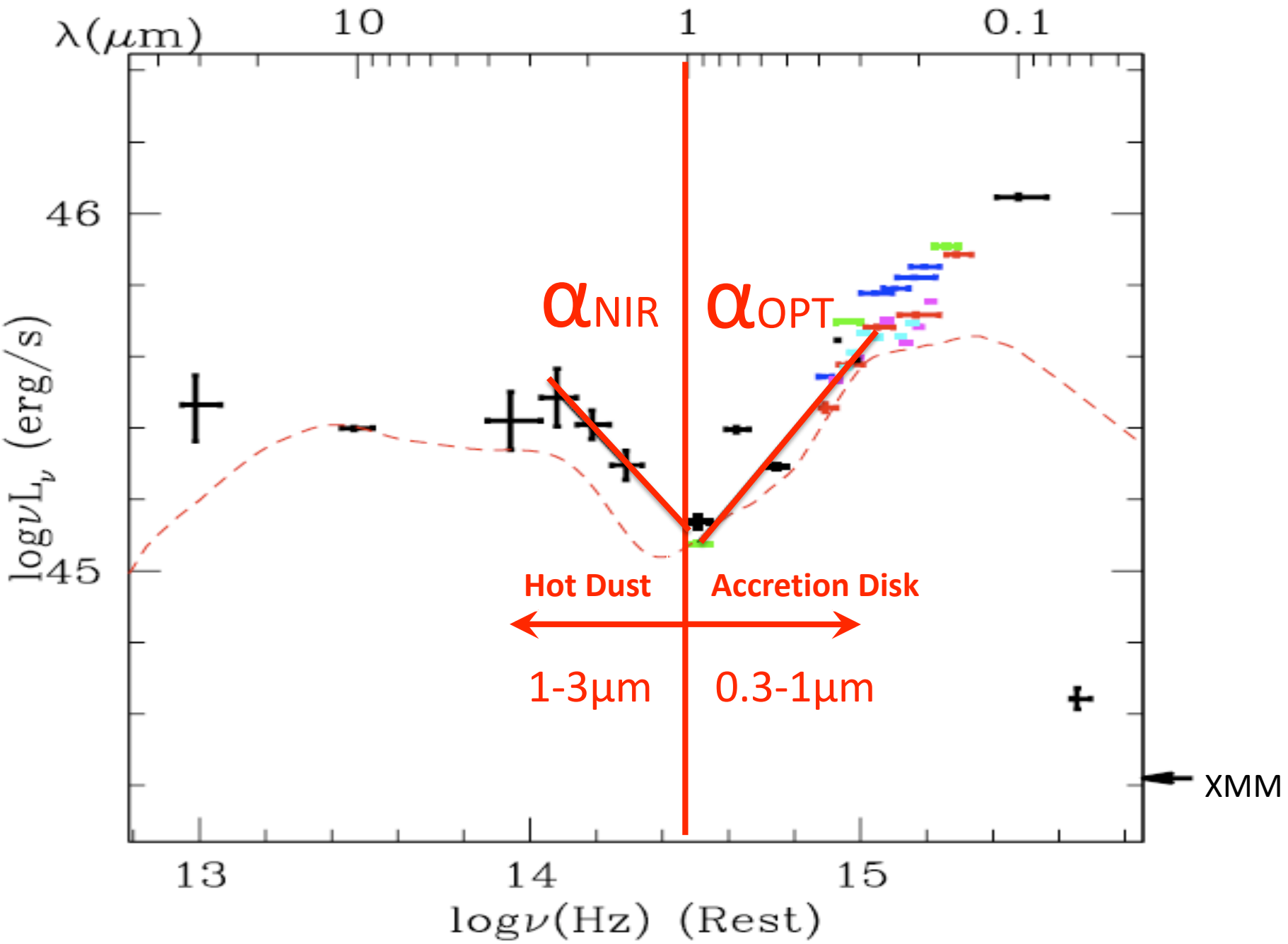
Jiang et al. 2008, 2010

COSMOS Type 1 AGN Sample

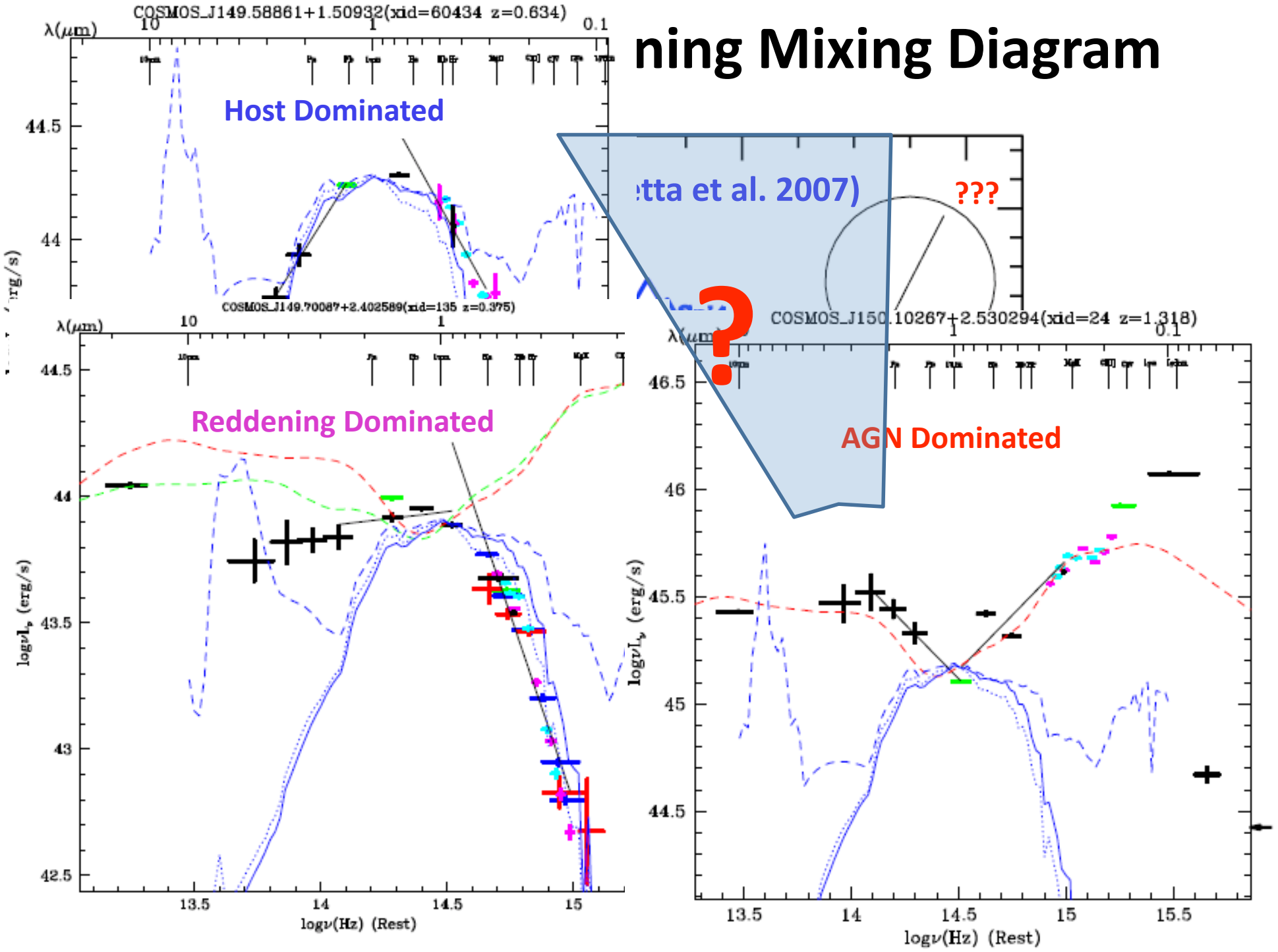
	Elvis 94 Sample	SDSS Sample	COSMOS Sample
Sample Size	47	259	**406**
Selection Method	Blue (Biased)	Optical (SDSS)	**X-ray** (XMM) FWHM>2000km s^{-1}
Redshift Range	0.05-0.9	0.1-5.2	**0.1-4.3**
Photometry	14 (Low S/N)	10	**43**
Reference	Elvis et al. 1994	Richards et al. 2006	Lusso et al. 2010 Brusa et al. 2010 Elvis et al. 2010


Eddington ratio
1
0.1
10^{-2}
10^{-3}
10^{-4}
$L_{bol} \sim 10^{43}$ erg s^{-1}
$\sim 10^{45}$
$\sim 10^{47}$
$\sim 10^{41}$
$\sim 10^{39}$
10^5
10^6
10^7
10^8
10^9
Black hole mass ($M_\odot$)
0
0.5
1
2
4
10
Redshift

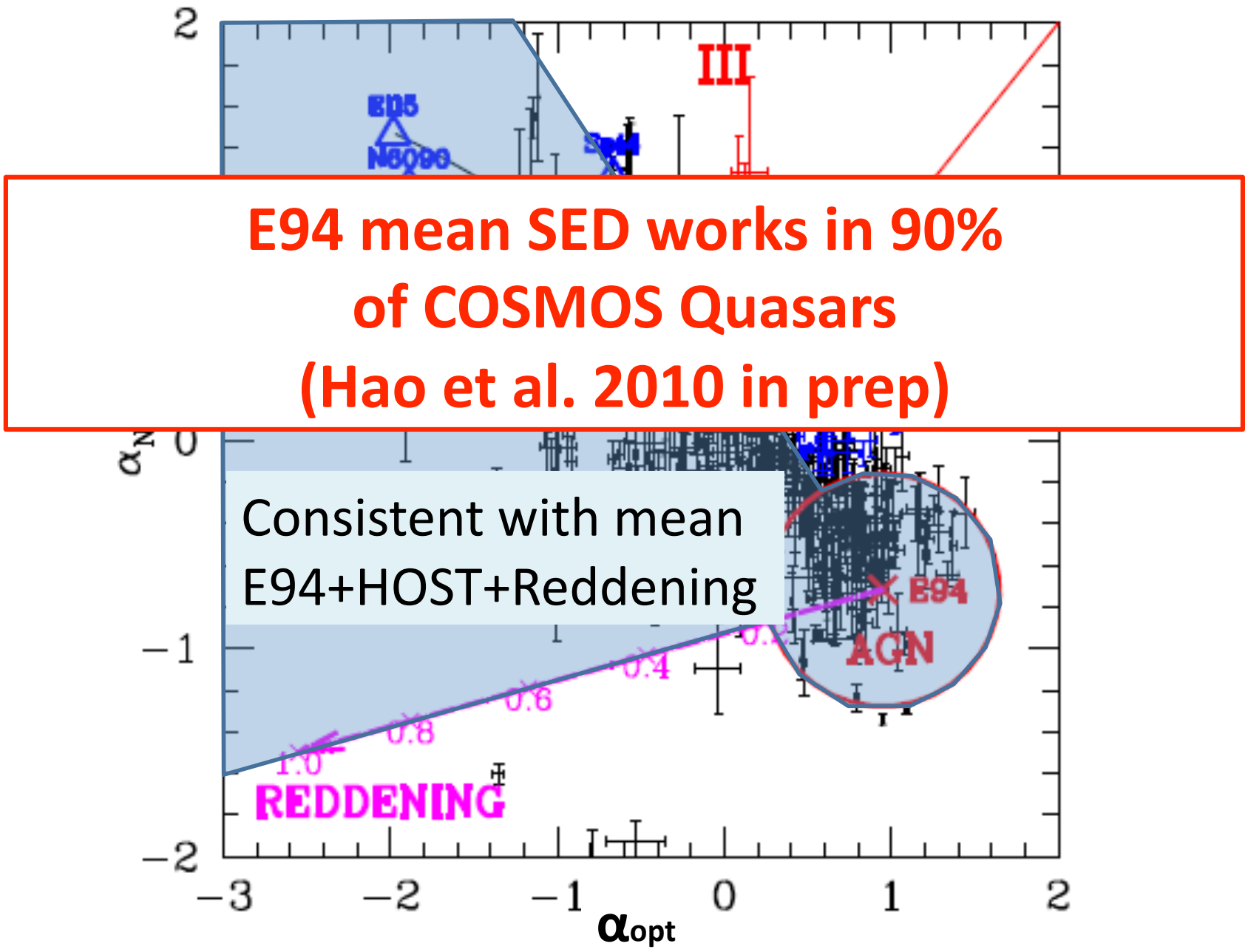
Near IR and Optical Slopes of COSMOS AGNs



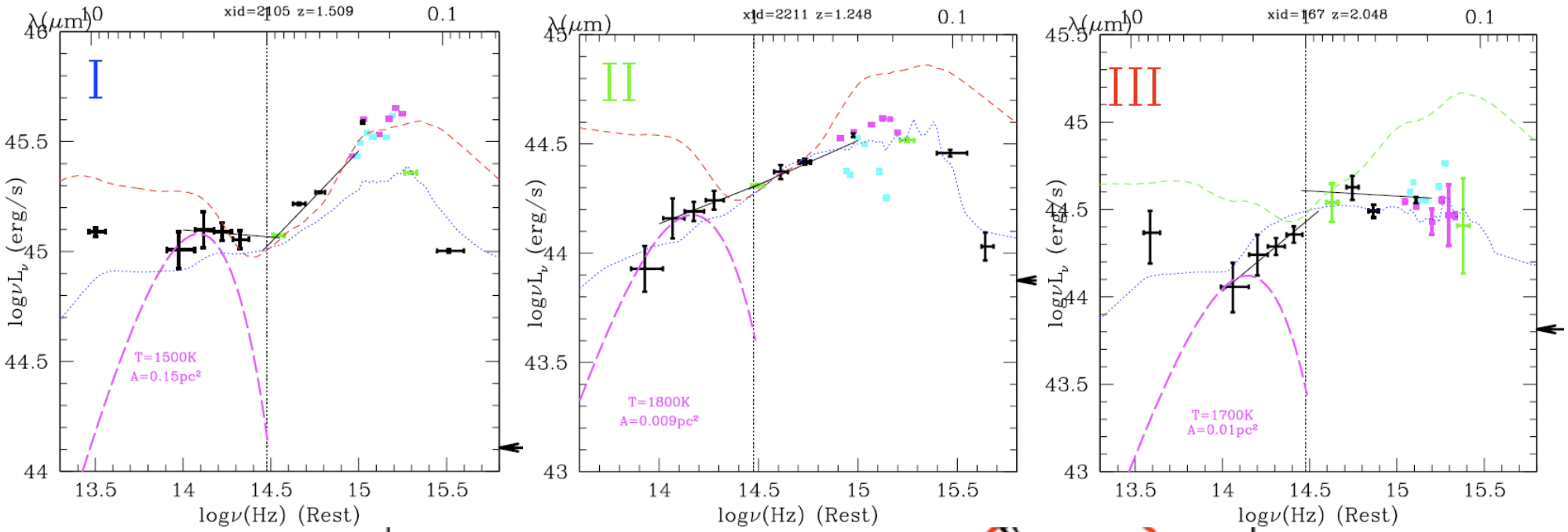
ning Mixing Diagram



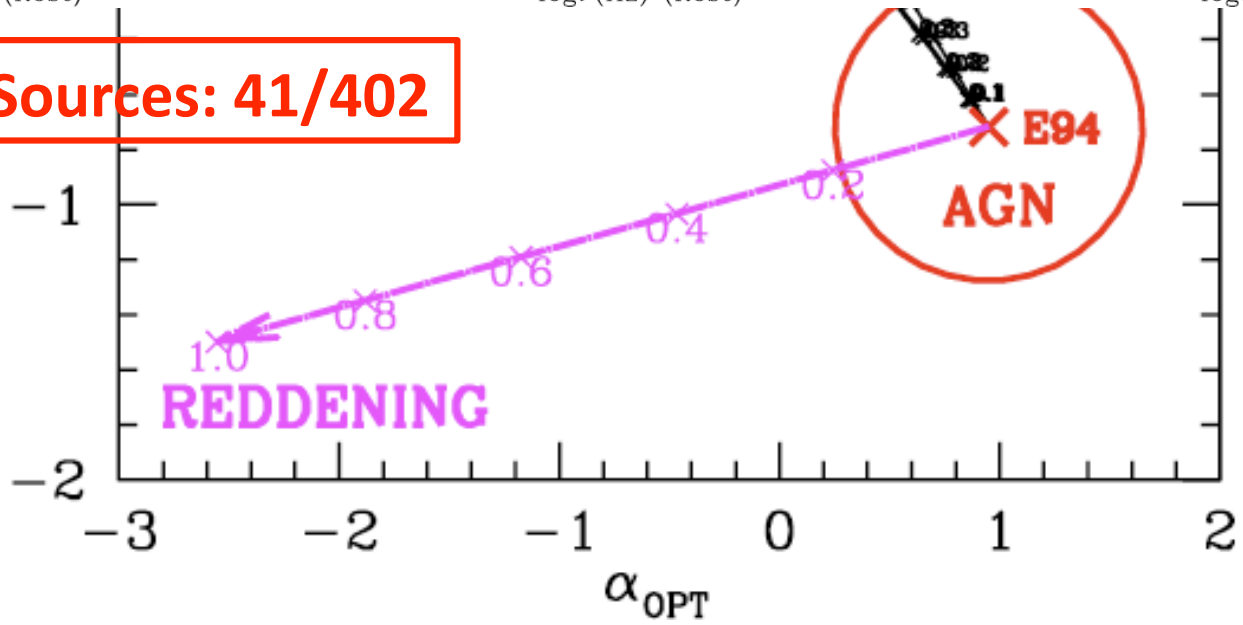
COSMOS AGN on Mixing Diagram



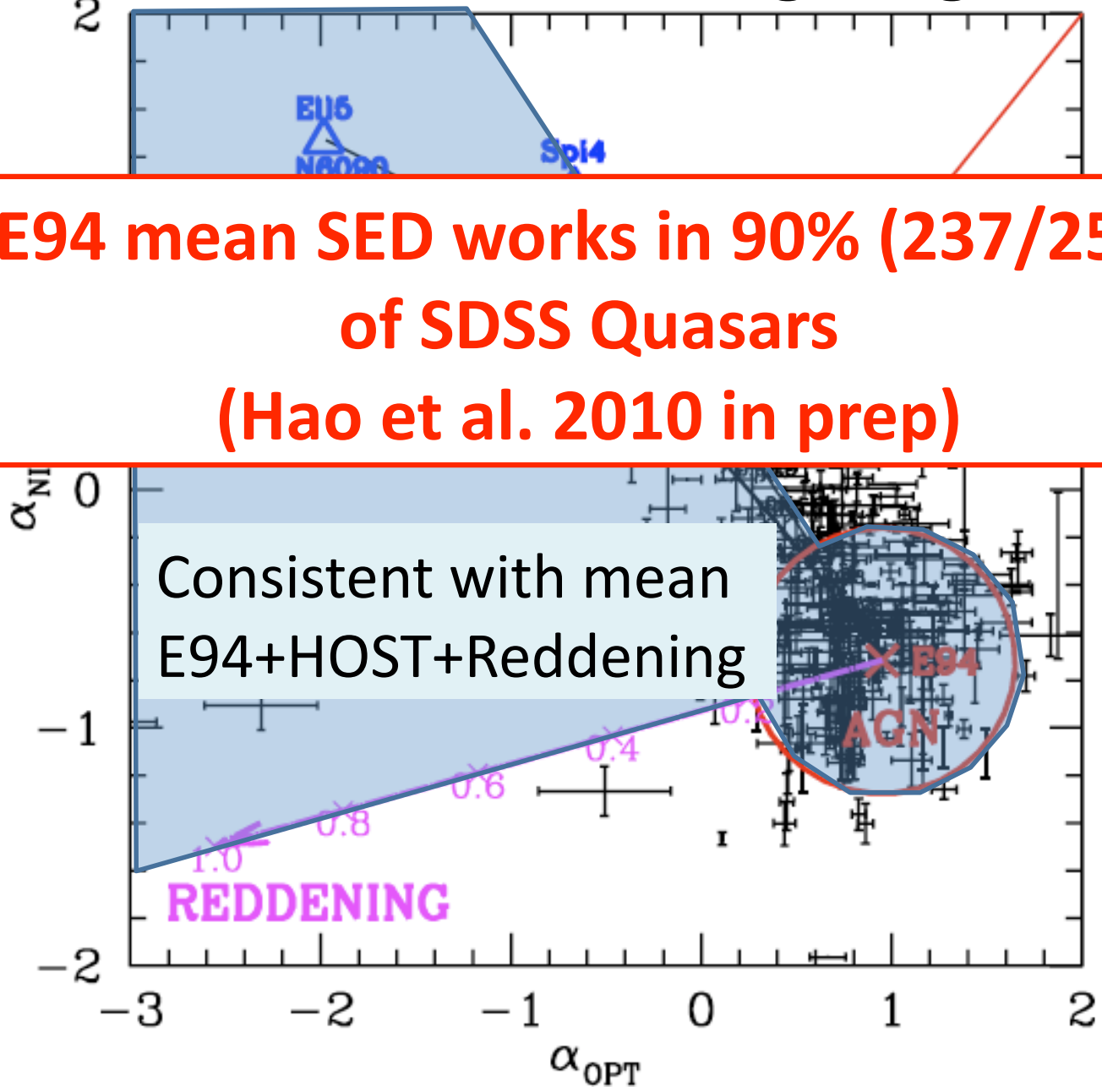
Hot-Dust Poor Outliers



Number of Sources: 41/402



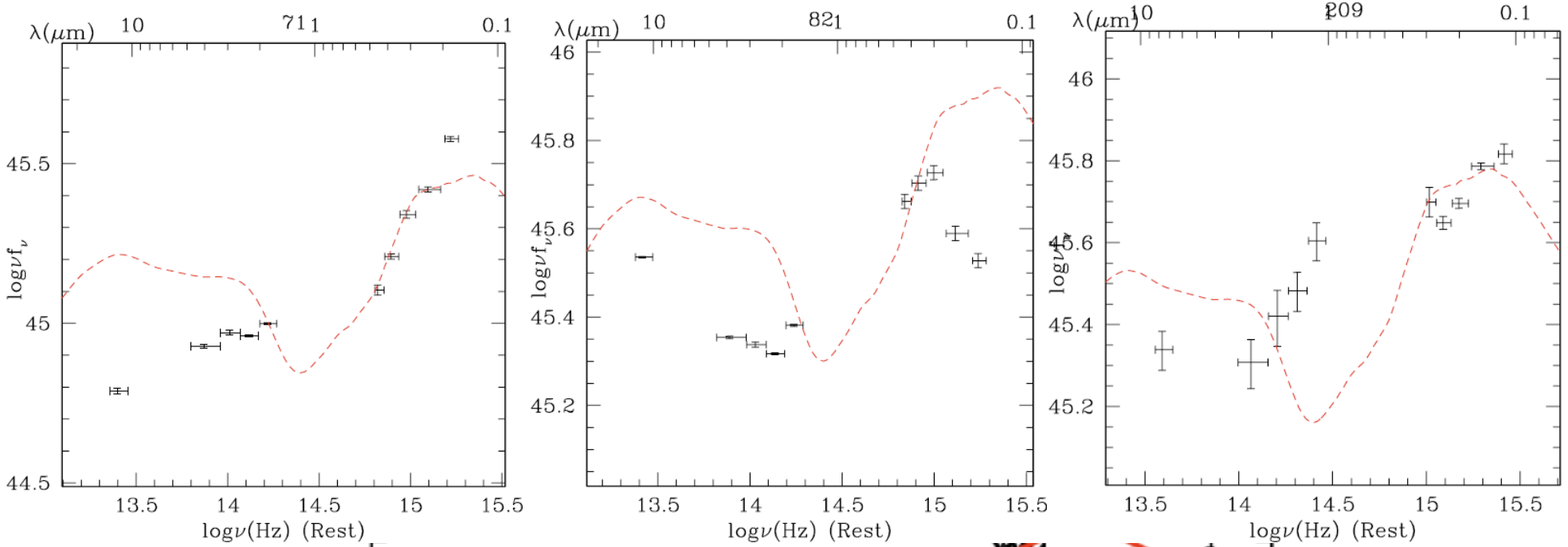
SDSS AGN on Mixing Diagram



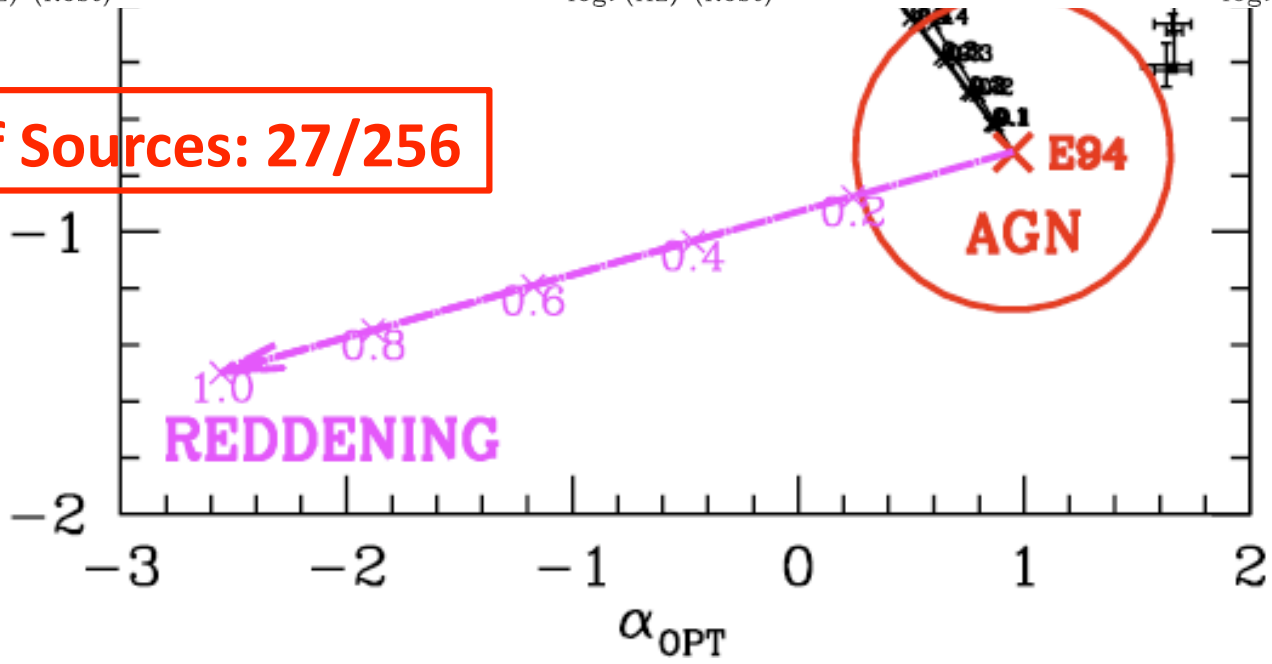
E94 mean SED works in 90% (237/256) of SDSS Quasars (Hao et al. 2010 in prep)

Consistent with mean E94+HOST+Reddening

Hot-Dust Poor Outliers for SDSS



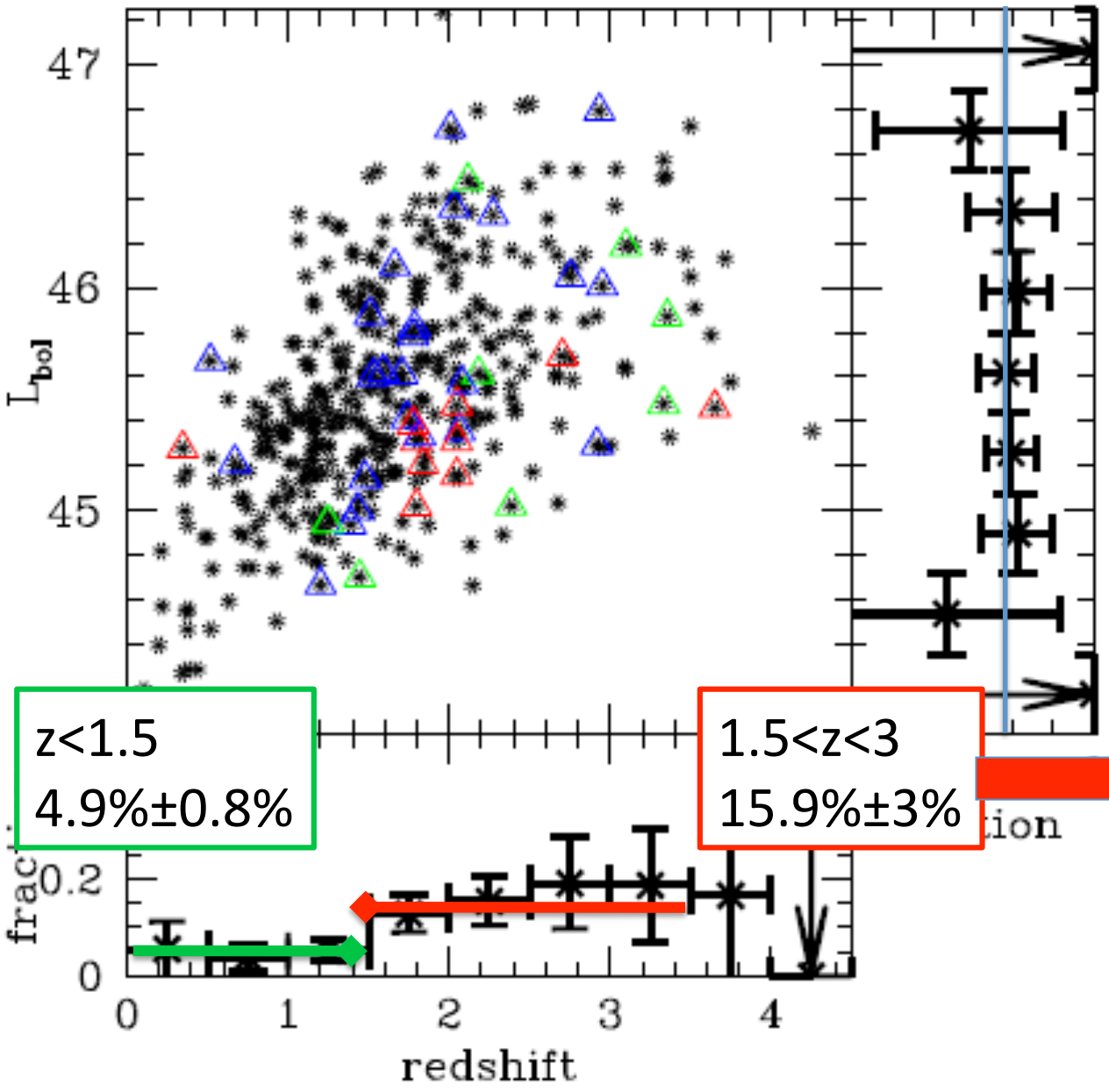
Number of Sources: 27/256



Hot-Dust Poor Quasars: Properties

Parameter	N(HDP)/N(total-HDP)	KS Prob
Redshift	41/361	0.0006
αox	41/361	0.04
Hardness Ratio	41/361	0.232
Black Hole Mass	17/187	0.527
2keV Luminosity	41/361	0.567
Eddington Ratio	17/187	0.710
Bolometric Luminosity	41/361	0.988

Bolometric Luminosity vs Redshift



Larger Fraction At z>1.5 = Evolution

$(1+z)^{1.27}$

HDP Quasars Summary

- E94 a good fit for ~90% of AGNs in NIR-OPT
- ~10% of COSMOS AGNs are “hot-dust-poor”
- Similar fraction in SDSS
- Evolution to z=2: 5% at z<1.5 to 16% at z>1.5
- No trend with L_{bol}, L_X, M_{bh}, α_{OX}, L/L_{Edd}

Physical Properties: 1. Hot Dust Covering Factor

Measure:

Dust temperature =1500 K

→Emission Area =0.15 pc^2

→Radius(1500 K) =0.81 pc

(Barvainis, 1987)

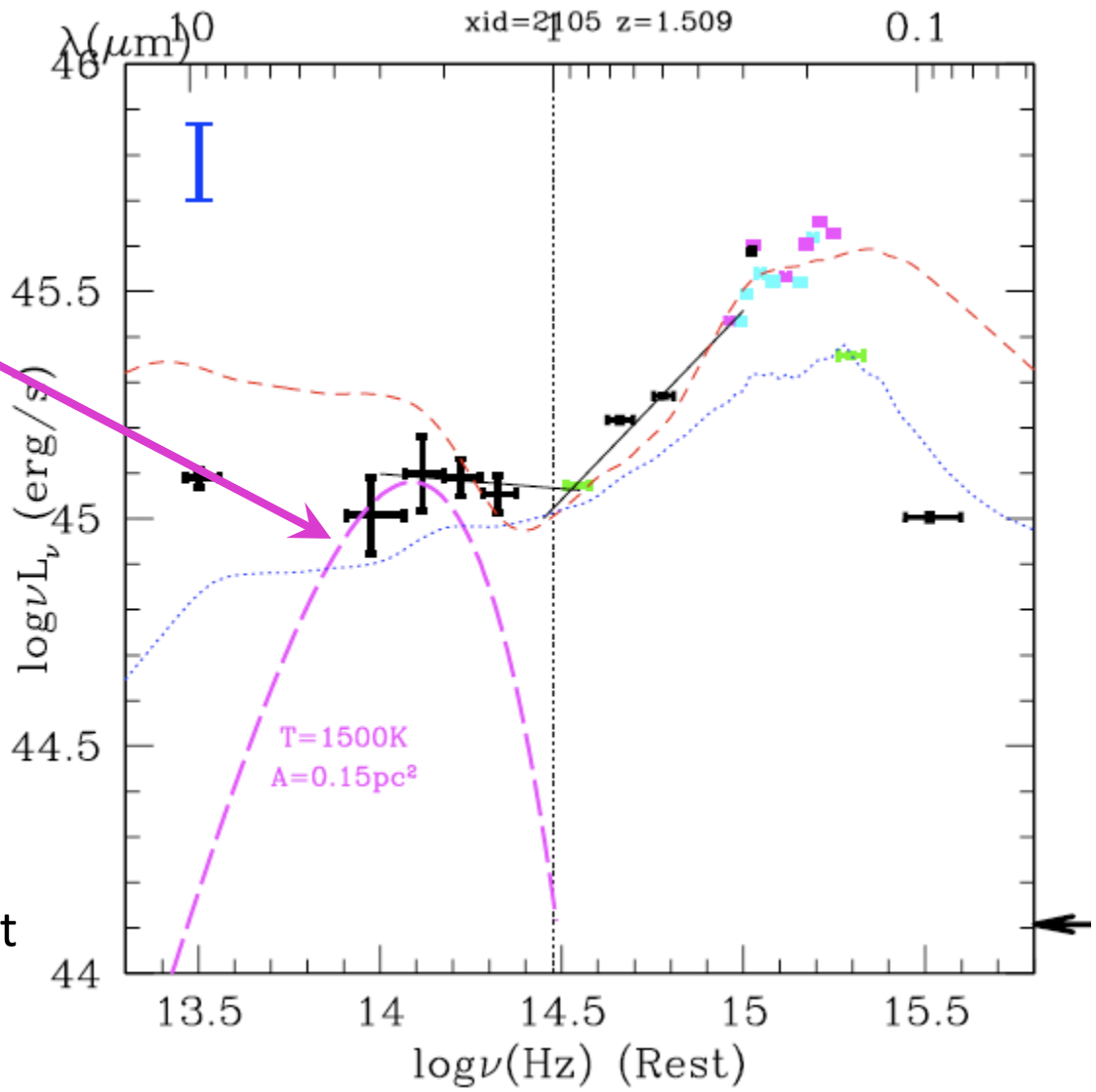
→Covering factor fc=18%

Class I HDP **fc: 6%~29%**

•75% for type1:type2 ratio at z=0

•50% for type1:type2 ratio for X bright

(eg. Gilli+2007)



Physical Properties: 2. Accretion Disk Size

Accretion Disk Outer Edge

$T_c \sim R^{-3/4}$ K

Measure T_c=1800 K

→R_{out}=0.24 pc ≈6000 R_s

(Frank, King & Raine 2002)

→~20x r_{gi}

Gravitational Instability radius

(r_{gi}≈ few x 10^2 R_s, Goodman et al. 2003)

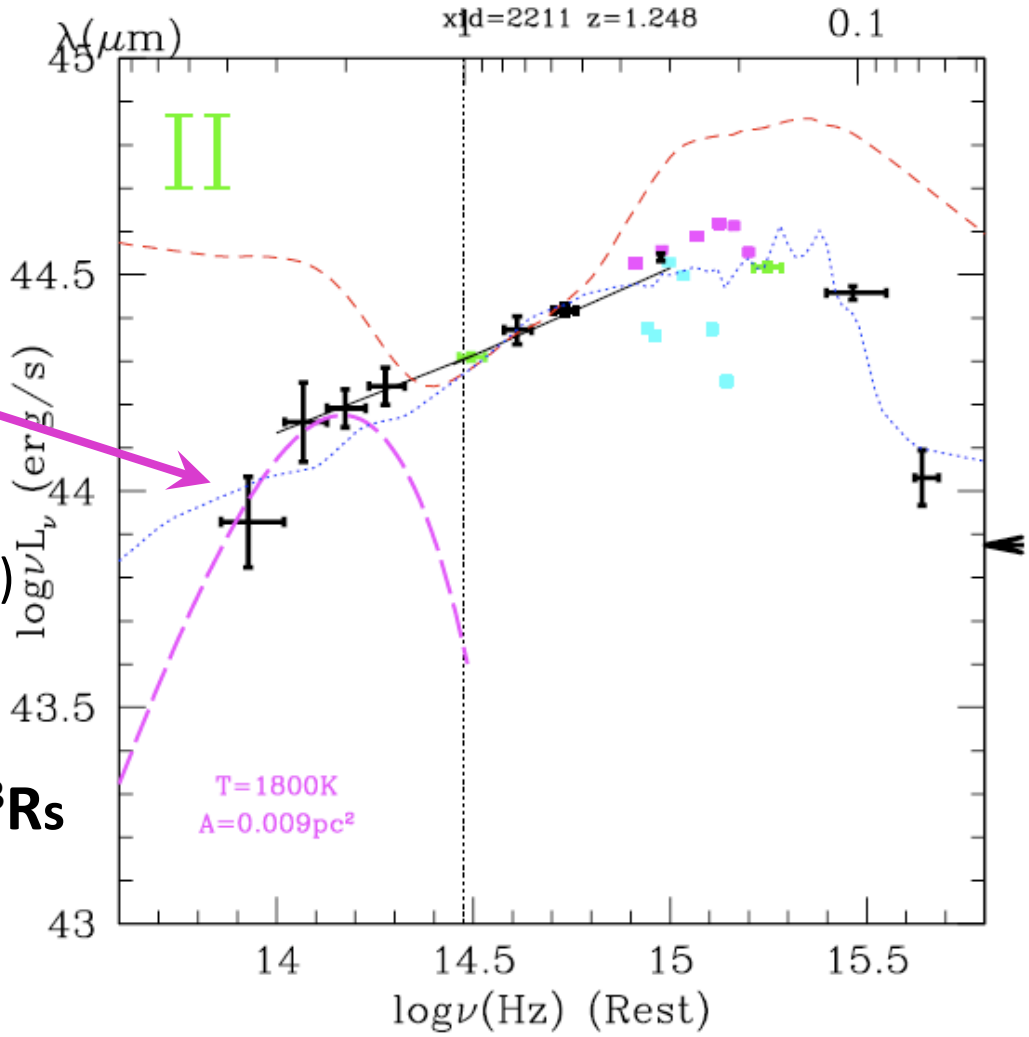
Class II HDP AGNs:

Rout=(0.18-0.91)pc=(2.4-26)×10^3Rs

-> (10-30)r_{gi}

Either Not R_{out}

Or something stabilizes disk



$T_c = 7.8\times10^5 \alpha^{-1/5} \eta^{-3/10} M_8^{11/20} \lambda_E^{3/10} R^{-3/4} f^{6/5}$ K

assumed α=0.1, η=0.1

What are Hot-Dust Poor Quasars?

- Torus not yet formed? (Jiang et al. 2010)
  - plenty of cosmic time at z~2
- Not enough accretion rate to drive wind? (Elitzur & Ho 2009) NO
- Too low L_{bol}? (Elitzur & Schlossman 2006) NO

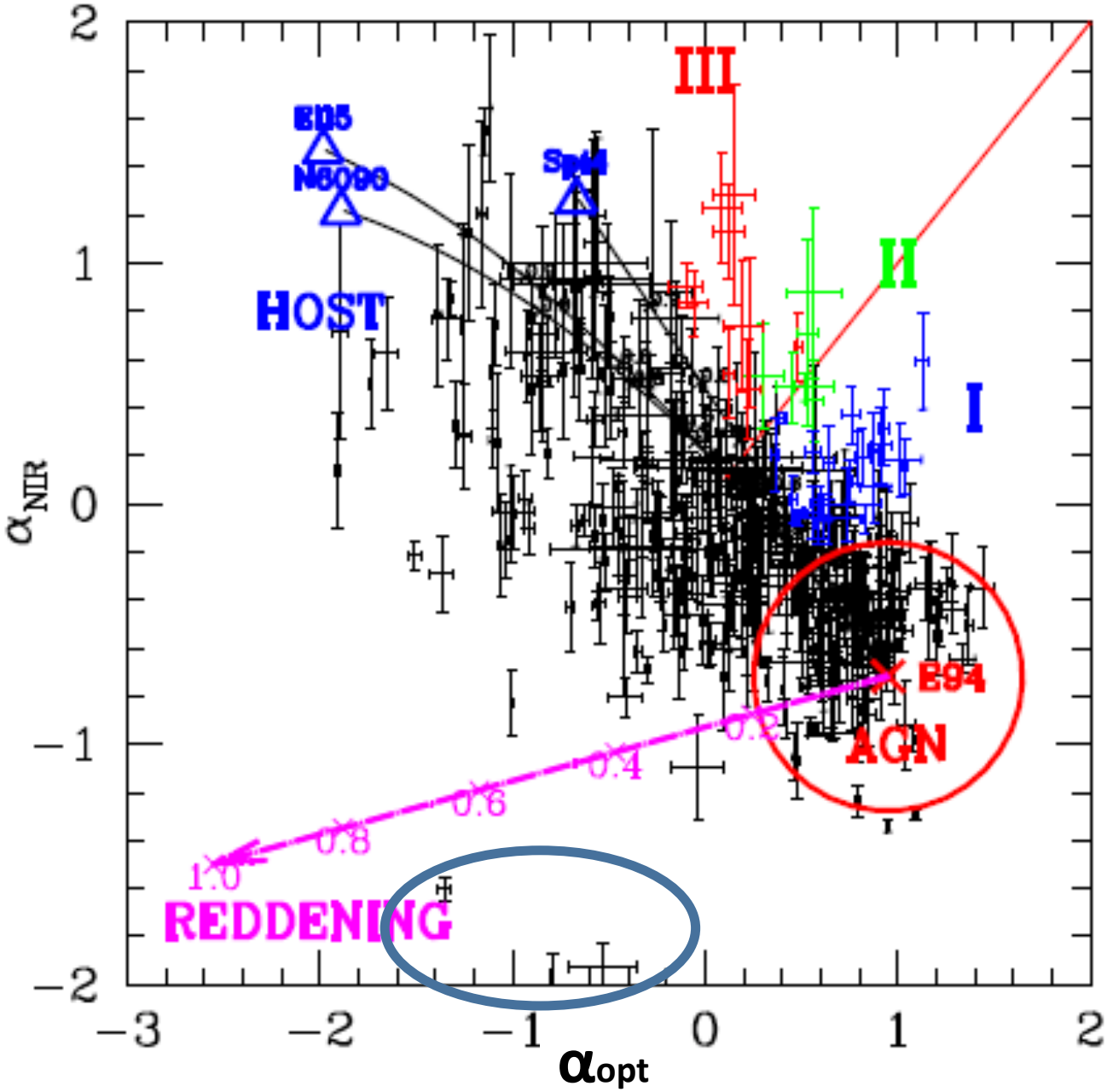
Hot Dust Destroyed:

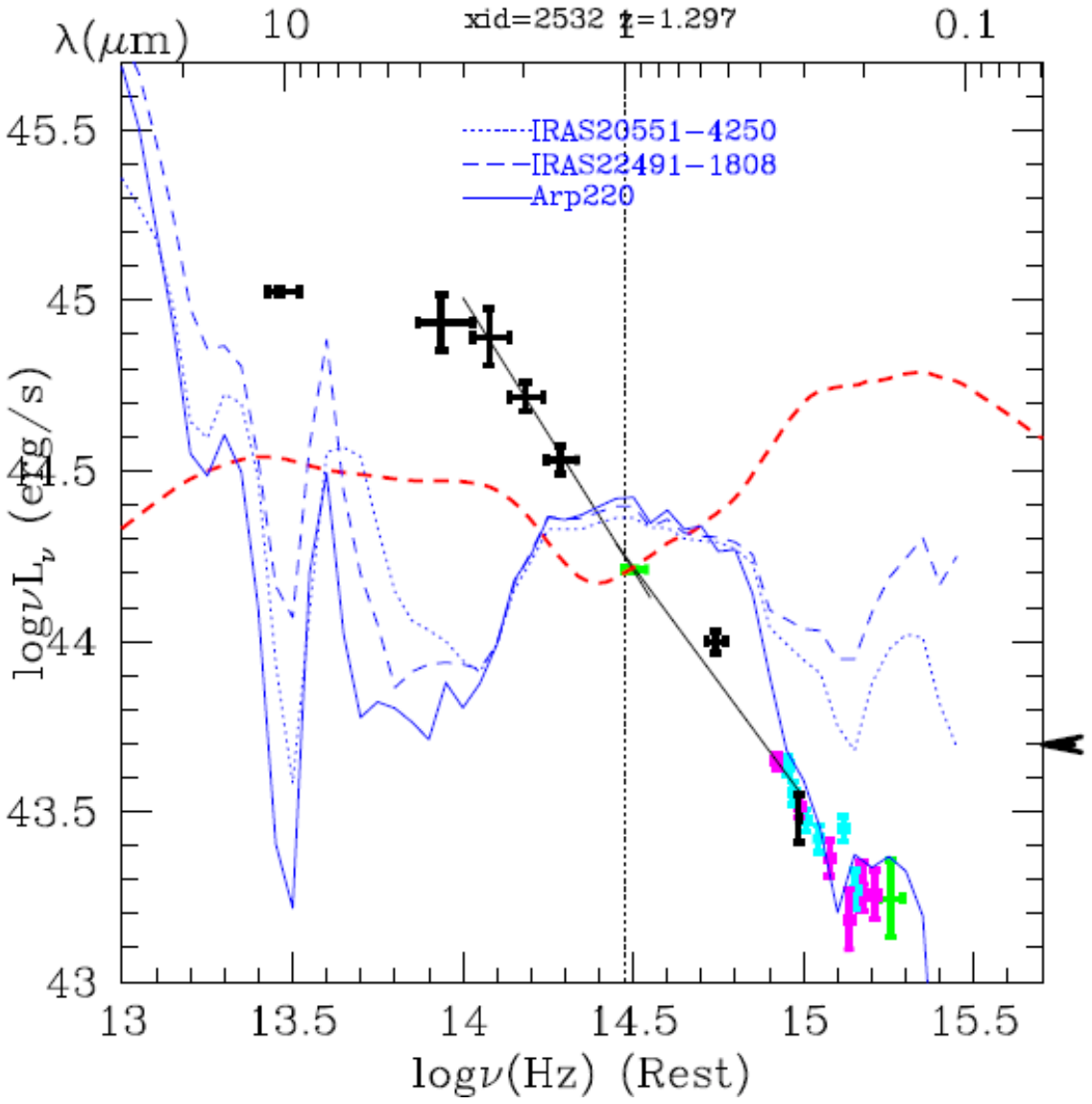
1. *Radiation:* Eddington Outburst? (Hopkins et al. 2008)
   - Dust formation time/ Quasar life time
   - Only hot dust destroyed. FIR emission normal?
2. *Dynamically:* During Merger?
   - Consistent with evolution of HDP fraction
   - Disrupt entire `torus'? FIR emission absent?

Work in Progress

- MIR and FIR SED: MIPS at 70μm; Herschel (Dieter Lutz's talk)
- X-ray spectra:
  - Harder slopes in HDP?
  - Test origin of narrow Fe-Kα
- Evolution of M-sigma relation: increased?
- Other Mixing Diagram outliers

COSMOS AGN on Mixing Diagram




λ(μm)
10
xid=2532 z=1.297
1
0.1
IRAS20551−4250
IRAS22491−1808
Arp220
45.5
45
44.5
44
43.5
43
logνL_ν (erg/s)
13
13.5
14
14.5
15
15.5
logν(Hz) (Rest)

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- No trend with L_{bol}, $L_{X,}$ $M_{bh,}$ α_{OX}, L/L_{Edd}
- Factor 2-3 low; 6%~29% covering factor
- Large outer accretion disk radii? $R\sim(2\text{-}20)\times10^3 R_S$