Overdense environments of WISE-selected, dusty, high-redshift, luminous galaxies

Suzy F. Jones

Chalmers University of Technology, Sweden

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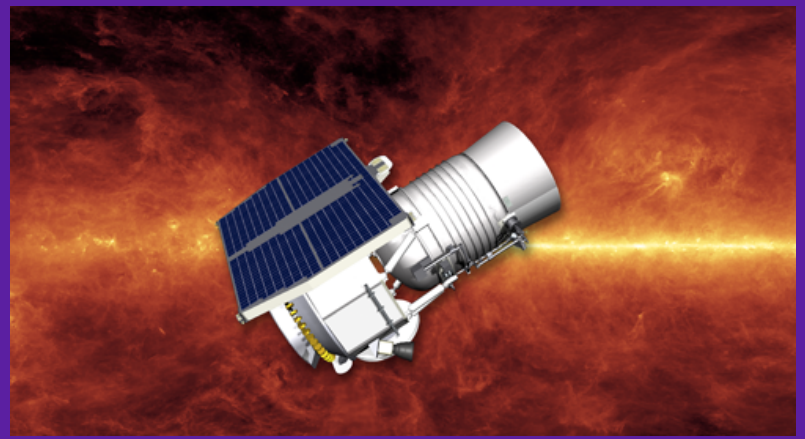
CHALMERS
UNIVERSITY OF TECHNOLOGY

University of Leicester

WISE

- WISE all-sky IR survey 3.4, 4.6 ,12, 22 μm = W1, W2, W3, W4
- Primary aim to identify most luminous galaxy
- AGN and Starburst activity emit in IR
- 5σ sensitivity 0.054, 0.071, 0.73, 5.0 mJy
- Angular resolution 6.1, 6.4, 6.5, 12.0 arcsec



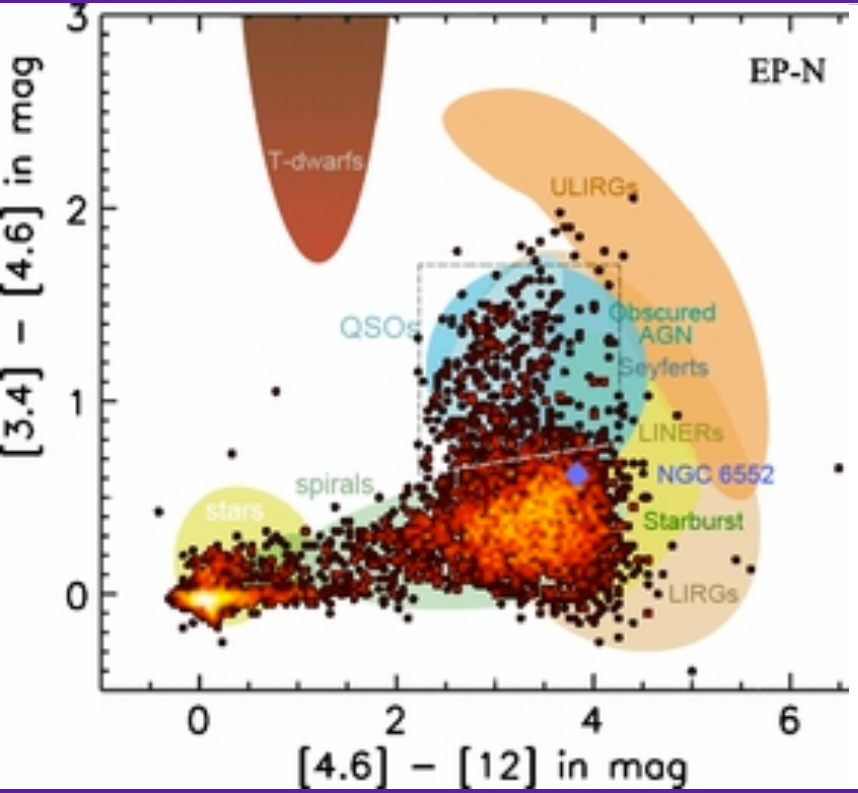
Eisenhardt+12, Wu+12, Lonsdale+15

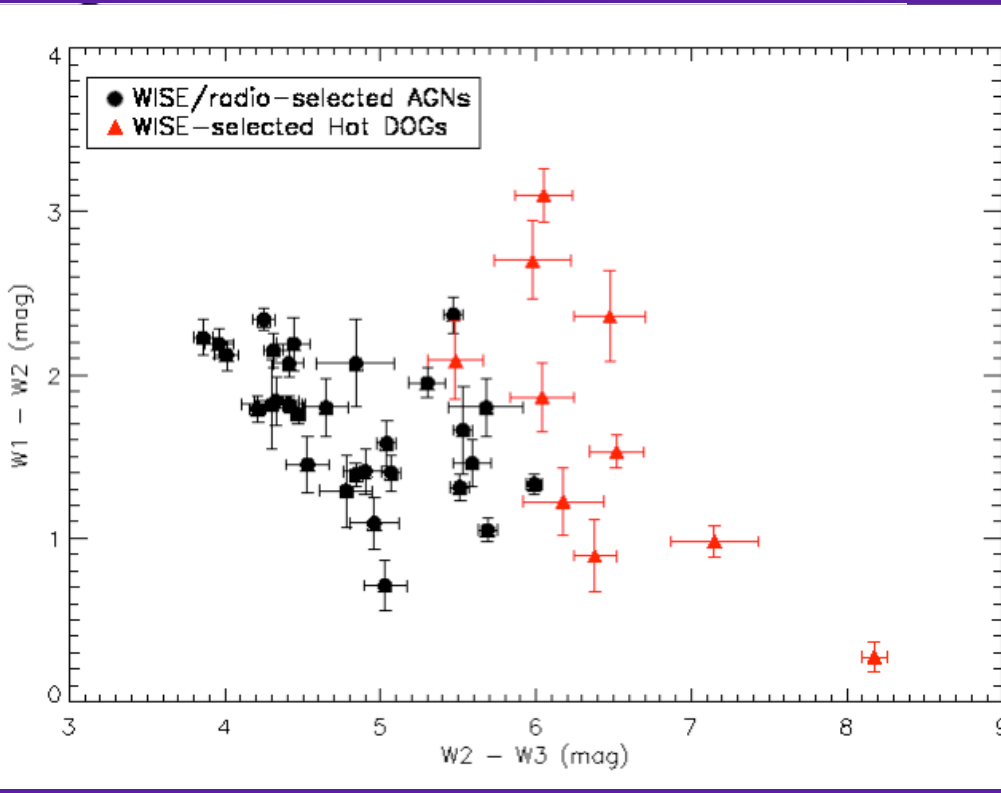
Selection cuts

- W1/W2 faint/undetectable but detectable in W3/W4
- Luminous AGN-dominated phase
- $2 < z < 3$
- ALMA observations SFRs 1000's $M_{\odot} yr^{-1}$ (Lonsdale+15)
- HST observations found Hot DOGs to be merging-driven transient phase (Fan+16)
- BH masses $10^{9} M_{\odot}$ accreting max rate (Wu+17)

Selection cuts

- First were radio blind = Hot DOGs
- 1000 galaxies over sky
- Second were radio selected = WISE/radio AGN
- Selected with NVSS/FIRST 1.4GHz data
- $0.1 < S(22\mu m)/S(1.4GHz) < 1$ radio-intermediate
- Find AGN with jet-induced feedback
- Cross matched 7arcsec with WISE
- 156 galaxies in sample



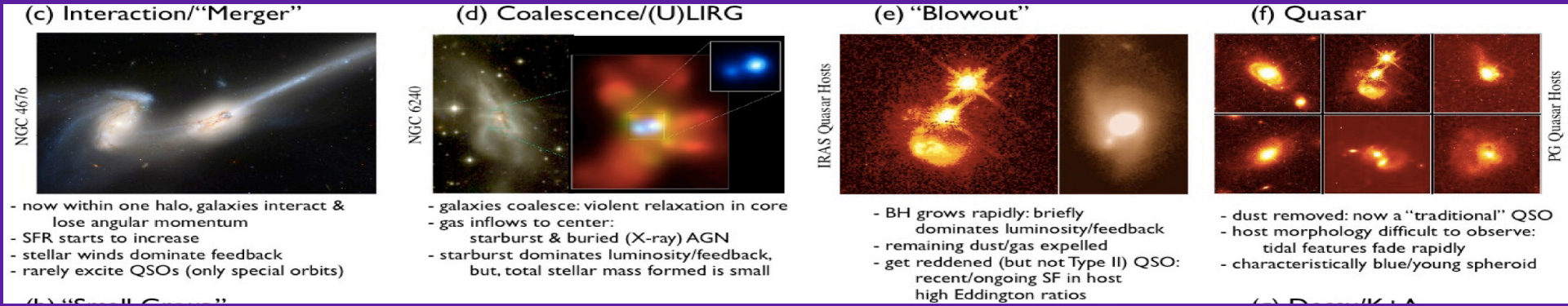


[4.6] – [12] in mag

Jarrett+11,Jones+17submitted

Why study these galaxies

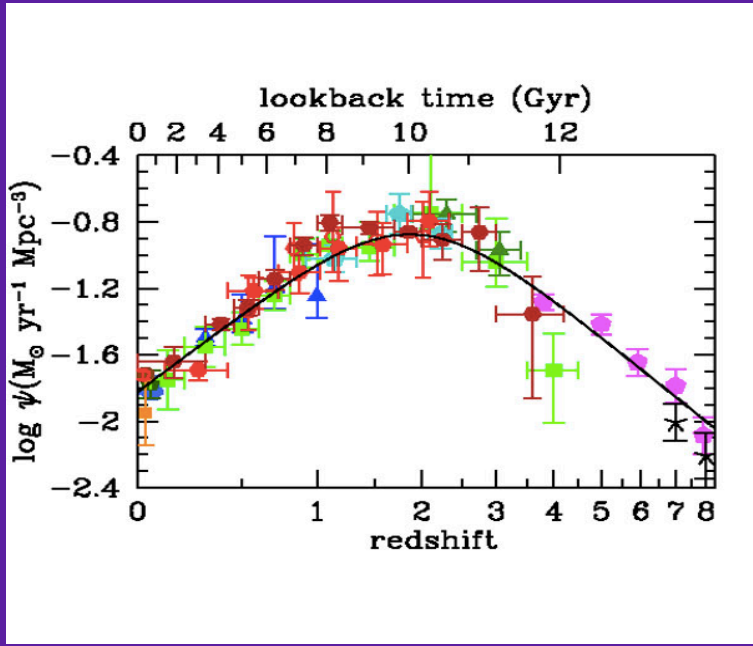
- Observing dusty high-z galaxies different stages of merger theory



Hopkins+08

Why study these galaxies

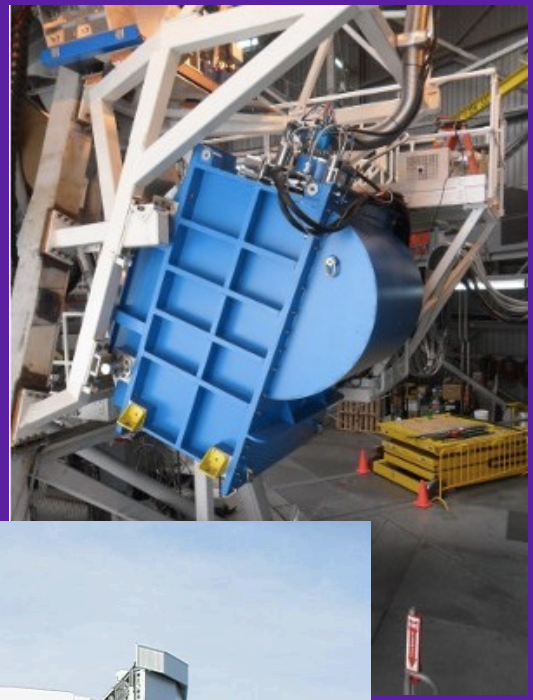
- AGN feedback plays role in galaxy evolution
- Especially in peak epoch of cosmic star formation $2 < z < 3$
- Mid-IR selection of AGN successful (Sanders+88; Stern+05; Assef+13)



Madau+14

Observations

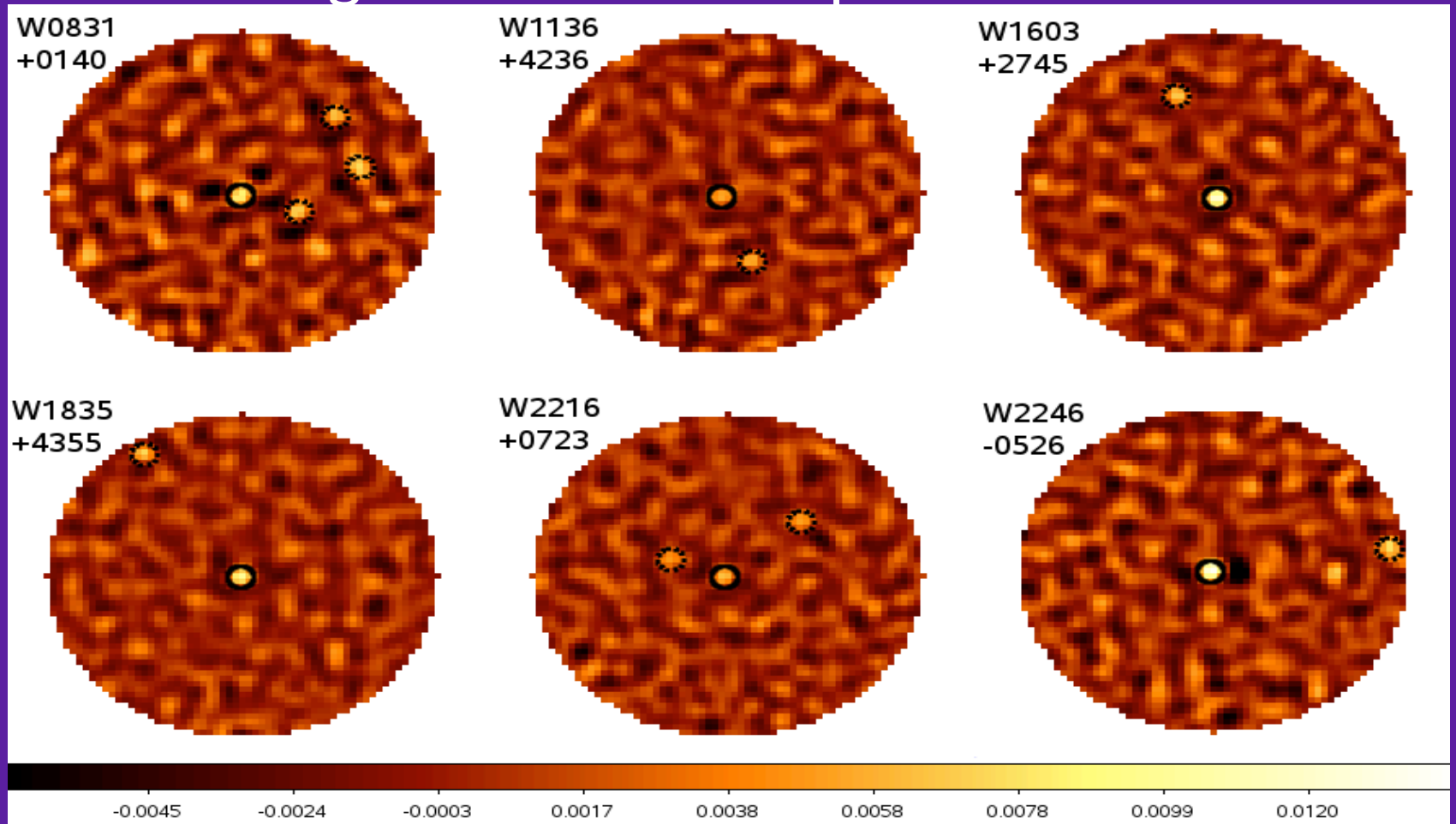
- JCMT SCUBA-2
- 15m telescope using bolometer camera 450/850μm
- FWHM 7.5, 14.5arcsec
- 3-arcmin region uniform noise
- ~1.8mJy/beam Hot DOGs
- ~2.1mJy/beam WISE/radio AGNs



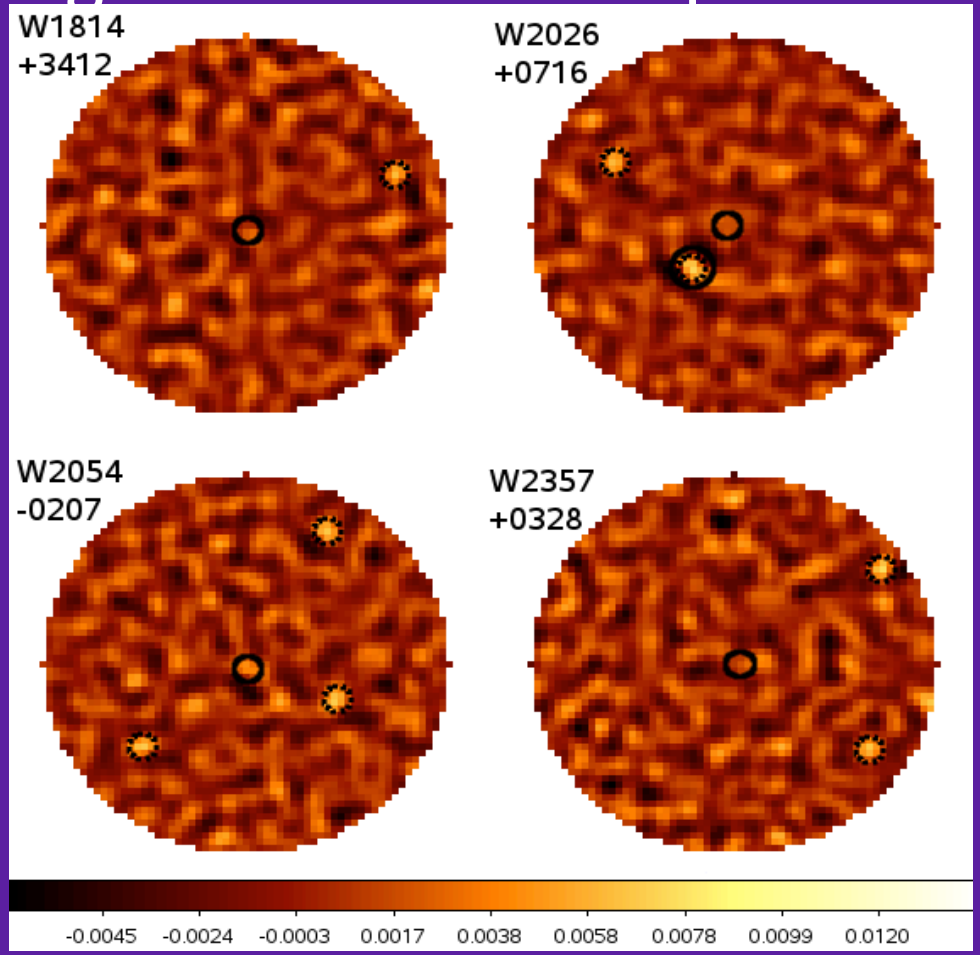
Photometry

- 10 observed Hot DOGs
- 6 detected, 4 undetected, stacked flux detected 3.4σ
- 30 observed WISE/radio AGNs
- 4 detected, 26 undetected, stacked flux detected 3.6σ

6 detected target SCUBA-2 850μm 1.5arcmin fields

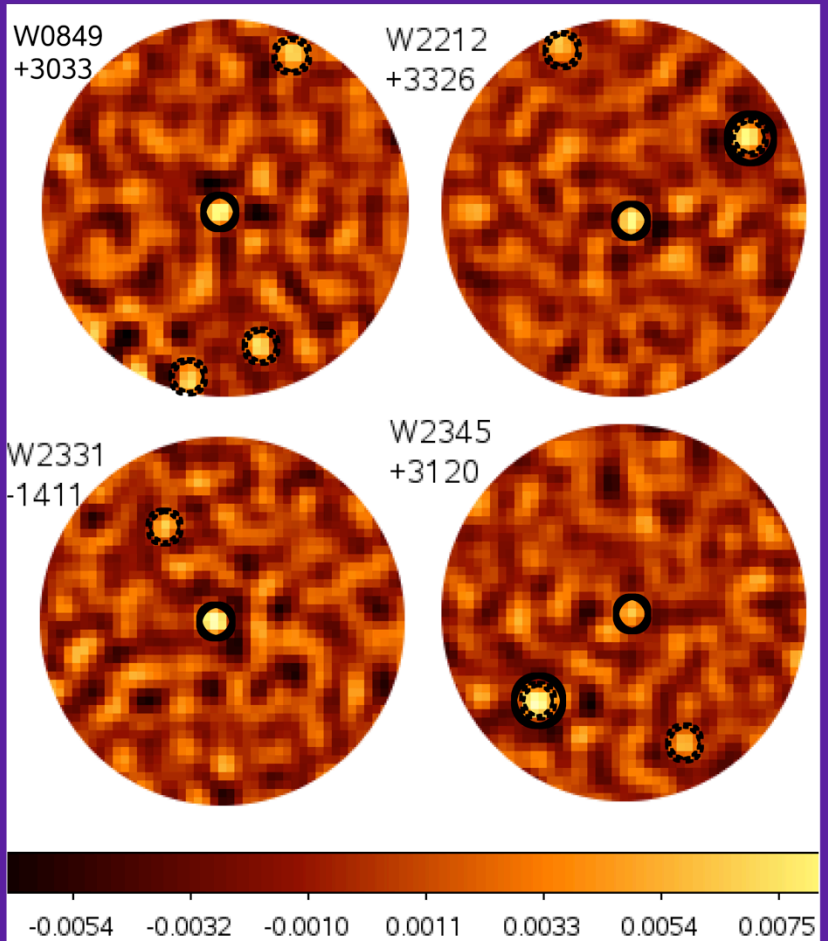


4 undetected targets SCUBA-2 850μm 1.5arcmin fields



Z~1 700kpc
~1.5arcmin

4 detected target SCUBA-2 1.5arcmin fields



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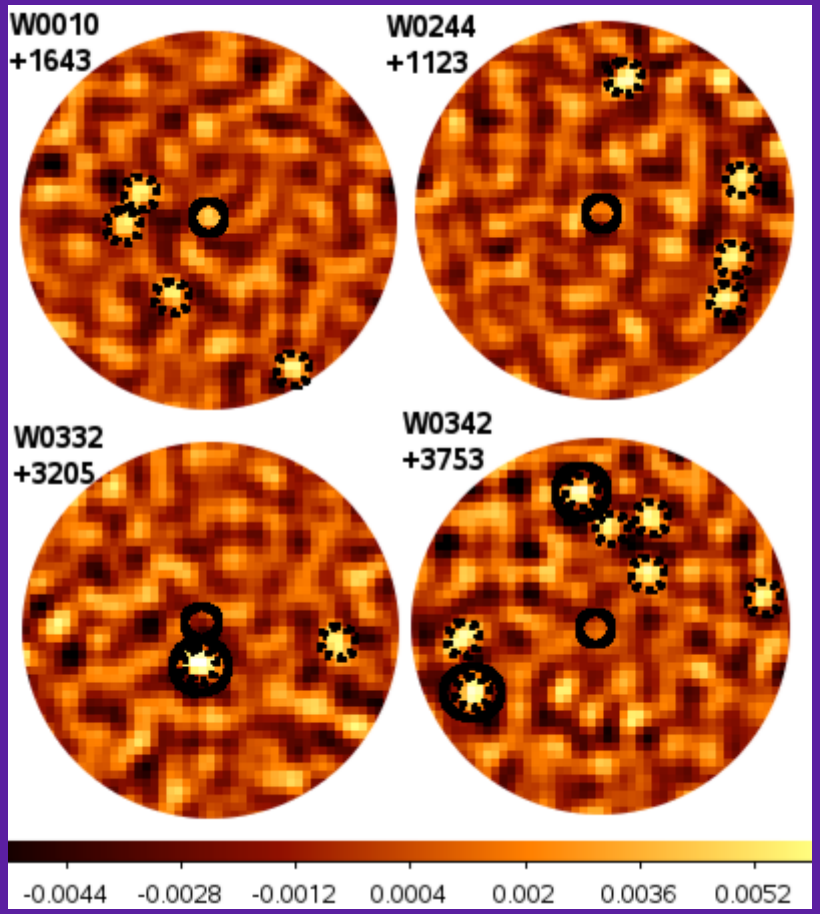
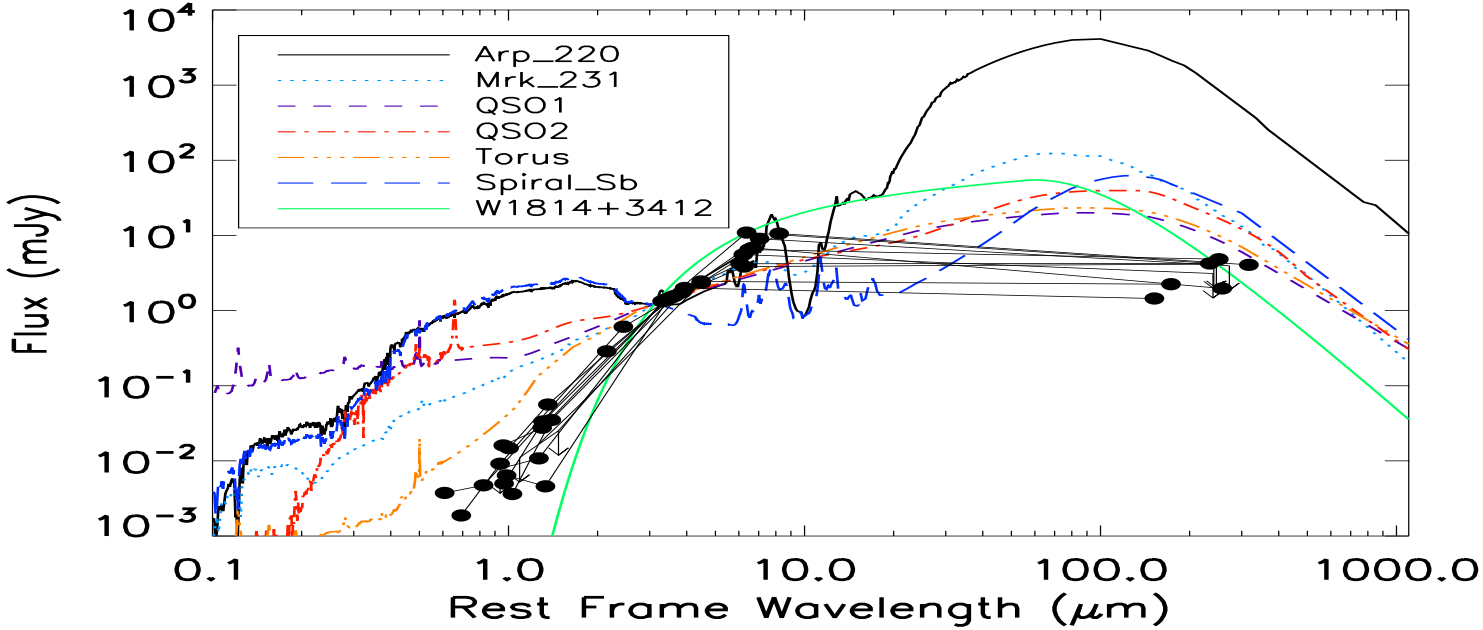


SEDs of HOT DOGs

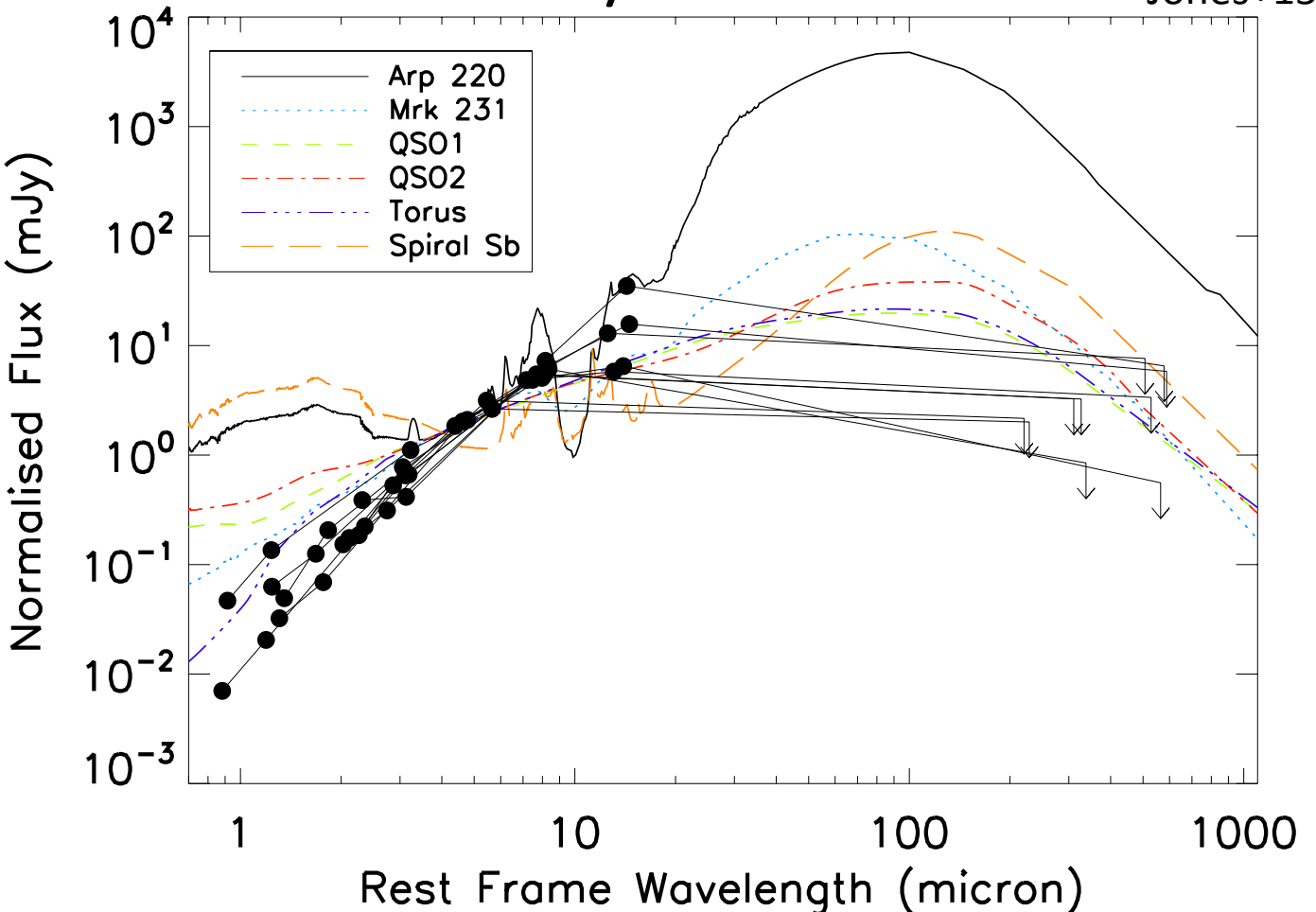
Jones+14



- SED closest fitting template Polletta torus
- W1814+3412 template 53±5K β=1.5 (Blain+in prep.)
- Extra dust extinction $A_V \geq 6.8$ mag, $N_H \sim 2.3 \times 10^{24} cm^{-2}$ Compton-thick AGN consistent with Stern+14 NuSTAR and XMM

SEDs of WISE/RADIO AGNs

Jones+15



Luminosities

- Hyper-luminous infrared galaxies, two $\geq 10^{14} L_{\odot}$
- No gravitational lensing from previous studies
- Limit underlying host galaxy
- Hot DOG: Sb ~2%L_{IR} SFR~30$M_{\odot} yr^{-1}$

  Arp 220 ~55%L_{IR} SFR~450$M_{\odot} yr^{-1}$
- WISE/radio: Sb ~4%L_{IR} SFR~110$M_{\odot} yr^{-1}$

  Arp 220 ~10%L_{IR} SFR~250$M_{\odot} yr^{-1}$

Warm vs cool dust

- Fan+16 torus emission IR dominated
- Cold dust ~24% total L_{IR}
- High L_{IR} due to increase dust temp (73K)
- Wu+12 60-120K
- See F. Stanley's talk tomorrow

Overdensity

- 17 serendipitous sources 10 Hot DOG fields 71’^{2}
- Weiss+09 LESS survey 126 SMGs 1260’^{2}
- Overdensity factor 2.6±0.7 average 3σ noise
- Highest noise level overdensity factor 2.7±1.0
- Random 10 1.5-arcmin-radius-circles factor 2.1±1.0

Overdensity

- Casey+13 COSMOS field 99 SMGs 394’^{2}
- Overdensity factor 2.4±0.7 average 3σ noise
- Highest noise level overdensity factor 2.8±1.1

Overdensity

- 81 serendipitous sources 30 WISE/radio AGN 212’^{2}
- Weiss+09 LESS survey
- Overdensity factor 6.3±1.1 average 3σ noise
- Overdensity factor 4.9±1.5 average 4σ noise
- Random 100 1.5-arcmin-radius-circles factor 6.3±1.4

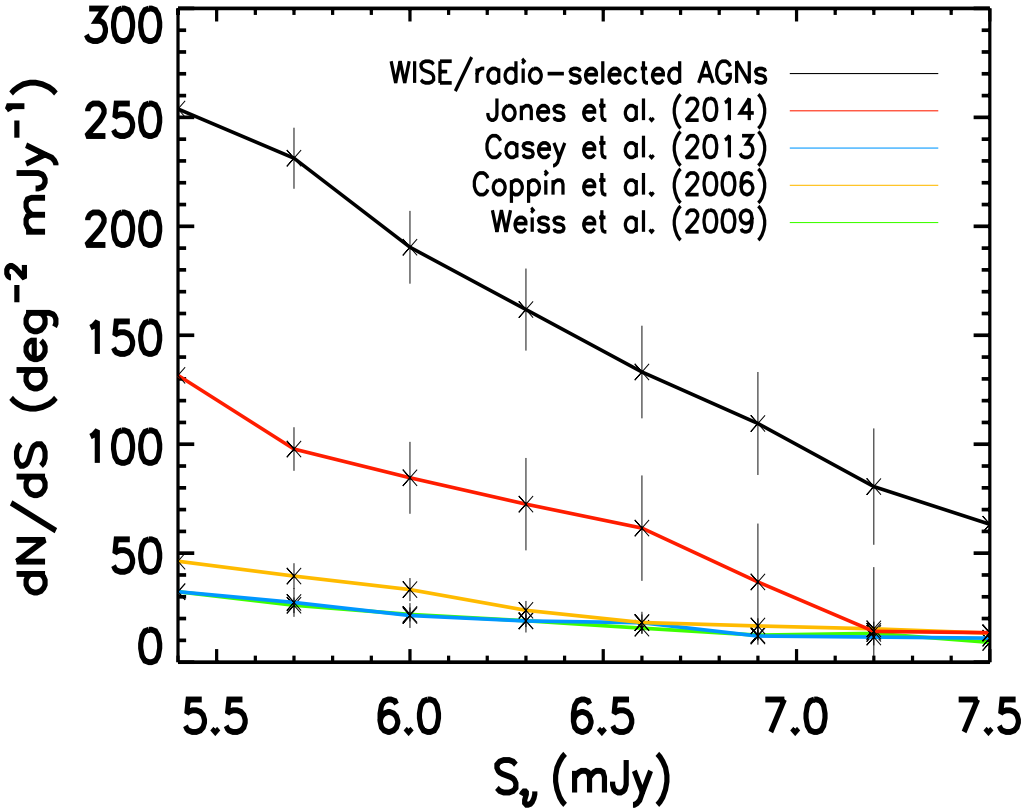
Overdensity

- Casey+13 COSMOS field
- Overdensity factor 5.7±1.4 average 3σ noise
- Overdensity factor 4.0±1.6 average 4σ noise
- WISE/radio AGN have 2.4±0.9 overdensity compared to Hot DOGs

Overdensity

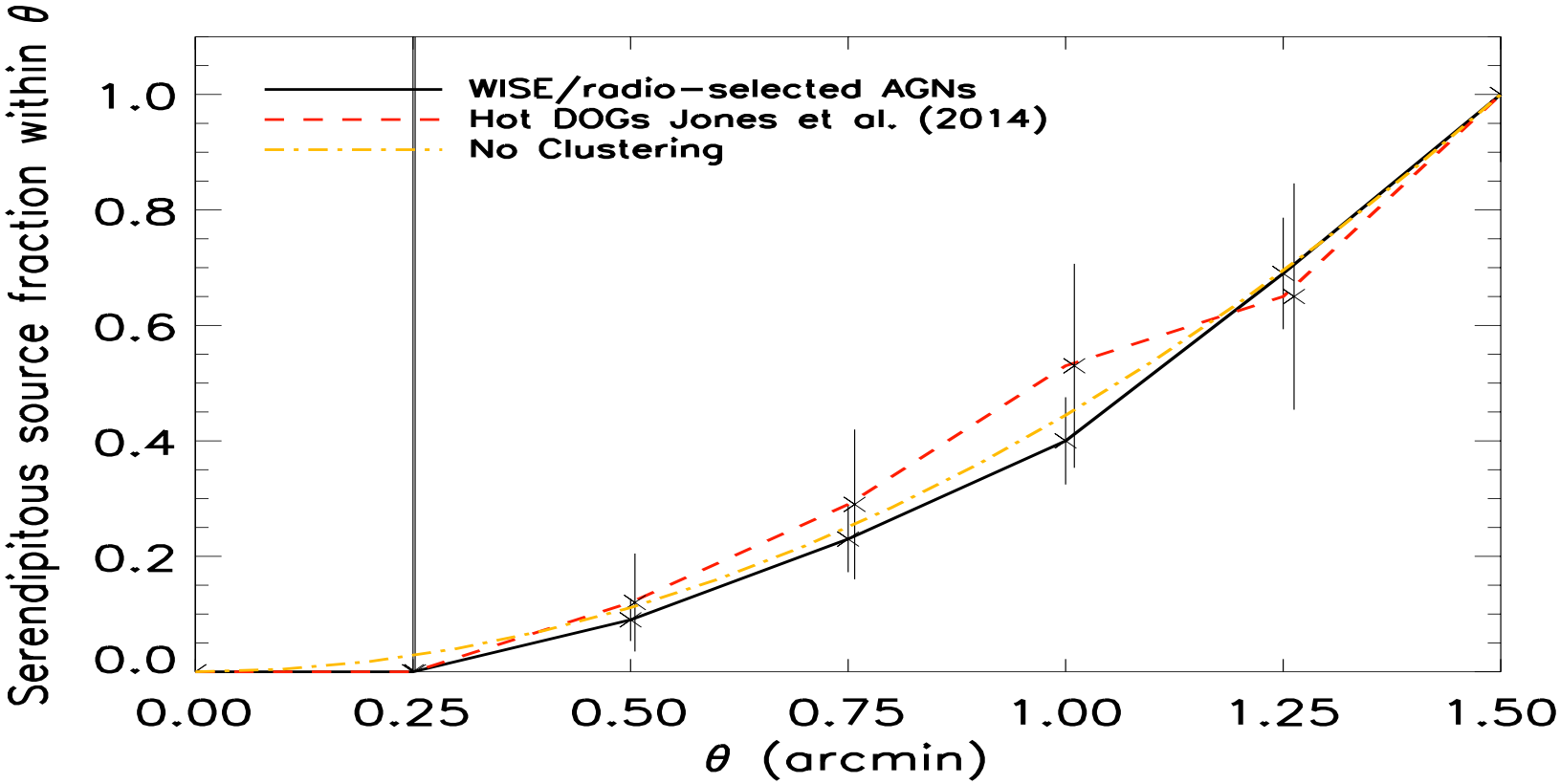
- 17 serendipitous sources 10 Hot DOG fields $71'^2$
- 81 serendipitous sources 30 WISE/radio fields $212'^2$
- Hot DOGs overdense factor ~2-3
- WISE/radio AGNs overdense factor ~5-6
- WISE/radio AGN 2.4±0.9 overdensity than Hot DOGs
- ALMA observations of 10 WISE/radio AGN (Silva+15) overdense by factor 10

Differential Number Counts



Jones+15

Clustering



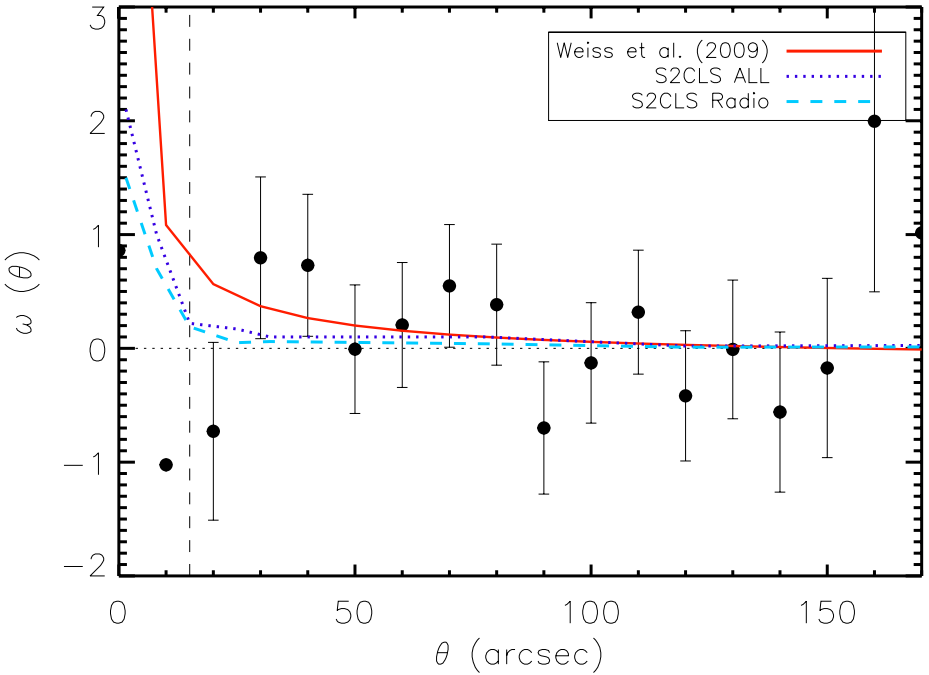
Jones+15

Clustering

- 59” average separation between Hot DOG and ss
- 58” average separation between WISE/radio AGN and ss
- 60” Monte Carlo
- 67” between ss in Hot DOG fields
- 76” between ss in WISE/radio AGN
- 80” Monte Carlo
- Suggest no angular clustering on these 1.5’ scales at z~1 ~700kpc

Clustering

- Upper limit 2-point angular clustering signal
- Clustering angle >80”



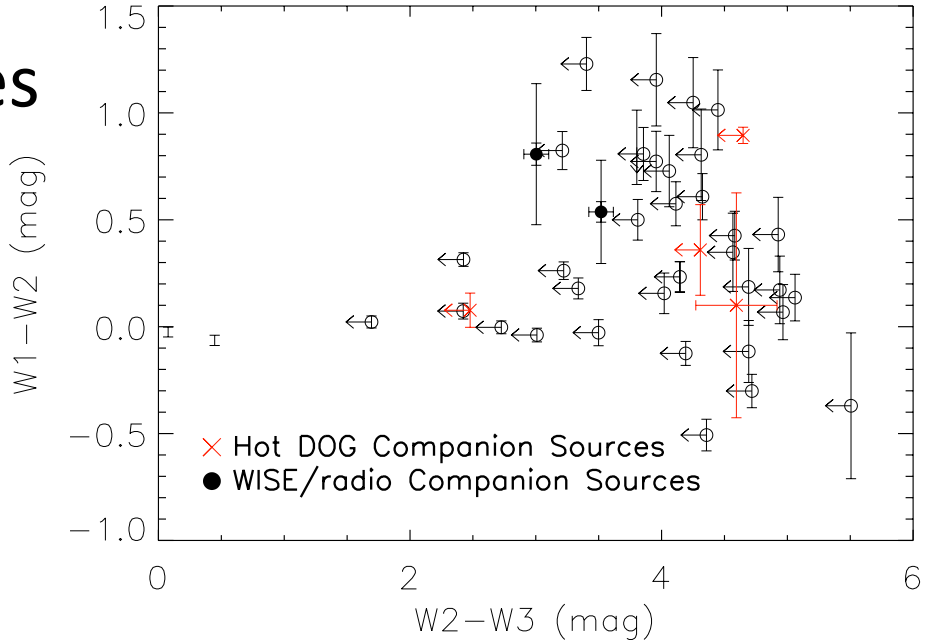
Jones+17submitted

Clustering

- Donoso+14 found stronger clustering in WISE AGN than unobscured AGN
- DiPompeo+14 found weaker clustering signal
- Mendez+16 found no difference
- Protocluster on extended scale (1.5’ at z~1 ~700kpc)?
- Muldrew+15 found z~2 protoclusters across 30’
- Or satellite galaxies?

SMGs

- SFRs > 1000 $M_{\odot} yr^{-1}$
- Starburst and AGN zones
- No detections in NVSS/FIRST
- SFRDs are higher than field consistent with clusters of dusty galaxies



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Summary

- WISE-selected AGNs are HyLIRGS, high-z, dusty
- Short evolutionary phase of merging galaxies
- Overdensity factor 2-3 Hot DOGs
- Overdensity factor 4-6 WISE/radio AGN
- Arcmin-scale overdensities
- Could be signposts of overdense regions of sky-extended? Or satellite galaxies?

Thank you

suzy.jones@chalmers.se

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