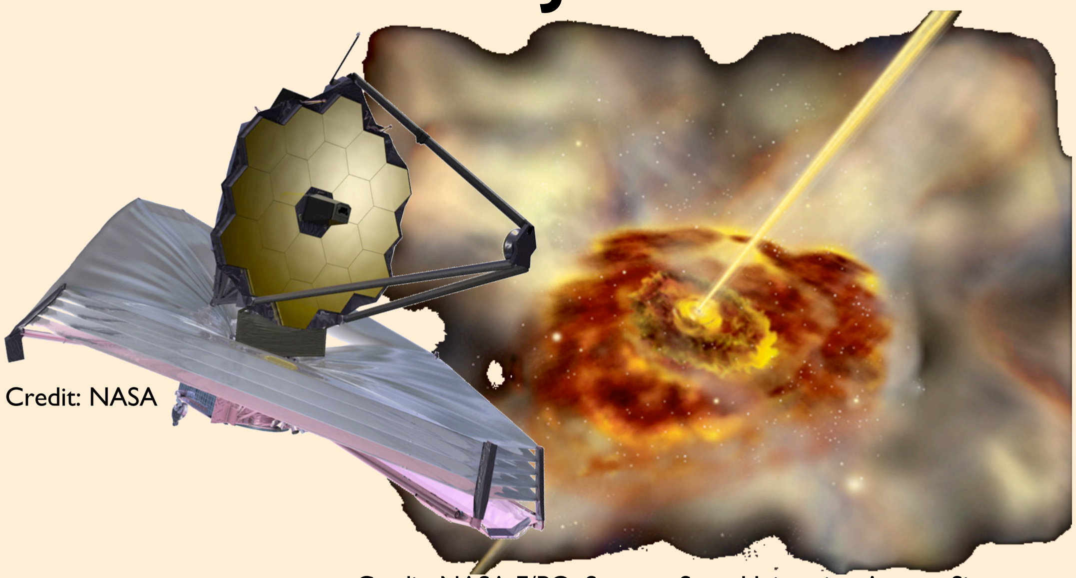
Faculdade Ciências Universidade Lisboa
OBSERVATÓRIO ASTRONÓMICO DE LISBOA

JWST and the ELTs:
an ideal combination
13-16 April 2010

Hugo Messias
Observatório Astromómico de Lisboa

Colour Selection of AGN (at High-z) with JWST



Credit: NASA

Credit: NASA E/PO, Sonoma State University, Aurore Simonnet

Supervisor: José Afonso (OALisboa, POR)
Collaborators: Mara Salvato (IPP-Garching, GER), Bahram Mobasher (UCRiverside, USA)

2010/04

Outline

My 18±2 minutes..

State of the art

- Caveats and Goals
- IR emission
- IR AGN selection

Working at high-z today

- Why (not) MIPS-24um beyond z~3?

A broader view

- Beyond z~1
- How to reject low-z SF systems?

Test (control samples)

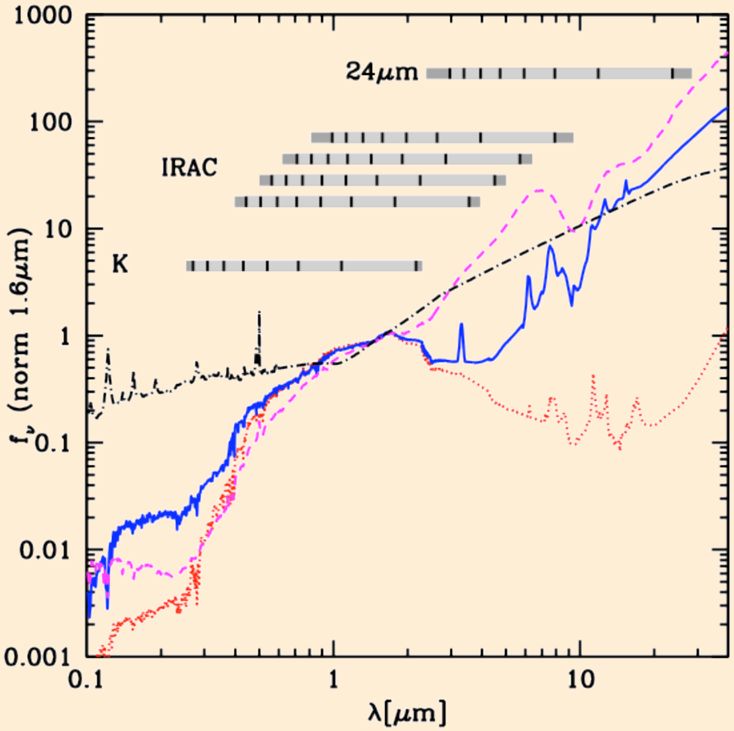
- X-rays (CDFS and XMM-COSMOS)
- Optical Spectroscopy (GOODS-S and XMM-COSMOS)
- SDSS QSO DR7
- High-z Radio Galaxies

JWST

- Filling the 8-24um gap

Caveats and Goals

Aiming to the best possible



Caveats

No AGN criterion is perfect and complete, whatever the wavelength regime! Better combine criteria! But even better if a good one is achieved through a single observation facility.

Know your input catalog (basic properties: flux range, time of observations [variability], etc...) and only then chose which criteria to use!

We work with what we have **today**, (local) models used and small high-z statistics might trick us (e.g.: Narayanan et al.2010);

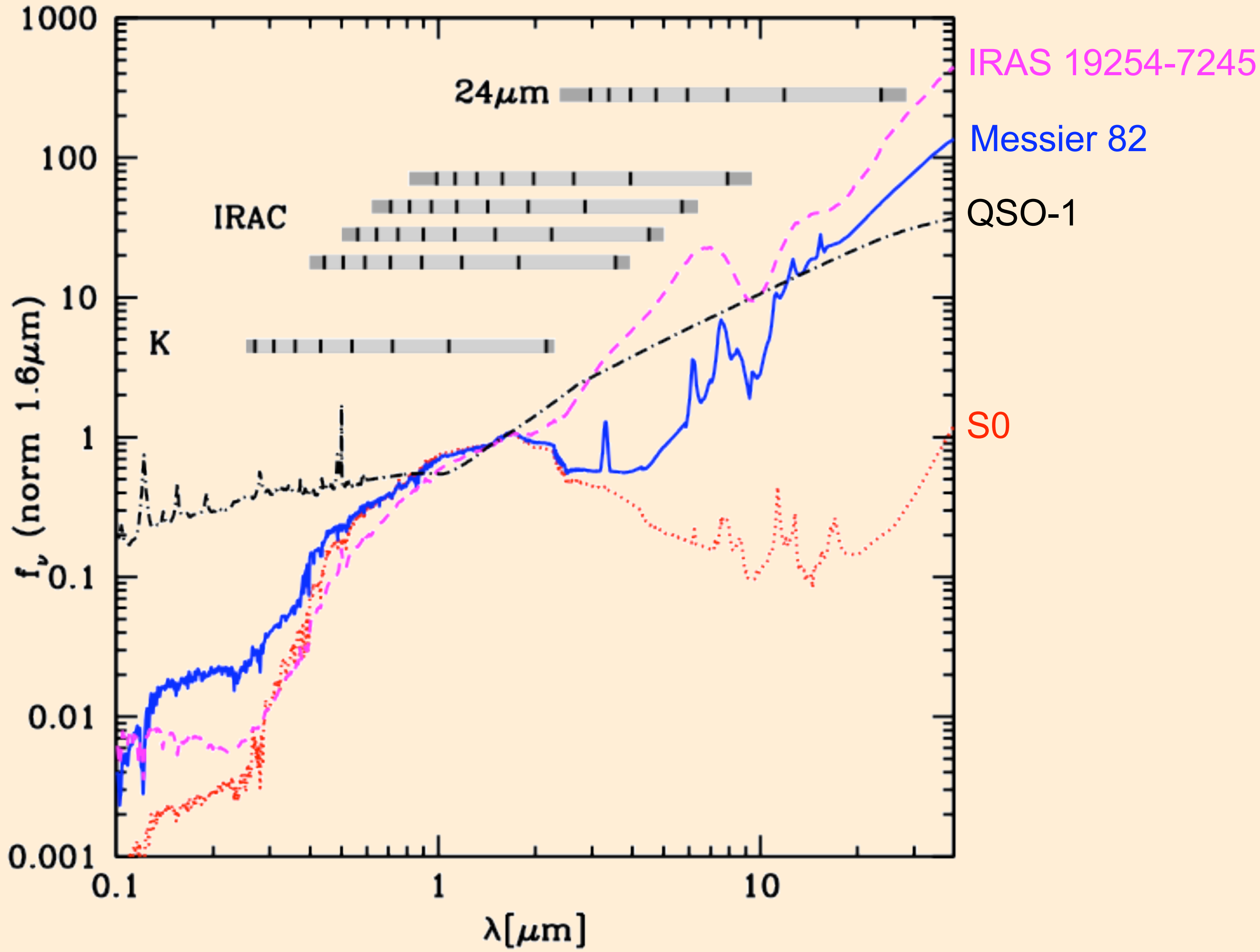
Goals

An AGN selection criterion preferably using the broad JWST wavelength range (1-25um), but quick and easy (3 to 4 bands);

Efficient over a wide redshift range and to low flux densities;

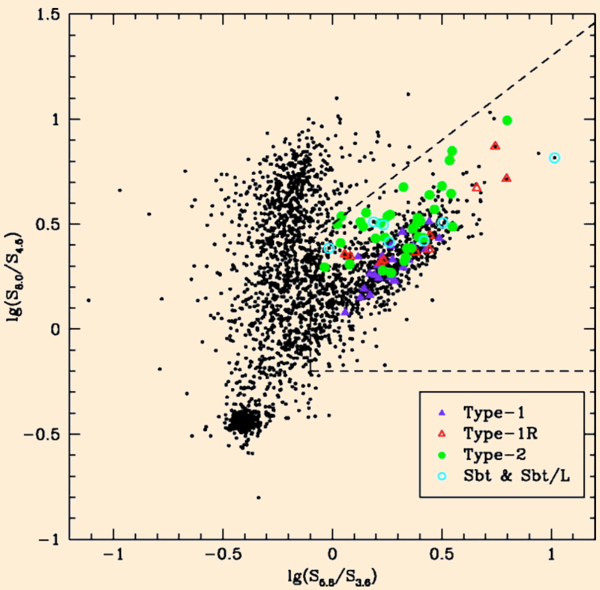
Sensitive to a variety of AGN scenarios.

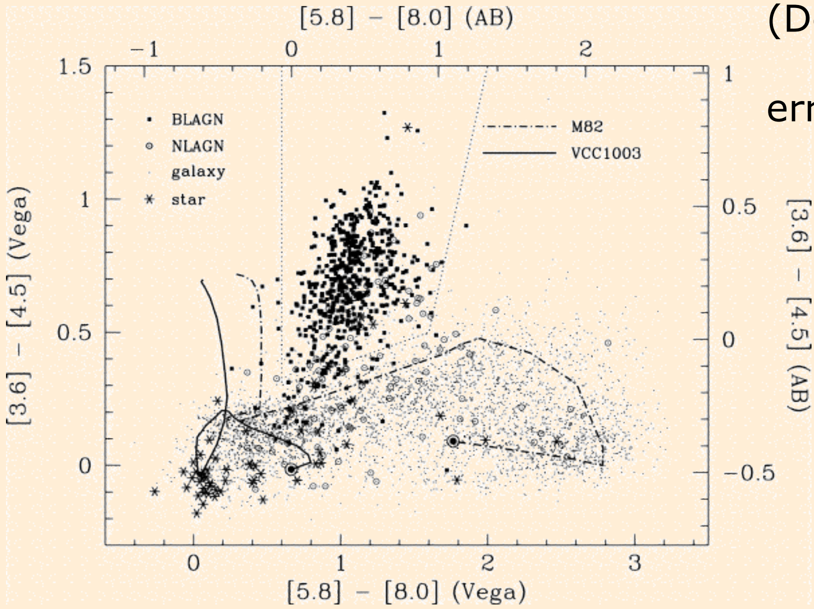
IR emission Stellar and Dust (Starburst or AGN) Emissions



SWIRE Template Library (Polletta et al.2007)

Spotting an AGN IR Colour-Colour criteria





Pros

Easy criteria to use requiring 4 bands (2 colours);

Recover many of the AGN unseen in Optical and shallow/soft X-ray surveys (Lacy et al.2004/2007, Stern et al.2005, Donley et al.2008);

Cons

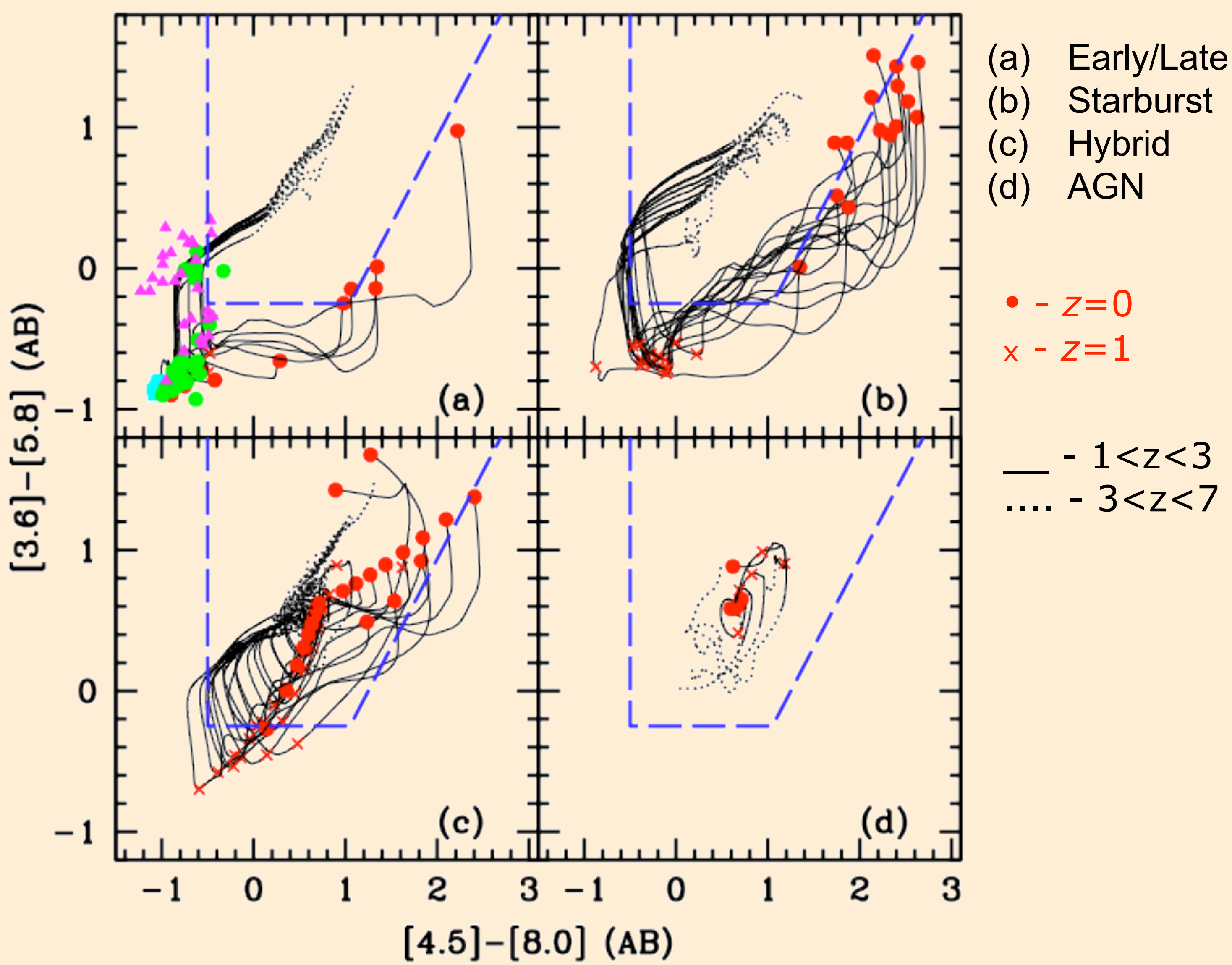
Created based on MIR shallow surveys and in a short wavelength range (3-8um, *SpitzerST*-IRAC);

Contaminated not only at high-z (z>3) but at low-z (Donley et al.2008);

Miss some highly obscured and/or less active AGN (Donley et al.2008, Eckart et al.2010);

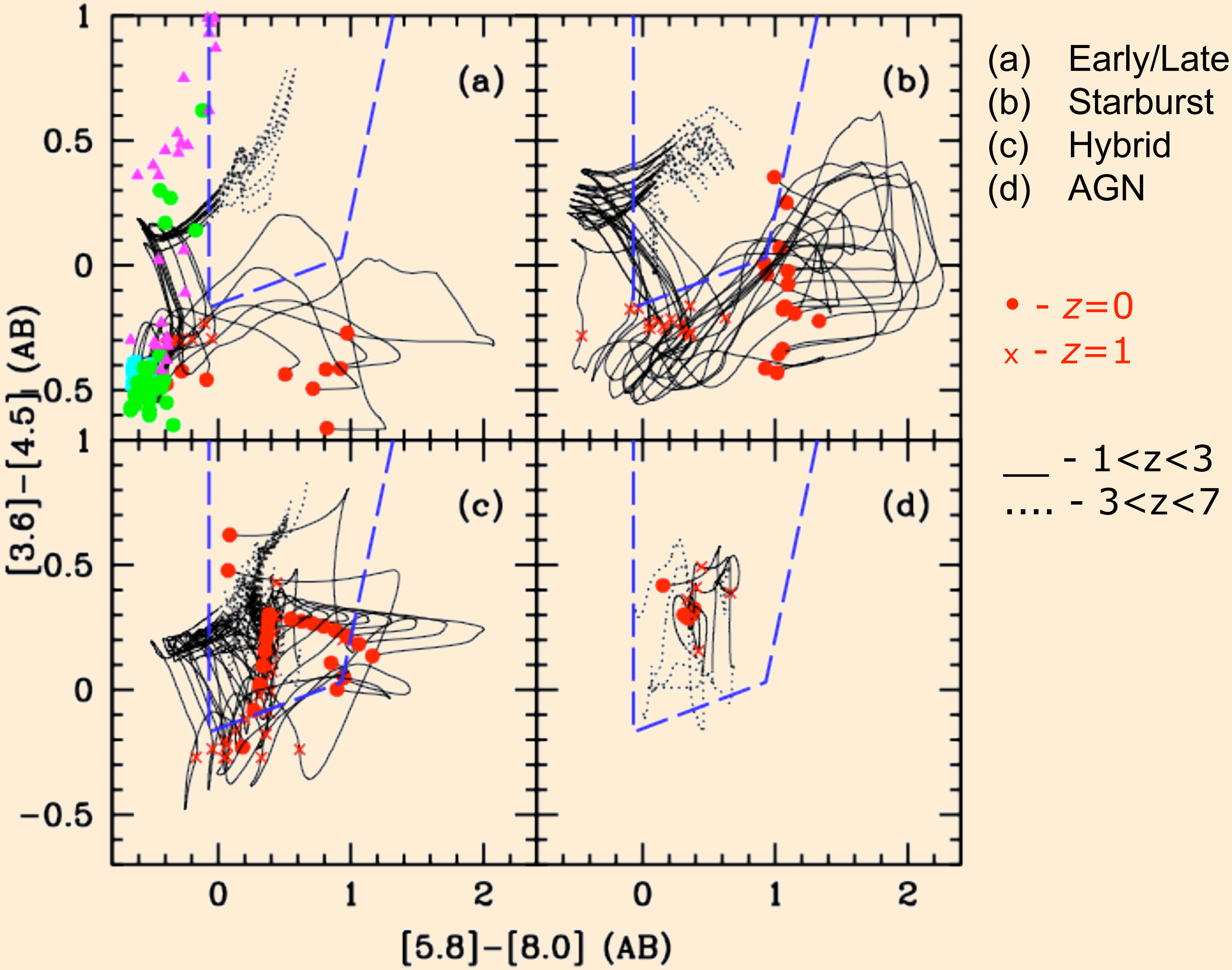
Adjacent/close bands require smaller photometric errors.

Spotting an AGN IR Colour-Colour criteria



Colour-Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009, on Lacy et al.2004/2007 region. Cyan, green and magenta data points are M, L, and T dwarfs, respectively.

Spotting an AGN IR Colour-Colour criteria



Colour–Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009, on Stern et al.2005 region. Cyan, green and magenta data points are M, L, and T dwarfs, respectively.

Spotting an AGN IR-Excess criteria

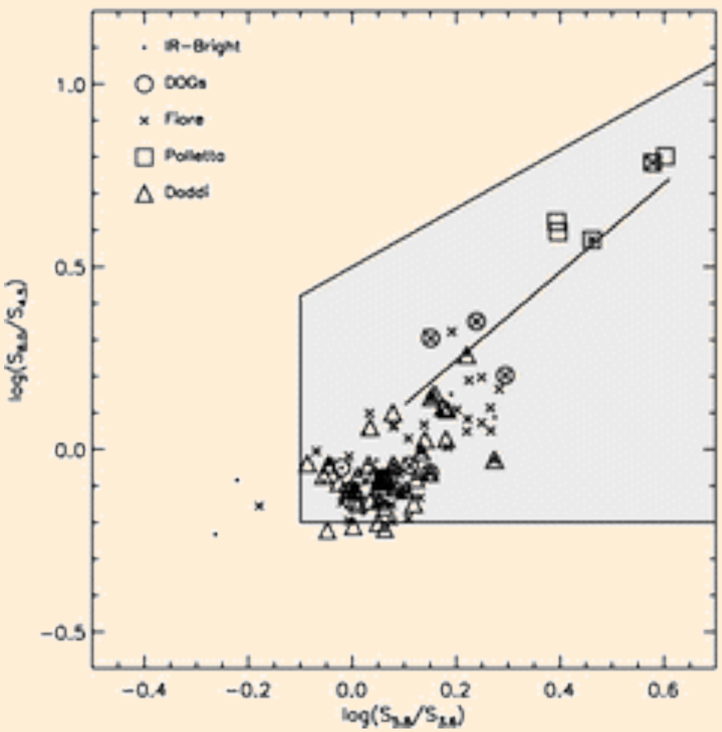


Figure 10 of Donley et al.2008. A few samples of IR-excess sources laid on Lacy et al.2004/2007 and Stern et al.2005 regions.

Pros

Some are simple requiring only 4 bands (2 colours);

Recover the extremely obscured AGN missed by Optical and shallow/soft X-ray surveys;

Some are efficient even to low-fluxes and low-activity.

Cons

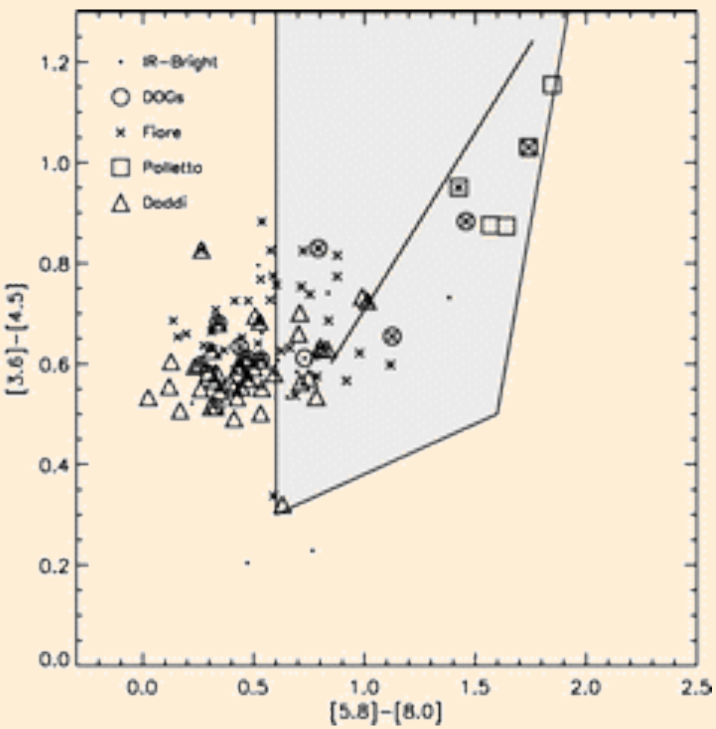
Restricted to obscured AGN;

Some extremely obscured SF dominated systems might comply with this type of criterion;

Those based in UV+IR SFRs (e.g.: Daddi et al.2007) are calibration and model dependent;

Need photometry out of the JWST spectrum range.

Spotting an AGN IR-Excess criteria



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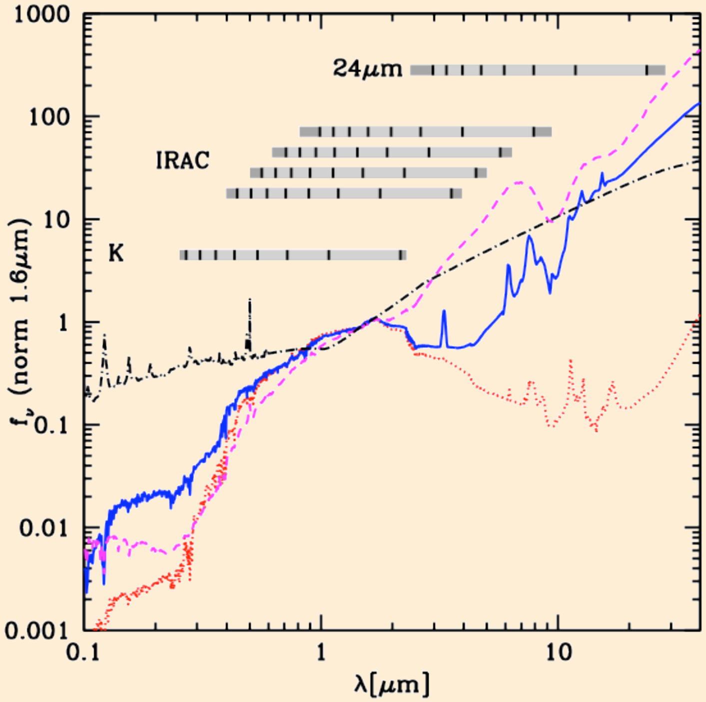
Working at High-z today



SWIRE Template Library (Polletta et al.2007): S0 (dotted red), M82 (continuous blue), type-1 QSO (black dotted-dashed line); IRAS 19254-7245 (magenta dashed line)

Why (not) MIPS-24um beyond z~3?

Why yes

At z>3, MIPS-24 stops probing the strong PAH features and 8um is starting to probe the peak of stellar emission;

It does help to separate Star-forming and AGN IR dominated systems.

Why not

Huge PSF and lack of sensitivity compared with IRAC channels;

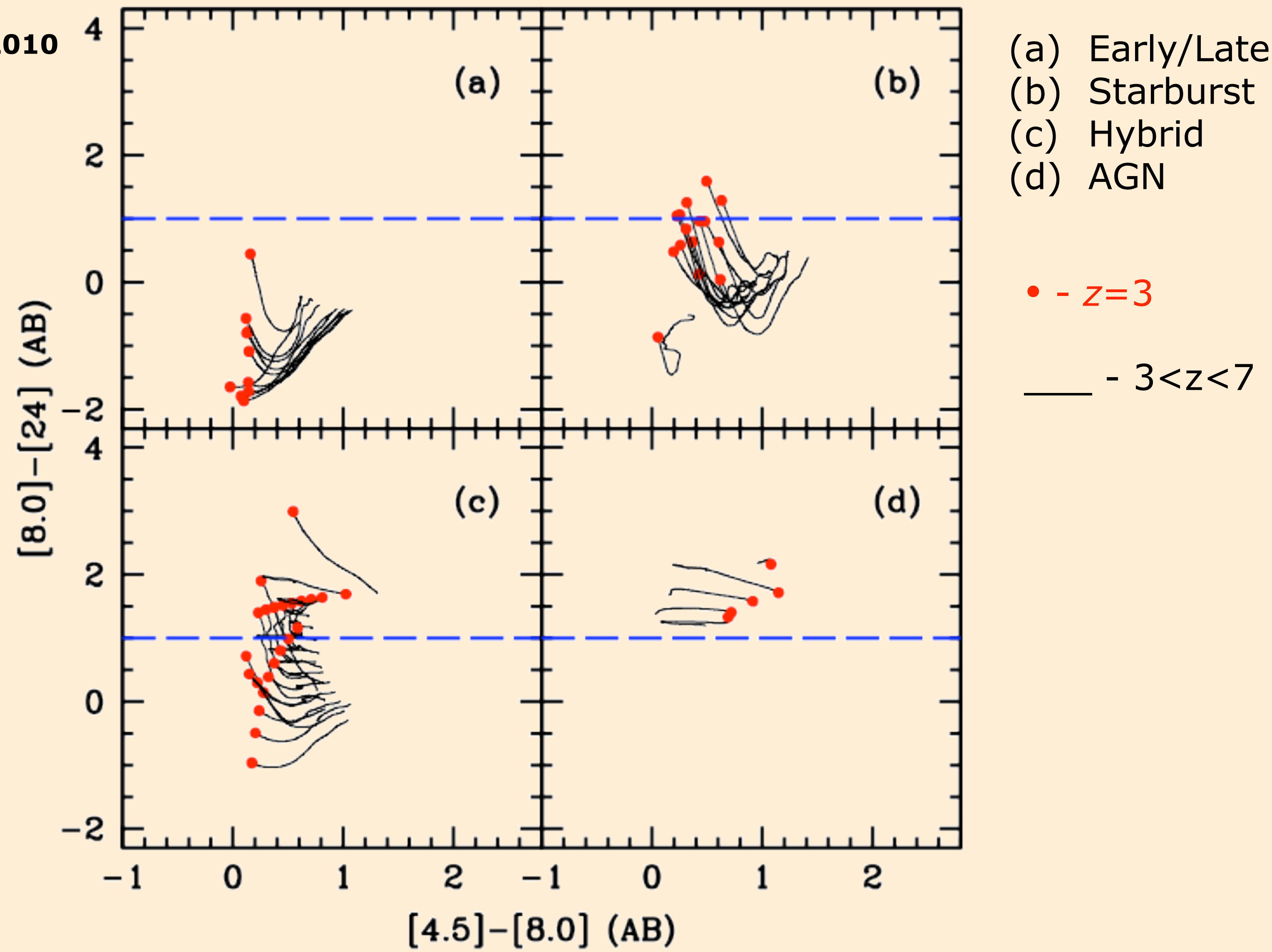
Huge spectrum gap between 8.0um for IRAC and 24um from MIPS (!!in reality, at high-z the observed 8 and 24um gap translates into a smaller 2 to 6um rest-frame range).

Some previous works using colours with 24um: Lacy et al.2004, Fiore et al.2008, Polletta et al.2008, Garn et al.2009.

[Note that Ivison et al.2004, Pope et al.2008 although they present a colour-colour plot with 24um included, their criteria is actually only based in a 4.5-8.0 colour.]

Working at High-z today Why (not) MIPS-24um beyond z~3?

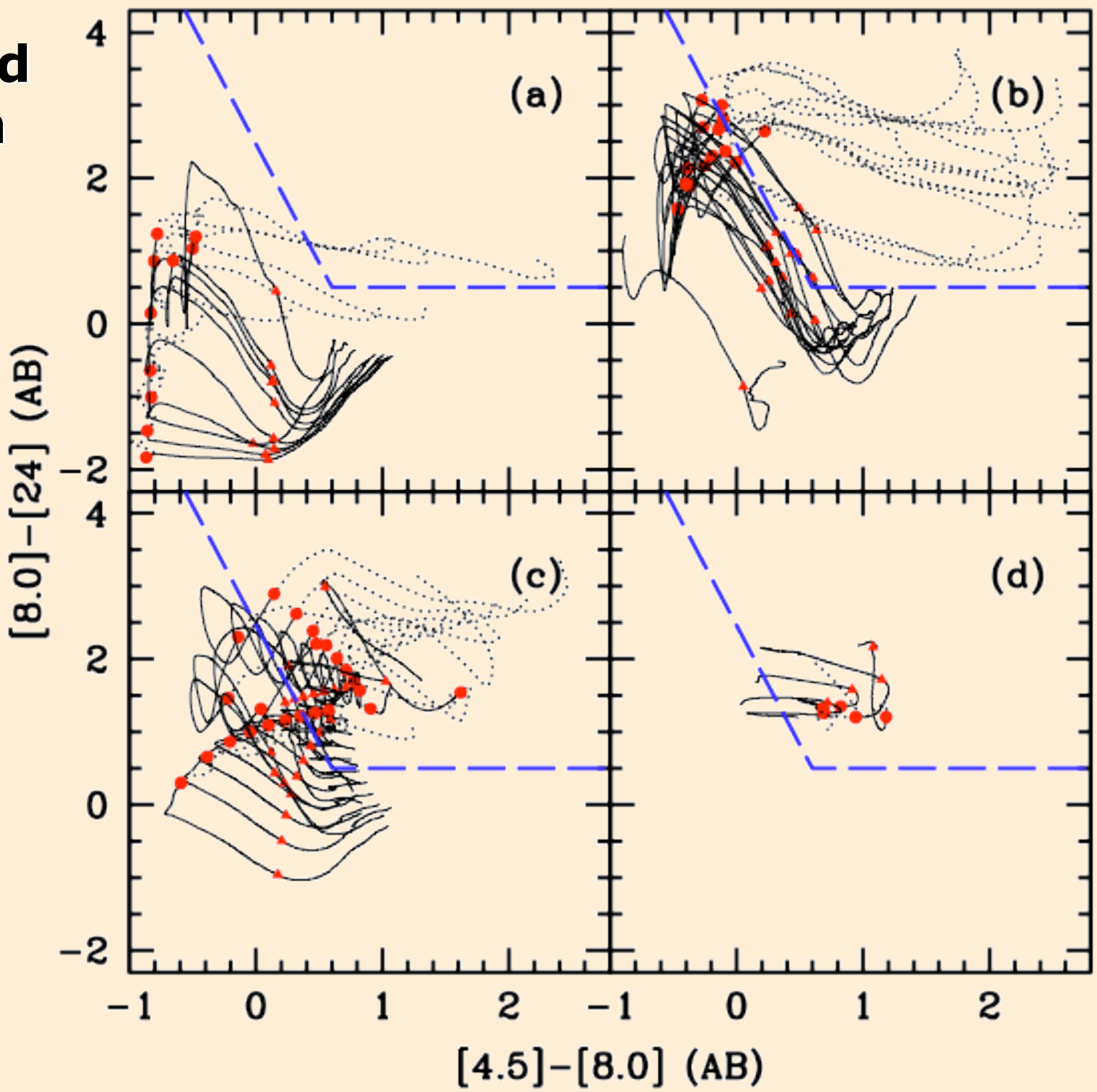
Messias et al. 2010 (ApJ subm.)



Colour–Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009.

A broader view Beyond z~1

Proposed criterion



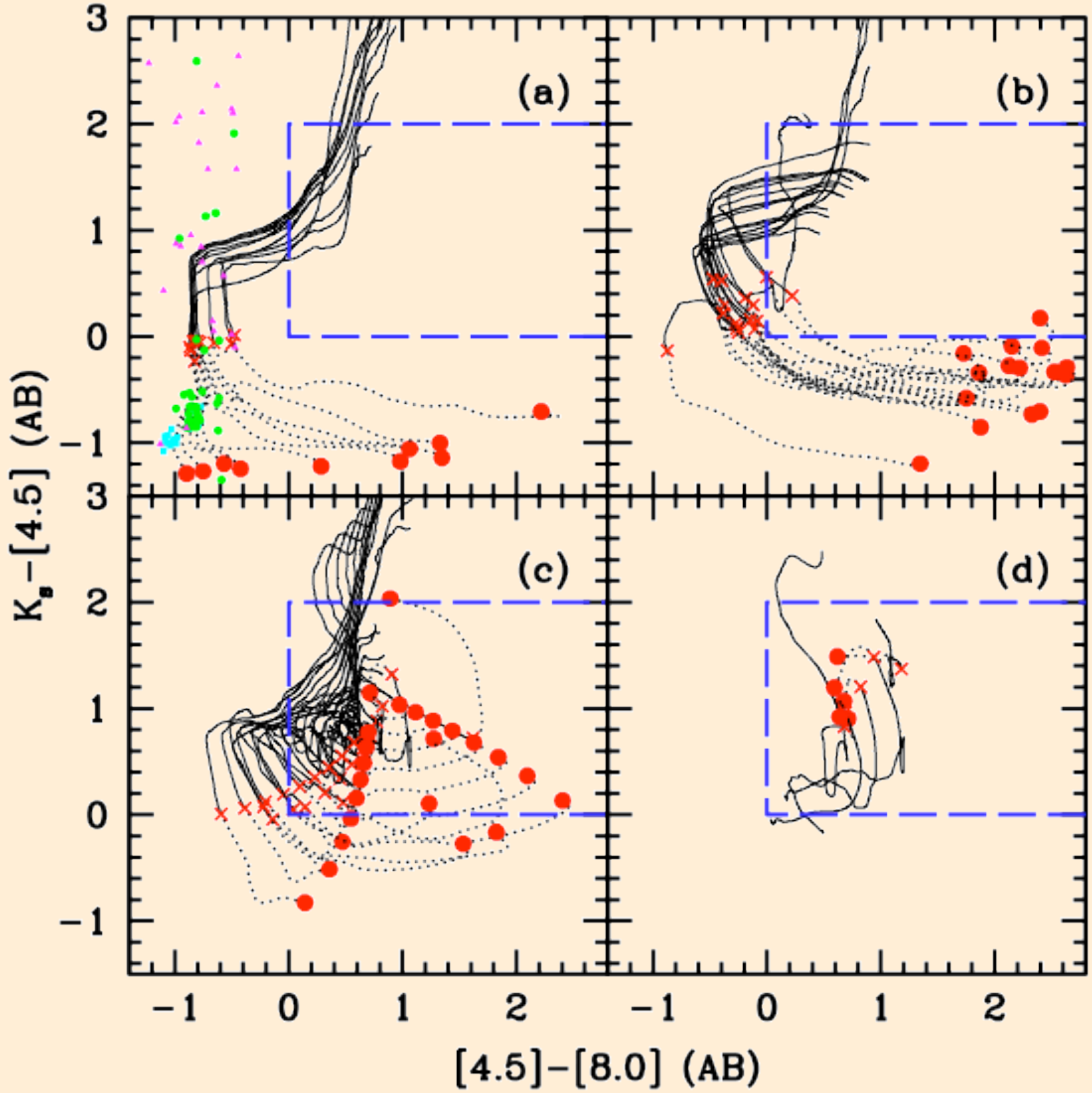
(a) Early/Late
(b) Starburst
(c) Hybrid
(d) AGN

• - $z=1$
▲ - $z=3$

..... - 0<z<1
____ - 1<z<7

Colour-Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009.

A broader view How-to reject low-z SF systems?



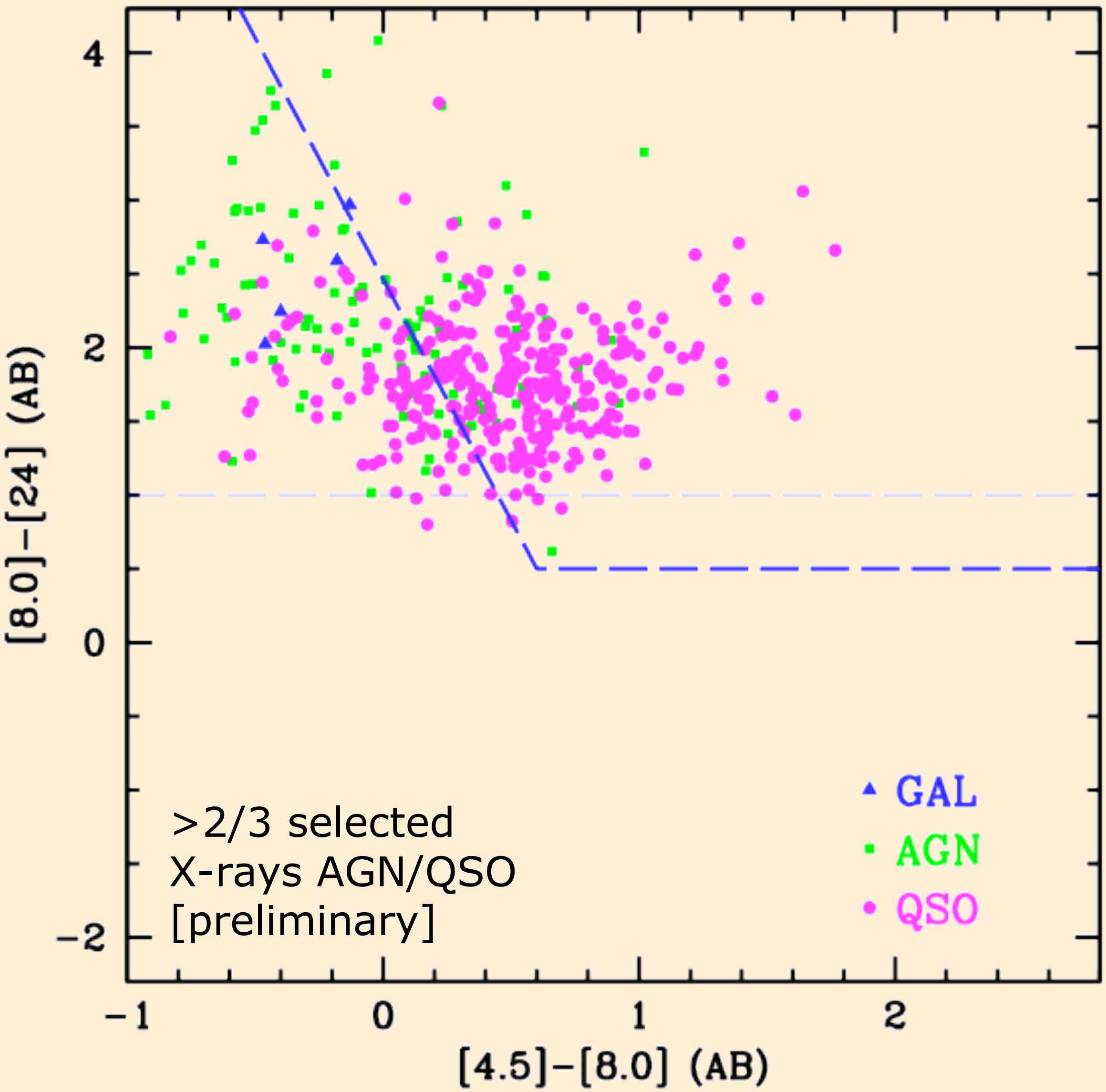
(a) Early/Late
(b) Starburst
(c) Hybrid
(d) AGN

• - $z=0$
x - $z=1$

.... - $z<1$

Colour–Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009. Cyan, green and magenta data points are M, L, and T dwarfs, respectively.

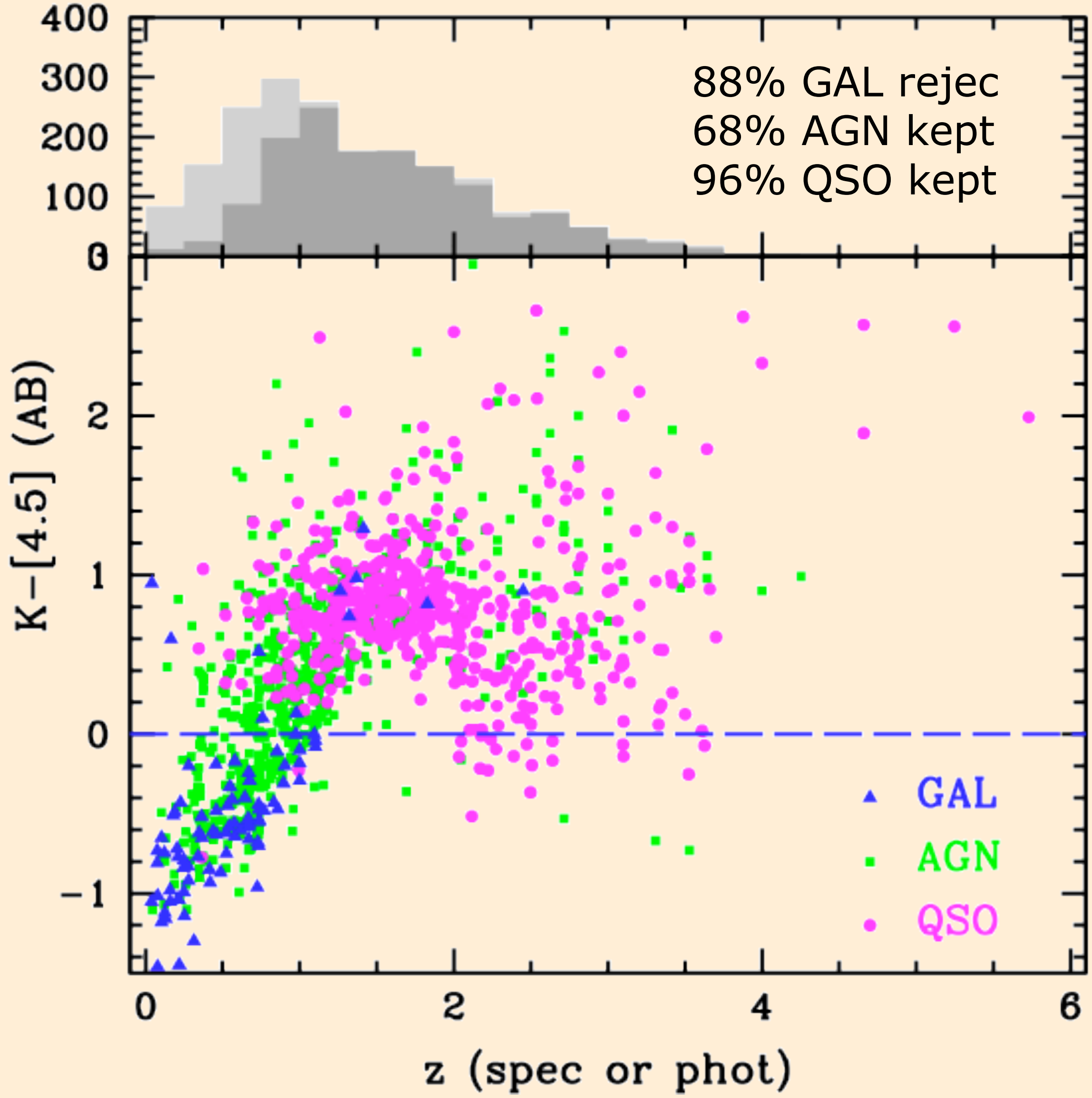
Test (control samples) X-rays: CDF-s and XMM-COSMOS



L04 - 88%
S05 - 80%
[24um detect!
And are
contaminated!]

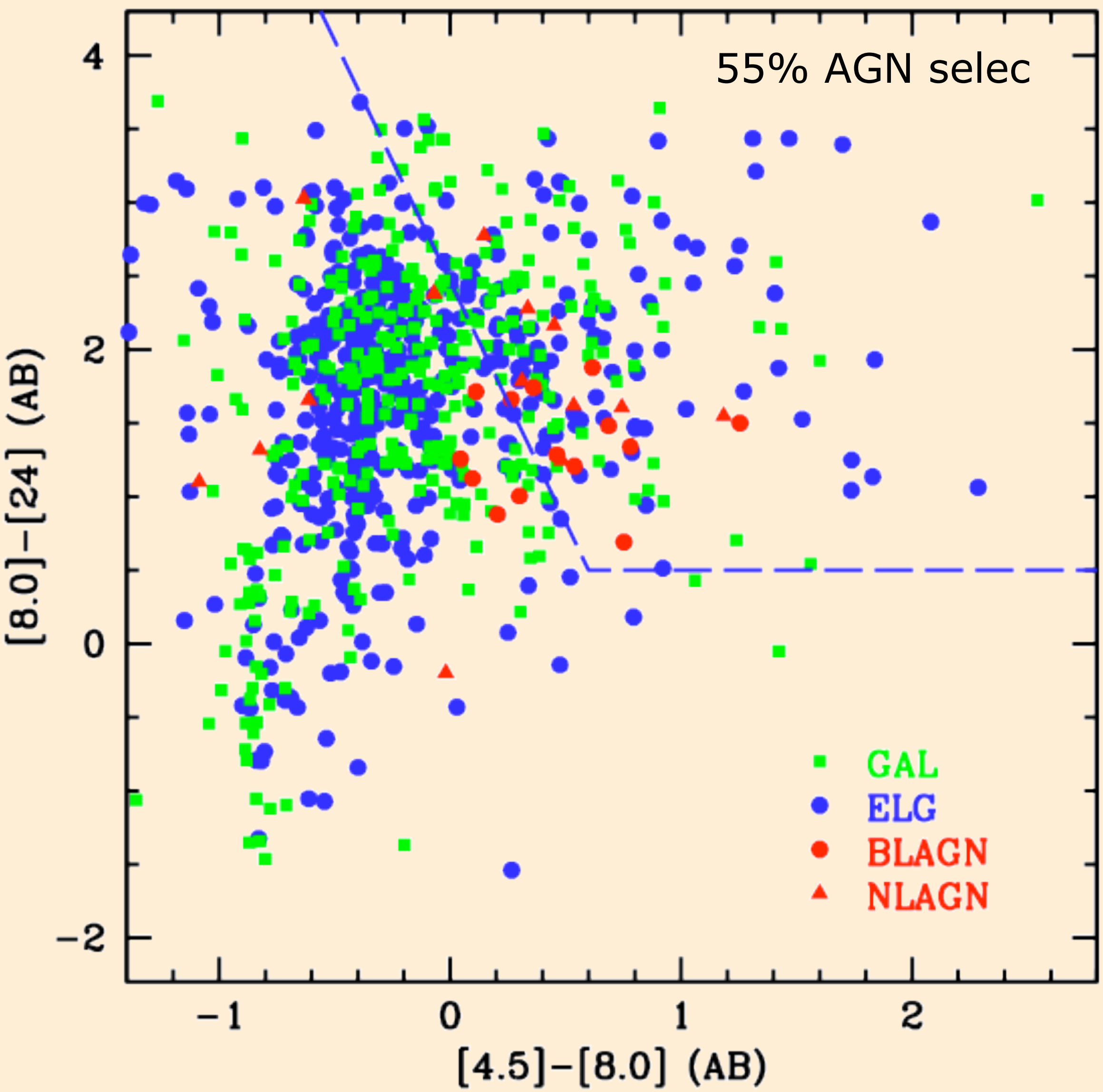
X-ray classified sample at z>1, from Luo et al.2010 (CDF-s) and Brusa et al.2010 (XMM-COSMOS, ApJ submitted).

Test (control samples) X-rays: CDF-s and XMM-COSMOS



The effect of applying a K−[4.5] cut. X-ray sample from Luo et al.2010 (CDF-s) and Brusa et al.2010 (XMM-COSMOS, ApJ submitted).

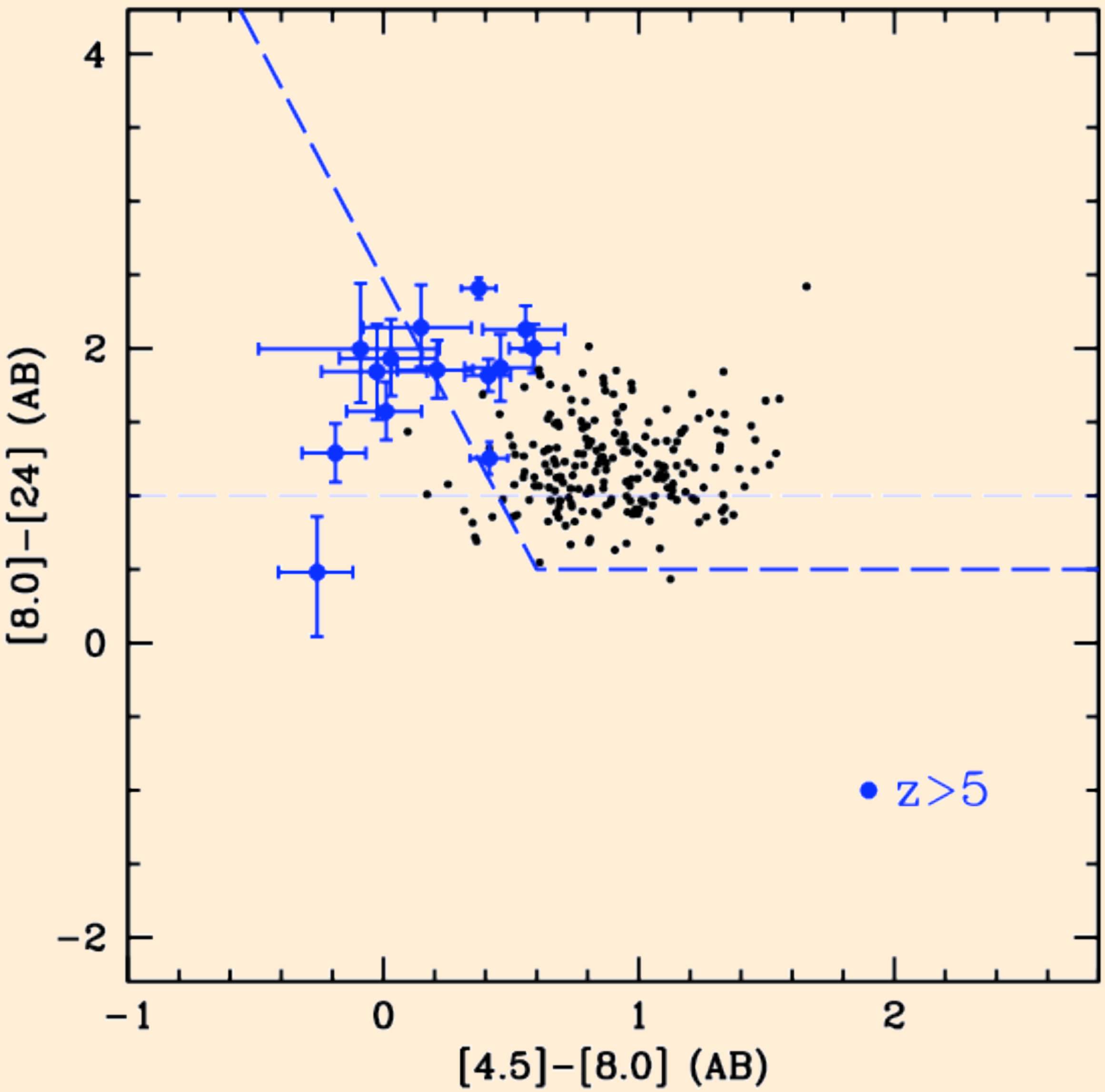
Test (control samples) Optical spectroscopy (CDF-S, MUSIC-2009)



L04 - 75%
S05 - 50%

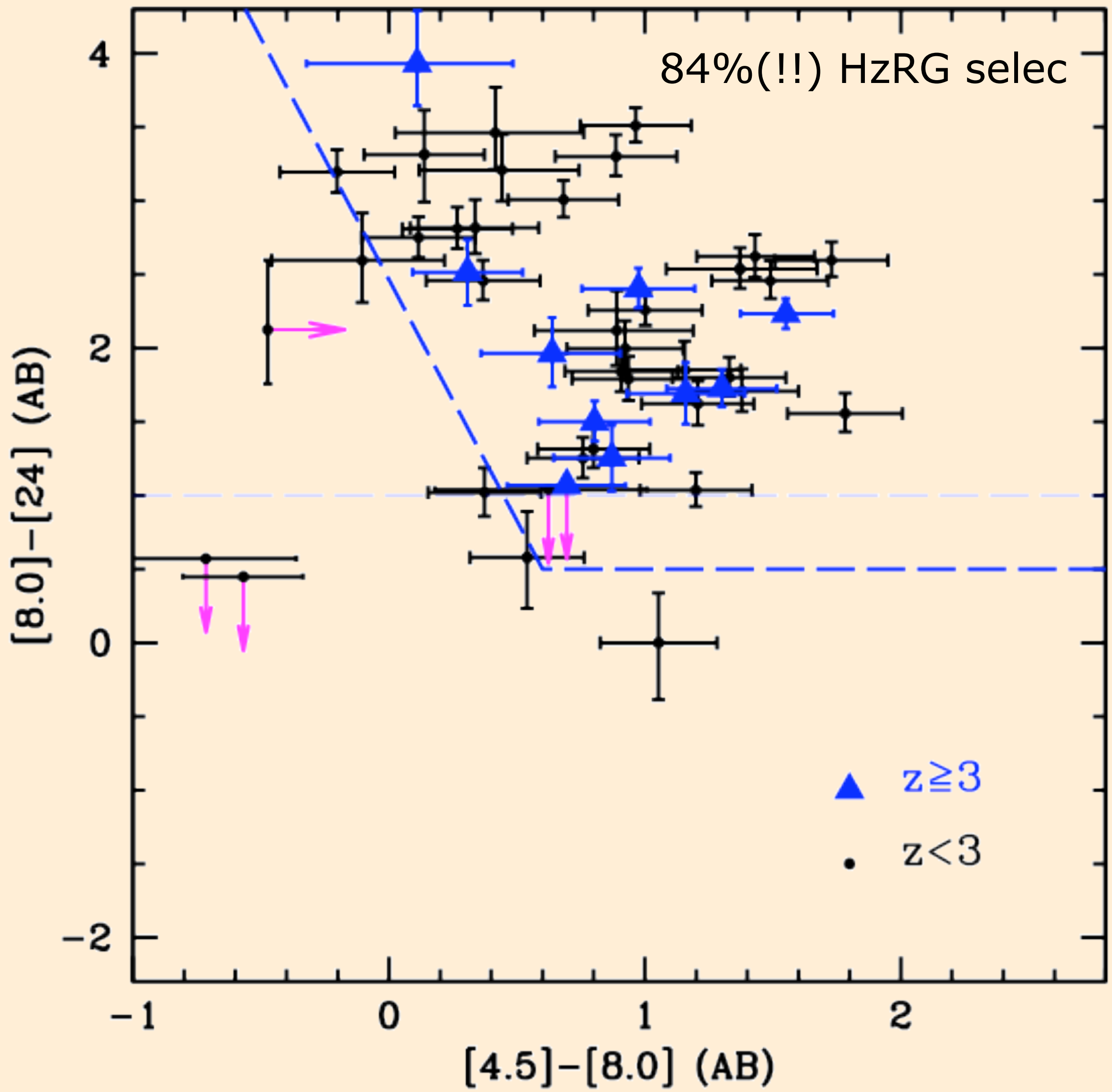
All sources with a good quality spectra and a redshift estimate of z>1.

Test (control samples) SDSS QSO DR7: SWIRE/SCOSMOS



SDSS DR7 cross-correlated with the SWIRE/SCOSMOS fields.
Some z~6 QSOs from Jiang et al.2006 were also added.

Test (control samples) High-*z* Radio Galaxies (z>1 and $L_{3GHz}>10^{26}$W Hz^{-1})



L04 - 88%
S05 - 67%

Seymour et al.2008 sample of High−z Radio Galaxies.

JWST Filling the 8-24um gap

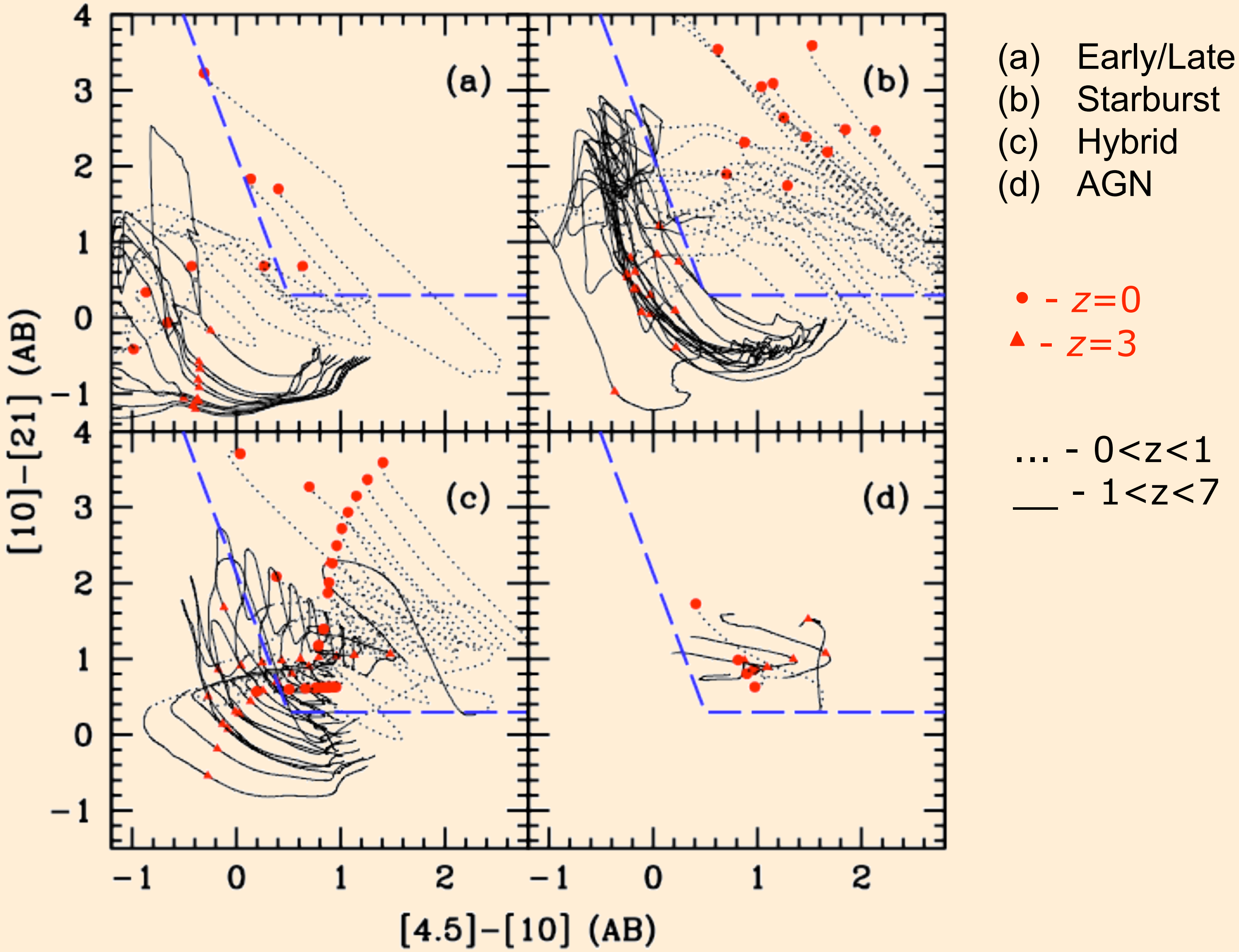
NIRCam

Wavelength range 0.6-5um

MIRI

Filter	λ(μm)	Δλ(μm)	Comment
F560W	5.6	1.2	Broad Band
F770W	7.7	2.2	
F1000W	**10**	**2**	**Silicate, Broad Band**
F1130W	11.3	0.7	PAH, Broad Band
F1280W	12.8	2.4	Broad Band
F1500W	15	3	Broad Band
F1800W	18	3	Silicate, Broad Band
F2100W	**21**	**5**	**Broad Band**
F2550W	25.5	4	Broad Band

JWST Filling the 8-24um gap



Colour-Colour tracks of models from Polletta et al.2007, Rieke et al.2008, Salvato et al.2009.
Assef et al.2010 also address this spectrum range but are reasonably incomplete at z>3-4.

Conclusions

A bright future!

A simple criterion efficient at $1<z<7$(or more), requiring solely 3 bands (2 colours), likely to be improved with JWST online;

Works at $z<1$ by adding only one band (K, ~2um), which allows the track of AGN behaviour from the local to the distant Universe;

Sensitive to a wide variety of AGN properties;

ELTs will contribute a lot with high-resolution imaging and spectroscopic follow-ups of the selected samples.