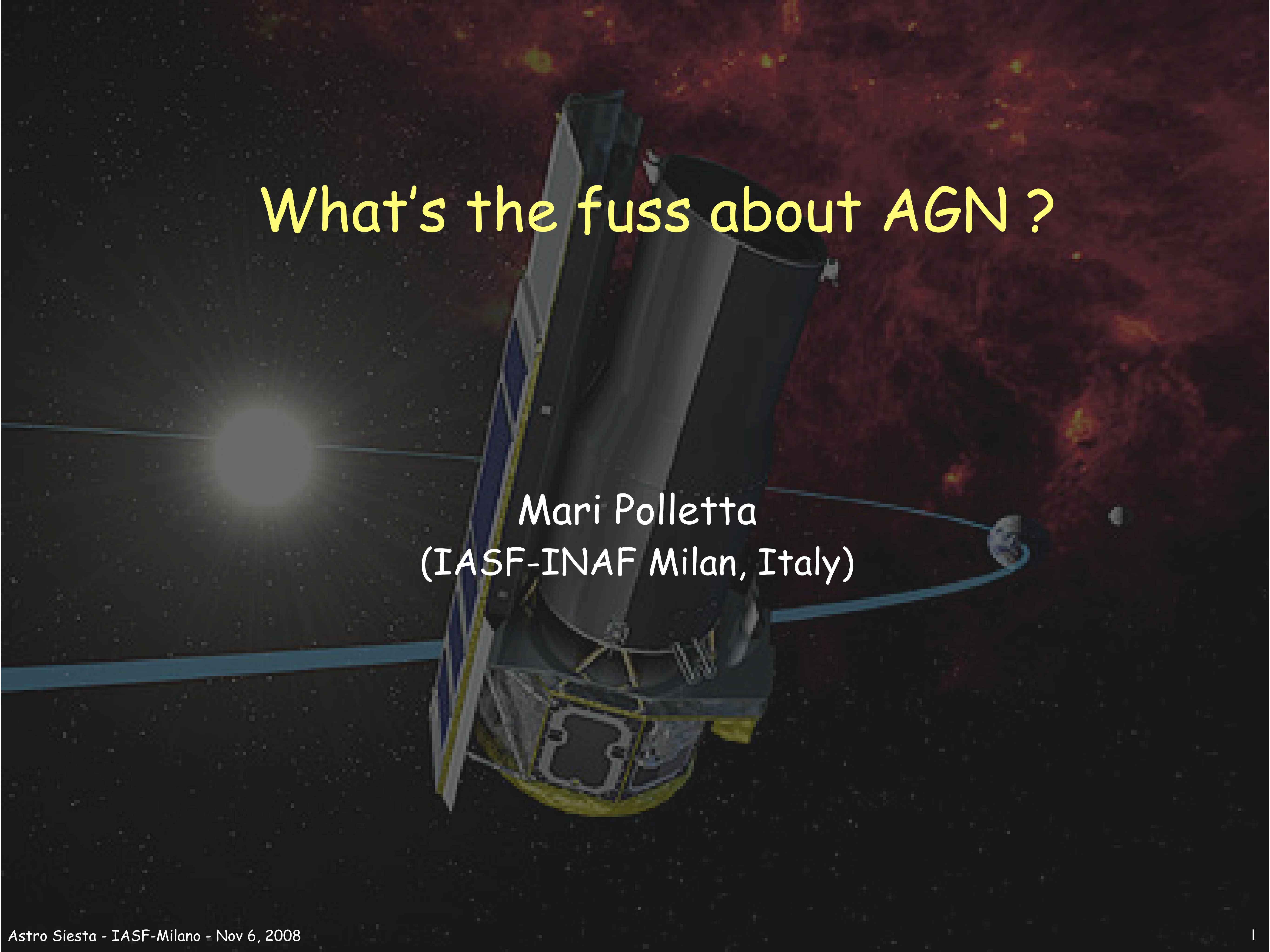


What's the fuss about AGN ?

Mari Polletta
(IASF-INAF Milan, Italy)

Outline

- What is an Active Galactic Nucleus (AGN) ?
- AGN role and importance
- AGN evolutionary models and feedback
- Star-formation and AGN activity at high redshifts and luminosities
- Feedback signatures and implications on models

Active Galactic Nuclei
Components and Taxonomy

AGN observed properties are orientation-dependent

λ	Type 1	Type 2
Optical spectrum	Broad lines	Narrow lines
Optical continuum	Blue	Red
Mid-infrared	Hot dust	Warm dust
X-ray	Soft/ unabsorbed	Hard/ absorbed

(Antonucci 1993)

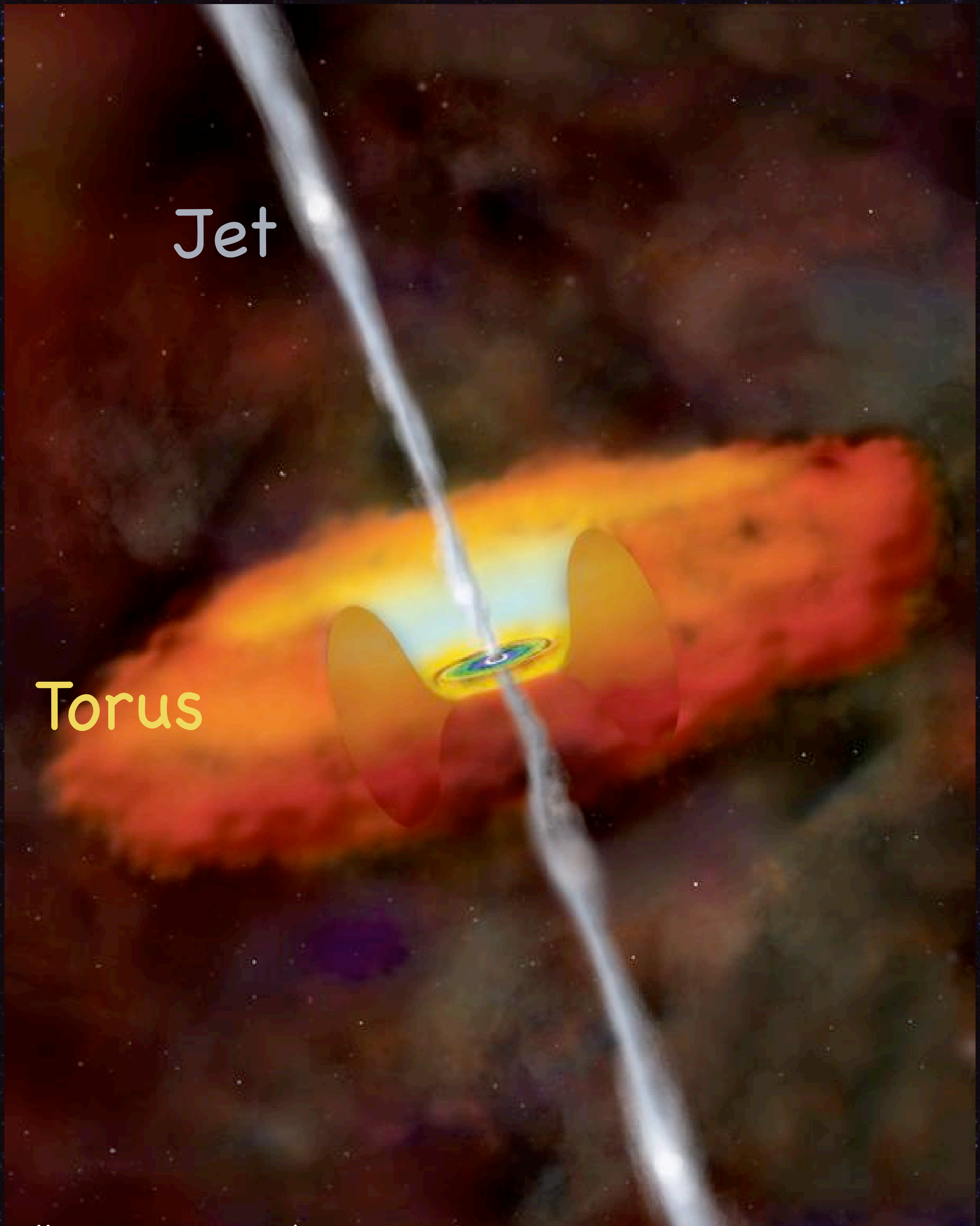
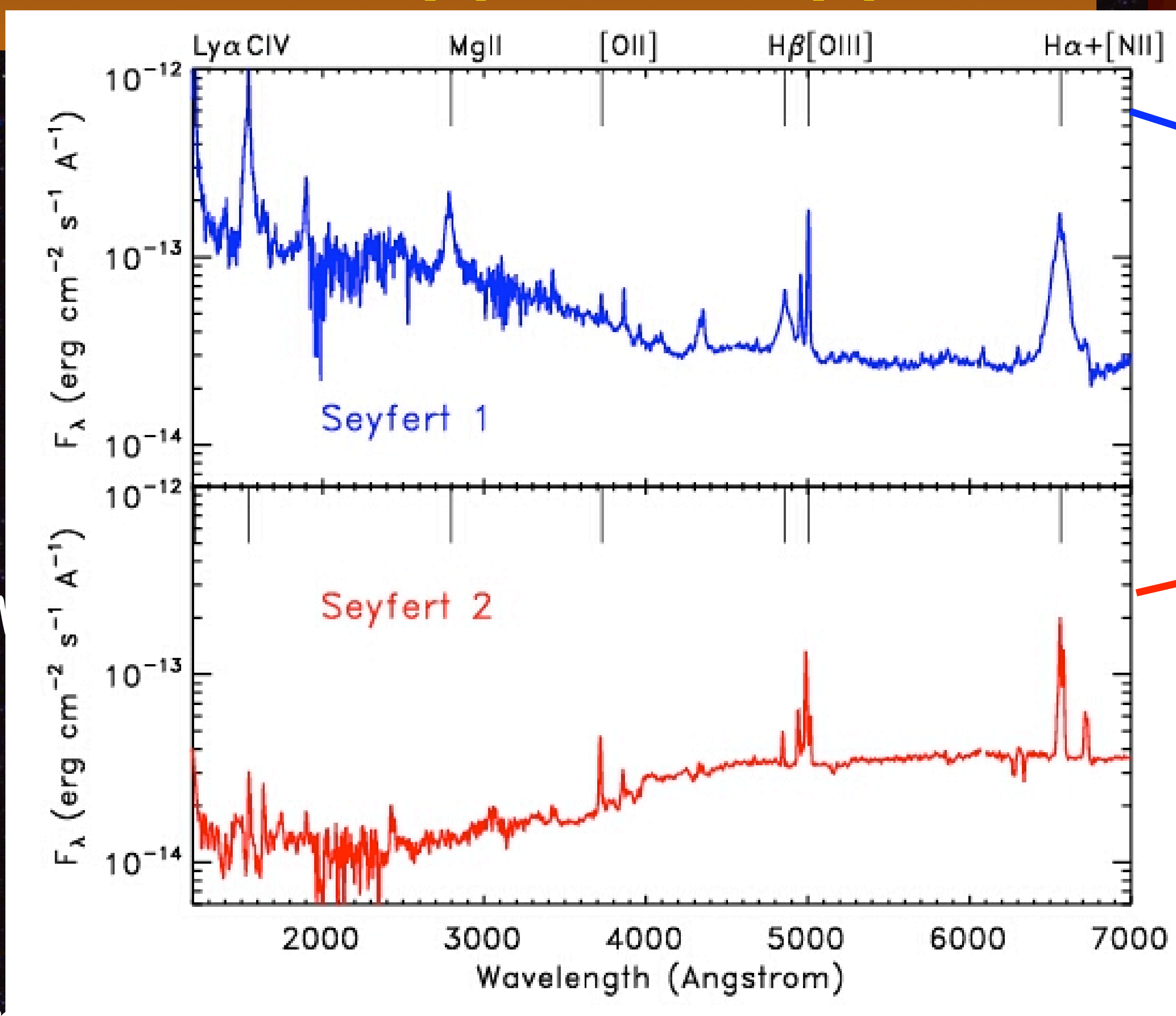


Illustration: CXC/Weiss

Active Galactic Nuclei
Components and Taxonomy

AGN observed properties are orientation-dependent

λ	Type 1	Type 2



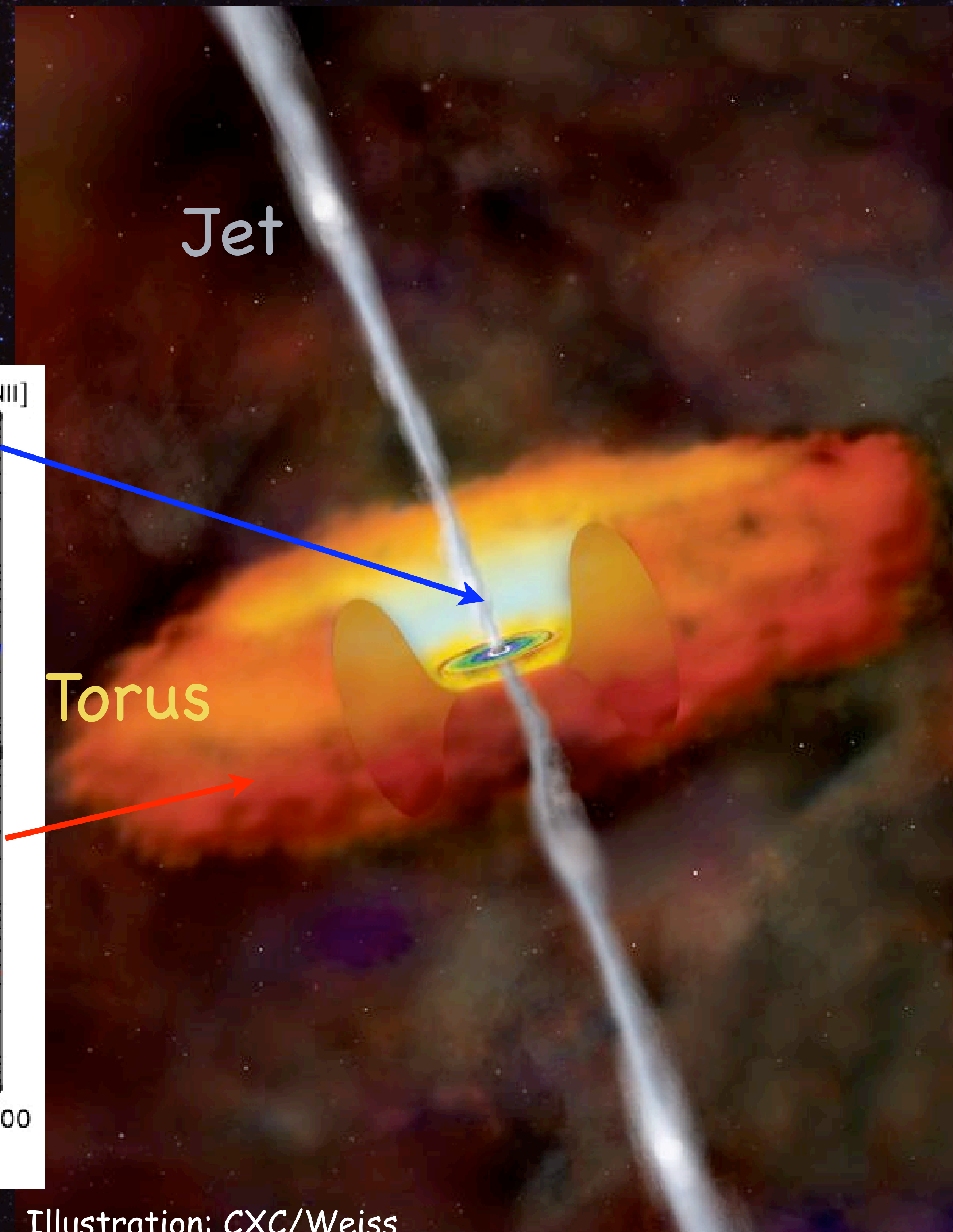
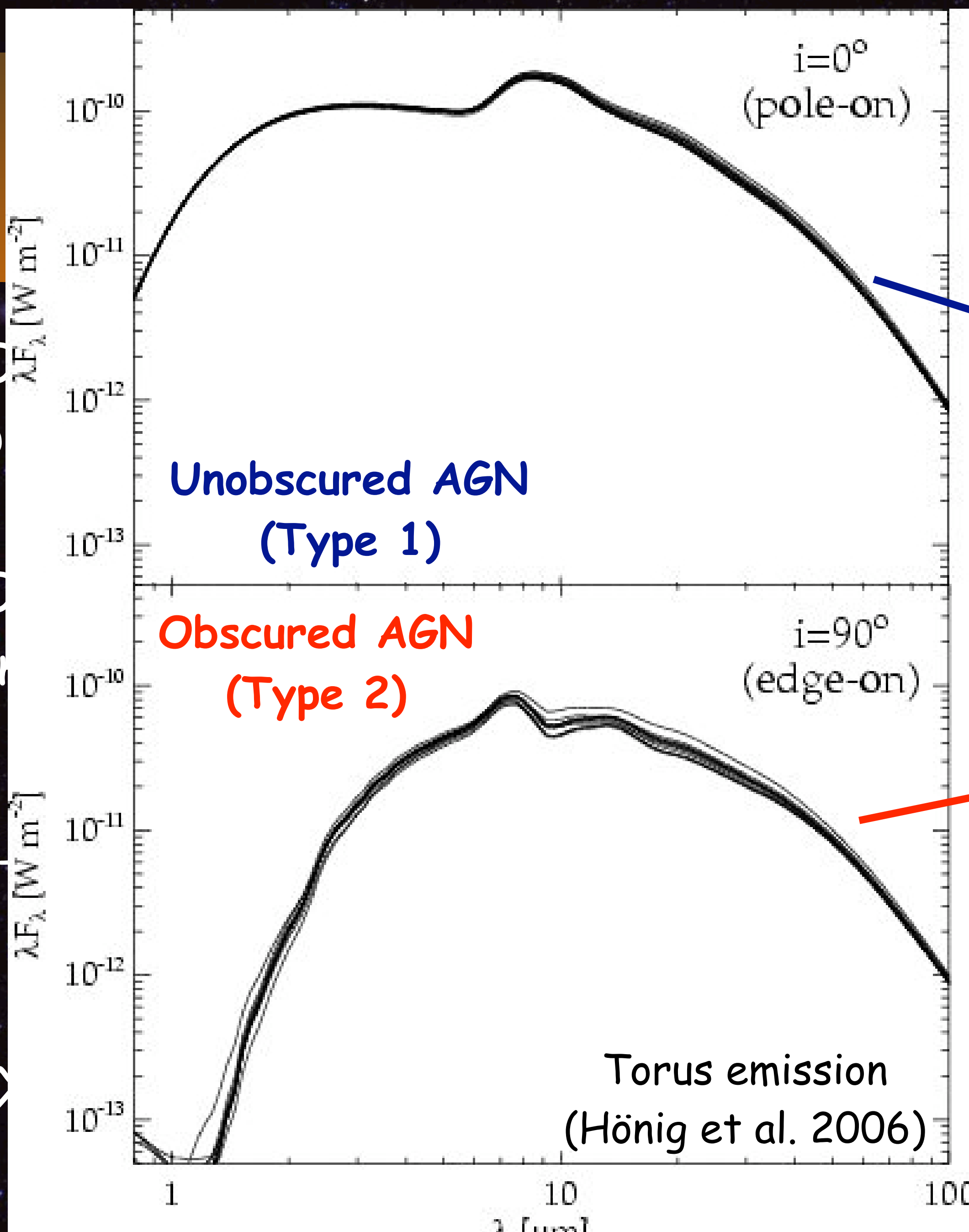


Illustration: CXC/Weiss

Active Galactic Nuclei
Components and Taxonomy

AGN observed properties are orientation-dependent



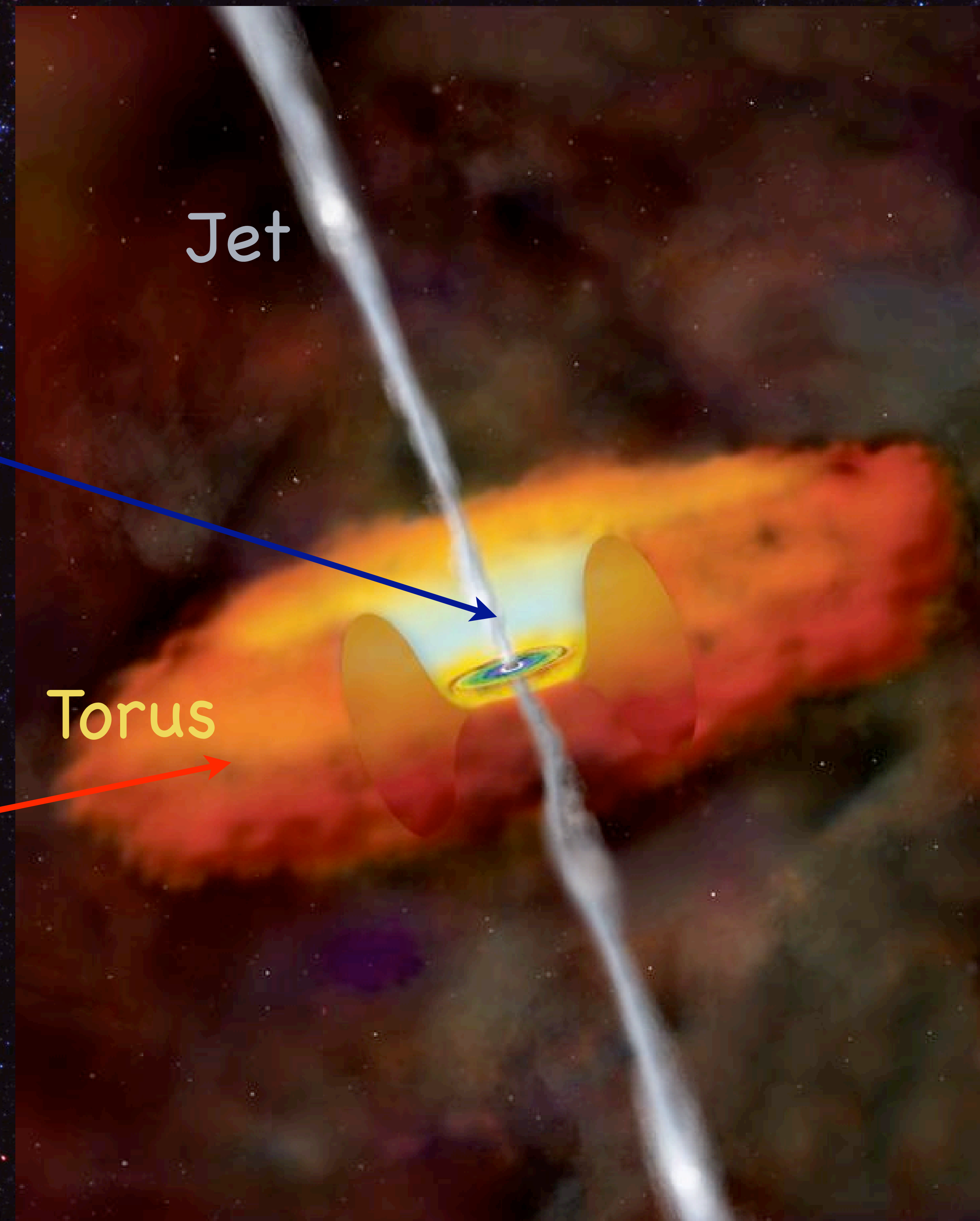
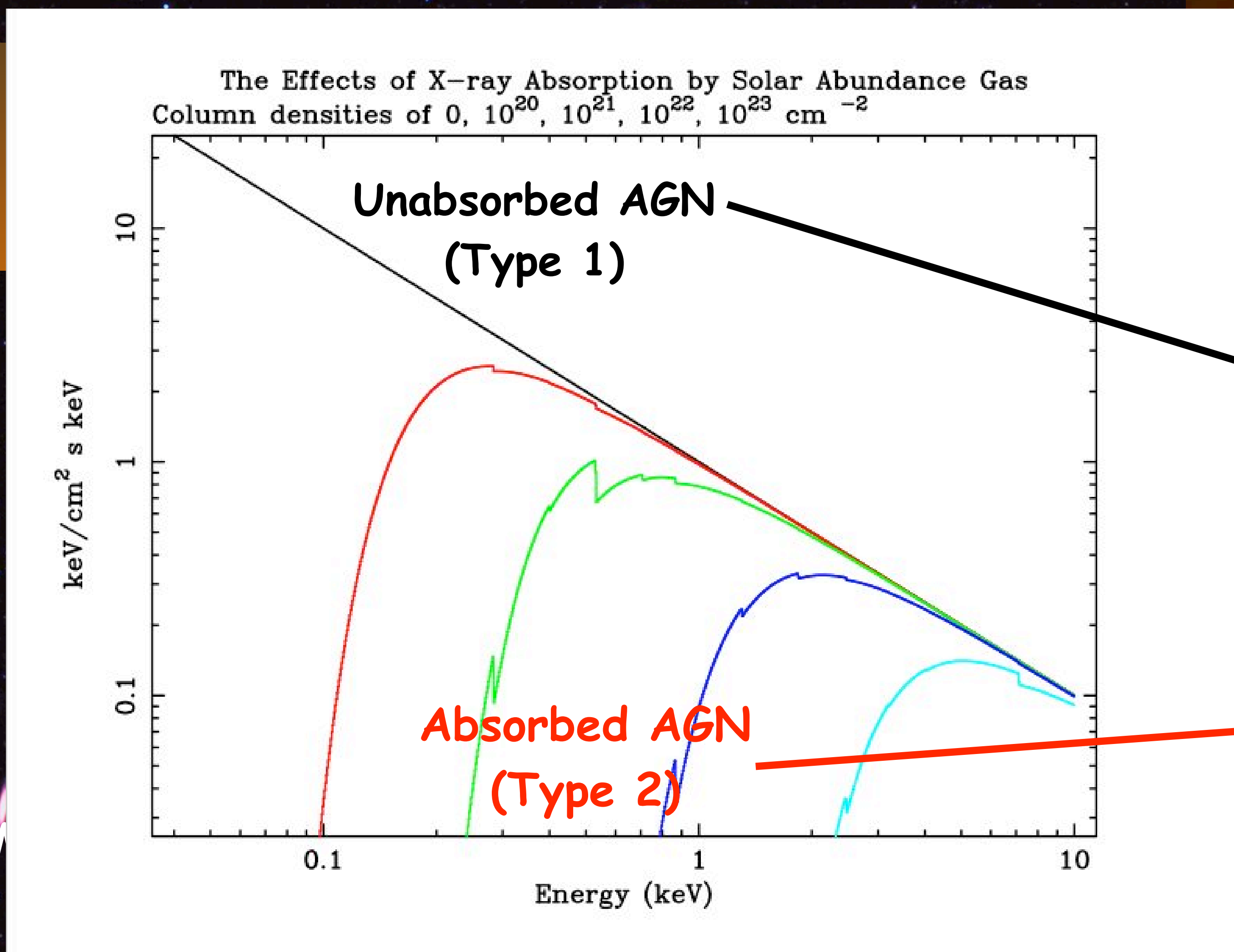


Illustration: CXC/Weiss

(Antonucci 1993)

Active Galactic Nuclei
Components and Taxonomy

AGN observed properties are orientation-dependent



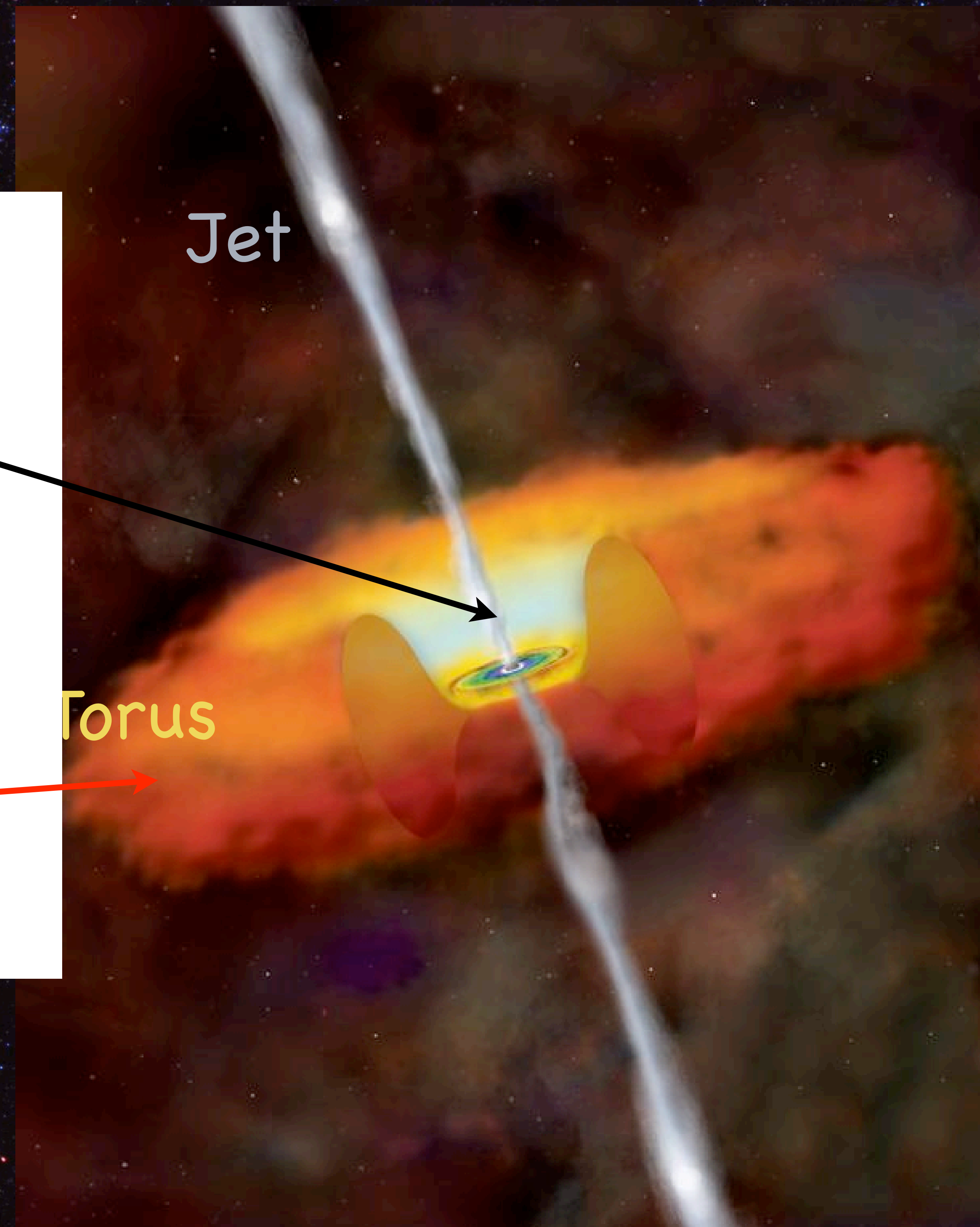


Illustration: CXC/Weiss

X-ray

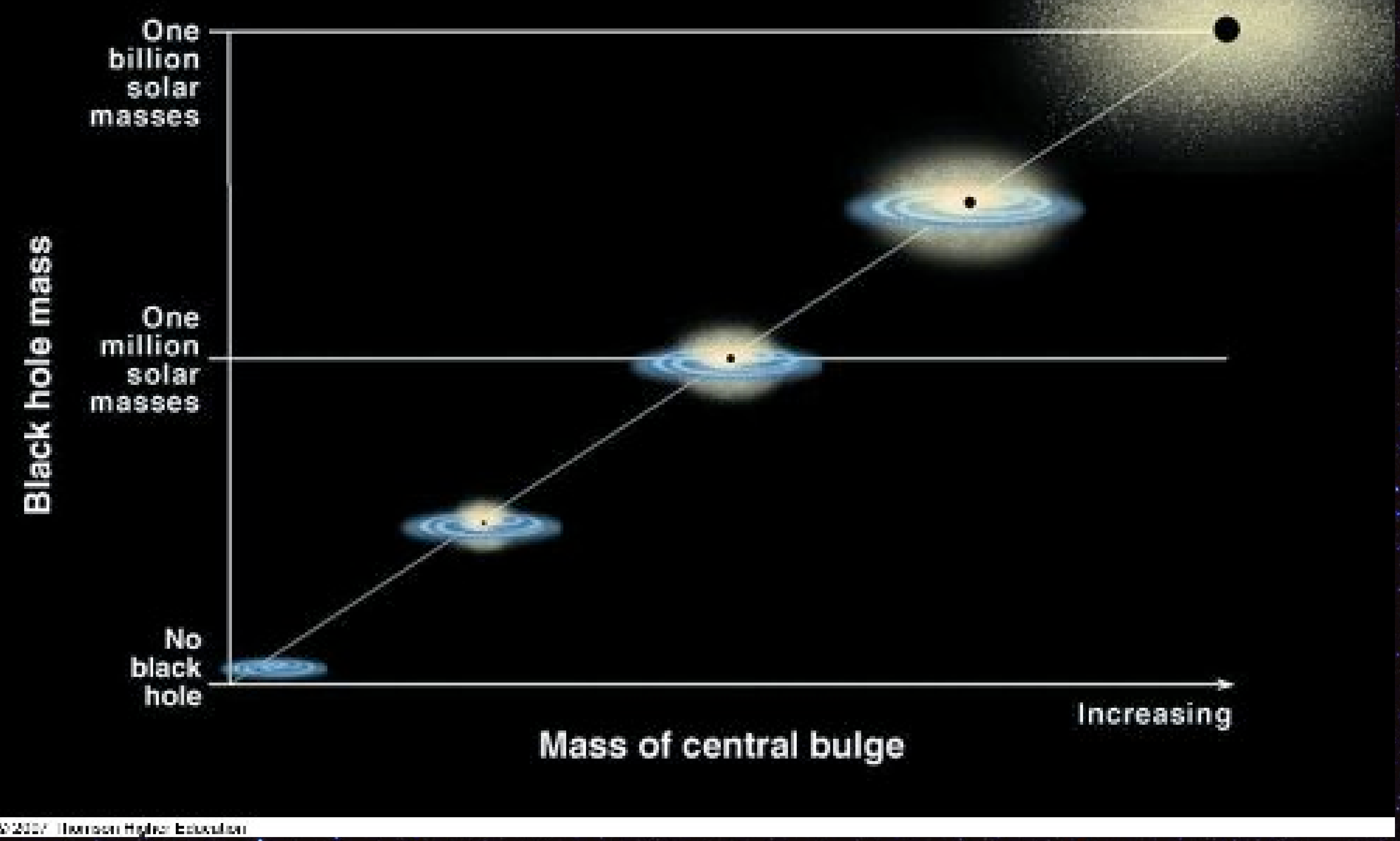
Soft/ unabsorbed

Hard/ absorbed

(Antonucci 1993)

Galaxies host black holes of mass proportional to their bulge mass, luminosity, velocity dispersion

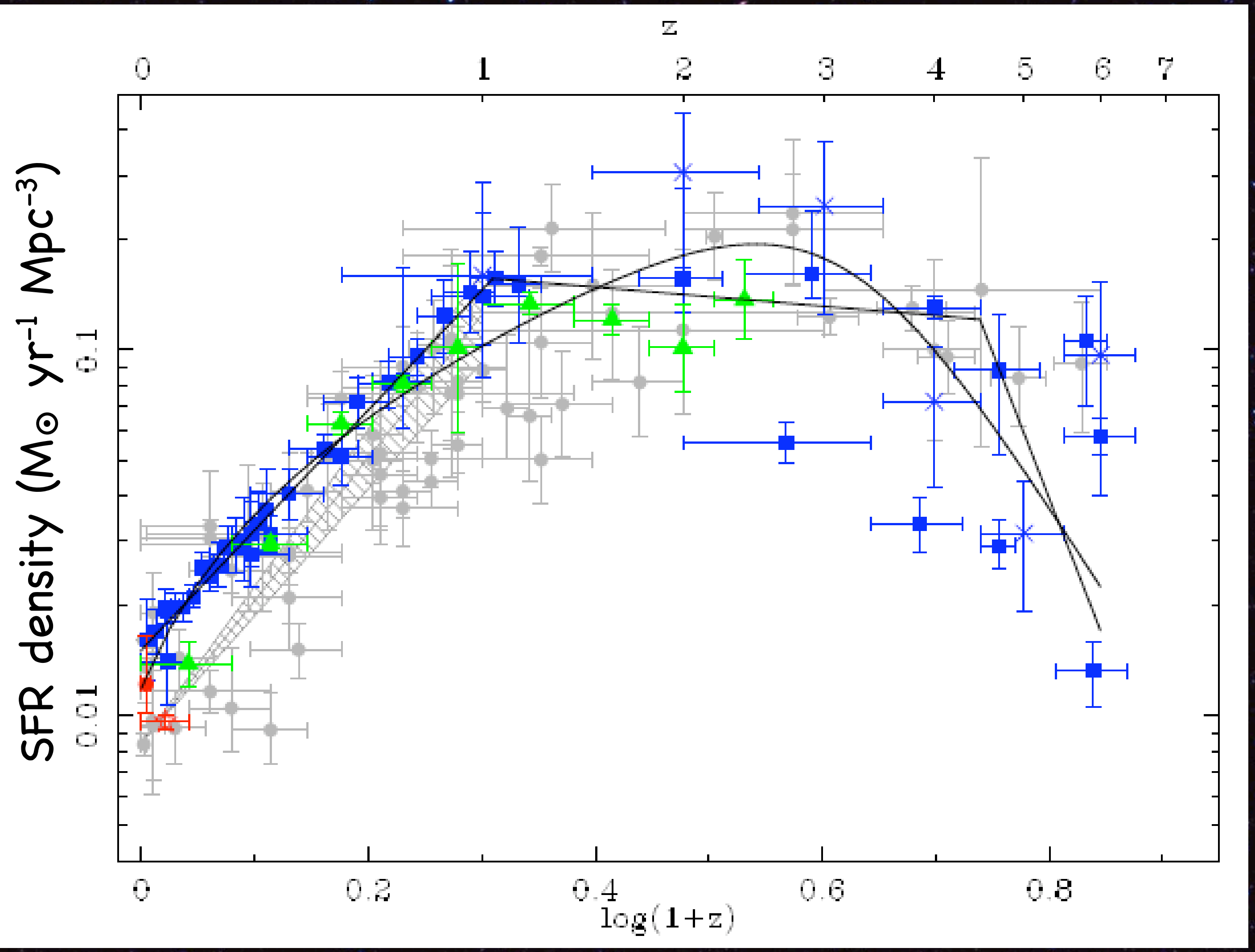
Fossil evidence that BHs regulated galaxies growth or viceversa



(Kormendy & richstone 1995; Magorrian et al. 1998; Ferrarese & Merritt 2000; Gebhard et al. 2000; Marconi & Hunt 2003; Häring & Rix 2004)

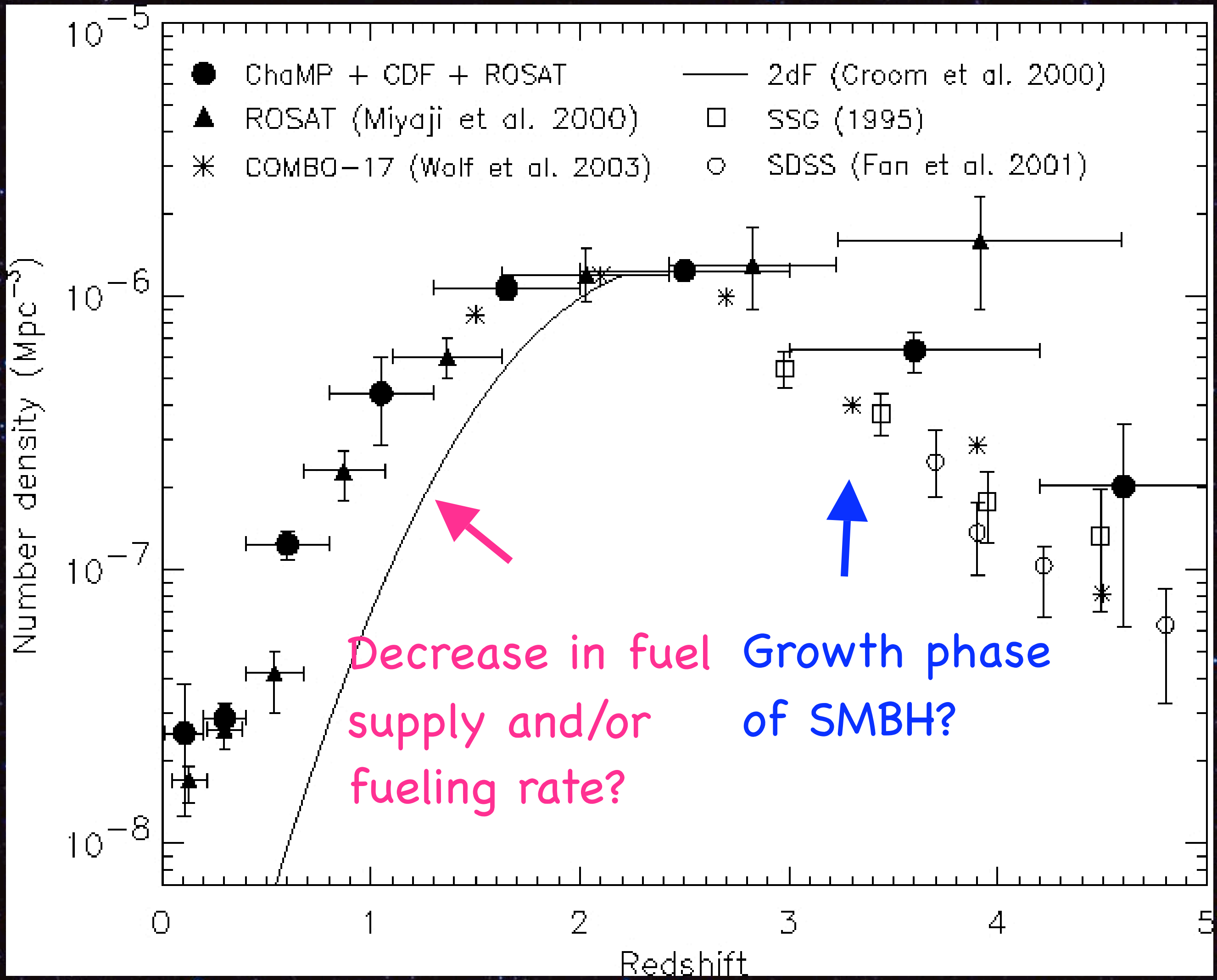
Star Formation and Accretion share a similar "history"

Star Formation Rate (SFR) density vs z



(Hopkins & Beacom 2006)

AGN Space Density vs z
(X-ray and optically selected)



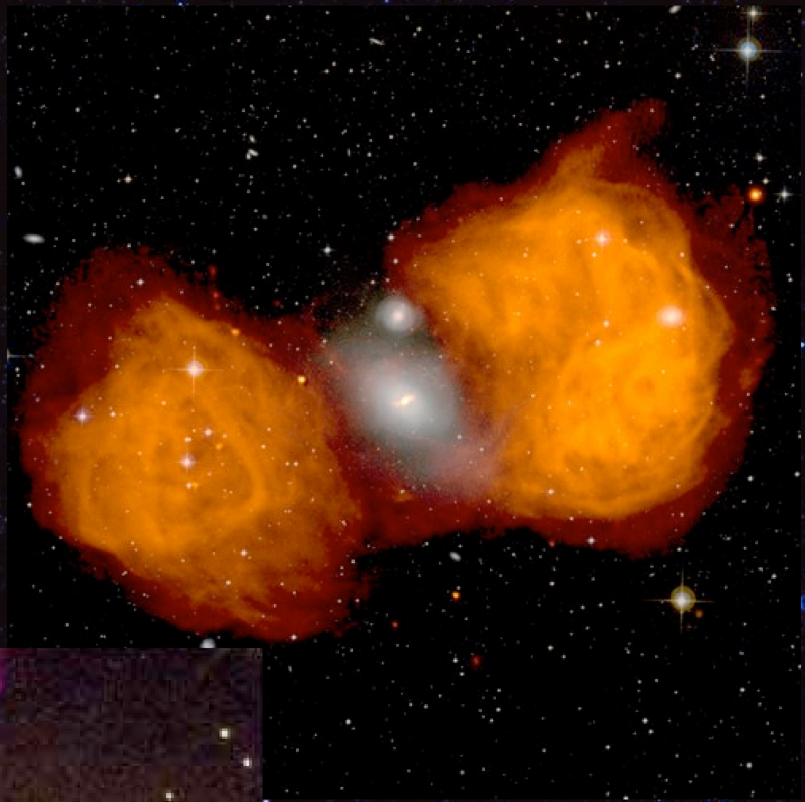
(Silverman et al. 2004)

The role of AGN in galaxy evolution

AGN through a feedback process regulates star formation in their host galaxies

Quasar mode

High luminosities
Rare
$z \sim 2$
Wind/Outflow
Starbursting host
Standard thin disk
Radiatively efficient
Cold gas blowout



Radio mode

Radio loud AGN
Common
$z \leq 1$
Jet
Radiatively inefficient
ADAF/ADIOS
Regulates star formation
Hot gas bubbles

(Silk & Rees 1998; Fabian et al. 1999; Granato et al. 2001; 2004; Springel et al. 2005; Di Matteo et al. 2005; Hopkins et al. 2005; Croton et al. 2006; Menci et al. 2008; Somerville et al. 2008)

The role of AGN in galaxy evolution

AGN through a feedback process regulates star formation in their host galaxies

Quasar mode

High luminosities
Rare
z~2
Wind/Outflow
Starbursting host
Standard thin disk
Radiatively efficient
Cold gas blowout

Galaxy Merger simulation with AGN feedback

(Silk & Rees 1998; Fabian et al. 1999; Granato et al. 2001; 2004; Springel et al. 2005; Di Matteo et al. 2005; Hopkins et al. 2005; Croton et al. 2006; Menci et al. 2008; Somerville et al. 2008)

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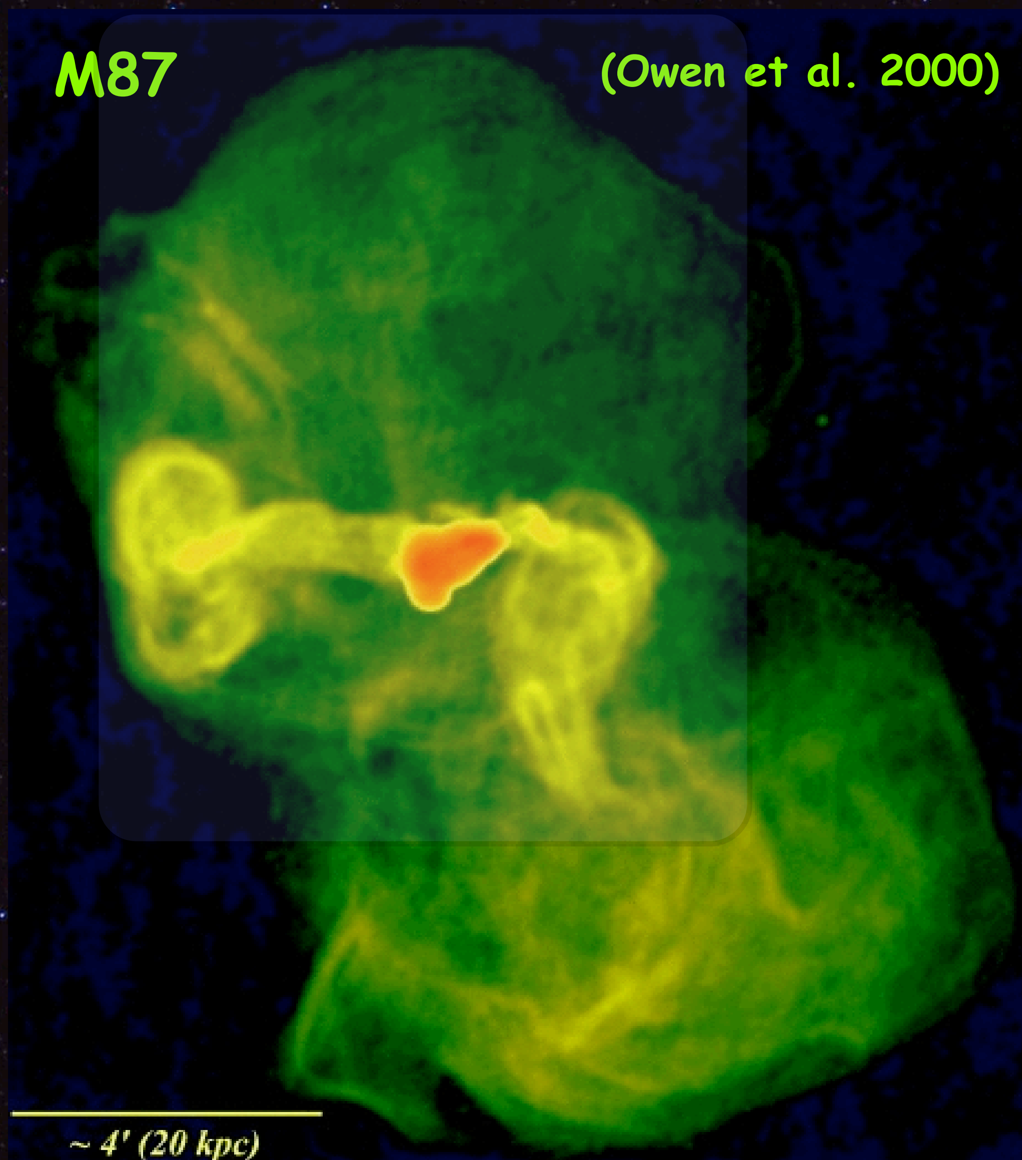
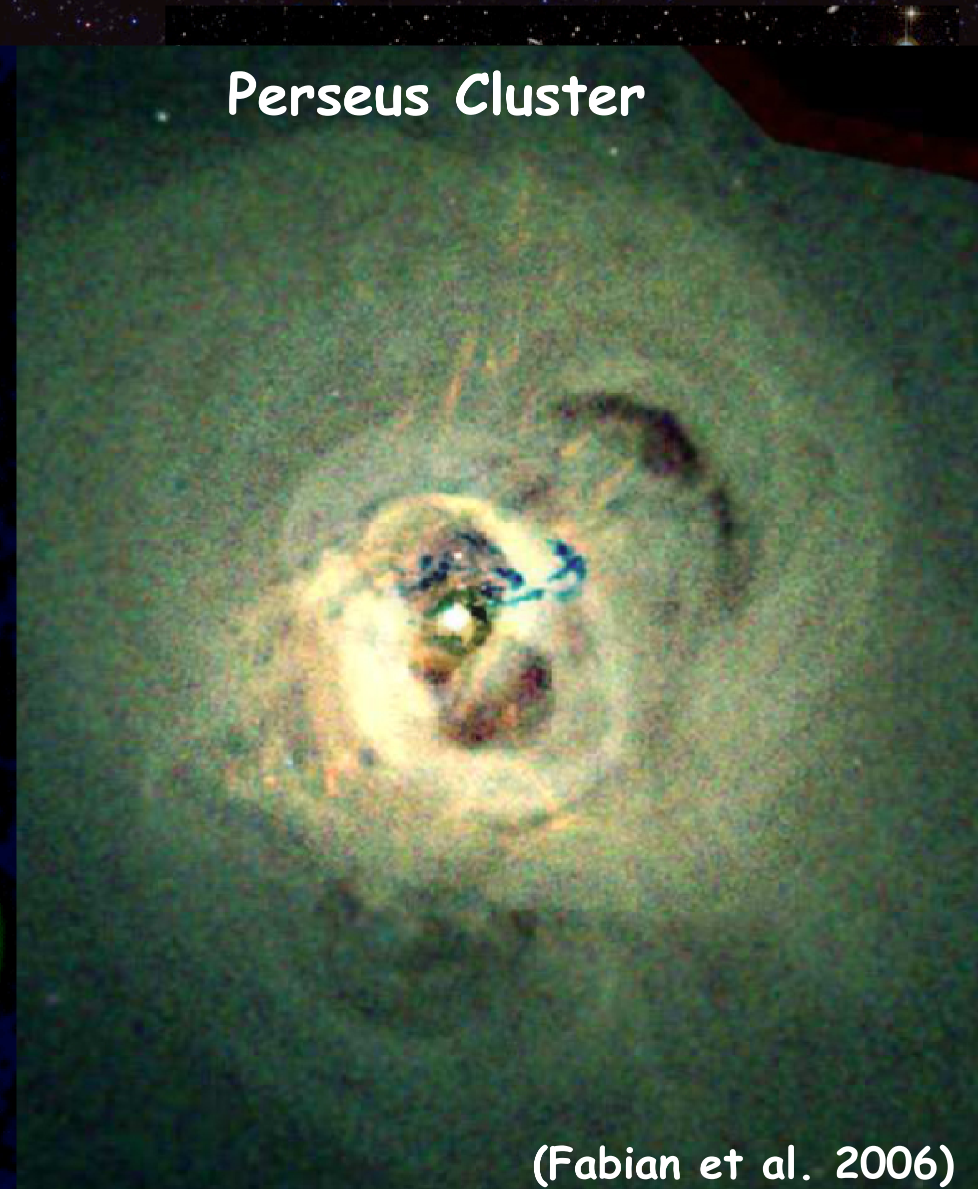
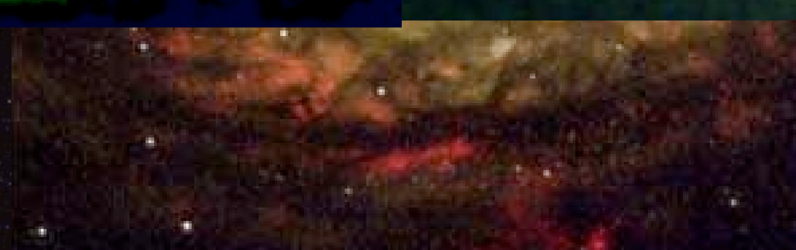






Radio mode
Radio loud AGN
Common
$z \lesssim 1$
Jet
Radiatively inefficient
ADAF/ADIOS
Regulates star formation
Hot gas bubbles

(Silk & Rees 1998; Fabian et al. 1999; Granato et al. 2001; 2004; Springel et al. 2005; Di Matteo et al. 2005; Hopkins et al. 2005; Croton et al. 2006; Menci et al. 2008; Somerville et al. 2008)

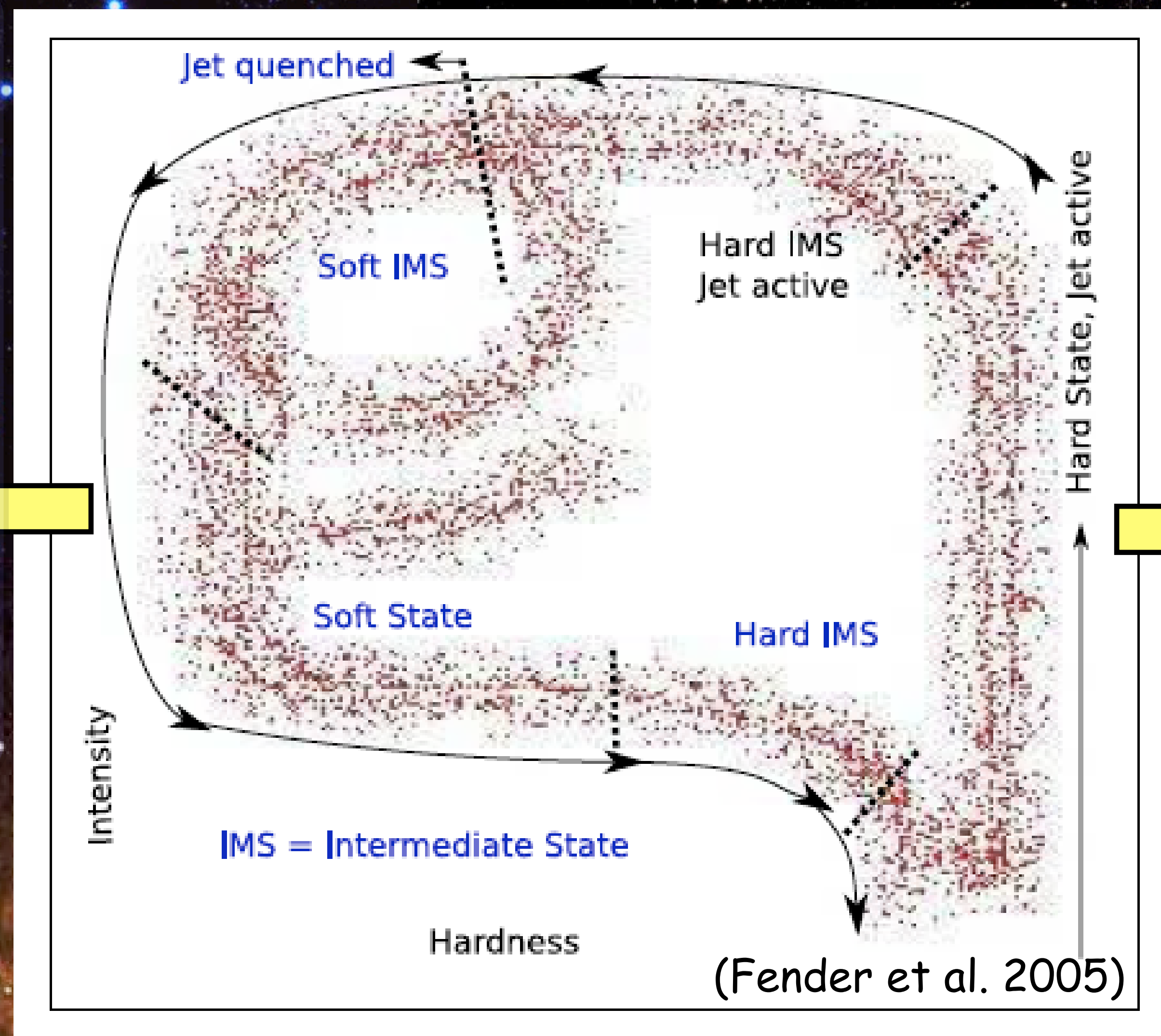
The role of AGN in galaxy evolution

AGN through a feedback process regulates star formation in their host galaxies

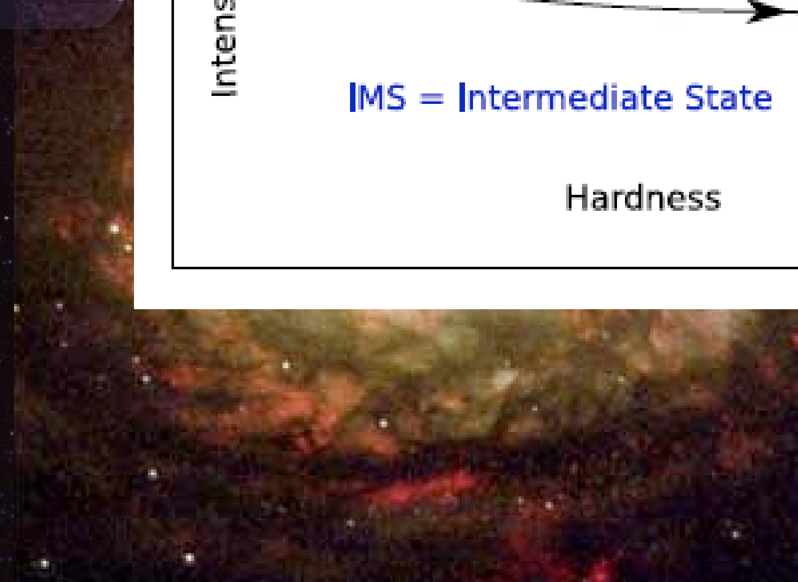
Quasar mode

High luminosities
Rare
$z \sim 2$
Wind/Outflow
Starbursting host
Standard thin disk
Radiatively efficient
Cold gas blowout

X-ray binaries Hardness-Intensity Diagram



(Fender et al. 2005)



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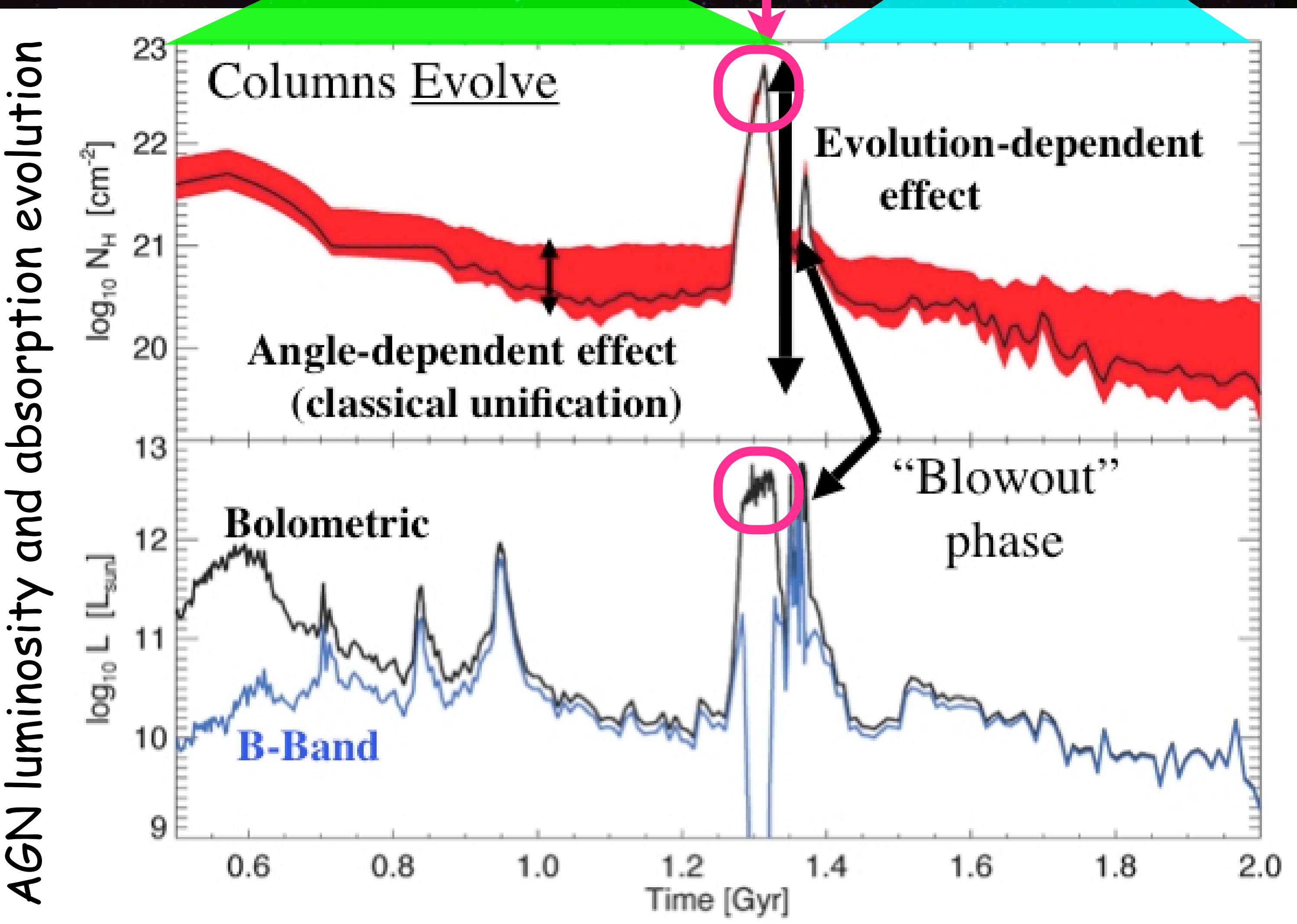
A laboratory to test and study the proposed scenario

Quasar mode laboratory:

Starburst & obscured AGN　　Obscured QSO　　Unobscured AGN



(Hopkins et al. 2005)

(Di Matteo et al. 2005)

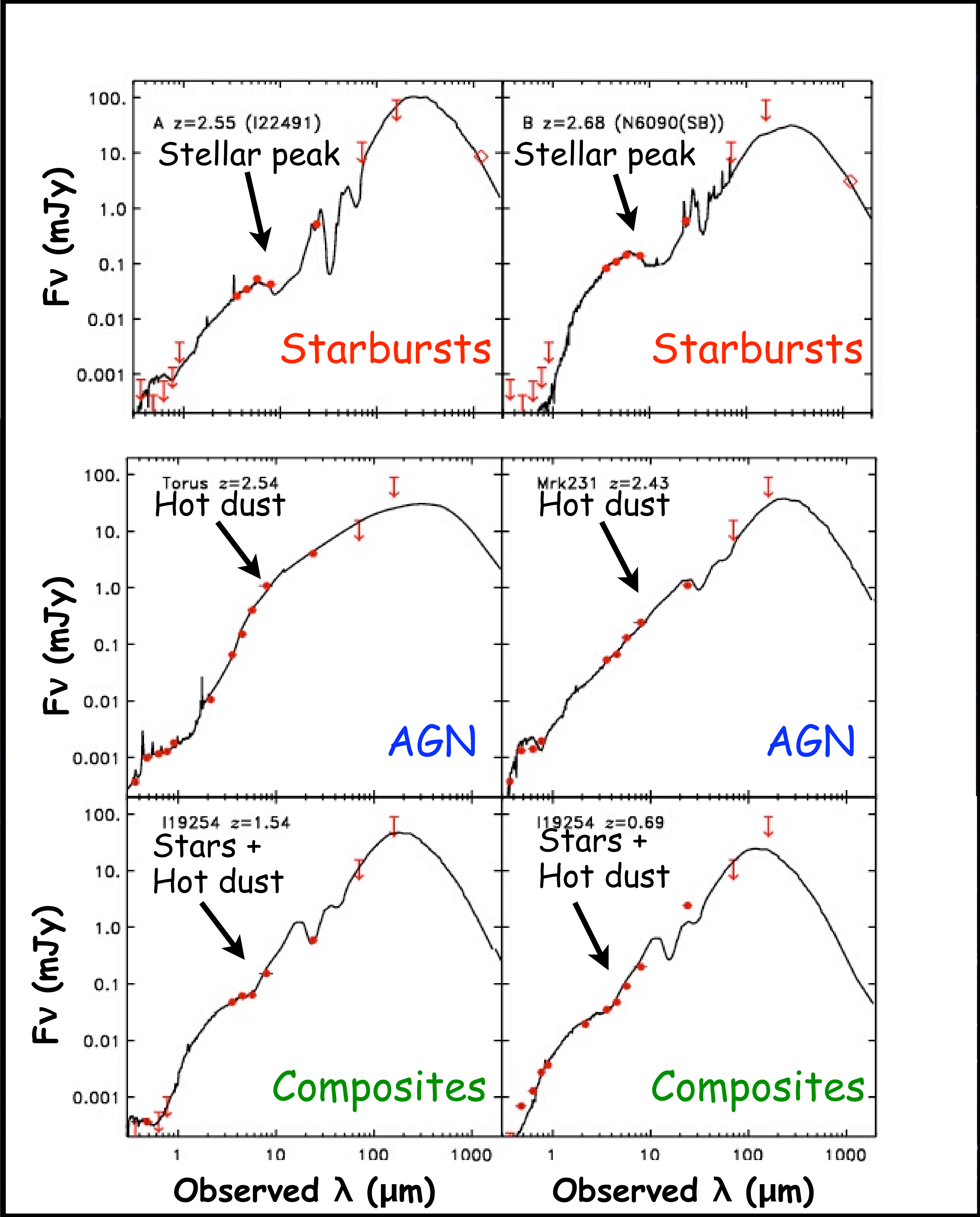
High-z luminous Infrared Galaxies

SWIRE to sample large volumes
Spitzer to identify starburst and AGNs

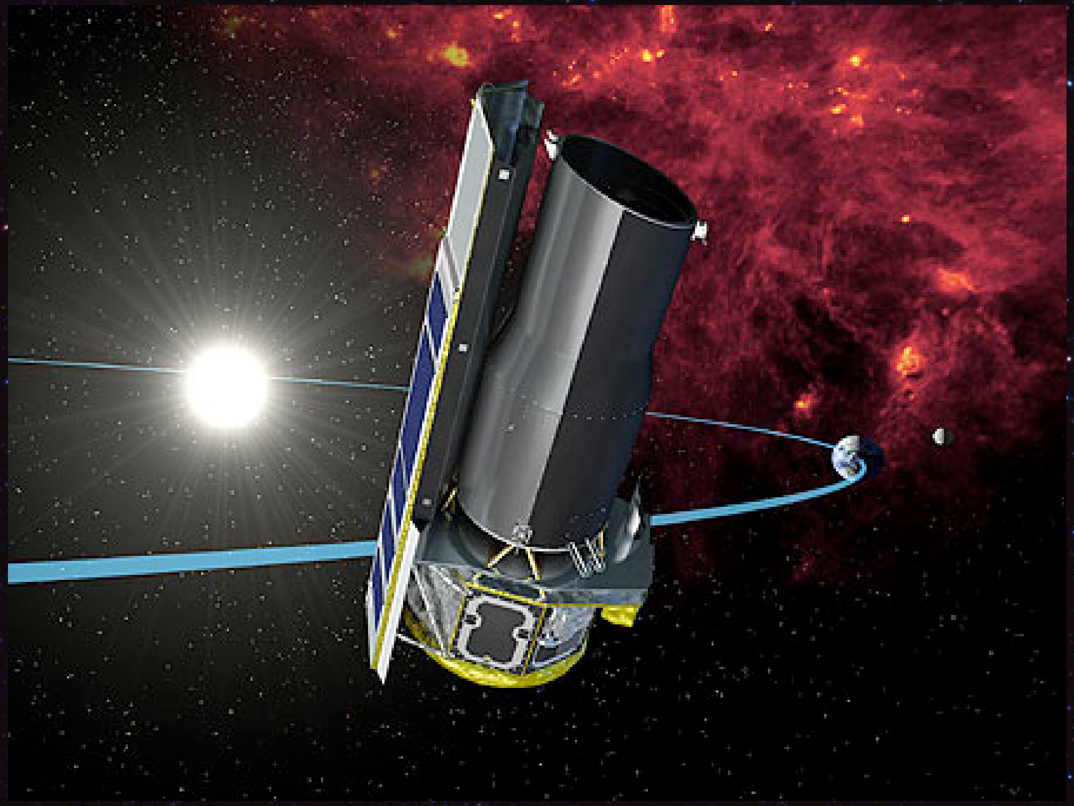
Selection

Fields: SWIRE Lockman Hole & XMM-LSS fields (20 deg^2)
F(3.6μm)/F(r') > 25 ⇨ high-z
F(24μm) ~ 0.3-6 mJy ⇨ high-L

SED types:
1) Starbursts [peak at 5.8μm]
2) AGN [red and smooth mid-IR SEDs]
3) Composite (AGN+starburst) [24μm excess on extrapolated IRAC power-law or peak at 5.8μm]



The Spitzer Wide Area Infrared Extragalactic Survey (SWIRE)



Spitzer Space Telescope
3.6, 4.5, 5.8, 8.0μm
24, 70, 160μm
+ multi-band optical data

⇨ 2 Million Galaxies up to z=3 & hundreds of 100 Mpc scale cells

Lonsdale et al. 2003

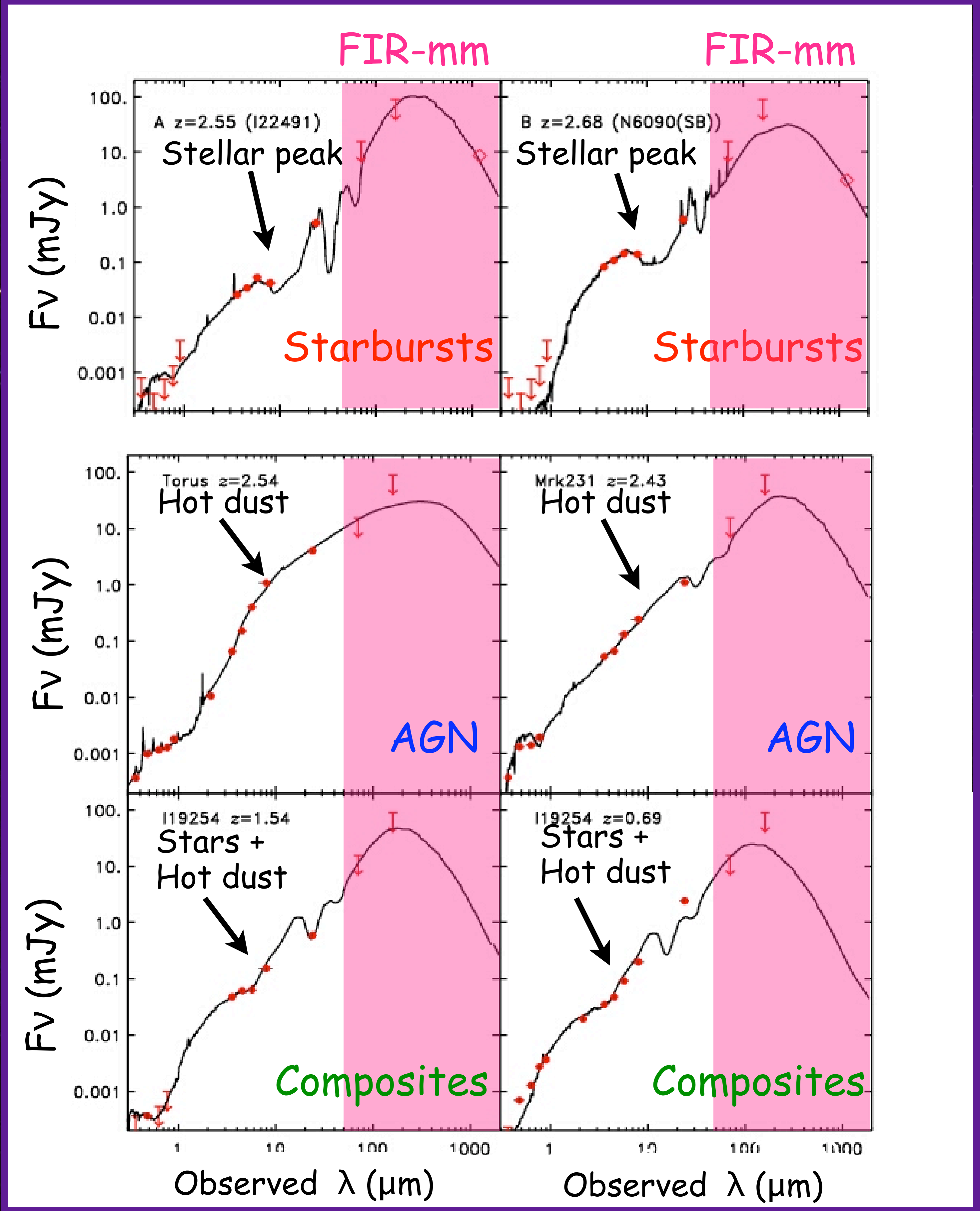
High-z luminous Infrared Galaxies

SWIRE to sample large volumes
Spitzer to identify starburst and AGNs

+

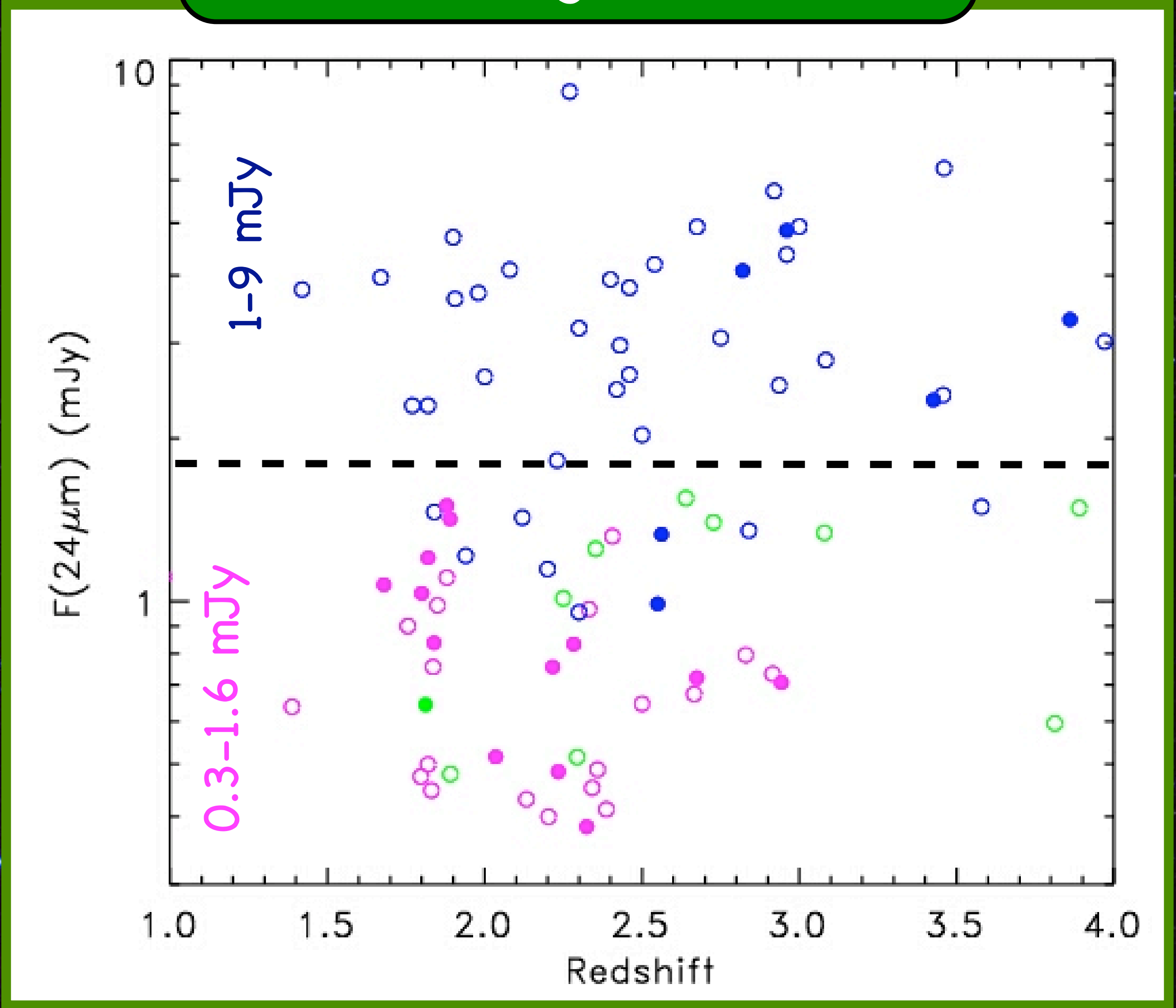
Spitzer/MIPS & IRAM/MAMBO
(70μm, 160μm, 1.2mm)

Far-infrared luminosity L(FIR)
Star formation rate (SFR)

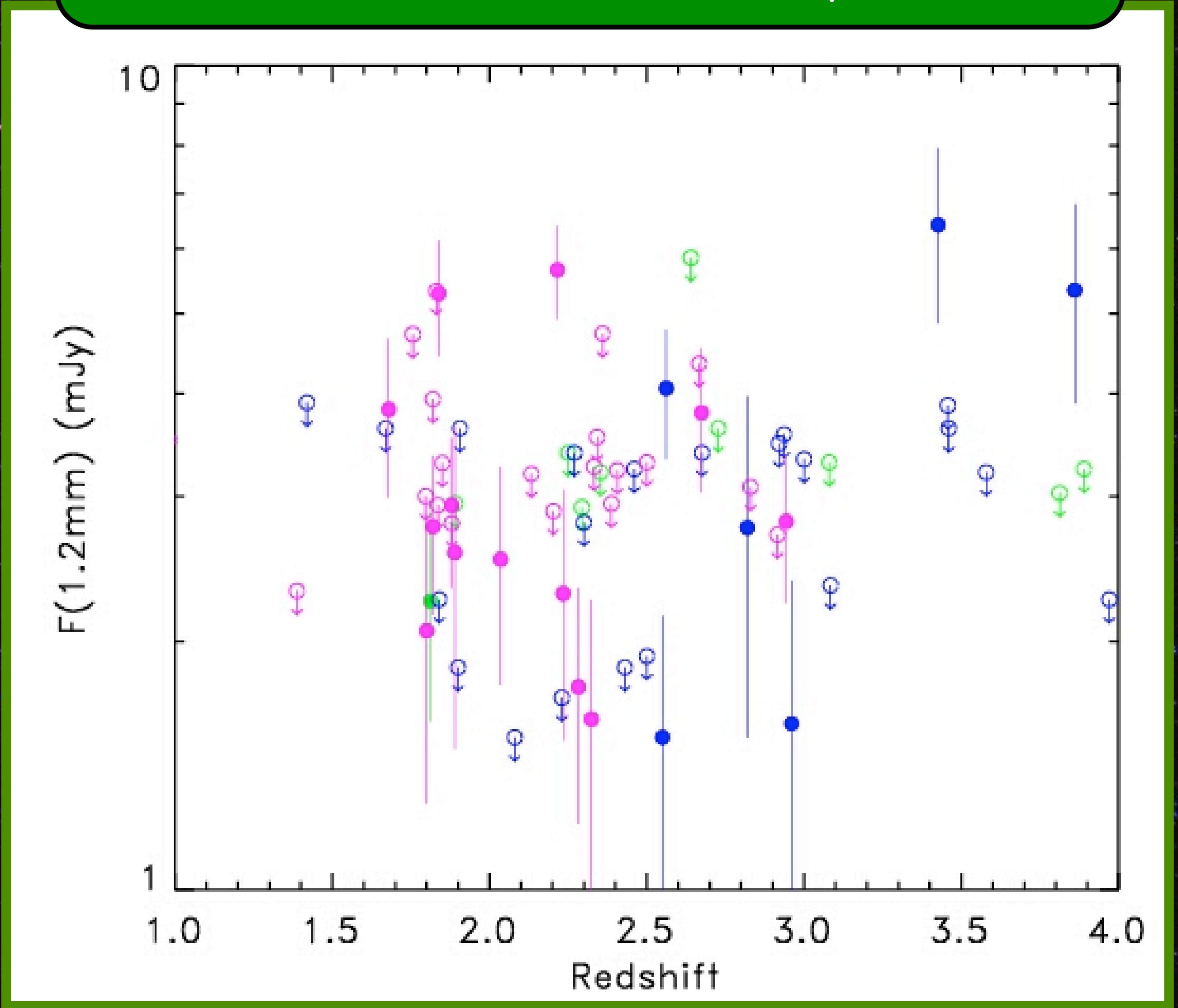


Millimeter emission of AGN and starbursts

AGNs are brighter at 24μm



1.2mm detection does not depend on z



Starbursts (33) 39% det.

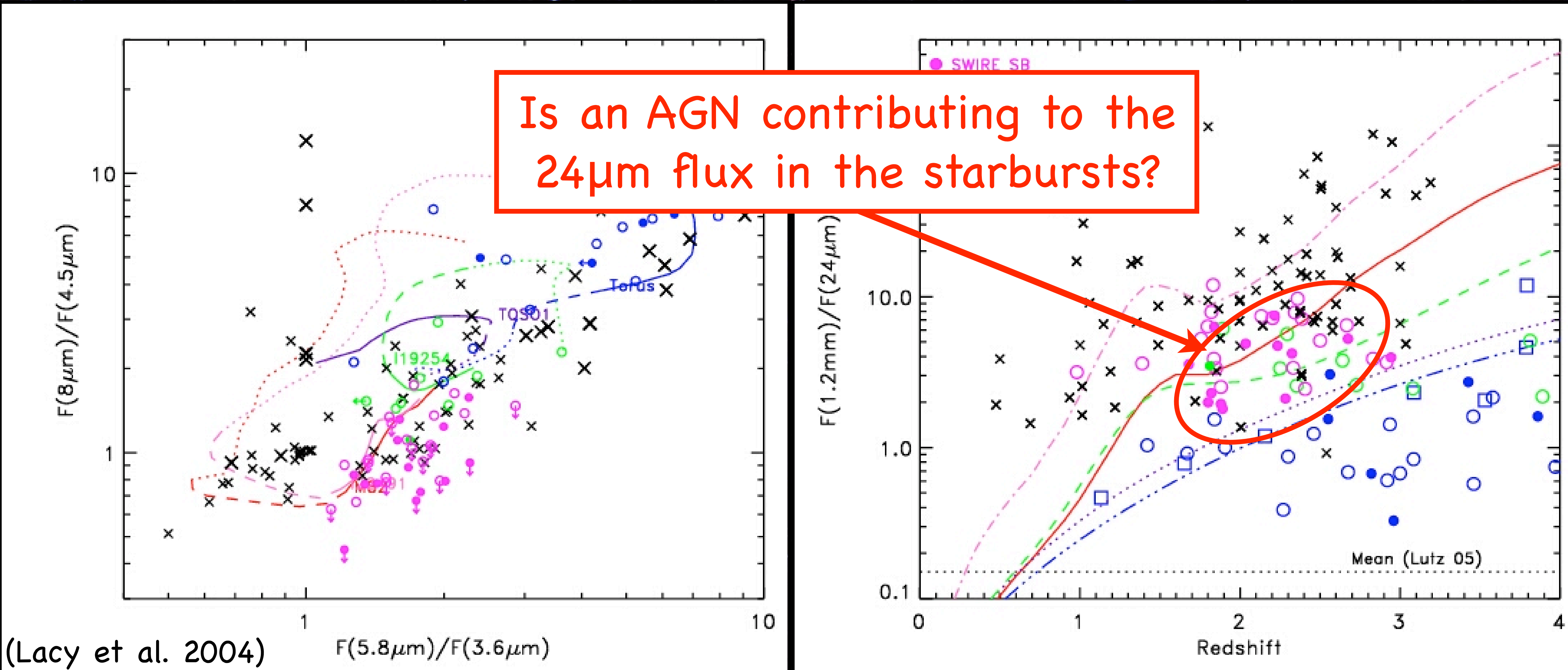
AGN (43) 22% det.

Composites (10) 10% det.

●1.2mm-detected

○1.2mm undetected

Infrared properties of SWIRE/MAMBO sources and comparison with SMGs



SWIRE sample: Distinct IRAC colors for different source types

SMGs: wider range of IRAC colors

Starbursts

AGN

Composites

× Literature SMGs

• 1.2mm-detected

o 1.2mm undetected

SMGs→Starbursts→AGNs

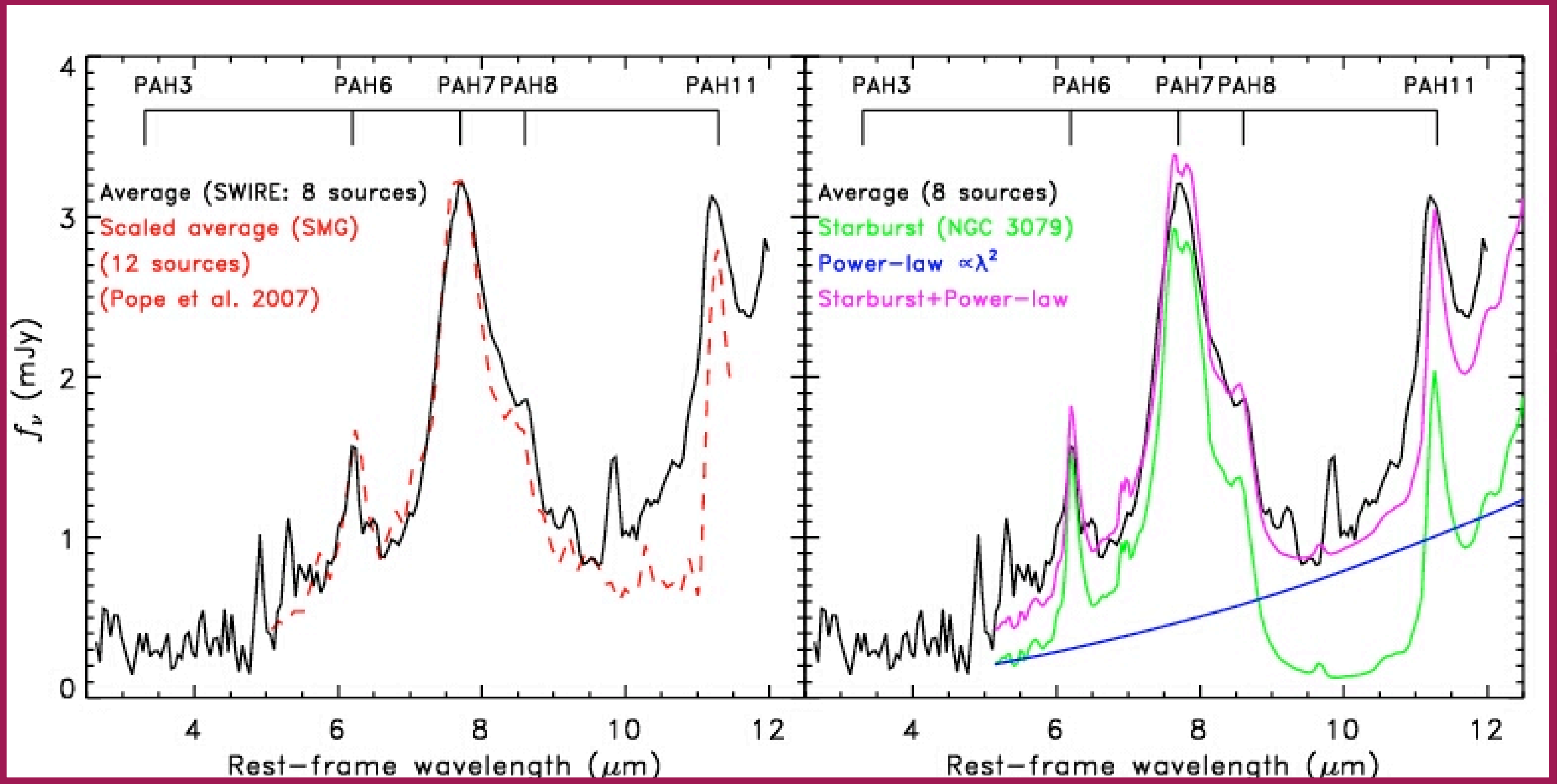
F(1.2mm)/F(24μm) decreases

AGN contribution in SWIRE/MAMBO starbursts

Mid-IR spectra (Spitzer/IRS):
6/8 sources are PAH-dominated with no warm dust continuum, 2/8 show PAHs+ continuum

↓

an AGN might be present in 25% of the sample



(Lonsdale, Polletta et al., 2008)

AGN contribution in SWIRE/MAMBO starbursts

Mid-IR spectra (Spitzer/IRS):
6/8 sources are PAH-dominated with no warm dust continuum, 2/8 show PAHs+ continuum
⇓
an AGN might be present in 25% of the sample

X-ray observations:
1/4 X-ray detected with $L_X=6\times10^{43}$ erg/s
⇓
X-ray luminous AGN in ~ 25% of the sample

Radio observations:
1/3 is radio luminous and extended
⇓
AGN-driven radio activity in ~33% of the sample

➪ ~30% of SWIRE-selected z~2 starbursts contain an AGN

vs 30-46% in z~2 SMGs (Alexander et al. 2005; Pope et al. 2008)

In most of the cases the starburst is the main energy source !

(Lonsdale, Polletta et al., 2008)

AGN contribution in SWIRE/MAMBO starbursts

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X-ray observations:
1/4 X-ray detected with $L_X=6\times10^{43}$ erg/s
⇓

Radio observations:
1/3 is radio luminous and extended
⇓

Conclusion N.1: ≥30% of starburst galaxies contain an AGN
the AGN is moderately luminous and obscured and contributes ~30-40% to the total luminosity

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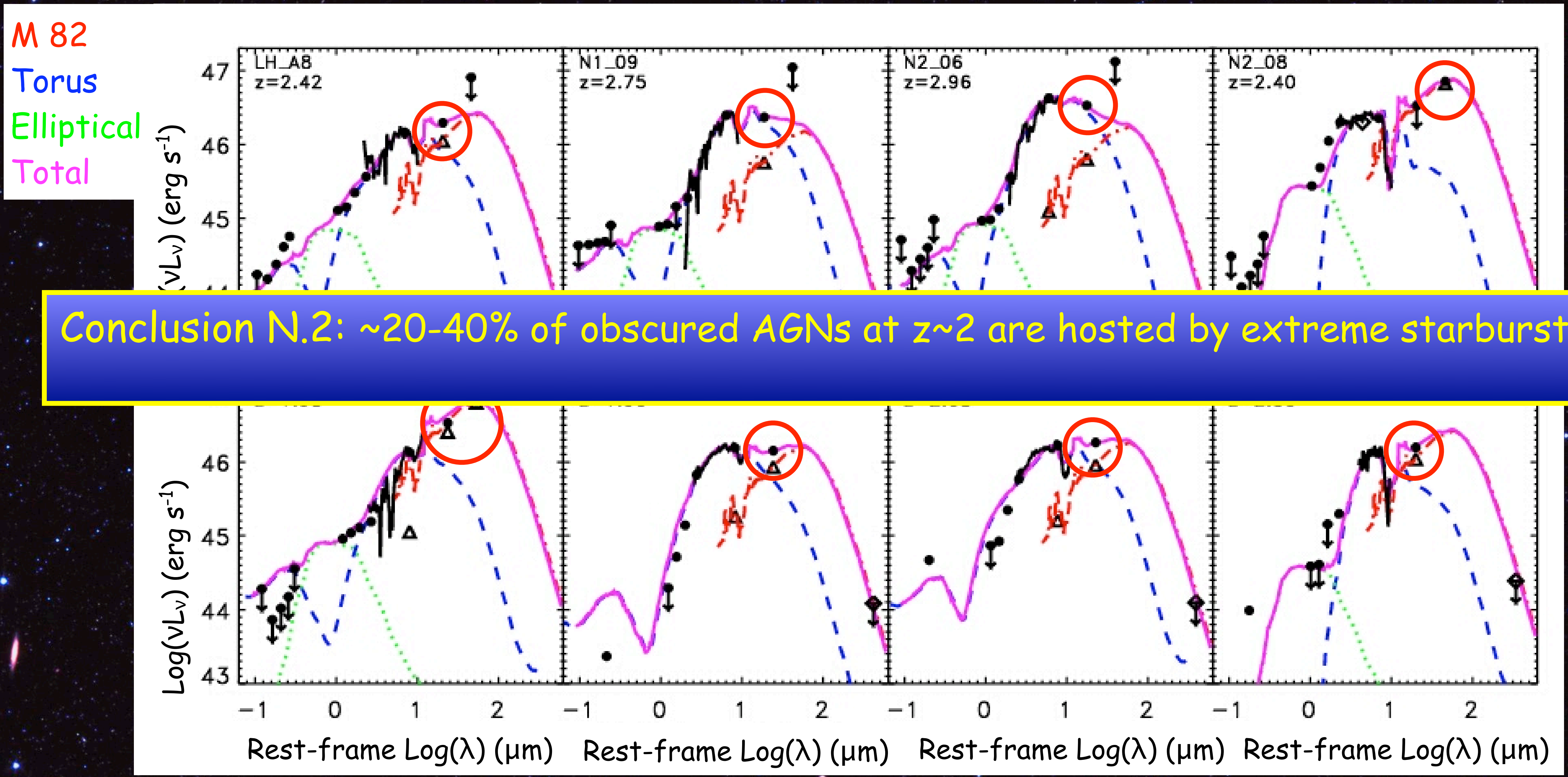
vs 30-46% in z~2 SMGs (Alexander et al. 2005; Pope et al. 2008)

In most of the cases the starburst is the main energy source !

(Lonsdale, Polletta et al., 2008)

Star formation rates in high-z obscured QSOs

AGNs detected at 70 or 160μm → evidence for starburst component



Conclusion N.2: ~20-40% of obscured AGNs at z~2 are hosted by extreme starbursts

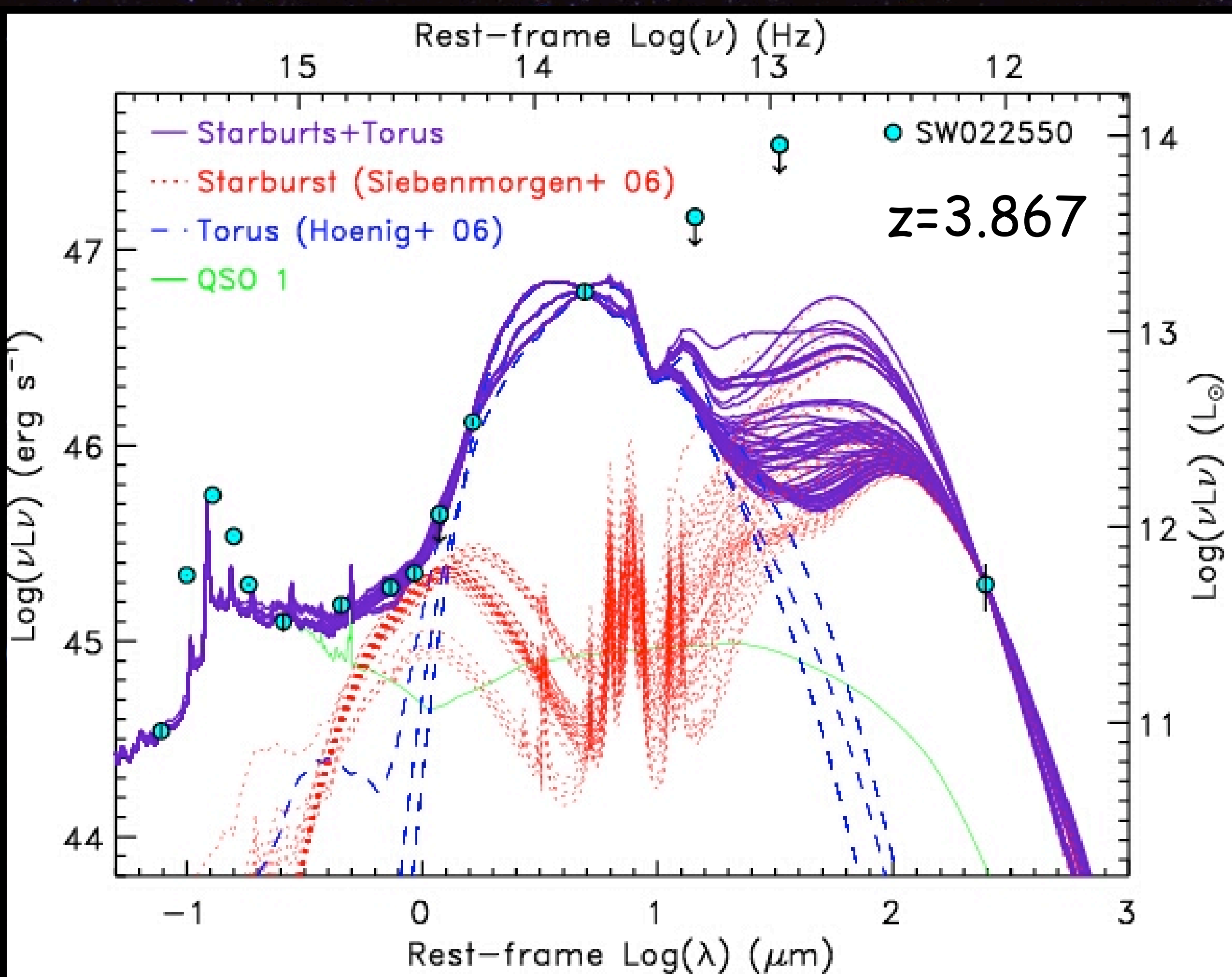
Starburst with L(FIR) ~ $10^{12.5-13.2}$ $L_\odot$ ⇨ SFR ~ 600-3000 $M_\odot$/yr

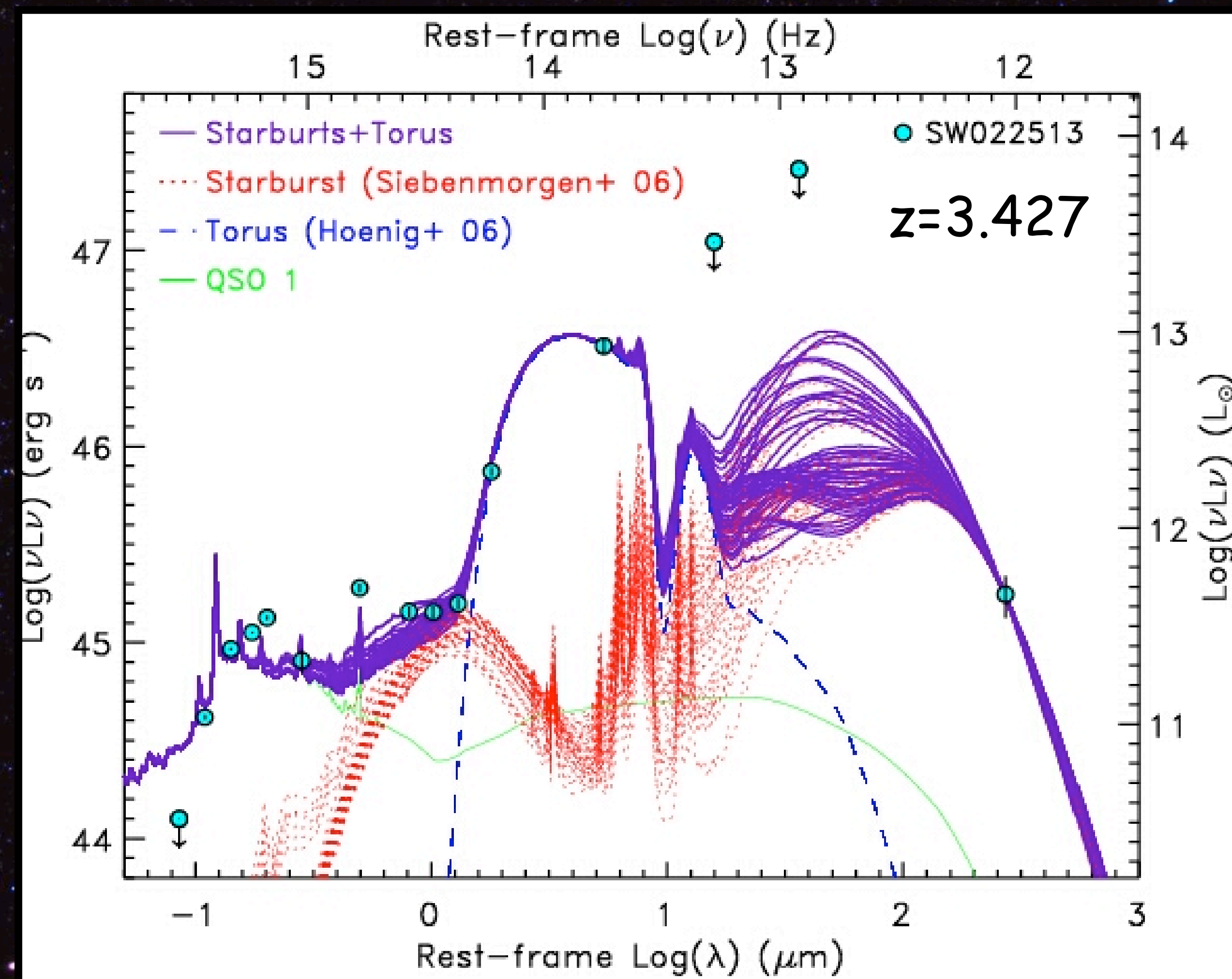
(Polletta et al., 2008a)

A closer look at these obscured QSOs

The brightest mm sources of the entire SWIRE/sample:
2 powerful and obscured AGN and starbursts at z~3.5

L(AGN) ~ 10^{13} $L_\odot$ & L(SB) ~ $10^{12.5\text{-}13.2}$ $L_\odot$

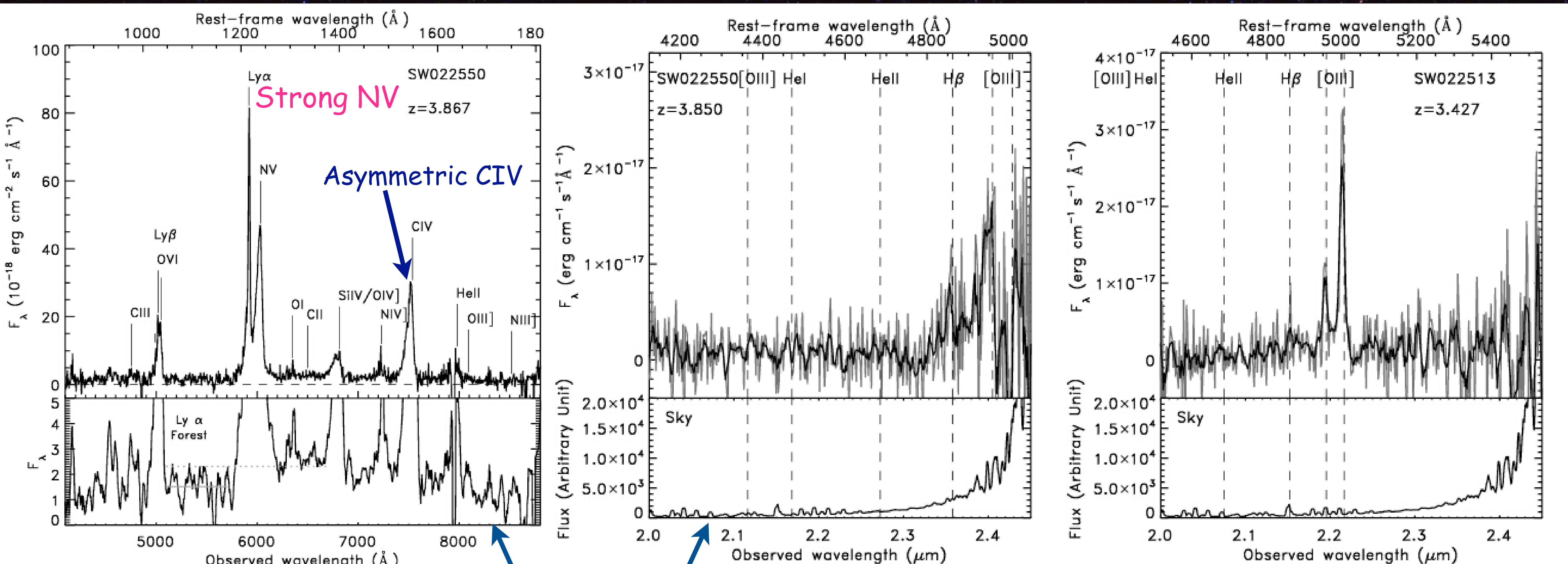




(Polletta et al. 2008b)

Ultraviolet & optical rest-frame spectra

Line FWHM, flux ratios and equivalent widths ➔ type 2 AGN



Optical spectrum
(Australian Telescope)

z offset
~ 500 km/s

Near-Infrared spectra
(ISAAC Telescope)

Line ratios ➔ High metallicity or shock-heated gas

(Polletta et al. 2008b)

AGN-driven radio activity: feedback signature ?

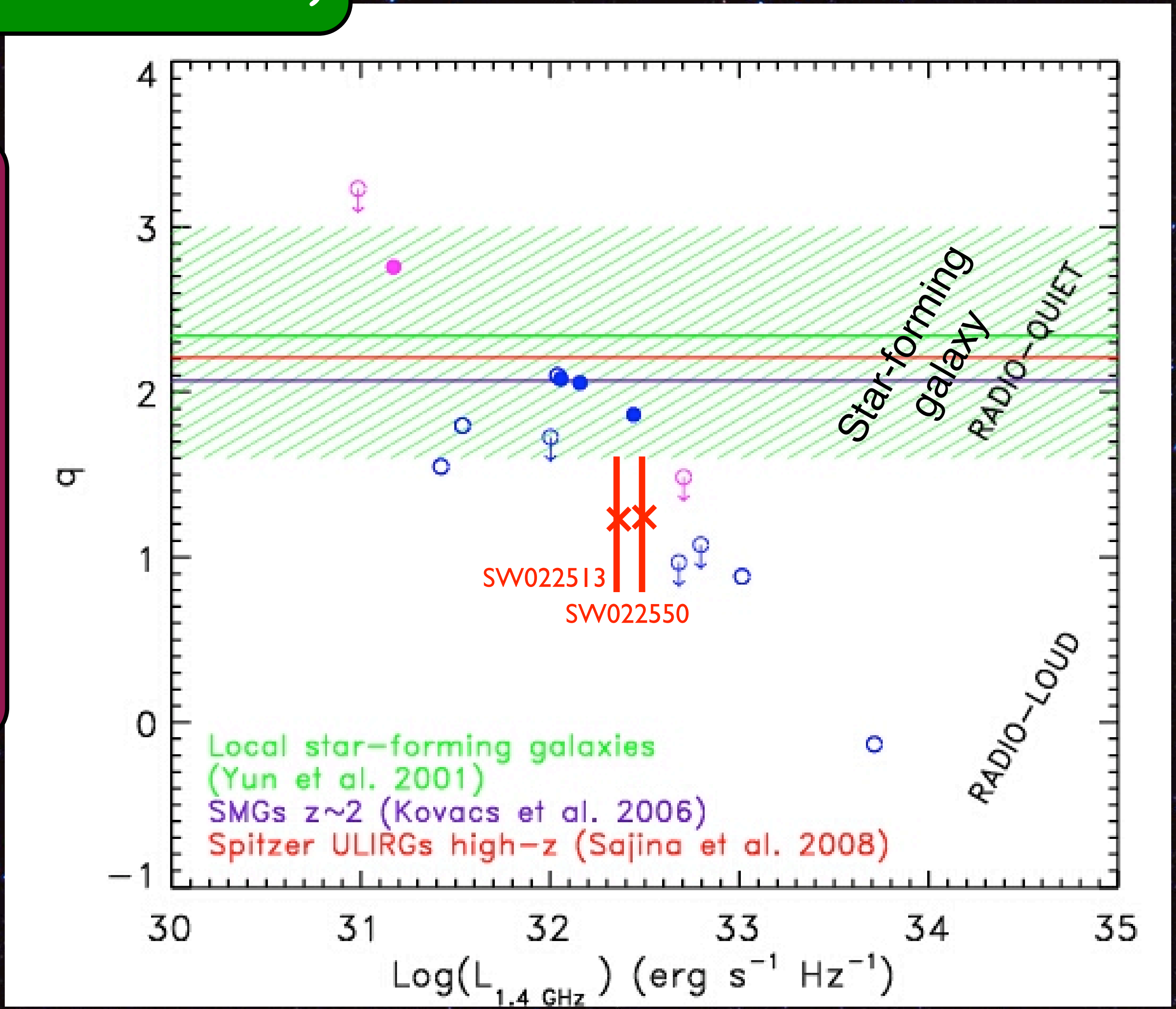
16 radio-detected sources (13 AGNs, 3 starbursts)

Radio-loud vs radio-quiet diagnostic:

q~L(FIR)/L(1.4 GHz) < 1.6 (Yun et al. 2001)

AGN-driven radio emission

➪ 8/16 = 50% are radio-`active'



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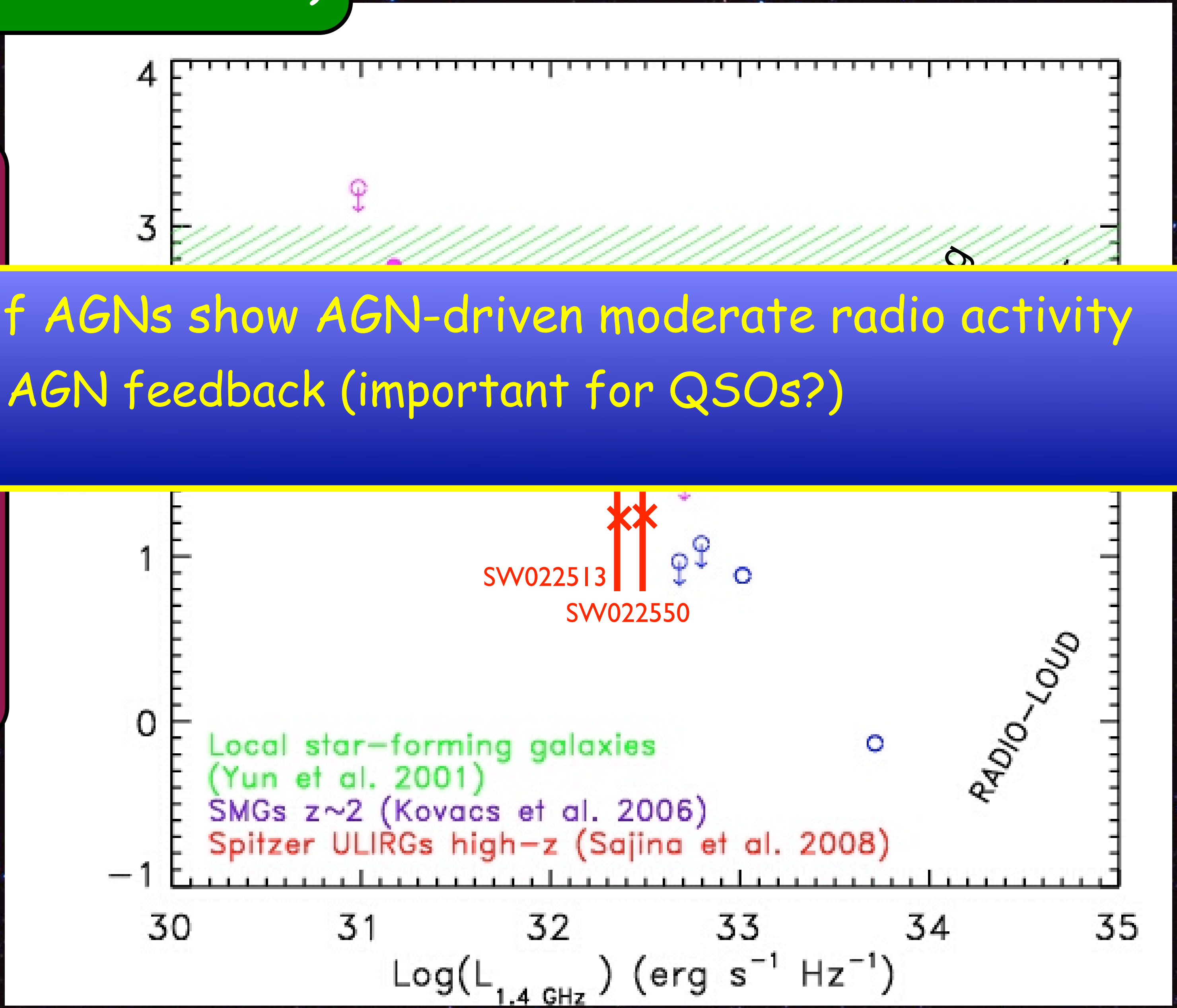

Conclusion N.3: A significant fraction of AGNs show AGN-driven moderate radio activity

- Radio activity might be a signature of AGN feedback (important for QSOs?)

AGN-driven radio emission

➪ 8/16 = 50% are radio-`active'

Summary

FIR-mm observations of SWIRE ULIRGs at z~2 (43 AGN, 33 Starbursts, 10 Composites)

≥30% of starburst galaxies contain an AGN. The AGN is moderately luminous and obscured and contributes ~30-40% to the total luminosity.

~20-40% of obscured AGNs are hosted by powerful starburst galaxies.

The peak of AGN activity is shorter than the starburst phase ➪ more chances to detect a moderately luminous AGN than a QSO in a starburst galaxy

A significant fraction of AGNs show AGN-driven moderate radio activity that might be a signature of feedback.

Final thoughts....

E con questa astro siesta
spero vi sia entrato in testa
che qualunque sia il vostro campo
senza AGN non c'è scampo.
Tu che degli ammassi prendi la temperatura
o che sulle galassie metti la fenditura;
tu che del cosmo misuri il fondo
o che guardi l'universo profondo;
tu che costruisci il rivelatore
o che programmi con il calcolatore;
tu che cerchi le binarie
o sbrighi faccende universitarie;
di AGN non si può evitare di parlare
per poter tanti misteri svelare.