"In medio stat virtus": the Chandra COSMOS Legacy Survey

Francesca Civano

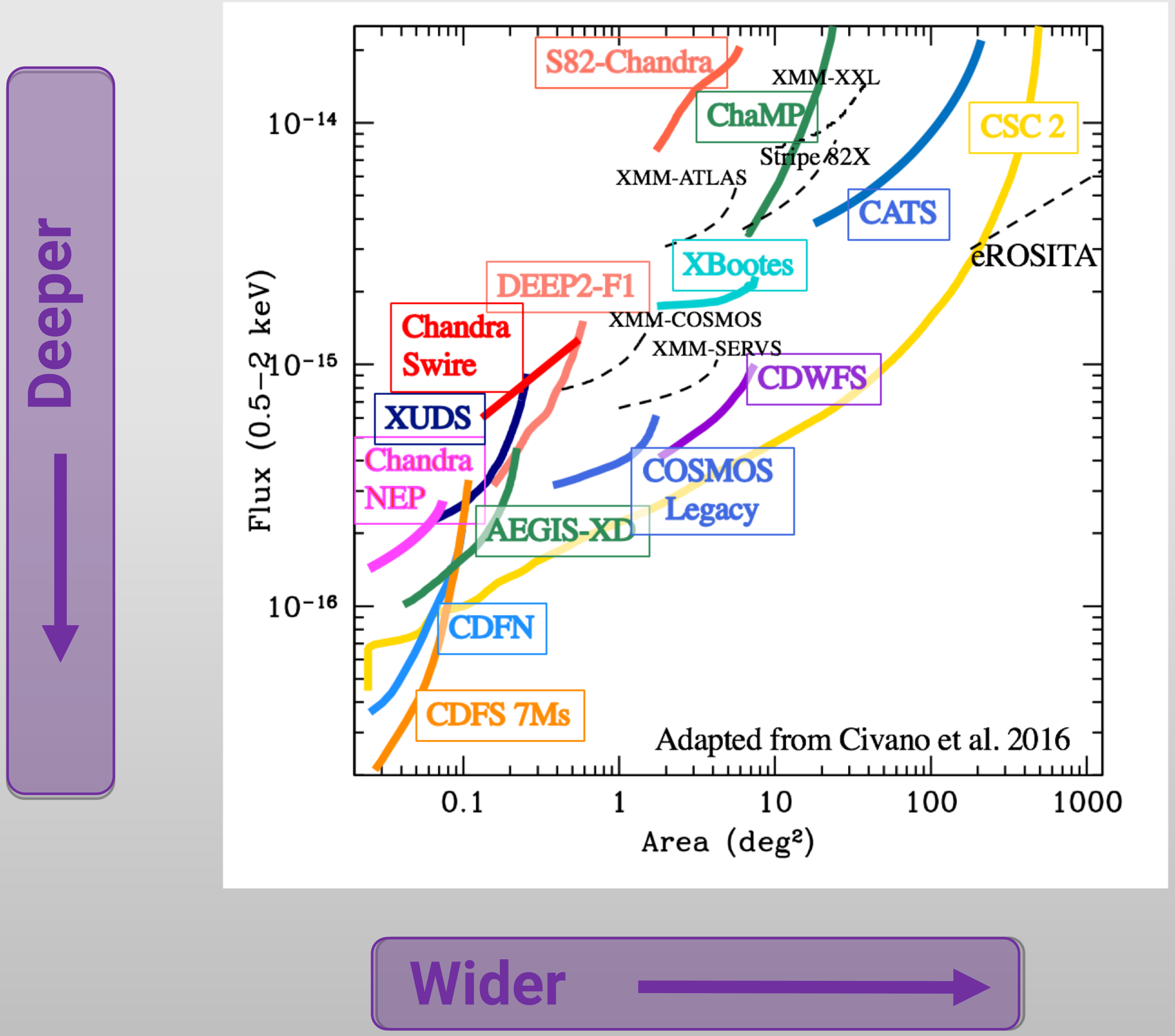
and the Chandra COSMOS team

Cosmic Evolution Survey
COSMOS

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

20 years of Chandra AGN surveys

Siemiginowska & Civano 2019 (Chapter 8, Chandra book)



Chandra COSMOS Legacy Survey

Civano+ 2016; Marchesi+ 2016

→ 4.6 Ms =1.8Ms (PI: Elvis) + 2.8 Ms (PI: Civano)

→ 92 single observations; 2.2 deg^2

→ 4016 sources (327,000 photons)

- 3950 exgal sources + 66 stars

→ Unresolved emission: ~100,000 photons

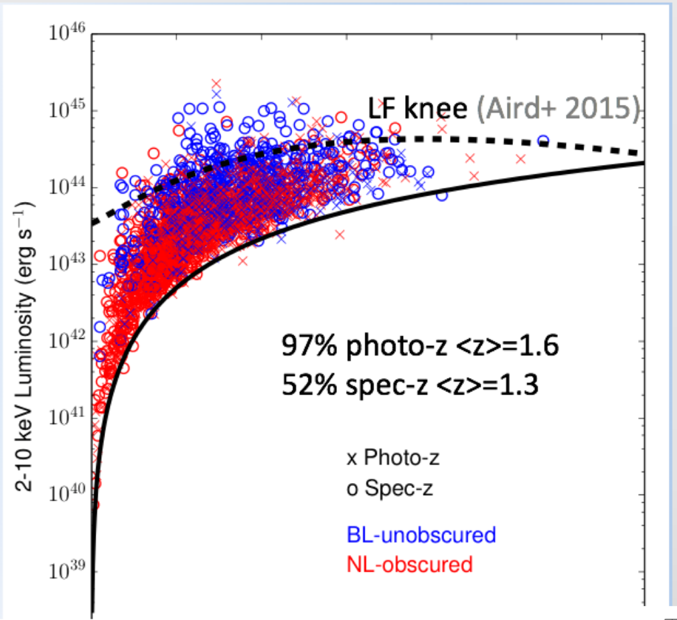
Stefano Marchesi

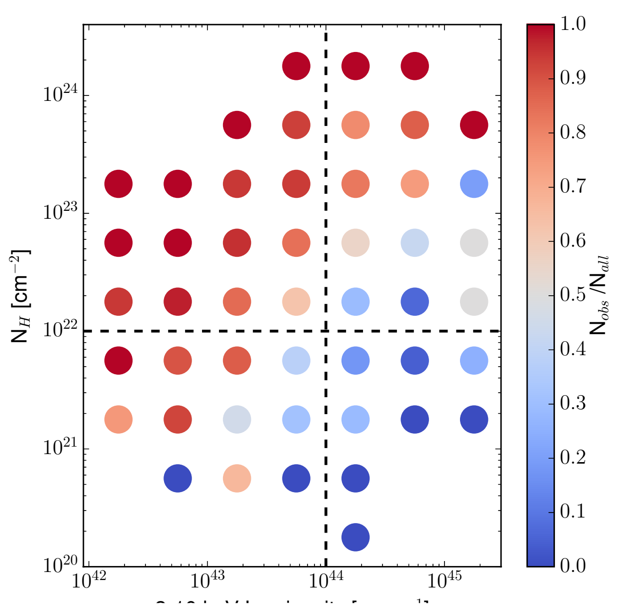
0.5-2 keV
2.0-4.5 keV
4.5-7 keV

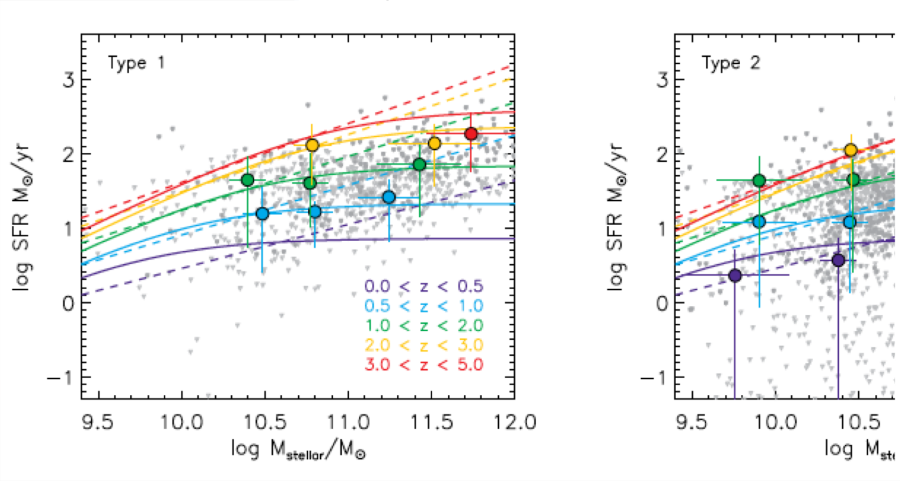
Source Characterization

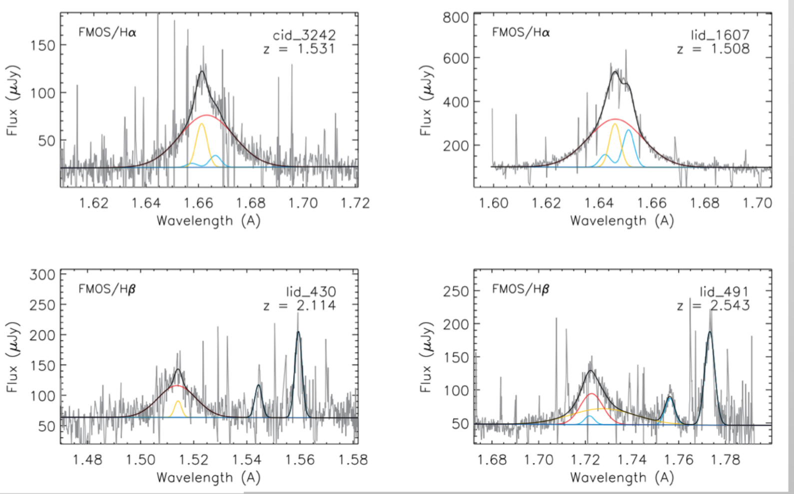
- Redshifts
- X-ray spectral analysis
- Galaxy Masses
- SFRs
- BH masses
- Accretion Rate

Marchesi, FC+ 2016a,b; Suh, FC+2017, 2019, 2020; Hasinger+2018









1. Compton Thick Obscuration
2. BH Spin
3. BH-Host relation at low and high-z
4. SMBH progenitors

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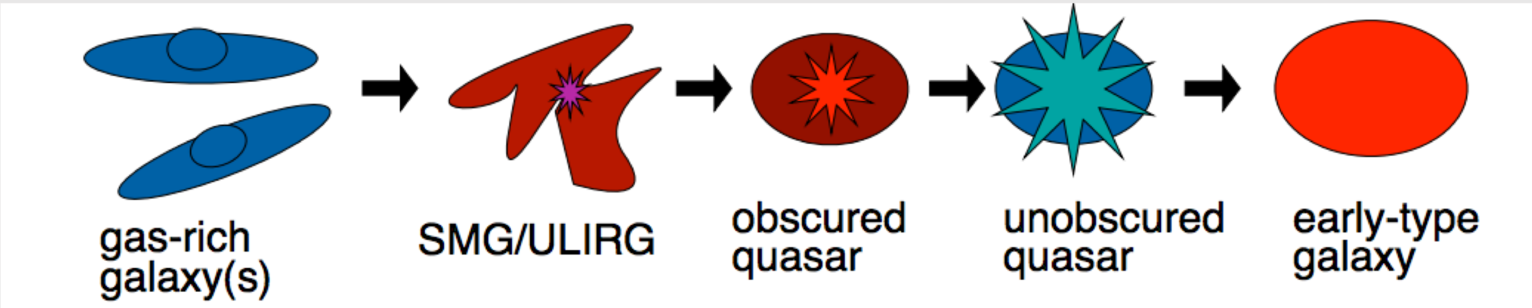
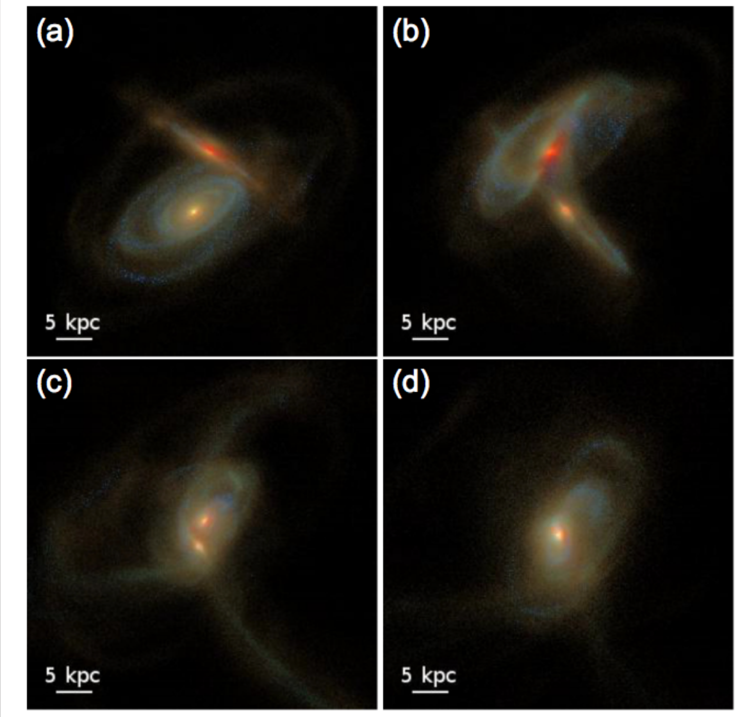
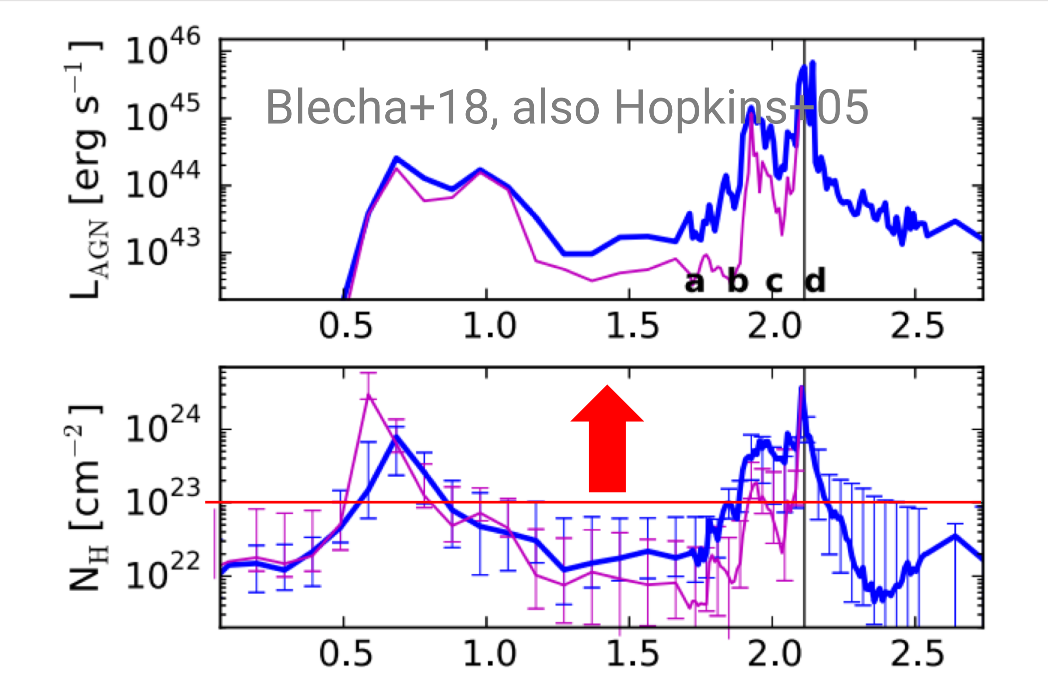
Obscured phase is important for co-evolution scenario



Alexander+Hickox 12, Sander+98, Hopkins+08

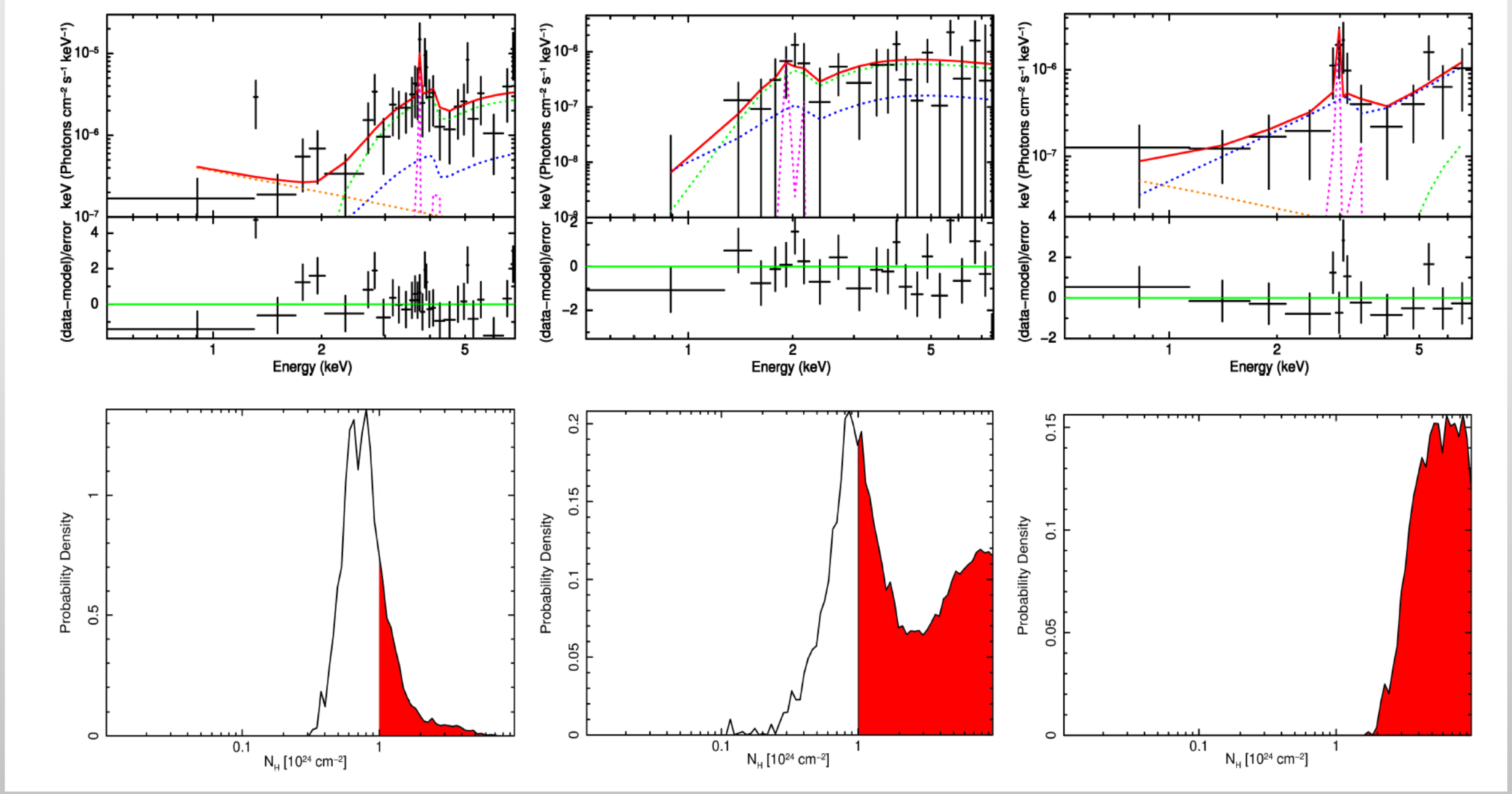




Blecha+18, also Hopkins+05

1 COSMOS searches of high-z CT AGN

Lanzuisi, FC+ 2018



1- Physically motivated modeling (Mytorus) of >30 counts spectra

2 - MCMC parameter estimation

3 - use of the full PDF

→67 individual sources with >5% probability of being CT

→41.5 true sources summing the P

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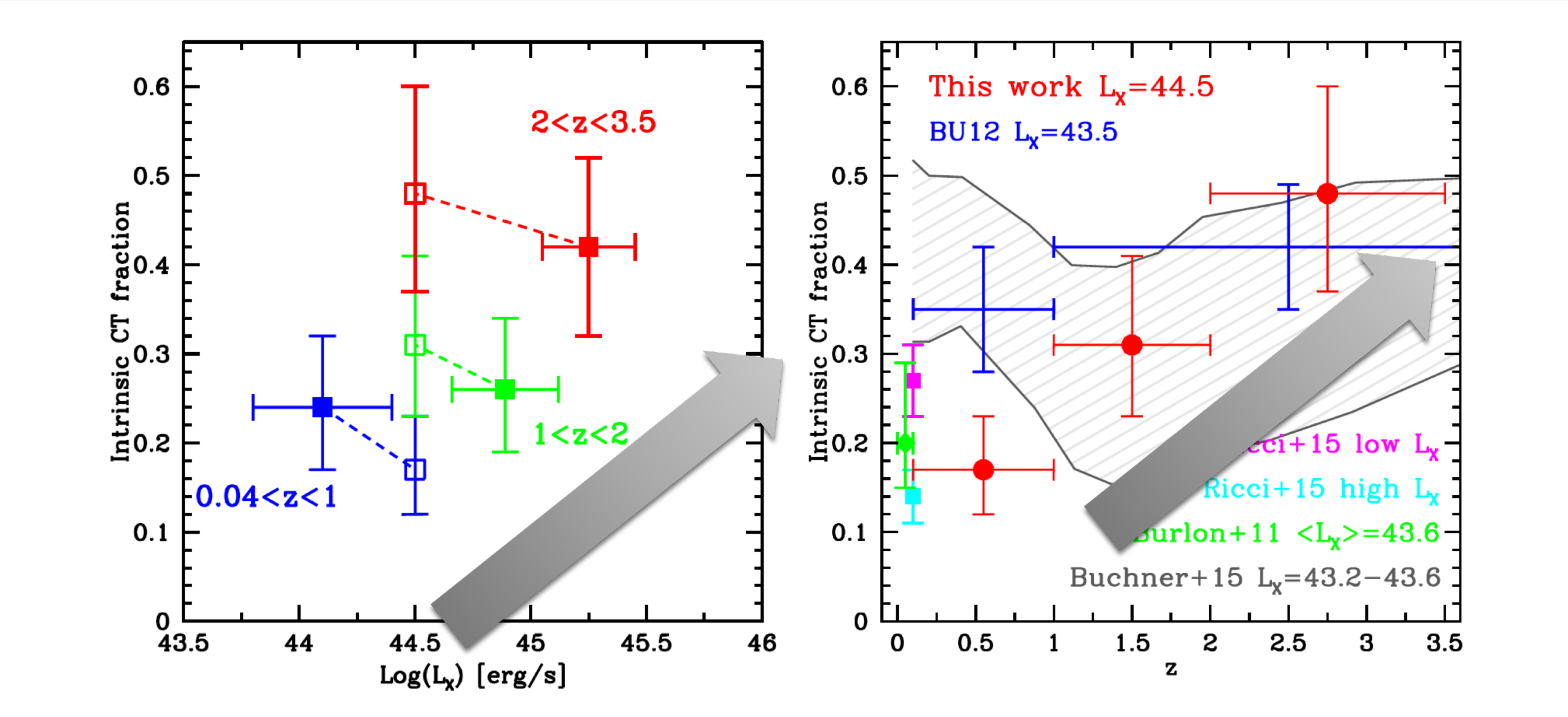
Intrinsic CT AGN fraction to z=3.5

Lanzuisi, FC+ 2018



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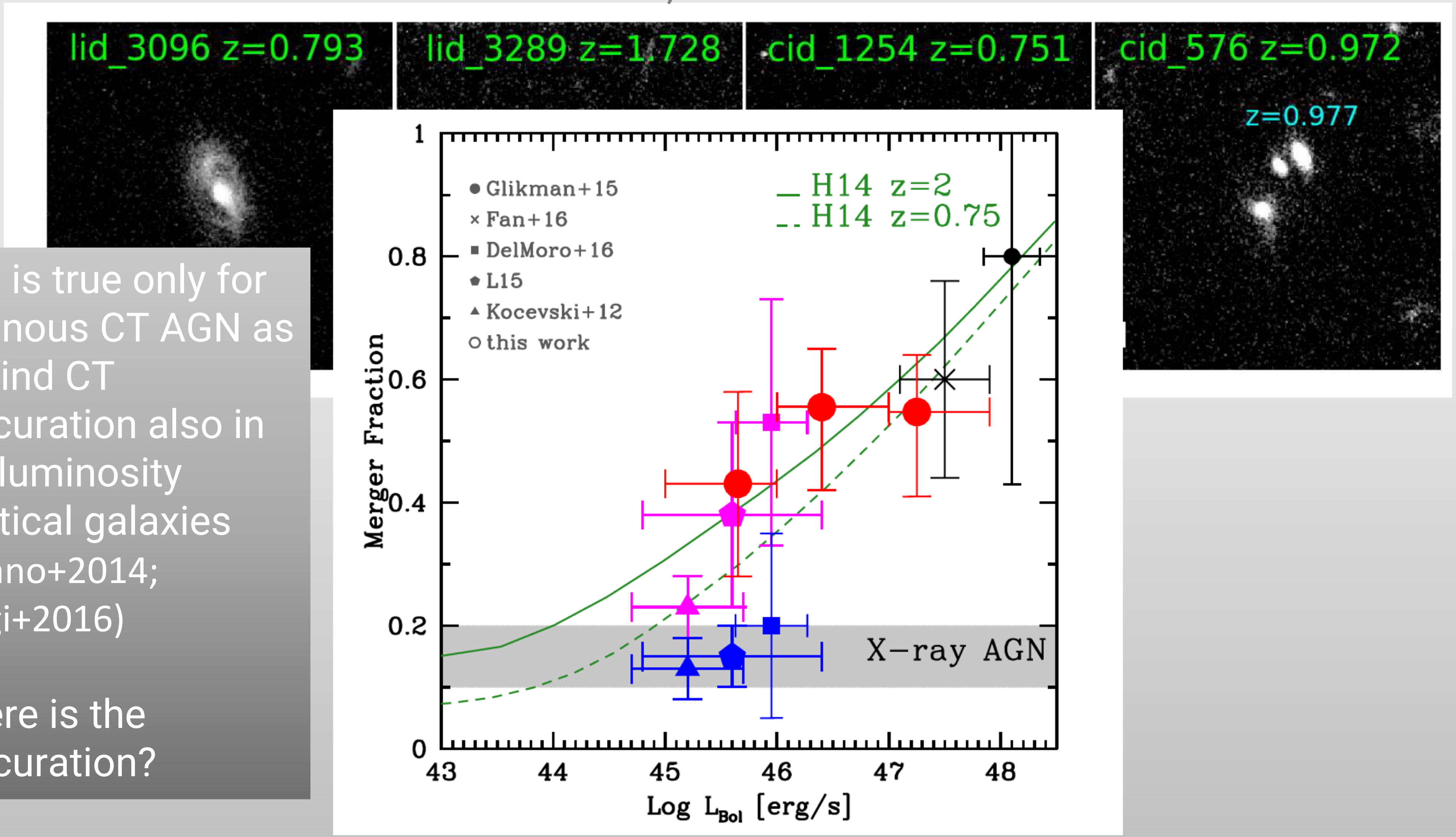
Enhanced Merger fraction

Lanzuisi, FC+ 2018



This is true only for luminous CT AGN as we find CT obscuration also in low luminosity elliptical galaxies (Civano+2014; Paggi+2016)

Where is the obscuration?

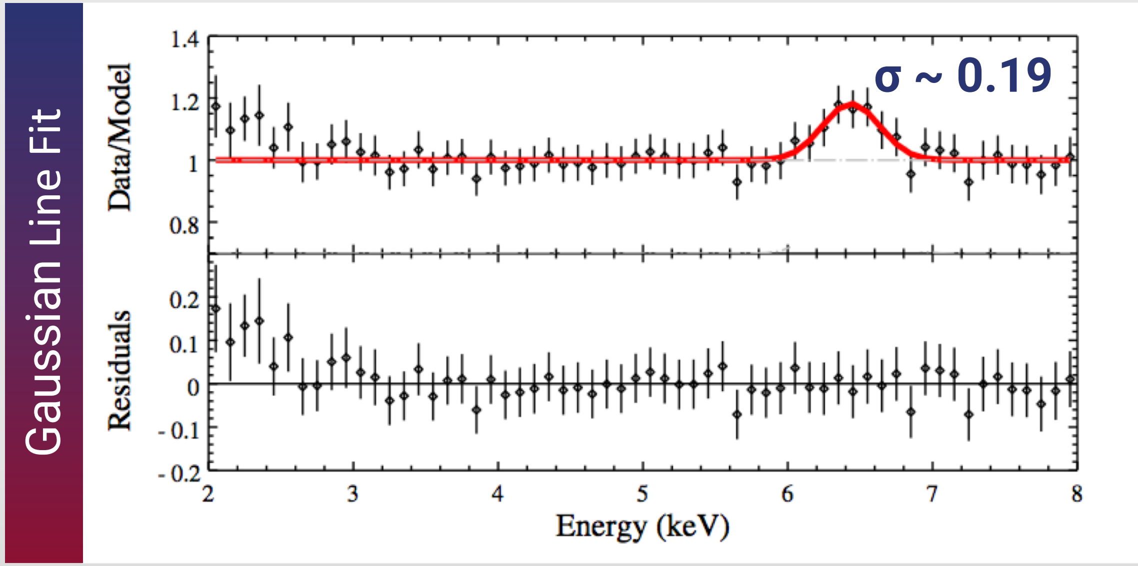
Measuring black hole spin

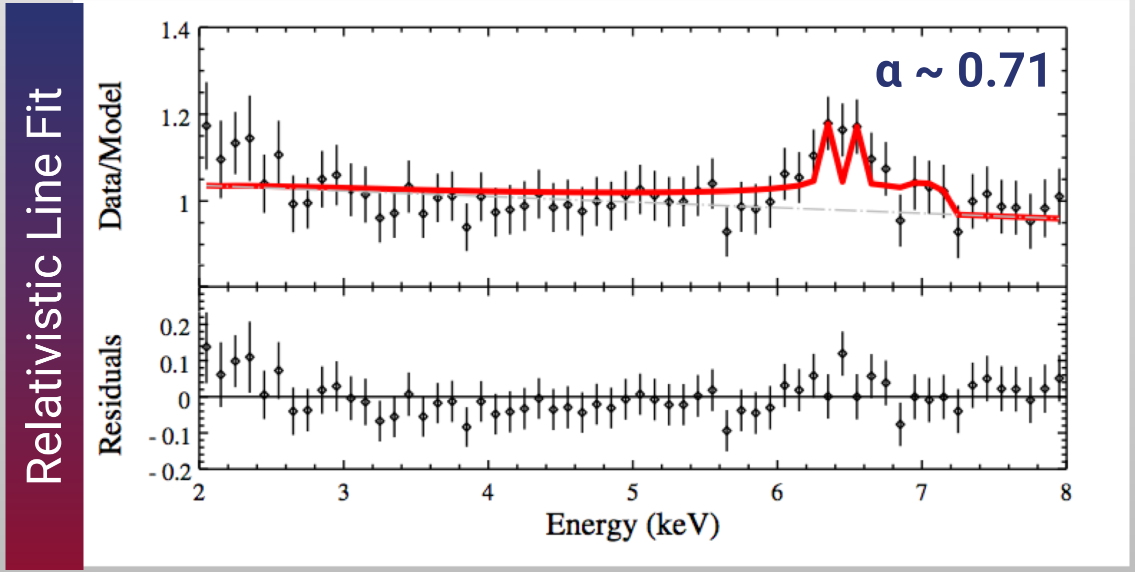
P79 by M. L. Jones

- ~2000 sources
- average broad Fe Kα line emission profile

- We fit this average profile with:
  - Gaussian line model (xsgaussian)
  - Relativisitic line model (reline)
- We bin our sample into AGN observables: redshift, luminosity, obscuration, host mass

Note: Fitting Fe Kα with a relativistic line model provides a measurement of black hole spin magnitude and direction.





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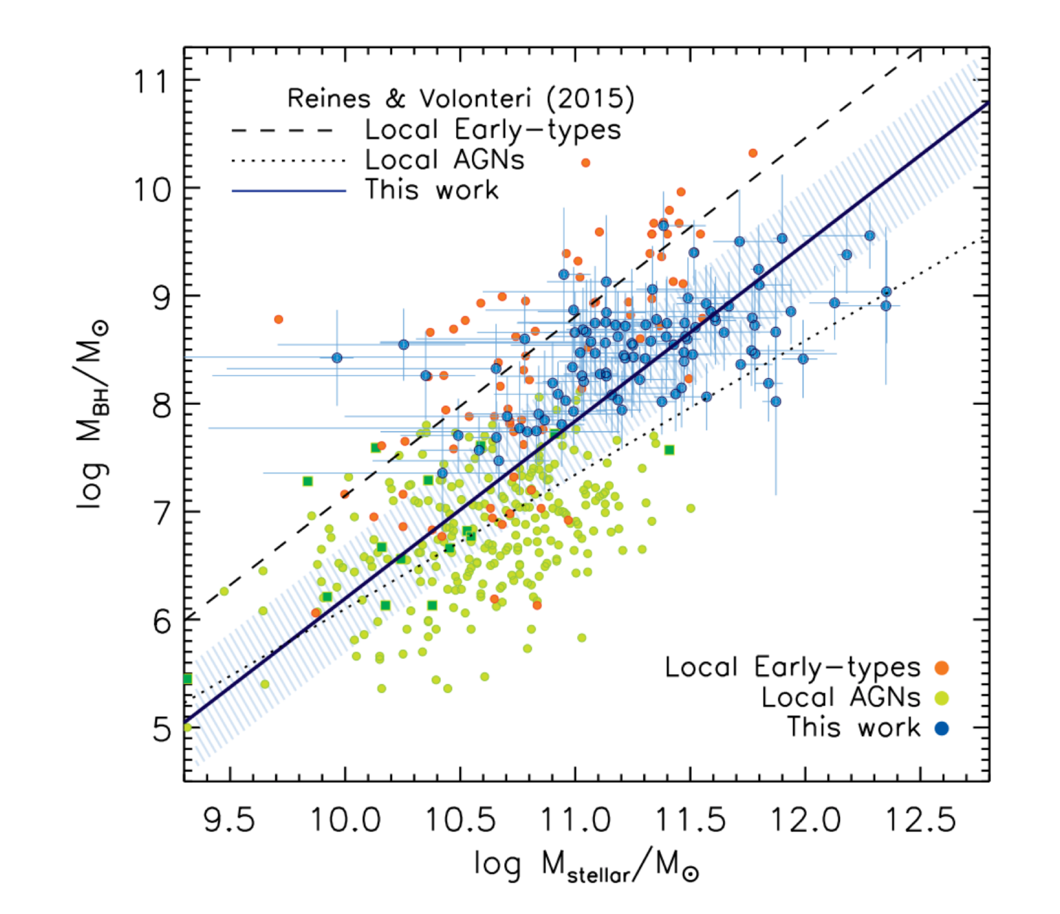
BH and host mass: scaling relation

Suh, FC, submitted

BH mass measurement from optical broad emission lines



- 100 broad line AGN
- Lbol/Ledd<=0.1 --> low accretion
- Low SFR

→BH/host mass ratio consistent with local

→No evolution with redshift to z=2.5

→BHs and galaxies must have grown and assembled their mass at z>3

3

Probing BH masses at z~3.5

Trakhtenbrot, FC +2016

- M_{BH} ~5x10^8 M_{sun}
- Fairly accreting:

L/L_{edd} = 0.1-0.4

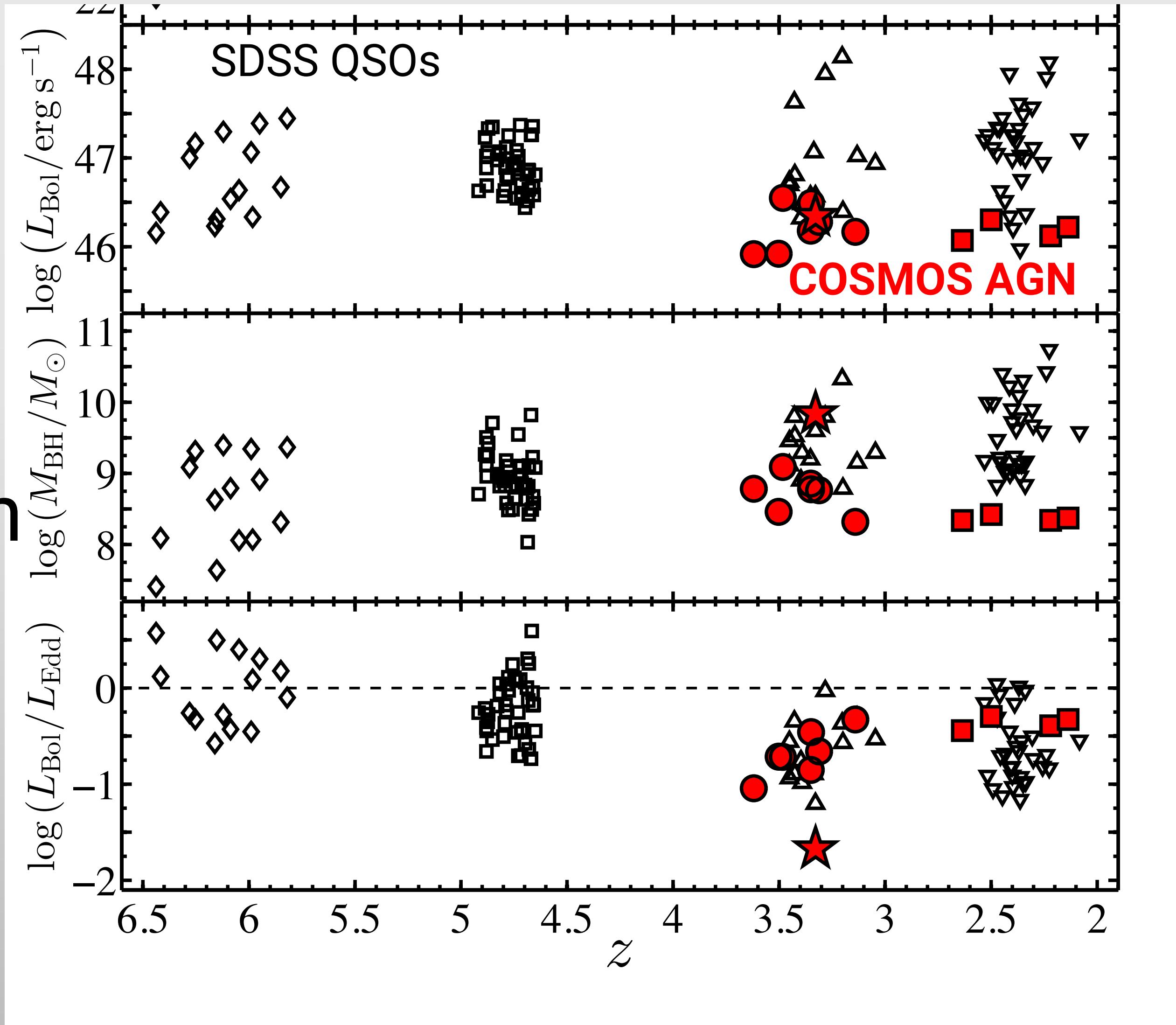
--> scale down version of massive quasars

● z~6.2 Willott+10, Kurk+07

▲ z~3.3 Shemmer+04,Netzer+07

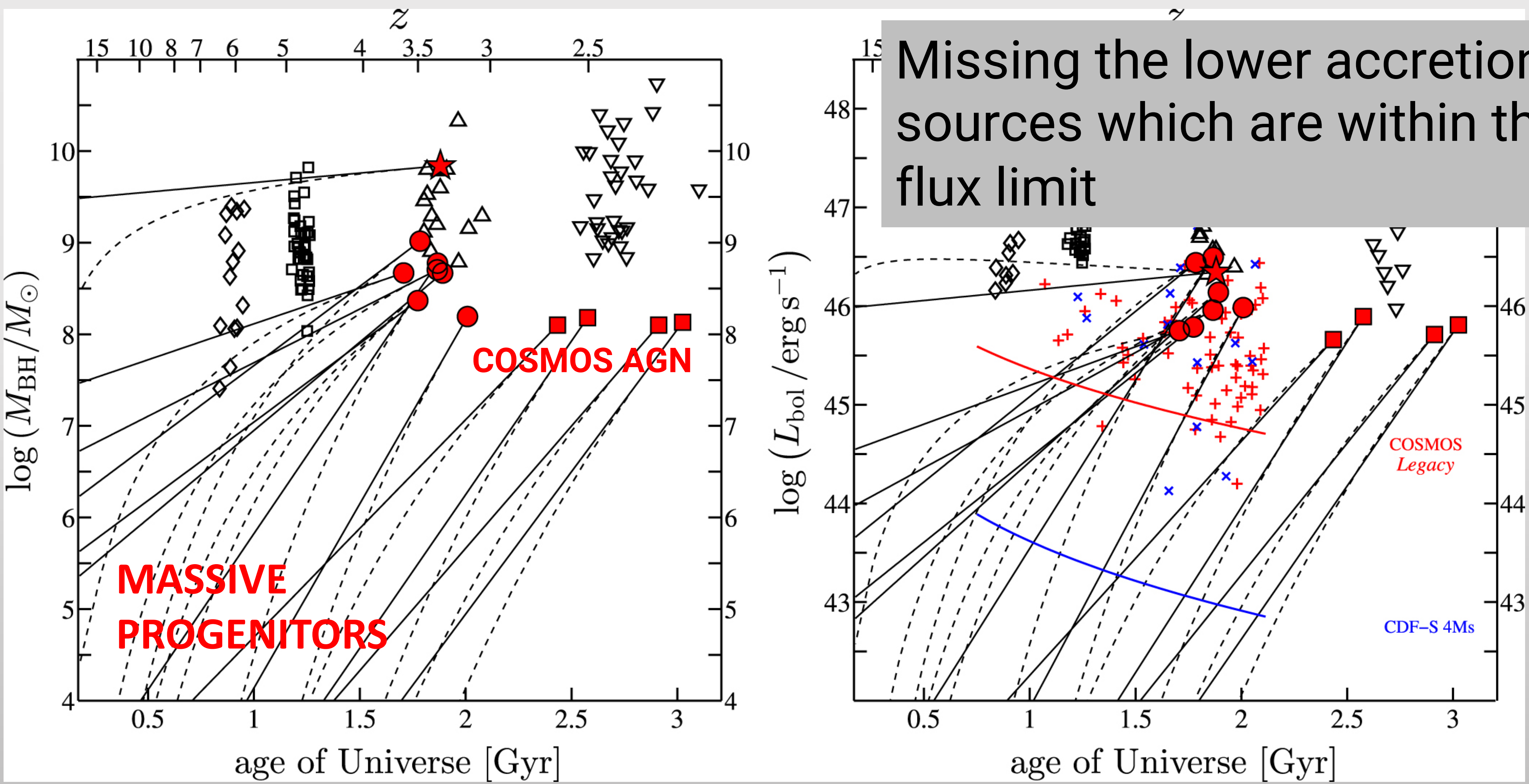
■ z~4.8 Trakhtenbrot+2011

▼ z~2.4 Shemmer+04,Netzer+07



Probing BH masses at z~3.5

Trakhtenbrot, FC +2016



Missing the lower accretion sources which are within the flux limit

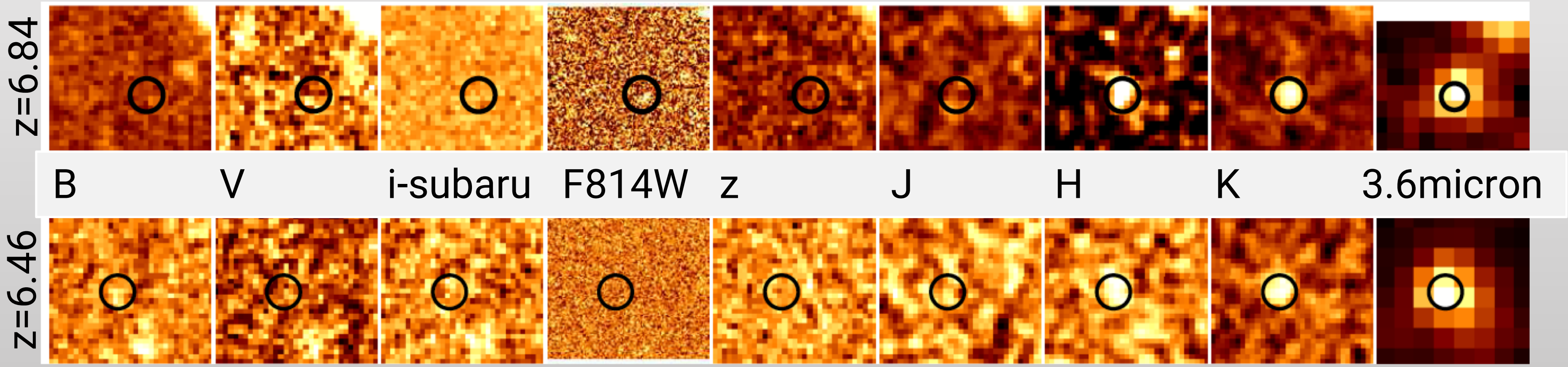
3 Beyond z=5.5 no confirmed detections

	COSMOS
5<z<5.5	2 spec-z
z>5.5	2 photo-z

As a reference 0 AGN at z>5.5 in CDFS (Vito+2017)

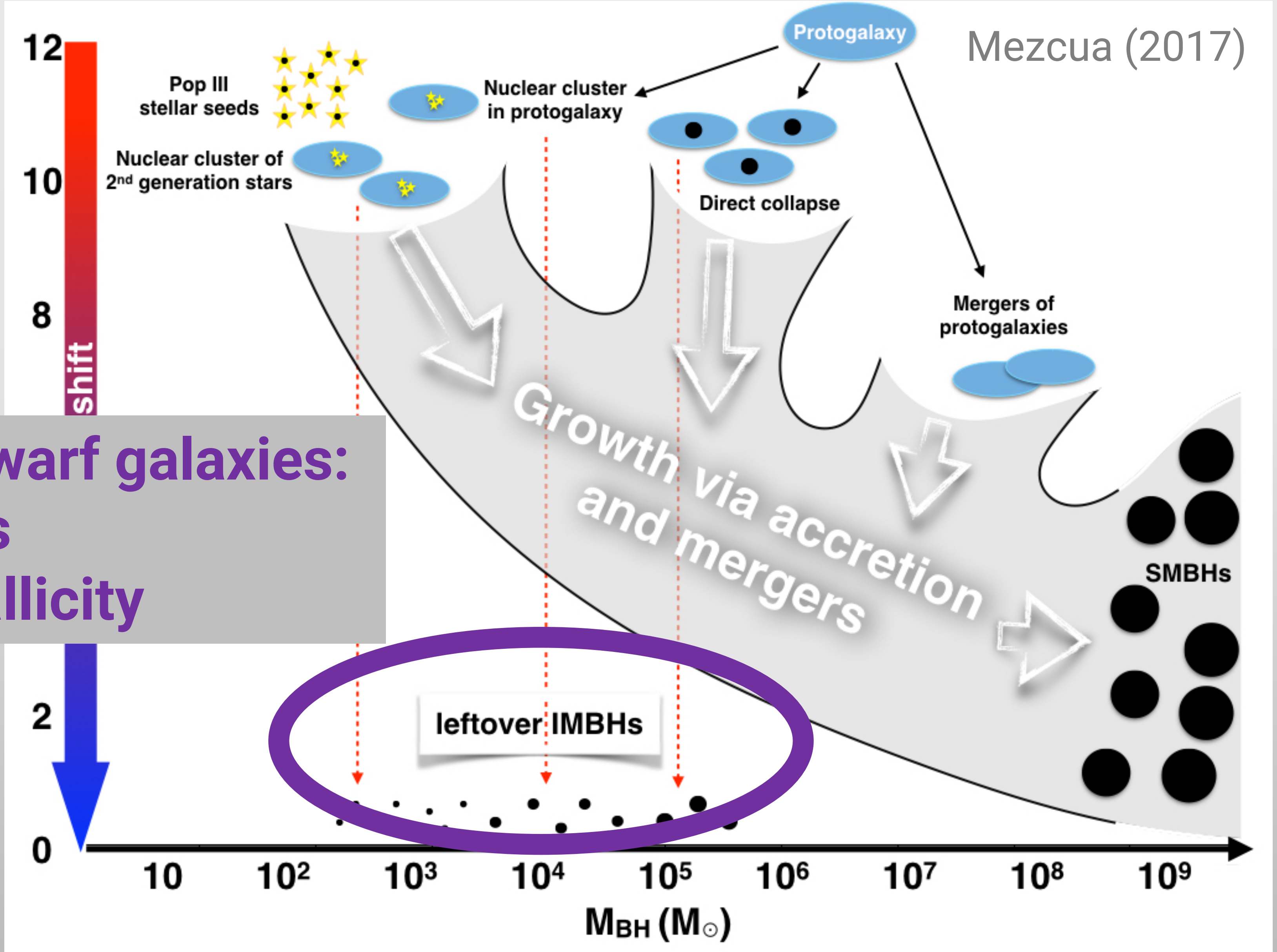
CR-7: z~6.6 LAE
M_{BH}~10^6 M_{sun} DCBH candidate
is NOT X-ray detected

Sobral+2015, Bowler+2016 Pacucci+2016, 2017



Many hours of Keck and VLT: not enough to see an emission line in the H and K bands

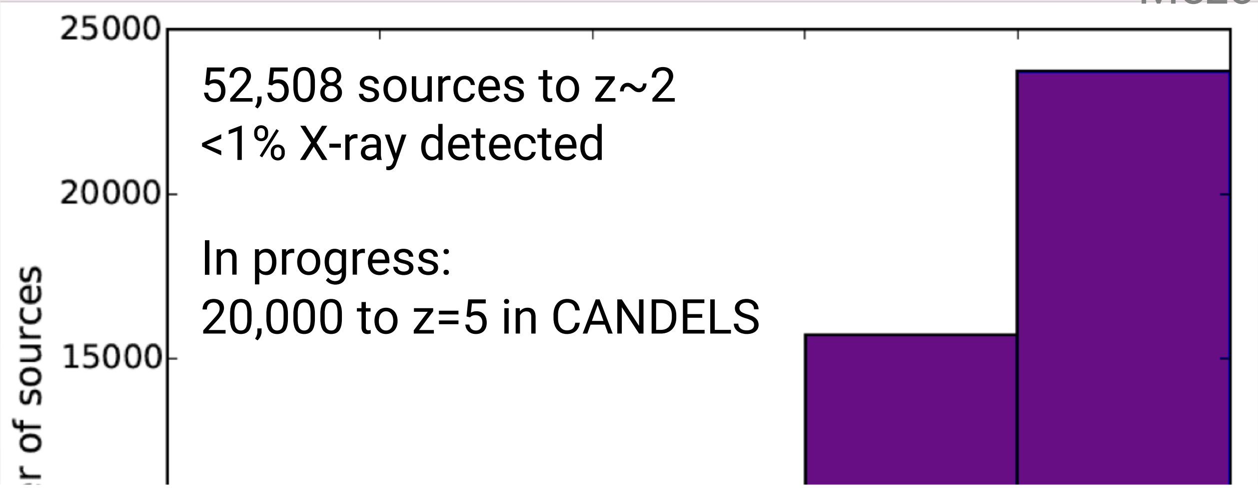
How to study the early BHs?

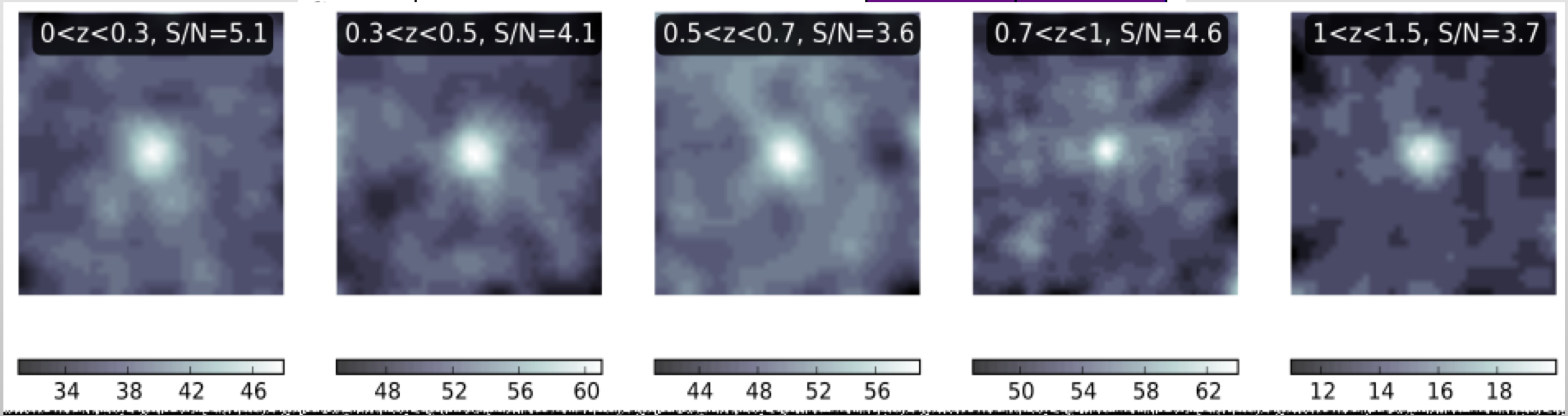


Nuclei of dwarf galaxies:
- Low mass
- Low metallicity

Low-mass galaxies in COSMOS

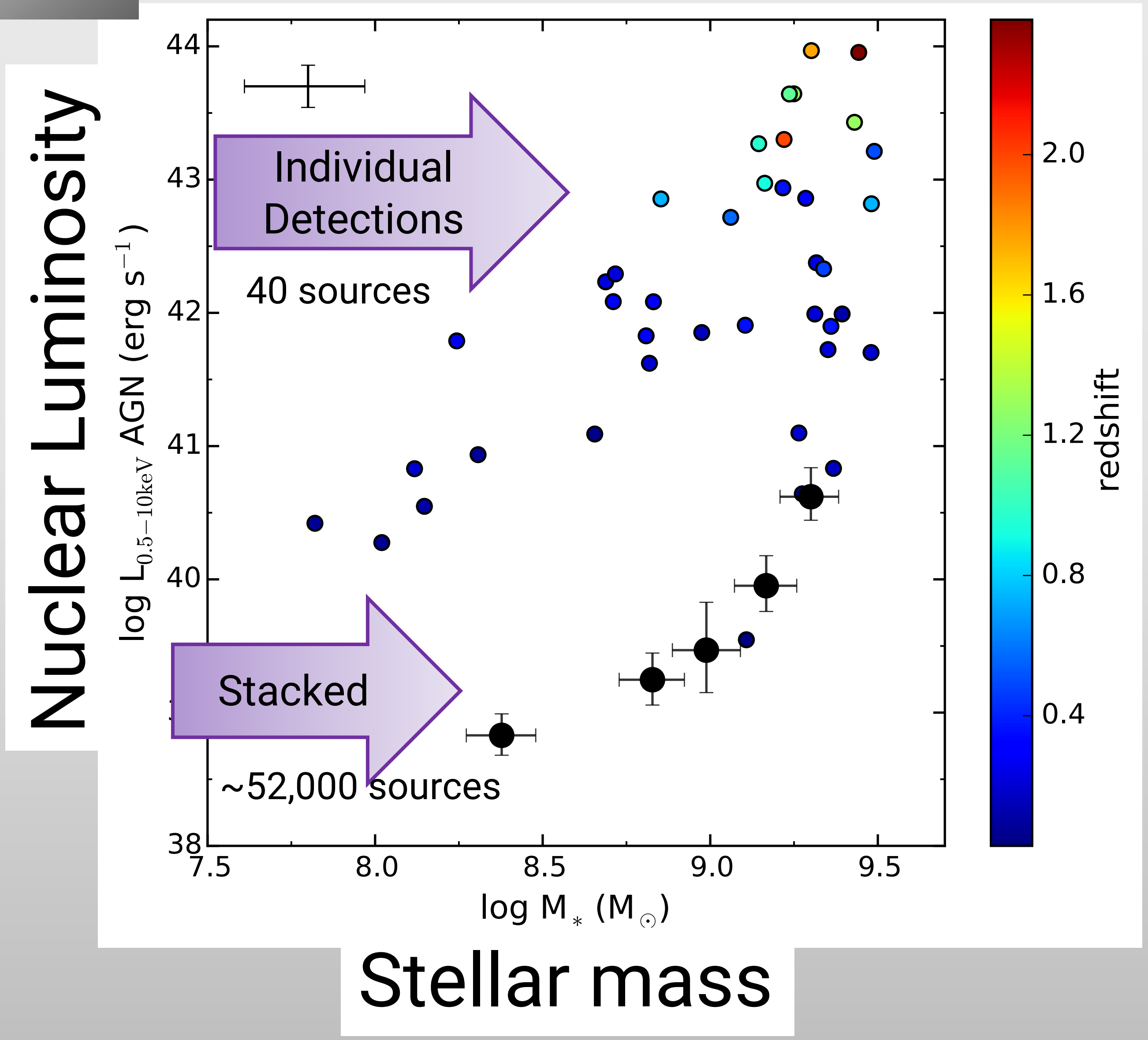
Mezcua, FC+ 2016, 2018





4 Dwarf Galaxies Nuclear Luminosity

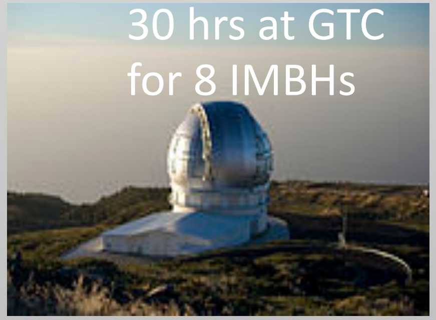
Mezcua, FC+ 2016, 2018



- Significant nucler emission
- Detections to z=>2
- M_{BH} < 10^6 M_{sun} (assuming Reines & Volonteri 2015)
- Four interesting sources: lowest IMBHs ever found
- Fairly accreting: $\lambda_{Edd}=L_{bol}/L_{edd}$ > 0.1

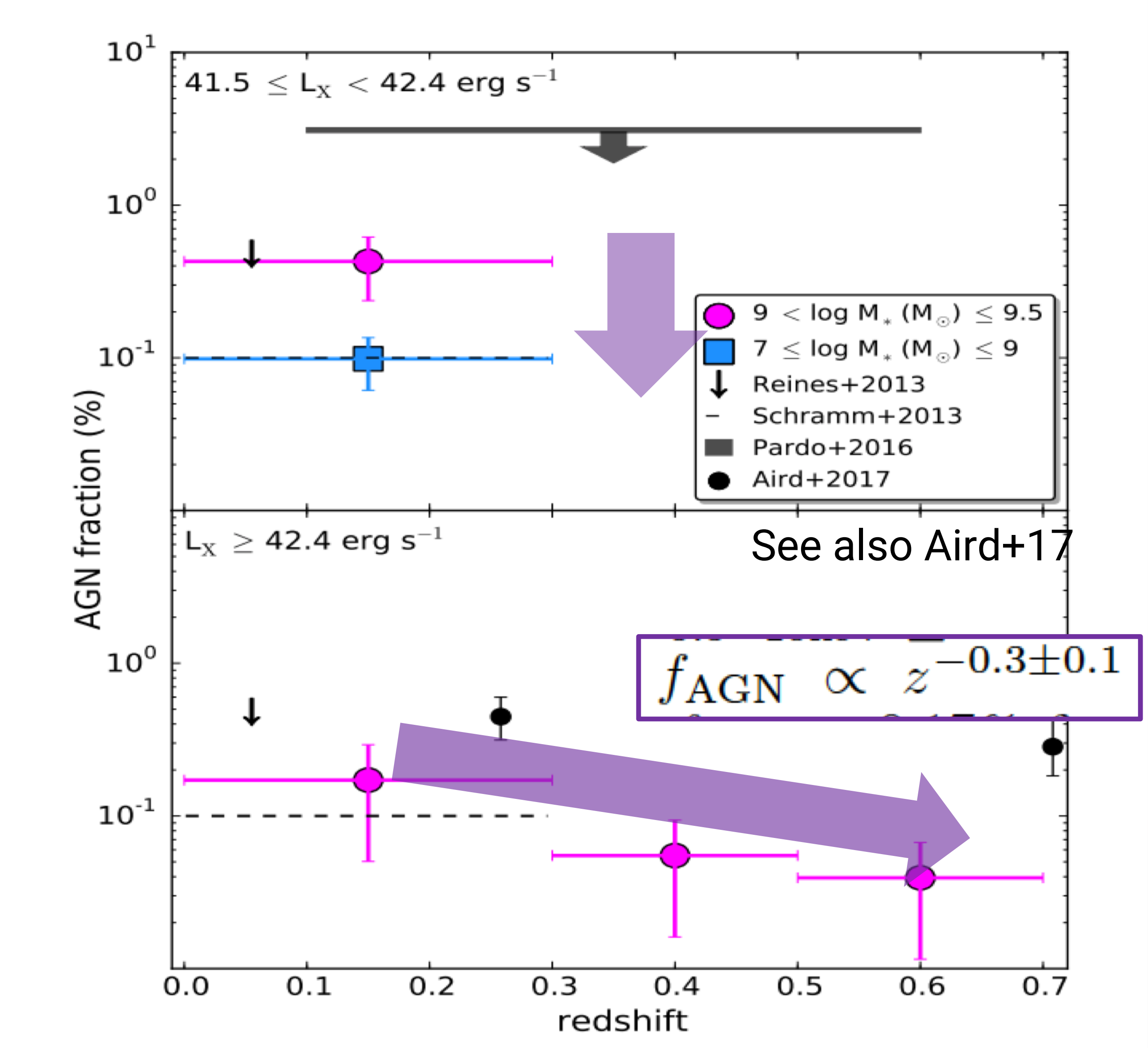
L_{XRB} α SFR, M_* (Lehmer et al. 2010)

$L_{hot\ gas}$ α SFR (Mineo et al. 2012)

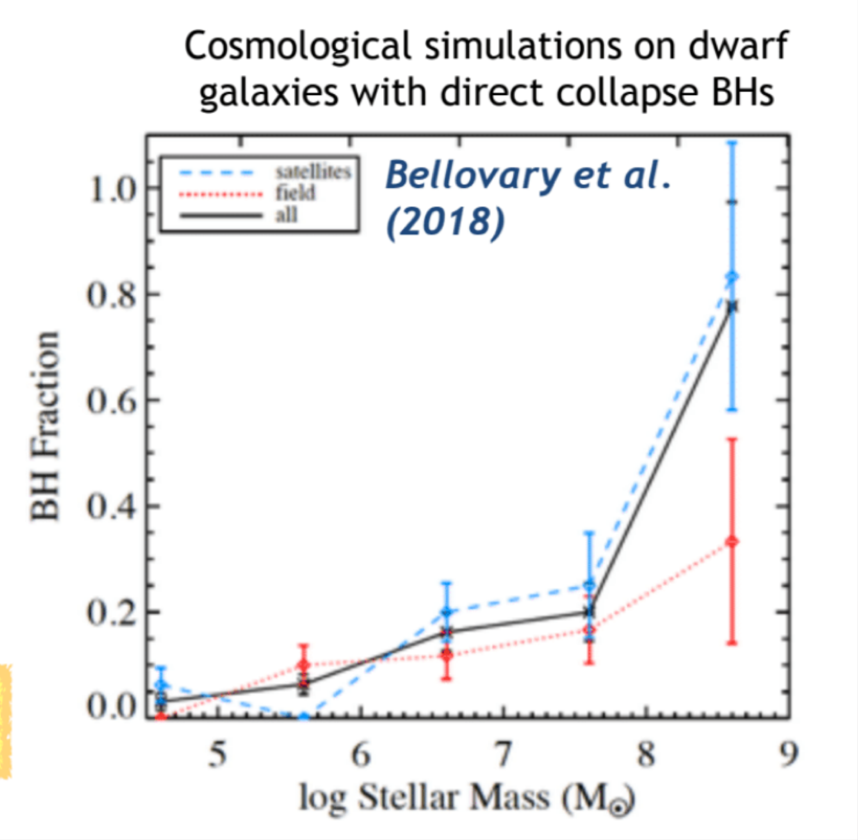


(Active) IMBH occupation fraction

Mezcua, FC+ 2016, 2018



Active fraction decrease with redshift and mass (opposite of massive sources)
→ AGN in dwarf galaxies evolve differently than those in massive galaxies



Summary

---> Large area of the COSMOS field allow to do population studies with a large variety of rare sources

1. **Obscuration** --> CT fraction increases to z=3
2. **BH Spin** --> see M. Jones poster P79
3. **Scaling relations at low and high-z** --> SMBH all formed by z=3; pointed observations of CR7 would be informative
4. **SMBH progenitors** --> dwarf galaxies hosts IMBH which seems to be related to DCBHs

---> Our catalogs of X-ray sources and all multiwavelength properties are all available. Please used them.

Conclusion: the future is bright

Civano+2019, Astro 2020 White Paper