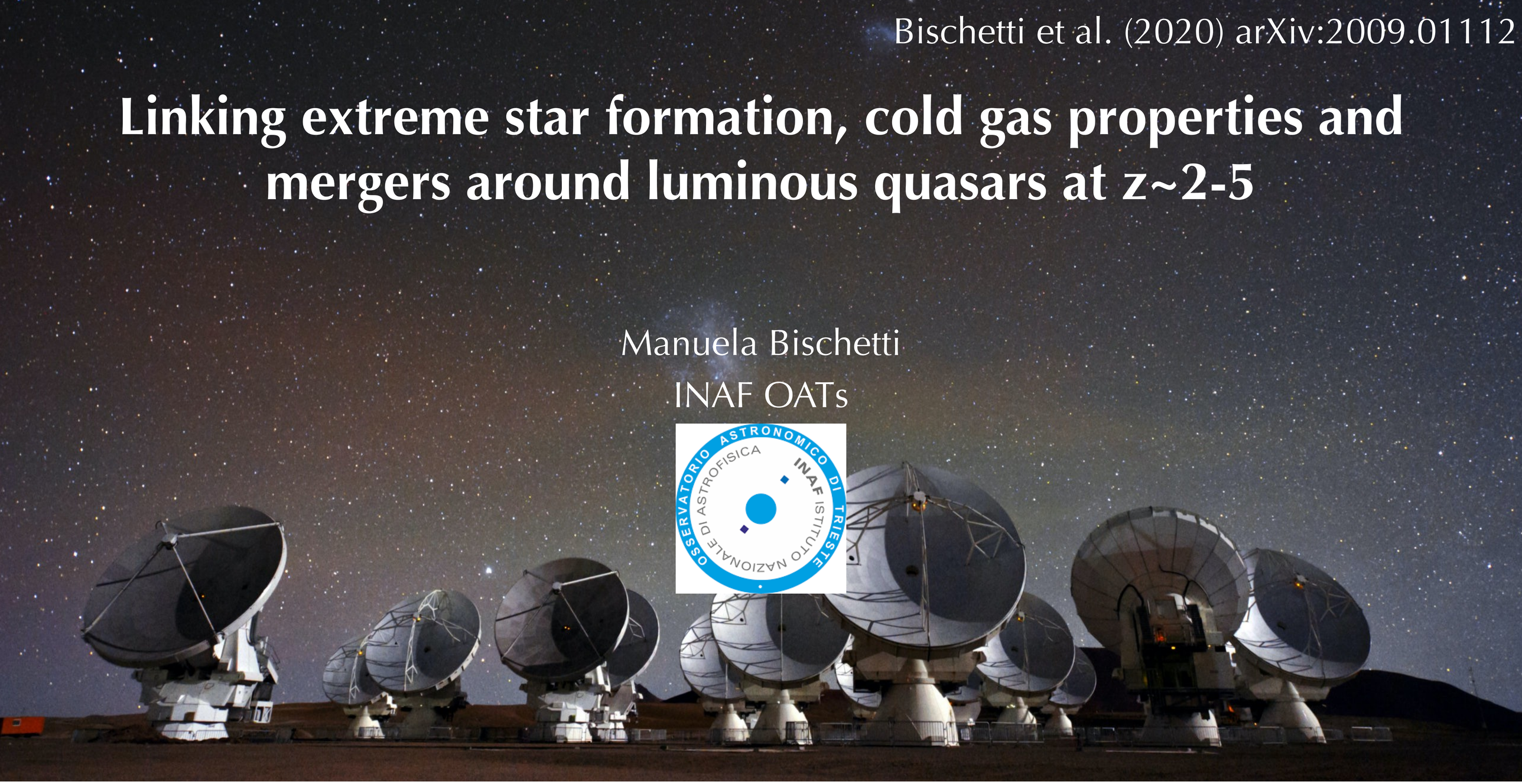
Bischetti et al. (2020) arXiv:2009.01112

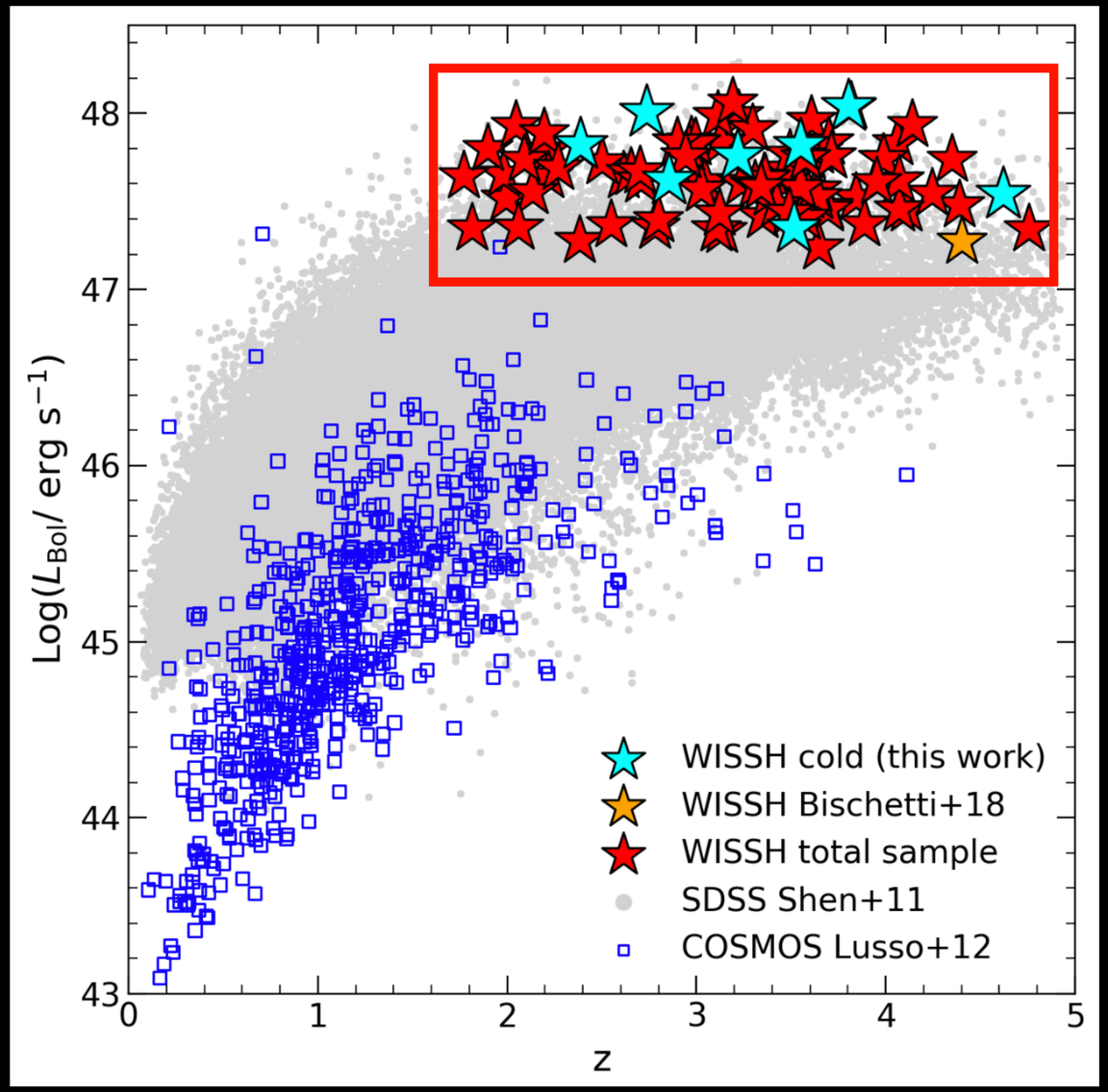
Linking extreme star formation, cold gas properties and mergers around luminous quasars at z~2-5

Manuela Bischetti
INAF OATs



Collaborators: C. Feruglio, F. Fiore, E. Piconcelli, F. Duras, M. Pèrez-Torres, R. Herrero, G. Venturi, S. Carniani, G. Bruni, I. Gavignaud, V. Testa, A. Bongiorno, M. Brusa, C. Circosta, G. Cresci, V. D'Odorico, R. Maiolino, A. Marconi, M. Mingozzi, C. Pappalardo, M. Perna, E. Traianou, A. Travascio, G. Vietri, L. Zappacosta

The most luminous QSOs at Cosmic Noon



The WISSH sample:
86 WISE/SDSS Selected Hyper-luminous QSOs

- SDSS DR7 broad-line QSOs with S(22 μm) > 3 mJy
- Log(L_{Bol} /erg s^{-1}) > 47.2
- 1.5 < z < 4.5

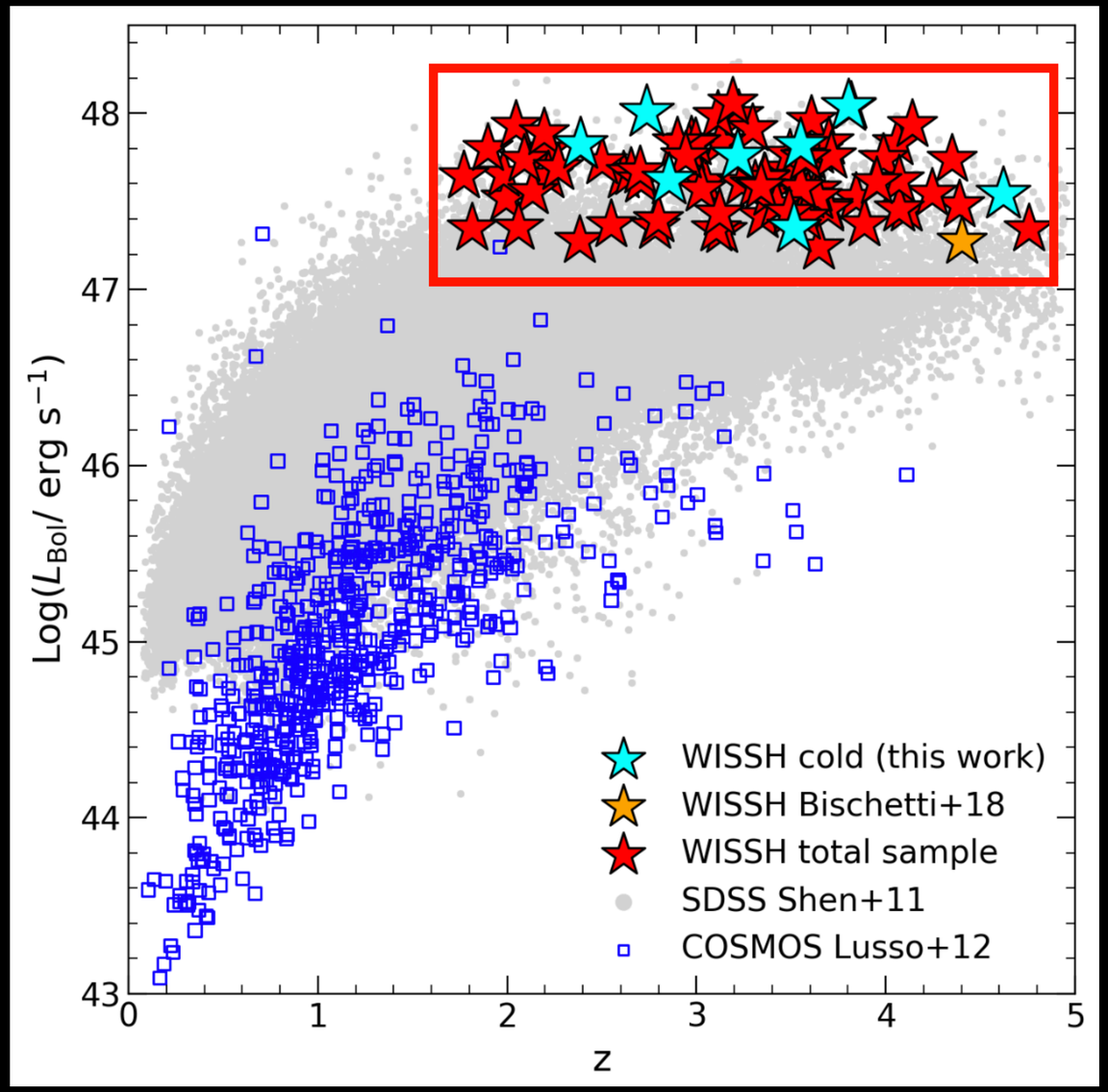
GOAL:

Observing AGN-driven feedback at its best!

(The "strength" of AGN-driven outflow correlates with L_{Bol}, e.g.Fiore+17,Fluetsch+19)

Widespread evidence of outflows
from nuclear (Vietri+18,Bruni+19,Zappacosta+20)
to galaxy (Bischetti+17)
and CGM scale (Travascio+20)

The most luminous QSOs at Cosmic Noon: the (sub-)millimetre view



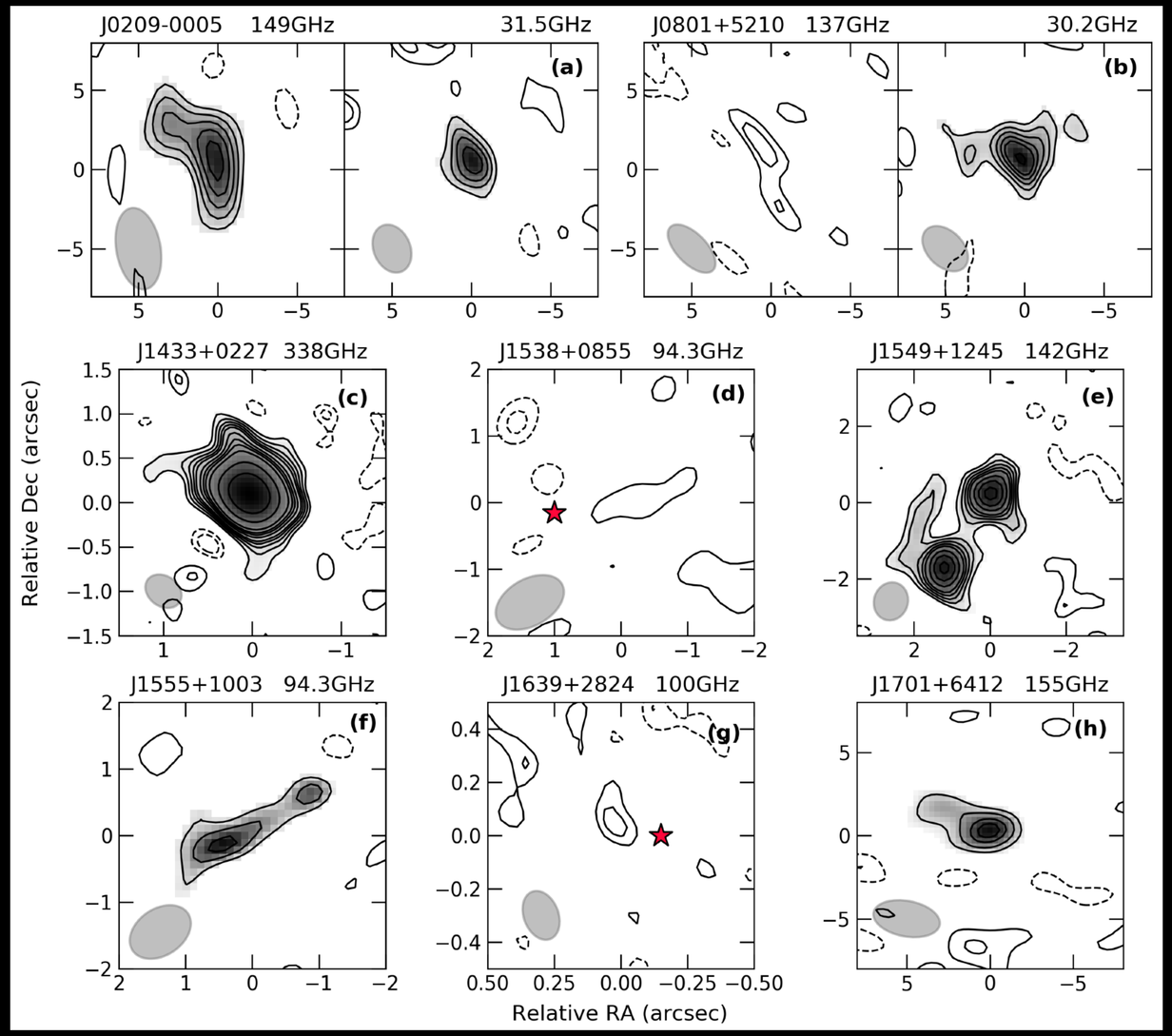
NOEMA, ALMA and JVLA observations
presented in Bischetti+20 arXiv:2009.01112 (see also Bischetti+18)

- **CO(5-4), CO(4-3), CO(1-0)** for **7 QSOs**
  [CII] for **2 QSO**
  Far-infrared continuum
- z =2.3–4.7
- logLBol = 47.5-48 erg/s

First systematic study of cold gas properties in the most luminous QSOs
characterisation of host-galaxies and environment

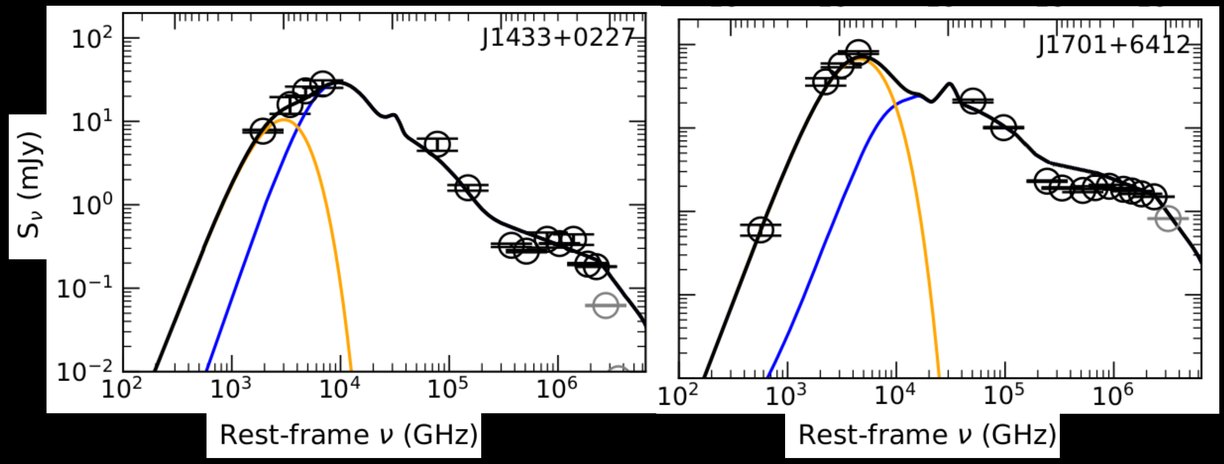
Extreme star formation in WISSH QSOs

Continuum emission maps



75% detection rate in continuum
(80% including Bischetti+18)

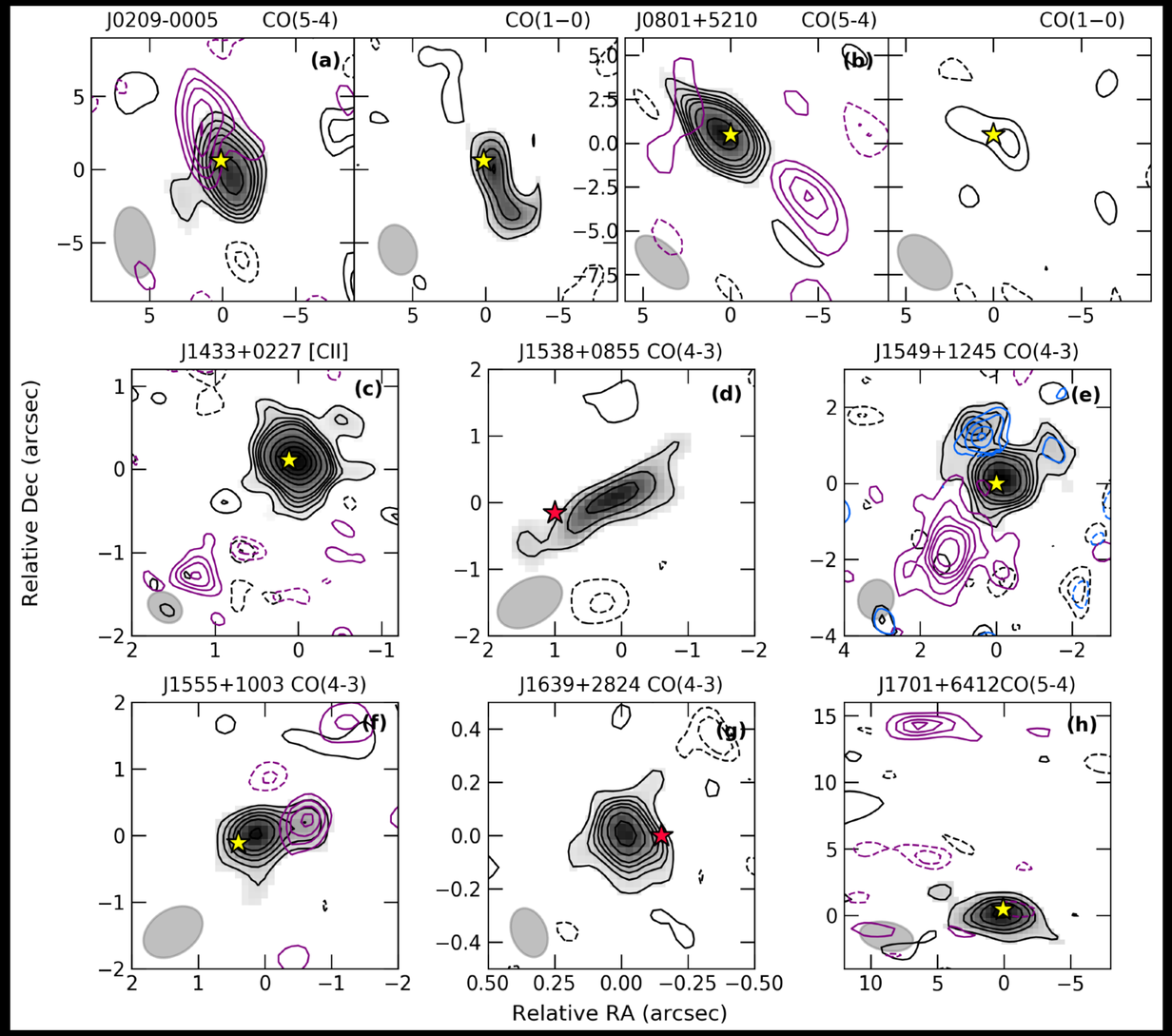
- Broad-band, UV-to-FIR SED based, **AGN-corrected SFR~200-1000 M_{Sun}/yr** in the QSO host galaxies (Bischetti+20 , Duras+17)



- 2 companion galaxies show bright continuum emission: **high SFR** (100-200 M_{Sun}/yr) **also in the companions**

Widespread companion galaxies: dense environment

Velocity-integrated emission line maps



QSO

companion galaxy

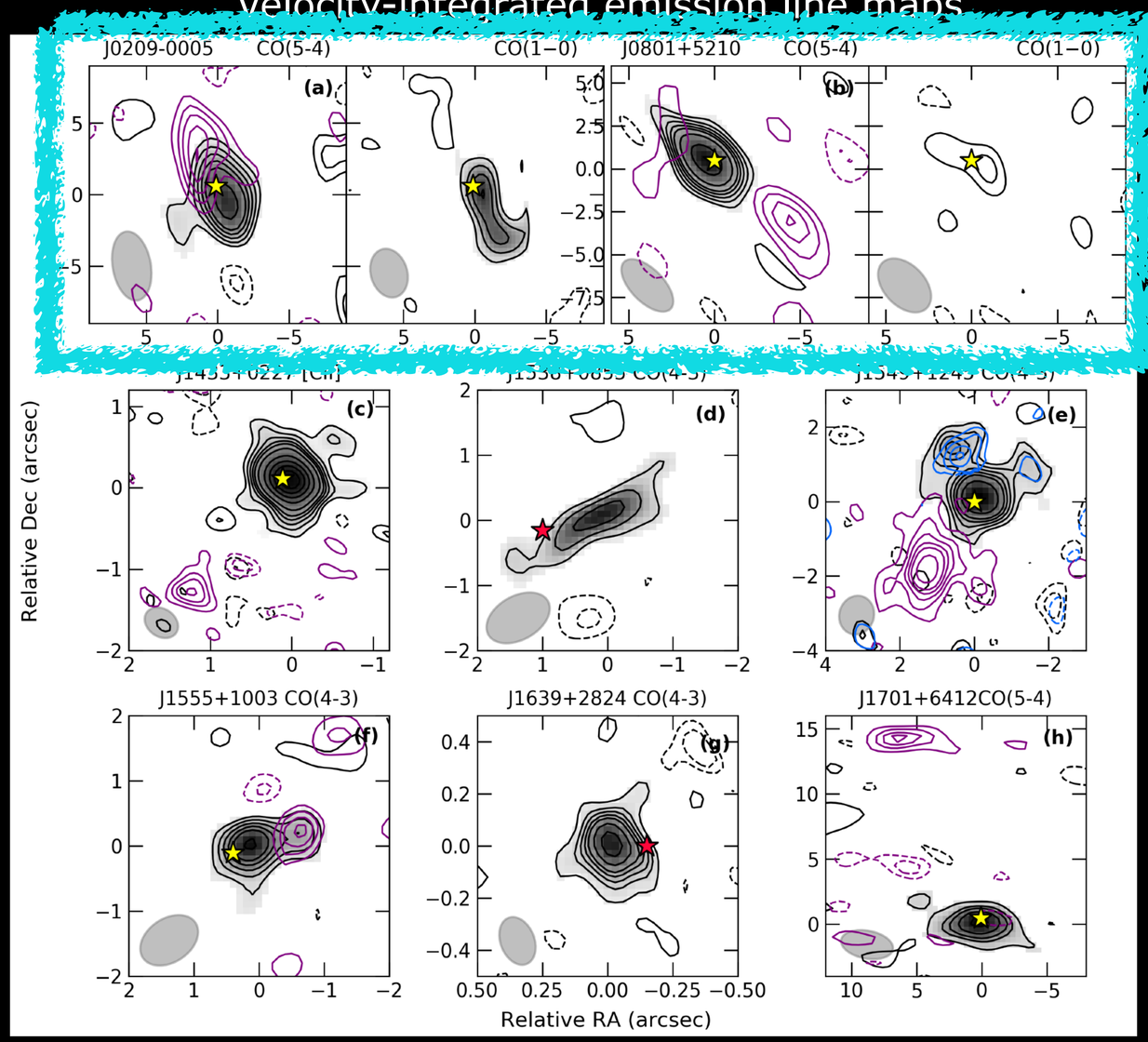
- 6 out of 8 QSOs show one (or more) nearby line emitter
- Bright CO or [CII] emission
- Typical projected distance 6-40 kpc

Merger fraction 75%
(80% including Bischetti+18)

100% detection rate in CO/[CII]

Bischetti+20 arXiv:2009.01112

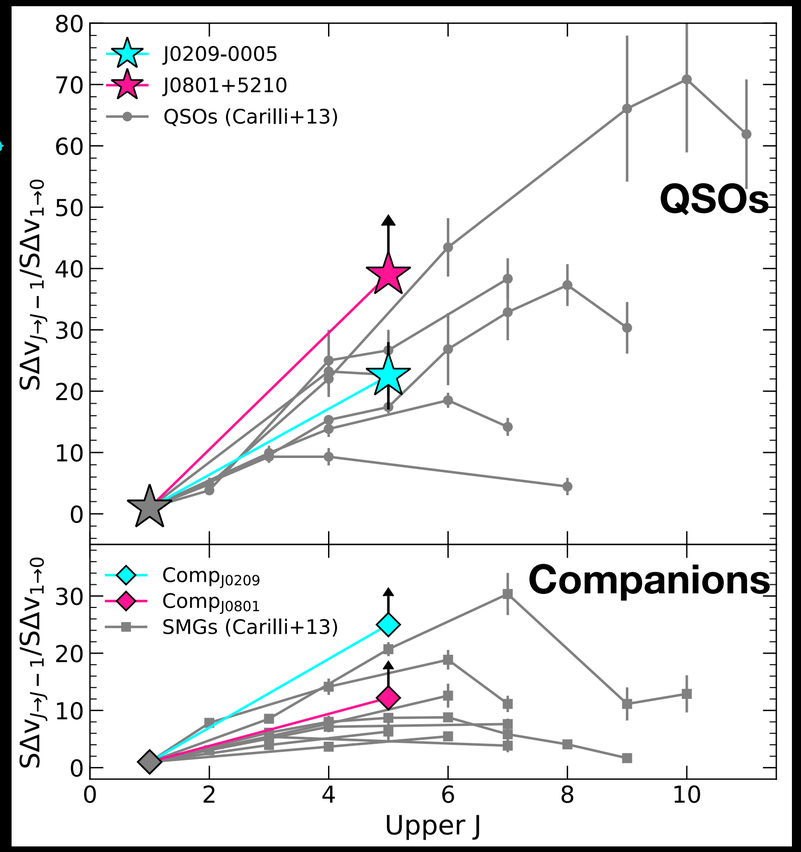
QSO radiation affects CO excitation in host and companion galaxies



QSO

companion galaxy

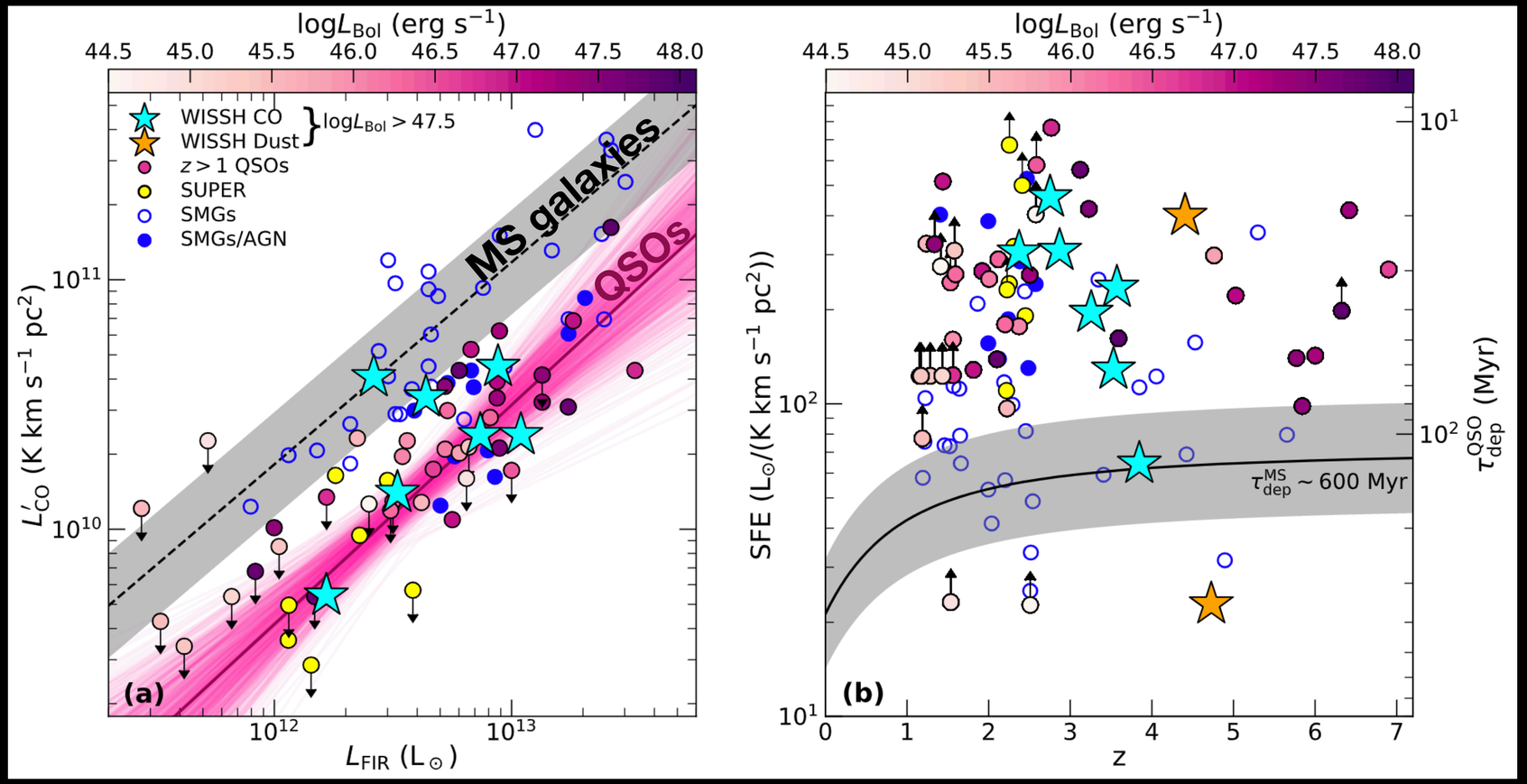
CO SLED based on CO(5-4) and CO(1-0)



- **CO excitation** in QSO hosts is **consistent with the steepest CO ladders observed so far**
- **High CO excitation** also in the companions

Bischetti+20 arXiv:2009.01112

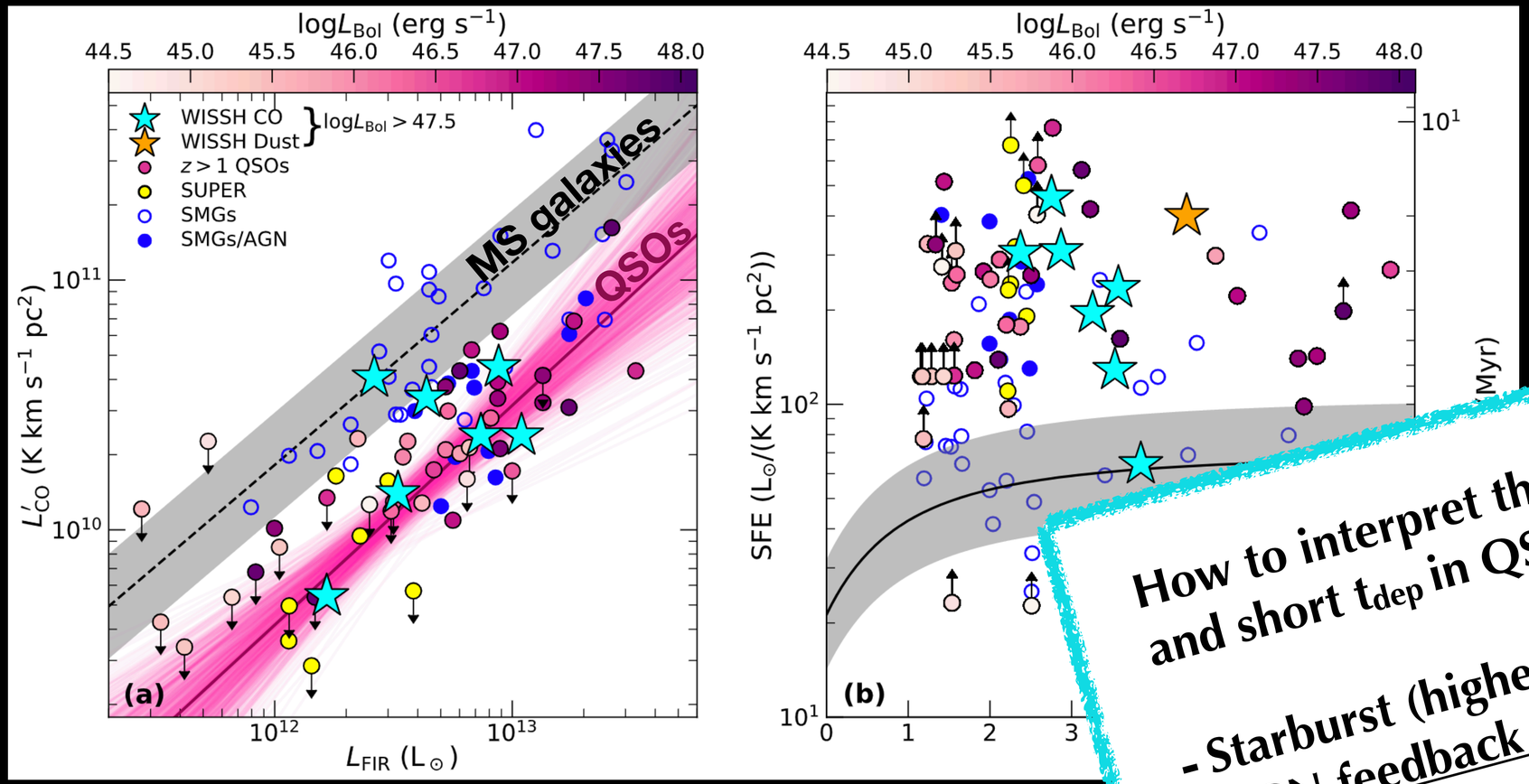
FIR-CO luminosity relation and star formation efficiency



- WISSH and z>1 QSOs typically show **a factor of ~4 lower L'CO** than z<~3 MS galaxies (Sargent+14)
- High **SFE=L_{FIR}/LCO>100** L_{sun}/(K km/s pc^2) —> short **depletion timescales ~20-50 Myr** for the molecular gas reservoir

Bischetti+20 arXiv:2009.01112

FIR-CO luminosity relation and star formation efficiency



How to interpret the high SFE and short t_{dep} in QSOS?

- Starburst (higher L_{FIR})

- AGN feedback (lower L'CO)

- WISSH and z>1 QSOs typically show **a factor of ~4 lowe** z<~3 MS galaxies (Sargent+14)
- High **SFE=L_{FIR}/LCO>100** L_{sun}/(K km/s pc^2) —> short **depletion timescales ~20-50 Myr** for the molecular gas reservoir

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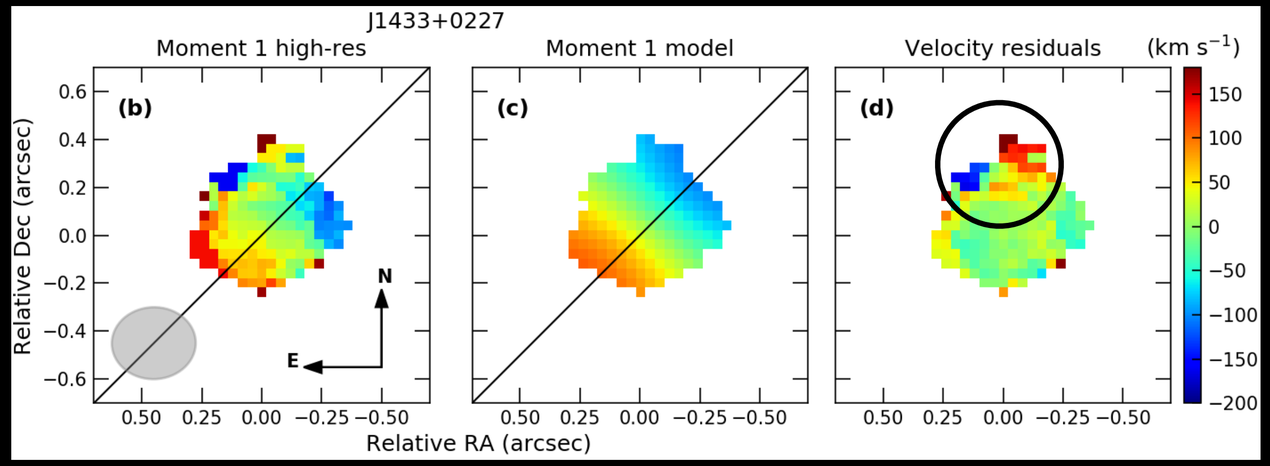
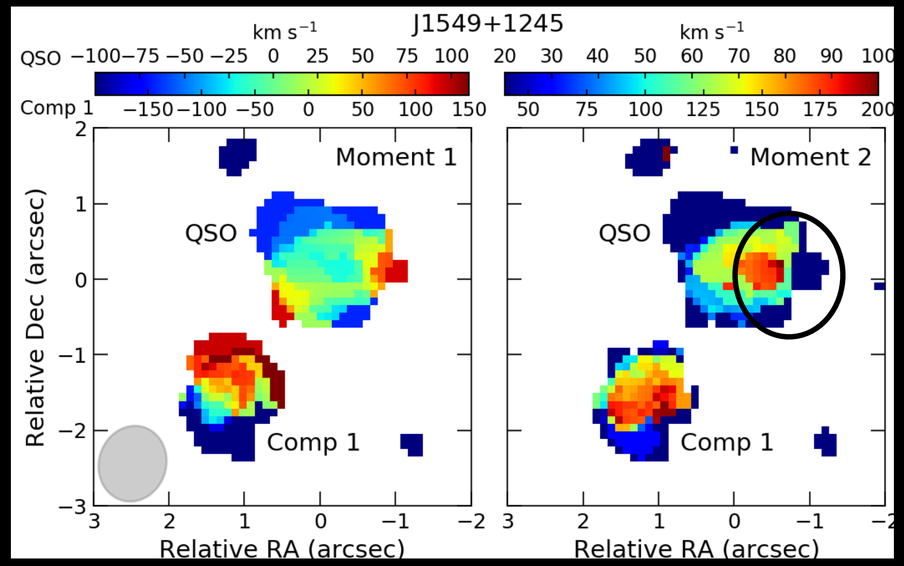
Cold gas kinematics

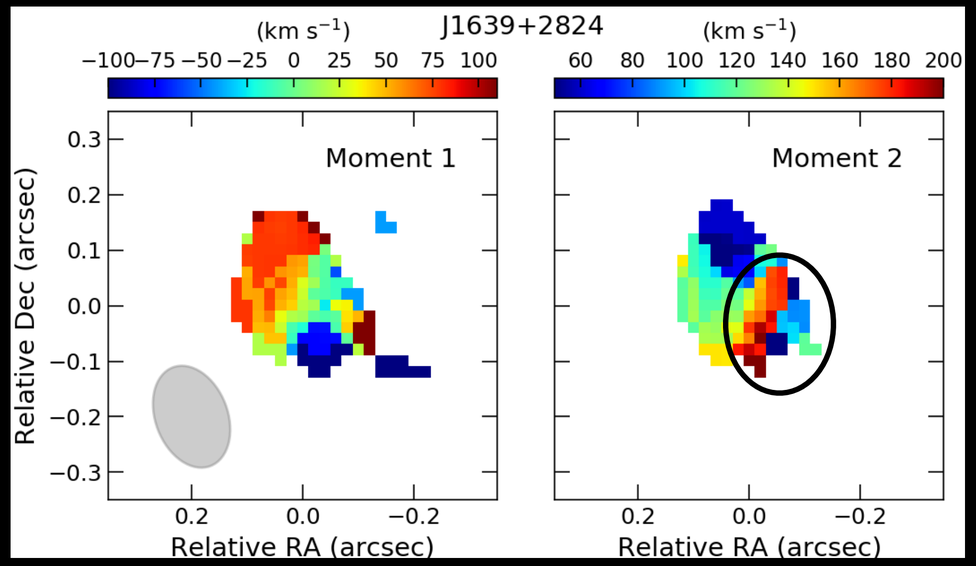
- Variety of **sizes** for the cold gas reservoirs **~1.7-10 kpc**
- Velocity gradients associated with **rotating disks + disturbed kinematics**



Large velocity residuals (data - disk model)



High velocity dispersion, offset from QSO position



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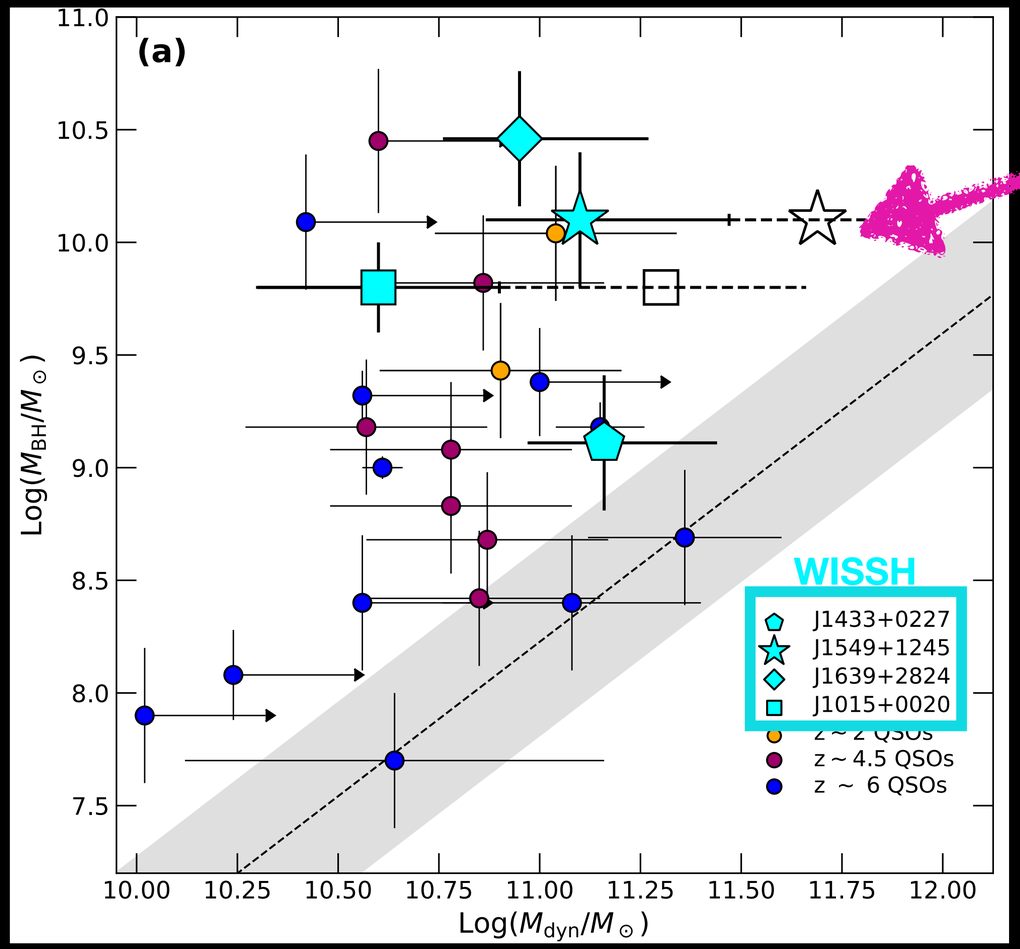
Dynamical vs SMBH mass



QSO + companion system

$\log(M_{dyn}/M_{Sun})$~10.5-11.1

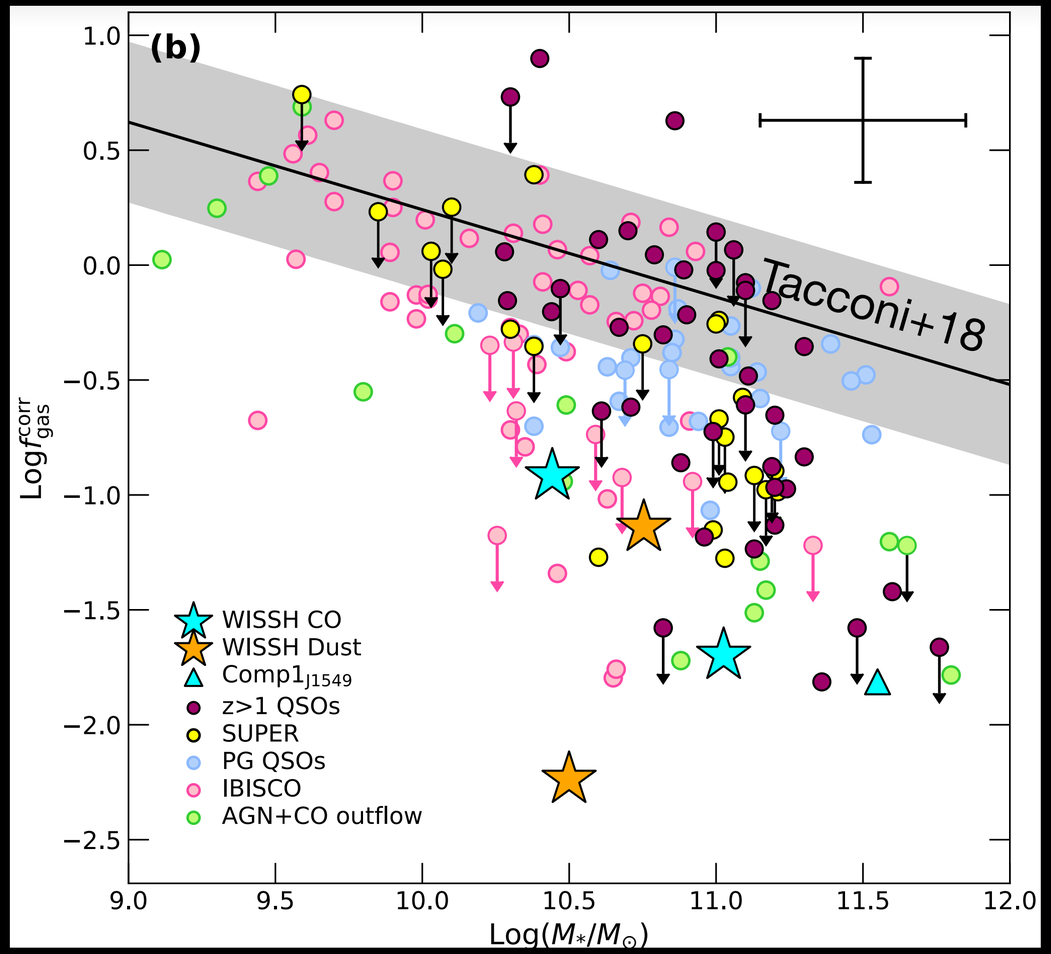
$\log(M_{BH}/M_{Sun})$ ~ 9-10.5

- Extreme dynamical to BH mass ratios **M_{dyn}/M_{BH}~3-10**, 100x smaller than local relation (Jiang+11)
- **$\log M_{dyn}/M_{Sun}$ >11.0** associated with QSO+SMG systems at z~2-4

Luminous QSOs pinpoint high density sites where giant elliptical galaxies assemble

Bischetti+20 arXiv:2009.01112

Molecular gas fraction and feedback from QSO winds



Stellar mass

$M^* = M_{dyn} - M_{gas} - M_{BH}$

Gas fraction

$f_{gas} = M_{gas}/M^*$

- WISSH QSOs show **lower f_{gas} by a factor of 10x - 100x** than star forming galaxies

(after correcting for trends with z and offset from MS, Genzel+15,Tacconi+18)

We interpret this as associated with AGN feedback heating/depleting the molecular gas reservoir in the QSO host galaxy

Bischetti+20 arXiv:2009.01112

Summary and Conclusions

WISSH QSOs sample built to observe AGN feedback at its extreme: these hyper-luminous QSOs show powerful AGN-driven outflows from nuclear to CGM scales

(Bischetti+17,Vietri+18,Bruni+19,Zappacosta+20, Travascio+20)

First systematic (sub-)mm investigation of their host galaxies and environment revealed:

- Concurrent **intense growth of** both **SMBH** and **host galaxy**
- **Growth** is likely **regulated by AGN-feedback**
- Molecular gas will be used up in **few tens of Myr**
- Hyper-luminous QSOs are **progenitors of "red&dead" giant ellipticals**
- **Mergers** significantly contribute to the final mass of the galaxy

all details in Bischetti+20 arXiv:2009.01112