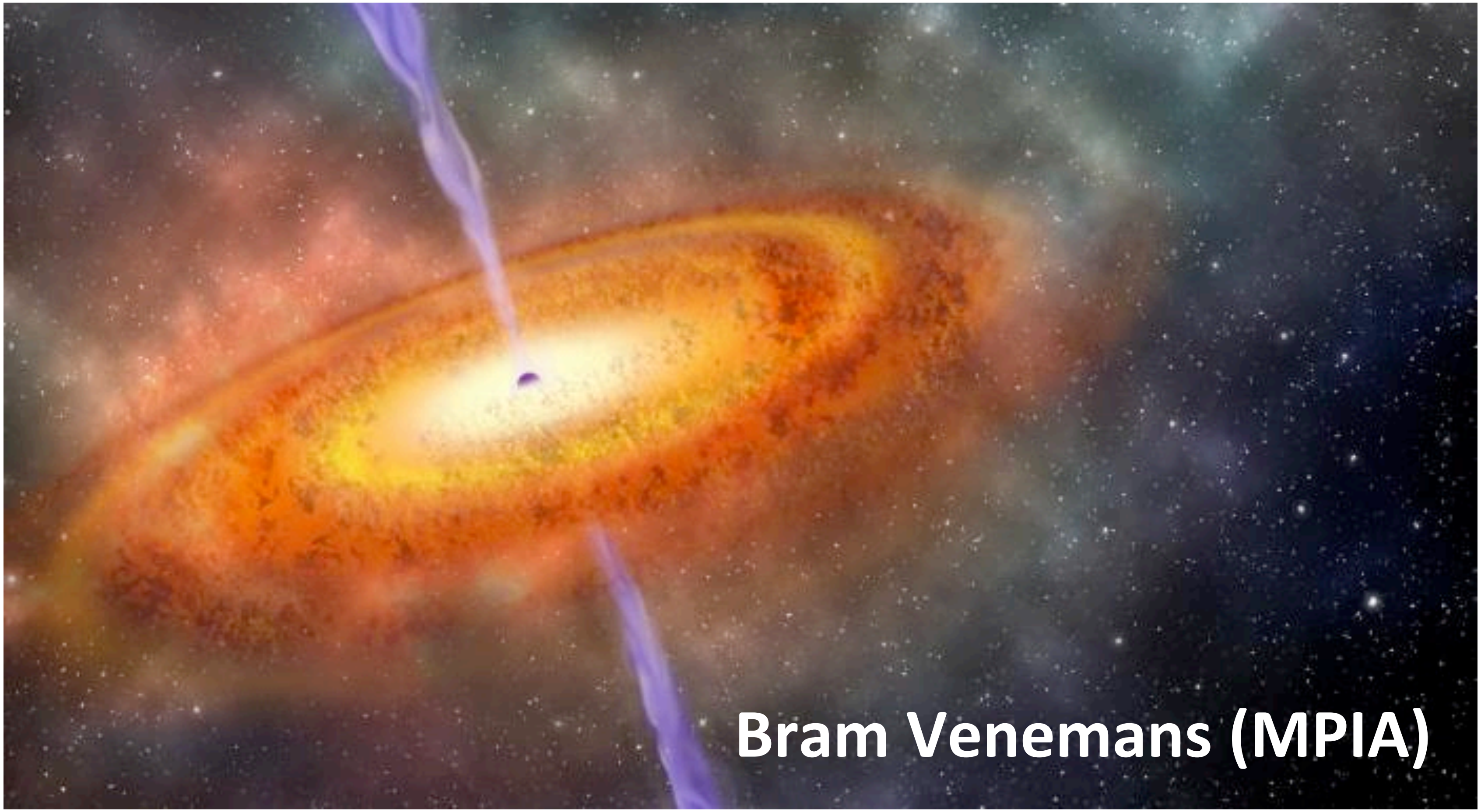
The birth of giants: Quasars and their host galaxies in the early universe



Chiara Mazzucchelli, Fabian Walter, Roberto Decarli, Eduardo Bañados, Ema Farina, Xiaohui Fan, Chris Carilli, Ran Wang, ...

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- Bright sources: measure properties of the IGM

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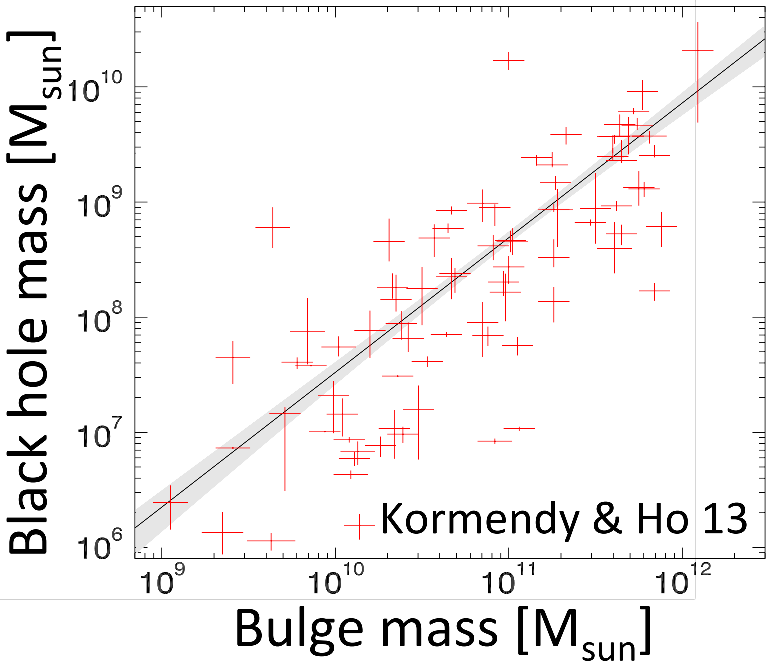

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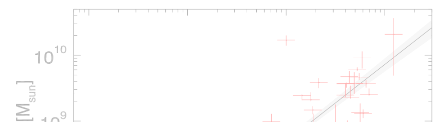
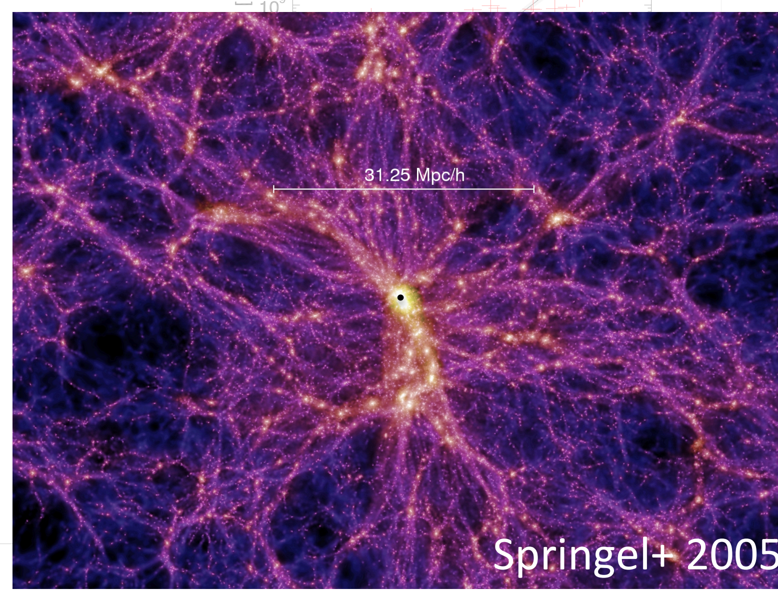
- Bright sources: measure properties of the IGM
- Constrain supermassive black hole formation models
- Properties of the host galaxies
  - coevolution?
  - AGN feedback?
- The environment of quasars





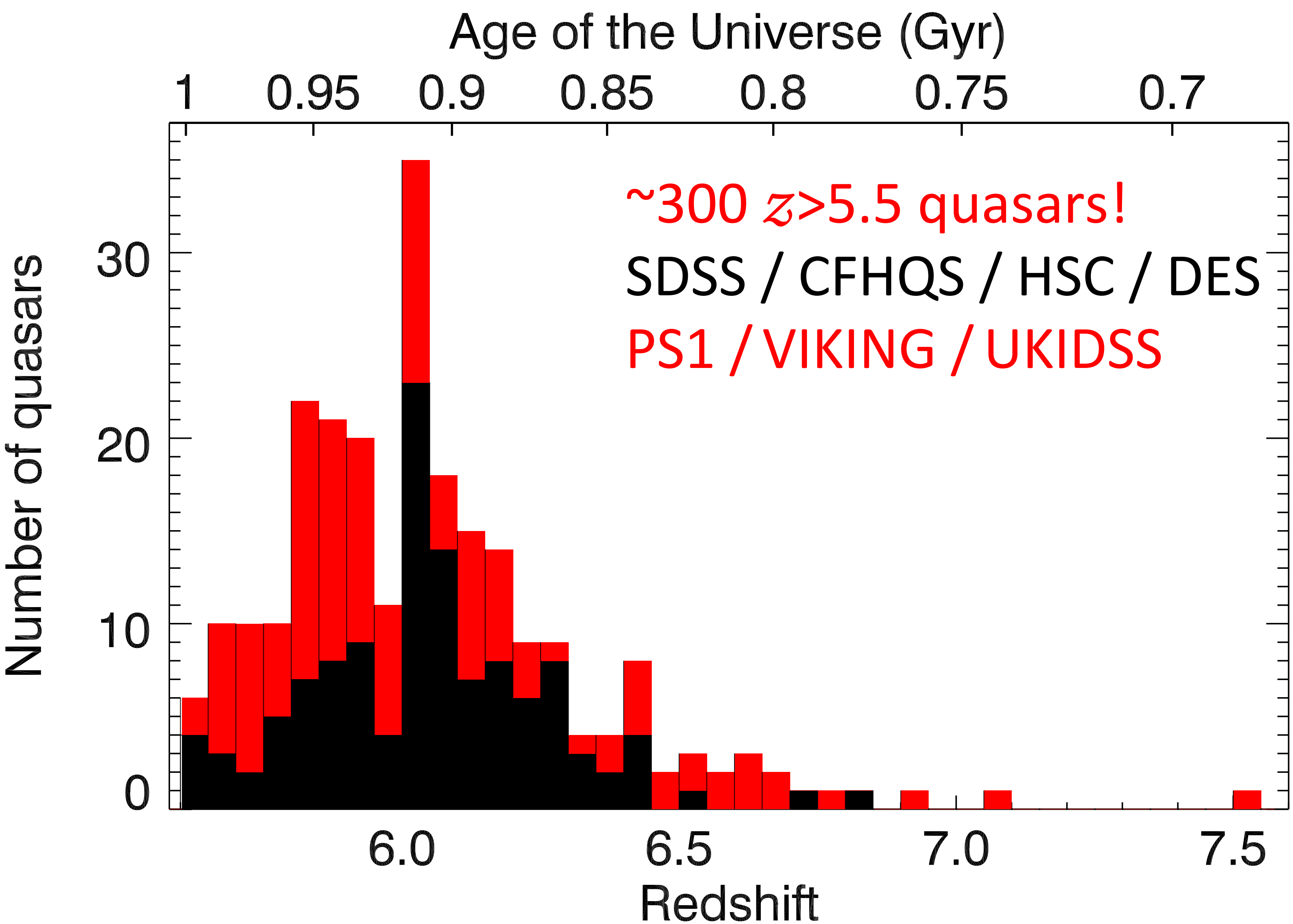
Springel+ 2005

The search for the most distant quasars

Extremely rare objects:

- < 1 quasar per Gpc^3 at z=6, or < 1 per 100 deg^2
- Requirement: very large area, multi-colour surveys
- Challenge: find the quasars among the billions of sources

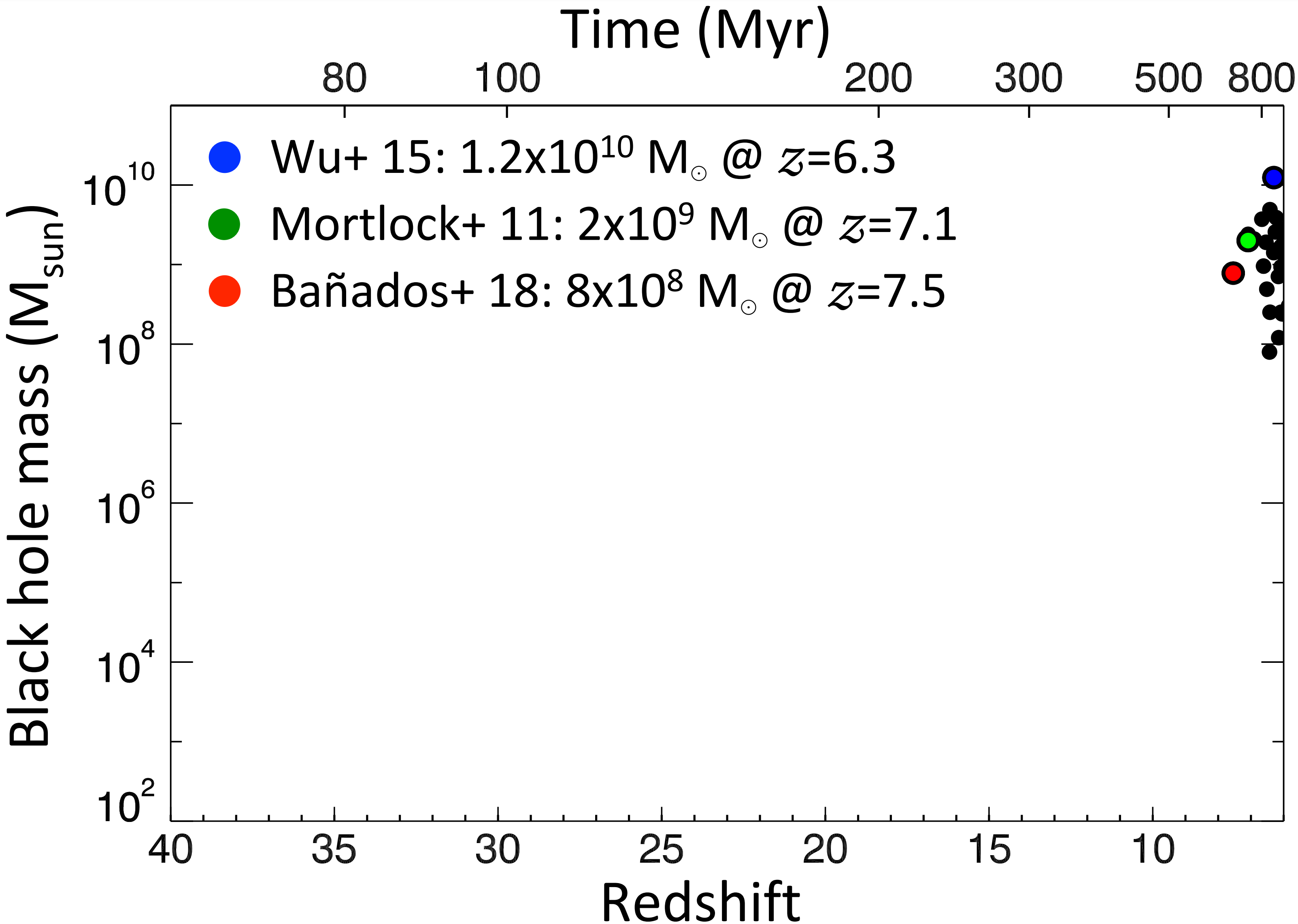
Progress in distant quasar searches



Mortlock+ 11
Morganson+ 12
BV+ 07,13,15ab
Bañados, BV+ 14, 15ab,16,18
Mazzucchelli+ 17

Fan+ 00-06
Willott+ 06-10
Jiang+ 08-09,15
Wu+ 15
Matsuoka+ 16,17
Reed+ 17

Constraints on early black hole growth



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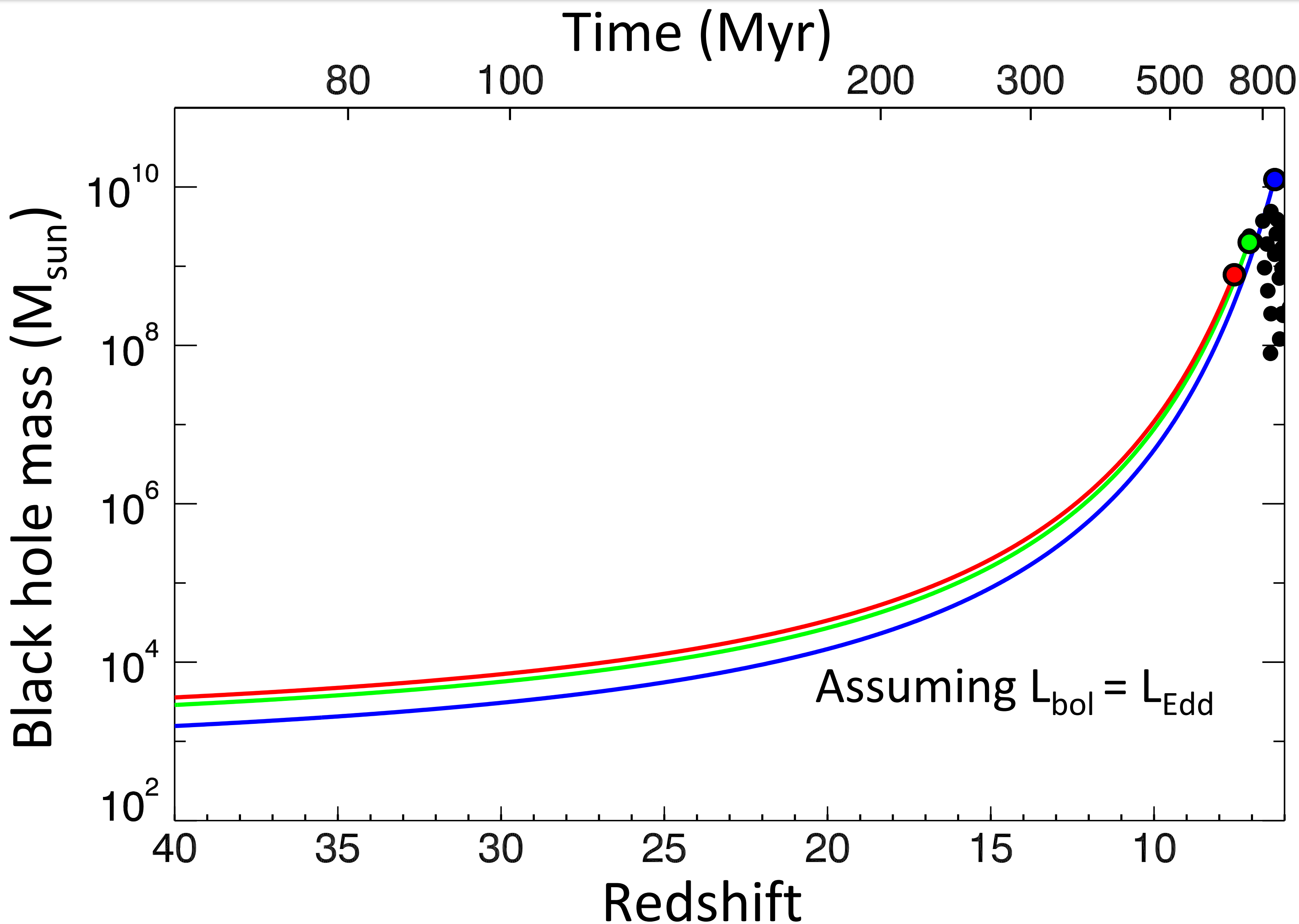

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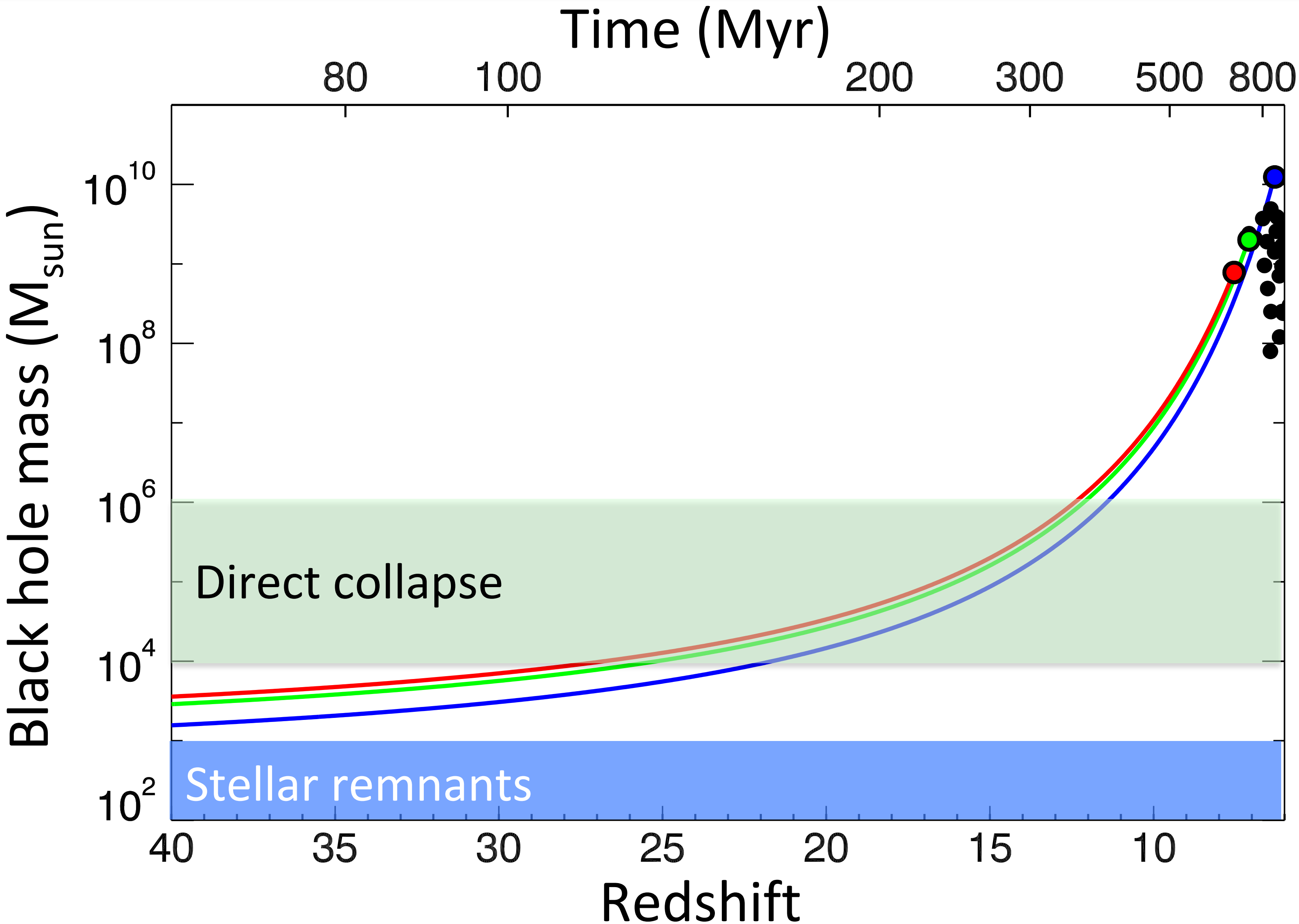
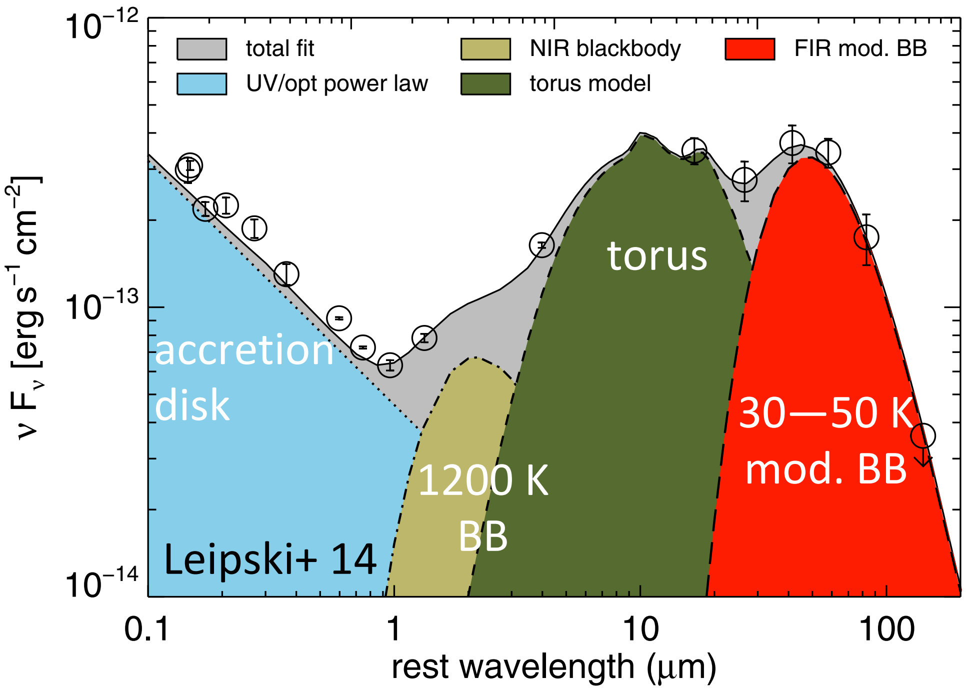


The host galaxies of distant quasars

The galaxy hosting the accreting black hole:
→ detectable in the far-infrared
(cold dust and atomic/molecular emission lines)

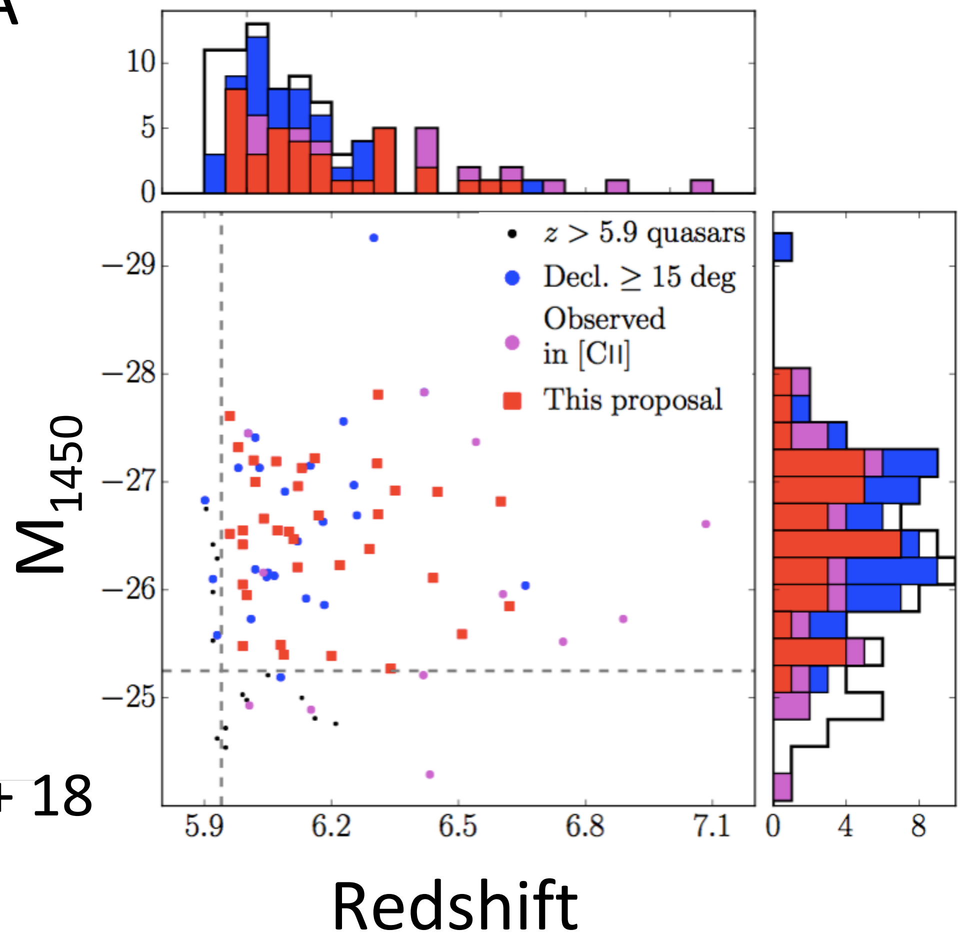


Spectral energy distribution

- UV/optical: accretion disk
- mid-infrared: hot dust and torus
- far-infrared: cold dust → host galaxy

ALMA Cycle 3: quasar host survey

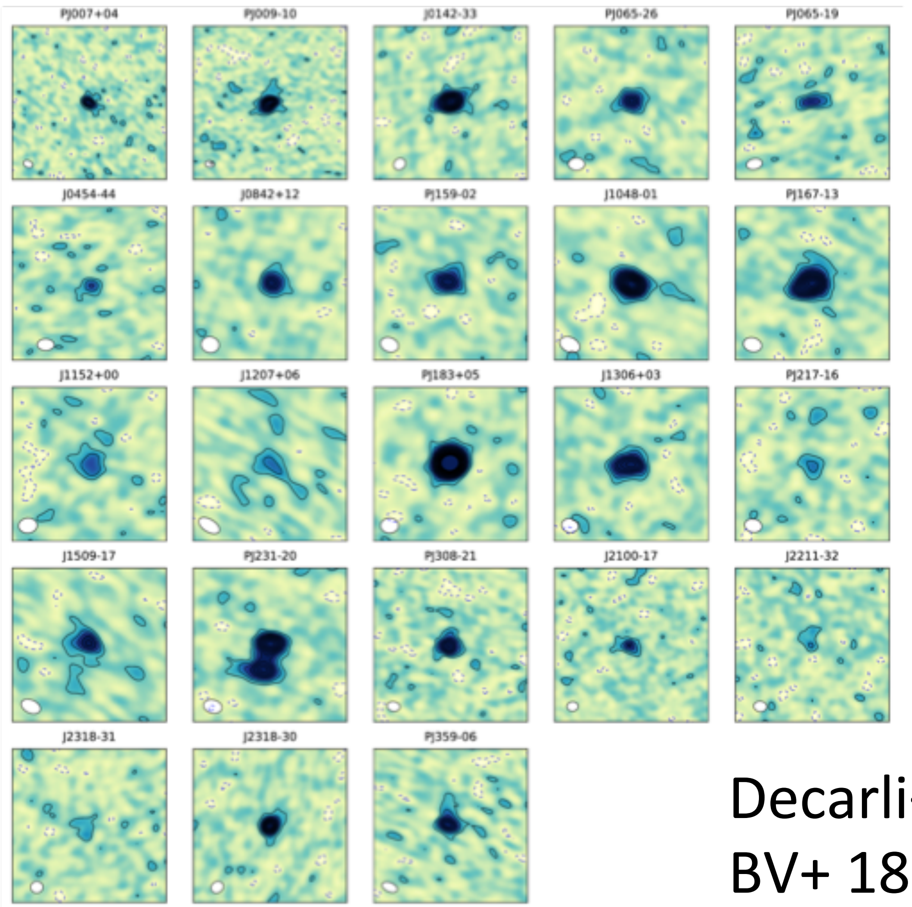
- Blind detection experiment, targeting all bright $z > 6$ quasars visible from ALMA
- 8 min on source
- Data for 27/36 targets
- Combined with literature



Decarli+ 18
BV+ 18

ALMA Cycle 3: quasar host survey

- 80% detection rate in [CII]
- 100% in continuum



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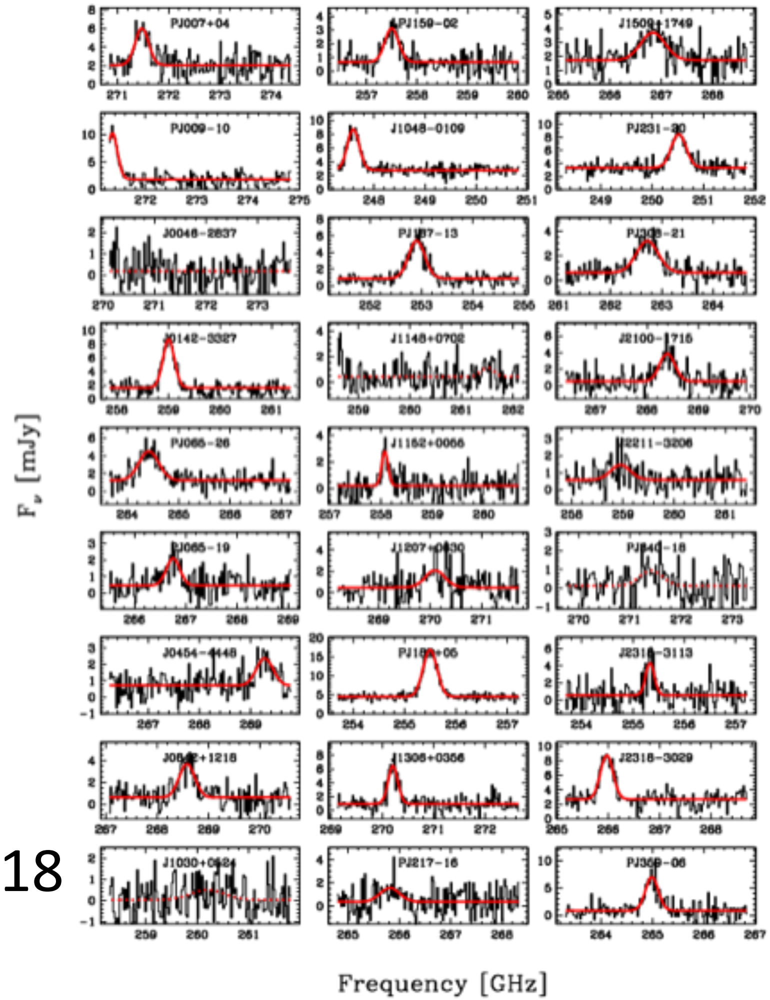
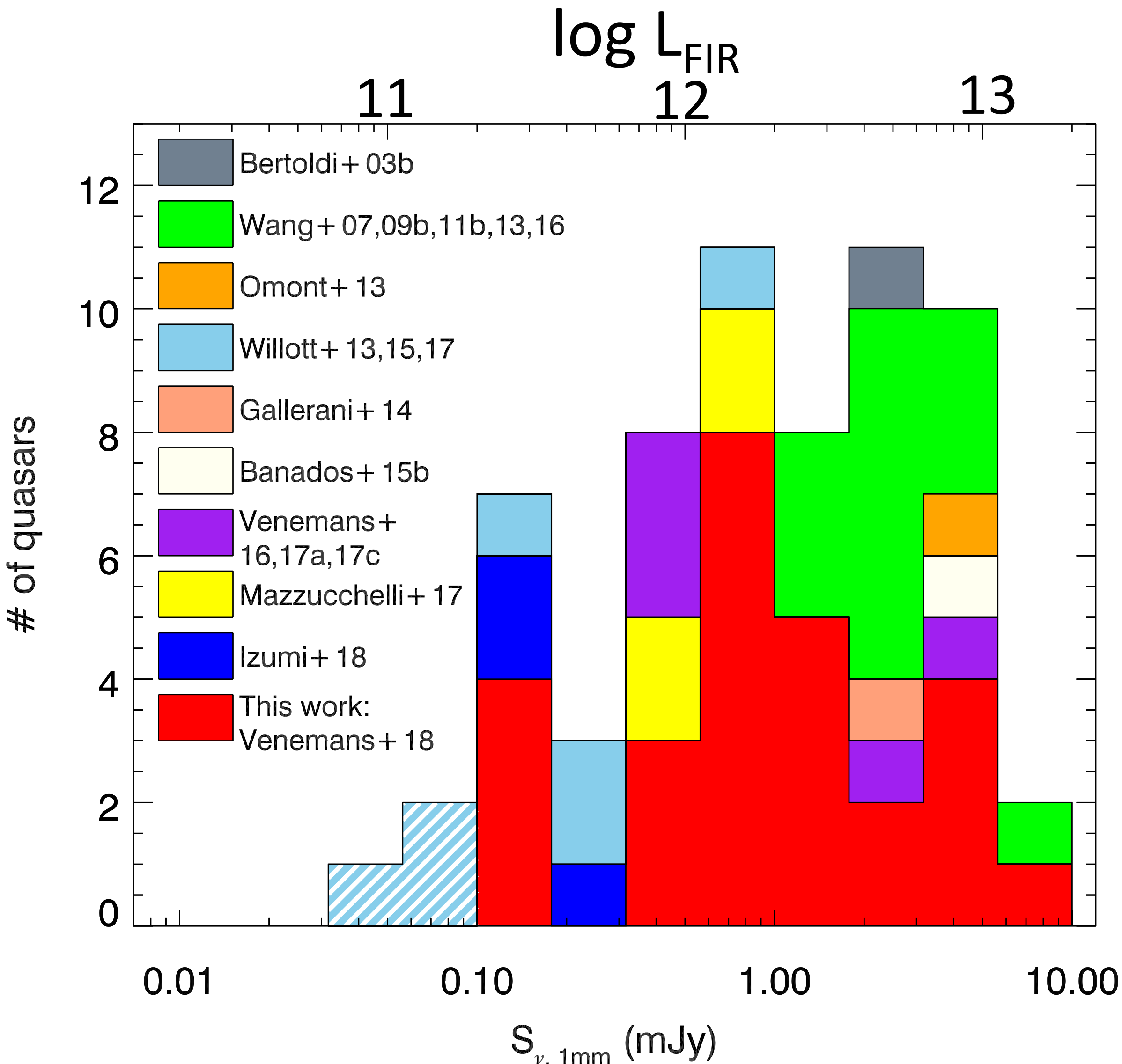


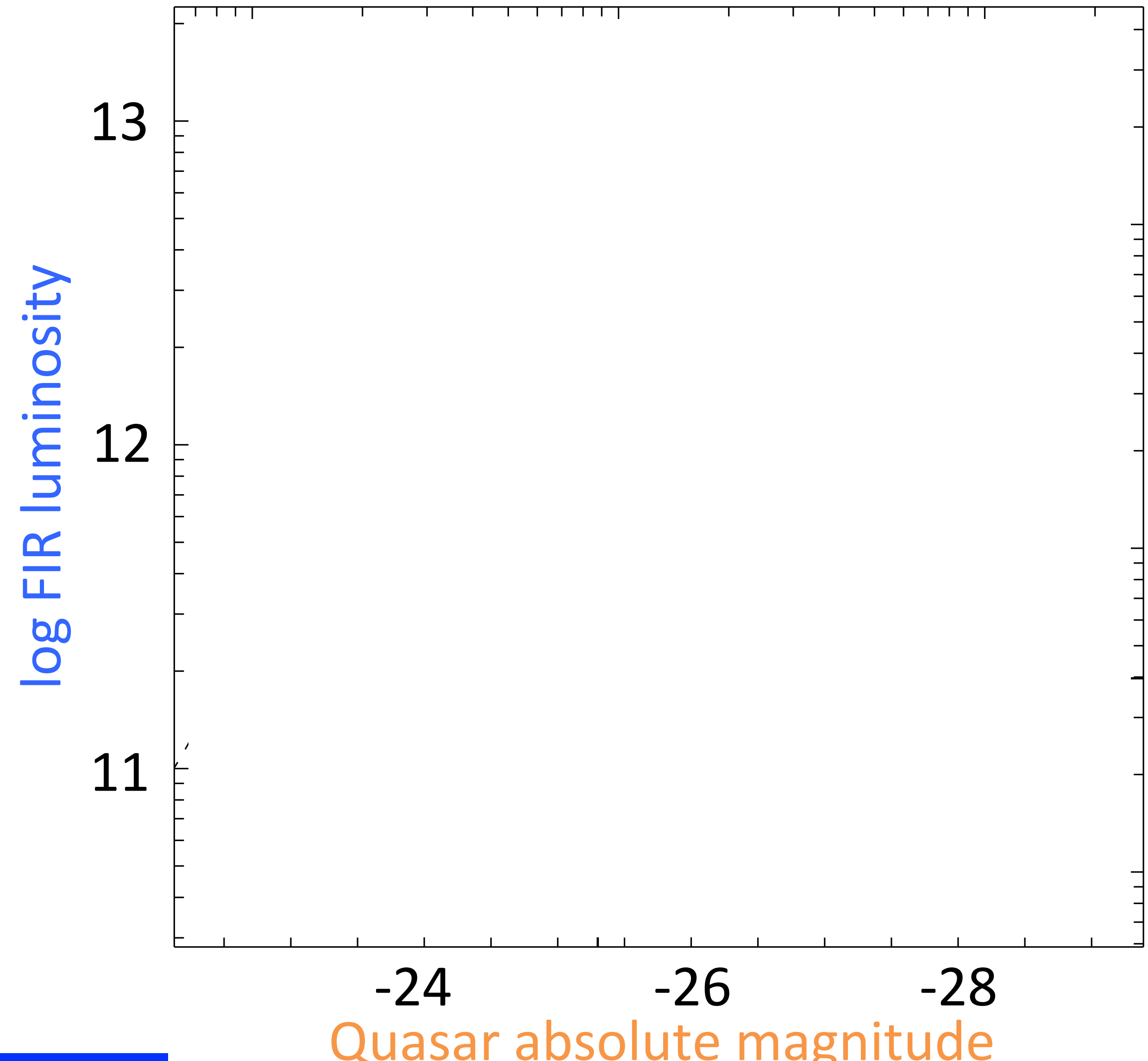
Dust emission in high redshift quasar hosts



A very large fraction of z>6 quasar hosts detected in the FIR

Decarli+ 18
BV+ 18

Dust emission vs. quasar luminosity



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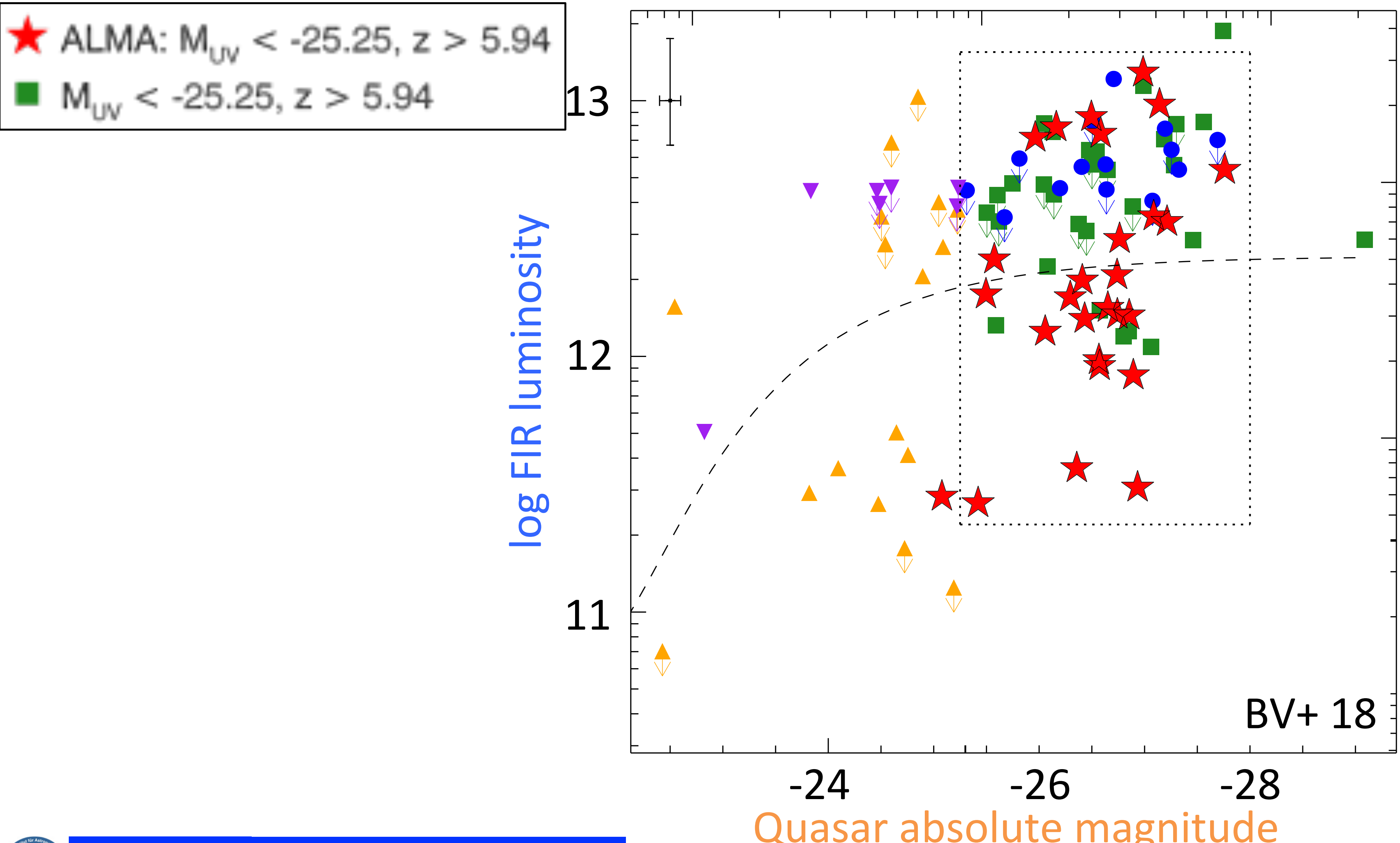
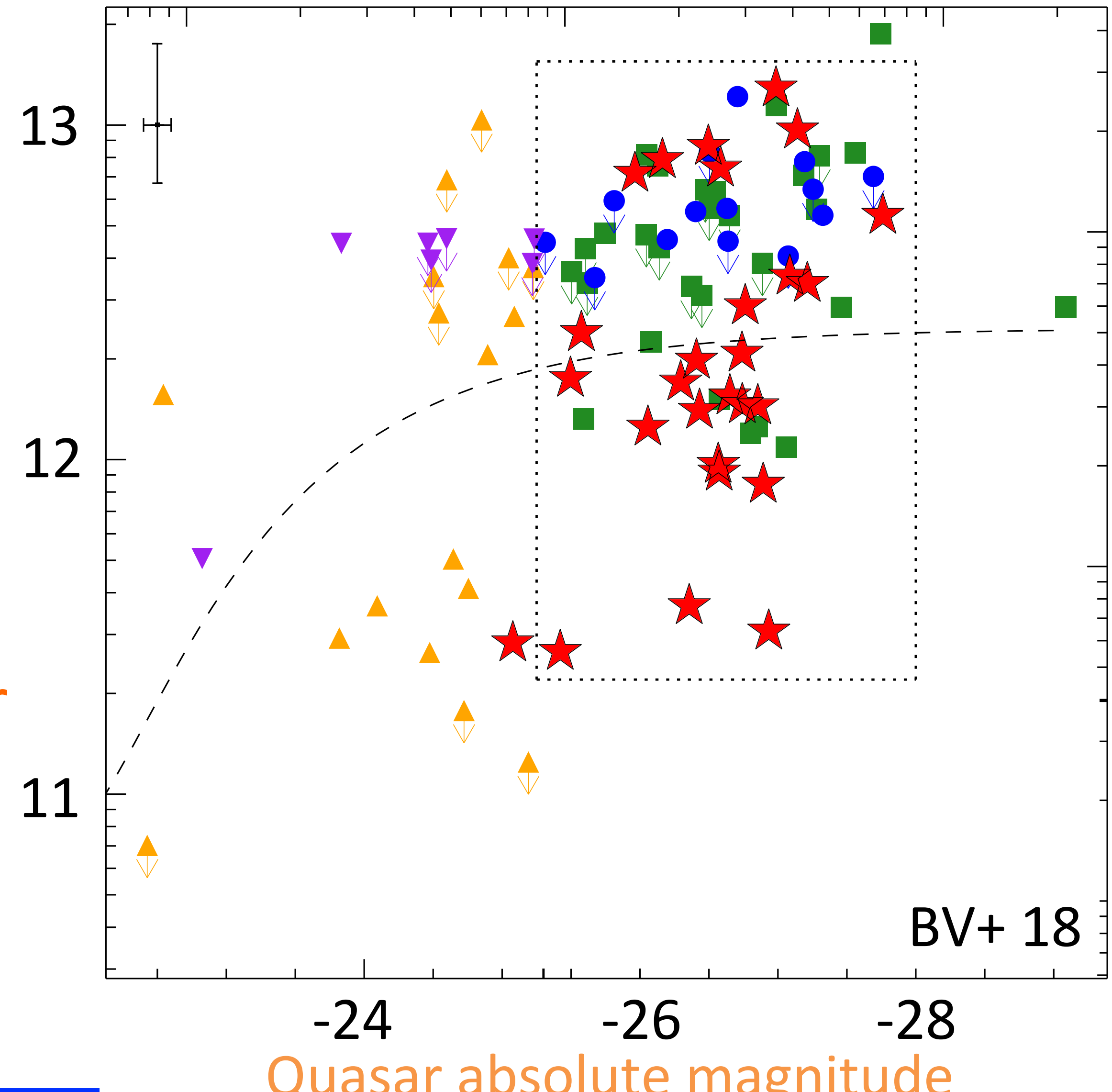


Dust emission vs. quasar luminosity

- Large spread in FIR luminosity at a fixed quasar brightness

and

- Large spread in quasar brightness at fixed FIR luminosity



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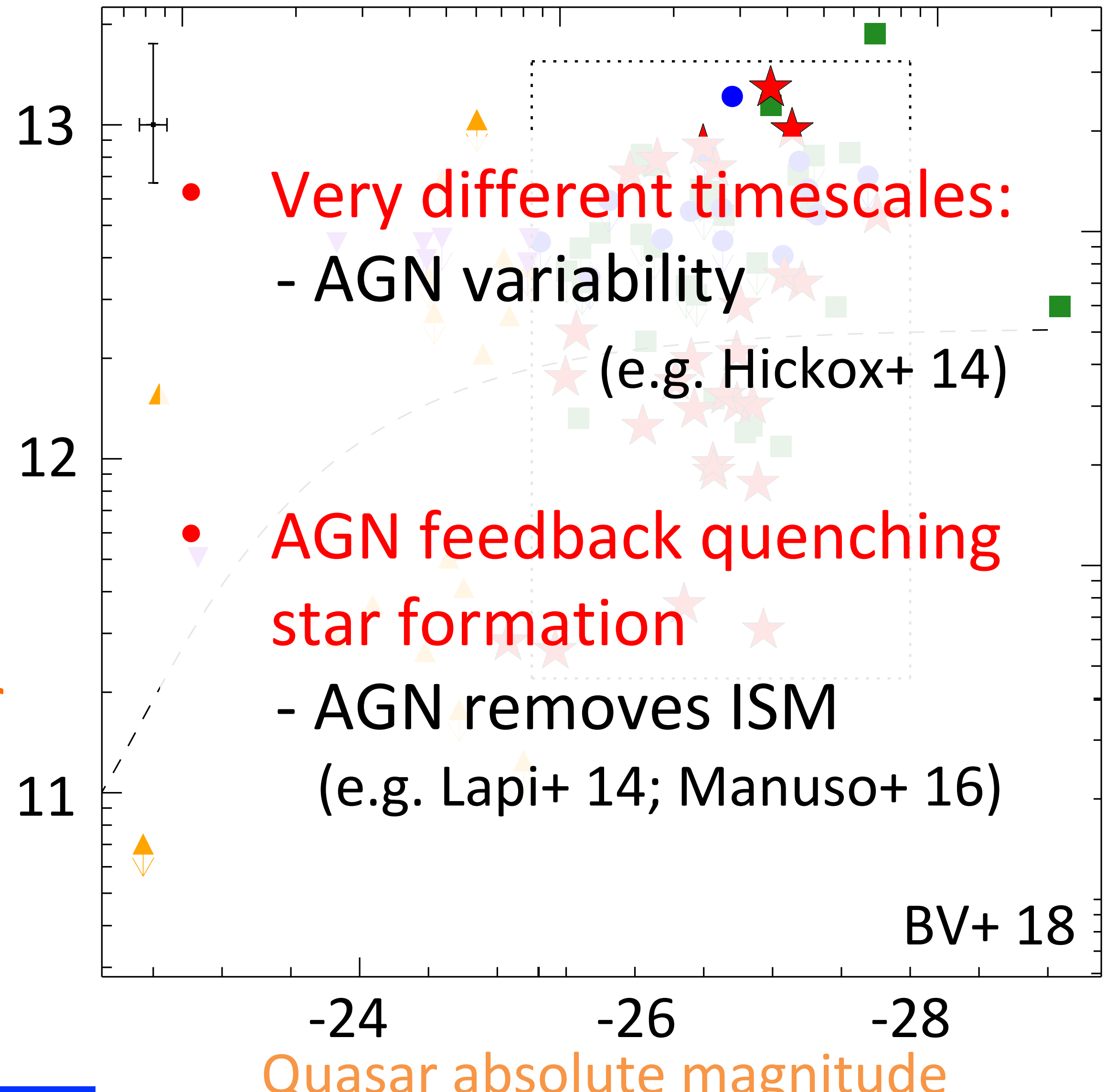
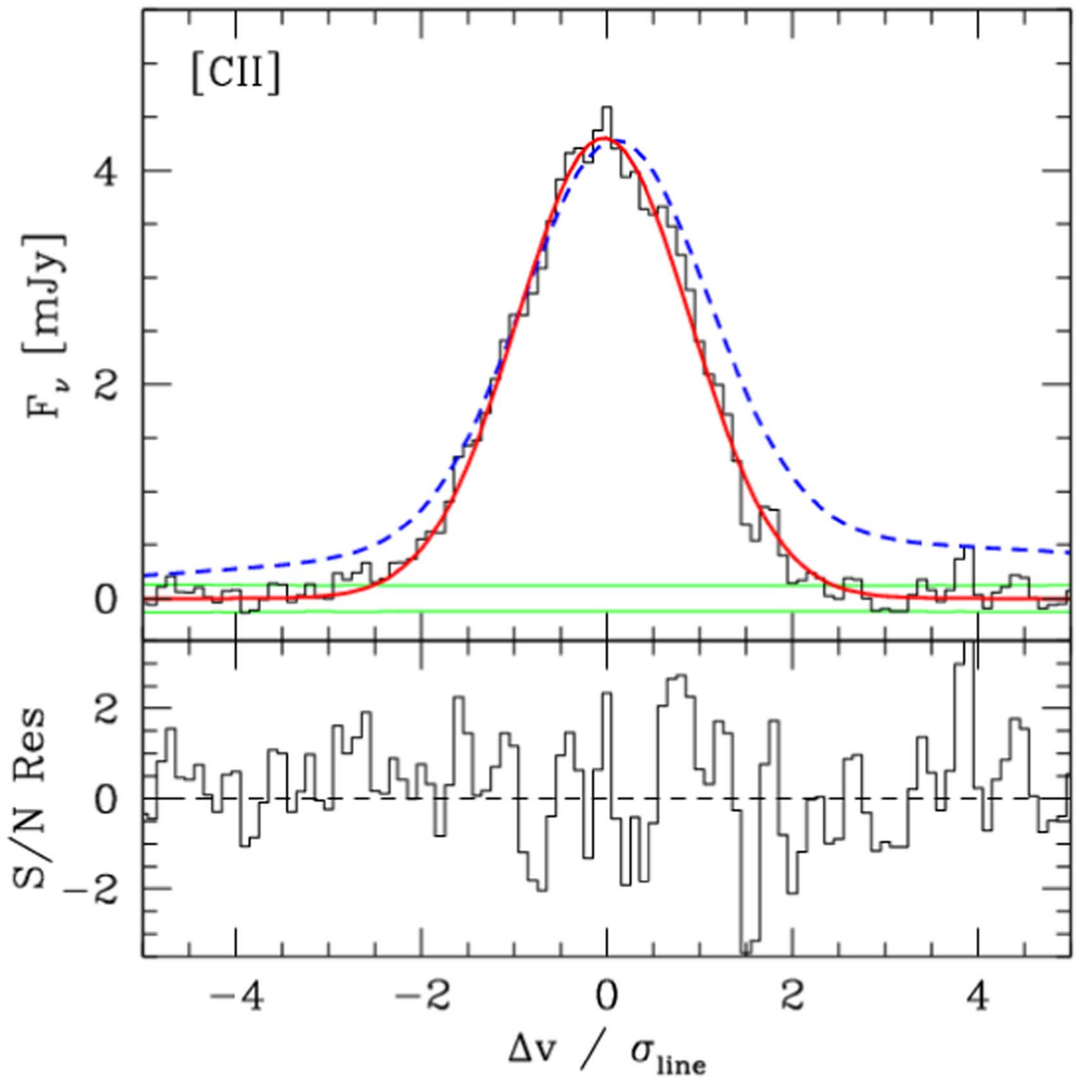


- Very different timescales:
  - AGN variability (e.g. Hickox+ 14)
- AGN feedback quenching star formation
  - AGN removes ISM (e.g. Lapi+ 14; Manuso+ 16)

AGN feedback at high redshift?



No evidence for high velocity outflows in stacked [CII] spectrum...

But see Bischetti's talk

Decarli+ 18

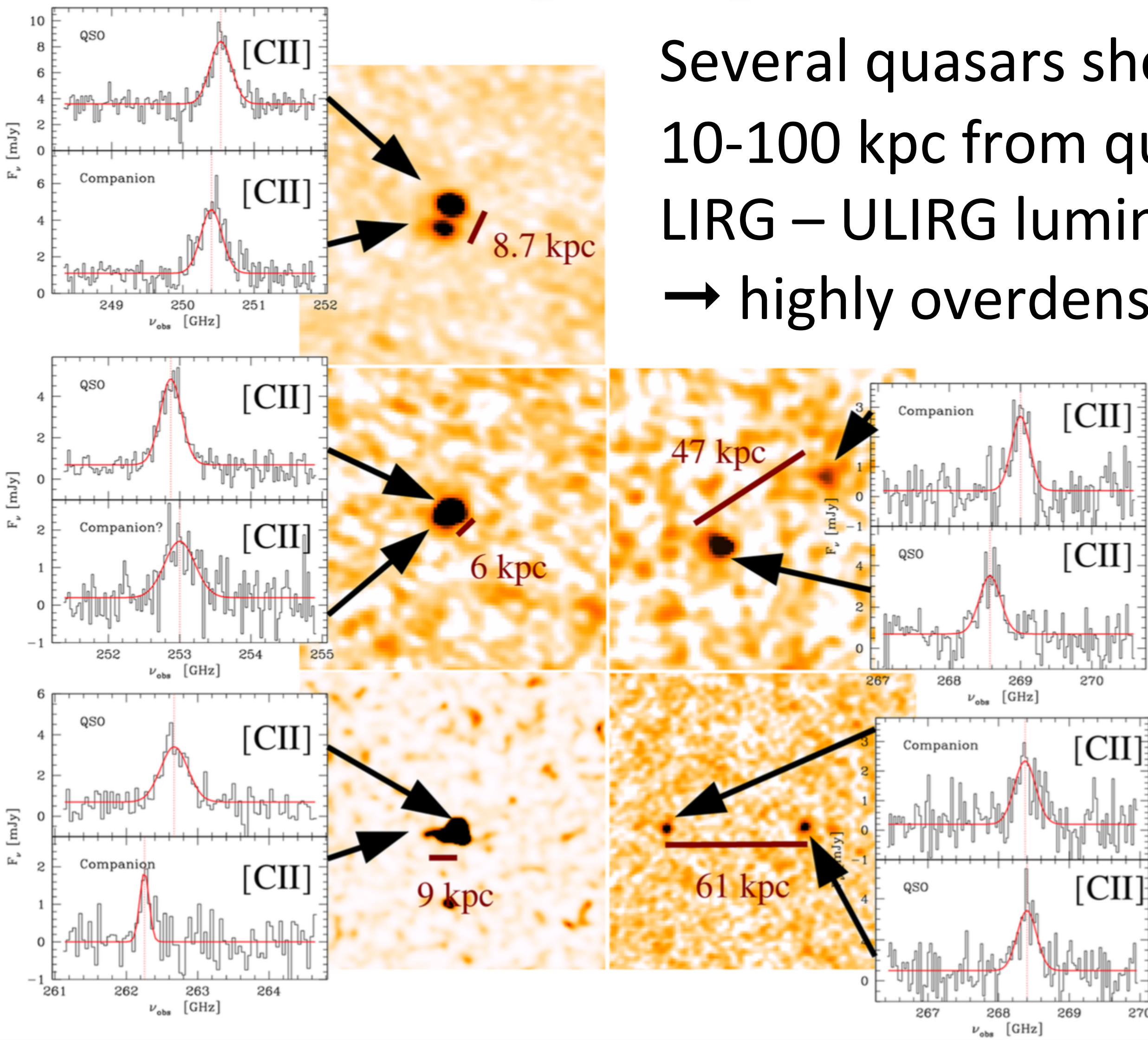
ALMA Cycle 3: [C II] emitting companions

Several quasars show companions

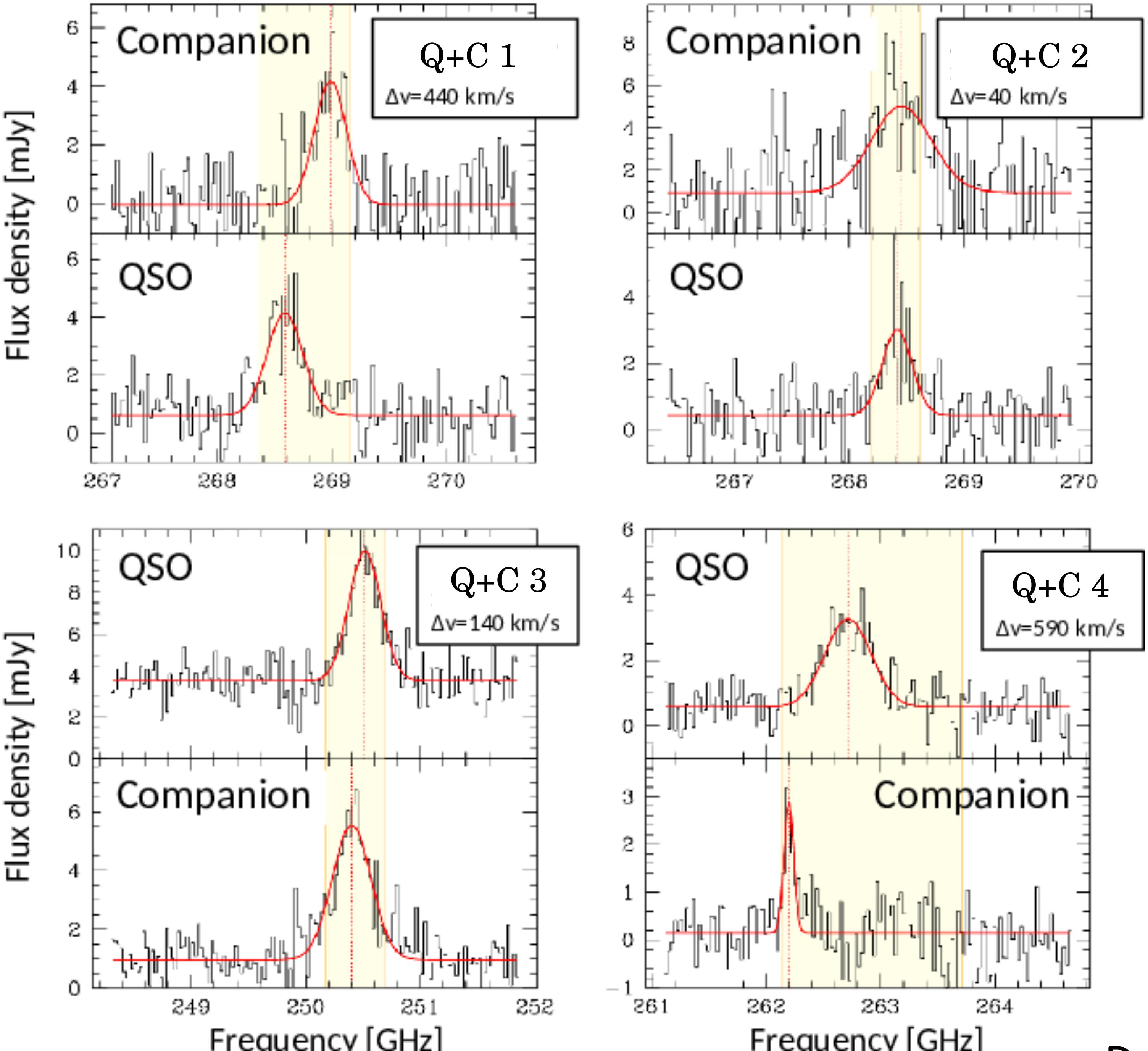
10-100 kpc from quasar, same z

LIRG – ULIRG luminosities

→ highly overdense regions

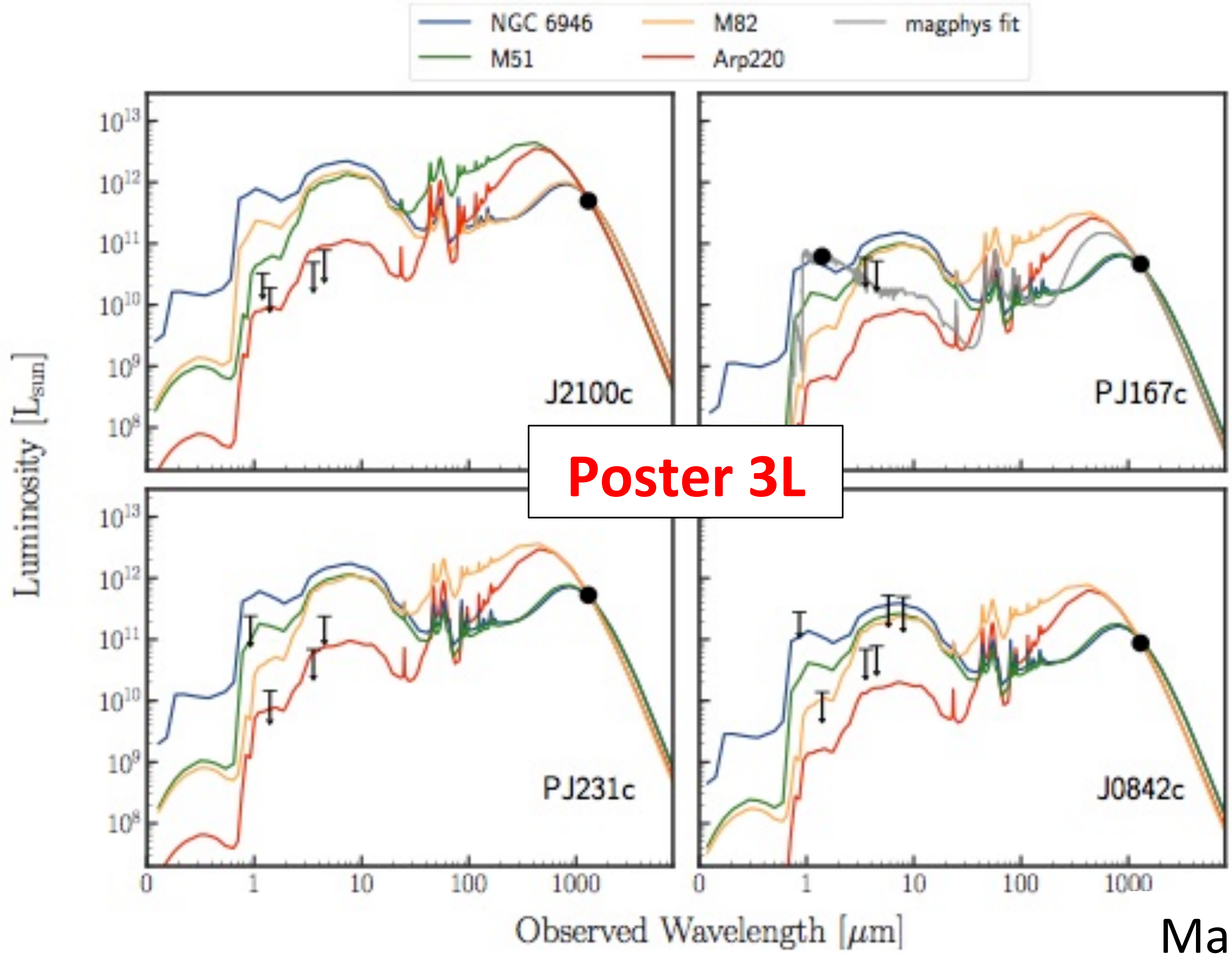


Decarli+17


Companion
Q+C 1
Δv=440 km/s
QSO
Companion
Q+C 2
Δv=40 km/s
QSO
QSO
Q+C 3
Δv=140 km/s
Companion
QSO
Q+C 4
Δv=590 km/s
Companion
Flux density [mJy]
Frequency [GHz]

Decarli+ 17

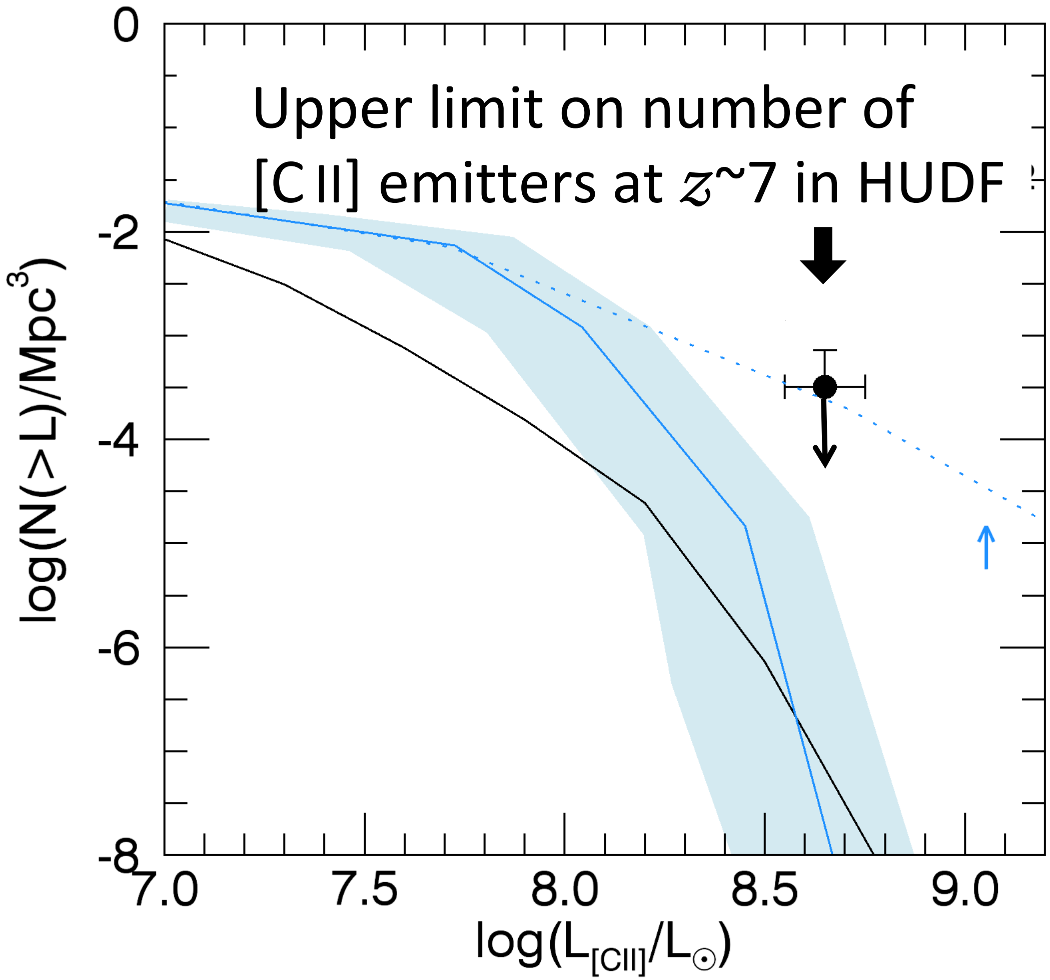
Companions: very dusty starburst galaxies



Poster 3L

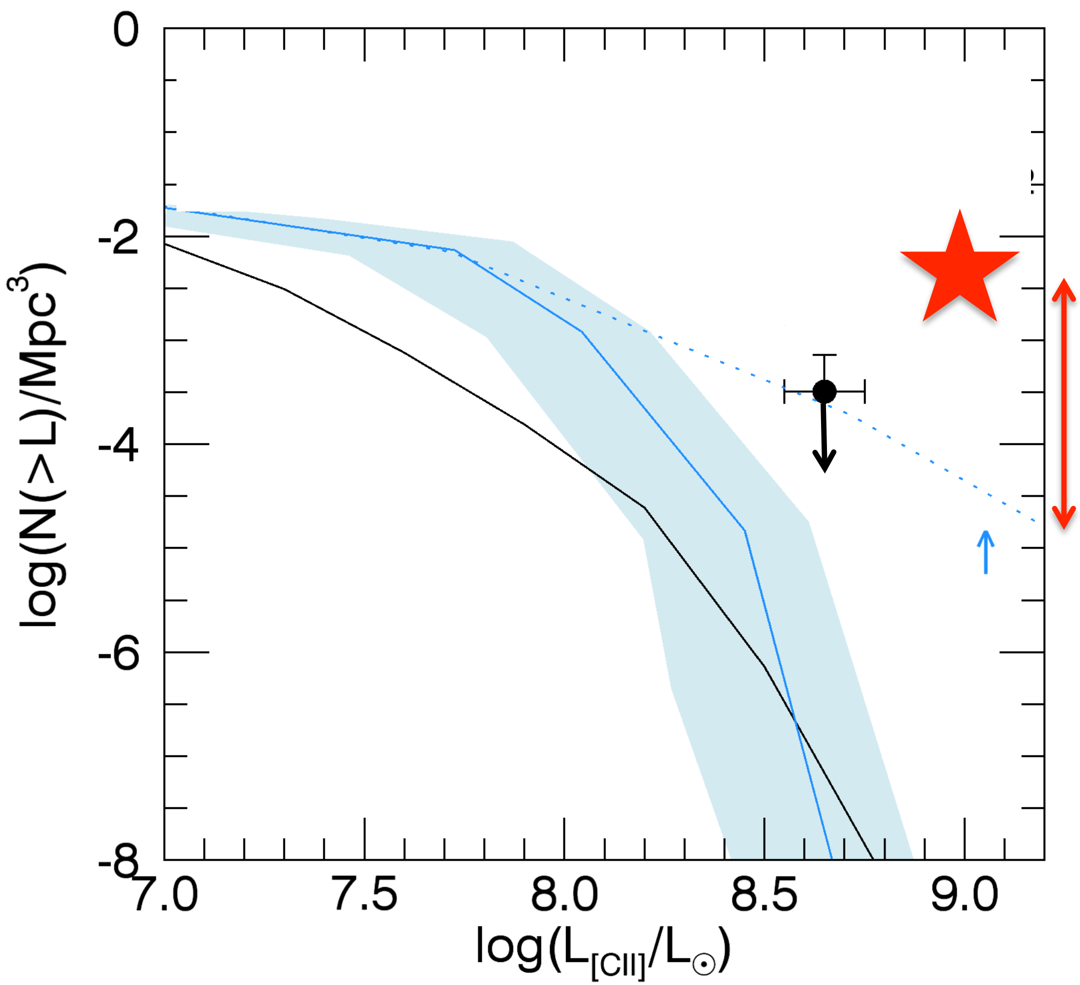
Mazzucchelli+ 18

Companion galaxies near distant quasars



Aravena+ 2016

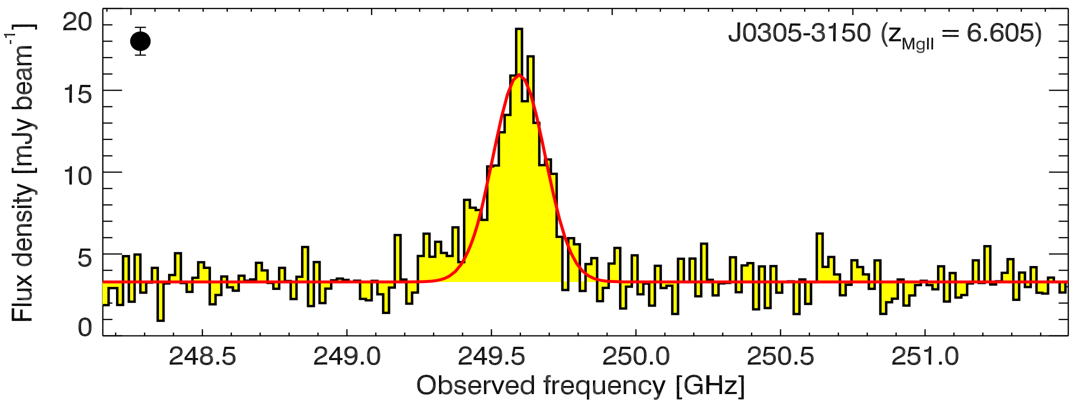
Companion galaxies near distant quasars

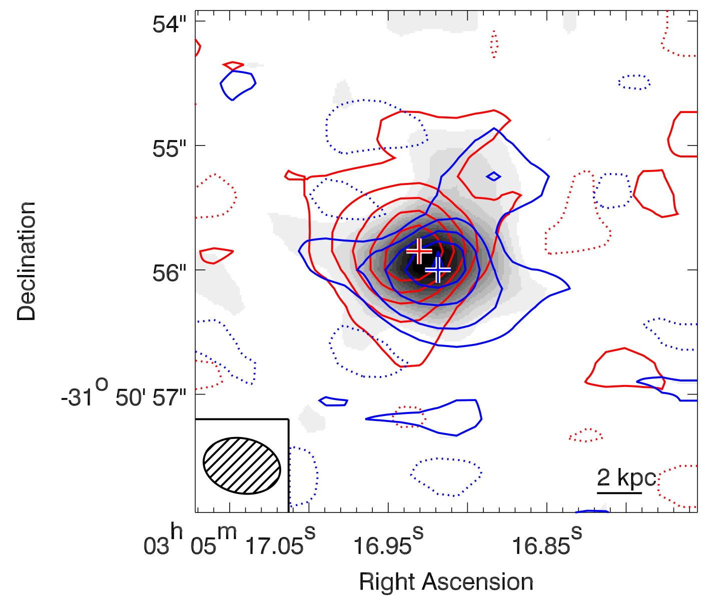


factor >100
higher than field

Properties of the distant quasar hosts

Dynamical mass of the host galaxies





- measure line width and size
- assume [CII] rotating disk

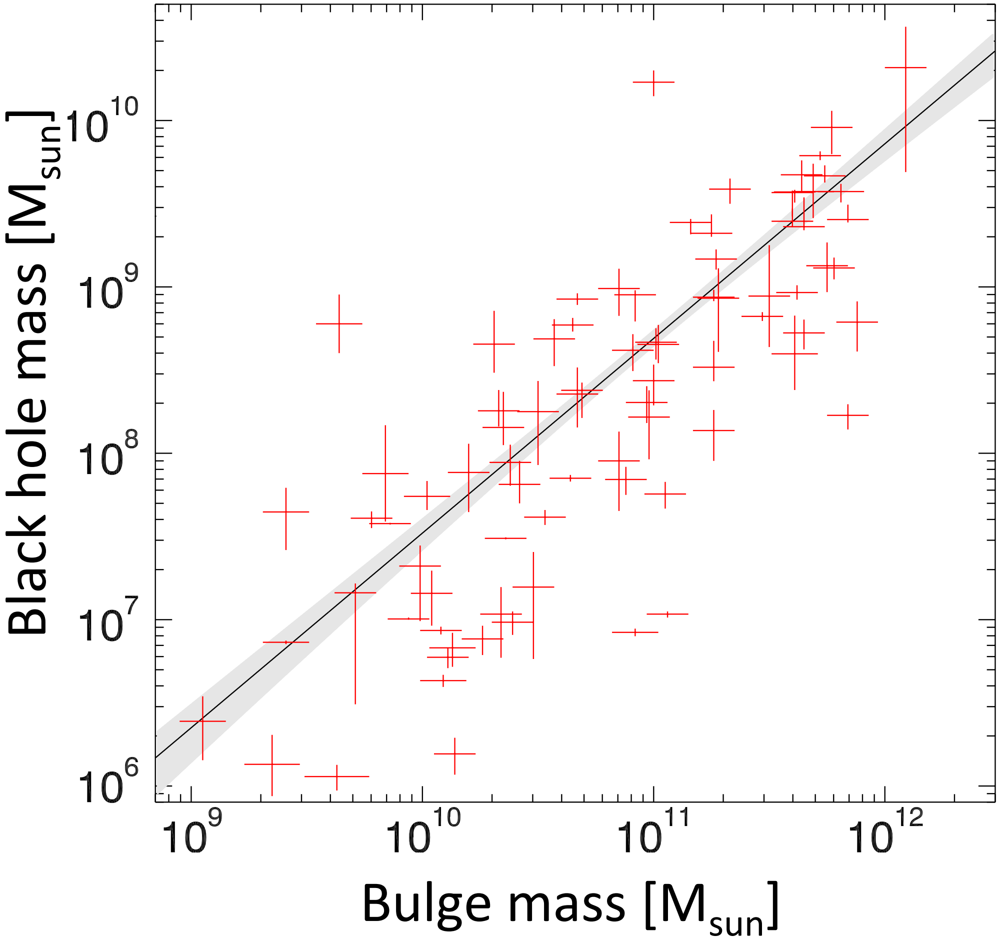
  → derive dynamical mass

- masses of $10^{10} – 10^{11}$ $M_\odot$

See, e.g., Wang+ 13, 16; Willott+ 13, 15, 17; BV+ 16; Izumi+ 18

Properties of the distant quasar hosts

Local black hole–bulge mass relation



Kormendy & Ho 2013

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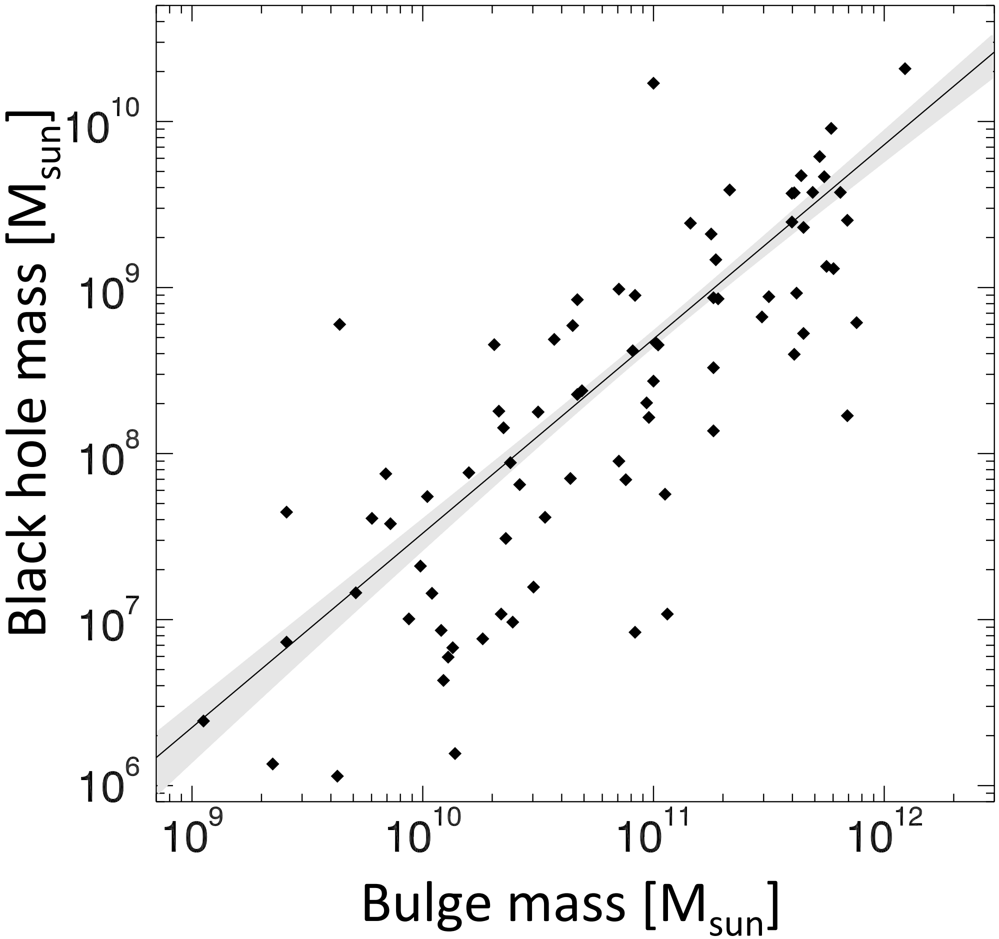

Kormendy & Ho 2013

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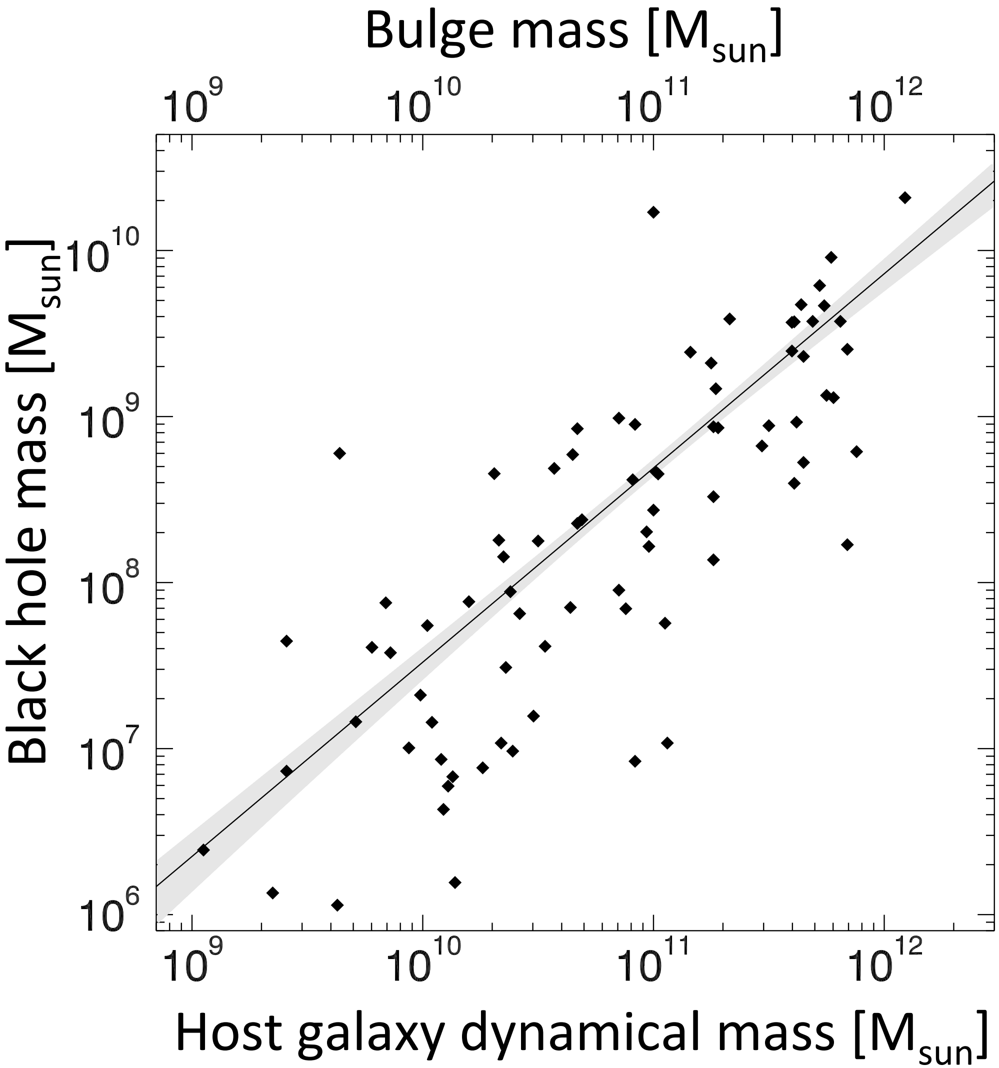

$z > 6$ quasar hosts (Walter+ 09; Willott+ 13,15,17; Wang+ 13,16; BV+ 12,16,17a)

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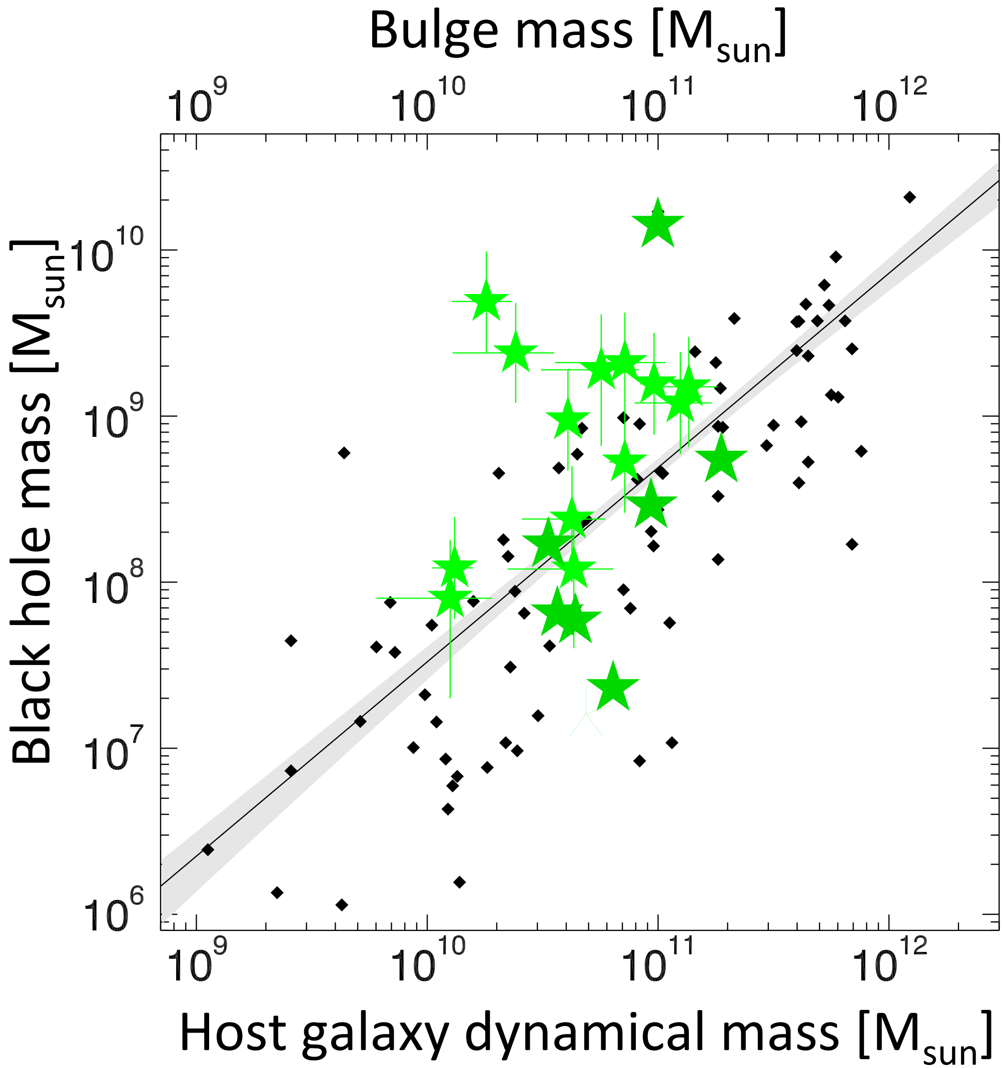

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Lower mass black holes already on local relation?

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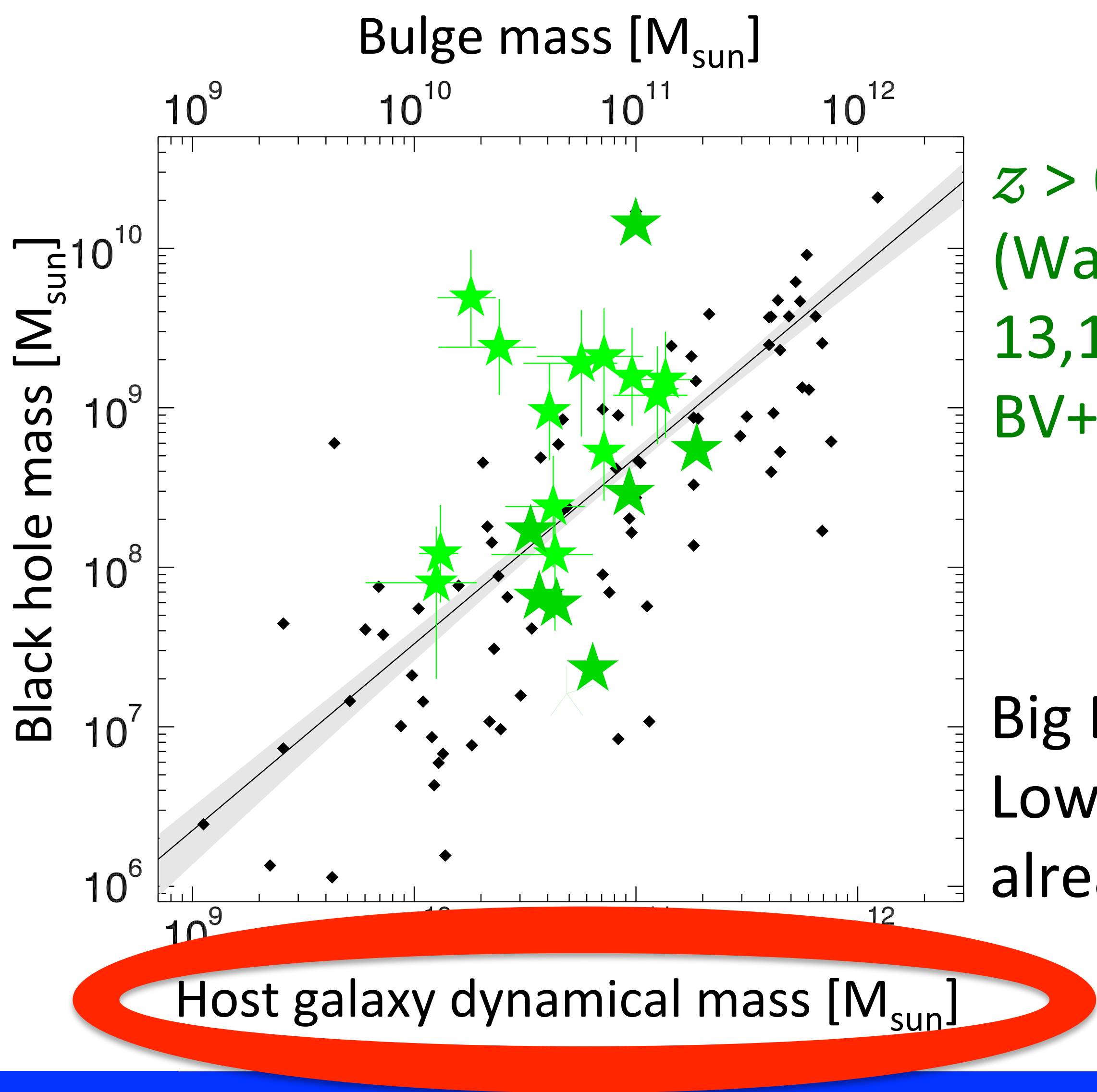

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- Many assumption to compute dynamical mass

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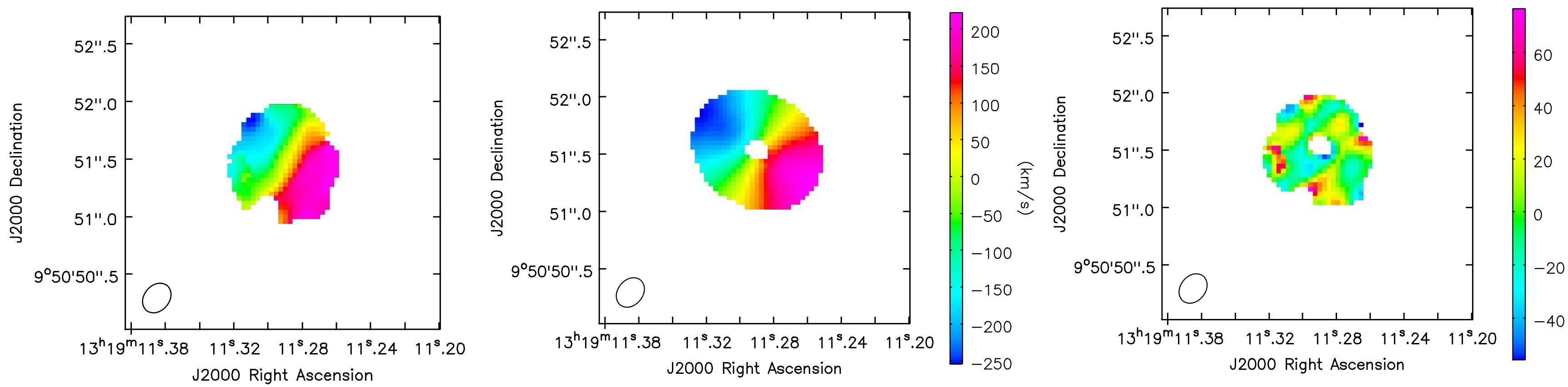
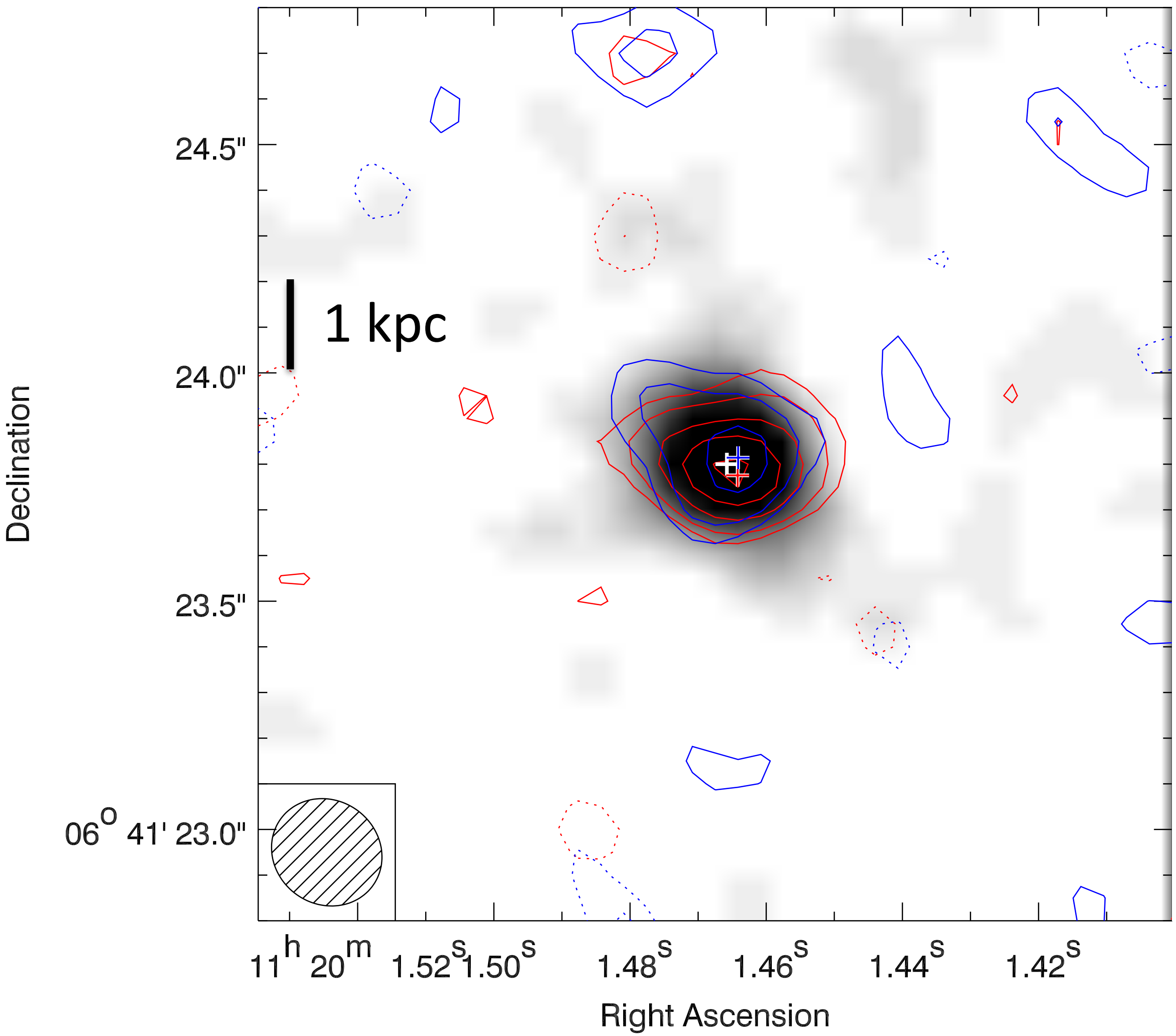


e.g. Walter+ 04,09; Shao+ 17

Higher resolution imaging:

- Rotating disk assumption valid

Host of z=7.1 quasar: no rotation!



Kpc resolution imaging does not show evidence for ordered gas motions

Mass in center dominated by molecular gas

BV+ 17a

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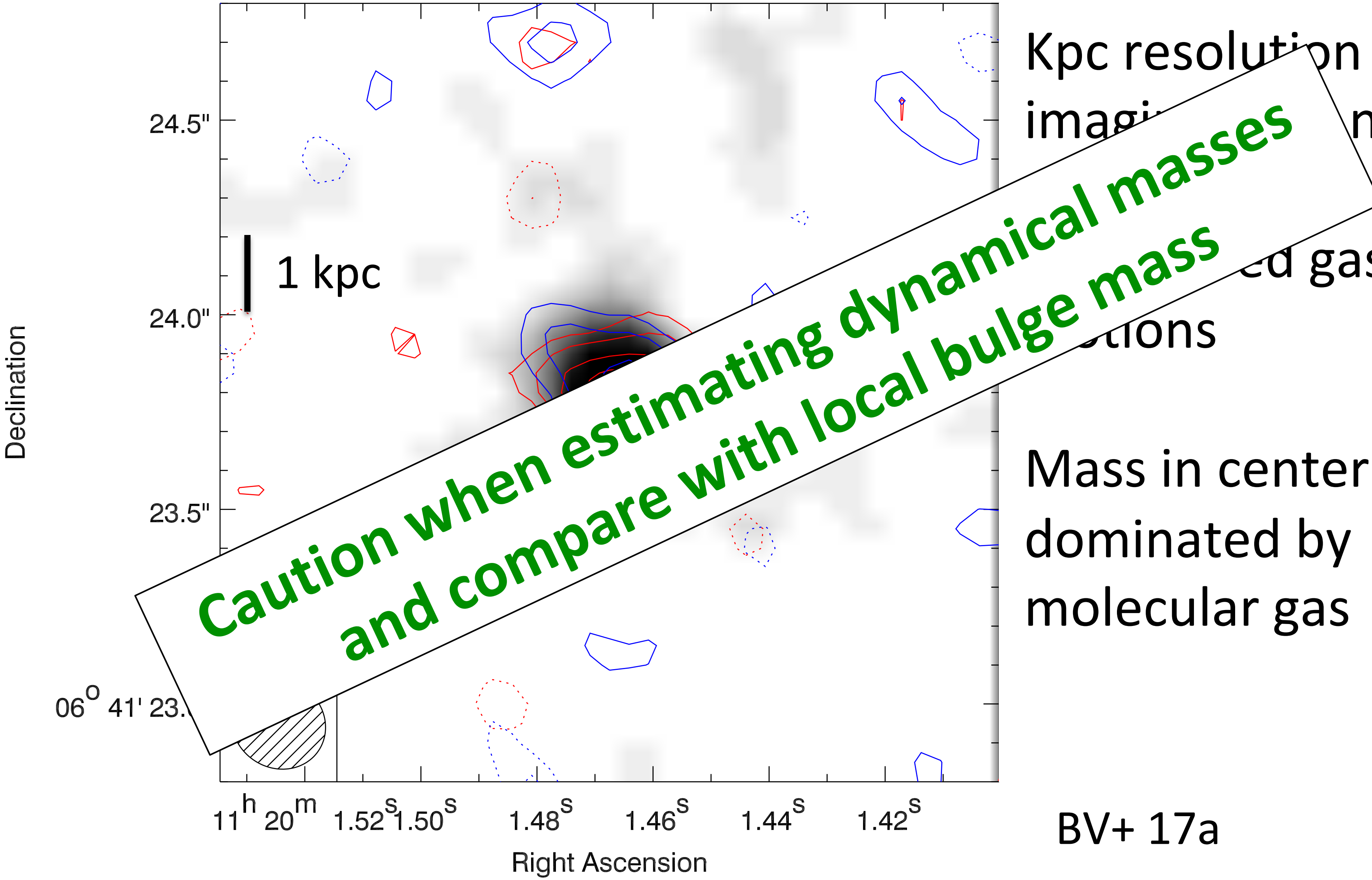

Kpc resolution imagi… not … …ed gas …tions

Mass in center dominated by molecular gas

BV+ 17a

Summary

- Host galaxies of the most distant quasars show a wide range of properties
- A fraction of (but not all) quasars show nearby companions / merger signatures
- Most massive black holes are above local M-σ relation, but estimating stellar masses are difficult