Fast outflows and star formation quenching in quasar host galaxies

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Marconi A., Maiolino R., Cresci G., Brusa M., Williams R., Fiore F., Cicone C., Ohad S., Netzer H., Schneider R., Balmaverde B., Nagao T., La Franca F., Comastri A, Mannucci F., Risaliti G., Piconcelli E., Feruglio C., Cano-Diaz M., Mainieri V., Testi L., Sani E., Ferrara A., Gallerani S.

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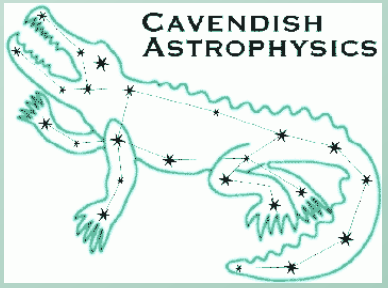
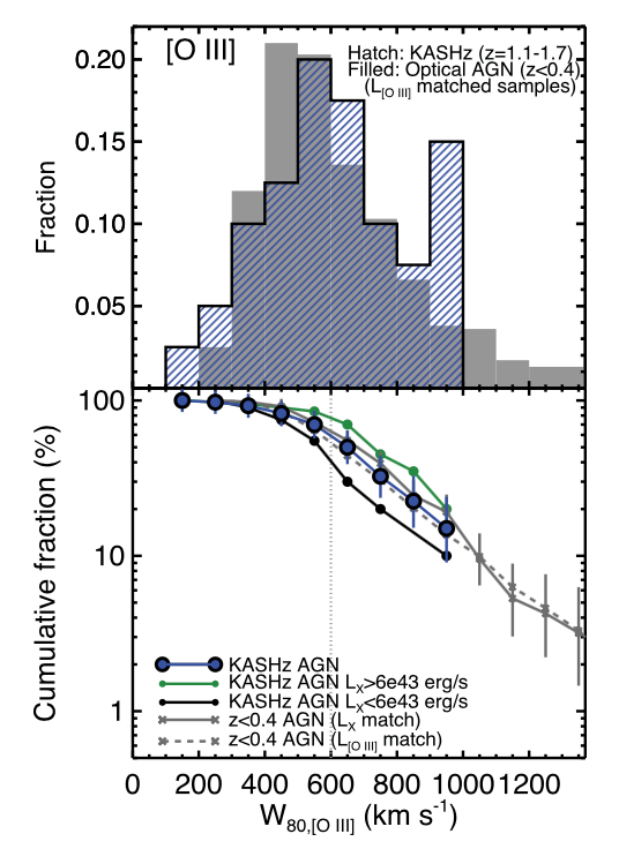


Ionised Outflows

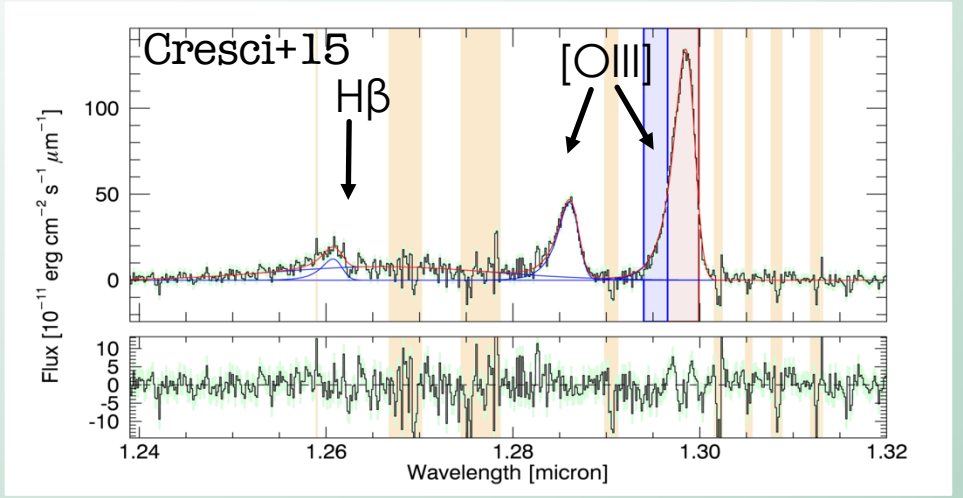
[OIII]5007
Tracer of Ionised Outflows

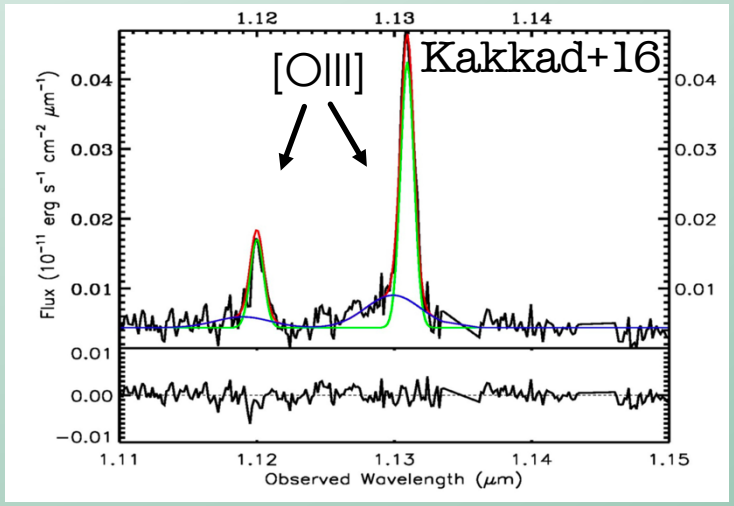
[OIII]5007Å cannot be produced in the high density sub-parsec scales typical of the AGN broad line regions (BLR) -> ideal tracer of extended outflows (no ambiguity with the BLR, in contrast with other nebular lines, e.g. Ha, Hb)

(e.g. Cano-Diaz+12, Alexander+10, Harrison+12,+14,+15,+16, Urrutia+14, Balmaverde+16, Brusa+15,+16, Cresci+15,+16, Perna+15, Kakkad+16, Wylezalek+16, Zakamska+16)



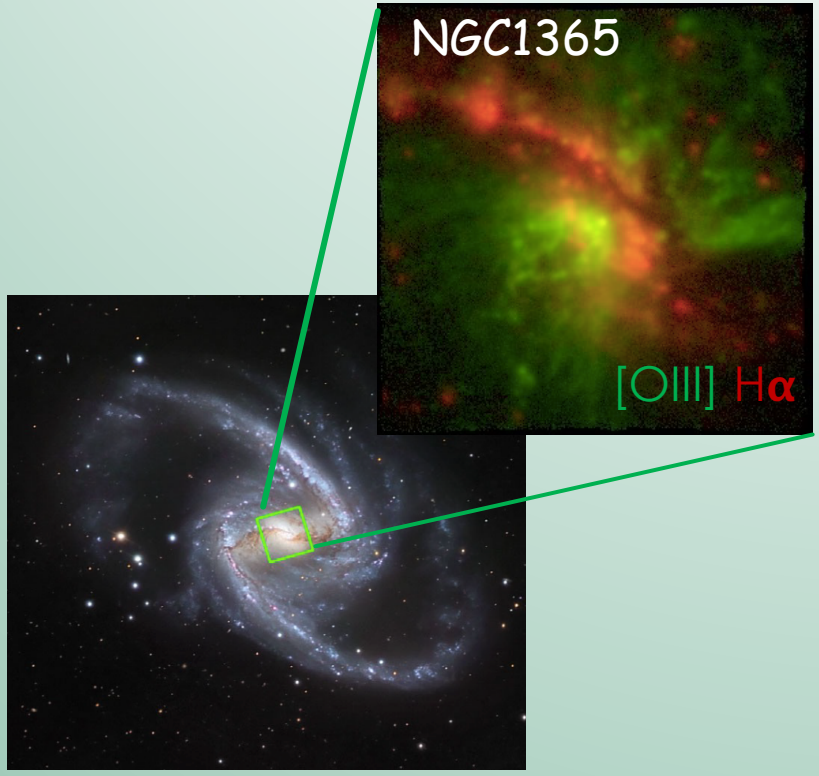
Harrison+16

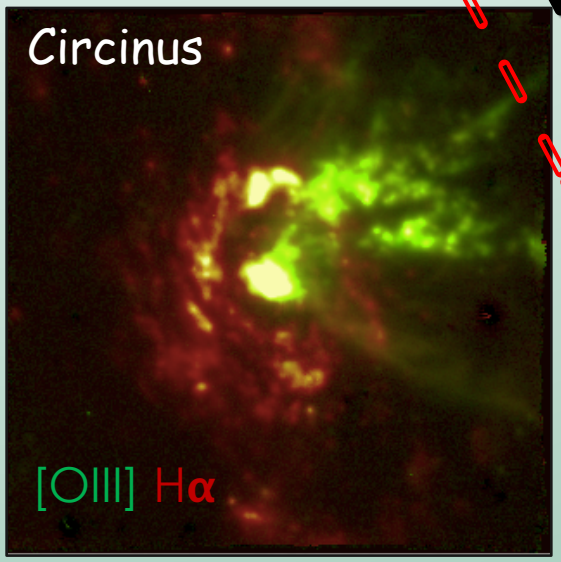




Local Ionised Outflows: MAGNUM survey

Measuring Active Galactic Nuclei Under the MUSE microscope (P.I. A. Marconi)
10 Nearby AGN (D < 30 Mpc)
Angular resolution ~15-115 pc
Multi-wavelength data: Chandra, XMM-Newton, HST, Spitzer, Herschel, ALMA

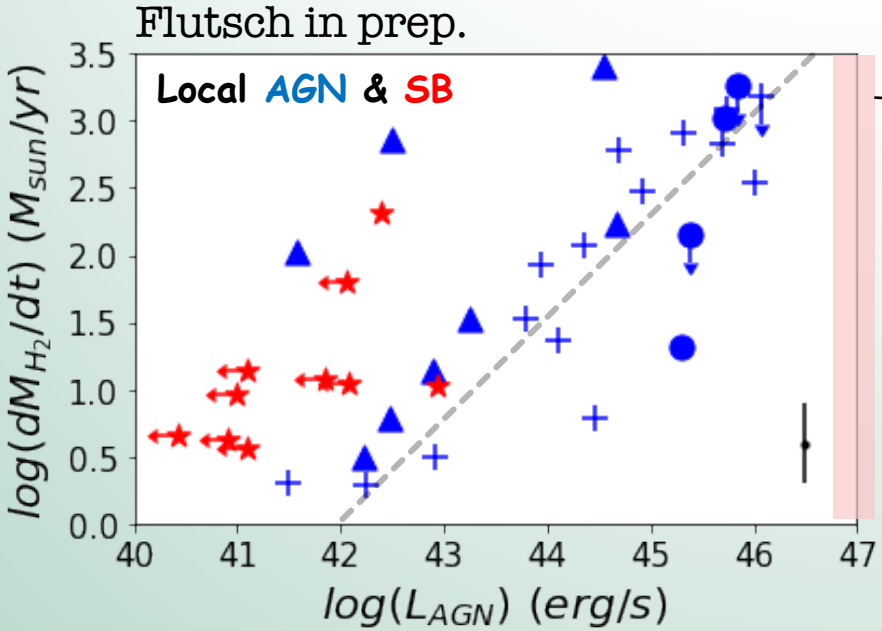


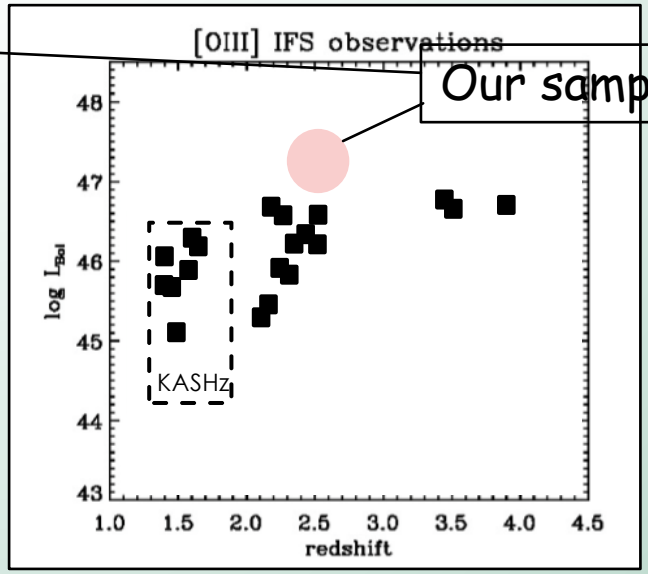


Poster D9
Venturi G.

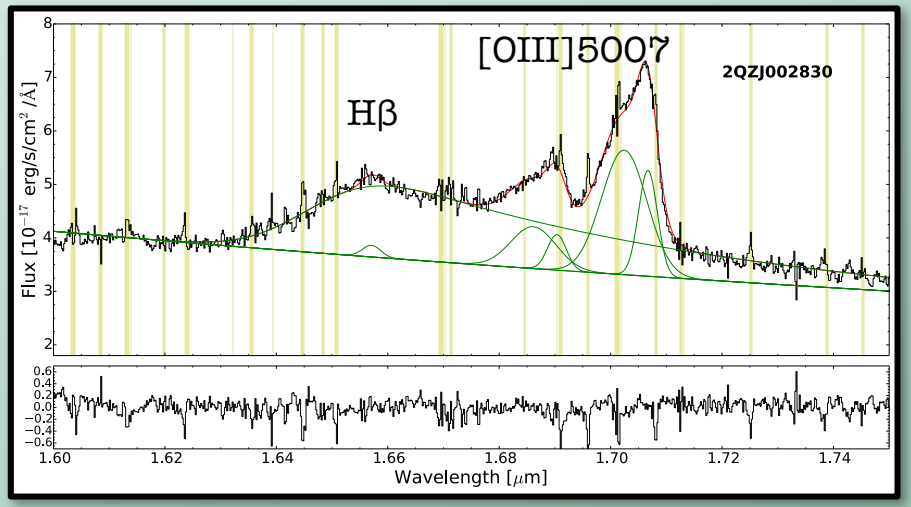
Negative Feedback?

High-z Ionised Outflows: sample

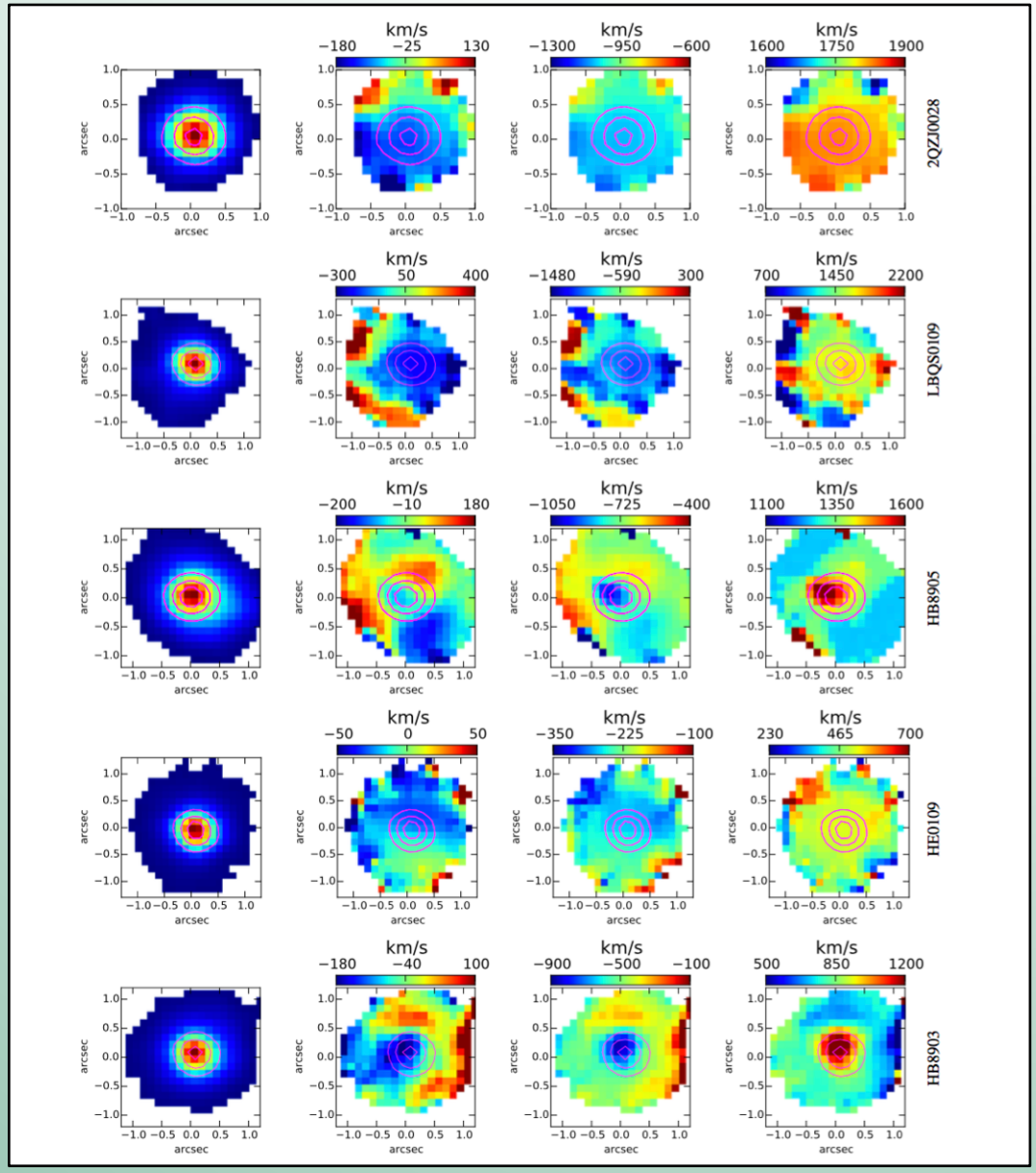


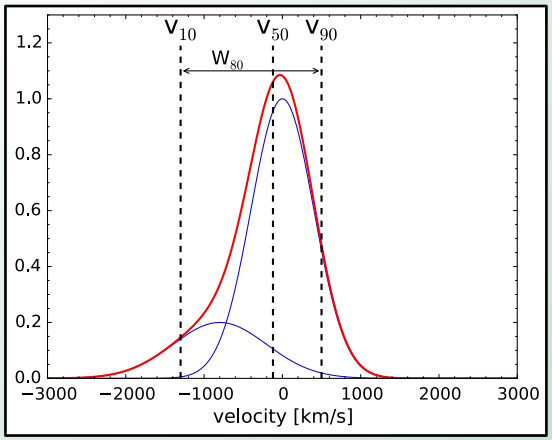


- A sample of 6 QSOs at redshift z=2.3-2.5
- Deep H- and K-band observations with SINFONI@VLT
- Seeing limited resolution (0.5"~4 Kpc)
- L_{AGN} ≈2-3 x 10^{47} erg/s
- Broad [OIII] (FWHM >1000 km/s)



[OIII] Kinematic Analysis





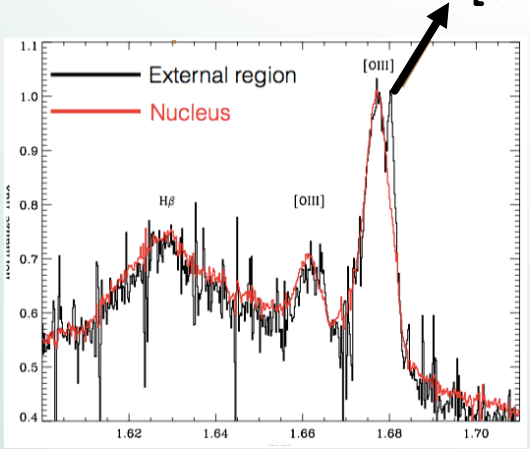
Spatially resolved [OIII] kinematical maps for 5 objects

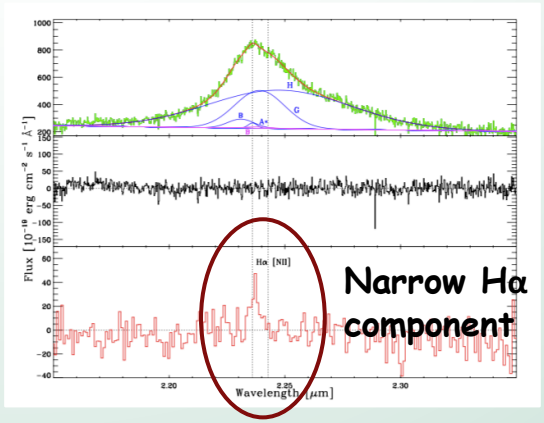
Velocity dispersion up to 900 km/s

Outflow velocities > 500 km/s

Narrow Component

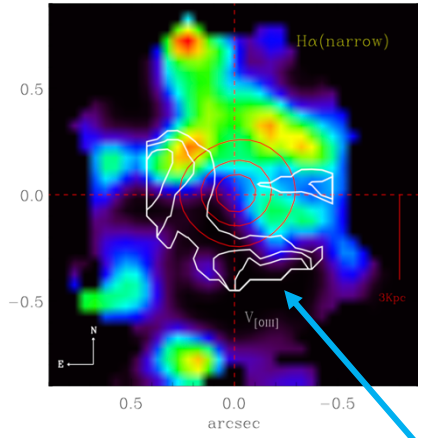
Narrow [OIII] component



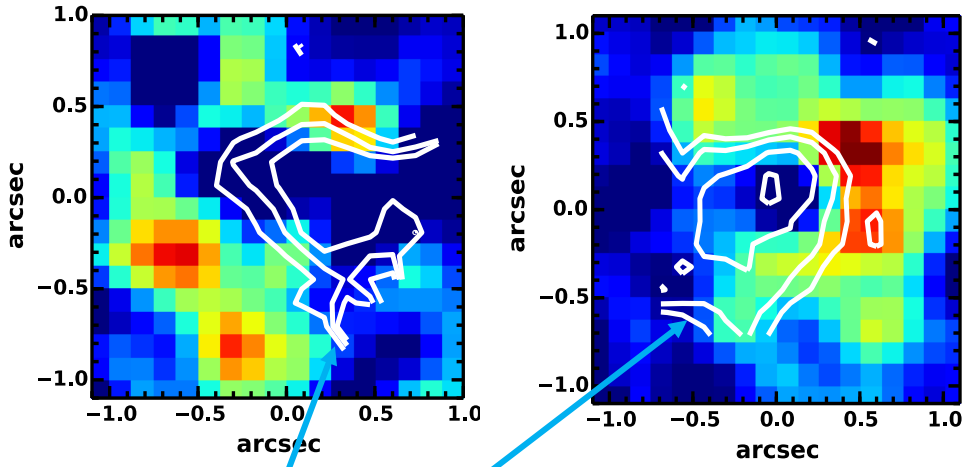


Ha flux maps -> SF in the host galaxy (~100 Msun/yr)

Cano+Diaz+12



Carniani+16



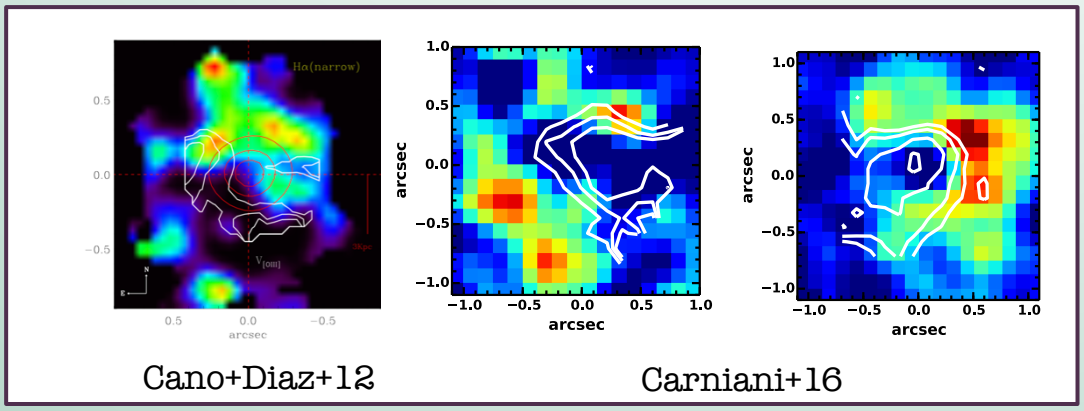
[OIII] velocity blue-shift -> AGN-driven outflows

Negative Feedback

The effects of AGN-driven outflows on SF are clearly visible.

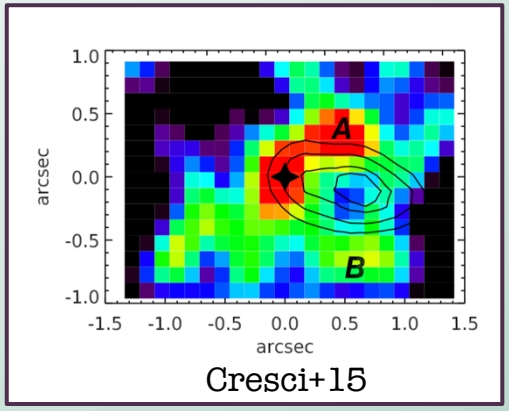
Is molecular gas swept away???

$z \approx 2.4$



Cano+Diaz+12 Carniani+16

$z \approx 1.6$



Cresci+15

CO(3-2) Observed with PdBI (Brusa+15)

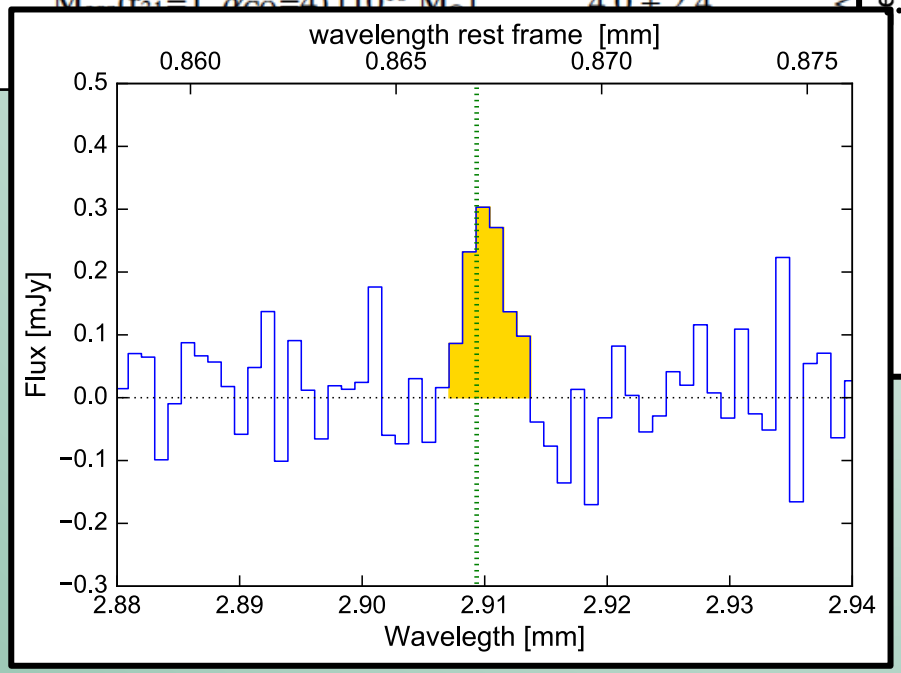
ALMA Cycle 2&3
Follow-up: Band 3 0.5" beam (~ SINFONI PSF)
GOAL: CO(3-2) emission

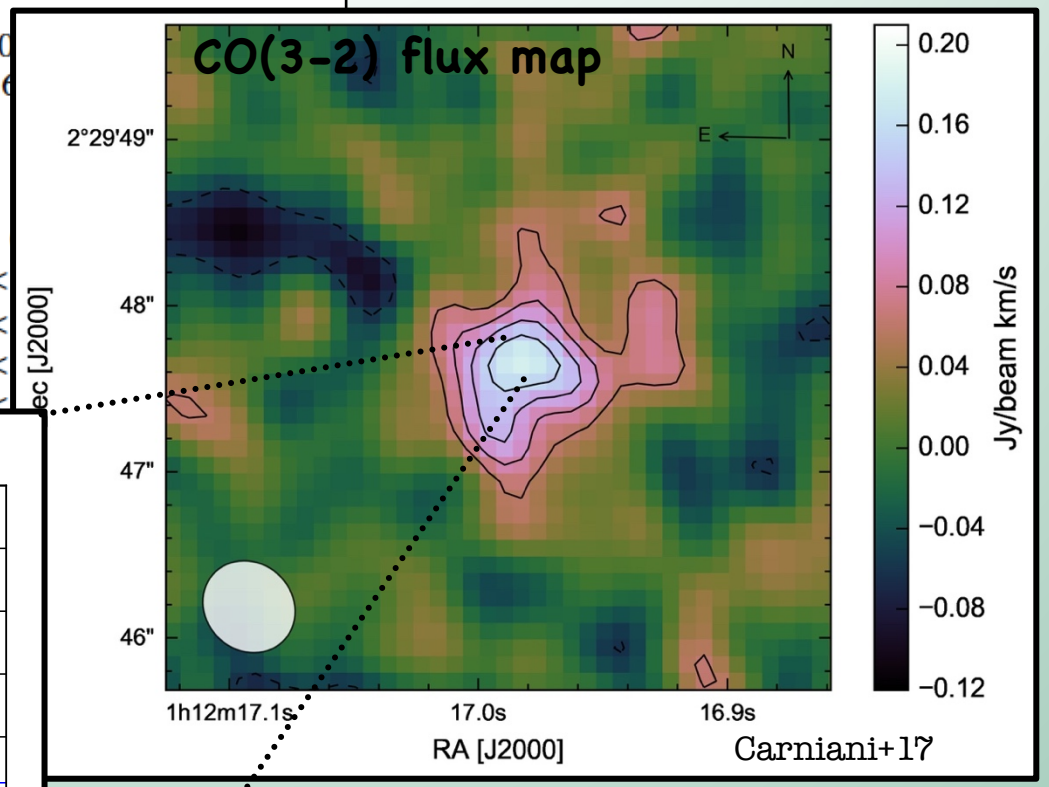
ALMA observations

t_{exp} ~1 h per target

CO(3-2) emission has been detected only in one out of the three QSOs

	LBQS0109	2QZJ0028	HB8903
S_{3mm} [μJy]	165 ± 12	170	
M_{dust} [10^9 $M_\odot$][a]	0.5-0.8	0.6	
$\lambda_{CO(3-2)}$ [mm]	2.9094±0.0004		
$z_{CO(3-2)}$ [mm]	2.3558±0.0005		
$FWHM_{CO(3-2)}$ [km/s]	400±60		
$S_{CO(3-2)}\Delta v$ [Jy km/s][b]	0.34 ± 0.03	<	
$L'_{CO(3-2)}$ [10^{10} K km/s pc^2]	1.04 ± 0.33	<	
$L_{CO(3-2)}$ [10^7 $L_\odot$]	1.4 ± 0.2	<	
$M_{gas}(r_{31}=1, \alpha_{CO}=0.8)$ [10^{10} $M_\odot$]	0.8 ± 0.5	<	
$M_{gas}(r_{31}=1, \alpha_{CO}=4)$ [10^{10} $M_\odot$]	4.0 ± 2.4	<	



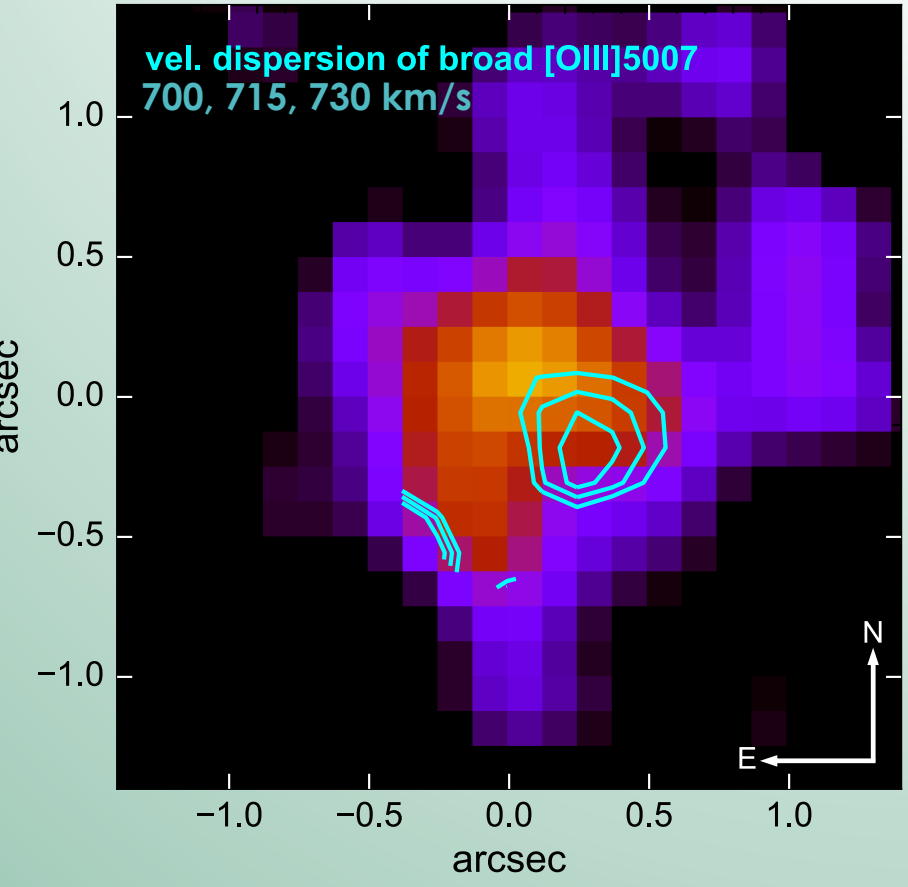


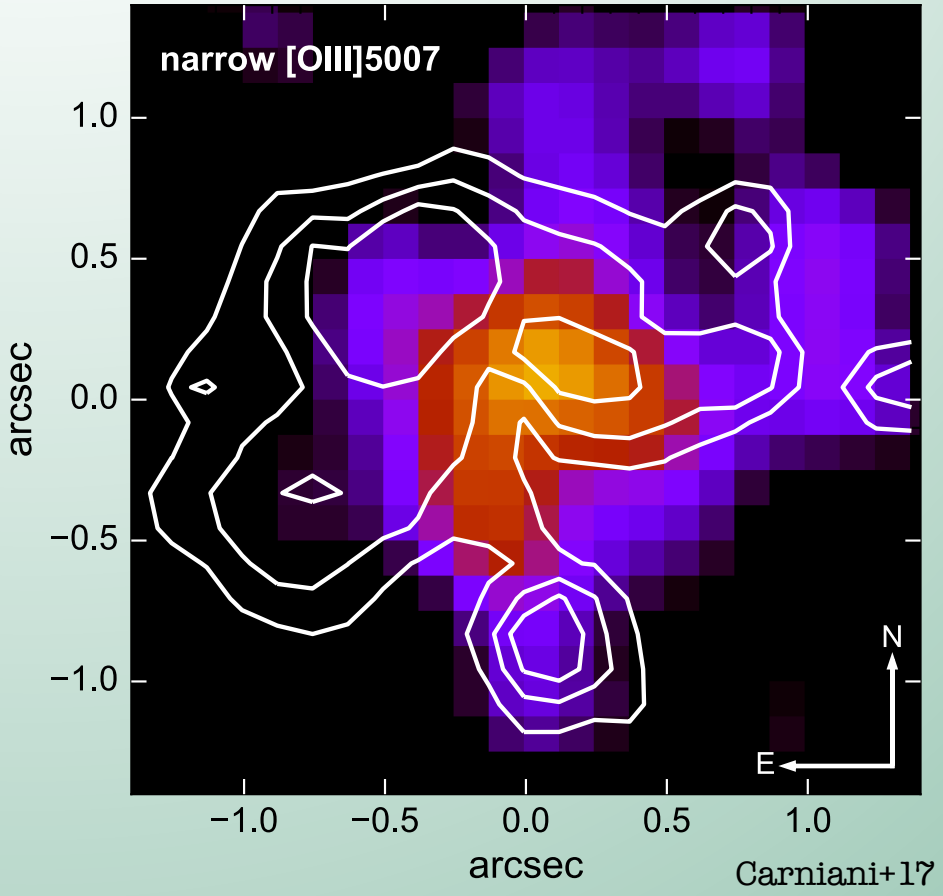
FWHM = 400 km/s

M_{mol} = 0.5- 4.0 10^{10} $M_\odot$

ALMA observations: LBQS0109

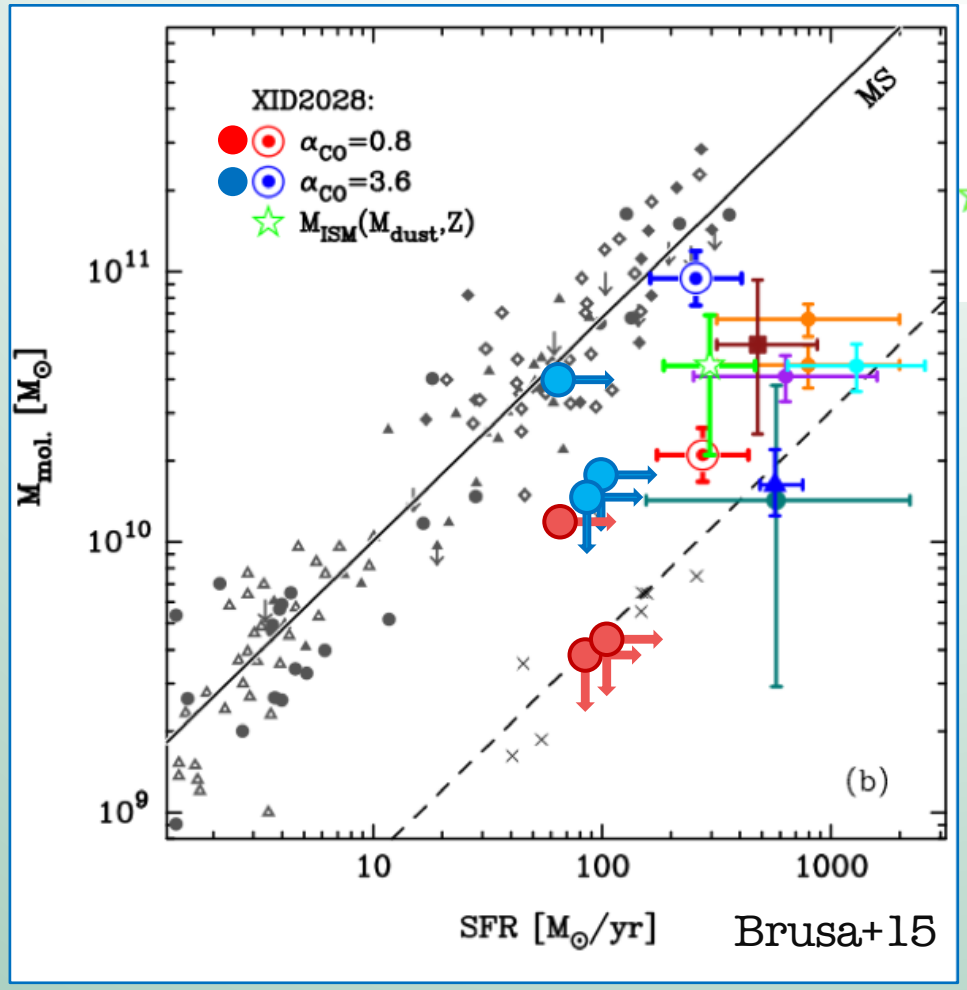
CO(3-2) flux map ≈ narrow [OIII] and Ha flux maps





CO emission faint/absent in the outflow region

Lack Of Molecular Gas



Aravena et al. (2008)
Polletta et al. (2011)
Feruglio et al. (2014)
z~2 SMG→QSO (Ya10)
XID2028 QSO z≈1.6 Brusa+15
QSOs z≈2.4 Carniani+16b

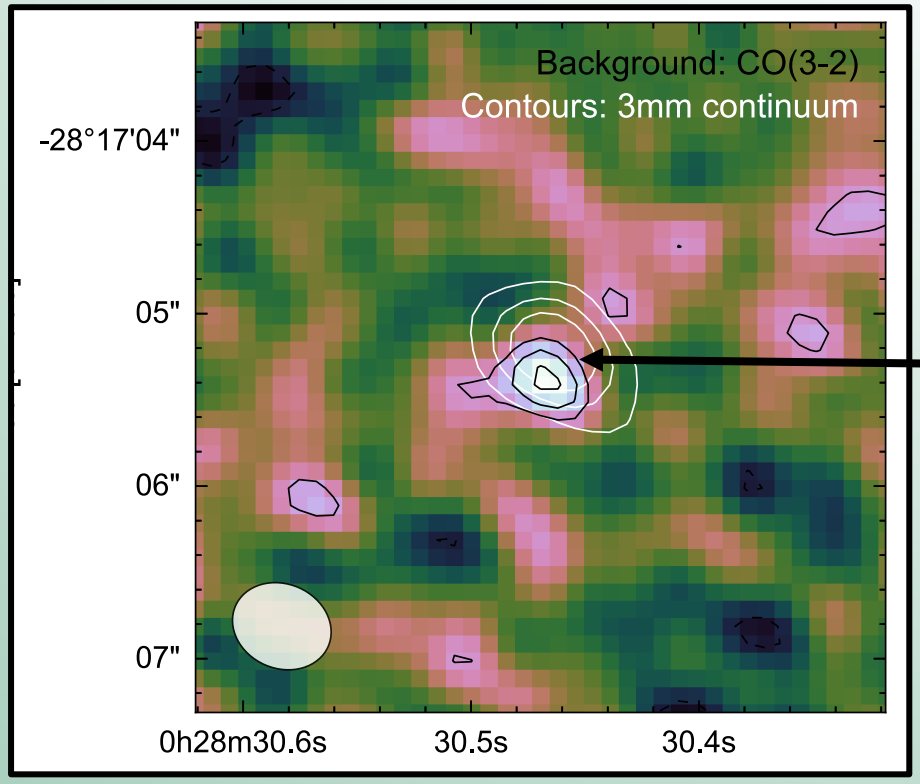
less gas than expected

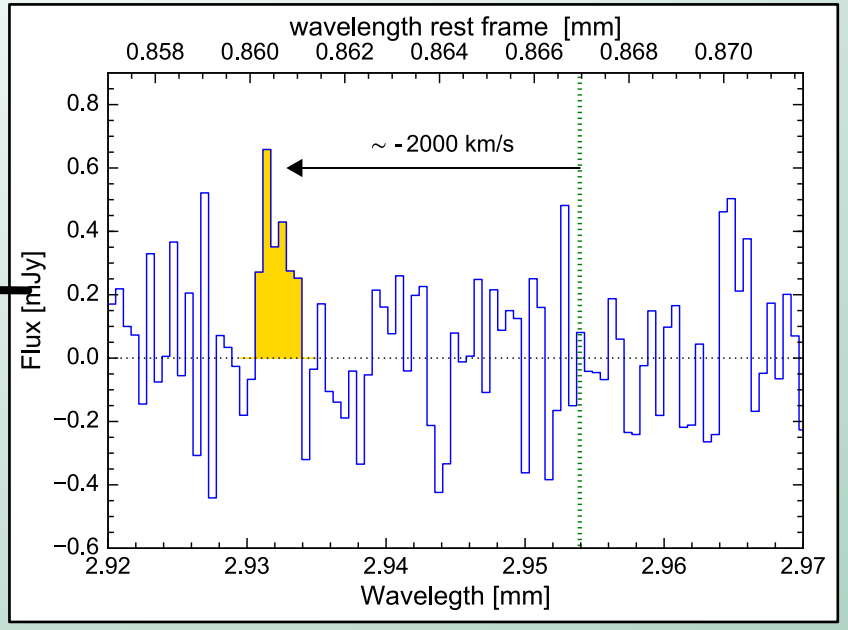
Negative feedback!?!?

Molecular Outflows?

2QZJ0028: Molecular Outflow?

The peak of the CO(3-2) emission is spatially offset by ~0.2″ (1.3kpc) toward South relative to the QSO centre

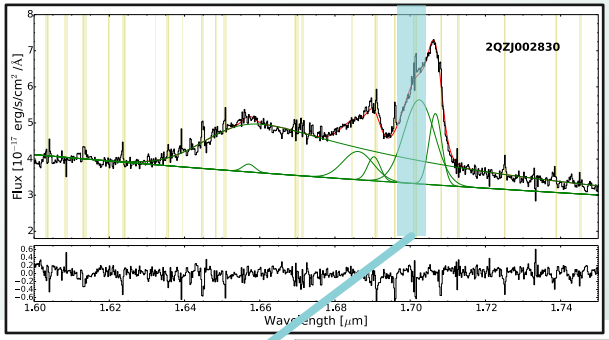


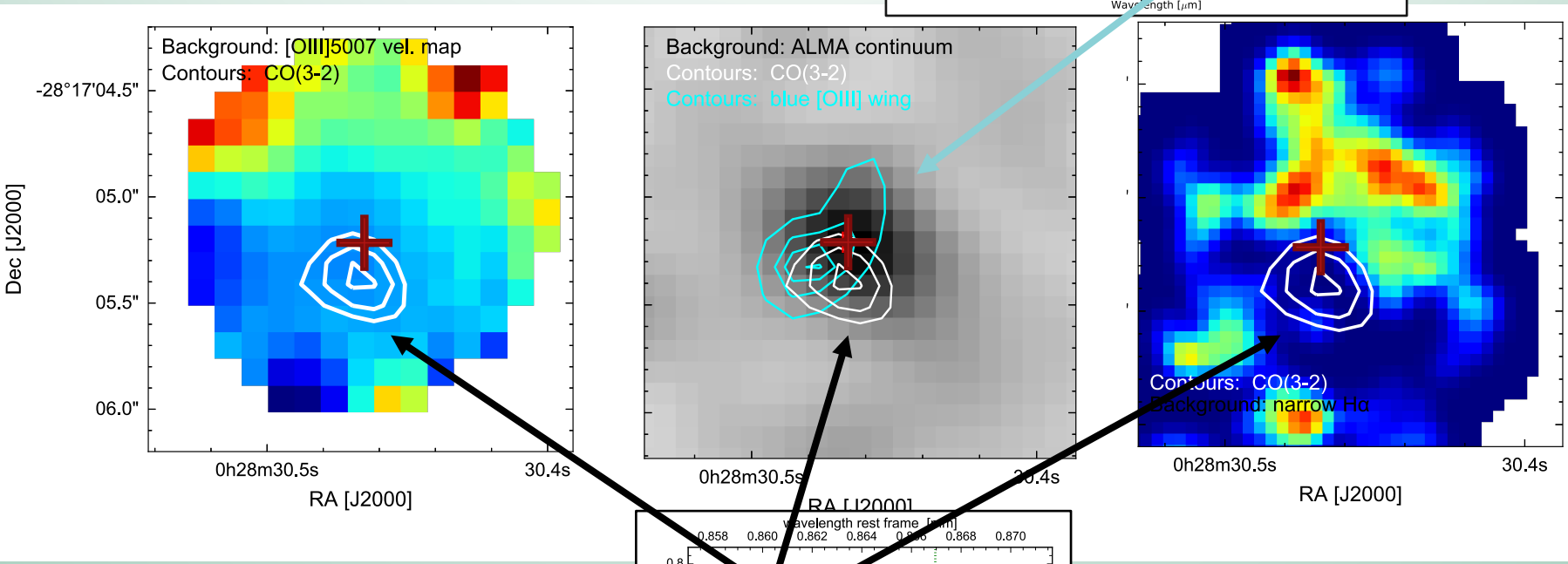


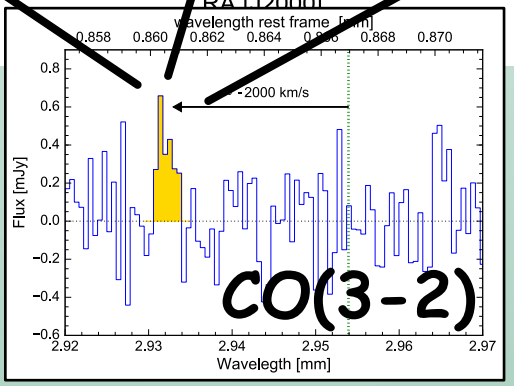
Carniani+17

2QZJ0028: Molecular Outflow?

CO(3-2) emission blueshifted by 2000 km/s and spatially coincident with the ionised outflow emission: molecular outflow??



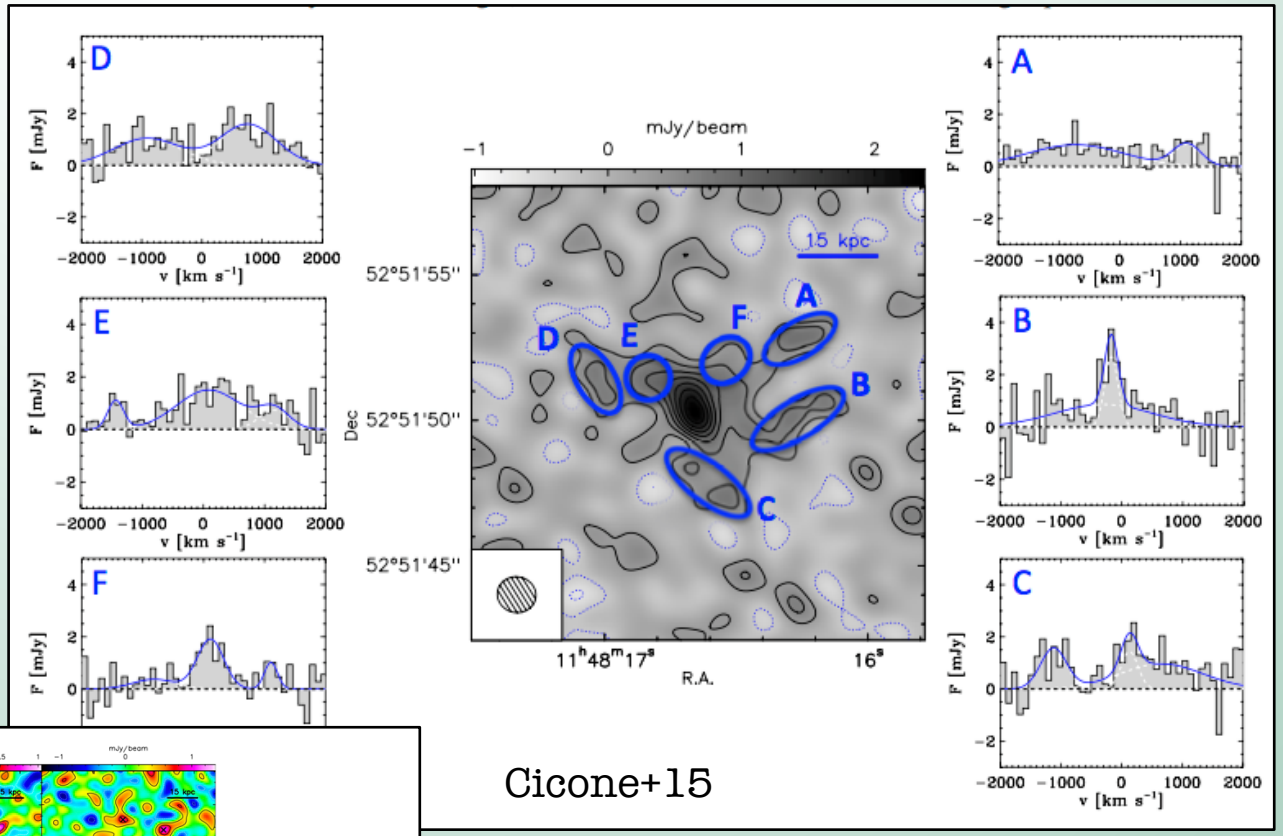




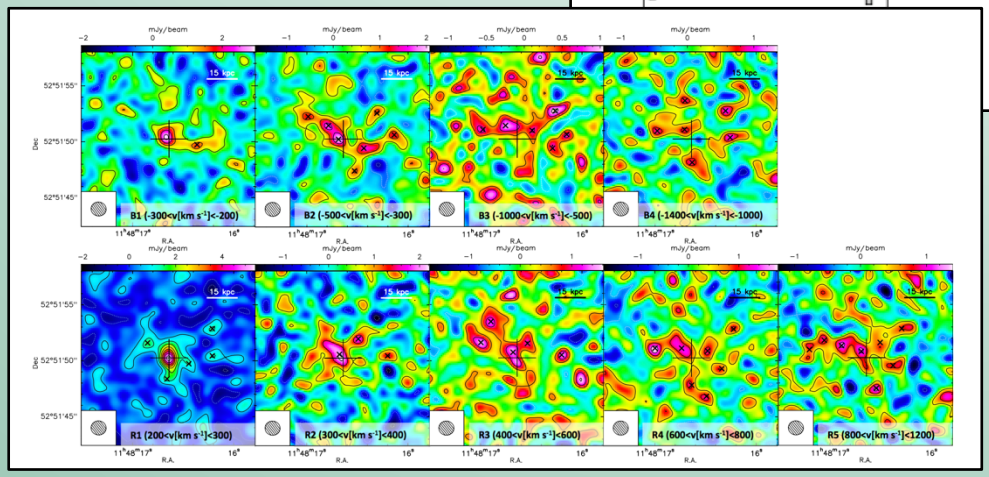
Outflows in High-z QSOs (1)

[CII] @ z=6.4189
SDSS J1148+5251

Multi-clump morphology
Extended up to 30 kpc
Velocity up to 1400 km/s



Cicone+15



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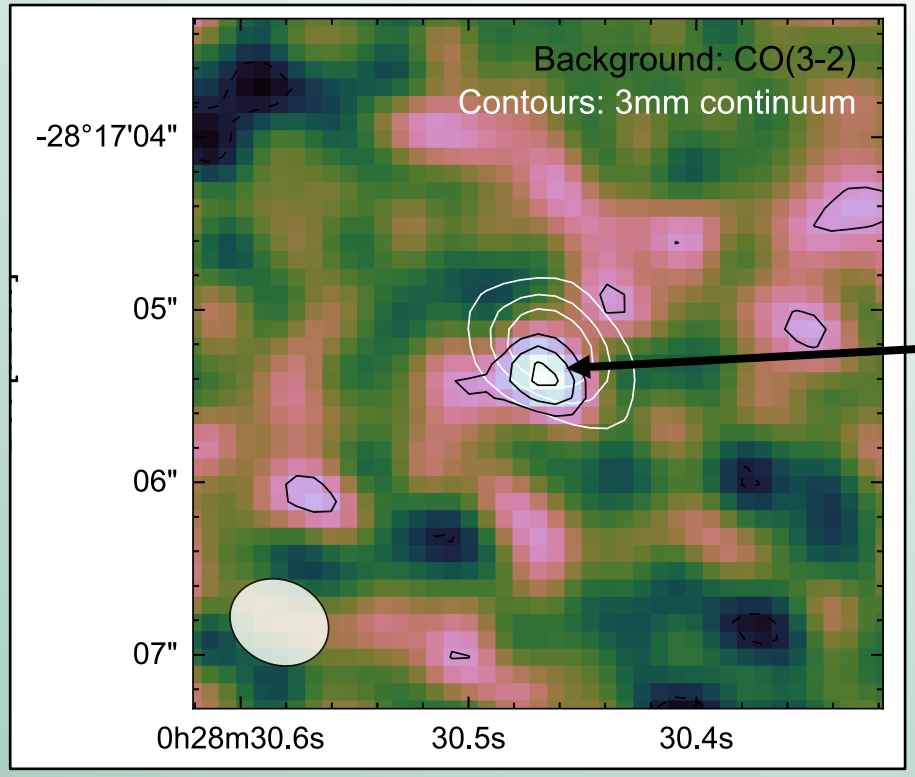
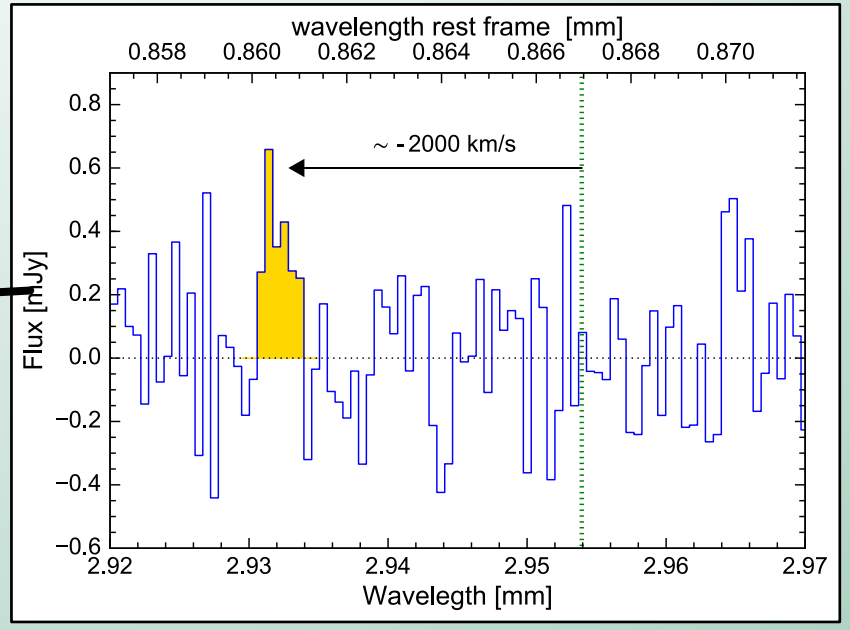
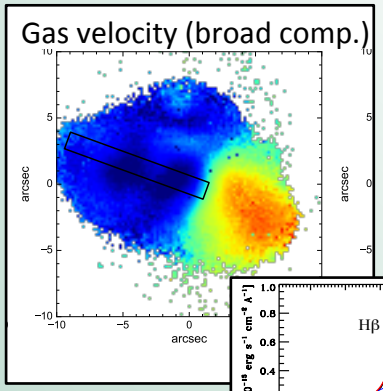




Carniani+17

molecular gas in the outflow region may be more highly excited than the rest of molecular gas in the host galaxy.

Do AGN-driven outflows only have a disruptive effect?



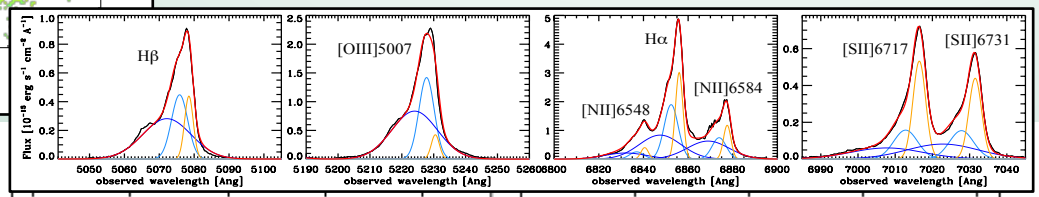
IRAS F23128-5919

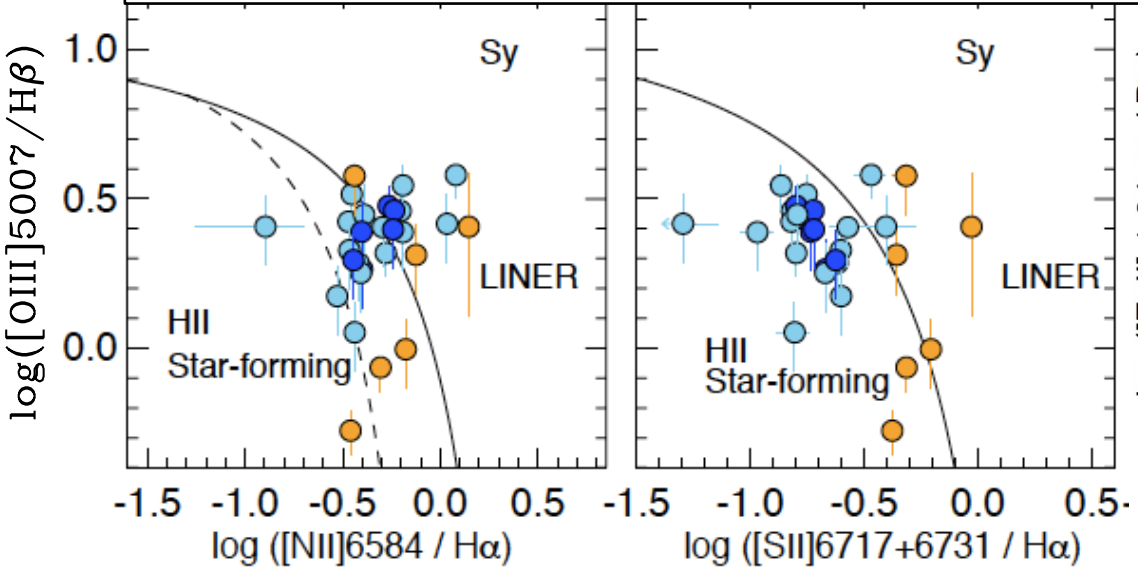
Maiolino+17 (Nature)

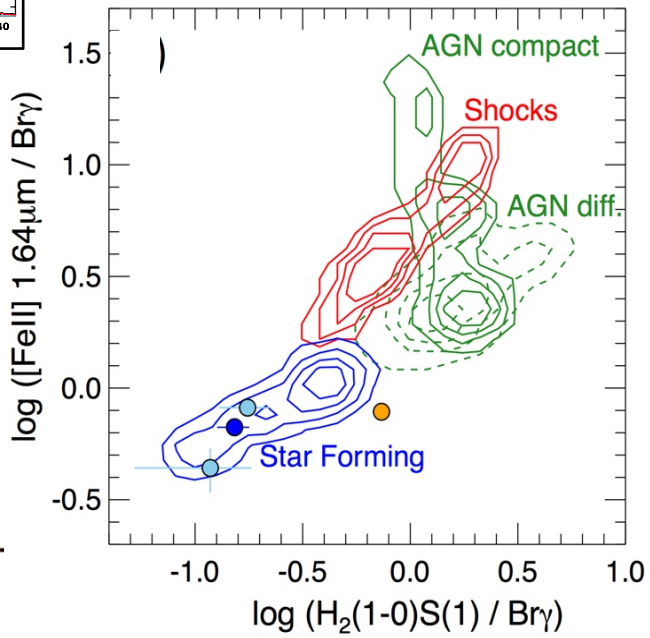
outflow

discs

- broad/bluesh. indiv. comp.
- broad/bluesh. total comp.
- narrow components

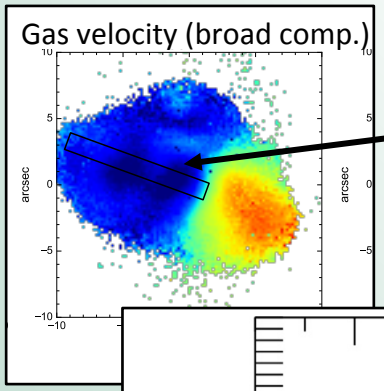




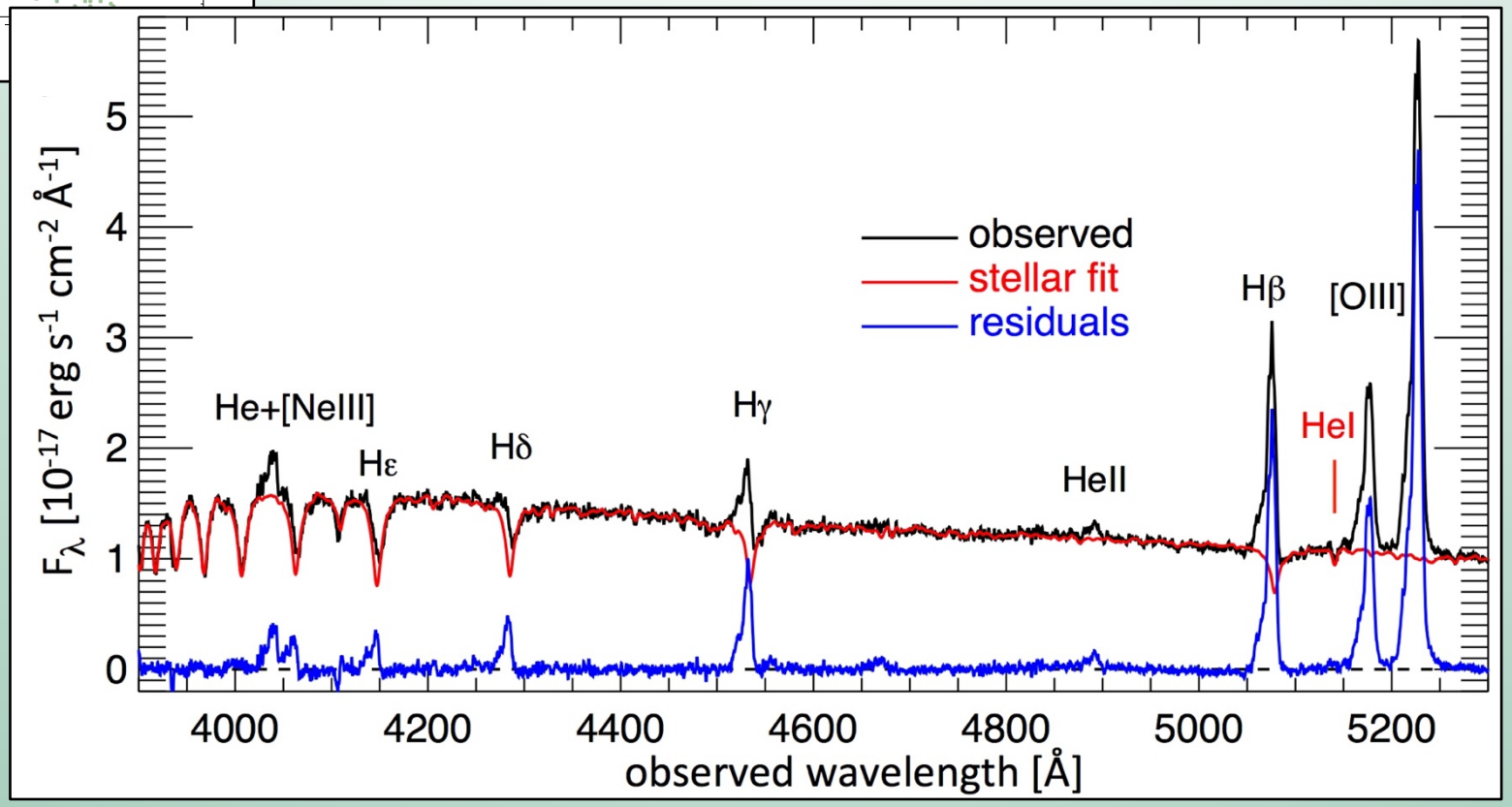


star formation *within* outflows

Kinematic in the outflow region

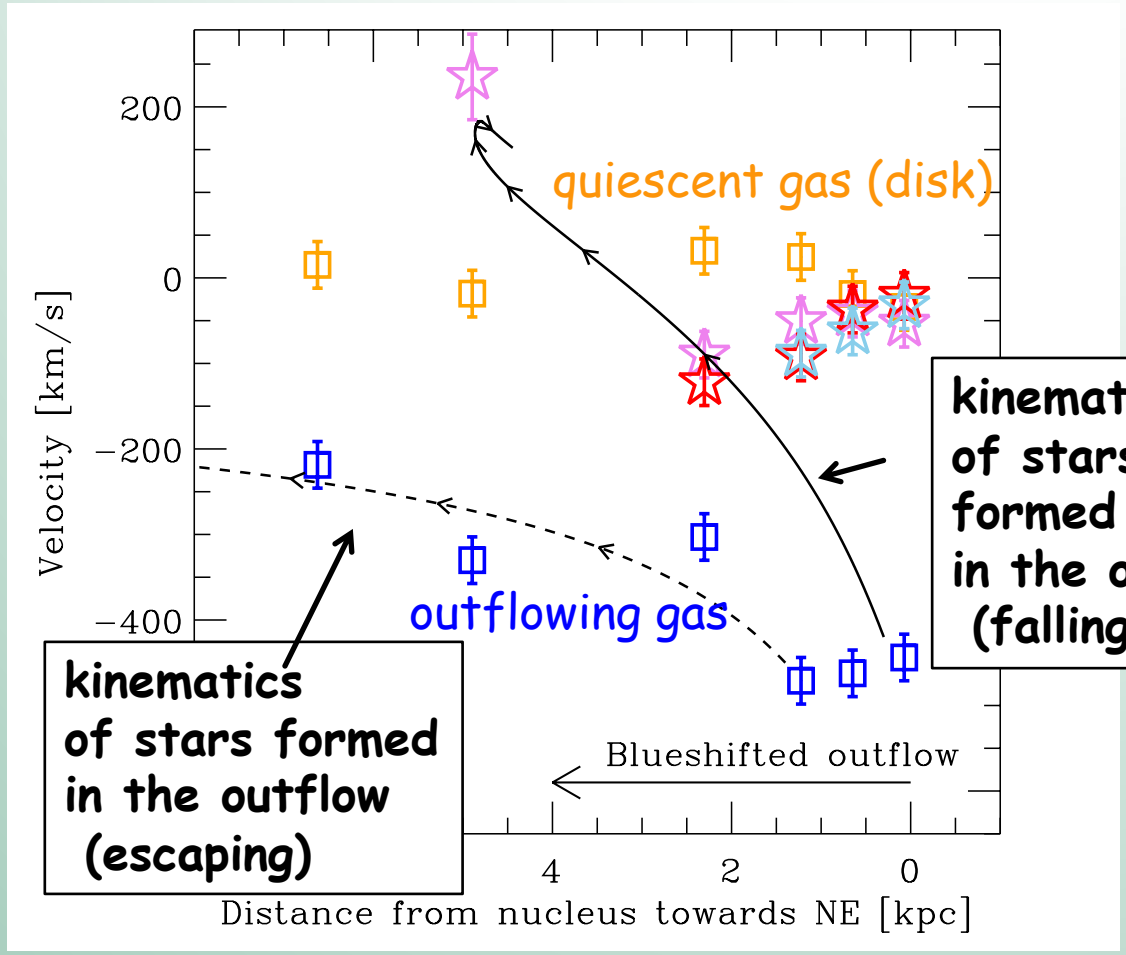


Xshooter slit

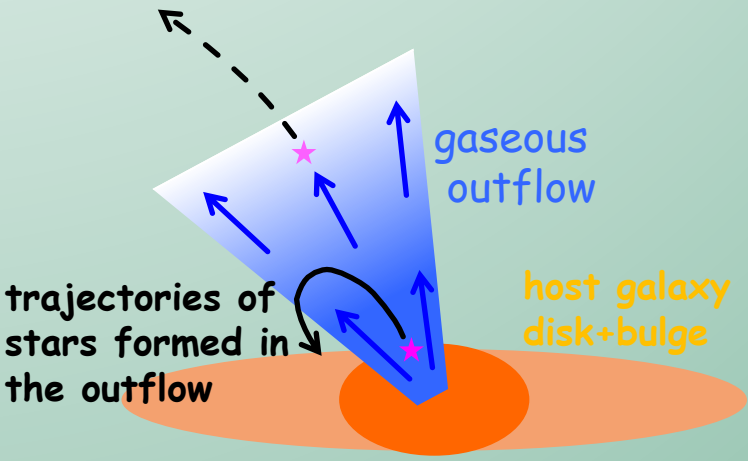


Stellar population with age <30 Myr (very young!)

Kinematic in the outflow region



gas: narrow comp. (host gal.)
gas: broad comp. (outflow)
O−B−A stars (Balmer lines)
Red Superg. and AGBs (CaII trip.)
B stars (HeI)
Ballistic tracks
bound
unbound



Young stellar kinematics consistent with stars formed in the outflow

Summary

- ✓ [OIII] is a good tracer of ionised outflows on large scales
- ✓ SF is suppressed in the region affected by outflow processes
- ✓ AGN-driven outflows sweep away ionised and molecular gas in quasar host galaxies
- ✓ AGN-driven outflows with multi-clump morphology
- ✓ SF may occur within the outflow region (this is a new mode of SF which may have been overlooked in other local and high-z outflows)

Carniani+15,
Carniani+16,
Carniani+17,
Maiolino+17,
Flutsch in prep.,
Venturi in prep.

Thanks