

# The WISSH QSOs project:



**the most powerful [OIII] outflows  
in WISE/SDSS selected hyper-luminous QSOs**

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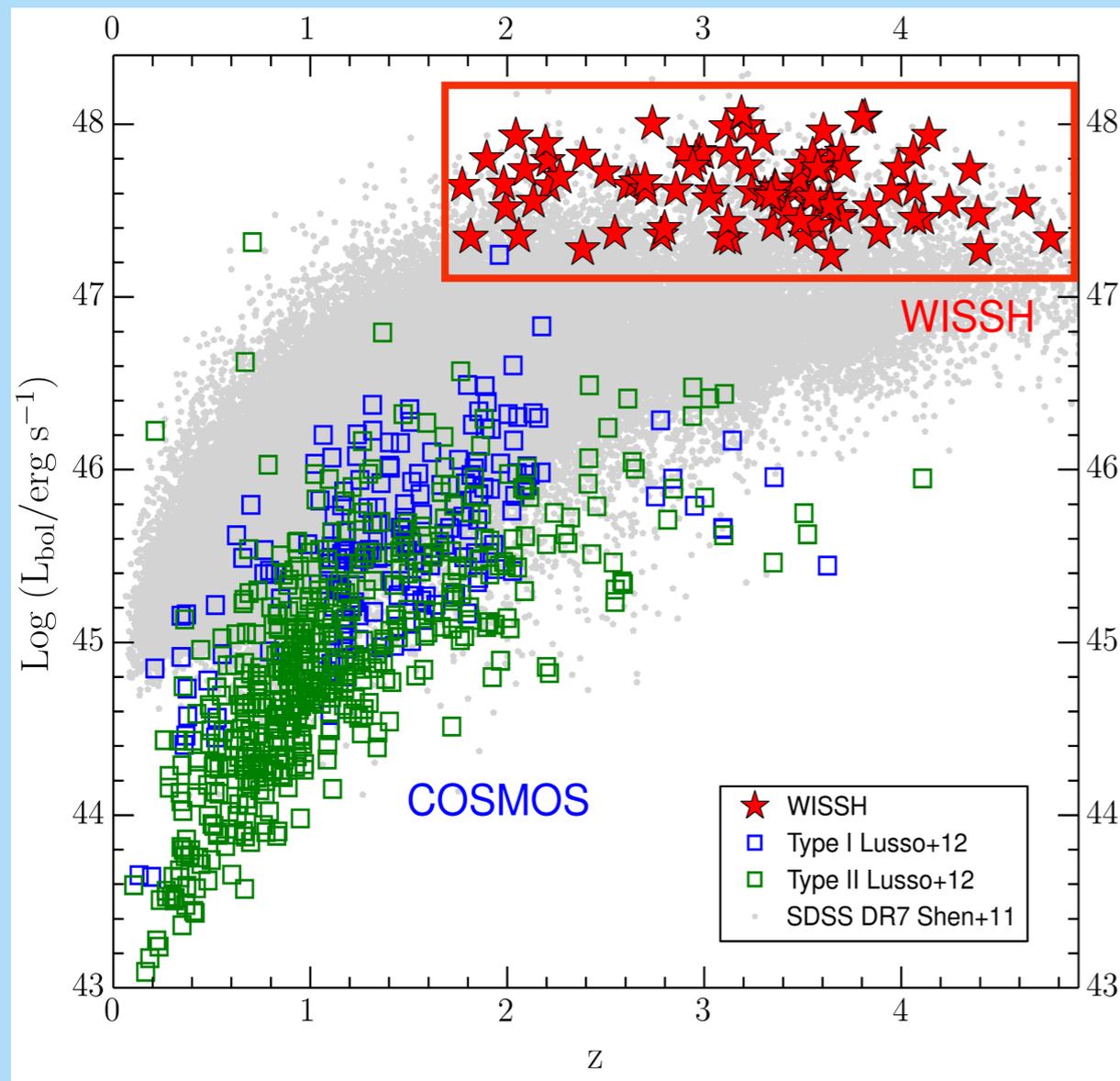


# The WISSH QSOs project

## SAMPLE: 86 WISE/SDSS Selected Hyper-luminous (WISSH) QSOs

- SDSS DR7 broad-line QSOs with  $S(22\ \mu\text{m}) > 3\ \text{mJy}$
- $\text{Log}(L_{\text{bol}} / \text{erg s}^{-1}) > 47.2$
- $1.5 < z < 4.5$
- Lensed objects removed

**GOAL: Observing the AGN-driven feedback at its best!**



**The most luminous  
broad-line IR-loud AGN  
at cosmic noon**

Theory & Observations:  
primary targets to search for  
AGN feedback  
(huge radiative output,  
powerful AGN-driven outflows)

# Multiband follow-up of WISSH

## WISSH Tasks

- Probing widespread presence of outflows from different gas phases/spatial scales
- Constraining the properties of the central engine
- Studying the ISM and SFR of the host galaxies

## Extensive multi- $\lambda$ observing program

XMM & Chandra X-rays  
LBT/LUCI - TNG  $H\beta$  + [OIII]  
SINFONI IFU spectroscopy  $H\beta$  + [OIII] +  $H\alpha$   
X-shooter  $H\beta$  + CIV + MgII + ...  
ALMA CO + CII + FIR continuum  
+ Herschel - WISE - 2MASS - SDSS

### *This talk:*

LBT/LUCI and VLT/SINFONI spectroscopy of [OIII] and  $H\beta$



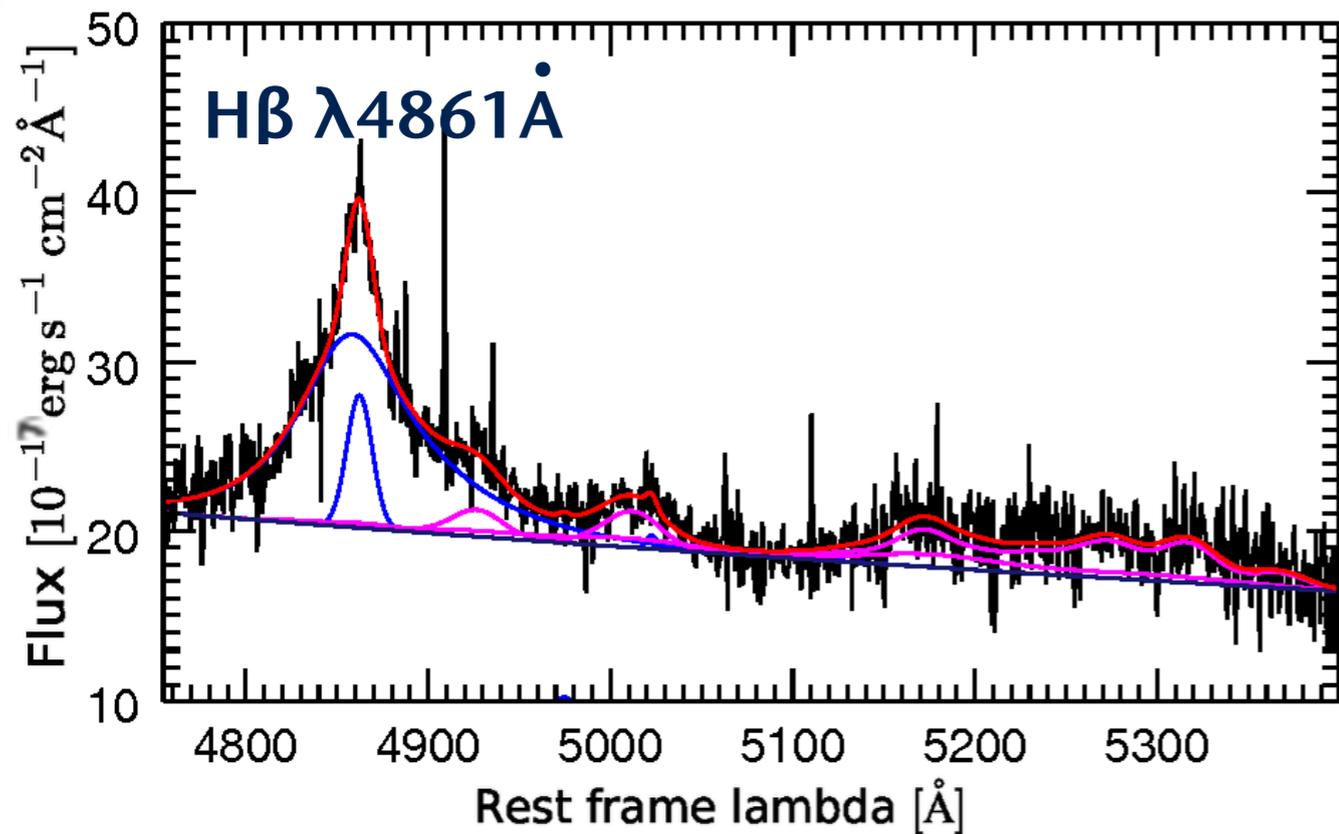
revealing ionised outflows  
measuring SMBH mass and  $\lambda_{\text{Edd}}$

ALMA maps of [CII]



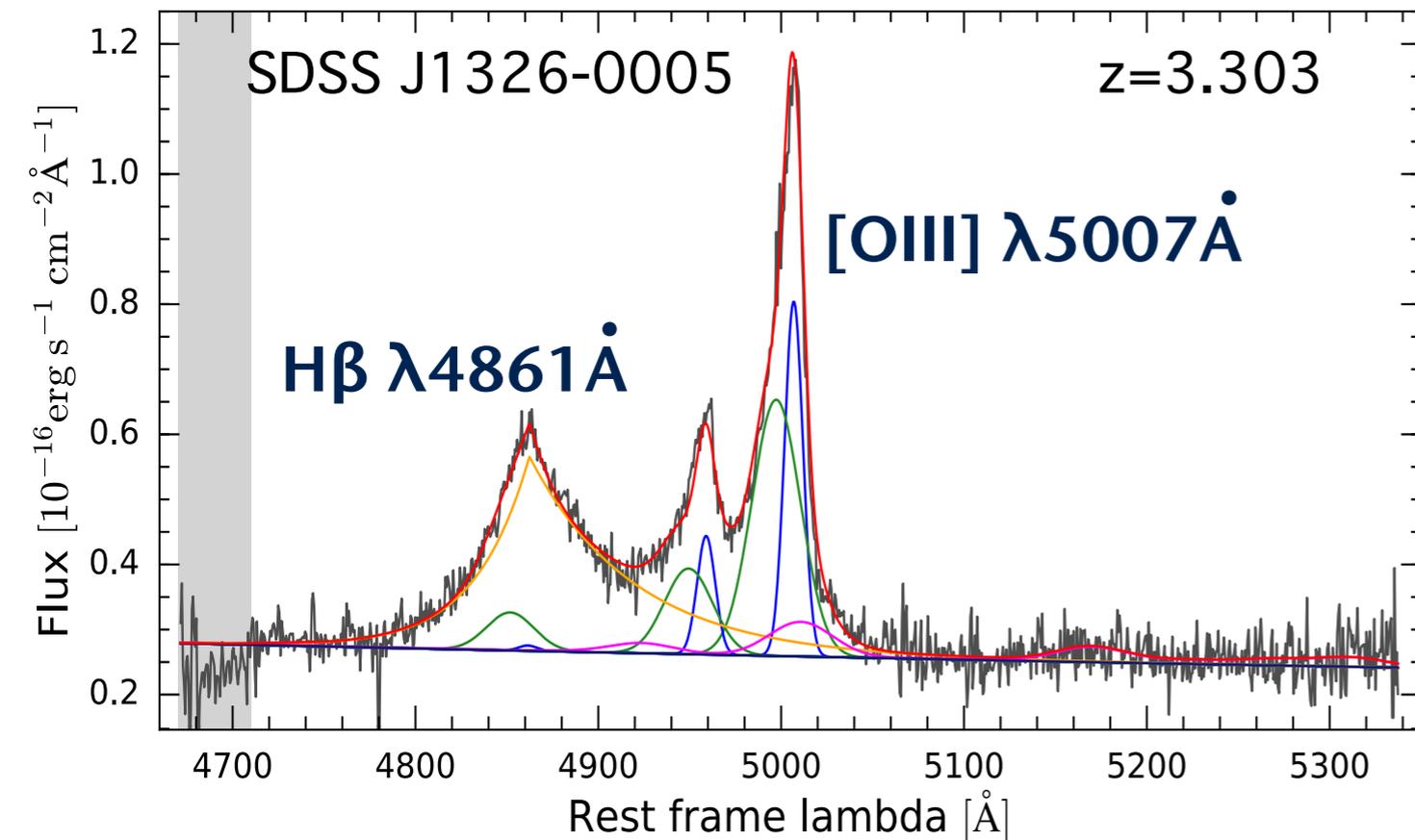
eyes on the host galaxy

# LBT/NIR spectra of WISSH QSOs



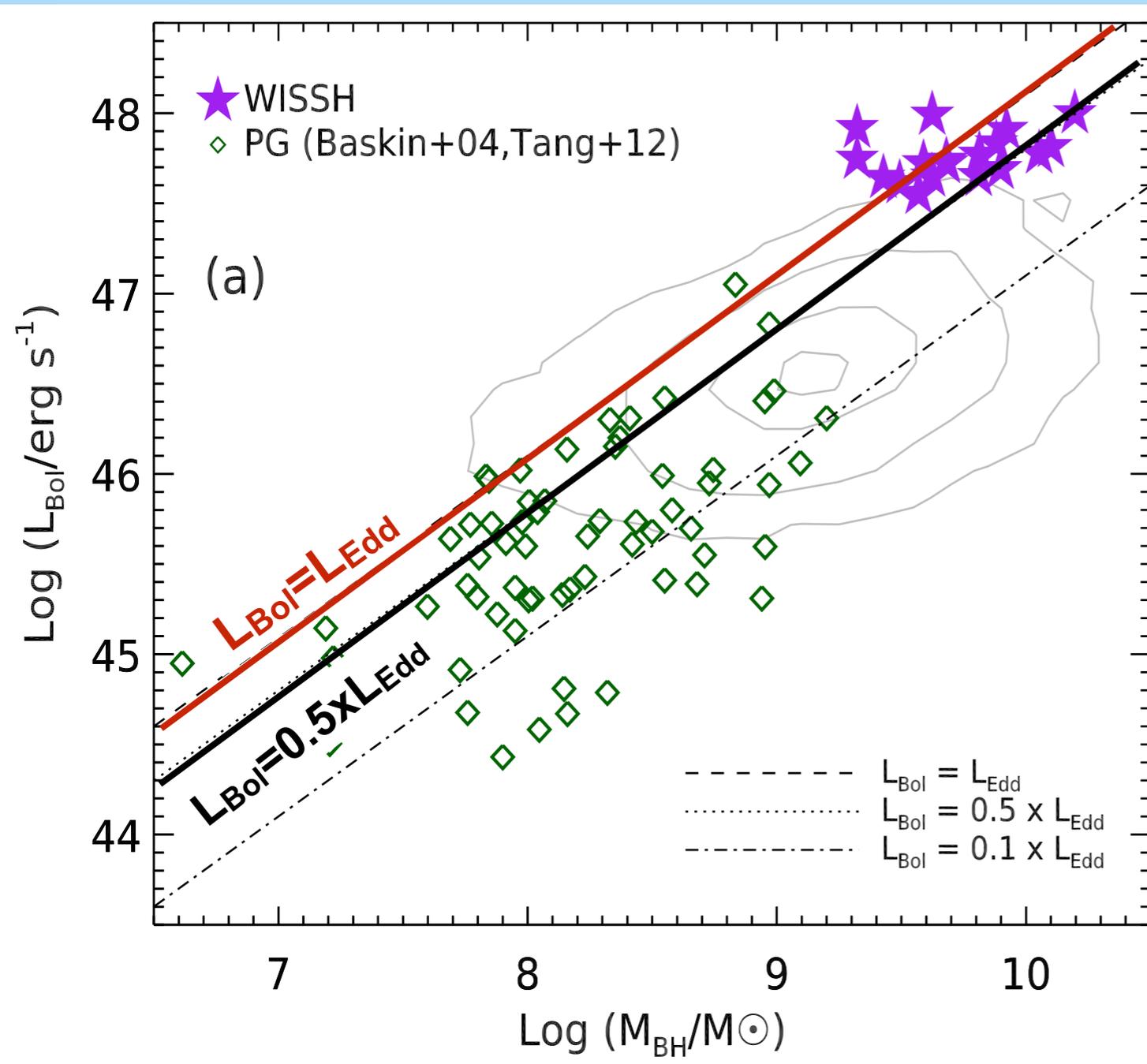
(see G. Vietri's talk this morning)

- 70 % lack of [OIII] emission
- Strong and complex FeII emission



- 30 % prominent [OIII] emission
- Broad blue-shifted profiles

# Powering WISSH QSOs

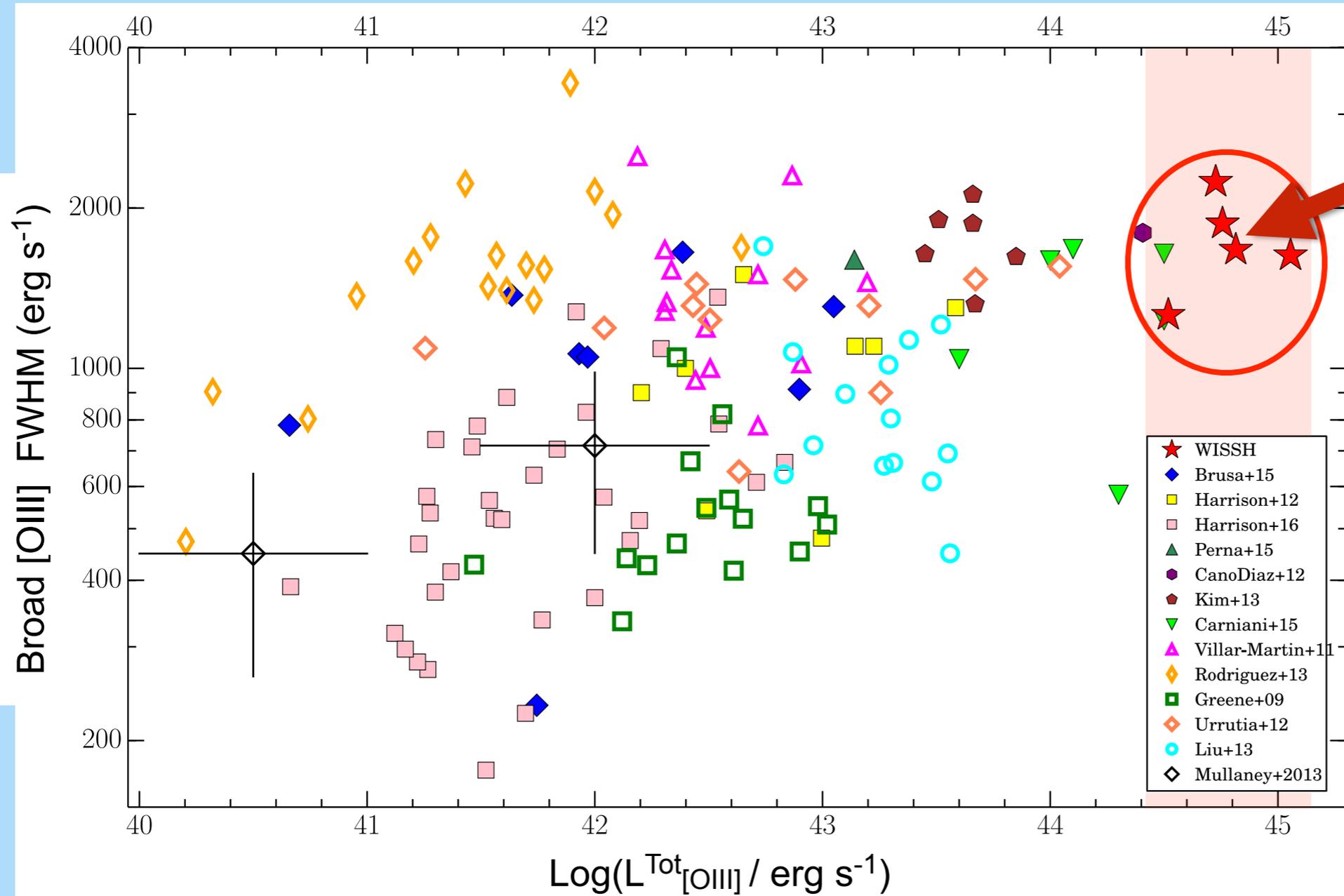


- $H\beta$ -based SMBH masses from  $\sim 2 \times 10^9 M_{\odot}$  up to  $\sim 2 \times 10^{10} M_{\odot}$  (Vietri et al. in prep)
- $L_{\text{Bol}}$  from multi-component broad-band (UV to FIR) SED fitting (Duras +17 A&A, arXiv170604214D)
- high accretion rates  $0.4 < \lambda_{\text{Edd}} < 3$

**Opportunity of collecting high-mass, highly accreting SMBHs at the peak of the quasars number density**

# The most luminous outflowing [OIII] emission

5 targets at  $z \sim 2.5 - 3.5$



**WISSH:**  
**max Lum[OIII]**

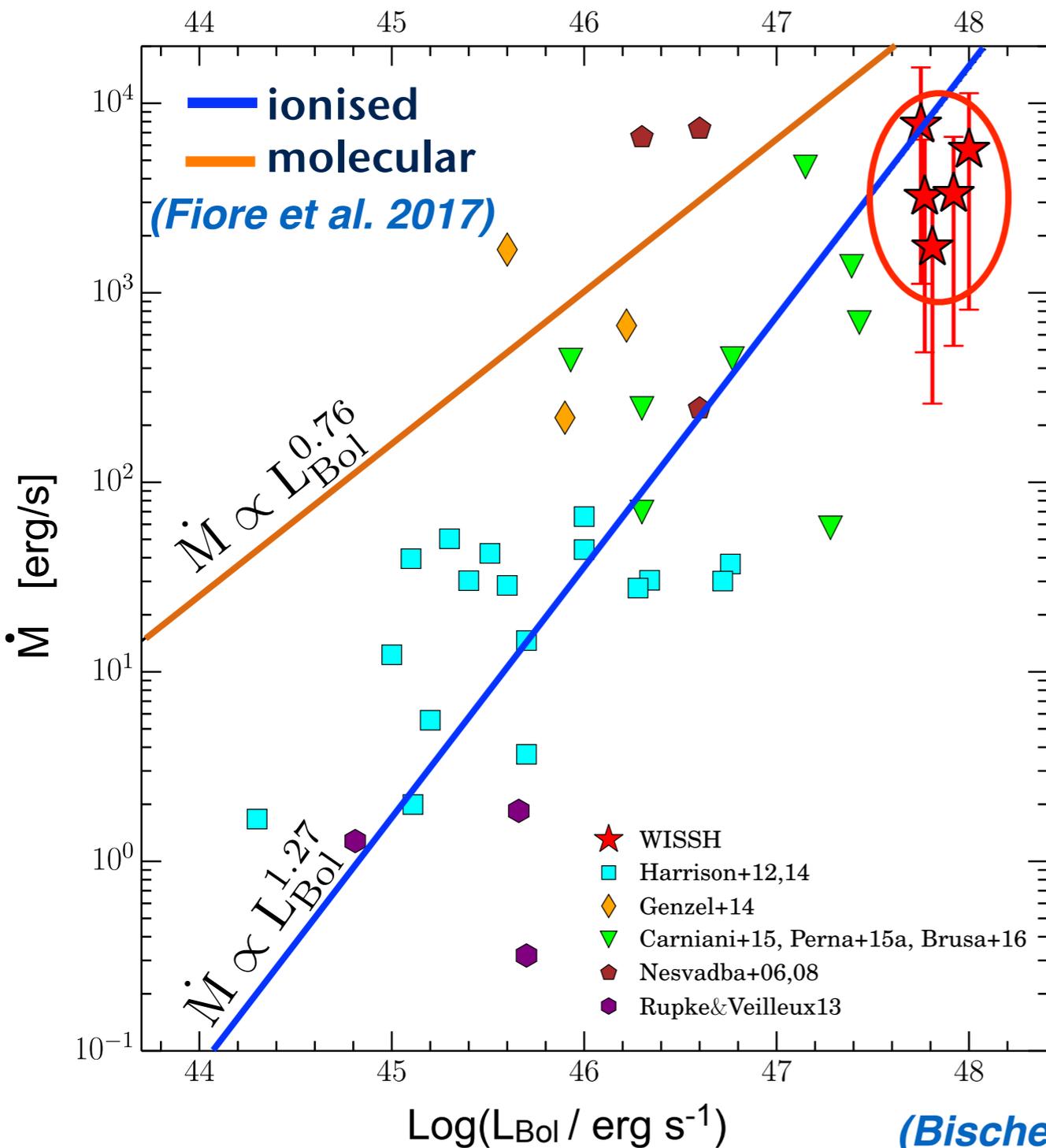
(Bischetti et al. 2017, A&A 598, A122)

**Very broad [OIII] lines**  $\text{FWHM}_{[\text{OIII}]} \sim 1200 - 2200 \text{ km/s}$

**Very strong [OIII] lines**  $\text{Log}(L_{[\text{OIII}]} / \text{erg s}^{-1}) > 44.7$

# Powerful [OIII] outflows in WISSH QSOs

mass outflow rates up to  $\sim 8000 M_{\odot}/\text{yr}$



Very simple scenario: spherically symmetric wind with  $v_{\text{max}}$  independent of  $R$

$$\dot{M} \sim 3 \frac{M_{\text{ion}} v_{\text{max}}}{R}$$

$$v_{\text{max}} = \Delta v + 2\sigma$$

$$n_e = 200 \text{ cm}^{-3}$$

$$[\text{O}/\text{H}] \sim 0$$

$$R = 7 \text{ kpc}$$

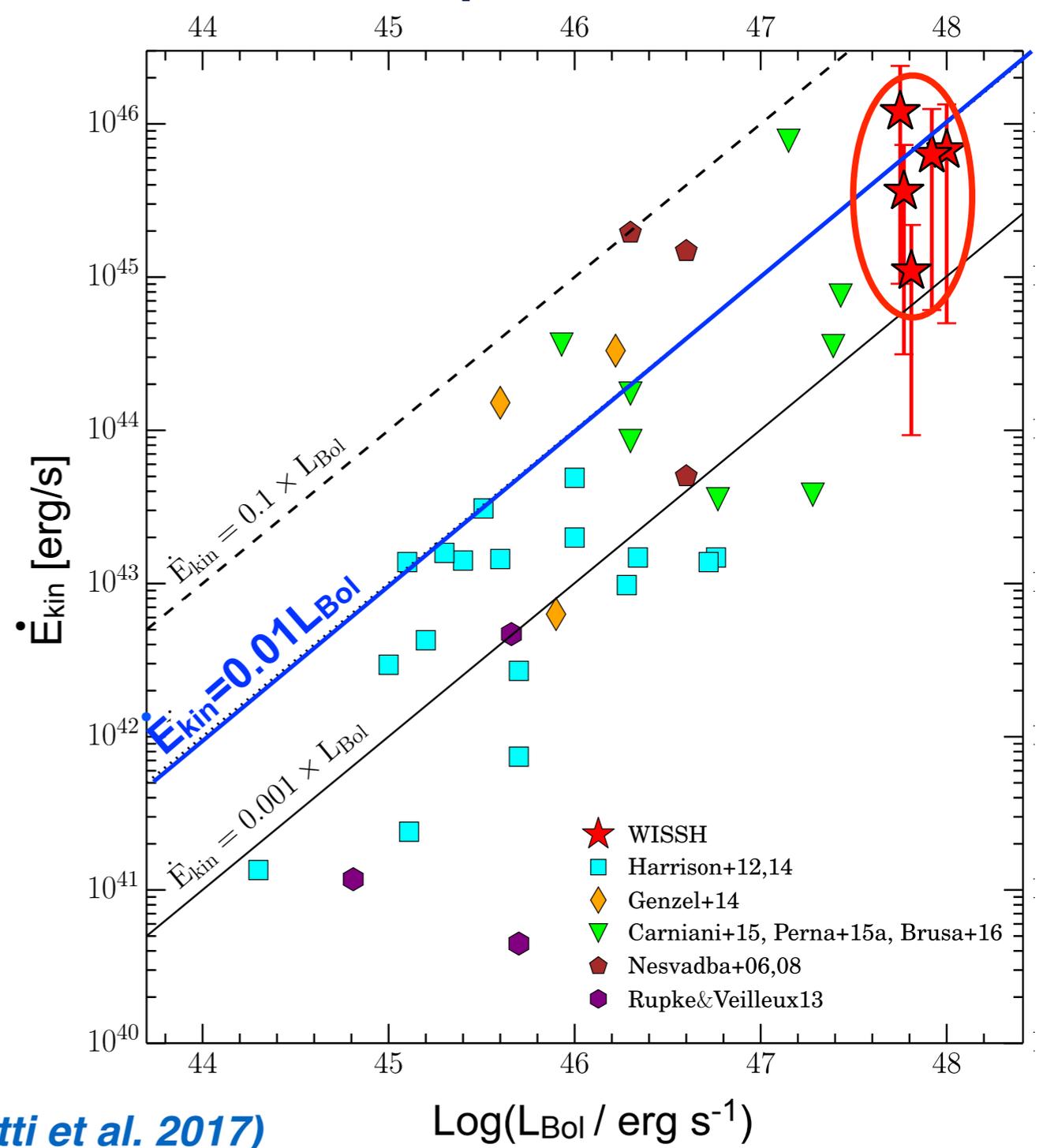
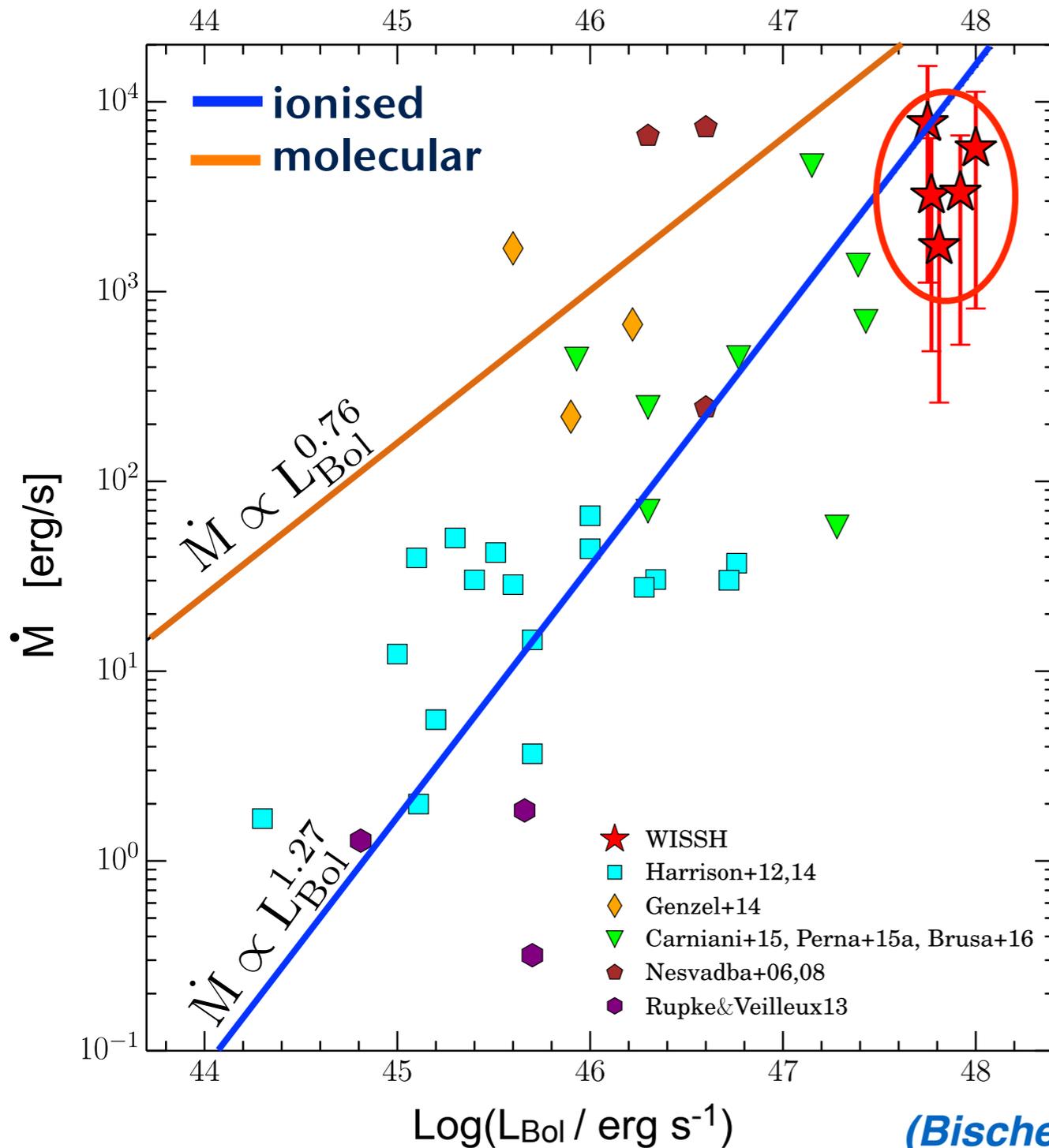
$$\dot{E}_{\text{kin}} = \frac{\dot{M} v_{\text{max}}^2}{2}$$

**At the highest  $L_{\text{Bol}}$ , the ionized outflow may trace a larger fraction of the total outflowing gas**

# Powerful [OIII] outflows in WISSH QSOs

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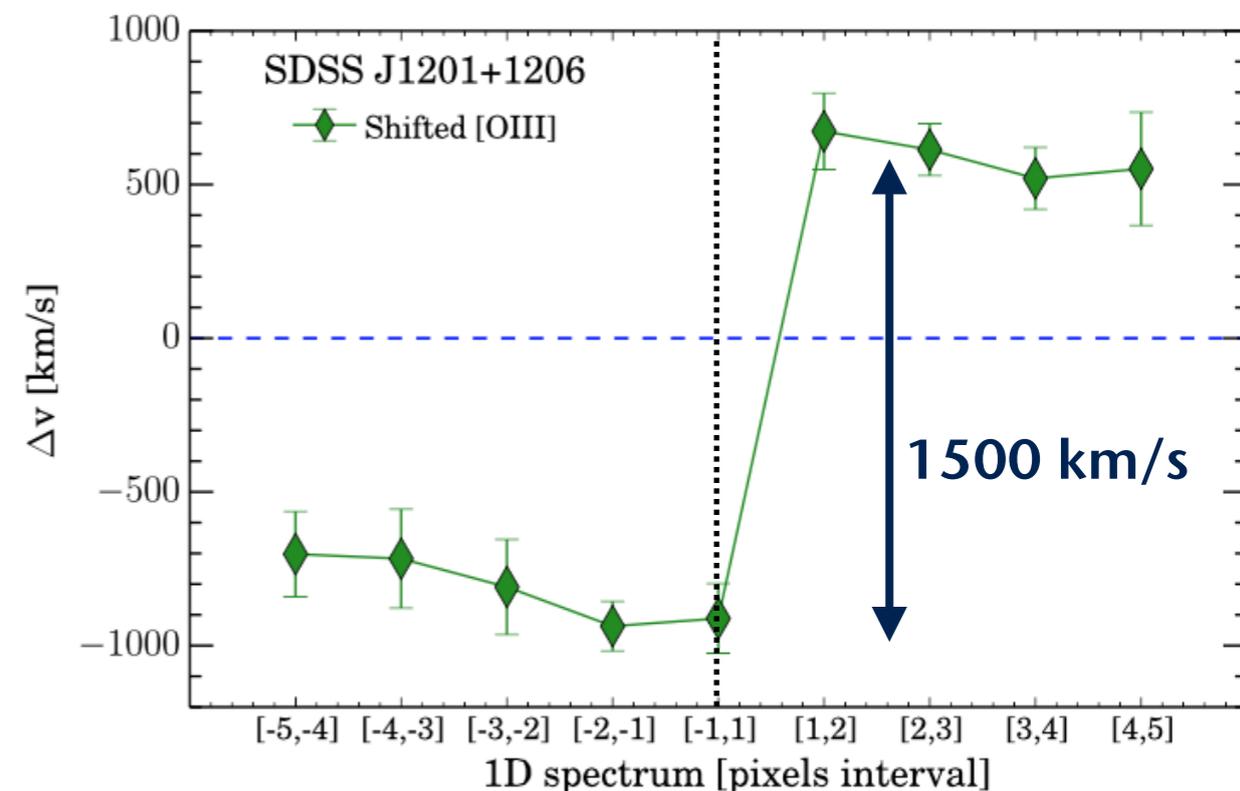
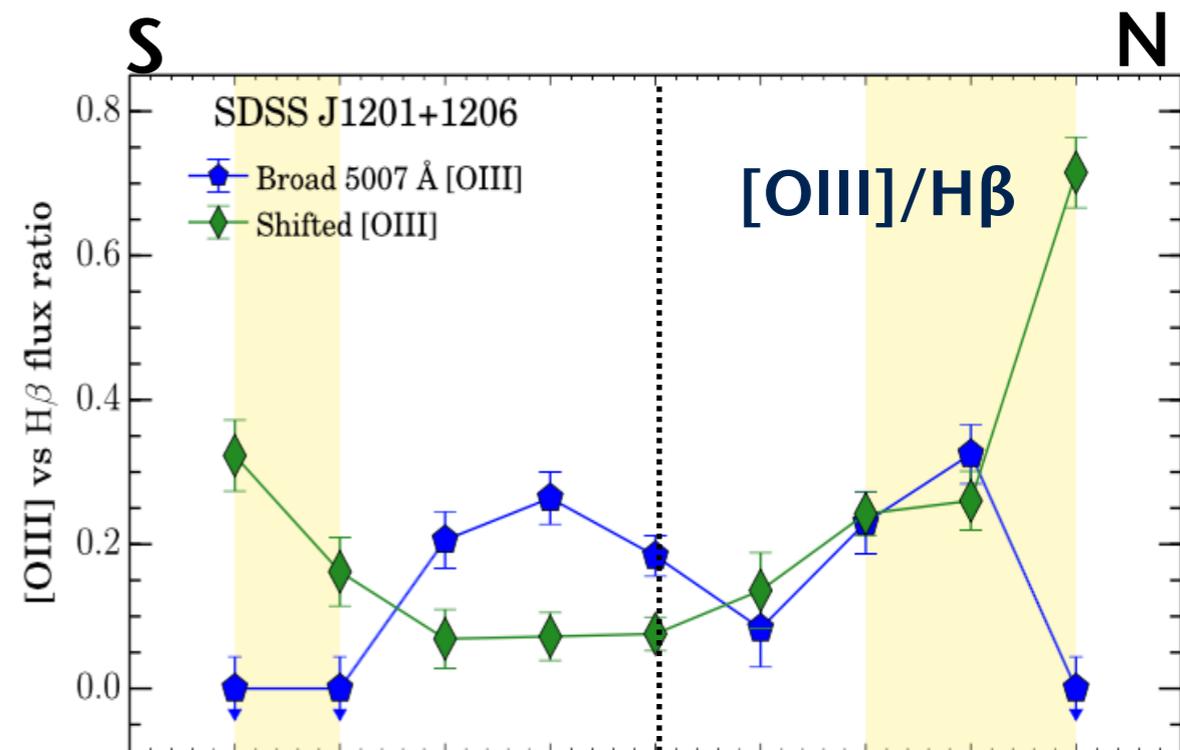
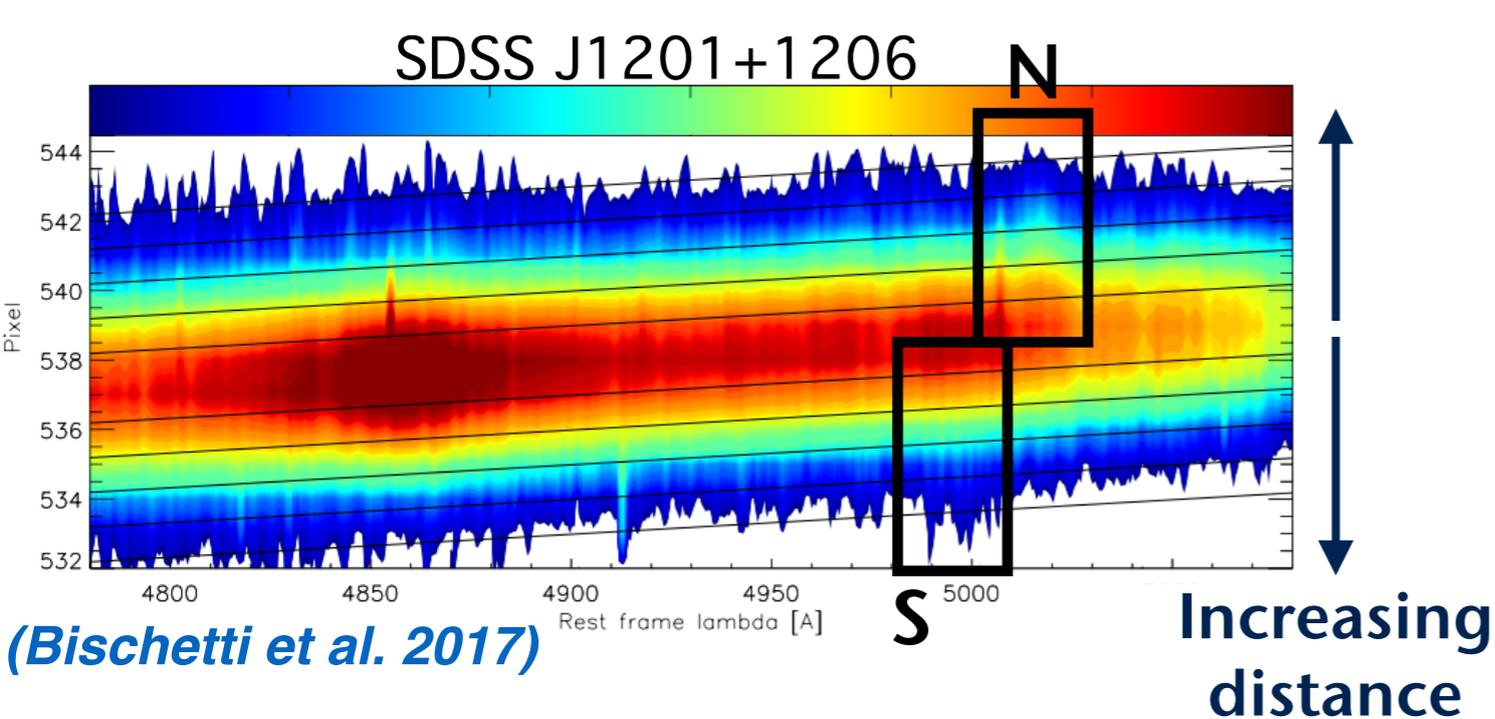
kinetic power  $\sim 1-3\% L_{\text{Bol}}$



**At the highest  $L_{\text{Bol}}$ , the ionized outflow may trace a larger fraction of the total outflowing gas**

# Kpc scale ionised outflows in WISSH QSOs

## Near-slit spectroscopy: revealing extended [OIII] emission



Increased [OIII]/ $H\beta$ (BLR) flux ratio indicating **truly extended outflowing gas** (in 2/5 sources)

Fast [OIII] emission up to  $\sim 7$  kpc

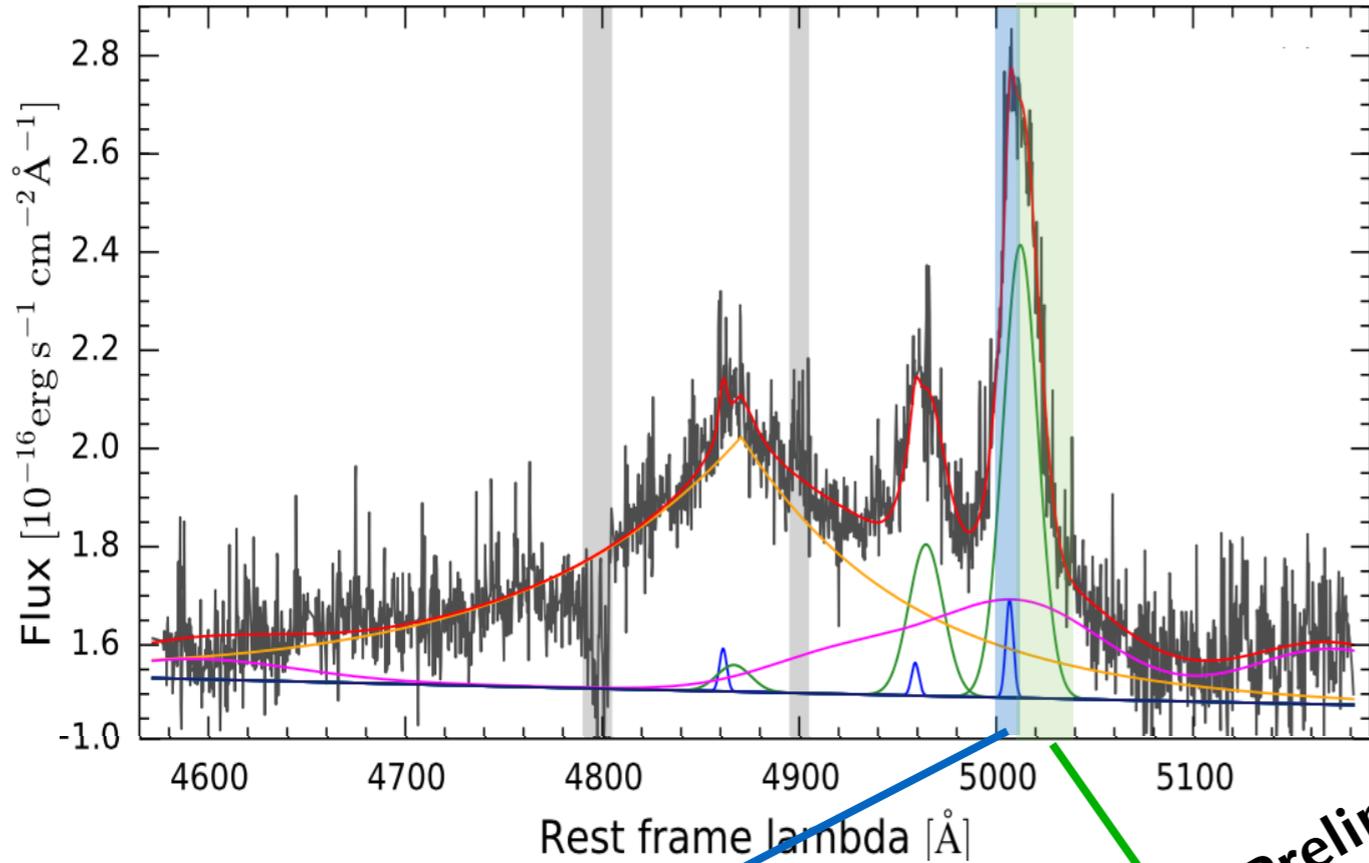
**Blue- red-shifted components** tracing a **bipolar outflow**

Increasing distance

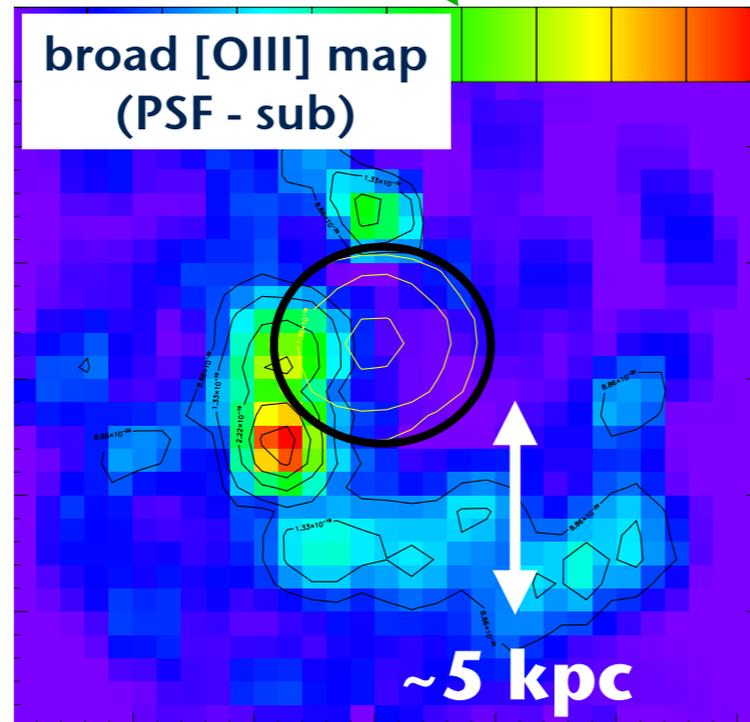
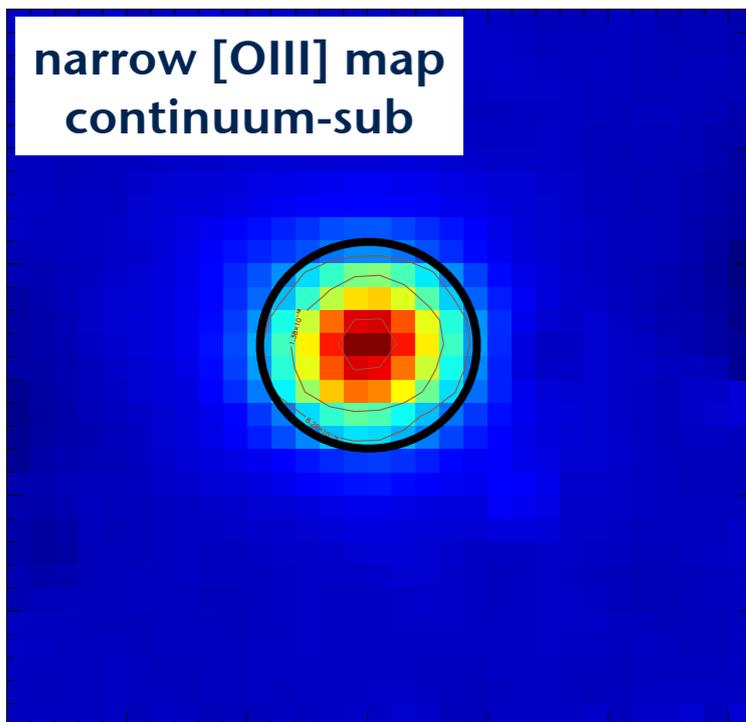
$\sim 7$  kpc

# Kpc scale ionised outflows in WISSH QSOs: IFU data

SDSS J1549+1245  $z = 2.365$



Preliminary results



$\sim 5$  kpc

$v = [+600, +1200]$  km/s

(Vietri et al. in prep)

Even where near-slit spectroscopy doesn't reveal extended emission...

VLT/SINFONI IFU spectroscopy:

- redshifted [OIII] emission
- **extended up to  $\sim 5$  kpc**

SINFONI follow-up as part of the ESO/LP SUPER  
(see *Circosta's talk tomorrow*)

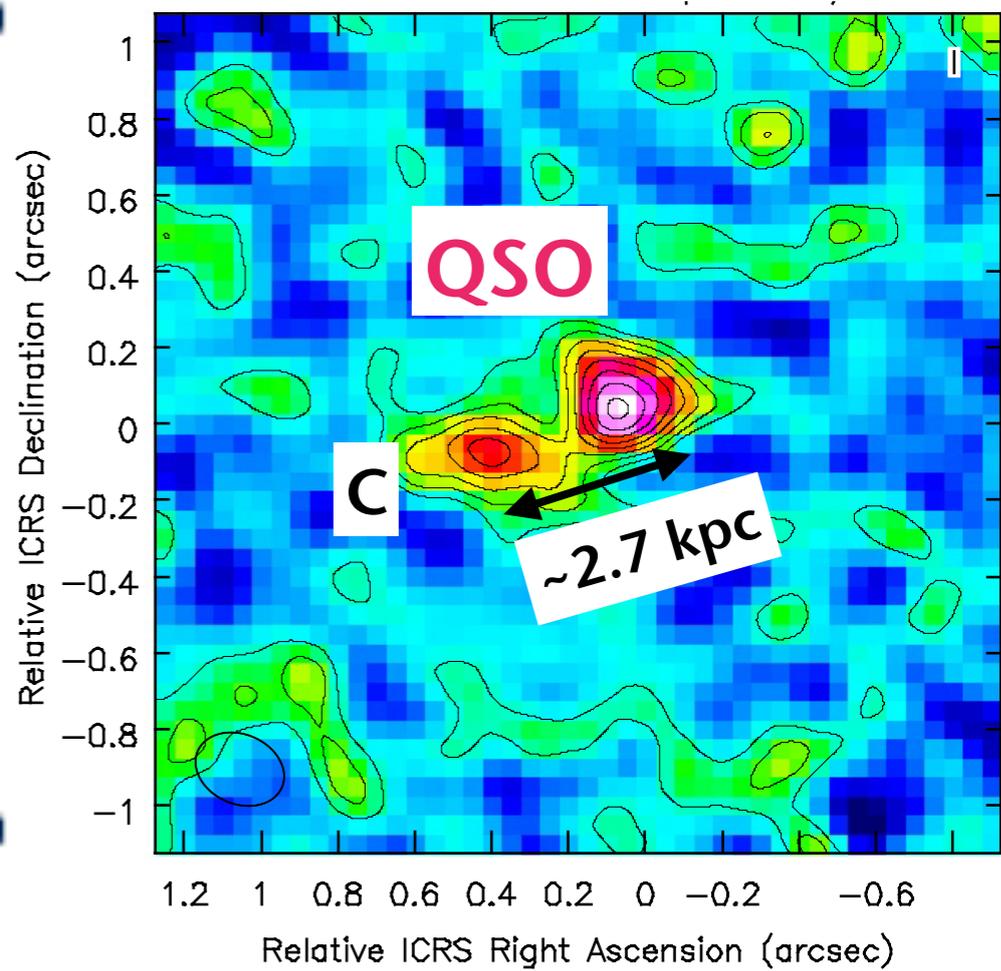
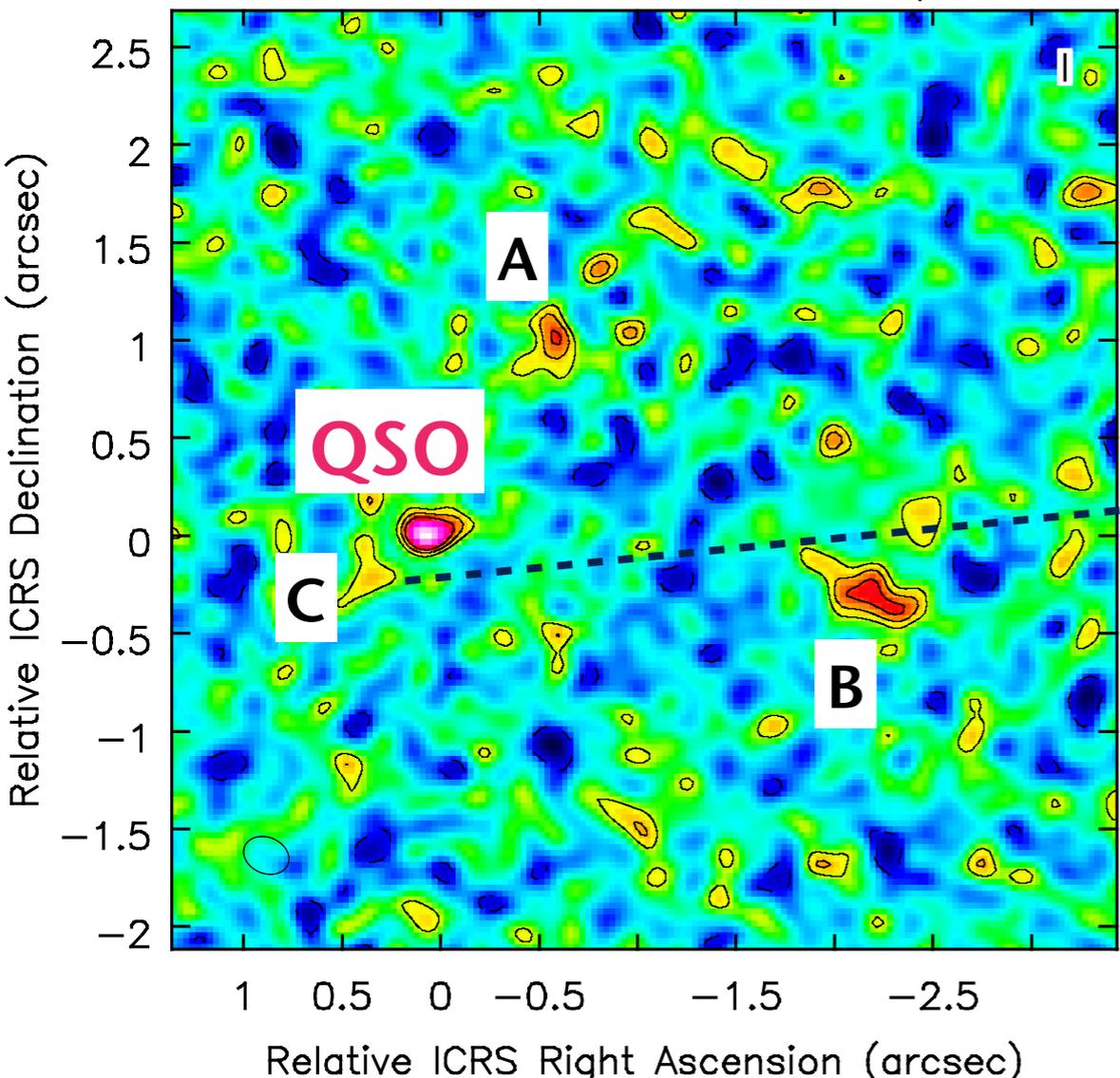
# Merger driven scenario for WISSH QSOs: ALMA view

Pilot ALMA follow up of WISSH

SDSS J1015+0020 [CII]158  $\mu\text{m}$  observations:  
Environment  
Host galaxy mass  
Fast, cold ionised gas on kpc scale

## Continuum subtracted [CII] map reveals companions

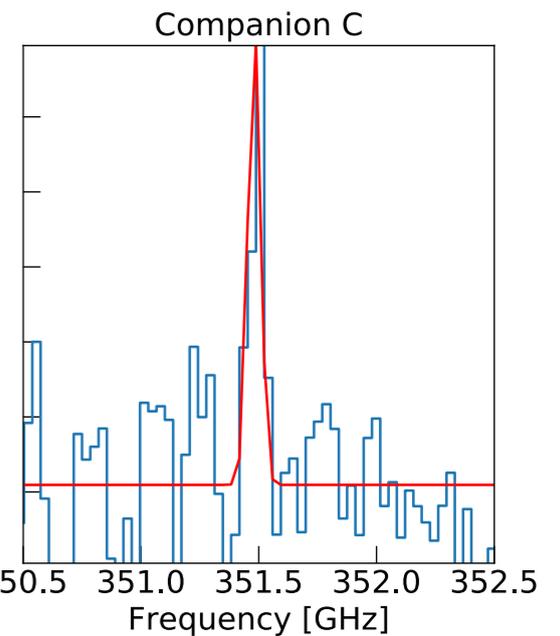
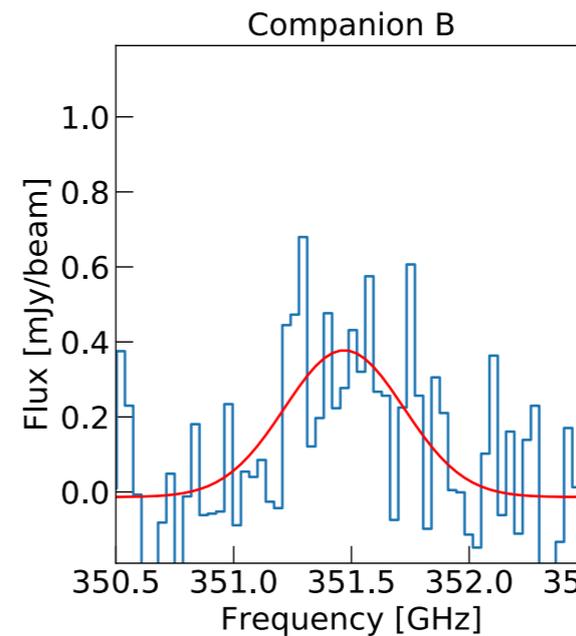
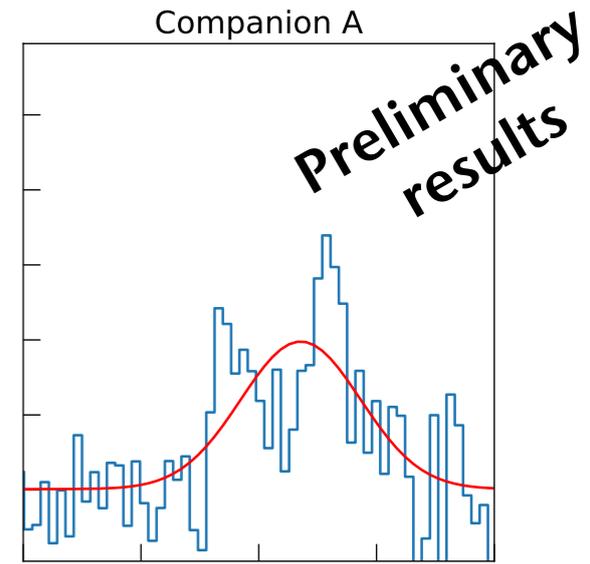
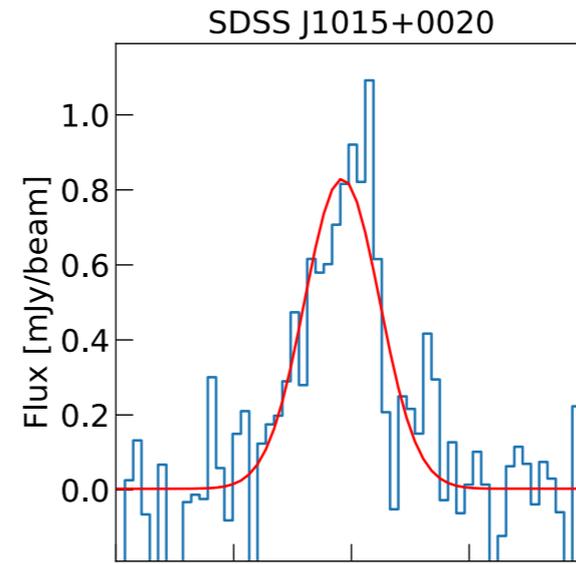
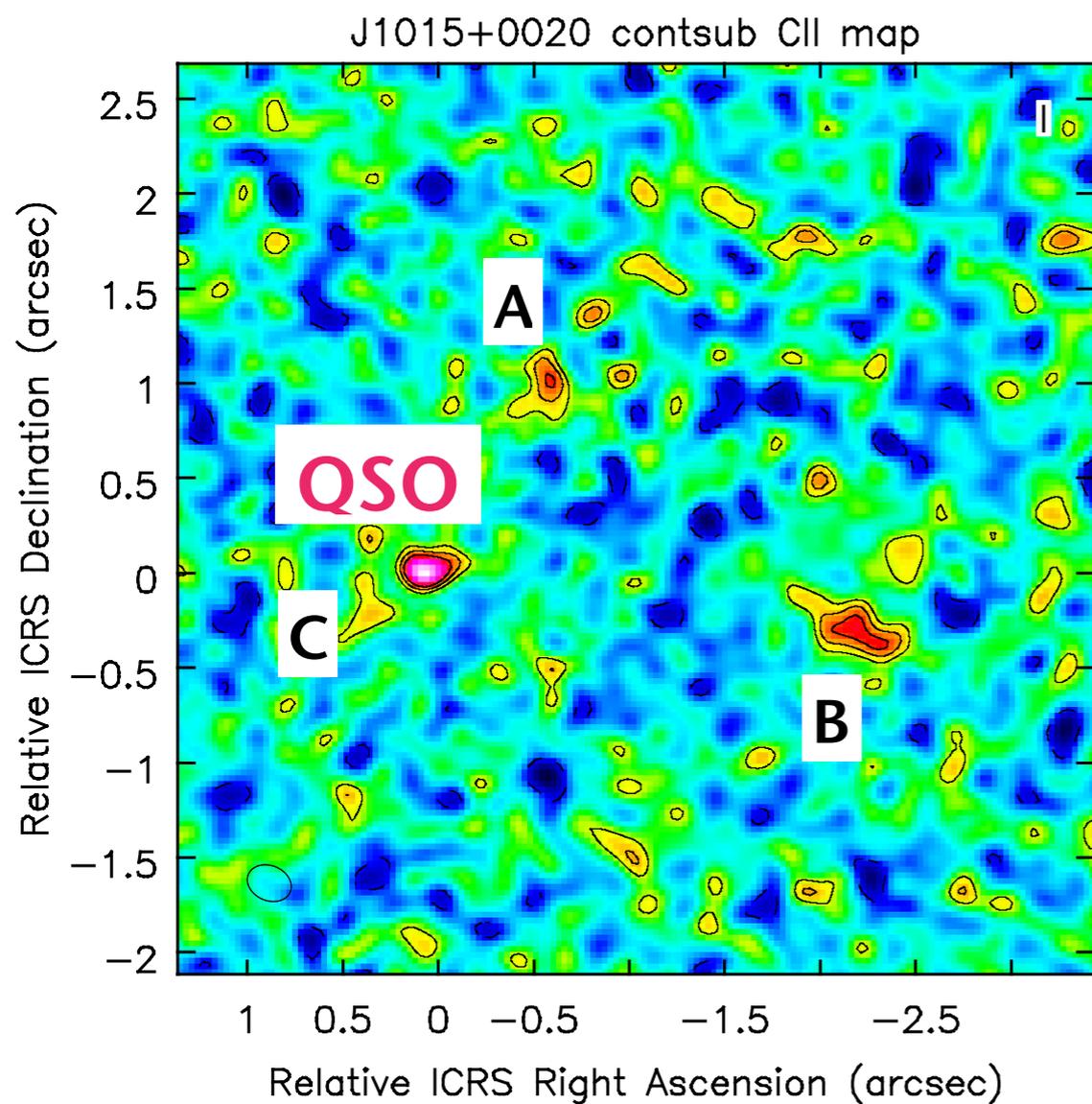
J1015+0020 contsub CII map



Preliminary results

# ALMA view of multi-phase gas in WISSH QSOs

## Continuum subtracted [CII] map of SDSS J1015+0020



*(Bischetti et al. in prep)*

[CII] lines within  $\Delta v \sim 50 - 500$  km/s  
Projected distance  $\sim 3 - 30$  kpc



**Over density of galaxies around hyper-luminous QSOs**

**Supporting a major merger-induced scenario** triggering:  
extreme SMBH accretion  
a SFR of  $\sim 1300 M_{\odot}/\text{yr}$  *(Duras et al. A&A accepted)*

# Summary & Conclusions

WISSH QSOs sample built to observe AGN feedback at its extreme: hyper-luminous QSOs confirmed as best targets to hunt for powerful AGN-driven outflows (*Bischetti et al. 2017, Duras et al. A&A accepted, Vietri et al. in prep*)

## From LBT/LUCI and VLT/SINFONI:

- Discovery of **ultra-massive** (up to  $2 \times 10^{10} M_{\odot}$ ) **highly accreting SMBH**
- Broad [OIII] lines with the **highest luminosities** observed so far
- Outflow mass rate **up to  $8000 M_{\odot}/\text{yr}$**  and kinetic power **of 1-3%  $L_{\text{BoI}}$**
- **Fast ionised gas extended up to  $\sim 5-7$  kpc** revealed so far in 3/5 sources

## From ALMA:

- The [CII] map of J1015+0020 suggests that WISSH QSOs are strongly interacting systems (at least 3 companions)
- Extreme accretion and SFR in WISSH may be likely triggered by mergers

## Ongoing:

- LBT/LUCI NIR spectroscopy: keeping on the hunt for ionised outflows
- NOEMA and ALMA follow up: assess cold gas properties in the host galaxies