

# Corrected C IV Black Hole Masses

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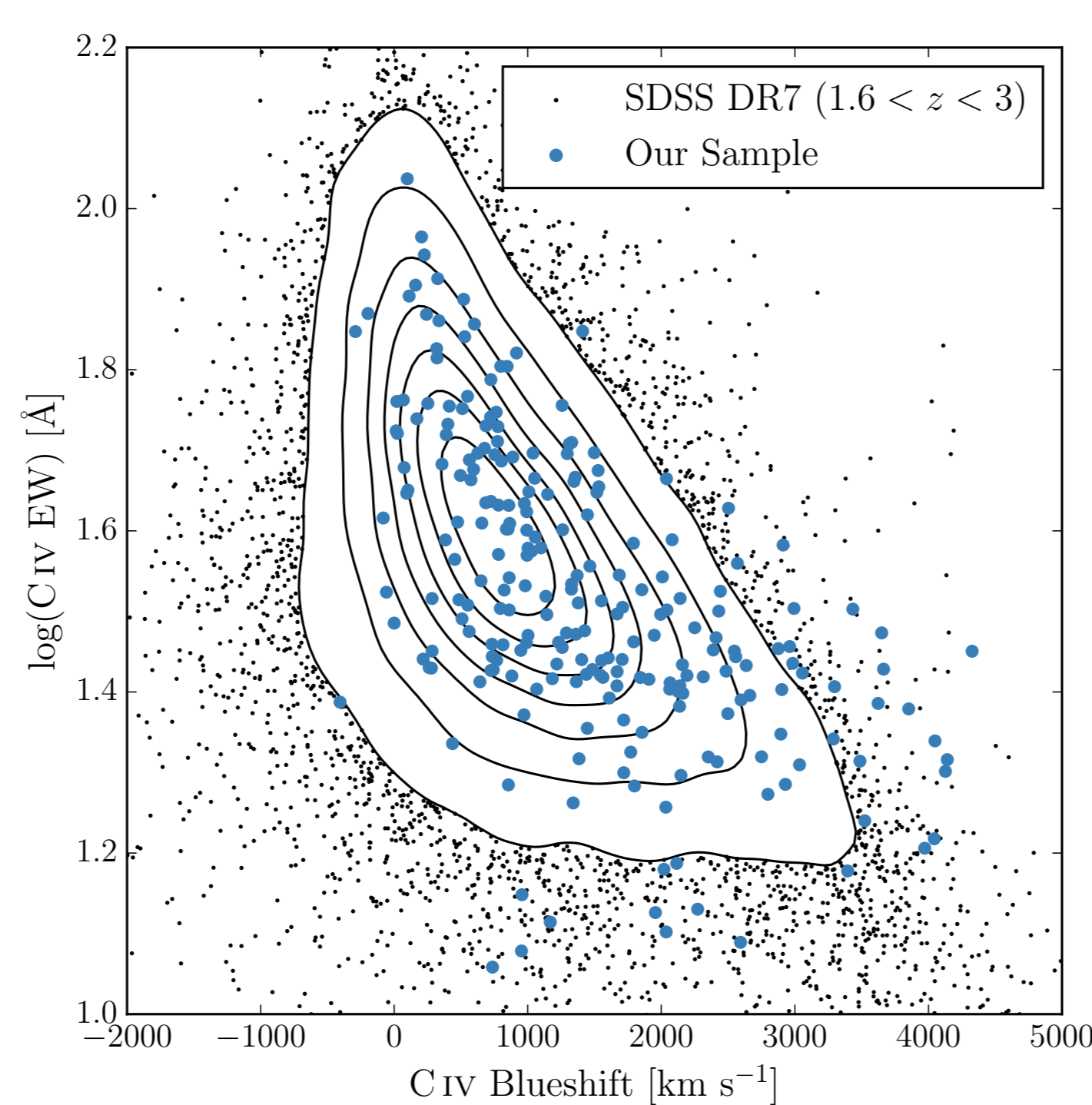


## Background

- ▶ At high redshift,  $z \gtrsim 2$ , **black hole (BH) masses are derived using the velocity-width of the C IV  $\lambda\lambda 1548, 1550$  broad emission line**, based on the assumption that the observed velocity-widths arise from virial-induced motions.
- ▶ So called 'single-epoch virial mass estimates' are calibrated via the reverberation-mapping of low- $z$  AGN.
- ▶ However, many authors have found large discrepancies when C IV-based masses are compared to masses derived from the low-ionisation H $\alpha$  and H $\beta$  lines in the same objects.
- ▶ This has cast doubt on the reliability of C IV-based BH masses.

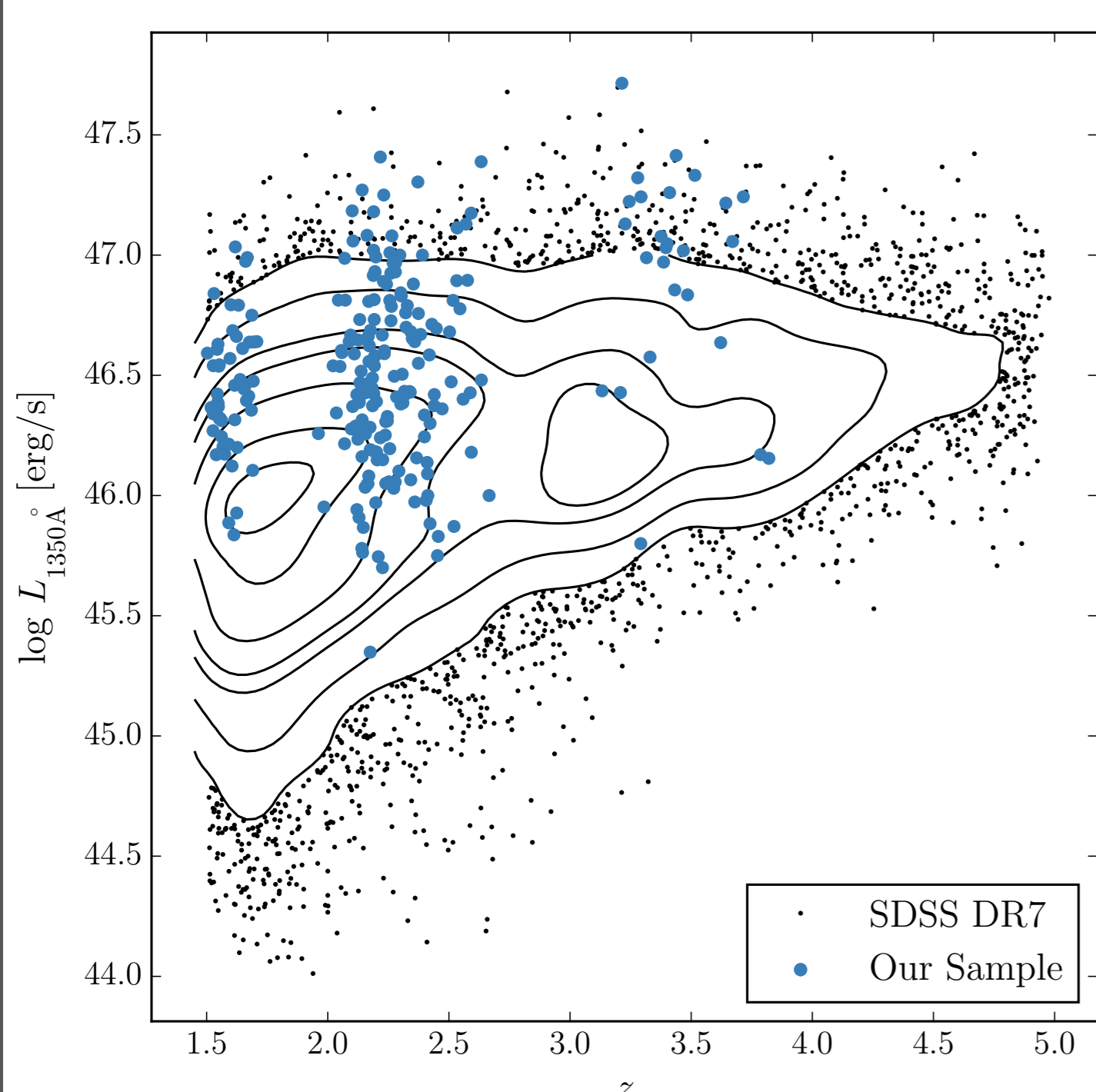
## C IV Blueshifts

- ▶ C IV exhibits a broad range of line shapes, with shifts of the line-centroid to the blue ('blueshifts') of up to several thousand  $\text{km s}^{-1}$ .
- ▶ These blueshifts signal the presence of strong outflows, most likely originating in a disc wind.
- ▶ The **non-virial wind component** makes a significant contribution to the observed FWHM in quasars with large C IV blueshifts and hence increases the inferred BH masses.



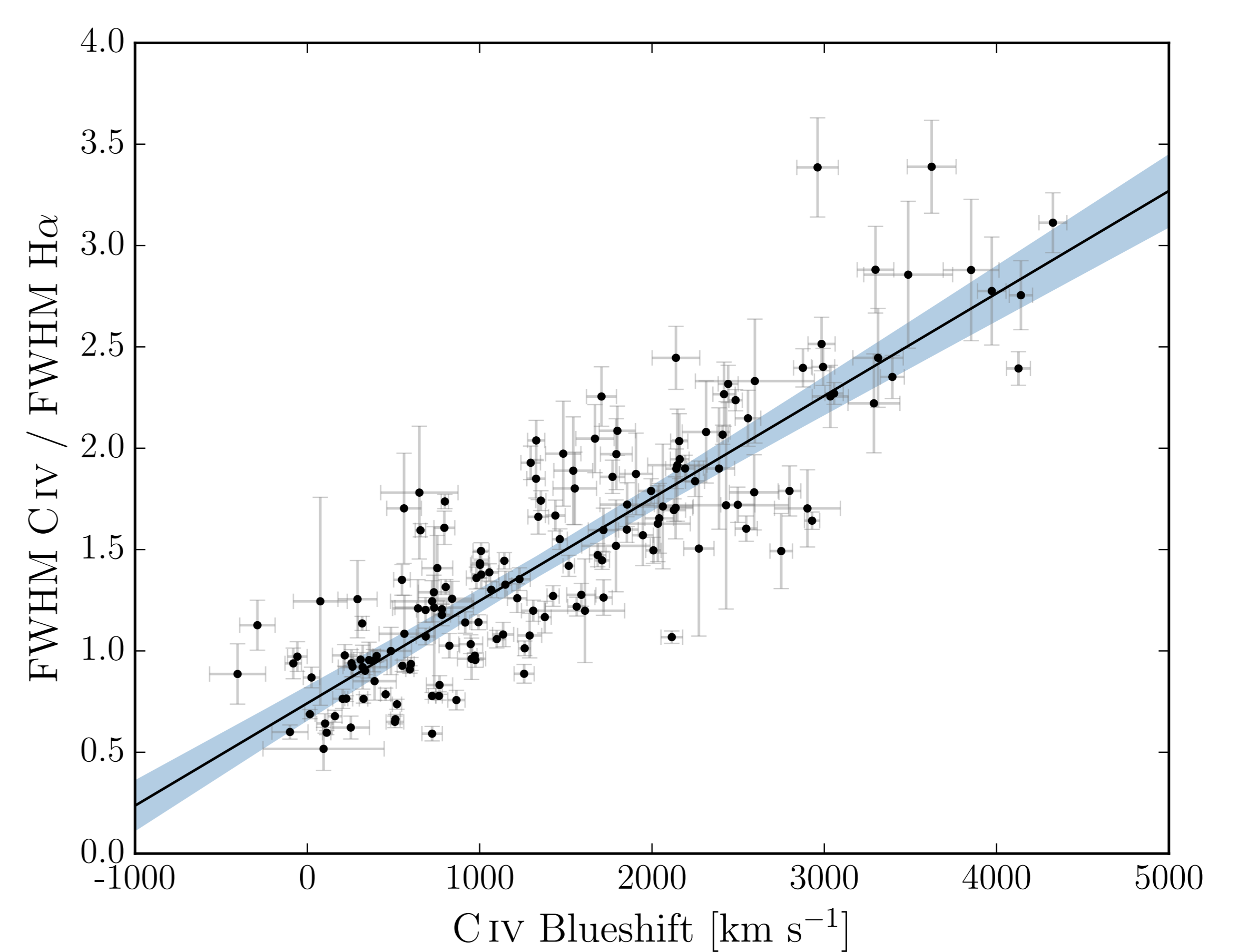
## Sample

- ▶ At these redshifts ( $z \gtrsim 2$ ) H $\alpha$  and H $\beta$  are shifted in to the near-IR band.
- ▶ By acquiring near-IR spectra the 'true' BH masses (i.e. unbiased by non-virial motions) of these quasars can be revealed.



- ▶ In Coatman et al. (2016) we found, using near-IR observations of 19 SDSS quasars, that the BH masses of quasars with large C IV blueshifts are being severely overestimated.
- ▶ We have now **obtained near-infrared spectra, including H $\alpha$ , for 164 quasars** at redshifts  $1.5 < z < 4$  (the majority from SDSS/BOSS).
- ▶ These quasars have C IV blueshifts spanning the full range observed in the population.

## Results



- ▶ For the quasars with the largest blueshifts, the BH masses based on C IV can be **overestimated by a factor of  $\sim 9$** .
- ▶ The systematic in the C IV masses cannot be corrected by changing the exponent on the FWHM or the overall scaling in standard virial relations.
- ▶ The scatter between the C IV and H $\alpha$  velocity widths is tightly correlated with the C IV blueshift.
- ▶ This means that the blueshift information can be used to correct for the non-virial contribution to the C IV FWHM.

## Correction Formula

$$\text{FWHM}(\text{C IV, Corrected}) = \frac{\text{FWHM}(\text{C IV, Measured})}{(0.51 \pm 0.02) \left(\frac{\text{C IV Blueshift}}{10^3 \text{ km s}^{-1}}\right) + (0.74 \pm 0.04)}$$

## Conclusion

- ▶ With this formula, single-epoch virial BH mass estimates can now reliably be applied at high- $z$ , using only information from the rest-frame UV spectrum.
- ▶ In a forthcoming paper, corrected C IV-based virial BH masses will be provided for all  $z \gtrsim 2$  quasars in SDSS/BOSS.

## References

- [1] Coatman L., Hewett, P. C., Banerji M., Richards G., 2016, MNRAS in press, arXiv 1606.02726
- [2] Coatman L., Hewett, P. C., Banerji M., Richards G., Hennawi J., Prochaska J. X., in preparation

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## Example Line Fits (in order of increasing C IV blueshift)

