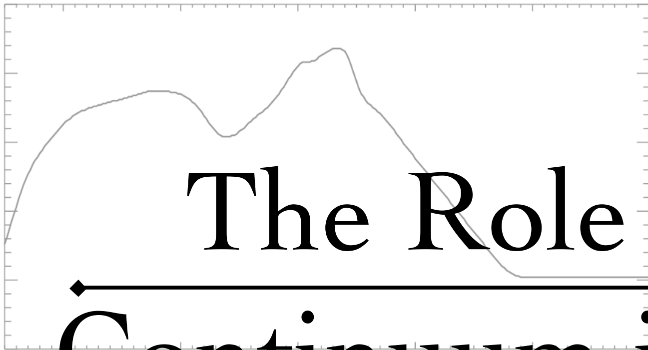
The Role of the High Energy Continuum in Quasar Disk Winds



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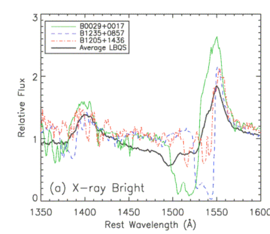
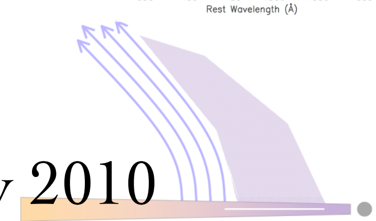
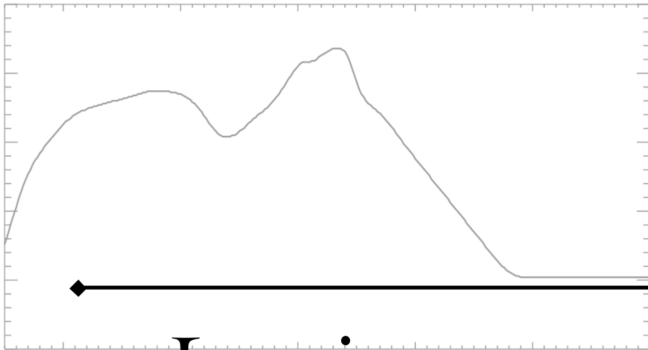




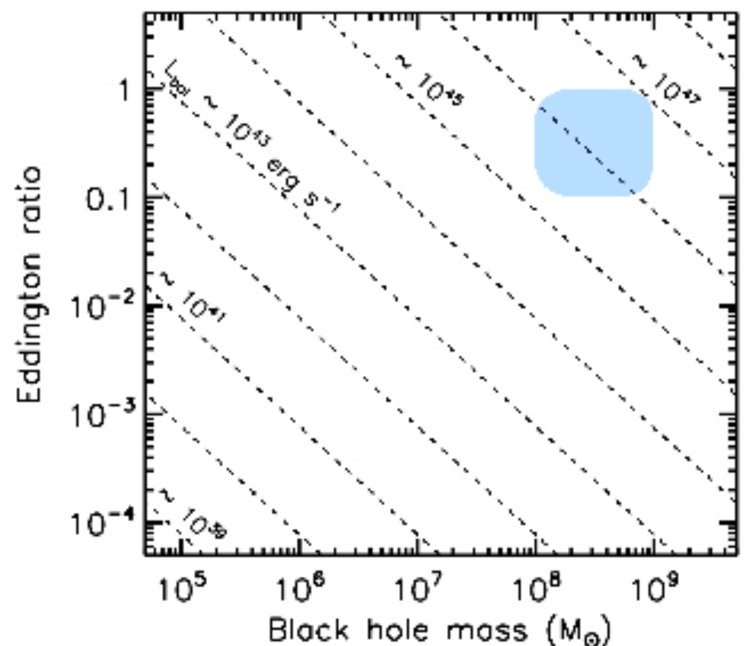
What Drives the Growth of Black Holes? — July 2010

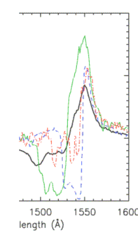


Focus

- Luminous quasars
  - – big black holes
  - – high L/L_{Edd}
- z~2

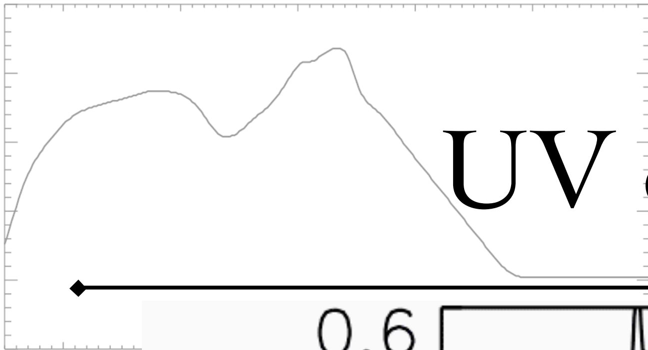
→ The systems where feedback in massive, cold gas-rich galaxies will happen.

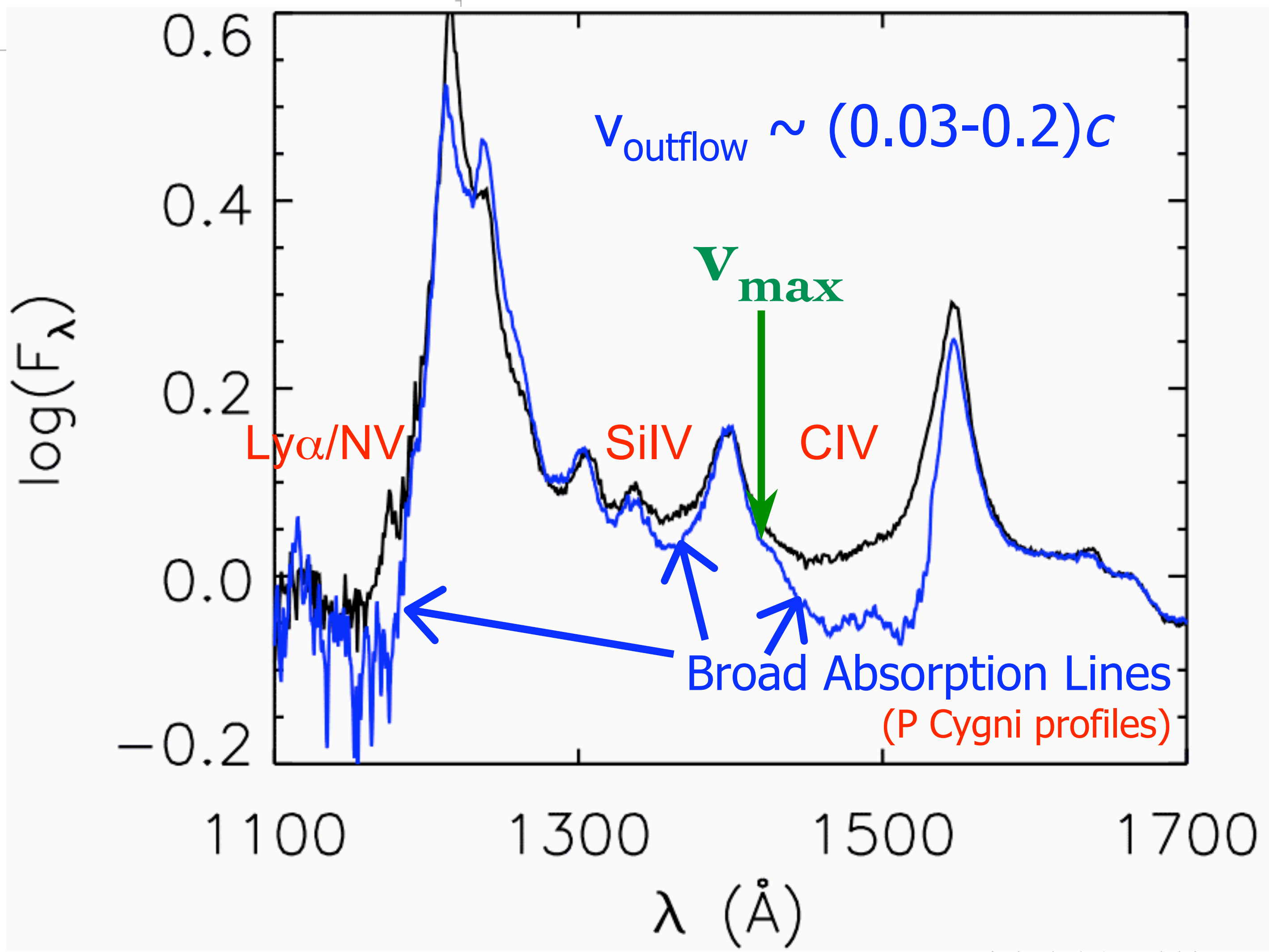


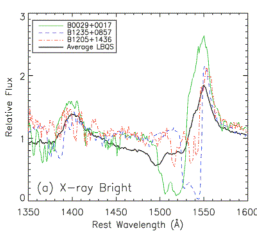


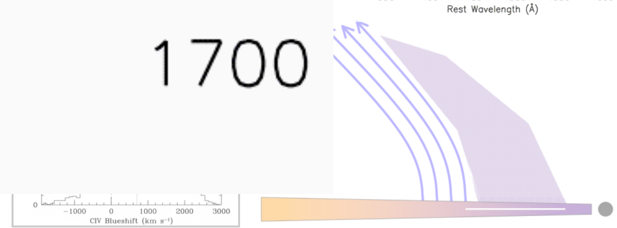
"AGN feedback is a more subtle & sophisticated process than it is generally given credit for." - C. Power, Monday talk

UV quasar spectra

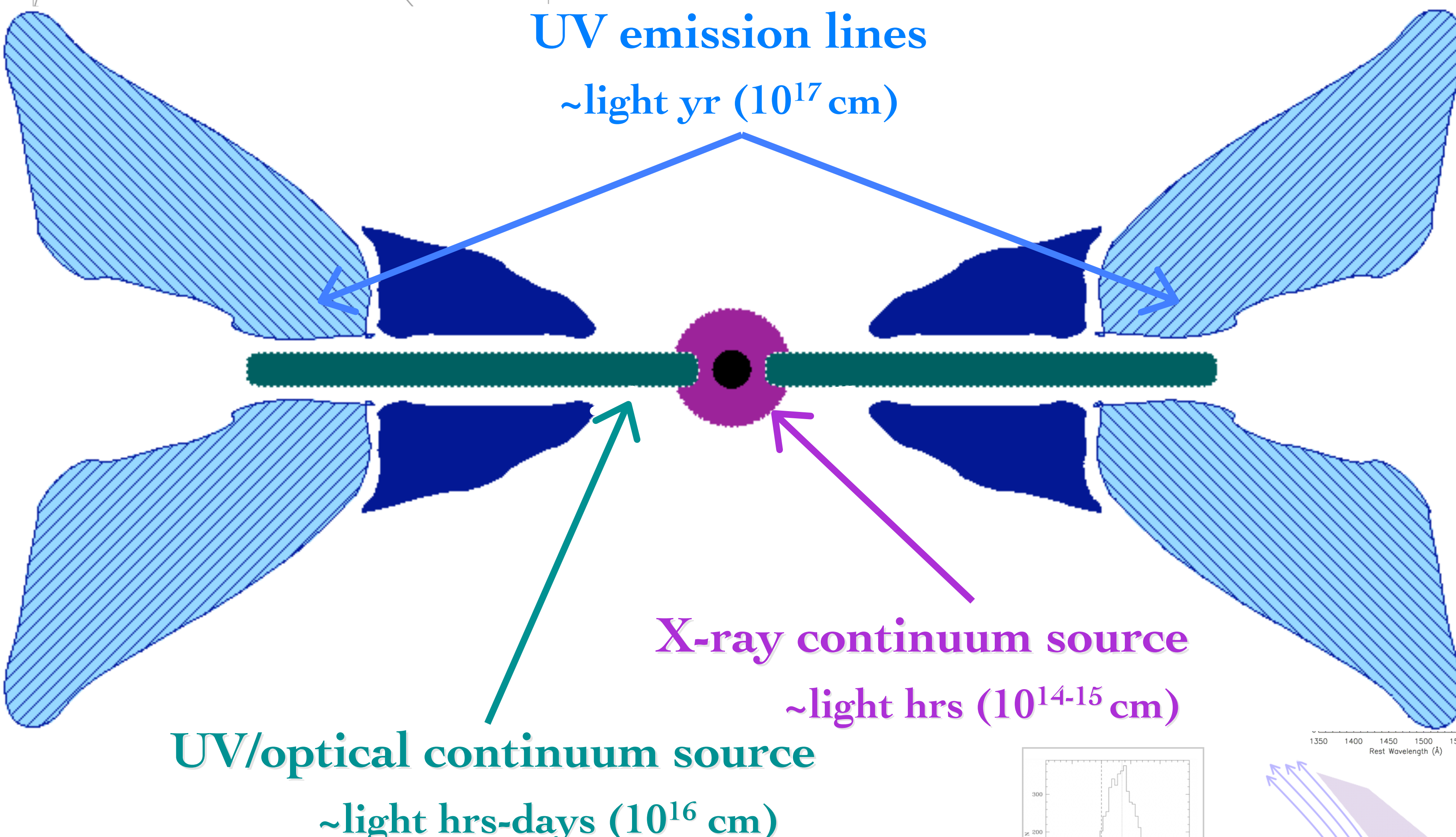




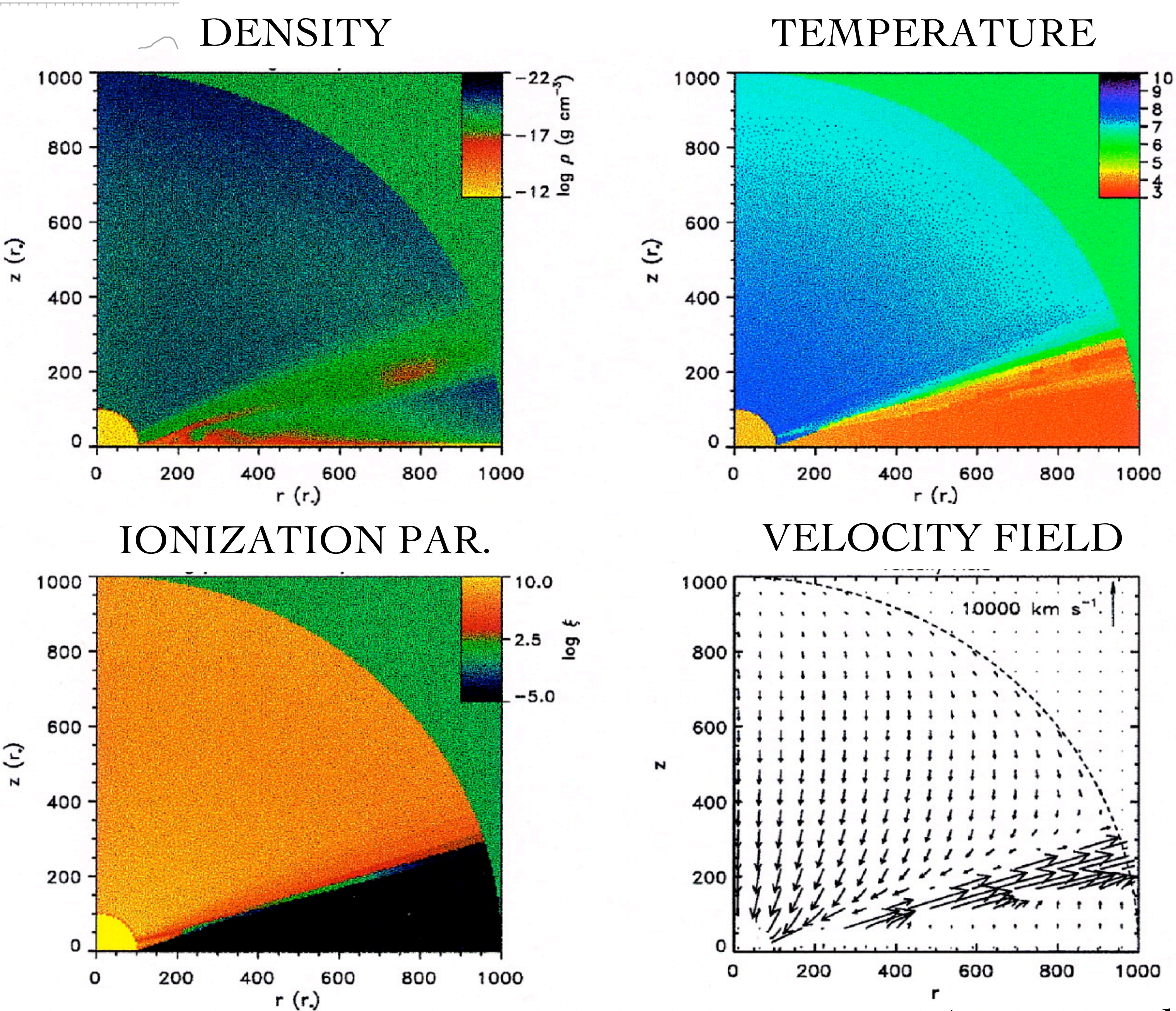




A paradigm for (most) radio-quiet quasars

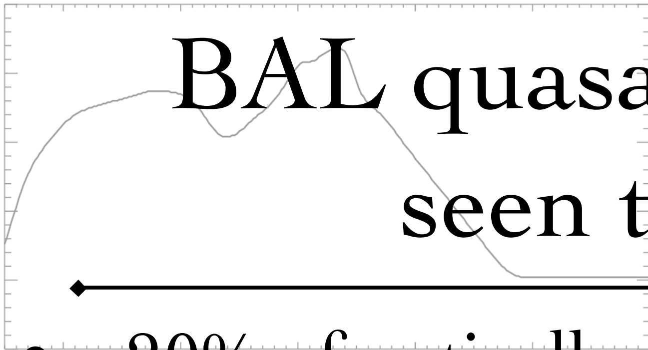


(Gallagher et al. 2002a: Adapted from Königl & Kartje 1994; Murray et al. 1995)



(Proga et al. 2000)

BAL quasars are normal quasars seen through the wind

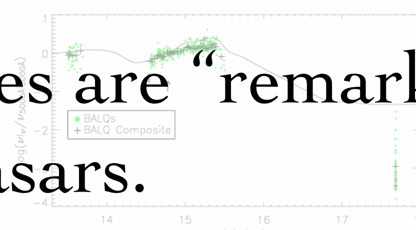


- ~20% of optically selected quasars show BALs.

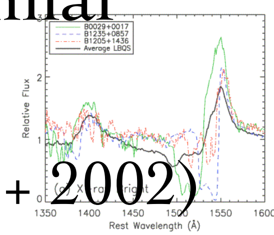
  (Hewett & Foltz 2003; Dai+ 2007; **see Allen+ poster**)

- From spectropolarimetry and emission-line studies, the covering fraction is constrained: **f_{cov} =10-50%**

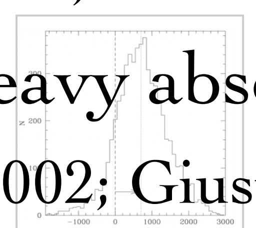
  (e.g., Hamann+ 1993; Hines & Wills 1995; Goodrich 1997; Ogle+ 1999)

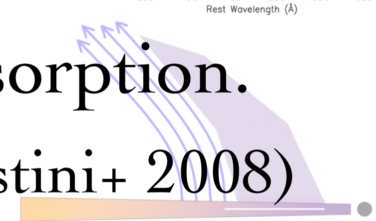


- UV emission line properties are "remarkably similar" to classes of non-BAL quasars.



  (Weymann+ 1991; Richards+ 2002)

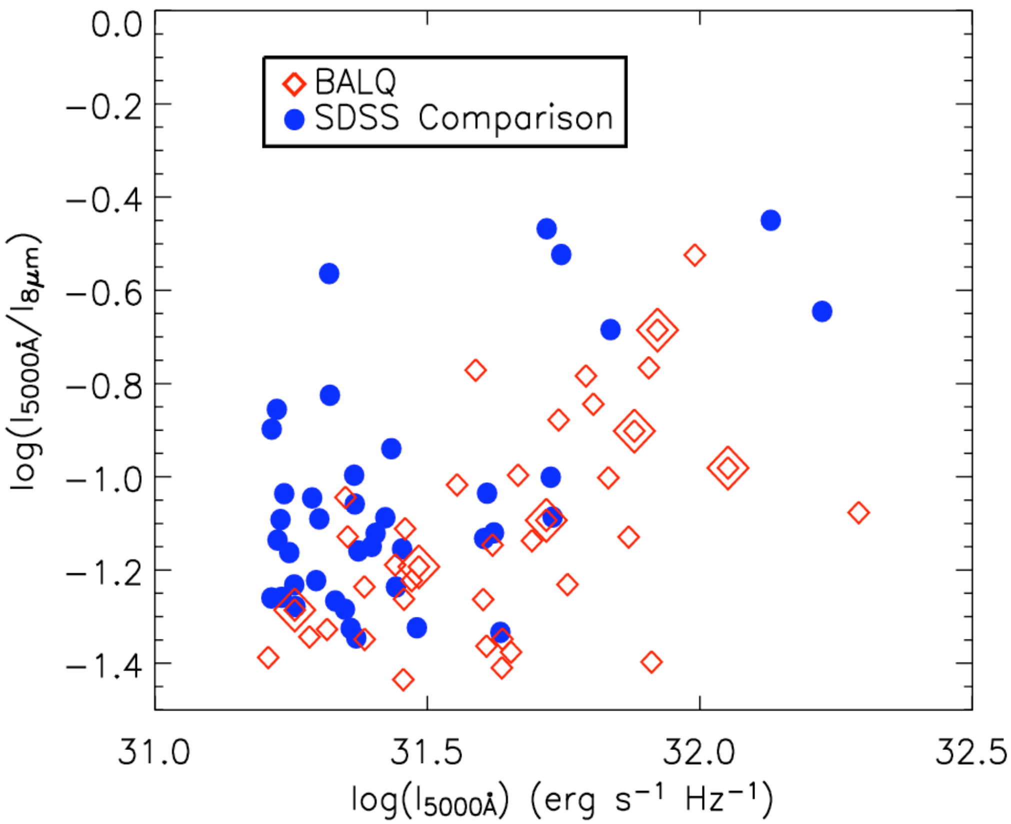


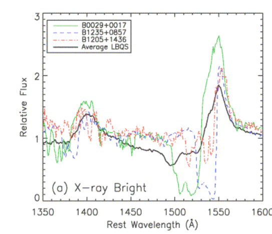


- X-ray properties are normal under heavy absorption.

  (e.g., Gallagher+ 2001, 2002; Giustini+ 2008)

From mid-IR: BAL quasars are normal quasars seen through the wind

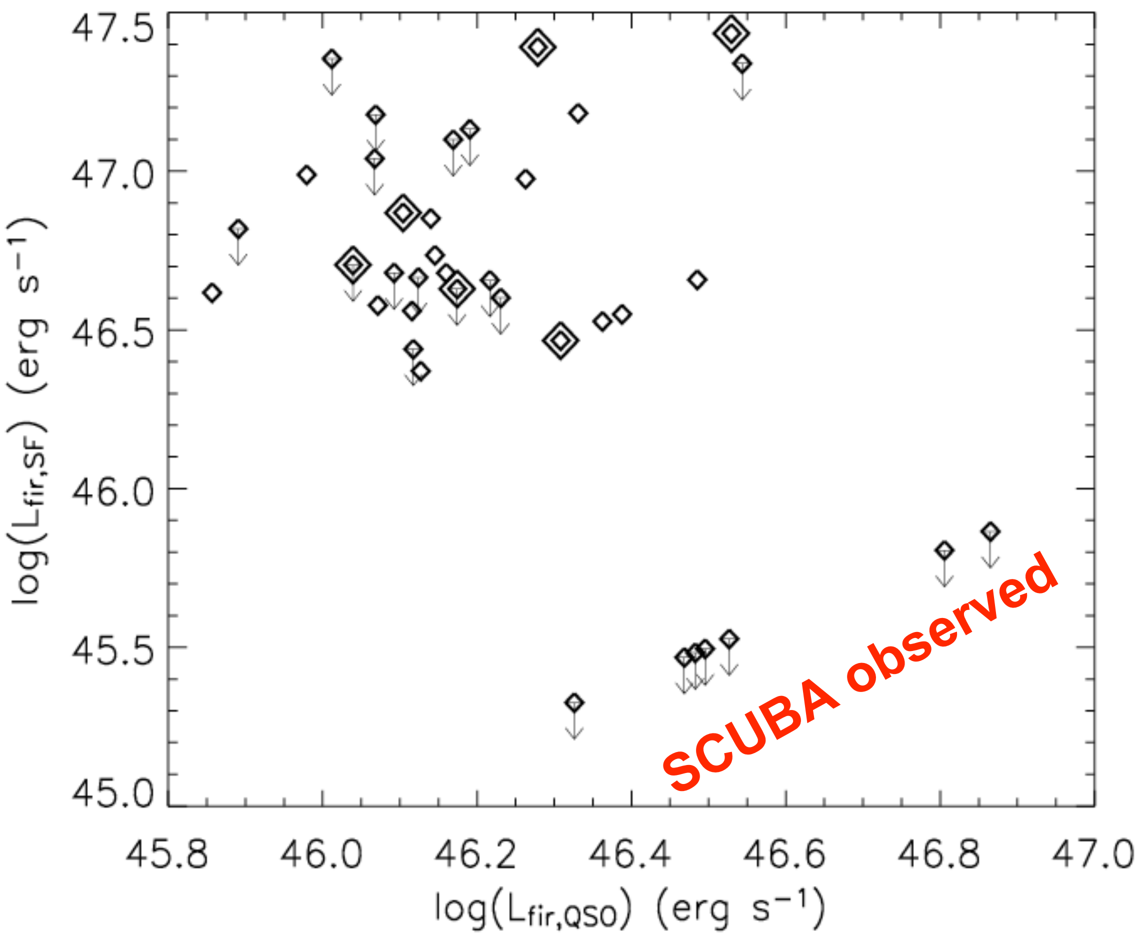


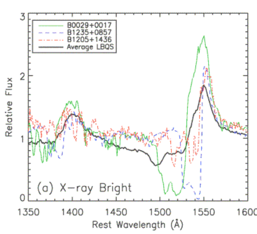


Their IR power ***is the same*** as other comparably luminous quasars; i.e., there is no evidence for dusty "enshrouding".

(Gallagher et al. 2007)

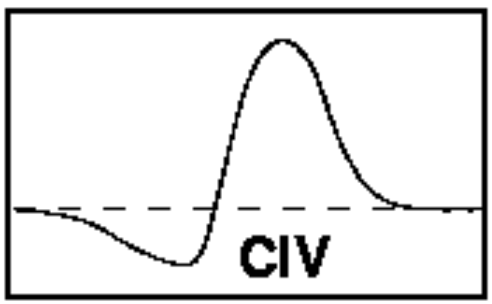
No evidence for enhanced SF in BAL quasars as a class



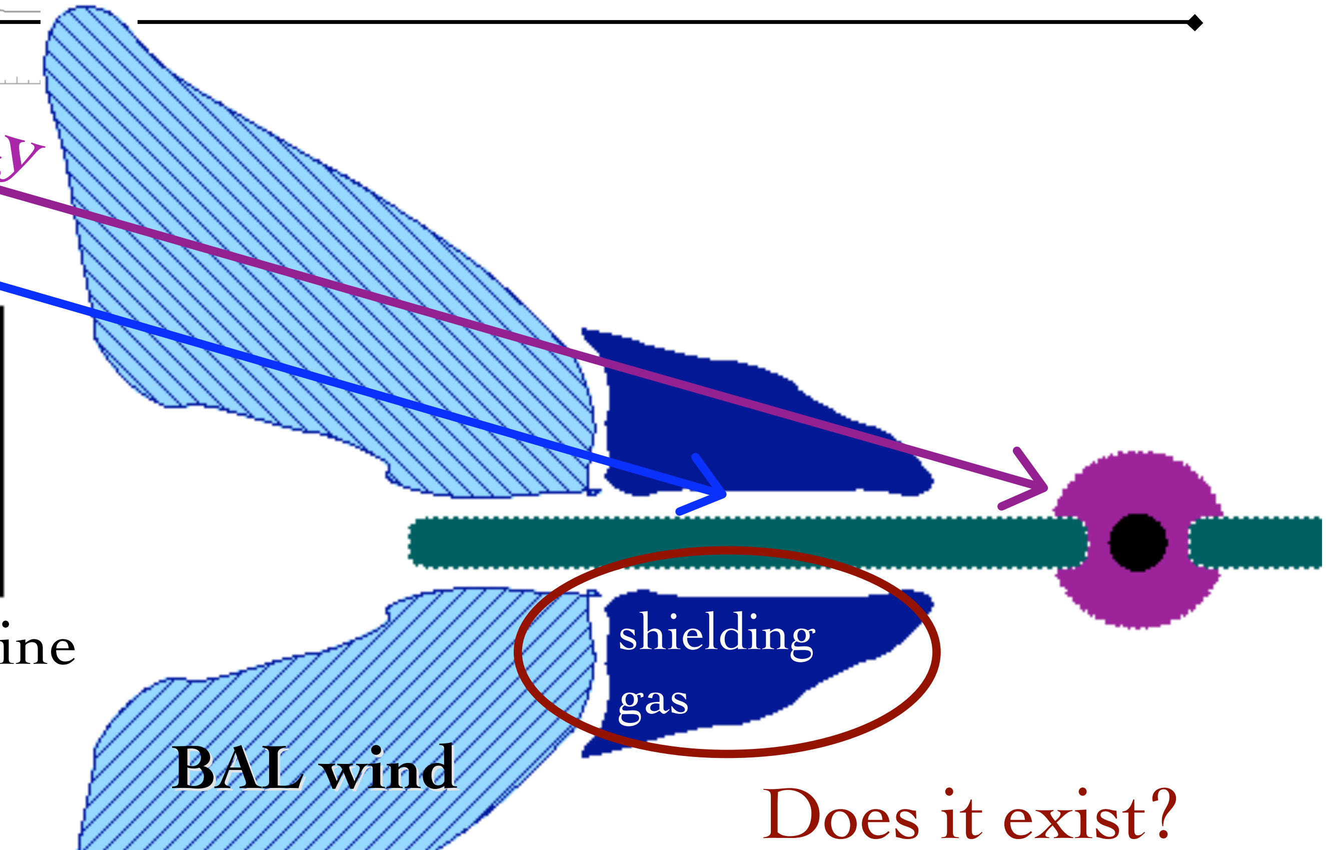


(Gallagher et al. 2007)

Two views through the wind



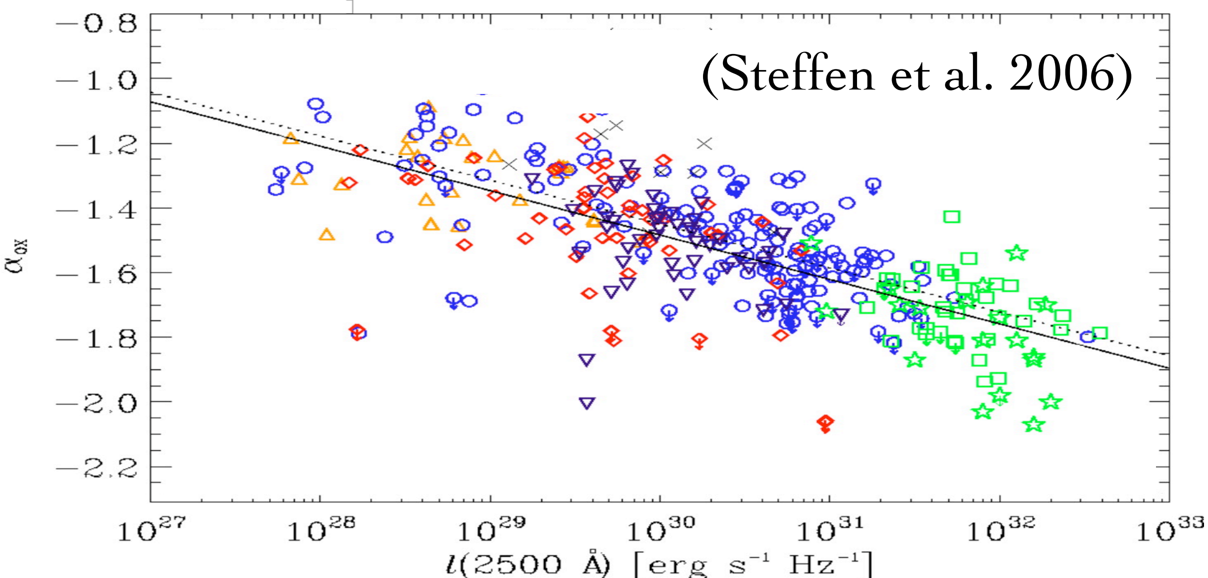
Broad Absorption Line (BAL) Quasars



Shielding gas is *required* to drive gas radiatively from small radii.

(Murray et al. 1995)

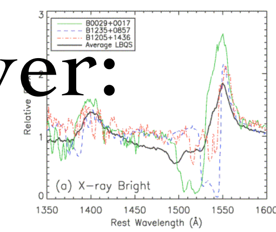
UV-luminous quasars are relatively X-ray faint



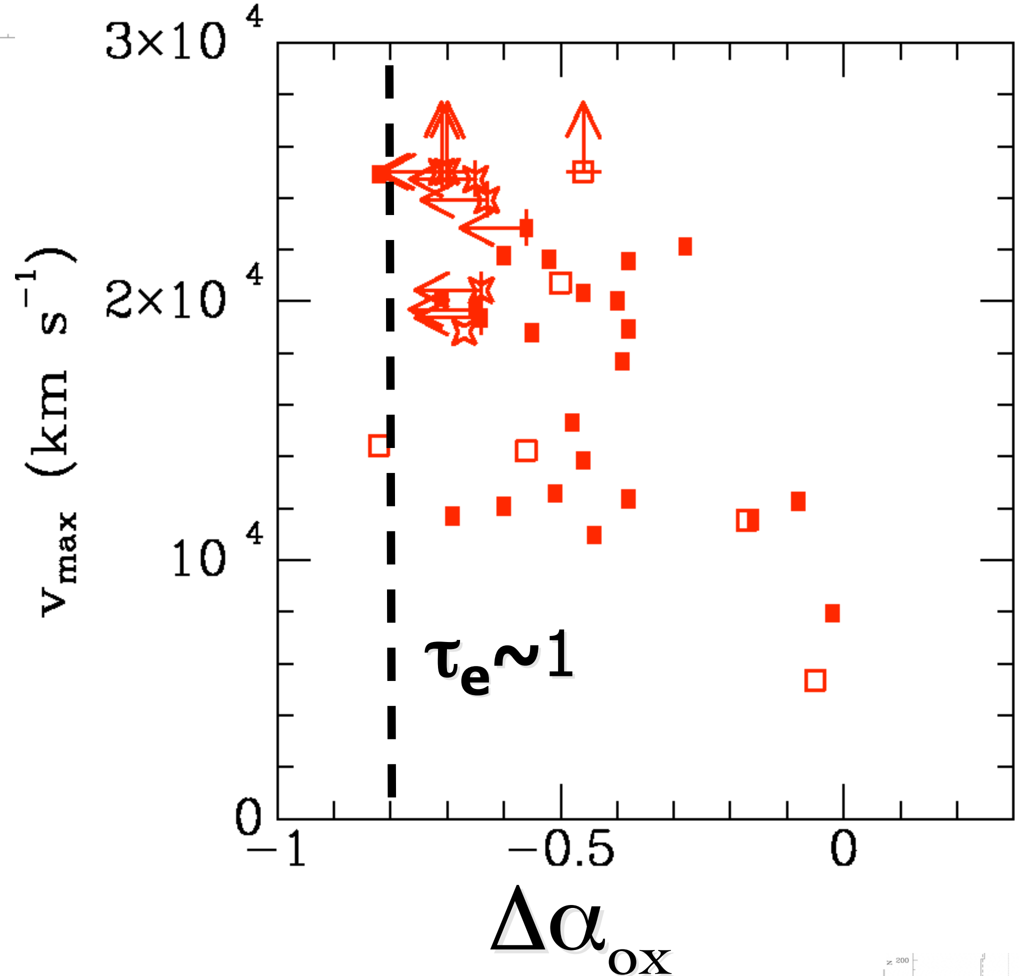
Measure of relative X-ray to UV power:

$$\alpha_{ox} = 0.384 \log (L_{2\ keV} / L_{2500\ Å})$$

$$\Delta\alpha_{ox} \equiv \alpha_{ox} - \alpha_{ox}(L_{uv})$$



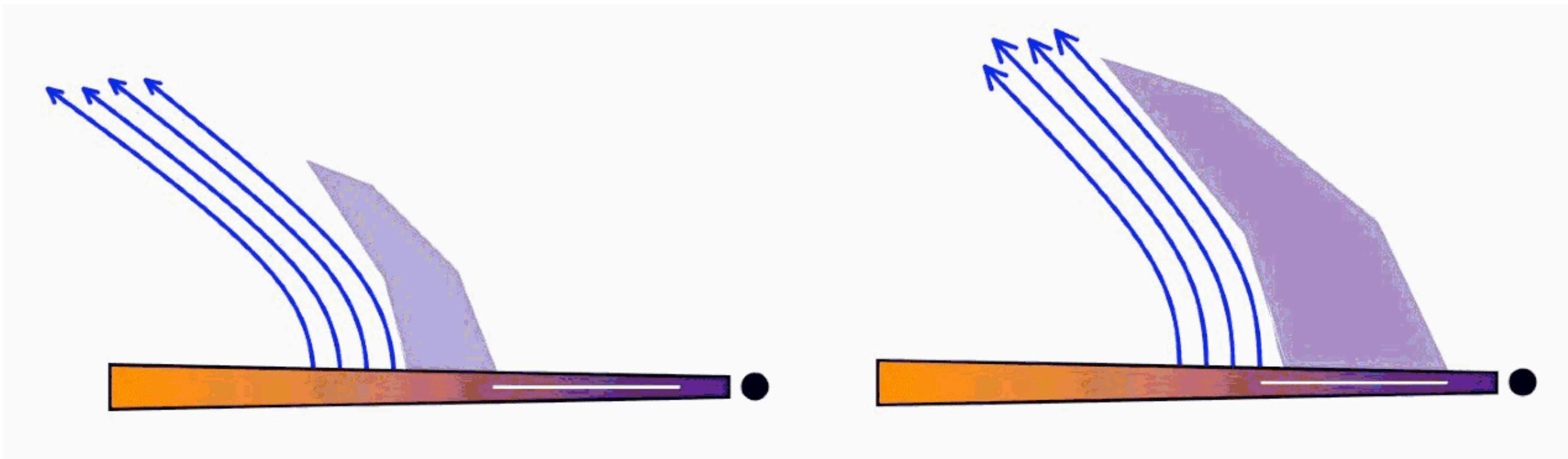
Wind terminal velocity, v_{term}, vs. X-ray weakness, $\Delta\alpha_{ox}$, for 35 BAL quasars



(Gallagher et al. 2006; Gibson et al. 2009)

Link between shielding gas and v_{max}

thinner shield → less X-ray weak **thicker shield → more X-ray weak**

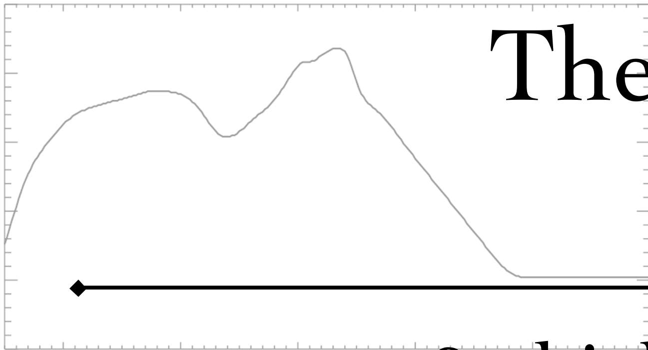


larger R_{launch} → lower v_{term} **smaller R_{launch} → higher v_{term}**

(Gallagher et al. 2006; Gallagher & Everett 2007)

$$v_{term} \sim (GM_{BH}/R_{launch})^{1/2}$$

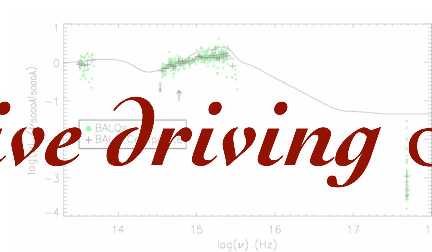
(cf. Chelouche & Netzer 2000; Everett 2005)



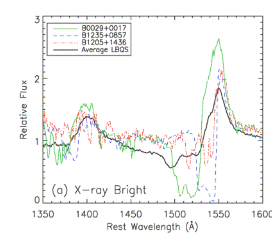
The shielding gas: it exists!

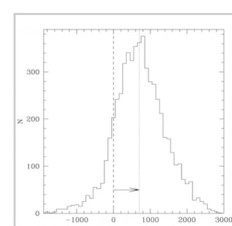
- compact & thick ‘X-ray—only’ absorbers
  - some absorbers appear to be Compton-thick!
    - (τ_e ~ 1; N_H ~ 1.5x10^{24} cm^2)
- correlation of v_{max} & $\Delta\alpha_{ox}$

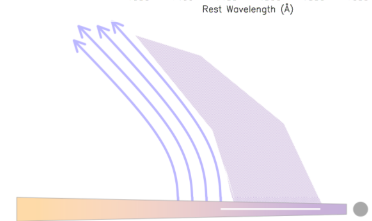
(see also Gibson et al. 2009; Fan et al. 2009)



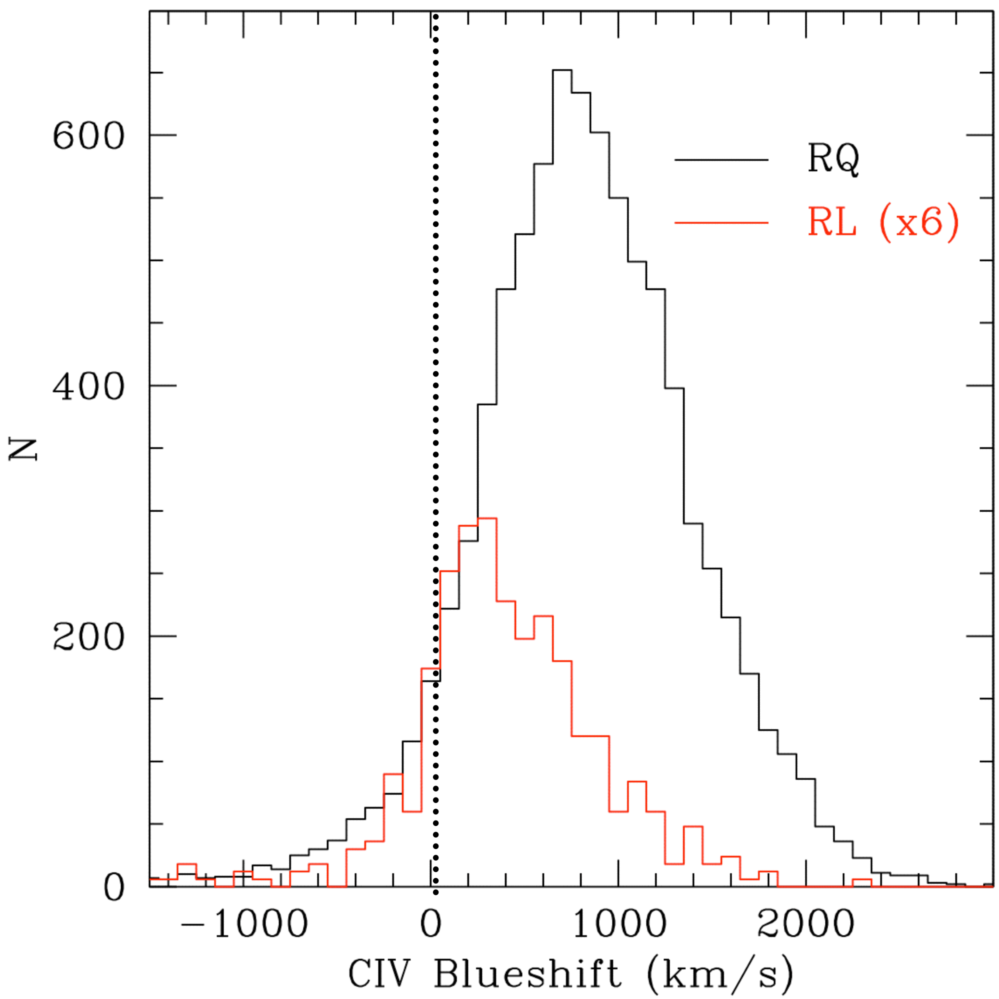
→ supports ***radiative driving*** of UV outflows





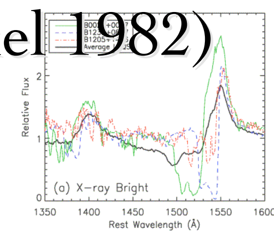


More evidence for outflows: CIV "blueshifts"

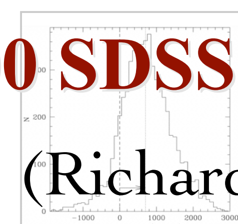


The peak of CIV emission is generally *not* at the expected laboratory wavelength based on the MgII redshift.

(e.g., Gaskel 1982)

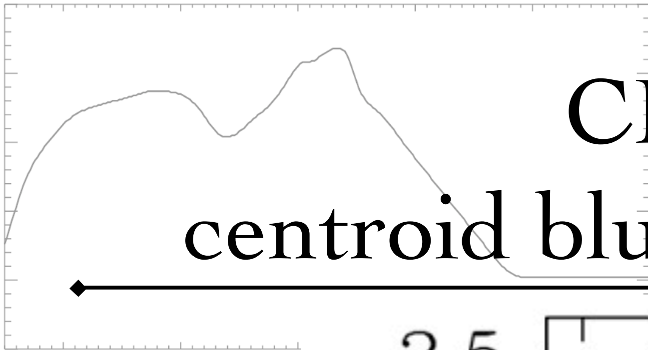


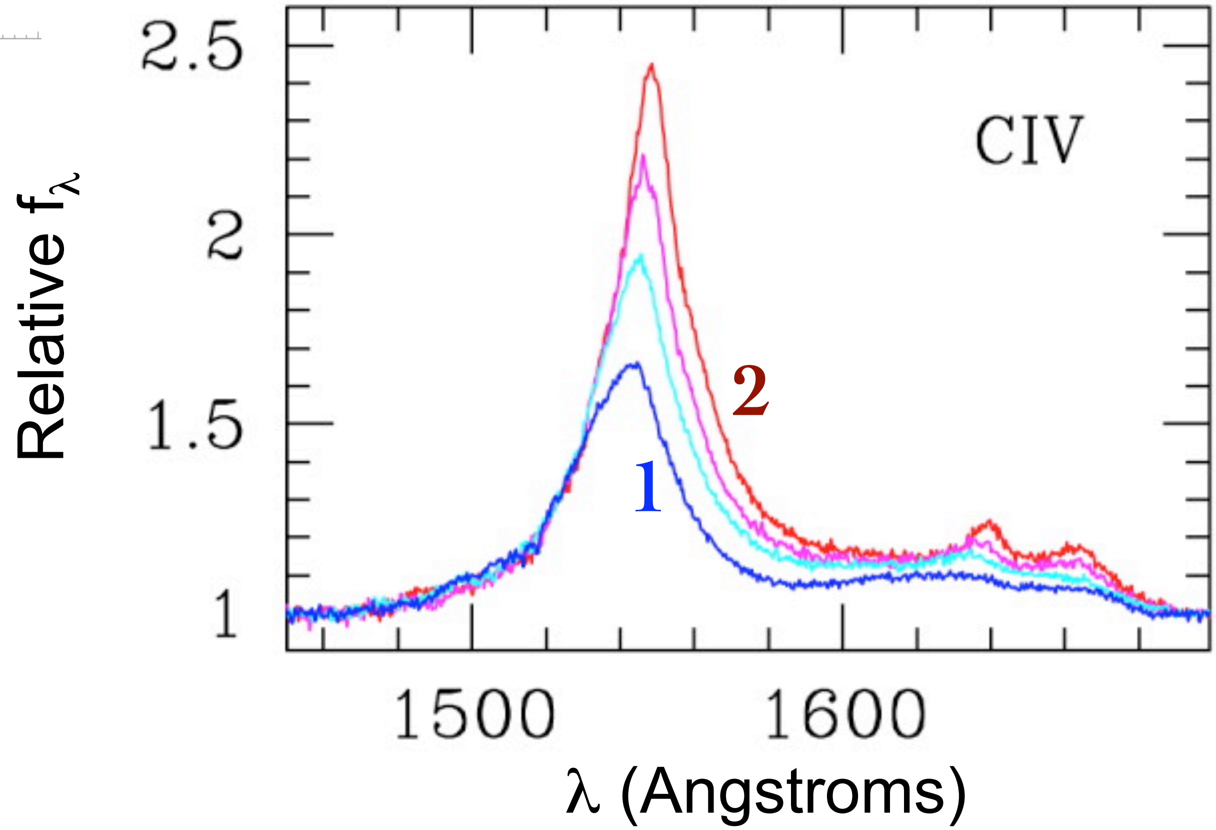
30,000 SDSS quasars

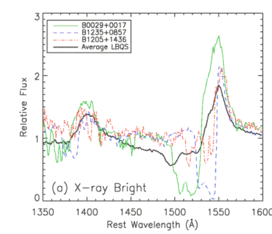


(Richards et al. 2010)

CIV composites: centroid blueshift = decrease in EW





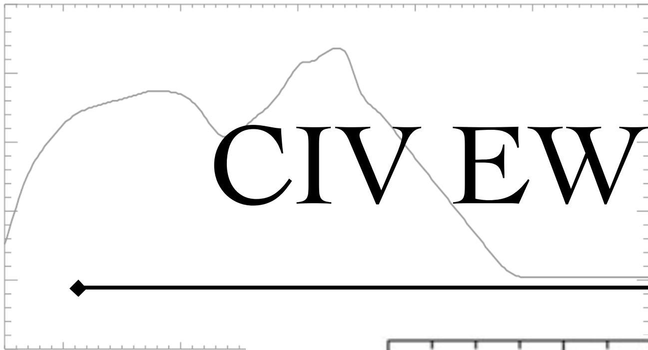


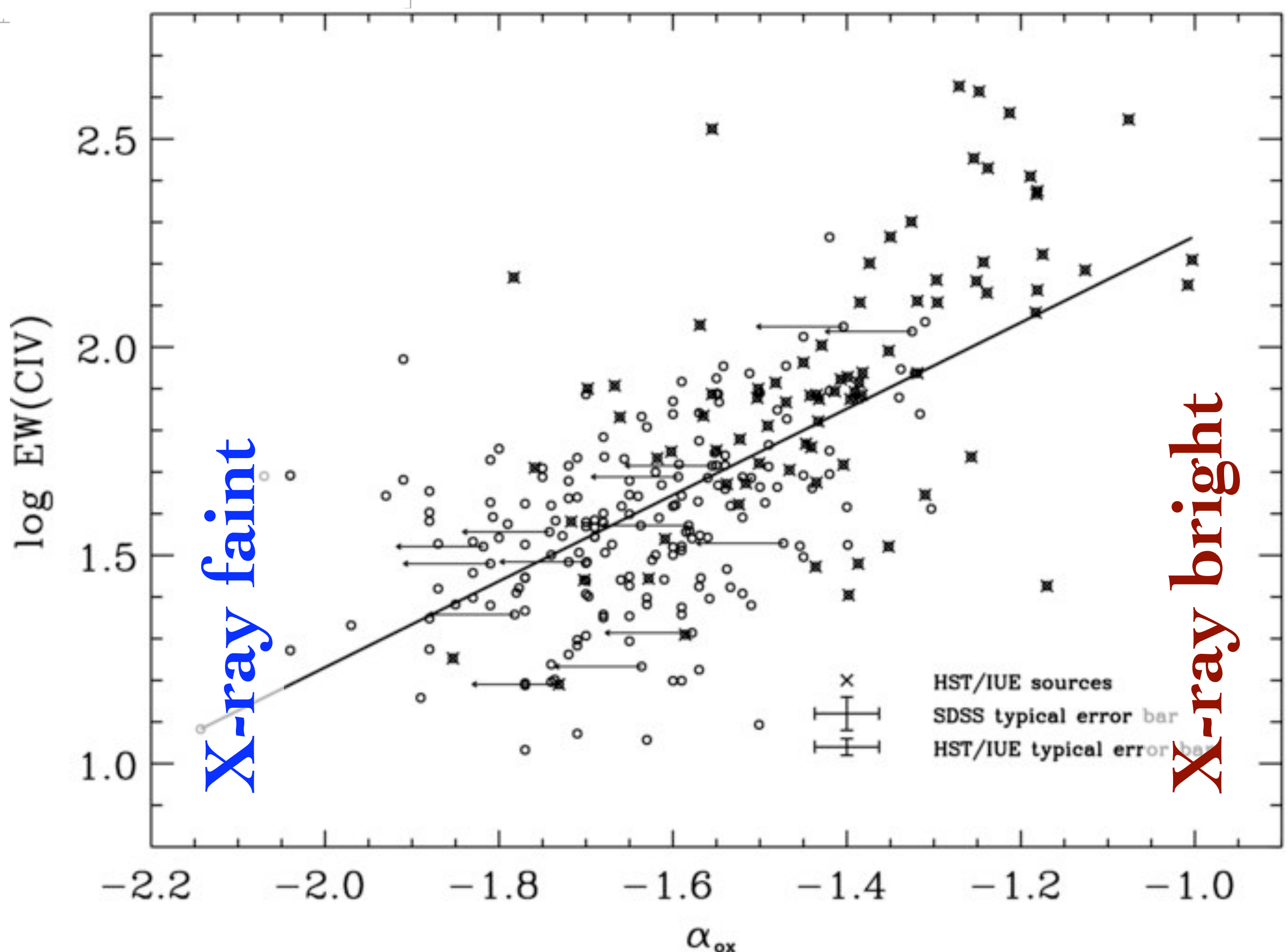
1: composite from largest CIV blueshift quasars

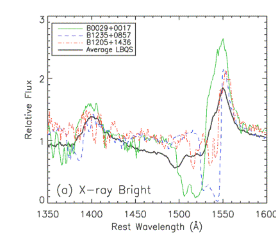
2: composite from smallest CIV blueshift quasars

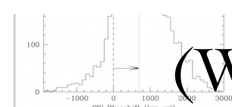
(Richards et al. 2002)

CIV EW correlates with α_{ox}



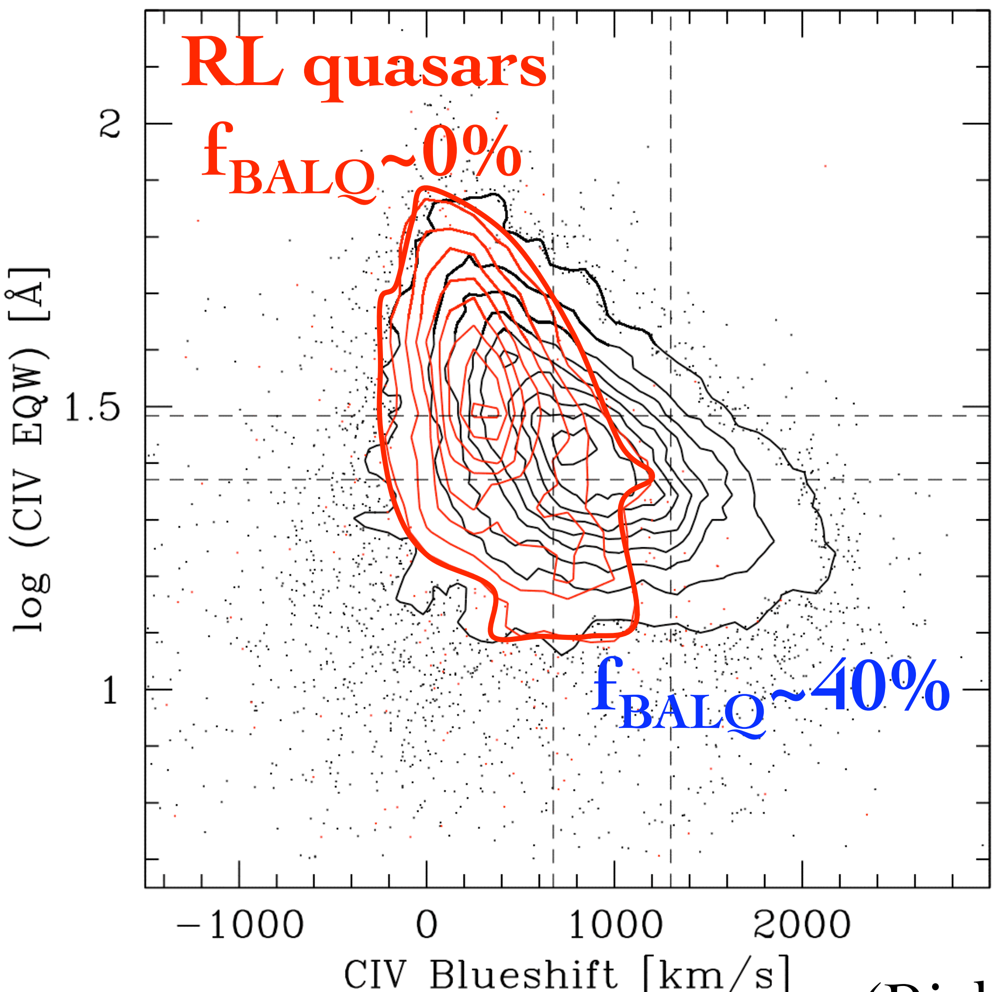


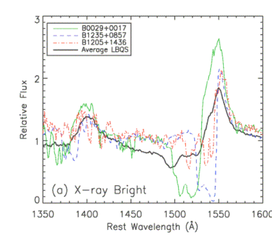




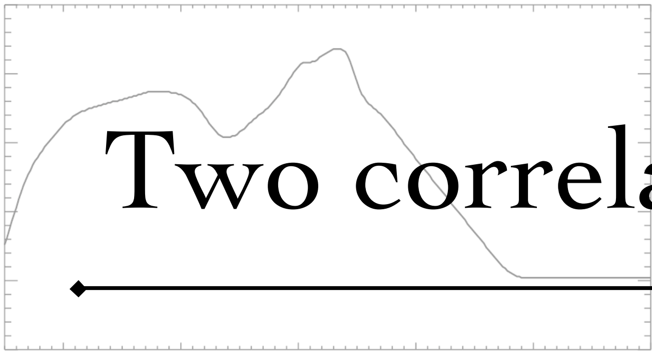
(Wu et al. 2009)

CIV blueshift anti-correlates with CIV EW



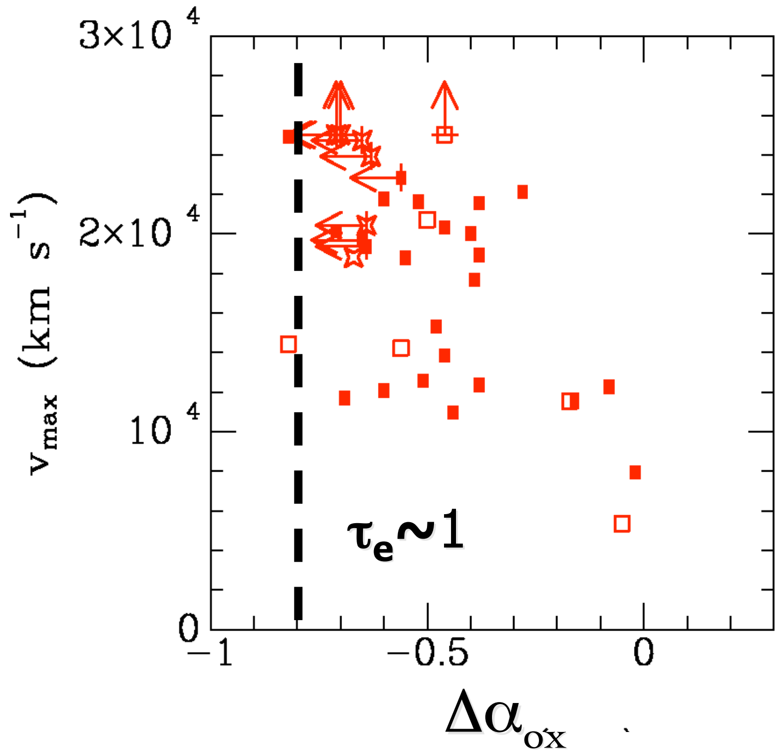


(Richards et al. 2010)

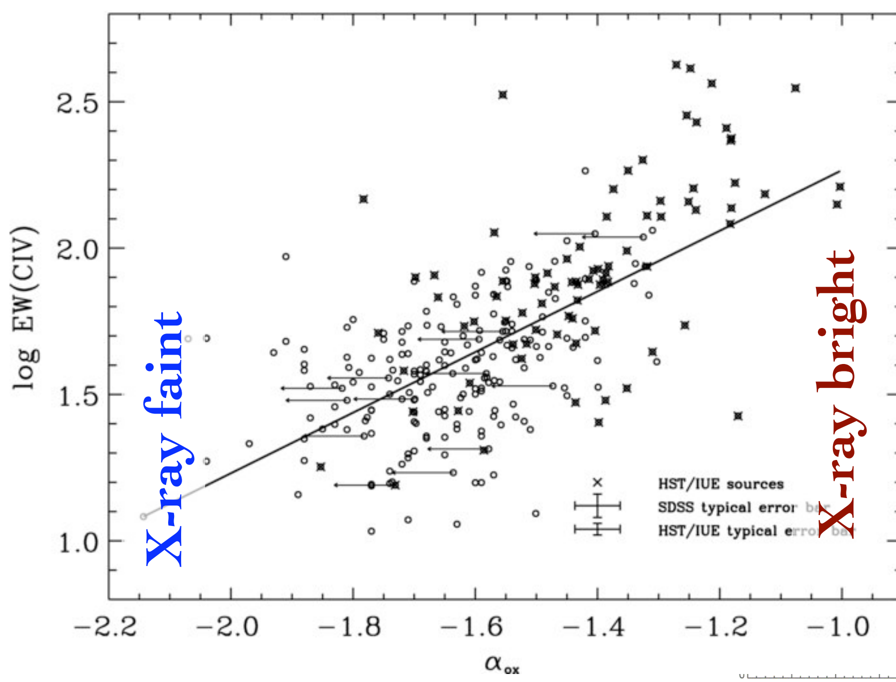


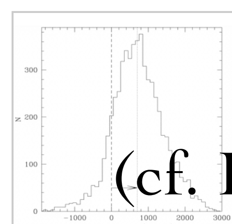
Two correlations: one root cause

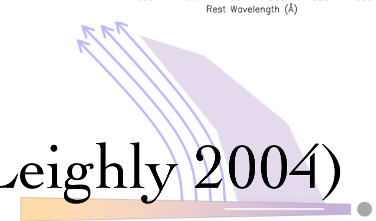
v_{max} vs. $\Delta\alpha_{ox}$



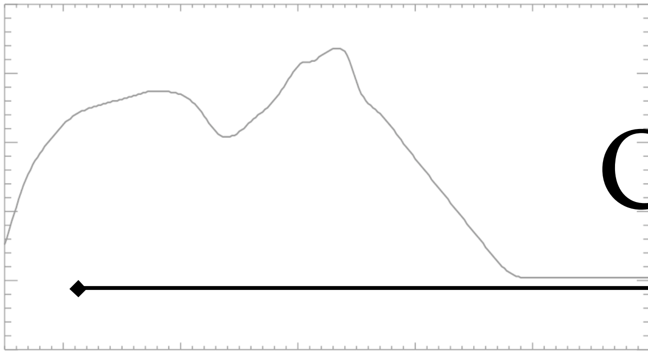
EW(CIV) vs. α_{ox}





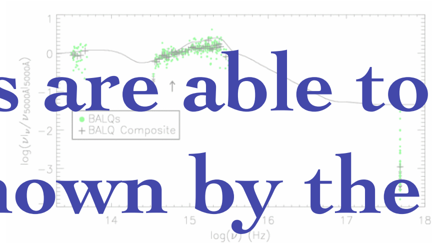


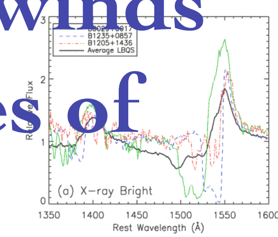
(cf. Leighly 2004)



Conclusions

(1) Outflows are present in most luminous, radio-quiet quasars.
(2) Radiation pressure is important for driving quasar winds.
(3) The shape of the spectral energy distribution (SED) affects the wind.
(4) The profiles of UV broad lines are sensitive to the SED because they are created in the wind.





X-ray — weaker quasars are able to drive winds more effectively, as shown by the profiles of broad absorption and emission lines.