QSO outflows: evidence from narrow absorption lines

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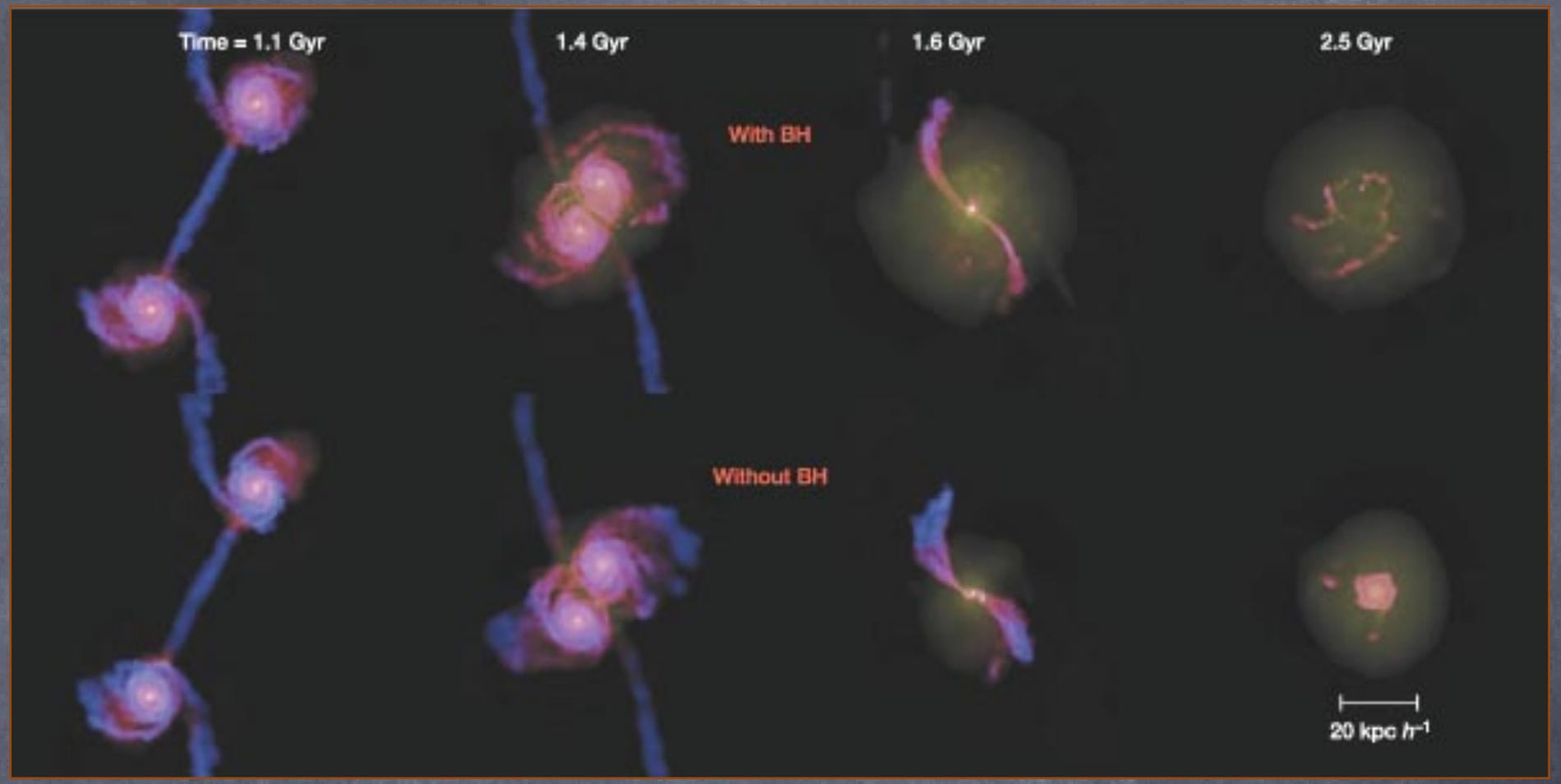
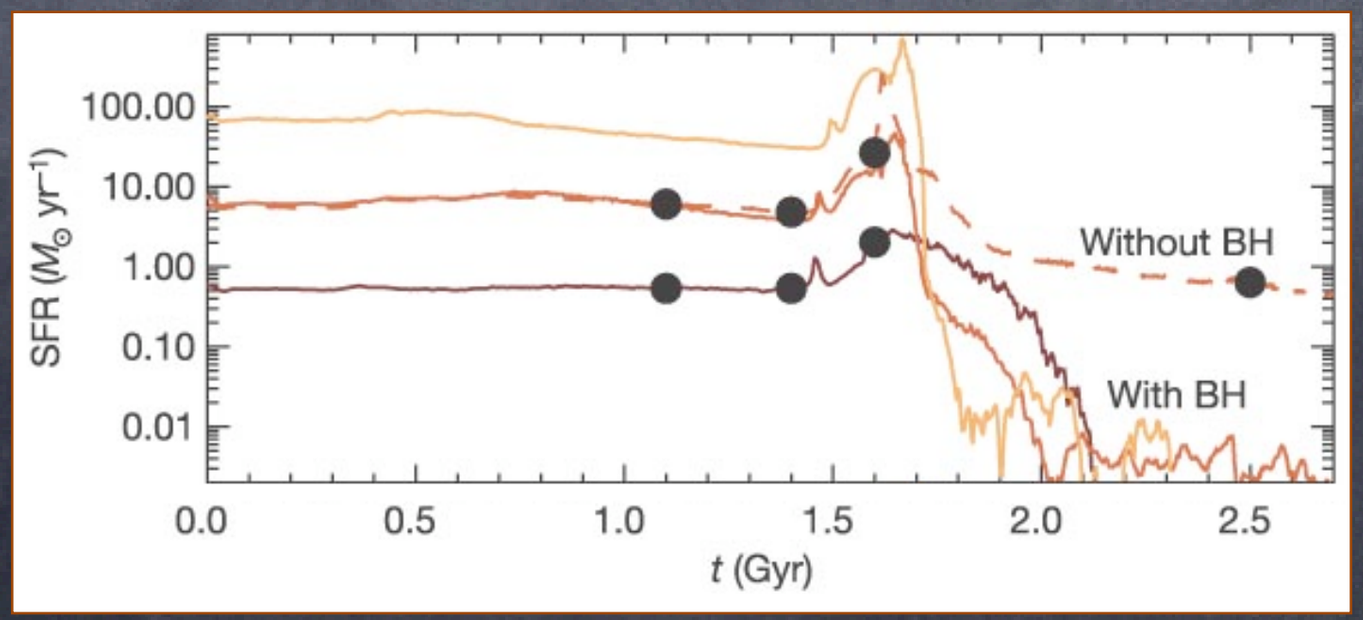
Galaxy Evolution and BH growth

One theoretical perspective

Di Matteo, Springel, Hernquist, Nature 2005





See also Cattaneo et al 2005; Hopkins et al 2006 etc.

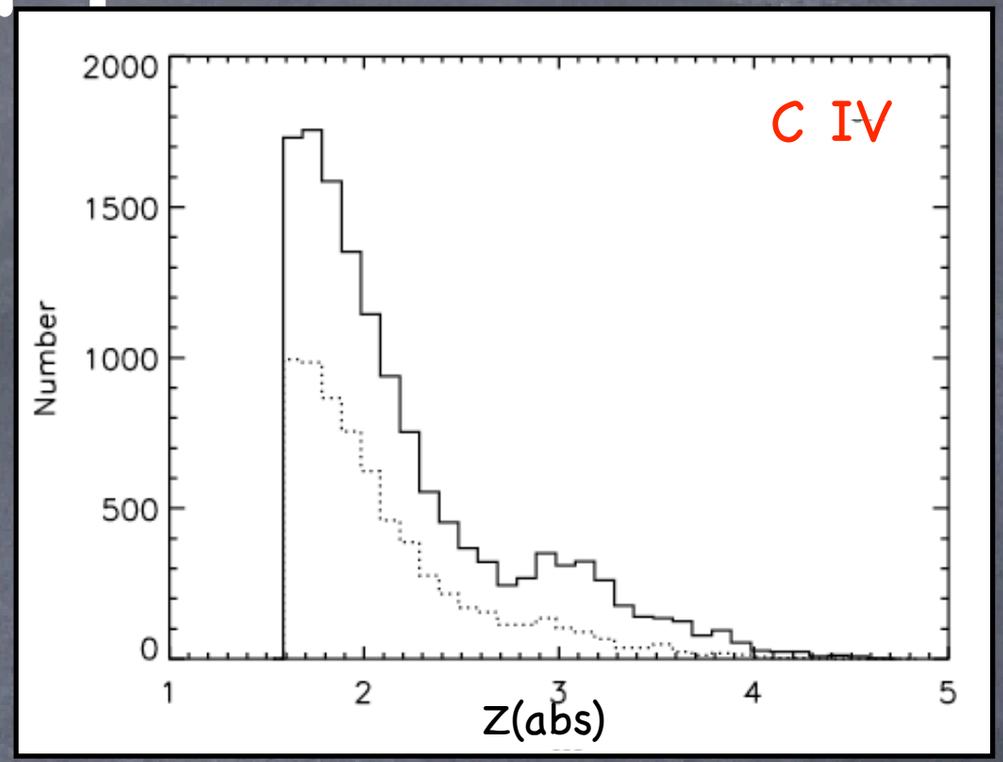
In reality....

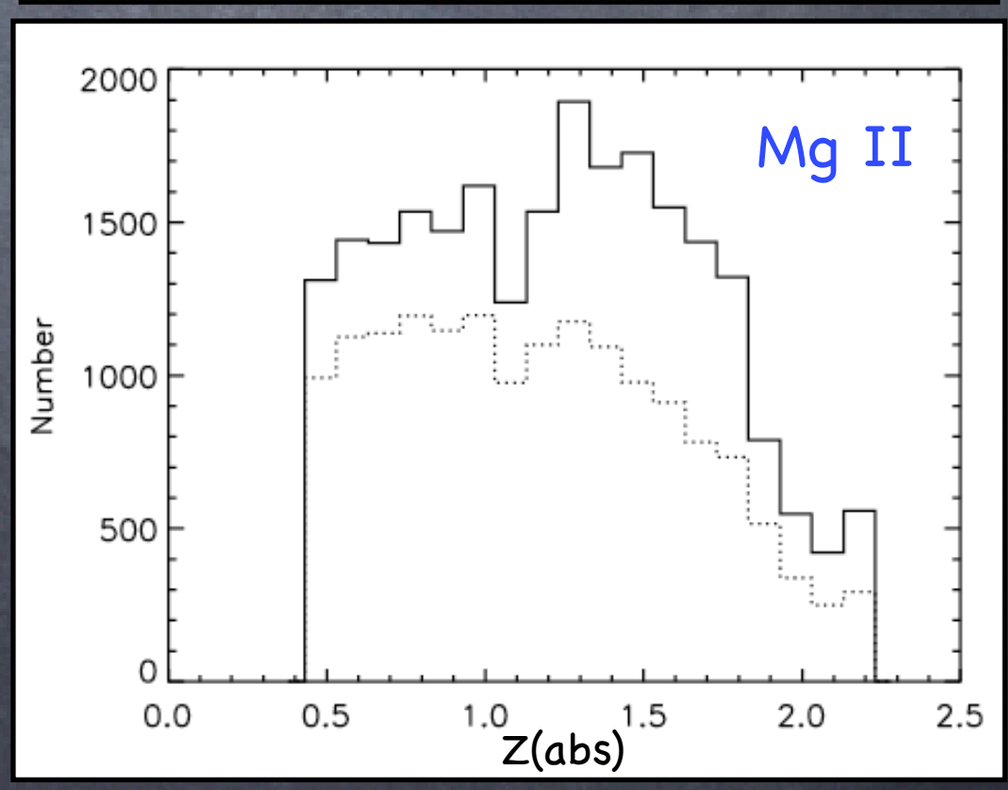
- How ubiquitous are QSO induced outflows? What is their true impact on the host galaxy?
  - X-ray absorption lines (accretion disk)
  - Broad Absorption Lines (BALs, accretion disk)
  - Jets (sub- to super-galactic scales)
  - Narrow "Associated" absorbers?? ([super]-galactic scales?)

A statistical approach...

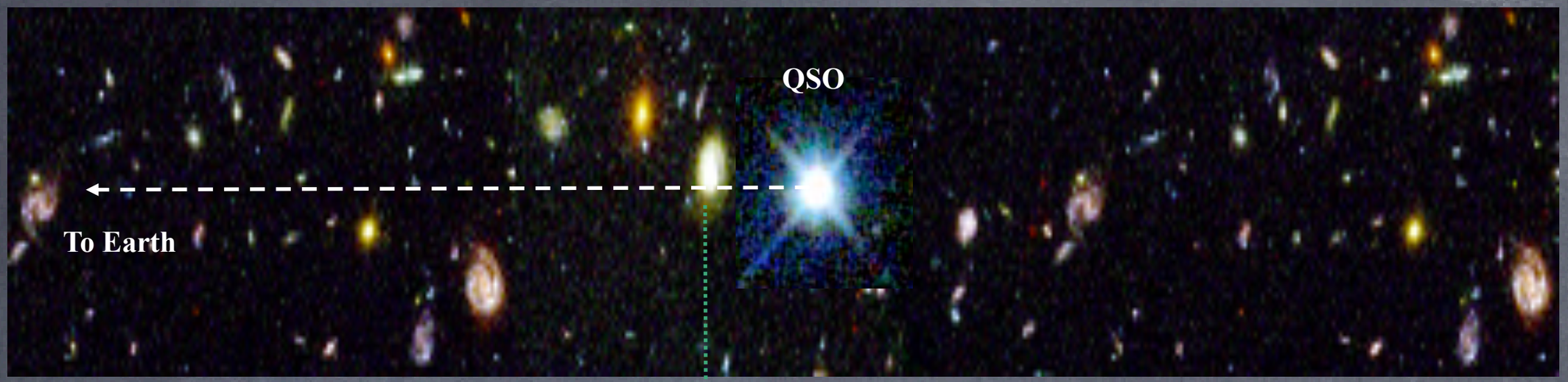
- SDSS DR3 QSO Absorber catalogue (York et al. 2006)
  - QSO spectra SNRg > 8
  - Observed frame 4000-9000A
  - Line width < 700km/s, EQW >0.5A
  - CIV: 6,456 absorbers
  - MgII: 16,137 absorbers

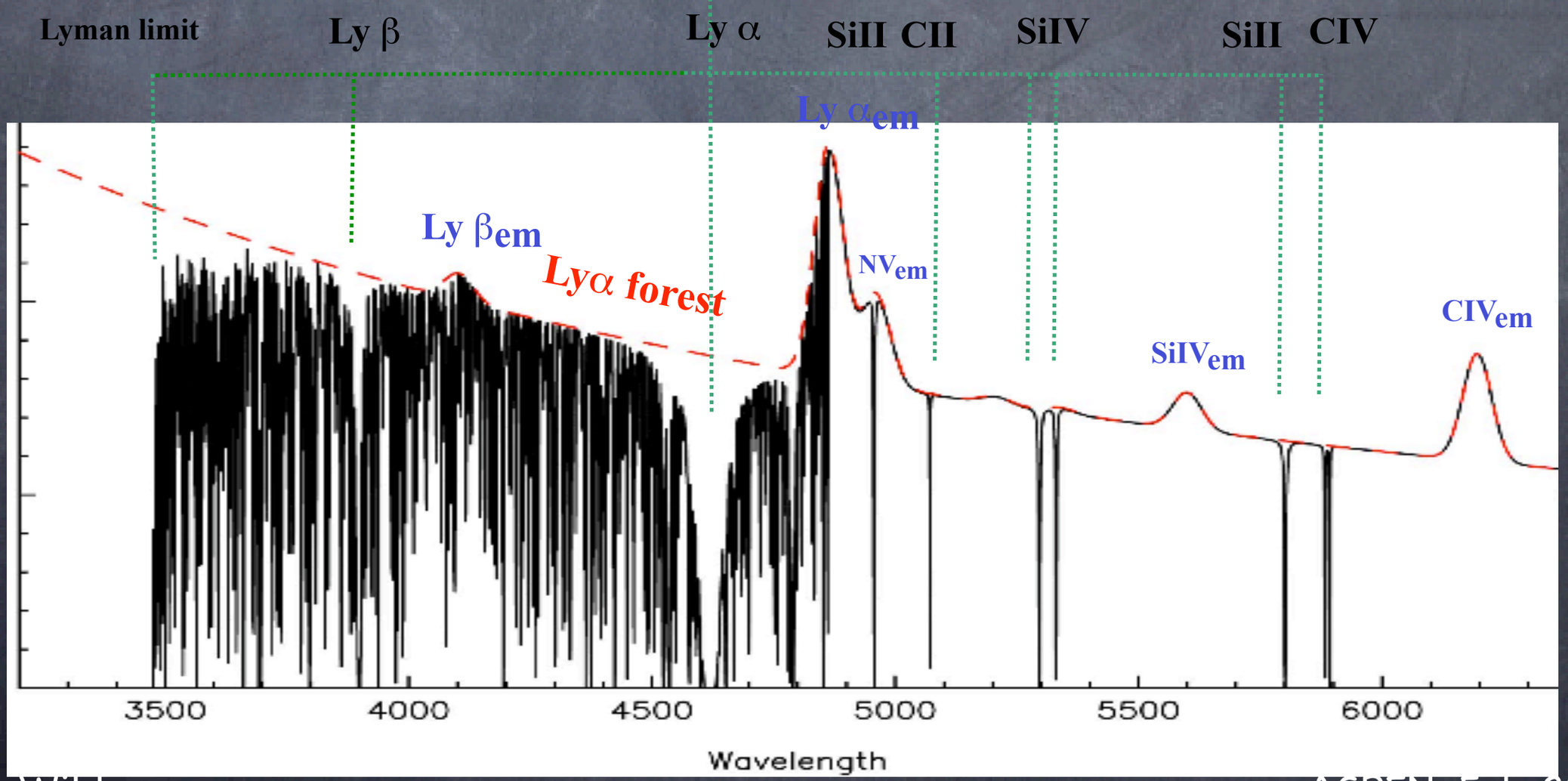
- Disadvantage of narrow ALs
  - Ordinary galaxies give rise to NALs
  - Galaxy clustering gives excess of absorbers close to QSO.....





QSO absorbers

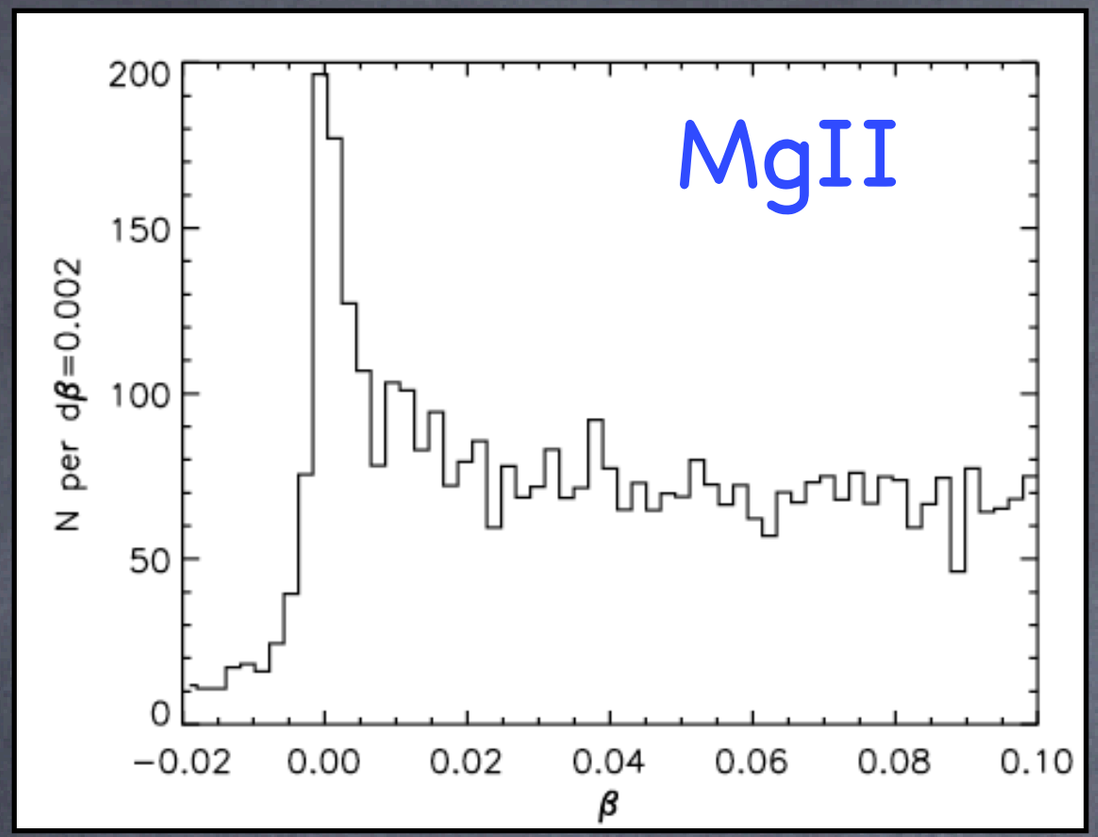


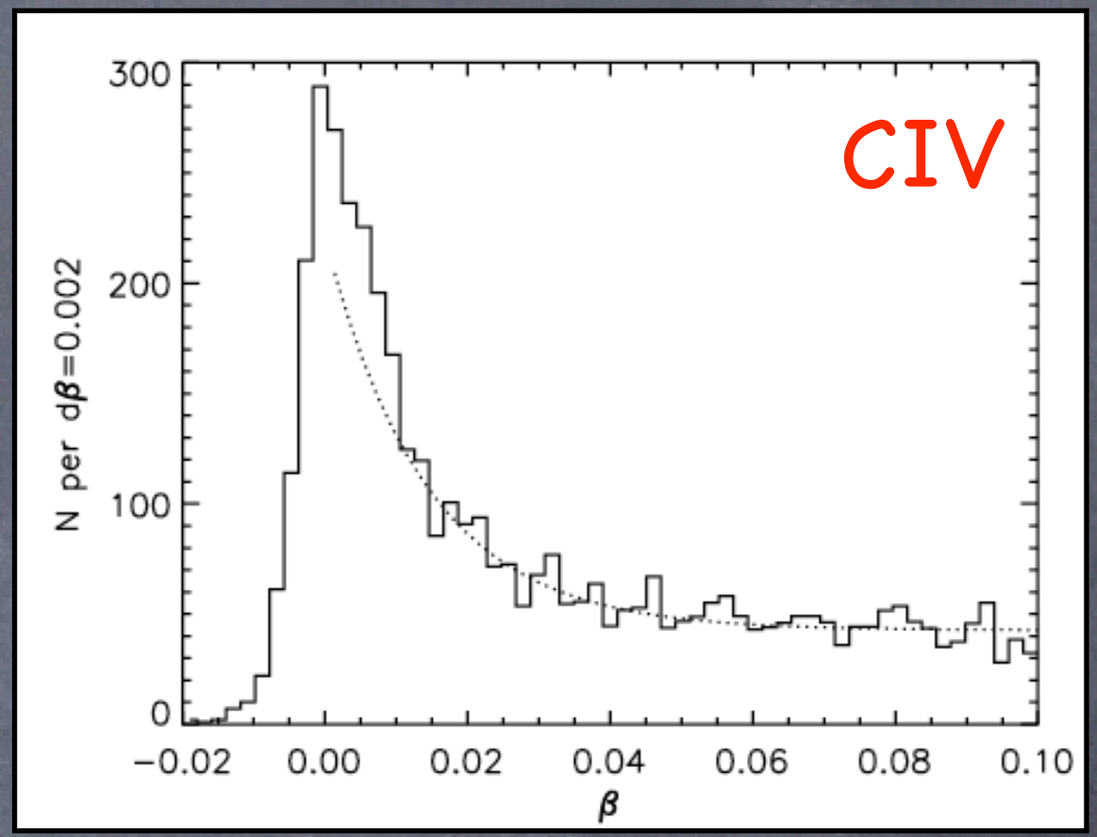


Courtesy John Webb

Velocity of absorbers

Number of absorbers





β=v/c

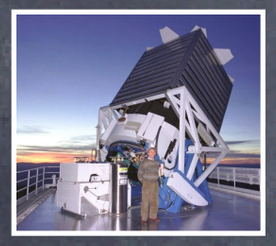
- At Δβ > 0
  - background level due to intervening galaxies
- At Δβ~0:
  - increase in absorbers, in part due to galaxy clustering (more next)
- At Δβ < 0.04 (12,000 km/s)
  - increase in CIV absorbers, relativistic outflows?

Calculate the clustering contribution

Δz=0.1

R

Observer



$$\xi(R) = N_{obs}/N_{exp} - 1$$
$$= (R/R_0)^{-\gamma}$$

KEY

QSO

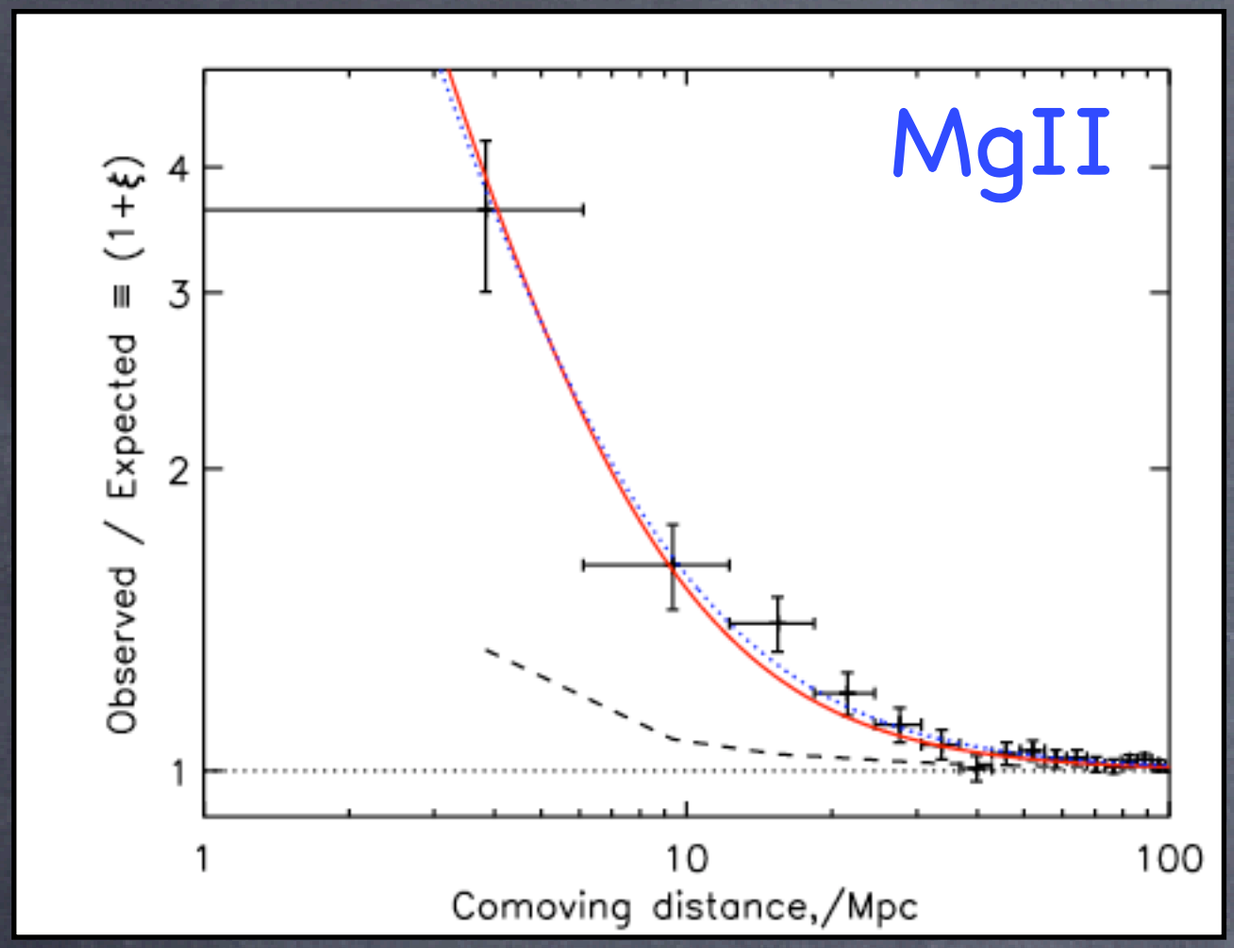
absorber

Redshift

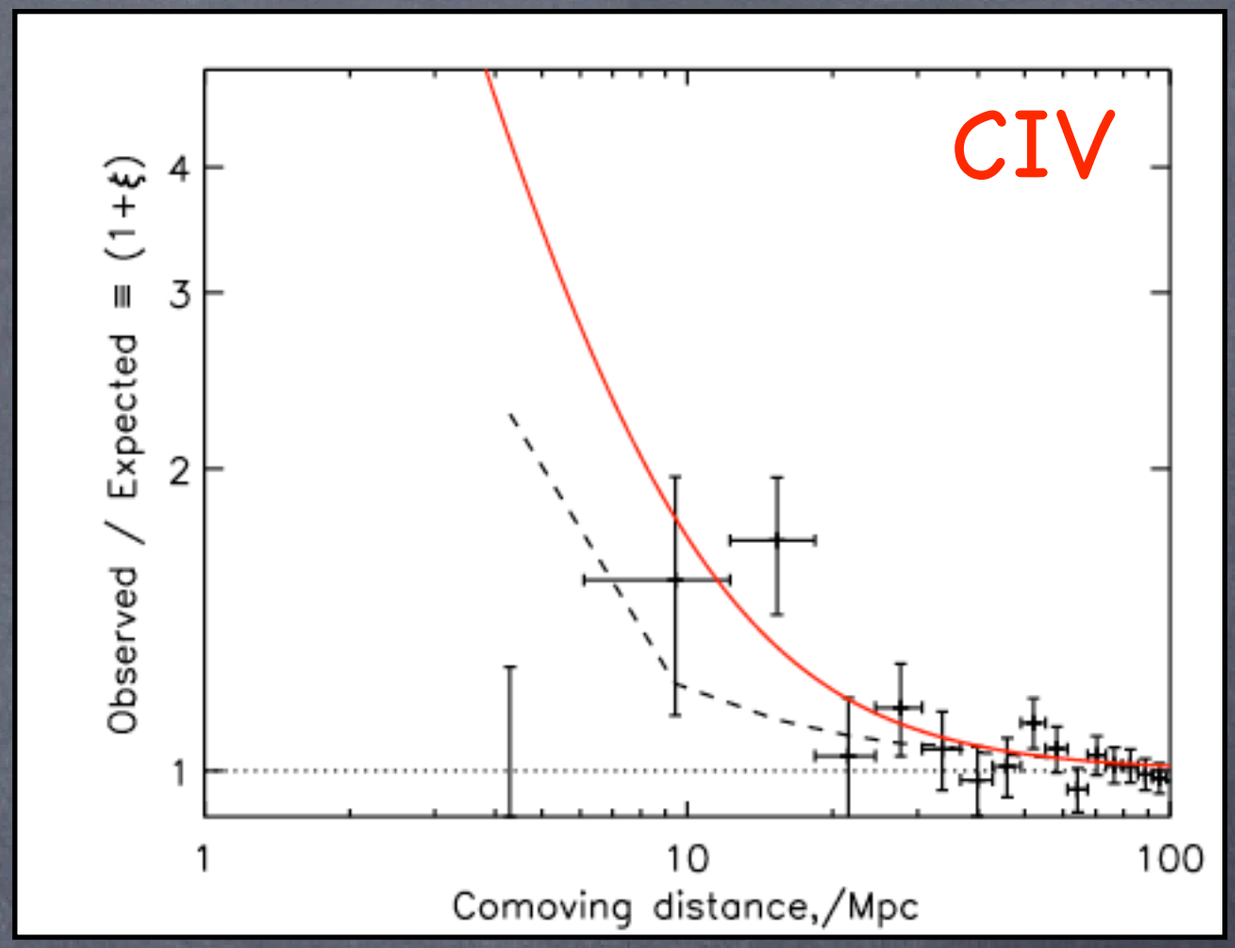
Vivienne Wild

ASPEN, Feb 2008

QSO-absorber **transverse** correlation



R (Mpc)

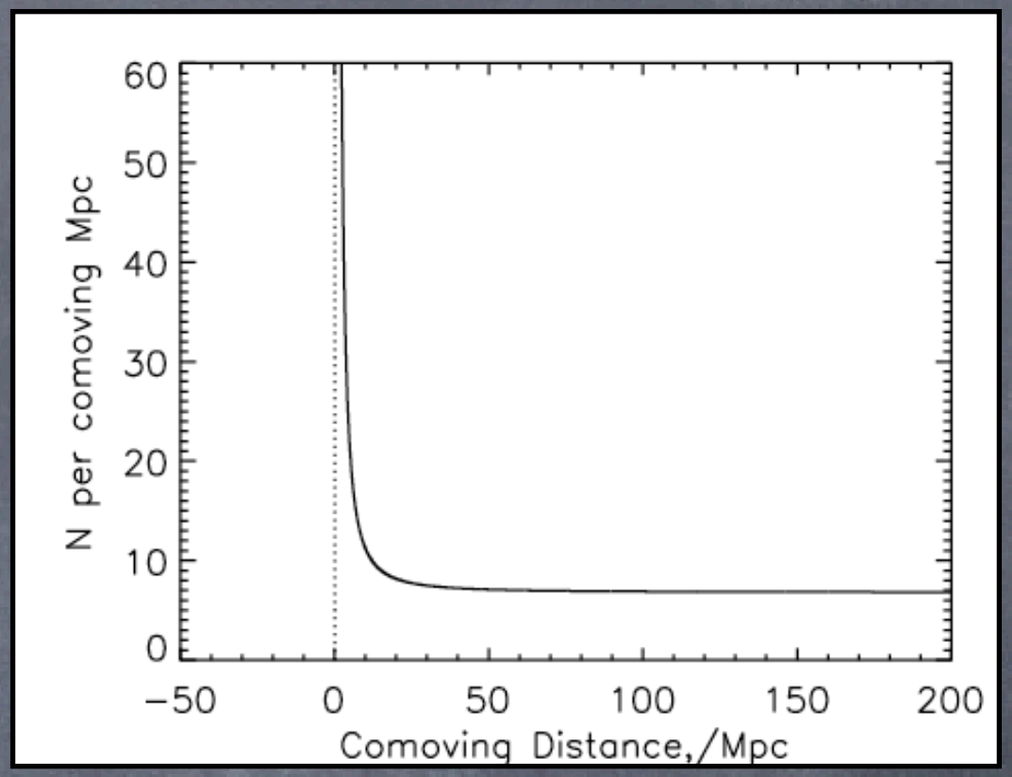


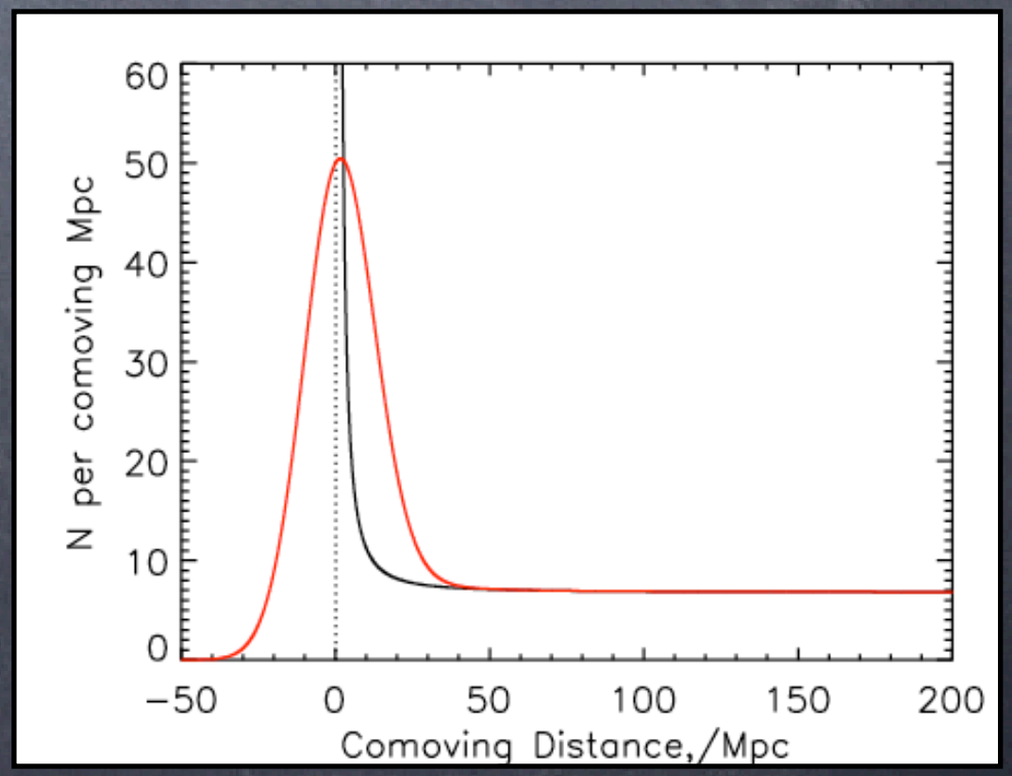
R (Mpc)

- r_0(MgII) = 5.0±0.4 h^{-1} Mpc ; γ = 1.69±0.09
  - No significant transverse proximity effect on these scales
- r_0(CIV) = 5.8±0.4 h^{-1} Mpc (γ=1.8)

Line of sight correlation

- model the l-o-s component due to intervening systems:
  - amplitude
    - from transverse correlation
  - Effect of QSO ionisation (R_{ion})
    - currently not well constrained
  - QSO-absorber velocity dispersion
    - large-scale stucture: σ_{12} (e.g. Li et al.)
    - redshift errors



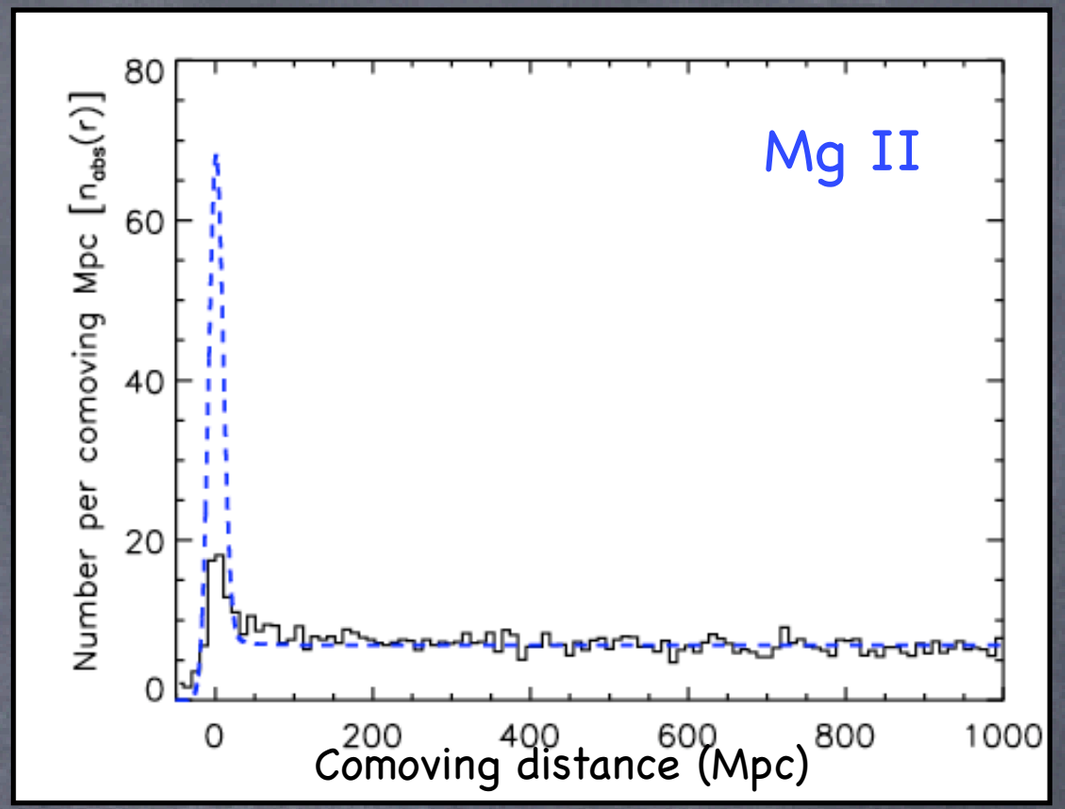


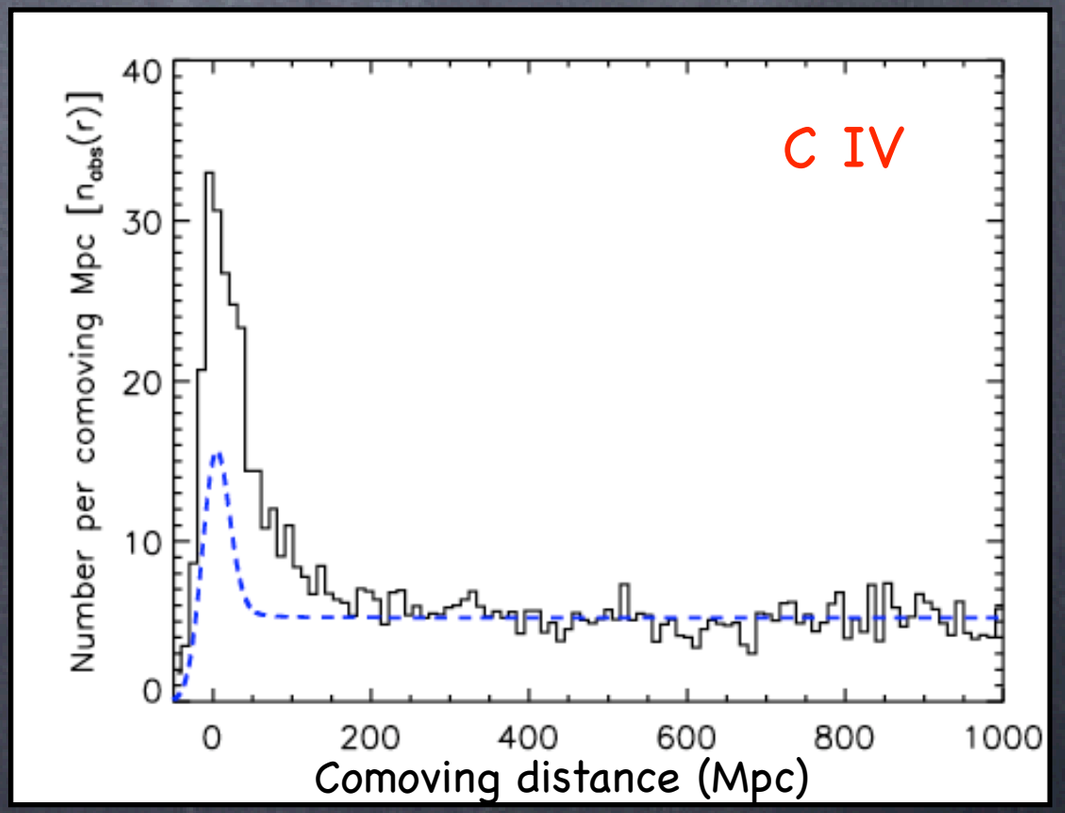
Line of sight correlation

- model intervening systems:
  - clustering amplitude
  - Effect of QSO ionisation (R_{ion})
  - QSO-absorber velocity dispersion

- 1) **IF** QSO only ionises all absorbers in its own halo
  - ~40 h^{-1} kpc (proper) MgII (Steidel et al.)
  - ~100 h^{-1} kpc (proper) CIV (Chen et al.)

- Conclude:
  - overpredict MgII absorbers by x2
  - QSO ionises MgII beyond assumed R_{ion}



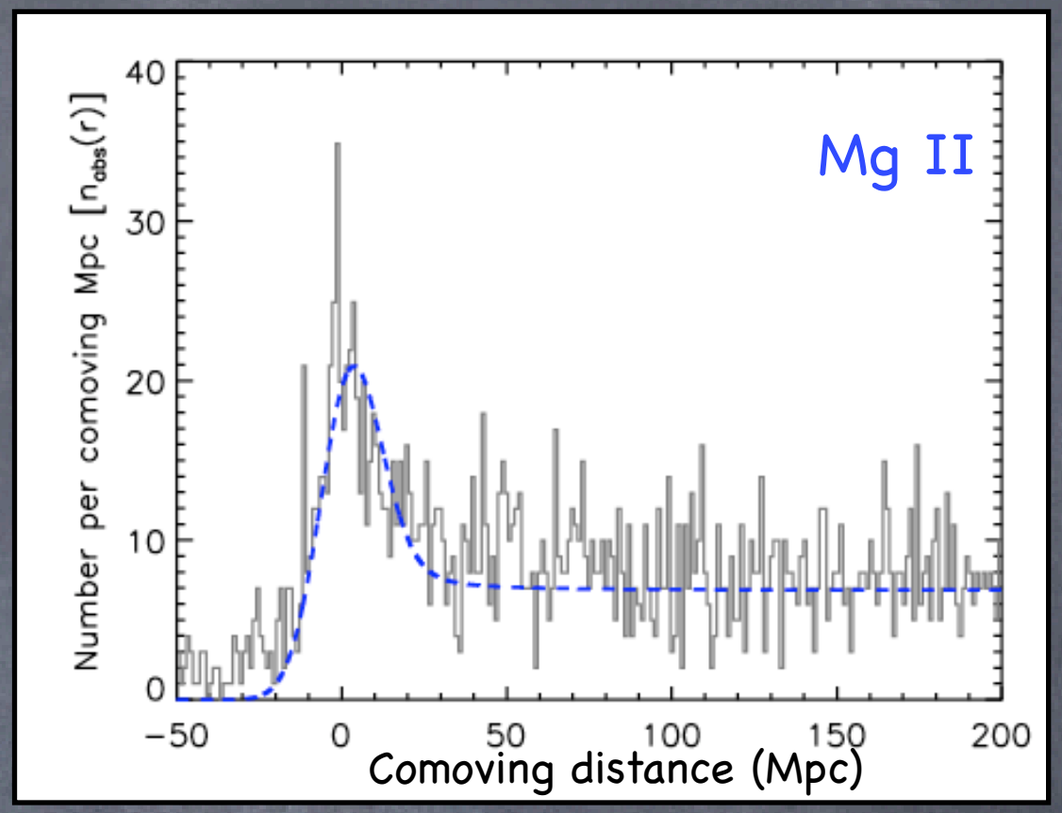


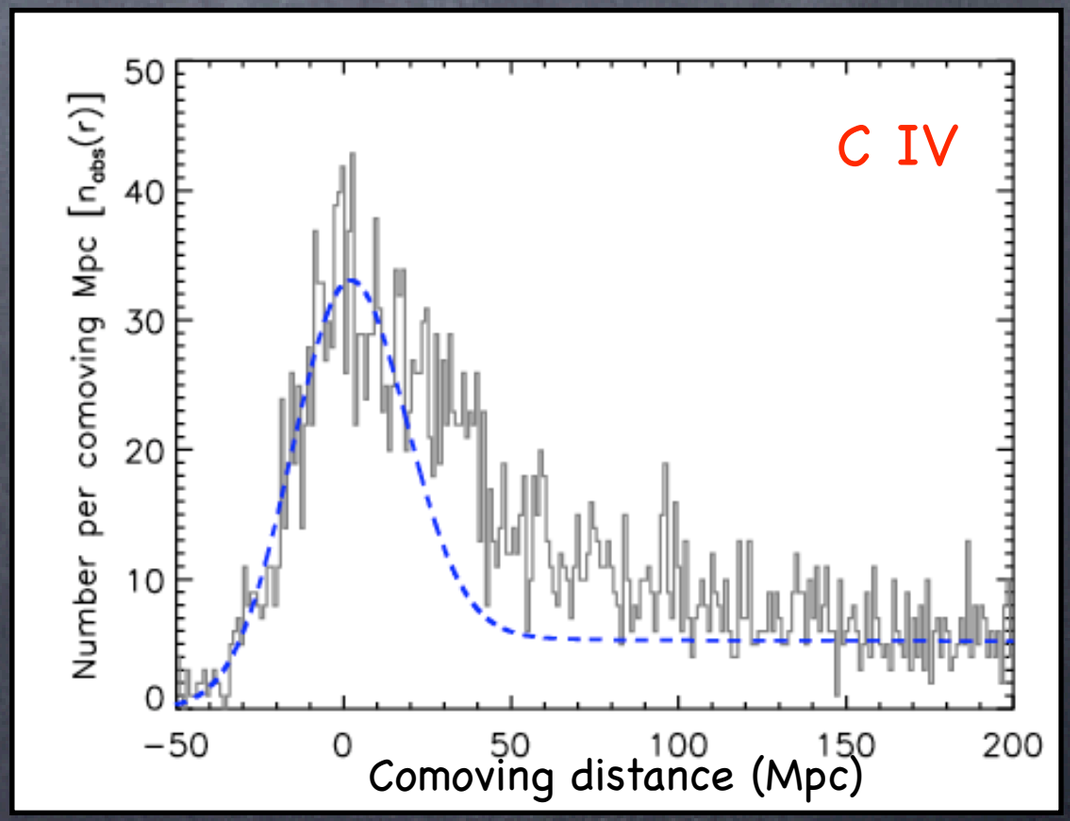
Line of sight correlation

- model intervening systems:
  - clustering amplitude
  - Effect of QSO ionisation (R_{ion})
  - QSO-absorber velocity dispersion

- 2) Vary ionisation radius:
  - 270 kpc (proper) MgII
  - 30 kpc (proper) CIV

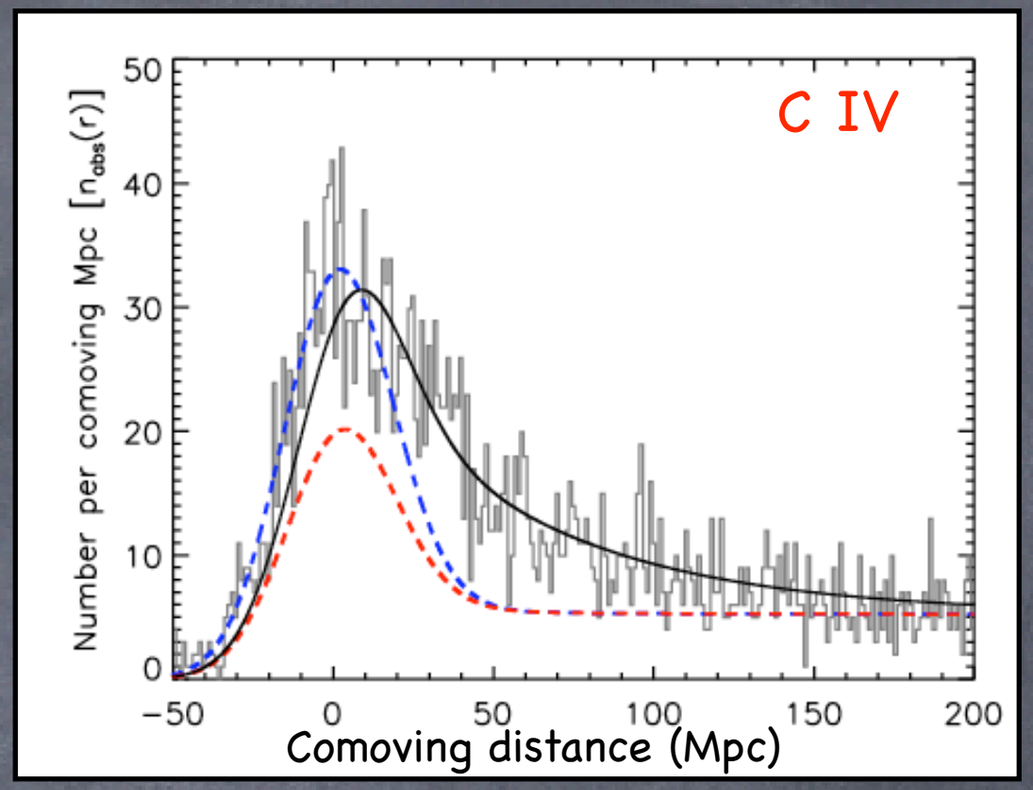
- Conclude:
  - QSO ionises MgII well **beyond** own halo, in halos of local galaxies
  - Blue shifted tail of CIV absorbers MUST be intrinsic to QSO/host

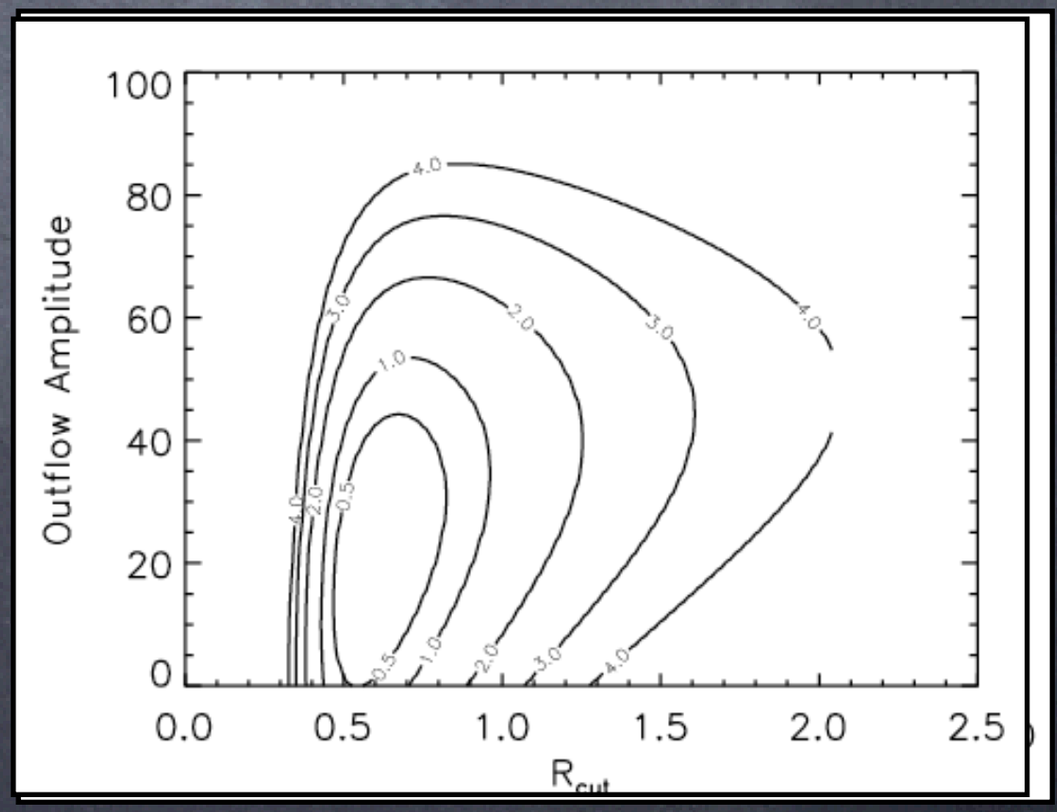




Outflows

- Model intervening systems:
  - clustering amplitude
  - Effect of QSO ionisation (Rcut)
  - QSO-absorber velocity dispersion
- 3) Include outflow distribution:
  - fit exponential to velocity distribution
  - vary ionisation radius to fit
- Conclude:
  - > 40% CIV absorbers at v/c<0.04 (v<12,000 km/s) = intrinsic to QSO/ host/halo and outflowing.
  - Δv~0 MgII absorbers might be outflows, but also consistent with being local galaxies





Some numbers

fraction of QSOs with absorber (EW>0.5A)

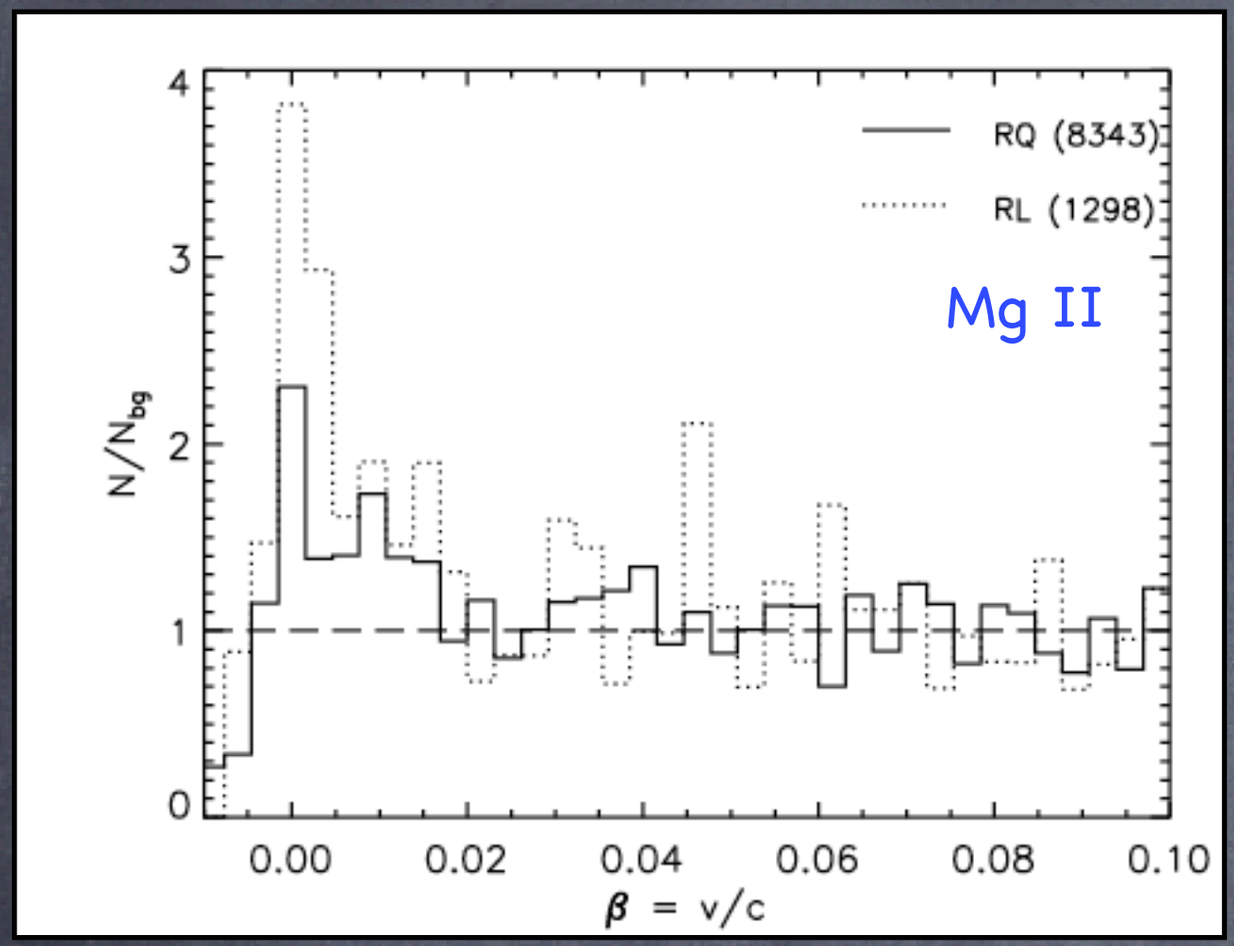
velocity	MgII	CIV
-0.01<β<0.01	3.4%	15%
0.01<β<0.04	4.4%	10%

cf. BALQSO fraction ~10-15%
Radio QSO fraction ~10%

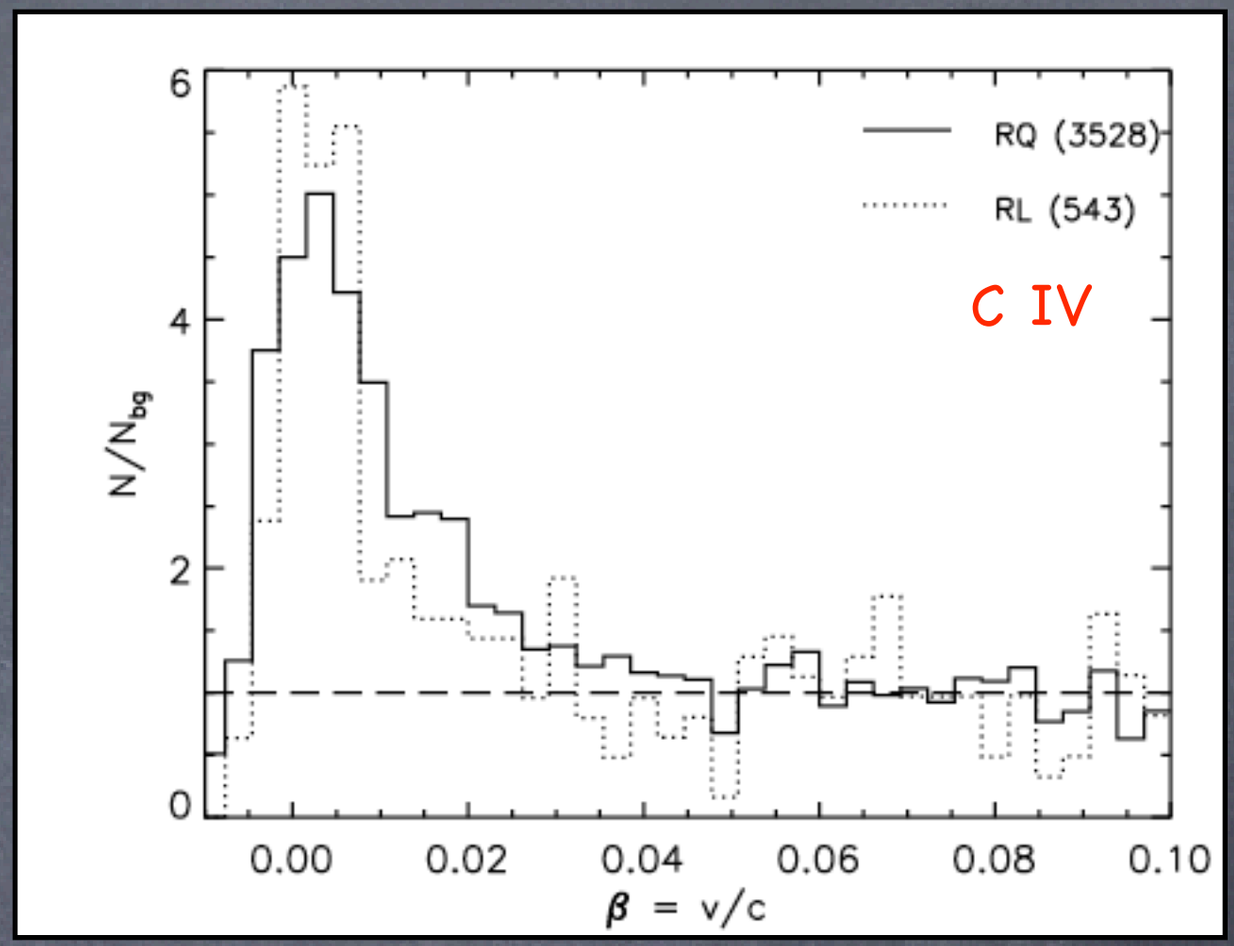
fraction of **intrinsic** absorbers
(i.e. not intervening galaxies)

velocity	MgII	CIV
-0.01<β<0.01	0% ?	>36%
0.01<β<0.04	~0%	>44%

Radio Loud vs. Radio Quiet



velocity from QSO

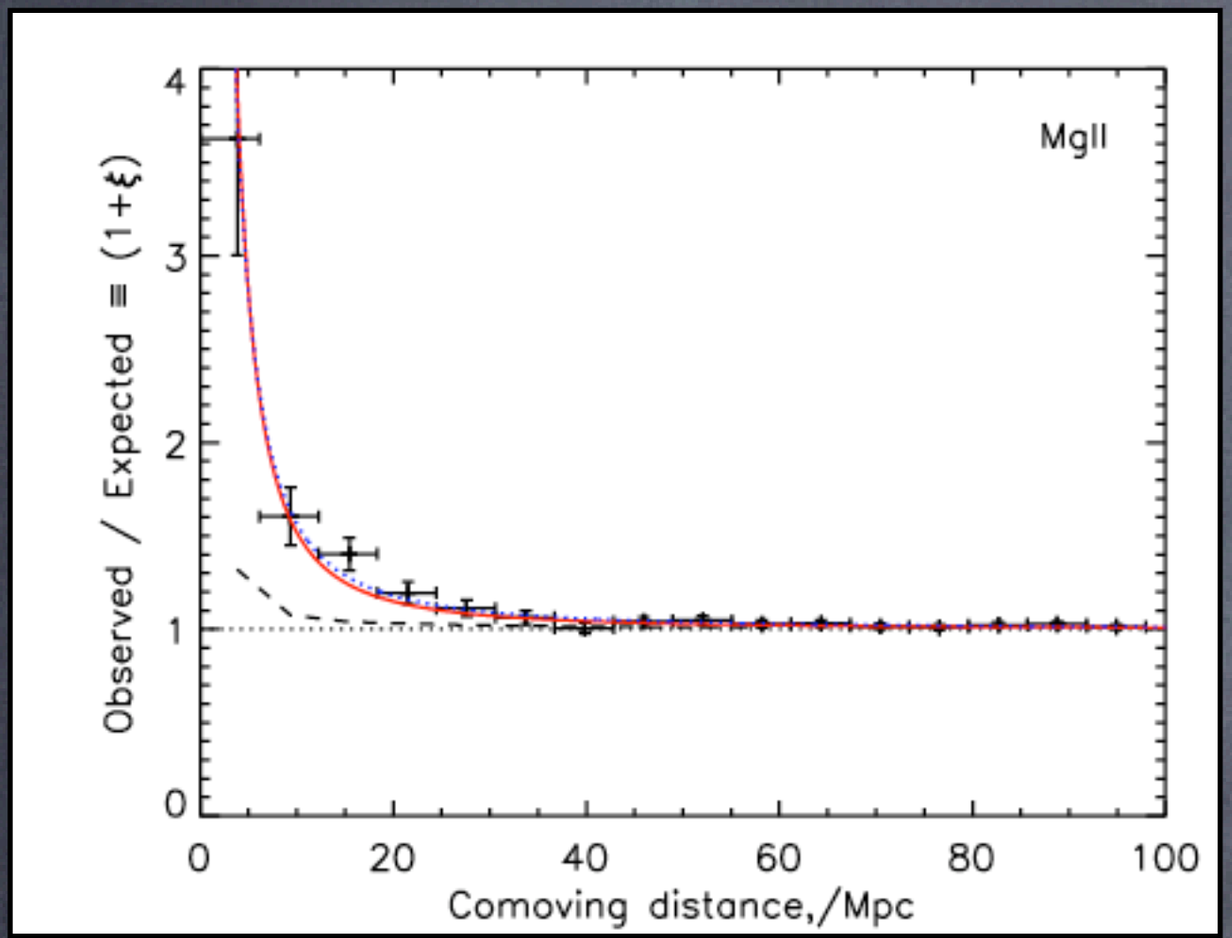


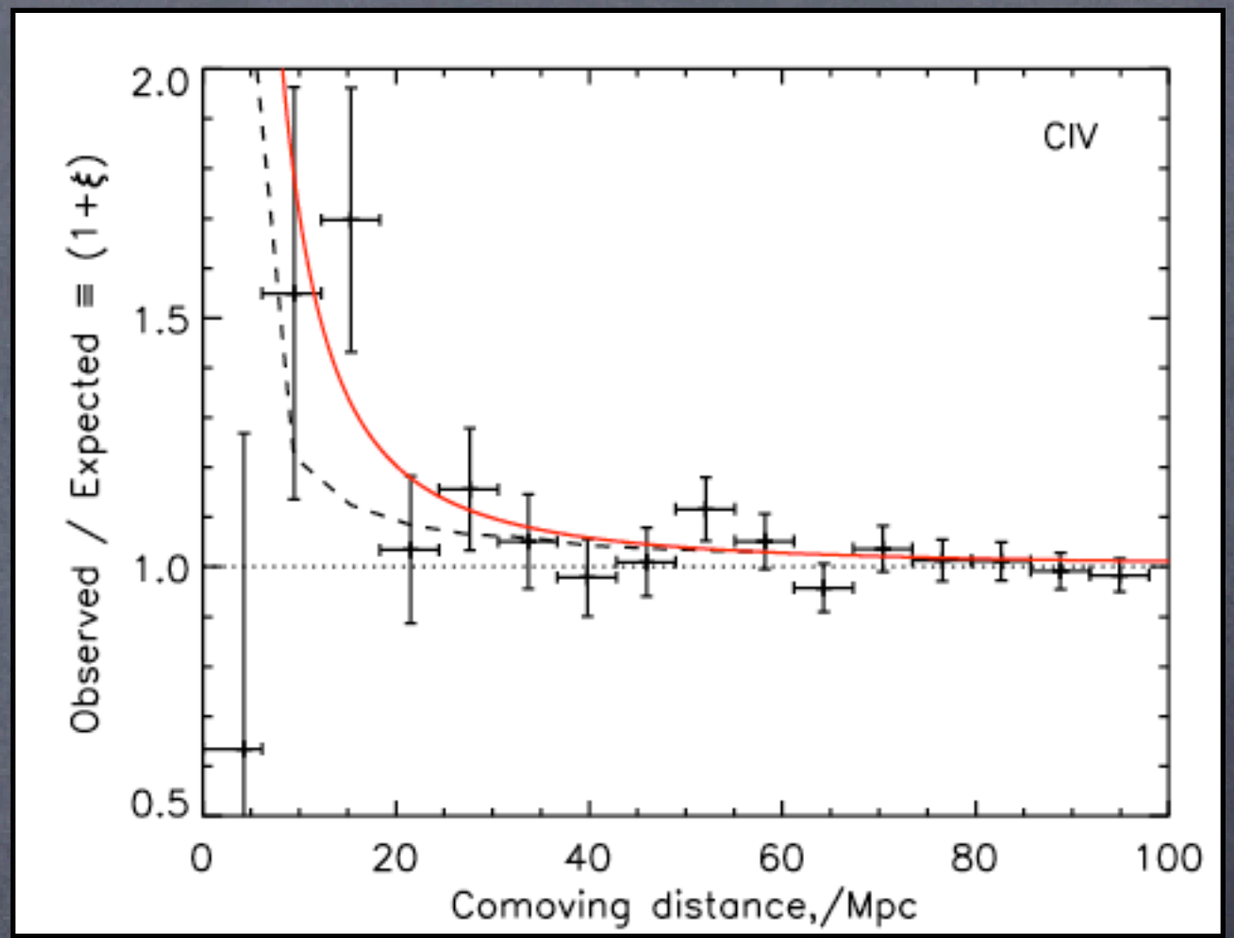
velocity from QSO

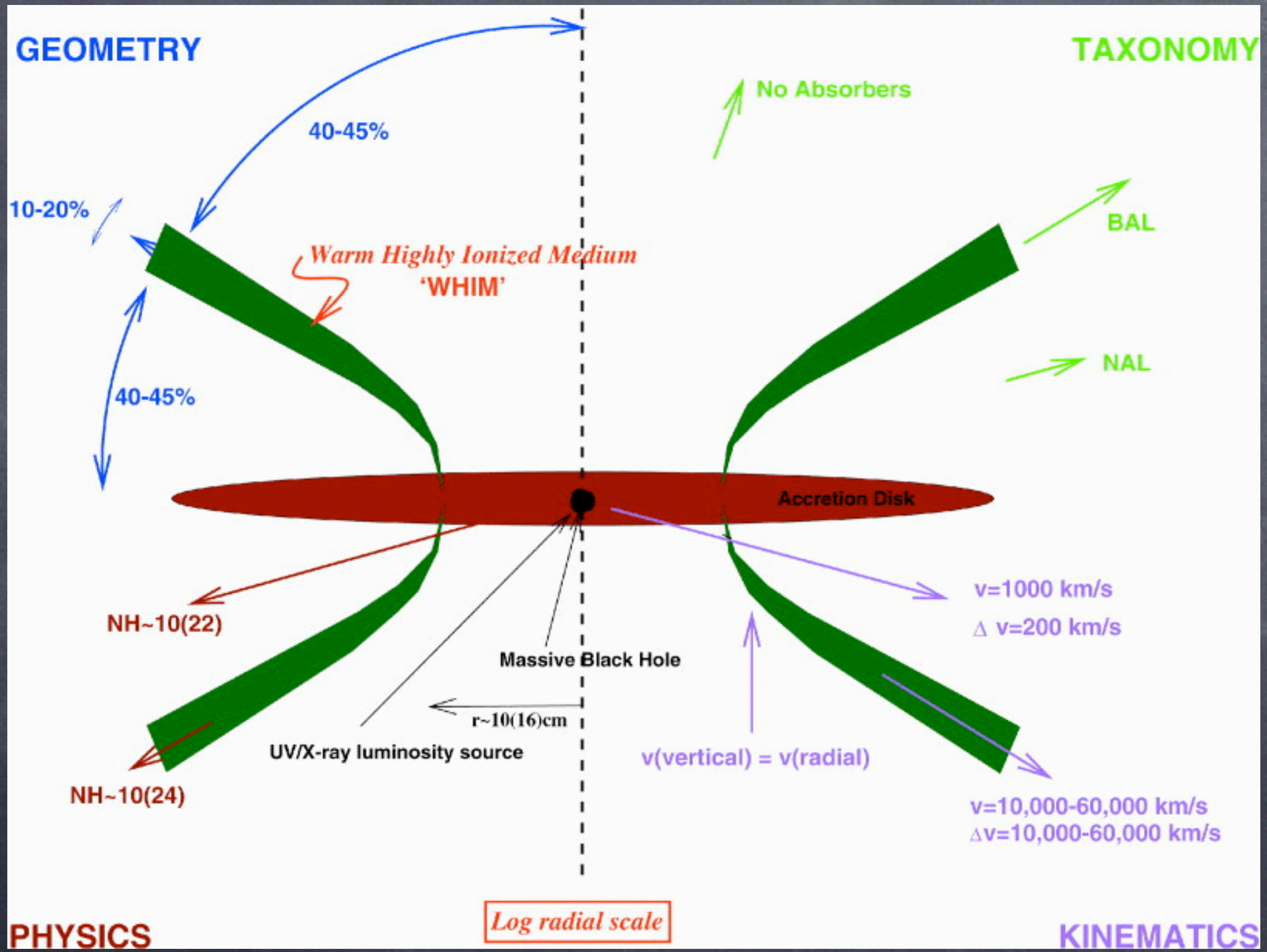
Conclusions

- Detect transverse clustering of absorbers around QSOs
  - Consistent with previous measures of galaxy clustering at similar redshifts (DEEP2, VVDS, LBGs)
  - No significant transverse proximity effect in MgII on 4Mpc scales (e.g. Bowen +2006, Hennawi & Prochaska 2007)
- QSO ionises MgII in clouds beyond 270kpc (proper)
  - i.e. in halos of local galaxies (Zibetti+2006, Tinker & Chen 2007)
- Conclusive evidence for outflows
  - Outflow velocities as high as 12,000km/s (see also Nestor+2008,subm)
  - but line widths < 700km/s
  - challenge for both accretion disk and galactic scale models!
- Excess low velocity absorbers around Radio Loud QSOs
  - jet induced outflows? (Morganti+2007, Nesvadba+2007)
  - higher clustering amplitude? (Smith & Heckman 1990, Kauffmann + 2007)

QSO-absorber **transverse** correlation






GEOMETRY
TAXONOMY
40-45%
10-20%
No Absorbers
BAL
Warm Highly Ionized Medium
'WHIM'
NAL
40-45%
Accretion Disk
v=1000 km/s
Δ v=200 km/s
NH~10(22)
Massive Black Hole
r~10(16)cm
UV/X-ray luminosity source
v(vertical) = v(radial)
NH~10(24)
v=10,000-60,000 km/s
Δv=10,000-60,000 km/s
PHYSICS
Log radial scale
KINEMATICS

Elvis 2000