The sources of intergalactic metals

The Sources of Intergalactic Metals

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Basic Idea

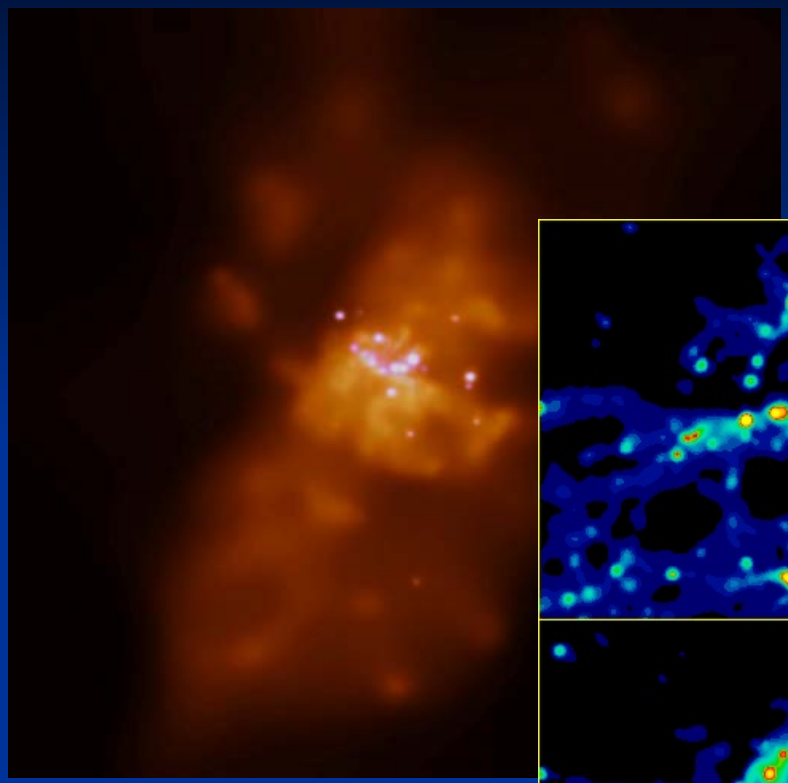
--Different enrichment models predict very different spatial distributions of metal "components" as quantified by the correlation function

--Use an automated method of identifying such components in a large sample of QSO spectra, concentrating on CIV and SiIV

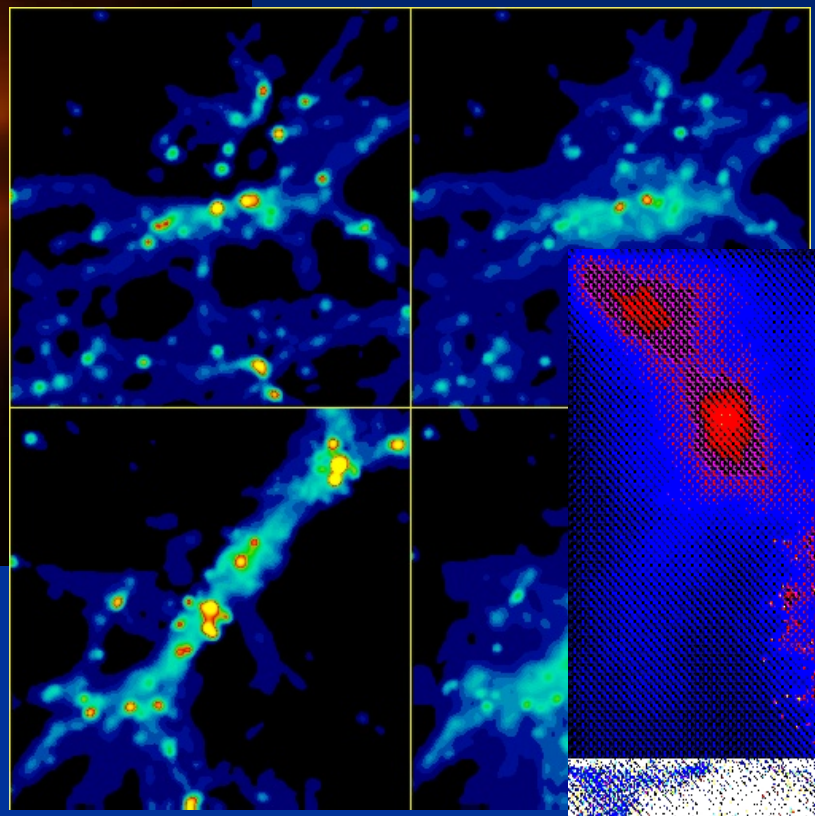
-- Apply precisely the same procedure to identify these features in simulated spectra from models that parameterize metal enrichment in a simple way

-- Compare simulated and measured correlation functions to derive best fit model parameters and uncertainties.

Metal Enrichment

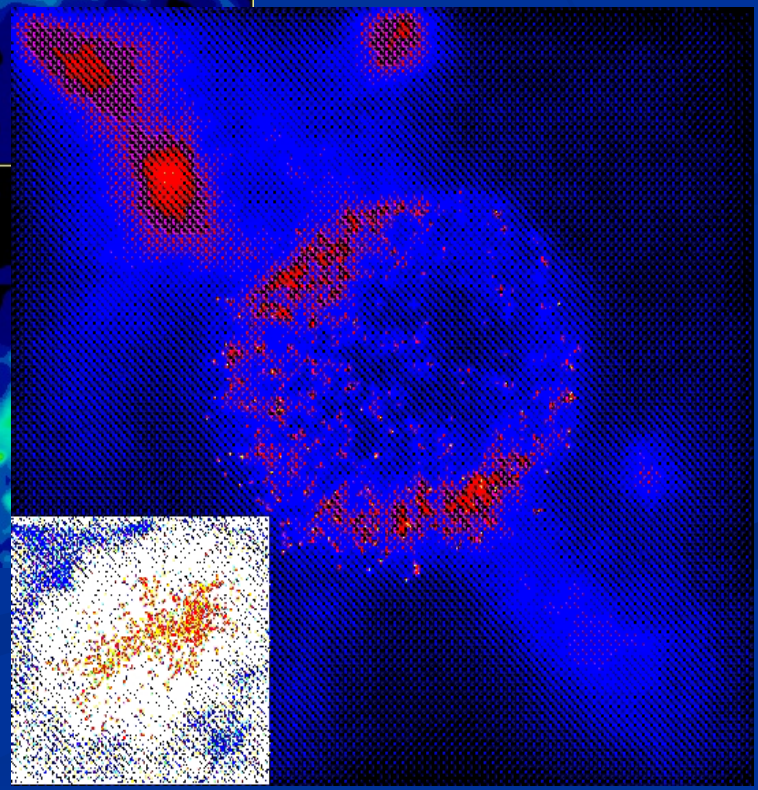


Lyman-Break type z=3-6 starbursting galaxies
Aguirre, Hernquist, Schaye, Weinberg, Katz, Gardner (01)



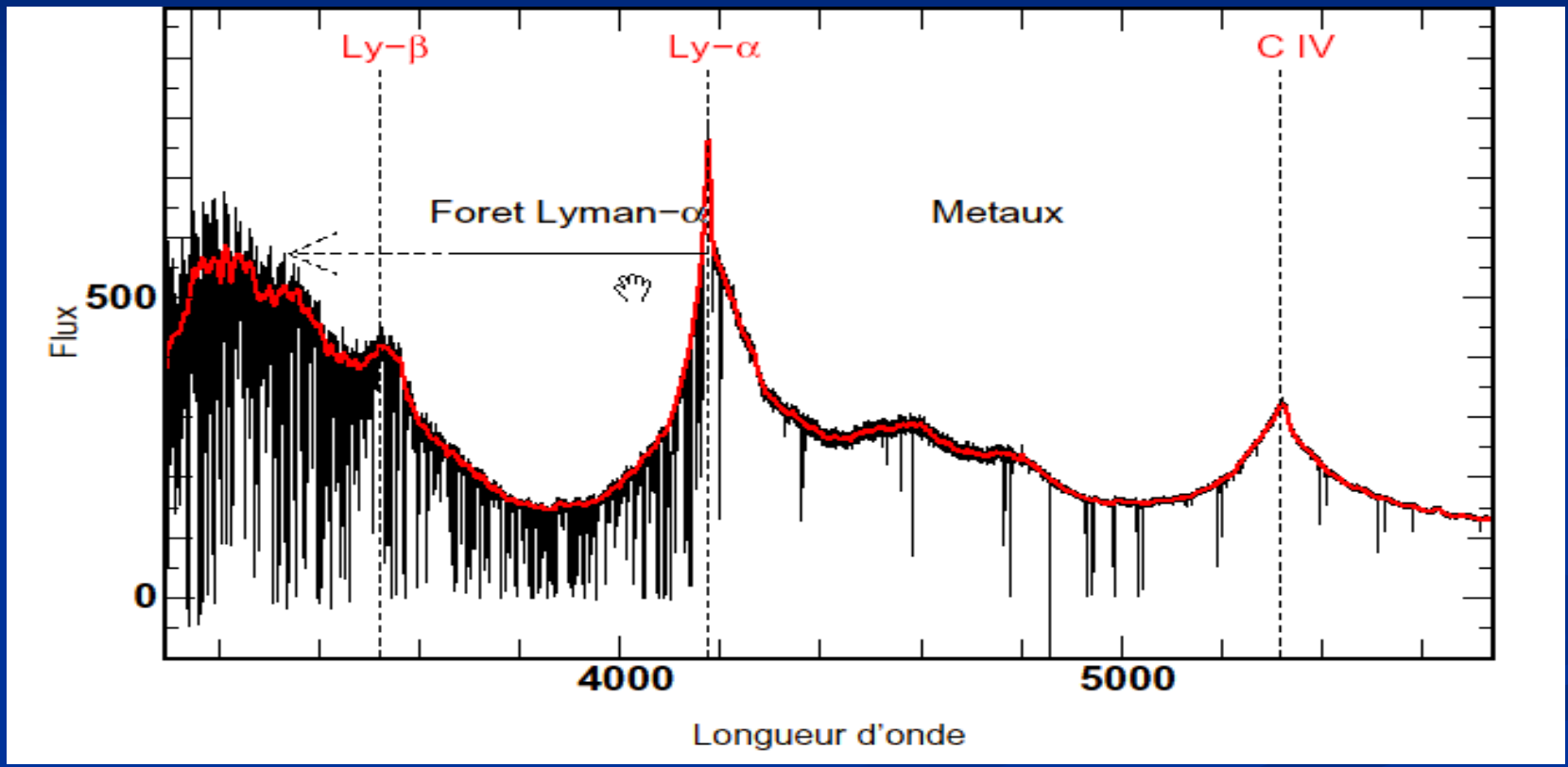
z=>6 protogalaxies
ES, Ferrara, Madau (02)
Thacker, ES, Davis (02)
Madau, Ferrara, Rees (01)

Primordial Stars
Bromm,Yoshida, Hernquist (03),
ES, Schneider, Ferrara (03)



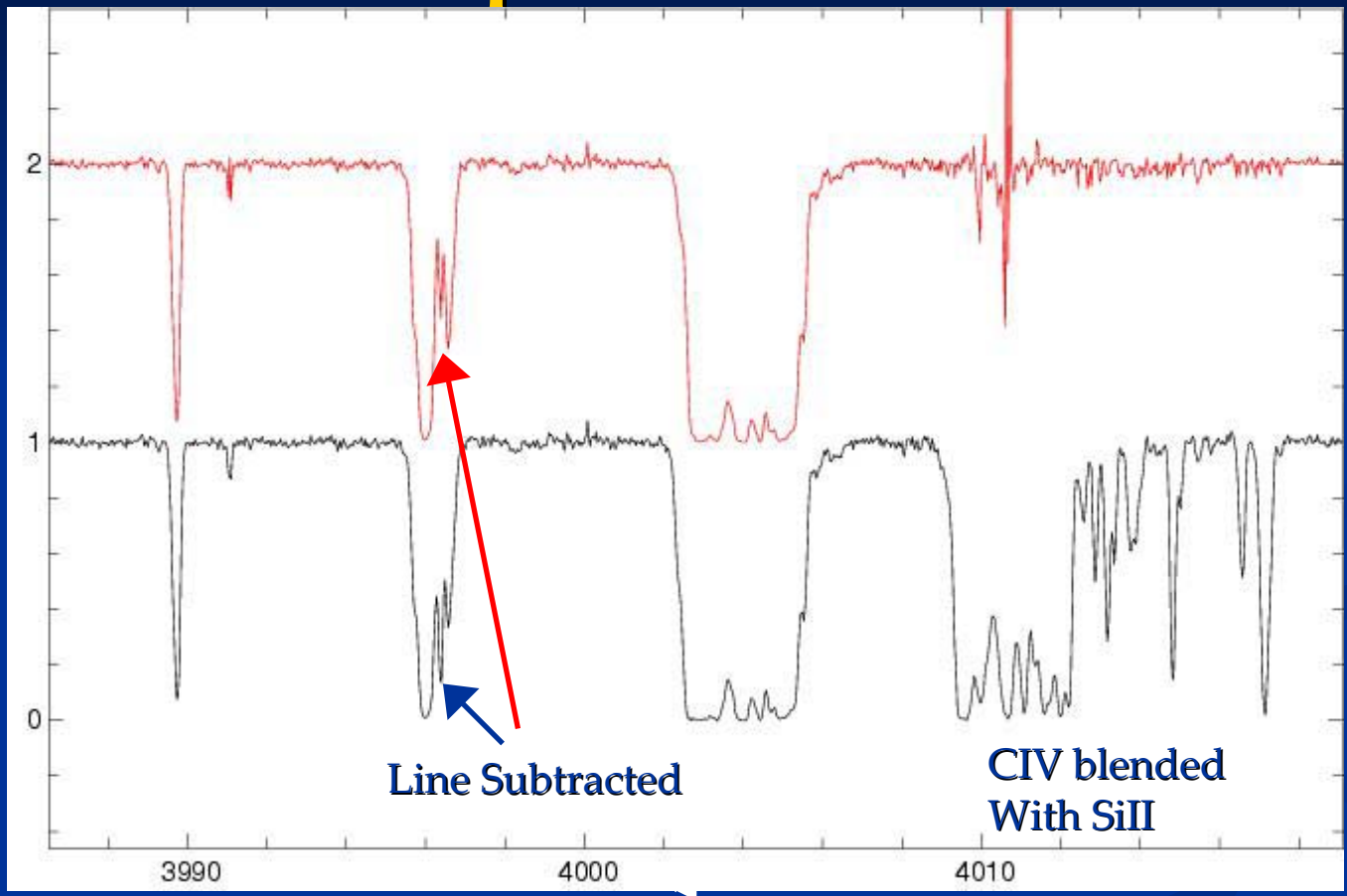
ESO-LP: "The Cosmic Evolution of the IGM"

B. Aracil, R. Badde, J. Bergeron, P Boisse, R. Carswell, S. Cristiani, V. d'Odorico, A. Ferrara, A. Fontana, E. Gialolongo, M. Haehnelt, T.-S. Kim, C. Ledoux, S. Lopez, C. Mallouris, P. Moller, P. Petitjean, C. Peroux C. Pichon, M. Rauch, E Scannapieco, P. Shaver, G. Vladillo



Focus on properties of CIV (z=1.5-3.0) and SiIV (z=1.8-3.0)

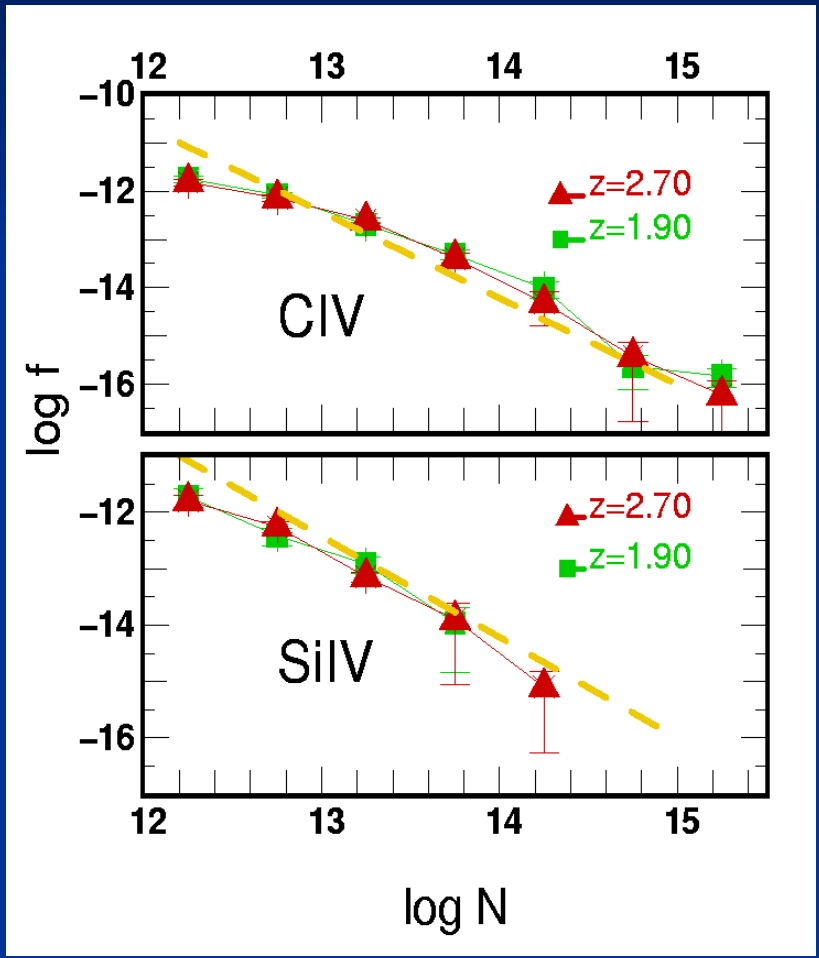
Automatic Detection of Subcomponents (B Aracil & C. Pichon)



For each species compare spectrum with shifted and rescaled spectrum pixel by pixel.

- Choose regions >= 2 pix flux<-1 compute S/N and apply a cut(5)
- Use profile criteria to eliminate multiple ids, testing various blends
- Fit identified lines with VPFIT, first guess (wmin, wmax, species), propagating information from unblended into blended regions.

Number Densities



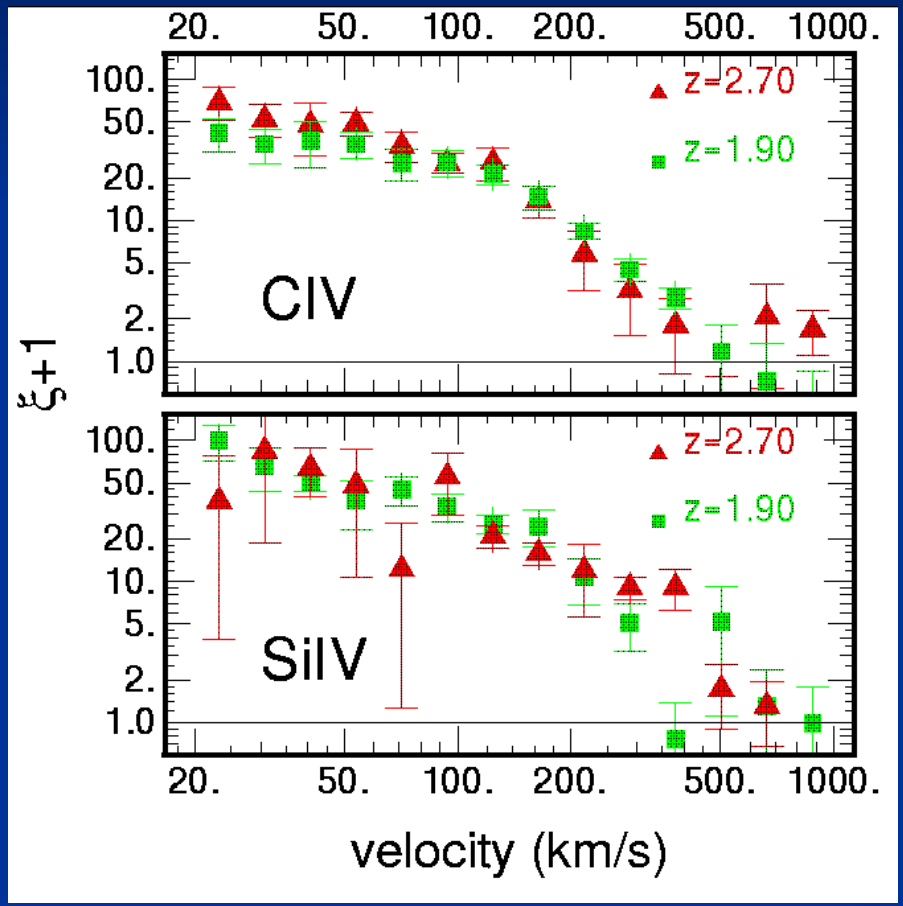
1. No Evolution Detected: fixed Comoving density, fixed Physical size

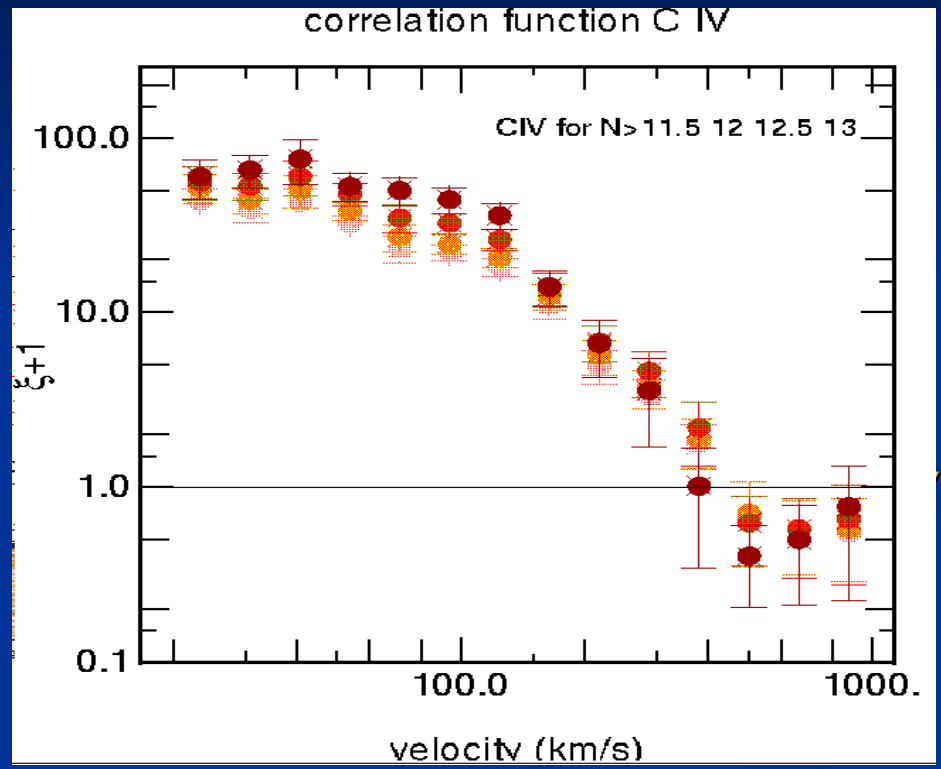
2. Number densities consistent with previous estimates

380 CIV and 92 SiIV systems
$N >= 10^{12}$ cm^{-2}

Dashed line is fit by Songaila (2001)

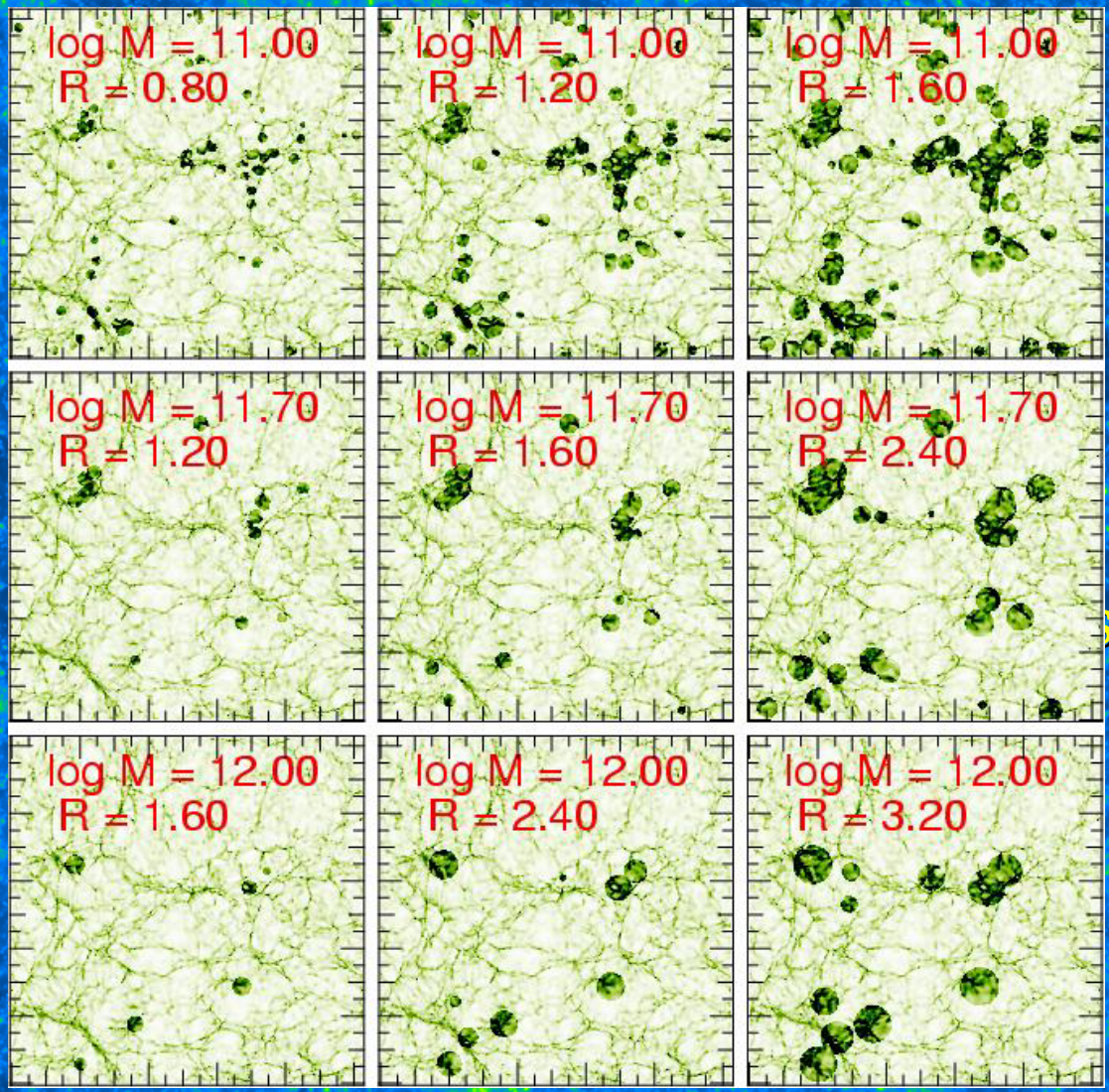
Correlation Function





turn over– bubble size
large scale clustering–
correlation function or "bias"
of sources.

Numerical Modeling (R Thacker)



Paint Spheres of

-- a fixed metallicity Z_s

--- with a fixed radius R_s

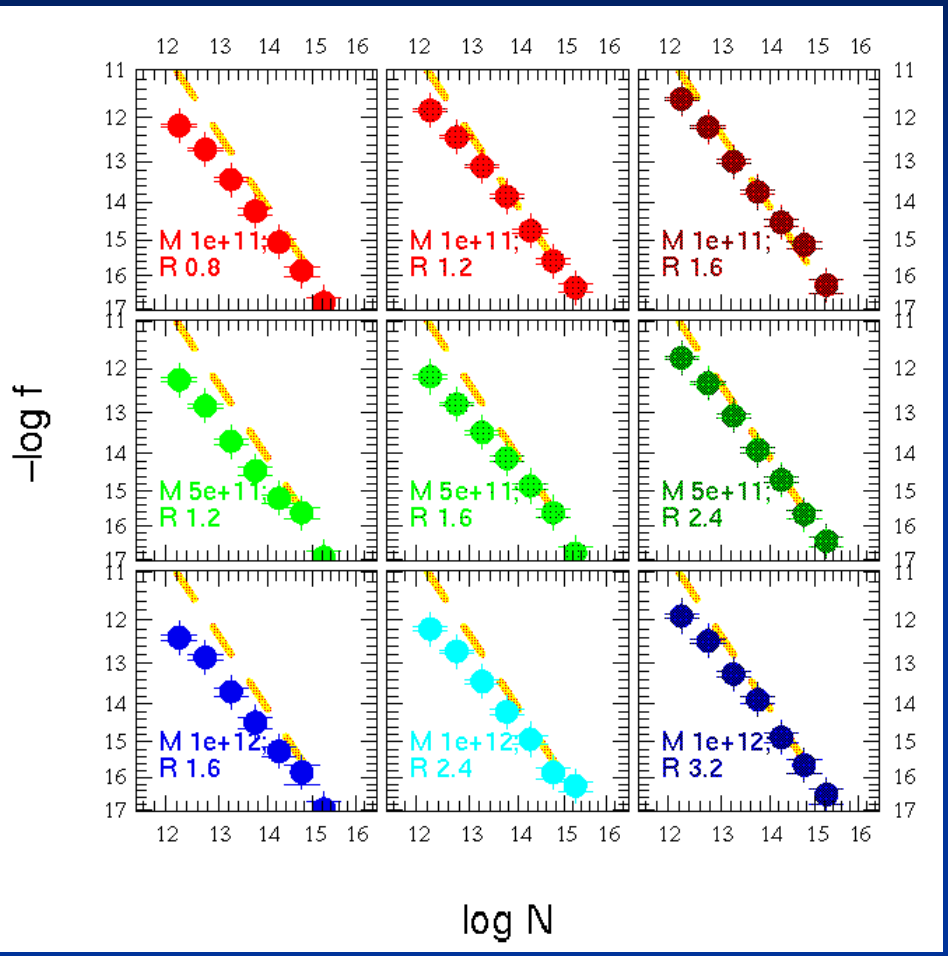
about z=3 groups of

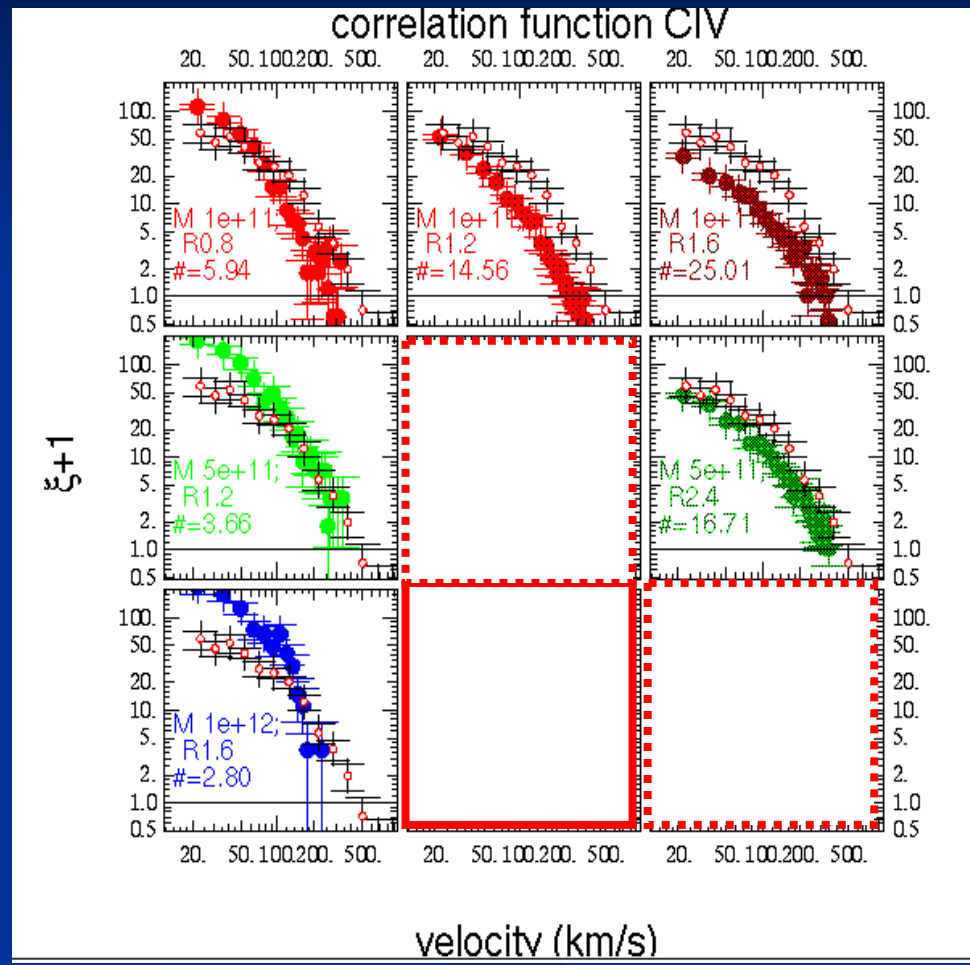
--- a fixed mass M_s

Tracers of BIAS

Extract spectra using CLOUDY + Haart and Madau Background.

Number Densities and Clustering

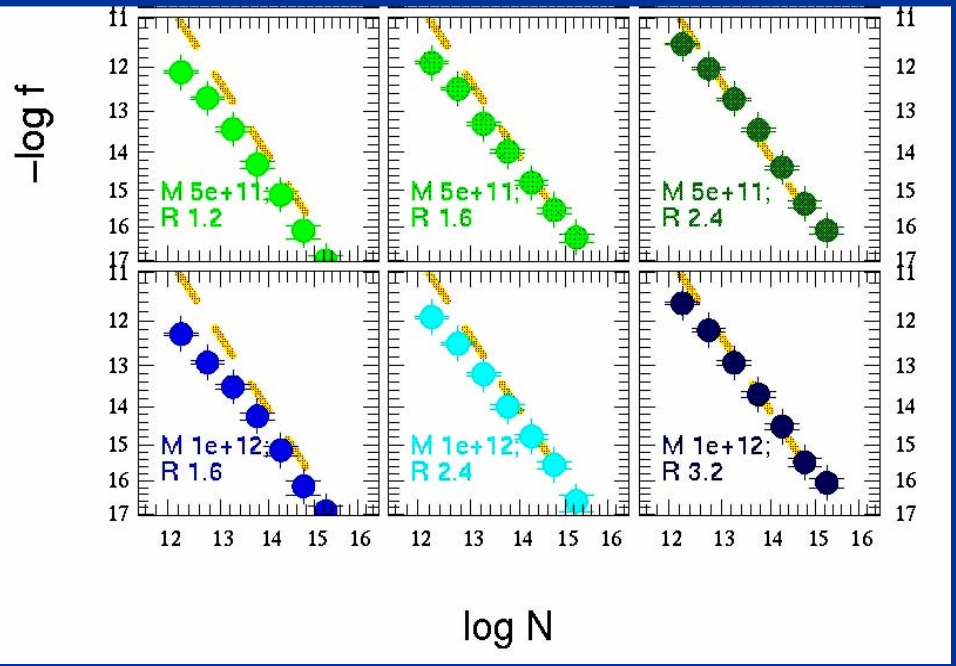


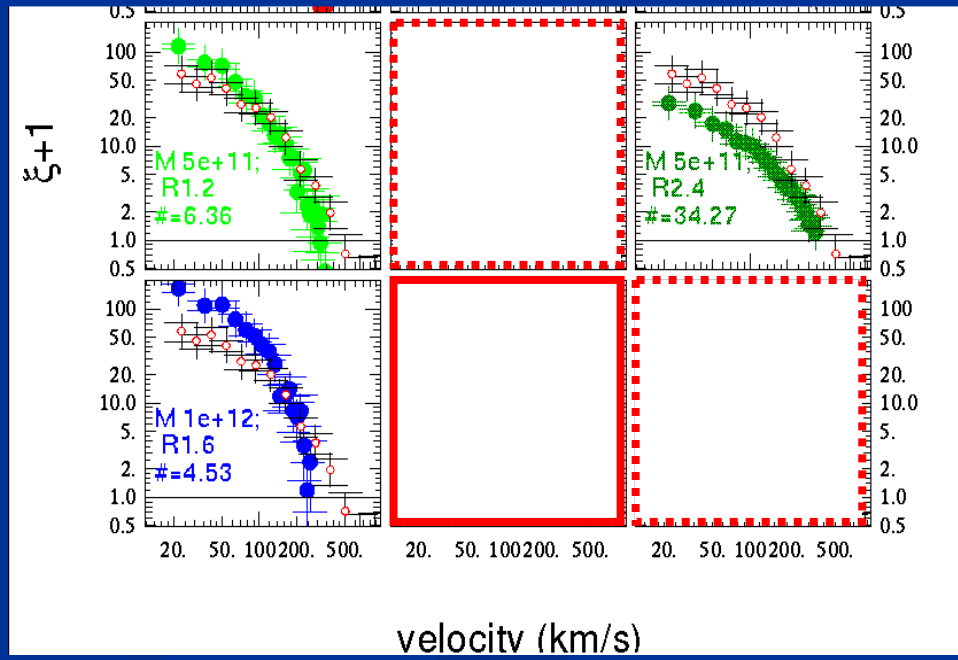


Z=1/50 solar

Number Densities and Clustering

1. Clustering is largely independent of Z
2. Very biased – argues strongly for enrichment from rare peaks
3. Filling factor of bubbles in these models is ~ 10%





Z=1/10 solar

Conclusions

1. We have studied the clustering of 380 CIV and 92 SiIV systems detected automatically in a homogenous sample of z ~ 3 high S/N, high resolution QSOs
2. No evolution is detected, both species follow each other closely
3. Correlation function exhibits two slopes with an elbow at 150 km/s, largely independent of N_{min}
4. Detailed comparisons with simulations imply that such metals are contained in R~2 comoving Mpc bubbles around sources biased like $10^{11.5}$ -10^{12} Msun z=3 galaxies.
5. The volume filling factor in such a model is ~10%