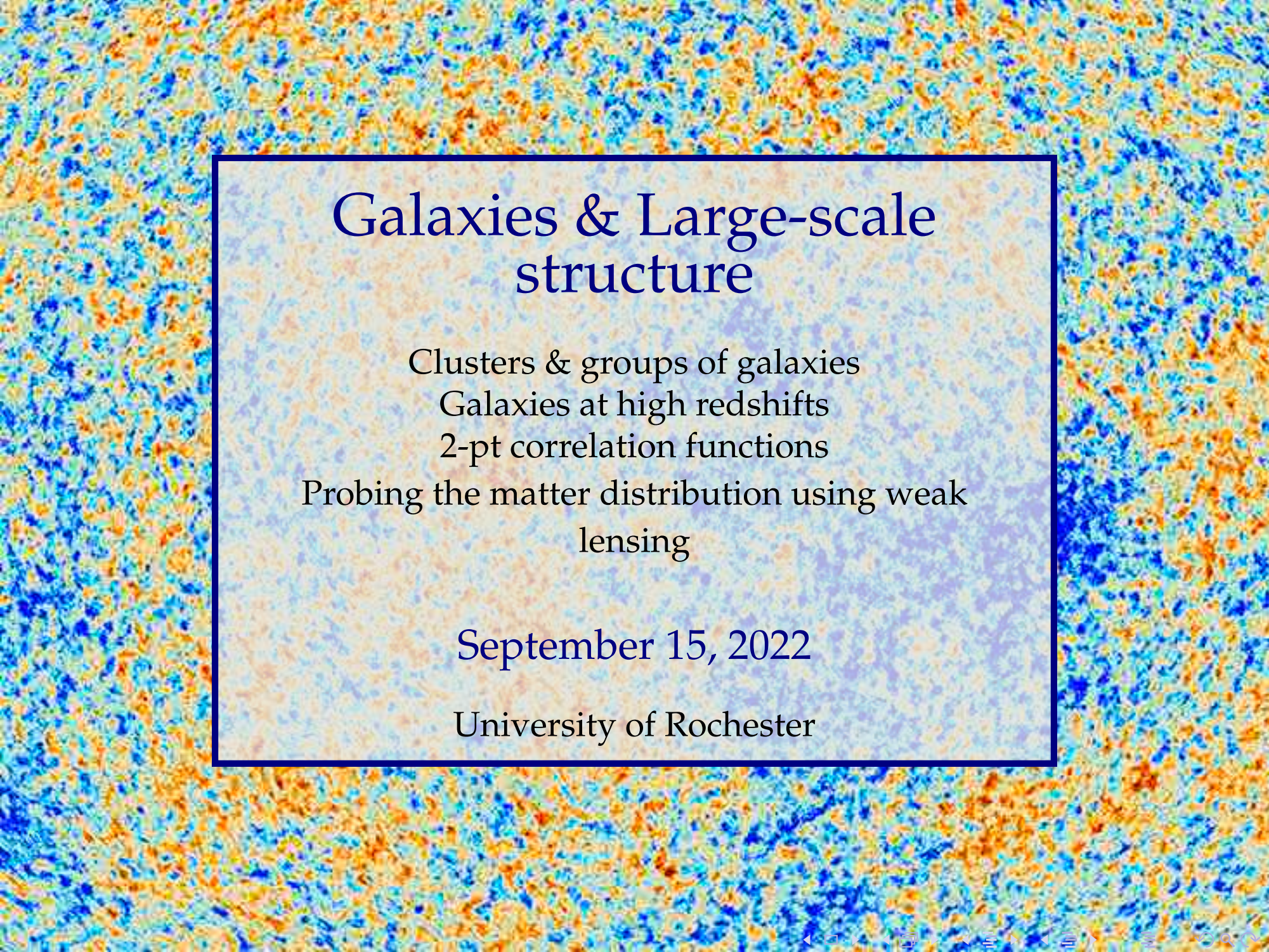


Galaxies & Large-scale structure

Clusters & groups of galaxies
Galaxies at high redshifts
2-pt correlation functions
Probing the matter distribution using weak lensing

September 15, 2022

University of Rochester

cD galaxies

A2261-BCG

Galaxy cluster mass

Estimated from the virial theorem:

$$M = A\frac{\sigma_{\rm los}^2 R_{\rm cl}}{G} \sim 10^{15} M_\odot/h$$

where

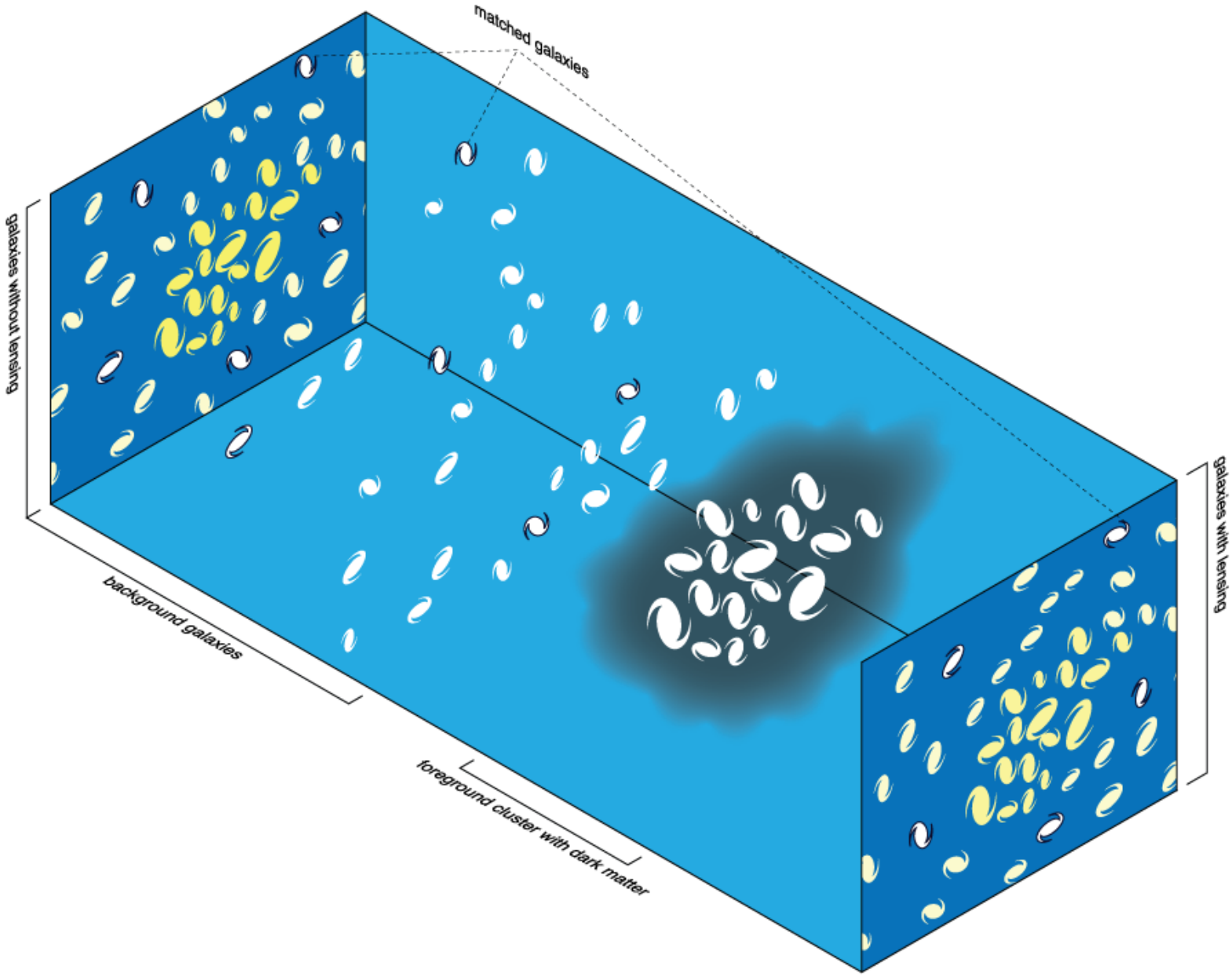
$R_{\rm cl}$ $\equiv$ cluster radius

A depends on density profile and definition of $R_{\rm cl}$

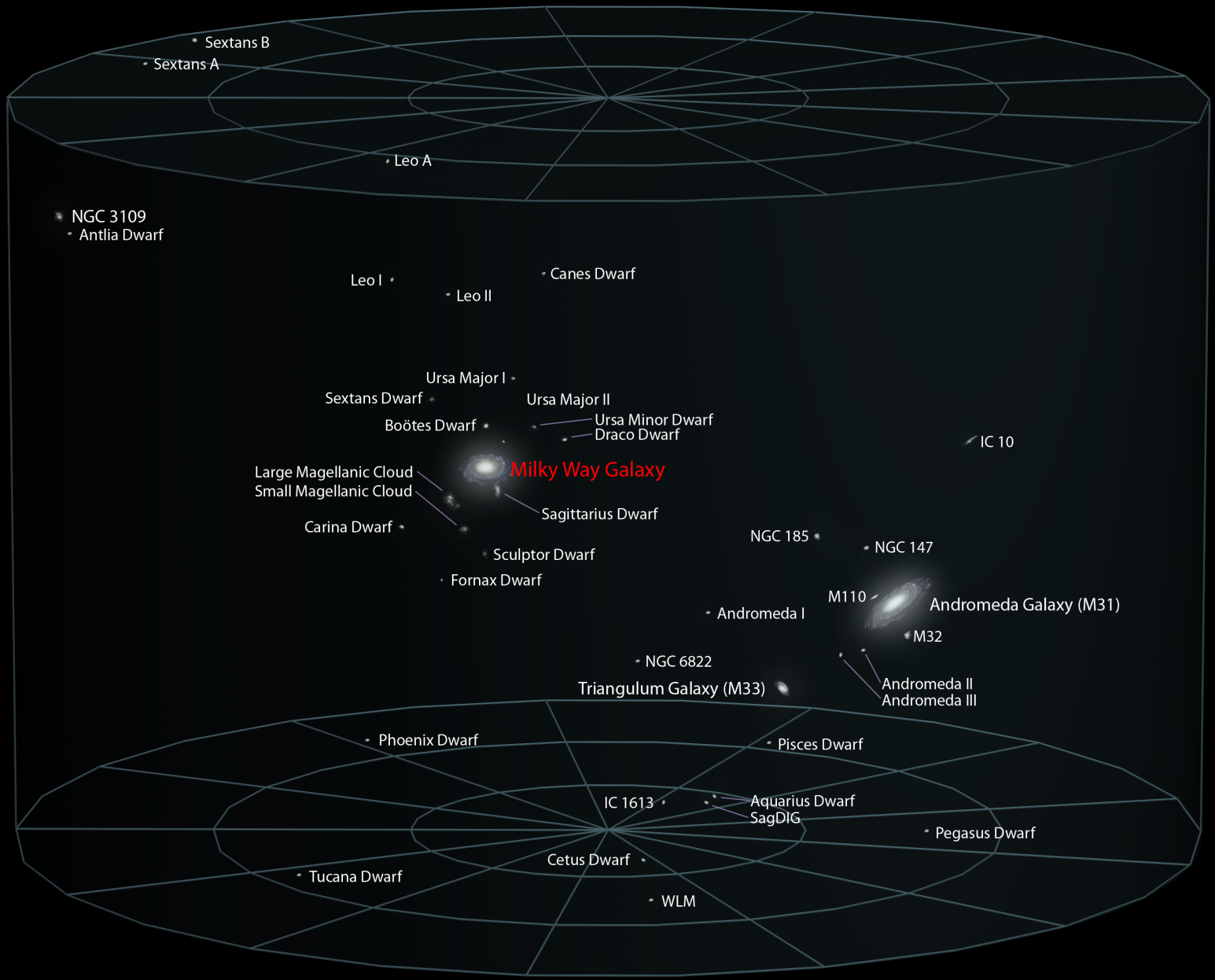
Resulting mass-to-light ratio:

$$\left(\frac{M}{L_B}\right)_{\rm cl} \sim 350h\left(\frac{M_\odot}{L_\odot}\right)_B$$

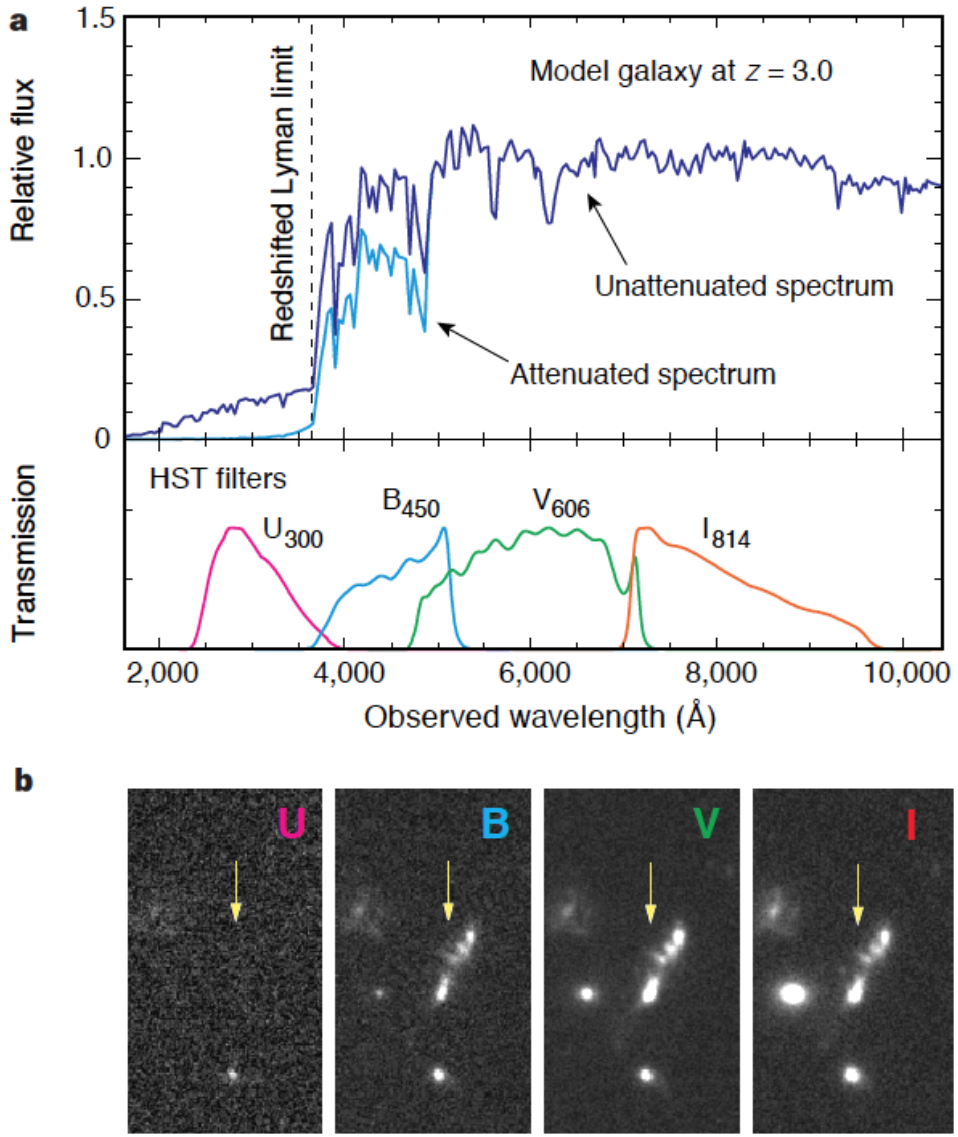
Gravitational lensing



The Local Group



Lyman-break galaxies



Star formation rate through time

Measure total gas mass converted into stars per unit time per unit volume at redshift z:

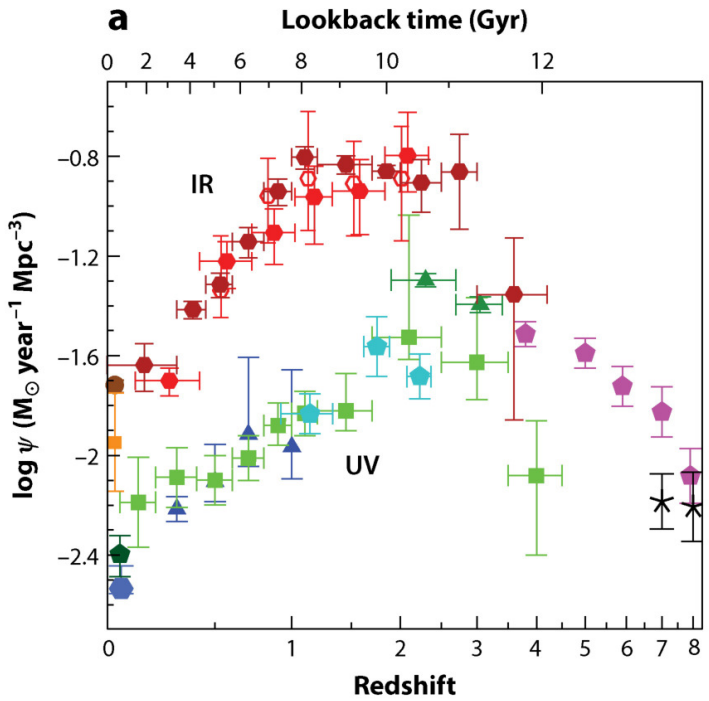
$$\dot{\rho}_*(z) = \int d\dot{M}_* \, \dot{M}_* \int P(\dot{M}_*|L,z)\, \phi(L,z)\, dL$$
$$= \int \langle \dot{M}_* \rangle (L,z) \phi(L,z)\, dL$$

where

$P(\dot{M}_*|L,z)\, d\dot{M}_* \equiv$ probability for galaxy with luminosity L at redshift z to have SFR in range $(\dot{M}_*, \dot{M}_* + d\dot{M}_*)$

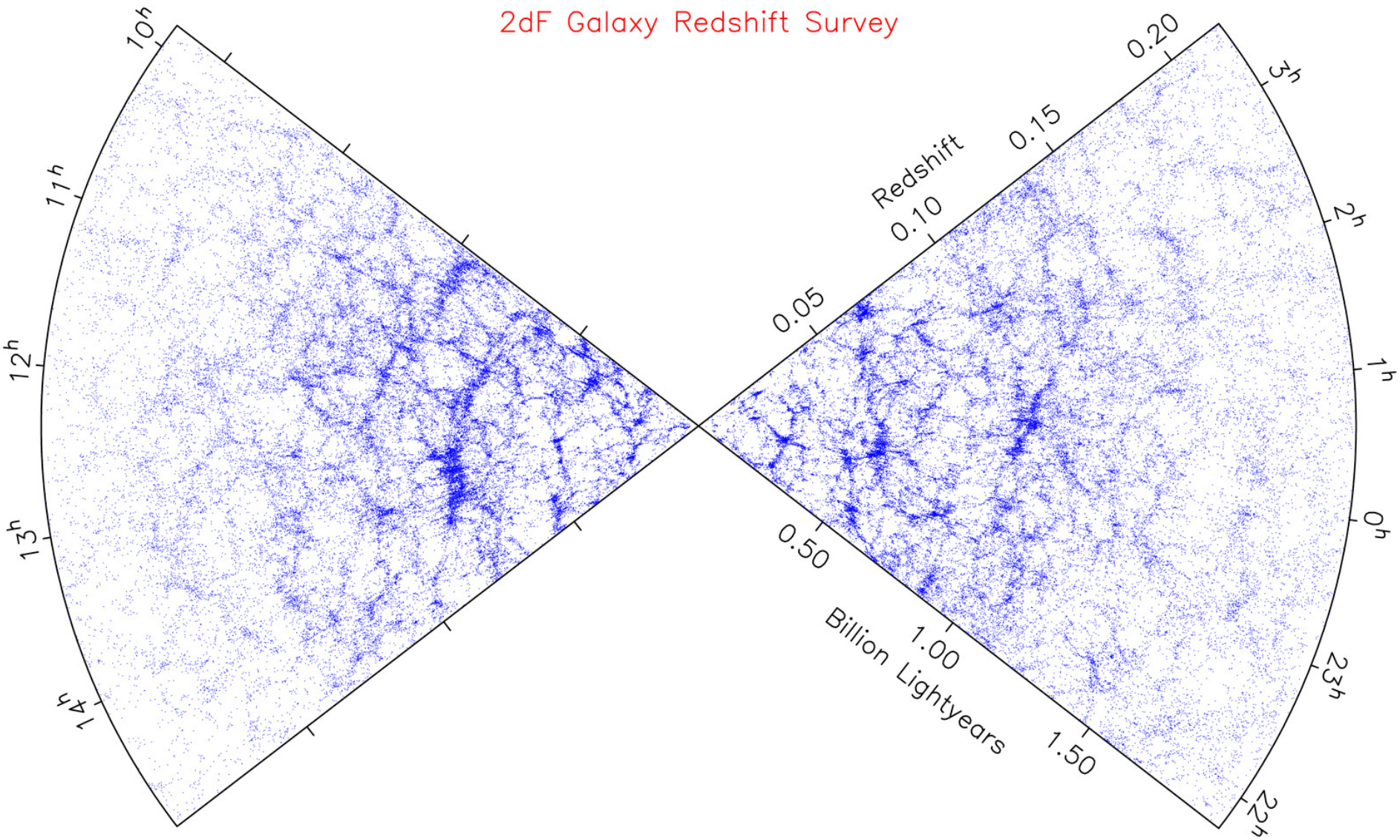
$\langle \dot{M}_* \rangle (L,z) \equiv$ mean SFR for galaxies with luminosity L at redshift z

$\phi(L,z) \equiv$ luminosity function



Madau P, Dickinson M. 2014. Annu. Rev. Astron. Astrophys. 52:415–86

The cosmic web



2-point correlation function

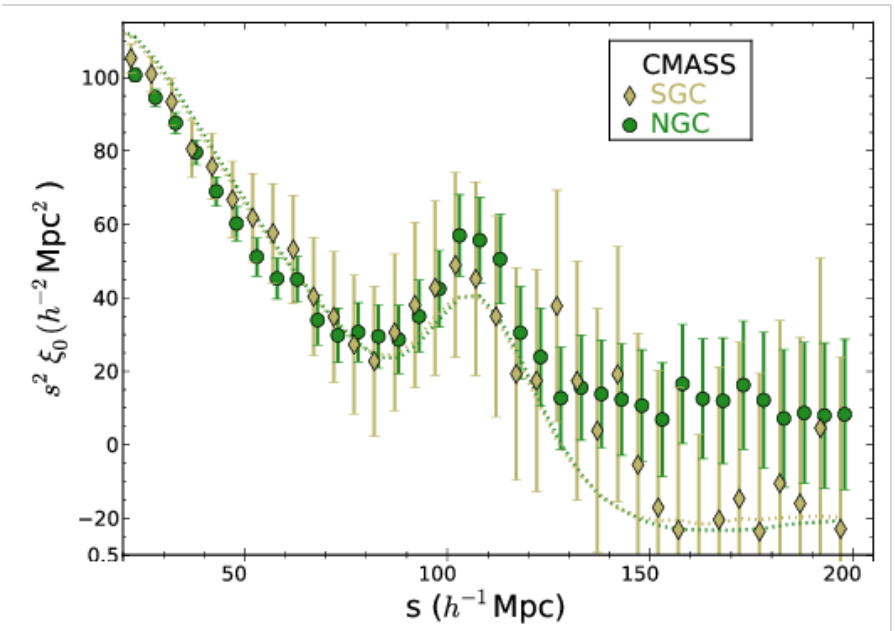
$$\xi(r) = \frac{DD(r)\Delta r}{RR(r)\Delta r} - 1$$

where

$DD(r)\Delta r \equiv$ number of galaxy pairs with separation $r \pm \frac{\Delta r}{2}$

$RR(r)\Delta r \equiv$ number of randomly-distributed galaxy pairs with separations $r \pm \frac{\Delta r}{2}$

On small scales ($r \lesssim 10$ Mpc$/h$), $\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma}$, where $\gamma \sim 1.8$ and $r_0 \sim 5$ Mpc$/h$.



Number variance

$$\sigma^2(r) \equiv \frac{1}{(\overline{n}V)^2}\frac{1}{M}\sum_{i=1}^{M}(N_i - \overline{n}V)^2$$

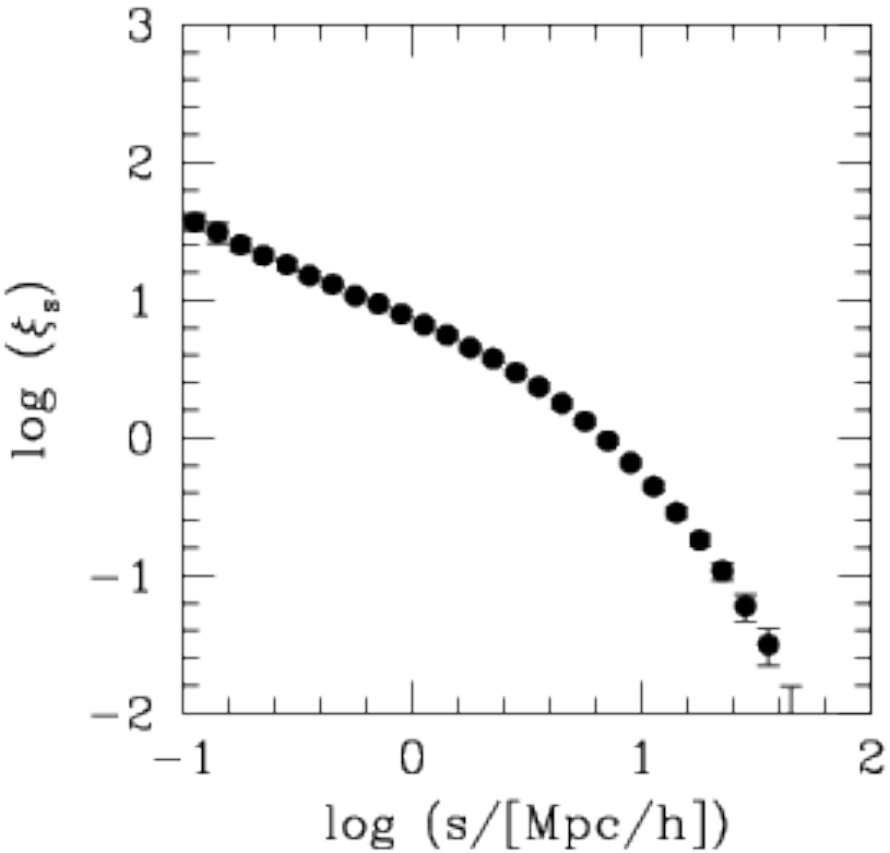
where

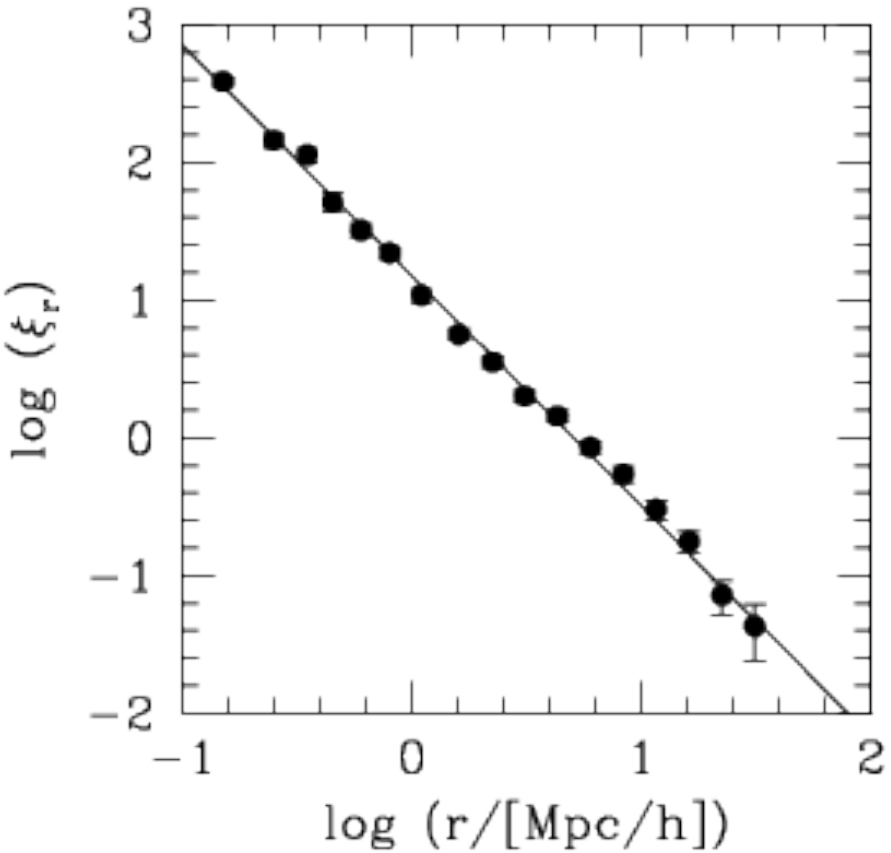
$\overline{n}$ $\equiv$ average number density

V $= \frac{4}{3}\pi r^3$

$N_i(i = 1, \ldots, M)$ $\equiv$ number counts of objects in M randomly placed spheres

Measuring the galaxy velocity field





Weak lensing