

Lecture XIV: Galaxy Surveys, Part 2

Physics 8803
April 12, 2019

Contents

- Selection of galaxies for cosmology
- Observational results

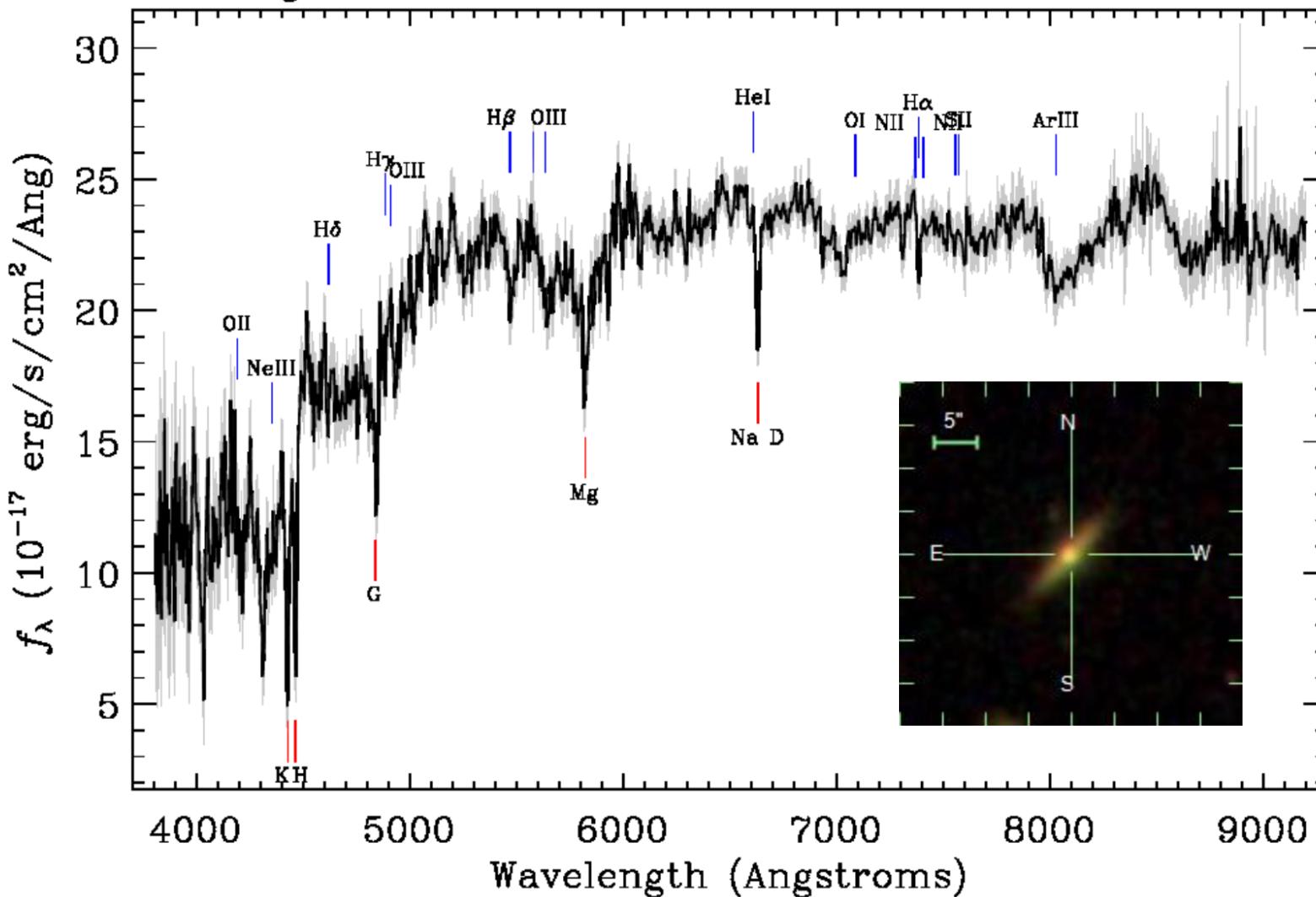
Which Galaxies to Use?

- In principle, any sample of galaxies should do.
- For **weak lensing**, use all resolved galaxies (need shapes)
- For (targeted) **redshift surveys**, pre-select galaxy types that are likely to be in the z range of interest, and where there are strong features in the wavelength range of your spectrograph.
- Examples:
- All galaxies above a magnitude limit
- Luminous red galaxies
- (Color-selected) star-forming galaxies (bright emission lines)
- Quasars (also for Lyman- α forest)

Example SDSS spectrum

(low star formation rate galaxy at magnitude r = 17.14)

Survey: *sdss* Program: *legacy* Target: *GALAXY*
RA=179.58269, Dec=-0.43457, Plate=285, Fiber=231, MJD=51930
 $z=0.12482 \pm 0.00002$ Class=GALAXY
No warnings.



BOSS Target

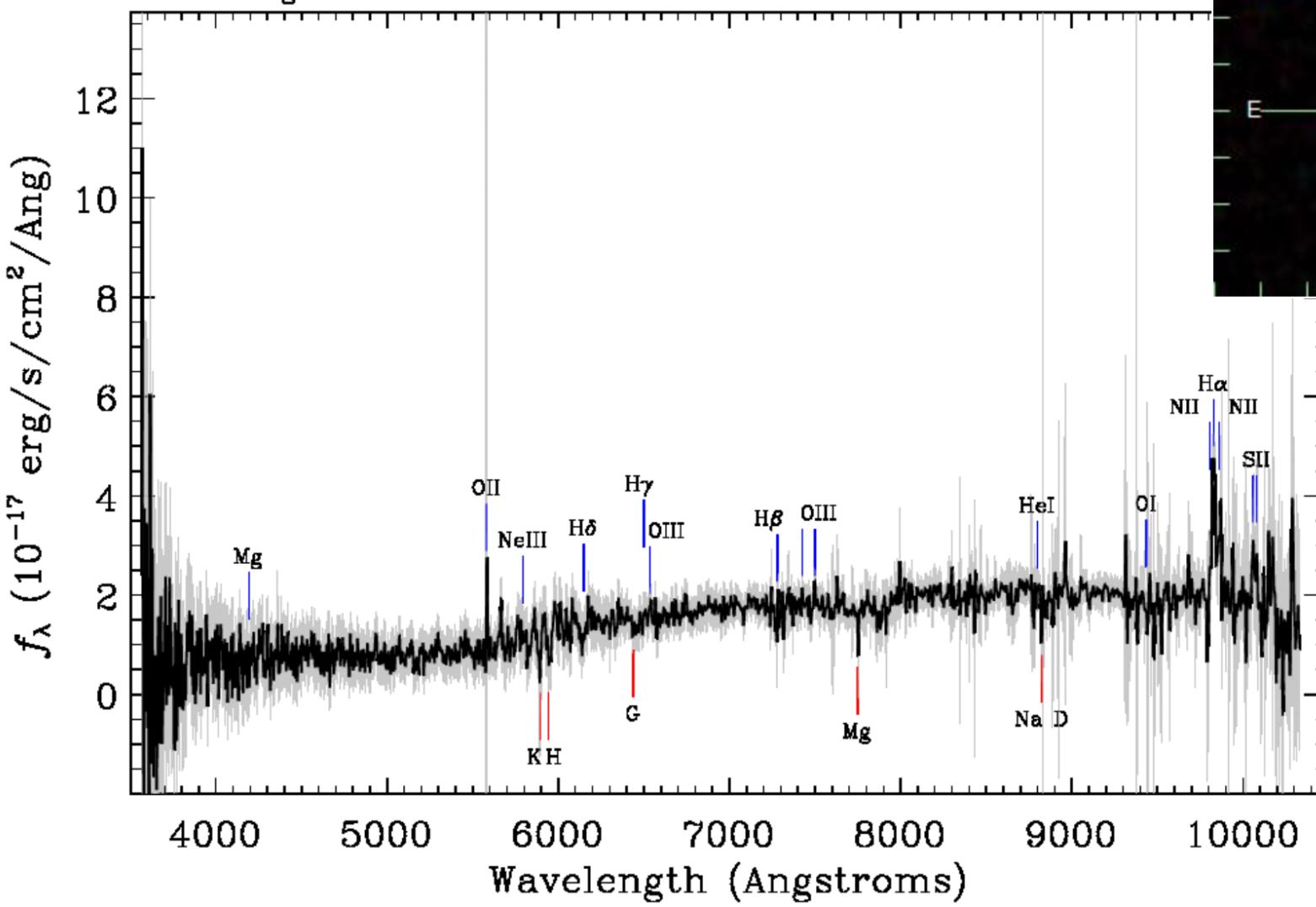
(luminous galaxy; turns out to be star-forming; $r = 20.22$)

Survey: *boss* Program: *boss* Target: *GAL_CMASS GAL_CMASS_COMM GAL_CMASS_ALL*

RA=179.36016, Dec=-0.51344, Plate=3843, Fiber=179, MJD=55278

$z=0.49727 \pm 0.00008$ Class=GALAXY STARFORMING

No warnings.



BOSS Target

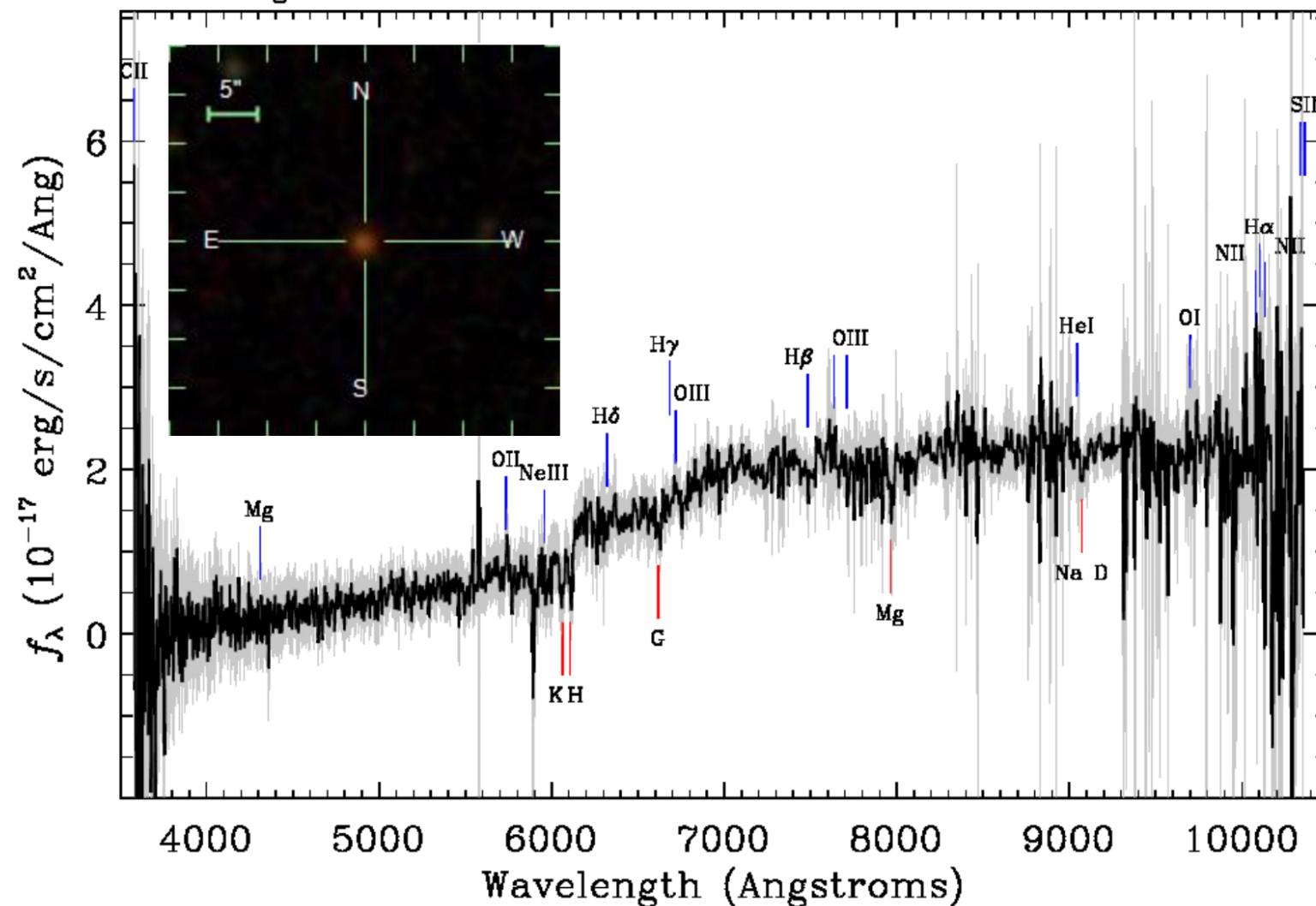
(luminous galaxy; not star-forming; $r = 20.38$)

Survey: *boss* Program: *boss* Target: *GAL_CMASS GAL_CMASS_COMM GAL_CMASS_ALL*

RA=179.19557, Dec=-0.47559, Plate=3776, Fiber=705, MJD=55209

$z=0.53919 \pm 0.00011$ Class=GALaxy

No warnings.



Low redshift quasar

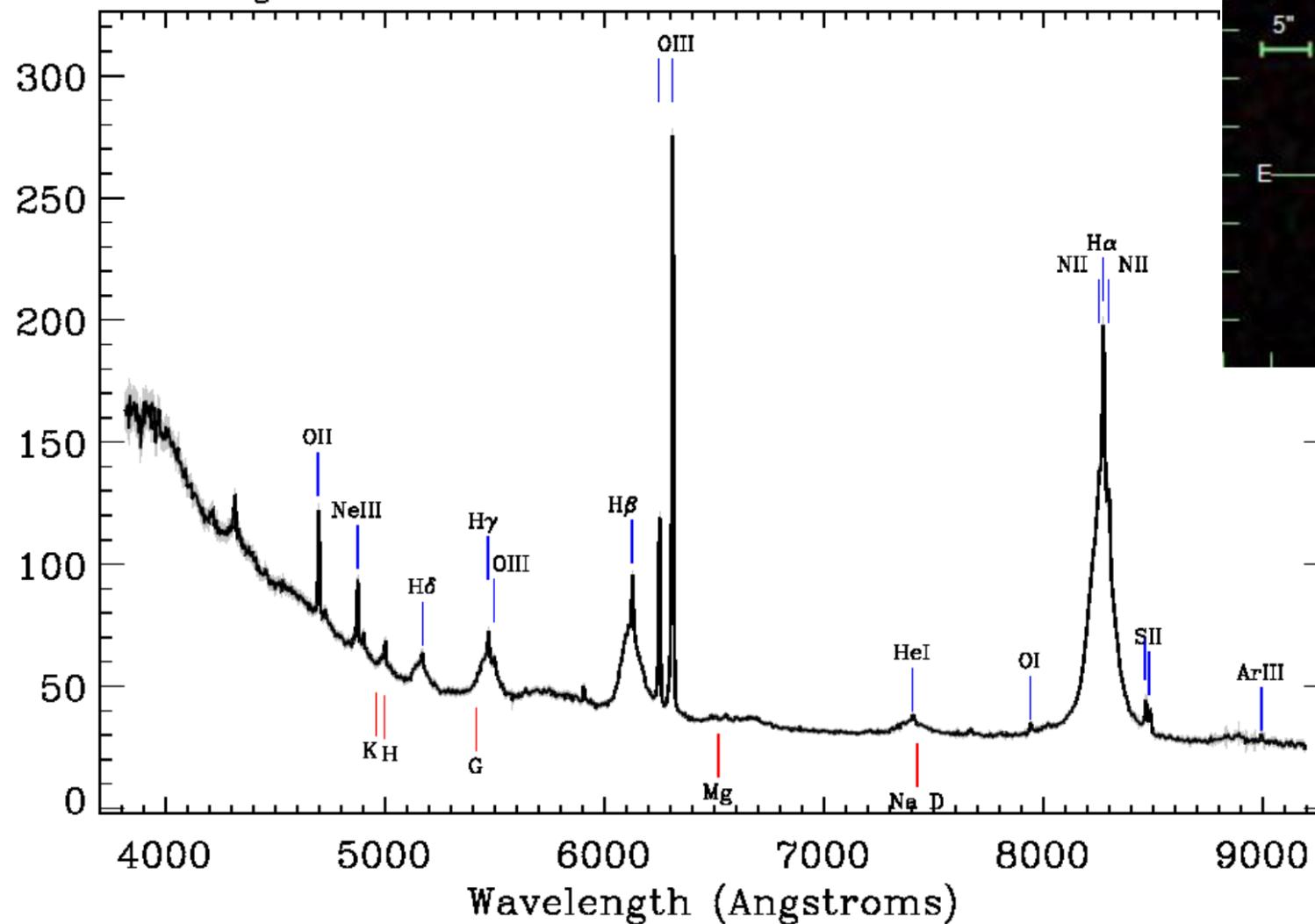
(magnitude g = 17.31)

Survey: *sdss* Program: *legacy* Target: *QSO_SKIRT ROSAT_B ROSAT_C ROSAT_D*

RA=179.49471, Dec=-0.37244, Plate=285, Fiber=280, MJD=51930

$z=0.25969 \pm 0.00009$ Class=QSO BROADLINE

No warnings.



Medium redshift quasar

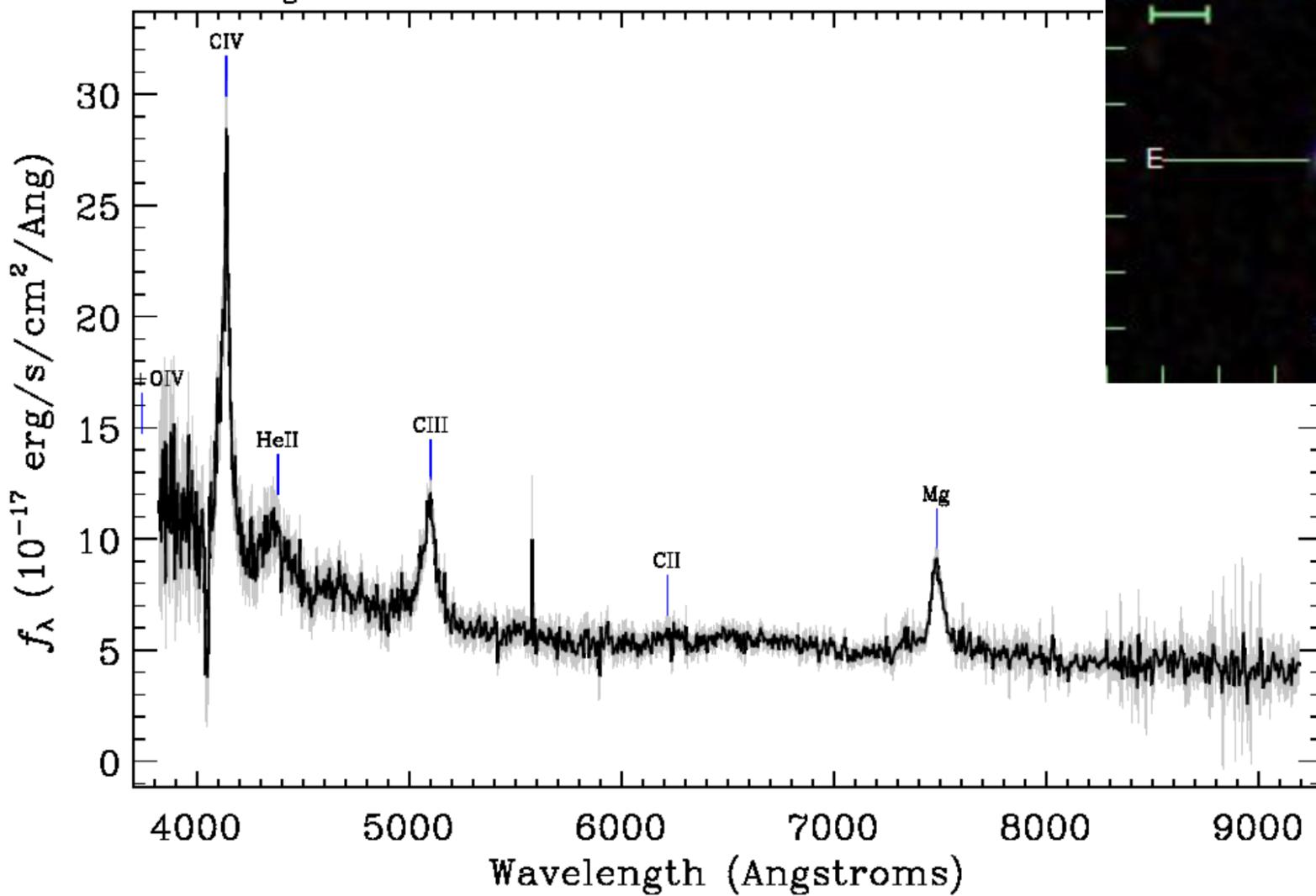
(magnitude g = 19.48)

Survey: *sdss* Program: *legacy* Target: *QSO_SKIRT SERENDIP_BLUE*

RA=178.48864, Dec=-0.46501, Plate=285, Fiber=302, MJD=51930

$z=1.67255 \pm 0.00026$ Class=QSO BROADLINE

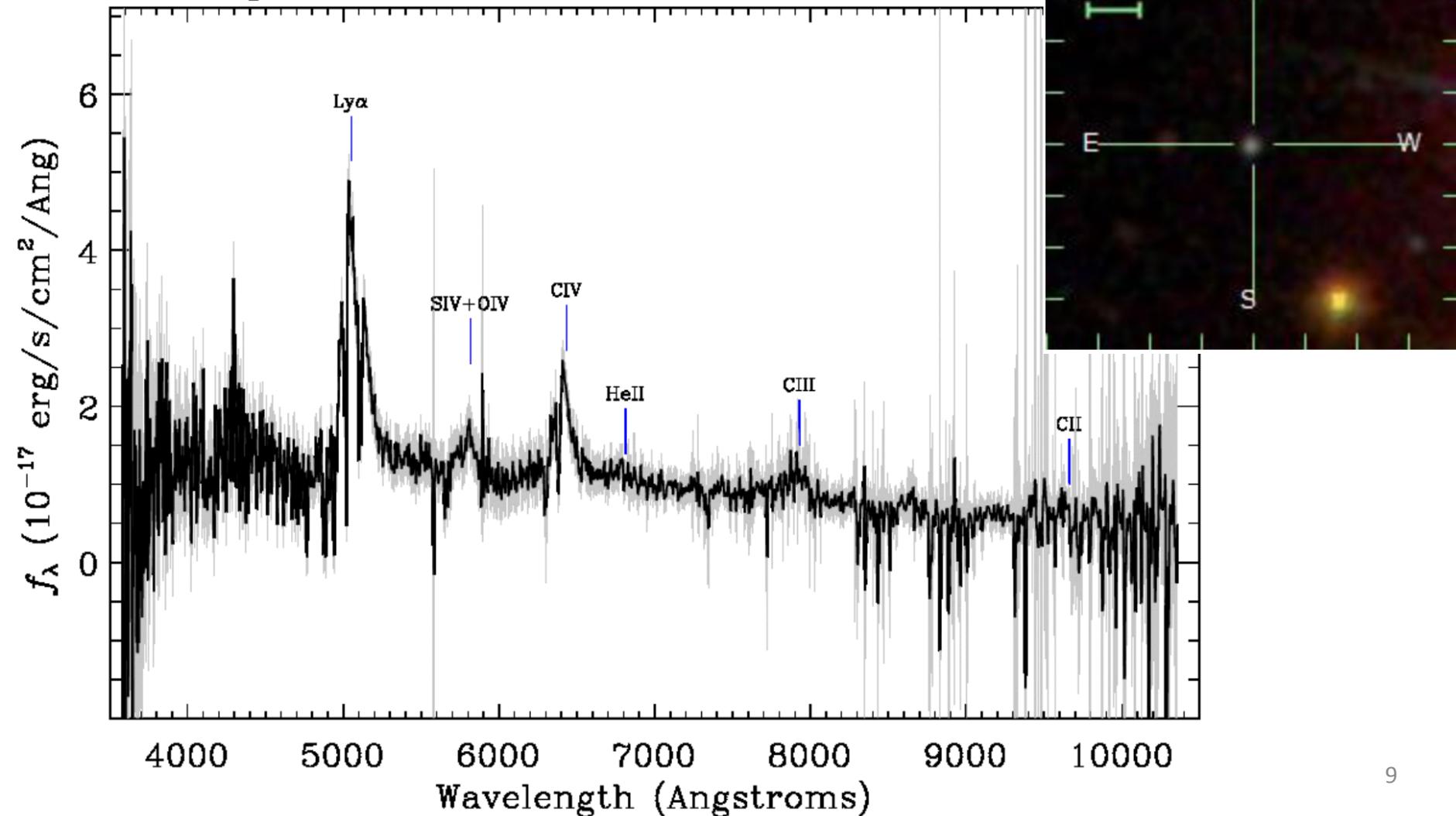
No warnings.



High redshift quasar

(magnitude g = 21.01)

Survey: *boss* Program: *boss* Target: *QSO_NN QSO_LIKE QSO_CORE_MAIN QSO_BONUS_MAIN*
RA=177.76946, Dec=-0.67529, Plate=3790, Fiber=870, MJD=55208
 $z=3.15398 \pm 0.00056$ Class=QSO BROADLINE
No warnings.



Emission line galaxy

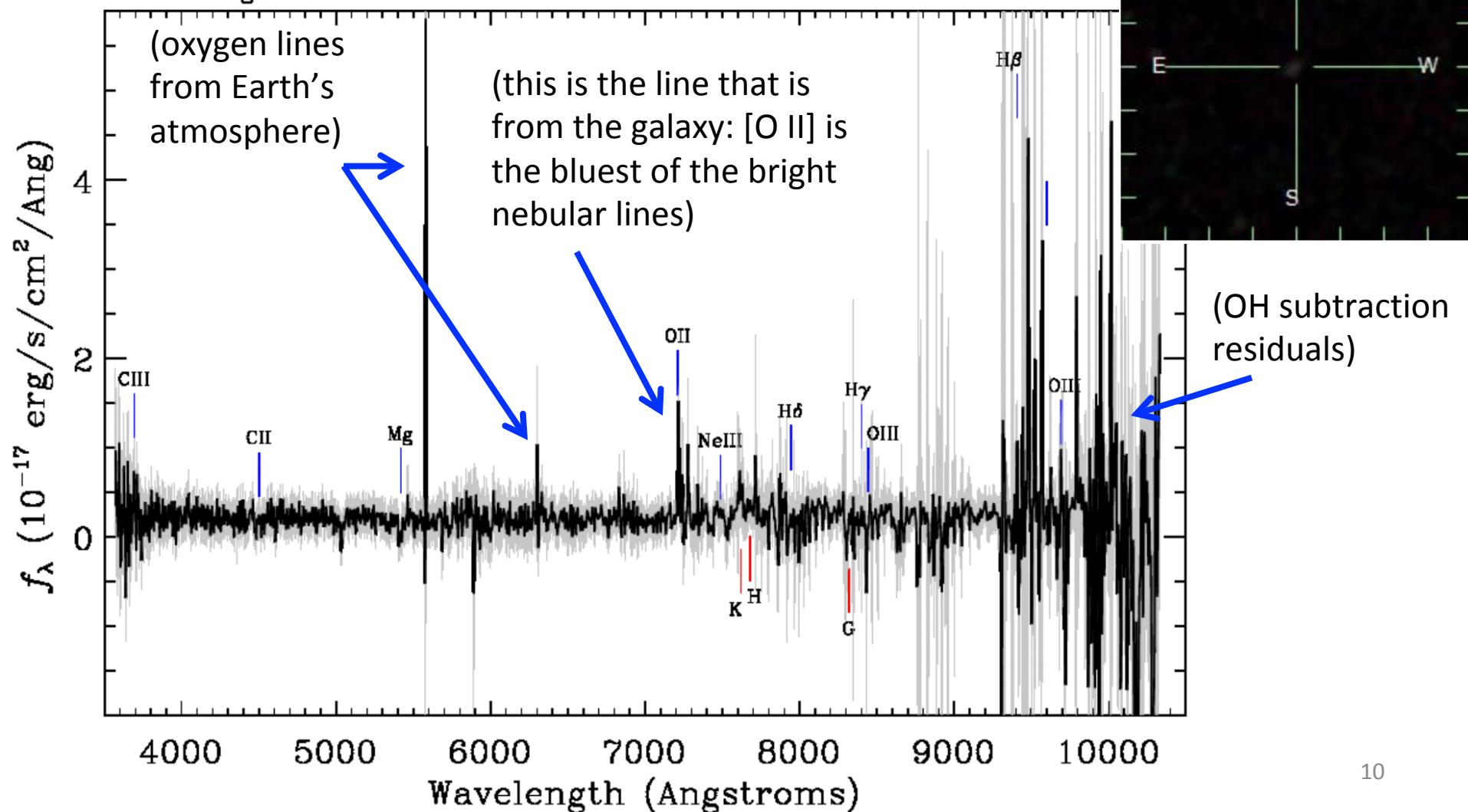
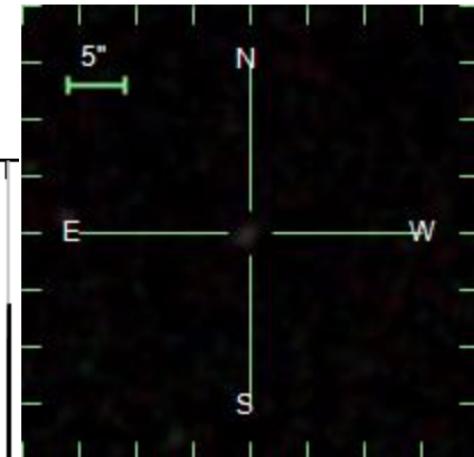
(eBOSS target, Nov. 12, 2015, r = 22.16)

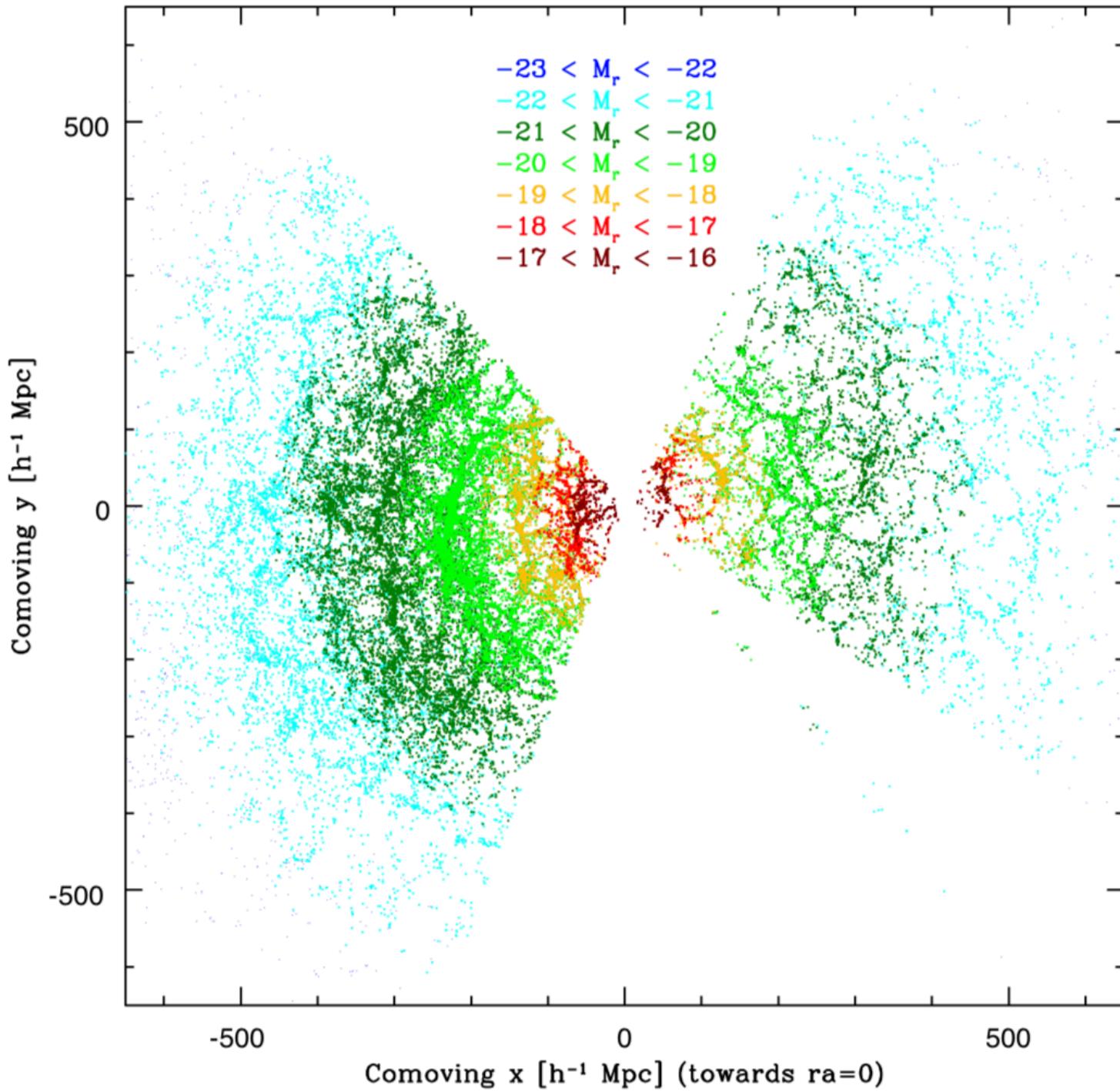
Survey: *eboss* Program: *eboss* Target:

RA=359.87747, Dec=0.10483, Plate=8789, Fiber=36, MJD=57338

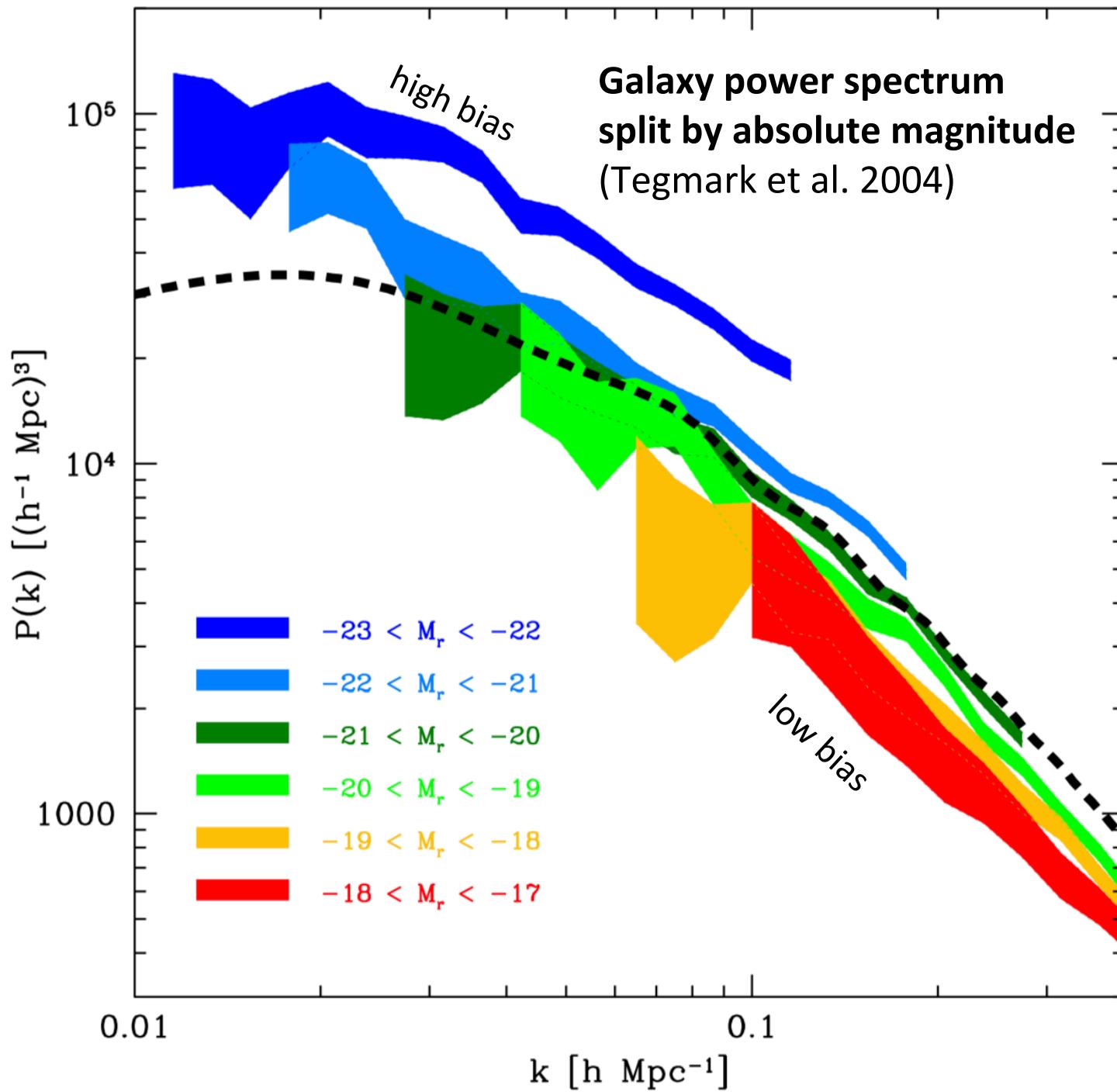
$z=0.93512 \pm 0.00007$ Class=GALAXY

No warnings.





(Figure goes
out to $z=0.2$)



Galaxy-Galaxy Lensing

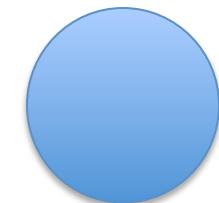
SOURCE



Lens galaxy acts as a:

↔ **Converging lens** in tangential direction
↔ **Diverging lens** in radial direction

Mean distortion of source galaxy:



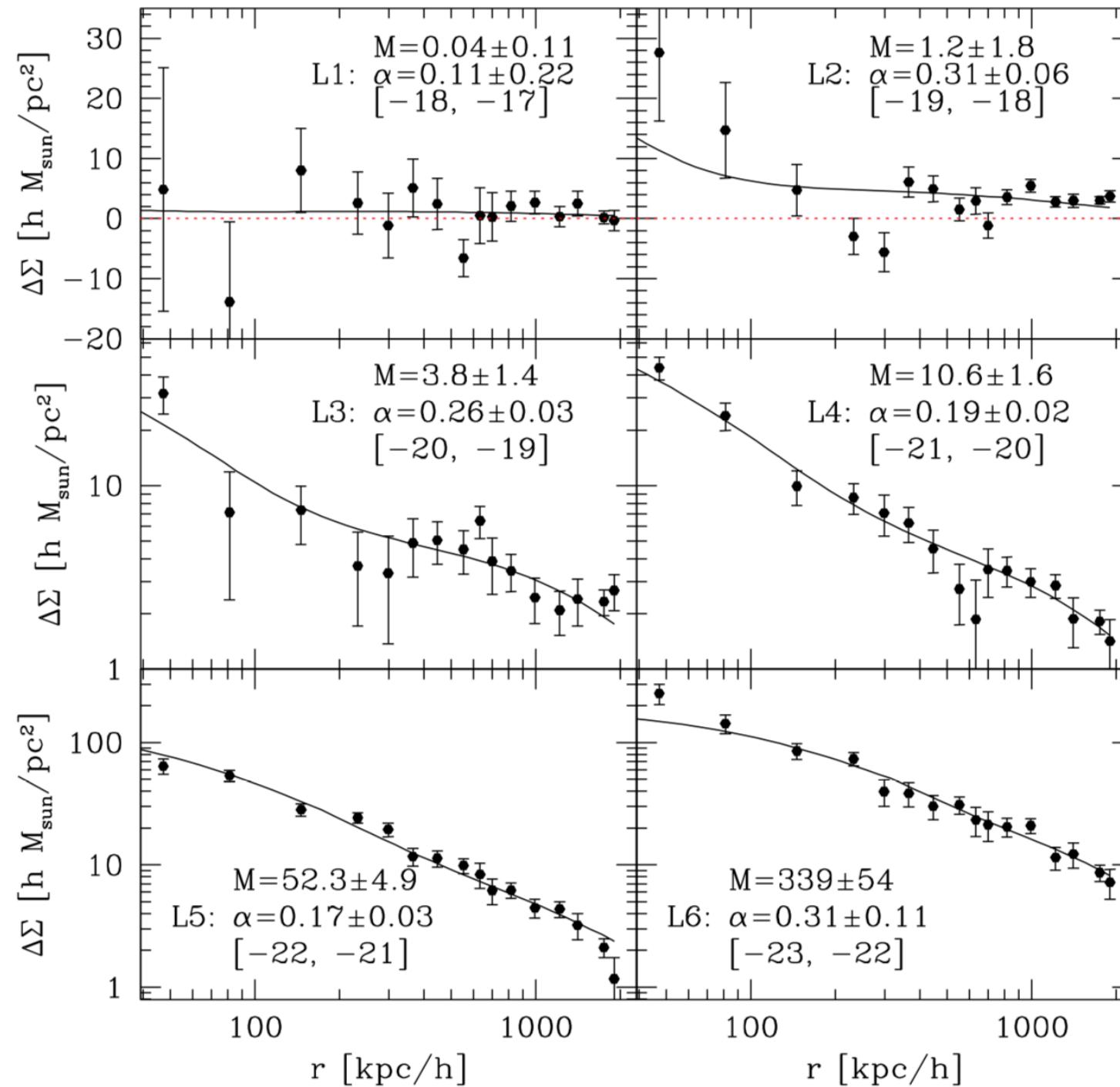
LENS

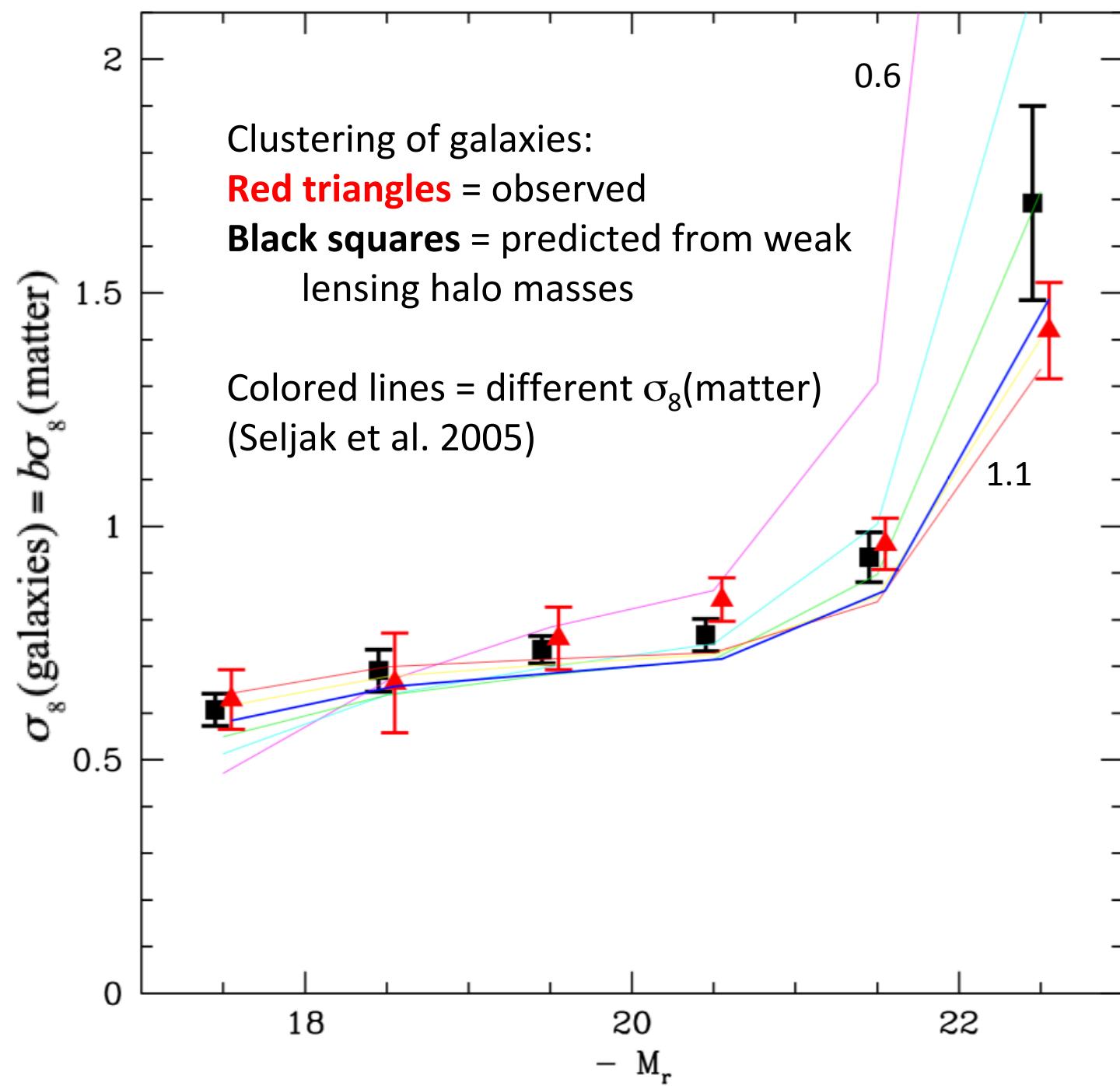
$$\gamma = \left\langle \frac{a-b}{a+b} \right\rangle = \frac{4\pi G D_L (D_S - D_L) (1+z_L)^2}{c^2 D_S} \Delta\Sigma(r)$$

$$\Delta\Sigma(r) = \bar{\Sigma}(< r) - \Sigma(r)$$

(See first detection by Brainerd, Blandford & Smail, 1996)

Weak lensing signals
around galaxies
(Seljak et al. 2005)

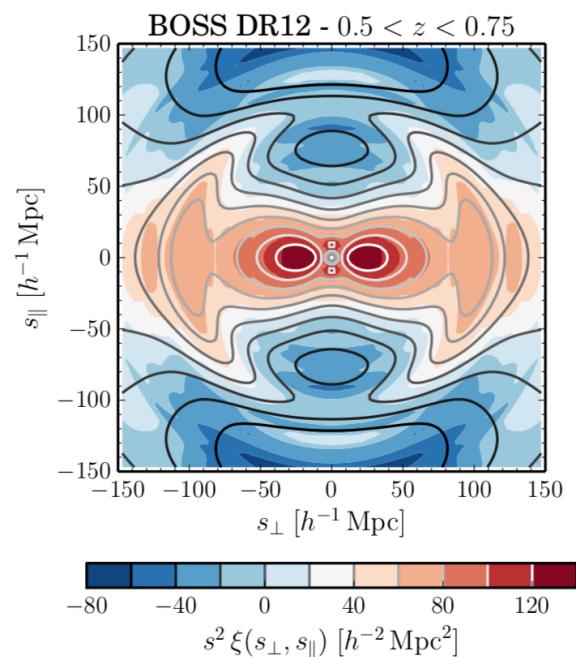




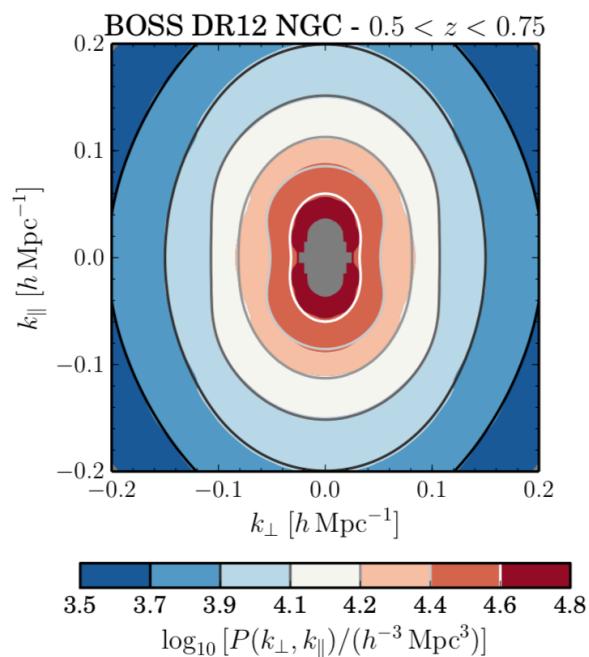
Statistics from BOSS

($0.5 < z < 0.75$ sample; Alam et al. 2017)

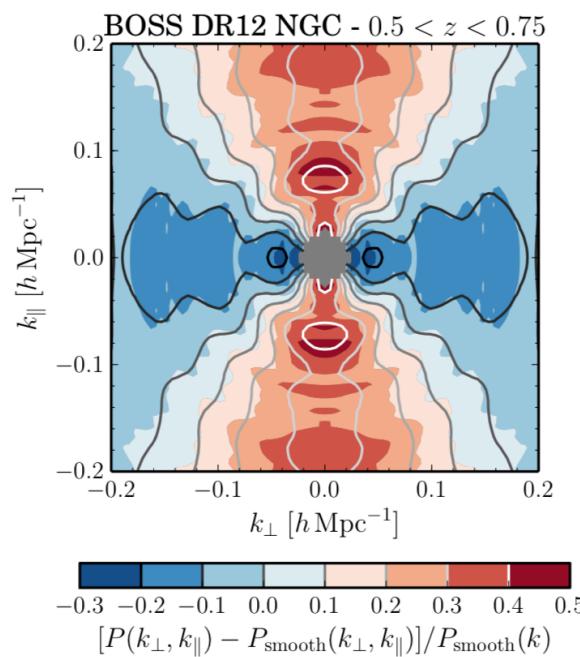
Correlation function



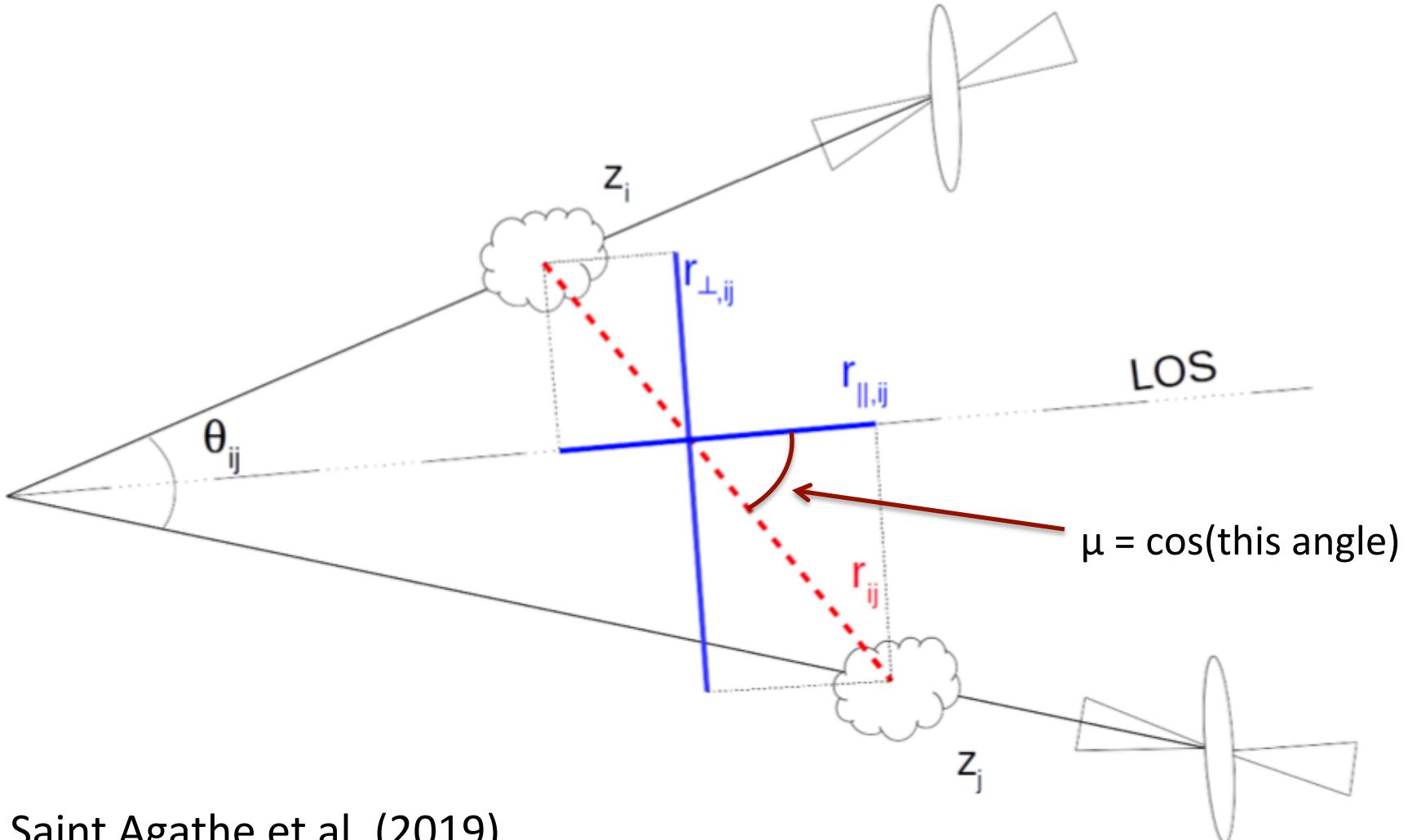
Power spectrum



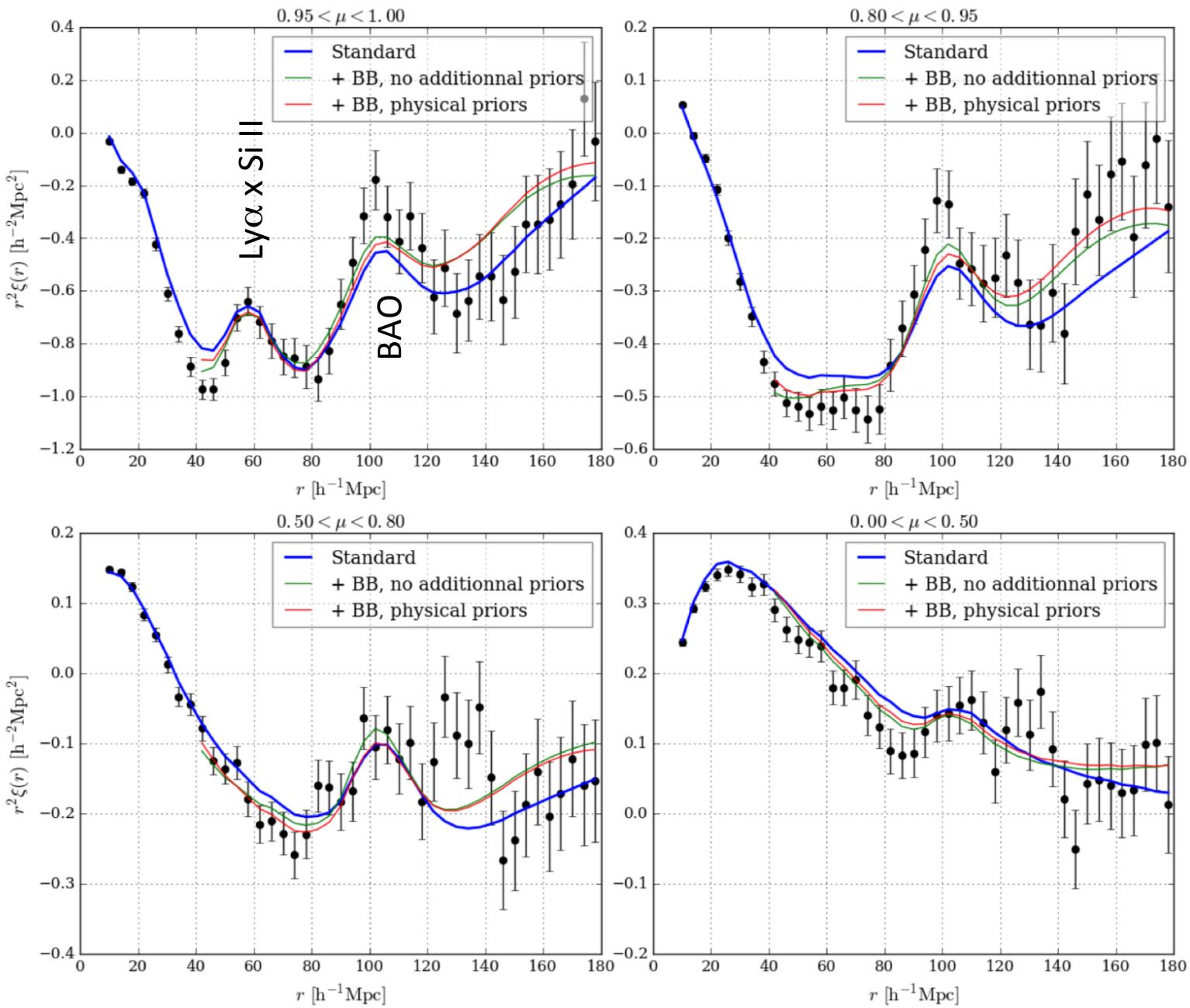
Power spectrum
(smooth component removed)

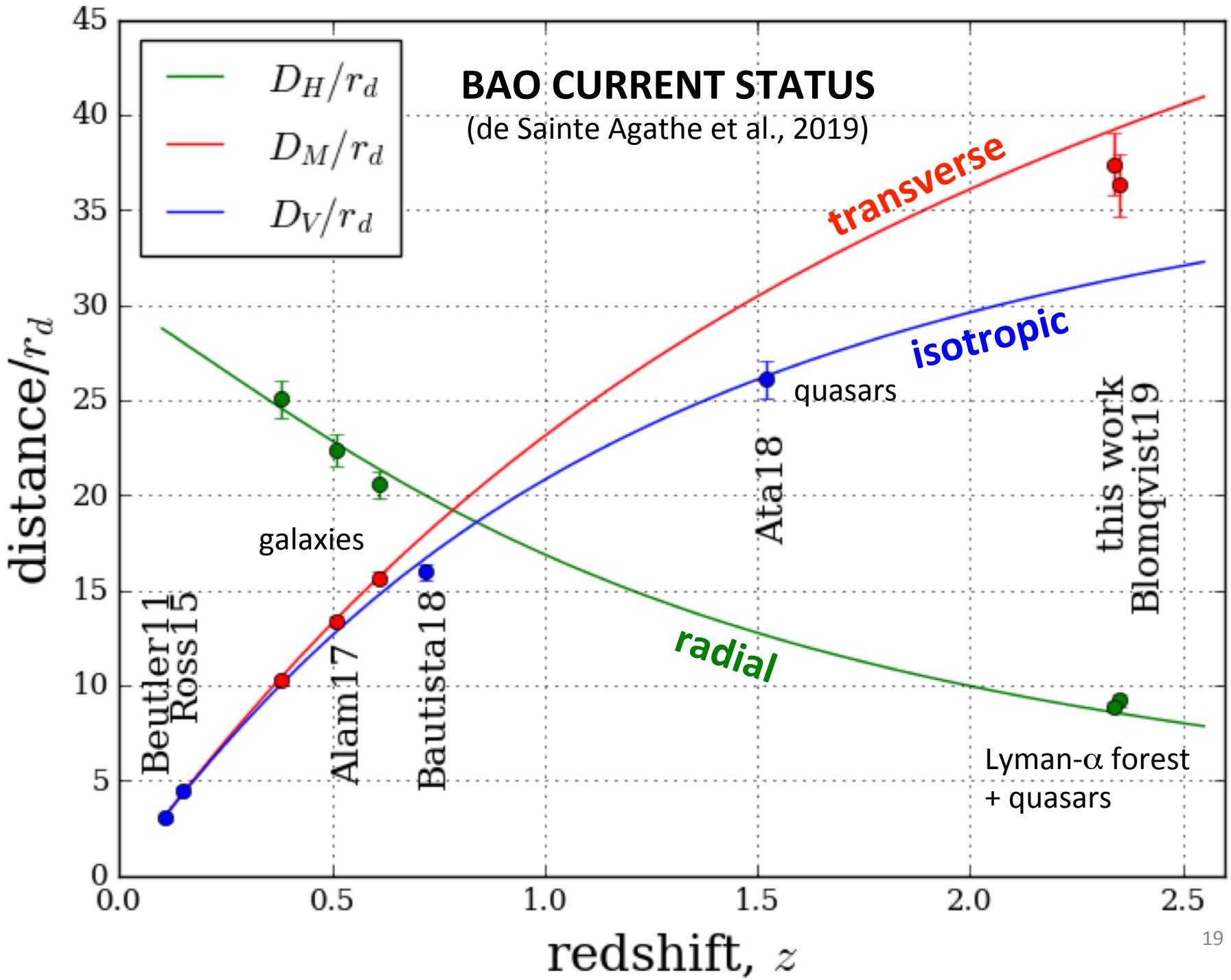


Lyman- α forest in 3D



Saint Agathe et al. (2019)
 $(\theta_{ij}$ is exaggerated)





Growth of Structure from Redshift Space Distortions

(Alam et al. 2017)

