Quasar clustering with SDSS

Hyunmi Song (KIAS)

2016/2/1-3

SSGW @High-1

Quasars in ‘survey’ science

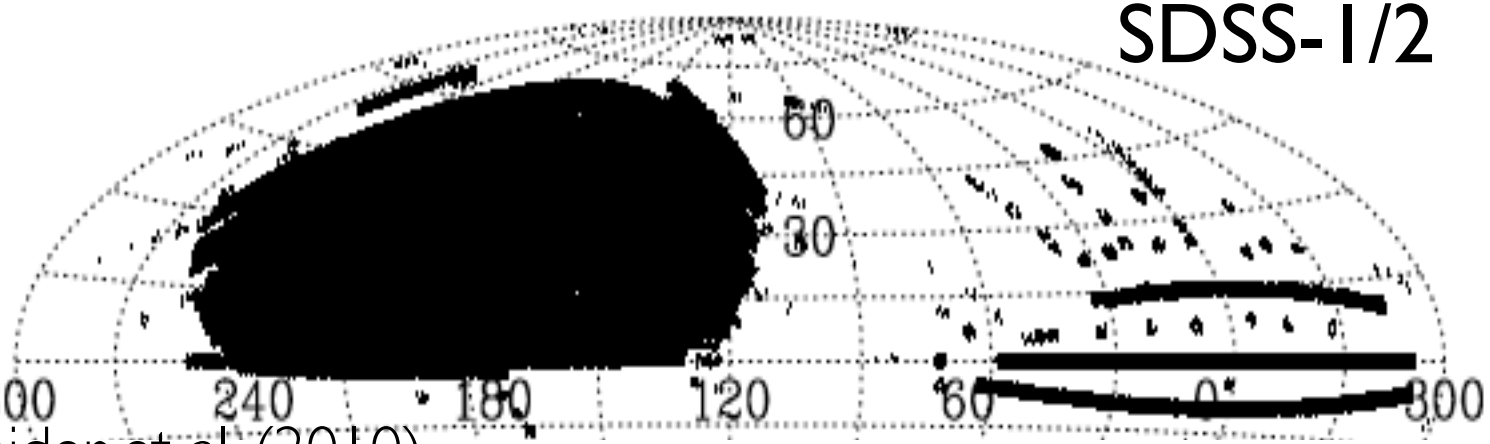
- In recent years, large surveys like SDSS and 2dF QSO redshift survey have accumulated large spectroscopic data sets of quasars.
- SDSS has surveyed optically-selected quasars over a quarter of the all-sky and wide range of redshift ($0<z<6$).
- Many statistical studies of quasars have been done with the survey data.

Quasars in SDSS-1/2/3

- SDSS-1/2 (Data Release1-7; 1999-2008)
  - Quasar catalog by Schneider et al. (2010)
  - 105 783 quasars @0<z<5 (<z>=1.49)
- SDSS-3 (DR8-12; 2008-2014)
  - Baryonic Oscillation Spectroscopic Survey (BOSS)
  - Quasar catalog by Paris et al. (2016)
  - 297 301 quasars (184 101 @z>2.15)

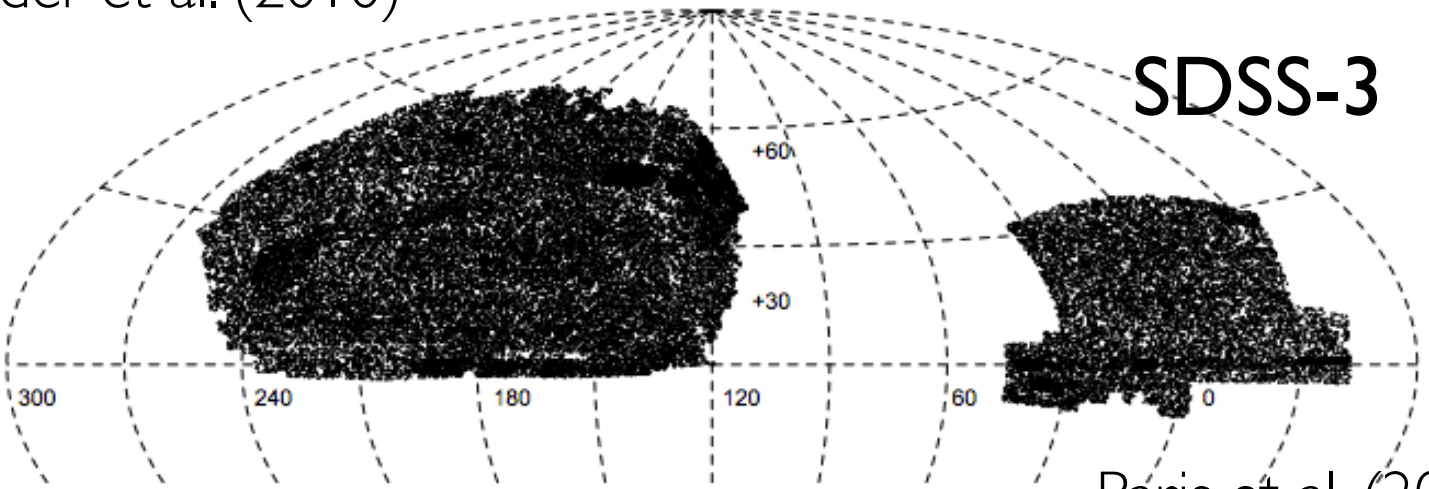
Quasars in SDSS-1/2/3

SDSS-1/2



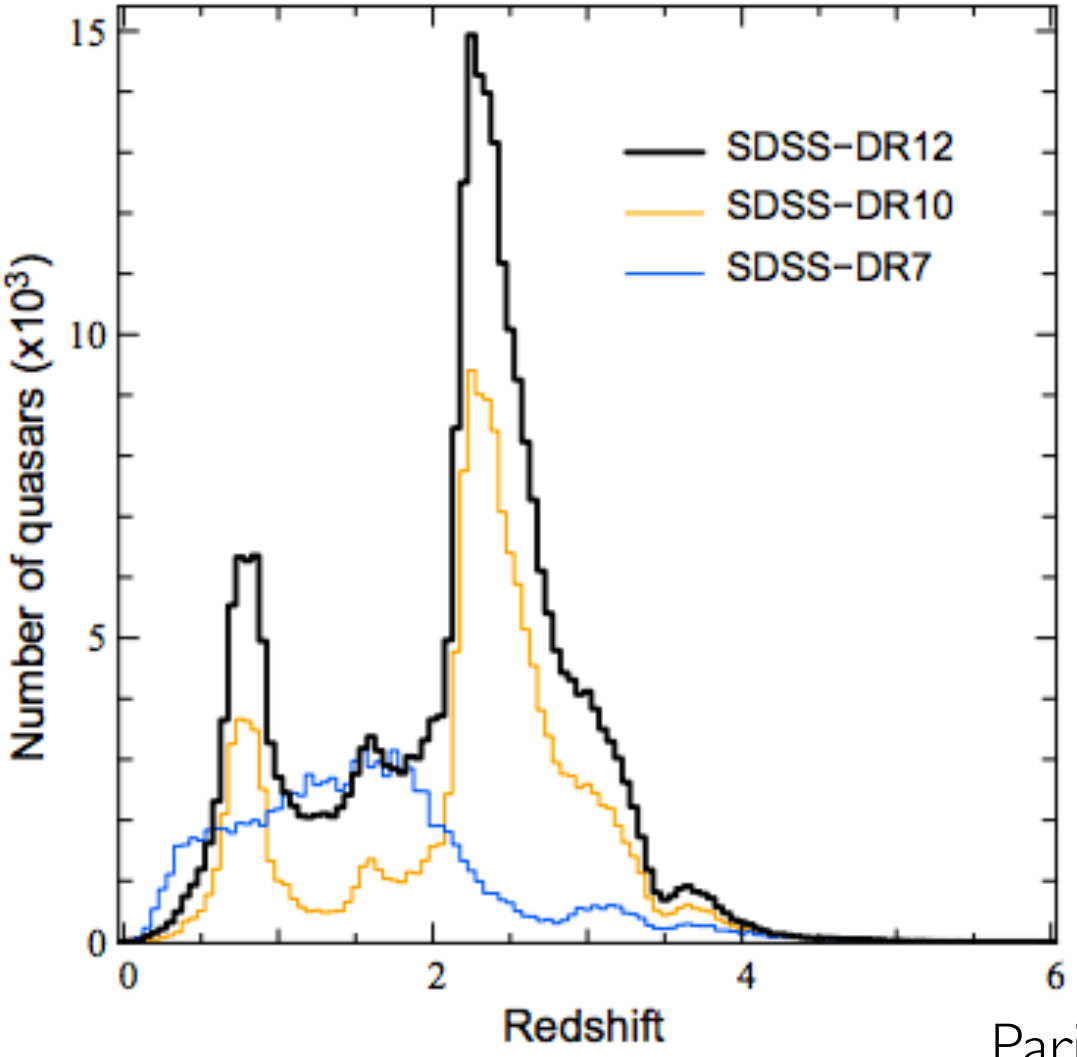
Schneider et al. (2010)

SDSS-3



Paris et al. (2016)

Quasars in SDSS-1/2/3

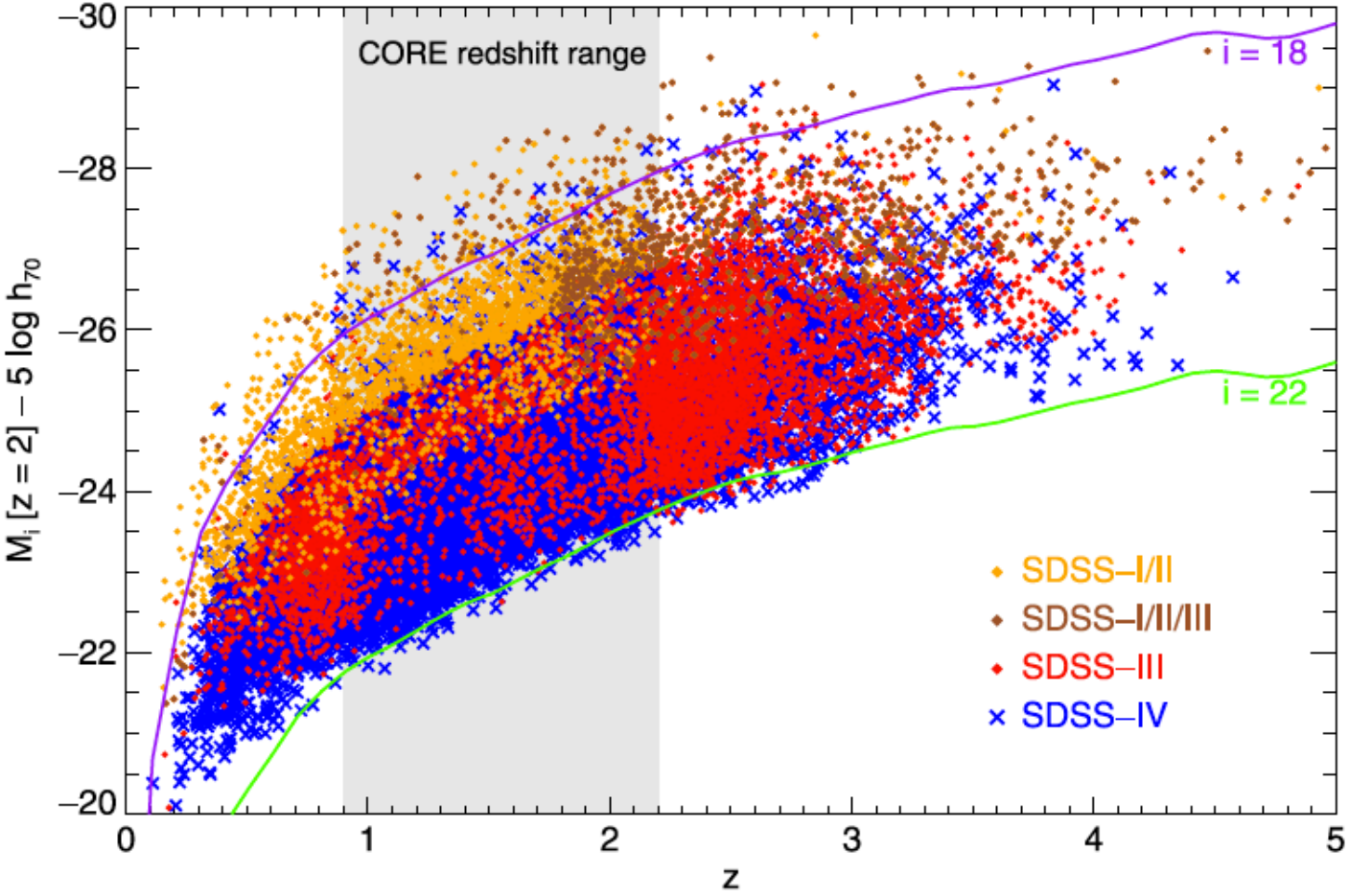


Paris et al. (2016)

Quasars in SDSS-4

- SDSS-4 through 2014 to 2020
- First DR (DR13) will come out on 31st July.
- Quasars in extended-BOSS (eBOSS) program
- 700 000 mid-z ($1<z<2.2$) quasars
  and 40 000 high-z ($2.2<z<3.5$) quasars
  to be targeted

Quasars in SDSS-4



Myers et al. (2015)

To do statistics

- We need to understand a quasar sample: is it reflecting the real quasar population completely and unbiasedly?
- To answer this question, we need to look into how a quasar sample is made.

Quasar candidates

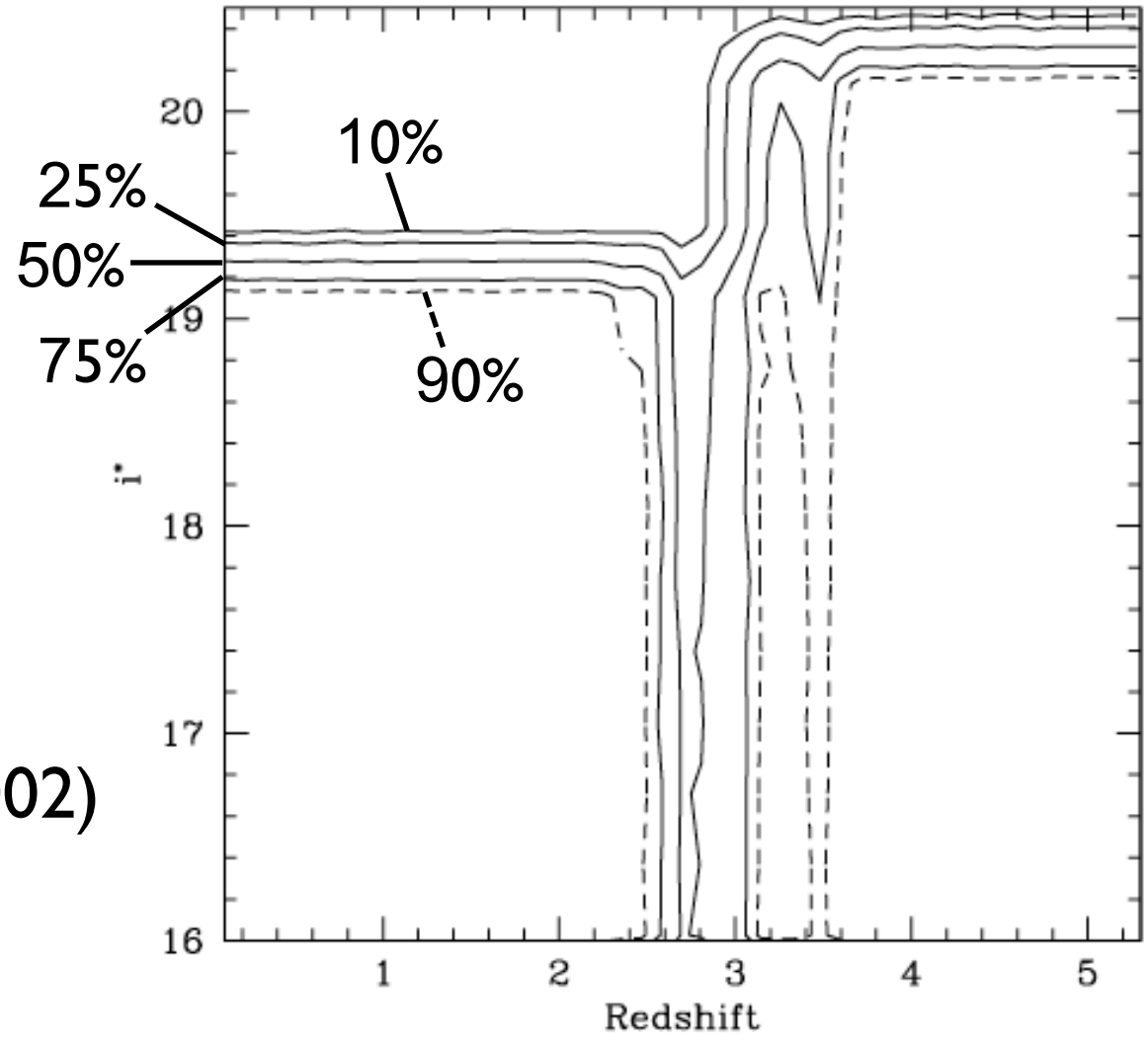
- Quasars appear as point sources in photometry, but not all point sources are selected for spectroscopic follow-up observation because of efficiency issue.
- Quasar target selection (QTS) chooses quasar targets.
  - Main concern is to separate quasars from non-quasars (mostly stars) in color-color space.
  - SDSS QTS has evolved through each iteration.

QTS

- QTS of SDSS-1/2 selects outliers
  from stellar locus in color-color space
  as quasar candidates, Richards et al. (2002)
  while QTS of SDSS-3/4 calculates probability
  of being a quasar of a point source
  given flux and color
  with photometric error accounted
  more thoroughly. Bovy et al. (2009, 2011, 2012)

Completeness of quasar sample

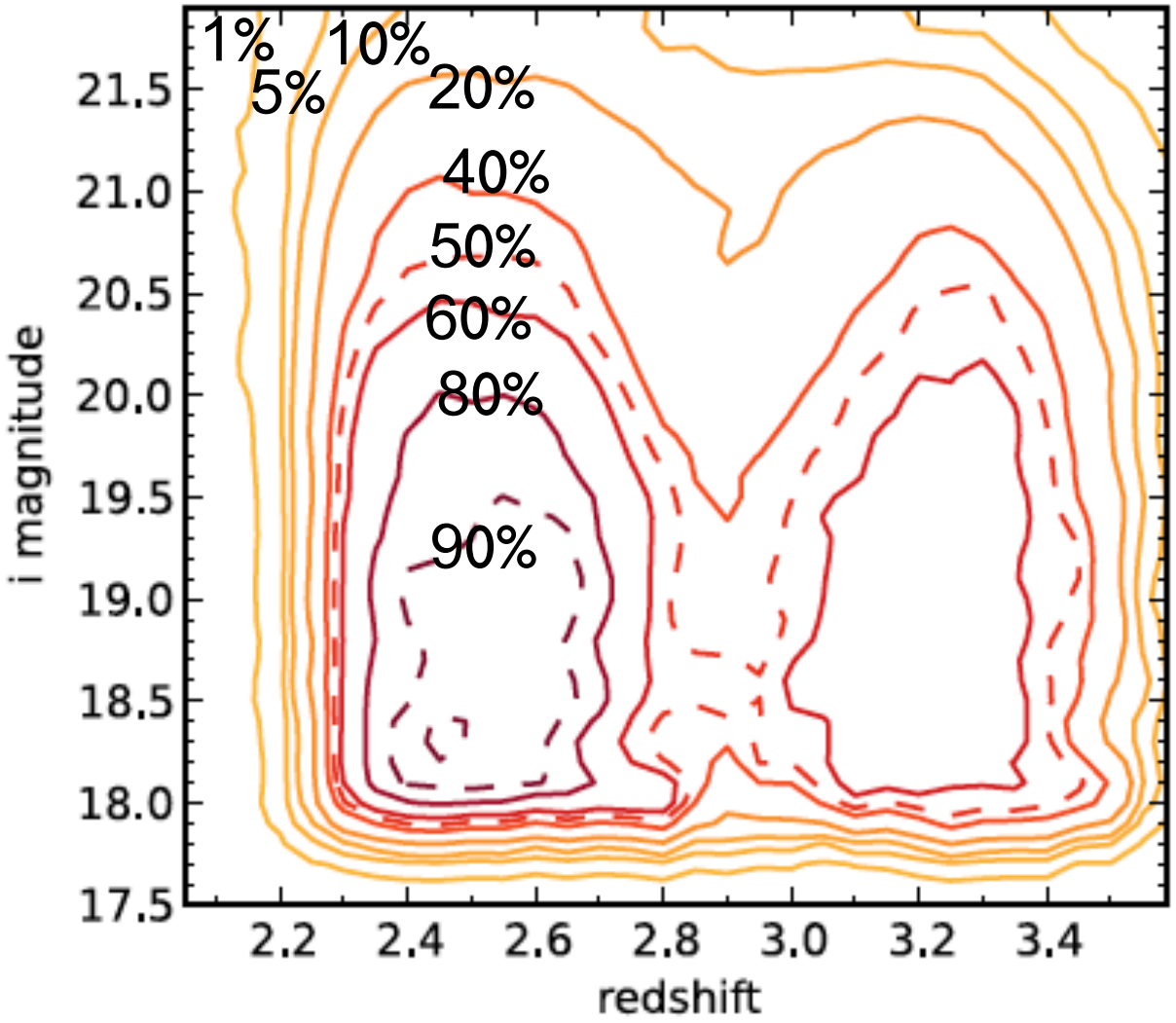
Completeness
= fraction of simulated quasars that are selected by QTS algorithm



- SDSS-1/2
  Richards et al. (2002)

Completeness of quasar sample

- SDSS-3
  Ross et al. (2013)

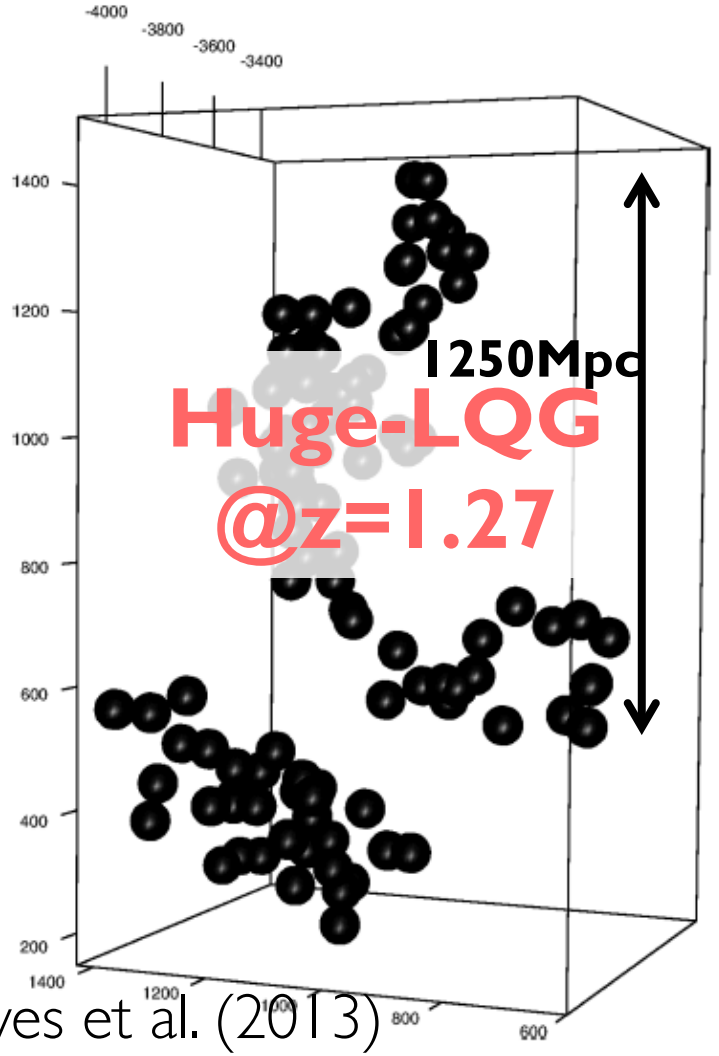


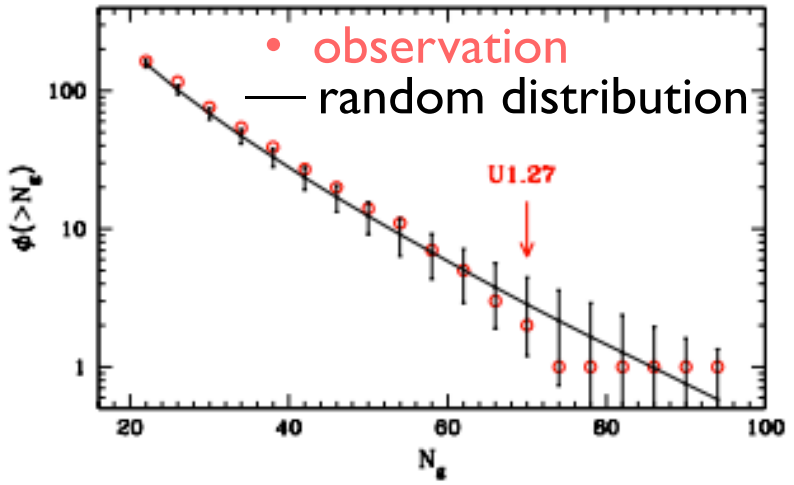
Quasar clustering

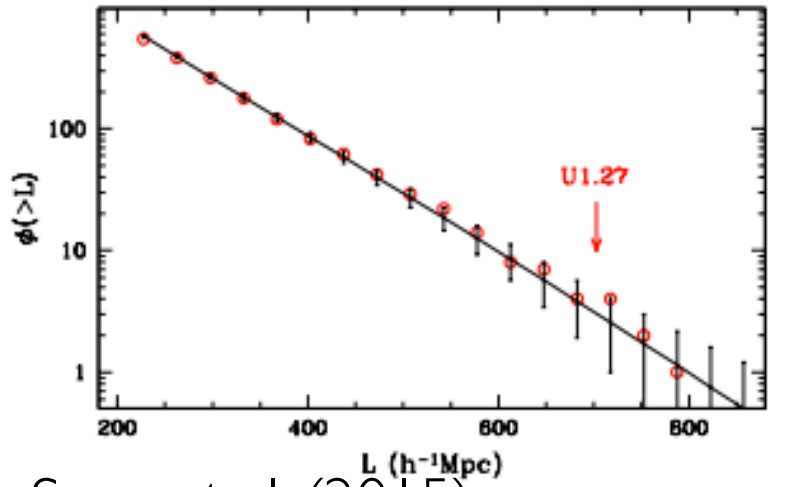
- Quasar
  an efficient object to probe the early universe
- Clustering
  a way to probe large-scale structures, which sheds light on galaxy formation and evolution, and cosmology

Quasar clustering
quasar groups

- Test on the cosmological principle (homogeneity)





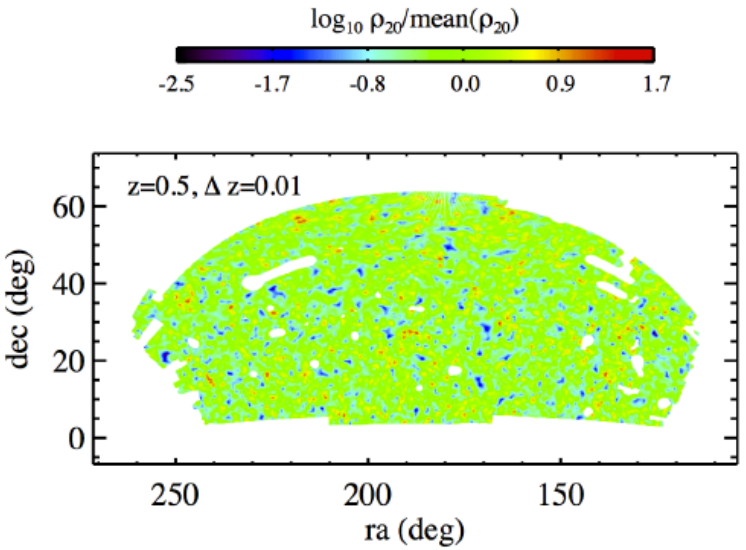


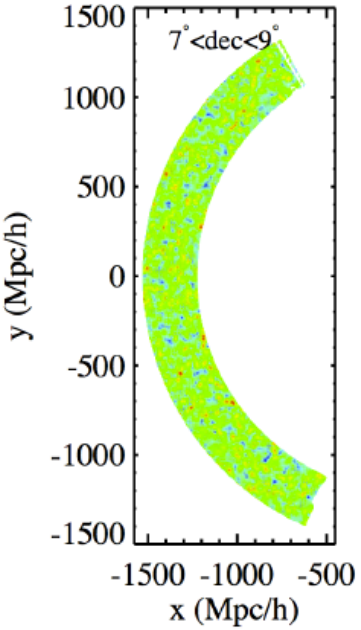
Clowes et al. (2013)

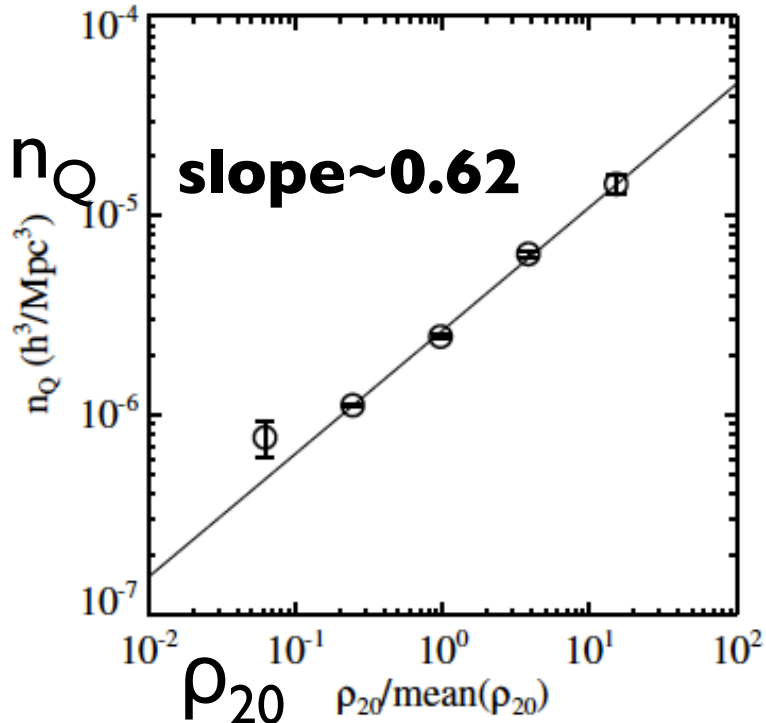
Park, Song et al. (2015)

Quasar clustering
quasar density

- Song et al. (2016, under review)
- Quasar distribution on density map of CMASS galaxies @z~0.5

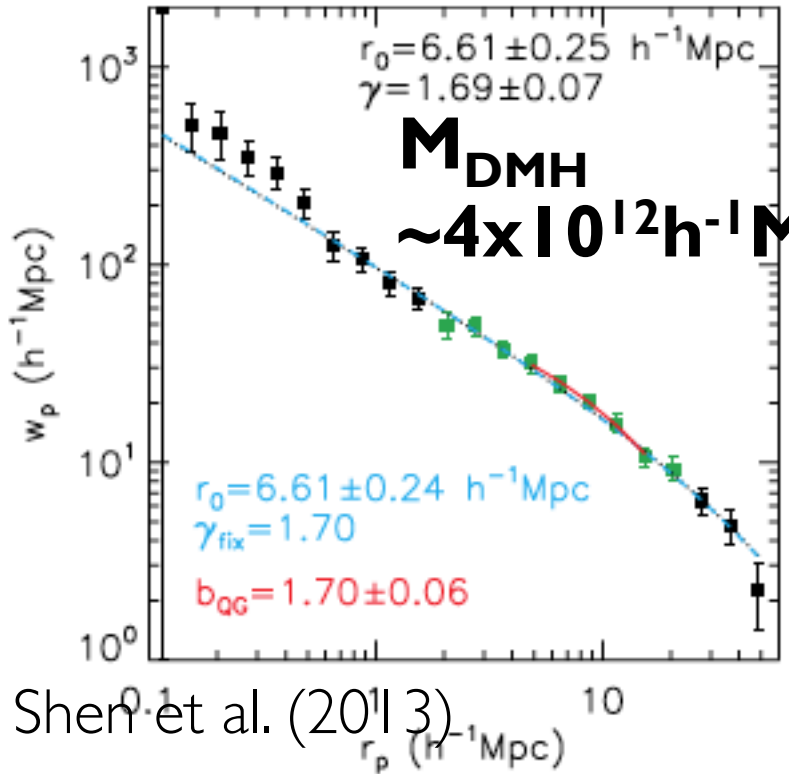




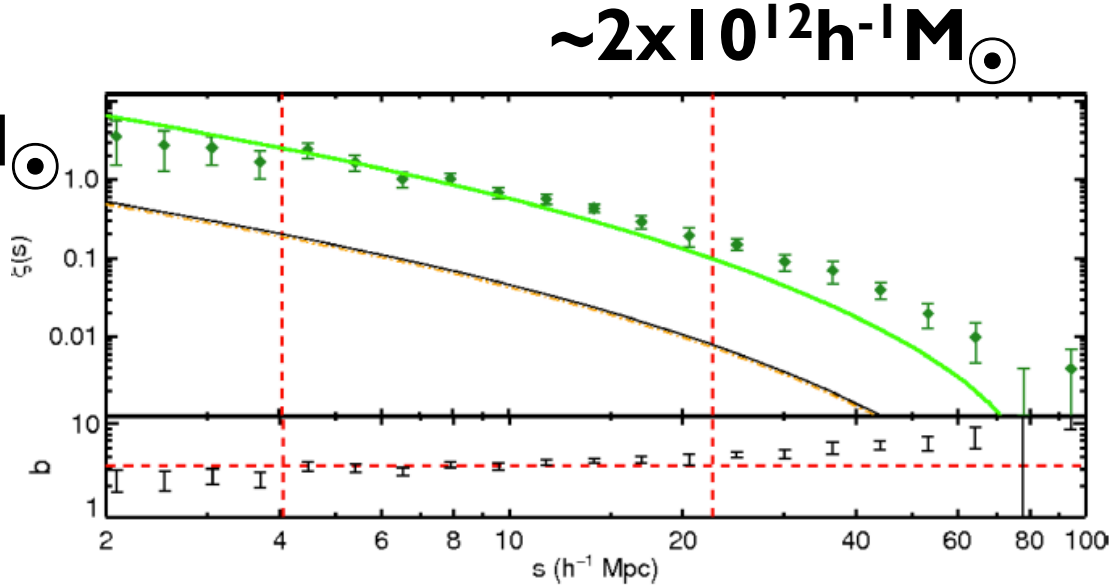


Quasar clustering correlation functions (CFs)

- Shen et al. (2013) :
  cross-CFs of quasars and CMASS galaxies @z~0.5
- Eftekharzadeh et al. (2015) : auto-CFs of quasars @z~2.5



Shen et al. (2013)



Eftekharzadeh et al. (2015)

Conclusion

- Large survey data of quasars are available.
- To do statistics with the survey data, it is important to understand the data first.
- Quasar clustering can be studied in several ways, and be used to understand large-scale structures and cosmology.