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Photometric Objects Around Cosmic Webs (PAC) Delineated in a Spectroscopic Survey. VI. High Satellite Fraction of Quasars

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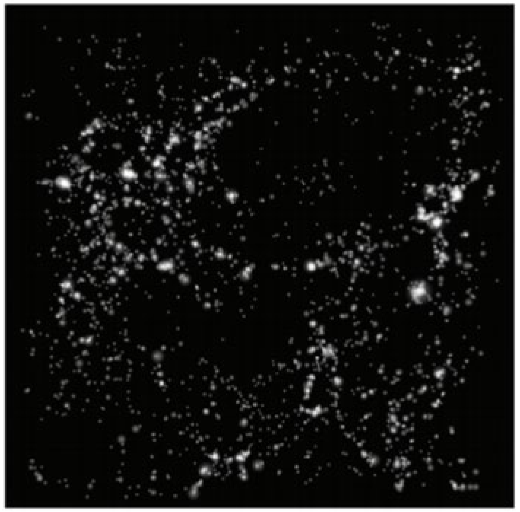
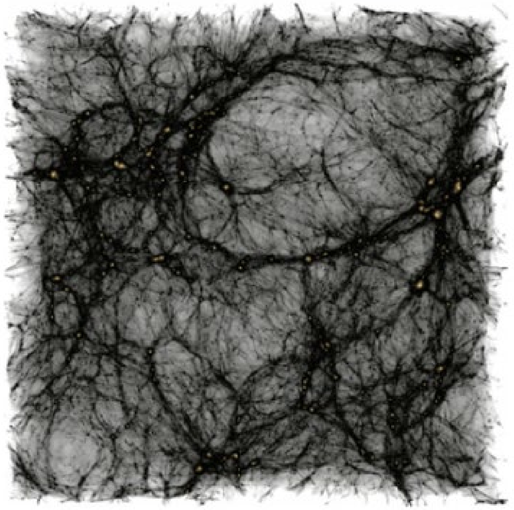
Outline

Background

Galaxy-halo Connection



- 5/6 dark matter
- galaxies form, evolve and merge
- spatial distribution (galaxies and dark matter halos)
- understand the physics of galaxy formation; infer cosmological parameters; probe the properties and distribution of dark matter



Approaches to modeling the galaxy–halo connection

← Physical models | Empirical models →

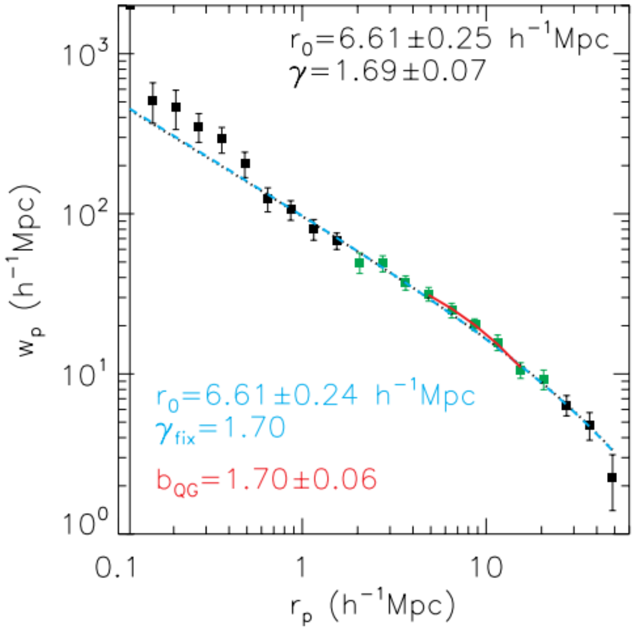
Hydrodynamical simulations	Semianalytic models	Empirical forward modeling	Subhalo abundance modeling	Halo occupation models
Simulate halos and gas; star formation and feedback recipes	Evolution of density peaks plus recipes for gas cooling, star formation, feedback	Evolution of density peaks plus parameterized star formation rates	Density peaks (halos and subhalos) plus assumptions about galaxy–(sub)halo connection	Collapsed objects (halos) plus model for distribution of galaxy number given host halo properties

Wechsler et al. (2018)

- subhalo abundance matching (SHAM)
- halo occupation distribution (HOD)

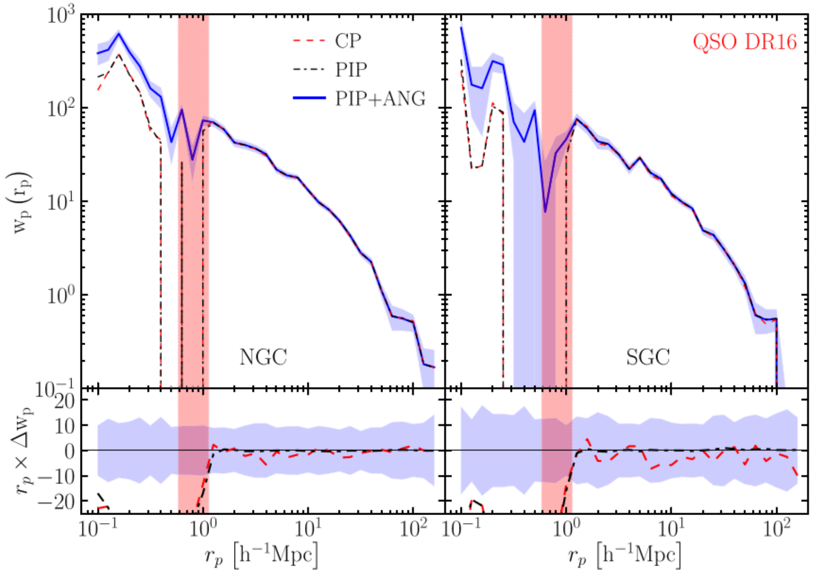
- luminous red galaxies (LRGs), emission line galaxies (ELGs), quasars (qso)

Quasars (galaxy) -halo Connection



Shen et al. (2013)

- two point correlation function (2pcf)
- 2df qso redshift surveys; SDSS-I/II/III/IV
- DESI; PFS



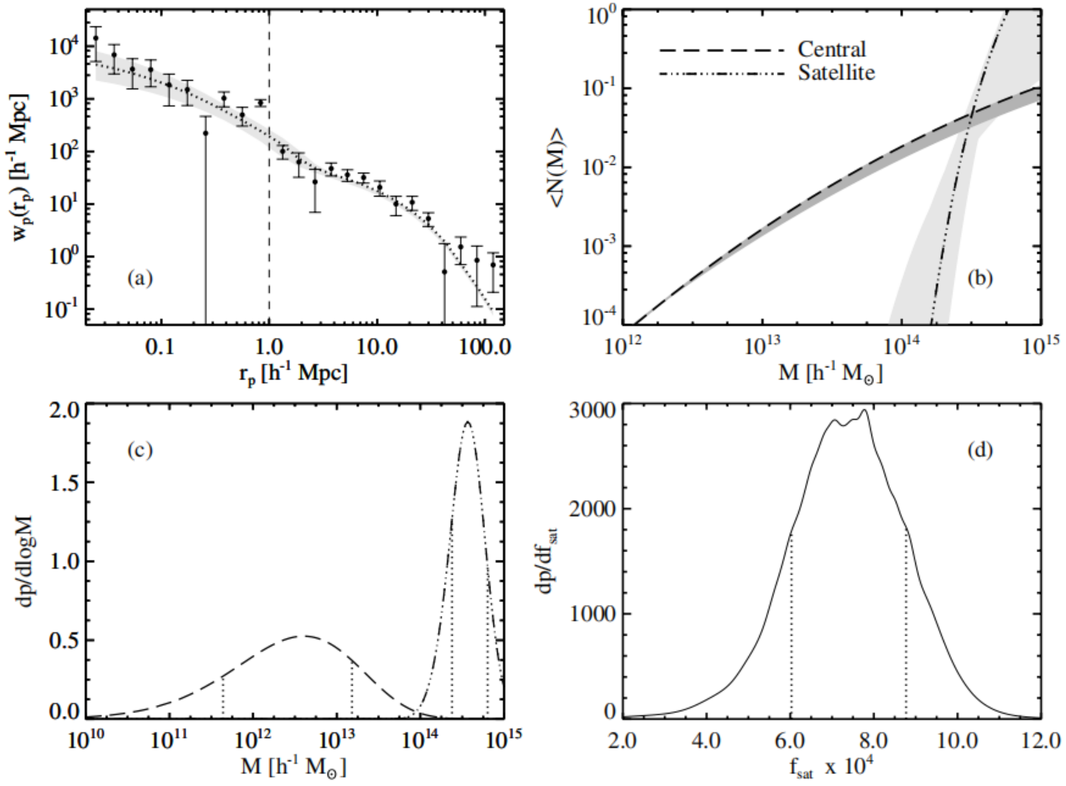
Faizan et al. (2020)

- fiber collision (0.55") for SDSS
- low quasar number density

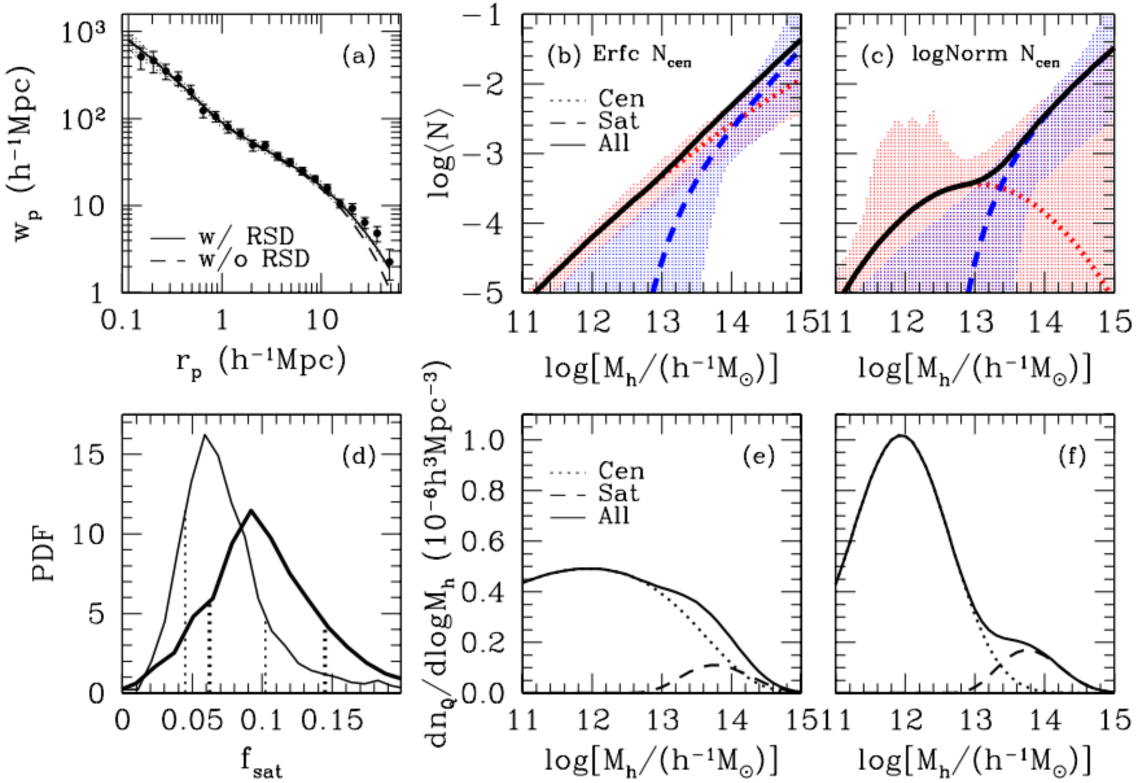
Background

the Two Largest Samples

Auto



Cross



- SDSS DR7 + (Hennawi et al. 2006) extra observation
- redshift: 0.4 - 0.25

Richardson et al. (2012)

SDSS DR7 +BOSS DR10 CMASS galaxies

Redshift: 0.3 – 0.9

shen et al. (2013)

Motivation

Argument: 2pcf at small scale is still hard to measure accurately due to the technically fiber collision problem and low number density of quasars in specotrscopic surveys.

combine the spectroscopic and photometric surveys to avoid fiber collision problem and get more and deeper galaxies in photometric surveys to cross it with quasars.

Xu et al (2022 PAC I) make this as a pipeline, confirm the completeness of photometric catalogue and use deeper and fainter galaxies. (wang et al. 2011)

Photometric objects Around Cosmic Webs (PAC)

Xu et al. (2022)

general idea: For a spectroscopic source i at redshift $z_{s,i}$, only those objects in the photometric sample around $z_{s,i}$ are correlated to source i and share a similar redshift.

method

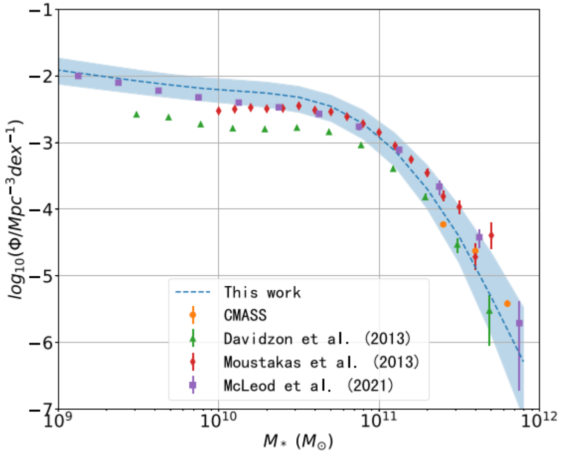
1. spectroscopic sample (pop1, z_s) **No photo-z!!!**
2. photometric sample (pop2)
3. Assume all pop2 at z_s
4. SED (pop1 and pop2)
5. pop1 × pop2 (ACCF, $\bar{n}_2 w_p$)
6. properties and distributions of pop2

$$\bar{n}_2 w_p(r_1\theta) = \frac{\bar{S}_2}{r_1^2}\omega_{12,\mathrm{weight}}(\theta)$$

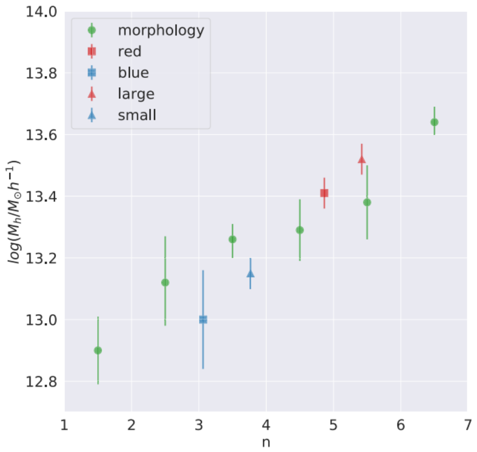
Motivation

Photometric objects Around Cosmic Webs (PAC)

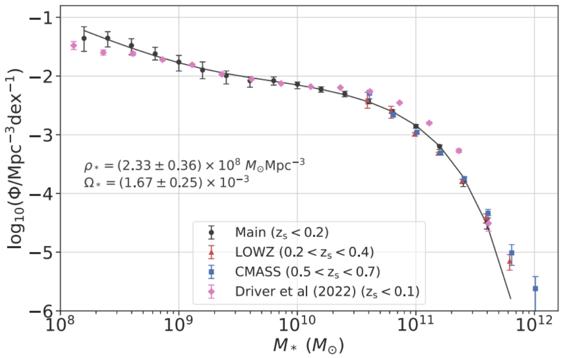
some nice results with PAC



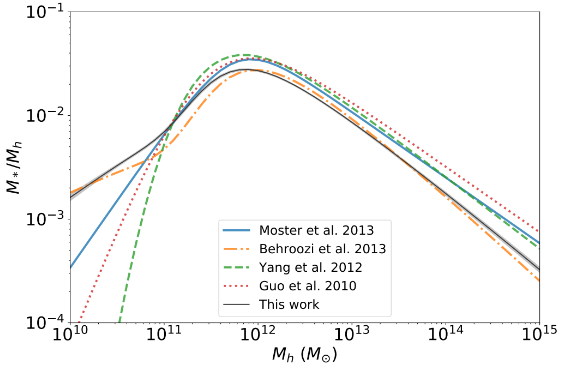
Xu et al. 2022 PAC I



Xu et al. 2022 PAC II



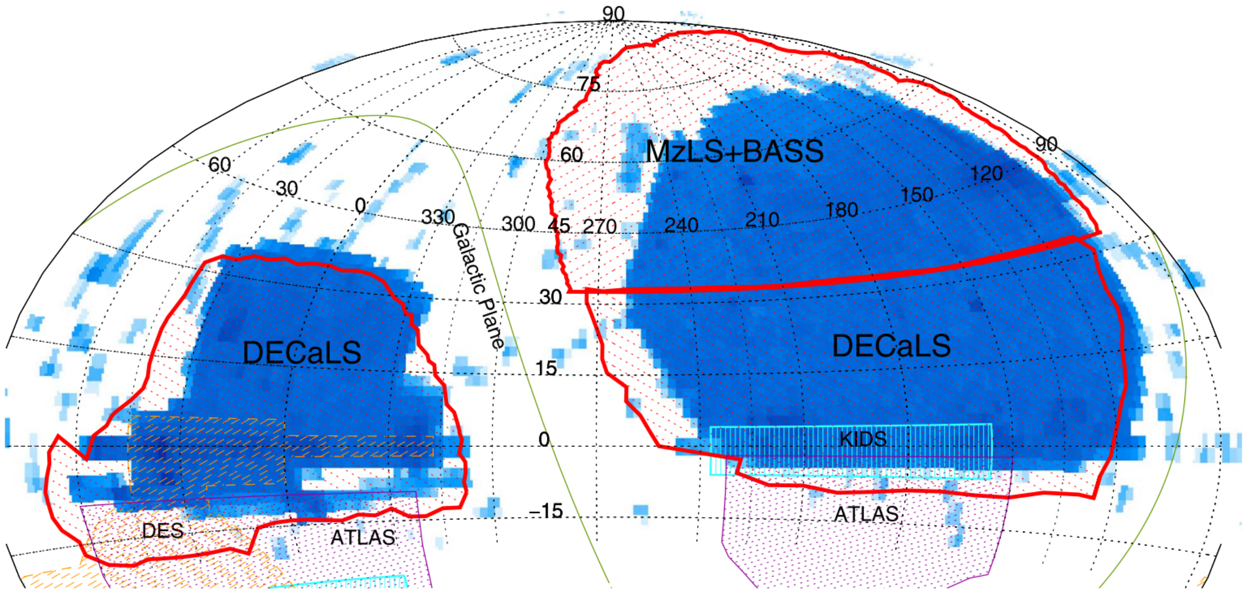
Xu et al. 2022 PAC III



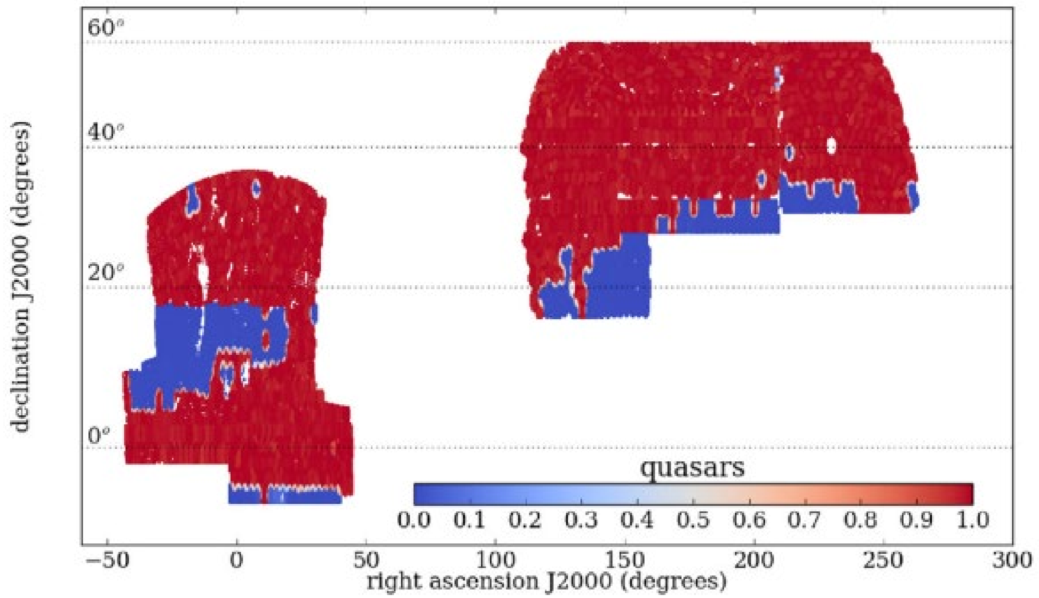
Xu et al. 2022 PAC IV

Methodology

DATA and Purpose



Dey et al. (2019)

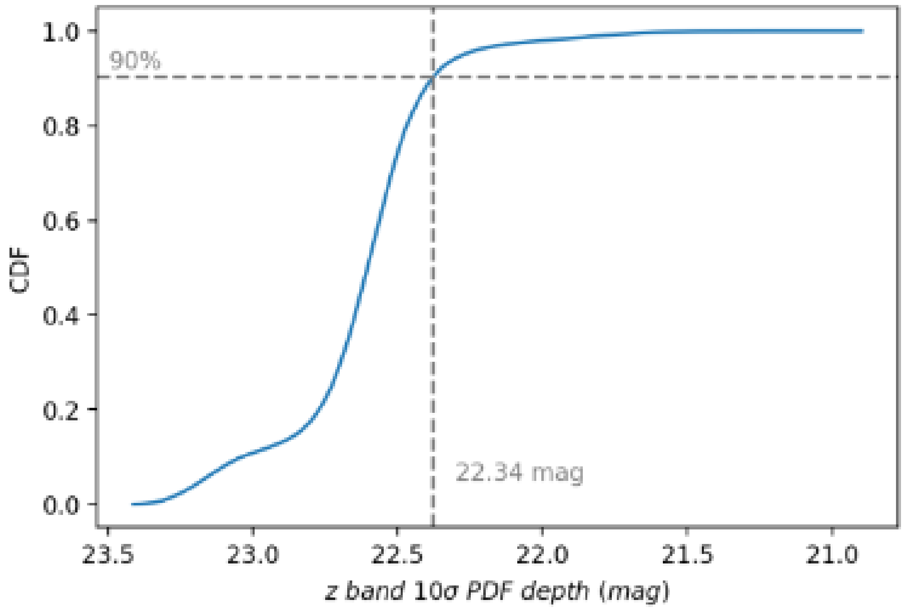


Ross et al. (2020)

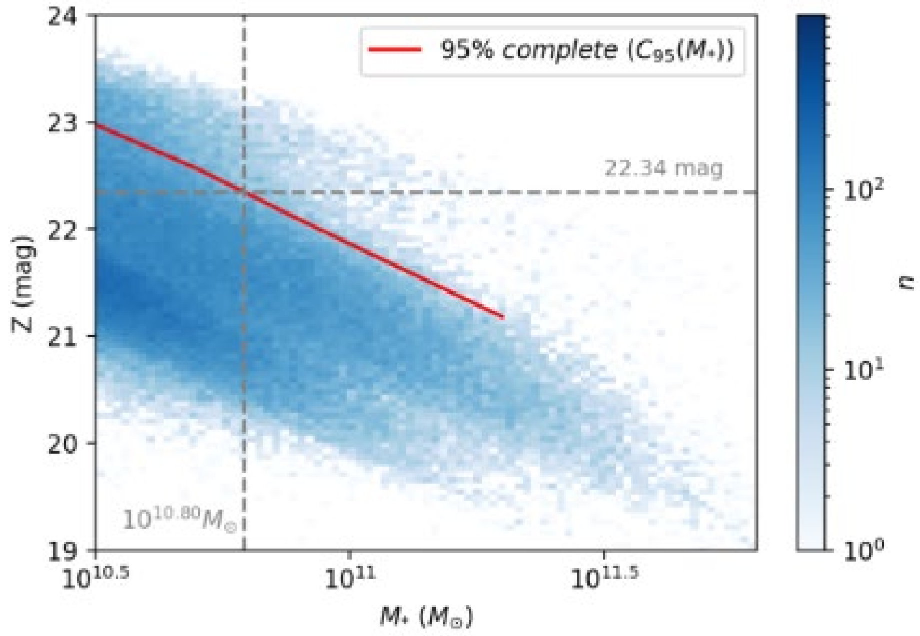
- DR16 quasars in SDSS-IV/eBOSS
- DR9 in DESI Legacy Imaging Surveys

To study quasar clustering at redshift 0.8-1.0 with PAC under the framework of SHAM

Confirmation of completeness of photometric objects



DESI image survey cross-match
with SDSS-IV quasar footprint



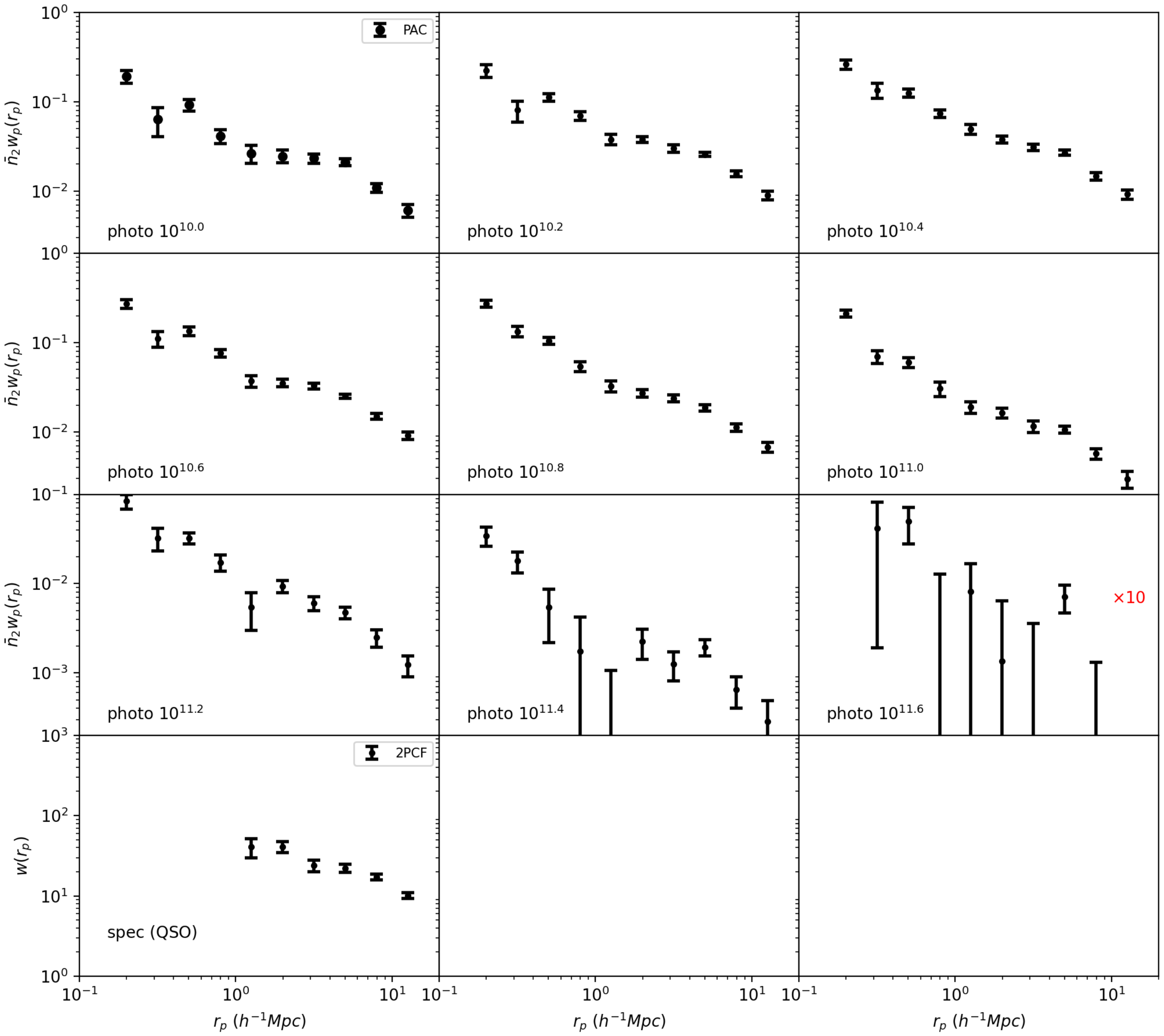
DR9 deepest 50 deg^2 (23.37)
Photo-z (zhou et al. 2021)

$$k_{\mathrm{obs}} = \frac{N_{\mathrm{obs}}(Z_{\mathrm{mag}} > 22.34)}{N_{\mathrm{obs}}(\mathrm{all}\ z_{\mathrm{mag}})}.$$

The complete stellar mass are $10^{10.8} M_{sun}$ at redshift 0.8 – 1.0 according to the DESI Image survey z band galaxy depth of 22.34 mag.

Gui et al. to be submitted

Methodology



Follow xu et al. (2022 PAC I)

$[0.1 < r_p < 15]\ h^{-1}\ MPC$

Range: 10.0-11.8 ($\Delta \log(M) = 0.2$)

Gui et al. to be submitted

Methodology

Simulation

CosmicGrowth: N-body simulations (P3M) (Jing 2019)

- λCDM with cosmological parameters: $\Omega_m = 0.268$, $\Omega_\Lambda = 0.732$, $h = 0.71$, $n_s = 0.968$, $\sigma_8 = 0.83$
- 3072^3 dark matter particles in a 600 $h^{-1}Mpc$
- Groups (friends-of-friends algorithm Davis et al. 1985); subhalo (HBT+ Han et al. 2012, 2018)
- Snapshot 76 at redshift around 0.92 (our simulation data)

Methodology

Populate halos (subhalos) with galaxies, quasars in simulation

For galaxies: $M_* = \left[\frac{2k}{(M_{\rm acc}/M_0)^{-\alpha} + (M_{\rm acc}/M_0)^{-\beta}}\right]$ $\{M_0, \alpha, \beta, k, \sigma\}$ Wang et al. 2010

For quasars: same μ and σ_q for gaussian distribution of logarithmic halo mass $\log_{10}(M_h/h^{-1}\,M_{sun})$ for central quasars and candidate satellite quasars

$$f_{\rm q} = \frac{N_{\rm cand}({\rm satc}) \times {\rm B}}{N_{\rm cand}({\rm satc}) \times {\rm B} + {\rm N(cen)}}$$ $\{\mu, \sigma_{\rm q}, f_{\rm q}\}$

For incomplete stellar mass bin: four different constant k

$\{k_1, k_2, k_3, k_4\}$

Markov Chain Monte Carlo (MCMC)

three sets of parameters: $\{M_0, \alpha, \beta, k, \sigma\}$ $\{\mu, \sigma_q, f_q\}$ $\{k_1, k_2, k_3, k_4\}$

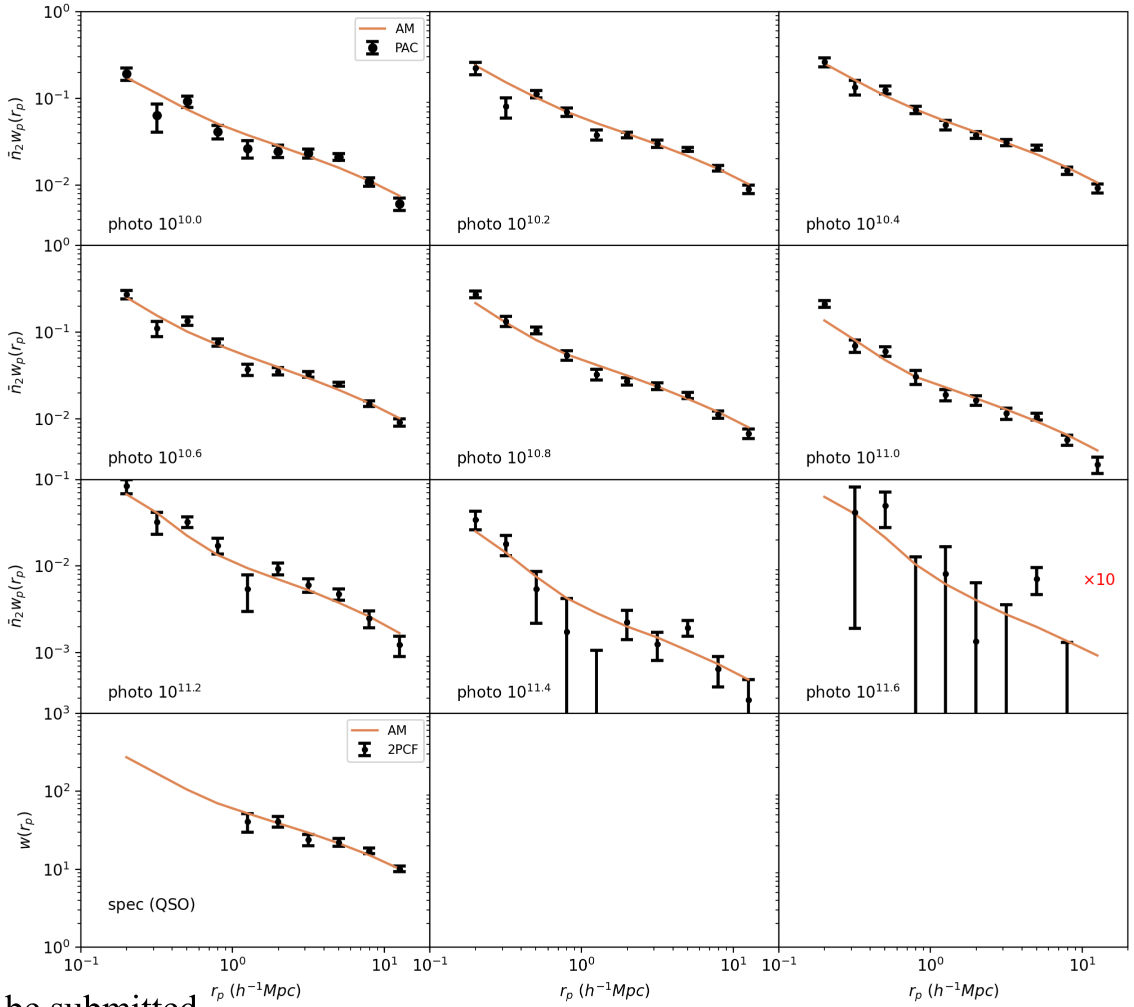
We define χ^2 of $\bar{n}_2 w_P(r_p)$ and $w_P(r_p)$

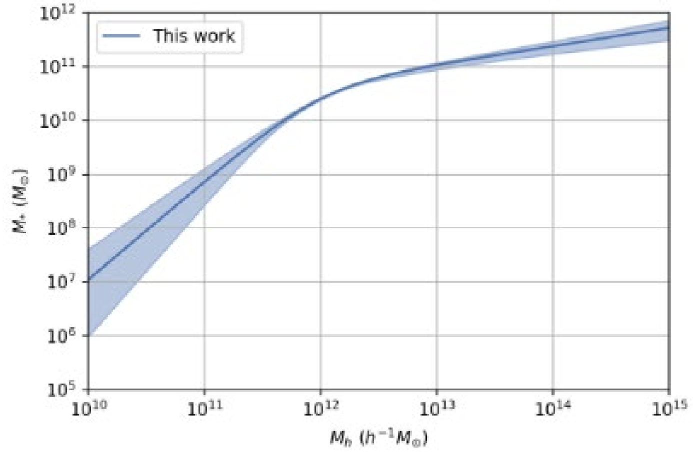
$$\chi^2 = \sum_{i=1}^{N_{\mathrm{mp}}} \sum_{k=1}^{N_{\mathrm{r_i}}} (\frac{(\mathcal{A}_i^{\mathrm{PAC}}(r_k) - \mathcal{A}_i^{\mathrm{AM}}(r_k))^2}{\sigma_i^2(r_k)} + \sum_{j=1}^{N_{\mathrm{r_q}}} \frac{({w_p}^{\mathrm{auto}}(r_j) - {w_p}^{\mathrm{AM}}(r_j))^2}{\sigma^2(r_j)} .$$

use emcee (Foreman-Mackey et al. 2013) to perform MCMC

Results

$\log_{10}(M_0)$	α	β	$\log_{10}(k)$	σ	μ	σ_q	k_1	k_2	k_3	k_4	f_q
$11.98^{+0.11}_{-0.10}$	$0.36^{+0.05}_{-0.06}$	$1.87^{+0.39}_{-0.29}$	$10.38^{+0.11}_{-0.10}$	$0.20^{+0.05}_{-0.05}$	$13.85^{+0.90}_{-0.56}$	$0.92^{+0.25}_{-0.19}$	$0.37^{+0.06}_{-0.06}$	$0.60^{+0.05}_{-0.08}$	$0.74^{+0.04}_{-0.07}$	$0.89^{+0.05}_{-0.05}$	$0.23^{+0.01}_{-0.01}$



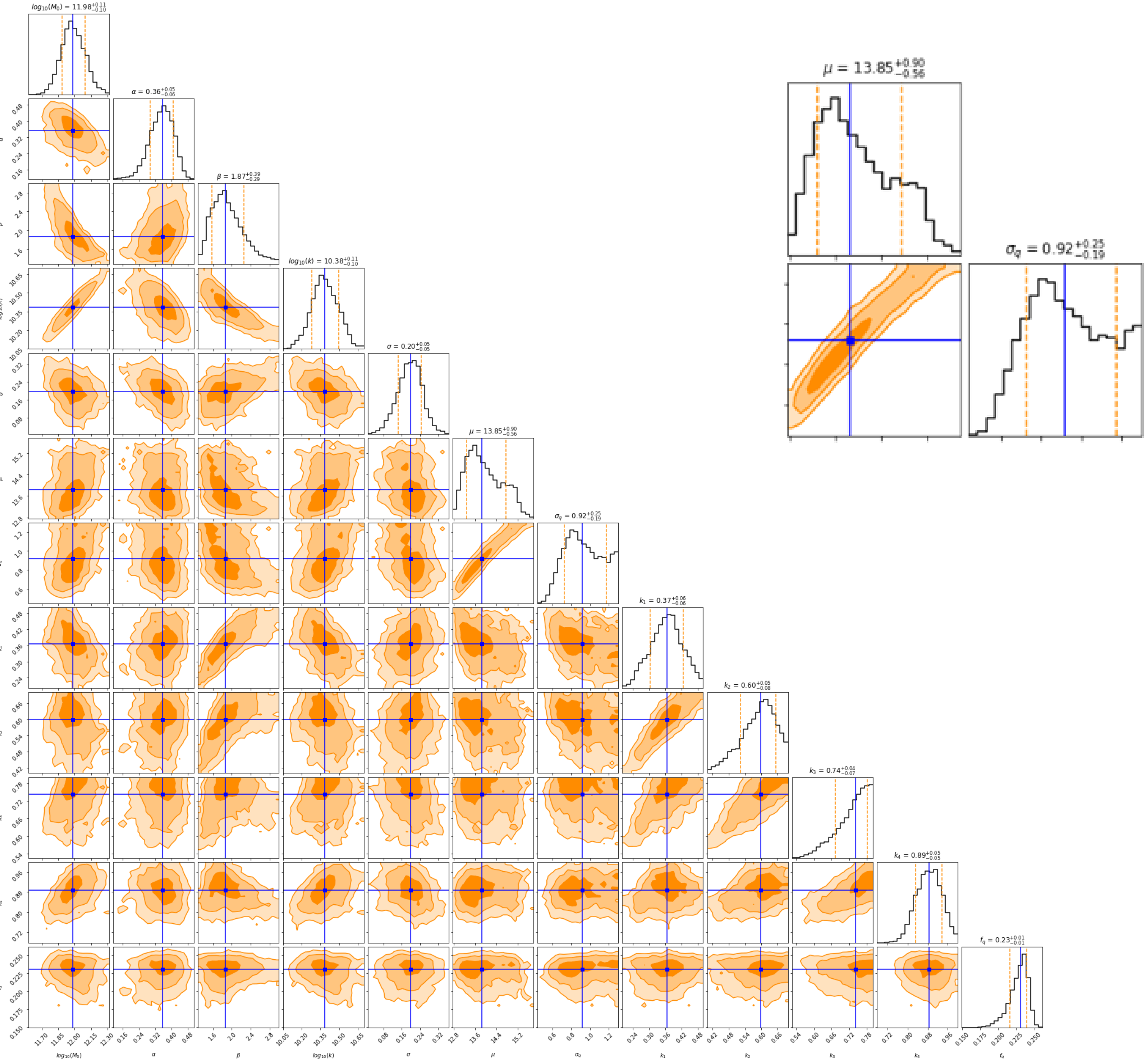


- Previous works show a tiny f_q
- Whether the degeneracy of μ and σ_q affects such a high f_q

- We made two tests to illustrate the necessity of a high f_q

Gui et al. to be submitted

Results



the degeneracy of μ and σ_q

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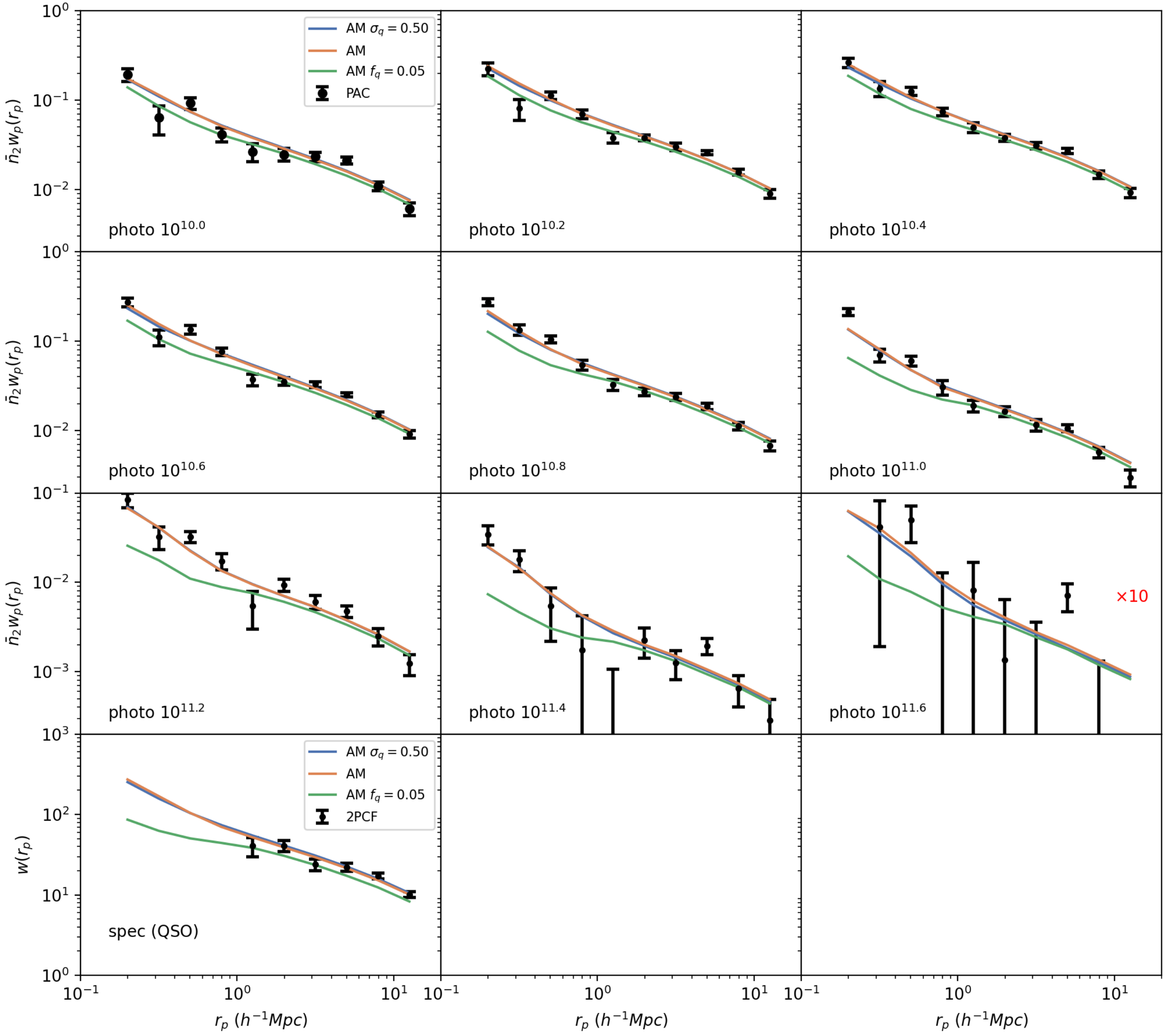
Results



- $f_q = 0.05$
- $\sigma_q = 0.5$ Richardson et al. (2012)

Blue curve: μ=12.81

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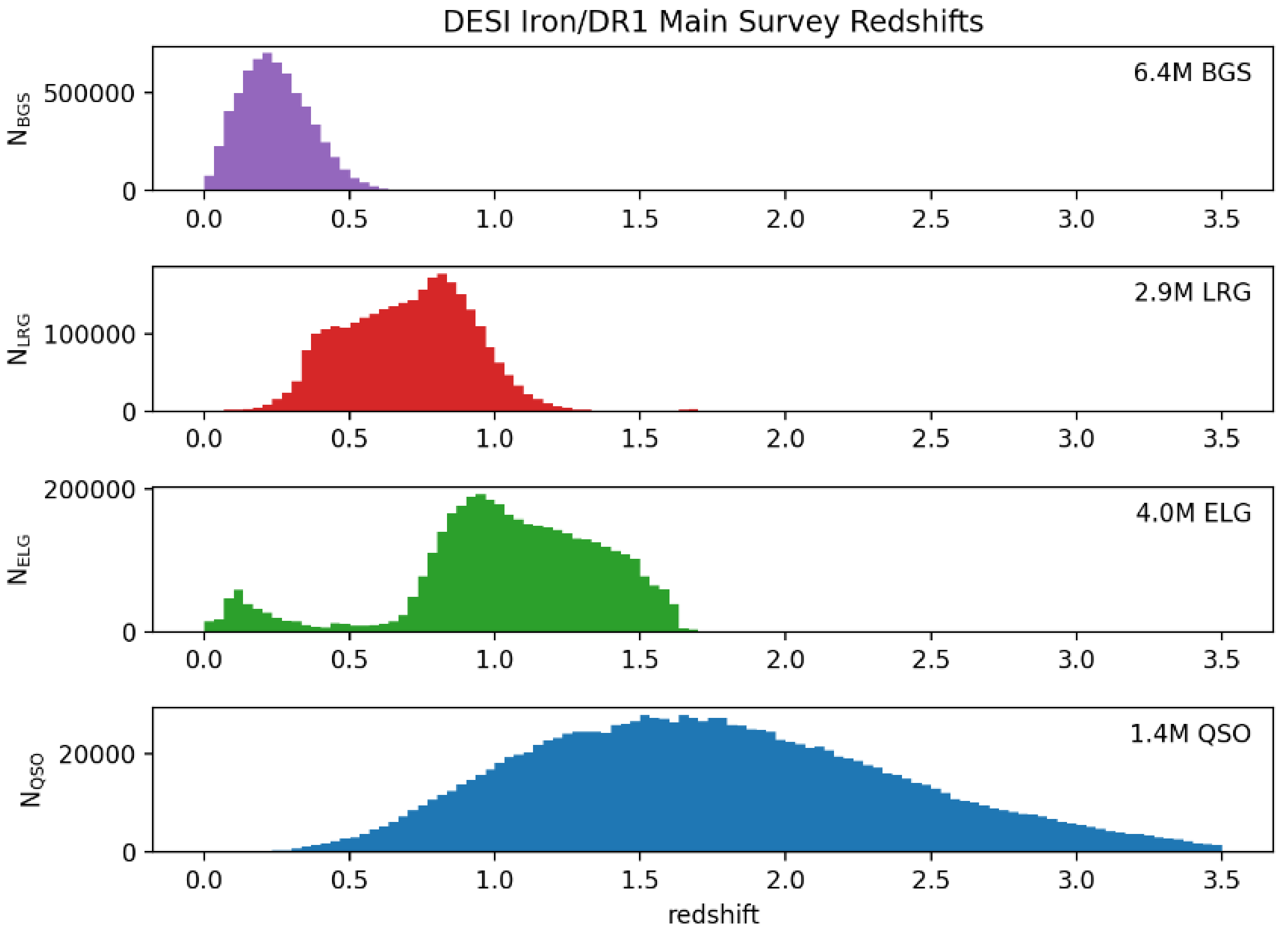
Outlook



- a better parameter constrain
- do quasar mock for DESI.

https://desi.lbl.gov/trac/wiki/Pipeline/Releases/Iron

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Thank you!

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