

A General 3-Parameter SHAM for Galaxy Surveys

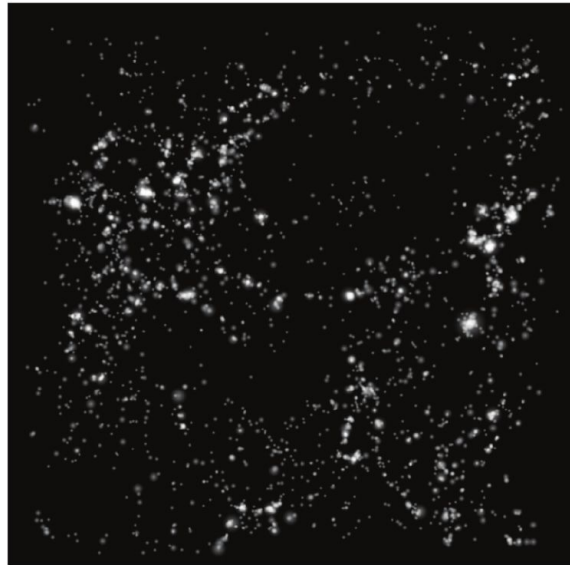
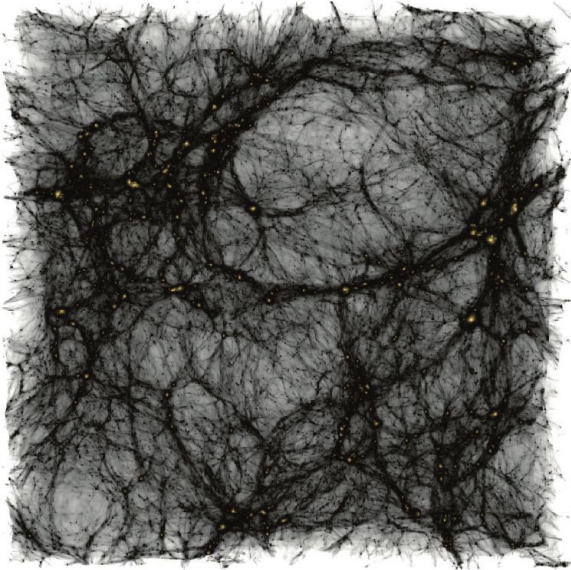
Jiayi Yu, EPFL, Switzerland

Cheng Zhao, Chia-Hsun (Albert) Chuang, Julian Bautista, Ginevra Favole, Ashley Ross, Anand Raichoor, Jean-Paul Kneib, Faizan Mohammad, Arnaud de Mattia, Charling Tao, Rongpu Zhou, Kyle Dawson, Graziano Rossi etc

Thesis Advisor: Jean-Paul Kneib

SubHalo Abundance Matching (SHAM): Introduction

- In galaxy surveys for cosmological studies, we need
N-body simulations & Galaxy distr. from obs. & A galaxy-halo relation



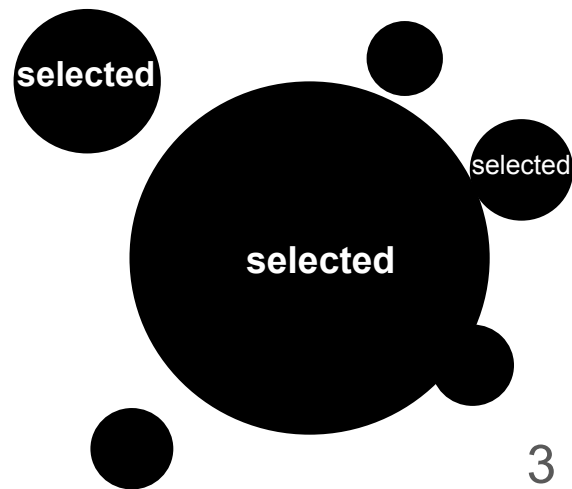
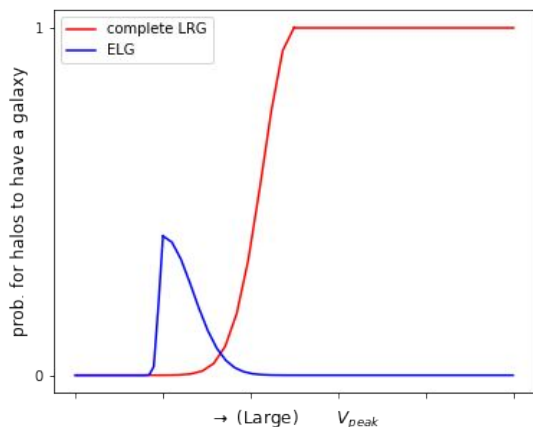
Wechsler, R. H., & Tinker, J. L. 2018

<https://esahubble.org/images/potw1035a/>

SubHalo Abundance Matching (SHAM): Introduction

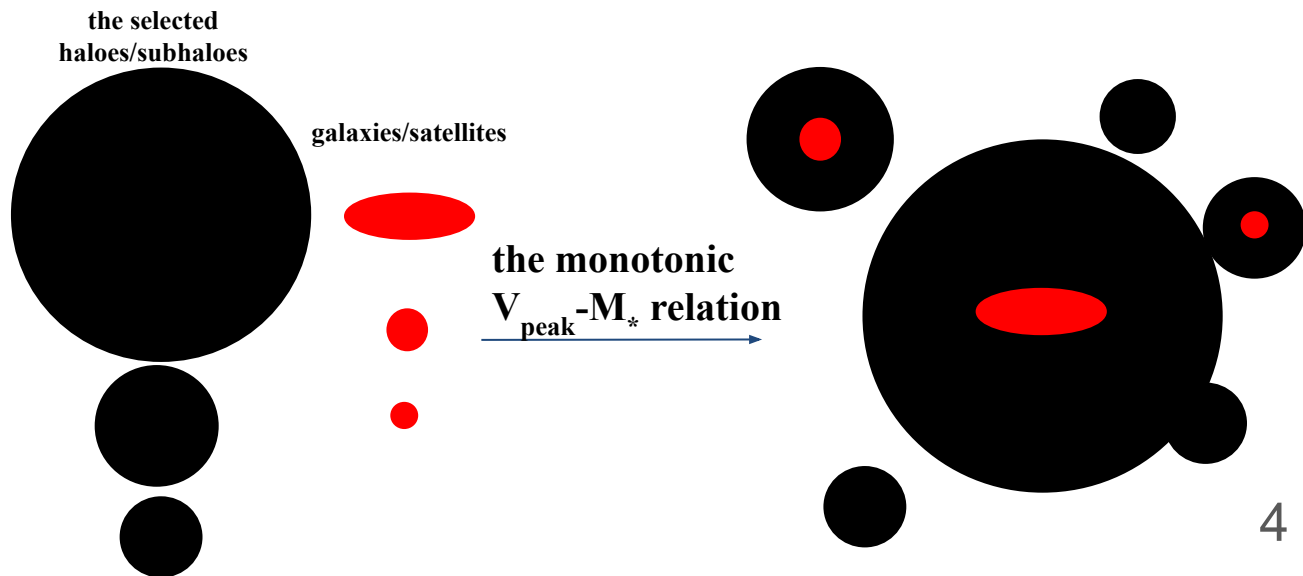
- In galaxy surveys for cosmological studies, we need
 - N-body simulations & Galaxy distr. from obs. & A galaxy-halo relation
- **SHAM: a simple and intuitive empirical galaxy-halo relation** (Kravtsov et al 2004, Tasitsiomi et al. 2004, Conroy et al. 2006, Behroozi et al. 2010, Trujillo-Gomez et al. 2016, Rodríguez-Torres et al. 2016, etc)

empirical $P(V_{\text{peak}})$



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Single-tracer SHAM: Implementation

➤ Classical SHAM:

- Scattered V_{peak} to match M_* , fitting the projected 2PCF wp

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- Scattered V_{peak} to match M_* , fitting the projected 2PCF

➤ Our 3-parameter SHAM:

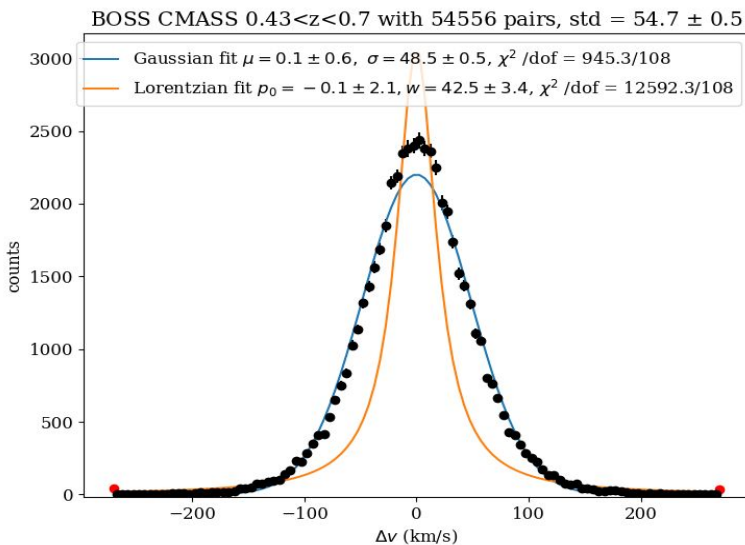
- Scattered V_{peak} , fitting the 2PCF ξ_0 and ξ_2 at 5-25Mpc/h
- Massive halo truncation $V_{\text{ceil}}\%$:
 - Quenching effect for ELGs (Dekel & Birnboim 2006)
 - Special target selection (eBOSS, Prakash et al. 2016)
- Redshift uncertainty v_{smear} :
 - Smearing the peculiar velocity of mock galaxies with random numbers

$$v'_{\text{pec}} = v_{\text{pec}} + \mathcal{R}(v_{\text{smear}})$$

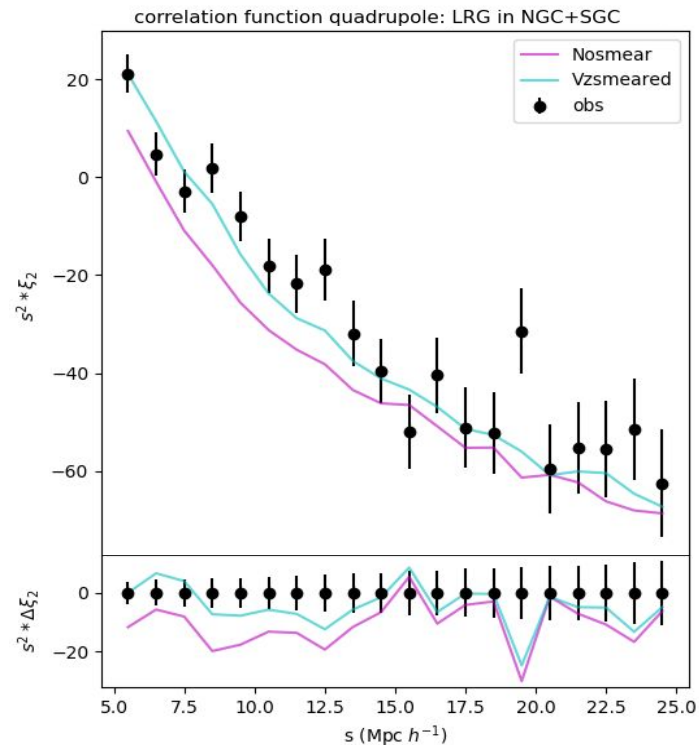
Single-tracer SHAM: why we need v_{smear}

➤ Redshift uncertainty is inevitable and affects the small-scale clustering

* Statistical measurements from repeat obs.: $\sigma_{\Delta v}$

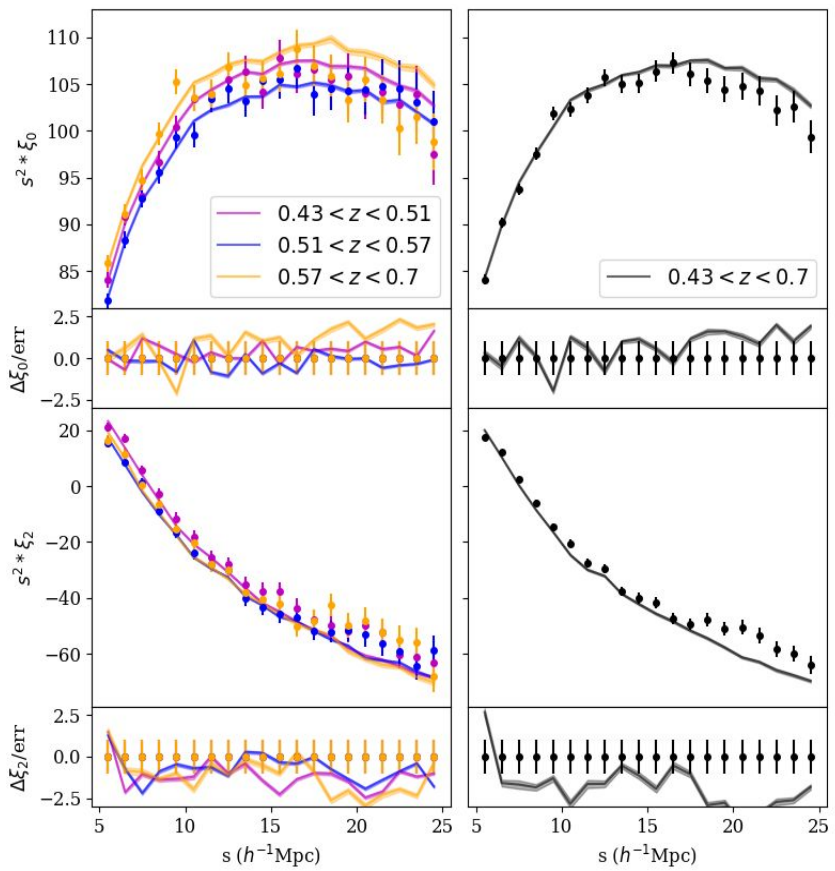
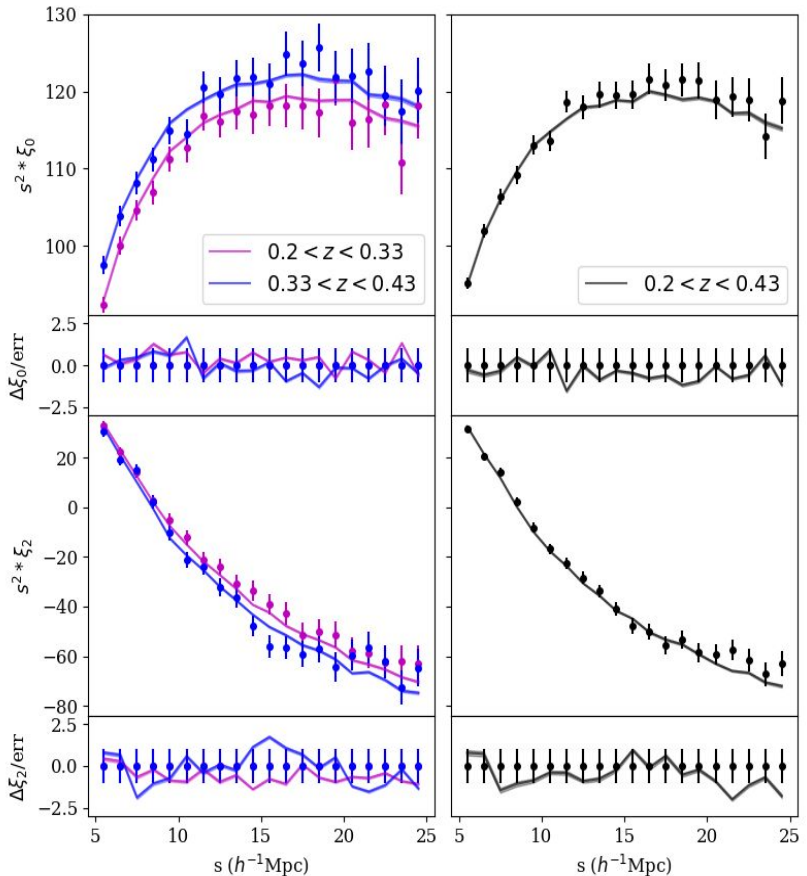


* What if we don't have v_{smear} ?



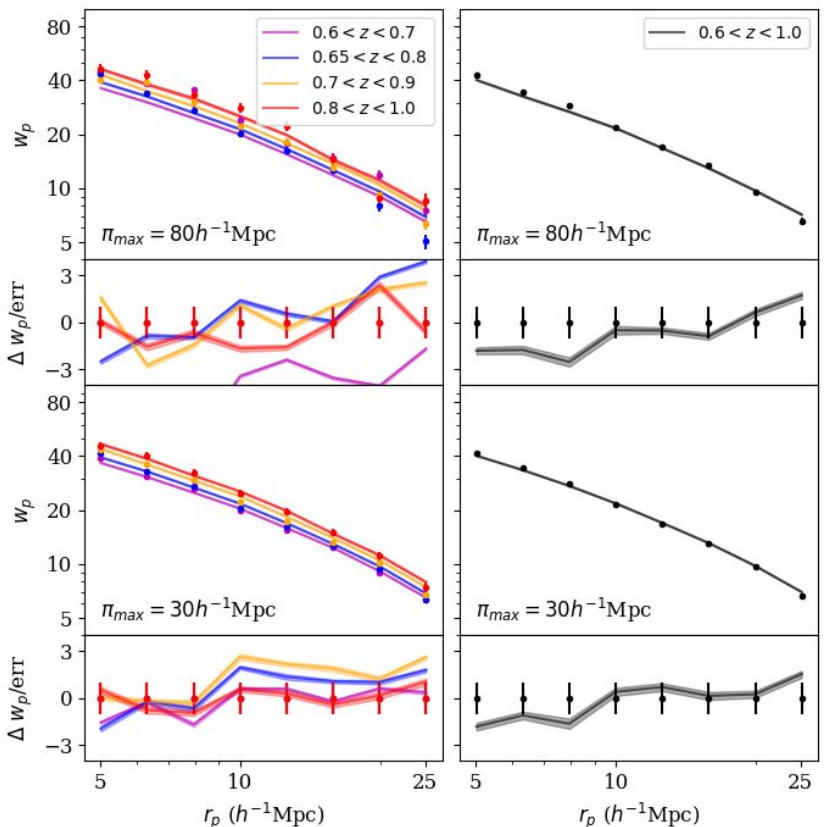
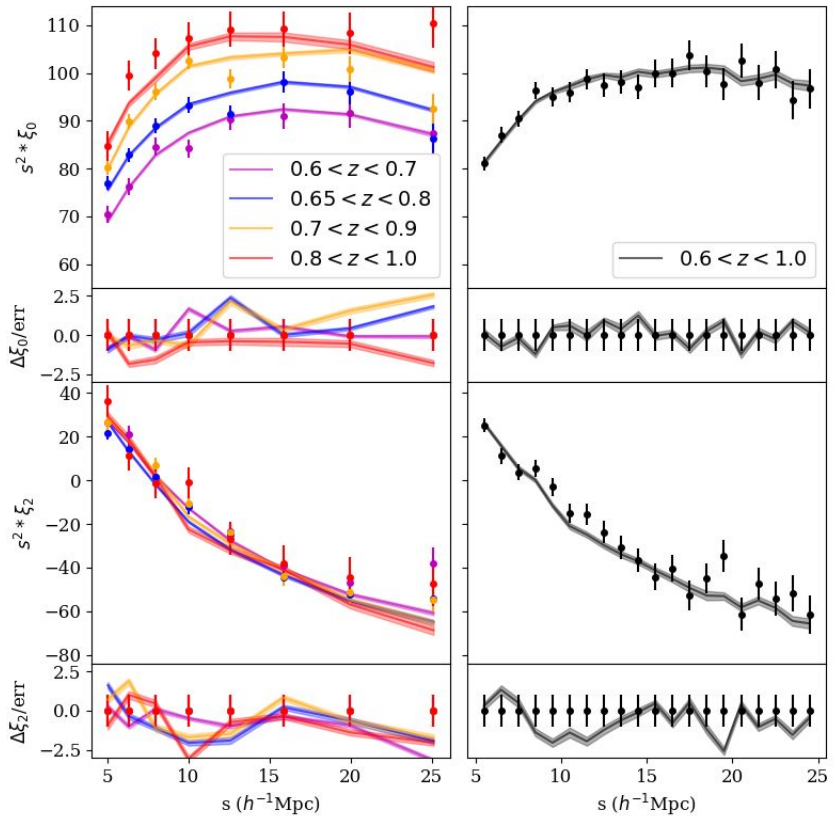
Single-tracer SHAM: LOWZ, CMASS LRGs

➤ It fits well the 2PCF at $0.2 < z < 0.7$



Single-tracer SHAM: eBOSS LRGs

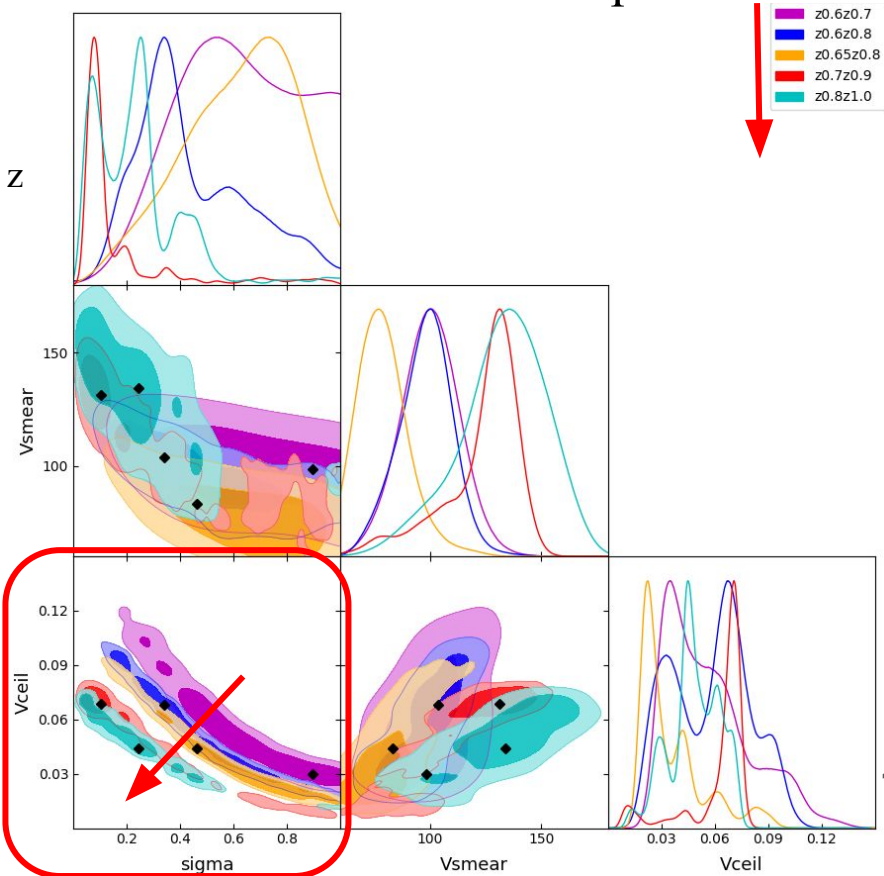
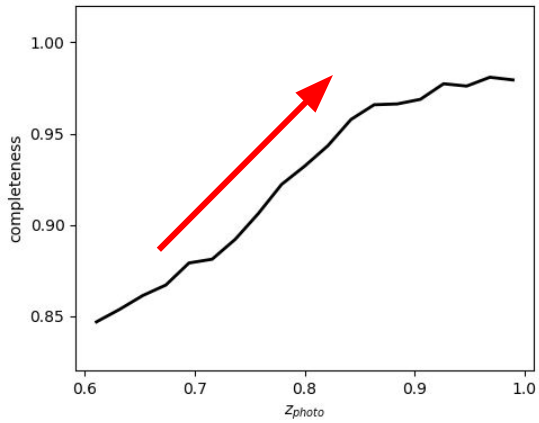
➤ It fits well the 2PCF at $0.6 < z < 1.0$; choosing $w_p \pi_{\max}$ should be careful



Single-tracer SHAM: eBOSS LRGs

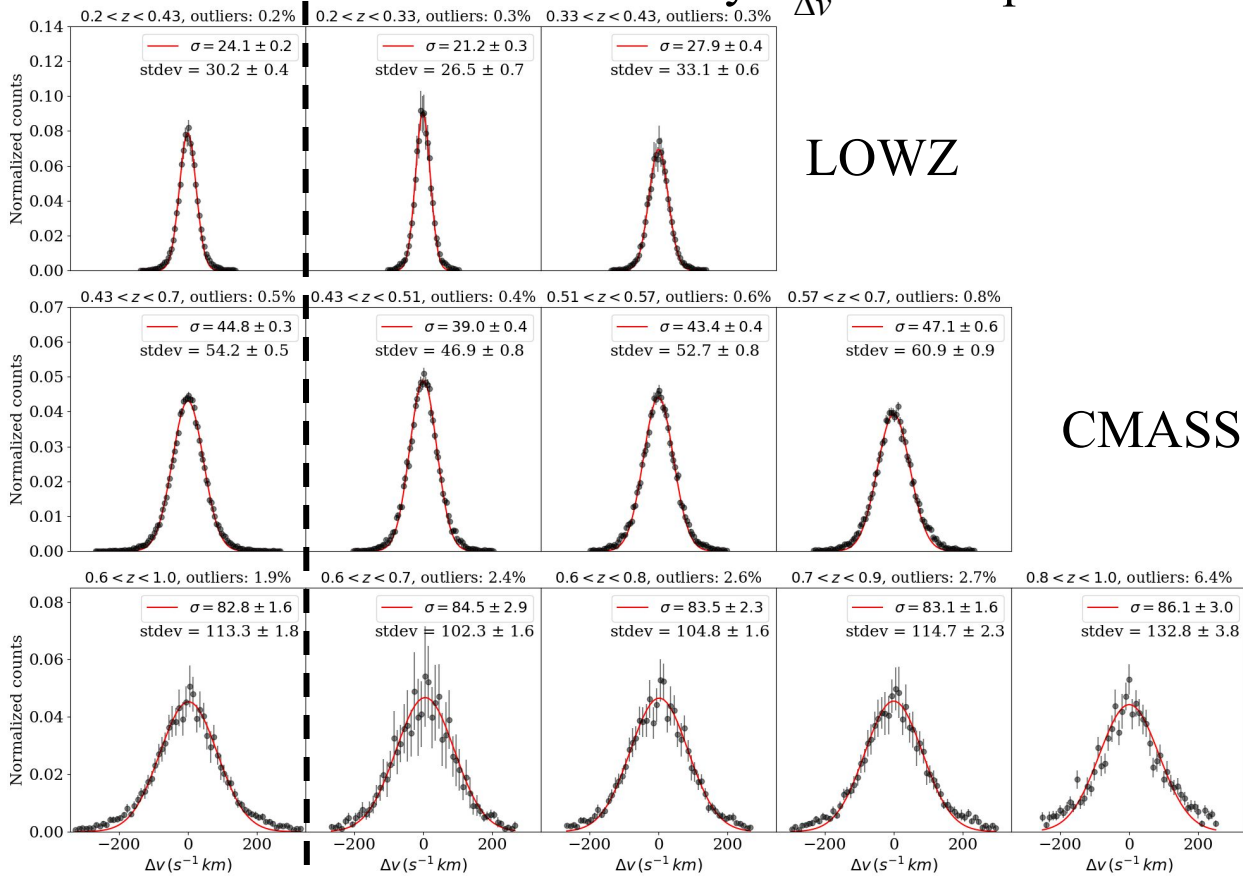
➤ The completeness evolution due to the i-band cut is reflected on posteriors

* For eBOSS, LRGs have a target selection criterion $i \geq 19.9$, resulting in an increasing galaxy completeness with z



Single-tracer SHAM: v_{smear} VS $\sigma_{\Delta v}$

➤ The statistical redshift uncertainty $\sigma_{\Delta v}$ from repeat observations



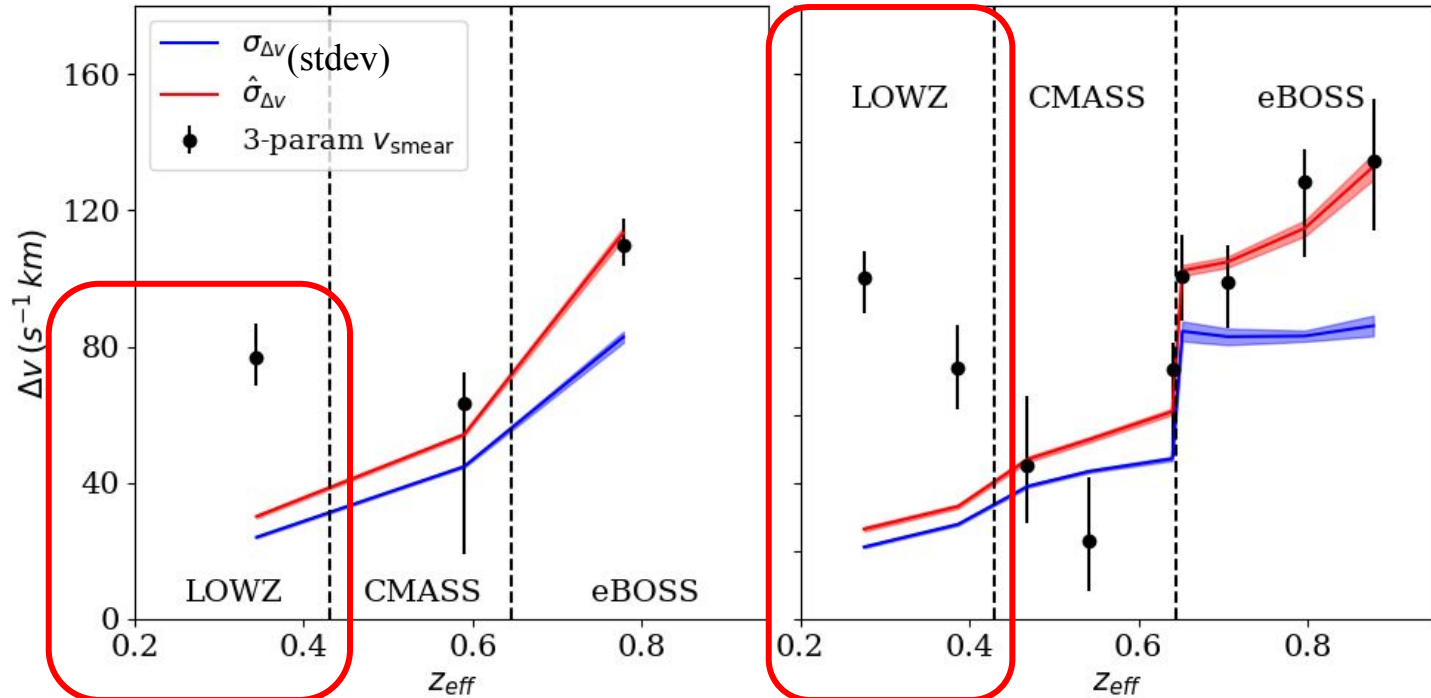
LOWZ

CMASS

eBOSS

Single-tracer SHAM: v_{smear} VS $\sigma_{\Delta v}$

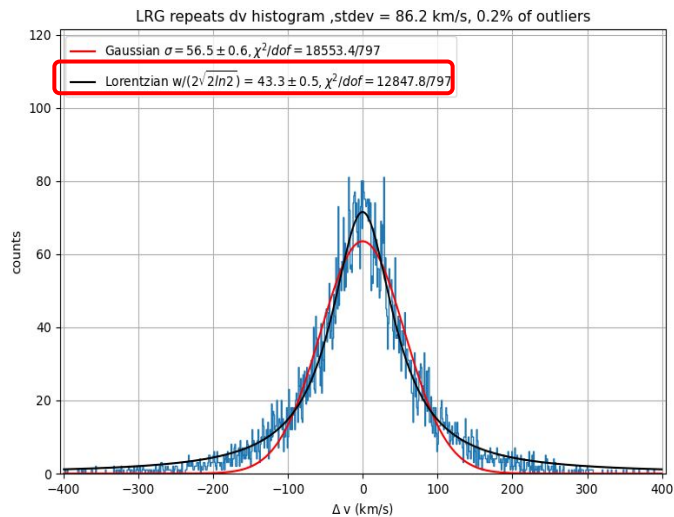
- v_{smear} is consistent with $\sigma_{\Delta v}$ except for LOWZ
 - Not because of problems in simulations, SDSS pipeline upgrade, $\sigma_{\Delta v}$ underestimation
 - Could be a special subclass of LRGs



SHAM Tests for DESI:

➤ Single-tracer SHAM

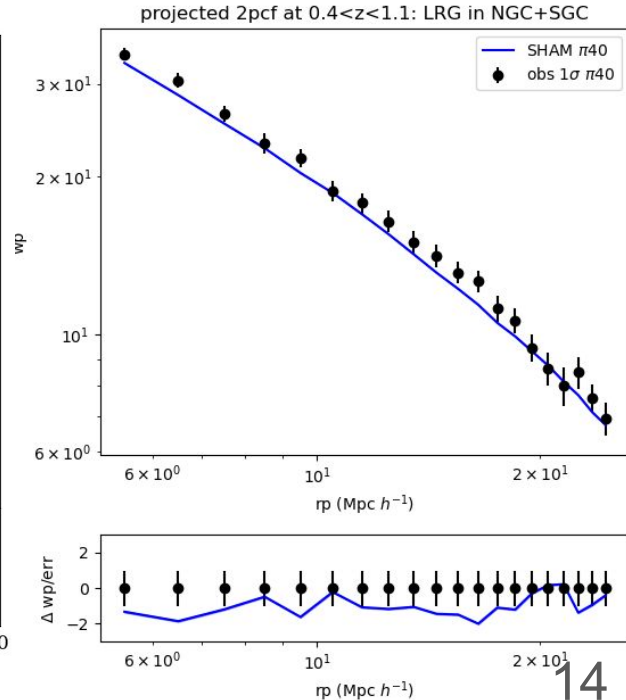
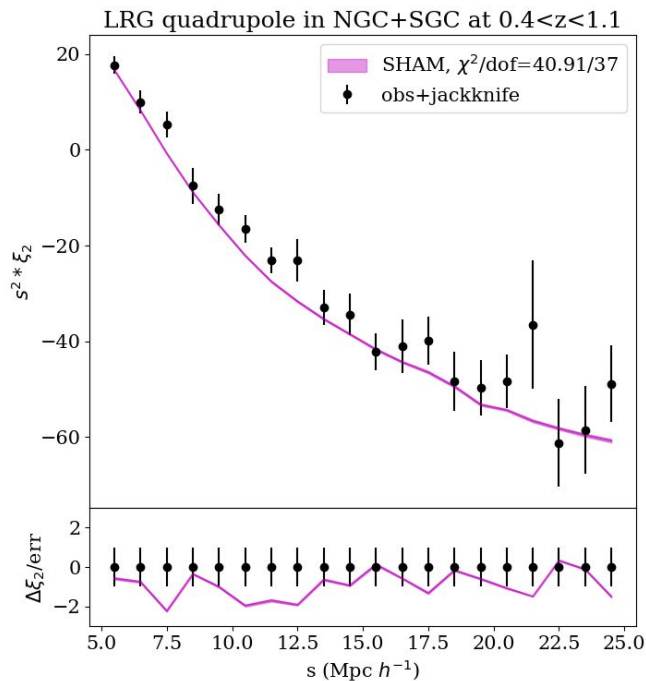
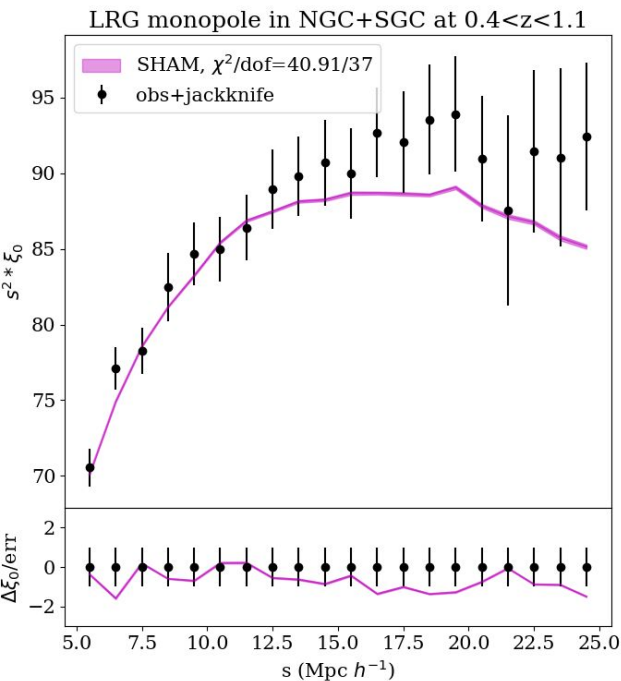
- LRG: the Lorentzian redshift uncertainty



SHAM Tests for DESI: LRG with Lorentzian(v_{smear})

obs: /global/cfs/cdirs/desi/survey/catalogs/SV3/LSS/fuji/LSScats/3/xi/smu/xipoles_LRG_0.4_1.1_default_angular_bitwise_lin1_njack120.txt

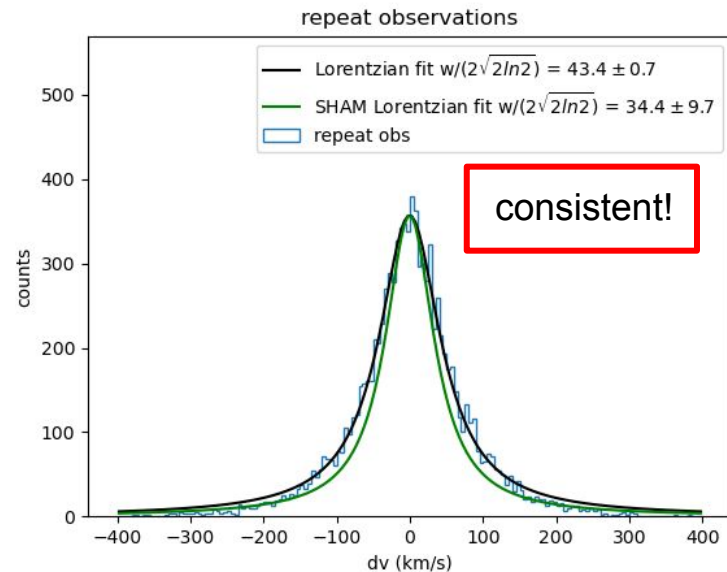
➤ The best-fit 2PCF at 5-25 Mpc/h & the reproduced wp



SHAM Tests for DESI: LRG with Lorentzian(v_{smear})

➤ v_{smear} v.s. $\sigma_{\Delta v}$

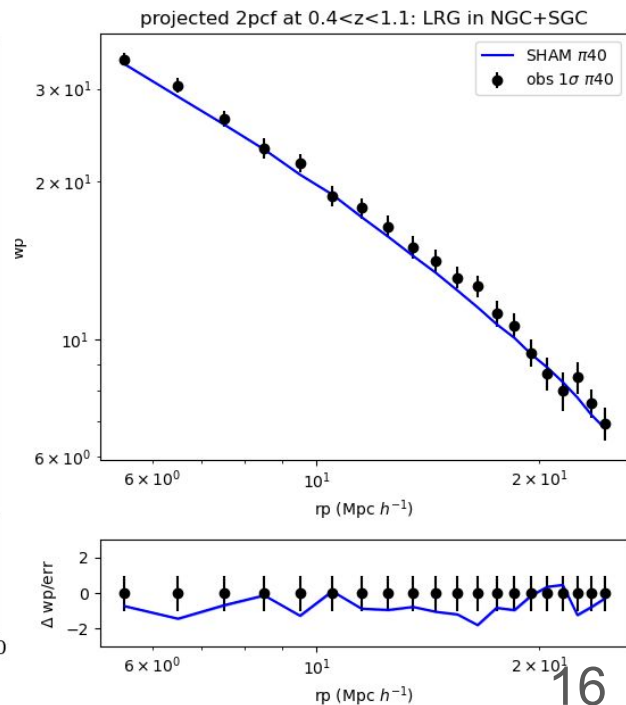
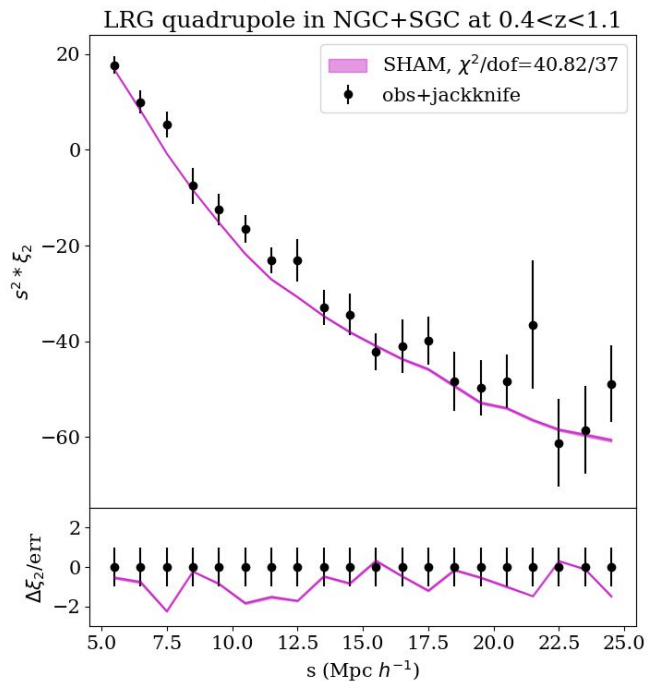
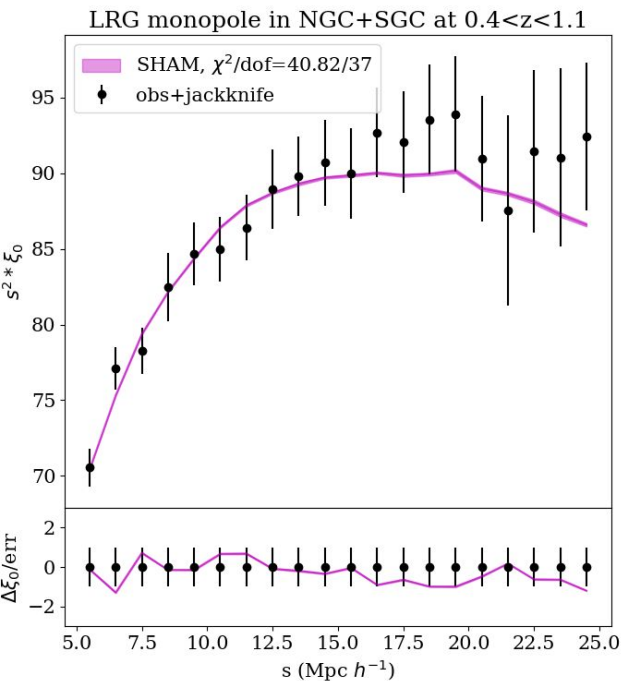
- $v_{\text{smear}}/2\text{sqrt}(2\ln 2) = [24.7, 44.4] \text{ km/s}$
- $\sigma_{\Delta v}/2\text{sqrt}(2\ln 2) = [42.7, 44.1] \text{ km/s}$
- Cutoff $\text{abs}(dv) = 400 \text{ km/s}$



SHAM Tests for DESI: LRG with Gaussian(v_{smear})

obs: /global/cfs/cdirs/desi/survey/catalogs/SV3/LSS/fuji/LSScats/3/xi/smu/xipoles_LRG_0.4_1.1_default_angular_bitwise_lin1_njack120.txt

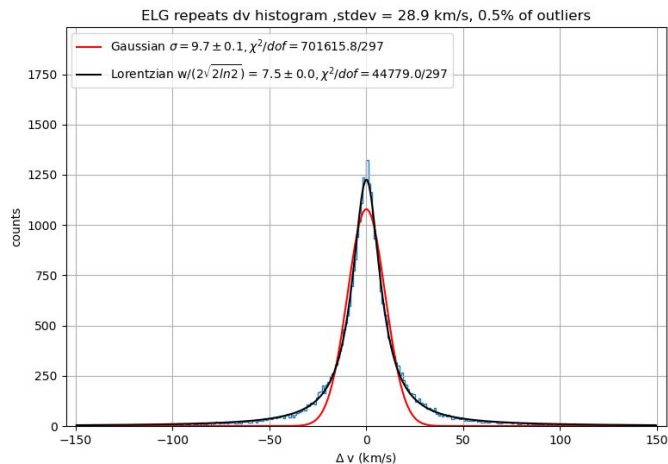
➤ **The best-fit 2PCF at 5-25 Mpc/h** & **the reproduced wp**



SHAM Tests for DESI:

➤ Single-tracer SHAM

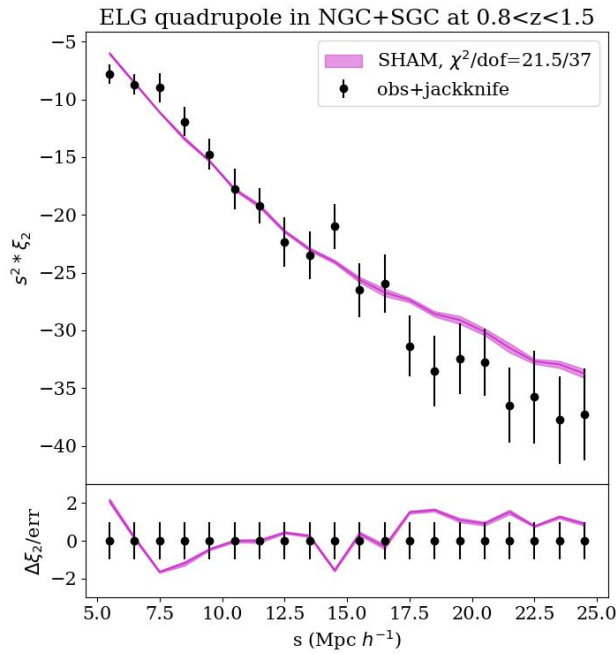
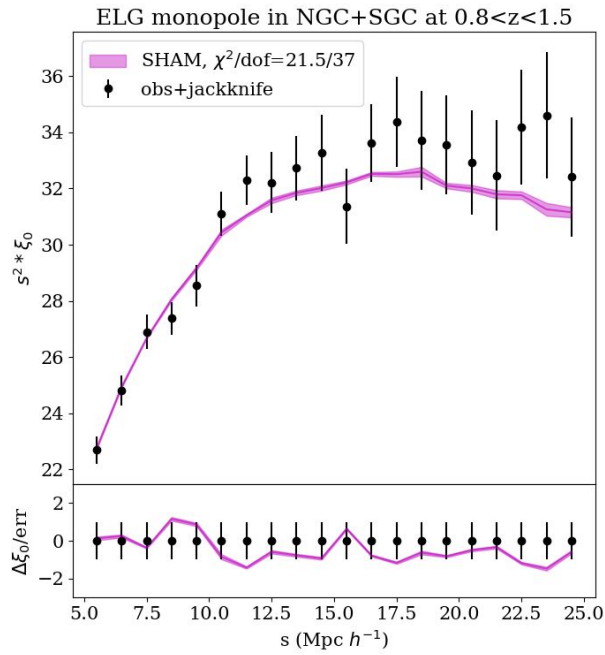
- LRG: Lorentzian(v_{smear}) or Gaussian(v_{smear})
- ELG: the implementation with f_{sat} and $v_{\text{smear}} = 0$



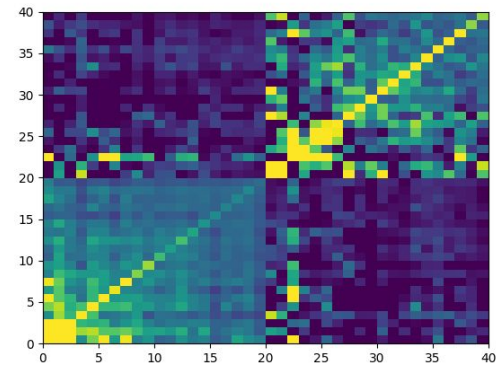
SHAM Tests for DESI: ELG with $\nu_{\text{smear}} = 0$ and f_{sat}

obs: /global/cfs/cdirs/desi/survey/catalogs/SV3/LSS/fuji/LSScats/3/xi/smu/xipoles_ELG_0.8_1.5_default_angular_bitwise_lin1_njack120.txt

➤ The best-fit 2PCF at 5-25 Mpc/h



* There is covariant on small scales



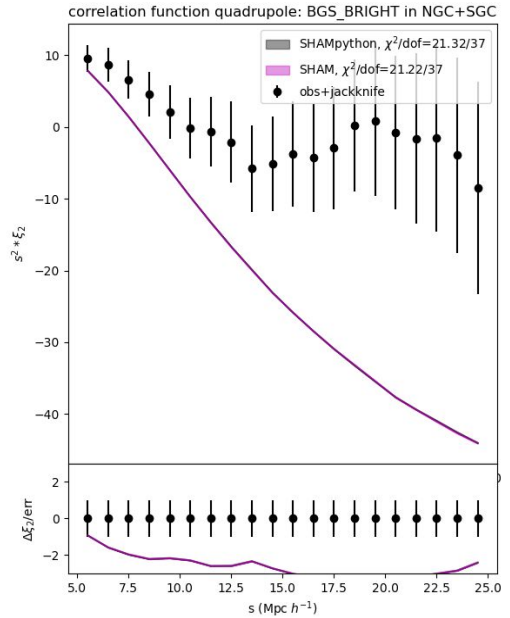
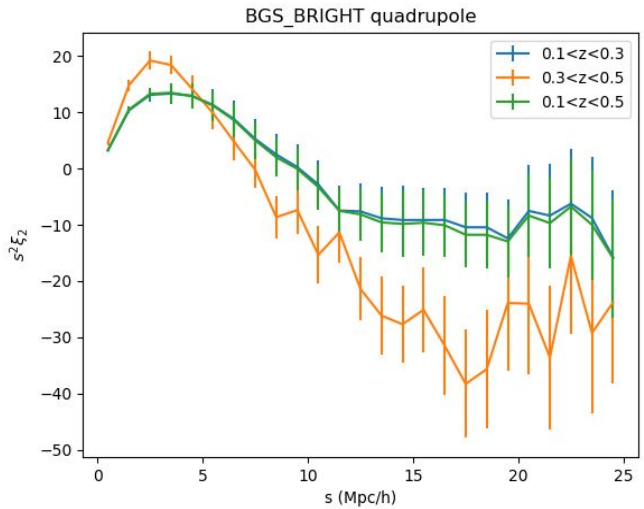
SHAM Tests for DESI:

➤ Single-tracer SHAM

- LRG: Lorentzian(v_{smear}) or Gaussian(v_{smear})
- ELG: the covariant small scales
- BGS: whether we see a similar discrepancy in v_{smear} like LOWZ?

SHAM Tests for DESI: BGS with Lorentzian(v_{smear})

➤ The flat 2PCF ξ_2 in SV3 needs extra effort to fit



SHAM Tests for DESI:

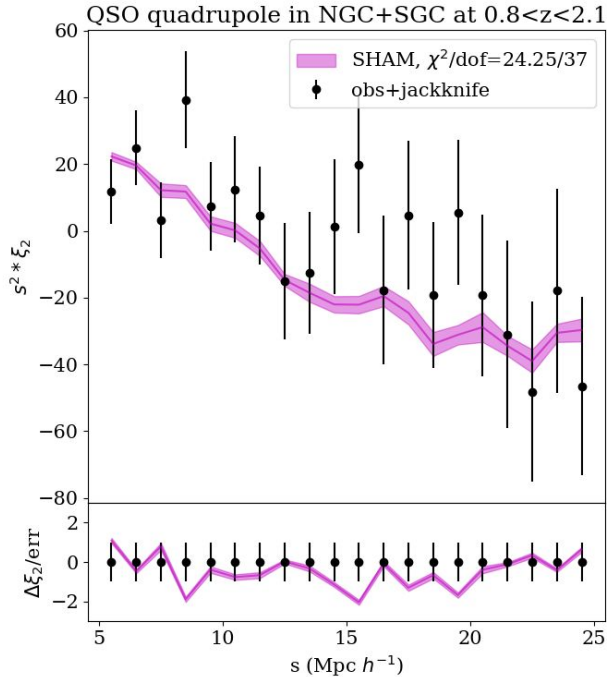
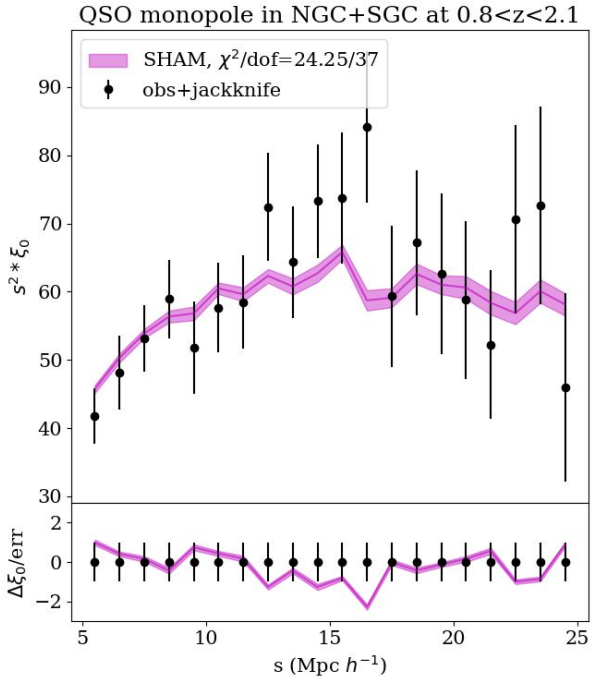
➤ Single-tracer SHAM

- LRG: Lorentzian(v_{smear}) or Gaussian(v_{smear})
- ELG: the covariant small scales
- BGS: the flat ξ_2 issue (solved in DA02)
- QSO: high-redshift behaviours

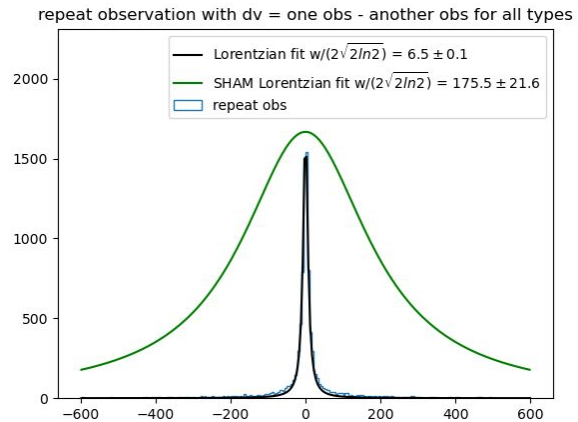
SHAM Tests for DESI: QSO with Lorentzian(v_{smear})

obs: /global/cfs/cdirs/desi/survey/catalogs/SV3/LSS/fuji/LSScats/3/xi/smu/xipoles_QSO_0.8_2.1_default_angular_bitwise_lin1_njack120.txt

➤ The best-fit 2PCF at 5-25 Mpc/h



* repeat obs. cannot measure $\sigma_{\Delta v}$



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- QSO: a better $\sigma_{\Delta v}$ measurement and v_{smear} model for SHAM

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- QSO: a better $\sigma_{\Delta v}$ measurement and v_{smear} model for SHAM

➤ Next Steps:

- Parameter evolution in redshift slices for all the tracers
- Multi-tracer SHAM: ELGxLRG, ELGxQSO, LRGxQSO

A General 3-Param. SHAM: Summary and Outlooks

- **BOSS/eBOSS LRG SHAM** (Yu et al. arxiv: 2203.11069):
 - A good model for LRGs at $0.2 < z < 1.0$
 - The completeness evolution captured by the eBOSS SHAM posteriors
 - The consistent ν_{smear} with $\sigma_{\Delta\nu}$ except for LOWZ

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- The completeness evolution captured by the eBOSS SHAM posteriors
- The consistent v_{smear} with $\sigma_{\Delta v}$ except for LOWZ

➤ **DESI SHAM for all the tracers** (DESI Project [222]):

- Issues: LRG v_{smear} model, ELG covariance matrix, QSO $\sigma_{\Delta v}$ measurements
- Todo: Parameter evolution
- Todo: Multi-tracer SHAM

EPFL



Thanks!