Institute for
Computational
Science

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modeling
Intrinsic Galaxy Alignment
in Flagship

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intrinsic galaxy alignment

2D axis ratio q=b/a *position angle*

shear definition

$$\vec{\gamma} = \begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix} \equiv \frac{(1-q^2)}{(1+q^2)} \begin{pmatrix} \cos(2\alpha) \\ \sin(2\alpha) \end{pmatrix}$$

IA contribution

$$\gamma^{obs} = \gamma + \gamma^{I}$$

shear correlation

GG GI IG II

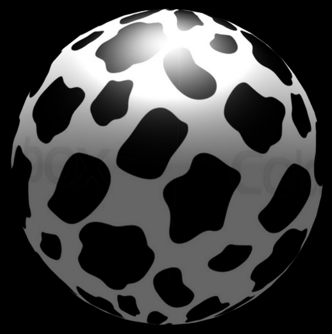
$$\langle \gamma_i^{obs} \gamma_j^{obs} \rangle = \underbrace{\langle \gamma_i \gamma_j \rangle}_{\text{lensing signal}} + \underbrace{\langle \gamma_i \gamma_j^{I} \rangle + \langle \gamma_i^{I} \gamma_j \rangle + \langle \gamma_i^{I} \gamma_j^{I} \rangle}_{\text{IA contamination}}$$

overview

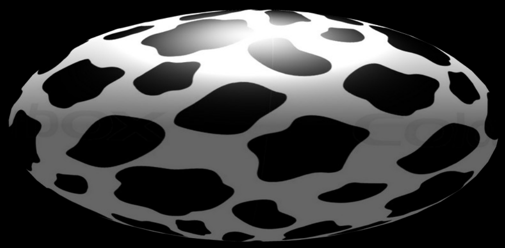
1) modeling intrinsic shapes

2) modeling intrinsic orientations

the spherical cow

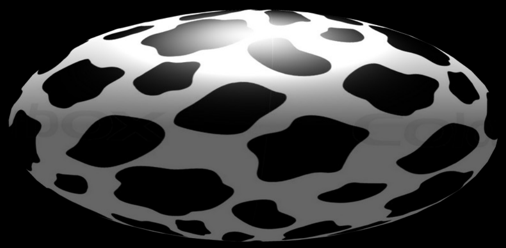


the ellipsoidal cow



- model all galaxies (disks and ellipticals) as 3D ellipsoids

the ellipsoidal cow



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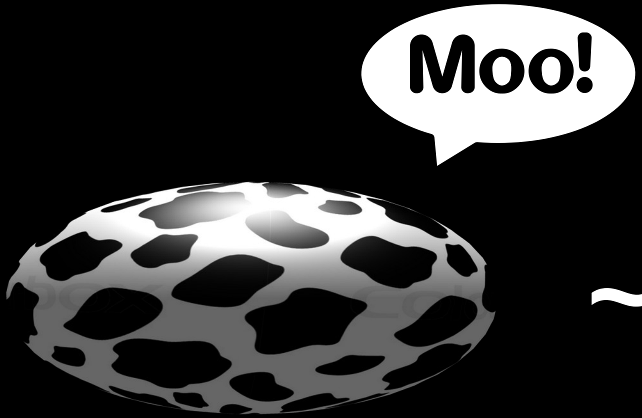
@realCow

- model all galaxies (disks and ellipticals) as 3D ellipsoids

the ellipsoidal cow



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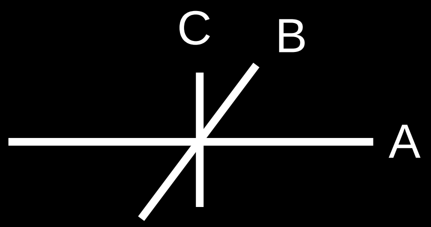
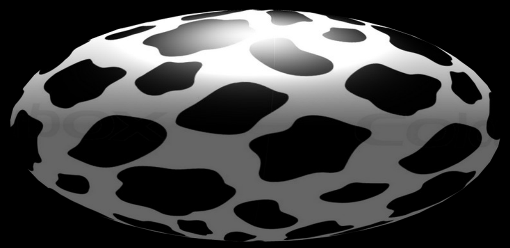
@realCow

- model all galaxies (disks and ellipticals) as 3D ellipsoids

the ellipsoidal cow



principle axes



- model all galaxies (disks and ellipticals) as 3D ellipsoids
- shapes are characterized by principle axes ratios q= B/A, s = C/A

triaxial axes ratios

$$P(q,r)=\frac{1}{norm}\exp\left(-\frac{1}{2}\frac{(q-q_0)^2+(r-r_0)^2}{\sigma^2}\right)$$

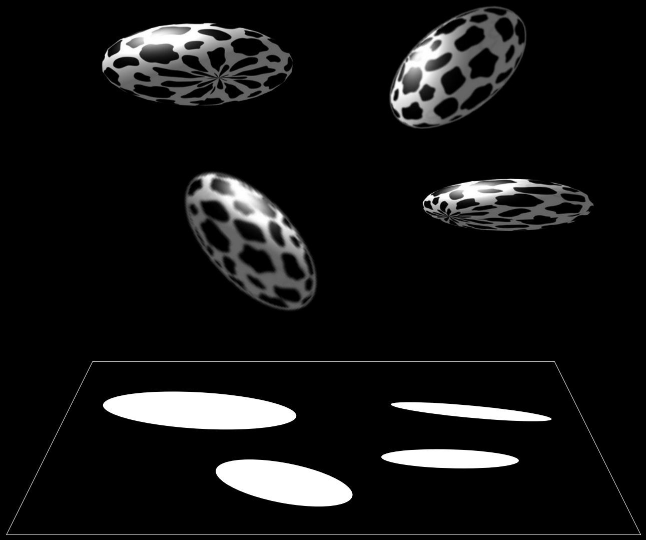
- q = B/A, r = C/B in [0,1] => s = C / A = r * q < q
- 3 free parameters: q0, r0, sigma

projected axes ratio distribution

$$P(q,r) = \frac{1}{norm} \exp\left(-\frac{1}{2}\frac{(q-q_0)^2+(r-r_0)^2}{\sigma^2}\right)$$

- draw 3D axes ratios from P(q,r)
- project on plane
- measure 2D axes ratio pdf

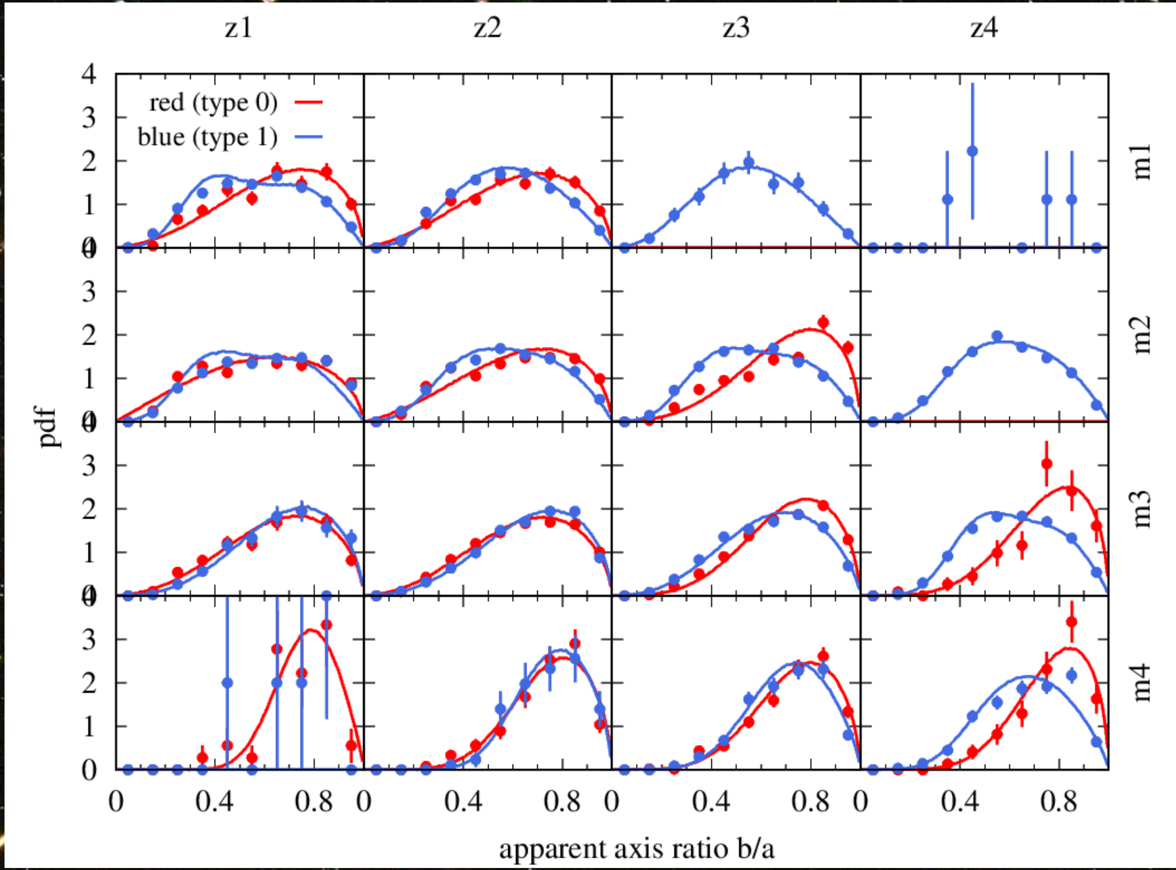
distribution of
3D ellipsoids



distribution of
2D ellipses

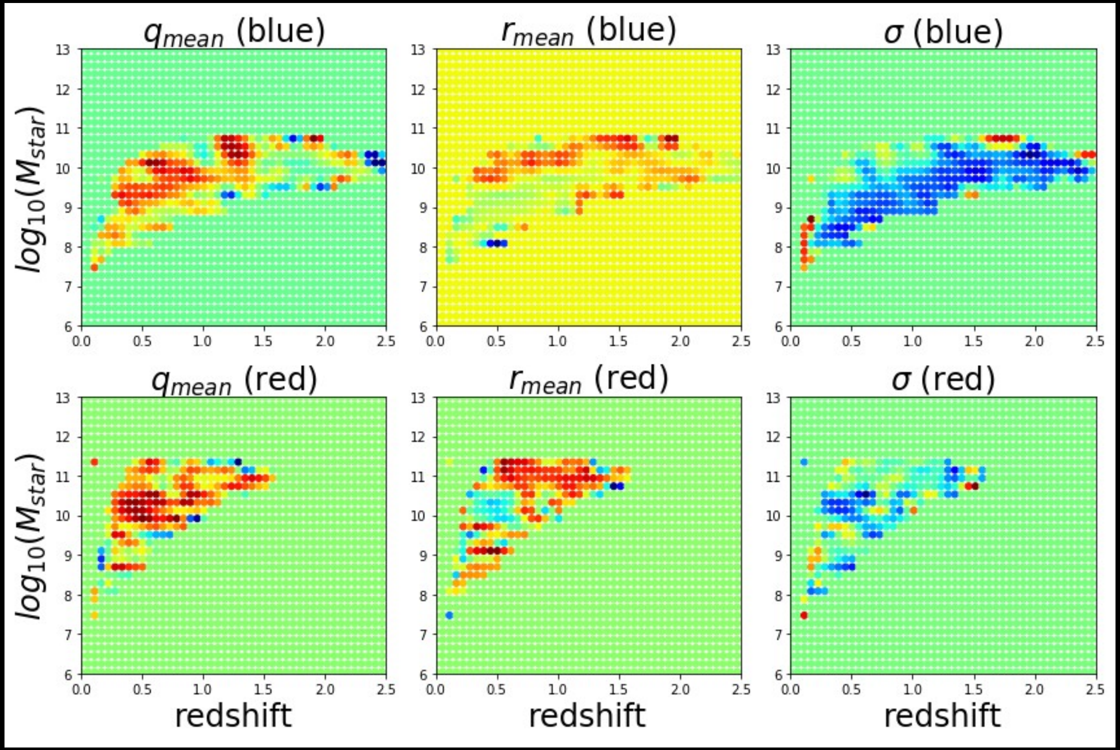
e.g. Hubble E. P., 1926, ApJ, 64, 321
Ryden B. S., 2004, ApJ, 601, 214
Zhang H., et al., 2019, MNRAS, 484, 5170

fits to pdf of apparent axes ratios in COSMOS

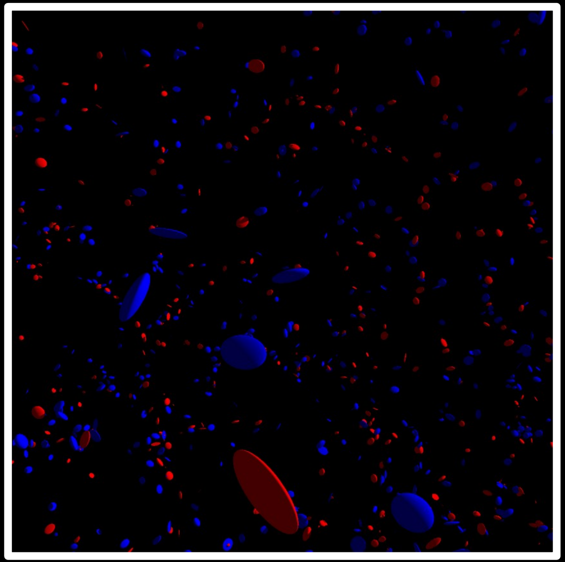


interpolated parameters for mock production

parameters of axes ratio pdf as function of redshift, color and stellar mass

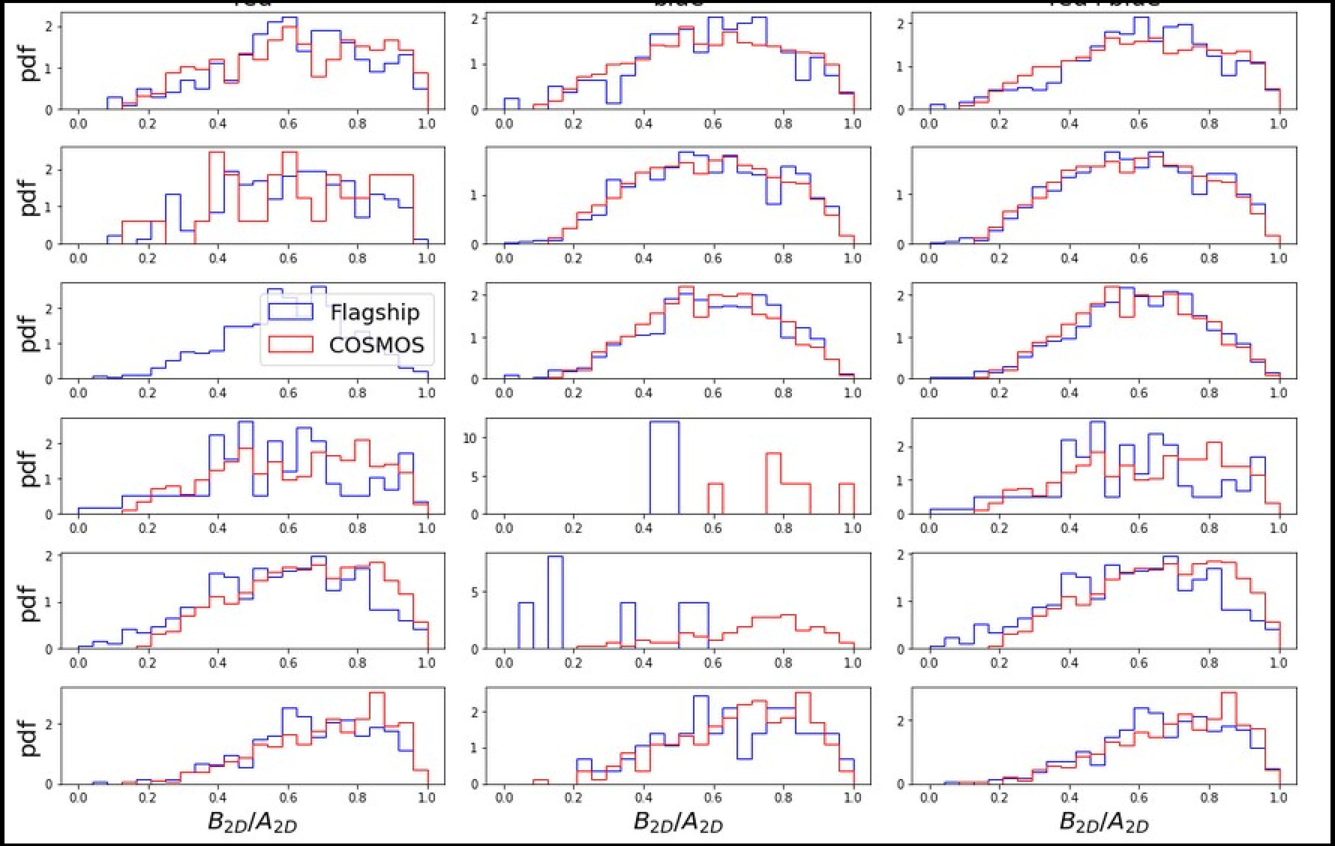


mock shape catalogue



projected shapes: Flagship vs. COSMOS

red | blue | red+blue



z=0.45
z=0.85
z=1.25

$\lg M_* = 9.50$

z=0.45
z=0.85
z=1.25

$\lg M_* = 10.75$

overview

1) modeling intrinsic shapes (✓)

2) modeling intrinsic orientations

toy model for galaxy orientations

red centrals

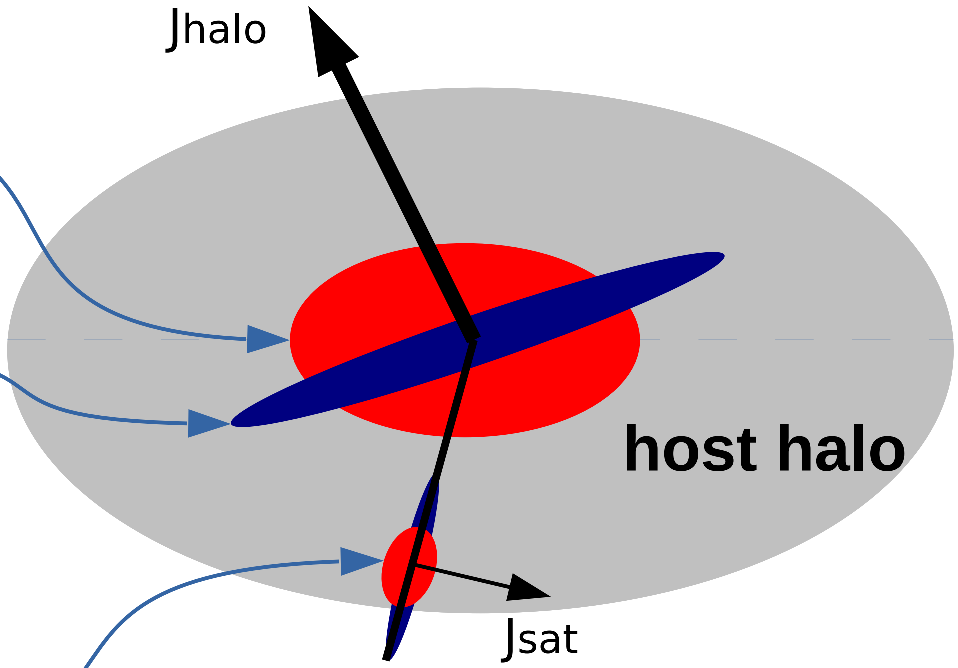
- same major and minor axis as host halo

blue centrals

- minor axis perp. to Jhalo
- major axis random on plane perp. to Jhalo

red & blue satellites

- major axis pointing to halo center
- minor axis random on tangential plane



all galaxies are ellipsoids

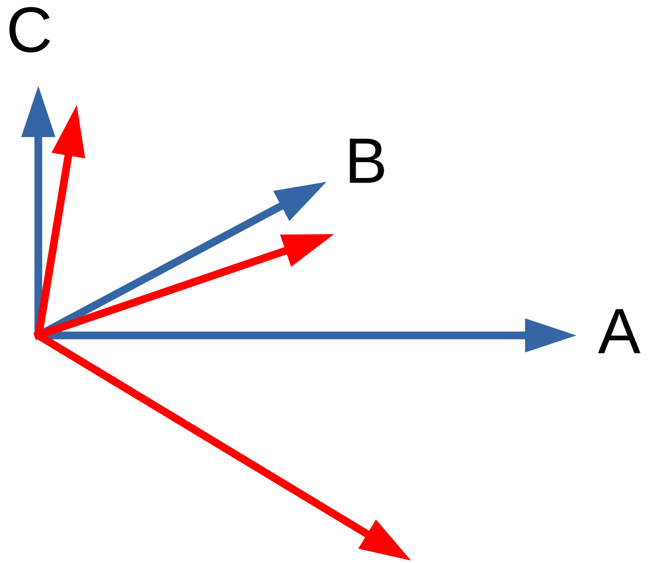
similar to Joachimi et al. 2013/14 (1203.6833, 1305.5791)

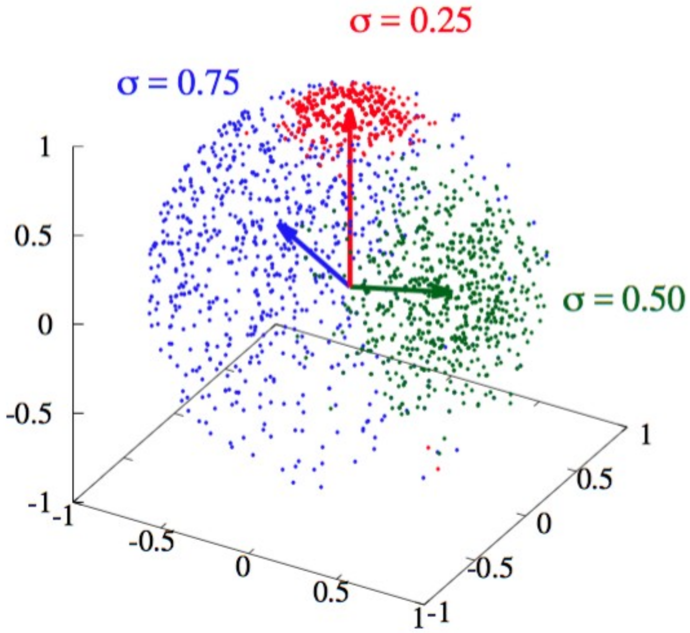
intrinsic misalignment

random distortion of
galaxy orientations

Misis-Fisher distribution

$$P(\cos\vartheta) = \frac{1}{2\sigma^2 \sinh \sigma^{-2}} \exp\left(\frac{\cos\vartheta}{\sigma^2}\right)$$



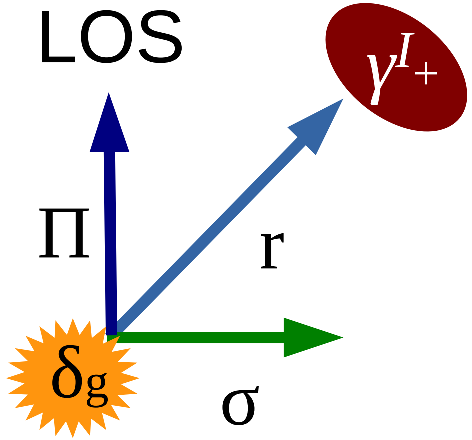


projected galaxy-shear correlation

2D galaxy-shear

$$\xi_{g+}(\sigma,\Pi) = \langle \delta_g \gamma_+^I \rangle (\sigma,\Pi)$$

(γ^I_+ and δ_g are in same redshift bin)



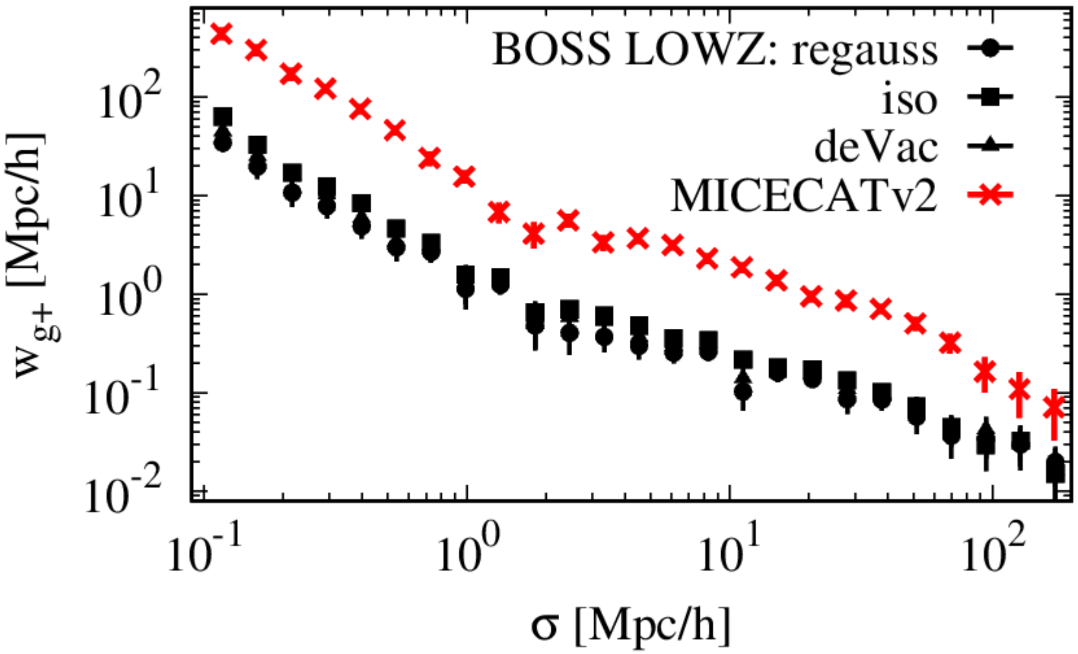
projection along line of sight

$$w_{g+}(\sigma) = \int_{-\Pi_{max}}^{\Pi_{max}} \xi_{g+}(\sigma,\Pi) d\Pi$$

Π_{max} = 60 Mpc/h

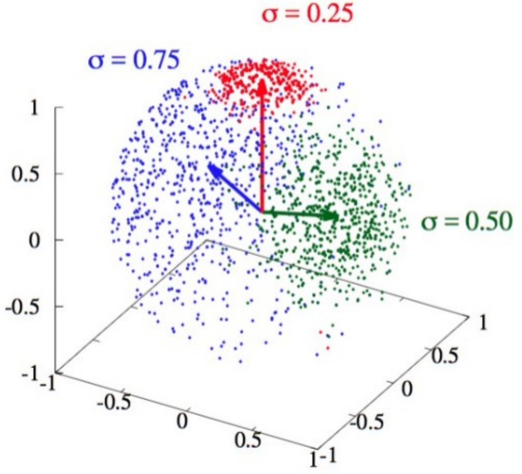
projected galaxy-shear correlation

σ_{sat}=0.1 σ_{cent}=0.1



Misis-Fisher distribution

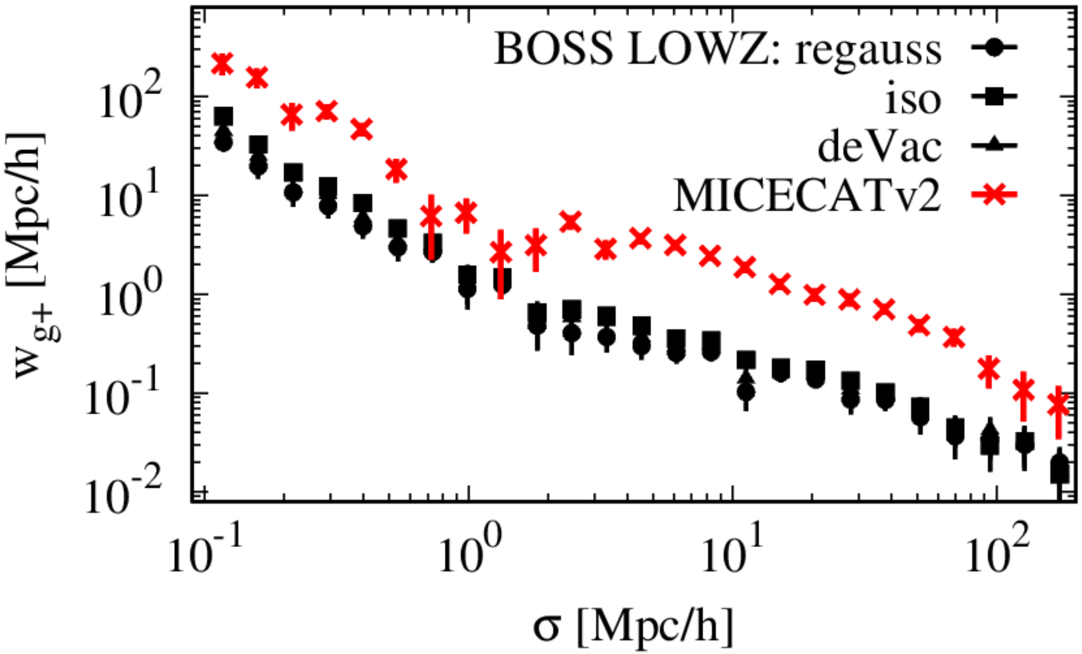
$$P(\cos\vartheta) = \frac{1}{2\sigma^2 \sinh \sigma^{-2}} \exp\left(\frac{\cos\vartheta}{\sigma^2}\right)$$



BOSS data from Singh S., Mandelbaum R., 2016, MNRAS, 457, 2301

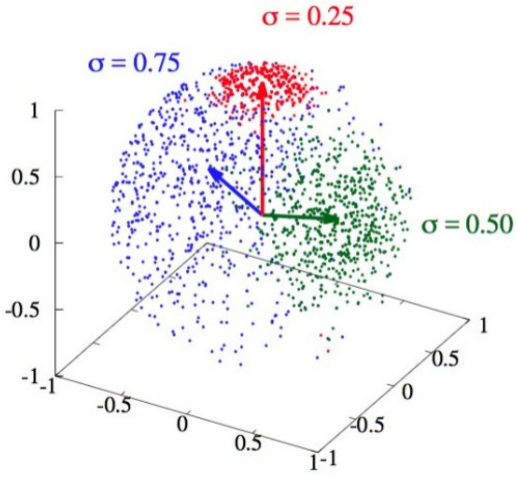
projected galaxy-shear correlation

σ_{sat}=0.5 σ_{cent}=0.1



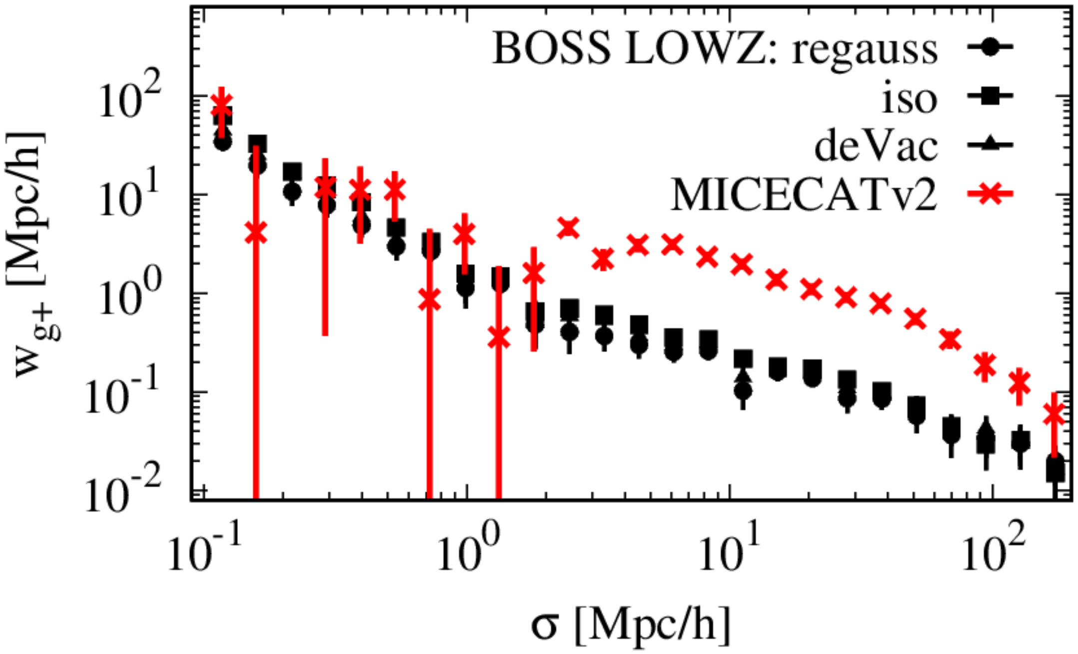
Misis-Fisher distribution

$$P(\cos\vartheta) = \frac{1}{2\sigma^2 \sinh \sigma^{-2}} \exp\left(\frac{\cos\vartheta}{\sigma^2}\right)$$



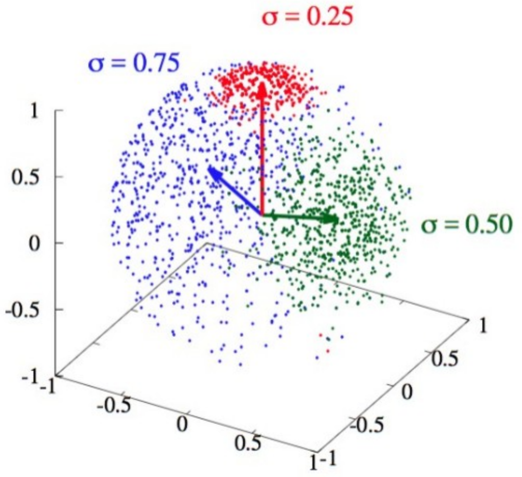
projected galaxy-shear correlation

σ_{sat}=1.0 σ_{cent}=0.1

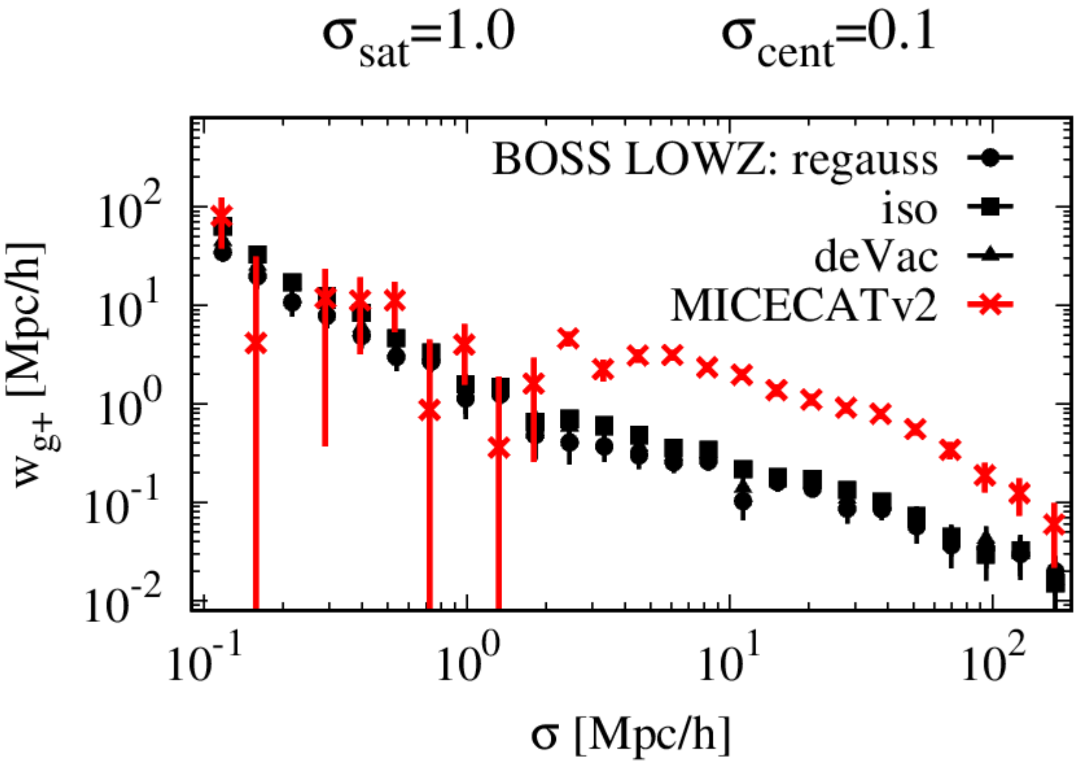


Misis-Fisher distribution

$$P(\cos\vartheta) = \frac{1}{2\sigma^2 \sinh \sigma^{-2}} \exp\left(\frac{\cos\vartheta}{\sigma^2}\right)$$



projected galaxy-shear correlation



Misis-Fisher distribution

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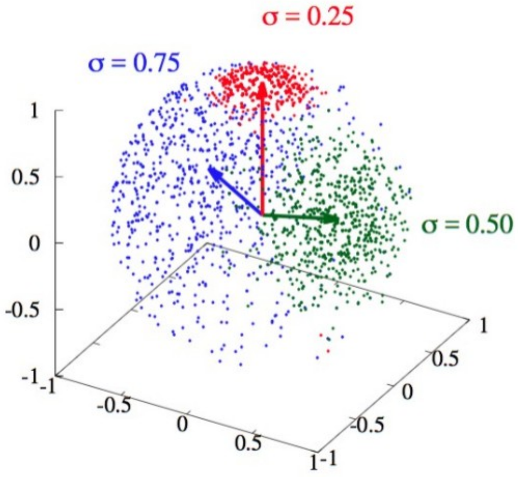
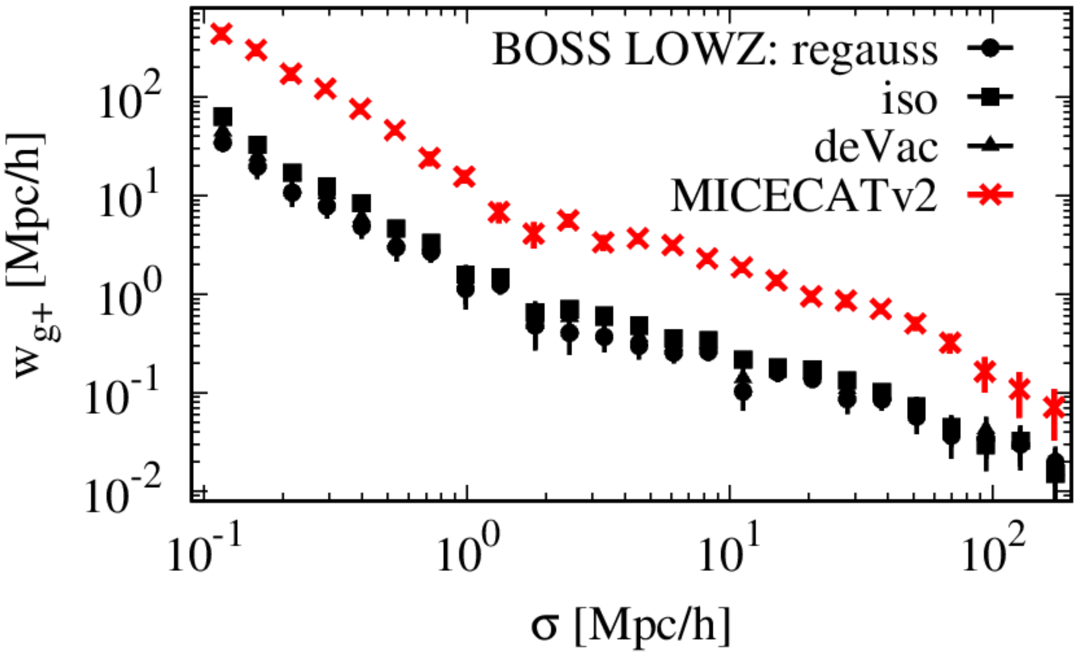


projected galaxy-shear correlation

σ_{sat}=0.1 σ_{cent}=0.1



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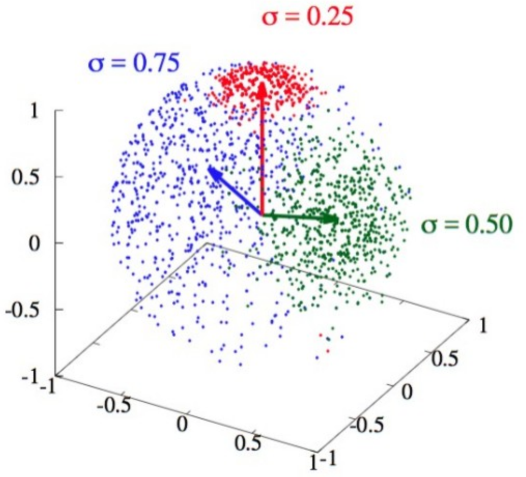
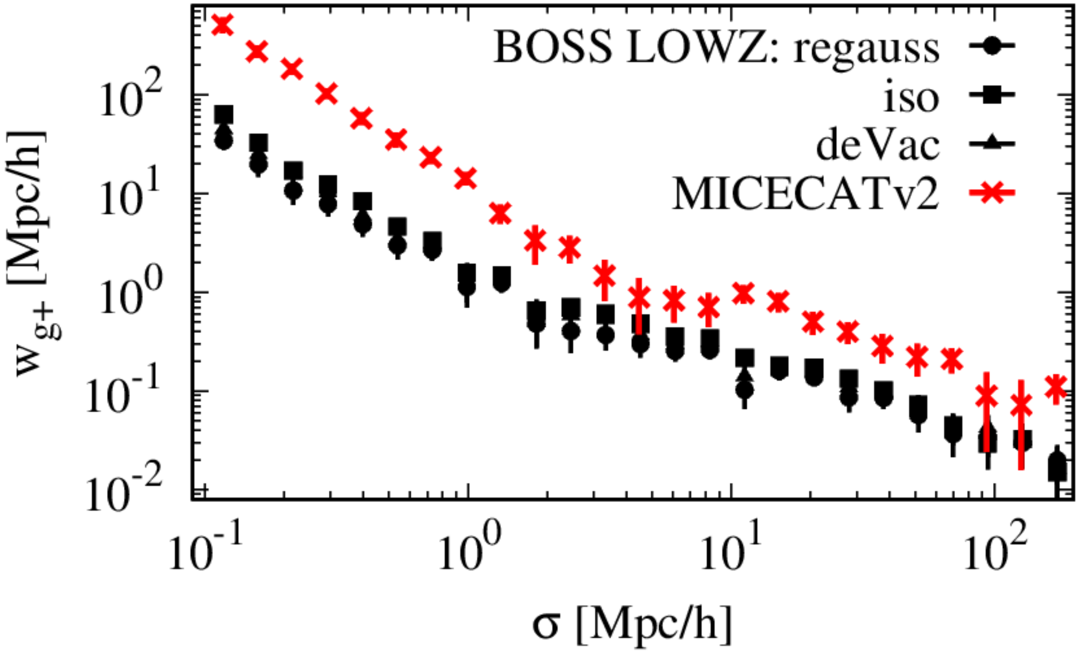


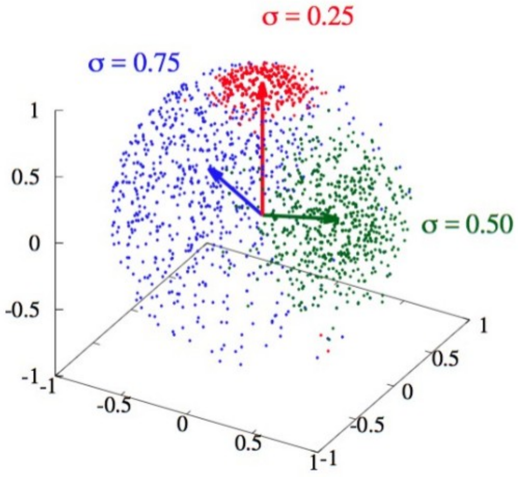
projected galaxy-shear correlation

σ_{sat}=0.1 σ_{cent}=0.5



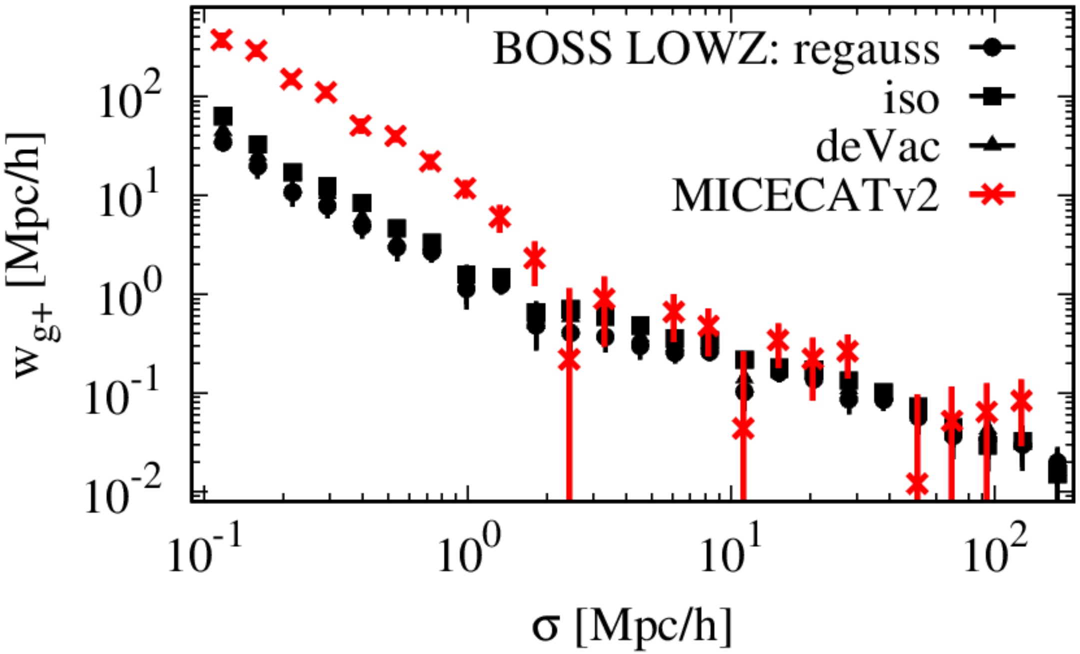
Misis-Fisher distribution

$$P(\cos\vartheta) = \frac{1}{2\sigma^2 \sinh \sigma^{-2}} \exp\left(\frac{\cos\vartheta}{\sigma^2}\right)$$



projected galaxy-shear correlation

σ_{sat}=0.1 σ_{cent}=1.0



Misis-Fisher distribution

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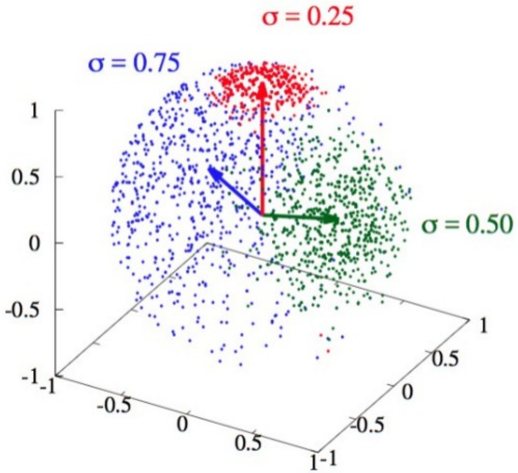
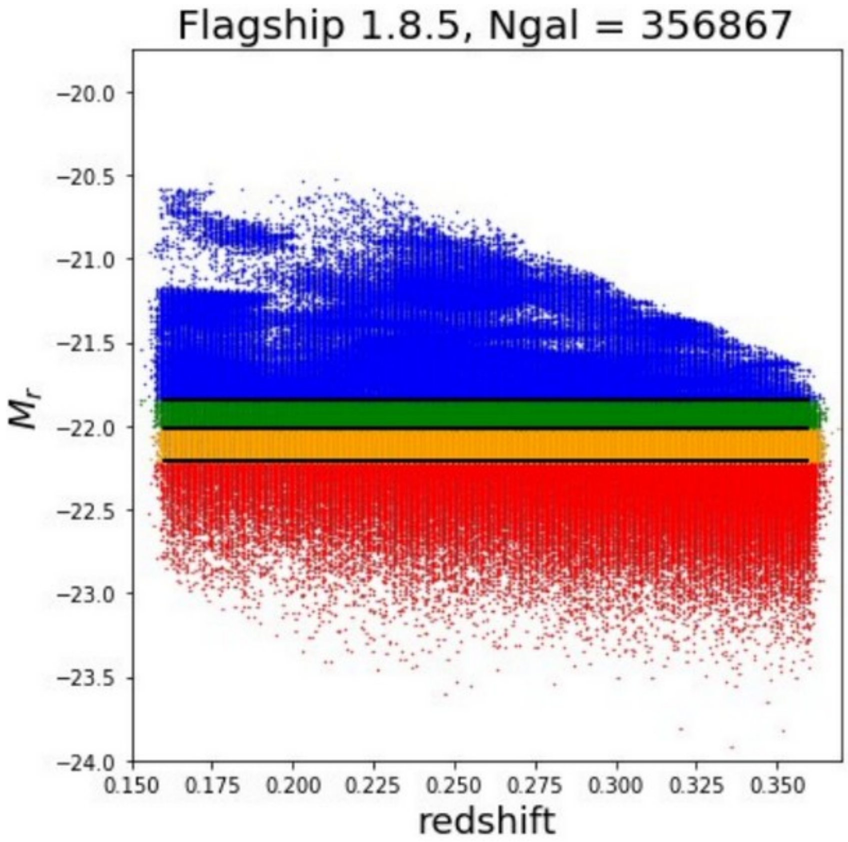


BOSS LOWZ samples



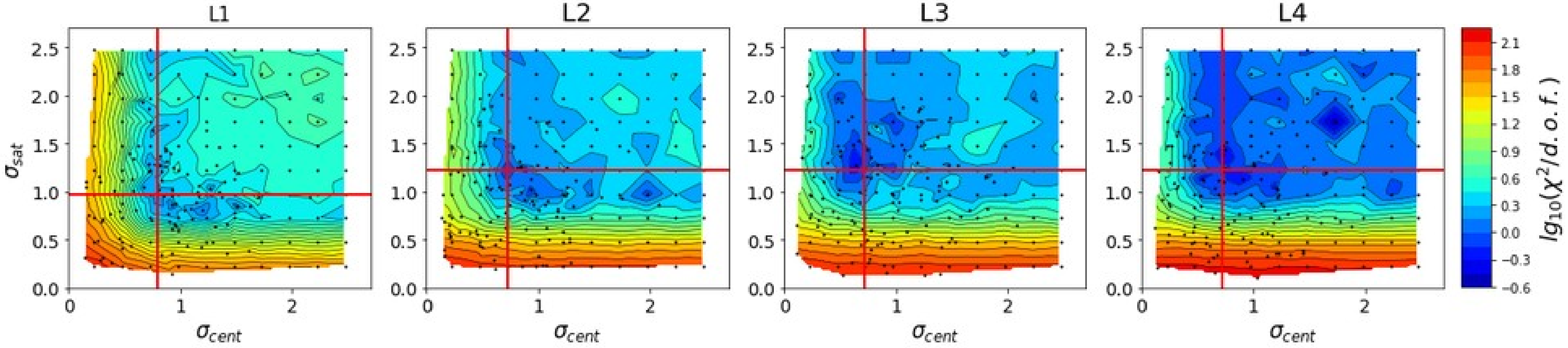
L4 (40%)

L3 (20%)

L2 (20%)

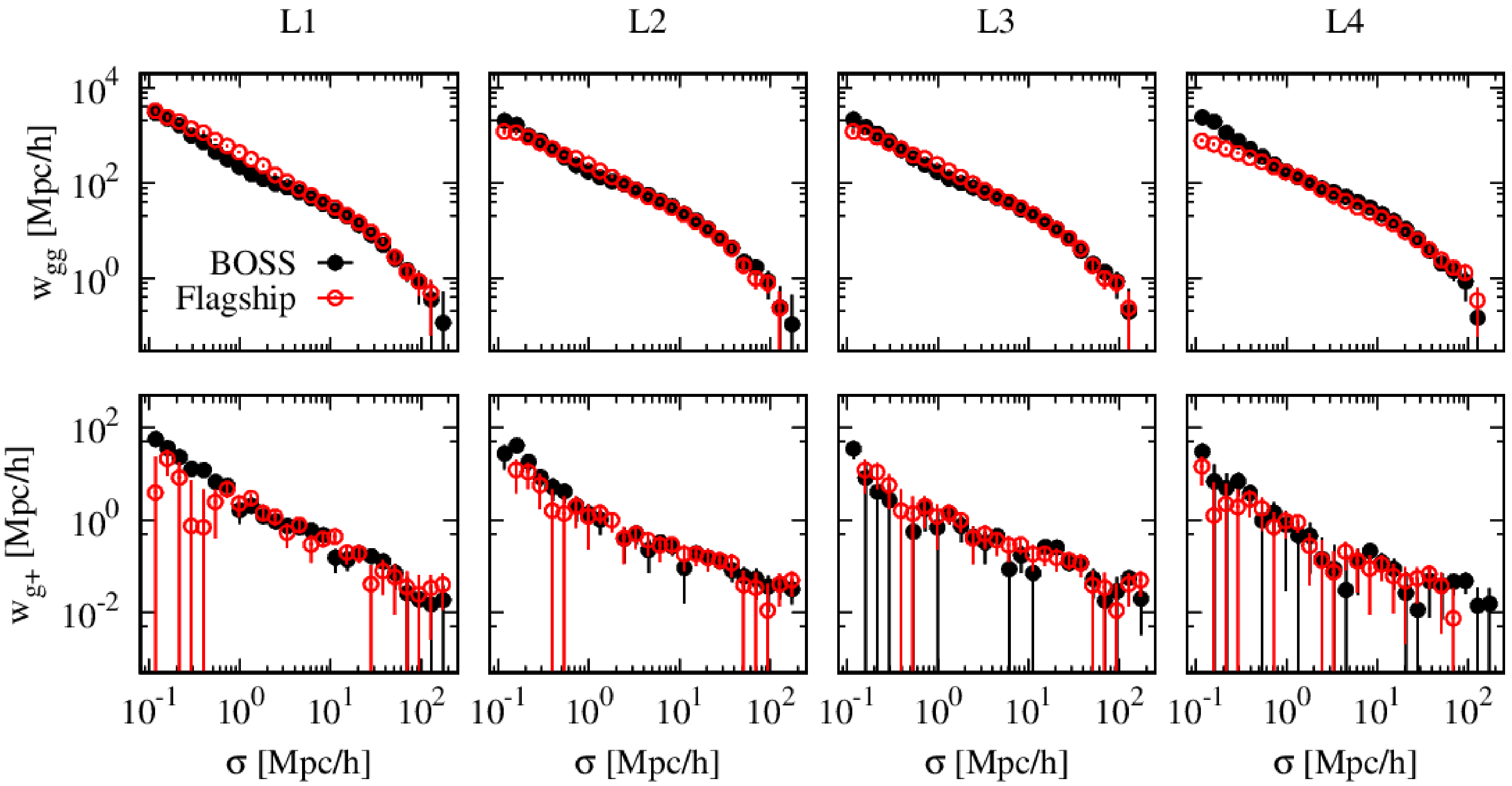
L1 (20%)

constraints on misalignment parameters



$$\chi^2 \propto \sum_{i=1}^{N_{bin}} \frac{(w_{g+,i}^{data} - w_{g+,i}^{model})^2}{(\sigma_i^{data})^2 + (\sigma_i^{model})^2}$$

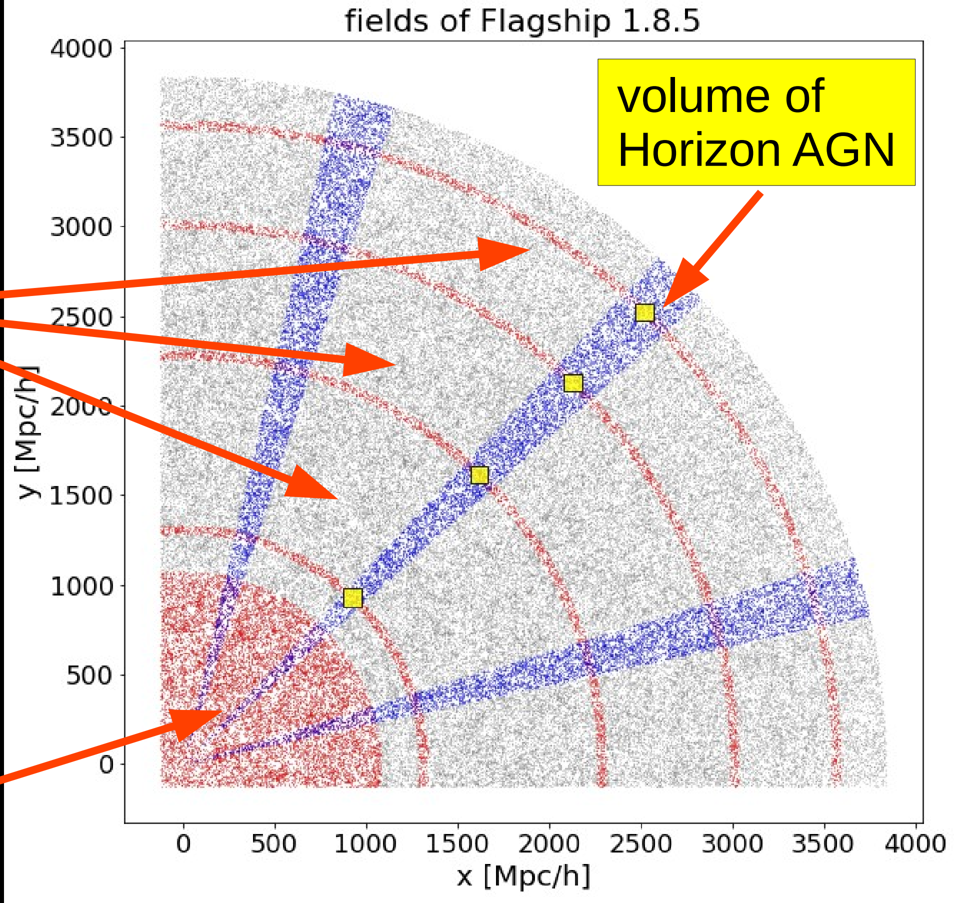
projected galaxy-shear correlation



Flagship 1.8.5

sources

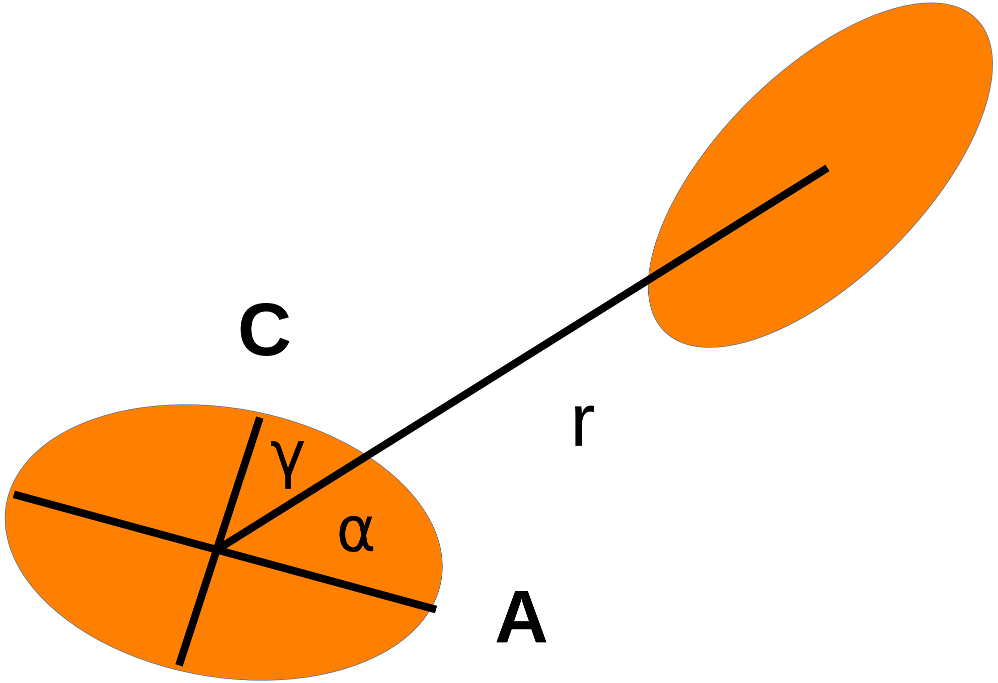
BOSS LOWZ



problem:
observational
constraints
at low redshifts,
IA important
at high redshifts

=> use high-z
constraints
from hydro-sims

galaxy alignment in Flagship and HAGN



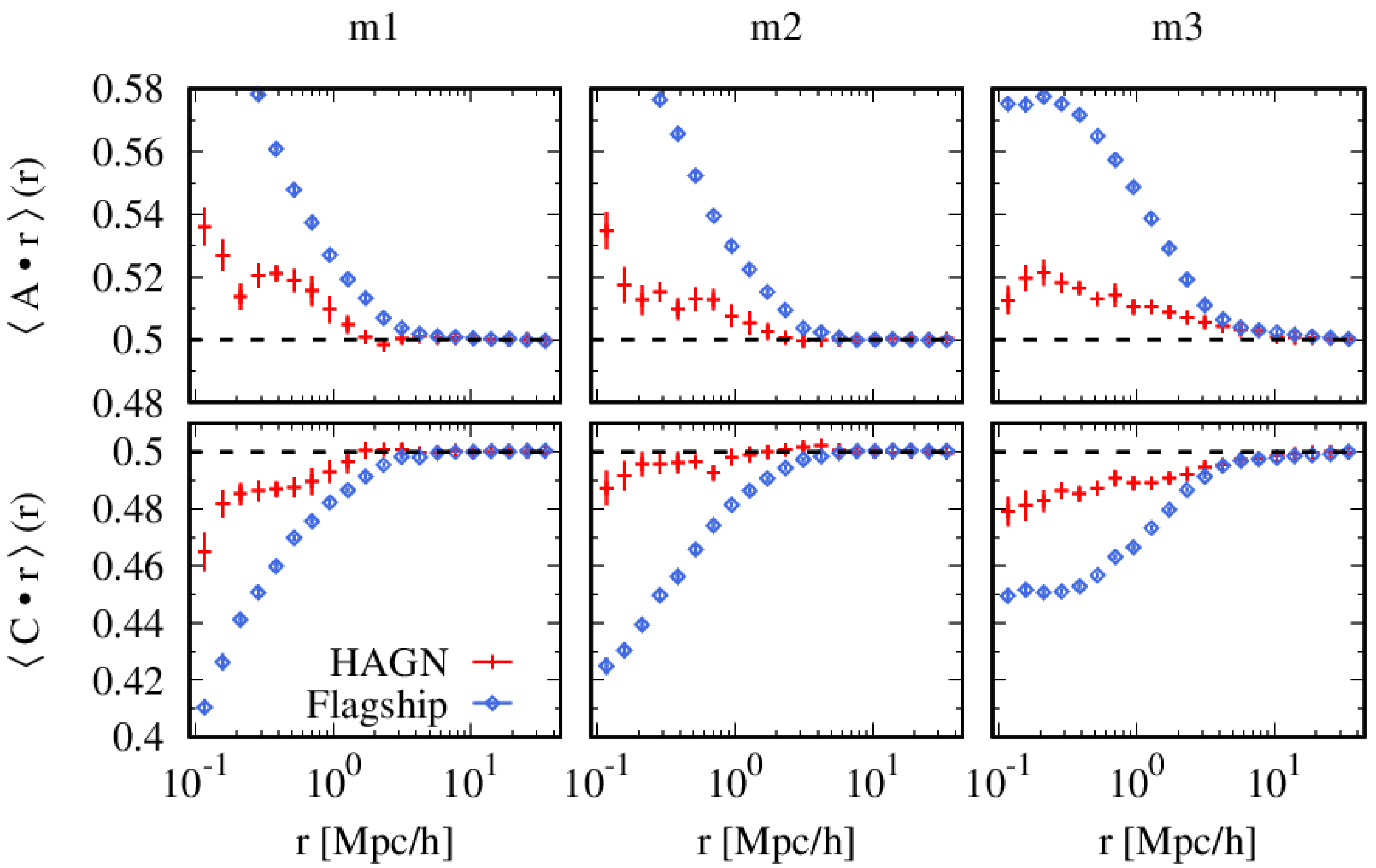
alignment statistics

$$\langle|\hat{A}\cdot\hat{r}|\rangle(r)=\cos(\alpha)$$

$$\langle|\hat{C}\cdot\hat{r}|\rangle(r)=\cos(\alpha)$$

independent of galaxy shapes

principle axes alignment in Horizon AGN and Flagship

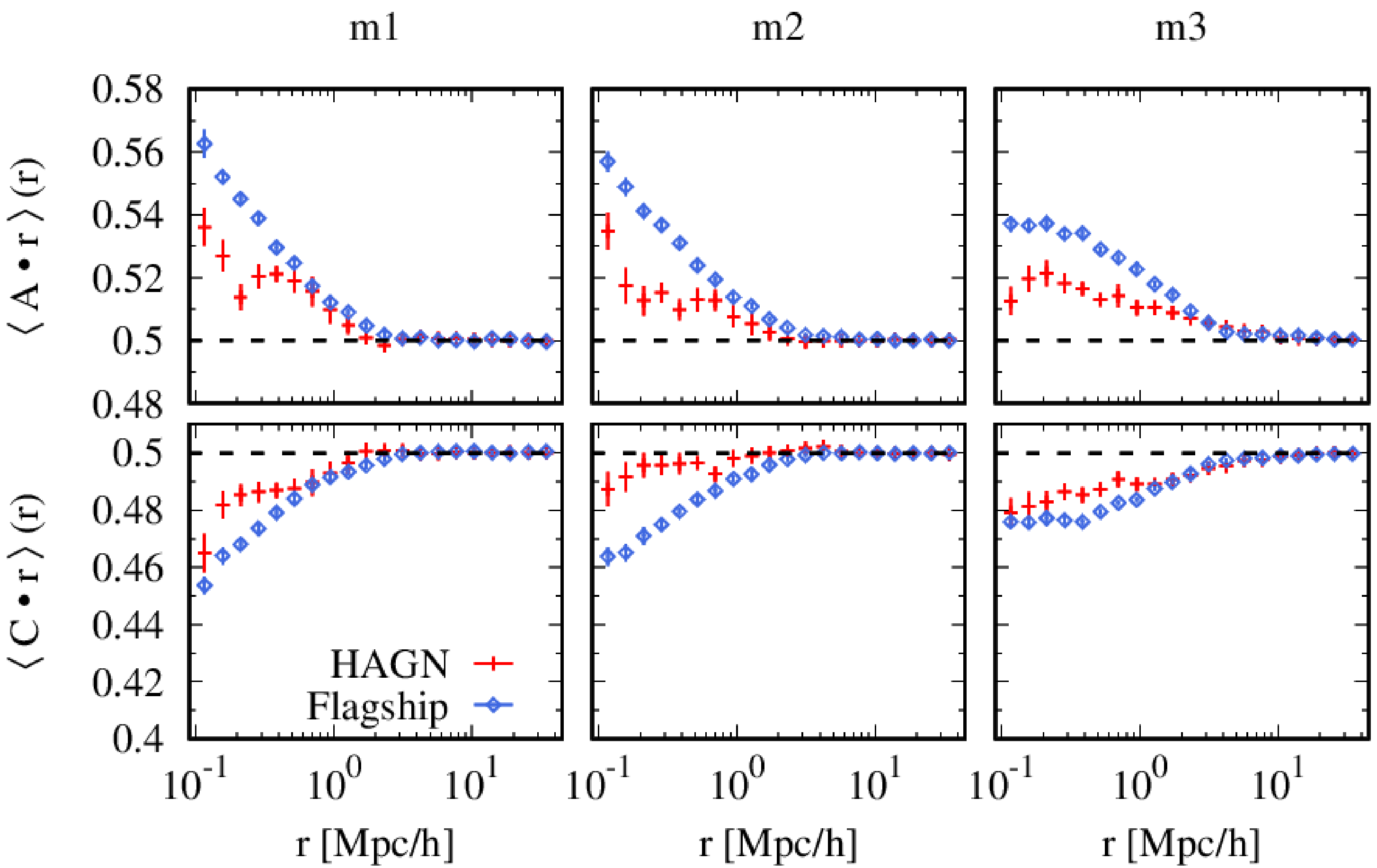


z=0.5

global misalignment parameter for Flagship:

$\sigma = 0.5$

principle axes alignment in Horizon AGN and Flagship

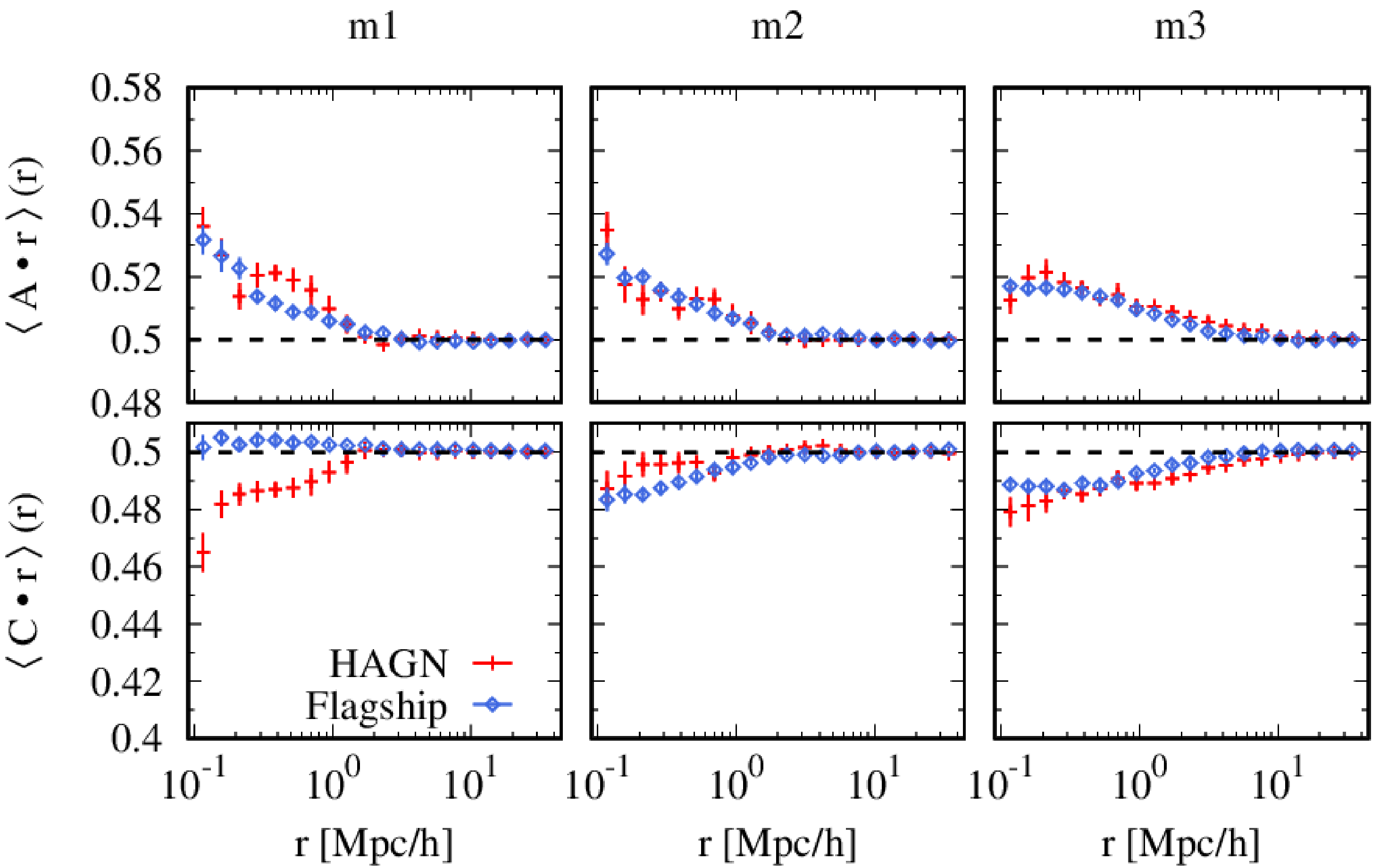


z=0.5

global misalignment parameter for Flagship:

$\sigma = 0.7$

principle axes alignment in Horizon AGN and Flagship



z=0.5

global misalignment parameter for Flagship:

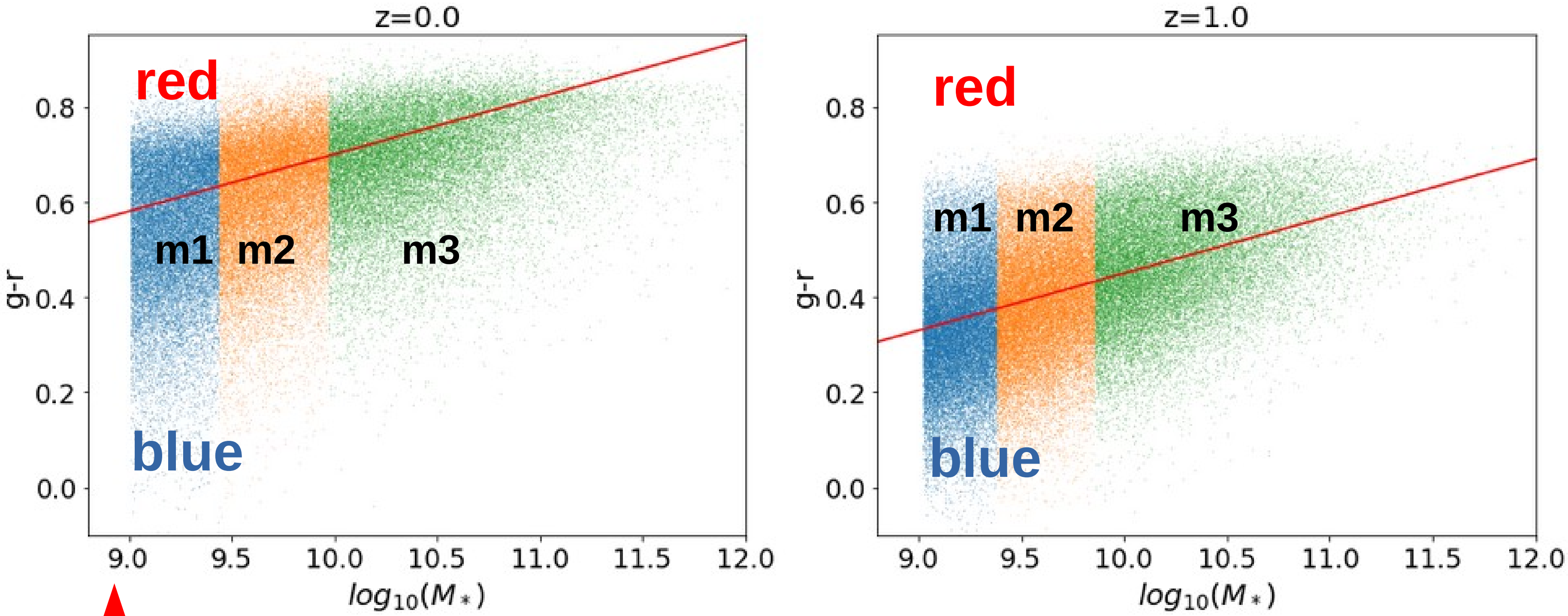
$\sigma = 0.9$

Summary

model component	param.	constraints	
		observable	data
axes ratios	• r0 • q0 • σ	2D axis ratio pdf	• COSMOS
orientations	• σ_{cent} • σ_{sat}	wg+ <A r>(r) <C r>(r)	• BOSS LOWZ • hydro sims (HAGN et al.) • KiDS+Gama, PAU, DES

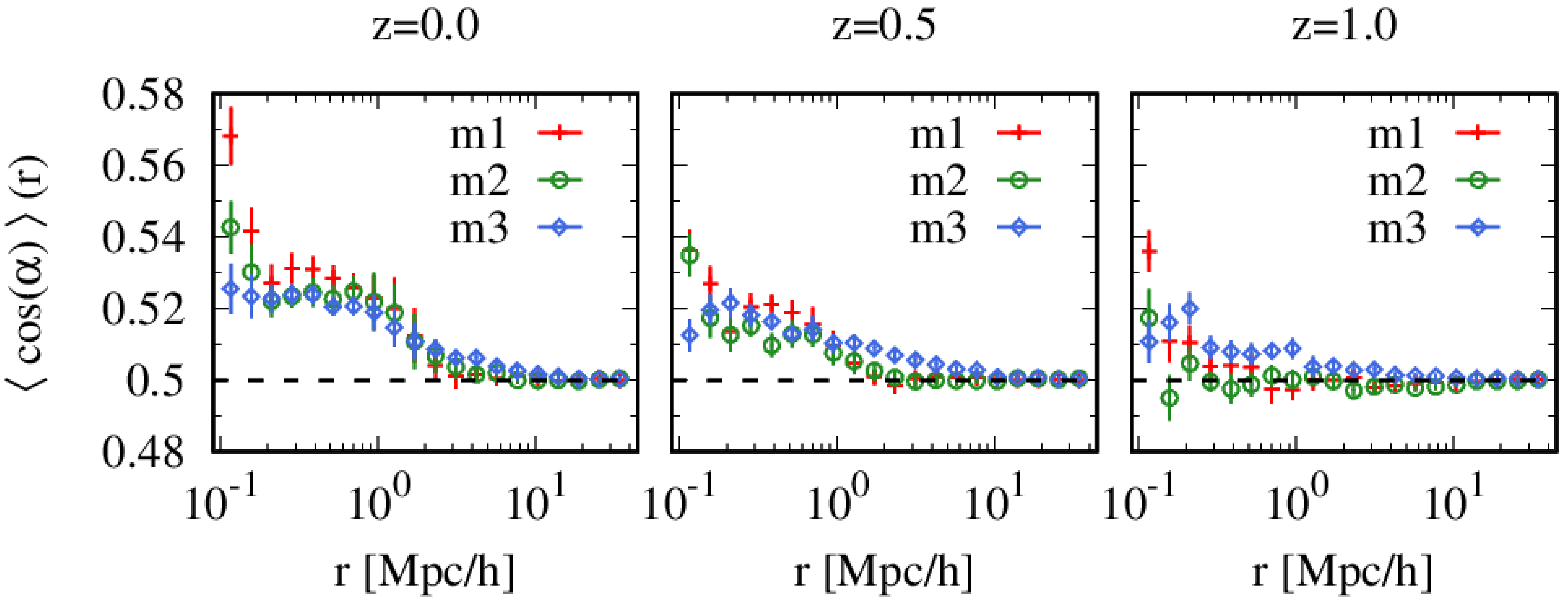
future model improvements:
- anisotropic satellite distribution
- scale dependence misalignment
- delensing cosmos shapes

stellar mass – color samples in HAGN



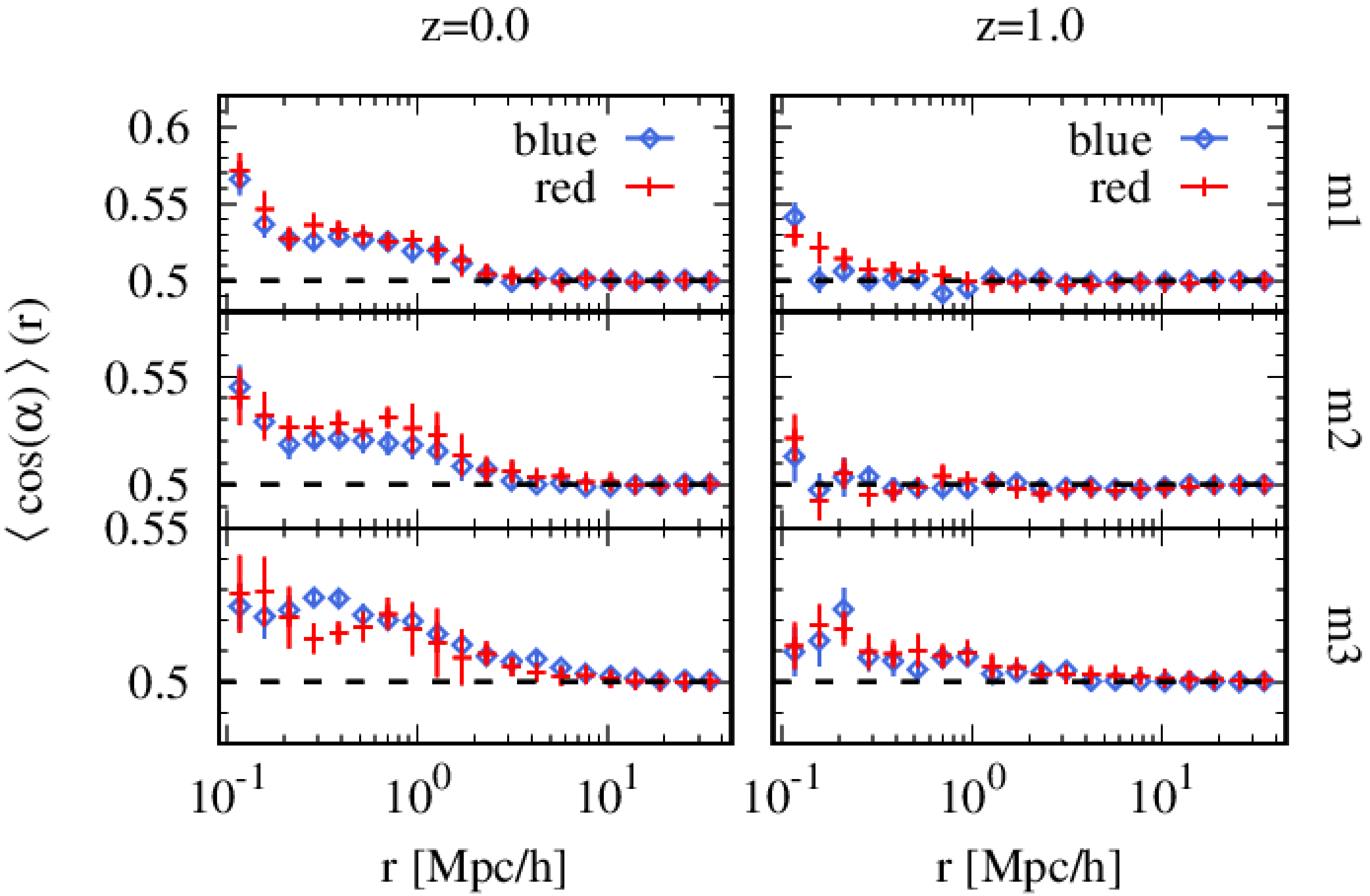
Np > 300

principle axes alignment in Horizon AGN



- lower amplitude at higher redshifts
- weak mass dependence

principle axes alignment in Horizon AGN

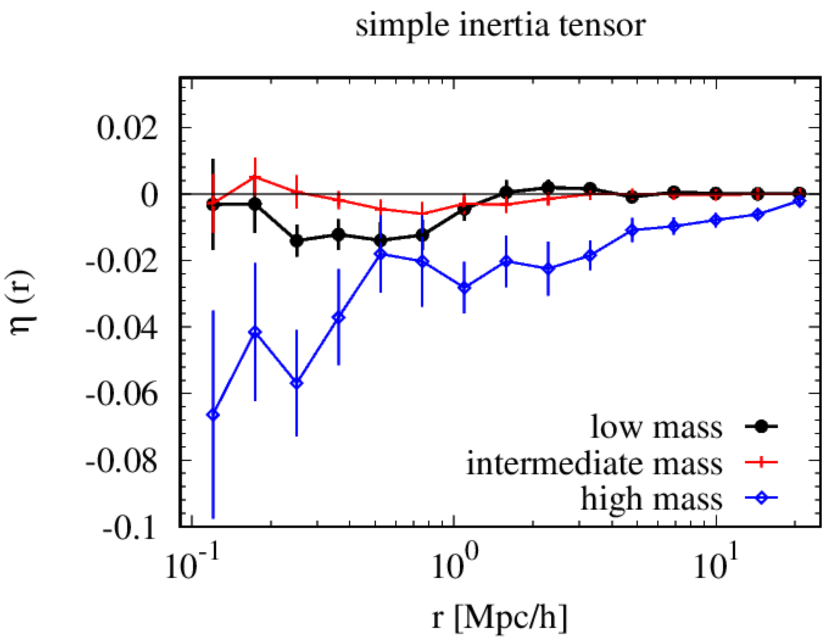


- weak color dependence

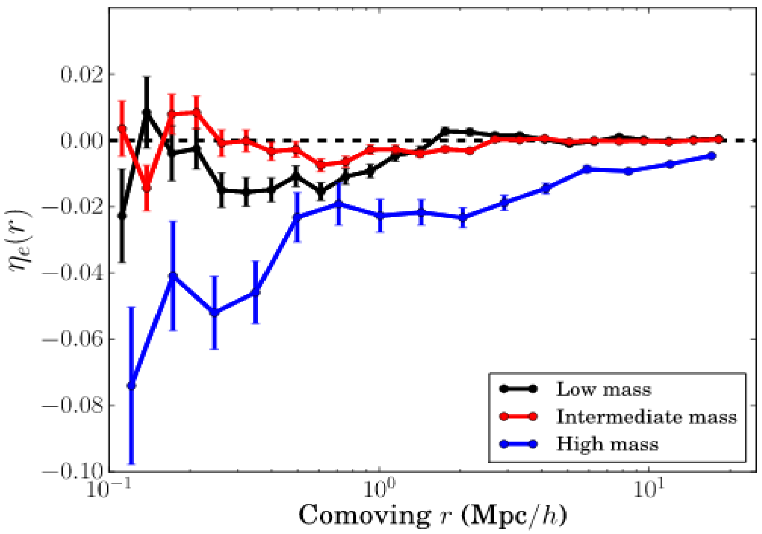
validation

alignment between minor axes and distance vector

This work



Chisari 2015



alignment in MBII

provided by Ananeth Tenneti