Redshift Distortions

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OUTLINE

- ☐ INTRODUCTION
- ☐ A FIRST EXPLORATION
  - ☐ LOGNORMAL SIMULATIONS IN LINEAR REGIME
  - ☐ MONTE CARLO REALIZATIONS OF A N-BODY SIMULATION (HORIZON PROJECT)
- ☐ PERSPECTIVES.

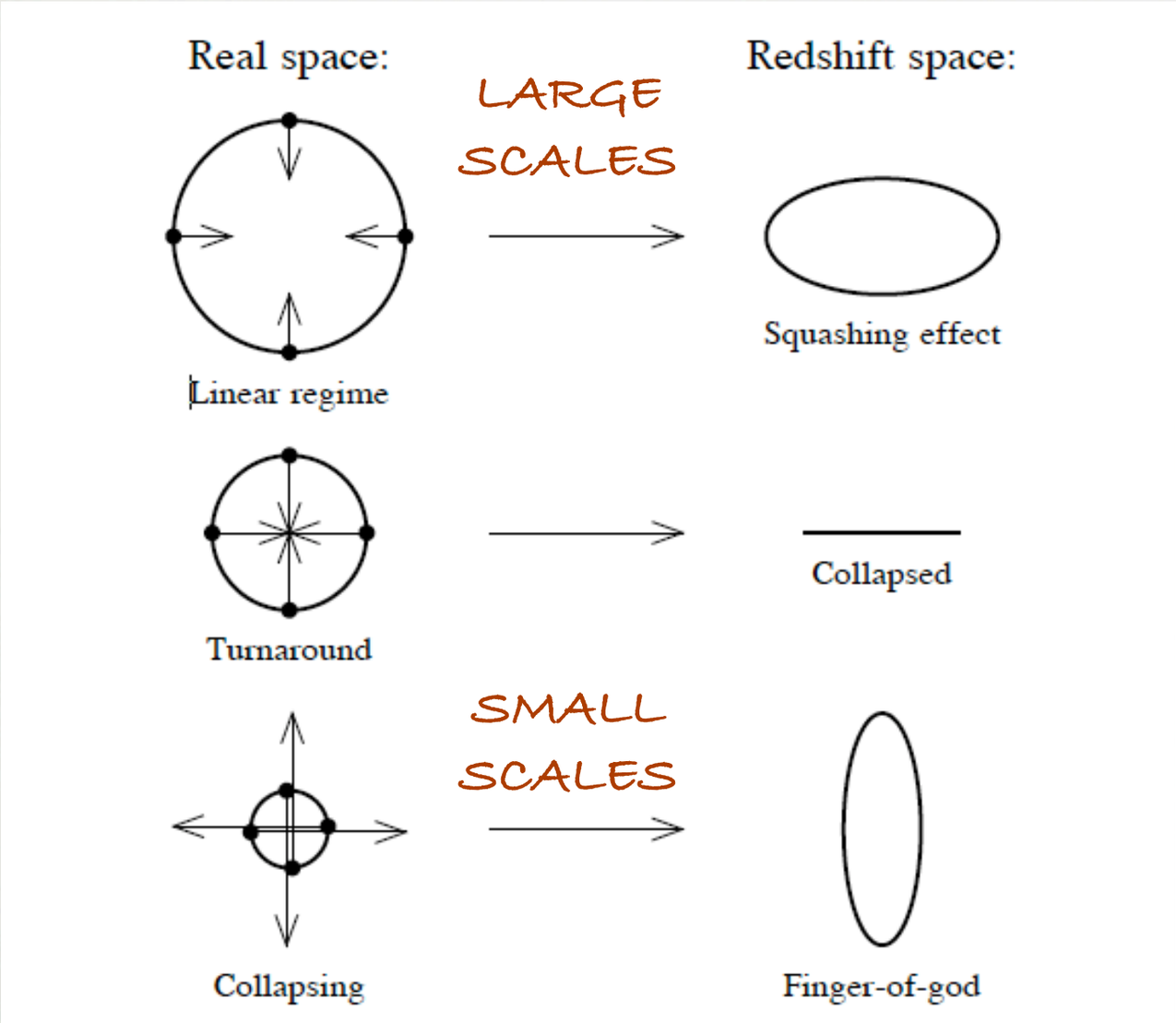
INTRODUCTION TO REDSHIFT DISTORTIONS

- IN REDSHIFT SURVEYS WE MAP THE UNIVERSE IN 3 DIMENSIONS USING REDSHIFT TO MESURE DISTANCE.
- REDSHIFT DISTANCES S ($s \equiv cz$) DIFFERS FROM TRUE DISTANCES R ($r = H_0 d$)BY PECULIAR VELOCITIES.

$$s = r + v \qquad\qquad v \equiv \widehat{r} \cdot v$$

- PECULIAR VELOCITIES CAUSE THAT DISTANCES TO APPEAR DISPLACED ALONG THE LINE OF SIGHT IN REDSHIFT SPACE.

ILUSTRATION OF REDSHIFT DISTORTIONS



GALAXIES UNDERGOING INFALL VELOCITIES TOWARS A SPHERICAL OVERDENSIY

- LARGE SCALES, PECULIAR VELOCITY OF INFALL SHELL IS SMALL COMPARED WITH ITS RADIUS.
- SMALL SCALES, RADIUS OF SPHERE IS SMALLER, ALSO PECULIAR VELOCITY IS LARGER

WHY STUDING REDSHIFT DISTORTIONS?

- REDSHIFT DISTORTIONS GIVE ACCESS TO THE LINEAR GROWTH RATE FACTOR OF DENSITY PERTURBATION "THAT IS A POWERFUL OBSERVABLE QUANTITY OF FUTURE LARGE REDSHIFT SURVEYS TO PROBE PHYSICAL PROPERTIES OF DARK ENERGY AND TO DISTINGUISH AMONG VARIOUS GRAVITY THEORIES."[TEPPEI OKUMURA AND Y. P. JING arXiv:1004.3548v2]

LINEAR REGIME APPROXIMATION

- IN LINEAR REGIME , KAISER'S FORMULA'S [1987] APPLIES, THE EFFECT OF REDSHIFT DISTORTIONS IS THE AMPLIFICATION OF THE UNREDSHIFTED MODE BY A FACTOR

$$P^s(k) = (1 + \beta \mu_k^2)^2 P(k)$$

AMPLITUDE REDSHIFT DISTORTIONS

ANGLE BETWEEN WAVE VECTOR & LOS DIRECTION

- $$\beta = f(\Omega_M) = \frac{dLnD}{dLna}$$

LINEAR GROWTH RATE OF DENSITY PERTURBATIONS

$$f(\Omega_M) = \frac{\Omega_M}{b}^{\gamma}$$

GROWTH INDEX

$\gamma = 0.55$ FOR GR (LINDER 2005)

MASS DENSITY PARAMETER AT Z

LIGHT TO MASS BIAS

$$\delta = b\delta_M$$

- REDSHIFT DISTORTIONS ALLOWS TO PROBE DEVIATIONS FROM GR.
- DEGENERATE PARAMETER COMBINATION (DENSITY OF MATTER & BIAS)

DECOMPOSITION IN HARMONICS IN THE LINEAR REGIME

- FOR PLANE PARALLEL APROXIMATION, POWER SPECTRUM CAN BE WRITTEN AS A SUM OF EVEN HARMONICS.

$$P^s(k) = \Sigma P_l(\mu_k) P_l^s(k)$$

- (KAISER'S FORMULA)IN LINEAR THEORY REDSHIFTED POWER SPECTRUM IS COMPLETLY CHARACTERZED BY L=0,2,4, THE HEXADECAPOLE (L=4) IS SMALL COMPARED WITH THE OTHERS & NOISY

- HARMONICS OF REDSHIFT CORRELATION ARE DEFINED SIMILARLY TO THOSE OF POWER SPECTRUM [HAMILTON (1992)]

$$\xi^s(s,\mu) = P_0(\mu_s)\xi_0^s(s) + P_2(\mu_s)\xi_2^s(s) + P_4(\mu_s)\xi_4^s(s)$$

$$\xi_0^s(s) = (1 + 2/3\beta + 1/5\beta^2)\xi(r)$$

$$\xi_2^s(s) = (4/3\beta + 4/7\beta^2)(\xi(r) - \bar{\xi}(r)) \qquad \bar{\xi}(r) = 3r^{-3}\int_0^r \xi(s)s^2 ds$$

$$\frac{\xi_0(s)}{\xi(r)} = 1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2 \qquad \frac{\xi_2(s)}{\xi_0^s(s) + (3/s^3)\int_0^s \xi_0^s(s')s'^2 ds'} = \frac{\frac{4}{3}\beta + \frac{4}{7}\beta^2}{1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2} = G(\beta)$$

- THESE RATIOS YIELD AN ESTIMATE OF β AT EACH DISTANCE.

MODELING REDSHIFT DISTORTIONS IN NONLINEAR REGIME

- EXTRACT INFORMATION WHERE THE POWER SPECTRUM DOES NOT MATCH TO THE LINEAR REGIME.
- NON-LINEARITY IN THE VELOCITY AND DENSITY FIELDS PRODUCES DISTORTIONS IN AN OPPOSITE SENSE TO THE LINEAR THEORY PREDICTIONS, LEADING TO LOWER ESTIMATES OF β
- IN ORDER TO ESTIMATE β USING CURRENTLY AVAILABLE REDSHIFT SURVEYS IS ESSENTIAL TO MODEL THE NON-LINEARITIES ACCURATELY
- STANDARD PROCEDURE CONSIST ON THE MODIFICATION OF KAISER'S FORMULA INCLUDING A TERM TAKING IN ACCOUNT THE UNCORRELATED VELOCITY DISPERSION .

$$P^s(k) = (1 + \beta\mu_k^2)^2 P(k) \; G(k, \mu^2)$$

$$lim_{k \to 0} G(k, \mu^2) = 1$$

DISTRIBUTION OF RANDOM PAIR VELOCITIES , (EXPONENCIAL. GAUSSIAN)

BIAS PARAMETER OVERSIMPLIFIED?

$$\beta = \frac{\Omega_m^{0.6}}{b} \longrightarrow \beta = \frac{\Omega_m^{0.6}}{b_\sigma(r)}$$

$$b(r) = \sigma_g(r)/\sigma_m(r)$$

RATIO OF RMS GALAXY FLUCTUATIONS TO RMS MASS FLUCTUATIONS ON SCALE R.

- RELATION BETWEEN THE GALAXY AND MASS DENSITY FIELDS DEPENDS ON THE COMPLEX PHYSICS OF GALAXY FORMATION, AND IT CAN BE IN GENERAL NON-LINEAR, STOCHASTIC, AND PERHAPS NON-LOCAL..

- β WAS ESTIMED USING DIFFERENT TECHNIQUES AND USING COMPLEX BIAS MODELS. IT WAS FOUND THAT β ESTIMATED FROM DIFFERENT METHODS WAS SIMILAR TO THE ASYMPTOTIC VALUE OF ($\beta = \frac{\Omega_m^{0.6}}{b_\sigma(r)}$) FOR R LARGE. [ANDREAS A. BERLIND , VIJAY K. NARAYANAN ,DAVID H. WEINBERG arXiv:astro-ph/0008305v1]

CONVENTIONAL INTERPRETATION OF β CONTINUES TO HOLD EVEN FOR COMPLEX BIAS MODELS.

FIRST EXPLORATION....

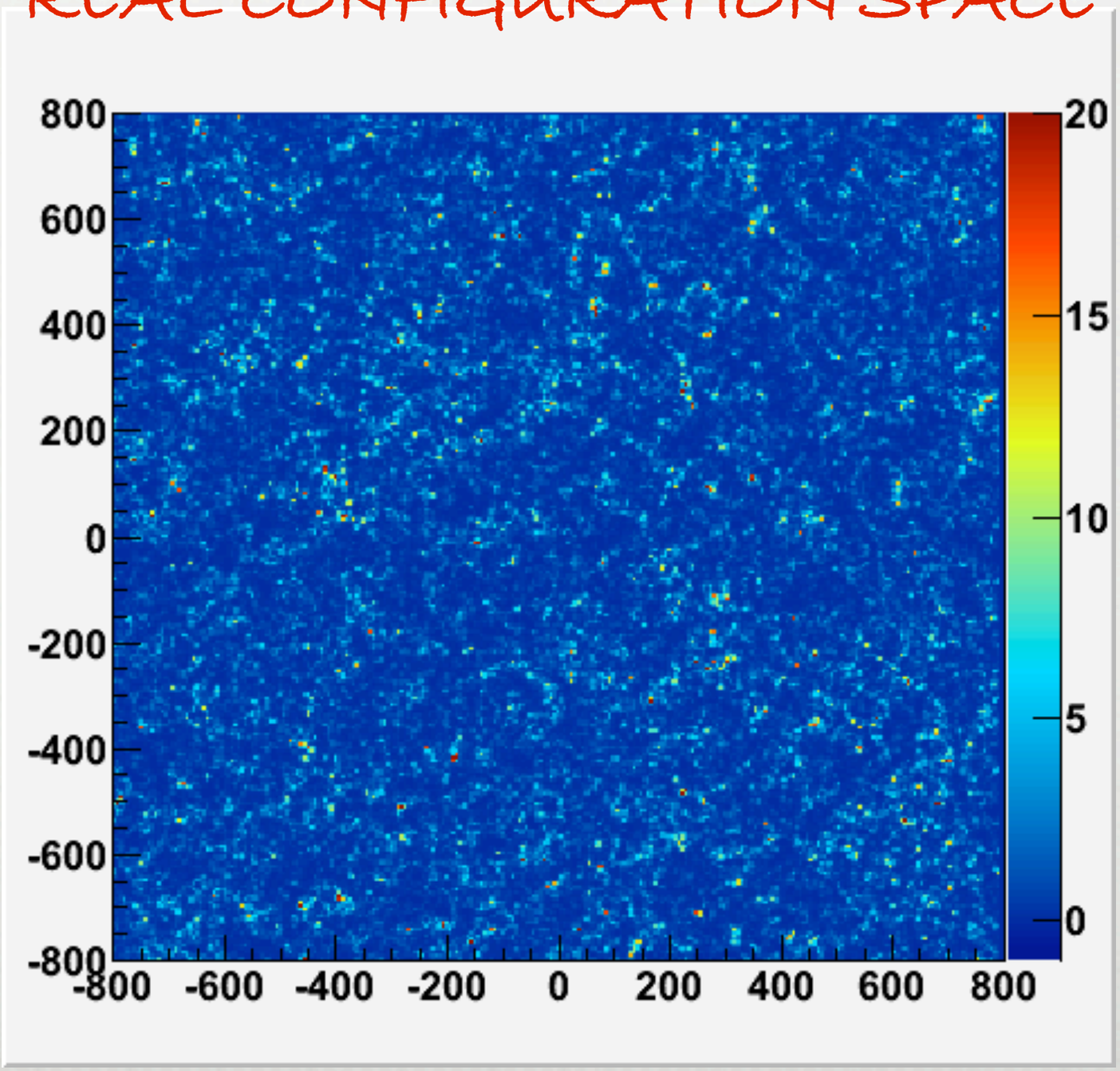
FIRST GOAL INVESTIGATE HOW WELL I CAN RECONSTRUCT AMPLIFICATION REDSHIFT PARAMETER WITH SIMULATIONS.

- ☐ GENERATE LOG NORMAL RANDOM FIELD FOLLOWS ΛCDM .COSMOLOGY TO SIMULATE DENSITY FIELD, AND USE THIS FIELD AS PDF TO POPULATE WITH GALAXIES.

- ☐ GENERATE VELOCITIES USING EXPRESSION FROM LINEAR REGIME .

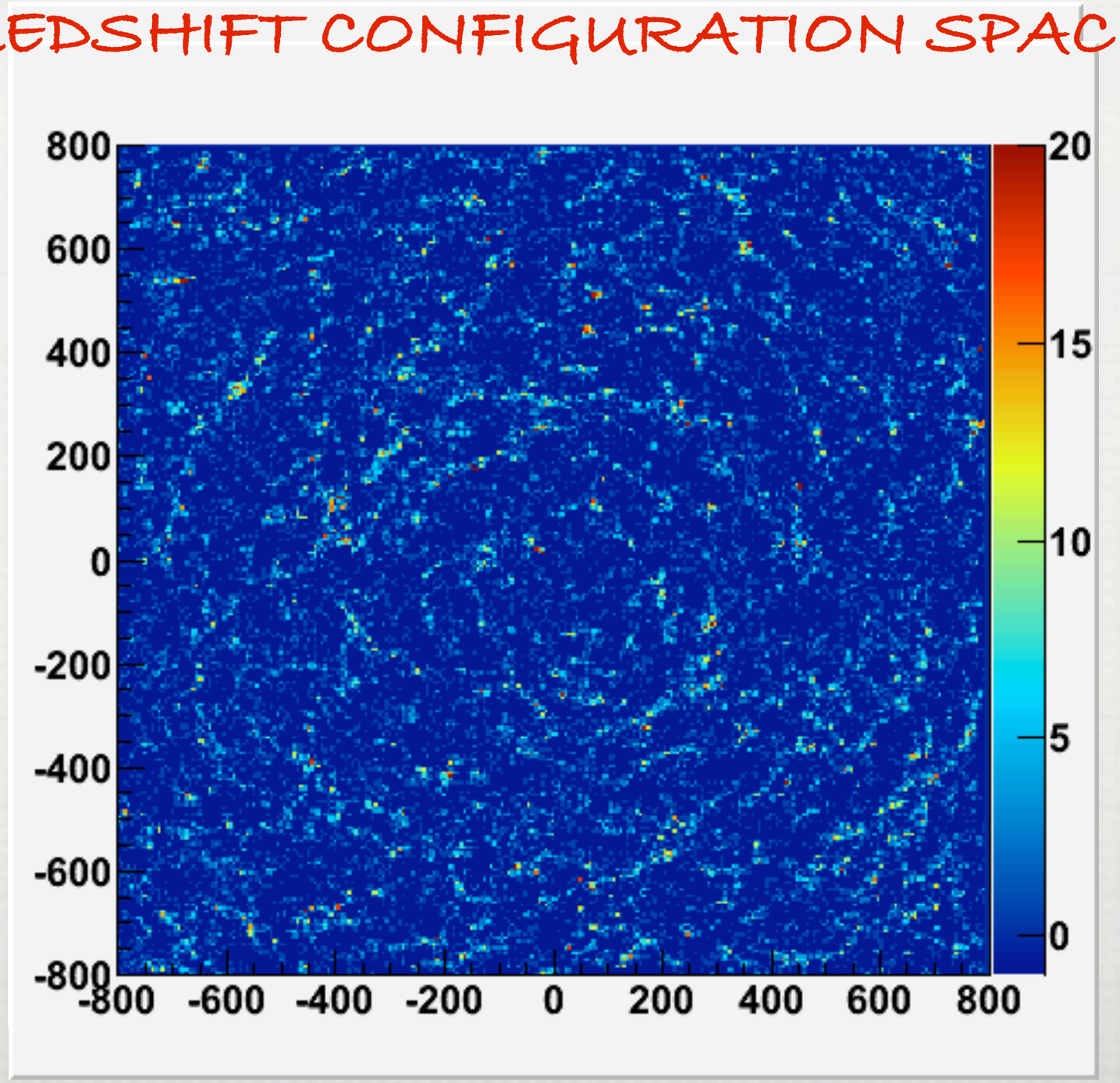
SIMULATION LOGNORMAL GALAXIES

REAL CONFIGURATION SPACE



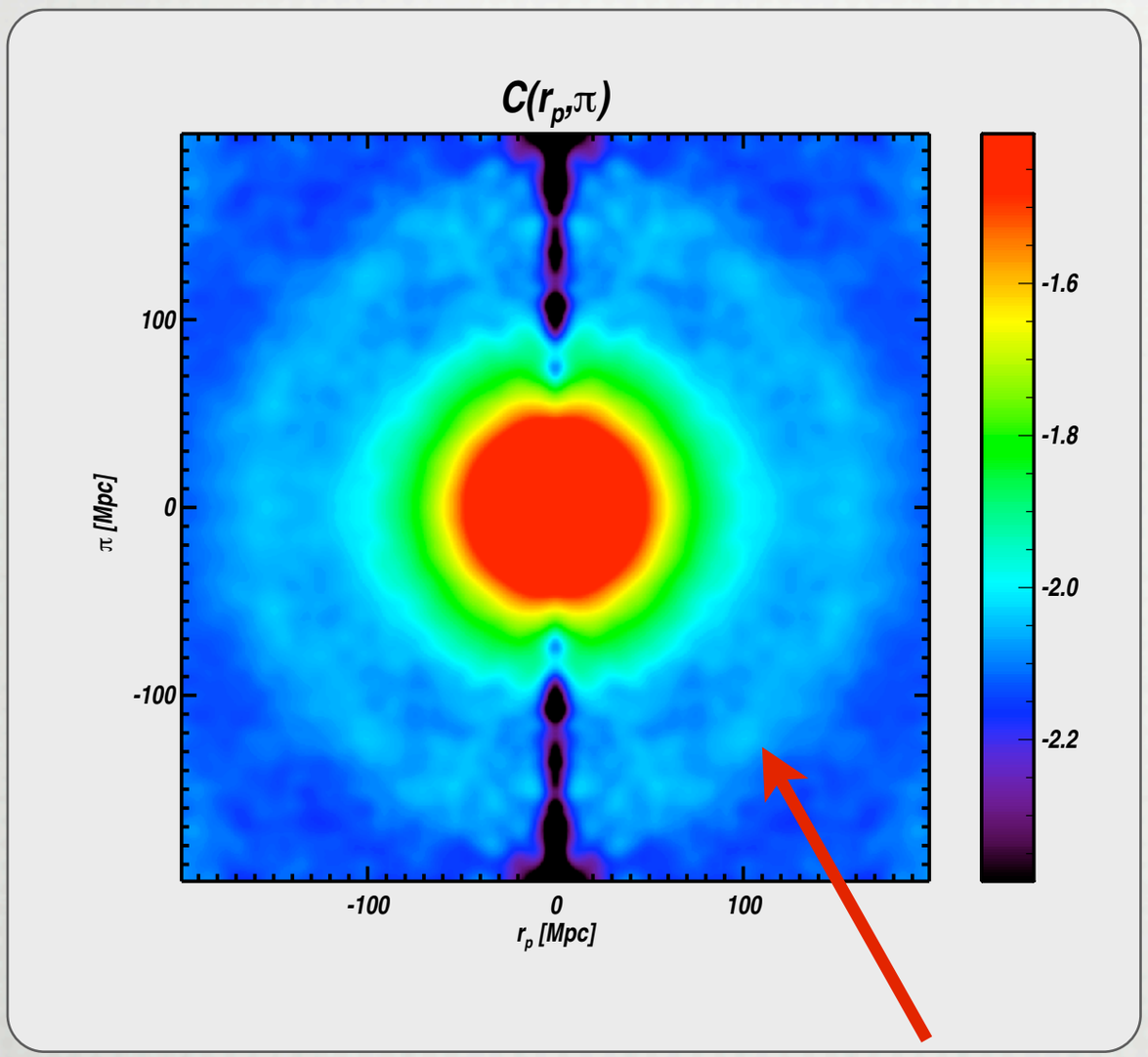
SIMULATION LOGNORMAL GALAXIES

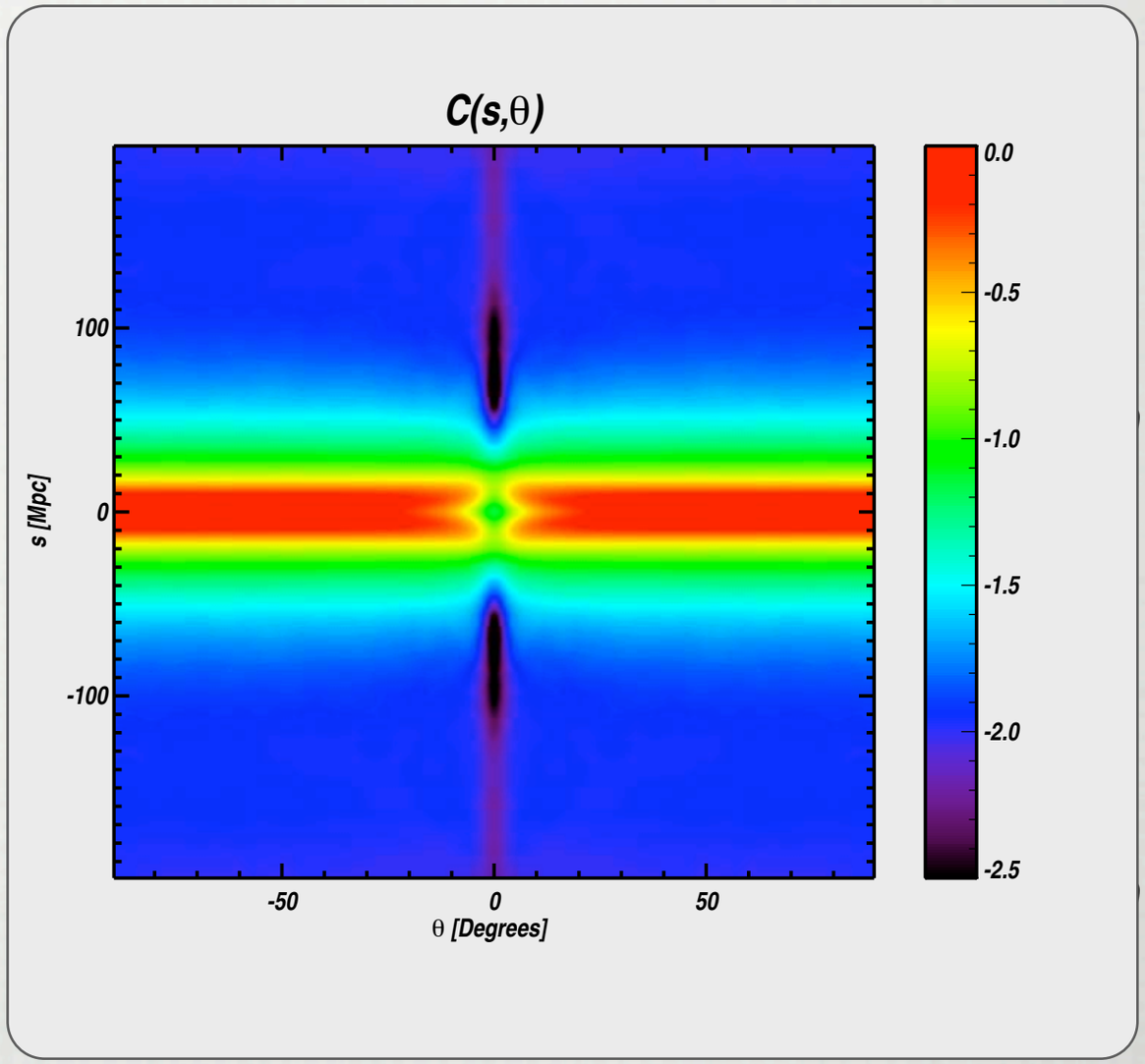
REDSHIFT CONFIGURATION SPACE



CORRELATION FUNCTION IN 2D

NO VELOCITIES

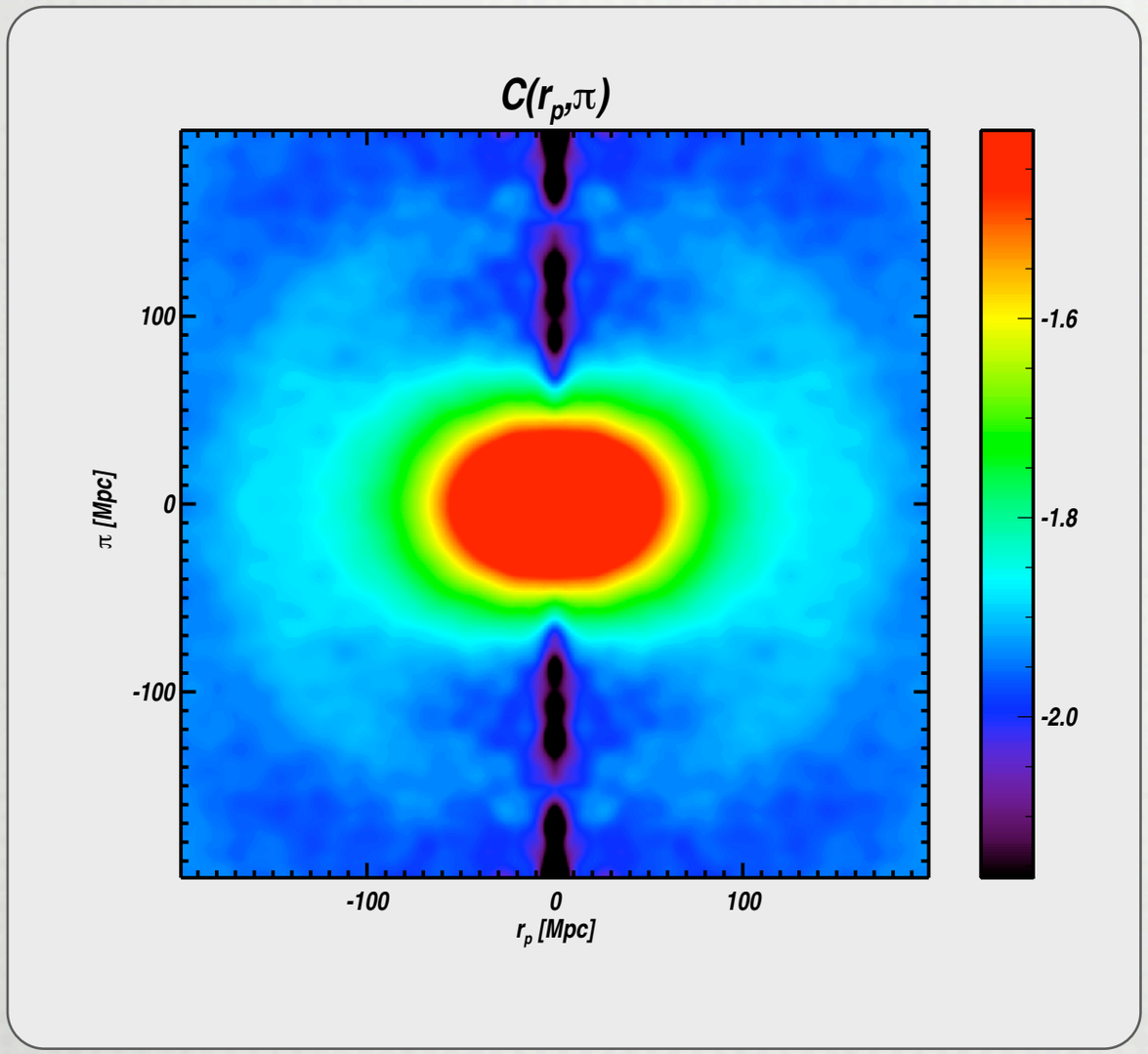


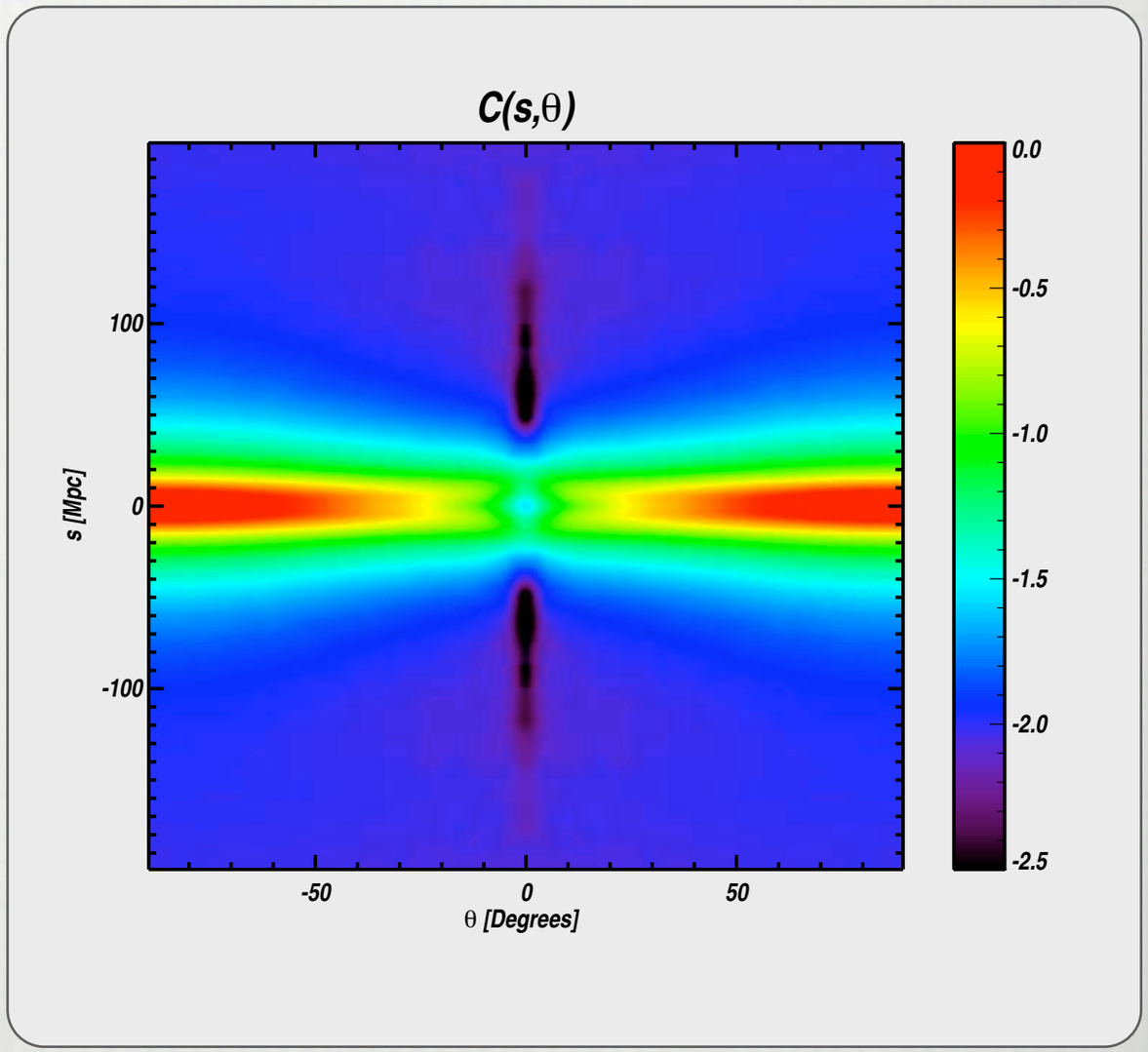


BAO PEAK

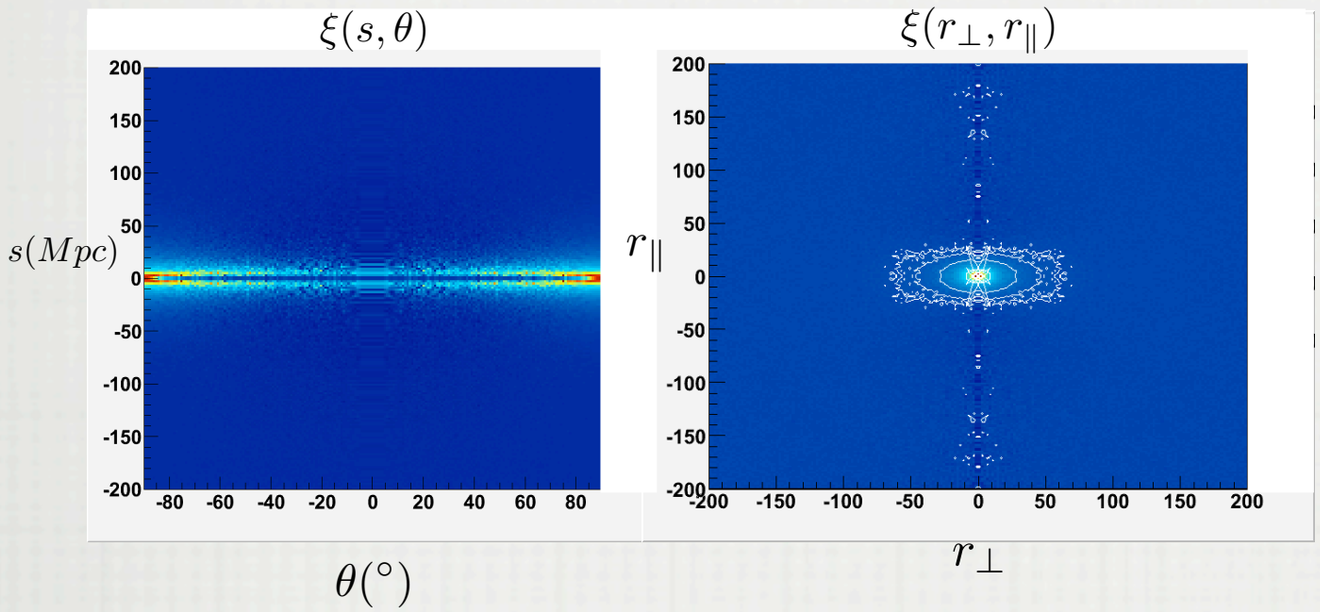
CORRELATION FUNCTION IN 2D

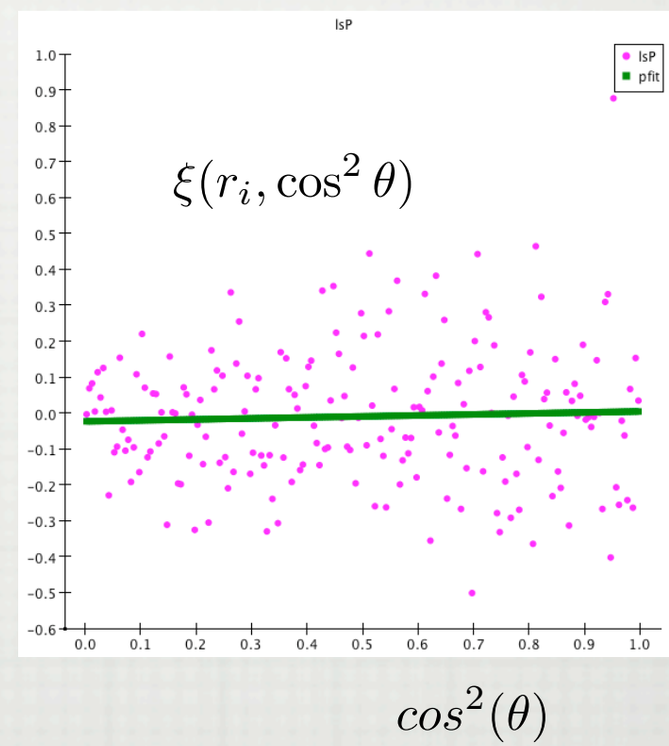
WITH VELOCITIES





CORRELATION FUNCTION 2D & MONOPOLE AND QUADRUPOLE ESTIMATION

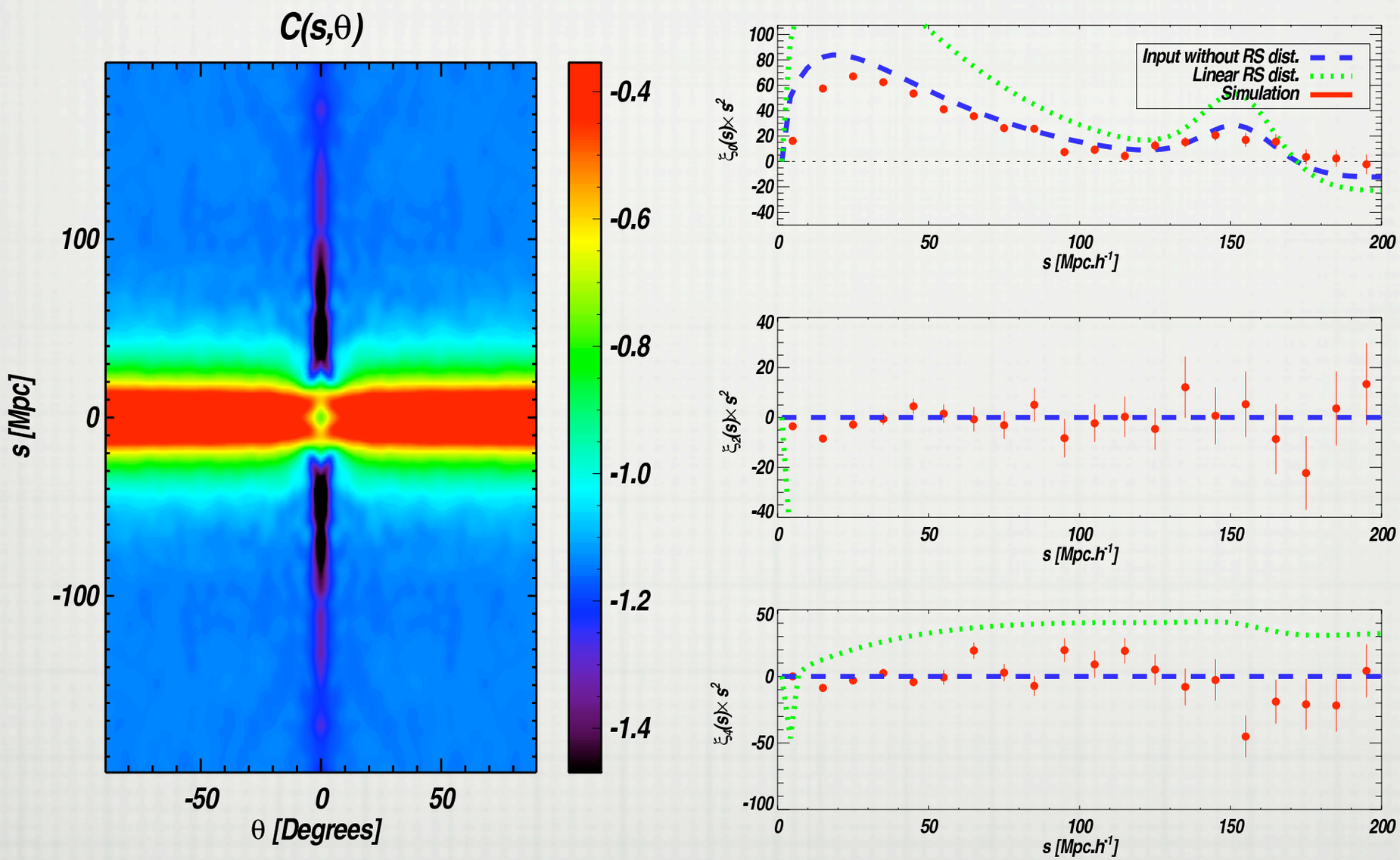




FOR EACH BIN IN R, A POLINOMIAL FIT IS DONE TO CORRELATION FUNCTION

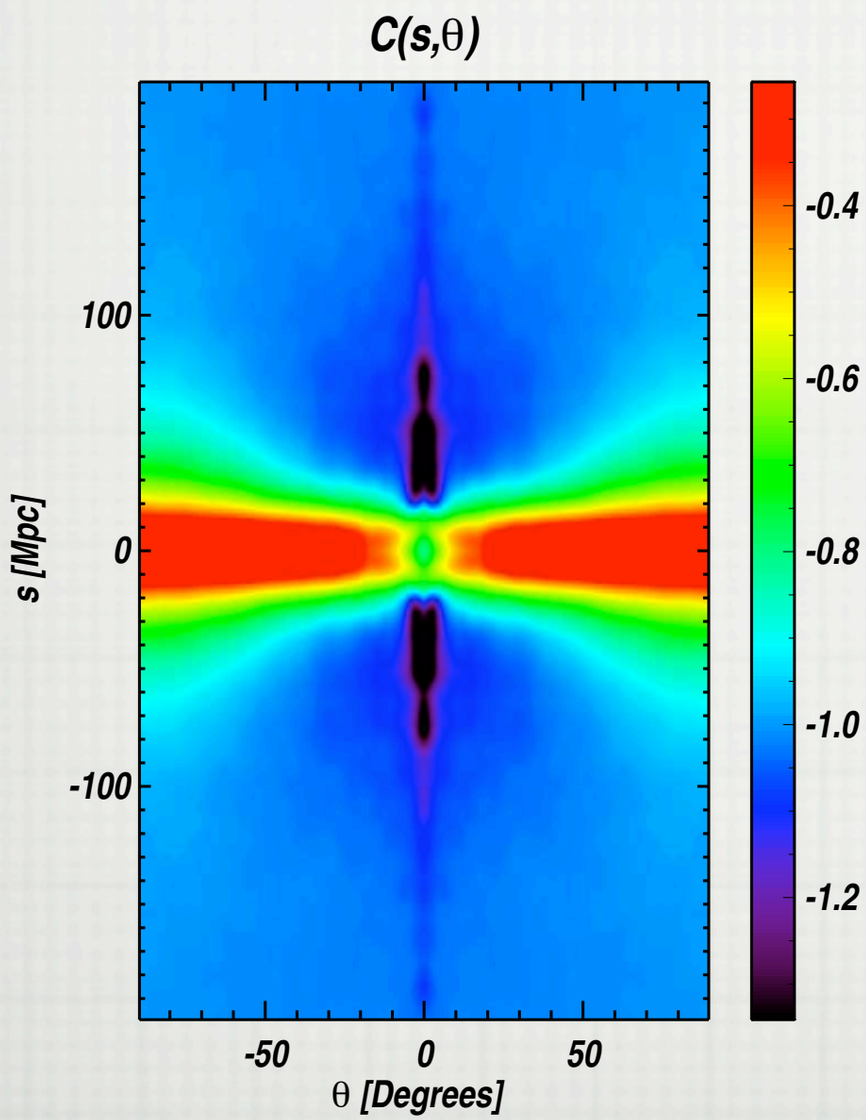
$$\xi^s(s,\mu) = P_0(\mu_s)\xi_0^s(s) + P_2(\mu_s)\xi_2^s(s) + P_4(\mu_s)\xi_4^s(s)$$

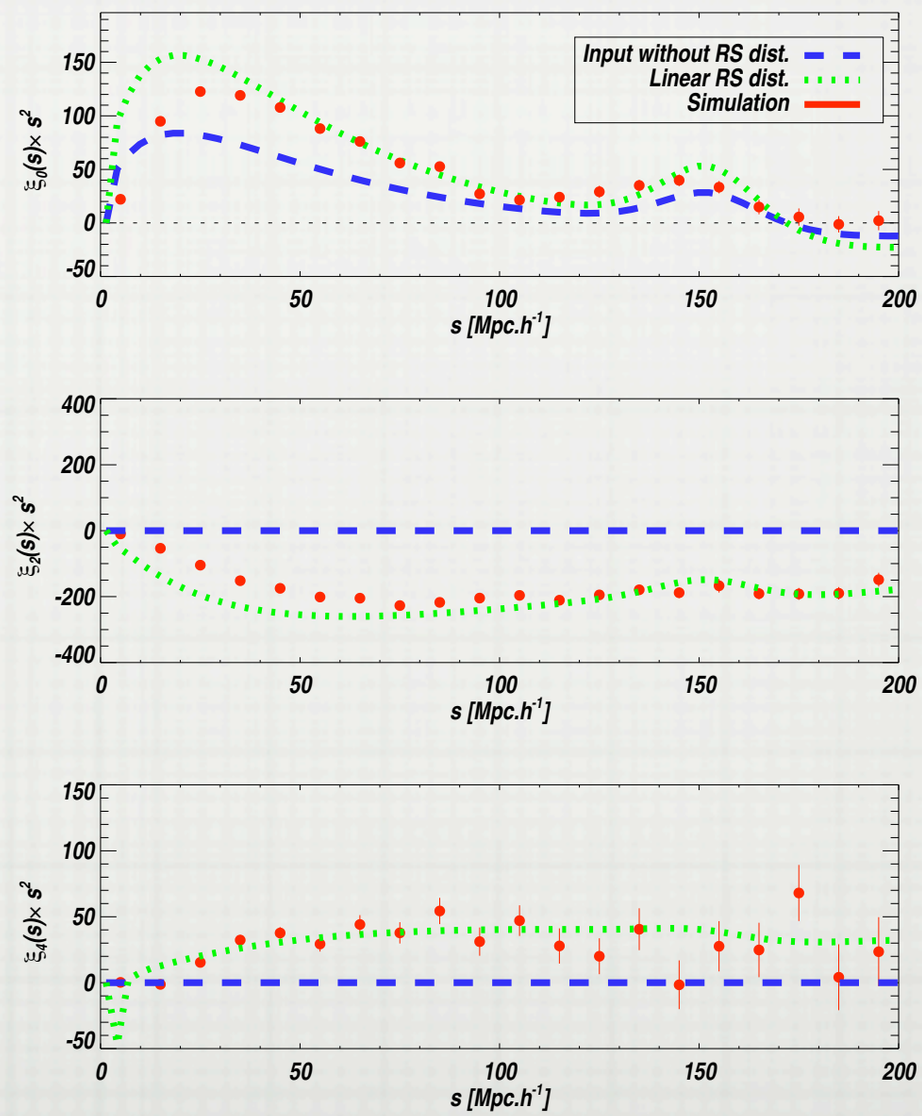
LOG-NORMAL SIMULATION



REAL SPACE

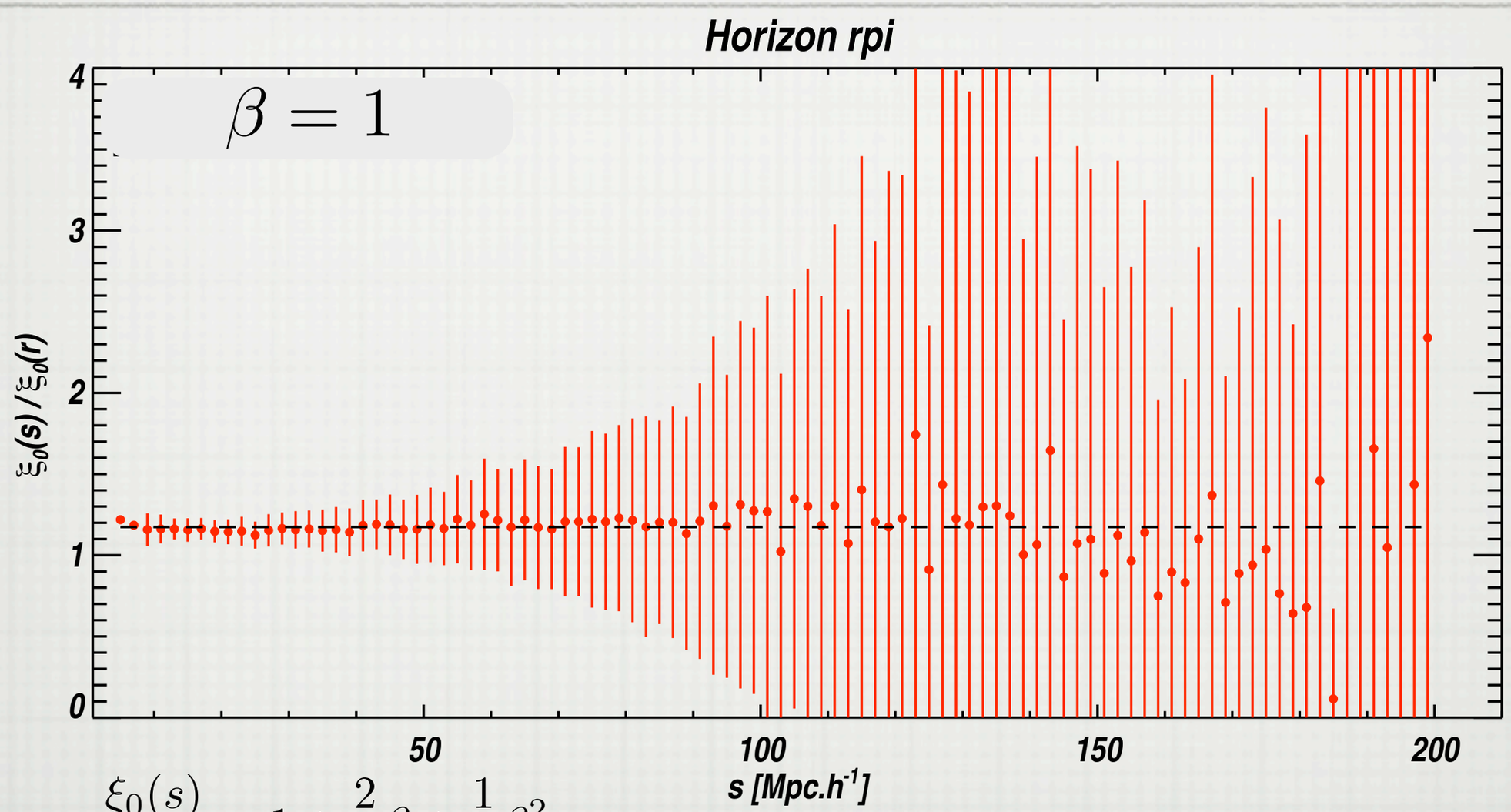
LOG-NORMAL SIMULATION





REDSHIFT SPACE

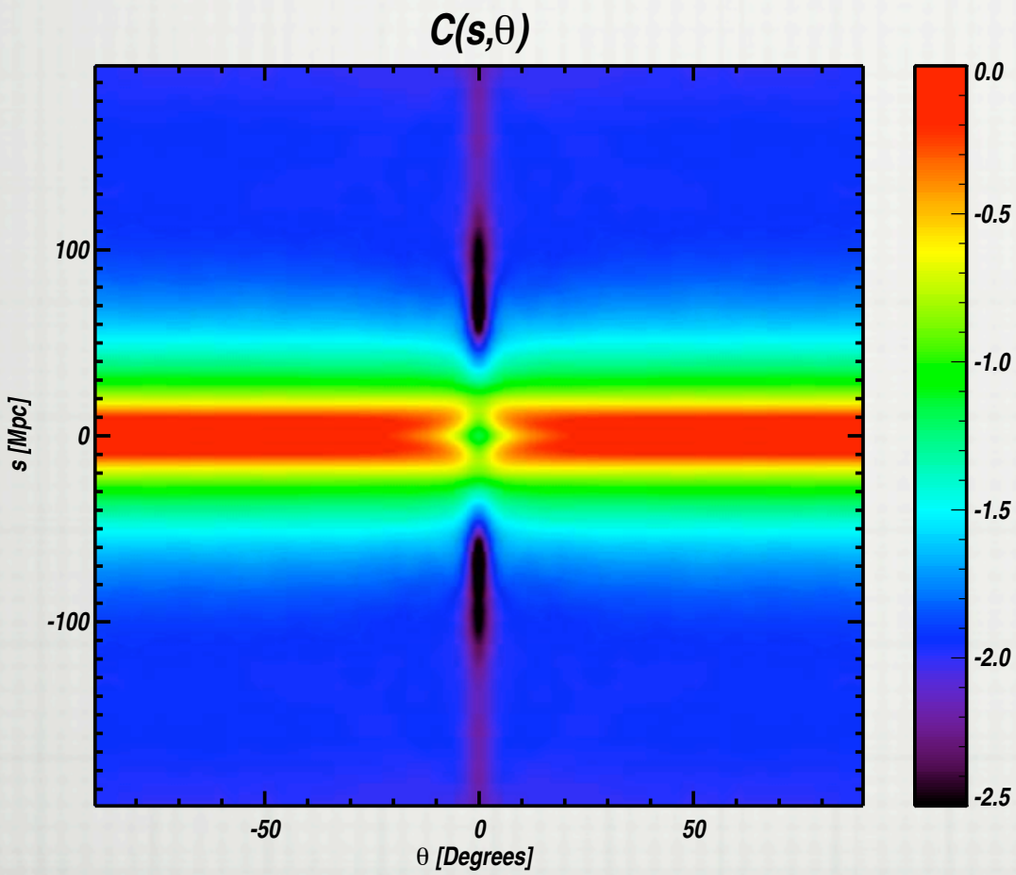
BETA STIMATION USING REDSHIFTED AND REAL MONOPOLE RATIO

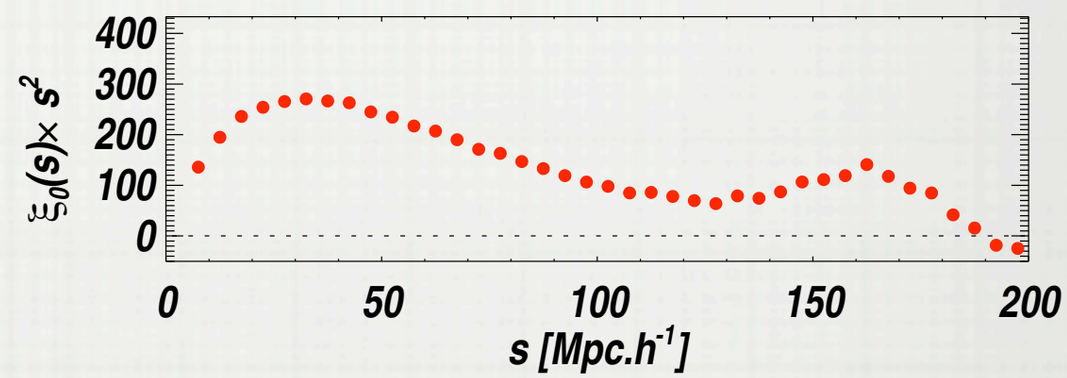


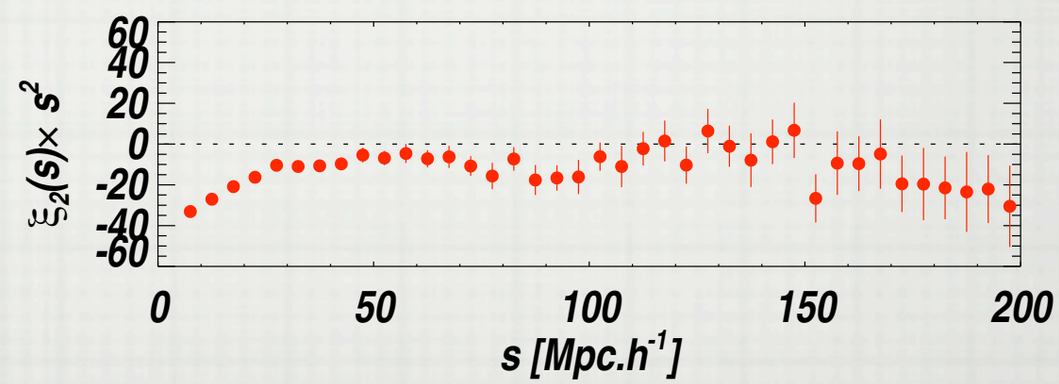
$$\frac{\xi_0(s)}{\xi(r)} = 1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2$$

HORIZON SIMULATION

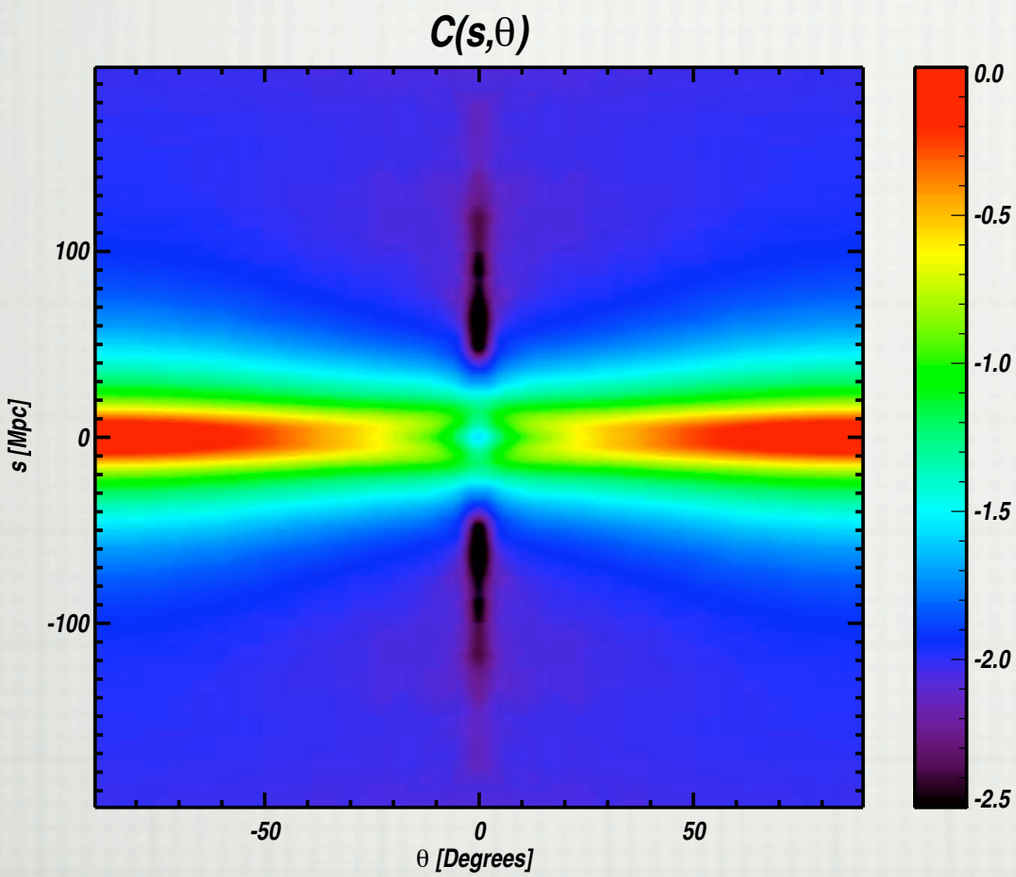
HALOS OF DARK MATTER OF N-BODY SIMULATION, 2 GPC SIDE

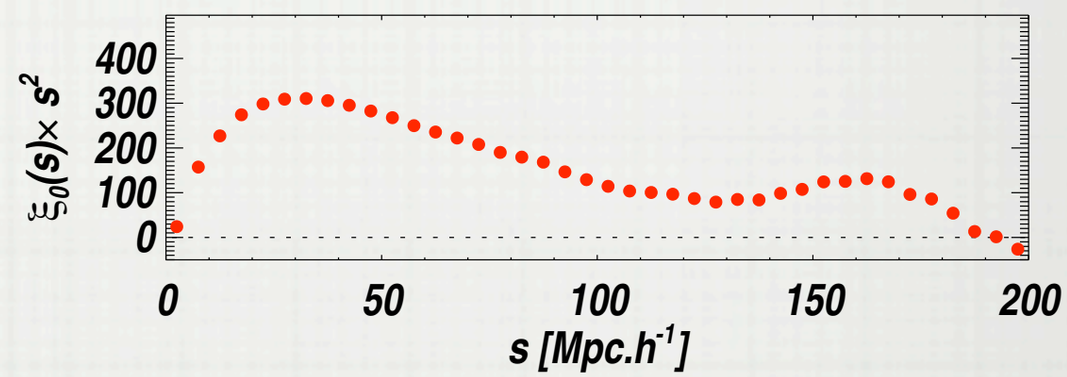


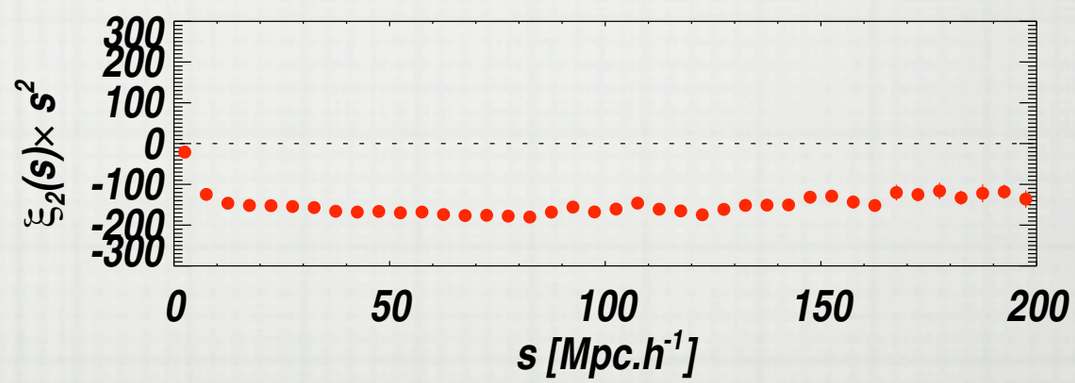




HORIZON SIMULATION

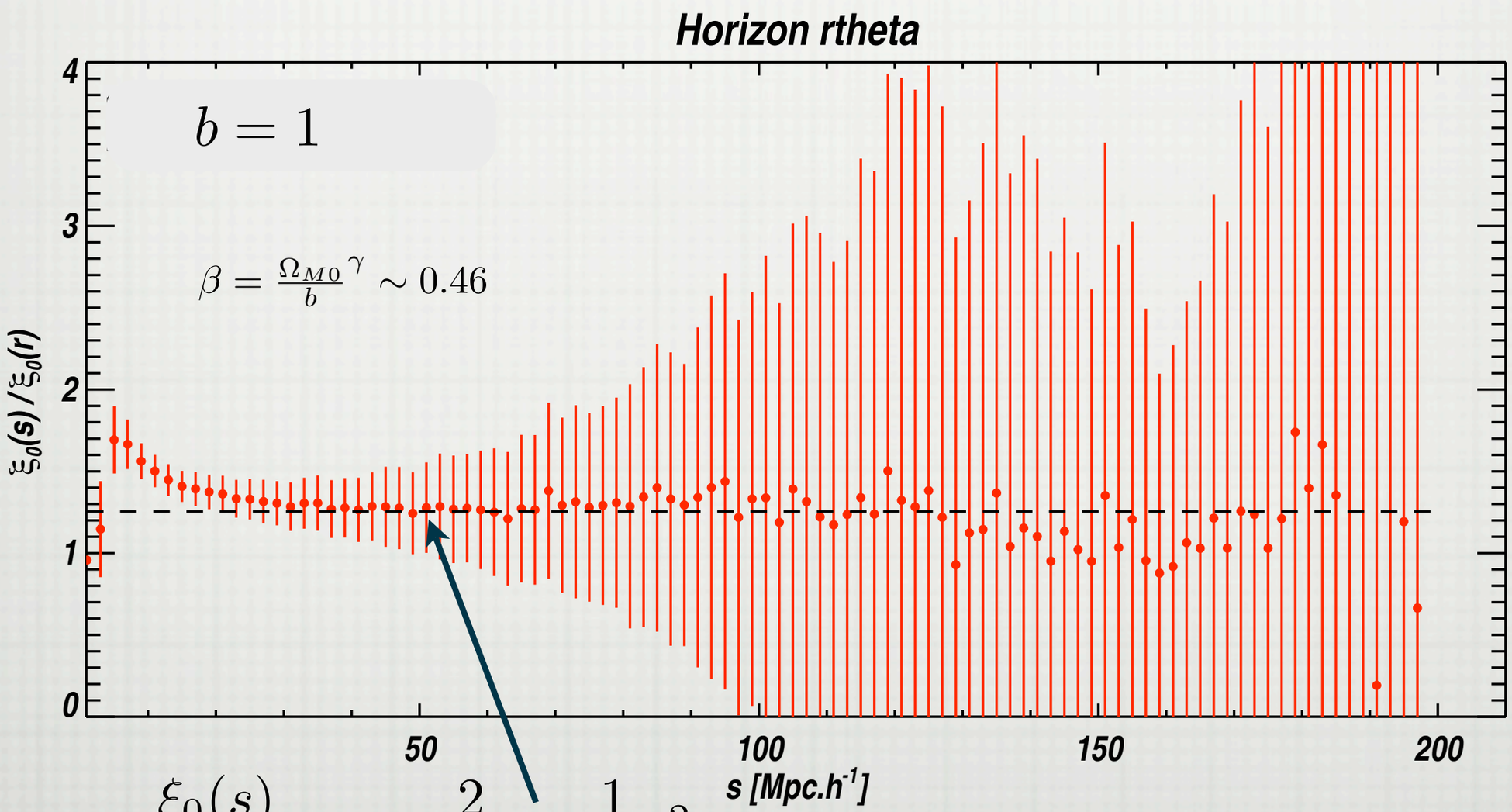






BETA STIMATION IN HORIZON

BIAS USING RATE BETWEEN REDSHIFTED /REAL MONOPOLE



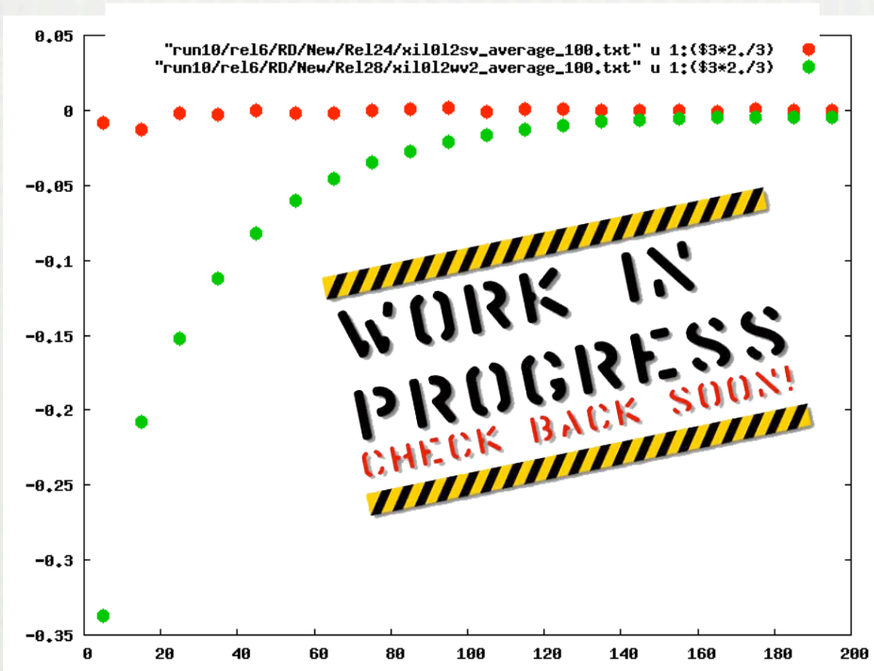
$$\frac{\xi_0(s)}{\xi(r)} = 1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2$$

PERSPECTIVES...

- ☐ FINISH BIAS ESTIMATON USING QUADRUPOLE.
- ☐ ADD ANGULAR AND RADIAL SELECTION FONCTIONS TO SIMULATE REAL DATA.
- ☐ APPLIED TO OTHERS MOCK CATALOGUES OF GALAXIES (LAS DAMAS) TO SEE SMALL SCALES (FINGERS OF GOD).
- ☐ GENERATE MOCK CATALOGUES OF GALAXIES USING FOF OF HORIZON SIMULATION WITH DIFERENT PRESCRIPTIONS FOR BIAS ?
- ☐ APPLIED TO SDSS PUBLIC DATA (DR7) AND COMPARED WITH PREVIOUS WORK
- ☐ APPLIED TO SDSS-III BOSS DATA.

FIN

BIAS USING QUADRUPOLE NORMALIZED



$$\frac{\xi_2(s)}{\xi_0^s(s) + (3/s^3)\int_0^s \xi_0^s(s')s'^2 ds'} = \frac{\frac{4}{3}\beta + \frac{4}{7}\beta^2}{1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2} = G(\beta)$$

QUADRUPOLE ET BIAS IN HORIZON

$$\frac{\xi_2(s)}{\xi_0^s(s) + (3/s^3)\int_0^s \xi_0^s(s')s'^2 ds'} = \frac{\frac{4}{3}\beta + \frac{4}{7}\beta^2}{1 + \frac{2}{3}\beta + \frac{1}{5}\beta^2} = G(\beta)$$

GENERATION DE SIMULATION LOG NORMAL

- GENERATION OF A LOG NORMAL RANDOM FIELD,FOR EACH MODE K WITH VARIANCE PROPORCIONAL TO PK INPUT.
- LES GALAXIES ARE PLACED USING DENSITY FIELD AS A PROBABILITY DENSITY FUNCTION.
- VELOCITIES ARE GENERATED USING DENSITY FIELD IN THE LINEAR APROXIMATION :

$$v = -\beta \nabla \nabla^{-2} \delta$$