
# Large Scale HI Bias

Felipe Marin
University of Chicago

Science with Fast Radio Telescopes
Fermilab 10-8-2009

# Outline

- Introduction
- HI Mass Function
- HOD model
- Results
- Conclusion

*Based on Marin, Gnedin, Seo & Vallinotto 2009 (in prep.)*

# Introduction

- HI mapping offers a powerful new probe of the clustering of the universe in big volumes and on a wide range of redshifts.
- Apart from probes of reonization, these surveys want to help constraint cosmological models & parameters
- How do we relate HI clustering to the total (dark) matter clustering? $\Rightarrow$ HI bias.
- It's important to now the scale & redshift dependence of this bias.

# HOD-based model of HI clustering

- HOD models spatial distribution of objects such as galaxies.
- First part: the mass function of halos: Sheth & Tormen

$$n_h(M) = \frac{\bar{\rho}_m}{M^2}\left|\frac{d\ln\sigma}{d\ln M}\right| f(\nu)$$

$$\sigma^2(M) = \int \frac{d^3k}{(2\pi)^3}\left|W(k,R(M))\right|P_{lin}(k),\ \nu(M) = \frac{1.69}{\sigma(M)}$$

- Second part: how much HI there is in a halo of mass M: $\langle M_{HI}(M_{tot})\rangle$: then our density is given by

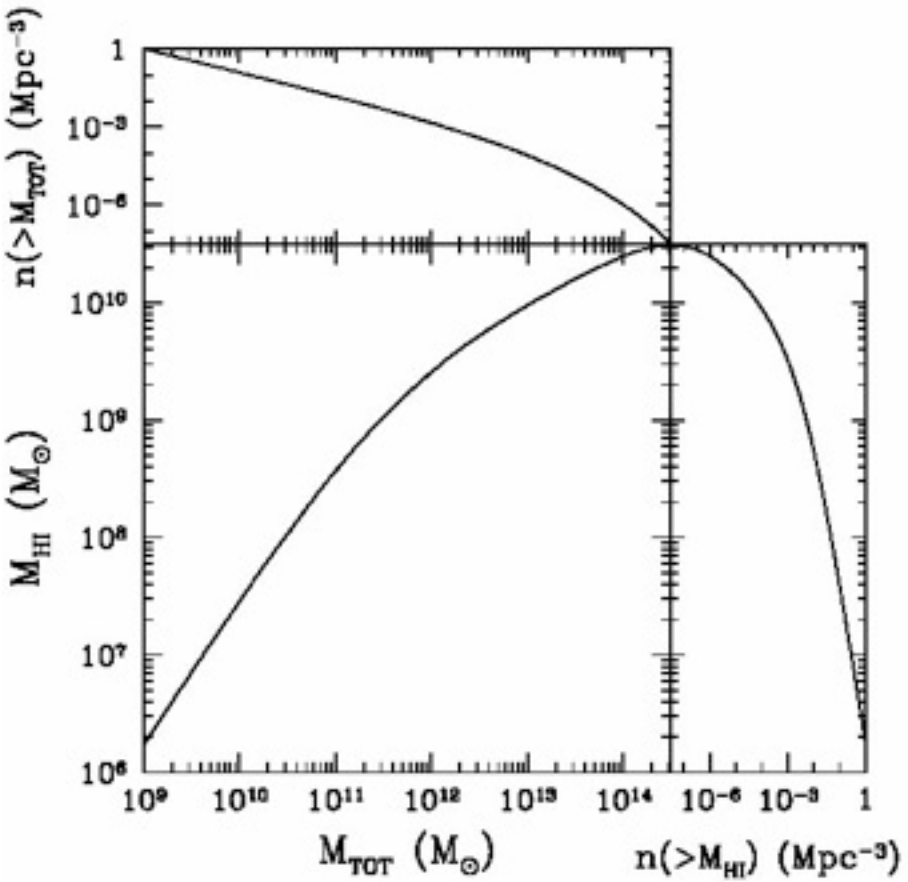
$$\rho_{HI} = \int_{M_{\min}}^{\infty} n_h(M)\left\langle M_{HI}(M)\right\rangle dM$$

# Neutral Hydrogen Mass

- Mass function of $M_{HI}$ $n(M_{HI})$ has been measured by HIPASS Survey.
- Relation between $M_{HI}$ and $M_{tot}$ is unknown
- We assume a one-to-one correspondence between $M_{HI}$ and $M_{tot}$ matching cumulative functions

$$n(> M_{HI}) = n(> M_{tot})$$

- This matching has given good results in correlation functions & other observable tests.
- This way, we get a relation $M_{HI}(M_{tot})$



# Evolution with redshift

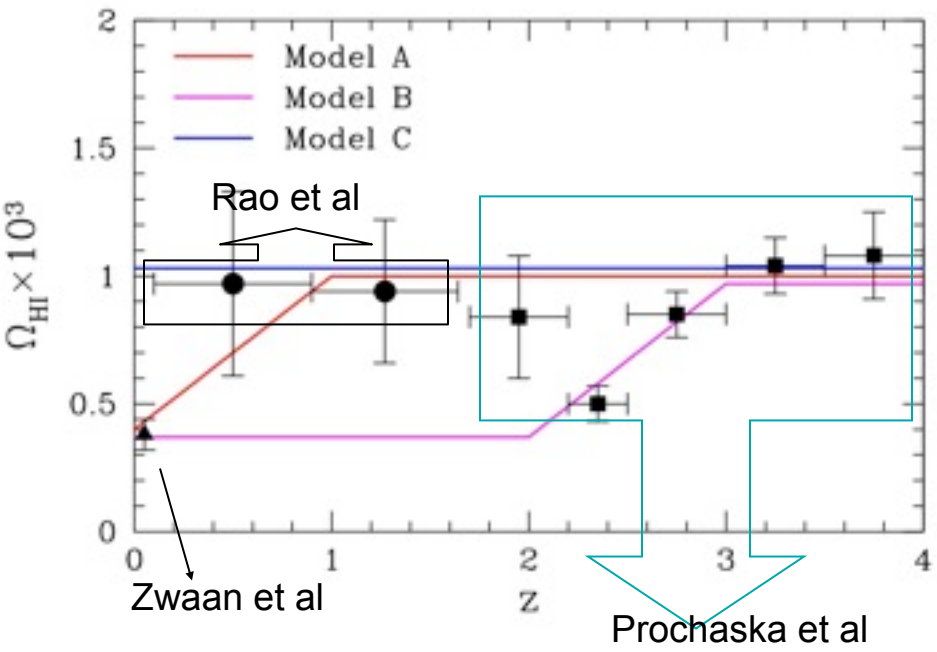
- We must extrapolate $n(M_{HI})$ to earlier times
- 3 Different models of $\Omega_{HI}(z)$ based on observations
- 2 Different models of $n(>M_{HI})$ evolution

✓ Pure Number Evolution

$$n_{PNE}(>M_{HI},z) \equiv \frac{\Omega_{HI}(z)}{\Omega_{HI}(0)} n_0(>M_{HI})$$

✓ Pure Luminosity Evolution

$$n_{PLE}(>M_{HI},z) \equiv n_0\left(>\frac{\Omega_{HI}(0)}{\Omega_{HI}(z)} M_{HI}\right)$$



# HI Bias

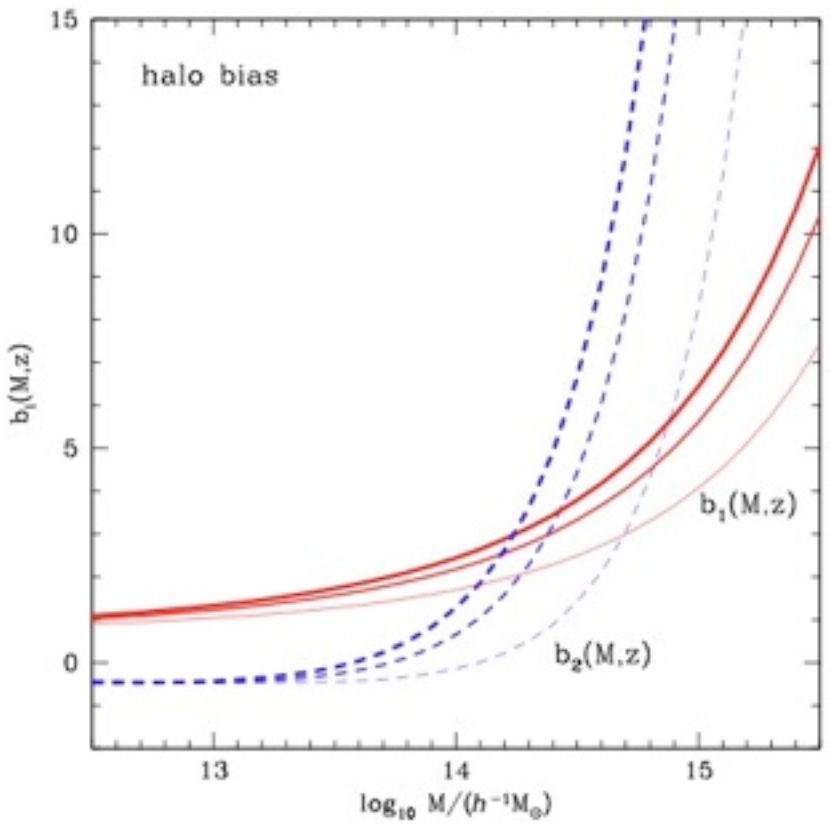
- The difference between dark matter & HI clustering is the bias. On large scales, the HI and DM correlation functions can be related as

$$\xi_{HI} \approx b_1^2 \xi_{dm}$$

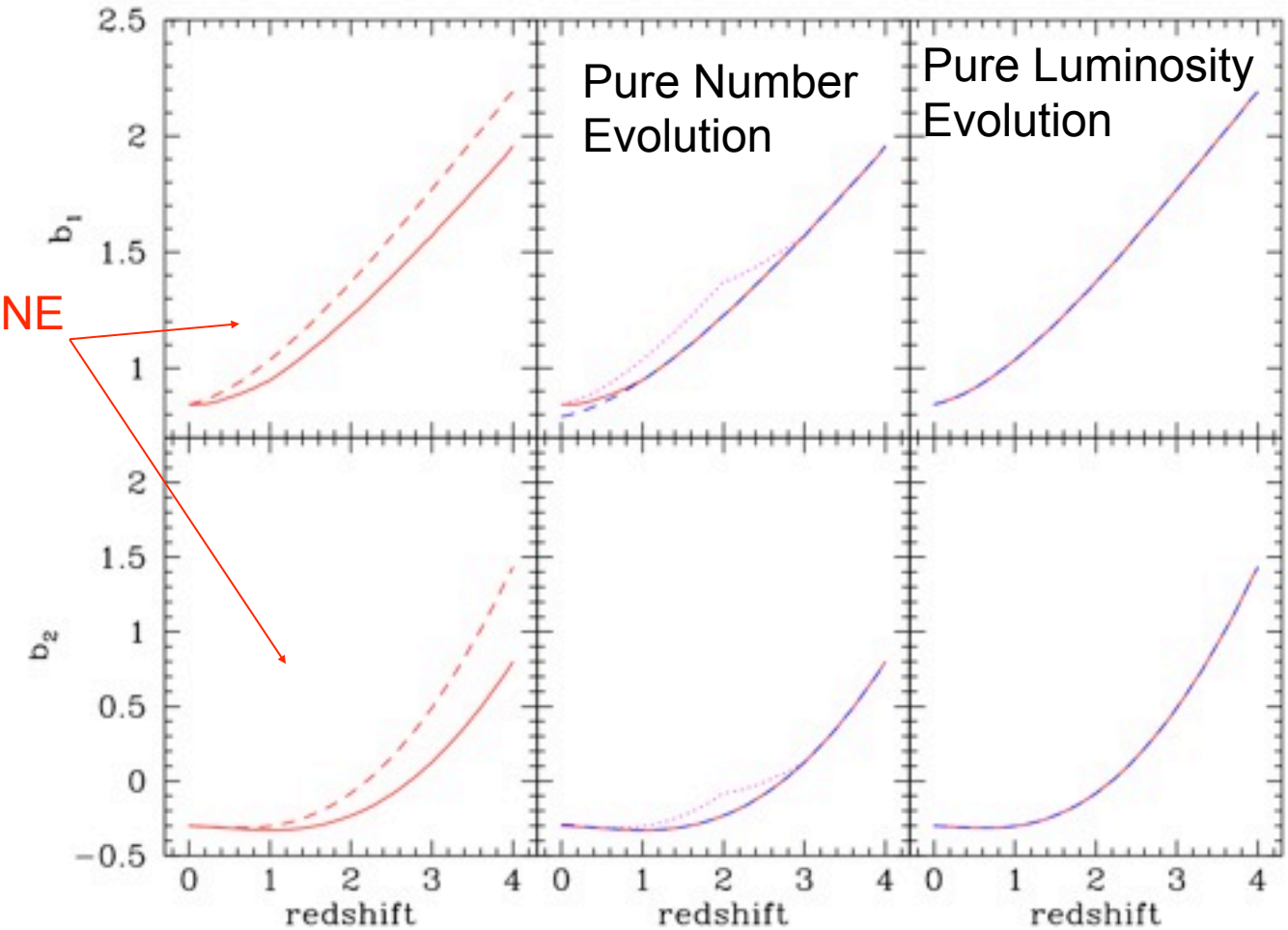
$$\zeta_{HI}^{(1,2,3)} \approx b_1^3 \zeta_{dm} + b_2 b_1^2 (\xi_{dm}^{(1)} \xi_{dm}^{(2)} + perm)$$

- In the HOD model, the bias of HI is calculated by integrating the halo bias over all masses:

$$b_{i,HI} = \frac{1}{\rho_{HI}} \int_{M_{\min}}^{\infty} b_i^h n_h(M) \langle M_{HI}(M) \rangle$$



# Bias as function of redshift



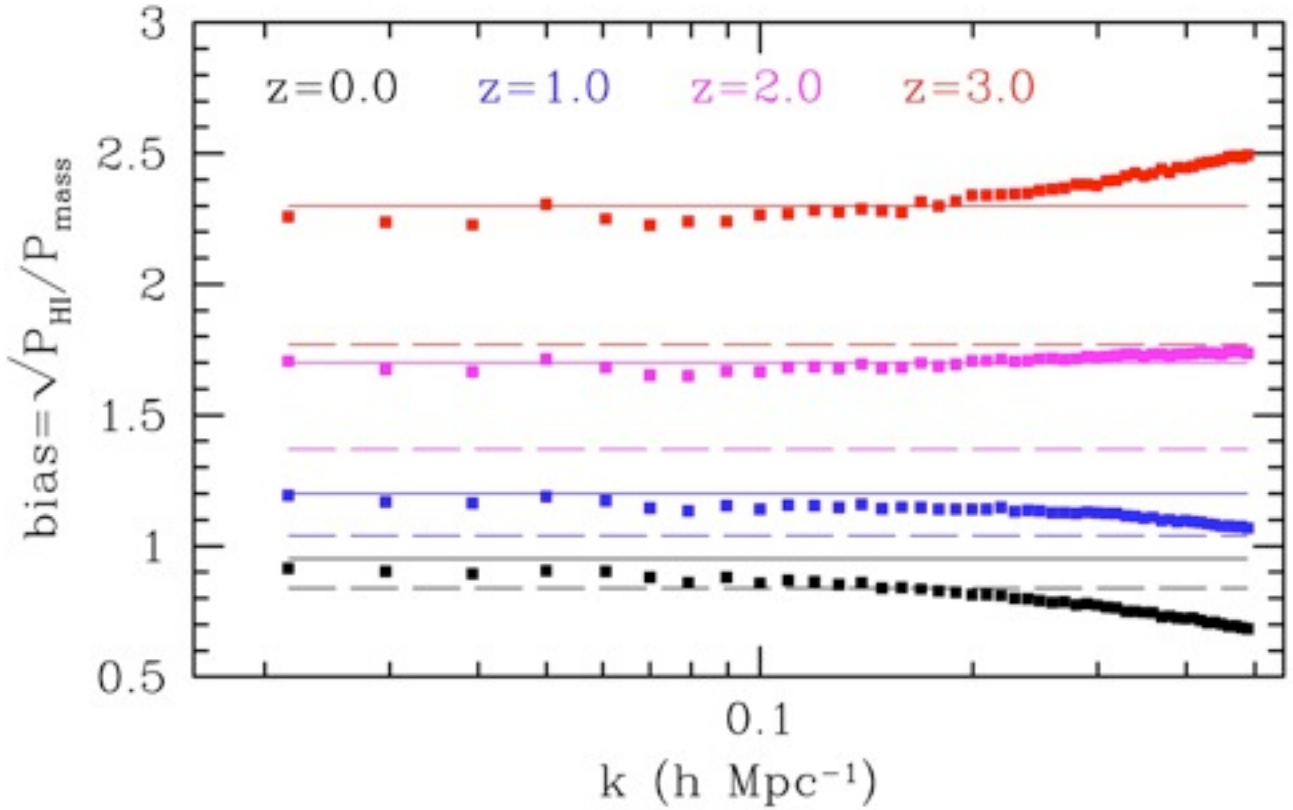

PLE vs PNE
Model A

Model A
Model B
Model C

Science with Fast Radio Telescopes
Fermilab 10-8-2009

# Results from simulations

- We measured the bias from Power Spectrum using the Millennium Simulation
- Mass cuts: Dashed line $M_{min}=0$, solid line $M_{min}=10^{11}$ $h^{-1}M_{sun}$

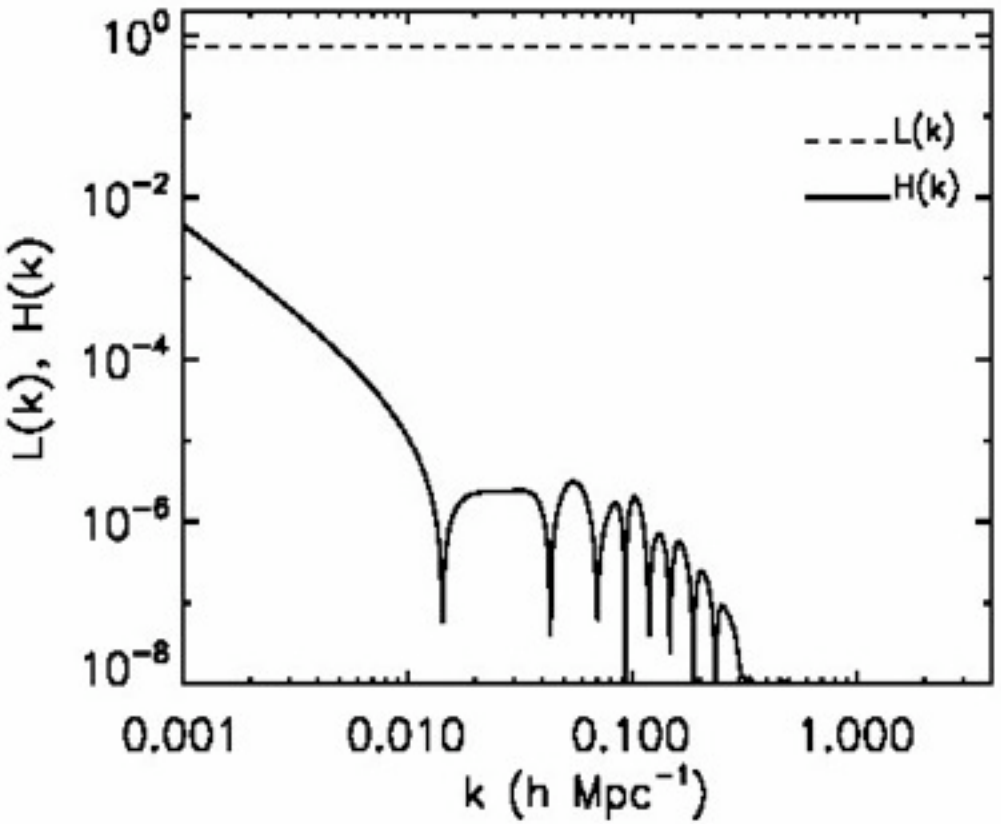


# Changes in P(k) from b(z)

- How the b(z) evolution changes measured P(k)?

$$P_{21}\left(\vec{k}\right) = \left[L(b,k) + \cos^2(\theta)H(b,k)\right]P_{dm}(k)$$

- Here we do not take redshift effects (from peculiar velocities) into account.
- The effect from bias evolution is small



# Summary

- We used an HOD-based method to estimate the bias a function of redshift.
- The differences of the bias between the models are small.
- The evolving b(z) has a small influence on the P(k)
- Future work includes adding redshift-distortion effects, mapping, etc.