The Distribution of Cold Gas in the Local Universe

NISHIKANTA KHANDAI

NISER, Bhubaneswar

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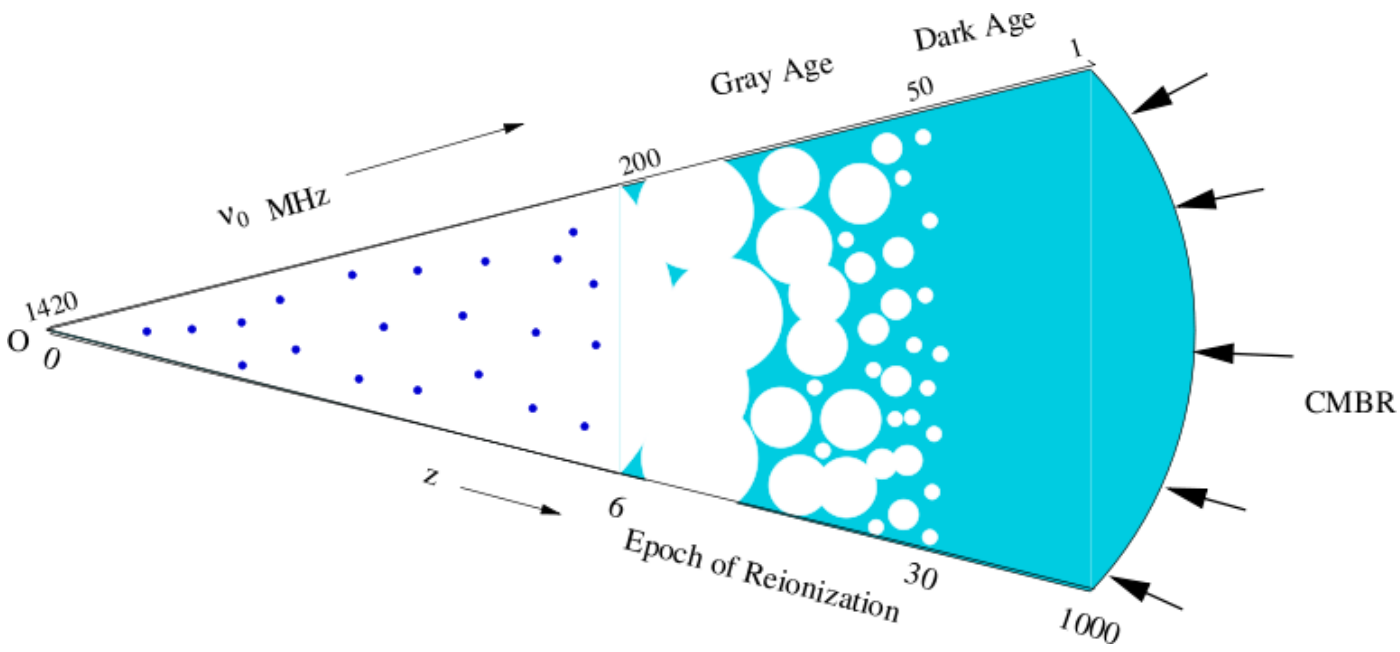
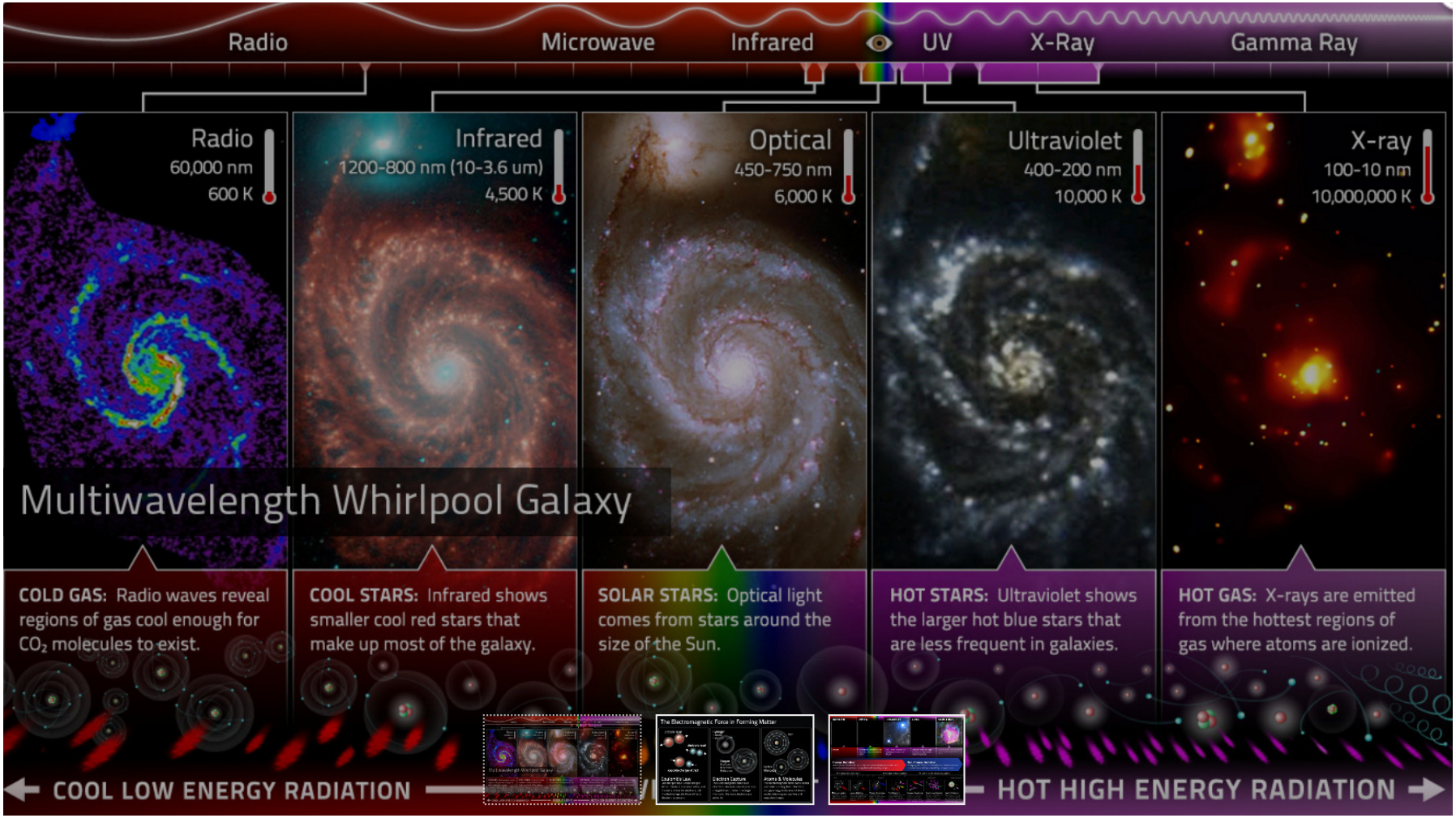
With Saili Dutta, Sandeep Rana, Biprateep Dey and Tanya Tripty

Evolution of Neutral Hydrogen (HI)



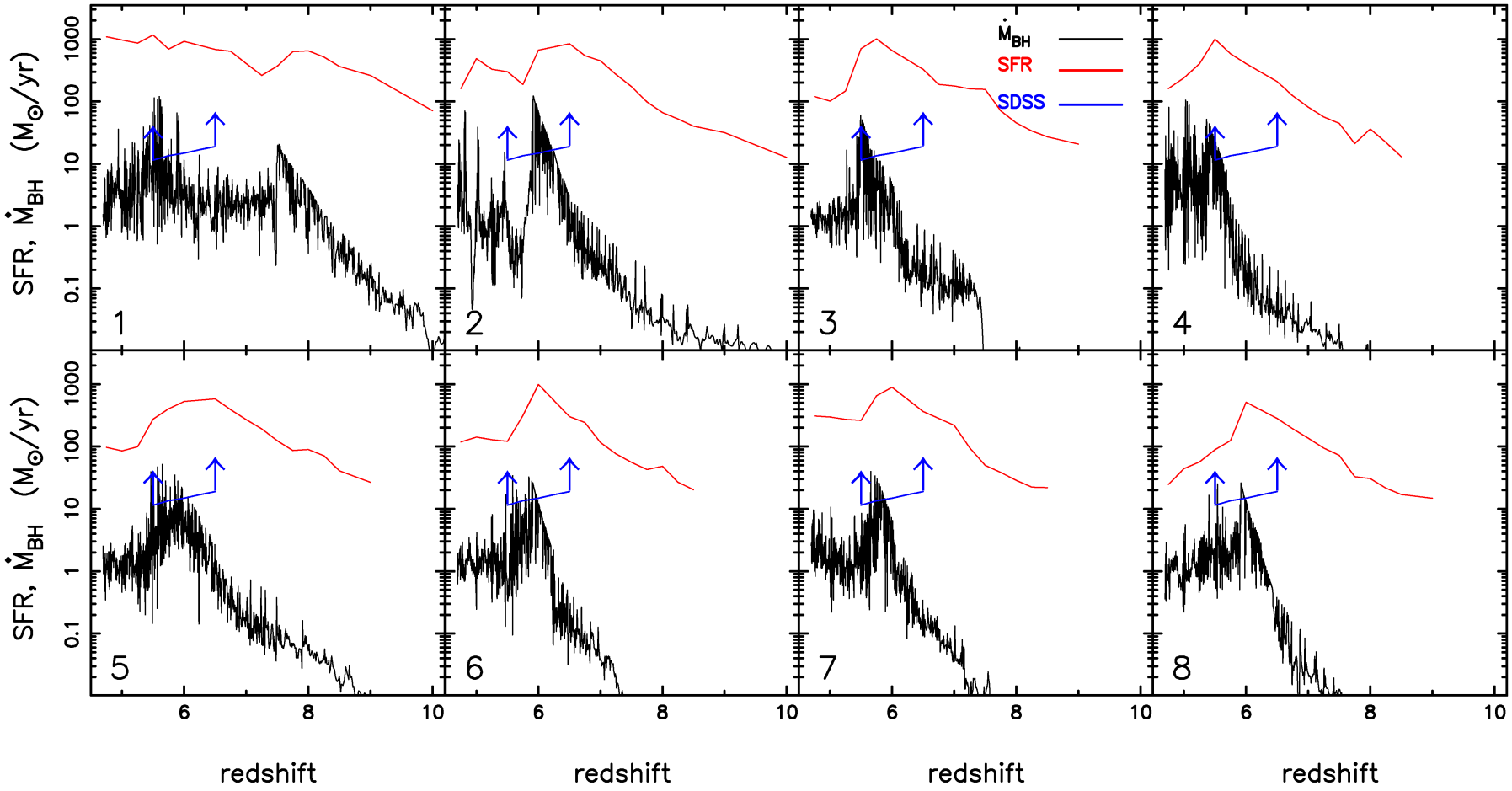
Ali & Bharadwaj 2005

A Multi-Wavelength View of M51



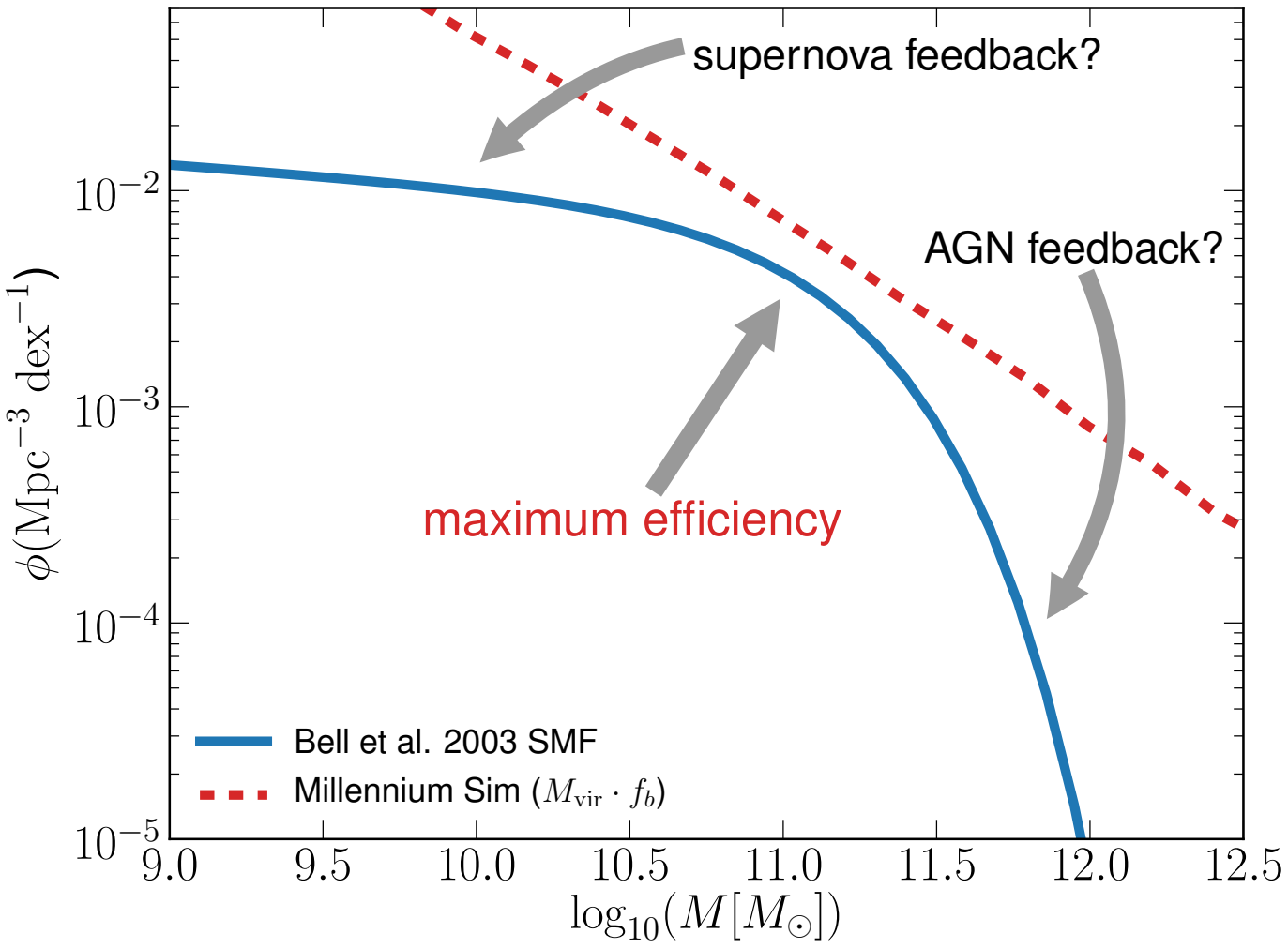
https://ecuip.lib.uchicago.edu

Quasars and Star Formation



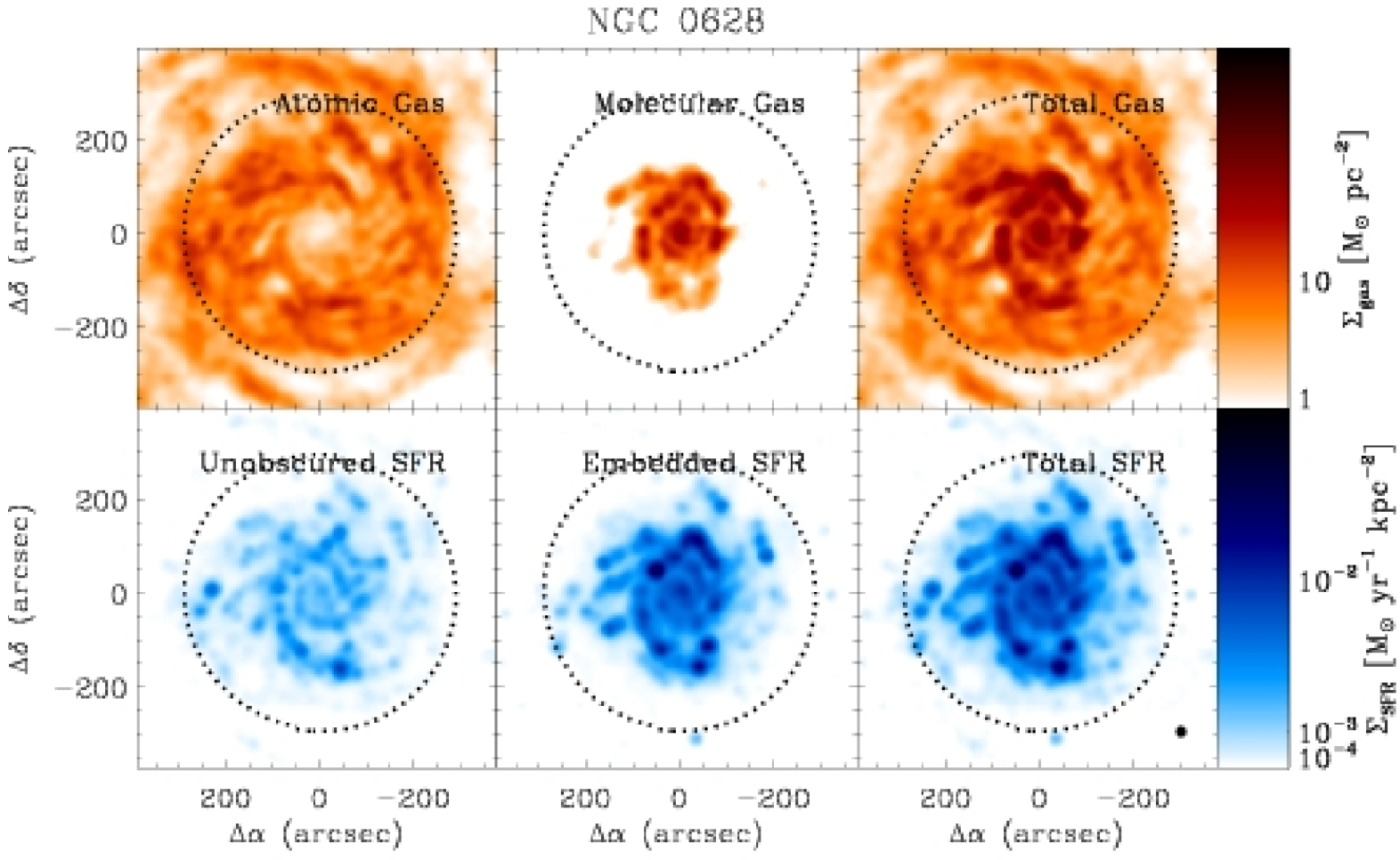
NKet al 2012

Baryonic Effects: The Galaxy Stellar Mass Function



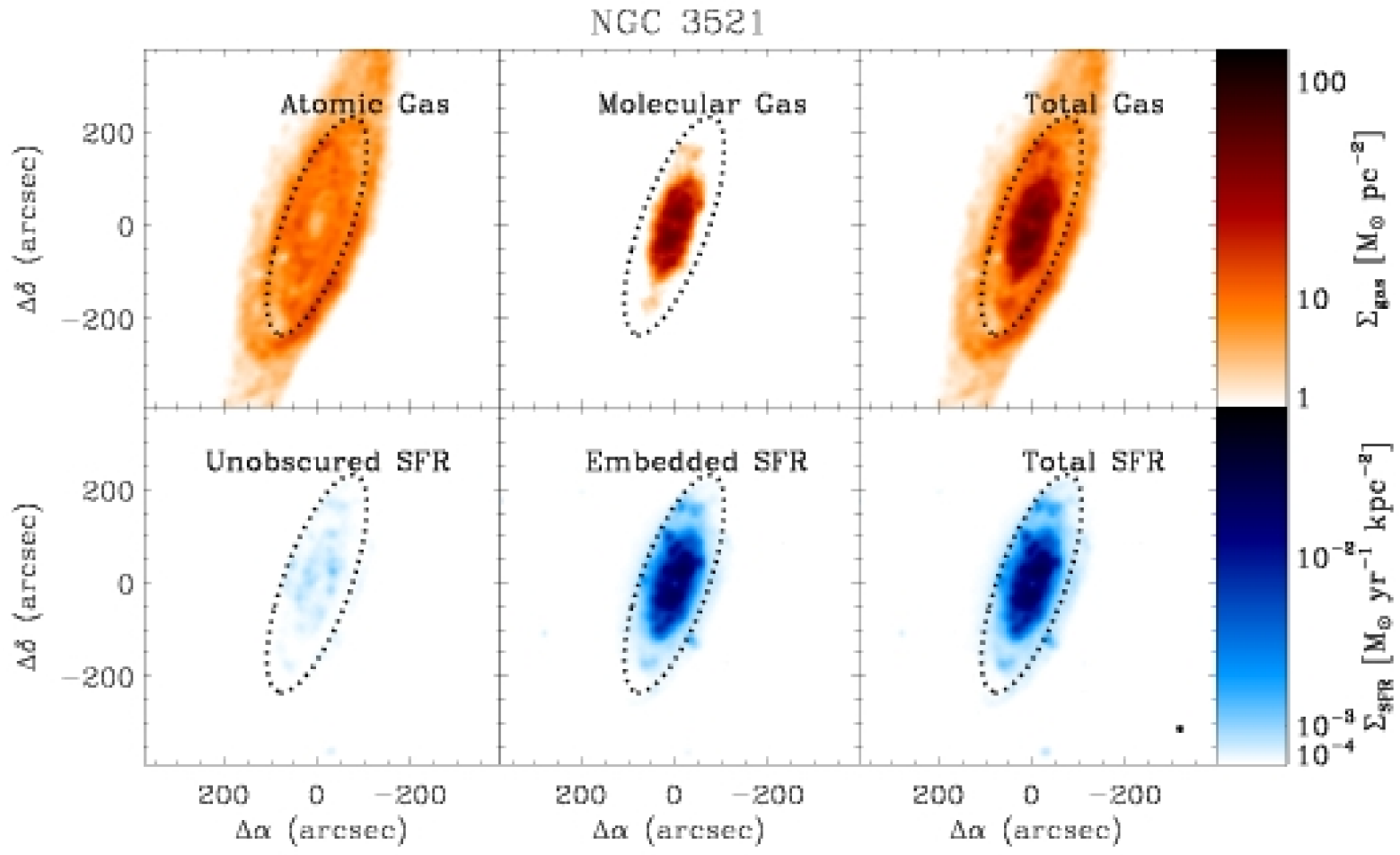
Mutch et al 2013

Cold Gas and Star Formation



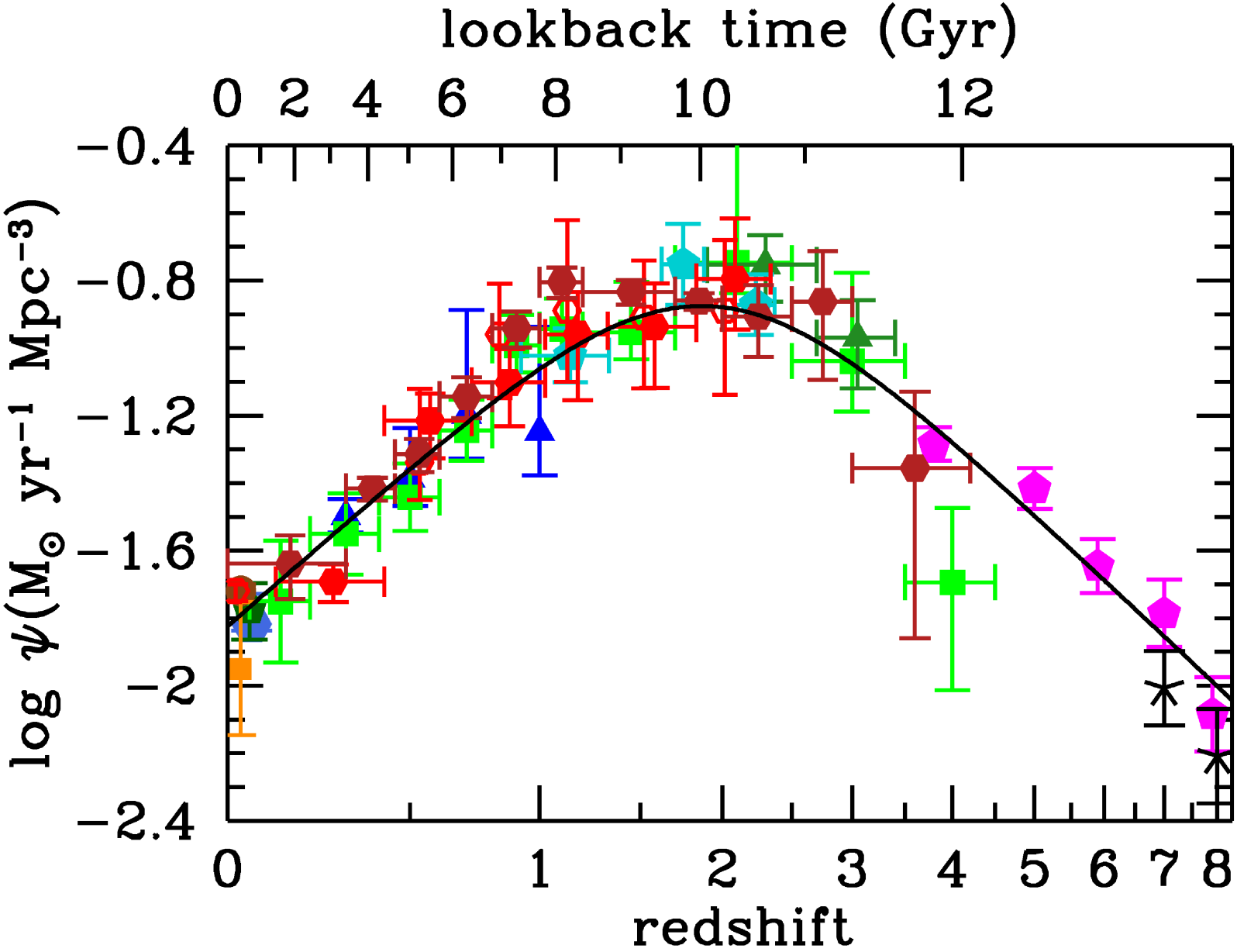
Leroy et al 2008

Cold Gas and Star Formation



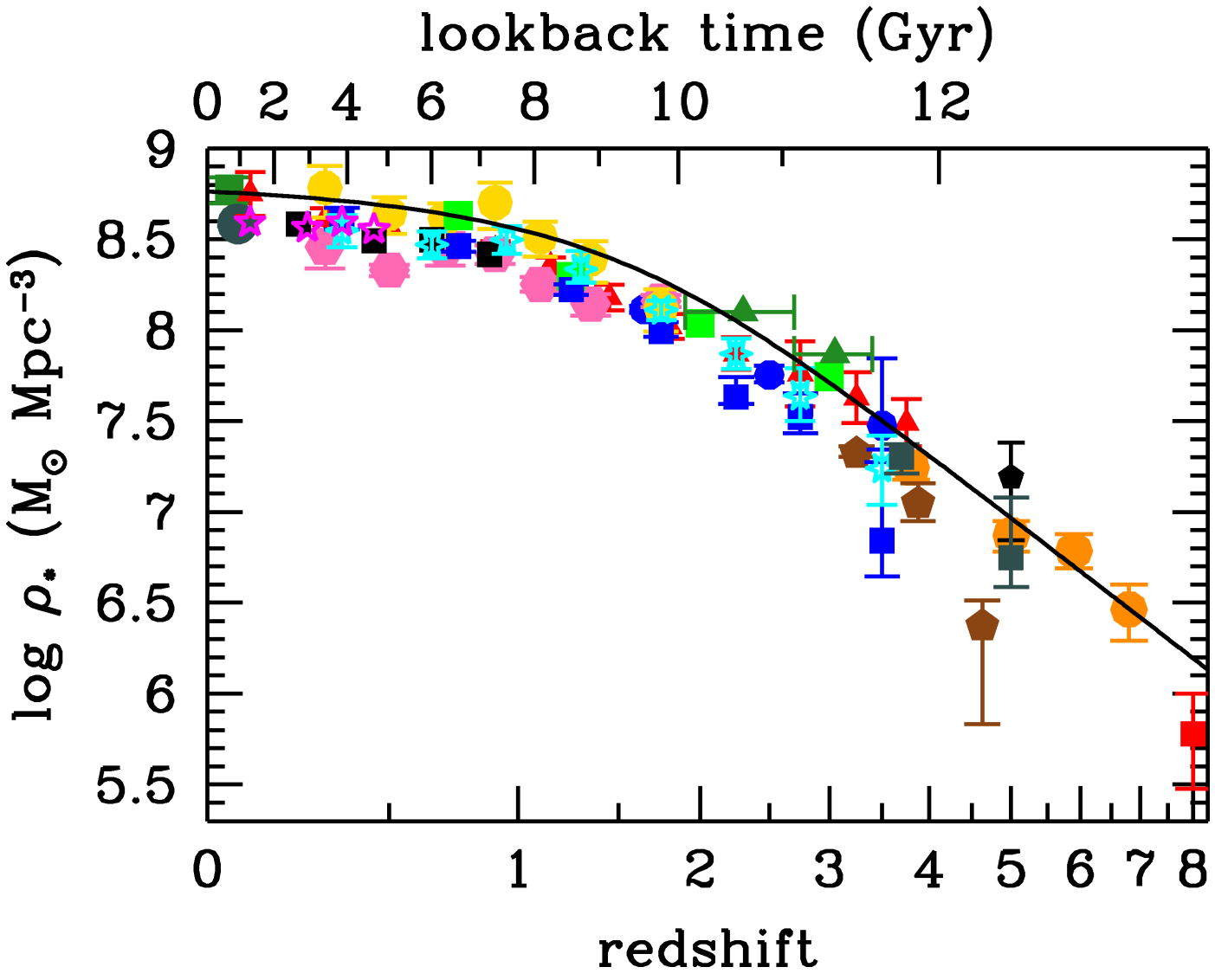
Leroy et al 2008

HI and Galaxy Formation



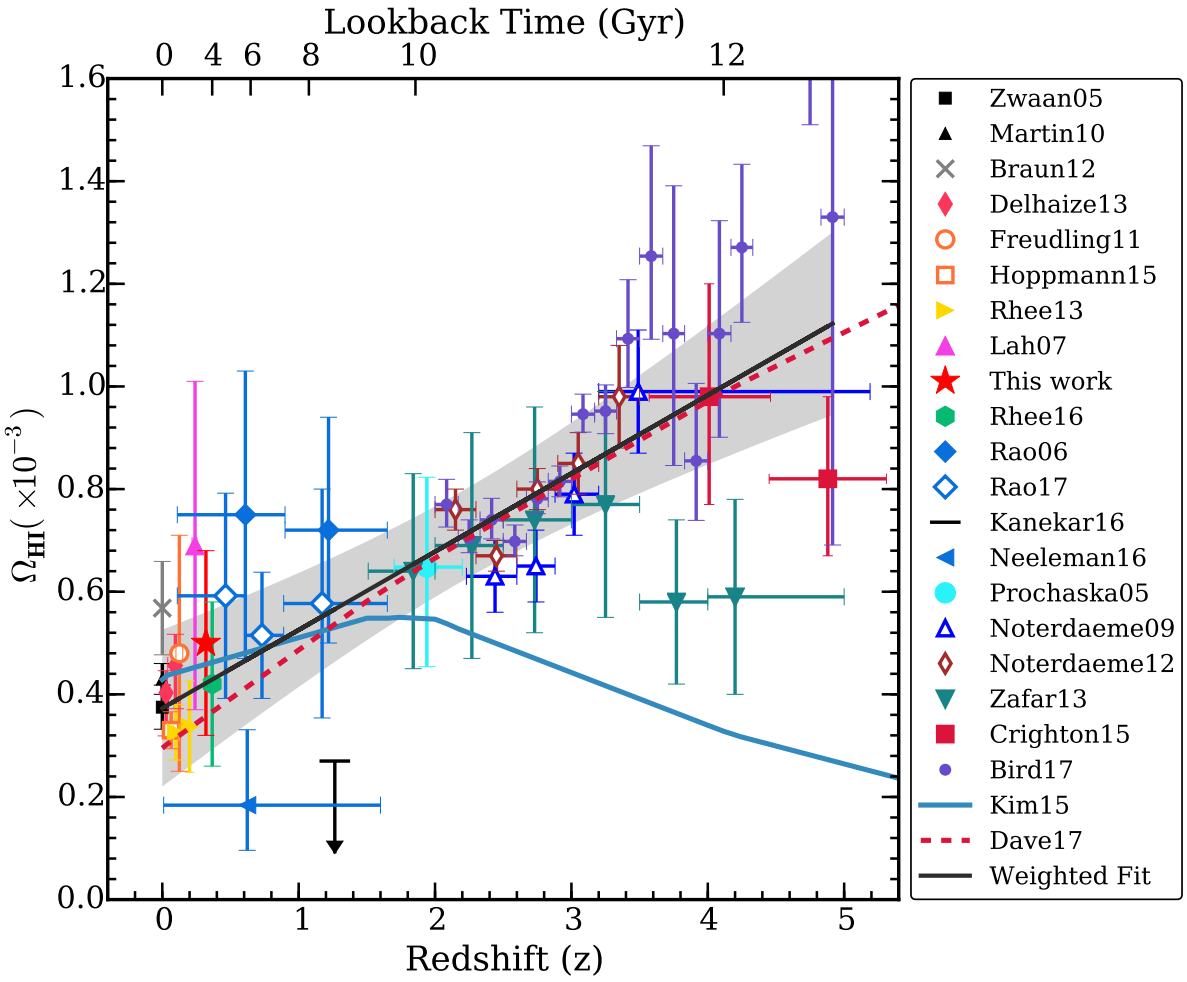
Madau and Dickinson. 2014

HI and Galaxy Formation



Madau and Dickinson. 2014

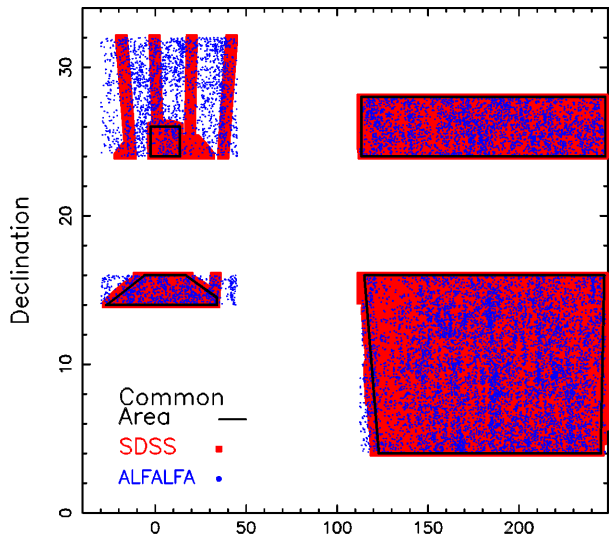
HI and Galaxy Formation

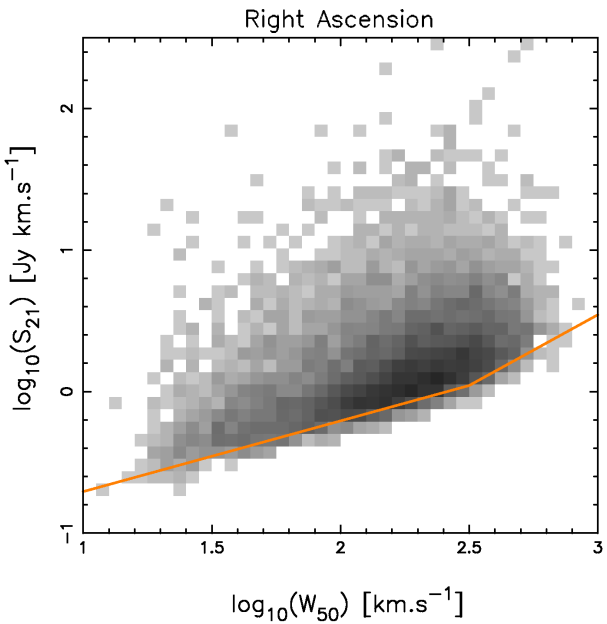


Rhee et al. 2018

ALFALFA Data

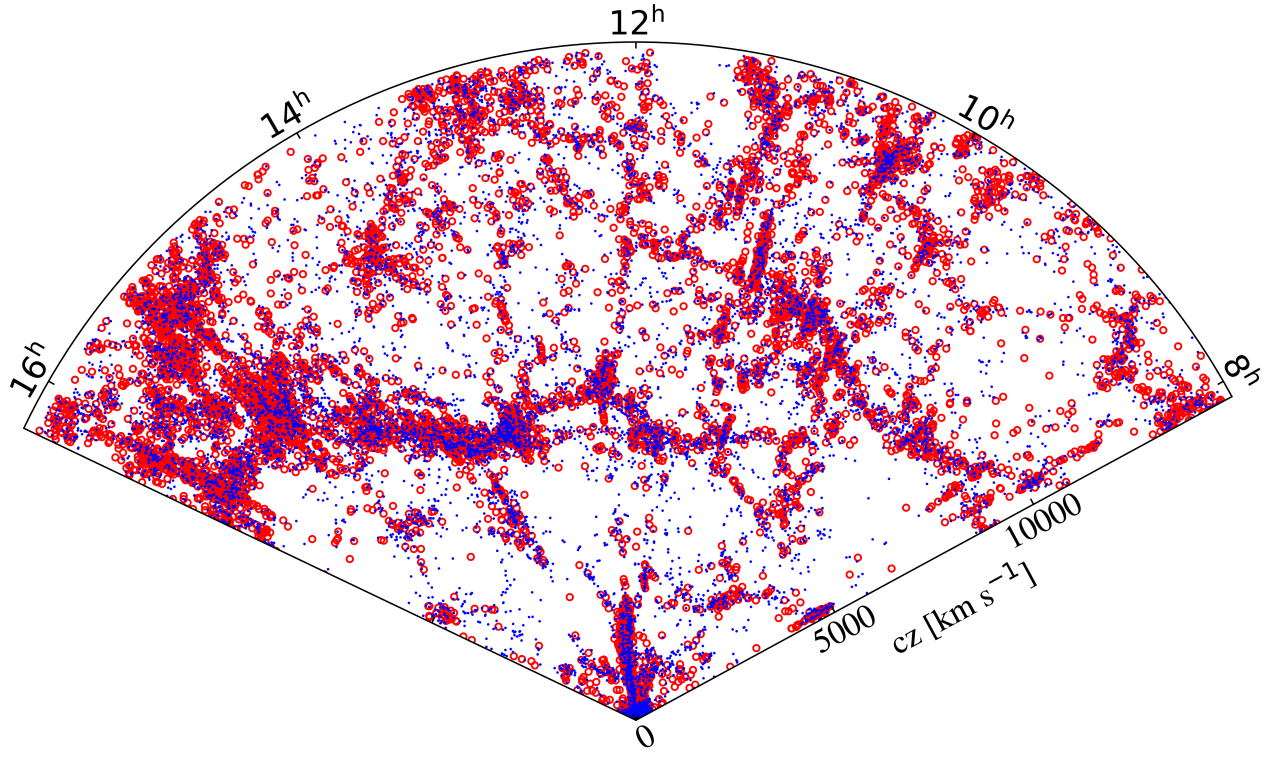
- ALFALFA 40% catalog
  - 7^h30^m <R.A.< 16^h30^m, $4° <$ dec.$< 16°$, $24° <$ dec.$< 28°$ and 22^h <R.A.< 3^h, $14° <$ dec.$< 16°$, $24° <$ dec.$< 32°$
  - 15855 galaxies
- Cuts:
  - $cz < 15000$ Km/s
  - only code 1 galaxies ($S/N > 6.5$)
  - 10785 galaxies
- SDSS-ALFALFA common patch catalog
  - 4 sub-regions shown with black boundary
  - 8344 galaxies
  - angular area ~ 2100 deg^2
  - comoving volume of $\sim 2.1 \times 10^6$ Mpc^3
- Estimate bivariate $\phi = \phi(M_{HI}, w_{50})$ Method : 2DSWML



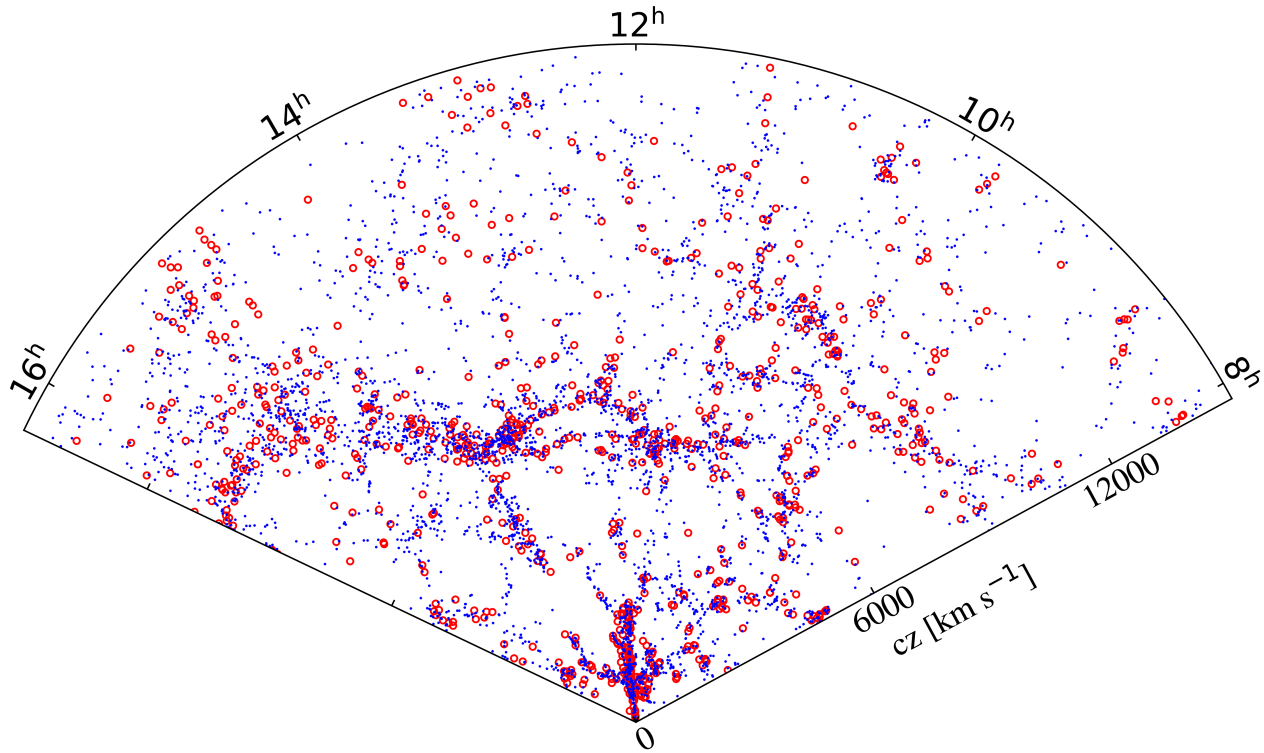


Haynes M. P., et al., 2011, AJ, 142, 170

SDSS



ALFALFA



ALFALFA and SDSS

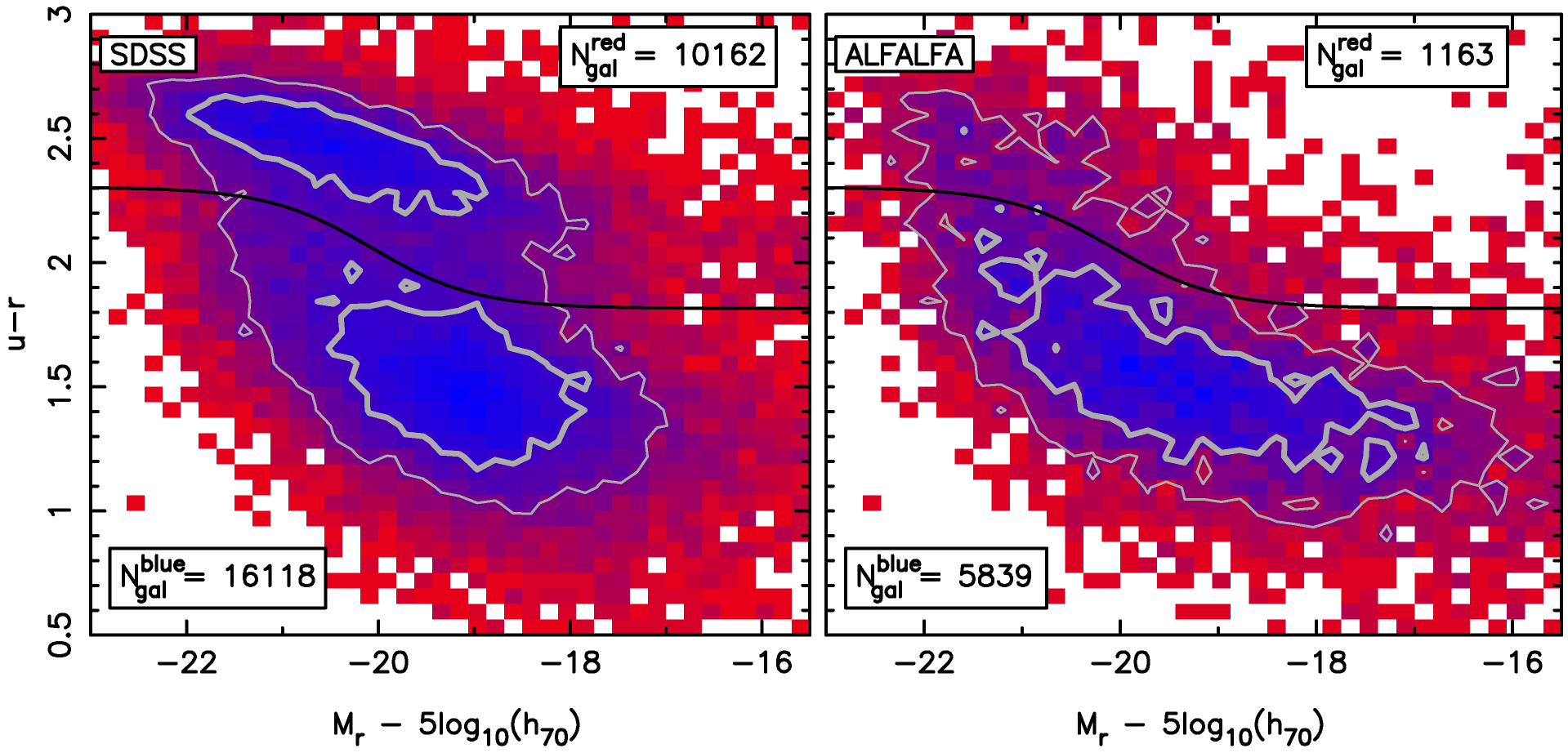
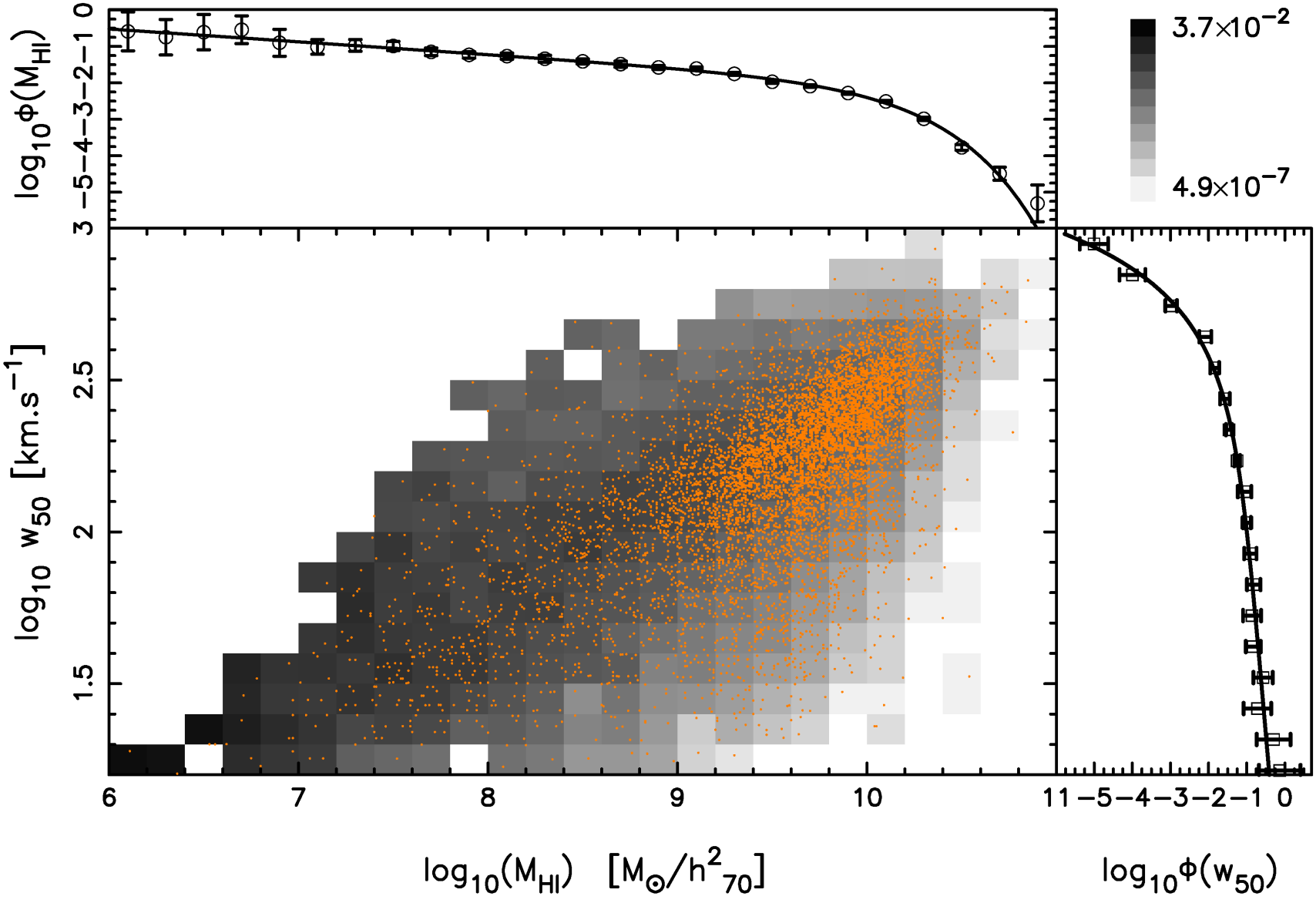


Figure: Dutta, **NK**, Dey 2020

Estimation of HIMF & HIWF



HIMF & HIWF for the Red & Blue Populations

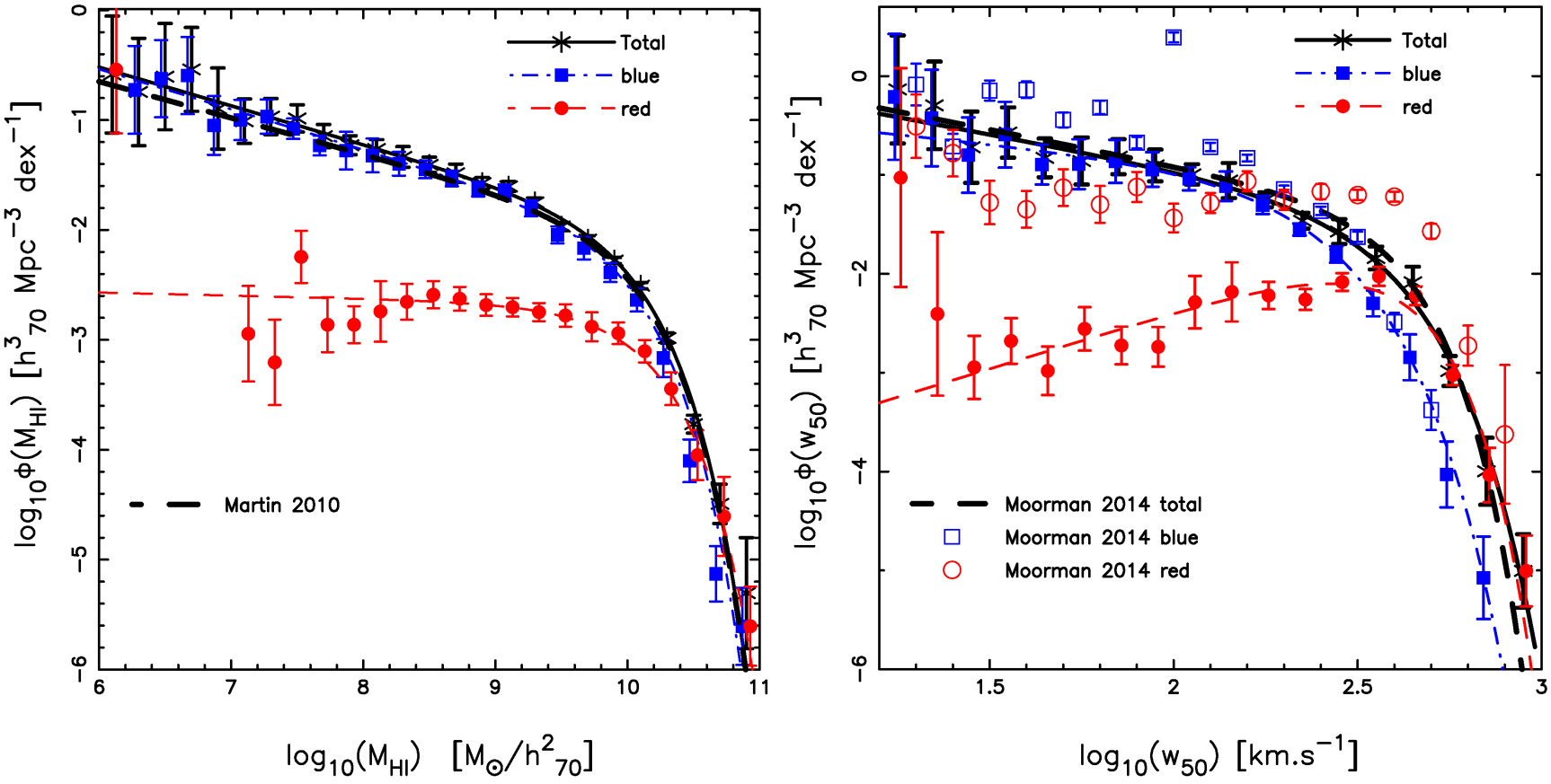


Figure: Dutta, **NK**, Rana 2022

Conditional HIMF

$$\phi(M_{\rm HI}|X^t) \;=\; \phi(M_{\rm HI})|_{X>X^t}$$

$$\phi(M_{\rm HI}|C^t_{ur}, M^t_r) \;=\; \phi(M_{\rm HI})|_{(C_{ur}>C^t_{ur}),(M_r<M^t_r)}$$

$$\Omega^{\rm norm}_{\rm HI}(C^t_{ur}, M^t_r) \;=\; \frac{\Omega_{\rm HI}(C^t_{ur}, M^t_r)}{\Omega^{\rm tot}_{\rm HI}} = \frac{1}{\Omega^{\rm tot}_{\rm HI}\rho_c}\int_0^\infty M_{\rm HI}\;\phi(M_{\rm HI}|C^t_{ur}, M^t_r)\;dM_{\rm HI}$$

$$\Omega^{ij}_{\rm HI} \;=\; \int_{M^i_r}^{M^{i+1}_r}\int_{C^j_{ur}}^{C^{j+1}_{ur}} \frac{\partial^2\Omega^{\rm norm}_{\rm HI}(C_{ur}, M_r)}{\partial C_{ur}\partial M_r}\;dC_{ur}\;dM_r$$

$$\;=\; \int_{M^i_r}^{M^{i+1}_r}\int_{C^j_{ur}}^{C^{j+1}_{ur}} p(\Omega^{\rm norm}_{\rm HI}(C_{ur}, M_r))\;dC_{ur}\;dM_r$$

Distribution of $\Omega_{HI}(M_r, C_{ur})$

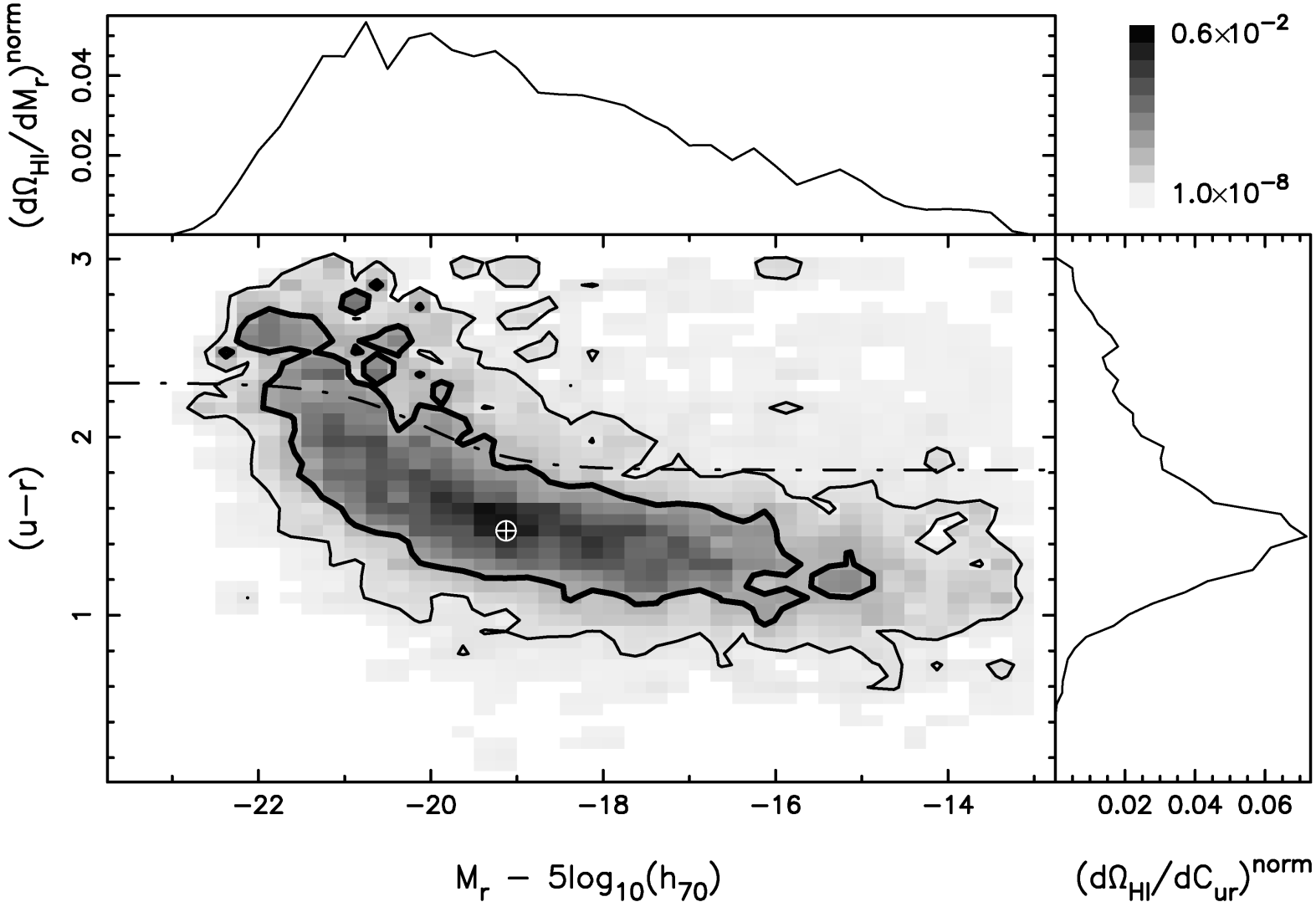
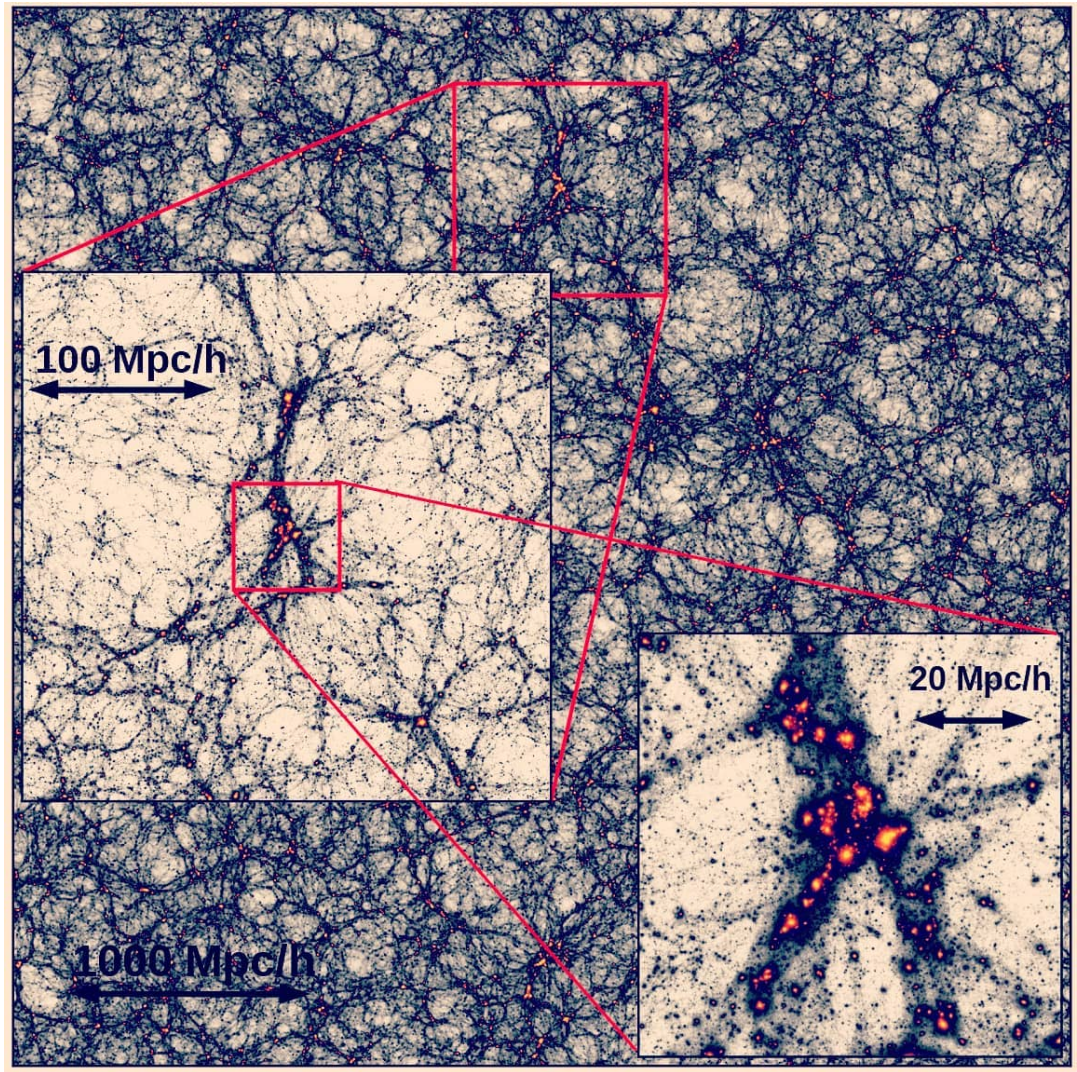


Figure: Dutta, **NK**, 2021

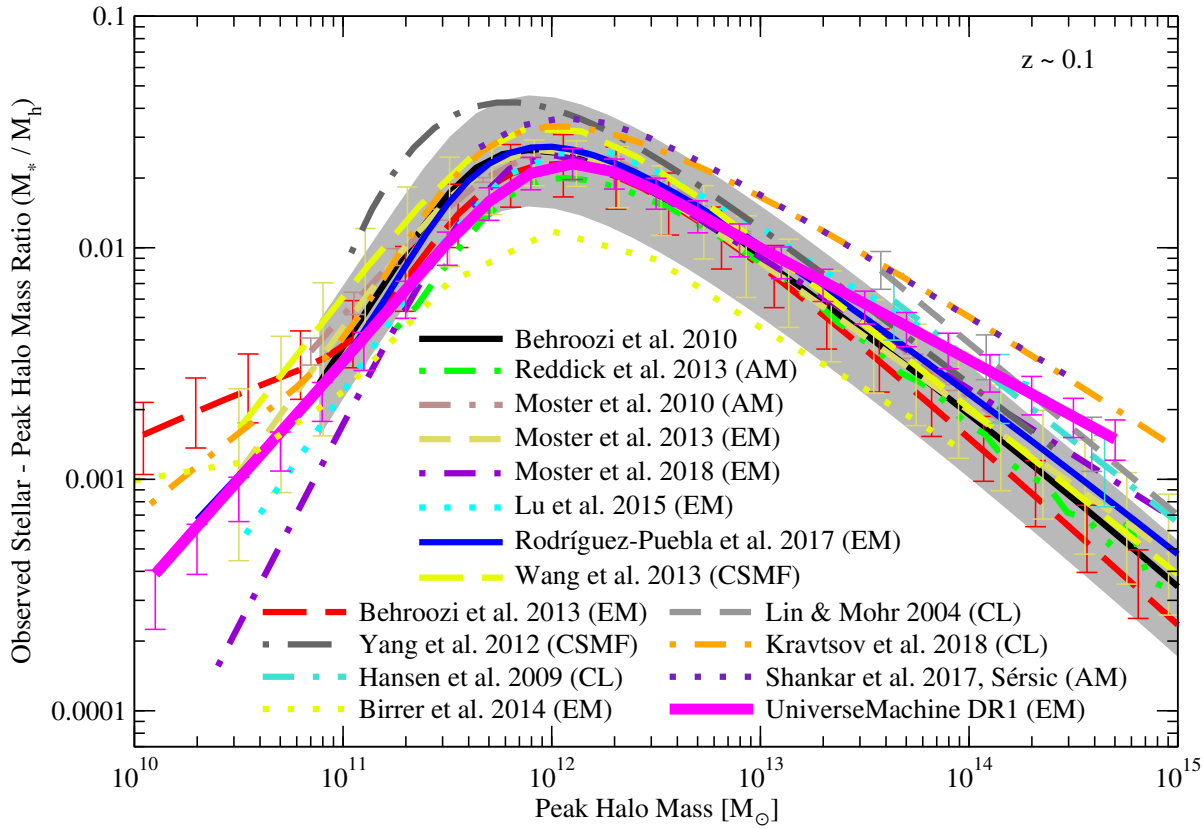
Galactic Halos in Dark Matter Simulations (Klypin et al 2016)



MDPL2: $\mathrm{L}_{box} = 1 Gpc/h \quad \mathrm{N}_{part} = 3840^3 \quad m_{dm} = 1.5 \times 10^9 M_\odot/h$

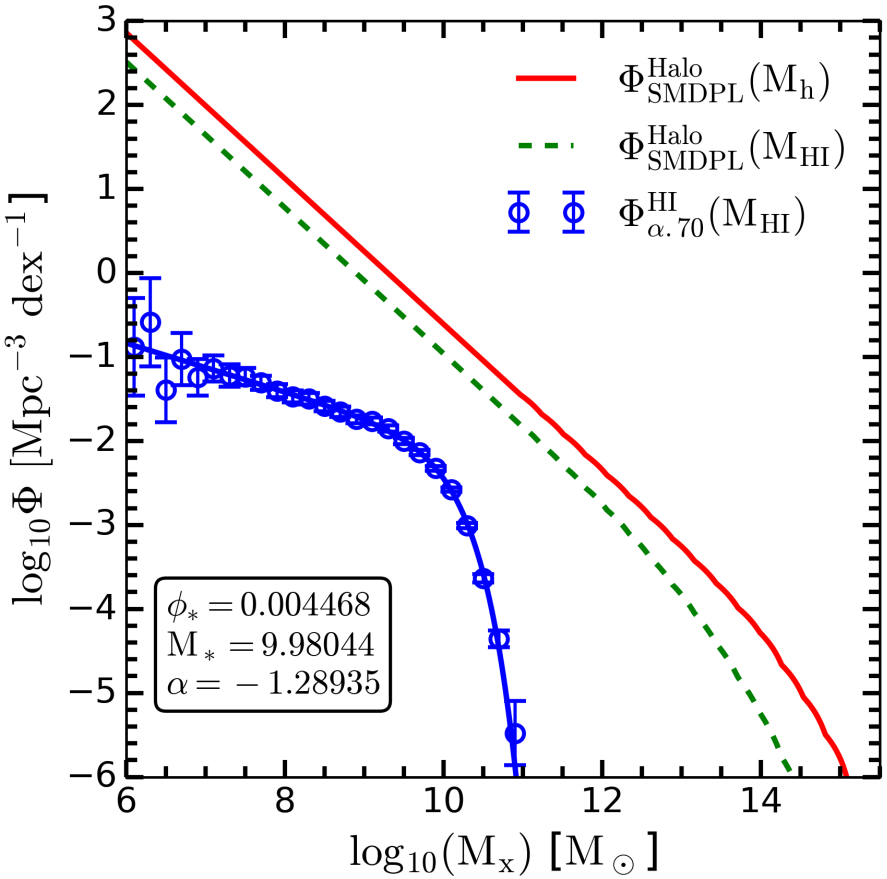
SMDPL2: $\mathrm{L}_{box} = 400 Mpc/h \quad \mathrm{N}_{part} = 3840^3 \quad m_{dm} = 10^8 M_\odot/h$

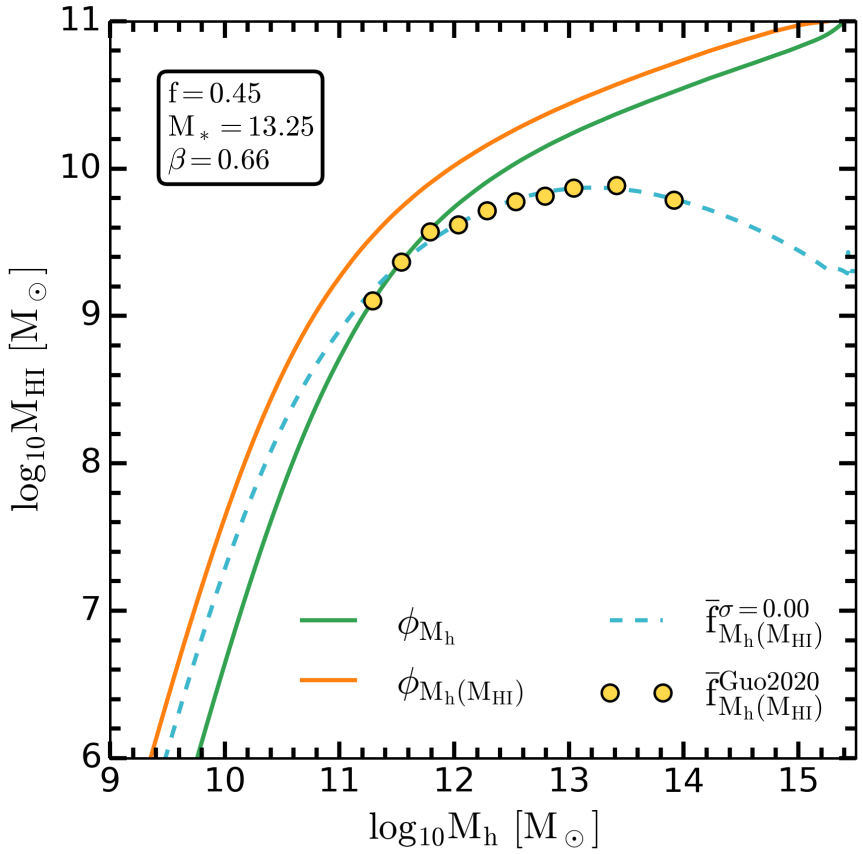
The Halo Mass - Stellar Mass relation



Behroozi et al 2019

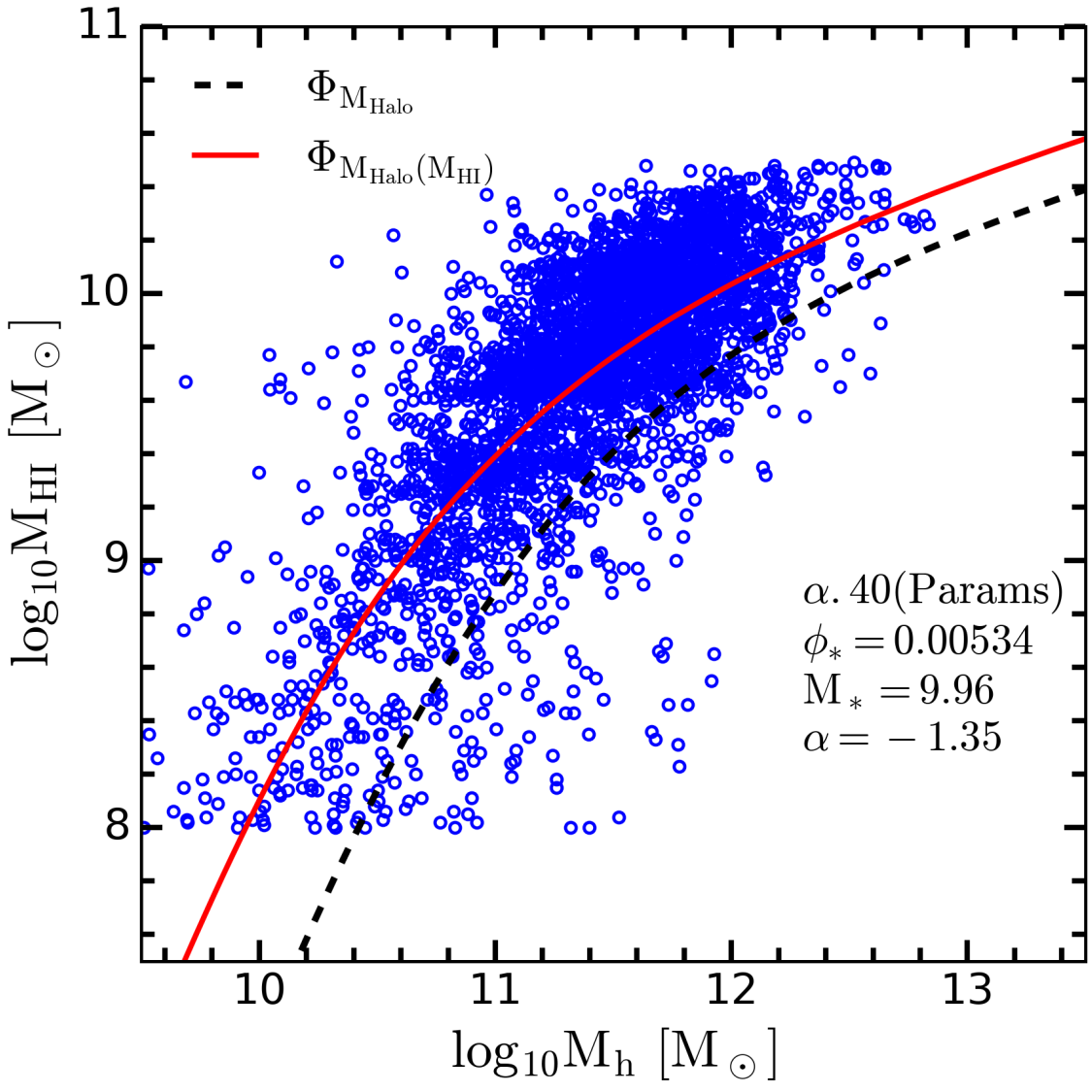
The HI-Selected HMF





$$\phi^{\rm HI}(M_{\rm halo}) = \phi(M_{\rm halo}) \times \frac{f}{1 + \left(\frac{M_{\rm halo}}{M_*}\right)^{\beta}}$$

Consistency Check: The HI Mass - Halo Mass Relation



Abundance Matching with Scatter (Behroozi et al 2010)

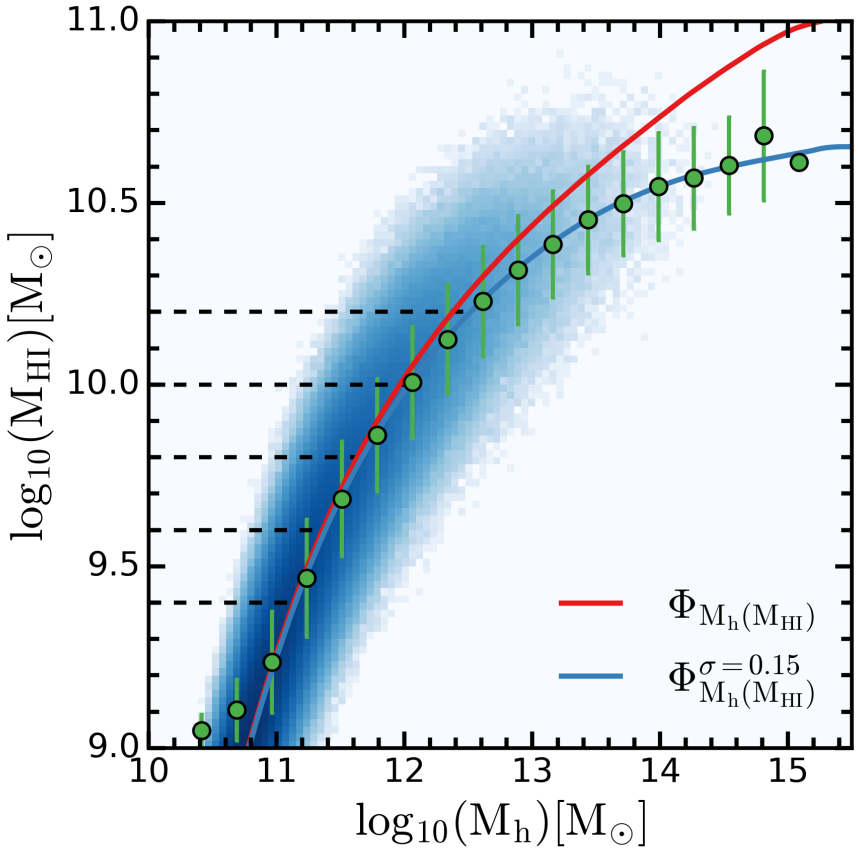
$M \equiv \log_{10} M$

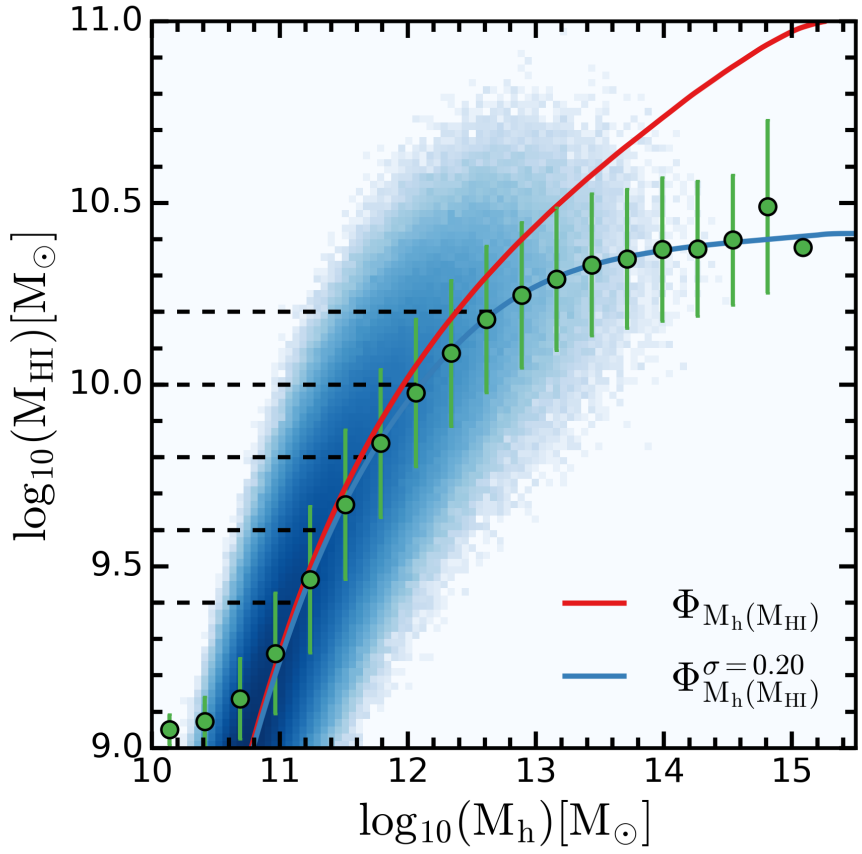
$$\phi(M_{\rm HI}) = \int_0^\infty \phi^{\rm HI}(M_{\rm halo})\phi(M_{\rm HI}|M_{\rm halo})dM_{\rm halo} \quad (1)$$

$$\phi(M_{\rm HI}|M_{\rm halo}) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[\frac{-(M_{\rm HI} - M_{\rm HI}(M_{\rm halo},\sigma))^2}{2\sigma^2}\right] \quad (2)$$

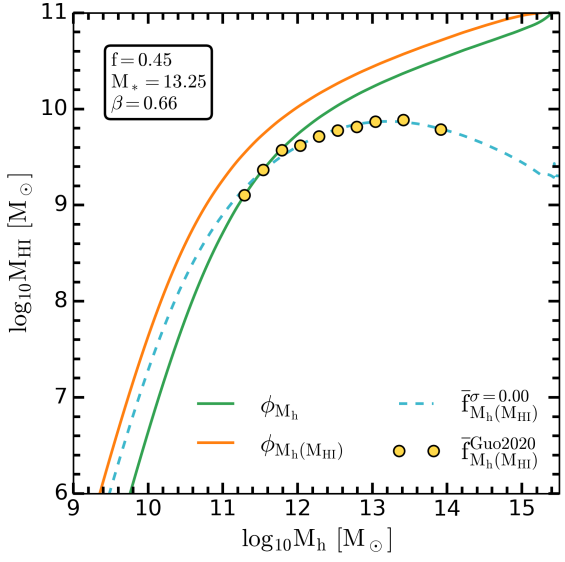
Solve iteratively for $M_{\rm HI}(M_{\rm halo})$ for a given σ

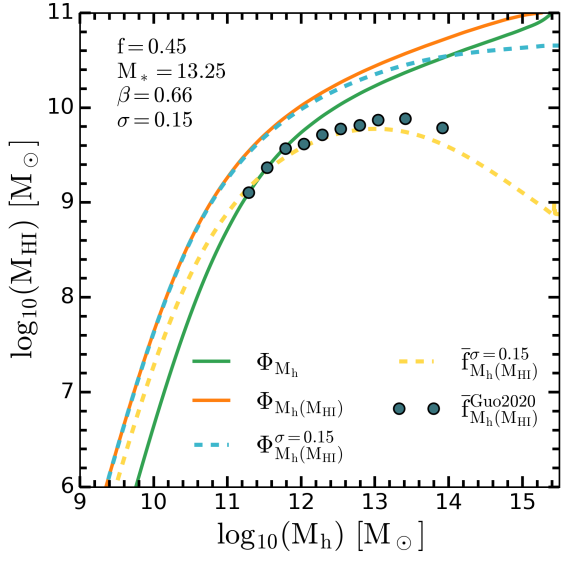
Abundance Matching with Scatter contd.

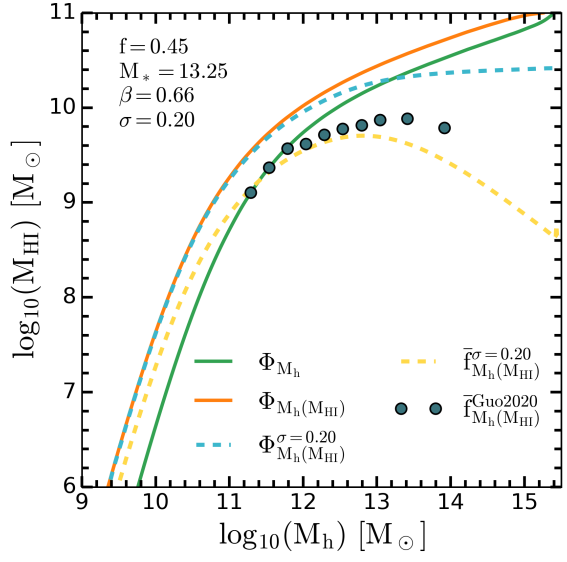




Abundance Matching with Scatter contd.







The next 20 slides discussed results from ongoing, unpublished work, namely:

- Clustering Predictions of gas-rich galaxies
- The Stellar Mass function of gas-rich galaxies

Interested people can contact me in case they need to discuss anything related to the above mentioned results.