International Centre for
Radio Astronomy Research

Galaxy Formation Modelling for the TAIPAN & WALLABY Surveys

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Curtin University

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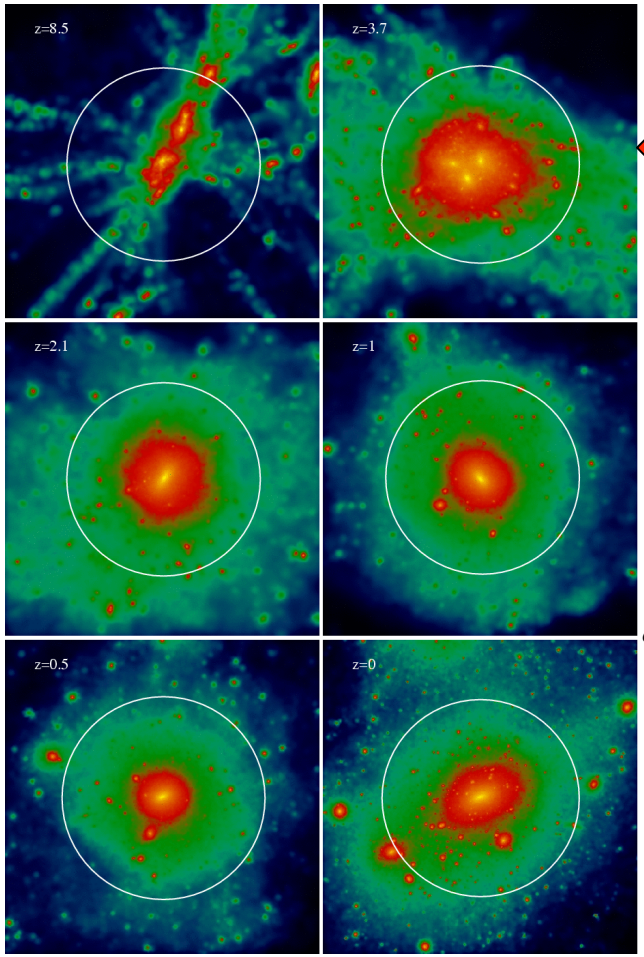
Outline

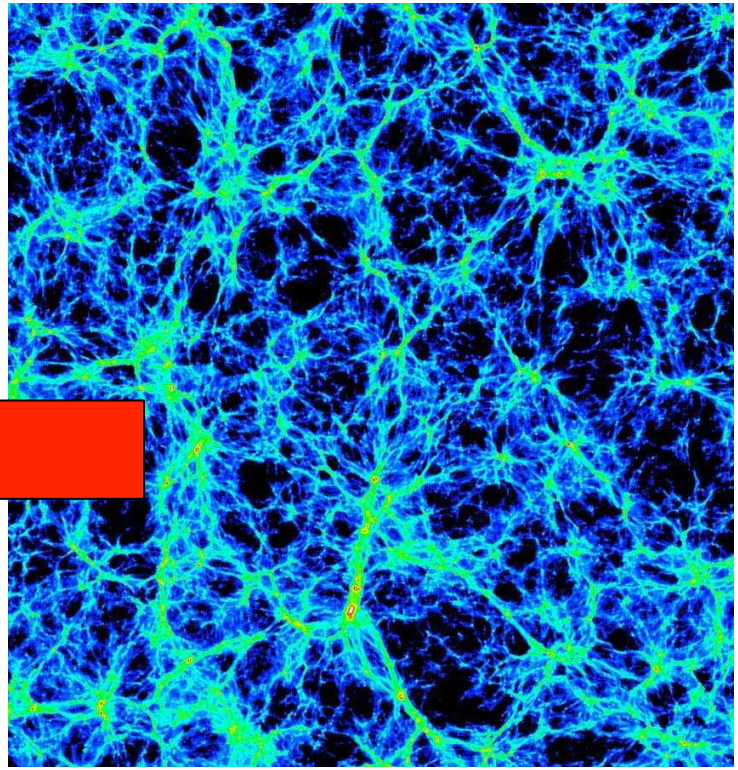
- Background: galaxy formation models and the tyranny of scales...
- Overview: semi-analytical approach.
- Innovation: modelling neutral hydrogen in galaxies.
- Comparison : HI properties of r-band selected galaxies.

How do Galaxies Form?



Gravity

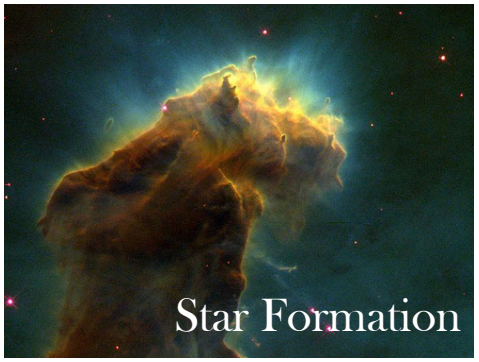
✔

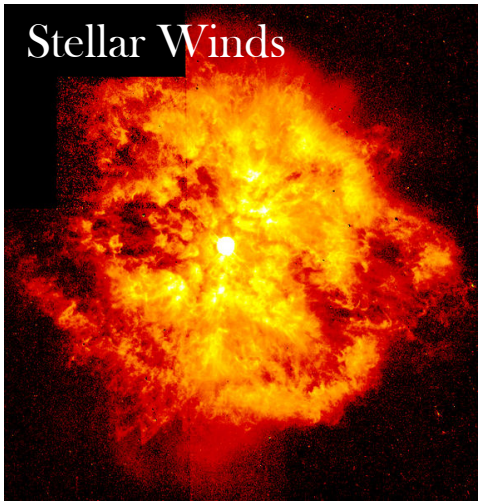


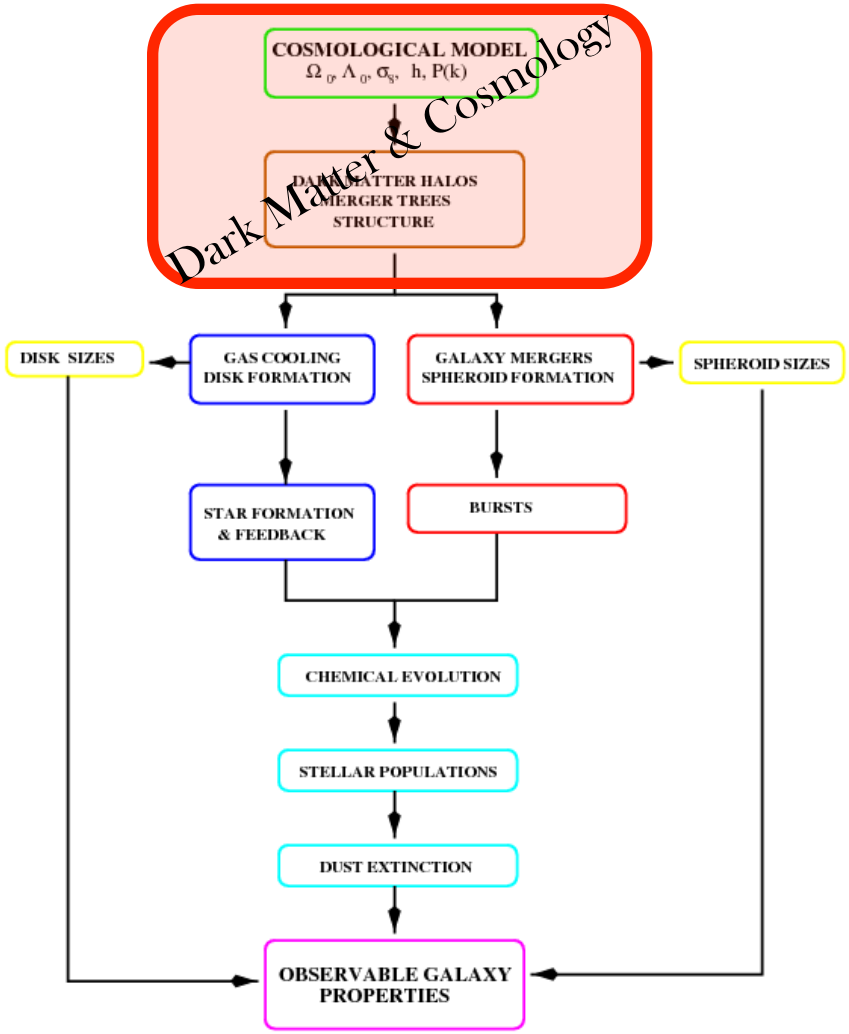
"Gastrophysics"

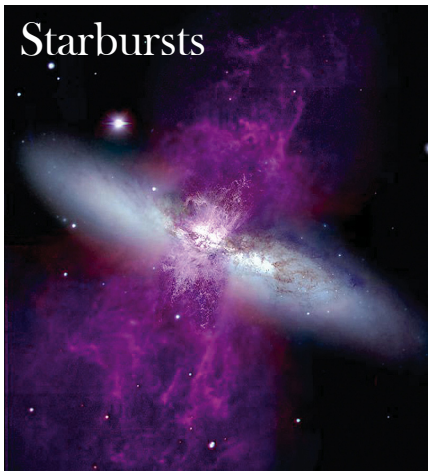
?

Physics of Galaxy Formation



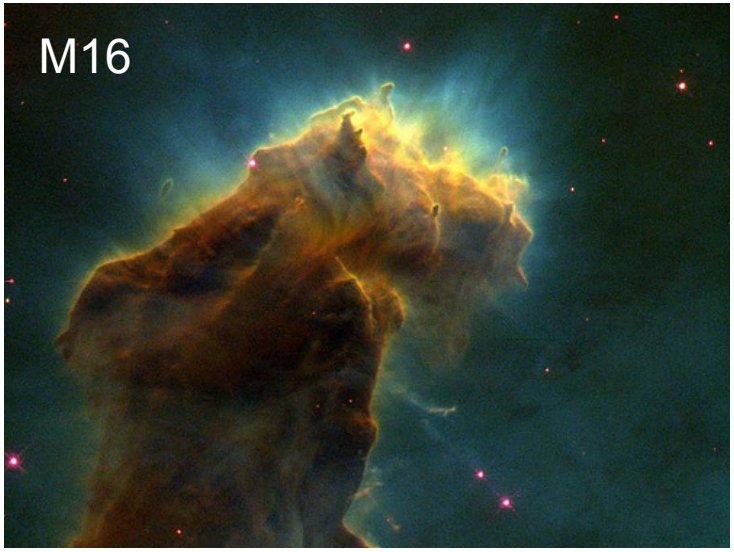




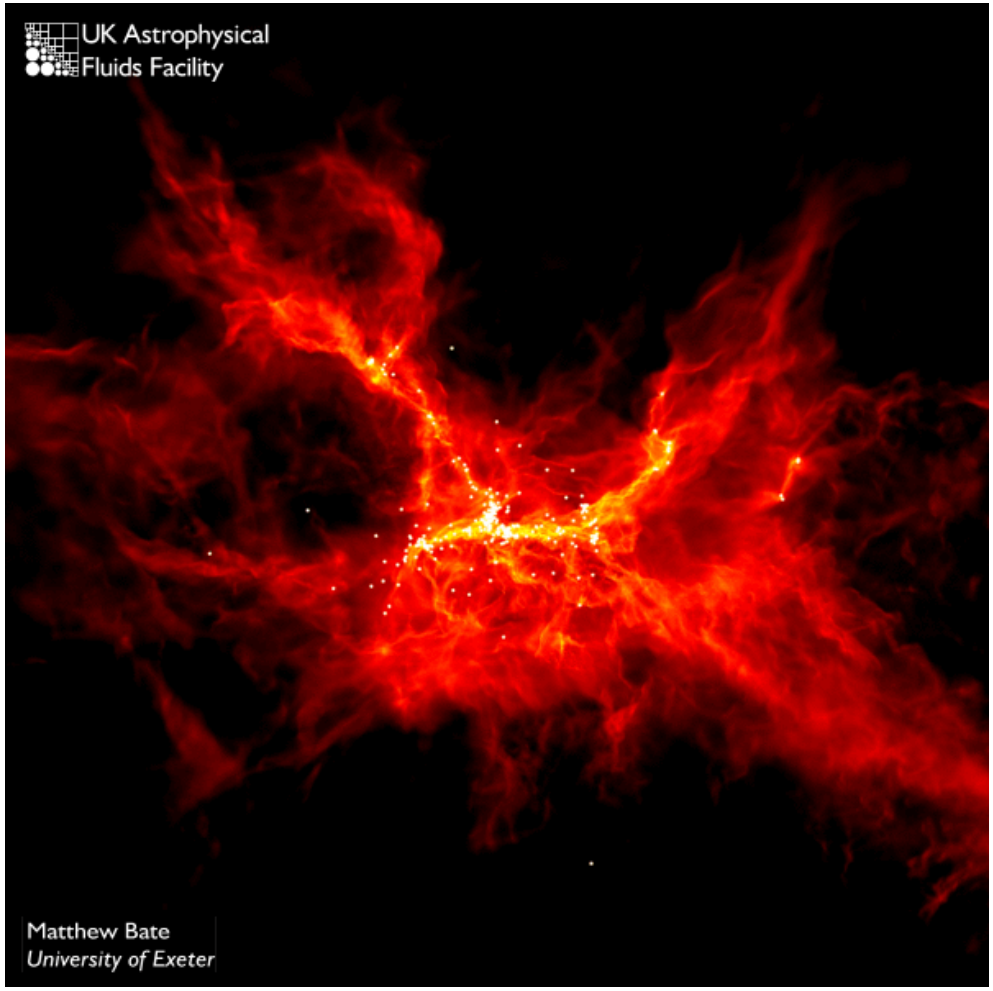


From Baugh (2006)

Case Study: Parameterising Star Formation

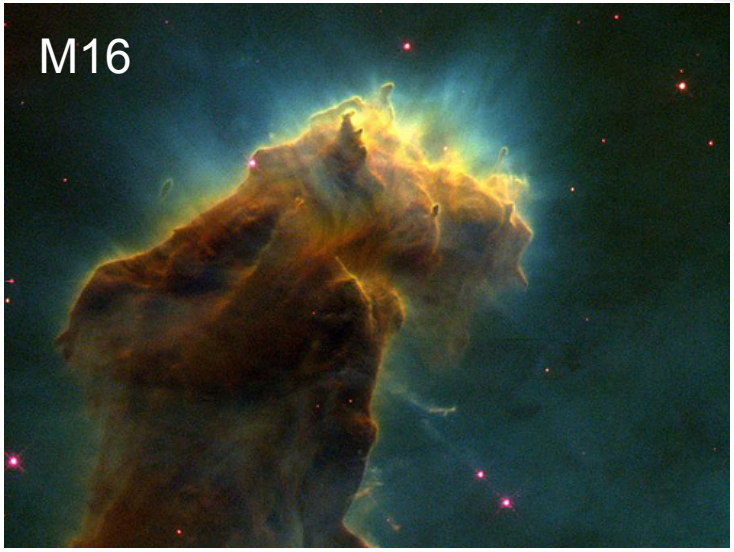


- Star formation is a tough problem.
- Physically: Magnetic fields? Radiation field? Chemistry?
- Numerically: resolve sub-pc scales in typical galaxies?

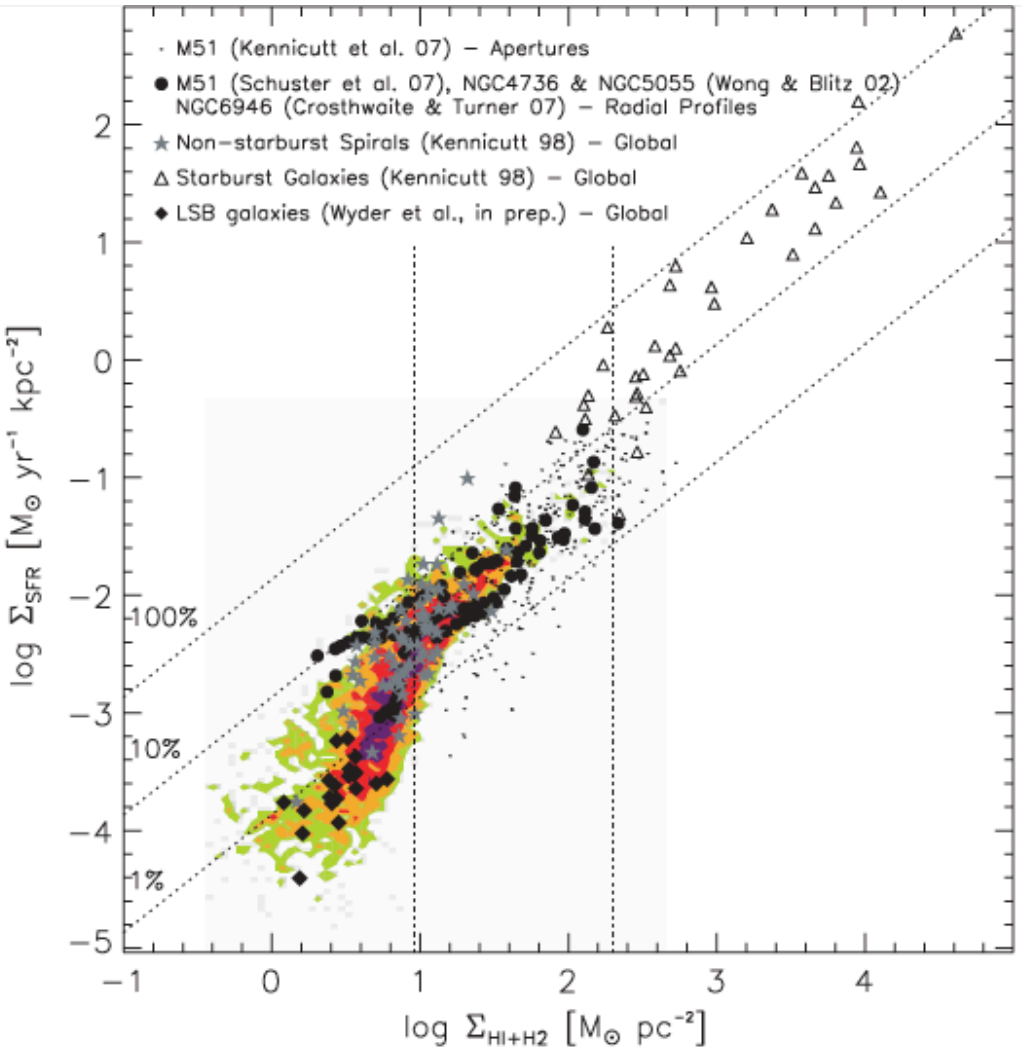


Simulated Trapezium; Bate 2009

Case Study: Parameterising Star Formation



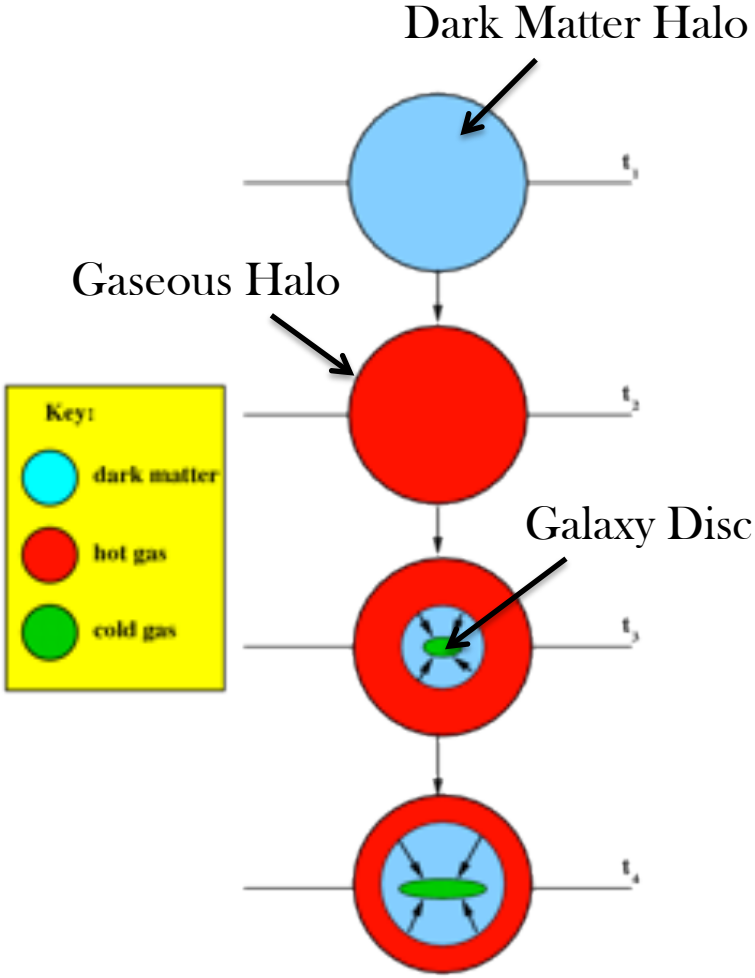
- Observe scaling relation between star formation rate and surface density.
- Parameterise models to reproduce observed scaling relation.



THINGS Survey; Bigiel et al. 2008

Parameterised Galaxy Formation

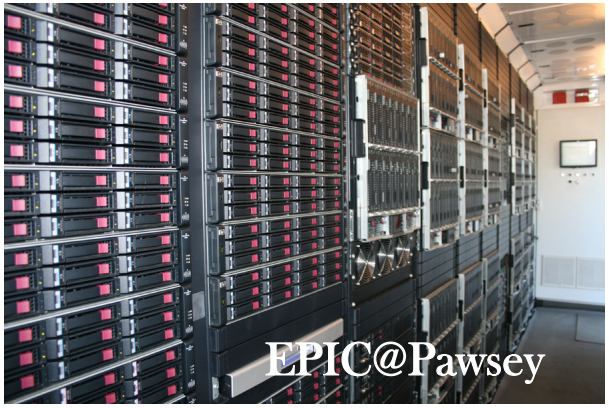
- Gas cools from hot gaseous halo.
- Angular momentum conserved, so disc forms.
- Dense cold gas forms stars.
- Supernovae expel gas from disc.
- Replenishes and enriches hot halo.
- Self-regulating cycle? Mergers?



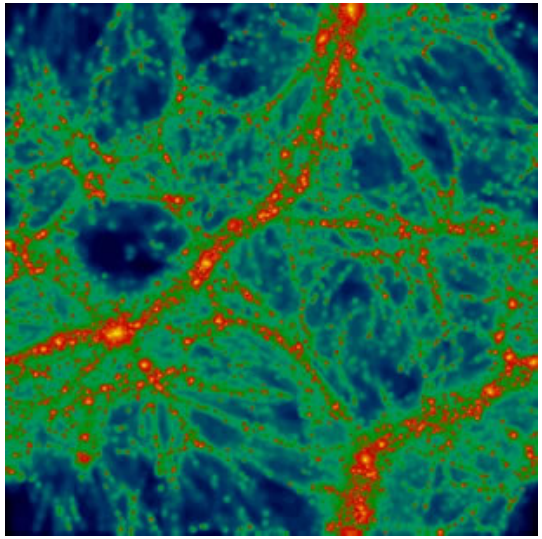
From Baugh 2006

Building a Synthetic Universe

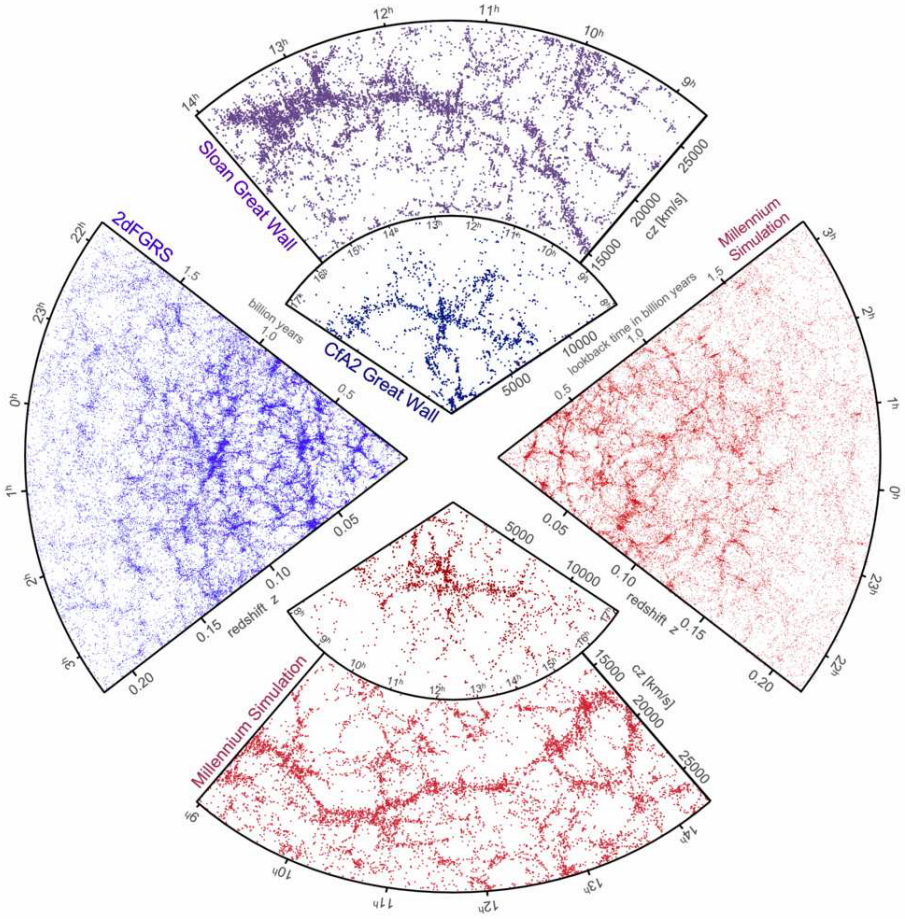
Take a state-of-the-art supercomputer...



... build a model Universe ...

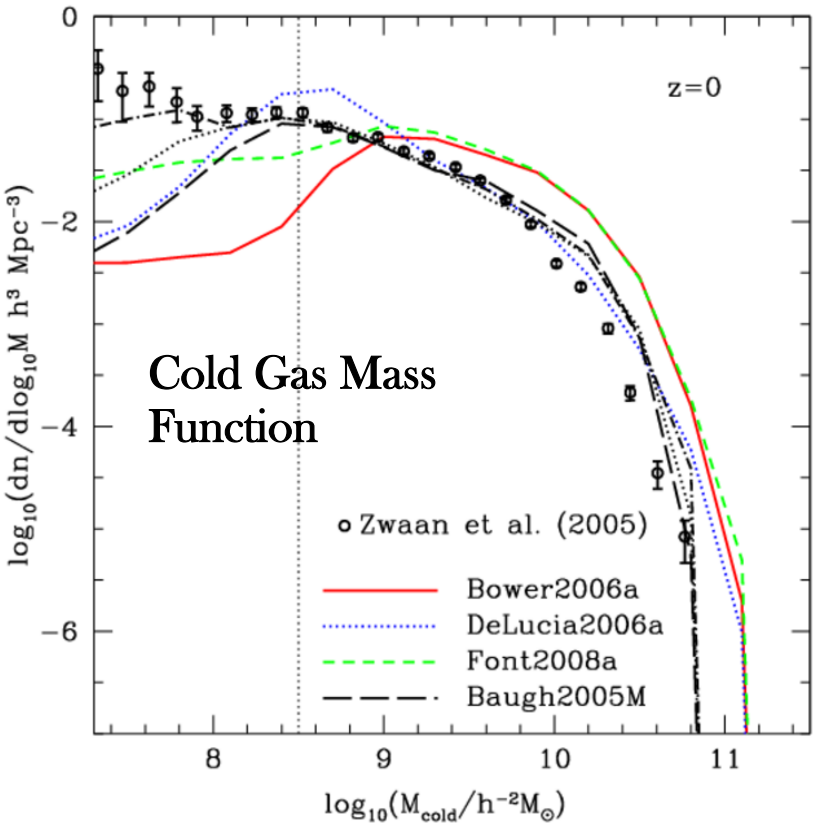


Credit: Springel, Frenk & White 2006



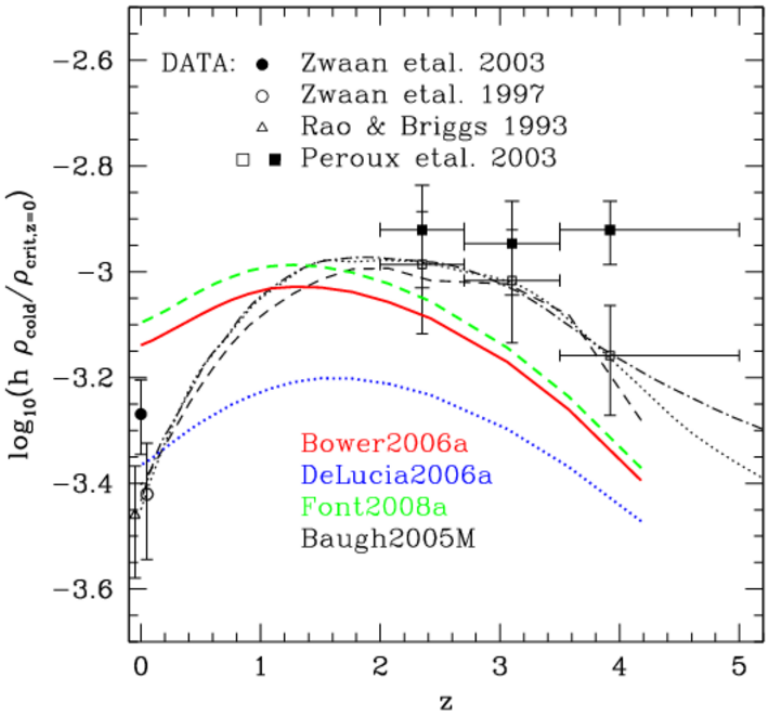
... and compare with the real Universe!

Modelling Cold Gas in Galaxies



From Power, Baugh & Lacey 2010

- Observed and predicted mass functions in reasonable agreement.



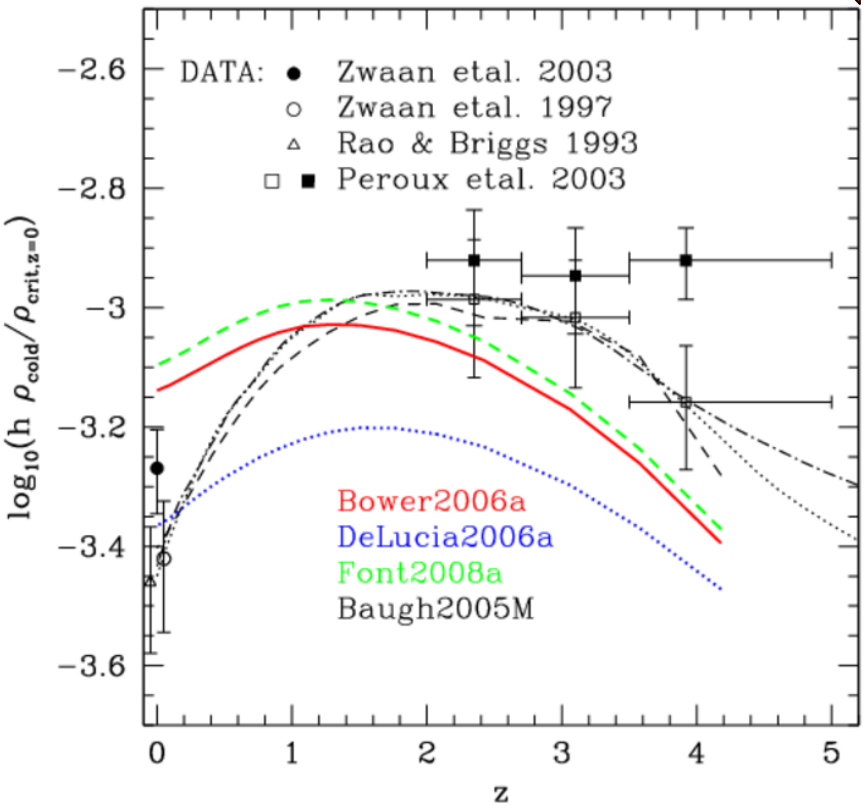
Global Density of Cold Gas

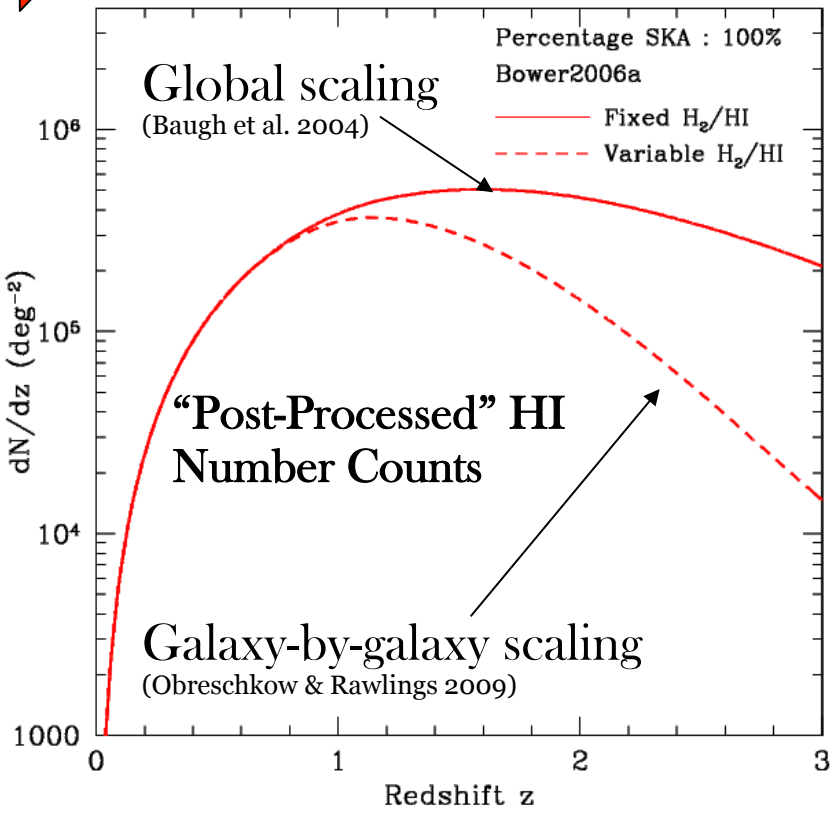
Redshift Evolution of Cold Gas Content

Prediction: Cold Gas

?

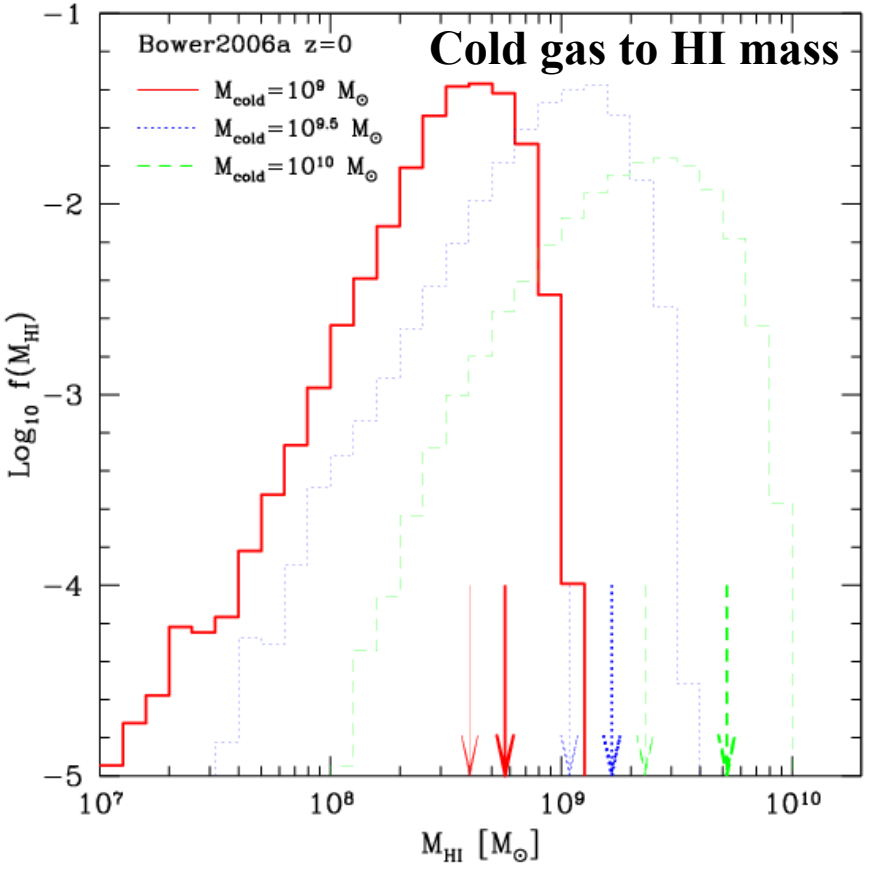
Observable : HI/H2/CO

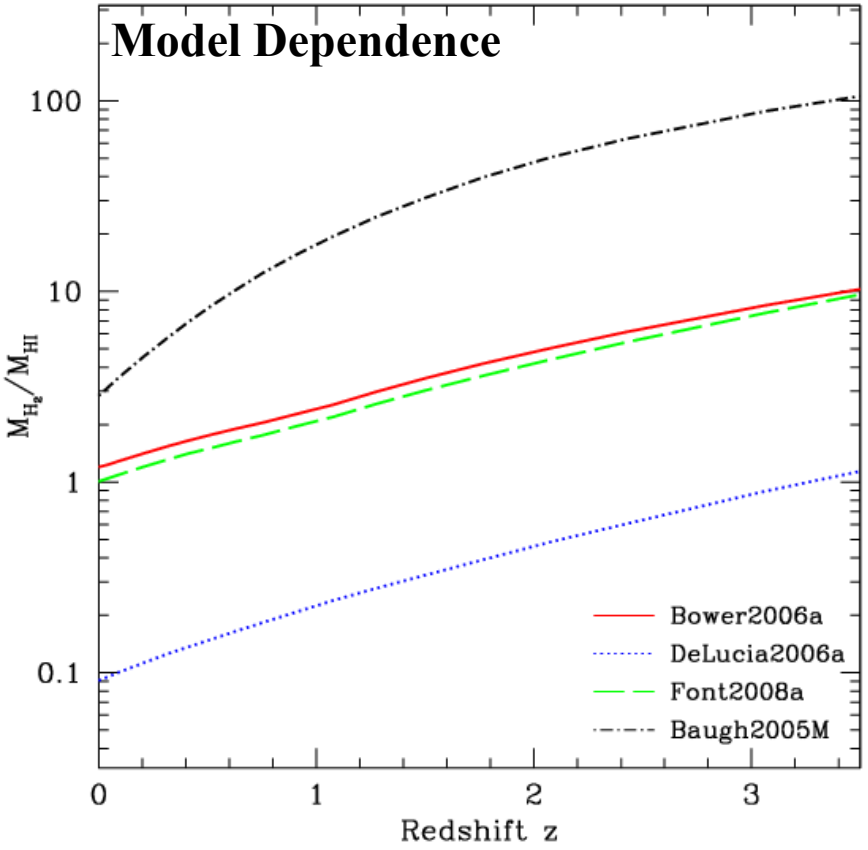




From Power, Baugh & Lacey 2010

The Problem of Conversion Factors





From Power, Baugh & Lacey 2010

Linking SFR to H_2

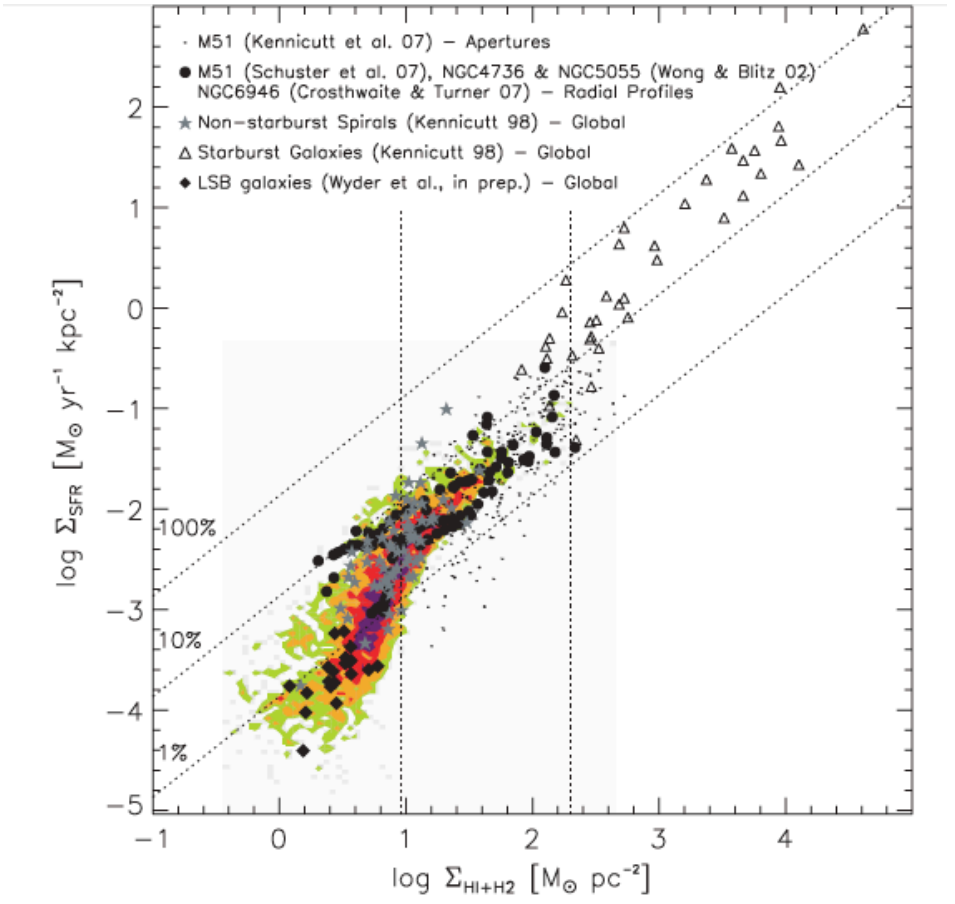
- Lagos et al. 2011 : assume SFR determined by Σ_{H2}

$$\Sigma_{SFR} = \nu_{SF} f_{mol} \Sigma_{gas}$$

where f_{mol} captures the split between HI and H_2.

- Blitz & Rosolowsky 2006 – midplane pressure in disc

- Krumholz, McKee & Tumlinson 2009 – ambient radiation field



THINGS Survey; Bigiel et al. 2008

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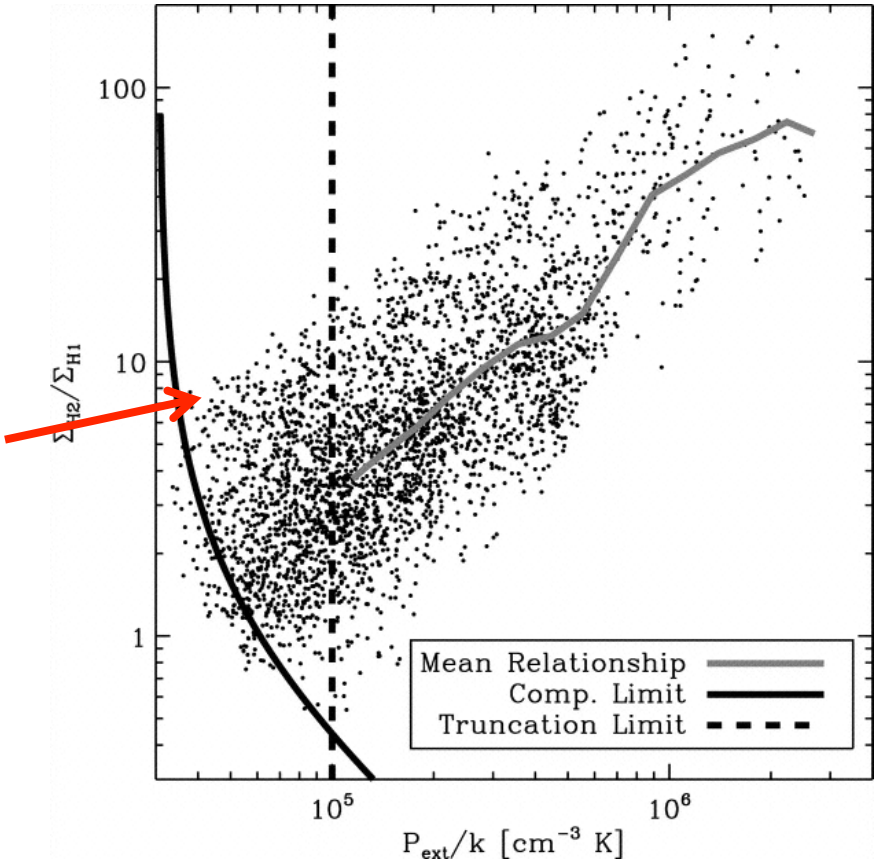
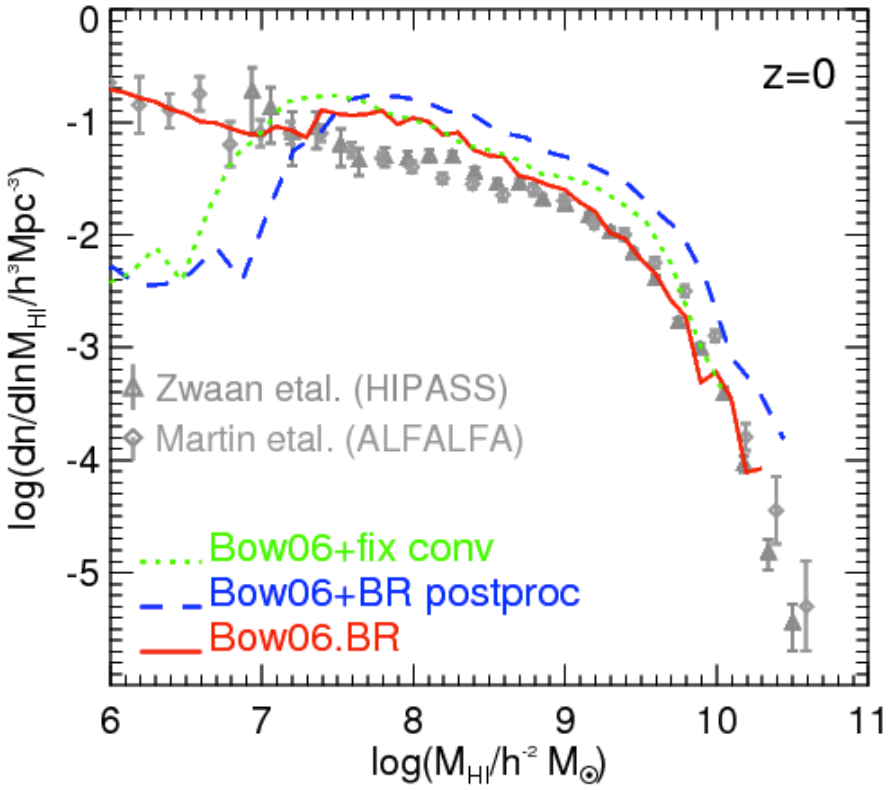
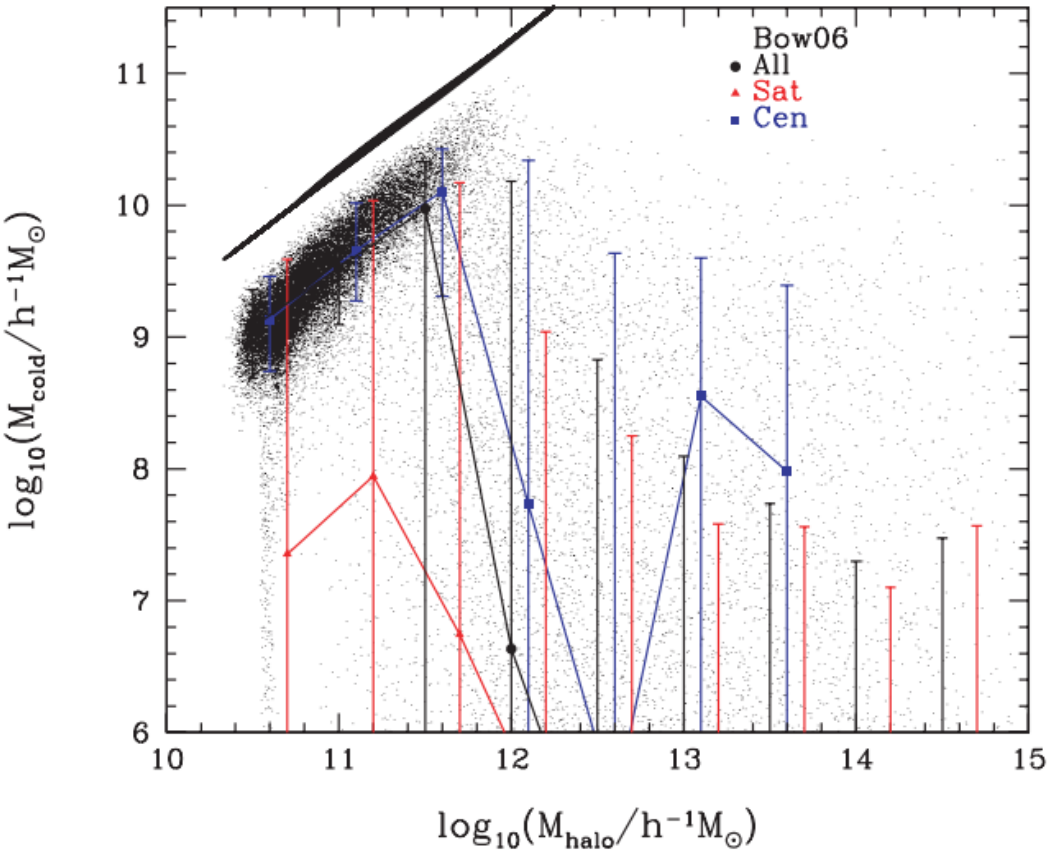


Self-Consistent HI Mass Function



Lagos et al. 2011 : self-consistent calculation of HI and H2 masses.

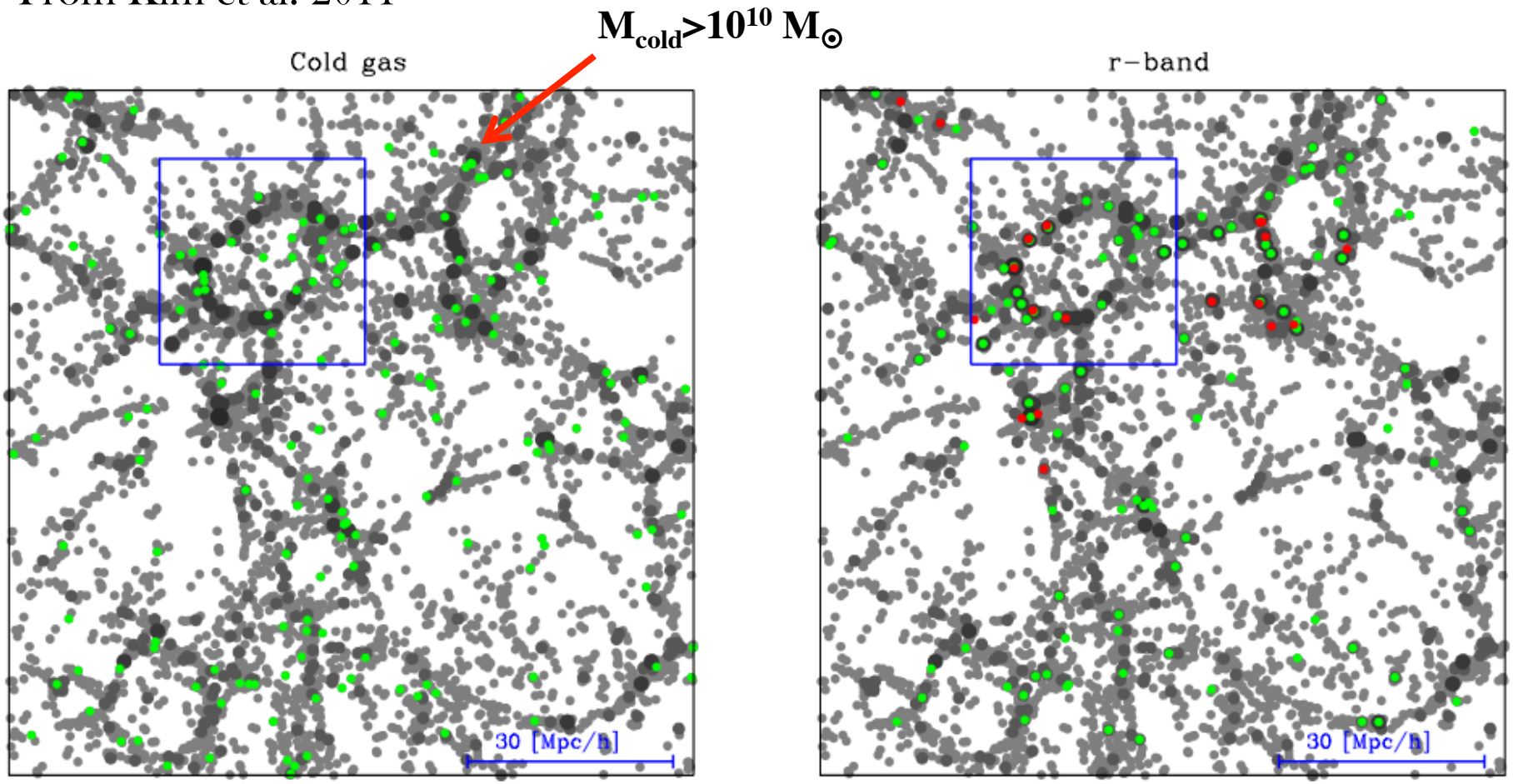
Where are the gas-rich galaxies?



Kim et al. 2011 : relationship between halo mass and cold gas mass

Where are the gas-rich galaxies?

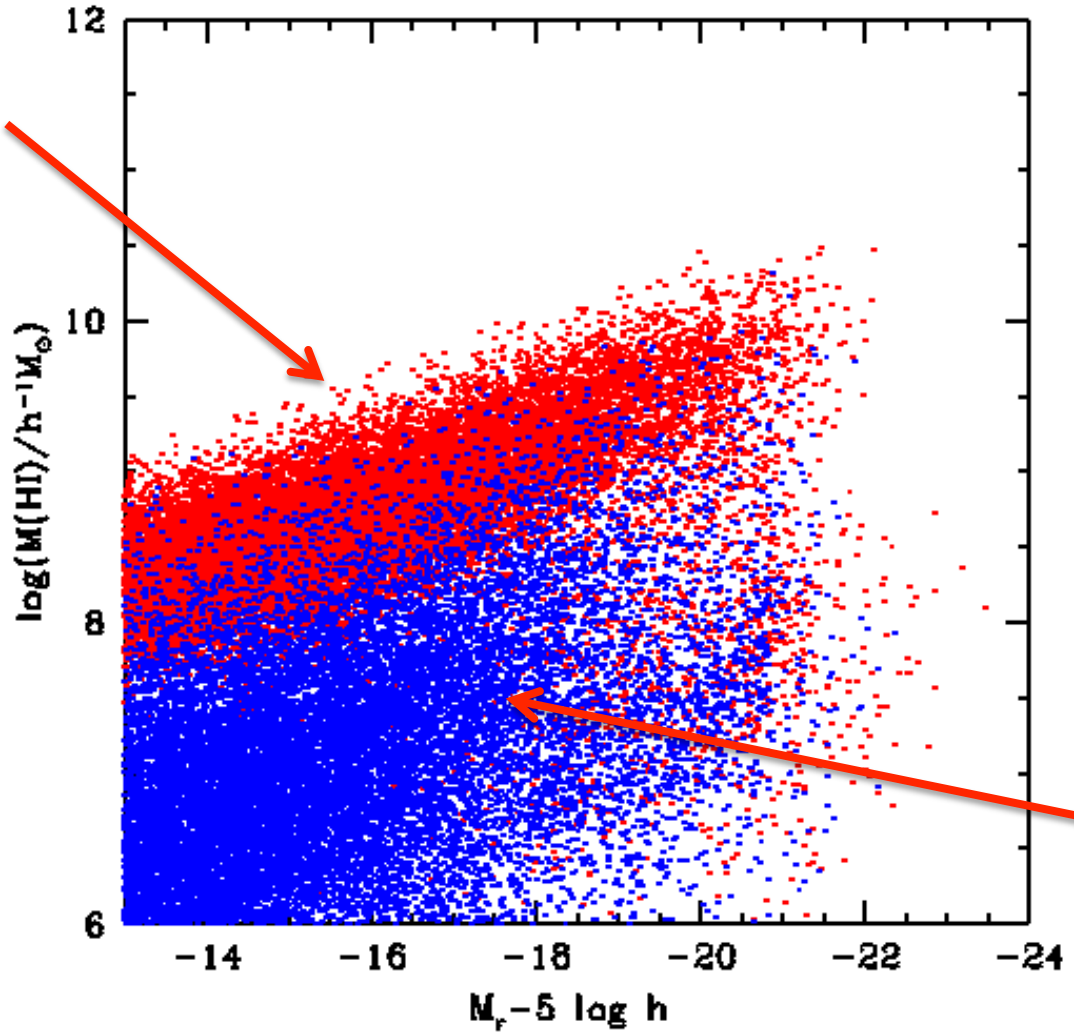
From Kim et al. 2011



Green (red) circles are central (satellite) galaxies. Note deficit of satellites with cold gas in high density regions.

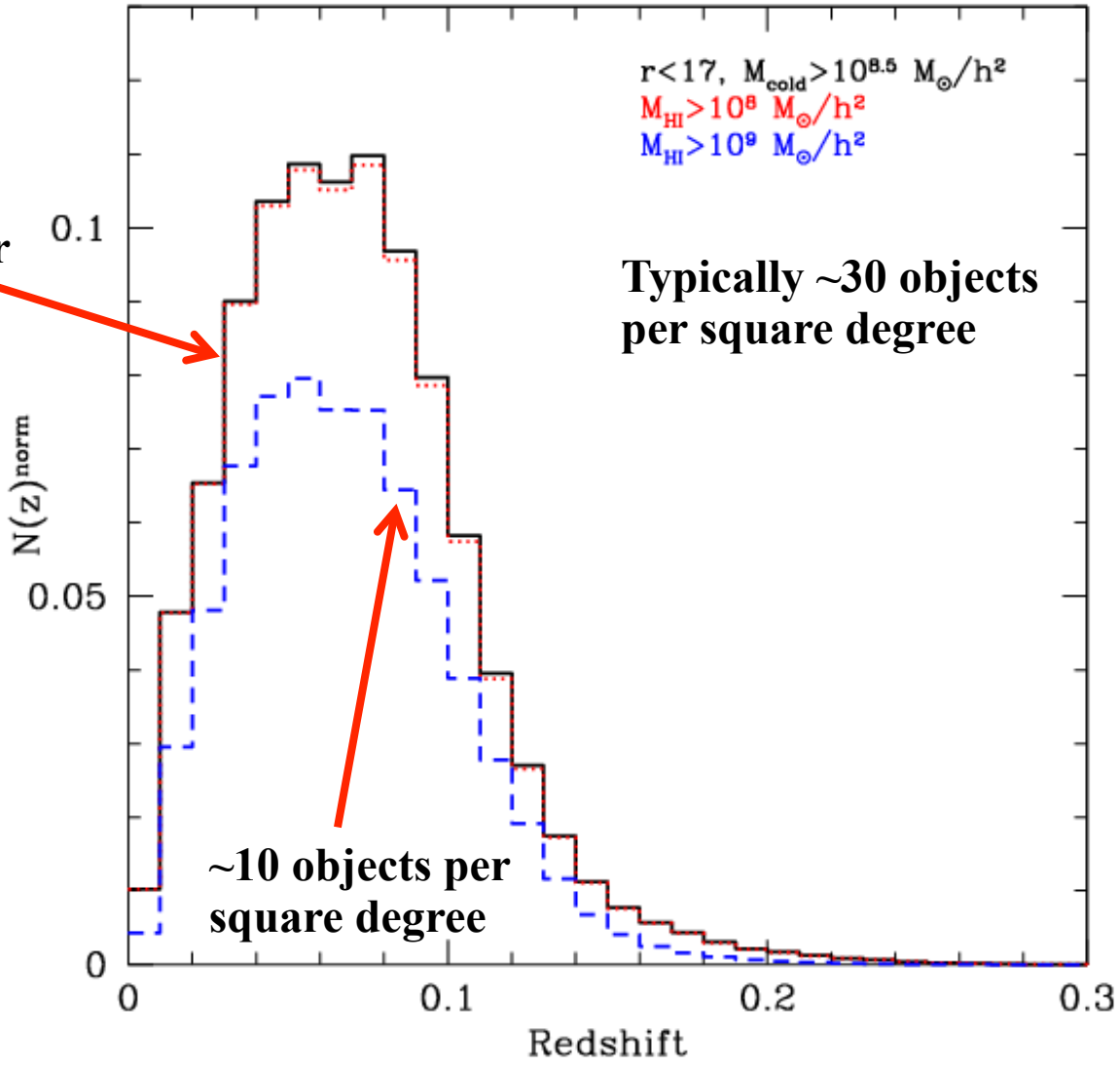
Correlation of r-band with HI mass

Central Galaxies



Satellites Galaxies

Numbers of Objects



~15 objects per square degree

Typically ~30 objects per square degree

~10 objects per square degree

Summary

- Parameterised approach unavoidable when modelling galaxy formation in cosmological volumes.
  - Cold gas surveys drive innovations in next generation of models.
- Gas rich galaxies tend to trace filaments and avoid high density region.
- Gas-richness differentiates satellites from centrals – no such differentiation in r-band.
- Expect 30 (10-15) objects per square degree in r-band (& gas-rich).