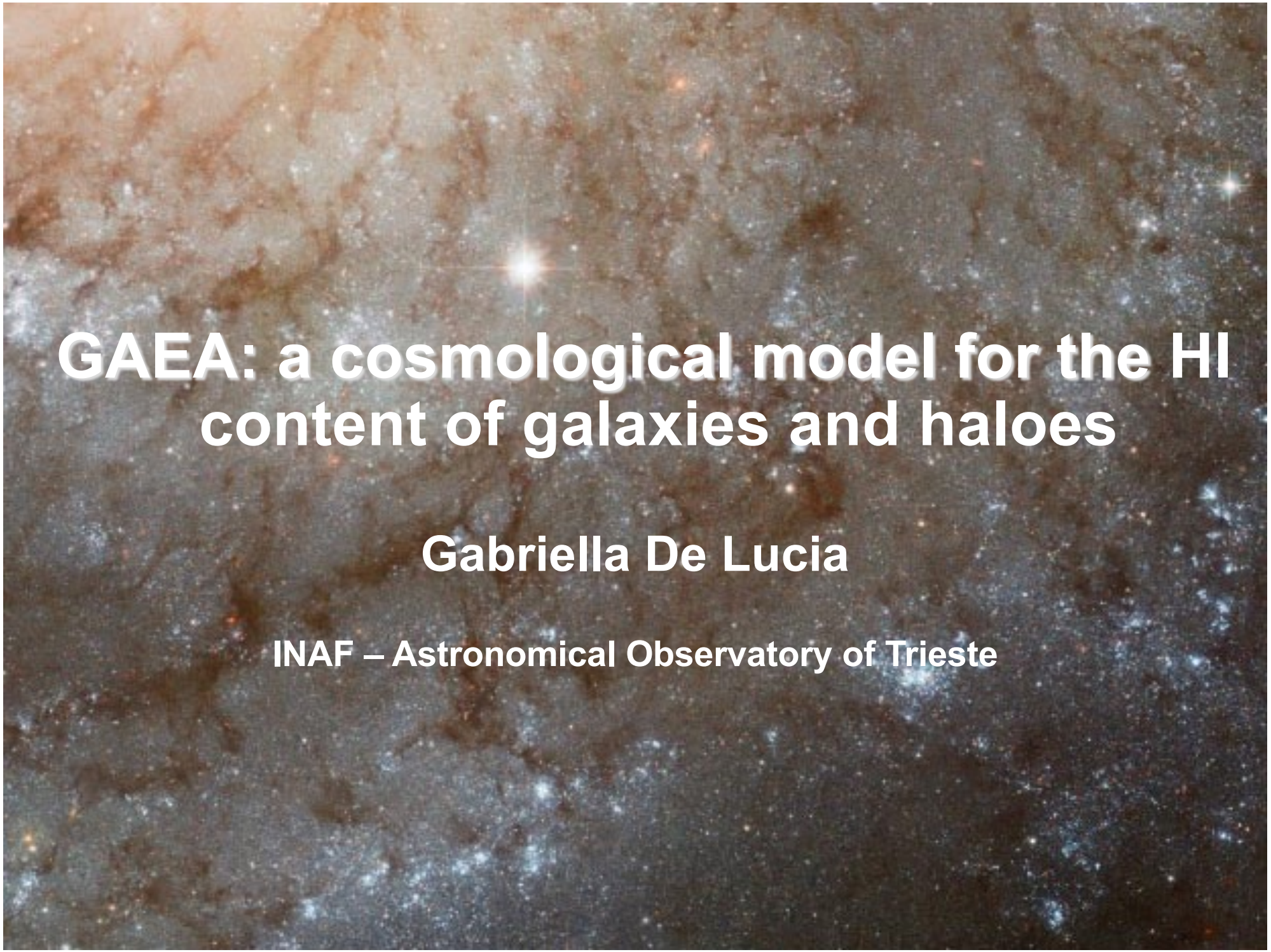


GAEA: a cosmological model for the HI content of galaxies and haloes

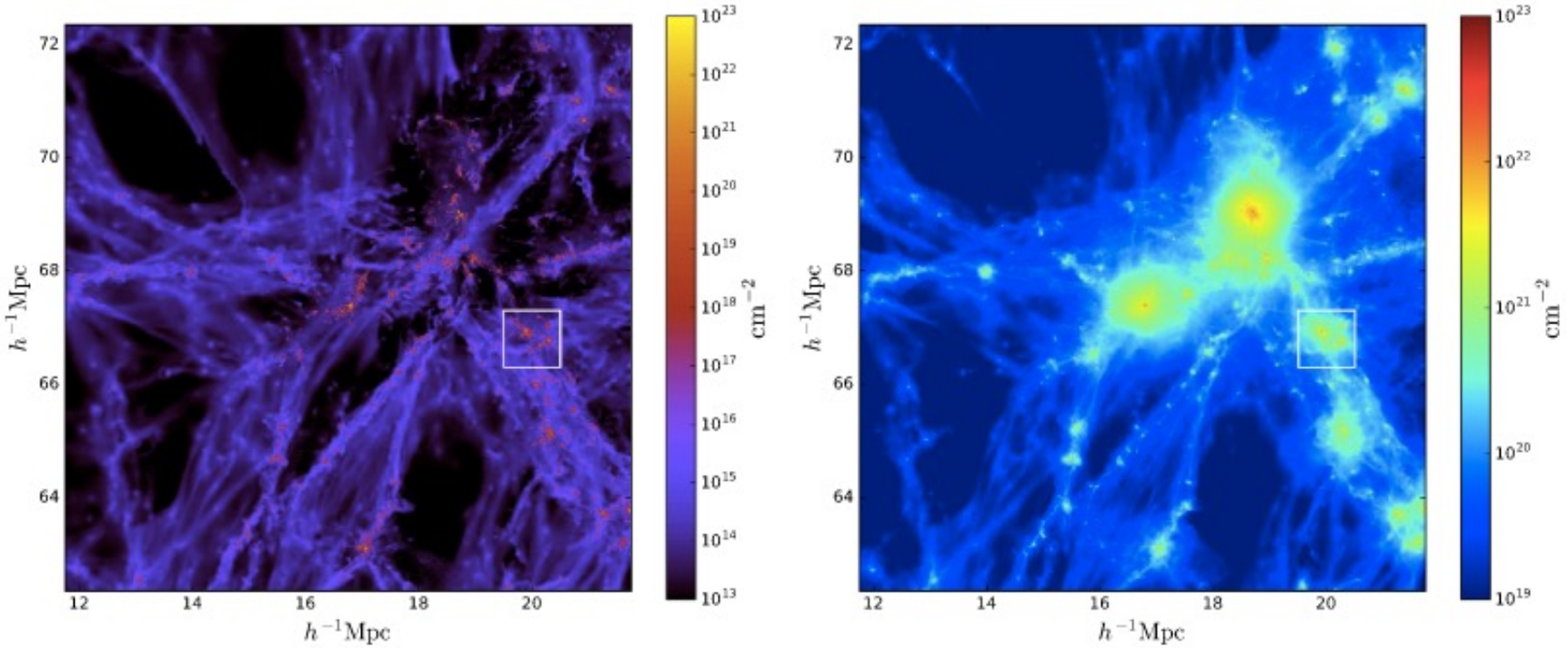
Gabriella De Lucia

INAF – Astronomical Observatory of Trieste

A complex physical problem

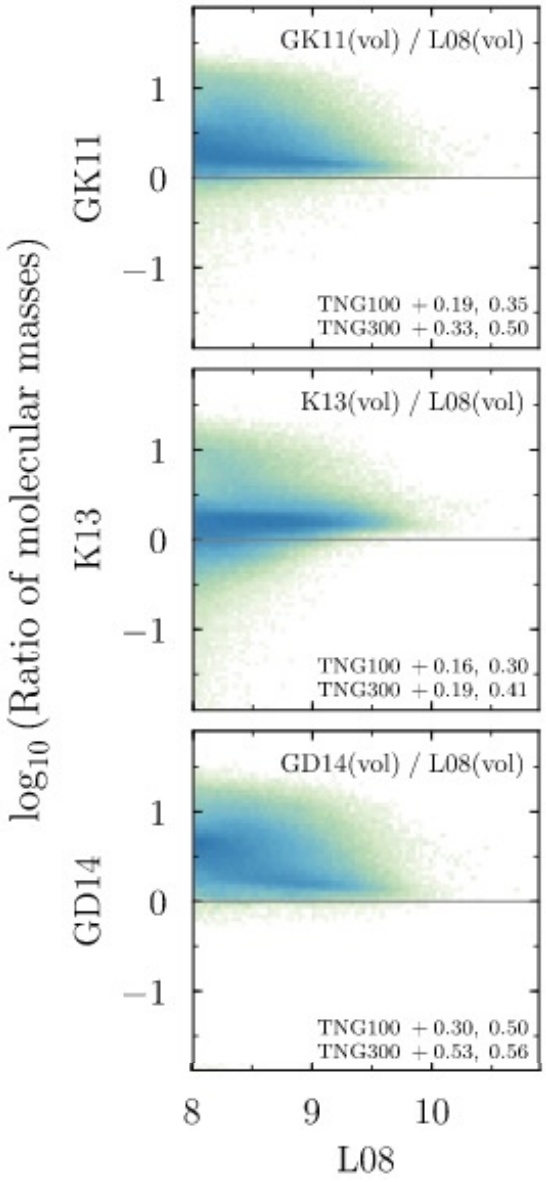
H_2 forms predominantly on the surface of dust grains (not typically modeled), and is efficiently destroyed by UV radiation in the LW band, shielded by dust, HI and H_2.

Very difficult (impossible) to account for all these processes self-consistently in cosmological simulations: post-processing.



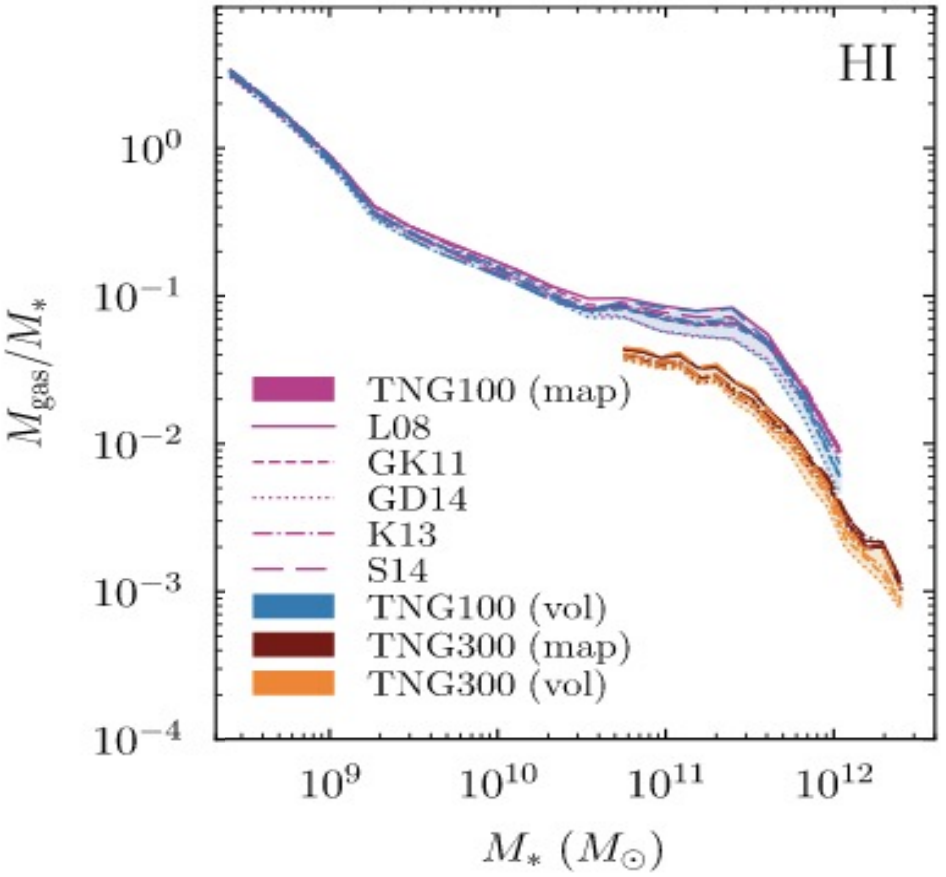
Villaescusa-Navarro et al. 2018

Post-processing of hydro-simulations



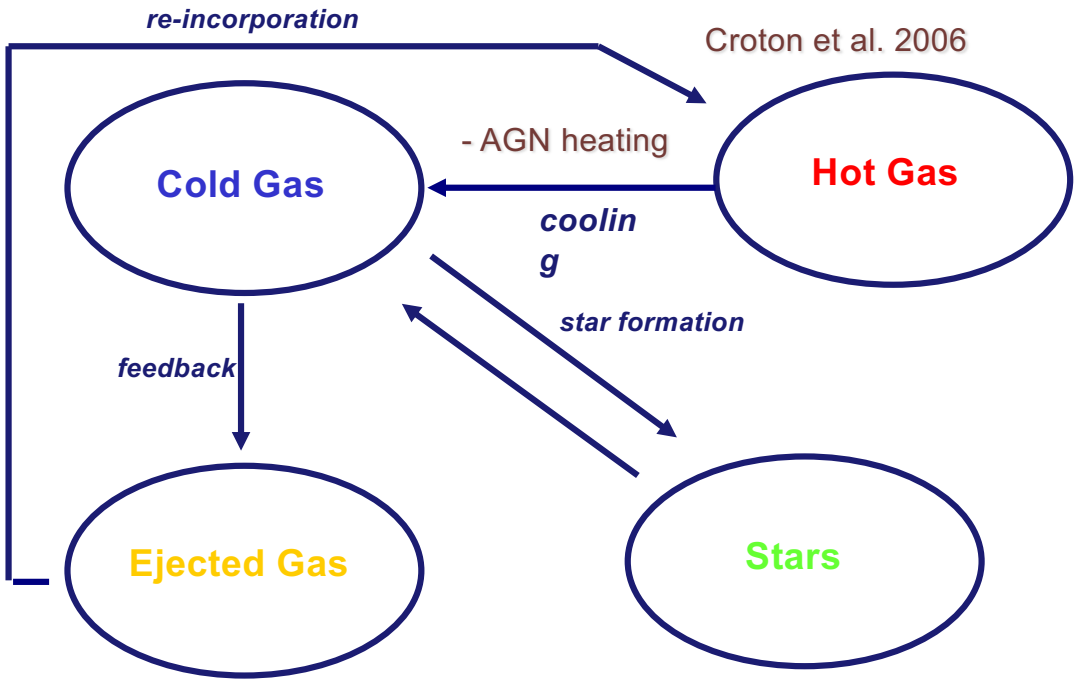
Good agreement between average properties but predictions diverge for integrated properties, as well as spatial distribution of molecular/atomic gas in individual galaxies

Diemer et al 2018

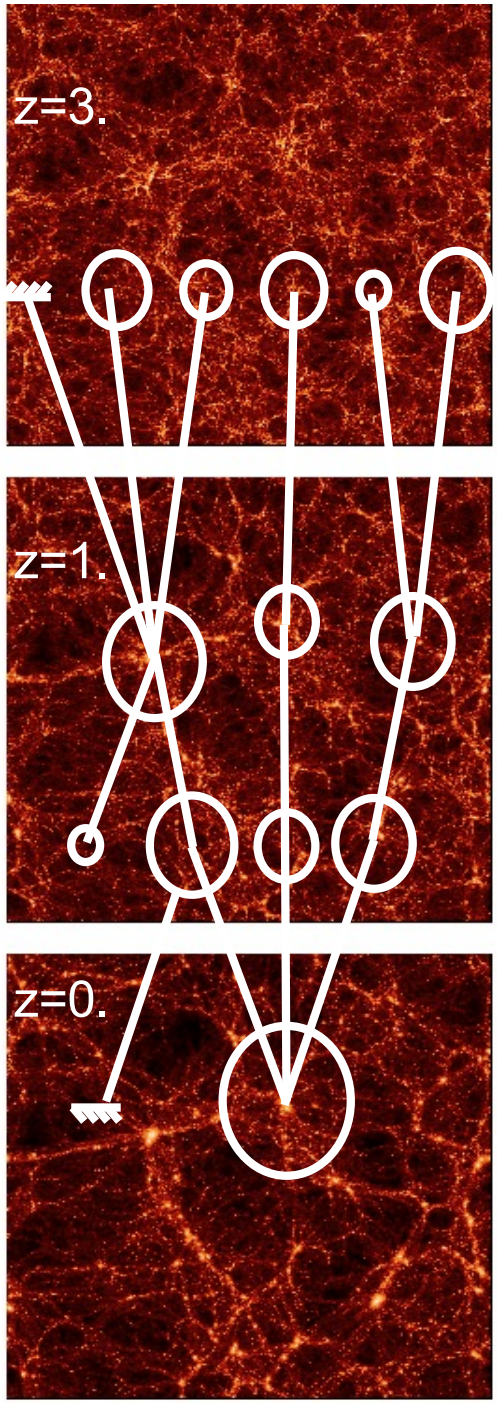


Semi-analytic models

Rely on simple, yet physically and/or theoretically motivated prescriptions to model the evolution of the baryons. Coupled to dark matter simulations that are used to specify the location and evolution of dark matter haloes. Limited computational times. But no explicit description of the gas dynamics.

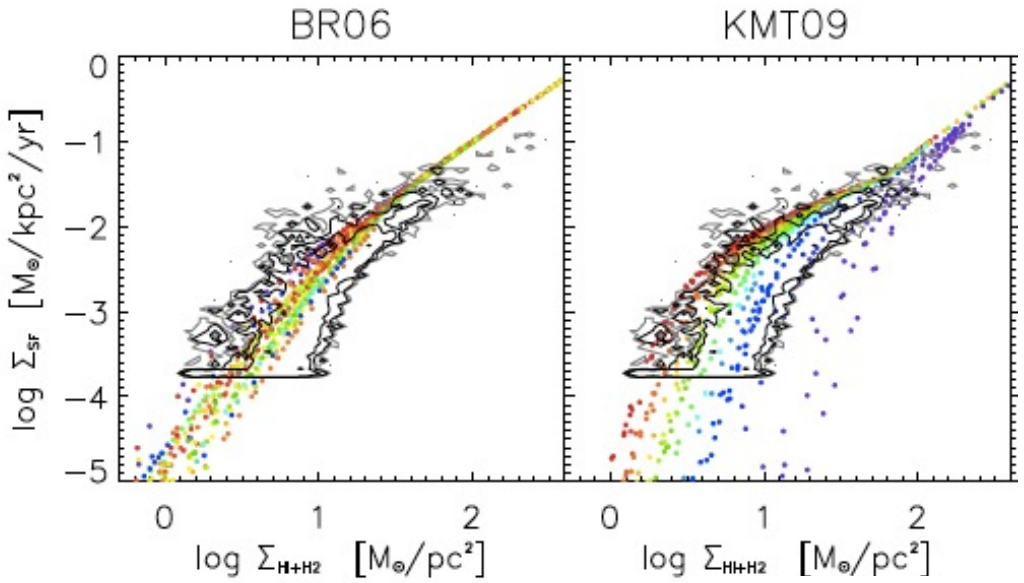


De Lucia, Kauffmann & White, 2004



Kauffmann et al., 1999

Molecular and atomic hydrogen

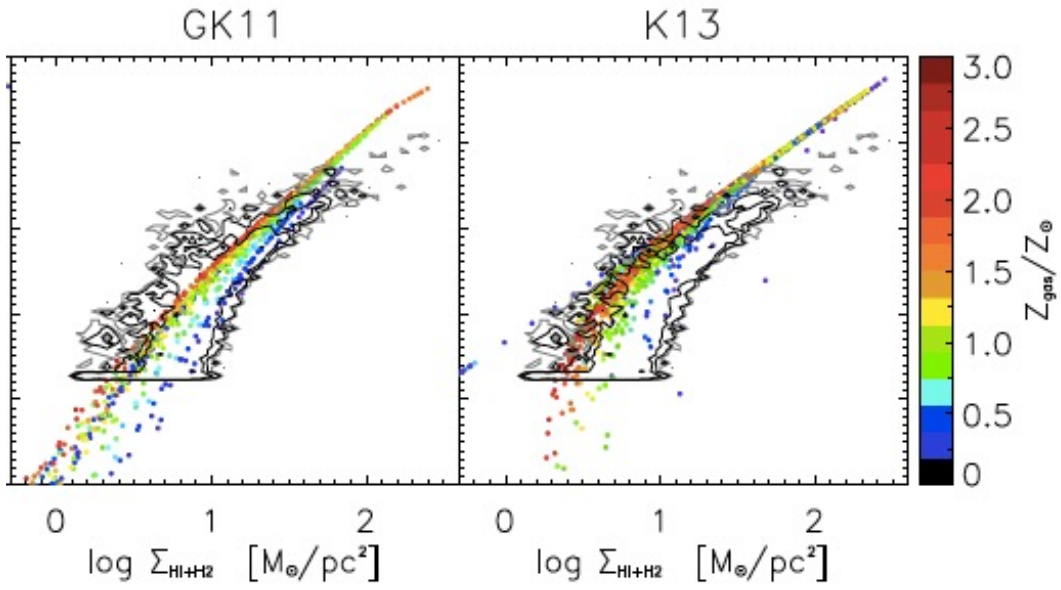


Different prescriptions to model the partition of the cold gas in its molecular and atomic components

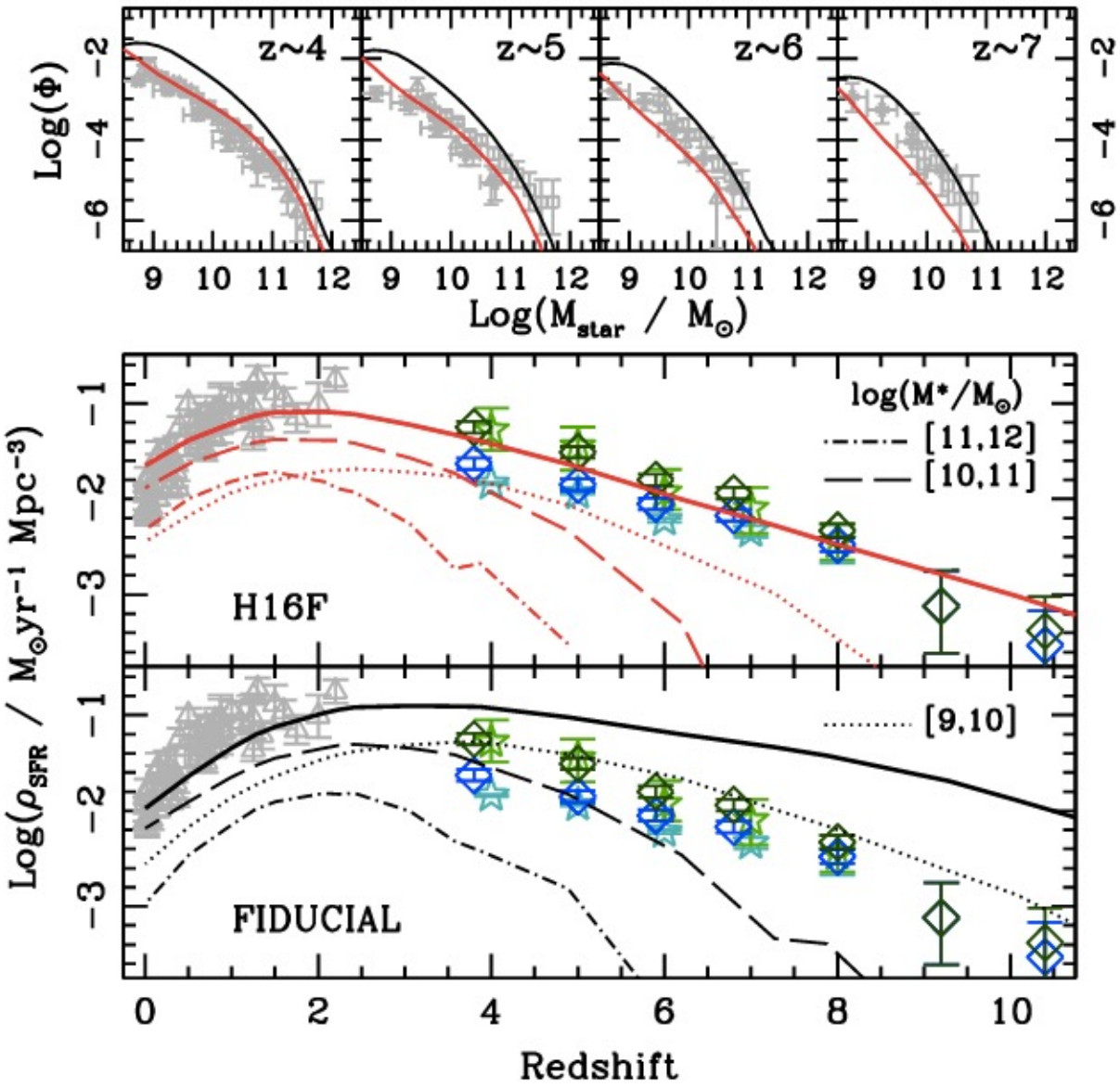
Tracing of the angular momentum evolution and H_2 based star formation law

Our reference model is calibrated mainly on the HI and H_2 local mass functions.

Lagos et al. 2011;
Somerville et al. 2015;
Xie et al. 2017



The GSMF, out to the cosmic dawn



Our reference model reproduces nicely the measured galaxy mass function out to z~7 and the cosmic SFR out to z~10 (these data have NOT been used to `tune' the model).

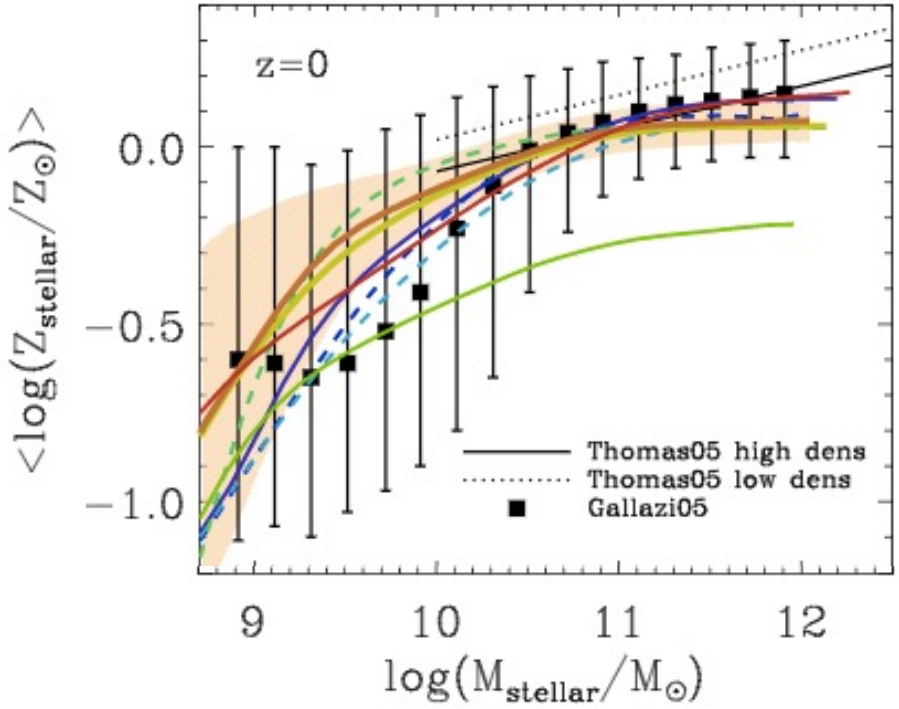
Reference model (**Hirschmann, De Lucia & Fontanot 2016**) is publicly available at **https://apps.sciserver.org** (contact us!)

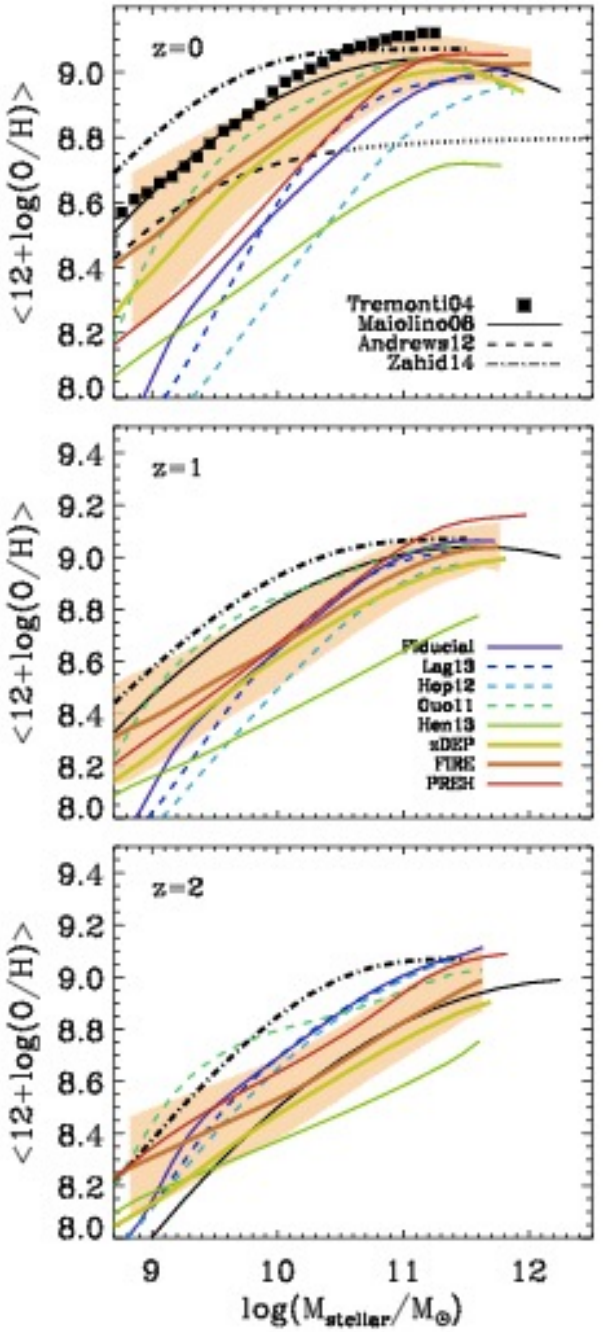
Fontanot et al. 2017

Metals in stars and gas

GAEA reproduces the observed mass-metallicity relations at z=0 and predicts an evolution of these as a function of z (qualitative agreement with data)

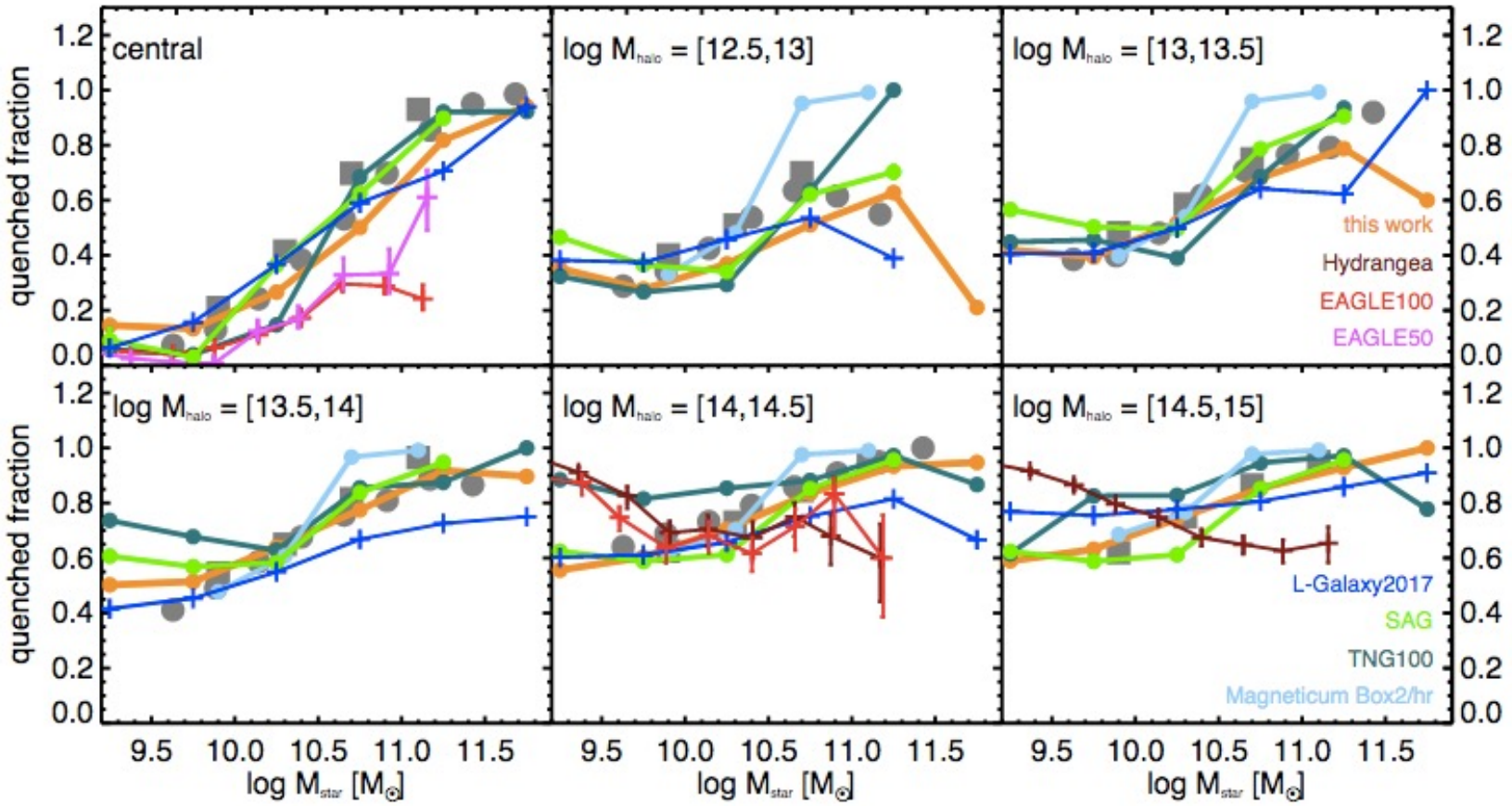
Results are robust against modifications of the chemical parameters (elemental yields, DTD of SNIa, IMF, etc.)





Hirschmann, De Lucia & Fontanot 2016

Quiescent fractions

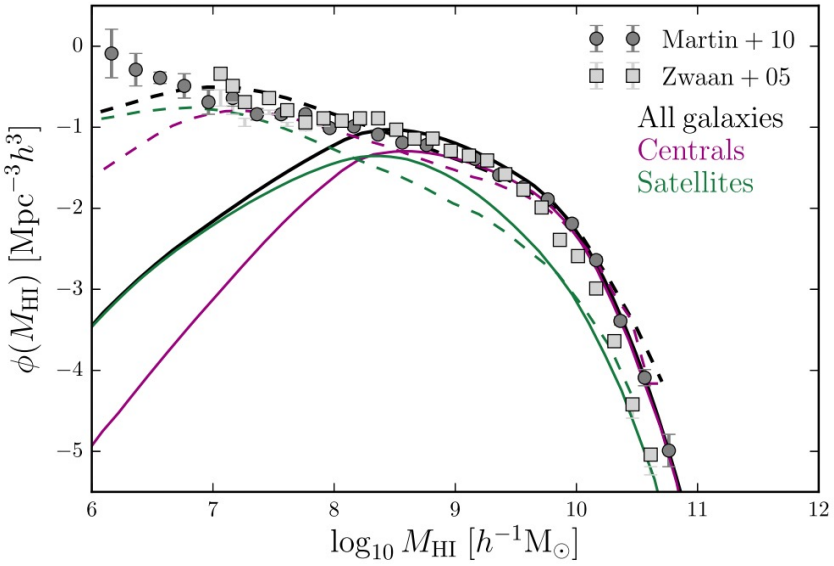


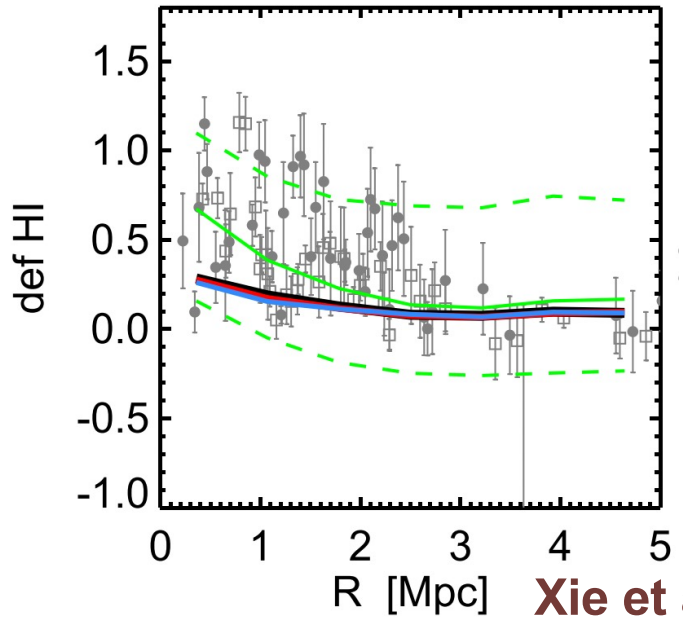
GAEA predictions in a context: no model/simulation provides a perfect match with available data at z~0. Our model performs quite well and can be used to make predictions to higher redshift.

Xie et al. 2020

HI in GAEA

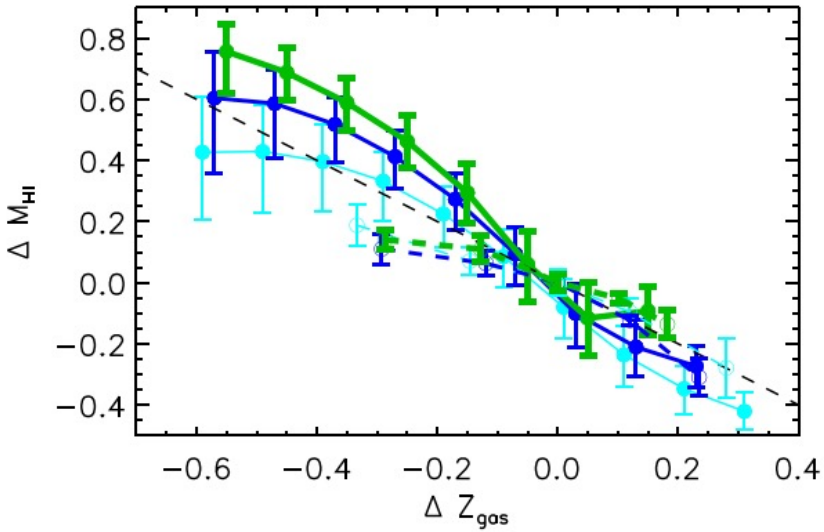
Spinelli et al. 2020

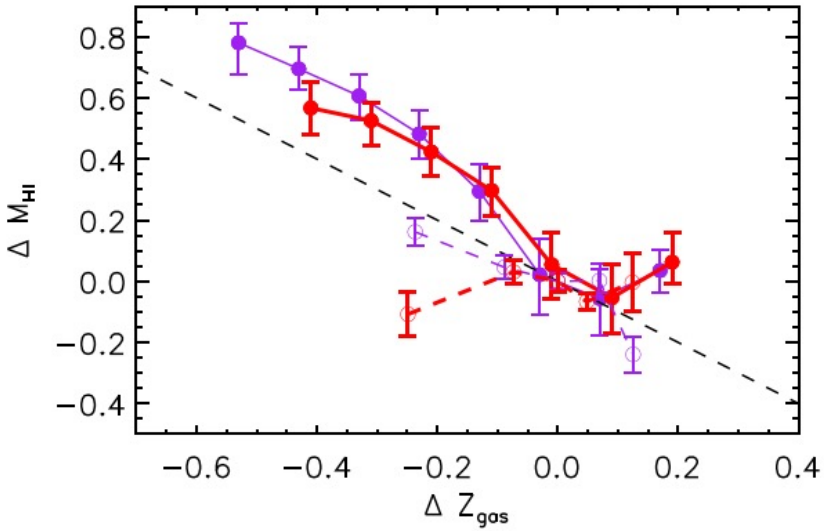




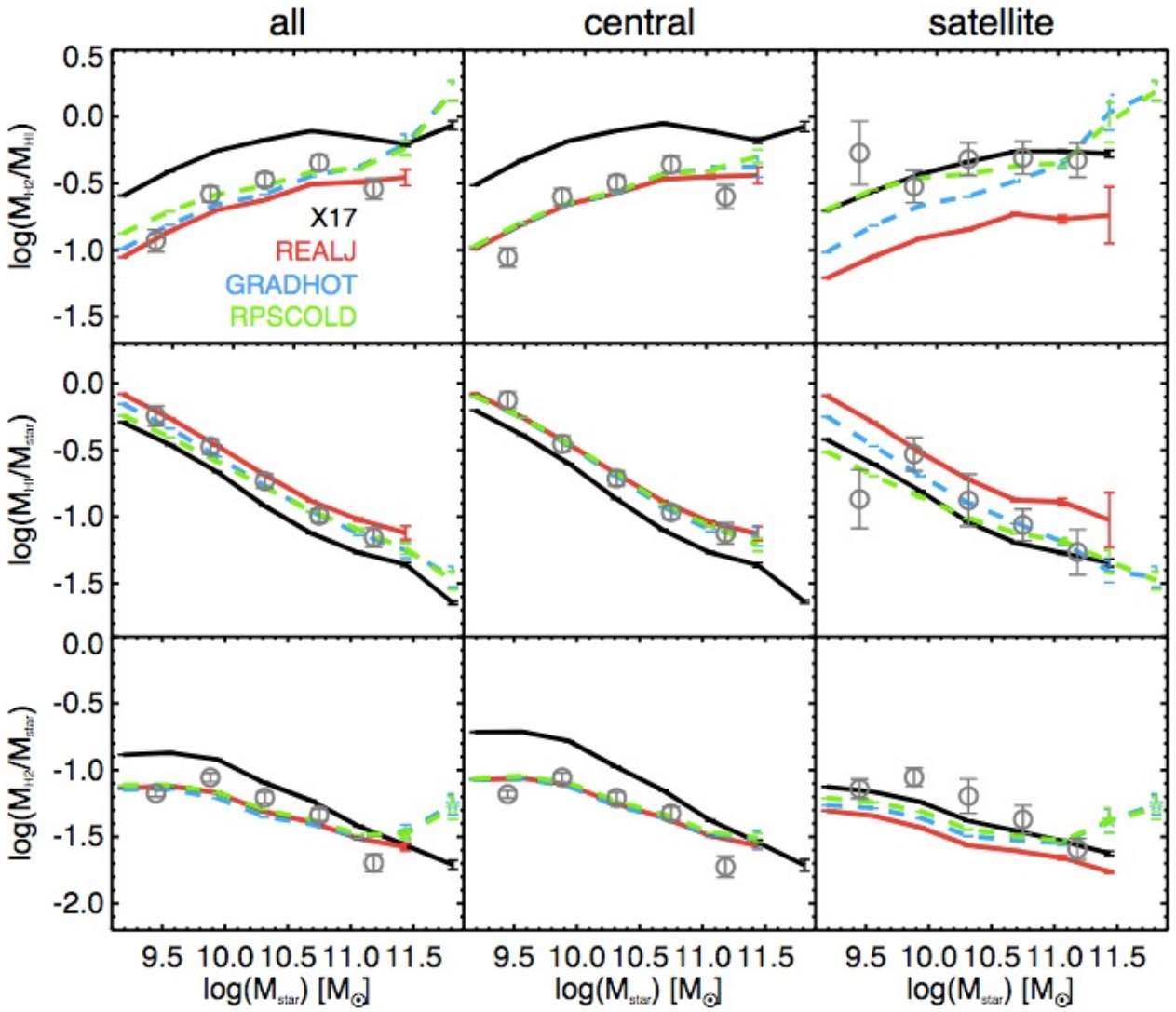
Xie et al. 2020

De Lucia et al. 2020





Gaseous content of centrals/satellites



Our updated model includes:

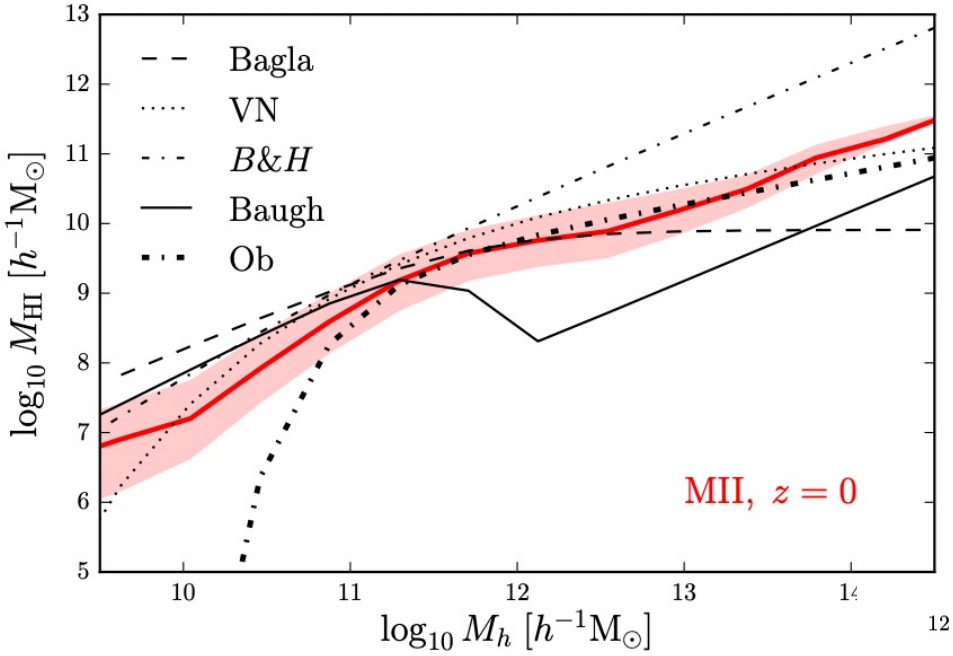
(i) A refined treatment for the angular momentum transfer;

(ii) A treatment for the gradual stripping of hot gas;

(iii) A treatment for ram-pressure stripping of cold gas.

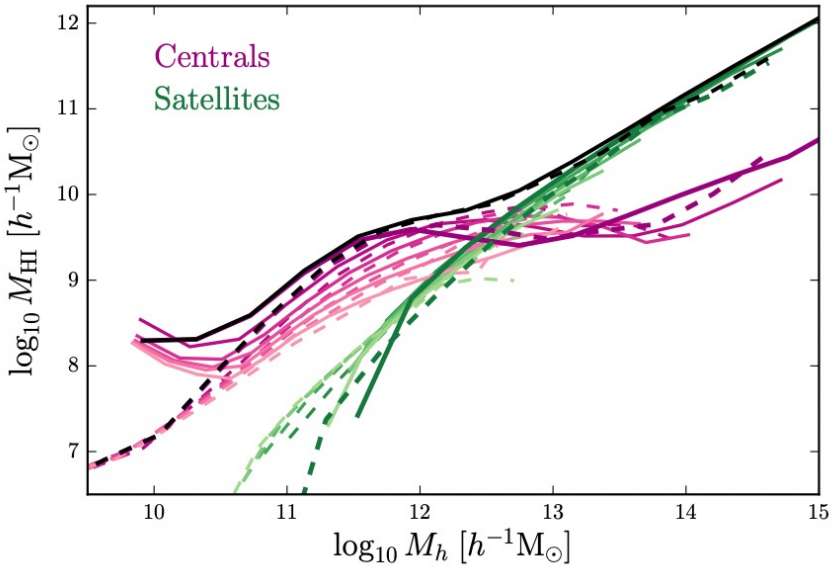
Xie et al. 2020

Intensity mapping forecasts



Very efficient tool to investigate the influence of different processes on the HI – halo mass relation (basic ingredient for intensity mapping calculations).

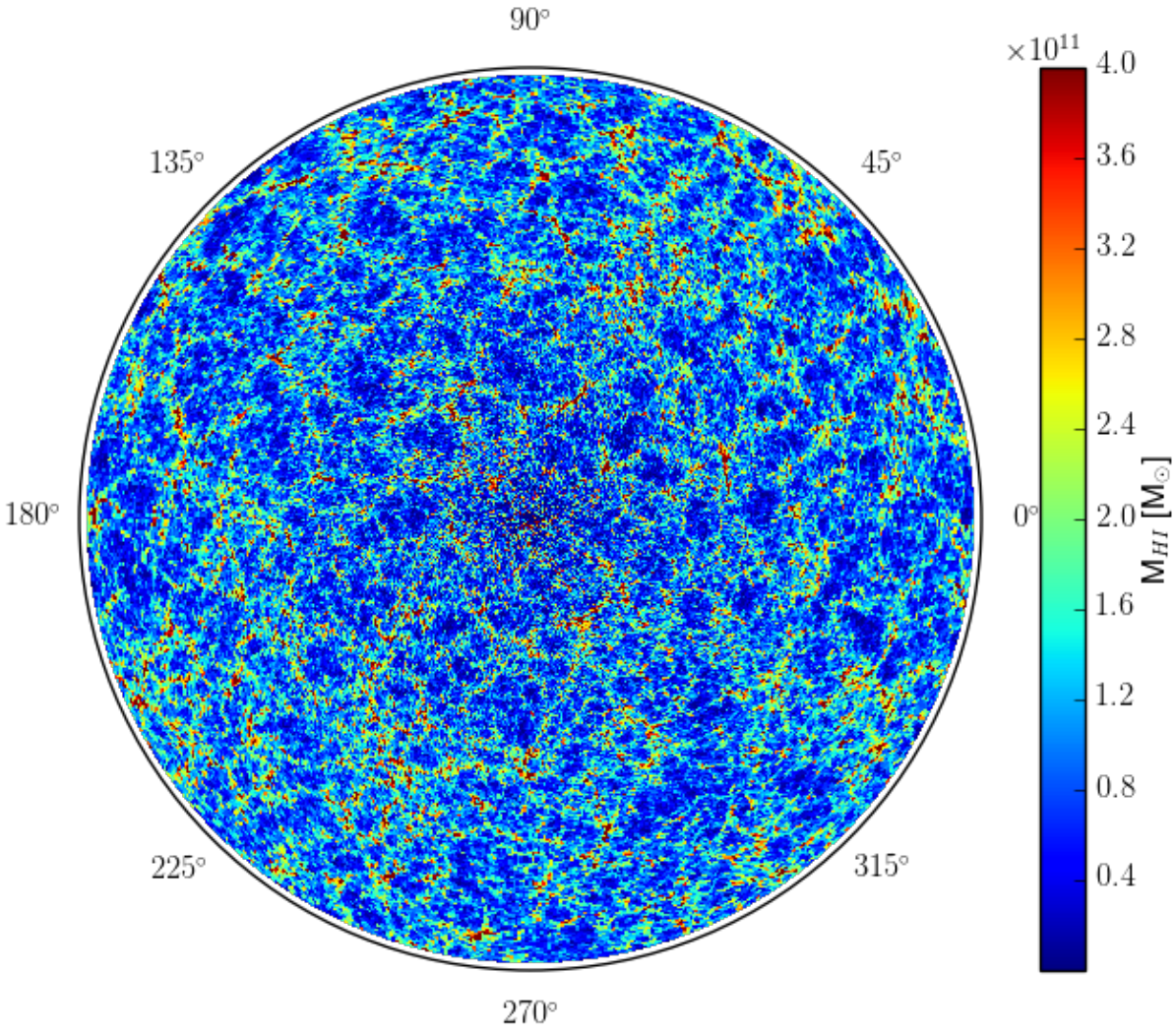
Can be used to populate dark matter only simulations in a more realistic way than using a simple HOD.



Realistic, physical models are very much needed for different applications (e.g. see talks on Tuesday).

Spinelli et al. 2020

Light-cones



Dedicated light-cones can be built, and easily cross-correlated with other properties of galaxies.

N.B. Independent mocks require large simulations. Work planned to couple GAEA with fast methods like e.g. PINOCCHIO (many independent light-cones).

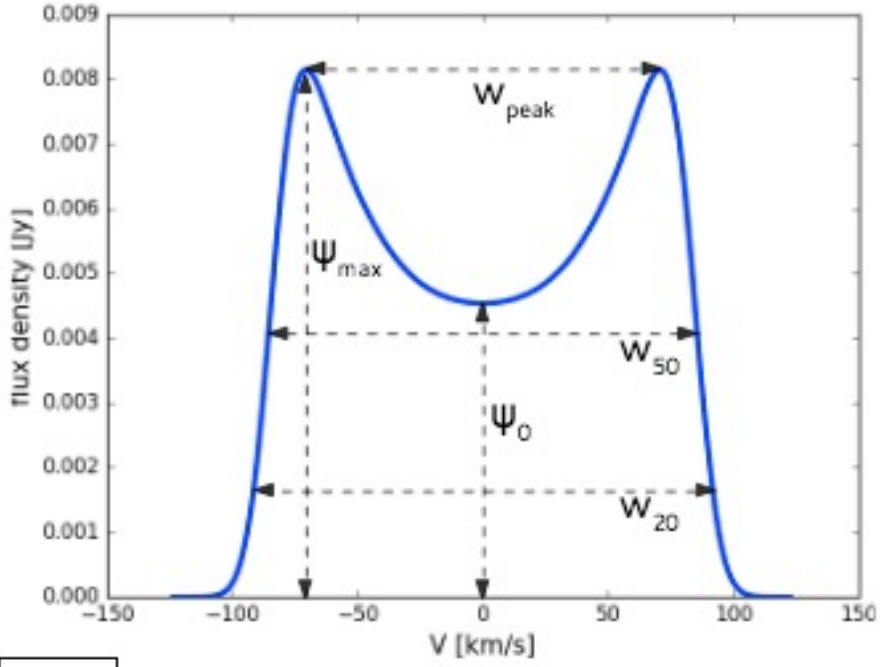
Courtesy: Anna Zoldan

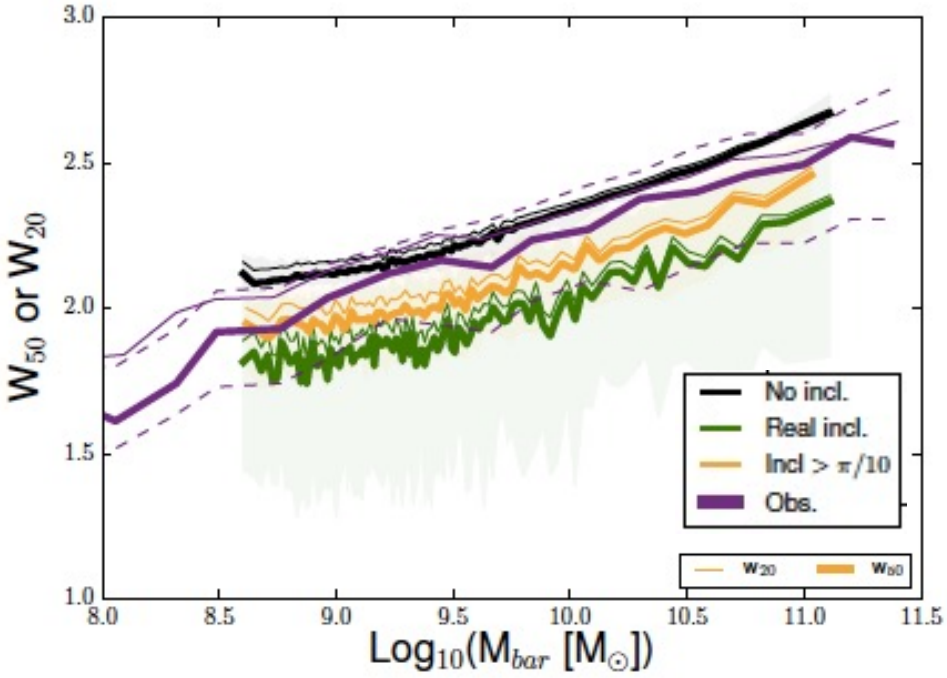
Artificial 21cm lines

As in Obreschkow et al. (2009), but:

(i) self-consistent treatment for the partition of cold gas and H_2 based star formation law;

(ii) detailed tracing of angular momentum of the gaseous disk (this gives an inclination for each galaxy);





Analytic, simplified geometry (axisymmetric), but based on a self-consistent physical model coupled to a cosmological simulation.

Zoldan A., PhD Thesis

Summary

✓ GAEA represents a state-of-the-art semi-analytic model of galaxy formation and evolution, that reproduces a very wide range of physical properties over a wide range of redshifts. It includes an explicit treatment for the partition of the cold gas into its atomic and molecular gas components.

✓ Already in use within some SKA SWGs (cosmology in particular); currently working on constructing updated galaxy mocks including masses for different baryonic phases, as well as artificial 21cm lines. Ideal tools for cross-correlation studies but also for galaxy evolution studies.

✓ The model is not perfect (no model is perfect!), but the approach allows a rapid verification of the influence of different physical assumptions. Work is planned to couple with fast methods (possibility to build several independent light-cones with high resolution).

✓ Many results are publicly available or on disk: contact us if interested!