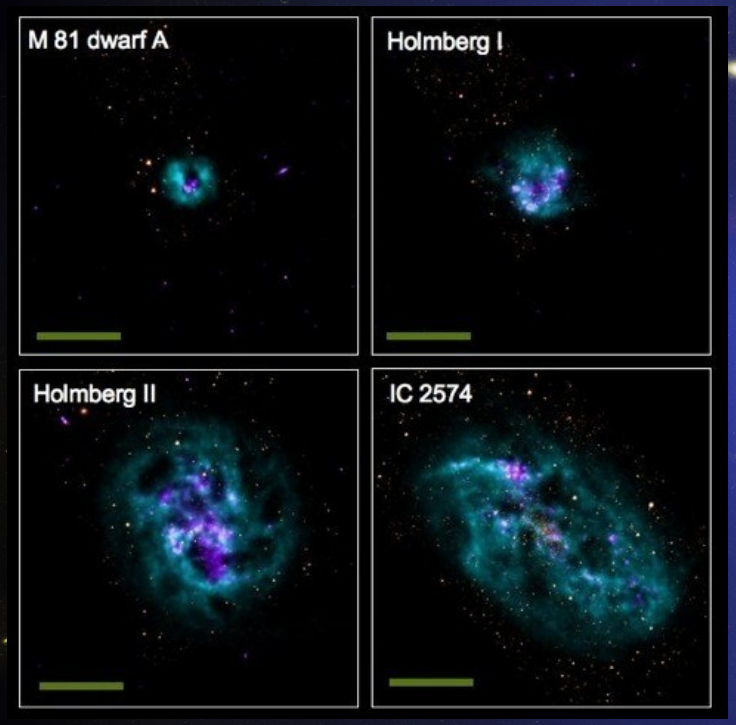
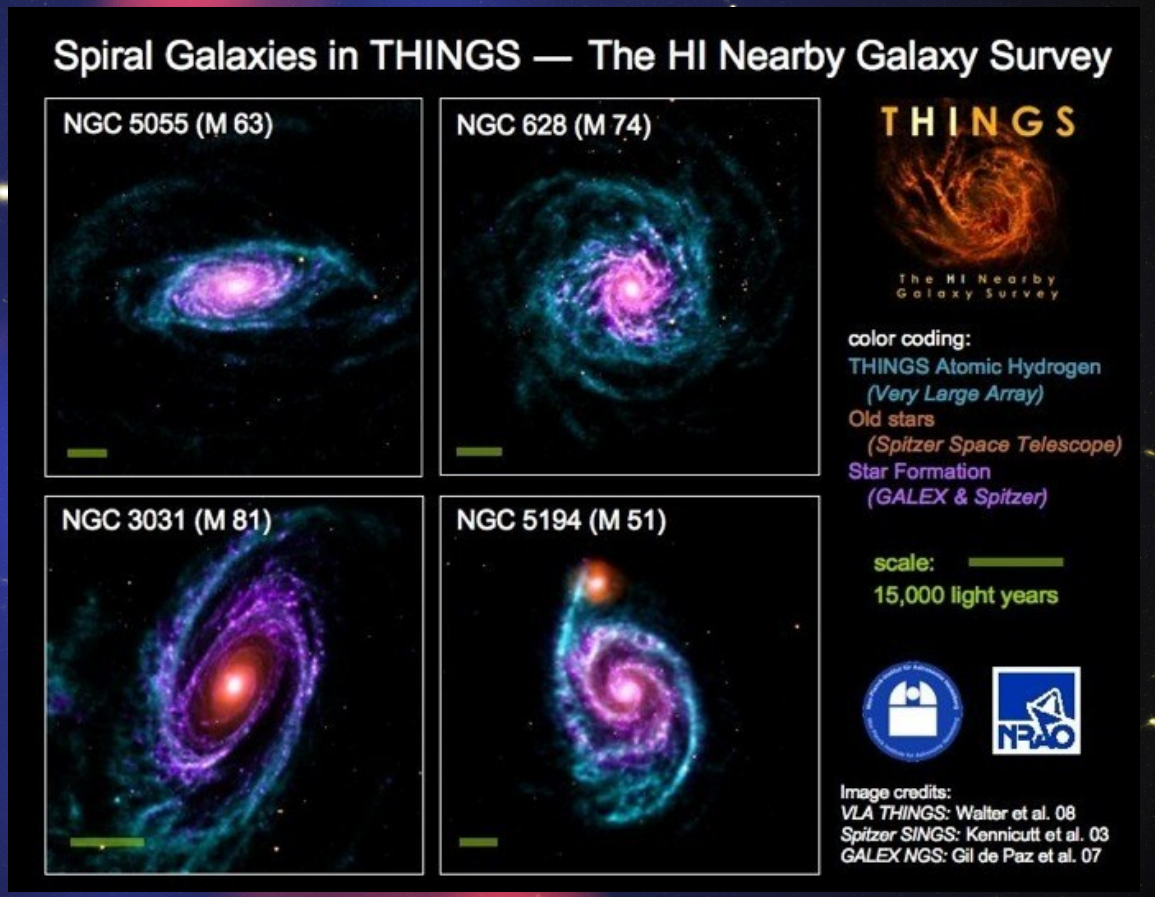
HI and Galaxy Evolution



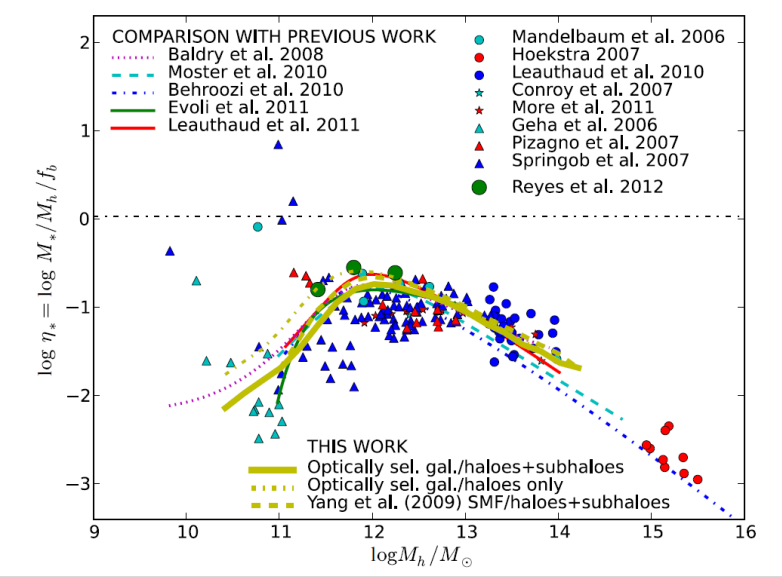


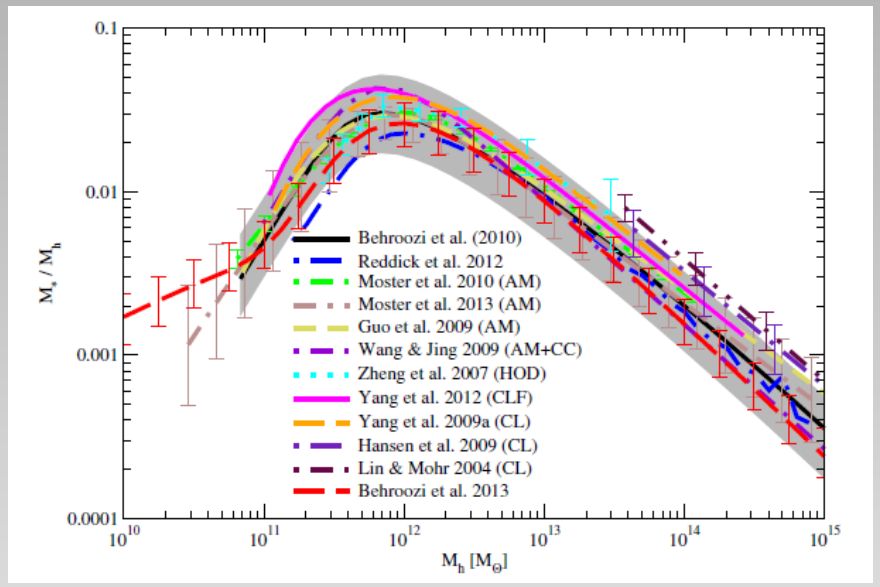
Matt Lehnert - IAP

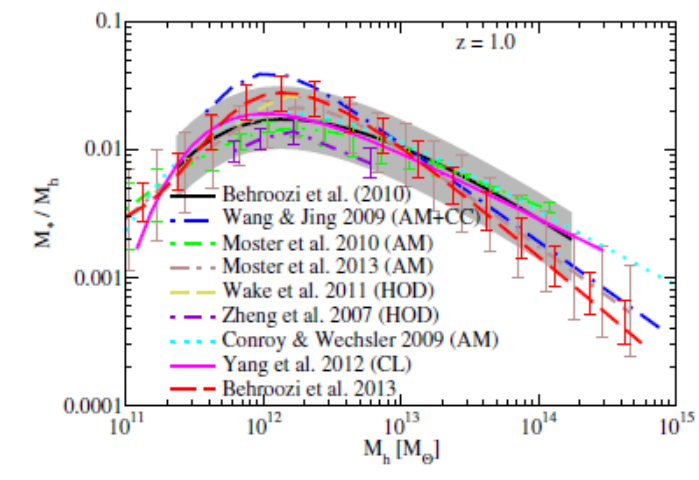
Three key questions in contemporary galaxy formation and evolution studies

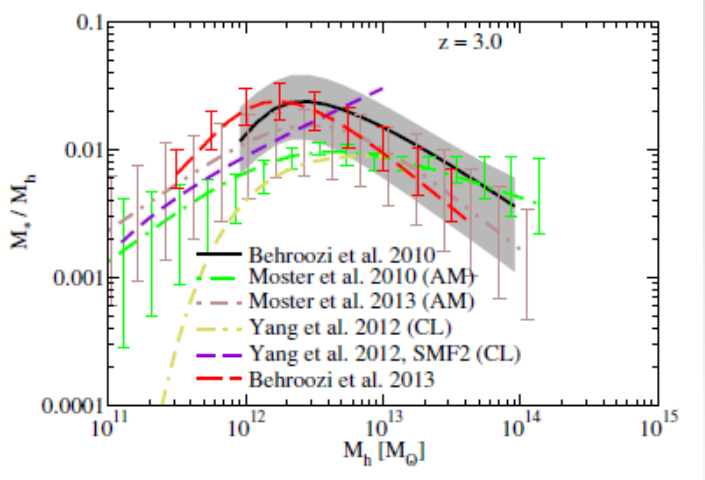
Why is galaxy formation so inefficient?

M_*/M_{halo} vs. M_{halo}



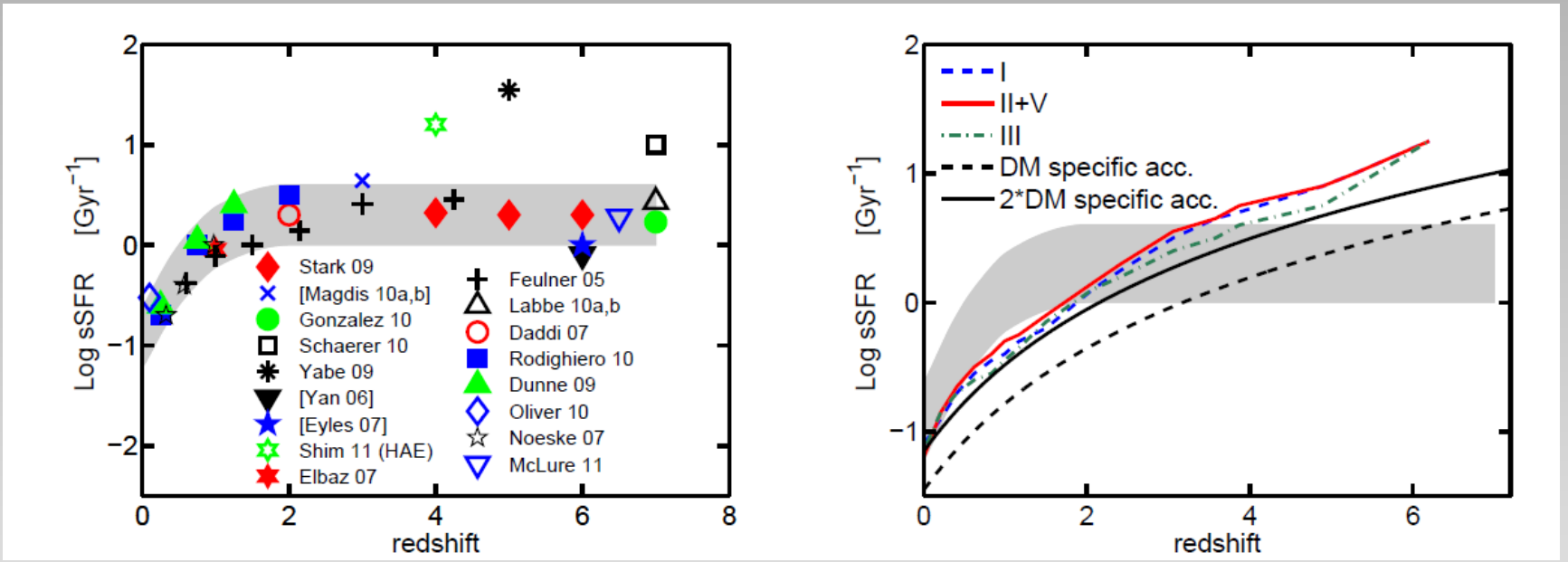






Papastergis et al. (2013); Behroozi et al. (2012)

What drives the time evolution of the mass growth?



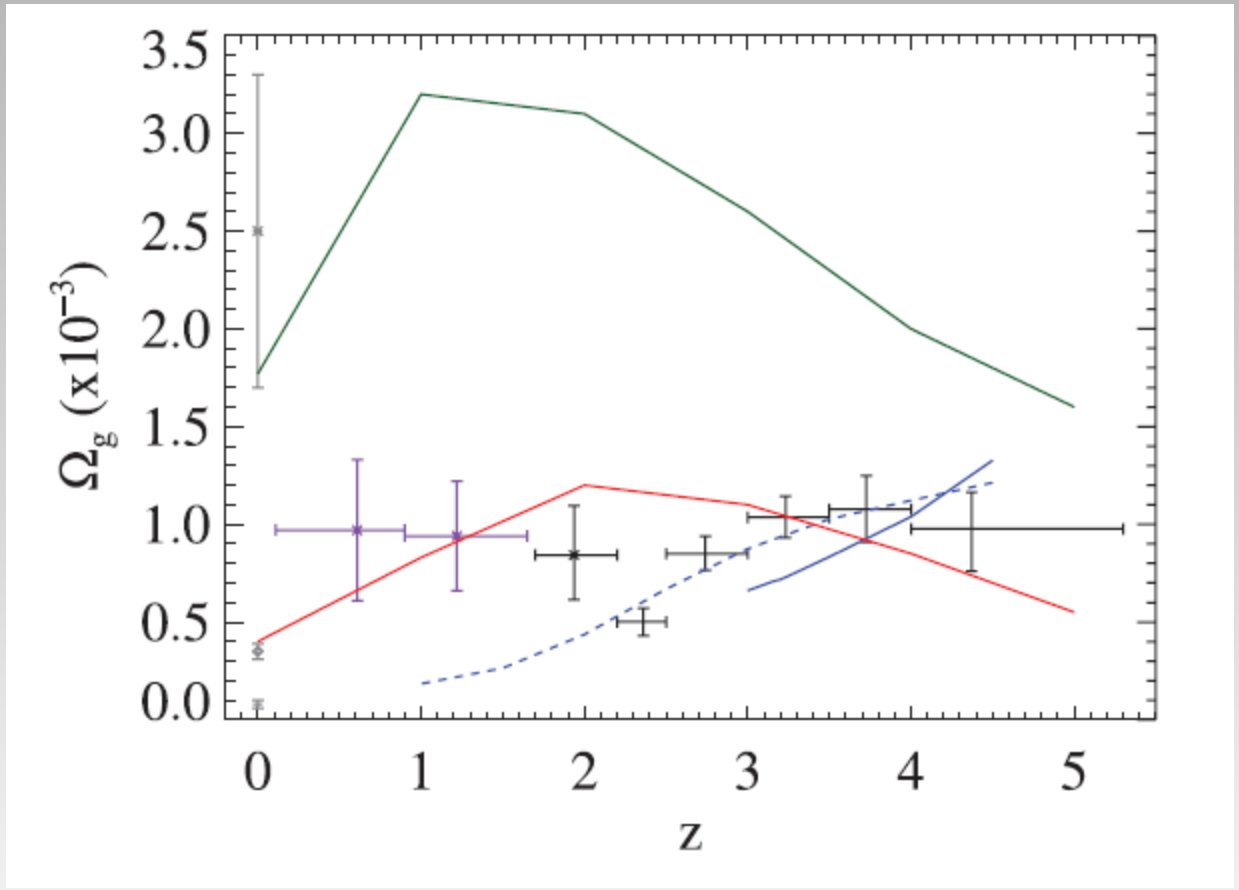
Weinmann et al. (2011)

Why doesn't the specific growth rate follow the specific accretion rate of the gas?

- Outflows?
- Angular momentum?
- Accretion rate over-estimated (over-cooling)?

Is HI the reservoir out of which galaxies grow as the accretion rate drops?

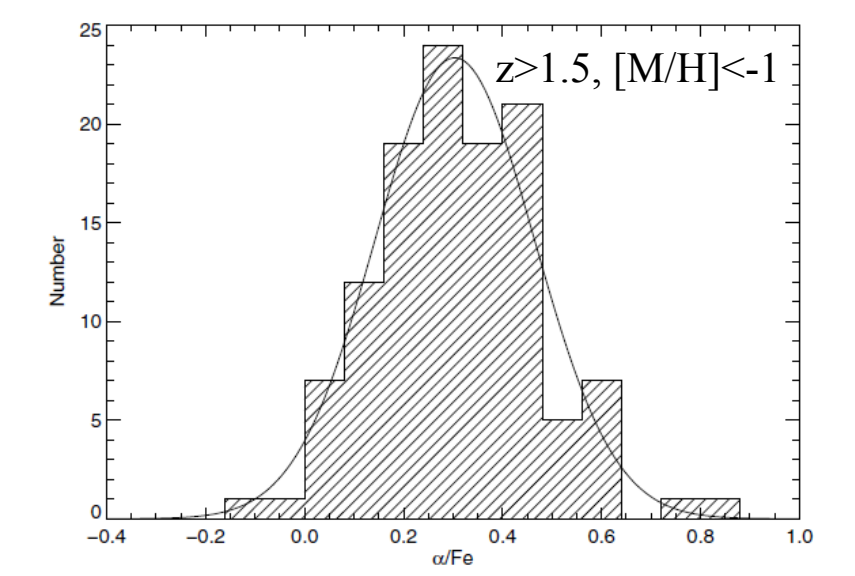
Why is there no apparent evolution in the neutral gas content?

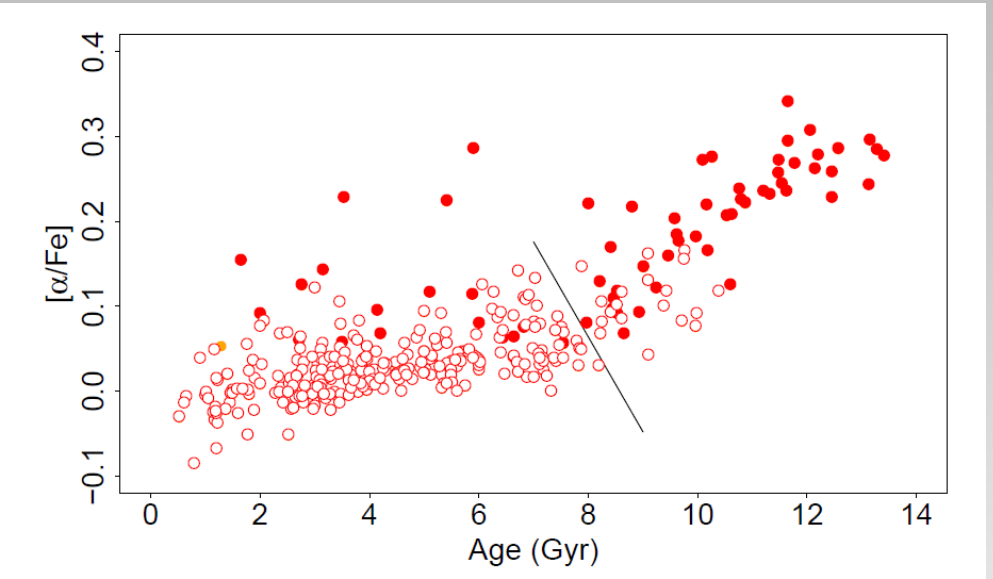


see Celine Peroux's talk on Thursday

Prochaska et al. (2006);
Peroux et al. (2001; 2003)

What is the nature of "extended" HI gas in distant galaxies?



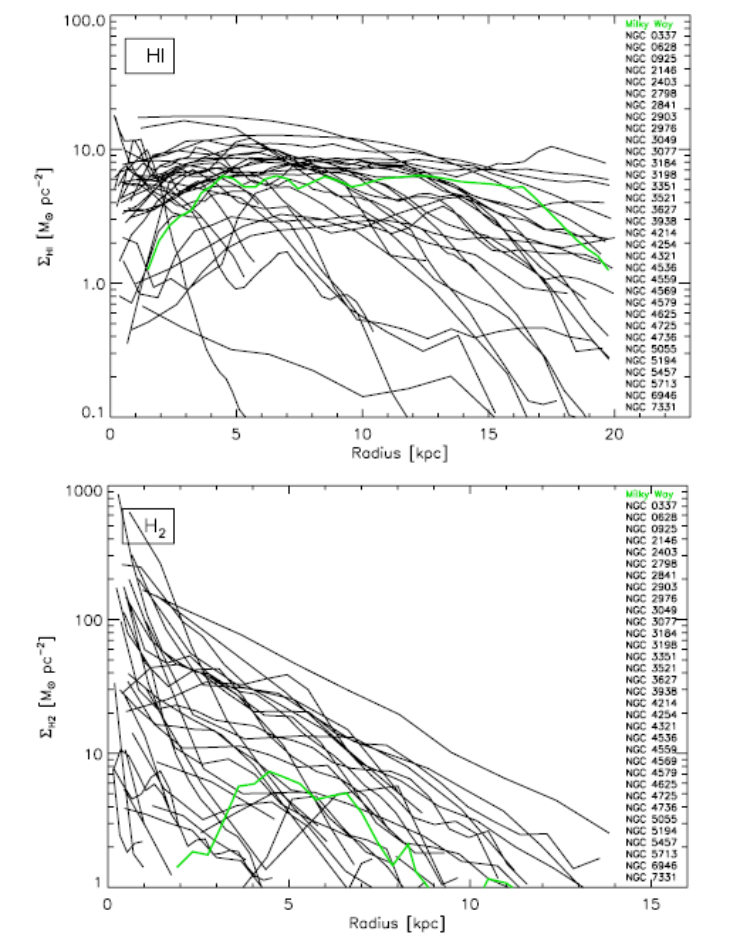


What is the relationship between DLAs observed at high redshift and the stellar and dynamical components of galaxies?

Rafelsky et al. (2012);
Haywood et al. (2013)

What do we know about HI in local galaxies?

HI is extended beyond H2 and bright stellar disk

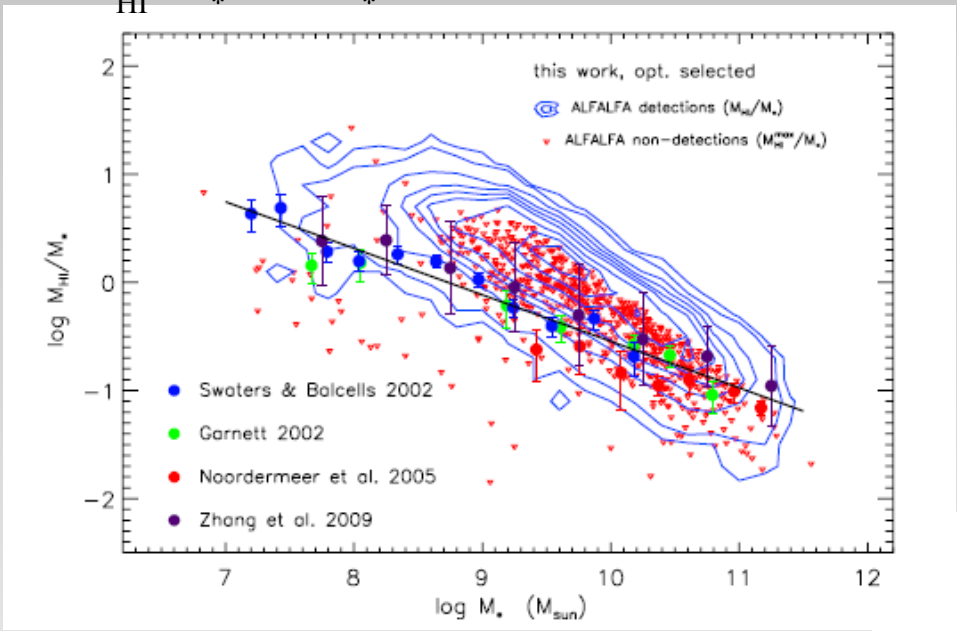


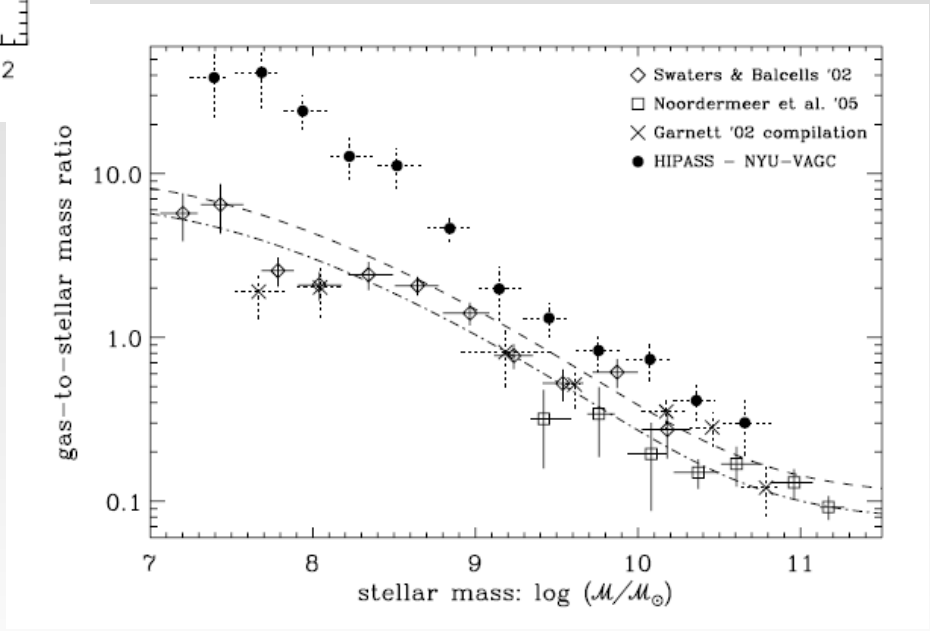
How does the HI radial profile evolve?

Bigiel & Blitz (2012)

HI Contribution to the mass budget

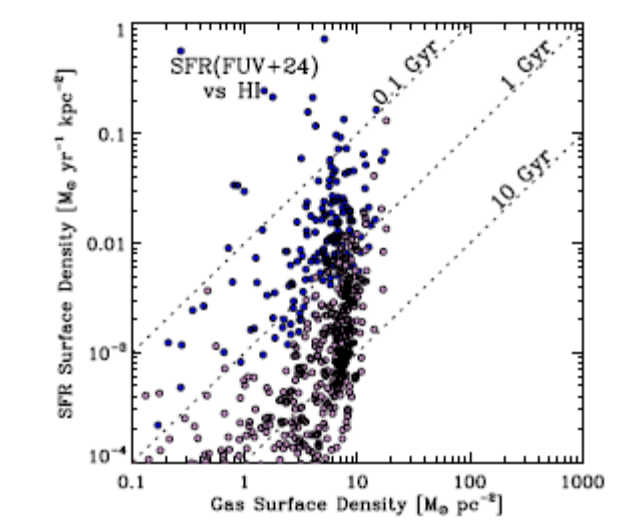
M_{HI}/M_* vs. M_*

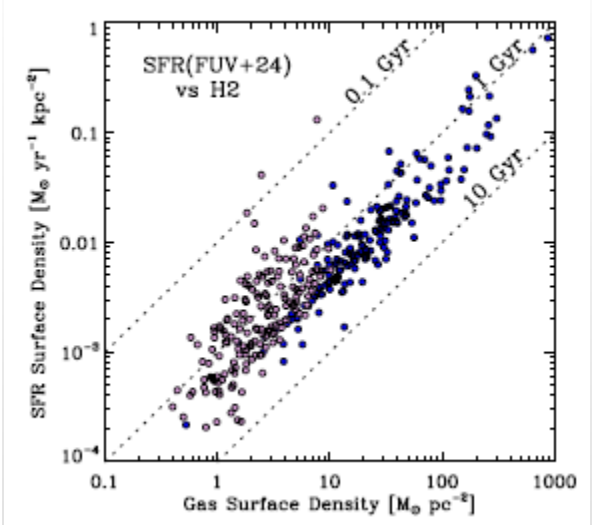




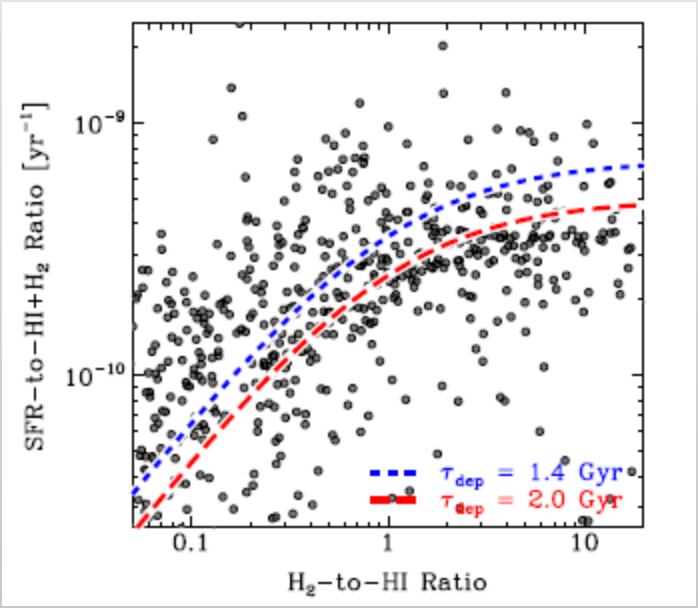
Papastergis et al. (2012);Baldry et al. (2006)

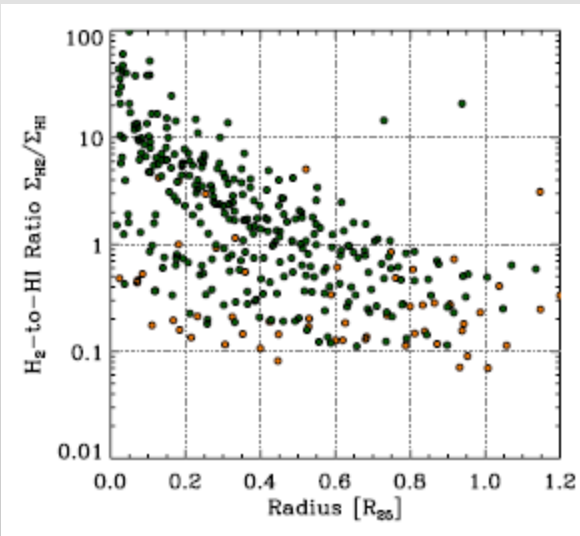
HI Relation to star formation

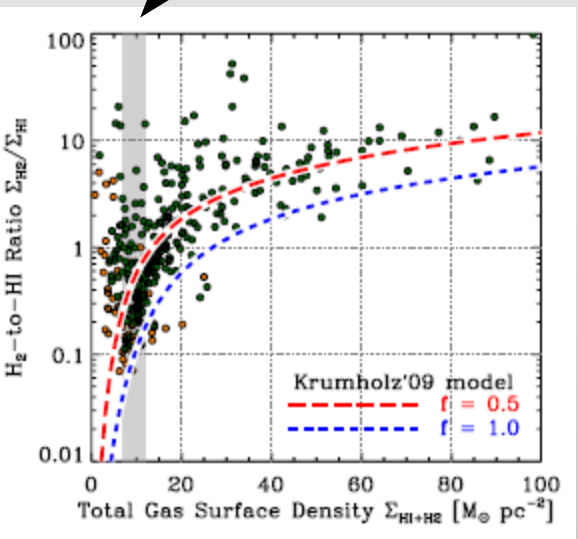




"shielding column"

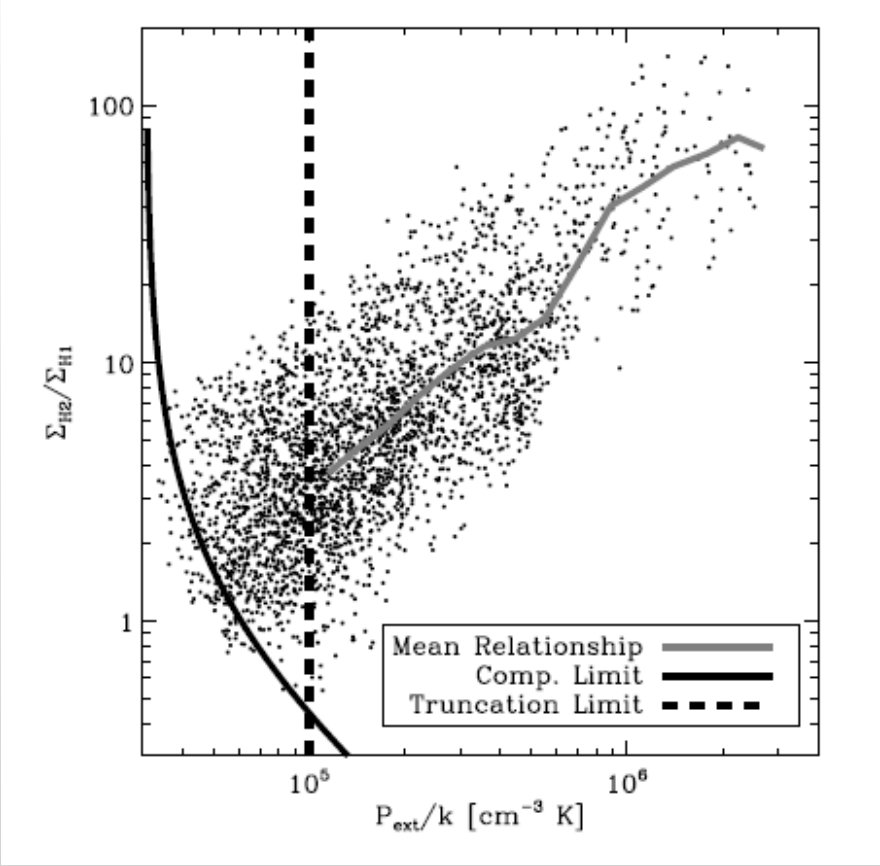


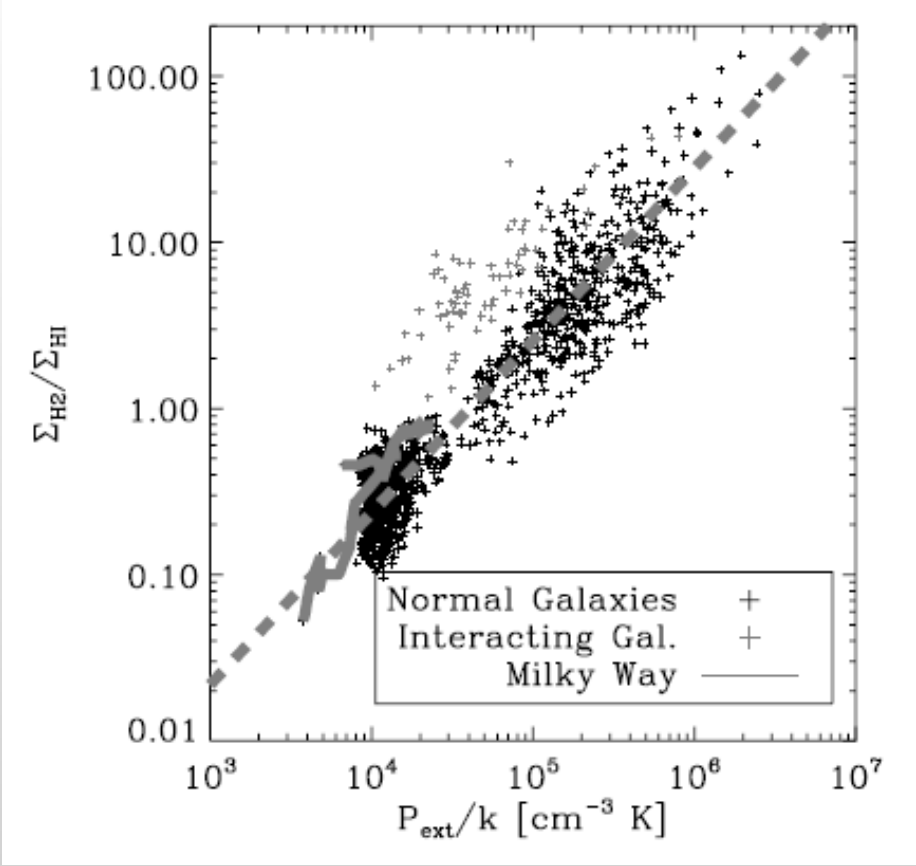




Schruba et al. (2011)

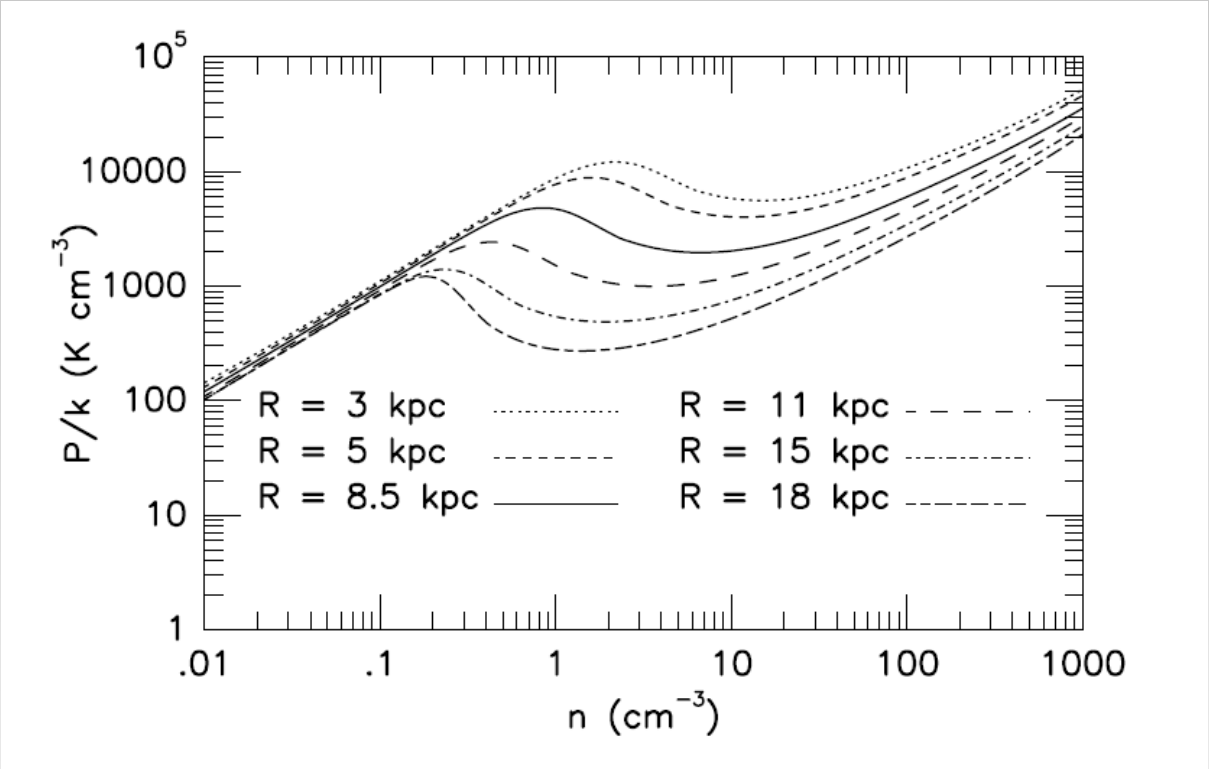
Phase related to pressure





Blitz & Rosolowski (2006)

The stability of a two phase medium



Wolfire et al. (2003)

Requires:
-ionization balance
-radiation field
-cooling time vs. shock heating rate
-pressure

Missing some elements, turbulence for example.

However, conditions in disks at high redshift likely very different:

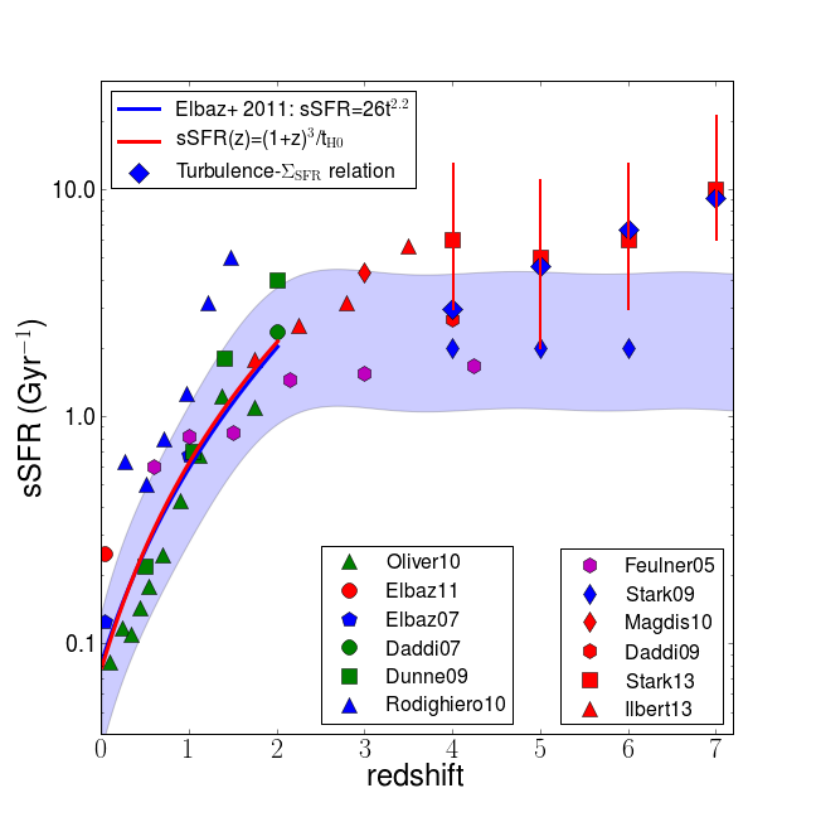
High turbulent pressures (e.g. Lehnert et al. 2009; 13 and reference therein)

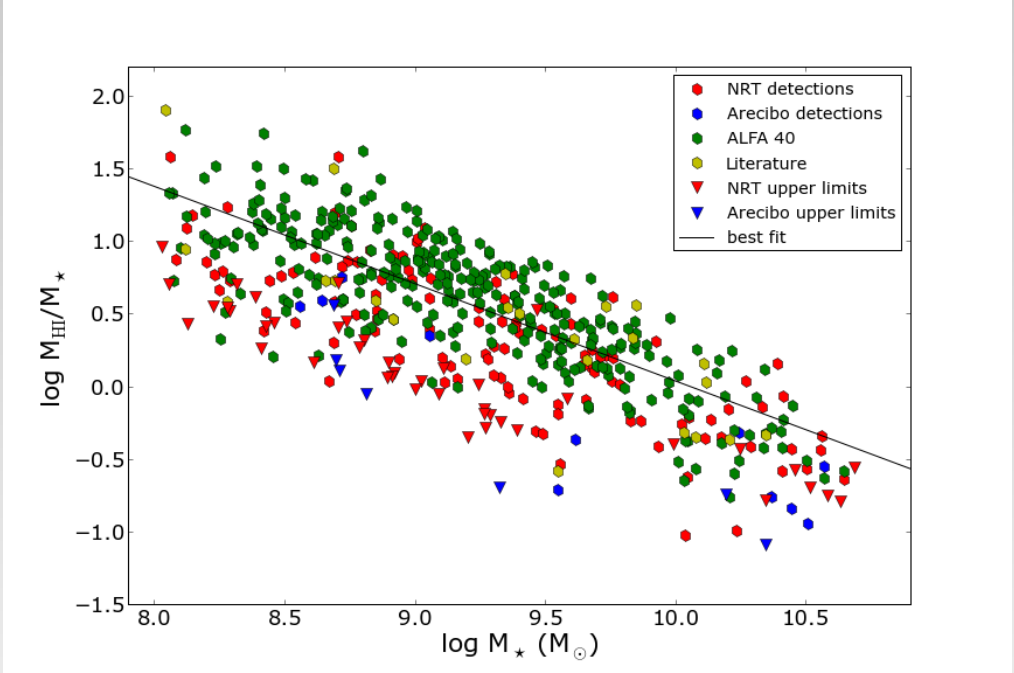
Turbulence likely generated by stellar radiation, winds, and SNe

⇒ Efficient formation of molecular gas

⇒ Self-regulated star formation

NRT/Arecibo HI survey of local galaxies with high sSFR





If truly analogous to high z galaxies, HI dominates the gas mass budget at low/intermediate stellar masses, while at higher mass $M_{HI} \sim M_{H2}$

Lehnert, van Driel (2014)

The future

What role does HI play in the growth of galaxies?

Is HI the reservoir out of which galaxies grow?

HI contains a significant amount of angular momentum and there may be an “over-accretion” of gas at high redshift.

Evidence from the MW suggests this is plausible – metallicity of outer disk stars is similar to that of the thick disk for example.

How does turbulence regulate the transition of HI to H2 and back again?

What keeps star formation and galaxy growth so inefficient? Is it turbulence moderated star formation, plus large reservoirs of HI gas at high z? Is it simply outflows – AGN driven and starburst driven?

We need a large aperture radio telescope that can probe HI down to moderate masses, 10^9 $M_\odot$, out to z=2-3, with sub-arcsecond resolutions. This is a full SKA and with long integration times (100s of hours).

Strangely, theory is starting to need this input!