Modelling Neutral Hydrogen in Cosmological Hydrodynamic Simulations

Kloster Seeon - June - 2011

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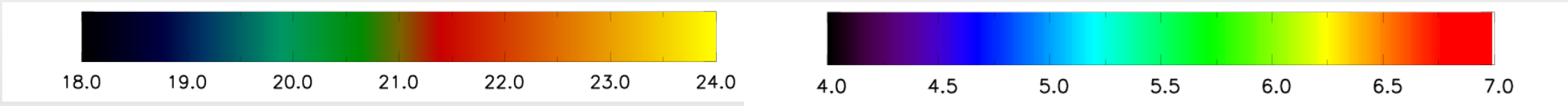
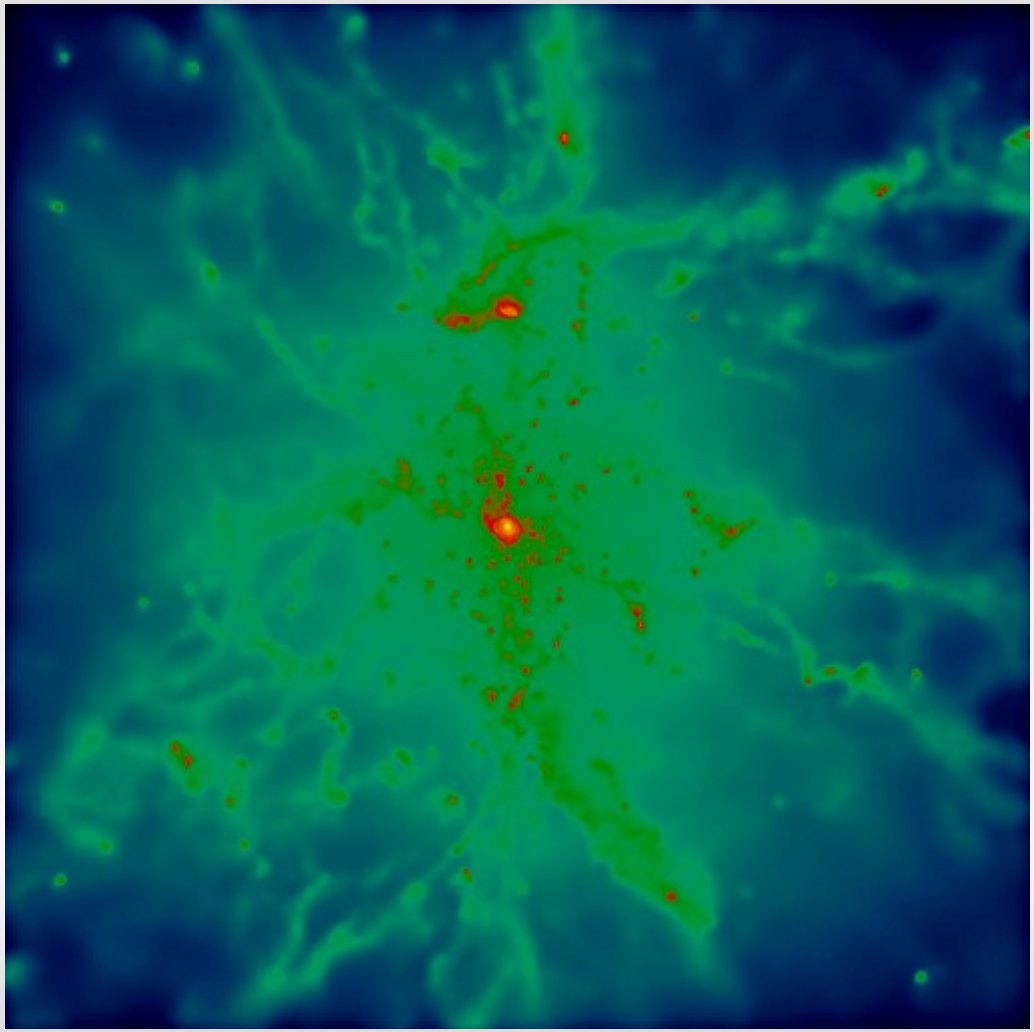
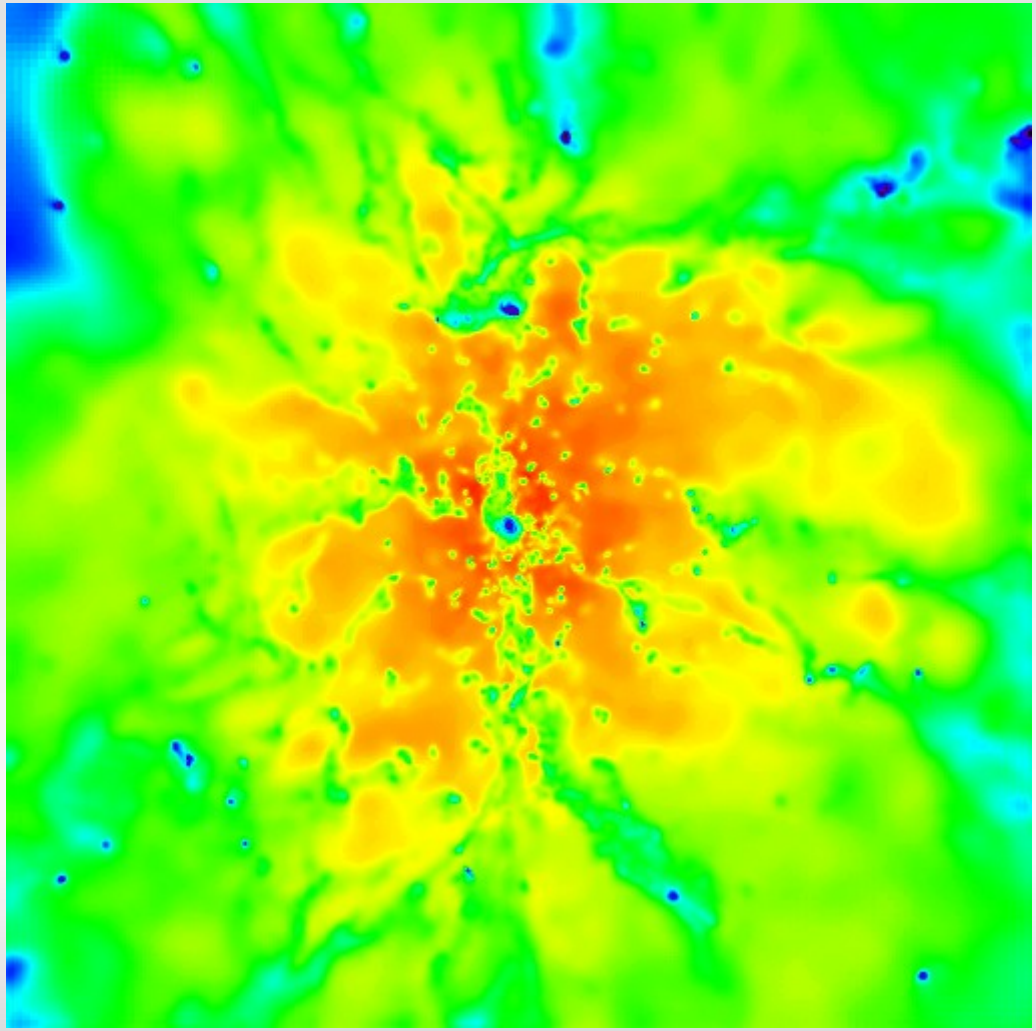
H Column Density / Temperature



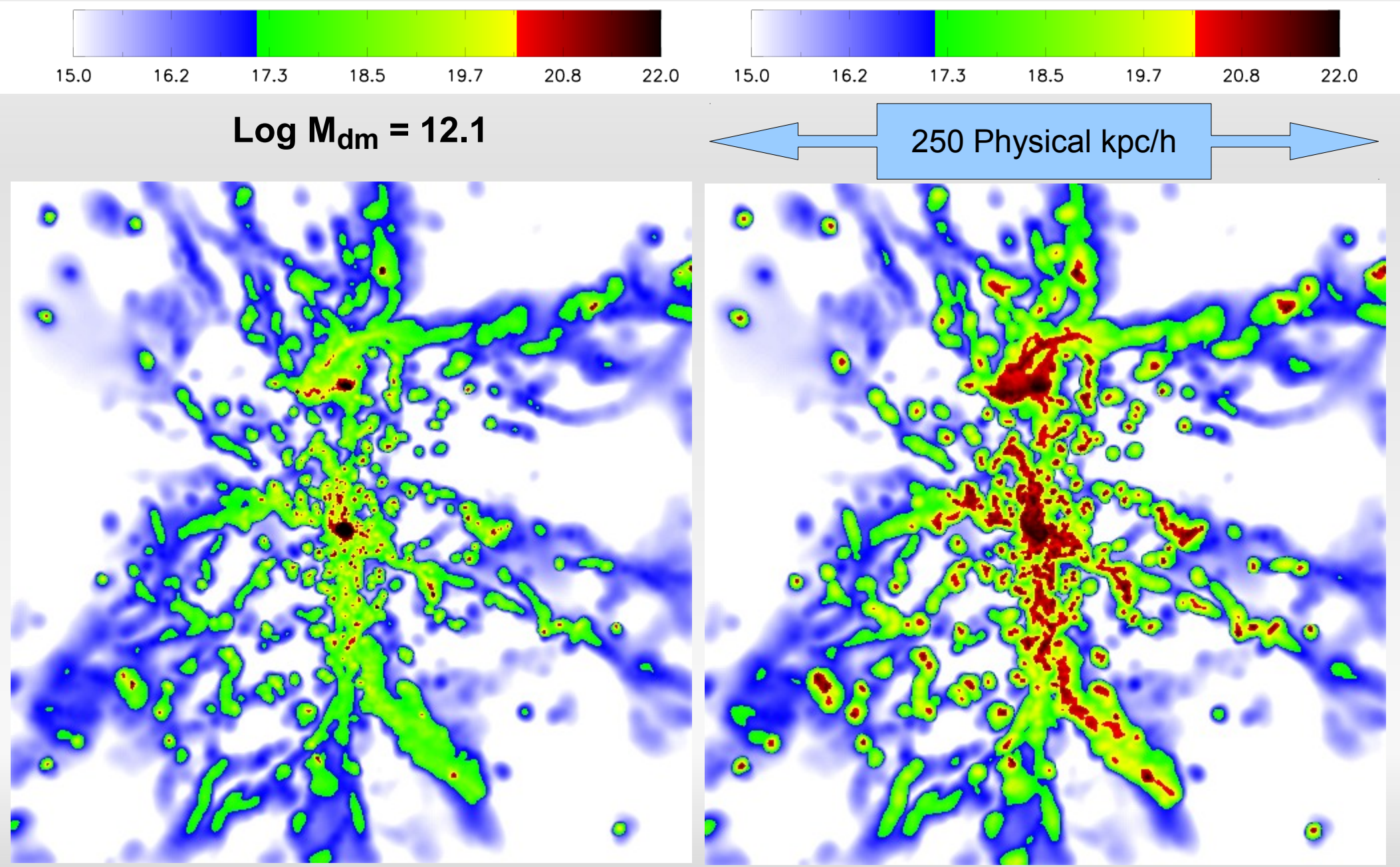
Log M_{dm} = 12.1

250 Physical kpc/h

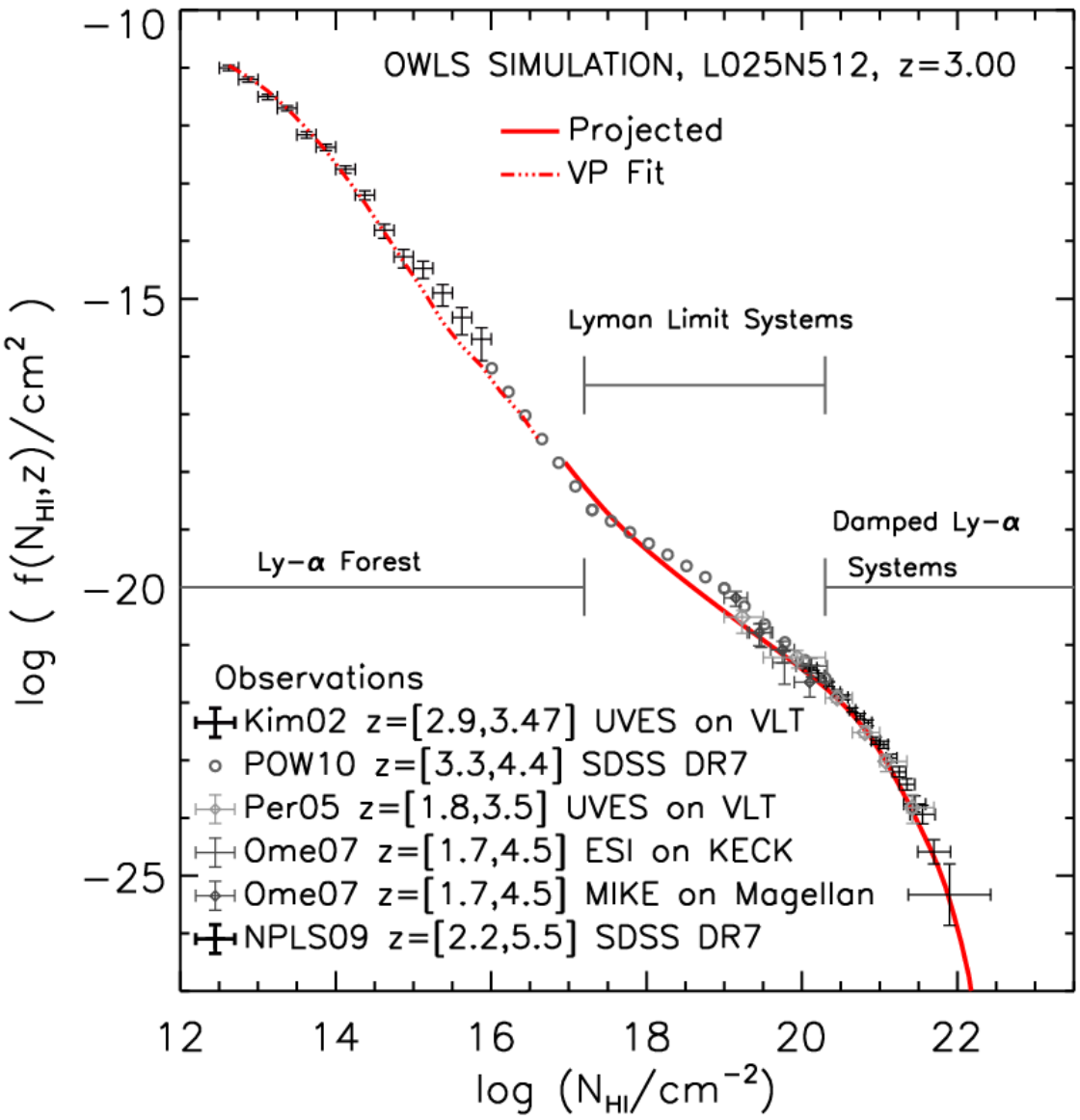




HI Col. Den. Thin / Shielded

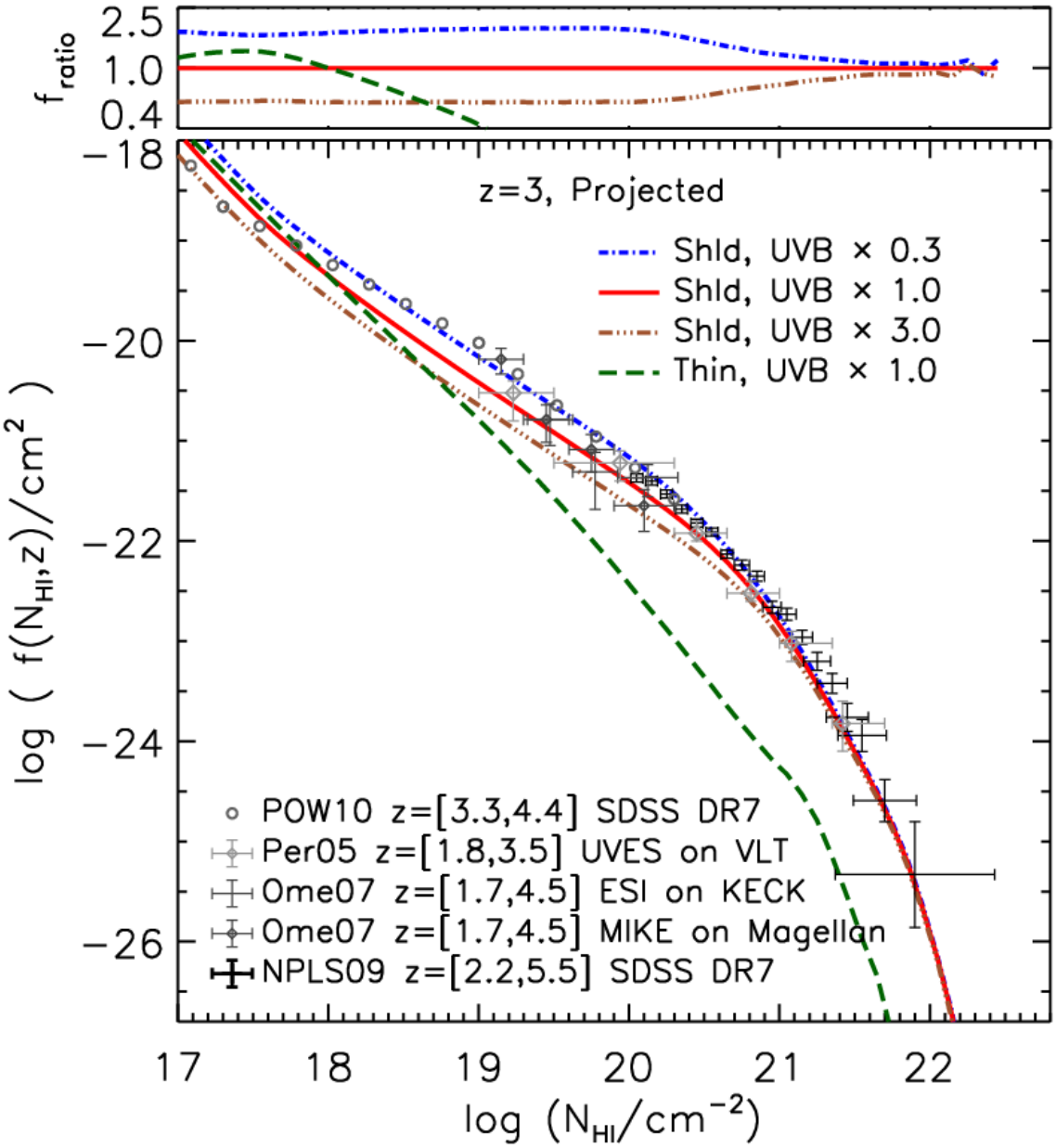


Reference WMAP7 Model



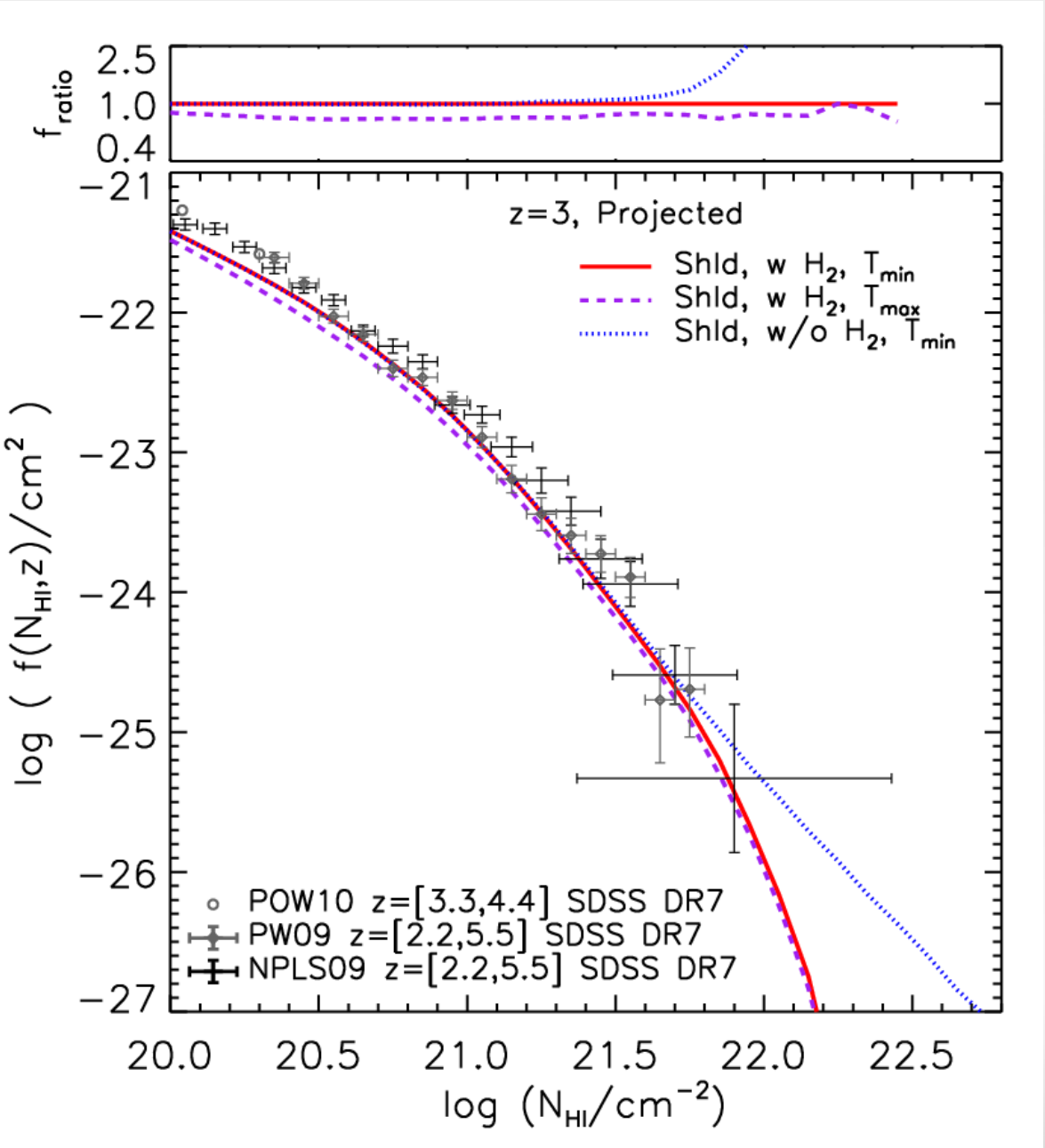
- UV Background from Haardt & Madau 2001
- $\Gamma_{12} = 1.2$
- Mid range observations still inferred
- No tuning of simulation parameters or RT
- Temperature adjusted b/c we know its too high in hydro run.

UV Background Normalization



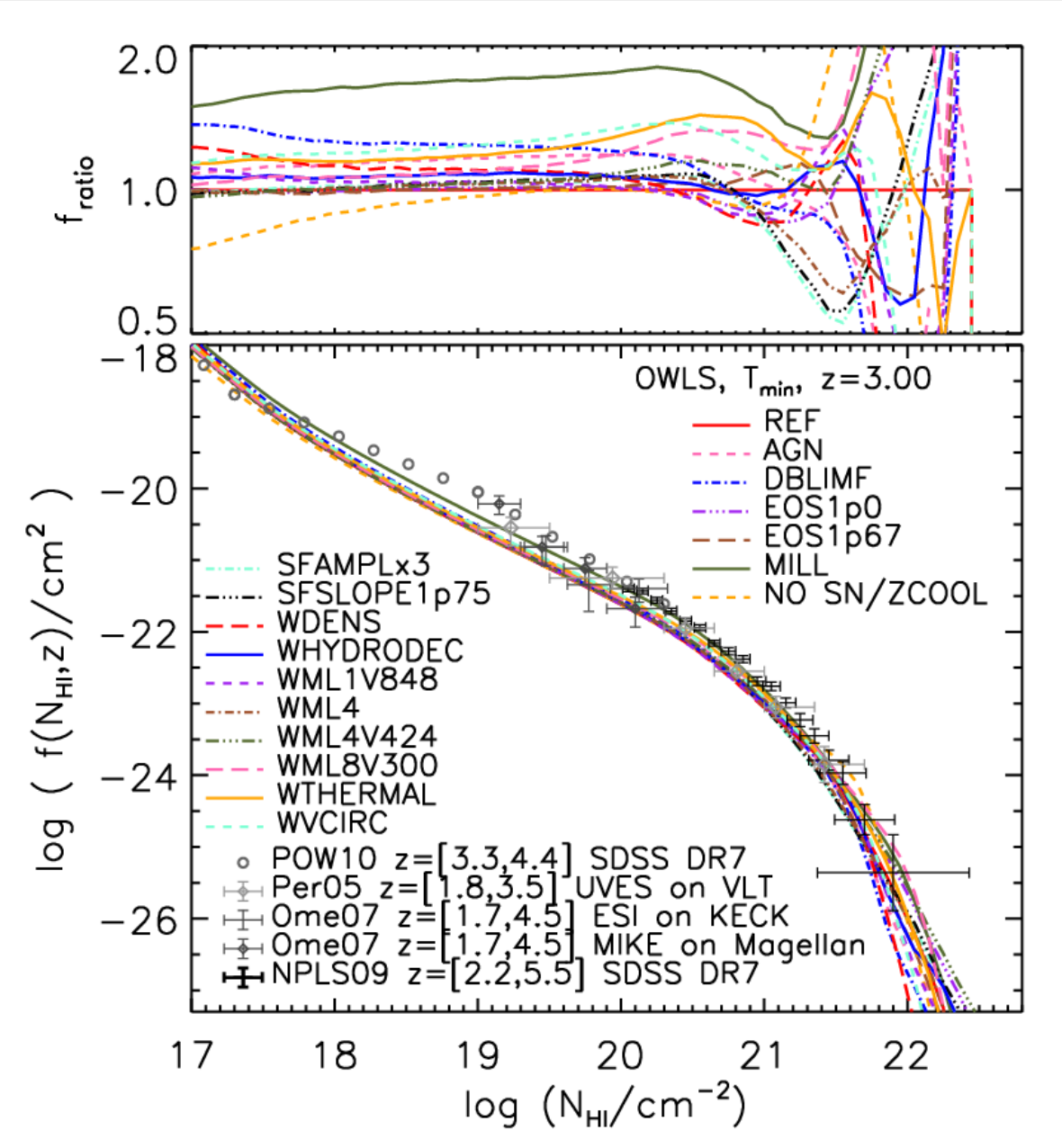
- What if HM01 are wrong about the UV normalization?
- UV Normalization has linear effect below log NHI ~ 20
- Γ_{12} = 1.2 */ 3
- Optically thin approx. breaks down around log N_HI = 18.0
- Max disagreement in low column DLAs

Molecular H and Temperature



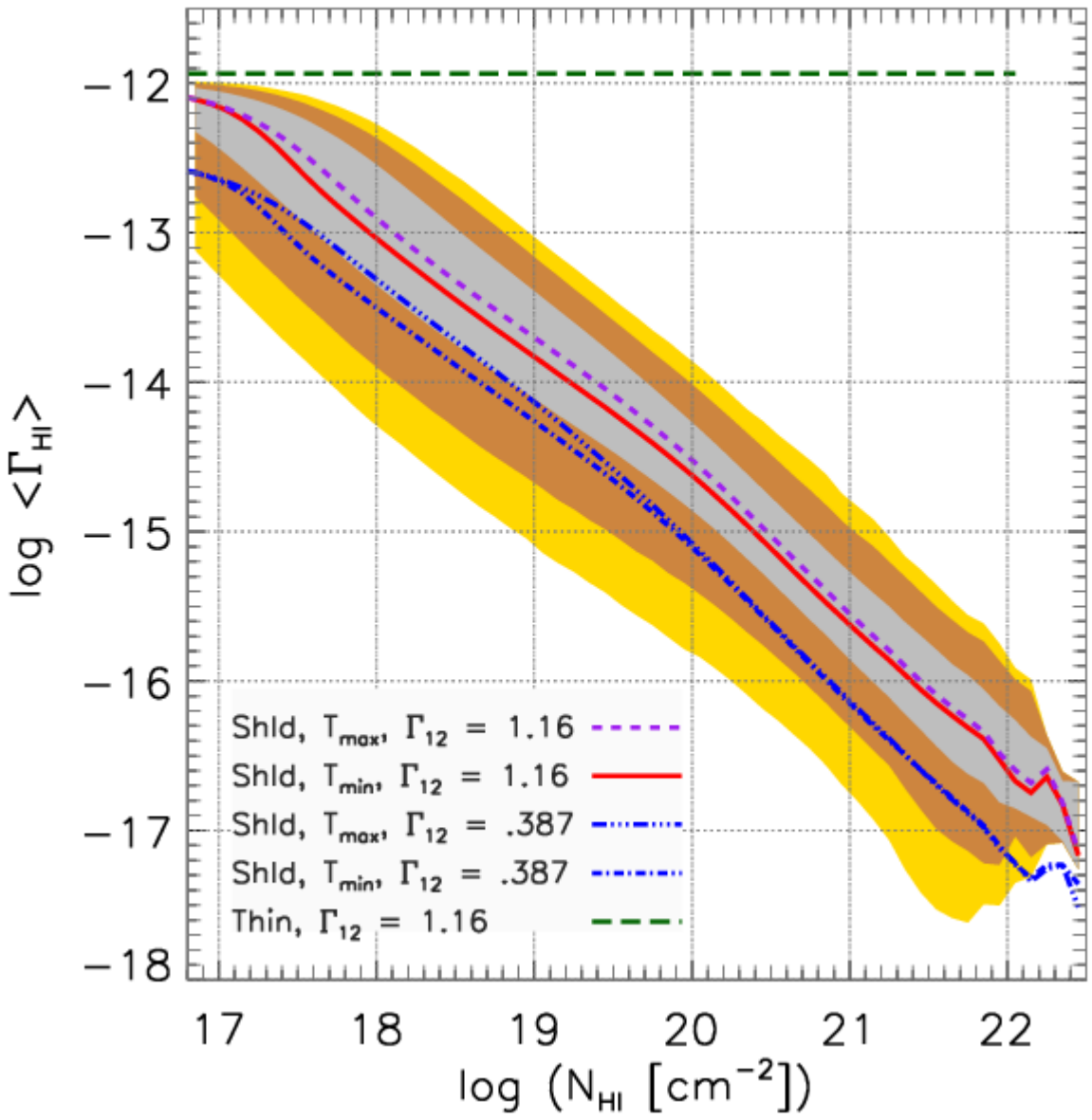
- Temperature adjustment is a “small” effect (scale of plot is very large)
- Collisional Ionizations set neutral fraction ceiling (more later)
- H2 becomes important above log NHI ~ 21.5
- Need direct observations of H2/CO for more constraining power.

Full Range of OWLS Models - II



- OWLS run sig8 = 0.74, WMAP7 sig8 = 0.81
- Headline: Subgrid physics prescriptions have a relatively minor effect on the CDDF except where the H2 / Star forming gas is involved
- Sig8 = Abundance of Halos does.

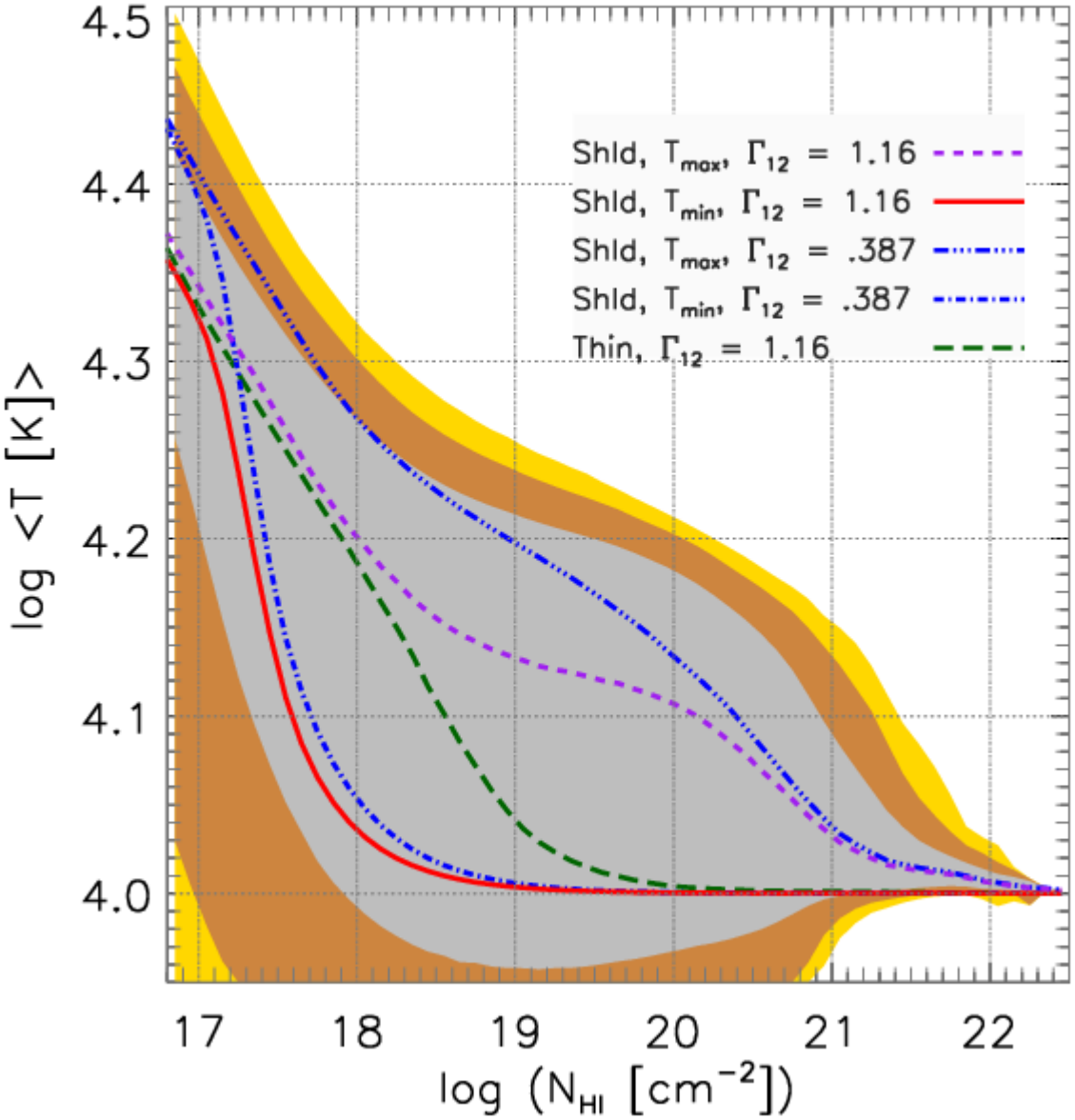
HI Weighted Quantities - Γ



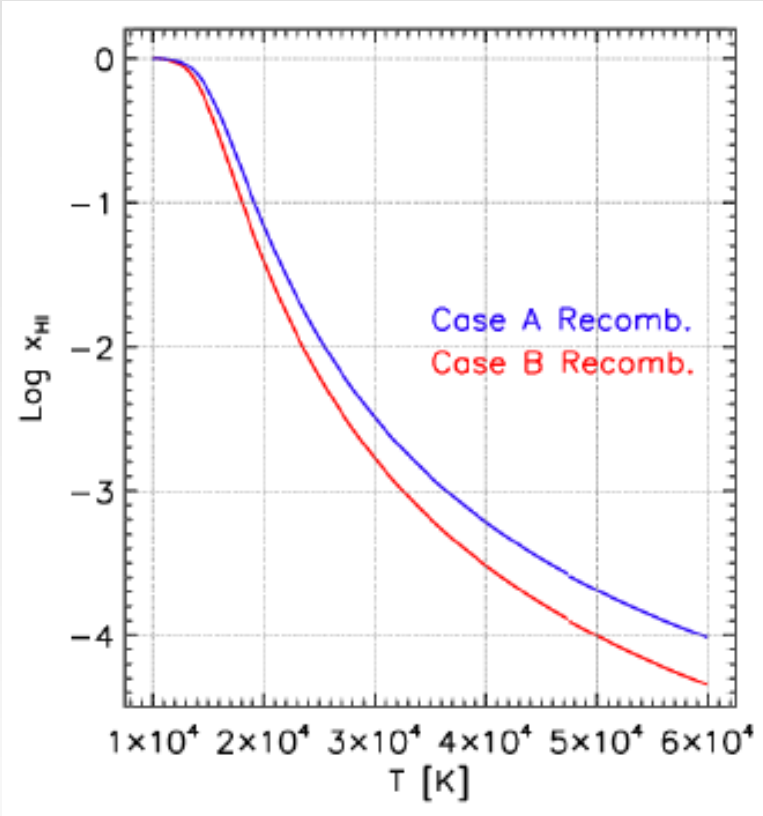
$$\frac{\text{Line int}\{ Q * n\_HI \}}{\text{Line int}\{ n\_HI \}}$$

- $\Gamma_{12} = 1.16$
- Γ falls of like a power law.
- Same behaviour as plane parallel radiation incident on a slab.

HI Weighted Quantities - T

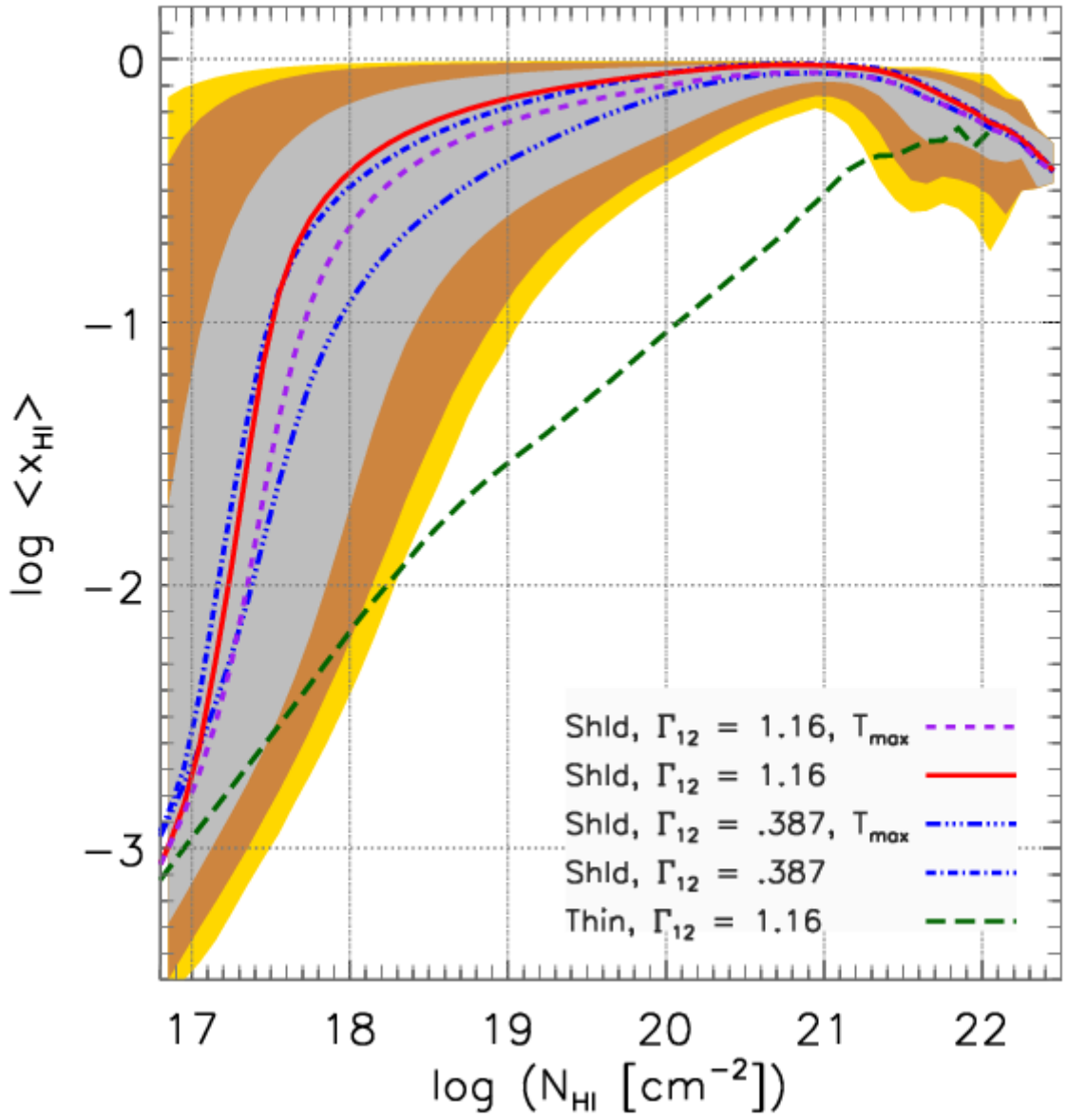


$$\frac{\text{Line int}\{ Q * n\_HI \}}{\text{Line int}\{ n\_HI \}}$$



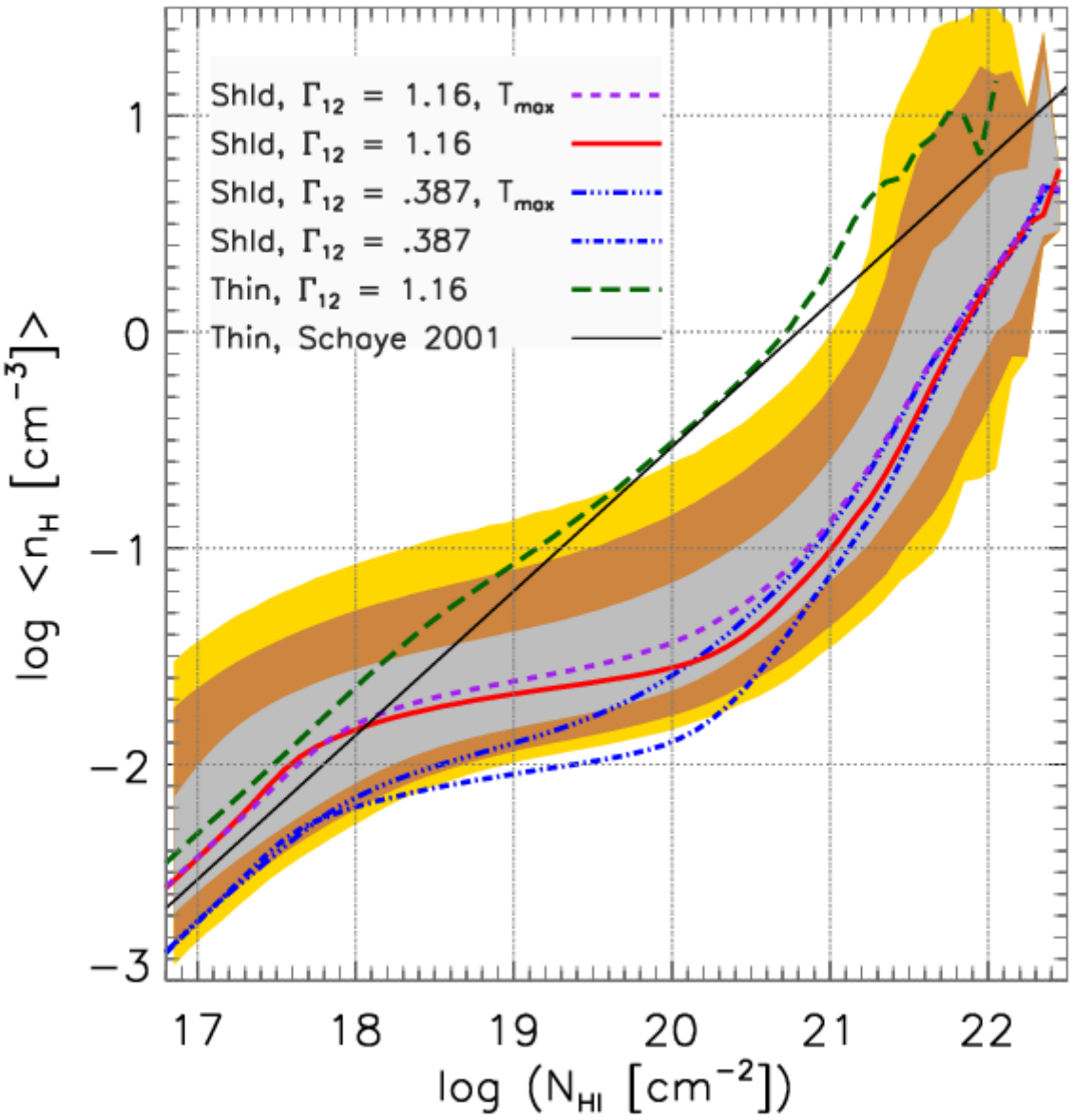
- x_{HI} sensitive to collisional ionizations

HI Weighted Quantities - x_{HI}



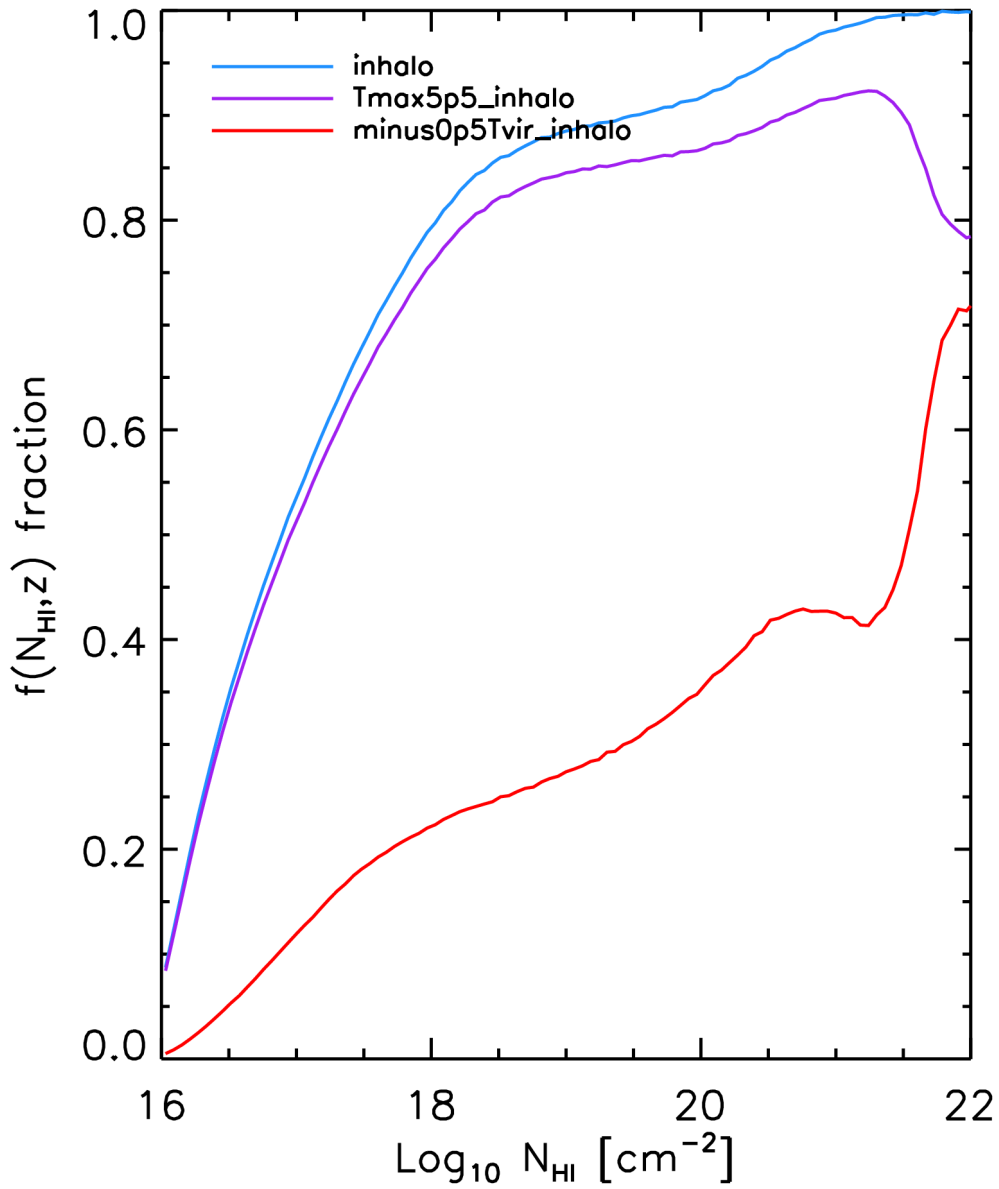
- UVB Normalization / hardness and temperature choices determine how far the deviation from power law behaviour is.
- Large spread in values in LLS regime

HI Weighted Quantities - n_H



- Flattening in LLS range depends on UV Bgnd. and Temperature treatment.
- Above DLA threshold gas is fully neutral and must become more dense to add column density

Decomposing the CDDF - I

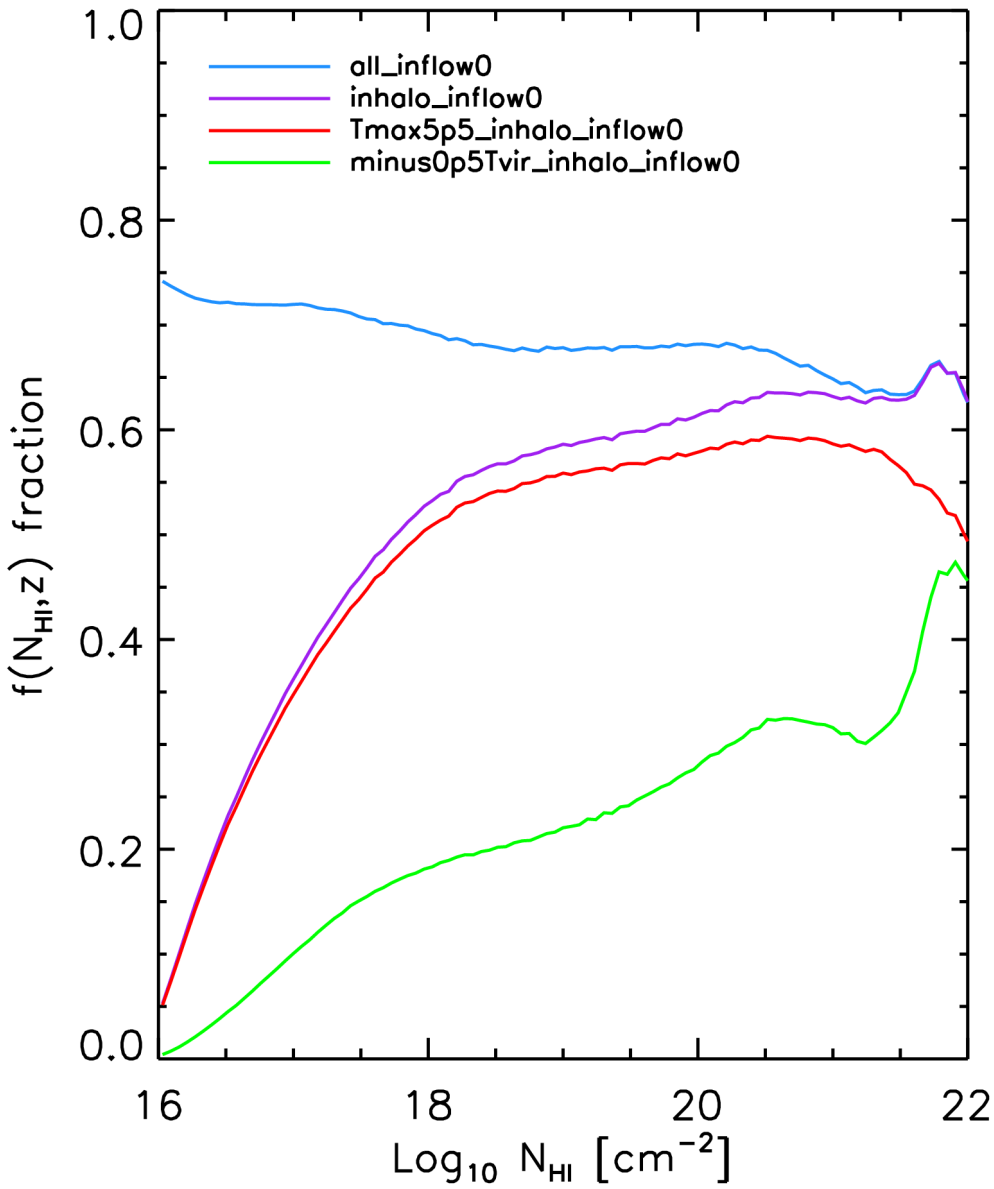


In FoF halos

Tmax < $10^{5.5}$

Tmax/Tvir < $10^{-0.5}$ ~ 0.3

Decomposing the CDDF - II



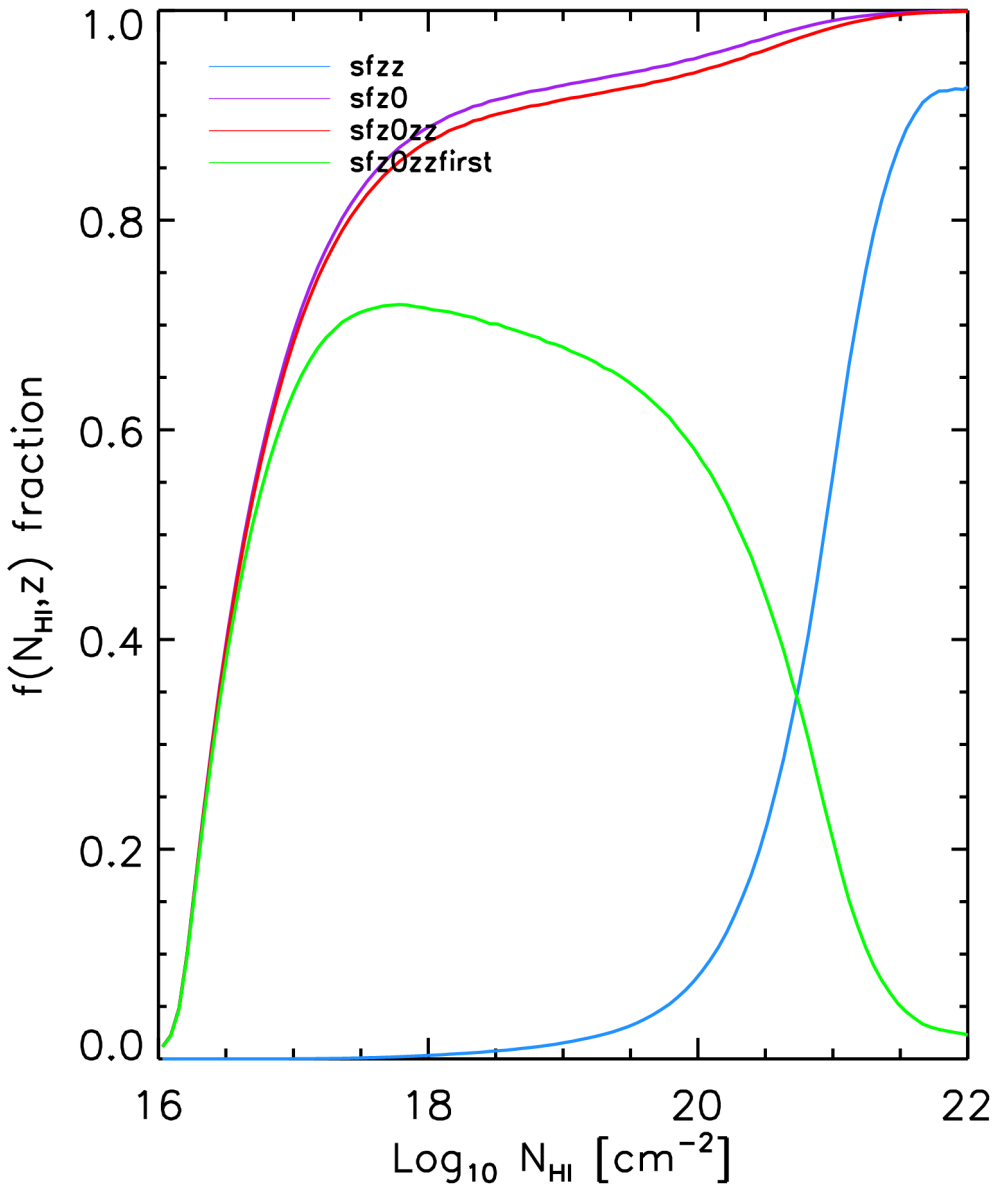
Flowing toward central galaxy

In FoF halos & inflowing

Inflow, In halo, & Tmax < $10^{5.5}$

Inflow, In halo, & Tmax/Tvir < $10^{-0.5}$

Decomposing the CDDF - III



In ISM ever

In ISM 0 < z < 3

In ISM now

In ISM 0<z<3 for first time

Conclusions

- The OWLS models with the correct cosmology, HM01 UVB, and a shielding correction match the observed CDDF over ten orders of magnitude in column density
- The various sub-grid prescriptions have a smallish effect especially at log NHI < 20.5
- The most important influences are temperature treatment (including thermal feedback, metal line cooling, shielding of photo heating) and sigma 8.
- Depending on your definition of cold accretion the fractional contribution to the CDDF is either roughly half (fixed Tmax) or at most half (fixed Tmax/Tvir).