Morphologies & Star Formation in Small Galaxies

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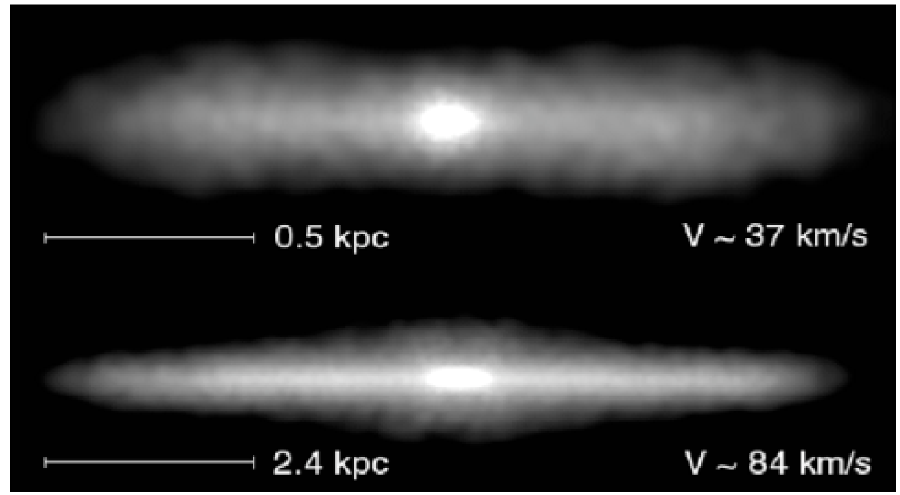
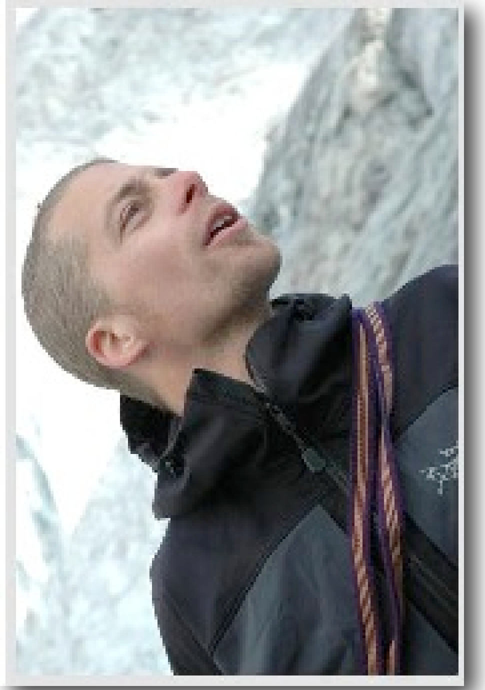
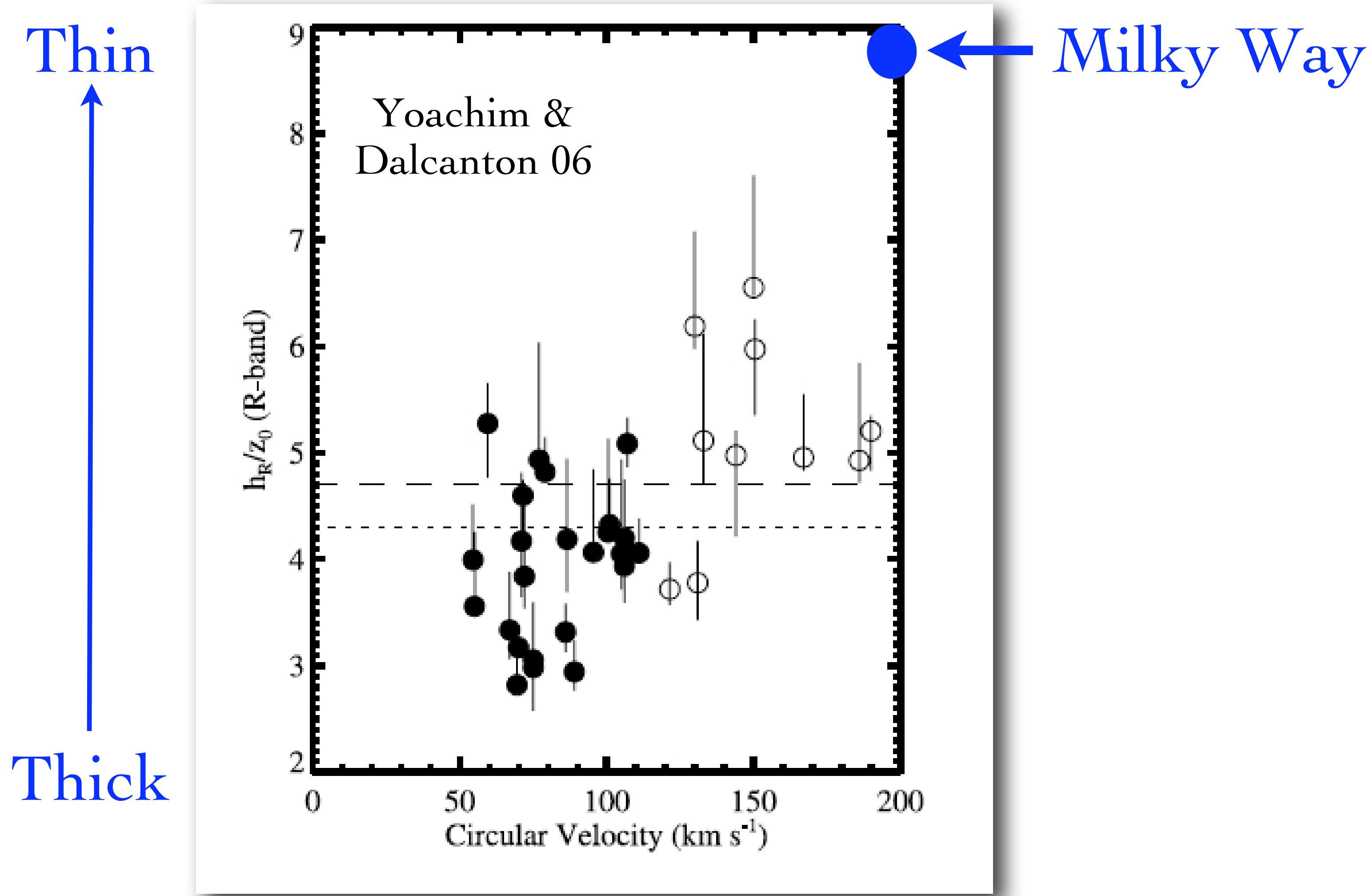


Tobias Kaufmann,
Coral Wheeler &
JSB astro-ph/07

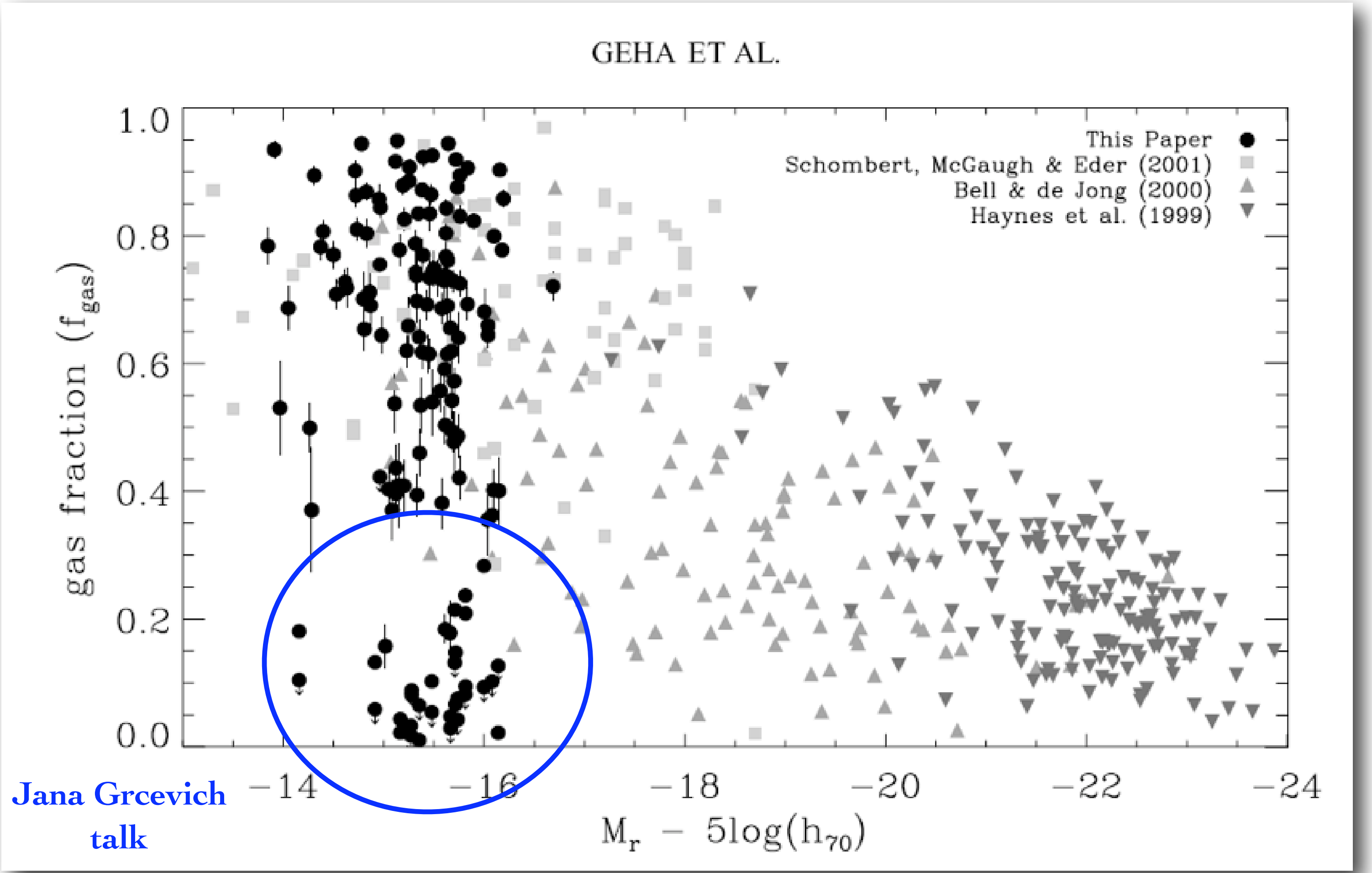
Tobias Kaufmann



Small galaxies: puffier than big ones

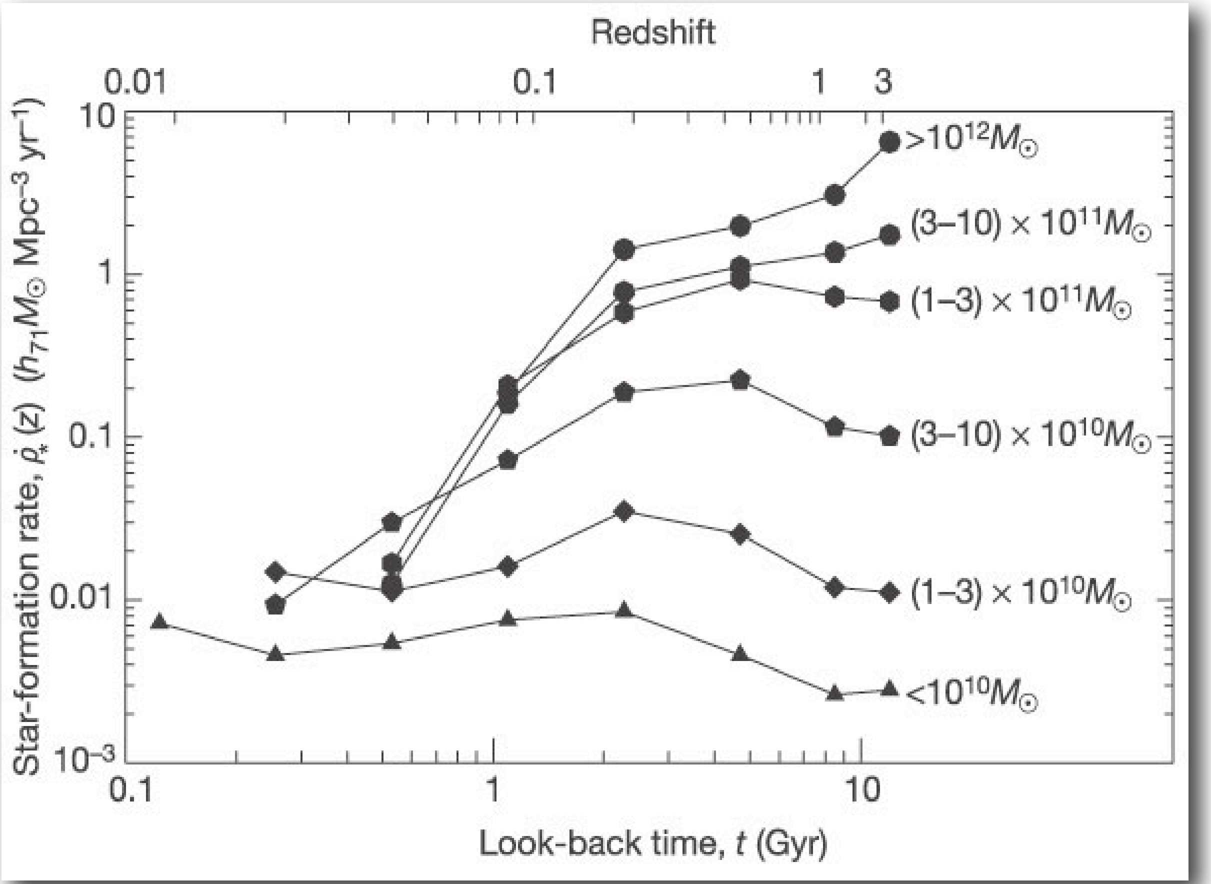


Small galaxies: more gas rich than big ones



Jana Grcevich talk

Small galaxies: longer star-formation times

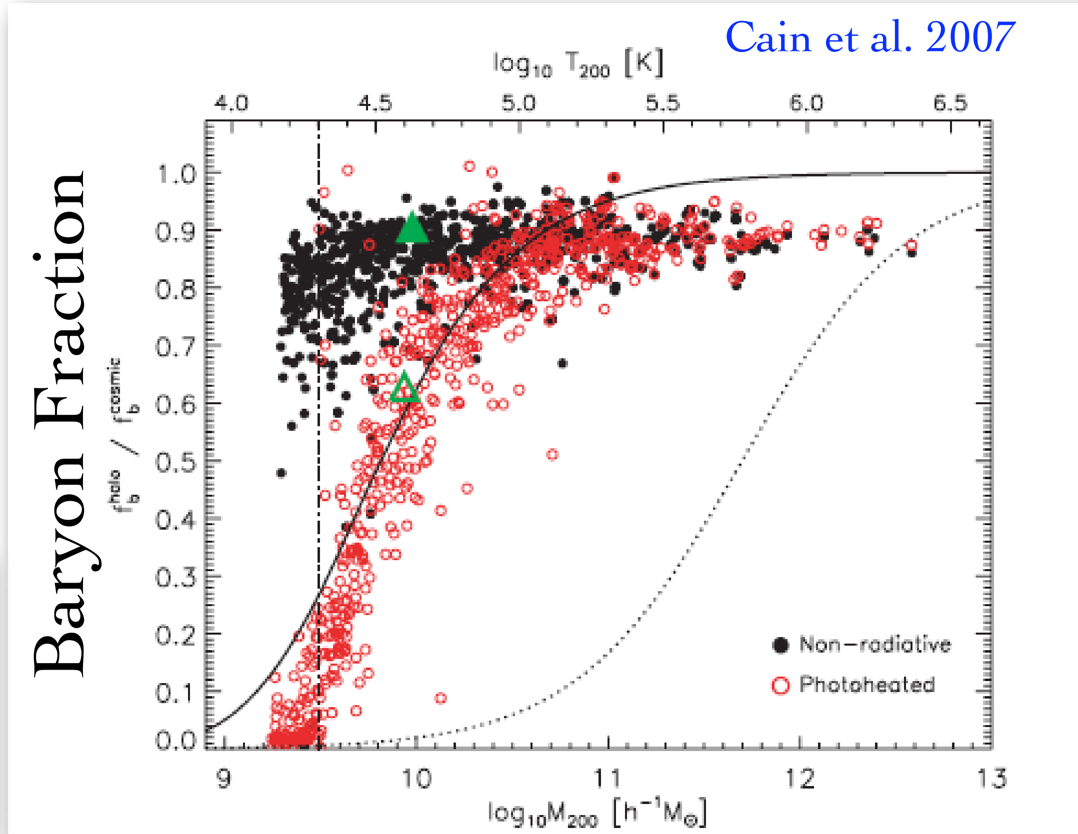


Heavens et al. 04

Photo-heated (~10^4 K) gas & small galaxies

- Well-known: Stops gas accretion in tiny halos:
  - ★ V ≤ ~20 km/s
  - ★ Helps solve dwarf satellite problem?

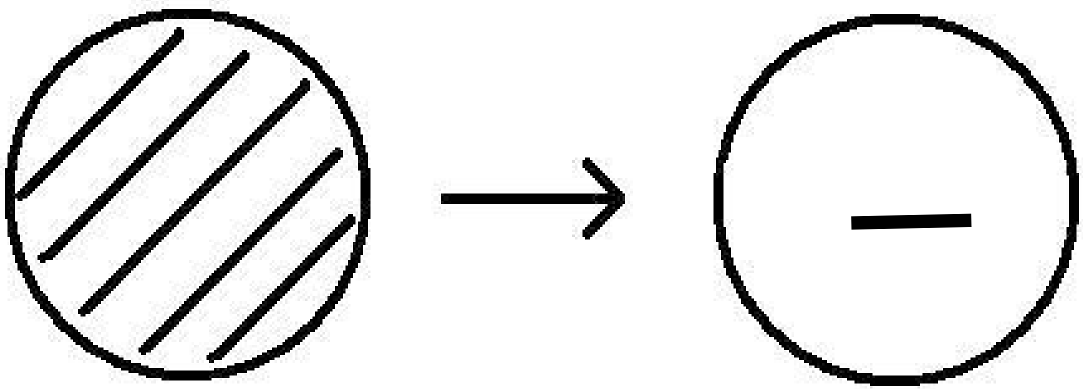
- What about slightly larger halos,
  - ★ V≈30-60 km/s?



Halo Mass

Standard picture of galaxy formation

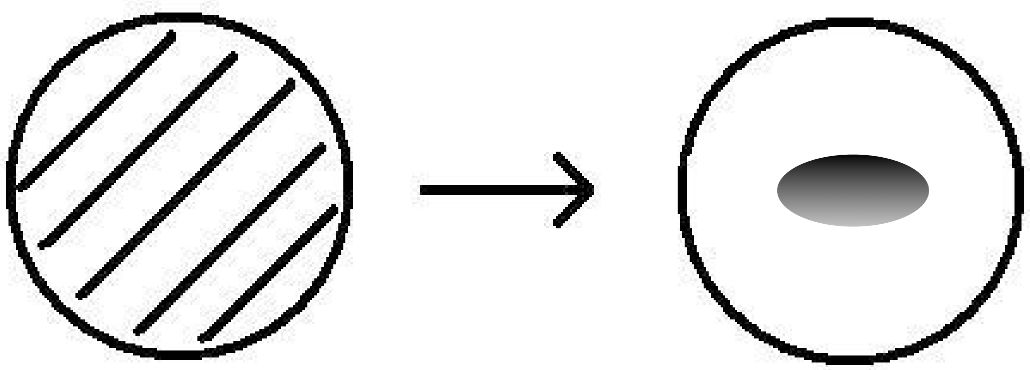
- Big galaxy halos: hot ~10^6K gas cools to ~10^4K.
- Angular momentum conserved, forms thin disk



$$R_d \simeq \lambda R_{\rm vir} \sim 0.03 R_{\rm vir}$$

Small galaxies: dispersion support should matter

- Small galaxy halos: warm ~10^5K gas cools to ~10^4K.
- Dispersion & Angular momentum of similar importance



Toy model: Estimate importance

★ Gas of temperature T_g in hydrostatic equilibrium within a halo with circular velocity curve V(r)

$$\frac{r}{\rho_g}\frac{\mathrm{d}\rho_g}{\mathrm{d}r} = \frac{-V^2(r)}{c_g^2} \propto -\frac{T_{\rm vir}}{T_{\rm gas}}$$

<u>For NFW halo</u>:

$$\rho_g = \rho_0 \exp\left[9.26\frac{T_{\rm vir}}{T_{\rm gas}}\left(\frac{\ln(1+r/r_s)}{r/r_s} - 1\right)\right]$$

$$r \to 0 \qquad \rho_g \sim \rho_0 \exp[-r/r_{\rm T}]$$

$$r_{\rm T} \simeq 0.02\frac{T_{\rm gas}}{T_{\rm vir}}R_{\rm vir}$$

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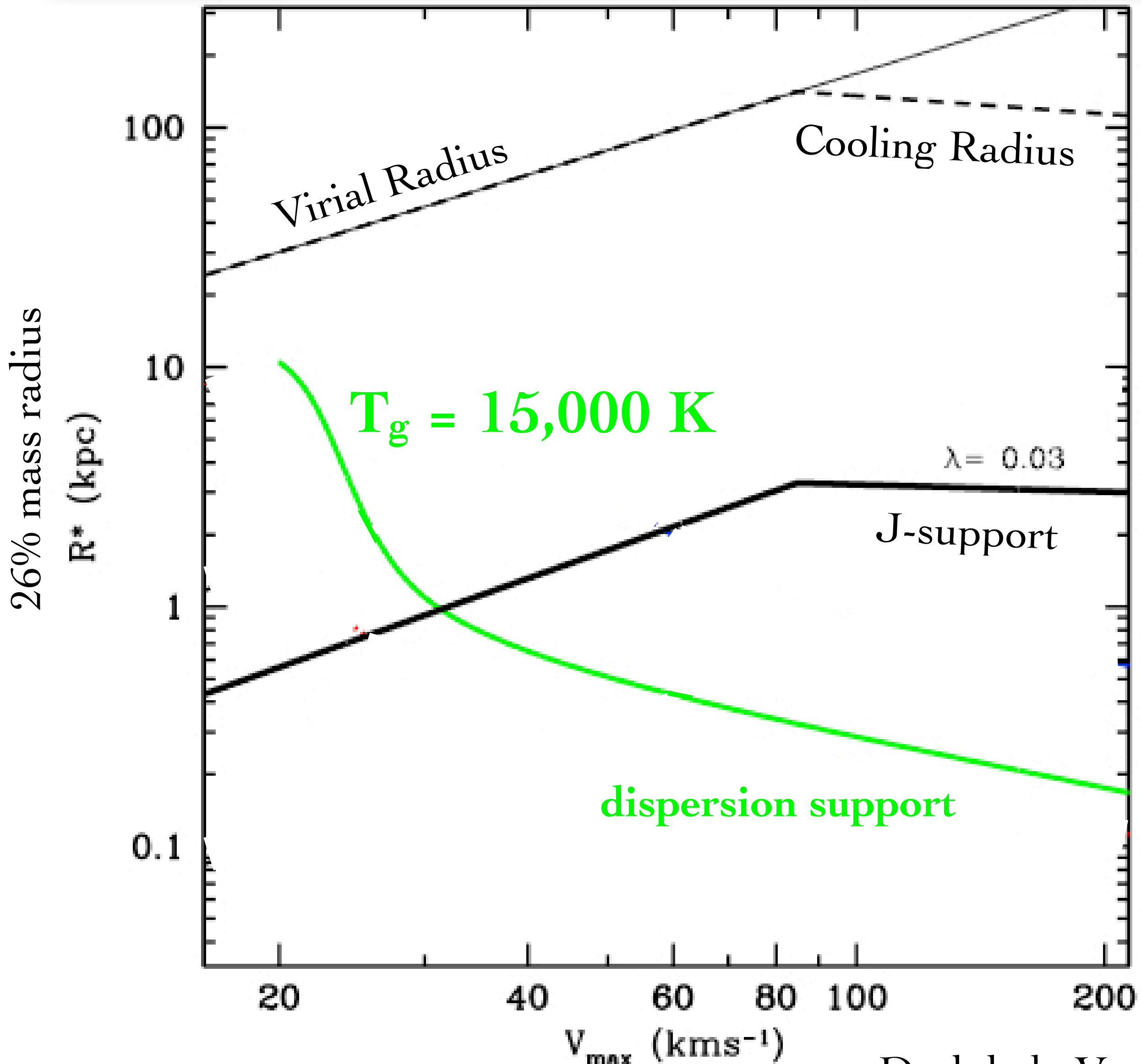
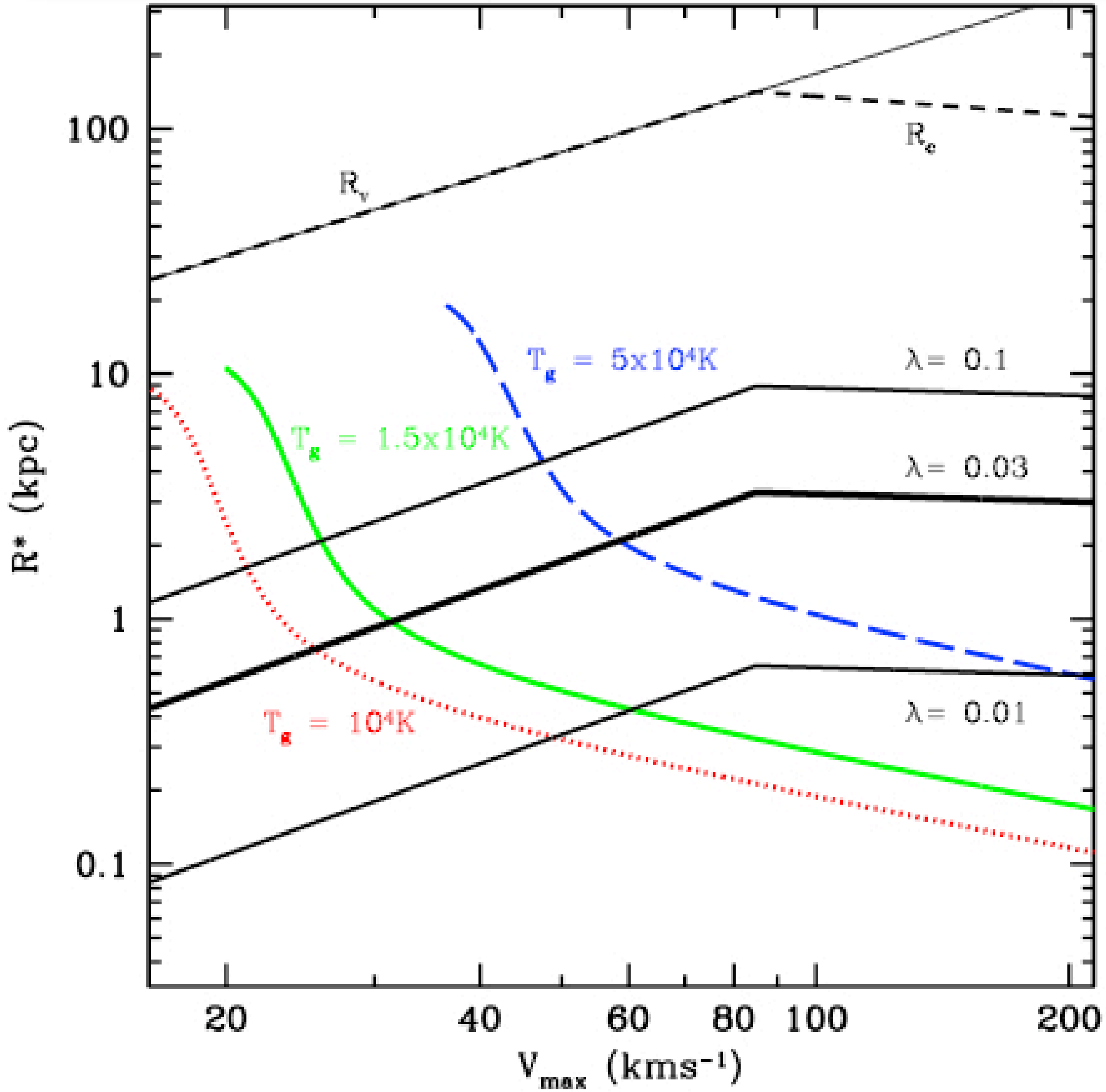


$R_d \cong \lambda R_v$

Dark halo Vmax



100
10
1
0.1
R* (kpc)
R_v
R_c
T_g = 5x10^4K
T_g = 1.5x10^4K
T_g = 10^4K
λ= 0.1
λ= 0.03
λ= 0.01
20
40
60
80
100
200
V_max (kms^-1)

SPH Simulations

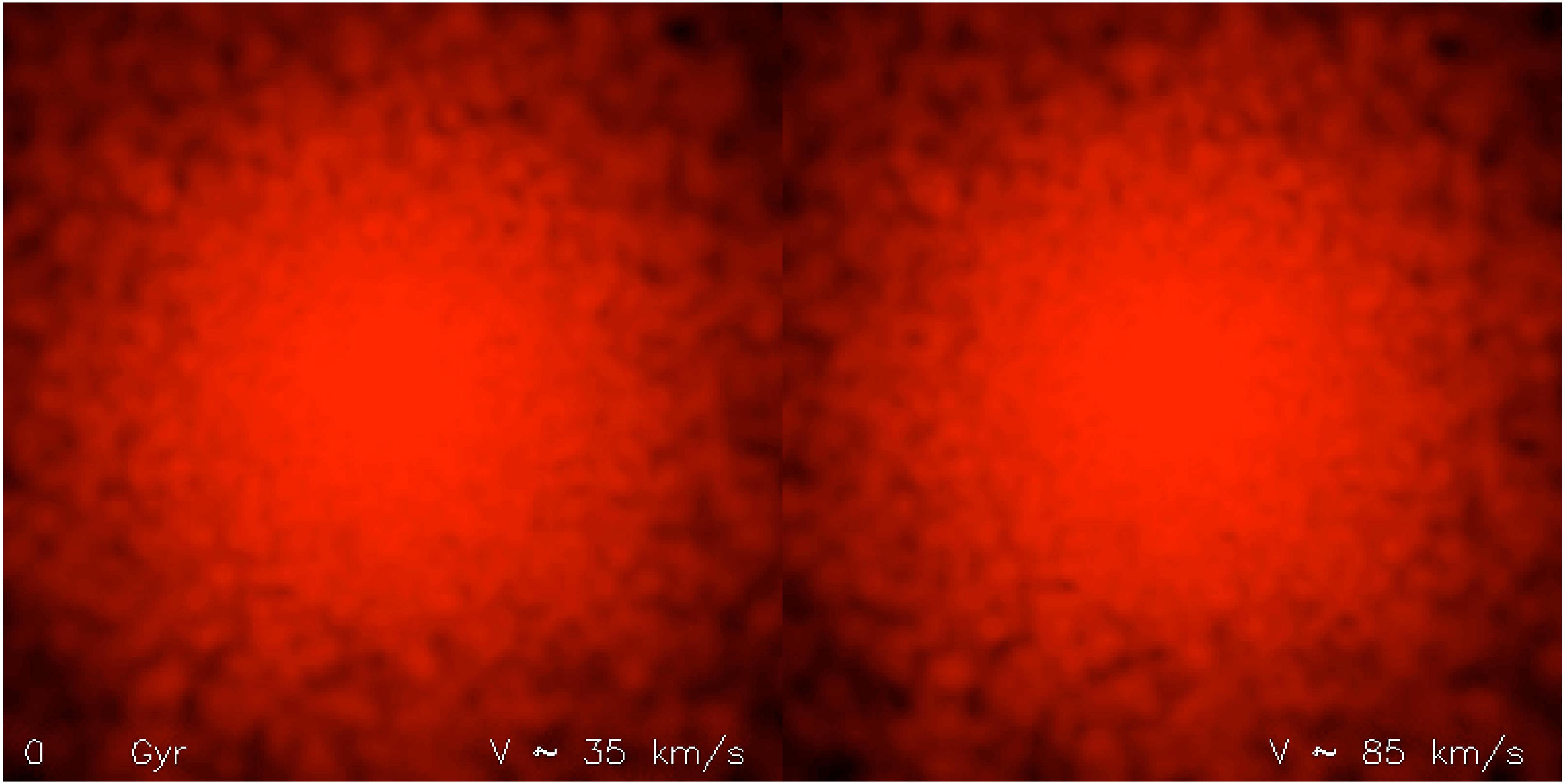
- Set of 17 GASOLINE simulations
- Temperature Floors: T_f = 15, 30, 50 x 10^3K
- Halo sizes: V_{max} = 24 - 148 km/s
- $N_g = 10^5$, $N_{DM} = 2.10^5$
- Cooling with & without star formation
- Simple star formation prescription:

  $\rho_g > \rho_{SF} = 2.5 \times 10^6\ M_\odot\,\mathrm{kpc}^{-3}$

  + efficiency parameter set such that MW-size halo matches kennicutt law

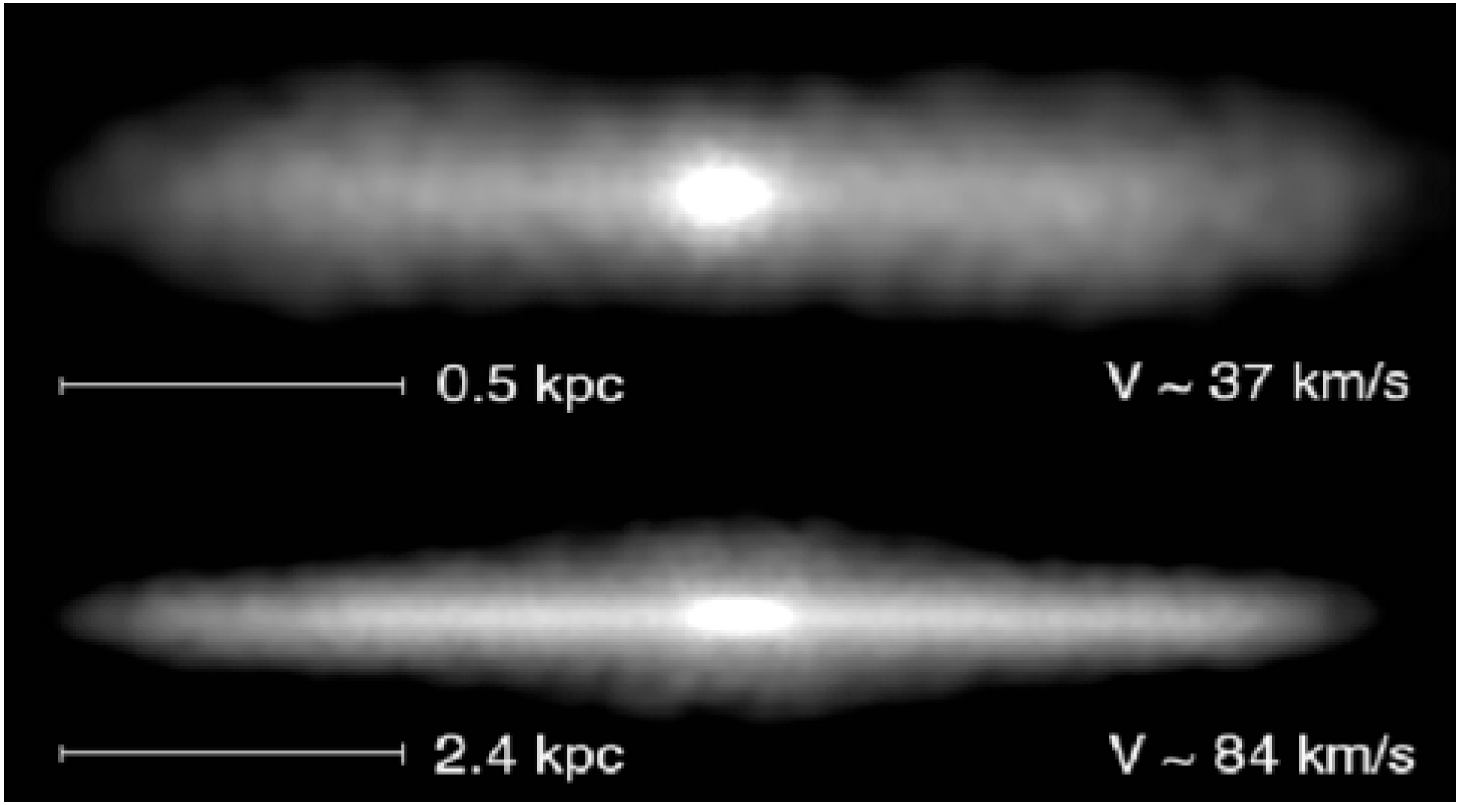
Little Halo ~ 35 km/s

Big Halo ~ 85 km/s



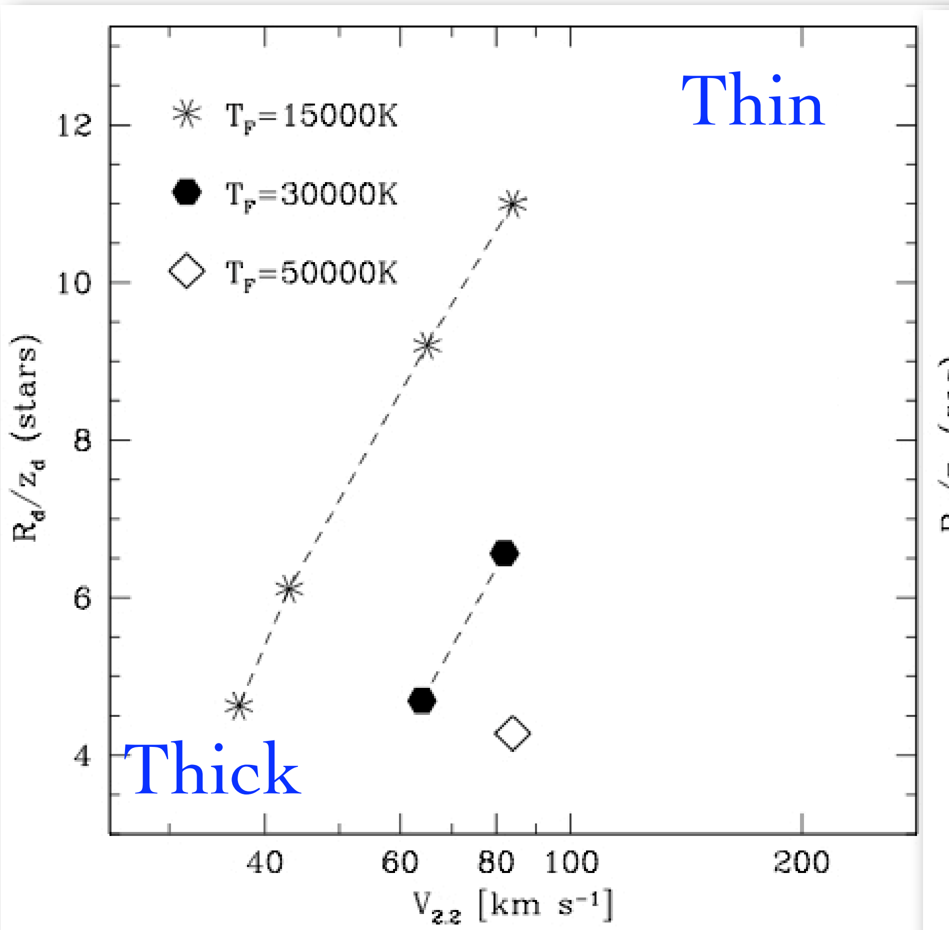
Kaufmann et al. 07

Kaufmann, Wheeler & JSB 2007

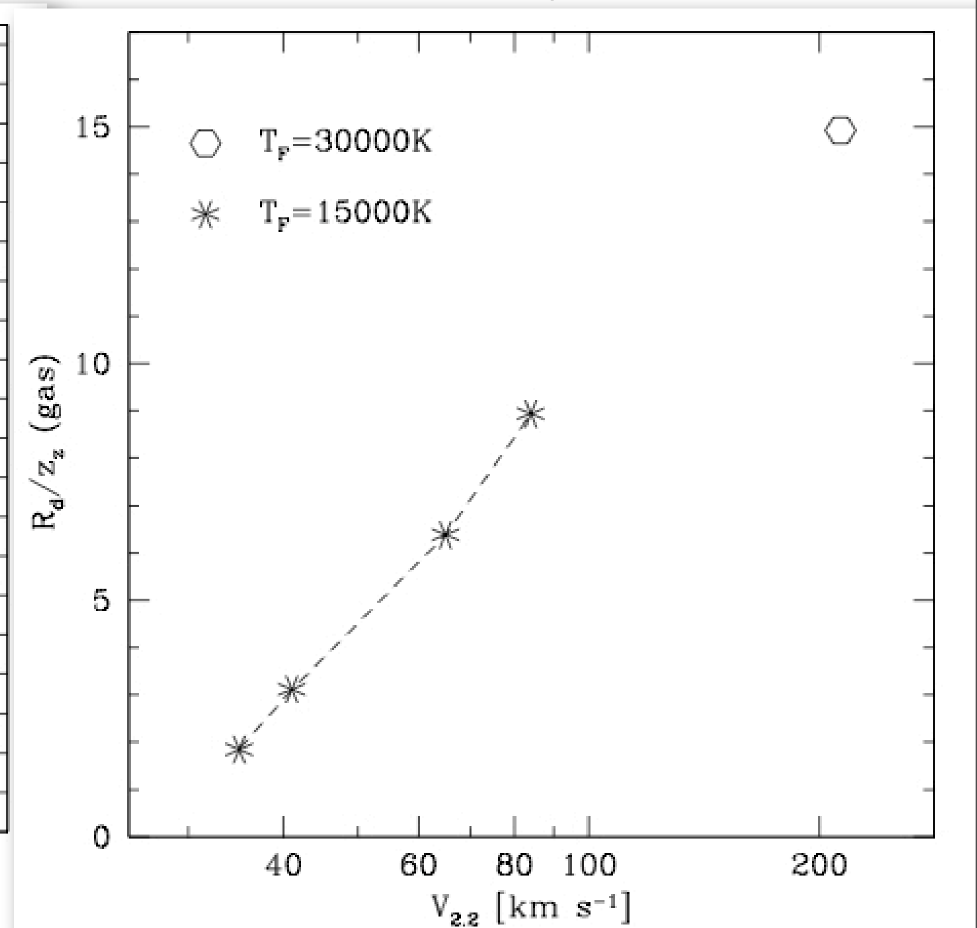


Disk "Thinness"

Star Formation Runs



Gas Only Runs



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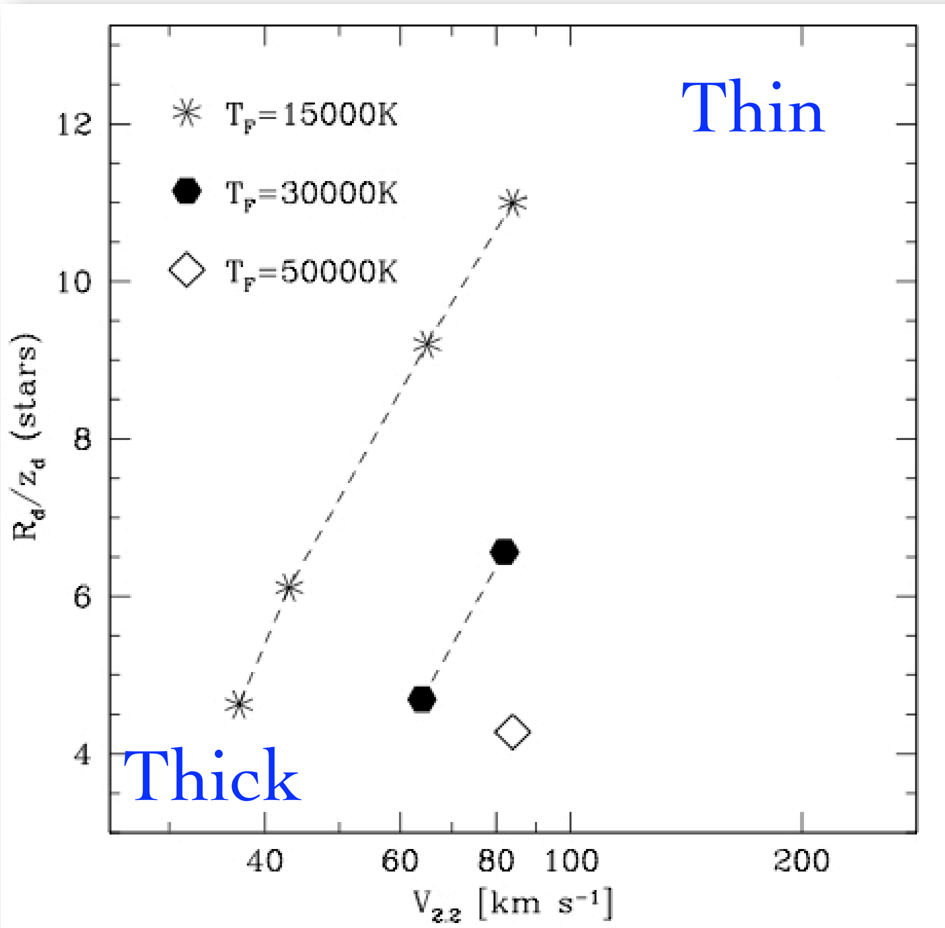
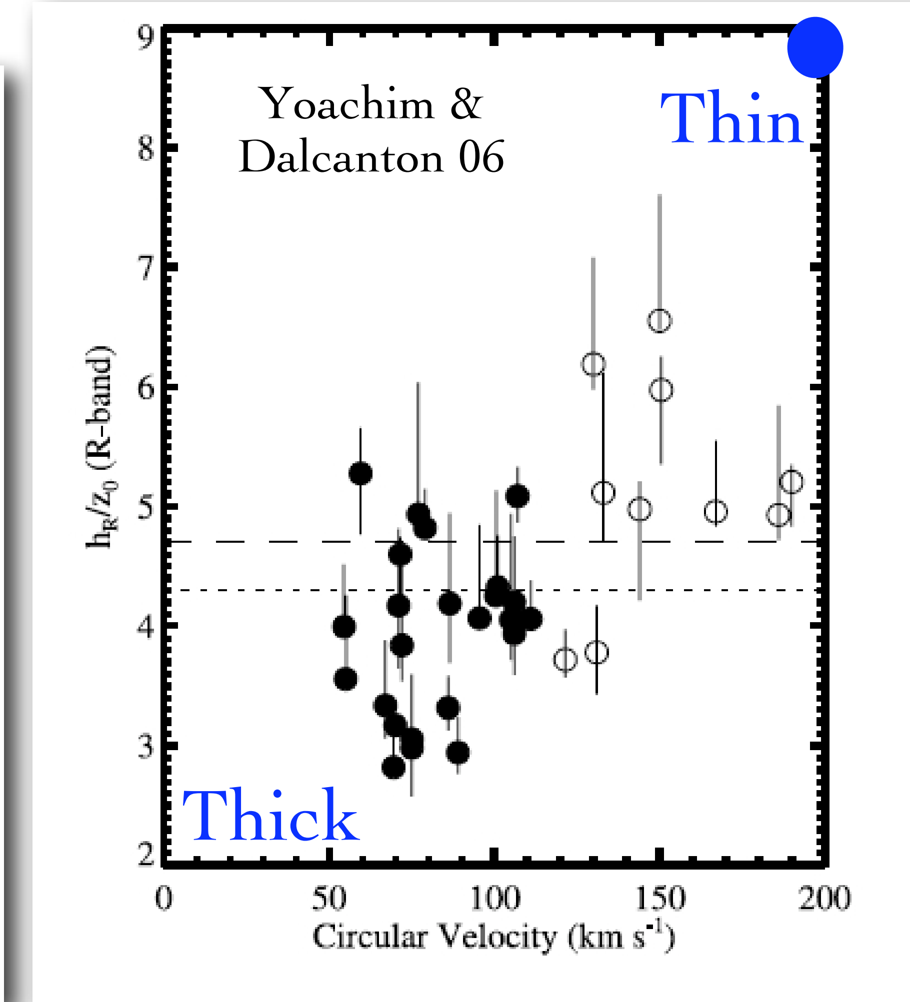
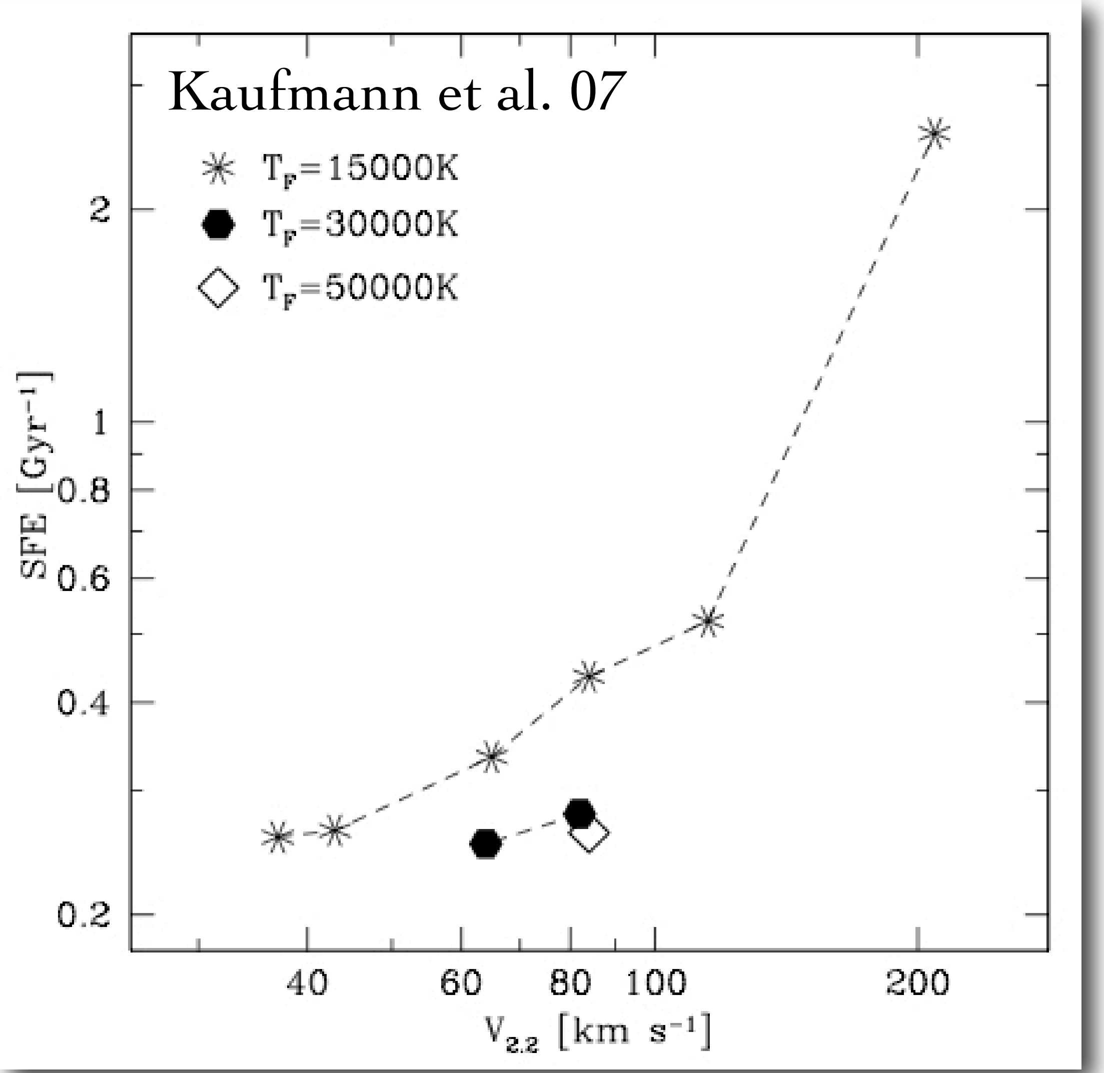


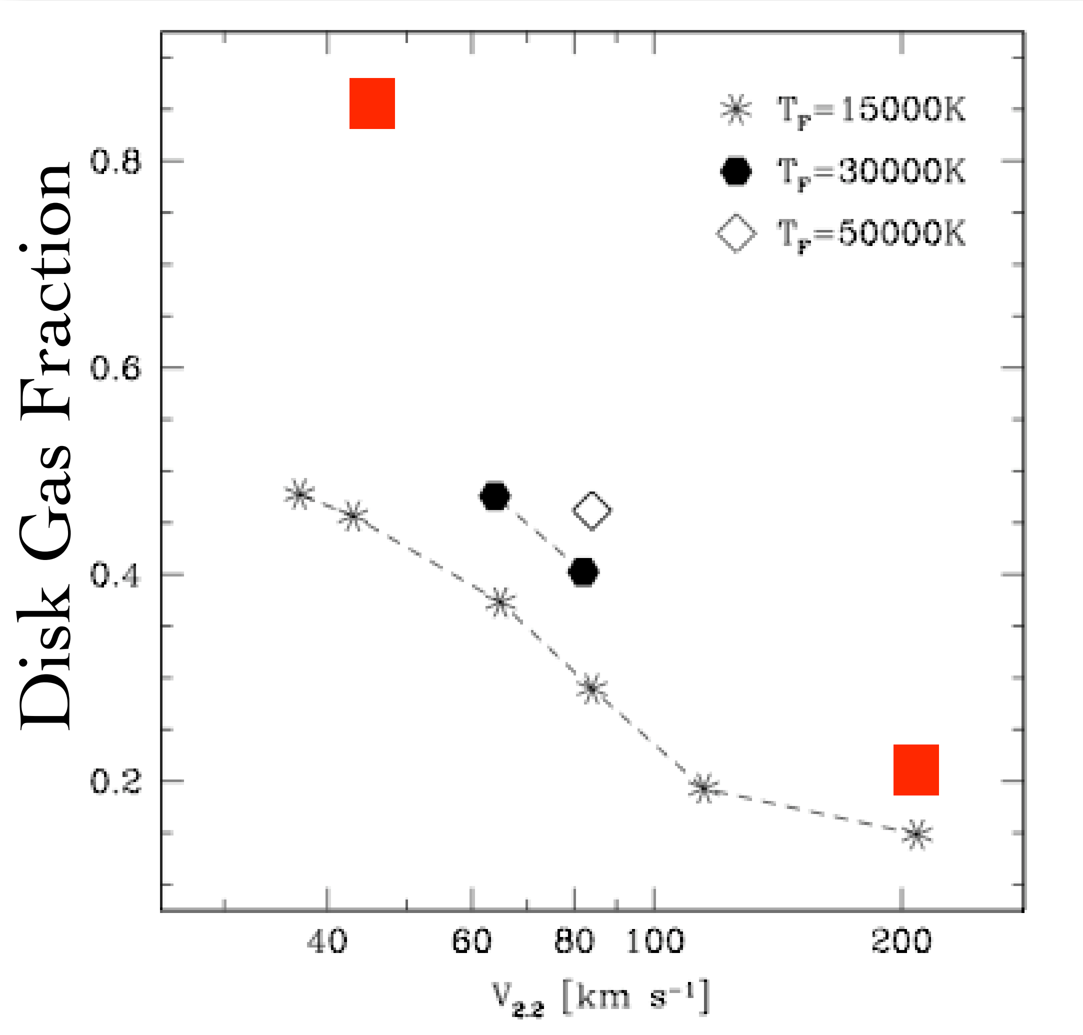


Star Formation Efficiency

$$\frac{1}{m_{\rm gas}}\frac{{\rm d}m_\star}{{\rm d}t}$$

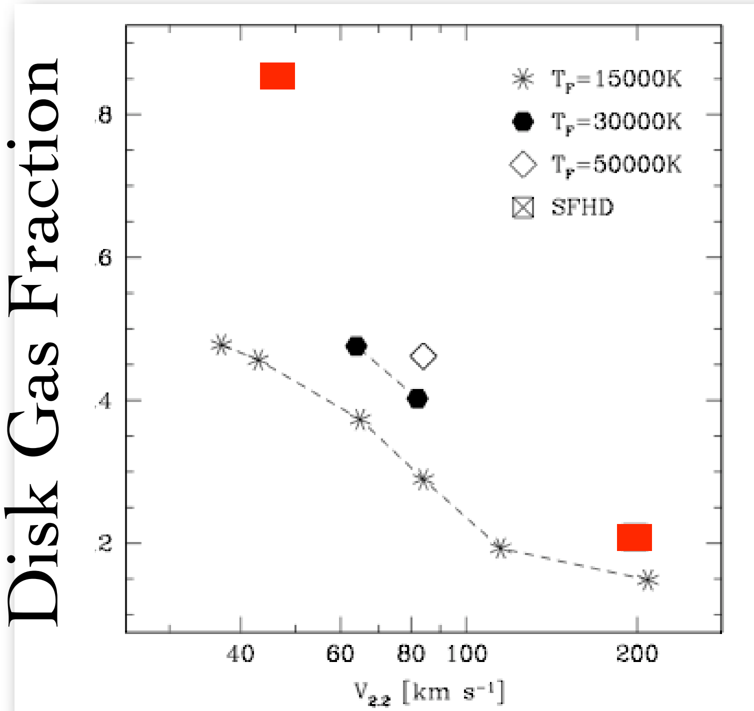


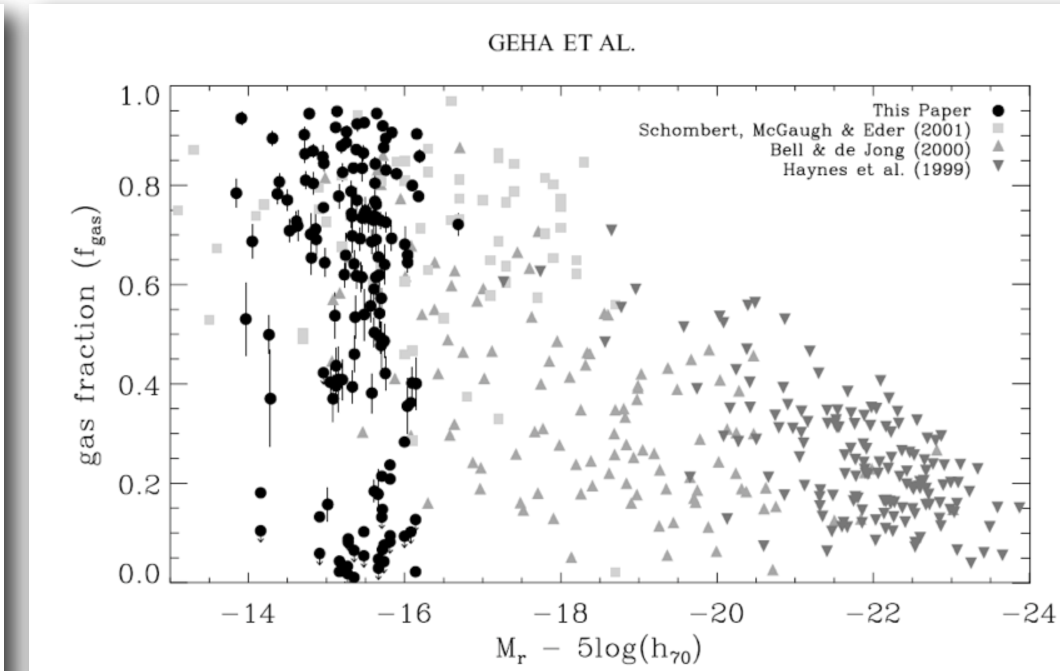
Cool Gas Fraction



$\rho_{SF} \rightarrow 100\rho_{SF}$

Cool Gas Fraction





Conclusions

- $T_{eff} \sim 10^4$K ISM produces pressure support radii comparable to rotational support radii in small galaxies
- Dwarf galaxies should be "born" puffy
- Trend for small galaxies to be thicker, more gas rich, and inefficient at turning gas into stars than large galaxies.
- No feedback required other than heating.

Kaufmann et al. astro-ph/07

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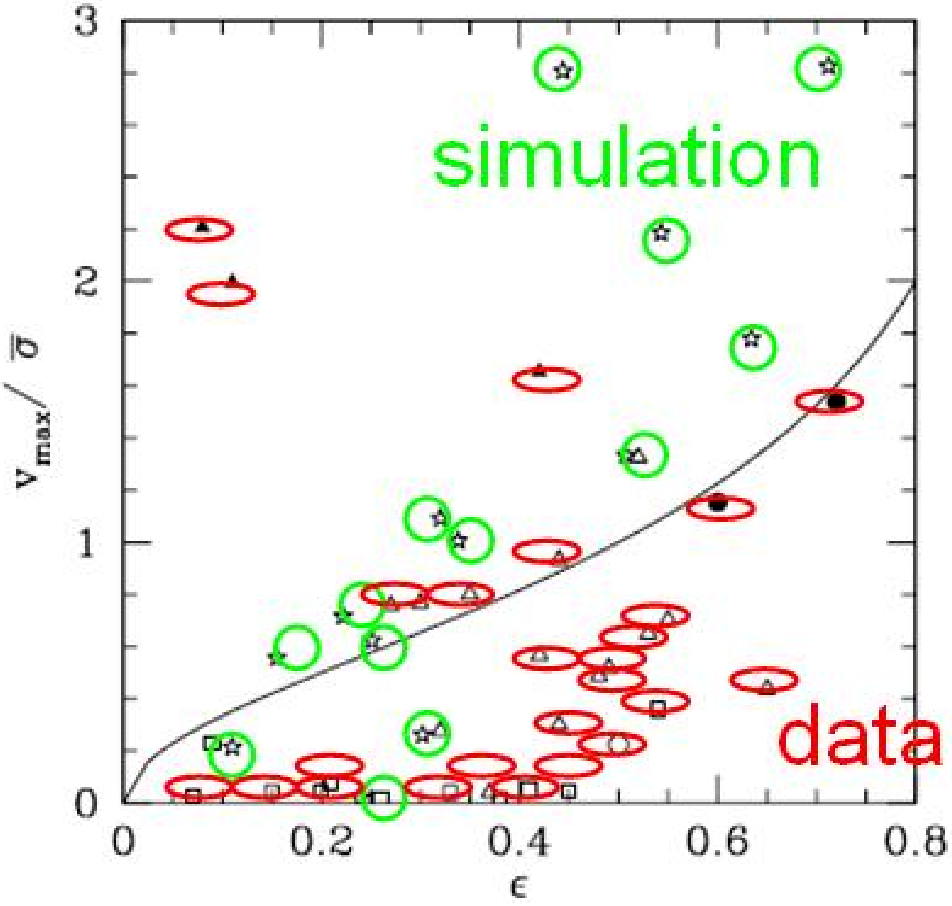
See Brant Robertson's talk for more realistic models...

Low V/σ dwarfs?

Mastropietro et al. 2005



- Galaxy harassment / transformation simulations, starting with thin low-mass disks
- Hard to explain dispersion-supported dwarf galaxies if they all start off as thin disks.
- Conjecture: Dwarfs initially form as puffy disks; harassment more easily transforms them into pressure supported systems