The degeneracy between star-formation parameters in dwarf galaxy simulations and the M_{star}-M_{halo} relation

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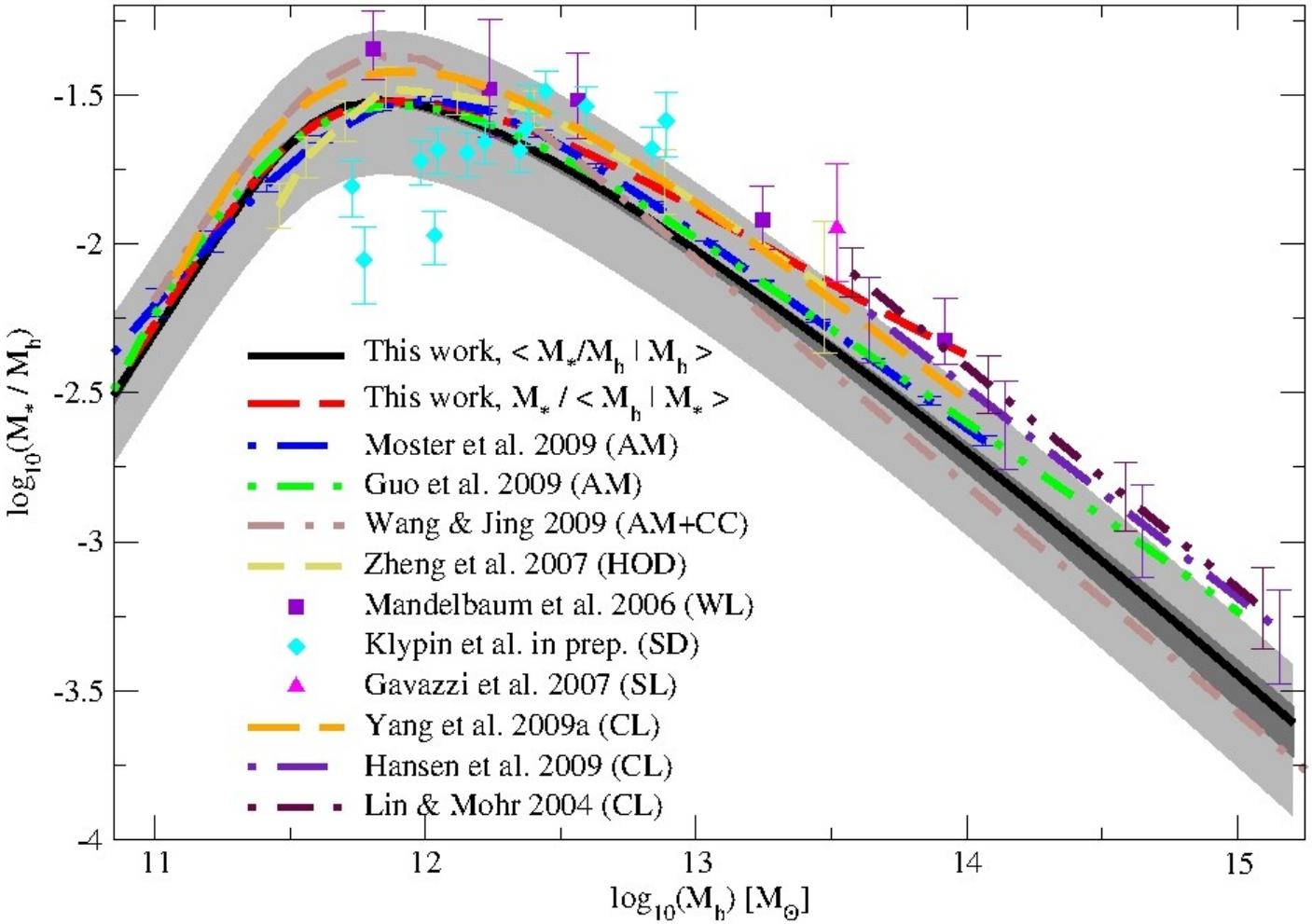
Outline

- **Galaxies:**
  - Gas
  - Stars

  } Directly observable
  - DM → indirectly observable:
    - Gravitational lensing (Mandelbaum 2006, Liesenborg 2009)
    - Dynamical modeling of kinematical tracer (Kronawitter 2000, De Rijcke 2006, Barnabe 2009, Napolitano 2011)

→ M_{star}-M_{halo} relation:

- High mass range: determined from
  - Observations
  - Abundance matching techniques (Guo 2010, Moster 2010, ...)
- Low mass range: extrapolations / simulations



Behroozi, 2010

→ M_{star}-M_{halo} relation:

- High mass range: determined from
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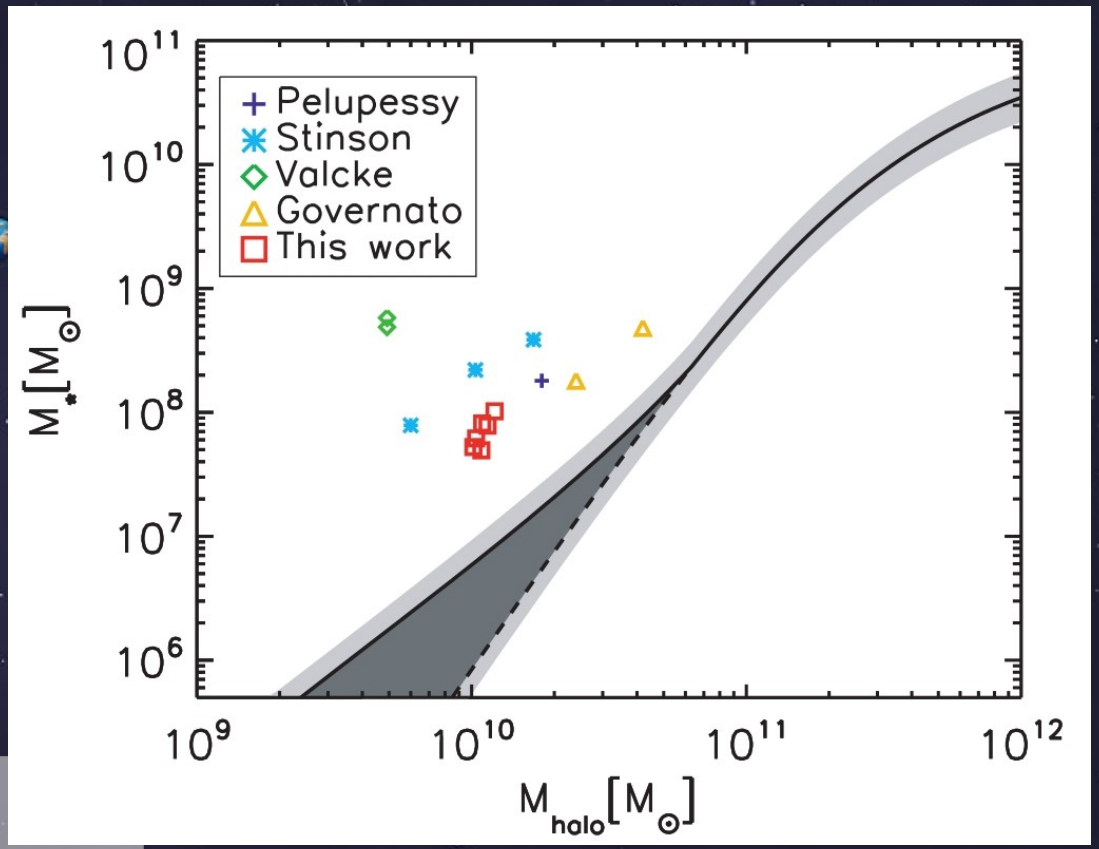
M_{star}-M_{halo} for dwarf galaxies

- Difficult to observe
- Simulations!!

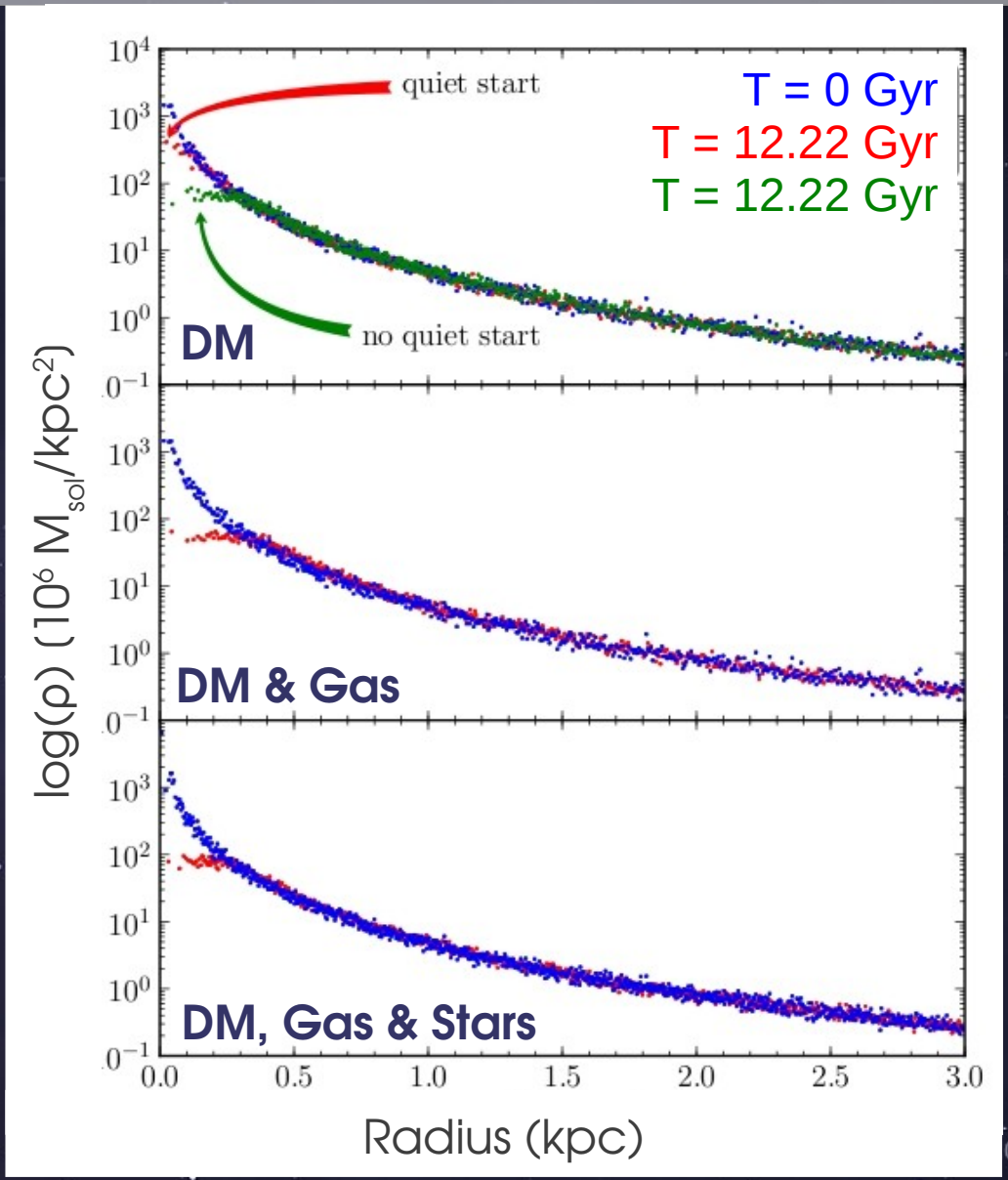


→ too high stellar mass compared to halo mass.

Sawala, 2010

Simulations

- **Initial setup:**
  - Spherically symmetric DM halo with NFW profile
  - Gas cloud
    - Homogeneous
    - Pseudo isothermal
- **Cusp-to-core problem:**
  - NFW profile stable in DM only simulations (quiet start)
  - Conversion to core when gas/star formation is included



Simulations

- **Code:** modified version of Gadget2

(Springel et al. 2005)

- Star formation

$$\rho_g \geq \rho_{SF}$$
$$\nabla \cdot \boldsymbol{v} \leq 0$$

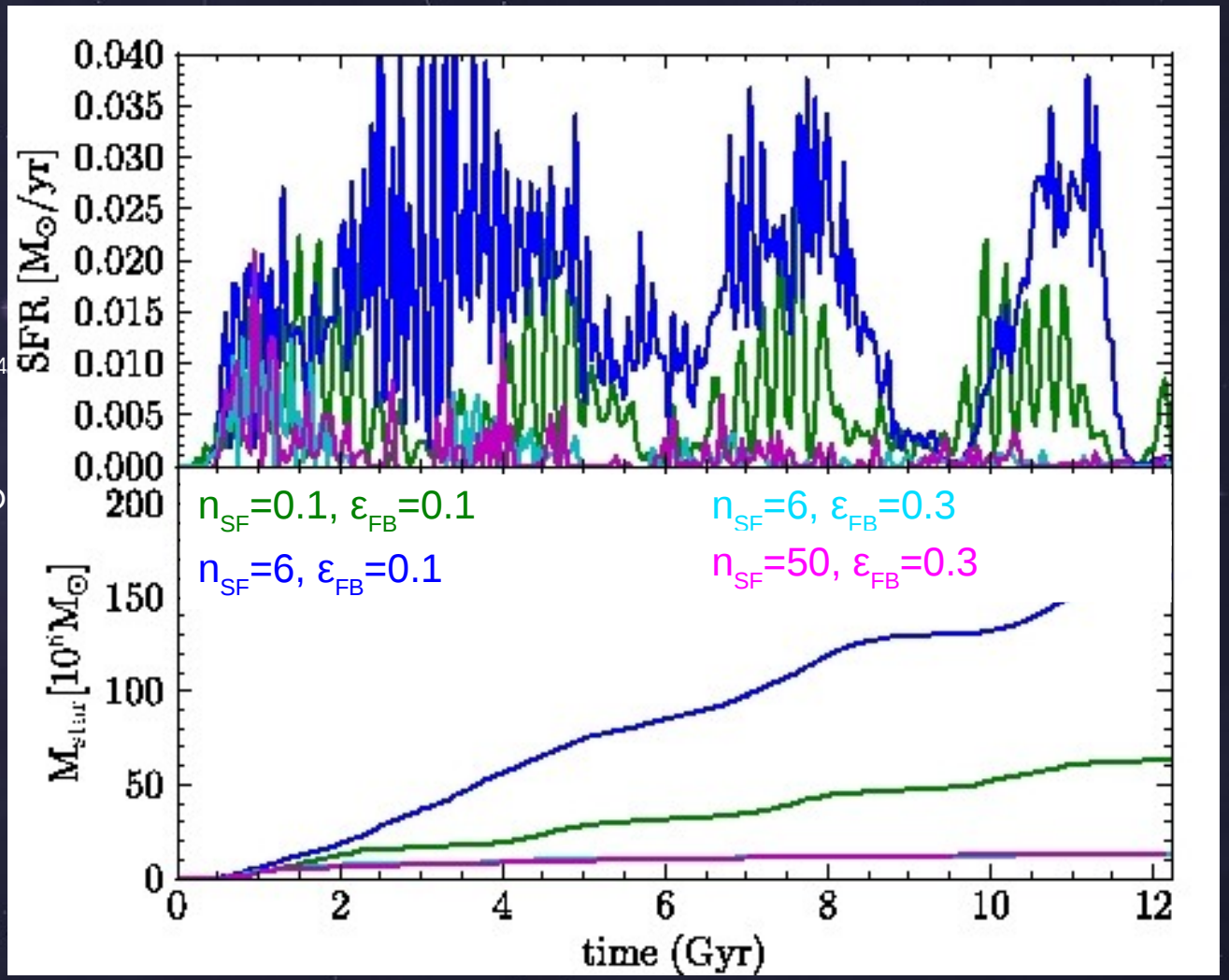
- Feedback efficiency ε_{FB}
- Cooling:
  - Metallicity dependent radiative cooling (Sutherland and Dopita 1993)
  - Cooling below 10^4 K (see talk Joeri Schroyen)
  - New cooling curves (much more at Sven De Rijcke's talk)

Simulations

- influence of <u>feedback efficiency</u>

  → In literature trend towards increasing ρ_{SF} (Governato 2011)

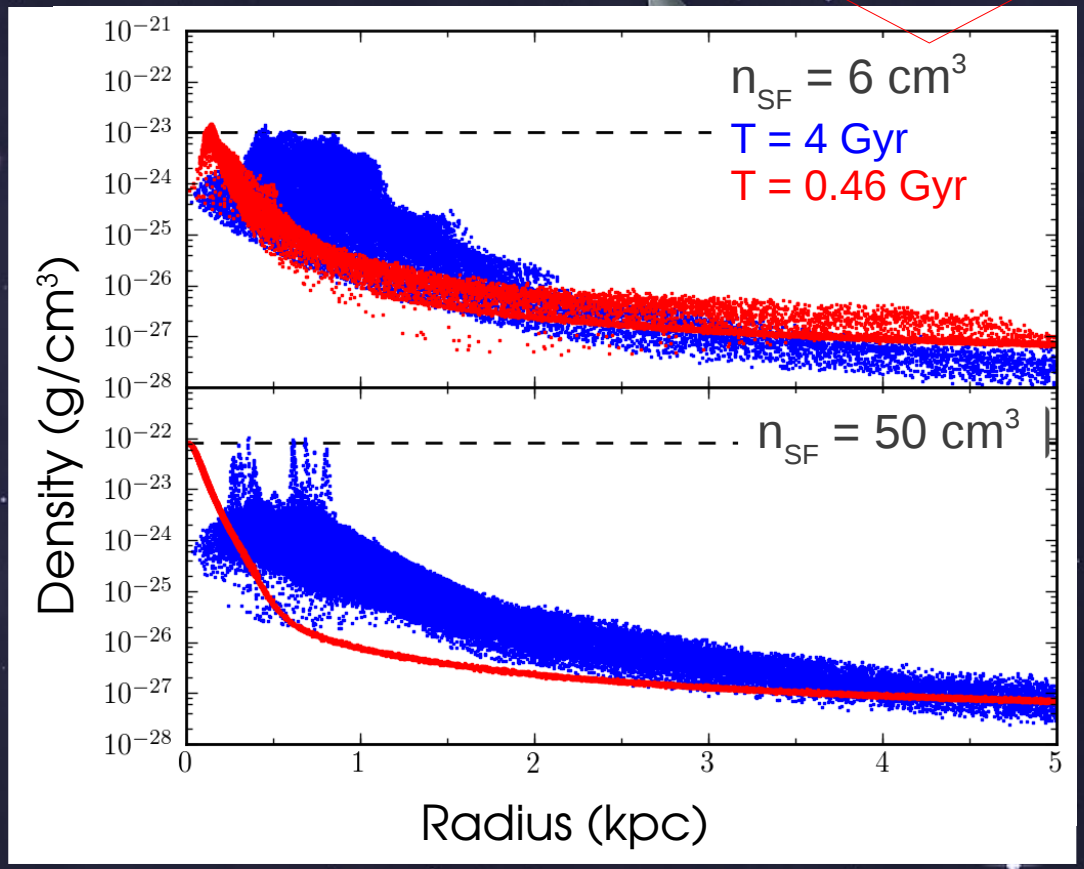
  - Gas collapse to smaller gas clumps → cooling below 10^4 K needed.
  - <u>Results</u>: permanent SF → too metal rich and compact compared to observations
  - <u>Solution</u>: increase ε_{FB} → extra energy in ISM stops continuous SF



More about star formation

- Influence of density threshold

Number density = # hydrogen atoms/cm^{-3}

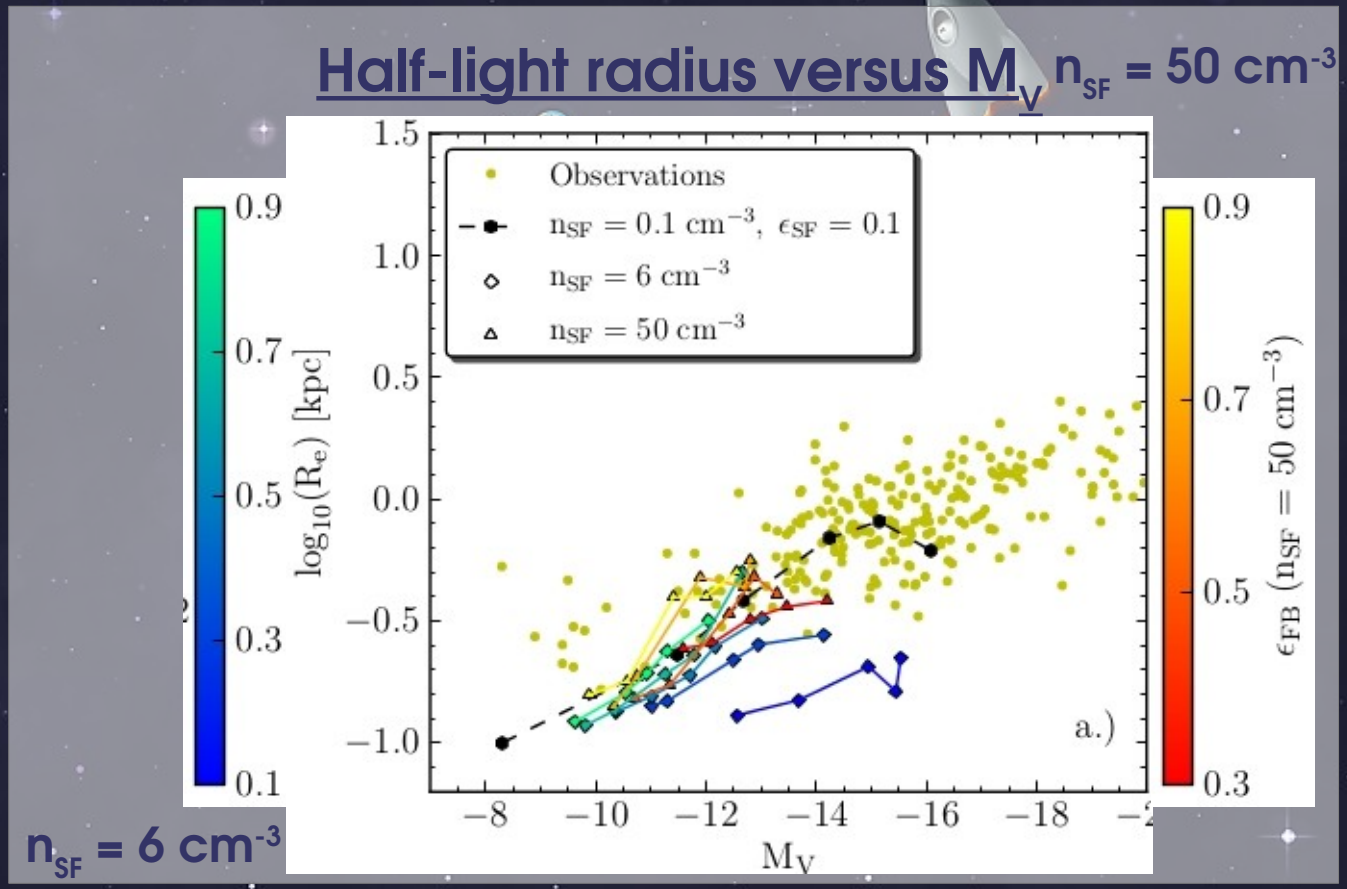


Parameter Survey

- n_{SF} = 0.1 – 6 - 50 cm^{-3}
- ε_{FB} = 0.1-0.3-0.5-0.7-0.9

→ simulated galaxies move along the kin&phot scaling relations

Half-light radius versus M_V n_{SF} = 50 cm^{-3}

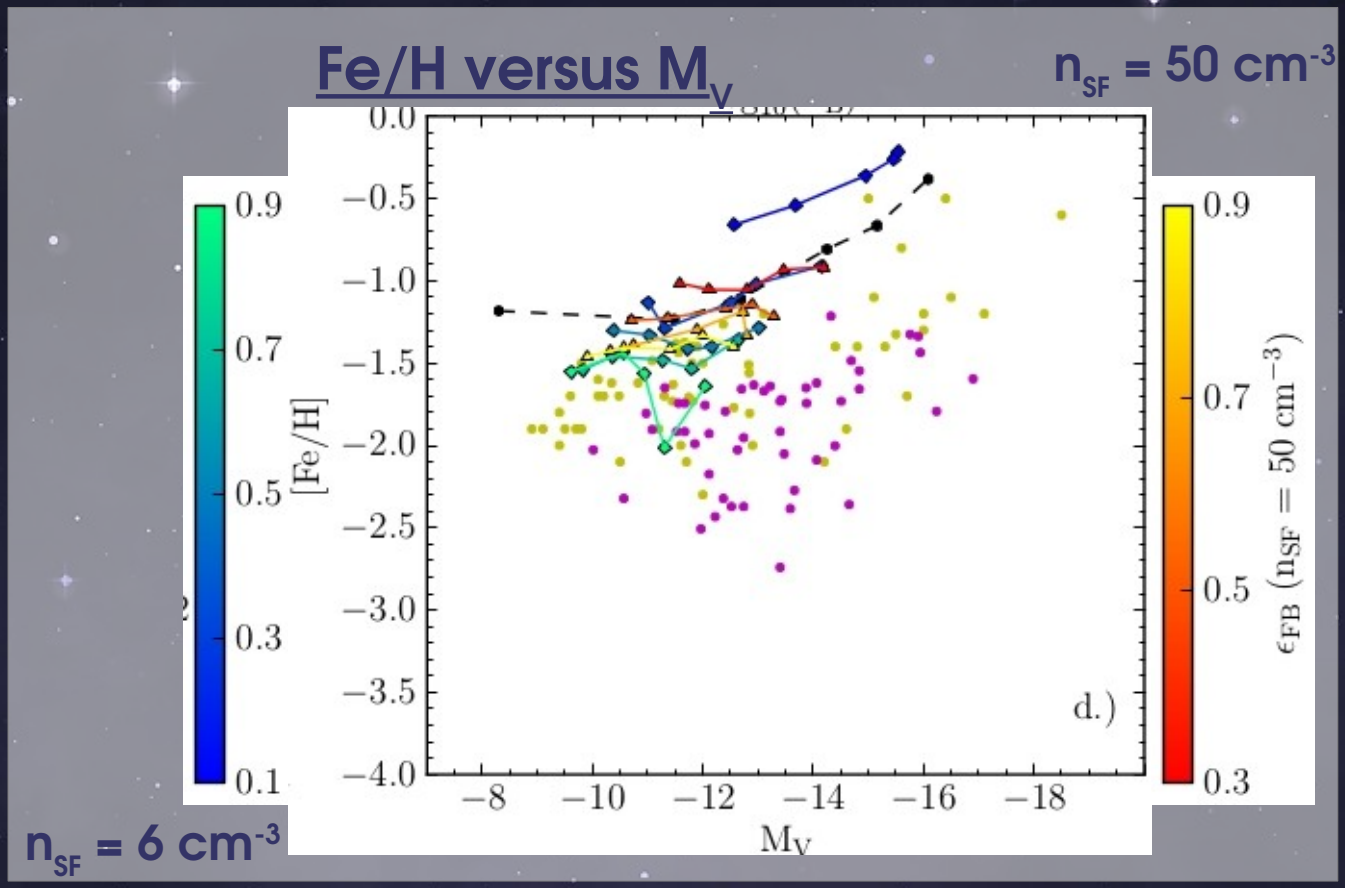


n_{SF} = 6 cm^{-3}

Vladstudio

Fe/H versus M_V

n_{SF} = 50 cm^{-3}



n_{SF} = 6 cm^{-3}

'Best' values:

- n_{SF} = 6 cm^{-3} & ε_{FB}=0.7
- n_{SF} = 50 cm^{-3} & ε_{FB}=0.9

→ different galaxies which line up along the same scaling relations.

→ **Degeneracy**!

Star formation: CMD

- Observations:

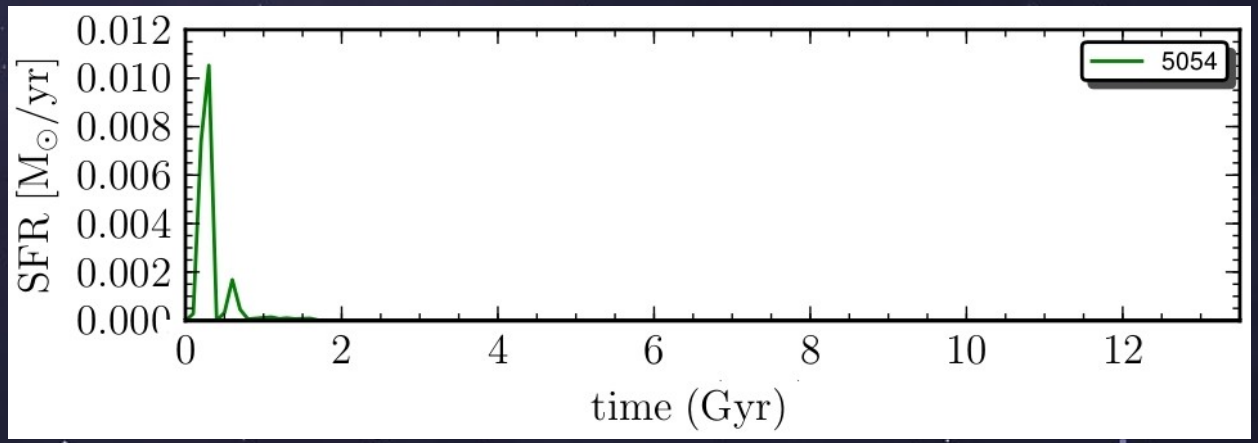
  Tucana dwarf galaxy from LCID (Monelli 2010)

  - M_{star} = 1.81 10^6 M_{sol}
  - M_V = -9.55 mag
  - $\mu_{0,V}$ = 25.05 mag/arcsec^2
  - SFH:
    - 10% stars formed 13.2 Gyr ago
    - 50% stars formed 12.1 Gyr ago
    - 95% stars formed 9.7 Gyr ago

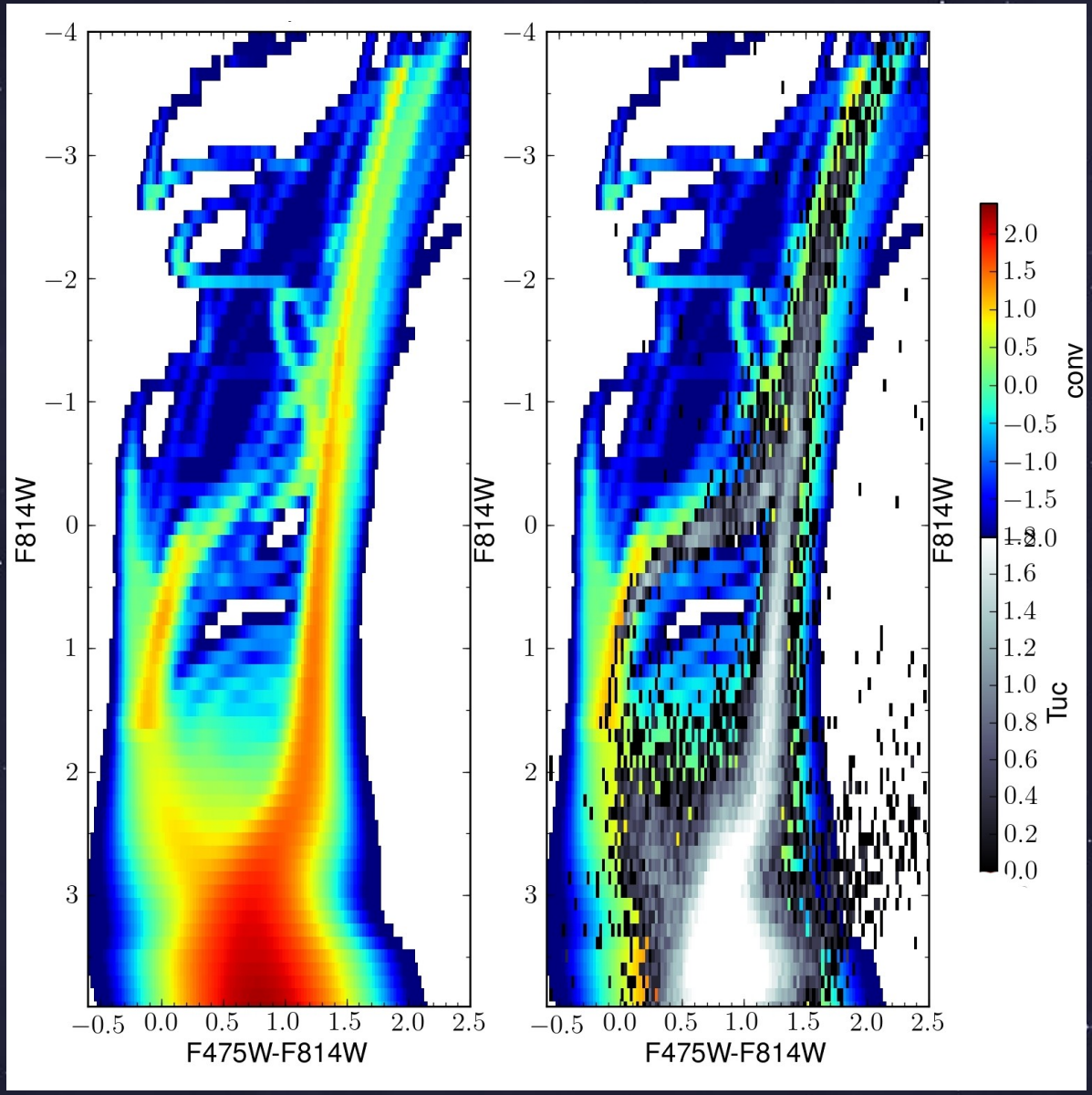
- Simulations:

  Dwarf galaxy with

  - M_{star} = 1.936 10^6 M_{sol}
  - M_V = -9.71 mag
  - $\mu_{0,V}$ = 24.41 mag/arcsec^2
  - Comparable SFH:

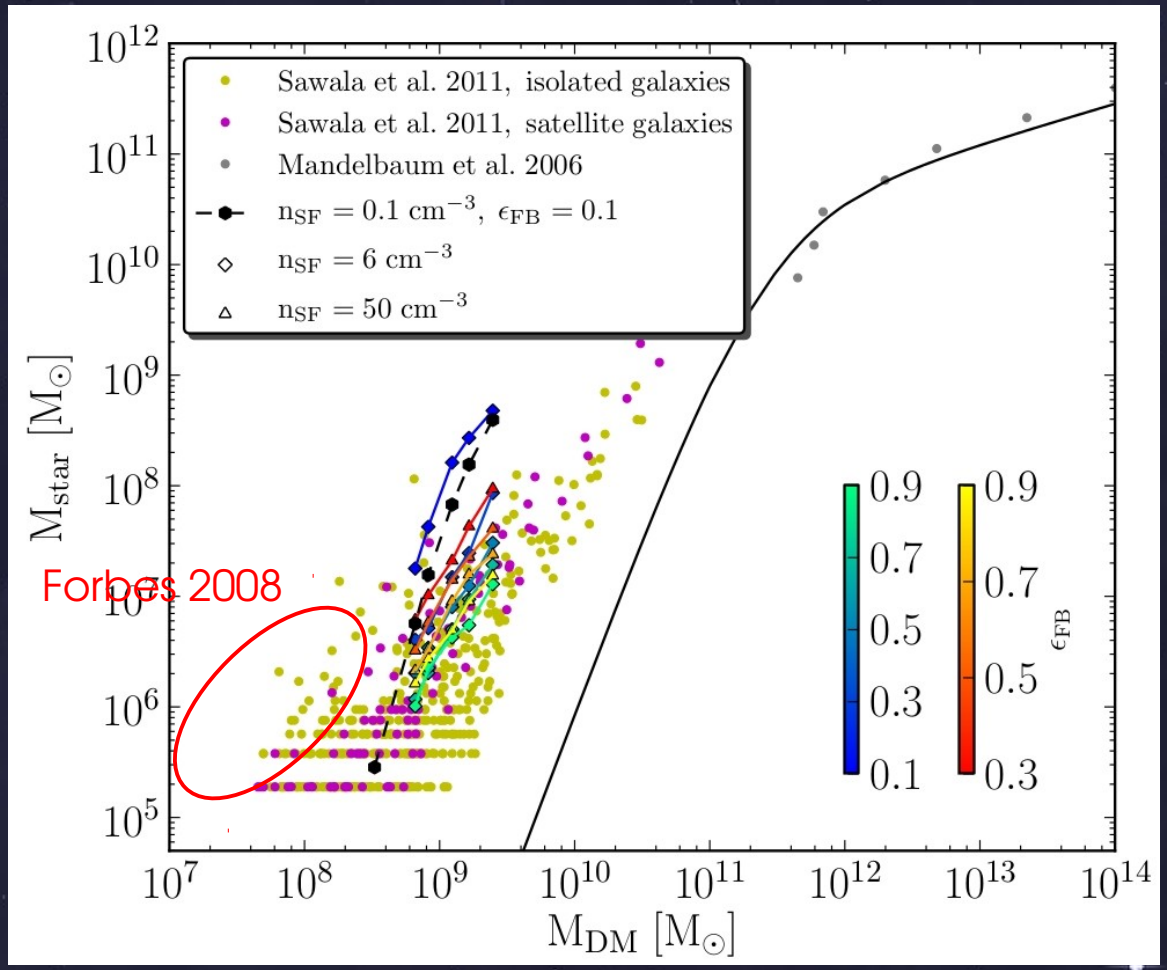


CMD



M_{star}-M_{halo}

- Put our modeled galaxies next to the observations and other literature.



Conclusions

- Natural conversion from **cusp to core** due to the response of DM to the evacuation of gas from the central parts.
- In our simulations we see a **degeneracy** between n_{SF} and ε_{FB}
- The simulations are not in agreement with the extrapolated **M_{star}-M_{halo} relation**
  - is the extrapolation correct?
  - Look for other parameters/processes that might lower the stellar mass in our simulations.