Early evolution of tidal dwarf galaxies

Simone Recchi

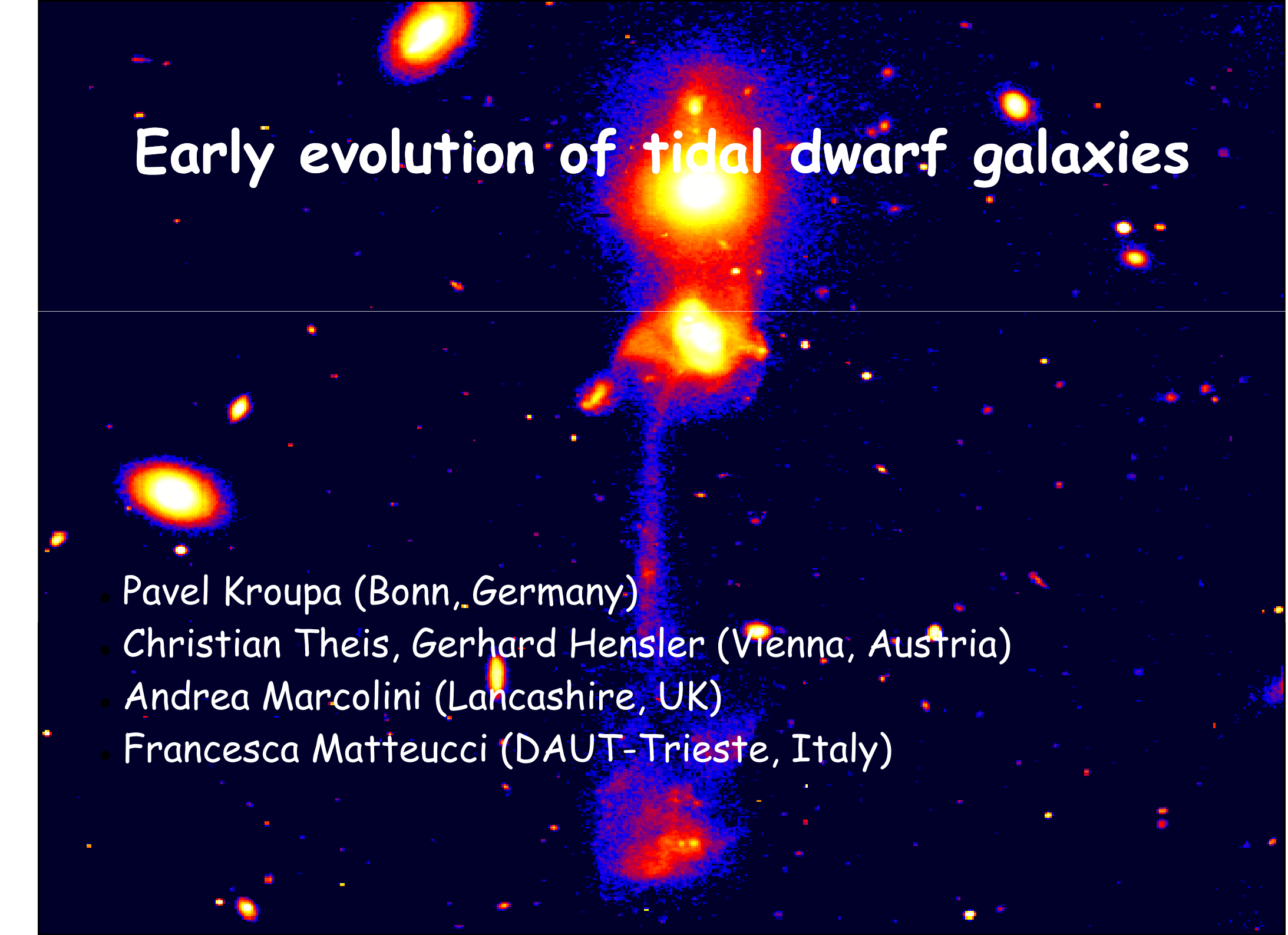
INAF – Trieste Observatory

V Estallidos Workshop "Star Formation and Metallicity"

Albayzin – Granada

2 March 2007





Early evolution of tidal dwarf galaxies

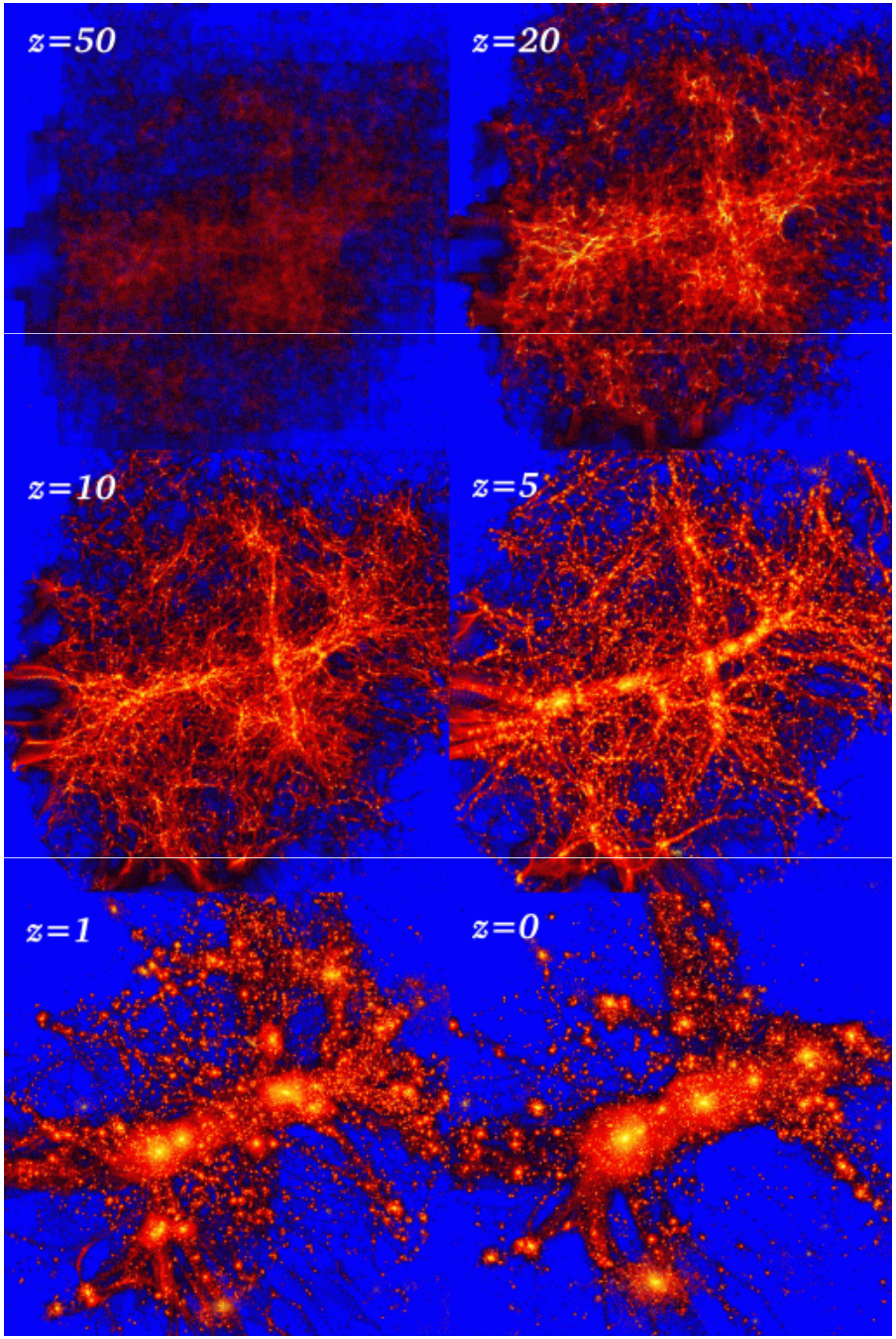
- Pavel Kroupa (Bonn, Germany)
- Christian Theis, Gerhard Hensler (Vienna, Austria)
- Andrea Marcolini (Lancashire, UK)
- Francesca Matteucci (DAUT-Trieste, Italy)

Early evolution of tidal dwarf galaxies

outline:

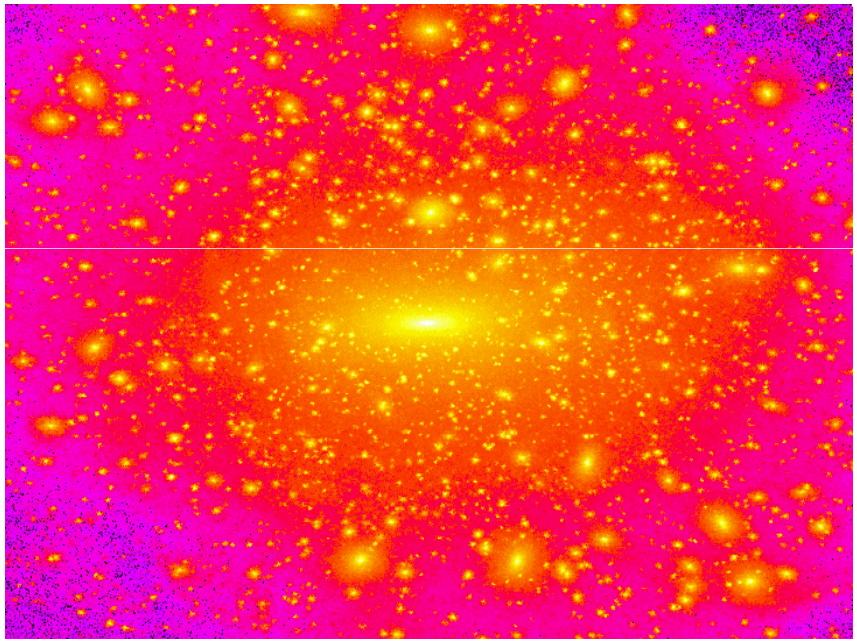
- The astrophysical context
- Investigation method
- Preliminary results

The hierarchical buildup of a Milky Way halo

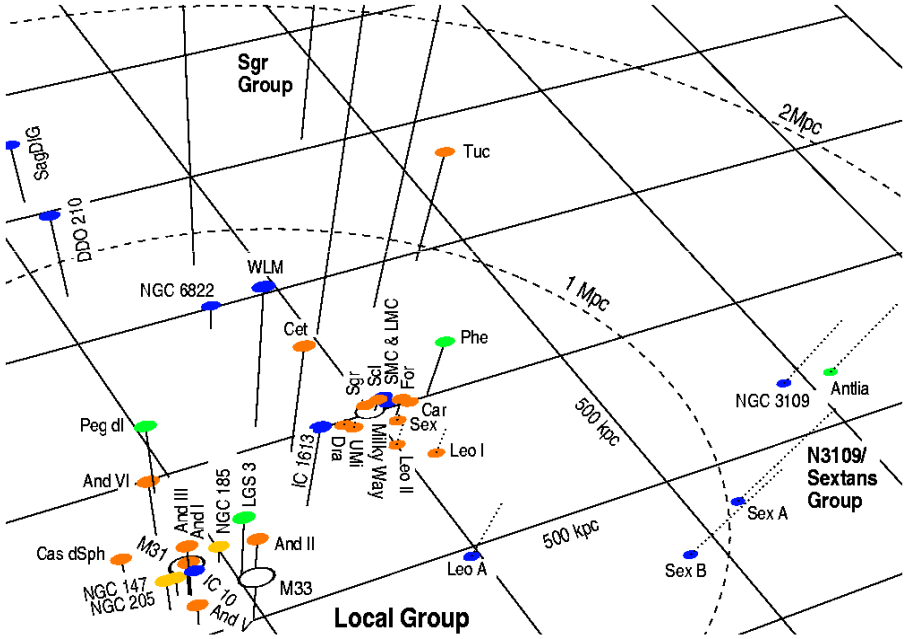


(from Ben Moore's web site www.nbody.net)

The "missing satellites" problem

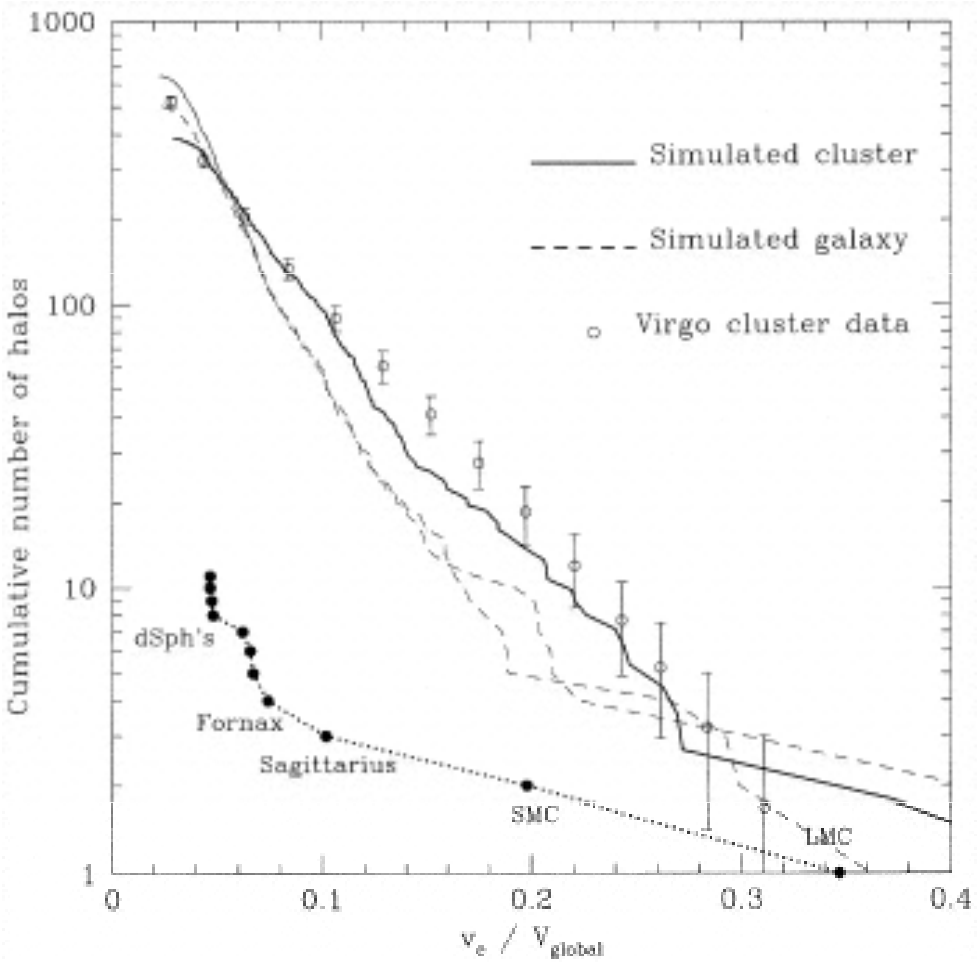


Ben Moore web site



Grebel (2000)

The "missing satellites" problem

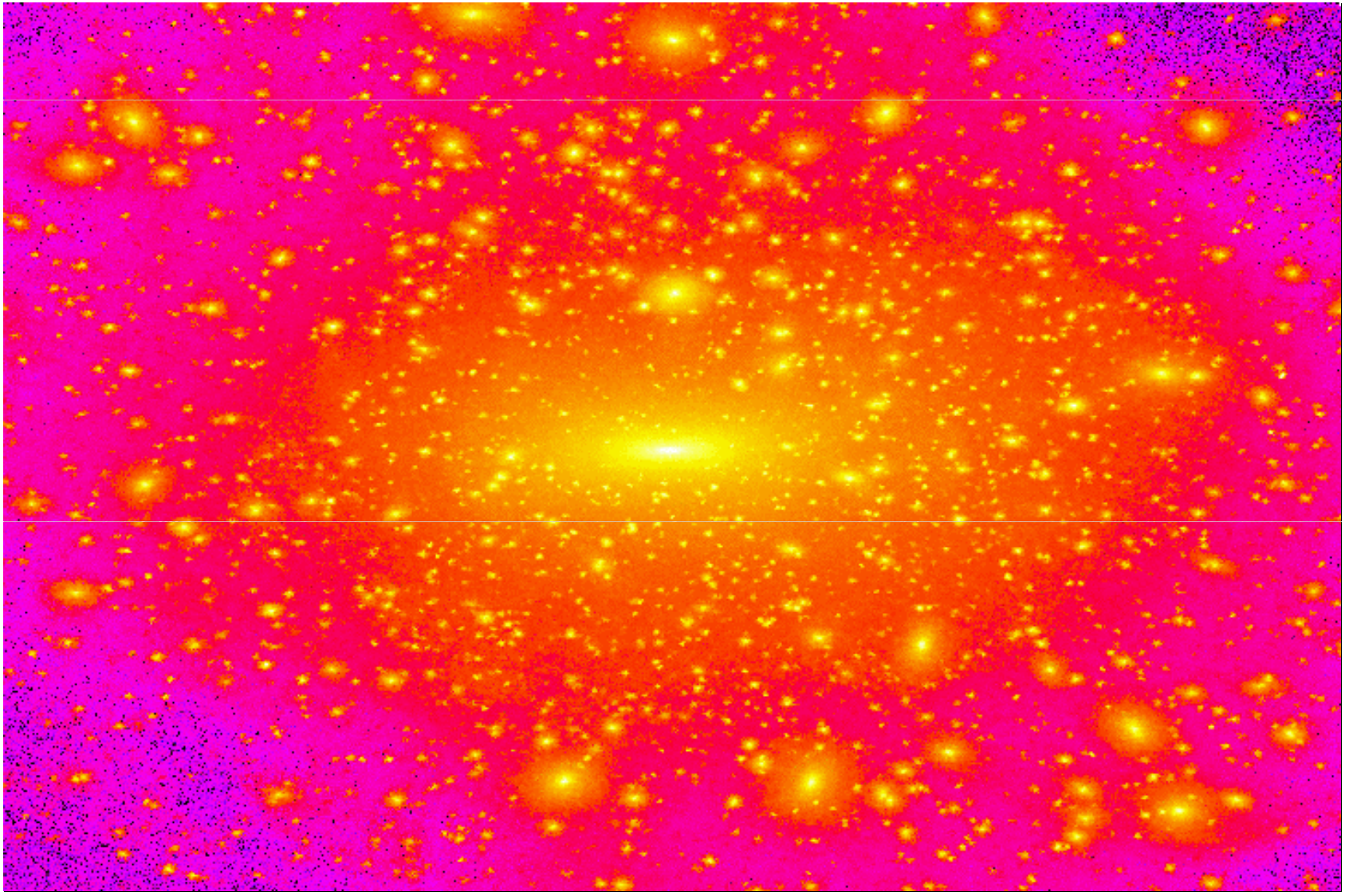


Moore et al. (1999)

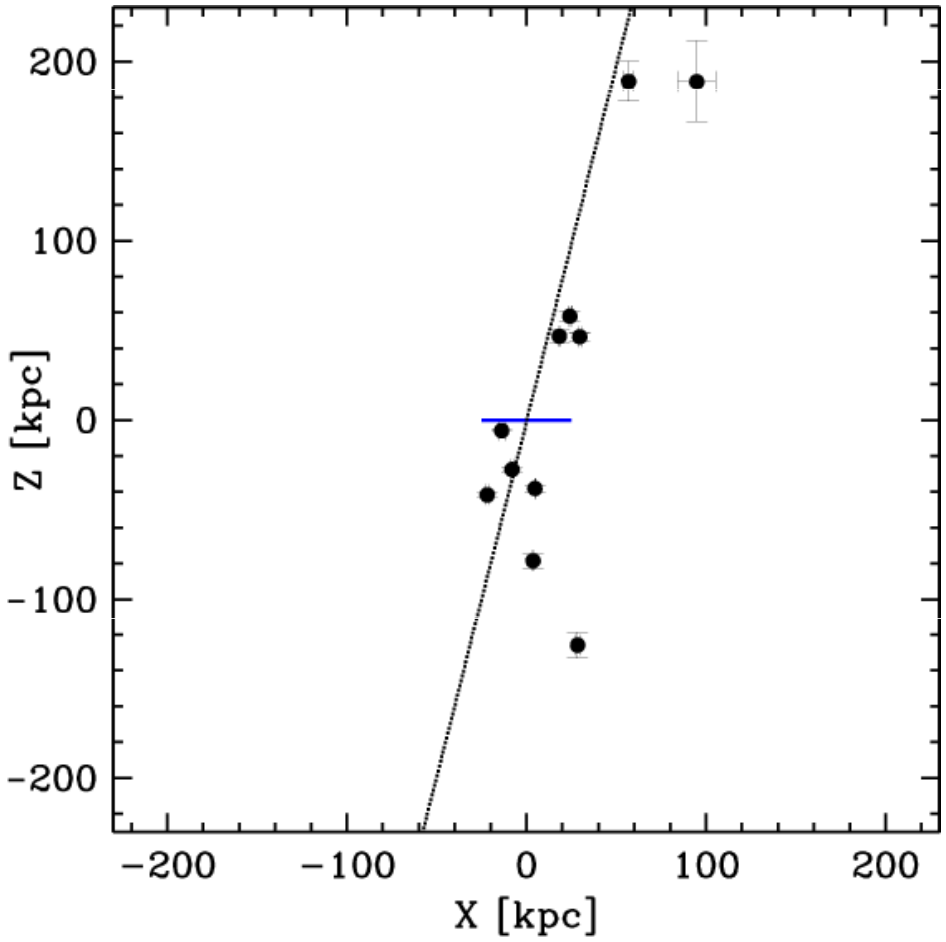
The "missing satellites" problem
possible solutions

- Gas is held/captured only by the 11 most massive CDM sub-halos (Stoehr et al. 2002)
- Ionization from UV radiation prevents gas accretion in most of the DM halos (Gnedin 2000) and/or can photoevaporate gas (Shaviv & Dekel 2003)
- Tidal interactions reduce drastically the masses and the circular velocities of sub-halos (Kravtsov et al. 2004)
- Some satellite can be identified with the high-velocity clouds surrounding the Milky Way (Klypin et al. 1999)

The "missing satellites" problem is not the only one..



The "missing satellites" problem is not the only one..



Kroupa et al. (2005)

The "Durham Pancake" solution

Libeskind et al. et al. (2005)

The major axis of the satellite distribution is co-aligned to that of the host DM halo

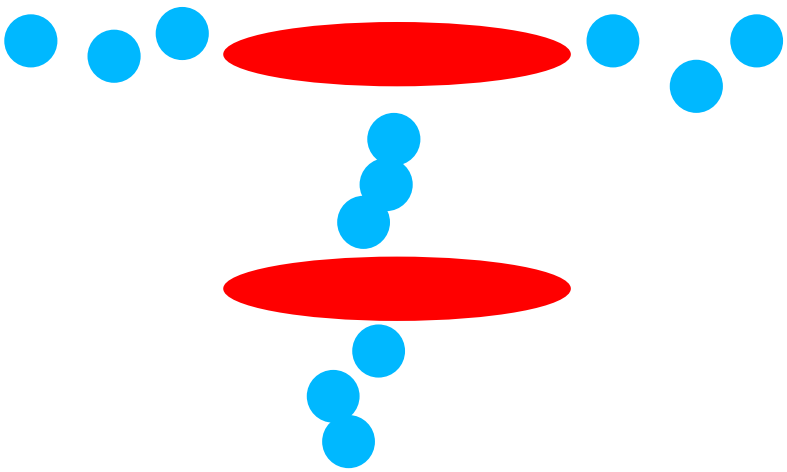
but..

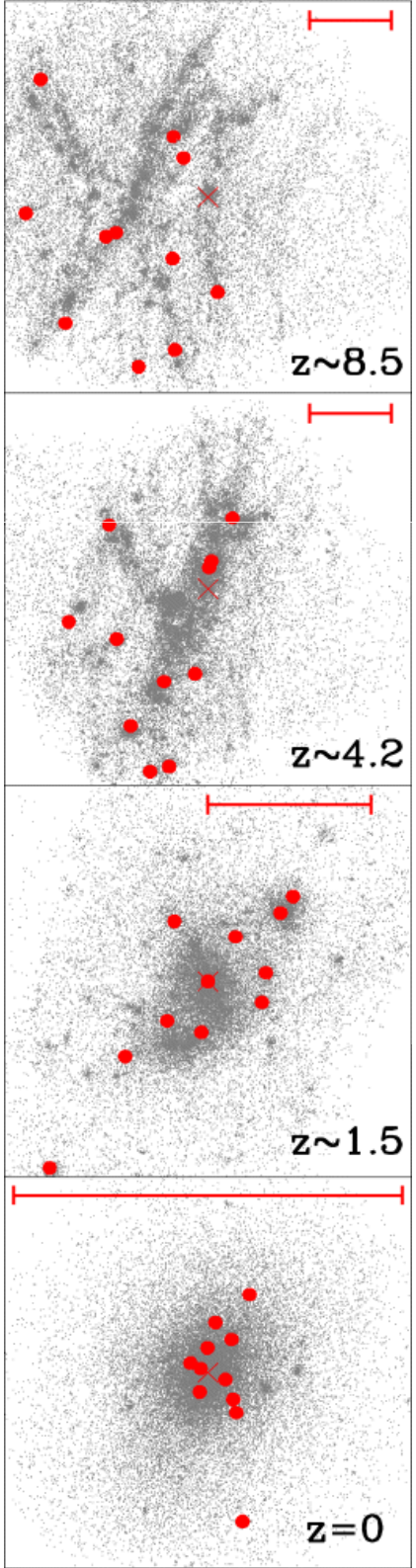
The major axis of the host DM halo should be coplanar to the Galactic disk

Okamoto et al. et al. (2005)

thus

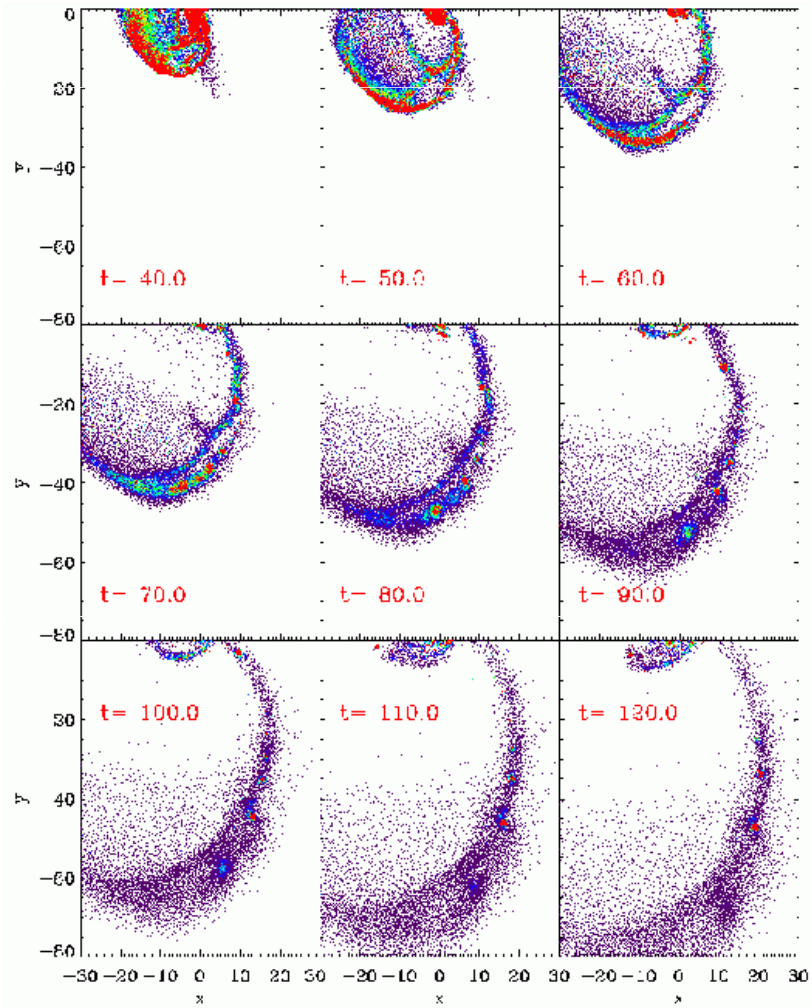
and not





The Milky Way satellites look like they are causally connected.. what if they are originated in

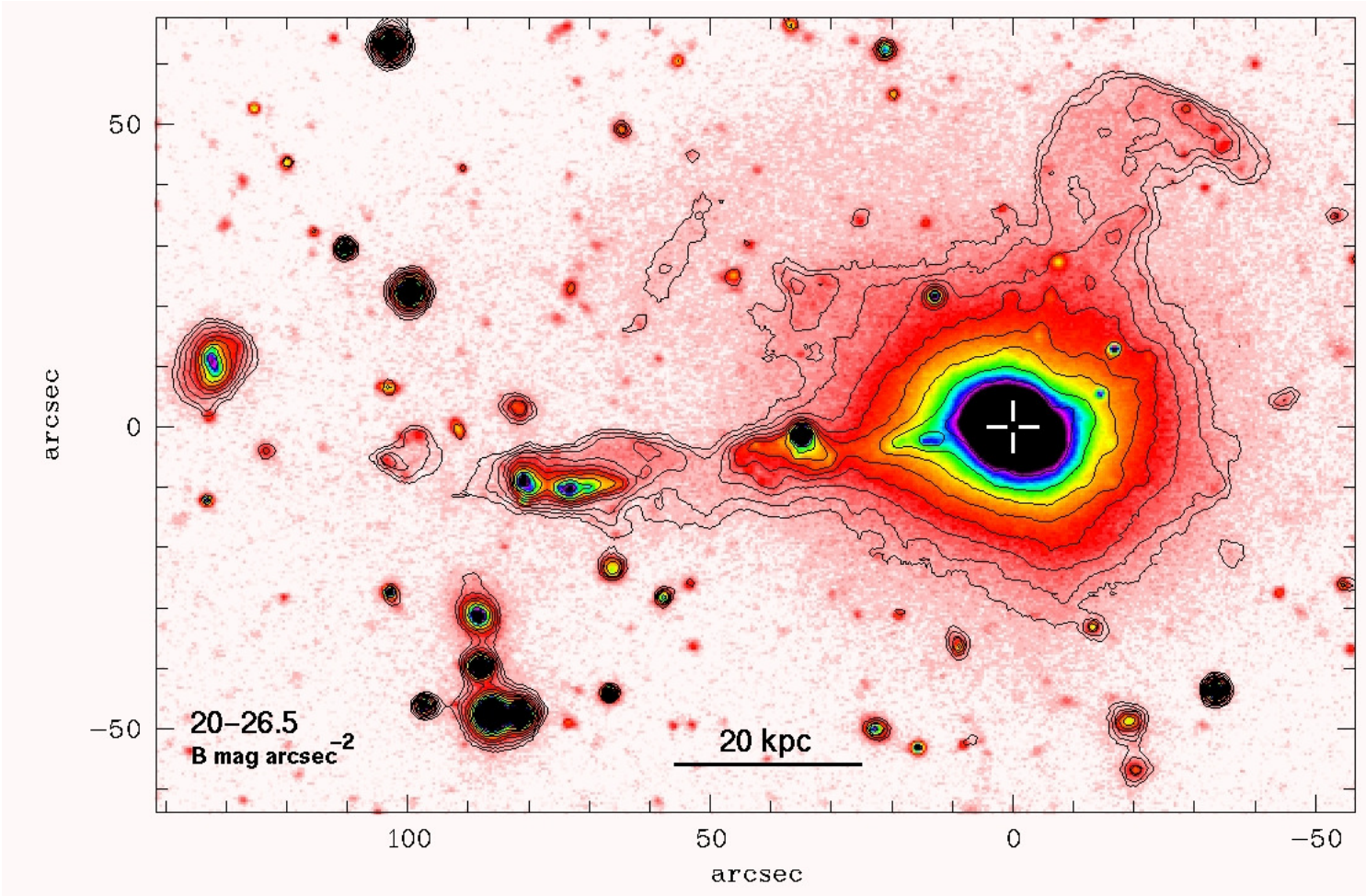
tidal streams?



Wetzstein et al. (2006)

The Milky Way satellites look like they are causally connected.. what if they are originated in

tidal streams?



Papaderos 5 min. ago

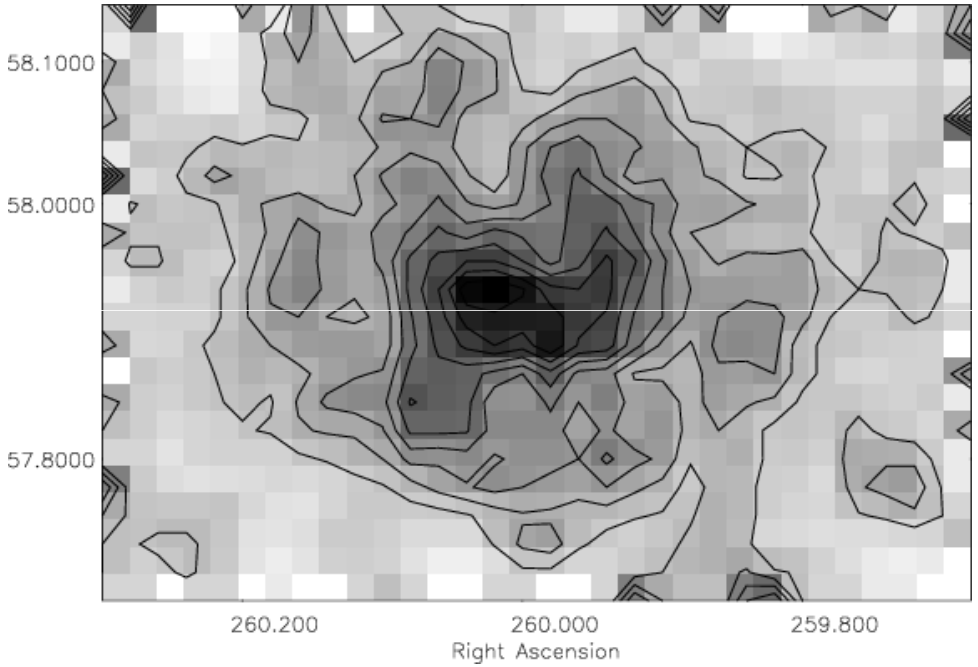
..but tidal dwarf galaxies are baryon dominated!

(Barnes & Hernquist 1992)

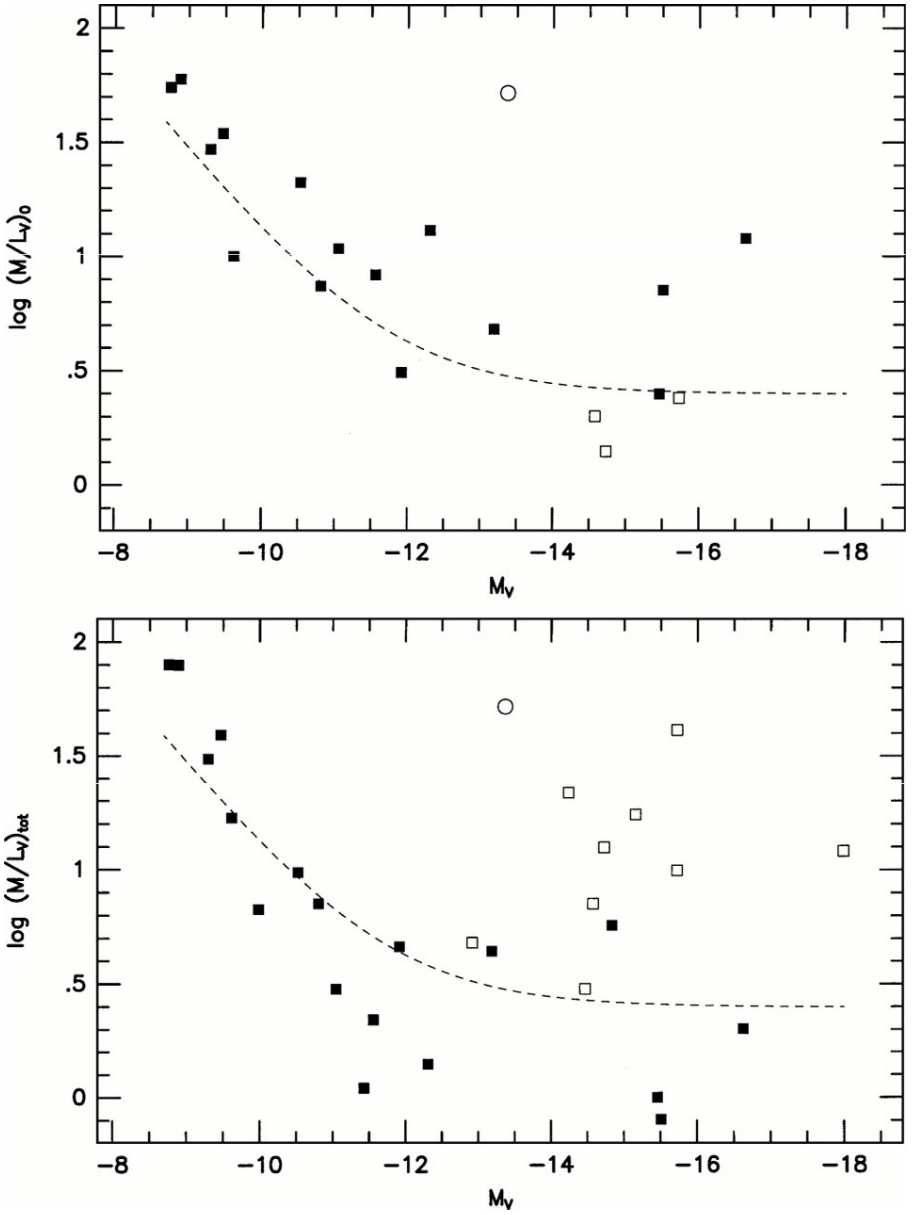
then how to explain this?

(Mateo 1998)

Isophotes of Draco



(Cioni & Habing 2005)

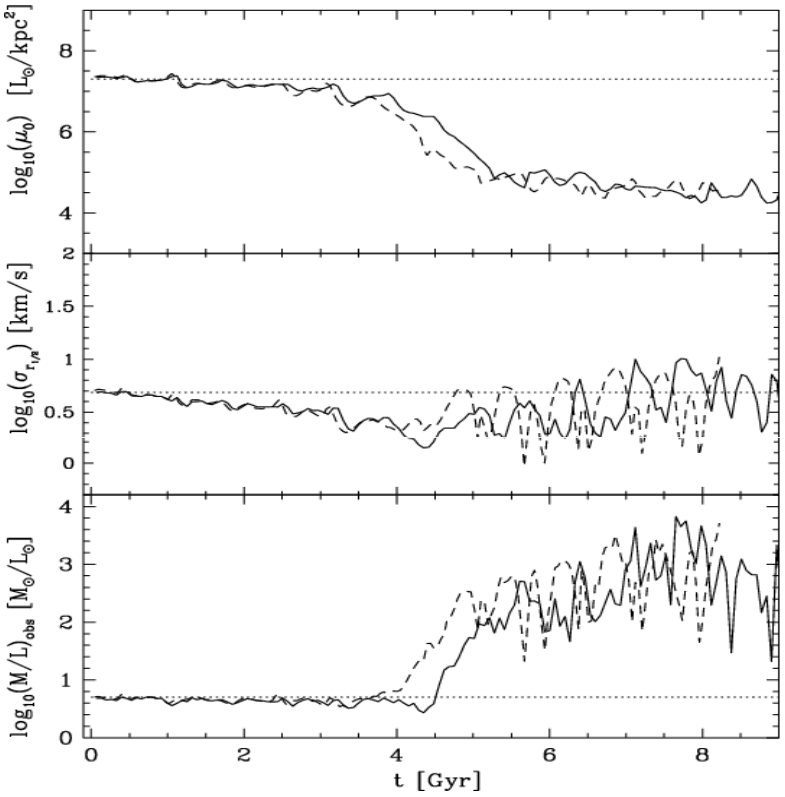


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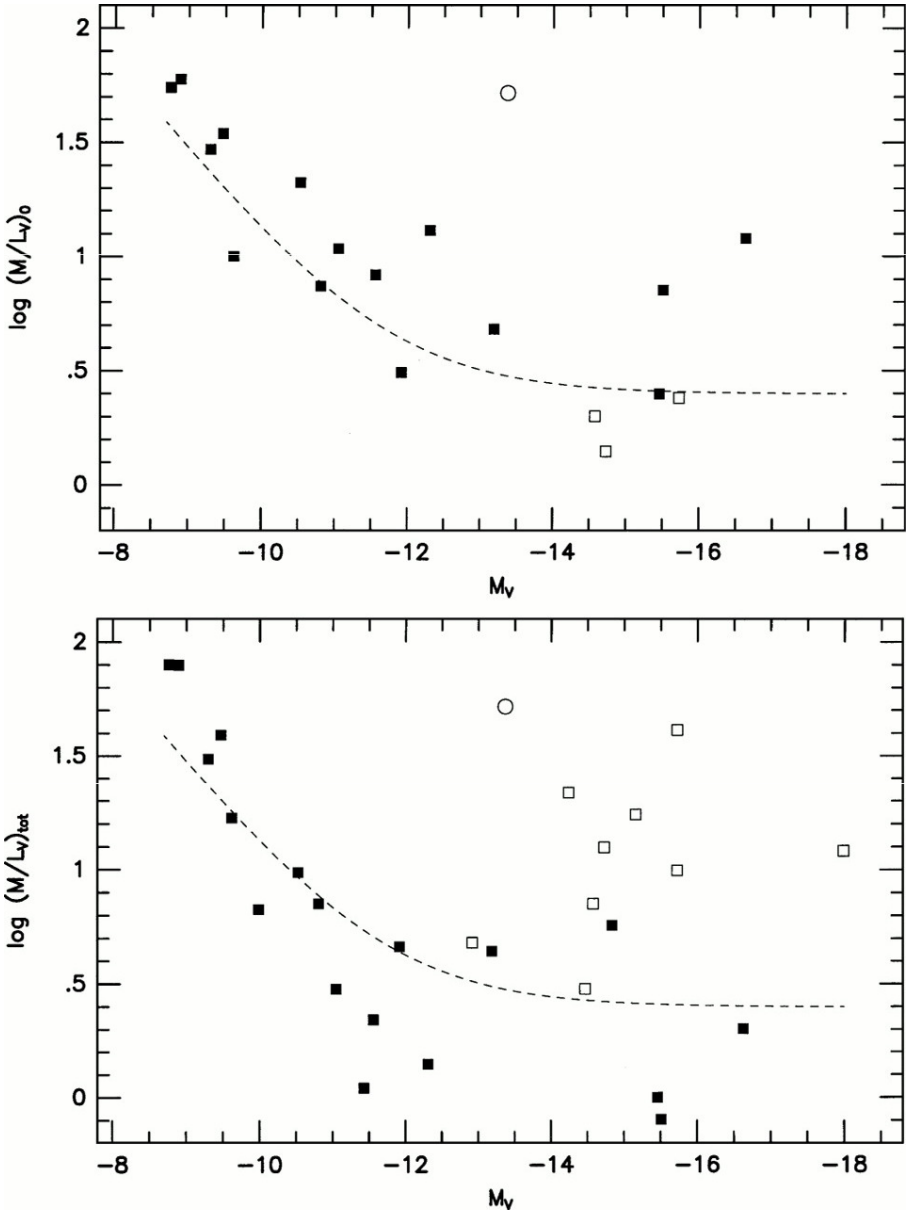
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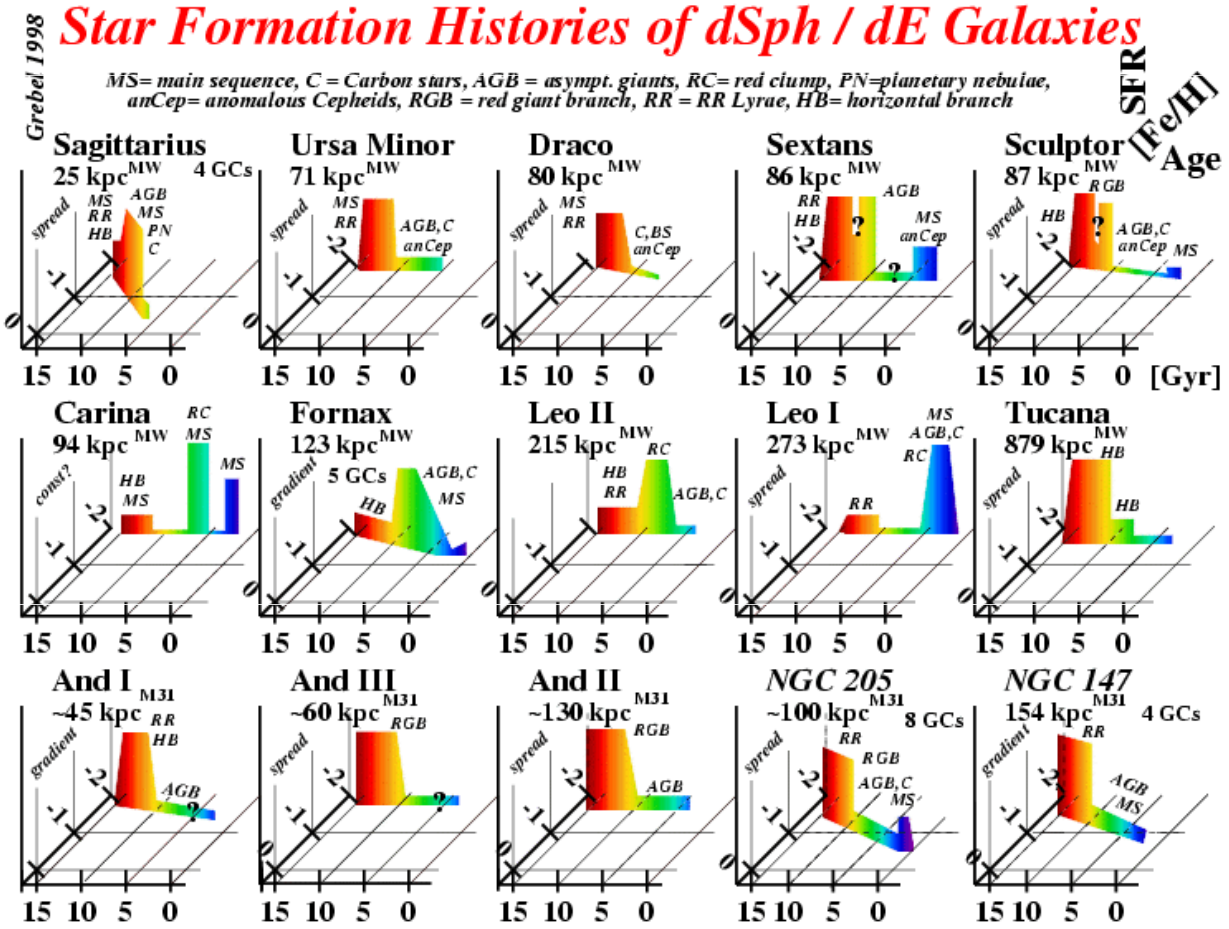


(Klessen & Kroupa 1997)



My problem:

tidal dwarf galaxies are not dark-matter dominated.. how can they survive the feedback of SNe and stellar winds and form stars for some Gyrs?



Grebel (1998)

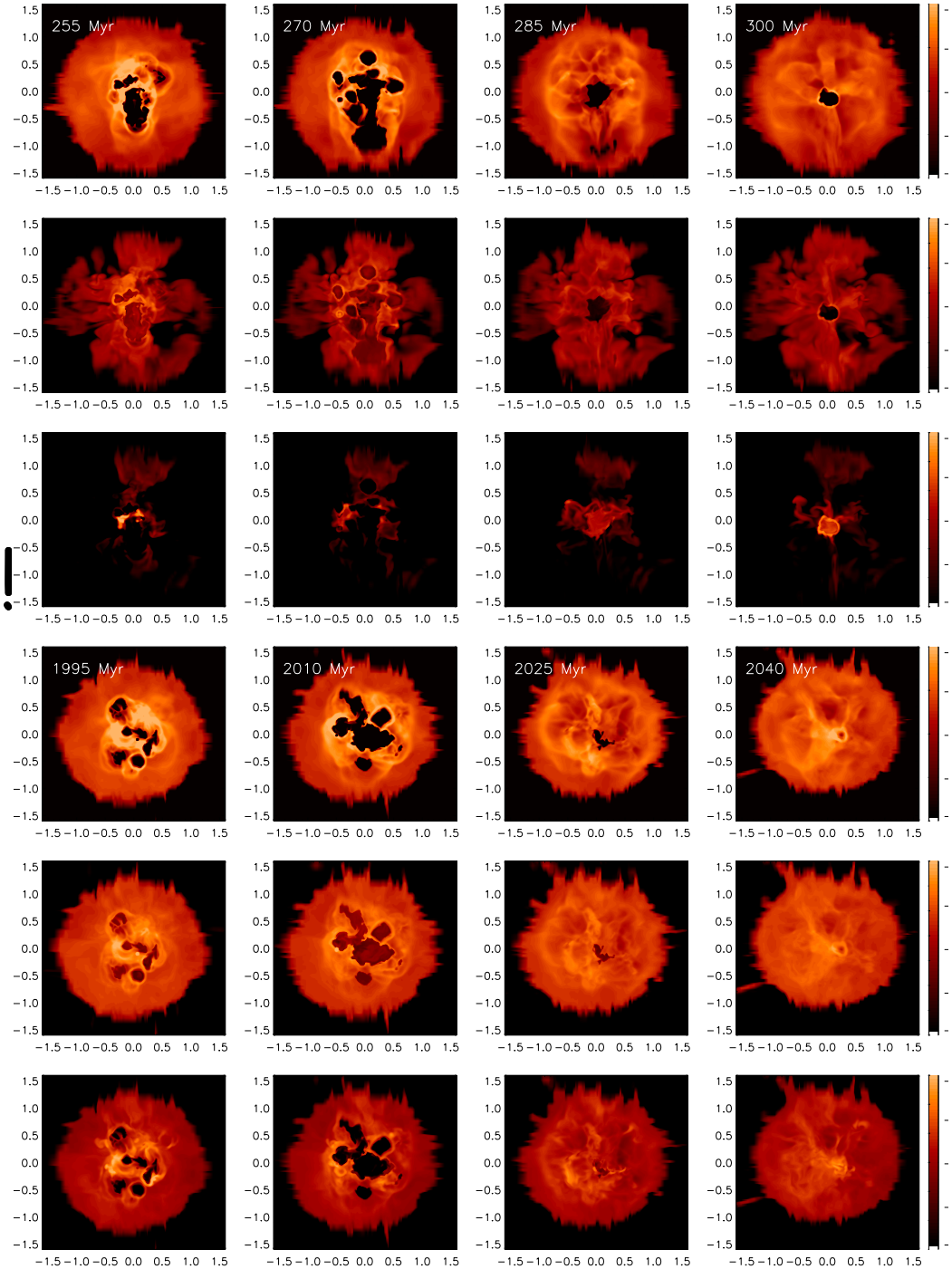
How to solve the problem?

Hydrodynamical simulations: let's check whether a DM-poor proto-galaxy can sustain the feedback of the ongoing star formation for long enough

Previous results

(Marcolini, D'Ercole,
Brighenti & SR 2006)

..but this was with DM!
It is possible to
reproduce similar
results without DM?



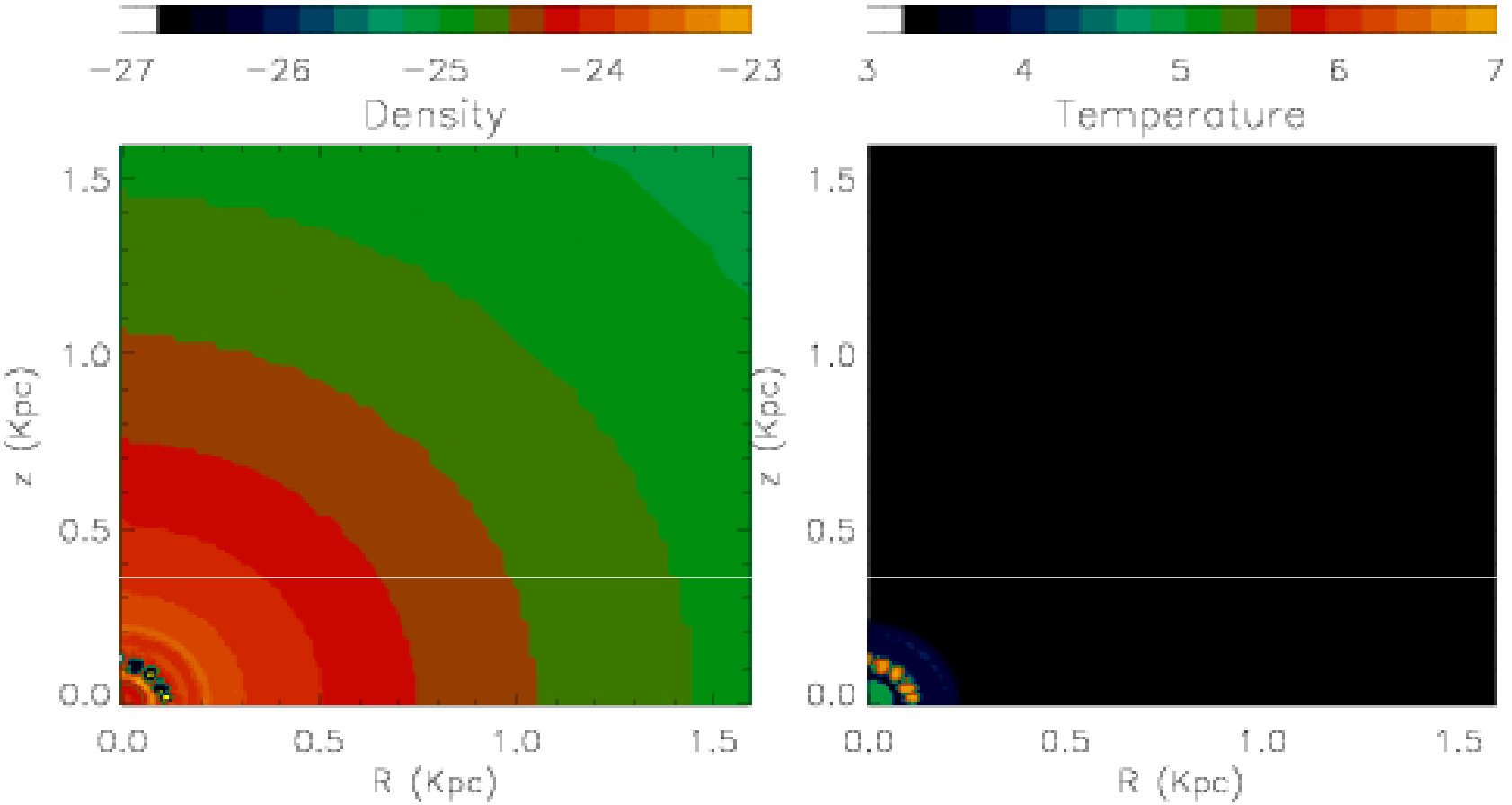
The model:

- 2-D hydrodynamical models in cylindrical coordinates
- Self-gravity
- Star formation depending on the thermodynamical properties of the ISM
- Each "stellar population" (all the stars born within intervals of 1 or 5 Myr) is treated separately and its feedback is followed consistently
- (Metallicity-dependent) luminosities from stellar winds are considered
- Fully treatment of the chemical evolution of the ISM and of the stellar components
- Metallicity-dependent cooling function
- Environmental effects

The "reference" model:

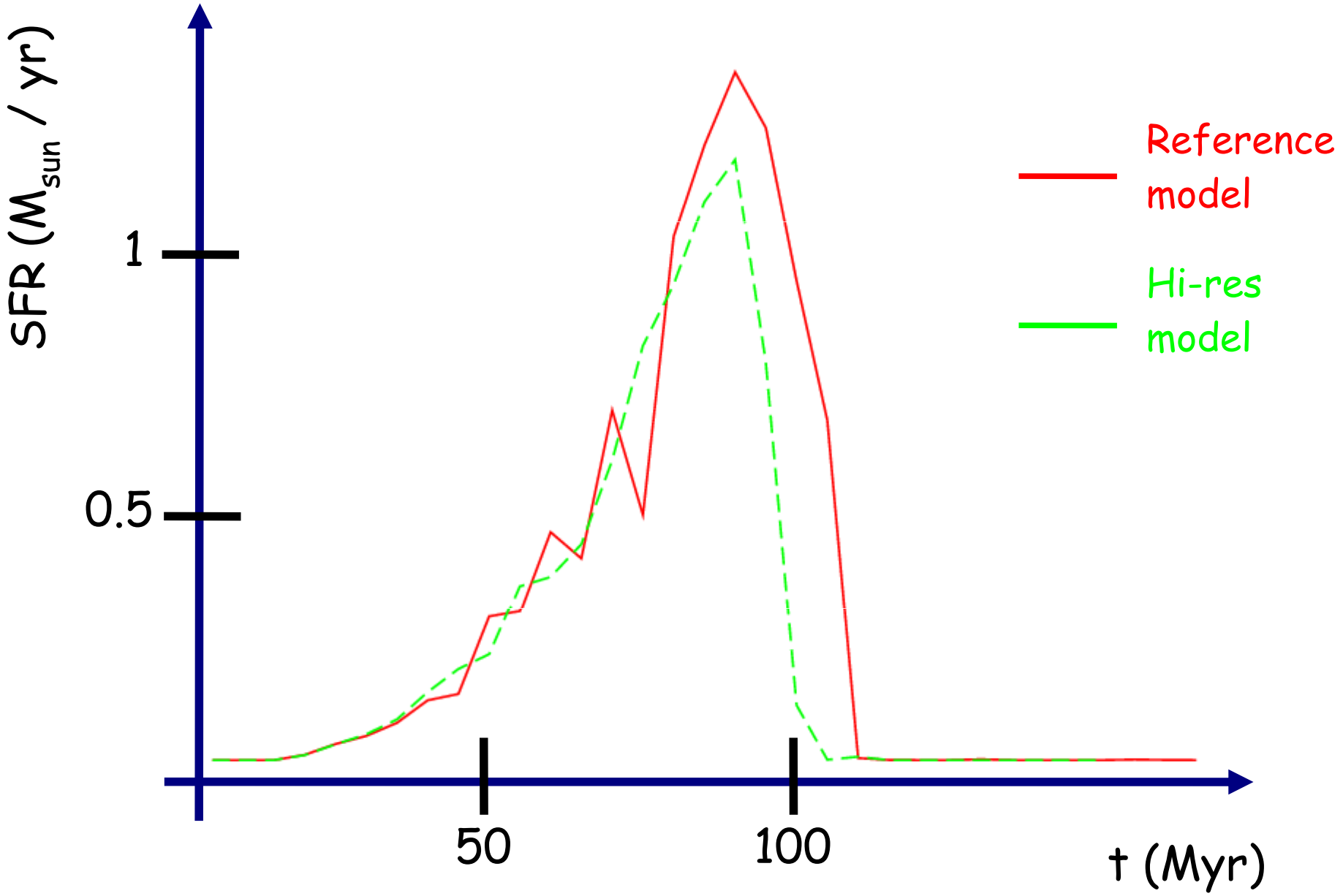
- No stellar dynamics (the stars remain where they are born)
- Linear Schmidt star formation law with a temperature threshold of 10^4 K.
- Efficiency of star formation: 0.2
- Initial King density profile with core radius r_0 = 500 pc.
- Initial mass $4 * 10^8$ M_{sun}
- The galaxy is isolated
- It has no rotation

Dynamical evolution of the "reference" model

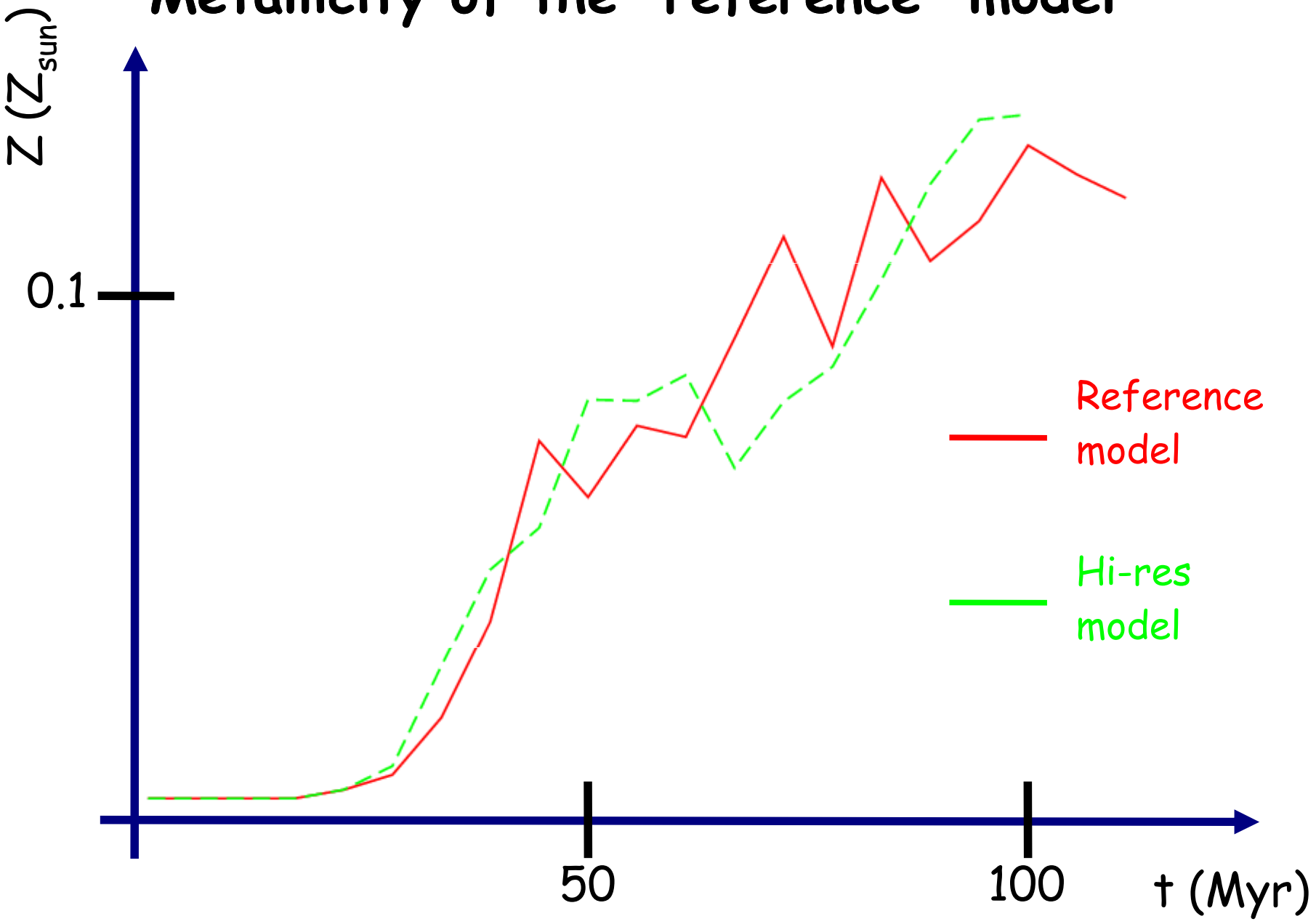


Final time: 120 Myr

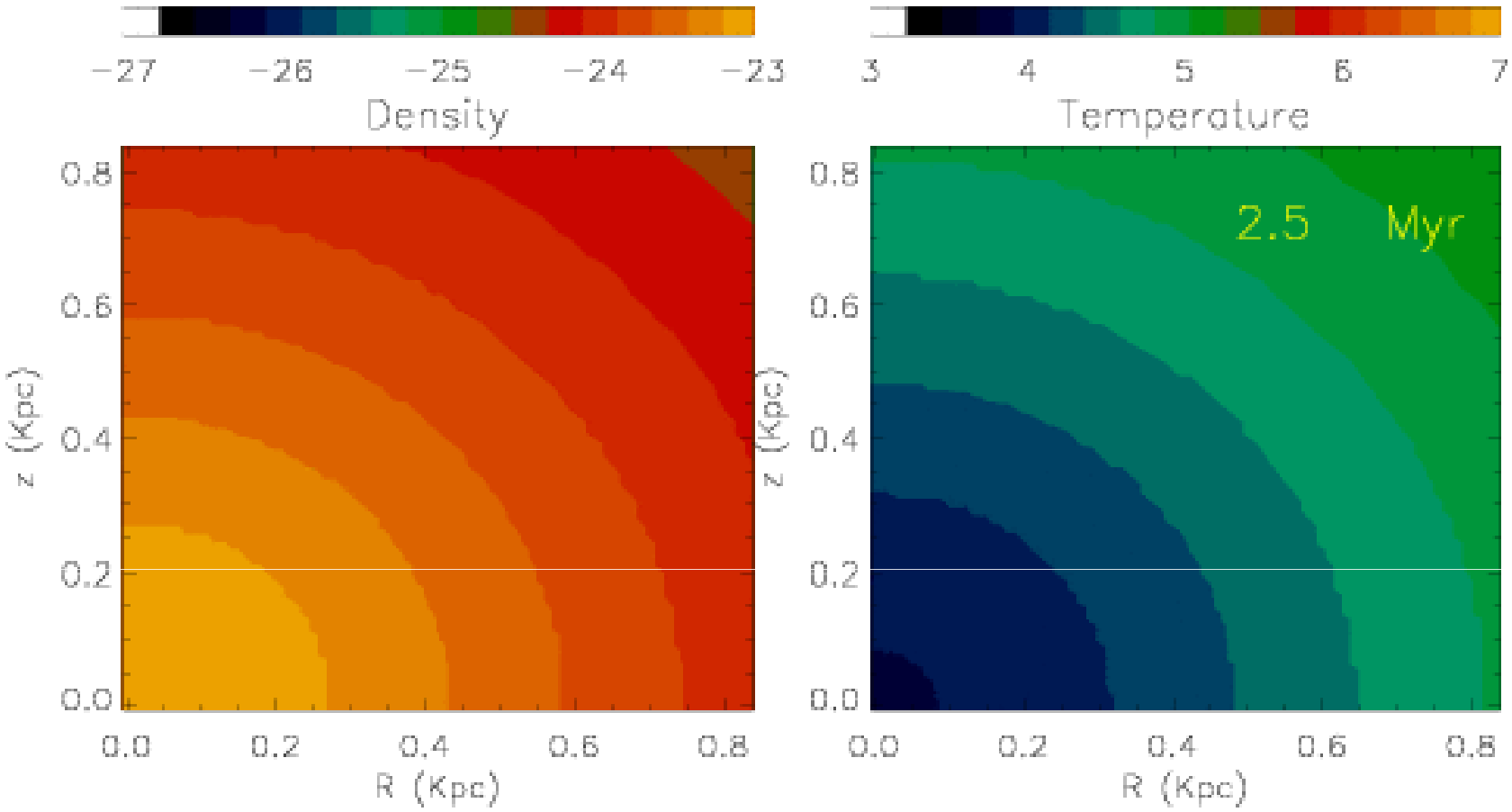
Star formation of the "reference" model



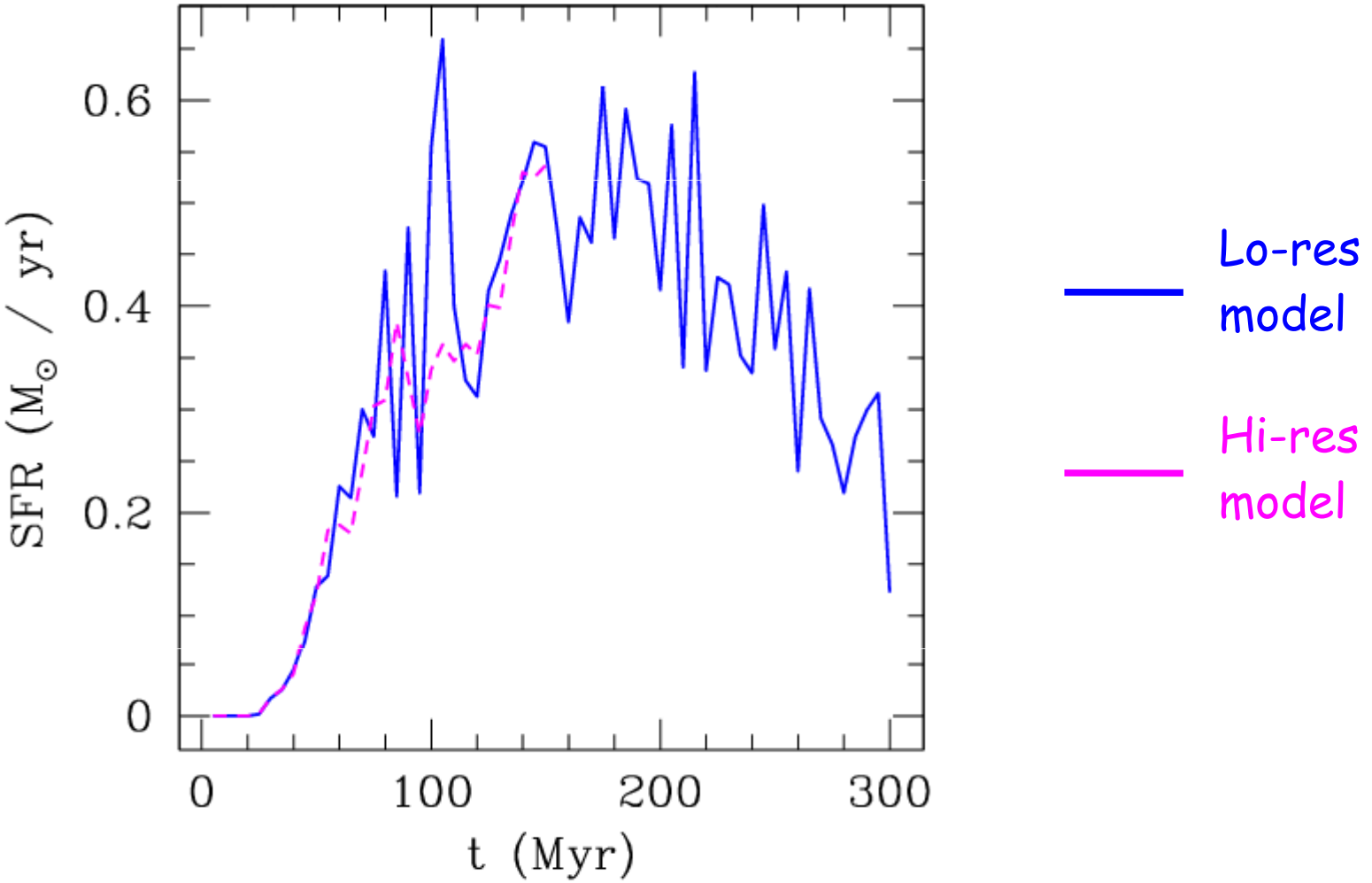
Metallicity of the "reference" model



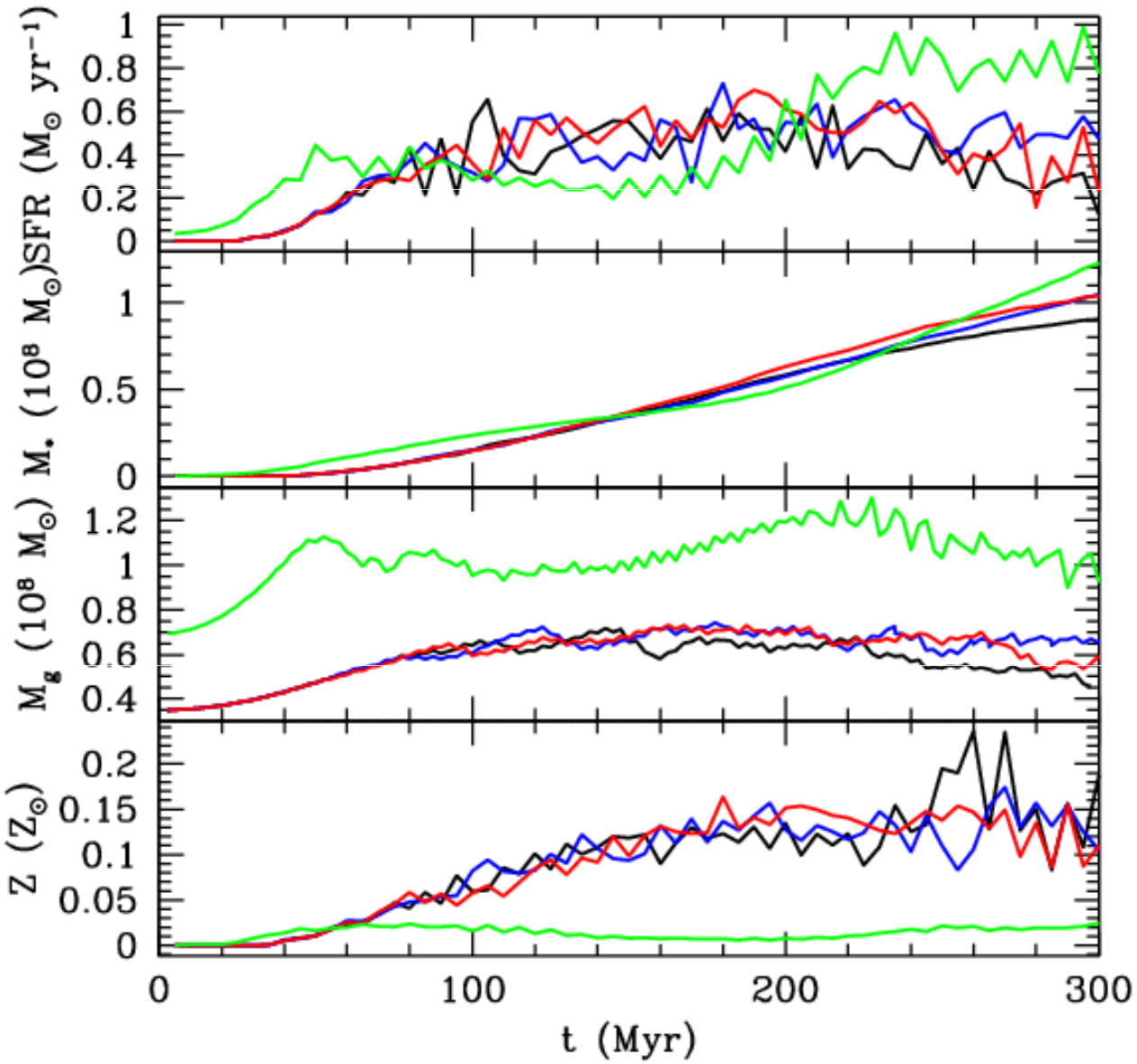
Star formation efficiency 0.1



Star formation efficiency 0.1



Exploring the parameter space

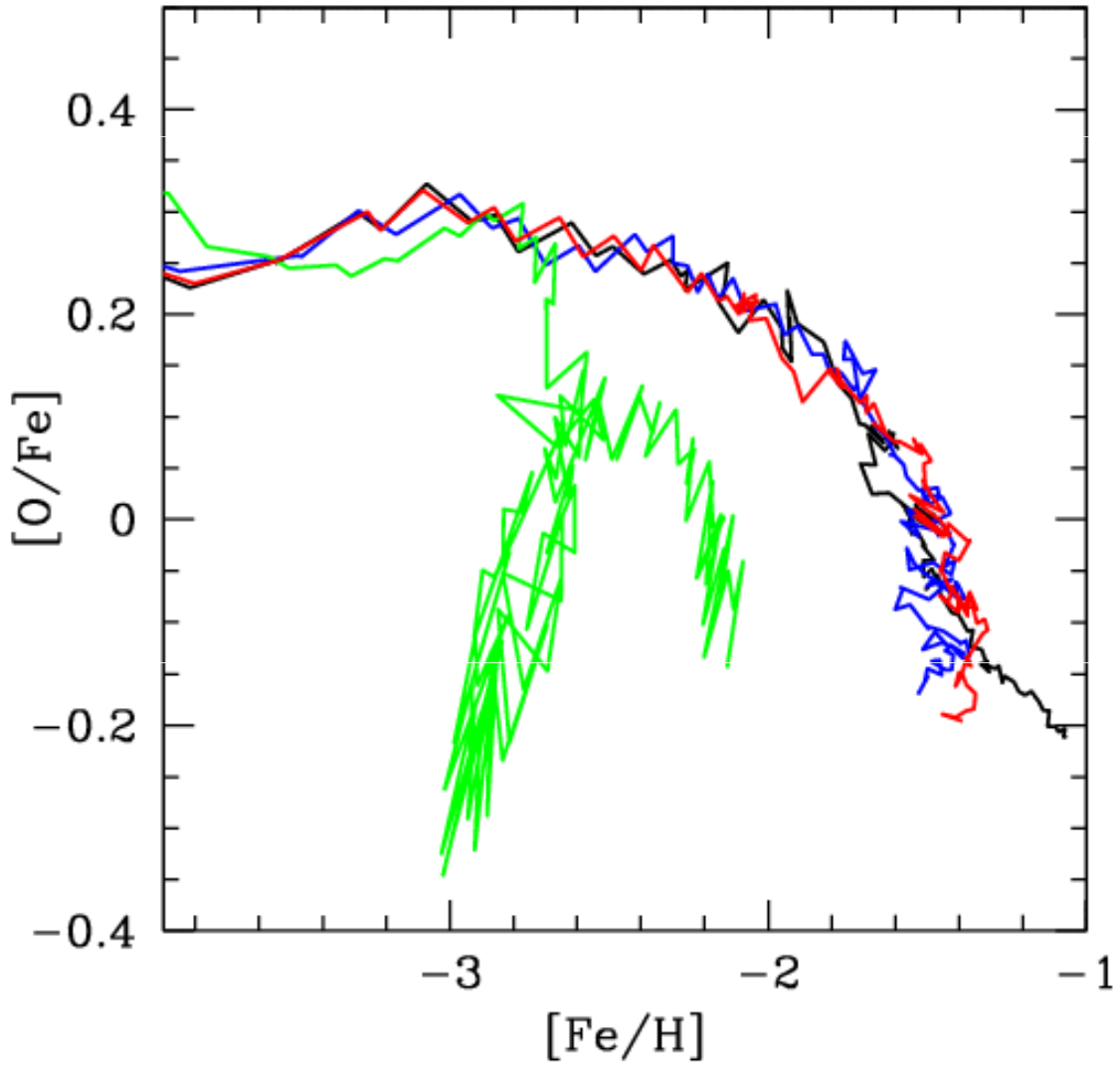


no stellar winds

temperature threshold 5000 K

Star formation efficiency 0.05

[O/Fe] evolution

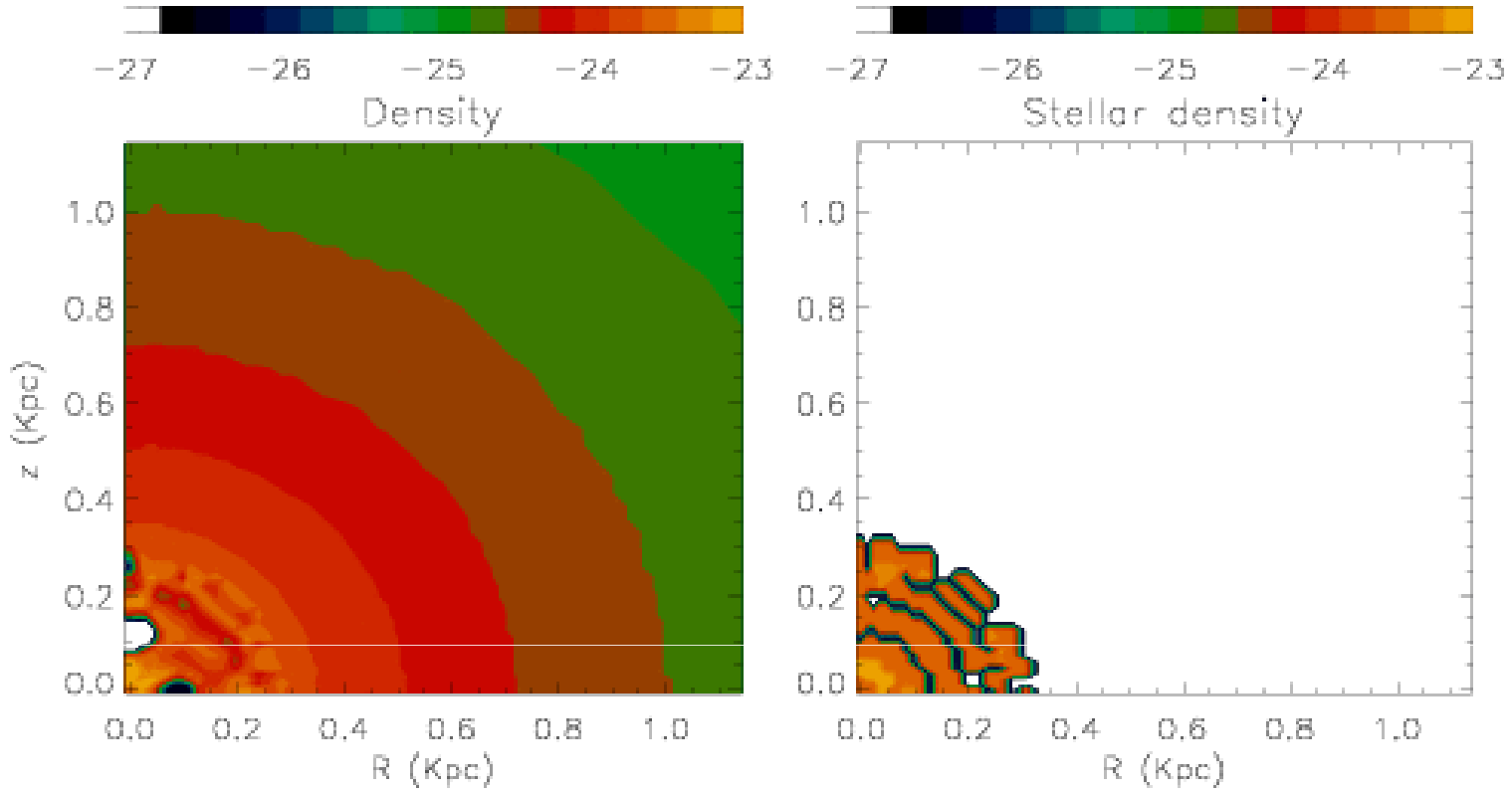


no stellar winds

temperature threshold 5000 K

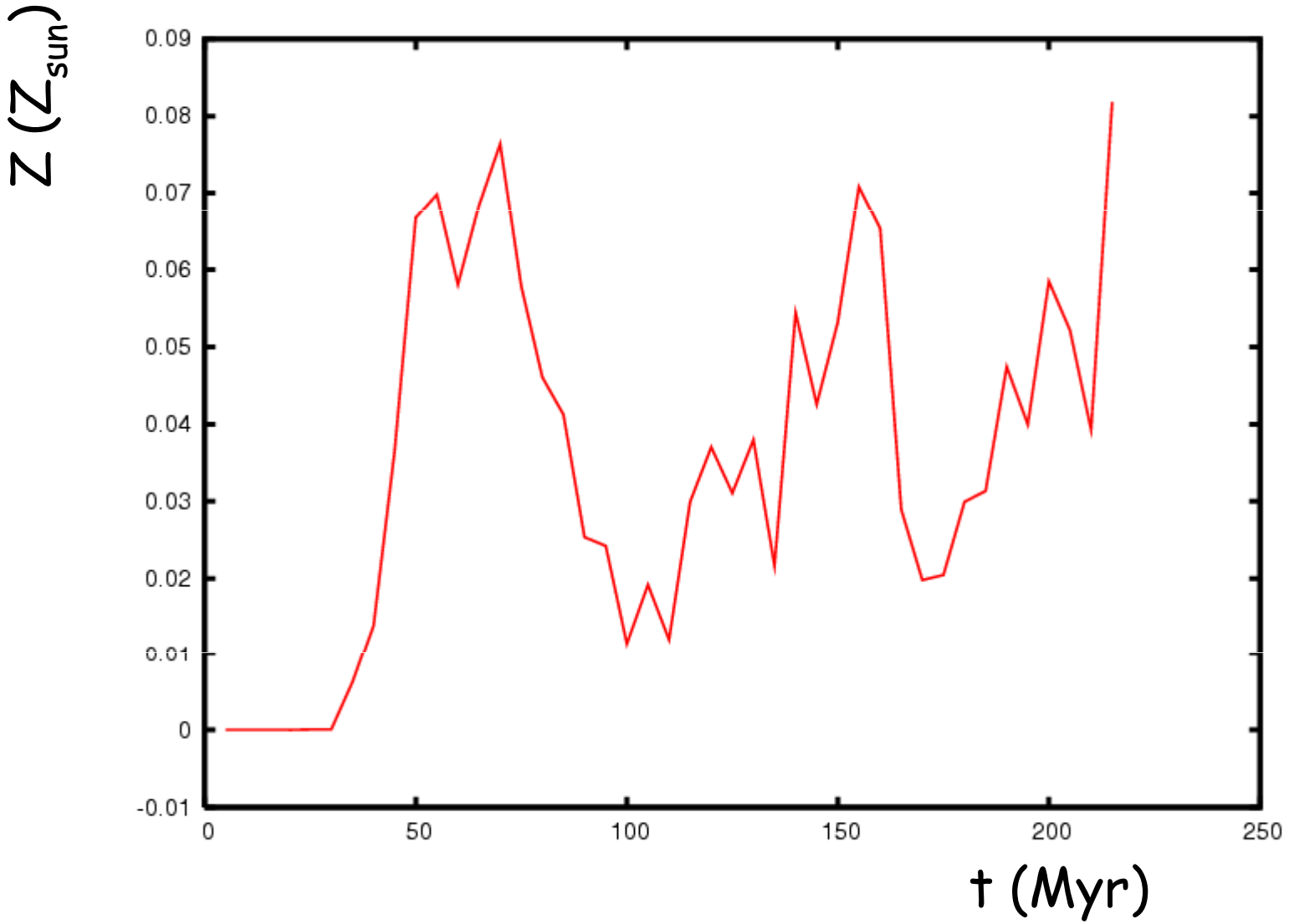
Star formation efficiency 0.05

Asymmetric model



Final time: 220 Myr

Asymmetric model

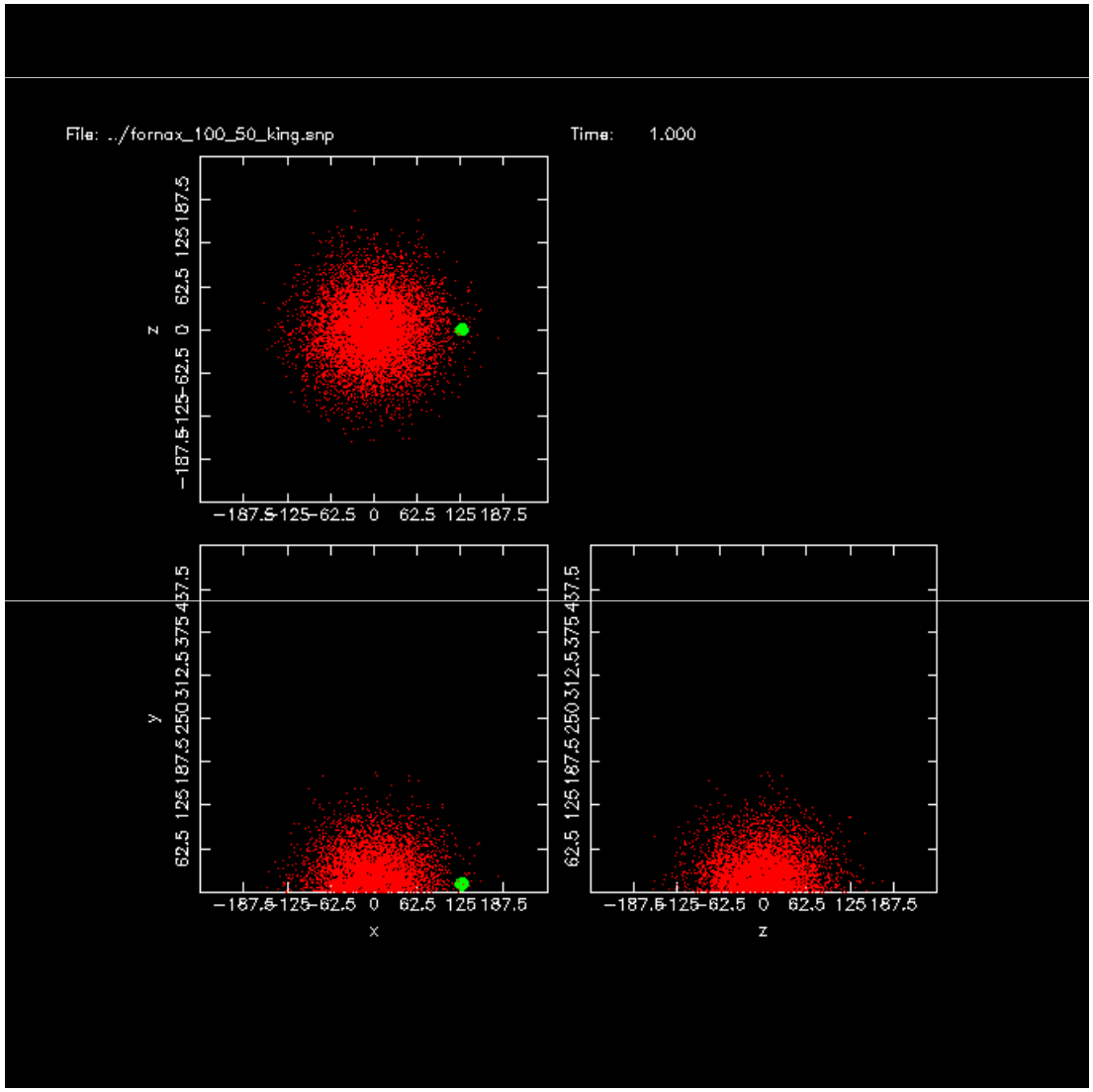


The future:

- Explore more in detail the results and expand the parameter space.
- Consistent dynamics of the stellar component (work in progress)
- Constant infall of gas, coming from the stream (work in progress)

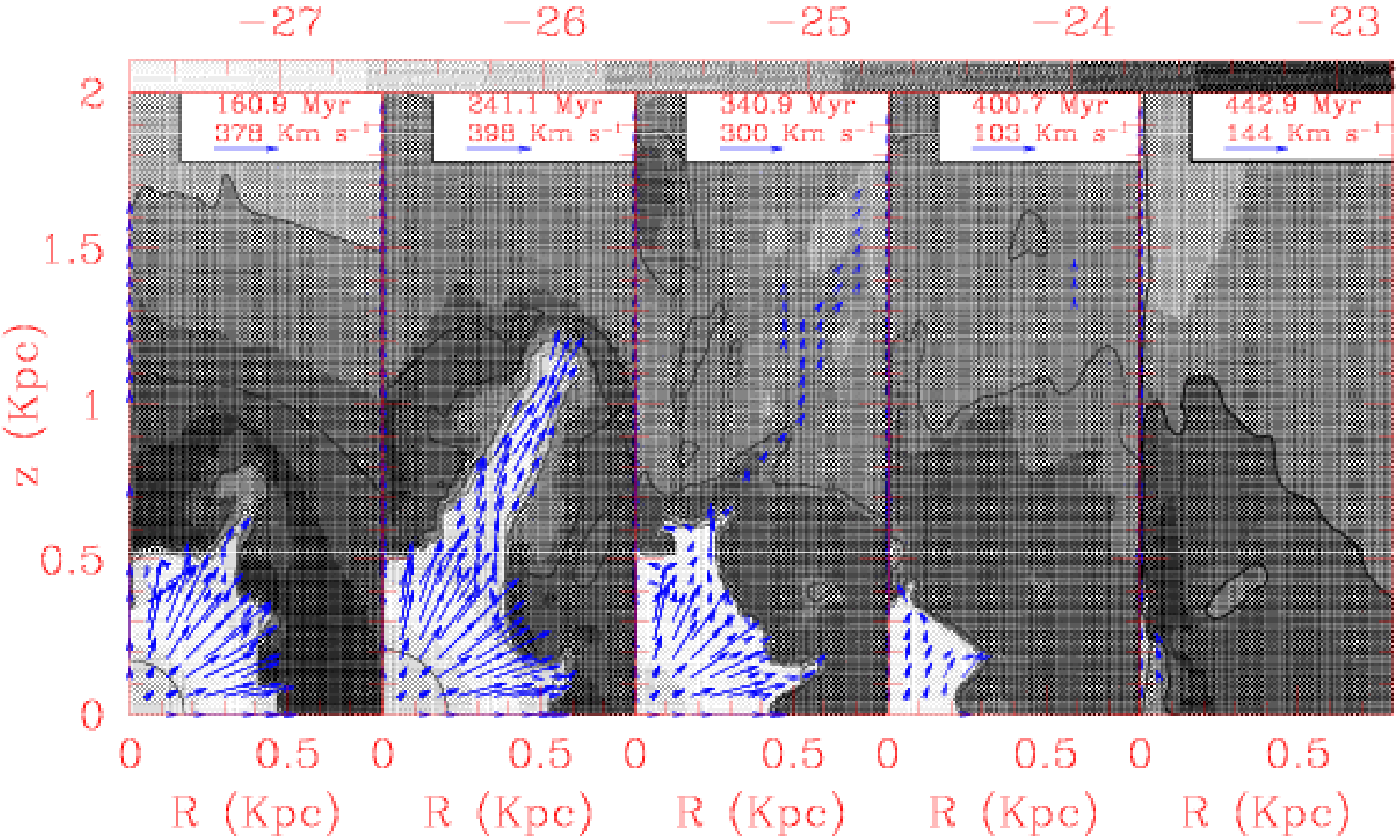
The future:

- Models with reliable interactions between the dwarf galaxy and a perturbing giant galaxy



The future:

- Long-term evolution of the models



SR & Hensler (2006)

The future:

- Long-term evolution of the models

Model	M_g (10^8 M_{sun})	SF duration (Myr)	SF rate (M_{sun} yr^{-1})	Refilling time-scale
LS	1	25	0.5	415 Myr
LL	1	200	0.05	600 Myr
HS	1.8	25	0.5	125 Myr
HL	1.8	200	0.05	200 Myr

SR & Hensler (2006)

Conclusions:

- Not necessarily dwarf galaxies without dark matter are quickly destroyed.
- Not necessarily galactic winds quench completely the star formation
- The future is interesting