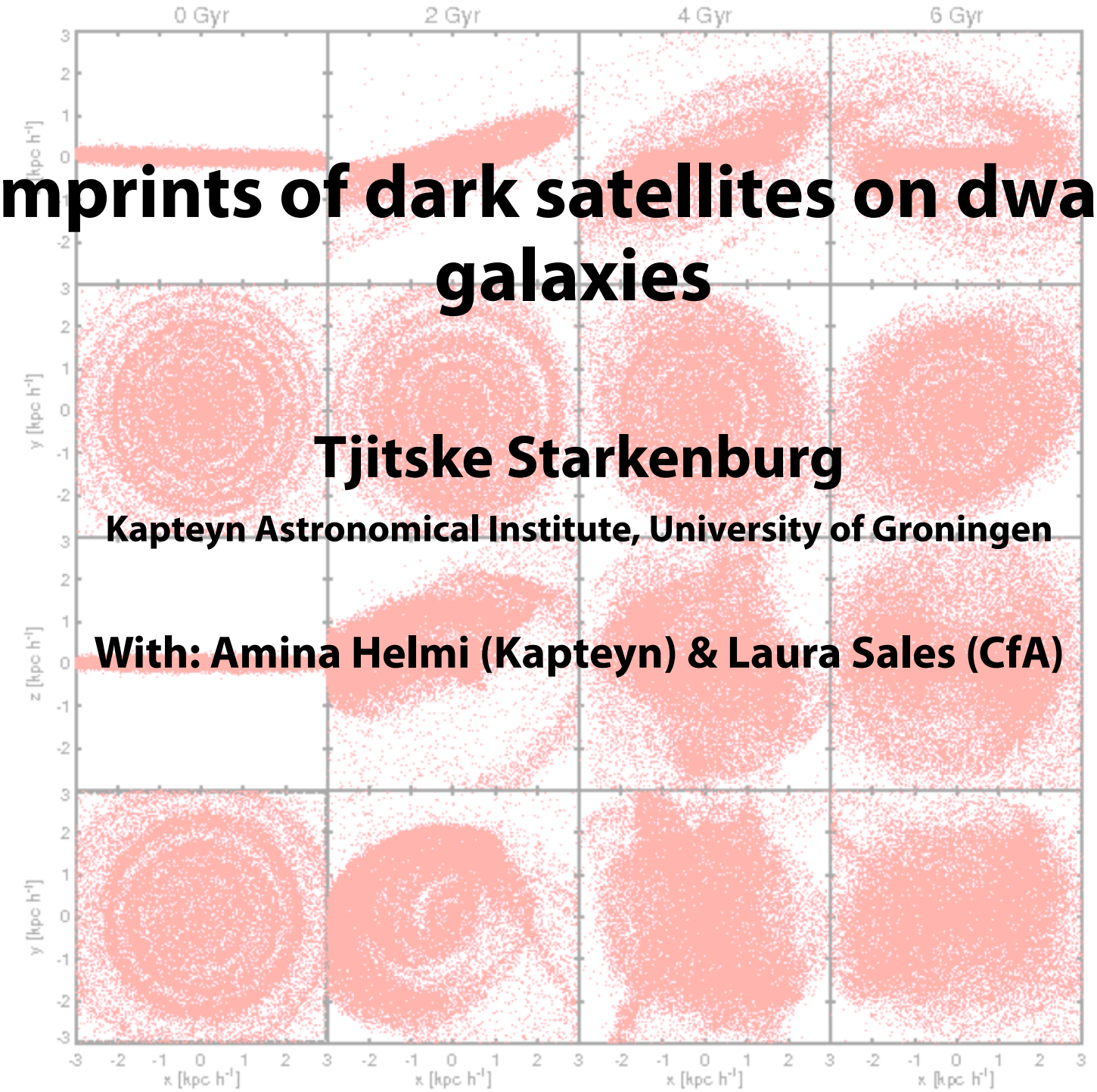

Imprints of dark satellites on dwarf galaxies

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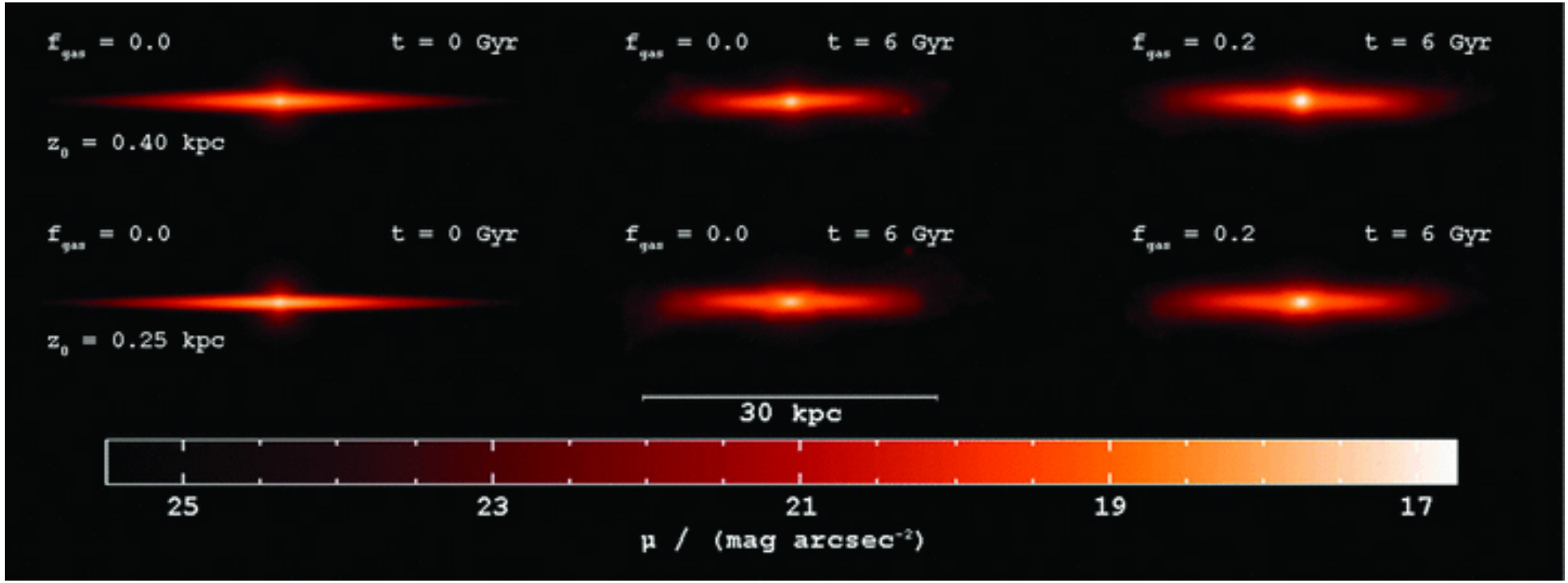
With: Amina Helmi (Kapteyn) & Laura Sales (CfA)

Galaxy interactions are well studied for Milky Way-like galaxies

- Minor mergers can induce disk heating/thickening, bulge growth, bar formation, warps and spiral structure



Moster et al. 2010

- In ΛCDM the halo mass function is scale-free
- all haloes have their own substructure

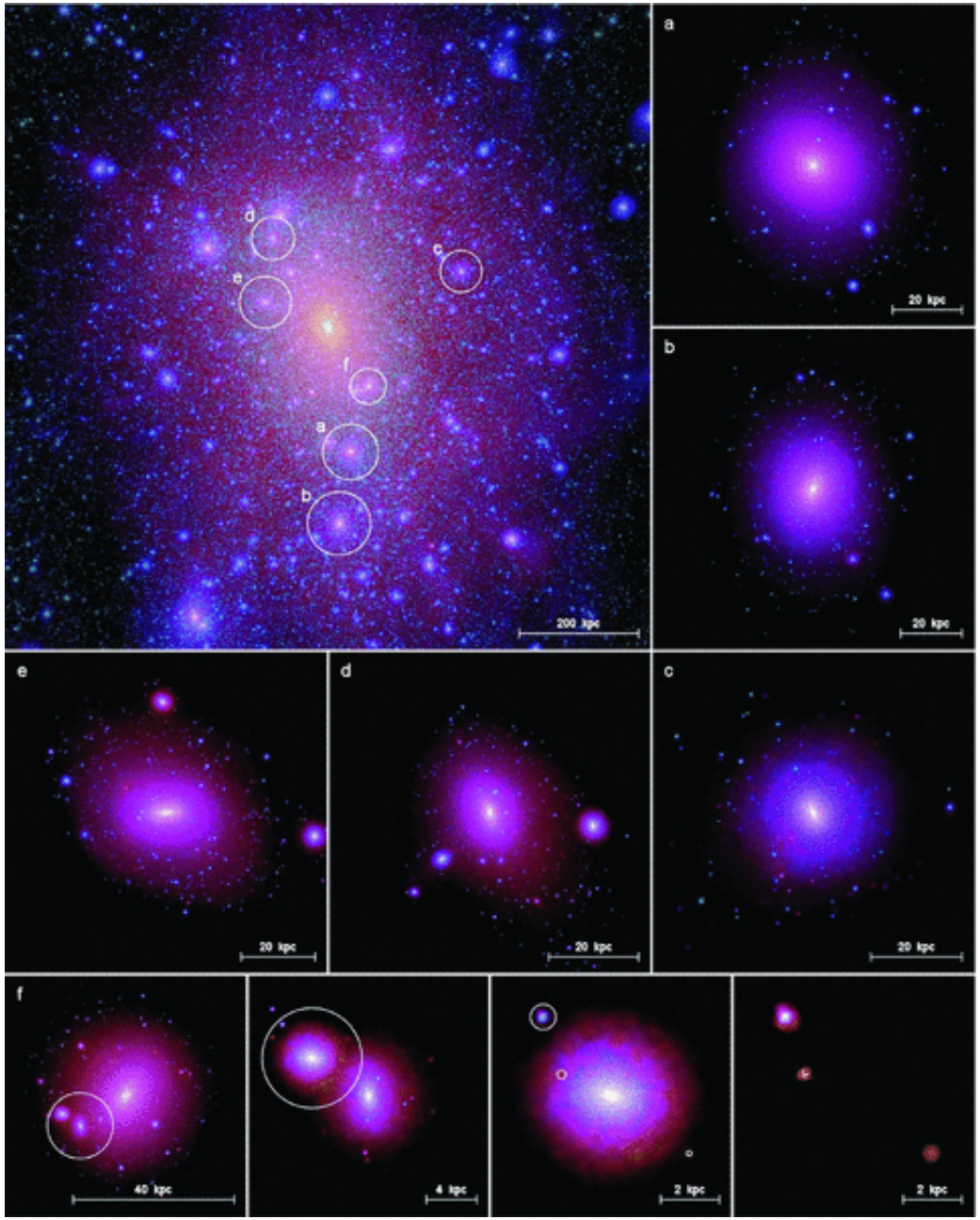
-> Also on the dwarf scale

- The baryon content of galaxies is not scale-free

->M_{star}/M_{halo} is lower for smaller mass galaxies

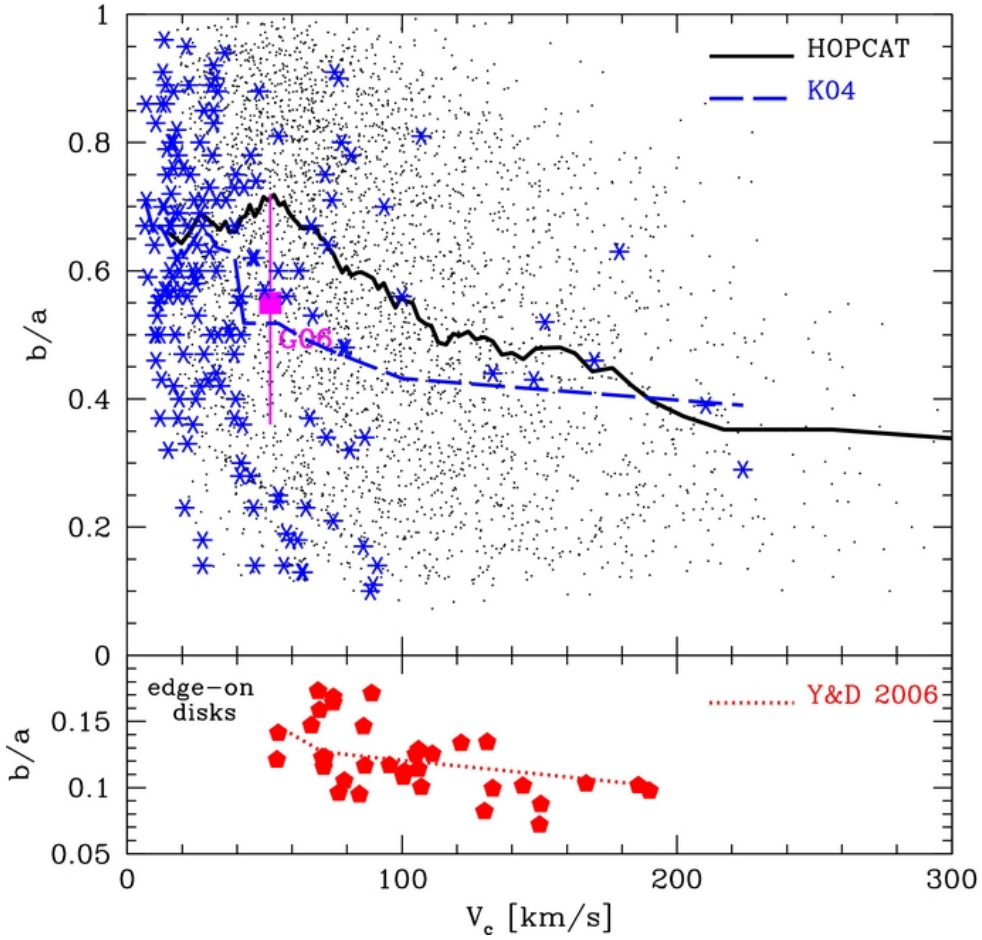
(all M_{star}/M_{halo} relations we have seen agree on that)

- Dwarfs will be much more perturbed by the same mass-ratio mergers
- Perturbers (satellites) will be predominantly dark



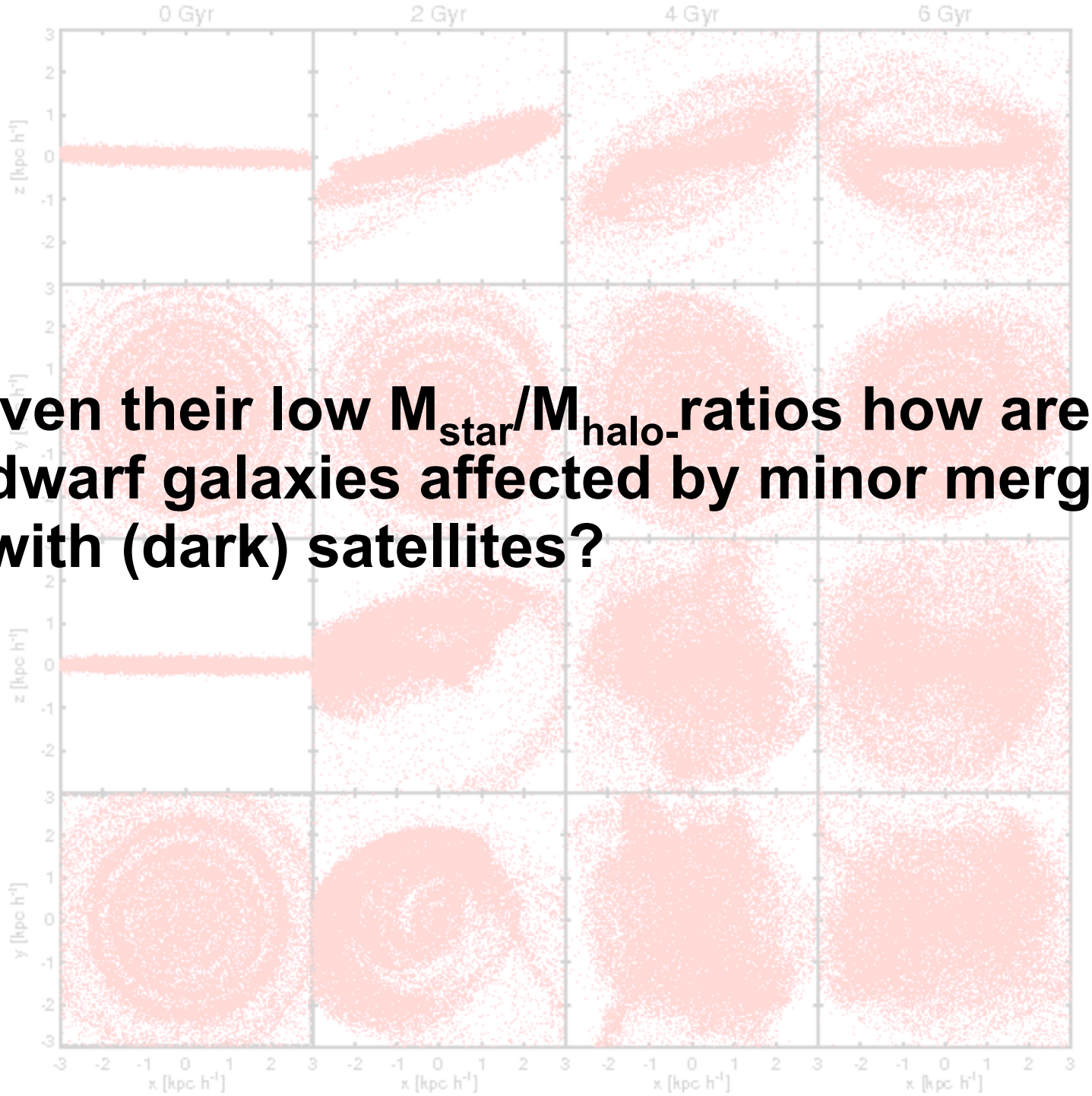
Springel et al. 2008

Dwarf galaxies



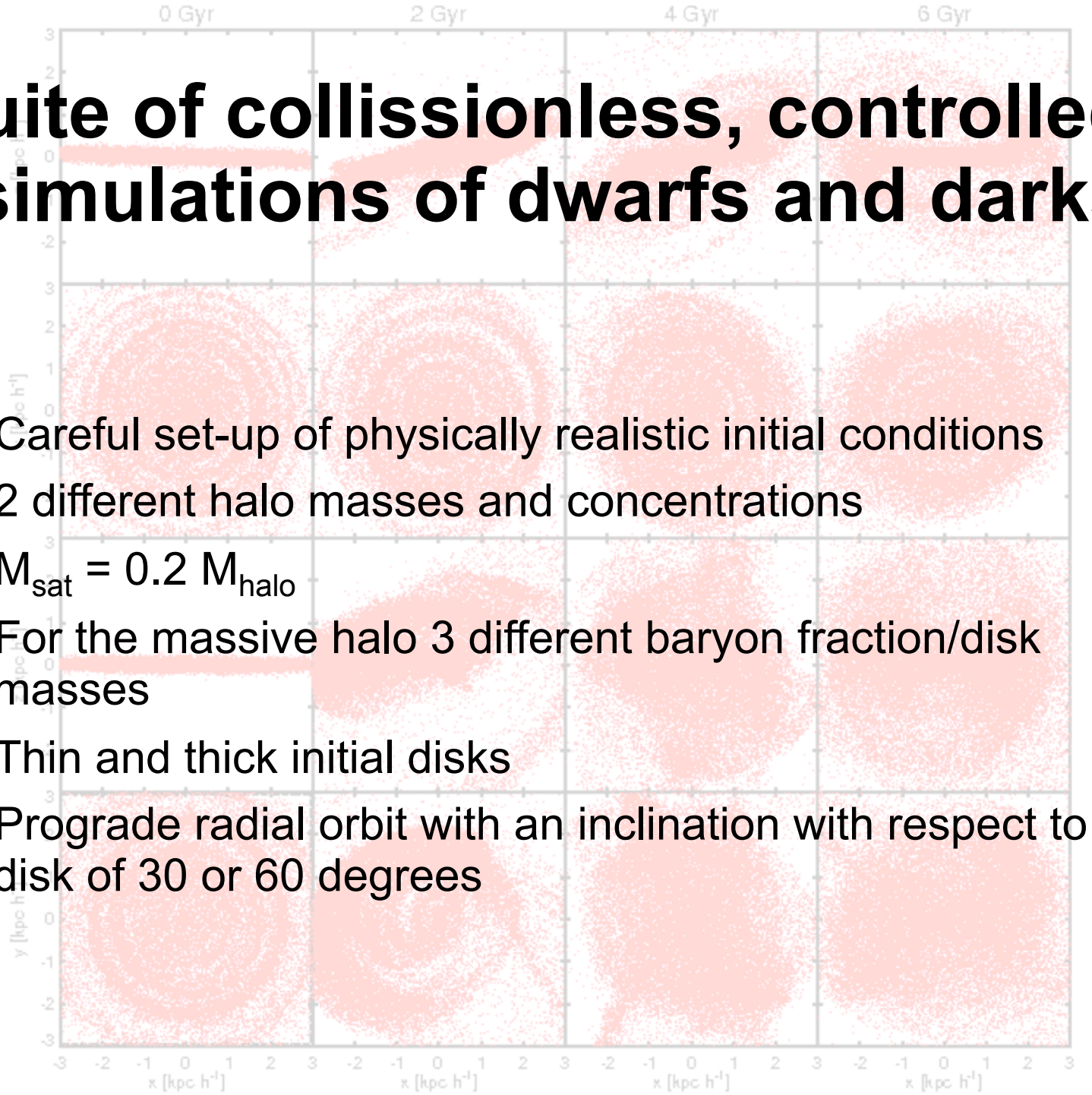
- Smaller galaxies seem to be thicker
- Also some spheroidal or transitional type dwarf galaxies found far from larger systems (Karachentsev+06;08;11;14)
- As well as starbursting or disturbed systems without companion (Bergvall+ 12; Lelli+12; Ashley+13; Lokas+14)

Helmi, Sales, E. Starkenburg, TK Starkenburg, et al 2012; data from Yoachim & Dalcanton 2006, Doyle et al 2005, Geha et al 2006 and Karachentsev et al 2004



Given their low M_{star}/M_{halo}-ratios how are dwarf galaxies affected by minor mergers with (dark) satellites?

Suite of collissionless, controlled, simulations of dwarfs and darks



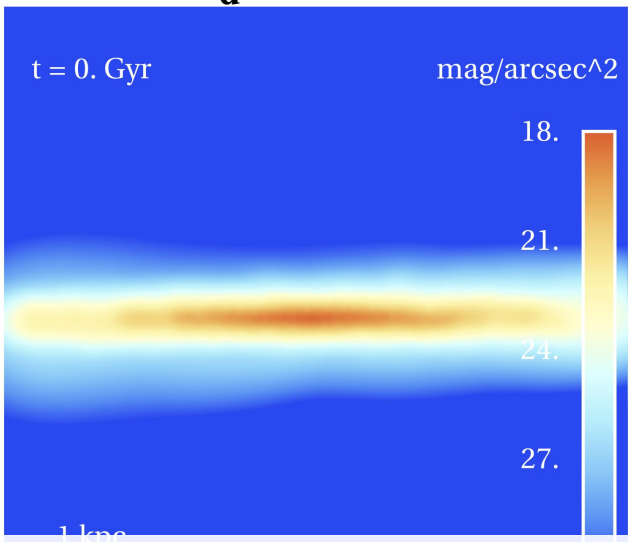
- Careful set-up of physically realistic initial conditions
- 2 different halo masses and concentrations
- $M_{sat} = 0.2\ M_{halo}$
- For the massive halo 3 different baryon fraction/disk masses
- Thin and thick initial disks
- Prograde radial orbit with an inclination with respect to the disk of 30 or 60 degrees

Morphology:

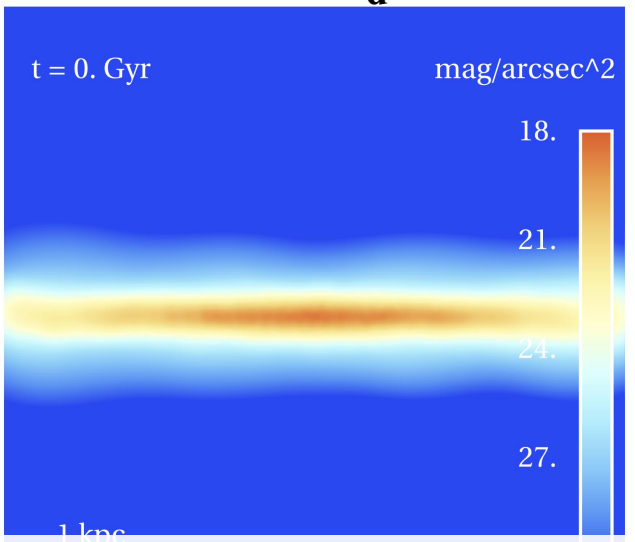
c=15; $m_d = 0.02$

c=5; $m_d = 0.008$

initial



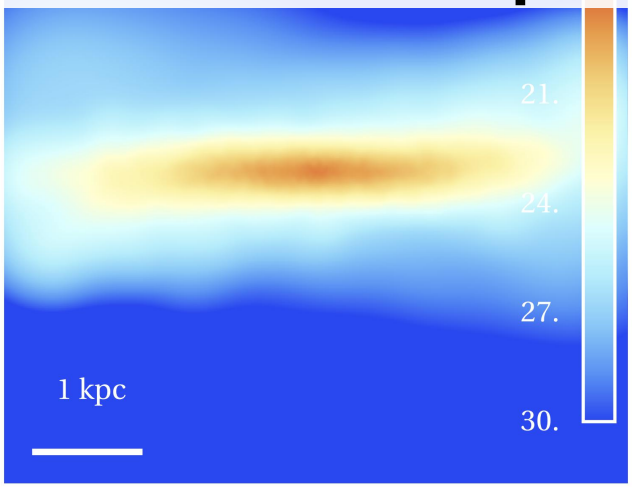
initial



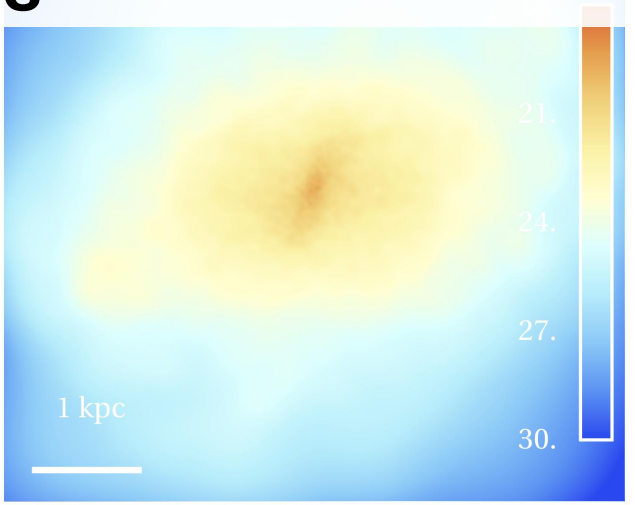
Larger M_{sat}/M_{disk}-ratio results in stronger perturbations

Lower $\rho_{c;dwarf}/\rho_{c;sat}$-ratios result in much stronger perturbations

final



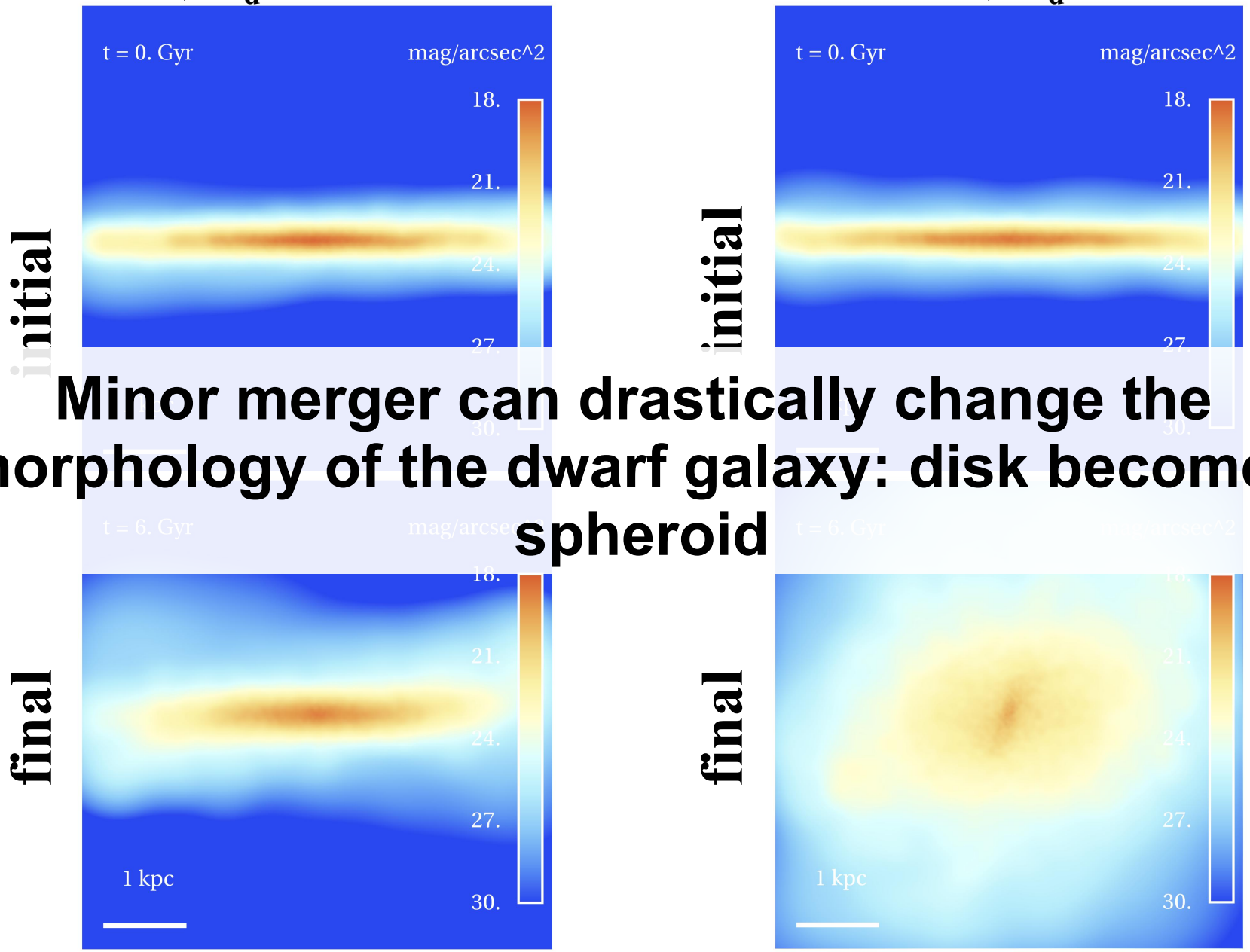
final



Morphology:

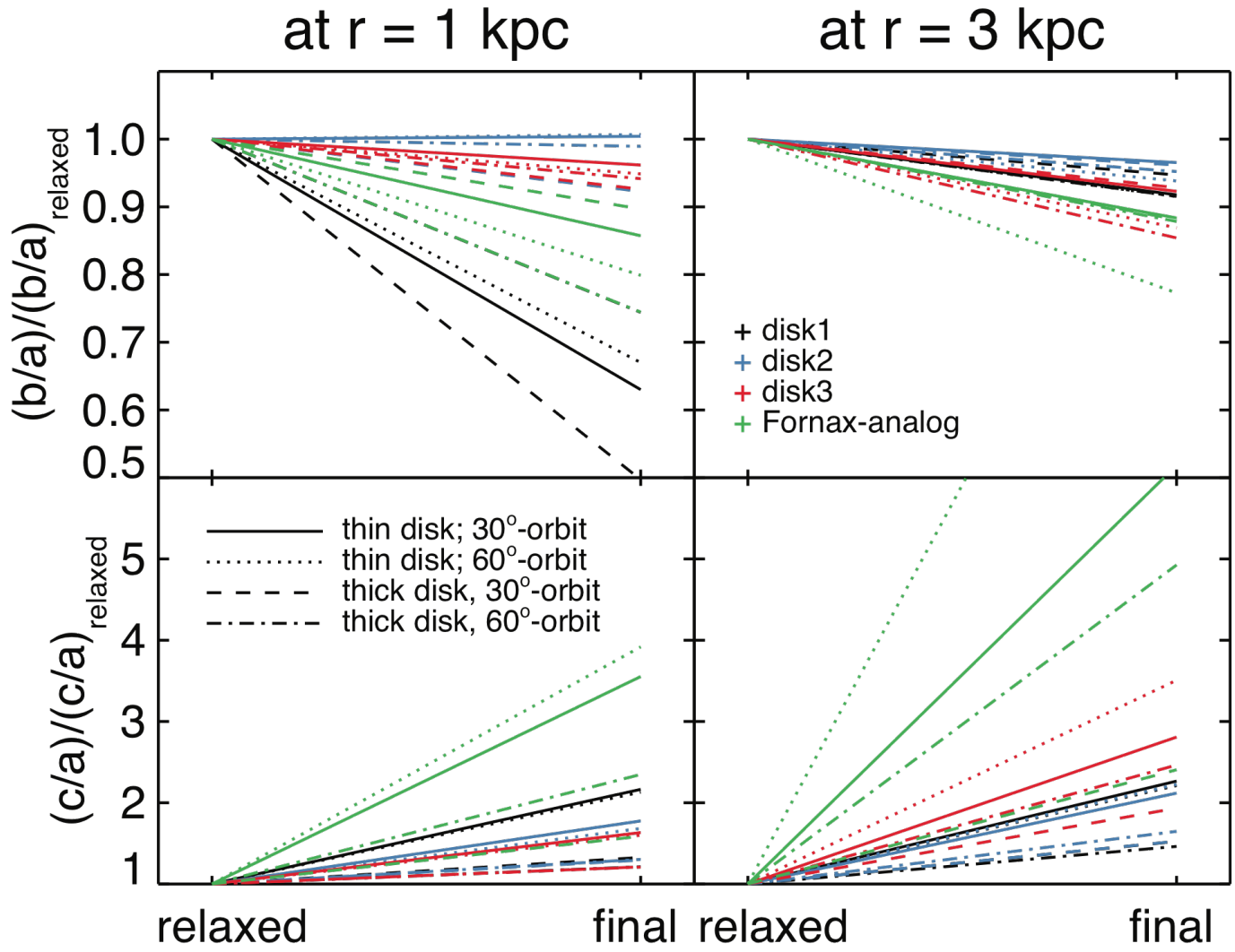
c=15; $m_d = 0.02$

c=5; $m_d = 0.008$



Minor merger can drastically change the morphology of the dwarf galaxy: disk becomes spheroid

Shapes for all disks

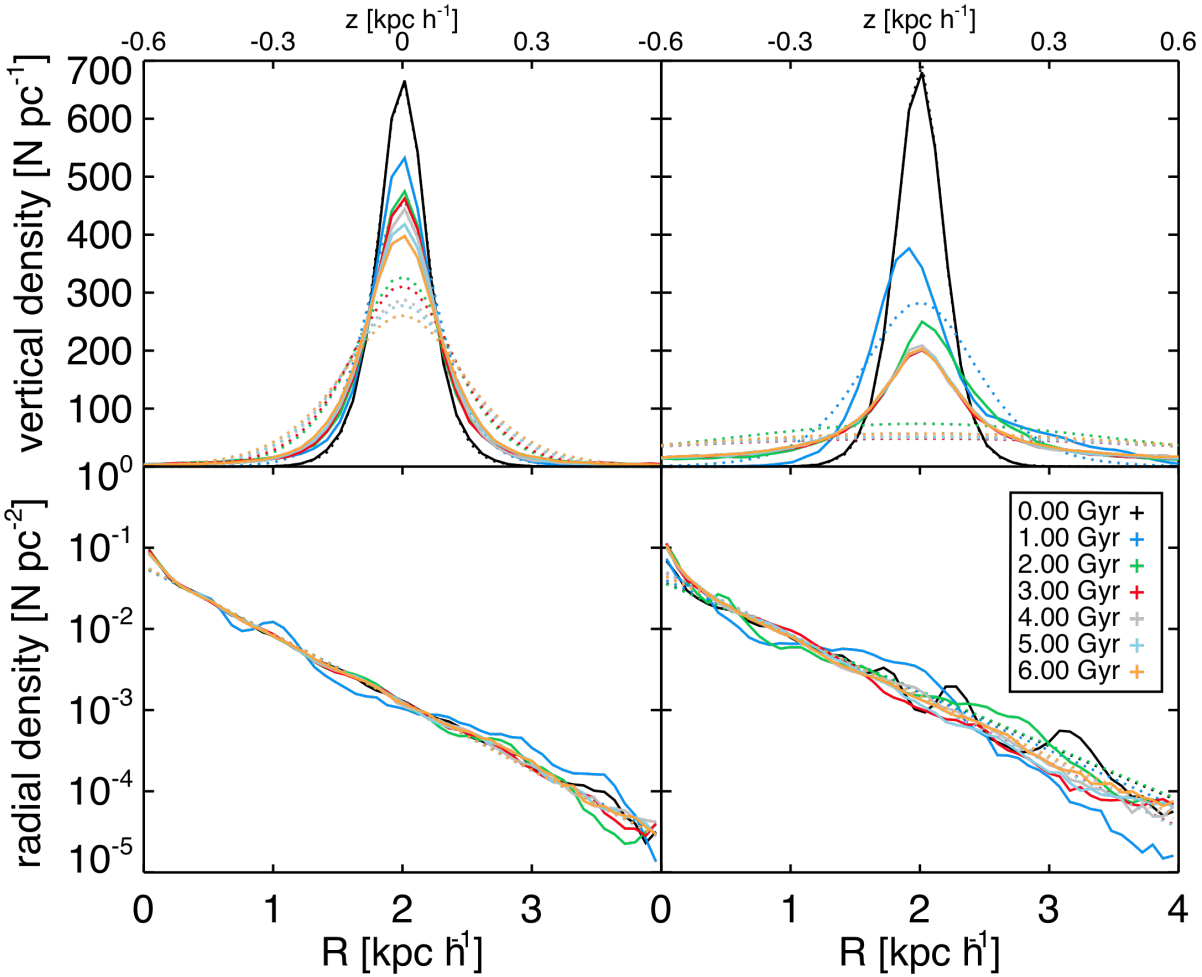


Minor merger can drastically change the morphology of the dwarf galaxy: disk becomes spheroid

Morphology:

Vertical and radial density profiles

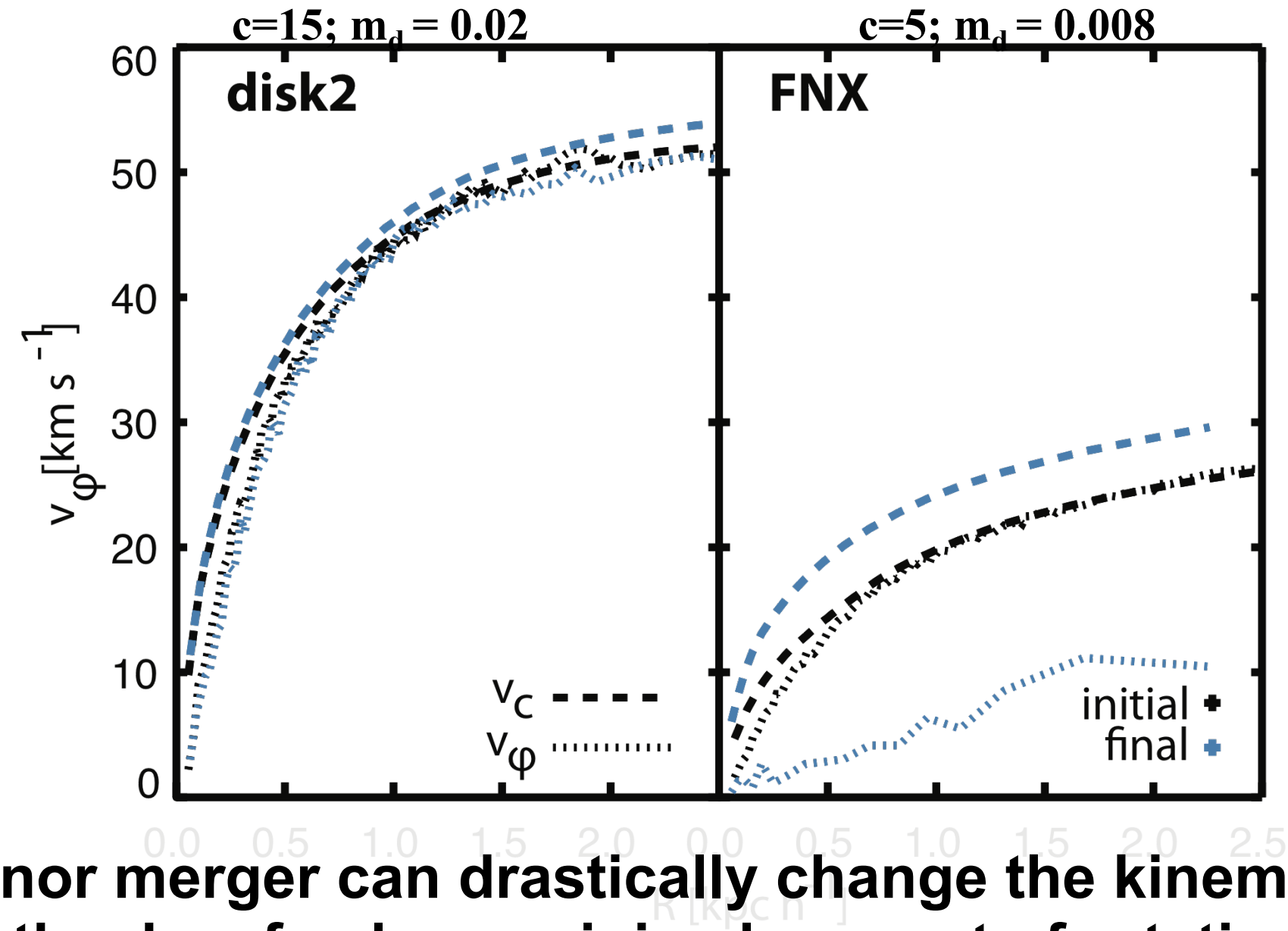
c=15;
$m_d = 0.02$



c=5;
$m_d = 0.008$

Radial density profiles are preserved
Vertical density profiles change radically

Kinematics:

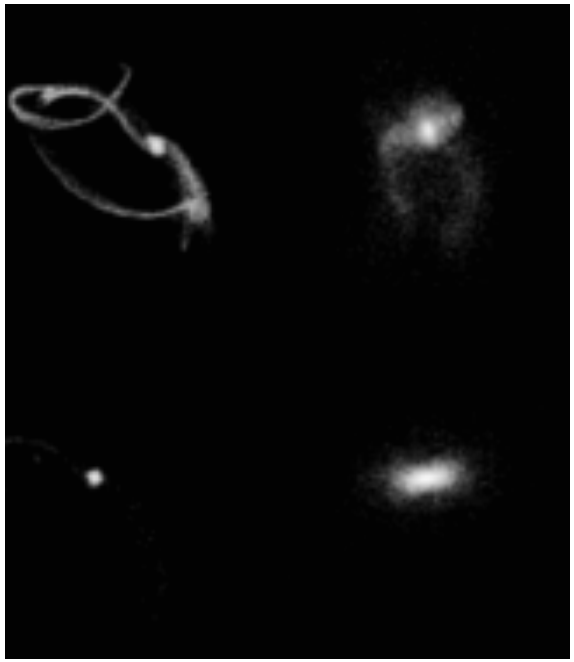


Minor merger can drastically change the kinematics of the dwarf galaxy: minimal amount of rotation left

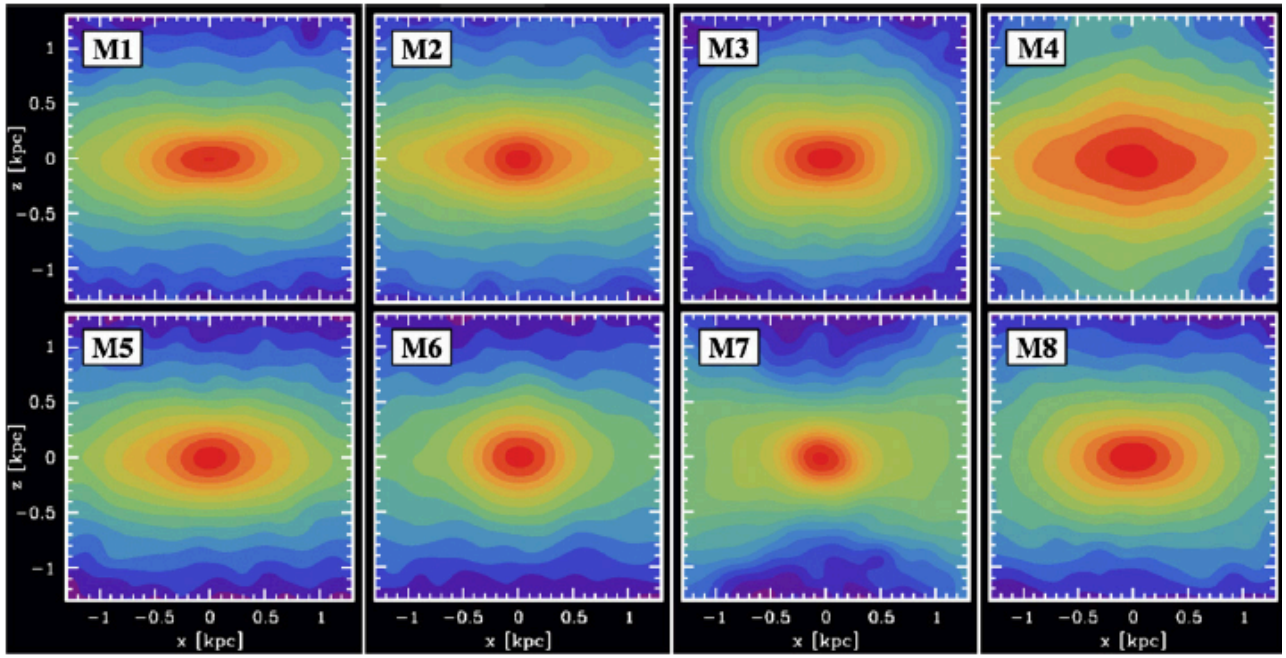
an additional route to dSphs…

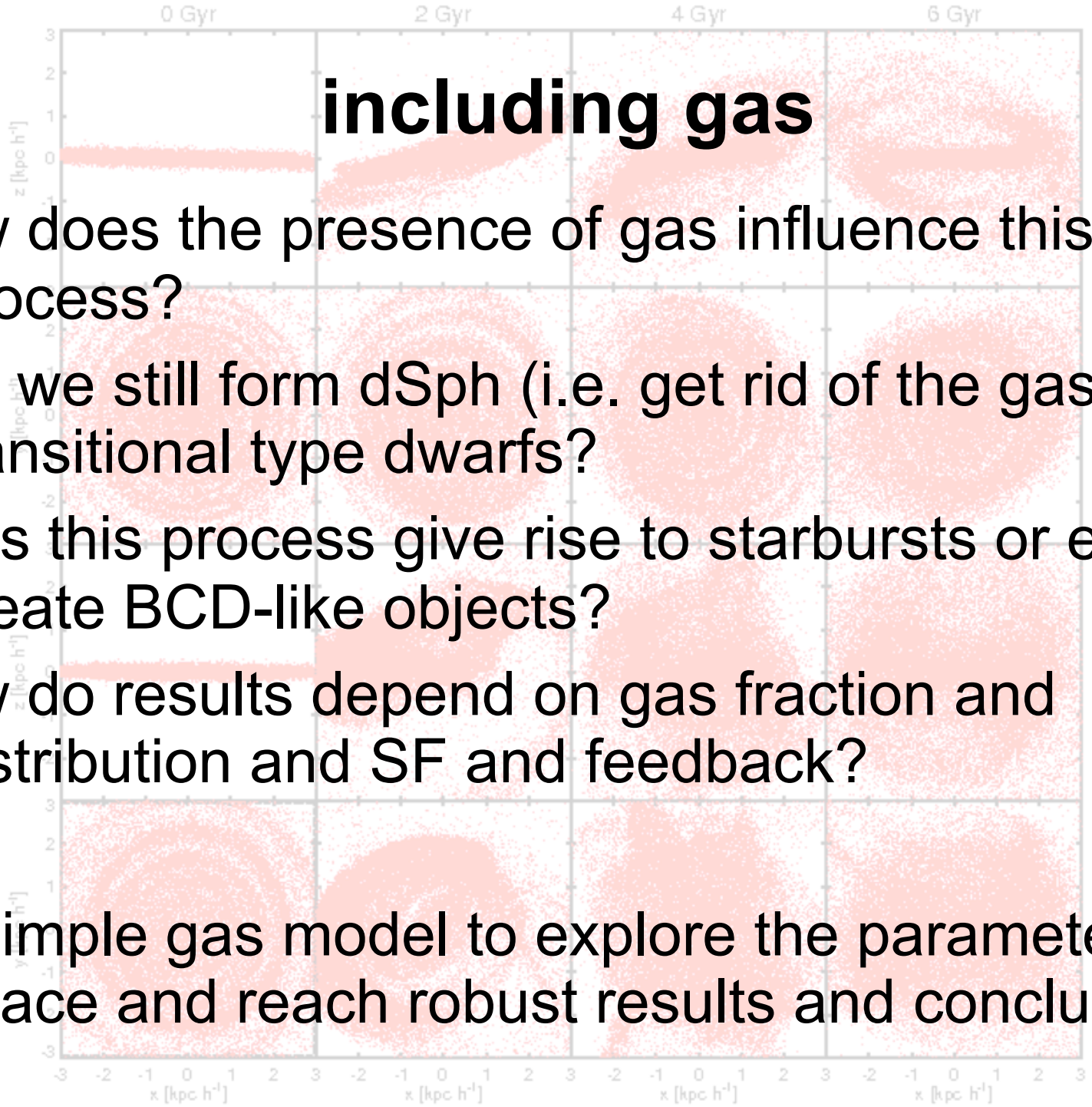
Minor merger can drastically change the morphology and kinematics of the dwarf galaxy:
-> disk becomes spheroid
-> rotational dominated system becomes dispersion dominated

Moore et al. 2001: tidal stirring of dwarfs falling into the MW-halo



Kazantzidis et al. 2011: dry dwarf-dwarf mergers





including gas

How does the presence of gas influence this process?

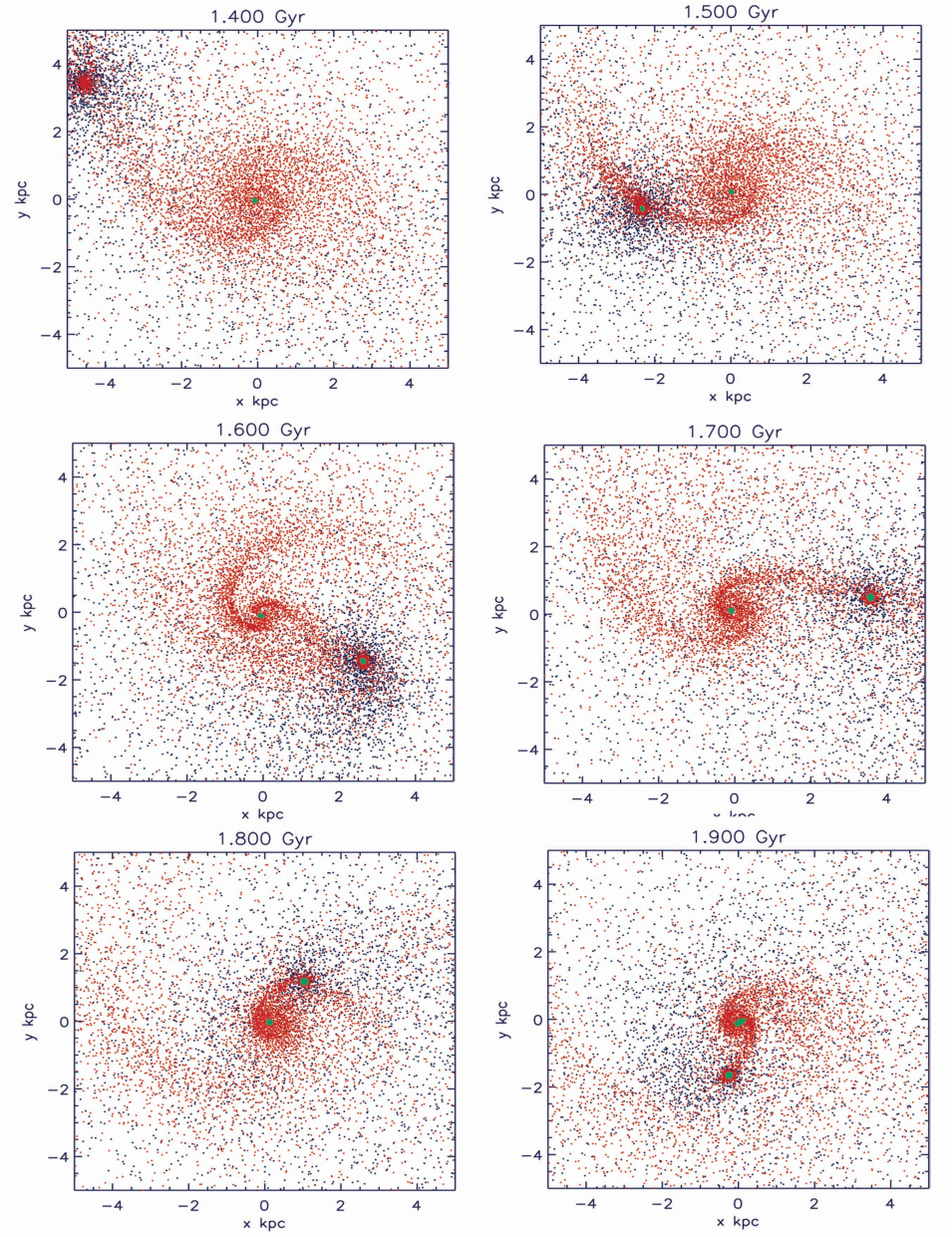
Can we still form dSph (i.e. get rid of the gas) or transitional type dwarfs?

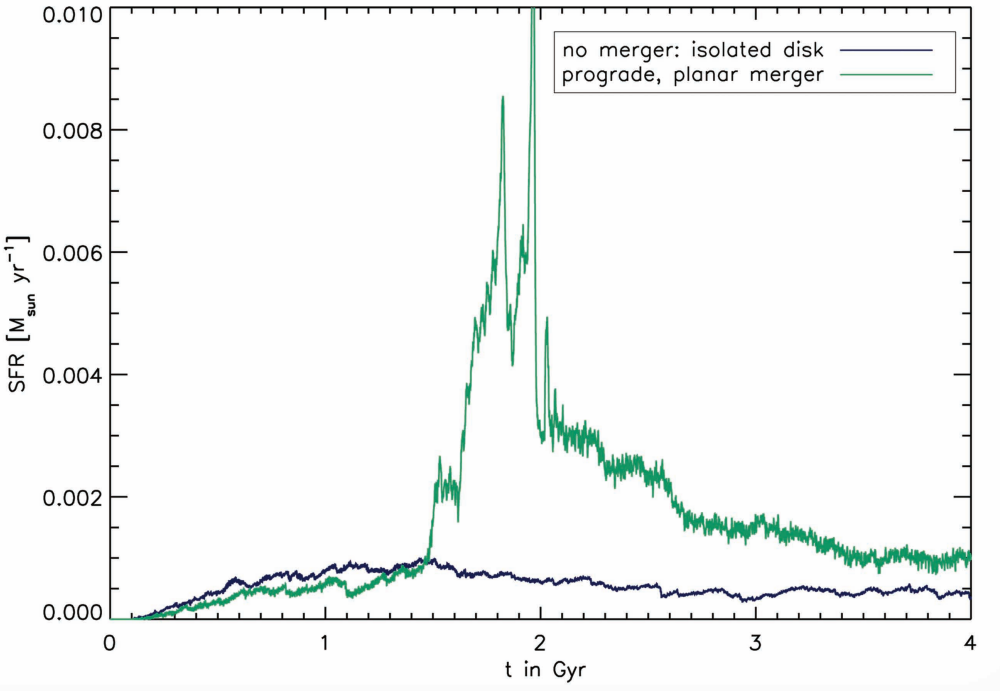
Does this process give rise to starbursts or even create BCD-like objects?

How do results depend on gas fraction and distribution and SF and feedback?

-> Simple gas model to explore the parameter space and reach robust results and conclusions

Including gas (very preliminary tests)





- Merger causes a starburst
- Satellite accumulates gas from the primary
- Satellite major part of the peak in star formation

Summary

- Dwarf galaxies are much more likely to be severely disturbed by minor mergers than Milky Way-like galaxies
- 1:5 minor merger can completely change a Fornax-like system
  - morphologically from a disky system into a spheroidal system
  - kinematically from a rotational dominated system into a dispersion dominated system
- Future research: the influence of gas and estimating the significant minor merger fraction