Is the core cusp problem a matter of perspective?

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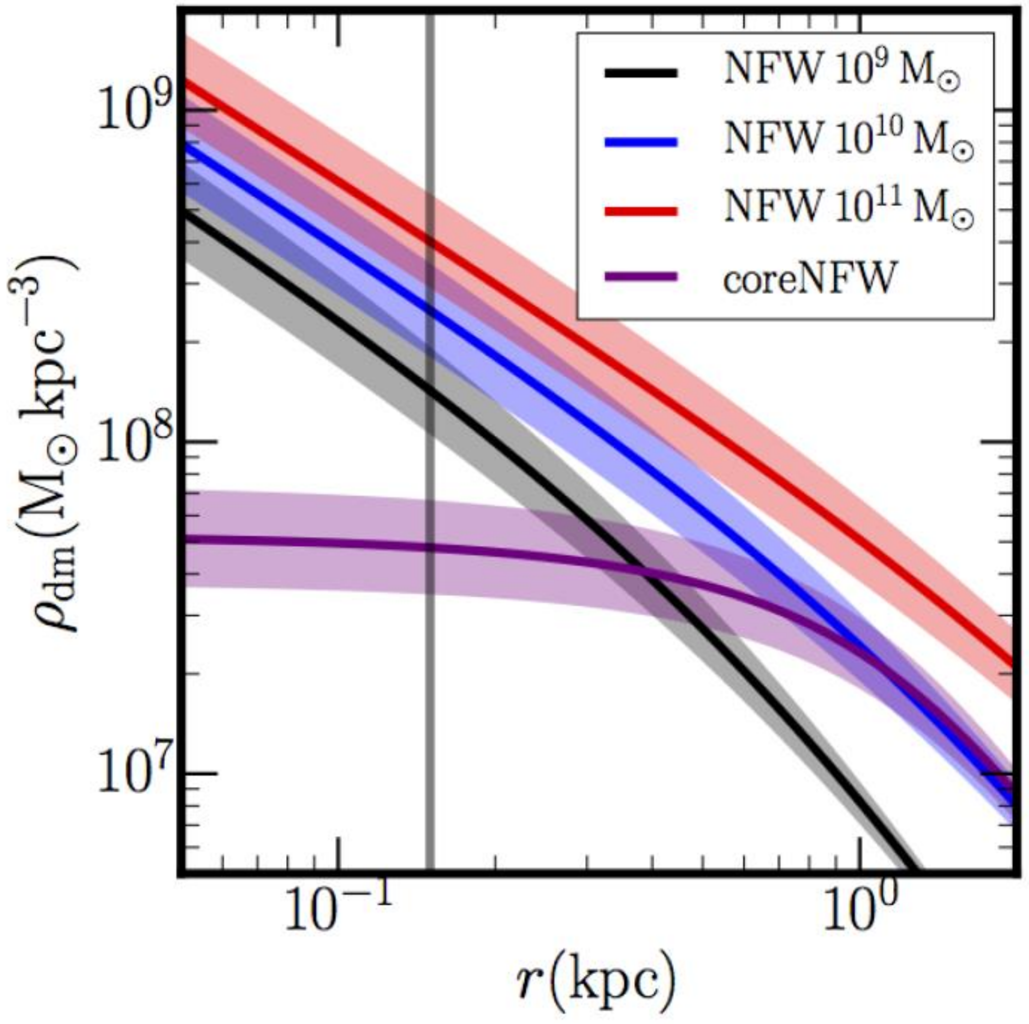
The core-cusp problem of dwarf galaxies?

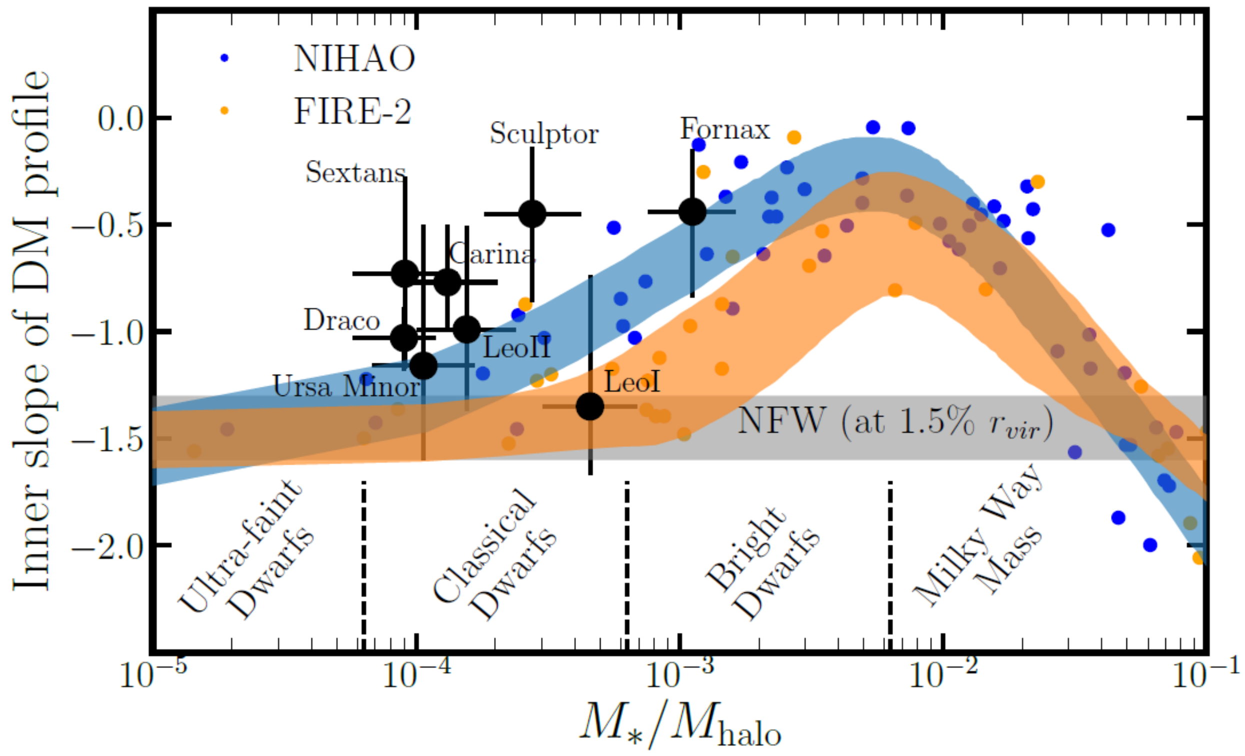


Read, et al., 2019

- ➢ Cold dark matter (CDM) simulations predict that the inner density slopes of dark matter halos are close to -1 (cusp).
- ➢ Dynamically modelling of real observed dwarf galaxies suggest close to 0 inner slopes (core).
- ➢ How to explain：
- • alternative dark matter model (SIDM)?
- • baryonic physics?

The core-cusp problem of dwarf galaxies?

- Stellar feedback can only form cores for relatively bright dwarfs. (e.g. Hayashi, et al., 2020; Read, et al., 2018)



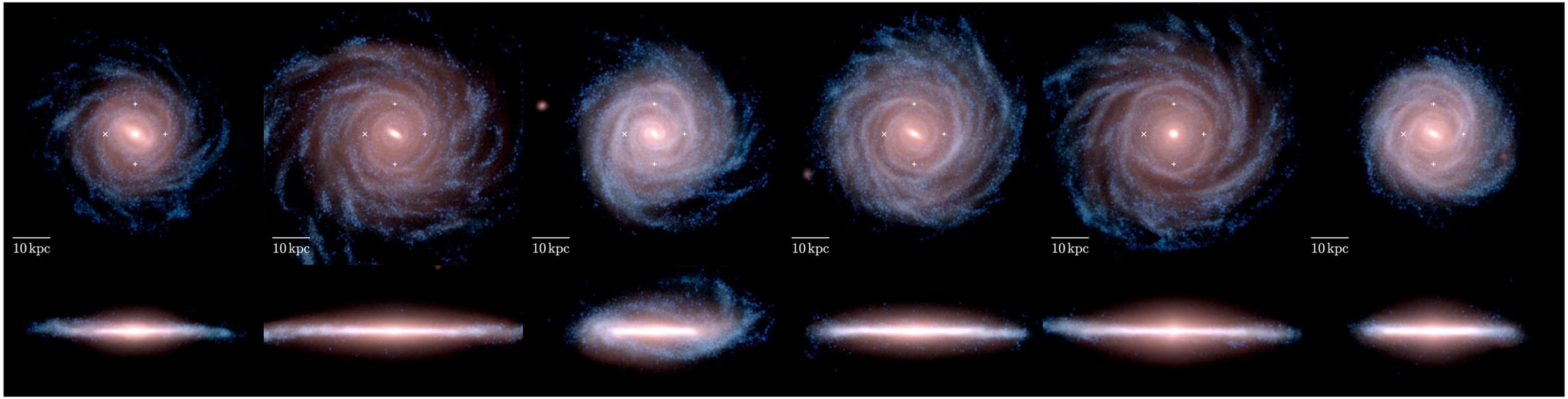
Hayashi, et al., 2020

- Do we understand systematics behind dynamical modelling?

- Violations of some model assumptions might mistakenly result in core inner slopes (Genina, et al, 2018)

Validate model assumptions with numerical simulation

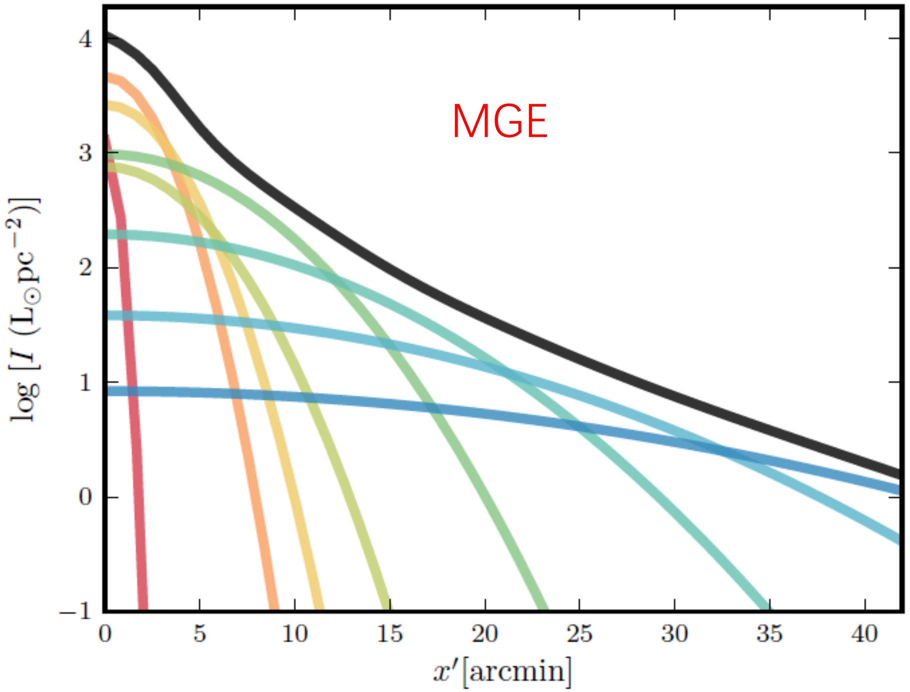
- ~30 dwarf galaxies selected from Auriga (Grand et al. 2018).
- Half star-forming, half quiescent – 6 are Sagittarius dSph-like systems.

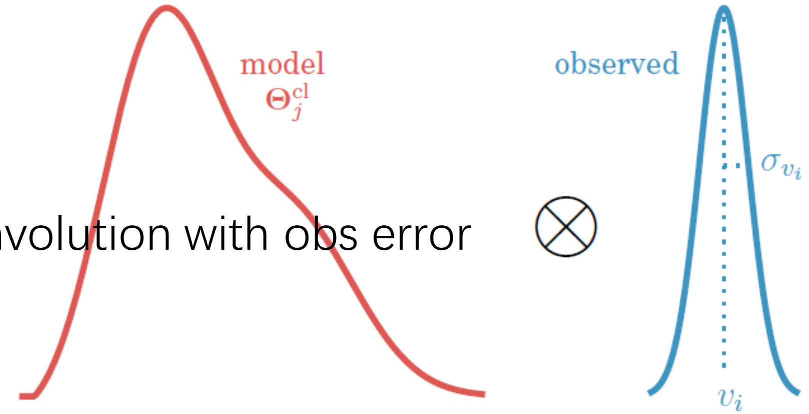


JAM

➢ The dynamical method (JAM):
Jeans Anisotropic Multi Gaussian Expansion modelling
(e.g. Watkins, et al., 2013
Zhu et al., 2016)

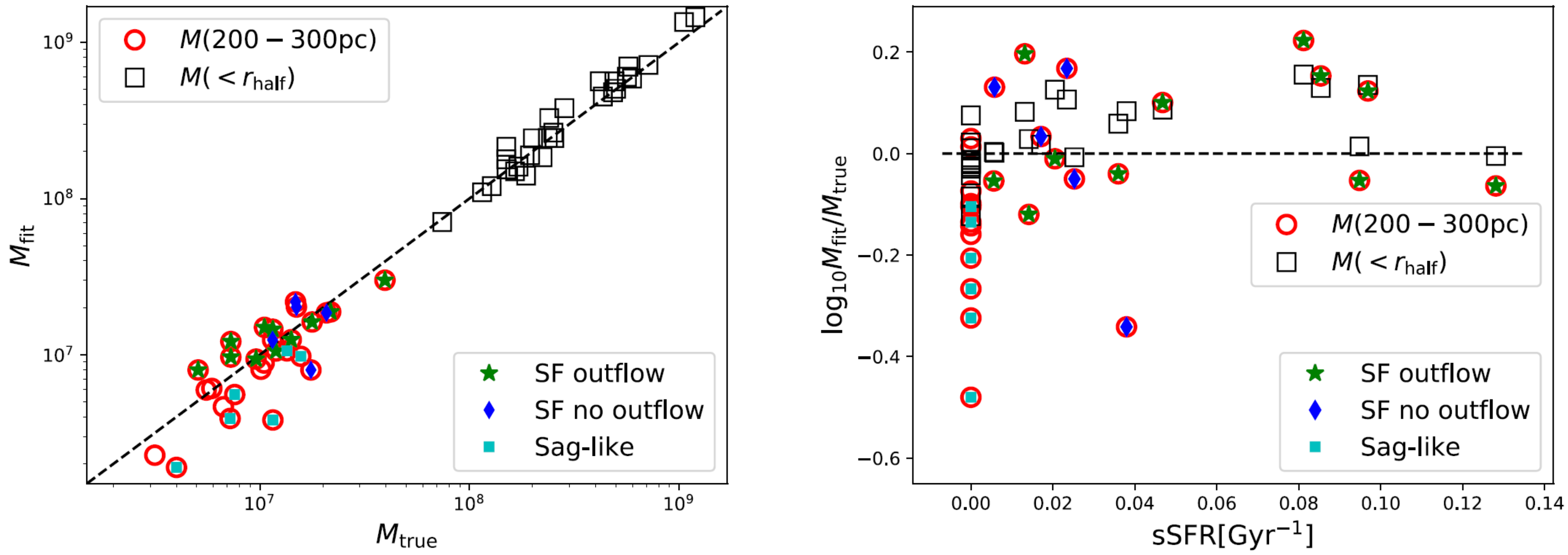
➢ Feature of JAM:
- Axis-symmetric
- Can be applied to both radial velocity and proper motions
- Can fit any functional form of the underlying potential model through Multi-Gaussian Expansion (MGE)
- **Can model observational errors**
- **Can model a constant fore/background**





Bias correlates with SFR

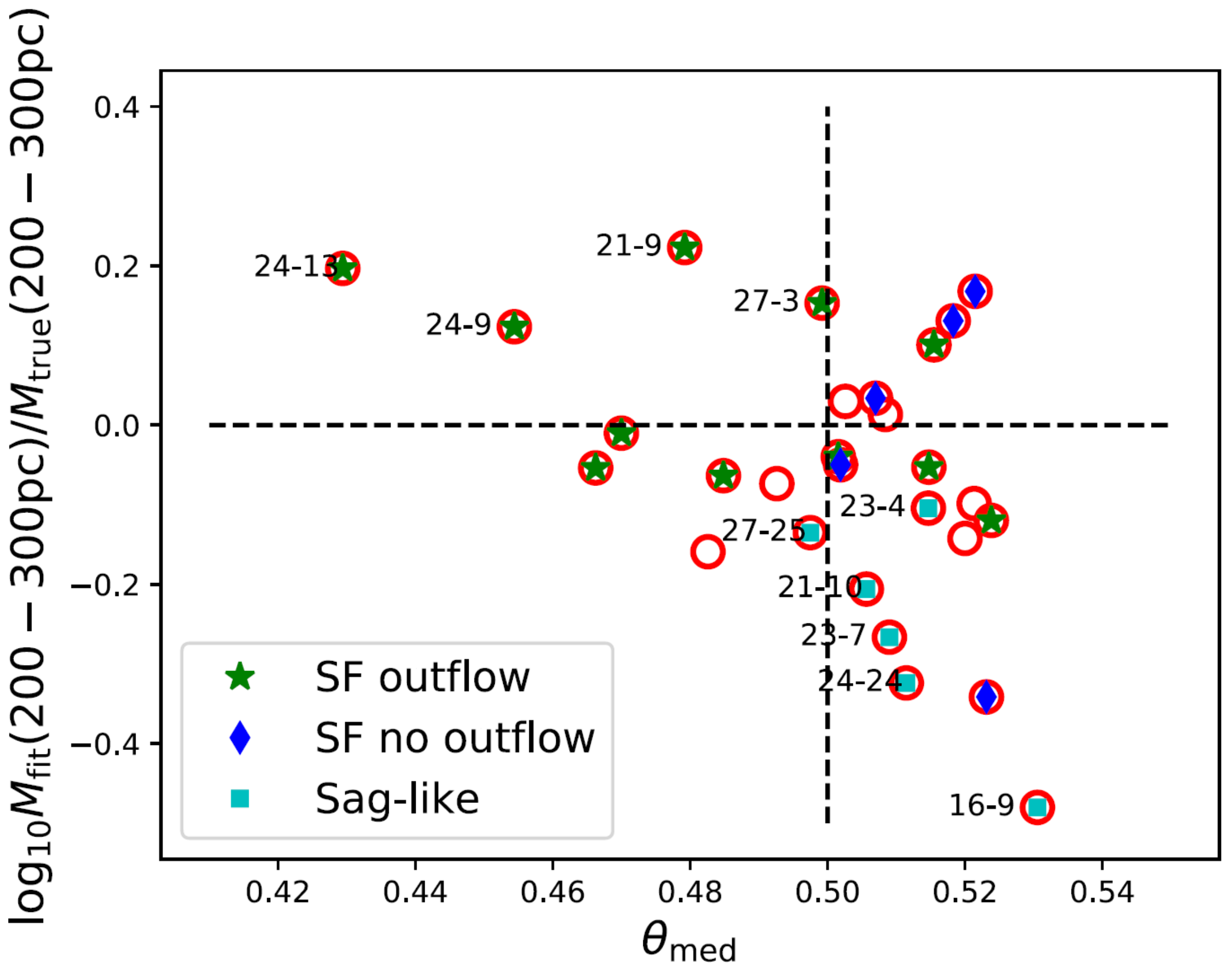
~30 dwarf galaxies from Auriga



Wang, Zhu et al. 2022

- The best-fits are ensemble unbiased, but the signs and amount of bias depend on the star formation rate.
- The mass within half-mass radius is constrained better.

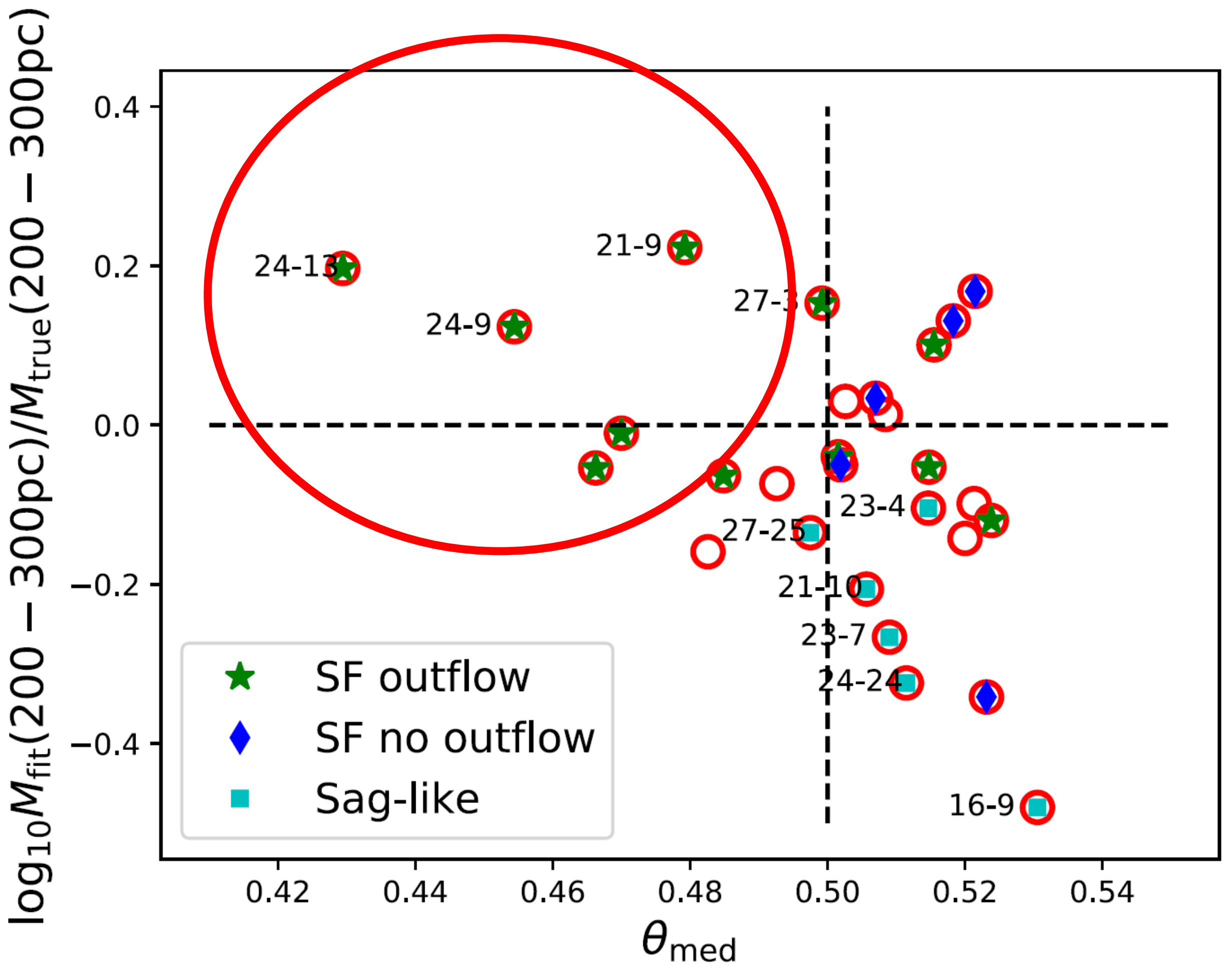
Bias correlates with dynamical status

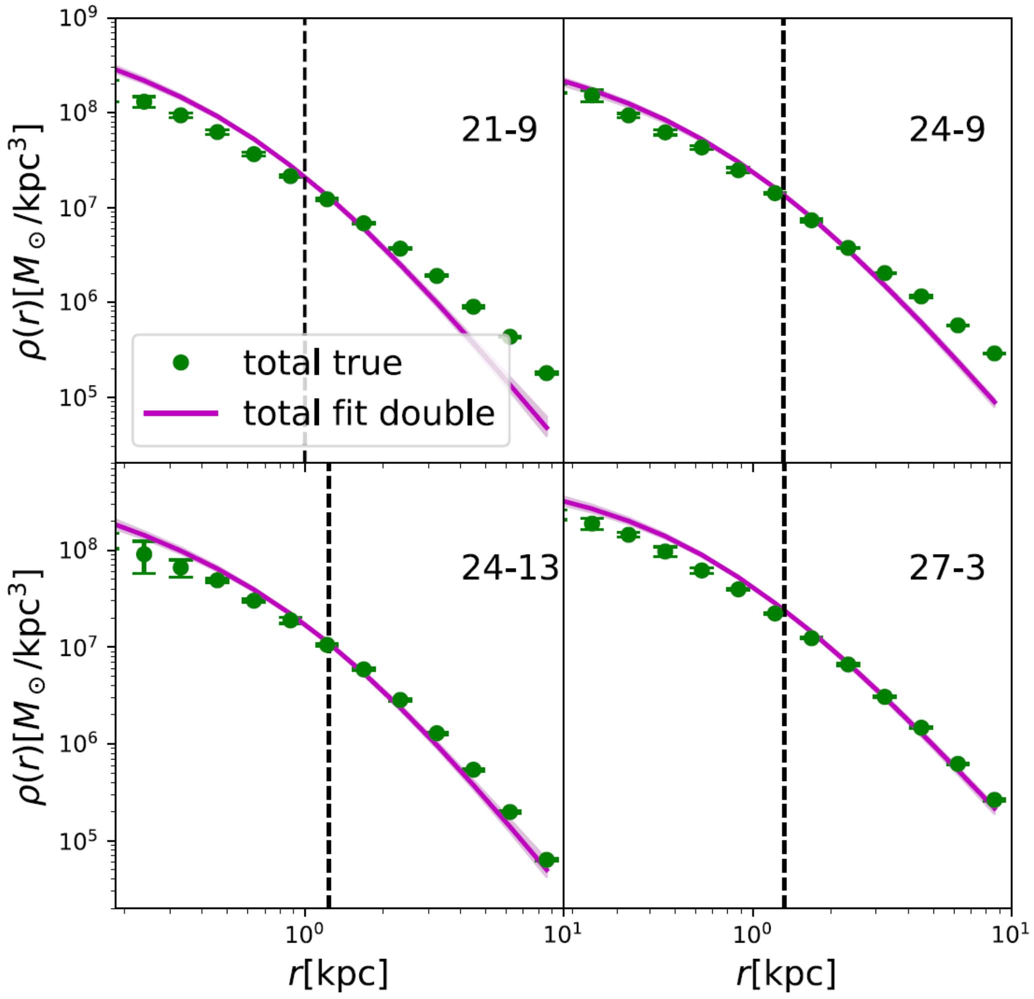


Wang, Zhu et al. 2022

- The bias in best fits depends on the dynamical status of the systems.
- x-axis is the median of the radial action angle distribution: 0.5 means in steady state.

Bias correlates with dynamical status





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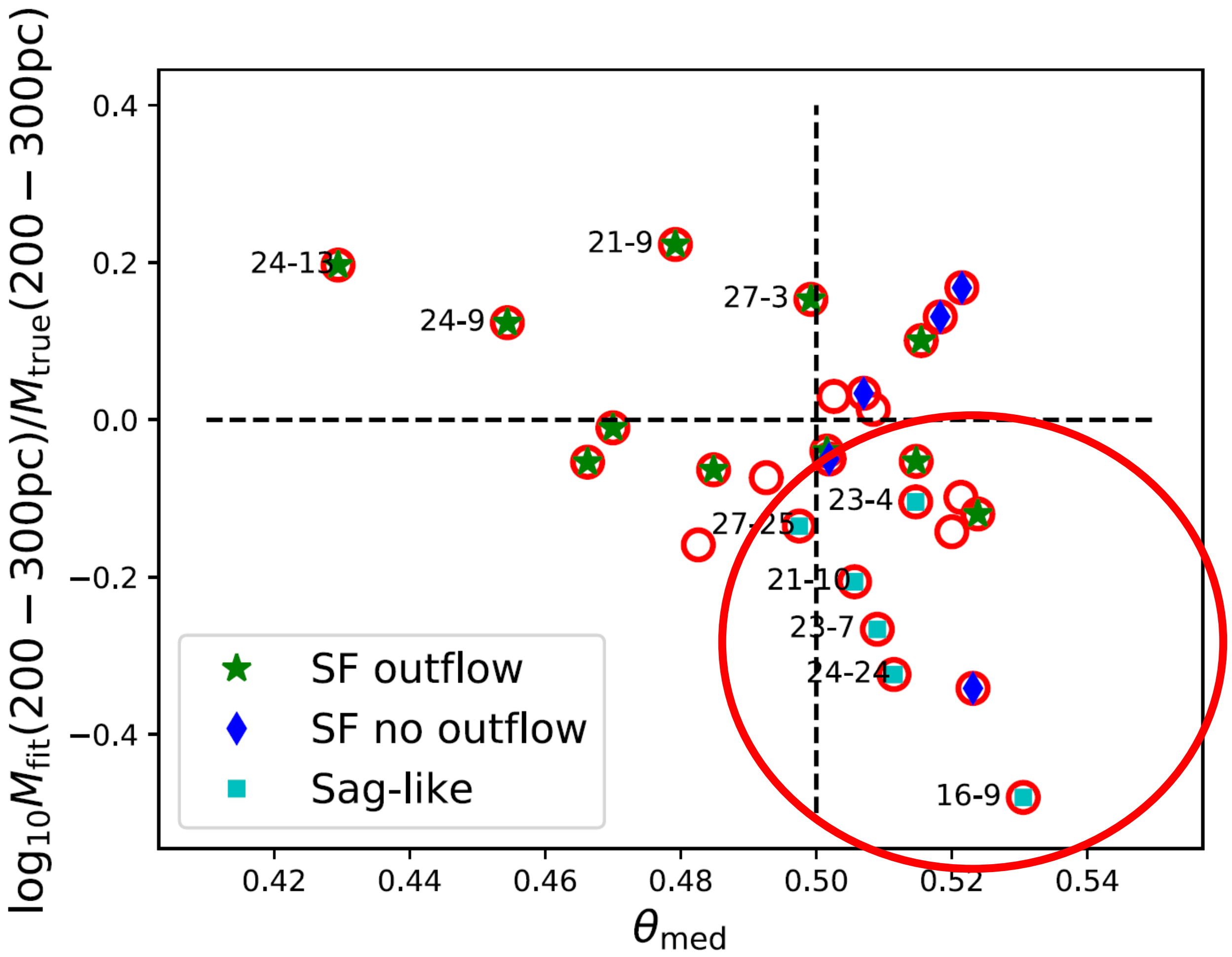
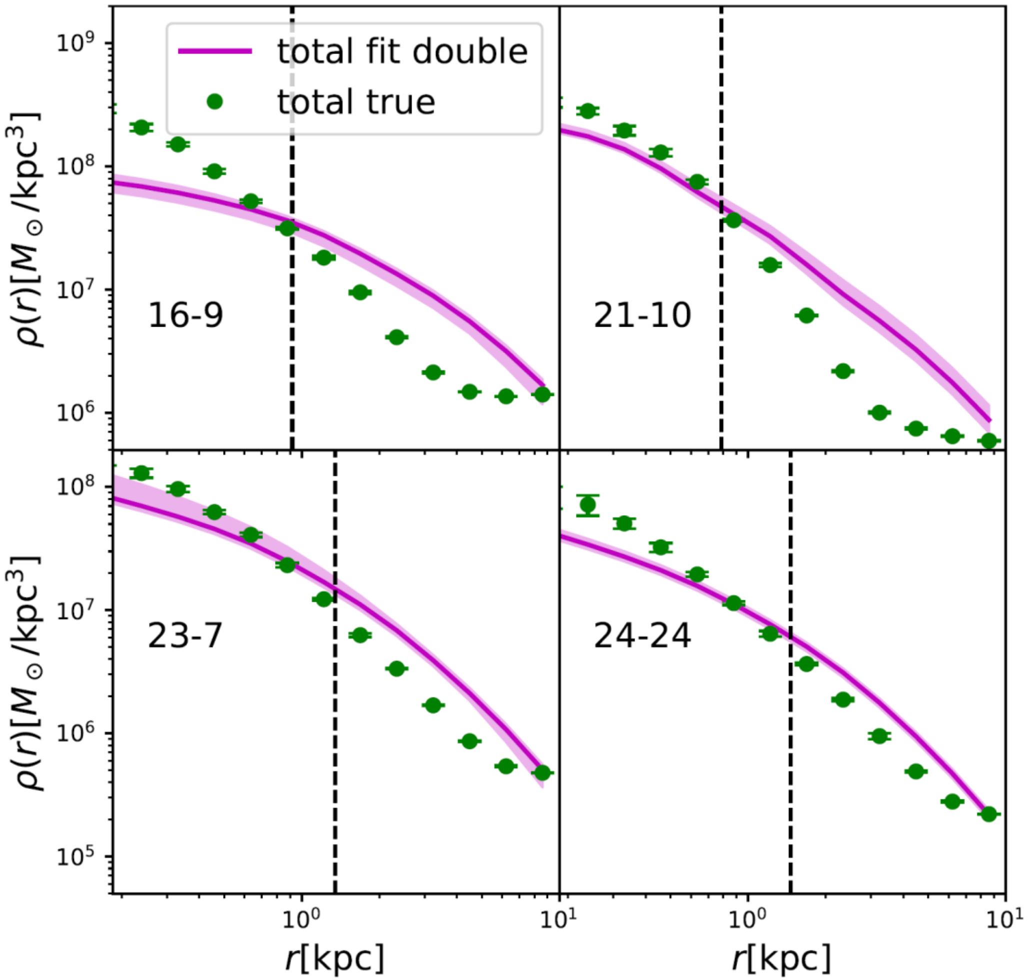
Bias correlates with dynamical status



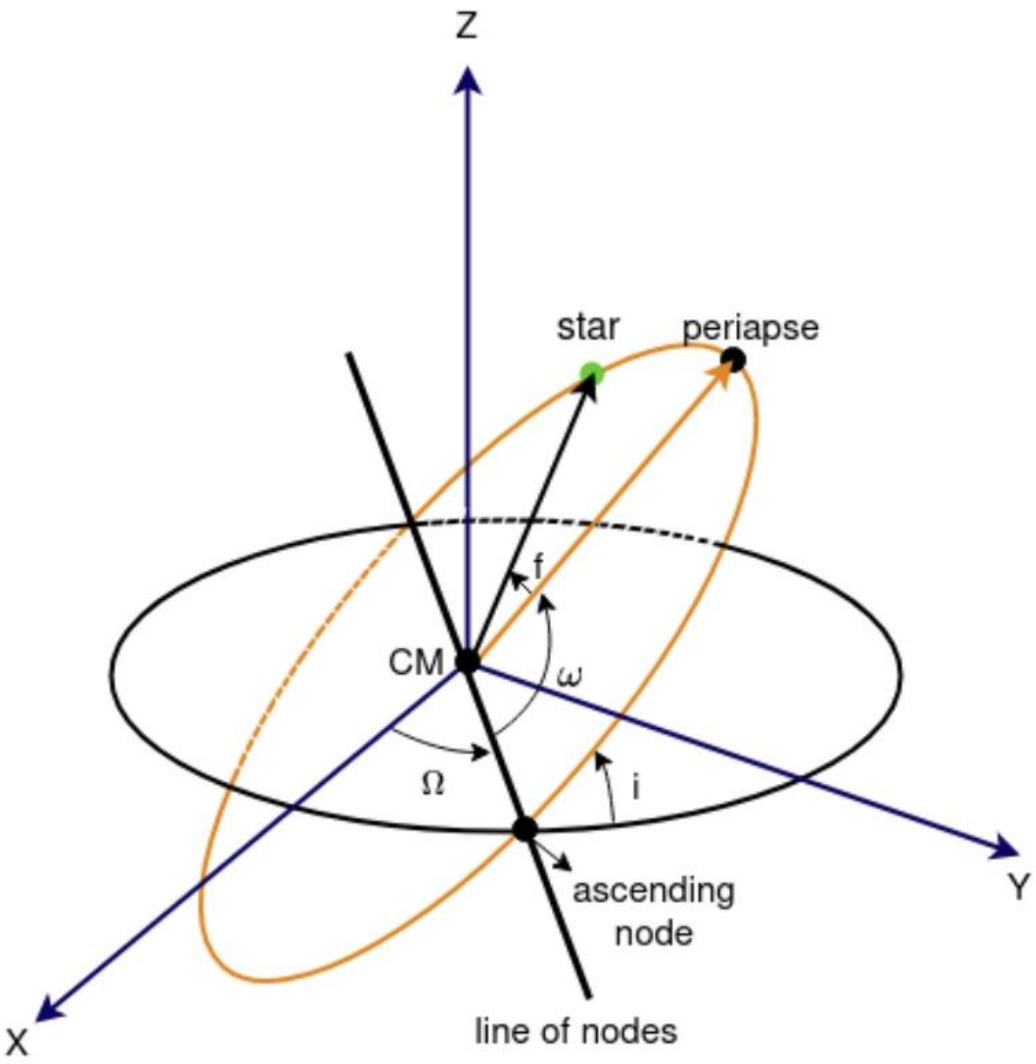


Wang, Zhu et al. 2022

How to get precise constraints on inner slopes?

- Multiple populations
- Focus on ensemble averaged results
- Selecting steady state systems

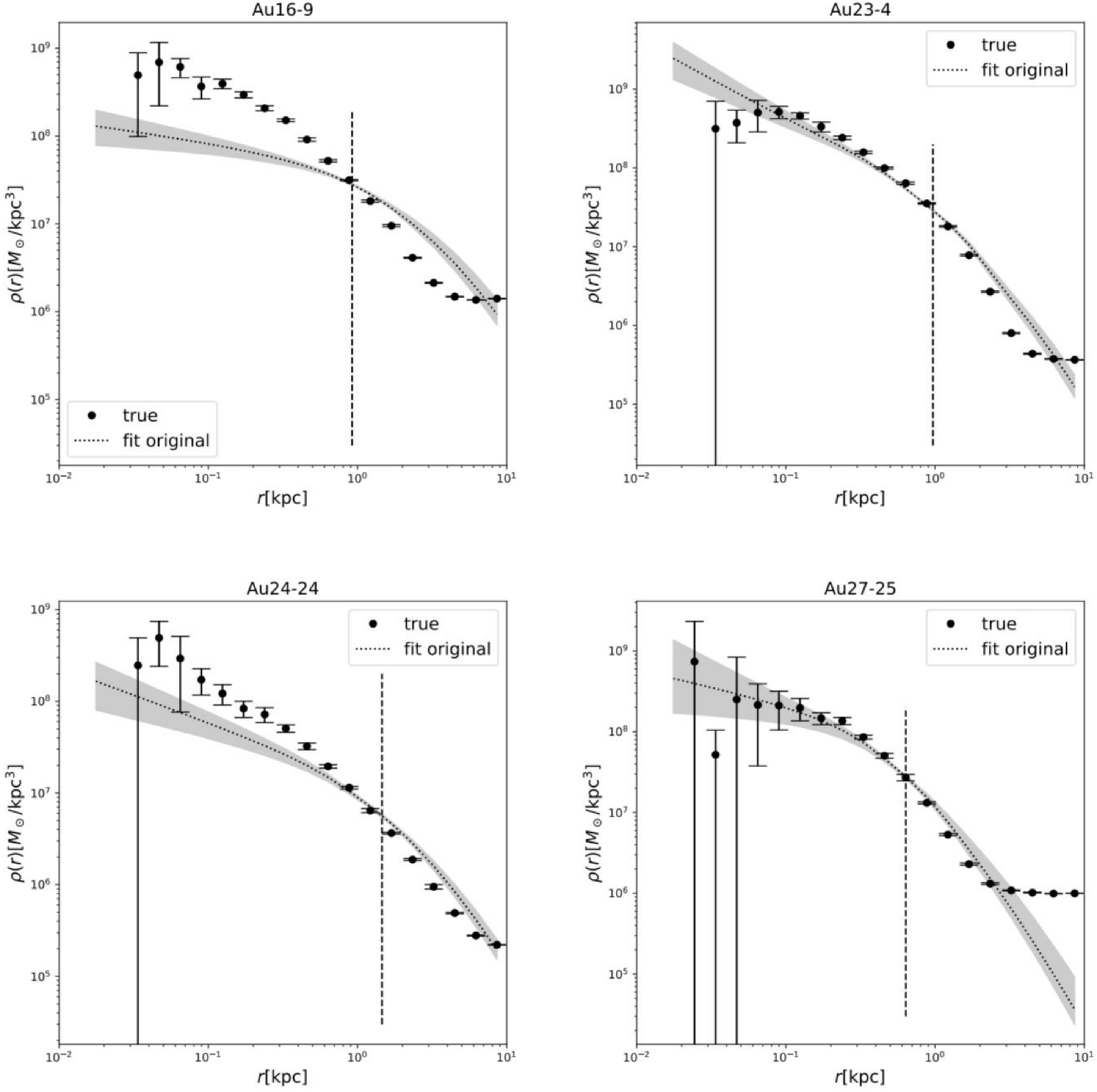
The effect of binaries



- It has long been known that binary orbital motions act to increase the observed velocity dispersions of galaxies.
- It is not a problem for MW-mass galaxies and massive classical dwarfs.
- But maybe a problem for ultra faint dwarfs.

The effect of binaries

- Binary orbital motions tend to **DEFLATE** the best constrained inner densities.
- As a secondary effect, it makes the best constrained inner densities more cored.



Wang, et al., 2023

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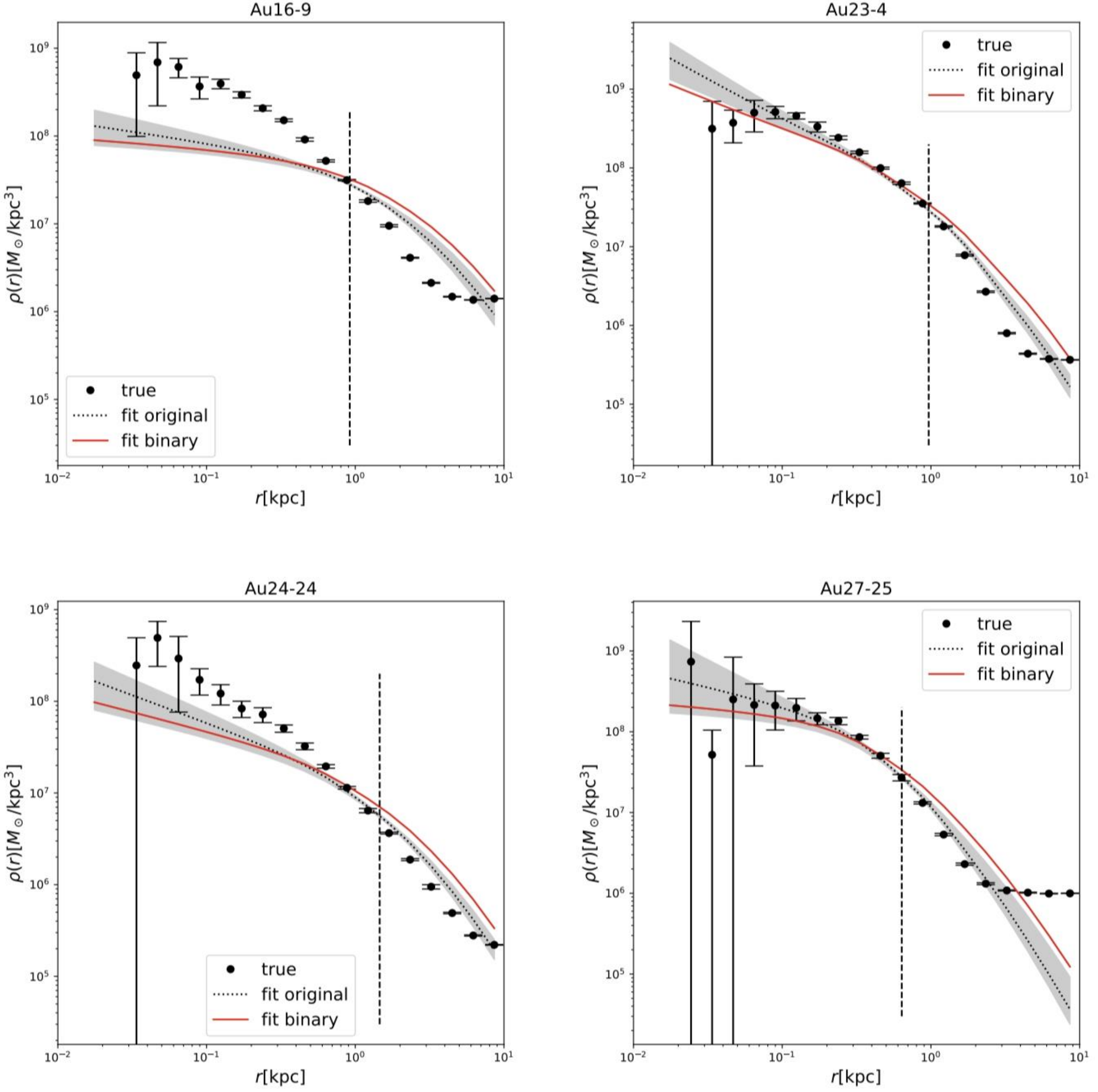

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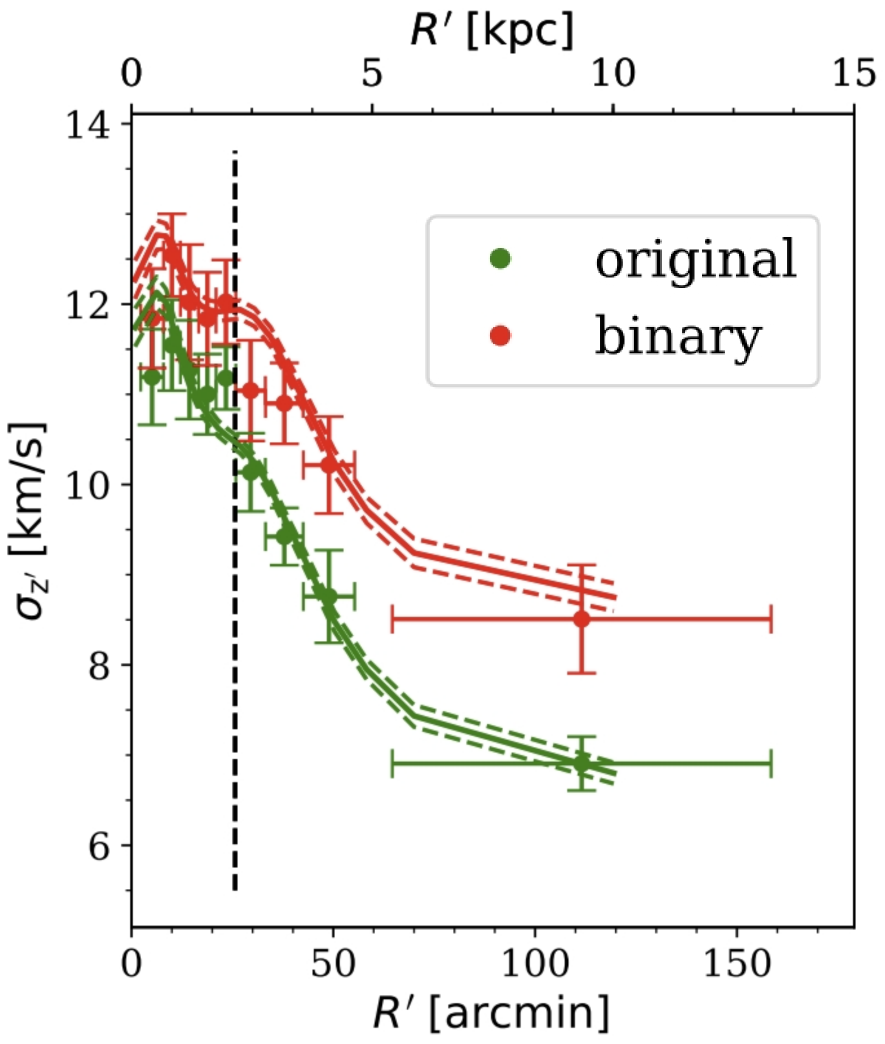
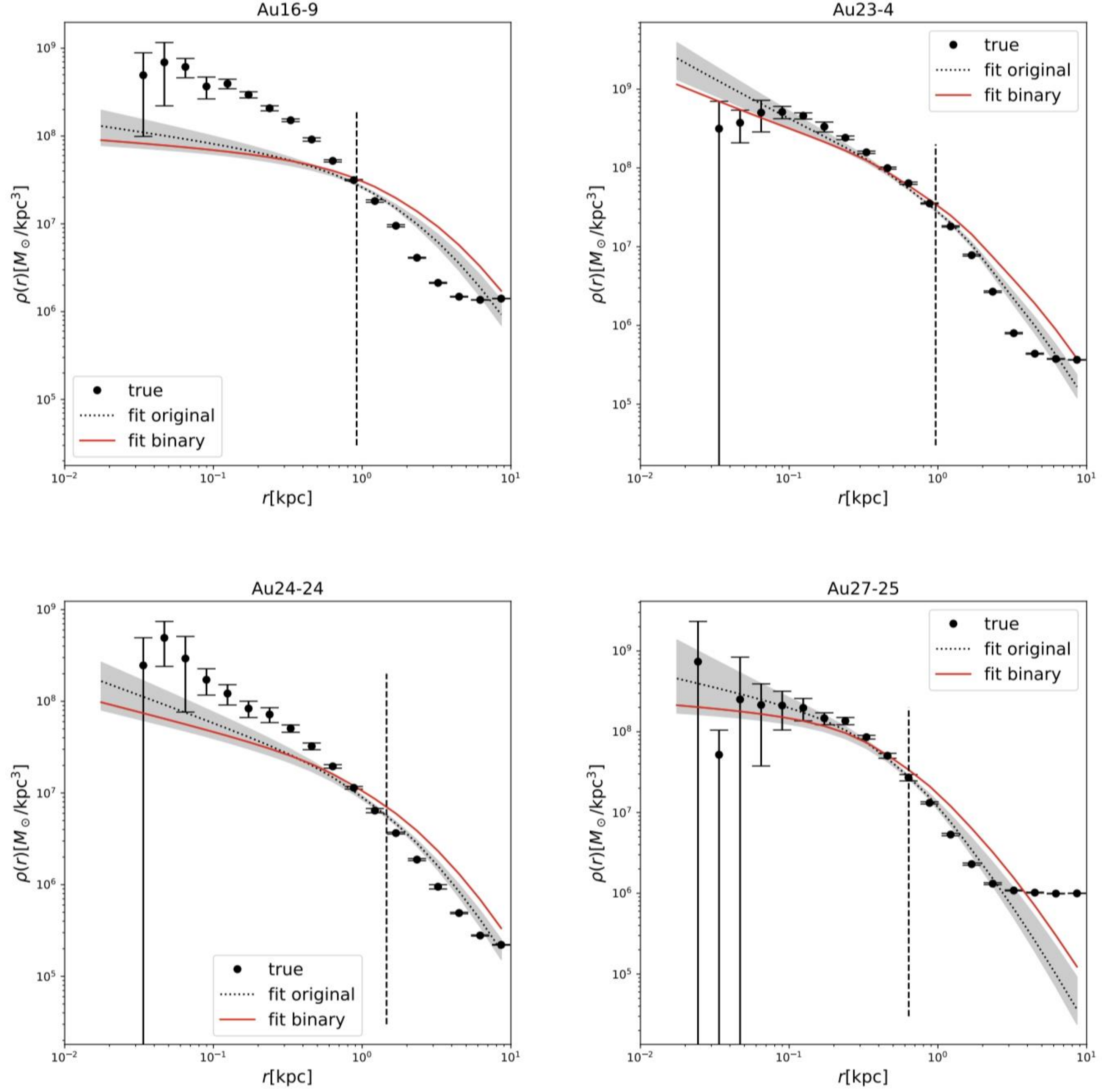
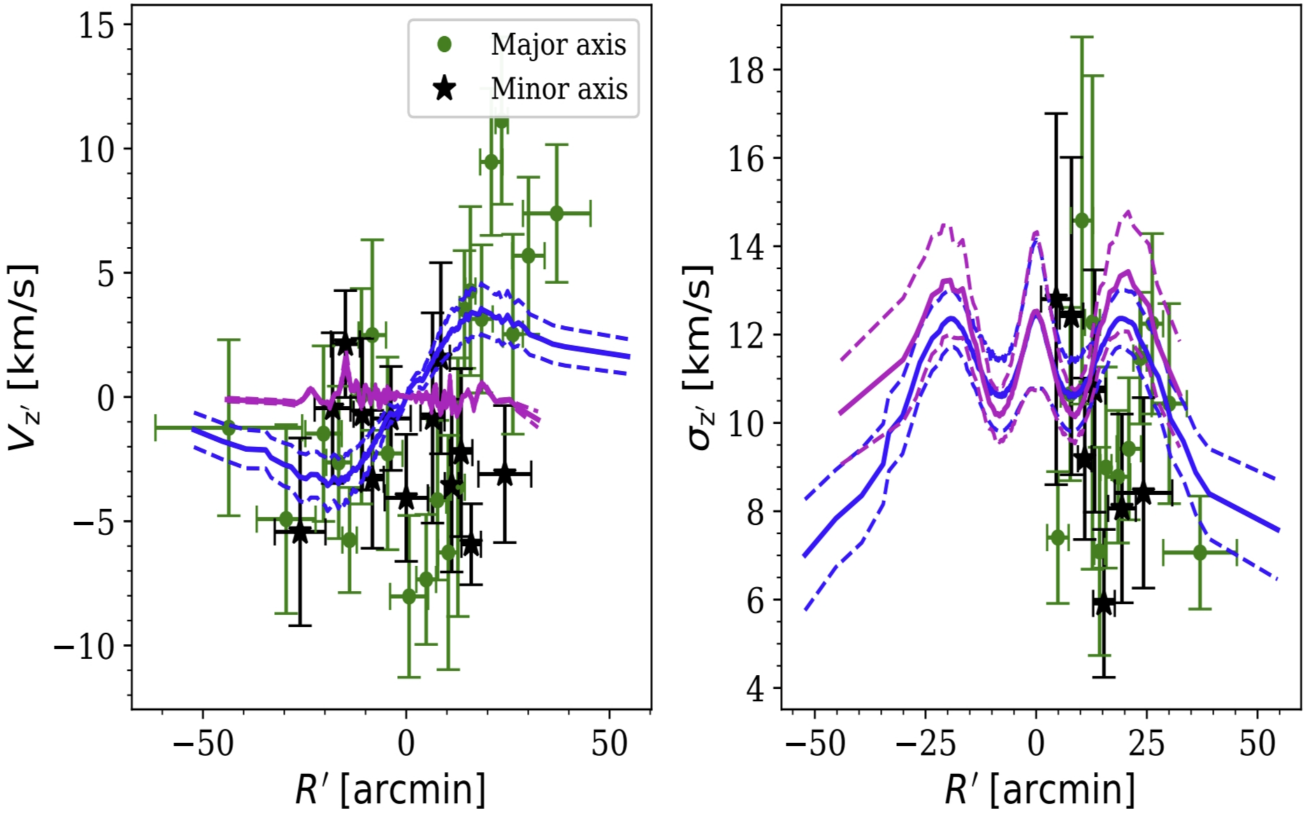


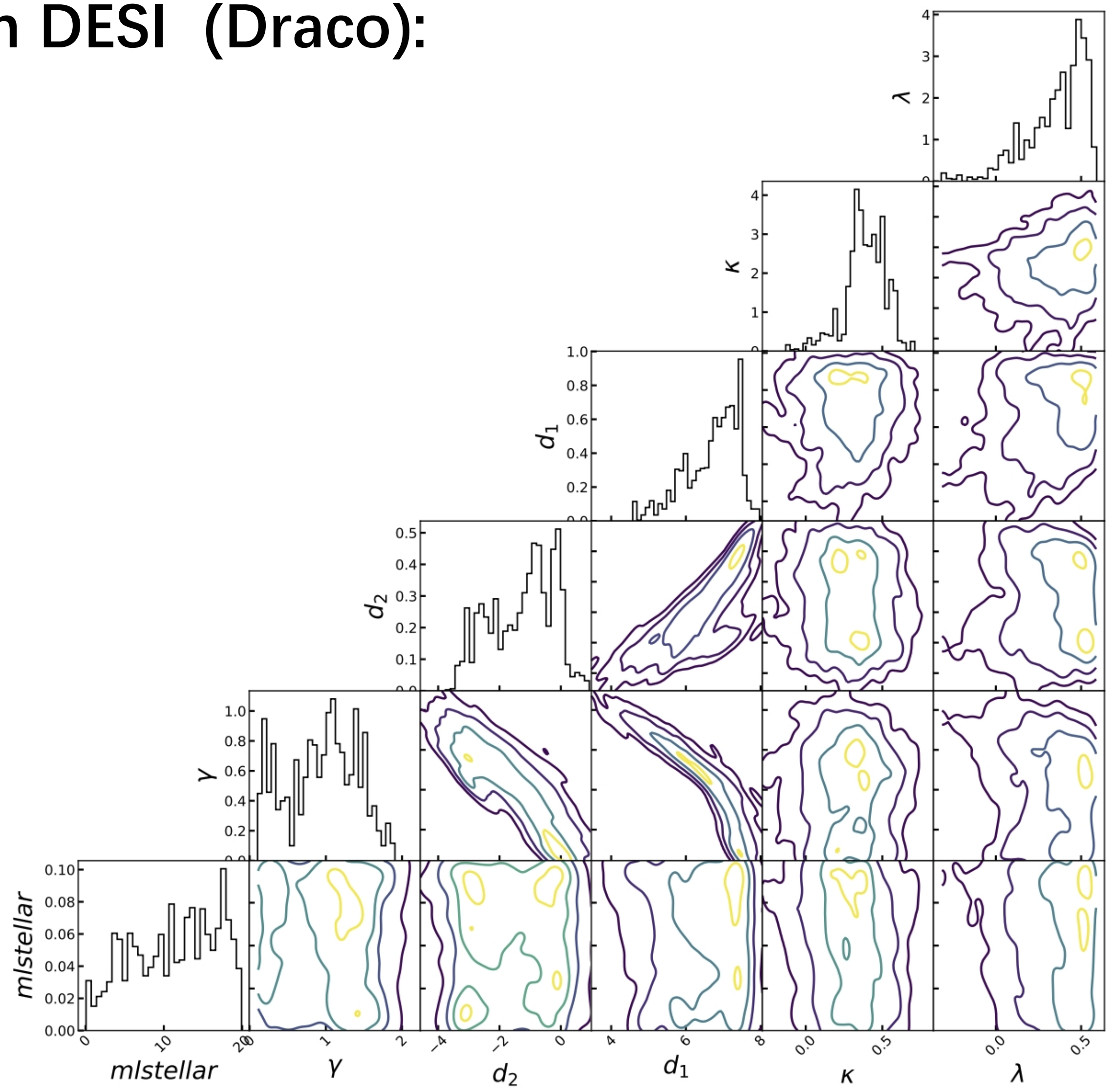


Wang, et al., 2023

Modeling of Draco

➢ **Preliminary results based on LOSVs from DESI (Draco):**



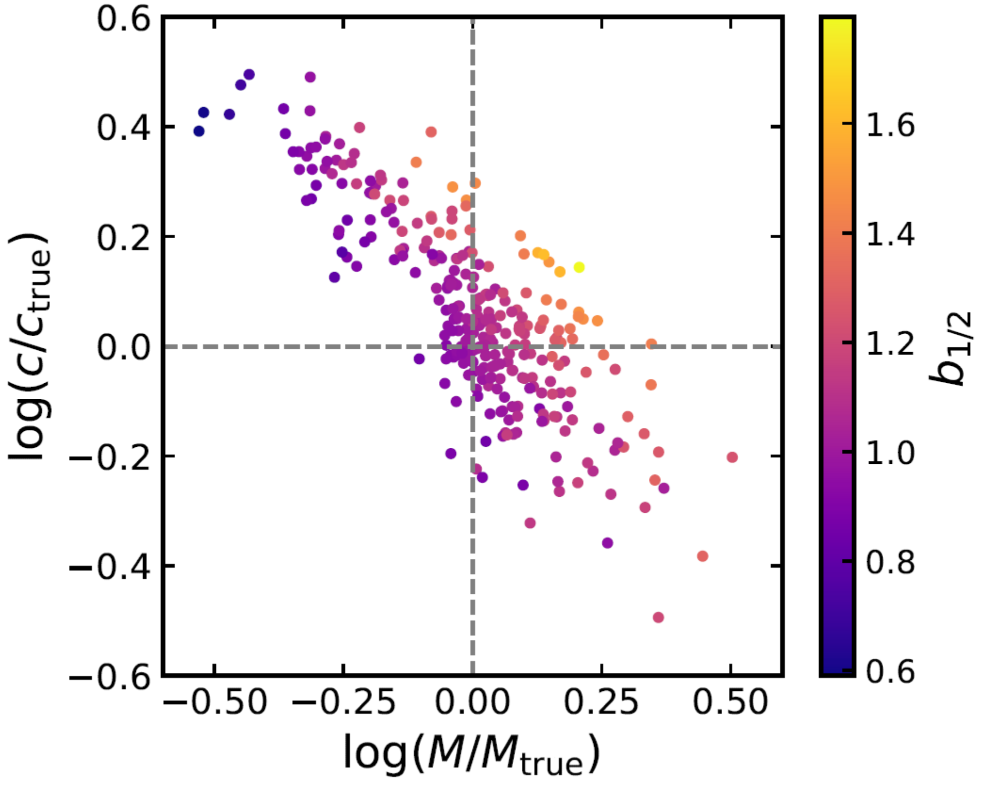


By: Hao Yang

Summary

- It is difficult to get good constraints on the inner density slopes for individual dwarf systems due to deviations from steady states.
- Global contraction – under estimates in inner density
  Global expansion – over estimates in inner density
- Total mass within the half-mass radius of tracers can be constrained the best.
- Using ensemble averaged results over a large sample of steady-state systems is a secure approach to constrain inner density profiles of dwarf galaxies.
- Global contractions are possible to be detected for nearby systems.
- Binary orbital motions can deflate the dynamically constrained inner densities.

How to get precise constraints on inner slopes?



Li et al. 2022

The effect of binaries