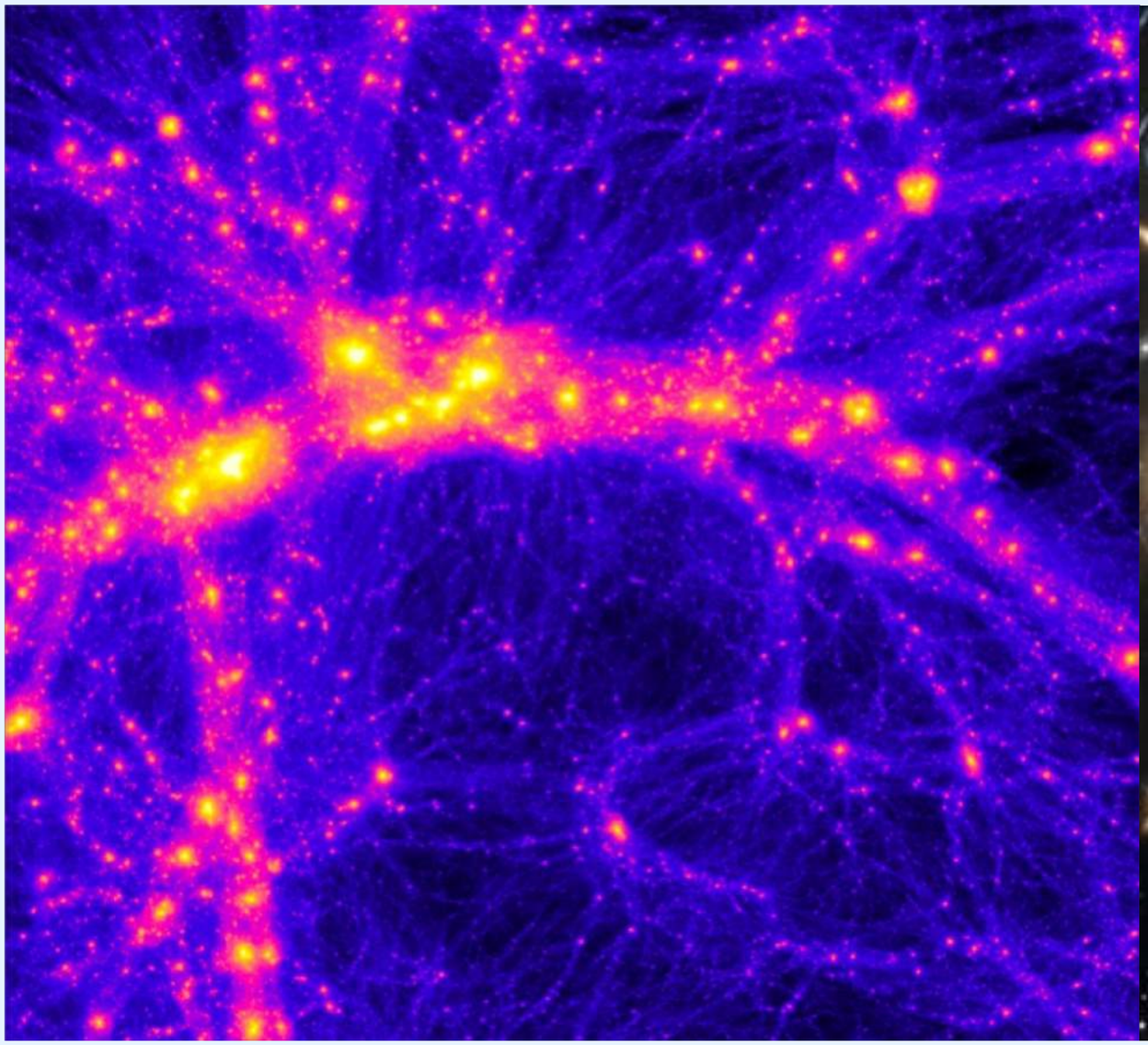
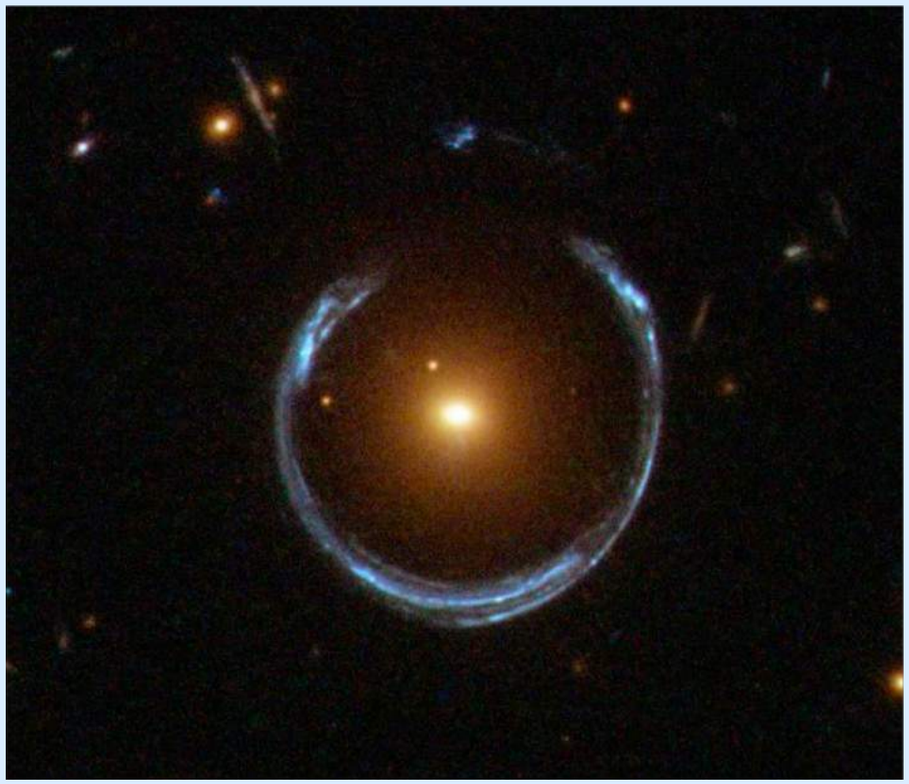
Shapes and Intrinsic Alignments of Star-Forming Gas in EAGLE



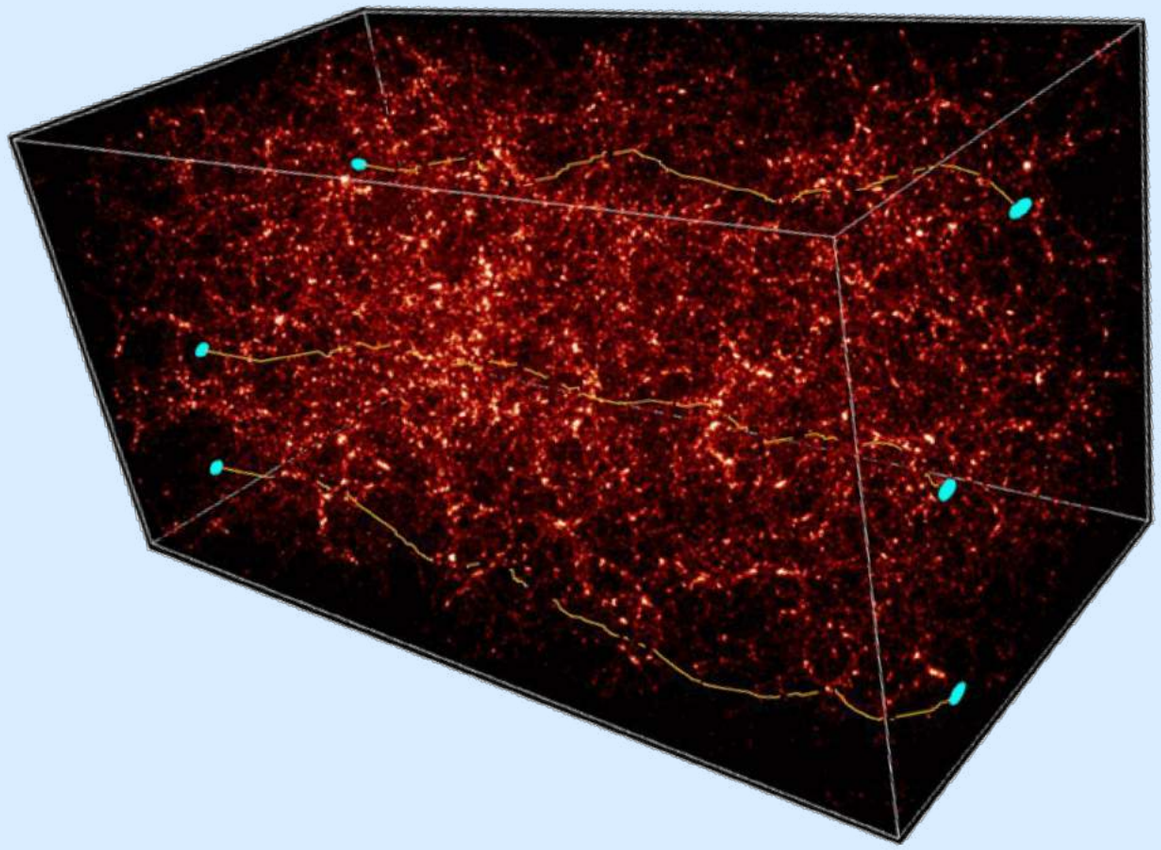
Alex Hill
with Rob Crain and Ian McCarthy

Gravitational Lensing

Gravitational lensing can be used to probe the distribution of dark matter on the largest scales



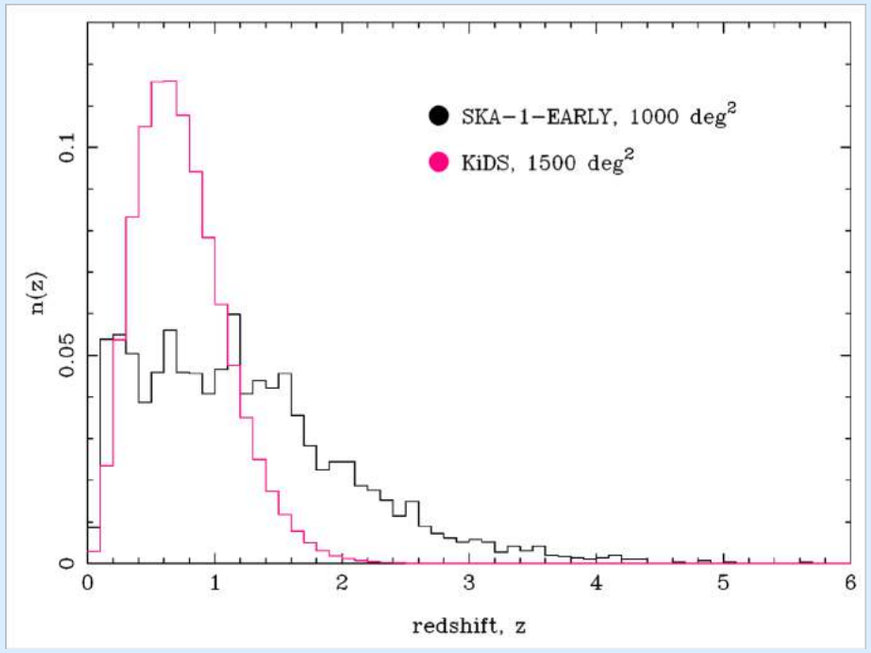
Strong Lensing



Weak Lensing

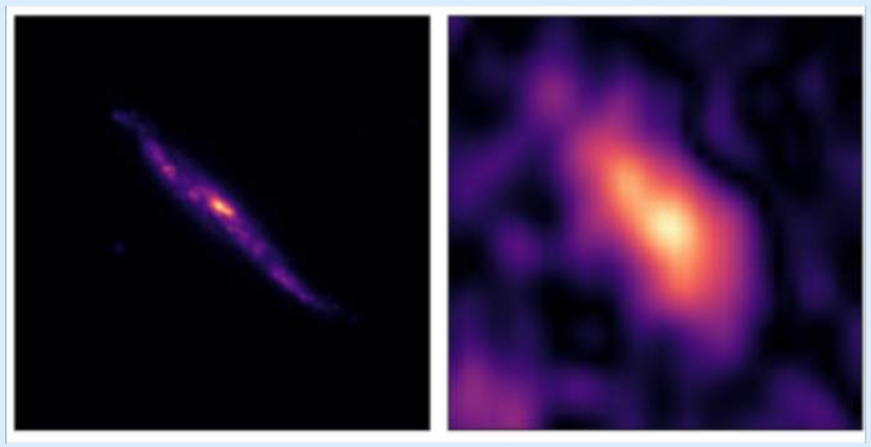
Radio Continuum Observations with the Square Kilometer Array

- Potential to reach a higher characteristic redshift than optical counterparts, with a commensurate number density over larger sky area
- Correlation with optical lensing measurements removes systematics
- Velocity and polarization maps of galaxies can mitigate against the IA effect
- Requires understanding of expected morphologies and alignments!



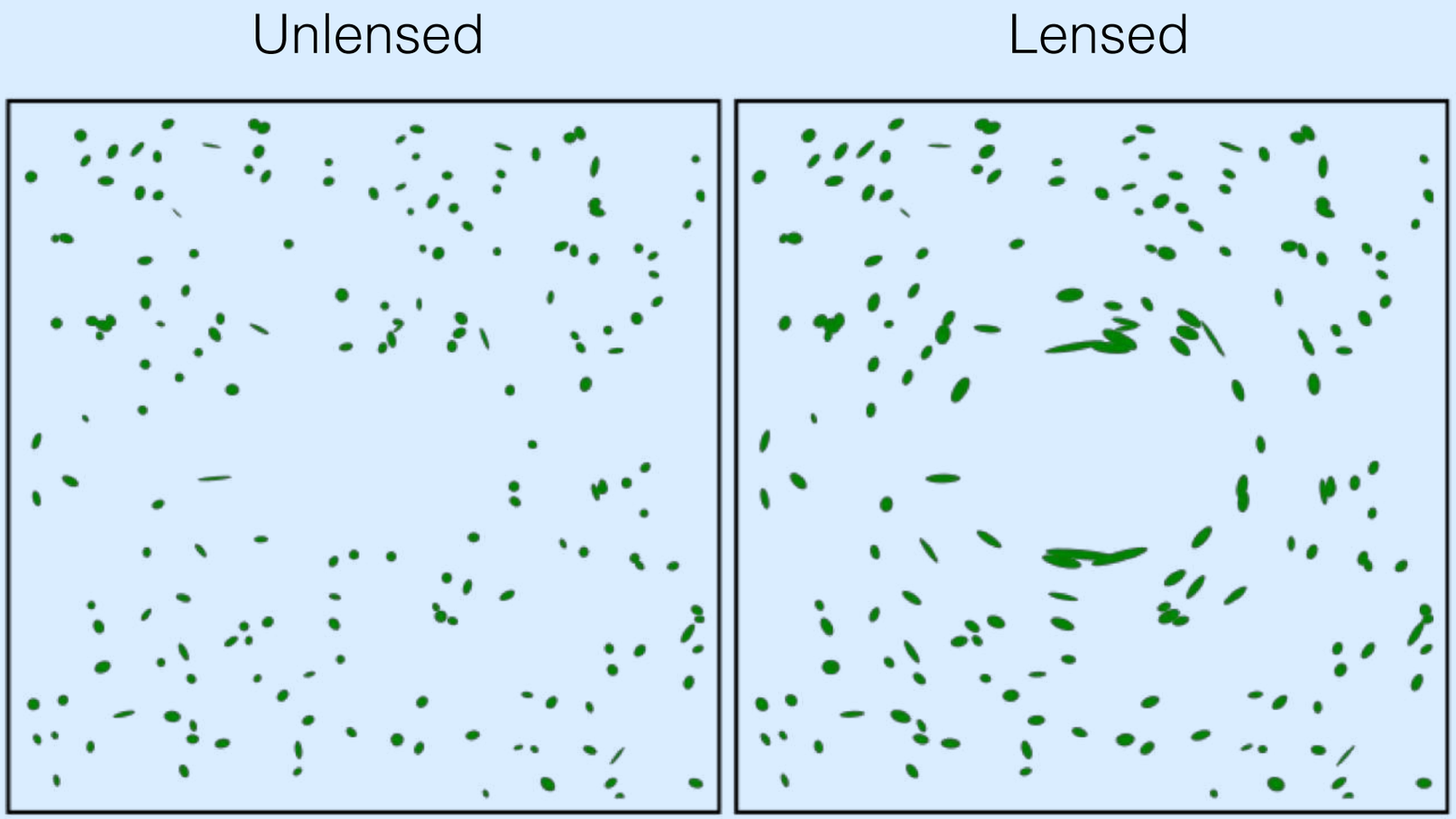
Brown+ 2015

Optical (HST) Radio Continuum (VLA)



Tunbridge et al. 2016

Weak Lensing



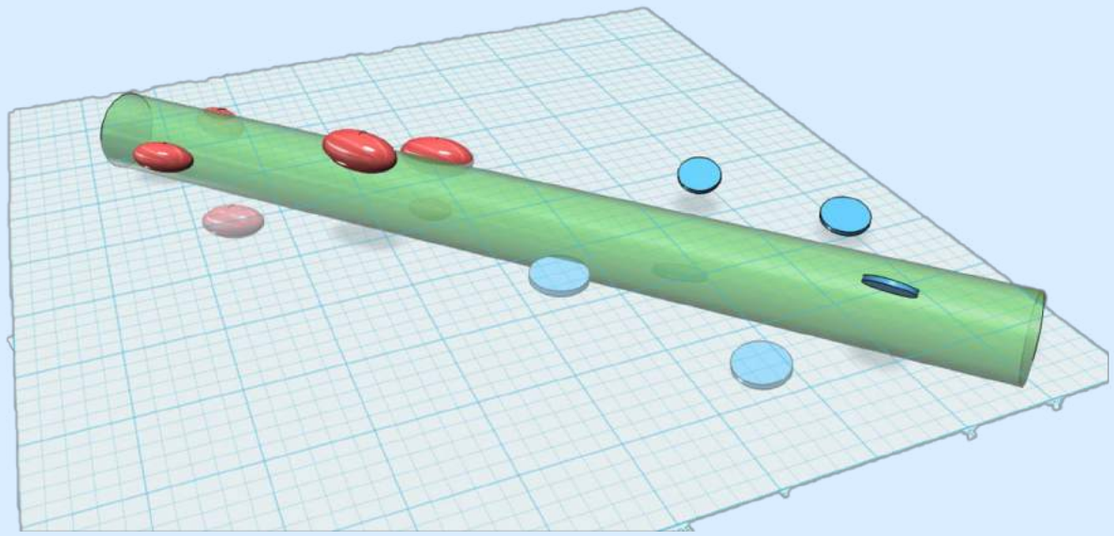
$$\vec{\epsilon} = \frac{1-\frac{b}{a}}{1+\frac{b}{a}}(\cos\varphi + \sin\varphi)$$

$$\overrightarrow{\epsilon_{\mathrm{im}}} = \overrightarrow{\epsilon_{\mathrm{sus}}} + \vec{\gamma}$$

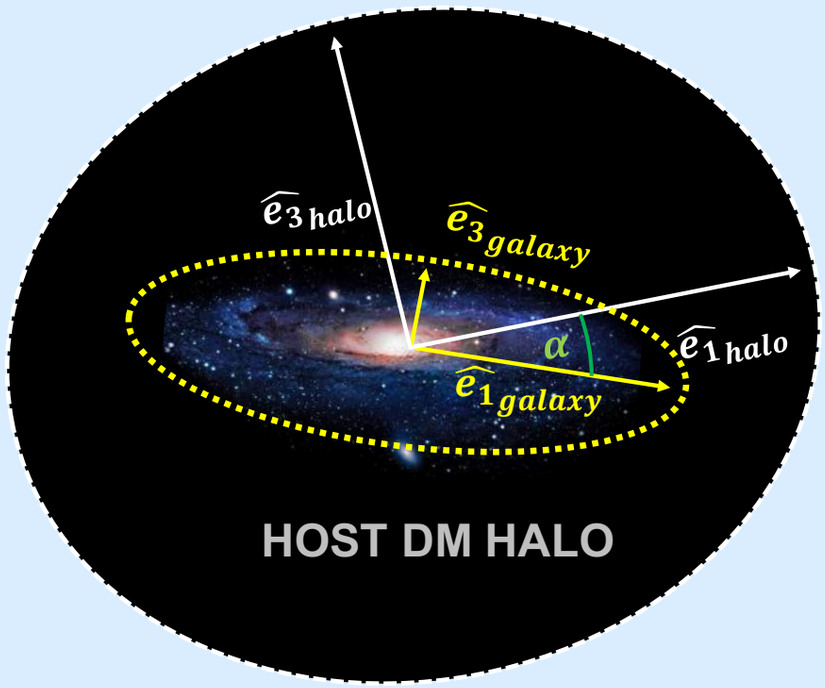
$$< \overrightarrow{\epsilon_{\mathrm{im}}} > \approx < \vec{\gamma} >$$

But…

Need for Theoretical Understanding



Galaxies are preferentially aligned with their neighbours (INTRINSIC ALIGNMENTS)



Galaxies are not perfect tracers of host dark matter haloes (GALAXY-HALO ALIGNMENTS)

Previous Work

The alignment and shape of dark matter, stellar, and hot gas distributions in the EAGLE and cosmo-OWLS simulations

Marco Velliscig,[1⋆] Marcello Cacciato,[1] Joop Schaye,[1] Robert A. Crain,[†,1,2] Richard G. Bower,[3] Marcel P. van Daalen,[1,4,5] Claudio Dalla Vecchia,[6,7] Carlos S. Frenk,[3] Michelle Furlong,[3] I. G. McCarthy,[2] Matthieu Schaller[3] and Tom Theuns[3]

Galaxy–halo alignments in the Horizon-AGN cosmological hydrodynamical simulation

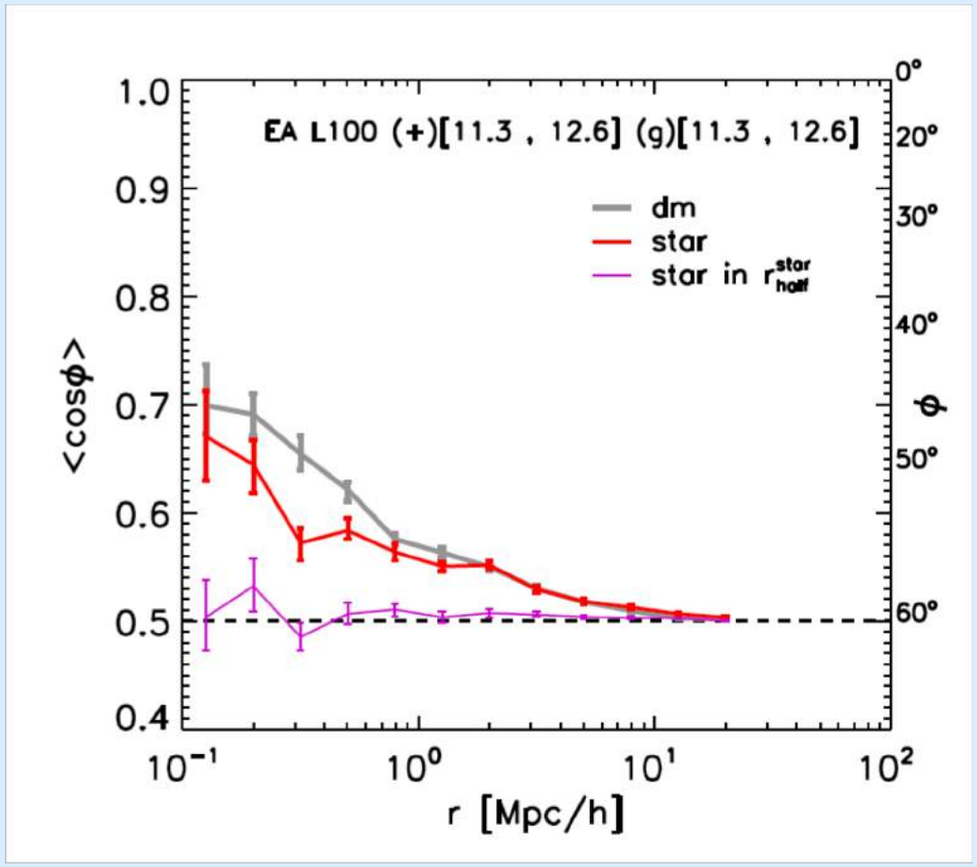
N. E. Chisari,[1⋆] N. Koukoufilippas,[2] A. Jindal,[3] S. Peirani,[4] R. S. Beckmann,[1] S. Codis,[3] J. Devriendt,[1] L. Miller,[1] Y. Dubois,[4] C. Laigle,[1] A. Slyz[1] and C. Pichon[4,5]

Galaxy shapes and intrinsic alignments in the MassiveBlack-II simulation

Ananth Tenneti,[1⋆] Rachel Mandelbaum,[1] Tiziana Di Matteo,[1] Yu Feng[1] and Nishikanta Khandai[2]

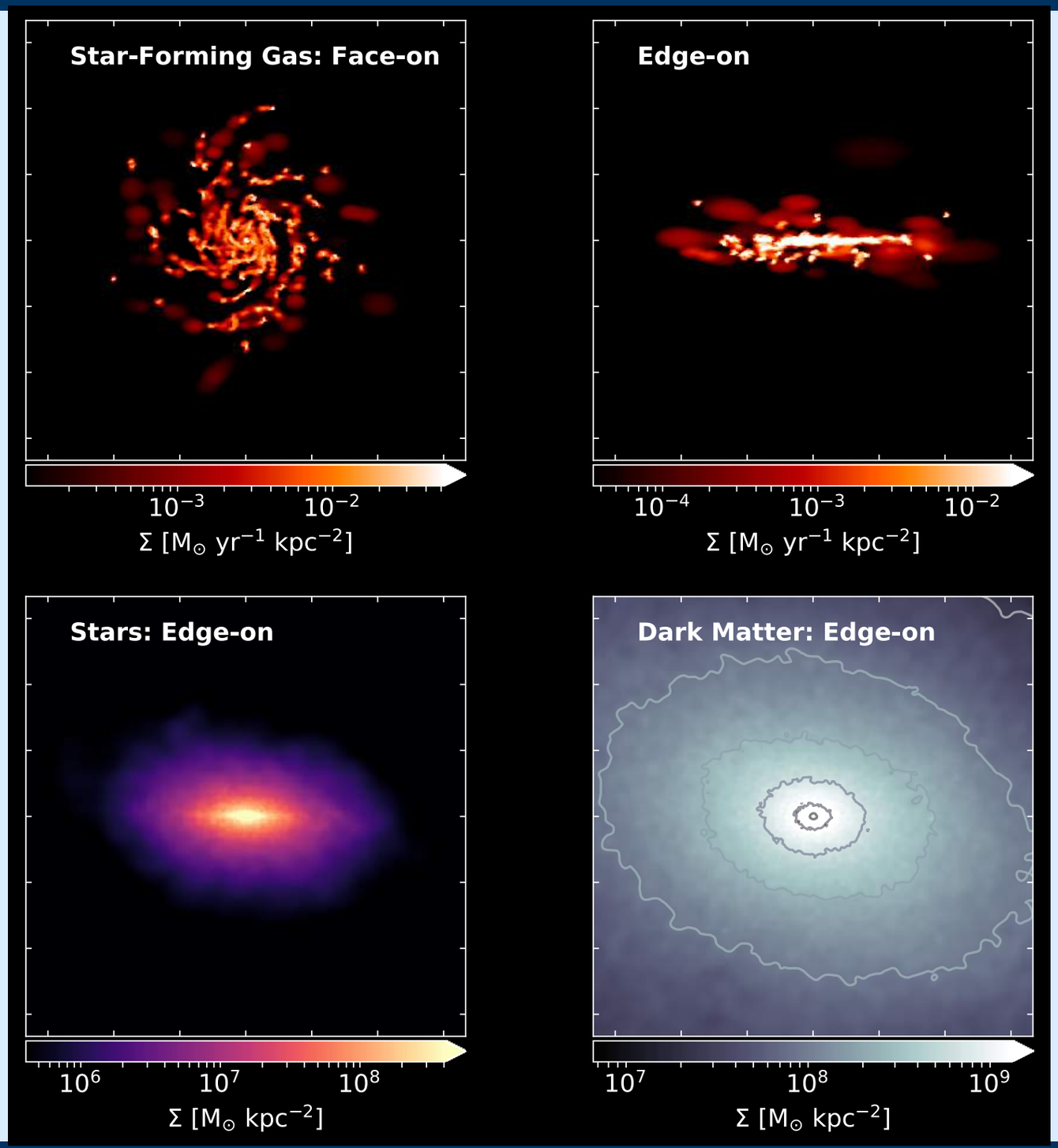
First Results from the TNG50 Simulation: The evolution of stellar and gaseous disks across cosmic time

Annalisa Pillepich[1⋆], Dylan Nelson[2], Volker Springel[2], Rüdiger Pakmor[2], Paul Torrey[3], Rainer Weinberger[4], Mark Vogelsberger[5], Federico Marinacci[5,6], Shy Genel[7], Arjen van der Wel[1,8], and Lars Hernquist[4]



Velliscig + 2015

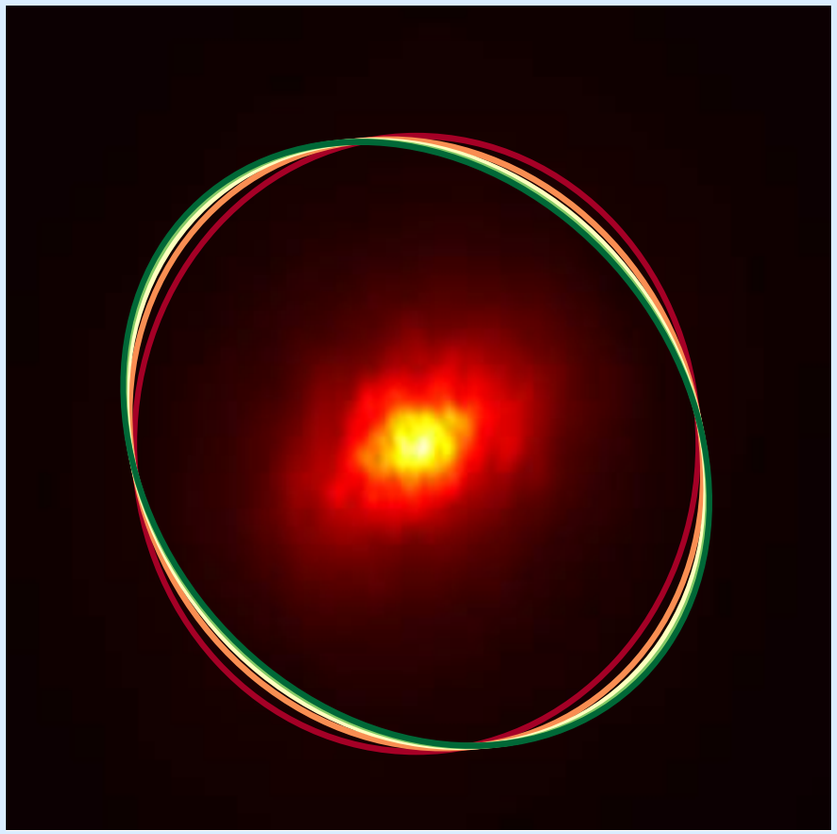
Extended Radio Continuum Emission in EAGLE

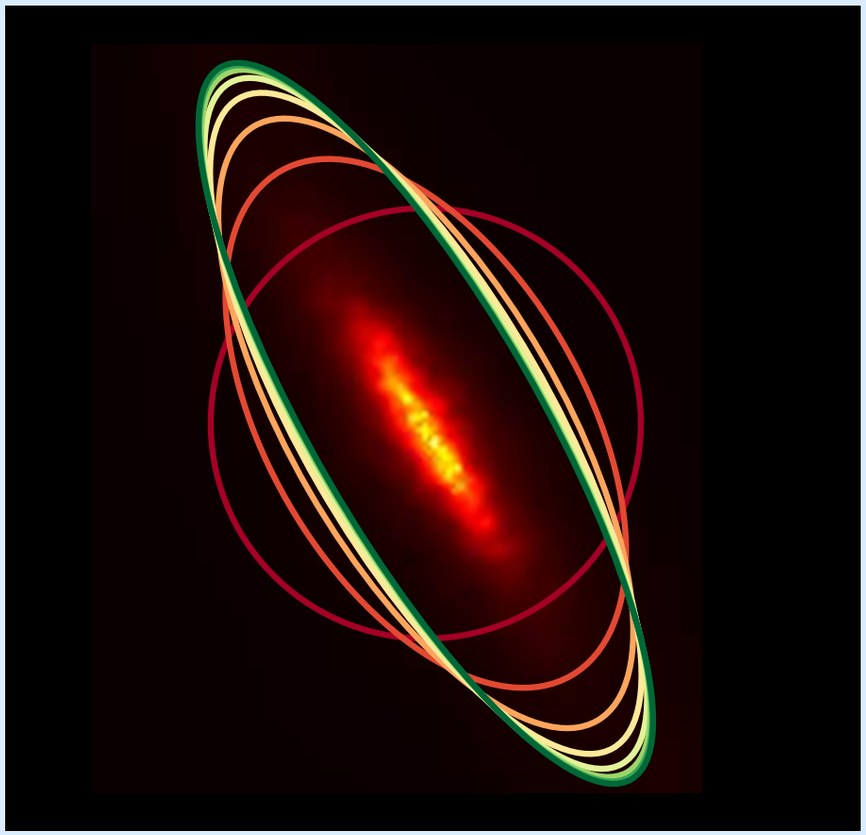


- Radio continuum emission is modelled as the star-forming gas particles
- Compute the shapes, orientations and various alignments
- Projected shapes, consequences for observations

Hill + in prep

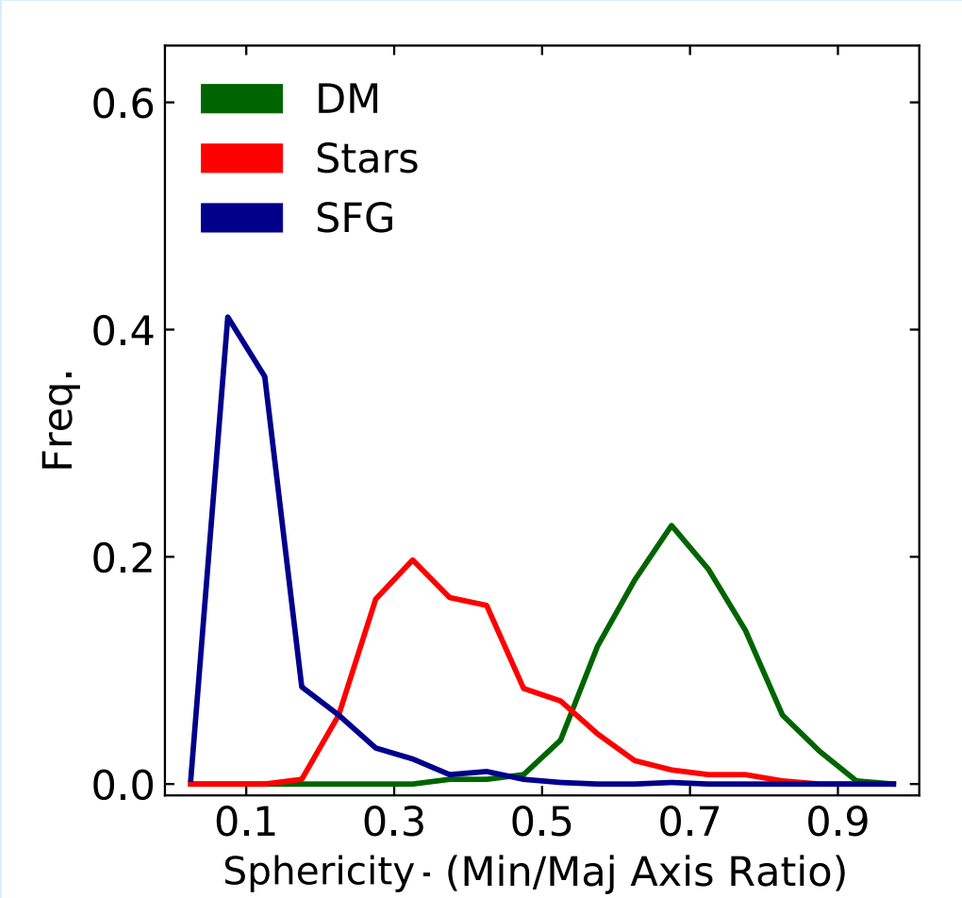
Methodology



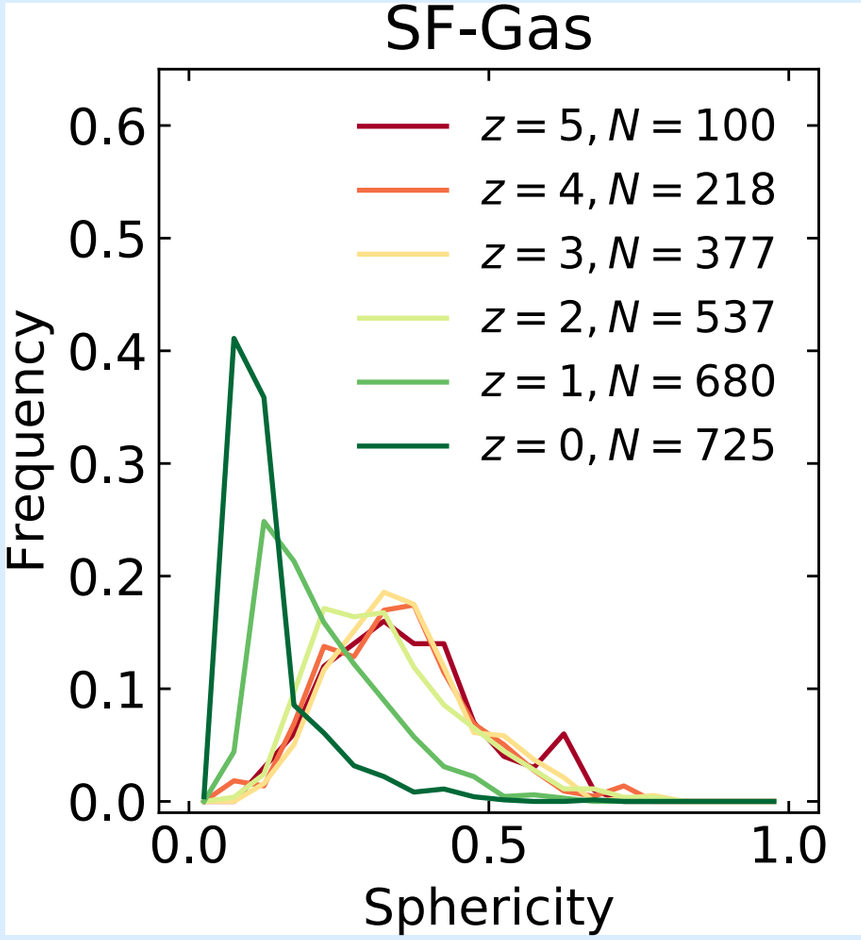


- Fit 3D ellipsoids to particle distributions
- Use the iterative reduced inertia tensor
- Constant volume criteria

3D - Morphology

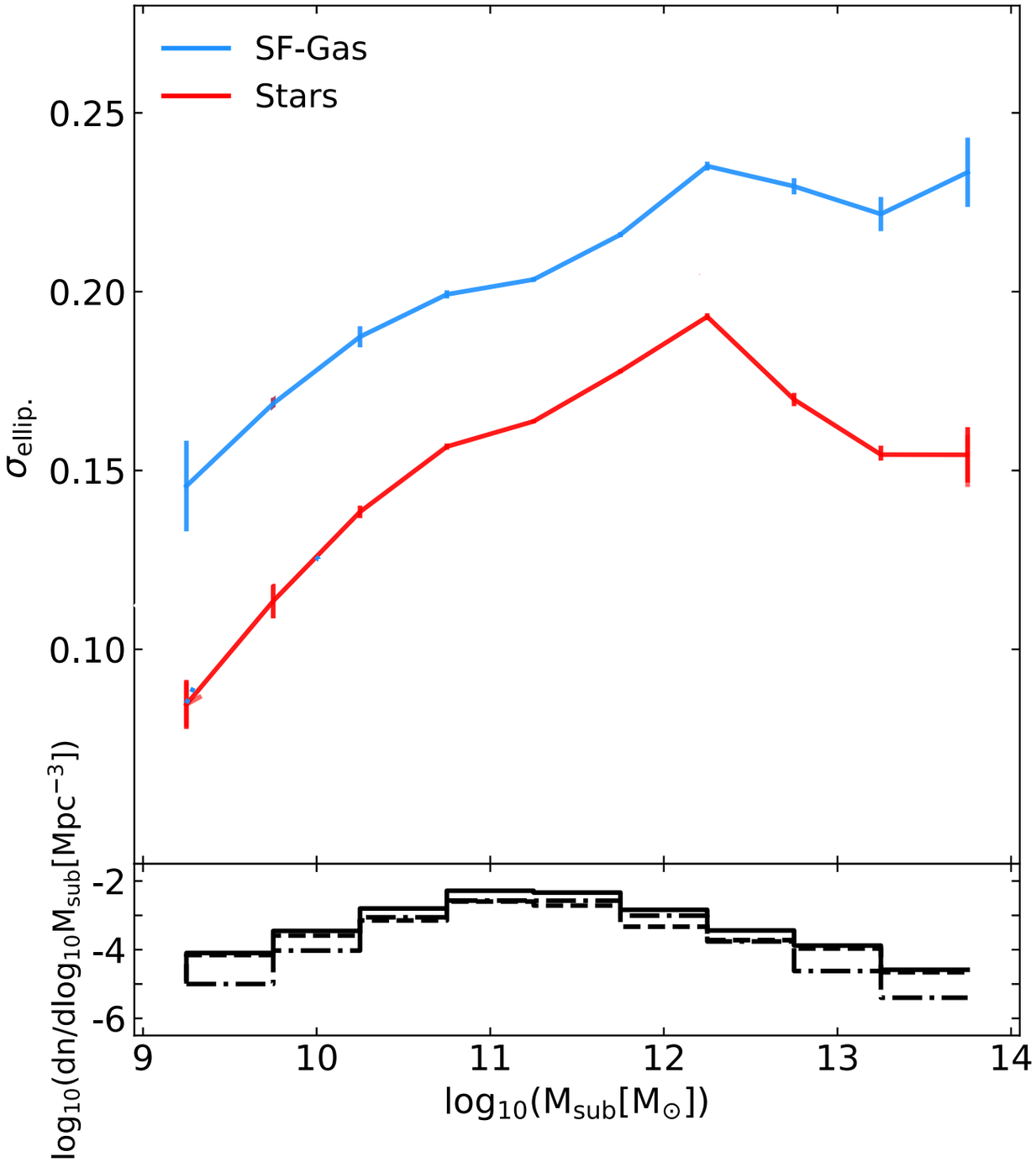


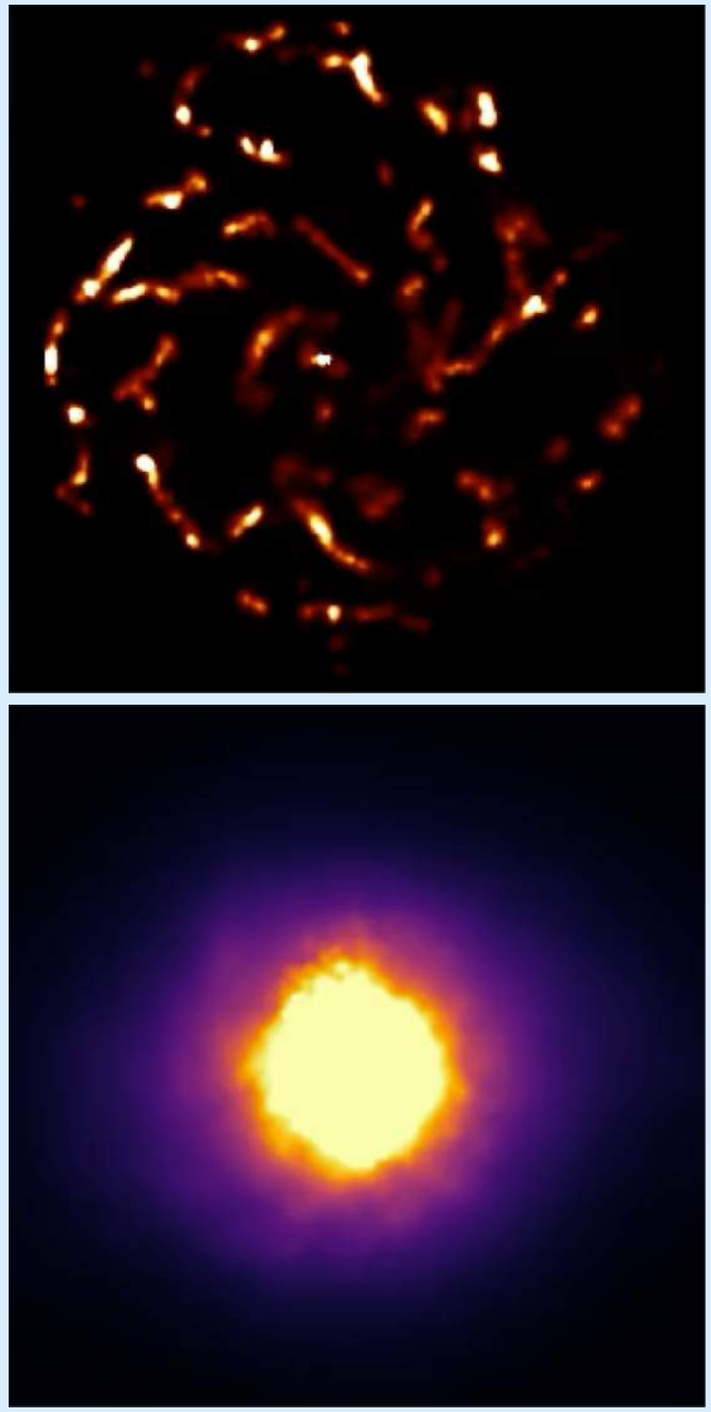
SF-gas is typically more flattened than the stars and dark matter



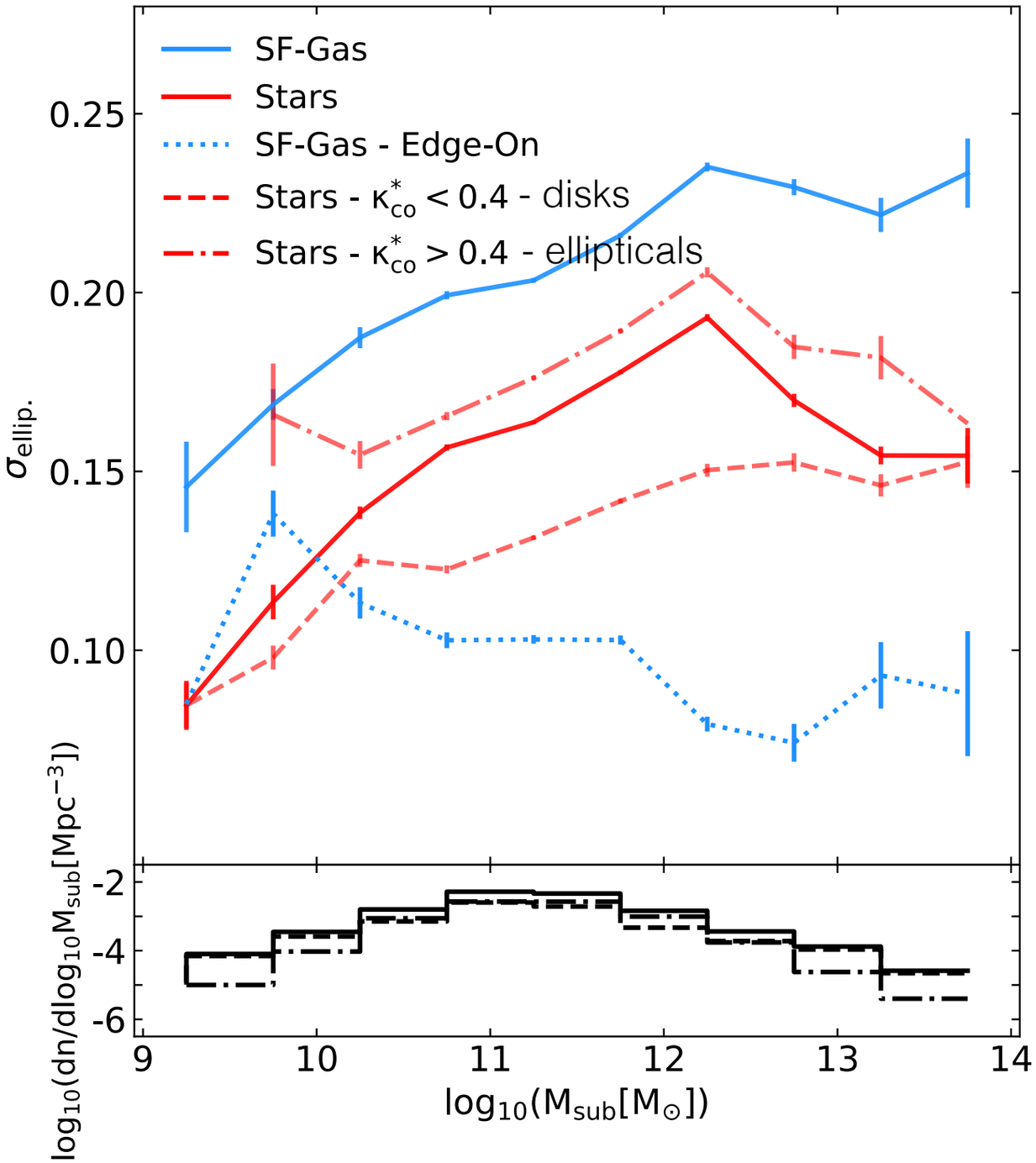
SF-gas sphericity decreases with time

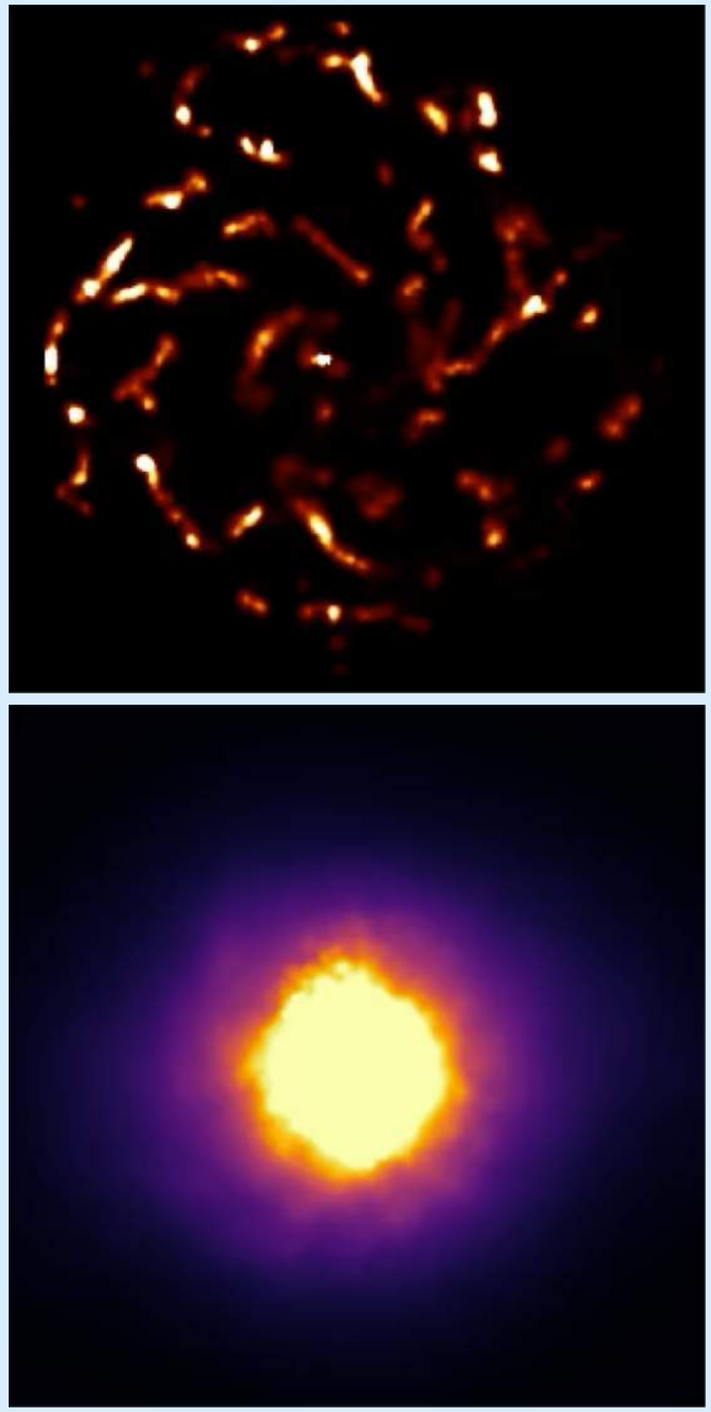
2D Observation - Projected Shapes



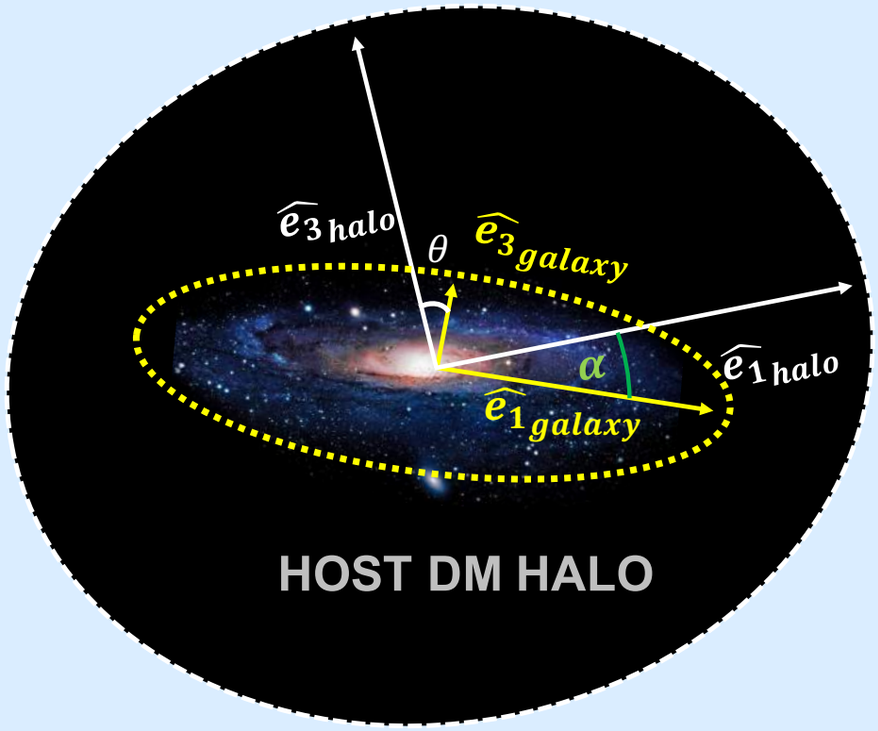


2D Observation - Projected Shapes

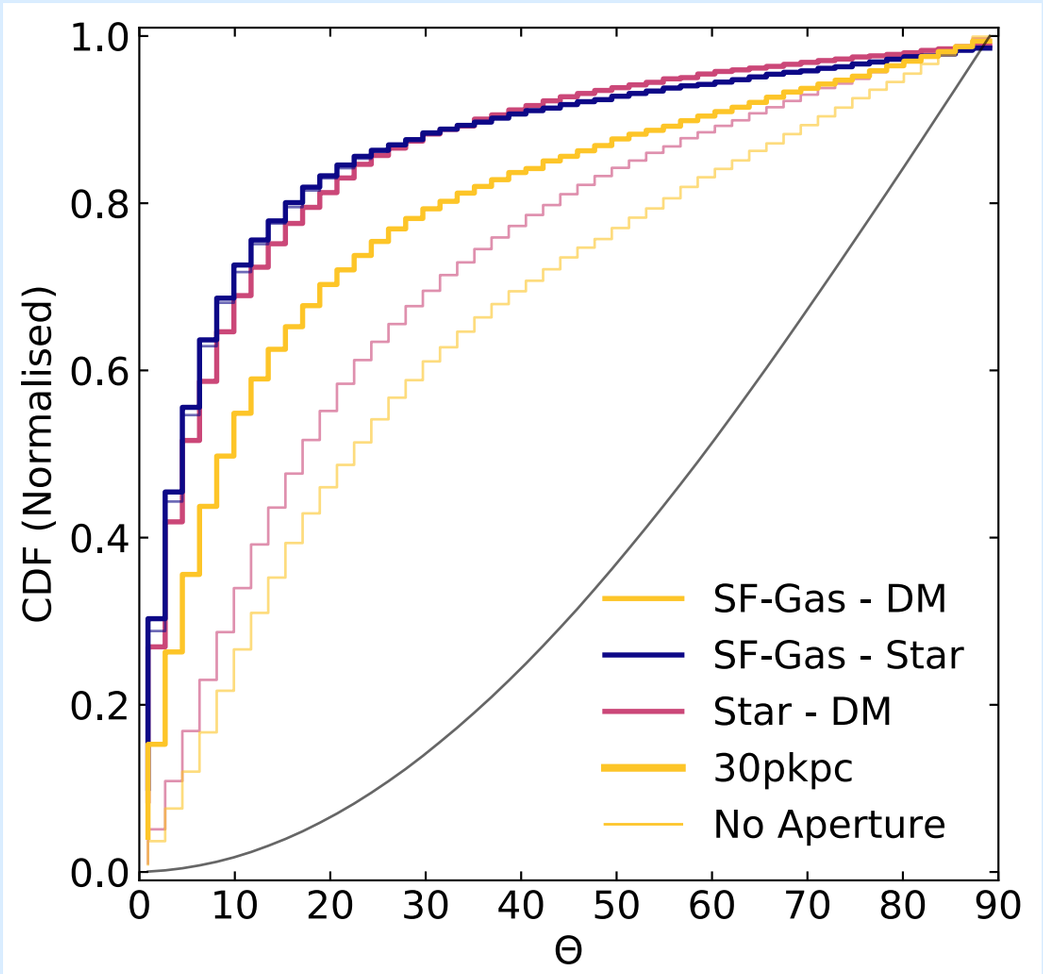




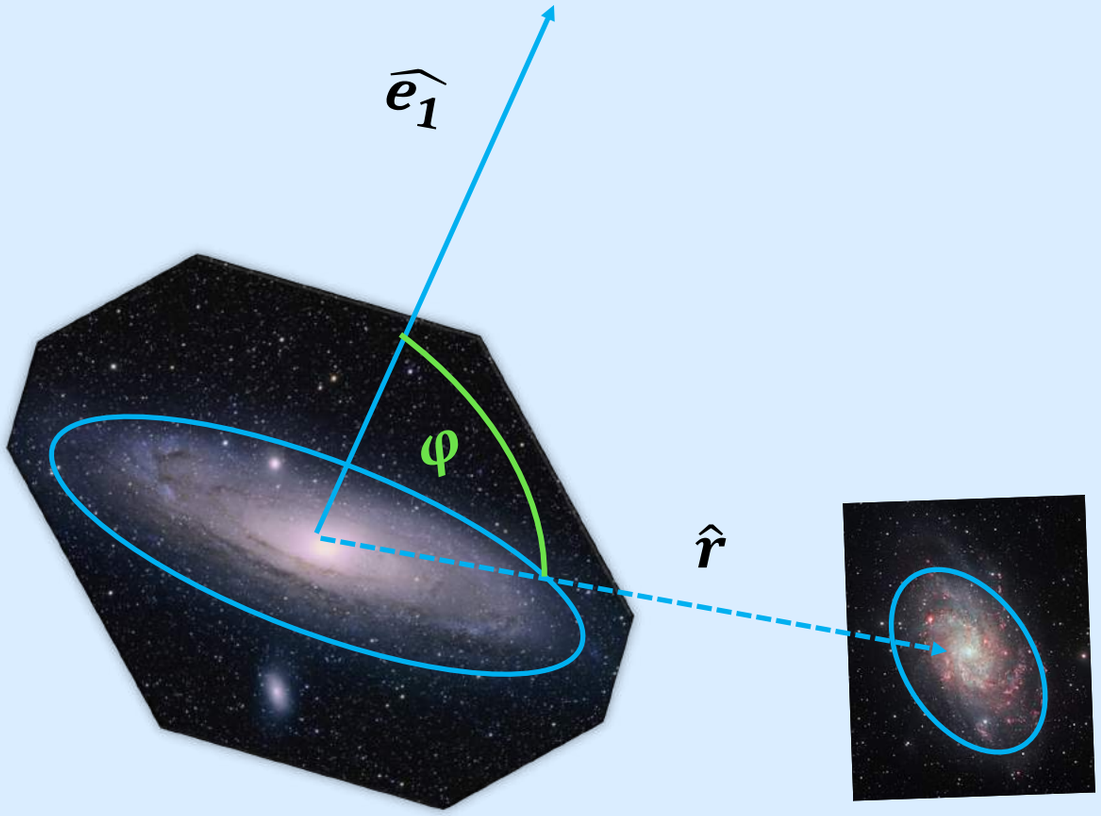
Internal Alignments

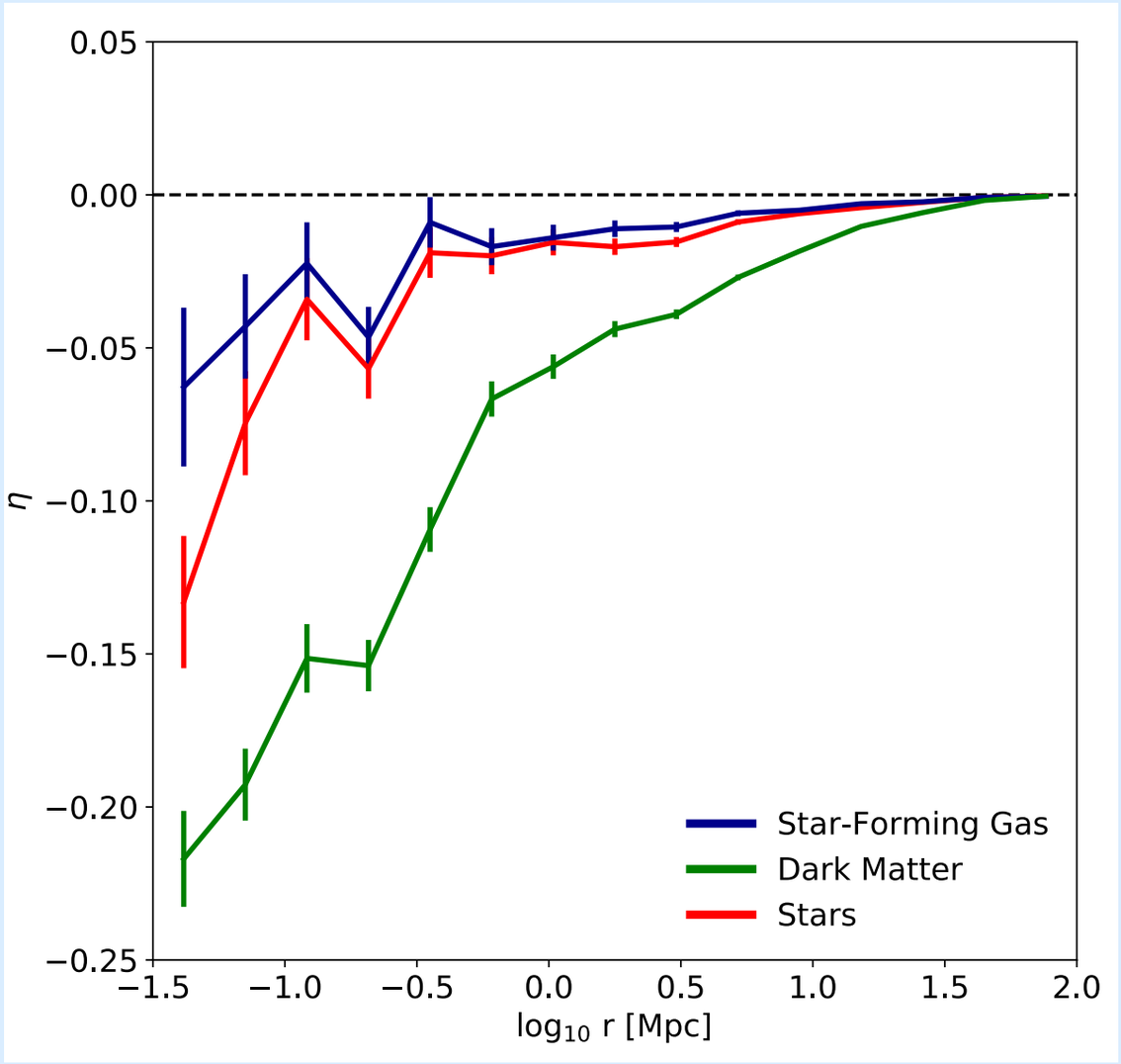


The radio continuum (star-forming gas) tends to align more weakly with the host dark matter halo than in the optical (stars)



Intrinsic Alignments

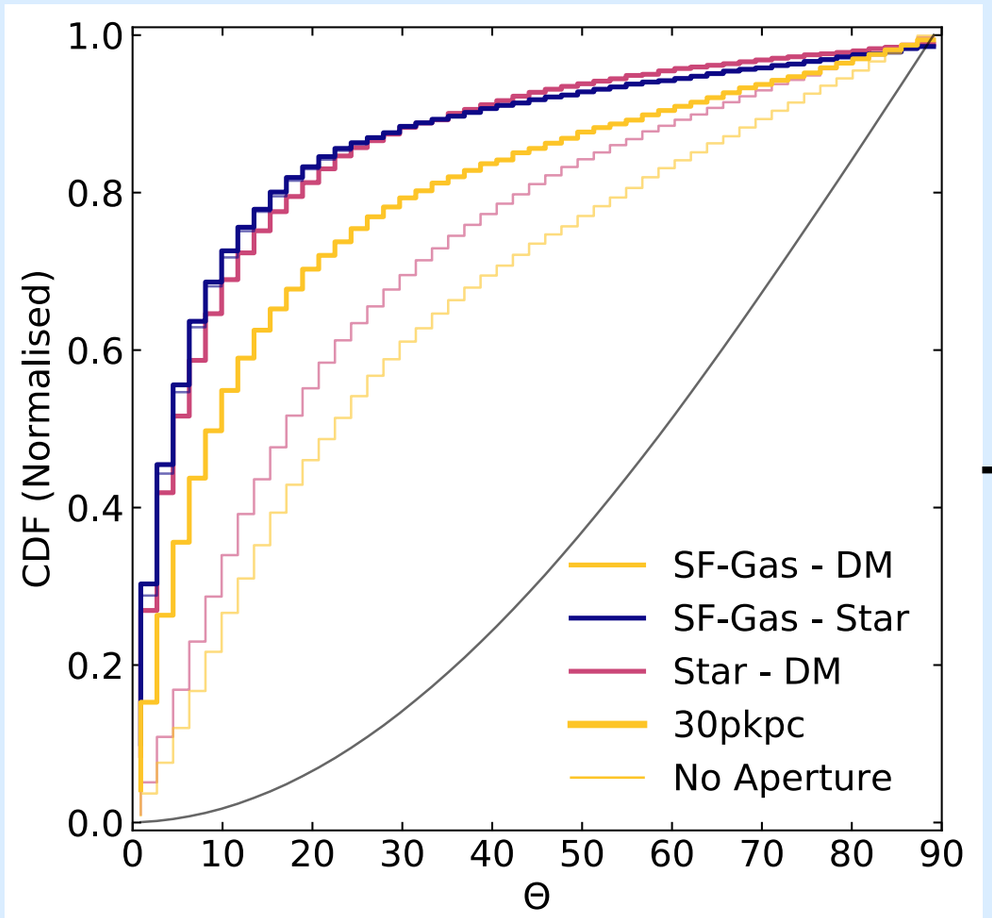


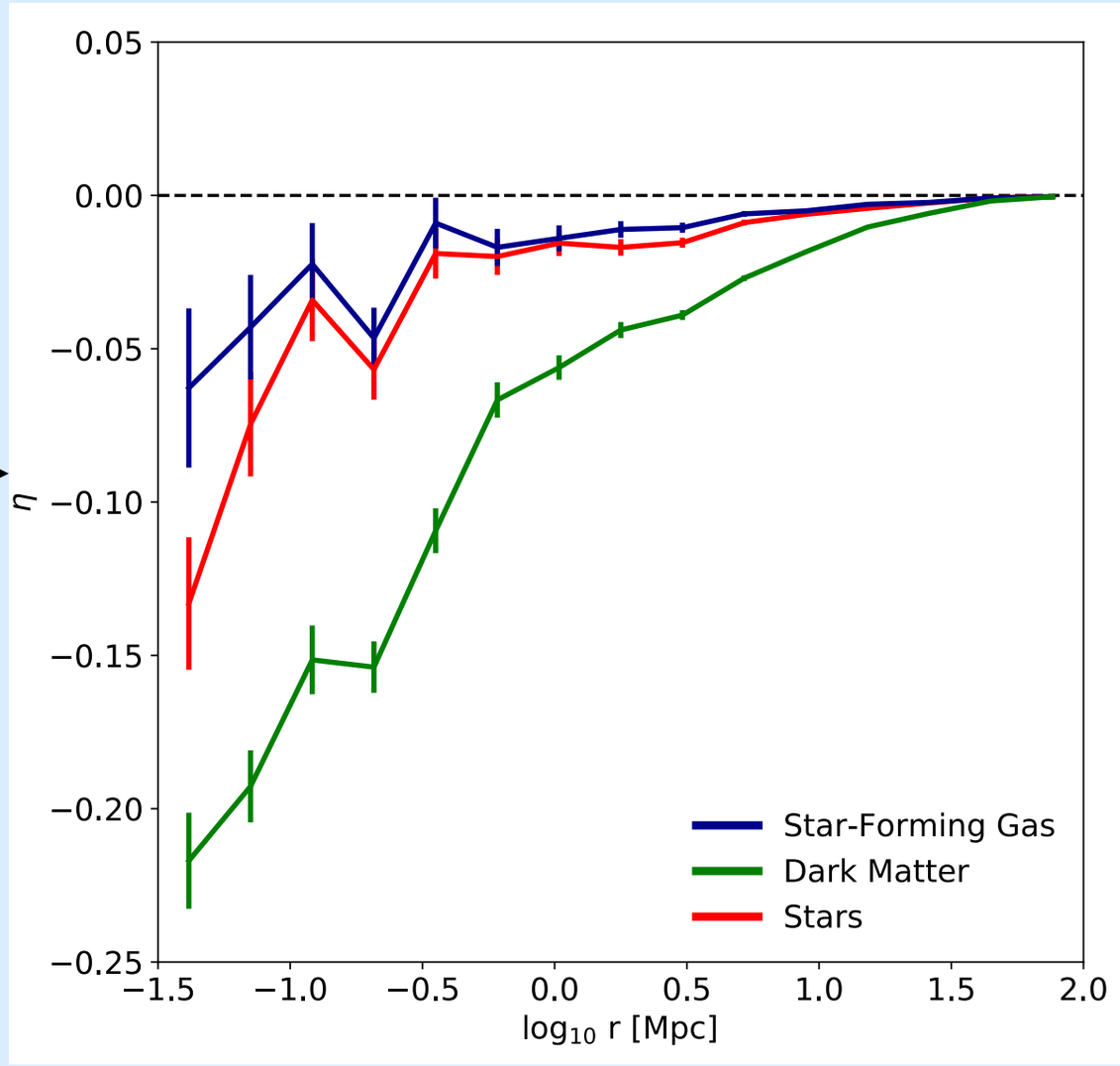


The intrinsic alignment decreases as a function of distance, and appears weaker in the radio continuum than in the optical

$$\eta_{\mathrm{OrSep}} = \langle\, |\hat{\mathbf{r}} \cdot \hat{\mathbf{e}}(\mathbf{x}+\mathbf{r})|^2 \rangle \text{ - } 1/3$$

Intrinsic Alignment Strength as a Consequence of Internal Alignments





Conclusions

- Weak lensing in the radio continuum could probe large scale structure at intermediate redshifts

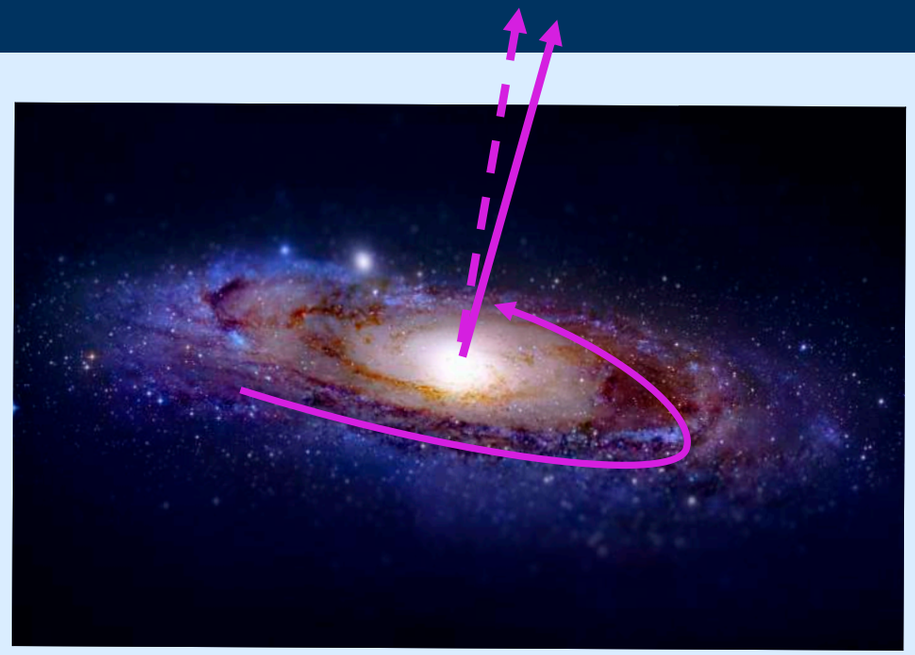
- Indications from EAGLE are that:

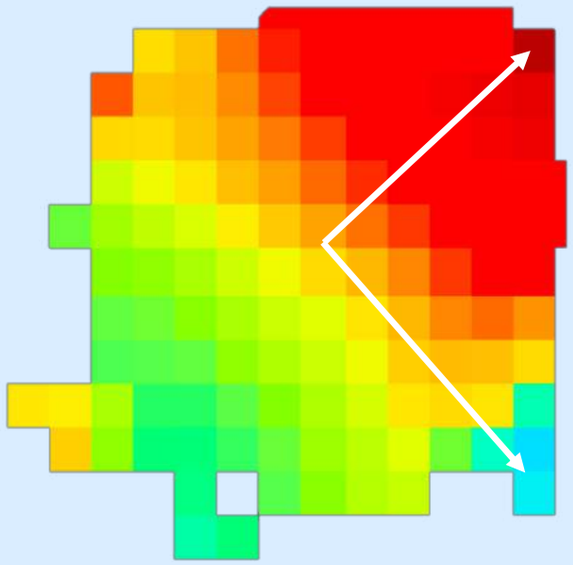
  - The star-forming gas has a higher shape noise in 2D than the stars

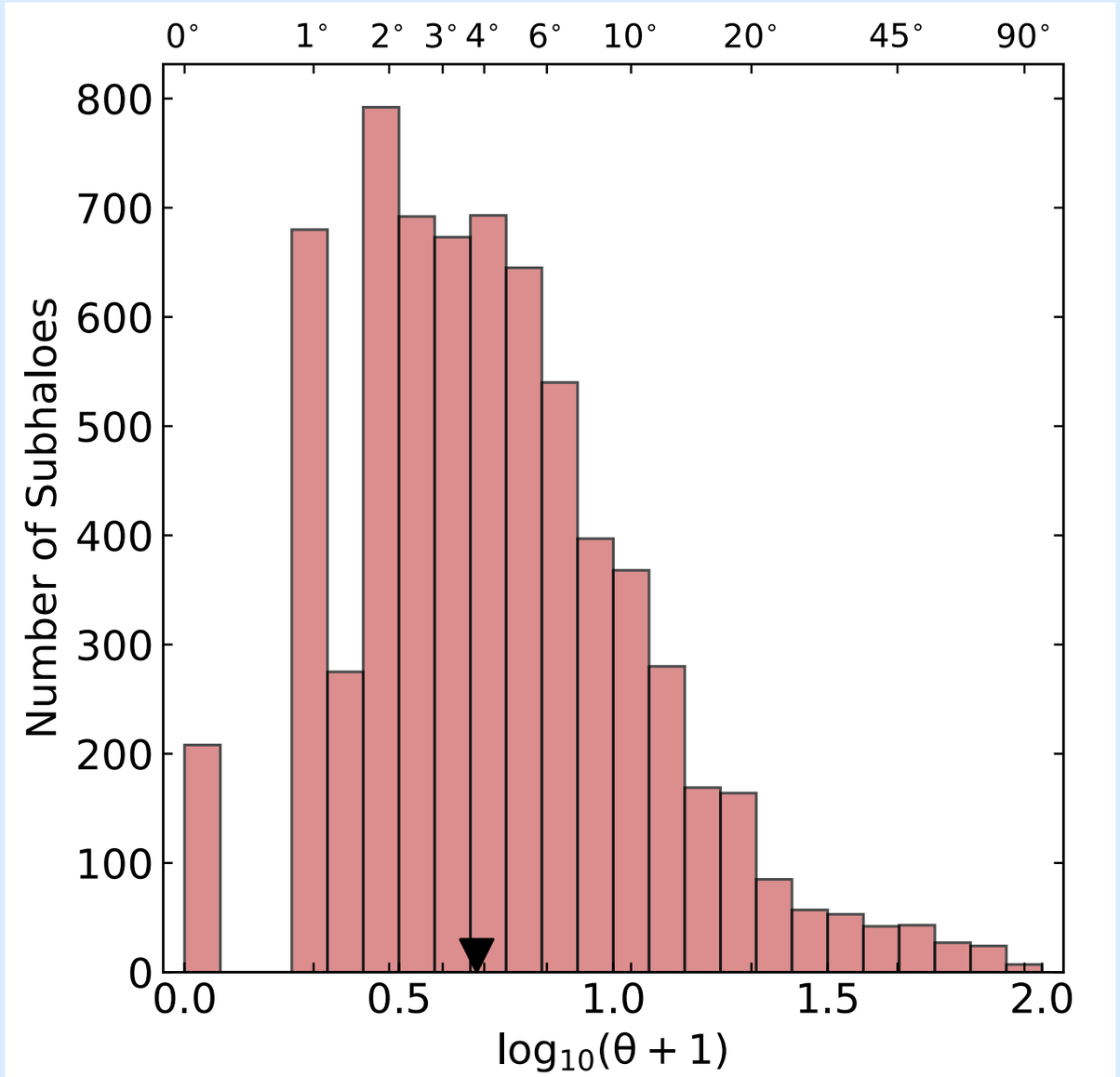
  - The star-forming gas is preferentially aligned with the host halo, though to a lesser degree than the stars

  - This likely results in a lower intrinsic alignment signal (if any exists) in neighbouring galaxies when observed in the radio continuum rather than the optical

Kinematic/Morphological Alignment

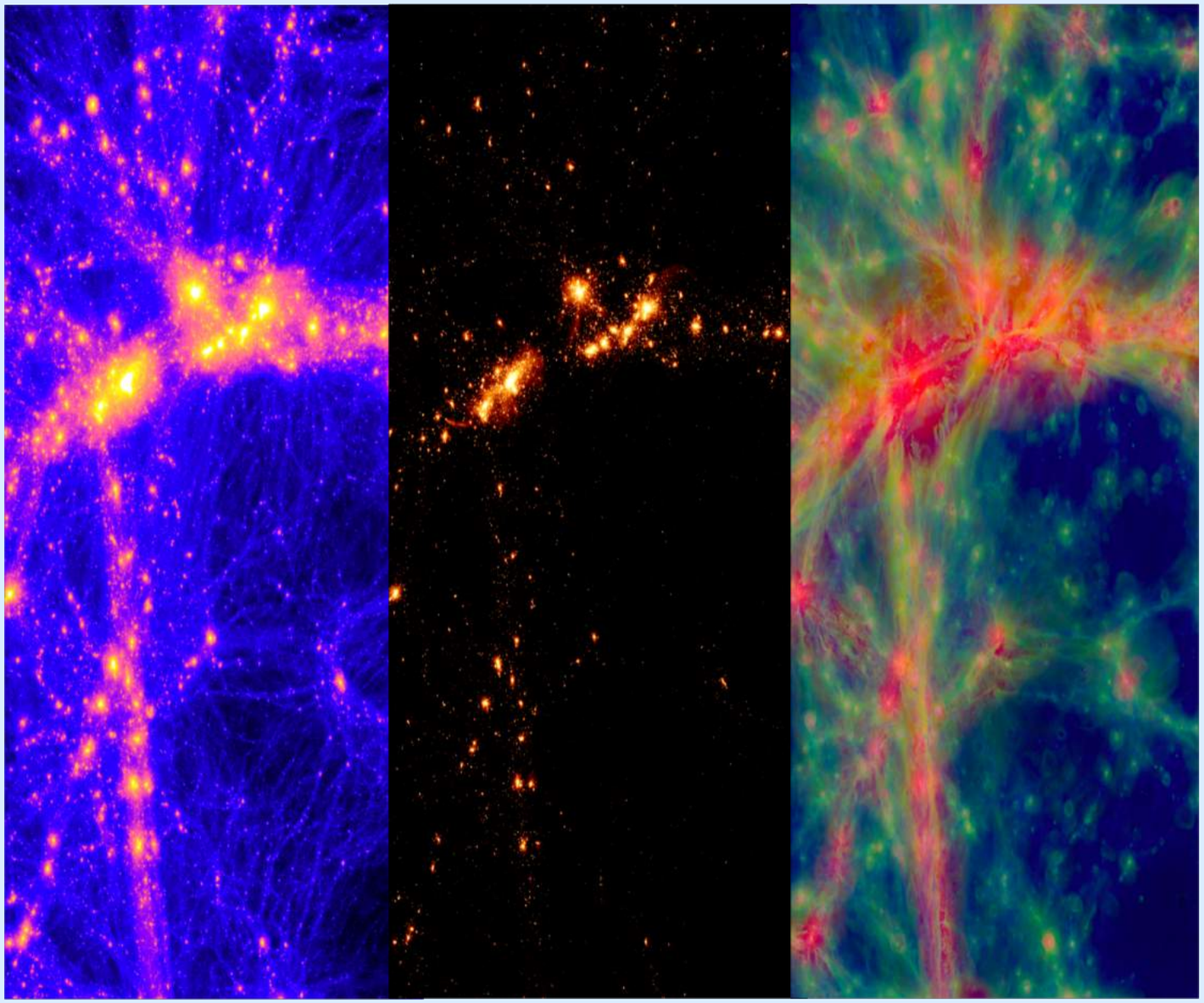




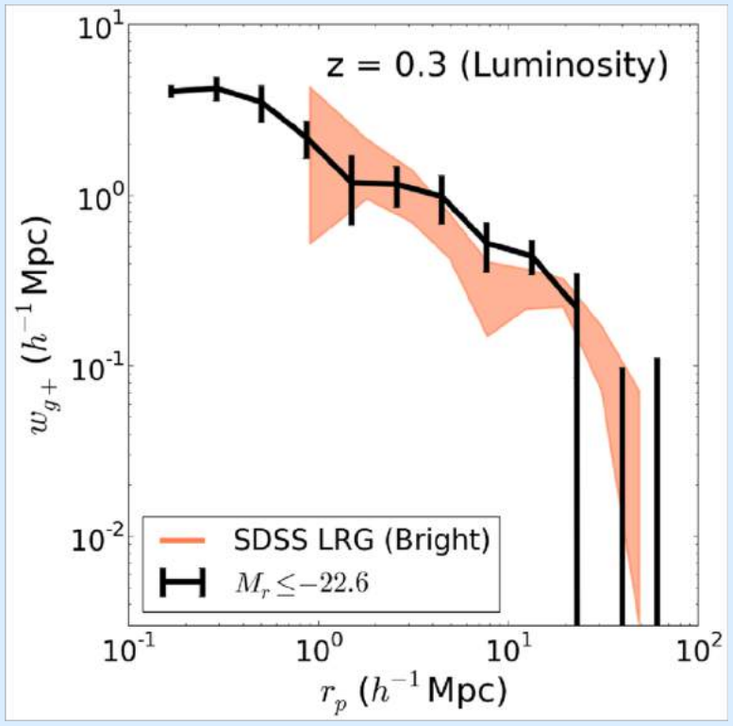


The kinematic axis of a radio emitting region is closely aligned with morphology

Simulations



- Simulations are a useful tool to investigate the astrophysical sources of observational uncertainties



Tenneti+ 2015