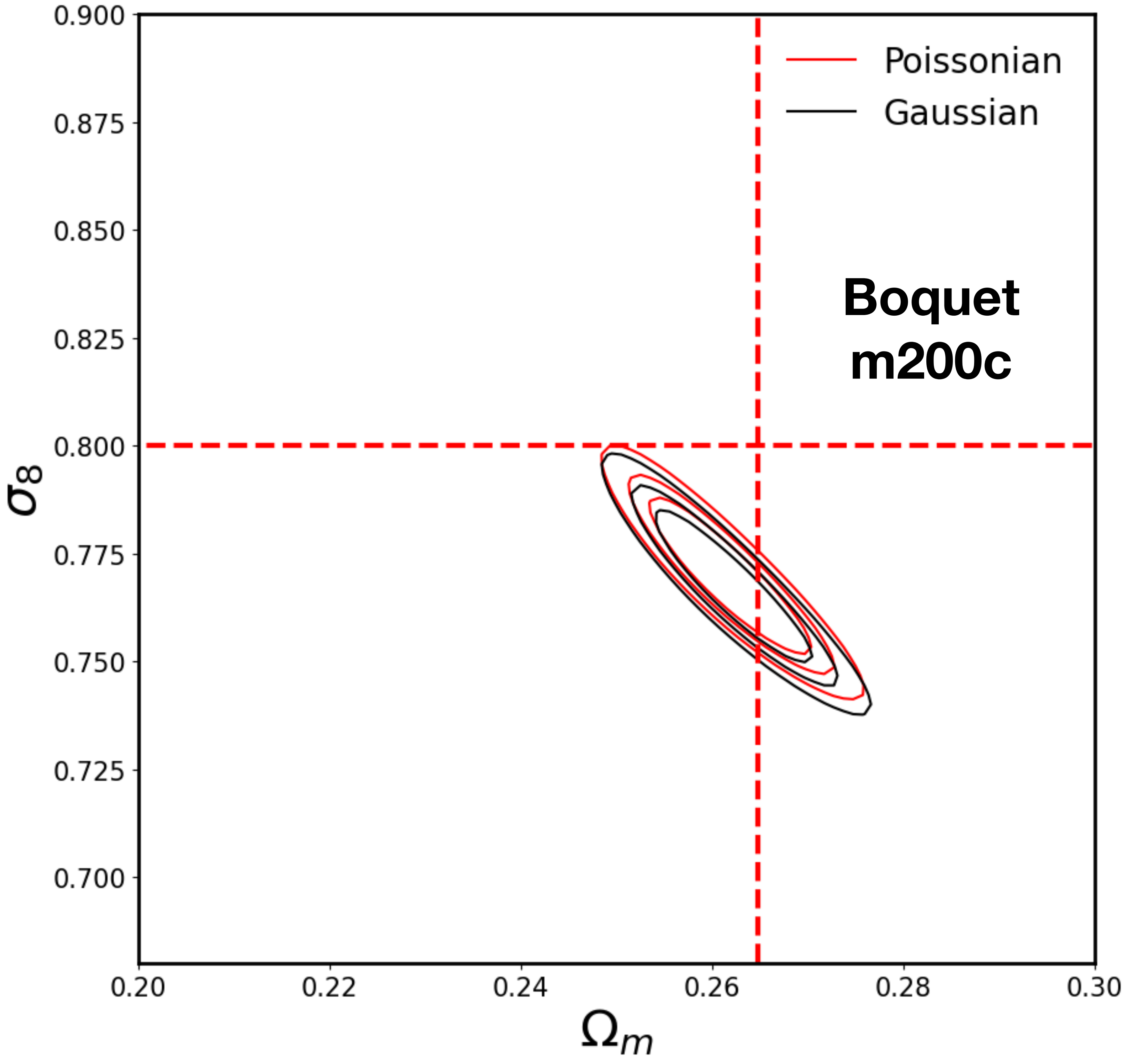
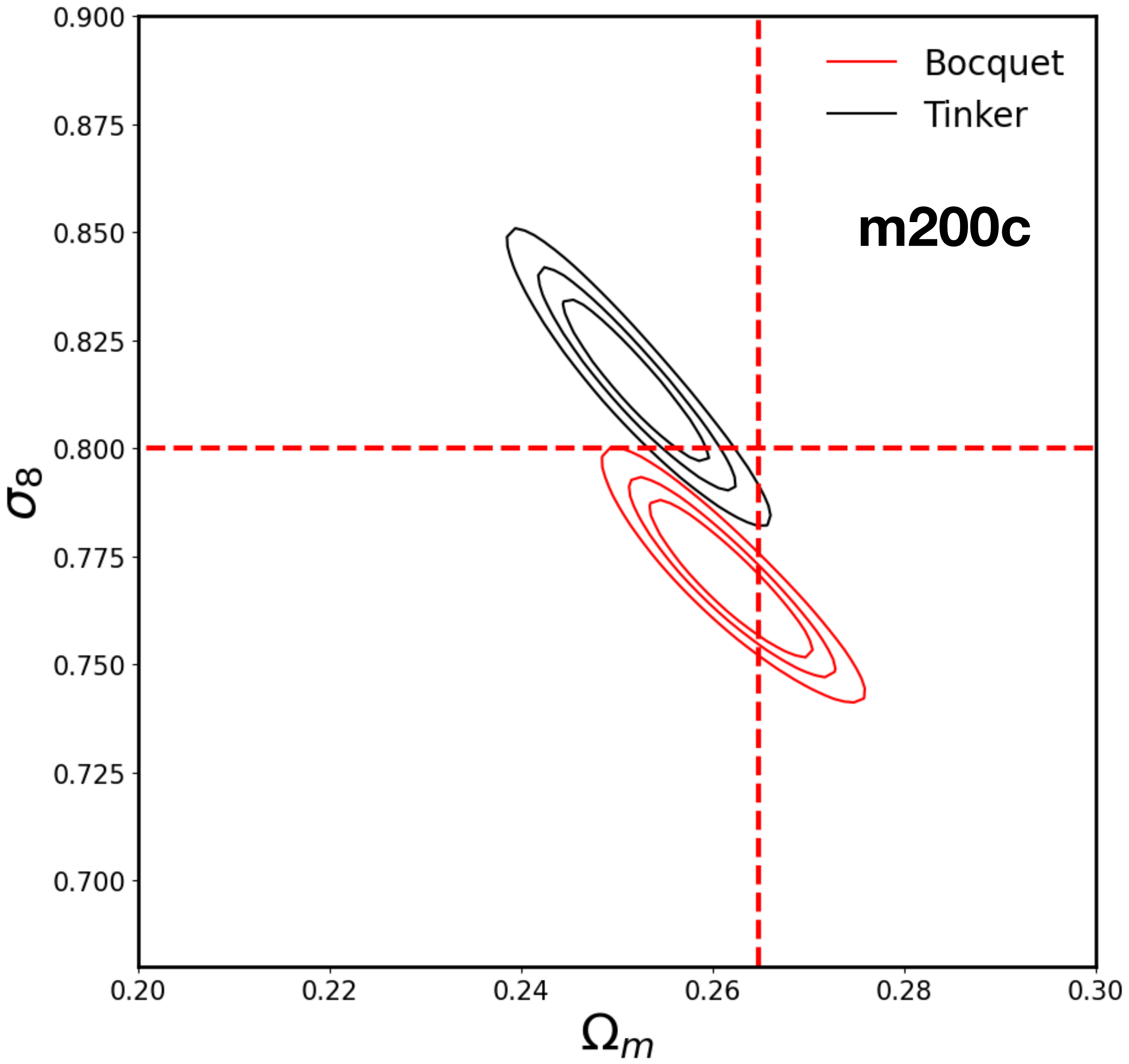
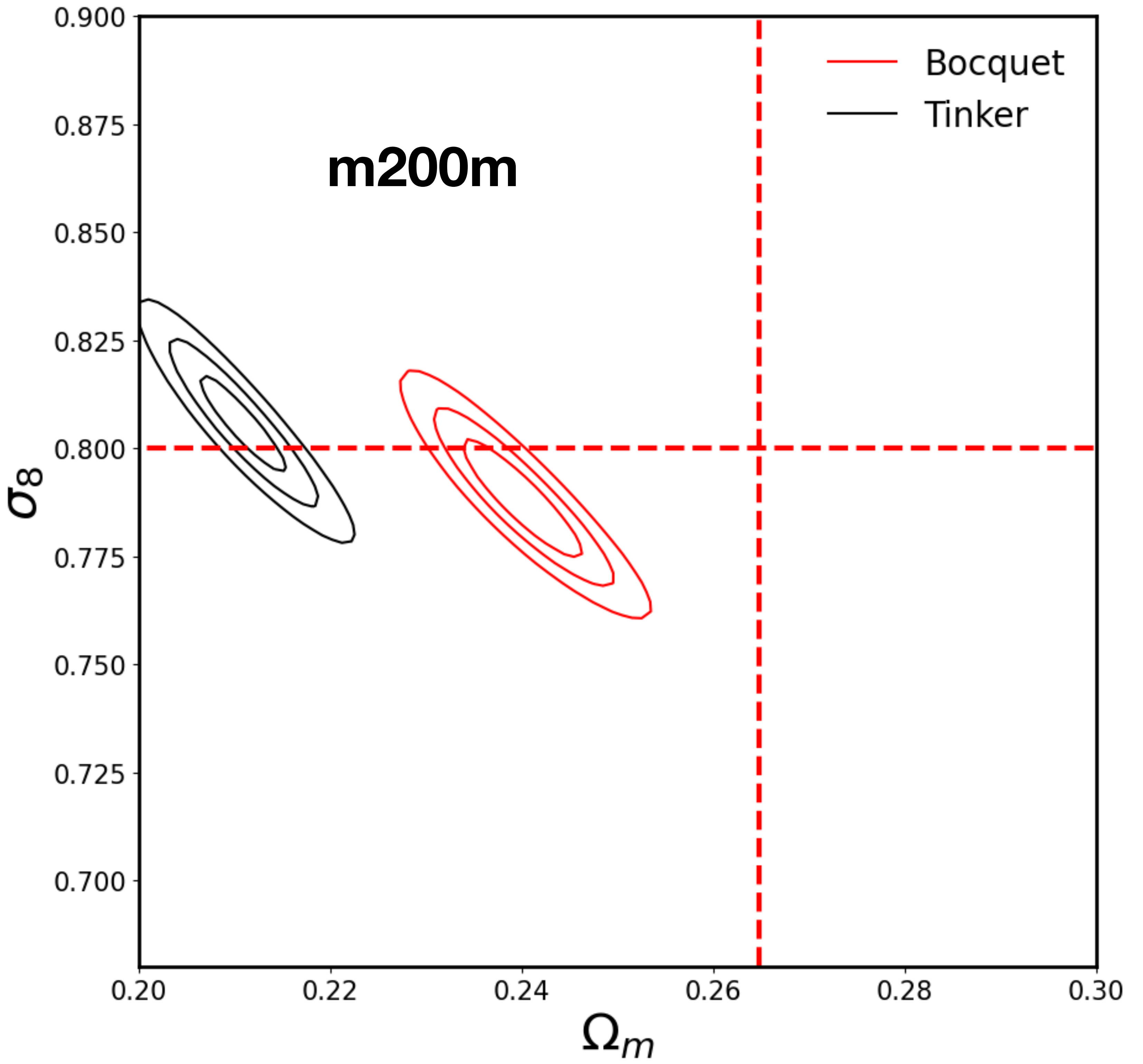
Update on mass functions

Constantin's code updated to new CCL



- High sensitivity to mass definition

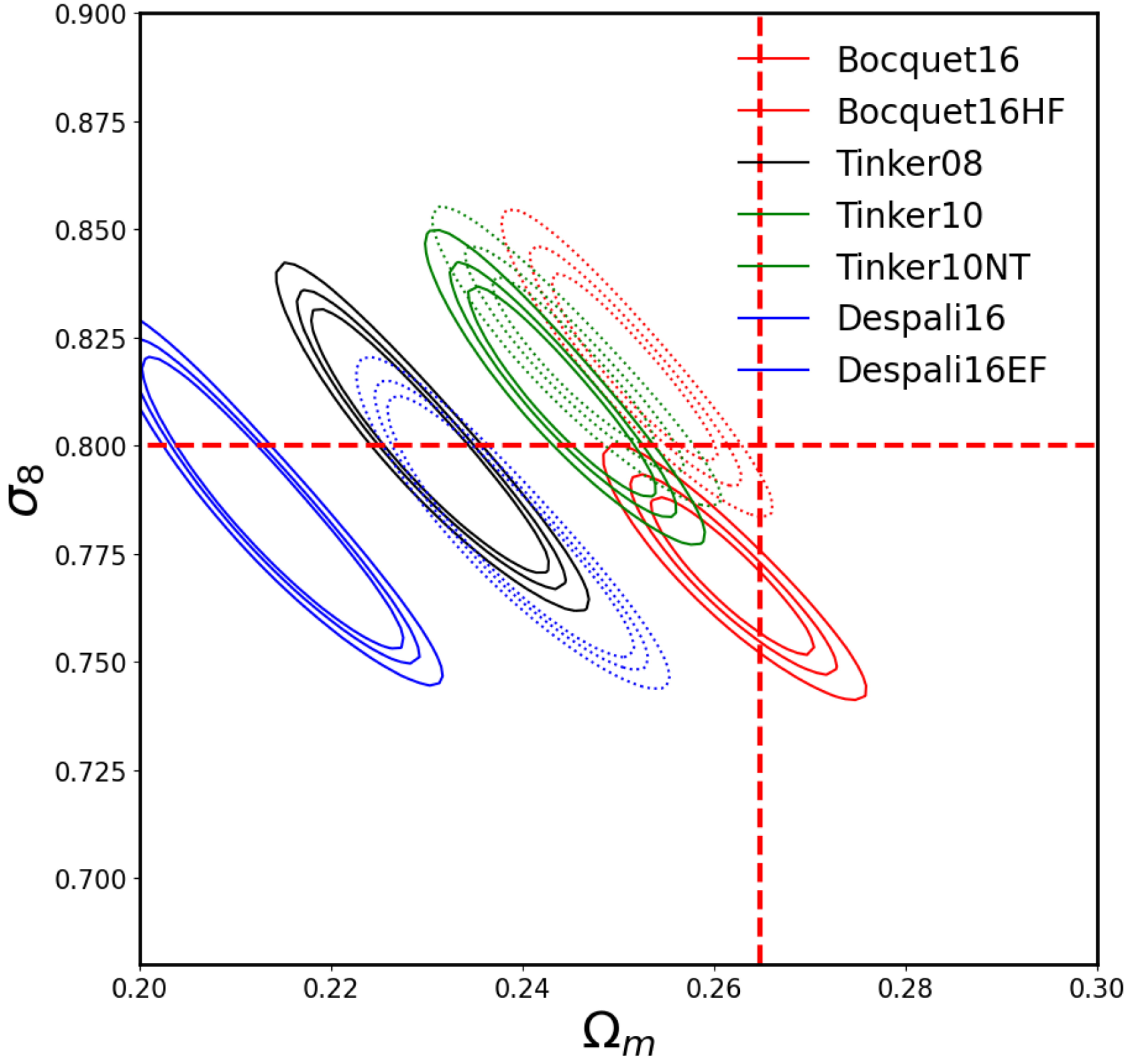




Mass functions: fof or SO ?

- Not really possible to compare 200c and mfof, no much mass functions can use both (in CCL)
- **Only SO masses:**
  - m200c:
    - Bocquet16 (Include or not baryonic effects),
    - Bocquet20 (use MiraTitanHMFEmulator),
    - Despali16 (can be ellipsoidal)
  - m200m: Bocquet16, Despali16, Tinker08 (can be translated to m200c), Tinker10 (idem + mass function can be normalised to yield total matter density when integrated over mass at all redshifts)
- **Only fof masses**
  - Augulo12, Jenkins01, Press74, sheth99,
- **Both**:
  - Watson13

M200c



- **Bocquet16 has the option of (Hydro, True or False)**
  - True (-): use the parametrization using dark-matter-only simulations. False (..): include baryonic effects
- **Tinker10 has the option of normalisation of HMF (True or False)**
  - True (..) : mass function normalised to yield the total matter density when integrated over mass at all redshifts (as opposed to z=0 False (-))
- **Despali16 has the option of using ellipsoidal parametrization (True (..) of False (-))**
  - BTW, there is typo in the CCL implementation: « coeffs = [[A1, A0], [a2, a1, a0], [p2, p2, p0]]» -> should be [p2, p1, p0]]
    - https://ccl.readthedocs.io/en/latest/_modules/pyccl/halos/hmfunc/despali16.html#MassFuncDespali16
    - discussed here : http://111.229.182.18:9999/LSSTDESC/CCL/issues/1195
      - should be corrected soon. Maybe explain why this is so off !

Despali, ellipsoidal

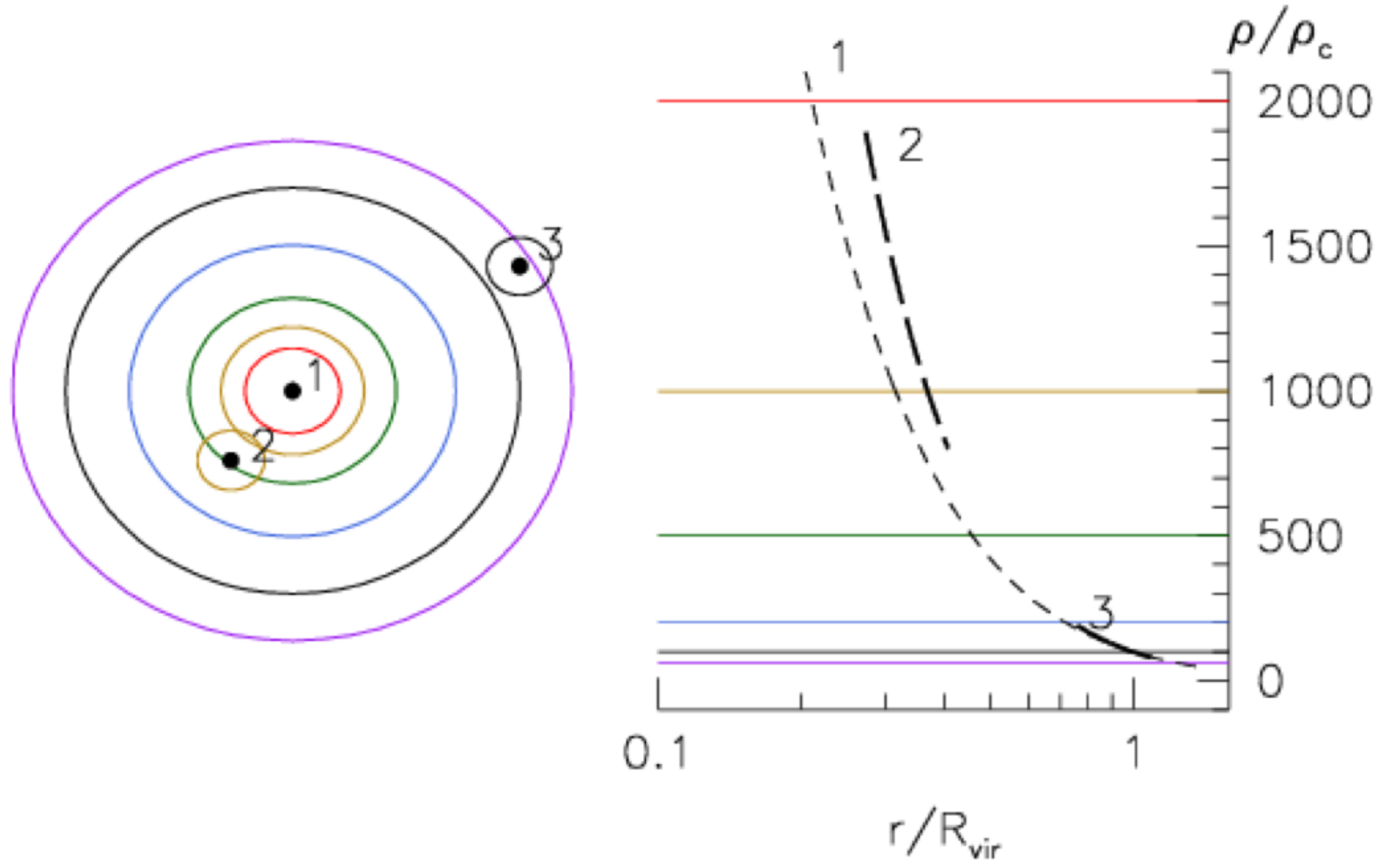


Figure 1. Schematic representation of the halo identifications in the particle density distribution at $z = 0$. Different colours represent the various overdensities, from $2000\rho_c$ down to $200\rho_b$. Since our SO halo finder starts to grow the sphere starting from the densest particle, the halo centered at 1 is common to all the catalogues, whereas the ones at 2 and 3 belong only to $1000\rho_c$ and to the virial catalogue, respectively. This is clearer in the right hand panel of the figure which shows the density profiles of the three systems.

- Ellipsoidal Halo Finder
- Despali 2013: paper

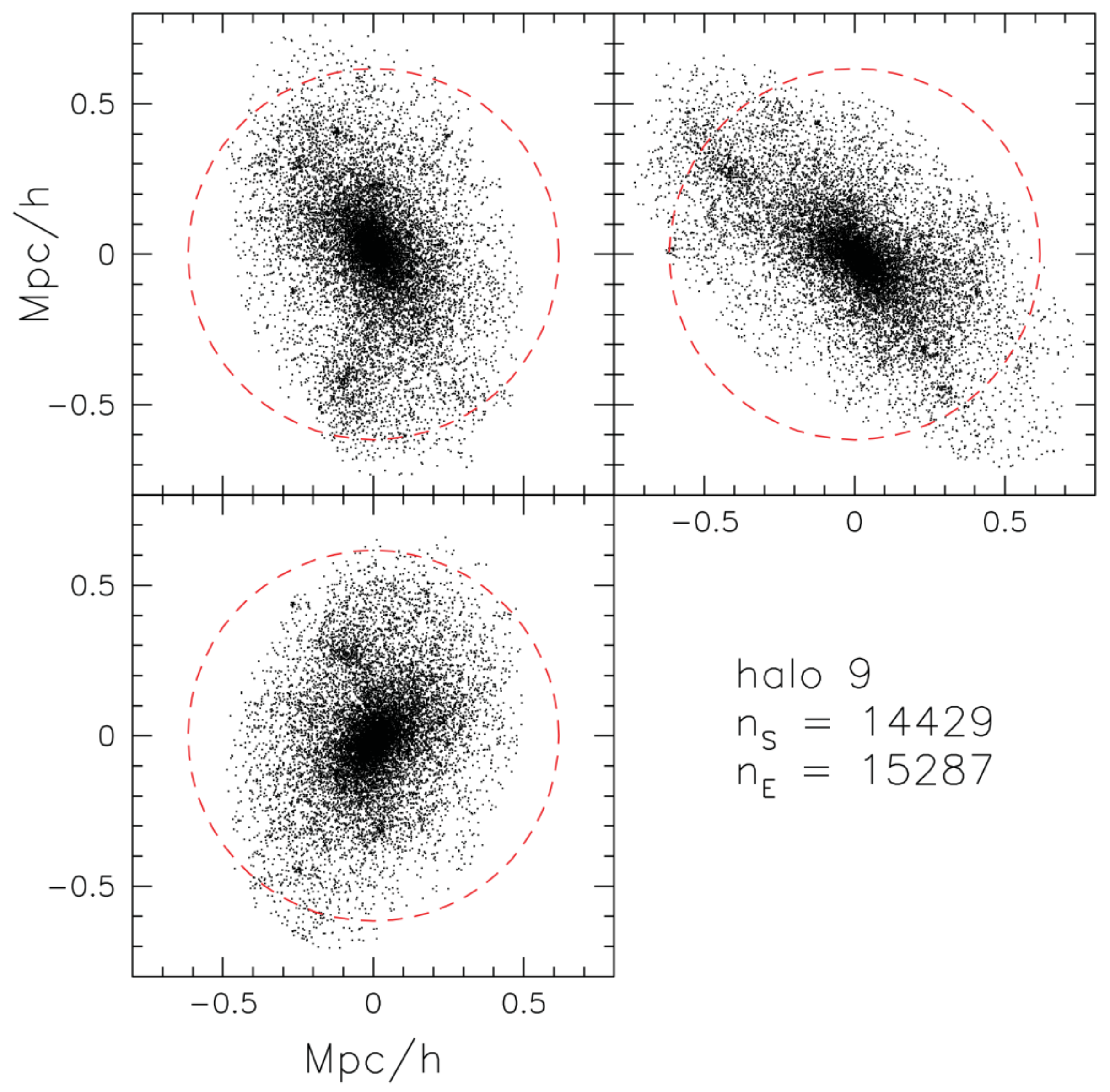


Figure 1. Example of the difference between the final ($z = 0$) spherical and ellipsoidal identification for a halo of the simulation: we show the projected distribution (in the x–y, y–z, x–z planes) of the halo particles inside the ellipsoid; the red dashed circle indicates the radius of the halo in the spherical identification. We note that the shape becomes in general more elongated and that the number of particles increases, indicating that the ellipsoidal shape traces the isodensity contours better than the spherical one.

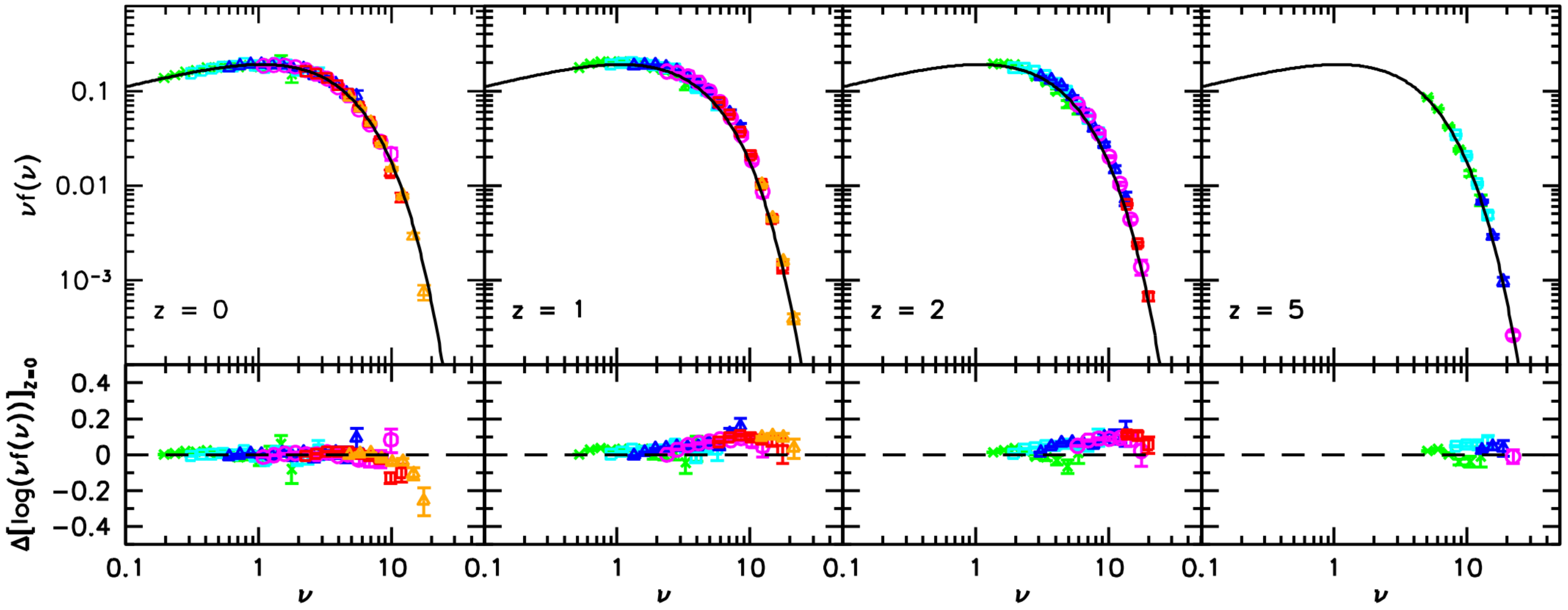


Figure A1. Same as Figure 2, but for the haloes in the Ellipsoidal Overdensity catalogue.

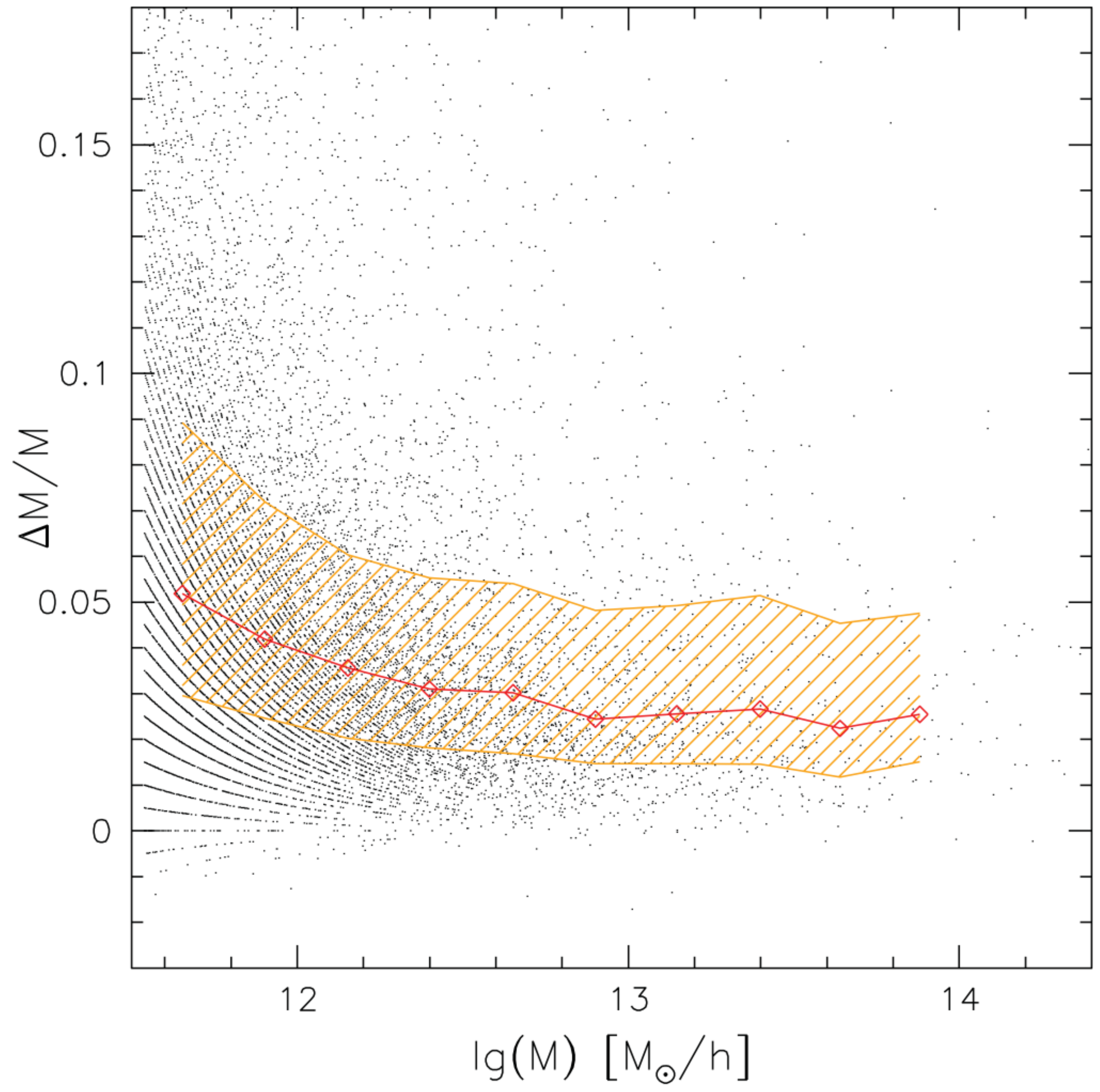


Figure 2. The mass difference between the ellipsoidal and spherical identification methods, shown as a function of the spherical mass. The medians of the distribution are shown in red and the region which lies between the first and third quartiles is shaded orange.

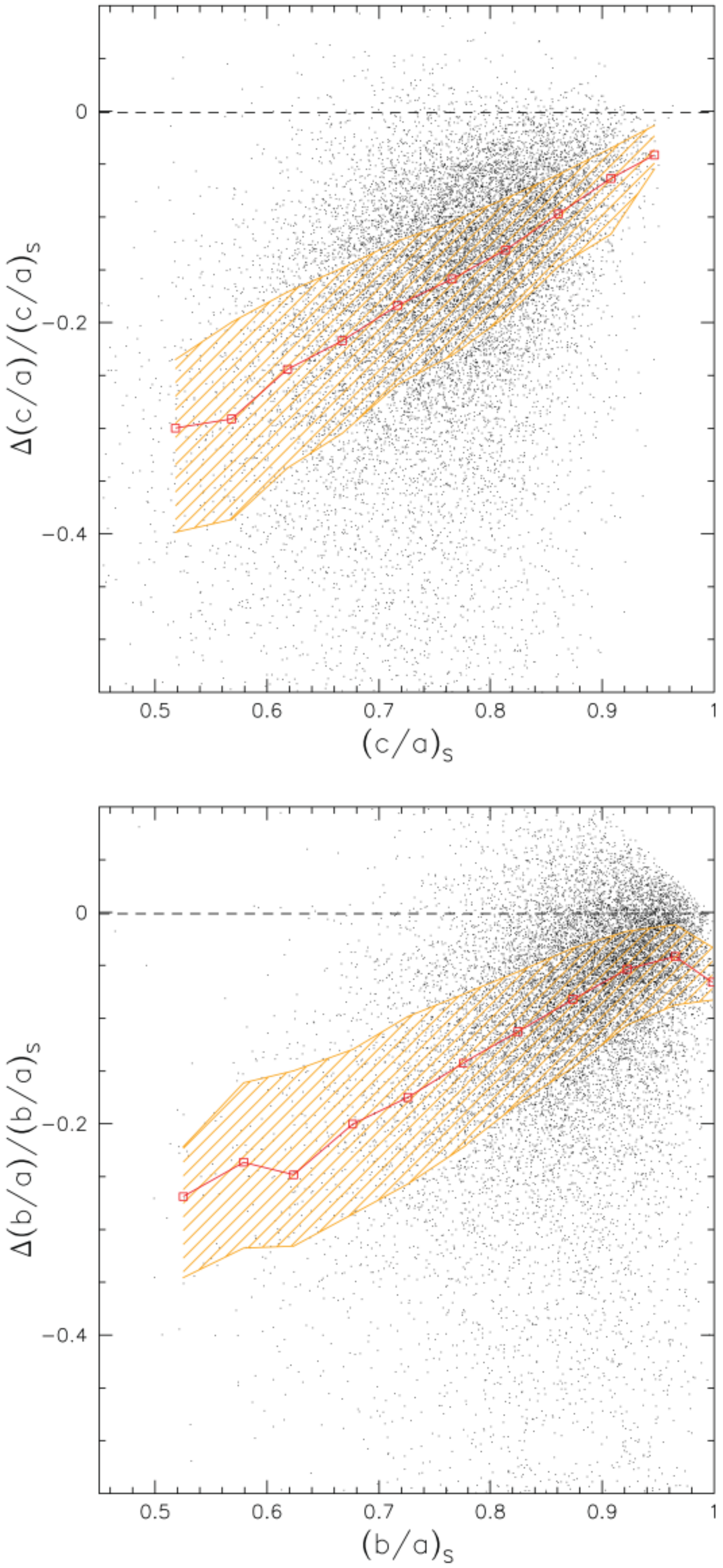


Figure 3. The difference in the final axial ratios *c/a* and *b/a* ($a \leq b \leq c$), as a function of the spherical ones. The orange shaded region lies between the first and third quartiles; red points show the median. The relative difference is generally negative, indicating that fitting ellipsoids yield more elliptical and prolate shapes than fitting spheres.

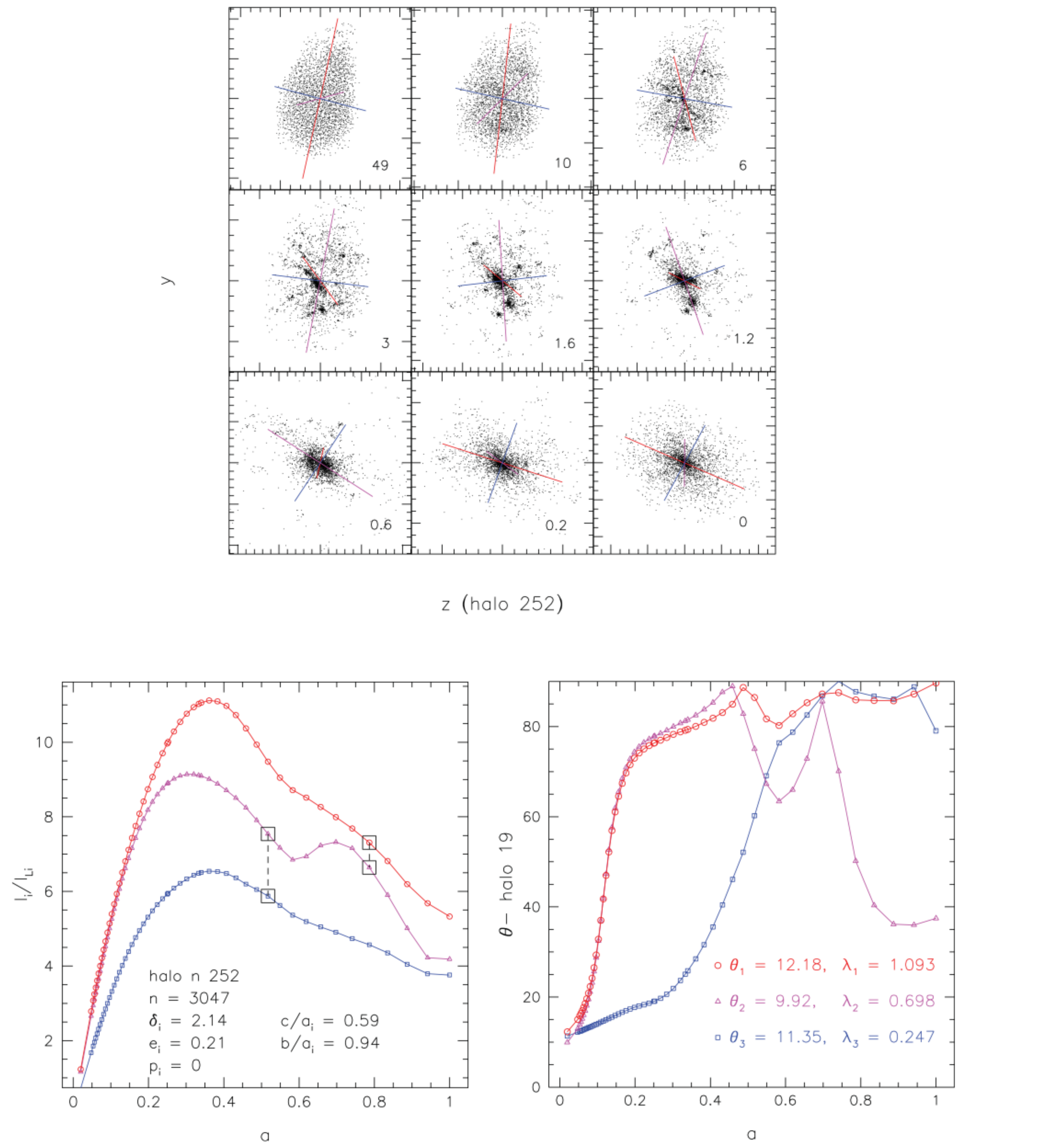
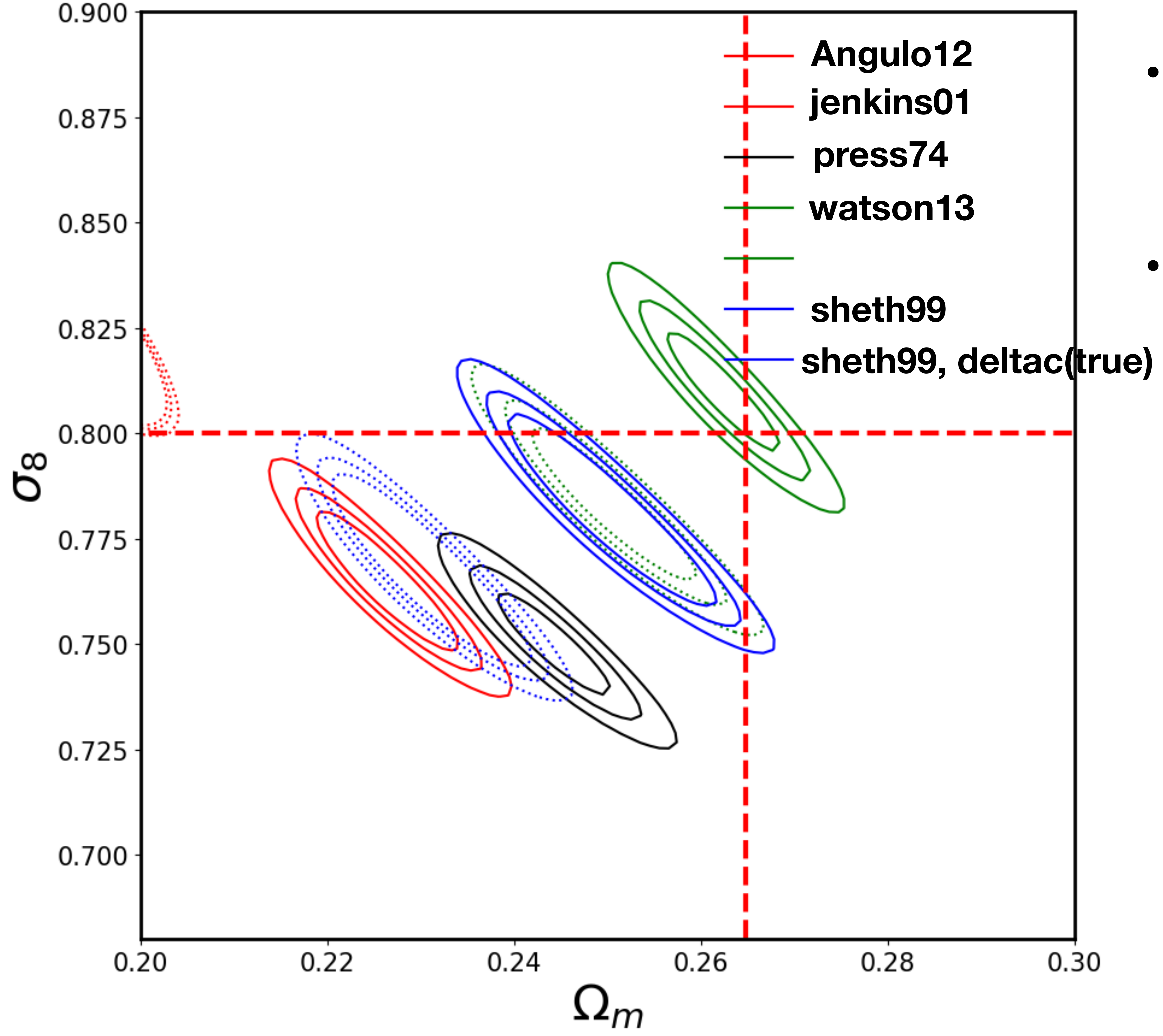


Figure A1. Evolution of an object of mass M_*. The axis colour scheme is the same in all the panels: blue – shortest; magenta – medium; red – longest. Top: the projected particle distribution at nine different redshifts; the thinnest red line stands for the longest axis, while the thin blue one for the shortest axis at each time-step. Bottom left: the evolution of the three mass axes; the black squares show the moments of inversion of direction between two axes. Bottom right: the evolution of the angle between the mass tensor axes and the initial deformation tensor axes ($\widehat{l_1\lambda_1}$ – red, $\widehat{l_2\lambda_2}$ – magenta, $\widehat{l_3\lambda_3}$ – blue, with the same point like of the left-hand panel).

mfof



- Sheth99: can use the fit to the critical overdensity deltac by Nakamura&Suto97 (True (..)), otherwise use deltac=1.69 (False (-))
- Watson13 has the best fit to the DC2 catalog !
  - accept both fof and SO masses (https://arxiv.org/pdf/1212.0095)
    - «The mass function from SO haloes exhibits a clear evolution with redshift, especially during the recent era of dark energy dominance (z < 1). » -> redshift-parameterised fit for the SO mass
    - «The FOF mass function displays a weaker evolution with redshift. » -> universal fit for the FOF mass function

m200c vs mFOF

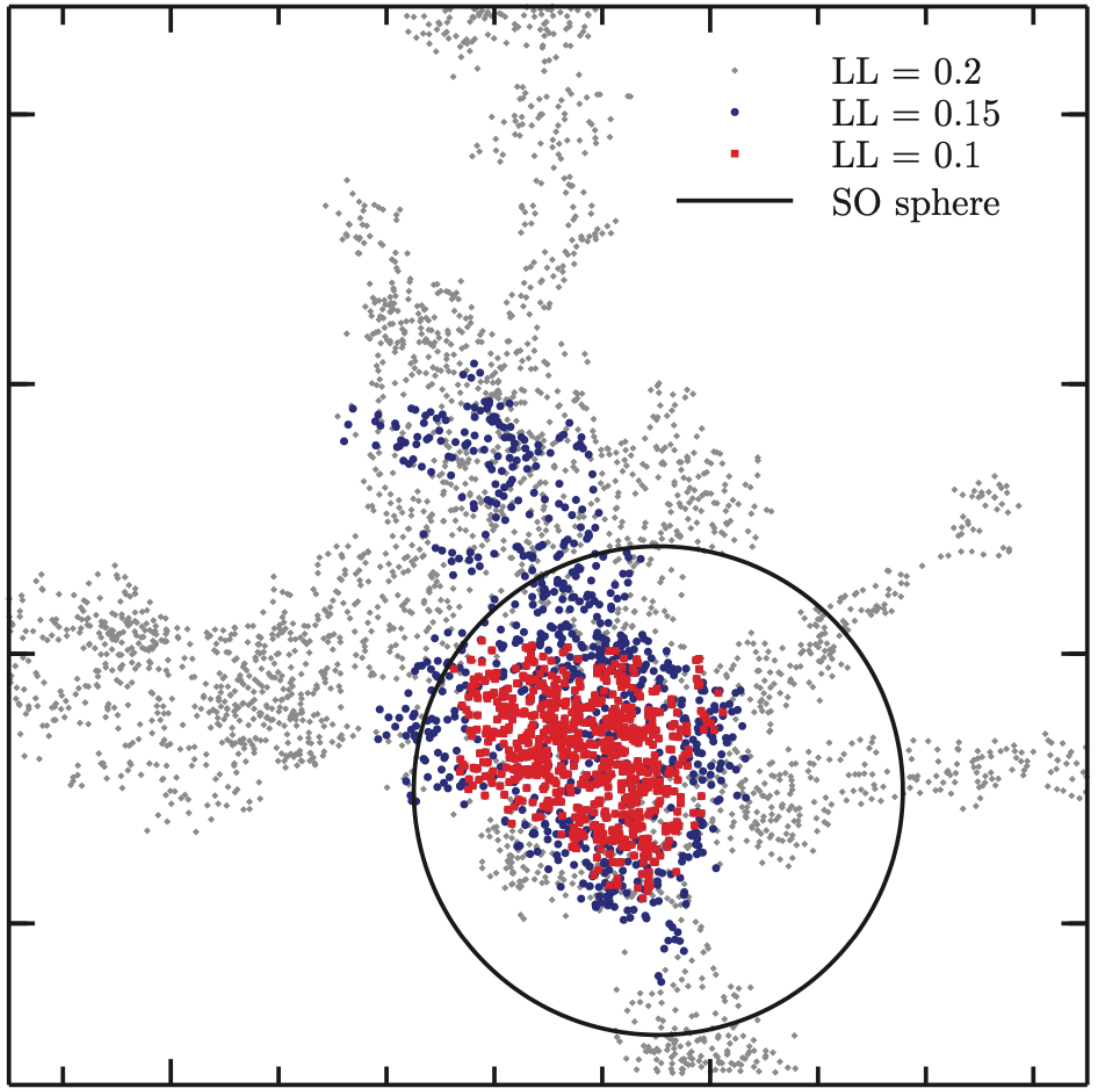


Figure 15. Image of a large halo in the 20 h^{-1}Mpc box at $z = 8$. The circle represents the extent of the Δ_{178} cutoff used in CPMSO. The z direction has been projected onto the x-y plane. The CPMSO halo mass is $3.1\times10^{10}h^{-1}\mathrm{M}_{\odot}$ and it contains 9.3 million particles. The dots represent aggregations of at least 20 particles found in the FOF version of the same halo. Grey shows the halo captured with a linking length of 0.2, blue 0.15 and red 0.1. The masses (particle counts) are $4.8\times10^{10}h^{-1}\mathrm{M}_{\odot}$ (13.1 million), $3.7\times10^{10}h^{-1}\mathrm{M}_{\odot}$ (8.9 million) and $2.1\times10^{10}h^{-1}\mathrm{M}_{\odot}$ (5.8 million) for $b = 0.2, 0.15, 0.1$ respectively.

The halo mass function through the cosmic ages 15

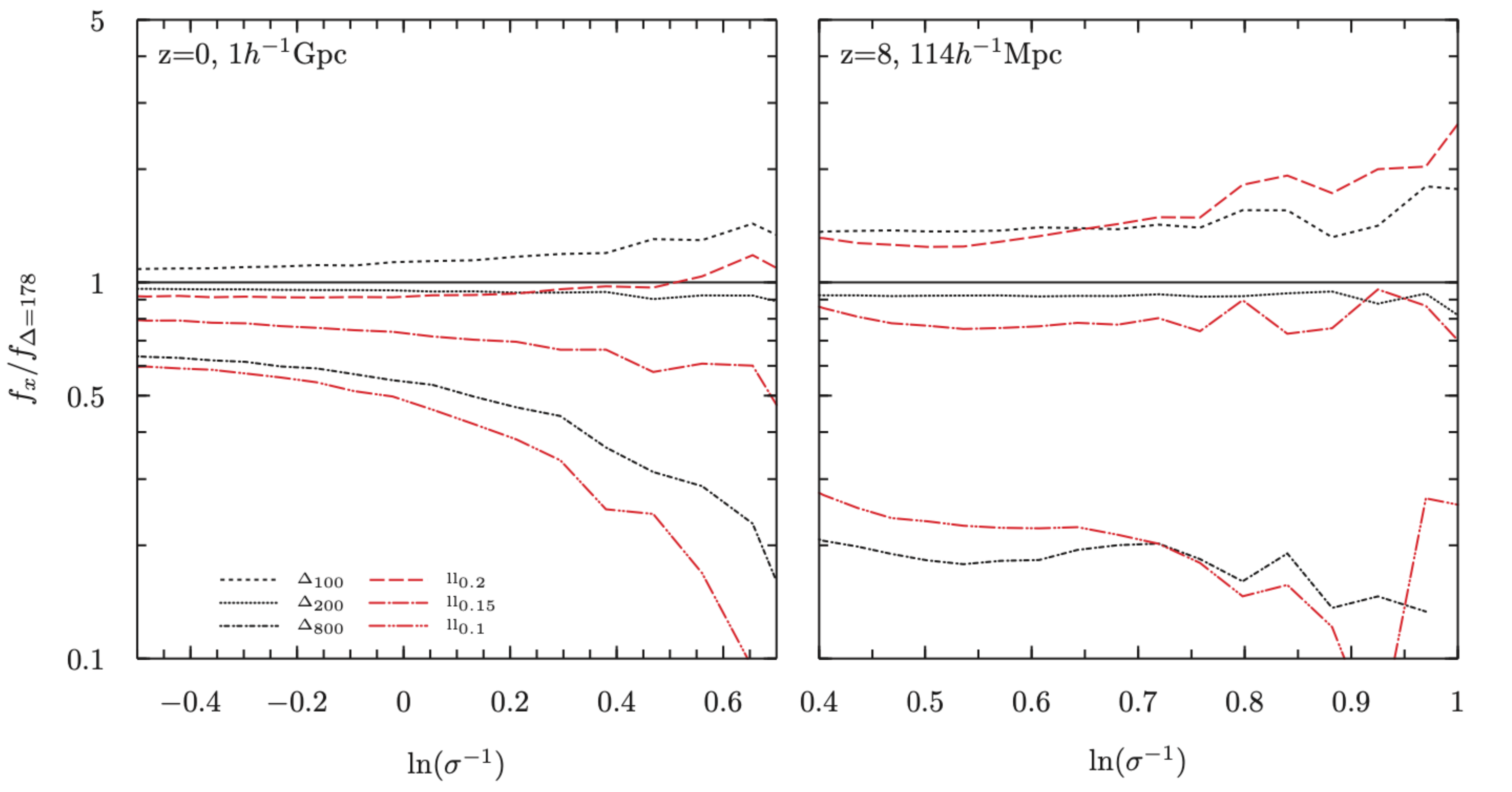


Figure 16. Comparison of mass functions from the $1h^{-1}$Gpc simulation at $z = 0$ and the $114h^{-1}$Mpc simulation at $z = 8$ using AHF with a variable overdensity and FOF with a variable linking length. All ratios are plotted on a base of the $\Delta = 178$ results.

- LL = linking length (for FOF algorithm)

Next steps

- use emulators to see how this compare
- Run all mass function on a generated catalog built with a given mass function, to extract systematic uncertainties
  - maybe some HMF can be removed ? (Despali, Press74)