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PARIS-SACLAY

Characterising galaxy clusters' completeness in Planck with hydrodynamical simulations

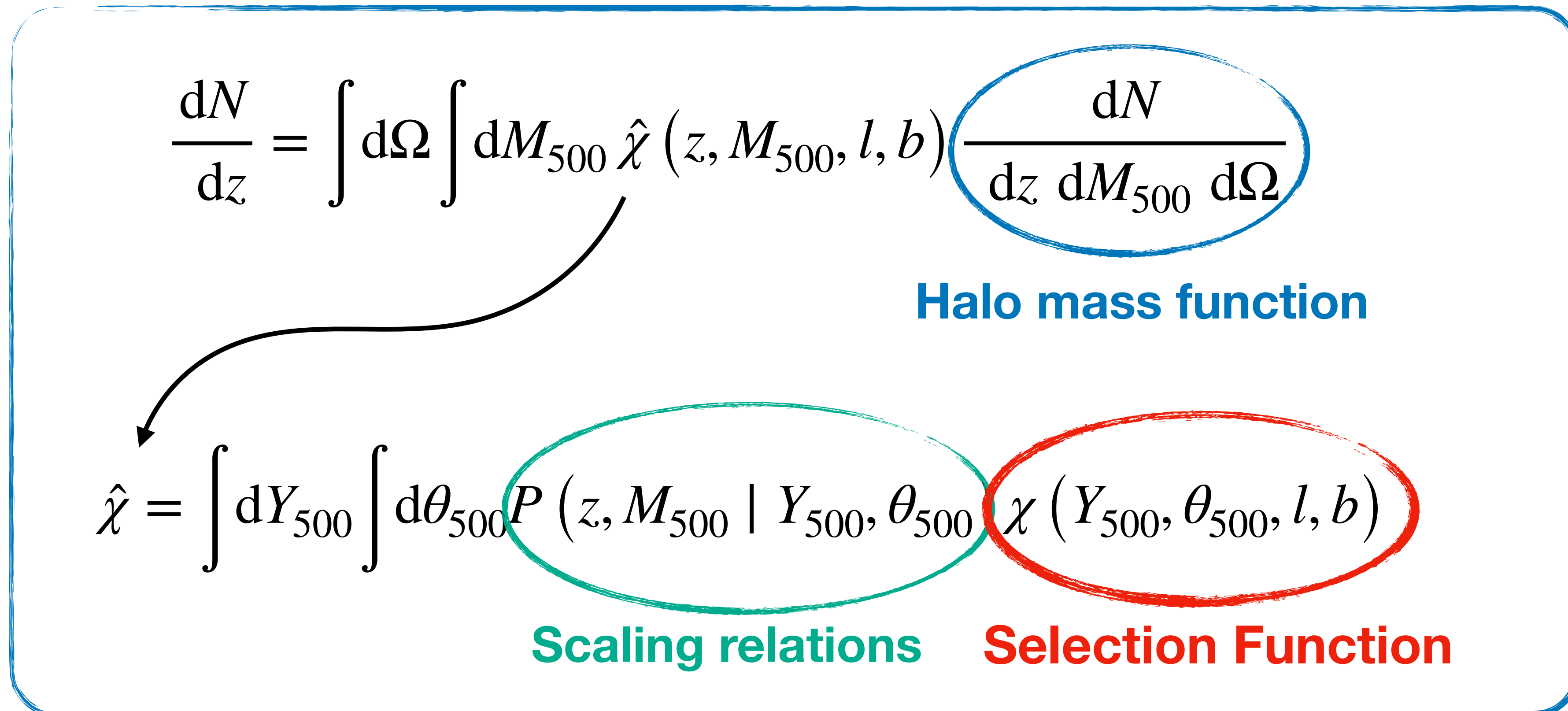
Stefano Gallo, Marian Douspis, Elie Soubrié

mm Universe 2023, 29/06/2023

Cosmology with Galaxy Clusters

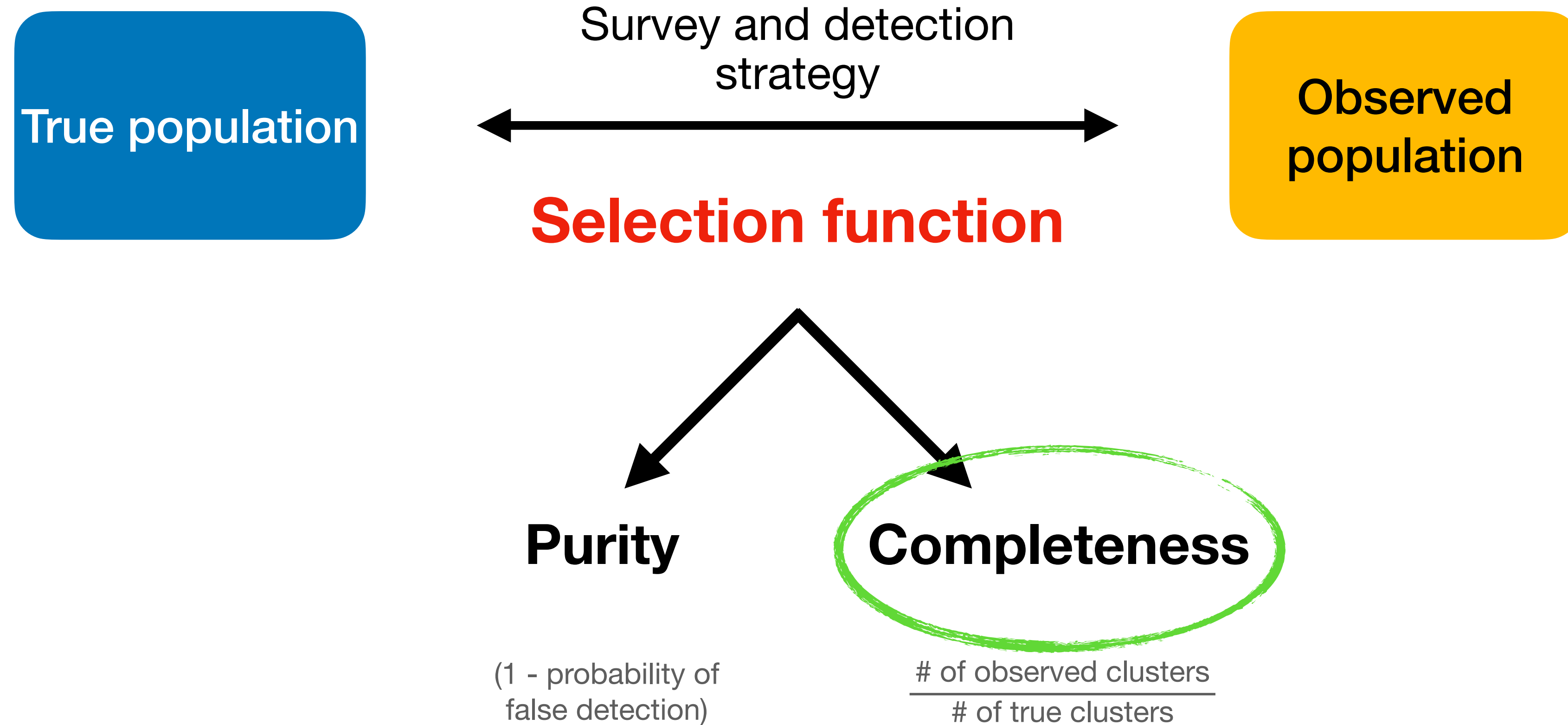
Galaxy clusters number counts → depend on cosmological parameters: $\Omega_m, \sigma_8, \dots$

Different ingredients are needed to compare the observed counts with the theory:



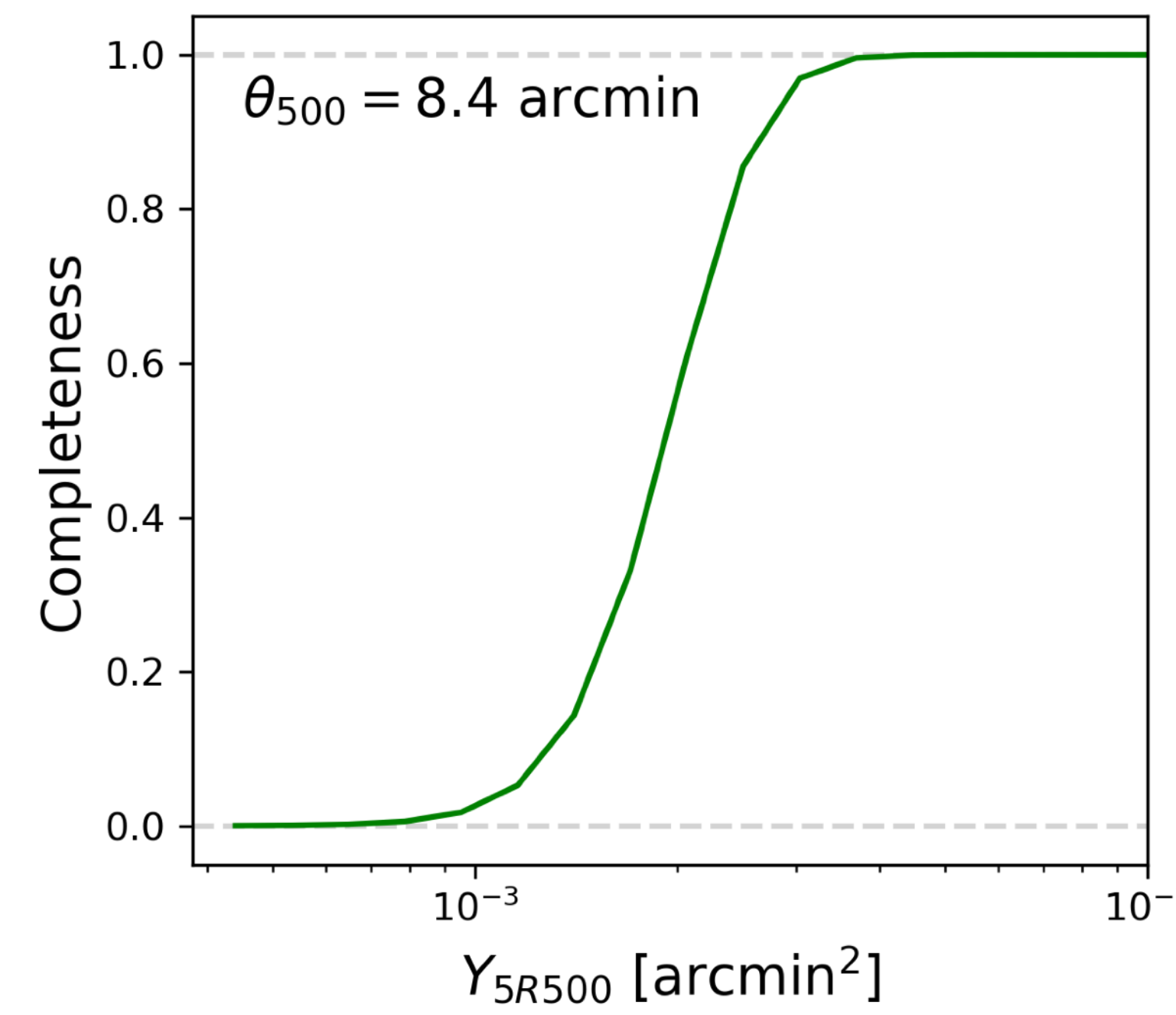
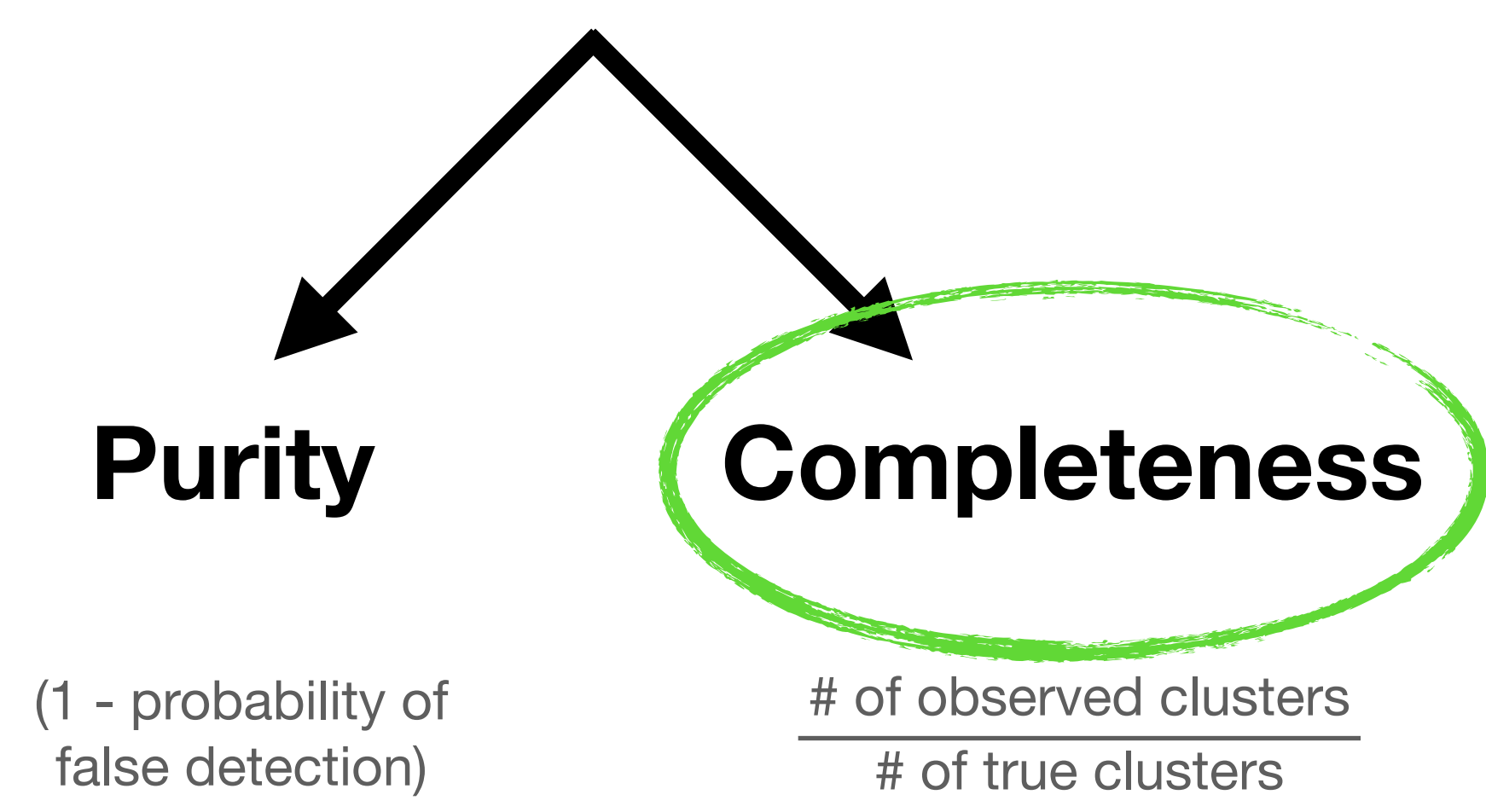
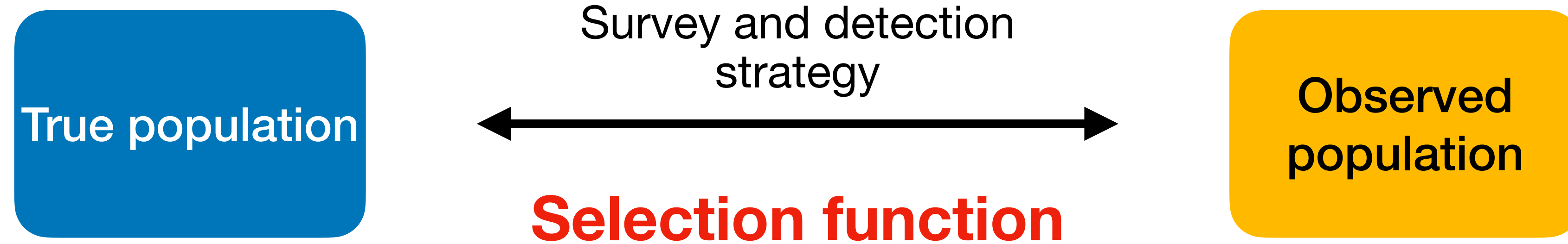
Selection Function

One of the main ingredients in cosmological analyses:



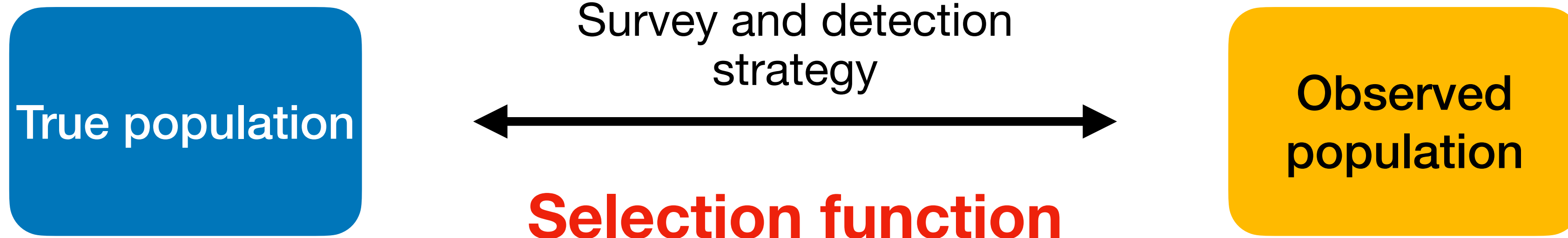
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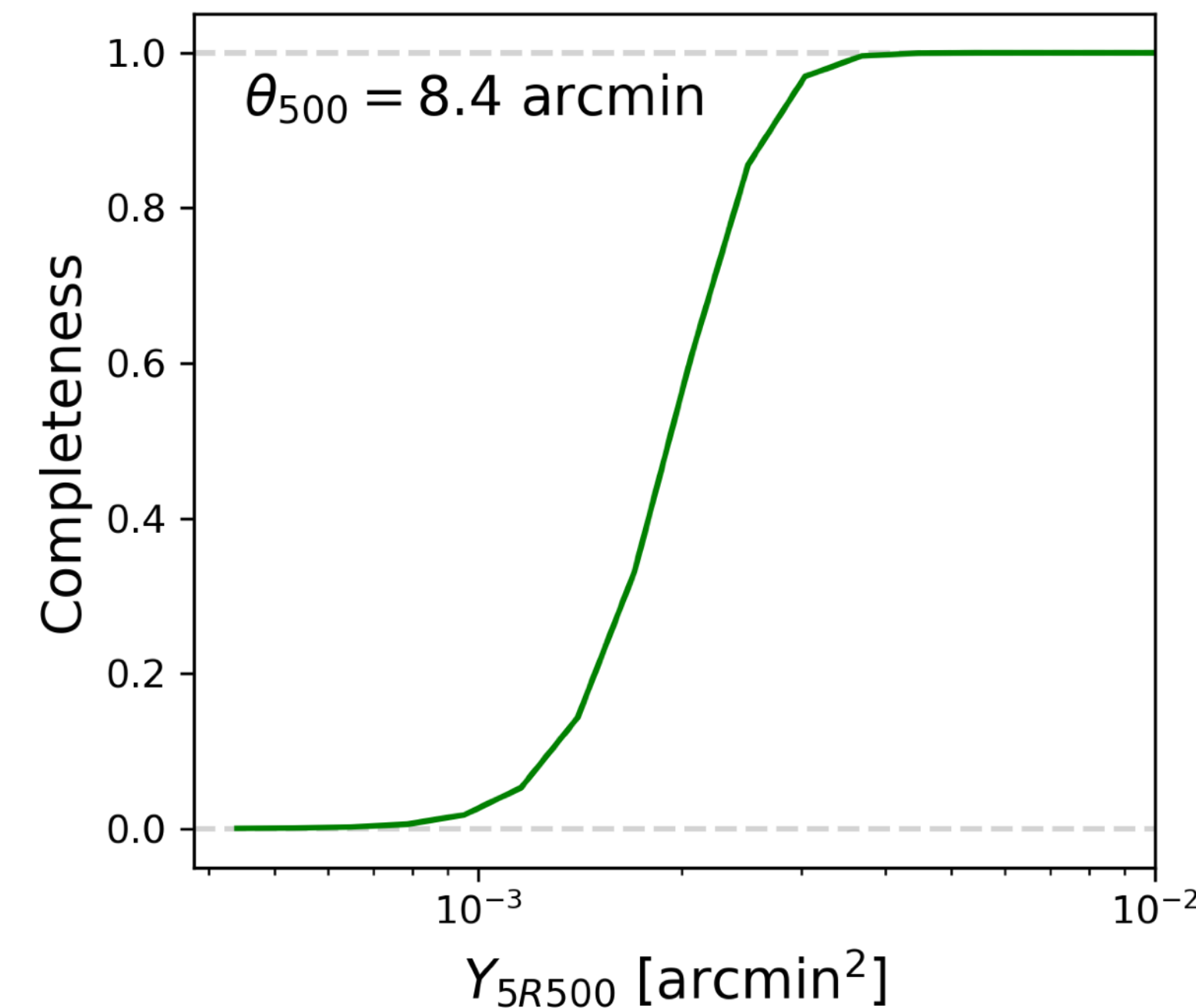
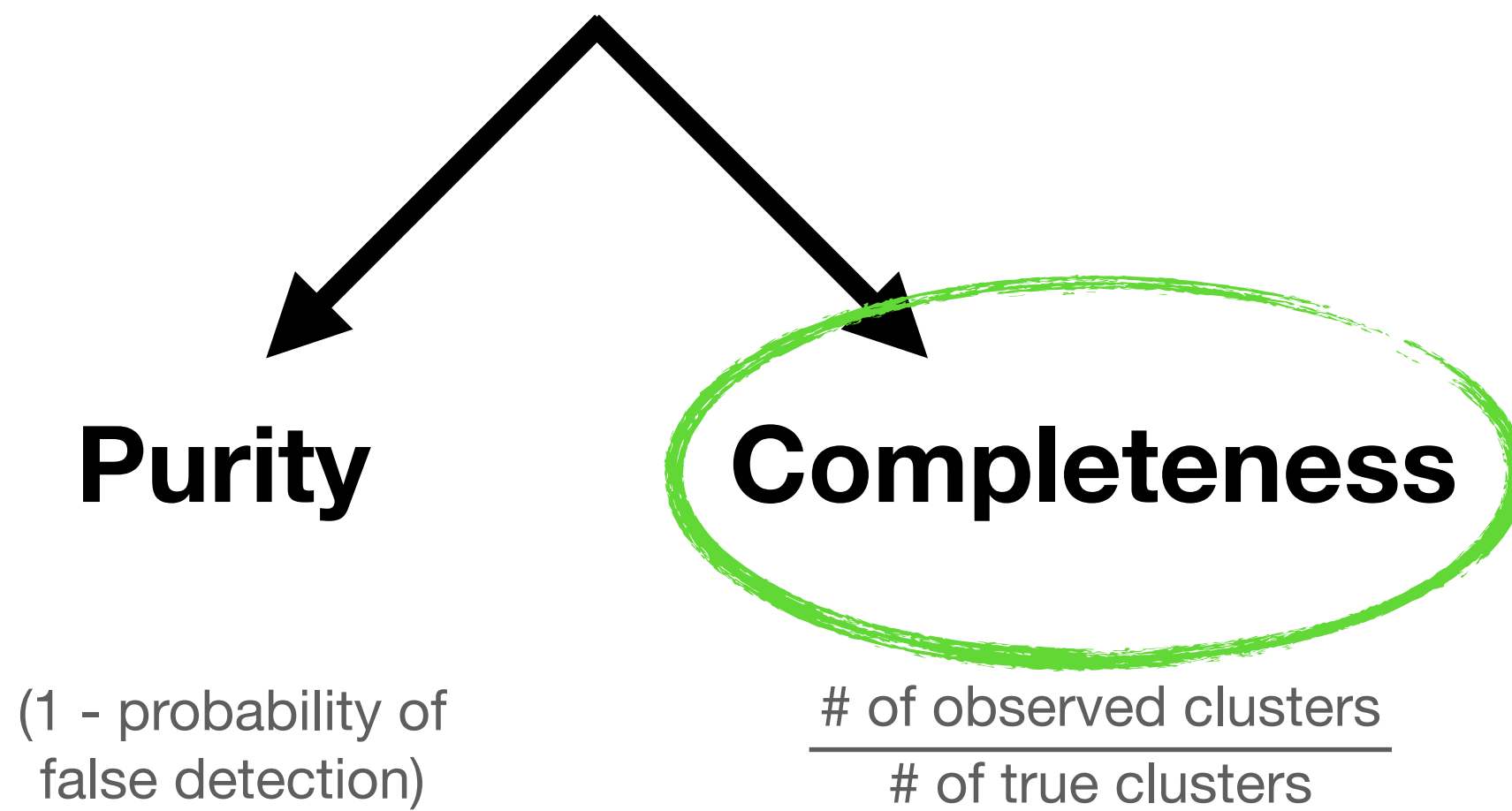


Selection Function

One of the main ingredients in cosmological analyses:



Incorrect characterisation
=
Possible biases in cosmological parameters



- If one assumes **Gaussian errors** on the Compton- y signal, the completeness can be estimated as:

$$P(d | Y_{5R500}, \sigma(\theta_{500}), q) = \frac{1}{2} \left[1 + \operatorname{erf} \left(\frac{Y_{5R500} - q \sigma(\theta_{500})}{\sqrt{2} \sigma(\theta_{500})} \right) \right]$$

PlanckXX(2013),
PlanckXXIV(2015)

- **Another approach: inject** simulated cluster signals in the Planck frequency maps, and check how many are **recovered** by the detection algorithm

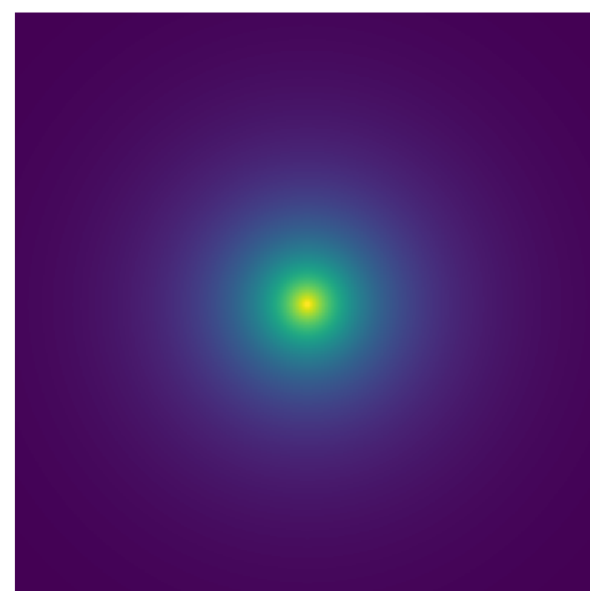
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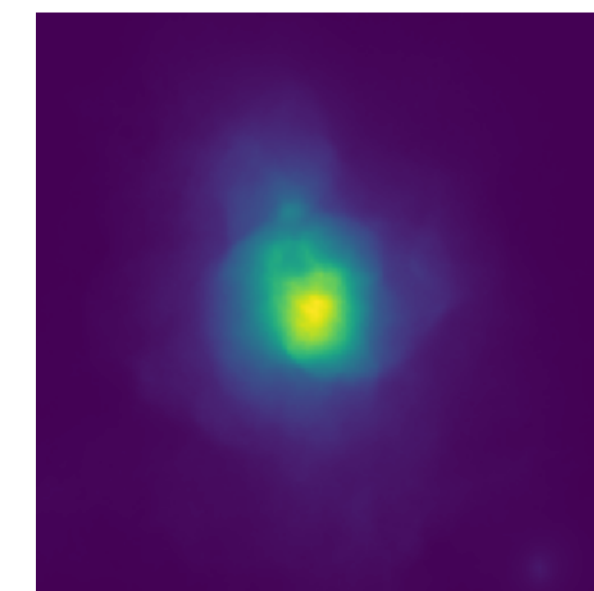
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Spherical images



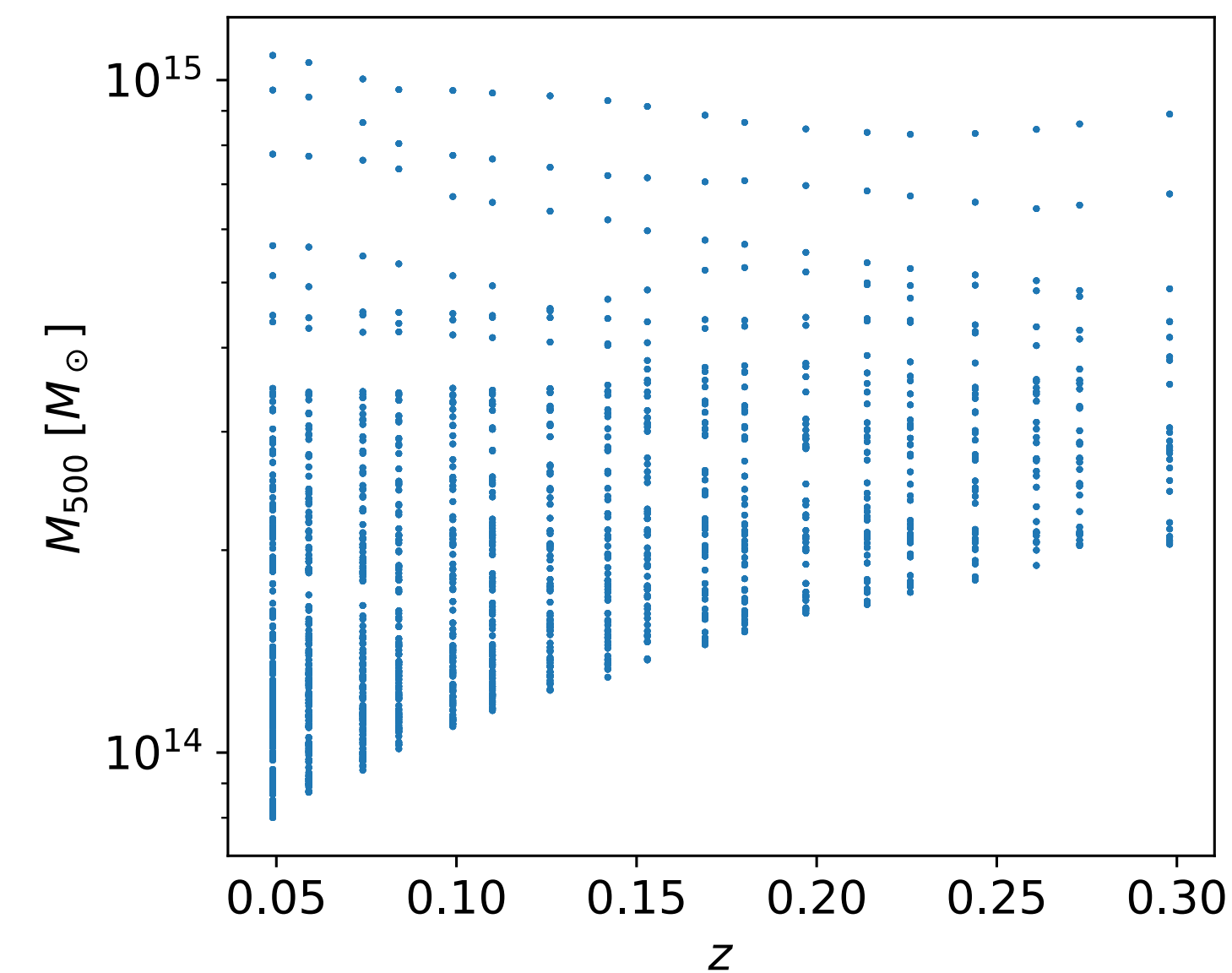
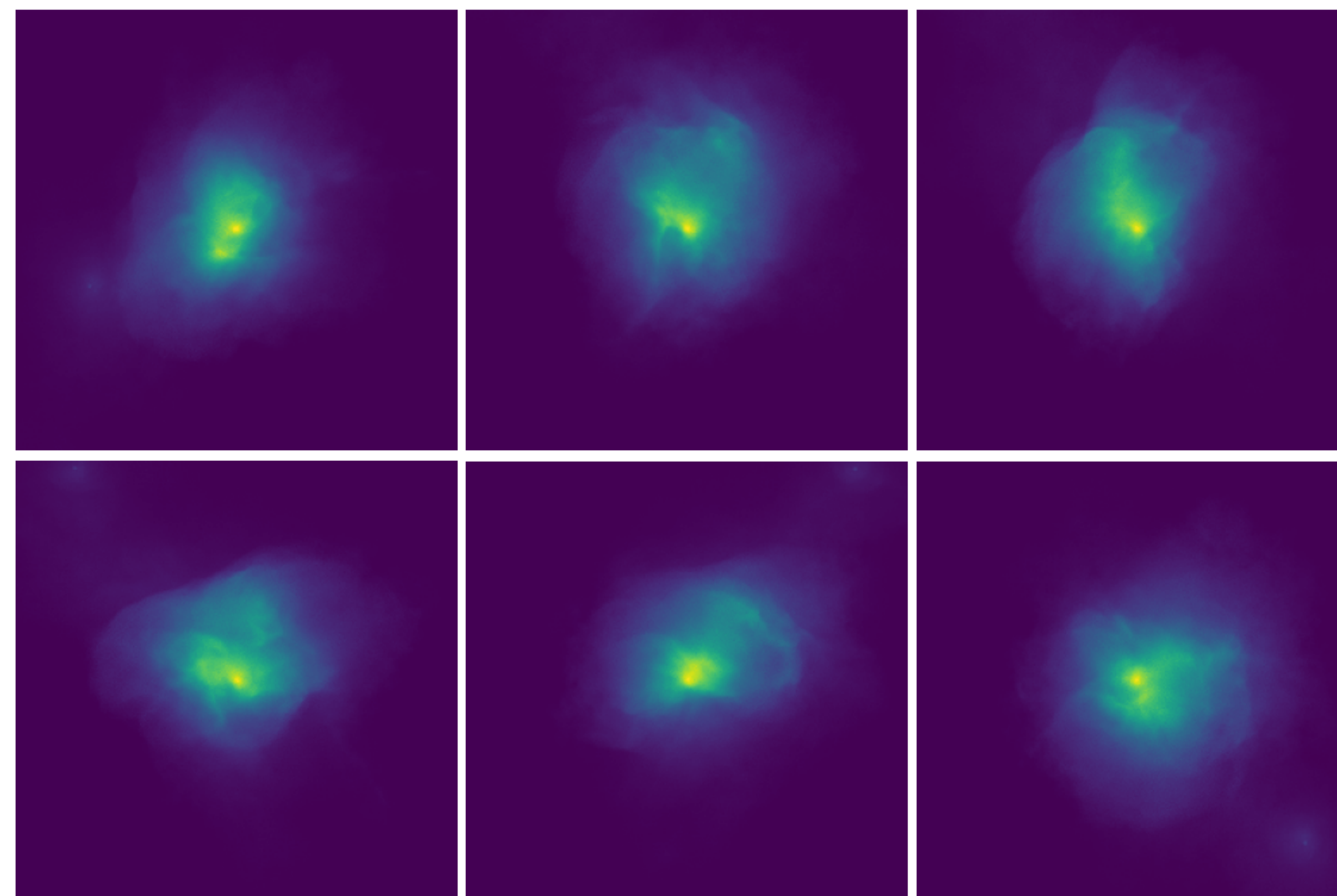
Simulation images



Injected Cluster Images

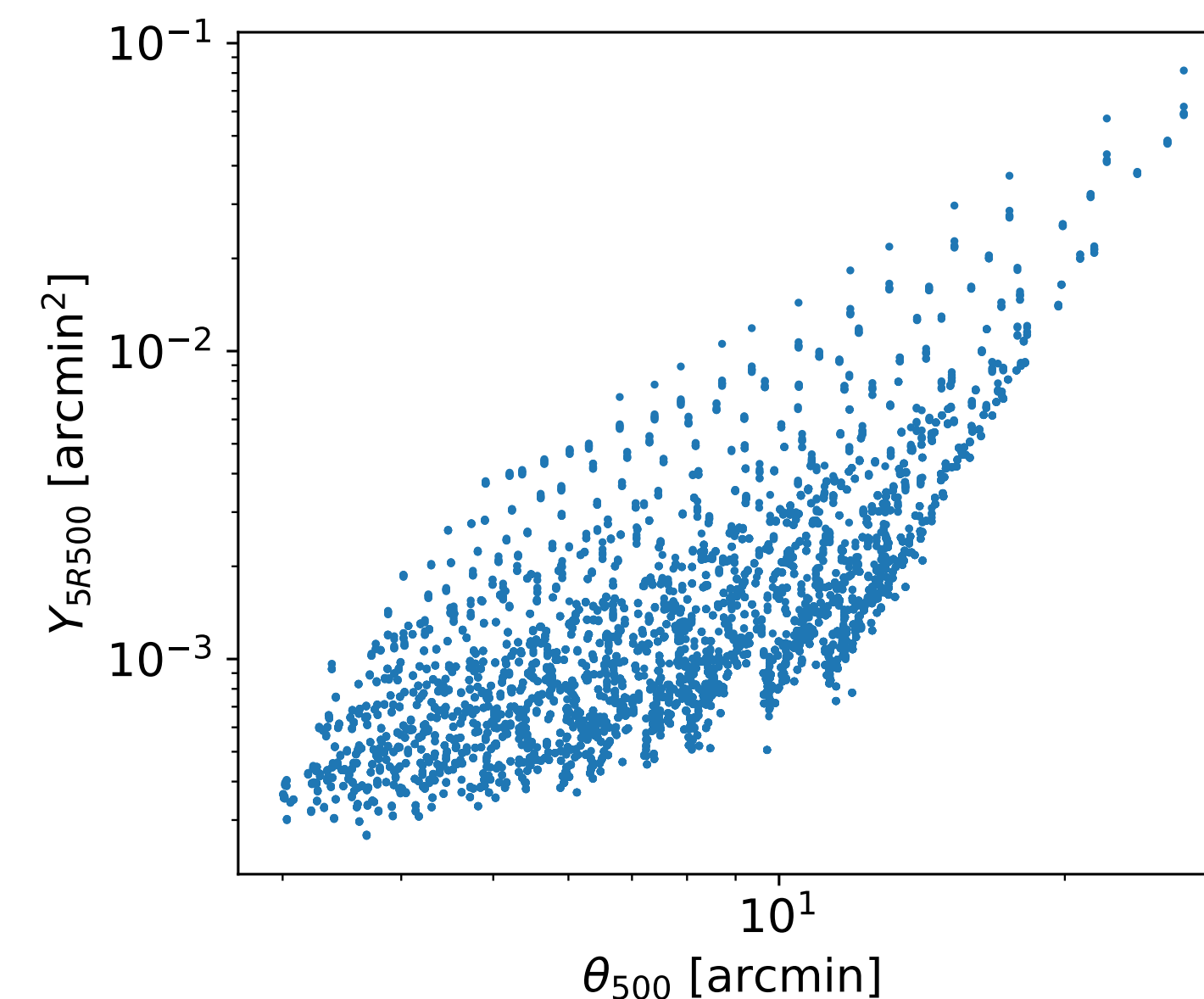
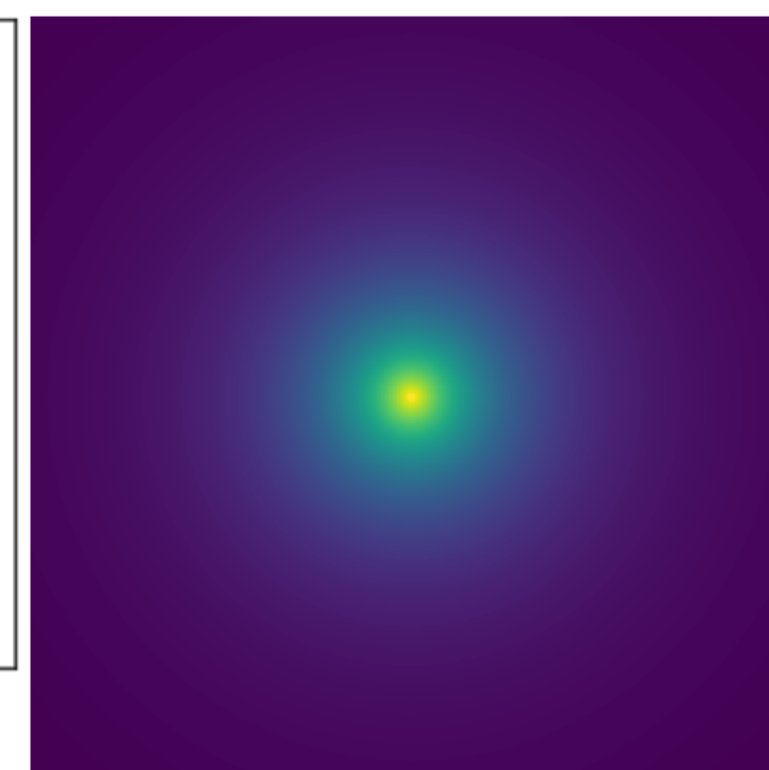
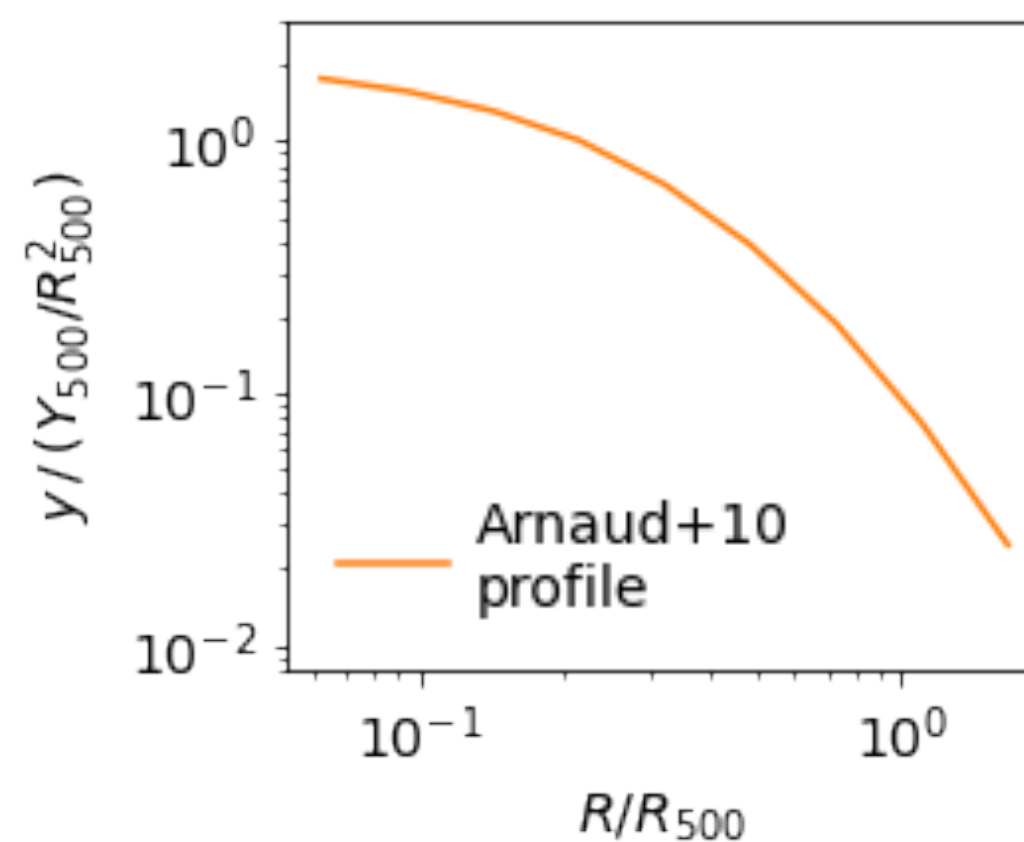
Simulation images

- IllustrisTNG-300 hydrodynamical simulation
- $M_{500} \gtrsim 1 - 2 \times 10^{14} M_{\odot}$
- $0.05 < z < 0.3$
- 6 projections per cluster
→ almost 9000 images

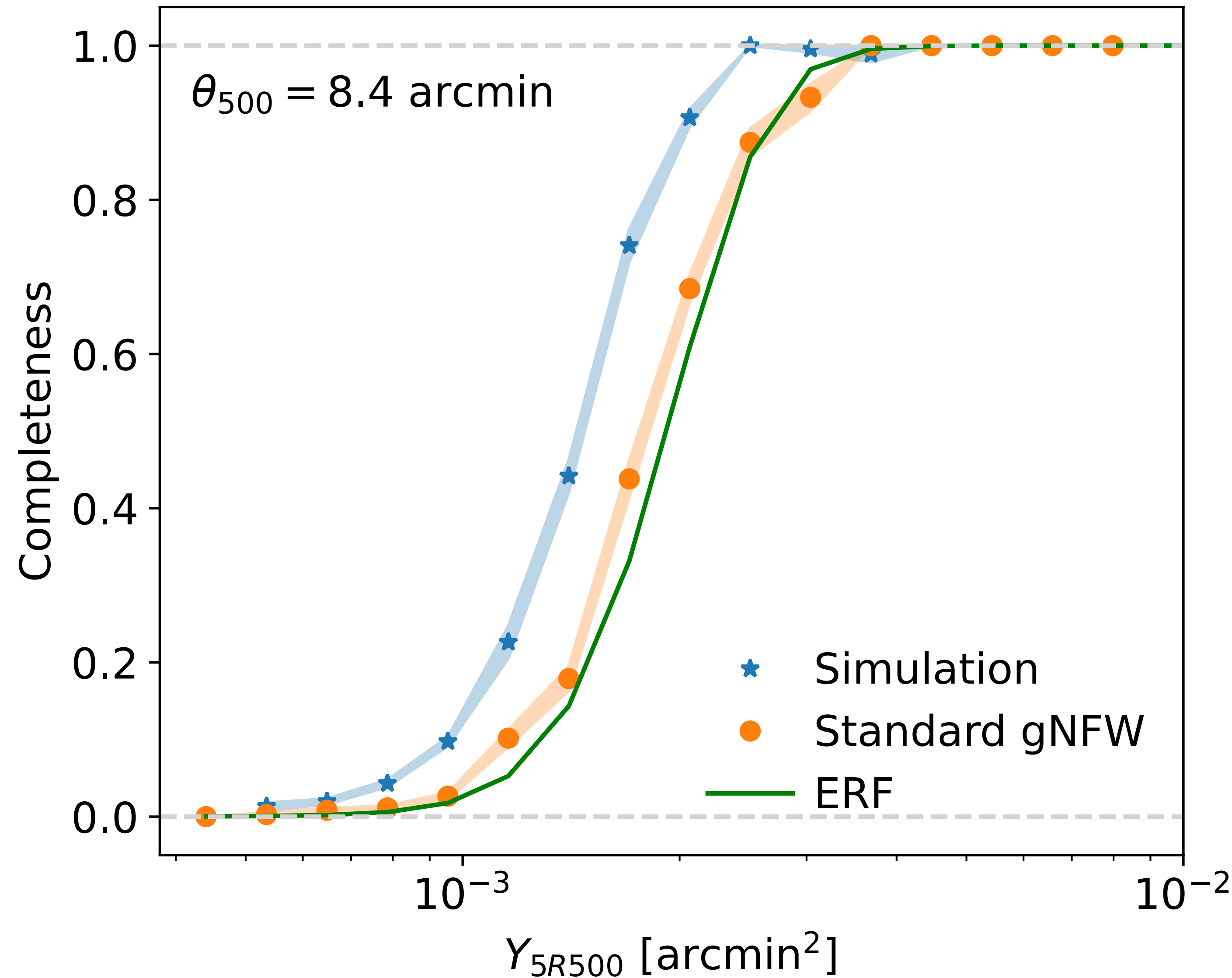


Spherical images

- Integrated gNFW profile (Arnaud+2010)
- Same $(Y_{5R500}, \theta_{500})$ distribution as simulation



Results

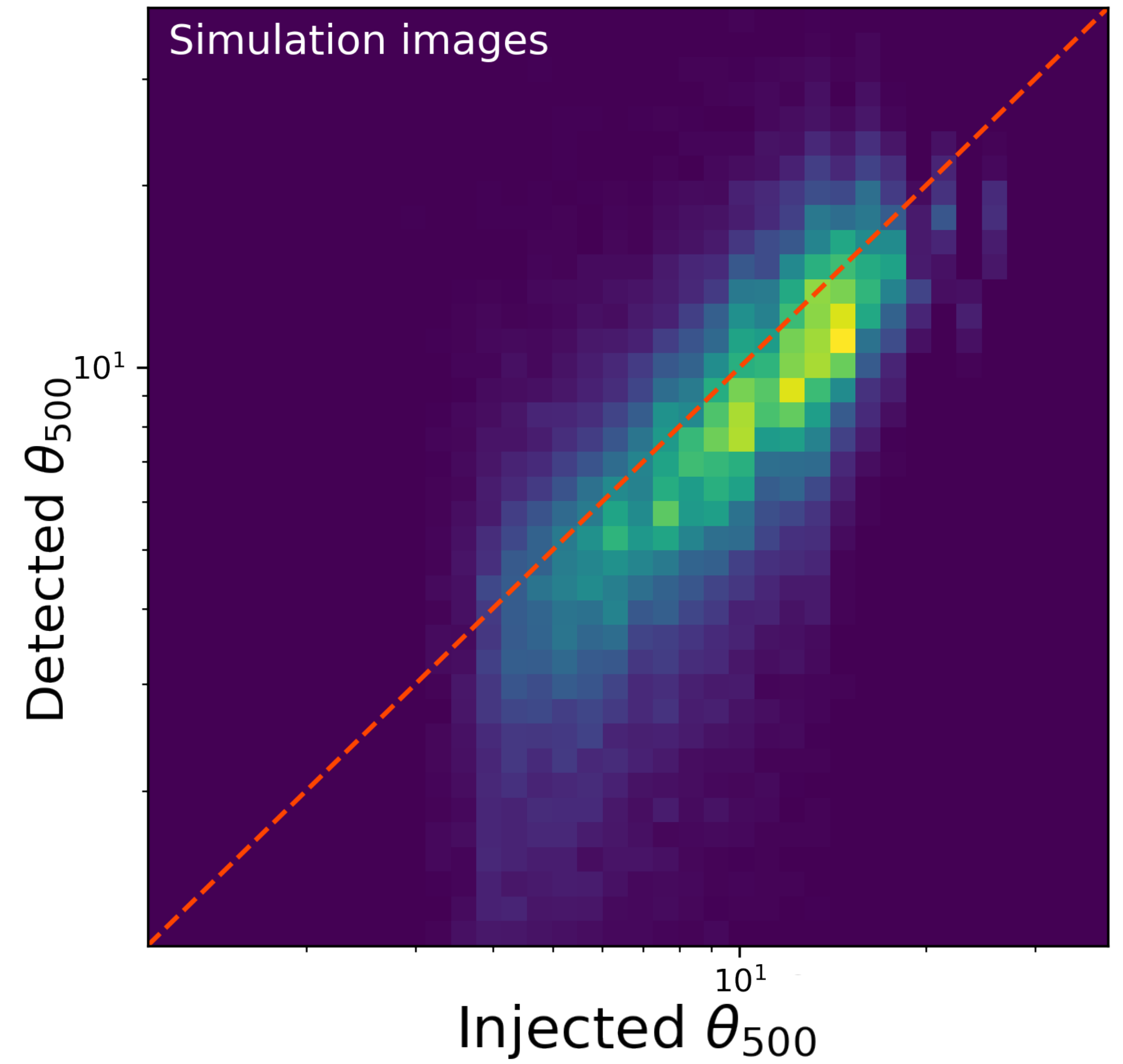
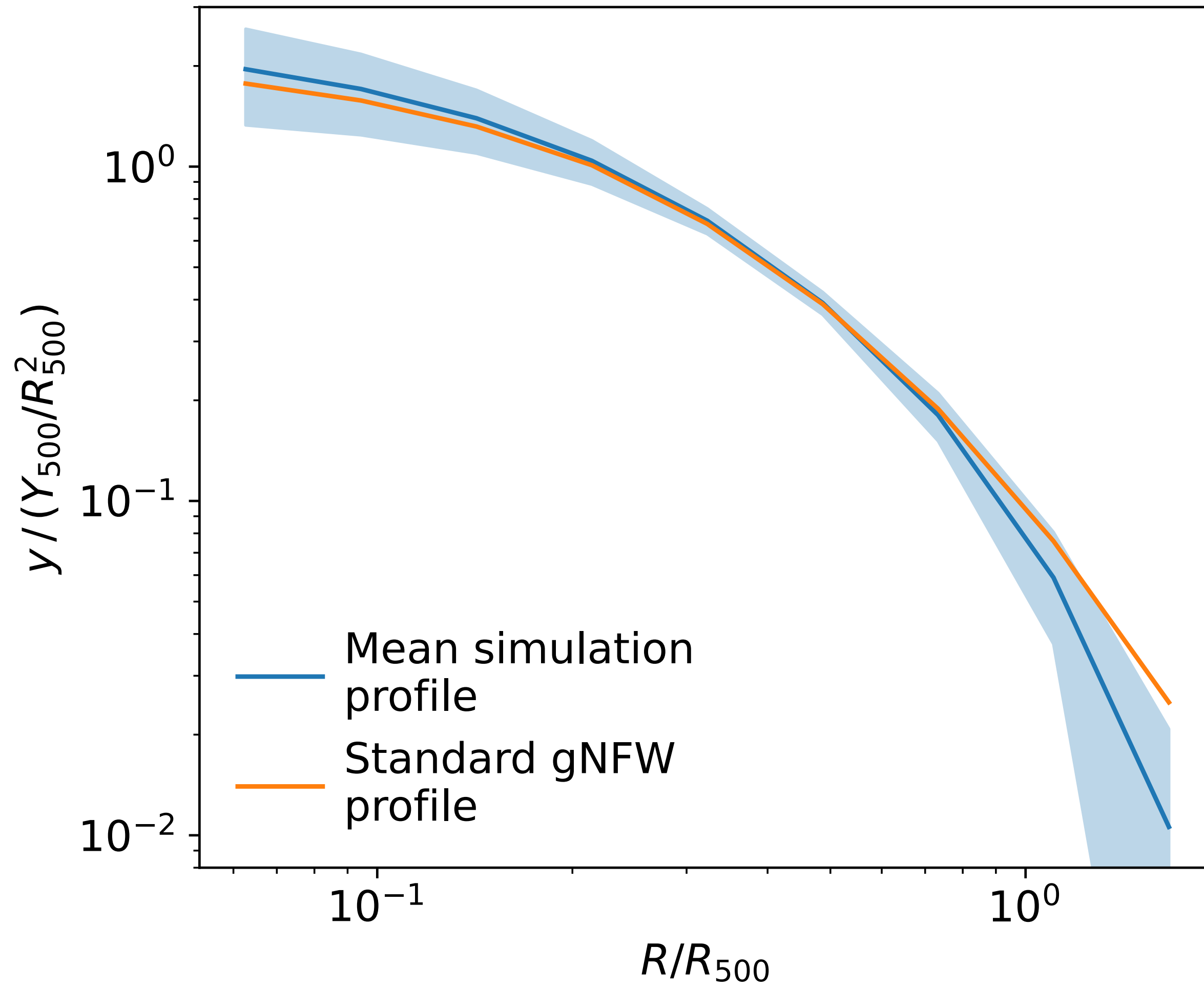


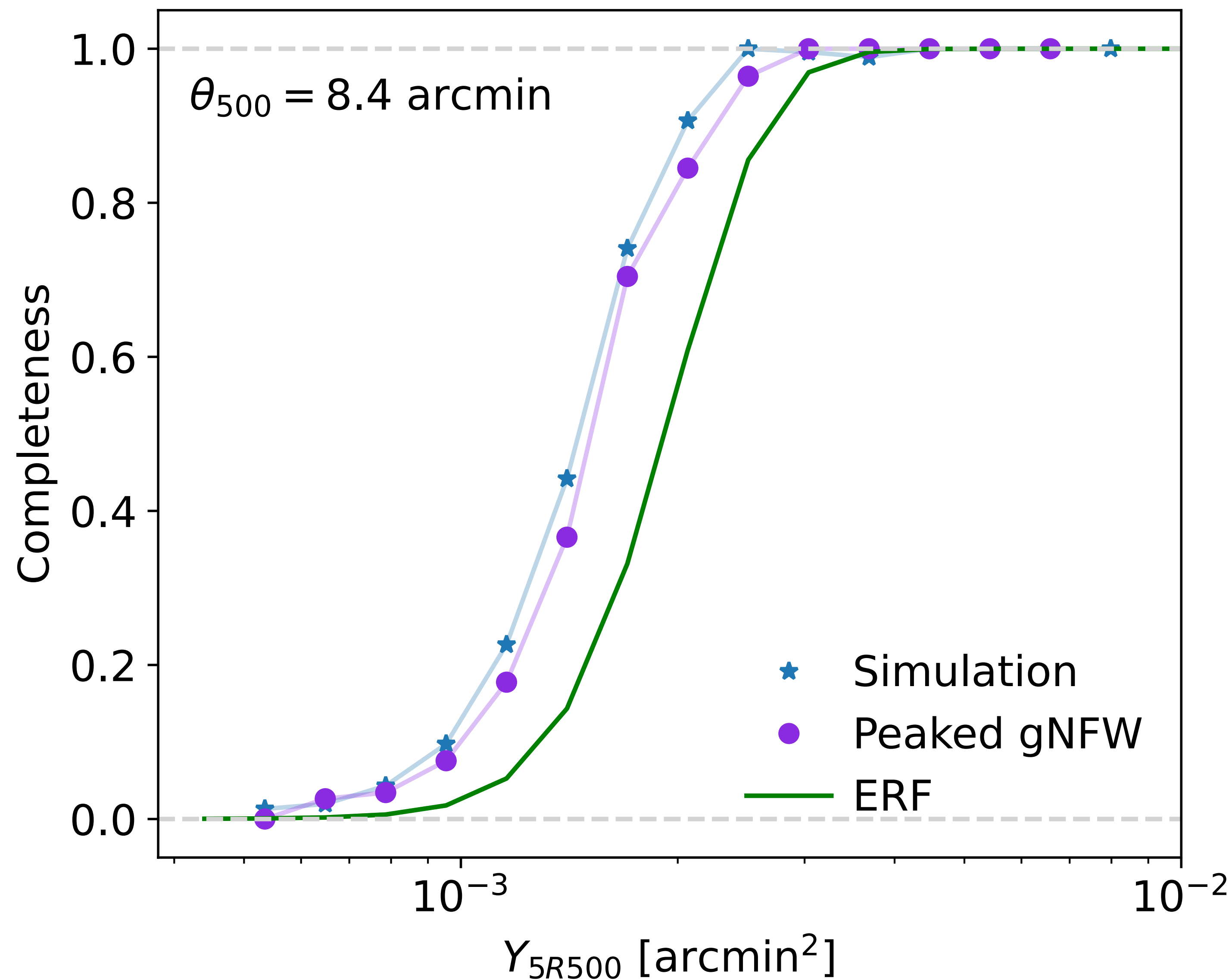
Completeness of **spherical** images ~ **analytical ERF estimation**

BUT

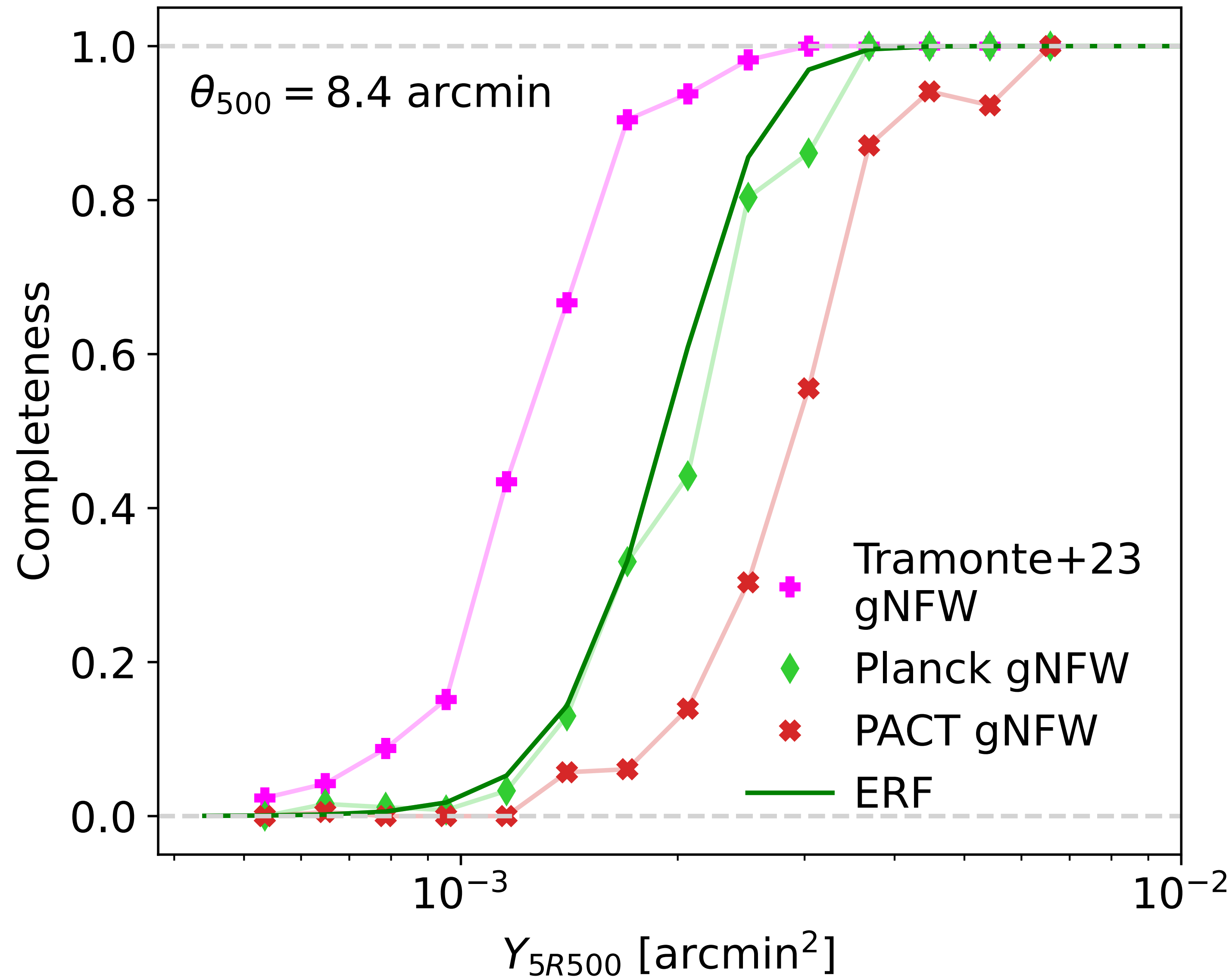
Simulation images show higher completeness than **spherical** ones

Results

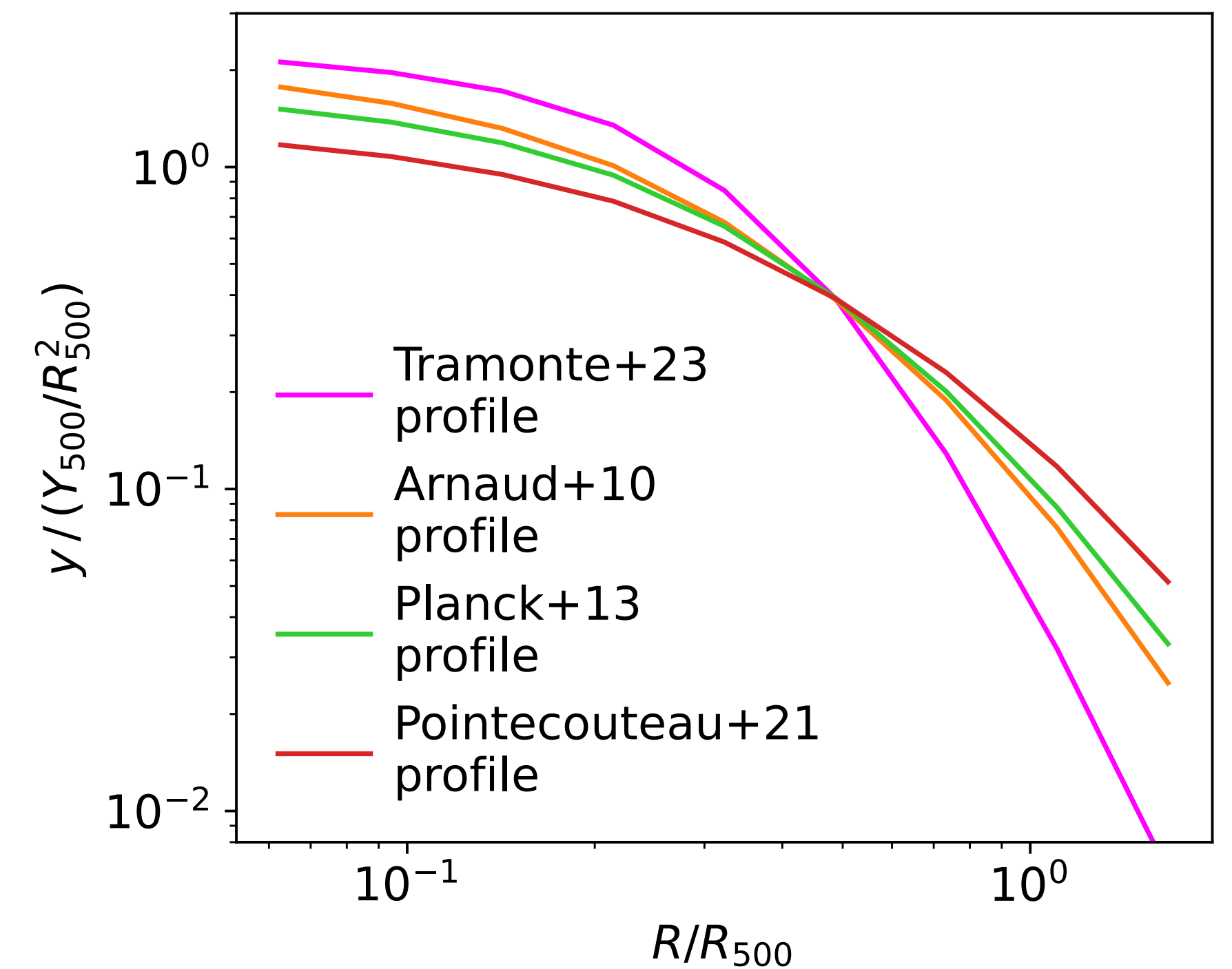




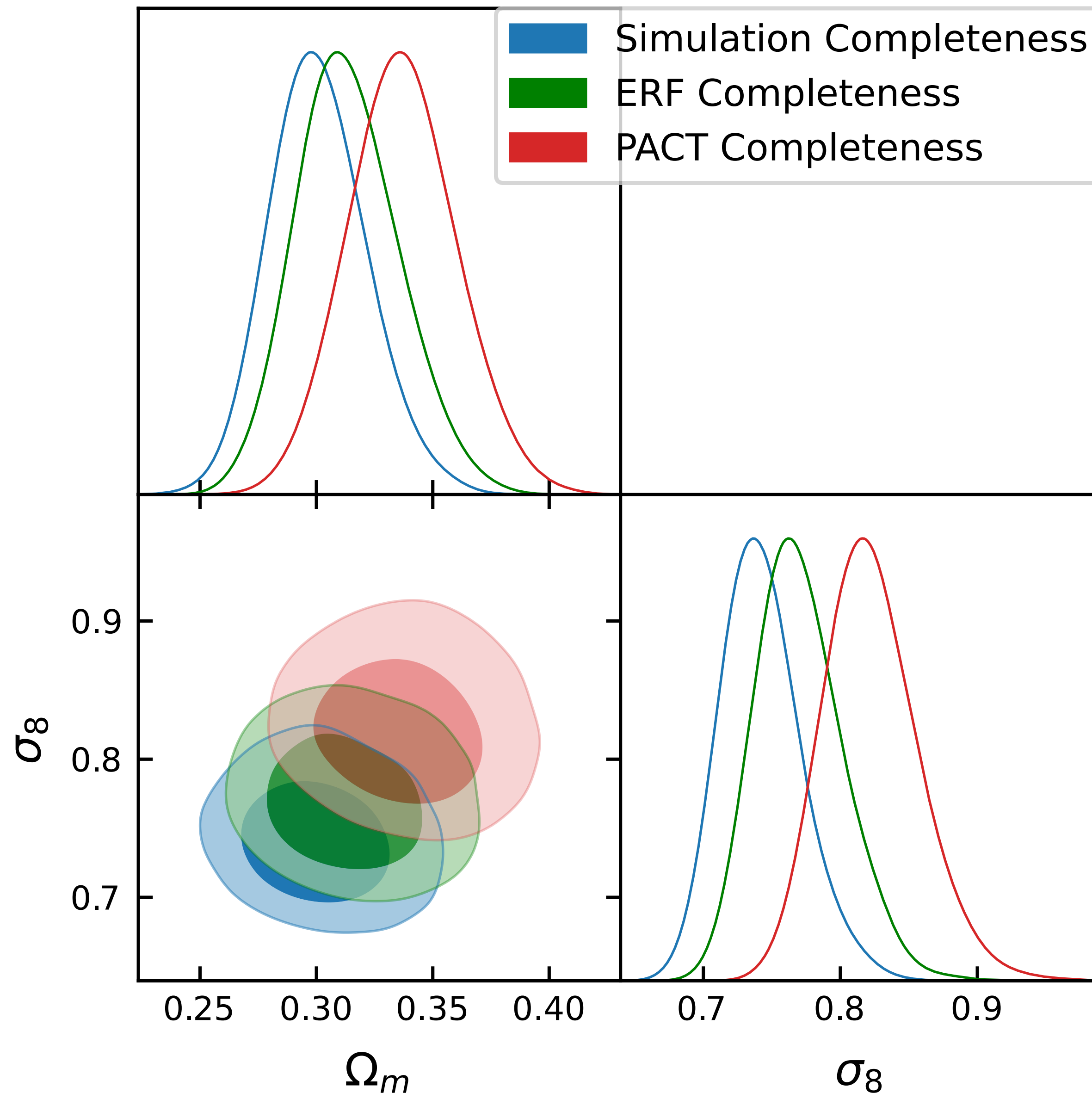
If we use a set of images with **higher concentration**, we get a completeness similar to the one of the **simulation images**



We test **different profiles** derived from observations, showing the spread it produces in the completeness



Impact on Cosmological Analysis



Testing the impact of two completeness cases on cosmological constraints

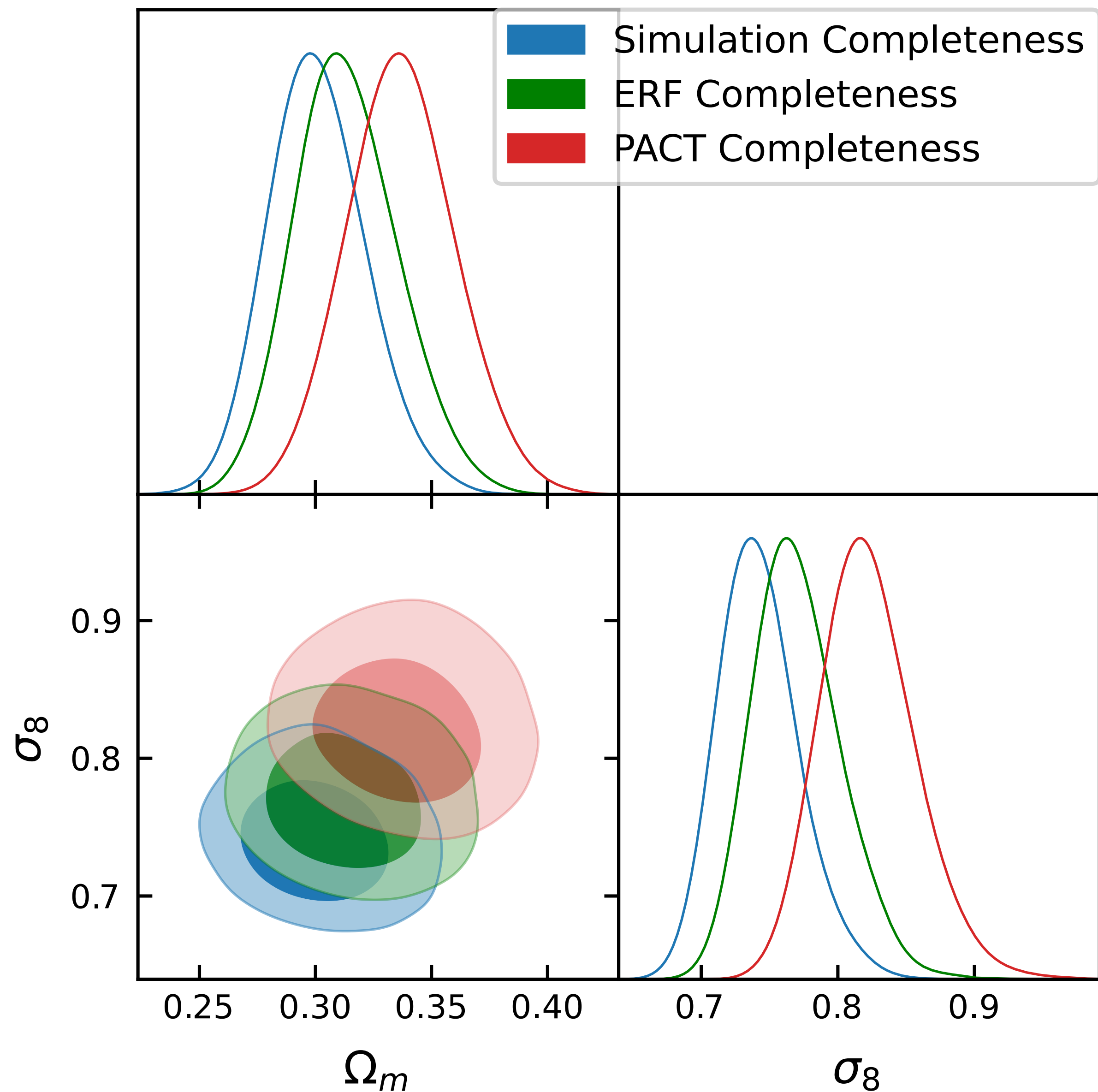


Shift in (Ω_m, σ_8) space:

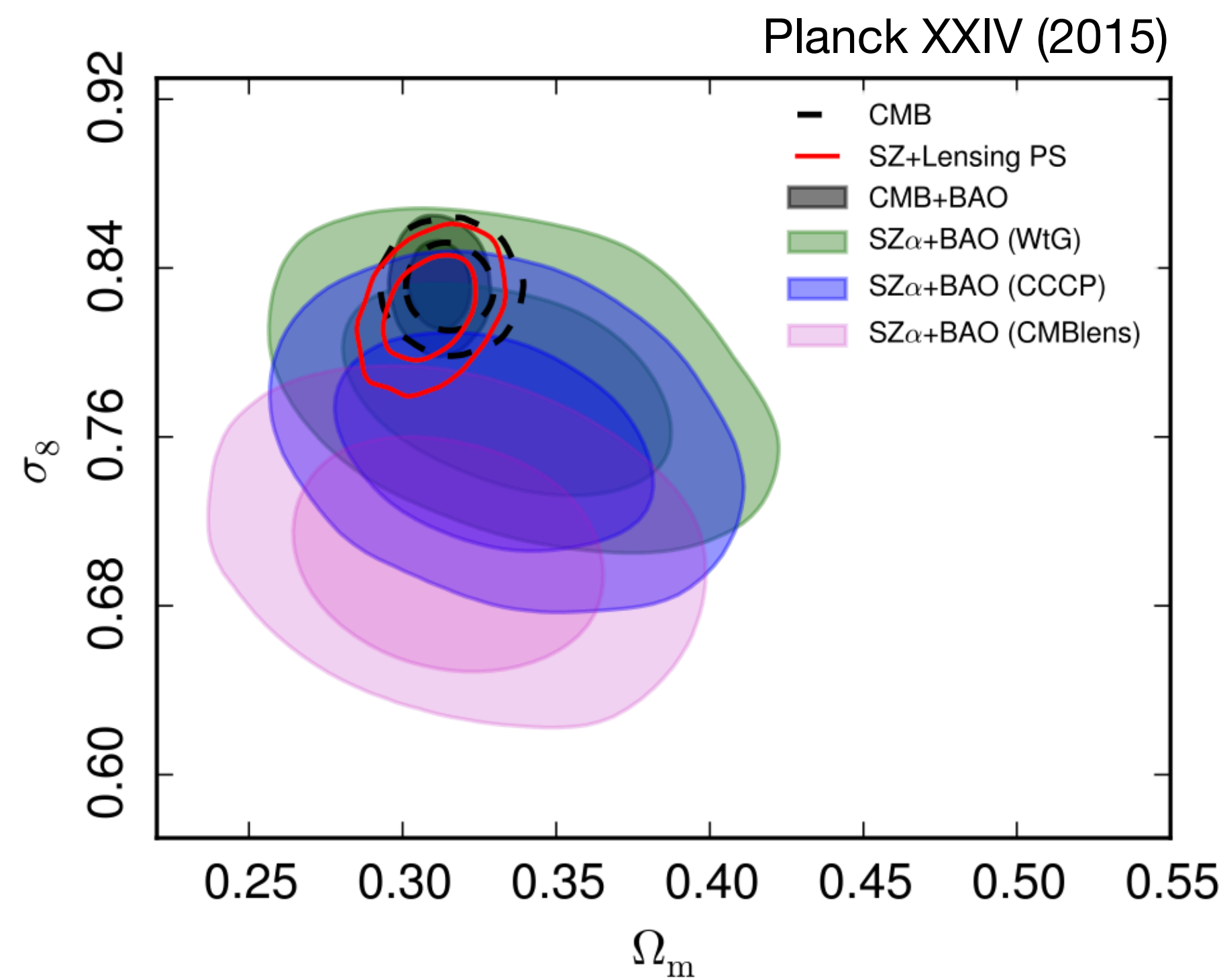
Higher completeness \rightarrow **Lower values**

Lower completeness \rightarrow **Higher values**

Impact on Cosmological Analysis



Shift in (Ω_m, σ_8) space similar to changing the scaling relations priors

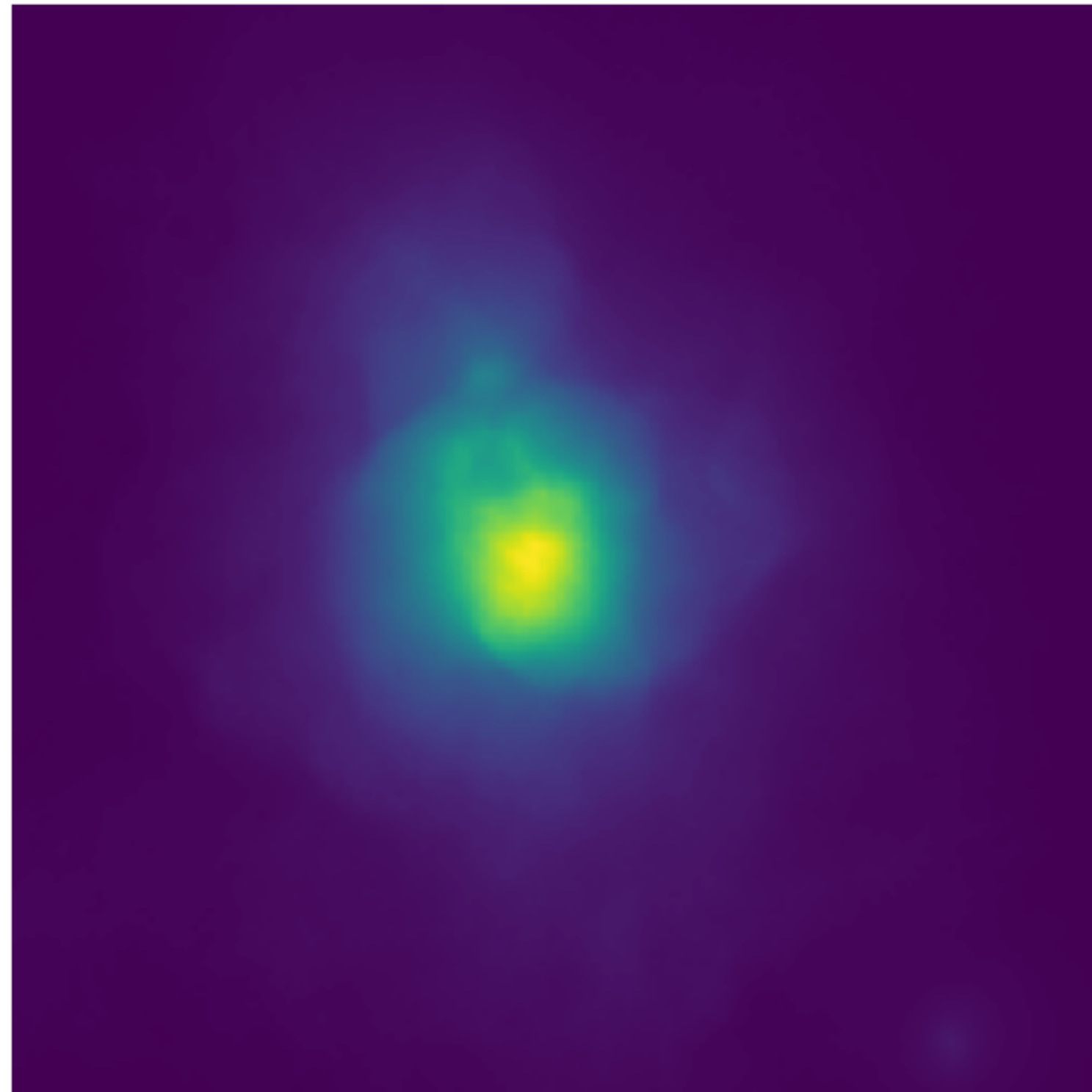
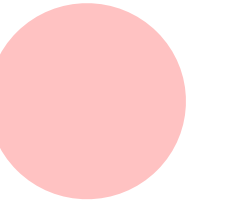


- These results suggest that the completeness depends on **different cluster parameters** beyond those of the ERF estimate.
 - In particular, we see how a **steeper** cluster profile leads to an increased probability of detection, while a **flatter** profile reduces it.
 - Furthermore, we tested the impact of **cluster morphology** on the completeness, finding that more elliptical objects are slightly more difficult to detect.
 - Changing the completeness in the cosmological analysis moves the constraints on (Ω_m, σ_8) along the same direction of the mass scaling relations.
- Need for more precise determination of clusters' profiles

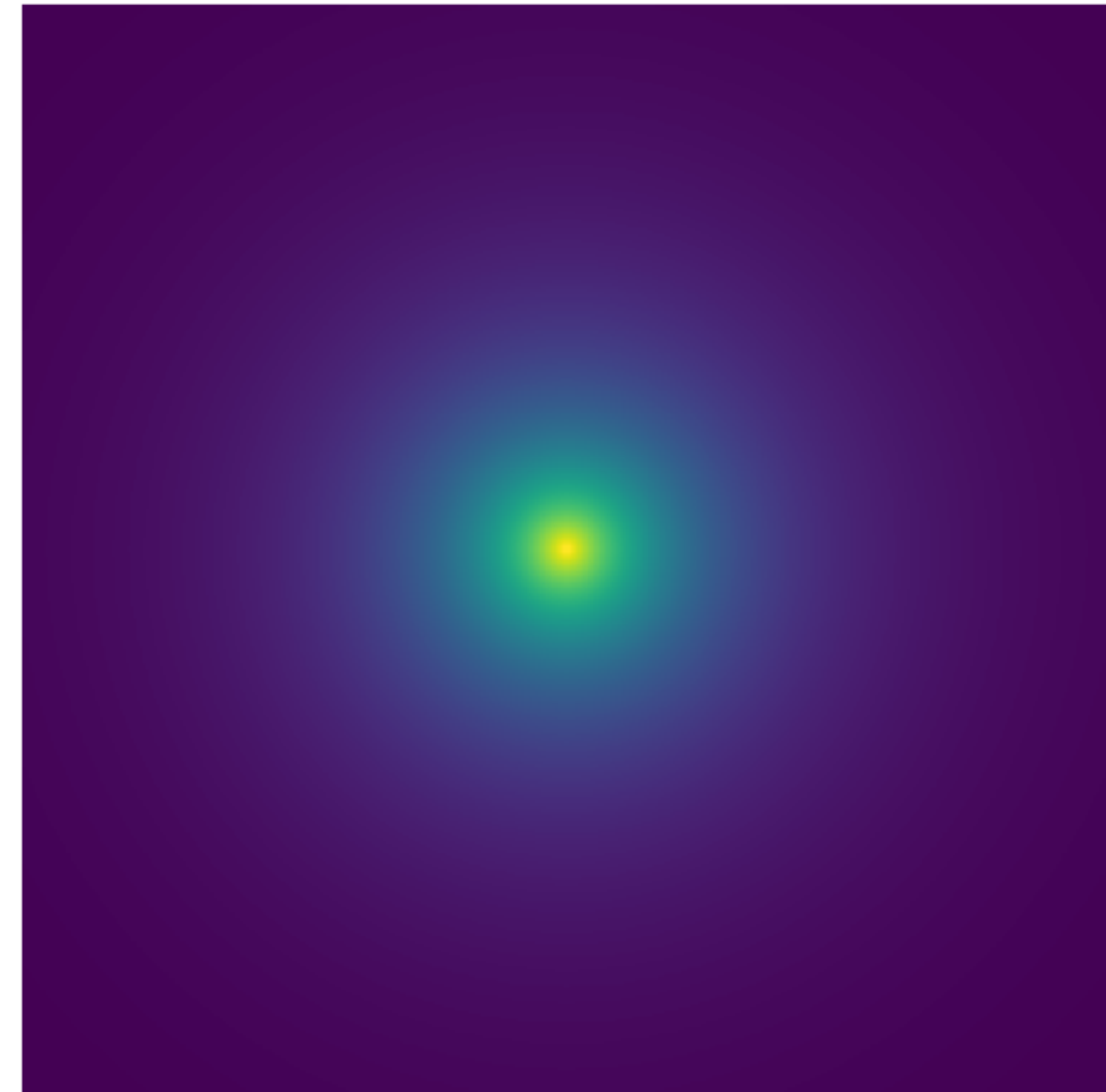
Thank you

Backup

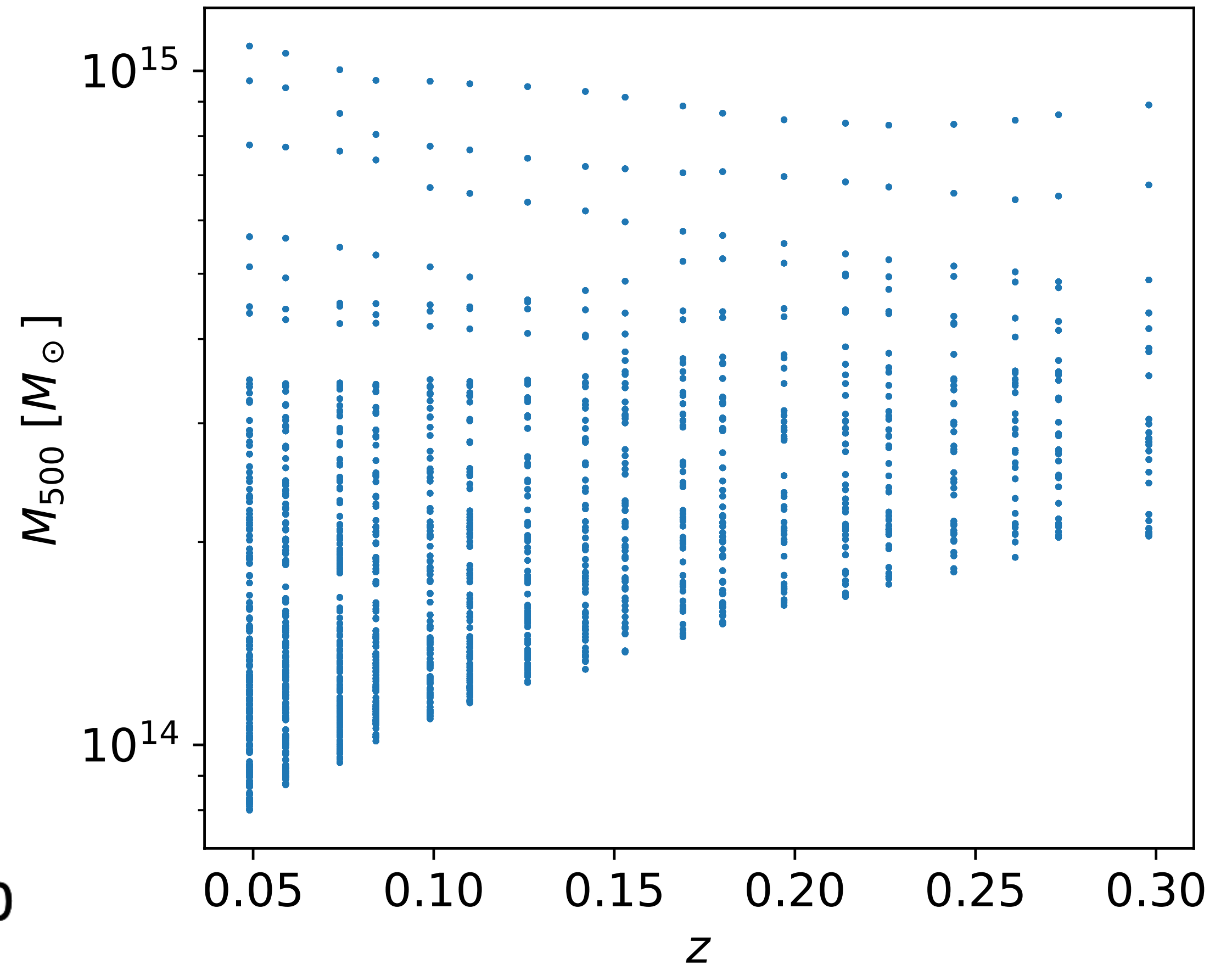
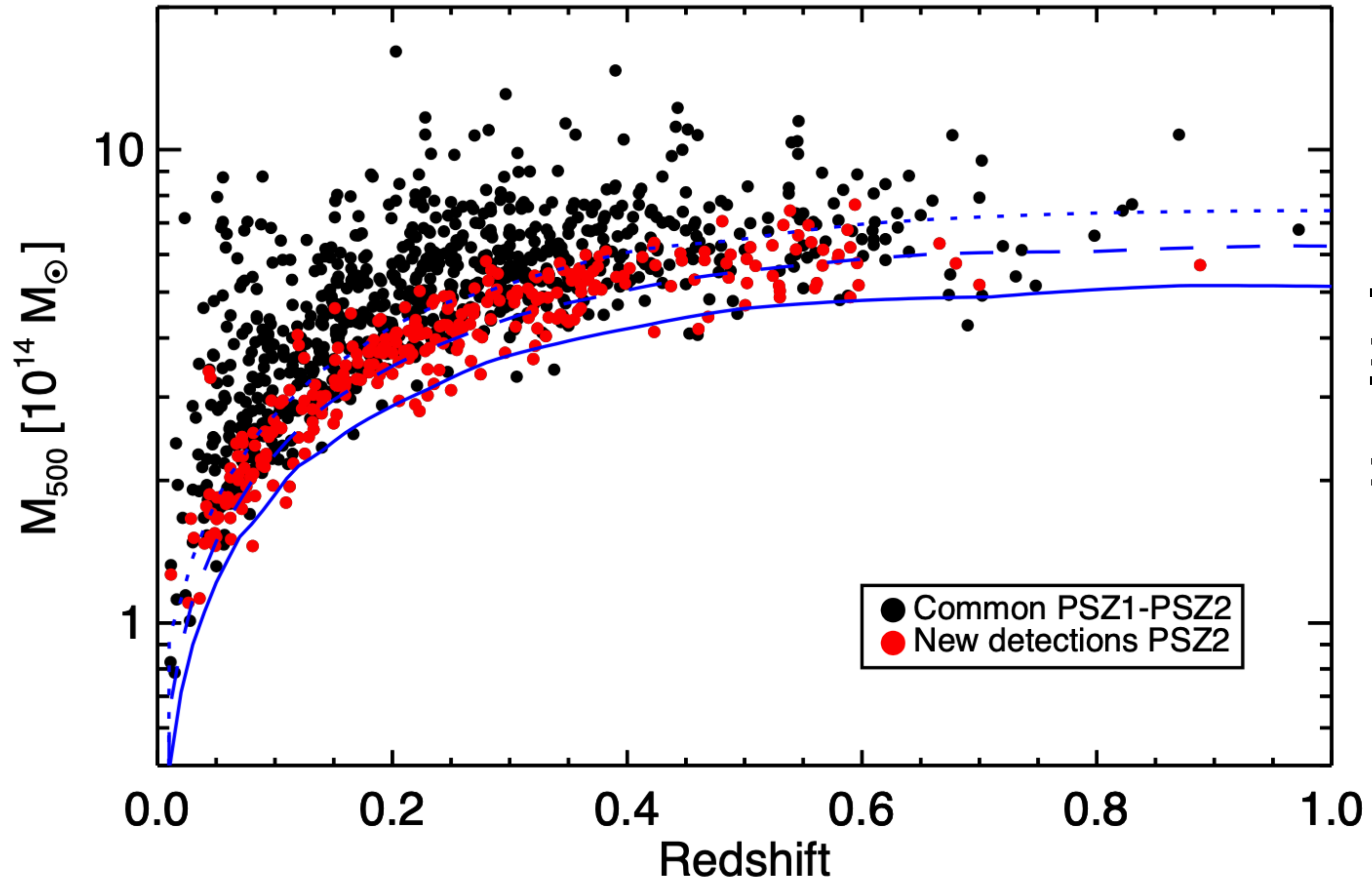
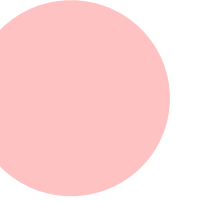
Cluster images

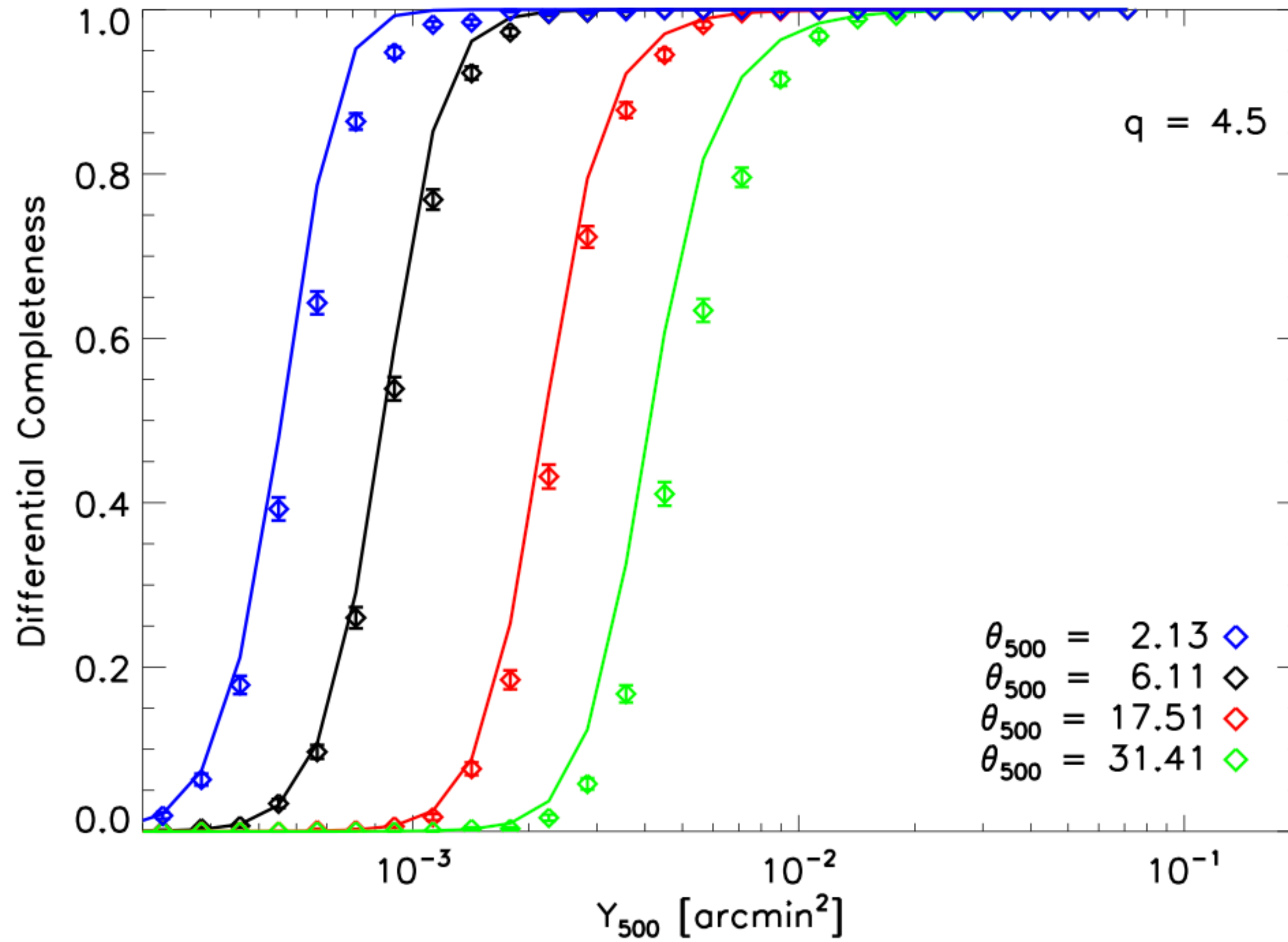
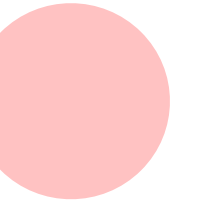


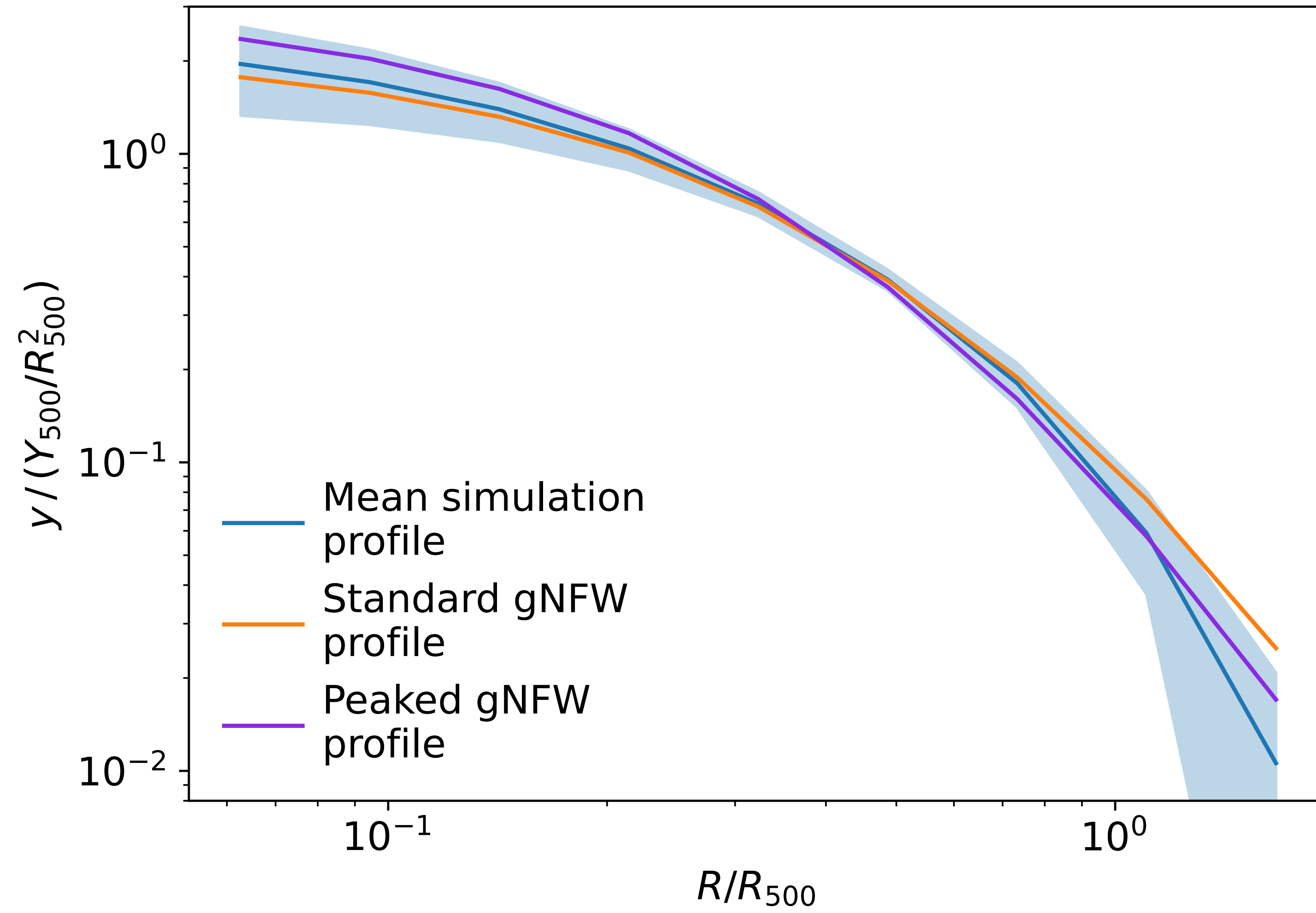
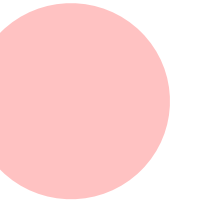
Simulation

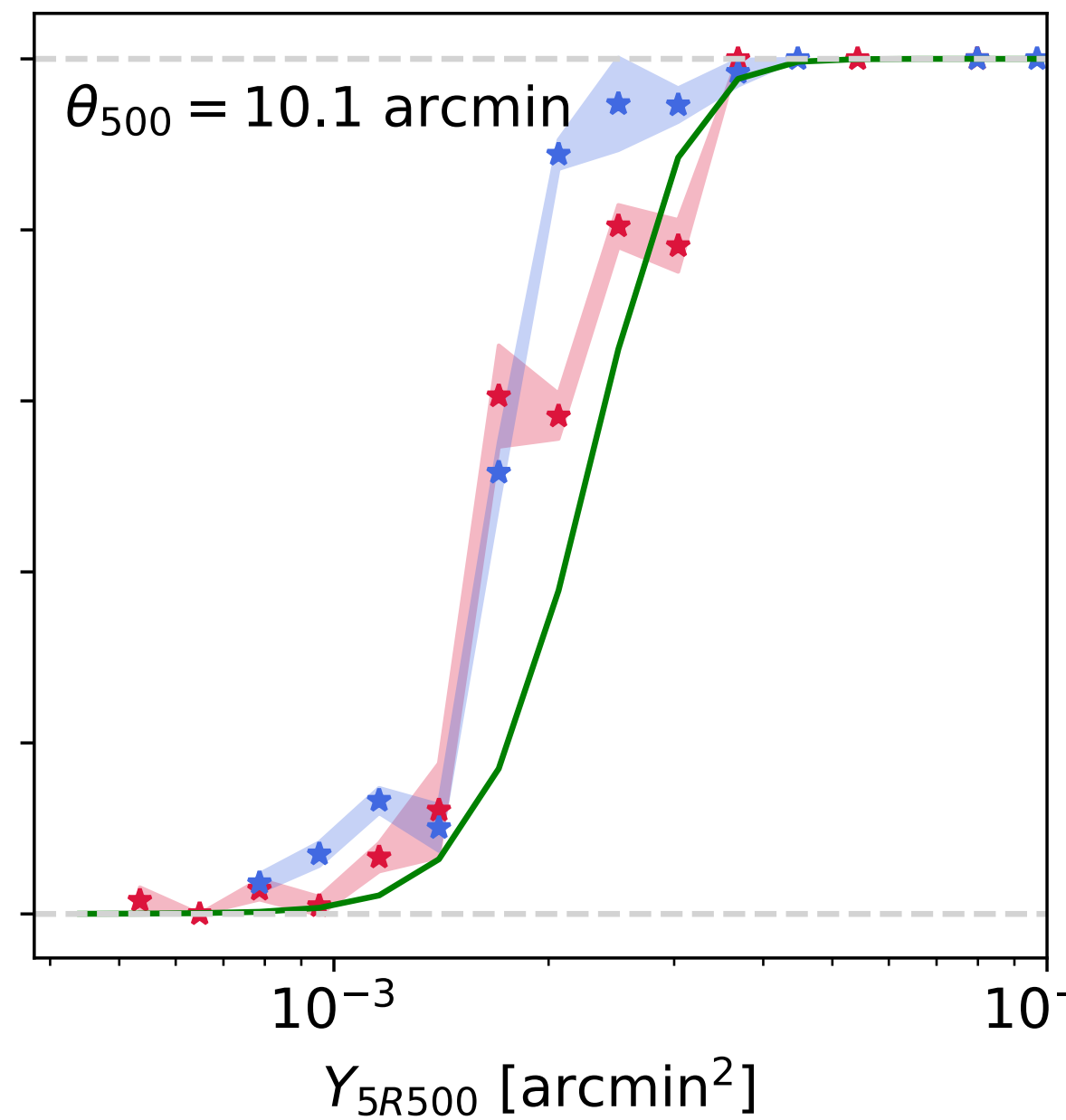
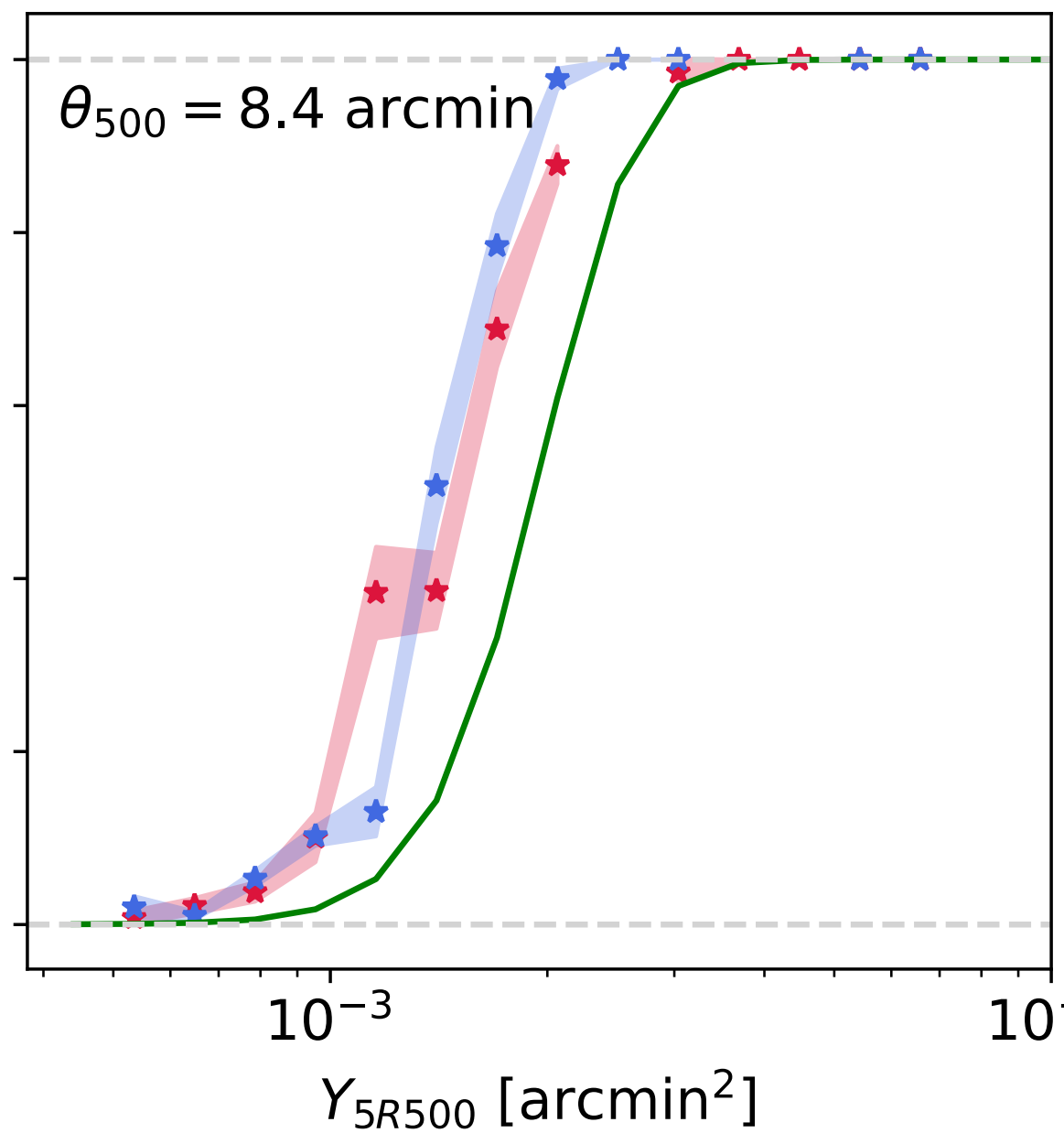
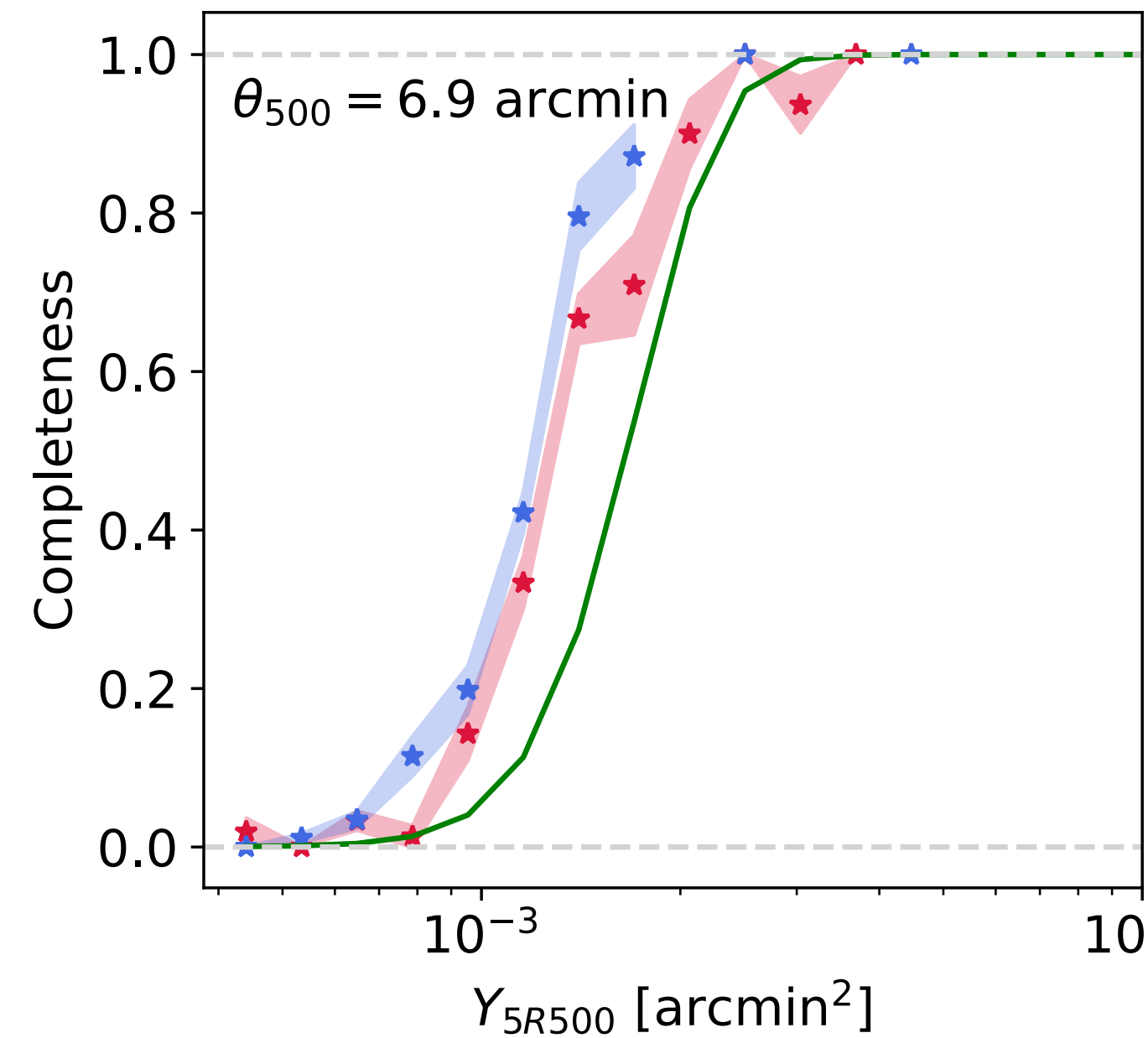
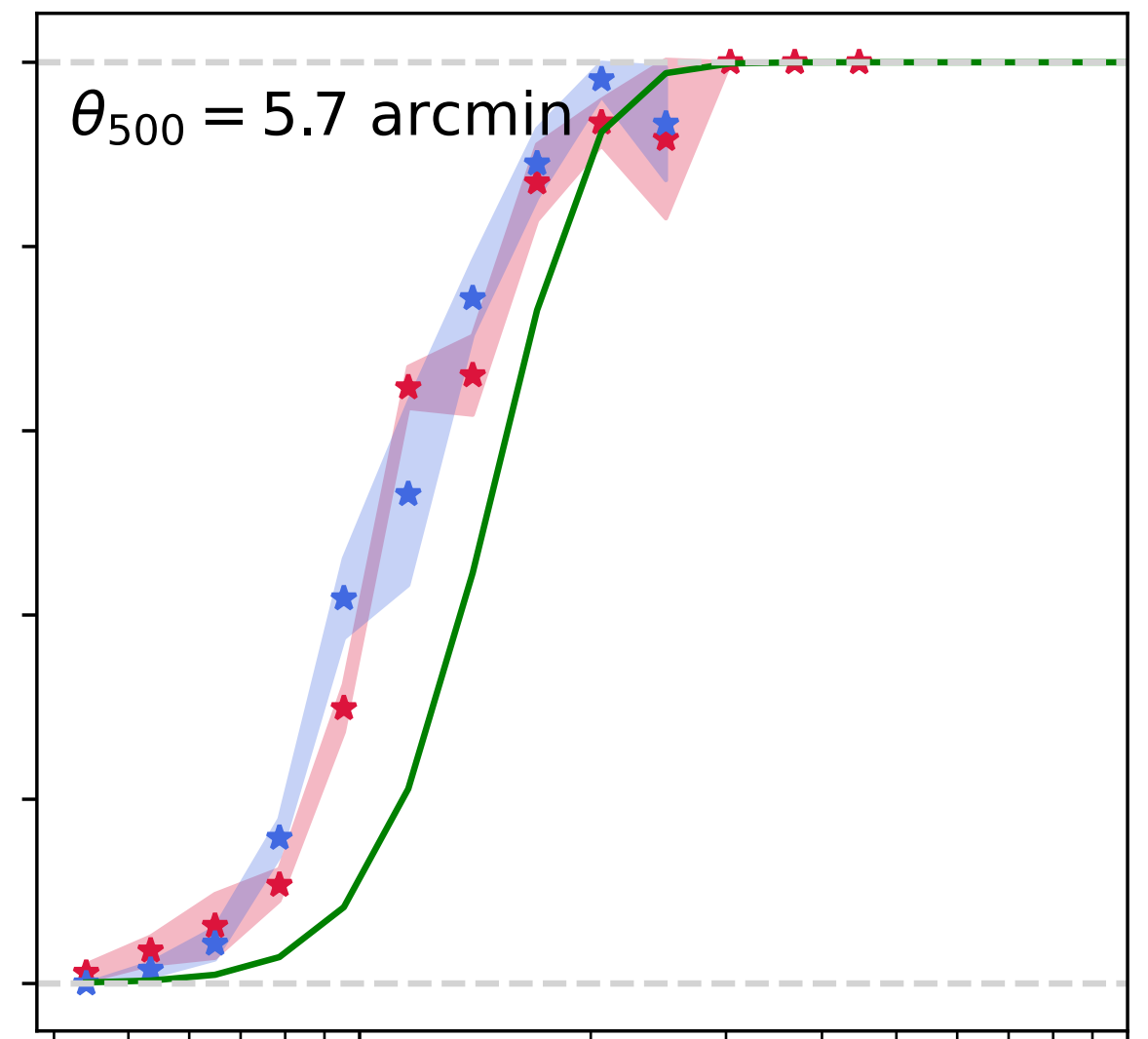
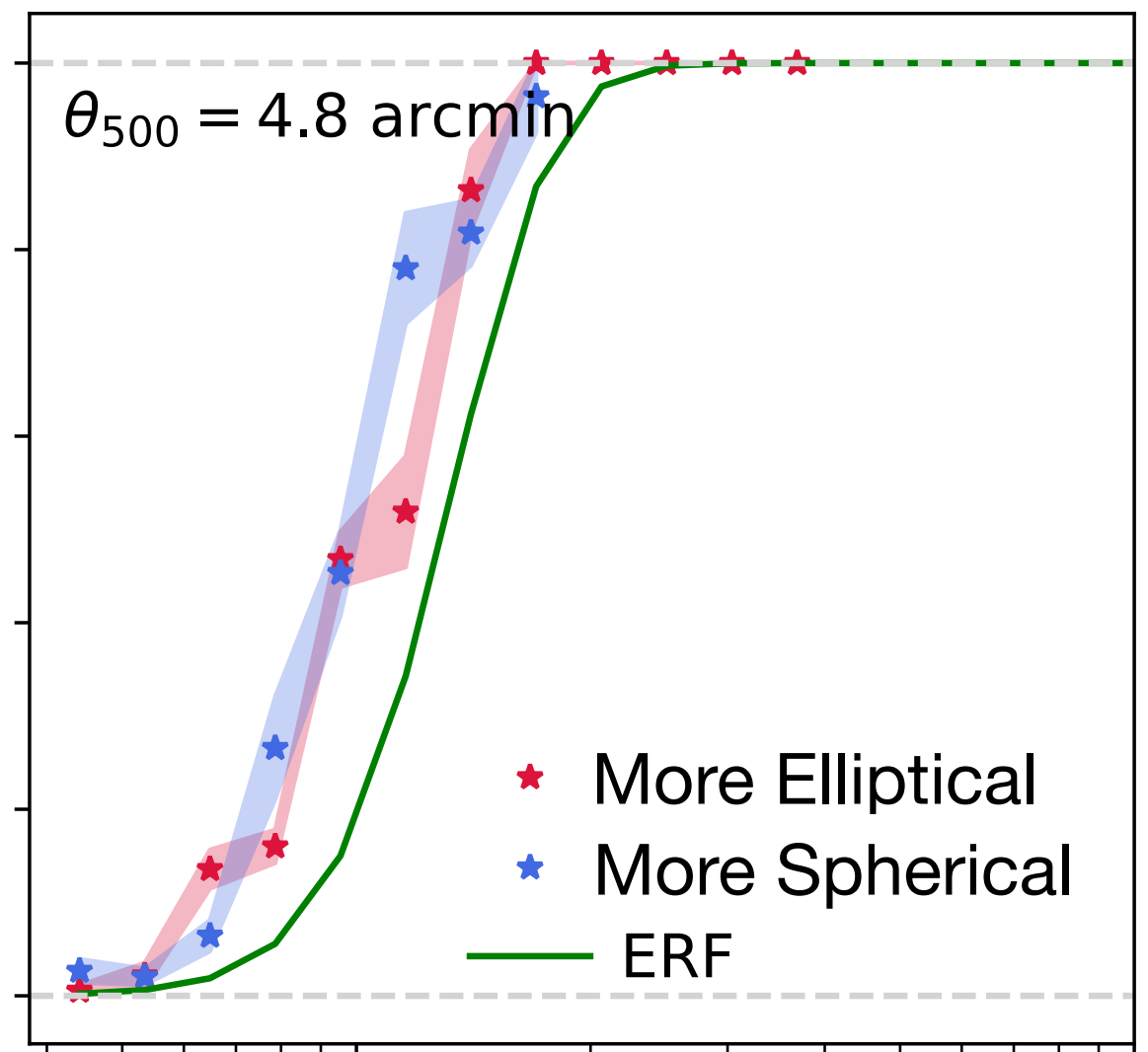
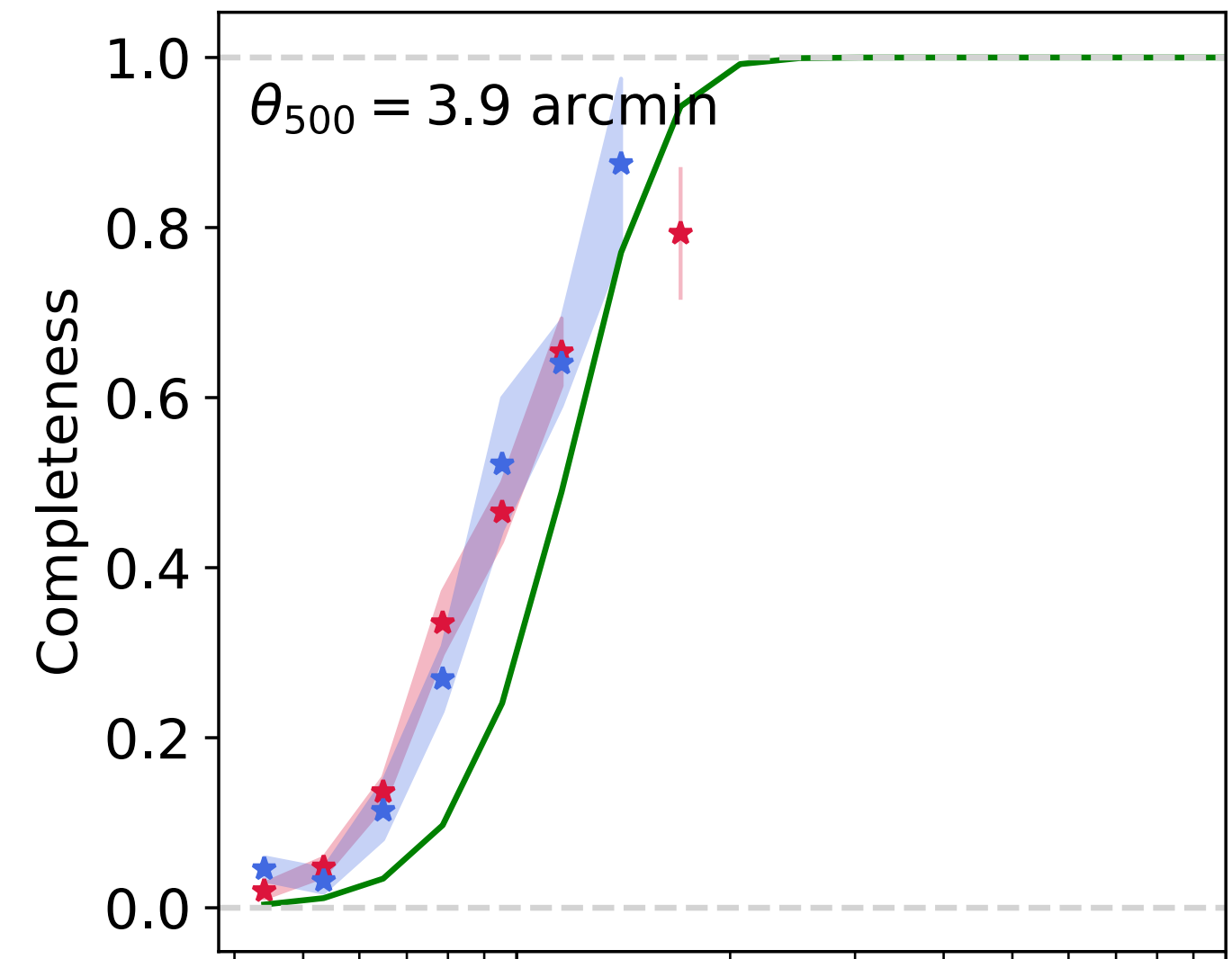
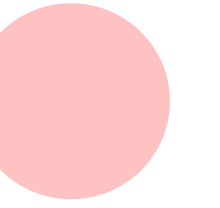


gNFW

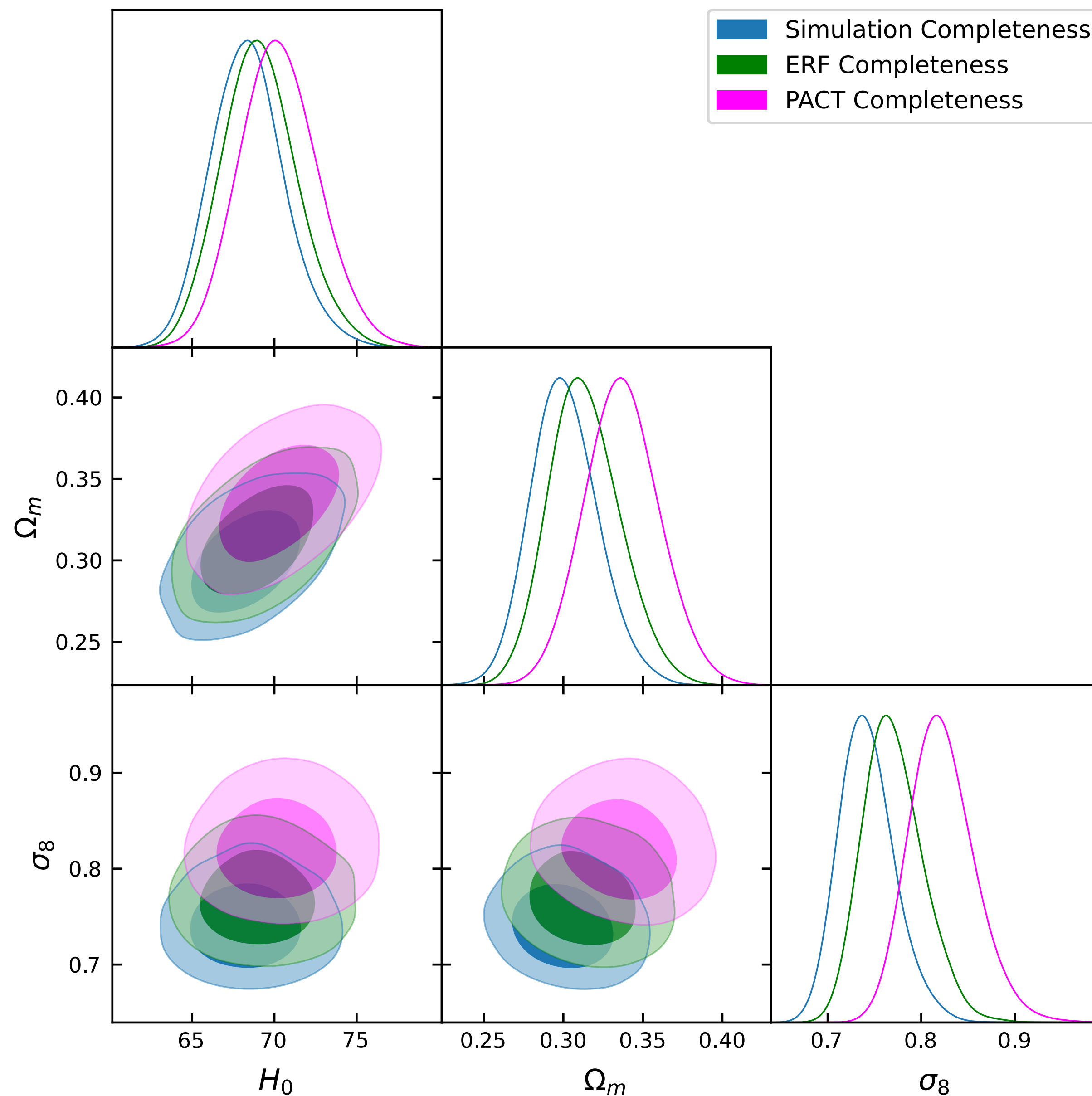
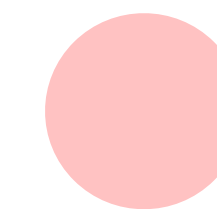








Impact on Cosmological Analysis



Impact on Cosmological Analysis

