A strong lensing view of the core-cusp problem

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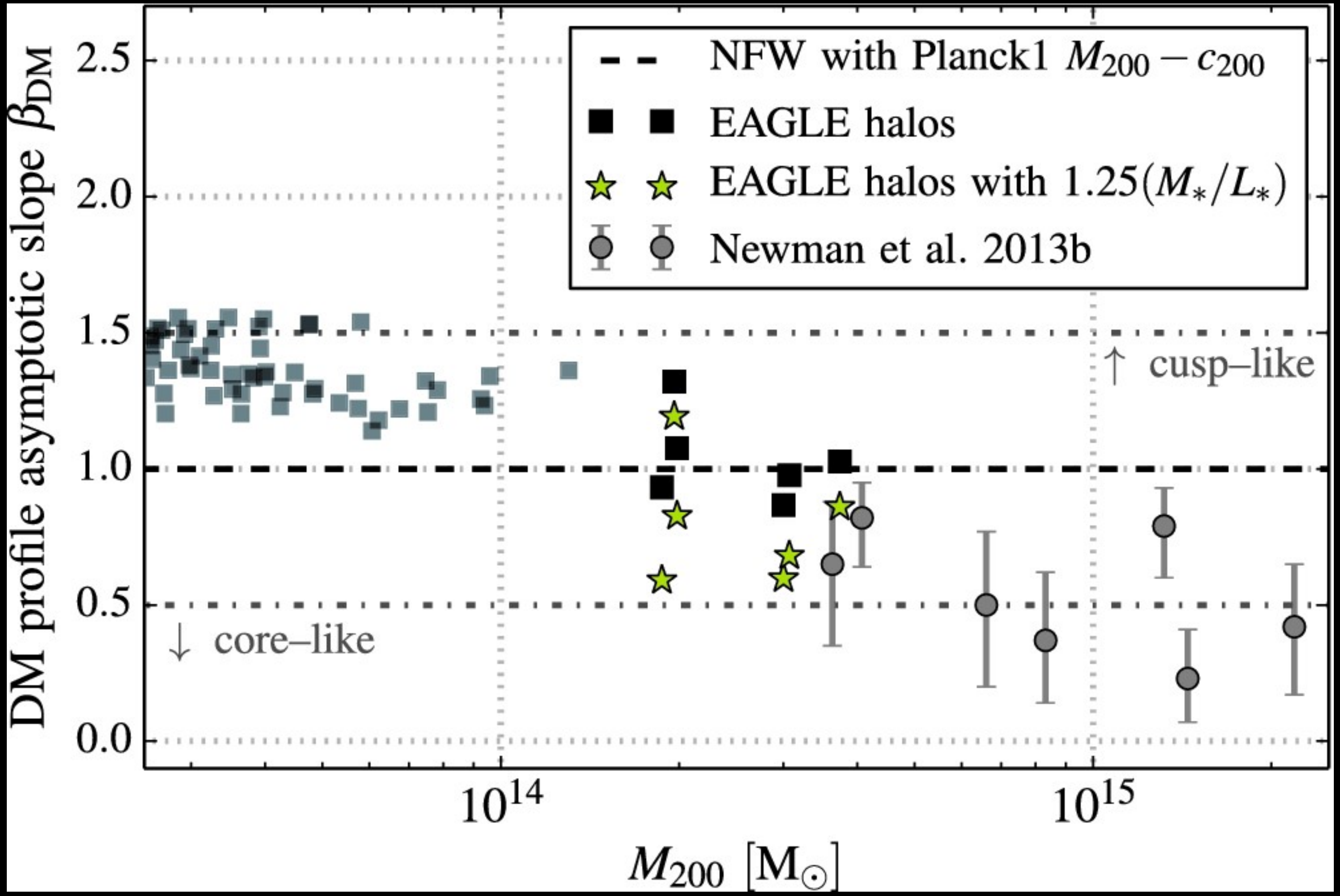
The core-cusp problem in massive galaxies

Theory

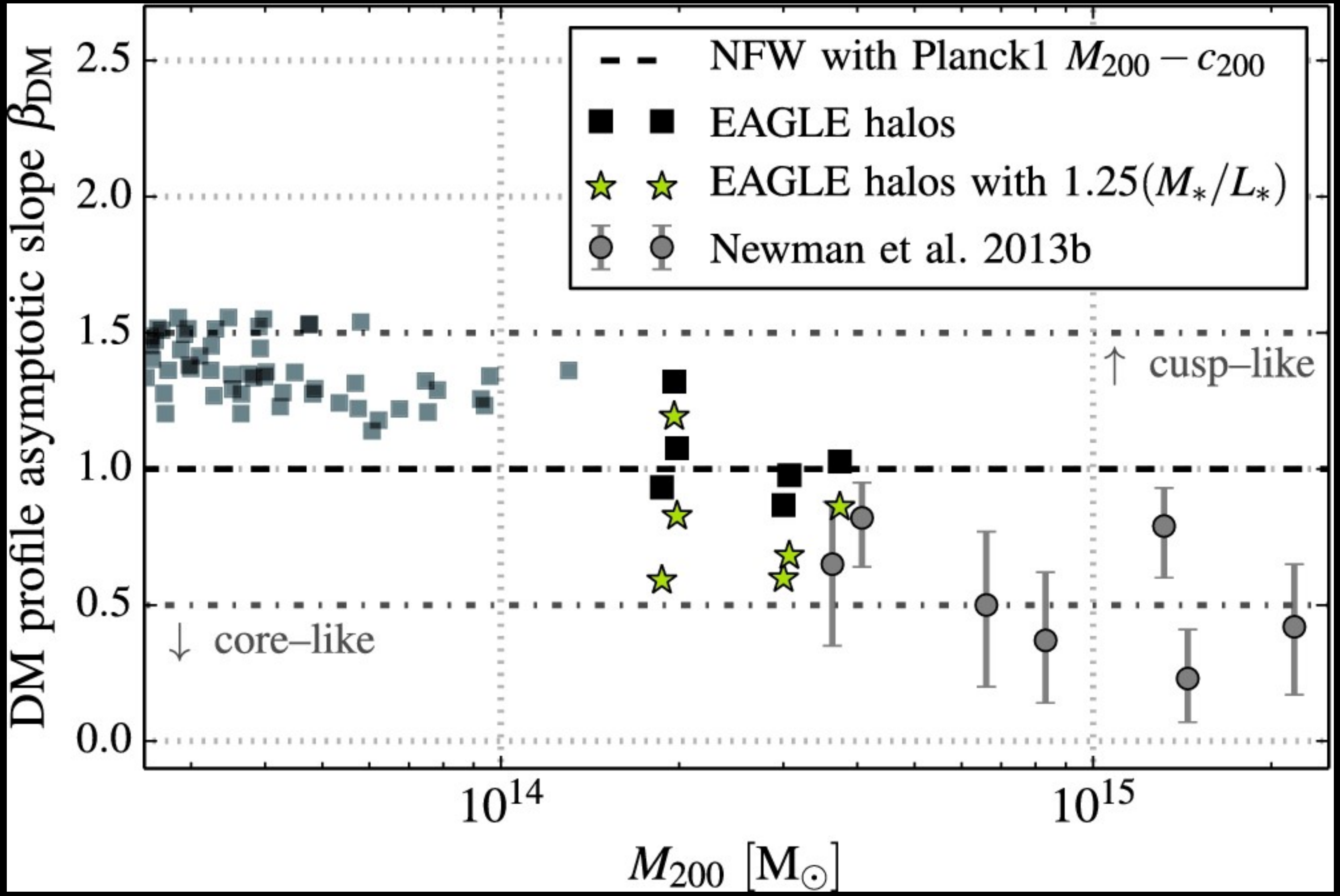


Schaller et al. (2015)

Observations

The core-cusp problem in massive galaxies

Theory

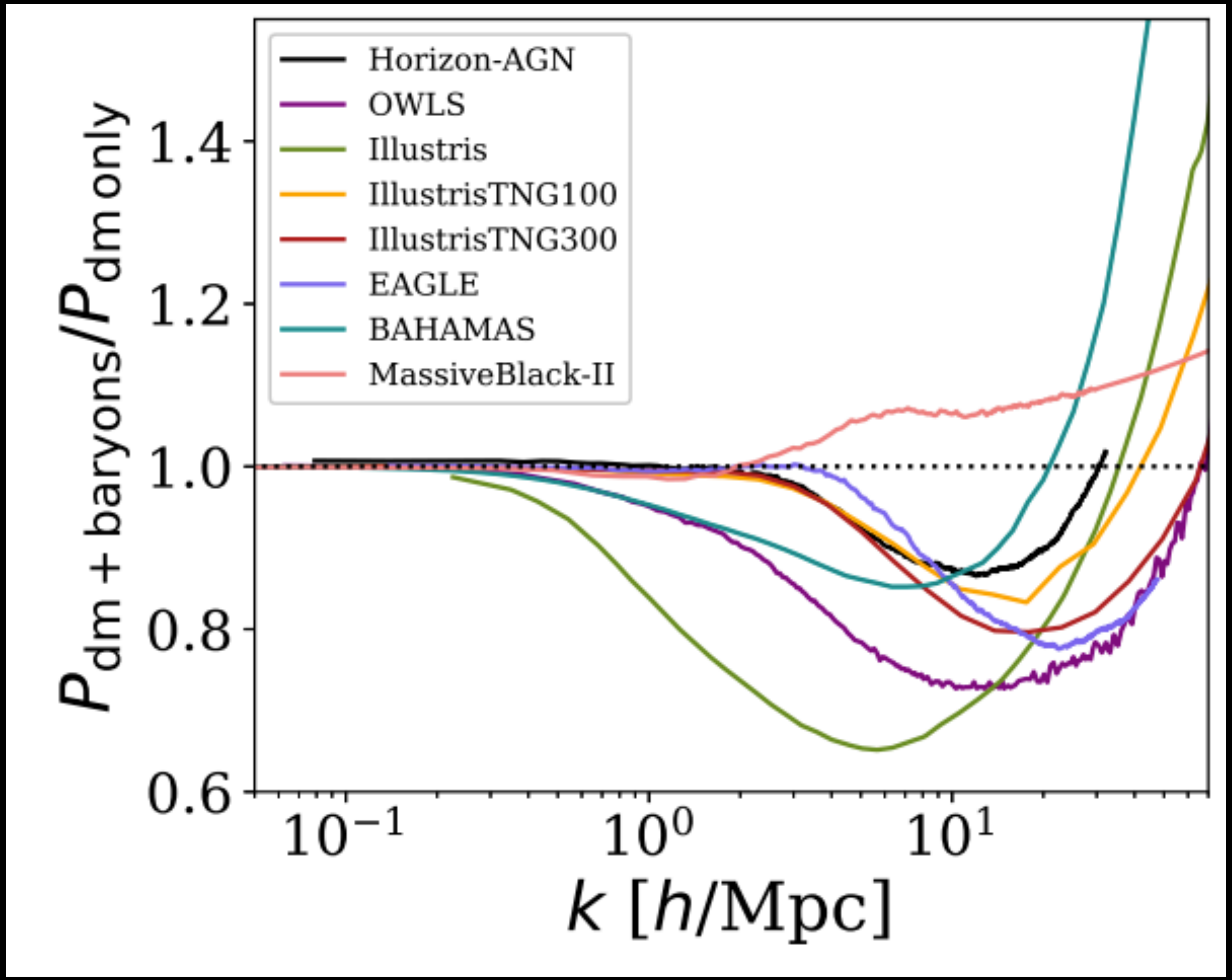


Schaller et al. (2015)

Observations

?

Sensitivity to baryonic physics



Chisari et al. (2019)

P(k) = matter power spectrum

Strong gravitational lensing

$$\theta_{\mathrm{Ein}} = \sqrt{\frac{4GM}{c^2}\frac{D_{\mathrm{ls}}}{D_{\mathrm{l}}D_{\mathrm{s}}}}$$

- Rare event (~1 per square degree)
- Probes mass on scales of 5-10 kpc (1” at z=0.5)
- ~1000 strong lenses known

What a single lens tells us

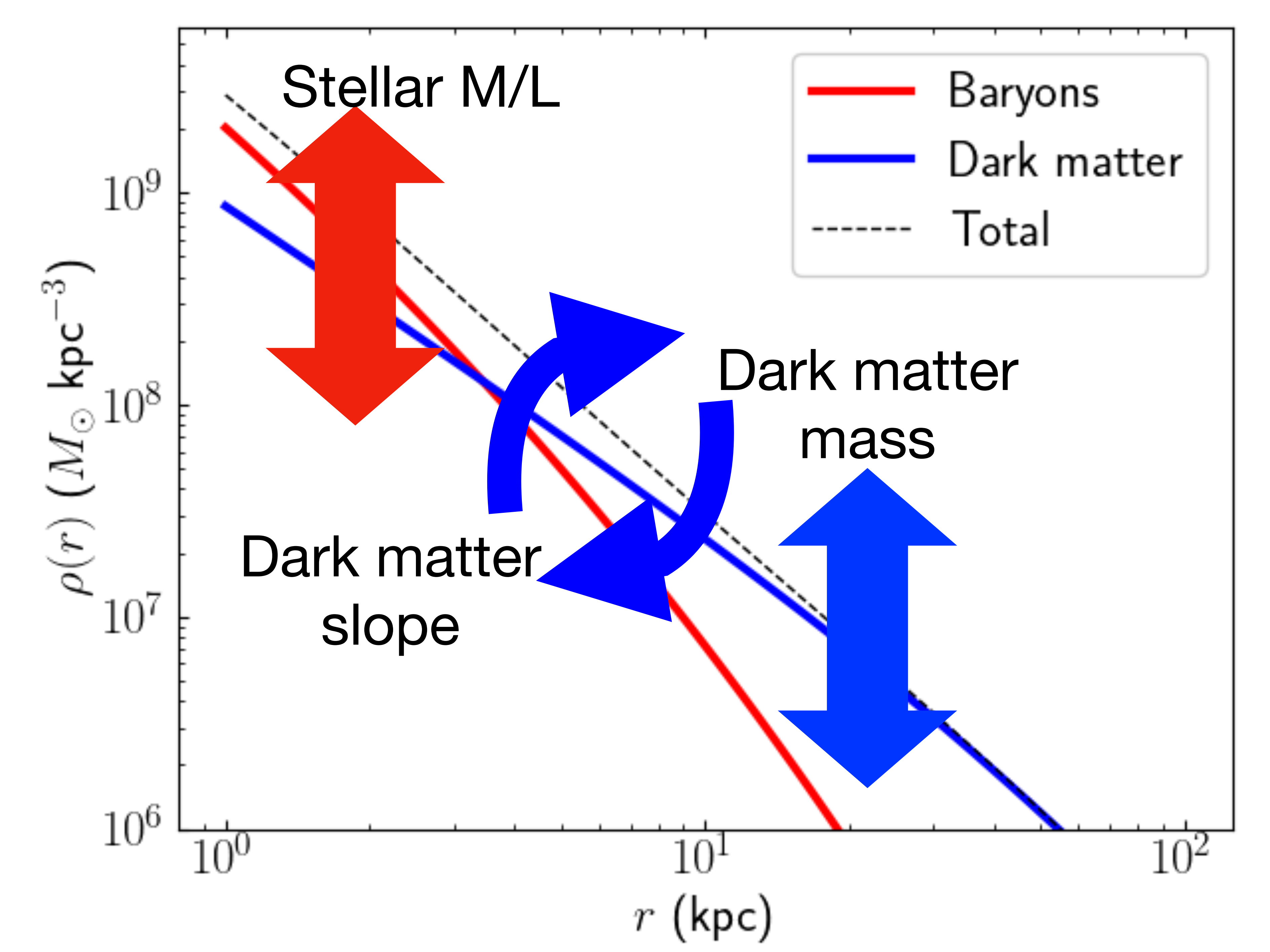
- Total projected mass within the Einstein radius
- Third derivative of the lens potential at the Einstein radius (maybe)
- Number of constraints on the radial profile <= 2

$$\rho(r) \propto r^{-\gamma}$$

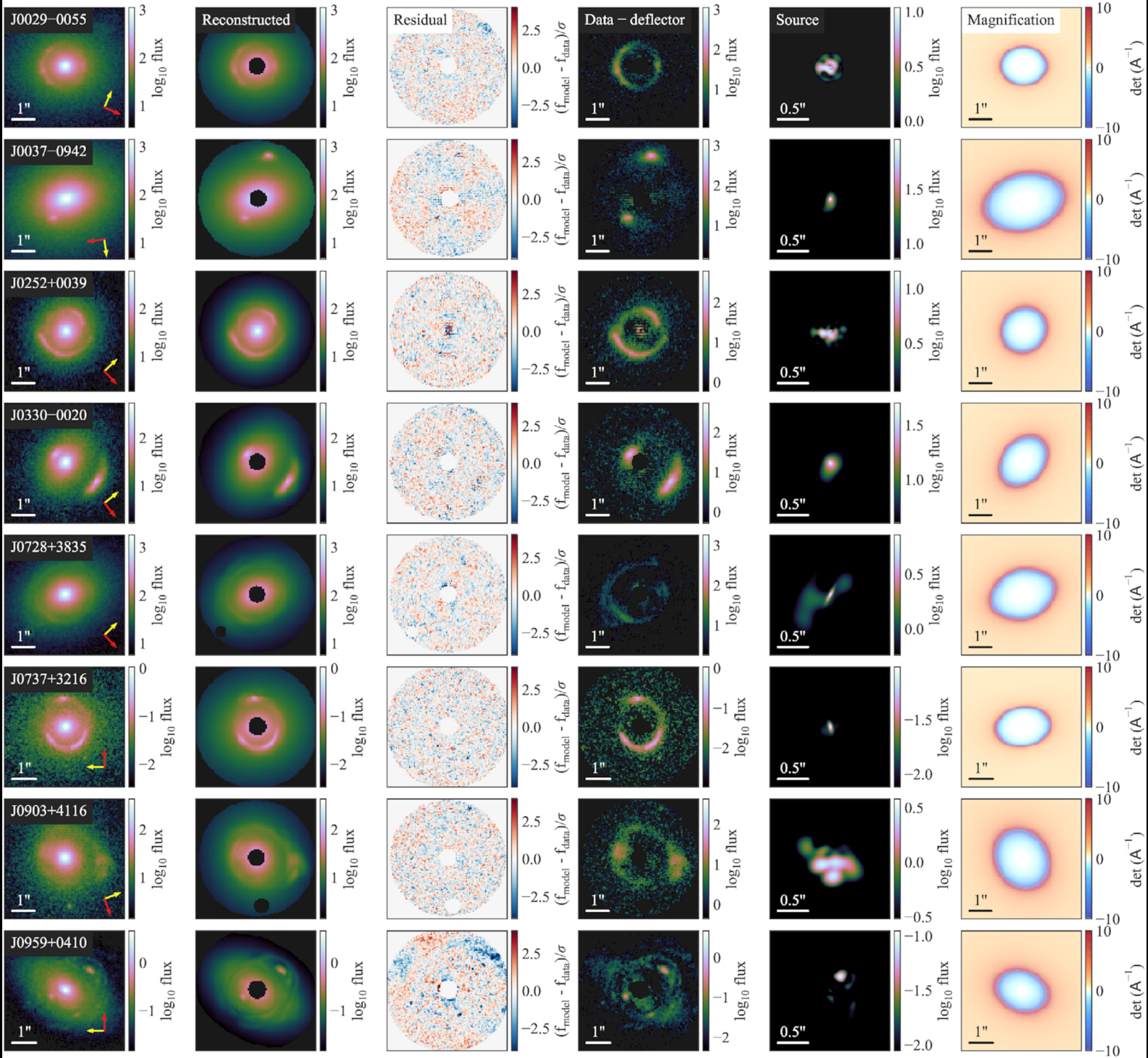
$\gamma = 1.8$ $\gamma = 2.0$ $\gamma = 2.2$

What we want to measure

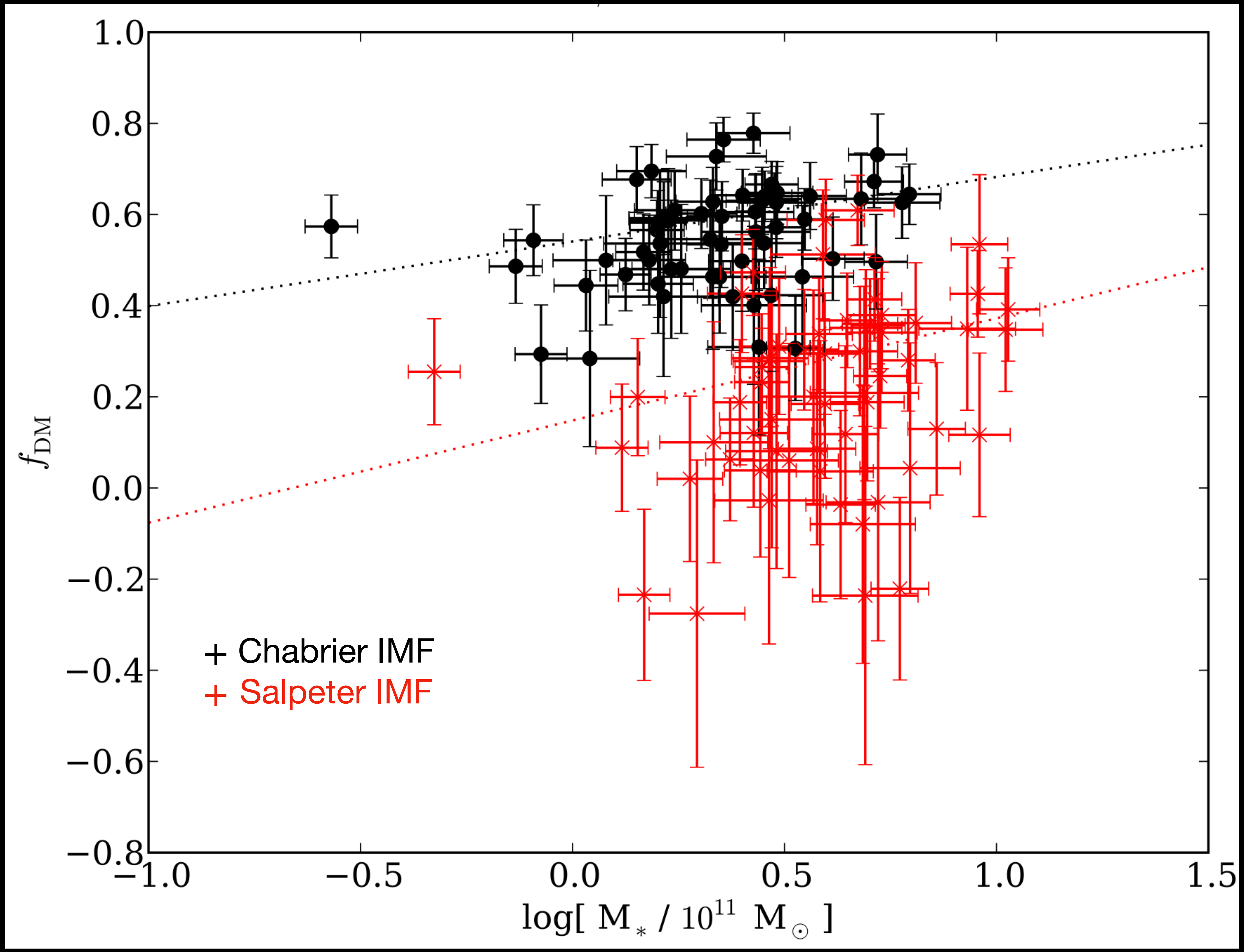
- The simplest physically interesting model has 3 degrees of freedom in the radial direction



Shajib et al. (2021)

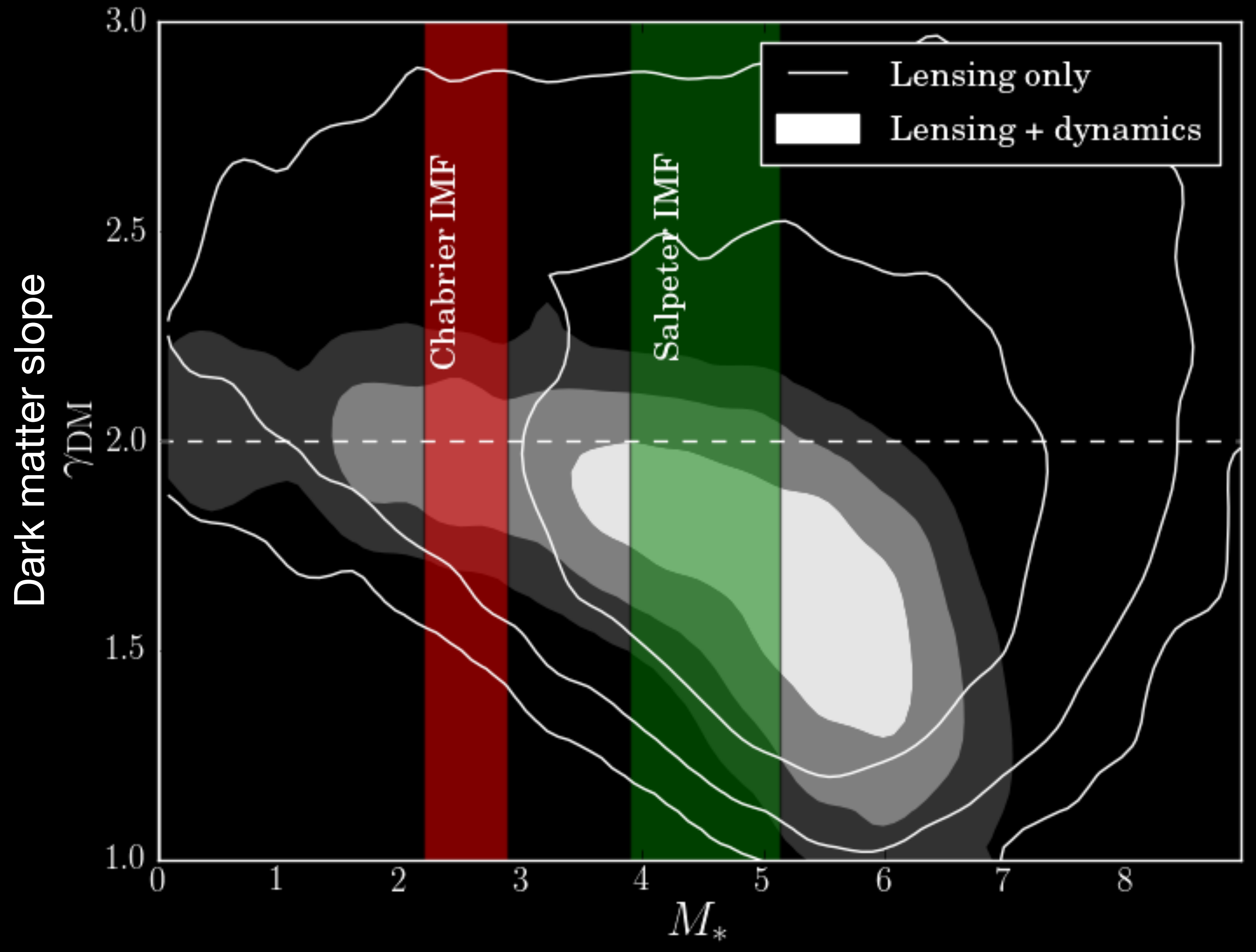


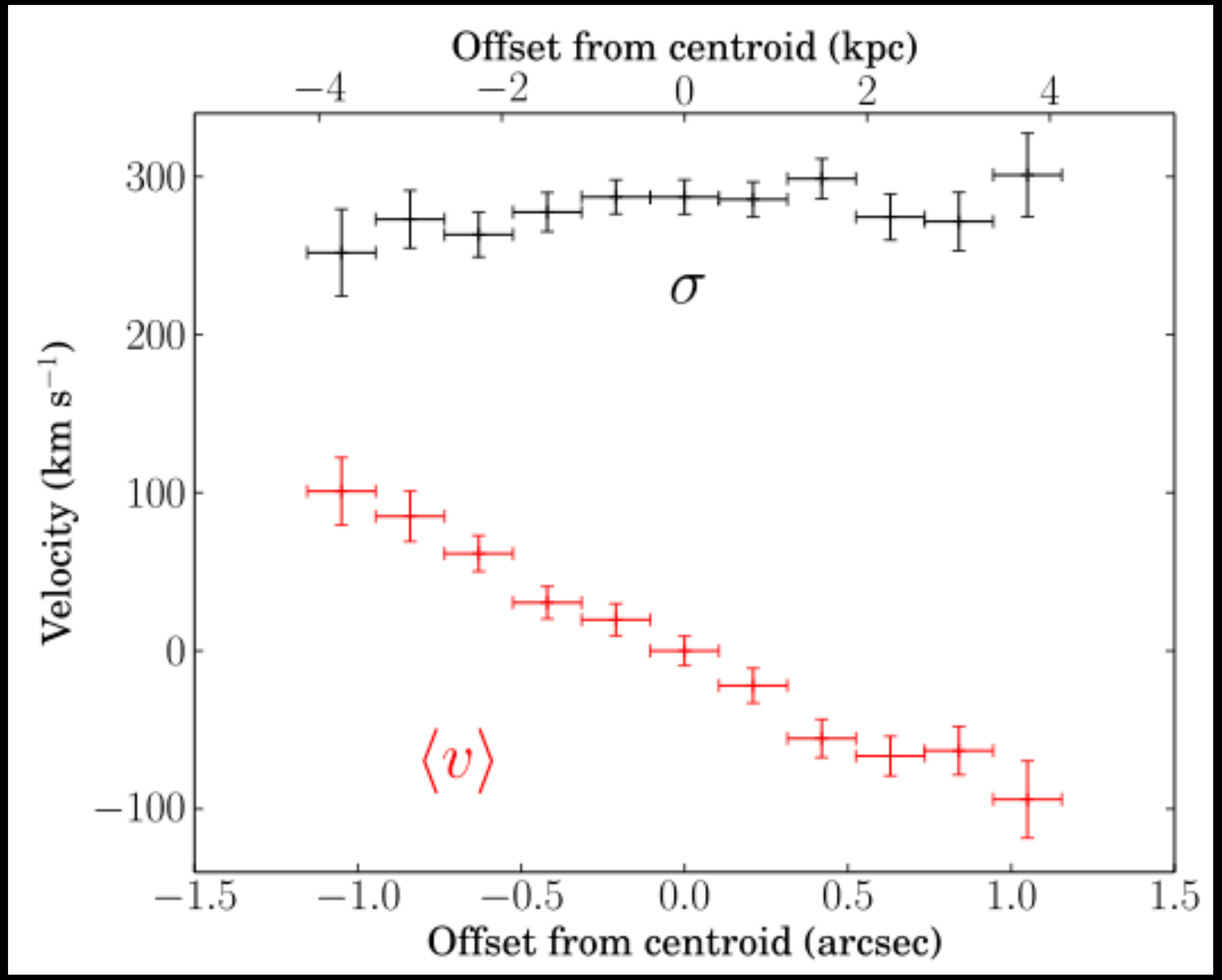
Stars-dark matter degeneracy



Auger et al. (2010)

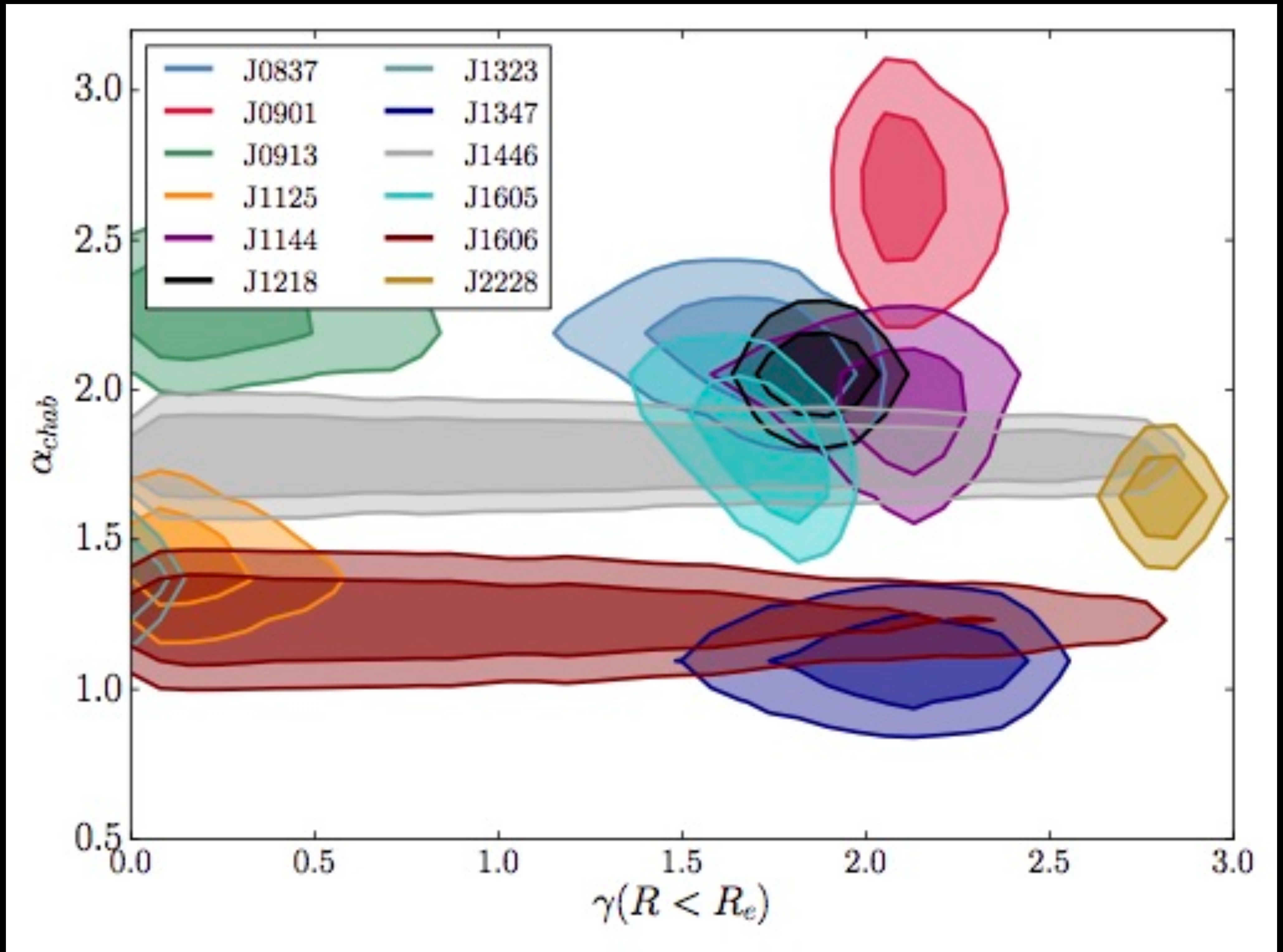
Strong lensing and stellar kinematics

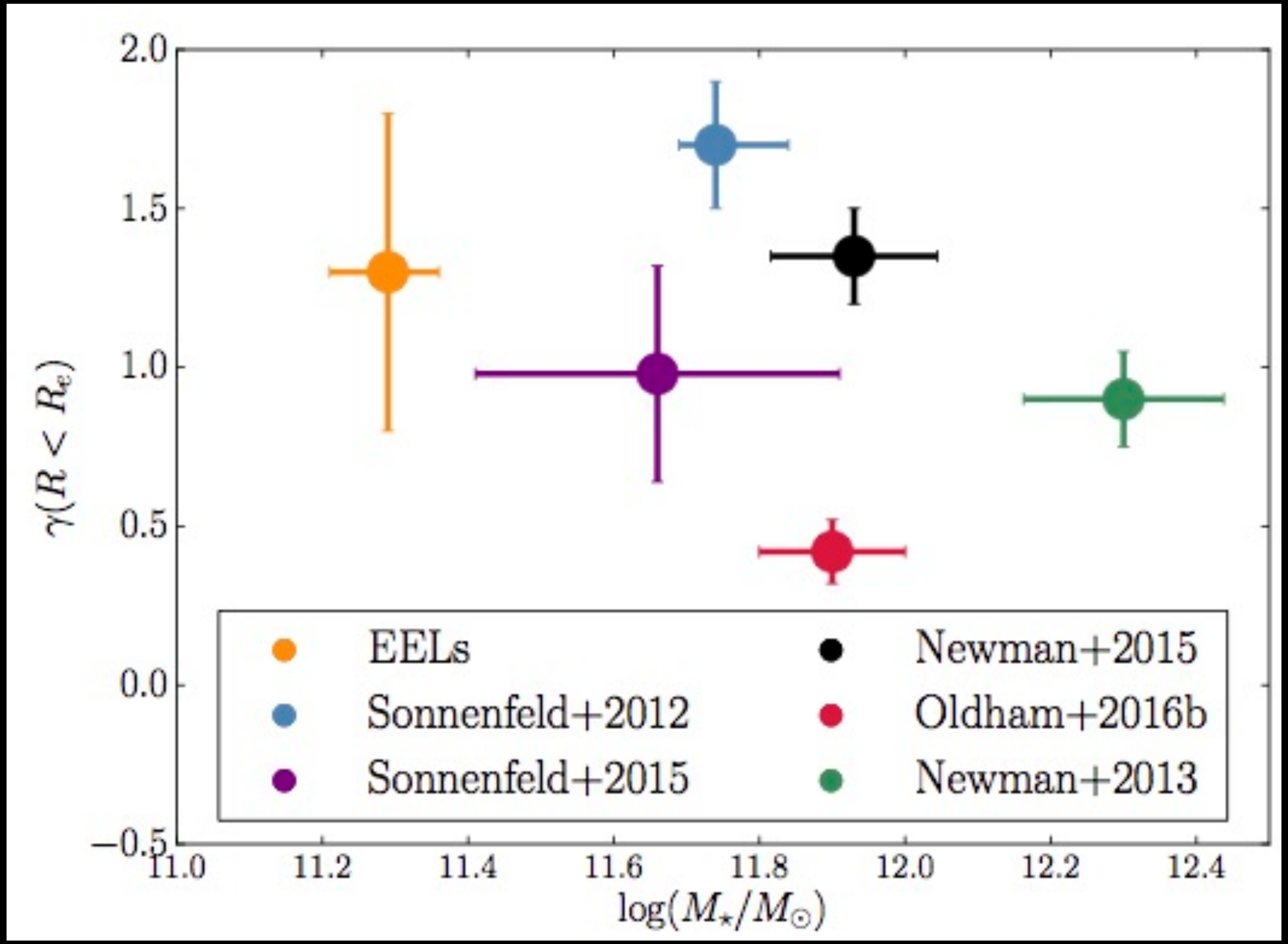




Sonnenfeld et al. (2012)

Strong lensing and stellar kinematics





Oldham & Auger (2018)

Strong lensing and stellar kinematics

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Dark matter haloes of massive elliptical galaxies at $z \sim 0.2$ are well described by the Navarro–Frenk–White profile

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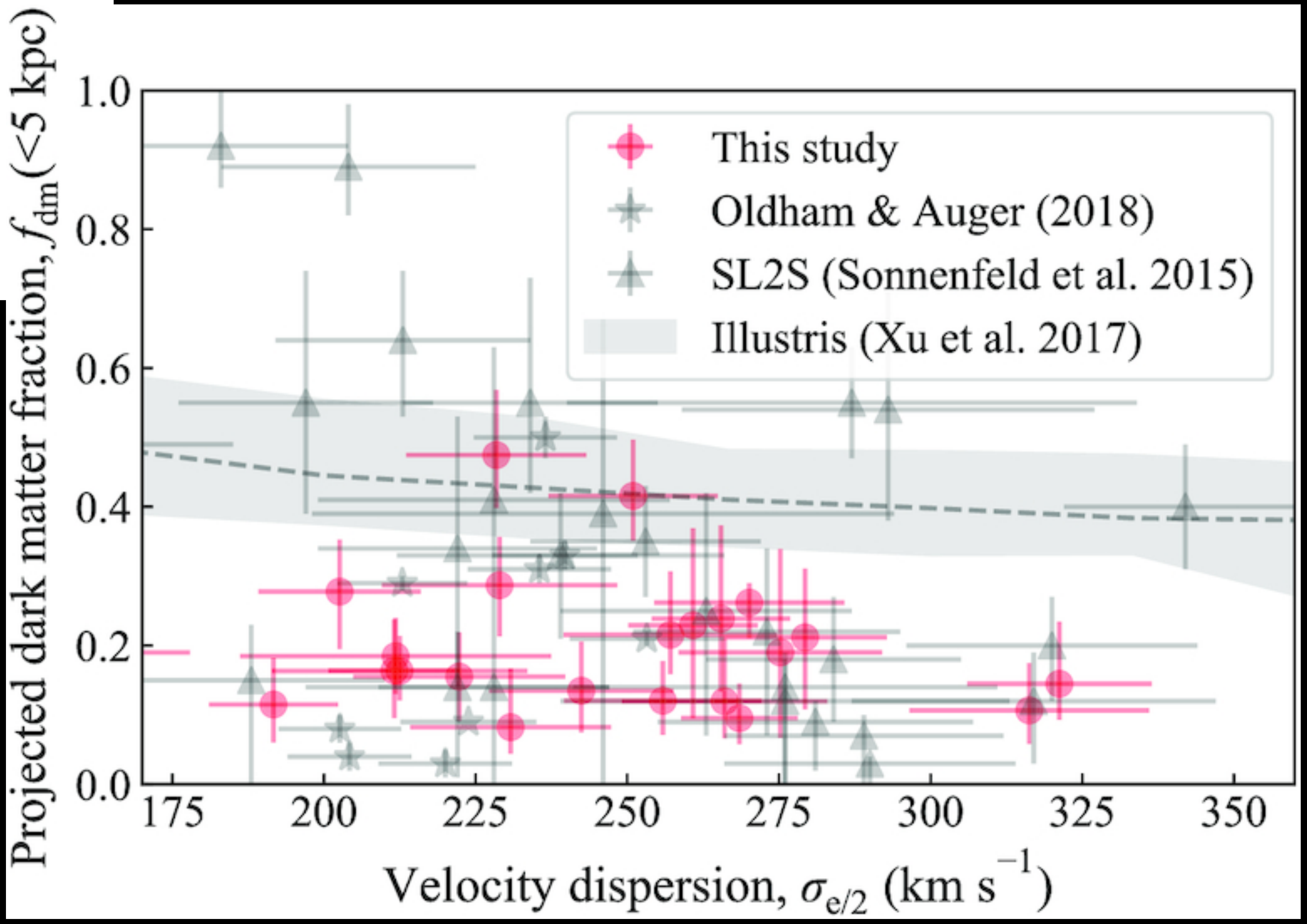
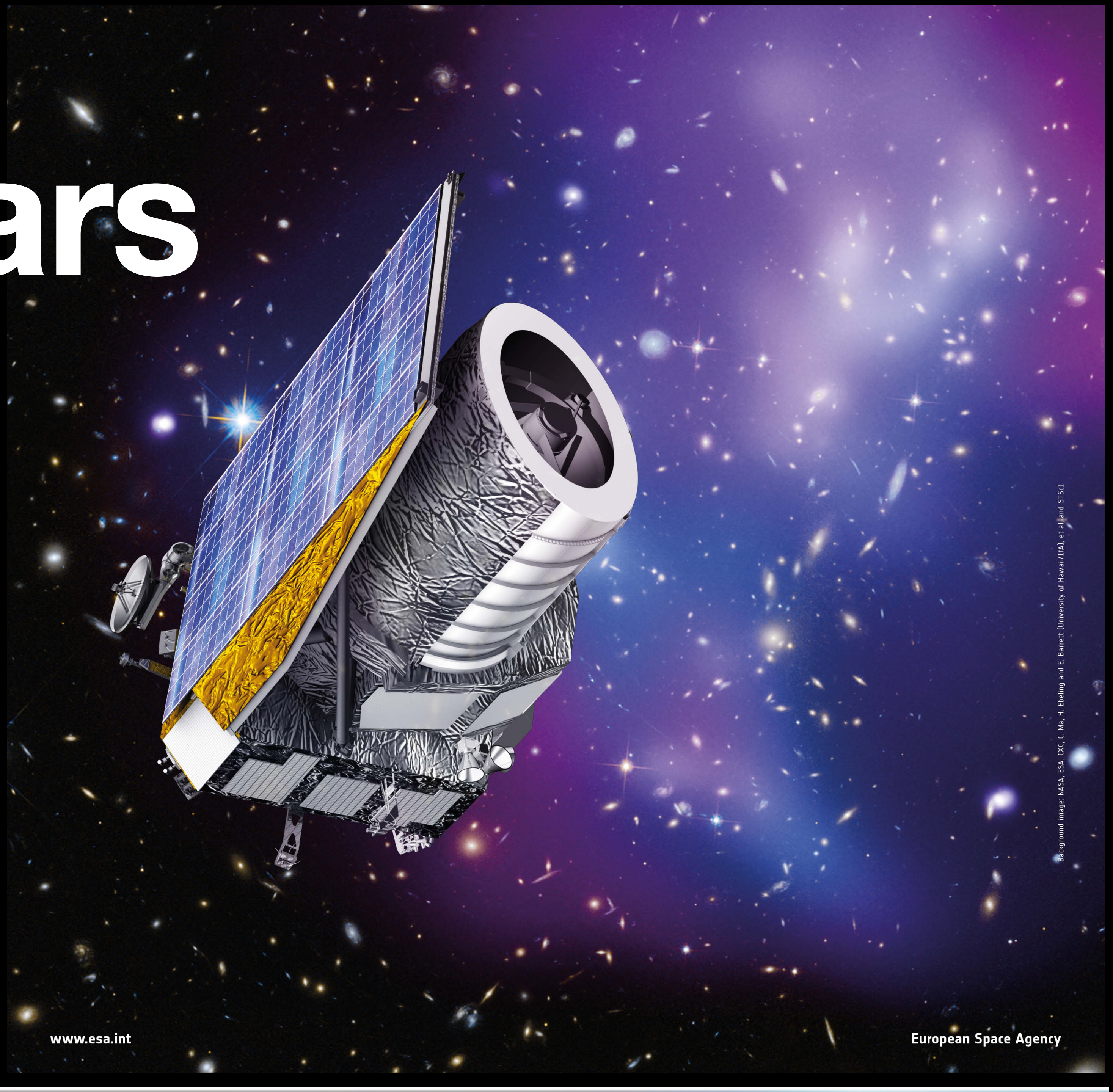


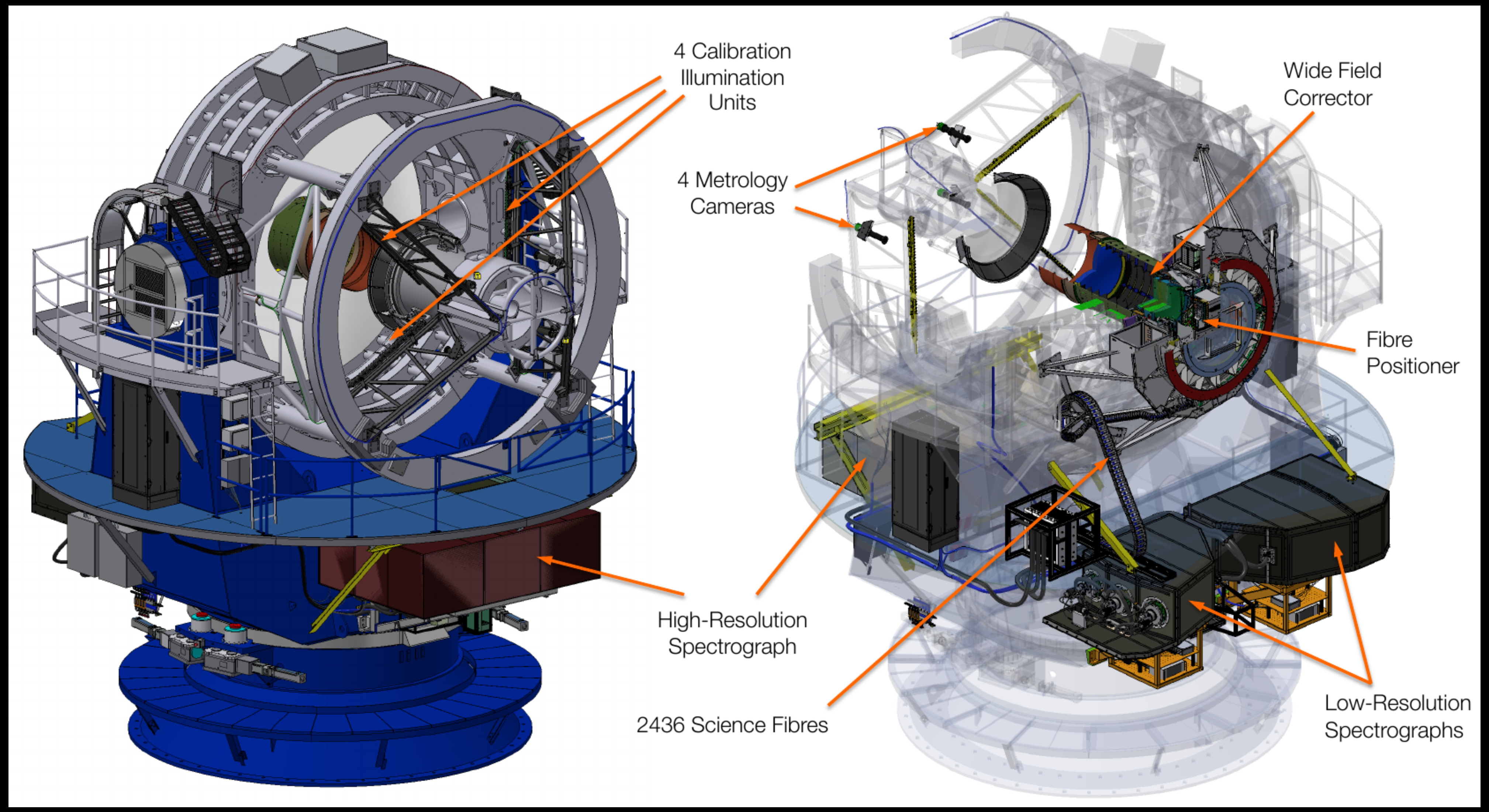
Challenges in stellar dynamics modelling

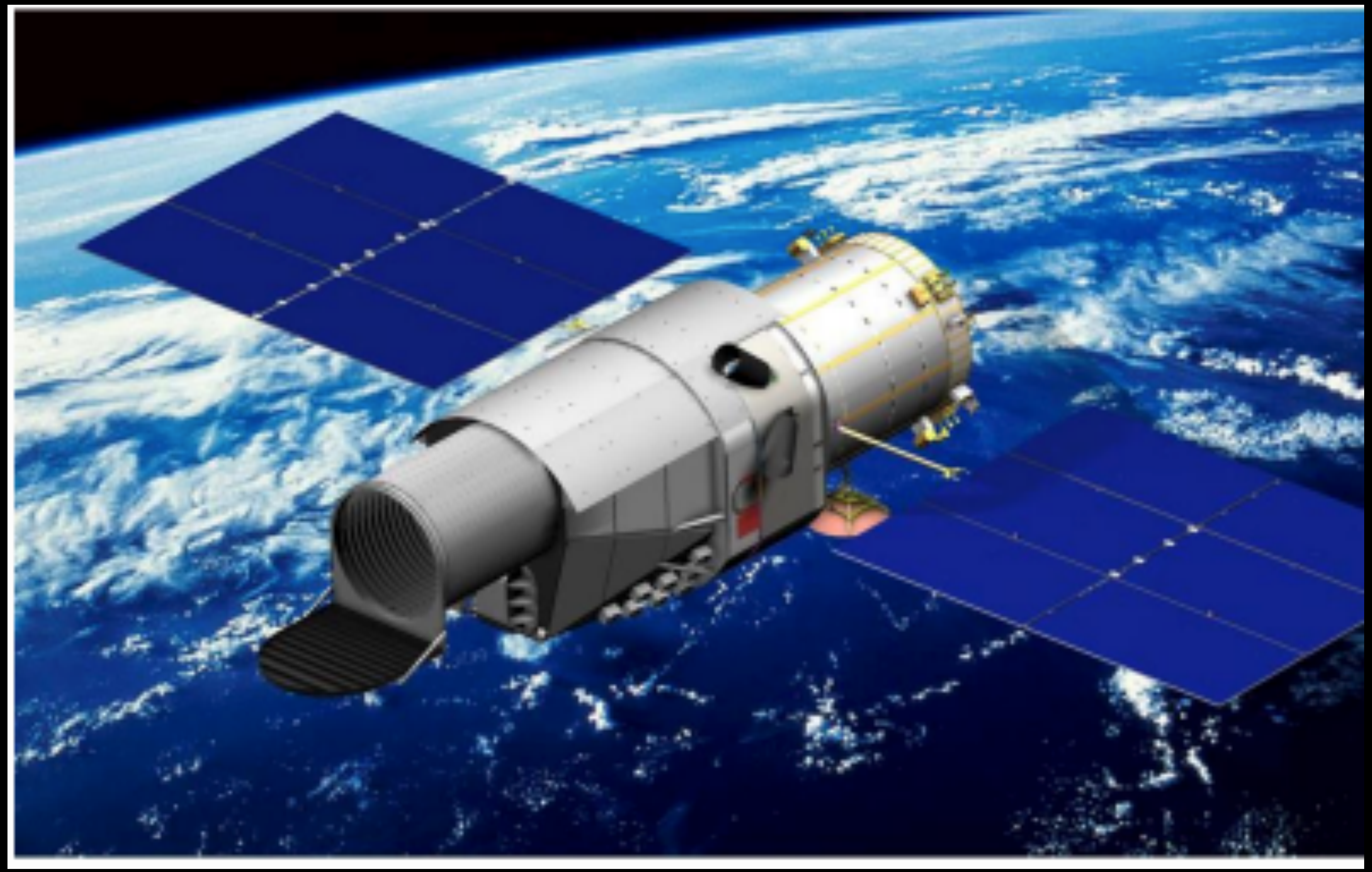
- Mass-anisotropy degeneracy
- Mass-geometry degeneracy
- Sensitivity to gradients in M*/L

Strong lensing in the coming years

- Euclid, CSST and Rubin will discover 10^5 lenses
- 4MOST will take spectra of 10^4 lenses

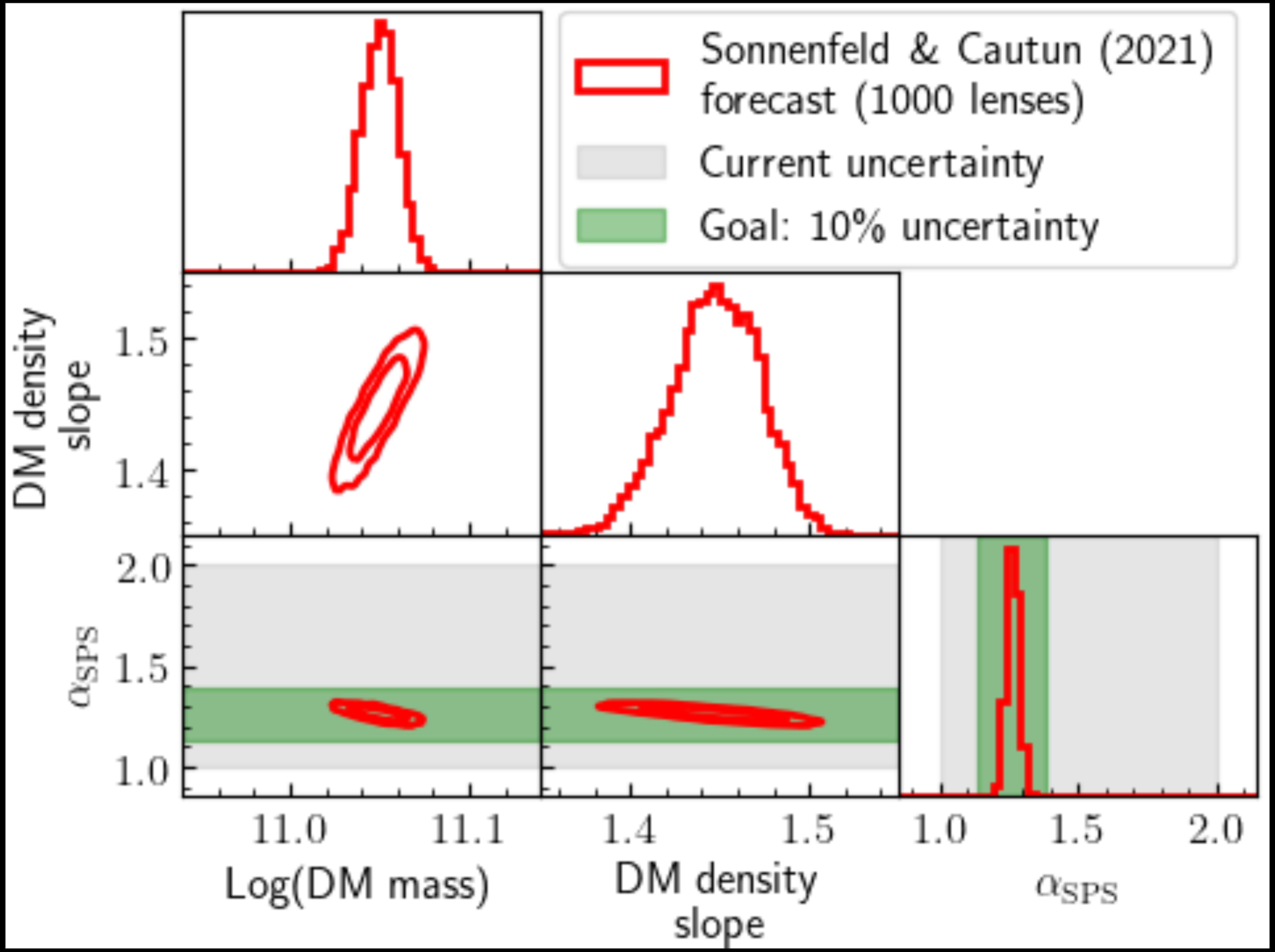






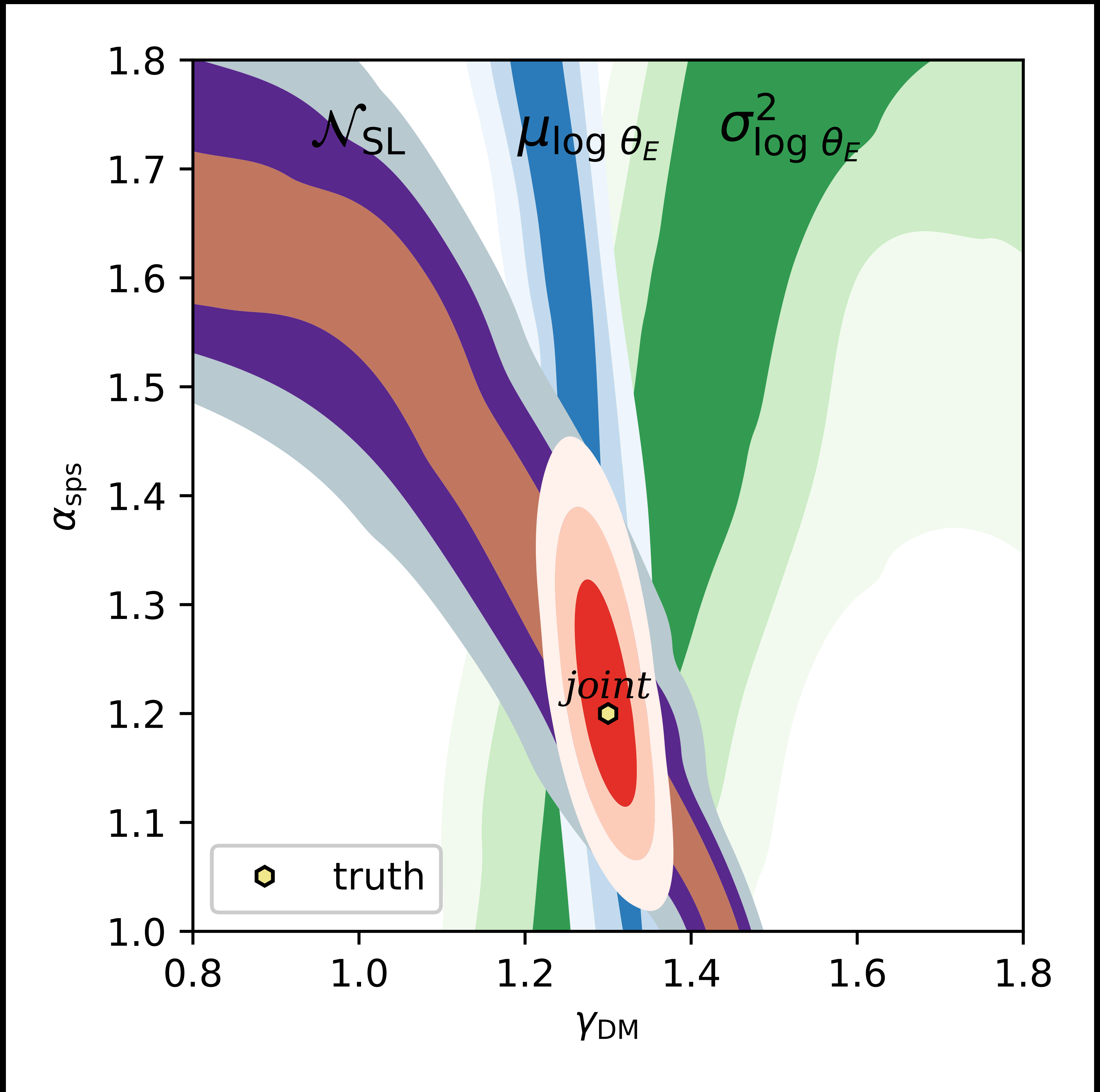
Forecasts

- Assumptions:
  - 1000 lenses, known lens and source redshift
  - 2 constraints per lens: image positions and radial magnification ratio



Forecasts

- Complete sample of strong lenses
- Fit to Einstein radius distribution



Zhou et al. (in prep.)

Strong lensing in the coming years

- Can we do without stellar kinematics?
- Can we extract more information than just the Einstein radius?
- Can we achieve high completeness in strong lens samples?
- Can we correct for selection effects?