A Hyper Suprime-Cam view of the CMASS galaxy sample

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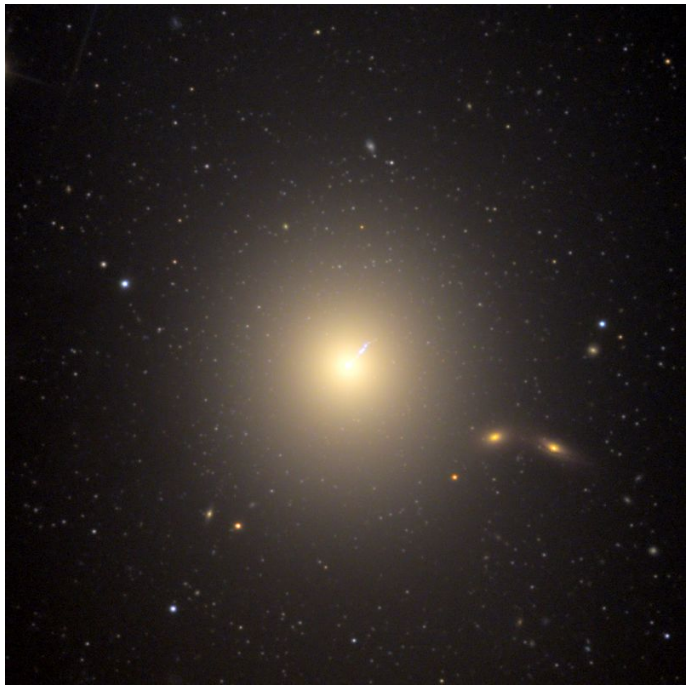
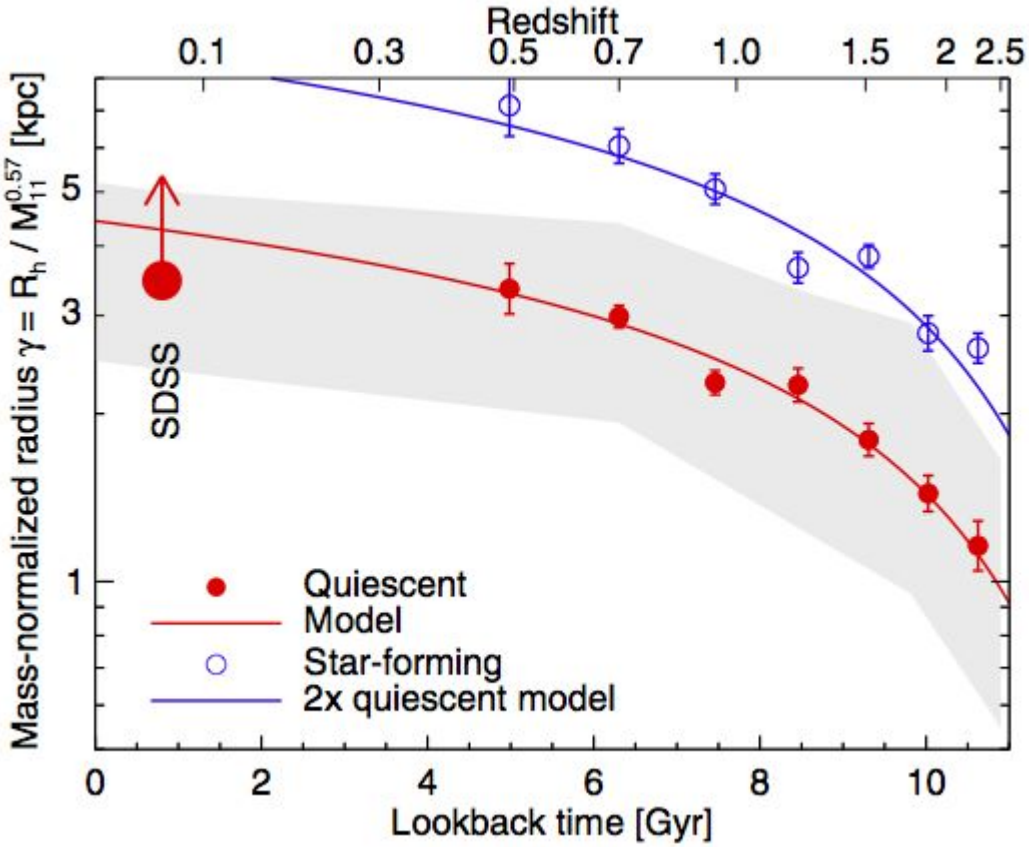
The size evolution of early-type galaxies





Newman et al. (2012)

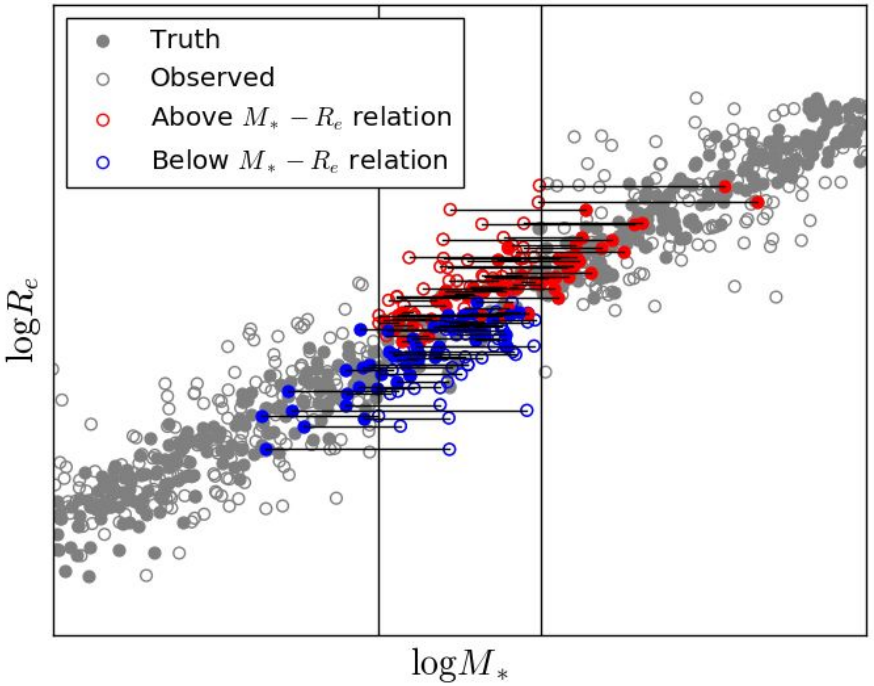
- The size of quiescent galaxies increases by a factor of a few between z=2 and z=0, at fixed M_*
- Massive ($M_* > 10^{11}$) galaxies grow mostly by mergers
- Minor mergers increase size more efficiently than major mergers (build up extended stellar envelope)

- Merger rate is difficult to constrain observationally (merger timescale is uncertain)

The halo mass - stellar mass - size relation

- Merger rate is set by the dark matter halo
- If ratio between minor/major merger rate varies with halo mass, by z=0 there should be a correlation between size and halo mass at fixed M_*
- We can measure halo mass with weak gravitational lensing

Naive approach: make a bin in stellar mass, split it in two according to size, compare the stacked weak lensing signal in the two bins



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A Bayesian hierarchical approach to galaxy–galaxy lensing

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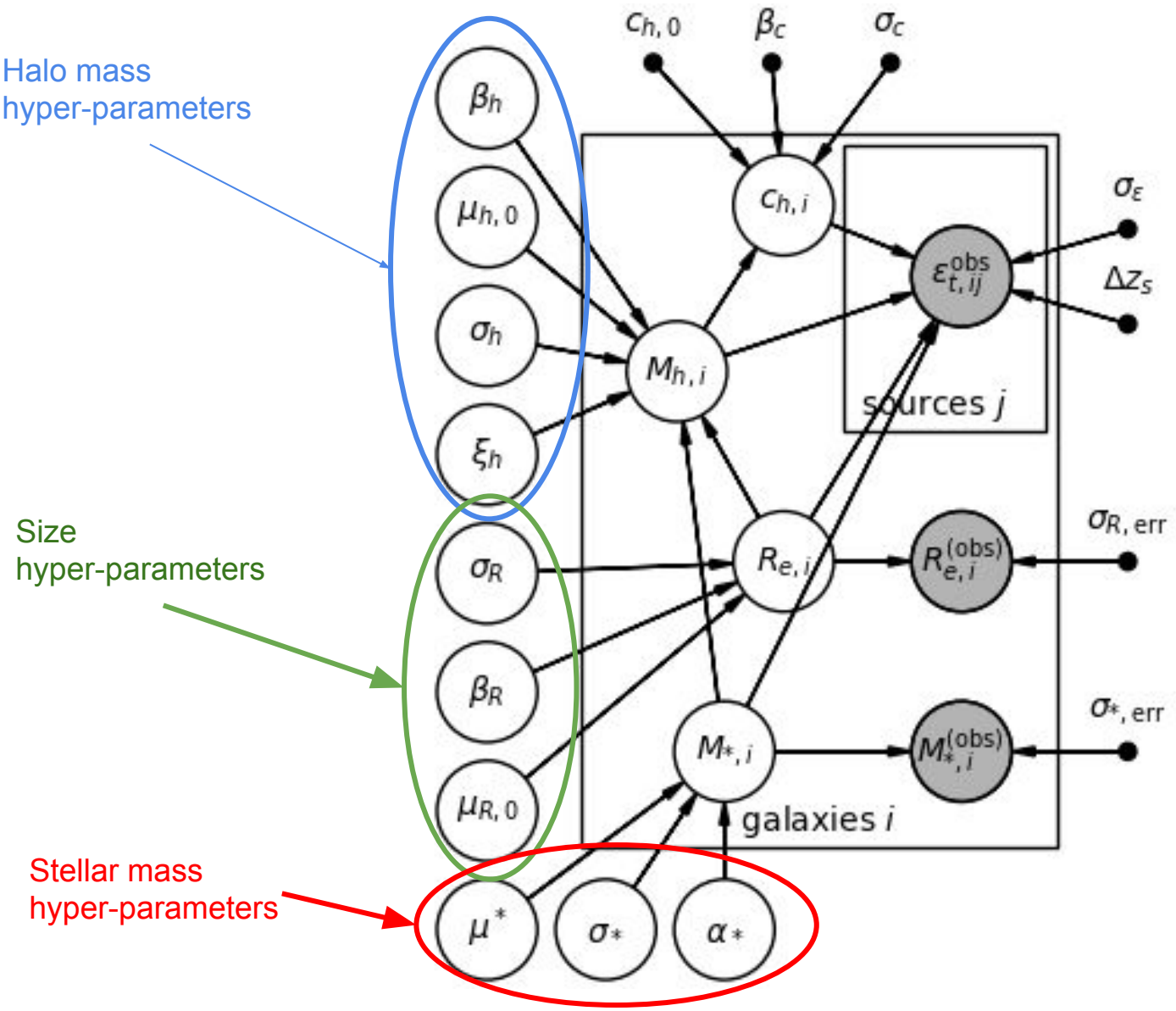
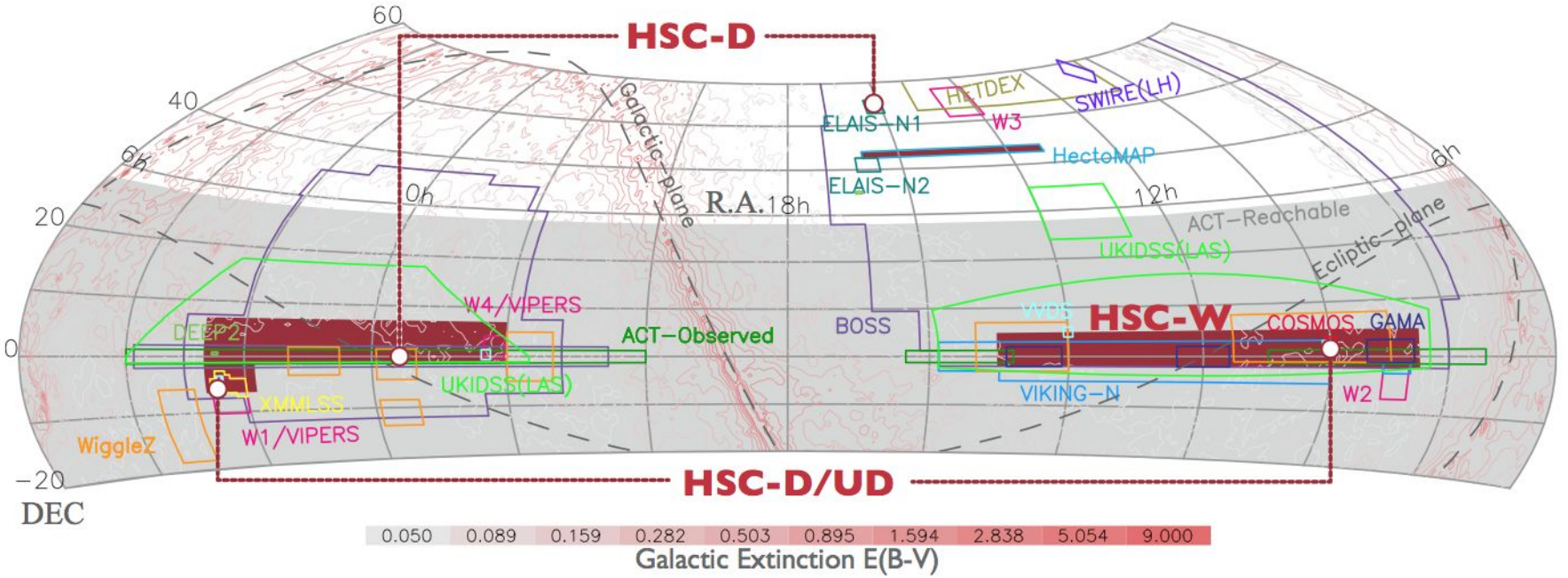
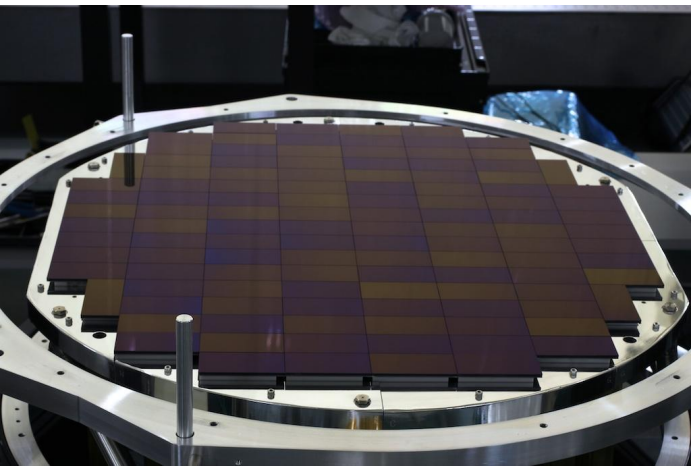
- Sample of objects drawn from the same population. Each object described by a set of parameters. Example: stellar mass, halo mass, half-light radius
- Individual object parameters are drawn from a distribution, which in turn is described by population parameters (the hyper-parameters). Example: average halo mass, halo mass-stellar mass correlation, halo mass-size correlation, scatter in halo mass.
- We infer the hyper-parameters and the individual parameters simultaneously, given the data (weak lensing and stellar mass and size measurements).
- Advantages: very flexible, especially in many dimensions, accurate (observational errors are all forward-modeled)
- Cost: need to assume a model (e.g. NFW density profile for dark matter halo)

Bayesian hierarchical inference

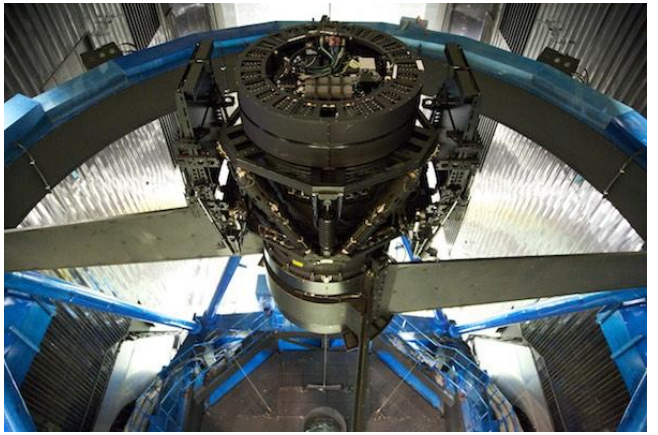


Hyper Suprime-Cam Survey





- ~1,000 square degrees
- Depth ~26 mag (i-band)
- Typical seeing 0.7”



An HSC view of the CMASS galaxy sample. Halo mass as a function of stellar mass, size and Sérsic index.

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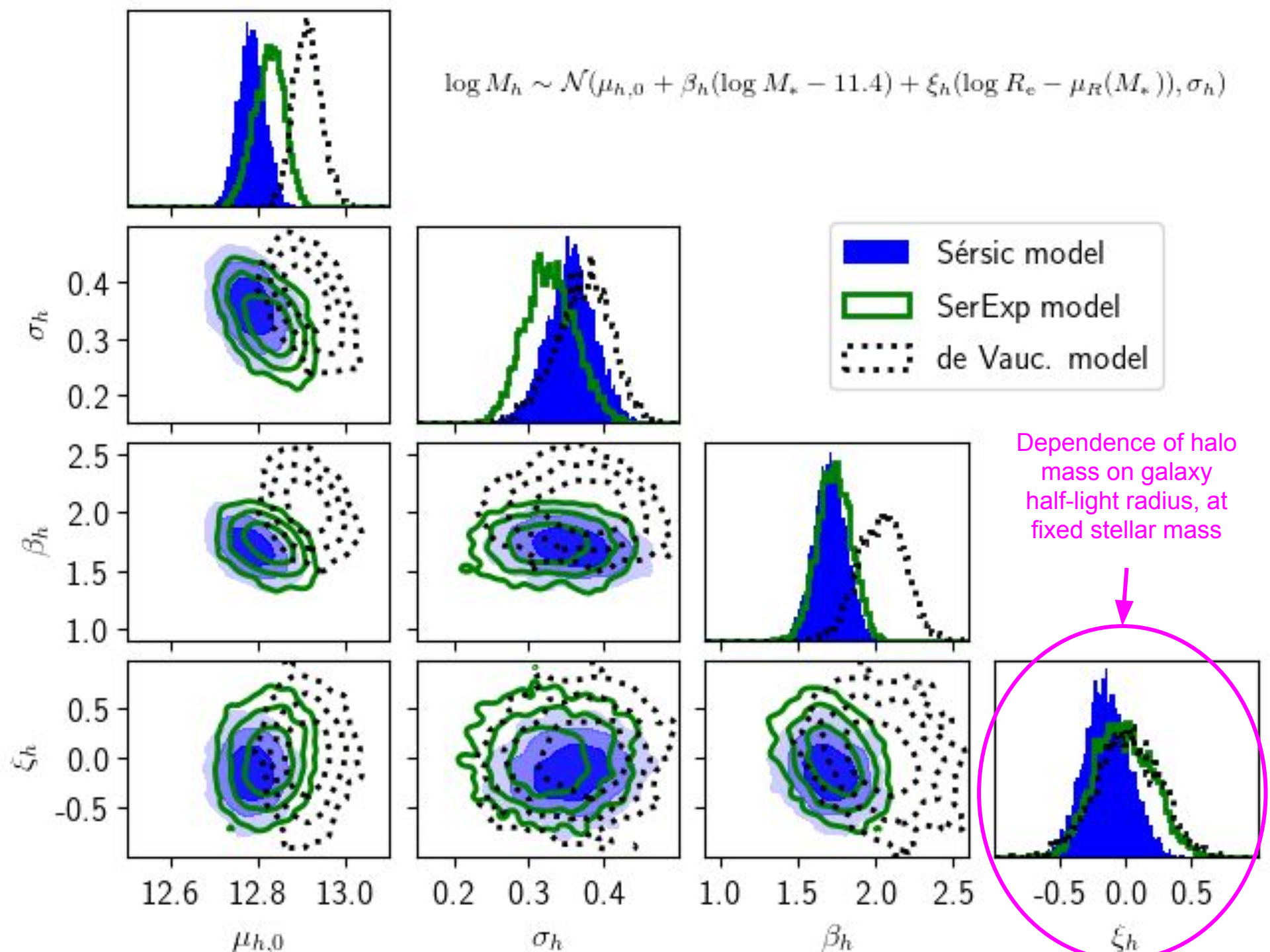
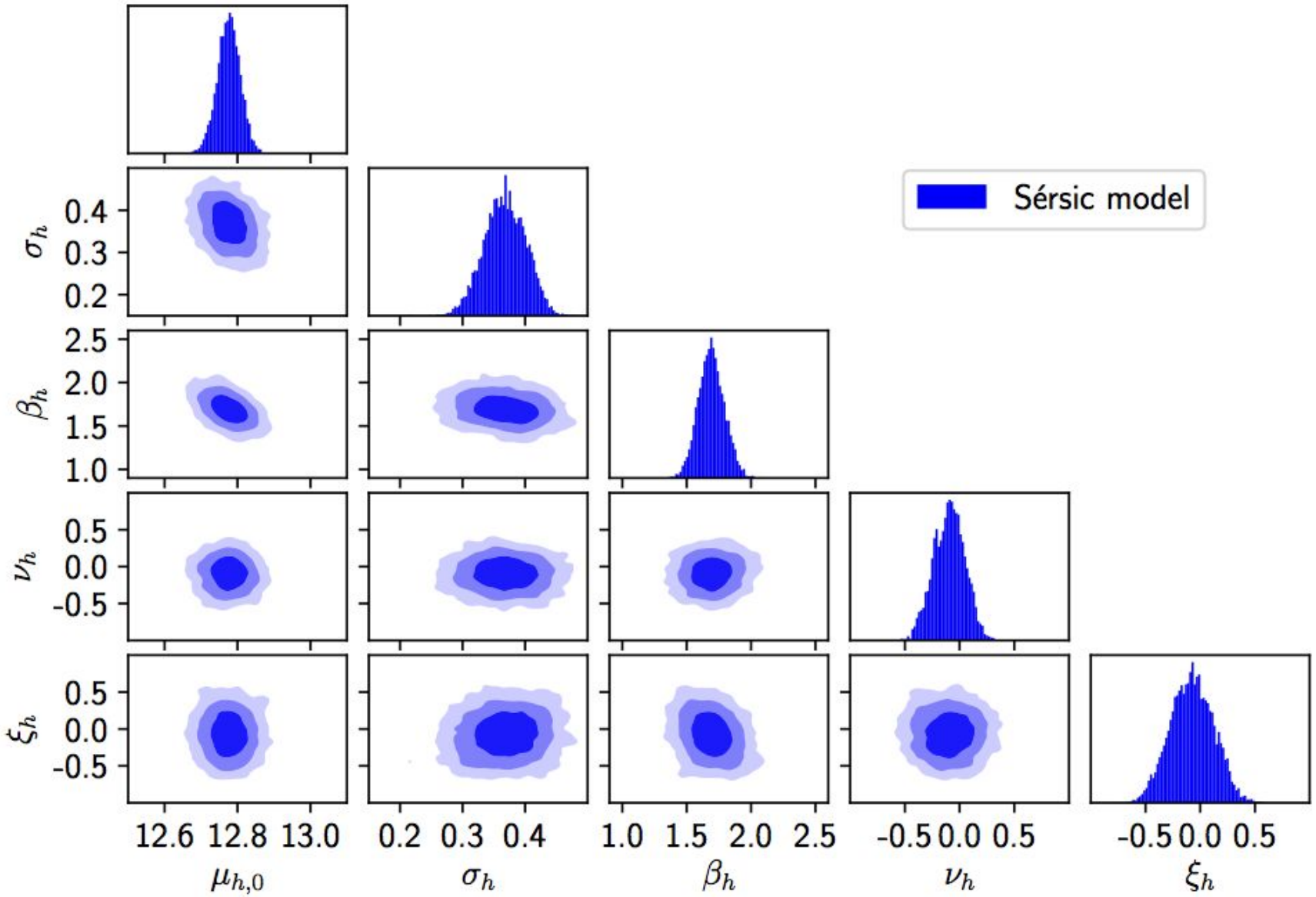
- 10,000 massive galaxies (M* > 10^11) from BOSS CMASS sample (median redshift z~0.55)
- Stellar masses and sizes from HSC grizy photometry
- HSC weak lensing shape measurements on 140 square degrees
- Bayesian hierarchical inference of halo mass-stellar mass-size-Sersic index relation


$\log M_h \sim \mathcal{N}(\mu_{h,0} + \beta_h(\log M_* - 11.4) + \xi_h(\log R_e - \mu_R(M_*)), \sigma_h)$
Sérsic model
SerExp model
de Vauc. model
Dependence of halo mass on galaxy half-light radius, at fixed stellar mass
$\mu_{h,0}$
σ_h
β_h
ξ_h
12.6
12.8
13.0
0.2
0.3
0.4
1.0
1.5
2.0
2.5
-0.5
0.0
0.5

Dependence on size and Sérsic index

$$\log M_h \sim \mathcal{N}(\mu_{h,0} + \beta_h(\log M_* - 11.4) + \nu_h(\log n - \mu_n(M_*)) + \xi_h(\log R_e - \mu_R(M_*, n)), \sigma_h)$$

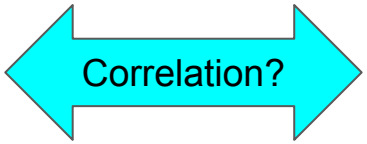


Summary

- HSC Weak lensing measurements rule out strong correlations between halo mass and galaxy size (or Sérsic index) at fixed stellar mass.
- Implications for size evolution of massive quiescent galaxies: ratio between major and minor mergers is a weak function of halo mass.

Potential for future studies

- Stellar pop. age
- Velocity dispersion
- AGN activity
- X-ray emission (e-Rosita)



- Halo mass
- Halo concentration
- Halo shape (flattening)
- Halo density profile