GAMA: Stellar Mass Budget
(1) by galaxy type
(2) of Spheroids/Disks

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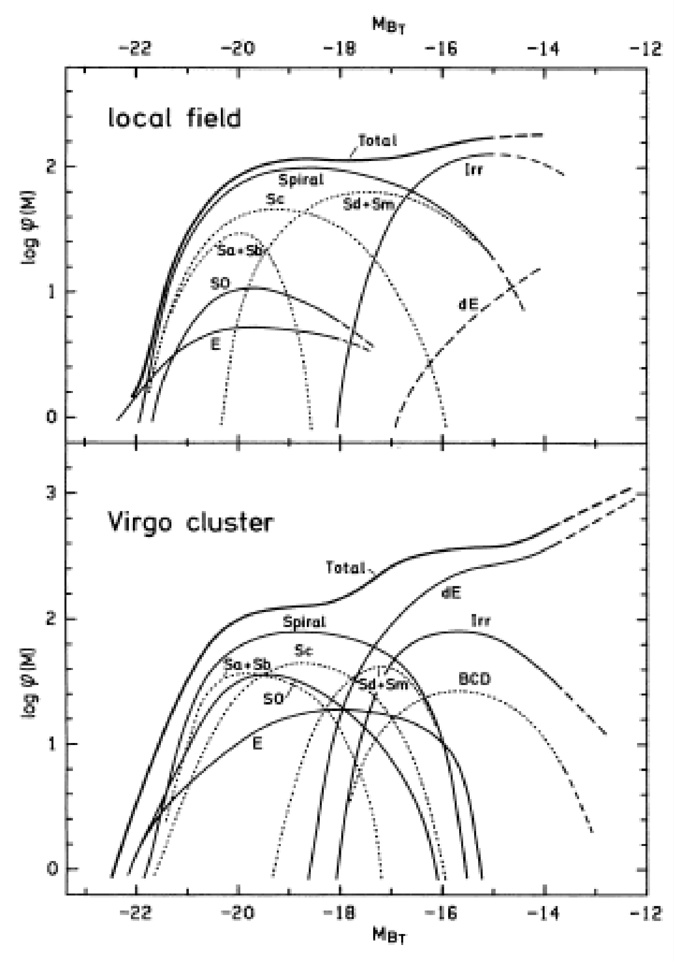
Papers

- (1) Galaxy And Mass Assembly (GAMA): the stellar mass budget by galaxy type
Moffett et al. 2016, MN 457, 1308
http://adsabs.harvard.edu/abs/2016MNRAS.457.1308M
- (2) Galaxy And Mass Assembly (GAMA): the Stellar Mass Budget of Galaxy Spheroids and Disks
Moffett et al. 2016, MN accepted(arXiv:1608.05526)
http://adsabs.harvard.edu/abs/2016arXiv160805526M

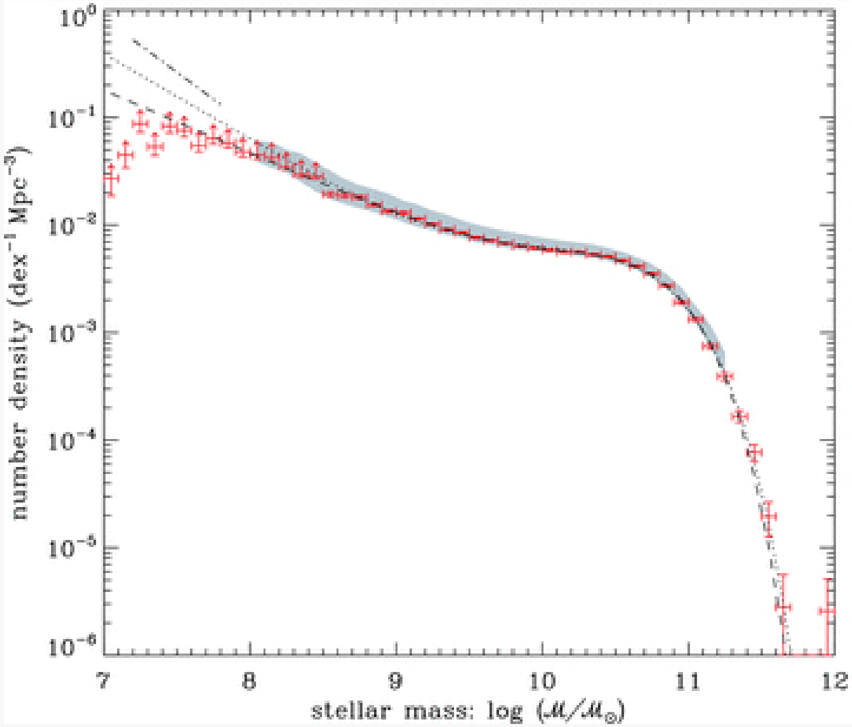
Luminosity/Stellar mass function

luminosity function



Bingegeli, Sandage, Tammann 1988 ARAA

stellar mass function



Baldry, Glazebrook, Driver 2008, MNRAS

Motivation (i)

- toward understanding two-component nature of the galaxy stellar mass function
  - what is responsible for it?
  - e.g. ‘red’ and ‘blue’ galaxy (Baldry+ 2012)
- the two papers focus on basic population divisions; (1) morphology, (2) spheroid/disk

Motivation (ii)

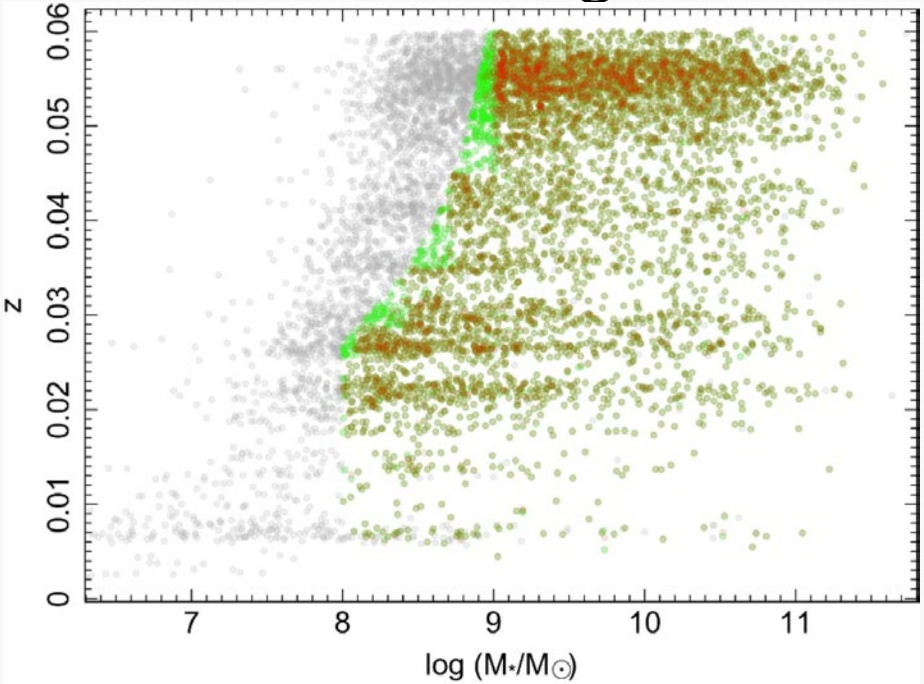
- impose detailed constraints on galaxy formation evolution simulations
  - observational measurement of the galaxy mass assembled in each morphologies or spheroids/disk down to low mass regime is required
- attain more accurate measures
  - studies with 3000~6×10^5 galaxies have been done but there is still diversity in conclusions

Advantages over other works

- gets down to lower stellar mass (10^8 M_{sun})
  - thanks to deeper redshift range
- visually classified morphology
- 2-D decomposition by single/double Sérsic components fitting (GALFIT)

Sample galaxies

- GAMA II equatorial regions (180 deg^2)
  - ~7500 galaxies w/redshift, r<19.8 mag
  - $0.002 < z < 0.06$
  - $10^8 < M^* < 10^{11.5}$
  - define volume-limited subsample with mass limits w/ function of redshift



Stellar mass estimation

- Taylor+ 2011 for details
  - NIR data are not in use
- (1) total stellar mass = optical photometry + Chabrier(2003) population synthesis model
- (2) individual (spheroid/disk) stellar mass = color corrected mass-to-light ratio

$$\log M_* / M_\odot = -0.68 + 0.7\ (g - i) - 0.4\ (M_i - 4.58). \qquad (1)$$

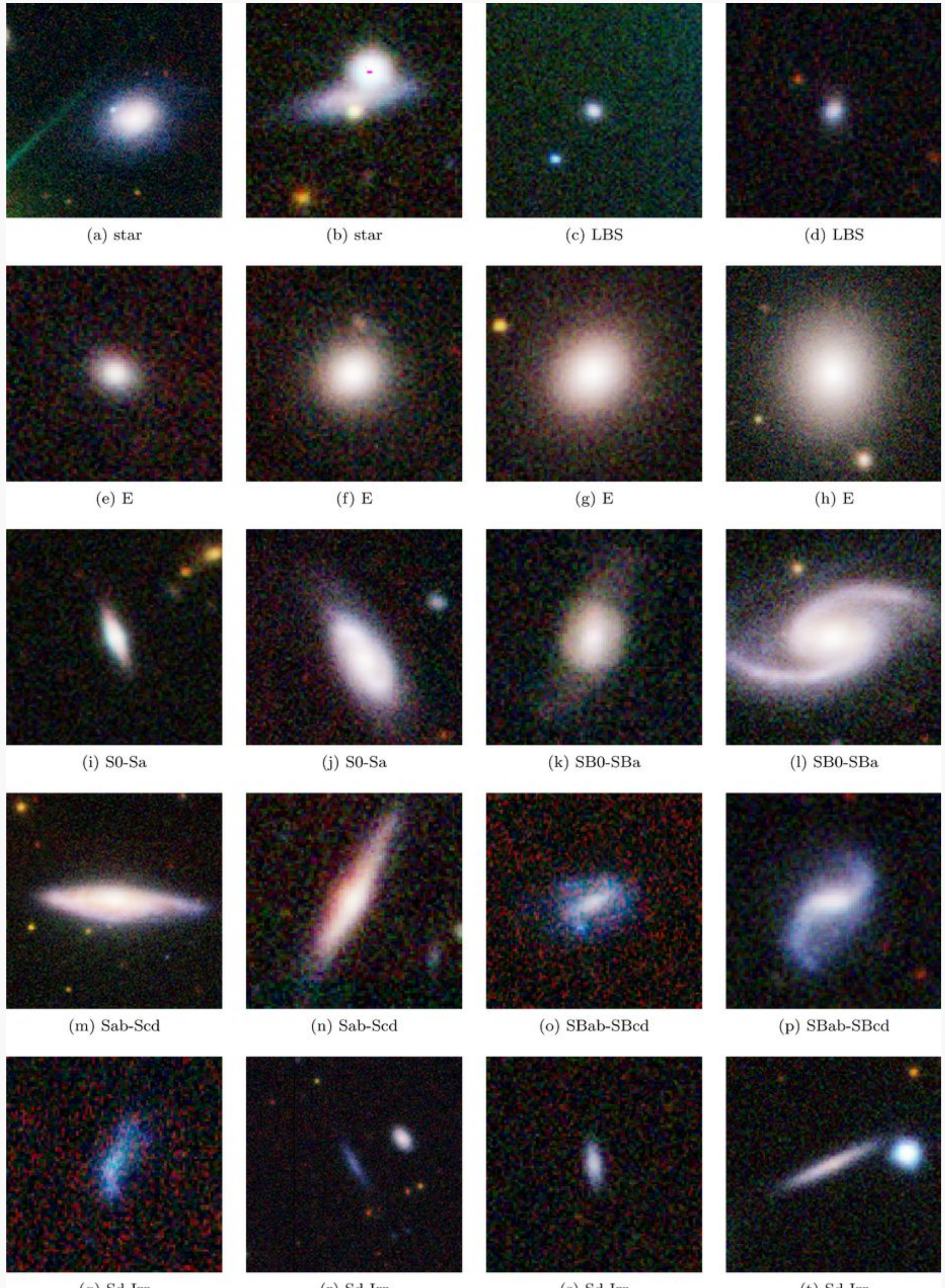
Stellar mass function fits

- parametric maximum likelihood fitting
- adopting Schechter function for PDF

$$\Phi(\log M)d\log M = ln(10) \times \phi^* 10^{log(M/M^*)(\alpha+1)} \times \exp(-10^{\log(M/M^*)})d\log M \quad (2)$$

  - M*: characteristic mass (knee), α: slope at low-mass end, ϕ*: normalization
- employ MCMC to analyze and derive the most likely α and M* per sample

(1) Portrait of sample galaxies



(a) star (b) star (c) LBS (d) LBS

(e) E (f) E (g) E (h) E

(i) S0-Sa (j) S0-Sa (k) SB0-SBa (l) SB0-SBa

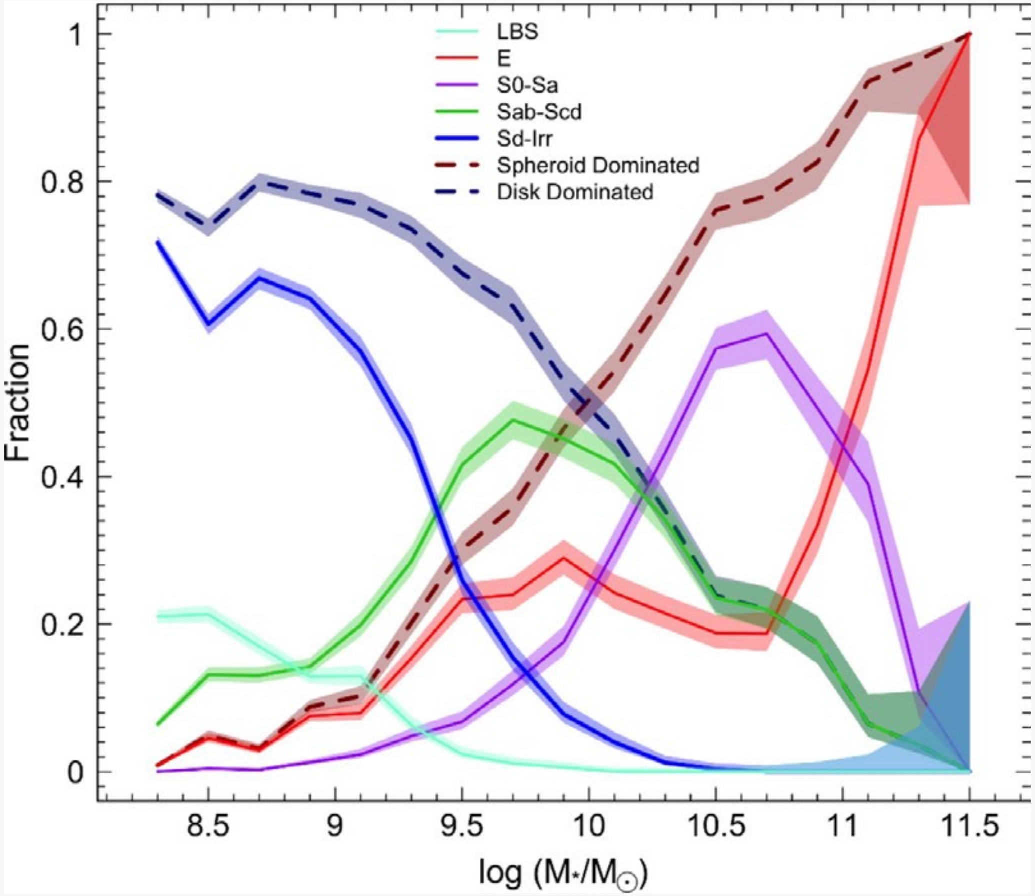
(m) Sab-Scd (n) Sab-Scd (o) SBab-SBcd (p) SBab-SBcd

(q) Sd-Irr (r) Sd-Irr (s) Sd-Irr (t) Sd-Irr

(1) Morphology classifications

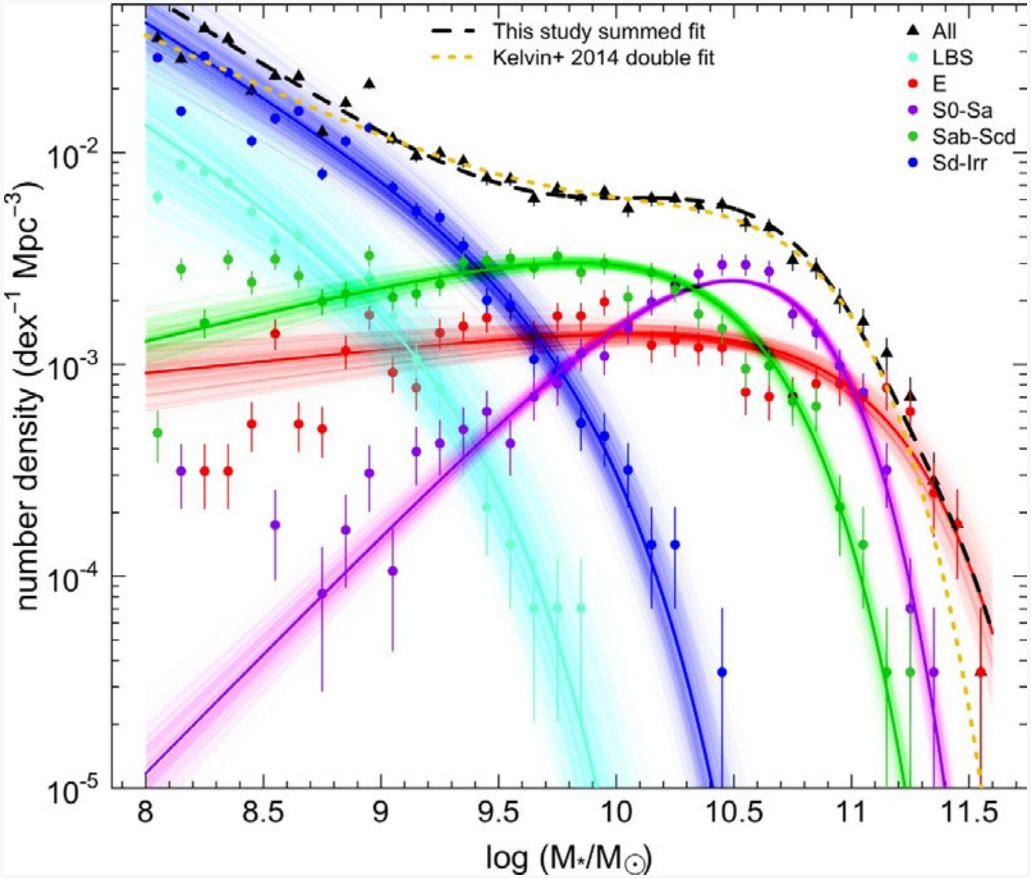
- visually classified of three-color images
  - SDSS *i,g* , VIKING *H*
  - E, S0-Sa/SB0-SBa, Sab-Scd/SBab-SBcd, Sd-Irr, LBS (little blue spheroid; Kelvin+ 2014)
  - three initial classifiers + review by three persons

(1) Number fraction of morphology w.r.t. stellar mass



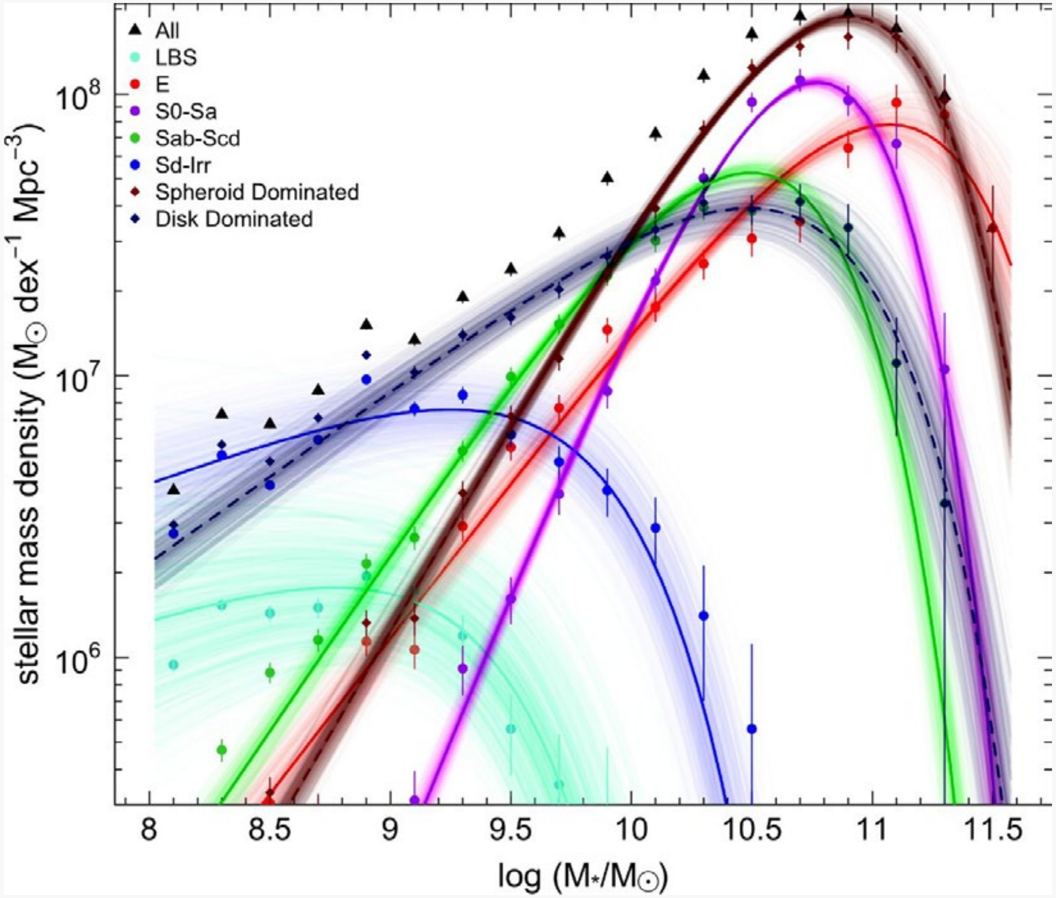
- E dominates in high-mass regime
- LBS frequency reaches 20% at low-mass

(1) Stellar mass function by morphology



- individual MFs are represented by single Schechter function
  - Sd-Irr and LBS have steep α (-1.8), similar to dwarfs in cluster
- total MF is represented by double Schechter function

(1) Stellar mass density by morphology

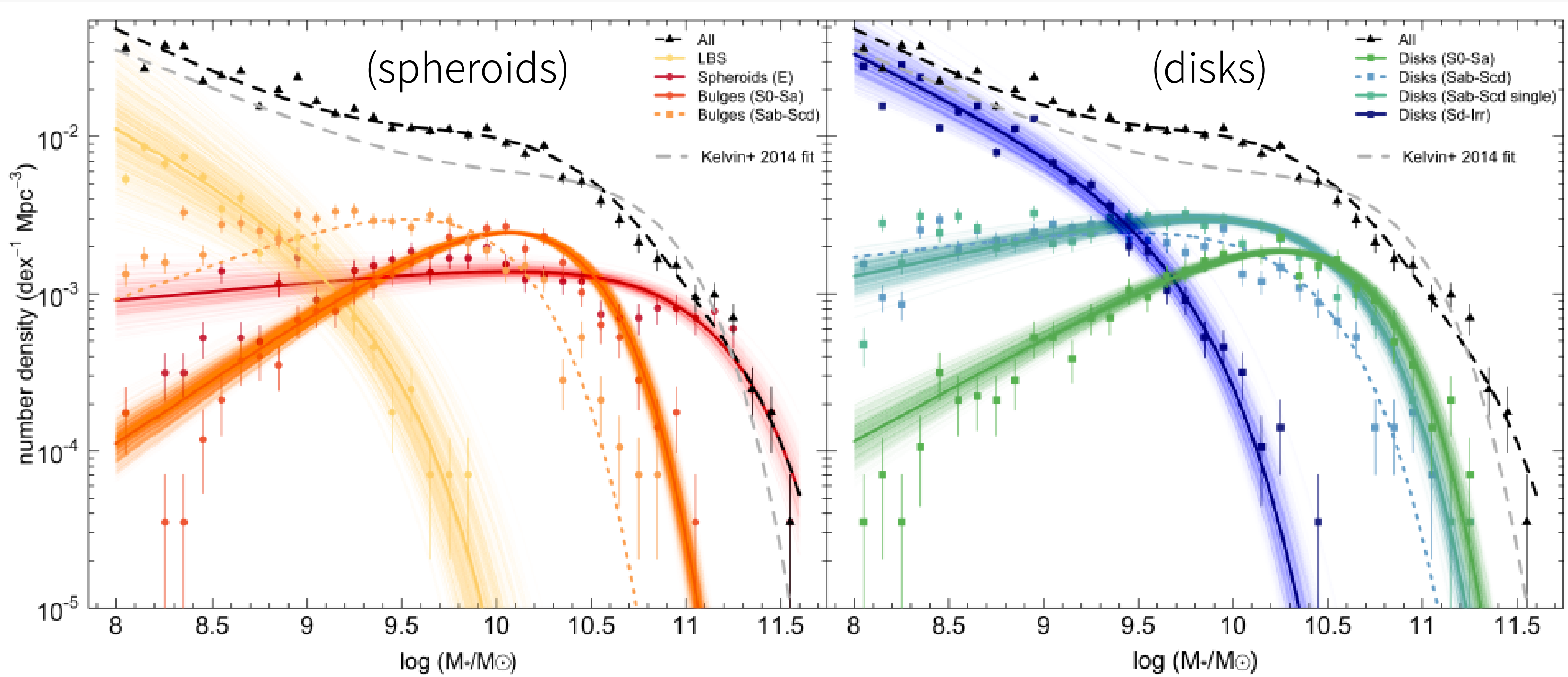


- spheroid-dominate (E=35%,S0-Sa=35%)~70%, disk-dominate (Sab-Scd=22%,Sd-Irr=7.4%) ~ 30 %, LBS~2% of total
- integrate total mass density give $\rho_* = 2.5 \times 10^8 M_\odot Mpc^{-3}$ and $\frac{\Omega_{stars}}{\Omega_{barion}}$~$4\%$

(2) Spheroid/disk decomposition

- fit SDSS *r*-band images with 2-D Sérsic profile models using GALFIT
  - large grid as initial input
  - final model = median of “good” model fits
    - note: Mendel+ (2014) point out “SDSS data are generally insufficient to provide good constraints on bulge light profiles when the shape parameter n is left unconstrained”. Is the point averted?
- single or double components?
  - galaxy morphology type dependent

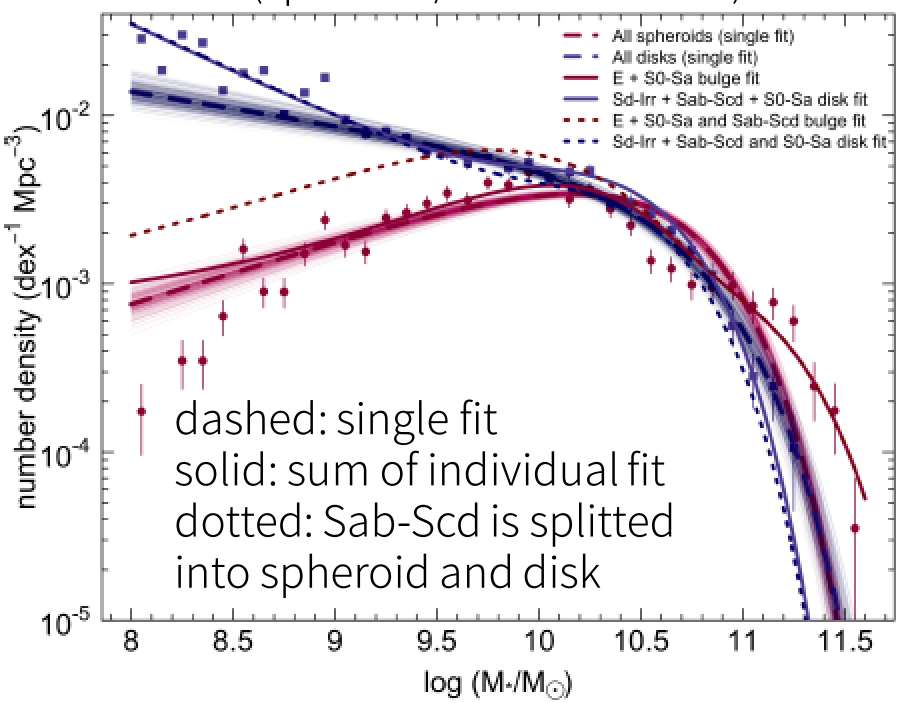
(2) Stellar mass function spheroid vs disk



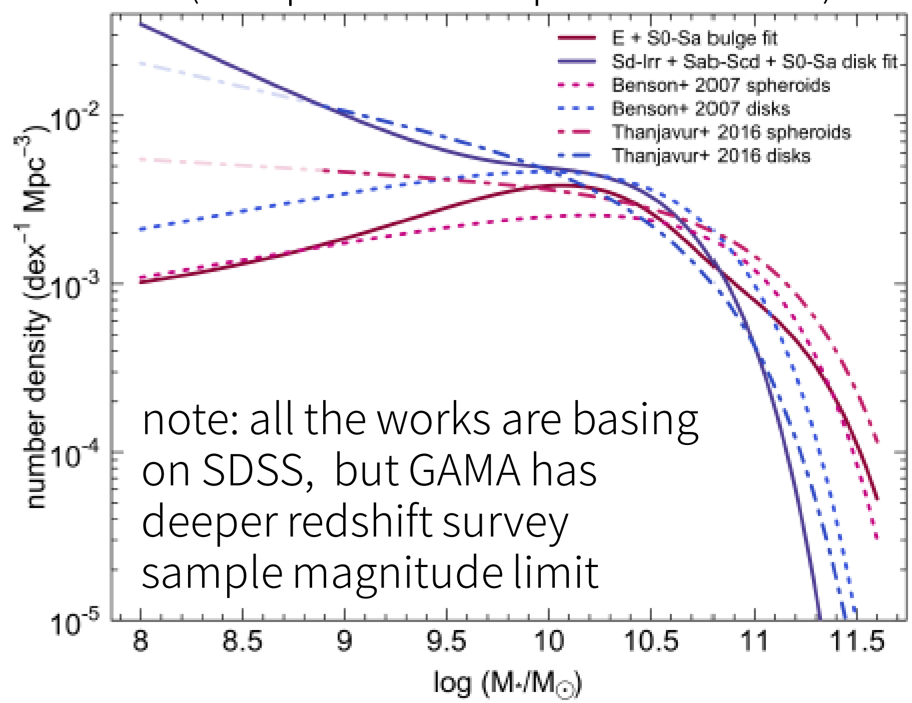
- single Schechter functions provide a reasonable description
- for multi-component system (S0-Scd), the mass functions are differ significantly for the their spheroids and disks

(2) Stellar mass function spheroid vs disk: combined

(spheroid/disk combined)

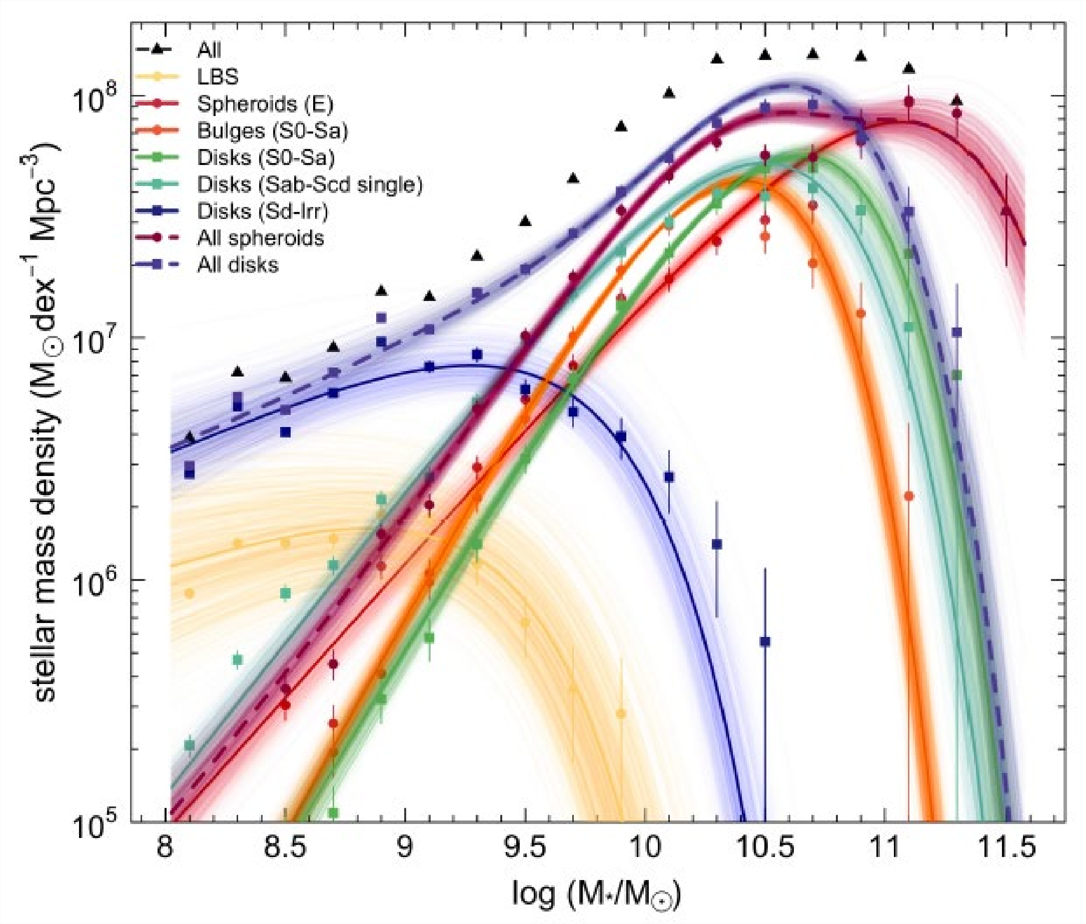


(comparison with previous works)



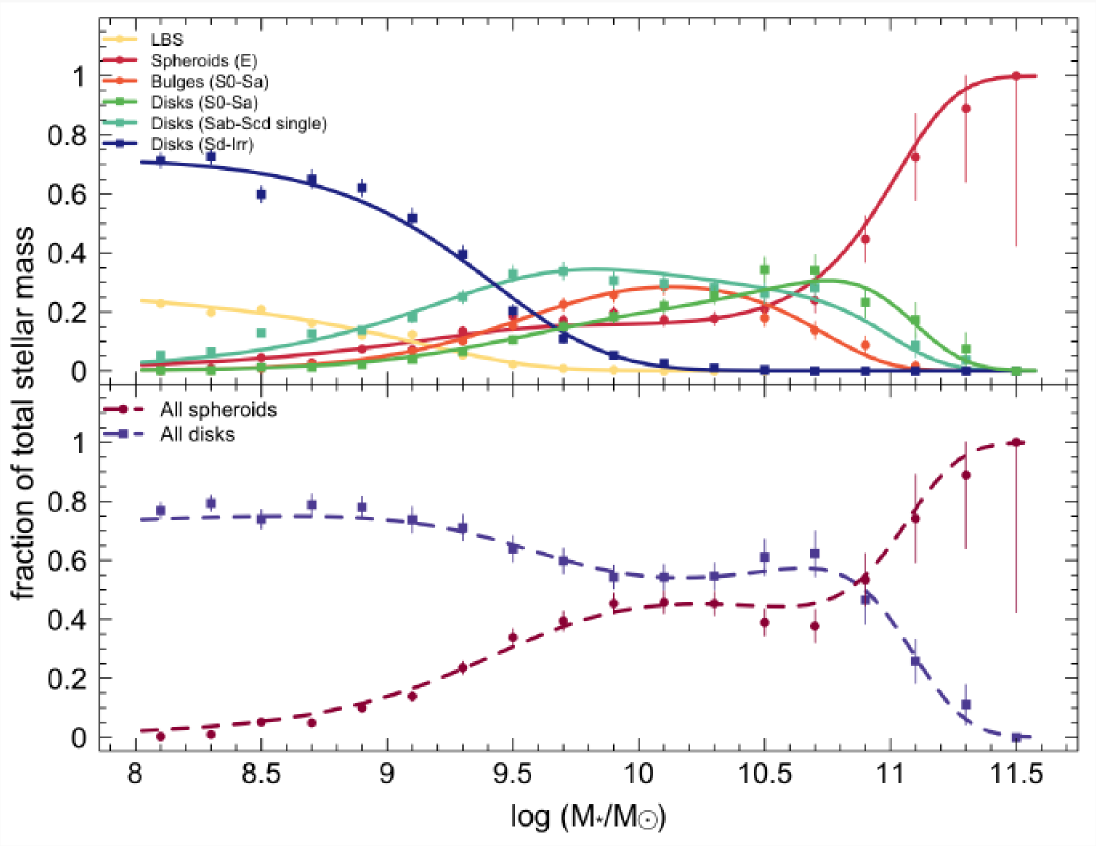
- combined spheroid/disk are poorly fit by single Schechter function
- differences between the previous works (Benson+, Thanjavur+) come from 1) sample (deeper redshift survey), 2) mass function fitting strategy (combined vs individual), 3) shallow survey area (biased against bright and/or massive galaxies), 4) mass-to-light ratio, 5) Sab-Scd single disk (this work) vs spheroid+disk (Thanjavur+ 2016)

(2) Total spheroid/disk mass densities



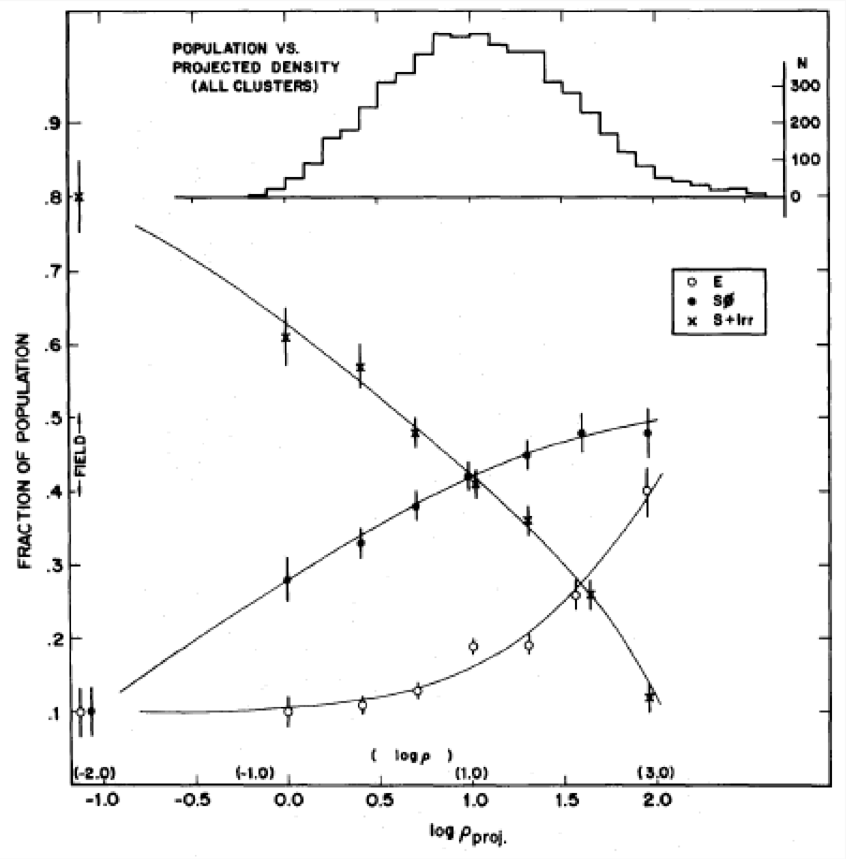
- ~50% of total stellar mass density is in spheroid, ~48% is in disk, and a few % in LBS

(2) Stellar mass contribution by spheroid/disk



- spheroid mass dominance at high mass → disk mass dominance at low mass. transition occurs at M*~$10^{10.9}$Msun

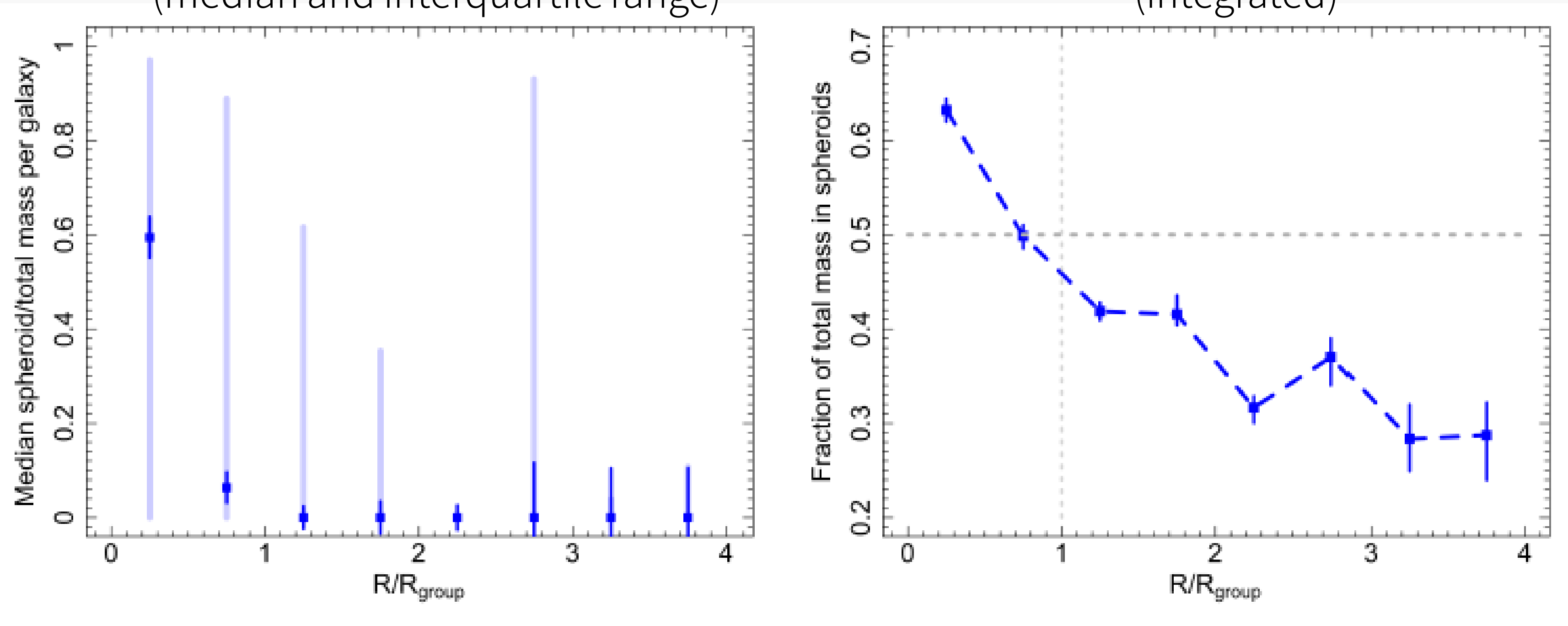
Environmental effect: Morphology-density relation



- Morphology-density relation proposed by Dressler (1980) is now quantitatively translated into spheroid mass distribution in high density environment

(2) Spheroid mass in group

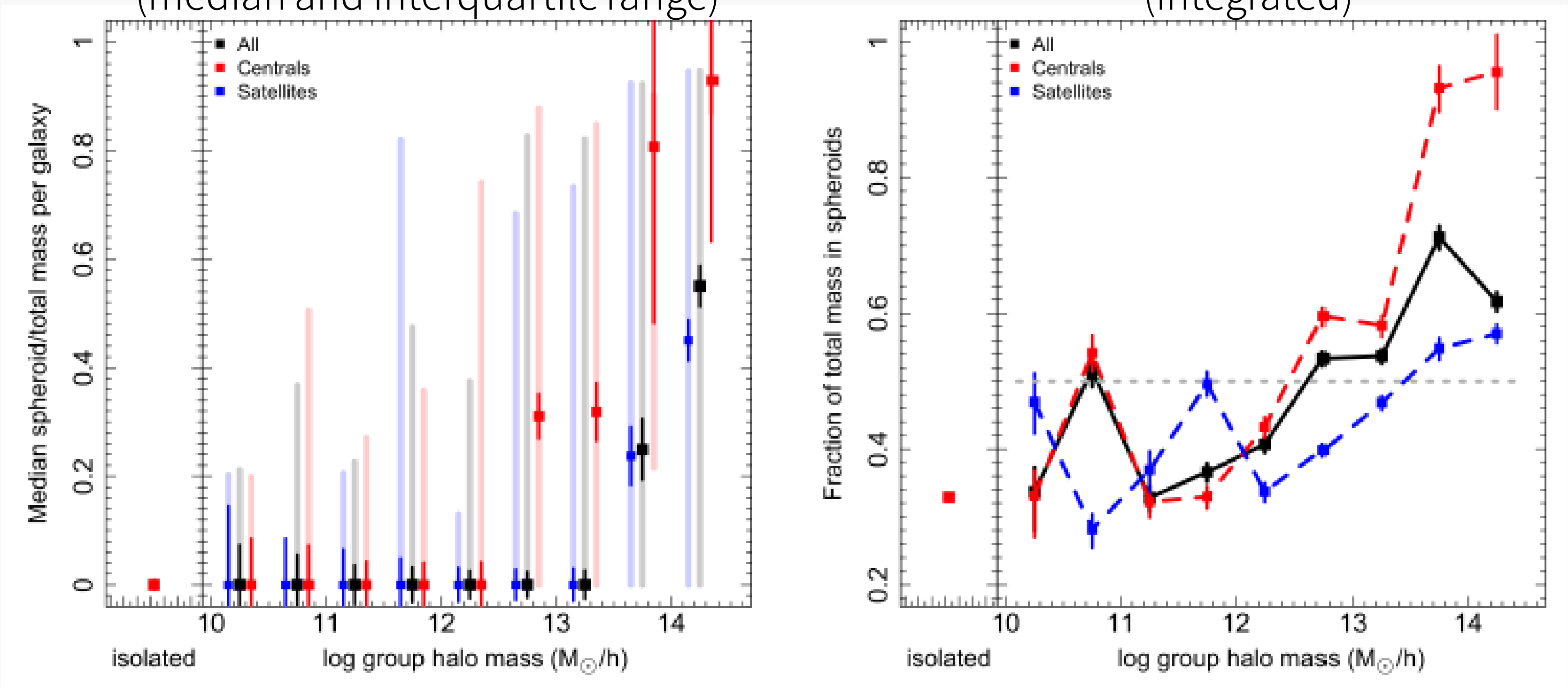
(median and interquartile range) (integrated)



- total mass become spheroid dominated just R/Rgroup < 0.5
  - Rgroup is a radius encompassing 50% of group members
- large scatter in spheroidal/total mass ratio in at fixed radius

(2) Spheroid mass and halo mass

(median and interquartile range) (integrated)



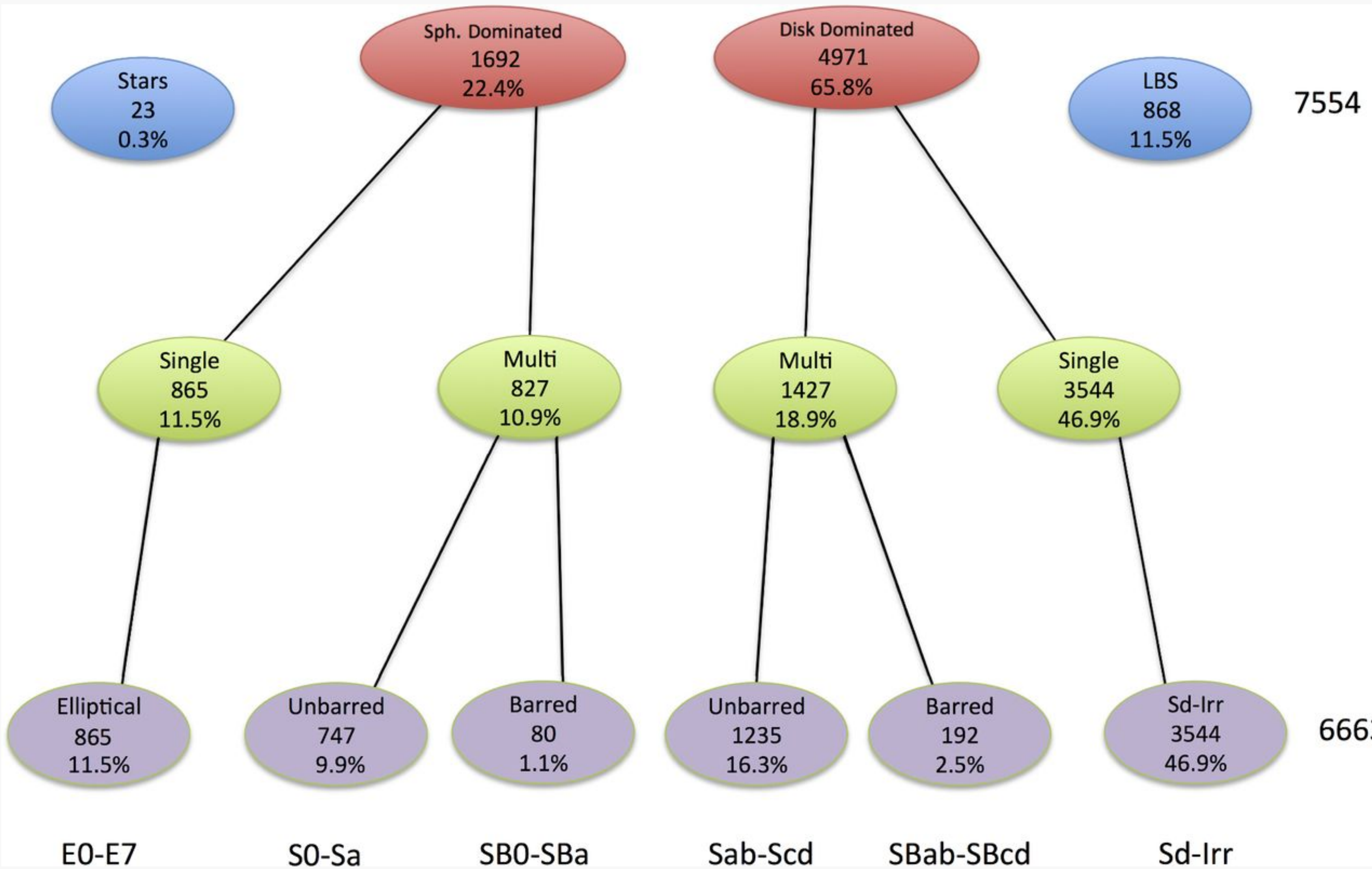
- strong decrease in spheroid mass fraction toward low halo mass, especially in ‘Centrals’
  - it’s not clear how the authors divide ‘Centrals’ and ‘Satellites’; cf. Robotham+ 2011
- reproducing mass ratios of spheroid and disk across various environments should be a benchmark for future cosmological galaxy formation models

Wrap up & Future prospects

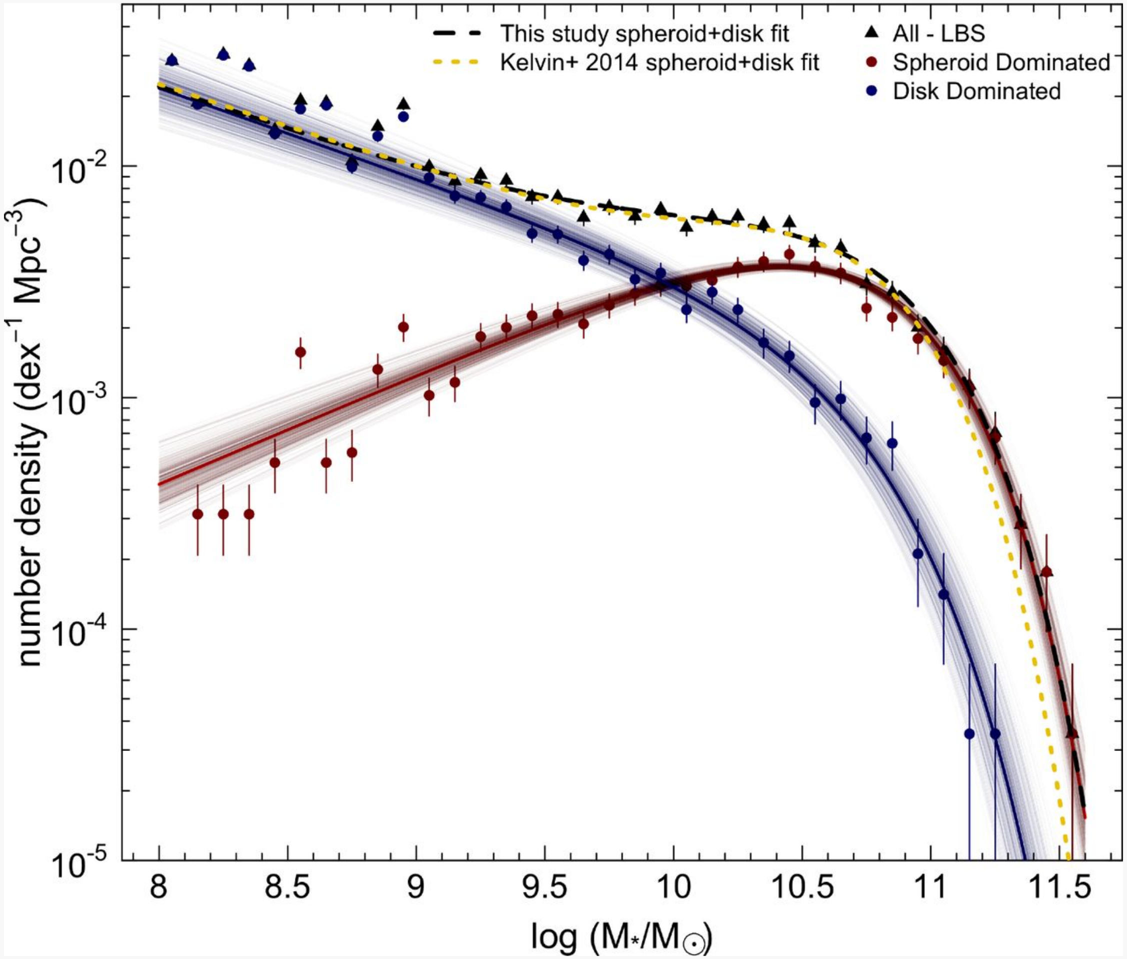
- What is the constraint on galaxy formation and evolution models and simulations?
  - not clear; models/simulations are going to be asked to fully reproduce the results
- Future prospects
  - deeper/wider survey to break limitations (fainter/brighter/more massive populations)
  - kinematics; IFU surveys (e.g. HECTOR; 10^5 gals) will put more direct constraints
  - ISM (HI/H_2) surveys will refine KS-relation, baryonic Tully-Fischer, environmental effects

SUPPLEMENTAL SLIDES

(1) Morphology classifications



(1) Stellar mass function: spheroid dominated vs disk dominated



- more detailed study and discussions can be found in paper (2)

(2) Sab-Scd spheroids has different nature from those of E/S0-Sa?

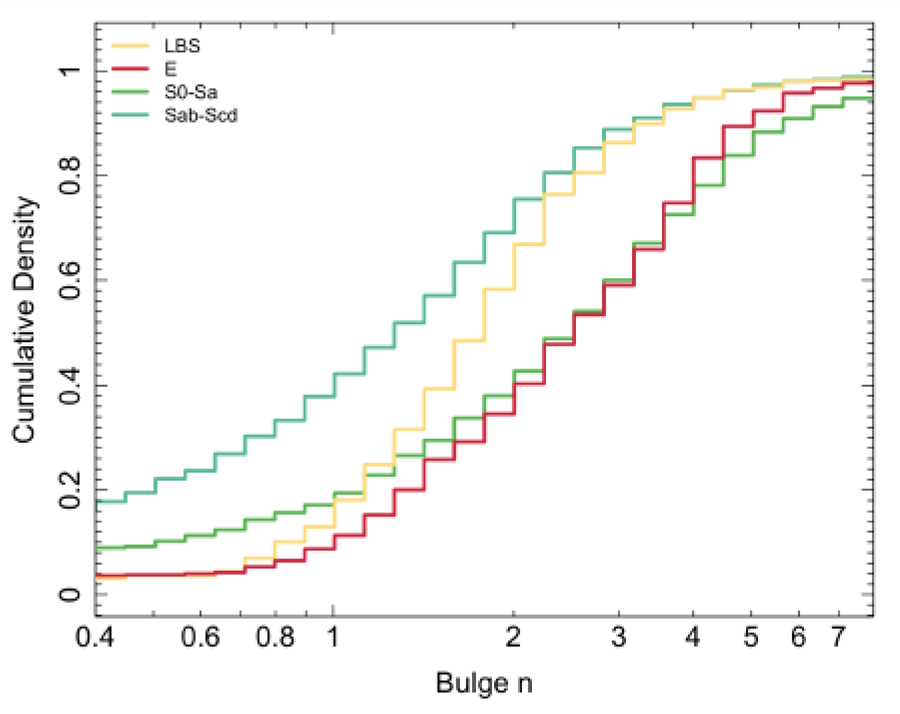


Figure 5. Cumulative distribution of bulge Sérsic index values by morphological type. The majority of Sab-Scd bulges display low Sérsic indices more consistent with disky or pseudobulge structures than classical bulges.

- single Sersic fits are sufficient to describe Sab-Scd (Lange+ 2016)
- combined disk stellar mass function is made of single-component fit for Sab-Scd